# 超级陶粲装置

# Super Tau-Charm Facility

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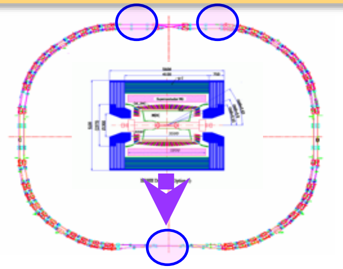
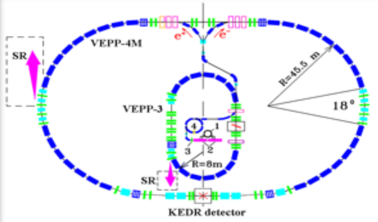
**University of Science and Technology of China**

**IOPP Colloquium, CCNU, Wuhan**
**Nov. 11, 2025**

# Particle Physics with Colliders

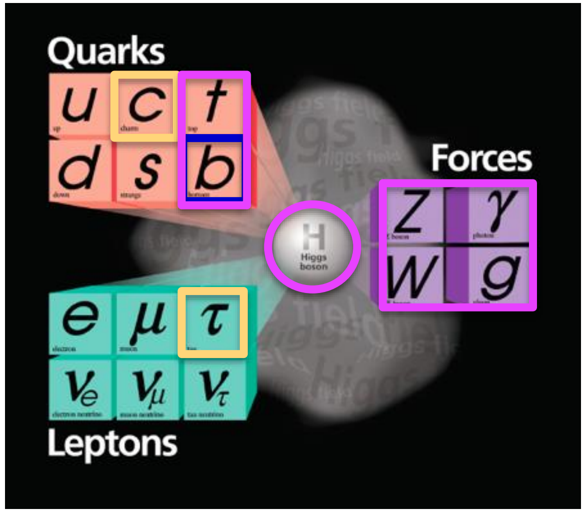


China BEPC II

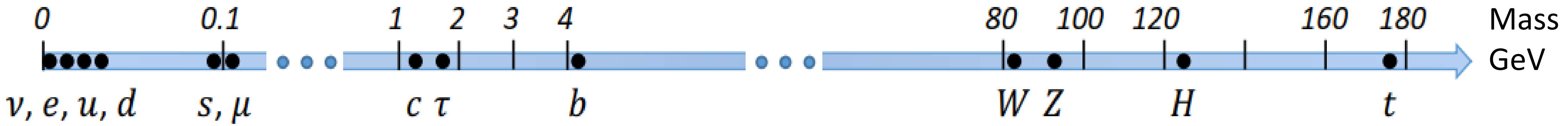



Russia VEPP-4M

Japan SuperKEKB




Europe LHC




BEPCII, STCF/SCTF, SKEKB

**Precision Frontier**

**hadron structure, exotic states, nature of strong interaction, flavor physics & CPV …**

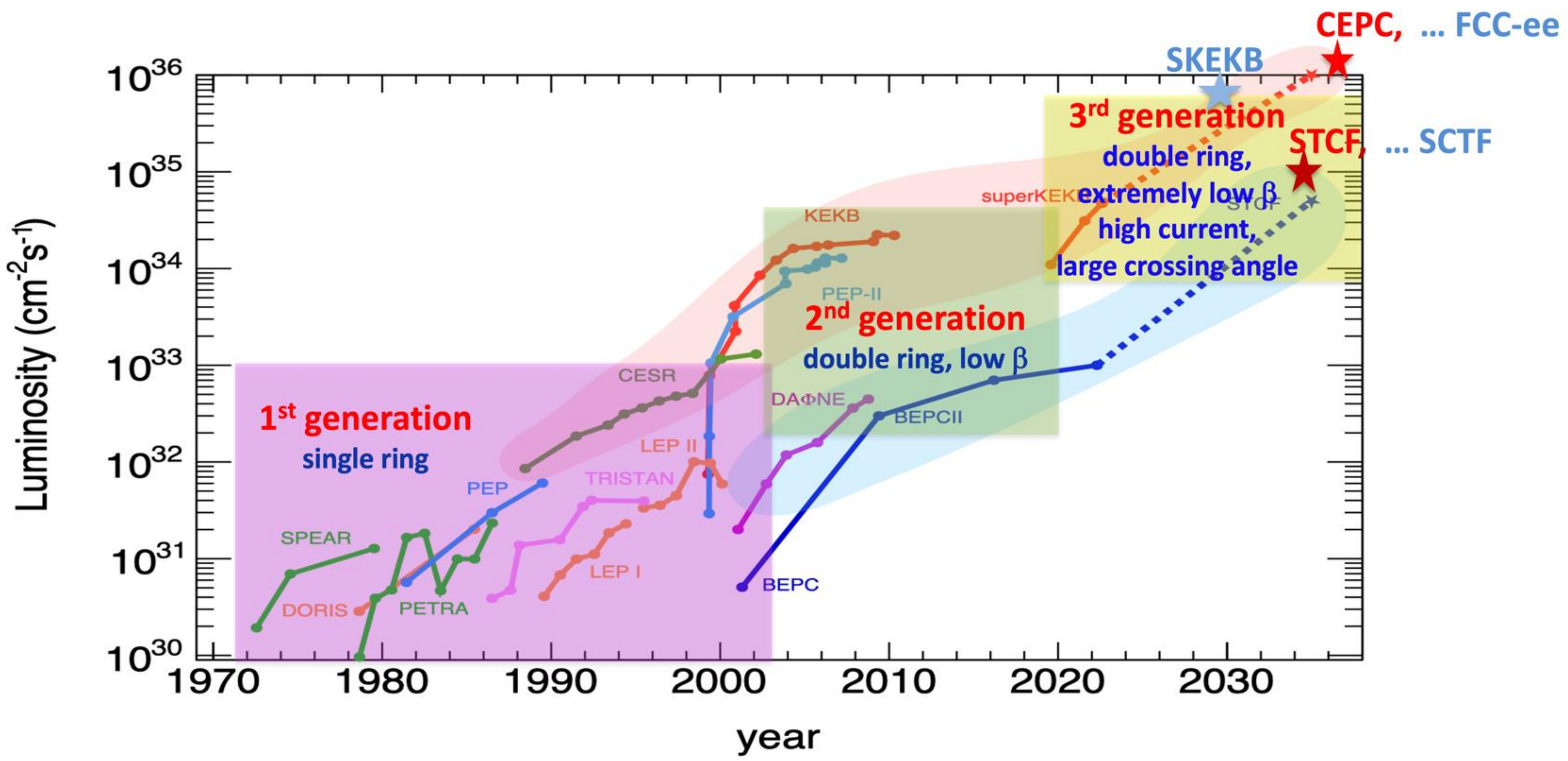
LHC, ILC/CLIC, FCC, CEPC-SPPC

**Energy Frontier**

**origin of mass, nature of EWSB, new physics with Higgs, SUSY, Dark matter, universe evolution …**

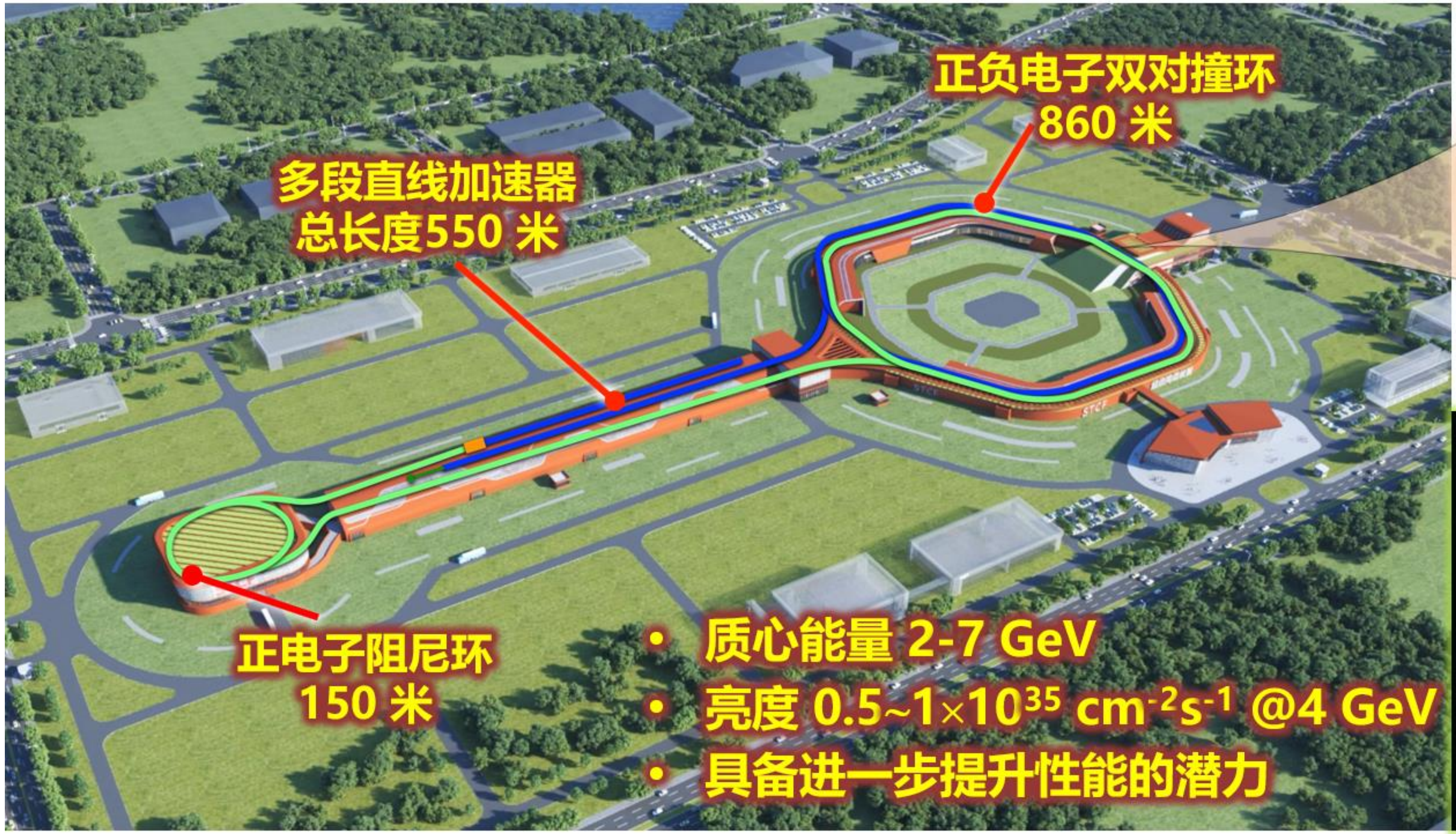
**In-depth exploration at both precision and energy frontiers is called for more than ever in the post Higgs era**

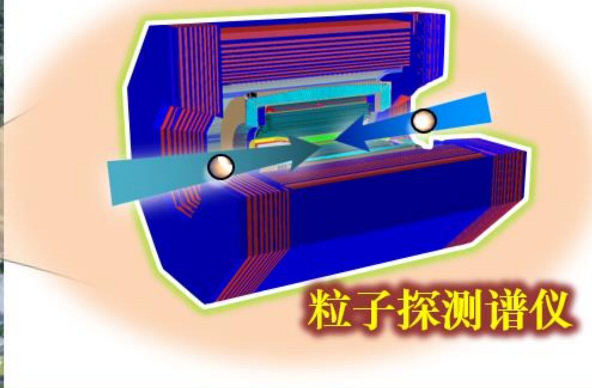
# Evolution of e+e- Colliders

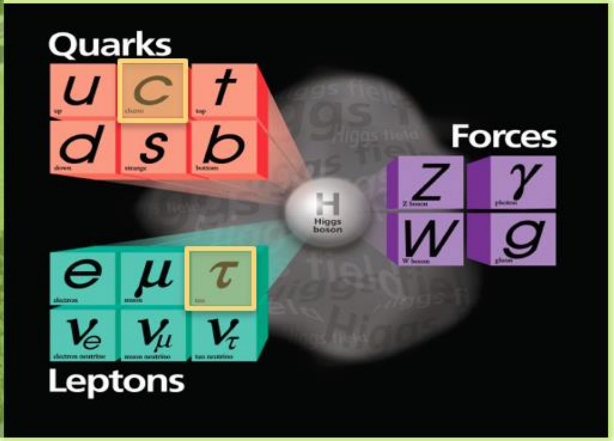



- **e+e- colliders are entering the era of 3rd generation, playing pivotal roles at both frontiers**

# Super Tau-Charm Facility (STCF)



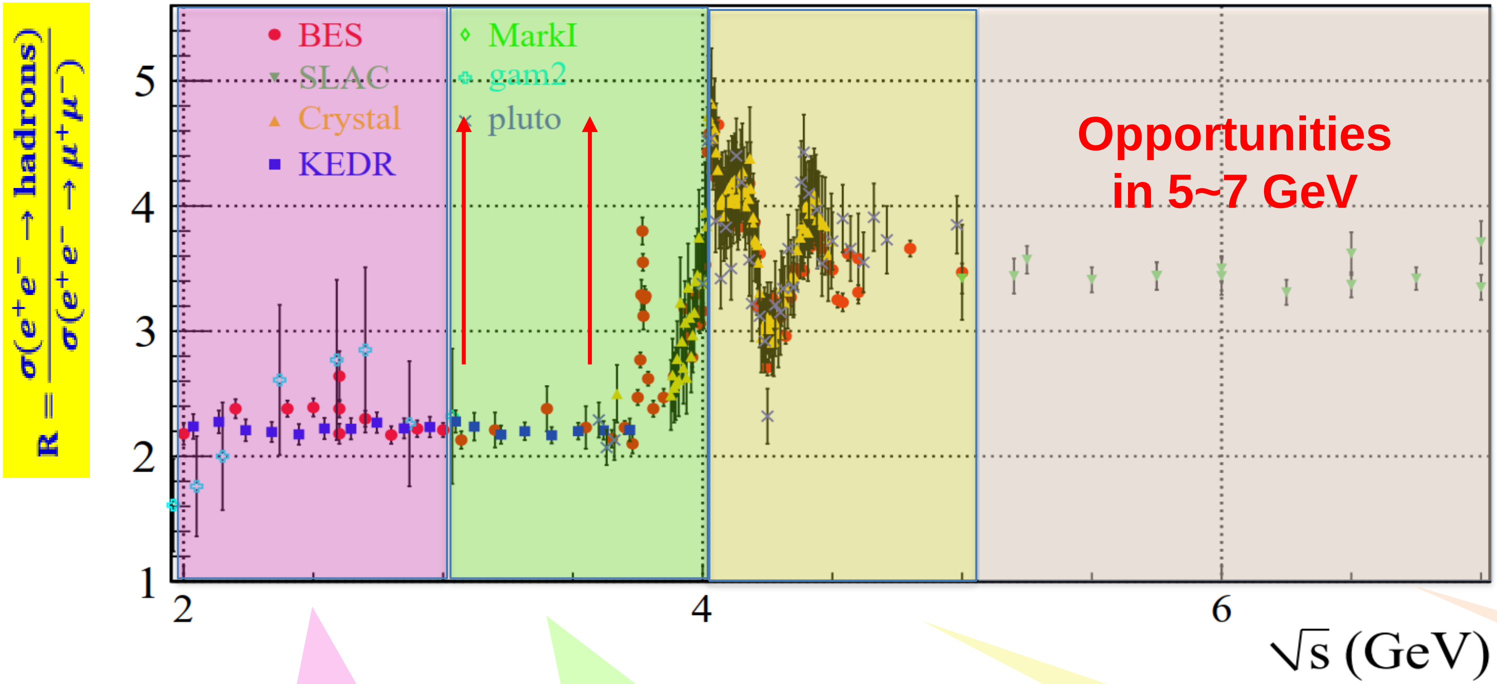




**STCF**, a flagship collider at the **precision frontier**, can produce a large number of clean tau leptons and hadrons, allowing full exploration of the unique physics potential in the tau-charm energy region: QCD, hadron physics, flavor physics …

**Building upon China's great success and well-established international position in tau-charm physics (Beijing Electron-Positron Collider / BEPC)**

# Unique Tau-Charm Energy Region




- **Transition region between perturbative and non-perturbative QCD**
- **Pair production of hadrons and τ leptons at threshold and/or with quantum correlation**
- **Abundant resonances**
- **Large production X-sec for charmonium(-like) states and exotic states**

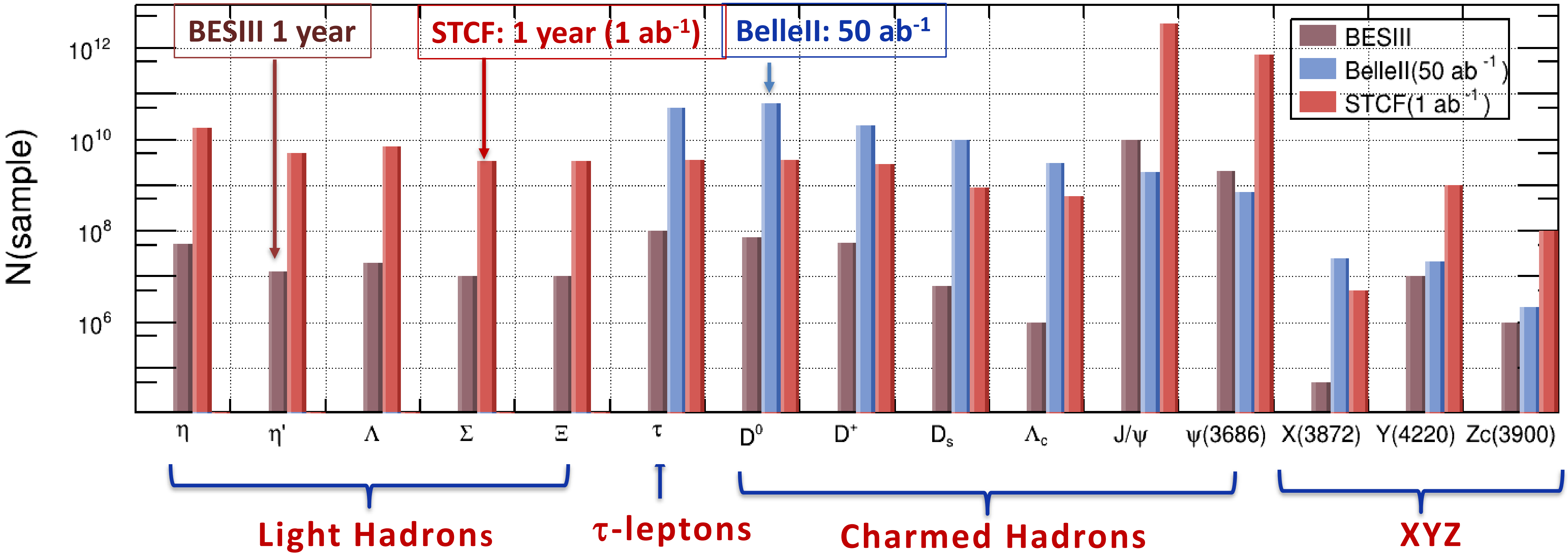
- Hadron form factors
- $Y(2170)$ resonance
- Mutltiquark states with s quark
- R value / g-2 related

- Light hadron spectroscopy
- Gluonic and exotic states
- Processes of LFV and CPV
- Rare and forbidden decays
- Physics with τ lepton

- $XYZ$ particles
- Physics with D mesons
- $f_D$ and $f_{D_s}$
- $D^0 - \overline{D}^0$ mixing
- Charm baryons

- Complete $XYZ$ family
- Hidden-charm pentaquarks
- Search for di-charmonium states
- More charmed baryons
- Hadron fragmentation

# STCF: A Super Factory of Various Particles




- **STCF is not only a super τ-charm factory, but also a super factory of XYZ, hyperons and light hadrons to unravel the mystery of how quarks form matter and study the symmetries of fundamental interactions with unprecedented precision**

# Scientific Questions and Objectives

**Symmetry breaking in fundamental interactions**

**Origin of matter-antimatter imbalance**

**Discovering CP violation in hyperons**

**Mystery of color confinement in particle physics**

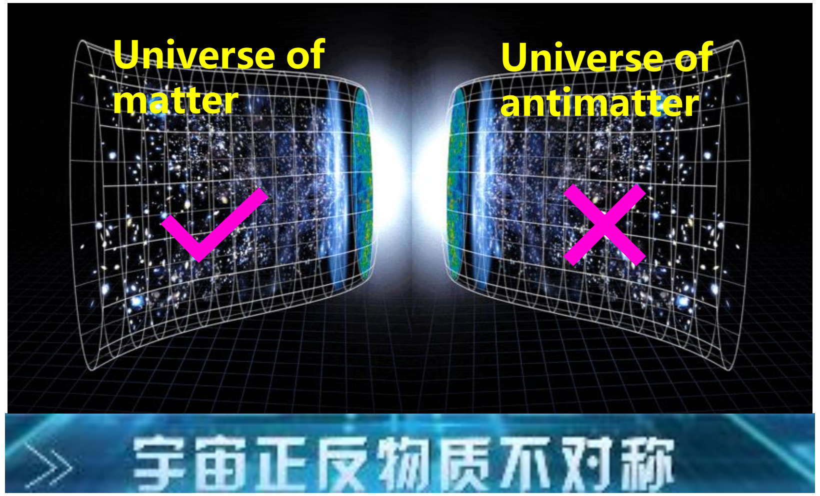
**Examining the structure of nucleons**

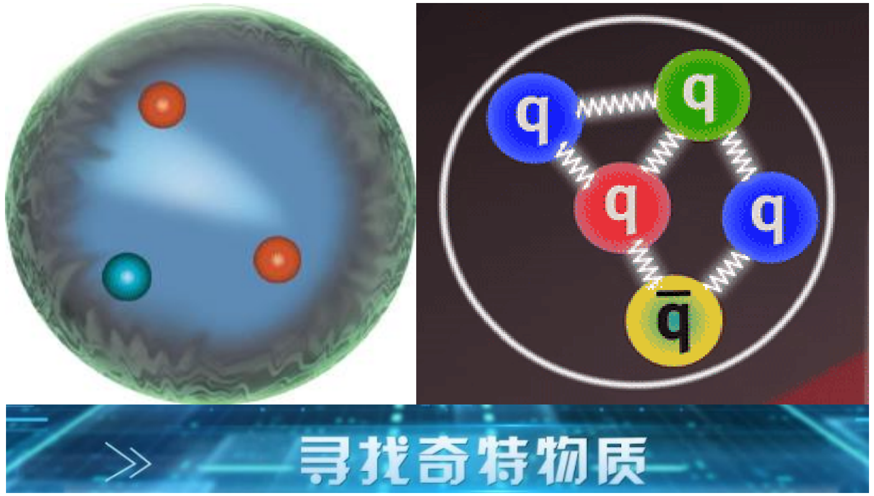
**Exploring how quarks and gluons form hadrons**

**Precision measurement of fundamental parameters**

**Examining the Standard Model**

**Searching for new physics**




# STCF Project Development

**2011**

Super Charm-tau Factory

**Proposed at "Workshop for acc. based high energy physics development strategy"**

**2015**

香山科学会议简报

**Fragrant Hills Science Forum**
**Demonstrated its importance and necessity, urging to lauch fesibility study and R&D**

**2017**

**Hefei Comprehensive National Science and Technology center,**
**STCF listed as a big science facility to be promoted**

**2018**

**USTC "double first-class" key project**
**Launched the conceptual design study and feasibility study**

**2021**

STCF Conceptual Design Report

**Conceptual Design report**
**Released the CDR for the physics and Detector, and the pre-CDR for accelerator**

**2022.4**

**Governments of Anhui Province and Hefei City**
**Endorsed the STCF Key Technology R&D project**

# STCF Project Development

**2023.01**

Initial budget for the Key technology R&D project of 20 M RMB from the local government

**2023.08**

Key technology R&D project kick-off and strategy development meeting
Over 170 attendees, including 30 academicians of CAS

**2023.12**

Budget Review for Key technology R&D project Approved for 364 M RMB

**2024.01**

1st International Advisory Committee meeting

**2024.05**

1st National Consulting Committee meeting

**2024.09**

The pre-proposal for Major National Science and Technology Infrastructure Projects for the 15th Five-Year Plan submitted to CAS

# R&D Project Review and Kick-Off Meetings

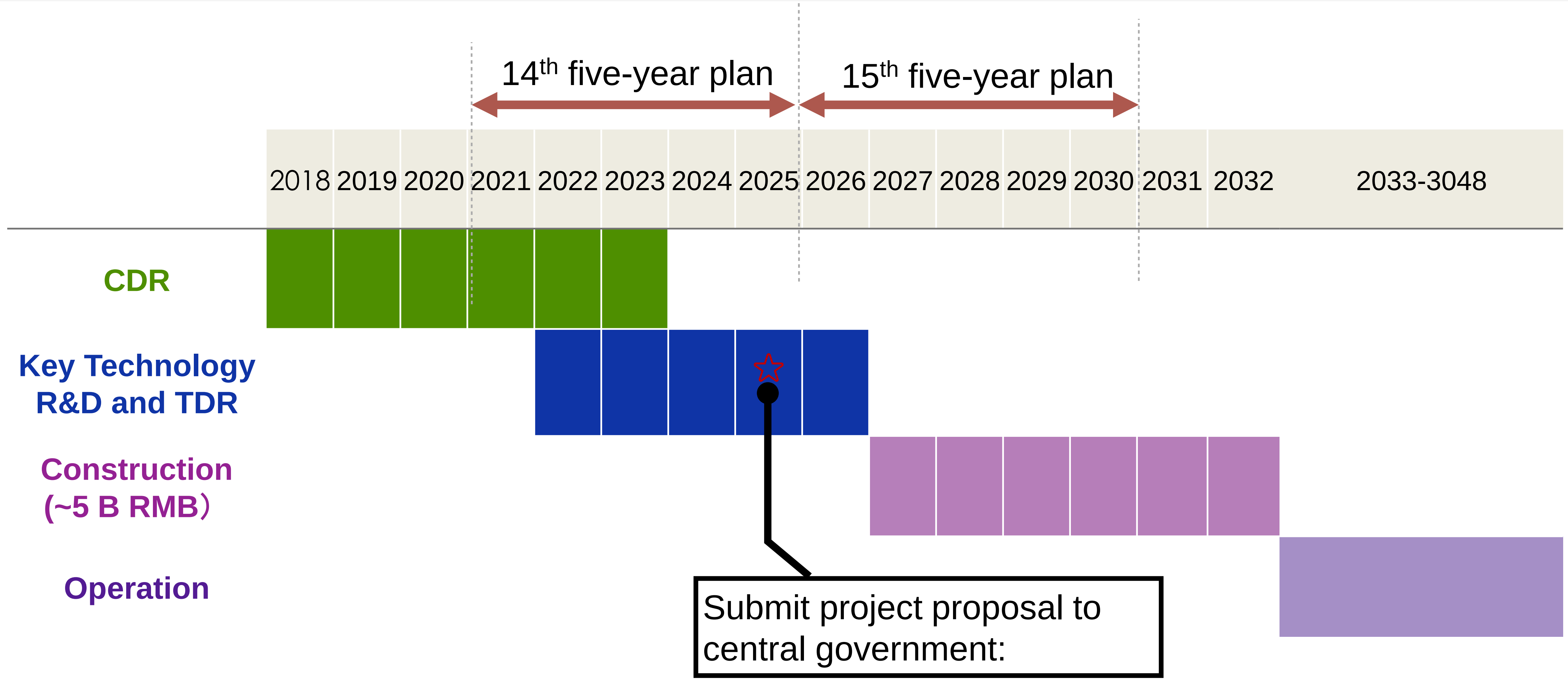
**Kick-off Meeting, Aug. 2023, USTC**

**More than 30 academicians of CAS, as well as government officials of Anhui province and Hefei city, along with representatives from various domestic research institutions, totaling 170 attendees.**

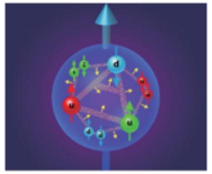
**R&D Project Review, Dec. 2023, USTC**

**Organized by Development and Reform Commissions of Anhui province and Hefei city. The R&D project was approved for a total budget of 364 M RMB and is jointly funded by Anhui, Hefei and USTC.**

# STCF Project Schedule



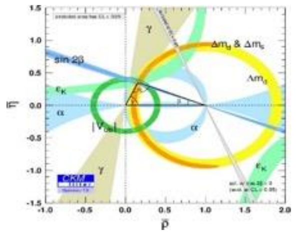
# STCF Physics Program

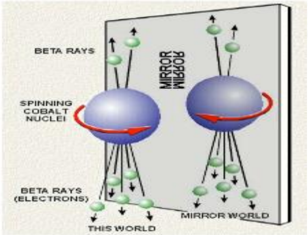



## Physics at STCF

### QCD and hadronic physics

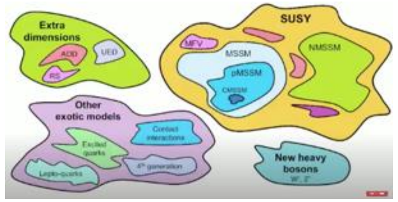
- **XYZ Properties:** e+e-→Y→γX,ηX,φX; e+e-→Y→πZc, KZcs
- **Hadron Spectroscopy:** Excited ccbar and their transition, Charmed hadron spectroscopy, Light hadron spectroscopy
- **R value:** e+e-→inclusive; τ mass: e+e-→τ+τ-
- **Nucleon Form Factors:** e+e-→BBbar from threshold
- **Pentaquarks:** e+e-→J/ψppbar, Λc Dbar pbar, Σc Dbar pbar
  **Di-charmonium:** e+e-→J/ψηc, J/ψhc
- **Muon g-2:** e+e-→π+ π-, π+ π- π0, 4π, K+ K-, γγ→π0, η(′),π+ π-
- **Fragmentation functions:** e+e-→(π,K,p,Λ,D)+X, e+e-→(ππ,KK,πK)+X




### Flavor Physics and CP Violation

- **CKM matrix (Vcd, Vcs):** D_(s)+→l+ν, D→P l+ ν
- **Charm hadron decay:** Λc+, Σc, Ξc, Ωc decay
- **CPV in Hyperons:** J/ψ→ΛΛbar, ΣΣbar, Ξ- Ξ+bar, Ξ0 Ξ0bar
- **D0-D0bar mixing:** ψ(3770)→(D0 D0bar)(CP=-), ψ(4140)→π0 (D0 D0bar)(CP=-) or γ(D0 D0bar)(CP=+)
- **CPV in τ:** τ→Ks πν, EDM of τ, τ→π/K π0 ν for polarized e- beam
- **CPV in Charm:** D0→K+K-/π+π-, Λc→pK-π+π0/Λπ+π+π-/pKs π+π-
- **γ/ϕ3 measurement:** D0→K(s/L) π+ π-, K(s/L) K+ K-,K3π, 4π
- **γ polarization:** D0→K1 e+ ν_e




### Forbidden/Rare decay and New Particle

- **LNV, BNV:** D(s)+→l+ l+ X-, J/ψ→Λc e-, B→Bbar…
- **Symmetry violation:** η(′)→llπ0, η′→ηll…
- **FLV decays:** τ→γl, lll,l P1 P2 , J/ψ→ll′, D0→ll′ (l′≠l)…
- **FCNC:** D→γV, D0→l+ l-, e+e-→D∗ , Σ+→pl+ l-…
- **Dark photon:** e+e-→γA′(→l+ l- ), J/ψ→e+e-A′…
  **Millicharged:** e+e-→χχ̄γ…

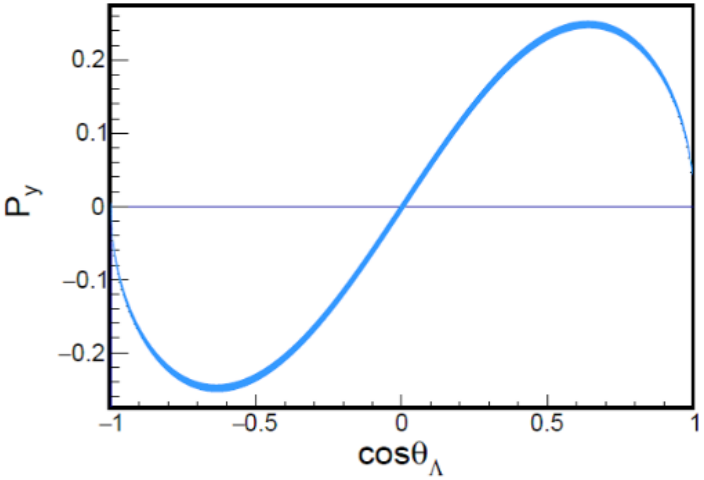
- Leading role
- Competing with Belle II/LHCb
- Complementary to BelleII/LHCb/Eic/EicC

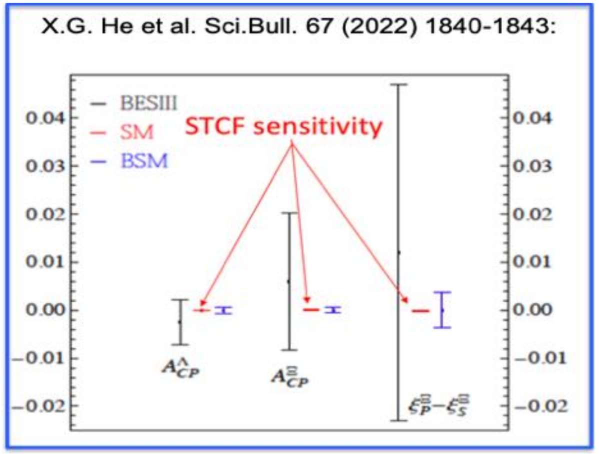
# (I) Tests of Fundamental Symmetries

- **The discrete symmetries (C, P, T …) play a crucial role in understanding natural laws**
- **There is experimental evidence of parity (P), time reversal (T), charge conjugation (C), and combined CP violation.**
- **STCF will enable more precise tests of symmetry-breaking properties and more sensitive searches for new symmetry breaking with huge numbers of K, $\tau$, hyperons and charmed hadrons.**
- **STCF prospects:**
  - CPV in hyperons and charmed hadrons
  - EDM of hyperons and tau
  - CLFV in tau and charmonium decays
  - CPT in neutral Kaon system

# CP Violation in Hyperons

- CP violation observed in K, B, D mesons and B baryons, all consistent with CKM theory in SM
- Baryon asymmetry of the universe indicates the existence of non-SM CPV sources
- Only strange baryons and charm baryons remain unexplored for CP violation
- STCF has great potential for discovering CPV in hyperons using hyperon pairs in J/psi decays
- Unique advantages at STCF: quantum correlated, large statistics, clear environment




$$\sigma_{A_{CP}} \approx \sqrt{\frac{3}{2}} \frac{1}{\alpha_1 \sqrt{N_{sig}} \sqrt{\langle P_B^2 \rangle}}.$$

$1\times10^{9}\ \Lambda\bar{\Lambda},\ \langle P_B^2\rangle=0.1 \Longrightarrow \sigma_{A_{CP}} \sim 1.4\times10^{-4}$

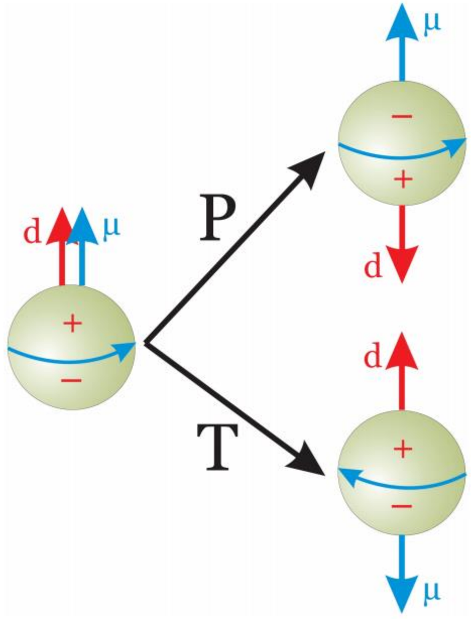
$1\times10^{9}\ \Lambda\bar{\Lambda},\ \langle P_B^2\rangle=0.8 \Longrightarrow \sigma_{A_{CP}} \sim 5\times10^{-5}$

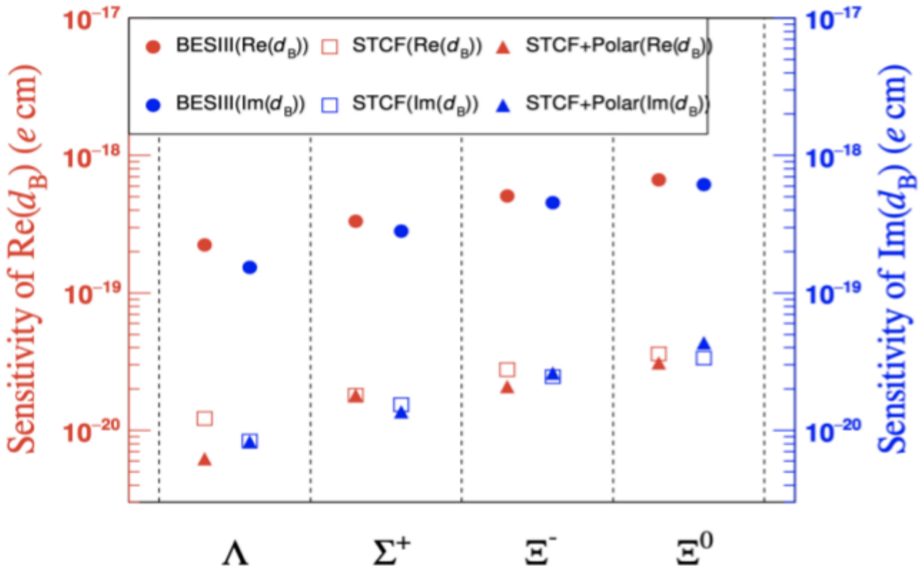
**Highest sensitivity on hyperon CPV in the world**

# EDM of Hyperons

- **Non-zero EDM indicates T violation, and hence CP violation if CPT holds**
- **J/psi decays to hyperon pairs at STCF offer an excellent laboratory for in-direct measurement of hyperon EDM**

μ: magnetic dipole moment
d: electric dipole moment




(a)Sensitivity of $Re(d_B)$ and $Im(d_B)$

**X.G.He, J.P. Ma, Phys.Lett.B 839(2023)137834**

SM: $\sim 10^{-26}$ $e$ cm

BESIII: milestone for hyperon EDM measurement
$\Lambda$ $10^{-19}$$e$ cm ( FermiLab $10^{-16}$ $e$ cm)
first achievement for $\Sigma^+$,$\Xi^-$ and $\Xi^0$ at level of $10^{-19}$$e$ cm
a litmus test for new physics

STCF: improved by 2 order of magnitude

**Highest sensitivity on hyperon EDM in the world**

# Milestone in CPV studies at STCF

## $CP$ violation studies at Super tau-charm facility

Hai-Yang Cheng[a], Zhi-Hui Guo[b], Xiao-Gang He[c], Yingrui Hou[d], Xian-Wei Kang[e], Andrzej Kupsc[f,g], Ying-Ying Li[h], Liang Liu[h], Xiao-Rui Lyu[d], Jian-Ping Ma[i], Stephen Lars Olsen[j,k], Haiping Peng[h], Qin Qin[q], Pablo Roig[m,n], Zhi-Zhong Xing[o], Fu-Sheng Yu[p], Yu Zhang[q], Jianyu Zhang[d], Xiaorong Zhou[h]

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**Abstract**

Charge-parity ($CP$) violation in the tau-charm energy region is one of the promising areas to search for. The future tau-charm facility of next generation is designed to operate in a center-of-mass energy from 2.0 to 7.0 GeV with a peak luminosity of $0.5 \times 10^{35}$ cm$^{-2}$s$^{-1}$. Huge amount of hadrons and tau ($\tau$) leptons will be collected with good kinematic constraint and low-background environment. In this report, possibilities of $CP$ violation studies in tau-charm energy region and at the future tau-charm facility are discussed from various aspects, *i.e.* in the production and decay of hyperons and $\tau$ lepton; in the decay of charmed hadrons. The $CPT$ invariance test in $K^0 - \bar{K}^0$ mixing is also presented.

