



Status of R&D on ASHIPH system for the Super Tau Charm facilities in Hefei, China

Ivan Kuyanov on behalf of BINP Aerogel team.

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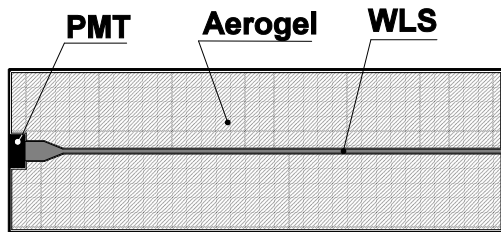
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with the participation of FDU (Shanghai, China) and USTC (Hefei, China)

TIPP 2026, TIFR, Mumbai

5 February 2026

ASHIPH method for particle identification

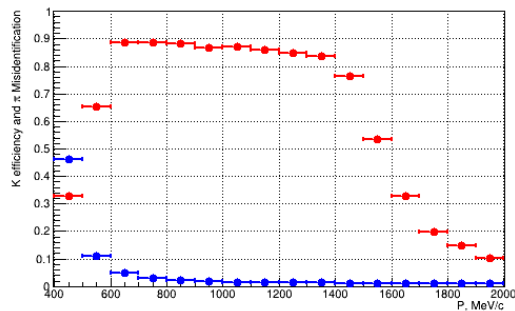
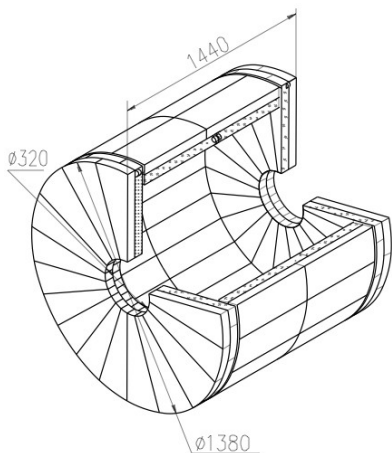


ASHIPH (Aerogel, SHifter, PHotomultiplier) method of light collection was suggested in 1992 (A. Onuchin et al. NIM A315, 1992, 517-520)

PMMA based light guide doped with BBQ dye is used as WLS

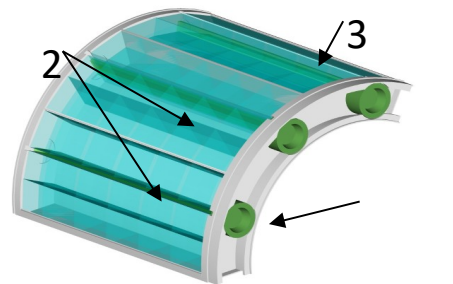
ASHIPH systems at the BINP (Novosibirsk):

KEDR detector at VEPP-4M

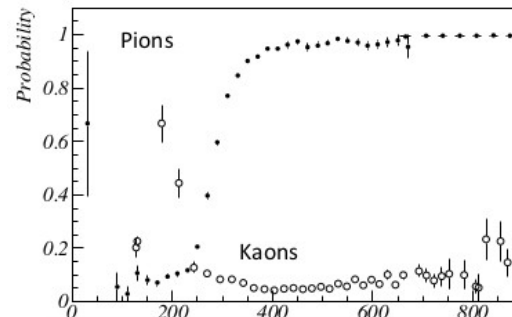


- 160 counters (2 layers)
- $N=1.05$ (1000 l.)
- MCP PMT $\varnothing_{PC}=18$ mm
- $0.97 \times 4\pi$

SND detector at VEPP-2000



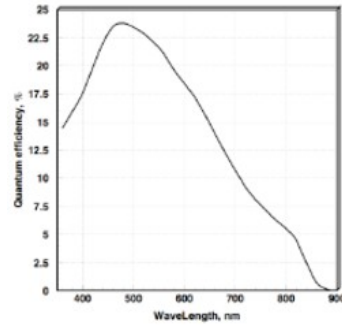
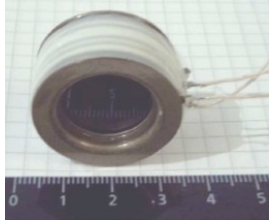
1 - PMT, 2 – aerogel, 3 - WLS



- 9 counters (1 layer)
- $n=1.13$ (π/K -separation)
- $n=1.05$ (e/π -separation)
- MCP PMT $\varnothing_{PC}=18$ mm
- $0.6 \times 4\pi$

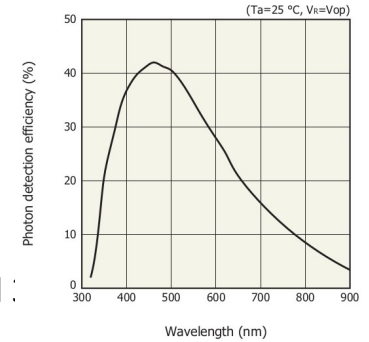
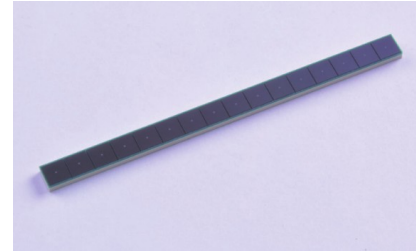
ASHIPH upgrade: MCP PMTs → SiPMs

MCP PMT («Ekran FEP»)



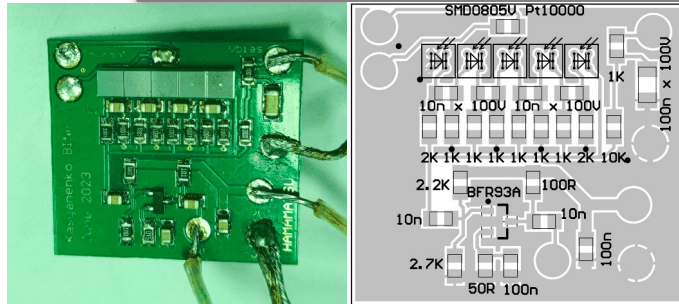
- $PDE = QE * CE = 23 * 0,6 \approx 14\%$
- $\varnothing PC = 18 \text{ mm}$

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



- Effective photosensitive area/channel :
- $PDE = 40\%$ при $\lambda = 500 \text{ nm}$
- High level of DCR (0.5 Mcps)

