Beam Test Results from Prototypes of Aerogel Cherenkov Detector

for the H-dibaryon search experiment (E42) at J-PARC

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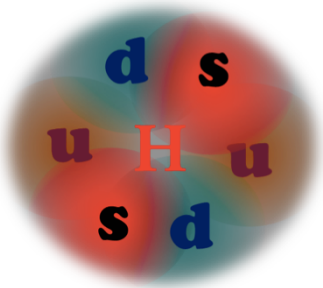
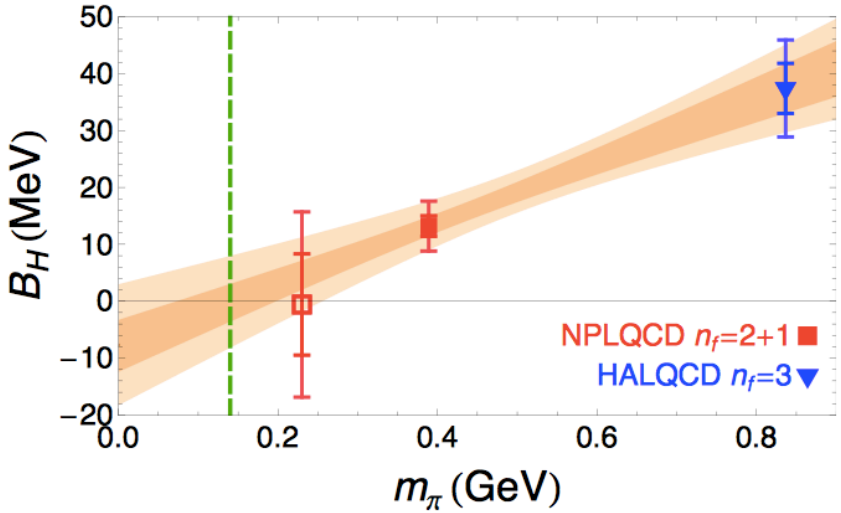
for the E42 collaboration

H-dibaryon, an Exotic Hadron

"H-dibaryon"
Six quarks
$J^{\pi} = 0^{+}$

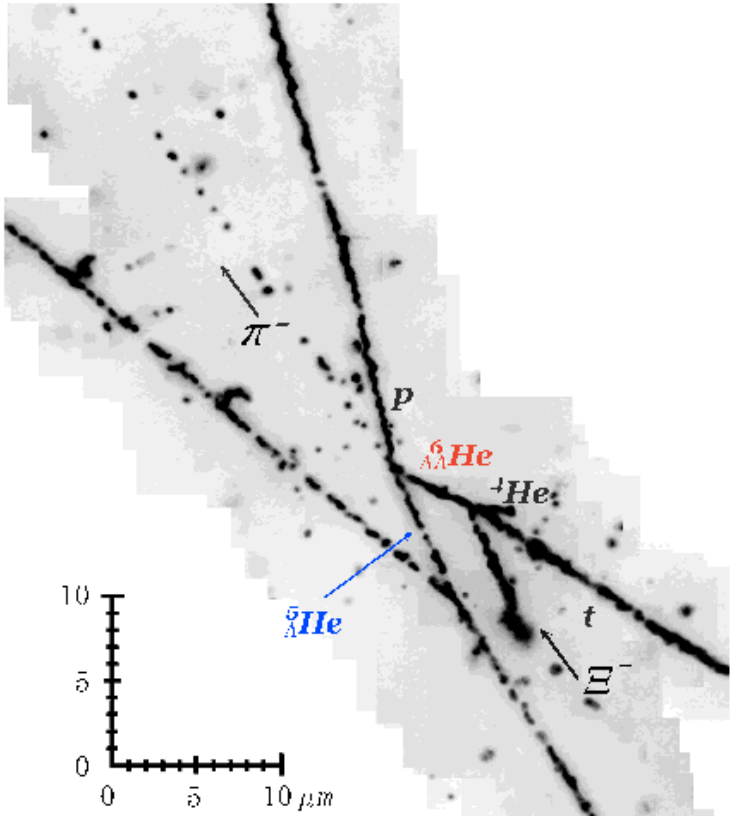


HALQCD, NPLQCD collaboration



Nagara event

$\Xi^- + {}^{12}\mathrm{C} \rightarrow {}^{6}_{\Lambda\Lambda}\mathrm{He} + {}^{4}\mathrm{He} + \mathrm{t}$
${}^{6}_{\Lambda\Lambda}\mathrm{He} \rightarrow {}^{5}_{\Lambda}\mathrm{He} + \mathrm{p} + \pi^-$

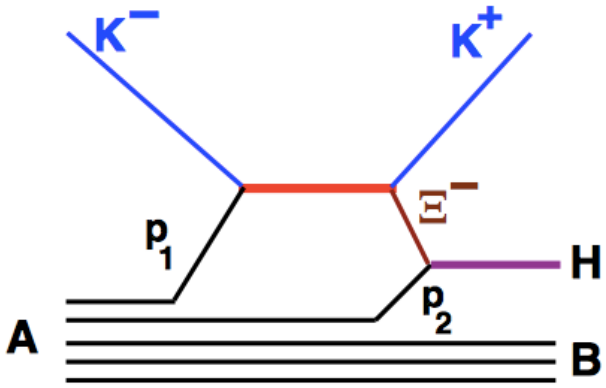


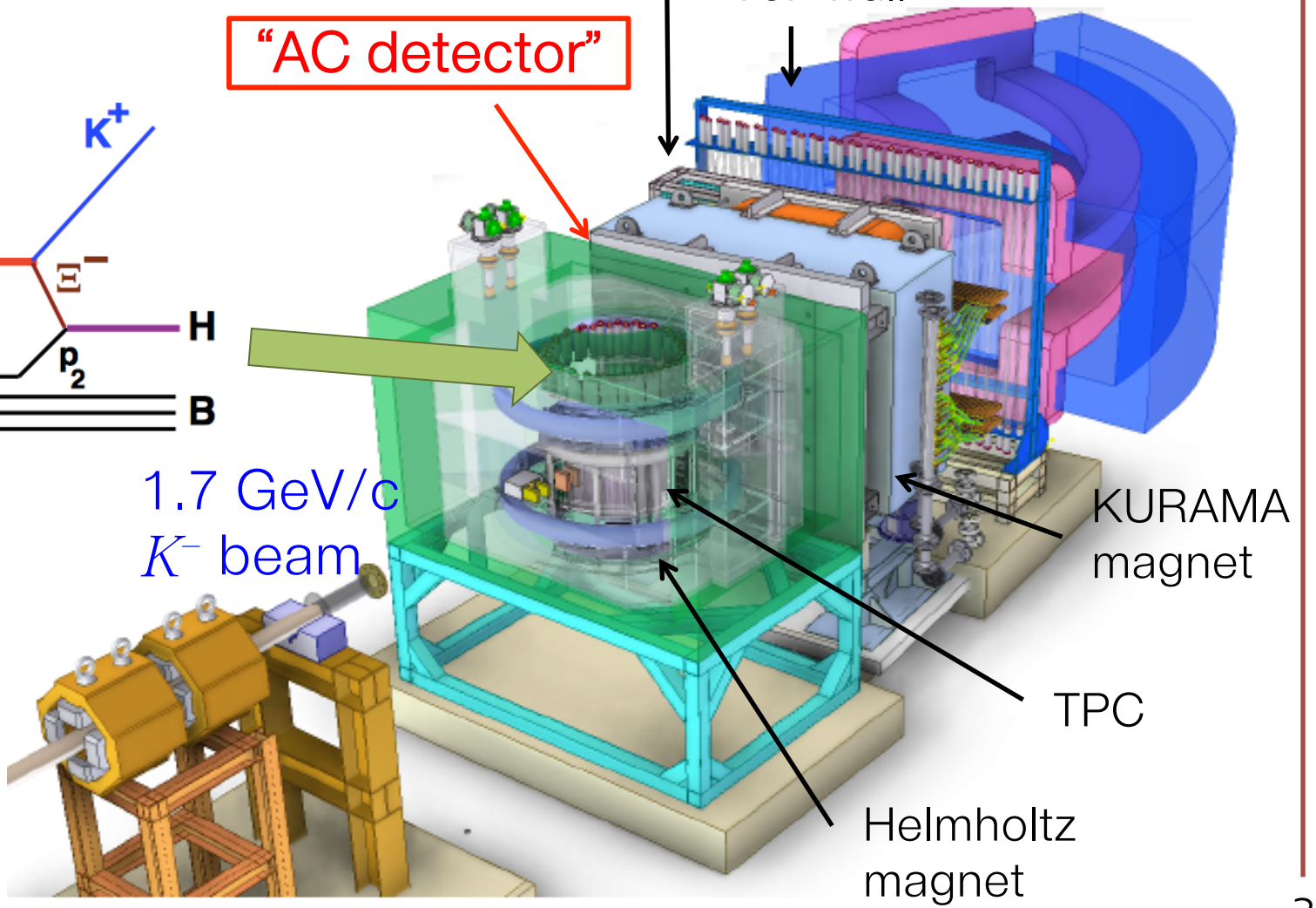
Loosely bound or unbound: $M(H) \geq 2M(\Lambda) - 7.25$ MeV

