HADRON 2023

Progress of **Super Tau Charm Facility** in China

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On behalf of the STCF working group

08/06/2023

Outline

1. **Physics motivation**
2. Accelerator progress
3. Detector progress
4. Simulation studies
5. Summary

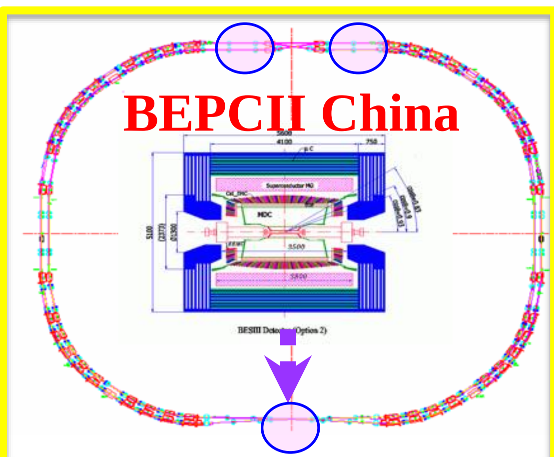
Accelerator-based HEP experiments

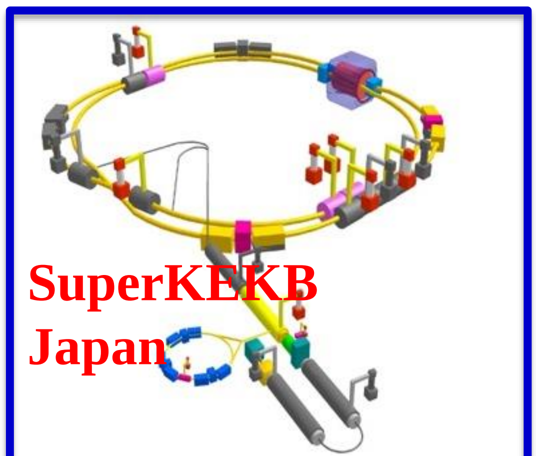
□ Complementary and synergistic facilities:

- B-factory
- τ-Charm factory
- Large Hadron Collider
- ……

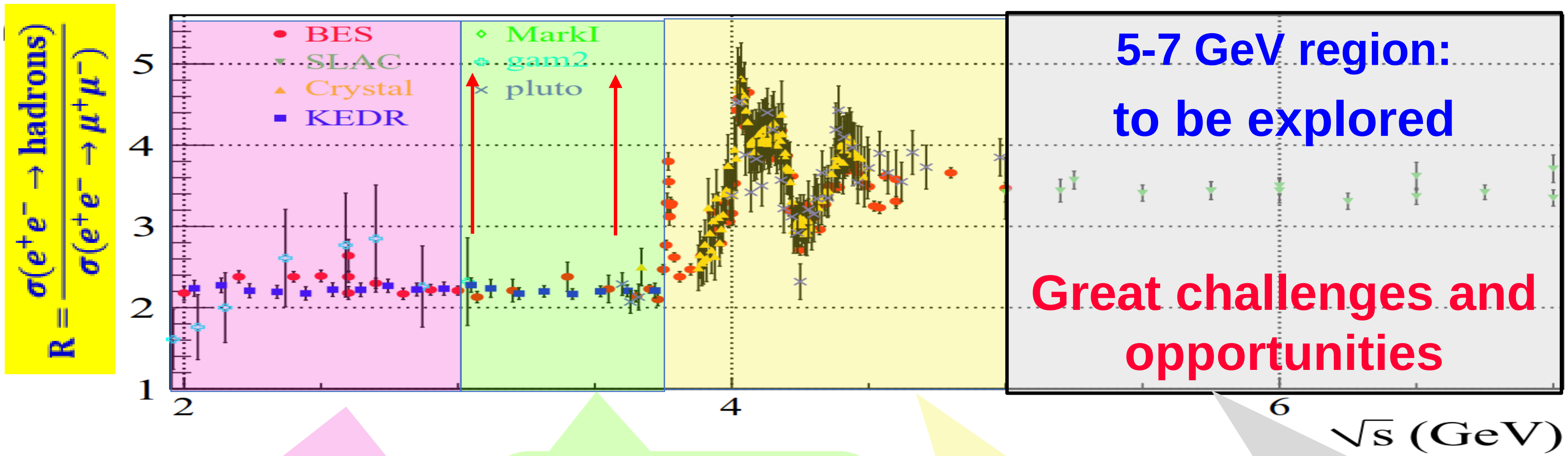
High intensity frontier

High energy frontier





Physics in τ-Charm energy region



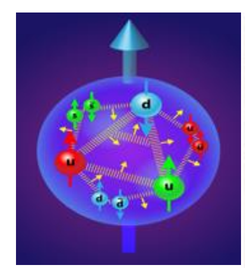
- Hadron form factors
- Y(2175) resonance
- Multiquark states with s-quark
- MLLA/LPHD and QCD sum rule predictions

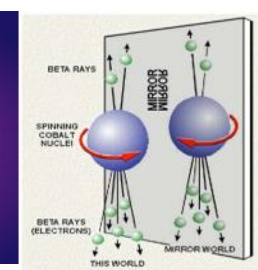
- LH spectroscopy
- Gluonic and exotic
- LFV and CPV
- Rare/forbidden decays
- Physics with τ lepton

- XYZ particles
- D mesons
- f_D and f_{D_S}
- $D^0 - \bar{D}^0$ mixing
- Charm baryons

- New XYZ particle
- Hidden-charm penta quark
- Multi quark state
- Di-charmonium state
- Charm baryons
- Hadron fragmentation

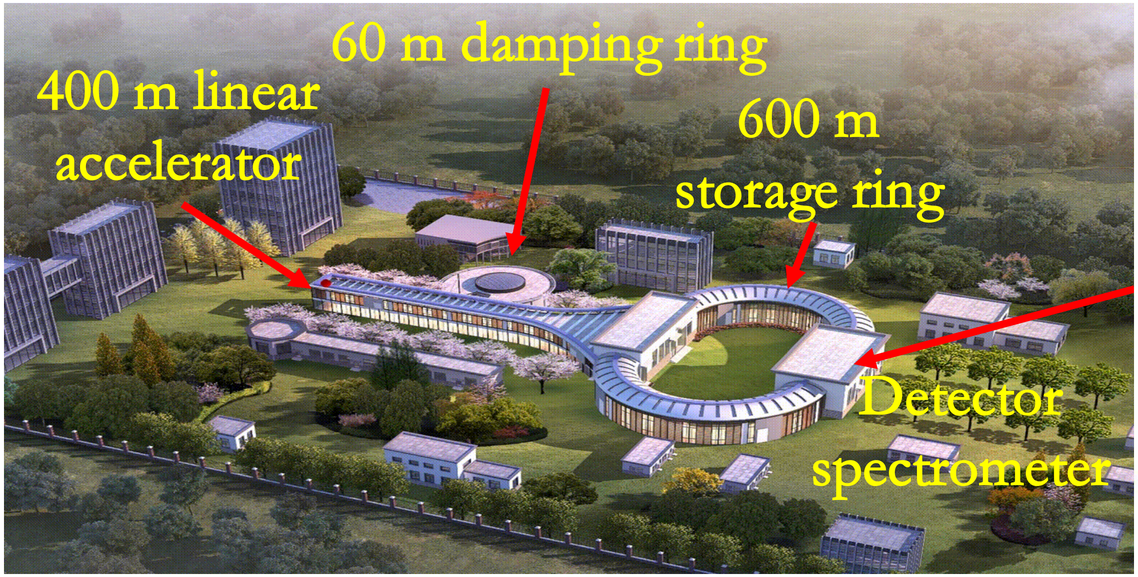
- **QCD** and **hadron physics**
- **Flavor physics** and **CP violation**
- Searching for **new physics**

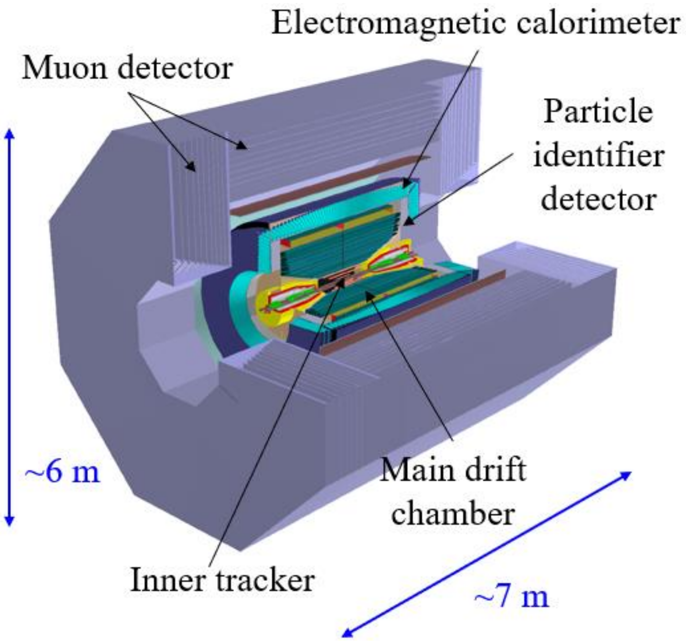




The Super Tau-Charm Facility

- **Key parameters in STCF:**
- Center-of-mass energy: **2-7 GeV**
- Peak luminosity: **>0.5×10^{35} $cm^{-2}s^{-1}$ at 4 GeV**
- Collision data: more than **1 ab^{-1}/y**
- With potential to further **increase luminosity** and **beam polarization**





Timeline

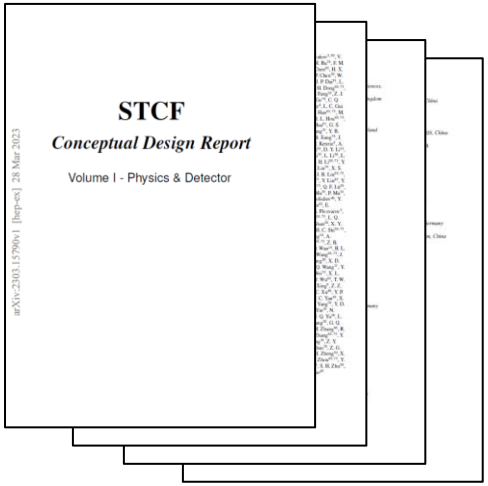
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032-2042	2043-2046
Form collaboration																
Conceptual design (CDR)																
R&D (TDR)																
Construction																
Operation																
Upgrade																

- CDR Volume I - Physics & Detector：

  arXiv: 2303.15790

- CDR Volume II – Accelerator:

  on Preparing



- **Funding**: **0.42 billion RMB** on the **R&D projects** from local government and USTC (**2022-2025**)

Physics aims

- QCD & Hadron structure
- Exotic hadrons
- Precision EW
- CP violation
- New physics

Sensitivities for some benchmark physics processes

Observable	BESIII (2020)	STCF (1 ab^{-1})
Charmonium(like) spectroscopy:		
Luminosity between 4-5 GeV	20 fb^{-1}	1 ab^{-1}
Collins fragmentation functions:		
Asymmetry in $e^+e^- \to KK + X$	0.3 [458]	< 0.002 [459]
Leptonic decays of $D_{(s)}$:		
V_{cd}	0.03 [460]	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 [461]	0.0015
f_{D_s}	0.02	0.0015
$\frac{\mathcal{B}(D_s\to\tau\nu)}{\mathcal{B}(D_s\to\mu\nu)}$	0.04	0.0038
τ properties:		
m_τ (MeV/c^{-2})	0.12 [463]	0.012
d_τ (e cm)	-	5.14×10^{-19}
cLFV decays of τ(U.L at 90% C.L.):		
$\tau \to lll$	-	1.4×10^{-9}
$\tau \to \gamma\mu$	-	1.2×10^{-8}
$J/\psi \to e\tau$	7.5×10^{-8}	7.1×10^{-10}

arXiv: 2303.15790

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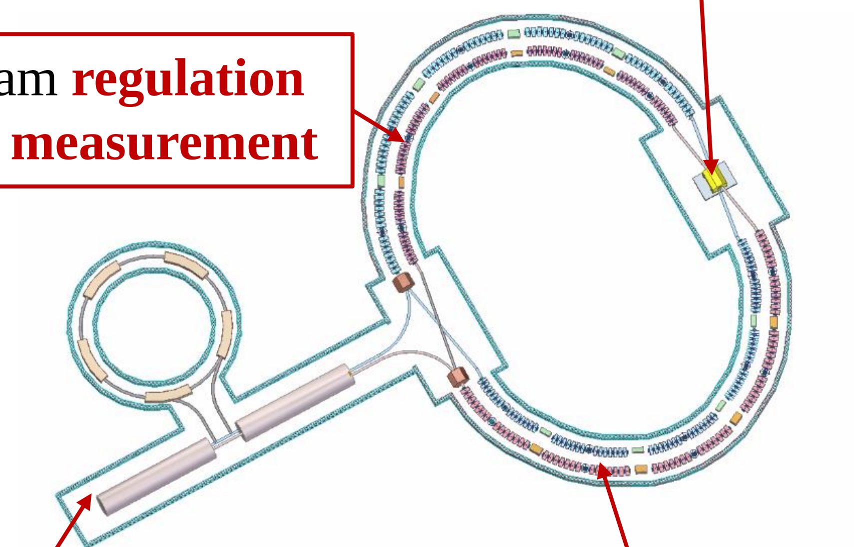
Accelerator-related challenges

Relativistic energy
Bunch number & intensity
Beam-beam parameter
Hourglass effect

$$\mathcal{L}^* = \frac{N_1 N_2 f N_{bunch}}{2\pi \Sigma_x^* \Sigma_y^*} \Rightarrow L = \frac{\gamma n_b I_b}{2 e r_e \beta_y^*} \xi_y H$$

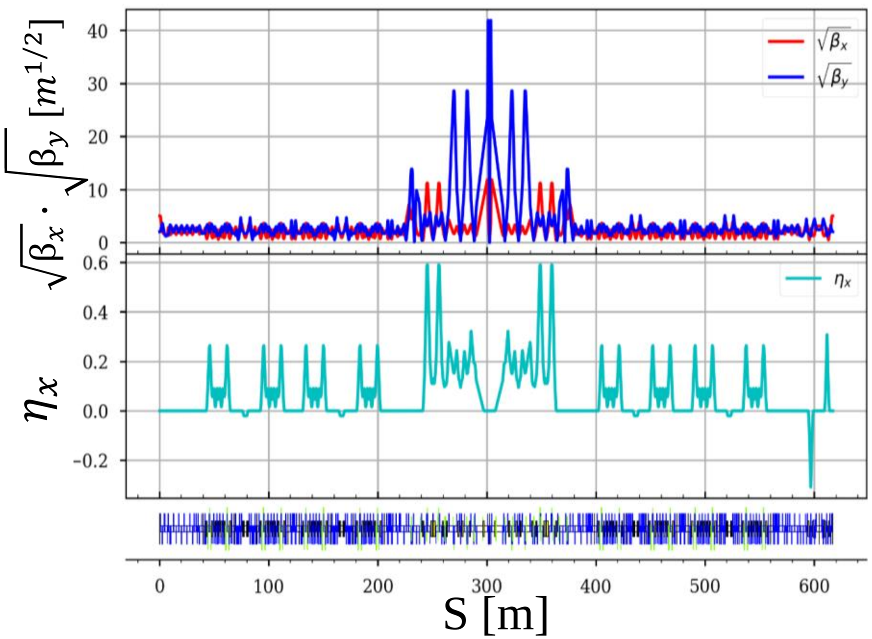
- **Extreme high luminosity:**
  - Low relativistic energy
  - Bunch intensity
  - Small bunch size
  - Hourglass effect

- **Large Piwinski Angle** and **crab waist:**
  - Developed by BINP and SuperKEKB
  - Effectively realize high luminosity



