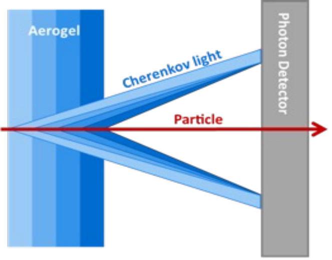
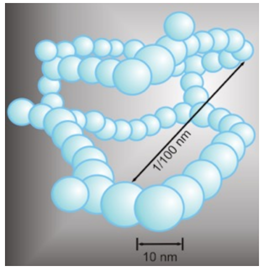




Prospects of aerogel R&Ds at the BINP

A. Barnyakov

on behalf of ``Aerogel group”

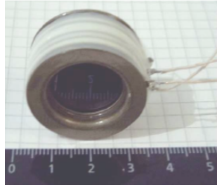
- ASHIPH technique for future colliding beam experiments
- FARICH method for PID in wide momentum range
- Ultralight aerogel based RICH for PID above 20 GeV/c

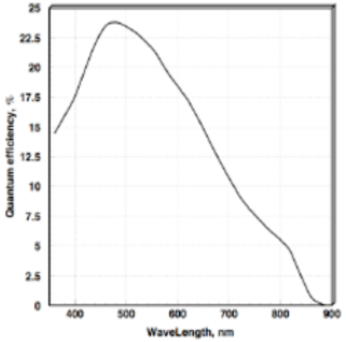
The International Workshop on Future Tau Charm Facilities,
Huangshan University, Huangshan 2025

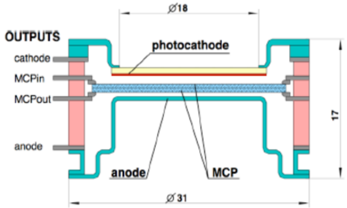
- Upgrade of the SND ASHIPH system
- ASHIPH-SiPM as backup option for the SPD
- The VEPP-6 PID system based on ASHIPH-SiPM
- The ASHIPH system option for the STCF

Upgrade of the SND ASHIPH system

MCP PMT

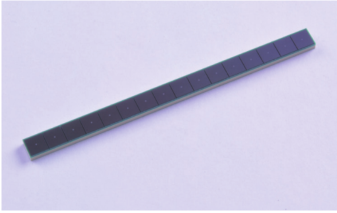


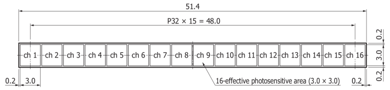


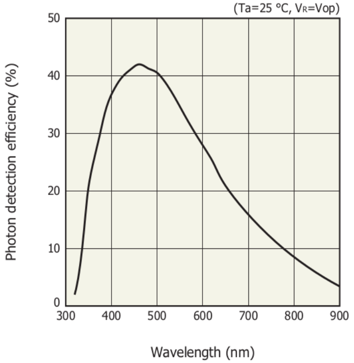


- Manufacturer: "Ekran FEP"(Novosibirsk)
- Borosilikate glass window
- Multialkali (Sb-Na-K-Cs) photocathode
- MCPs with channel diametr of 7 μm
- Maximum QE=23% at λ=500 nm
- Photoelectron collection coefficient $\sim$0.6
- PDE=QE*CE=23*0.6$\simeq$14%
- Axial magnetic field
- Power supply 3÷4 kV

MPPC (Multi-Pixel Photon Counter) S13363-3050NE-16





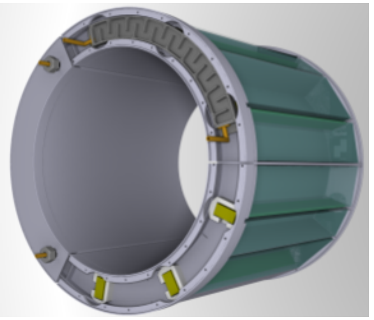


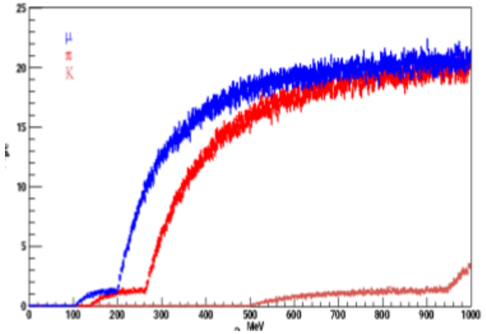
- Manufacturer: "Hamamatsu"
- Effective photosensitive area/channel 3$\times$3 mm
- Number of cells/pixel 3584
- PDE=40% at λ=500 nm
- Any direction magnetic field
- Power supply <100 V (V_{BR}=53 V typ.)
- High level of DCR (0.5 Mcps)

Change of MCP PMT to MPPC will alow us to increase N_{pe} by factor of 2÷2.5!!!

SND ASHIPH upgrade status

ASHIPH for SND (VEPP-2000, Novosibirsk)





N_{pe} from parametric simulation

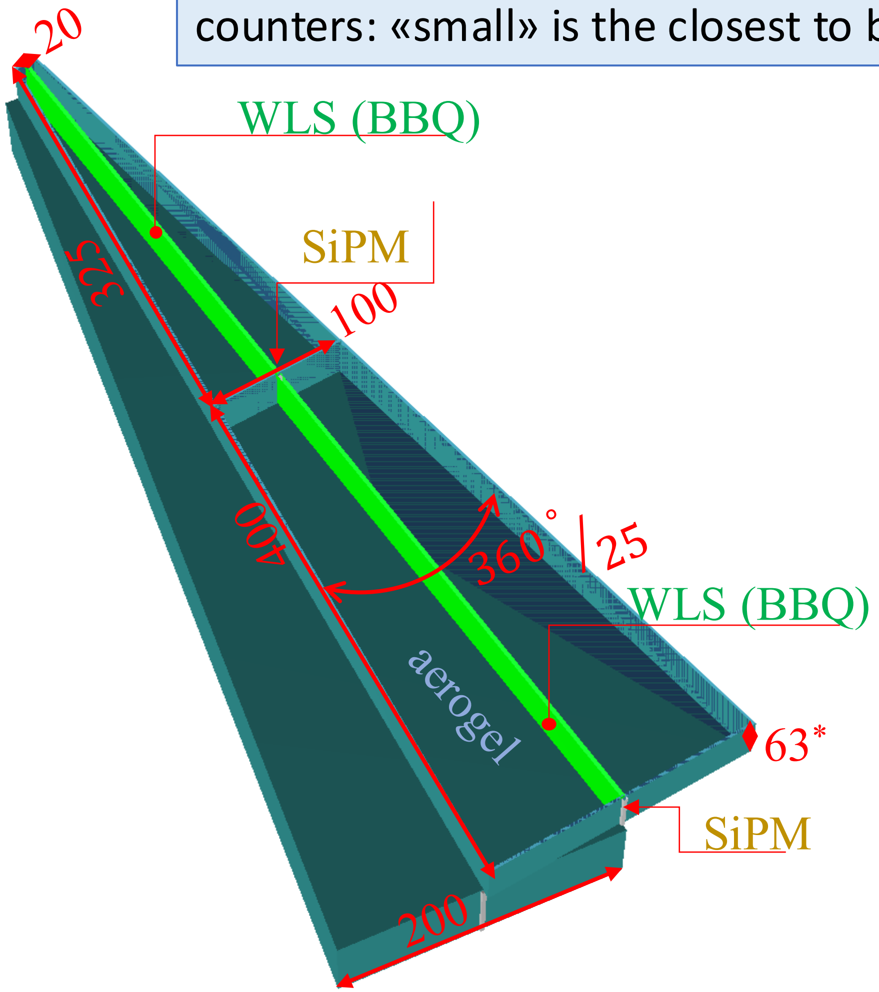
- 9 counters $26\times10\times3$ cm^3 in 1 layer
- WLS(BBQ) $260\times17\times3$ mm^3
- $5\times9=45$ SiPMs 3×3 mm^2
- Two system options: aerogel with n=1.13 and n=1.05 (thickness 3 cm)
- n=1.13 – $N_{pe}(\beta=1)\approx20$
  - π/K-separation $\geq5\sigma$ – 0.3÷1 GeV/c (thr. ∼4ph.e.)
- n=1.05 – $N_{pe}(\beta=1)\approx10$
  - e/π-separation $\geq4\sigma$ – 0.1÷0.4 GeV/c (thr. ∼3ph.e.)

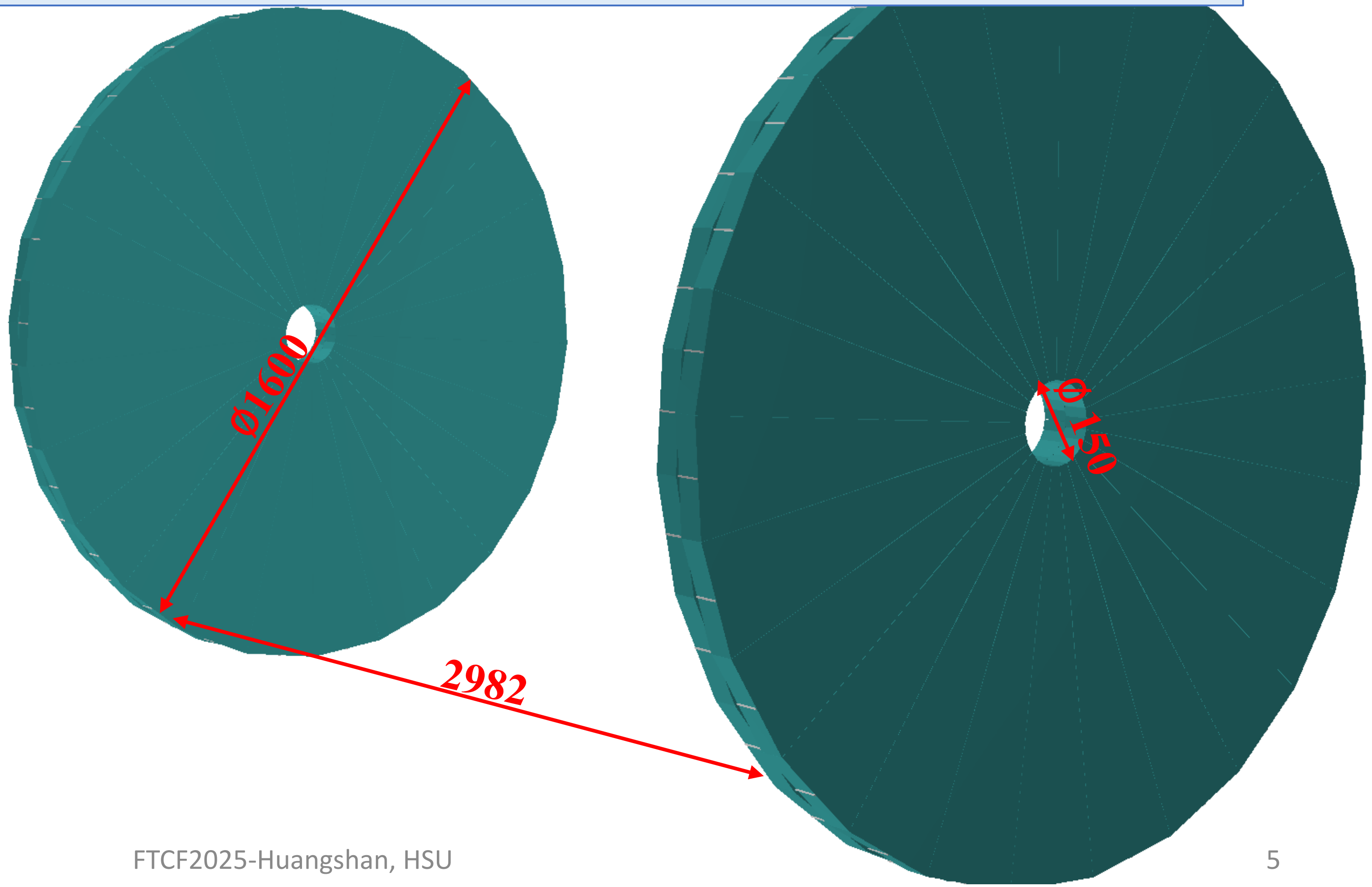
Upgrade is already in progress!

- There are two ASHIPH subsystems (with n=1.13 and n=1.05) for both of them new PDs based on MPPC (Hamamatsu) are under construction.
- Test beam results with relativistic electrons performed at the BINP beam test facility are in good agrement with simulation and expectations.
- Upgrade finalization is expected in 2026-2027
- See more details in publications:
  - *Int.J.Mod.Phys.A* 39 (2024) 26n27, 2442005
  - *Phys.Part.Nucl.* 56 (2025) 3, 687-691

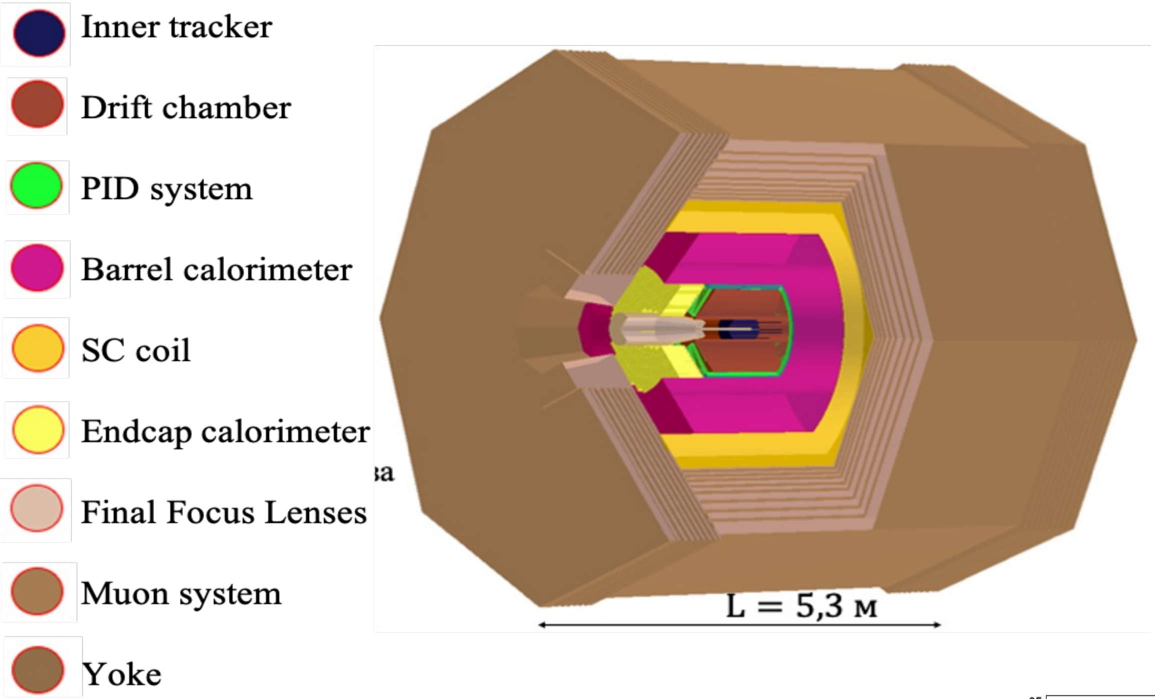
ASHIPH system proposal for SPD-NICA

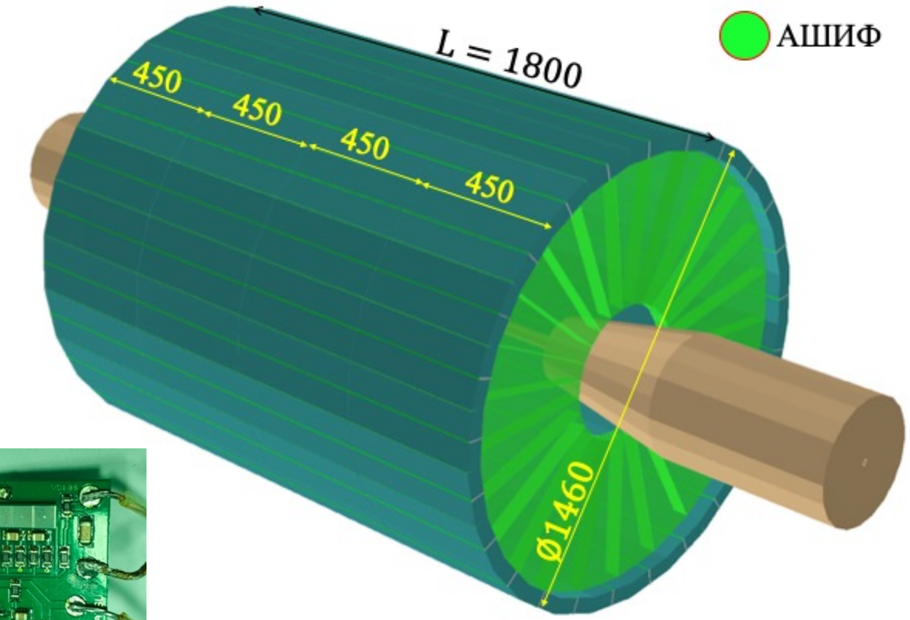
- 2 endcaps with 2 layer per each
- Each endcap formed by 25 sectors (trapezoidal shapes)
- Each layer is shifted by φ one from another at half of period: $^{360^\circ}/_{25\bullet 2}$
- Each sector is divided by two segments along radius of the system to form two light separated counters: «small» is the closest to beam-pipe and «large» at the far distance from the beam-pipe

