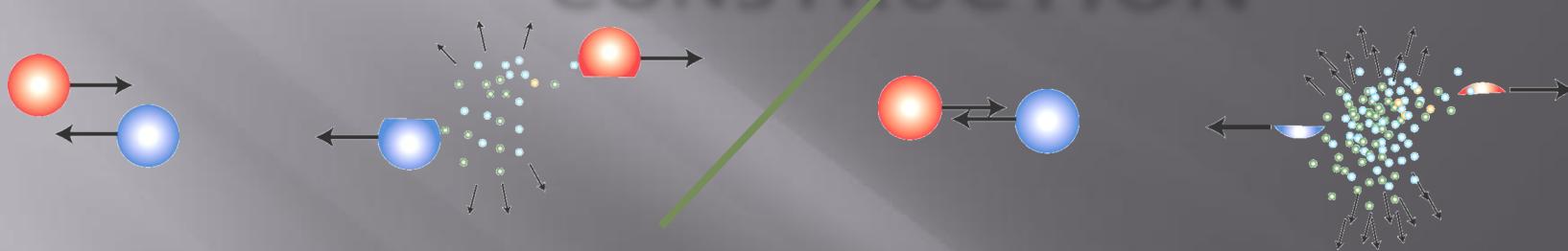


# PILOT EXPERIMENTS FOR SAMURAI-TPC PROJECT AND CURRENT STATUS OF TPC CONSTRUCTION

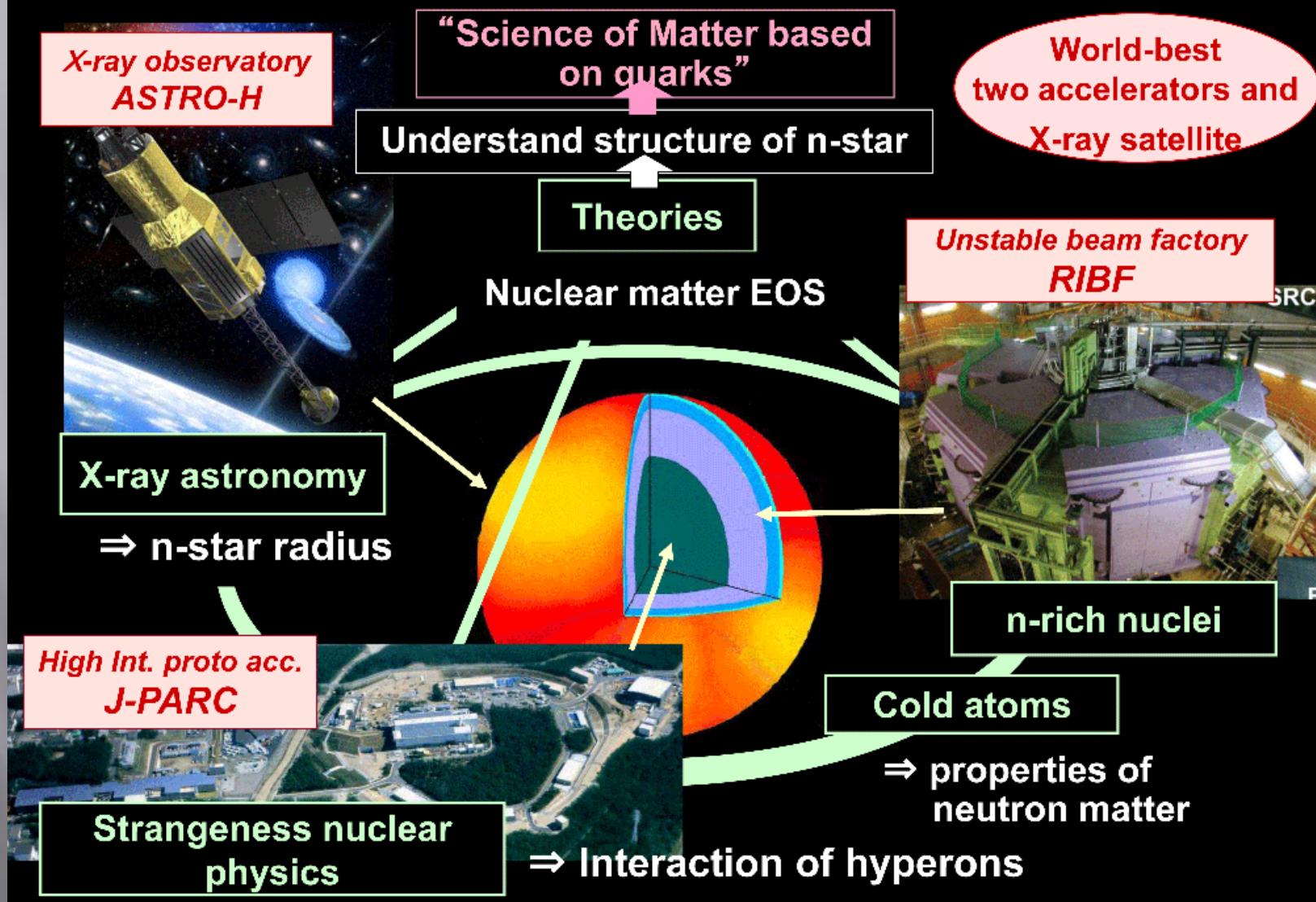


Co-sponsor of NuSYM13



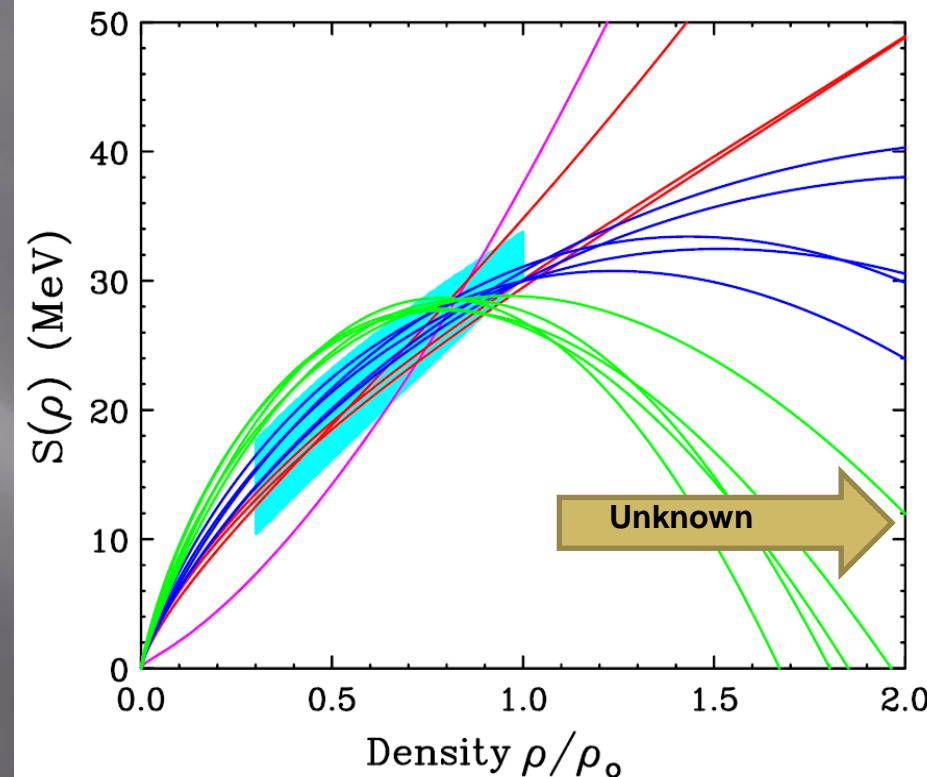
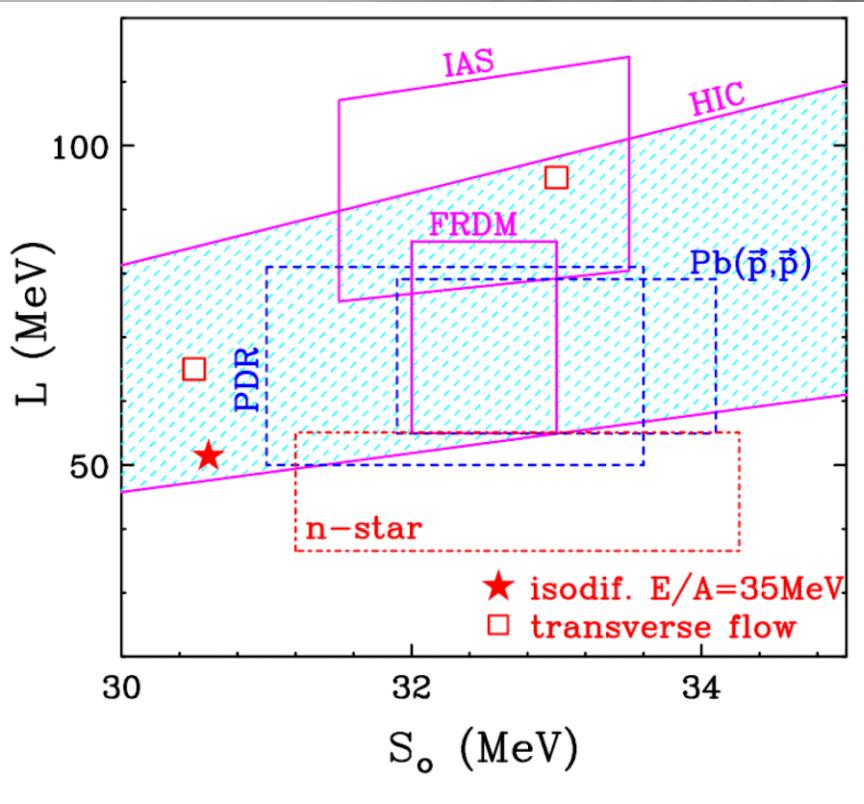
# Grant-in-aid for innovative area ; JFY2012-2016

