3rd International Symposium On Nuclear Symmetry Energy
NSCL/FRIB,MSU, MI,USA, July 22-26

Experimental effort to study Symmetry Energy with the Cooling Storage Ring at Lanzhou

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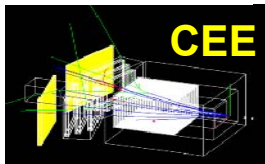
Tsinghua University, Beijing

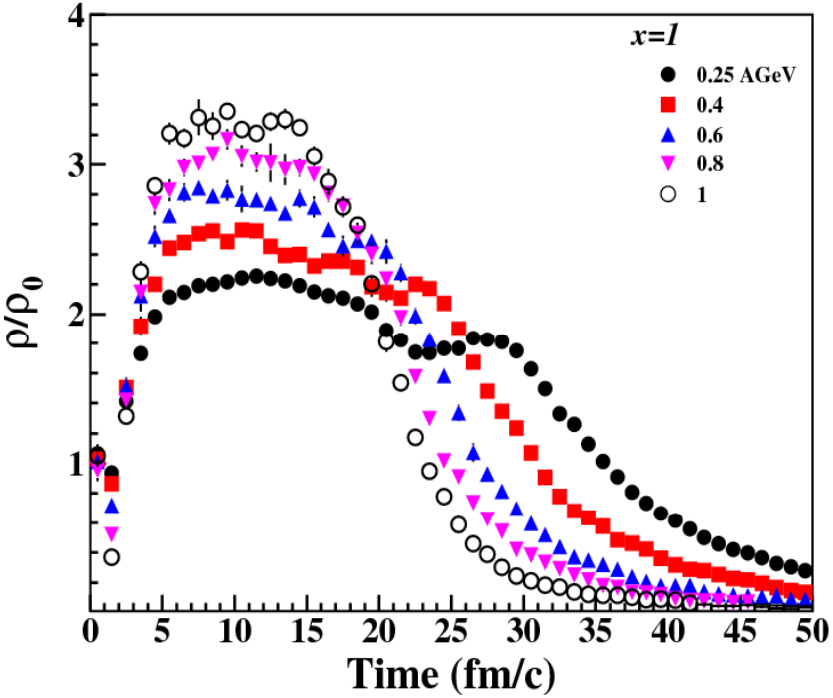
Nu Xu (CCNU) : Spokesperson
Zhiyu Sun (IMP-CAS) : Beam Line/Dipole/Experiment
Lei Zhao (USTC) : Read-out electronics/DAQ
L. M. Duan (IMP-CAS) : For MWDC design, assembling and test
Yi Wang (THU) : TOF
Ming Shao(USTC) : TOF
YuGang Ma, Fei Lu (SINAP): TPC
Xiang Ming Sun (CCNU) : Silicon Pixel Detector/ZDC

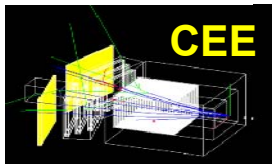
清華大學
物理系



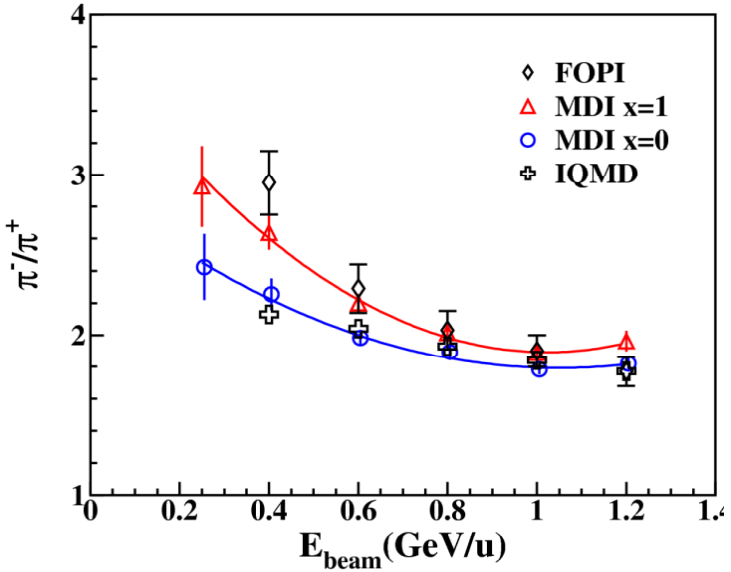
Outline

- Pion probe to $E_{sym}(\rho)$ at ~$2\rho_0$
- Machine and Detector
- Phase I Experiment and detector R&D
- Outlook

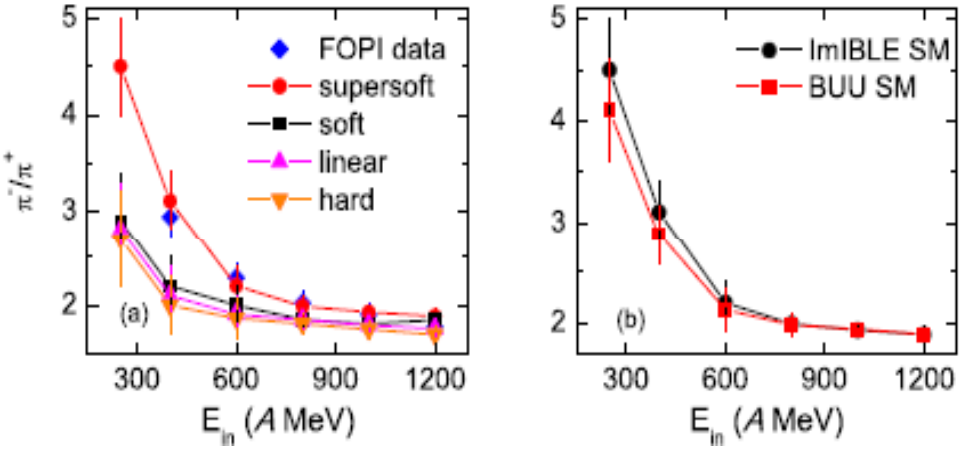




$E_{sym}(\rho)$ with π-/π+ ratio: Soft or Stiff ?

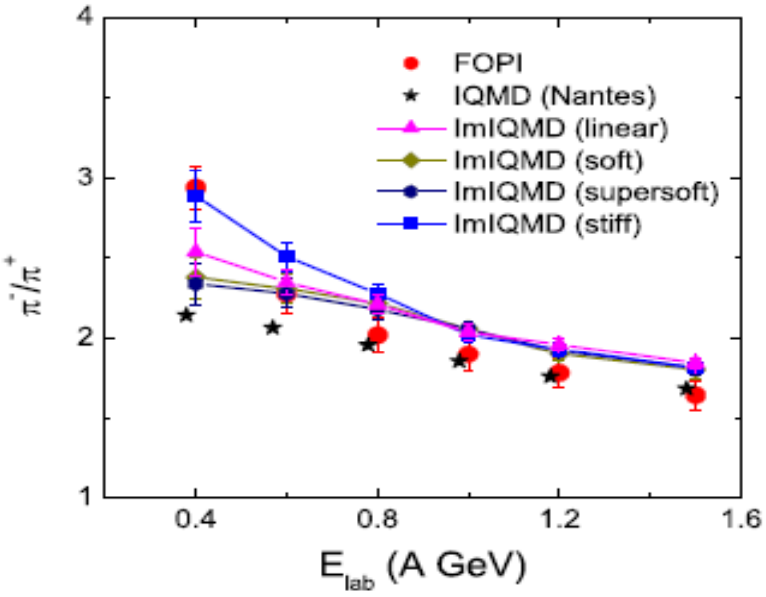


PRL 102 (2009) 062502



Physics Letters B 718 (2013) 1510–1514

- Soft



Physics Letters B 683 (2010) 140–144

- Stiff

- or loss sensitivity on γ

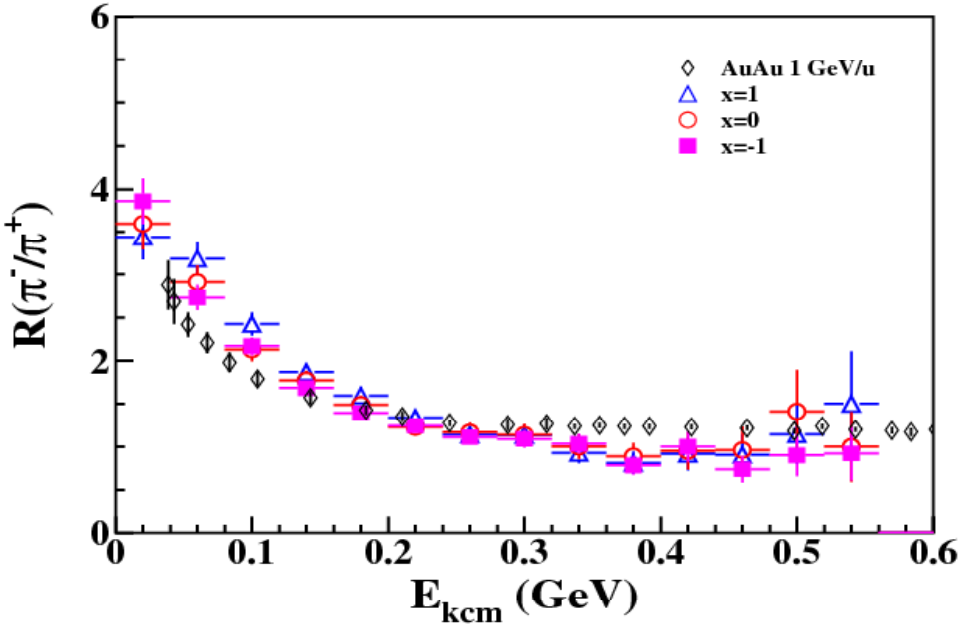
Jun Hong, NUSYM13 Poster

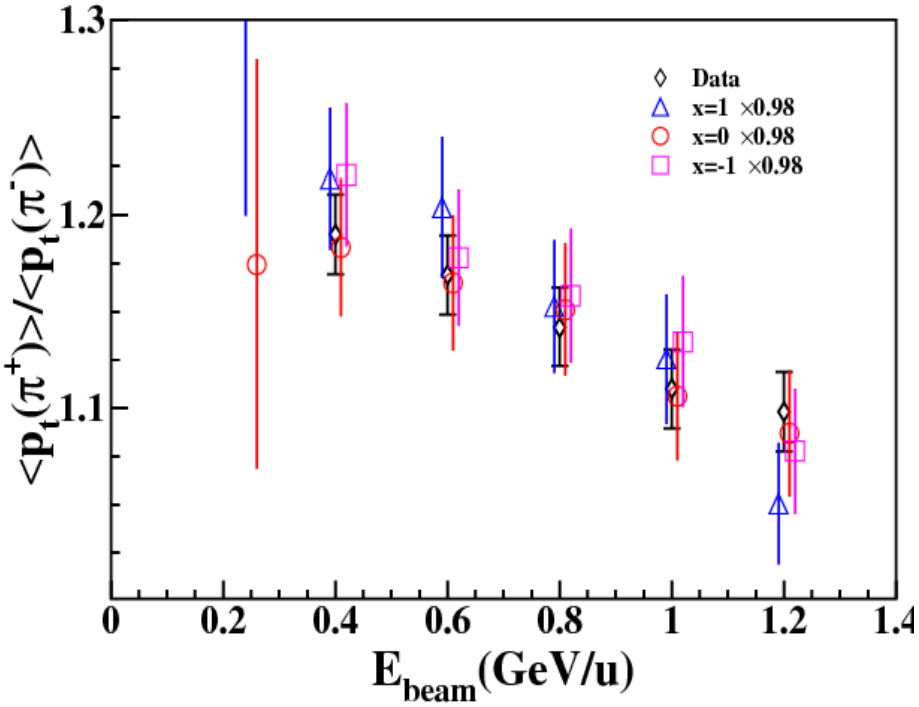
Model Dependent Puzzle

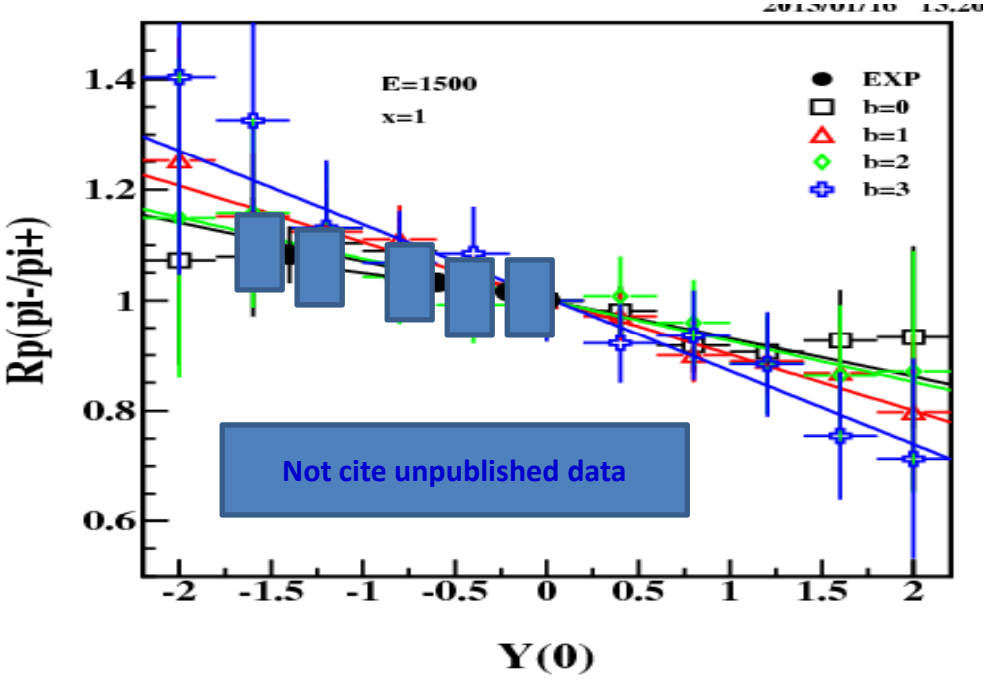
Theoretically:

- **Treating of pion is model dependent, other effects to be considered…**
- **Need to compare more pion related quantities, and more diagnostic spectra …**

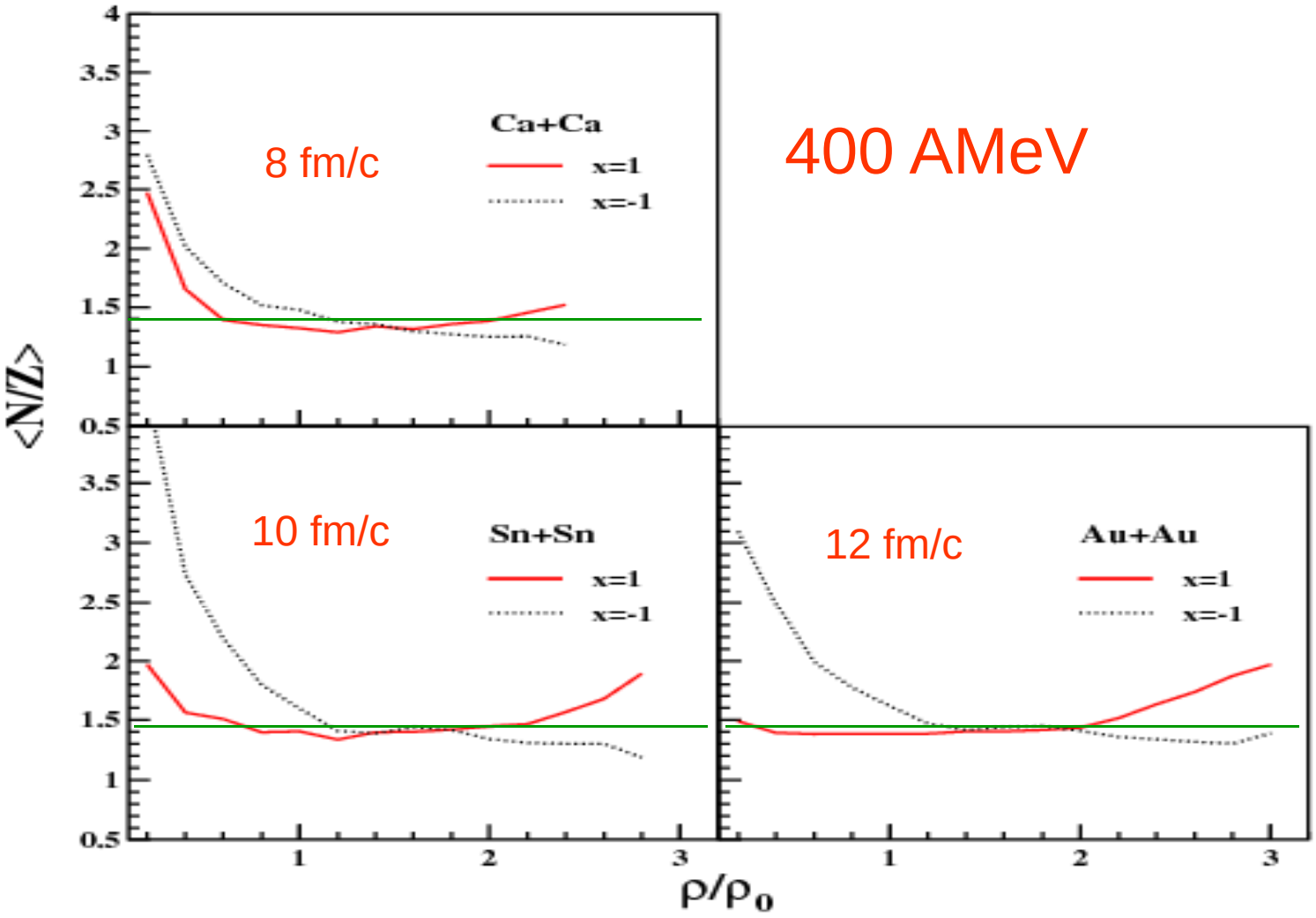
to achieve further understanding on pion production and transport in HIC