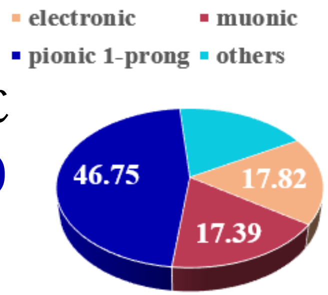
*Preprint submitted to PHYSICS REPORTS* *September 25, 2024*

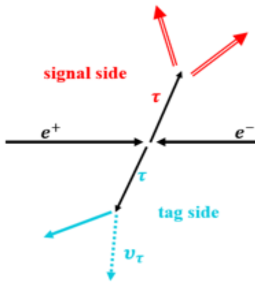
**Contents**

# Charged Lepton Flavor Violation

- Signal side: $\boldsymbol{\tau \to 3\ leptons}$
- Tag side: $\tau \to e\nu\bar{\nu},\ \mu\nu\bar{\nu}\ ,\ \pi\nu + n\pi^0$ ($\mathcal{B}r = 82\%$)
- Almost background free, sensitivity : $\mathcal{B}^{90}_{UL}\ (\tau \to \mu\mu\mu) \sim 1/\mathcal{L}$
- Best efficiency ($\tau \to \mu\mu\mu$ ): 22.5% **(including the tag $\mathcal{BF}$)**

$$\boldsymbol{\mathcal{B}^{90}_{UL}(\tau \to \mu\mu\mu) < \frac{N^{90}_{UL}}{2\varepsilon N_{\tau\tau}} \sim 1.4 \times 10^{-9}}$$




| Model | Ref. | $\tau \to \mu\gamma$ | $\tau \to \mu\mu\mu$ |
|---|---|---|---|
| SM + heavy majorana | PRD 66.034008 | $10^{-9}$ | $10^{-10}$ |
| Non-universal $Z'$ | PLB 547(3)252 | $10^{-9}$ | $10^{-8}$ |
| SUSY + seesaw | PRL 89:241802 | $10^{-10}$ | $10^{-7}$ |
| SM + 4th generation | arXiv.1006.530 6 | $10^{-8}$ | $10^{-8}$ |

- The cLFV decays of vector mesons $\boldsymbol{V \to l_i l_j}$ are also predicted **in various of extension models** of SM:

$$\mathcal{B}^{90}_{UL}(J/\psi \to e\mu) < 10^{-13}$$

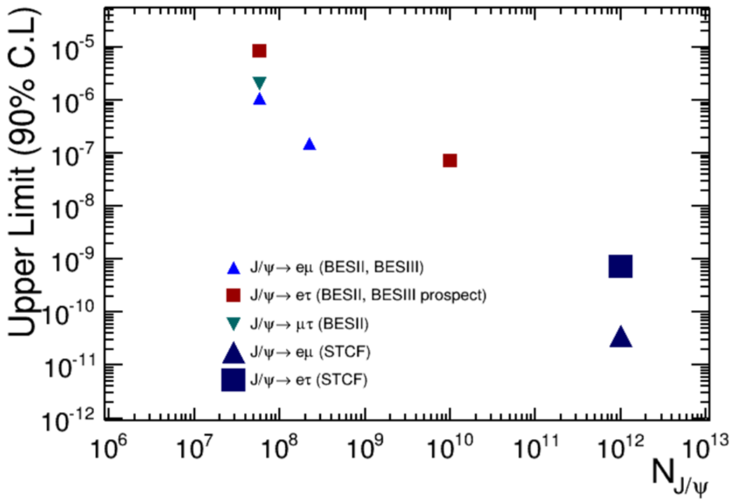
$$\mathcal{B}^{90}_{UL}(J/\psi \to e(\mu)\tau)\ ) < 10^{-9}$$

- At **STCF**, **1 trillion $\boldsymbol{J/\psi}$** can be obtained in one year, taken efficiency from BESIII, the upper limit is predicted to be:

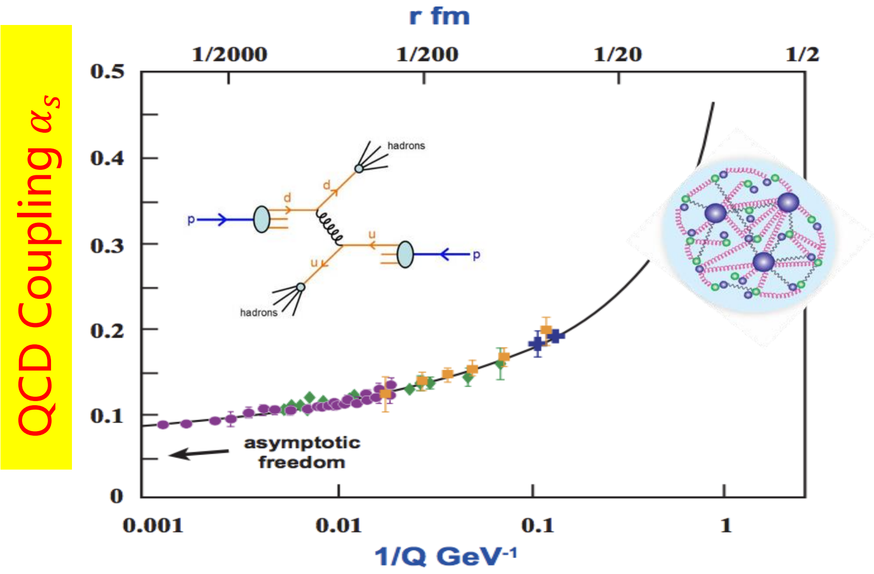
$$\boldsymbol{\mathcal{B}^{90}_{UL}(J/\psi \to e\mu) < 3.6 \times 10^{-11}}$$

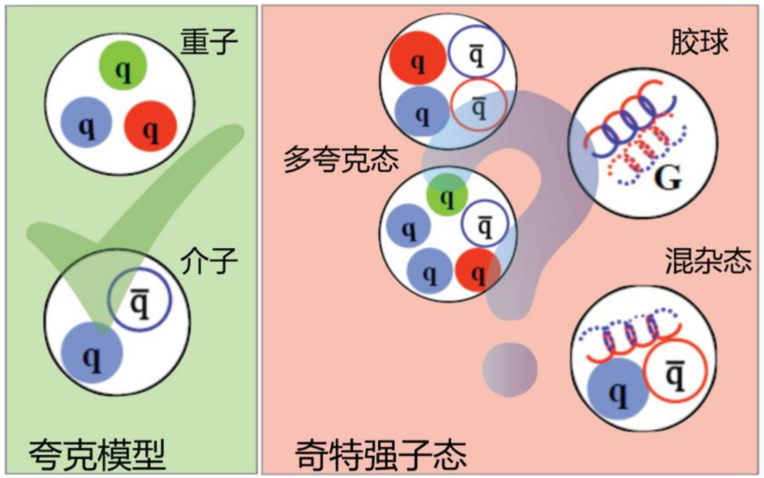
$$\boldsymbol{\mathcal{B}^{90}_{UL}(J/\psi \to e\tau)\ ) < 7.1 \times 10^{-10}}$$

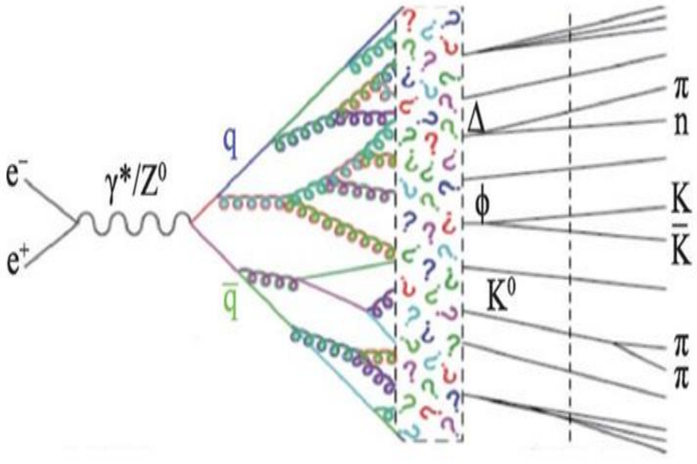
- The $\boldsymbol{\mathcal{B}^{90}_{UL}(J/\psi \to e\tau)\ )}$ can be further **optimized** with better PID.



# (II) Studies of Quark Confinement



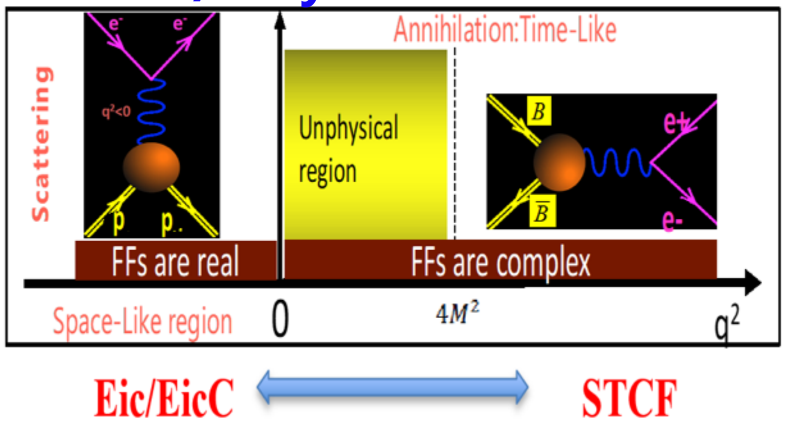



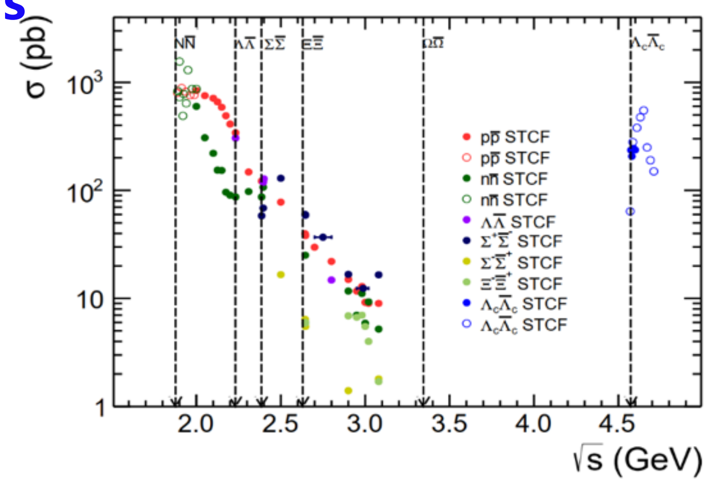

- Unraveling the mechanism of quark confinement requires comprehensive studies of **hadron spectroscopy**, hadron **production**, hadron **decays**, and hadron **structure**.
- The STCF will produce vast quantities of **charmed hadrons** and **light flavor hadrons**, enabling these studies to deeply explore how quarks and gluons form hadrons and how quark confinement shapes their internal structures.

# Hadron Production

**Hadron production at STCF is a key avenue for studies of EM form factors and fragmentation functions**

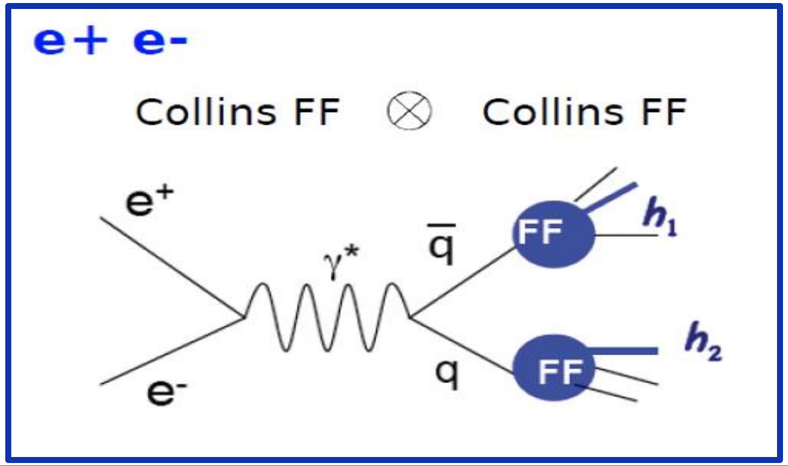
## Nucleons/Baryons EM form factors

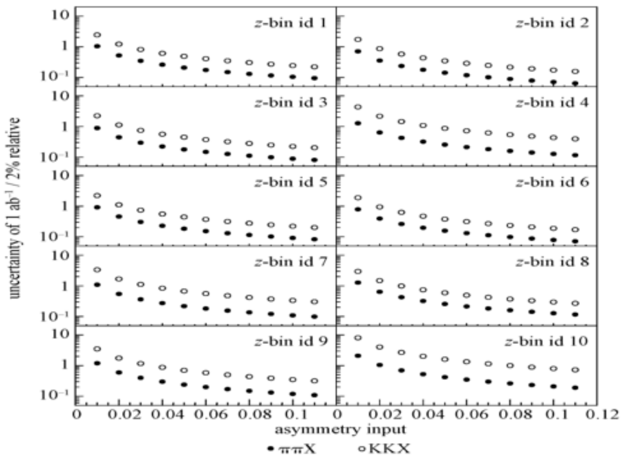



**STCF will improve the measurement precision by 2 orders of magnitude, revealing the near-threshold cross section singularity and mystery of $G_E$ and $G_M$**

## Fragmentation Functions



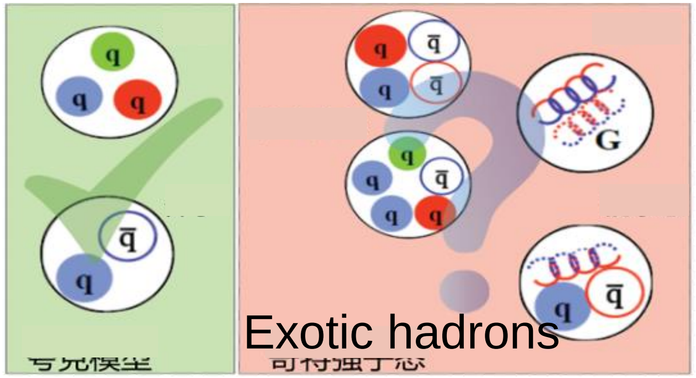



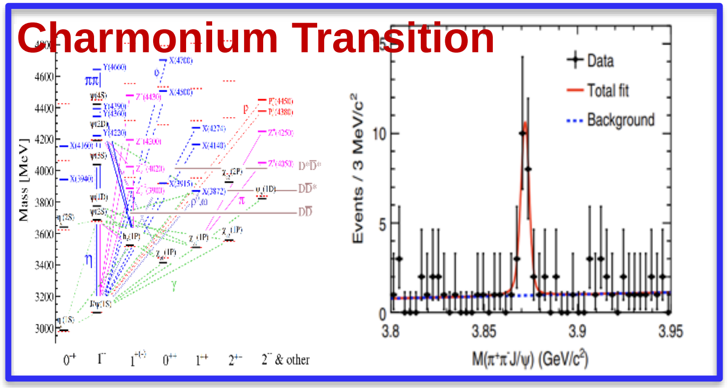

**Most precise FFs in q2 range 4-50 GeV² with multi-dimensional binning and important input for TMD extraction at EIC/EicC**

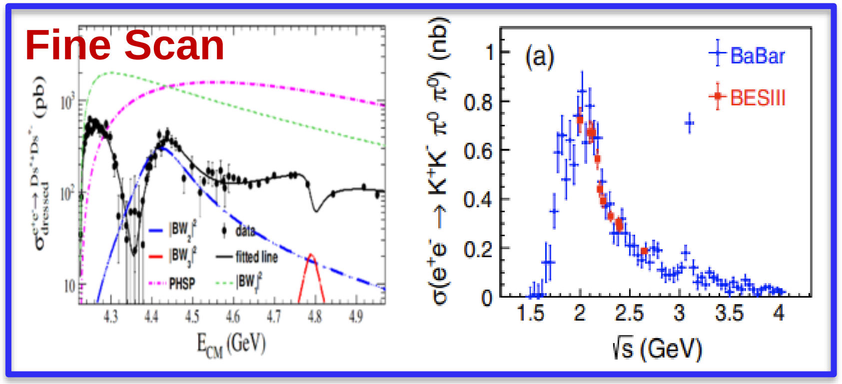
**Precise test the universality of FFs in different processes, and its evolution with q2**

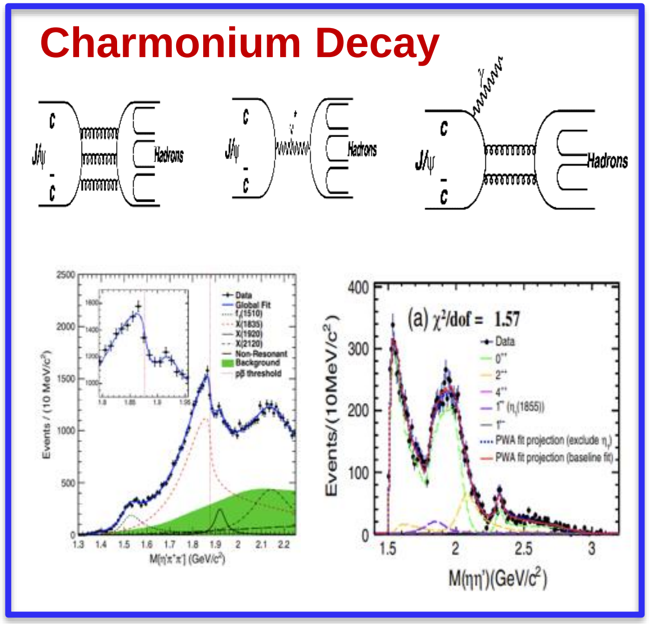
# Hadron Spectroscopy and Exotic States

## A **unique** territory for the QCD confinement




## A Charmonium(-like) factory (per year):

- 3T $J/\psi$, 0.6T $\psi(3686)$, 1B Y(4230), 100M $Z_c(3900)$ and 5M X(3872)

## Physics opportunities :

- Energy dependent structures of $Z_{c(s)}$
- More XYZ states → spectroscopy
- Missing Charmonium states and their transitions
- Glueballs and hybrid states

**STCF has an dominant advantage in studying hadron spectroscopy and exotic states, and is expected to make significant breakthroughs**

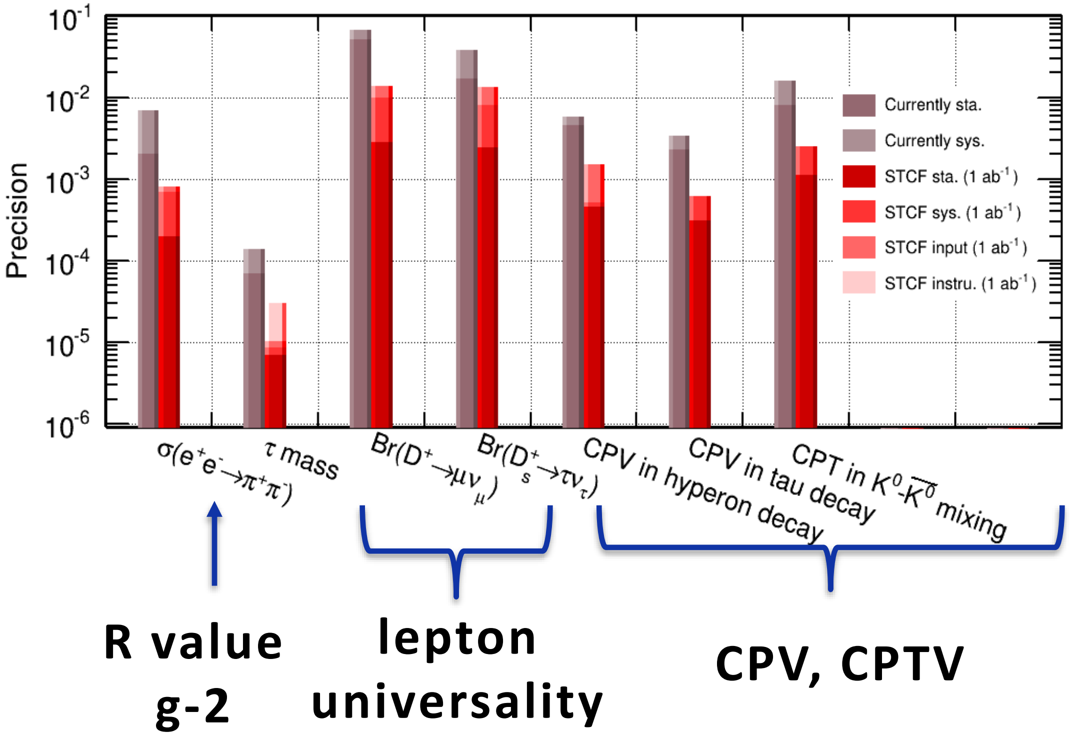
# (III) Measurements of Fundamental Physics Parameters

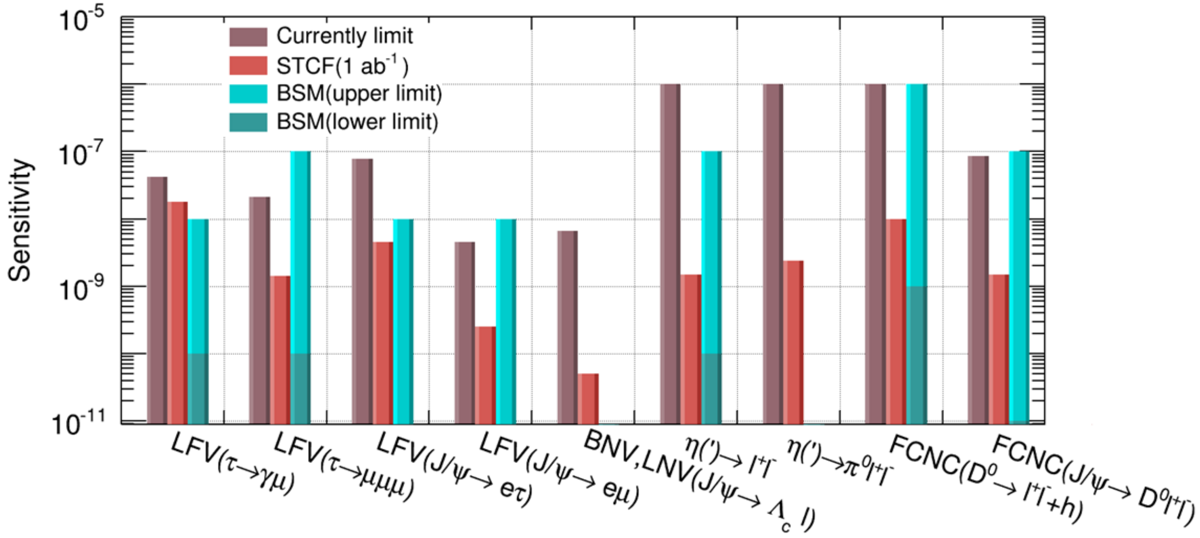
- **Essential for testing SM and searching for new physics**
- STCF enables high-precision measurements:
  - **R-value**: A fundamental quantity reflecting quark flavors/colors, with implications for new particle searches and theoretical inputs (e.g., fine-structure constant, muon g-2)
  - **Tau lepton mass**: Critical for testing lepton universality
  - **CKM matrix unitarity and triangle** : Violations could hint at a fourth quark generation
  - **Strong coupling constant ($\alpha_s$)** : Directly impacts Higgs/EW/top quark predictions and vacuum stability studies

| Observable | BESIII (2020) | Belle II (50 ab$^{-1}$) | STCF (1 ab$^{-1}$) |
|---|---|---|---|
| *Charmonium(like) spectroscopy:* | | | |
| Luminosity between 4–5 GeV | 20 fb$^{-1}$ | 0.23 ab$^{-1}$ | 1 ab$^{-1}$ |
| *Collins fragmentation functions:* | | | |
| Asymmetry in $e^+e^- \to KK+X$ | 0.3 [470] | – | $<0.002$ [471] |
| *CP violations:* | | | |
| $A_{cp}$ in hyperon | 0.014 [26] | – | 0.00023 |
| $A_{cp}$ in $\tau$ | – | $\mathcal{O}(10^{-3})/\sqrt{70}$ [251] | 0.0009 [250] |
| *Leptonic decays of $D_{(s)}$:* | | | |
| $V_{cd}$ | 0.03 [472] | – | 0.0015 |
| $f_D$ | 0.03 | – | 0.0015 |
| $\frac{\mathcal{B}(D\to\tau\nu)}{\mathcal{B}(D\to\mu\nu)}$ | 0.2 | – | 0.005 |
| $V_{cs}$ | 0.02 [473] | 0.005 | 0.0015 |
| $f_{D_s}$ | 0.02 | 0.005 | 0.0015 |
| $\frac{\mathcal{B}(D_s\to\tau\nu)}{\mathcal{B}(D_s\to\mu\nu)}$ | 0.04 | 0.009 | 0.0038 |
| *D mixing parameter:* | | | |
| $x$ | – | 0.03 | 0.05 [474] |
| $y$ | – | 0.02 | 0.05 |
| *$\tau$ properties:* | | | |
| $m_\tau$ (MeV/$c^{-2}$) | 0.12 [475] | – | 0.012 |
| $d_\tau$ (e cm) | – | $2.02\times10^{-19}$ | $5.14\times10^{-19}$ |
| *cLFV decays of $\tau$ (U.L at 90% C.L.):* | | | |
| $\tau\to lll$ | – | $1\times10^{-9}$ | $1.4\times10^{-9}$ |
| $\tau\to\gamma\mu$ | – | $5\times10^{-9}$ | $1.8\times10^{-8}$ |
| $J/\psi\to e\tau$ | $7.5\times10^{-8}$ | – | $7.1\times10^{-10}$ |

# Precision Measurements and Rare Decays

- **STCF is expected to improve the current precisions of many important measurements by ~1 order of magnitude and enhance sensitivities to various rare or forbidden decays by ~2 orders of magnitude**
- **Great potential to reveal new physics**

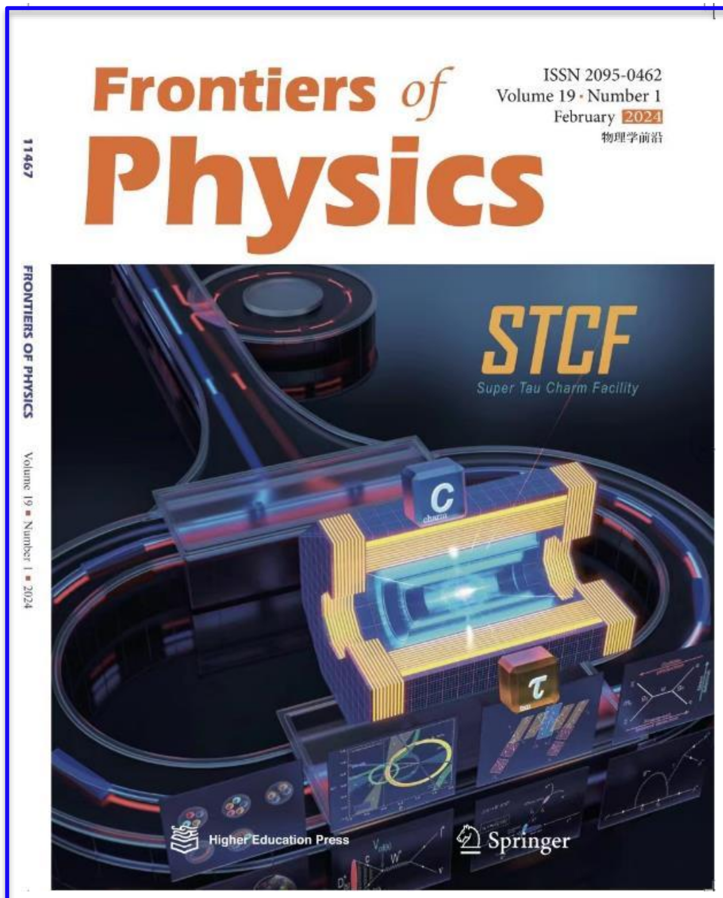



**LFV, BNV, FCNC to probe BSM**

# STCF Conceptual Design Studies

## Physics & Detector CDR





FRONTIERS OF PHYSICS

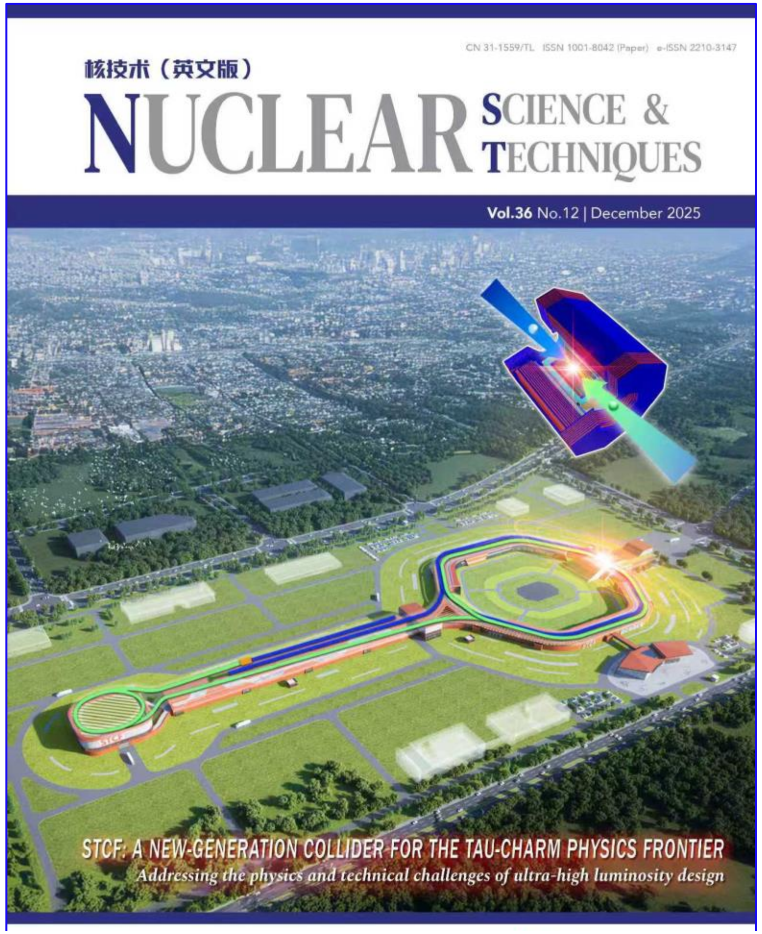
REPORT
Volume 19 / Issue 1 / 14701 / 2024


STCF conceptual design report (Volume 1):
Physics & detector


M. Achasov[3], X. C. Ai[82], R. Aliberti[38], Q. An[63,72], X. Z. Bai[63,72], Y. Bai[62], O. Bakina[39], A. Barnyakov[3,50], V. Blinov[3,50,51], V. Bobrovnikov[3,51], D. Bodrov[23,60], A. Bogomyagkov[3], A. Bondar[3], I. Boyko[39], Z. H. Bu[73], F. M. Cai[20], H. Cai[77], J. J. Cao[20], Q. H. Cao[54], X. Cao[33], Z. Cao[63,72], Q. Chang[20], K. T. Chao[54], D. Y. Chen[62], H. Chen[81], H. X. Chen[62], J. F. Chen[58], K. Chen[6], L. L. Chen[20], P. Chen[78], S. L. Chen[6], S. M. Chen[66], S. Chen[69], S. P. Chen[69], W. Chen[64], X. Chen[74], X. F. Chen[58], X. R. Chen[33], Y. Chen[32], Y. Q. Chen[36], H. Y. Cheng[34], J. Cheng[48], S. Cheng[28], T. G. Cheng[2], J. P. Dai[80], L. Y. Dai[28], X. C. Dai[54], D. Dedovich[39], A. Denig[19,38], I. Denisenko[39], J. M. Dias[4], D. Z. Ding[58], L. Y. Dong[32], W. H. Dong[63,72], V. Druzhinin[3], D. S. Du[63,72], Y. J. Du[77], Z. G. Du[41], L. M. Duan[33], D. Epifanov[3], Y. L. Fan[77], S. S. Fang[32], Z. J. Fang[63,72], G. Fedotovich[3], C. Q. Feng[63,72], X. Feng[54], Y. T. Feng[63,72], J. L. Fu[69], J. Gao[59], P. S. Ge[73], C. Q. Geng[15], L. S. Geng[2], A. Gilman[71], L. Gong[43], T. Gong[21], B. Gou[33], W. Gradl[38], J. L. Gu[63,72], A. Guevara[4], L. C. Gui[26], A. Q. Guo[33], F. K. Guo[4,69,2], J. C. Guo[63,72], J. Guo[59], Y. P. Guo[11], Z. H. Guo[16], A. Guskov[39], K. L. Han[69], L. Han[63,72], M. Han[63,72], X. Q. Hao[20], J. B. He[69], S. Q. He[63,72], X. G. He[59], Y. L. He[20], Z. B. He[33], Z. X. Heng[20], B. L. Hou[63,72], T. J. Hou[74], Y. R. Hou[69], C. Y. Hu[74], H. M. Hu[32], K. Hu[57], R. J. Hu[33], X. H. Hu[9], Y. C. Hu[49], J. Hua[61], G. S. Huang[63,72], J. S. Huang[47], M. Huang[69], Q. Y. Huang[69], W. Q. Huang[69], X. T. Huang[57], X. J. Huang[33], Y. B. Huang[14], Y. S. Huang[64], N. Hüsken[38], V. Ivanov[3], Q. P. Ji[20], J. J. Jia[77], S. Jia[62], Z. K. Jia[63,72], H. B. Jiang[77], J. Jiang[57], S. Z. Jiang[14], J. B. Jiao[57], Z. Jiao[24], H. J. Jing[69], X. L. Kang[8], X. S. Kang[43], B. C. Ke[82], M. Kenzie[5], A. Khoukaz[76], I. Koop[3,50,51], E. Kravchenko[3,51], A. Kuzmin[3], Y. Lei[60], E. Levichev[3], C. H. Li[42], C. Li[55], D. Y. Li[33], F. Li[63,72], G. Li[55], G. Li[15], H. B. Li[32,69], H. Li[63,72], H. N. Li[61], H. J. Li[20], H. L. Li[27], J. M. Li[63,72], J. Li[32], L. Li[56], L. Li[59], L. Y. Li[63,72], N. Li[64], P. R. Li[41], R. H. Li[30], S. Li[59], T. Li[57], W. J. Li[20], X. Li[33], X. H. Li[74], X. Q. Li[6], X. H. Li[63,72], Y. Li[79], Y. Y. Li[72], Z. J. Li[33], H. Liang[63,72], J. H. Liang[61], Y. T. Liang[33], G. R. Liao[13], L. Z. Liao[25], Y. Liao[61], C. X. Lin[69], D. X. Lin[33], X. S. Lin[63,72], B. J. Liu[32], C. W. Liu[15], D. Liu[63,72], F. Liu[6], G. M. Liu[61], H. B. Liu[14], J. Liu[54], J. J. Liu[74], J. B. Liu[63,72], K. Liu[41], K. Y. Liu[43], K. Liu[59], L. Liu[63,72], Q. Liu[69], S. B. Liu[63,72], T. Liu[11], X. Liu[41], Y. W. Liu[63,72], Y. Liu[82], Y. L. Liu[63,72], Z. Q. Liu[57], Z. Y. Liu[41], Z. W. Liu[45], I. Logashenko[3], Y. Long[63,72], C. G. Lu[33], J. X. Lu[2], N. Lu[63,72], Q. F. Lü[26], Y. Lu[7], Y. Lu[69], Z. Lu[62], P. Lukin[3], F. J. Luo[74], T. Luo[11], X. F. Luo[6], H. J. Lyu[24], X. R. Lyu[69], J. P. Ma[35], P. Ma[33], Y. Ma[15], Y. M. Ma[33], F. Maas[19,38], S. Malde[71], D. Matvienko[3], Z. X. Meng[70], R. Mitchell[29], A. Nefediev[40], Y. Nefedov[39], S. L. Olsen[22,53], Q. Ouyang[32,63], P. Pakhlov[23], G. Pakhlova[23,52], X. Pan[60], Y. Pan[62], E. Passemar[29,65,67], Y. P. Pei[63,72], H. P. Peng[63,72], L. Peng[27], X. Y. Peng[8], X. J. Peng[41], K. Peters[12], S. Pivovarov[3], E. Pyata[3], B. B. Qi[63,72], Y. Q. Qi[63,72], W. B. Qian[69], Y. Qian[33], C. F. Qiao[69], J. J. Qin[74], J. J. Qin[63,72], L. Q. Qin[13], X. S. Qin[57], T. L. Qiu[33], J. Rademacker[68], C. F. Redmer[38], H. Y. Sang[63,72], M. Saur[54], W. Shan[26], X. Y. Shan[63,72], L. L. Shang[20], M. Shao[63,72], L. Shekhtman[3], C. P. Shen[11], J. M. Shen[28], Z. T. Shen[63,72], H. C. Shi[63,72], X. D. Shi[63,72], B. Shwartz[3], A. Sokolov[3], J. J. Song[20], W. M. Song[36], Y. Song[63,72], Y. X. Song[10], A. Sukharev[3,51], J. F. Sun[20], L. Sun[77], X. M. Sun[6], Y. J. Sun[63,72], Z. P. Sun[33], J. Tang[64], S. S. Tang[63,72], Z. B. Tang[63,72], C. H. Tian[63,72], J. S. Tian[78], Y. Tian[33], Y. Tikhonov[3], K. Todyshev[3,51], T. Uglov[52], V. Vorobyev[3], B. D. Wan[15], B. L. Wang[69], B. Wang[63,72], D. Y. Wang[54], G. Y. Wang[21], G. L. Wang[17], H. L. Wang[61], J. Wang[49], J. H. Wang[63,72], J. C. Wang[63,72], M. L. Wang[32], R. Wang[63,72], R. Wang[33], S. B. Wang[59], W. Wang[59], W. P. Wang[63,72], X. C. Wang[20], X. D. Wang[74], X. L. Wang[63,72], X. L. Wang[20], X. P. Wang[2], X. F. Wang[41],