## Joint project between experiments, observations, theories



# Outcome of NuSYM11

## 40 citations (INSPIRE)

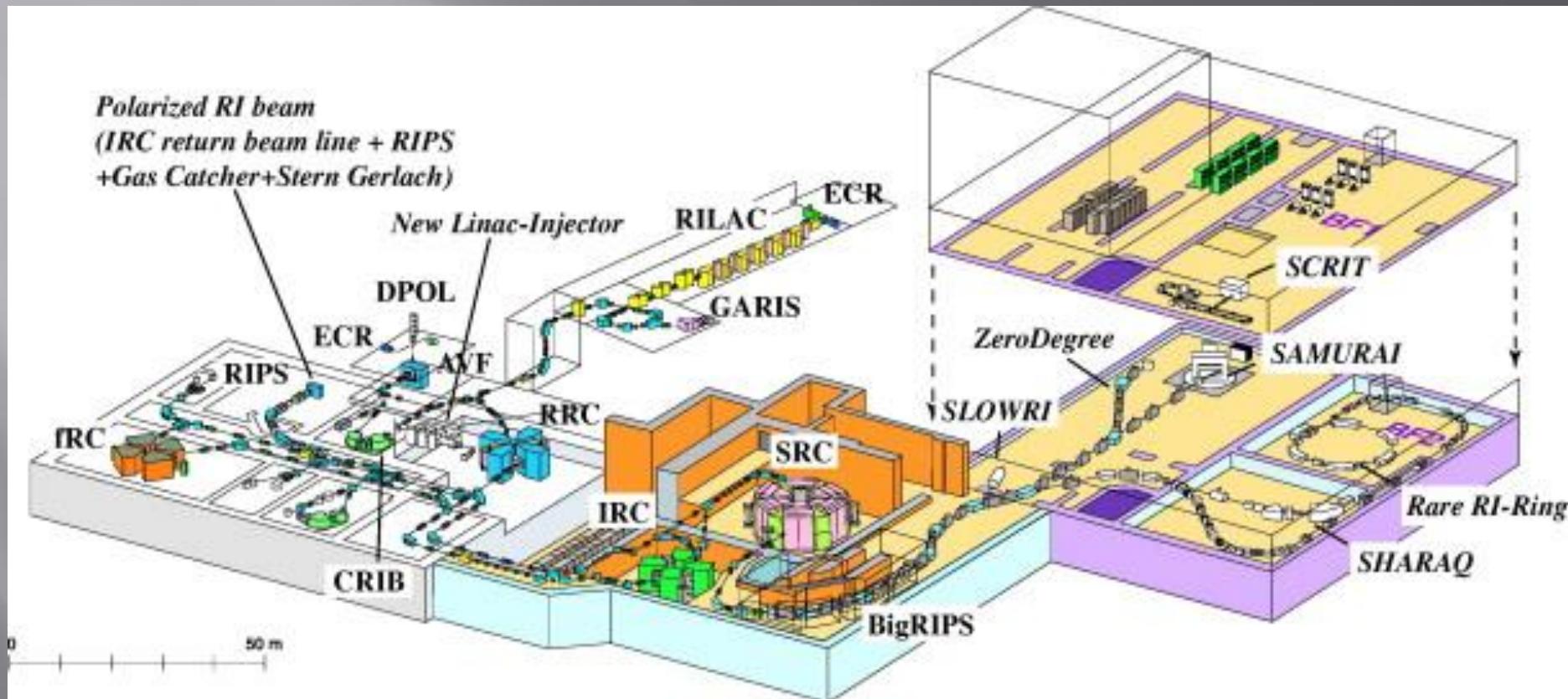


PHYSICAL REVIEW C 86, 015803 (2012)

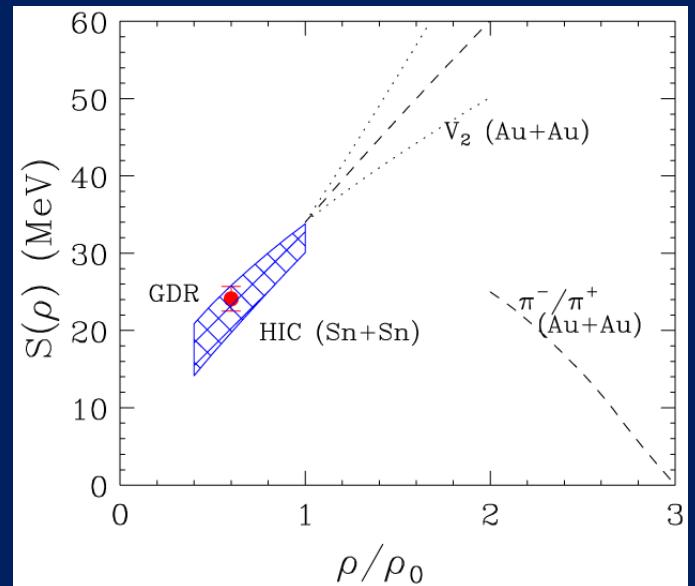
### Constraints on the symmetry energy and neutron skins from experiments and theory

M. B. Tsang,<sup>1</sup> J. R. Stone,<sup>2</sup> F. Camera,<sup>3</sup> P. Danielewicz,<sup>1</sup> S. Gandolfi,<sup>4</sup> K. Hebeler,<sup>5</sup> C. J. Horowitz,<sup>6</sup> Jenny Lee,<sup>7</sup> W. G. Lynch,<sup>1</sup> Z. Kohley,<sup>1</sup> R. Lemmon,<sup>8</sup> P. Möller,<sup>4</sup> T. Murakami,<sup>9</sup> S. Riordan,<sup>10</sup> X. Roca-Maza,<sup>3</sup> F. Sammarruca,<sup>11</sup> A. W. Steiner,<sup>12</sup> I. Vidaña,<sup>13</sup> and S. J. Yennello<sup>14</sup>

# RIBF; current our tool



- World Premiere Rare Isotope laboratory Energy range up to 350 MeV per nucleon
- Able to create nuclear matter up to twice the normal nuclear matter density

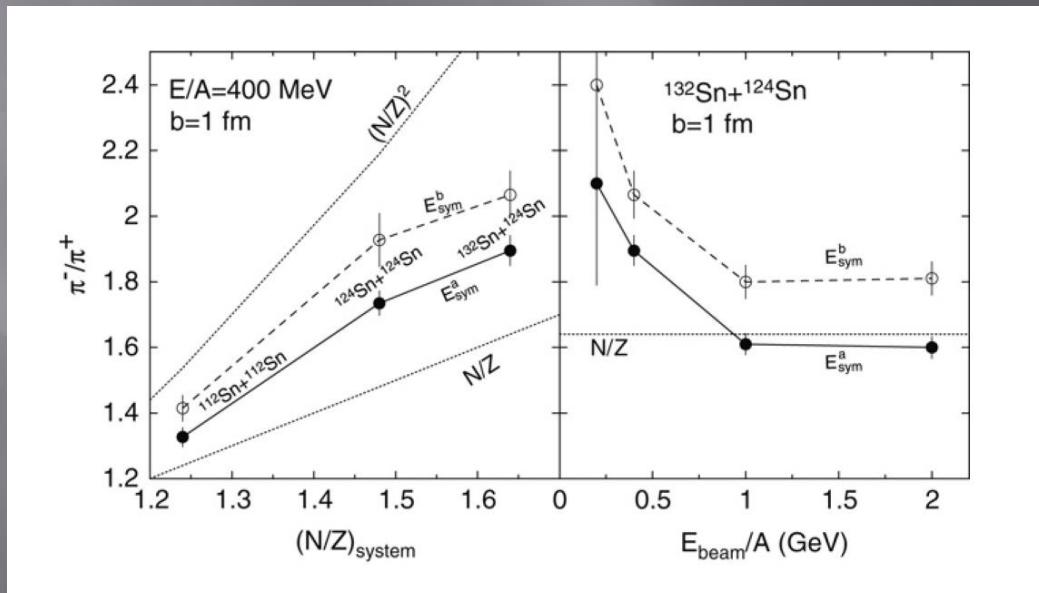


- Optimal to study of the high density dependence of symmetry energy.
- Require TPC inside a magnetic field.