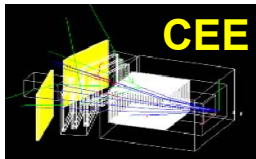




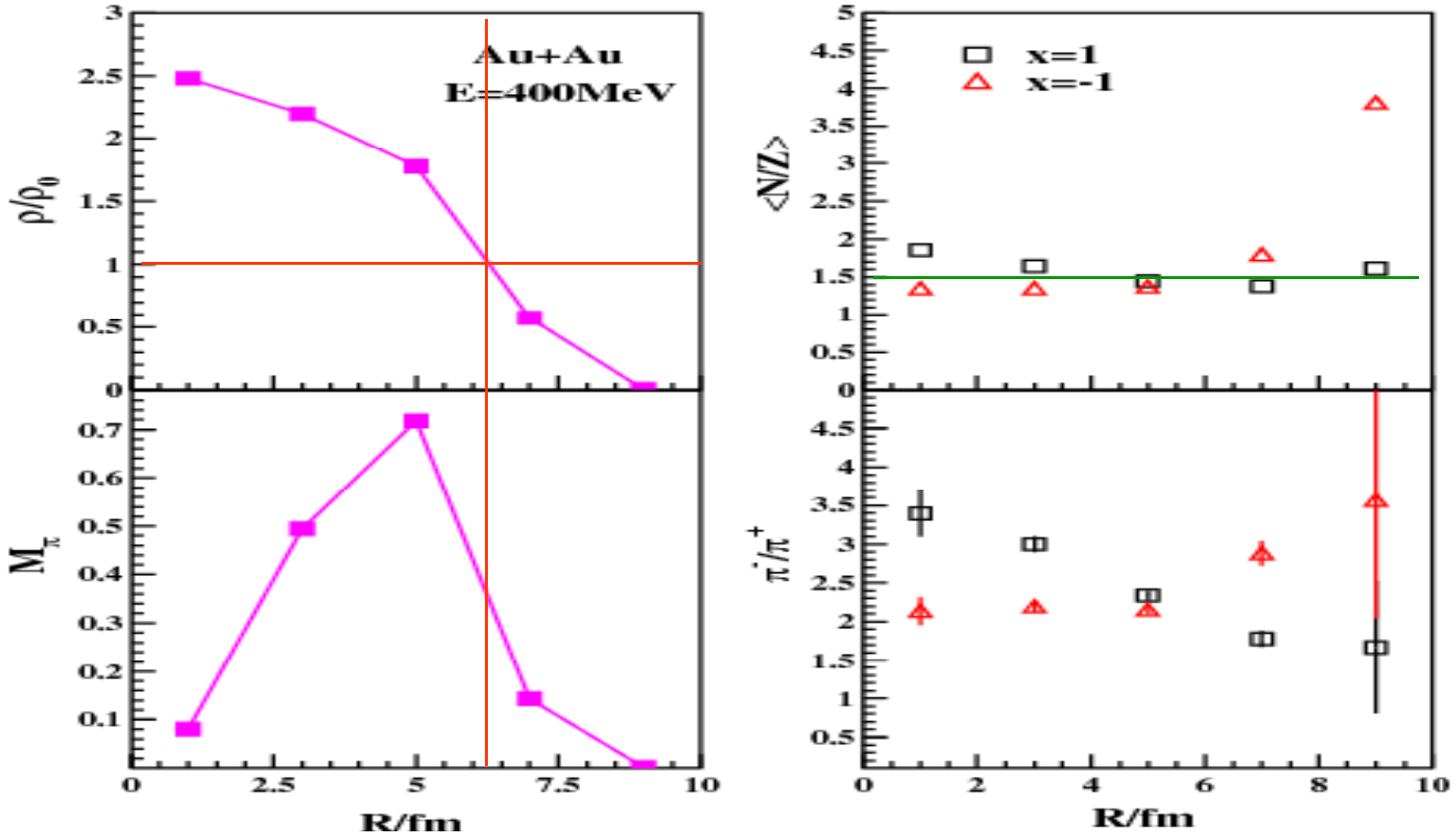
Diagnostics I



- A soft EOS leads to a enhanced N/Z at high density



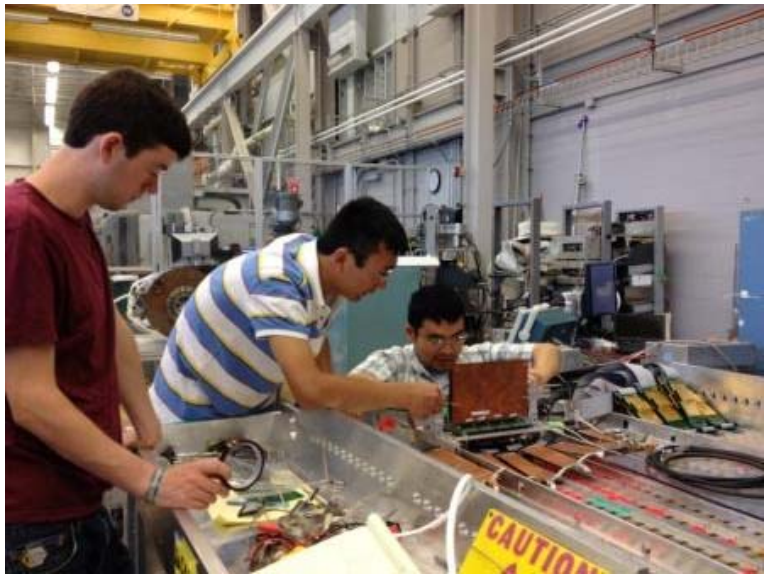
Diagnostics II



High density achieved in the central region, where a larger N/Z asymmetry is experienced with a softer $E_{sym}(\rho)$.

Experimentally …

- More data at different beam energy → Beam Energy Scan in sensitive regime
- More Systems with rather sensitivity
- More data at different phase coverage→ Whole phase space comparison



Samurai TPC project (MSU/RIKEN)

and others ……

Outline

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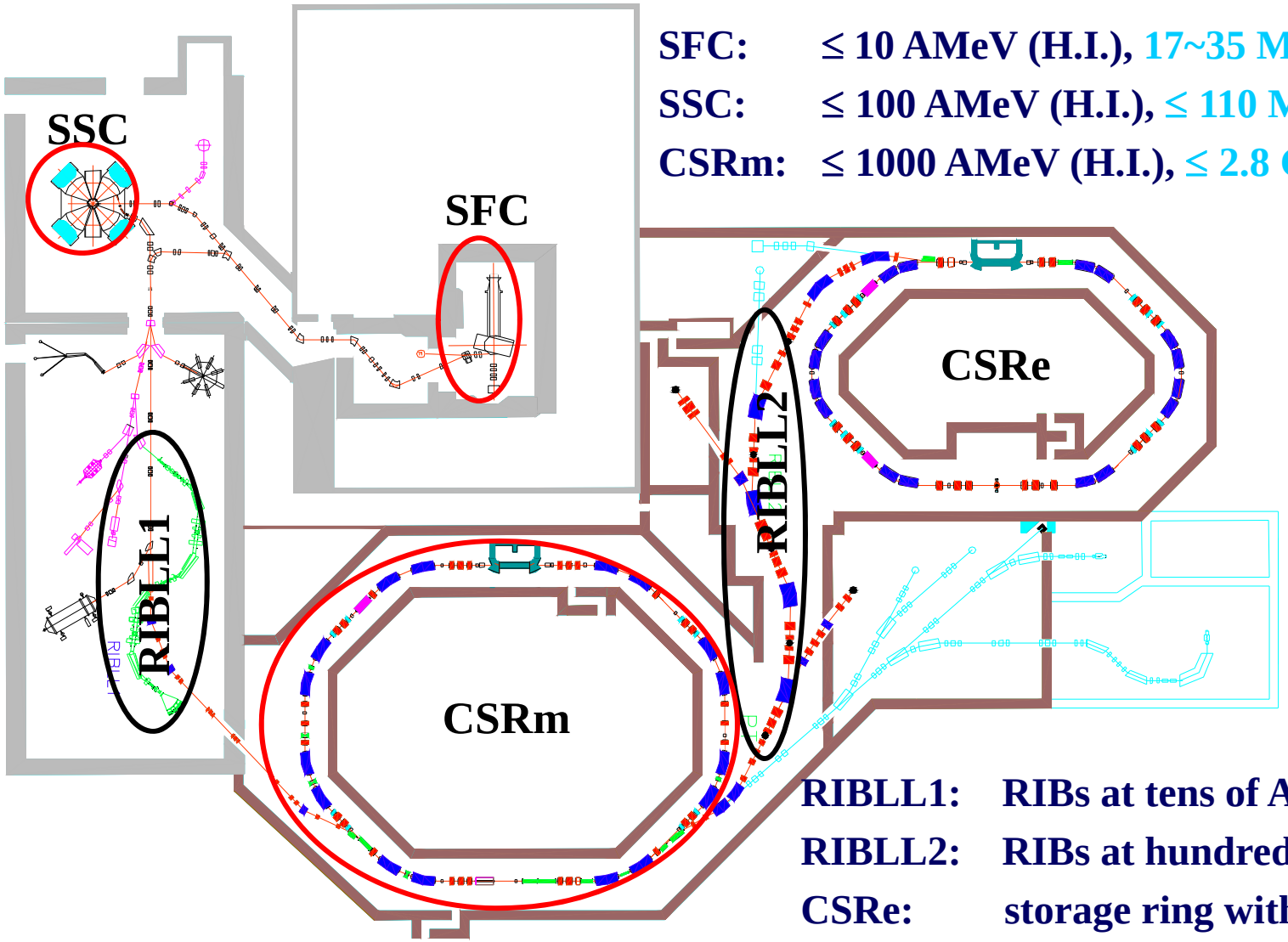
Introduction to HIRFL: Beam facilities



SFC: ≤ 10 AMeV (H.I.), 17~35 MeV (p)

SSC: ≤ 100 AMeV (H.I.), ≤ 110 MeV (p)

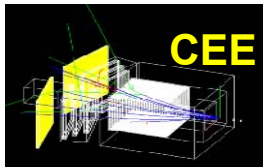
CSRm: ≤ 1000 AMeV (H.I.), ≤ 2.8 GeV (p)

N

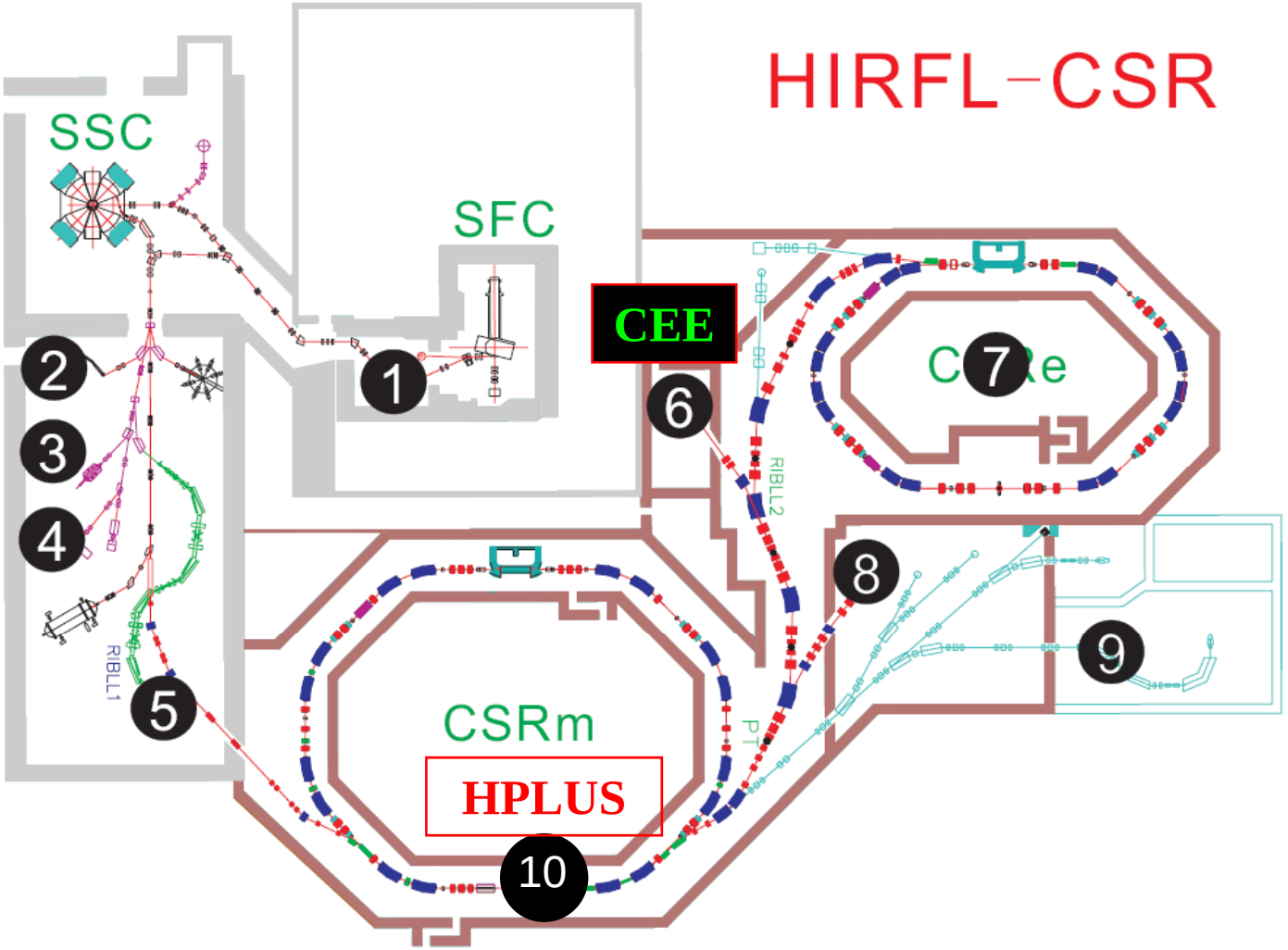
RIBLL1: RIBs at tens of AMeV

RIBLL2: RIBs at hundreds of A MeV

CSRe: storage ring with deceleration

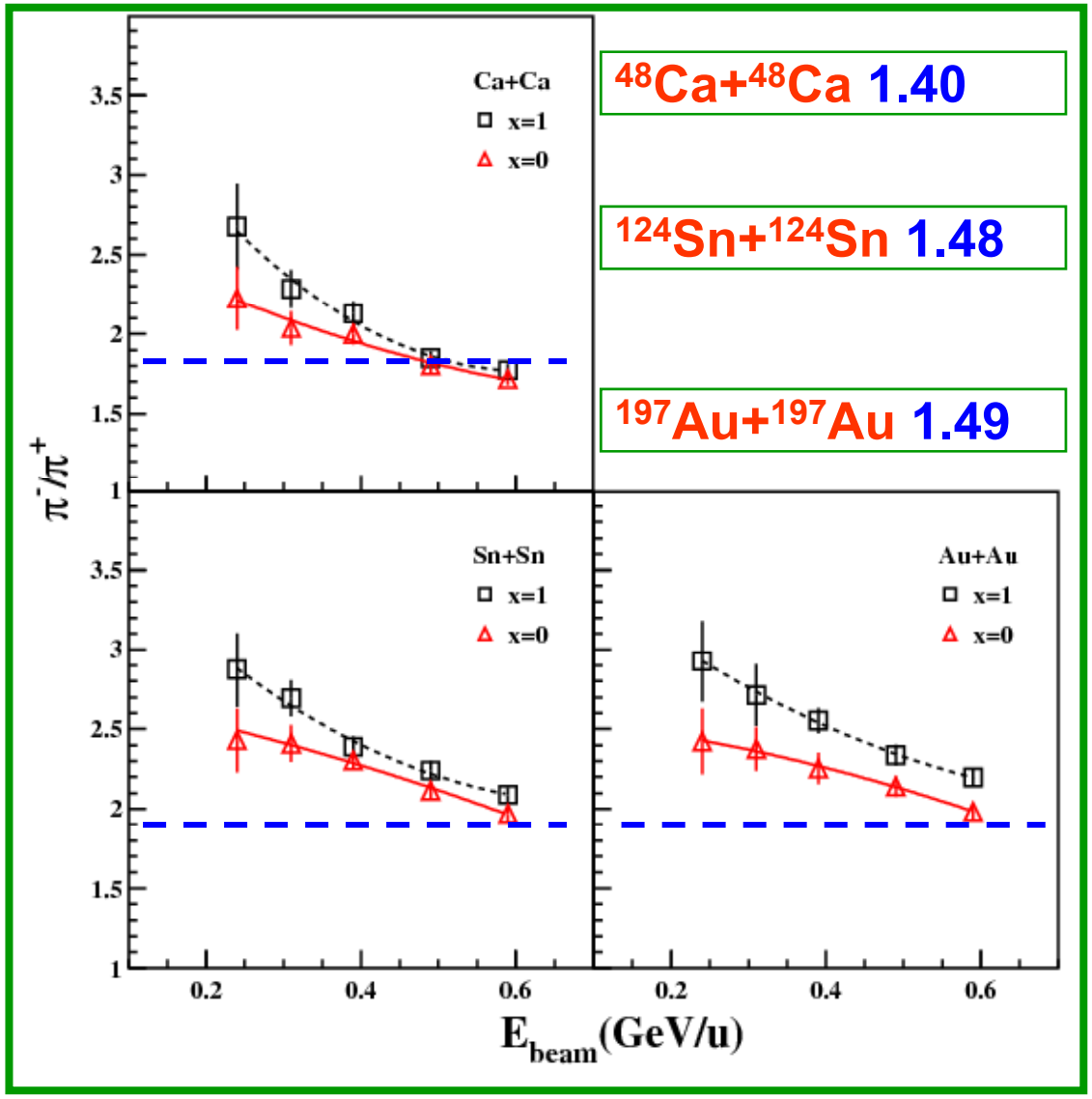


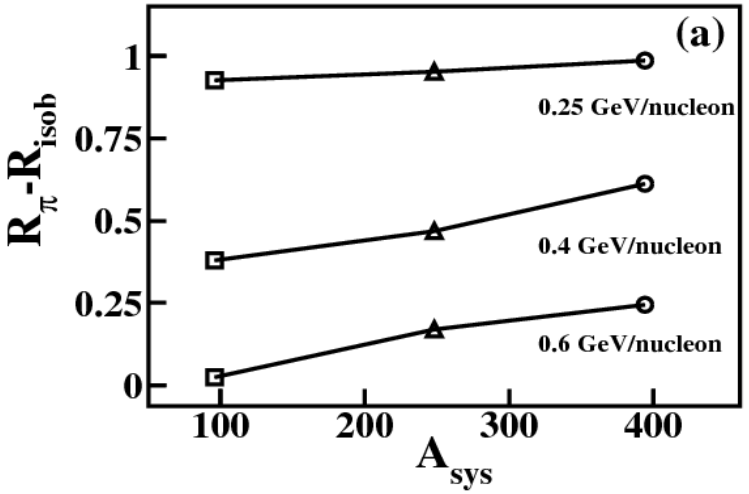
Introduction to HIRFL: Exper. Sites

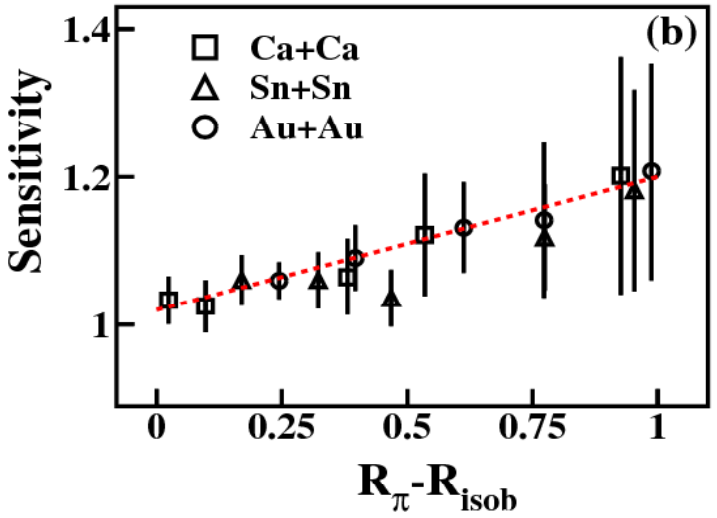


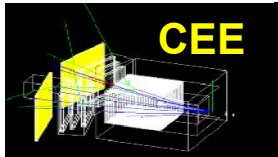
⑥ **CEE – CSR External-Target Experiment**