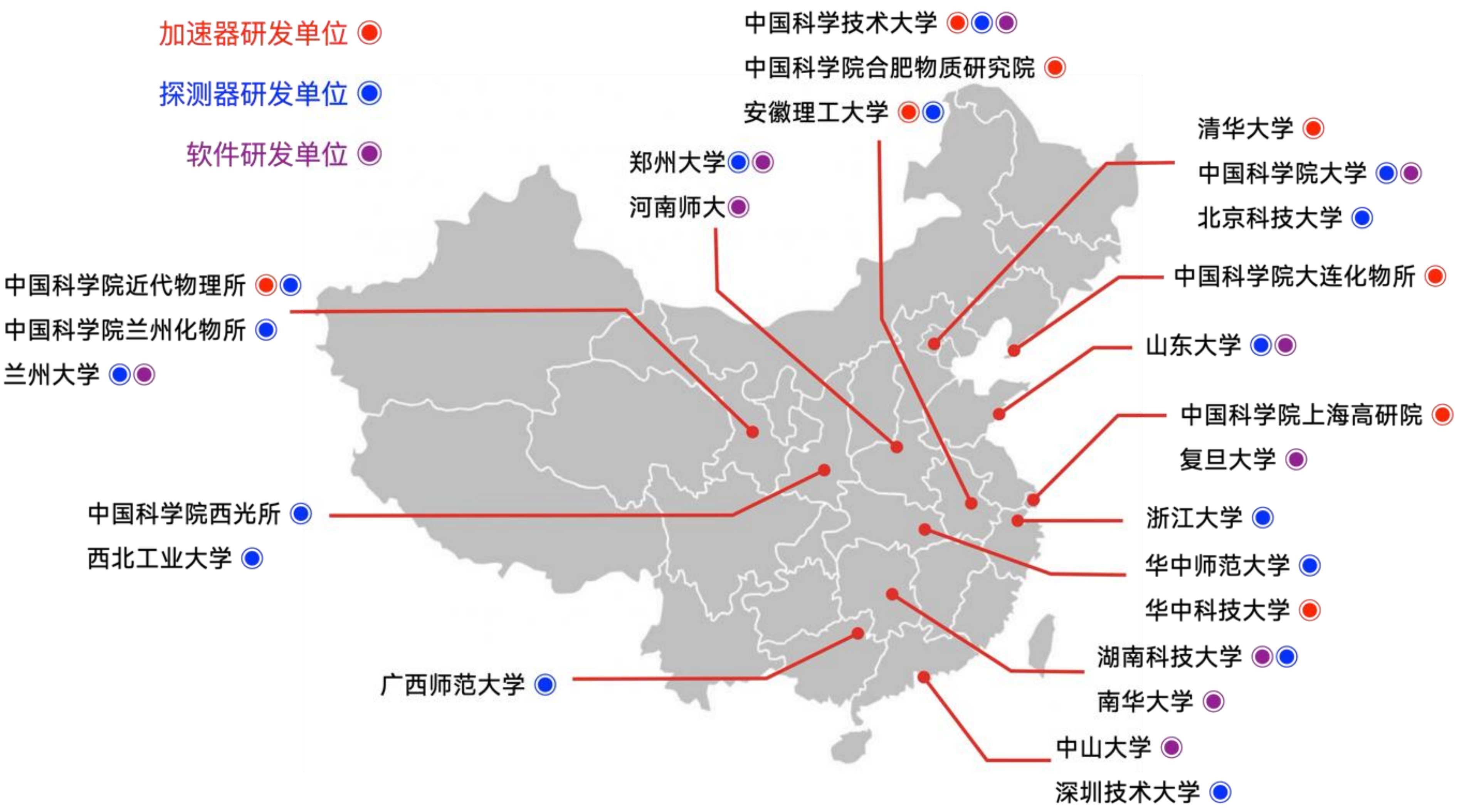

82 institutions, 453 authors

## Accelerator CDR




114 institutions, 460 authors

# STCF Team for Technology R&D and Physics Studies



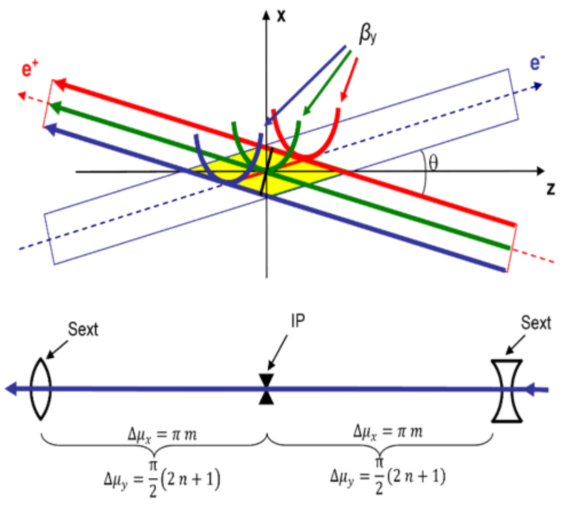

**其他参与物理研究的单位：**

- 北京大学
- 中科院高能所
- 中科院理论所
- 上海交通大学
- 北京师范大学
- 武汉大学
- 中国地质大学
- 辽宁大学
- 南京师范大学
- 南京大学
- 河北师范大学
- 南开大学
- 华南师范大学

**25 universities/institutes participating in the R&D project: ~200 faculty/staff members and ~300 students**

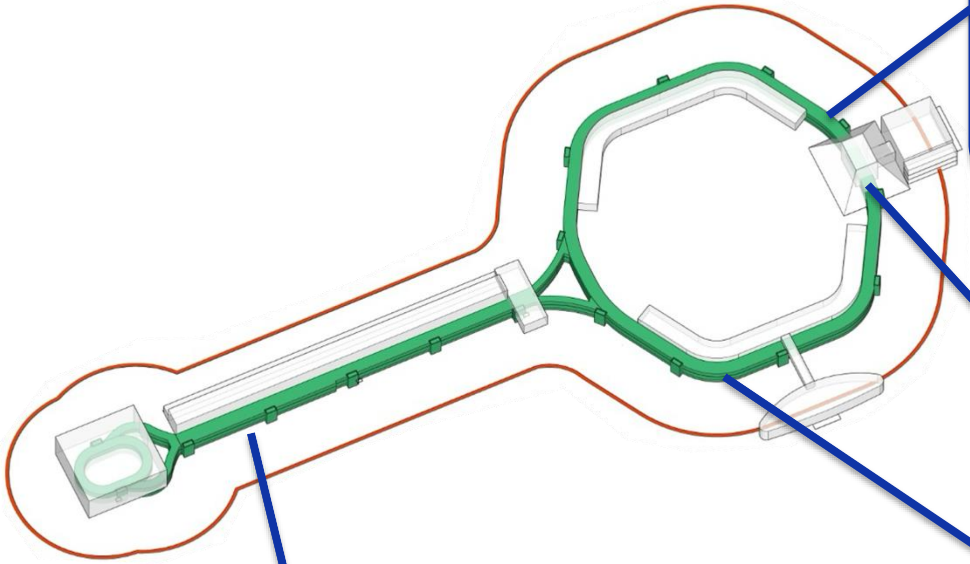
# Challenges of STCF Accelerator

- **Ultra-high luminosity in the tau charm energy region, high-quality beam, stable operation**
- **Characterized by extremely small bunch size, high beam current, strong nonlinearity and collective effects**




$$L = \frac{\gamma n_b I_b}{2 e r_e \beta_y^*} \xi_y H$$

Large Piwinski angle
+ Crab Waist



**Collider Ring and IR Physics Design**
IP beam size (Y) nm scale, Crab-Waist, nonlinear compensation extremely difficult

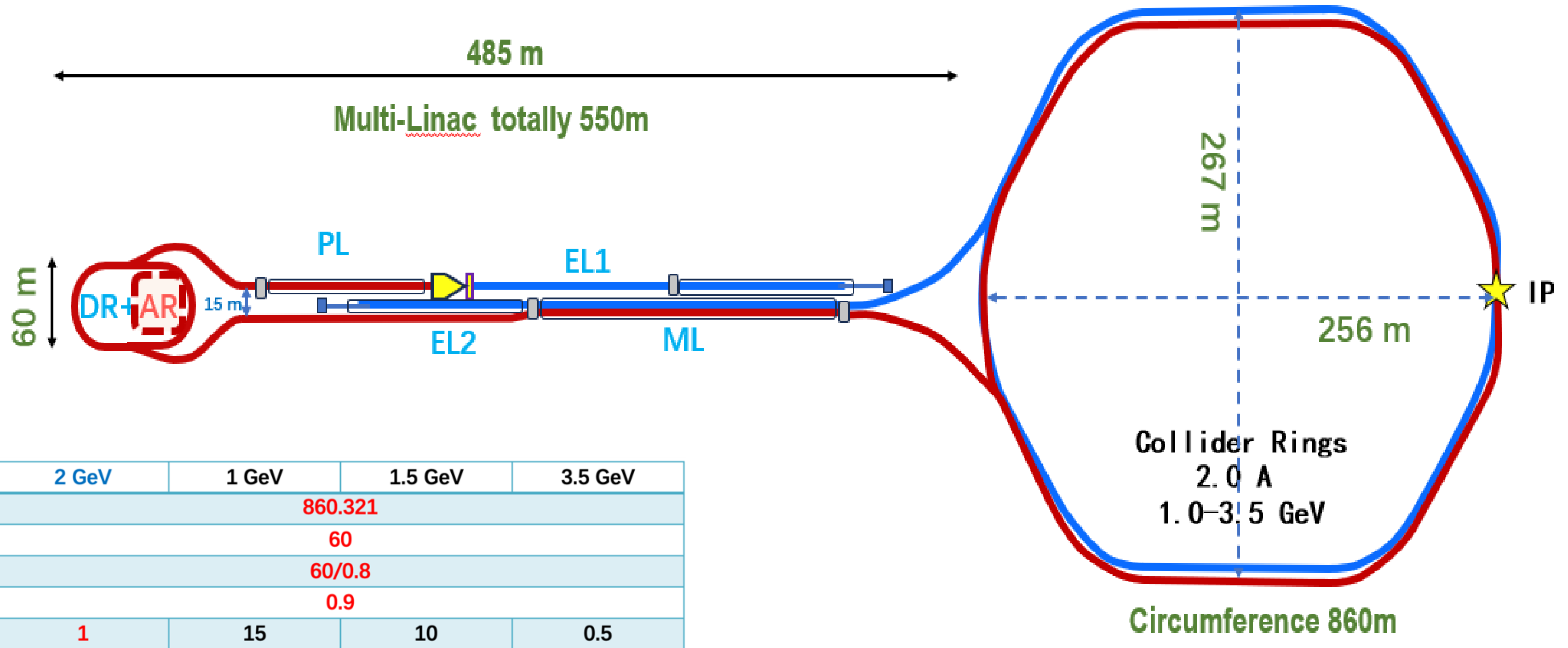
**IR Technologies**
SC magnets, MDI

**Injection into CR (small DA)**
high $I_b$ and low ε e+/e- sources

**Other key technologies**
Ring RF, beam instrumentation and control, beam injection…

# STCF Accelerator Conceptual Design

**Injector:**
- full-energy linac
- positron DR or AR for different injection modes: off-axis(baseline), swap-out

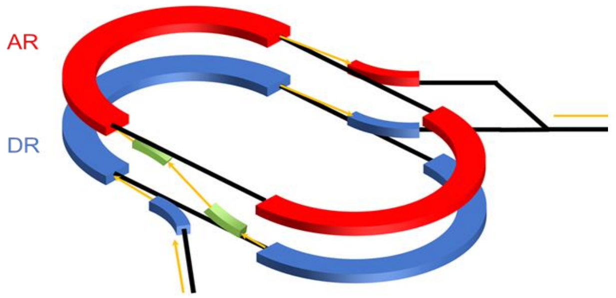


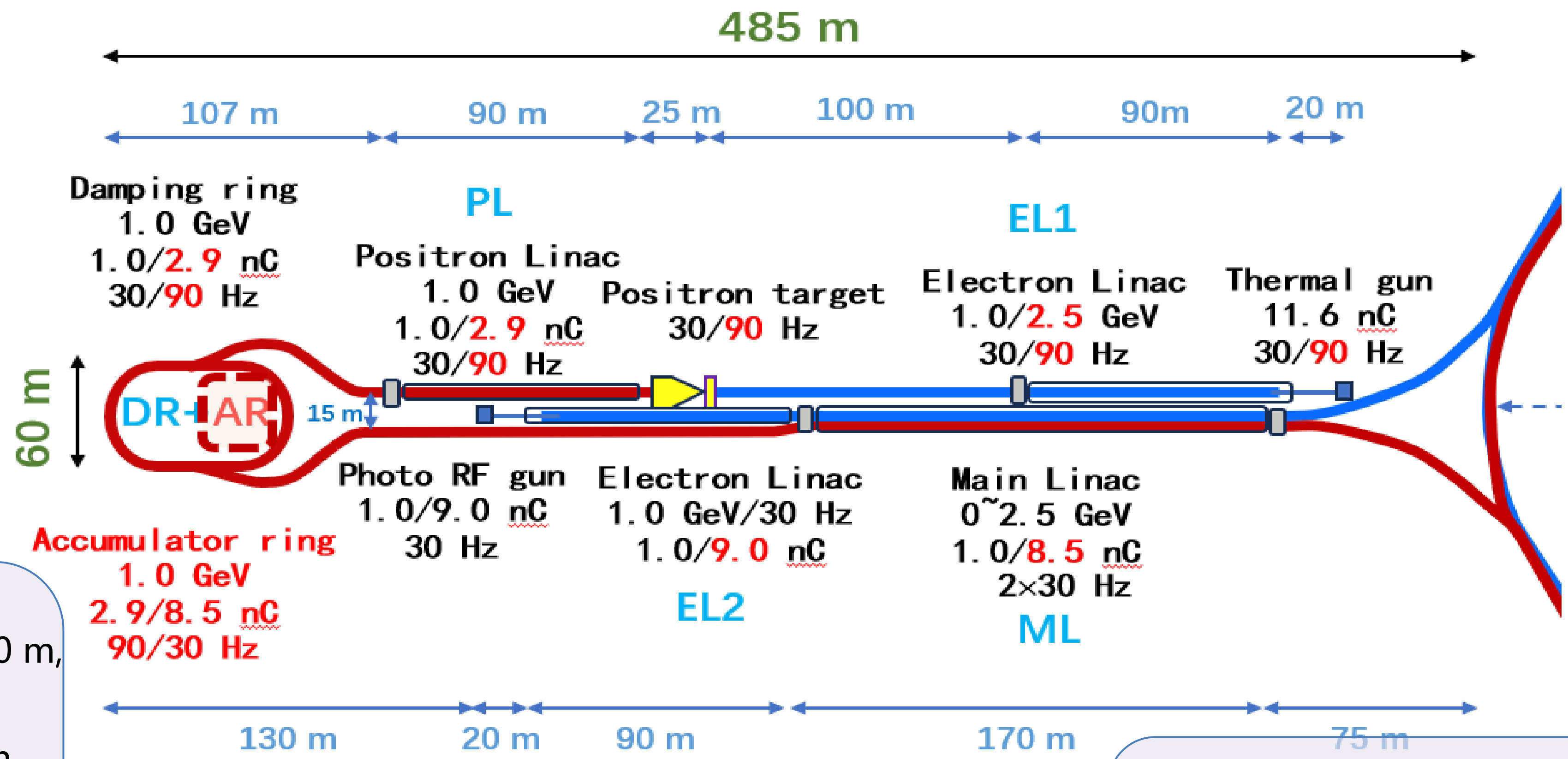

| Parameters | Units | 2 GeV | 1 GeV | 1.5 GeV | 3.5 GeV |
|---|---|---|---|---|---|
| Circumference, $C$ | m | 860.321 | | | |
| Crossing angle, $2\theta$ | mrad | 60 | | | |
| Hor. /Ver. beta function at IP, $\beta_x^*/\beta_y^*$ | mm | 60/0.8 | | | |
| $L*$ | m | 0.9 | | | |
| Ratio, $\varepsilon_y/\varepsilon_x$ | % | 1 | 15 | 10 | 0.5 |
| Hor./Ver. betatron tune | | 30.543/34.58 | 30.555/34.57 | | |
| Beam current, $I$ | A | 2 | 1.1 | 1.7 | 2 |
| Hori. emittance (SR/DW+IBS) | nm | 8.79/4.63 | 2.2/5.42 | 4.94/3.82 | 26.9/26.91 |
| Momentum compaction factor, $\alpha_p$ | $10^{-3}$ | 1.35 | 1.26 | 1.32 | 1.37 |
| Energy spread (DW+IBS) | $10^{-4}$ | 7.8 | 6.18 | 6.93 | 10.02 |
| Energy loss per turn (SR+DW), $U_0$ | keV | 543 | 106 | 267 | 1494 |
| SR power per beam (SR+DW), $P$ | MW | 1.086 | 0.117 | 0.453 | 2.988 |
| RF voltage | MV | 2.5 | 0.75 | 1.2 | 6 |
| Synchrotron tune, $\nu_s$ | | 0.0194 | 0.0146 | 0.0154 | 0.0228 |
| $\delta_{RF}$ | % | 1.68 | 1.44 | 1.35 | 1.88 |
| Bunch length (Nature/0.1Ω+IBS) | mm | 7.21/8.70 | 6.62/9.79 | 7.89/8.56 | 8.26/8.89 |
| Hor./Ver. beam-beam parameter, $\xi_x/\xi_y$ | | 0.005/0.095 | 0.005/0.023 | 0.004/0.033 | 0.003/0.032 |
| Luminosity | $cm^{-2}s^{-1}$ | 9.4E+34 | 6.19E+33 | 2.09E+34 | 4.48E+34 |

**Double-Ring Collider**
- low emittance
- high current
- large Piwinski angle
- Crab-waist collision scheme

# Injector Design

## Design compatible with both off-axis and swap-out injection schemes



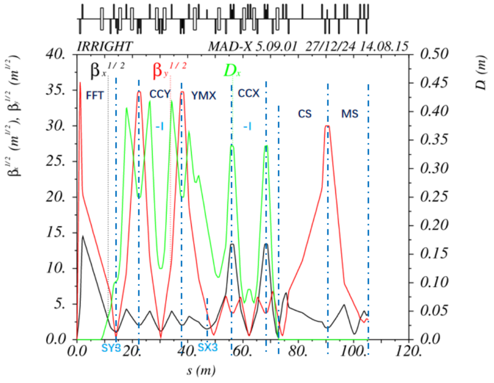

**DR (+AR):**

- **Damping ring (DR)**: 1 GeV, 150 m, 3 bunches circulating
- **Accumulator ring (AR)** : 150 m stacked over DR
- **Operation**: off-axis (DR); swap-out (DR+AR)

**$e^+$ and $e^-$ beams at exit.:**

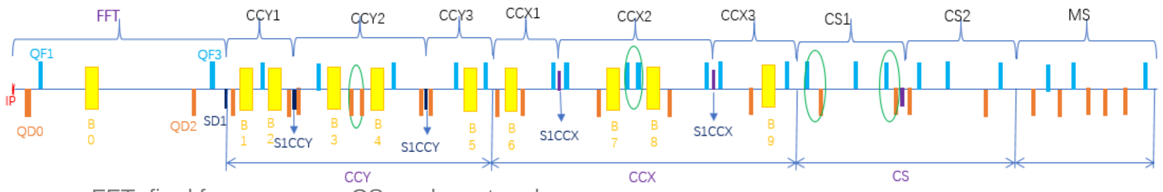
- **1-3.5 GeV, 30 Hz**
- **1 nC for off-axis**
- **8.6 nC for swap-out**

# Collider Rings Design

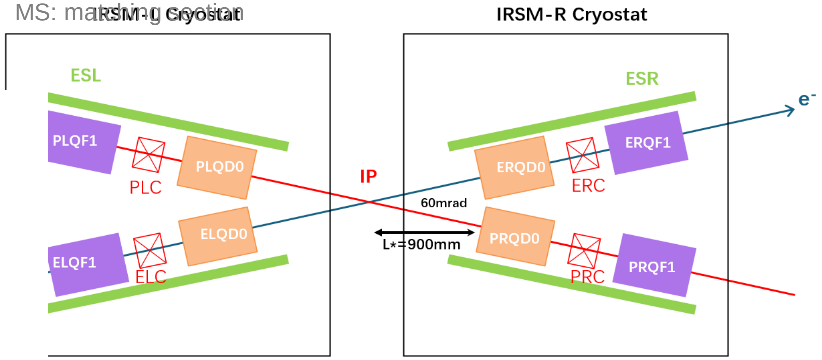



## IR design

- Length~200 m, bending 60°
- Crossing angle: 60 mrad
- $\beta_y^*$: 0.8 mm
- CCT SC quadrupole magnets

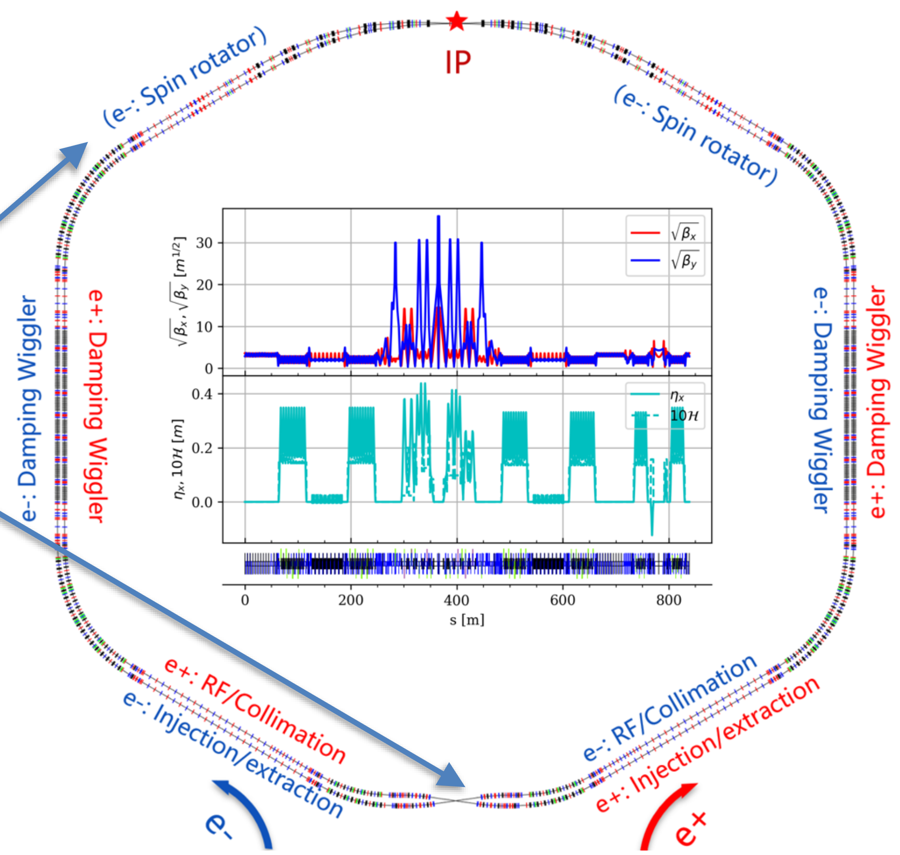



- FFT: final focus telescope
- CCY/CCX: local chromaticity correction
- CS: crab sextupoles
- MS: matching section




## Space reserved for upgrades:

- Spin rotator
- Second IP




## Damping Wiggler

- Adjusting damping time, energy spread, emittance

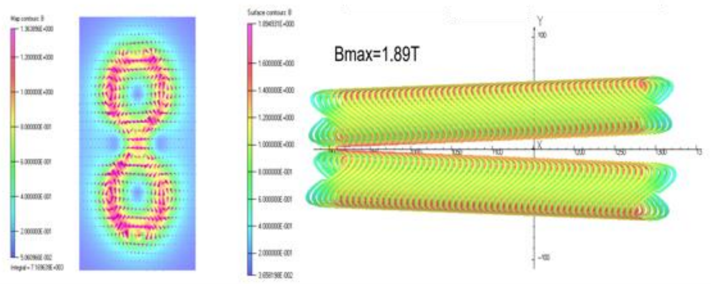
## RF cavity

- RT TM020-mode cavity

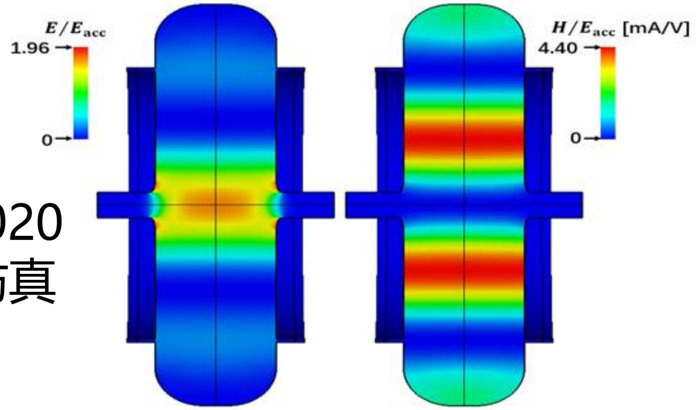
# STCF Accelerator R&D

## IR SC Magnets

Very constrained Space，50T/m, CCT technology

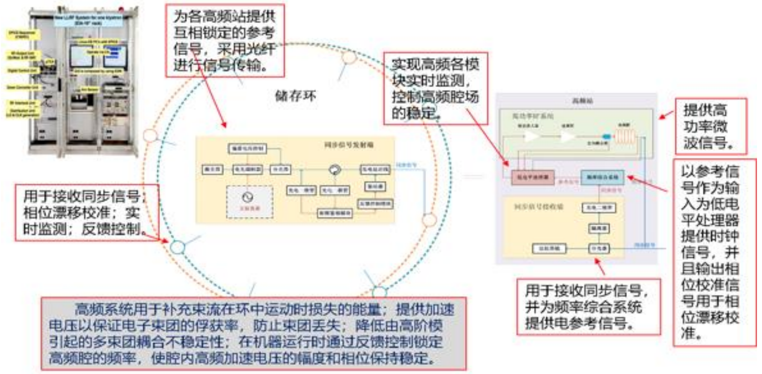



## Room-temperature RF cavity

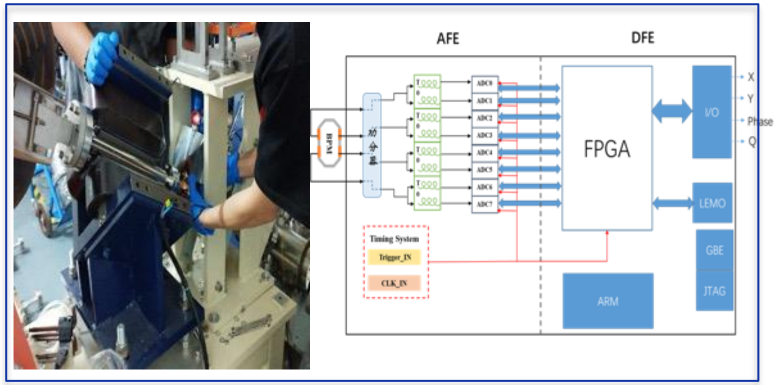



TM020
腔仿真

## Low-level RF control system

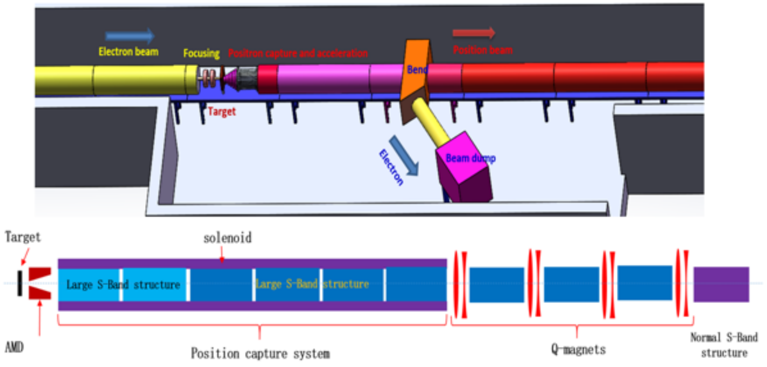



## Bunch by bunch 3D beam position measurement



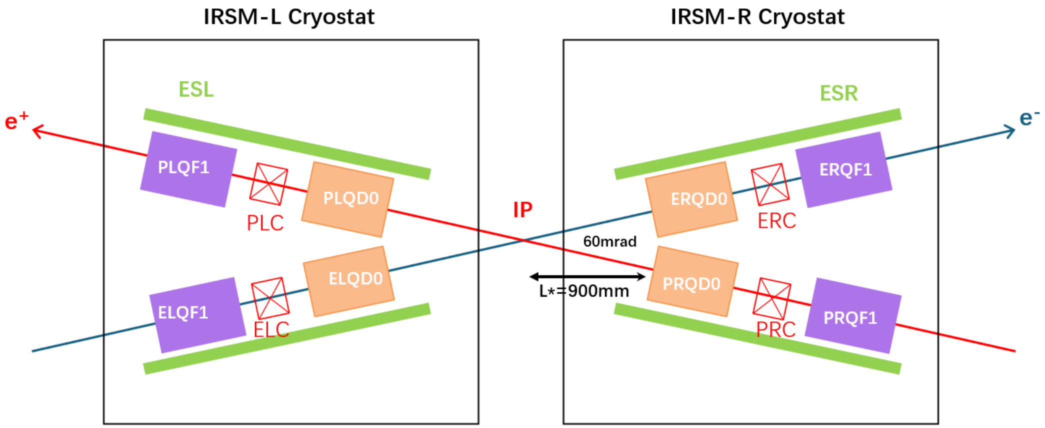

## Photo-cathode electron gun

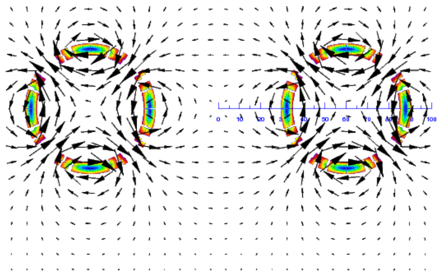
## Positron source



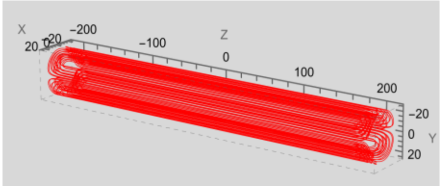
# IR SC Magnets (1)

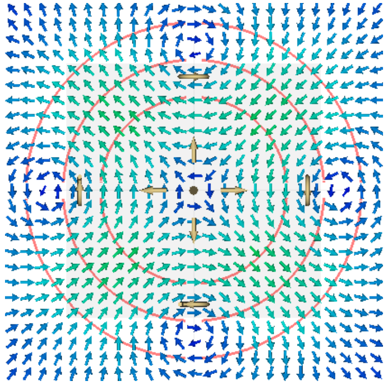
- IR SC magnet technique selection
  - Joint effort by experienced persons from several domestic institutions including HMFL (High Magnetic Field Lab), IHEP, IMP and others
  - Four different techniques studied: CCT, Cos2θ, DCT, Serpentine
  - CCT was chosen for the further R&D and prototype at this stage



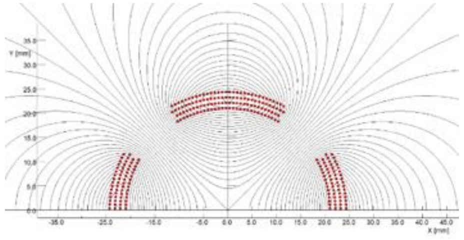



Cos2θ coil EM

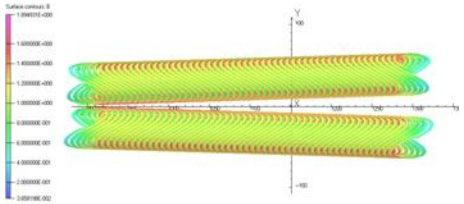




Single aperture DCT coil EM



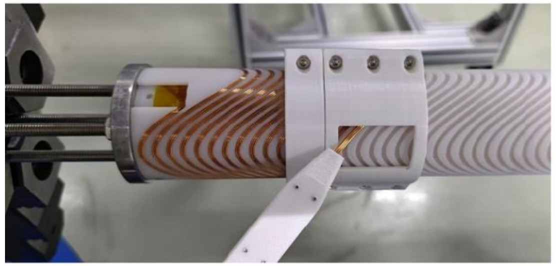
Single aperture serpentine coil

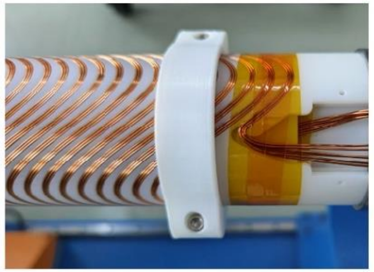


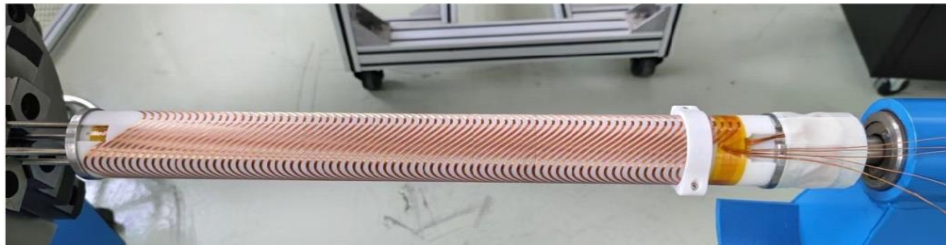
CCT coil EM

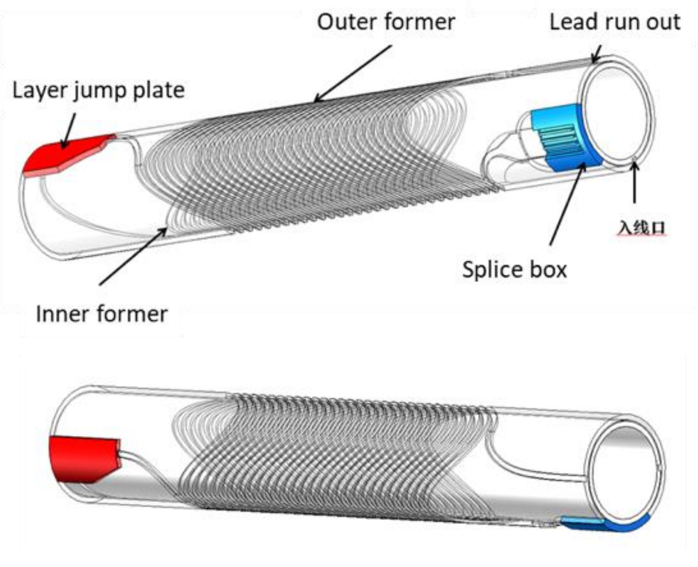
# IR SC Magnets (2)

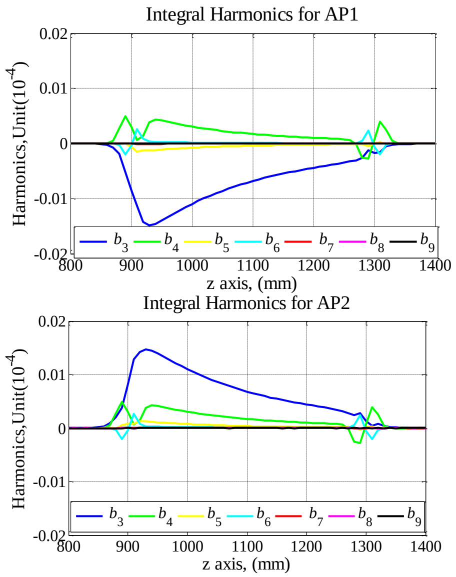
- R&D and prototyping
  - Focusing on QD0 design (most challenging), both in EM and dimensions;
  - Twin-aperture QD0 coil harmonics and cross-talk are under optimization, challenging but almost there!
  - CNC machine of the QD0 former is under investigation, local manufacturer has been identified.

