Integration of GET electronics on TPC for HIC program at RIBF

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ATTPC 2015 Workshop

RIBF-SPiRIT exp: study of symmetry energy for high dense region ($\rho \sim 2\rho_0$)

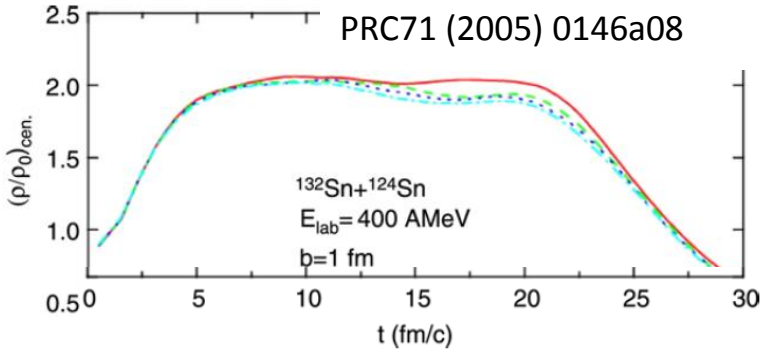
$$E(\rho, T=0, \delta) = \varepsilon(\rho, \delta=0) + S(\rho)\delta^2$$

?

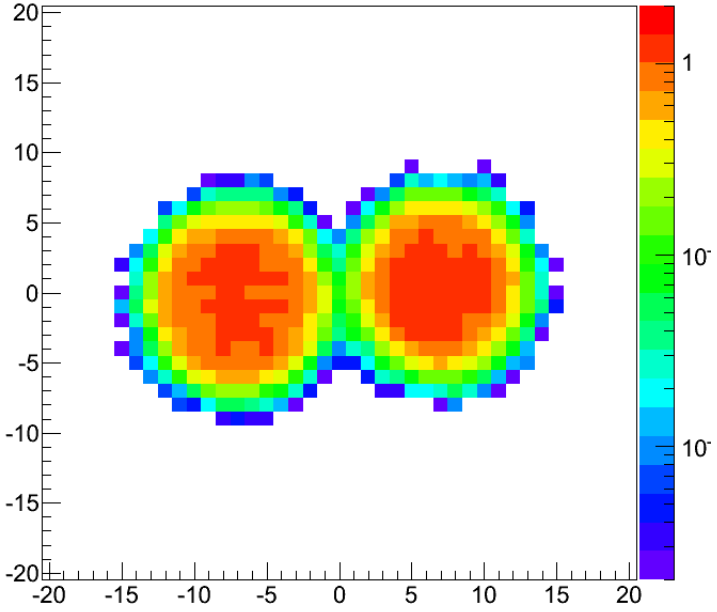
- Study of density dependent symmetry energy.
  - Mainly for high dense region.
- Study with asymmetric dense matter realized with heavy "RI" collision.

→ $\rho \sim 2\rho_0$ with HI collisions at RIKEN-RIBF

  - Same-Z, different-N.
  - Control coulomb effect.

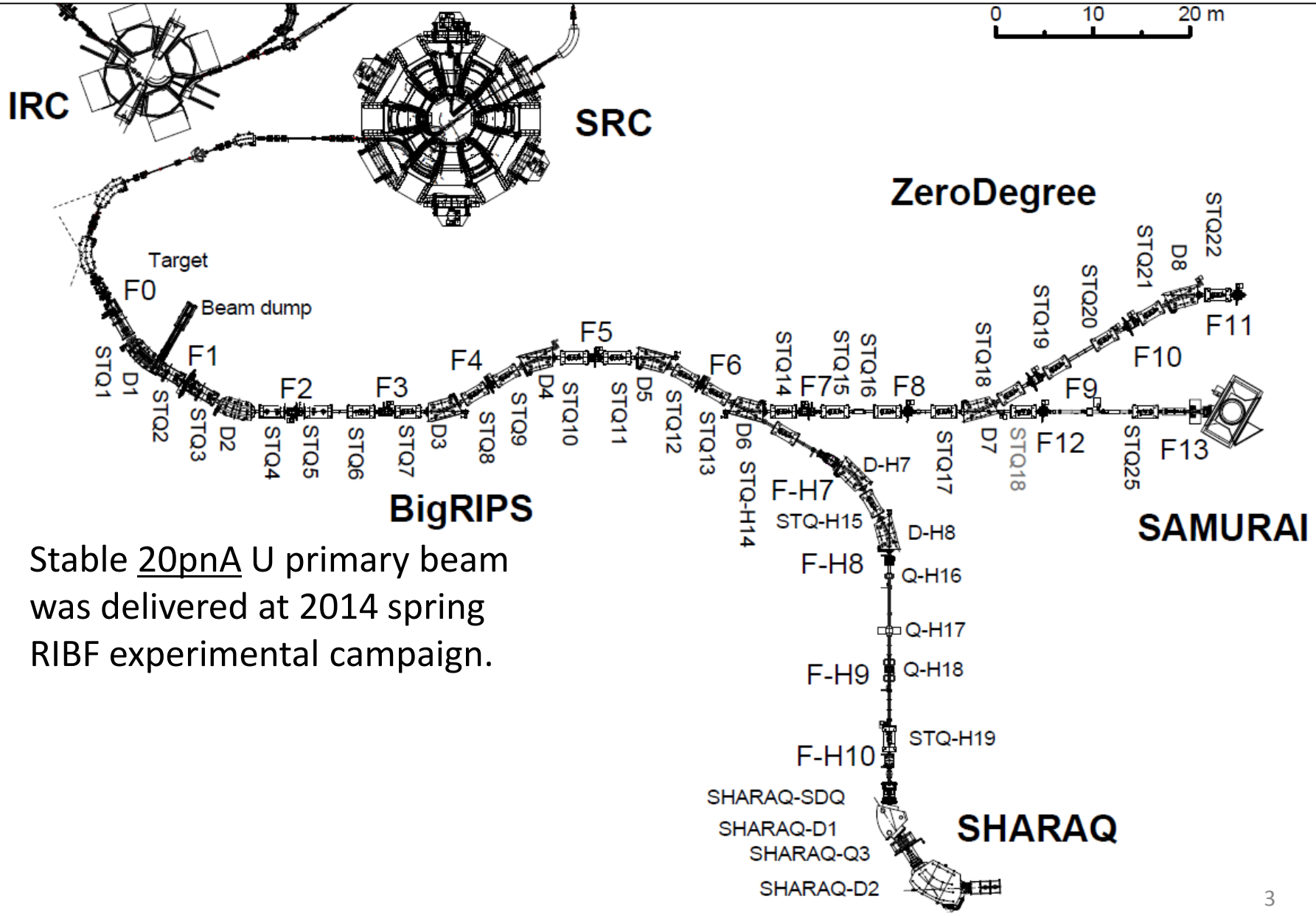


Y = 0, t = 1



IBUU $^{124}Sn+^{132}Sn$ E=300AMeV

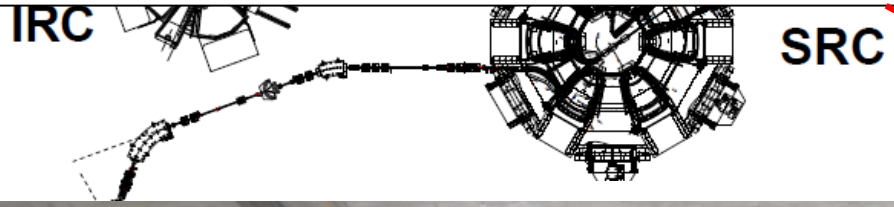
RIKEN RIBF



- Stable <u>20pnA</u> U primary beam was delivered at 2014 spring RIBF experimental campaign.

