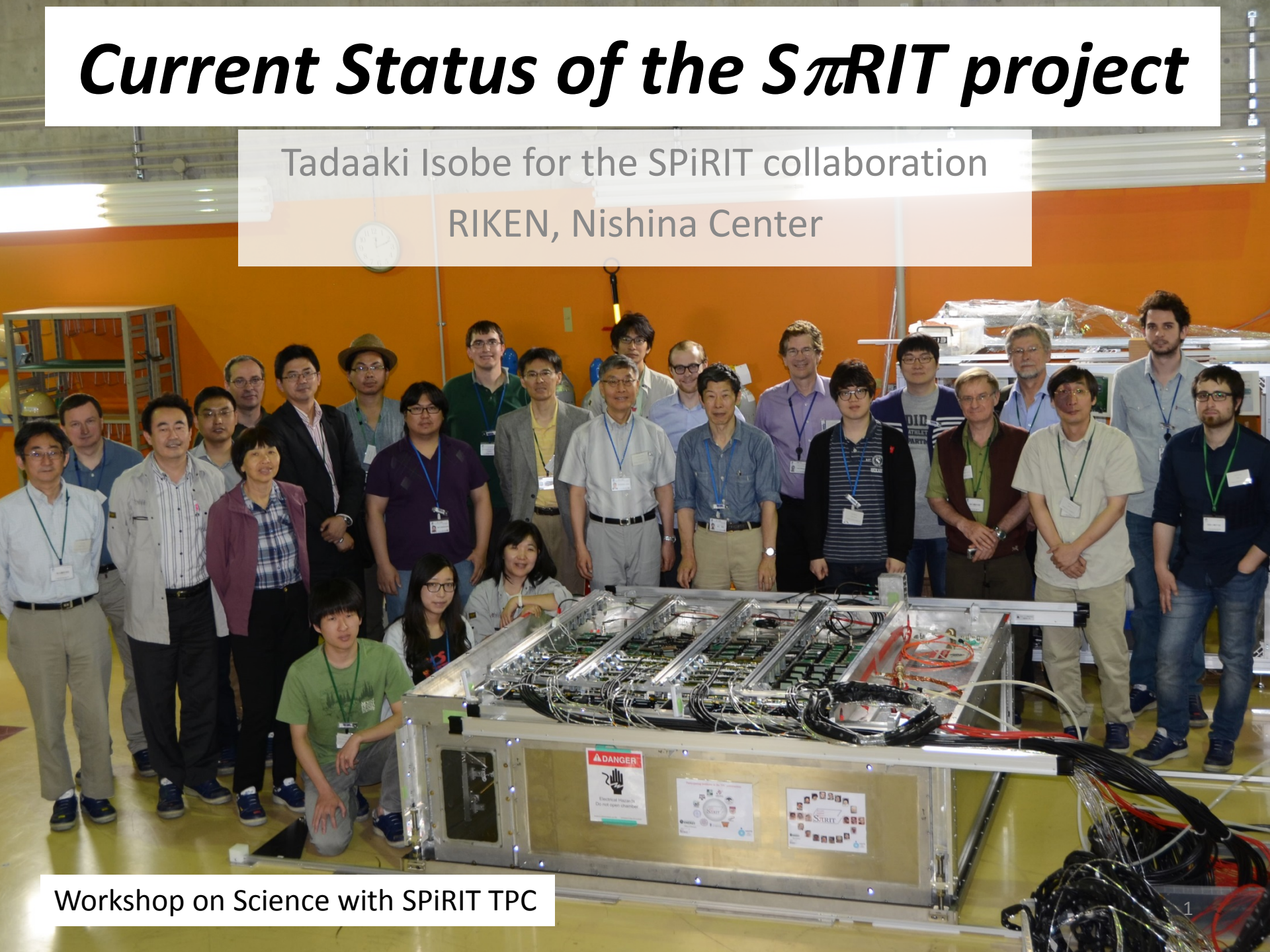
Current Status of the SπRIT project

Tadaaki Isobe for the SPiRIT collaboration

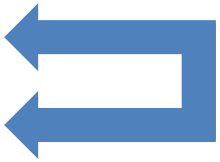
RIKEN, Nishina Center



Workshop on Science with SPiRIT TPC

What is SπRIT project?

- Experimental program at RIKEN-RIBF to give a constrain on the density dependent symmetry energy main for high dense region.
- Realize dense matter with heavy ion collisions.
- It is unique to use rare isotope (RI) as projectile of heavy ion collisions.
- Control
  - System size
  - System asymmetry
  - Beam energy → density



Independent control is possible at SπRIT!

SPiRIT Collaboration (2009~)

SAMURAI Pion Reconstruction and Ion-Tracker

RIKEN : T. Isobe, M. Kurata-Nishimura, H. Baba, H. Otsu, K-I Yoneda, H. Sato, Y. Nakai, S. Nishimura, J. Lee, H. Sakurai, He Wang, N. Fukuda, H. Takeda, D. Kameda, H. Suzuki, N. Inabe, T. Kubo, Y. Shimizu

Kyoto Univ.: T. Murakami, N. Nakatsuka, M. Kaneko

MSU: W.G. Lynch, M.B. Tsang, S. Tangwancharoen, Z. Chajecki, J. Estee, R. Shane, J. Barney, Z. Chajecki, P. Palni

TAMU: A. Mchintosh, S. Yennello, M. Chapman

Liverpool/ Darsbury: M. Chartier, W. Powell, J. Sampson, R.Lemmon

TITech: T. Nakamura, Y. Kondo, Y. Togano

IFJ-PAN: J. Lukasik, P. Pawlowski

Jagiellonian Univ.: Z. Sosin, P. Lasko

Korea Univ.: B. Hong, G. Jhang, J. Lee

Tsinghua Univ.: Z. Xiao, R. Wang, Z. Yan

Lanzhou: Z. Sun

CEA: E. Pollacco

ORNL: A. Galindo-Uribarri

Tohoku Univ.: T. Kobayashi

Rikkyo Univ.: K. Ieki

GSI: T. Aumann

Heavy RI collision experiment at RIBF

- Approved beam time at RIBF
  - NP1306-SAMURAI15, NP1312-SAMURAI22

Primary	Beam	Target	E_{beam}/A	δ_{sys}	Goal	Days
^{238}U	^{132}Sn	^{124}Sn	300	0.22	Probe maximum δ	3
	^{124}Sn	^{112}Sn	300	0.15	Probe intermed. δ, σ_{nn}, σ_{np}	3
^{124}Xe	^{108}Sn	^{112}Sn	300	0.09	Probe minimum δ	3
	^{108}Sn	^{124}Sn	300	0.15	Probe intermed. δ, σ_{nn}, σ_{np}	3

- Experiment with lower energy beam, different system in the future.

Summary at NuSYM14

- SPiRIT project has been formed for the study of density dependent symmetry energy by using asymmetric heavy RI collision.
  - $\rho \sim 2\rho_0$
- Systematic measurement of:
  - Pion measurement
  - Proton/Neutron measurement
  - Light ions

  at different energy and different system is possible.
- Dayone experiment next year.
  - First report at next NuSYM!

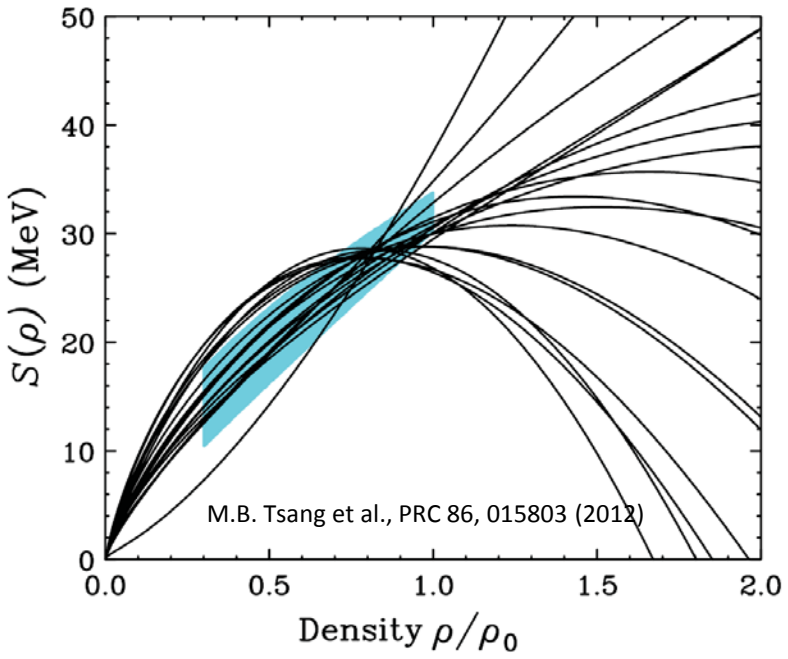
Contents

- Physics motivation
- RIBF
- SPiRIT experiment
  - TPC
  - Trigger
- Progress after NuSYM2014
- Summary

Physics motivation:
Constrain the density dependent symmetry energy

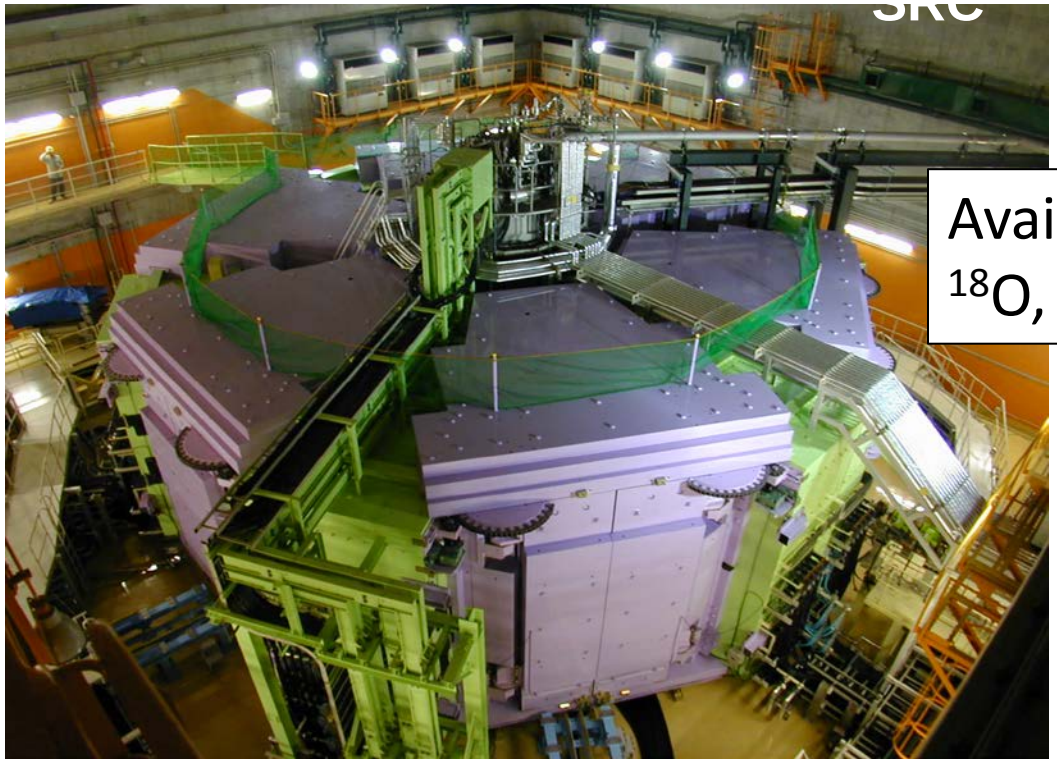
- Well studied for $\rho \sim \rho_0$ region and below.
- Towards high dense region.
  - Essential to understand the extreme matter such as NS.