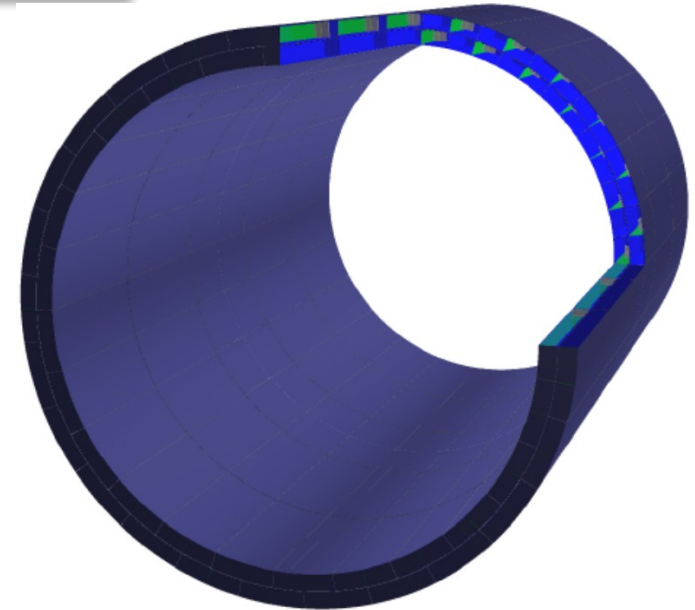
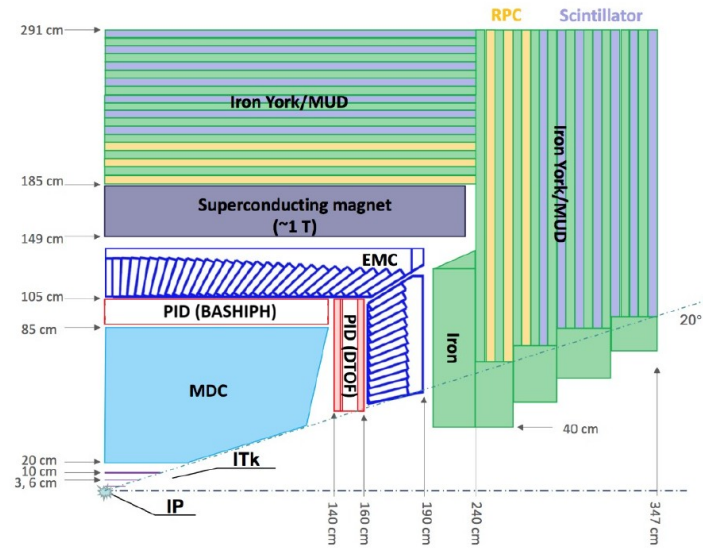
Move to SiPMs must increase detected number of photoelectrons in 2.5 times!
 $8 \div 10 \Rightarrow 20 \div 30 \text{ ф.э.}$



Serial connection of the SiPM with parallel bias voltage distribution.
(the idea of the connection is taken from the article NIMA 925 (2019)
148, 155

ASHIPH for STCF(Hefei) detector proposal

Energy range $E_{cm} = 2-7$ GeV, Peak luminosity $> 0.5 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ at 4 GeV

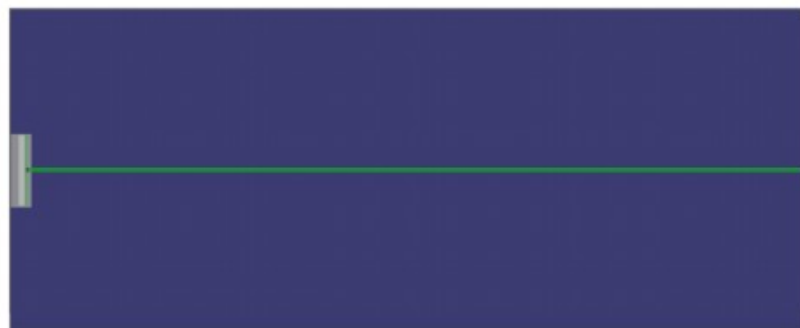


BASHIPH system:

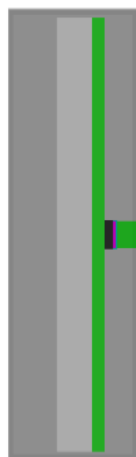
- Total number of counters: 250 (~1740 l. of aerogel)
- 2 layers: are shifted relative to each other by half a period

- Thickness the system: 12.5 cm
- 5 segments: 1 segments content of 25 counters
- Length the system: 280 cm (counter length: 56 cm)

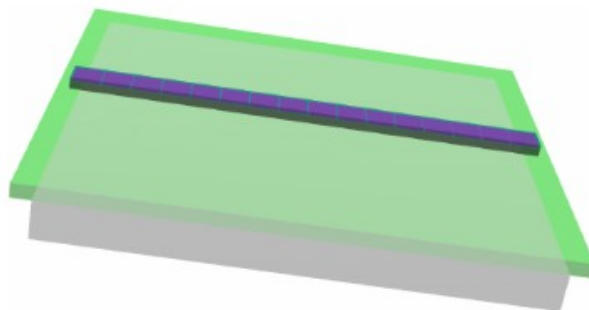
BASHIPH simulation with OSCAR framework



Counter



Electronic box



SiPMs + PCB(5×5.4 cm)+
Peltier(5×5 cm)

Geometry description:

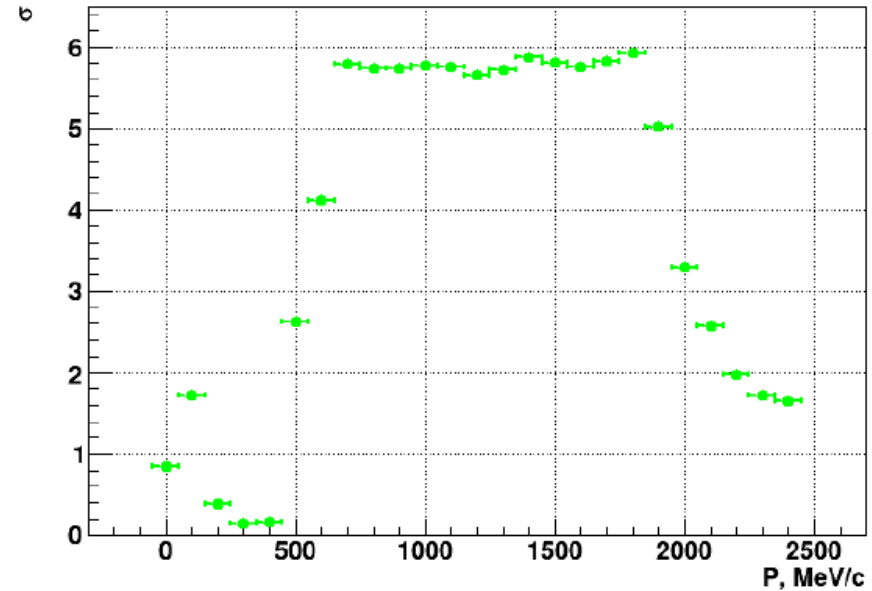
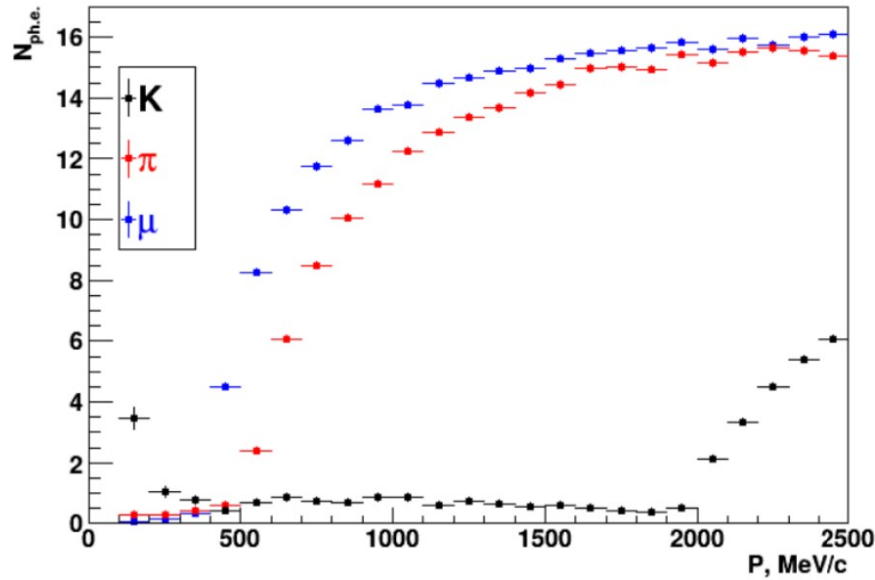
- Teflon covered from inside
- Aerogel
- WLS assembly at the middle of counter
- SiPM optically coupled to WLS
- Electronic box with SiPMs, PCB and
- Peltier module