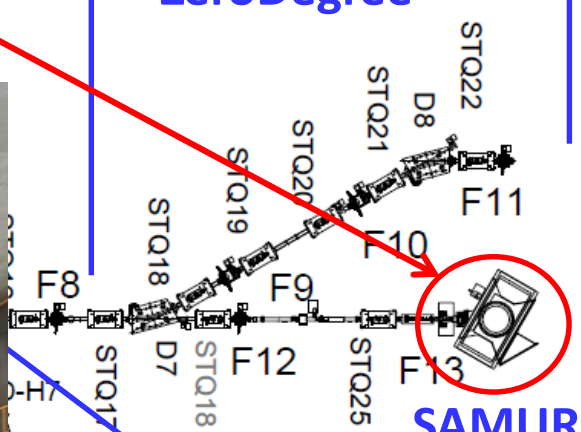
SAMURAI Spectrometer

Superconducting Analyzer for Multi particles from Radio Isotope Beams



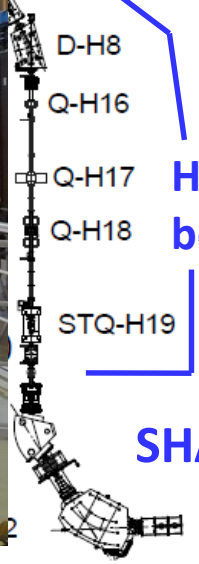
F0-F11: 125.983m

ZeroDegree



SAMURAI

Field integral =7Tm

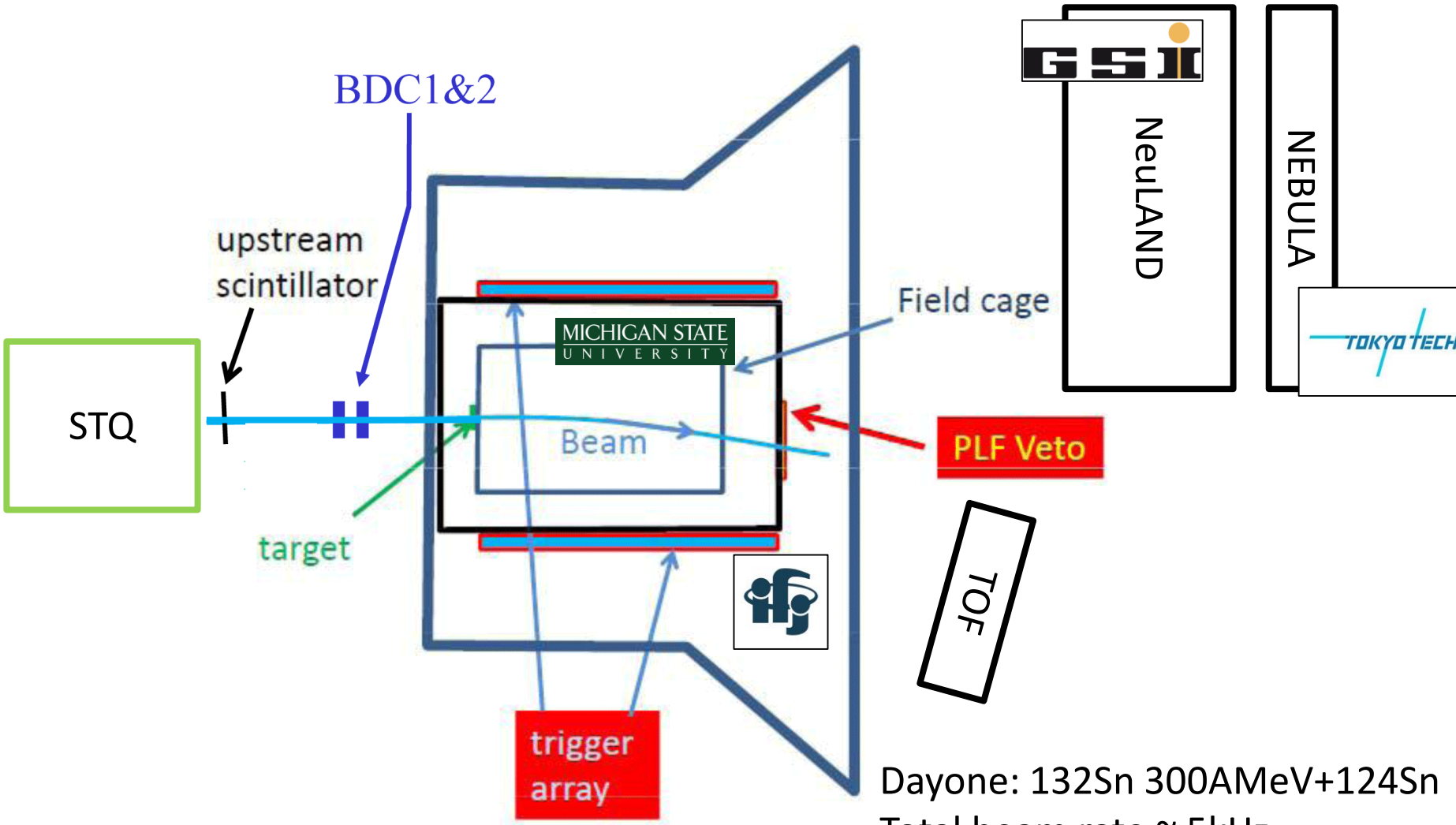


High-resolution beam line

SHARAQ by U. of Tokyo

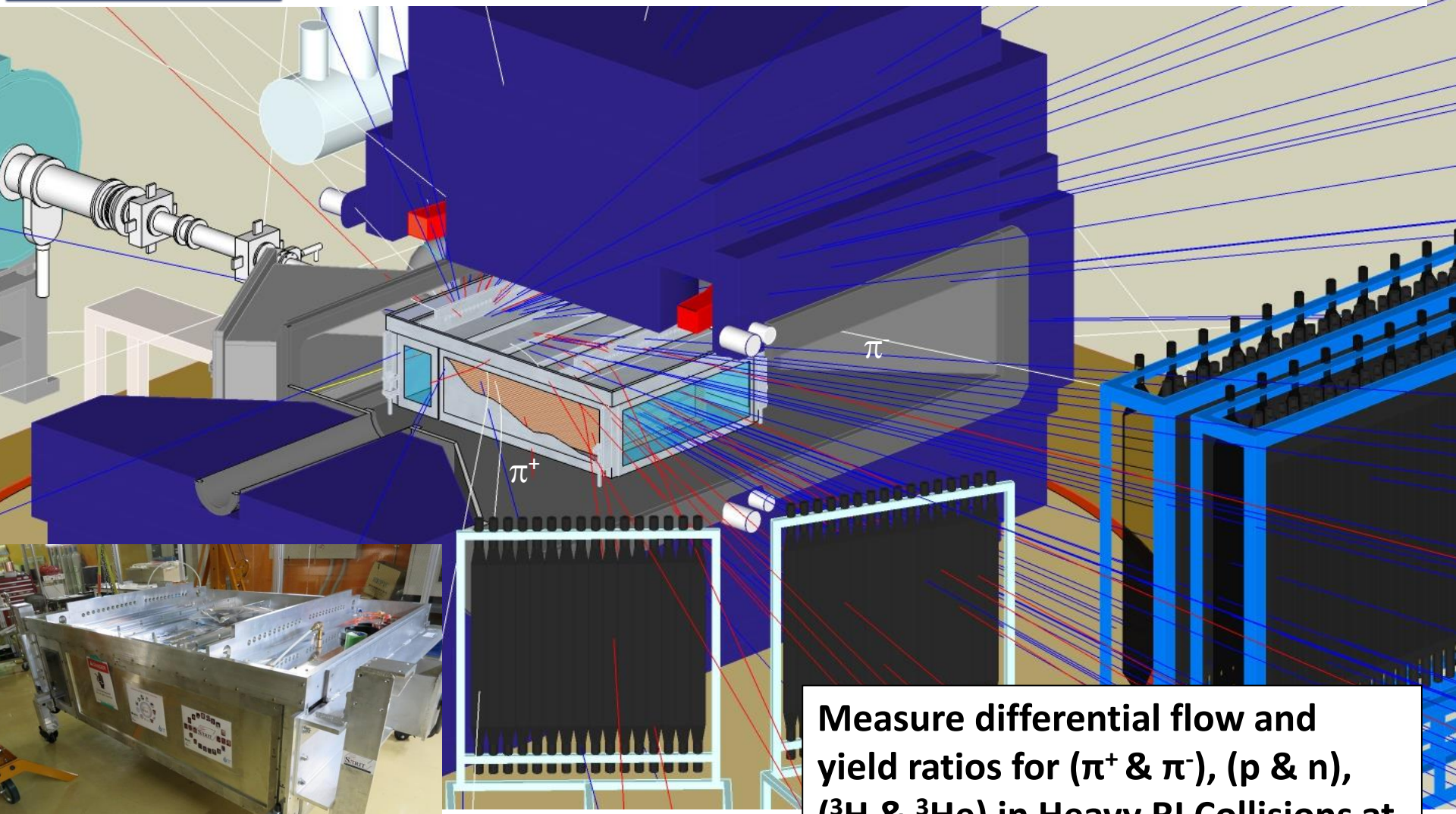
Max. rigidity =6.8Tm max.