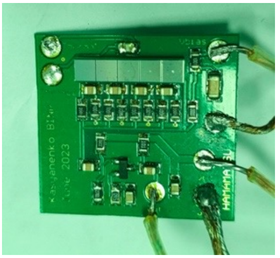


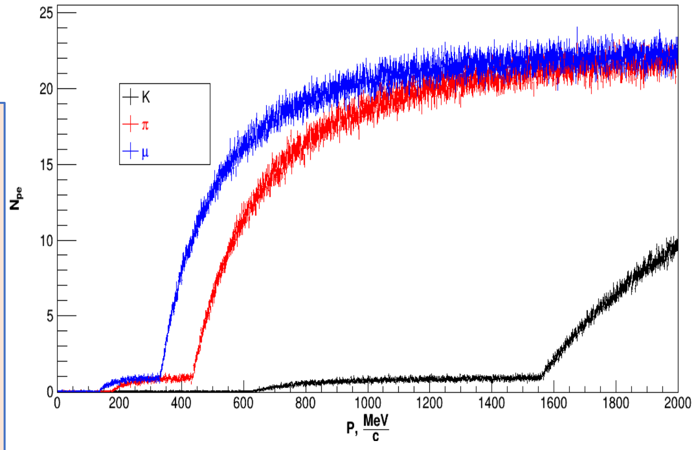


ASHIPH system concept for experiment at VEPP-6







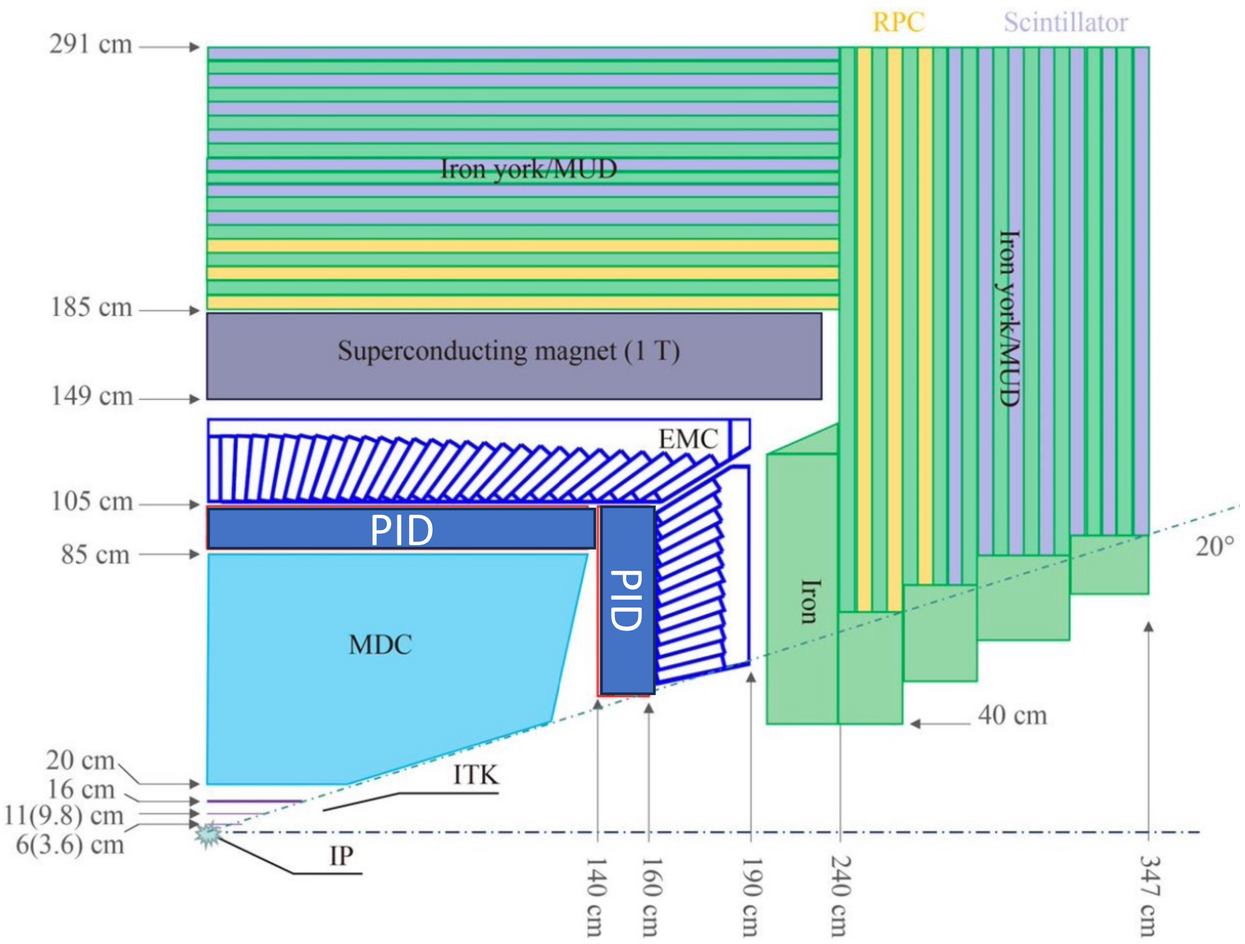


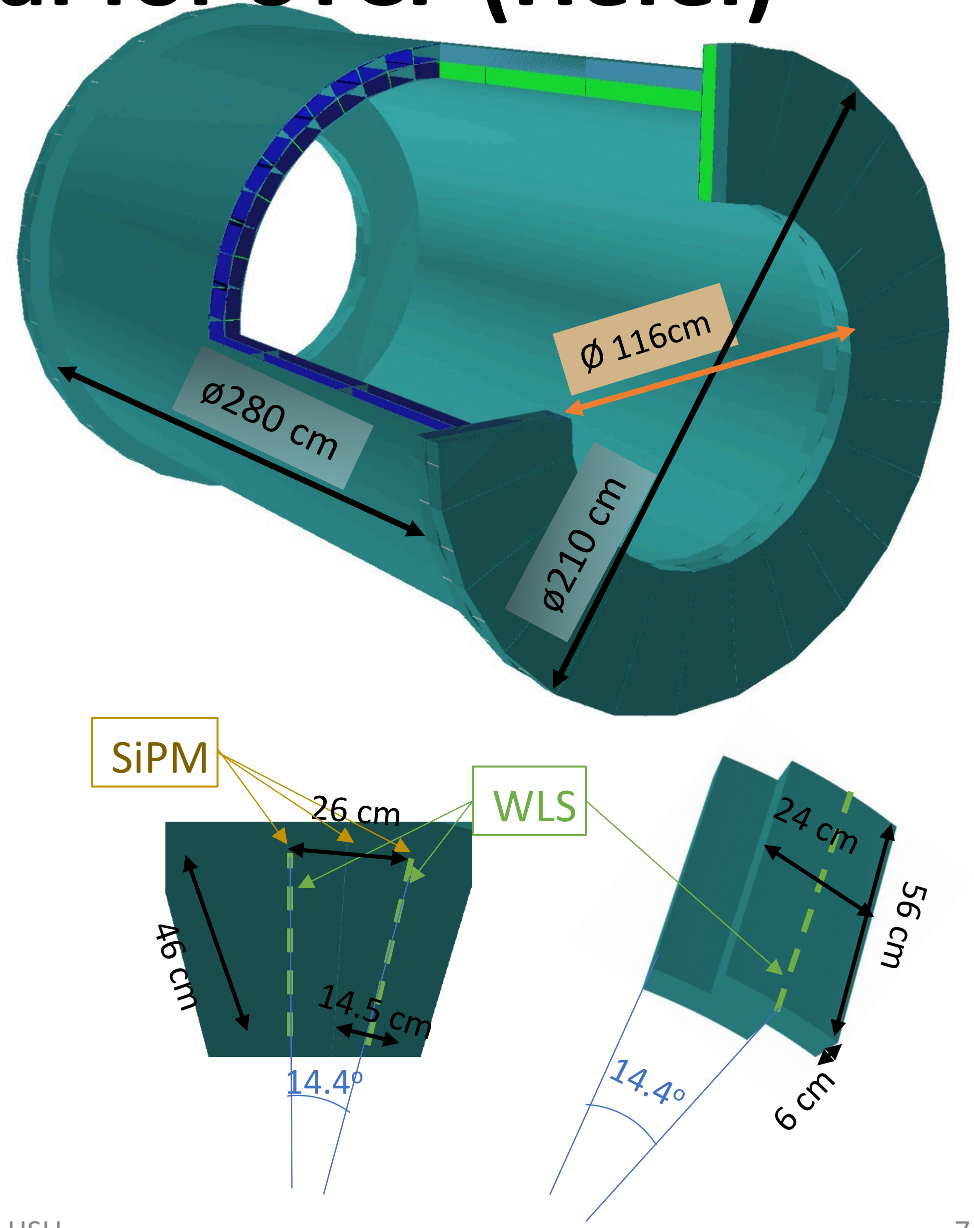
- t[cm]/n : 8[cm]/1.05
  - $N_{pe}^{\Sigma}(\beta = 1) \approx 20$
  - 300 counters 45x17x4 cm^3 in 2 layers
  - WLS – BBQ 45x20x3 mm^3
  - (6÷12)x300=1800÷3600 SiPM 3x3 mm^2
- π/K– separation:
  - $\geq 4\sigma$ – 0.5÷1.5 GeV/c (threshold ~5pe)
  - $\geq 2.5\sigma$ – 1.5÷2.0 GeV/c (threshold ~10pe)

An universal detector concept for experiments at the VEPP-6:

- L ~ 10^{34}cm^{-2}s^{-1}
- 2E = 2÷4(5) GeV
- e^+e^-– collider
- Magnetic field – 1÷1.5 T

ASHIPH system proposal for STCF (Hefei)





Thickness of ASHIPH system for the STCF

Substances and details

- G10 – X_0=32.17 g/cm²; ρ=1.8 g/cm³ → X_0= 32.17/1.8= 17.87 cm
- PMMA – X_0=40.55 g/cm²; ρ =1.19 g/cm³ → X_0= 40.55/1.2= 34.08 cm
- Quartz – X_0=25.66 g/cm²; ρ =2.40 g/cm³ → X_0= 25.66/2.4= 10.69 cm
- Peltier module for cooling system (like ceramics) –
  X_0=27 g/cm²; ρ =2.5 g/cm³ → X_0= 27/2.5= 10.8 cm
- Aerogel n=1.03 – X_0=27.25 g/cm²;
  ρ =0.14 g/cm³ → X_0= 27.3/0.14= 196.04 cm
- Aluminum → X_0= 8.9 cm
- Carbon fibre → 0.5V X_0(C)=42.7/2.=21.3 cm + 0.5V X_0(epoxy)=43.25/1.39=32.5cm

[https://cds.cern.ch/record/1279627/files/PH-EP-Tech-Note-2010-013.pdf],

then 1.69/X_0=0.5·2/42.7+0.5·1.39/43.25 → X_0=42.92g/cm² and ρ(CFRP)=0.5*1.39+0.5*2=1.7g/cm³

→X_0(CF)=42.9/1.7= 25.32cm

2 layers of the cylindrical system with ø180 cm and 200 counters for perpendicular tracks:

- 12 cm of aerogel (n=1.03) – 12/196 =6.1% X_0
- WLS averaged for whole barrel: 200·0.3·6·50=18 000 cm³/(π·ø·200) ~ 0.15/34.1 =0.45%X_0
- Electronics averaged for whole barrel: 200·6·6·0.2=1440 cm³/(π·ø·200) ~ 0.013/17.9 =0.07%X_0
- Peltier modules (2 modules 3·3=9 cm² with 0.5 cm thick per each counter) averaged for whole barrel:
  200·2·9·0.5=1 800 cm³/(π·ø·200) ~ 0.016/10.8=0.14%X_0

In TOTAL 6.8%X_0 + wall's material for perpendicular tracks.

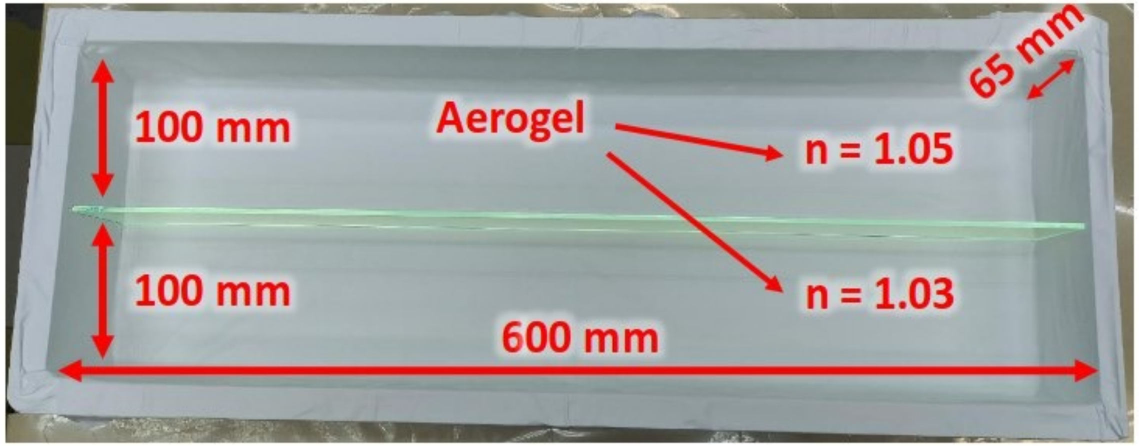
The walls of the counters will be 1 mm thick, therefore 4 mm from cylindrical shapes of the system plus rear edges of the counter's boxes averaged for whole barrel part of the system: 200·6·0.1·(50+20+50+20)=16 800cm³/(π·ø·200)~0.15cm

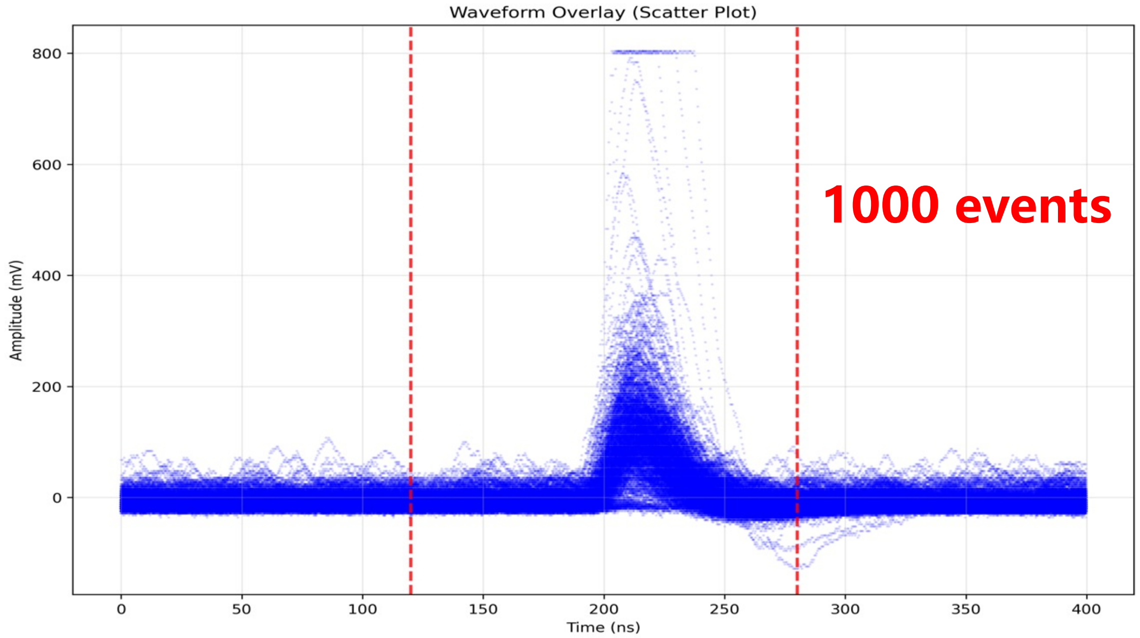
- If the wall's will be made from Al 0.55cm/8.9 cm= 6.2%X_0
- If the wall's will be made from CF 0.55cm/25.3 cm= 2.2%X_0

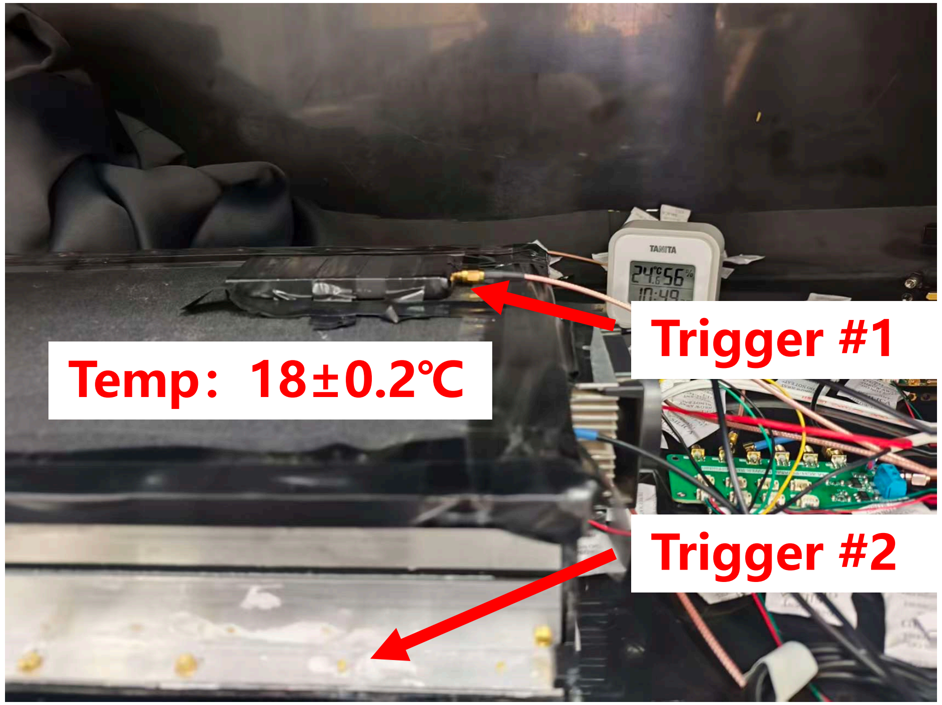
SUMMARY:

- ASHIPH system could be as thin as 9%X_0 if its frames will be made from CFRP (Carbon Fiber Reinforced Plastic)
- And it could be 13%X_0 if its frames will be made from *Al*
- In any case it semms like ASHIPH is the most thin reliable specialised PID system now

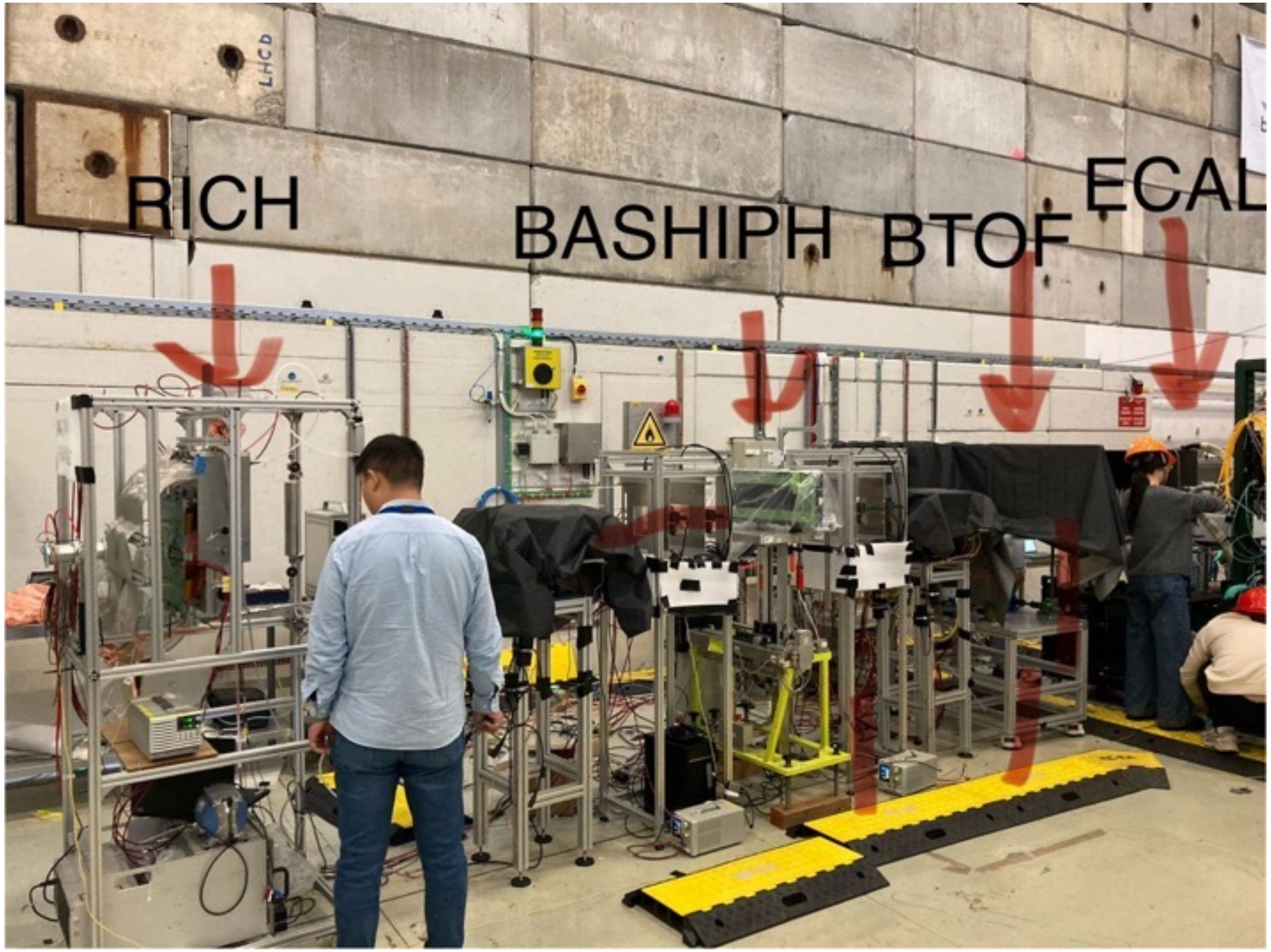
ASHPH-SiPM prototype assembled/tested @ FDU







STCF beam test campaign 15 – 29 October 2025 at PS-T9 (CERN)



5 prototypes were tested:

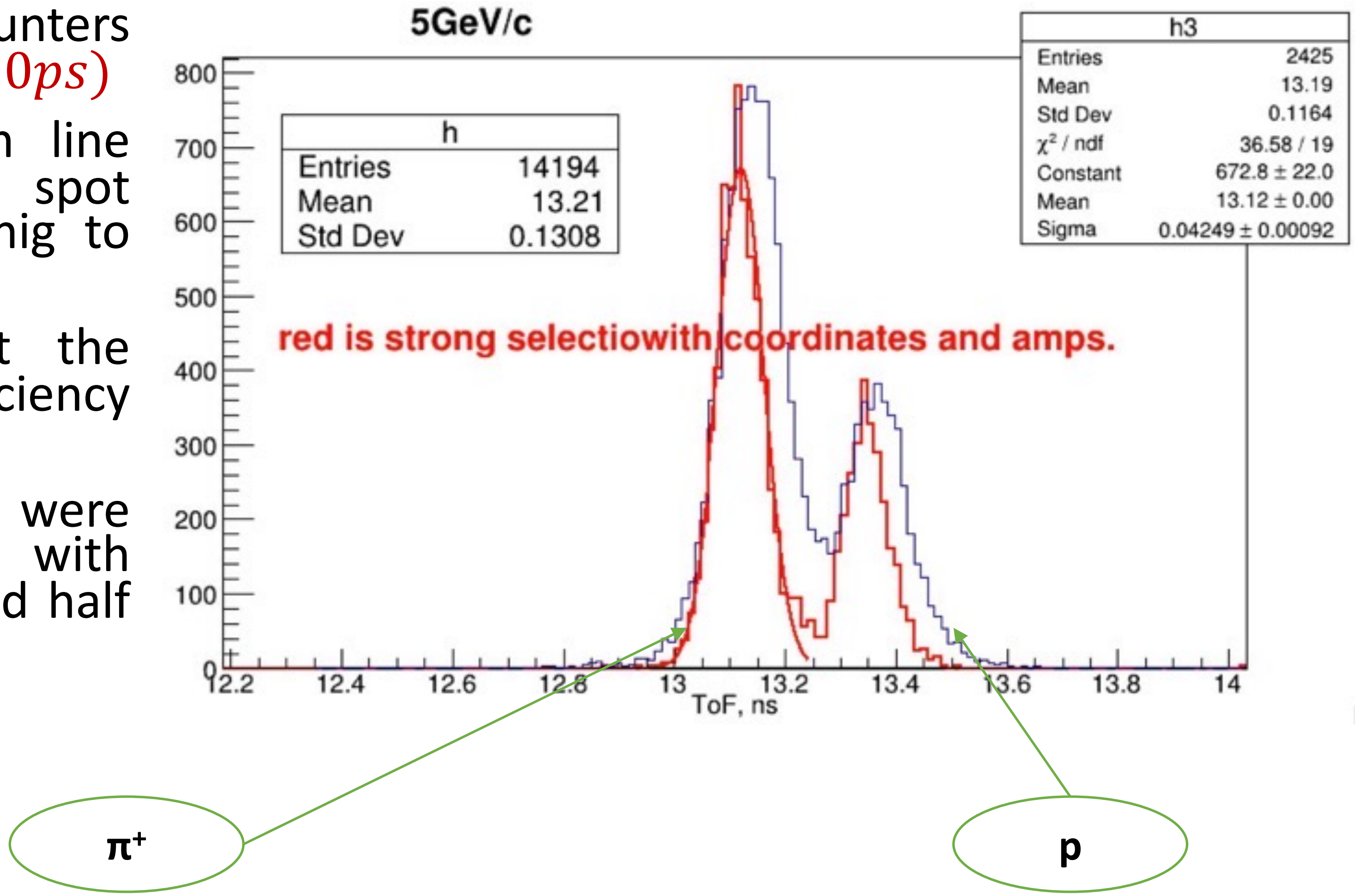
- ECAL (array of 25 pCsI crystals painted by NOL-9)
- C_6F_{12} RICH based on MPGD with CsI-PC as photon detector
- Barrel DIRC-Like-TOF (BTOF) based on fused silica and MCP-PMT (Hamamatsu)
- ***Barrel ASHIPH (BASHIPH) based on aerogel with n=1.05 and 1.03 plus NDL-SiPM and FDU-readout***
- Transition Radiation Detector (TRD) for some space experiment