H-Dibaryon Search Experiment, E42

Signal : $p(K^-, K^+)\Xi^-$

Background: $p(K^-, \pi^+)\Sigma^-$





Forward Aerogel Cherenkov Detector

Fine-mesh PMT

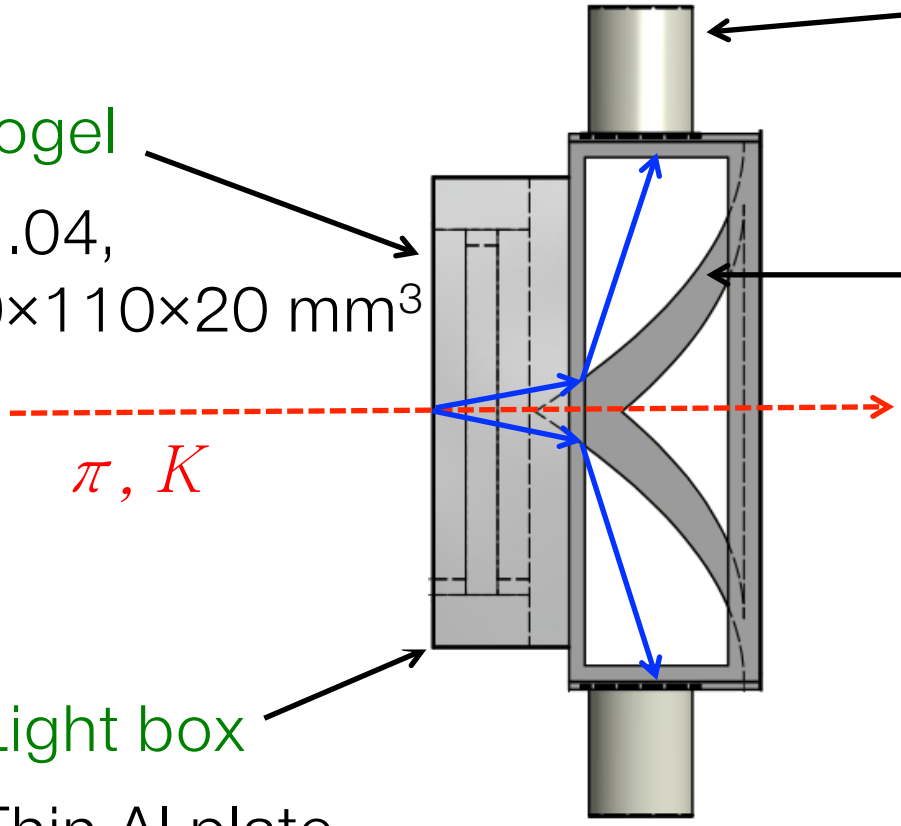
Strong to B field

Aerogel

n=1.04,
110×110×20 mm^3

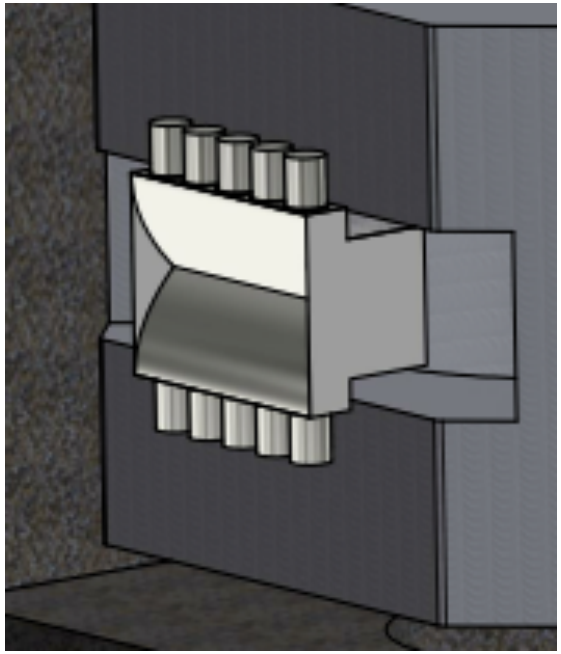
Parabolic reflector

Al mylar



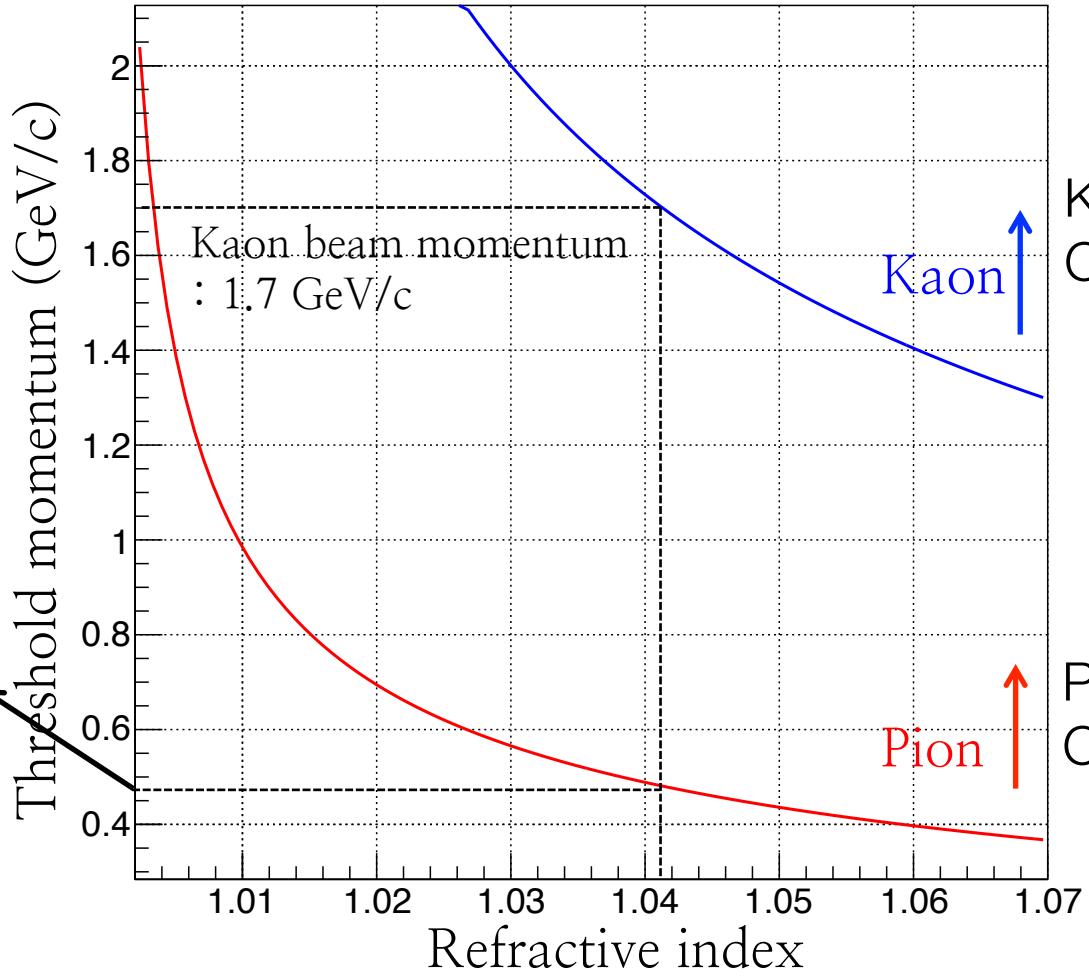
Light box

Thin Al plate



At the exit of Helmholtz magnet.

FAC Aerogel



$p_{\min}$ FAC can reject is about 0.48 GeV/c.

