Some considerations on the future

Y. Kwon (Yonsei) in discussion with L. Musa (CERN)

Active target

- Initiation by L. Musa
  - Beam split option (LHC)
  - Event & their reconstruction inside the active target
  - Like digital emulsion chamber (based on the fine spatial resolution)

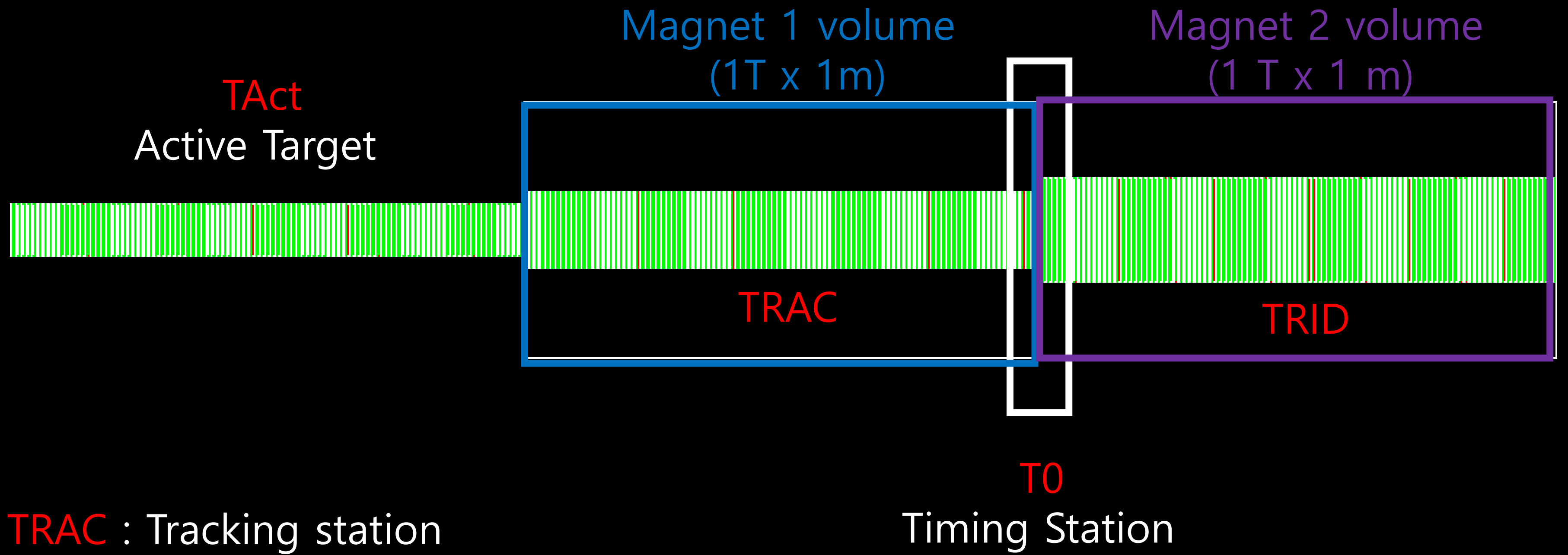
Fixed Target @ LHC

$7\ TeV\ p$ → $y_{beam} = 9.6$

$2.5\ TeV/u$ → $y_{beam} = 8.6$ (35A GeV + 35A GeV)

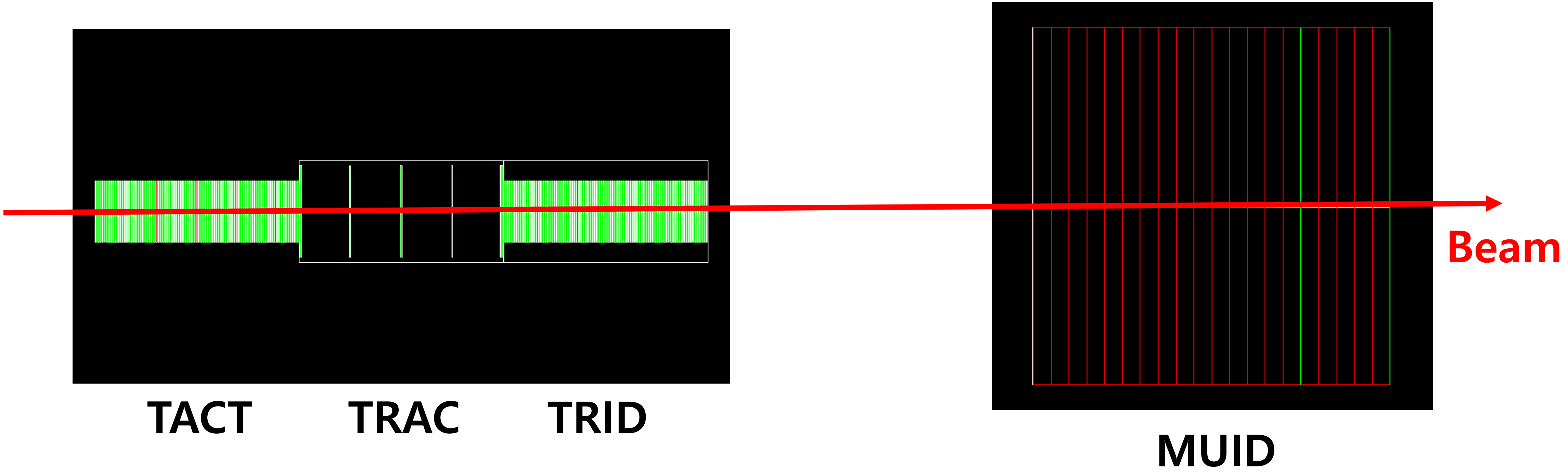
RHIC-like condition with large forward acceptance,
pixel detector with extremely fine granule!