4 beamline rearrangements were performed during the week from 22 to 29 Oct. 2025

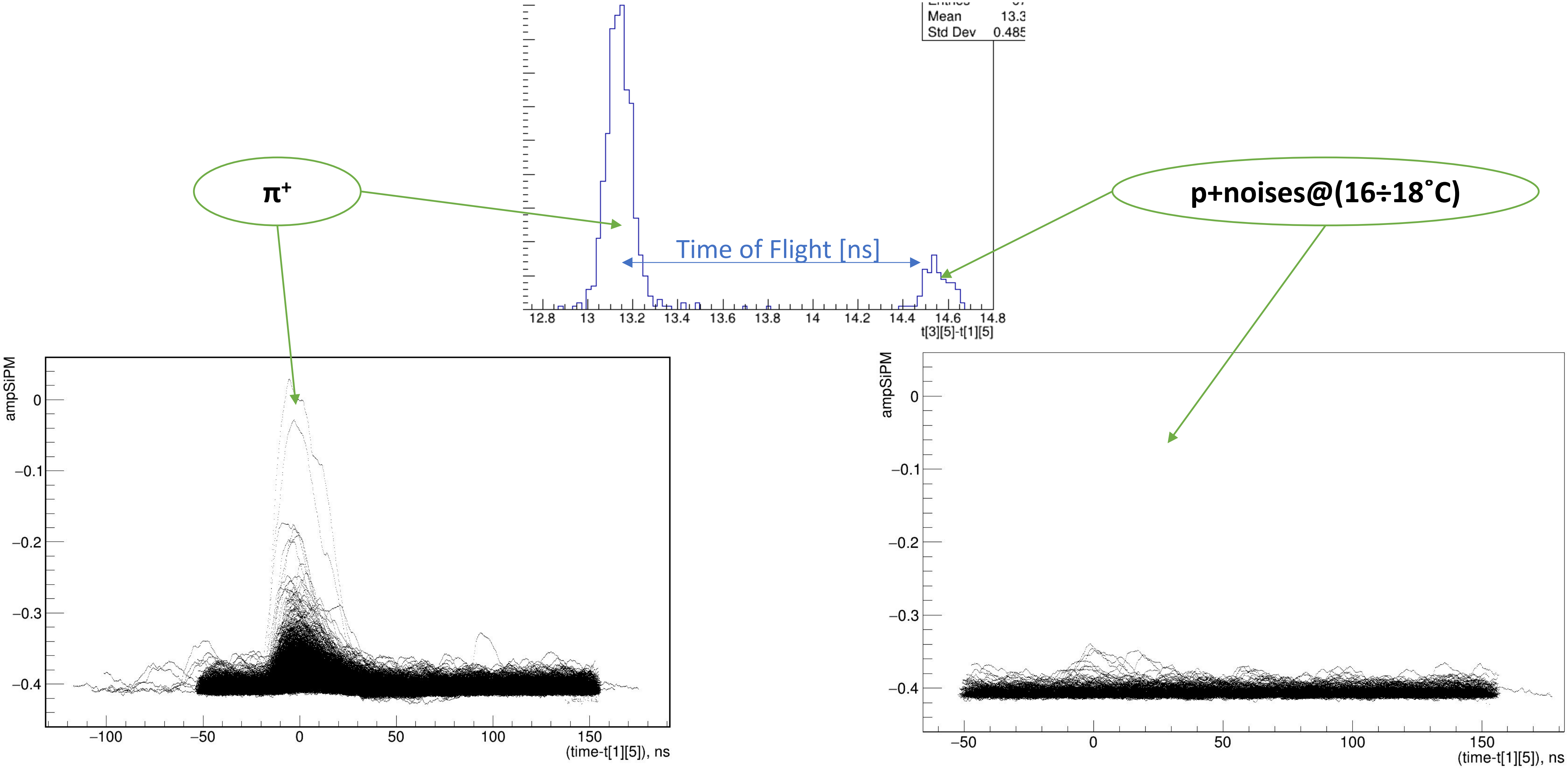
- ECAL first
- RICH first
- DTOF first
- TRDT first
- BASHIPH was always at the 2nd or 3rd positions

BEAM conditions

- Mixed hadrons: pions and protons in general
- Particle selection preformed by ToF counters based on PLEX+MCP PMT $(\sigma_t \approx 20 \div 30ps)$
- Total material budget at the beam line without ECAL is about $1X_0$, beam spot increased from ø5 mm at the beginig to ø50 mm at the end (~7÷8 m)
- Active trigger area ø18(10)mm at the distance 3.9 m → track selection efficiency is about 7÷15%
- At the most stable configuration were collected about 1.6M hadron tracks with BASHIPH prototype (half in n=1.05 and half in n=1.03):
  - 1 GeV/c 40k
  - 2 GeV/c 17k (44k)
  - 3 GeV/c 413k
  - 4 GeV/c 860k
  - 5 GeV/c 110k

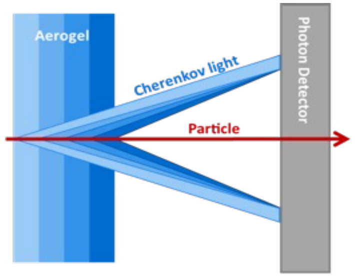


Rough data from ASHIP-SiPM prototype @ 2GeV/c

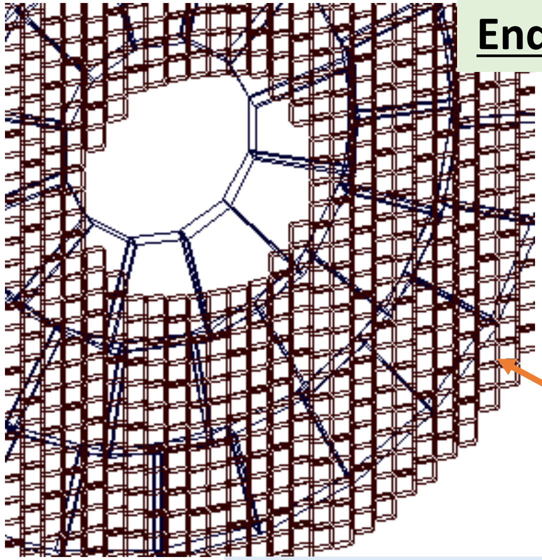


- FARICH system for the SCTF project
- FARICH system for the SPD-NICA experiment

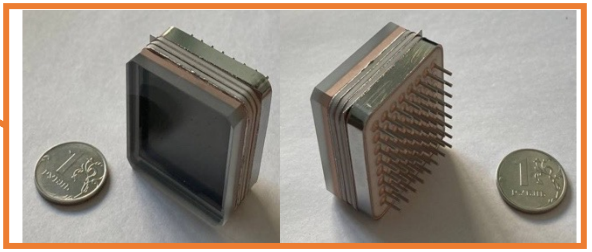
FARICH system for the SCTF project



Endcap part Sketchs & key elements



- 2x55 trapezoidal aerogel tiles in end caps:
- 2x1000 MCP PMTs 34x34mm^2 from "Ekran FEP"
- MCP PMTs can operate without cooling

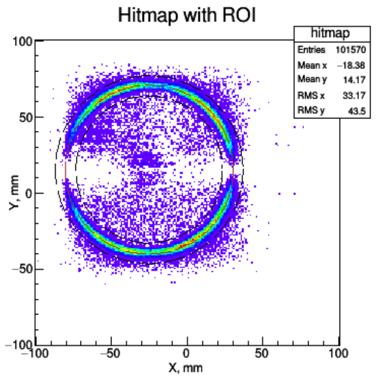


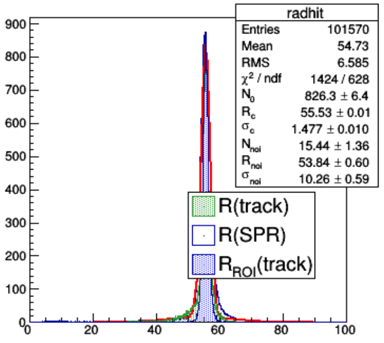
The first square MCP PMT produced in Russia

All details and components are produced in Russia

- 33×33 mm^2 total area
- 27×27 mm^2 sensitive area
- 8×8 pixels with 3×3 mm size

Measured angle resolution

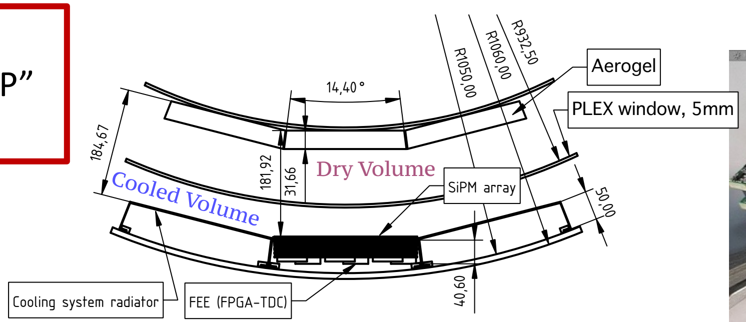


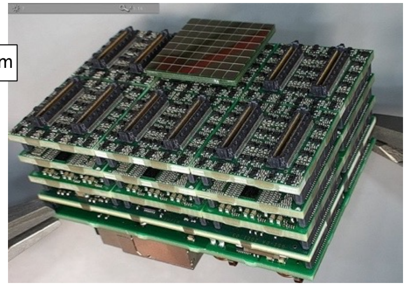


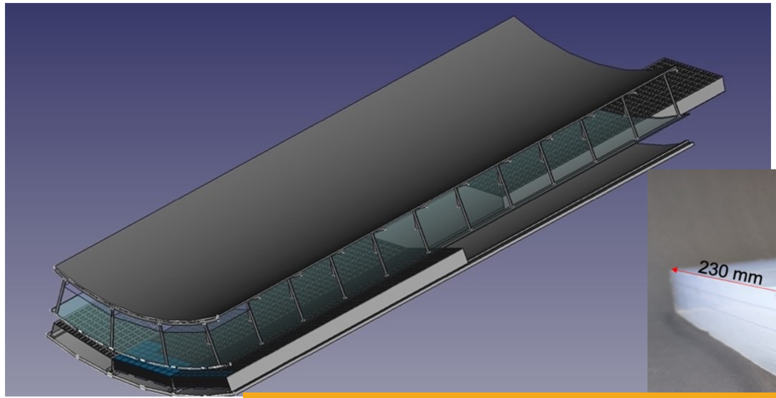
Single PE resolution 7.5 mrad was measured

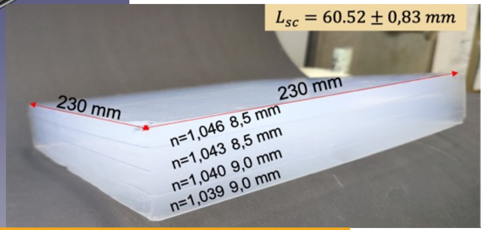
It corresponds to:

- Exccelent π/K–separation in whole operation momentum range
- Reliable μ/π–separation up to 1.5 GeV/c







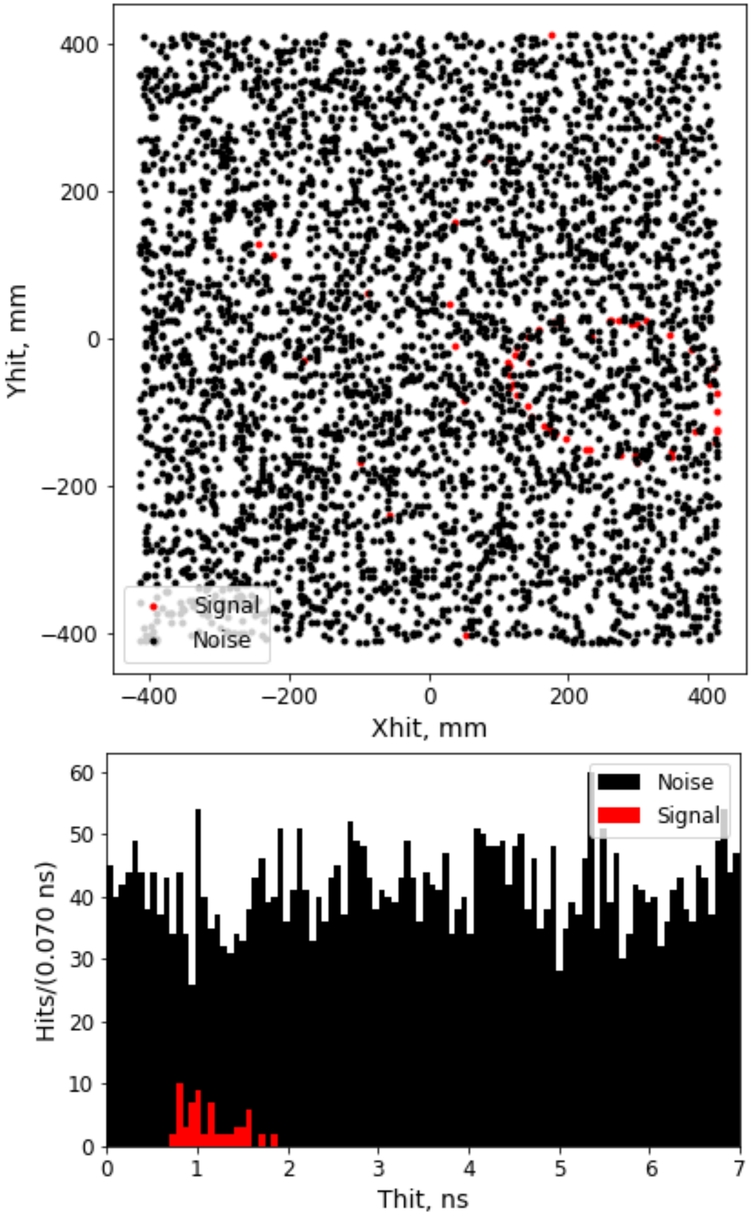


Barrel part Sketchs & key elements

- 275 aerogel tiles 200x202x35 in barrel part
- only SiPM will operate in magnetic field
- effective cooling system is required

Several R&Ds on reconstruction of events in the FARICH

Single FARICH event in with DCR ~ 10^6 cps/mm^2.



• **<u>LPI group</u>** developed classical approach so called "slider box"

– X,Y-scan of the PD area is performed with fixed geometry box to search its position when the maximal number of hits are inside the box

– The scan on time axis is also performed to find the time gate with maximal number of hits

– It was shown that such method works very well until the DCR~10^5cps/mm^2

Bulletin of the Lebedev Physics Institute, 2023, Vol. 50, No. 12, pp. 534–539.

• **<u>HSE group</u>** developed reconstructions algoritms based on ML aproaches

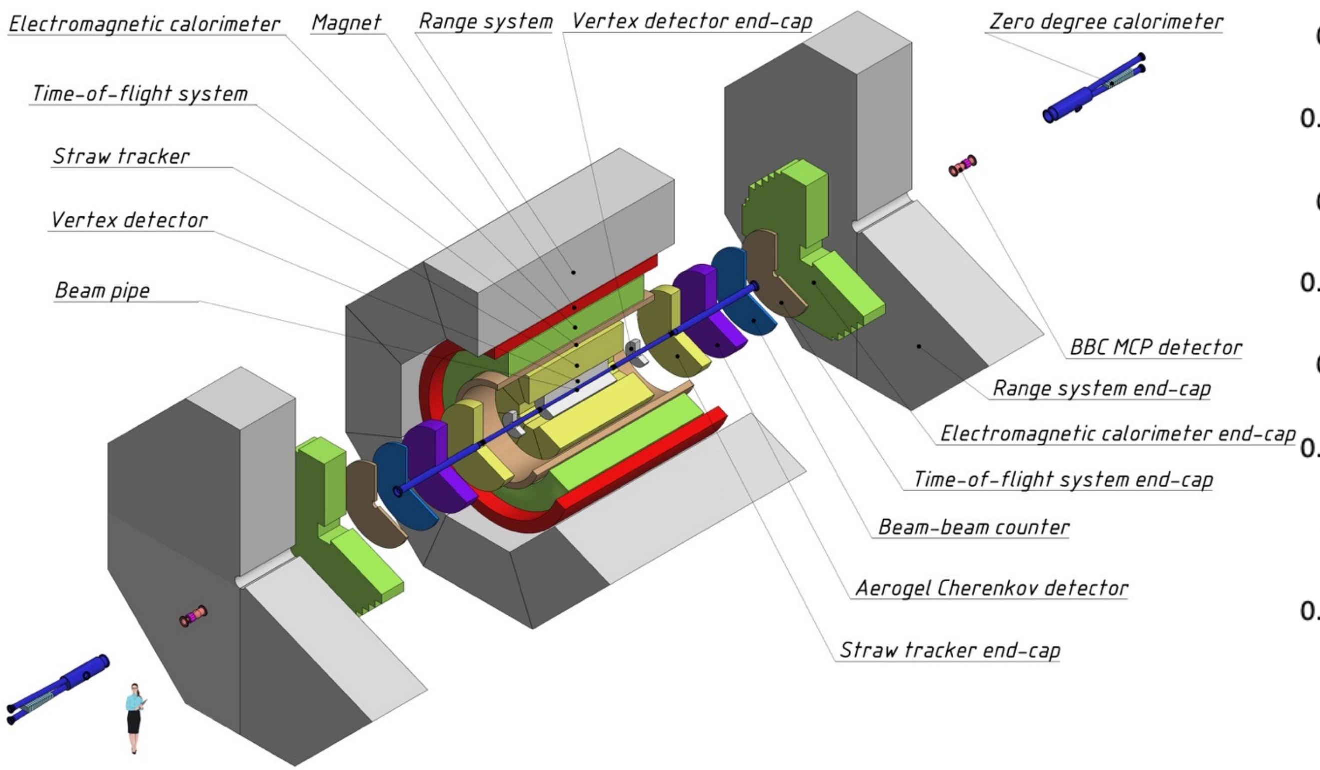
– It was shown that CNN could help to suppress nose pile-up suficiently without degradation of events reconstruction efficiency up to DCR~10^5cps/mm^2.

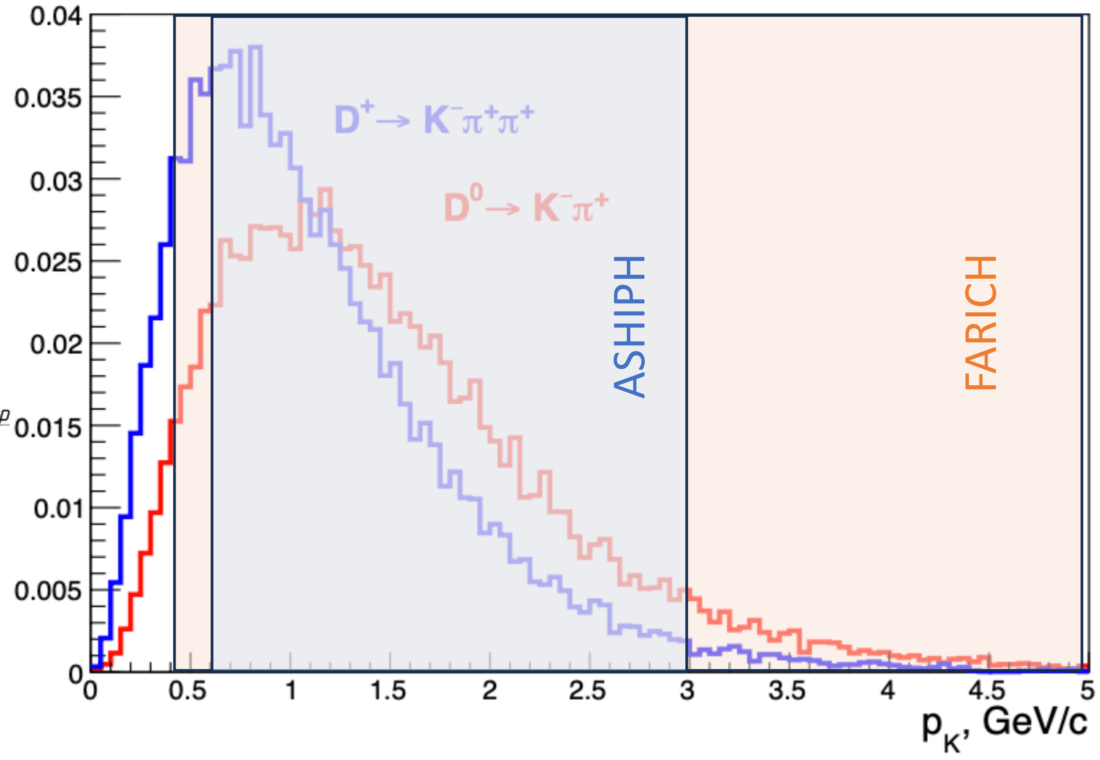
– ML based algorithms are working in case of DCR~10^6cps/mm^2, however with some less reconstruction efficiency.

Physics of Atomic Nuclei, 2023, Vol. 86, No. 5, pp. 864–868.

Details on recent progress of R&Ds in these groups see in two topics:
Foma Shipilov & Platon Rogozhin

PID based on FARICH for the SPD–NICA experiment

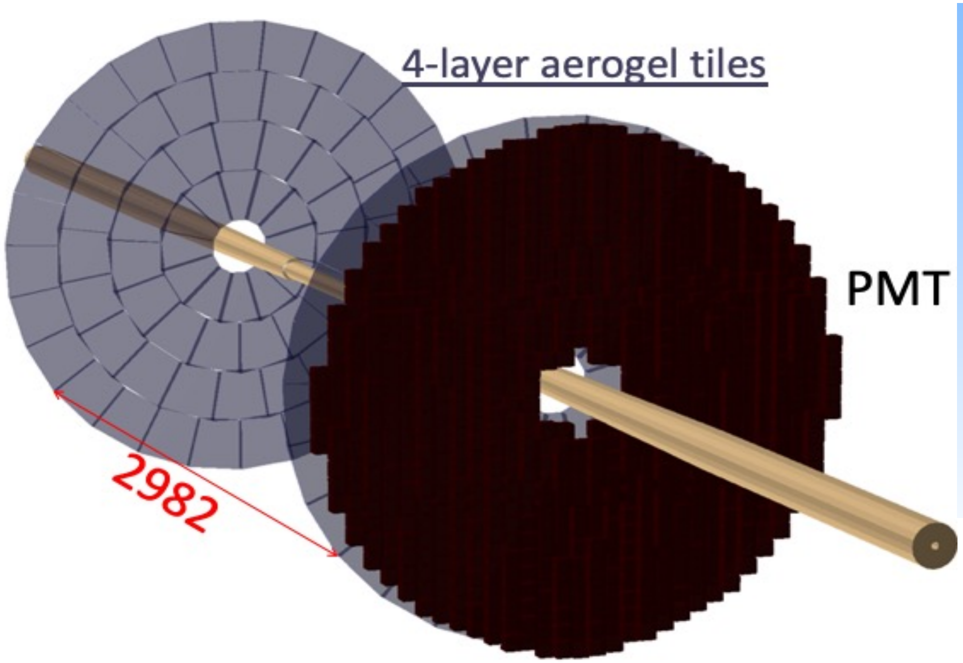


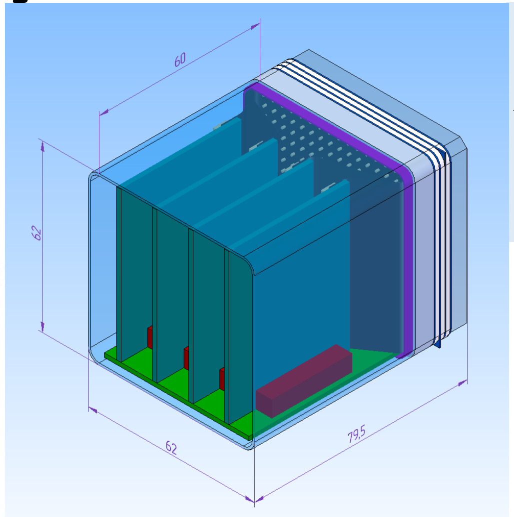


Two options of PID system based on aerogel are considered now:

- ASHIPH system based on aerogel with n=1.02÷1.03 and SiPMs for π/K–separation at P=0.6÷3 GeV/c
- FARICH with 4-layer aerogel with n_{max}=1.05 and multi-anode MCP PMTs for π/K–separation at P=0.4÷6 GeV/c