HIRFL-CSR energy range is favored

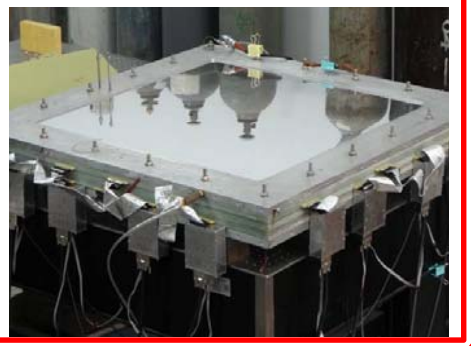


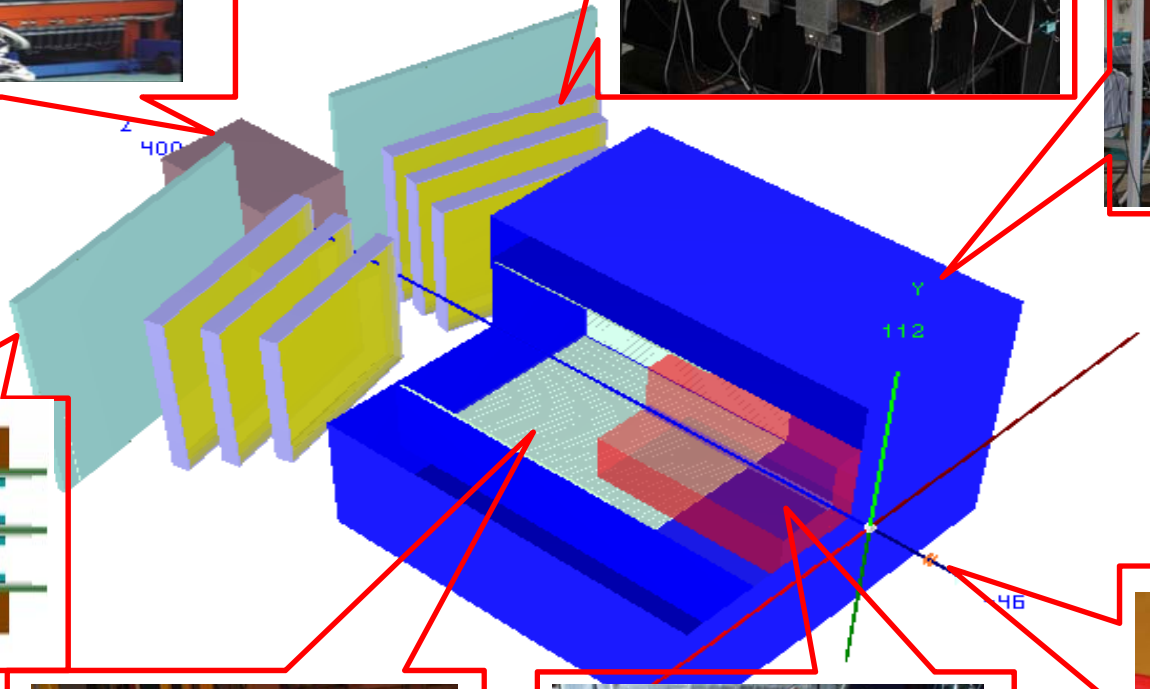


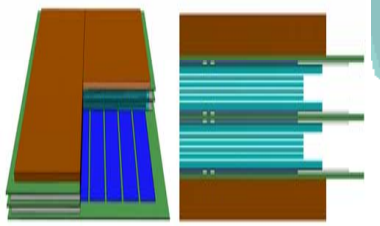


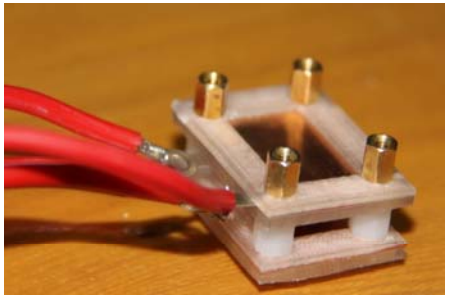


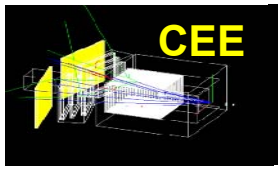
CEE conceptual design



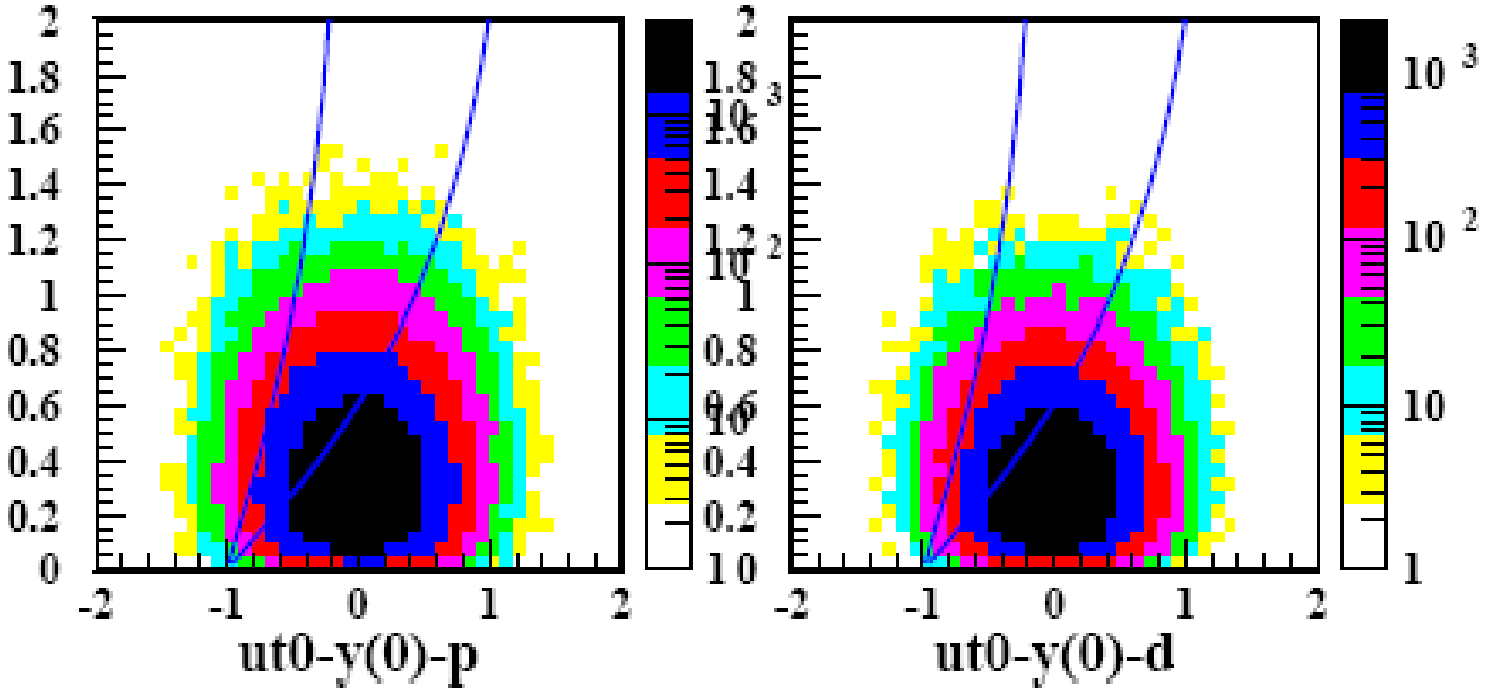




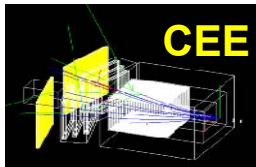




Main Parameters

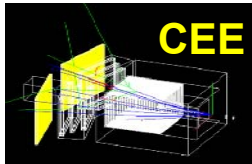


Main Feature	Designed	Main Feature	Designed
Emin	0.3 GeV/u	Emax	2.8 GeV/u (p)
Heaviest Sys.	U+U	Max. Rate	10^4 Hz
# Channels	$2*10^4$	Coverage	>50%
P Resolution	5%	Syst. Error	10%



Physics with CEE

1）**Asymmetry nuclear EOS**
2）**Reaction dynamics**
3）**Medium Effect**
4）**Λ hyper-nuclei**
5）**N***



Possible Observables

Isospin related observables

Isotope resolved phase space distribution

Isospin diffusion at high energy

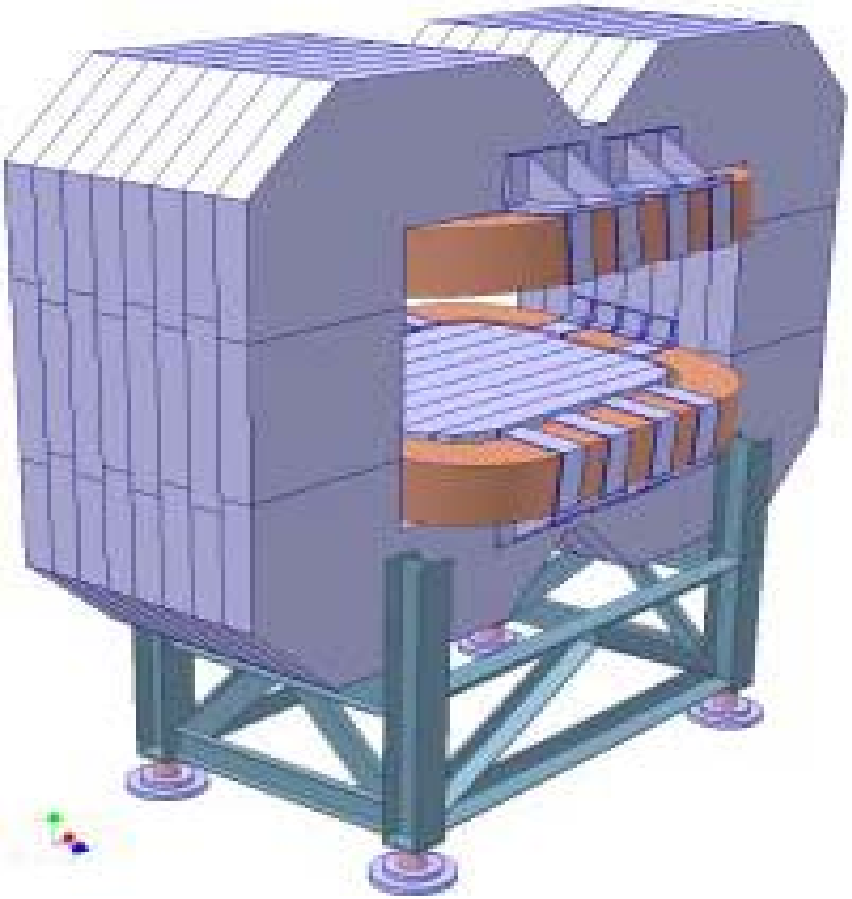
Nucleon scattering by mean field

Flow…

Elastic scattering and few body process

Hyper nuclei and N* research

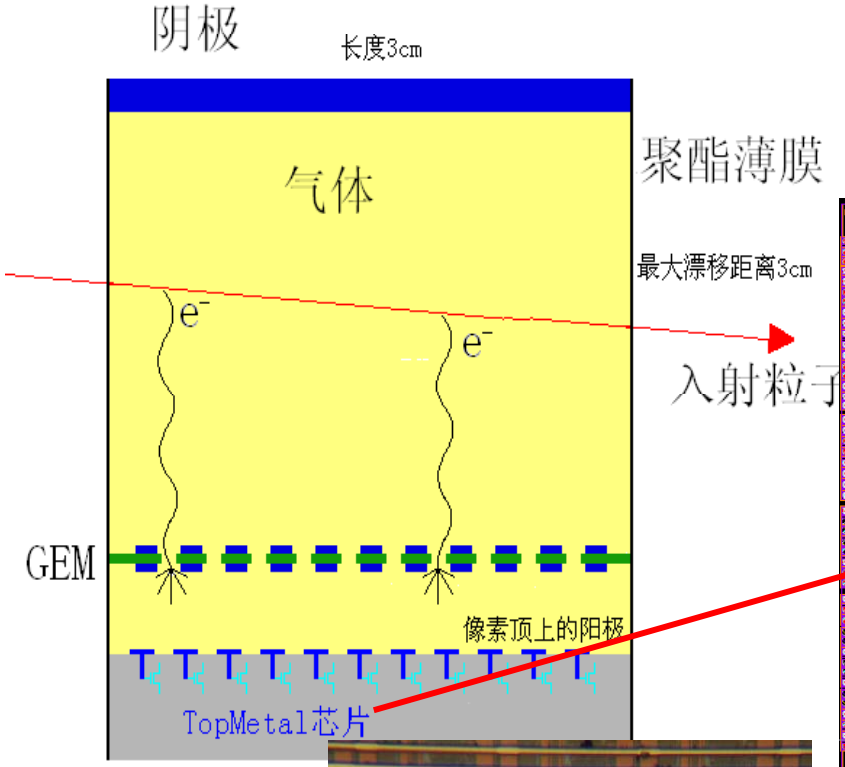
Dipole concept

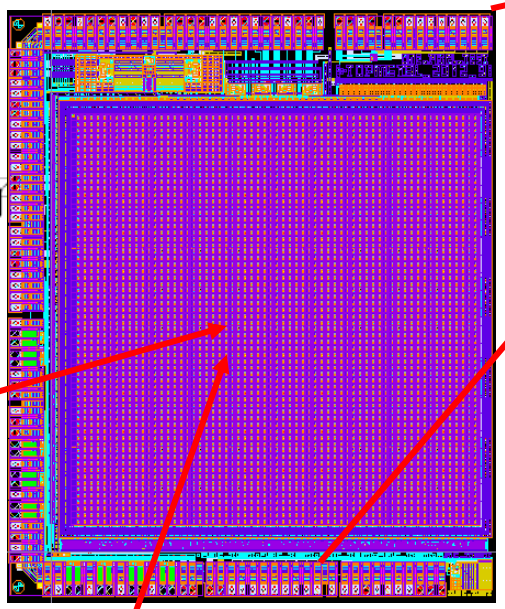


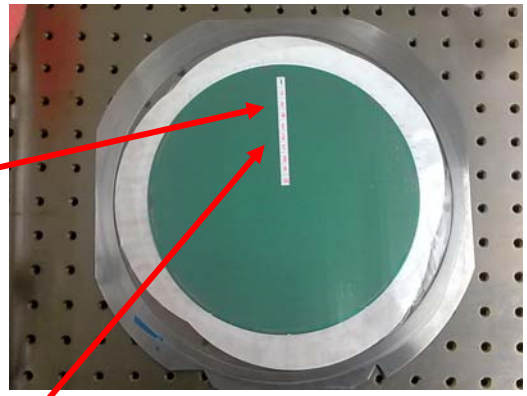
Central Field	0.5 T
Field Dimension	~1 m×1 m×1.5 m^3
Inhomogeneity	1%
Total Size	～2.5×3×4 m^3
Total Weight	200 Ton

Prototype of a superconductive magnet (Made in IMP, for FAIR)

Silicon Pixel Detector







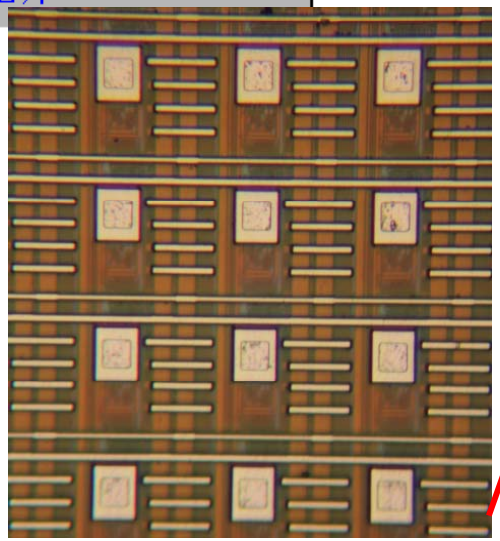
Wafel

Chip

Pixel Dimension：
64x64

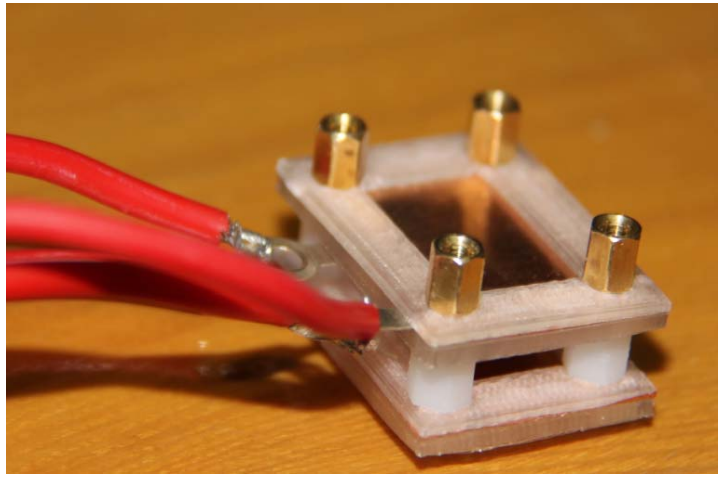
Pixel Size：

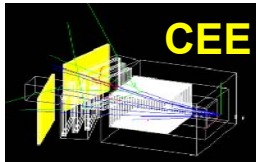
80umx80 um



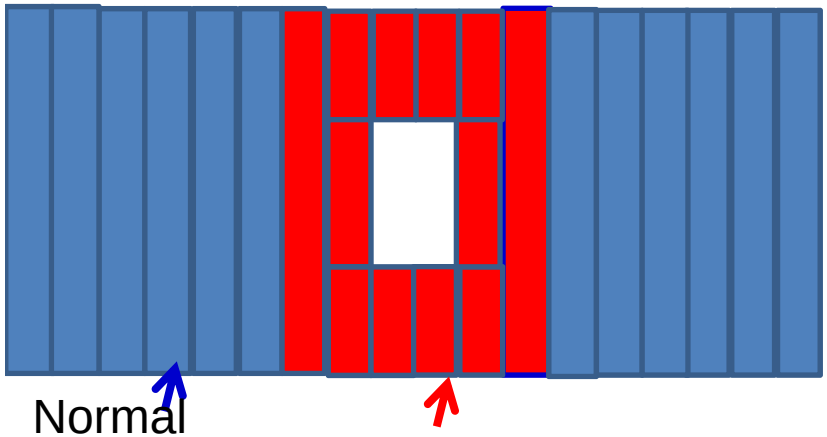
(TopMetal)

CCNU



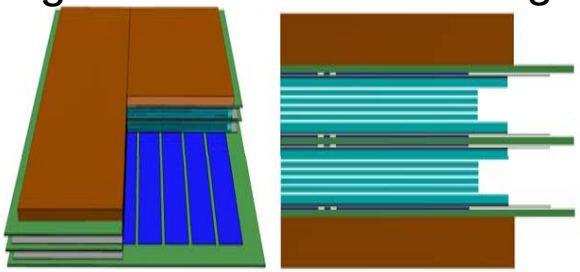


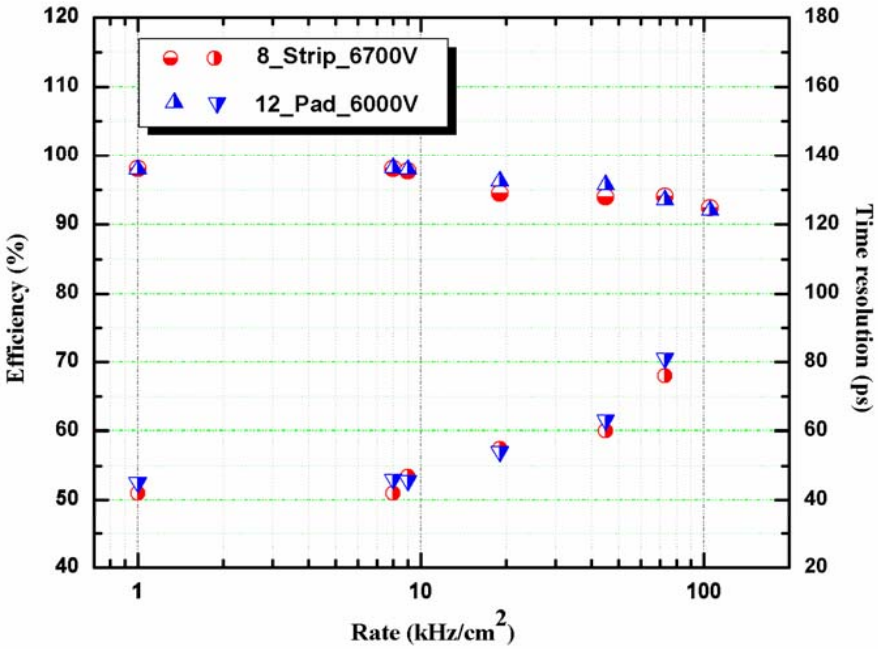
MRPC – TOF concept



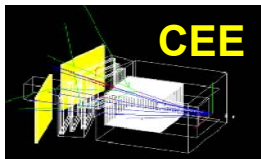
Normal
High Gra.
High Reso. MRPC

High Count、
High Gra. High Reso.