Setup of SPiRIT Dayone experiment



Dayone: 132Sn 300AMeV+124Sn
Total beam rate ~ 5kHz
Trigger rate ~ 10Hz

SPiRIT-TPC as tracker for multi particles from HIC



Measure differential flow and yield ratios for (π^+ & π^-), (p & n), (^{3}H & ^{3}He) in Heavy RI Collisions at E/A=300MeV

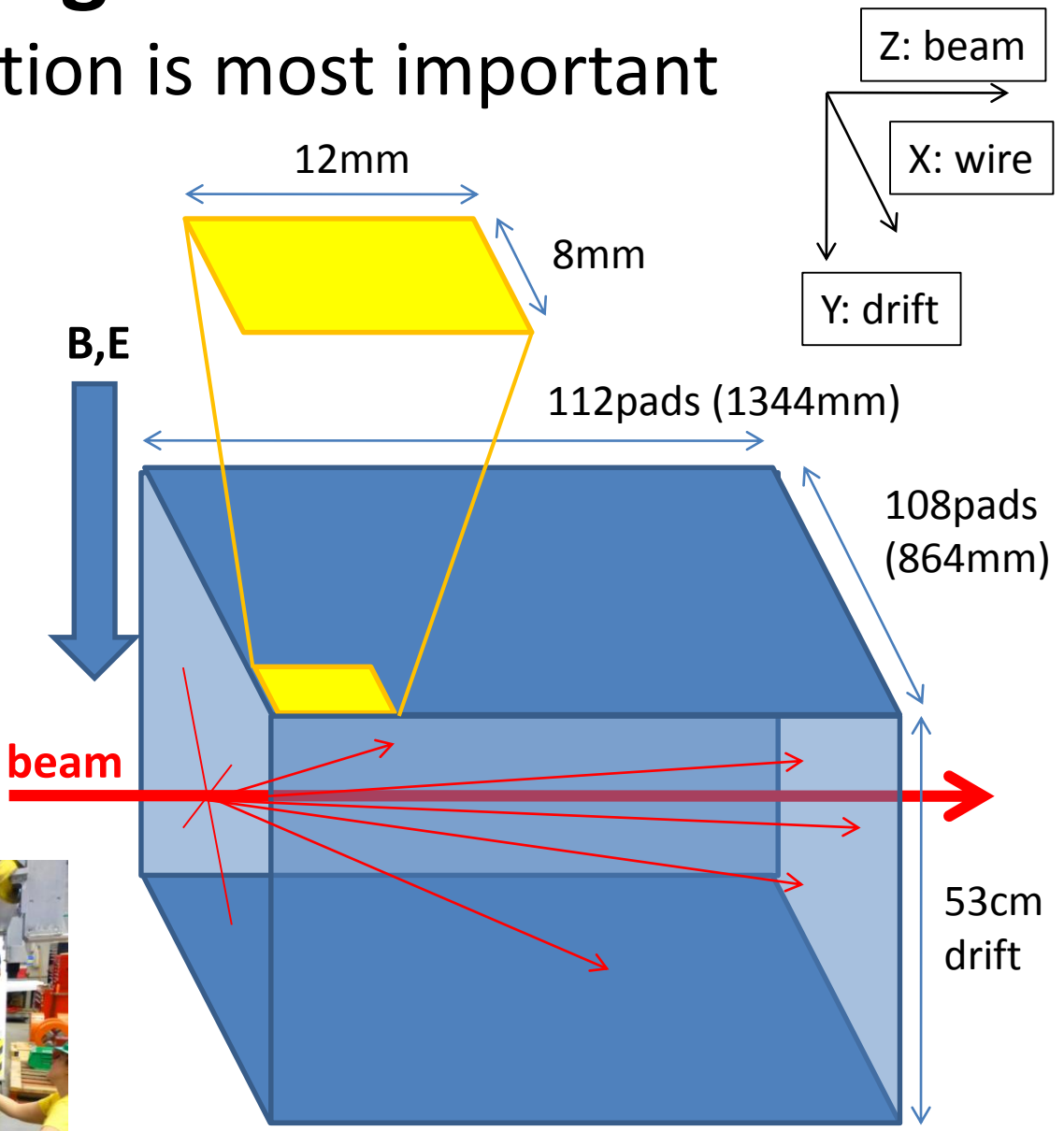
Basic design of chamber

stable operation is most important

- Beam passes through chamber as well.

- Based on Bevalac EOS TPC.
- Wire amplification with P10 gas (1atm).
- Target at the entrance of chamber.
- Readout with ~12000 pads.
- Multiplicity: 10~100
- Operation under B~0.5T

- External trigger with scintillator paddles + MPPC



Series of SPiRIT TPC talk

- Integration of GET electronics on TPC for HIC program at RIBF (T. Isobe)
- Current Status of SπRIT Time-Projection Chamber Project (M. Kurata-Nishimura)
- The SπRIT-TPC data acquisition system and analysis framework (Y. Ayyad)
- Design of Gating grid driver for SπRIT Time Projection Chamber (S. Tangwancharoen)
- Photogrammetry measurements of the SpiRIT TPC (J. Barney)
- Garfield Simulation of the SpiRIT TPC Field Cage (J. Estee)

R&D for SPiRIT-TPC readout electronics

- We planned to use STAR-TPC readout system.

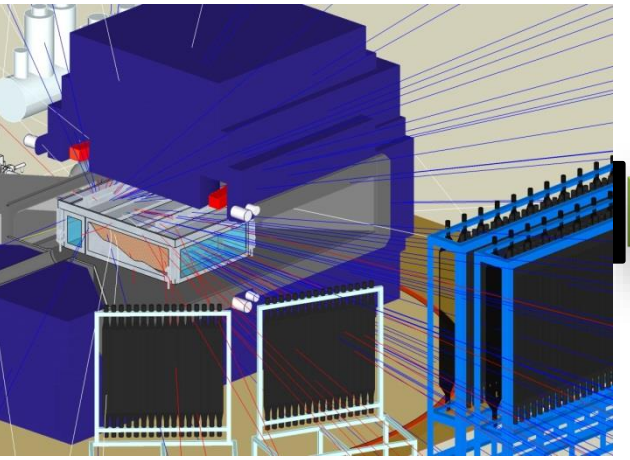
→ADC 10bit, 512SCA type FADC.

→R&D terminated now.

- Required performance: high DAQ rate (~1kHz) and good ADC resolution (>10bit). Z=1 particle measurement in the chamber where Z>50 beam passing through.
- → Employment of **GET** system. General Electronics for TPC.
  - R&D by GET (General Electronics for TPC) Collaboration for the next generation of readout electronics. France-USA(-Japan) Collaboration.
  - Not only for SPiRIT-TPC.
  - Make it possible to readout 12bit ADC 512 samples from 12000 pads under 1kHz DAQ rate.

SYSTEM GET

Generic Structure (H&S)
2^{12} Final Dyn Rnge
10Gbit B.width
4 Level Digital Trigger



V. Front End
Pre-amp
&
Filter
Protection

Concentrator
Embedded
System**S**:
.T. Stamp
. '0'-suppress
.Formatting
.Reduction
.Calibration
Slow Control

FARM
Trigger4
Event-Building
Data
Control
S. Control
Web Service
Security

ZAP

AsAd
AGET
ADC
FPGA
PULSER

CoBo
FPGA
+
Memo

μ-TCA

Mutant
FPGA

Front-End
Coding
V, I, EM & Temp
Control/Satb

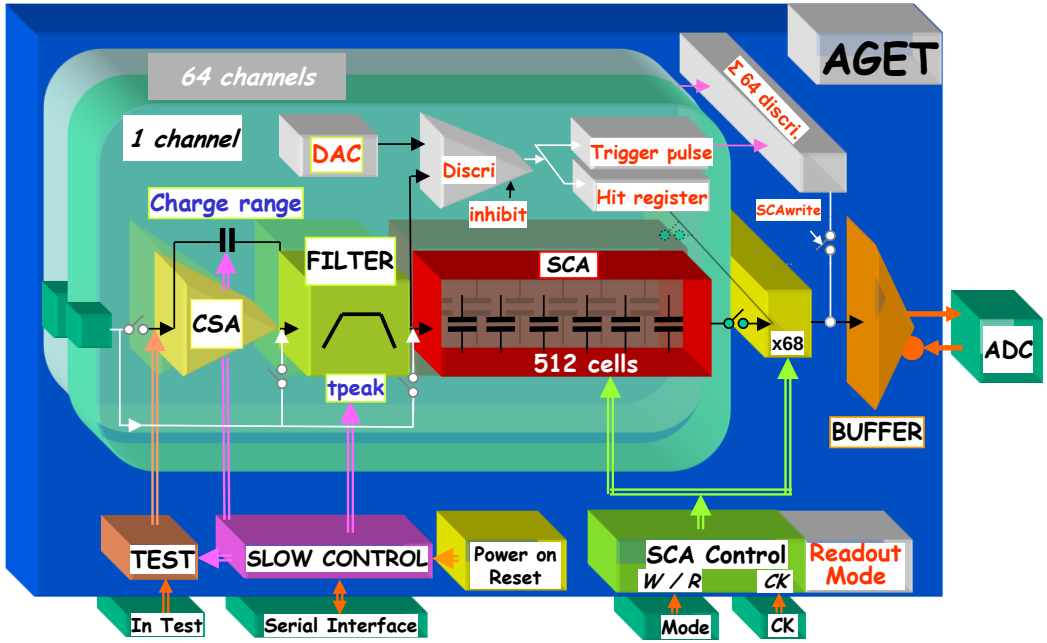
3-Level
.Trigger
.Clock
.Calculated
Selected
Read-out