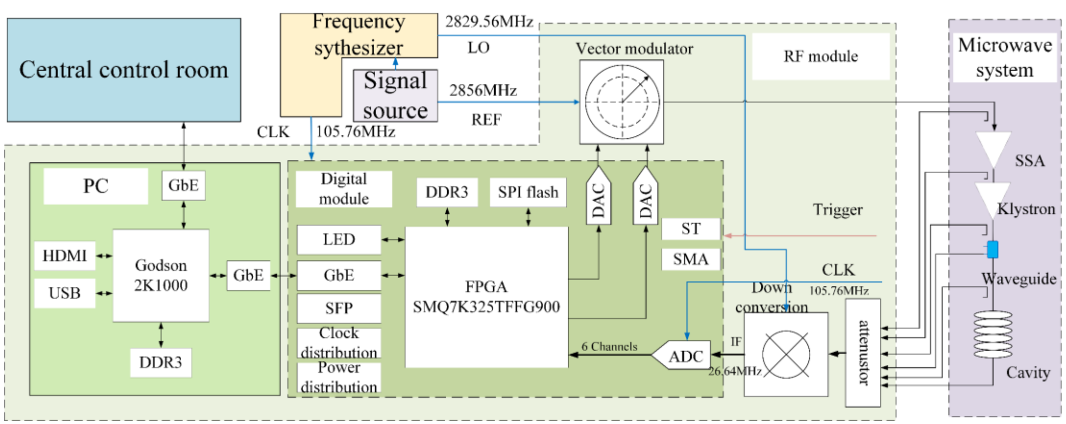
Storage ring

Beta function along storage ring



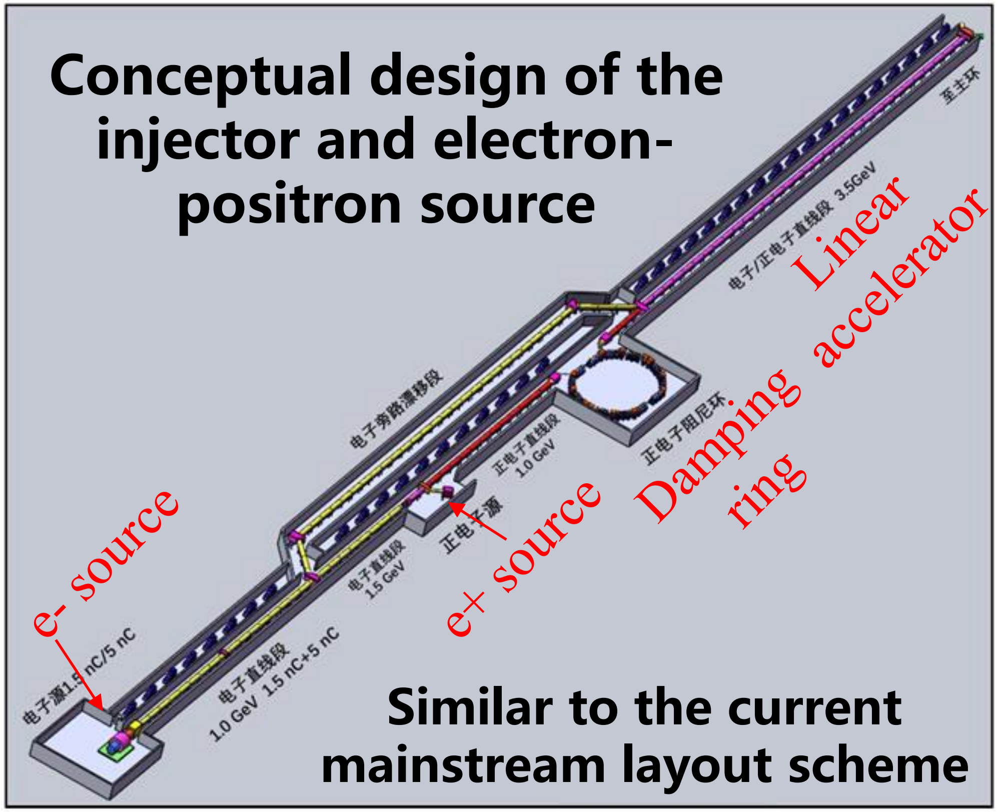
Preliminary physical design parameters

Parameters	Value	Unit
Optimize energy E	2.0	GeV
Circumference Π	617.06	m
f_{RF}	497.5	MHz
2θ	60	mrad
$\varepsilon_y/\varepsilon_x$	0.5	%
I	2.0	A
V_{RF}	3.0	MV
σ_s (w.o/w IBS)	7.3/10	mm
ε_x (w.o/w IBS)	2.84/4.29	nm
L_{HG}	≥0.5× 10^{35}	$cm^{-2}s^{-1}$
ξ_x/ξ_y	0.004/0.10	-
$\tau_{Touschek}$	180~200	s



- **Low Level RF system with domestic electronics**
  - **Hardware**: RF Source; Frequency Synthesizer; IF Signal processor
  - **Software**: FPGA Firmware; Control Algorithms; EPICS Control

Injector system



Design parameters:

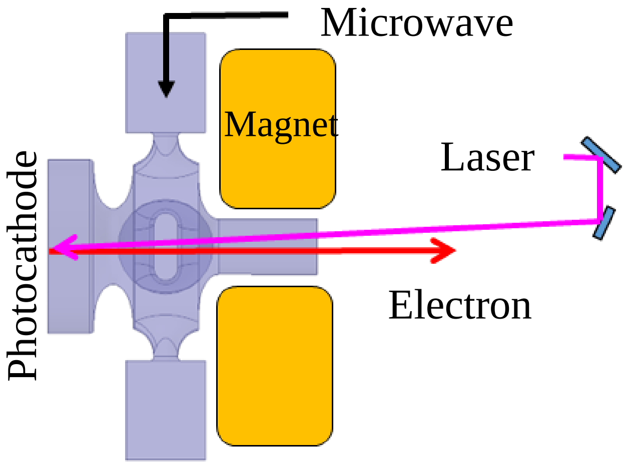
- Symmetric beam： **1-3.5 GeV**
- Photocathode microwave electron source: **1.5nC/5nC**
- Positron source: **1.5nC**
- Repetition frequency: **50 Hz**

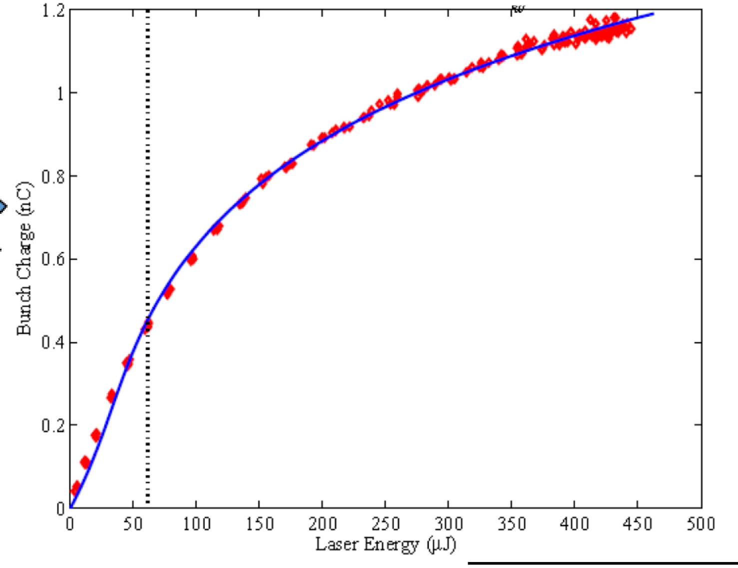
Main challenges：

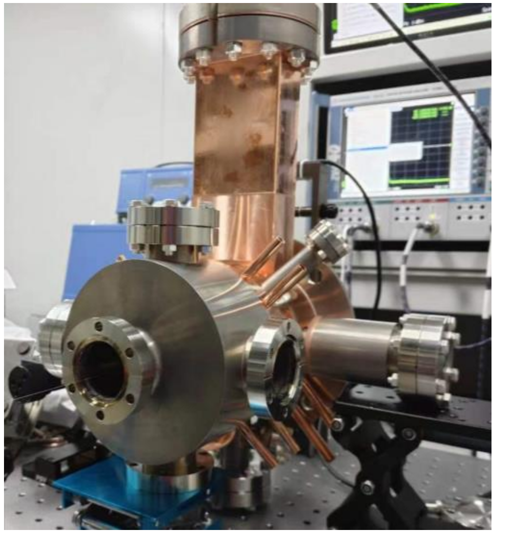
- High positron conversion efficiency
- Overcome CSR effects
- Error compensation
- Lossless injection realization

Electron and positron source

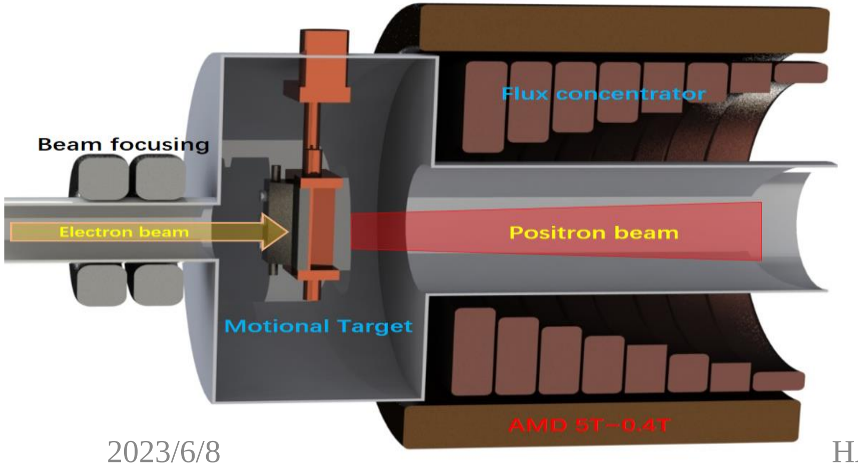
Photocathode microwave electron source







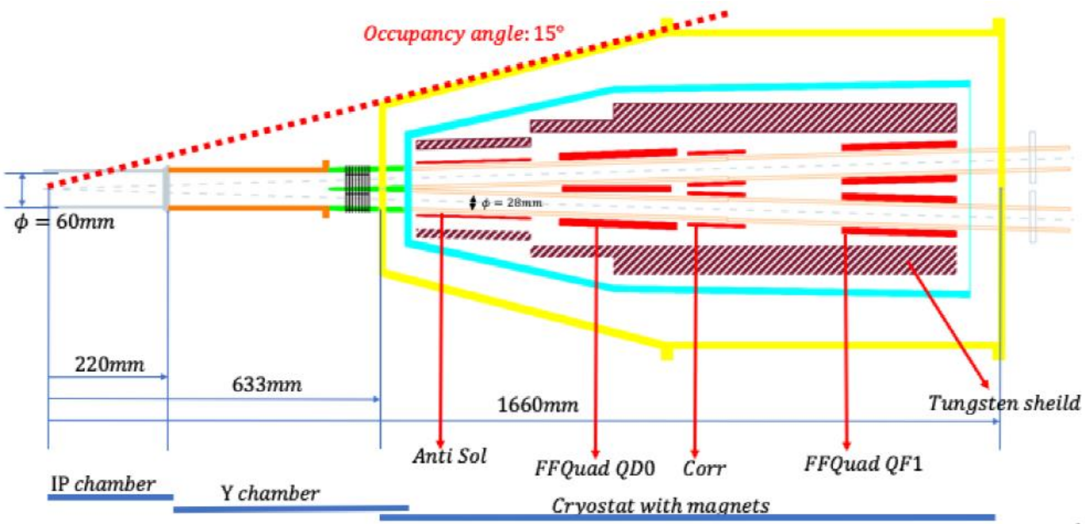
Positron source conceptual design



Parameter	Value
Electron bunch	**5 nC**
Electron energy	**1.5 GeV**
Rep. rate	**50 Hz**
Deposited power	**532 W**
Magnetic field	**5↘0.4**
Target thickness	**13 mm**
Target material	**Tungsten**
e^+ yield	**0.25**

MDI design and background simulation

☐ MDI: machine detector interface

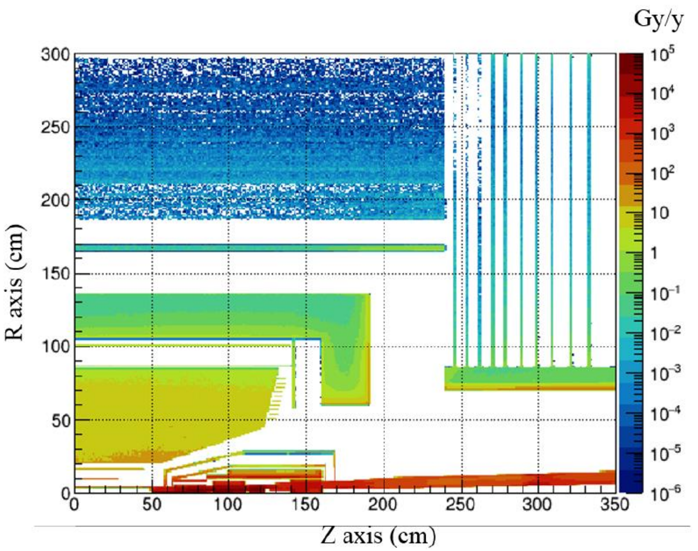


☐ Highest detector background:

- TID: **3.5 k**Gy/y,
- NIEL: **2×10^{11}** 1MeV n/cm^2/y,
- Counting rate: **1 M**Hz/cm^2

☐ Background simulation:

- Luminosity related:
  - radiative Bhabha scattering
  - di-photon process
- Single-beam related:
  - Touschek scattering
  - beam-gas interaction



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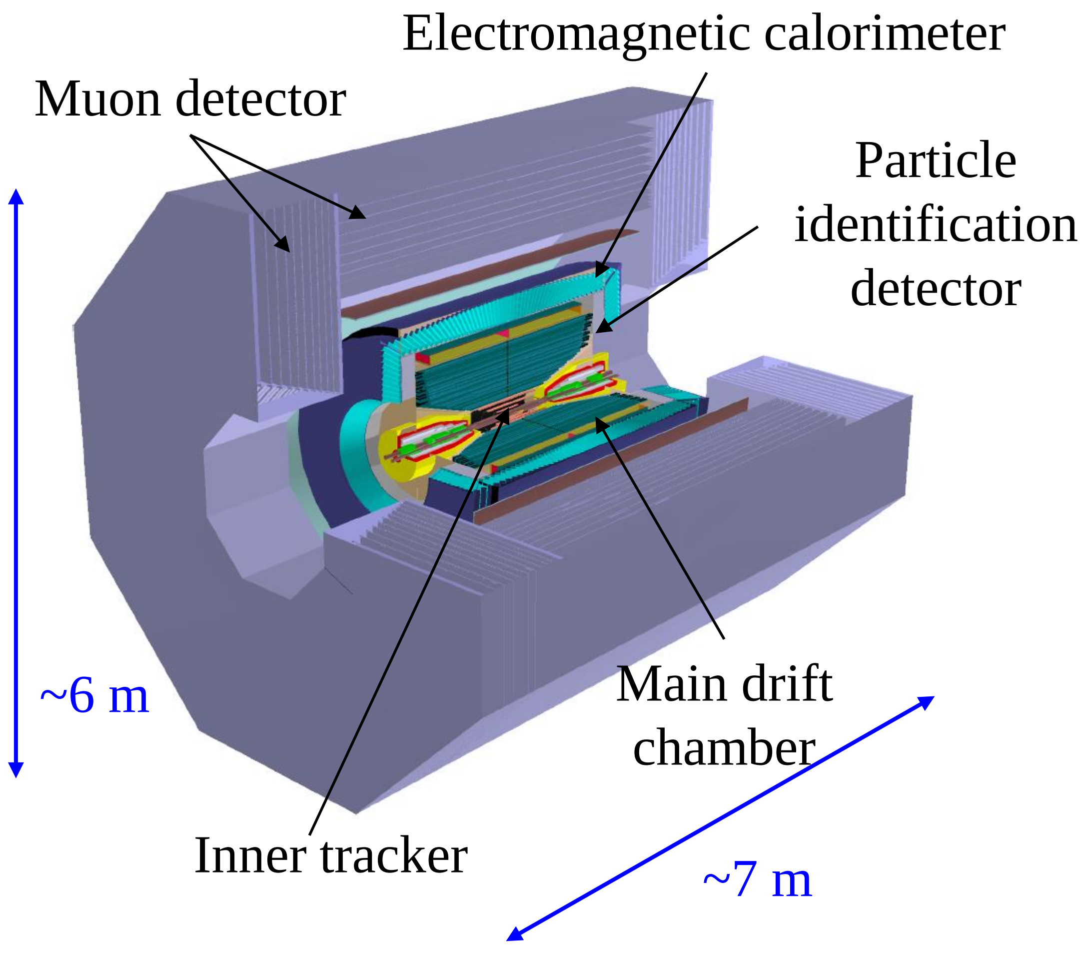
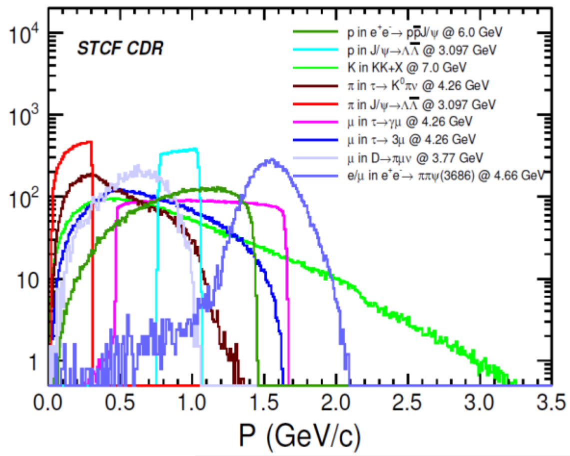
STCF Detector spectrometer