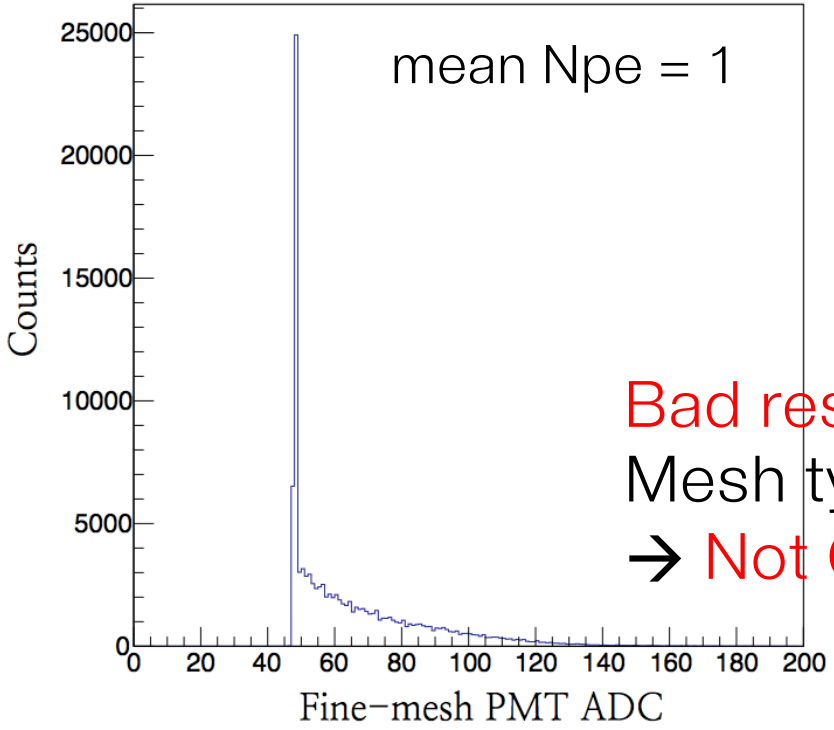
Kaon emits Cherenkov light.

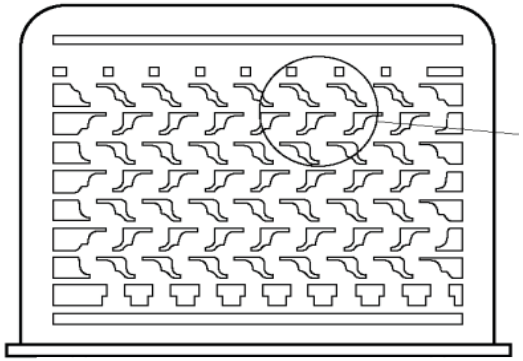
Pion emits Cherenkov light.

$$\cos\theta = \frac{1}{n\beta} = \frac{\sqrt{1+\left(\frac{p}{m}\right)^2}}{n\left(\frac{p}{m}\right)} < 1$$

Refractive index should be smaller than 1.04132.

FAC PMT, fine-mesh PMT



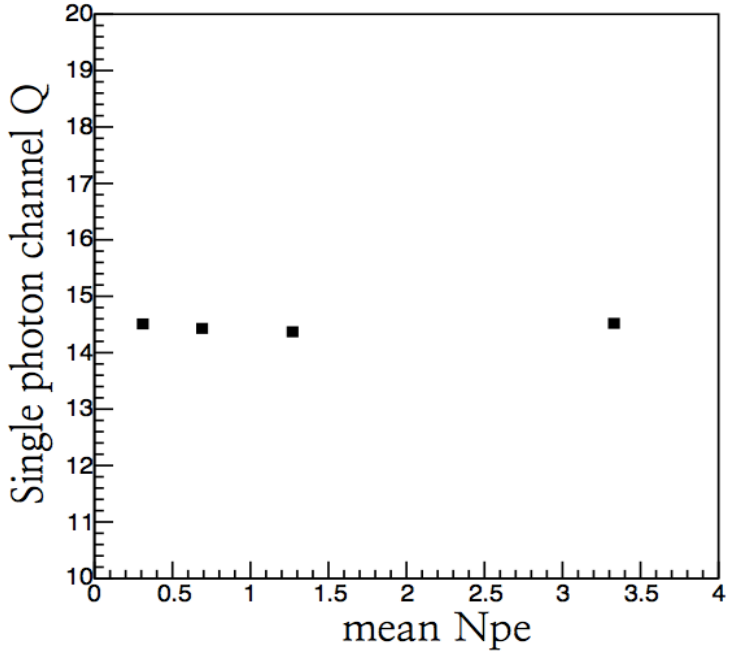


Bad resolution for photon counting.
Mesh type dynode
→ Not Gaussian shaped amplification.

Let's assume one photoelectron
→ mean ADC, +Q.