- Study of asymmetric dense matter realized with heavy RI collision at RIBF.
  - Same-Z, different-N.
  - Useful to control coulomb effect.
- $\rho \sim 2\rho_0$ nuclear matter at RIBF energy (E/A=300MeV).



Constraint at RIBF!

World's First and Strongest K2600MeV Superconducting Ring Cyclotron



400 MeV/u Light-ion beam
345 MeV/u Uranium beam

Available primary beam:
^{18}O, ^{48}Ca, ^{70}Zn, ^{78}Kr, ^{124}Xe and ^{238}U

beam intensity

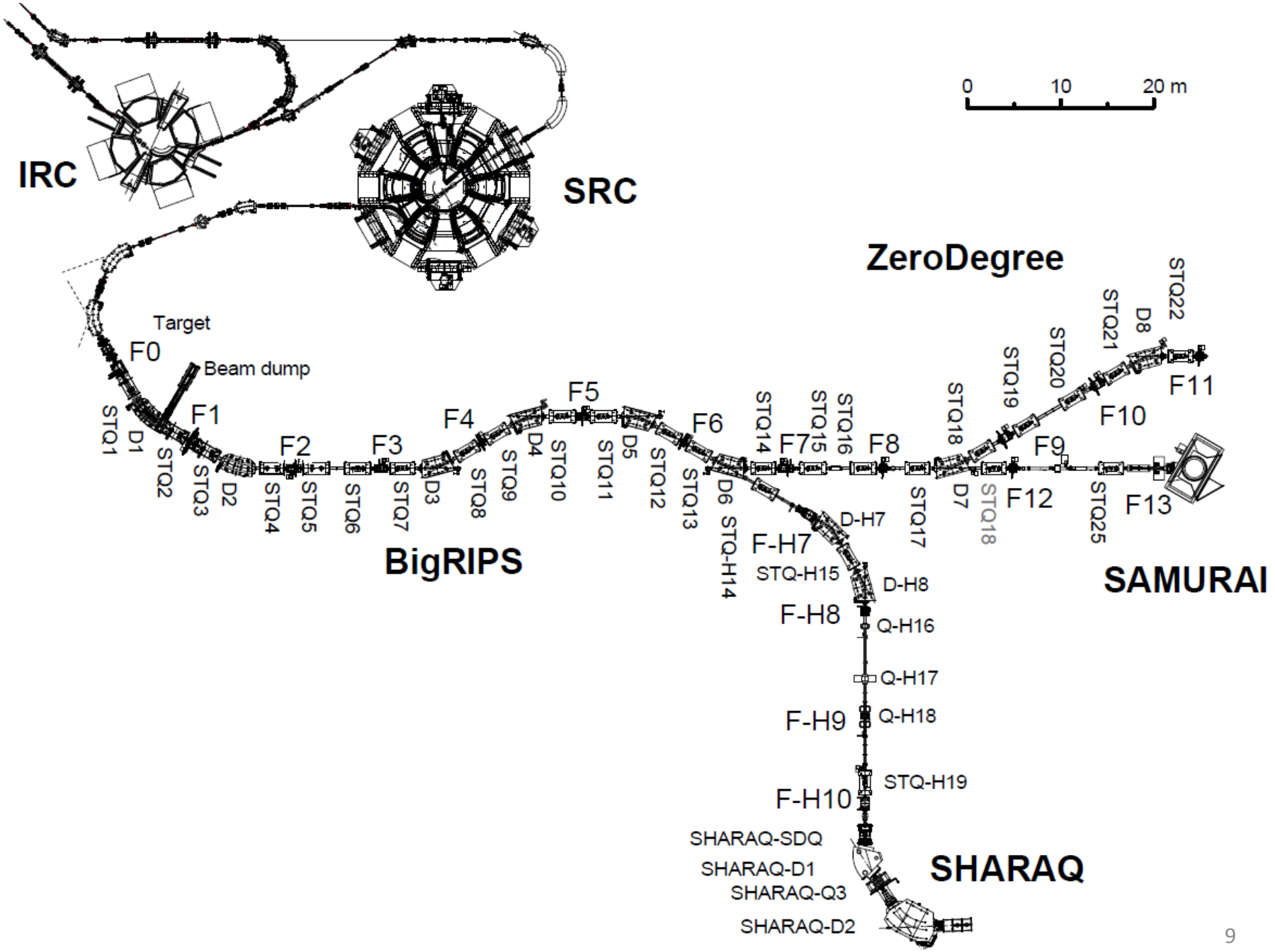
As of July 2015

^{48}Ca: 400 pnA

^{78}Kr: 370 pnA

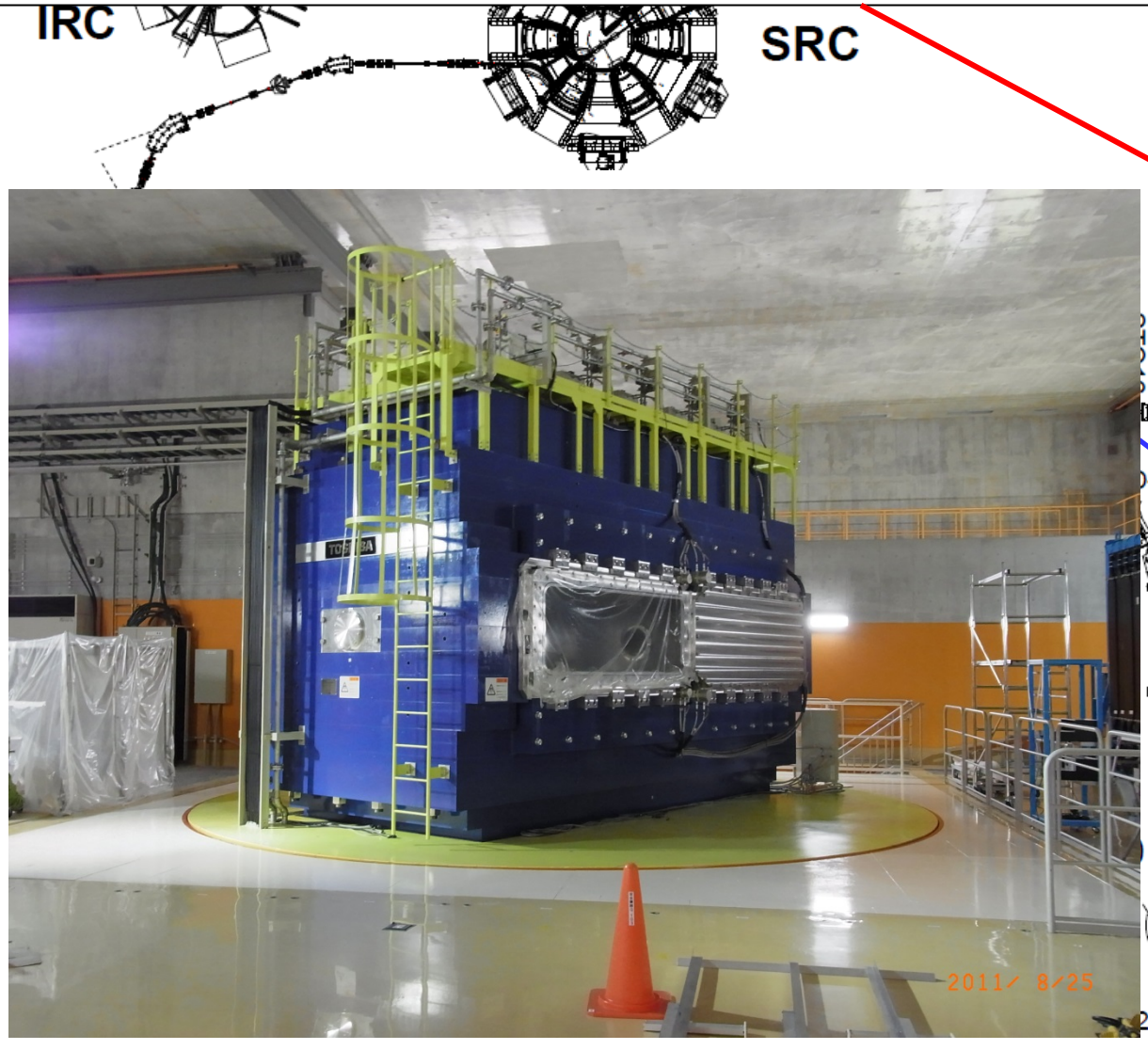
^{238}U: 27pnA

300AMeV ^{132}Sn: 10^5 pps


IRC
SRC
0
10
20 m
ZeroDegree
Target
F0
Beam dump
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
F11
F12
F13
STQ1
D1
STQ2
STQ3
D2
STQ4
STQ5
STQ6
STQ7
D3
STQ8
STQ9
D4
STQ10
STQ11
D5
STQ12
STQ13
D6
STQ-H14
STQ14
STQ15
STQ16
STQ17
D7
STQ18
STQ18
STQ19
STQ20
STQ21
D8
STQ22
STQ25
BigRIPS
SAMURAI
D-H7
F-H7
STQ-H15
D-H8
F-H8
Q-H16
Q-H17
F-H9
Q-H18
STQ-H19
F-H10
SHARAQ-SDQ
SHARAQ-D1
SHARAQ-Q3
SHARAQ-D2
SHARAQ