# Possible Probe

Prediction of Bao-An NPA 708 (2002) 365

- $\pi^+ - \pi^-$  ratio
- Proton-neutron ratio
- Light ion ratio ( $t - {}^3He$ )
- Particle flow of pions, protons, neutrons and light ions



# Agreement between US and Japan in 2008

- The U.S. collaborators will be responsible for the design and construction of the TPC and for initial testing of the TPC at MSU.
- RIKEN and the Japanese collaborators will be responsible for
  - Procurement of the SAMURAI dipole
  - Development of the TPC laser calibration system,
  - TPC gas handling system
  - TPC mounting and transportation hardware,
  - Target, the beam tracking
  - TPC electronics and data acquisition
  - Ancillary trigger scintillation array

# Superconducting Analuzer for Multi particles from Radio Isotope Beams (with 7 Tm)



Commissioning experiments in Mar, 2012  
Total budget: 1500 M JPY (including several detectors)

# Name Transition

SAMURAI-TPC



SPiRiT

# SAMURAI TPC: Exploded View

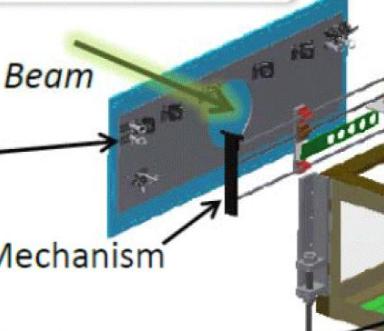
Testing of Front End Electronics



Field Cage

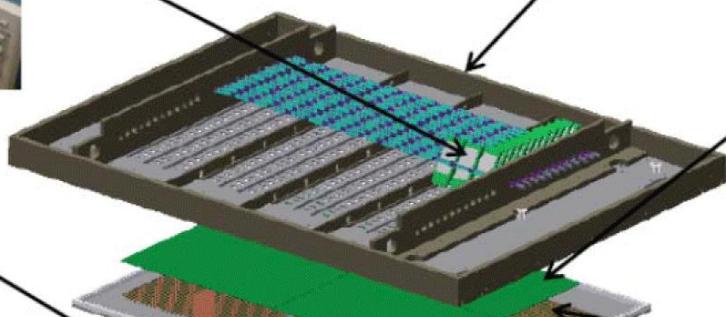


Calibration  
Laser Optics



Target Mechanism

Thin-Walled Enclosure



Rigid Top Plate



Pad Plane



Wire Planes



Voltage Step-Down



Rails

For inserting TPC into  
SAMURAI vacuum chamber



## GION Festival in Kyoto Main event on July 17

# GION Festival in Kyoto Main event on July 17



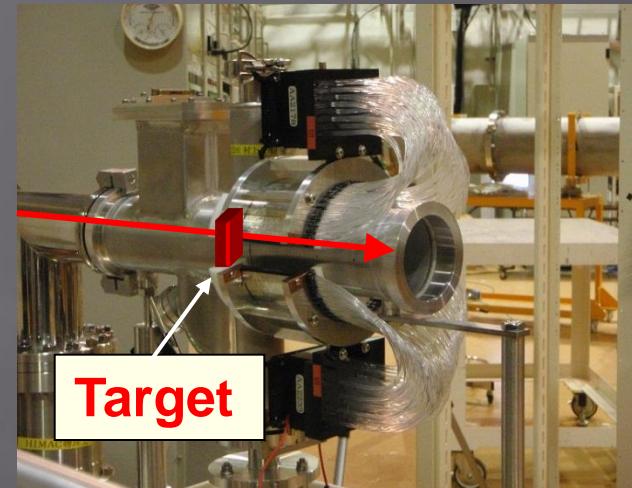
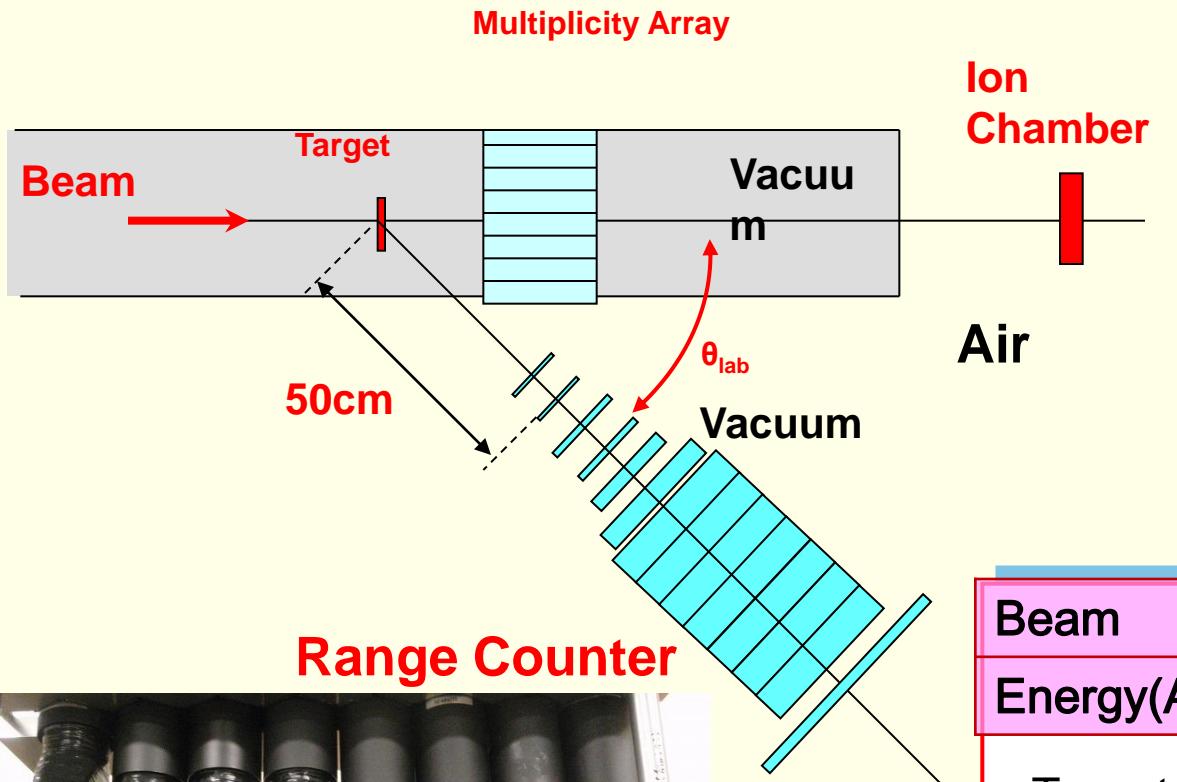
NuSYM13, NSCL/MSU July 22-  
26, 2013

# Pilot Experiments using HIMAC

- Investigate general trend of pion production in nucleus-nucleus collisions around RIBF energies.
- Test response of large TPC to heavy ( $Z>50$ ) nuclear beams.
- Test electronics for Gating Grid
- Test Sampling rate

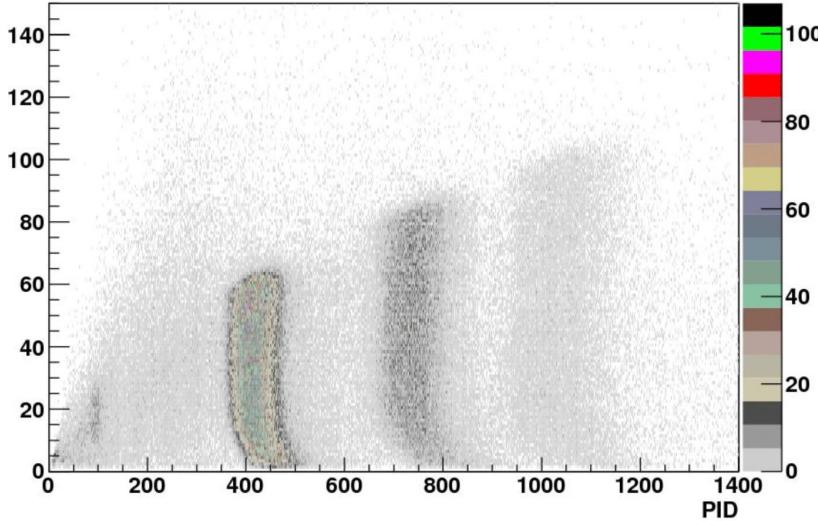
# Experimental Setup

## Multiplicity Array

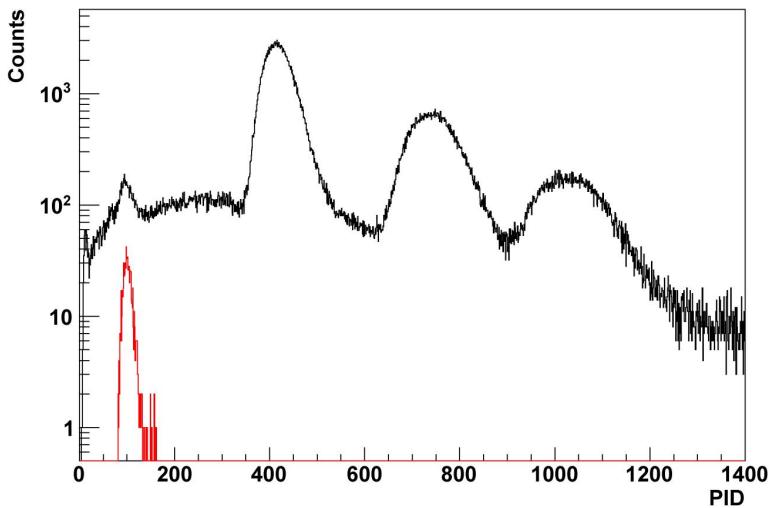


Beam	$^{28}\text{Si}$	$^{132}\text{Xe}$
Energy(AMeV)	400, 600, 800	400

- Target : In  $\sim 390 \text{ mg/cm}^2$
- Typical Intensity :  $\sim 10^7 \text{ ppp}$
- Range Counter : 14 layers (+2) of Sci.
- measured angle ( $\theta_{lab}$ )  
: 30, 45, 60, 75, 90, 120 degree
- solid angle : 10 msr