High accuracy | High background | High event rate

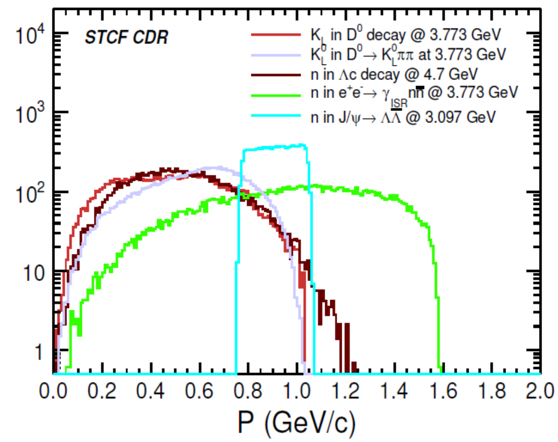


Physics requirements

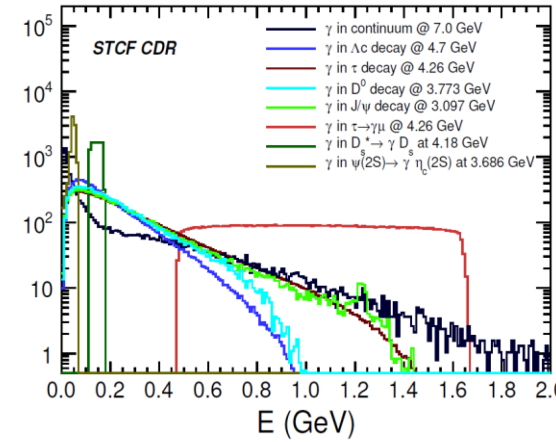
Charged particle



Neutron/K_L



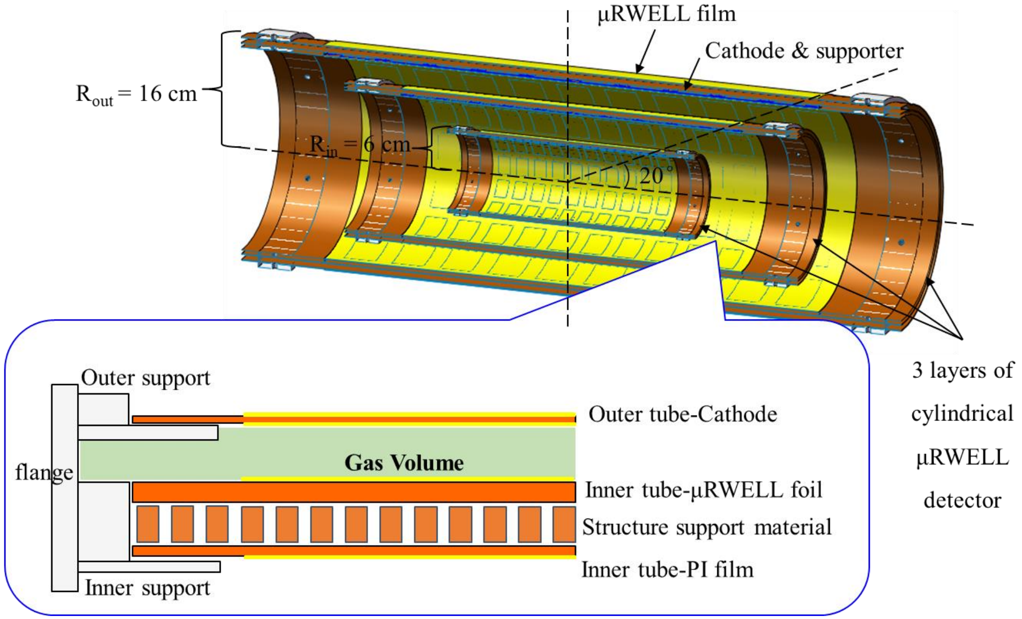
Photon



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 τ sector, CPV in the hyperon sector, Charm physics	ITK+MDC	acceptance: 93% of 4π; 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	π/K and K/π 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 τ, CKM matrix, LQCD etc.	PID+MUD	μ/π suppression power over 30 at $p < 2$ GeV/c, μ efficiency over 95% at $p = 1$ GeV/c
$\tau \to \gamma\mu$, $\psi(3686) \to \gamma\eta(2S)$	cLFV decay of τ, Charmonium transition	EMC	$\sigma_E/E \approx 2.5\%$ at $E = 1$ GeV $\sigma_{\text{pos}} \approx 5$ 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	$\sigma_T = \frac{300}{\sqrt{p^3(\text{GeV}^3)}}$ ps

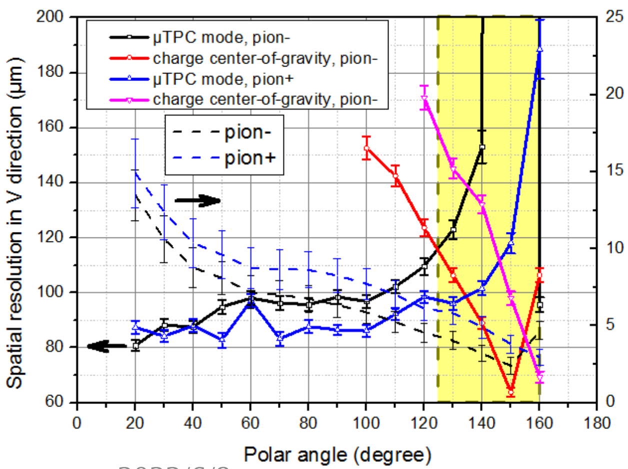
arXiv: 2303.15790

µRWELL-based Inner tracker

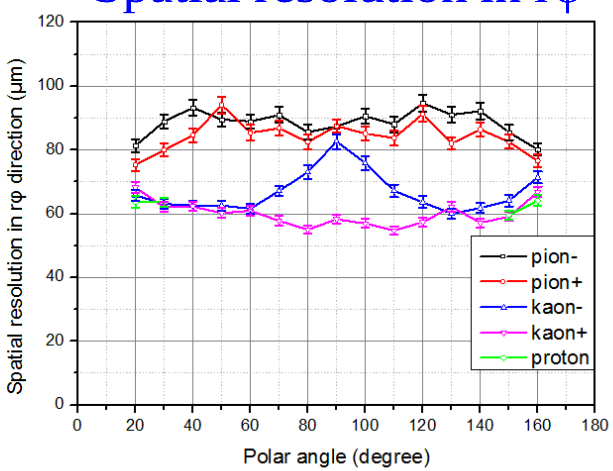


- **µRWELL (3 layers):**
  - Tracking efficiency > 90% @100 MeV/c
  - Low material budget ($< 0.01X_0$)
  - High occupancy
  - Cylindrical structure

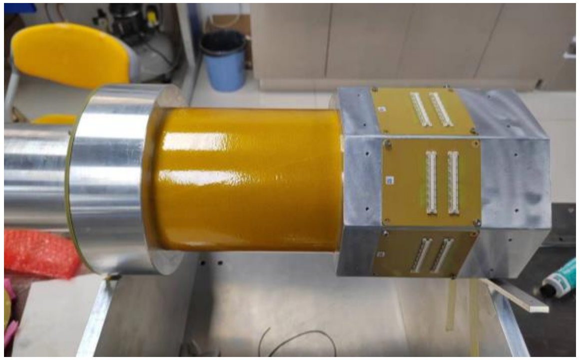
Hit reconstruction



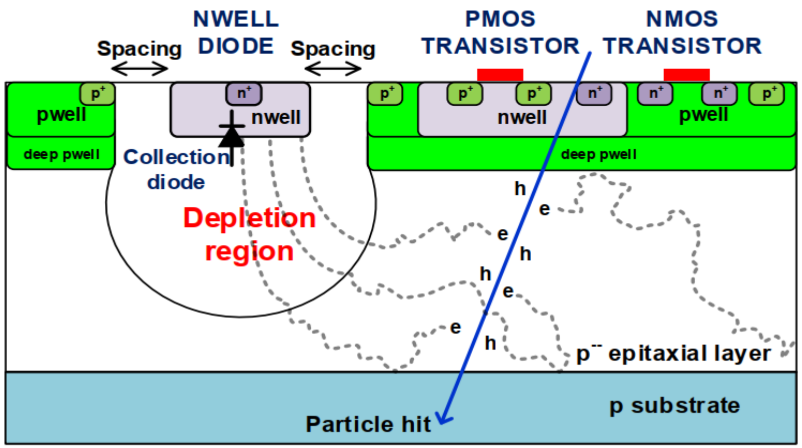
Spatial resolution in rφ



Manufacturing method research & budget control

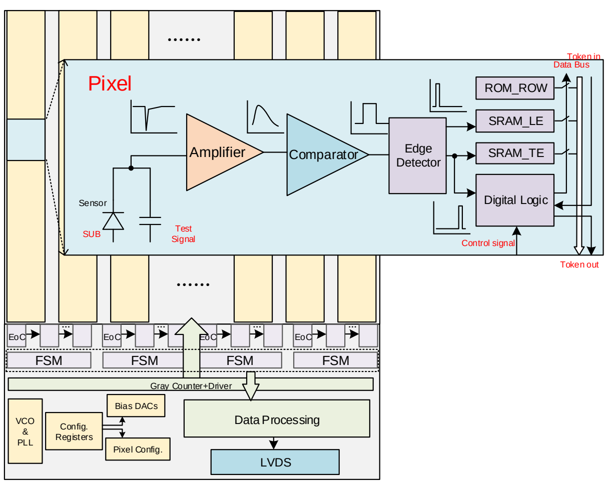


MAPS-based Inner tracker

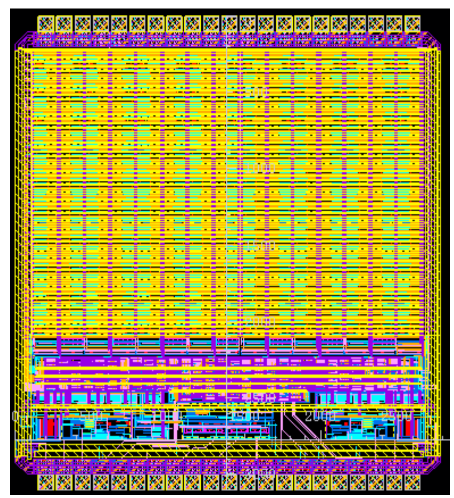


- **Monolithic active pixel sensor-based detector (3 layers):**
  - Tracking efficiency > 90% @100 MeV/c
  - Low material budget (< $0.01X_0$)
  - Time resolution

Chip framework
(in-chip, readout and peripheral circuit)

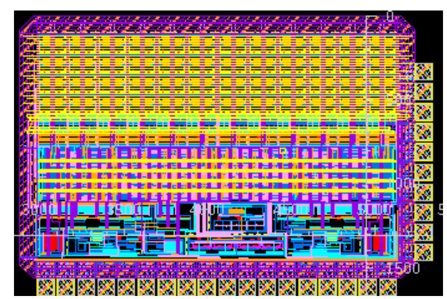


Chip A

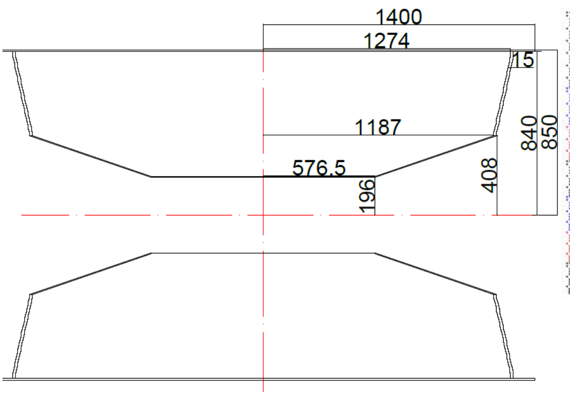


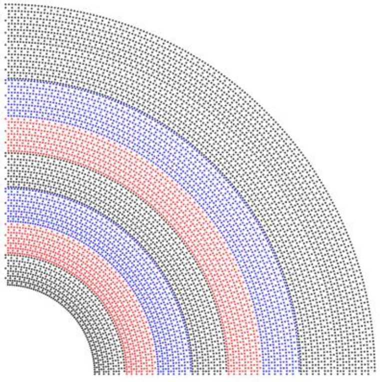
Two independent chips design

Chip B



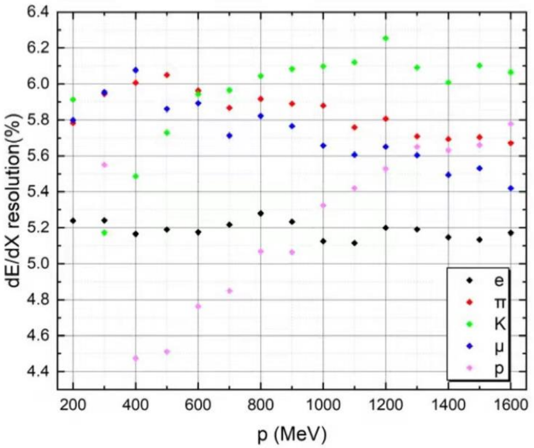
Main drift chamber progress

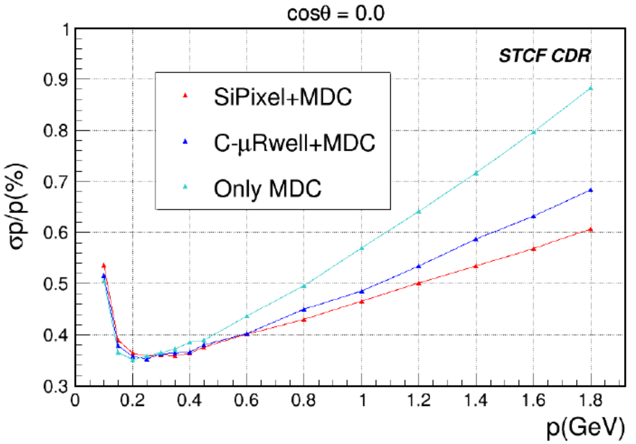


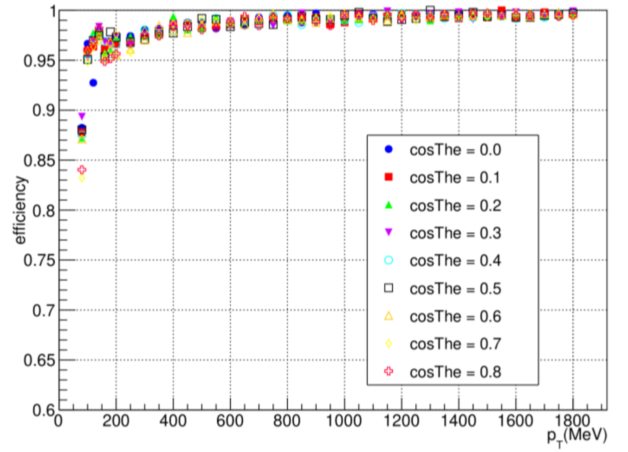


- **Wire chamber-based MDC (48 layers):**
  - Momentum resolution < 0.5% @1 GeV/c
  - dE/dx resolution < 6%
  - Low material budget (<$0.05X_0$)
  - High background influence
  - Waveform discrimination

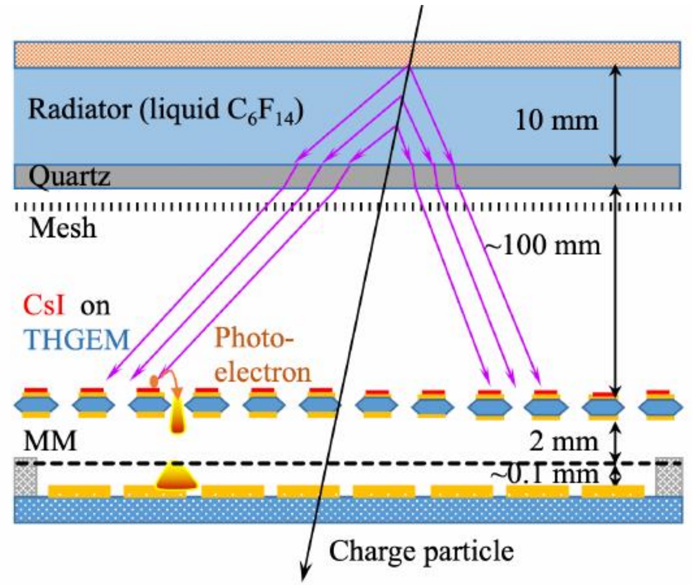
Simulated dE/dx resolution, momentum resolution and tracking efficiency