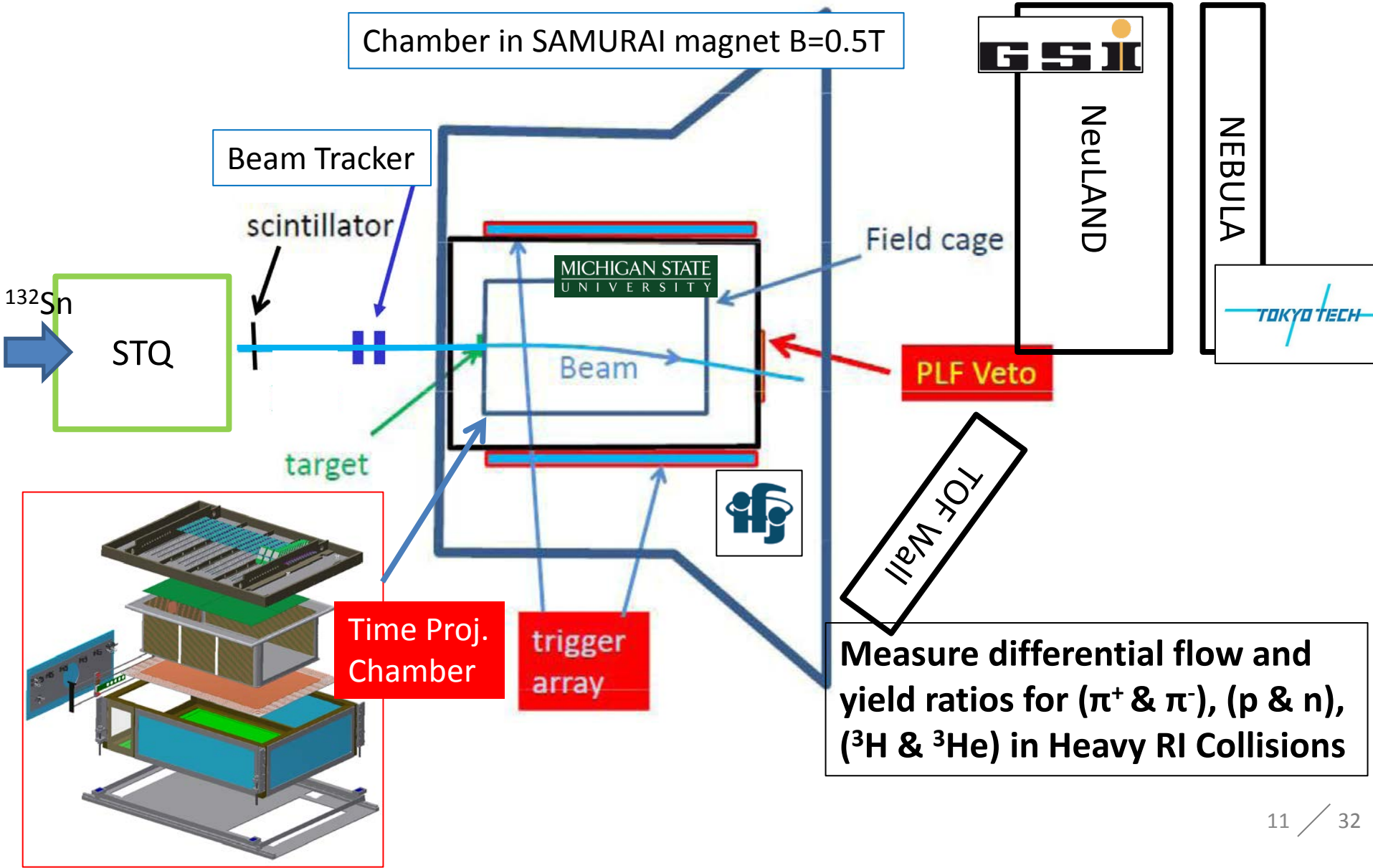
SAMURAI Spectrometer

Superconducting Analyzer for Multi particles from Radio Isotope Beams



Field integral =7Tm

Experimental setup (Dayone)



Measure differential flow and yield ratios for (π^+ & π^-), (p & n), (^{3}H & ^{3}He) in Heavy RI Collisions

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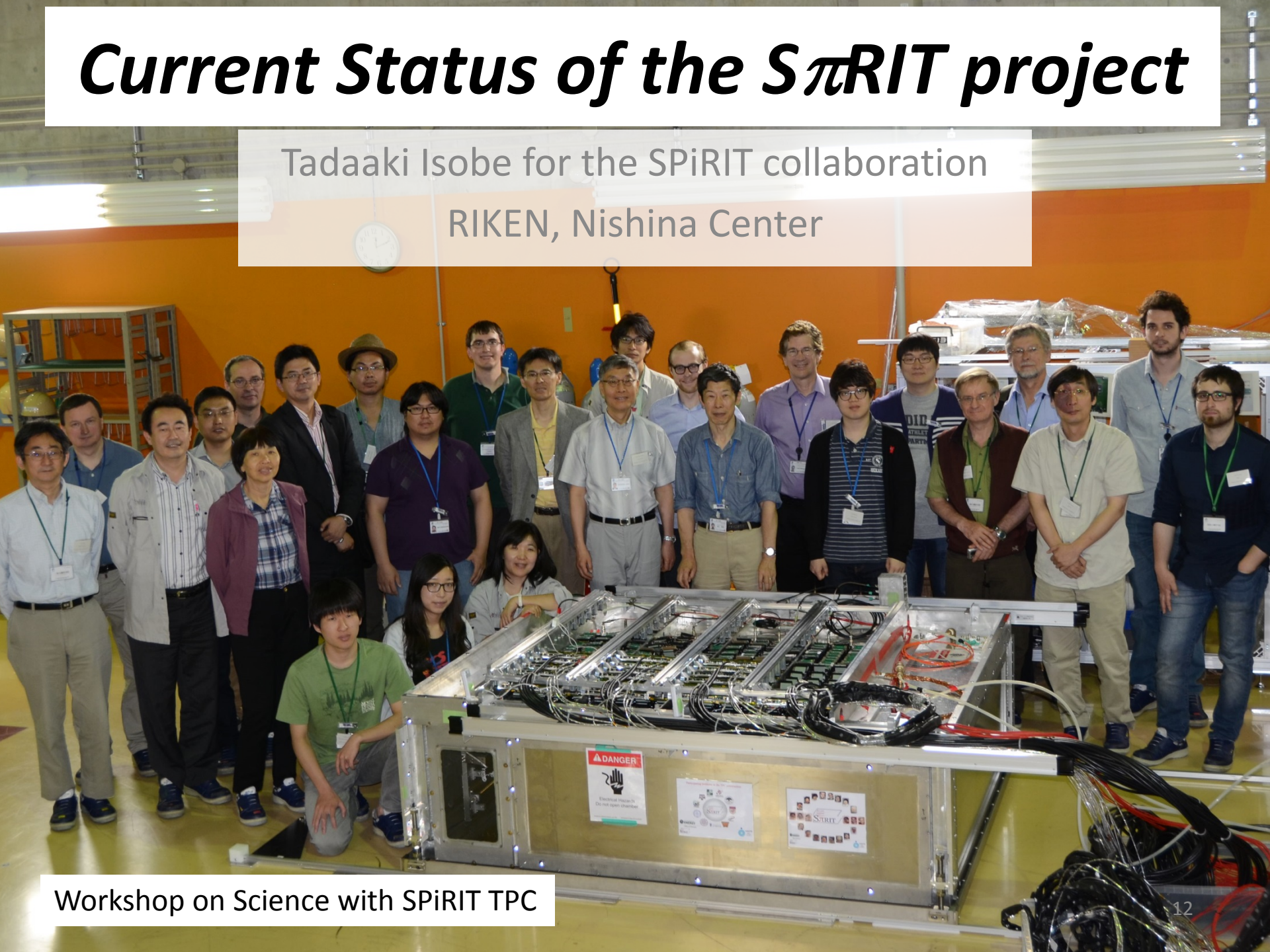
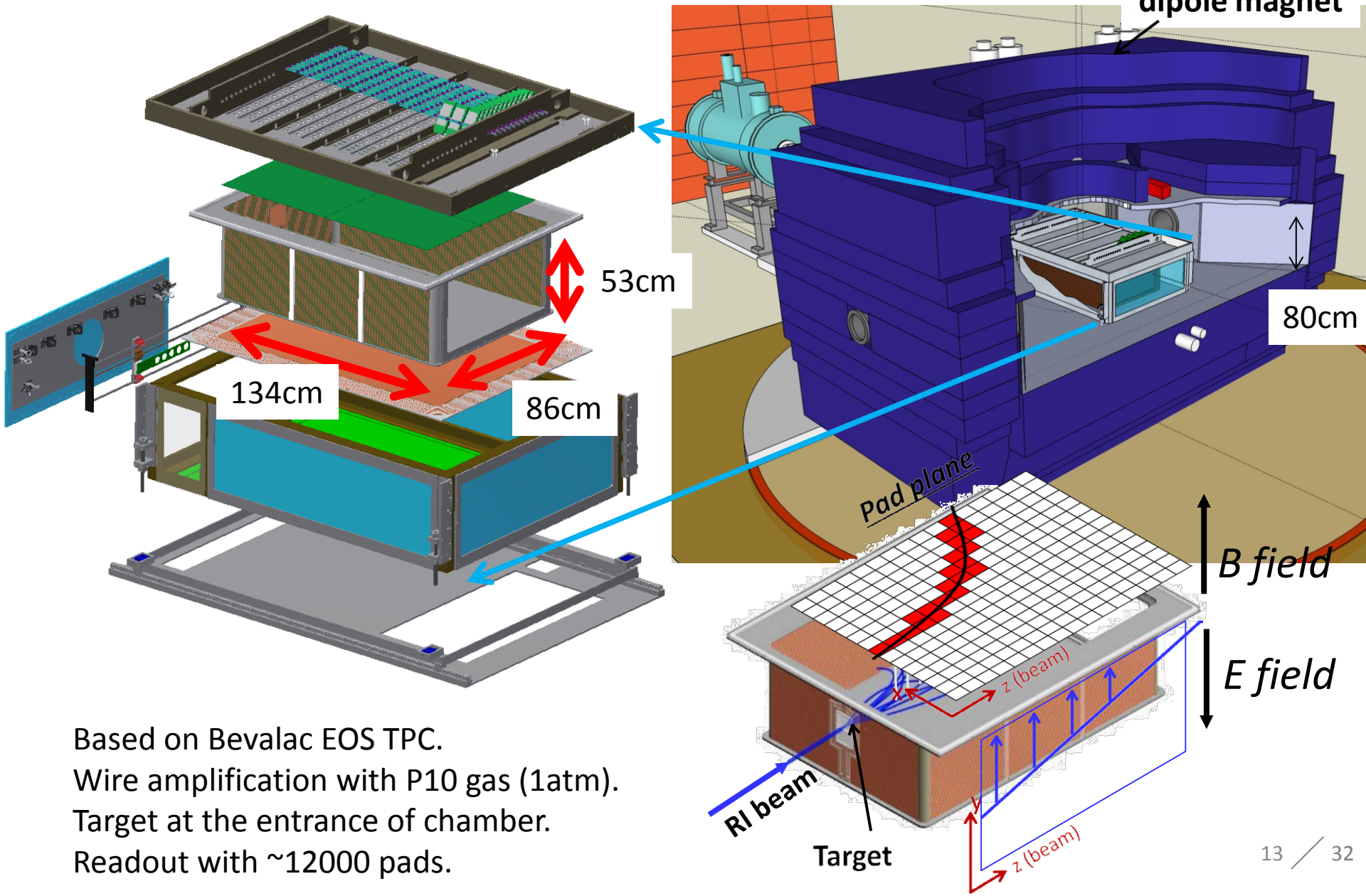