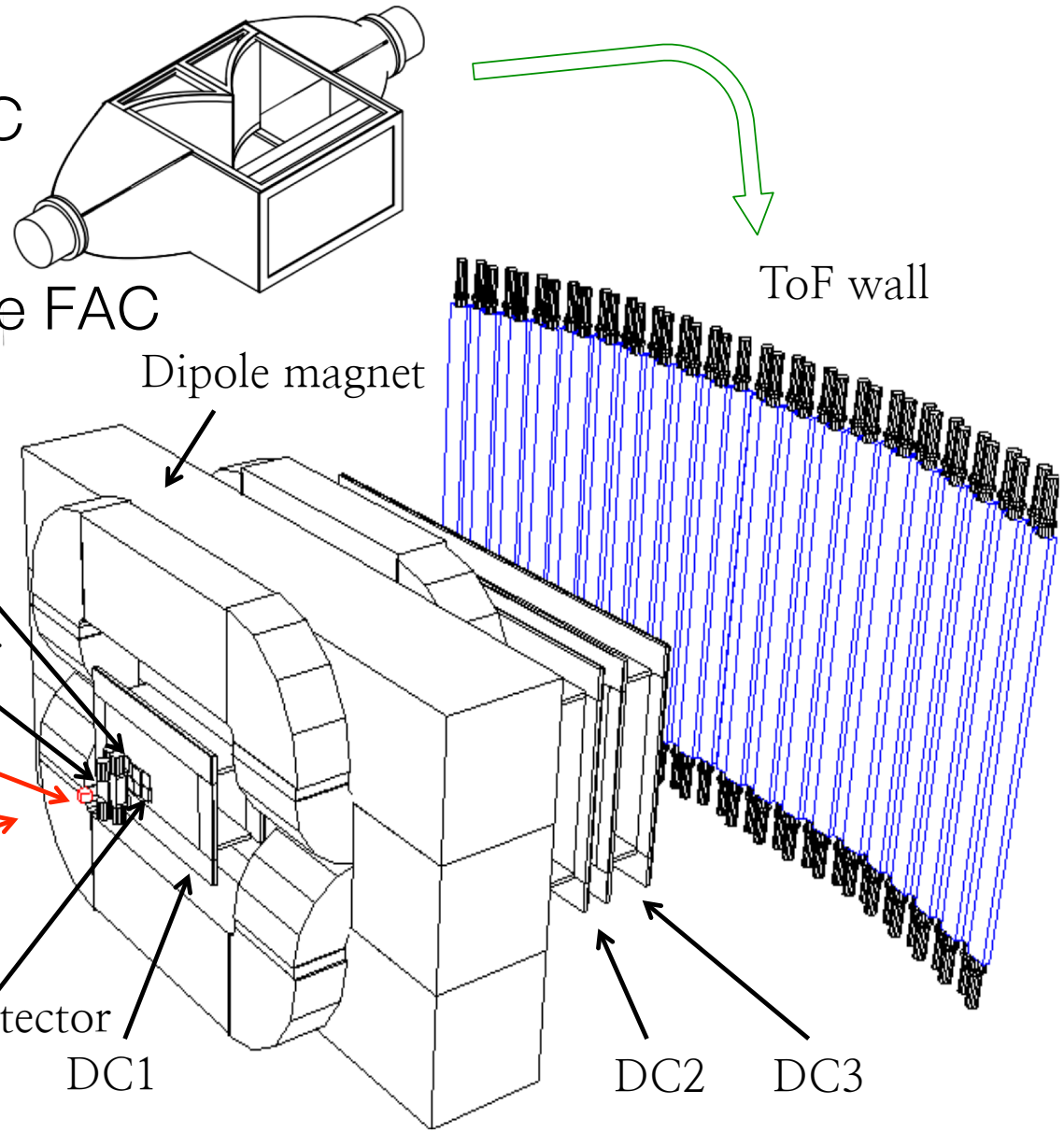
$$\mathrm{ADC_{mean}} = \sum_{i=0}^{\infty} iQ\left(\frac{\mu^i e^{-\mu}}{i!}\right)\left(\frac{1}{1-e^{-\mu}}\right)$$