Simulated physical processes:

- Aerogel optics
- WLS optics
- Teflon reflection
- SiPm simulation

PD: SiPMs (HAMAMATSU S13363-3050NE-16)

BASHIPH simulation with OSCAR framework

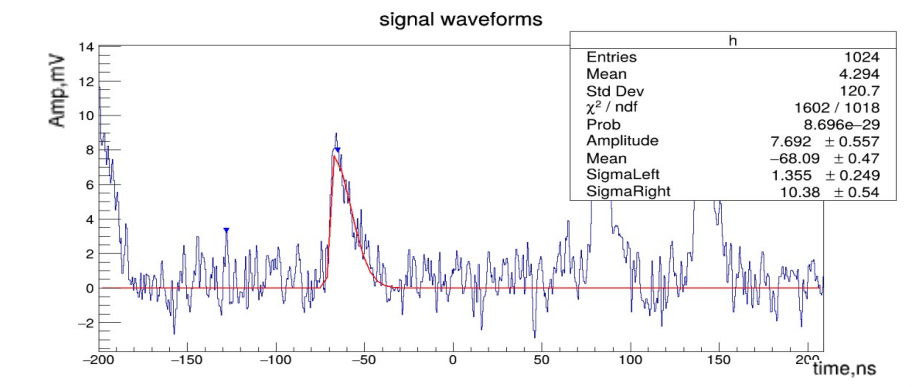
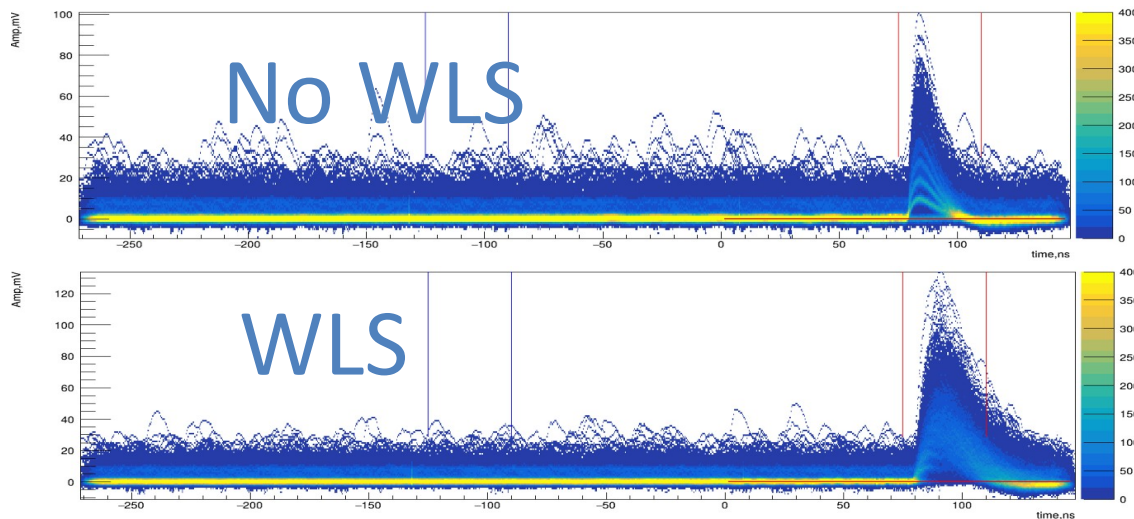