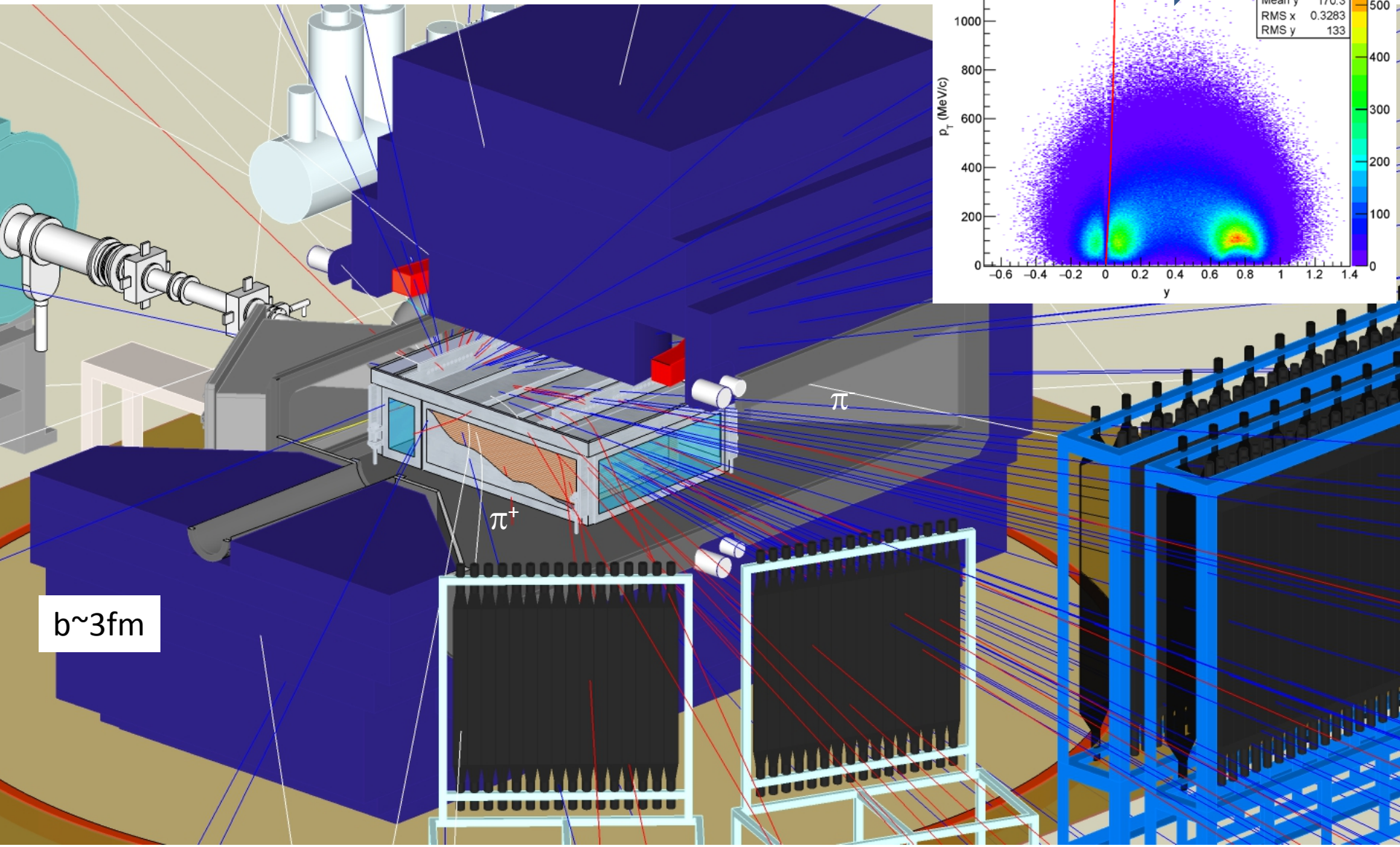
Time Projection Chamber installed in the SAMURAI magnet to detect pions, charged particles from HIC

NIMA 784 (2015) 513



Based on Bevalac EOS TPC.
Wire amplification with P10 gas (1atm).
Target at the entrance of chamber.
Readout with ~12000 pads.

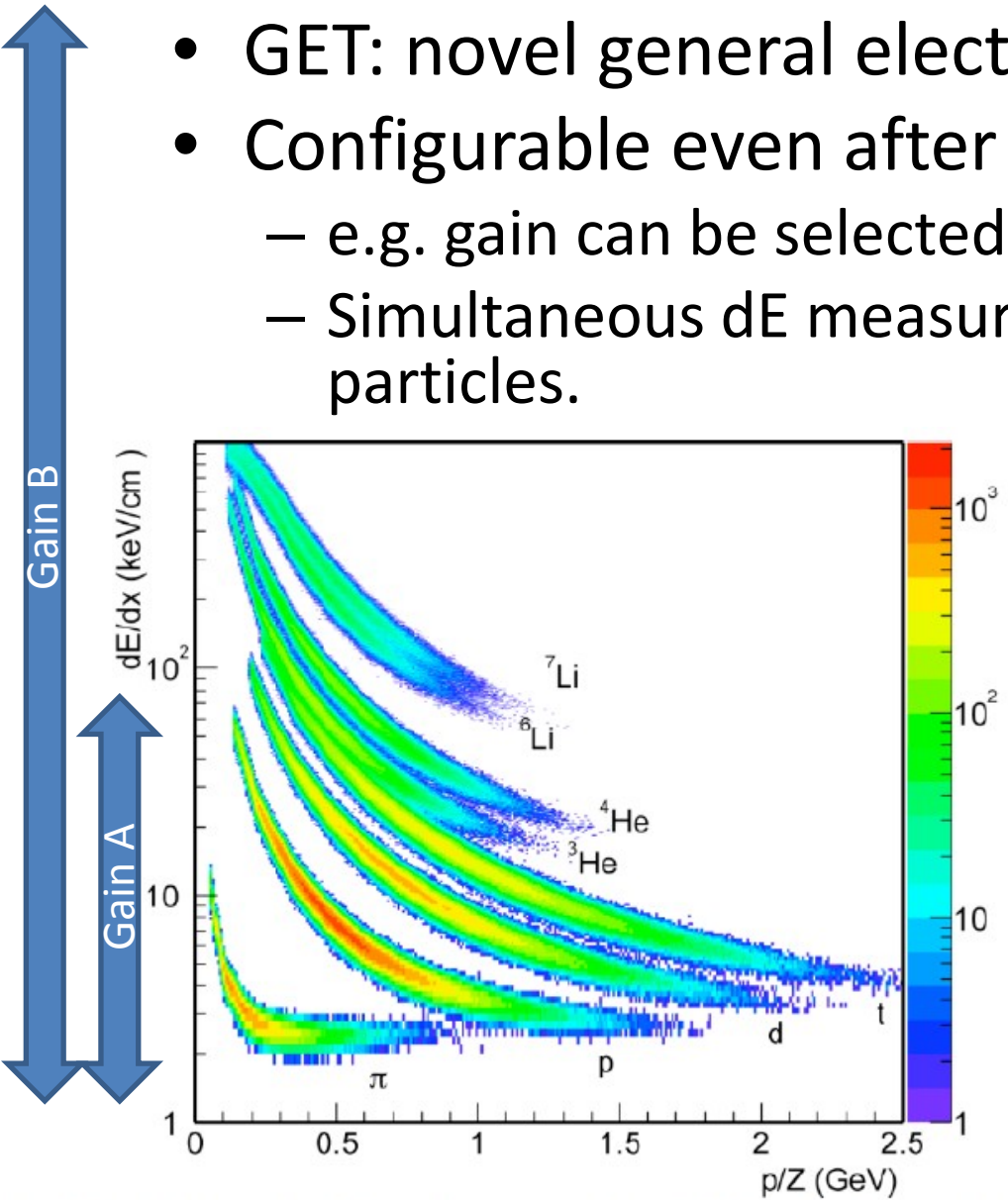
$^{132}Sn+^{124}Sn$ E/A=300MeV

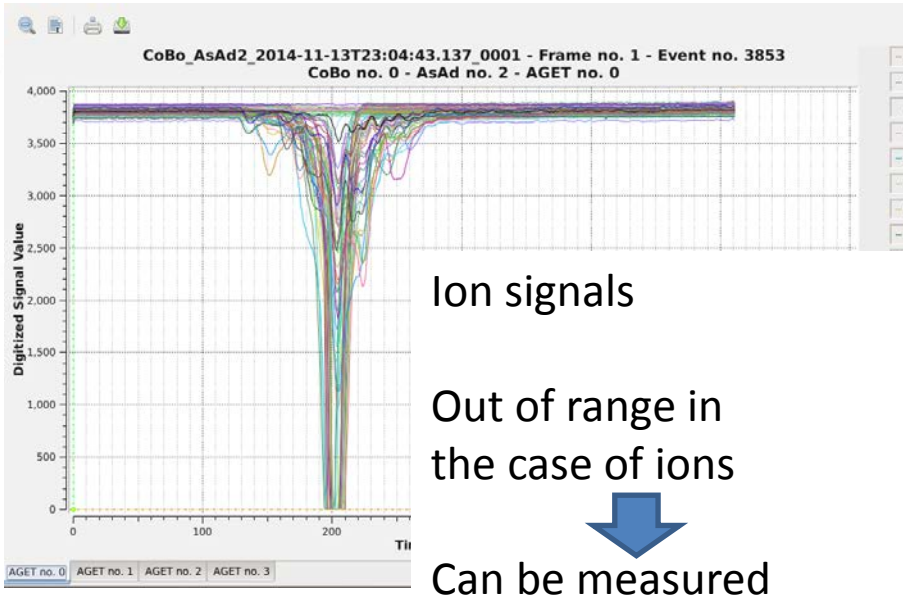


Proton acceptance

TPC readout electronics: GET

- GET: novel general electronics for TPC
- Configurable even after the installation
  - e.g. gain can be selected pad by pad: 120fC~10pC
  - Simultaneous dE measurement of Z=1 and Z=10 particles.