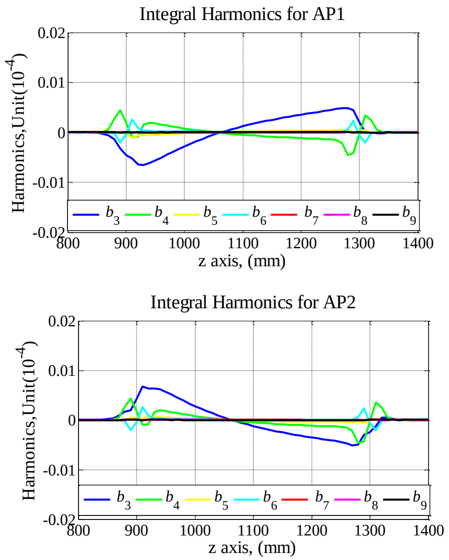








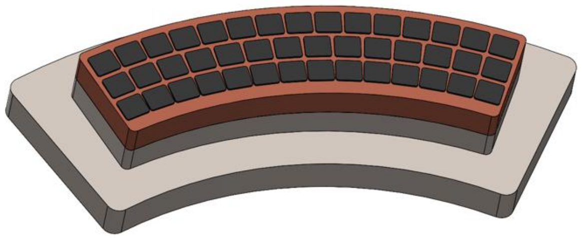




# Ring RF system

- Concerning two collider rings and DR/AR
  - CR: Challenging due to very high RF power, deep HOM damping and low R/Q
  - DR/AR: same RF frequency but relaxed requirements
  - Room-temperature TM020-mode RF cavity was chosen
- R&D and prototyping
  - Prototype fabrication under way at Lanzhou Taiji
  - Performance test will be in 2026 using HALF RF power source and test platform

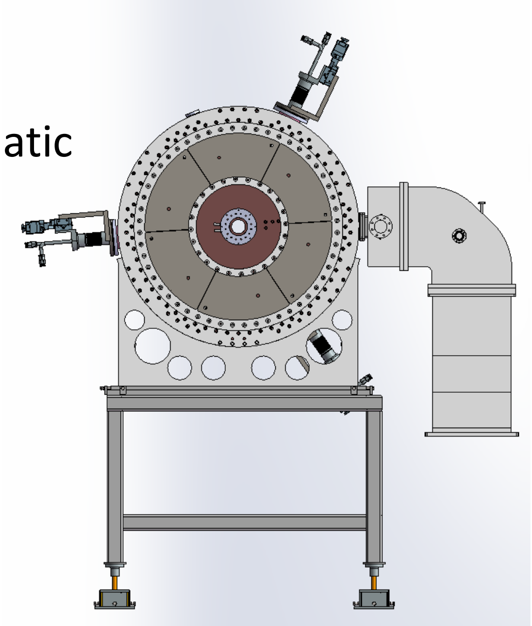
| RF parameters | |
|---|---|
| Working mode | TM020 |
| Frequency [MHz] | 499.7 |
| R/Q [Ω] | 95 |
| Unloaded quality factor | 63000 |
| $E_p/E_{acc}$ | 2.48 |
| $B_p/E_{acc}$ [mA/V] | 2.88 |

HOM damper



Cavity in fabrication

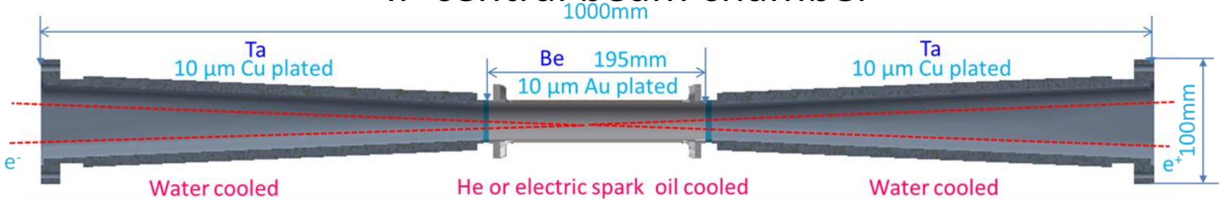
Schematic

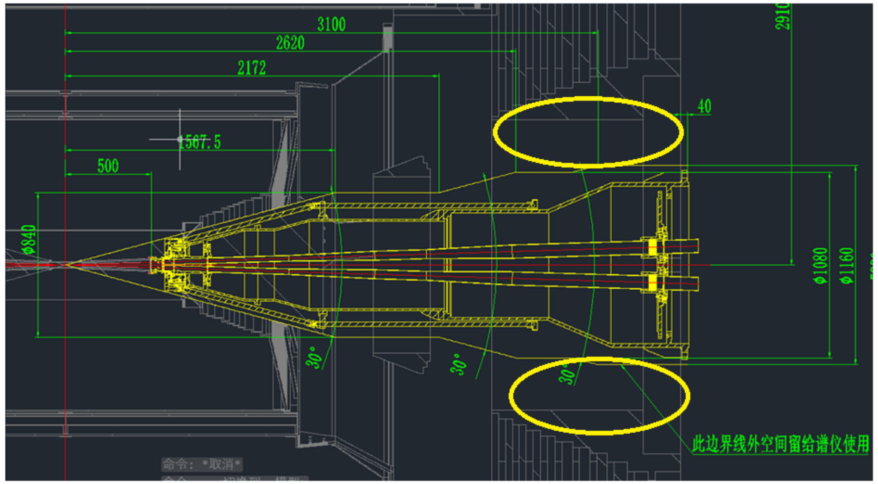


# MDI and Mechanics

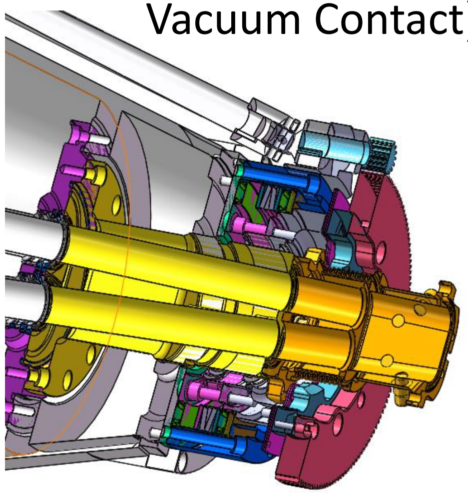
- key area to focus : Machine-Detector Interface (MDC)
  - Designed IP central beam chamber
  - MDI mechanical model design is under way: 3D design followed by model fabrication
  - Intense discussion required among different groups
- Technical design of the collimators in iteration with physics design

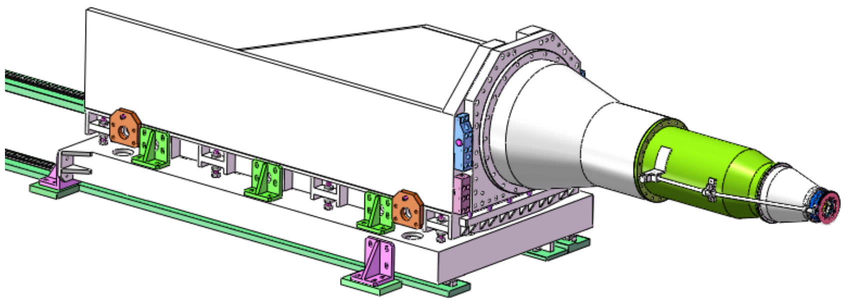
IP central beam chamber




RVC (Remote Vacuum Contact)

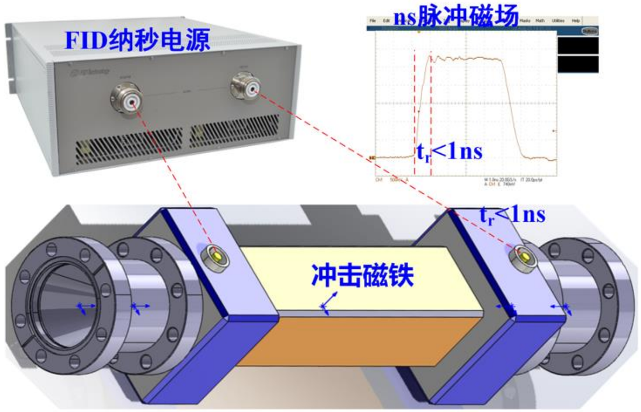




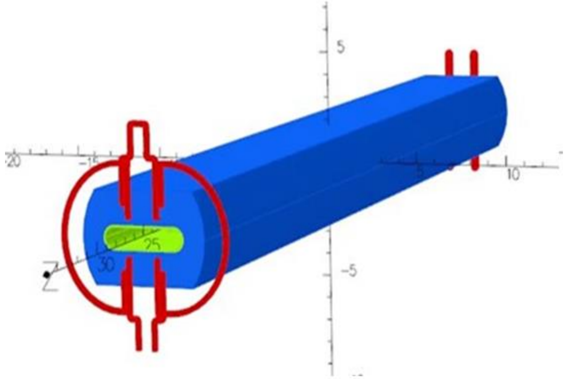
# Injection and Extraction System

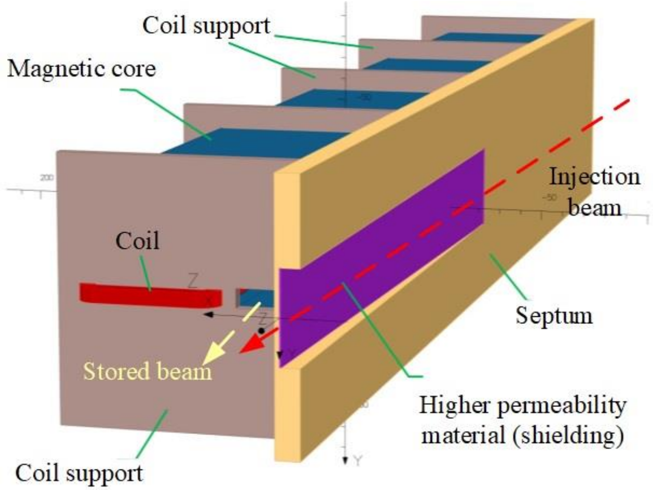
- Design requirements
  - For both off-axis and swap-out injections
  - Off-axis injection: local bump, nonlinear kickers
  - Swap-out injection: ultrafast kickers (stripline), < 6 ns (bottom)
  - Extraction: swap-out bunch by bunch, MPS extracting all bunches
  - Septum: Eddy current type
- R&D effort
  - Prototypes: both nonlinear kicker and ultrafast kicker
  - Well in progress, to complete by end 2025

Ultrafast kicker




Nonlinear kicker



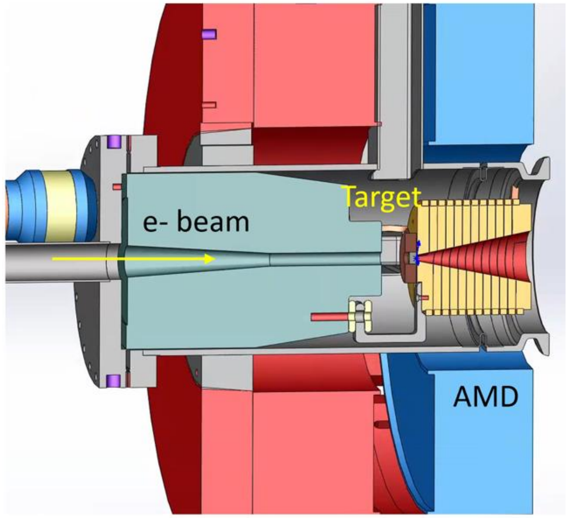



Eddy current septum

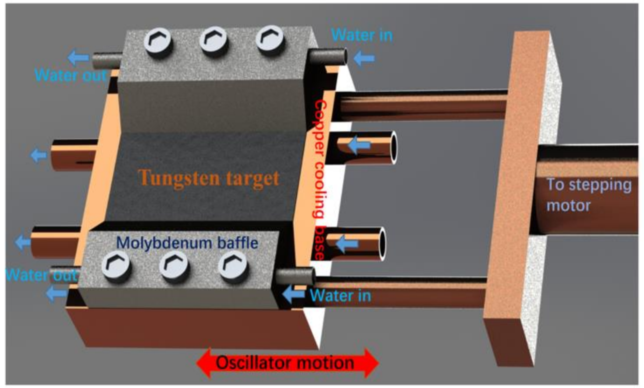
# Positron Source

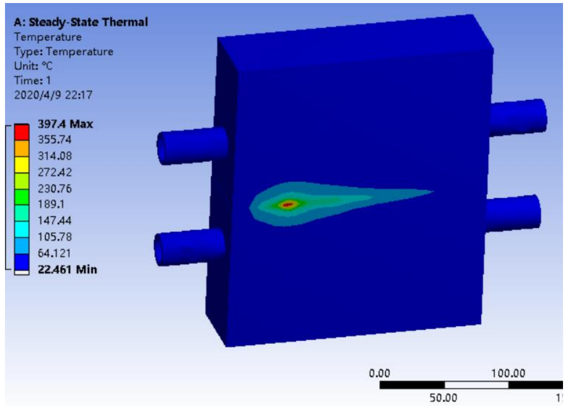
- Positron source design
  - Mature technique for off-axis injection scheme: heat load, 15.5 J/g
  - Technically challenging for swap-out injection scheme: heat load 31.8 J/g; moving target design adopted.
  - Prototype of the conventional design for the test beam platform under way

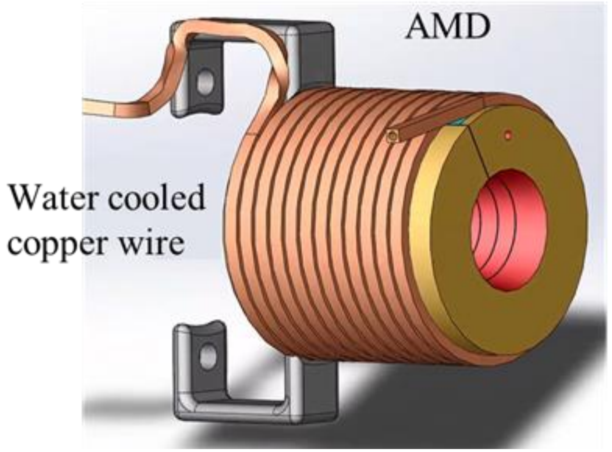
| | Parameter | Design | |
|---|---|---|---|
| | | Off-axis | Swap-out |
| 1 | e+ beam for DR/AR | 1 GeV/1.5 nC/50 Hz | 1 GeV/2.5 nC/100 Hz |
| 2 | e- beam on target | 1.5GeV/10nC/50 Hz | 2.5GeV/10nC/100Hz |
| 3 | Beam power | 745 W | 2340 W |
| 4 | Peak power dep. | 16.2 J/g | 31.8 J/g |
| 5 | Magnetic horn | 0.5-5 T | 0.5-5 T |
| 6 | e-/e+ conv. Rate | 15 % | 25 % |
| 7 | Solenoid field | 0.5 T | 0.5 T |
| 8 | Accel. tube diam. | 30 mm | 30 mm |




Conventional design



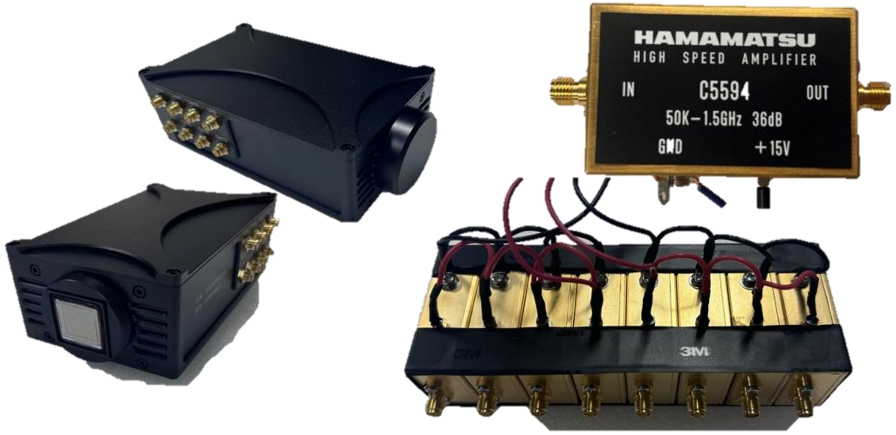




With moving target, temperature below 400°C

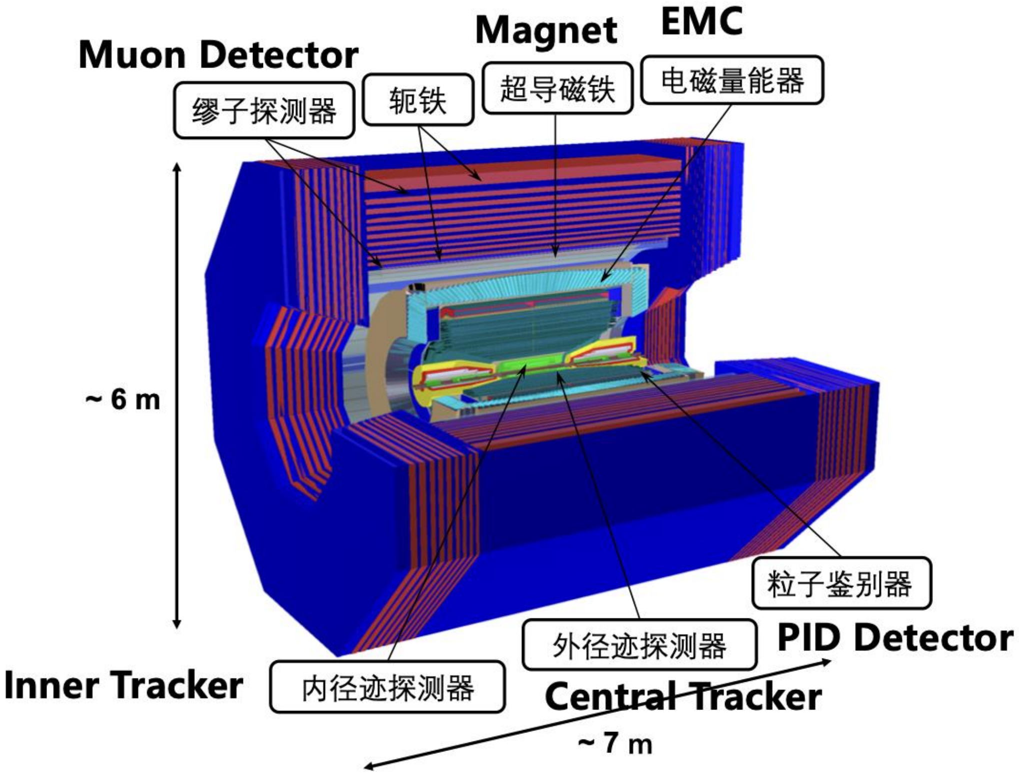
# Beam Instrumentation

- Design goals
  - CR precise bunch meas.: bunch-by-bunch 3D meas., trans. position res. <5 μm, long. phase res.<0.2 ps
  - CR B-by-B fast feedback: coupled bunch inst.
  - IP: orbit feedback
  - Injector: bunch length and charge meas.
  - Iterations between physics design and BI group are held regularly
- R&D efforts in progress, to be tested in light sources and e+/e- beam test platform
  - Bunch 3D meas.: probe, signal treat, electronics, S/N, integration
  - B-by-B fast feedback: raising bandwidth, avoiding interference to single bunch
  - Injector bunch length and charge meas.: cavity-based
  - Prototypes: beam tests in different machines (SSRF, HLS, DLS)




Bunch by bunch profile monitor prototype: photodetector, DAQ

# Physics Requirements for STCF Detector

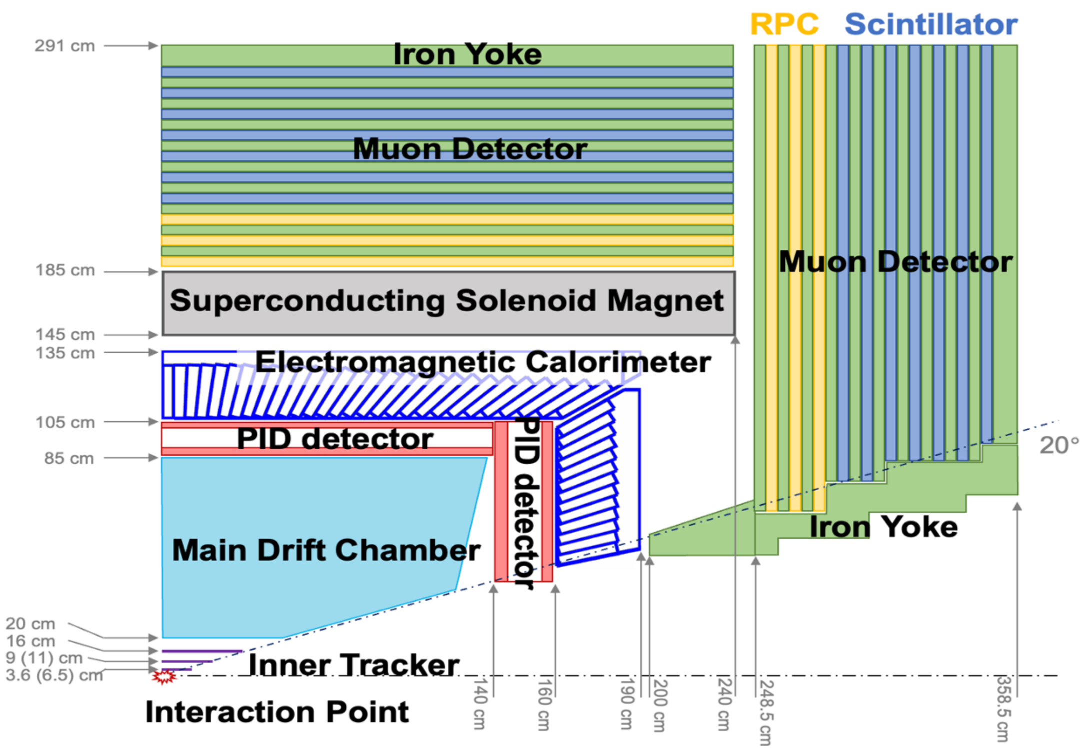



❖ **Highly efficient and precise reconstruction of exclusive final states produced in 2-7 GeV $e^+e^-$ collisions**

- Precise measurement of low-p (~>1GeV/c) particles → low mass tracking and PID detectors
- Excellent PID: π/K and μ/π separation up to 2 GeV and beyond

| Process | Physics Interest | Optimized Subdetector | Requirements |
|---|---|---|---|
| $\tau \to K_s\pi\nu_\tau$, $J/\psi \to \Lambda\bar{\Lambda}$, $D_{(s)}$ tag | CPV in the $\tau$ sector, CPV in the hyperon sector, Charm physics | ITK+MDC | acceptance: 93% of $4\pi$; trk. effi.: $> 99\%$ at $p_T > 0.3$ GeV/c; $> 90\%$ at $p_T = 0.1$ GeV/c $\sigma_p/p = 0.5\%$, $\sigma_{\gamma\phi} = 130\ \mu$m at 1 GeV/c |
| $e^+e^- \to KK + X$, $D_{(s)}$ decays | Fragmentation function, CKM matrix, LQCD etc. | PID | $\pi/K$ and $K/\pi$ misidentification rate $< 2\%$ PID efficiency of hadrons $> 97\%$ at $p < 2$ GeV/c |
| $\tau \to \mu\mu\mu$, $\tau \to \gamma\mu$, $D_s \to \mu\nu$ | cLFV decay of $\tau$, CKM matrix, LQCD etc. | PID+MUD | $\mu/\pi$ suppression power over 30 at $p < 2$ GeV/c, $\mu$ efficiency over 95% at $p = 1$ GeV/c |
| $\tau \to \gamma\mu$, $\psi(3686) \to \gamma\eta(2S)$ | cLFV decay of $\tau$, Charmonium transition | EMC | $\sigma_E/E \approx 2.5\%$ at $E = 1$ GeV $\sigma_{pos} \approx 5$ mm at $E = 1$ GeV |
| $e^+e^- \to n\bar{n}$, $D_0 \to K_L\pi^+\pi^-$ | Nucleon structure Unity of CKM triangle | EMC+MUD | $\sigma_T = \frac{300}{\sqrt{p^3(\mathrm{GeV}^3)}}$ ps |

# Detector Design and Key Technologies




## Major Performance Requirements

Acceptance: 94%×4π

Momentum res.: $\sigma_p/p$ ~ 0.5% @ 1 GeV

Energy res. : $\sigma_E/E$ ~ 2.5% @ 1 GeV

Hadron ID: π/K ~4σ @ 2 GeV

Muon ID: eff. >95%, mis-rate <3% @1 GeV

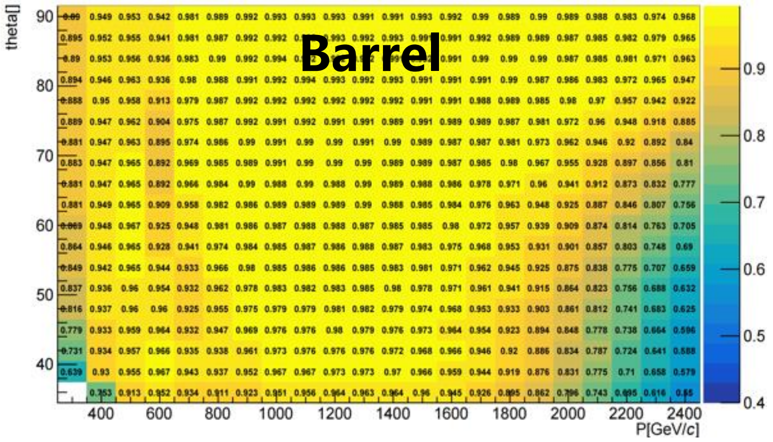
- Inner Tracker
  - MPGD: cylindrical uRGroove, $\sigma_x$ ~100 μm
  - Silicon: low-mass MAPS, <0.3%$X_0$/layer
- Central Tracker ($\sigma_p/p$~0.5% @ 1GeV)
  - Drift chamber with super-small cells, $\sigma_x$ <130 μm
- PID System (π/K ~4σ @ 2GeV)
  - Endcap: DIRC-like TOF - DTOF ($\sigma_t$~30 ps)
  - Barrel: RICH (<4mrad) or DTOF ($\sigma_t$~30 ps)
- EMC
  - pCsI + APD: ($\sigma_E/E$~2.5%, $\sigma_x$~5 mm, $\sigma_t$~300 ps @ 1GeV)
- Solenoid： 1 T
- Muon Detector (eff. >95%, mis-rate <3% @1GeV)
  - inner layers : glass RPC， > 300 Hz/$cm^2$
  - outer layers : scintillator strip + SiPM, ~ 2.4 m
- Trigger, DAQ, Clock and Data Transmission

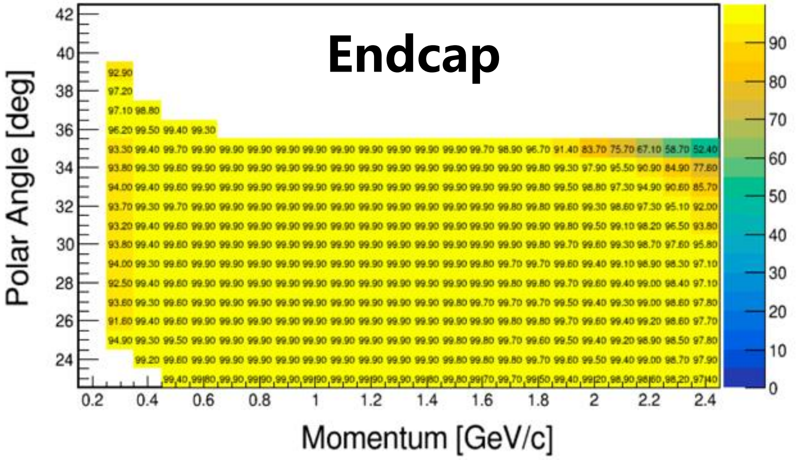
**Beam background at the inner most layer**

~1 Mrad/y, ~1×$10^{11}$ 1MeV n-eq/$cm^2$/y, ~1 MHz/$cm^2$

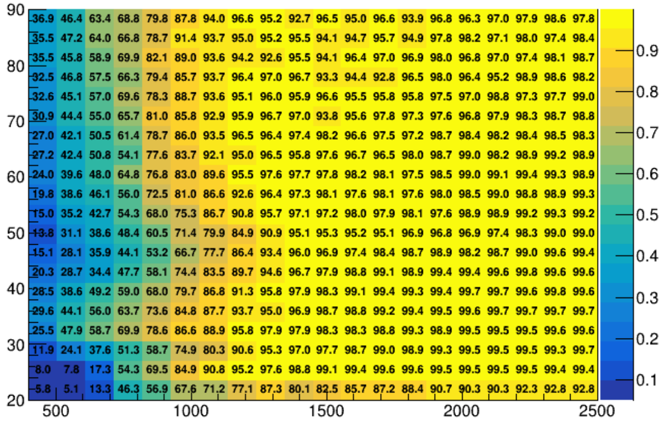
# Expected Performance

**PID: Pion ID eff. >97% @ mis-ID (K->pi)=2%**



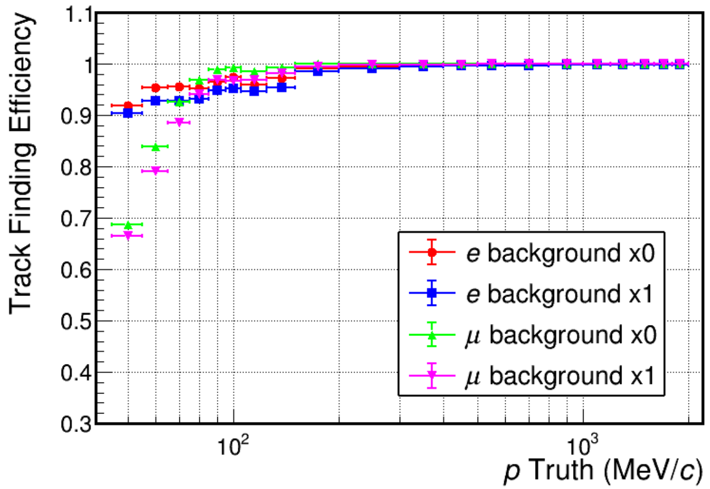




**Muon ID eff. @ pi suppression=30**

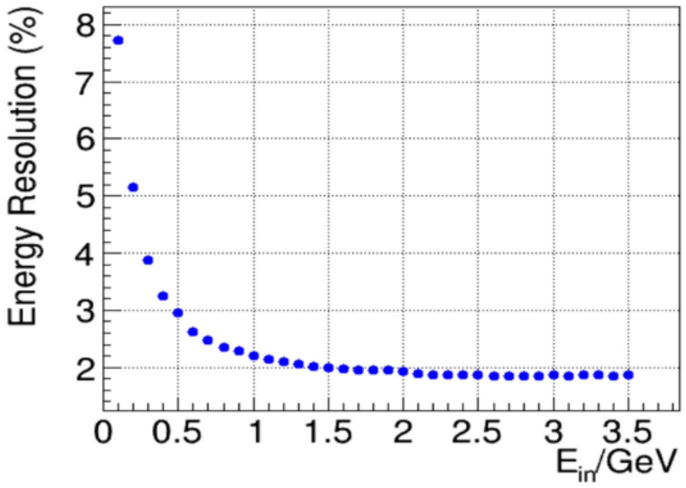


**eff. ~> 90% when p ~>1GeV/c**

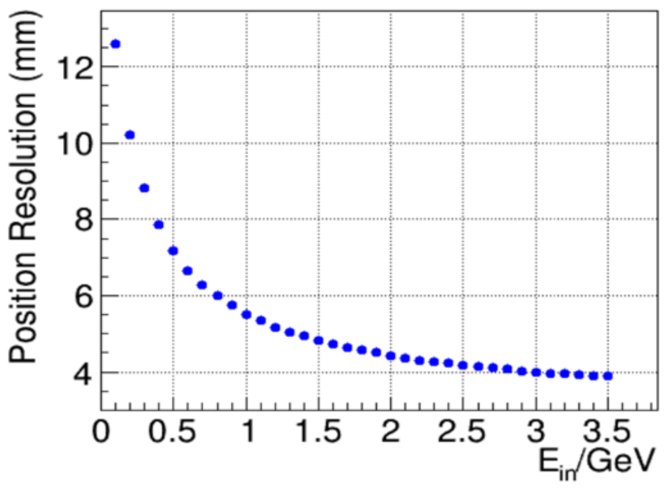
**Tracking efficiency**




**EMC energy resolution**

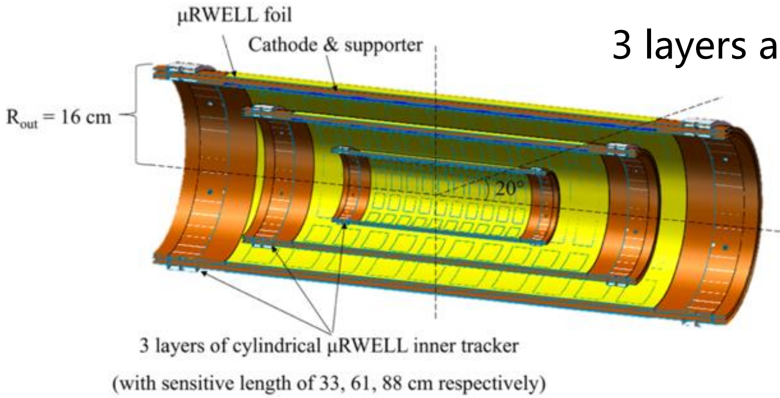



**EMC position resolution**

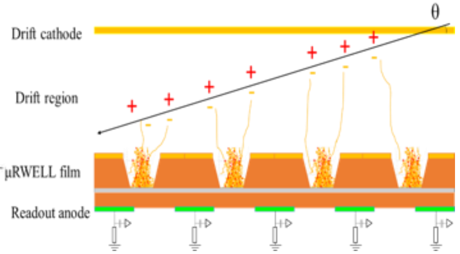


# Tracking System : ITK + MDC

## ITK Gaseous option : MPGD

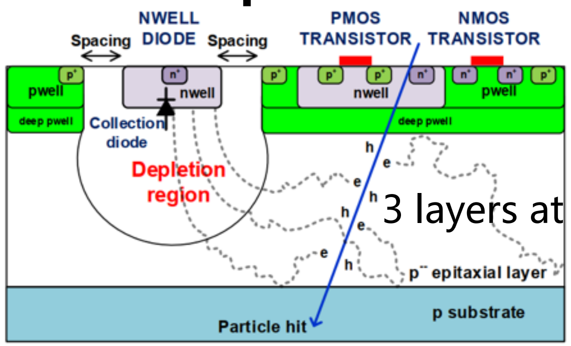



3 layers at 6cm, 11cm and 16 cm



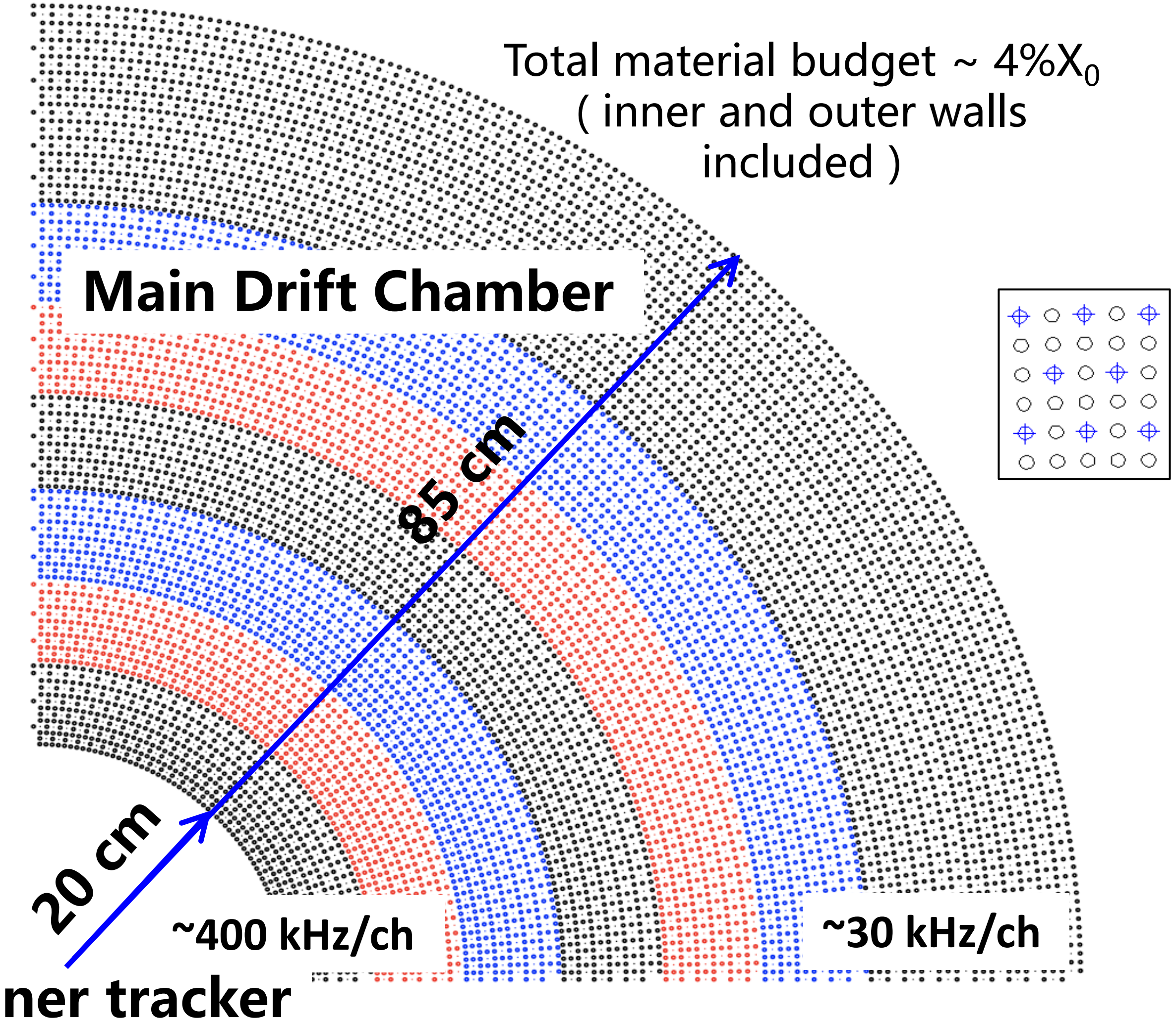

Material budget ~ 0.3%$X_0$/layer

## ITK Silicon option: CMOS MAPS




单片有源像素探测器

3 layers at 3.6cm, 9.8cm and 16 cm

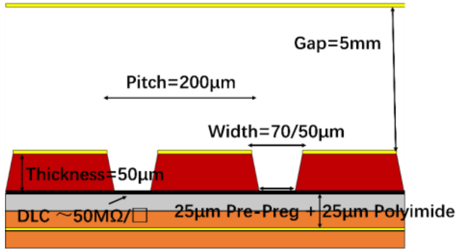


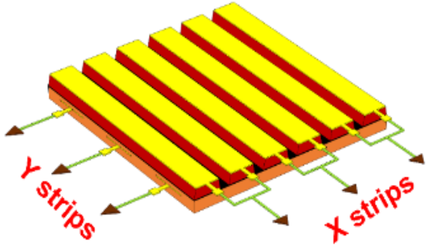

Total material budget ~ 4%$X_0$ ( inner and outer walls included )

**Inner-outer separate designs to accommodate different levels of radiation background**

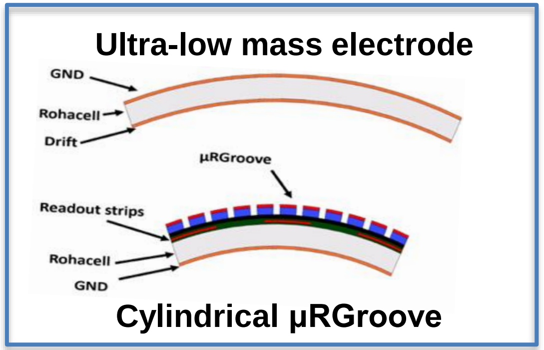
# MPGD ITK : μRGroove

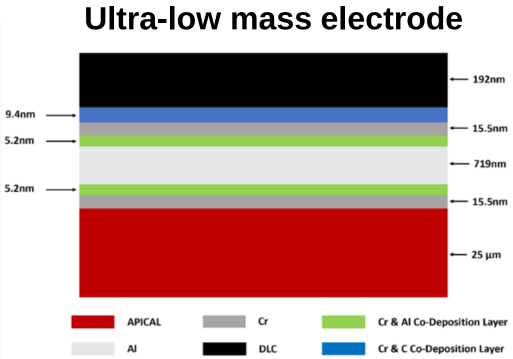
- Proposed and developed a novel single-stage MPGD, micro-resistive Groove detector (μRGroove), for the inner tracker: larger signals and easier production compared to μRWELL.

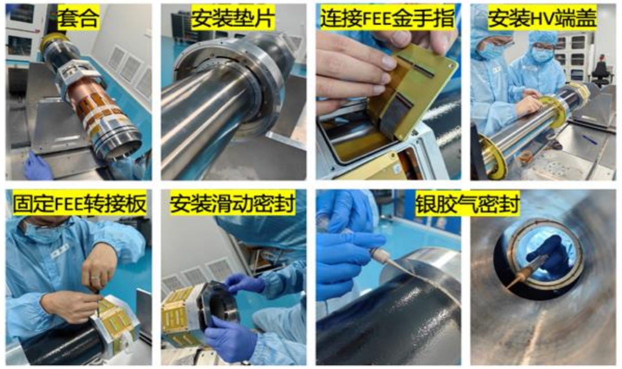


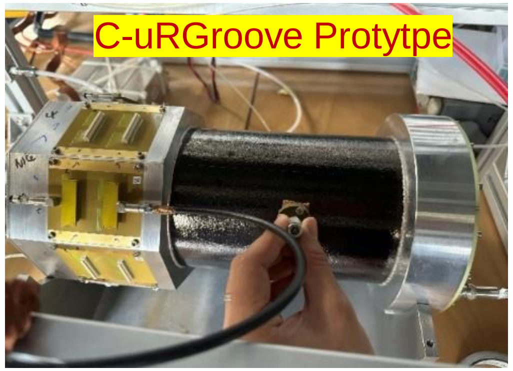




- Developed a set of techniques and procedures for fabricating a cylindrical low-mass μRGroove detector and built a low-mass c-μRGroove prototype: material budget ~ 0.23%X0/layer, the best in cylindrical MPGDs.

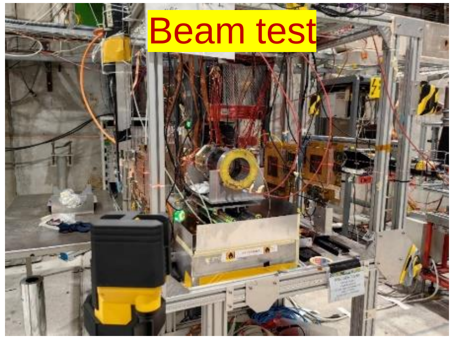


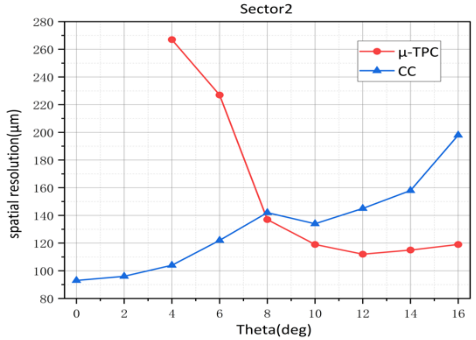




- Conducted multiple beam tests of the prototype at CERN. Position resolution < 100μm for vertical tracks, and <130μm for inclined tracks or in 1T magnetic field.