The track passed through two layers

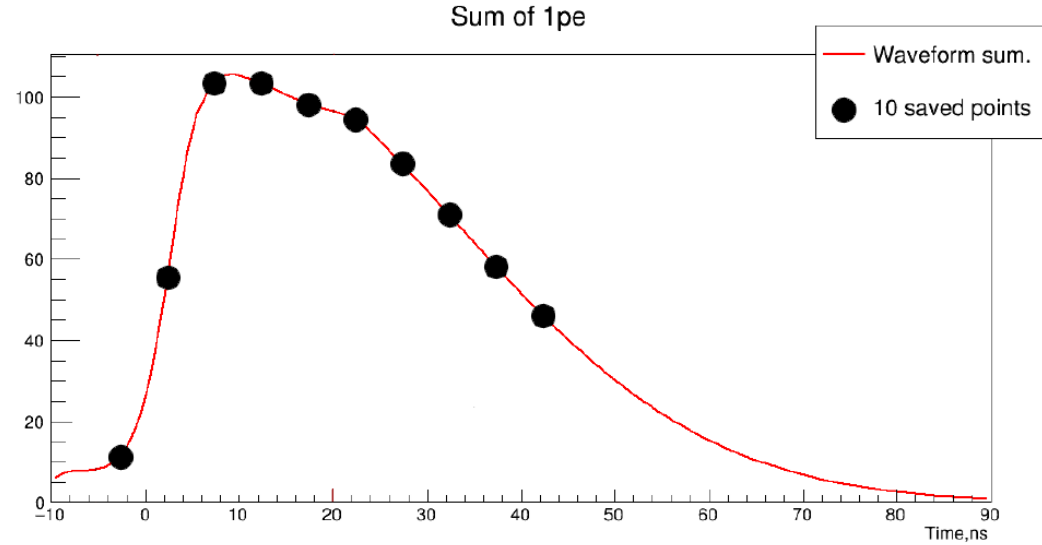
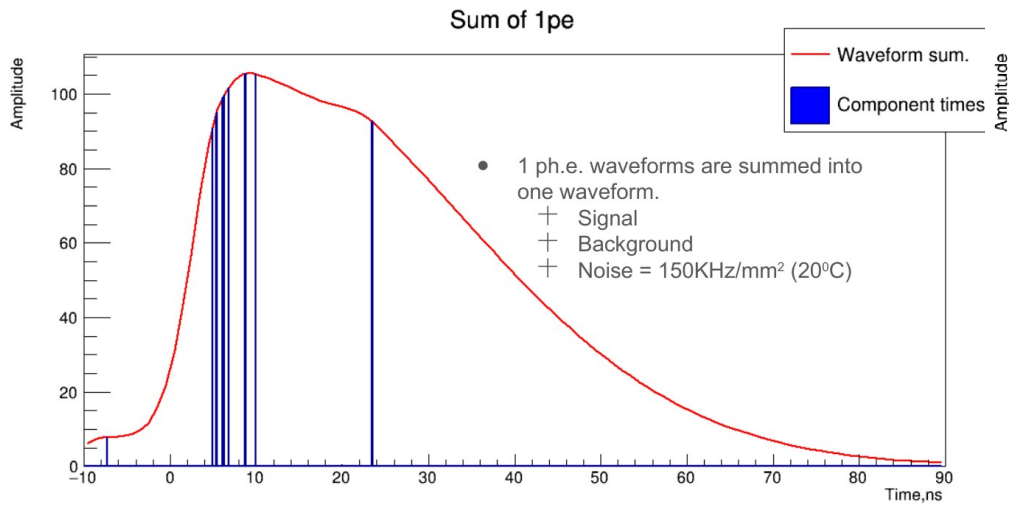
Signal output ~ 14.4 ph.e.
 π/K -separation better 5.5σ (0.6÷2.0 GeV/c)!

BASHIPH Digitization: The SiPM signal waveform

- The SiPM signal is the sum of the cell signals.
- The cell signal is a single-photon amplitude.
- Single-photon signals fitted by an assimetric gaussian.
- Asymmetric Gaussian function with average parameters from fits was used as a single-photon waveform (SW).
- The waveform from the SiPM is the sum of single-photon functions $SW(t_1) + SW(t_2) + \dots$, where t is the photon registration time.
- Further optimization of the waveform is needed

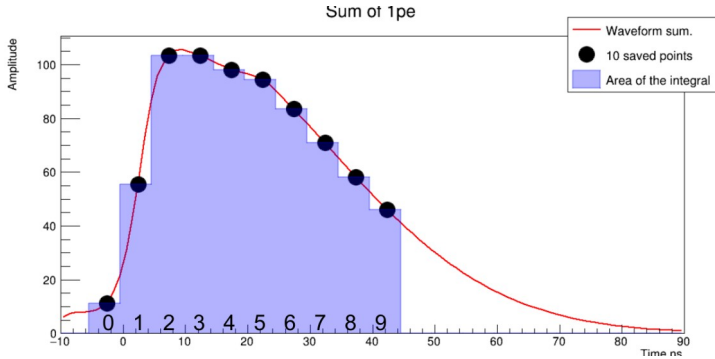


BASHIPH digitization



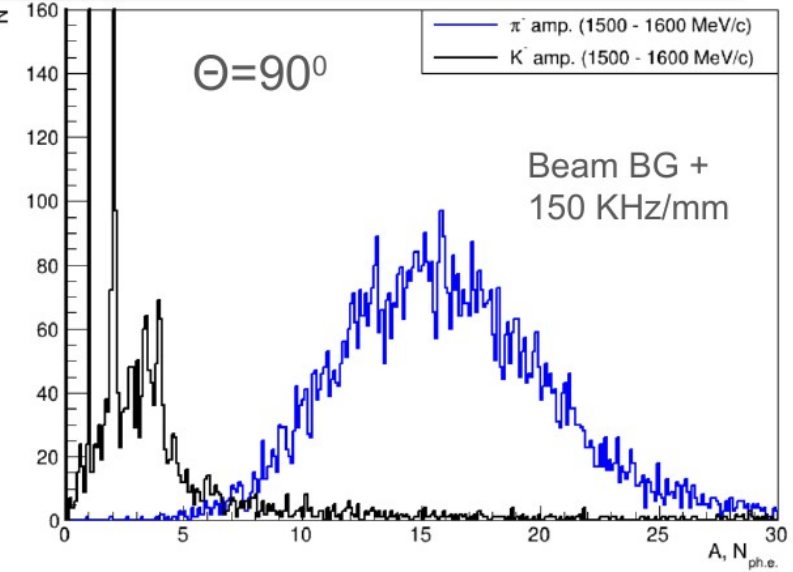
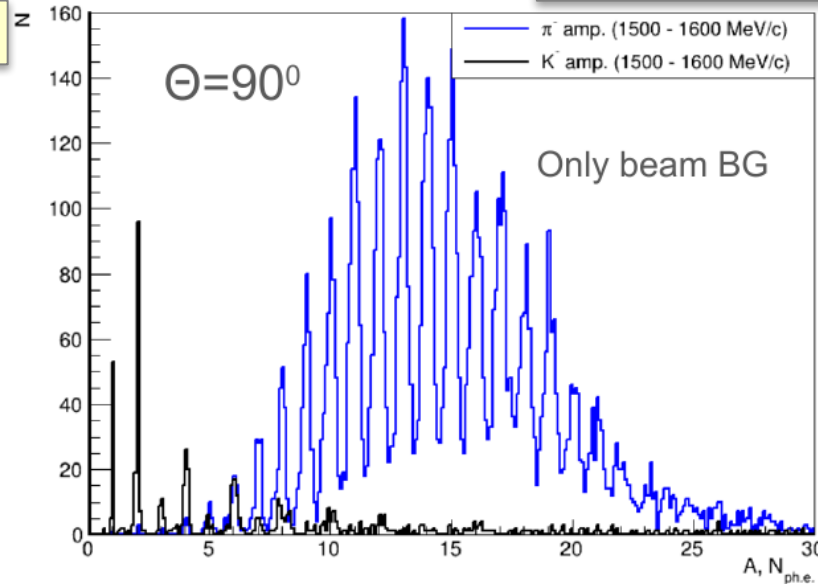
For each counter the hit time and several amplitudes are stored.