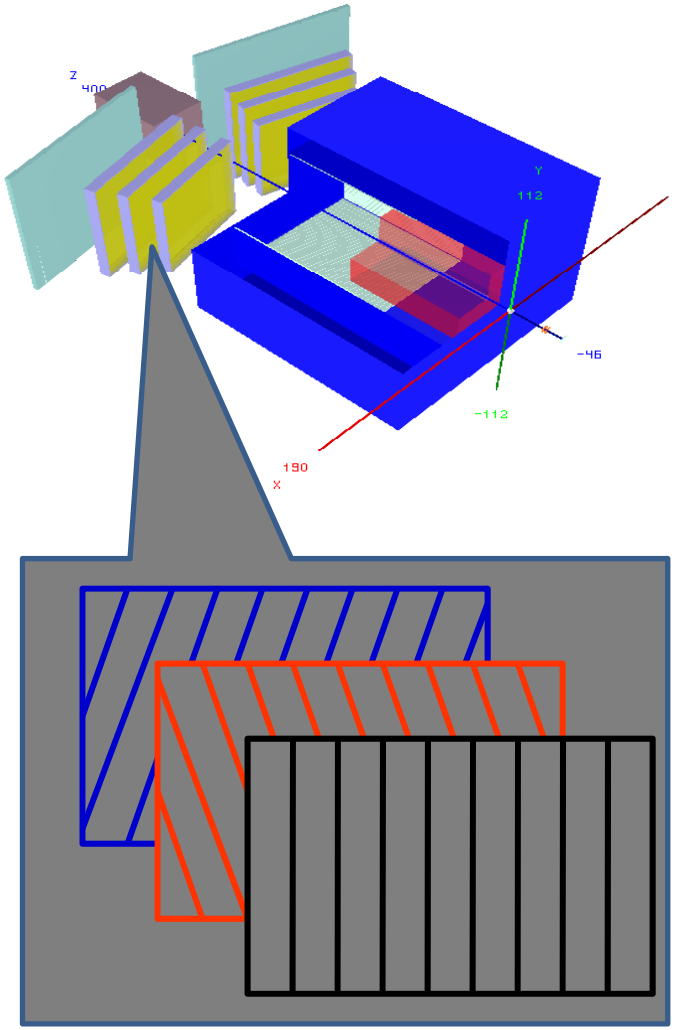


Momentum		500MeV	600MeV	800MeV
Pion sample	#1	56	47	45
	#2	51	48	40
	#3	46	48	45
Proton sample	#1	29	32	36
	#2	28	30	35
	#3	31	31	35



MWDC Concept

Large Area MWDC array



→ Structure:

Three sense plane， Two arms, Six MWDCs total area ~12 m^2.

→ Expected Performance:

R< 300 μm, MIPs Efficiency per layer >95%。

Area (W×H)	1280×1200	1440×1300	1760×1500
Sense Wires	416	464	560
Pieces	2	2	2
Structure Anode Plane	Φ20μm W(Au)， Tension 60g，Wire Distance10mm； Field Wire Φ75μm Be-Cu，Tension 120g		
Structure Cathode Plane	Φ75μm Be-Cu，Distance 2mm，Tension 120g；		
Total Readout	2880	Total Area	12.1m^2
MIP Efficiency	η>96％(Single Layer)	Position Resolution	σ<300μm

TPC concept

Readout Are	**~1.2 m× 0.9 m**
# Channel	~11000 (110×100)
Paddle Size	9 mm × 9 mm
Drift length	60 cm
Working Gas	90% Ar + 10% CH_4
Field	150V/cm
dE/dx Range	Z<=3, π,p,d,t,He-Li
Track Resolution	2.5~3 cm
Max. Multiplicity	200

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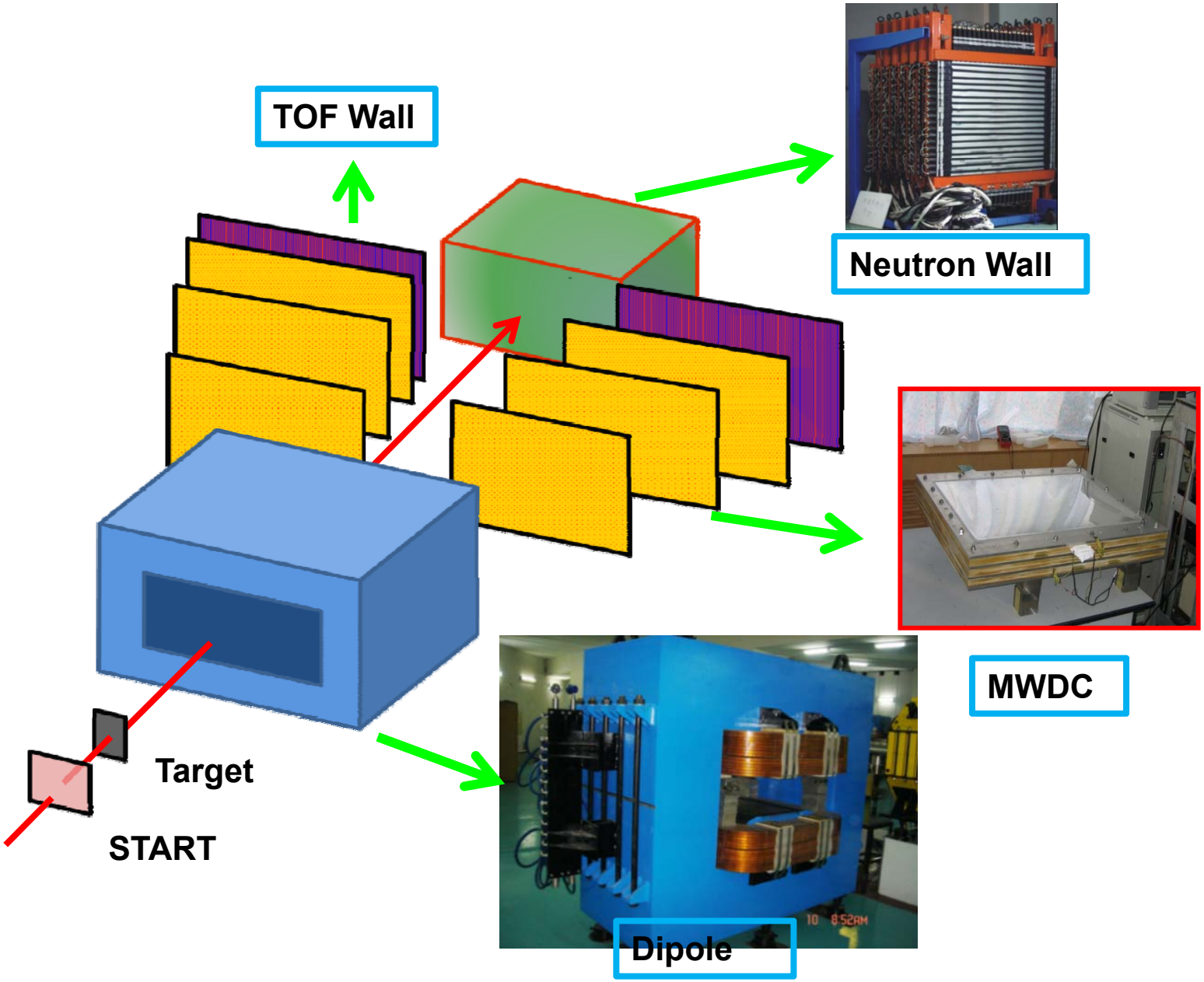
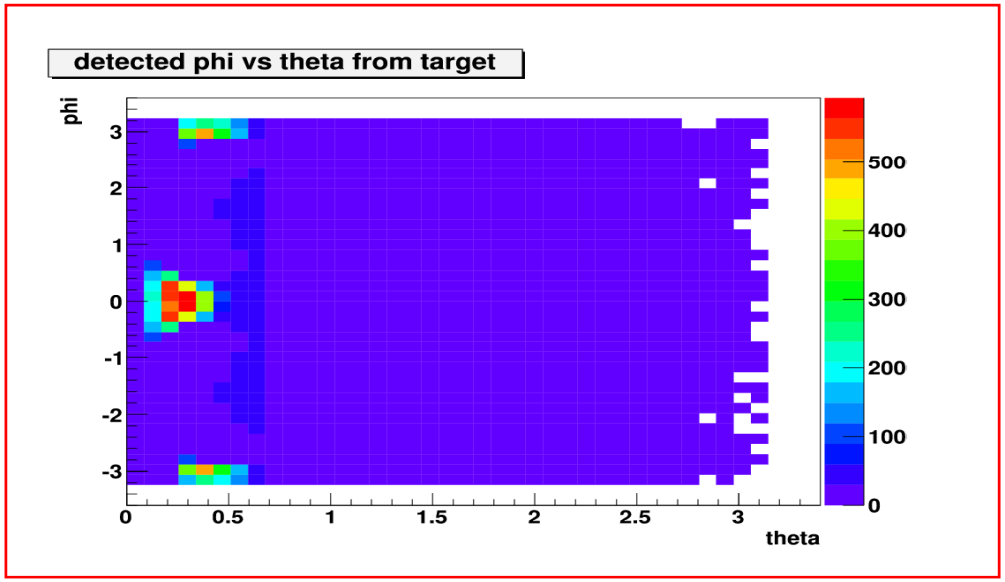
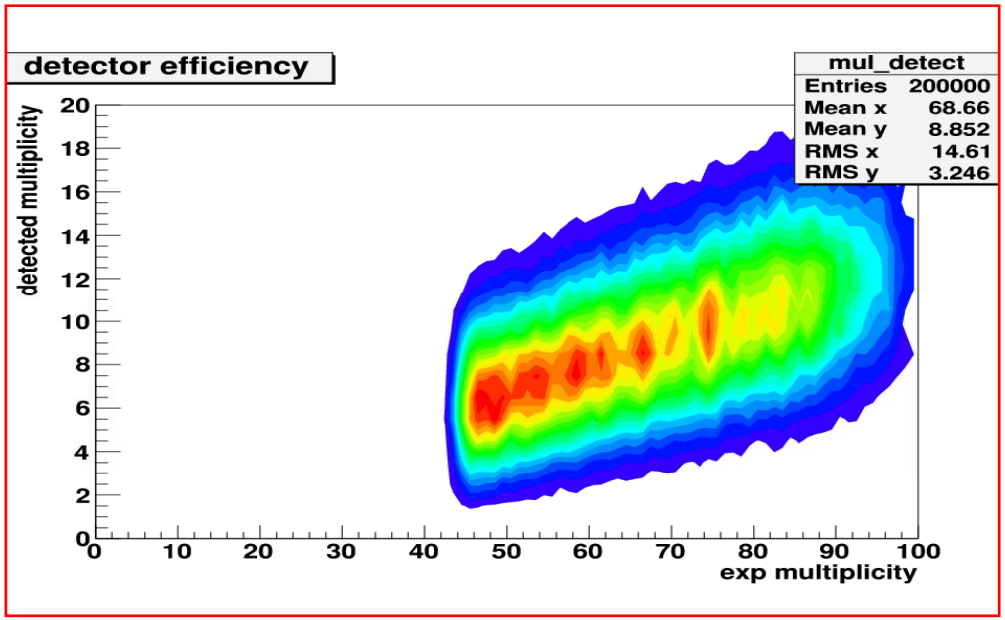
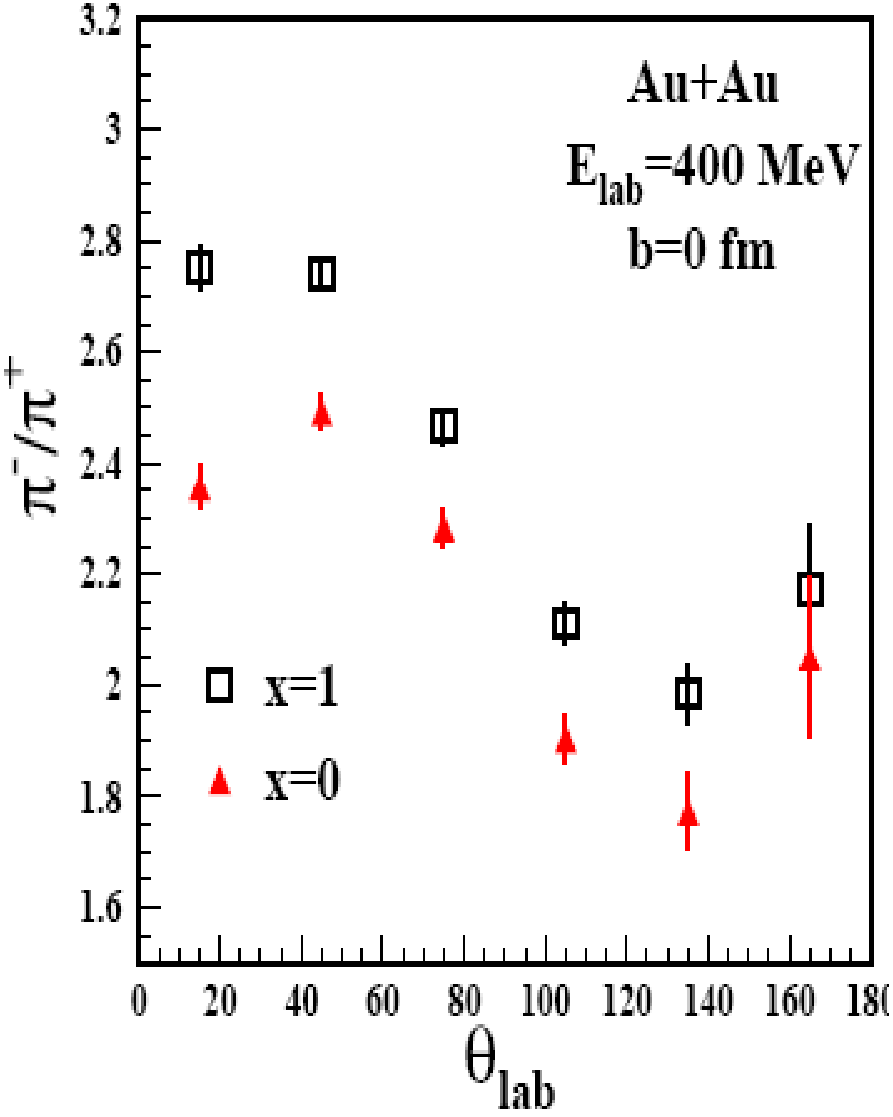
CEE Phase I



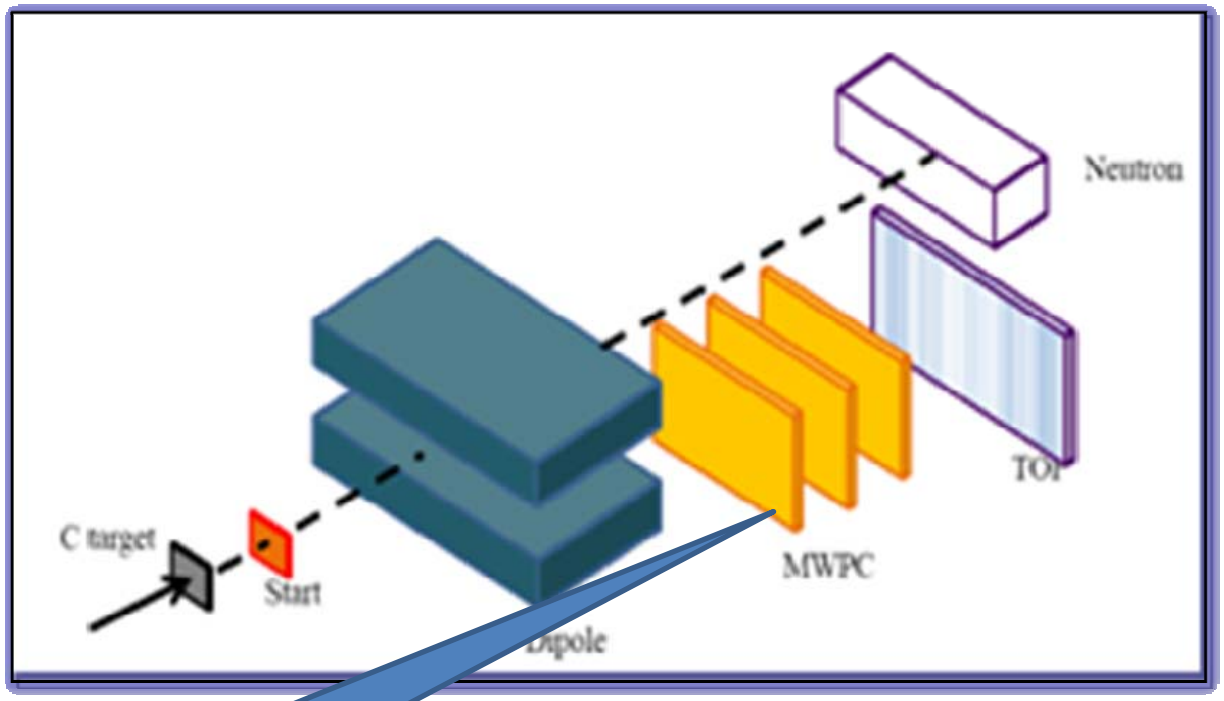
Whether The physics still there?



