中国科学院大学
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STCF RICH

detector design and R&D

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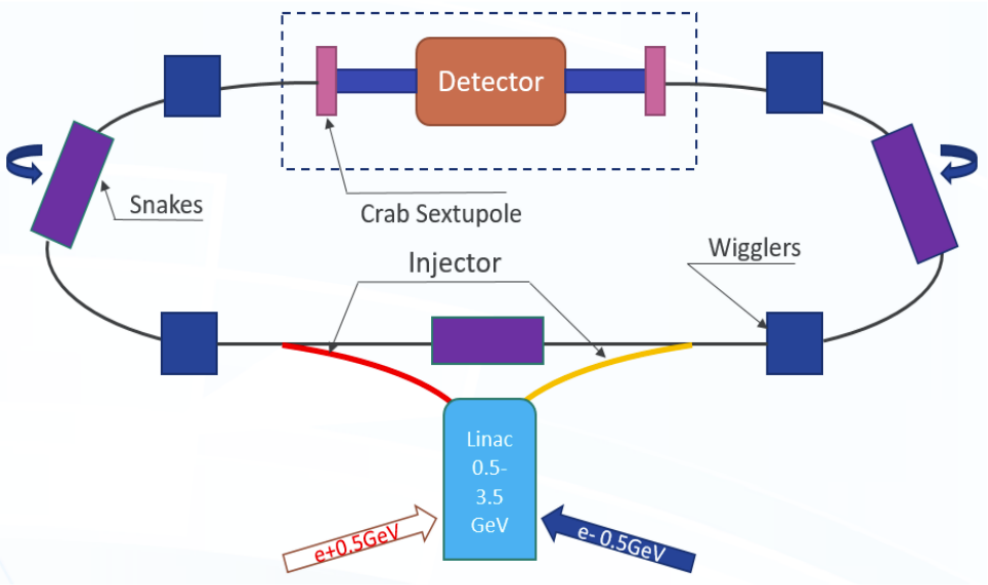
On behalf of the STCF RICH group

University of Chinese Academy of Sciences

The 5th TIPP Conference

• Super Tau-Charm Facility

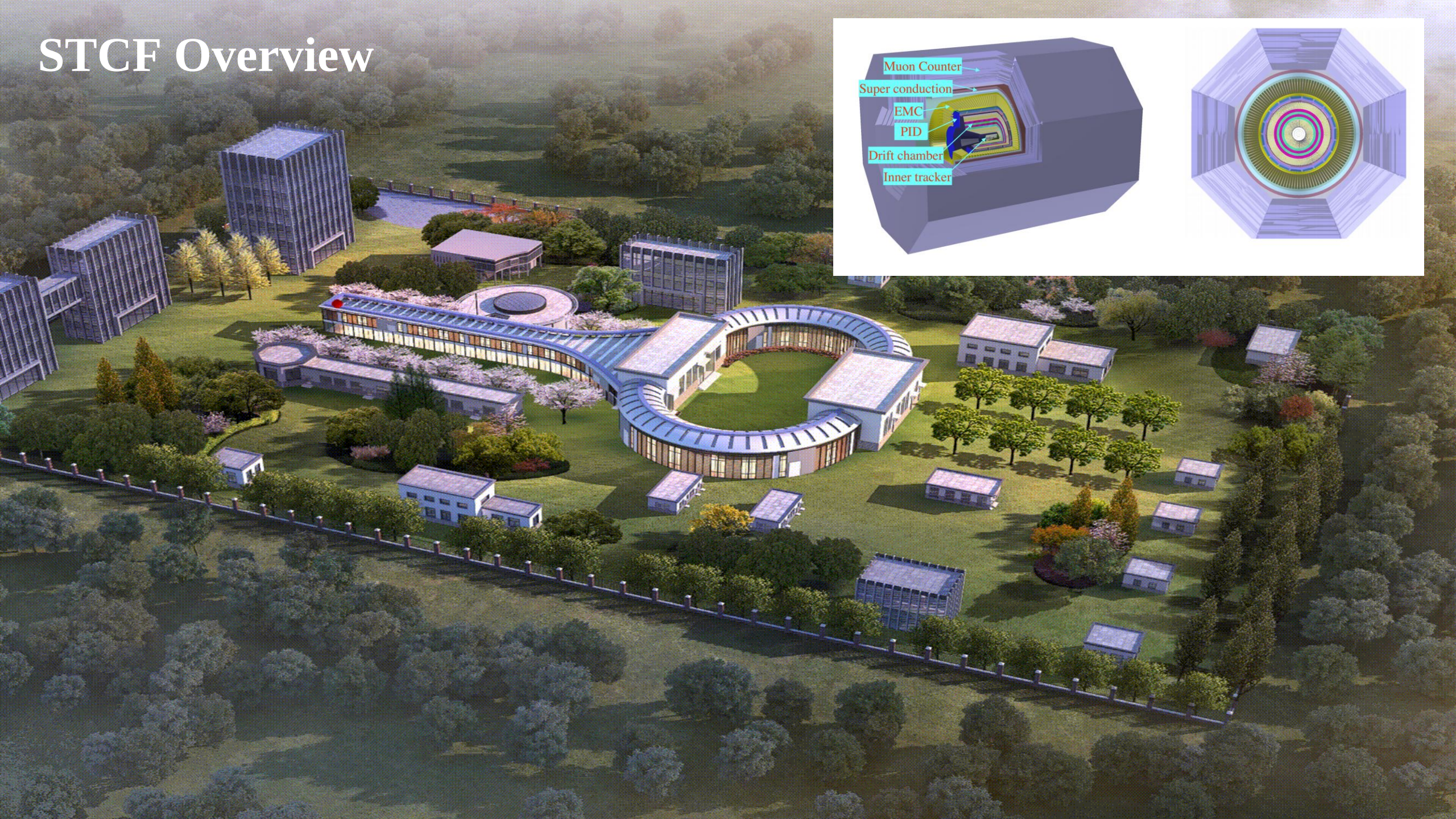
- STCF: a natural extension of BEPCII and a viable option for a post-BEPCII HEP project in China