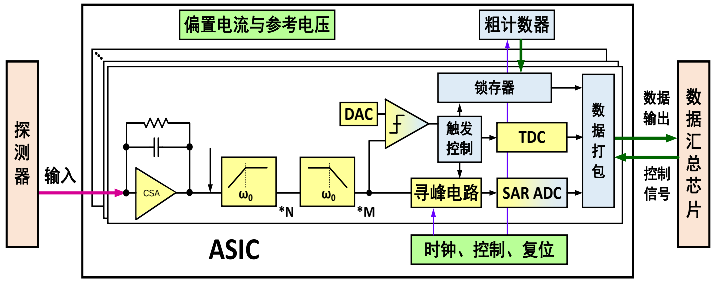


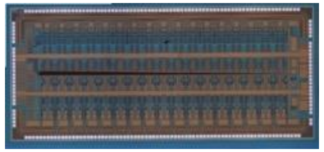
# MPGD ITK : Electronics

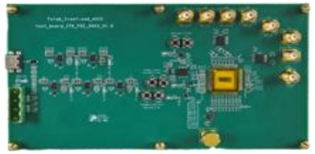
- **ASIC is required for readout. Very challenging performance requirements (event rate much higher than VMM). Designed and produced a 32-channel prototype ASIC chip with full function, and tested it with a detector prototype.**

- **Development of readout electronics with the ASIC is well underway**

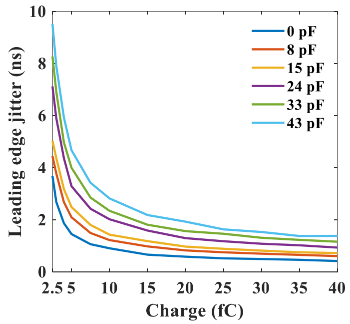



| ASIC Specs | Demands |
|---|---|
| Charge Range | 40 fC |
| Charge precision | ~ 1 fC RMS |
| Time precision | < 10 ns RMS |
| Max. event rate | 4 MHz |

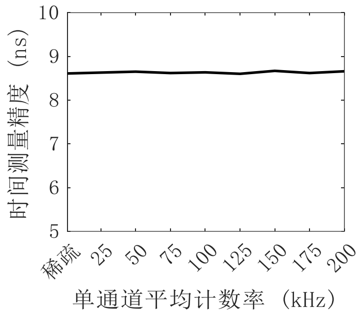


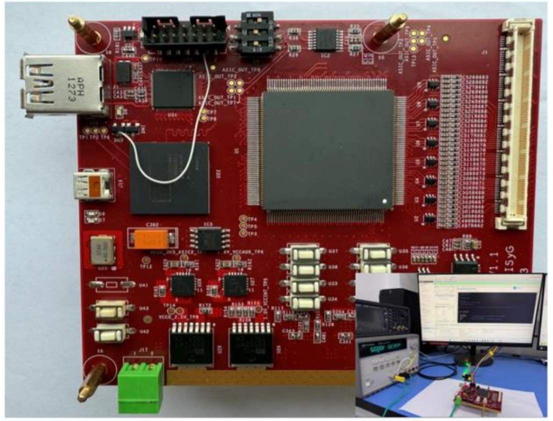


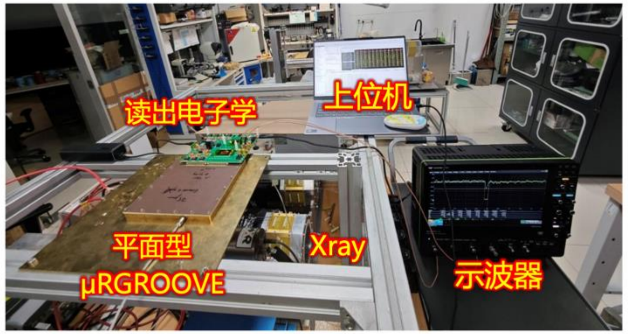
Time Resolution




Counting rate



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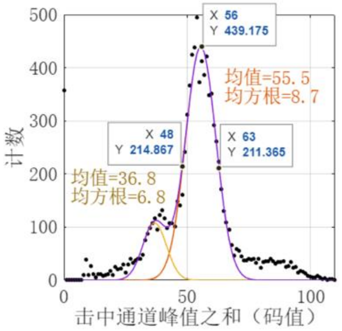
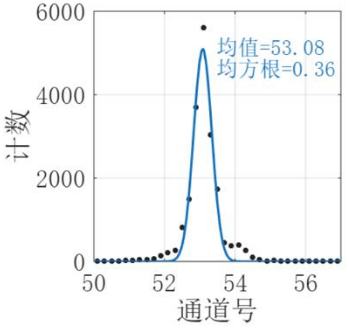


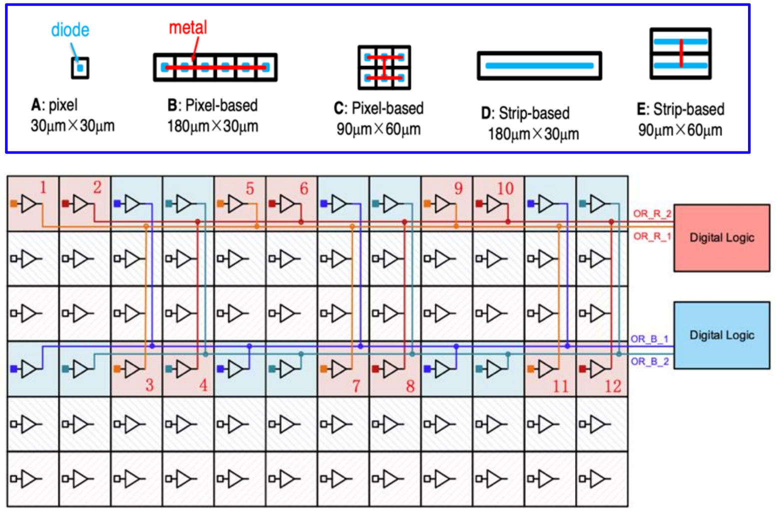

-475 V -1000 V偏压下
的能谱测量数据



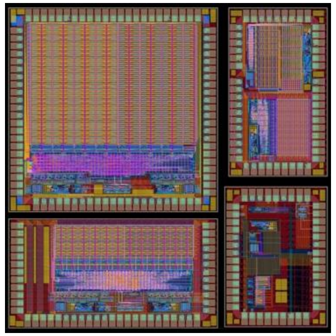

-475 V -2000 V偏压下
的位置测量结果

# MAPS ITK : MAPS Designs

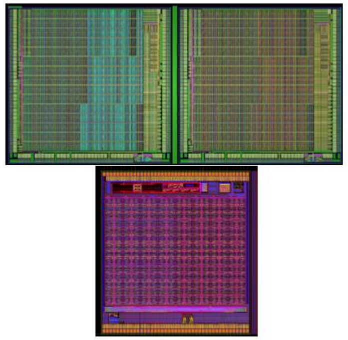
- **Core target: a low-power MAPS design with moderate position resolution and both timing and charge measurement capabilities.**
- **Low power outweighs position resolution: exploring strip-like or large-size pixel MAPS designs to reduce power.**
- **Exploring a super-pixel design that can provide both high position and high time resolutions for low power consumption.**
- **Various CMOS processes being explored**
  - **Mature technology: TowerJazz 180nm (HR epi)**
  - **Domestic foundries: NexChip BCIS 90nm (LR epi ) , GSMC 130nm (HR substrate), IRAY 180nm (HR epi)**



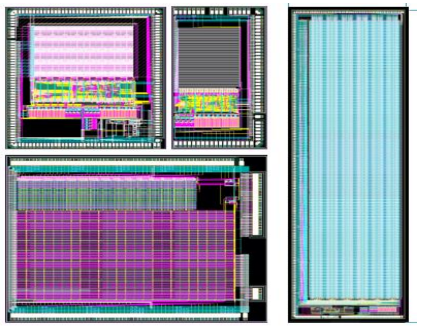

**TowerJazz 180nm**
Chips received,
testing underway



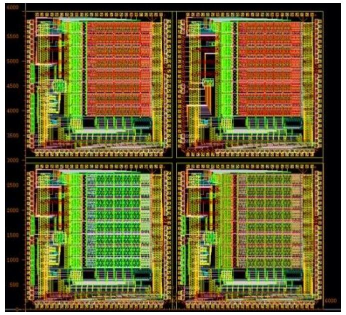
**NexChip BCIS 90nm**
Chips received,
to be tested



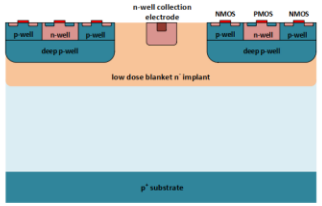
**GSMC 130nm**
Chips received,
testing underway



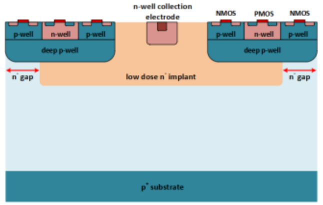
**IRAY 180nm**
Supporting quadruple-well with possibility of
N-blanket implant and N-gap. Chips received, to be tested



N-blanket implant

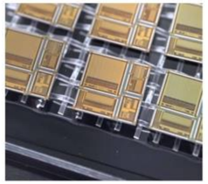


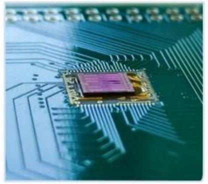
N-gap

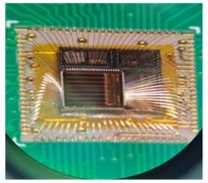


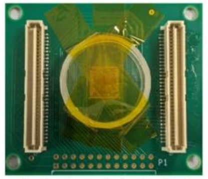
# MAPS ITK : MAPS Testing

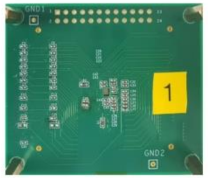
- **Characterized the TJ and GSMC chips for threshold, noise, fake hit rate and capacitance. Tested the chips with laser and radioactive sources (Fe55 and Sr90) for detection efficiency, charge collection efficiency and time resolution.**


TJ芯片

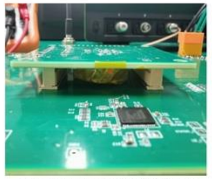

同尺寸芯片试粘接在绝缘胶上


未划片直接打线


子板背面(芯片+保护壳)

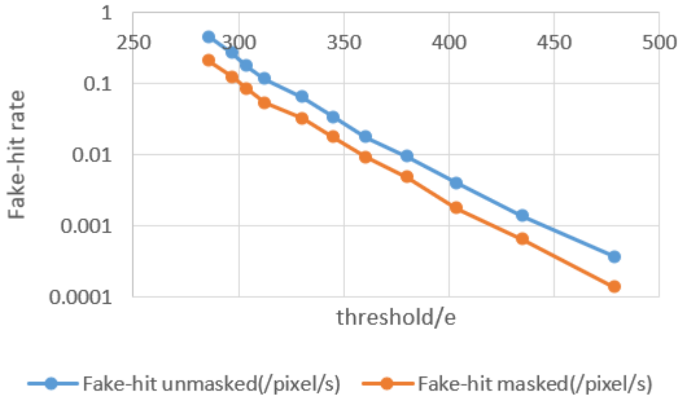


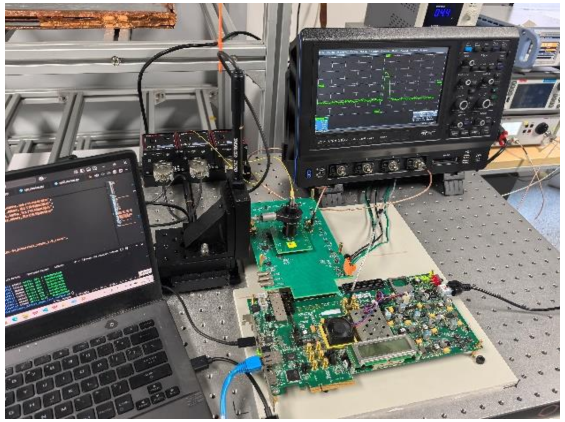
子板正面(绝缘胶挖洞)

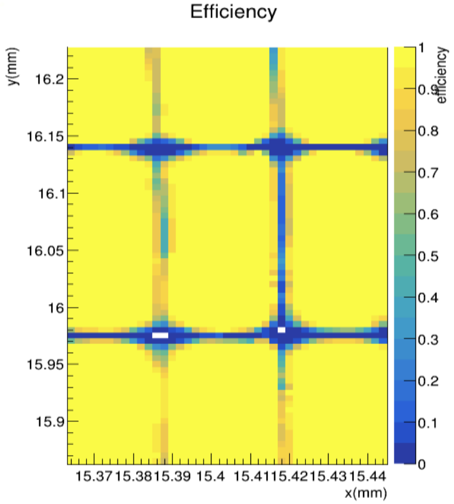

子板安装在测试转接板上

| 偏压/V | Threshold/e | FPN/e | TN/e | $A_{OUT}$/mV | 基线RMS/mV |
|---|---|---|---|---|---|
| -2 | 268.2 | 7.15 | 16.1 | 523 | 7.8 |
| -3 | 234.7 | 2.75 | 15.3 | 477 | 9.2 |
| -4 | 212.2 | 0.82 | 15.4 | 417 | 7.06 |
| -5 | 178.1 | 5.32 | 11.3 | 348 | 5.92 |
| -6 | 182.1 | 7.11 | 12.1 | 292 | 5.88 |

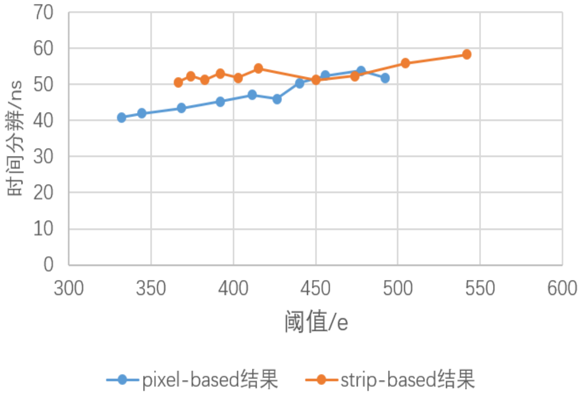
Background trigger rate



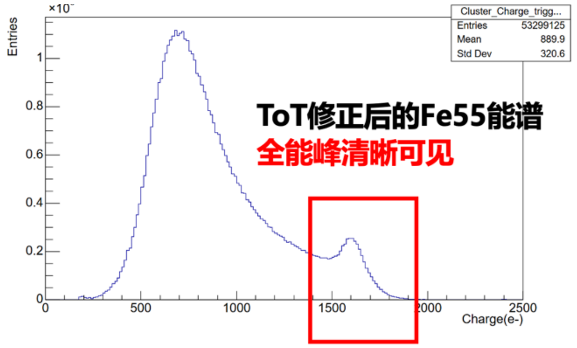






Time resolution (TJ)

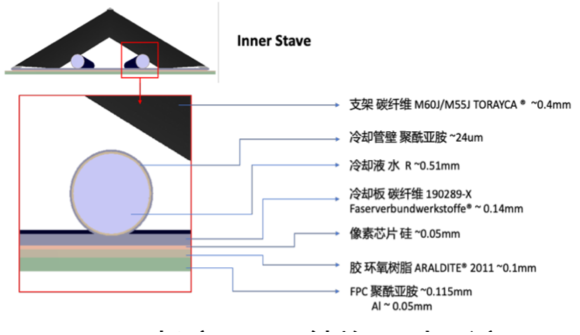


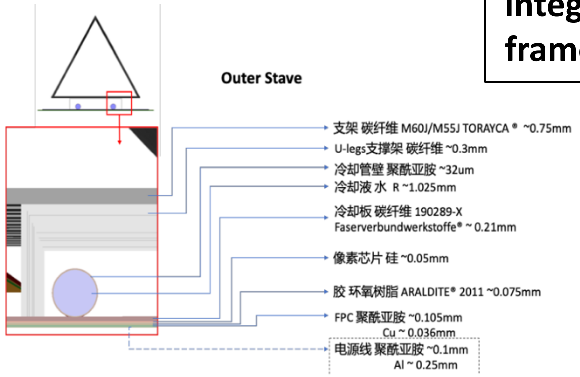

Fe55 energy spectrum (GSMC)



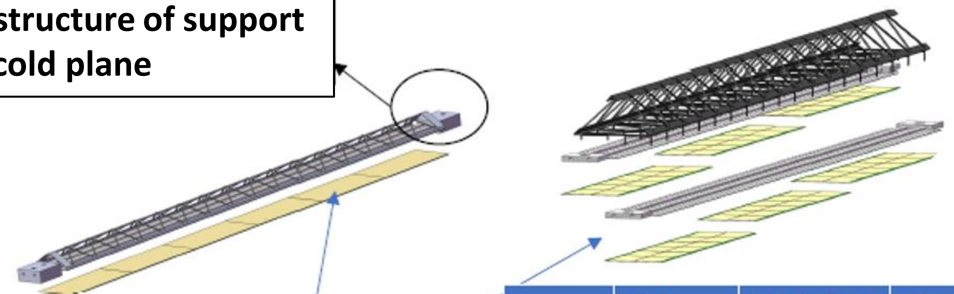
# MAPS ITK : Stave Design

- **Significant progress has been made in detector module (stave) mechanical design**

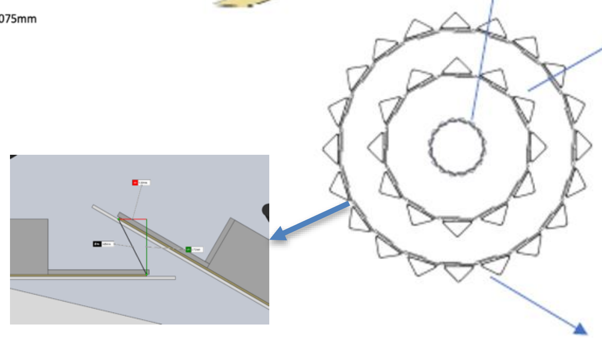


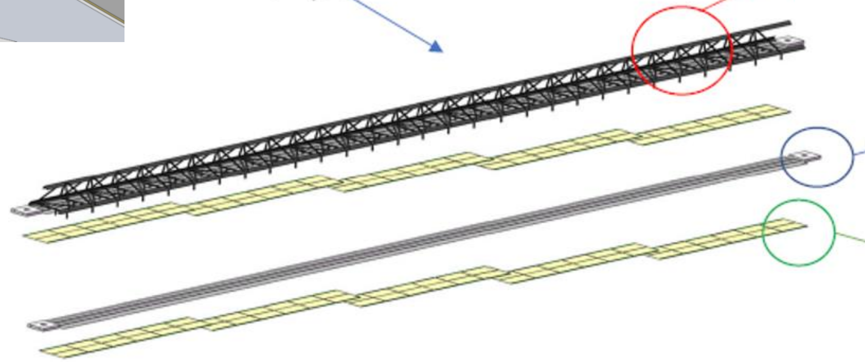




**The inner most layer: integrated structure of support frame and cold plate**



| | 半径 | STAVE数量 | STAVE全长 |
|---|---|---|---|
| 内层 | 36mm | 16 | 200.75mm |
| 中间层 | 98mm | 12 | 592.25mm |
| 外层 | 160mm | 20 | 954.55mm |



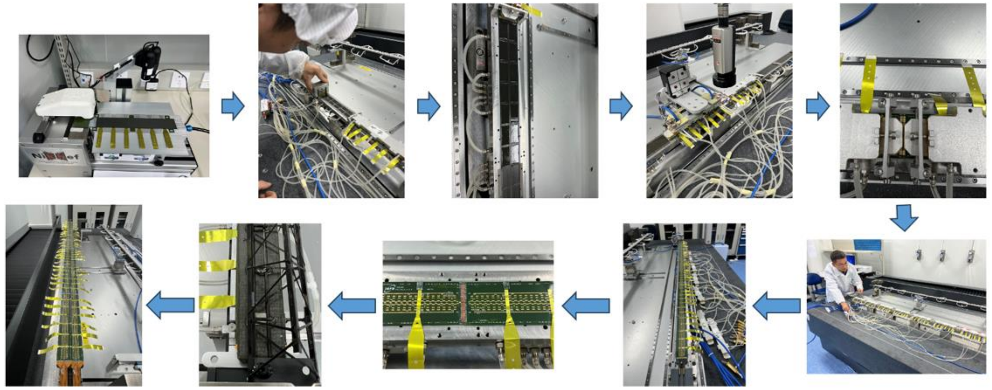


**CF support frame**

**Cold plate**

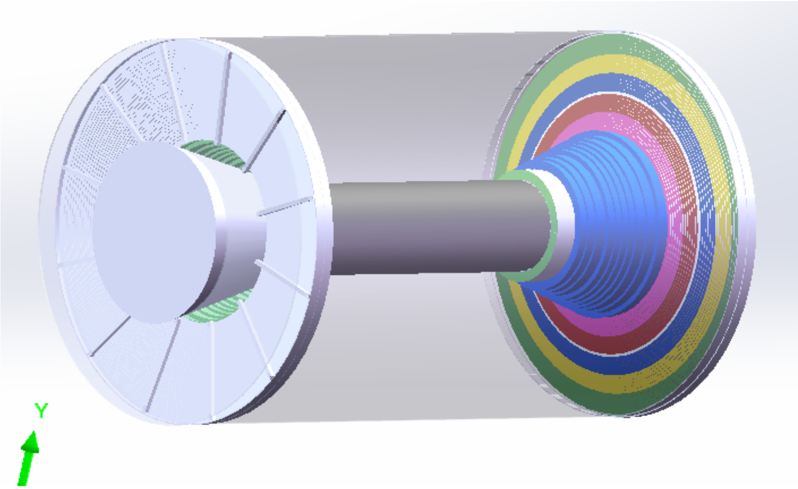
**Flex PCB & chips**

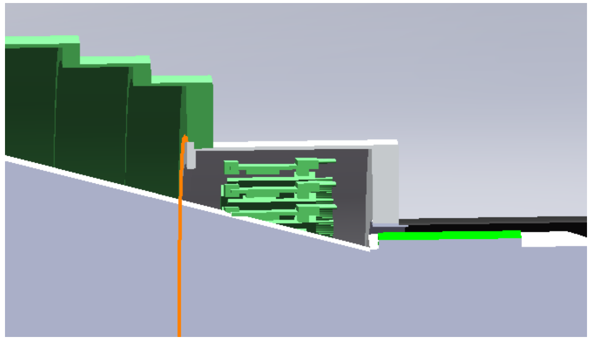
Stave assembly and integration infrastructure and experience

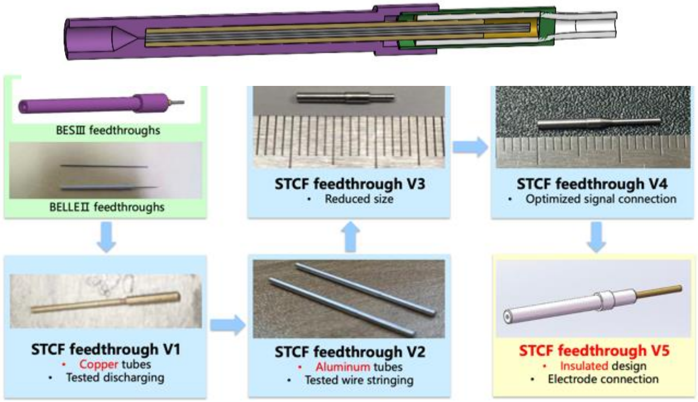


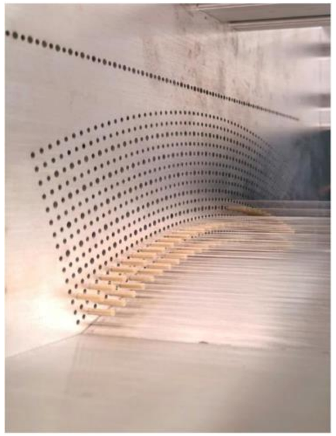
# Main Drift Chamber : Detector

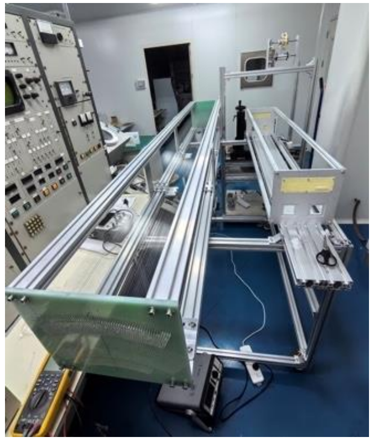
- **Endplate structure optimized to simplify the assembly process**
- **Intensive R&D effort on feedthrough for super-small cells (~5 mm)**
- **A full-length super-small cell drift chamber prototype is under construction.**



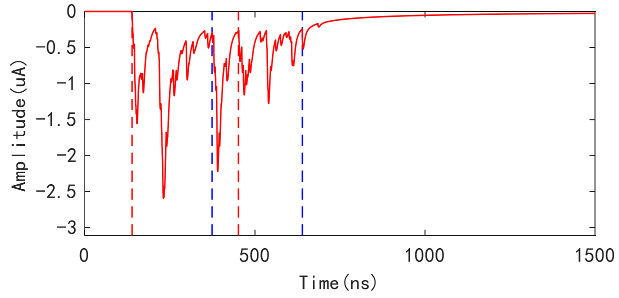


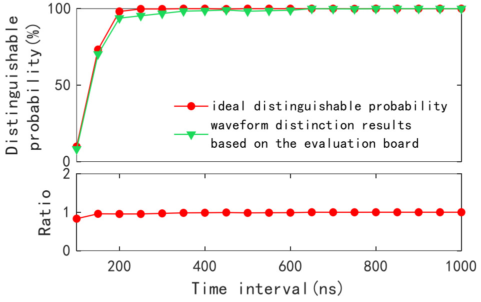



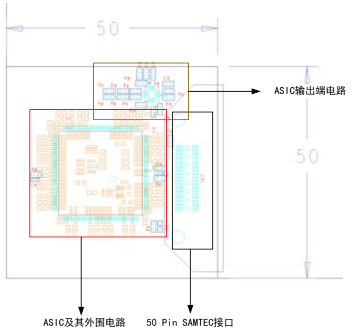


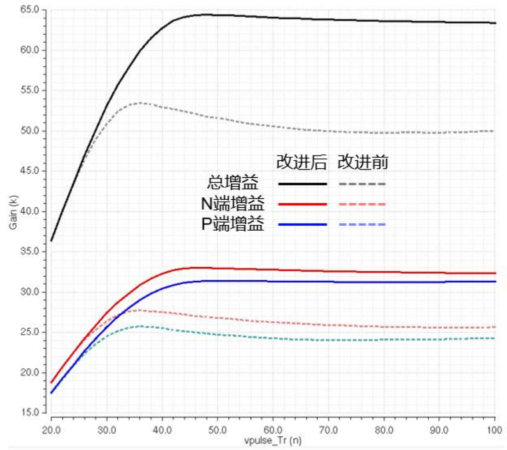
# Main Drift Chamber : Electronics

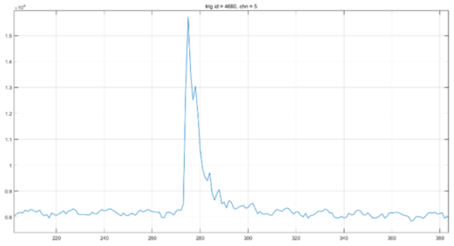
- A major challenge in MDC electronics: discriminating overlapping signal pulses (as a result of high counting rate ) that are irregular in shape.
- Waveform digitizing electronics is used to allow online waveform discriminating algorithms that run on PFGA. Developed the electronics with discrete components (TIA + shaper + ADC) and tested with detector prototypes.
- ASIC design is underway.  First version of the analogue part has been taped out. The chip prototype has been produced and is being tested.

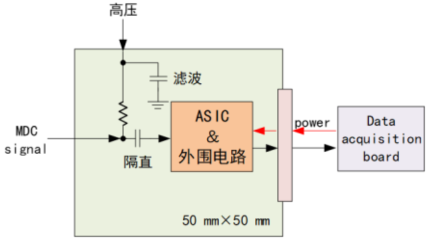


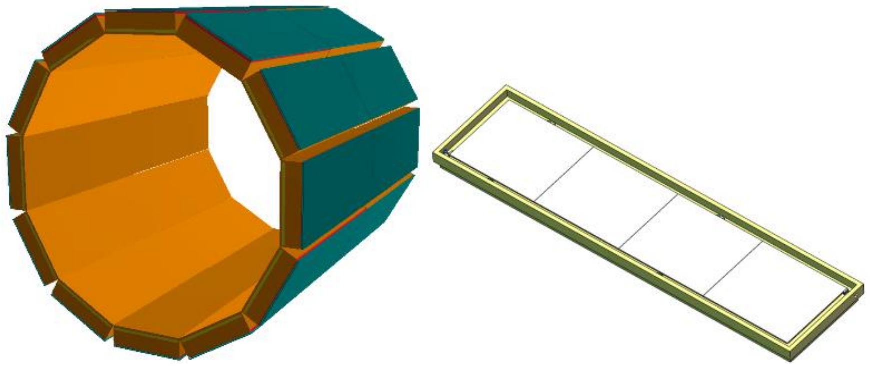



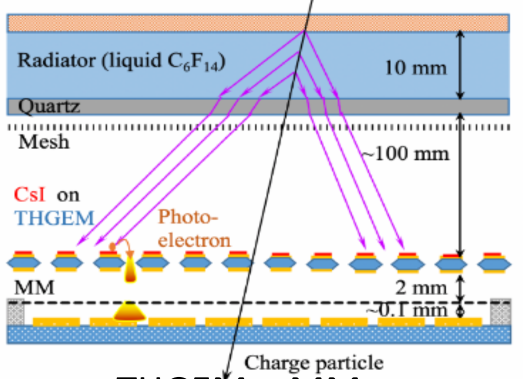


# PID System

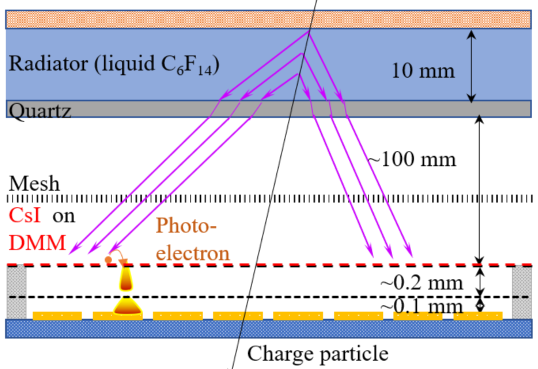
- **PID system: thickness < 20cm, material budget < $0.3X_0$, $\pi/K$ ~$4\sigma$ @ 2GeV**
- **Barrel PID: A RICH detector using MPGD with CsI for photon detection, $\sigma_\theta$ ~ 4 mrad**



Two MPGD-based photo detector options

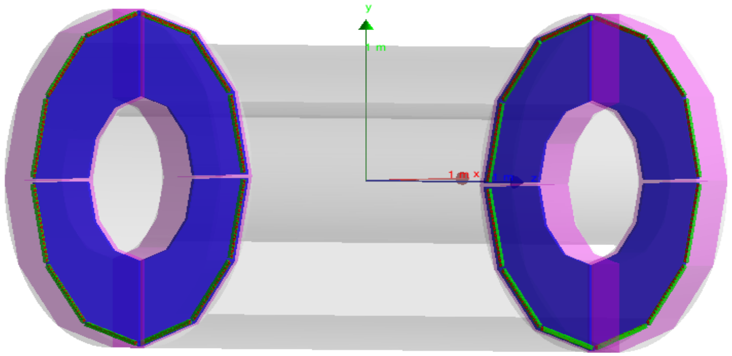


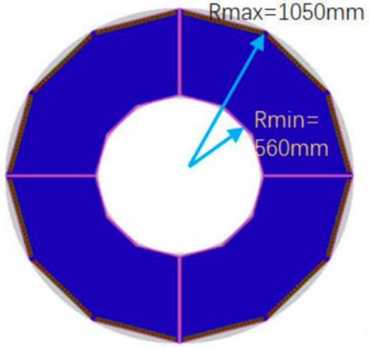

THGEM + MM

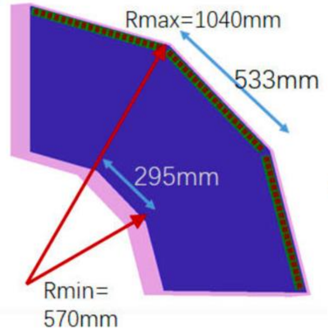


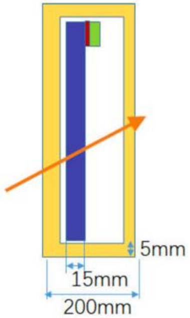

Double-MM/DMM

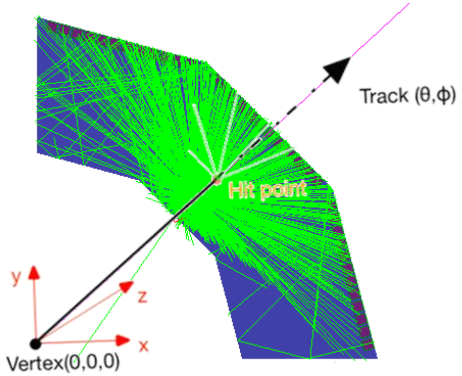
- **Endcap PID: A DIRC-like TOF detector, DTOF, quartz plate + MCP-maPMT , $\sigma_t$ ~ 30ps**





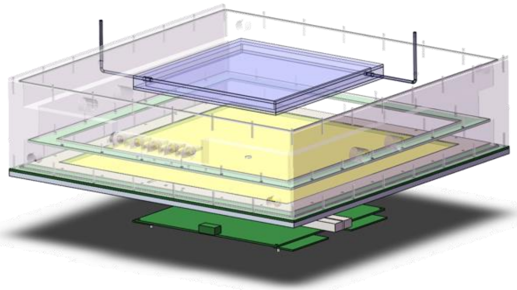



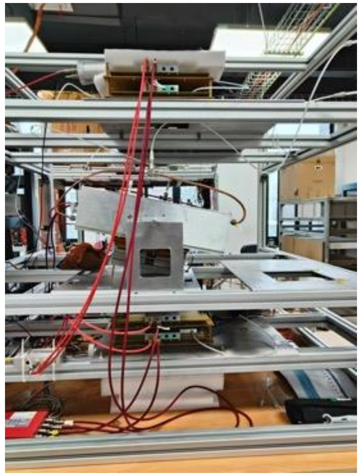



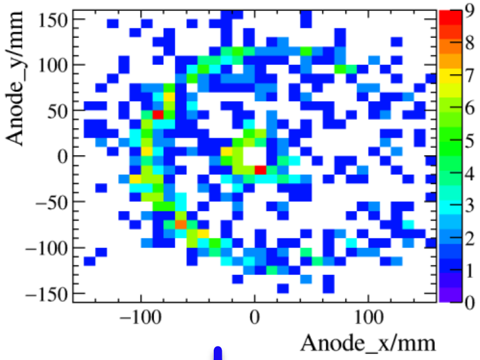
# PID Barrel : RICH Detector

**Cosmic-ray test of a 32×32 cm² RICH prototype with THGEM + MM**



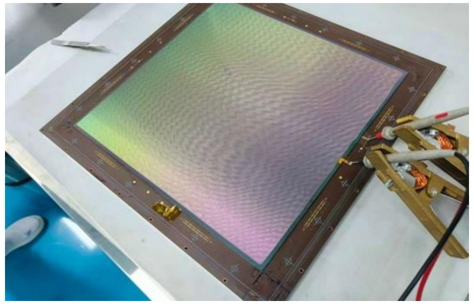


**Very low photoelectron yield** ~ 1/track. Likely causes: low radiator transparency, low cathode QE, low electron collection efficiency



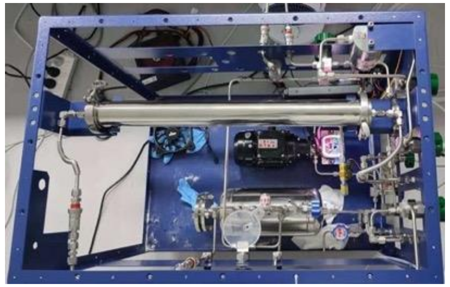

**Moved to DMM option : DMM-RICH**

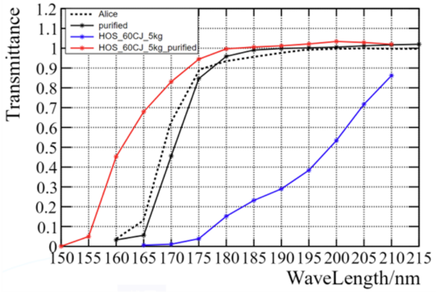
- Compact structure
- High gain & good time resolution
- High electron collection efficiency & low ion backflow



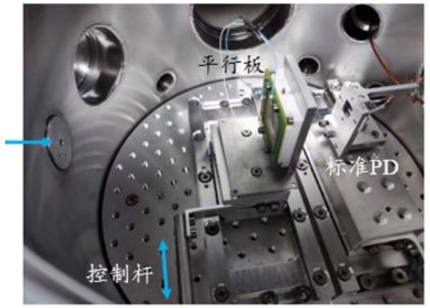
Ongoing test of a DMM-RICH prototype

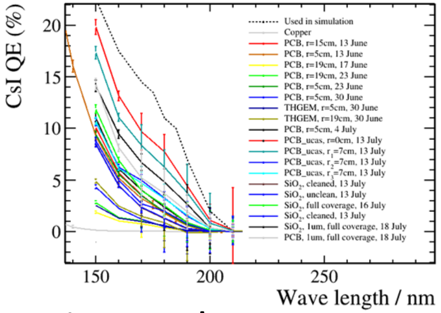
**Ongoing efforts to bring up the photoelectron yield**






Enhancing radiator transparency by purifying $C_6F_{14}$



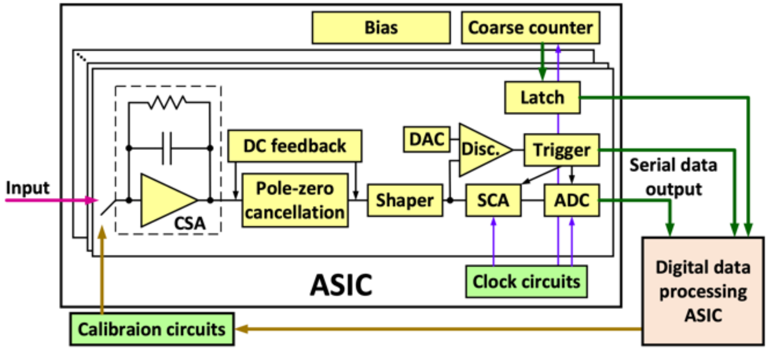



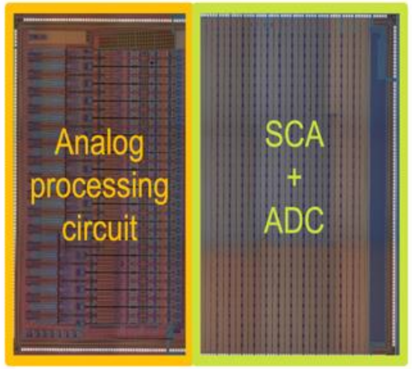

Improving QE: CsI coating and QE measurement

# RICH Readout ASIC

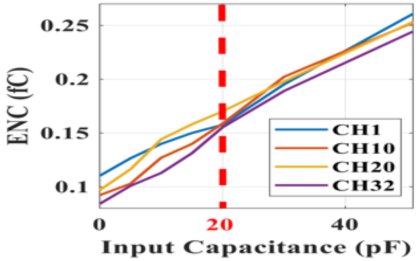
- **A large number of readout channels in high density: ~500 k, 5×5 mm$^2$ granularity , requiring ASIC**

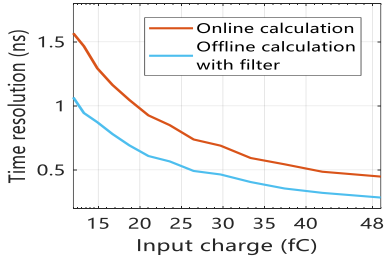
Design specs: $\sigma_t$ < 1ns @20fC&20pF, event rate ~ 30 kHz, 32-64 channels

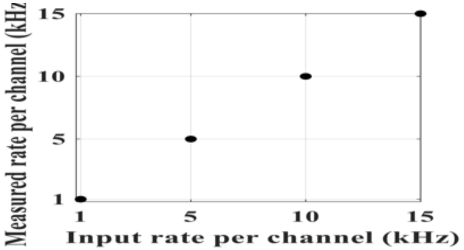



Test results



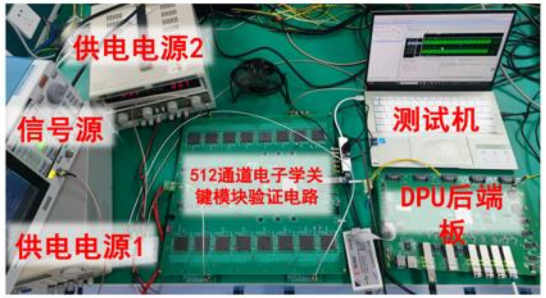




**RICH ASIC design evolution**

First version

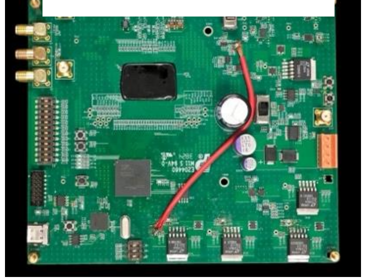
Second version

32 channels/chip




512-channel readout board using the 32-ch ASIC

Third version

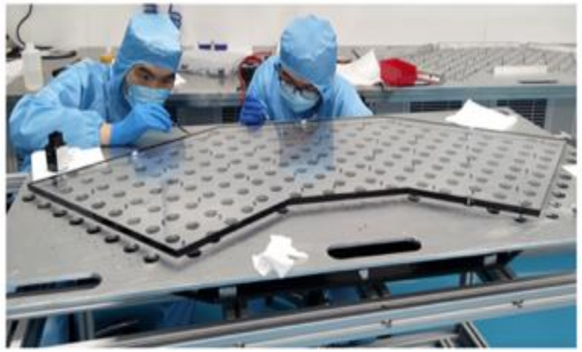


64 channels/chip

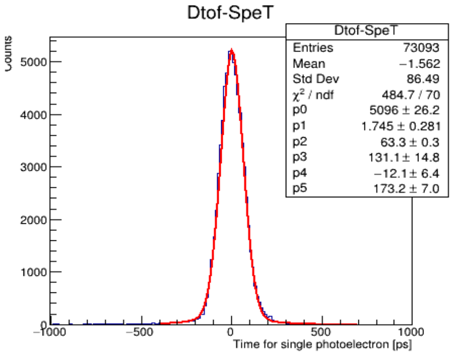

1024-channel readout board being developed

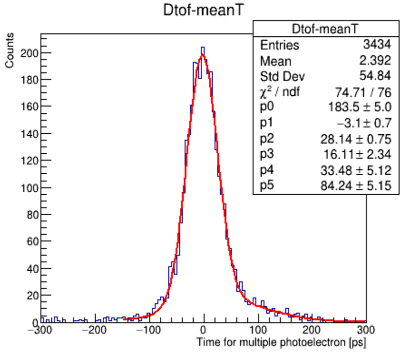
# PID Endcap: DTOF Detector

- A full-size DTOF prototype (a quadrant of STCF DTOF at one endcap) was built and tested with cosmic-rays to demonstrate the DTOF concept and technology on the full scale.



