Implementation of GET readout system for heavy RI collision experiment with SPiRIT-TPC at RIBF

RIKEN Nishina Center
Tadaaki Isobe for the SπRIT Collaboration

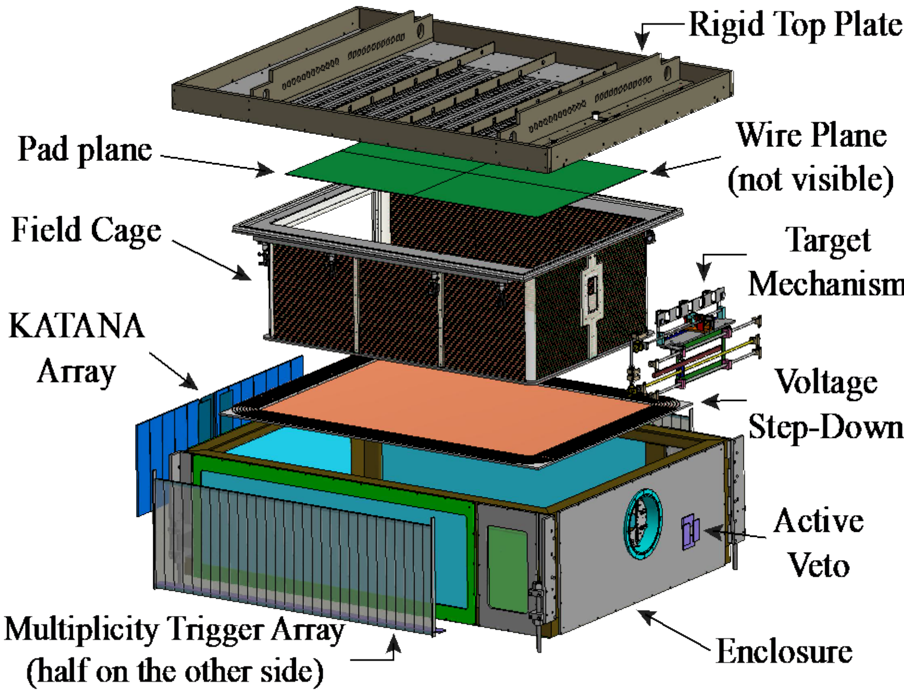
GET workshop
in Talence Bordeaux, Oct. 10th 2018

NIM A899 (2018) 43

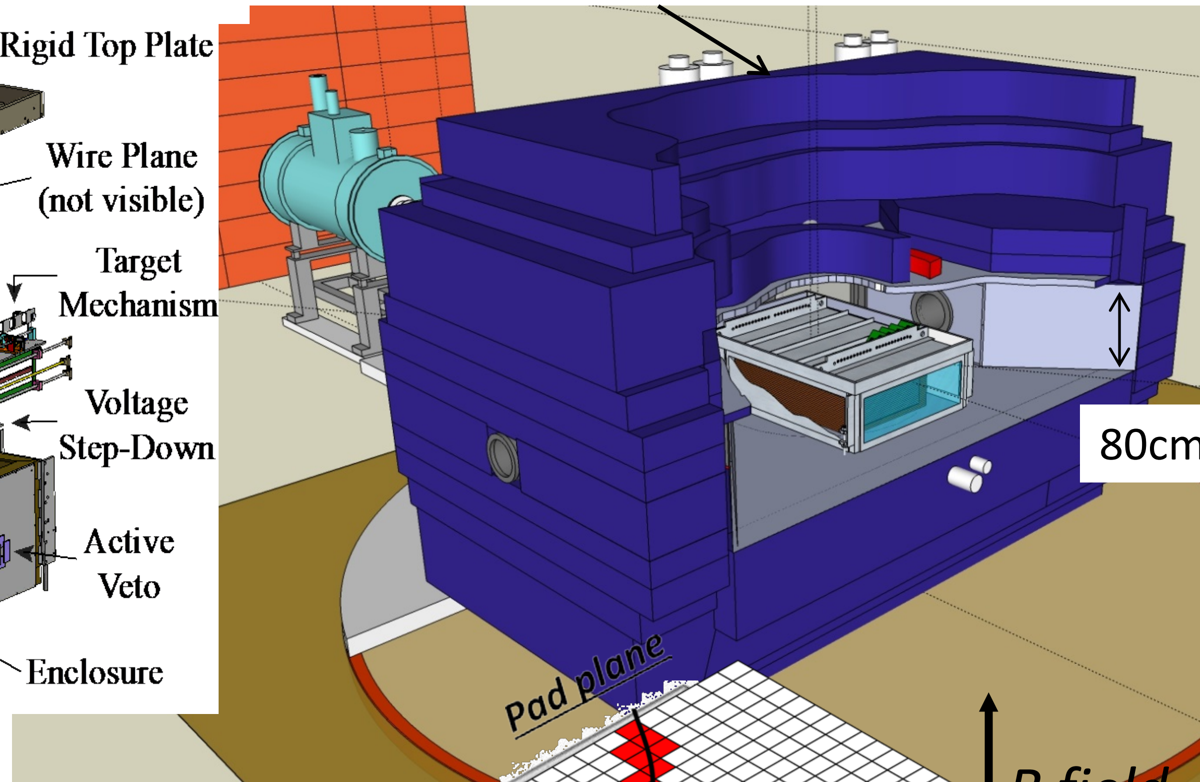
SPiRIT-TPC for HIC exp.

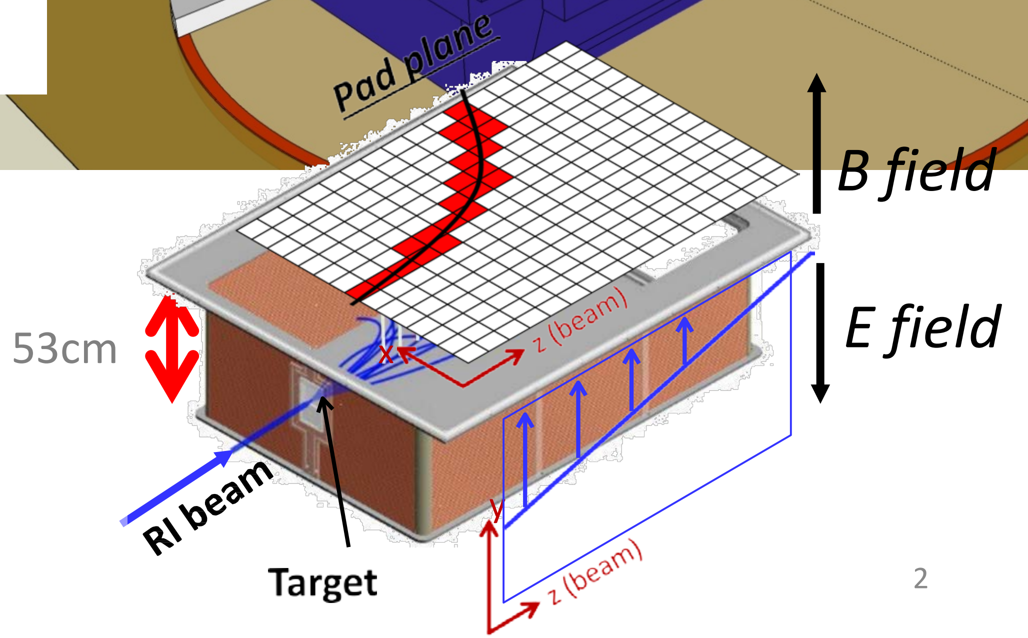
measurement of multiple charged particles

NIMA 784 (2015) 513



SAMURAI dipole magnet



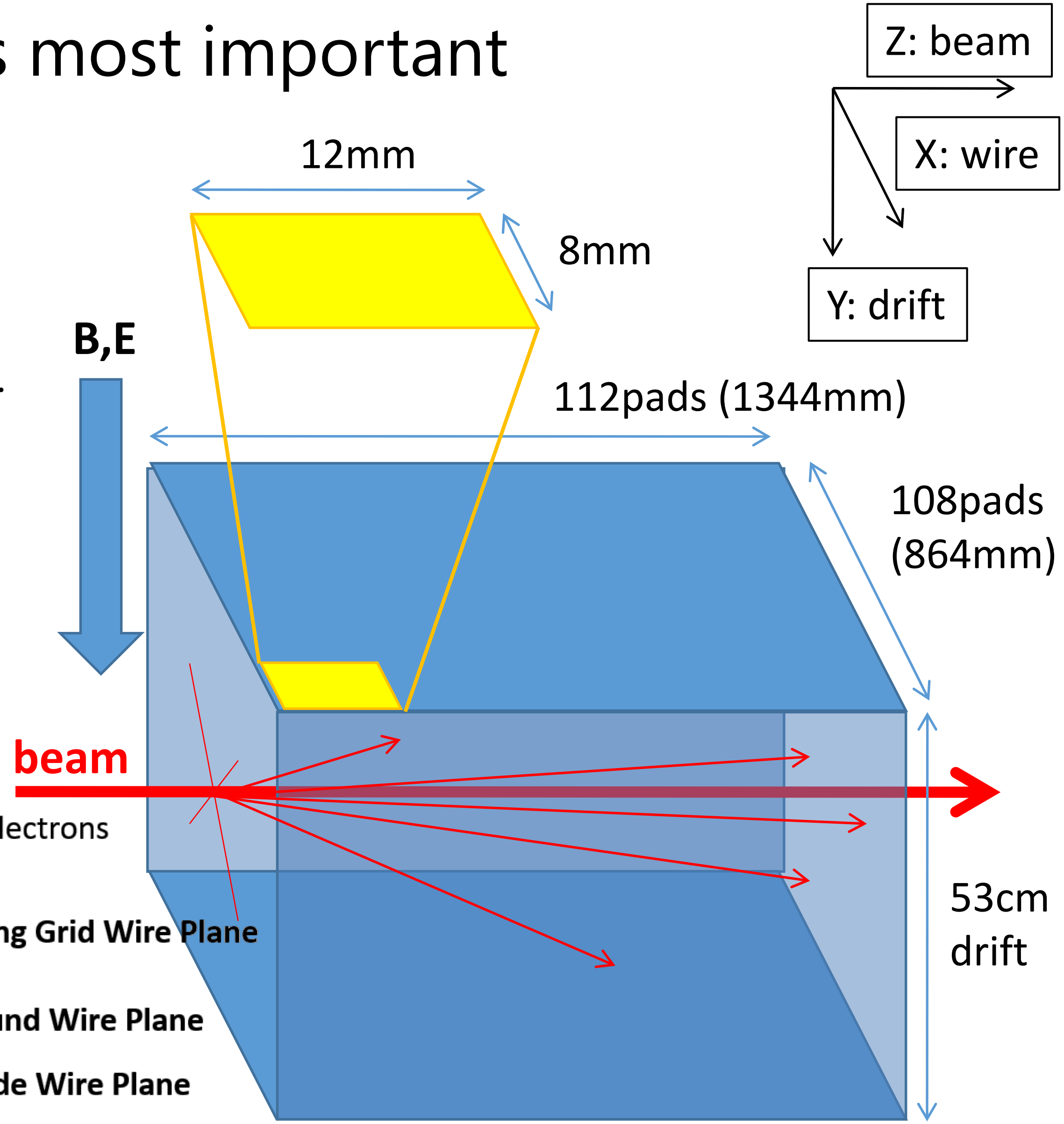


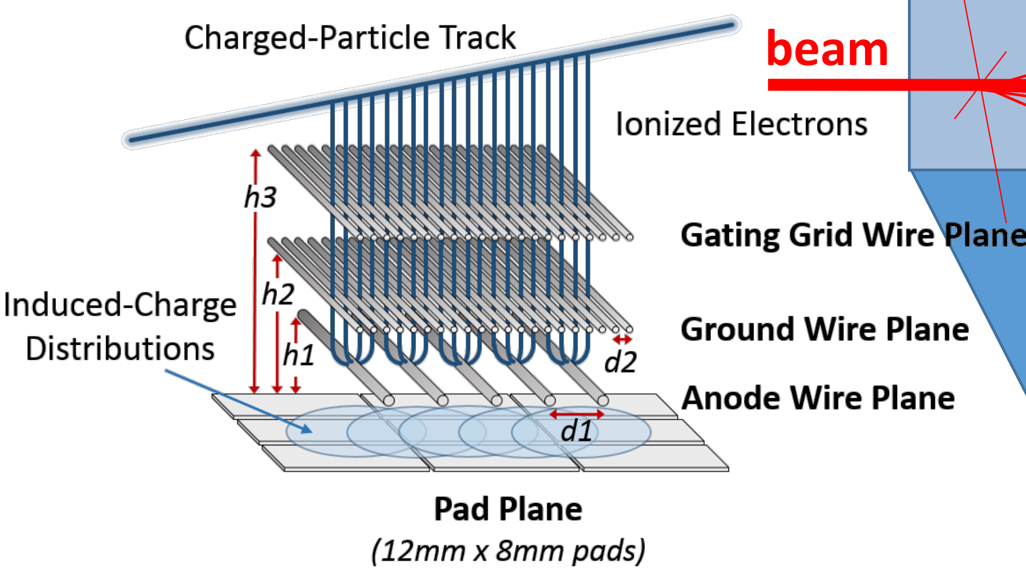
- dE/dX – Bρ particle identification.
- Readout with ~12000 pads.
- Operation under B~0.5T