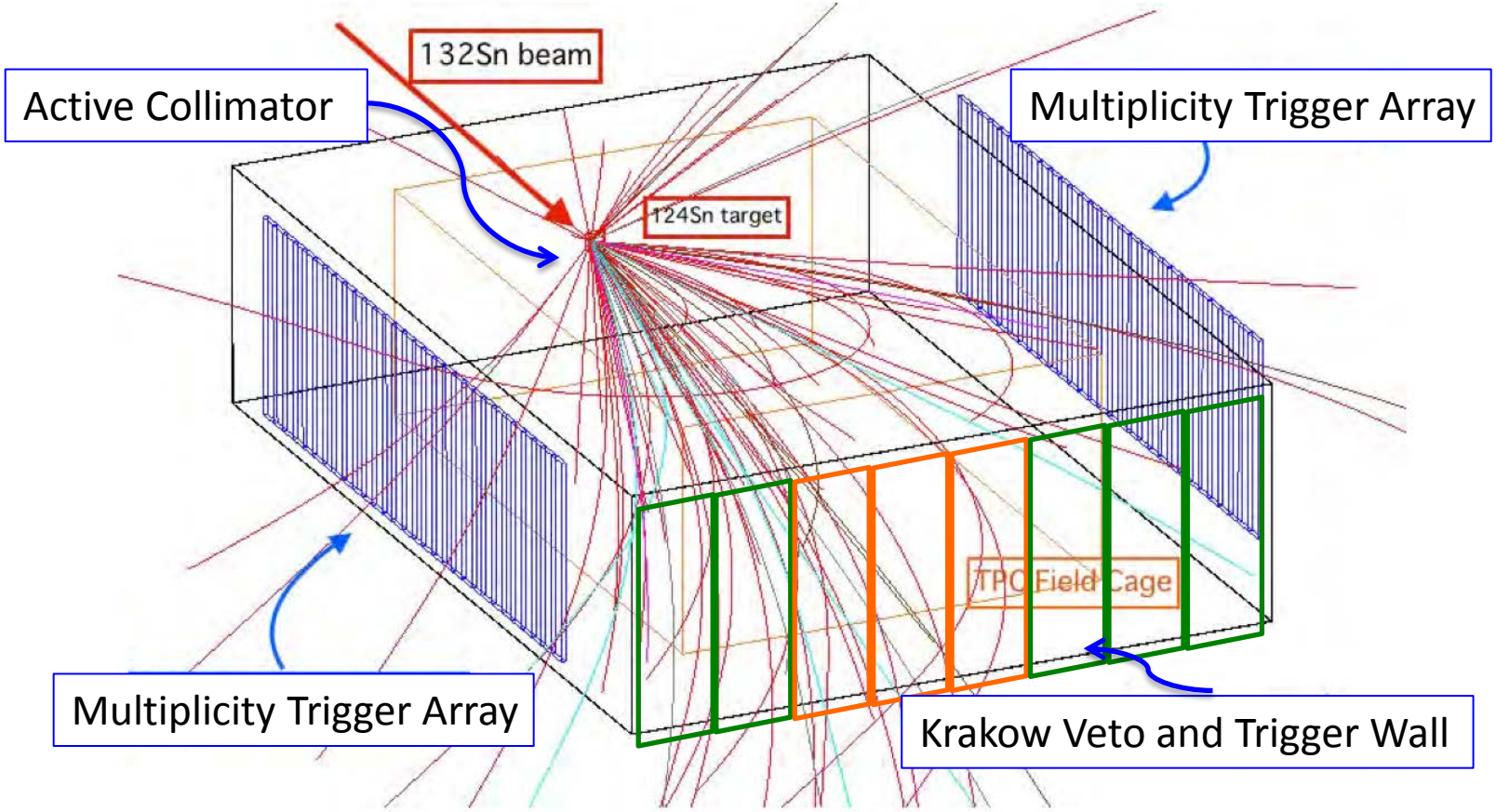
Ion signals

Out of range in the case of ions

Can be measured after decreasing gain(?).

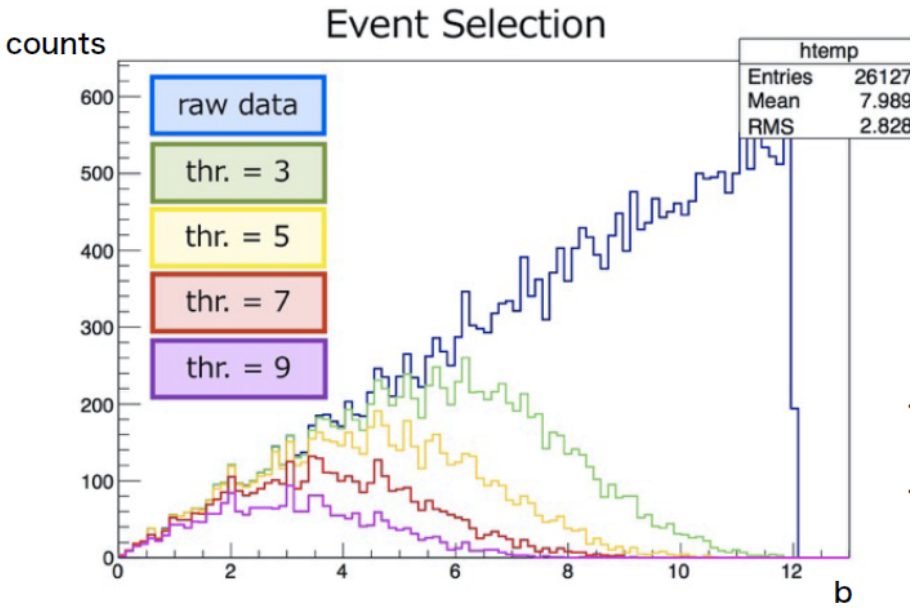
How to make a trigger at SPiRIT

Simulated tracks of central collision for ^{132}Sn + ^{124}Sn with 300MeV/u, generated by UrQMD and traced with GEANT4



Trigger efficiency: simulation

Side array



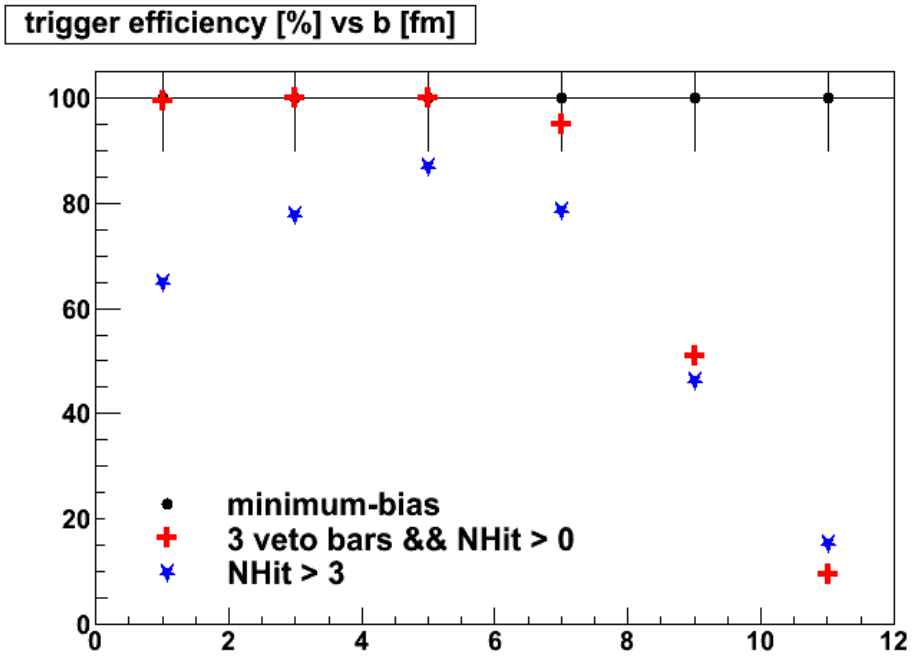
【 Input data of Simulation 】

UrQMD code is used for event generation

: 300 MeV/A, ^{132}Sn + ^{124}Sn, b = 0-12 fm,

& SAMURAI magnet magnet field map (0.5 T)

Forward array



What we are going to measure in HIC.

- Charged particles
  - Charged pions, protons, and light ions.
  - Identified with dE/dX – track rigidity.
  - Momentum can be reconstructed.
- Neutrons
- Event characterization
  - Impact parameter, reaction plane →flow

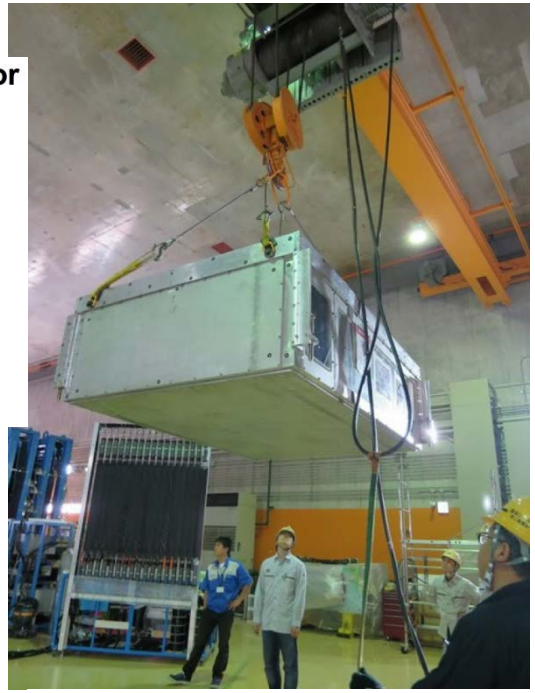
- Charged pion ratio, p/n ratio, ^{3}He/t ratio
- Spectrum of particles
- v1, v2 of particles