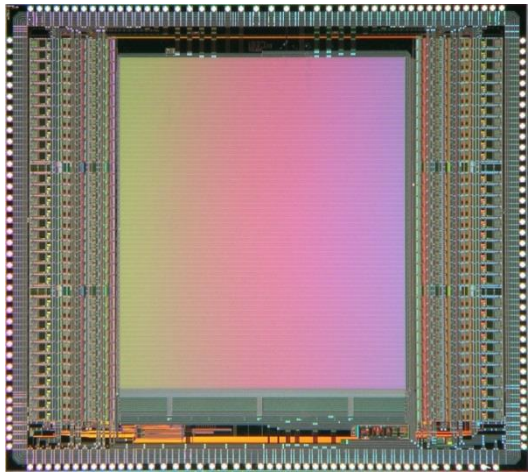
SPiRIT TPC:
48 AsAd boards
12 CoBo boards
2 μ-TCA crates
2 MuTANT boards

Novel ASIC Chip by GET project: AGET

Architecture

- **64 analog channels :** *CSA, Filter, SCA, Discriminator*
- **Auto triggering :** discriminator + threshold (DAC)
- **Multiplicity signal :** *analog OR of 64 discriminators*
- **Address of the hit channel(s); 3 SCA readout modes :** *all, hit or specific channels*



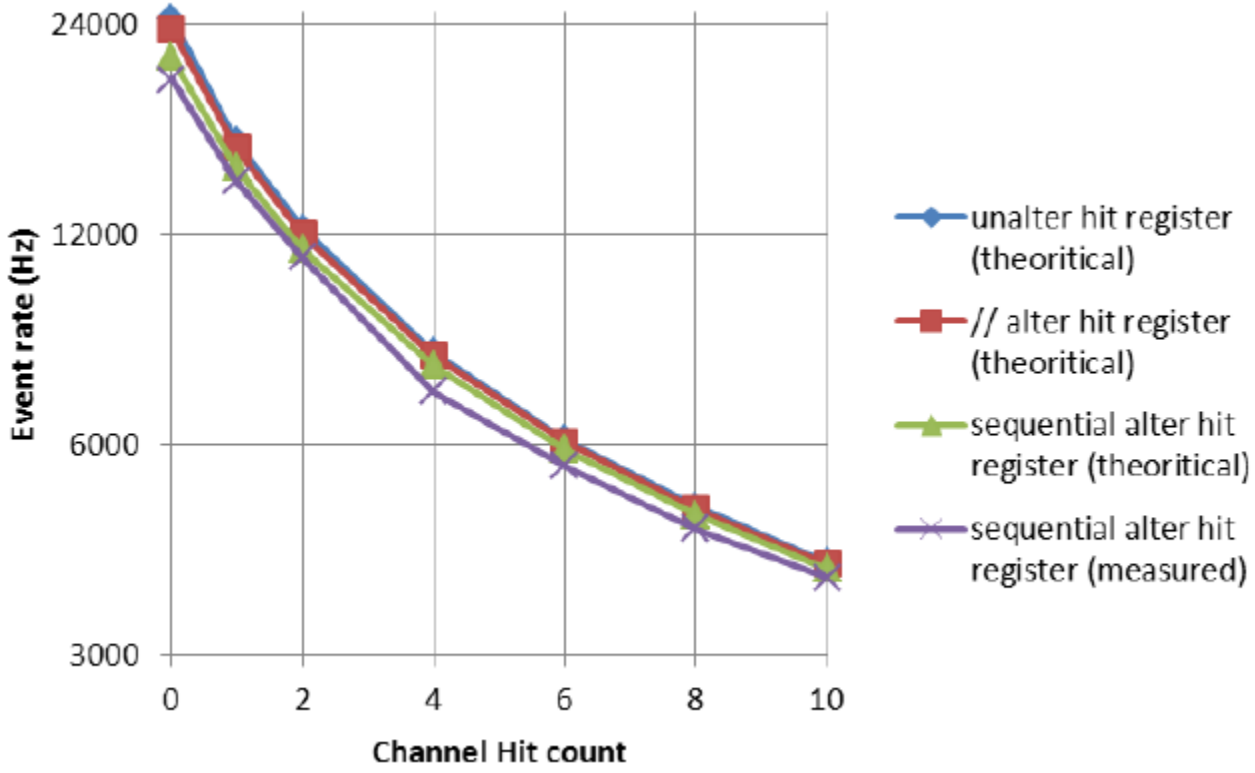


AMS CMOS 0,35 µm

- **4 charge ranges/channel :** *120 fC, 240 fC, 1 pC & 10 pC*
- **16 peaking time values :** *50 ns to 1 µs*
- **Fsampling :** *1 MHz to 100 MHz*
- **Possibility to bypass the CSA and to enter directly into the filter or SCA inputs**
- **Input current polarity :** *positive or negative*

Courtesy of P. Baron

Selective digitization : improvement of DAQ rate limit



- Digitize only the channel with hit register.
  - Most of the TPC channel have pedestal data.
  - →loss of conversion time
- Rate at 512 time-bins and 8 hit channels: 4500 Hz

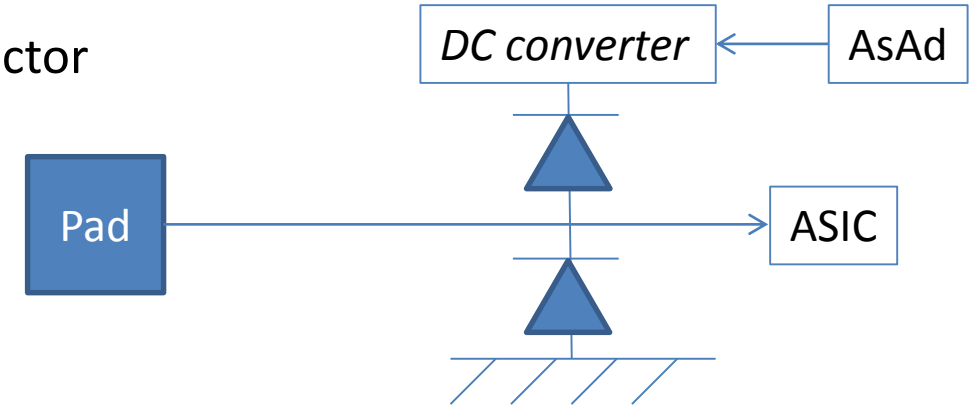
Courtesy of D. Calvet

Integration of GET electronics on SPiRIT-TPC

- Interface to TPC
  - A board to connect AsAd board to TPC has to be made by GET user.
- Interface to DAQ
  - Use need to integrate GET daq to local DAQ system so that the data taken by GET can be analyzed with the other detector information.
  - In addition, the software for the analysis of the data and the software for monitoring of TPC have to be made.
    - There are common parts which can be made as general monitoring software.
    - Temperature of the boards. Voltage and current supplied to boards.

Development of interface board: ZAP

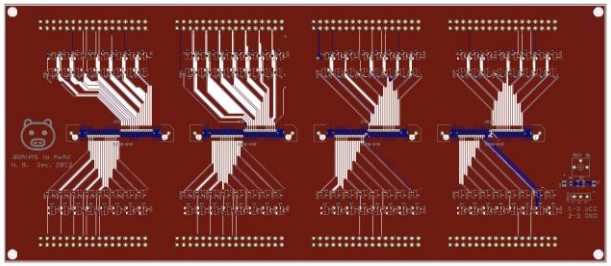
- Interface board has been developed to mount GET electronics on TPC.
  - For matching of the connector
  - Protection of the circuit