Basic design of TPC
stable operation is most important

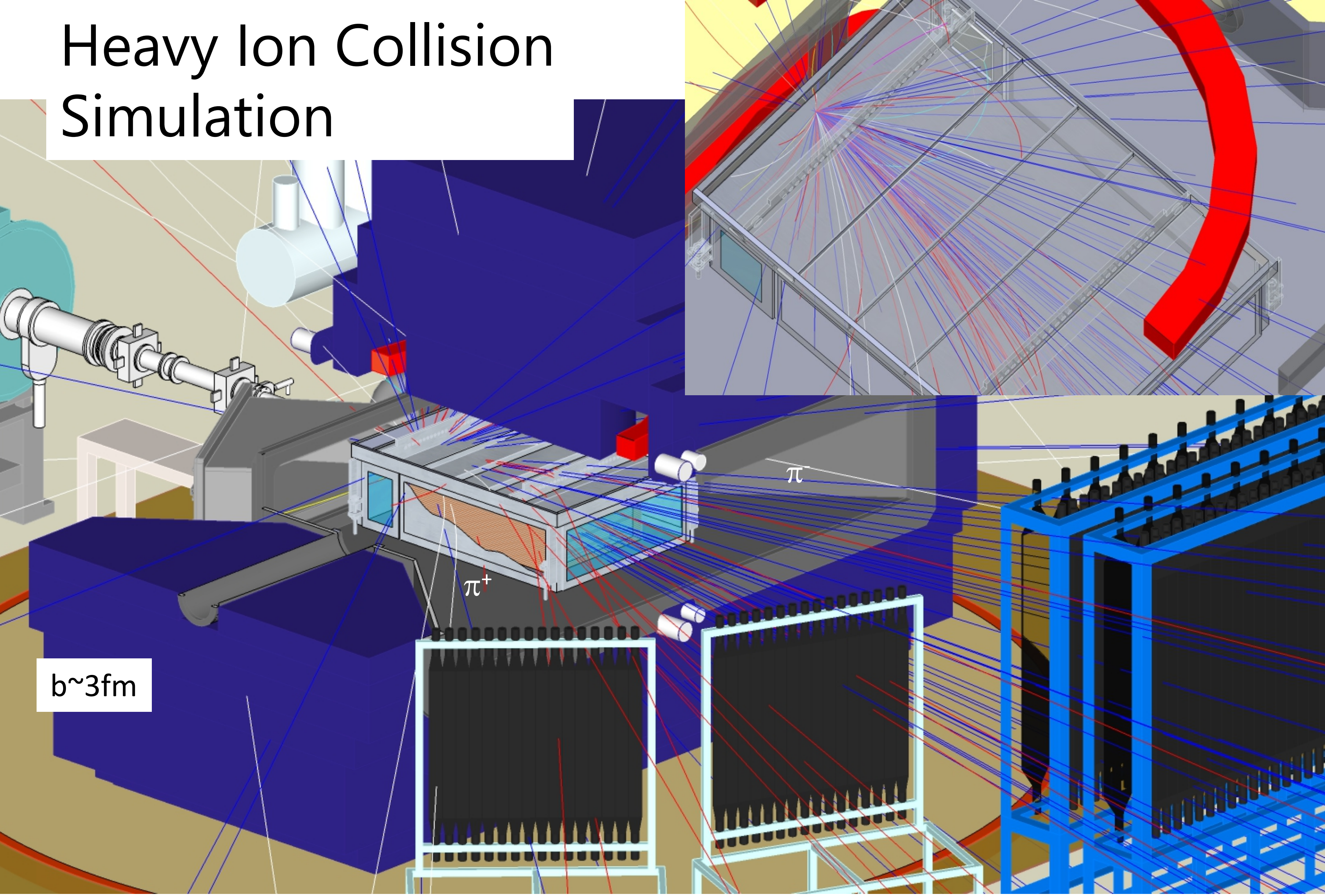
- Based on Bevalac EOS TPC.
- Wire amplification with P10 gas (1atm).
- Gating Grid
- Target at the entrance of chamber.
- ~12000 readout pads.
- Multiplicity: 10~100.

- <u>Beam passes through chamber as well.</u>



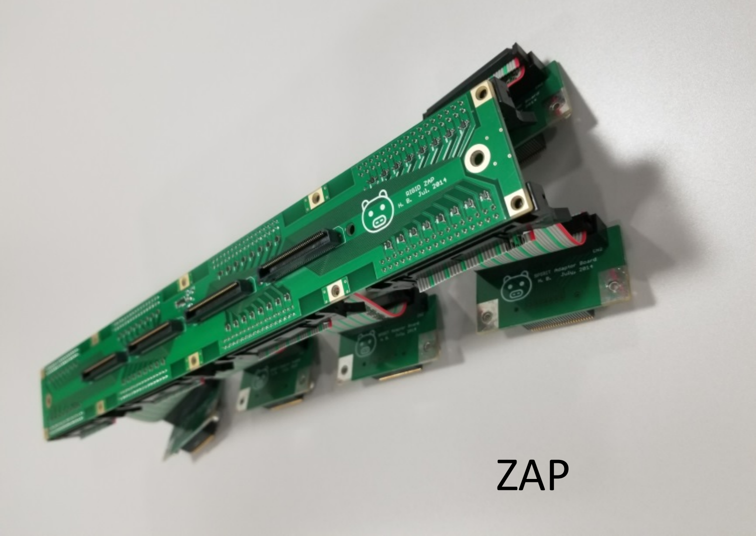


Heavy Ion Collision Simulation

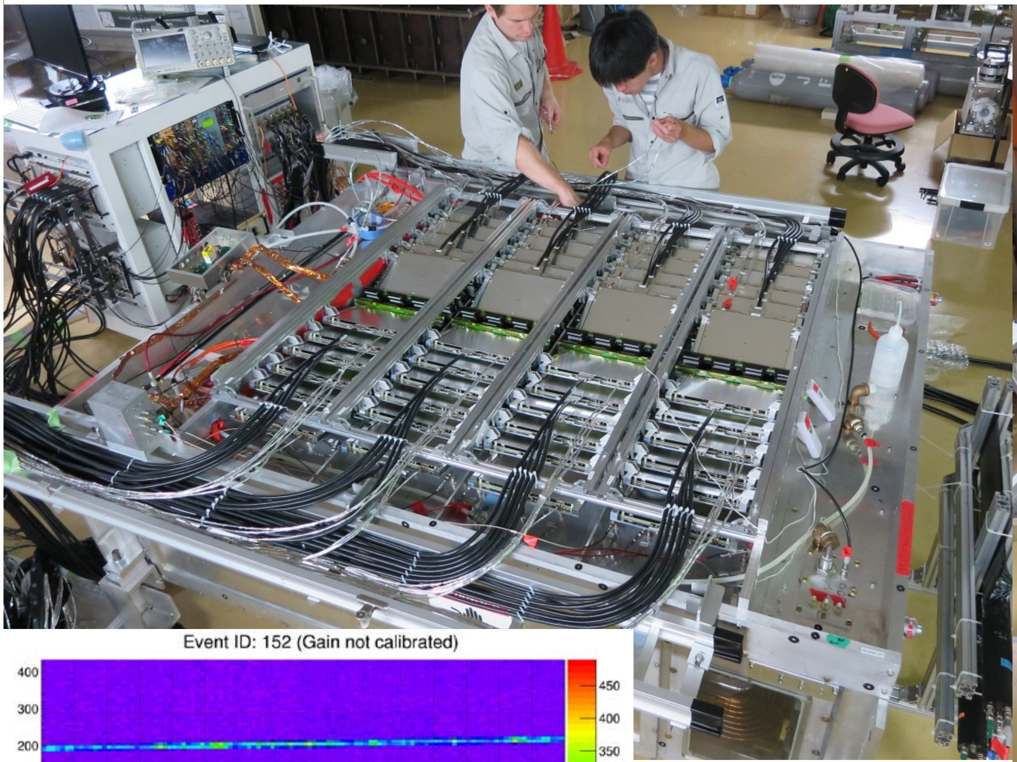


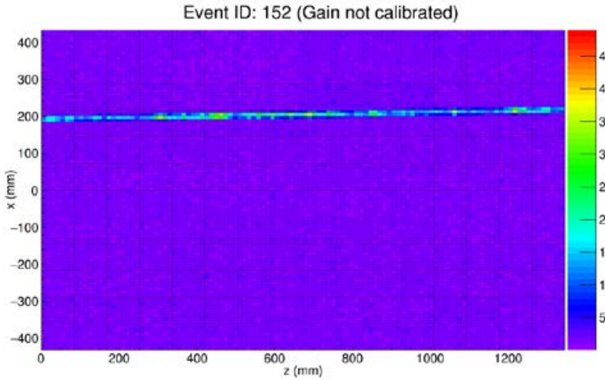
GET on SPiRIT-TPC

- 48 AsAd, 12 CoBo, 2 Mutant, 2 μ-TCA crate
- 2015 Aug.: Installation of electronics finished



ZAP



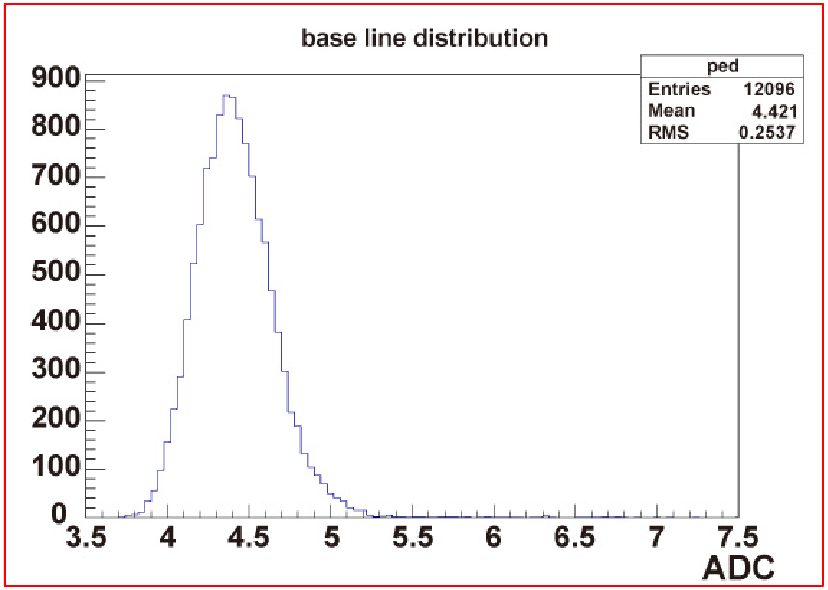


First cosmic measured by SPiRIT-TPC + GET

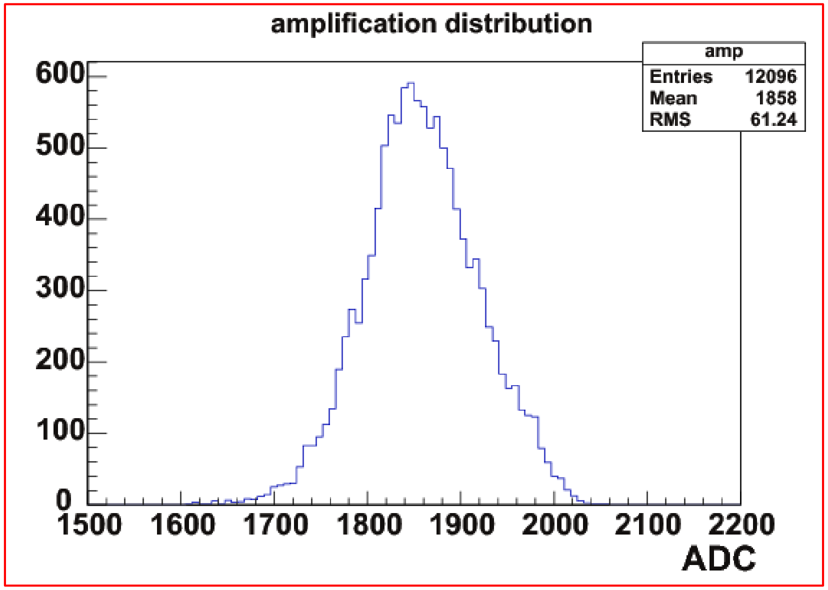
High gain, short shaping time
for large number of light particle measurement