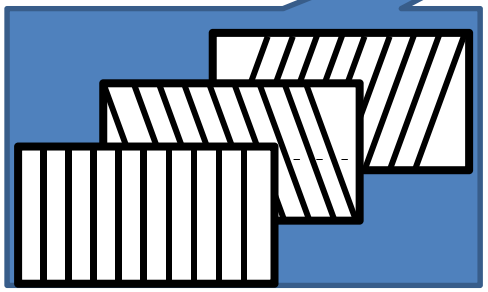




Test Beam

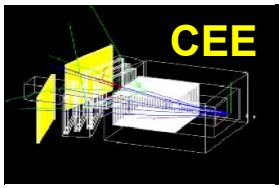


- C+C @ 200,600 MeV/u
- Three MWPC tracking
- 12 TOF Strips + Start
- 1 Neutron Wall
- Inclusive
- B~0.4T，reversible

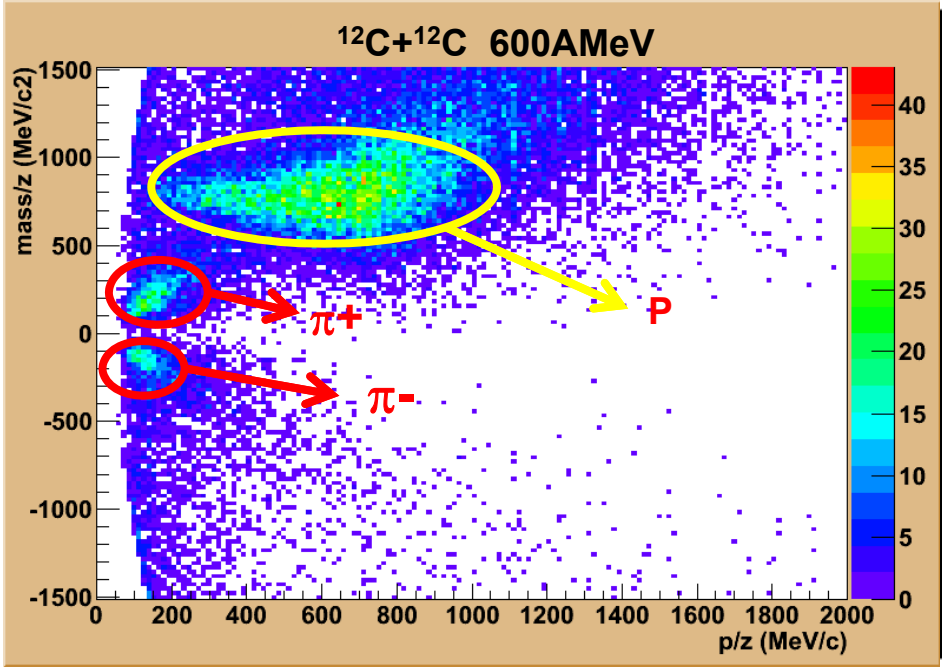


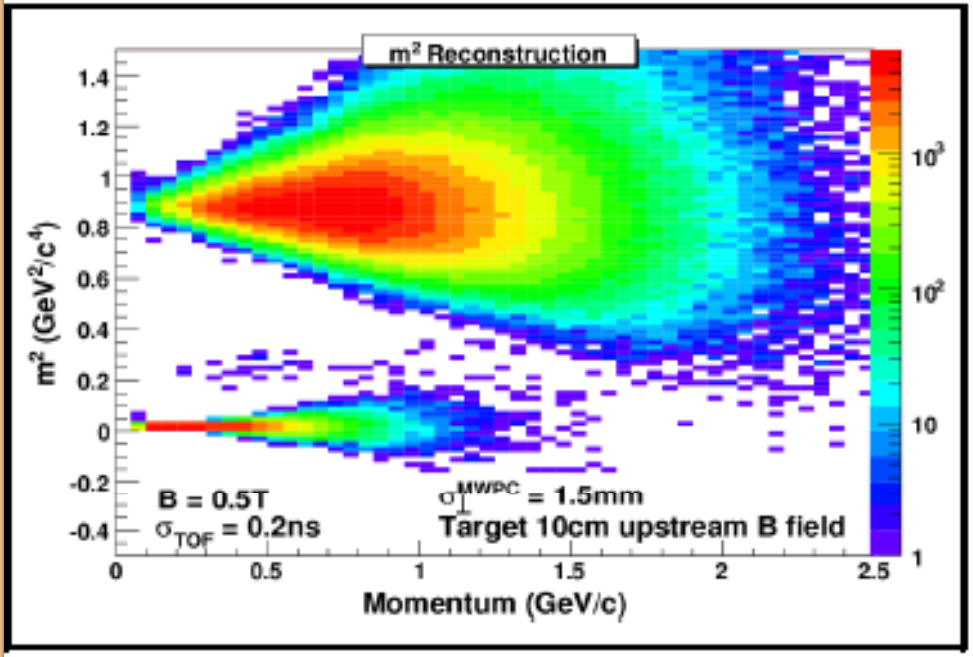
4 mm wire distance

0/1 resolution



Test Experiment Output





Experiment:
600 MeV/u

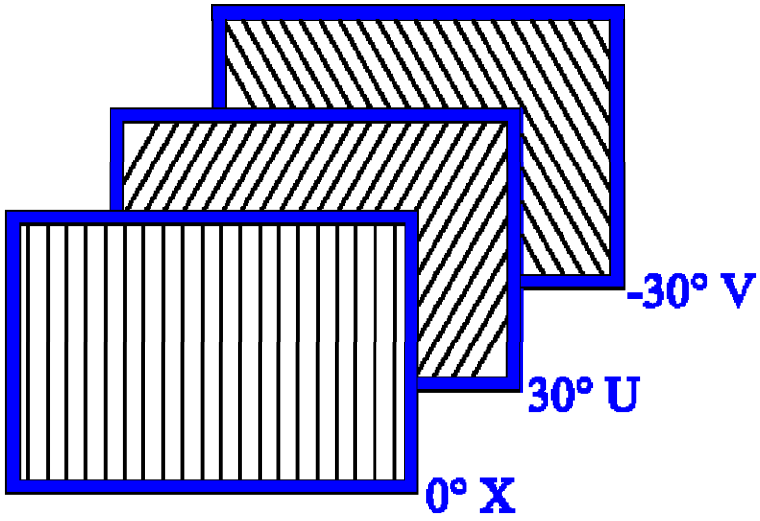
Simulation:
σ_{MWPC}=1.5 mm≈4/(12)$^{0.5}$