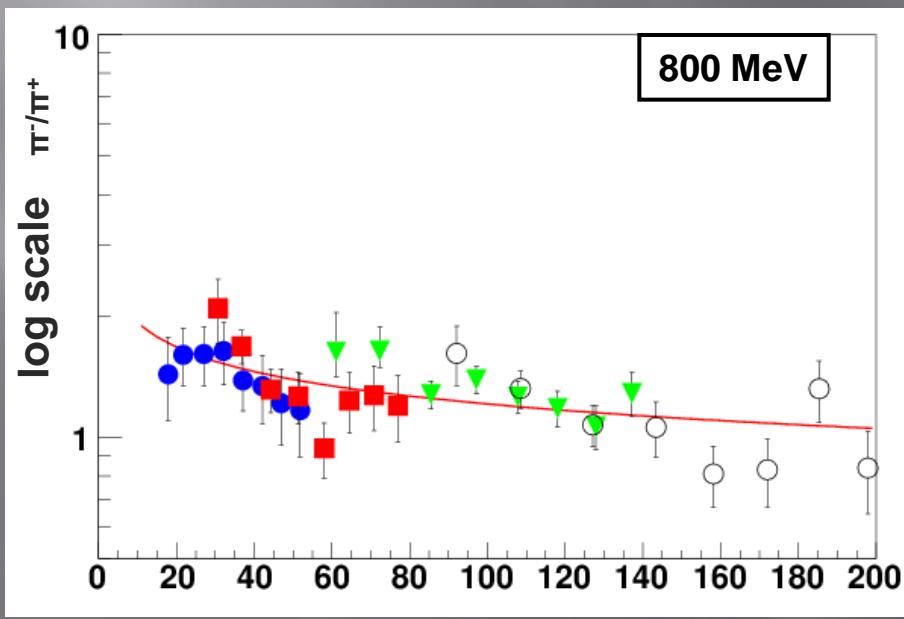
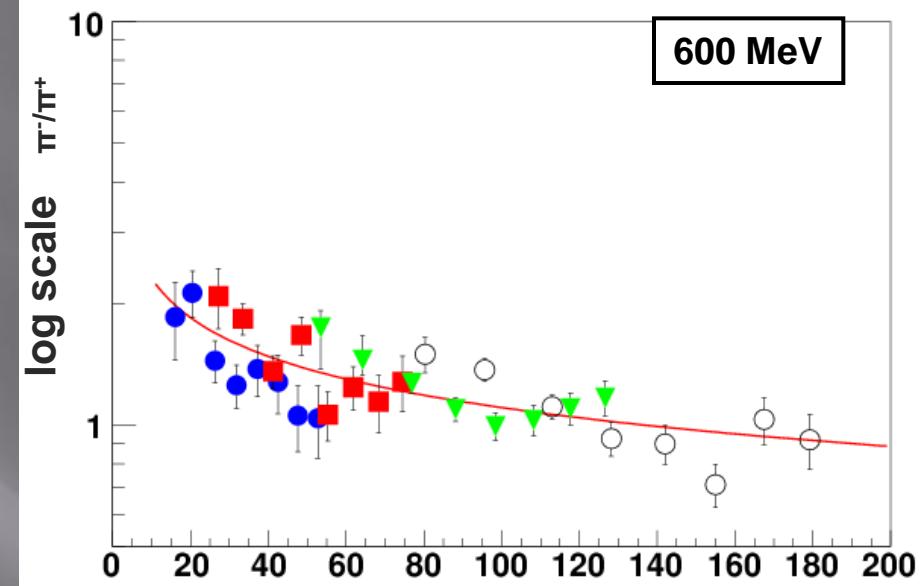
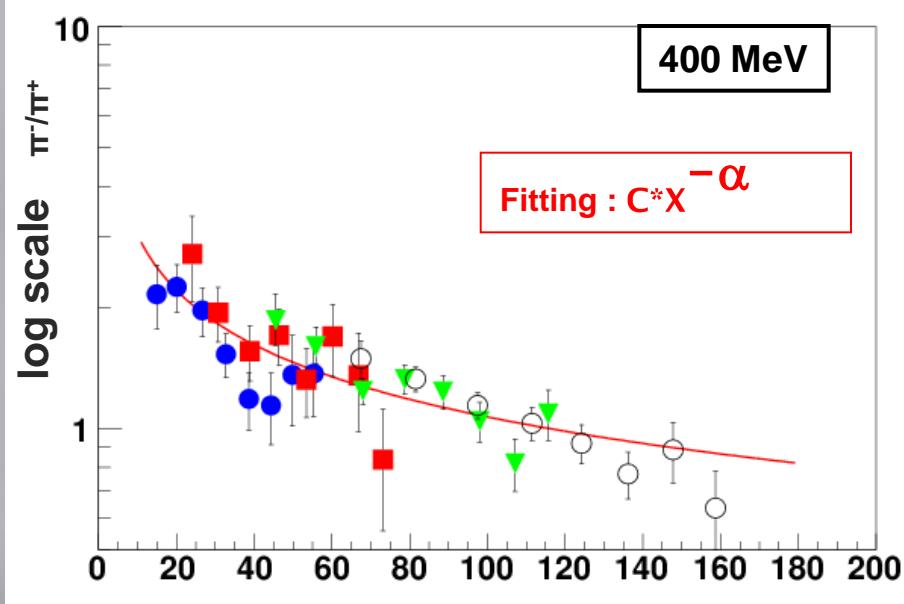
(a) PID vs Energy



□  $\sim 400\text{MeV/u}$   
Pion's are rare

less than 1/100 of  
protons

# Beam Energy Dependence : Si



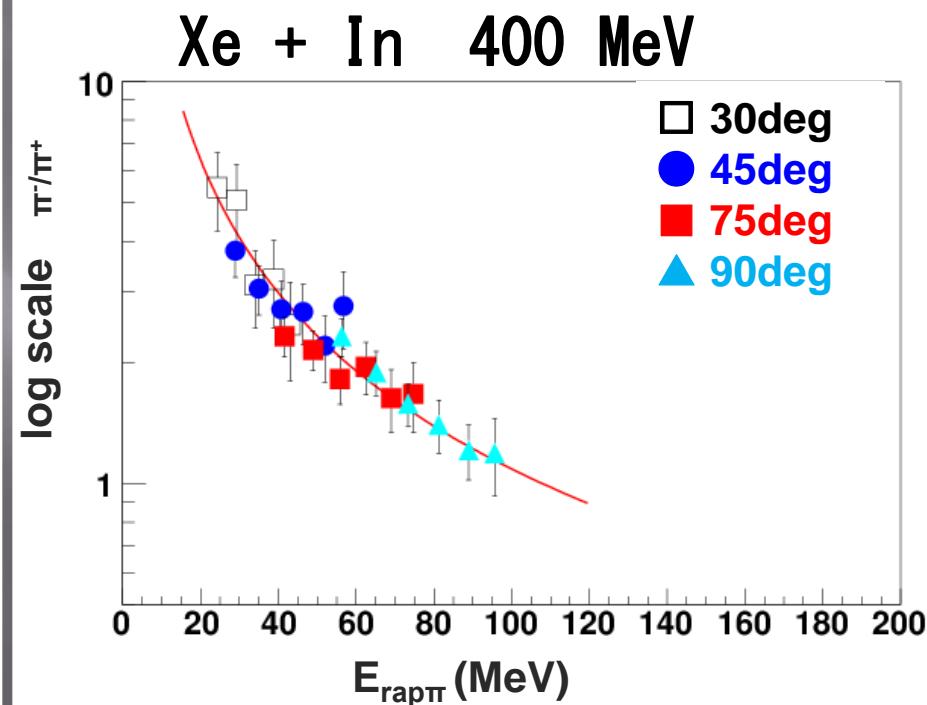
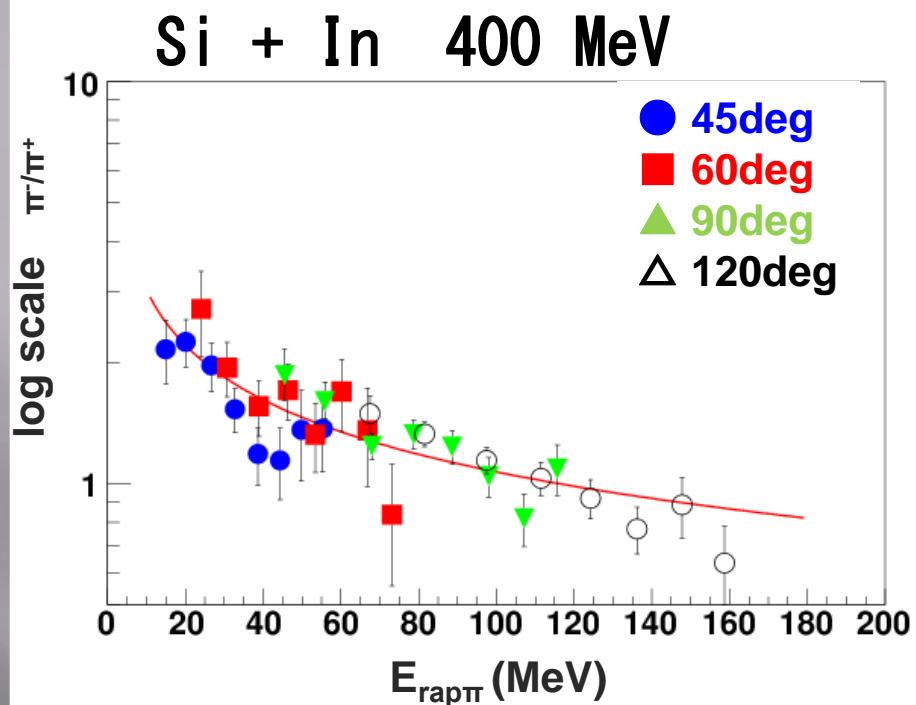
slope  $\alpha$ :