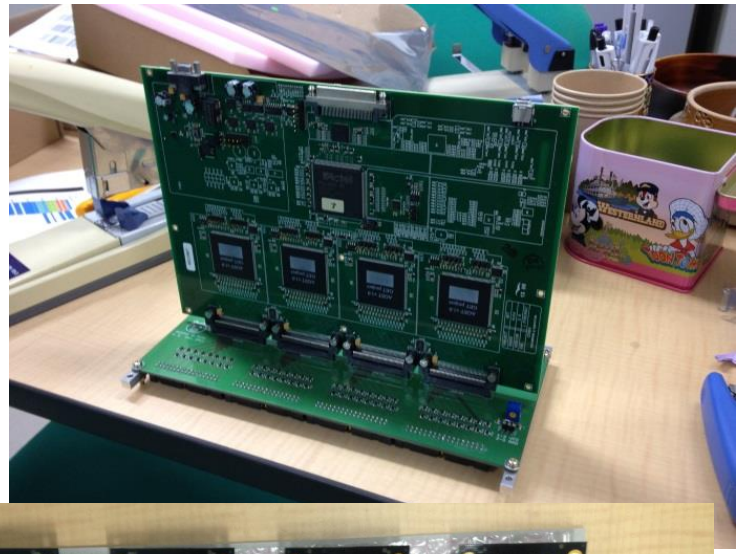


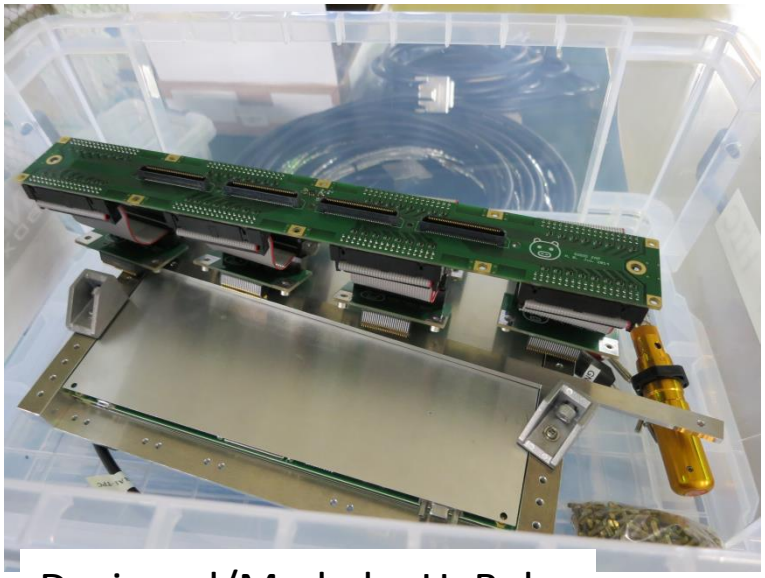
- Three issues addressed in terms of the development.
  - Space issue
    - Should be fit within 17cm. Size of AsAd is same as VME board.
  - Noise level
    - **Noise contribution is from AsAd, ZAP and TPC capacitor**
    - **Specified ADC dynamic range of 10.5 bit equates to rms noise = 2.8 ADC counts**
    - **Best Scenario: AsAd+ZAP+TPC rms ~ 3.0 ADC**
  - Transfer function (i.e. Gain)
    - Also contribution is from AsAd, ZAP and TPC capacitor

3 Interface boards were made as prototype

- 1st: for testing with smaller TPC
- 2nd: made with flexible board
  - expensive
- 3rd: rigid board (final)