Trial version 6 months ago



TRAC : Tracking station
TRID : ID & Tracking

Trial version

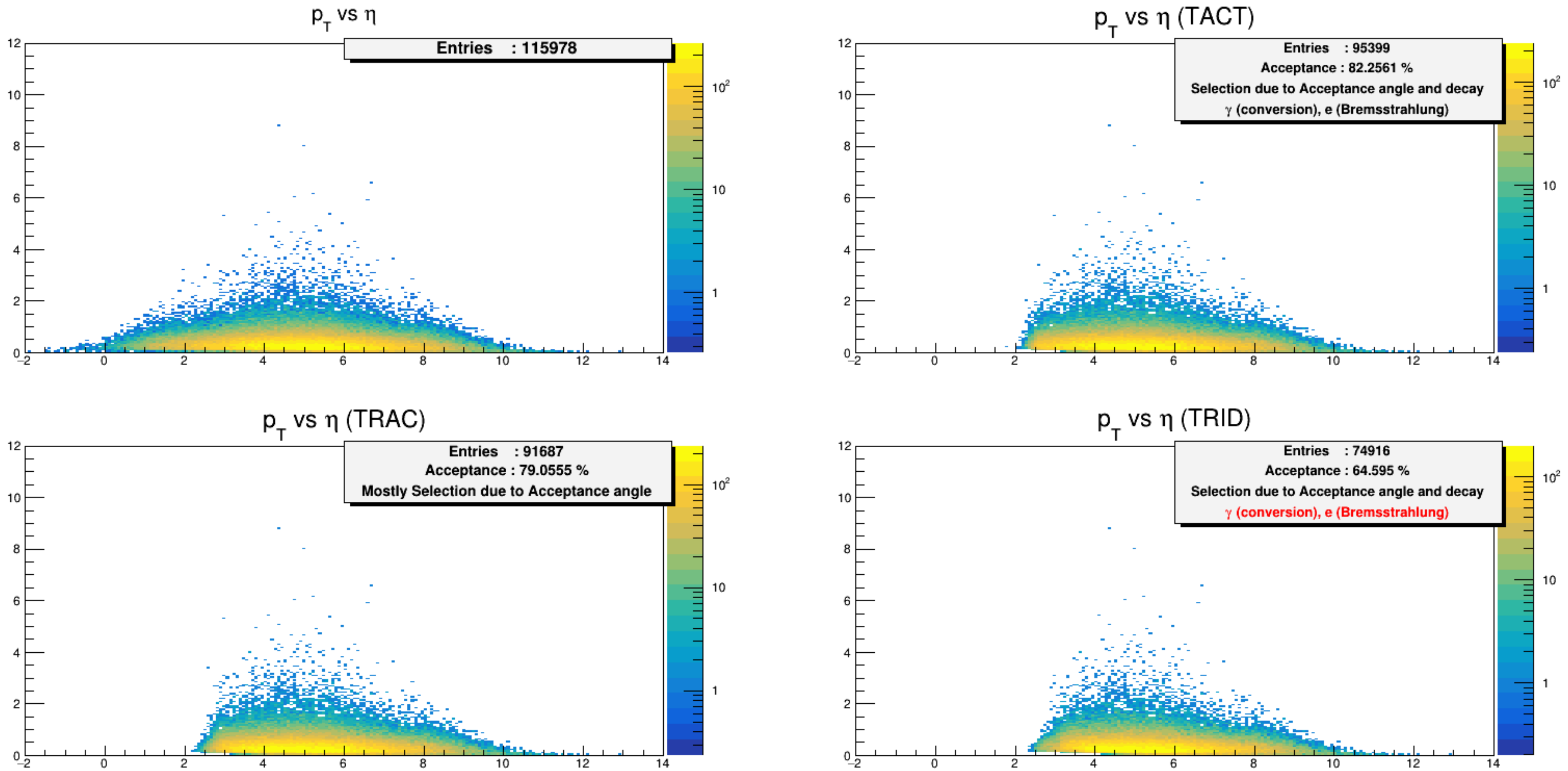


Geometric acceptance

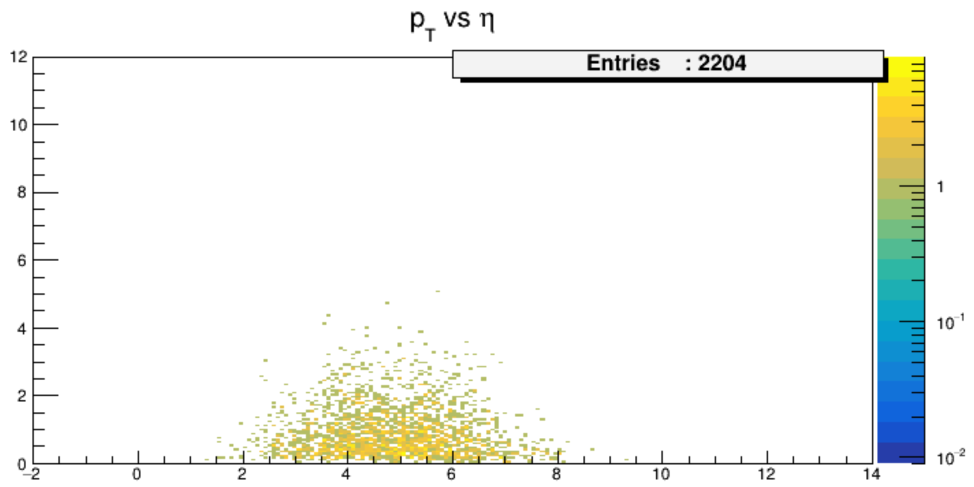
- Some dependence on the initial distribution, but large acceptance $\geq$ 80%.