FARICH system for the SPD-NICA





Rectangular MCP PMT with active area 50x50mm

- Construction and design are under development in Novosibirsk by BINP and Ekran FEP in close cooperation
- All details and components will be produced in Russia

Goal parameters:

- 62×62 mm^2 total area
- 50×50 mm^2 sensitive area
- 16×16 pixels with 3×3 mm size
- Multi-alkali or Bi-alkali PCs extended in blue region
- Fused silica entrance window
- Gain $\geq5\cdot10^5$

SPD – FARICH system concept

Aerogel:

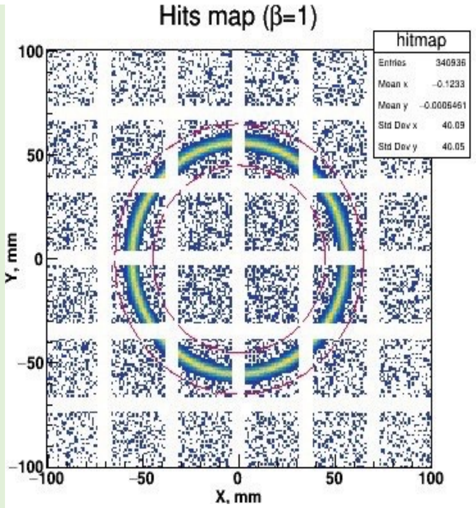
- 2 end-caps × 74 tiles (4 form-factors)
- 4-layer focusing aerogel:
  - $n_{max}\leq1.05$ (to be optimized soon)
  - Total thickness 35÷40 (to be optimized)
  - Focus distance ~20 cm

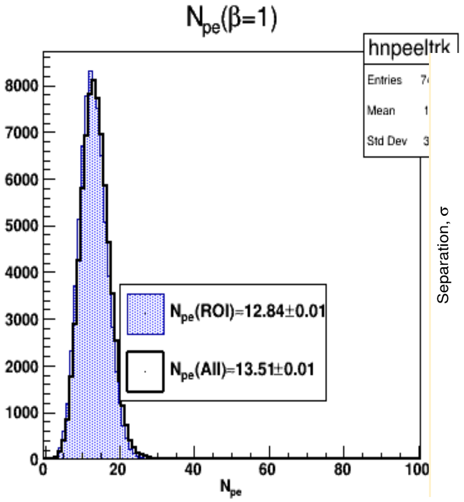
Position-sensitive MCP-PMT:

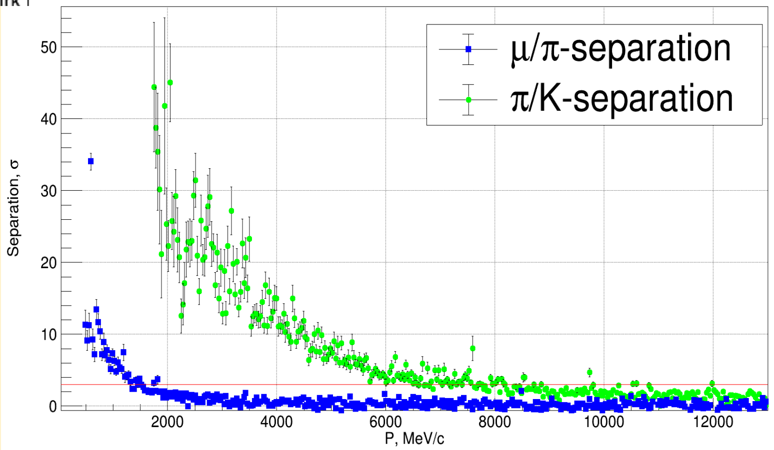
– 2 × 2200 PMTs ~33×33 mm^2 (pixel 3×3 mm^2) from Ekran FEP (soon)

– 2 × 550 PMTs ~60×60 mm^2 (pixel 3×3 mm^2) from BINP & Ekran FEP's R&D

Expected system parameters (obtained in G4 simulation)

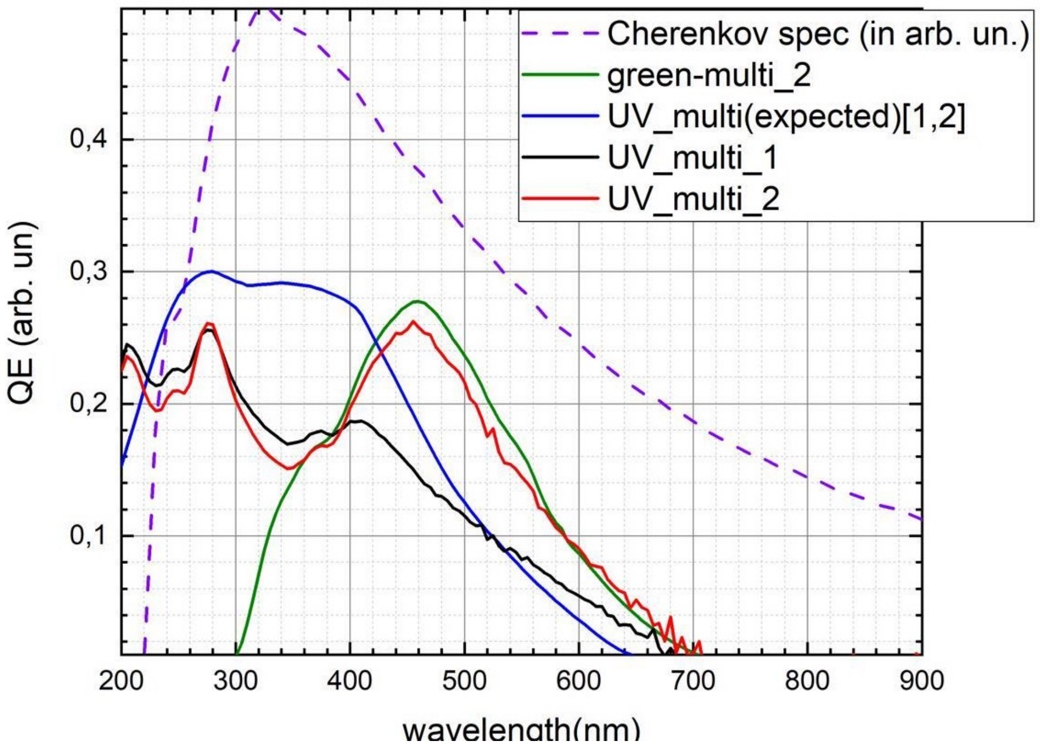






Photocathode & MCP optimization at “Ekran FEP”

Multi-alkali PCs options and Cherenkov spectrum



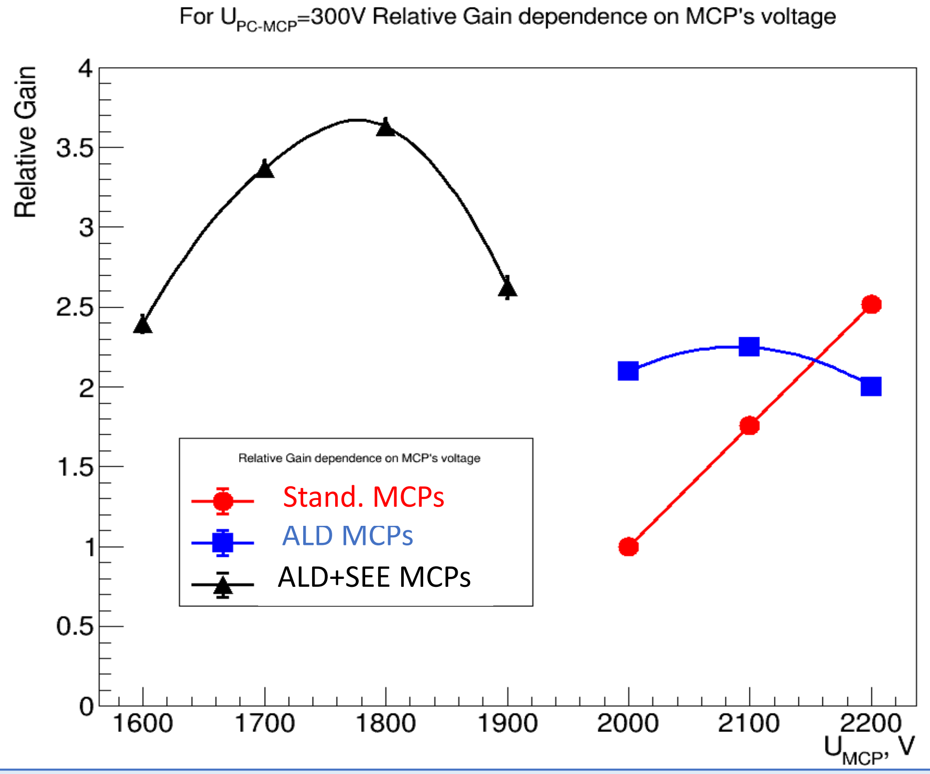
The advantage of **“UV_multi” PC (Quartz)** is **factor of 2** in comparison with standard “IR_multi” PC

“UV_multi” QE based on data from papers:

1. Orlov, D. A., et al., High quantum efficiency S-20 photocathodes in photon counting detectors. Journal of Instrumentation, 2016 11(04), C04015–C04015

2. Milnes, J., et al., UV photocathodes for space detectors. Proceedings Volume 12181, Space Telescopes and Instrumentation 2022: Ultraviolet to Gamma Ray, 121813B (2022).

Comparison of PMTs with and w/o ALD MCPs

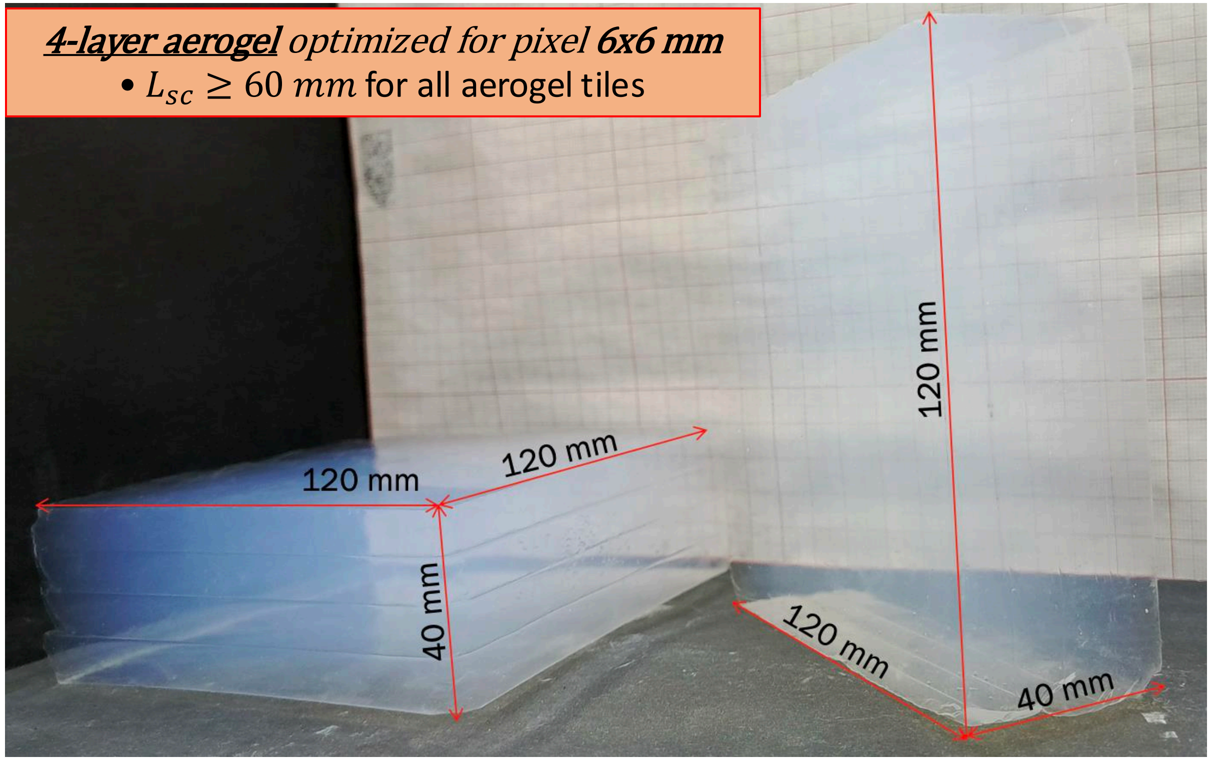


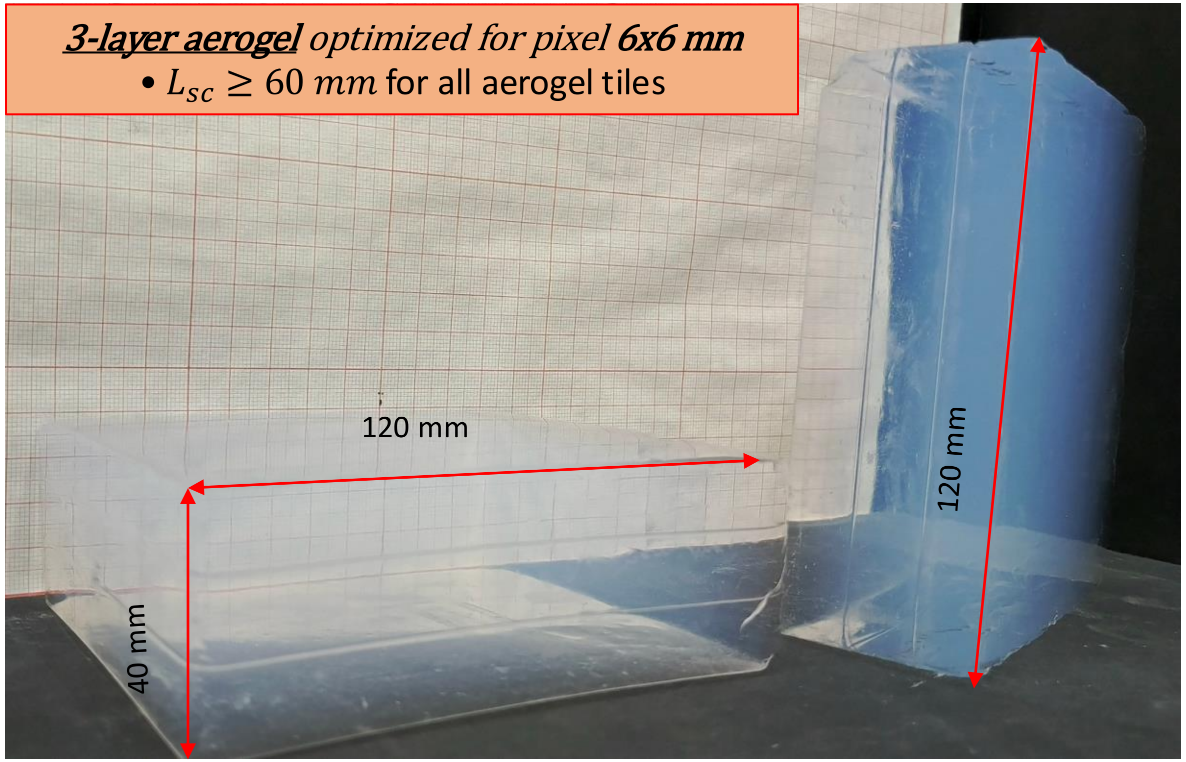
The advantages of **ALD MCPs** are:

- **longer PC lifetime by order**
- **better PE collection efficiency**
- **higher gain** under smaller voltages in comparison with traditional.

Multi-layer focusing aerogel radiator optimisation

n_{max}=1.05–> n_{max}=1.04 – to increase Cherenkov angle difference at the high momentum range;
t_{tot}=35 mm –> t_{tot}=40 mm – to compensate the Npe decrease connected with decrease of refractive index
Δ_{pix}= 3 mm –> Δ_{pix}= 6 mm – to decrease the number of electronics readout channels;
N_{layer}=4 –> N_{layer}=3 – to improve stability and reliability of production technology

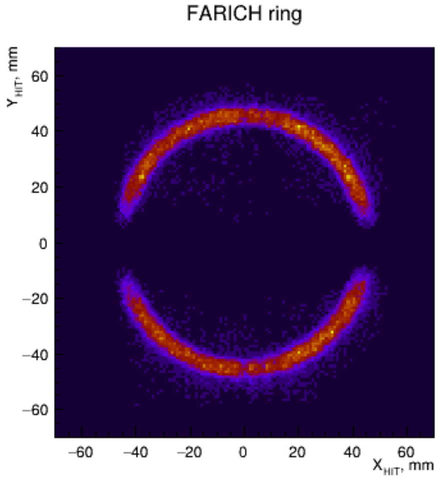


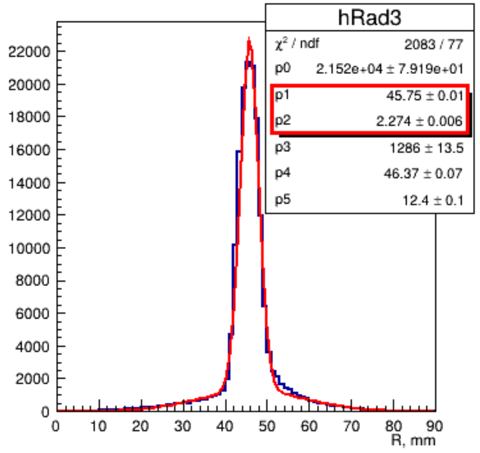


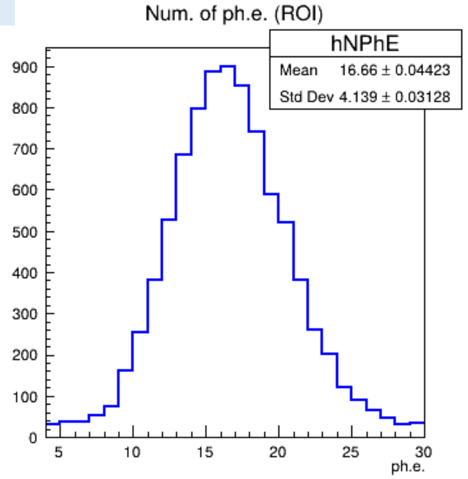
These new aerogels were tested in June 2025 with relativistic electrons at the BINP

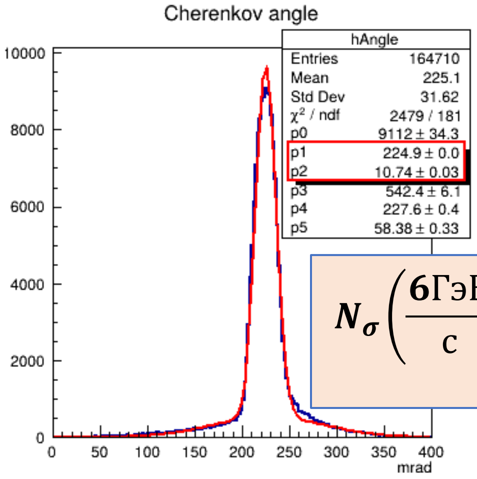
Beam test results with relativistic electrons: June 2025

4-layer, n_{max}=1.04, t=40 mm





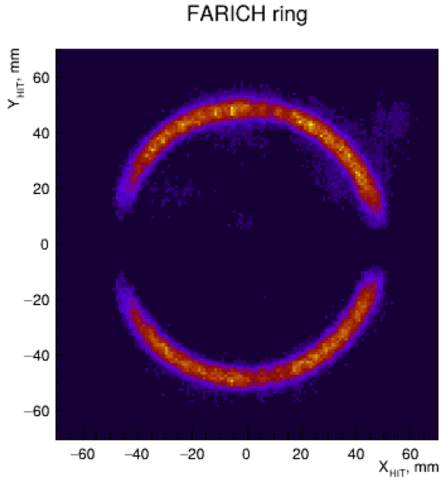


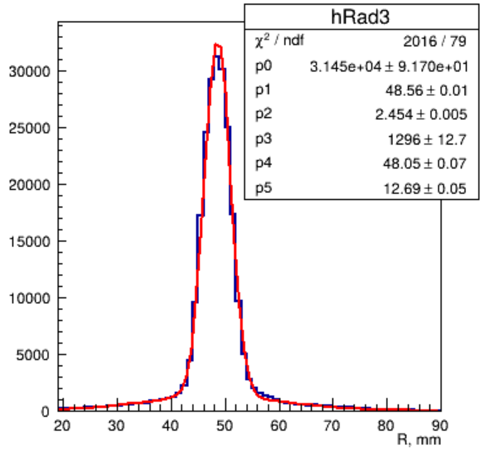


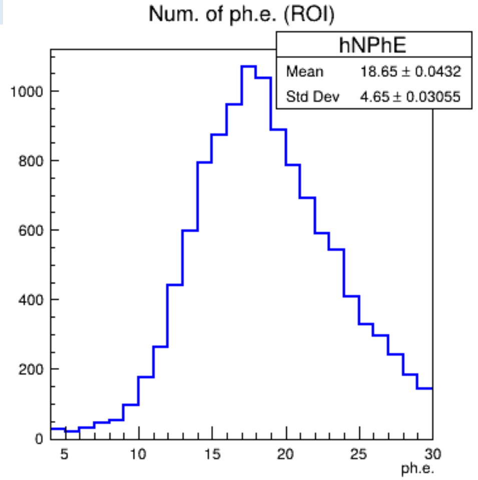
$$\boldsymbol{\sigma_{1pe}} \approx 10.7\ mrad$$

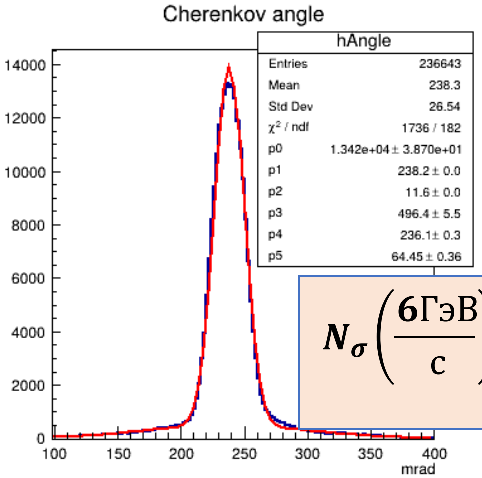
$$\boldsymbol{N_\sigma}\left(\frac{\mathbf{6}\text{ГэВ}}{\text{c}}\right) \approx \frac{11\ mrad}{10.7mrad/\sqrt{N_{pe}}} \approx 4.2$$