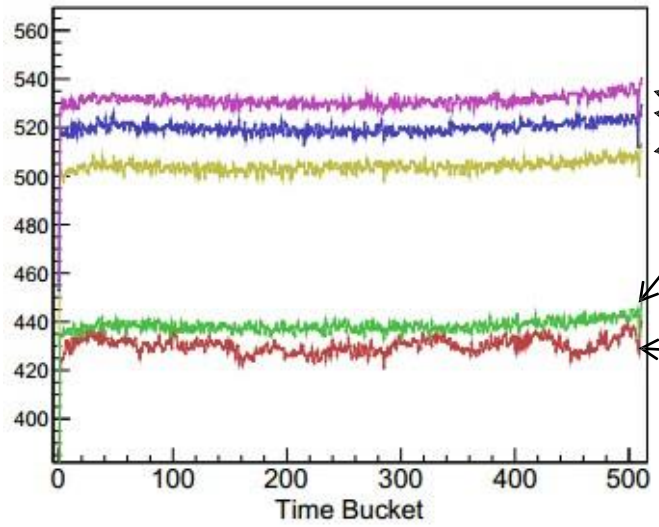




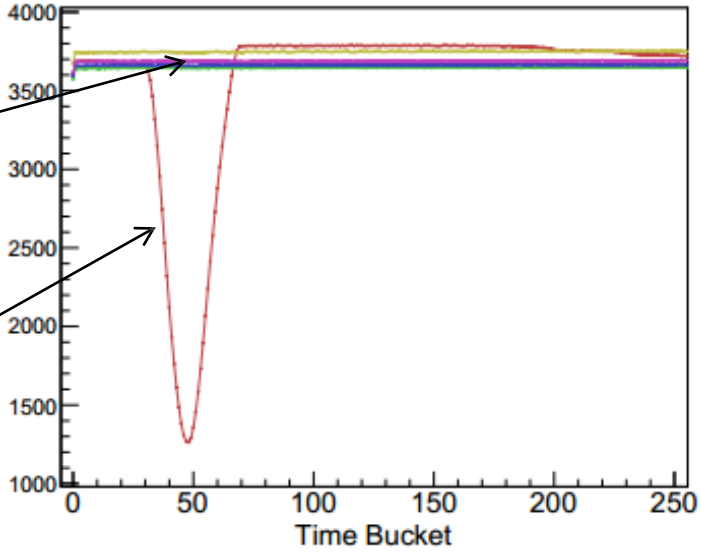
Designed/Made by H. Baba

Noise Analysis: 2nd board

Pedestal: 1 Event 5 Channels



Pulser: 1 Event 5 Channels

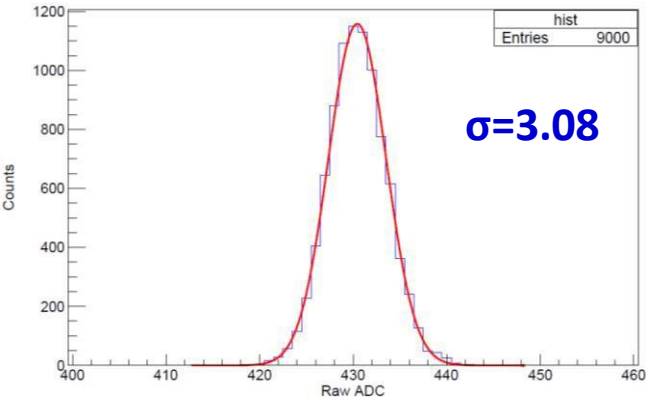


Unconnected

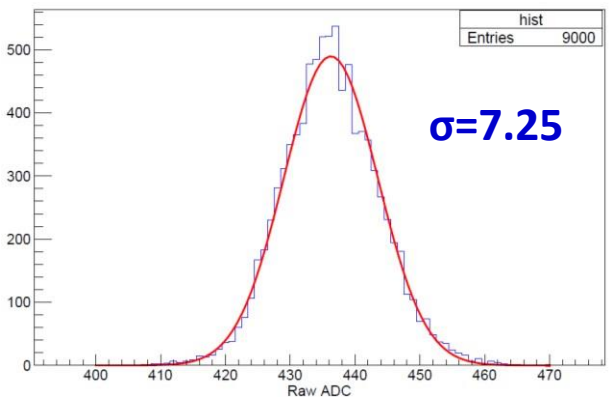
Connected

Channel 0

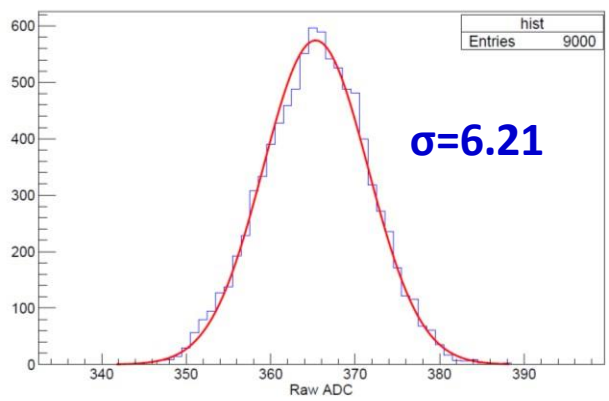
GET



GET+ZAP

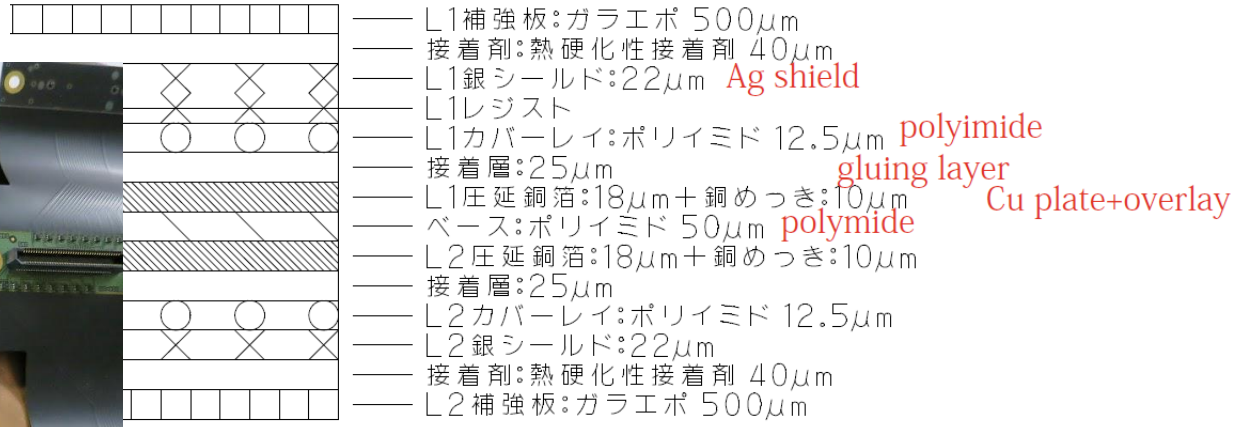


GET+ZAP+TPC



Courtesy of W. Powell

Noise shield made large noise

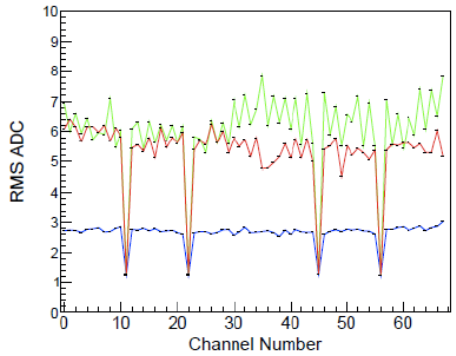


	GET	GET + ZAP	GET + ZAP + TPC
(1)RMS ADC w/ full ZAP	2.55	6.37	5.31
(2)RMS ADC w/ stripped ZAP	-	5.85	4.02

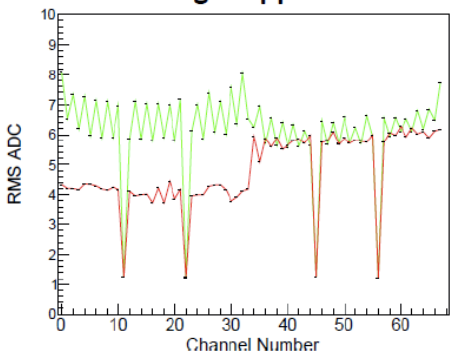
120fC, 233nsec

GET+ZAP+TPC

(1) Full ZAP



(2) 1st 34ch have ZAP shielding stripped off

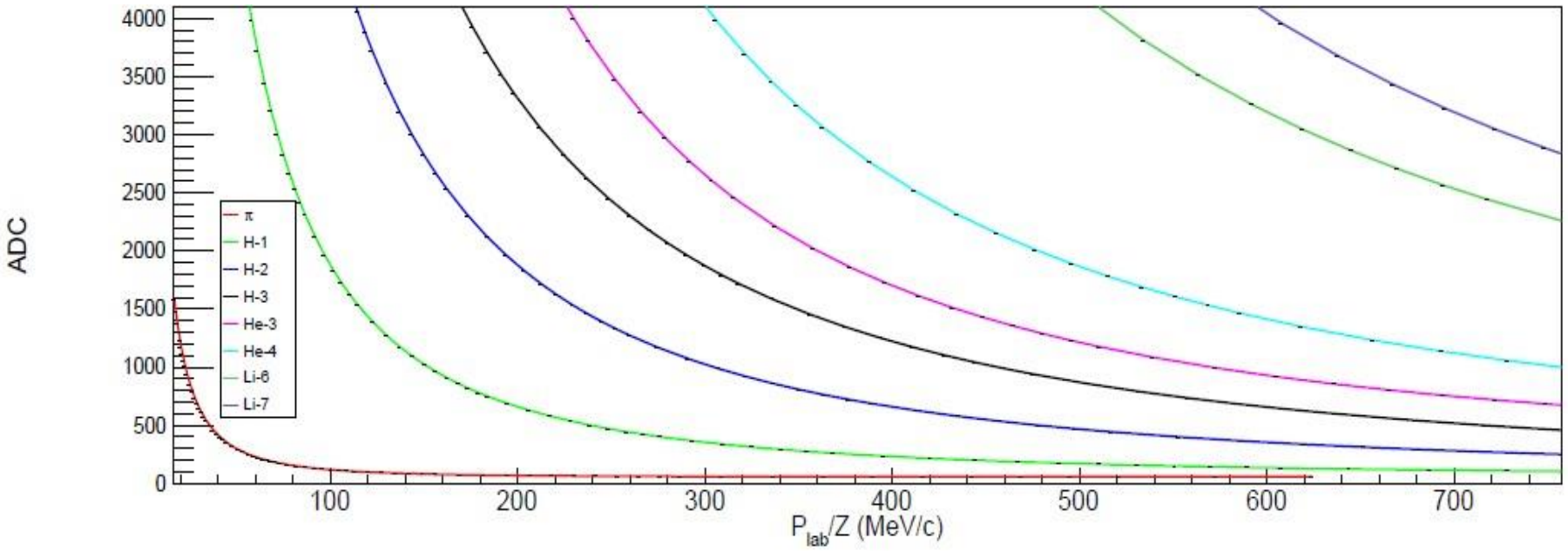


ZAP has Ag shield layer which increases the ZAP capacitance: Remove Ag layer → Reduce C_{in} → Reduce noise

Courtesy of W. Powell

Dynamic Range

- Assuming RMS = 3.1 ADC counts
- Signal:Noise = 20:1
- Minimum signal is pion with KE_{cm} = 90 MeV
- ADC = 4096 is maximum signal

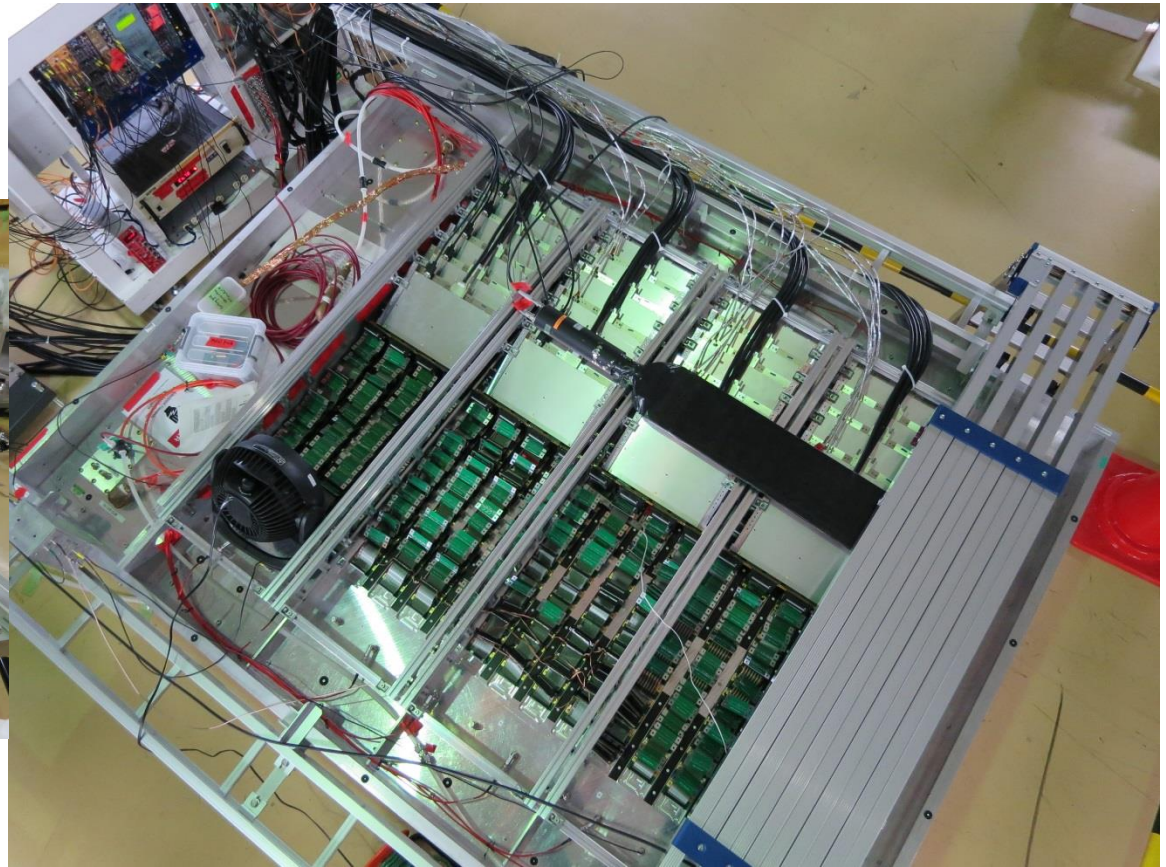


Courtesy of W. Powell

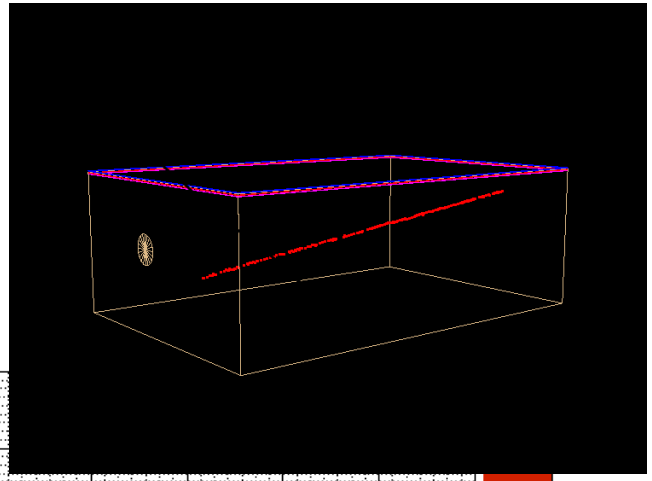
Assembly of electronics (2015, Feb.)