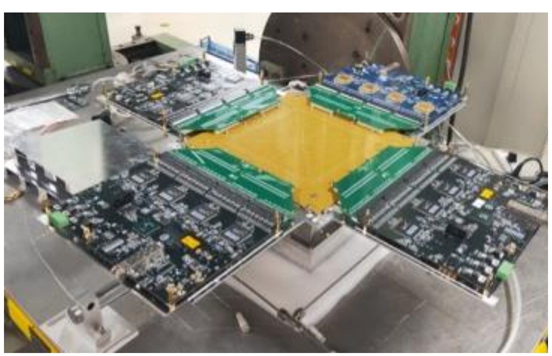


Particle Identification in the Barrel

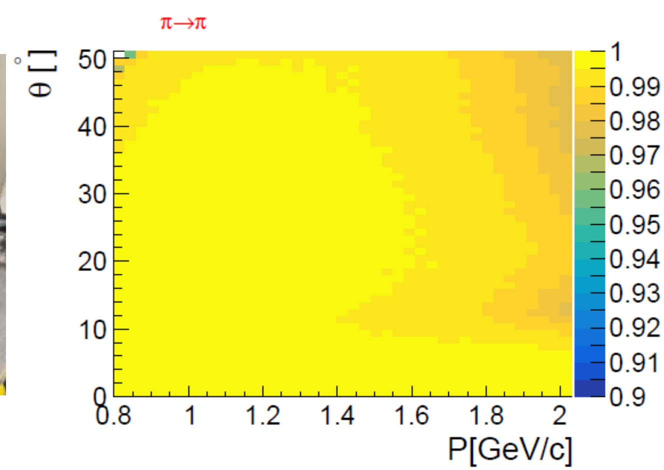


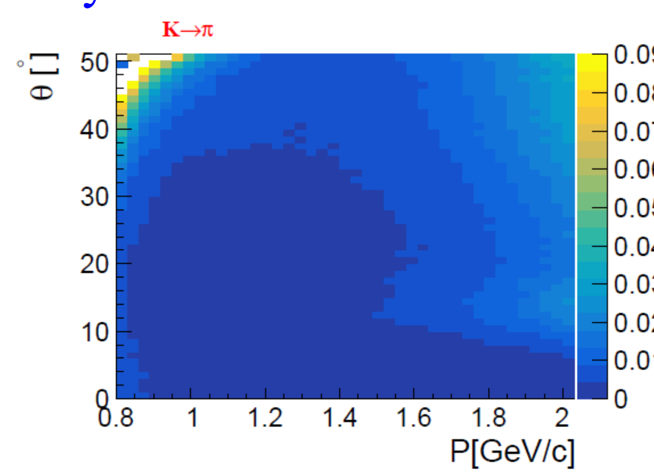
- **Ring imaging Cherenkov (RICH) detector:**
  - π/K misidentification rate < 2%
  - PID efficiency > 97% up to 2 GeV/c
  - 5mm × 5mm readout pads array
  - Reconstruction of Cherenkov ring

1st prototype module



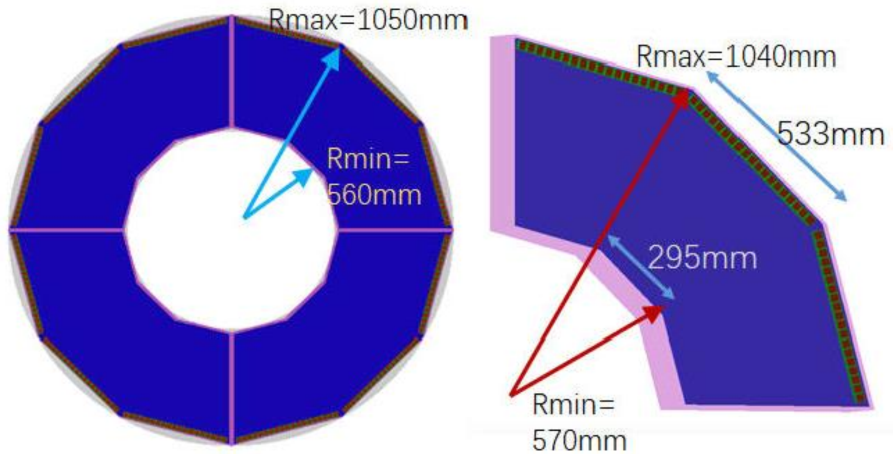
Simulated π efficiency and π/K mis-ID rate

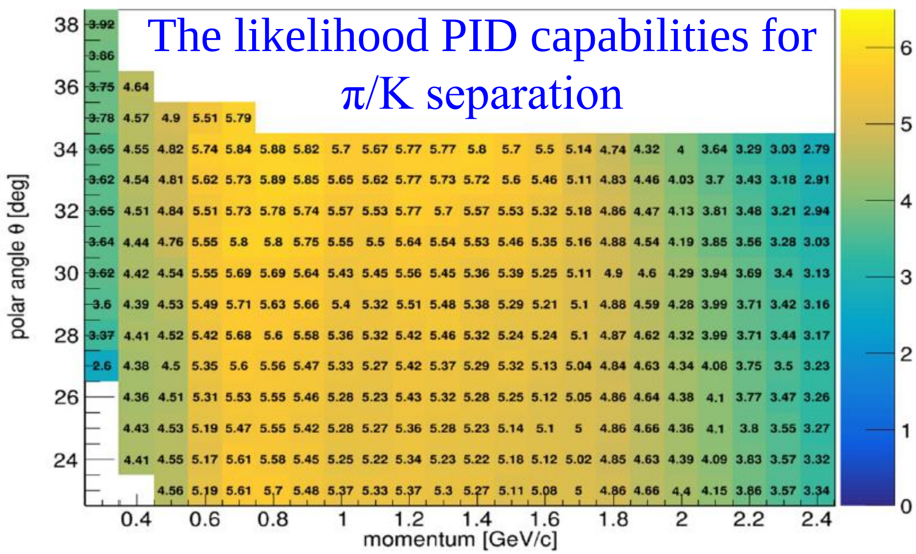




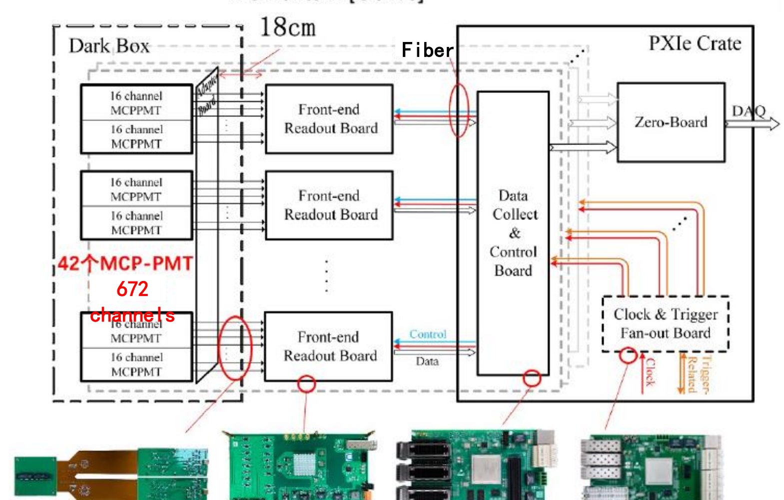
Particle Identification in the Endcap

- **Detection of internal total-reflected Cherenkov light (DIRC)-like TOF:**





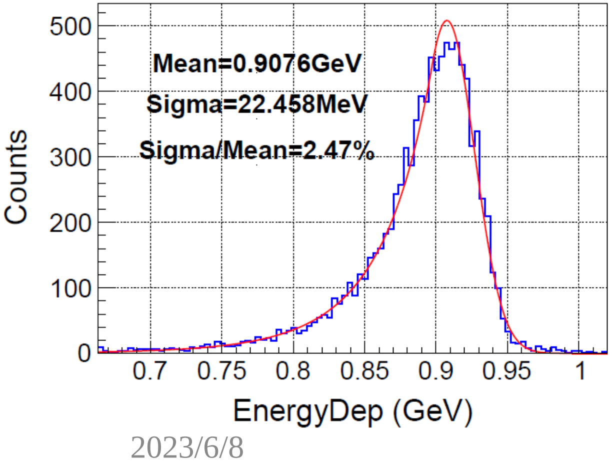
1st full size prototype and the electronics system

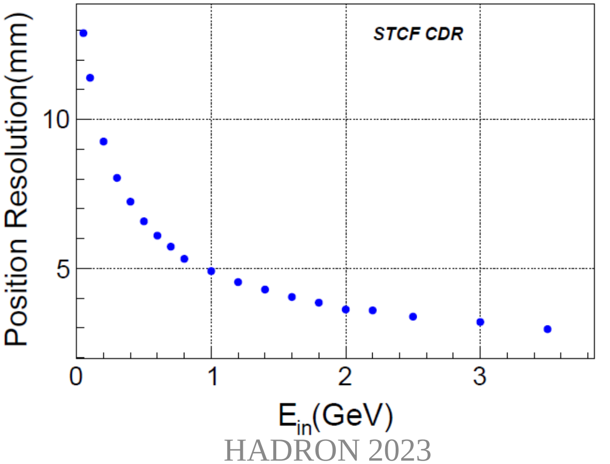


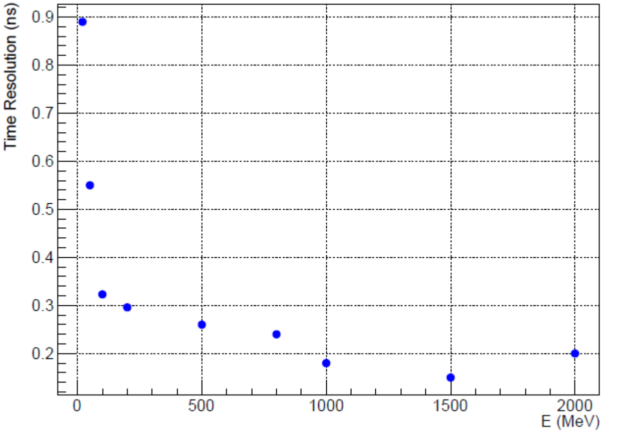
Electromagnetic calorimeter progress

- **pCsI scintillator:**
  - Energy resolution ~ 2.5%@1 GeV
  - Position resolution ~ 5 mm @1 GeV
  - Crystal length = 28 cm (15 X_0)
  - 8670 crystals in total
  - Promotion of light yield

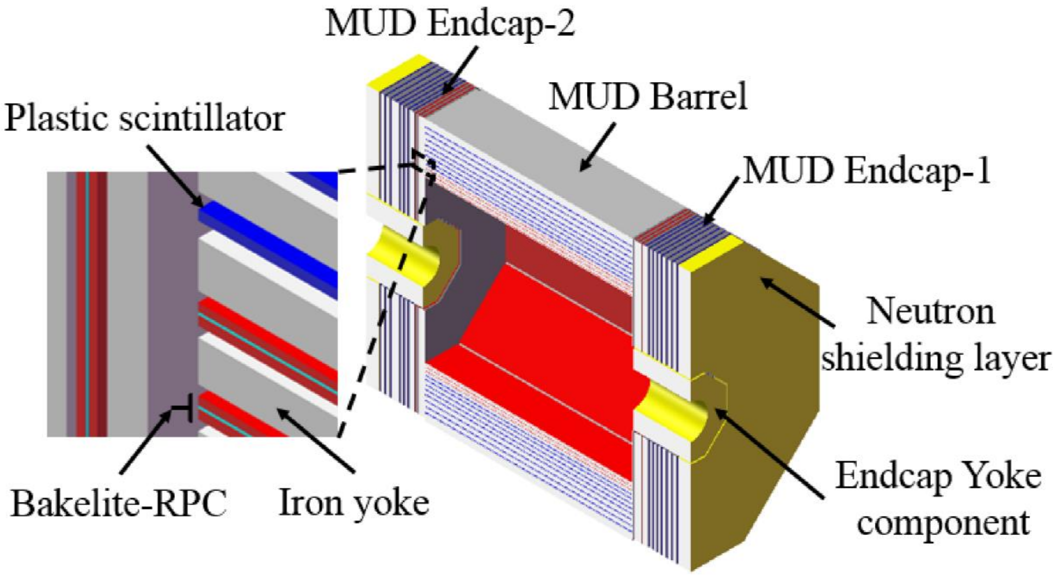
Simulated energy resolution@1 GeV γ, spatial and time resolution







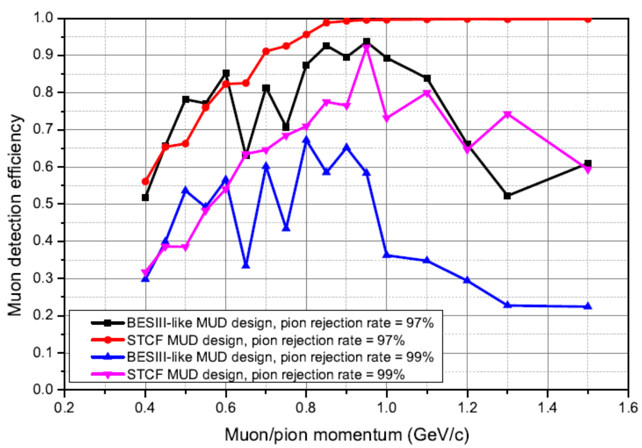
Muon detector progress

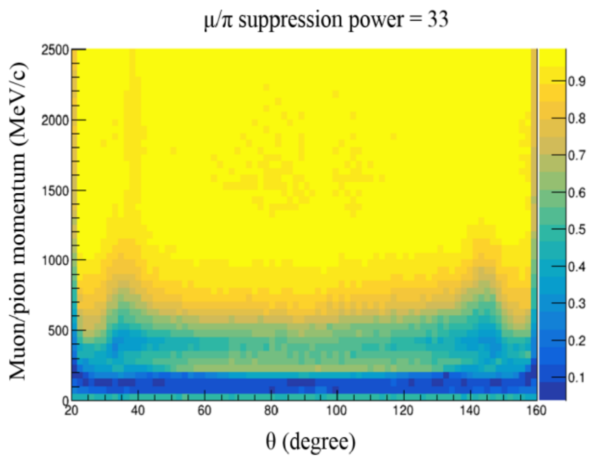


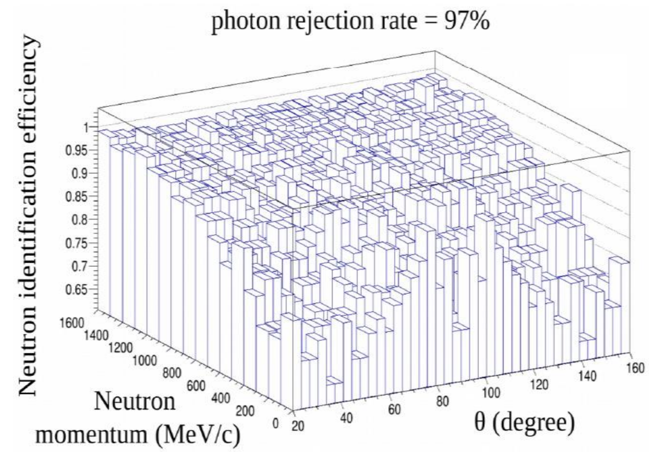
- **Hybrid detector design:**
  - μ/π suppression power > 30
  - μ detection efficiency > 70%
  - @ 0.7 > p > 0.5 GeV/c
  - μ detection efficiency > 95%
  - @ p > 0.7 GeV/c

μ/π ID performance promotion

Simulated neutron/γ ID performance



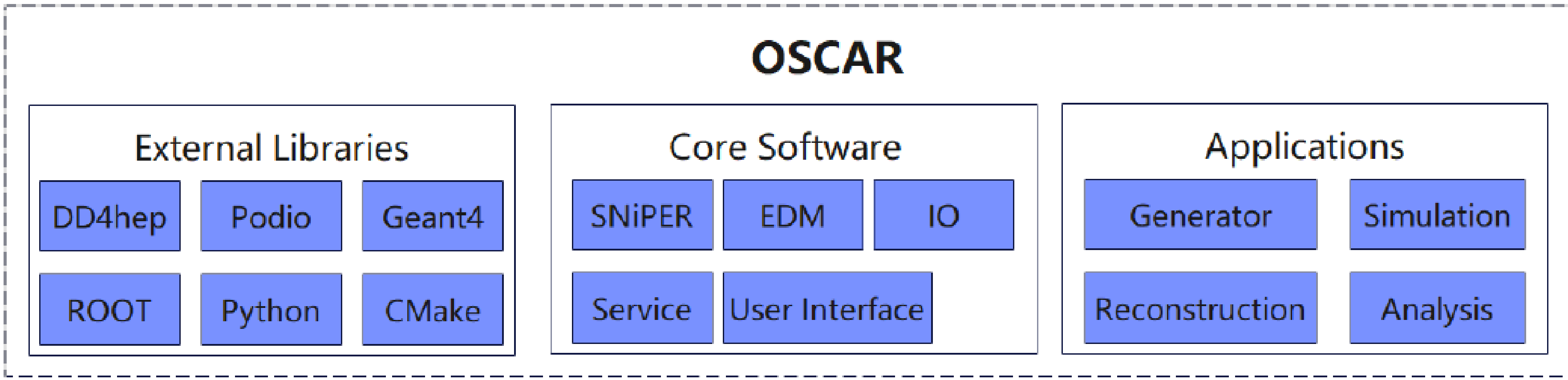


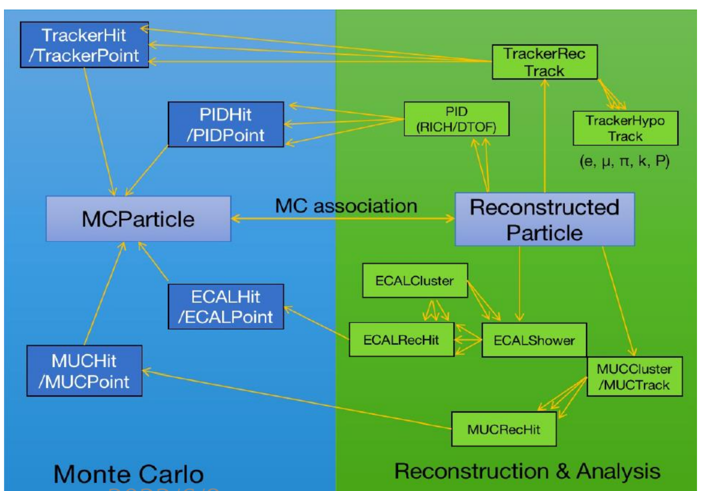


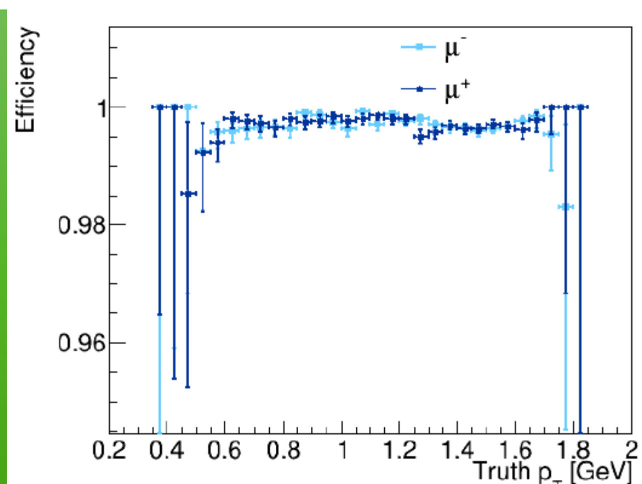
Software system research

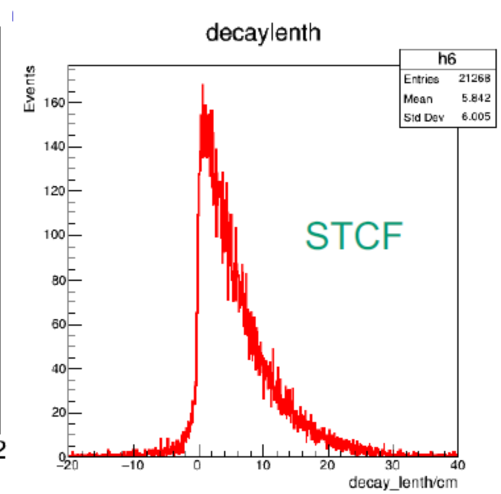
An unified computing environment and platform:

Offline Software System of Super Tau-Charm Facility (**OSCAR**)









Outline

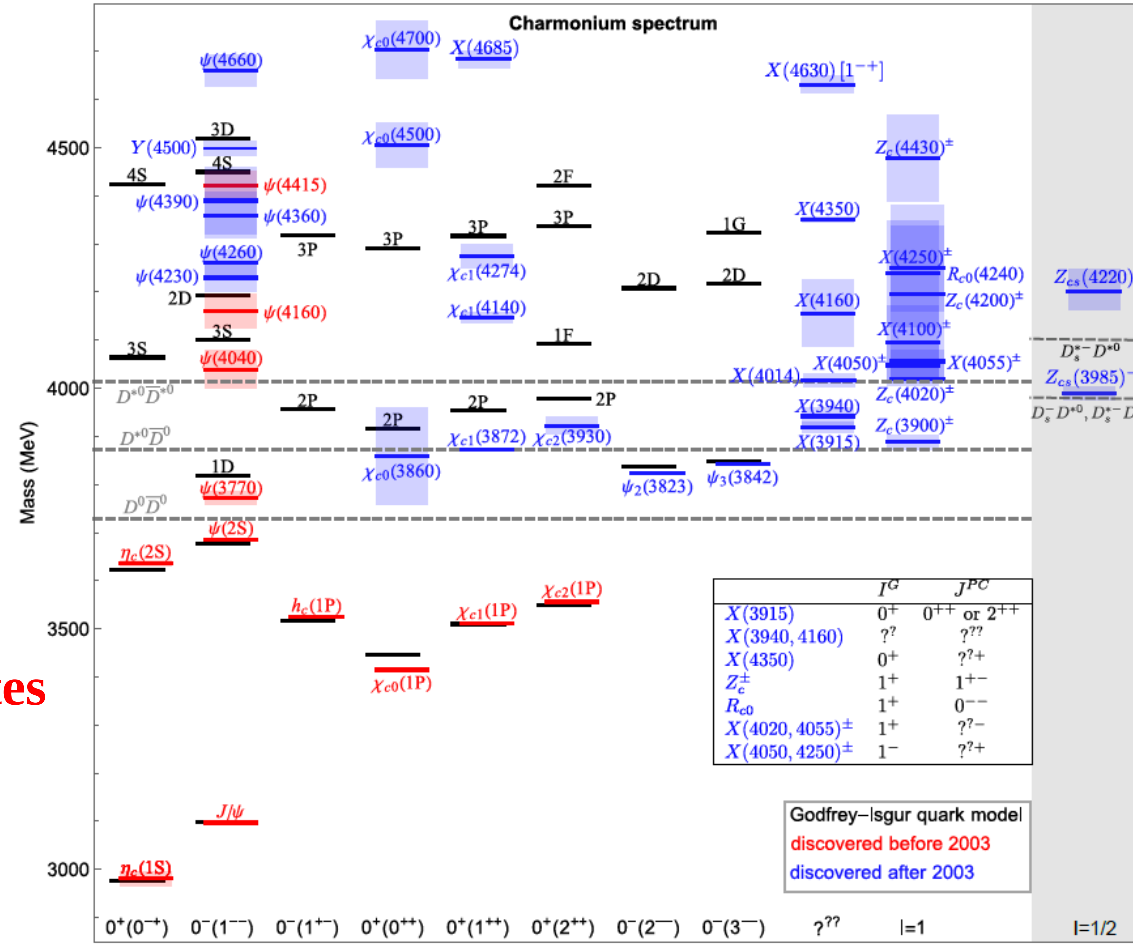
1. Physics motivation
2. Accelerator progress
3. Detector progress
4. **Simulation studies**
5. Summary

XYZ factory

XYZ	$Y(4260)$	$Z_c(3900)$	$Z_c(4020)$	$X(3872)$
No. of events	10^{10}	10^9	10^9	5×10^6

◻ Tasks :

- Precisely measurement the **transition**
- Search for the **missing states**
- Understand the nature of **unknown states**
- Search for the **new exotic states**



J/ψ factory

- Systematic study of **glueball, hybrid and conventional spectroscopy**
  - Precision multi-variable analysis
  - Comprehensive measurement of all possible decay modes, e.g. $J/\psi \to \gamma\eta\eta'$
- **Light hadrons η/η' factory** : important role in low energy QCD

Decay Mode	$\mathcal{B}$ ($\times 10^{-4}$) [9]	η/η' events
$J/\psi \to \gamma\eta'$	52.1 ± 1.7	5.21×10^9
$J/\psi \to \gamma\eta$	11.08 ± 0.27	1.1×10^9
$J/\psi \to \phi\eta'$	7.4 ± 0.8	7.4×10^8
$J/\psi \to \phi\eta$	4.6 ± 0.5	4.6×10^8

1T J/ψ

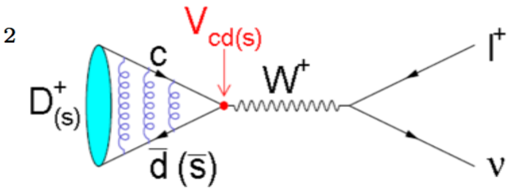
- **Baryon** spectroscopy
- **Hyperon decays** : CP asymmetry violation…

Decay mode	$\mathcal{B}$(units 10^{-4})	Angular distribution parameter α_ψ	Detection efficiency	No. events expected at STCF
$J/\psi \to \Lambda\bar{\Lambda}$	$19.43 \pm 0.03 \pm 0.33$	0.469 ± 0.026	40%	1100×10^6
$\psi(2S) \to \Lambda\bar{\Lambda}$	$3.97 \pm 0.02 \pm 0.12$	0.824 ± 0.074	40%	130×10^6
$J/\psi \to \Xi^0\bar{\Xi}^0$	11.65 ± 0.04	0.66 ± 0.03	14%	230×10^6
$\psi(2S) \to \Xi^0\bar{\Xi}^0$	2.73 ± 0.03	0.65 ± 0.09	14%	32×10^6
$J/\psi \to \Xi^-\bar{\Xi}^+$	10.40 ± 0.06	0.58 ± 0.04	19%	270×10^6
$\psi(2S) \to \Xi^-\bar{\Xi}^+$	2.78 ± 0.05	0.91 ± 0.13	19%	42×10^6

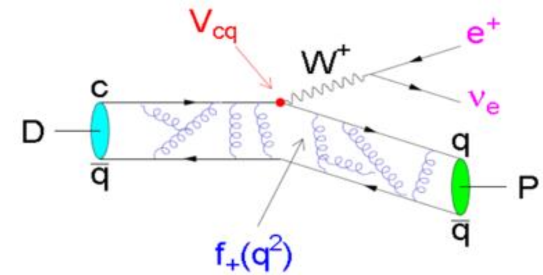
3T J/ψ

$D_{(s)}$ (semi-)leptonic decay

Purely leptonic: $\Gamma(D^+_{(s)} \to \ell^+\nu_\ell) = \frac{G_F^2 f^2_{D^+_{(s)}}}{8\pi} \mid V_{cd(s)} \mid^2 m_\ell^2 m_{D^+_{(s)}} \left(1 - \frac{m_\ell^2}{m^2_{D^+_{(s)}}}\right)^2$

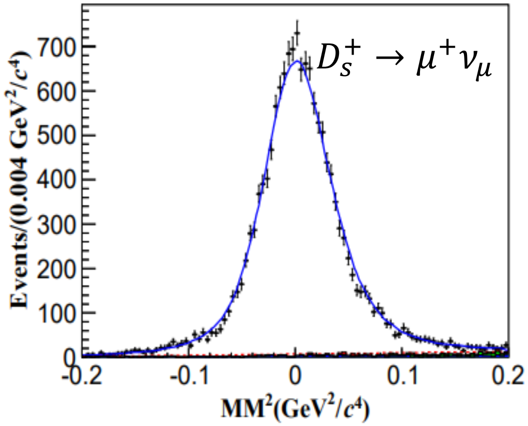


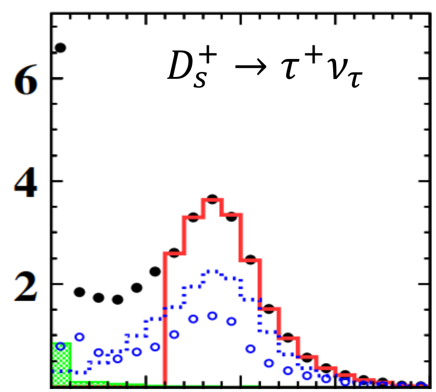
Semi-leptonic: $$\frac{d\Gamma}{dq^2} = \frac{G_F^2}{24\pi^3}|V_{cs(d)}|^2 p^3_{K(\pi)} |f_+^{K(\pi)}(q^2)|^2$$



Directly measurement : $|V_{cd(s)}| \times f_{D(s)}$ or $|V_{cd(s)}| \times FF$

- Input $f_{D(s)}$ or $f^{k(\pi)}(0)$ from LQCD $\Rightarrow |V_{cd(s)}|$
- Input $|V_{cd(s)}|$ from a global fit $\Rightarrow f_{D(s)}$ or $f^{k(\pi)}(0)$
- Validate LQCD calculation of Input $f_{B(s)}$ and provide constrain of CKM-unitarity





Source	BESIII [57]		This work at STCF	
	6 fb^{-1} at 4.178 GeV		1 ab^{-1} at 4.009 GeV	
$\mathcal{B}_{D_s^+\to\tau^+\nu_\tau}$	$1.6\%_{\rm stat.}$	$2.4\%_{\rm syst.}$	$0.3\%_{\rm stat.}$	$1.0\%_{\rm syst.}$
$f_{D_s^+}$ (MeV)	$0.9\%_{\rm stat.}$	$1.4\%_{\rm syst.}$	$0.2\%_{\rm stat.}$	$0.6\%_{\rm syst.}$
$\|V_{cs}\|$	$0.9\%_{\rm stat.}$	$1.4\%_{\rm syst.}$	$0.3\%_{\rm stat.}$	$0.7\%_{\rm syst.}$
$\frac{\mathcal{B}_{D_s^+\to\tau^+\nu_\tau}}{\mathcal{B}_{D_s^+\to\mu^+\nu_\mu}}$	$2.6\%_{\rm stat.}$	$2.8\%_{\rm syst.}$	$0.5\%_{\rm stat.}$	$1.4\%_{\rm syst.}$

H.J. Li, J. J. Liu et al., Eur.Phys.J.C 82 (2022) 4, 310; 337

Outline

1. Physics motivation
2. Accelerator progress
3. Detector progress
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Summary

- **STCF** is proposed with **high luminosity: $>0.5\times10^{35}\ cm^{-2}s^{-1}$ @ 4 GeV**
- **Large data** and **high sensitivity**
- **Accelerator**: detailed conceptual design
- **Detector**：R&D on prototypes and key technical points
- **Physics**: performance evaluation for various processes
- Welcome the **international collaboration**

Thanks for your attention!

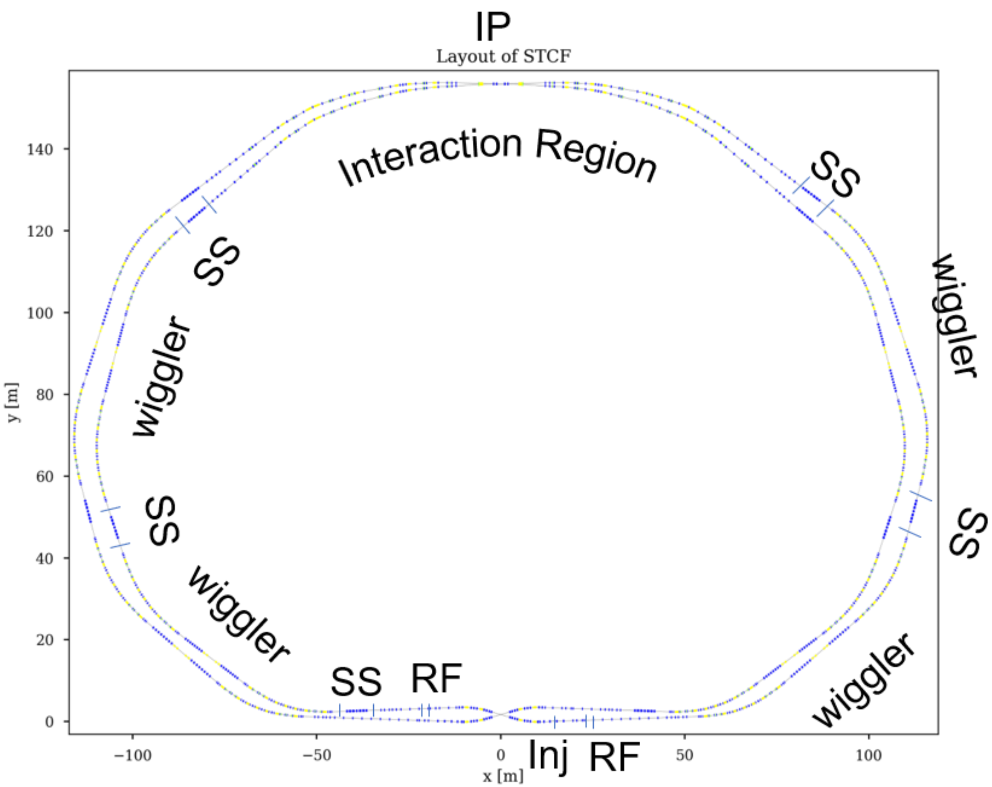
Back up

- QCD & Hadron structure
- Exotic hadrons
- Precision EW
- CP violation
- New physics