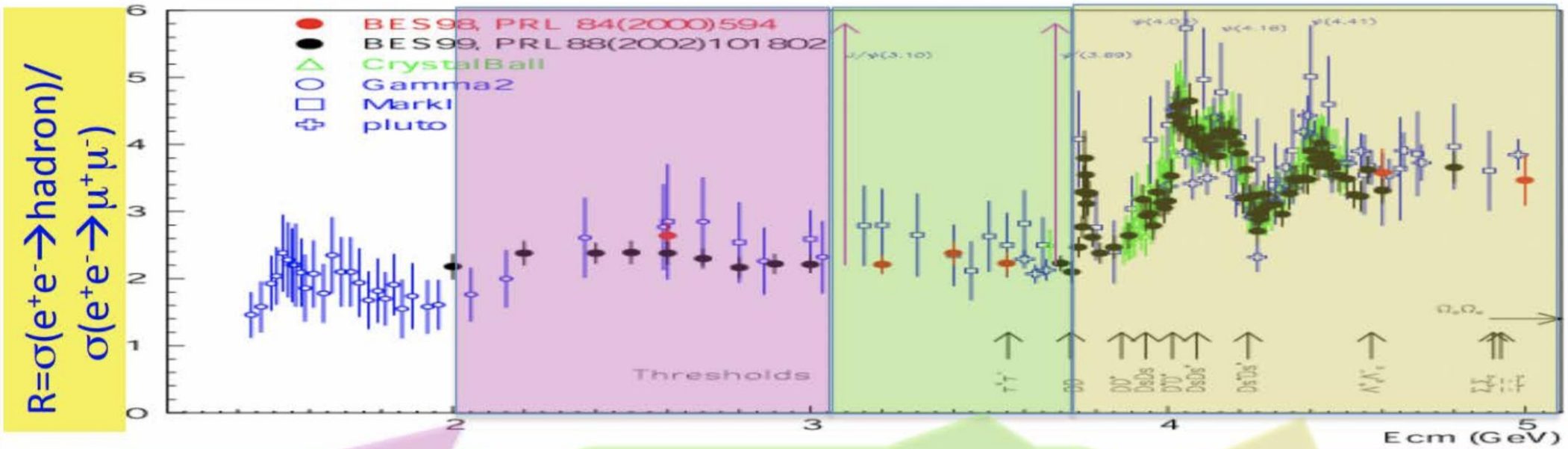
- $E_{cm} = 2 - 7$ GeV, $L \sim 0.5 \times 10^{35} \mathrm{cm}^{-2} s^{-1}$@4GeV
- Symmetrical collision
- double-ring, 600-800 m
- Large Piwinski angle & Crab waist
- Upgradable for polarized electron beam

A Super $\tau - C$ machine far beyond BEPCII

STCF Overview



Physics opportunities



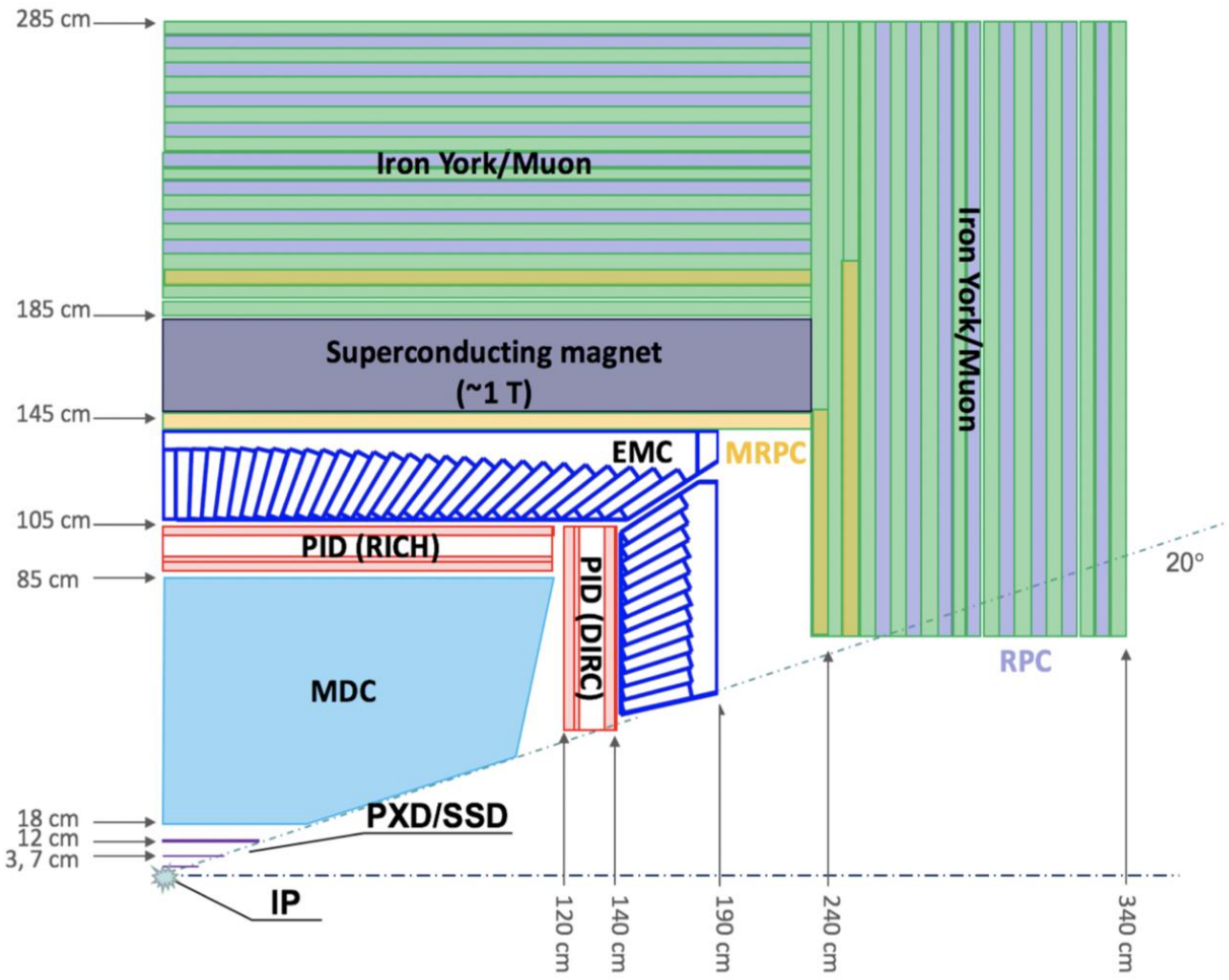
- Hadron form factors
- Y(2175) resonance
- Mutltiquark states with s quark, Zs
- MLLA/LPHD and QCD sum rule predictions