- Electronics for half of TPC pads were mounted.
- Trigger is made with coincidence of anode wire signals.
- Event size: 5.6MByte/eve (i.e. full readout)

AsAd fits in 17cm space!



Run157 Event82



SpiRIT Pad Plane

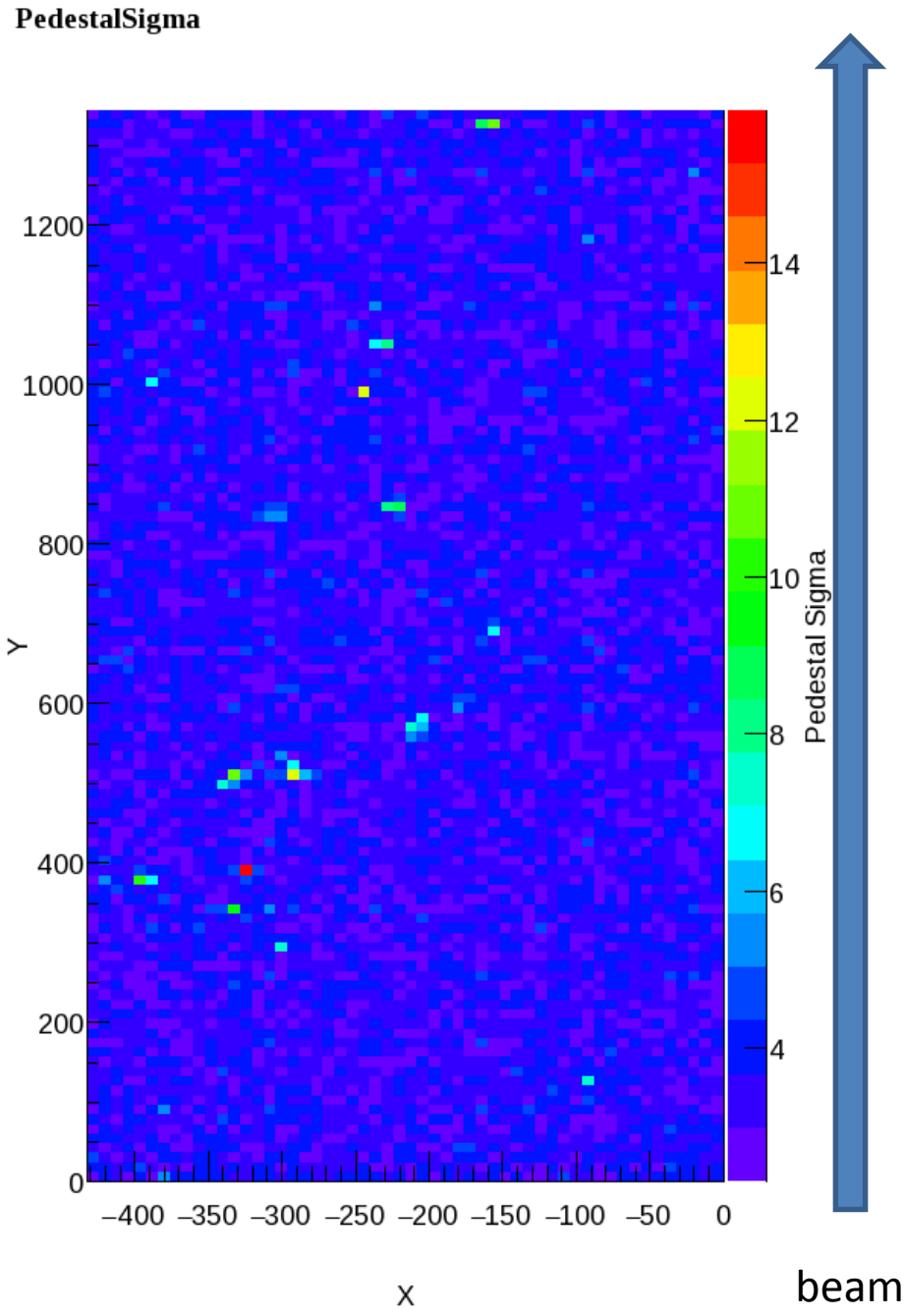
x (mm)

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

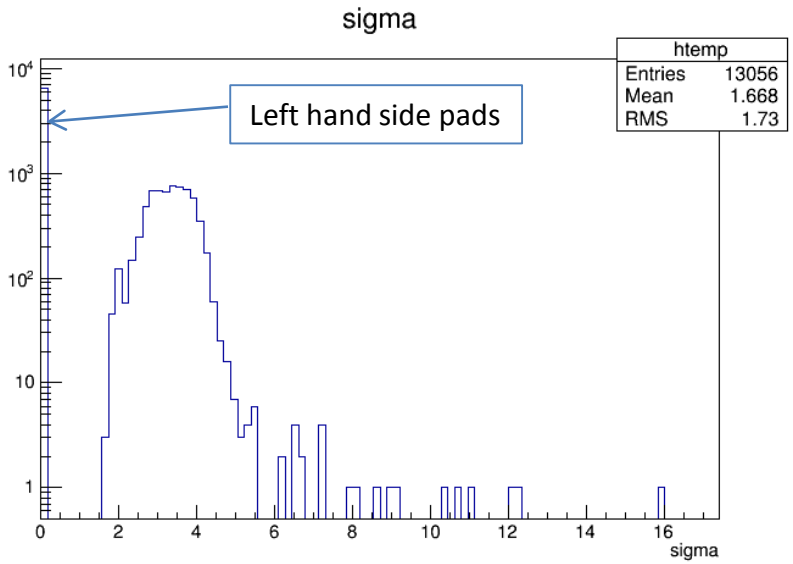
0
200
400
600
800
1000
1200

z (mm)