Progress after NuSYM14

- Installation test of TPC
- Assembly of GET electronics
- NeuLAND arrived

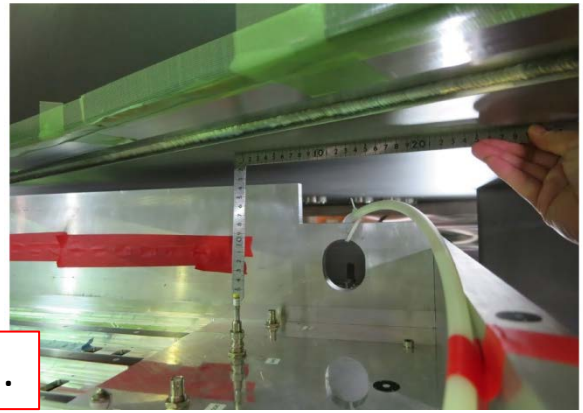
Installation test done last summer

Trusty crane operator



Push with jacks

Checking clearance outside

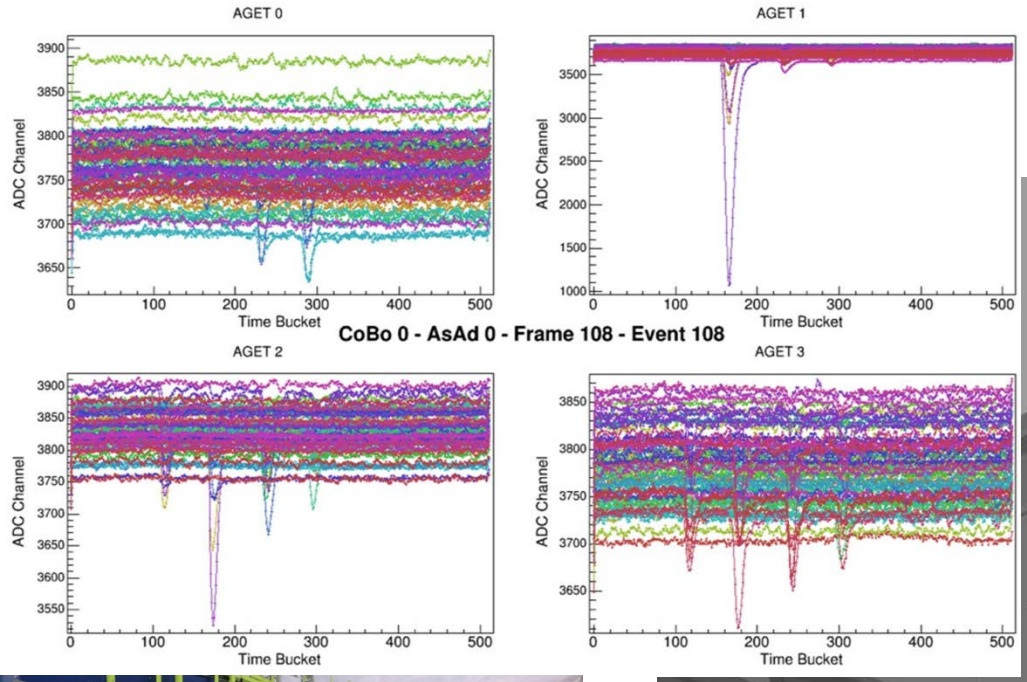


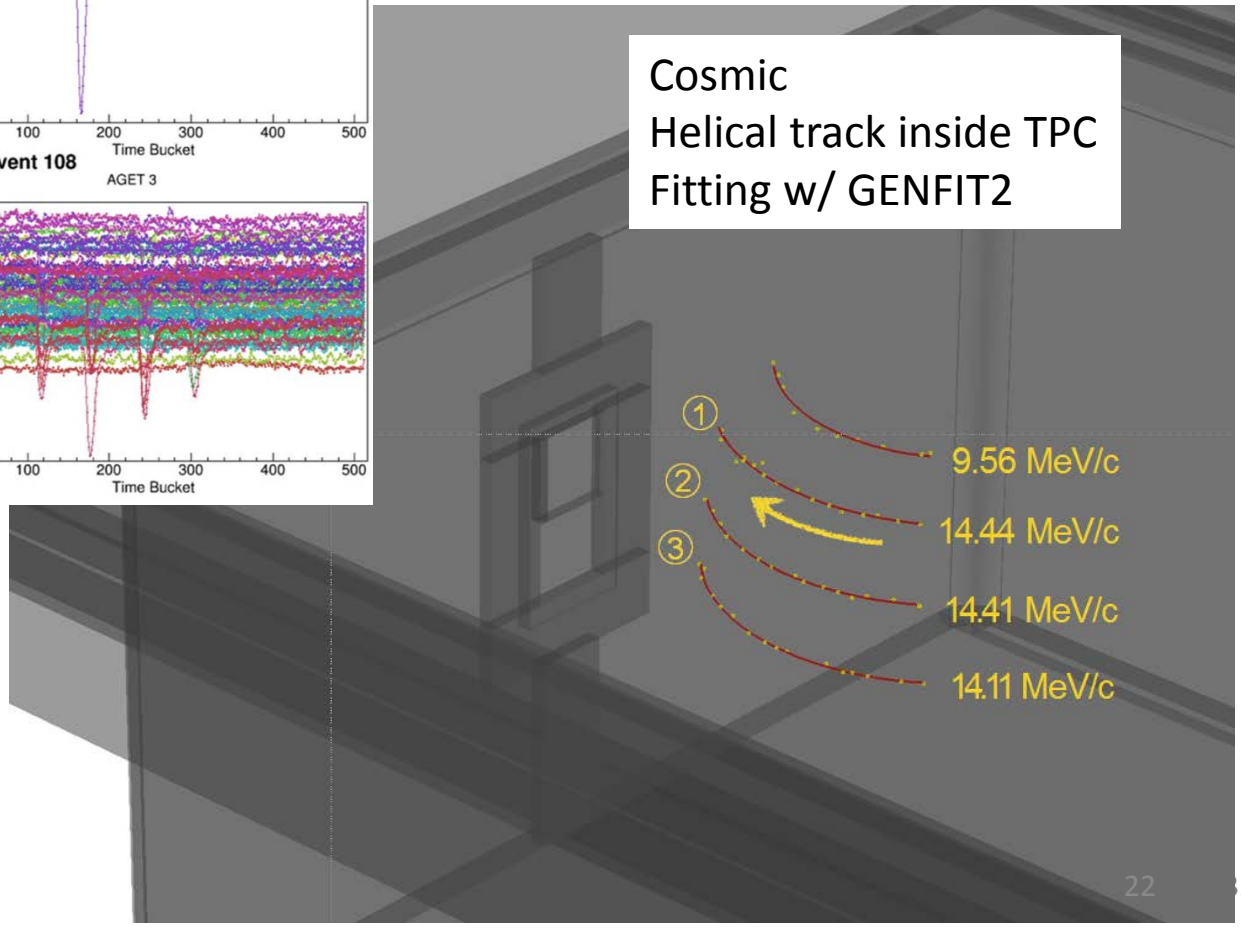
Clearance is less than 1cm.

Succeeded to install!

Charged particle track w/ SPiRIT-TPC

We succeeded following test:
- GET electronics on SPiRIT-TPC
- Readout 512 channels
- Operation under up to 0.6T



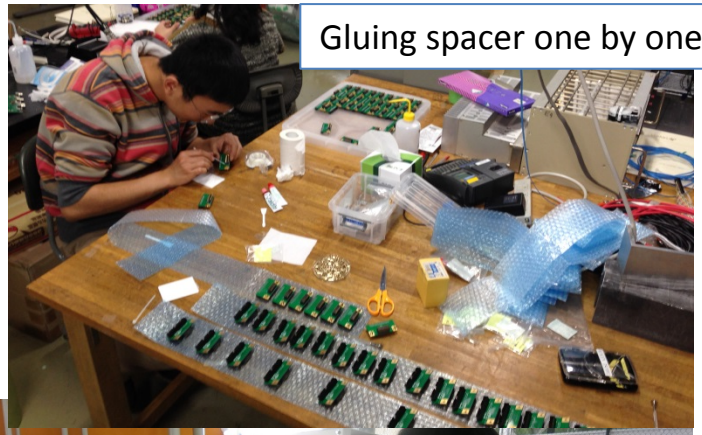


Assembly of electronics (Dec. 2014 ~ Feb. 2015)

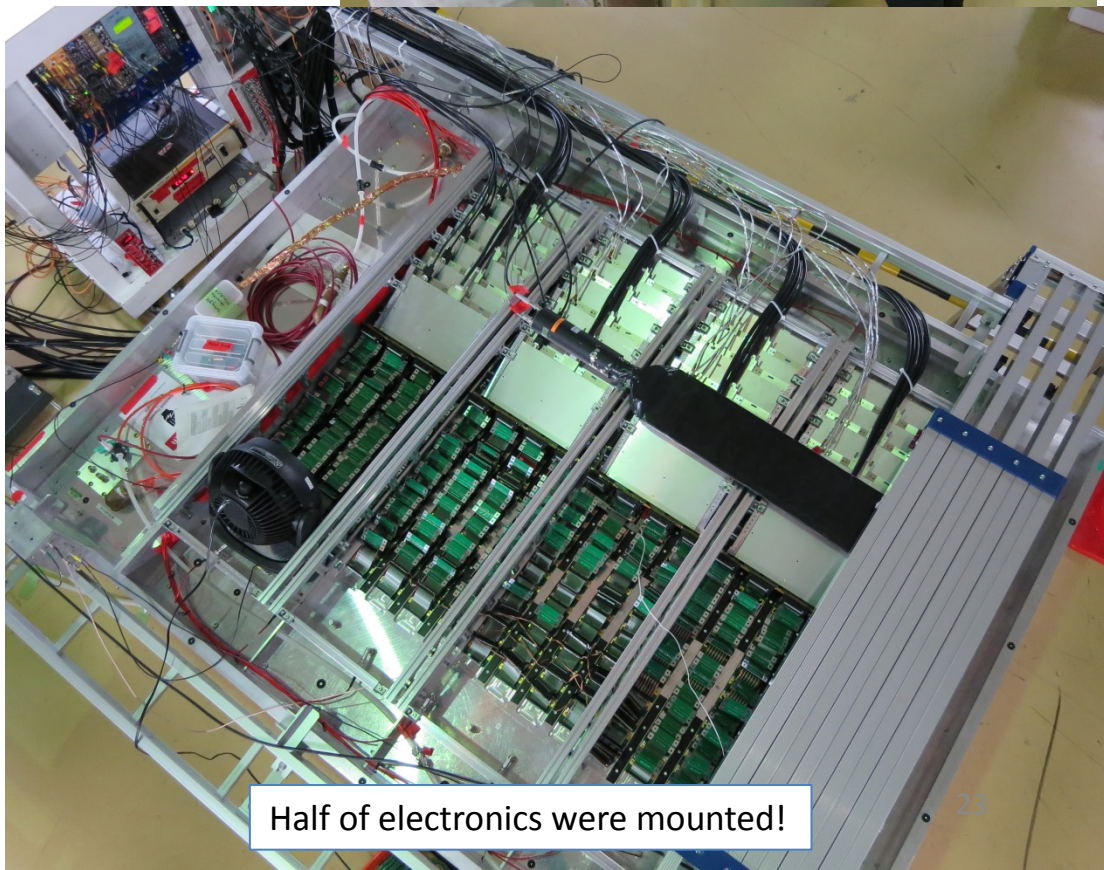
- Electronics for half of TPC pads were mounted.
- A critical problem was found and electronics were send back to France. →ongoing.