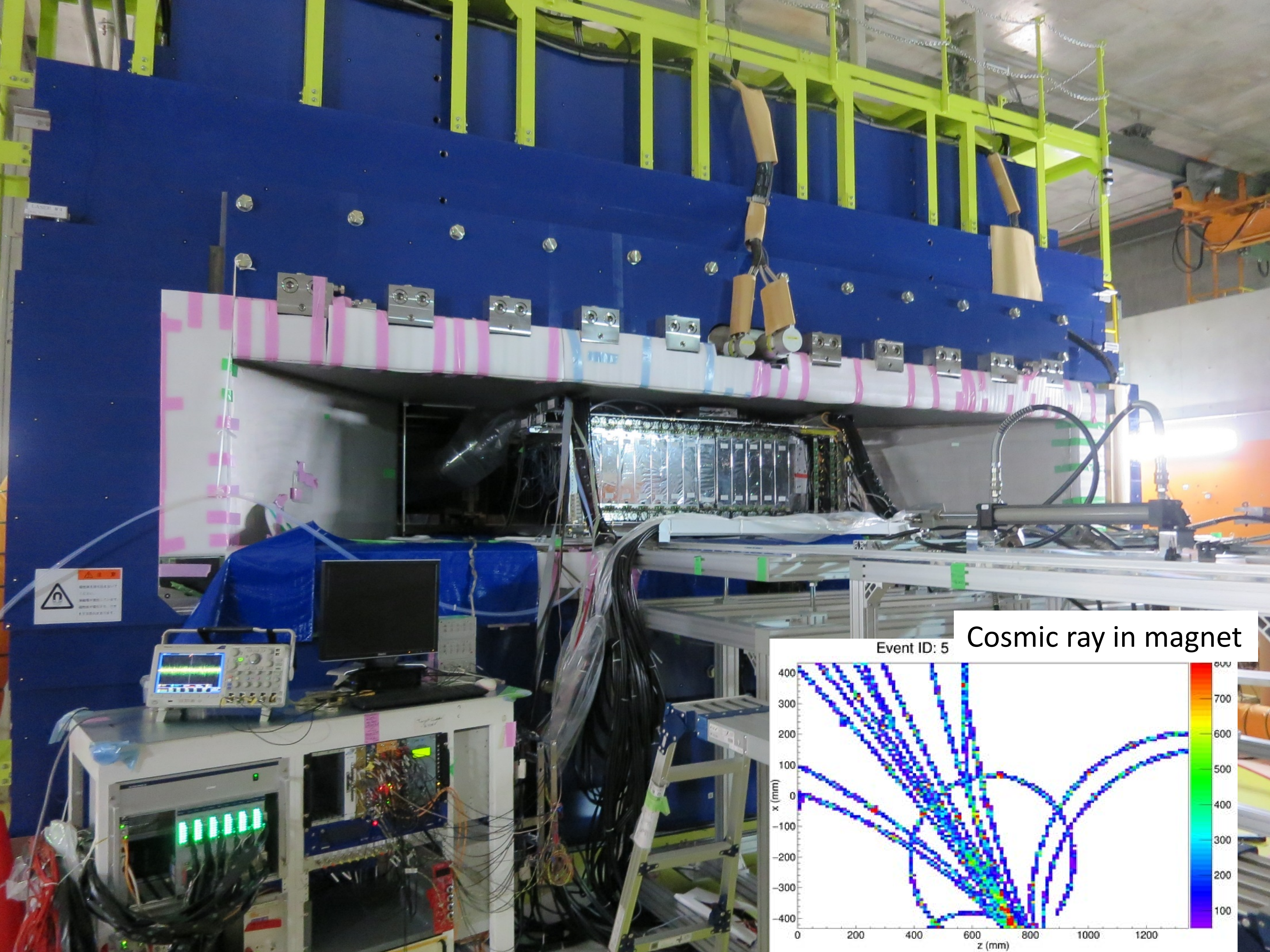
120fC gain, 117ns dynamic range, 25MHz sampling rate

Pedestal RMS for all of pads



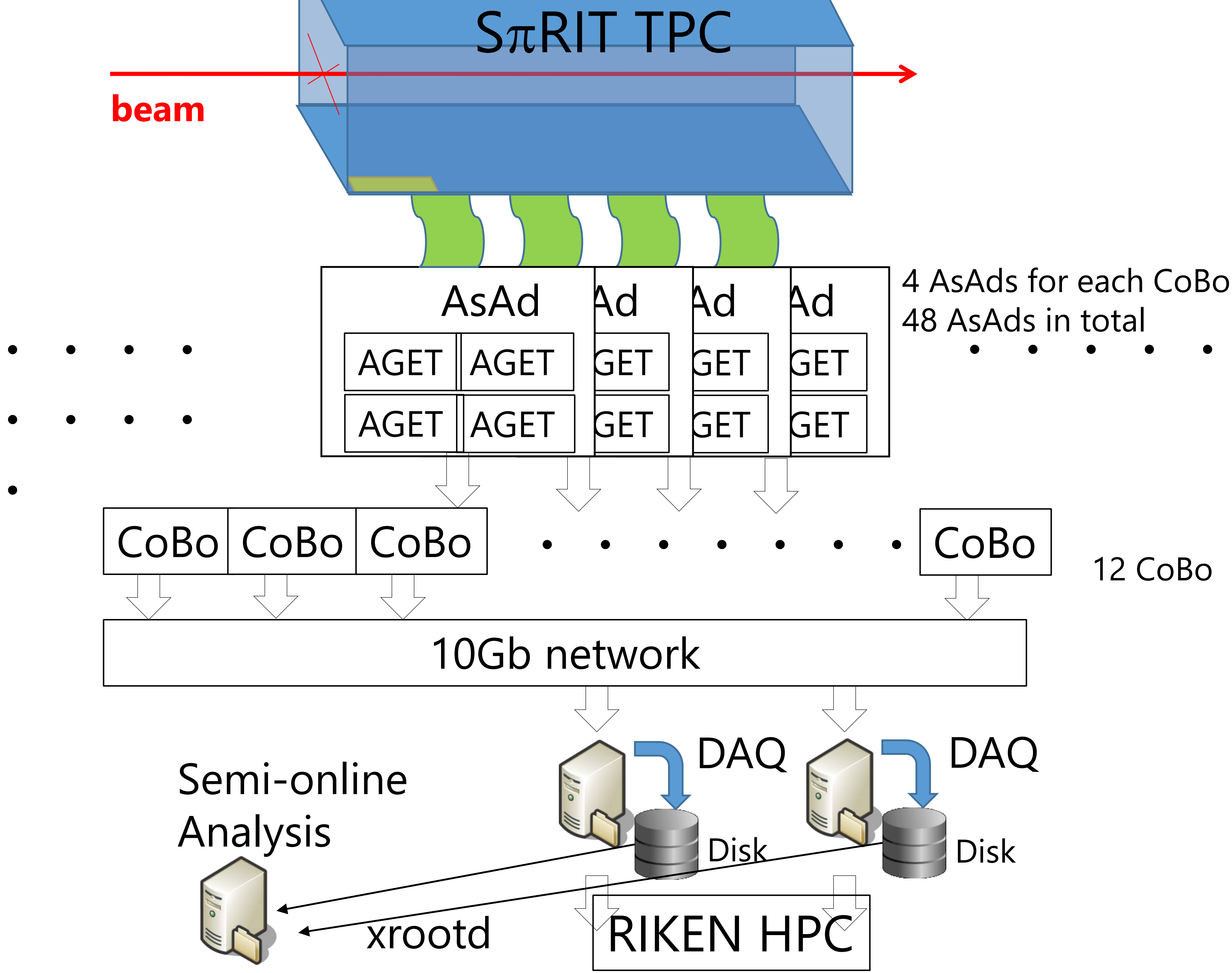
Gain (height of pulser) distribution




Cosmic ray in magnet
Event ID: 5
x (mm)
z (mm)
400
300
200
100
0
−100
−200
−300
−400
0
200
400
600
800
1000
1200
700
600
500
400
300
200
100

Cleaning up experimental area

5 sec./frame. No cut ! It was ~2.5 hour.



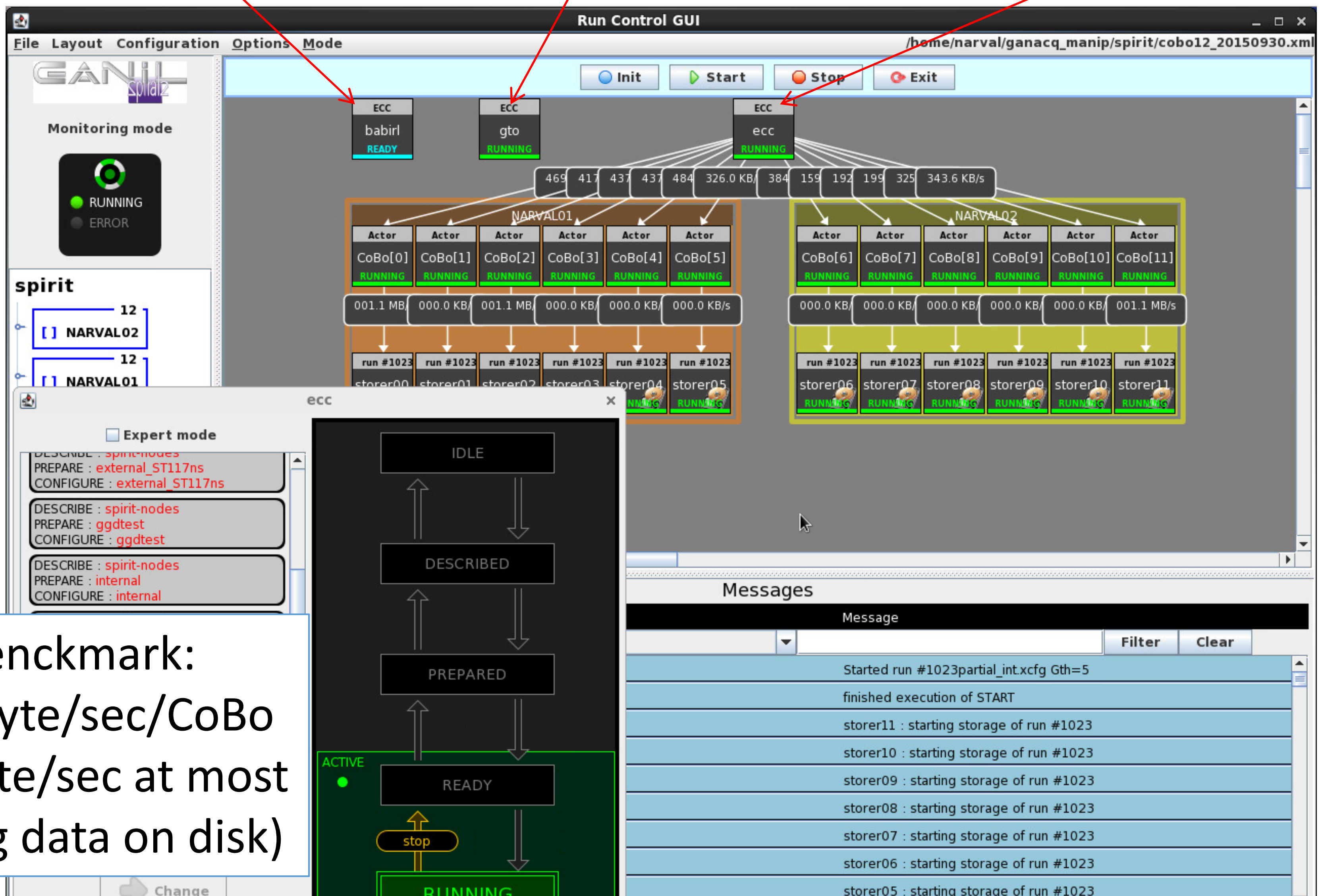
SπRIT TPC
beam
4 AsAds for each CoBo:
48 AsAds in total
AsAd
Ad
Ad
Ad
AGET
AGET
AGET
AGET
GET
GET
GET
GET
GET
GET
CoBo
CoBo
CoBo
CoBo
12 CoBo
10Gb network
DAQ
DAQ
Disk
Disk
Semi-online
Analysis
xrootd
RIKEN HPC

Control UI : GANIL RC

SOAP Server to control GTO

SOAP Server to control GET

SOAP Server to control other DAQ



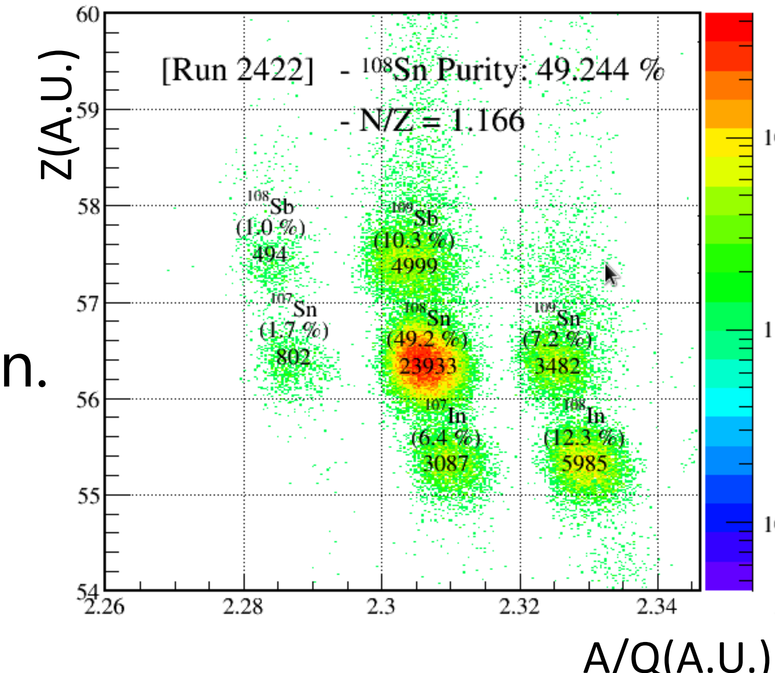
DAQ benckmark:
100MByte/sec/CoBo
1.2GByte/sec at most
(writing data on disk)

Dayone Heavy RI Collision experiment

- Systematic measurements in heavy RI collisions in same *Z* (Z=50) but different *N* system.
  - Charged pion is main observable. → TPC gain is relatively higher.