1) Tracks reconstructed well, Pion ratio ~ 1 in C+C

2) Limited electronics, detector resolution and dirty background …

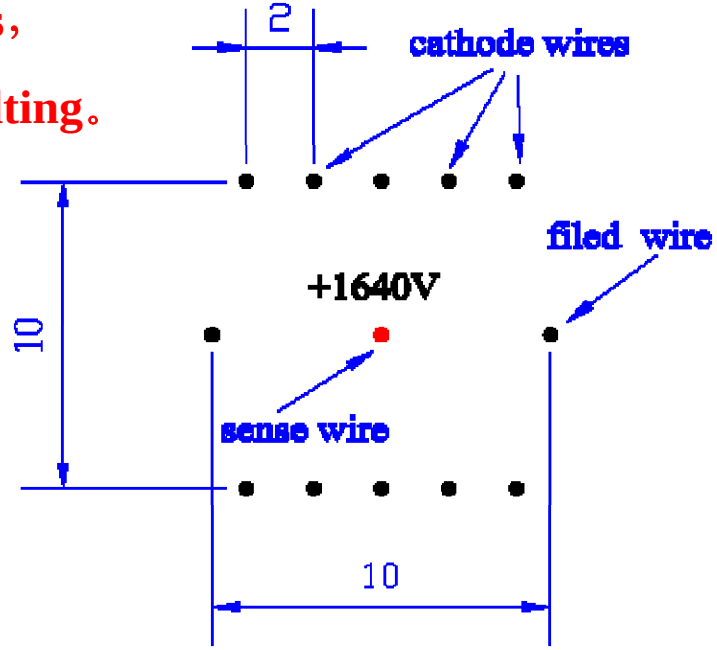
3) Systematic error not controlled

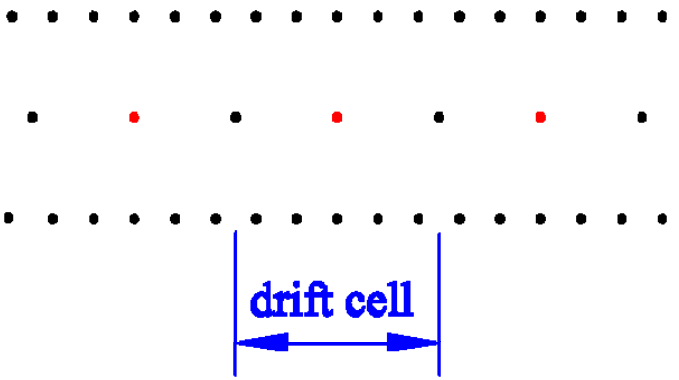
MWDC Parameters



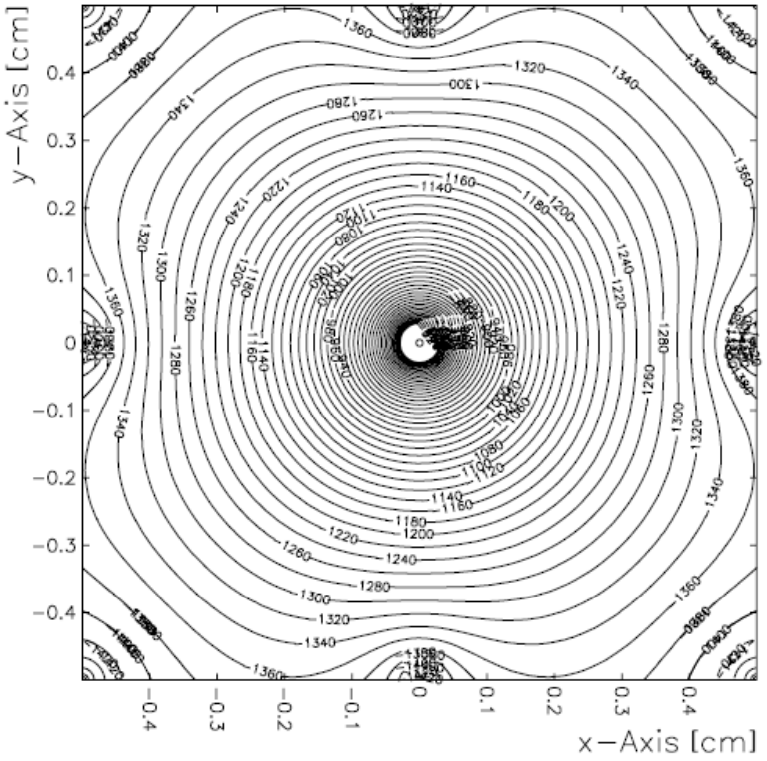
Three Layers，

0 and ±30° tilting。



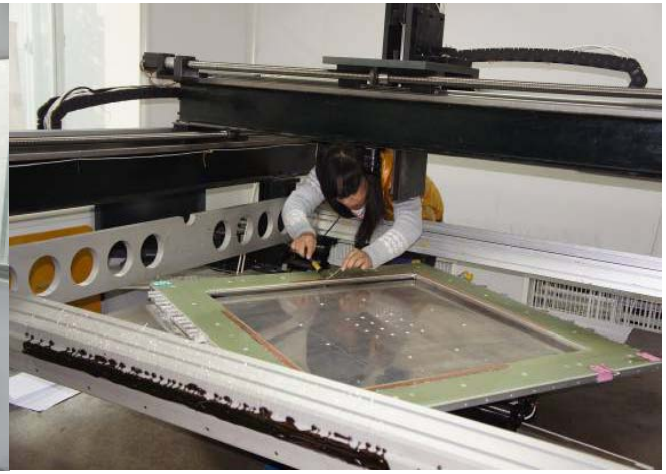


Contours of V

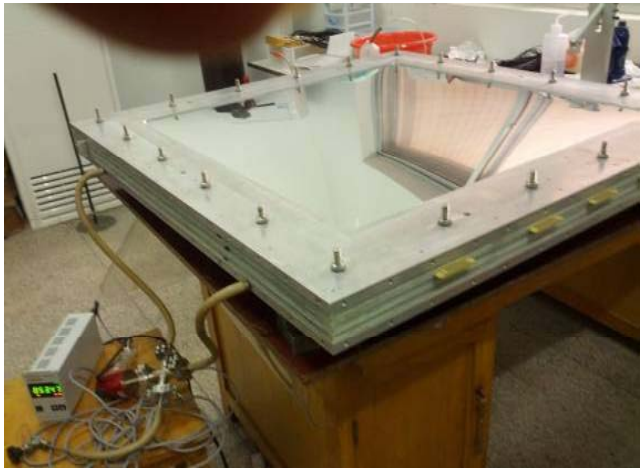


Design and Manufactory of MWDC

Wiring:
Frame=1.6m × 1.6m。

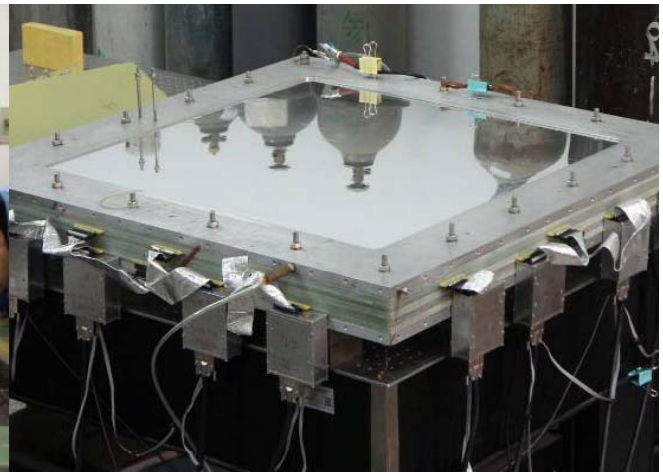


Soldering Wire and Frame

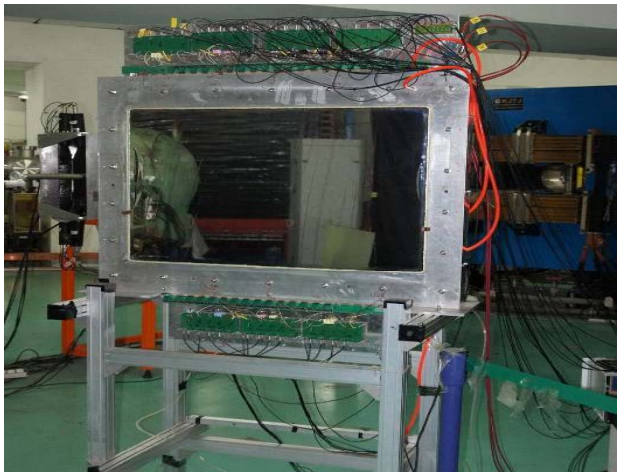


Leak rate Test

Wire Frame/Tension Preset

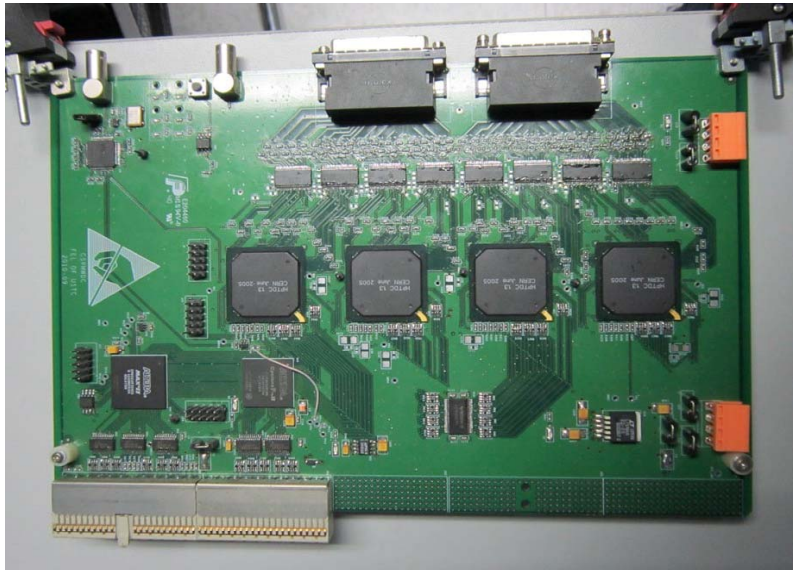


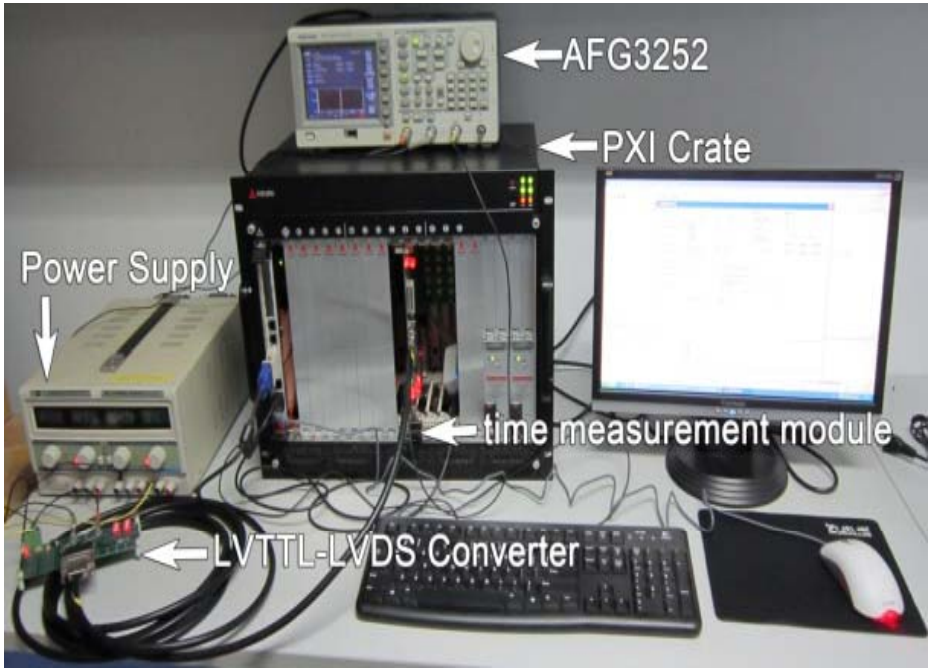
A Large MWDC to be completed



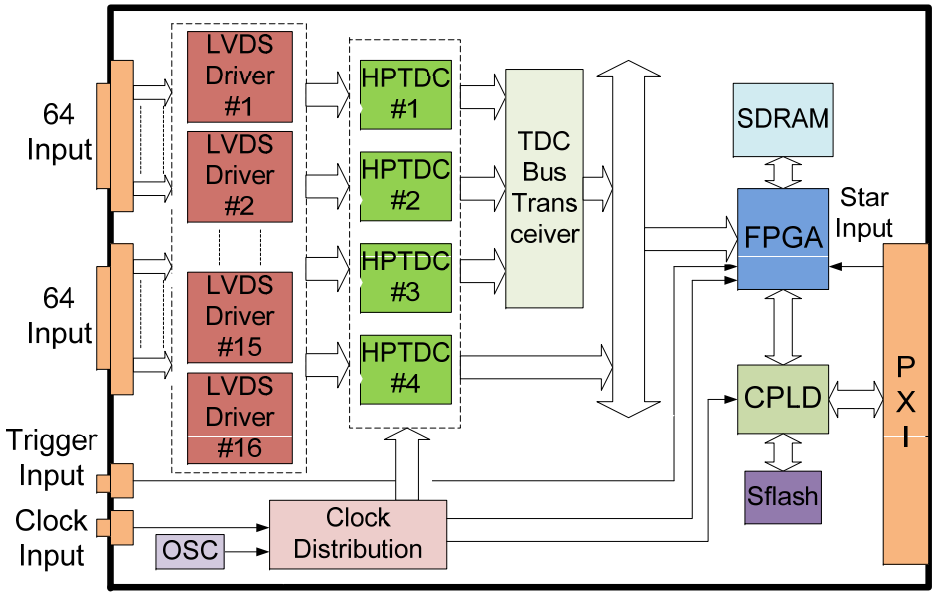
Installed for Beam Test

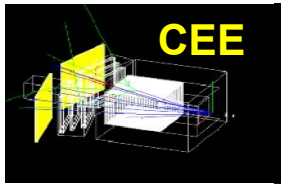
Electronics



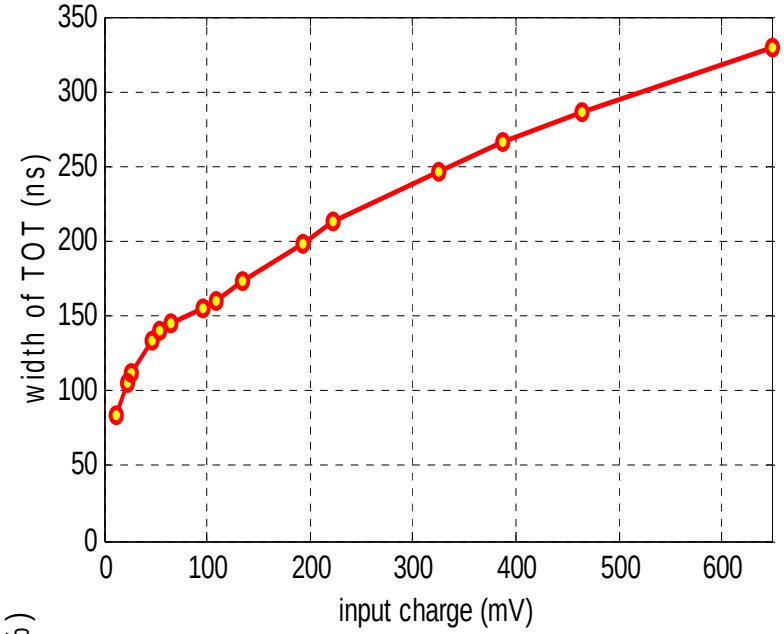


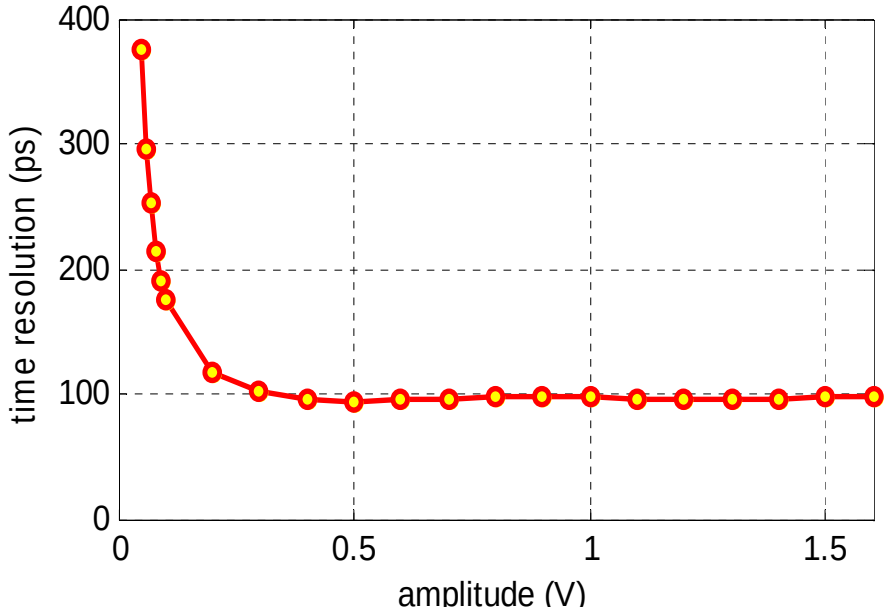
PXI based DAQ

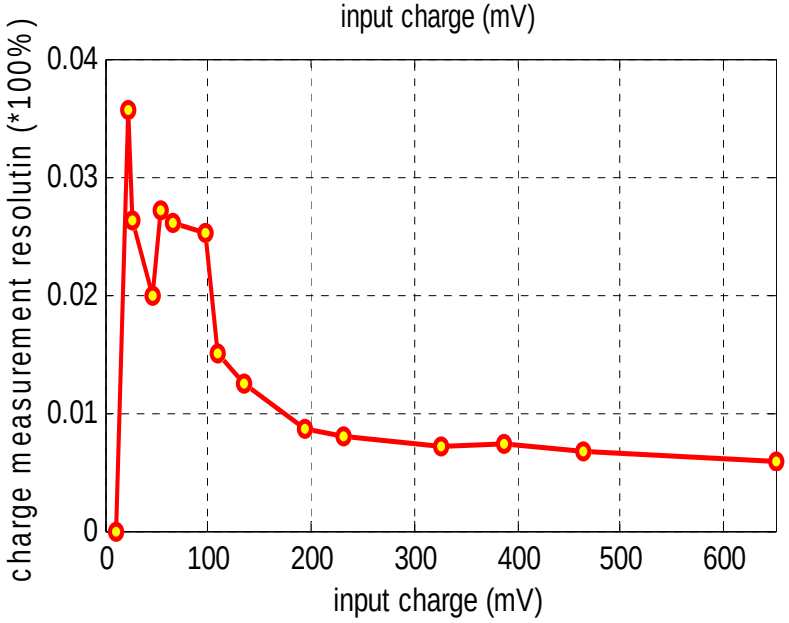


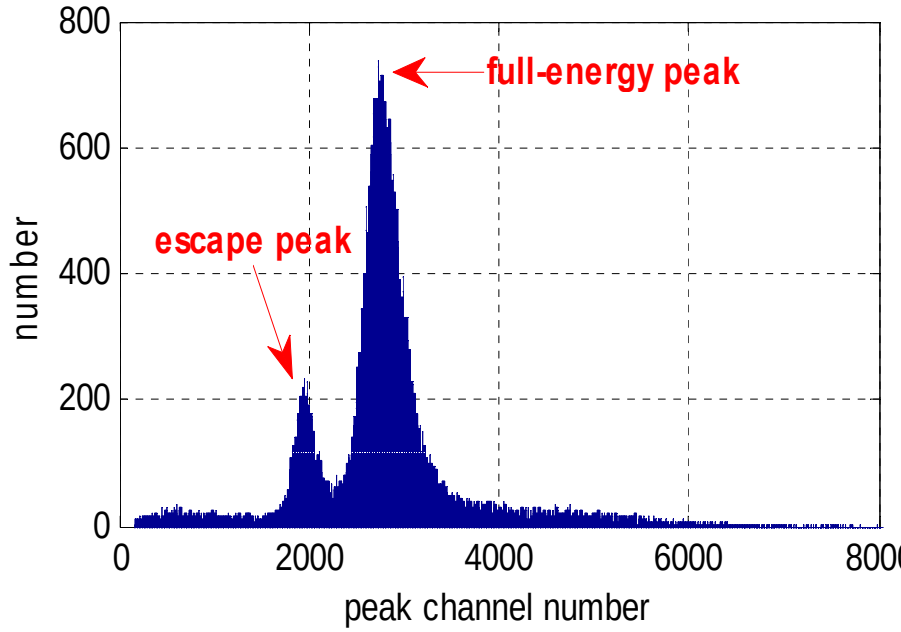


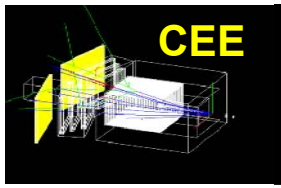
Electronics test with MWDC



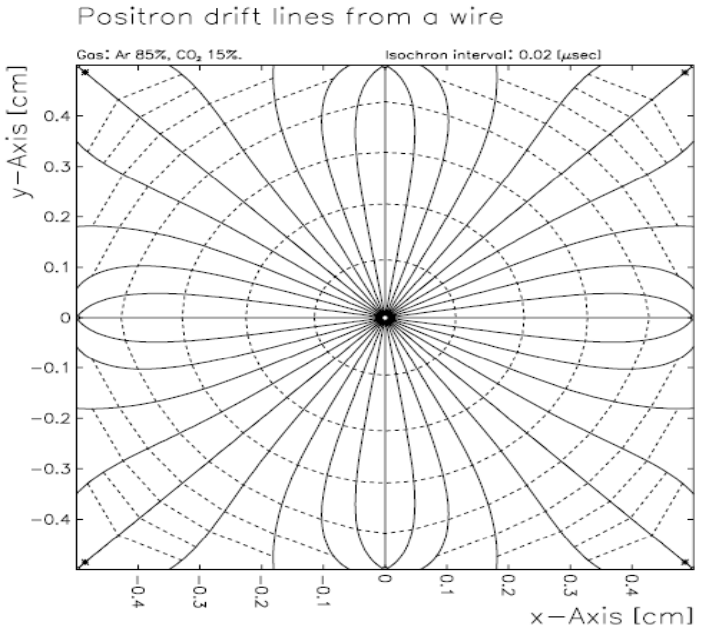


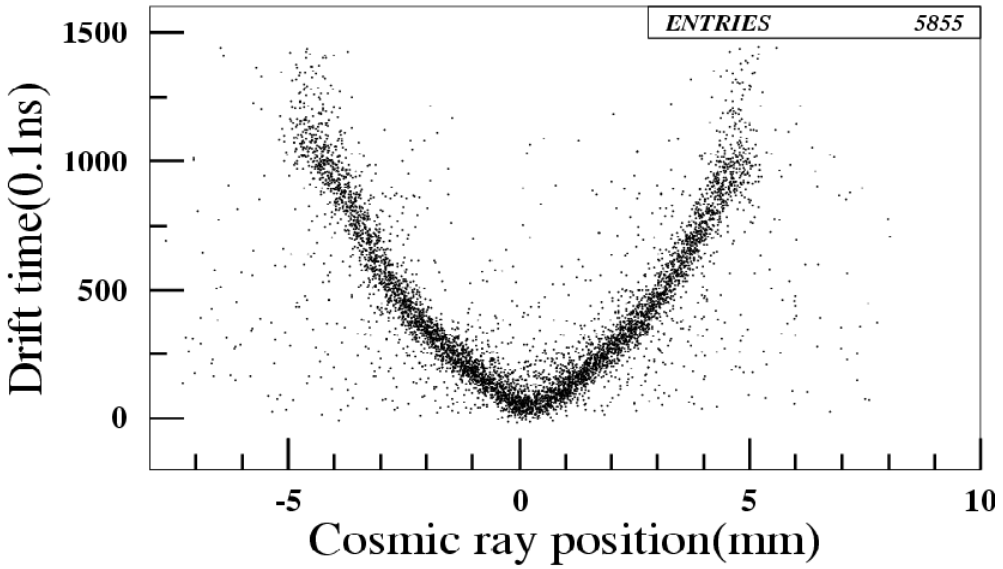