3-layer, n_{max}=1.04, t=40 мм





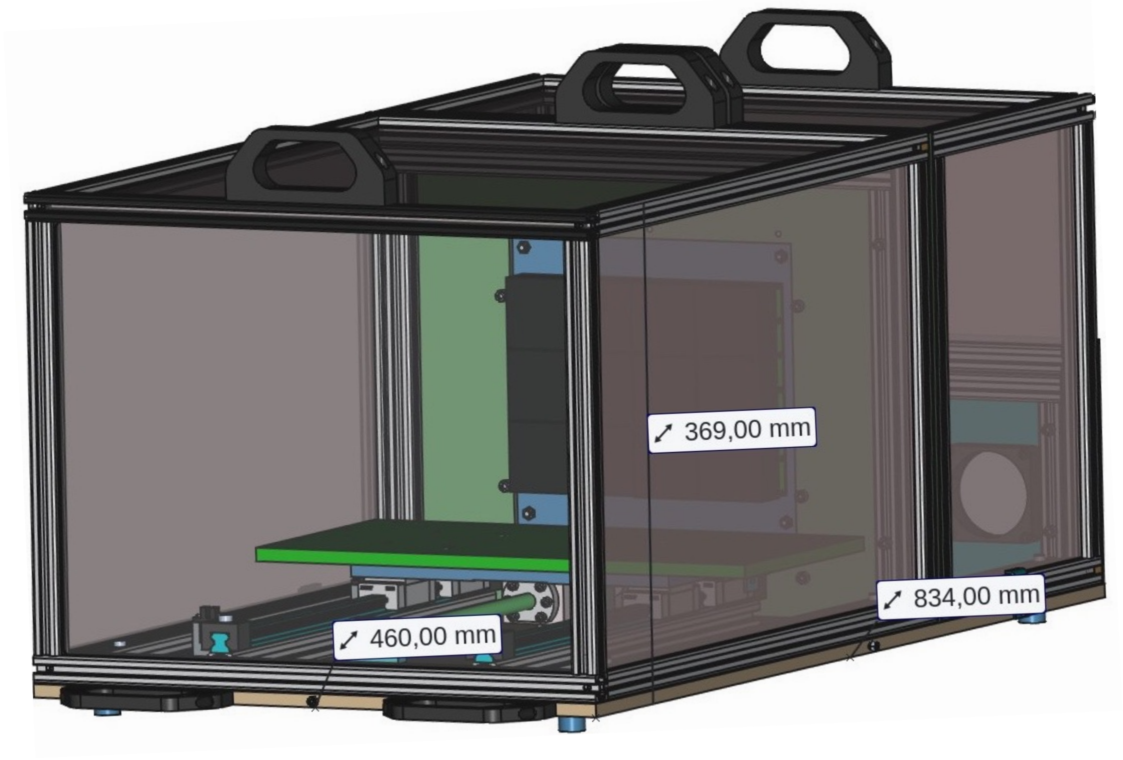


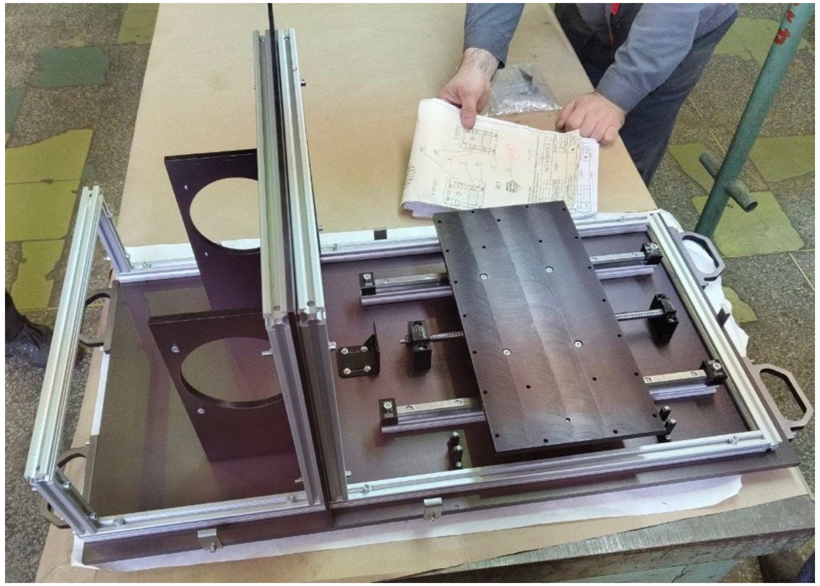


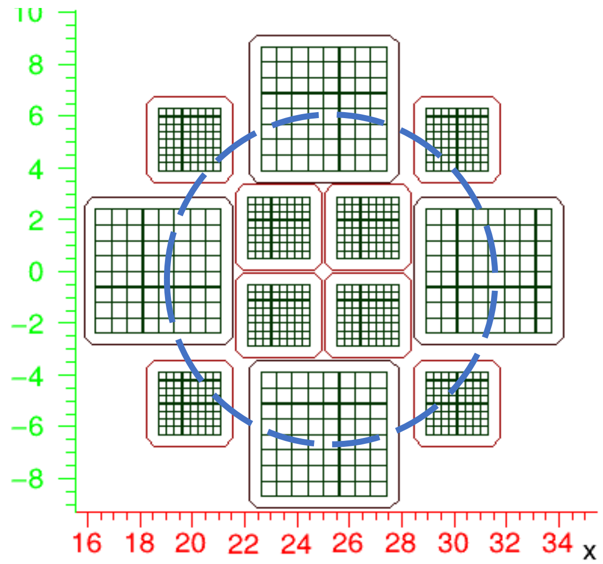
$$\boldsymbol{\sigma_{1pe}} \approx 11.6\ mrad$$

$$\boldsymbol{N_\sigma}\left(\frac{\mathbf{6}\text{ГэВ}}{\text{c}}\right) \approx \frac{11\ mrad}{11.6mrad/\sqrt{N_{pe}}} \approx 4.1$$

The compact FARICH prototype with full ring detection



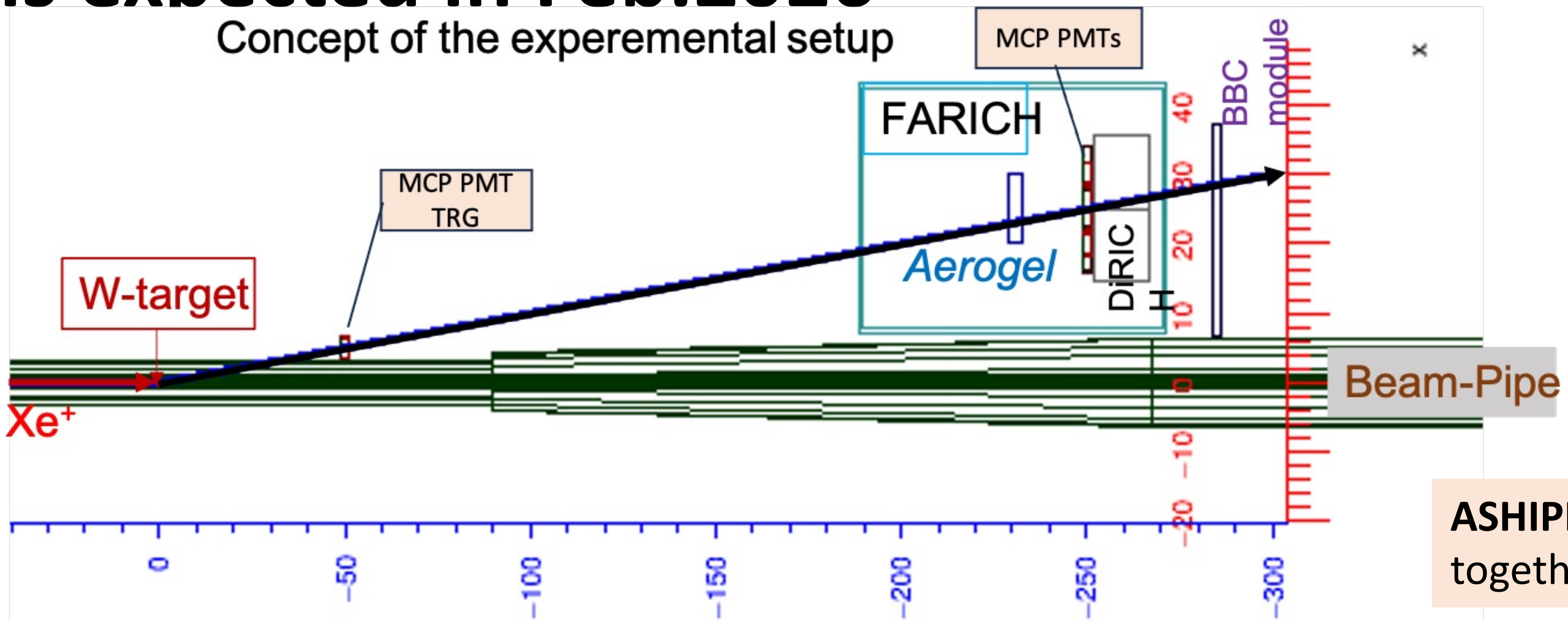


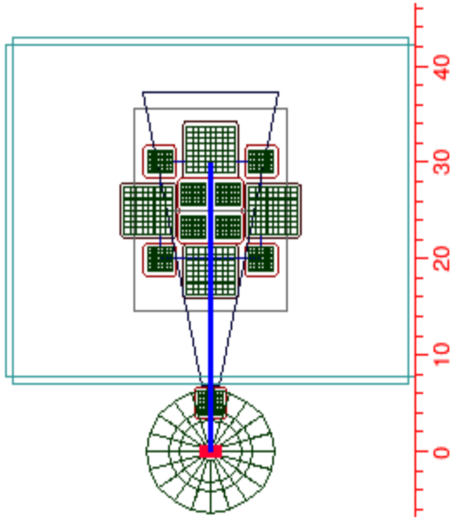


FARICH compact prototype based on MCP PMT:

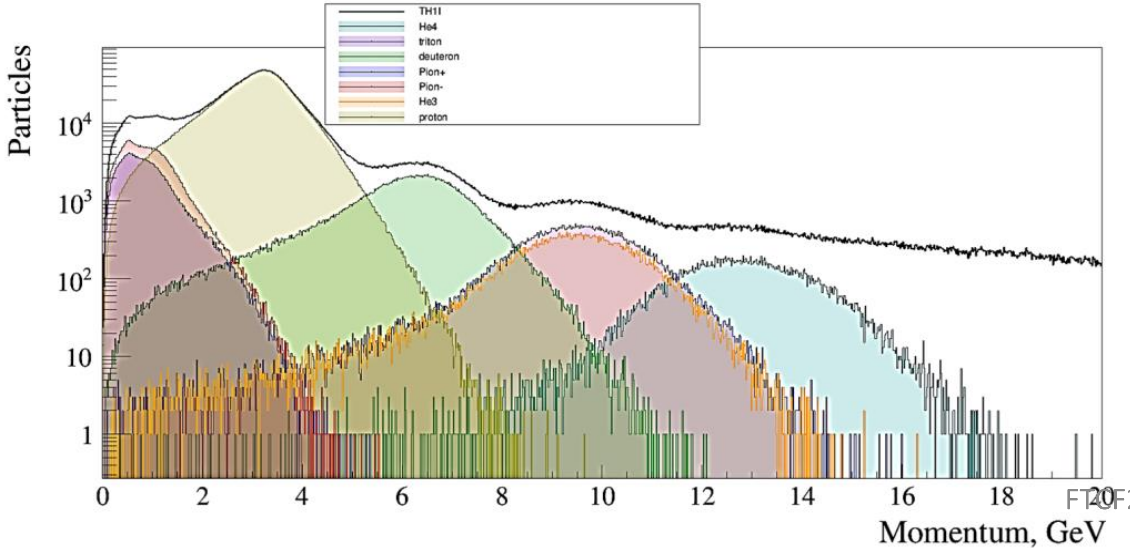
- Readout system (based on DiRICH+TRB3 boards from GSI) is ready
- FARICH prototype based on 12 PMTs H12700 + MCP PMTs is expected in Feb. 2026!

Aerogel prototypes @ SPD-Phase0 is expected in Feb.2026



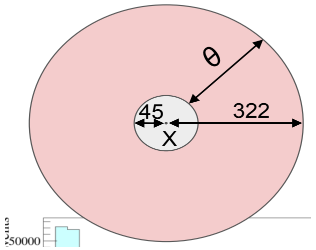


ASHIPH-SiPM prototype could be installed together with FARICH prototype at the line



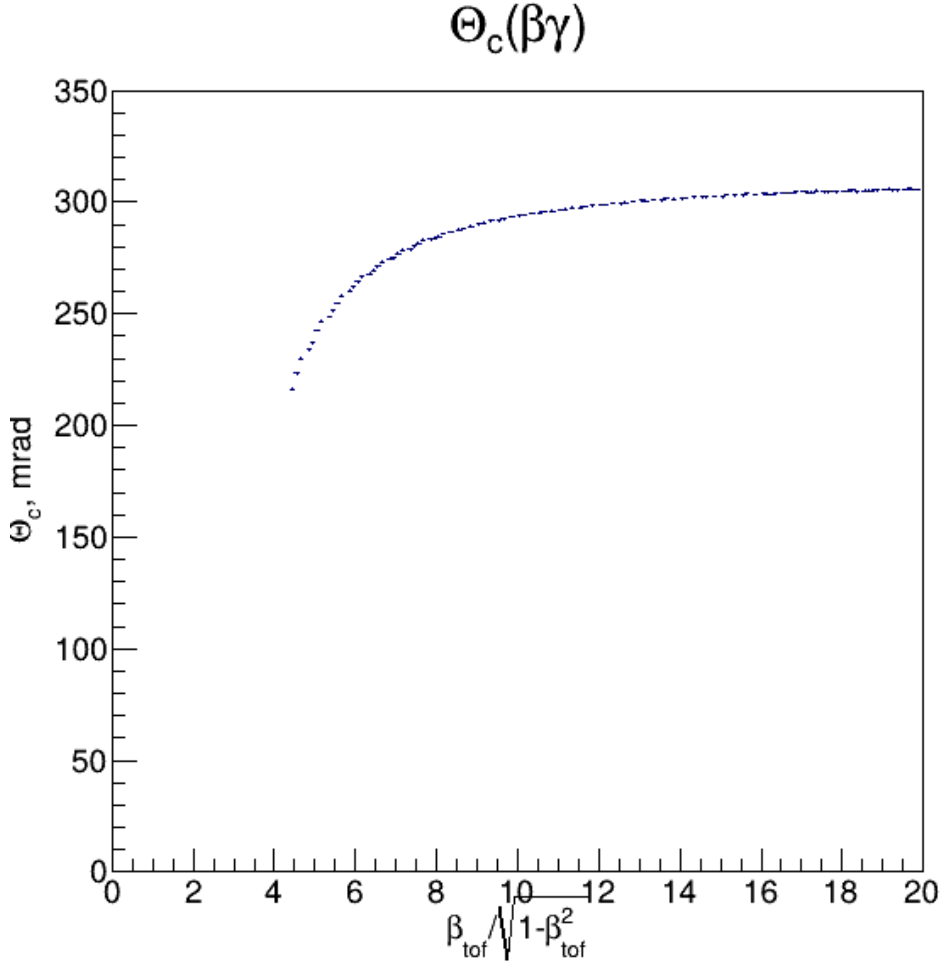
particles	p	π+	π−	^{2}H	^{3}H	^{3}He	^{4}He
%	74.26	4.03	6.18	5.16	1.26	0.98	0.52
average momentum GeV/n	3.02	0.90	0.93	2.96	3.12	3.10	3.19

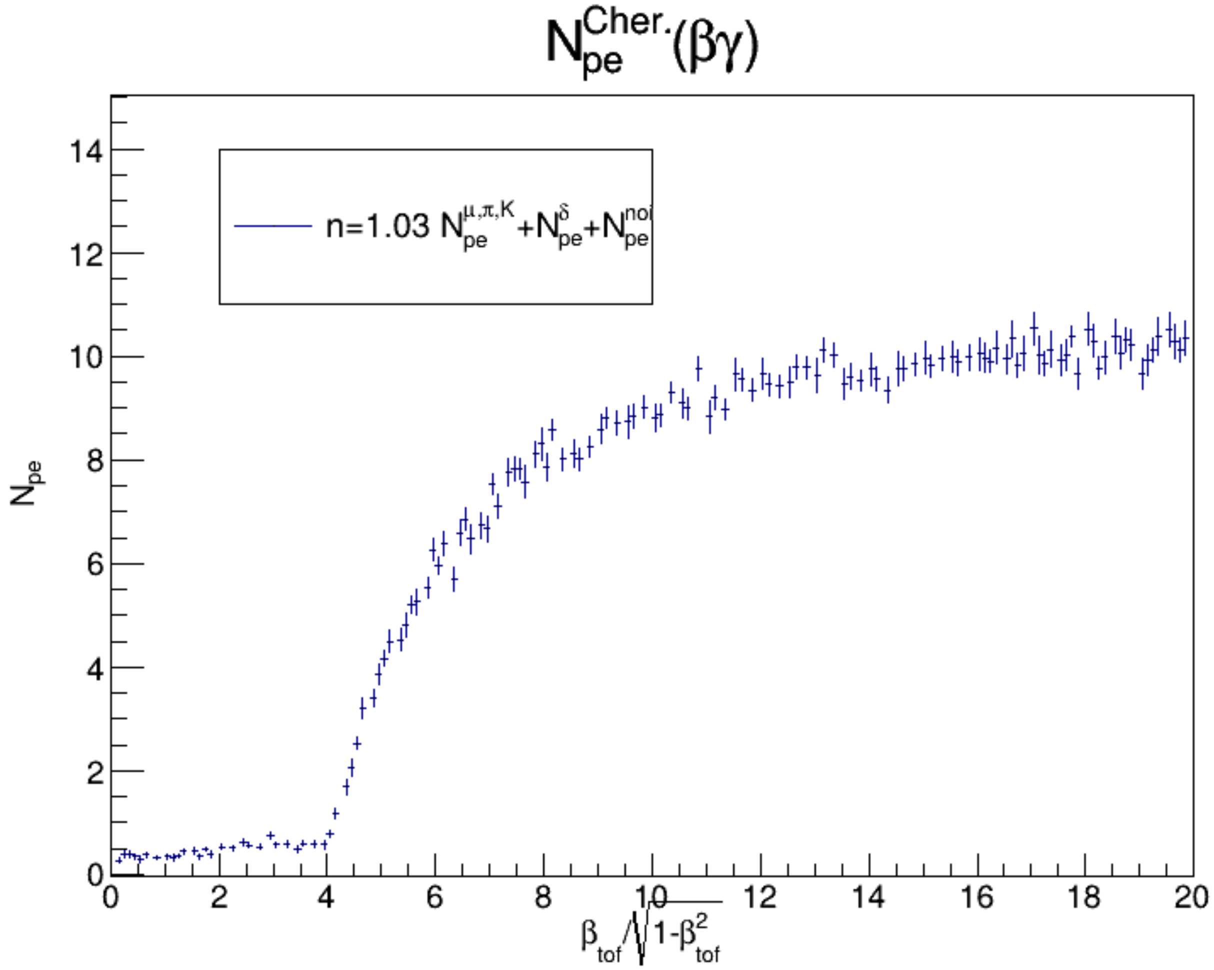
Condition of the simu



Volkova K. & Volkov I.

Aerogel based prototypes callibration options





FARICH:

– Calibrate dependences of **Cherenkov angle** and its **resolution** on particle velocity

ASHIPH-SiPM:

– Calibrate dependences of $\mathbf{N_{pe}(V)}$

– Calibrate underthreshold efficiency

- (FA)RICH based on n=1.008 aerogels for the CEPC
- FARICH with dual aerogel radiators

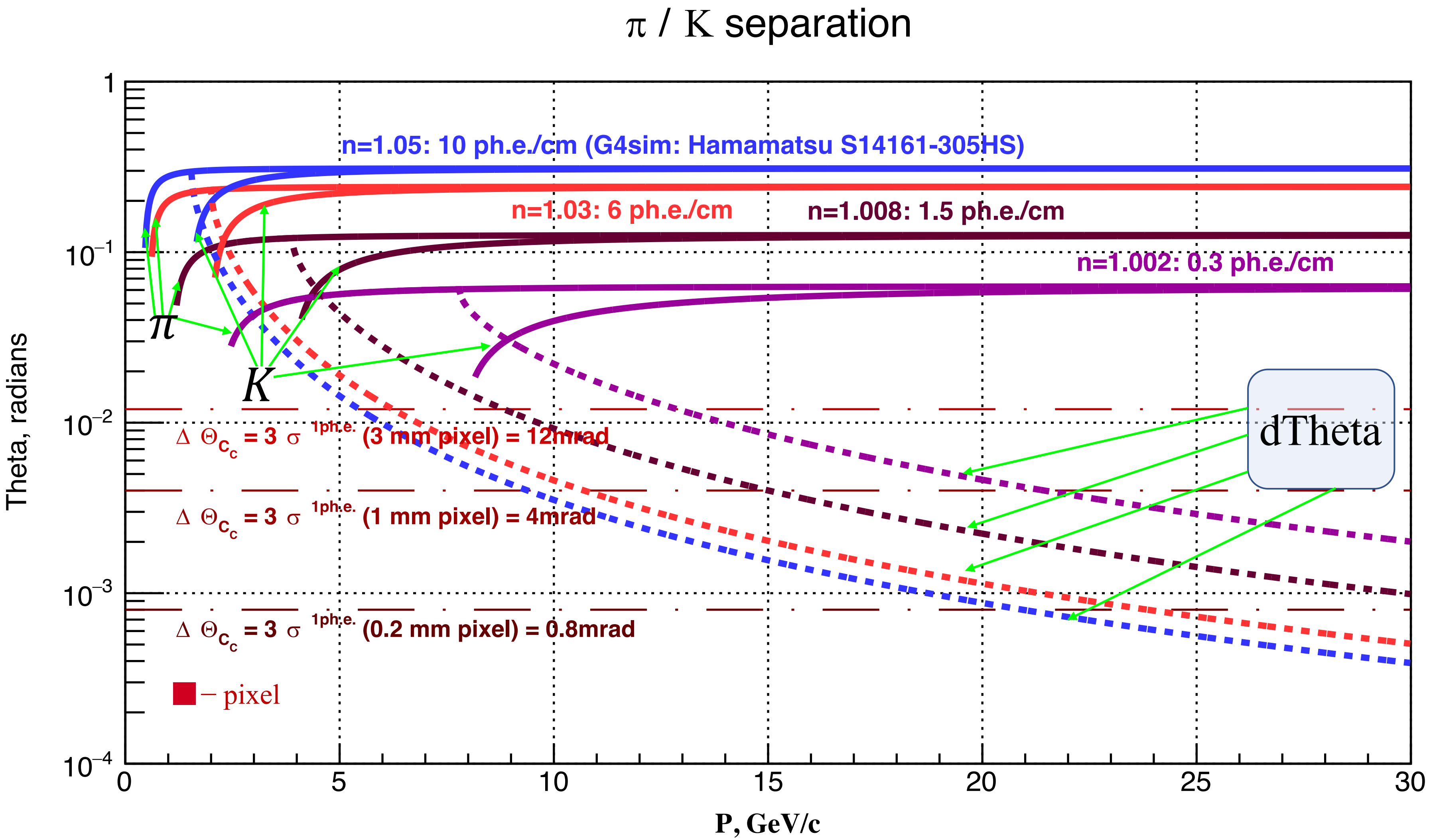
Motivations for π/K–separation above 20 GeV/c

- Future e^+e^- H-factories such like FCCee (CERN) and CEPC (China) have extensive physics programe at Z-pole $(\sqrt{s} = 91.2\ GeV)$.
- Expected $4{\times}10^{12}$ Z-bozons $\left(\int Ldt \approx 100ab^{-1}\right)$ will provide extensive statistic of $b\bar{b}$, $c\bar{c}$ and $\tau^+\tau^-$ for precise flavor physics investigations. *[arXiv:2412.19743v2 [hep-ex] 31 Dec 2024]*
- π/K– separation is needed not only to supress combinatorial background and to separate similar topology of final states like:

$B^0_{(s)} \rightarrow \pi^+\pi^-, B^0_{(s)} \rightarrow K^+K^-, B^0_{(s)} \rightarrow K^\pm\pi^\mp$ and so on.