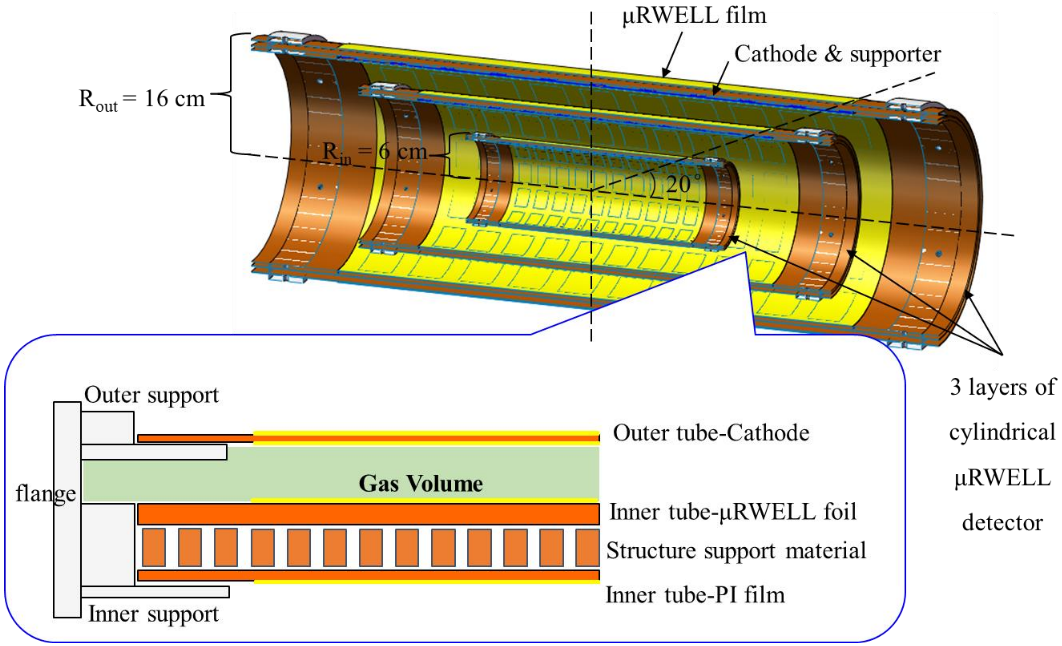
arXiv: 2303.15790

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 [458]	-	< 0.002 [459]
CP violations:			
A_{cp} in hyperon	0.014 [26]	-	0.00023
A_{cp} in τ	-	$O(10^{-3})/\sqrt{70}$ [251]	0.0009 [250]
Leptonic decays of $D_{(s)}$:			
V_{cd}	0.03 [460]	-	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 [461]	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 [462]
y	-	0.02	0.05
τ properties:			
m_τ (MeV/c^{-2})	0.12 [463]	-	0.012
d_τ (e cm)	-	2.02×10^{-19}	5.14×10^{-19}
cLFV decays of τ(U.L at 90% C.L.):			
$\tau \to lll$	-	1×10^{-9}	1.4×10^{-9}
$\tau \to \gamma\mu$	-	5×10^{-9}	1.2×10^{-8}
$J/\psi \to e\tau$	7.5×10^{-8}	-	7.1×10^{-10}

Storage ring structure



μRWELL-based Inner tracker



- **μRWELL:** high counting rate, low budget, high spatial resolution, large area MPGD
  - Low material budget (0.3%X_0)
  - 3 layers of detector: R=60mm, 110mm, 160mm
  - 400 μm readout strip pitch

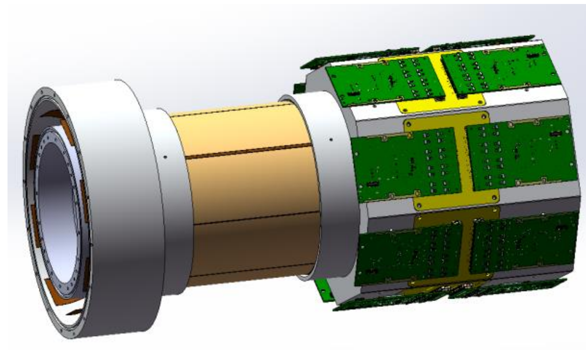
Key scientific & technology points:

Large area **resistive layer** realization	Design and manufacture of key **electrode**	**High occupancy** influence study
Low budget **manufacturing** process	Readout **electronics** & **ASIC** design	**Cylindrical structure** manufacturing

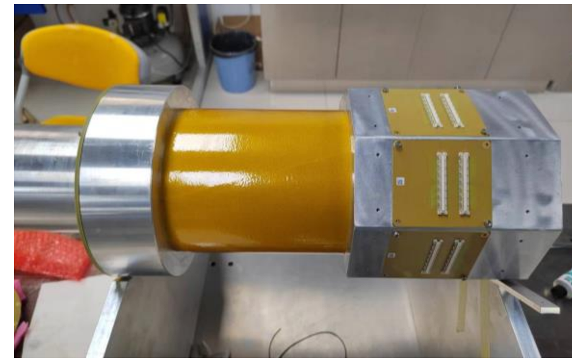
µRWELL-based Inner tracker

Large area Cu-DLC coating & test

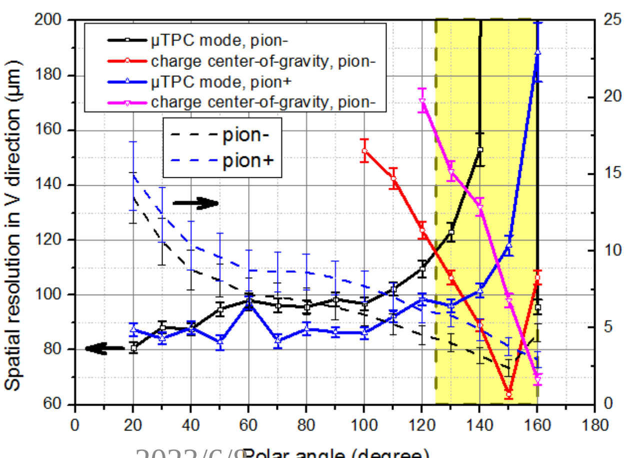
Cylindrical detector design



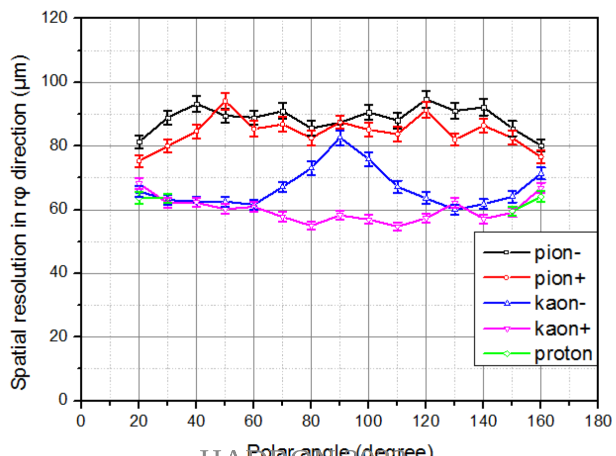
Manufacturing method research & budget control



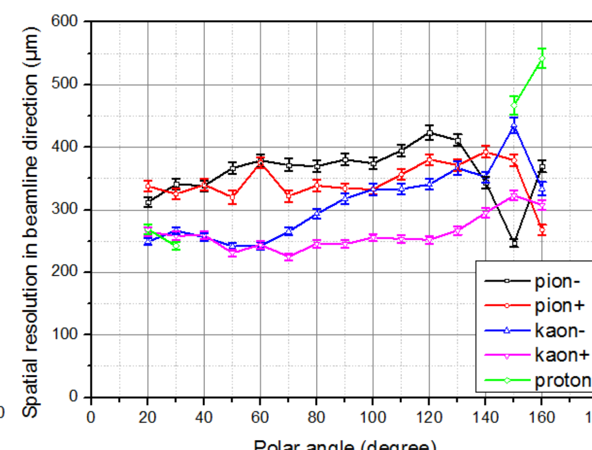
Hit reconstruction algorithm



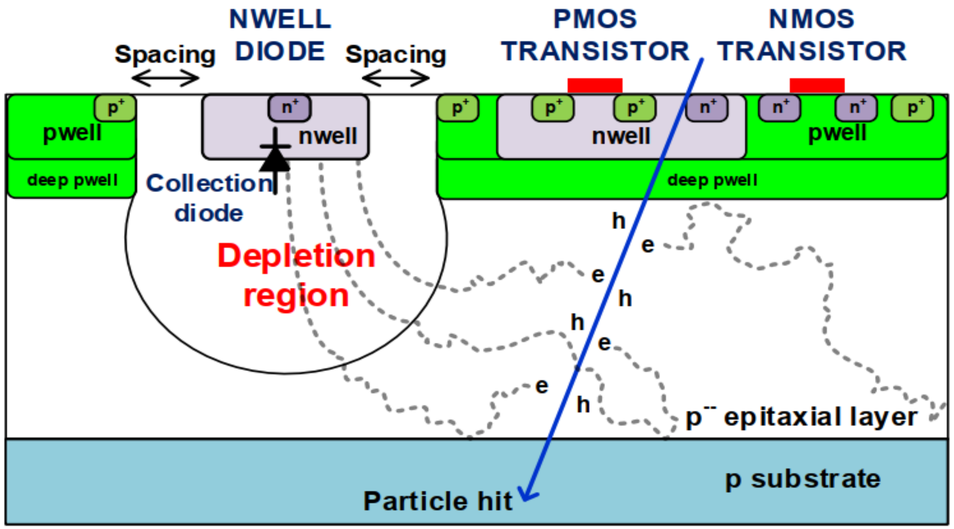
Spatial resolution in rφ direction



Spatial resolution in z direction



MAPS-based Inner tracker



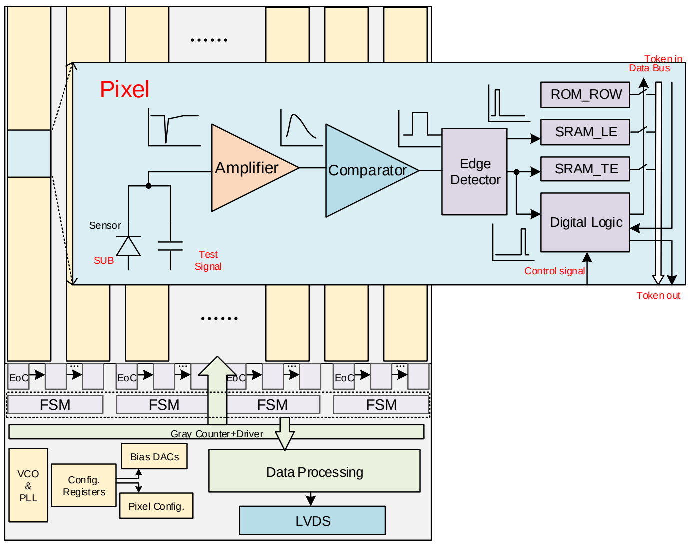
- **Monolithic active pixel sensor-based detector:**
  - High vertex resolution
  - High counting rate & low occupancy
  - 3 layers of detector: R=36mm, 98mm, 160mm
  - ~75μm thick silicon wafer

Key scientific & technology points:

MAPS pixel **layout** and sensor **parameters** design	**Readout and peripheral circuit** design	**Pile up effect** research & optimization
Low-power, low-noise **in-pixel circuit** design	Support **mechanics** and **cooling system** design	**Time resolution** optimization

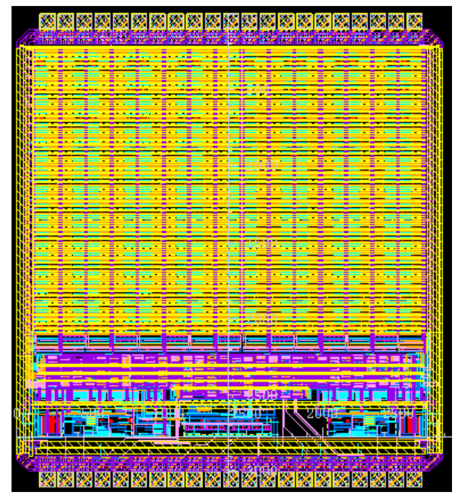
MAPS-based Inner tracker

Chip framework
(in-chip, readout and peripheral circuit)

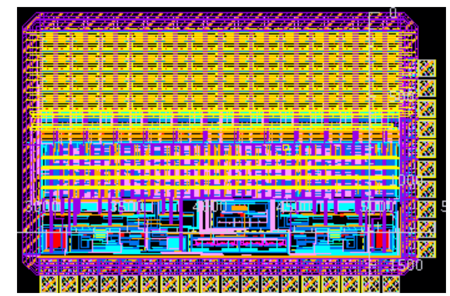


Two independent chips design

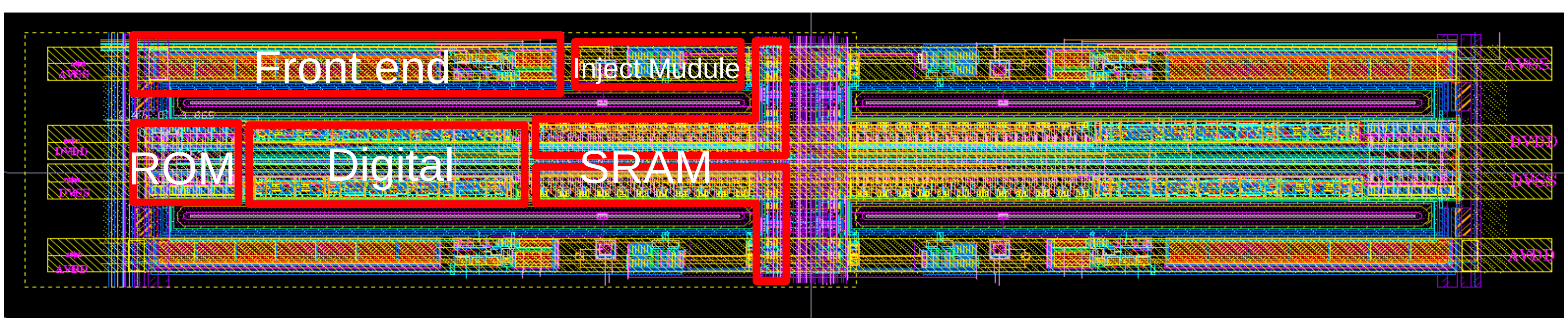
Chip A



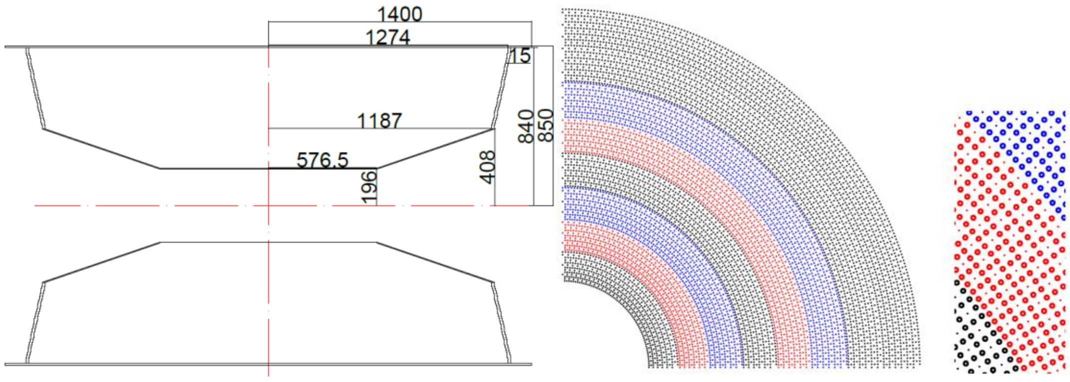
Chip B



Cell layout design with 4 pixels



Main drift chamber progress



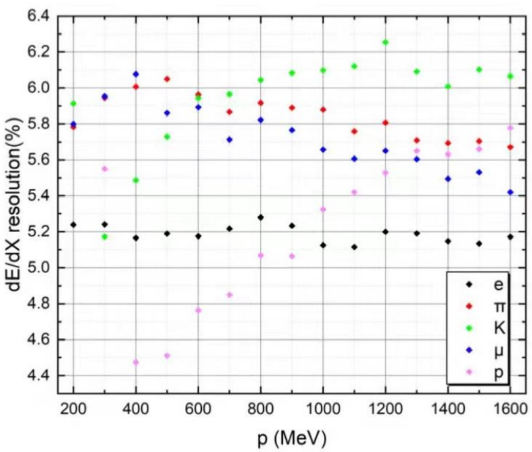
- **Wire chamber-based MDC:**
  - 48 layers of wires (8 superlayer)
  - R_{in}=20cm, R_{out}=85cm
  - Working gas He/C_3H_8 (60/40)
  - Φ=20μm for Au-coated W sense wires
  - Φ=100μm for Al field wires

Key scientific & technology points:

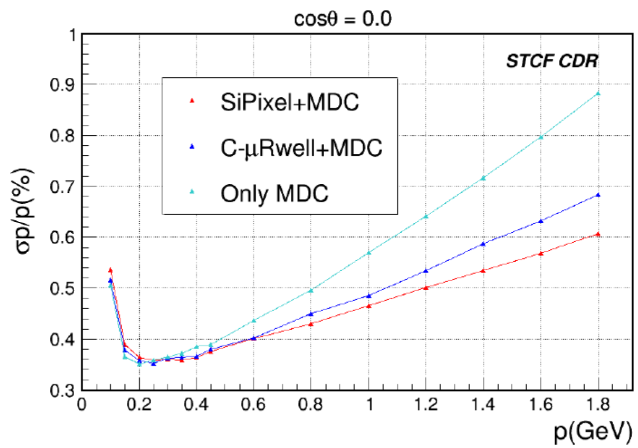
Detector design and **parameters** optimization	High density **wiring technology**	**High background** influence (pile up, tracking…)
Research and design of low-mass **wires**	TIA-based readout **electronics** design	**Waveform pulse** discrimination & time resolution