Checking the connection one board by one board.

Gluing spacer one by one.

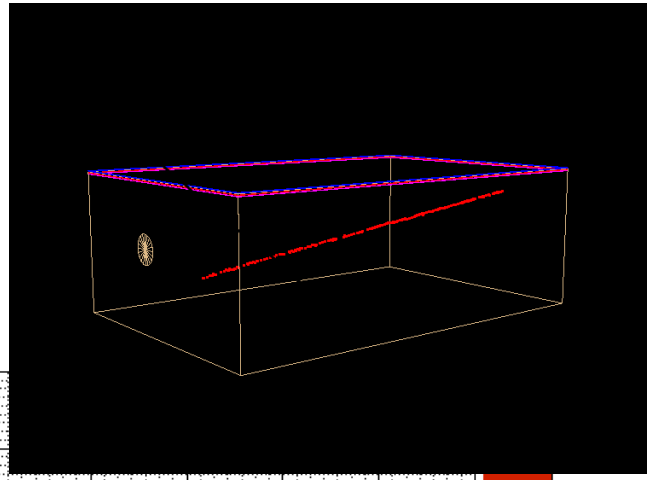


Connecting 384 boards.



Half of electronics were mounted!

Cosmic Run157 Event82



SpiRIT Pad Plane

x (mm)

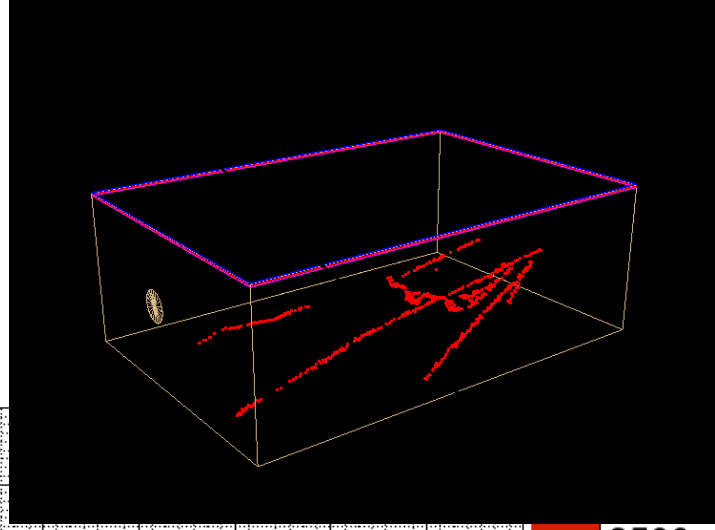
400
300
200
100
0
-100
-200
-300
-400

0
200
400
600
800
1000
1200

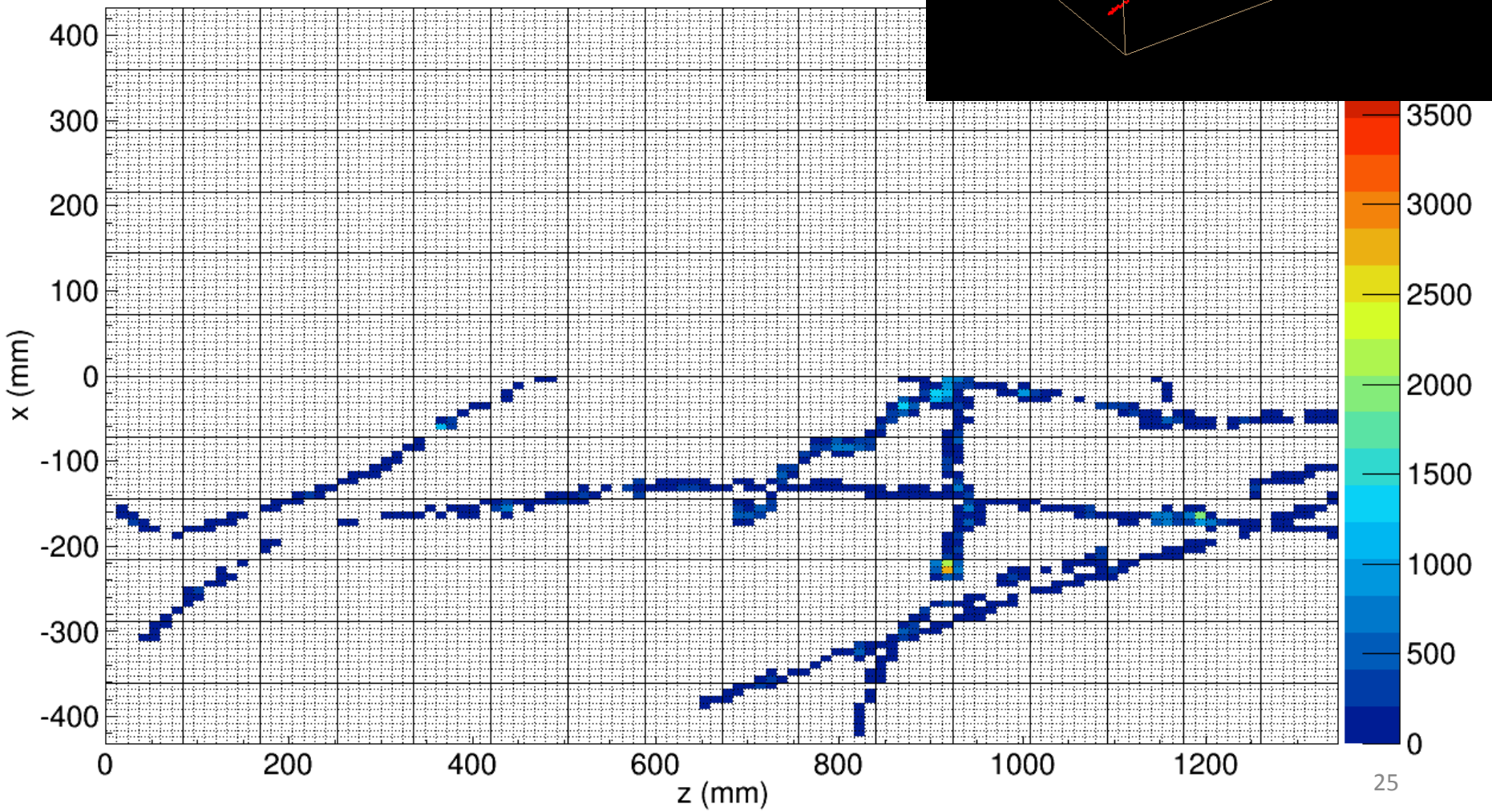
z (mm)

3500
3000
2500
2000
1500
1000
500
0

Cosmic Run157 Event28



SpiRIT Pad Plane



Neutron detector: NeuLAND+NEBULA

NEBULA

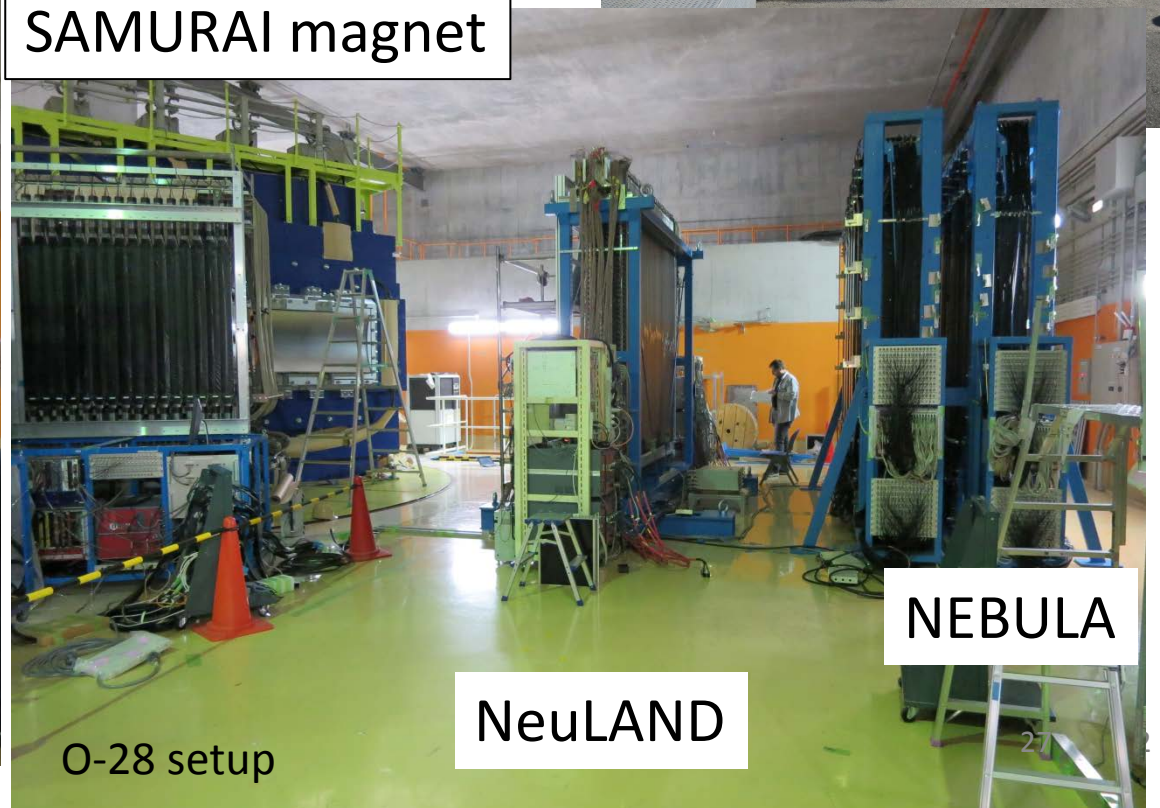
- 1scintilator: 180cm x 10cm x 10cm
- 4layer w/ 120 Neutron counters
- 12 VETO counters for every 2 layers
- Detection efficiency~40% for 1n
- Front acceptance: 3.6m (H) x 1.8m (V)

NeuLAND

- Tracking type neutron detector
- 1scintilator: 250cm x 5cm x 5cm
- Front acceptance 250cm x 250cm w/ 50 bars
- Depth: 3m with 60 layers
- 8 layers out of 60 layers come to RIBF.