$$= \frac{\mu Q}{1-e^{-\mu}}$$



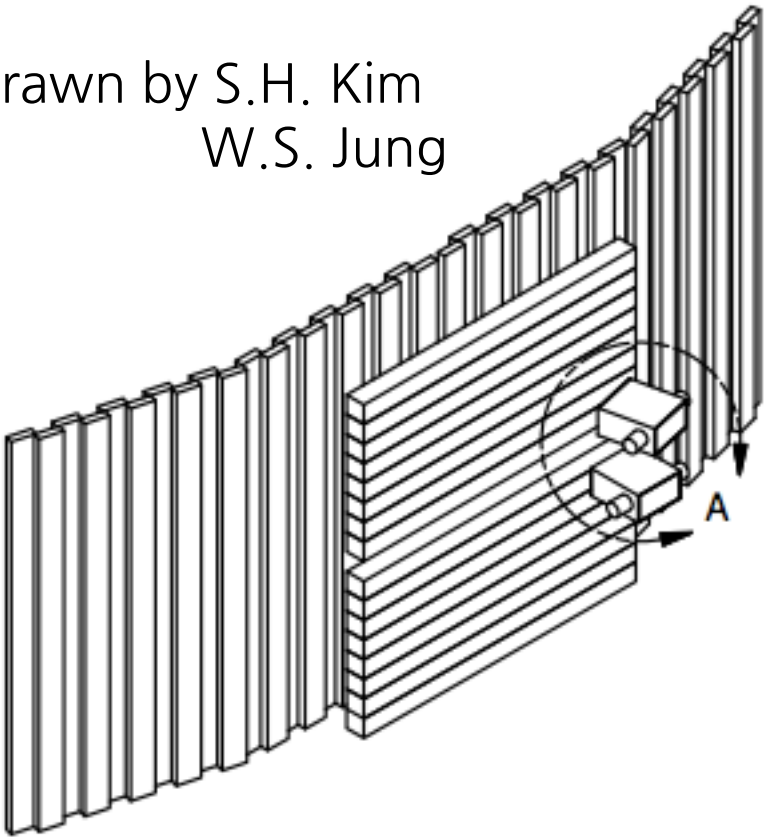
FAC Test Experiment at SPring-8

1. Parabola FAC
2. Teflon FAC
3. Winston cone FAC

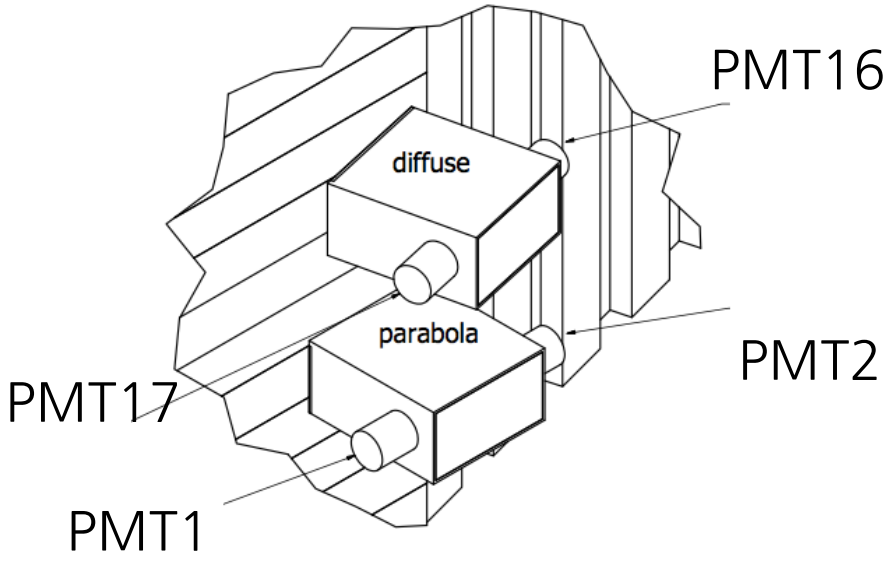


FAC Setup

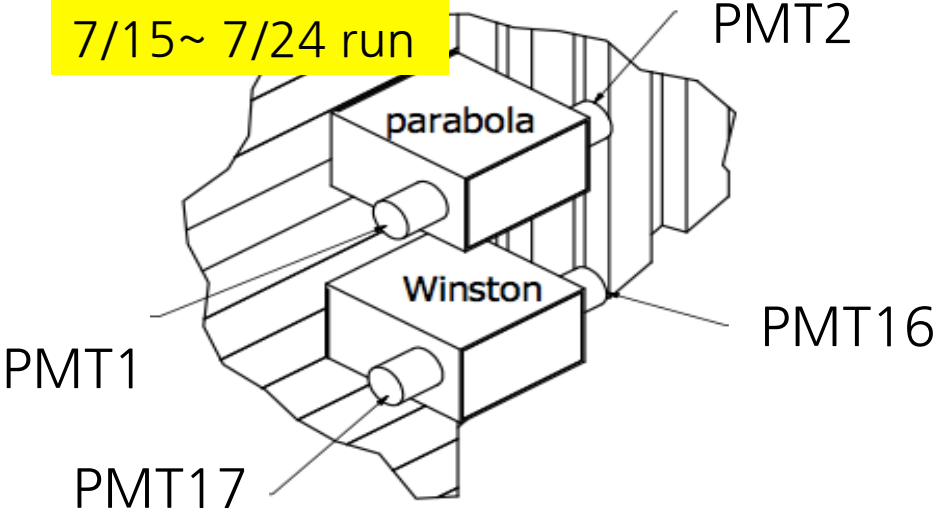
Drawn by S.H. Kim
W.S. Jung



6/9~7/4 run



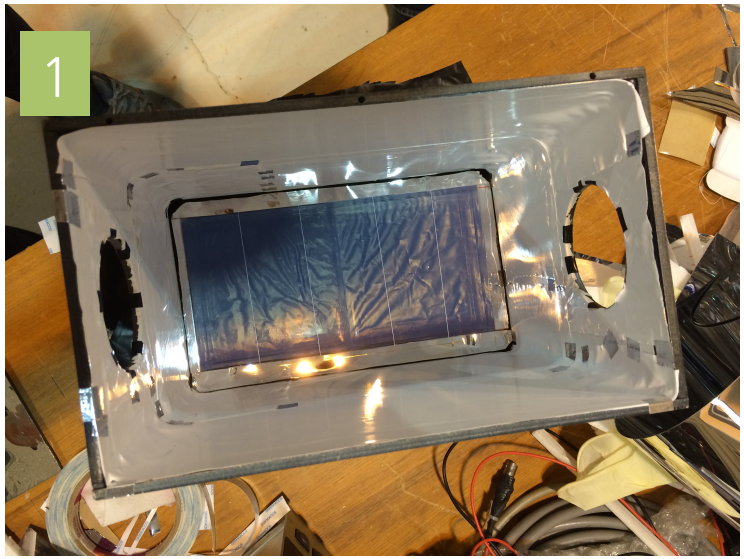
7/15~ 7/24 run

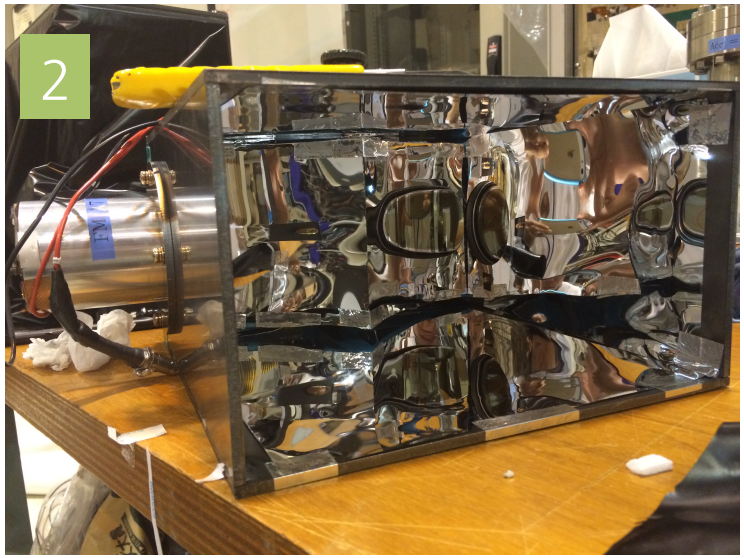


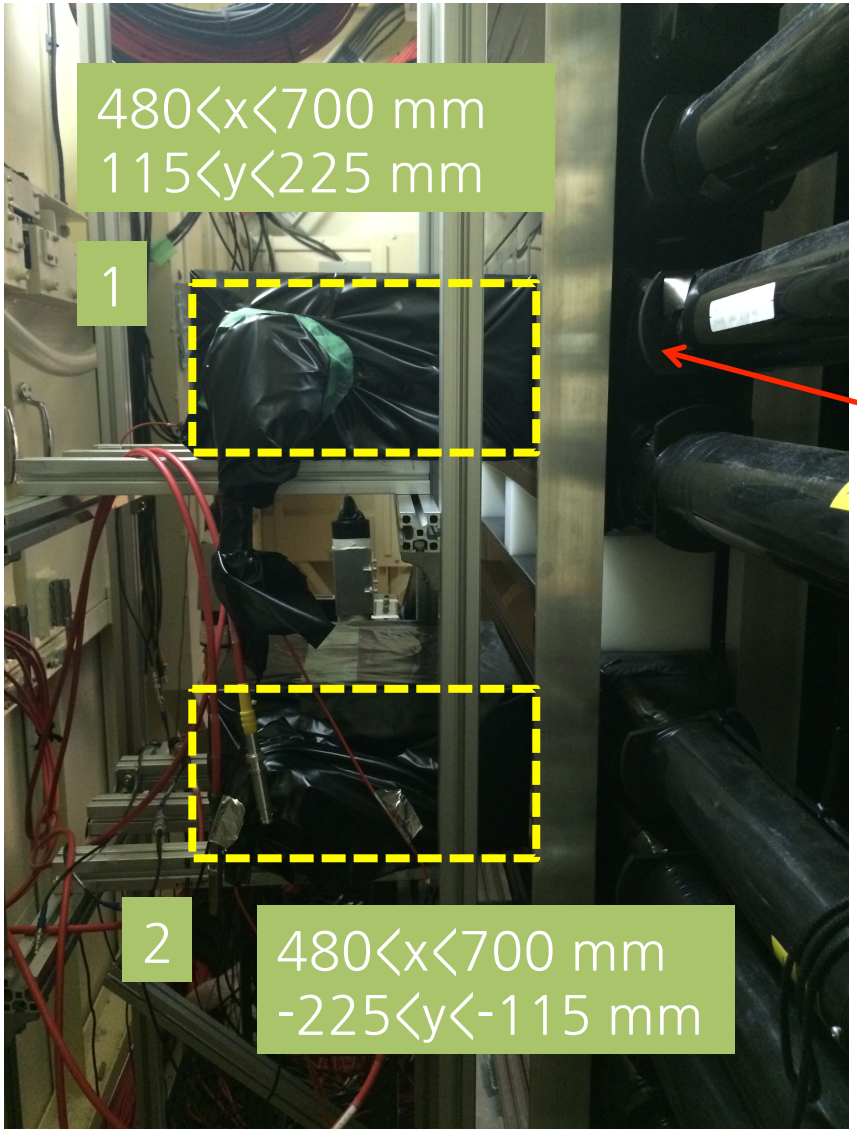
Same |x|, |y| position.

Similar pion momentum range with similar statistics.