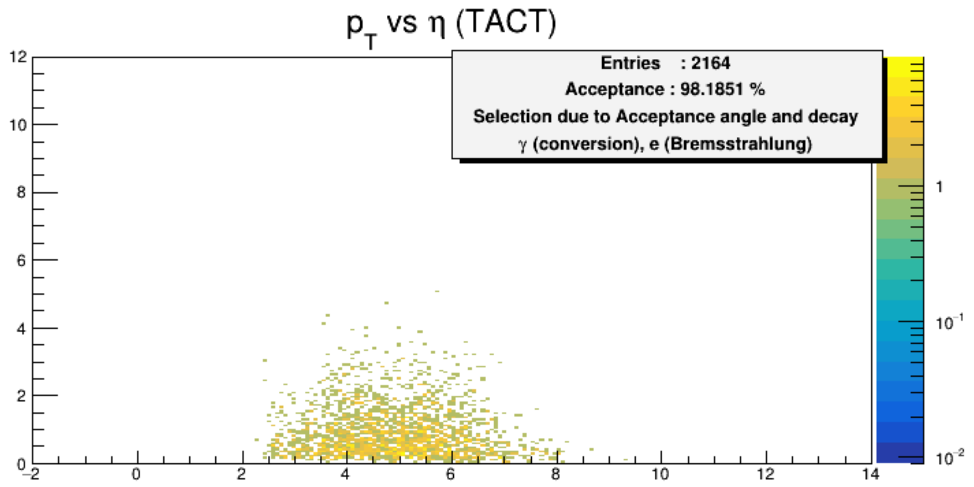
- Open issue: Cooperation with barrel in the collider mode towards very fine backward measurement and full kinematic coverage.
  - Missing forward & backward measurement at RHIC. “CGC”
  - Large rapidity correlation such as beam-target pair related.
  - Diffraction physics.

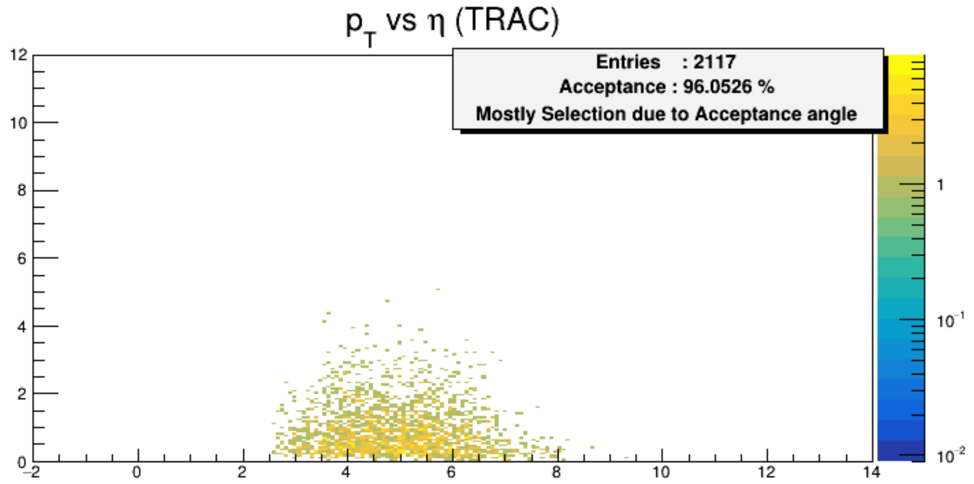
Acceptance analysis for $\pi^{\pm}$

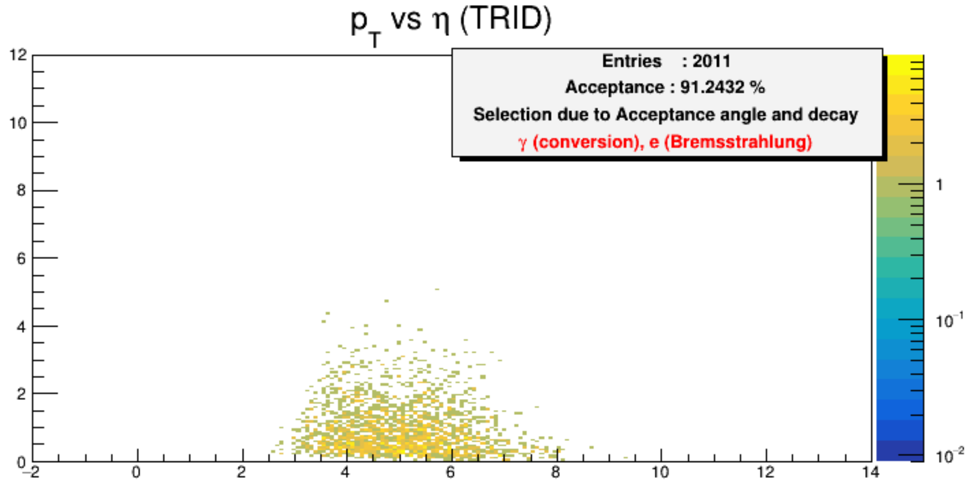


Acceptance analysis for μ^-









Single particle resolution

- Assumed pixel sensor
  - Fully depleted model, 20 (μ) x 20 (μ) pixel
  - 50 (μ) thick
  - Additional 50 (μ) thick Aluminum backplane
  - Arbitrary spacing between sensor layers, 5 (mm)