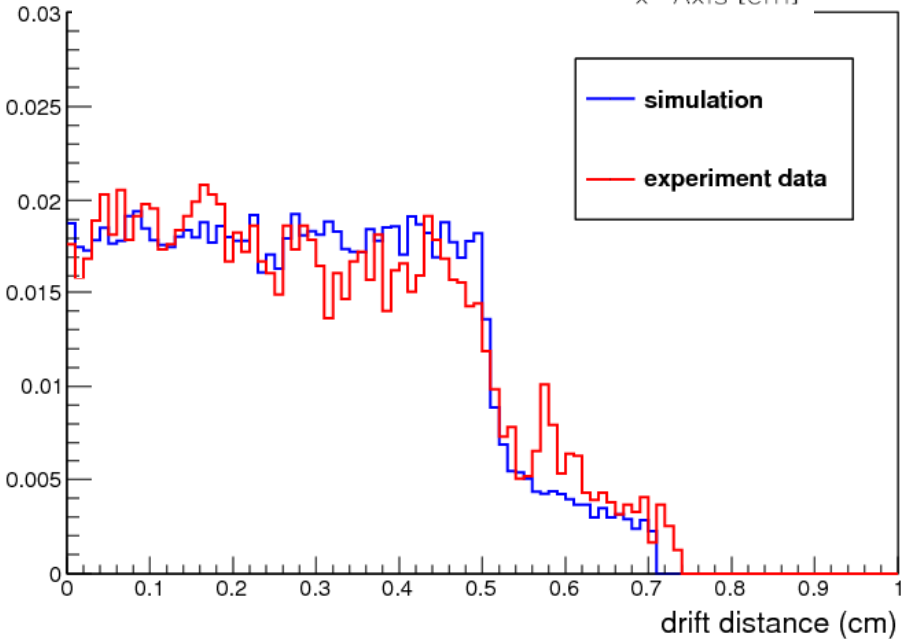


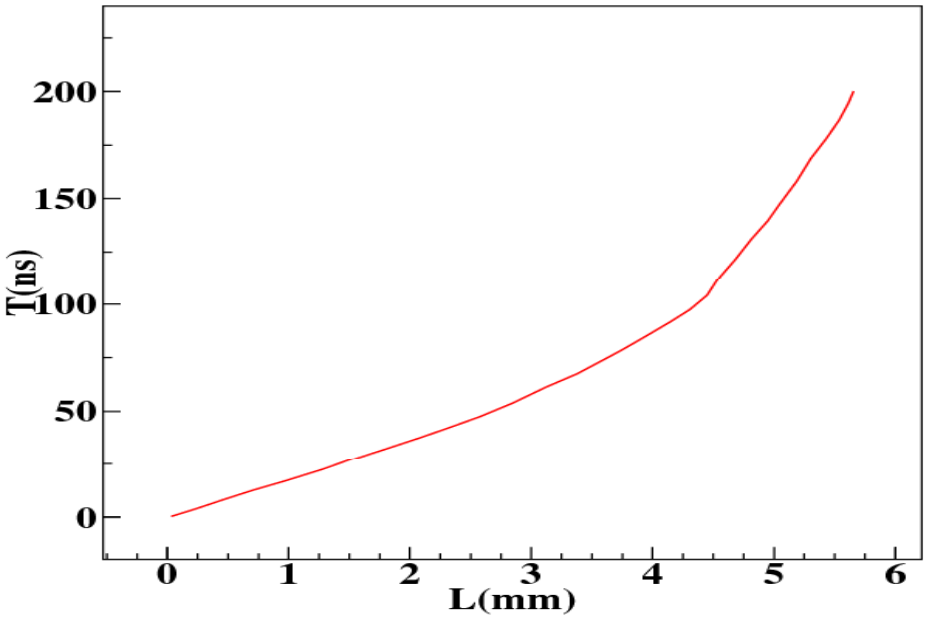


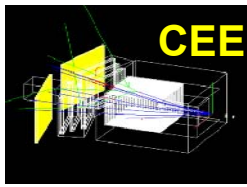
Large MWDC Prototype Test



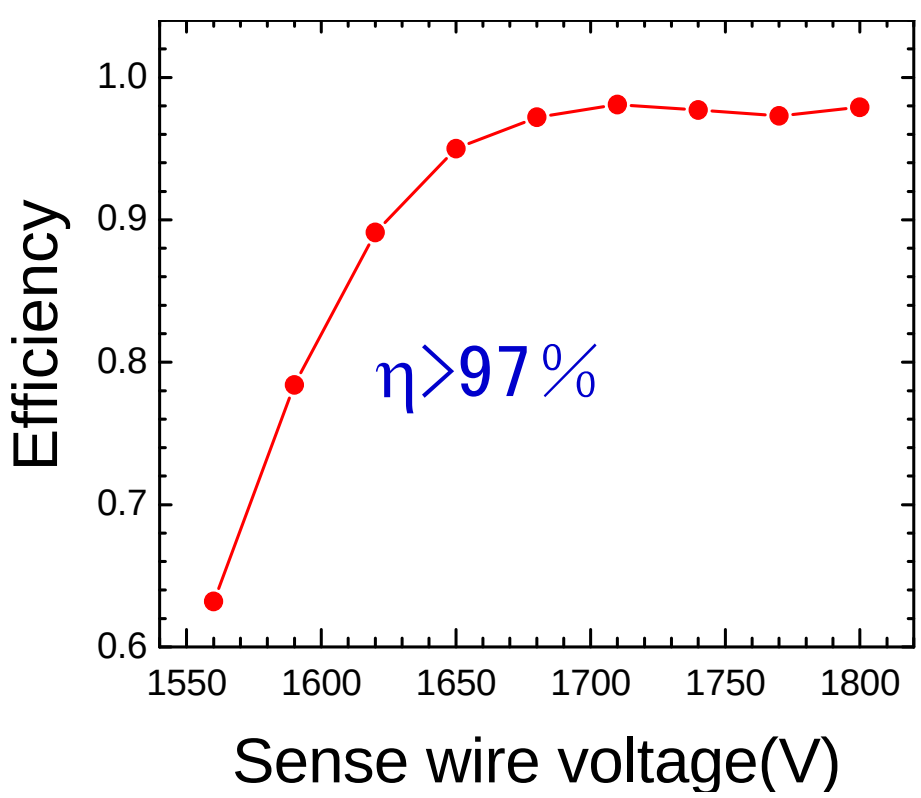


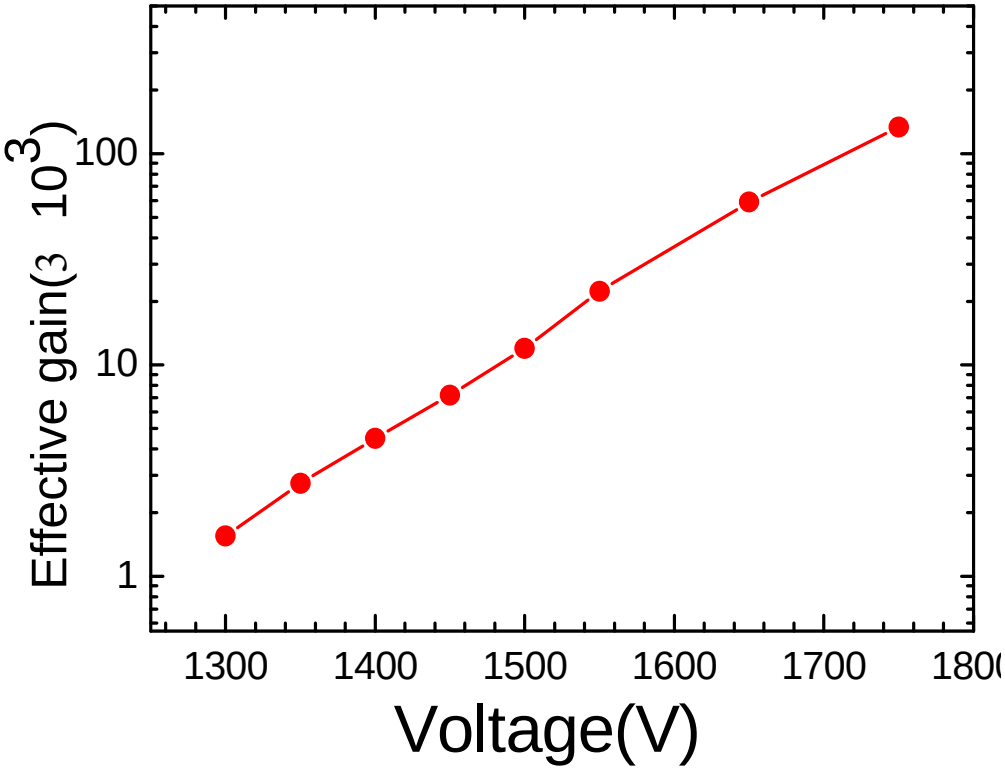


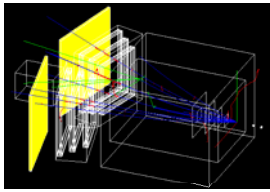




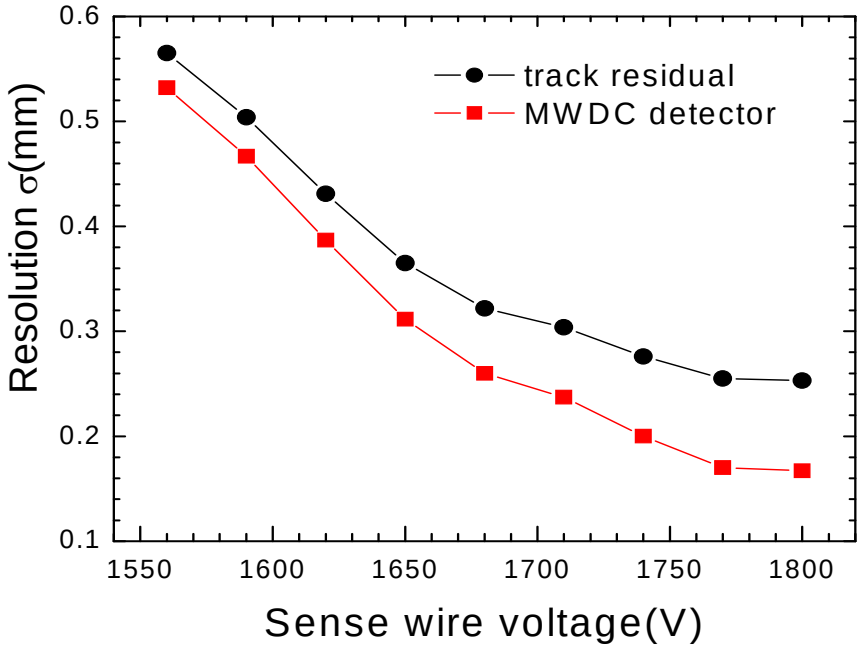
Large MWDC Prototype Test

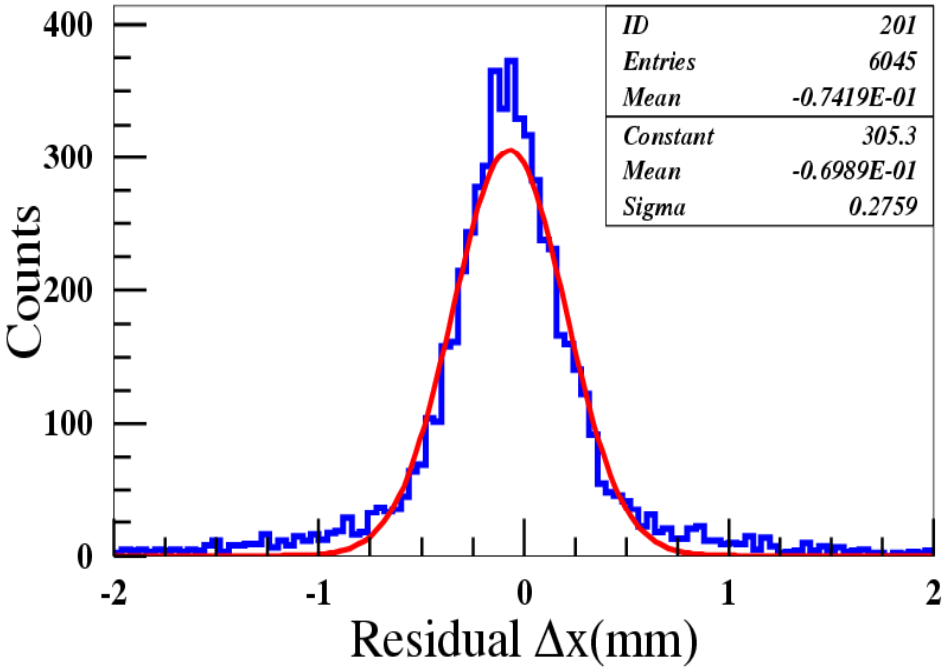






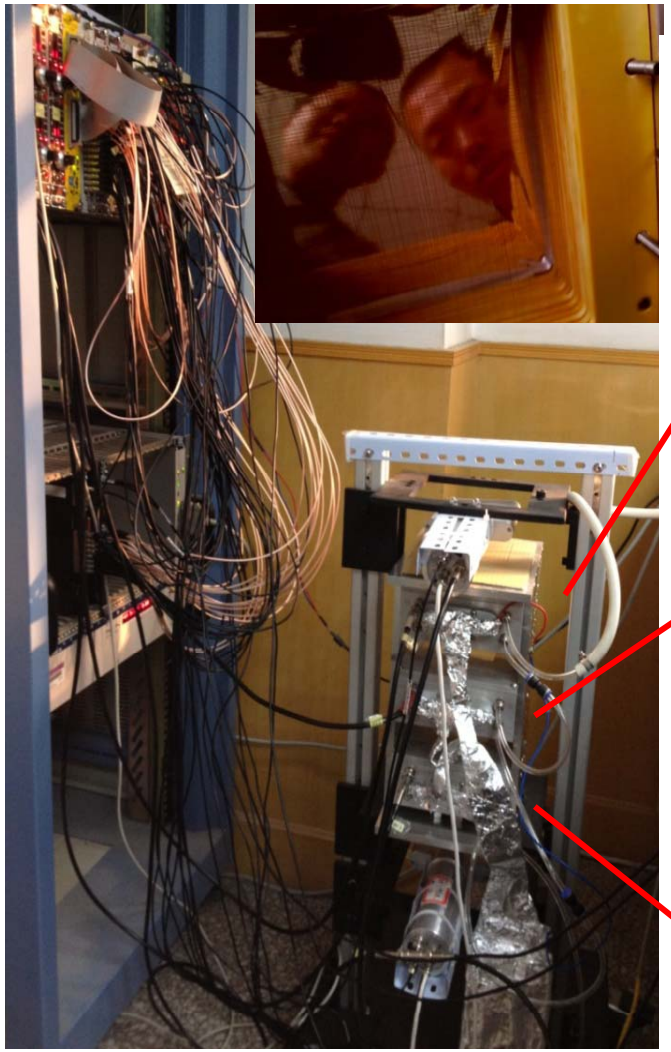
Large MWDC Prototype Test

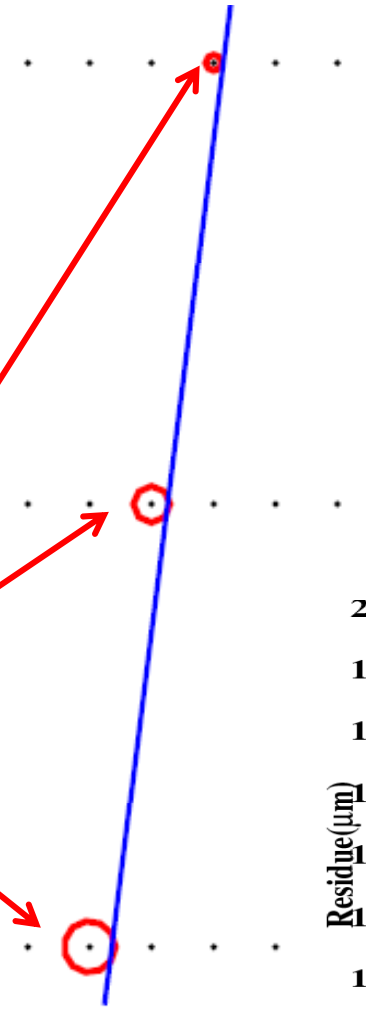


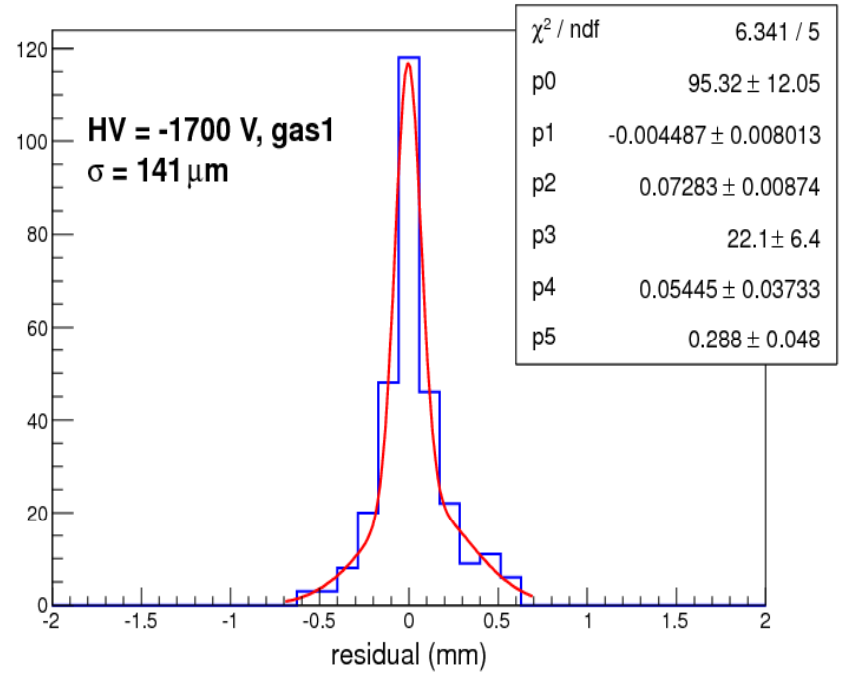


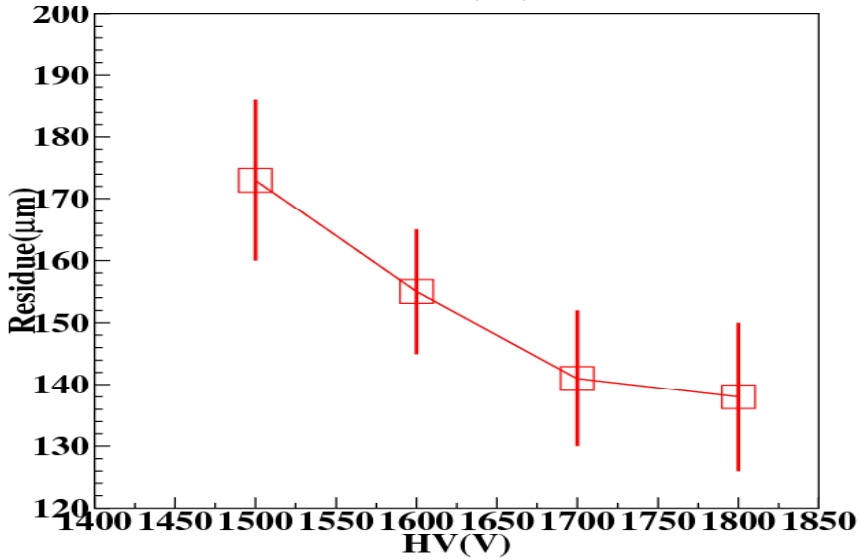
Best Residue: σ=240μm @ 1700⁺ V

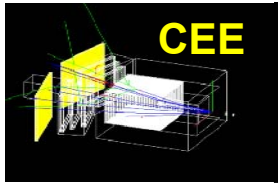
Tracking Test with MWDC array



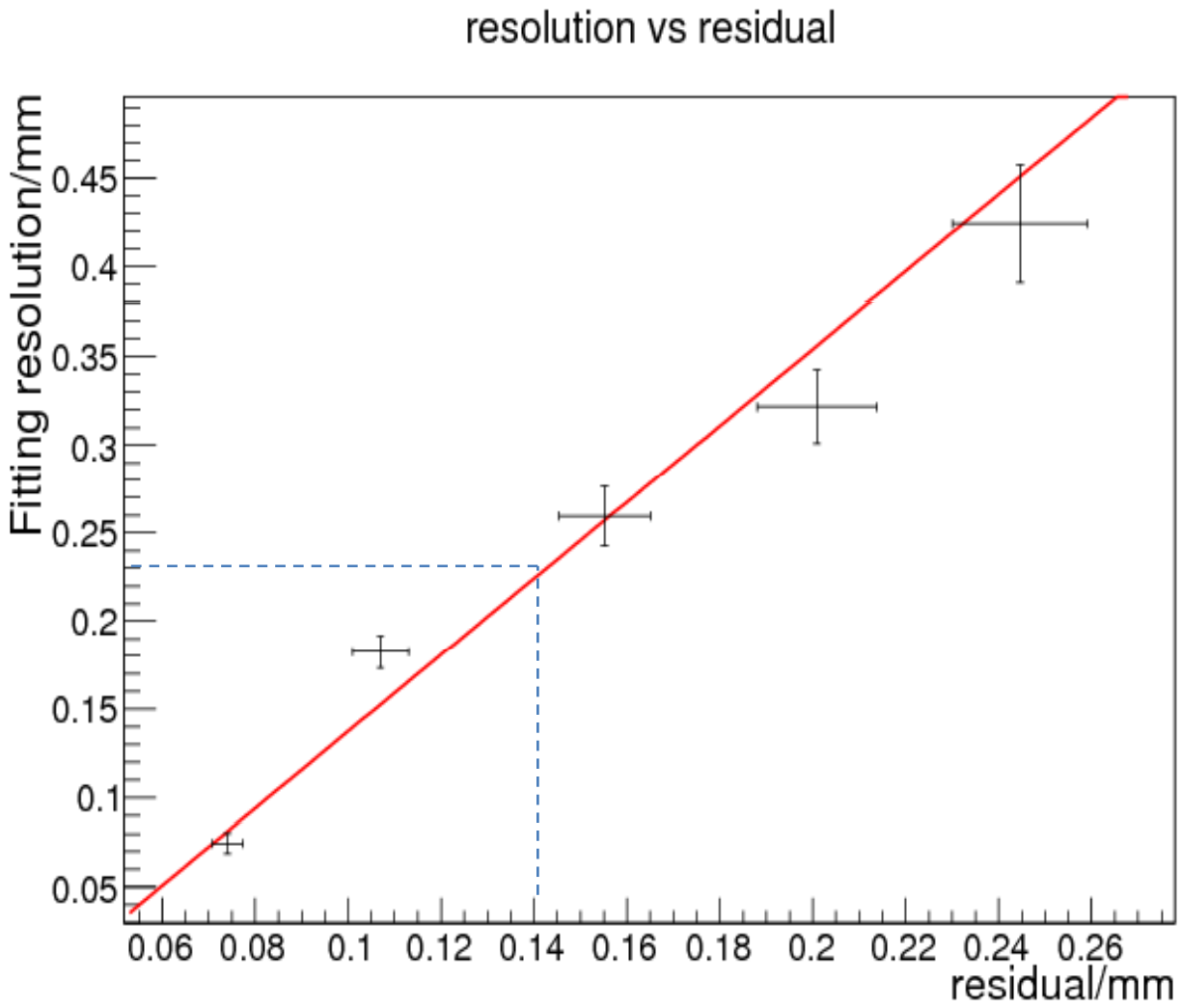


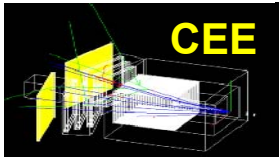




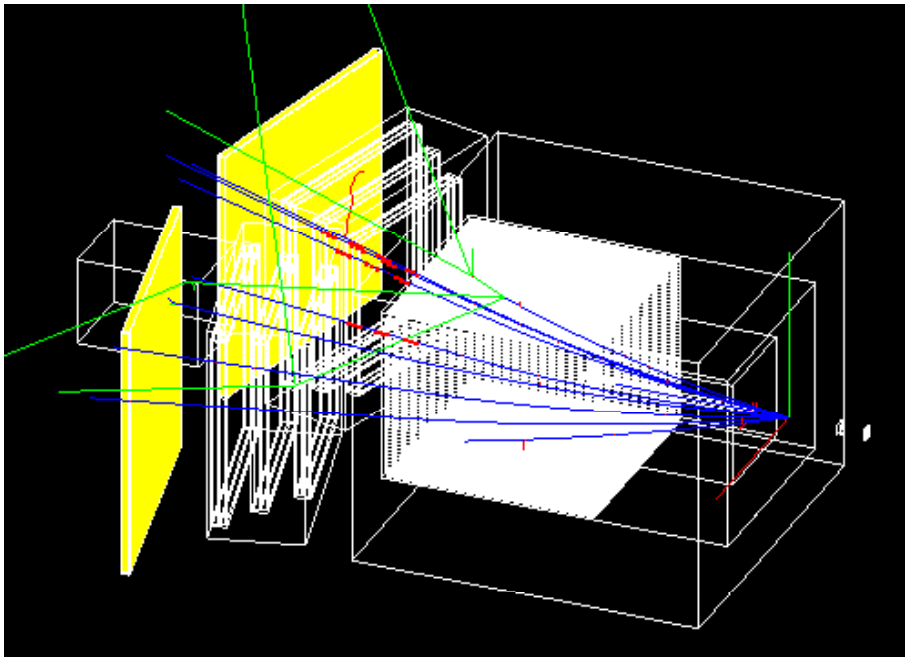


Drift Length Resolution

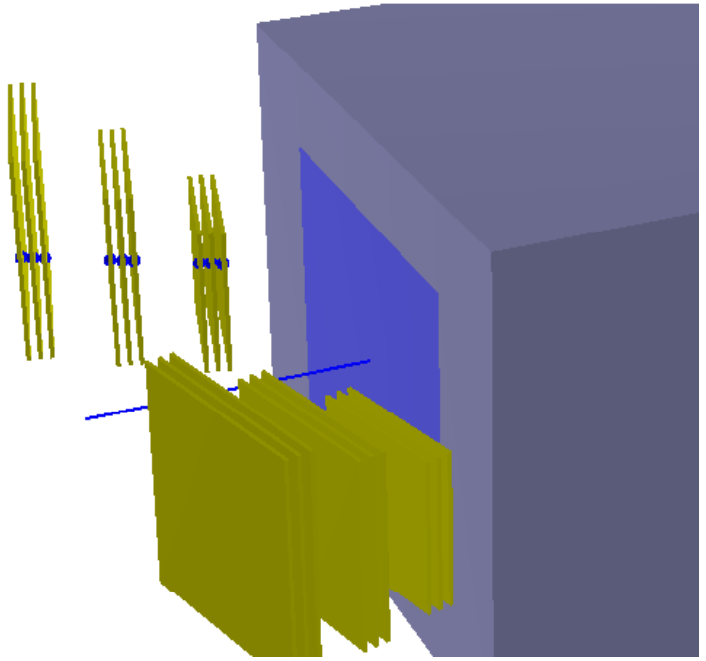




Simulations

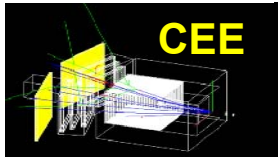


Detector Construction

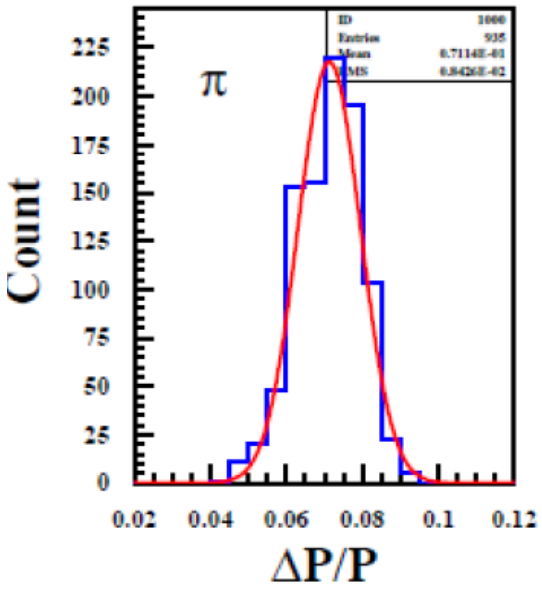


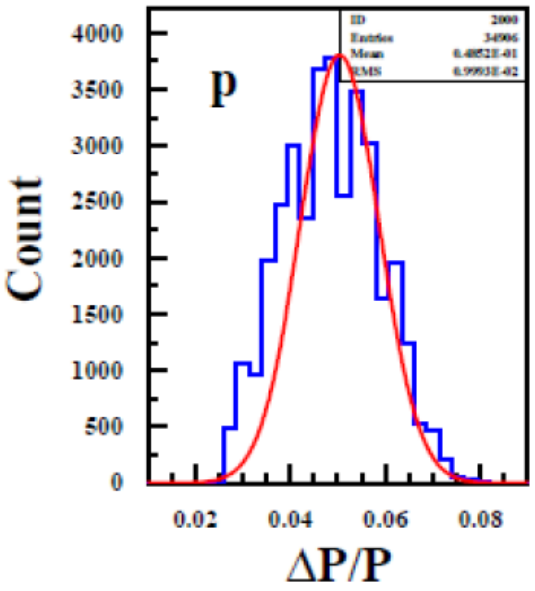
Digitization and Event Display

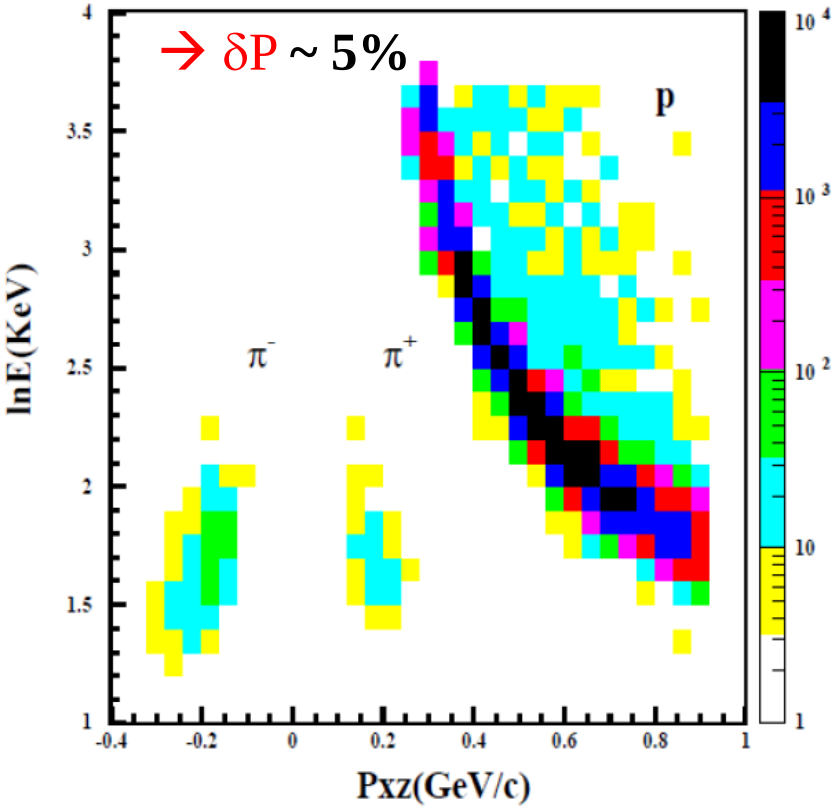
Geant 4 Simulation Framework Done