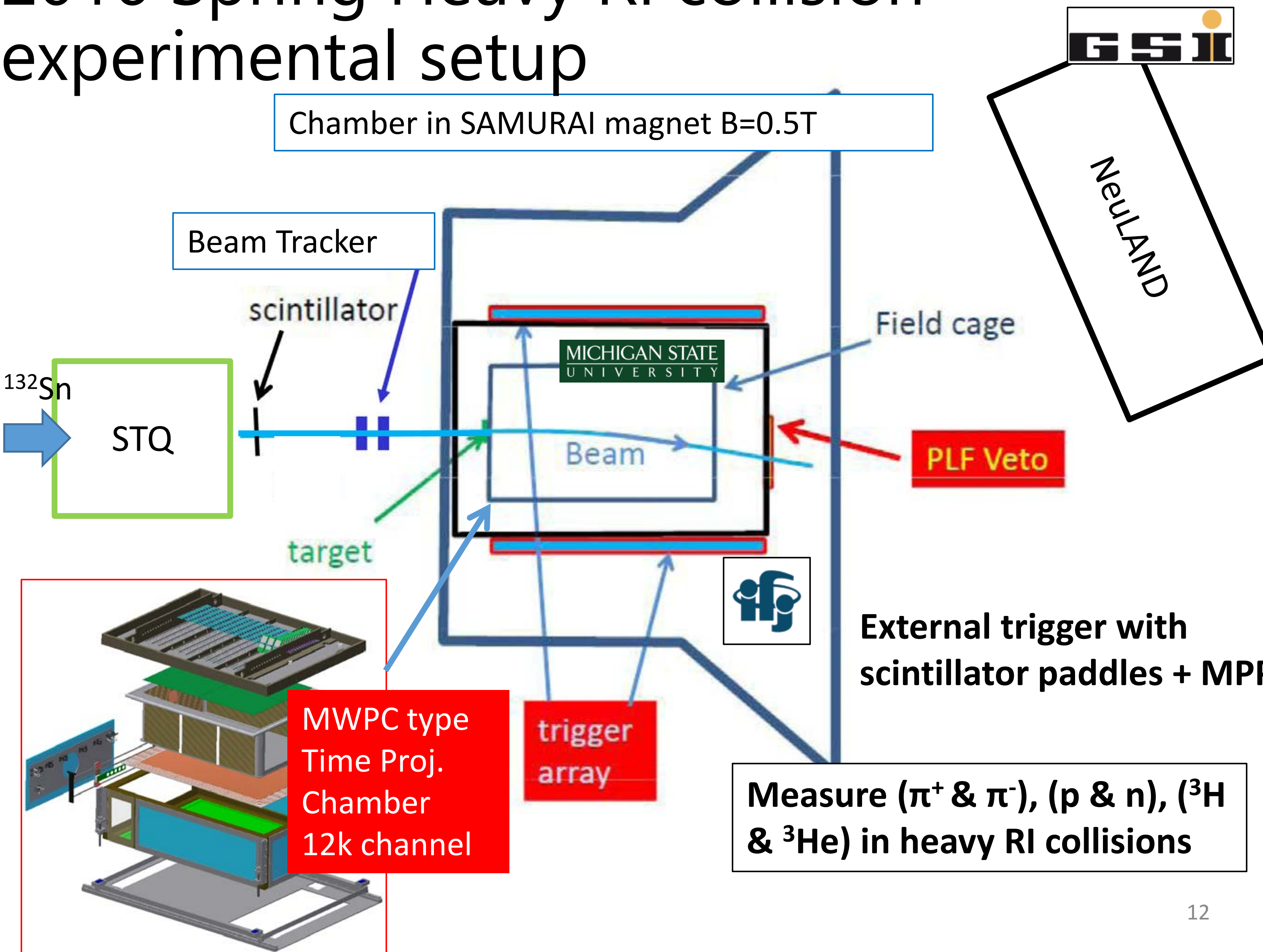
Primary	Beam	Target	E_{beam}/A	$(N\text{-}Z/A)_{sys}$
^{238}U	^{132}Sn	^{124}Sn	270	0.22
	^{124}Sn	^{112}Sn	270	0.15
^{124}Xe	^{108}Sn	^{112}Sn	270	0.09
	^{112}Sn	^{124}Sn	270	0.15

Beam PID



- Successfully finished. 2016 Apr. – Jun.
  - Beam rate: 10kHz, trig. rate: 70Hz
  - 30M Events: 60Hz, 5MB/eve →300MB/sec
  - 250TB/2week
  - No partial readout, No zero-suppress
  - We can compress the data size only to 30% in the case of partial readout.

2016 Spring Heavy RI collision experimental setup



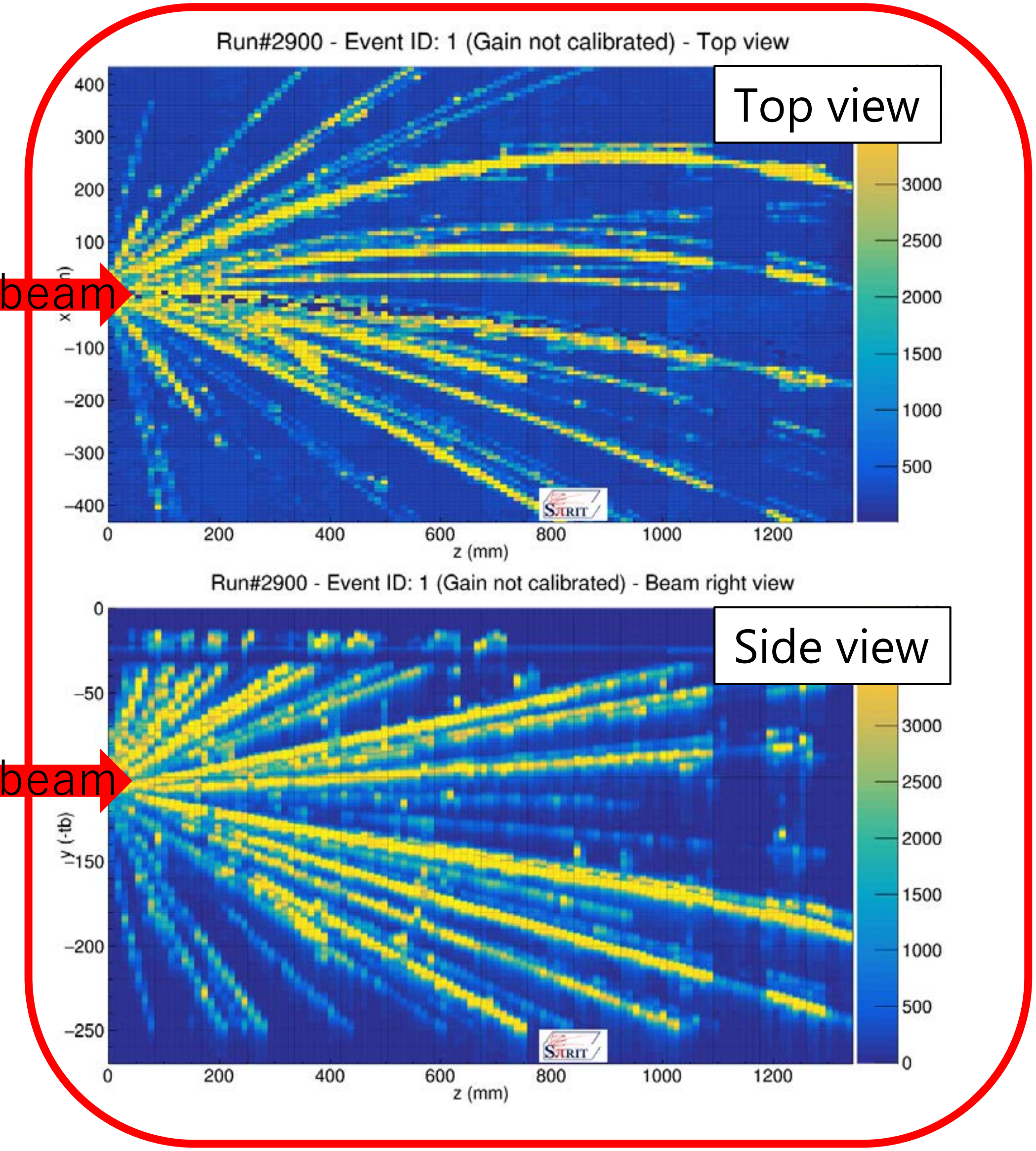
External trigger with scintillator paddles + MPPC

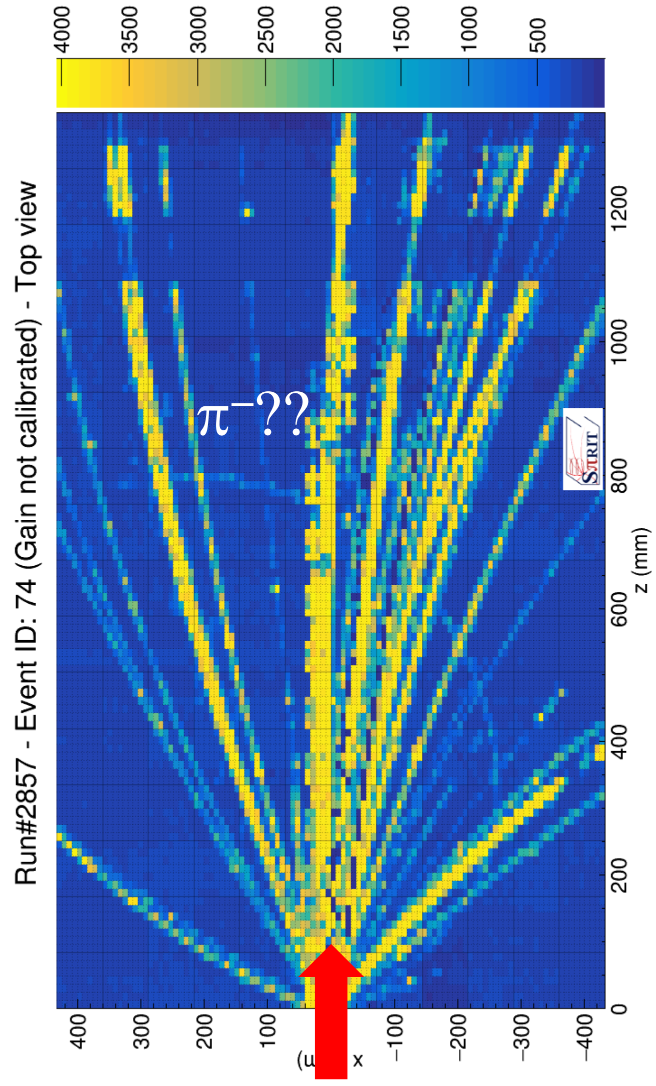
Measure (π^+ & π^-), (p & n), (^{3}H & ^{3}He) in heavy RI collisions