NeuLAND came to RIKEN at Feb. 2015

SAMURAI magnet



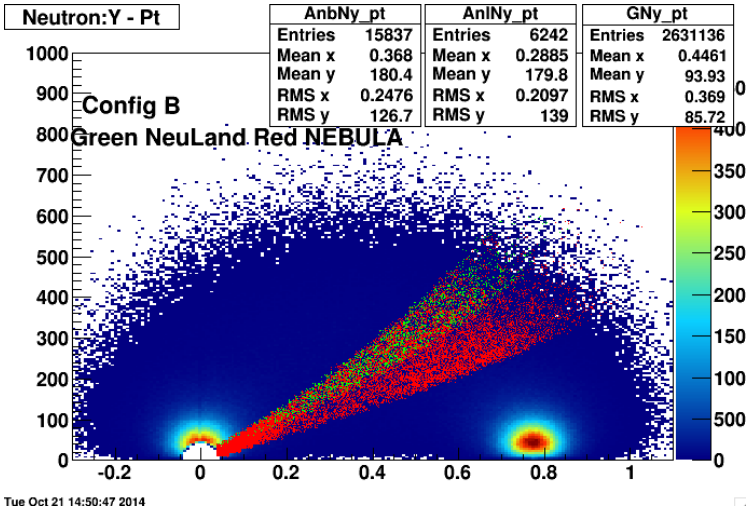
NEBULA

NeuLAND

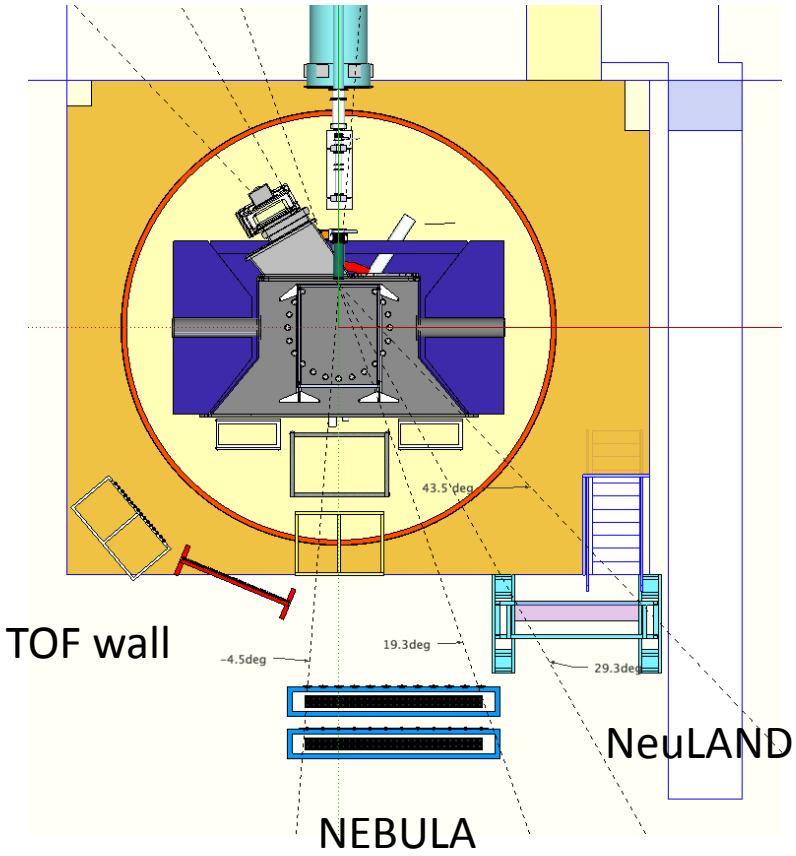
O-28 setup

Position of neutron detectors for SPiRIT program

Where is best position?

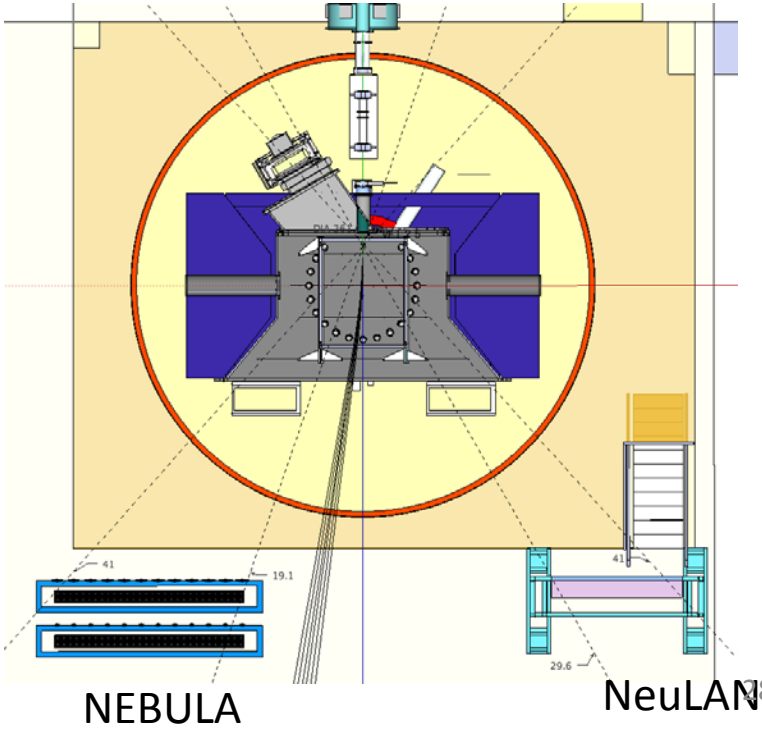


A: Wide coverage?



Any suggestions/comments are welcome!

B: Large acceptance on higher-pT?



Schedule

- Oct. 2015: Commissioning of TPC without magnetic field.
  - Located at the outside of dipole.
- Mar. 2016: Commissioning of TPC with magnetic field in SAMURAI magnet.
- Followed by ~1w physics run.
  - **^{132}Sn+^{124}Sn @300AMeV**

Summary

- SPiRIT project is ongoing for the study of density dependent symmetry energy by using asymmetric heavy RI collision.
- Systematic measurement of:
  - π, proton, neutron and ions

  at different energy and different system is possible.
- Dayone experiment 2015 spring.
  - First report at next NuSYM!

NIC-XIV (2016)

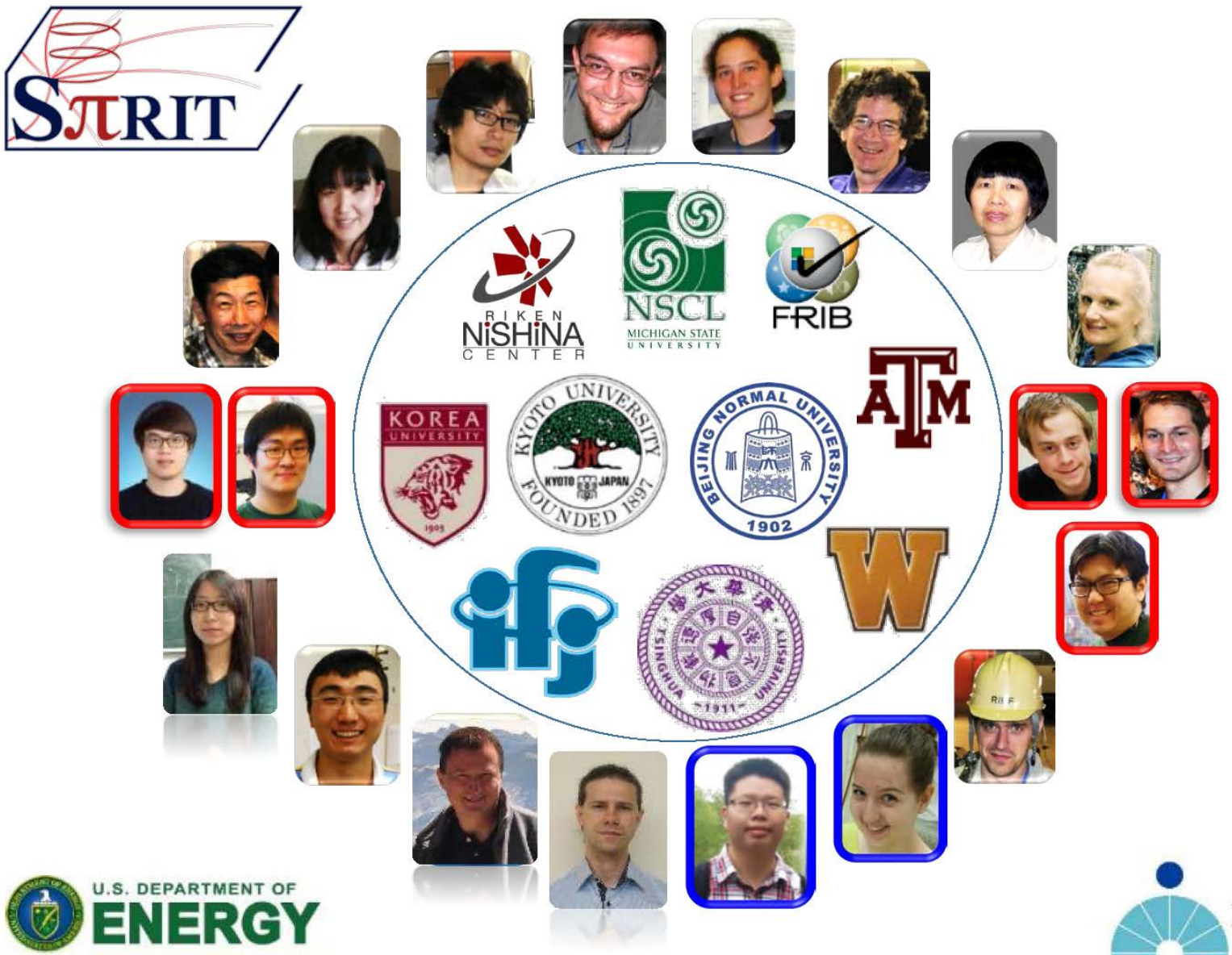
14th International Symposium on Nuclei in the Cosmos

June 19(Sun.) - 24(Fri.), Toki Messe, Niigata, Japan

Co-hosted by: National Observatory of Japan and RIKEN Nishina Center
Chair: Taka Kajino (NAOJ), Vice-chair: Shunji Nishimura (RIKEN)

http://nic2016.jp

Thank you!



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