- 400 :  $(4.5 \pm 0.5) \times 10^{-1}$
- 600 :  $(3.2 \pm 0.5) \times 10^{-1}$
- 800 :  $(2.0 \pm 0.5) \times 10^{-1}$

Slopes depend on Beam Energy

● 45deg  
■ 60deg  
▽ 90deg  
○ 120deg

# N/Z dependence : Si and Xe beam



Fitting :  $C^*X^{-\alpha}$

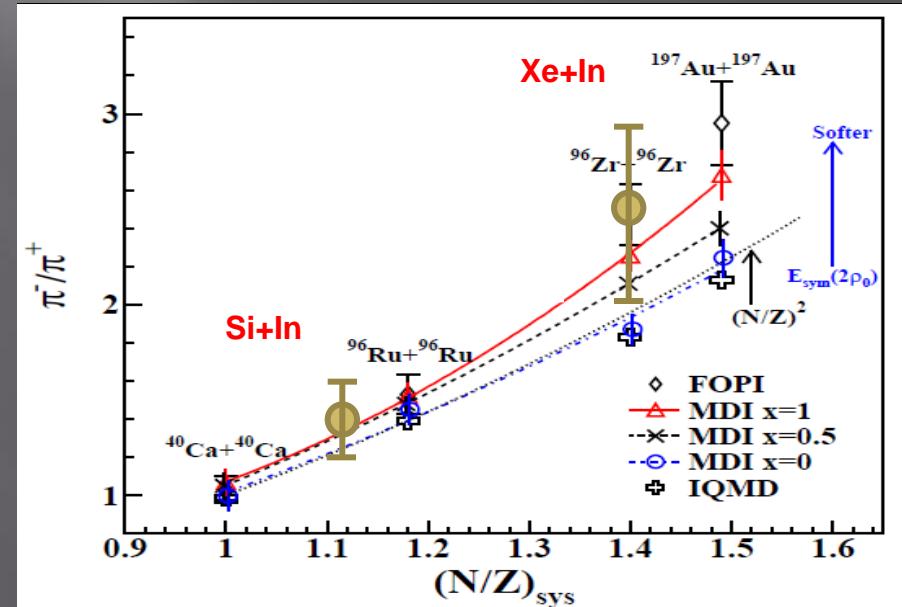
- slope  $\alpha$  Si + In :  $(4.5 \pm 0.5) \times 10^{-1}$   
Xe+In :  $(11.0 \pm 0.8) \times 10^{-1}$

# The integrated-yield ratio

Sum the data point  
like this formula

$$\sigma_{\pm i} = 2\pi \sum_i \sin \theta_i \Delta E_i \frac{d\sigma_{\pm i}}{dEd\Omega}$$

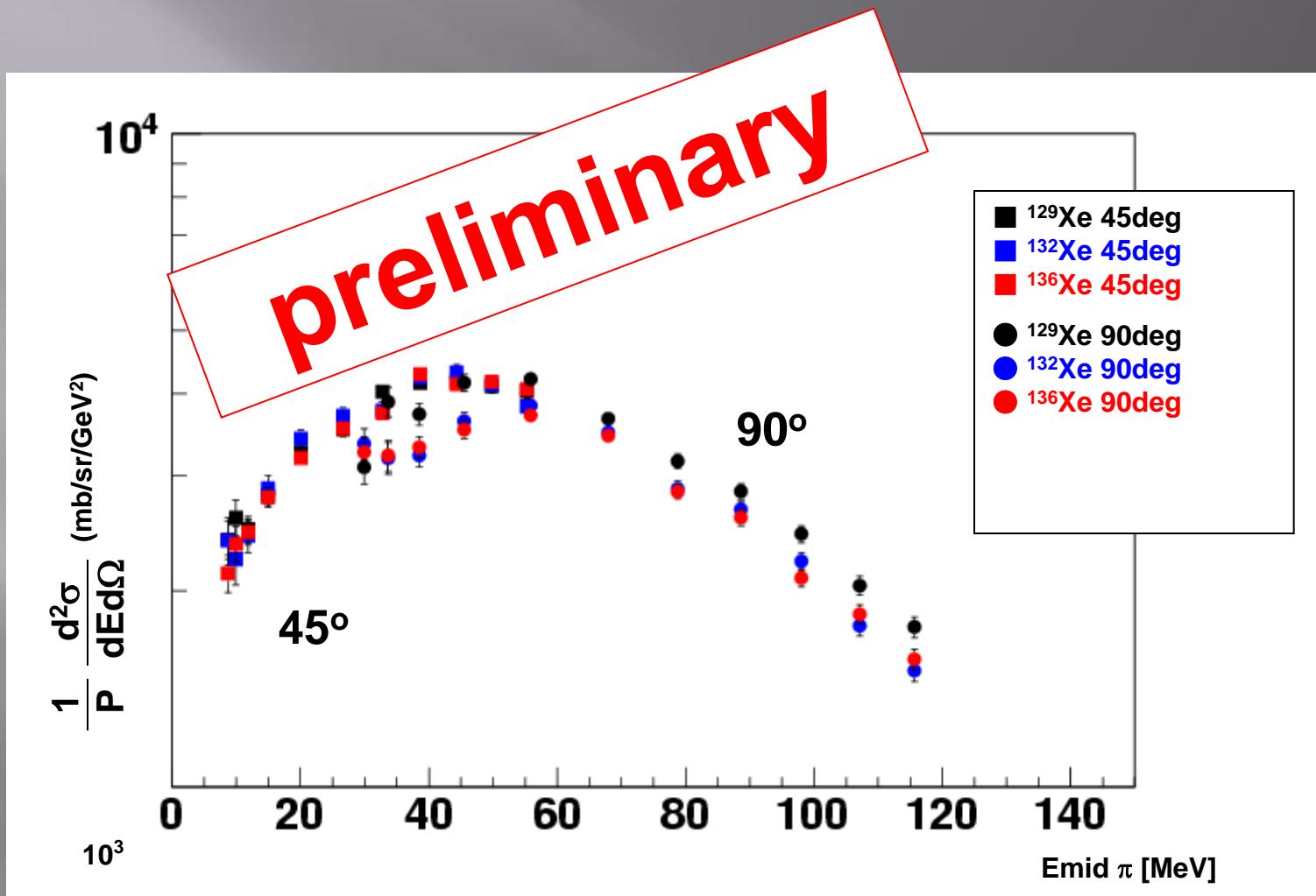
$$\frac{\pi_-}{\pi_+} = \frac{\sigma_-}{\sigma_+}$$



# New Sets of Data to scan N/Z dependence

- $^{129, 132, 136}\text{Xe} + \text{CsI}$  400 MeV/u
  - Minimize Coulomb effect
  - Mainly at 45° and 90° for high statistics
- Beam Time 2011/9/14-28 @ HIMAC
  - typical beam rate :  $1*10^7$  ppp
  - CsI ( $\sim^{130}\text{Xe}$ ) target  $350\text{ mg/cm}^2$
  - Event rate : 200~1200 event/s
  - Trigger rate : 200~600 events/s