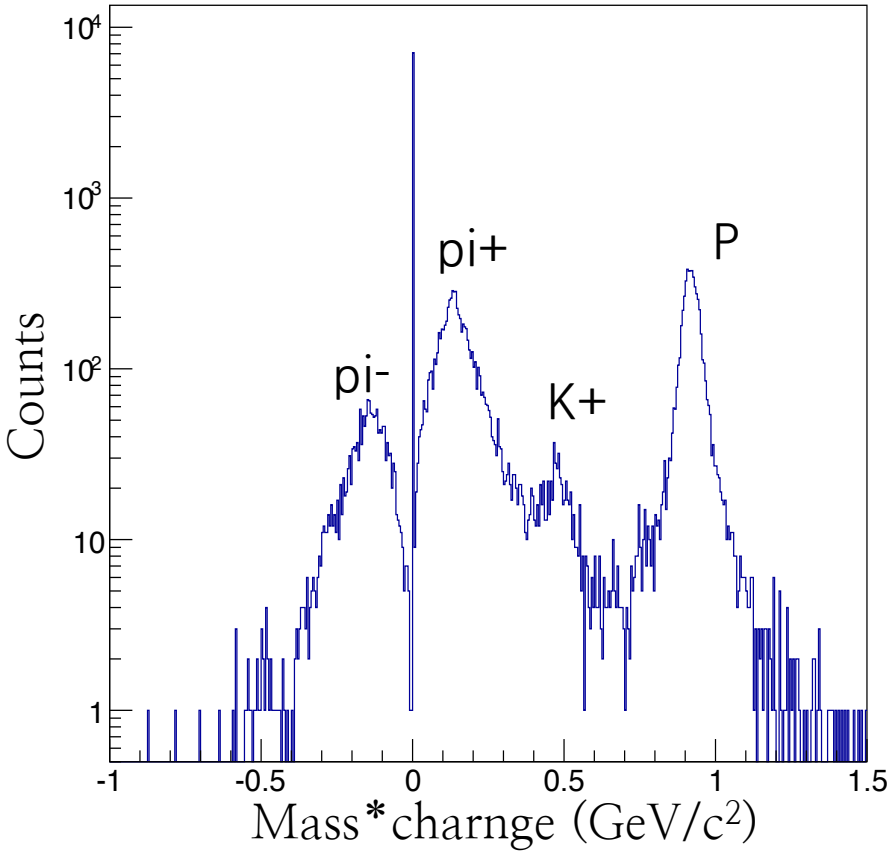
FAC Installation

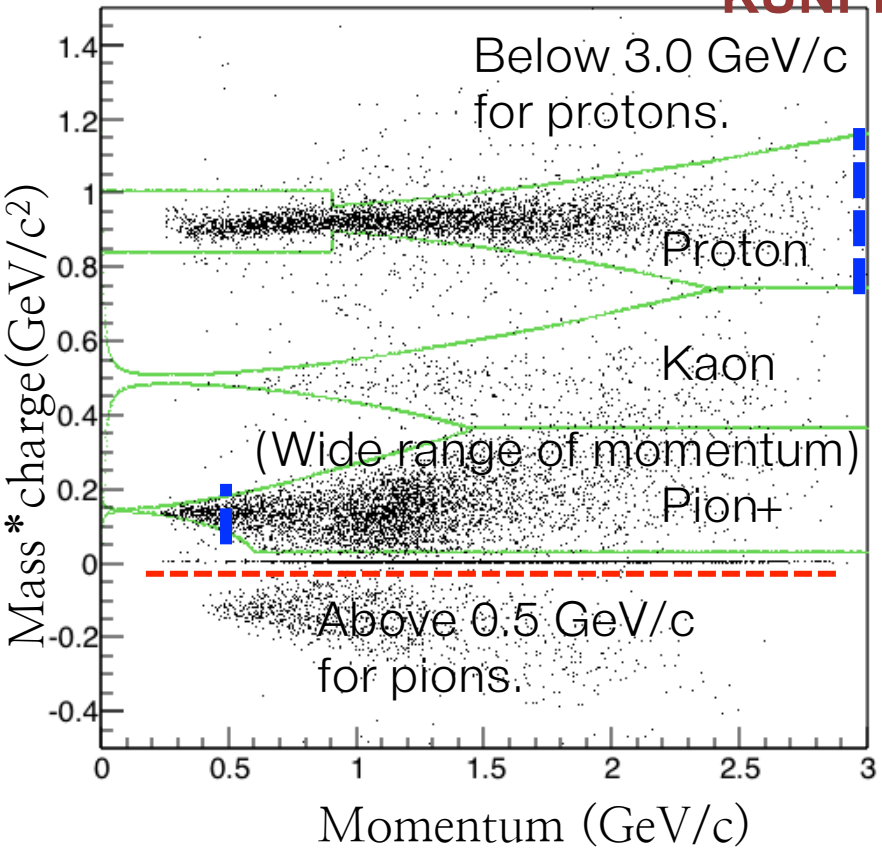






Particle Identification





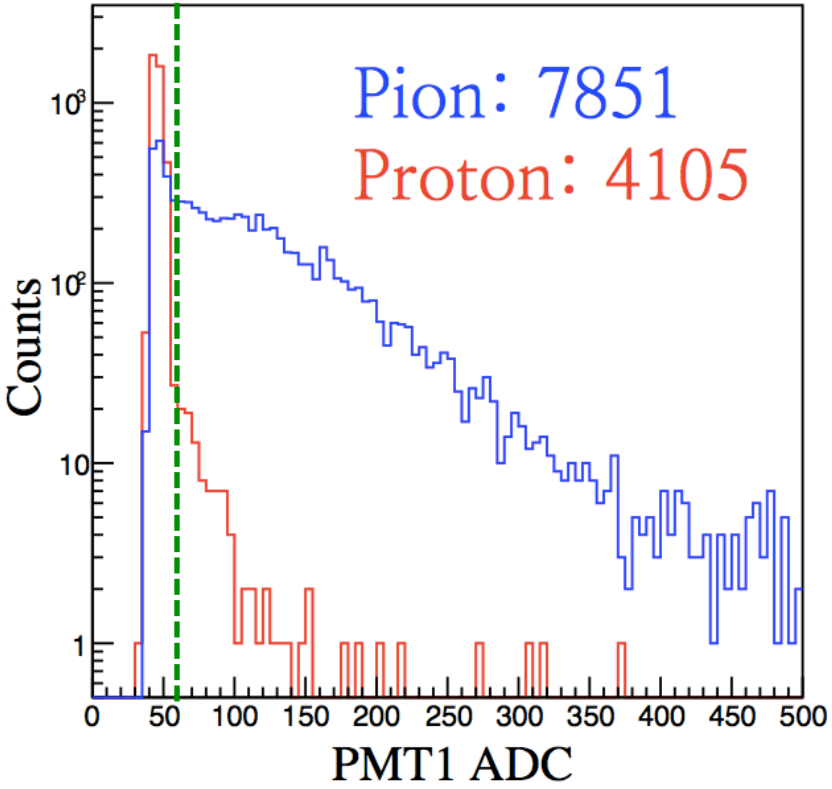
$$\sigma^2_{M^2} = 4M^4\left(1+\left(\frac{M}{p}\right)^2\right)a_1^2 + 4M^4p^2a_2^2 + 4p^2\left(p^2+M^2\right)\left(\frac{c}{L}a_3\right)^2$$