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

- XYZ particles
- D mesons
- f_D and f_{Ds}
- D_0-$\bar{D}_0$ mixing
- Charm baryons

S.Olsen HIEPA 2015 Workshop

STCF Detector Concept



PXD

- ~0.15%X_0 / layer
- σ_{xy}~50 μm

MDC

- σ_{xy}<~130 μm
- σ_p/p ~ 0.5% @ 1 GeV
- dE/dx~6%

PID

- π/K (and K/p) 3-4σ separation up to 2GeV/c

EMC

E range: 0.02-2.5GeV

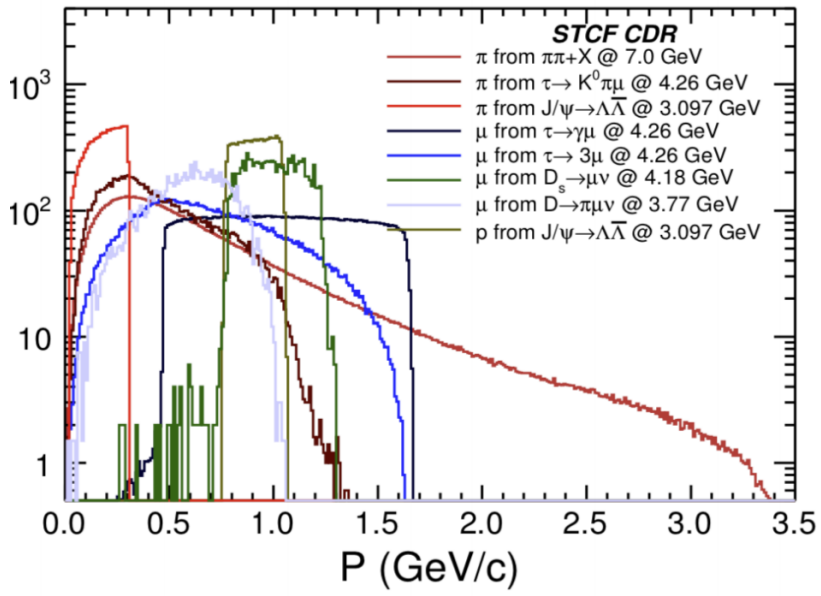
At 1 GeV	σ_E (%)
Barrel:	2
Endcap:	4

MUD

- Down to <~0.4GeV
- π suppression >10

PID Detector Requirements

- Wide PID range
  - Cherenkov-based technology
  - Low p region(<0.6GeV) covered by trackers dE/dx measurement
- Compact (<20cm) and low material budget (< $0.5X_0$)
  - Limited optical focusing methods
  - RICH/FTOF/DIRC
- Large solenoid angle coverage



Charged particles

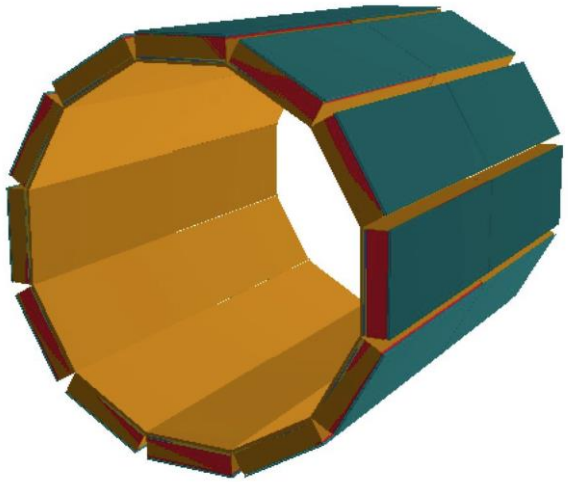
- E_{cm} being up to 7 GeV calls for PID in a large momentum range (up to 2GeV/c)
- Technology beyond dE/dx + TOF is required for PID up to 2GeV

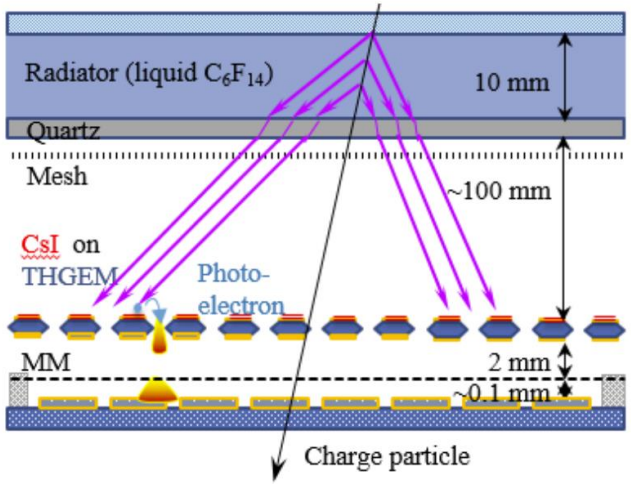
PID

- π/K (and K/p) 3~4σ separation up to 2 GeV/c
- π/μ separation capacity for low momentum.

RICH Design

- 3σ π/K @ 2GeV
- Material budget: ~15%
- Thickness: ~ 100mm
- Rate: <5kHz/cm^2@R>20cm
- Gain:~10^5
- IBF:~10^{-3}
- Cum.Charge:<2uC/cm^2@10year
- Pad: 0.5×0.5cm^2
- Expected Res: <1.5 mrad