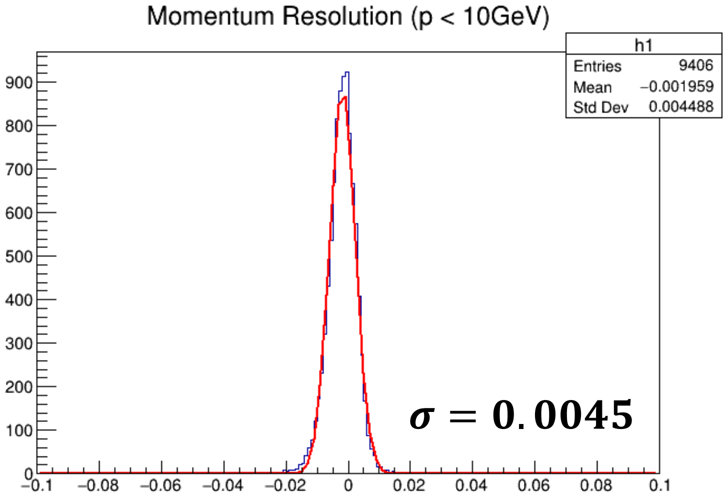
$\frac{\delta p}{p} \sim 0.4\% \,\&\, p\delta\theta \sim 10^{-3} (GeV)$ at low momentum and slow increase with p.

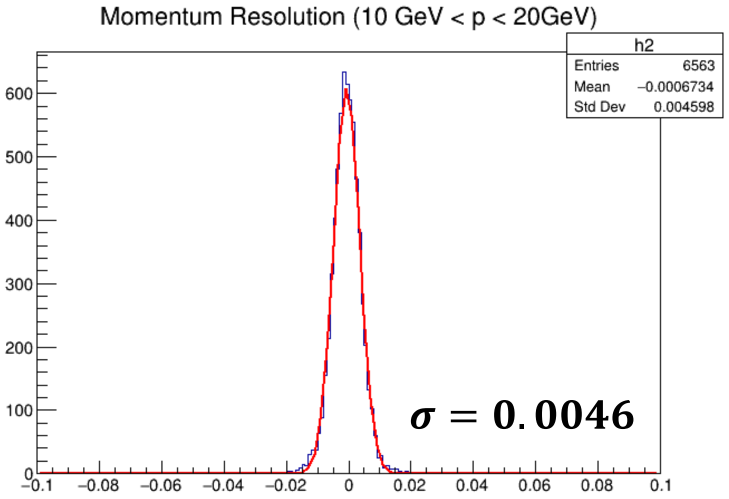
Prong vertex: vertex with multi-charged particles

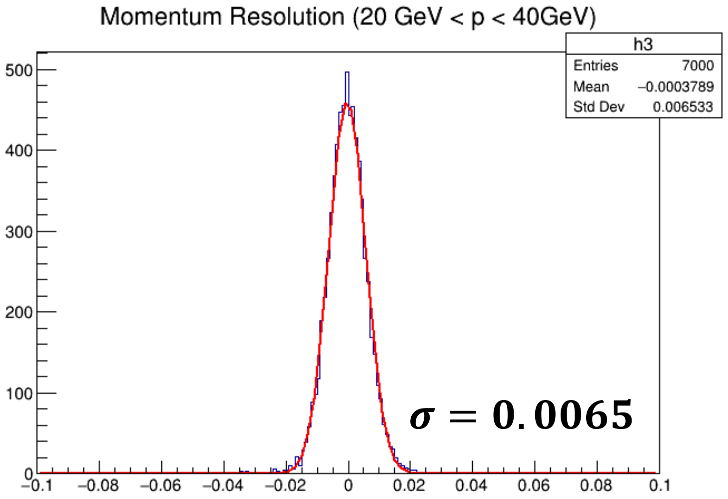
Lateral position resolution $\sim 3(\mu)$

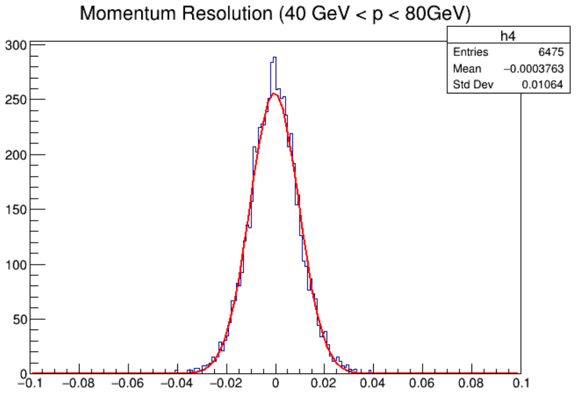
Longitudinal position resolution $\sim 1(mm)$