# $\pi^+$ from Xe+CsI Reactions

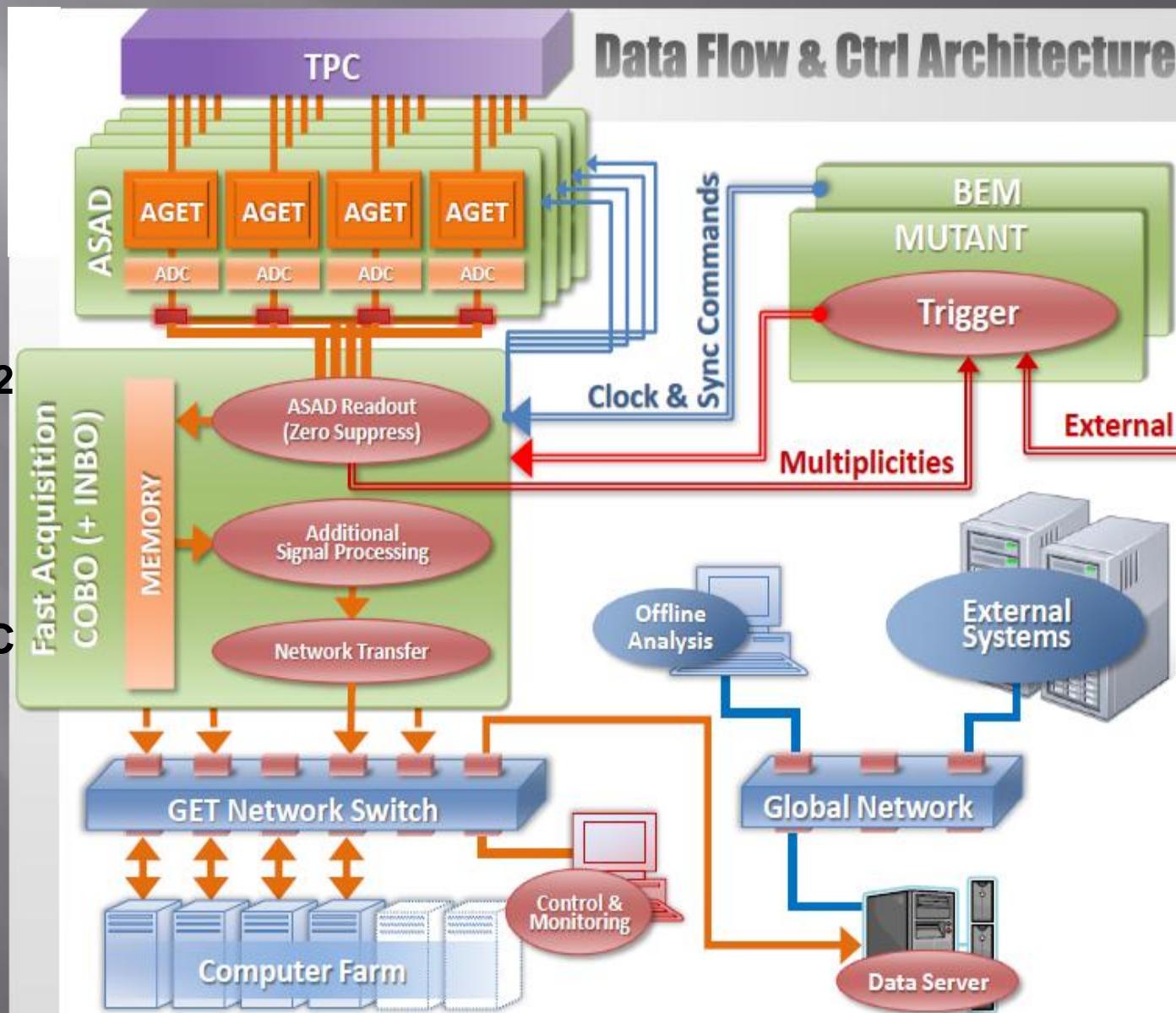


# TPC electronics (read-out; GET)

**Basic feature:**  
State of Arts  
technology  
**Capable to handle**  
1KHz – 10Gb/s  
**Wide dynamic range**  
10.5 bits  
**Capacitive Array 1-512**  
**Sampling 1-100MHz**



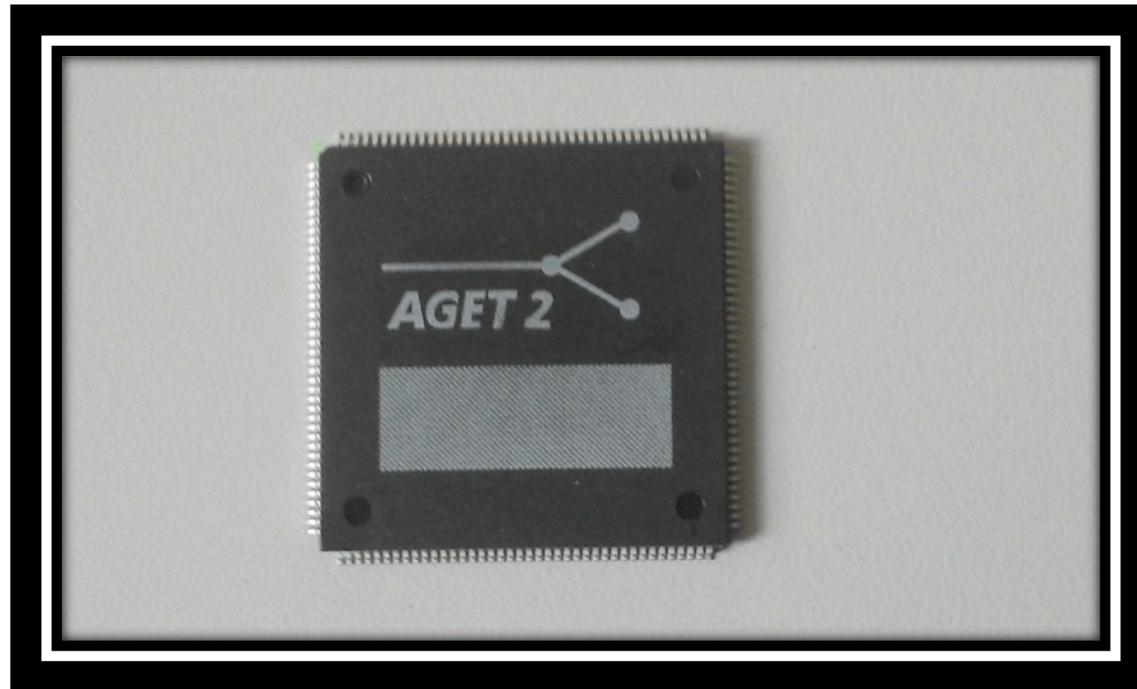
**Ideal for SAMURAI-TPC  
Read-out**



# July 5: 700 AGET ASICS received at IRFU

- First Test performs on one ASIC with:
  - Oscilloscope
  - Actual production test bench

*These results are obtained with the ASIC on the socket which is not optimal for the characterization of the circuit..*



# TPC electronics test @HIMAC

T2K electronics: The same A/D convertor as AsAd.

## What have we tested in HIMAC?

1. TPC & electronics responses to the heavy-ion beam:
  - Xe132 ( $Z=54$ ), 400MeV/u, 10k/spill, (1 spill=0.3sec in 3.3 sec)
2. Gating grid
3. Sampling rate dependency on the drift-axis resolution?

Prototype TPC: Similar structure as SAMURAI-TPC

Gas: P10

Wires:

G+G-: gating grid wires

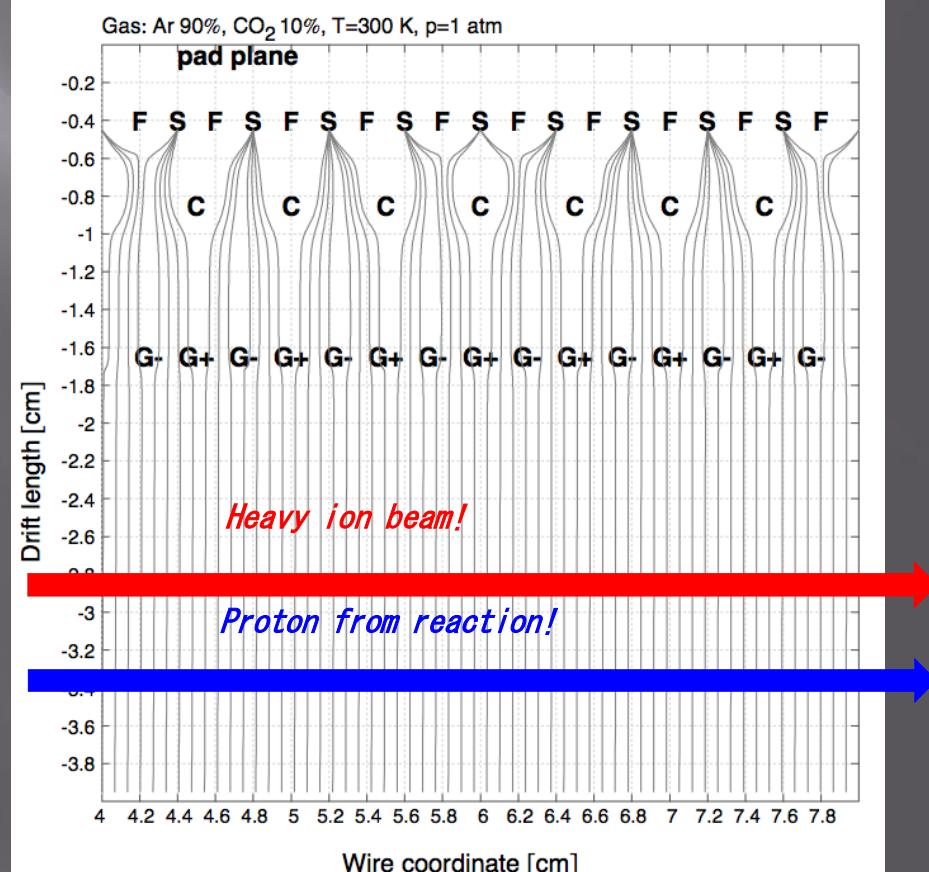
-180V, -180V to open, -260V, -100V to close