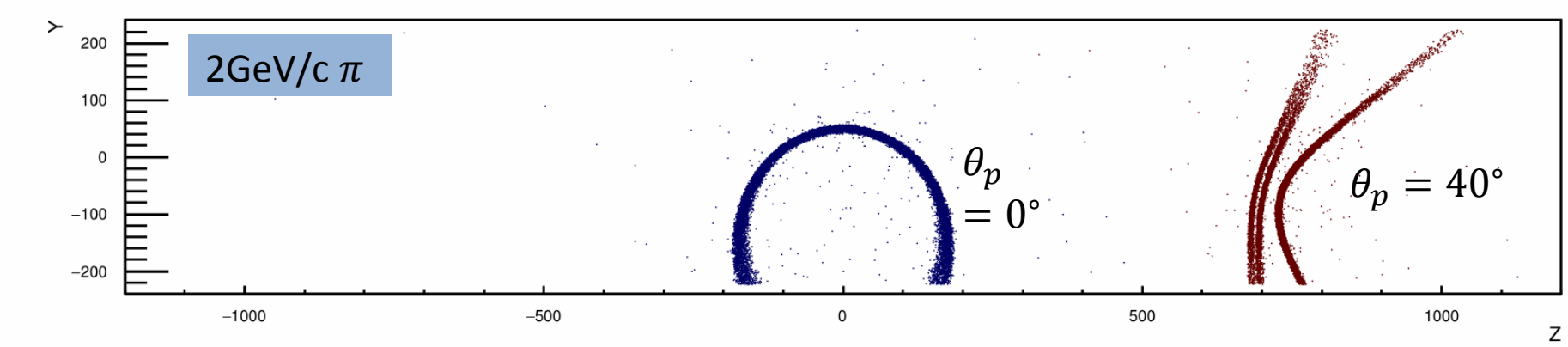


THGEM + MM

- **Proximity focusing RICH with CsI-coated MPGD readout**
- **Proximity gap ~ 10 cm, Sensor size 5mm*5mm**
- **Radiator: liquid C_6F_{14}, n~1.3**

• Likelihood Method

Hard to find analytic equation ⇒ Likelihood method.



- The photon collected in each anode pads follows the **Poisson distribution**

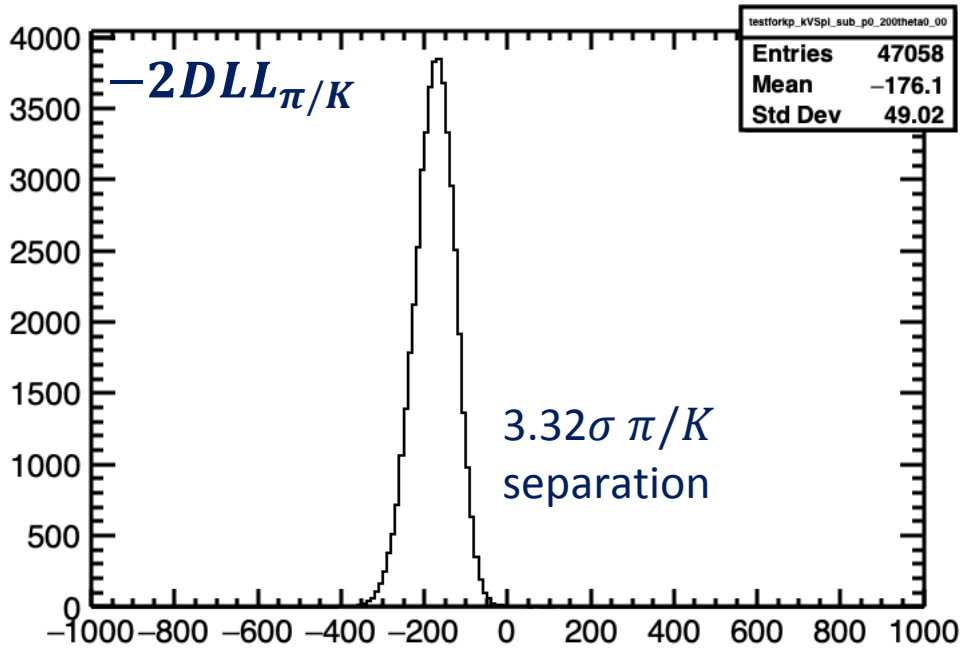
$$pdf_{i,h} = Poisson\left(N_i + 10^{-3}, mean_{i,h} + 10^{-3}\right),$$

- Likelihood of h hypothesis:

$$\ln \mathcal{L}_h = \sum_i^{npads} \ln pdf_{i,h}$$

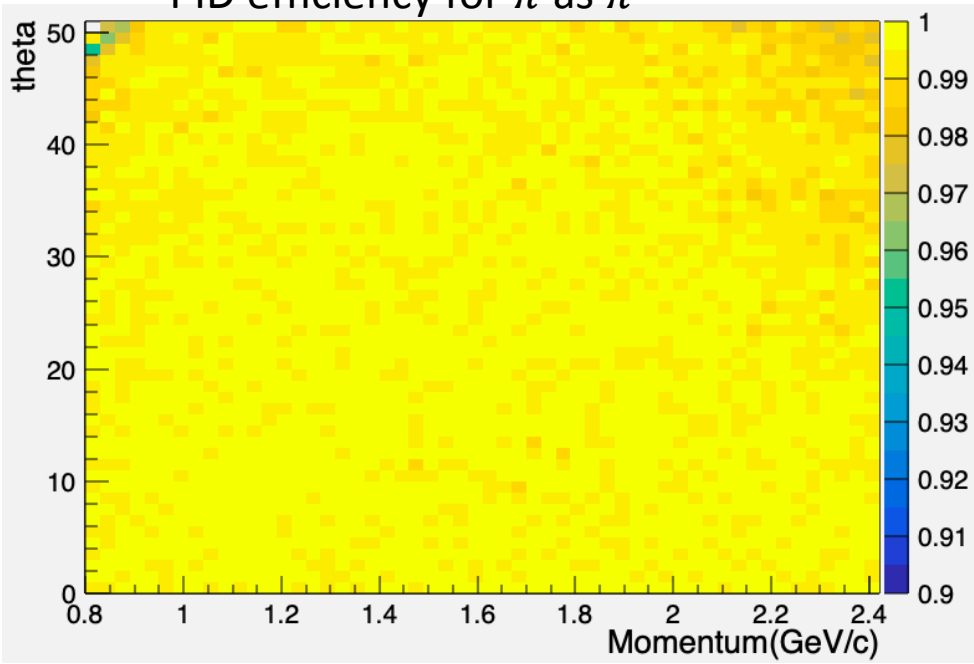
- π, K separation:

$$DLL = \sum_i^{npads} \ln \frac{pdf_{i,\pi}}{pdf_{i,K}}$$

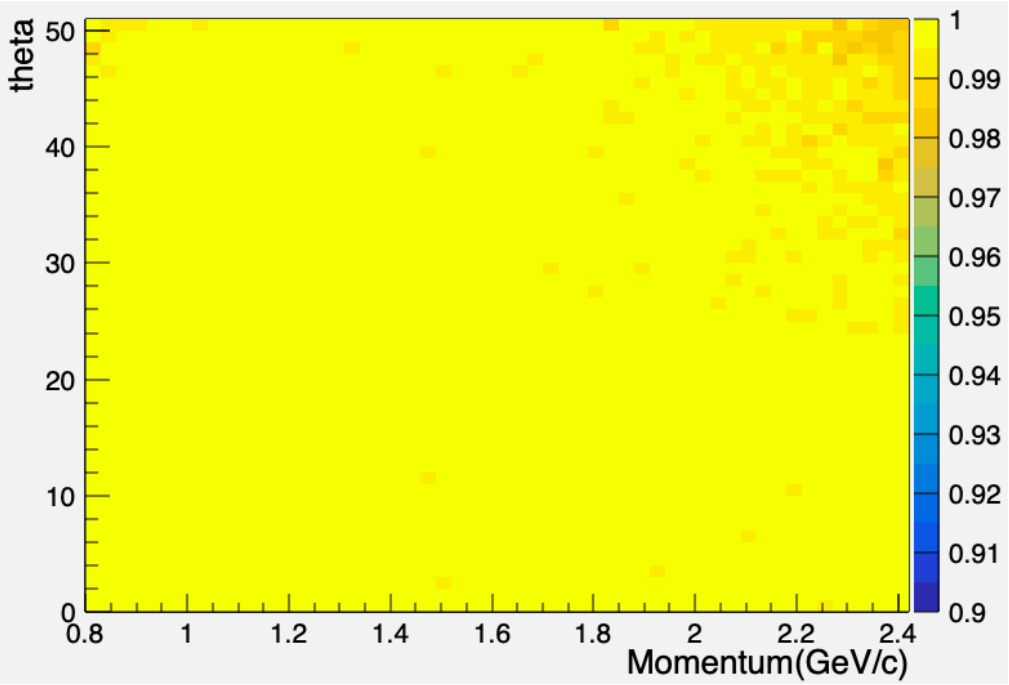


Likelihood Method PID Power

PID efficiency for π as π

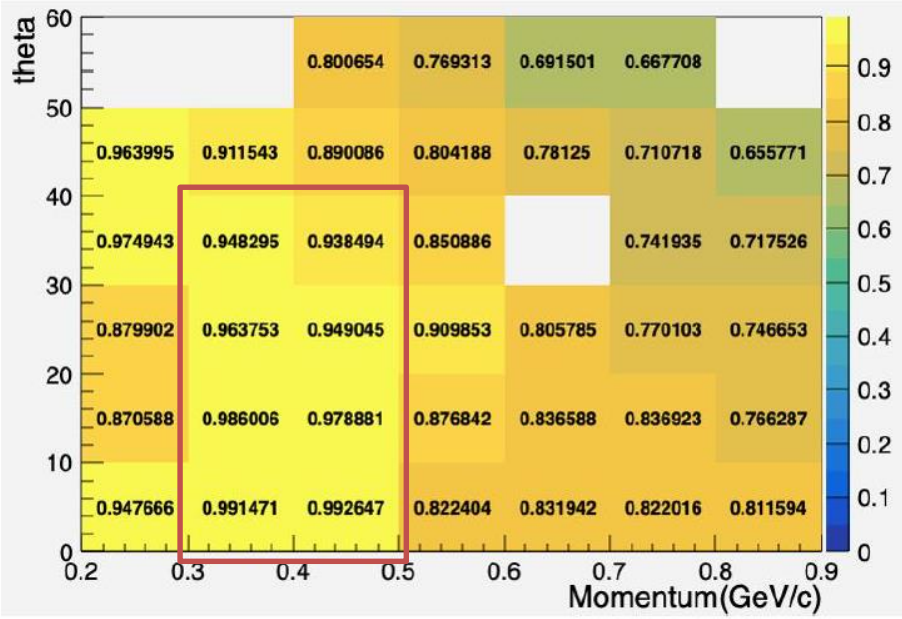


PID efficiency for K as K

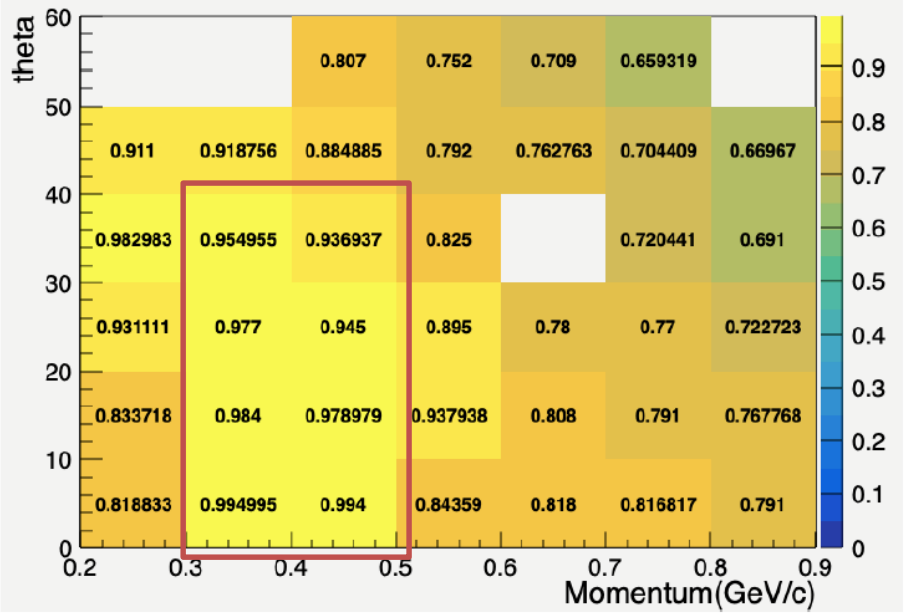


K/π 3.3σ separation up to 2.0GeV/c
K/p 3.3σ separation up to 2.0GeV/c

Low Momentum μ/π Separation