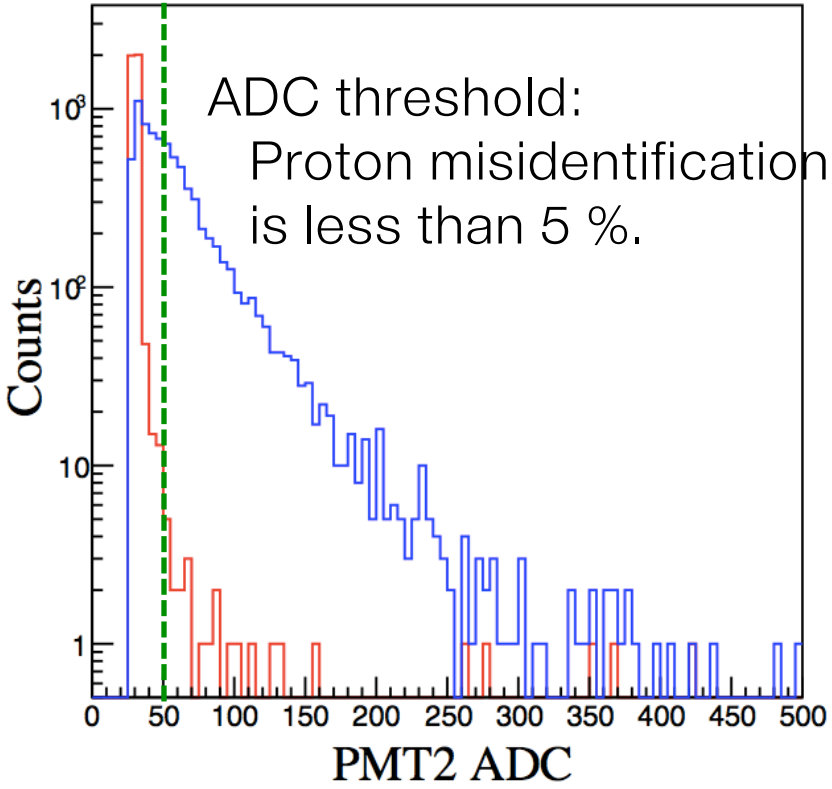
$$\sqrt{M^2-2\sigma_{M^2}} < \text{Particle mass} < \sqrt{M^2+2\sigma_{M^2}}$$

Pion Efficiency

KUNPL

Parabola FAC





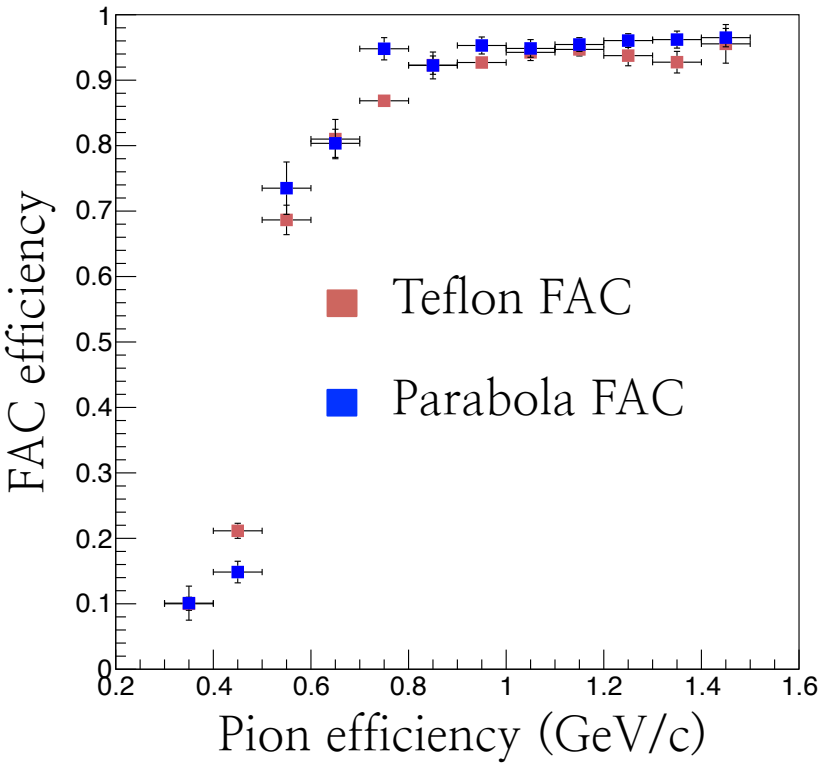
Pion efficiency in momentum interval, 0.3~0.4, 0.4~0.5, ..., 1.4~1.5 GeV/c.

Pion efficiency

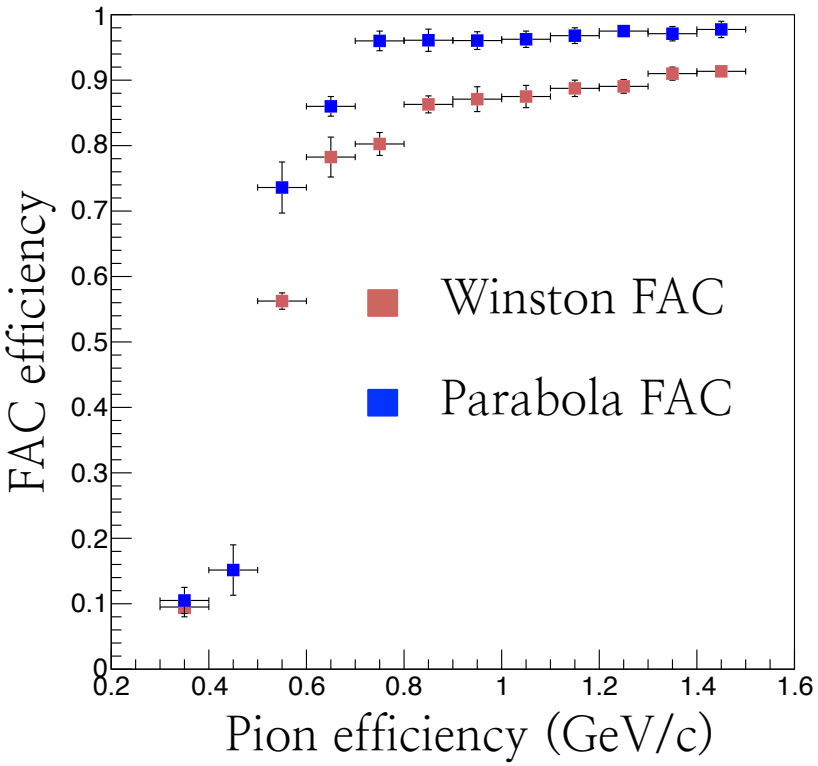
= (Events which pion leaves bigger ADC than threshold)
/ (All pion events in specific momentum range)