Combined DAQ: RIBF-DAQ + GET

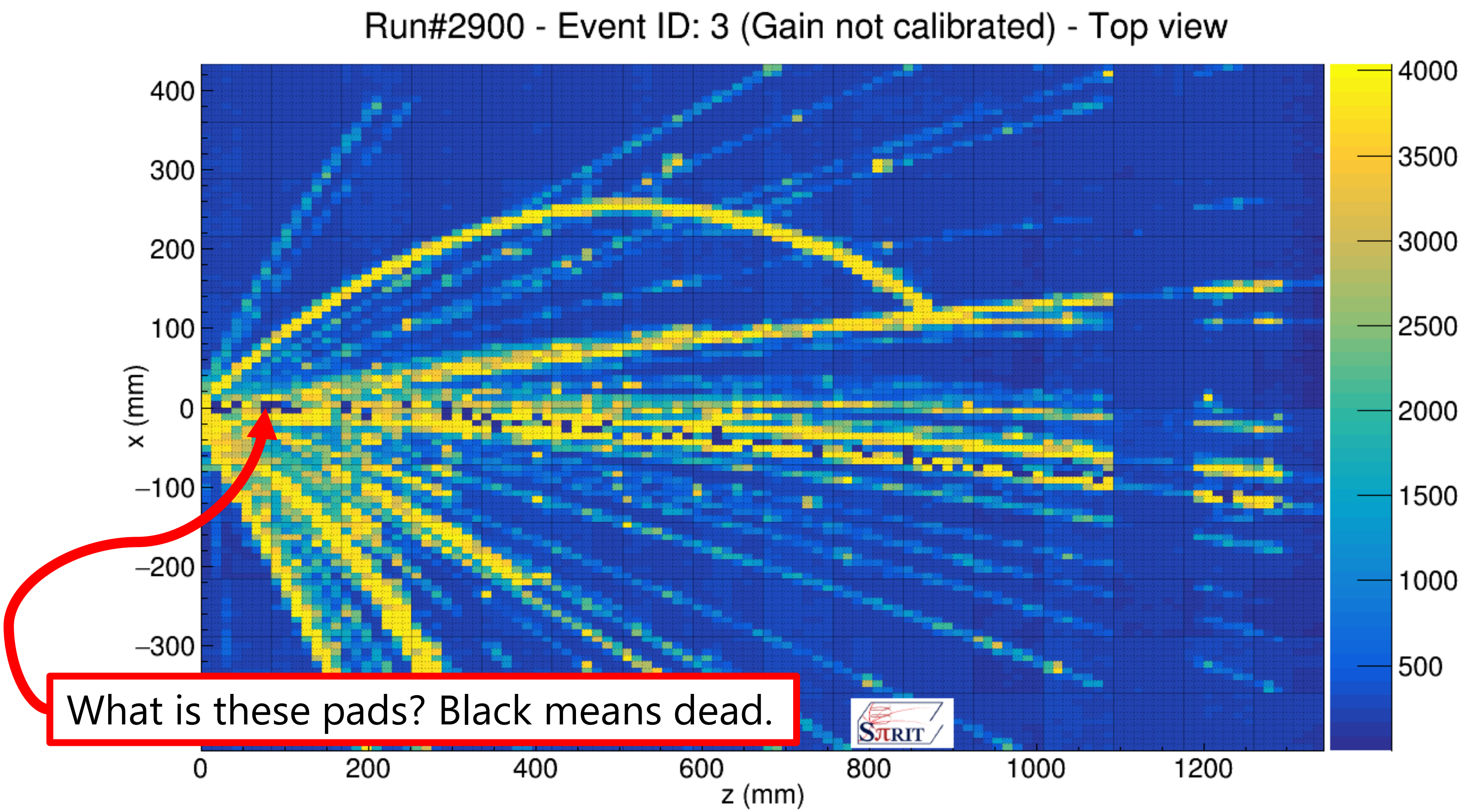
- Realized with common trigger
- Total dead time: 2~3ms
  - TPC-GET: 0.8 msec
    - Much longer in the case of more than 100Hz trigger rate because of full buffer in CoBo.
      - Data size/eve: 4(aget)x68(ch)x270(tb)x2x48(asad) = 7050240B ~ 7MB/eve
      - 256MByte RAM on CoBo : buffer for 36 events
  - Katana(CAEN V1730): 2~3msec
  - BigRIPS plastic (V1290): ~300 μsec
  - BigRIPS PPAC VME (V1190): ~100 μsec
  - IC (peak ADC) 100 μsec
  - BDC beam tracker (TDC): ~120 μsec
  - NeuLAND: ~100 μsec

Example of HIC events seen by TPC



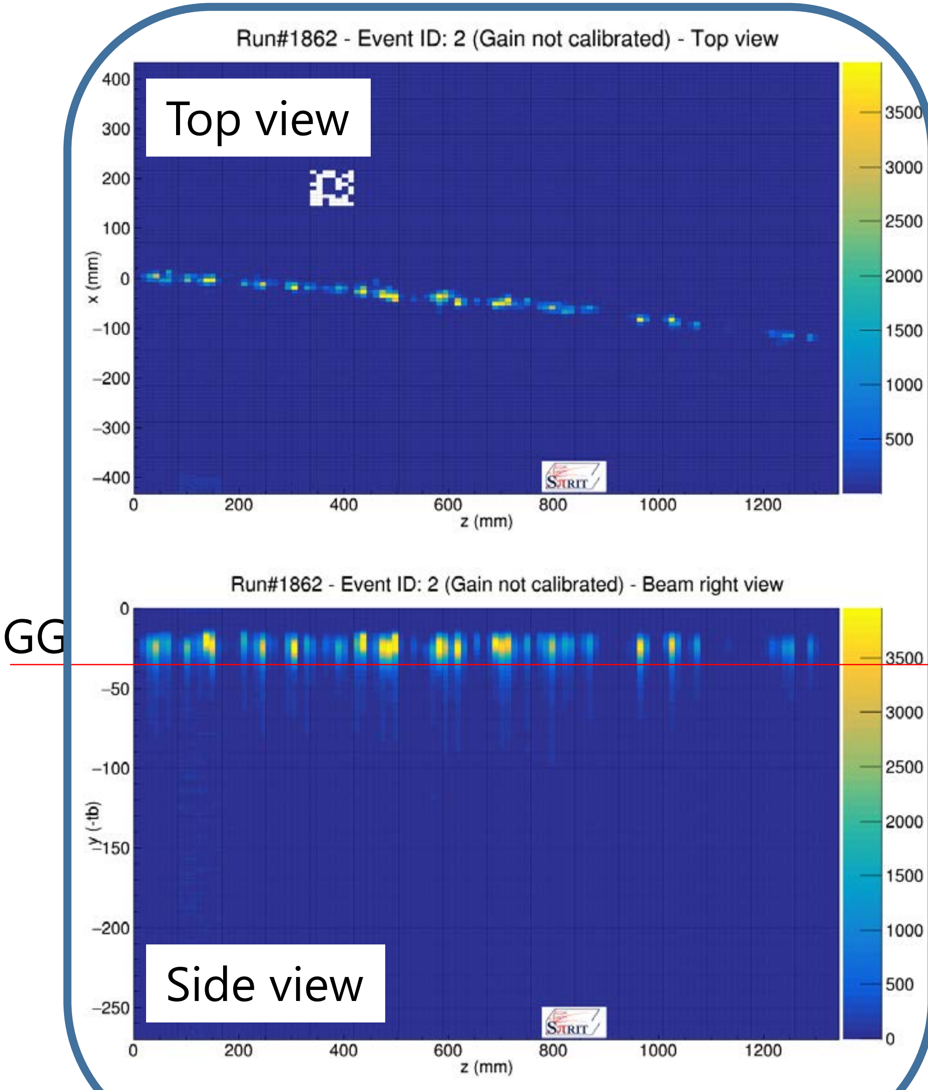


Dead channels along beam trajectory

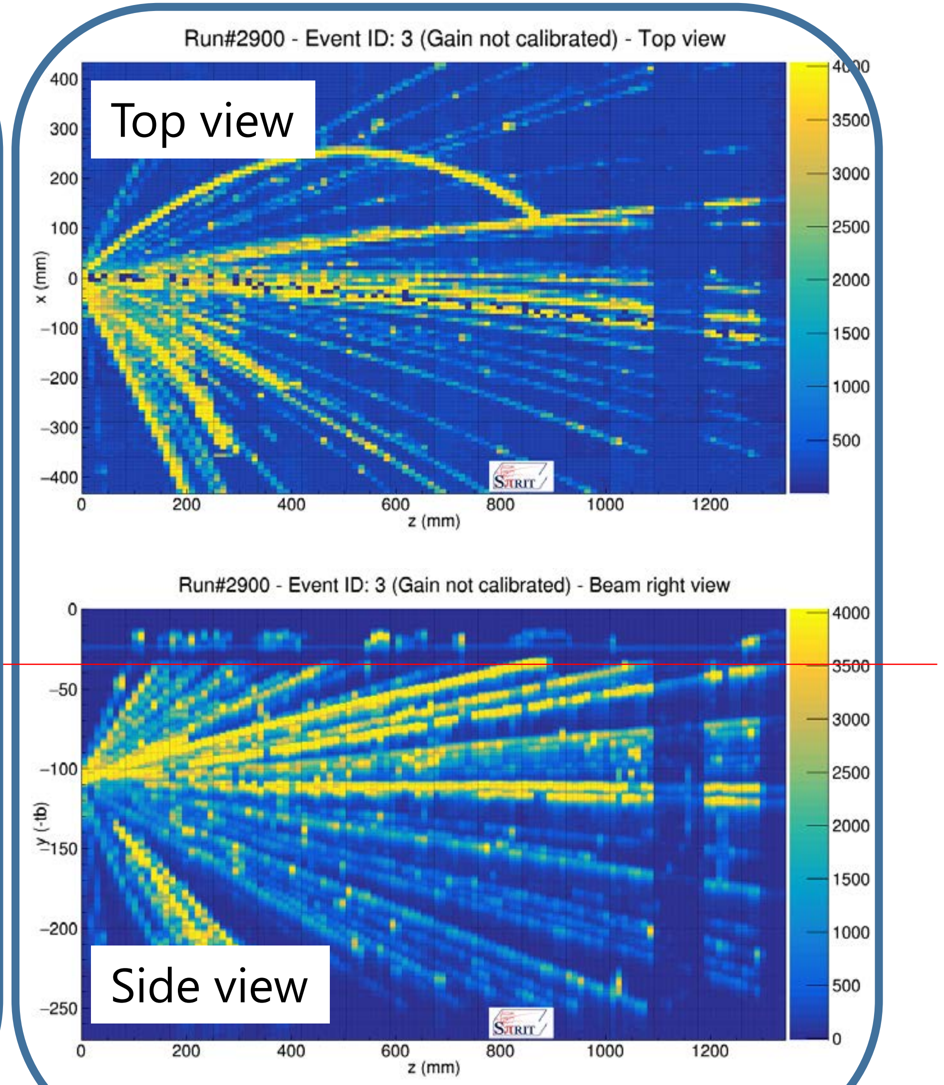


- Seen along beam trajectory → due to δ-ray?
  → but δ-ray is supposed to be suppressed with GG + B-field.
- Could not be seen in the case of cosmic
- Varies event by event