Momentum Resolution ($\delta p/p$)

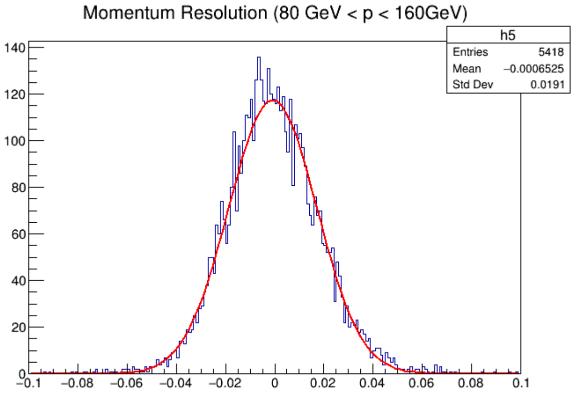




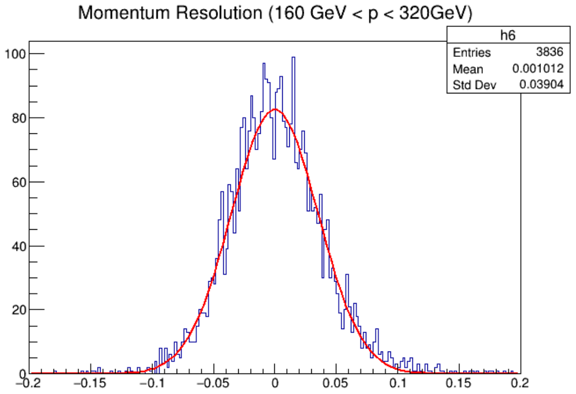




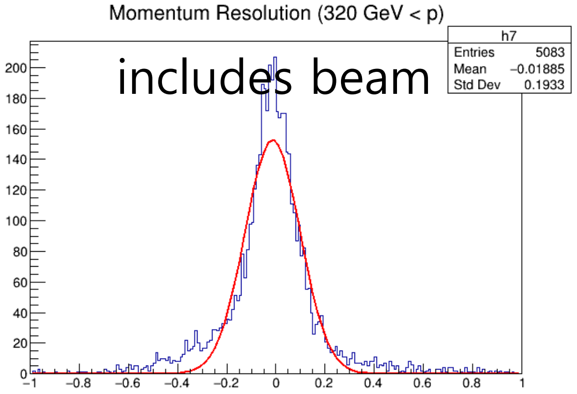
$\sigma = 0.011$



$\sigma = 0.019$



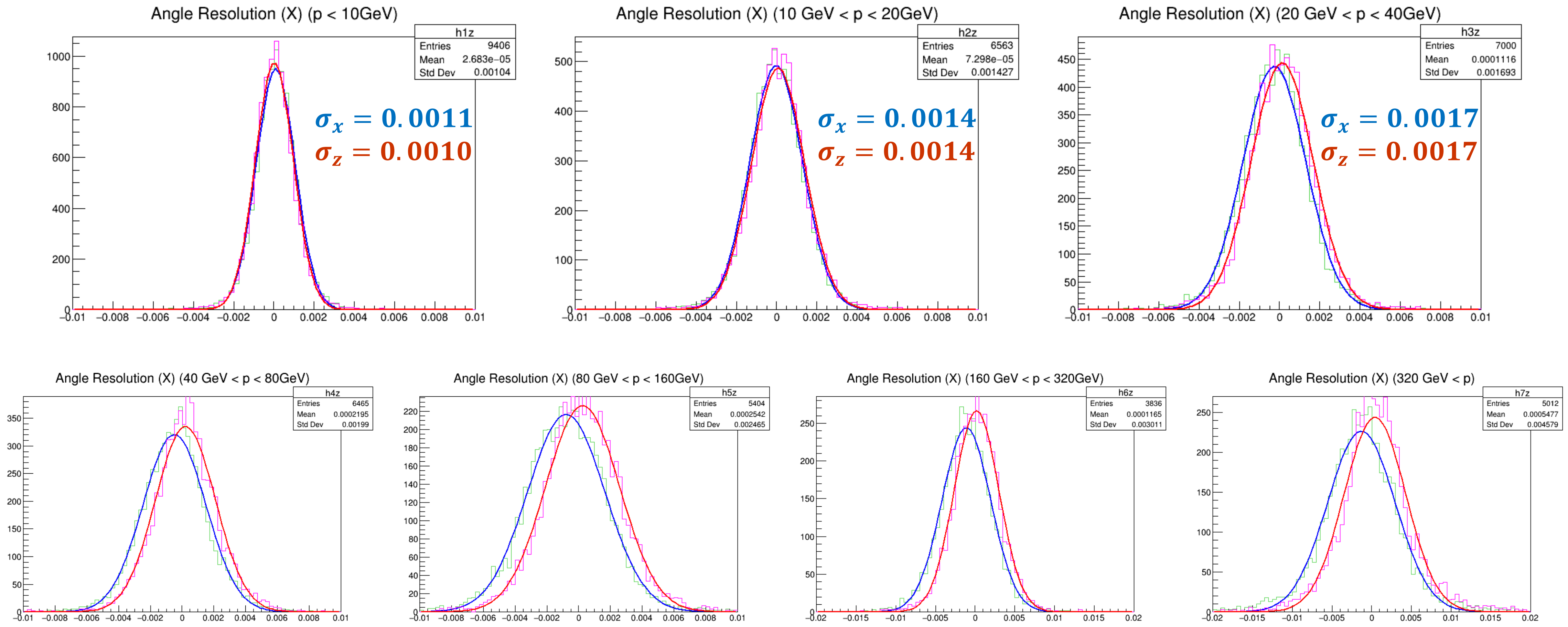
$\sigma = 0.039$



$\sigma = 0.193$

Using simulated Pythia events (MSEL=5)