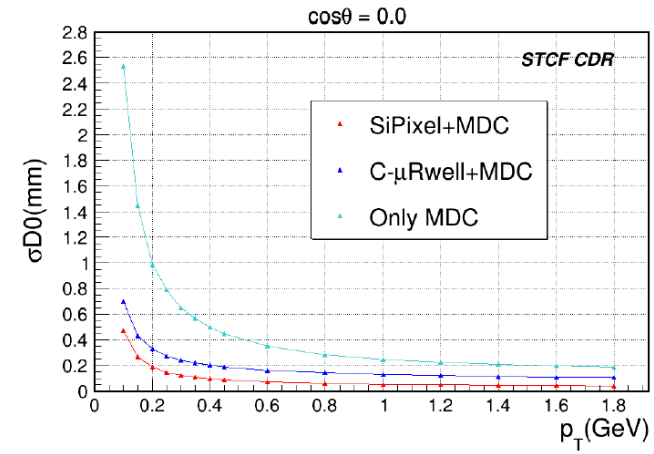
Main drift chamber progress

dE/dx resolution

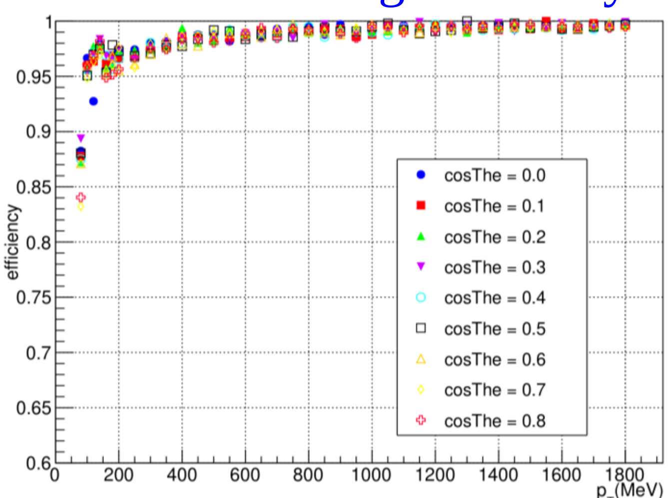


D_0 and momentum resolution of tracking system

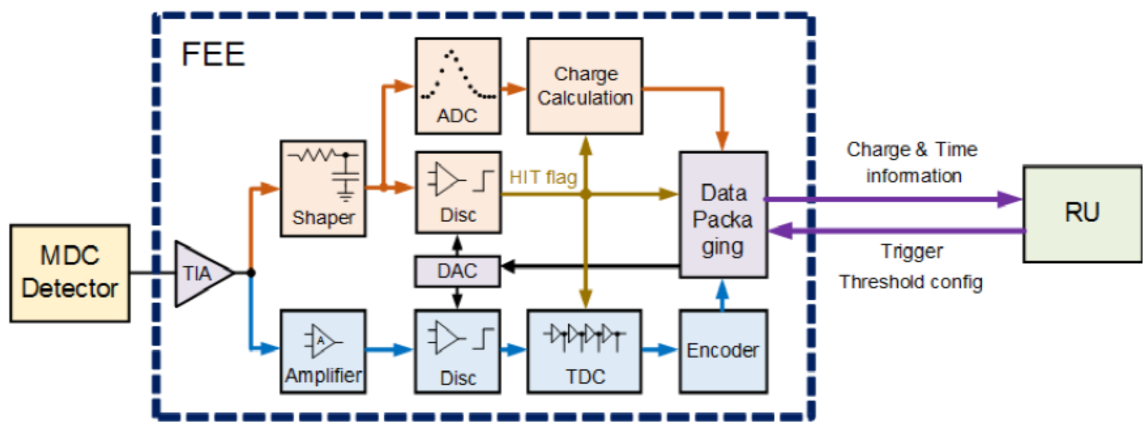




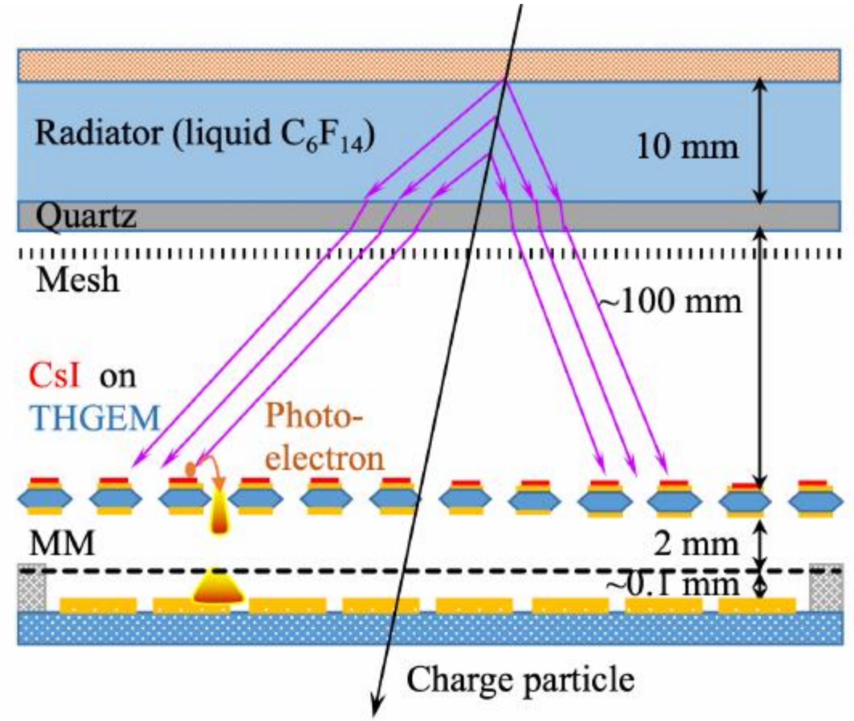
MDC tracking efficiency



TIA-based fast response T&Q measurement electronics



Particle Identification in the Barrel



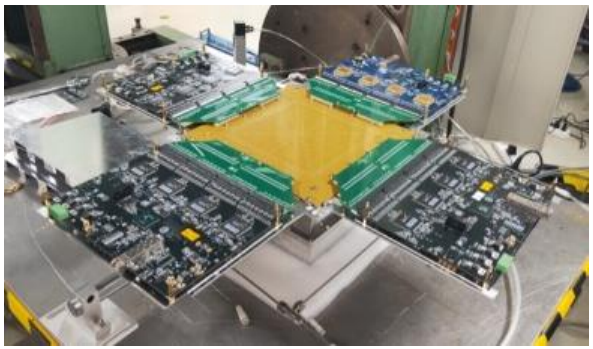
- **Ring imaging Cherenkov (RICH) detector:**
  - Solid angle: cos(θ)<0.83
  - Liquid C_6F_{14} as radiator
  - CsI as photocathode
  - MPGD as amplifier
  - 5mm × 5mm readout pads array

Key scientific & technology points:

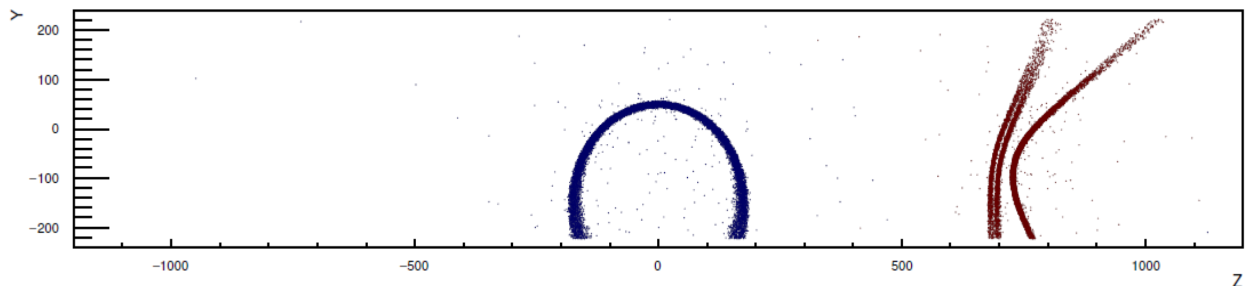
Purity and **cycling** of the liquid radiator	Compact prototype **manufacturing** & testing	High density, time and charge resolution needs **of electronics**
Large area **coating of CsI** photocathode	Front-End ASIC and **electronics** research	**Reconstruction** of the Cherenkov ring

Particle Identification in the Barrel

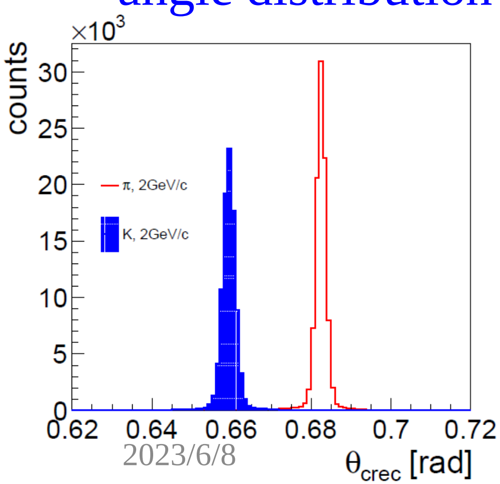
1st prototype module



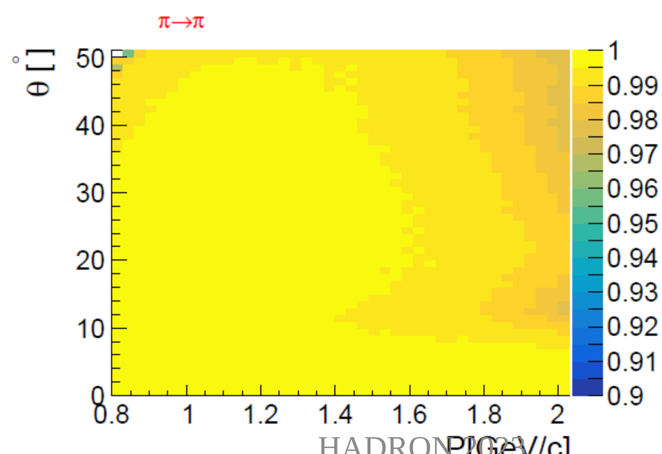
Simulated Cherenkov ring generated by 2GeV/c pion with θ=0° (blue) and θ=40° (red)

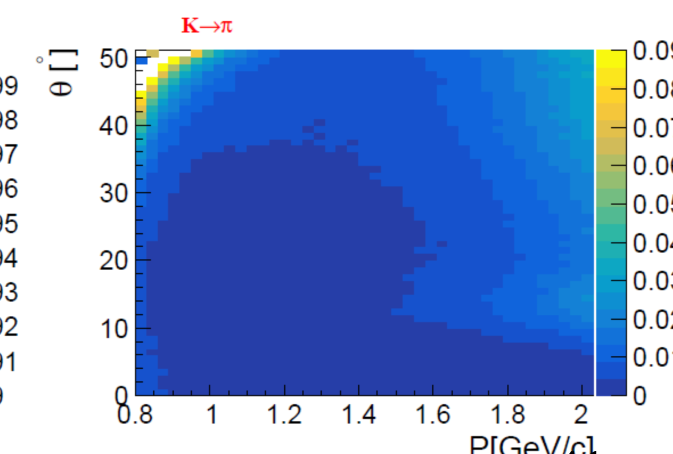


π/K Cherenkov angle distribution

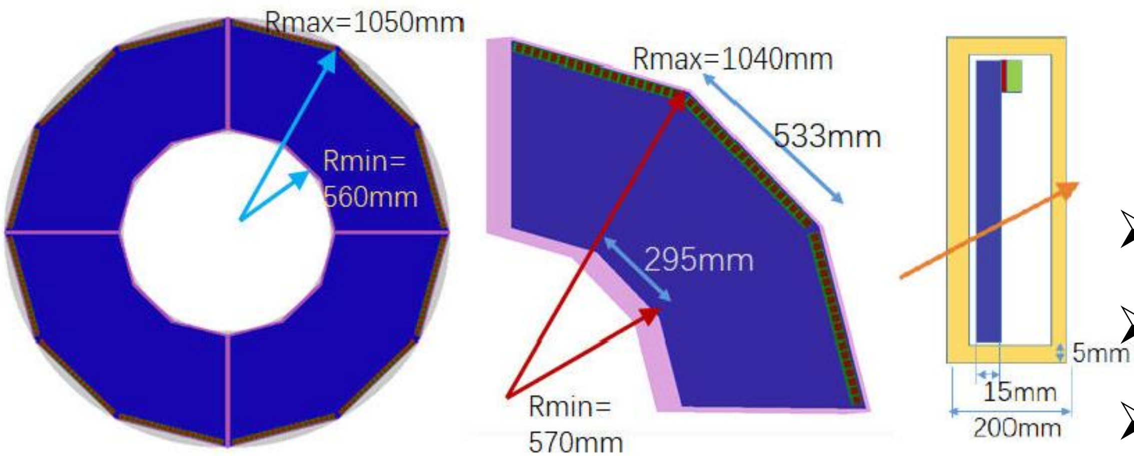


Simulated π efficiency and π/K mis-ID rate





Particle Identification in the Endcap



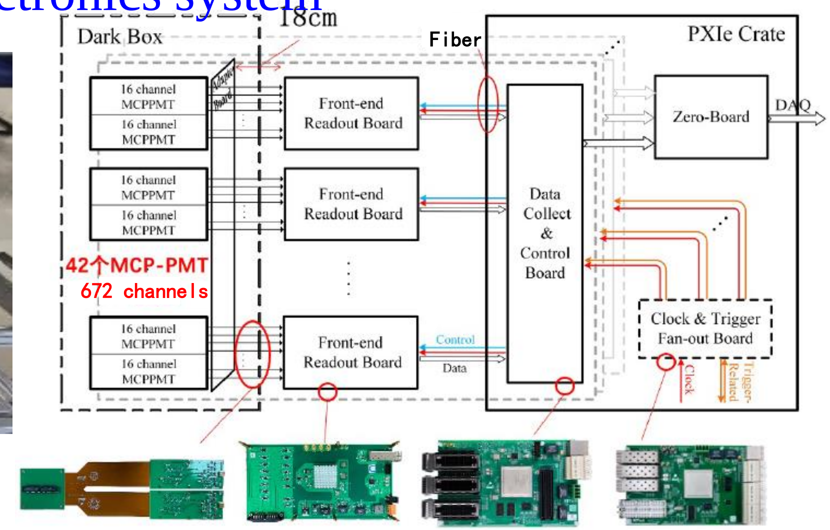
- **Detection of internal total-reflected Cherenkov light (DIRC)-like TOF:**
  - Solid angle: 0.81<cos(θ)<0.93
  - Quartz as radiator
  - Multi-anode MCP-PMTs as photosensor
  - ~ 20 ps intrinsic time resolution

Key scientific & technology points:

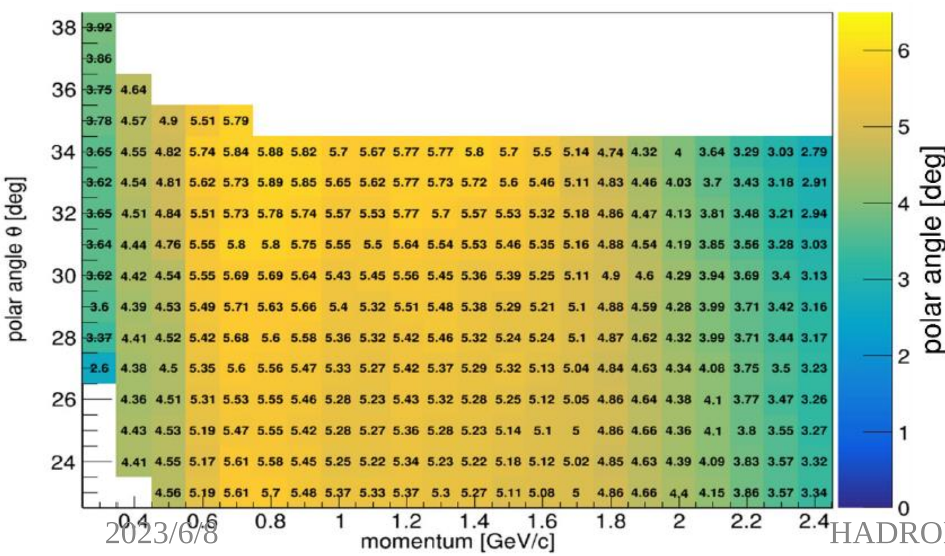
Optical design of the radiator and photosensor	High-precision processing and **surface control** of quartz
Readout **electronics** design with high precise time measurement	**Radiation resistance** and aging of ASIC

Particle Identification in the Endcap

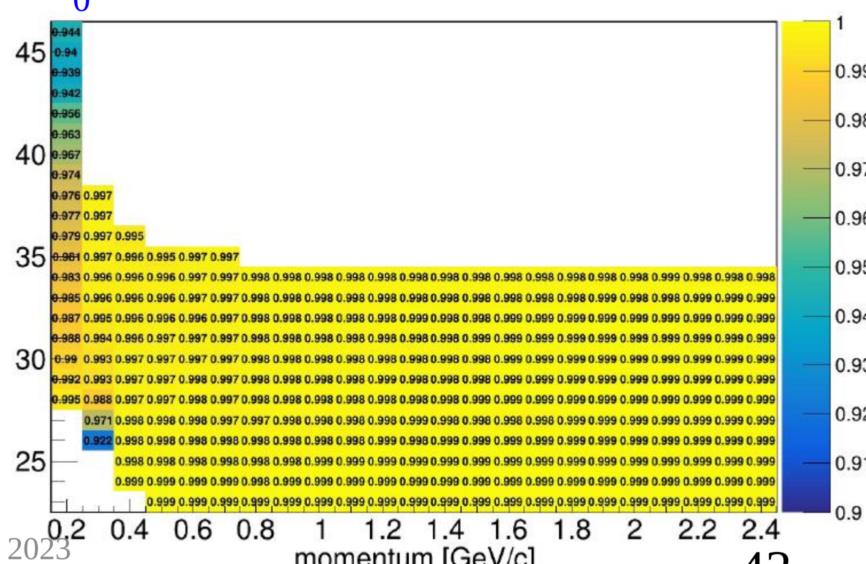
1st full size prototype and the electronics system