Pion Efficiency

Without nbar cut condition



With nbar cut condition

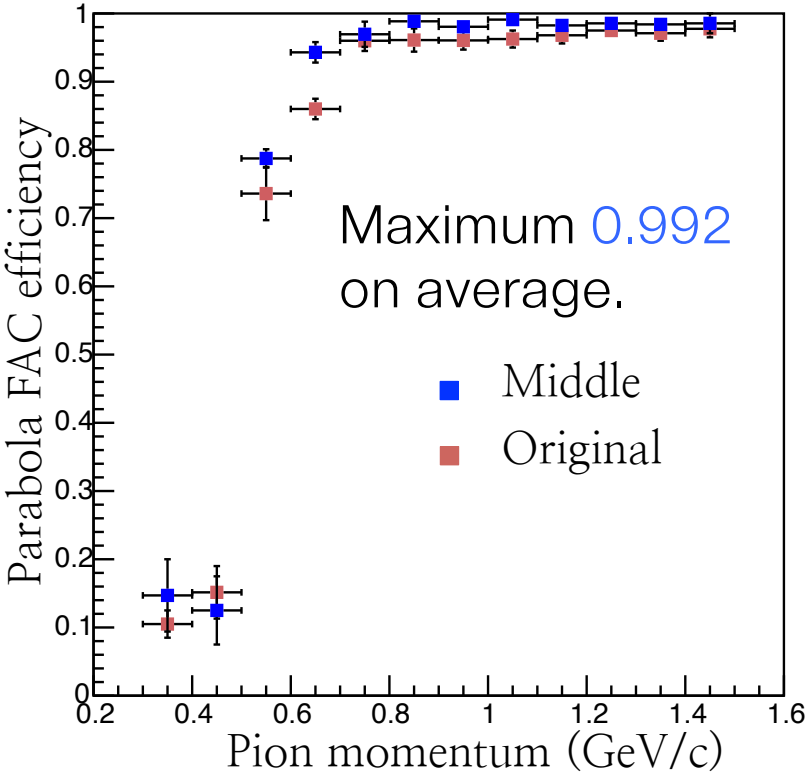


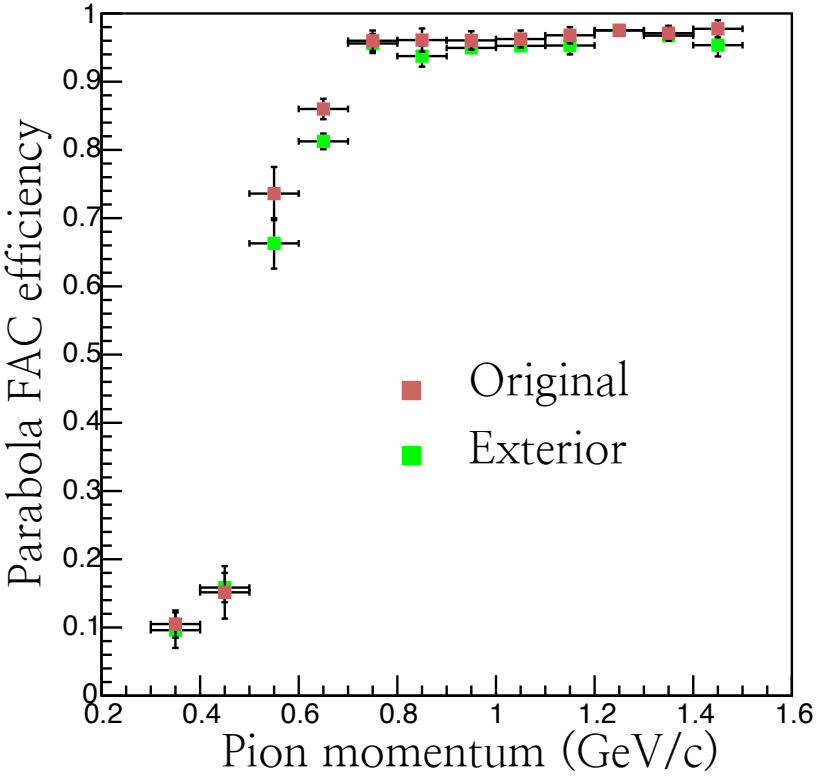
Parabola FAC shows better performance.

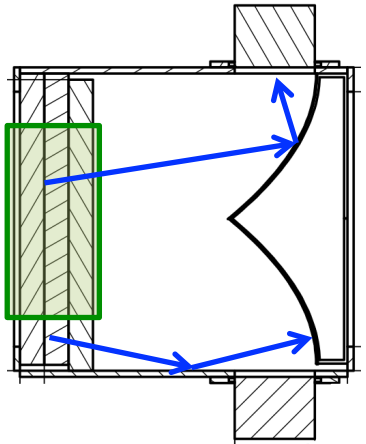
Maximum 0.980 efficiency on average with neutron bar cut condition(>0.7 GeV/c).

Position Dependence of Efficiency

Parabola FAC



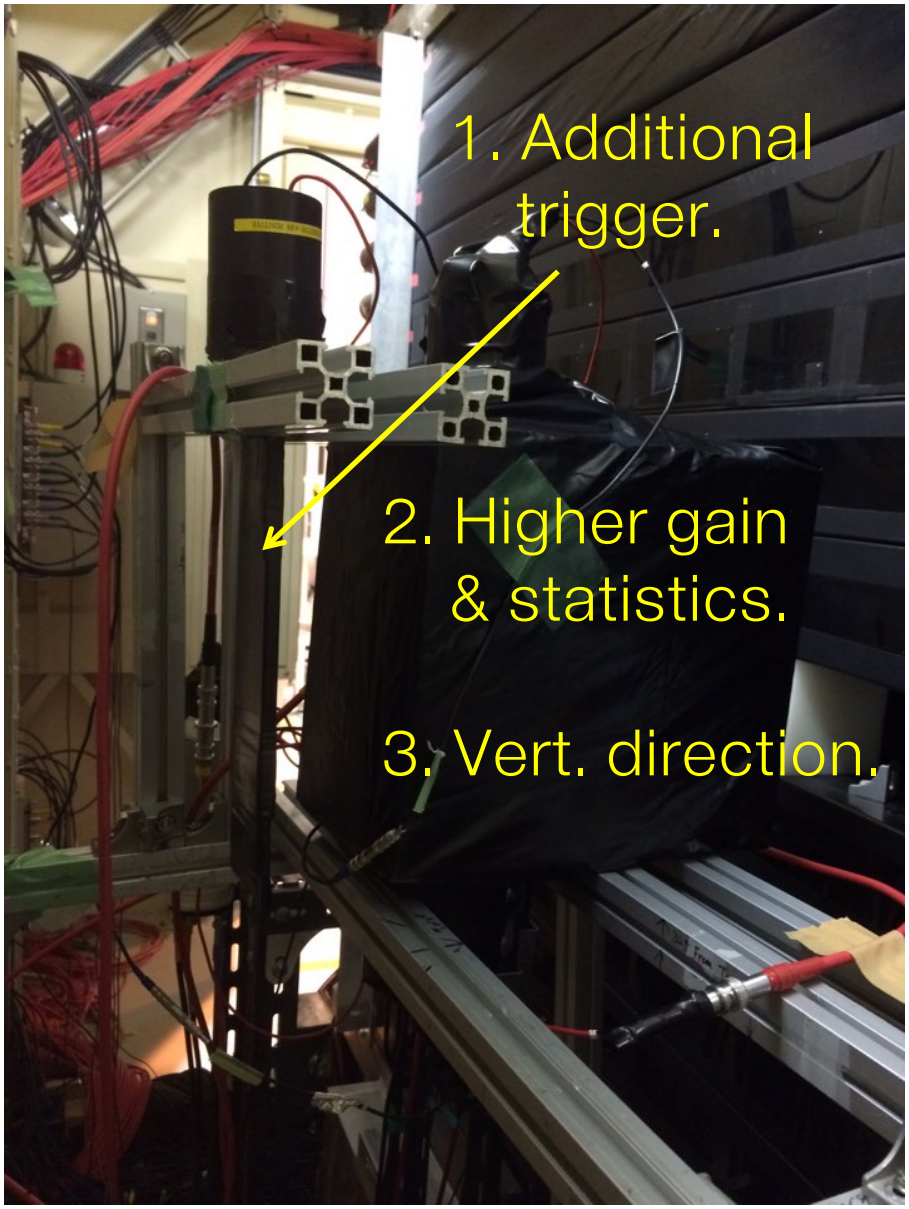




Exterior Cherenkov light goes towards surrounding plane surface first.

Perfect fit (to effective area) light box is not good.

Backup and Mockup Test at SPring-8



+ Npe study with normal PMT

FAC mockup