Angle Resolution ($p \cdot \delta\theta$)



$\sigma_x = 0.0021$
$\sigma_z = 0.0020$

$\sigma_x = 0.0026$
$\sigma_z = 0.0025$

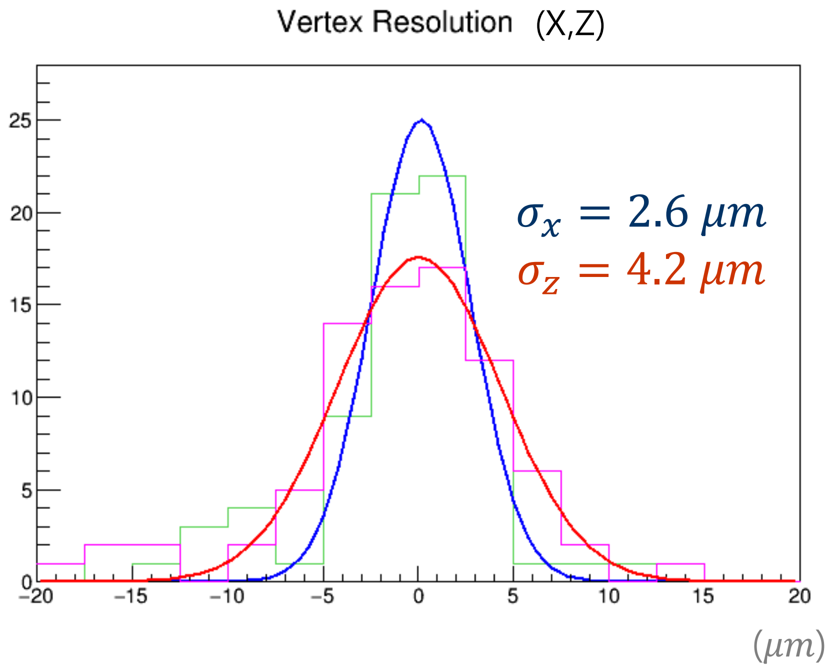
$\sigma_x = 0.0033$
$\sigma_z = 0.0030$

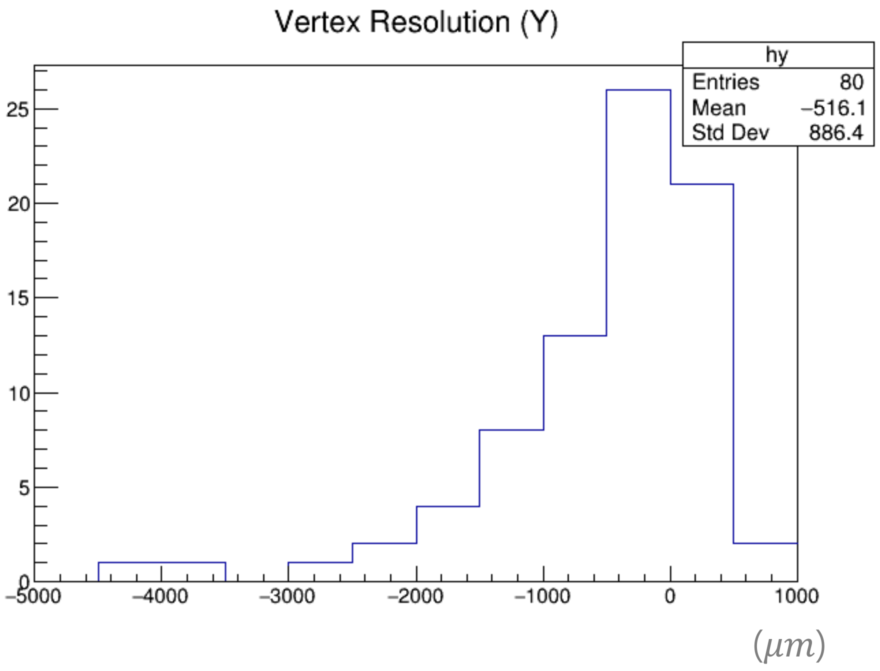
$\sigma_x = 0.0049$
$\sigma_z = 0.0046$

Using simulated Pythia events (MSEL=5)

Vertex Resolution

- B decay vertex (@ MSEL5 Single p-p Events, Total 100 Events each)