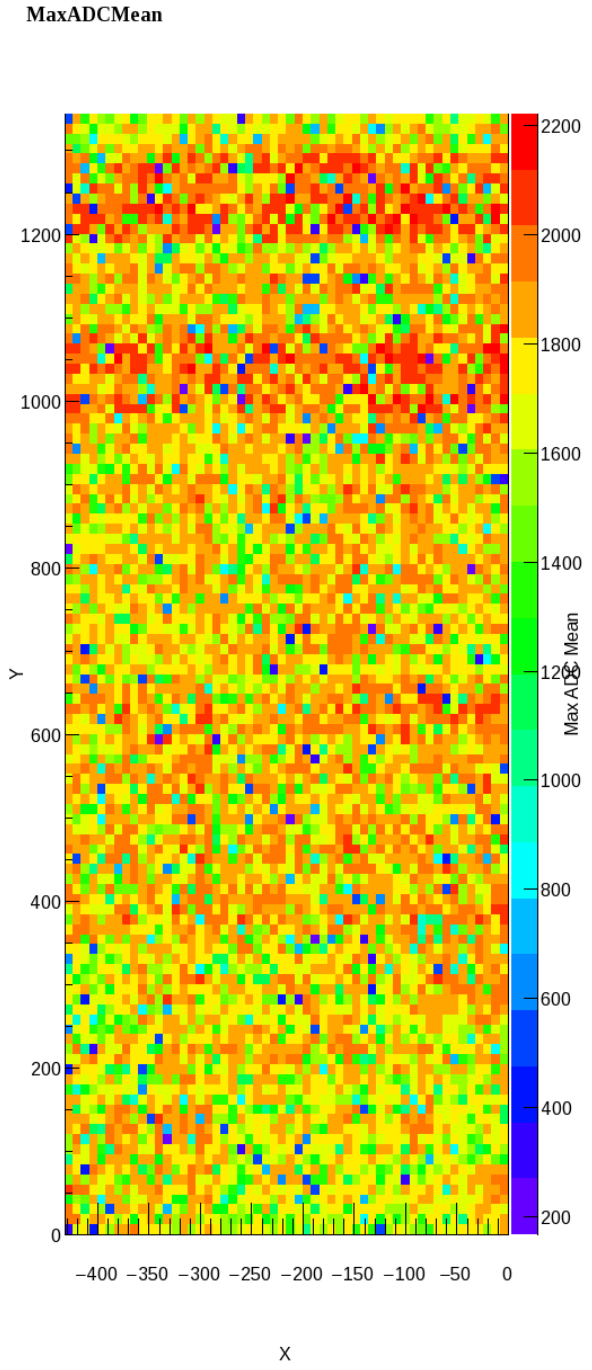
3500
3000
2500
2000
1500
1000
500
0



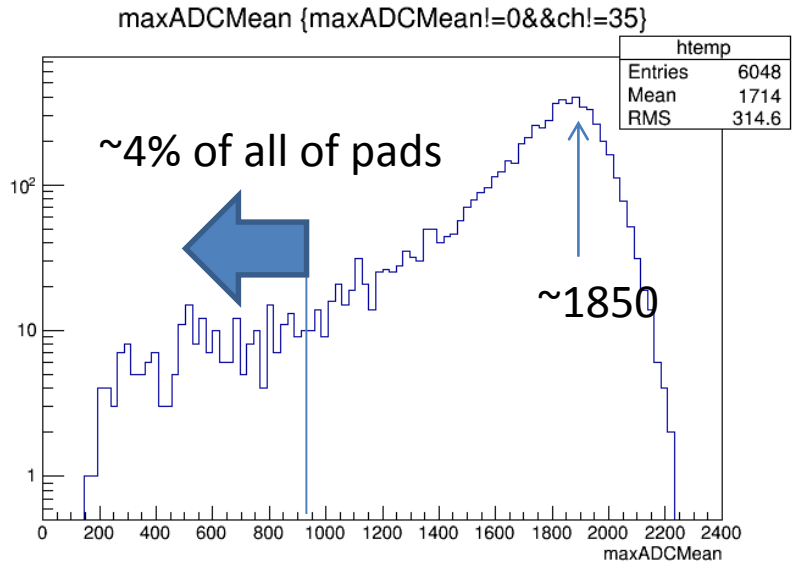
σ(pedestal)



Before FPN subtraction
Very good



Peak ADC (Pulser 3.2V)



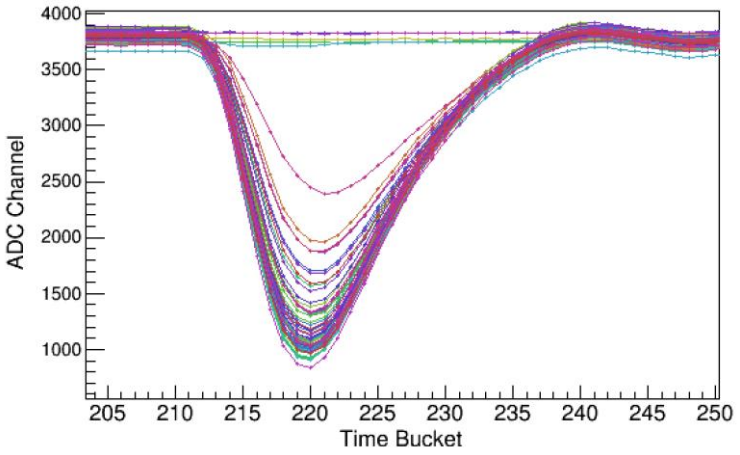
925

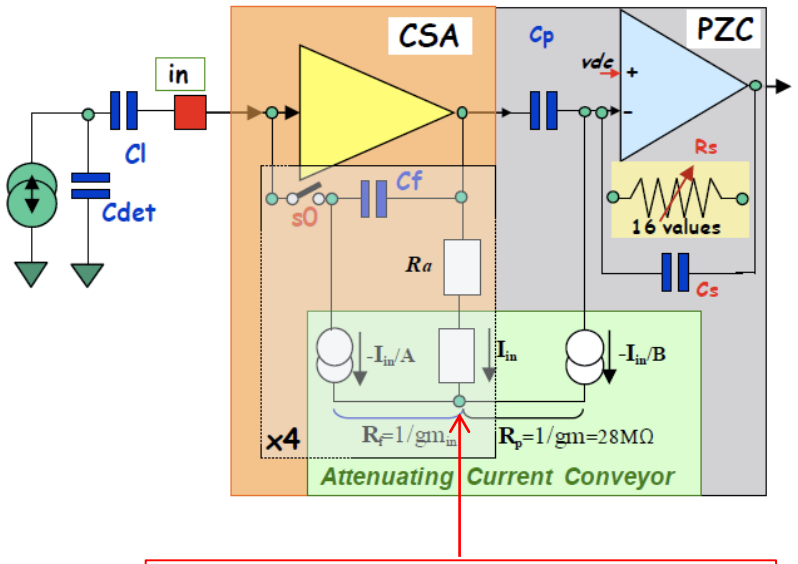
~4% of pads show the gain amplitude of less than half of that of majority

Gain deviation of the electronics

- Large gain deviation causes:
  - Bad dE resolution.
  - Bad position resolution.
  - Make it difficult to set threshold of discriminator.
- Origin of this problem is CSA output DC value.
- This problem can be fixed by replacing some components on the AsAd.
- →ongoing.

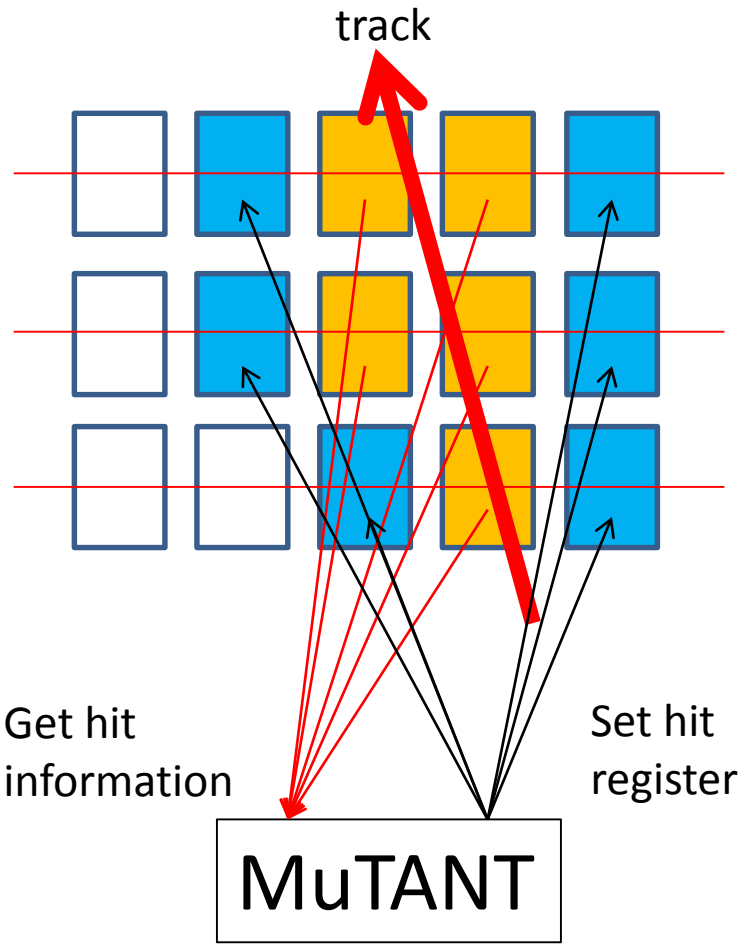
FADC data of 64 channel: 1ASIC





Configured to set the baseline

Upgrade in the future
Artificial registering hit pattern register



- Artificial registering of hit register with MuTANT.
- Easier to set the threshold of discriminator.
  - Data of neighboring pad is needed to get track position.
  - Signal of neighboring pad is smaller.
- Artificial registering should be finished within 2msec.
  - Evaluation of algorithm is necessary.

Summary

- Integration of GET electronics on SPiRIT-TPC is proceeded for the study of symmetry energy term of nuclear EoS.
- We succeeded to take cosmic(/beta-ray) data with half of pads of SPiRIT TPC.

- Massive readout of 12k channels is supposed to be ready sooner after mounting all of upgraded modules.

- First physics run: $^{132}Sn+^{124}Sn$, $^{112}Sn+^{108}Sn$

- This work is supported in part by the Japan Grant-in-Aide award and the US DOE grant DE-SC0004835 and JUSEIPEN.

SPiRIT Collaboration (2009~)

SAMURAI Pion Reconstruction and Ion-Tracker

RIKEN : T. Isobe, M. 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

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

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

INFN: G. Verde, P. Russotto

Tsinghua Univ.: Z. Xiao, R. Wang, Y. Zhang

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