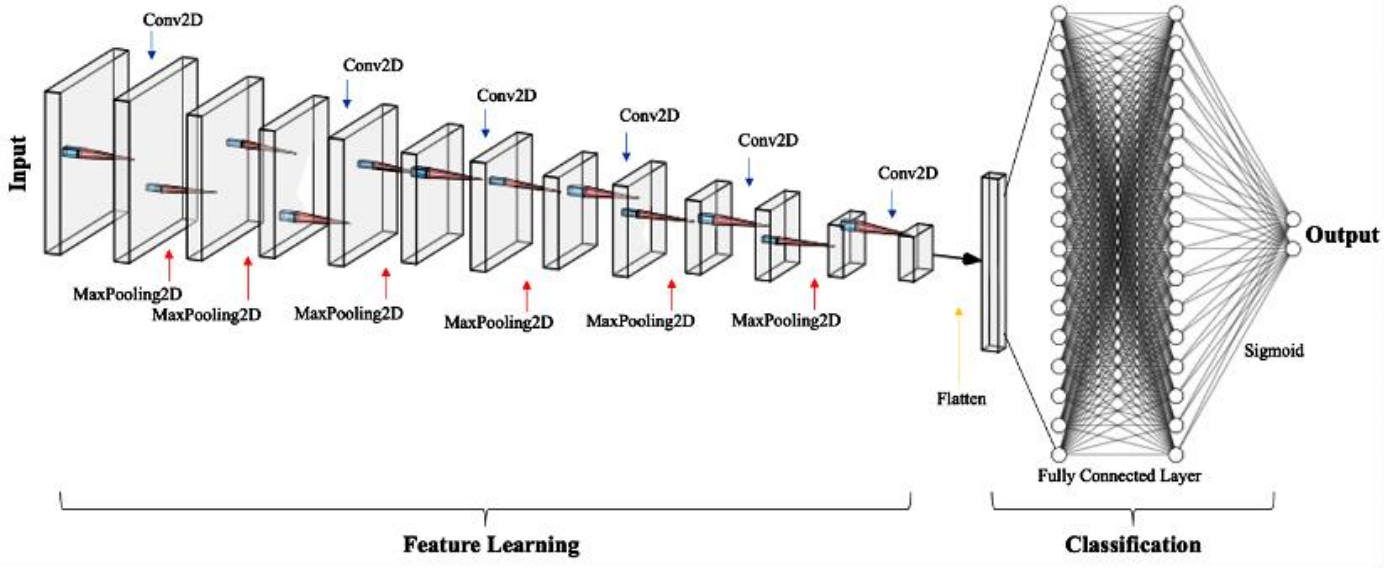
π efficiency

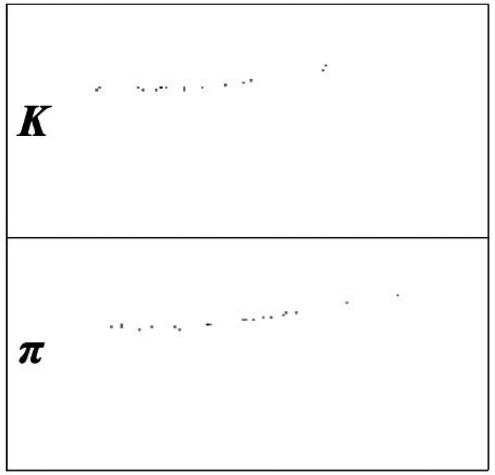


μ efficiency

>90% pid efficiency for momentum range (0.3GeV/c~0.5GeV/c) and polar angle (0°~40°)

Classification using CNN



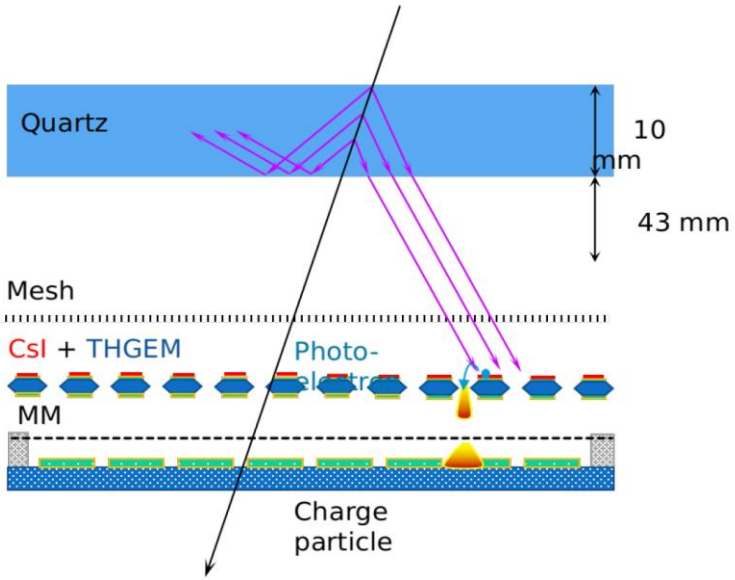


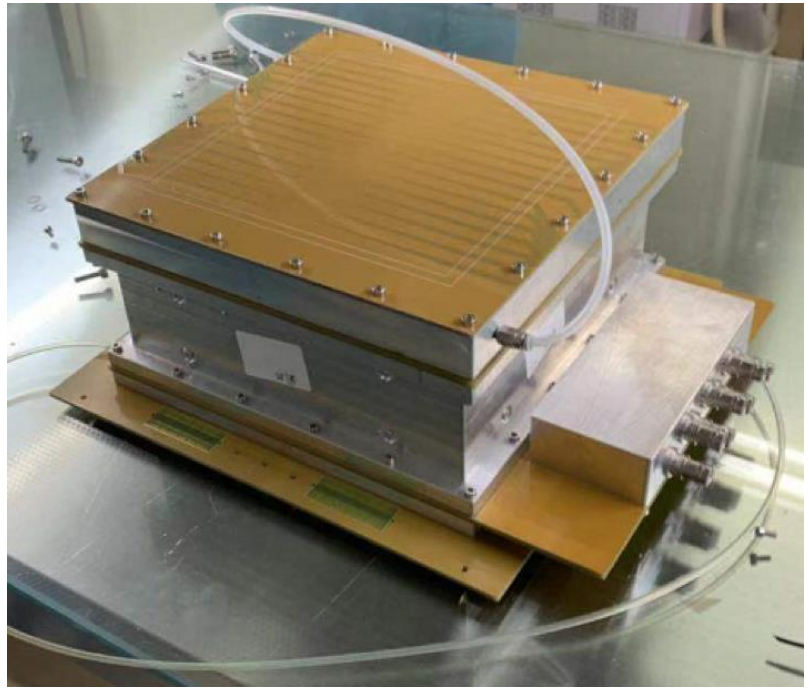
Using CNN to classify three hadrons.