- Baseline option of the CEPC detector is able to provide π/K– separation at the level of 2σ up to 20 GeV/c by combining ${}^{dE}/_{dx}$ and ToF techniques. *[Y.Zhu et al., NIM A 1047 (2023) 167835]*
- π/K–separation at the level $\geq 3\sigma$ in wider momentum range is highly desirable for such experiments.

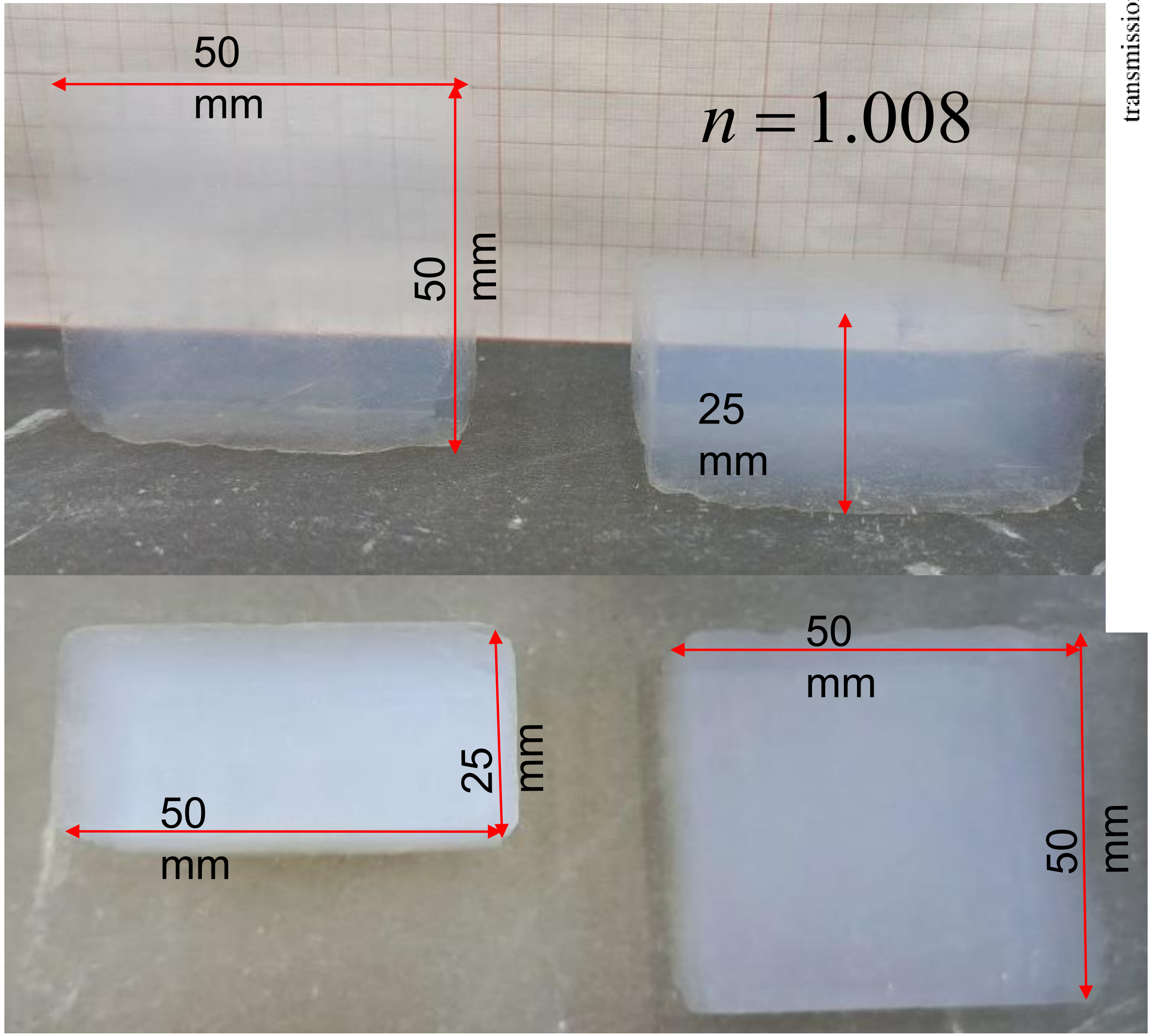
RICH detectors capability for π/K–separation

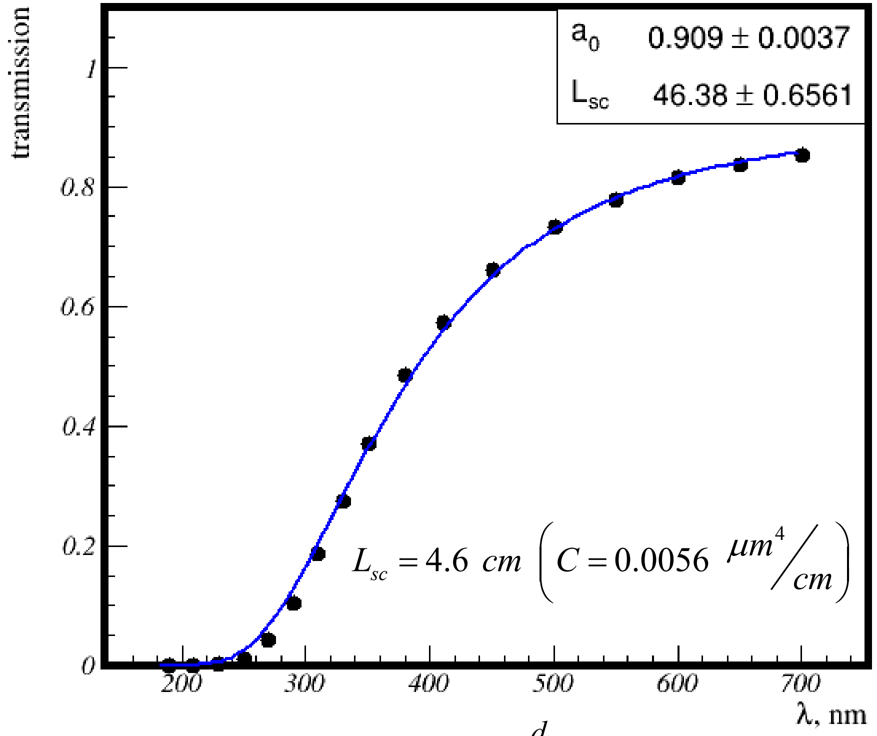


- $\sigma_C^{tr} = {}^{1}/_{\sqrt{N_{pe}}} \cdot \sqrt{\left(\frac{\Delta_{pix}\cdot\cos\theta_C}{L\cdot\sqrt{12}}\right)^2 + \left(\frac{\sigma_n}{n\cdot\tan\theta_C}\right)^2 + \left(\frac{t\cdot\sin\theta_C}{L\cdot\sqrt{12}}\right)^2 + \sigma_{tr}^2} \sim \sqrt{t}$
- $N_{pe}(\beta = 1) \sim 500 \cdot \frac{n^2-1}{n^2} \cdot t \cdot QE$

- At least 5 hits have to be detected to reconstruct Cherenkov ring.
- Thickness of Cherenkov radiator should be:
  - ≥1 cm for n=1.05 (aerogel)
  - ≥4 cm for n=1.008 (aerogel)
  - ≥15 cm for n=1.002 (C_5F_{12})
- Some focusing system is needed to provide impact from thickness at the level of few mrads for base 200÷300 mm!!!

Aerogel with n=1.008 (Novosibirsk)





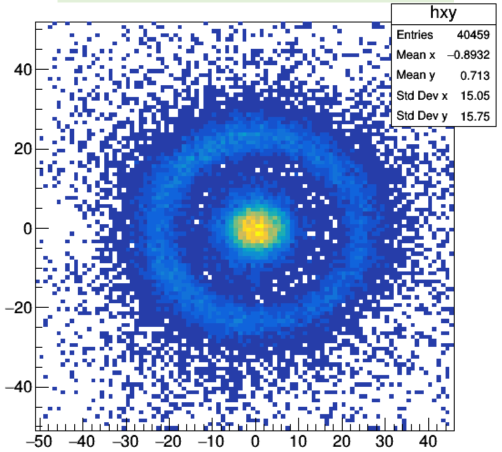
$$T = \frac{I}{I_0} = a_0 \cdot e^{-\frac{d}{L_{sc}\cdot\left(\lambda/400\right)^4}} = a_0 \cdot e^{-\frac{C\cdot d}{\lambda^4}}$$

d – thickness of a sample,
λ – wavelength in nanometers,
Lsc – scattering length at 400 nm,
a_0 – surface scattering coefficient,
C – clarity coefficient

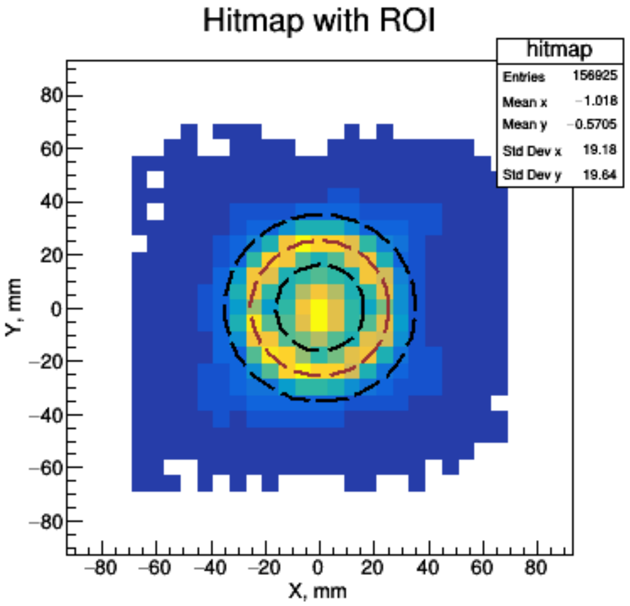
RICH based on aerogel n=1.008: some beam test results

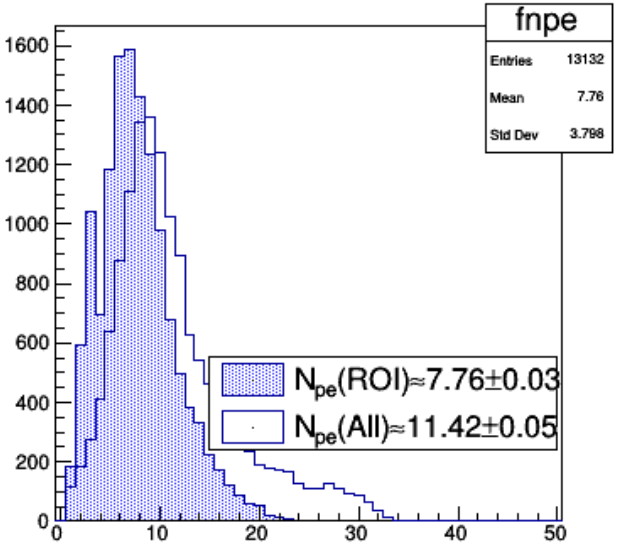
Tbeam e⁻@2.5GeV

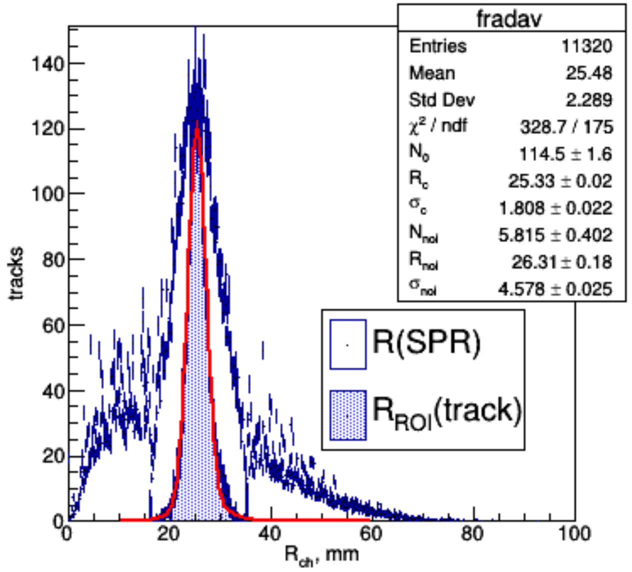
- t_{aer}=25+25=50 mm
- L_F=200 mm

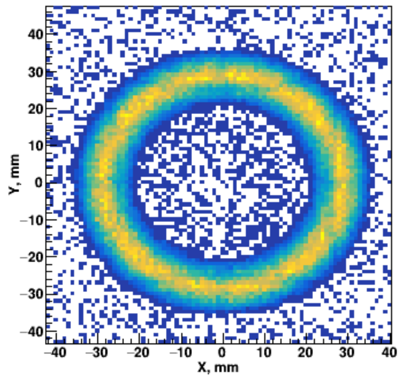


Hits map (β=1)









Geant4 sim.:

- t_{aer}=60 mm
- L_F=250 mm

TBeam results reconstructed w/o track information:

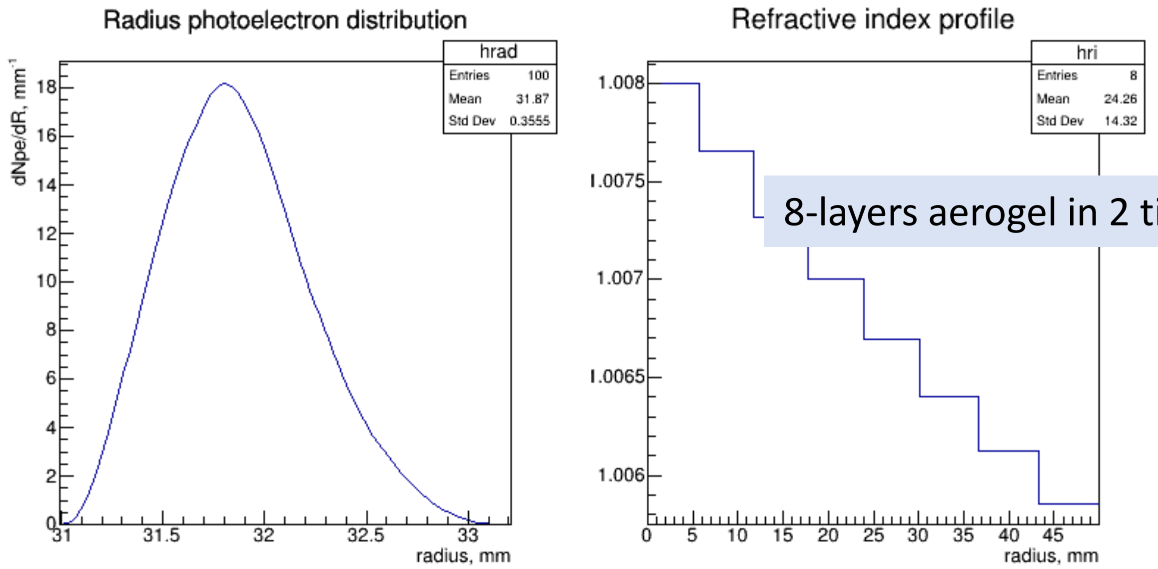
- MaPMT H12700 with QE(400nm) ≈ 20%
- Pixel 6x6 mm
- Aerogel:
  - stack of 3 tiles 25+25+25=75 mm
  - refractive index n≈1.008
- L_F=235 mm

OUTPUT:

- SiPM based photon detector with PDE(400nm)=45÷50% will alow us to detect ***10÷20 ph.e.*** for relativistic tracks
- RICH based on aerogel with n=1.008 and pixel 3x3mm is able to provide π/K-separtion at P=10 GeV/c
- ***Proximity focusing system and PD with $\sigma_x \leq 1\,mm$ is required to reach π/K-separation above 20 GeV/c***

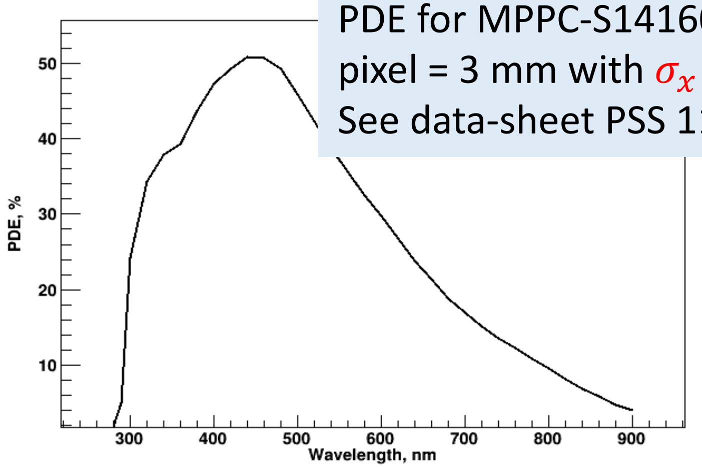
FARICH option for π/K–separation above 20 GeV/c

8-layer aerogel n_{max}=1.008; σ_x ≈0.2mm



8-layers aerogel in 2 tiles

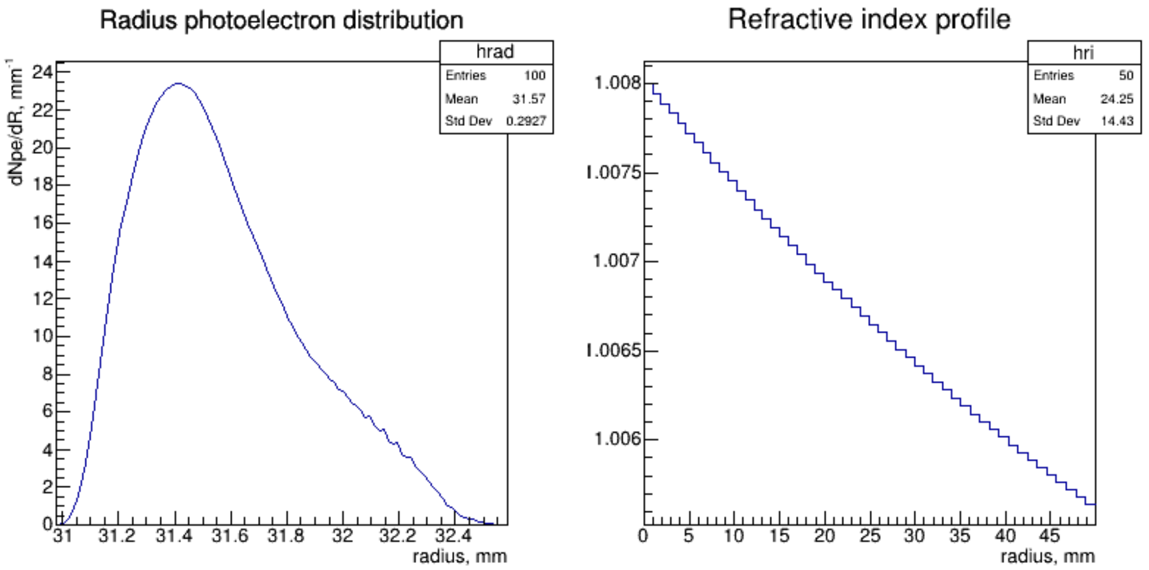
Focal distance is 300 mm



PDE for MPPC-S14160 (Hamamatsu)
pixel = 3 mm with $\sigma_x \approx 0.2mm$
See data-sheet PSS 11-3030-S (NDL)

- N_{pe}≈16
σ_C^{tr}≈0.33 mrad!!!