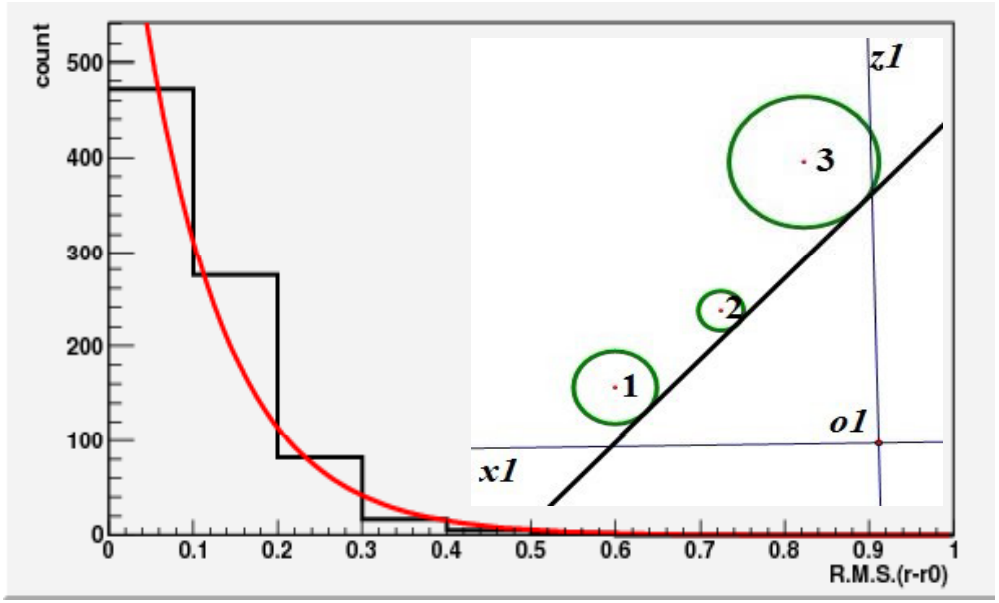


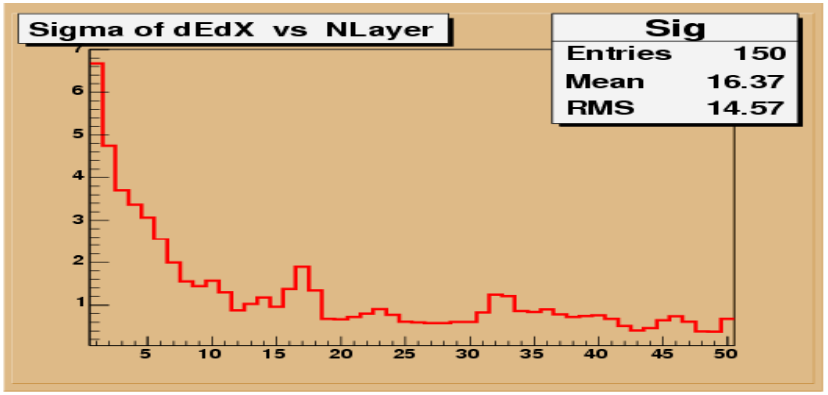
Track Reconstruction



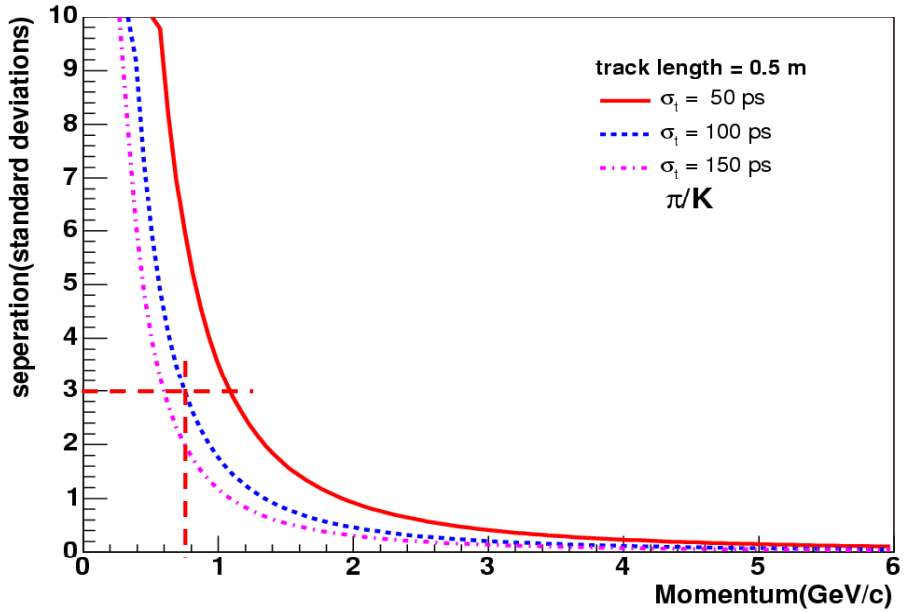


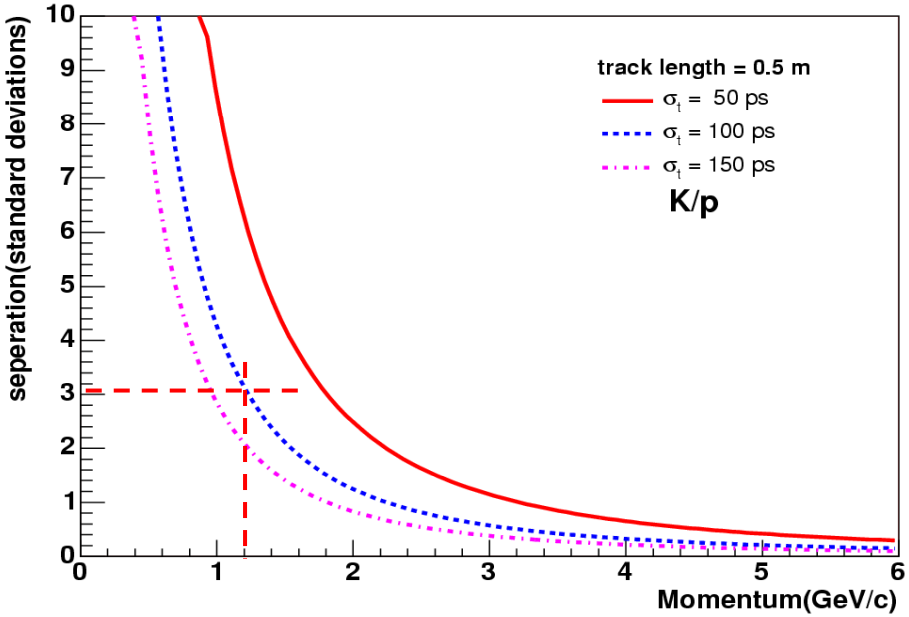






Simulation: ITOF – Short flight length

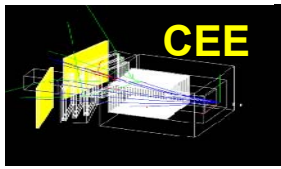




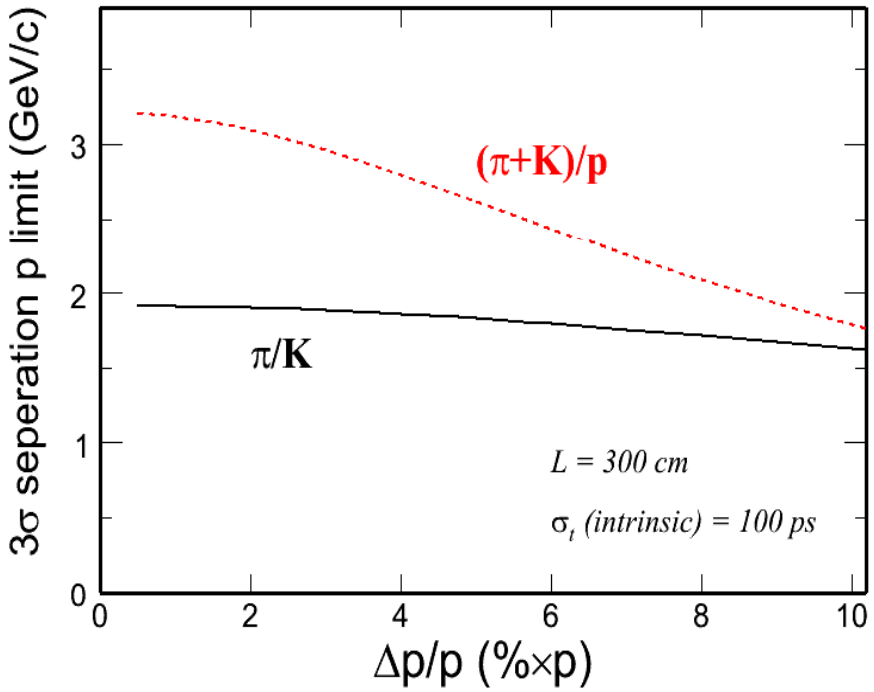
Typical flight length < 0.5m

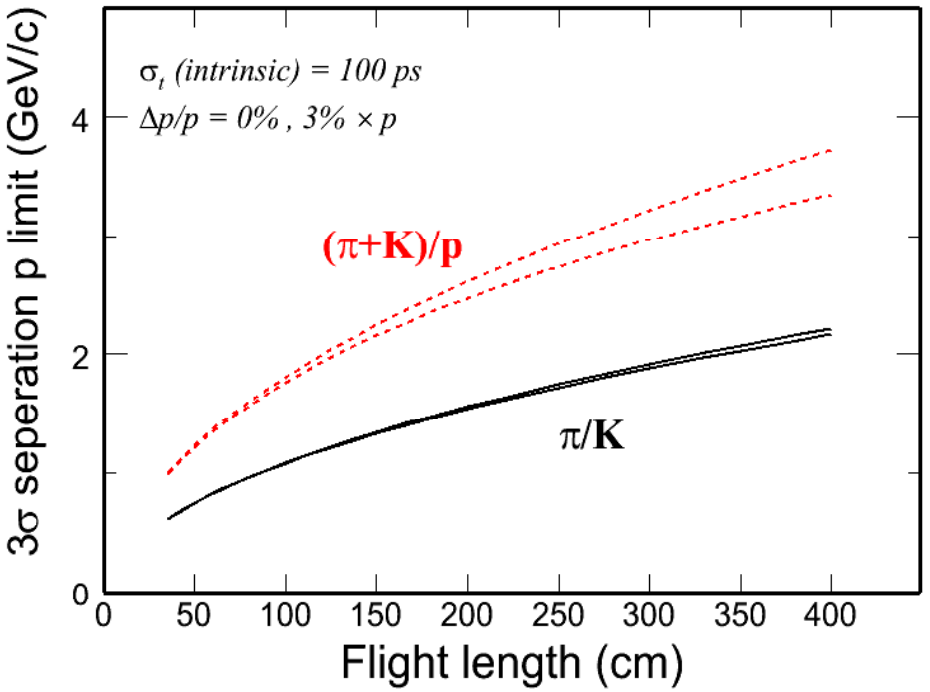
Due to short flight length, TOF PID can't extend the PID range of *dE/dx* much.

ITOF used as trigger detectors only



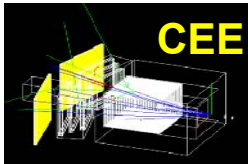
Momentum resolution / Flight Length effects





Y-axis: 3σ separation momentum limit

1. Forward momentum resolution: <5%
2. i-TOF for trigger only



To do next

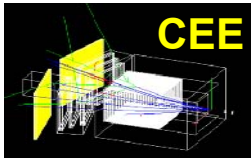
1) Detector Array Installation

2) Online System extension

3) Integration of the whole system

4) Tests ……

> 3 years' work !



Outlook

- The symmetry energy at supra-saturation density is of high scientific interest. Large pushing effort, both experimentally and theoretically, is witnessed in China.
- A large spectrometer, called CEE, is being proposed at HIRFL-CSR.
- A phase-I experiment is being built, with MWDC being the major tracking detector.

Thank you!