BASHIPH reconstruction

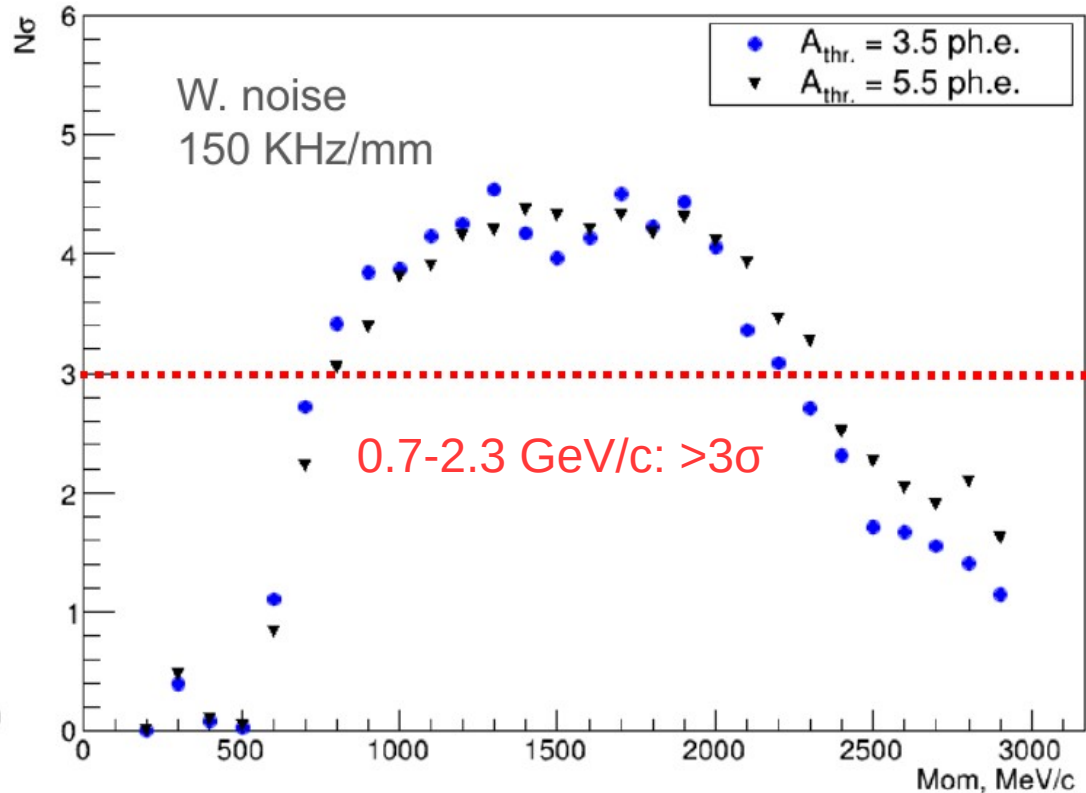
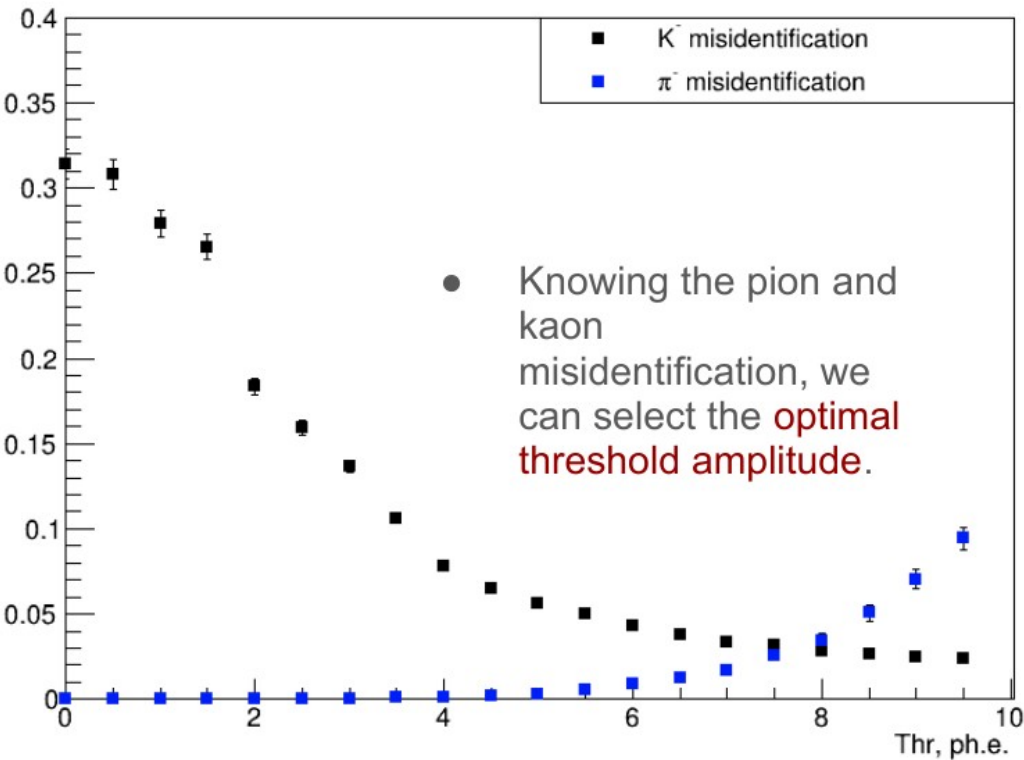


The sum of the amplitudes from the two layers.

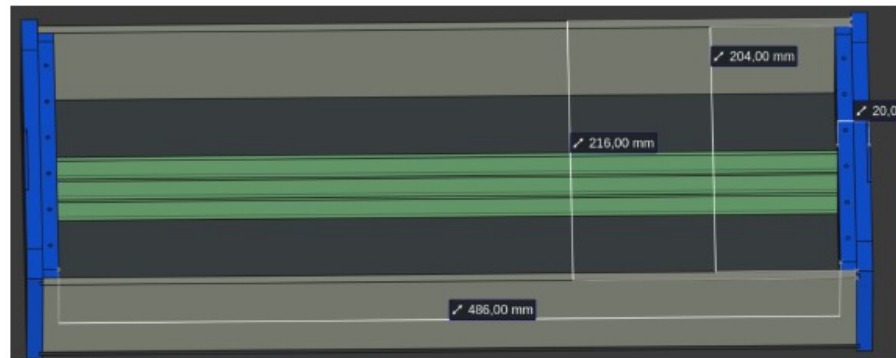
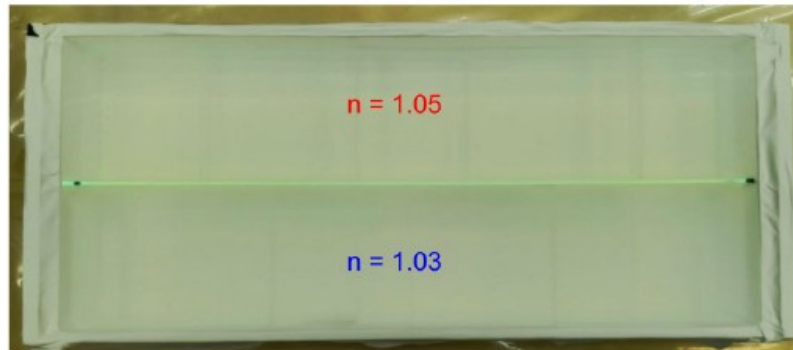
Integrated signal