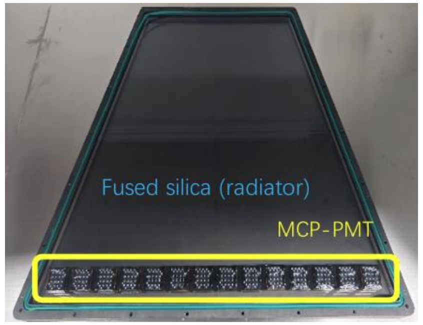
$\sigma_{spe}$=59 ps , $\sigma_{track}$=21 ps

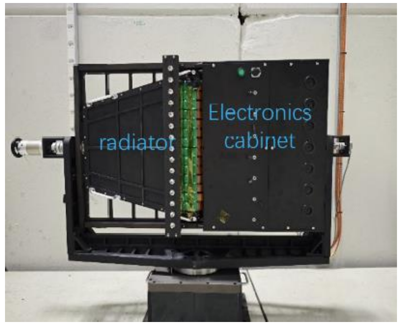


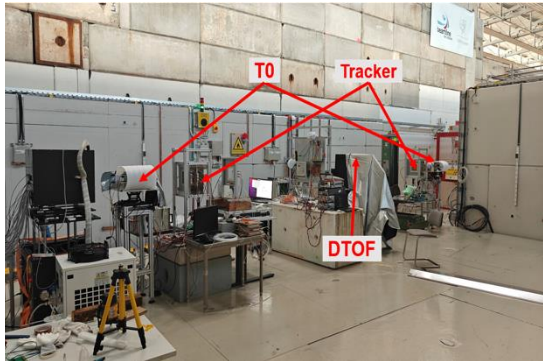



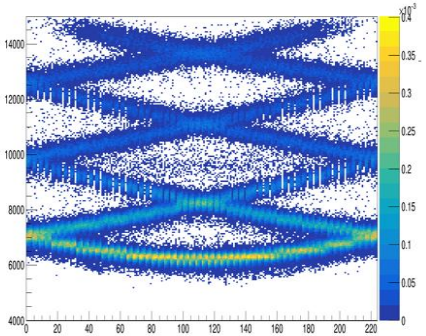

- A smaller DTOF prototype a third the size of the quadrant was built and tested with particle beams at CERN to demonstrate the PID capability of the DTOF detector

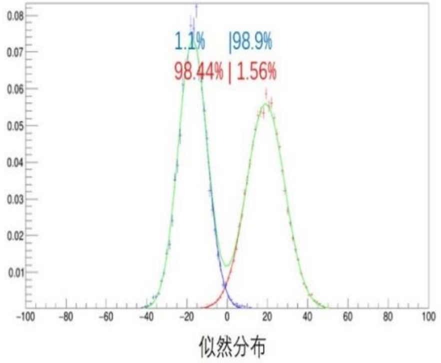
π/K separation >4σ @ 2GeV/c



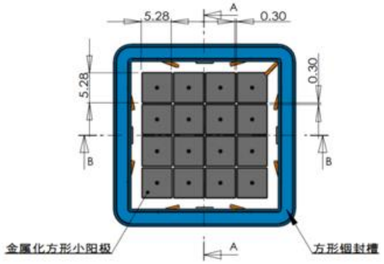



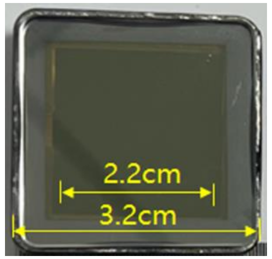





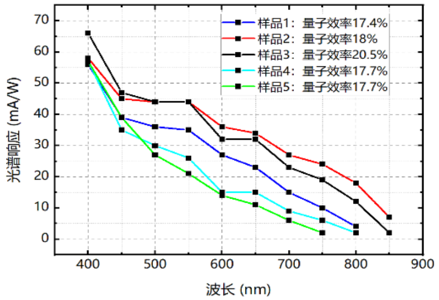
# MCP-maPMT and Readout ASICs

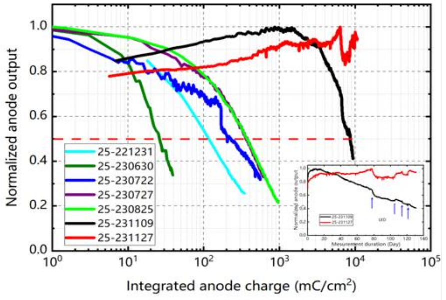
- MCP-maPMT: a critical component of the DTOF technology
- Intensive R&D on techniques (ALD and electron scrubbing) to produce long-life MCP-PMT (target Q > 10 C/cm$^2$ ).
- Designed and produced 1-inch MCP-maPMT prototypes with 16 annodes each.
- Carried out various tests of the MCP-maPMT prototypes
  - TTS<40 ps, QE>20%, G>$10^6$,
  - Aging : <10% gain drop when Q>11C/cm$^2$



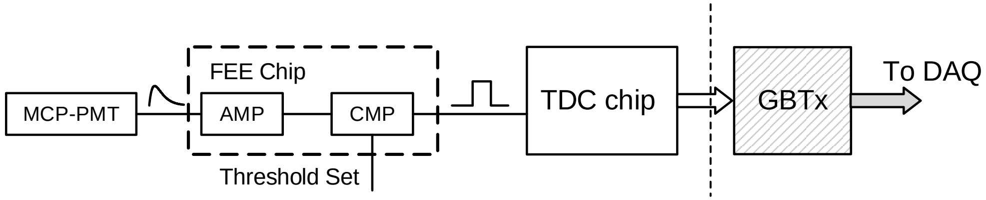



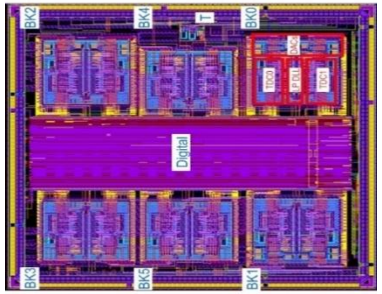

| MCP-PMT编号 | 25-240507 | 25-240521 | 25-240605 | 25-240620 |
| --- | --- | --- | --- | --- |
| MCP类型 | ALD-MCP，ALD镀膜厚度：D2 | | | |
| MCP厂家 | 厂家1 | 厂家1 | 厂家2 | 厂家2 |
| MCP电子清刷剂量 | 0.75 uA·h/cm² | 0.87 uA·h/cm² | 0.75 uA·h/cm² | 0.87 uA·h/cm² |

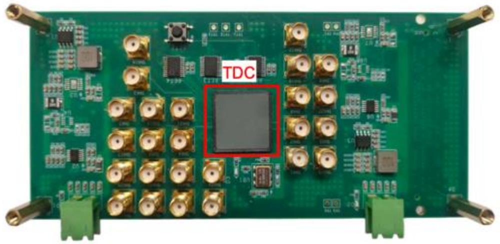


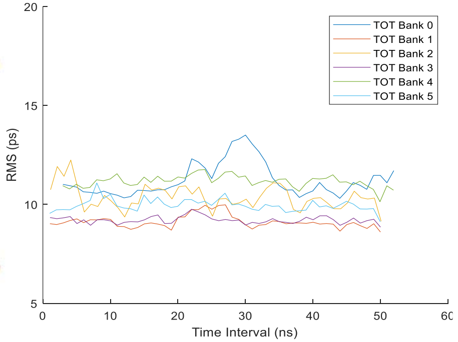




- Two ASICs designed for MCP-maPMT readout. Prototype chips produced and tested
  - FET: target ~ 15 ps, measured ~15 ps
  - TDC: target ~ 15 ps , measured ~10 ps



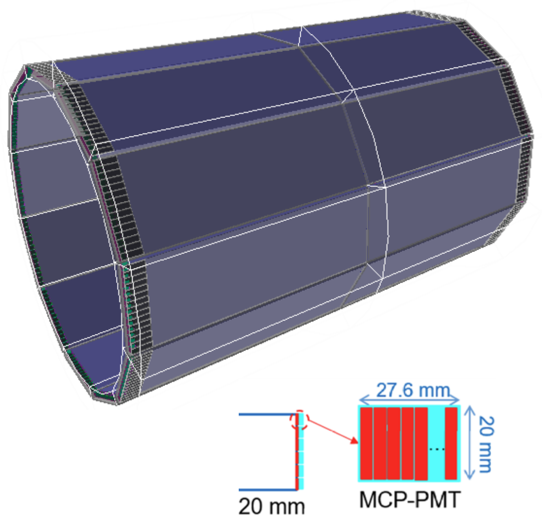



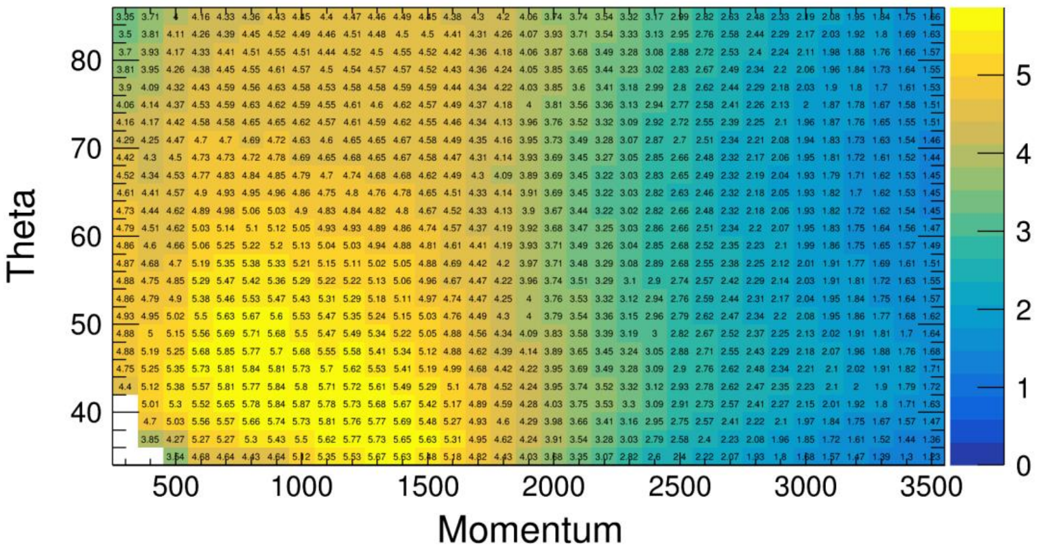



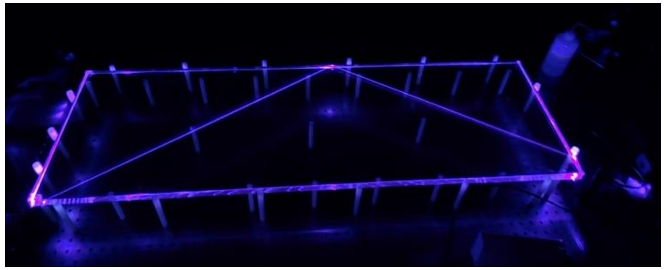



# BTOF : DTOF in Barrel (new baseline for barrel PID)

- **Design of a barrel PID detector based on the DTOF technology is available ( BTOF )**
  - 12 sectors with 2 modules placed longitudinally in each sector, 24 quartz plates in total
  - Quartz plate parameters : R = 875mm H = 20mm L = 1350mm D = 450mm
  - Inner side of a quartz plate is coated with light absorbing layer while the outer side is equipped with 15 SiPMs for readout
- **Performance with full simulation mostly meets PID requirements. Ongoing effort to optimize the design by scanning a variety of key parameters**
- **A full-length BTOF prototype has been built and tested with particle beams**

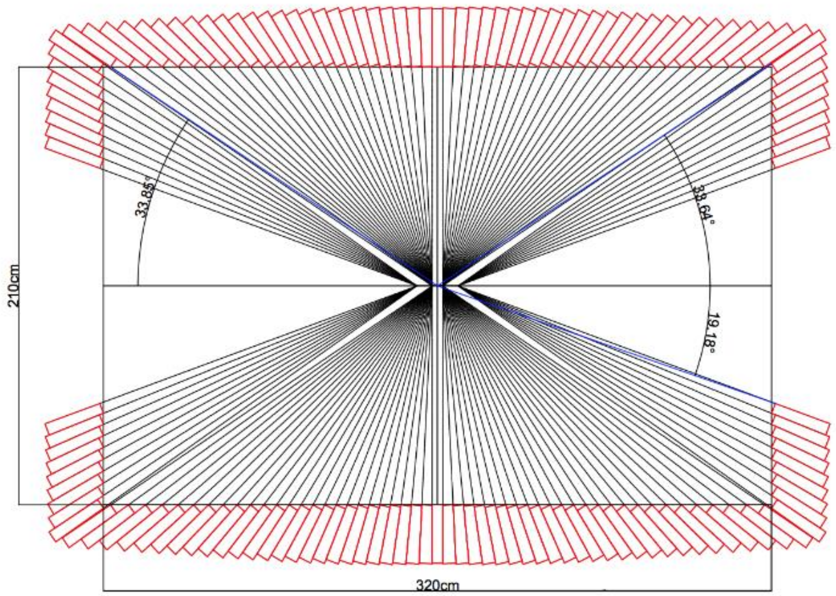


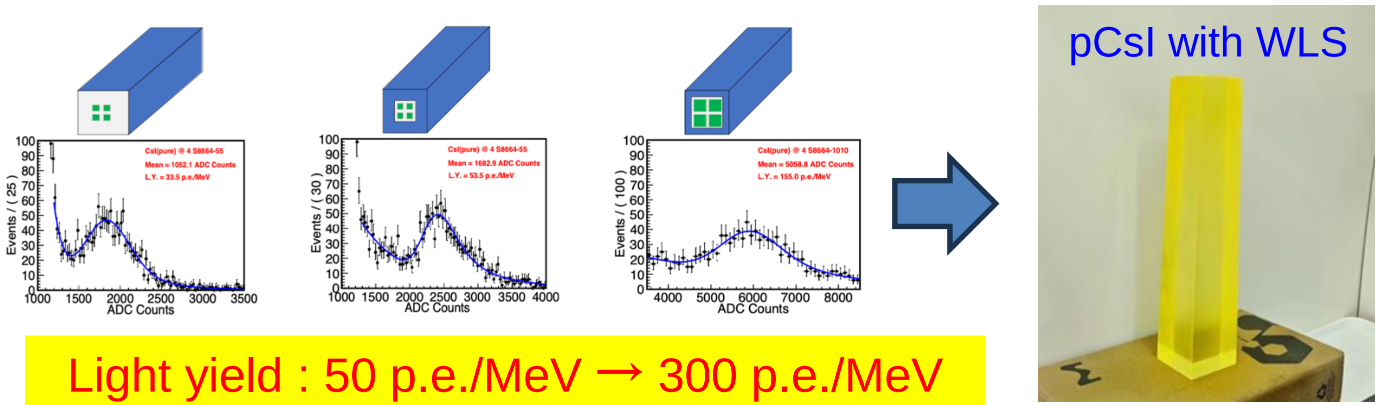



# Electro-Magnetic Calorimeter : EMC

- **A crystal calorimeter using pCsI ( short decay time of 30ns ) to tackle the high background rate (~1 MHz/crystal )**
  - Crystal size: 28cm ($15X_0$), $5\times5cm^2$
  - Defocused layout: 6732 crystals in barrel, 1938 crystals in endcaps
  - 4 large area APDs to address low light yield: $4\times(1\times1cm^2)$



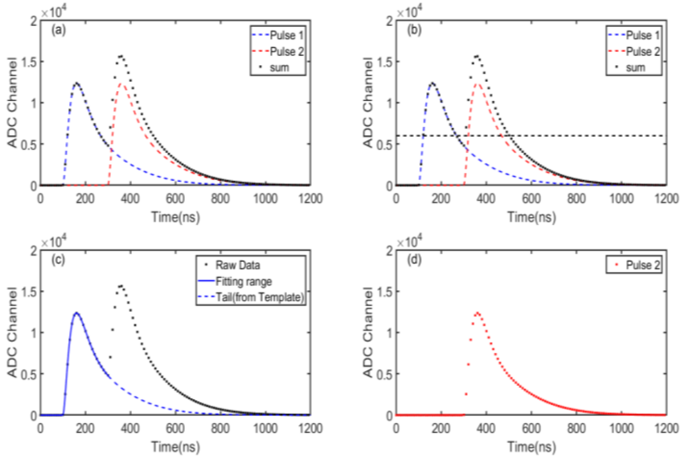

**A very low light yield of 3.6% for pCsI → a major R&D task : enhance the light yield of a pCsI unit**

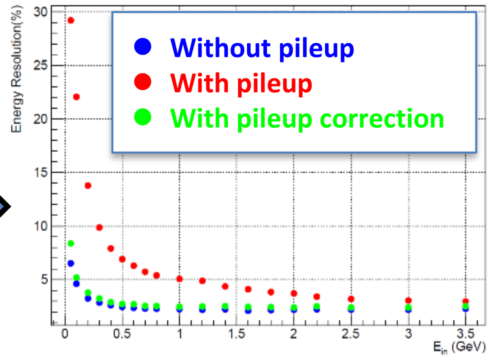



Light yield : 50 p.e./MeV → 300 p.e./MeV

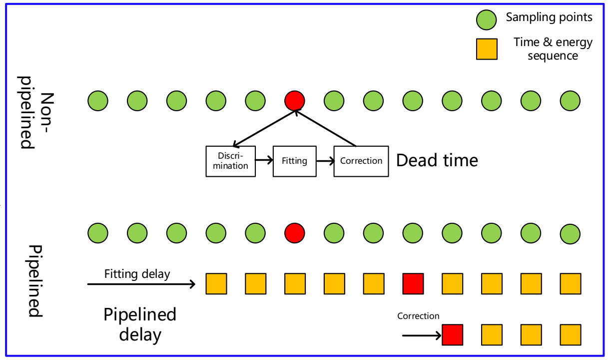
# EMC : Pileup Mitigation and Electronics

- **Significant pileup in EMC in the presence of beam background (~1 MHz/ch). A dead-time free pileup correction algorithm involving waveform fitting based on pipelined optimal filtering has been developed and implemented in FPGA**

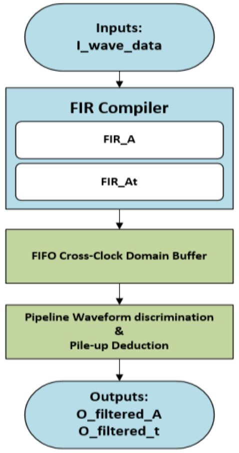



Very effective in mitigating the pileup effect

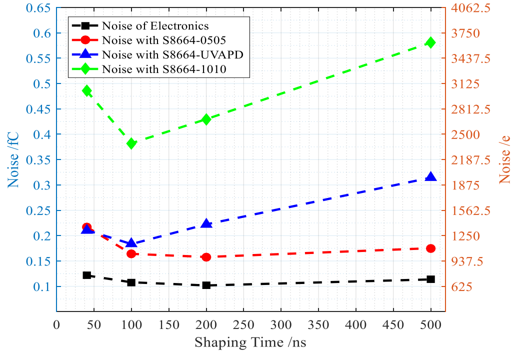


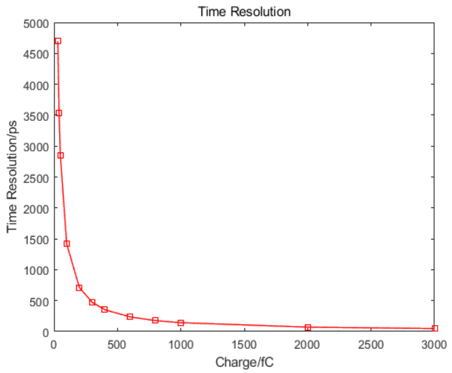

Pipelined correction algorithm




FPGA implementation

- **Development of waveform digitization electronics (CSA + shaper + ADC)**




- **Dynamic range** 3 MeV ~ 3 GeV
- **ENE :** ~ 0.5 MeV
- **Time resolution** < 150 ps@1GeV

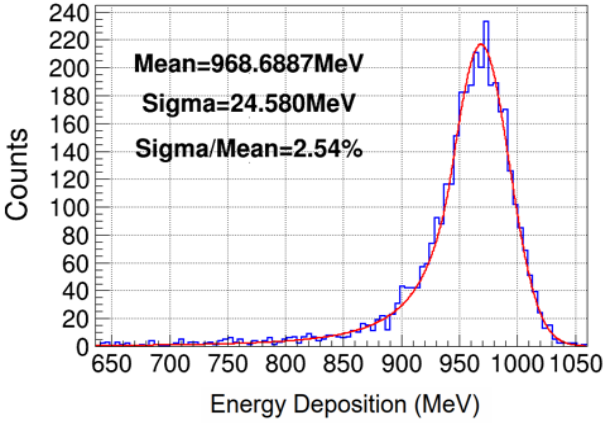
# 5×5 pCsI EMC Prototype

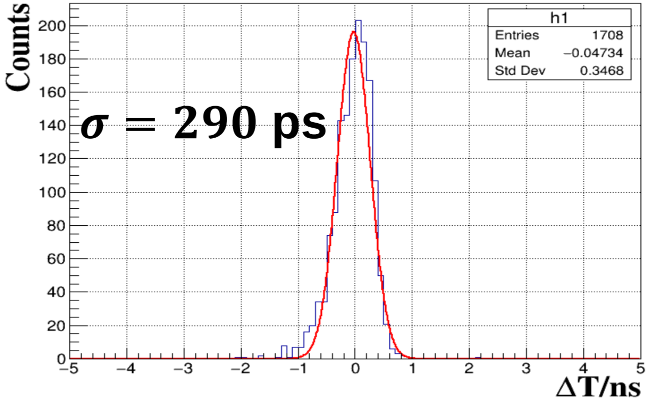
## EMC prototype in the making

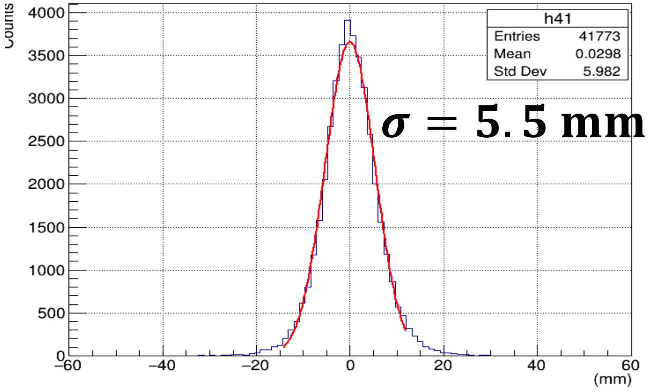


## Beam test at CERN PS

## Performance from the beam test with 1 GeV/c electrons

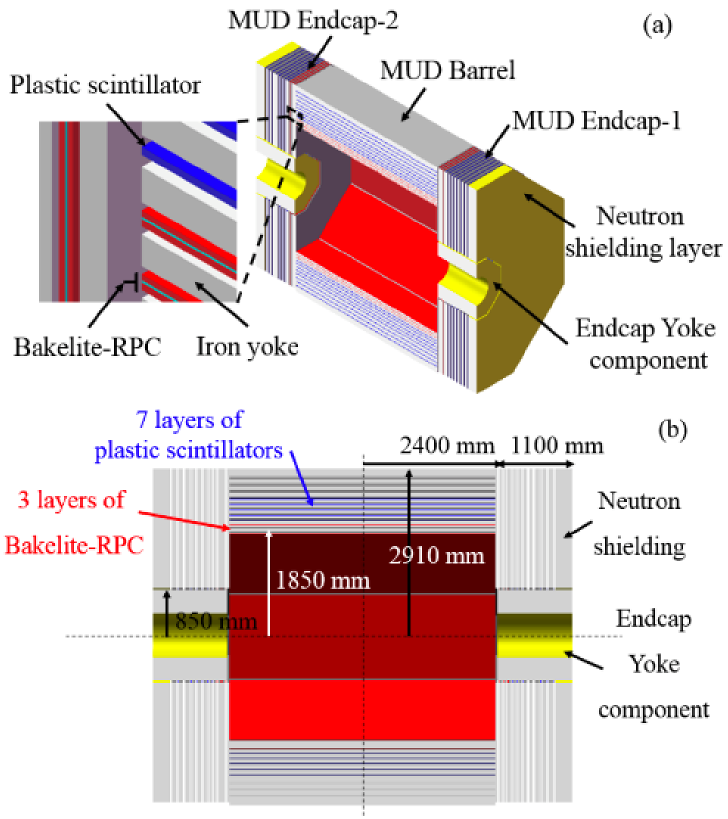


# Muon Detector

- **A hybrid design with RPC and scintillator strips for optimal overall muon and neutral hadron identification performance**
  - **RPC for inner 3 layers : not sensitive to background**
  - **Scintillator for outer 7 layers: sensitive to hadrons**

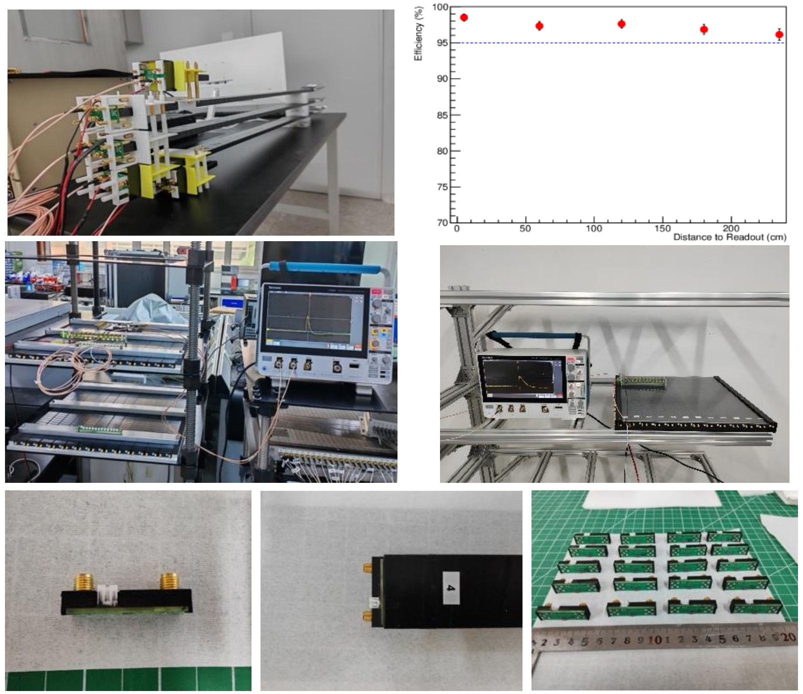



| Parameter | Baseline design |
|---|---|
| $R_{in}$ [cm] | 185 |
| $R_{out}$ [cm] | 291 |
| $R_e$ [cm] | 85 |
| $L_{Barrel}$ [cm] | 480 |
| $T_{Endcap}$ [cm] | 107 |
| Segmentation in $\phi$ | 8 |
| Number of detector layers | 10 |
| Iron yoke thickness [cm] | 4/4/4.5/4.5/6/6/6/8/8 cm |
| ($\lambda$=16.77 cm) | Total: 51 cm, 3.04$\lambda$ |
| Solid angle | 79.2%×4$\pi$ in barrel |
| | 14.8%×4$\pi$ in endcap |
| | 94%×4$\pi$ in total |
| Total area [$m^2$] | Barrel ~717 |
| | Endcap ~520 |
| | Total ~1237 |

# MUD R&D

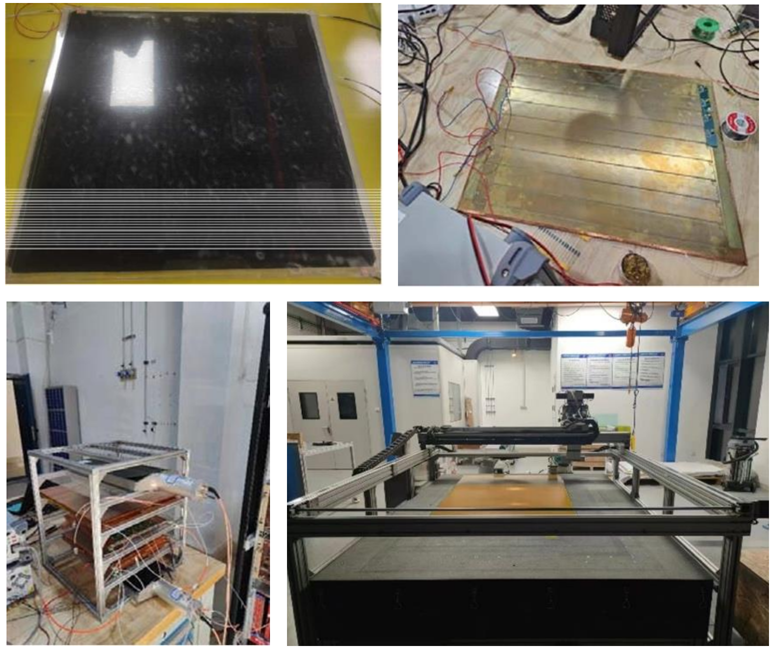
## Scintillator strip + WLS + SiPM

- Design and fabrication of the scintillator unit： reflector, fiber groove, optical coupling, surface processing.
- Fabricated 2.4 long scintillator units (efficiency>95%) and a 50×50 cm² scintillator strip array



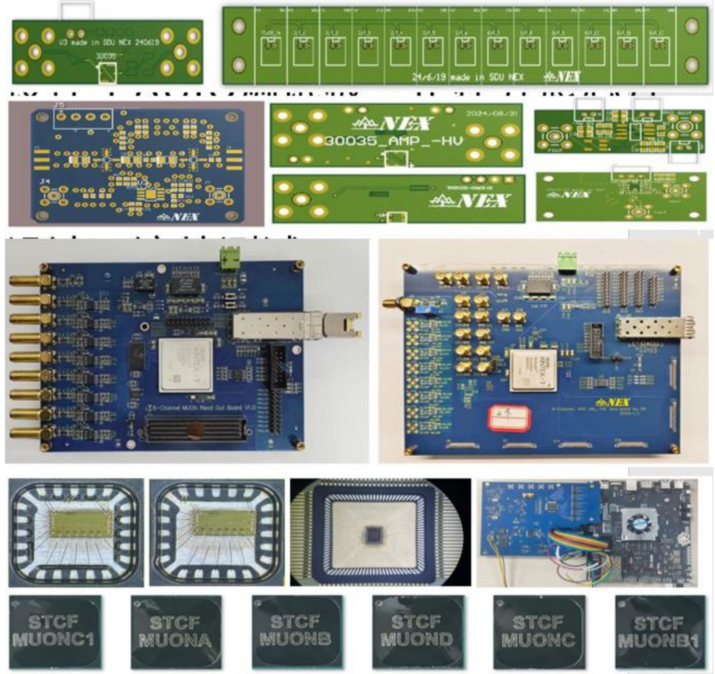

## Glass RPC

- Developed glass RPC fabrication techniques and built a 40×40 cm² glass prototype.
- Focusing on low-resistivity glass RPC for high count rate capabilities. Built some small prototypes.