The likelihood PID capabilities for π/K separation



T_0 corrected determination rate for π



Electromagnetic calorimeter progress

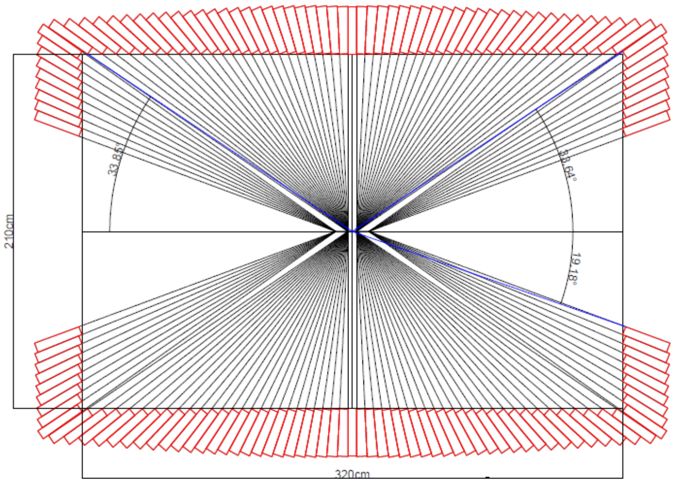
- **pCsI scintillator:**
  - Short decay time
  - Excellent radiation resistance
  - Crystal length = 28 cm (15 X_0)
  - Crystal size ~ 5cm × 5cm
  - 8670 crystals in total

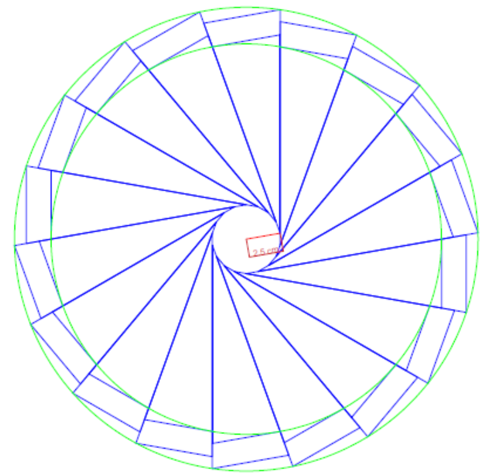
Key scientific & technology points:

Crystal **parameters** & **APD** optimization	Prototype detector **manufacturing** & testing	Promotion of **light yield**
Effective **wave fitting** algorithm	Large dynamic range **electronic** system	MHz **background influence** (pile up, △E…)

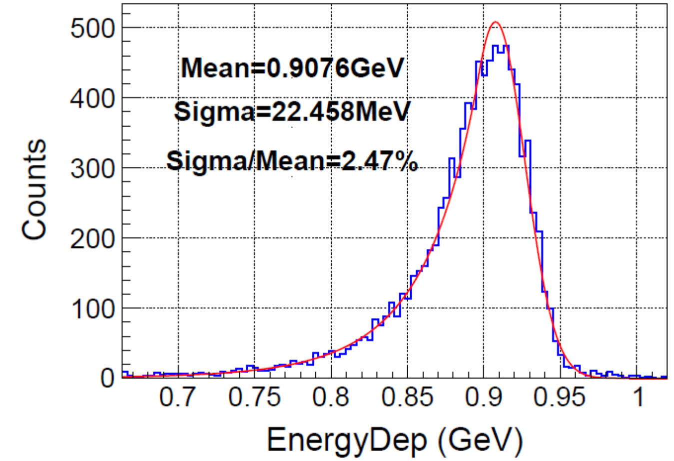
Electromagnetic calorimeter progress

The EMC layout and defocus design

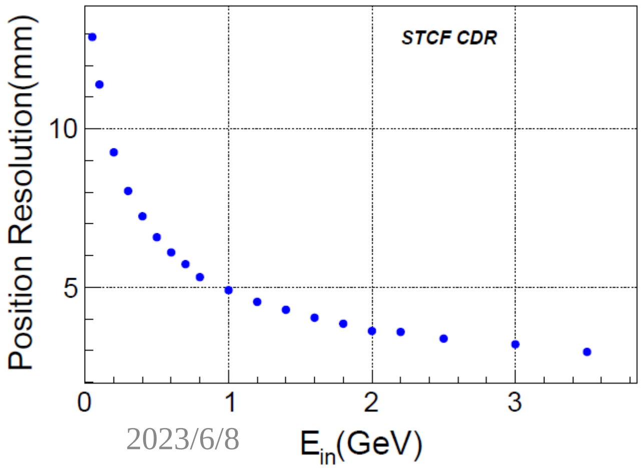


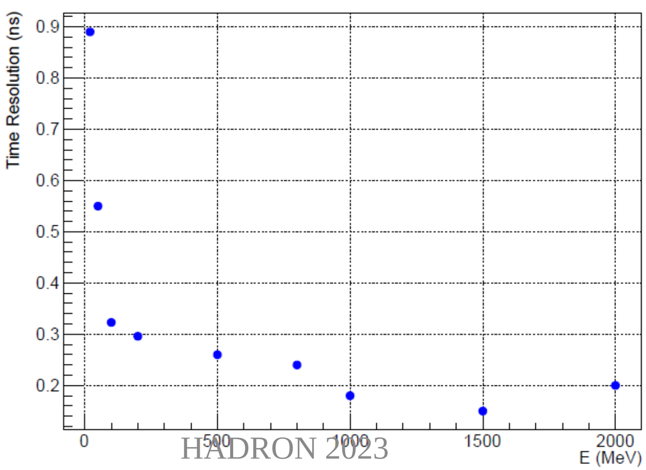


Energy resolution@1 GeV γ

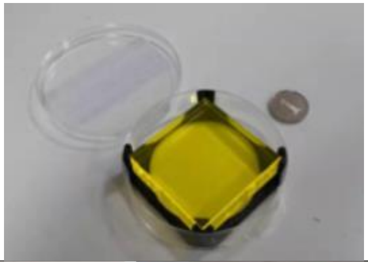


Simulated spatial and time resolution

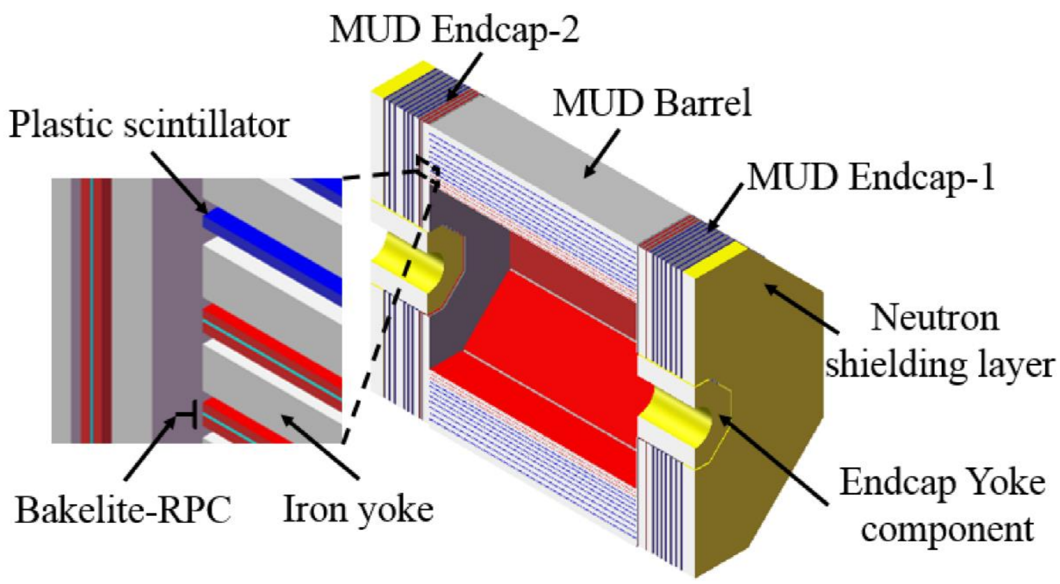




Electronic research and light yield test



Muon detector progress



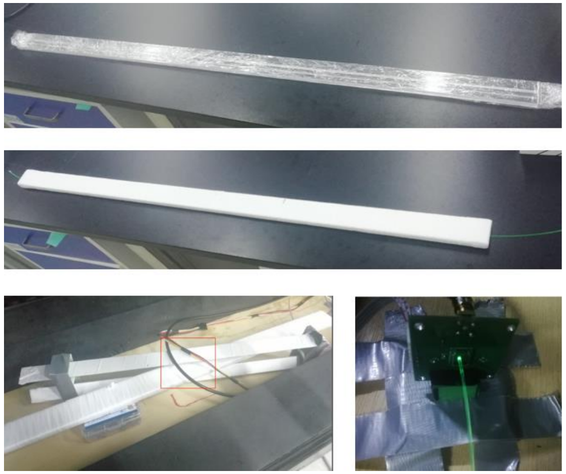
- **Hybrid detector design:**
  - (Inner) 3 layers of RPC
  - (Outer) 7 layers of plastic scintillator
  - 4 cm width RPC readout and scintillator strips
  - 51 cm of iron yoke in total

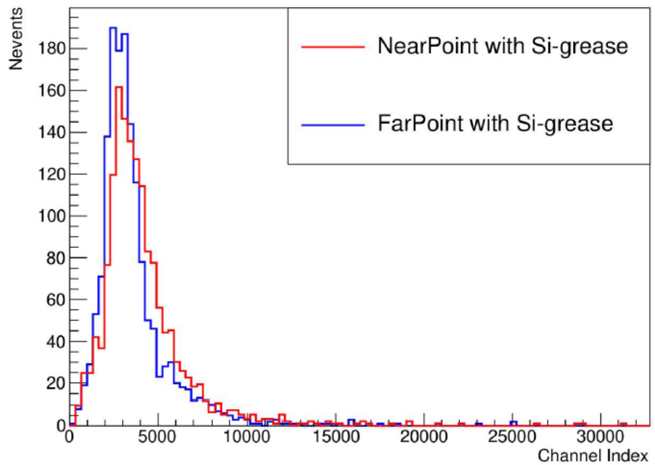
Key scientific & technology points:

Hybrid detector **parameters** optimization	**Timing** performance optimization	Large area detector module **manufacturing**
High rate and **large area** RPC develop	**Electronic** system suitable for both RPC and scintillator	**Algorithm** optimization for μ/π and neutral hadron

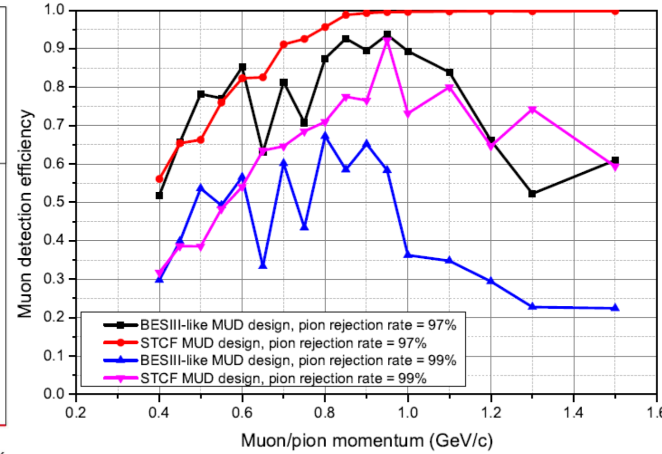
Muon detector progress

Double ended readout scintillator tests

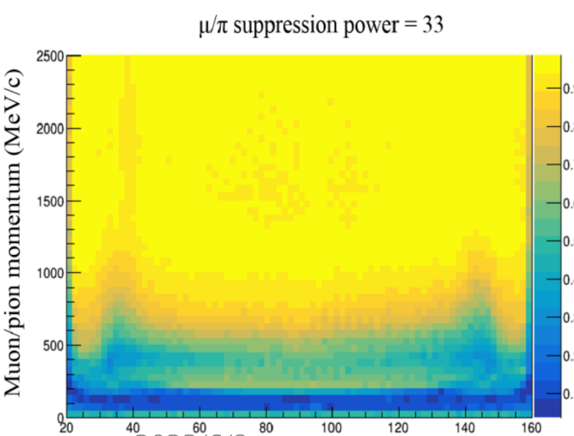




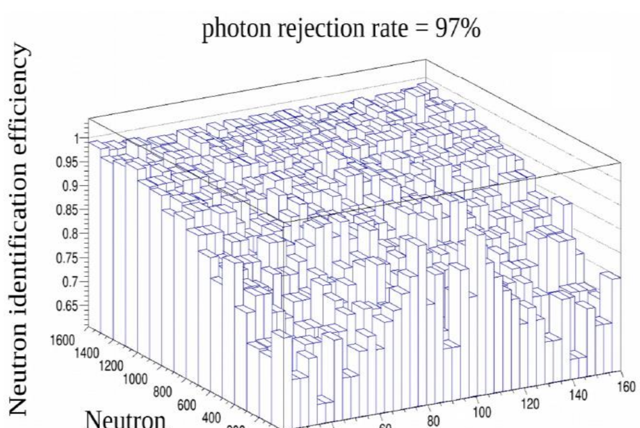
μ/π ID performance promotion

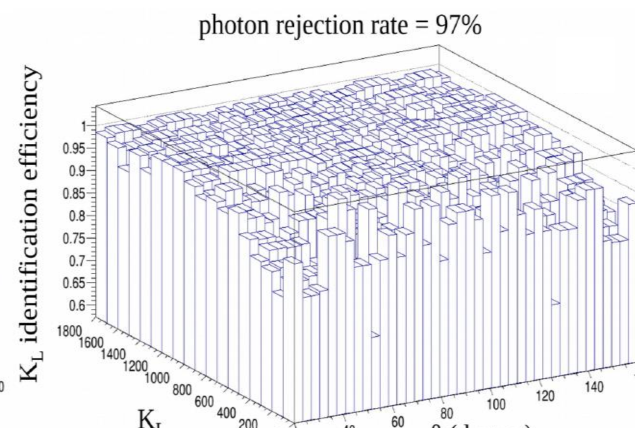


Simulated μ/π ID performance



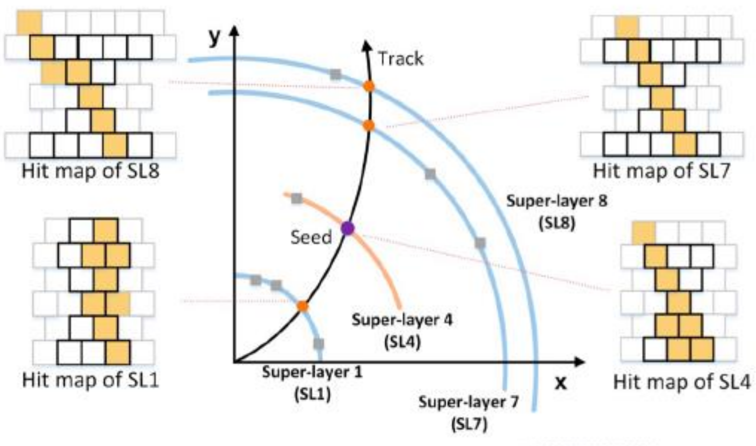
Simulated neutral hadron/photon ID performance



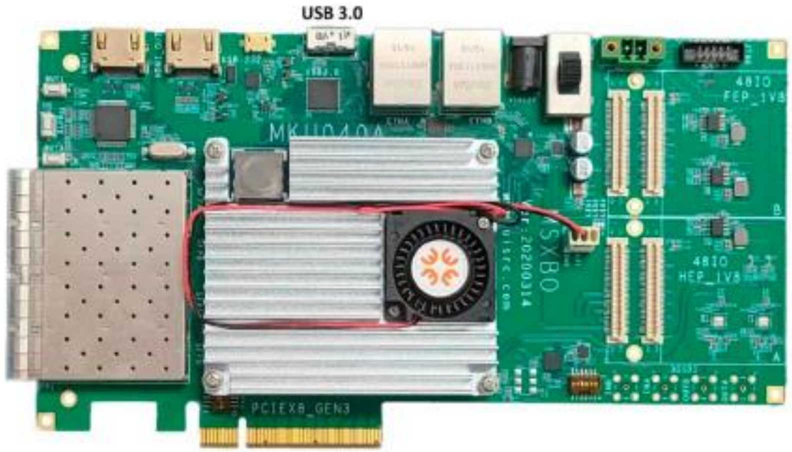


Trigger system research

Tracking logic in MDC



Logical evaluation platform for MDC sub-trigger



Simulated trigger efficiency for MDC and EMC