PID efficiency ~ similar level of likelihood method.

Highly accelerate the execution time to 2evt/ms (1 2080Ti).

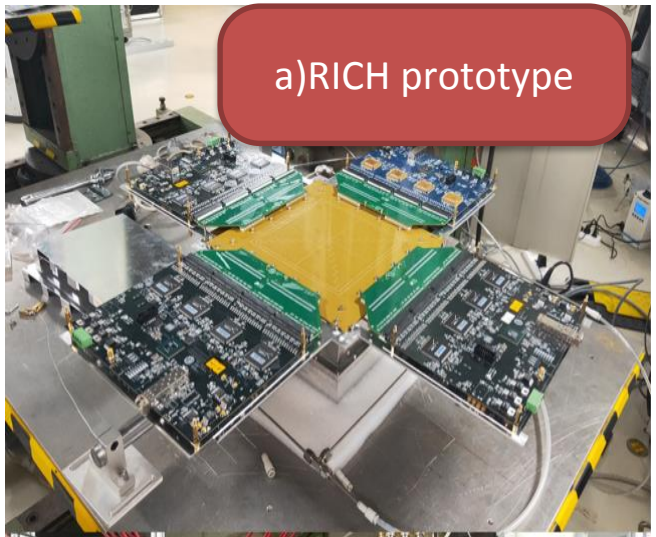
Develop the RICH Prototype

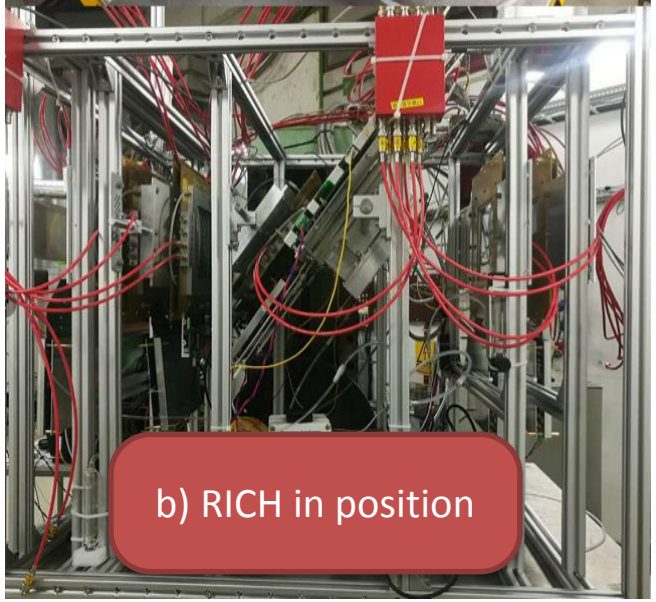




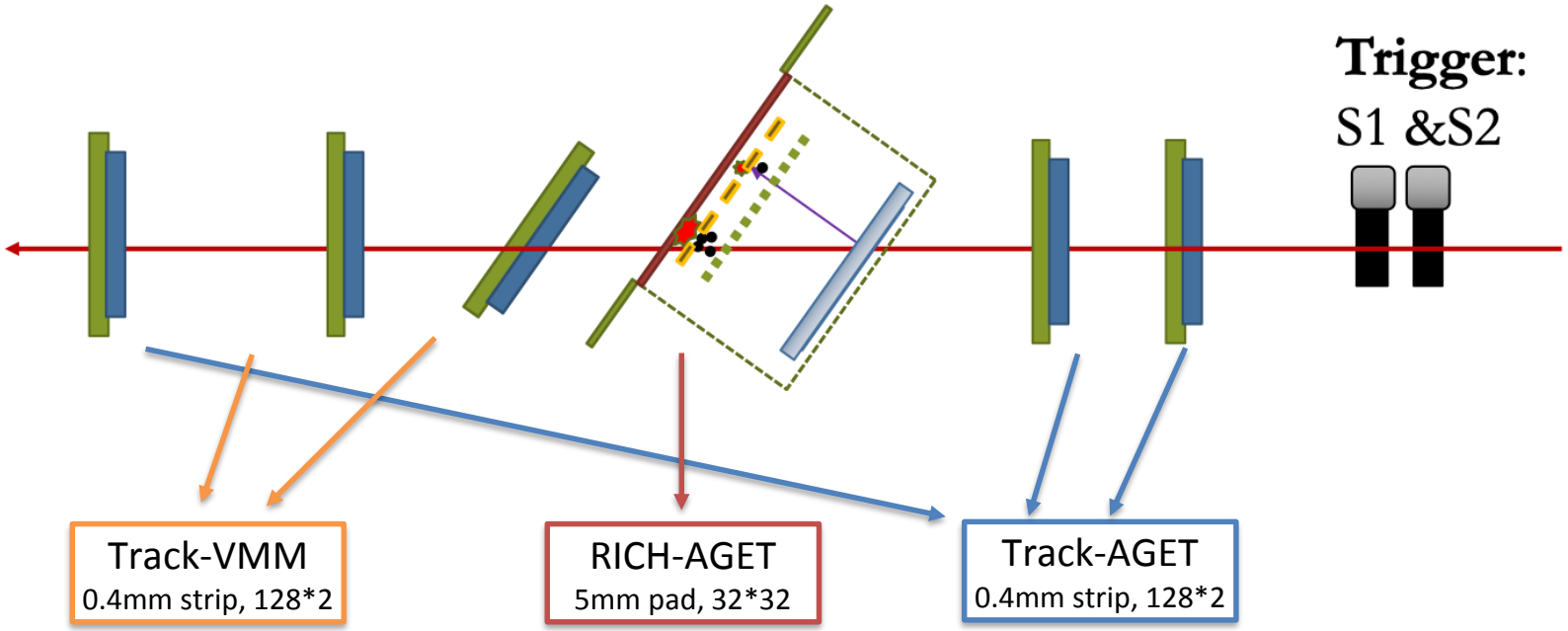
- Effective area: 16X16 cm^2
- Quartz as radiator (10mm) will be replaced by C6F14
- THGEM+CsI (700nm)
- Anode pad(5mm^2)
- AGET FEE: 1024 channels