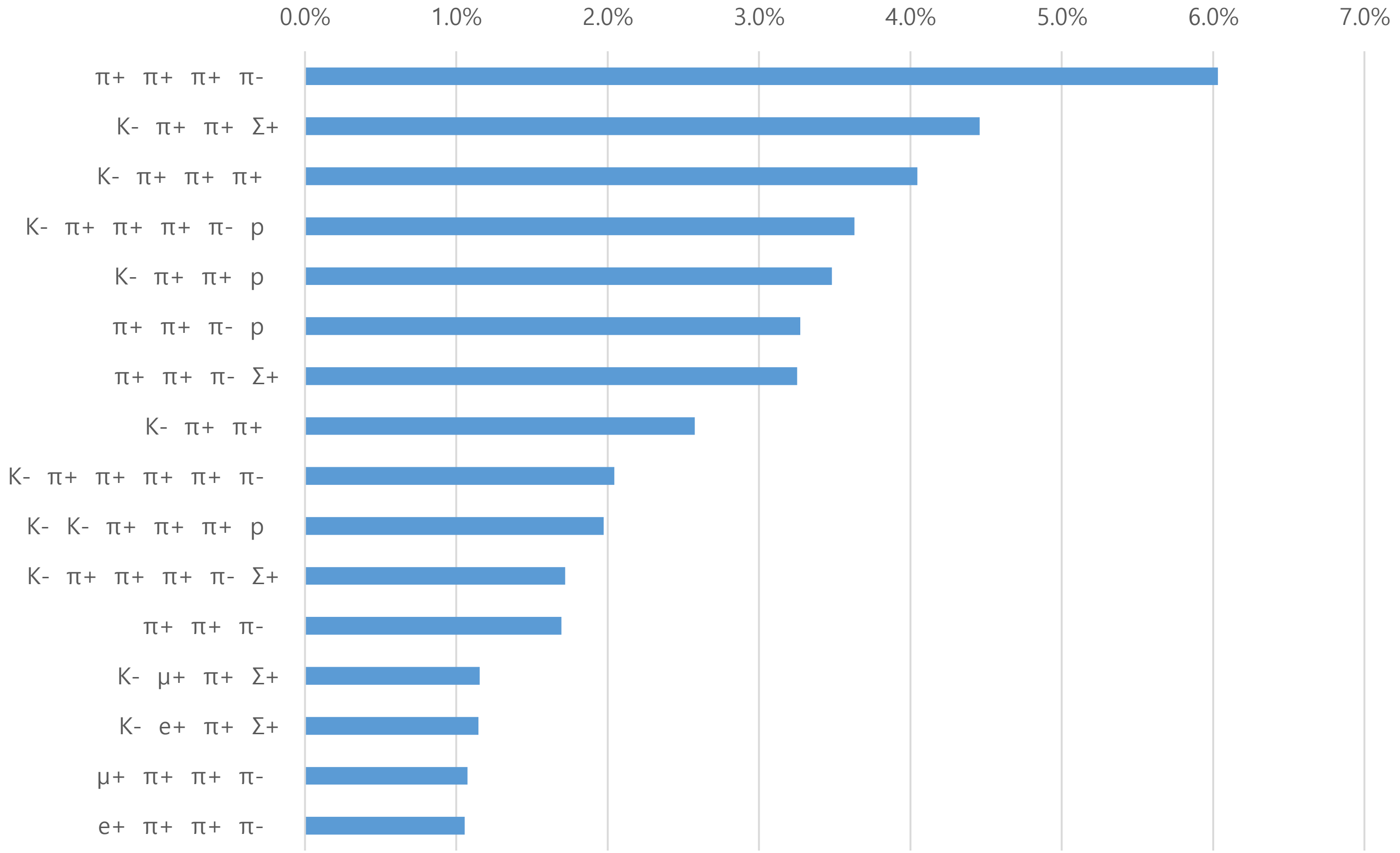


Heavy flavor measurement

Main decay modes that counts charged particles from Ξ_{cc}^{++}

Nc	Counts	Ratio
0	40	0%
1	16068	16%
2	27567	28%
3	16838	17%
4	23124	23%
5	3200	3%
6	11581	12%
7	236	0%
8	1309	1%
9	5	0%
10	32	0%
11	0	0%
Total	100000	100%

~50% ↑



We excluded neutral particles with strangeness from counting

Ξ_c^+ and Λ_c^+ make multi-prong vertex

The number of charged particles Nc distribution

Ξ_c^+

Nc	Counts	Ratio
0	0	0%
1	26866	27%
2	0	0%
3	61228	61%
4	0	0%
5	11520	12%
6	0	0%
7	386	0%
8	0	0%
9	0	0%
10	0	0%
11	0	0%
Total	100000	100%

~70% ↑

Λ_c^+

Nc	Counts	Ratio
0	817	1%
1	20426	20%
2	1853	2%
3	59664	60%
4	102	0%
5	16491	17%
6	0	0%
7	313	0%
8	0	0%
9	1	0%
10	0	0%
11	0	0%
Total	99667	100%

~70% ↑

Ignored uncategorized data fraction of 3%

We excluded neutral particles with strangeness from counting

Near future plan

- Connected prong vertexes with charge carrying baryons
- Prong vertexes with associated single hard lepton

e(μ) pair mass resolution

Simple formula for lepton pair mass

Assume $m_e \ll m_{ee}, p_1, p_2$ and taking electron 1 direction as z,

$$p_1^\mu = (p_1 \quad 0 \quad 0 \quad p_1)$$

$$p_2^\mu = (p_2 \quad p_2 \sin\theta \quad 0 \quad p_2 \cos\theta)$$

$$m_{ee}^2 = (p_1 + p_2)^\mu (p_1 + p_2)_\mu = 2p_1^\mu \cdot p_{2\mu} = 2p_1p_2(1 - \cos\theta) = 4p_1p_2 sin^2\frac{\theta}{2}$$

$$\frac{\delta m_{ee}}{m_{ee}} = \frac{1}{2}\left(\frac{\delta p_1}{p_1} \oplus \frac{\delta p_2}{p_2} \oplus \cot\frac{\theta}{2} \cdot \delta\theta\right)$$

$m_{ee} = 2\sqrt{p_1 p_2}\sin\frac{\theta}{2} = 2p_{GM}\sin\frac{\theta}{2} \approx p_{GM}\,\theta$ at zero mass limit

Possible limitation for mass resolution at zero limit

- The 1st look at angular resolution

$$p\delta\theta \sim 10^{-3}(GeV)$$

- Kalman filter suppresses multiple scattering, but momentum dependence of angular resolution suggests multiple scattering is still the dominant contributor. If better resolution is needed,
    1. smaller pixel size will be effective linearly,
    2. and less material per unit distance will help if possible (!).