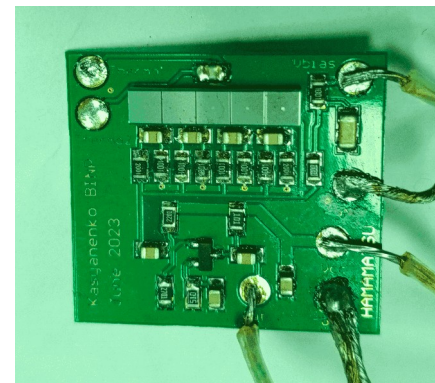
BASHIPH reconstruction: π/K separation quality



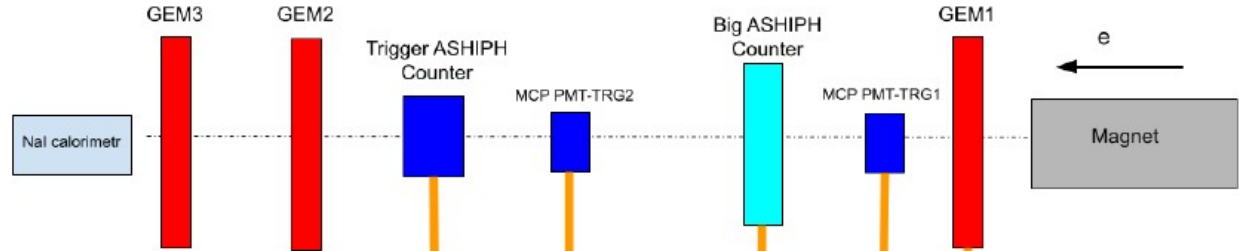
Testing the ASHIPH prototype at electron beam



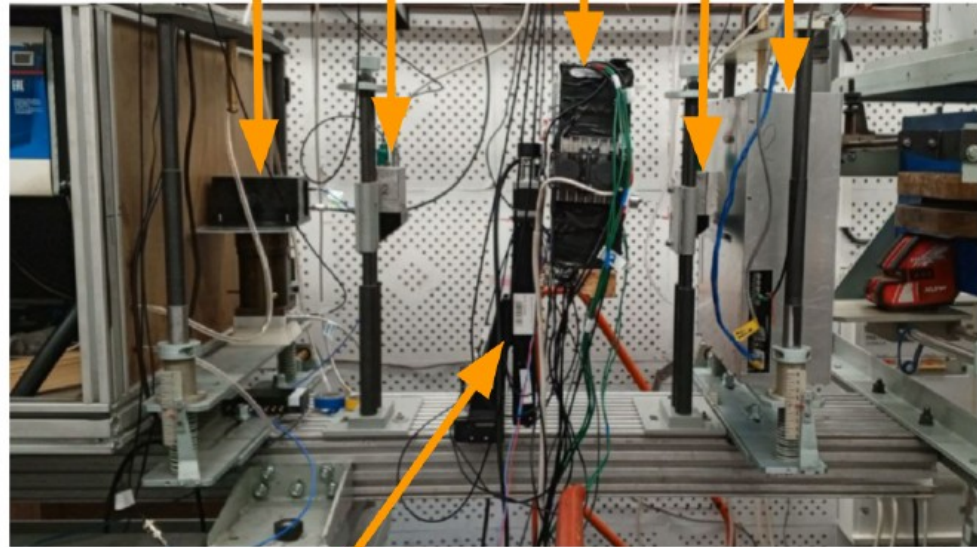
- Rectangular shape 50×22×6.4 cm
- Two types of aerogels with $n=1.03$ and $n=1.05$ for different halves the volume
- Aerogel blocks have a size 100×100×60 mm
- 3 WLS plates based on Plex with BBQ dope, cross-section size is 17×3 mm
- 3 arrays of 5 SiPMs each were made from MPPC S13365-3050NE-16 (Hamamatsu)



ASHIPH prototype at electron beam

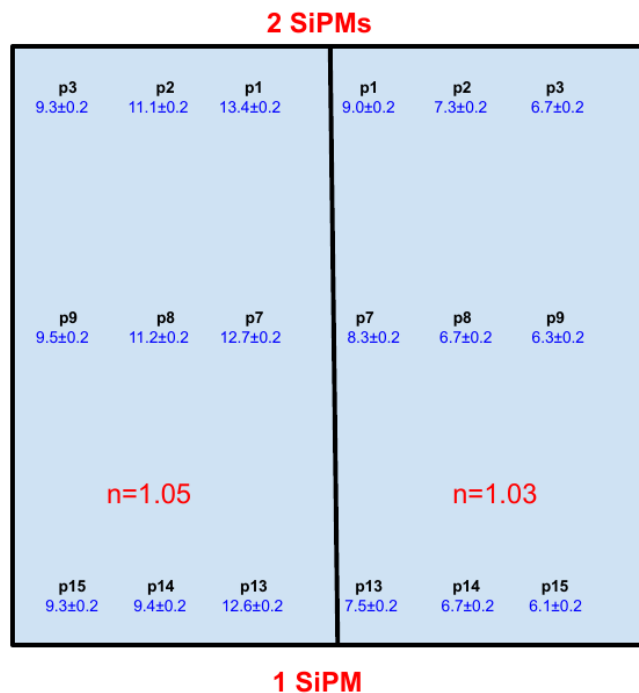


Beam energy:
580 MeV



2D mover to scan
Light collection uniformity

ASHIPH prototype at electron beam



Average number of photoelectrons per counter:

- Aerogel (n=1.03): 7.2 ph.e.
- Aerogel (n=1.05): 10.9 ph.e.