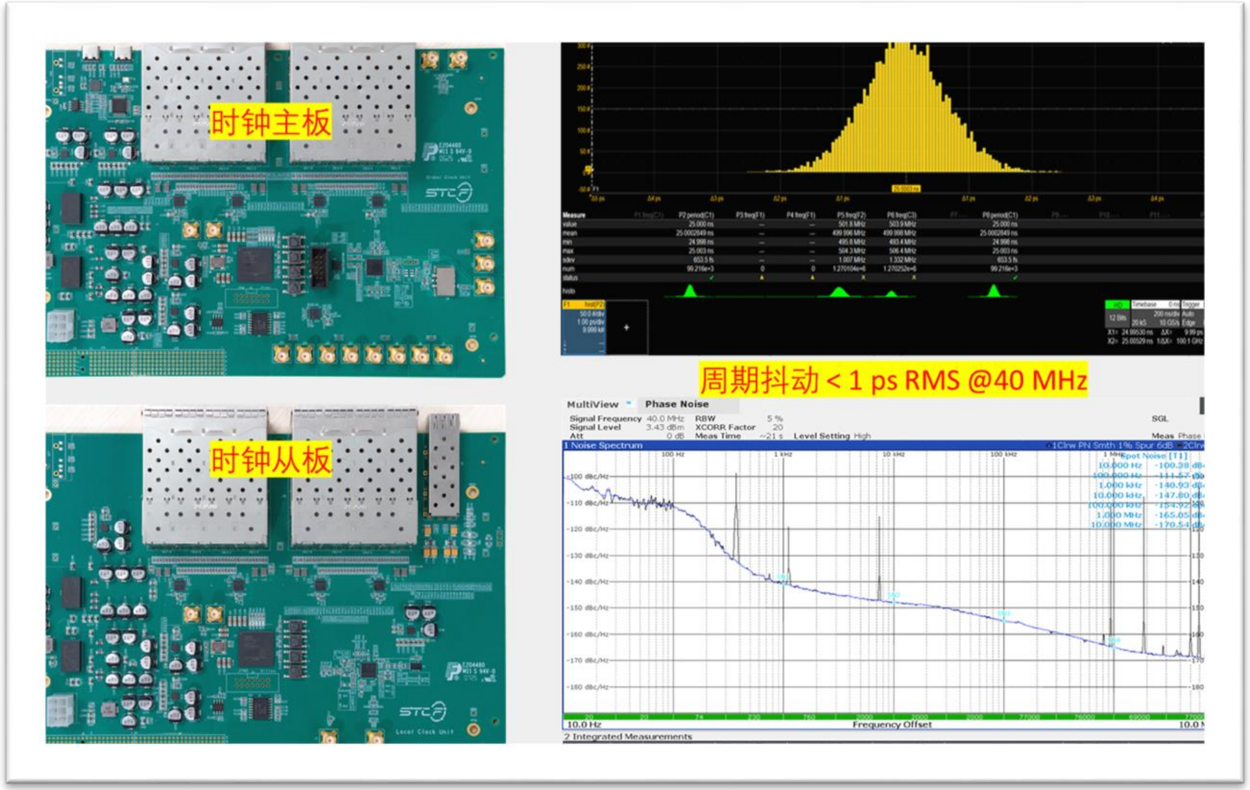
## Readout Electronics

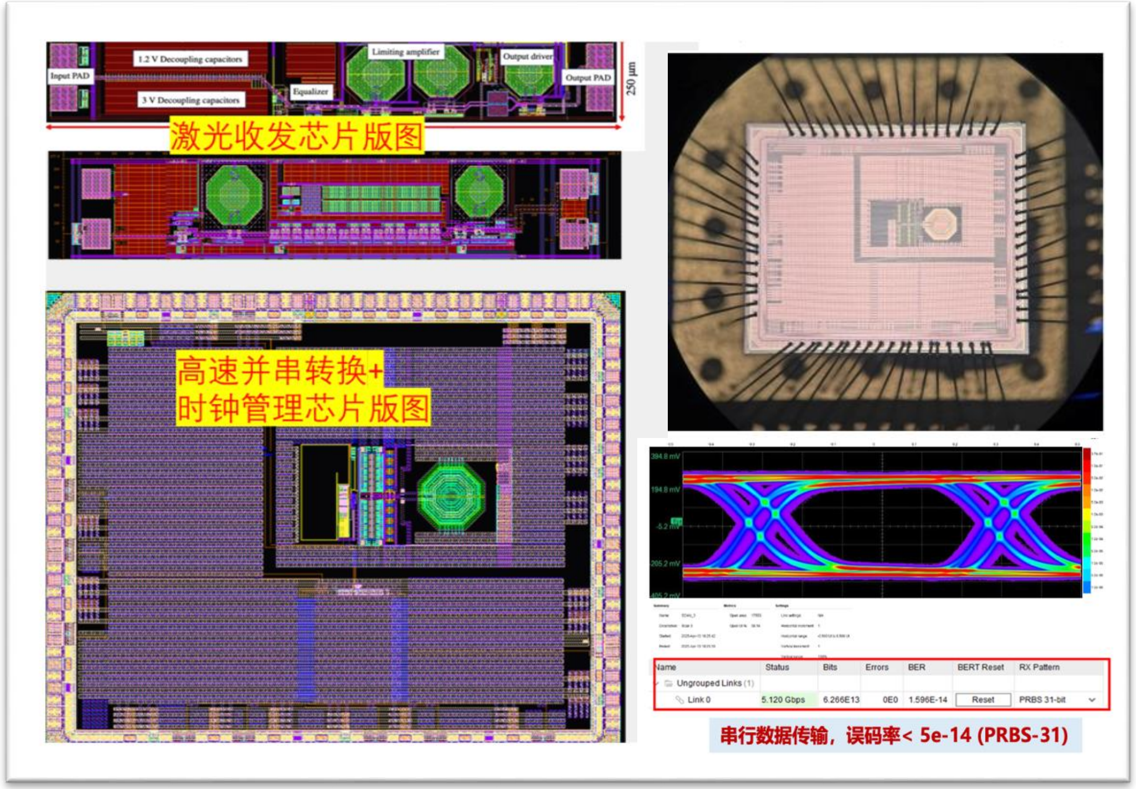
- Developed front-end amplifiers and readout boards. Tested with detector prototypes.
- Designed front-end ASICs for different input capacitance and gains. Prototype chips being tested



# Clock and Data Transmission

- Clock distribution system providing precise and stable clock signals with jitter < 5ps RMS
- High-speed serial data transmission：a GBTx-like ASIC, ADTC,  uplink ~5Gbps



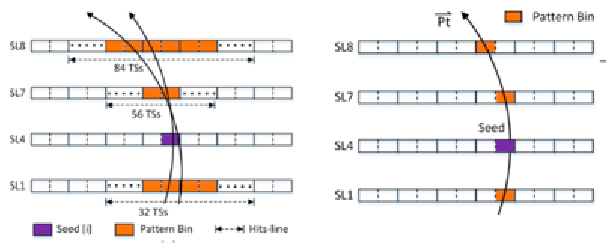



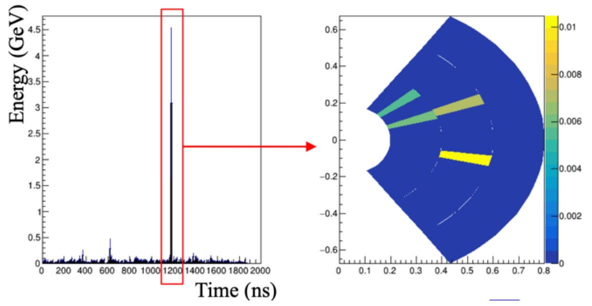

- Completed the design and test of clock distribution modules in a “master-slave” architecture
- Clock jitter tested ~1ps RMS
- joined the upcoming combined beam test

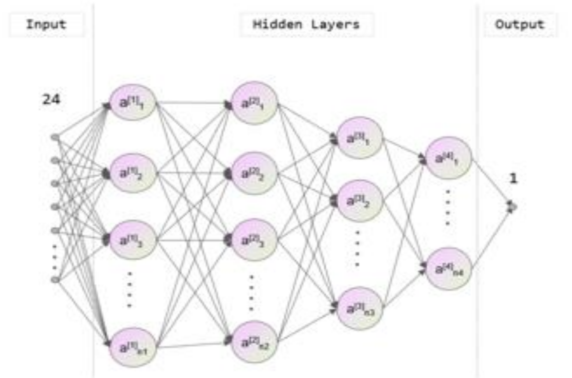
- Designed SerDes and clock managing modules in ADTC, and optical modules. Chips received and tested

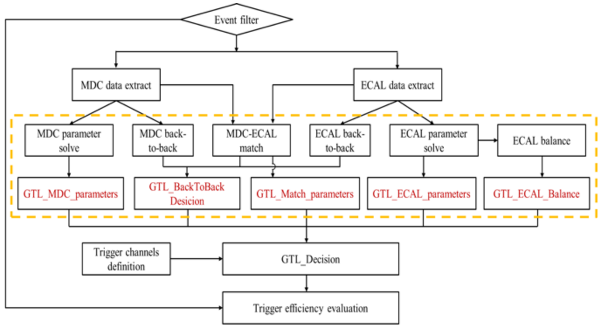
# Trigger : Algorithms Studies and Development

- **STCF trigger scheme： L1 ( MDC, ECAL and global trigger) + HLT**
- **L1-MDC trigger algorithms: 2D track reconstruction (track finding and parameters (pt, θ, ϕ, t) estimation) using pattern matching , 2D short-track reconstruction incorporating stereo layers using NN, Z impact parameter estimation using NN**
- **L1-ECAL trigger algorithms : overlapping events resolving, cluster reconstruction and splitting (E, θ, ϕ, t )**
- **L1 global trigger : track and cluster matching, event T0 estimation, trigger menus for charged and neutral channels**
- **HLT : currently focusing on MDC HLT aiming to remove noise hits and reduce event size**



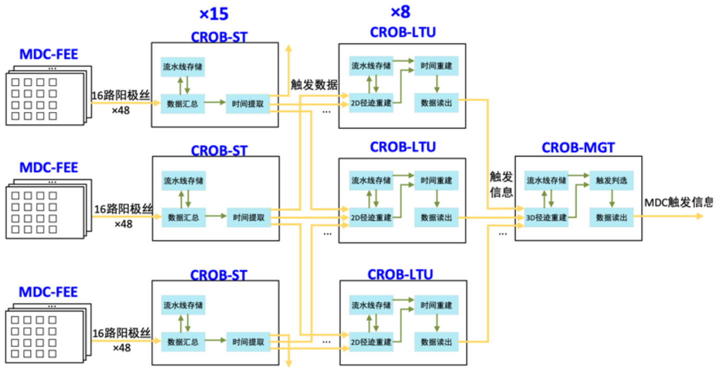



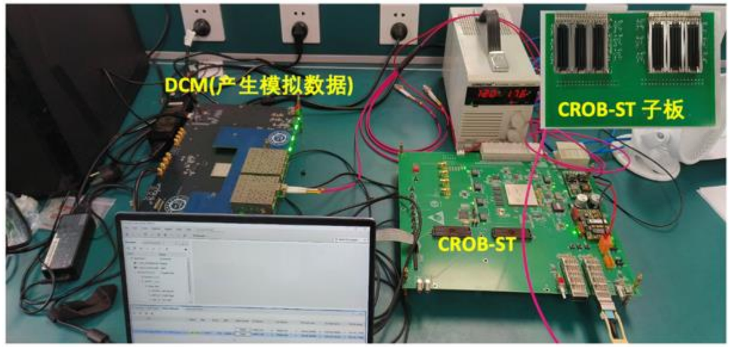

Background trigger rate < 50 kHz

| Trigger channel | Physics signal | Energy point | Background trigger rate(kHz) | Signal trigger rate |
|---|---|---|---|---|
| 带电道 | $e^+e^-$ -> $\pi^+\pi^-$Jpsi; Jpsi -> $e^+e^-$ | 4.26GeV | 43.3 | 99.7% |
| | $e^+e^-$ -> $\pi^+\pi^-$Jpsi; Jpsi -> $\mu^+\mu^-$ | 4.26GeV | | 99.8% |
| | $e^+e^-$ -> $\tau^+ \tau^-$ | 4.26GeV | | 98.2% |
| | $e^+e^-$ -> $\pi^+\pi^-$Jpsi; Jpsi -> $\Lambda \bar{\Lambda}$ | 3.097GeV | | 99.0% |
| | $e^+e^-$ -> $\pi^+\pi^-$Jpsi; Jpsi -> $\Xi \bar{\Xi}$ | 3.097GeV | | 99.1% |
| | $e^+e^-$ -> $K^+K^-$Jpsi; Jpsi -> $l^+l^-$ | 4.682GeV | | 100% |
| | $e^+e^-$ -> $D_0 \overline{D_0}$ | 3.773GeV | | 100% |
| | $e^+e^-$ -> $D^+ D^-$ | 3.773GeV | | 100% |
| | $e^+e^-$ -> $D_s^+ D_s^-$ | 4.04GeV | | 100% |
| | Jpsi -> inclusive | 3.097GeV | 46.6 | 97.7% |
| 中性道 | J/psi-> gam invisable | 3.097GeV | 39.4 | 99.7% |
| | e+e- -> n nbar | 3.097GeV | | 97.6% |
| | e+e- -> gam n nbar | 3.097GeV | | 99.7% |
| | e+e- -> gam n nbar(ISR) | 3.713GeV | | 93.1% |
| 亮度监测道 | RBB | 4.26GeV | | 98.4% |

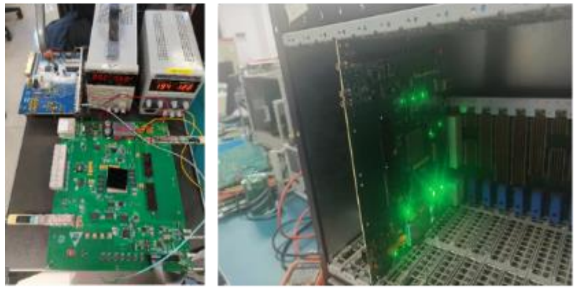
# Trigger : Hardware Development

- **Design of trigger hardware architecture. Development of various core trigger hardware components (CROB-ST, CROB-LTU, CROB-MGT/EGT, CTM, FMC …) . FPGA implementation of L1 trigger algorithms.**
- **A prototype L1 trigger system has been designed and built to demonstrate the trigger system design and its performance. An event simulator has been developed to generate pseudo data for the prototype trigger system.**
- **The prototype system has participated in the recent combined beam test at CERN**




CROB-LTU板卡调试及机箱测试



数据产生板机箱测试

**CROB-LTU板卡**

**数据产生板**

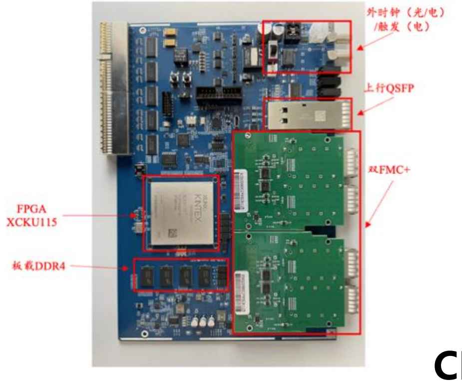
**FMC+子板**

**CTM板**

# DAQ Design and Development

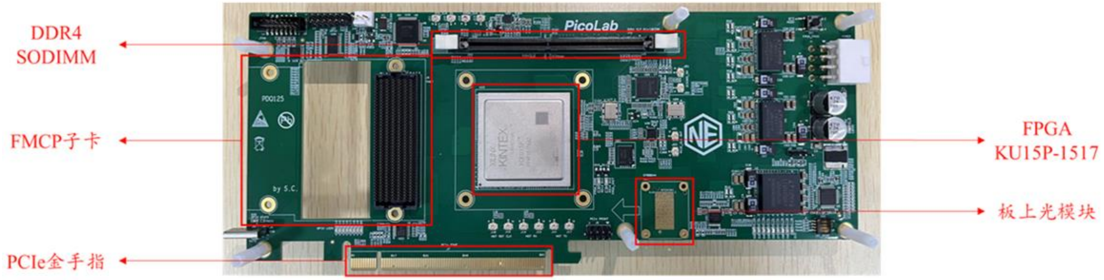
- System architecture based on Data-Matrix: flow processing, hetero-computing, standard interfaces and protocols, global pipeline
- Software and firmware development
- Development of core electronics boards: CROB-PXI, CROB-PCIe, FMCP optical interface board
- System testing and performance evaluation using simulation data
- A prototype DAQ system has participated in a recent combined beam test

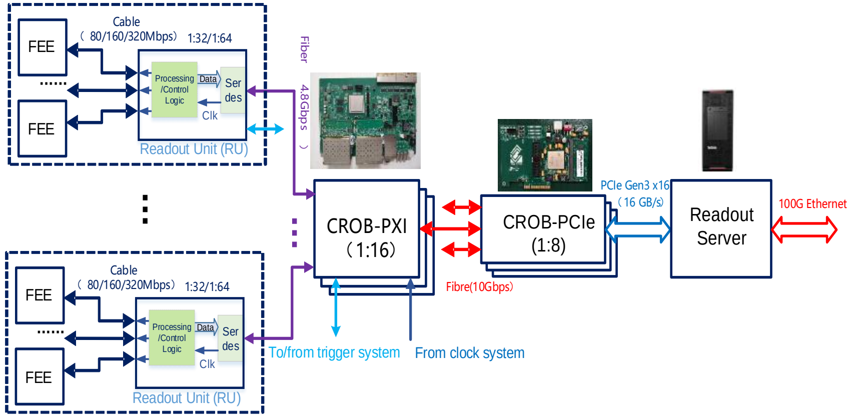
CROB-PXI board

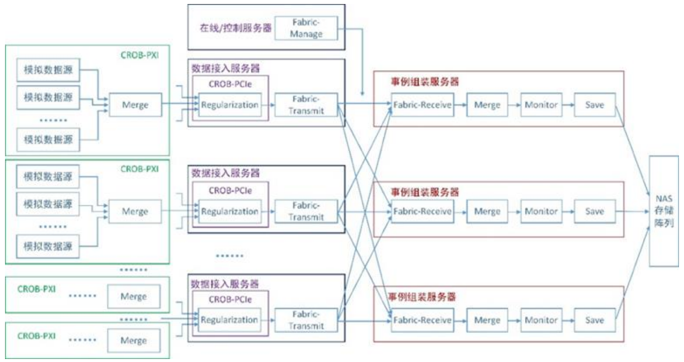



FMCP optical interface board

CROB-PCIe board



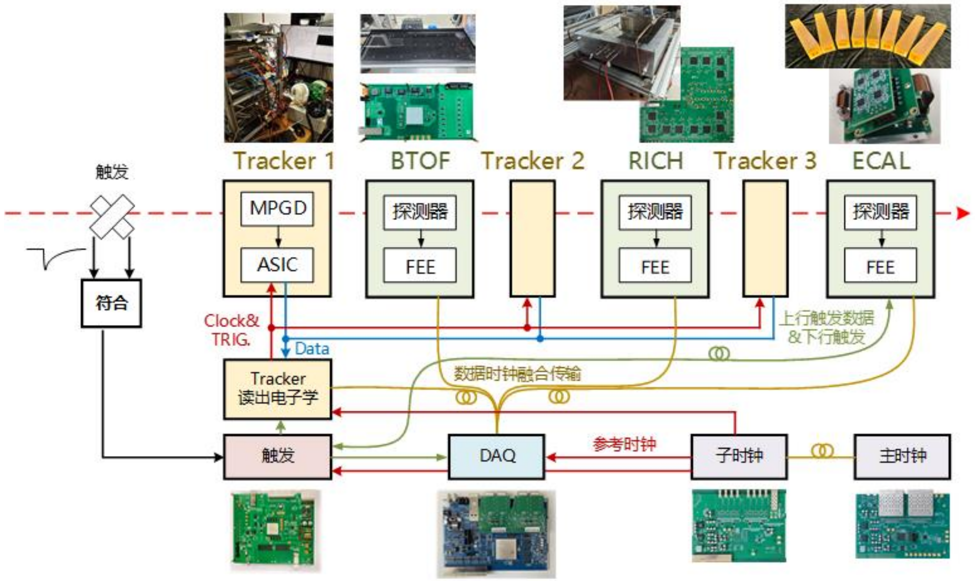




Test of event building

- 12 rack servers
  - 9 servers: readout+ 4 event builders
  - 3 servers: 4 event builders
- 33 simulated data sources
  - 17 big-frame sources: 20~32kB/frame
  - 16 small-frame source: 135 Byte/frame

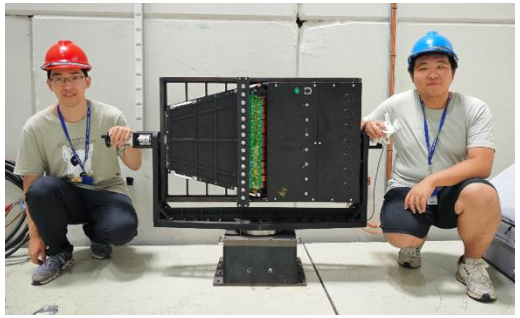
# Combined Beam Tests

## Two test beam campaigns for combined systems (ITK, RICH, DTOF, EMC, Clock, Trigger, DAQ)



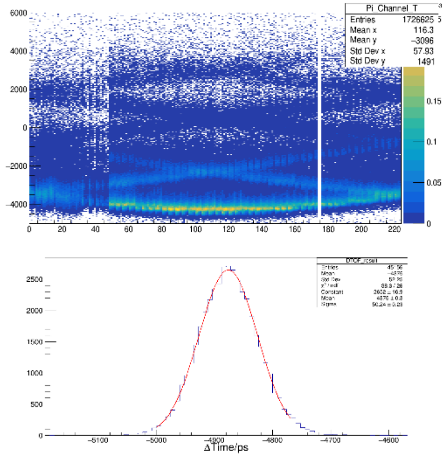

**CERN PS T9 beam line (Aug. 2025 & Oct. 2025 )**

**DTOF Prototype**

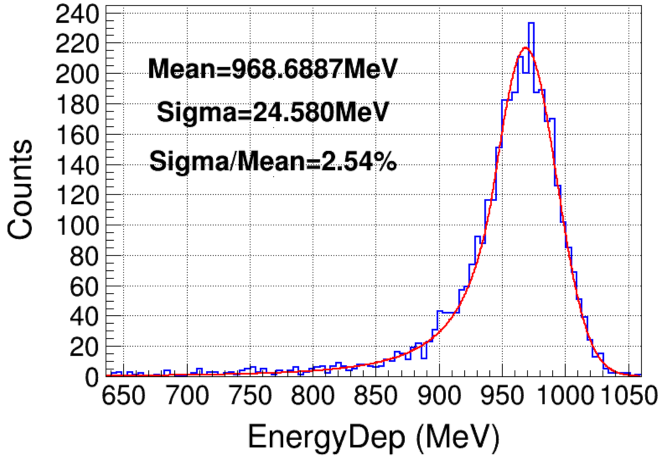


**EMC Prototype**

**DTOF: $\sigma_t$~25 ps**

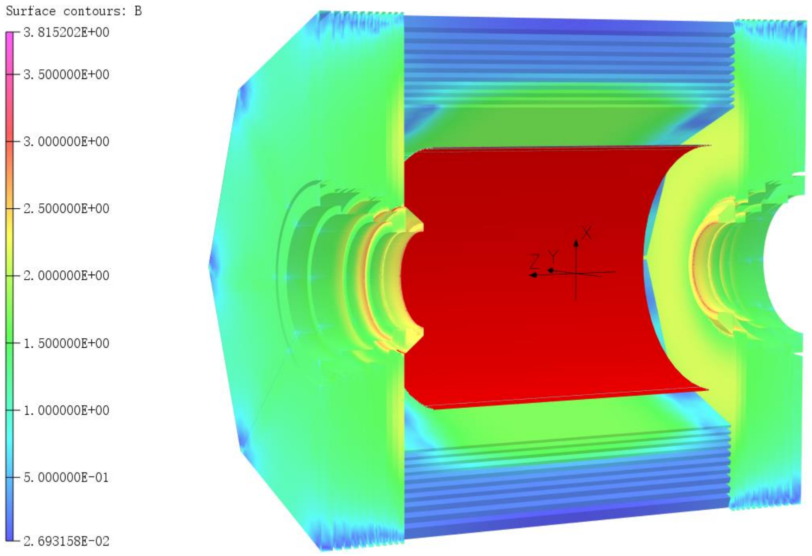


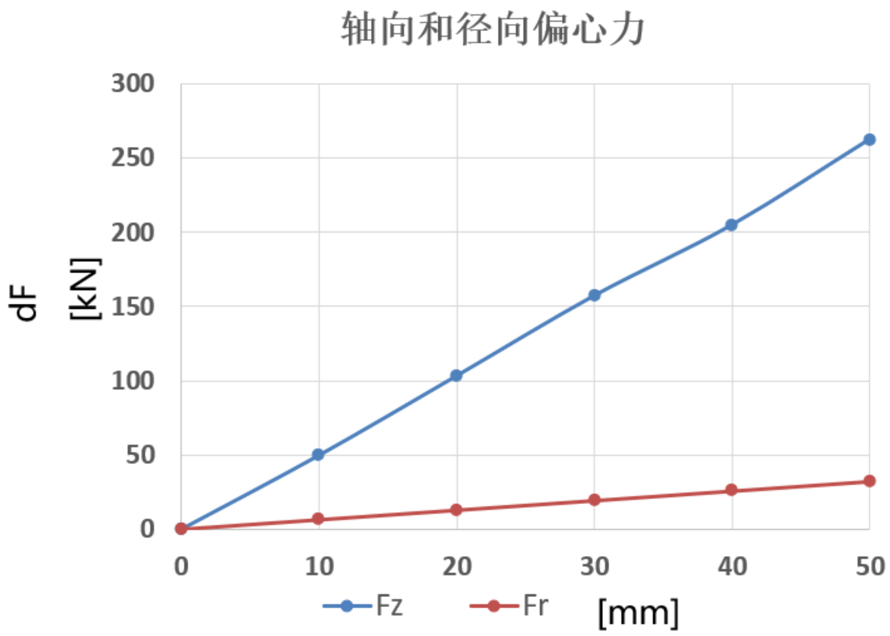

**EMC: $\sigma_E/E$ ~2.5%**



# Super-conducting Solenoid Magnet

- Optimized the physics design of the magnet by performing FEA of magnet field and unbalanced forces.
- Studied impact of non-uniformity of the magnetic field on tracking performance and solutions to improve magnetic field homogeneity.
- Designing the magnet support structure using carbon fiber. Investigating heat leakage issue.
- Studying cryogenic forced circulation and thermosiphon schemes with FEA.

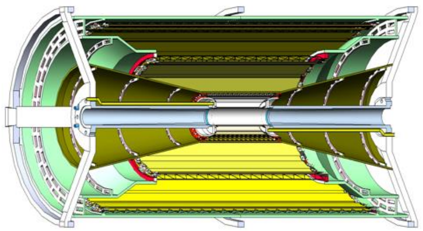


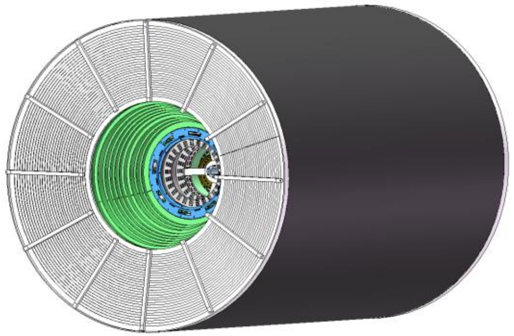
# Detector Mechanical Design

- Detector conceptual design has been transferred into engineering drawings
- Engineering design available for each sub-detector or system
- Design studies on detector assembly and installation

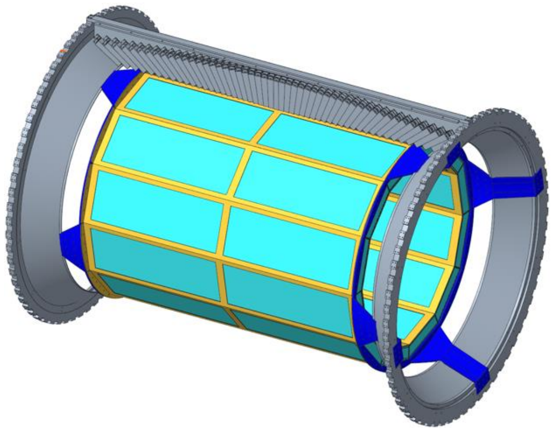
ITK-MAPS



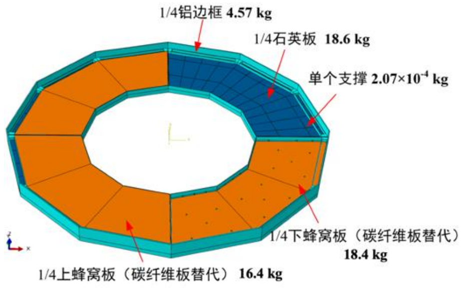
MDC



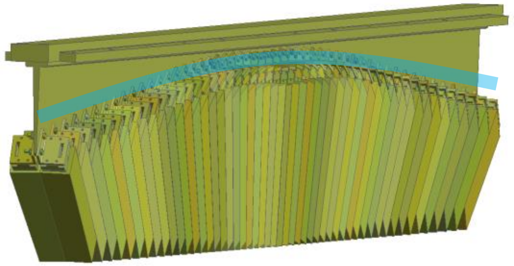
RICH

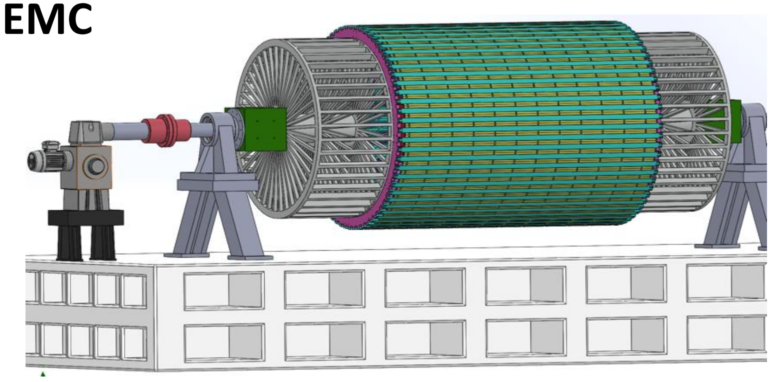


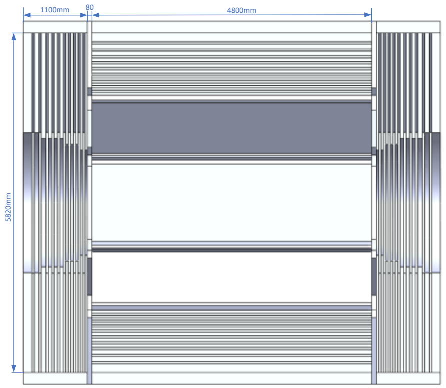
DTOF



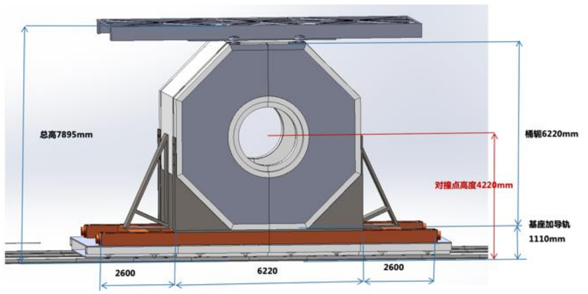

EMC





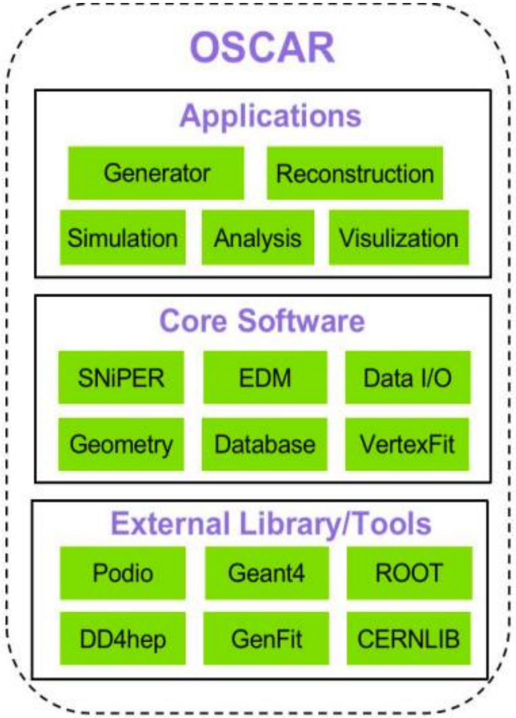



Iron Yoke



# Offline Software and Full Simulation

- **The full chain of event generation, full simulation, digitization, reconstruction and analysis has been established in the STCF offline software framework, OSCAR, for detector and physics studies. Full-simulation data production has been launched for detector performance validation and optimization, and TDR physics studies.**
- **Software and algorithms (simulation, digitization, reconstruction, PID ... ) continue to improve on both precision and resource demand (CPU, disk).**




✔ Good state

☑ Under optimization

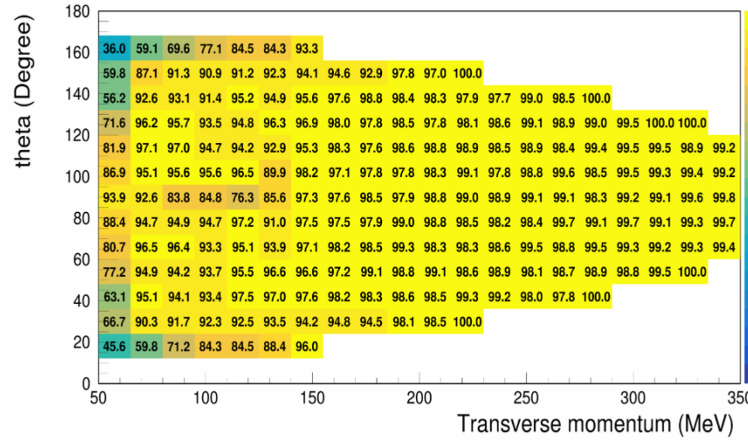
🟠 Under development

<table>
<tr><th rowspan="2">Detectors</th><th rowspan="2">Simulation</th><th rowspan="2">Digitization</th><th rowspan="2">Reconstruction</th><th colspan="3">Analysis tools</th></tr>
<tr><th>Global PID</th><th>Traditional combined PID</th><th>Kinematic& Vertex Fit</th></tr>
<tr><td>ITK</td><td>✔</td><td>✔</td><td>✔</td><td rowspan="7">Charged tracks: ✔<br>Neutral tracks: 🟠</td><td rowspan="7">✔</td><td rowspan="7">✔</td></tr>
<tr><td>MDC</td><td>✔</td><td>☑</td><td>✔</td></tr>
<tr><td>RICH</td><td>✔</td><td>✔</td><td>✔</td></tr>
<tr><td>DTOF</td><td>✔</td><td>✔</td><td>✔</td></tr>
<tr><td>BTOF</td><td>✔</td><td>✔</td><td>✔</td></tr>
<tr><td>EMC</td><td>✔</td><td>✔</td><td>✔</td></tr>
<tr><td>MUD</td><td>✔</td><td>✔</td><td>✔</td></tr>
</table>

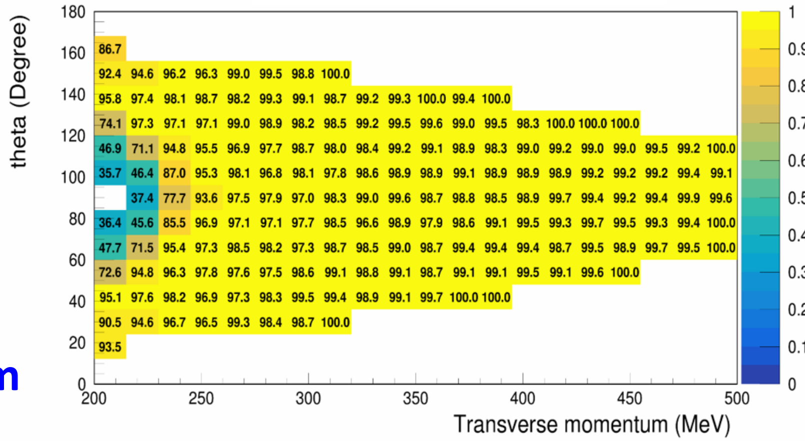
# Tracking Efficiency for Prompt Tracks

- **Tracking performance for prompt tracks has been well consolidated with > 90% tracking efficiency for $p_T$ > 75 MeV for both single particles (e, $\mu$, $\pi$) and particles in physics events in the presence of beam background.**

**single e-** p in [50-350] MeV

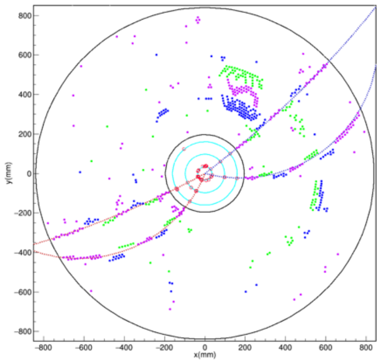



**single proton**

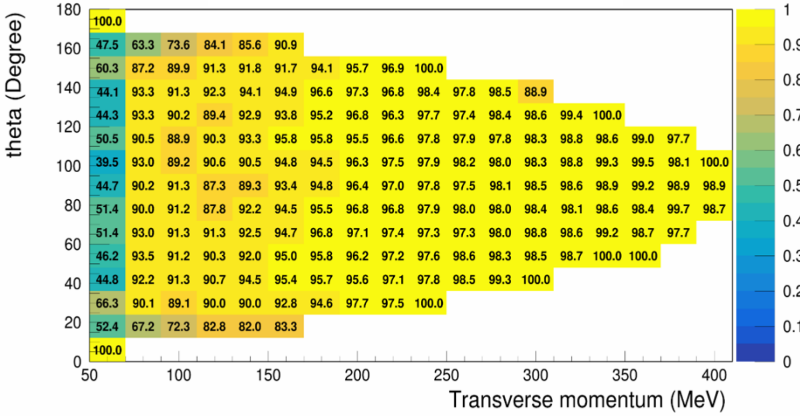



**All with beam background**

$$\psi(3686) \to \pi^+\pi^- J/\psi(\to \mu^+\mu^-)$$

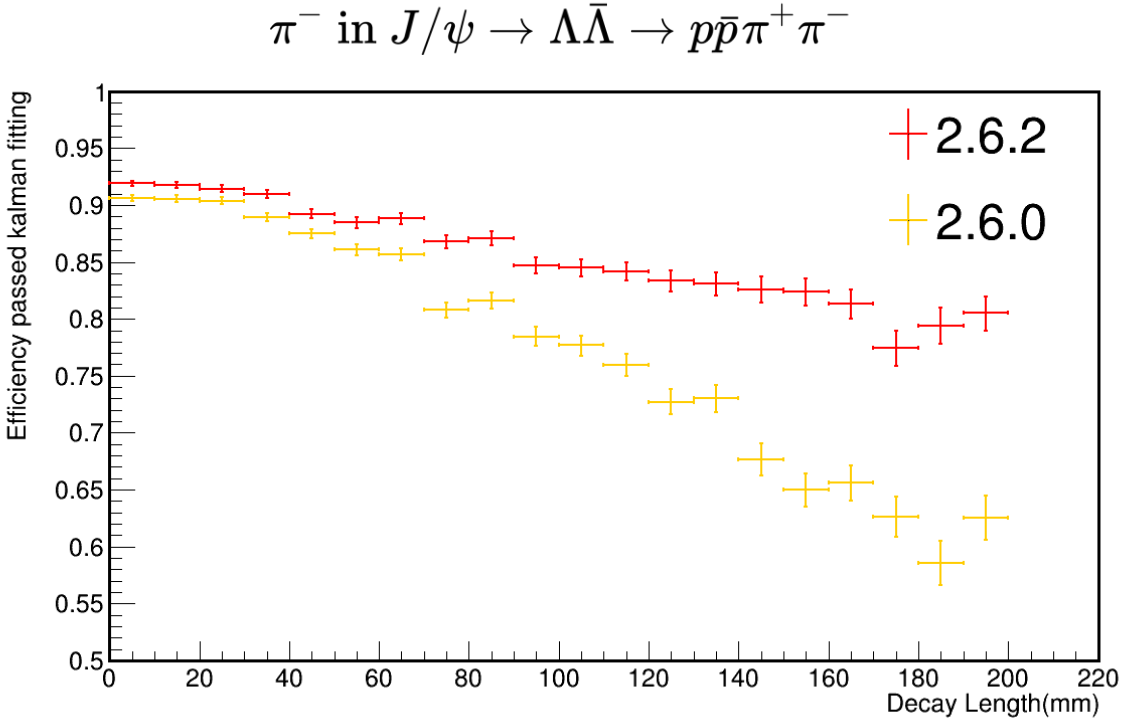



$$\pi^- \text{ in } \psi(3686) \to \pi^+\pi^- J/\psi(\to \mu^+\mu^-)$$



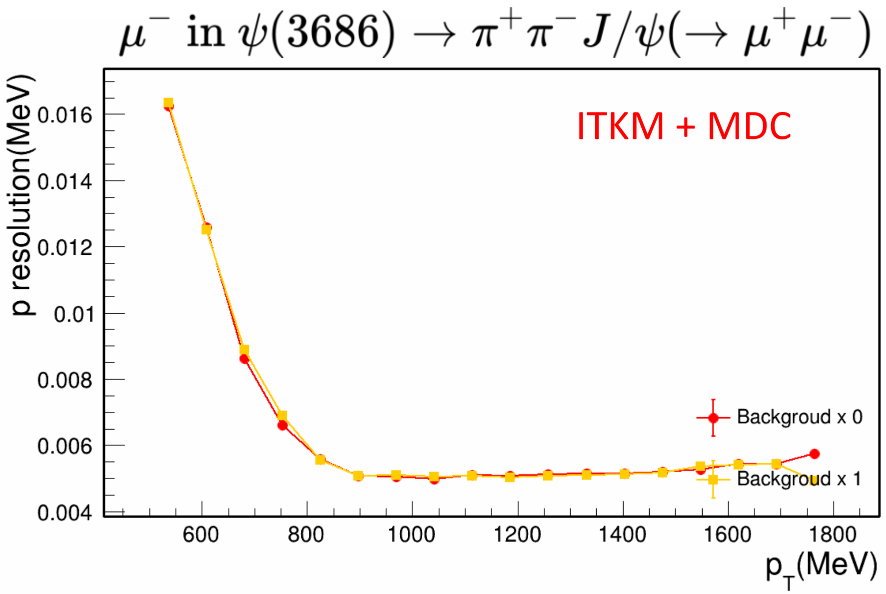
# Tracking Efficiency for Displaced Tracks

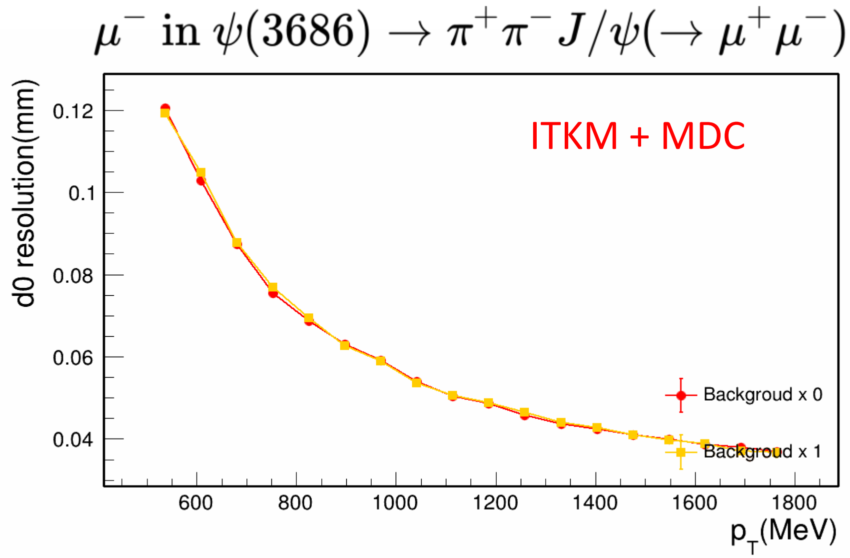
- Much improved performance for long-lived particles (Lambda, Xi) produced even in a complex scenario with low pT and displaced tracks
- Reconstruction of displaced tracks has been addressed by using additional Hough transform that takes a displaced segment position as the reference point.
- >80% tracking efficiency for particles with decay length up to 200 mm