δ-ray which cannot be blocked with GG
→ Make a dead time on the pad

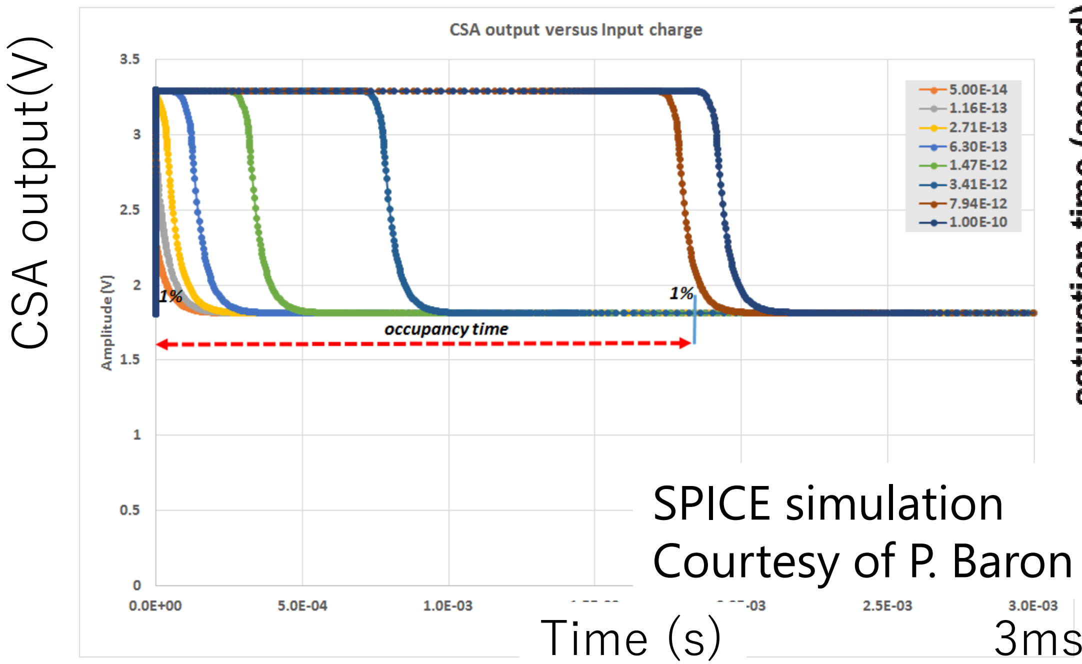


Beam event

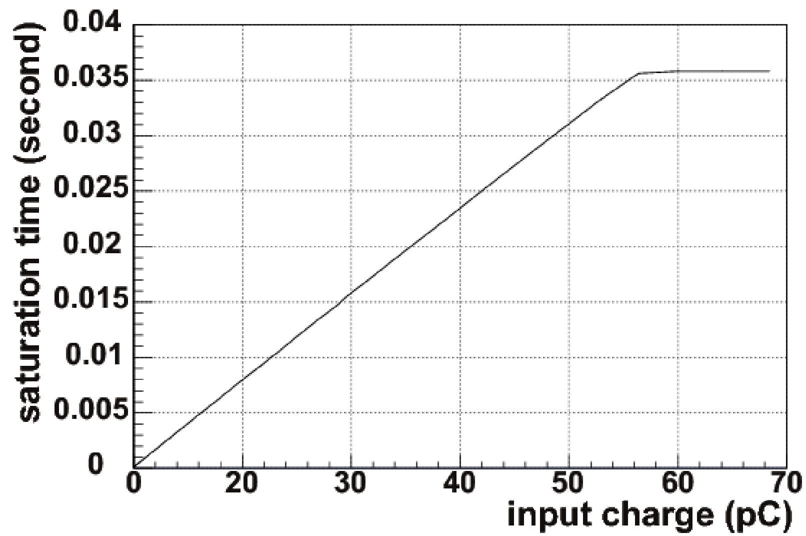


Reaction event

Preamp becomes dead for a certain time due to huge signal



SPICE simulation
Courtesy of P. Baron

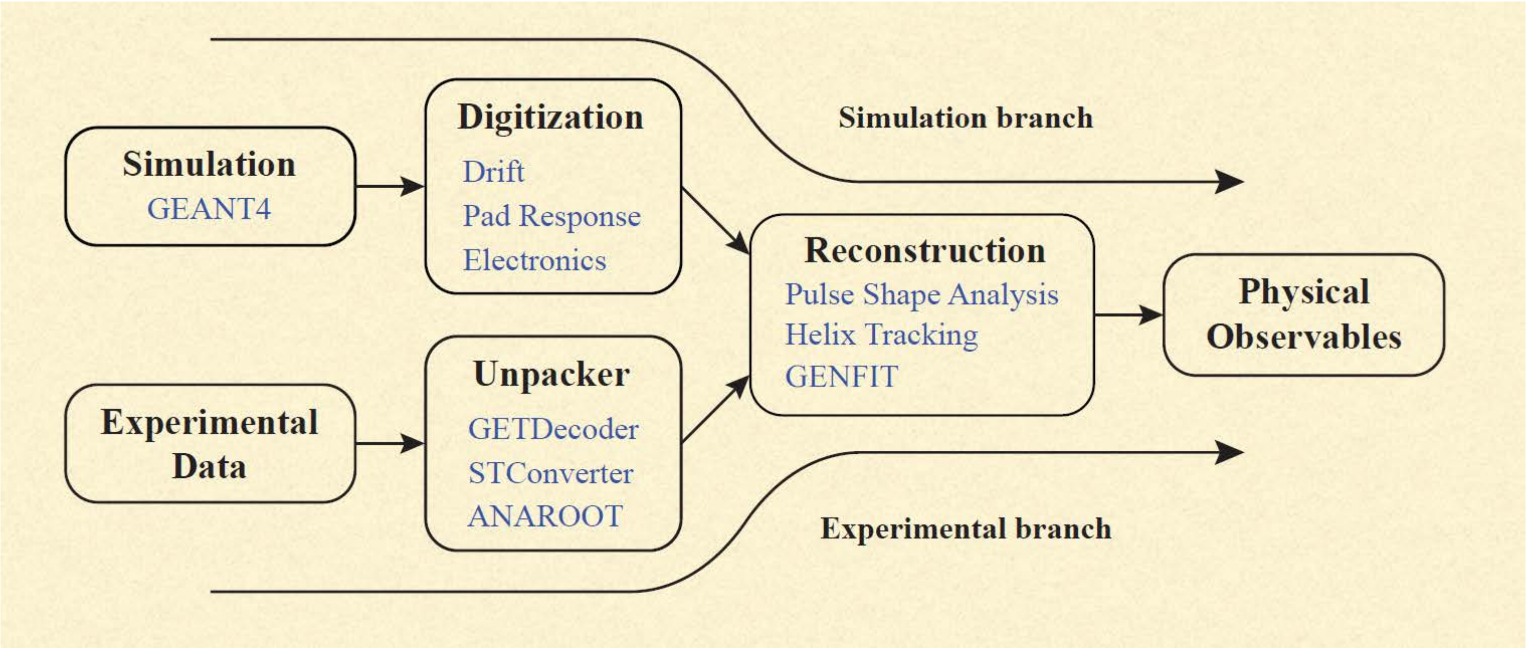


- Output of CSA is kept to be saturated in the case of huge signal
- As long as output is saturated, no signal comes out from following shaper →behaves as dead
- Dead for 2 msec in the case of 10pC charge input
- 10pC corresponds to the charge from Z~35 nuclei

✓ Acceptable beam rate of pads along beam line is limited due to this effect
✓ Independent from trigger rate, depending on beam rate (10kHz in our case)

SπRITROOT: the Analysis Software

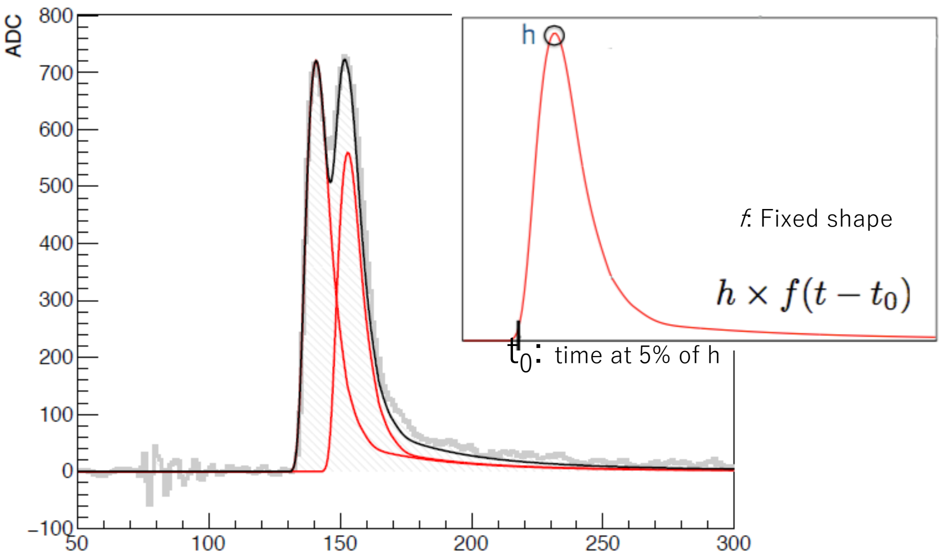
- High-density environment (~60 tracks/event)
- Reconstruct low momentum tracks (i.e. pions at ~50 MeV/c)
- Distinguish between collision on target and on gas events
- Identification of π^+ in the positively charged background

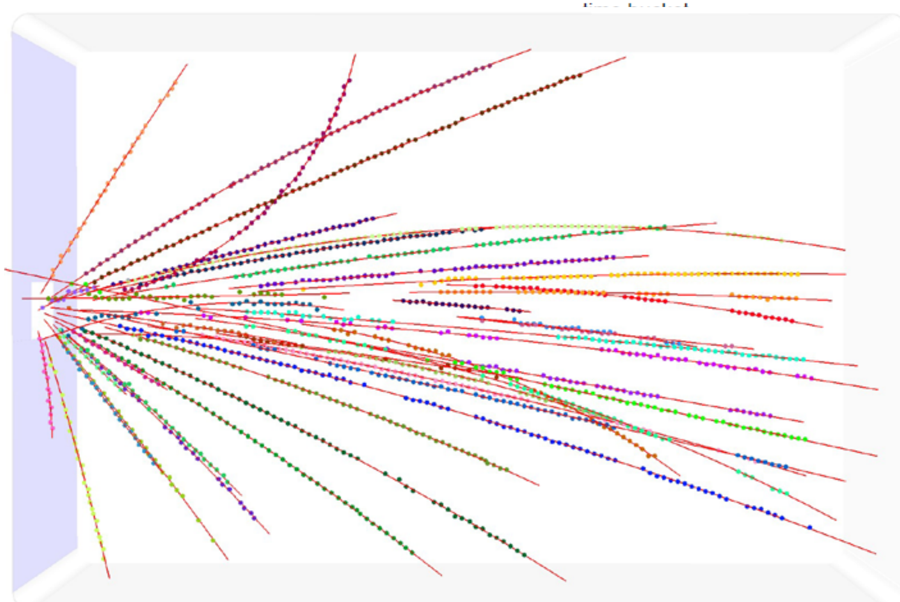


We adapted tools from High Energy Physics (FAIRROOT)

Courtesy of J.W. Lee, G. Jhang, G. Cerizza

Offline analysis: Charged particle tracking





1. Pulse Shape Analysis
   - in each of 12096 pads
2. Helix tracking: 3D momentum
   1. Track separation
   2. Riemann fit: 2D
   3. Helix fit: 3D
   4. Clustering Hits
   5. Initialize GENFIT parameters
3. GENFIT: precise fitting (Parameterization, extrapolation)
4. RAVE(Reconstruction vertices)

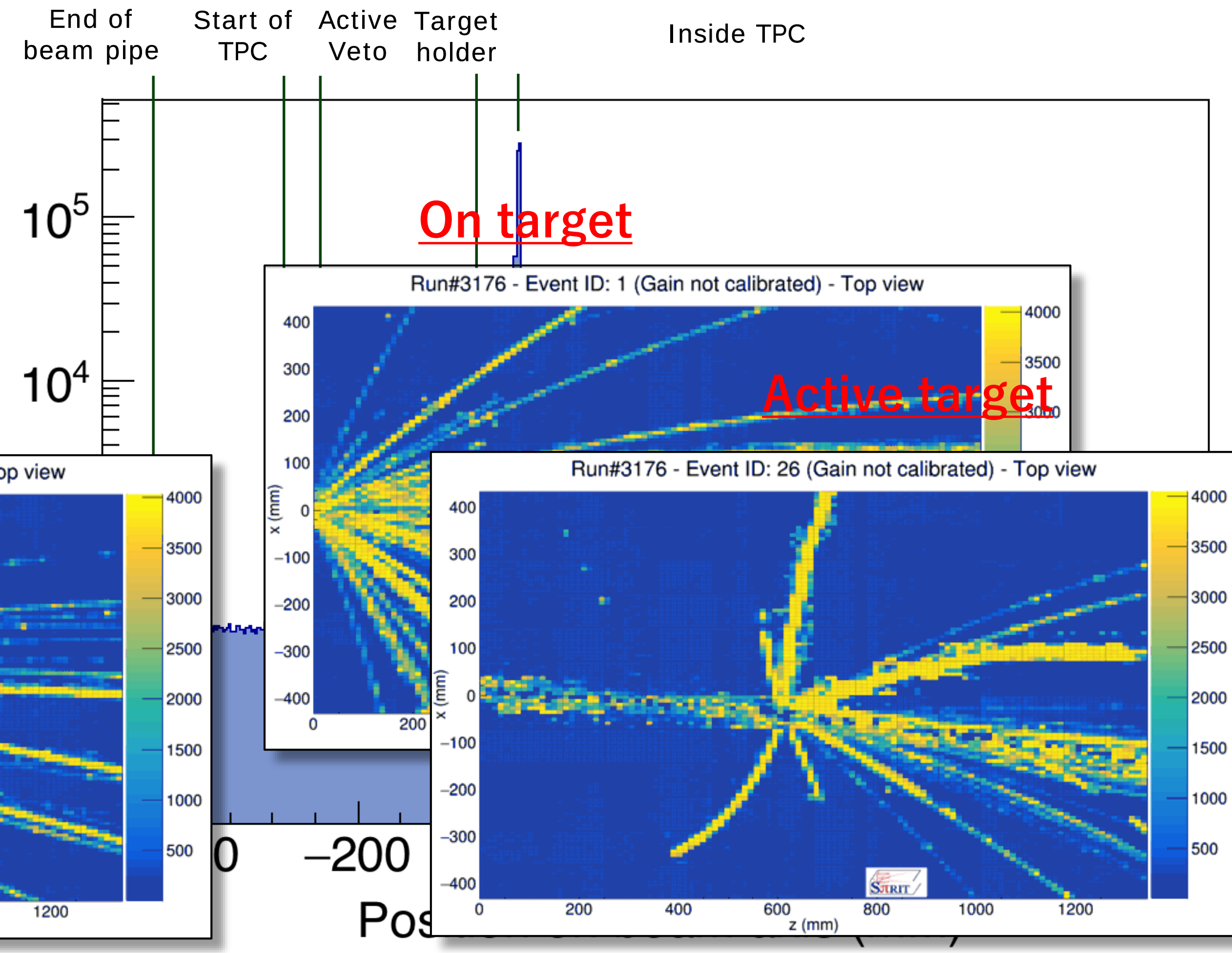
Courtesy of J.W. Lee, G. Jhang, G. Cerizza

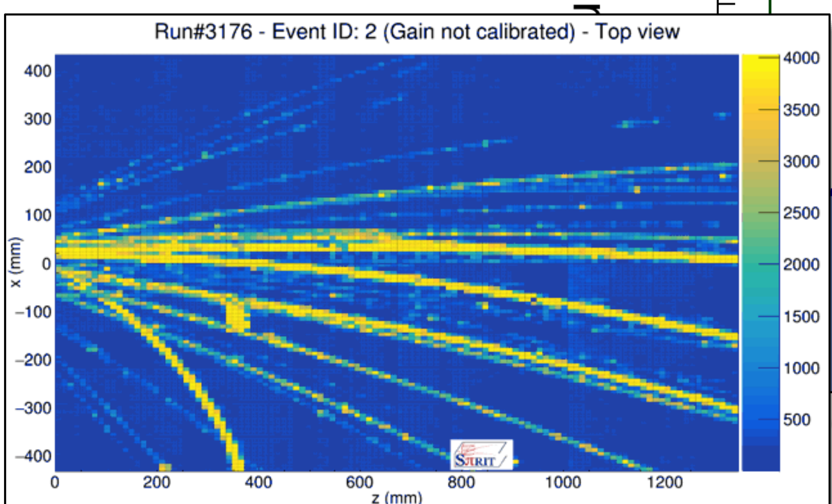
Junk removal – find vertex

- Vertex finding by RAVE package (Reconstruction in an Abstract Vertices Environment)