Inhomogeneity of light collection from average value is:

- Aerogel (n=1.03): ±20%
- Aerogel (n=1.05): ±18%

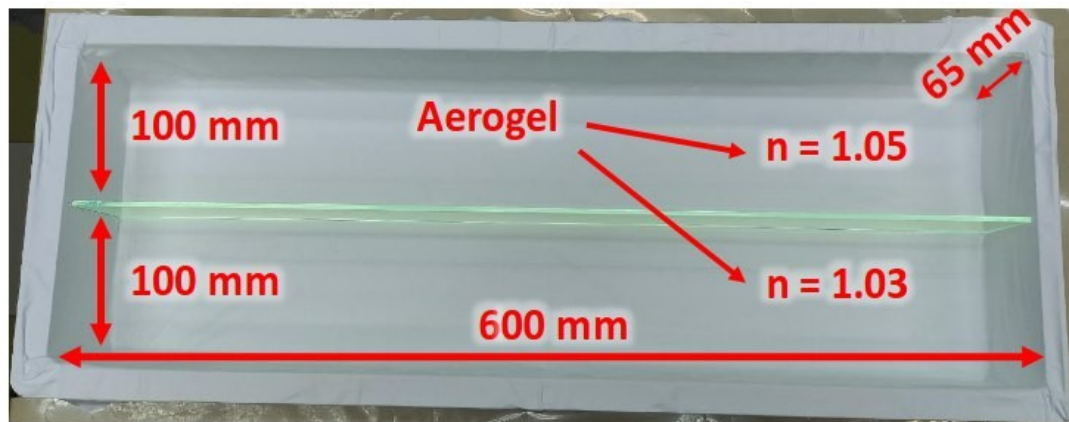
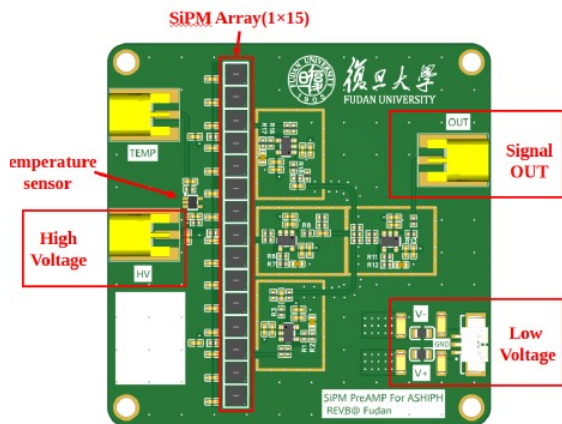
Inhomogeneity of light collection along(z-axis) the counter:

- Aerogel (n=1.03): ±7%
- Aerogel (n=1.05): ±5%

On the electron test-beam we can't observe the subthreshold efficiency or the beam background !

The results from the test beam are agreement with the simulation
BASHIPH counter!

ASHPH prototype assembled/tested at FDU



3 lines of 5 SiPMs (three WLS 17mm are readout)

⇒

1 line of 15 SiPMs (one WLS 60mm is readout)

Type	EQR20 11-3030D-S	EQR20 11-6060D-S
Effective Pitch	20 μm	
Element Number	1 \times 1	
Active Area	3.00 \times 3.00 mm ²	6.24 \times 6.24 mm ²
Micro-cell Number	2500 /mm ²	
Typical Breakdown Voltage (V_B)	27.5 V	
Temperature Coefficient for V_B	24 mV / °C	
Recommended Operation Voltage	$V_B + 5$ V	
Peak PDE @ 420nm	46 %	
Gain	8.2×10^5	
Dark Count Rate (DCR)	150 kHz / mm ²	

The SiPM and electronics were provided by Fudan University (Shanghai, China).

Aerogel, WLS, counter body and thermoregulation system were provided by BINP.

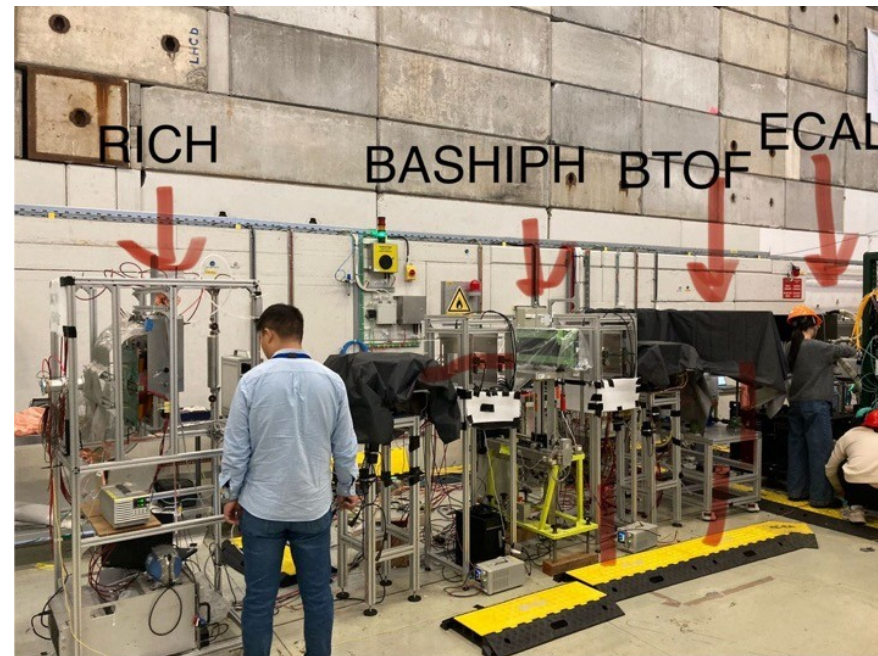
Final assembly and tests at Fudan University.

STCF beam test at PS-T9 (CERN). October 2025

Beam:

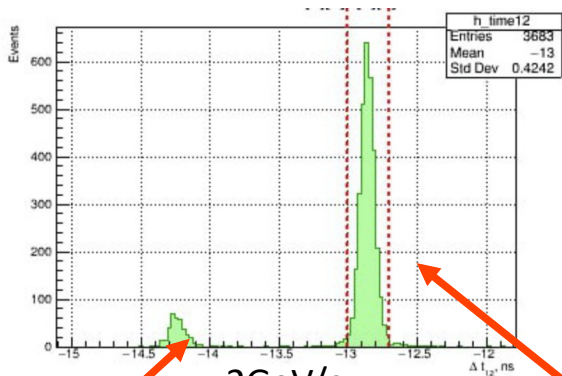
- Mixed pions and protons in general
- Particle selection performed by ToF counters based on PLEX + MCP PMT ($\sigma_t \approx 20 \div 30$ ps)
- Track selection efficiency 7-15%
- Measurements were performed at 5 different beam energy values:

1 GeV/c, 2 GeV/c, 3 GeV/c, 4 GeV/c, 5 GeV/c.



SiPM temperature 18°C.