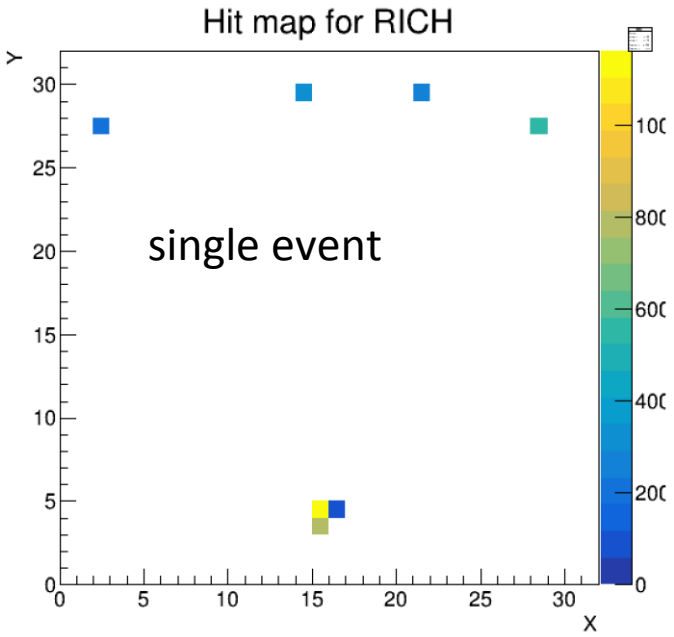
RICH prototype beam-test @DESY

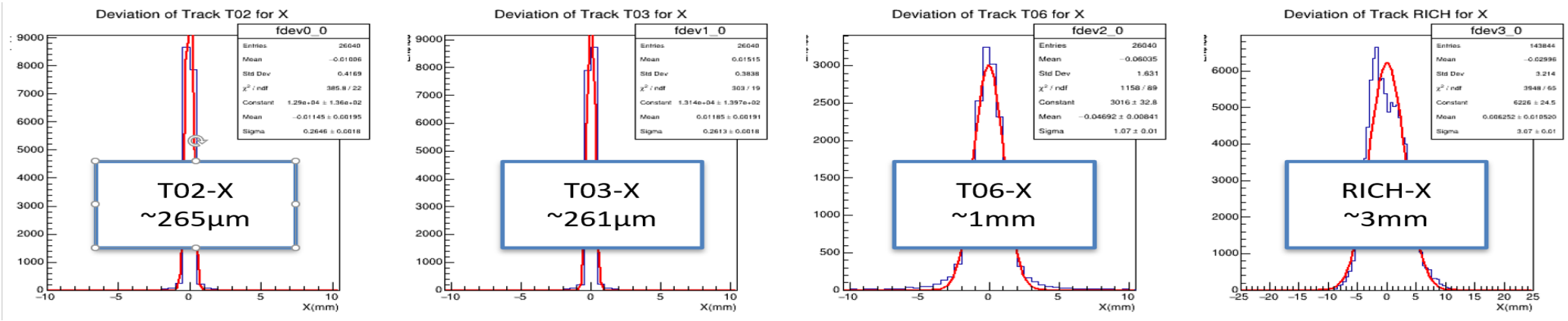




Spatial resolution







T06 is getting worse due to the e- scattering

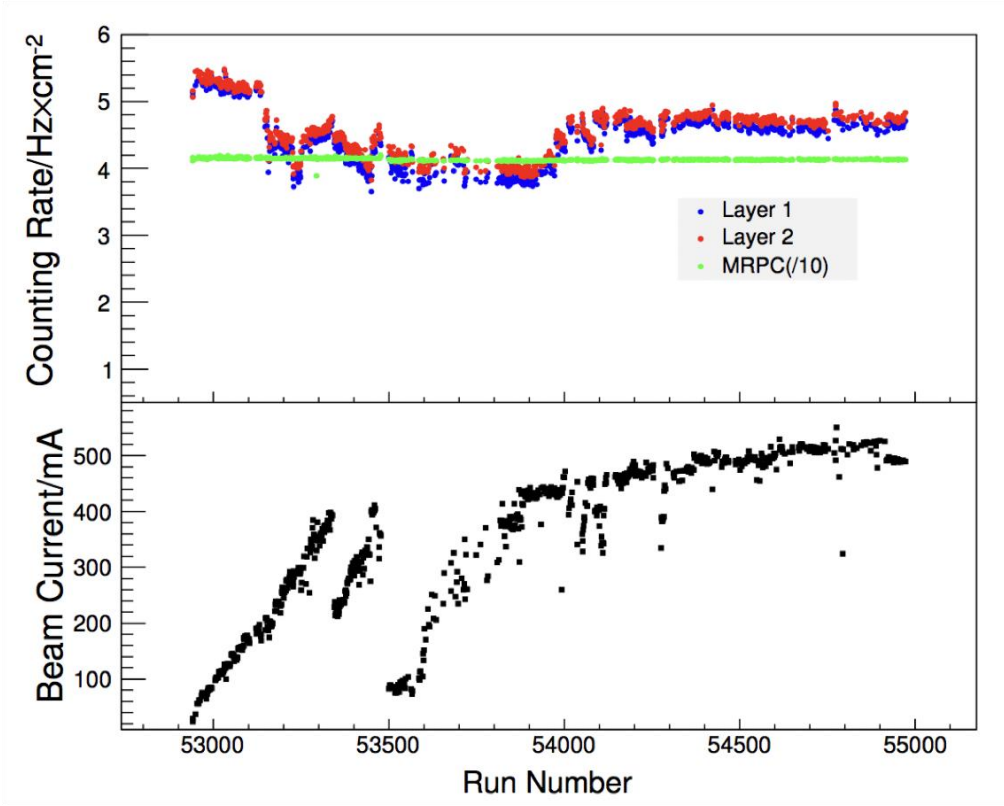
• Summary

- STCF PID requires 2GeV/c π/K separation, and RICH can satisfy this requirement.
- Via the Likelihood method, >3σ separation capability can be reached by RICH in STCF. and can offer π/μ PID in low momentum range.
- Test-beam @DESY shows the current base-line design is functional and can fulfill the requirements. Preliminary results are presented.

Thank you !!

- backup

counting rate extrapolated from BESIII



- Barrel: 400 Hz/cm^2
- Endcaps: 4kHz/cm^2
- May include significant contributions from detector/electronics noise since no clear dependence on beam current is seen