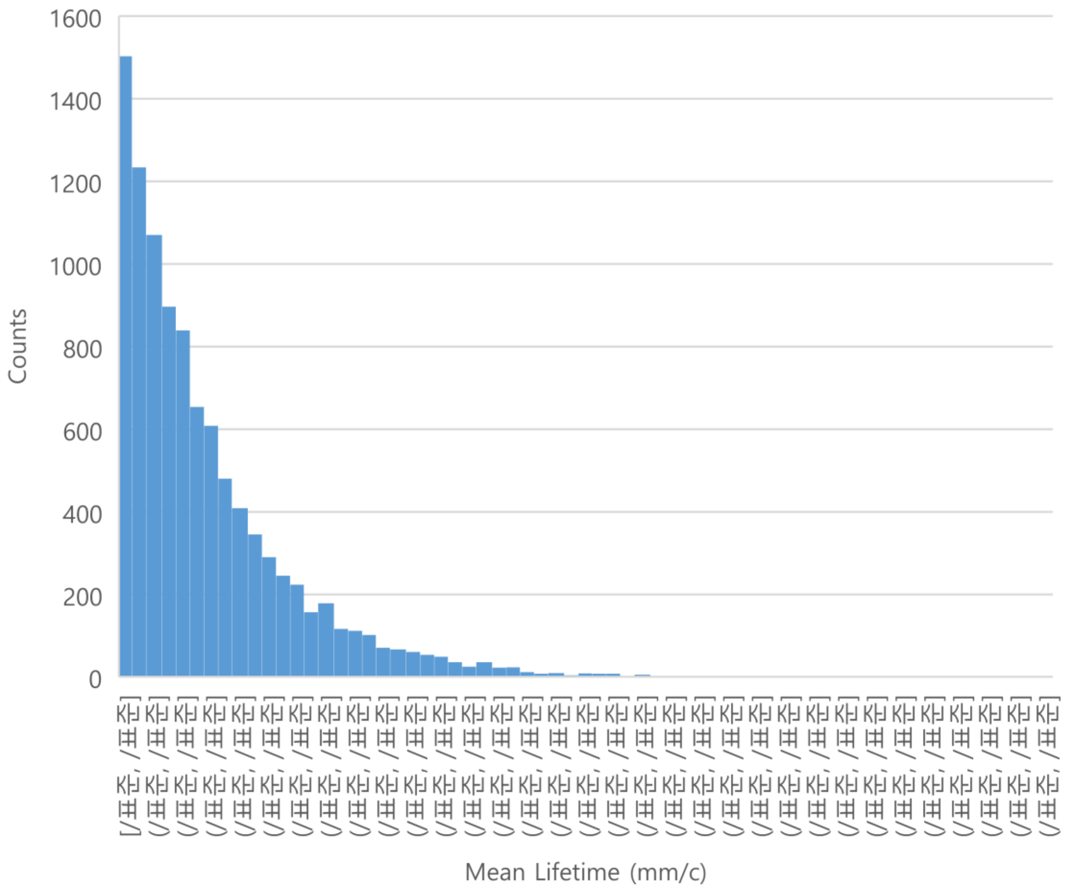
Particle physics for the charmed and bottomed

Our strength

Acquired experience for large volume pixel detector.

Still away from industrial scale, but closest to the scale (new dimension in experience)

Ξ_c^+ Lifetime from Pythia vs PDG – reconstructed prong vertex?



Ξ_c^+ MEAN LIFE

VALUE (10^{-15} s)	EVTS	DOCUMENT ID		TECN	COMMENT
442 ± 26 OUR AVERAGE		Error includes scale factor of 1.3.			See the ideogram below.
503 ± 47 ± 18	250	MAHMOOD	02	CLE2	$e^+e^- \approx \Upsilon(4S)$
439 ± 22 ± 9	532	LINK	01D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV
$340^{+70}_{-50} \pm 20$	56	FRABETTI	98	E687	γ Be, $\overline{E}_\gamma$ = 220 GeV
$400^{+180}_{-120} \pm 100$	102	COTEUS	87	SPEC	nA $\simeq$ 600 GeV
$480^{+210+200}_{-150-100}$	53	BIAGI	85C	SPEC	Σ^- Be 135 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$410^{+110}_{-80} \pm 20$	30	FRABETTI	93B	E687	See FRABETTI 98
200^{+110}_{-60}	6	BARLAG	89C	ACCM	π^- (K^-) Cu 230 GeV

Pythia : $3.50 \times 10^{-13} s$ $(0.105 mm/c)$
PDG : $4.42 \times 10^{-13} s$

Decay modes

- Particle ID?
- Some constraints for Leptonic modes?