Gradient aerogel n_{max}=1.008; pixel≈0.7mm

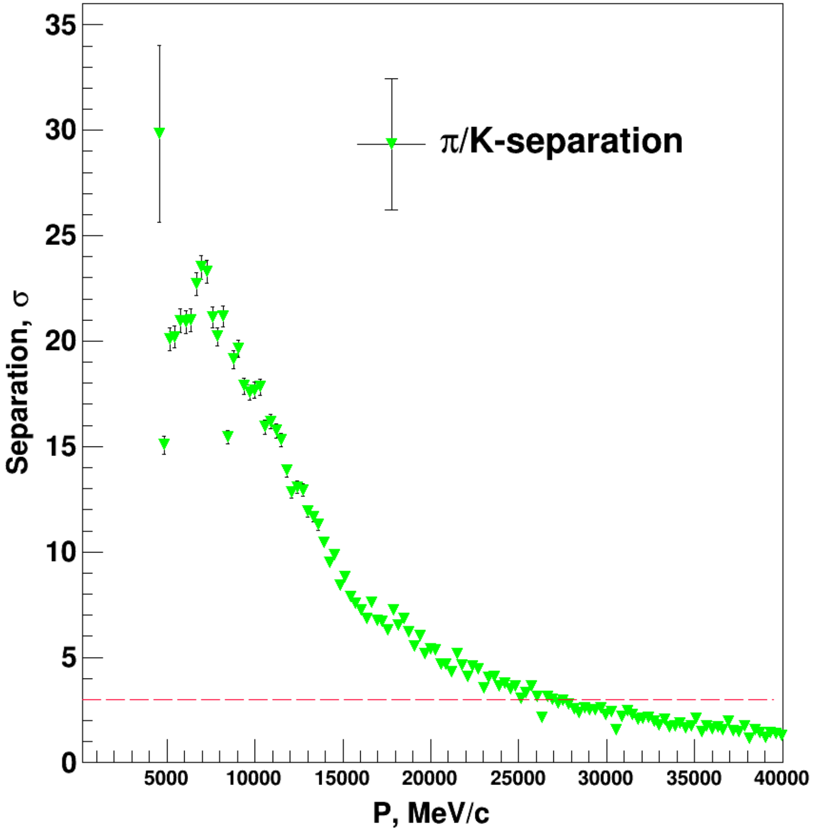


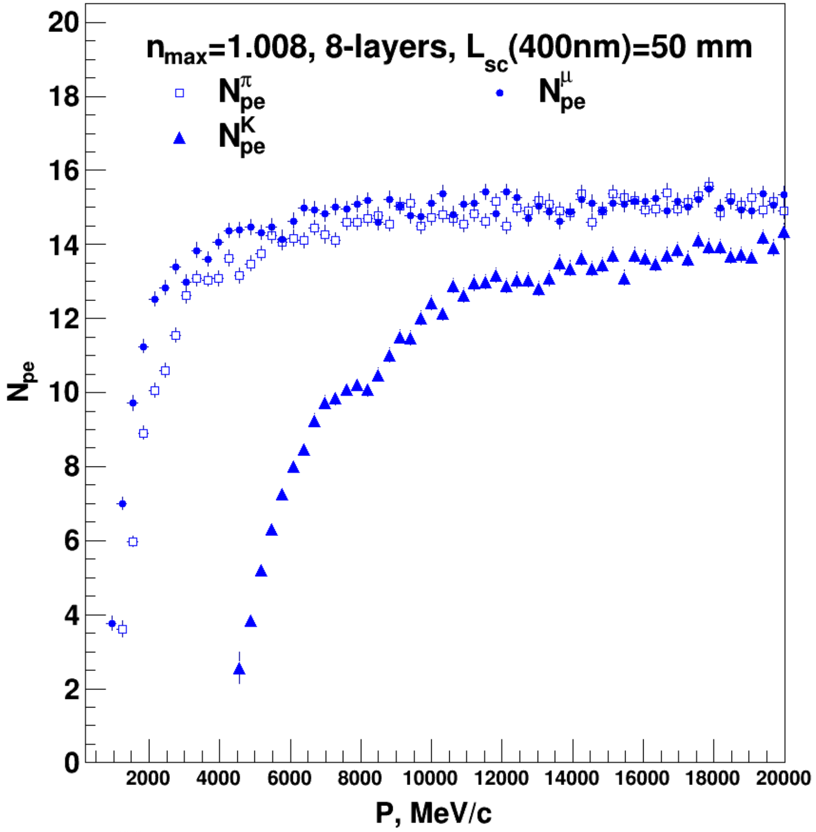
The possibility to produce of gradient aerogel was demonstrated in
NIM A766 (2014) 88-91 and NIM A766 (2014) 235-236

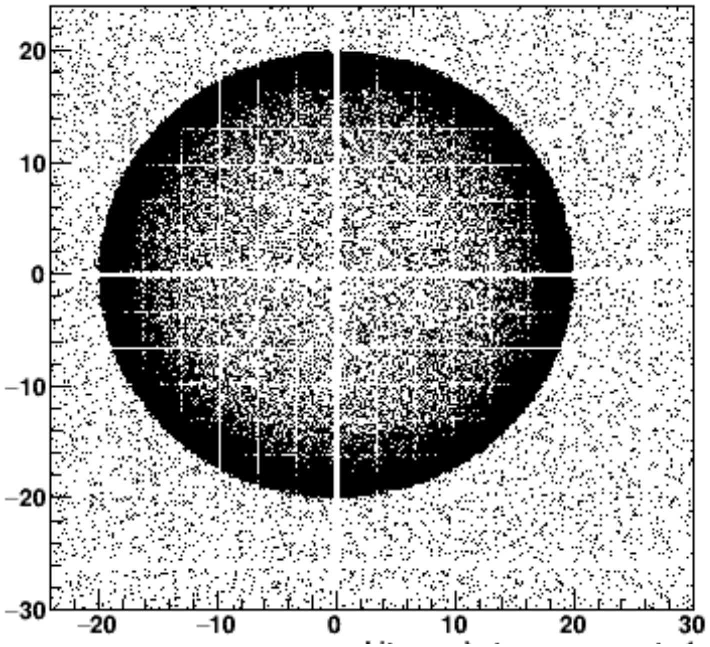
- N_{pe}≈16
σ_C^{tr}≈0.33 mrad!!!

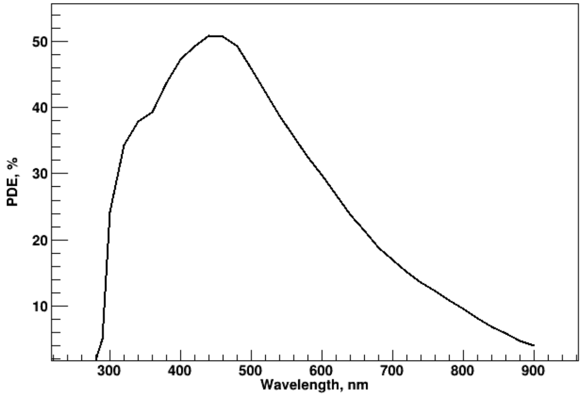
It looks good enough for reliable π/K–separation @ 30 GeV/c

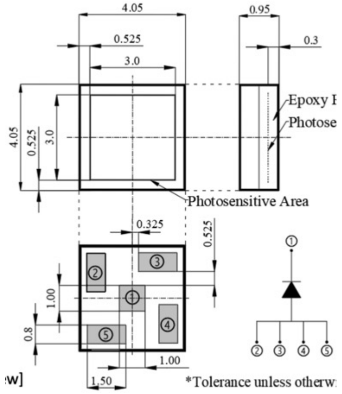
FARICH for π/K–separation at 30 GeV/c: G4sim results









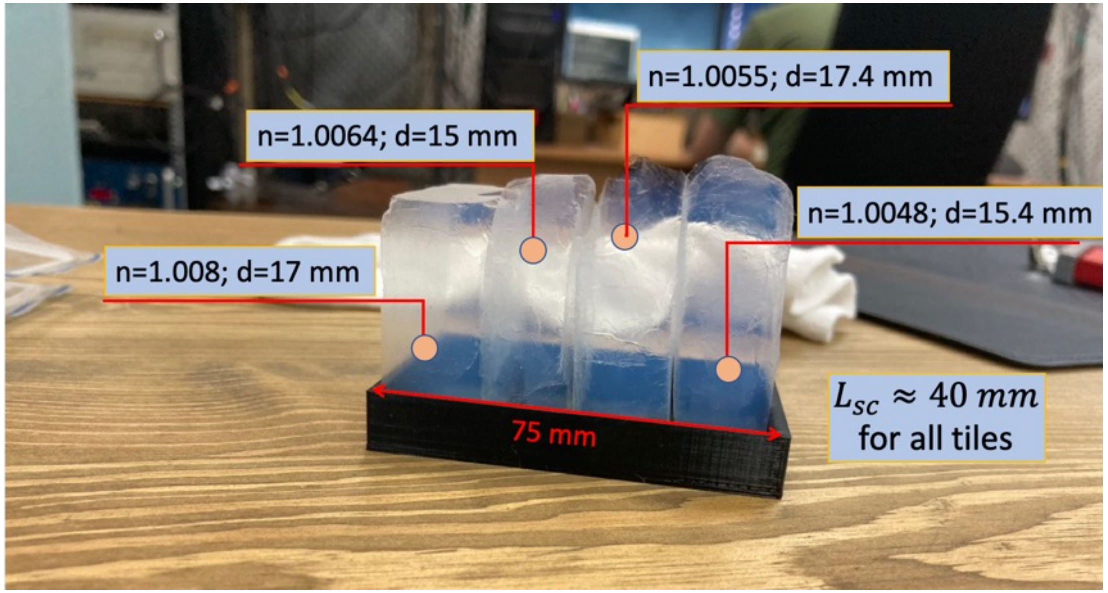


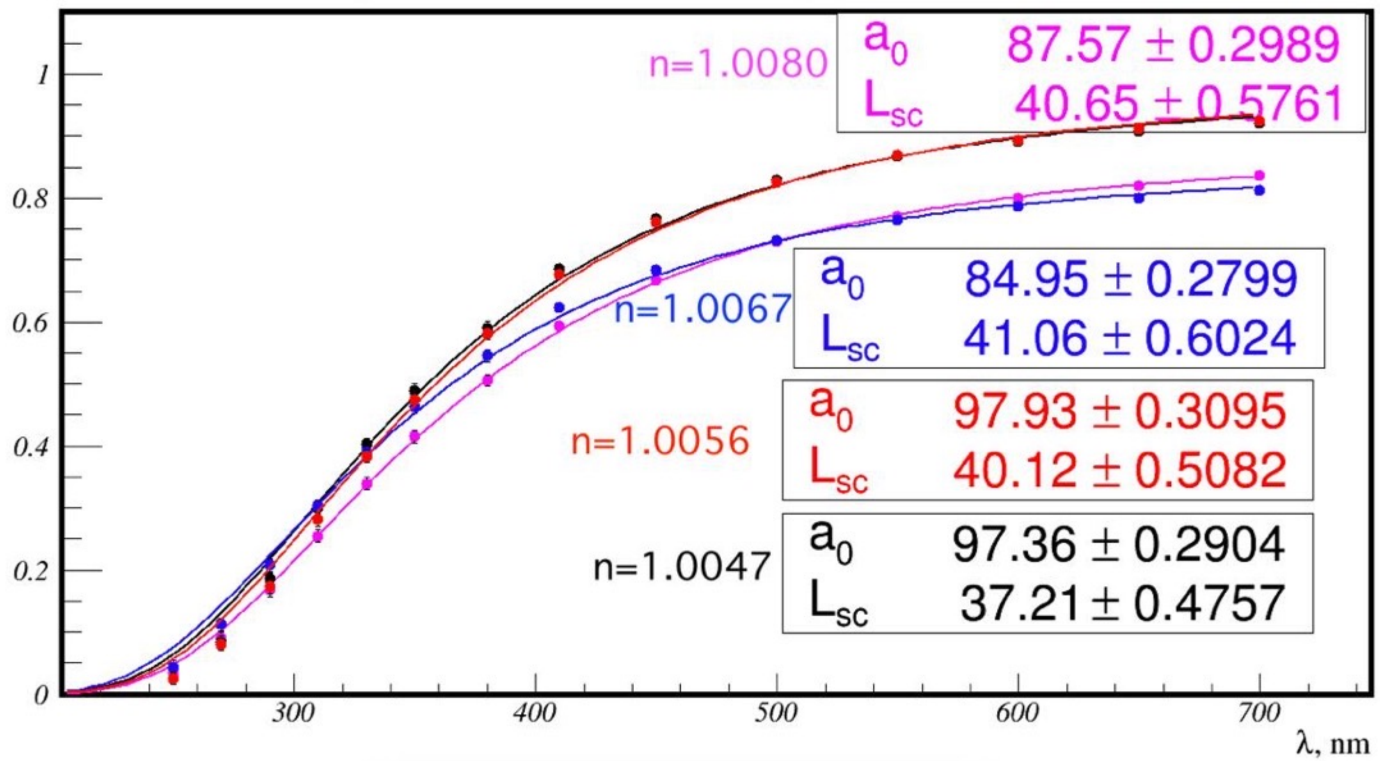
$$x_c = \frac{L}{2} \cdot k \cdot \frac{(Q_2 + Q_3) - (Q_1 + Q_4)}{(Q_1 + Q_2 + Q_3 + Q_4)}$$

$$y_c = \frac{L}{2} \cdot k \cdot \frac{(Q_3 + Q_4) - (Q_1 + Q_2)}{(Q_1 + Q_2 + Q_3 + Q_4)}$$

Exact hit positions from G4sim are smeared by Gaussian with $\sigma_x = 200\mu m$

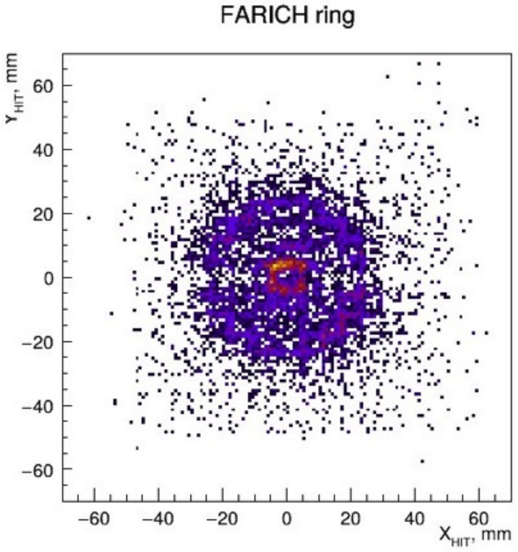
Some practical results of 2025

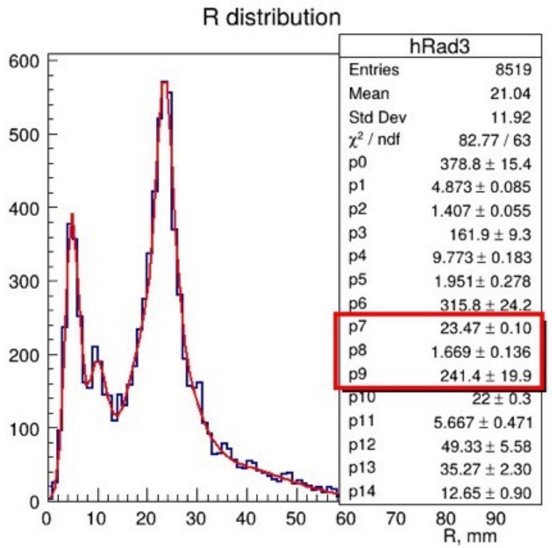


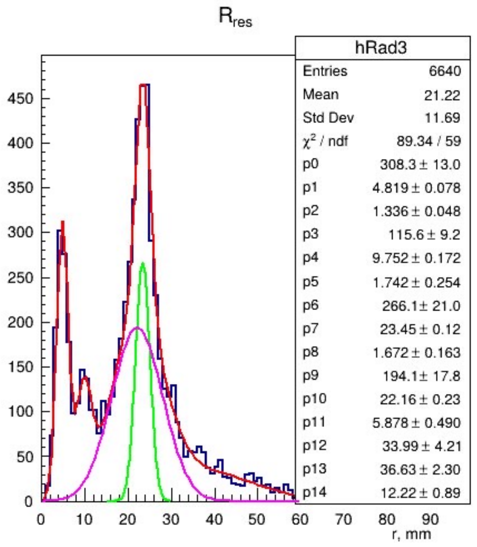


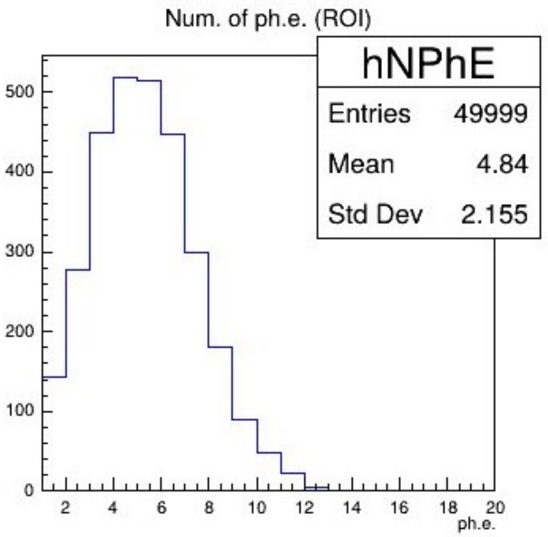
In 2025 for the first time ultra-light SiO_2 aerogels with high transperancy were produced in Novosibirsk!

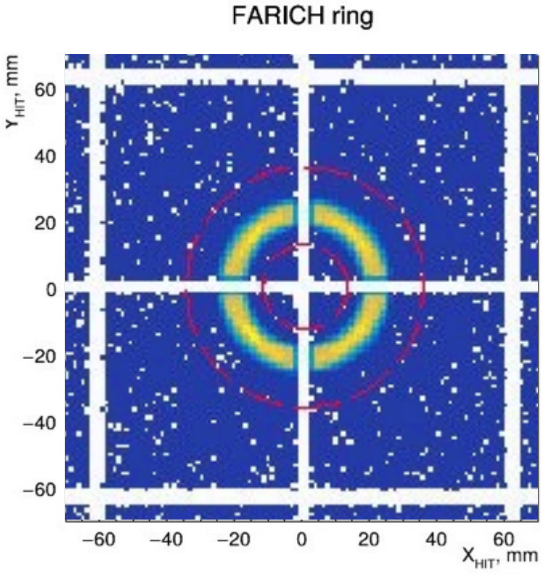
Ultralight aerogel FARICH beam test results and G4sim.

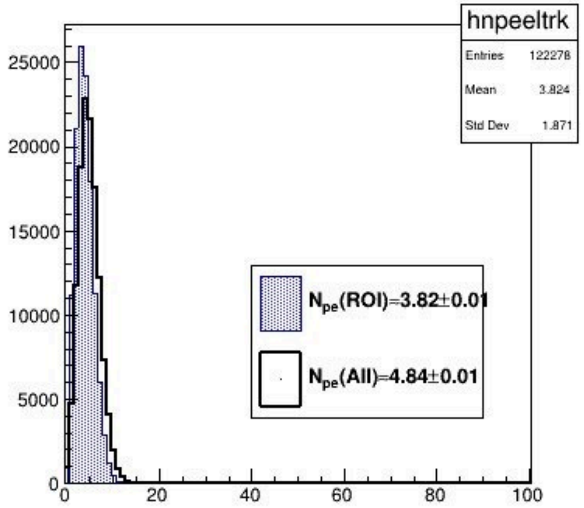


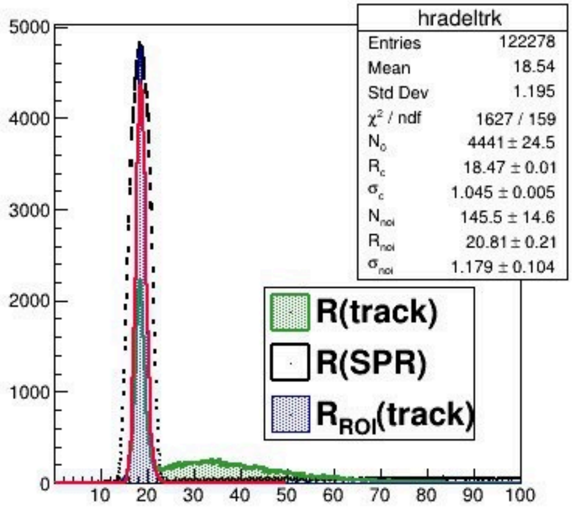






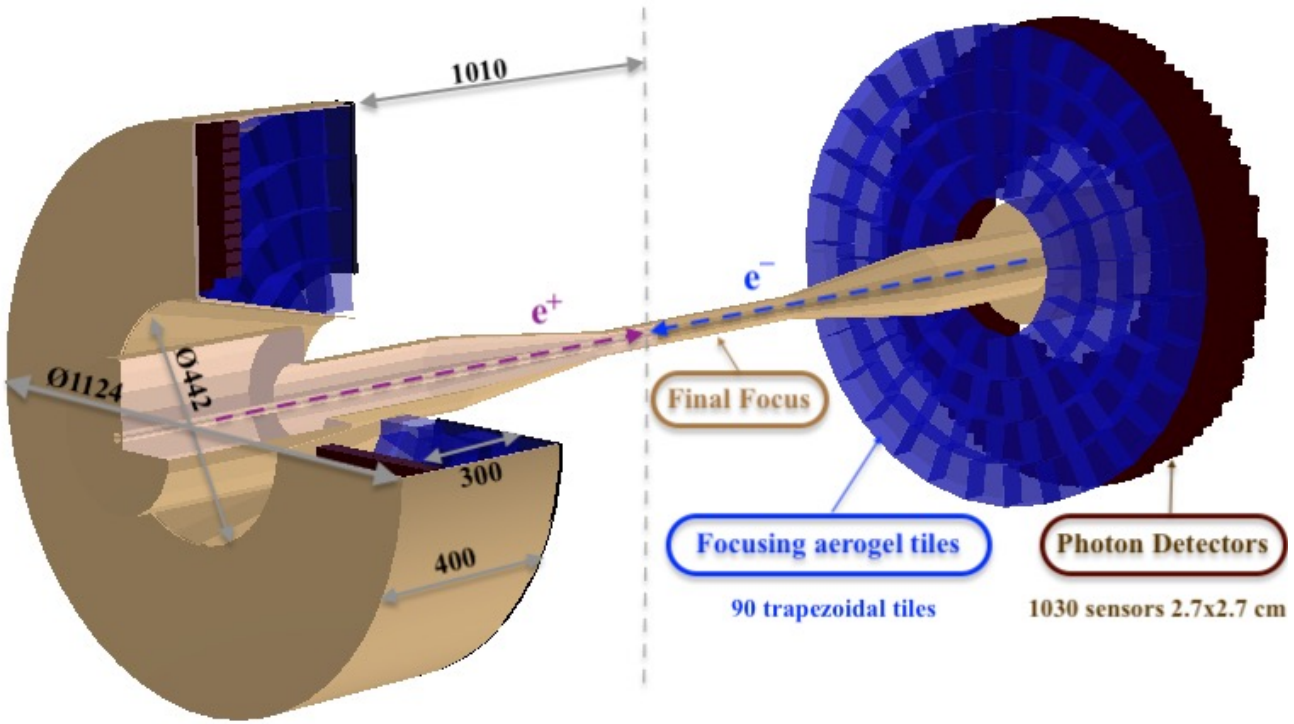


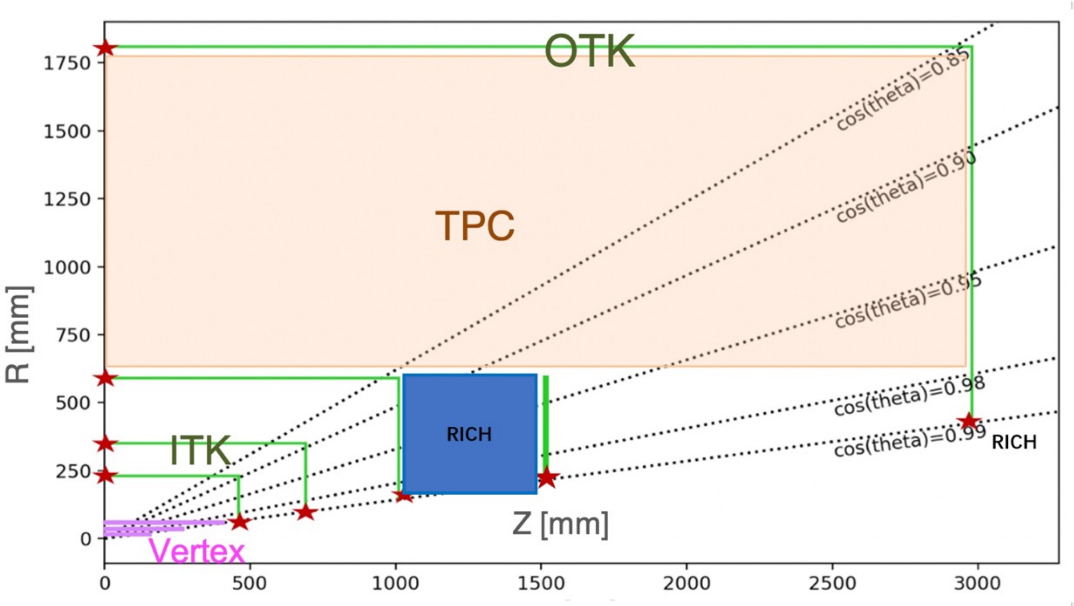


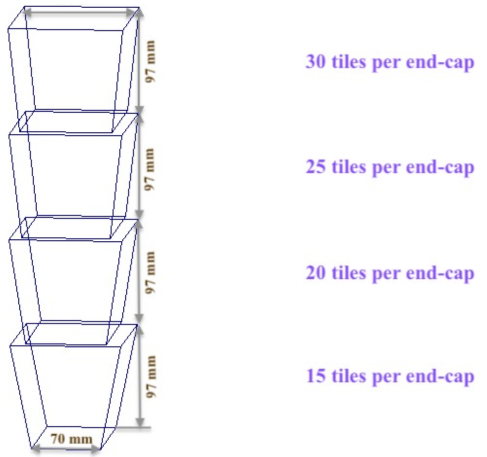


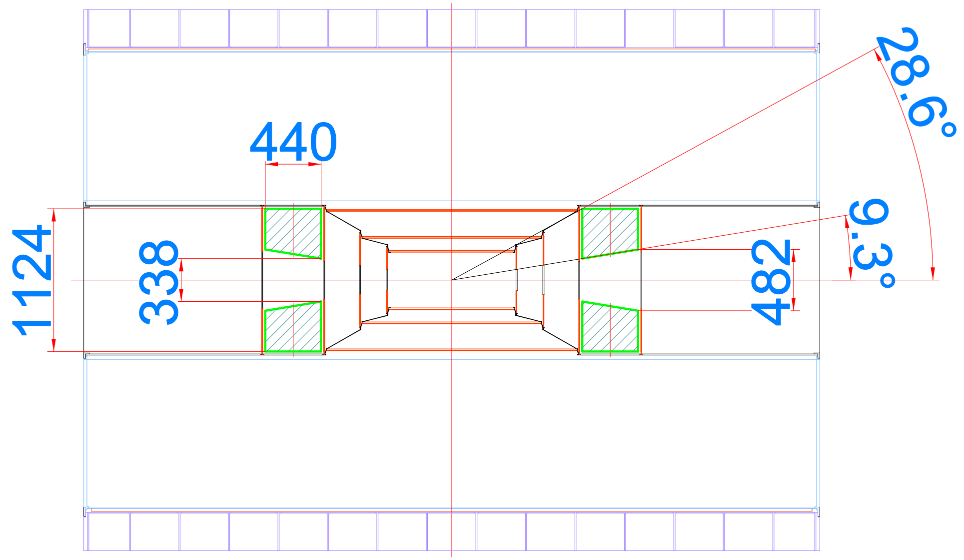
- More or less good agreement between G4sim and TBeam is observed.
- ***We need to use another type of PMT instead of flat-panel H12700 (Hamamatsu).***