F: field wire

S: sense wire

~550V for Z=54, ~1100V for Z=1

C: shield wire



# Z=54 beam through TPC

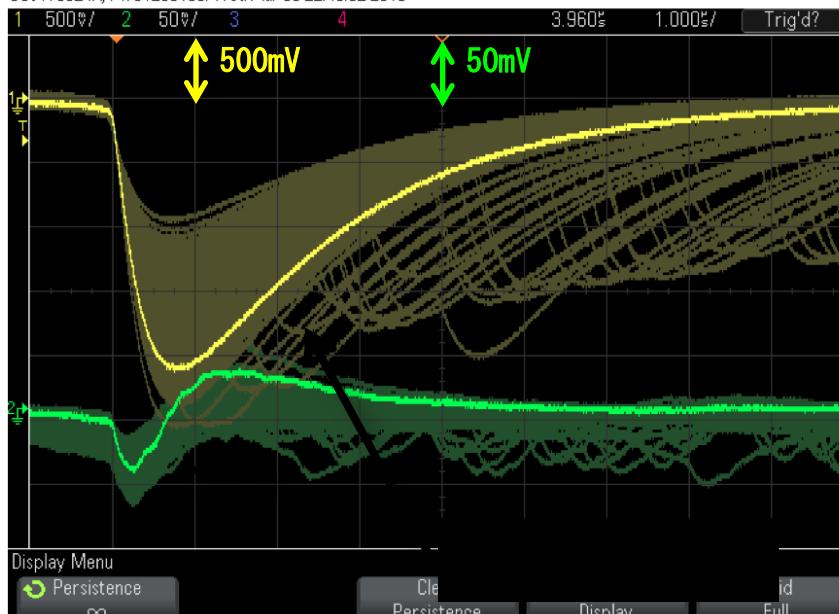
## *Test of Gating grid:*

- 1. prevent gain shift
- 2. protect wire from space charge

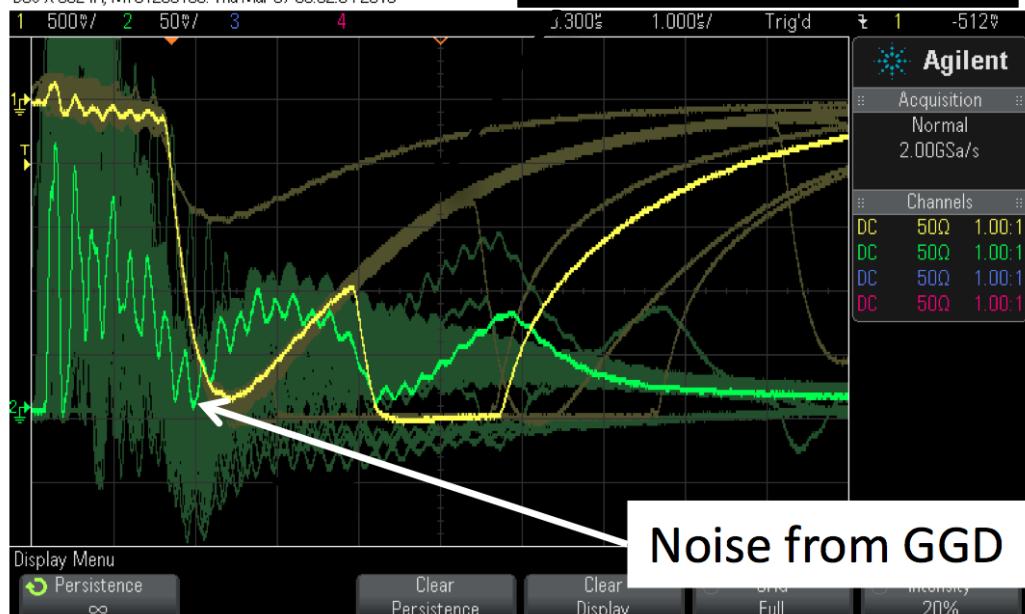


Gain->850V

DSO-X 3024A, MY51250186: Wed Mar 06 22:48:32 2013



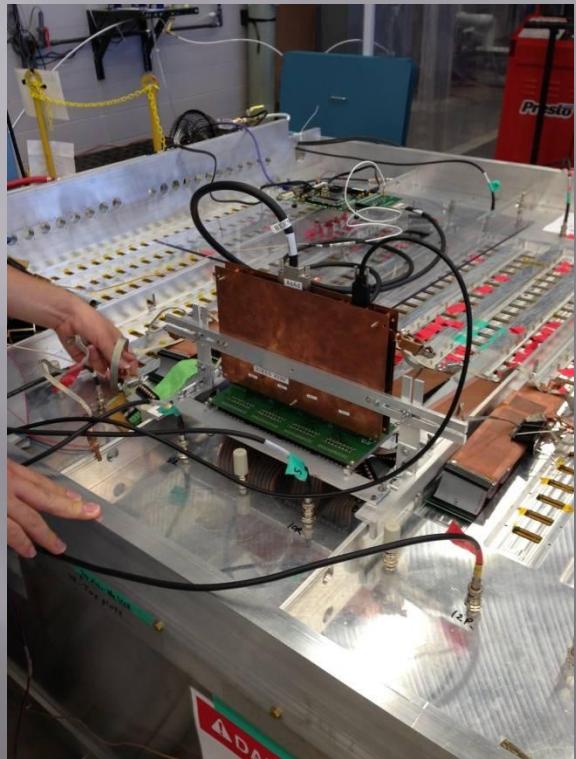
DSO-X 3024A, MY51250186: Thu Mar 07 00:02:34 2013



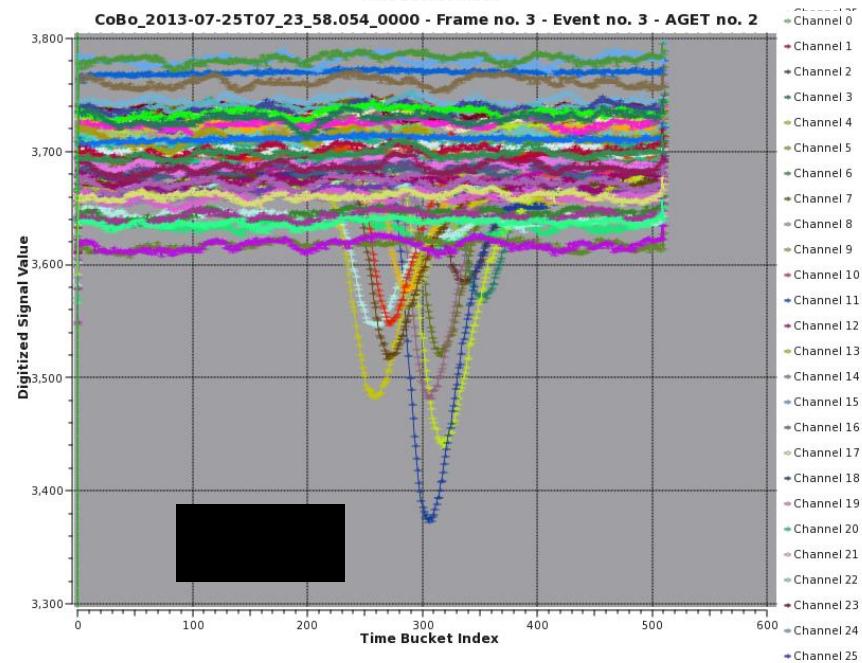
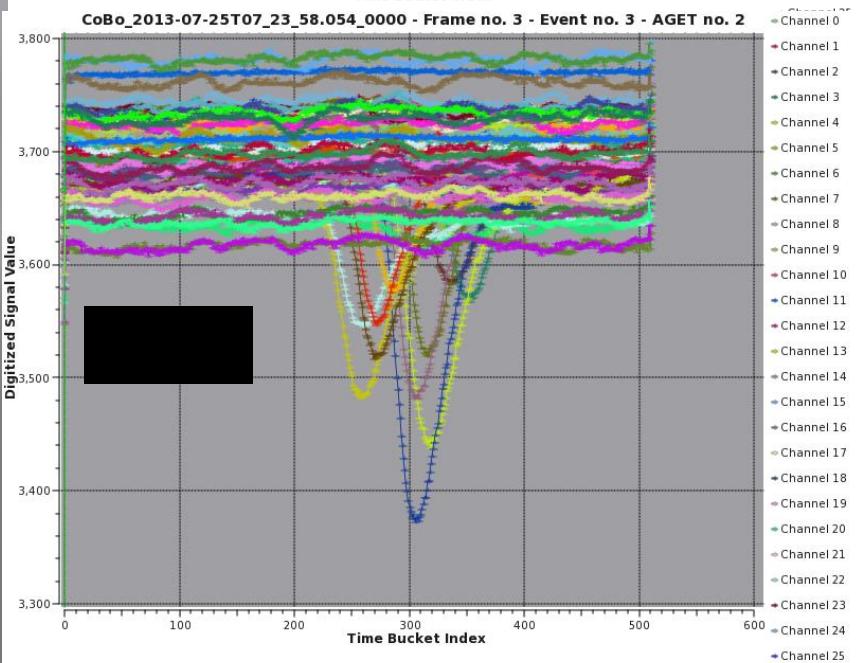
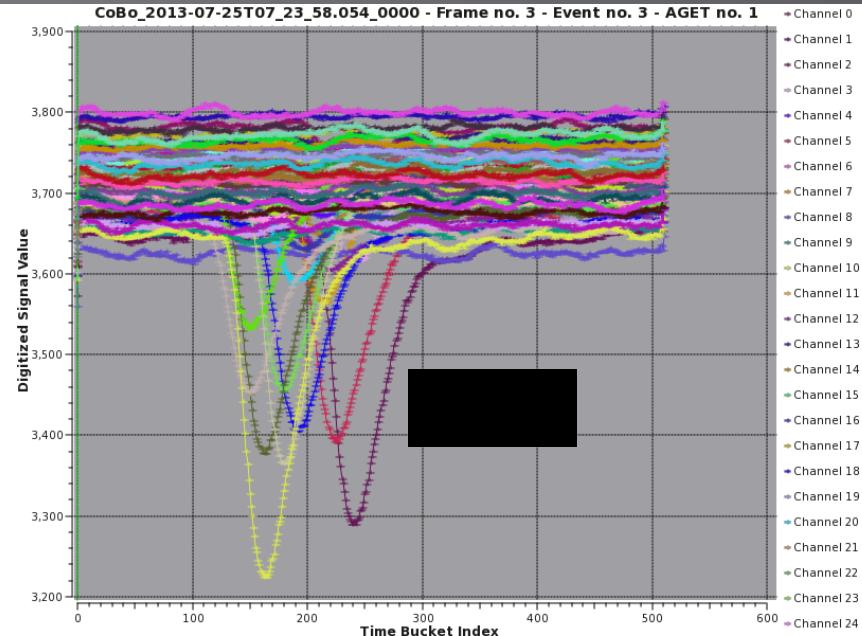
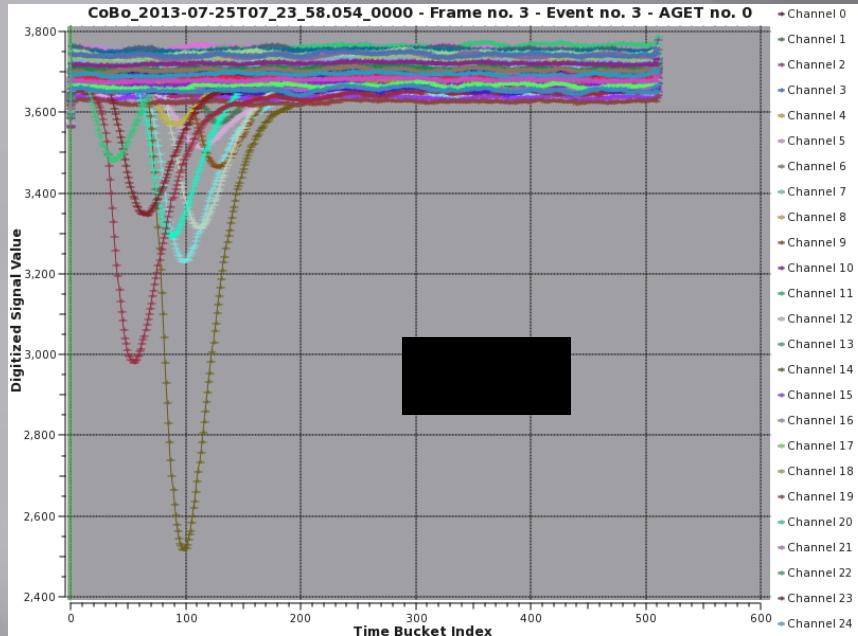
Gating Grid: OFF