- Vertices are reconstructed as 3D points at the converging point of the tracks event by event.
- Vertexing efficiency **99.3%**

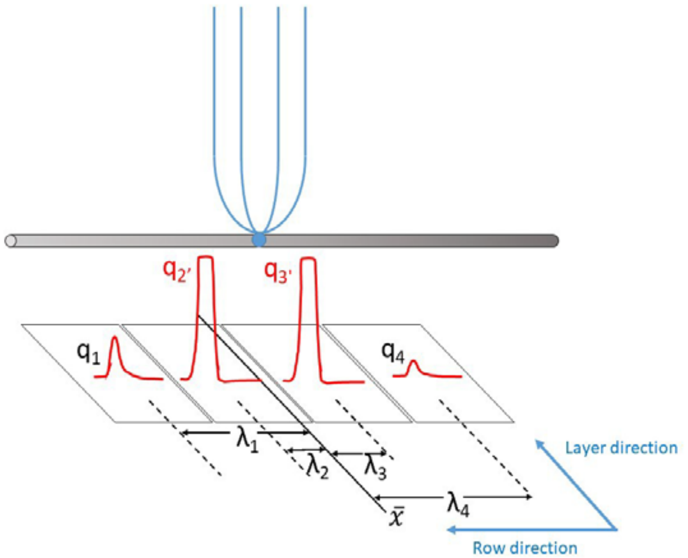
Before target

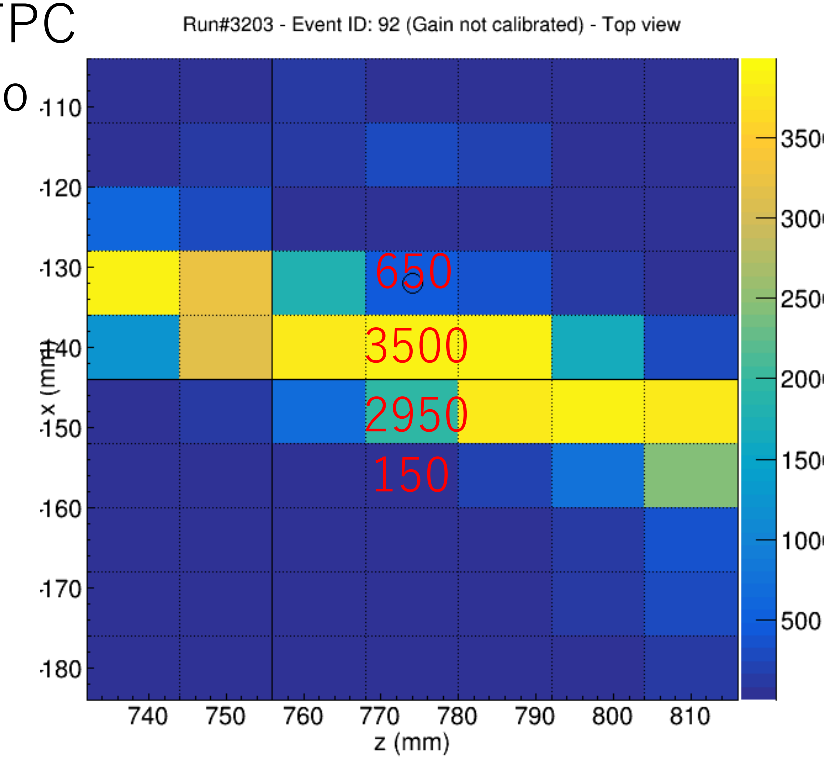




Pad Desaturation to recover PID and momenta of particles with saturated pads

- Goal: extend the dynamic range of the TPC
- Problem: saturated pads lose charge info





How do we correct and use the PRF?

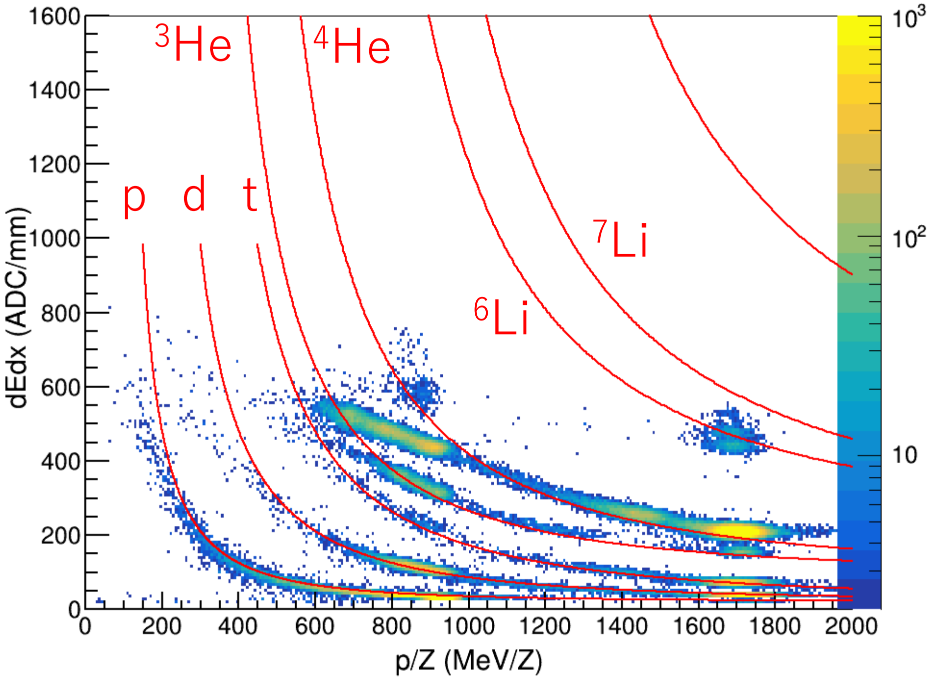
1) From the charge pads the distribution we can estimate the charge of a saturated pad
2) Find the charge center of gravity
3) Calculate the distance of the center of each pad from the c.o.g.
4) Calculate the fraction of charge of the pad over the total charge to get the PRF.

Courtesy of J. Estee

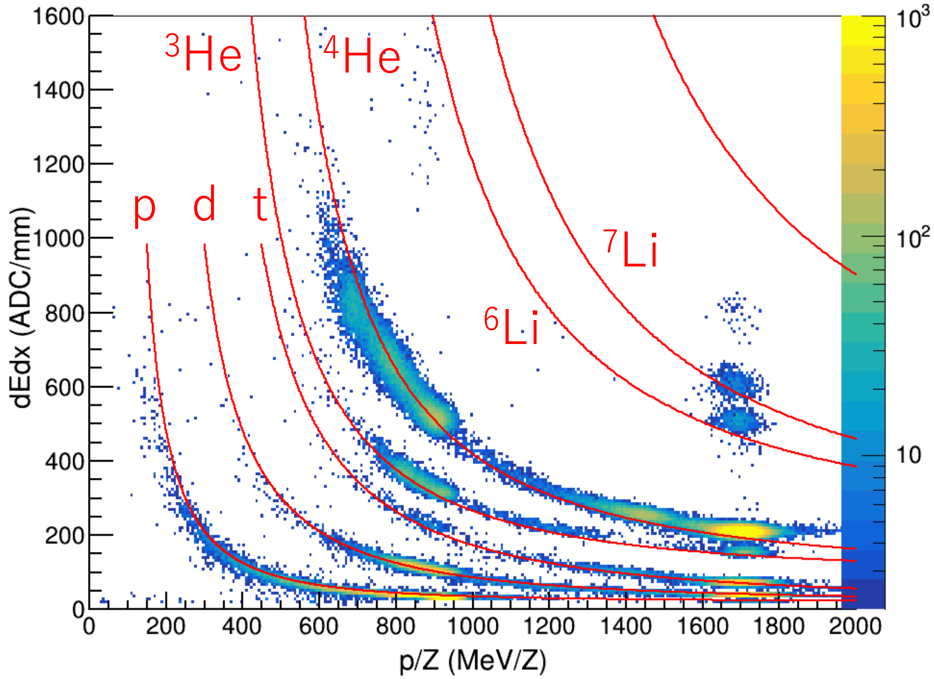
Pad Desaturation by Justin Estee

- Test performed on the E=100-300MeV Z=1-3 cocktail beam
- Preliminary overlap of energy loss calculation (Bichsel curves) with data

Before correction

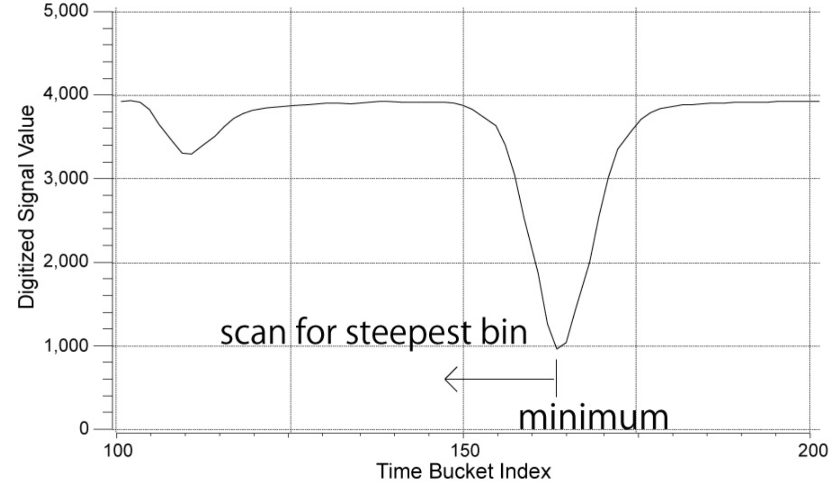


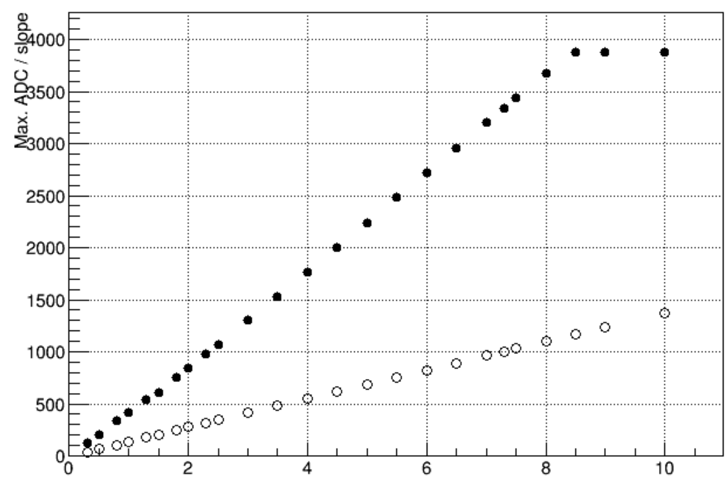
After correction



Another way: use signal slope value as deposited charge information

- Scan for steepest bin of a signal.
- Slope of signal shows linearity for higher pulser voltage.
- According to SPICE simulation, linearity can be kept up to 240fC input.
    - i.e. ~2 times wider



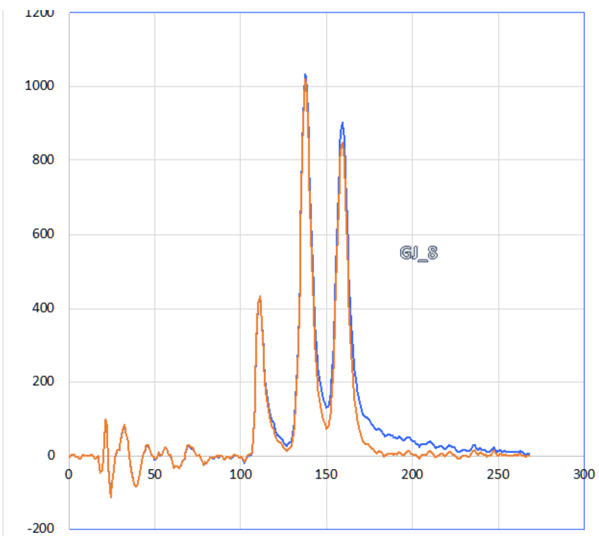


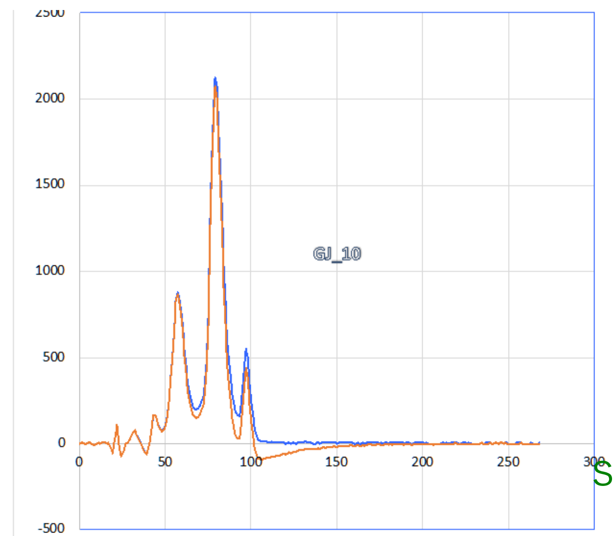
120fC D.R.,
117 ns Shaping time

Pulser voltage on TPC ground wire

Saturation → pads dead at later times

- Due to the characteristics of preamp PZ circuit, its saturation recovery time-scales can take ms.
- Blue is GET digitized signal. Red is signal after digital PZ subtraction.
- Three signals on left do not saturate the preamp, but the right signal is saturated.
- The negative lobe on the digital PZ subtracted signal indicates saturation. The right channel is dead after the negative lobe.