FARICH for the CEPC project

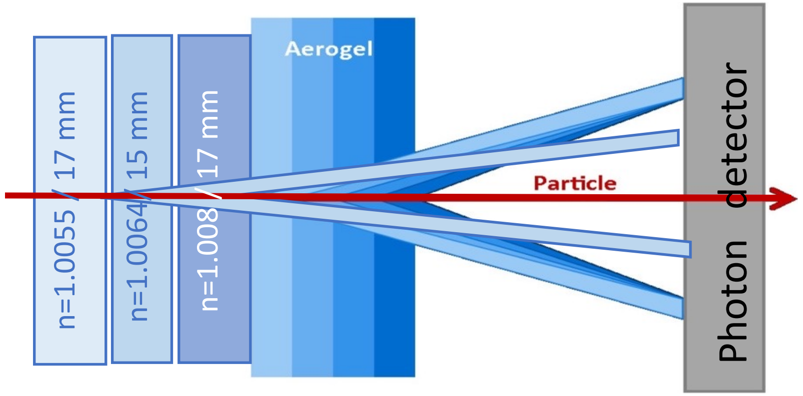








FARICH with dual aerogel radiator

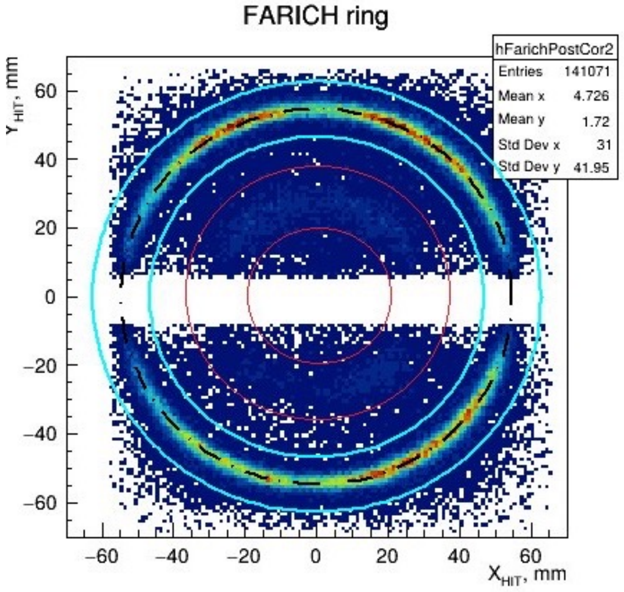


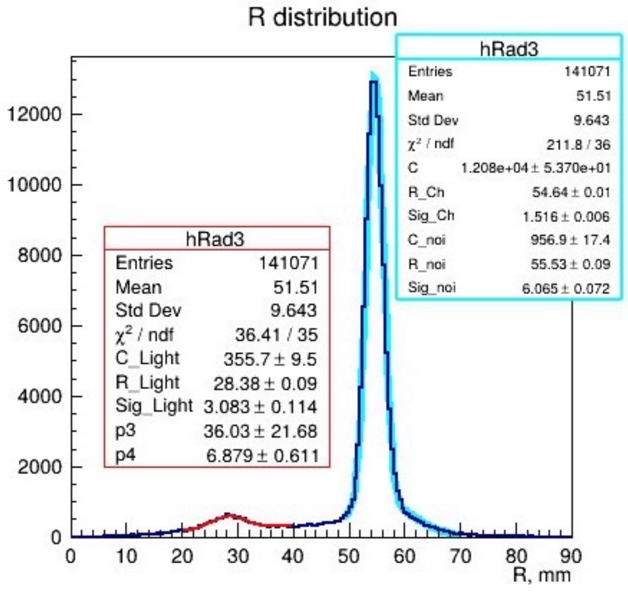
Main idea of concept

- FARICH with n_{max}≈1.008 will provide:
  - reliable μ/π–separation:
    - – from 0.8 to 2 GeV/c if pixel 6x6 mm;
    - – from 0.8 to 2.5 GeV/c if pixel 3x3 mm.
  - π/K–separation:
    - – from 1.1 to 10 GeV/c if pixel 6x6 mm;
    - – from 1.1 to 13 GeV/c if pixel 3x3 mm;
- Production of additional aerogel will take about 10% of total system cost

Combination of the from two beam tests:

- To fill the focusing effect pixel size was decreased with help of mask from 6x6 to **3x3mm** → **Geometrical Efficiency ~0.25**
- 4-layer focusing aerogel with n_{max}=1.046 and t=35 mm (N_{pe}=3.8);
- stack of 3 samples aerogel with n=1.008/1.0064/1.0055 and t_{Total}=49 mm (N_{pe}=1).

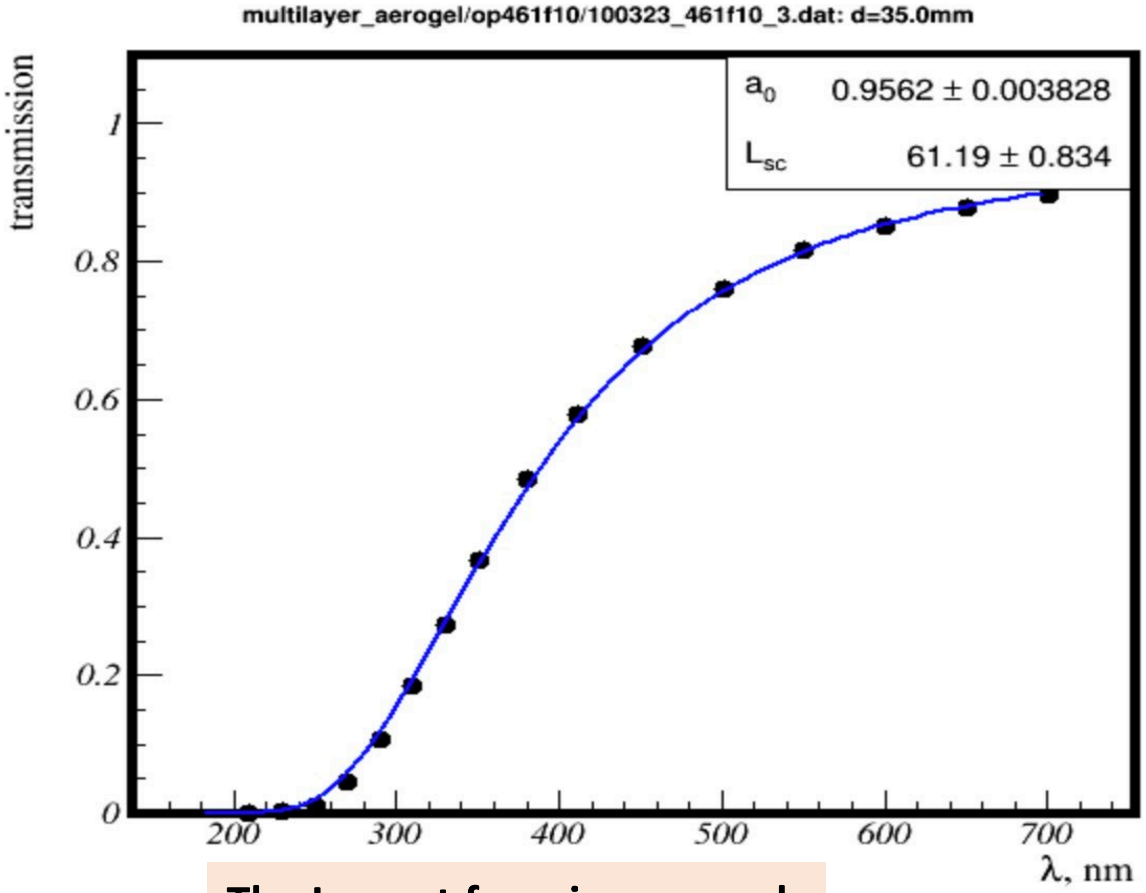


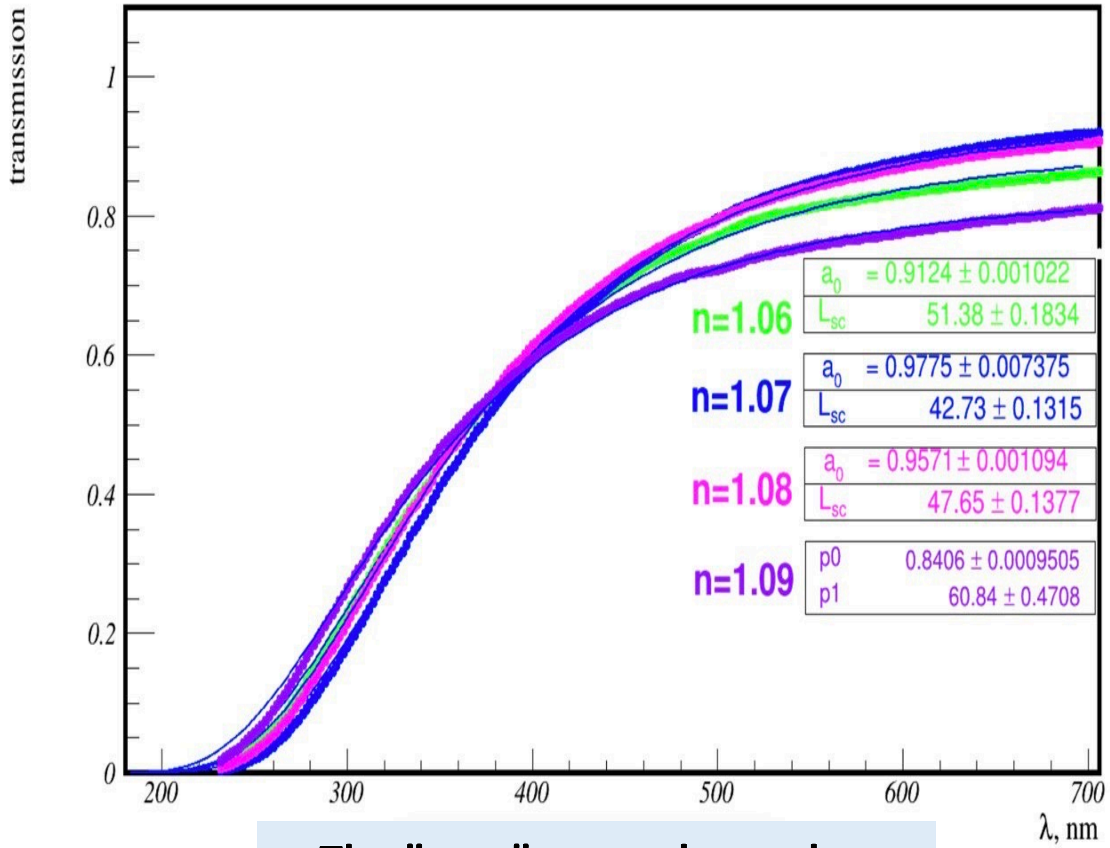


Summary

- The aerogel is a material with tuneable refractive index in wide range from 1.002 to 1.2
- Recent progress in production of highly transparent aerogels in Novosibirsk allows us to consider several proposals of aerogel based PID systems for the future colliding beam experiments:
  - FARICH for SCTF project
  - FARICH for the SPD-NICA experiment
  - FARICH based on ultra light ($n \leq 1.008$) multilayer focusing aerogel for the CEPC project
  - ASHIPH-SiPM for the
- Considering the SiPMs as photon detectors for the Cherenkov counters allows us to achieve new performance of the ASHIPH technique and propose new ASHIPH design for the several colliding beam experiments:
  - Upgrade of the SND detector ASHIPH counters for the future experiments at the VEPP-2000 e^+e^- collider (Novosibirsk)
  - ASHIPH-SiPM counters are considered as backup option of the PID system for the SPD-NICA experiment (Dubna)
  - PID system based on ASHIPH-SiPM for the VEPP-6 project (Novosibirsk)
  - ASHIPH PID system for the STCF project (Hefei)
- In 2025 the ASHIPH-SiPM prototype was tested with hadron beams at the CERN T9-PS beam test facility for the first time. ***The results are coming soon!***

Highly transparent aerogels with n>1.05





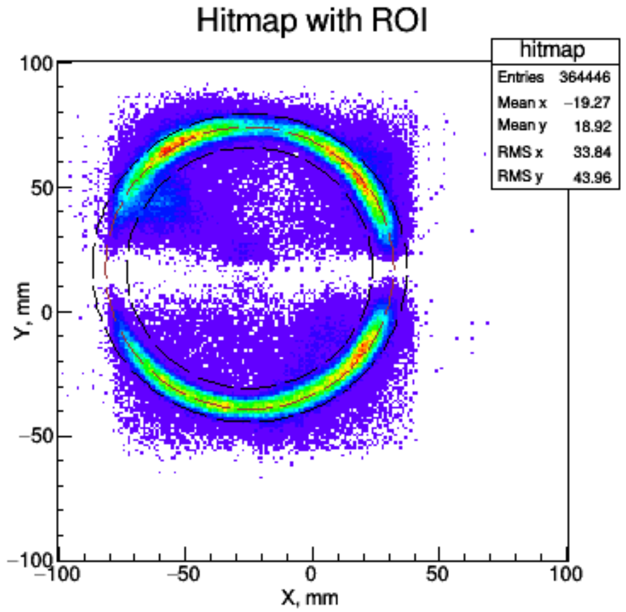
The Largest focusing aerogel:
- n_{max}=1.05
- 4 layers
- 230x230x35 mm

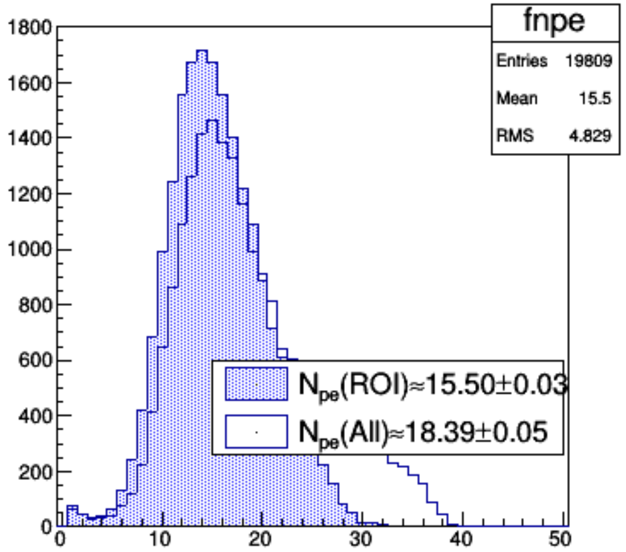
The "new" aerogel samples
with different refractive indexes:
from n=1.06 to 1.09
(thickness ~ 22 mm)

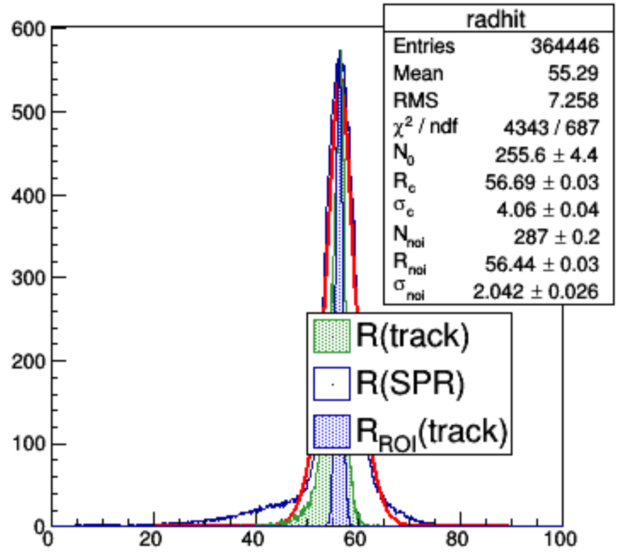
FARICH based on 4-layer aerogel with **n_{max}=1.08** will provide μ/π–separation from **250 MeV/c!!!**

Recent beam test results

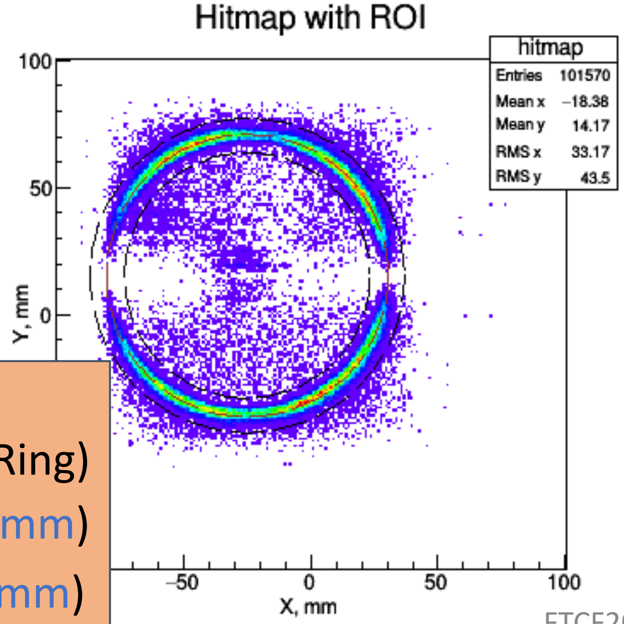
Pixel 6x6 mm
Geom.Eff. ~ 80%

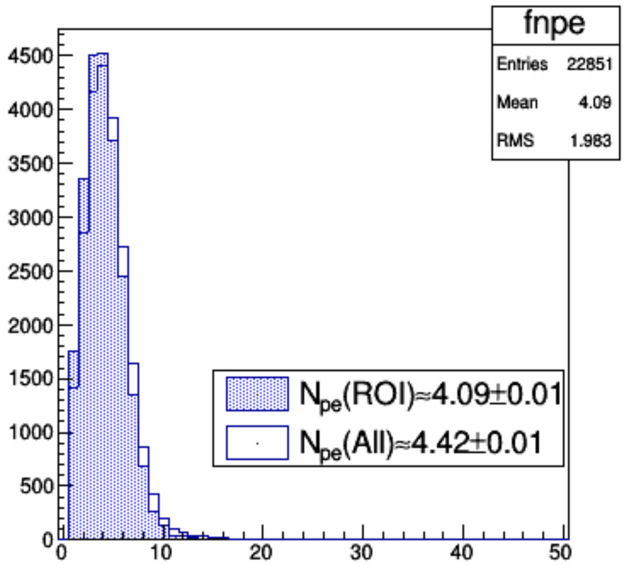


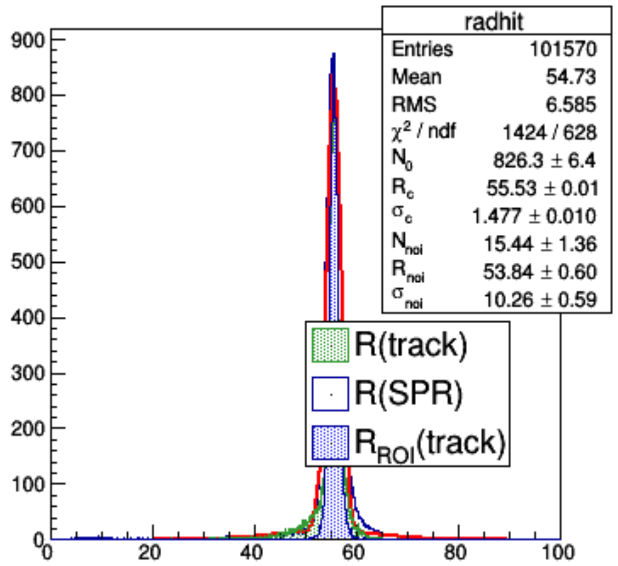




Pixel 3x3 mm
Geom.Eff. ~ 20%







Main results:

- $N_{pe} \approx 16$ (~ 0.8 of Ring)
- $\sigma_\theta^{1pe} \approx 13.5\ mrad$ (■ 6mm)
- $\sigma_\theta^{1pe} \approx 7.5\ mrad$ (■ 3mm)