Gating Grid: ON

# GET on SPiRiT

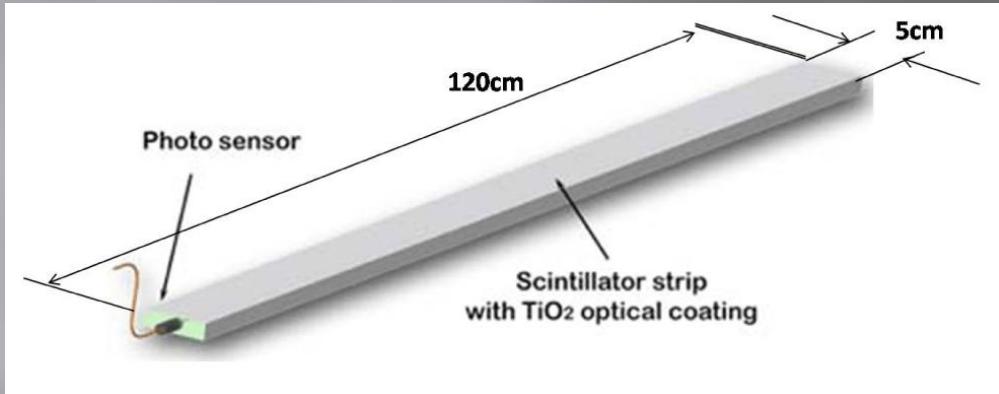


# Cosmic Event 3 (July 24<sup>th</sup>, 2013 @NSCL)

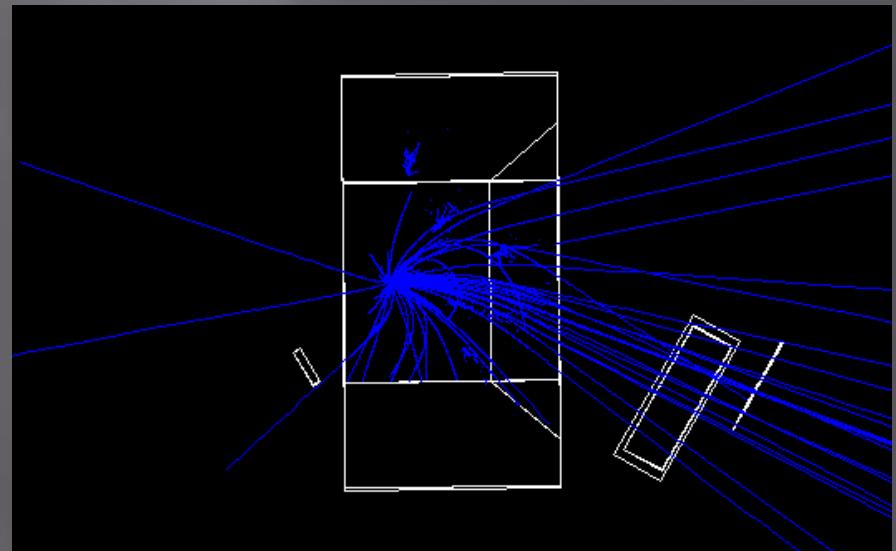


# Trigger Scintillation Array

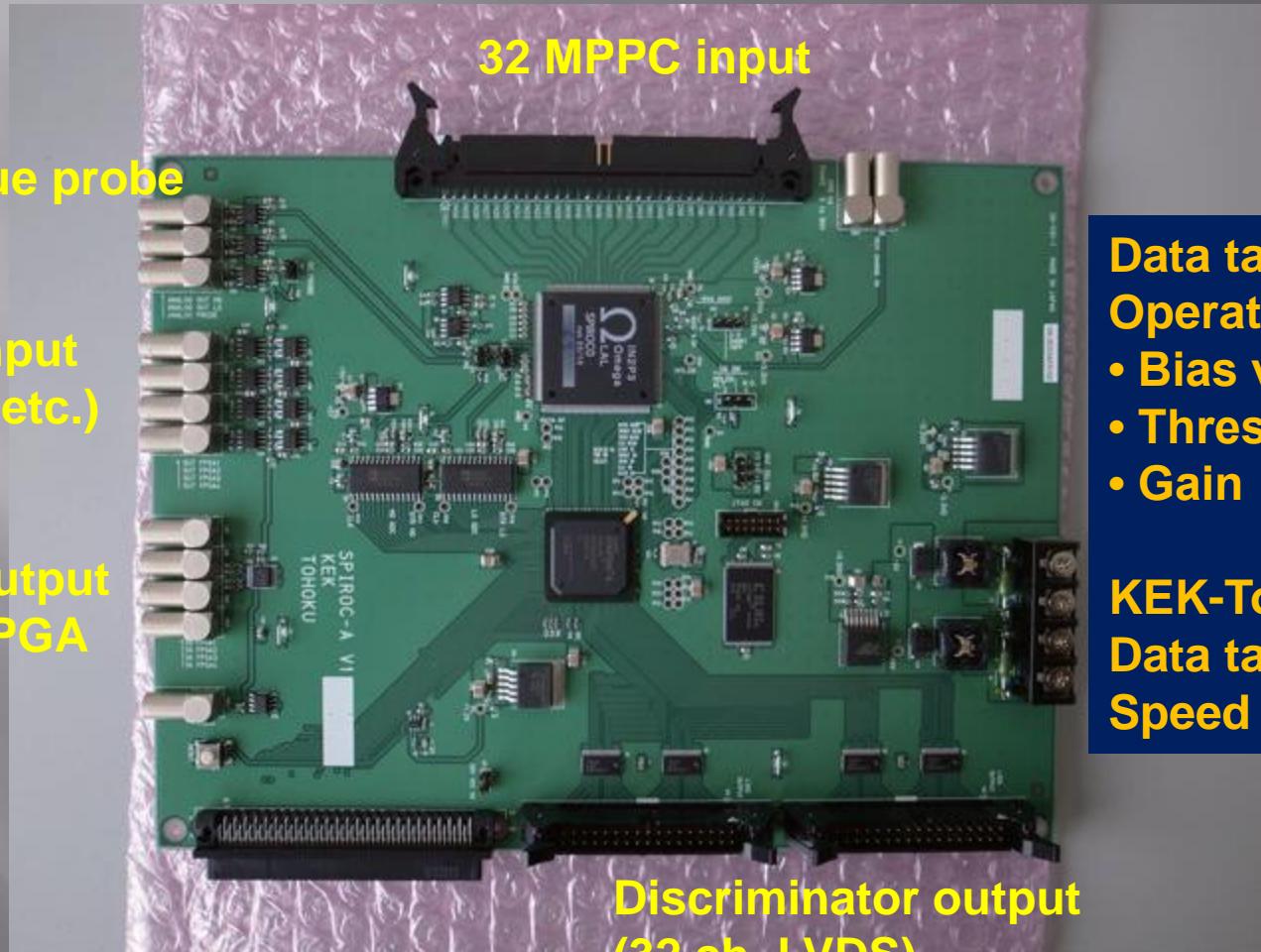
- Obtained 40 pieces of **Extruded Scintillators** developed for T2K experiment.



- Plan to use wave-length shifter and MPPC read-out
- Started simulation of event topology and R&D



# Readout for Trigger; SPIROC board (Developed by KEK-Tohoku Univ.)



**Data taking system  
Operation parameter**

- Bias voltage adjustment
- Threshold
- Gain

**KEK-Tohoku test board  
Data taking via network  
Speed 14kHz for 32 ch data**

# Summary

- We are preparing for SPiRiT used for symmetry energy experiments at RIBF.
  - We should be ready by the end of summer in 2014.
- 
- We expect another exciting and busy year .
  - Please Stay Tune with us.

# Collaborators

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M.B. Tsang,<sup>2</sup>  
S.J. Yennello,<sup>3</sup> and  
J. Yurkon<sup>2</sup>

# Also (experiment@HIMAC)

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