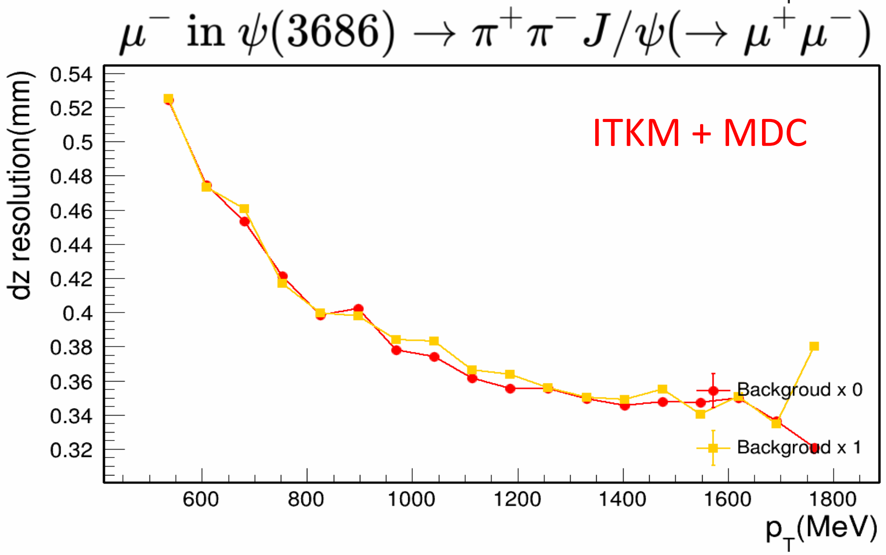


# Momentum and Impact Parameter Resolution

- **Momentum resolution is ~0.5% at $p_T$ = 1 GeV/c**
- **Resolution of impact parameters, d0 and z0, can reach 40 um and 350 um for $p_T$ > 1.5 GeV/c**

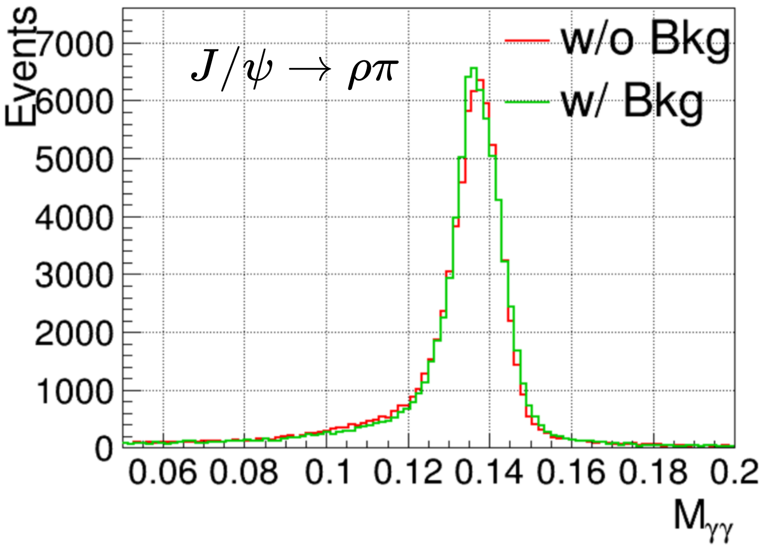


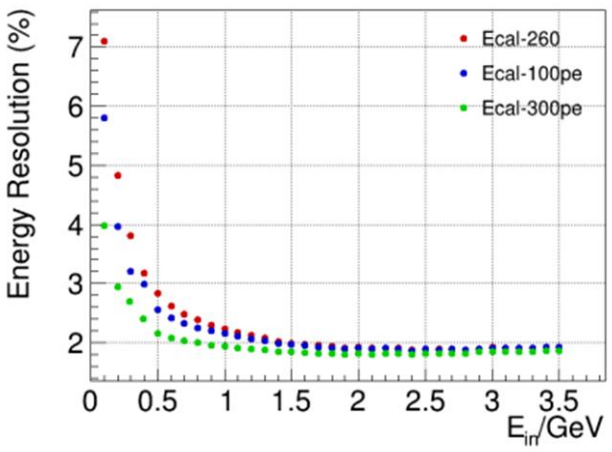



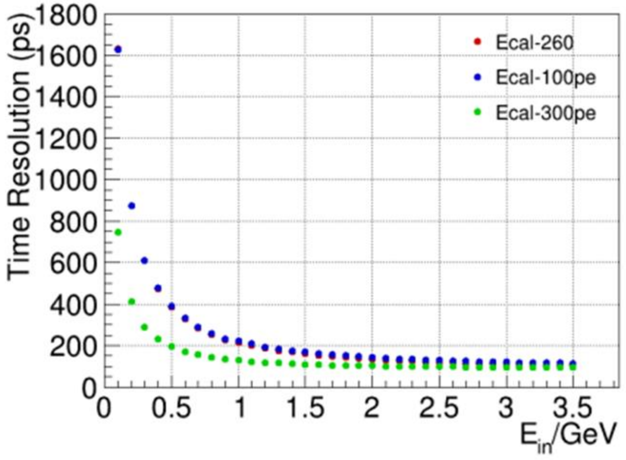
# Photon Performance

- **EMC digitization algorithm has been optimized with 50% reduction of CPU time**
- **Using realistic digitization parameters from beam test results**
- **Incorporated time in the EMC clustering algorithm to improve photon resolution against beam background**
  - **No degradation on pi0 resolution in the presence of beam background**

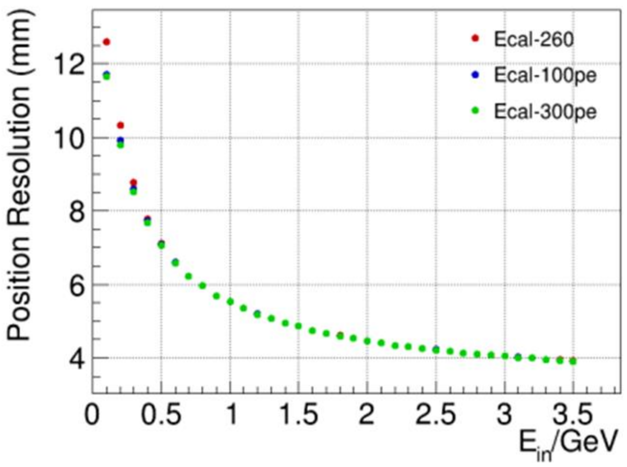



Energy



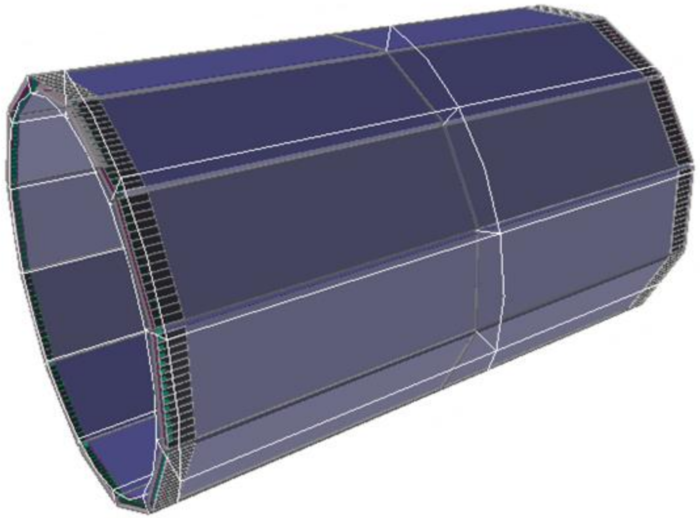

Time

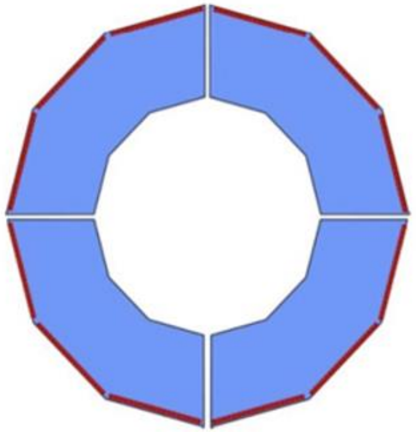


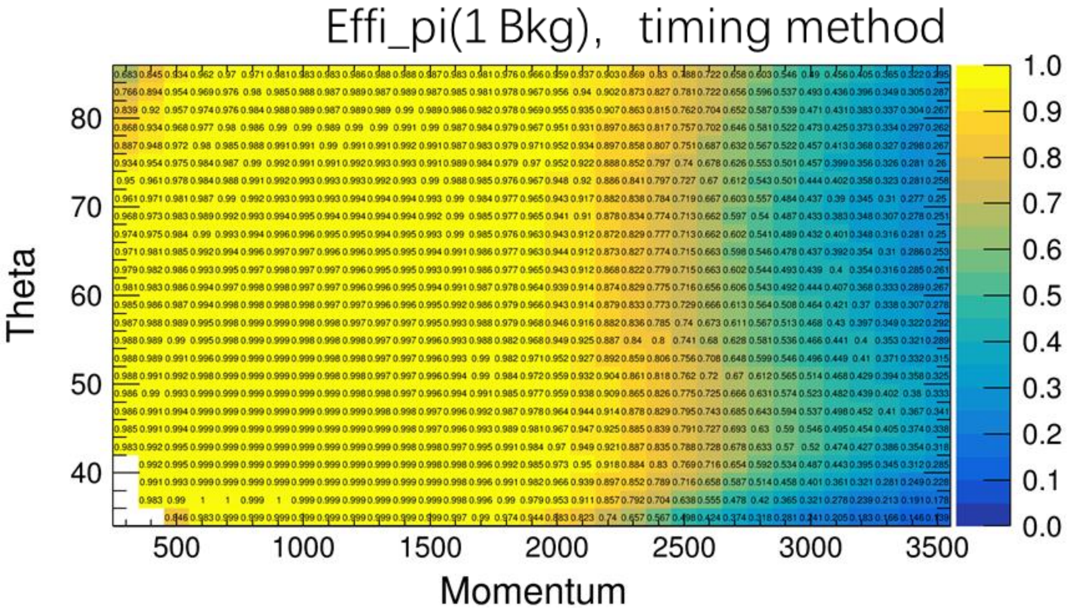

Position

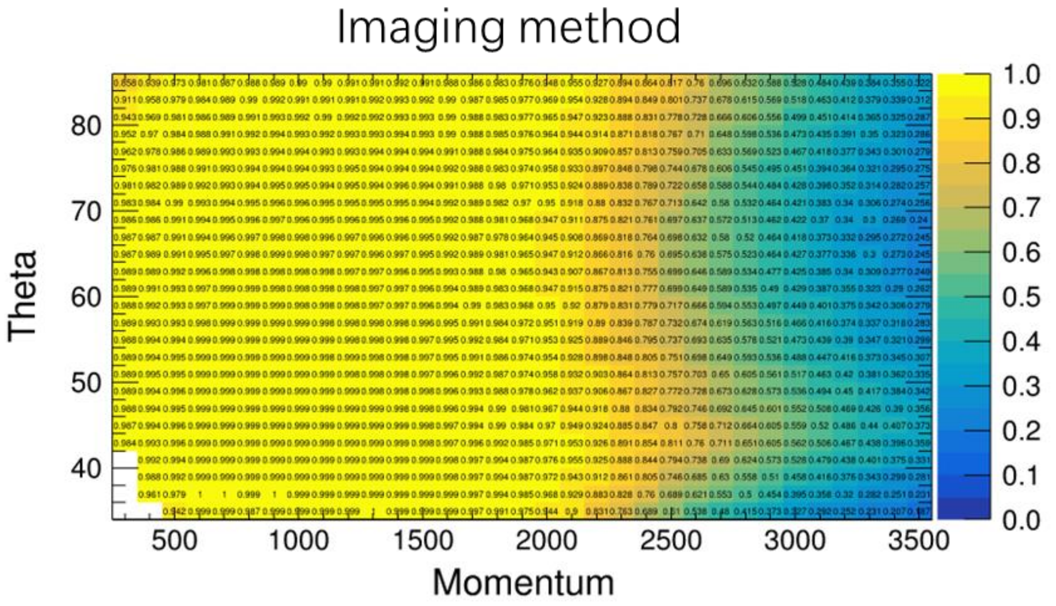
# π/K PID Performance (BTOF&DTOF)

- **Developed the full simulation, digitization and reconstruction chain for BTOF and DTOF.**
- **The performance fulfills the STCF requirement (>97% π eff @ K mis-ID=2% at 2 GeV/c)**
- **BTOF and DTOF geometries are being optimized to further improve its PID performance**



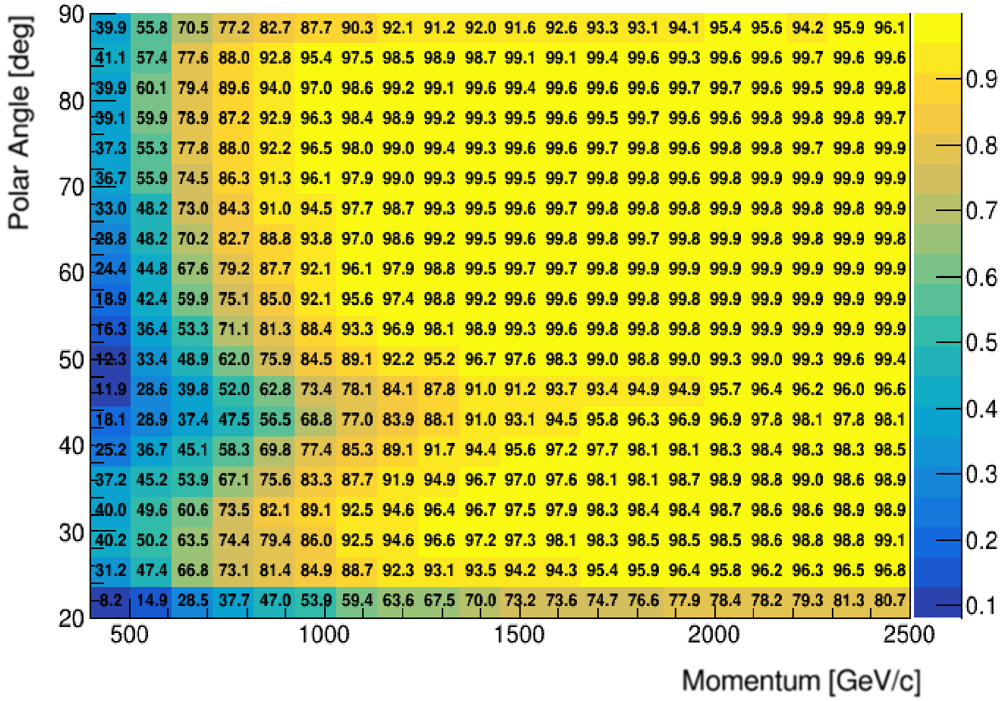


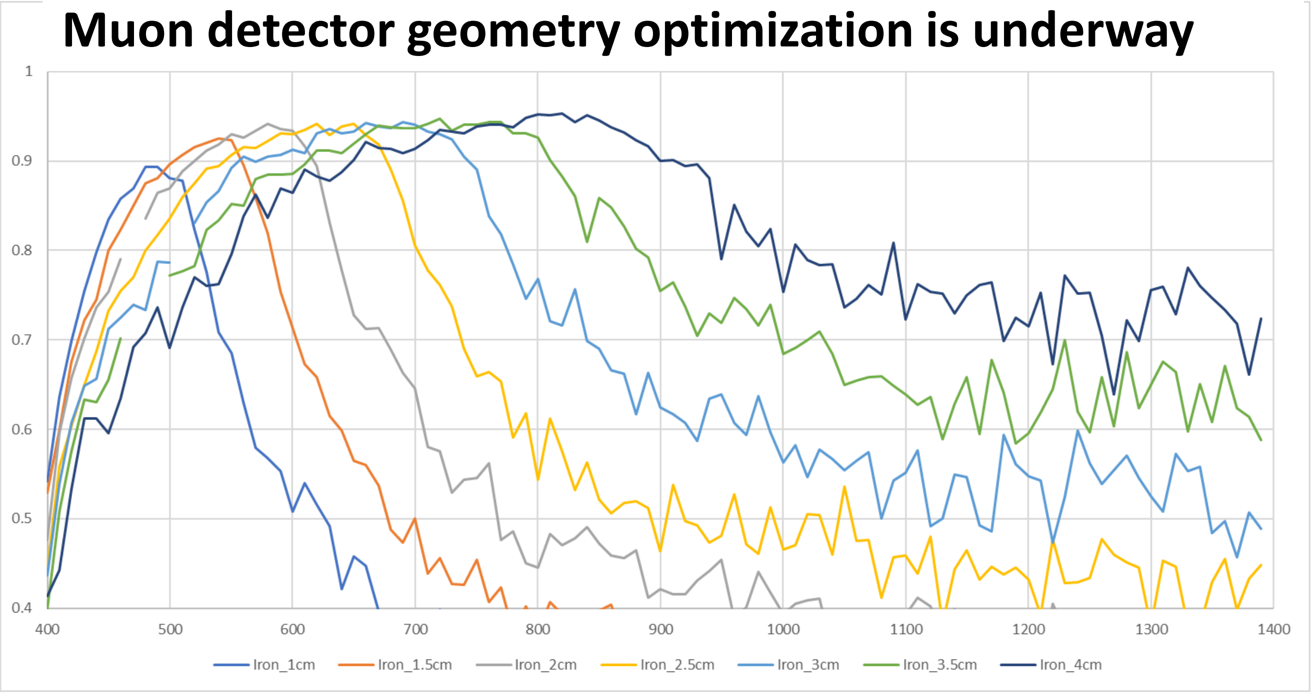


# μ/π PID Performance (MUD)

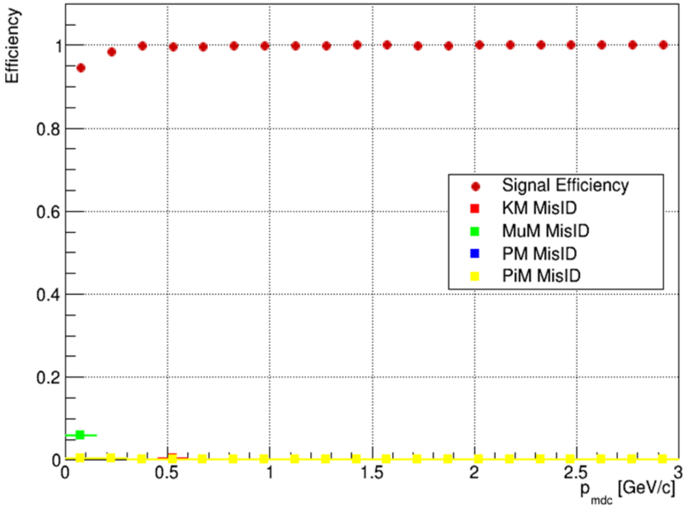
- μ/π identification using BDT on full simulation and realistic digitization
  - μ efficiency is above 95% @ $\pi$ suppression = 30 with momentum above 1 GeV in barrel region
- Identfication of neutral hadrons (n, $K_L$) against photon is being optimized



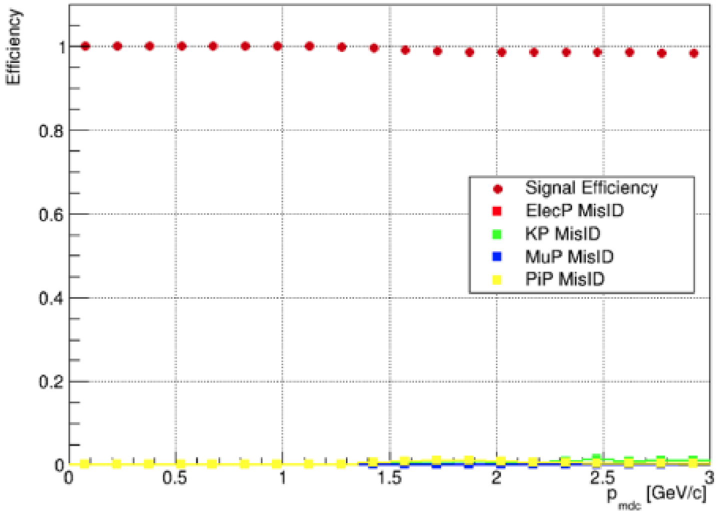



# Global PID Performance

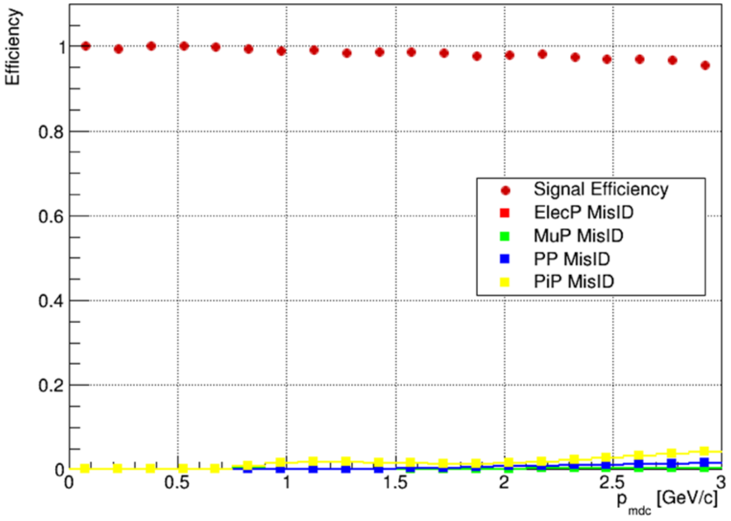
e identification against K/μ/p/π



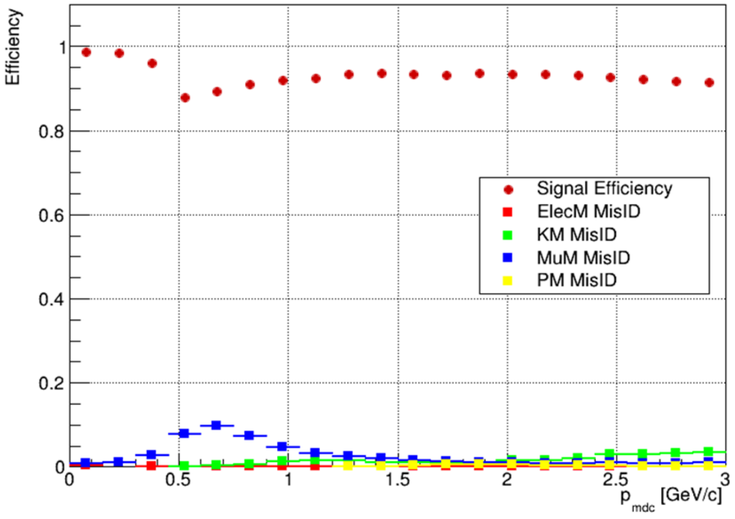

proton identification against e/K/μ/π



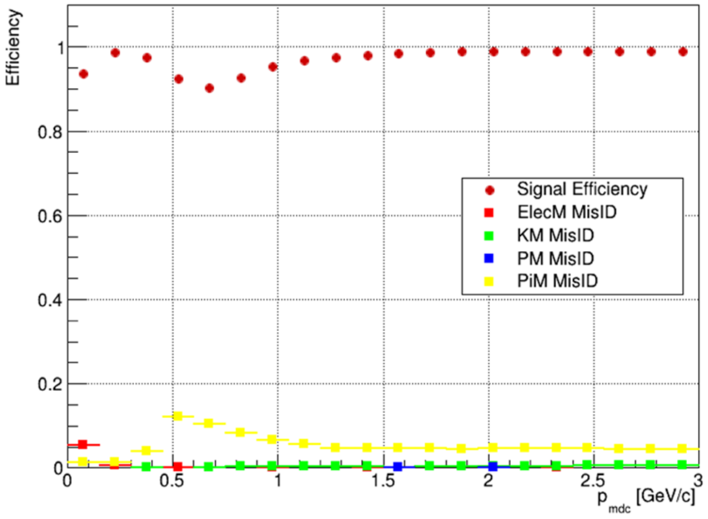

K identification against e/μ/p/π




π identification against e/K/μ/pi




μ identification against e/K/p/pi



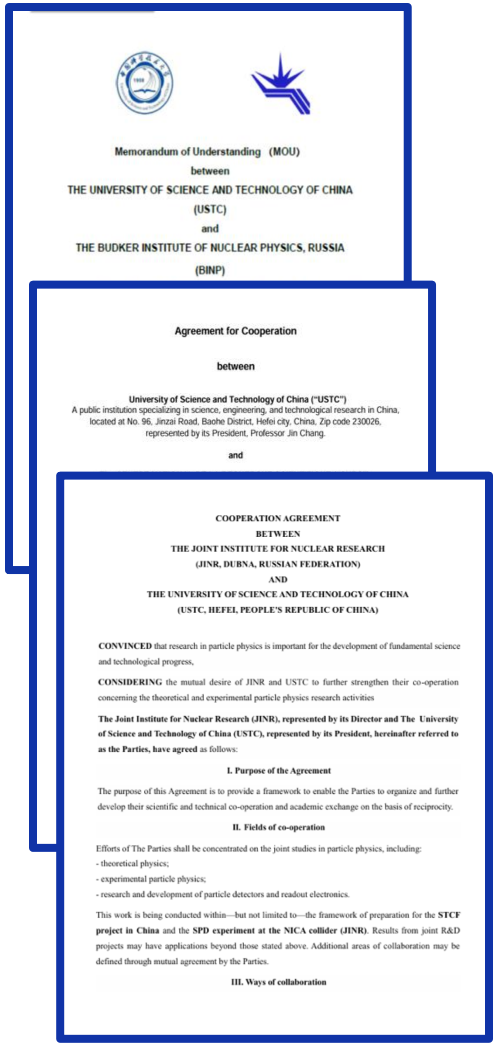
# International Collaboration and Exchanges

LHCb TORCH team

CERN thin film workshop

CERN GDD

KEK accelerator experts



Memorandum of Understanding (MOU)

between

THE UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA

(USTC)

and

THE BUDKER INSTITUTE OF NUCLEAR PHYSICS, RUSSIA

(BINP)

Agreement for Cooperation

between

University of Science and Technology of China ("USTC")
A public institution specializing in science, engineering, and technological research in China, located at No. 96, Jinzai Road, Baohe District, Hefei city, China, Zip code 230026, represented by its President, Professor Jin Chang.

and

COOPERATION AGREEMENT
BETWEEN
THE JOINT INSTITUTE FOR NUCLEAR RESEARCH
(JINR, DUBNA, RUSSIAN FEDERATION)
AND
THE UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA
(USTC, HEFEI, PEOPLE'S REPUBLIC OF CHINA)

**CONVINCED** that research in particle physics is important for the development of fundamental science and technological progress,

**CONSIDERING** the mutual desire of JINR and USTC to further strengthen their co-operation concerning the theoretical and experimental particle physics research activities

**The Joint Institute for Nuclear Research (JINR), represented by its Director and The University of Science and Technology of China (USTC), represented by its President, hereinafter referred to as the Parties, have agreed** as follows:

**I. Purpose of the Agreement**

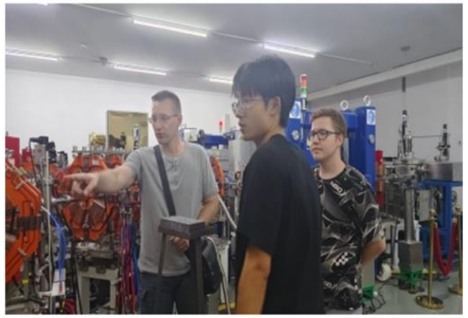
The purpose of this Agreement is to provide a framework to enable the Parties to organize and further develop their scientific and technical co-operation and academic exchange on the basis of reciprocity.

**II. Fields of co-operation**

Efforts of The Parties shall be concentrated on the joint studies in particle physics, including:
- theoretical physics;
- experimental particle physics;
- research and development of particle detectors and readout electronics.

This work is being conducted within—but not limited to—the framework of preparation for the **STCF project in China** and the **SPD experiment at the NICA collider (JINR)**. Results from joint R&D projects may have applications beyond those stated above. Additional areas of collaboration may be defined through mutual agreement by the Parties.

**III. Ways of collaboration**



BINP accelerator experts

BINP management


JINR detector experts


CERN accelerator experts

***Signed MoU for collaboration with BINP, JINR, IJCLab, KEK***

# International Workshops on Future Tau-Charm Facilities

| Time | Place | Content |
|---|---|---|
| 2015.01 | Hefei, China | International Workshop focused on Super tau-Charm Facility in China |
| 2018.03 | Beijing, China | International Workshop focused on Super tau-Charm Facility in China |
| 2018.05 | Novosibirsk, Russia | International Workshop focused on Super tau-Charm Facility in Russia |
| 2018.12 | Paris, France | 1st FTCF (Joint International Workshop) |
| 2019.08 | Moscow, Russia | 2nd FTCF |
| 2020.11 | Online, China | 3rd FTCF |
| 2021.11 | Online, Russia | 4th FTCF |
| 2024.01 | Hefei, China | 5th FTCF |
| 2024.11 | Guangzhou, China | 6th FTCF |



# STCF Workshops and Meetings

## (National) STCF Workshops

| Time | Place | Content |
|---|---|---|
| 2018.10 | Hengyang (USC) | STCF |
| 2019.03 | Beijing (UCAS) | STCF: Physics |
| 2019.07 | Hefei (USTC) | STCF: Accelerator |
| 2019.08 | Hefei (USTC) | STCF: Phys. & simulations |
| 2019.11 | Beijing (UCAS) | STCF: CDR |
| 2020.08 | Hefei (USTC) | STCF: From CDR to TDR |
| 2022.12 | Guangzhou (SYSU) | STCF: R&D kick-off |
| 2023.07 | Zhengzhou (ZZU) | STCF: Collaboration |
| 2024.07 | Lanzhou (LZU) | STCF: 15th-five-year plan |

STCF workshop 2022, online

STCF workshop 2023, Zhengzhou

STCF Key Technology R&D Project Kick-off Meeting, Hefei, 2023

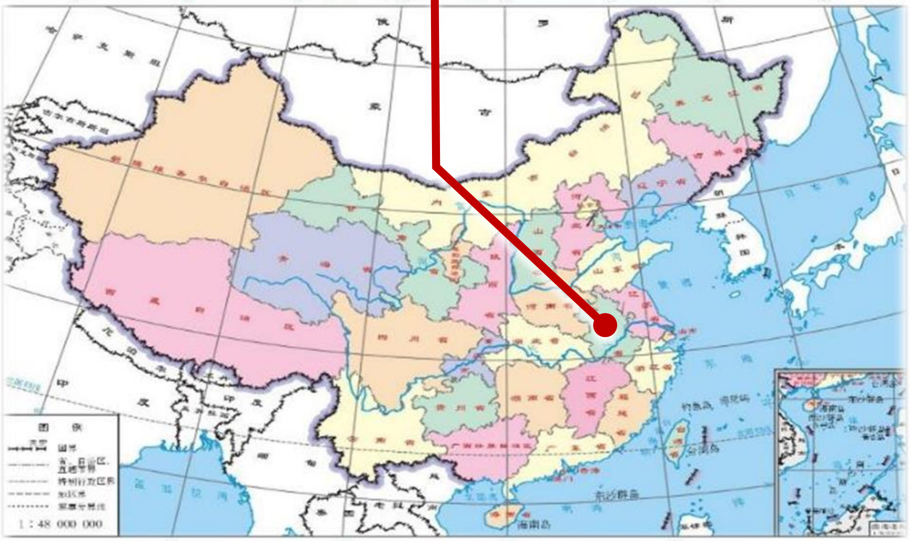
## STCF Project Development Meetings

| Time | Place | Meetings |
|---|---|---|
| 2022.04 | Hefei (USTC) | STCF Key Technology R&D Project Demonstration Meeting |
| 2023.08 | Hefei (USTC) | STCF Key Technology R&D Project Kick-off Meeting |
| 2023.12 | Hefei (USTC) | STCF Key Technology R&D Project Budget Review Meeting |
| 2024.01 | Hefei (USTC) | STCF 1st International Advisory Committee Meeting |
| 2024.05 | Hefei (USTC) | STCF 1st National Consultative Committee Meeting |

STCF 1st IAC meeting (Hefei, 2024)

STCF 1st NCC meeting (Hefei, 2024)

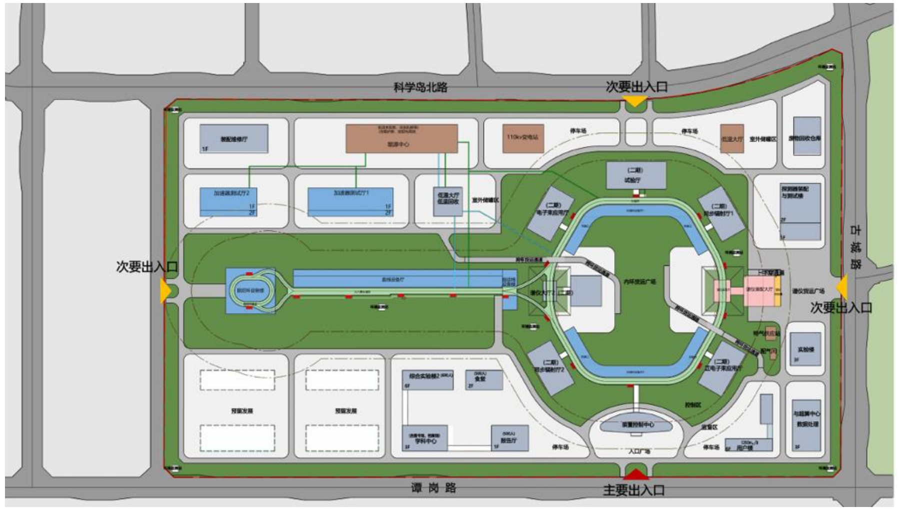
# Site : Hefei, Anhui Province

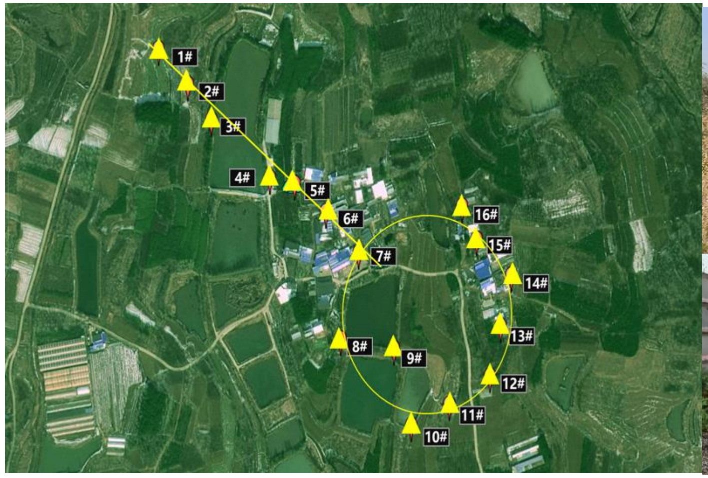




**Hefei Comprehensive National Science Center**

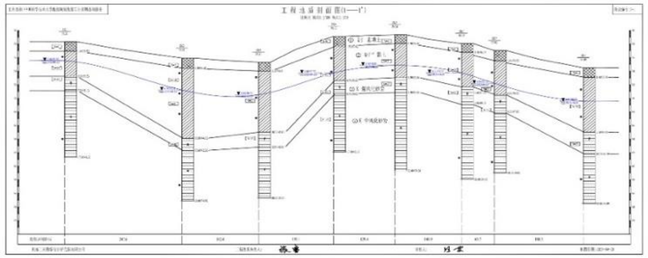
**"Future Big Science City", Hefei, Anhui Province**

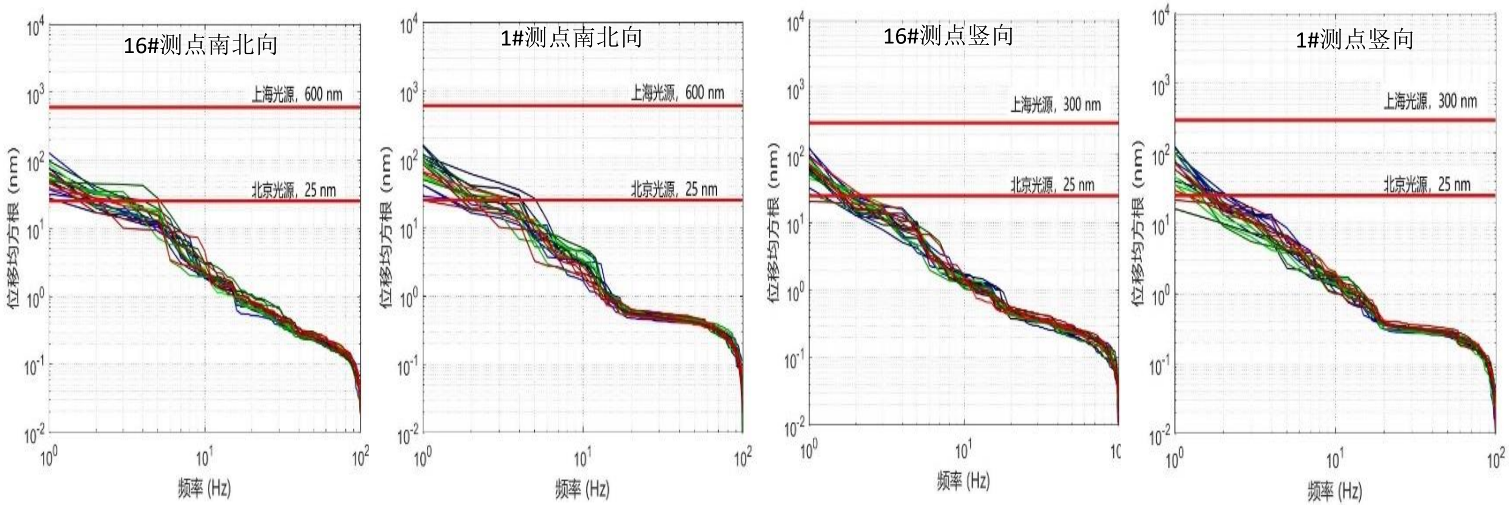
# Geological Survey and Civil Engineering Design










**Requirements are satisfied**

# Final Remarks

- As a key player in HEP precision frontier, STCF holds great potential for discoveries and breakthroughs in studies of strong interaction, CPV, and new physics search.
- STCF builds upon China's great success and well-established unique international position in tau-charm physics, constituting a viable near-term HEP project in China.
- Intensive conceptual design studies in the past few years have resulted in physics, detector and accelerator CDRs.
- The STCF project has transitioned to the technology R&D phase. A comprehensive STCF R&D project has been established and is being vigorously executed. Significant progress in the R&D has been made and some systems have reached milestones.
- The STCF project has passed the recent CAS review and  the project proposal has been submitted to the national government for starting STCF construction in the 15th five-year plan period.
- It is crucial to strengthen and expand domestic and international collaboration and explore synergies with other projects.