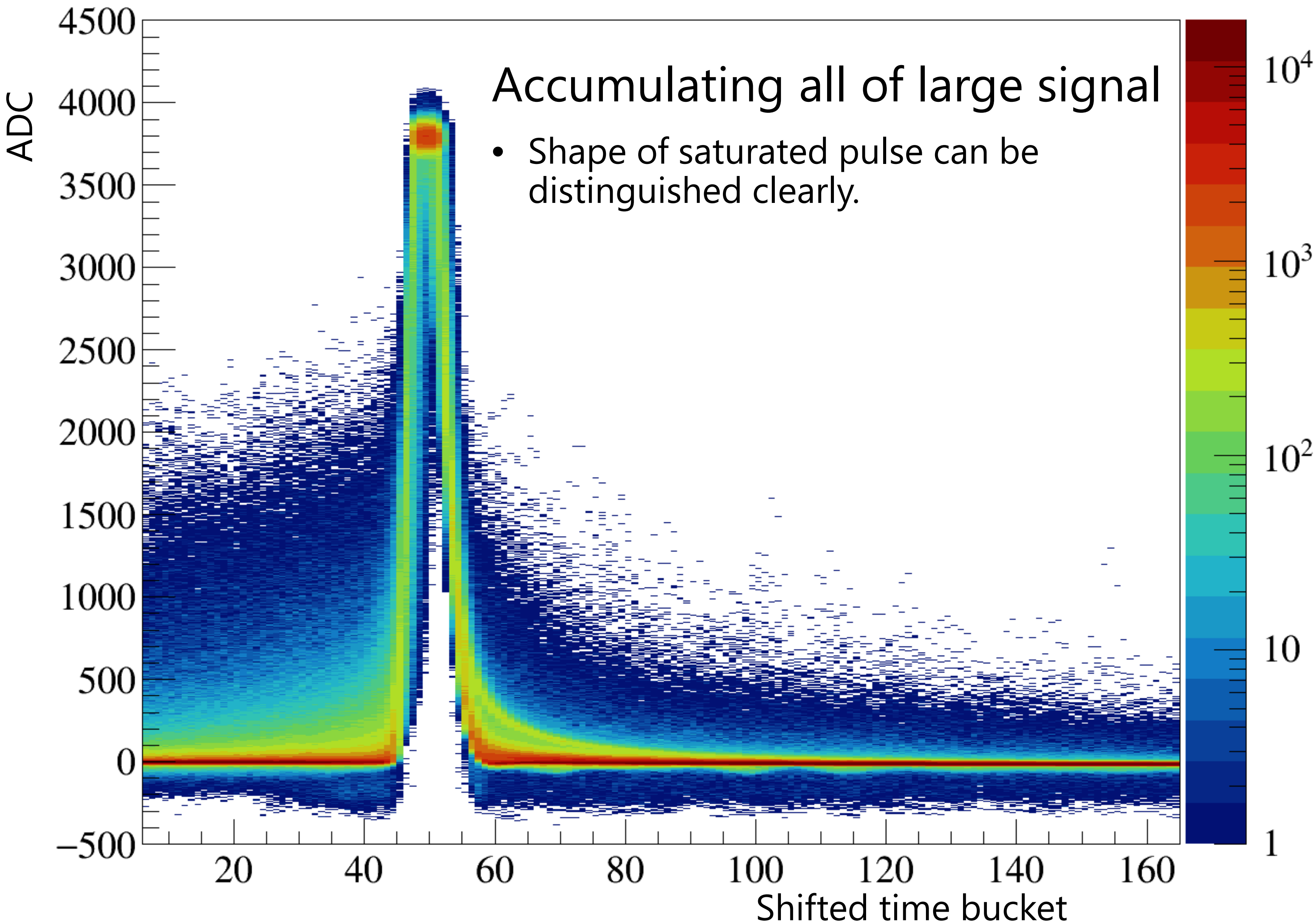




saturation

We tag the saturation to allow us to determine its effect on the efficiency and to facilitate removal of clusters with dead pads

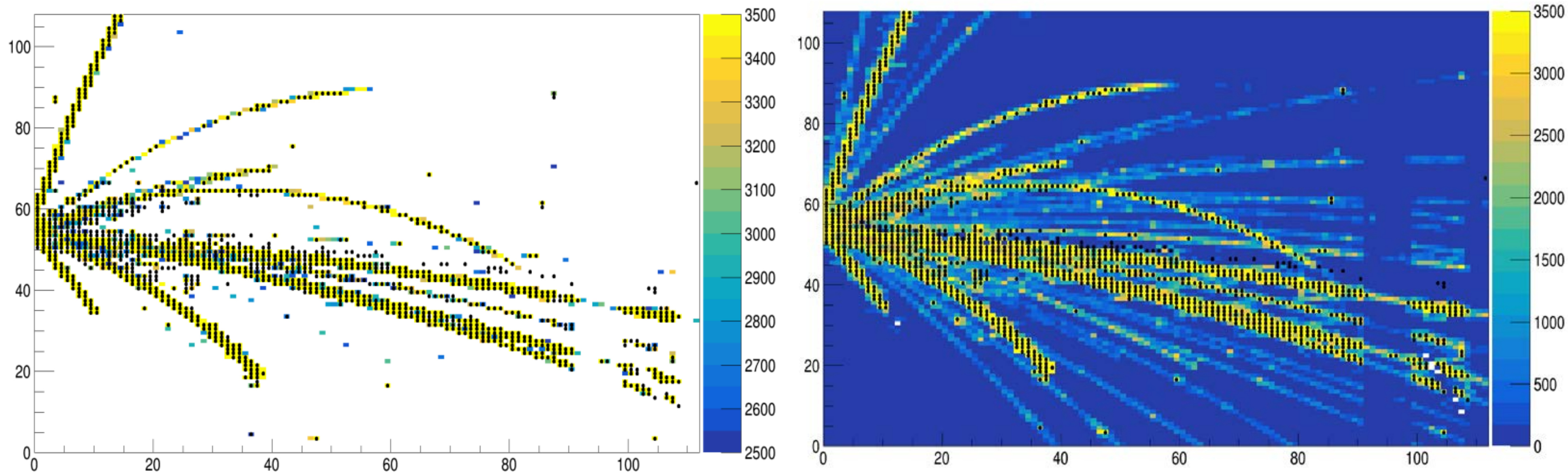
Saturation → pads dead at later times



Accumulating all of large signal

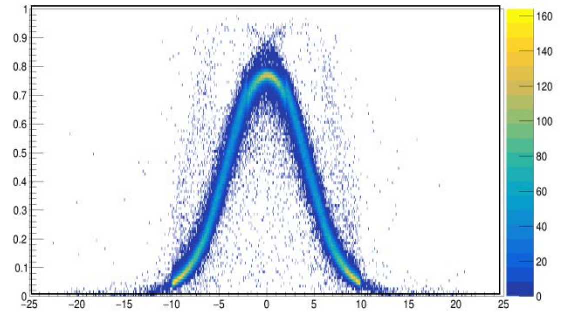
- Shape of saturated pulse can be distinguished clearly.

Identification of saturated hits



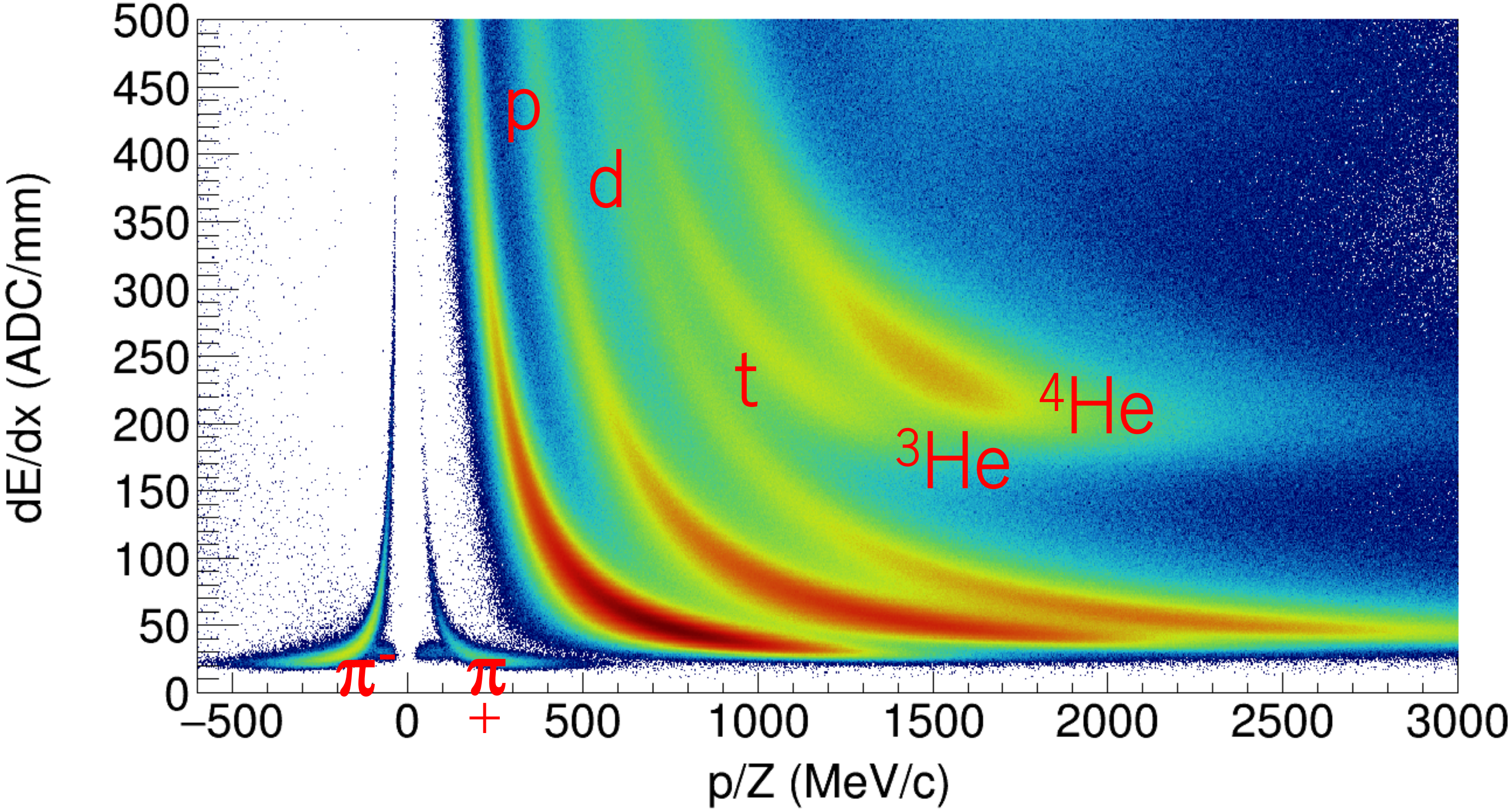
- Both figures show the same event:
  - Left Panel shows saturated pads that are fixed using the PRF. These pads are also marked to indicate that these pads will not respond to the charge from later (lower) tracks. This is needed for the efficiency calculation.
  - Right Panel shows the full event. Tracks that pass below a saturated track lose information in the crossing region.
  - Saturation is noted in the data stream to allow accurate efficiency correction.

PID cleanup



- Issues:
  - Saturation results in the loss and distortion of energy loss and momentum information.
    - Most significant near the vertex and under the beam.
    - Bad pads means bad PID, i.e. bad momentum resolution and high backgrounds in the PiD.
  - Clusters near the boundaries of TPC are incomplete, therefore incorrect.
  - Bad information is worse than no information.
- Solutions:
  - We do not track in the high density region near target.
  - We require the PRF to be reasonable.
  - We remove bad and incomplete clusters.
  - We compare the track length to the theoretical track length and reject short tracks.
  - We require tracks to originate from the event vertex
  - We add the BDC vertex to the tracks to improve the momentum resolution.

Latest Particle ID by TPC



Summary

- New experimental device of SPiRIT-TPC + GET has been constructed at RIKEN-RIBF.
- First HIC experiment campaign by using Sn isotopes was successfully finished.
  - E/A=270MeV
- Preliminary analysis shows the measurement of charged pion is promising.
- Part of pads along beam trajectory can be dead due to δ-ray from high intense beam.
- Saturation is key issue for us needs to be understood for final result.

SPiRIT Collaboration

Thank you!!

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MEXT
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SCIENCE AND TECHNOLOGY-JAPAN

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