STCF beam test: preliminary results



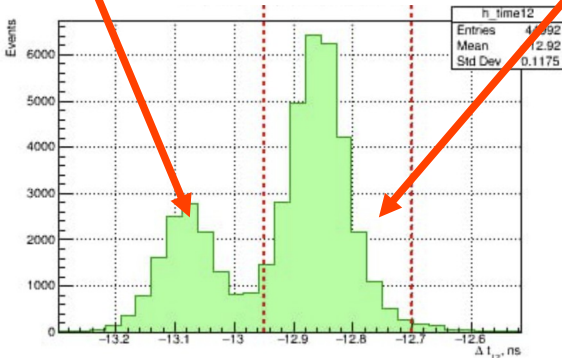
2 GeV/c

Particle selection

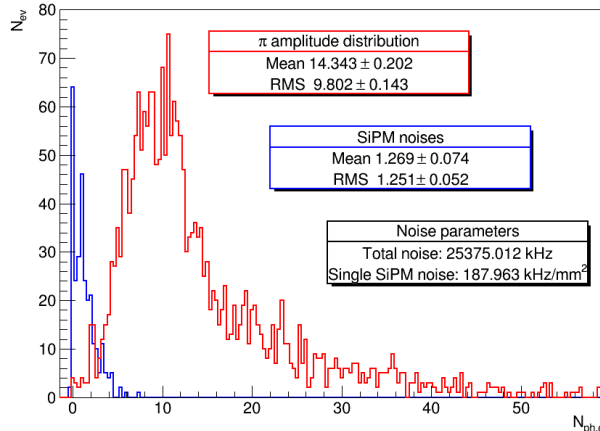
p

π^+

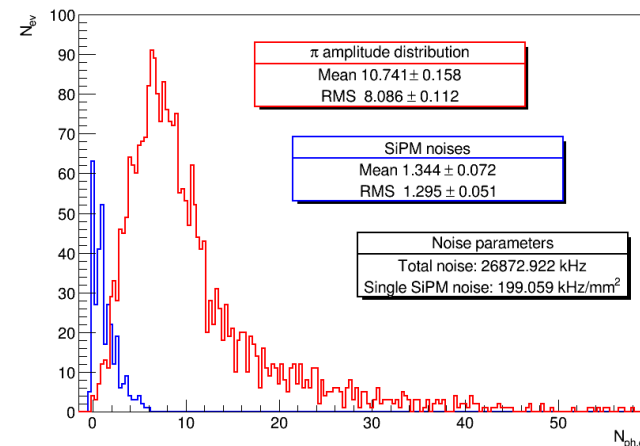
5 GeV/c



π , 2 GeV/c, 1.05

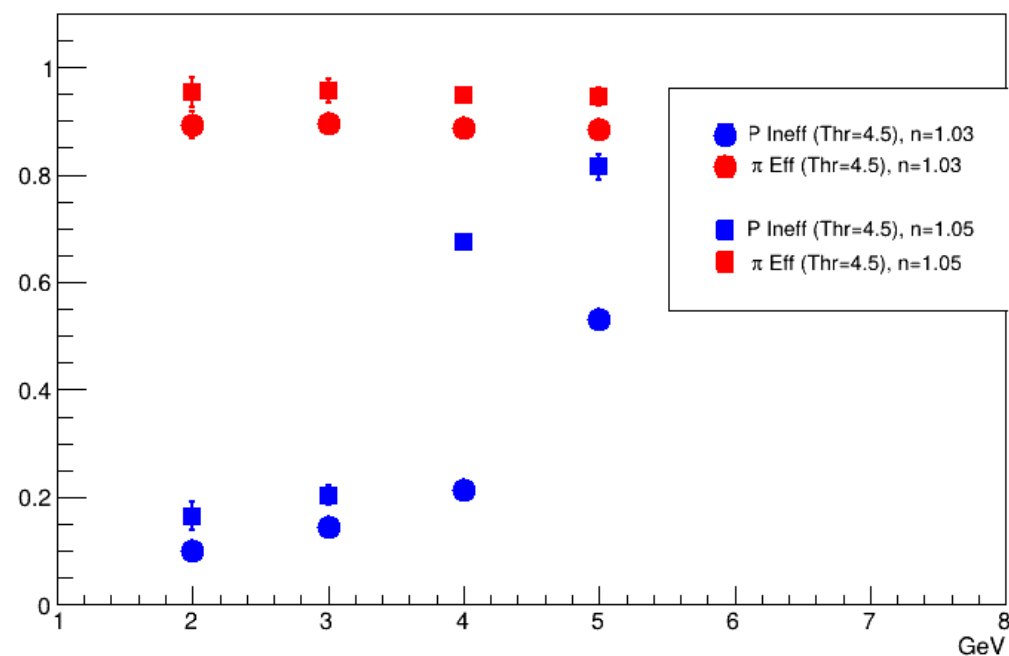
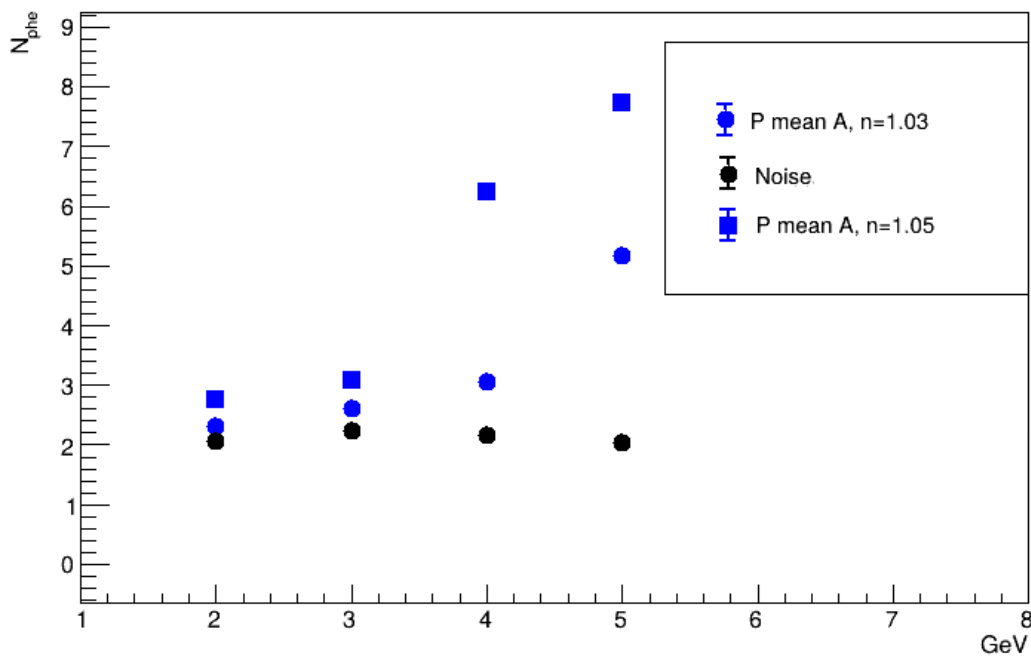


π , 2 GeV/c, 1.03



Data processing in progress !

STCF beam test: subthreshold efficiency (preliminary)



Parameterization of the SiPM noise effects on subthreshold efficiency is needed for tuning the ASHIPH counter simulation in the OSCAR framework and planning future experiments!

Summary and further plans

- The integration of the BASHIPH system into the OSCAR environment is continuing.
- The results from the electron test beam are agreement with the simulation BASHIPH counter.
- Further optimization of the waveform is needed.
- Data from the hadron beam is being processed.