SπRIT TPC Electronic Testing at RIKEN

William Powell

NuSYM14
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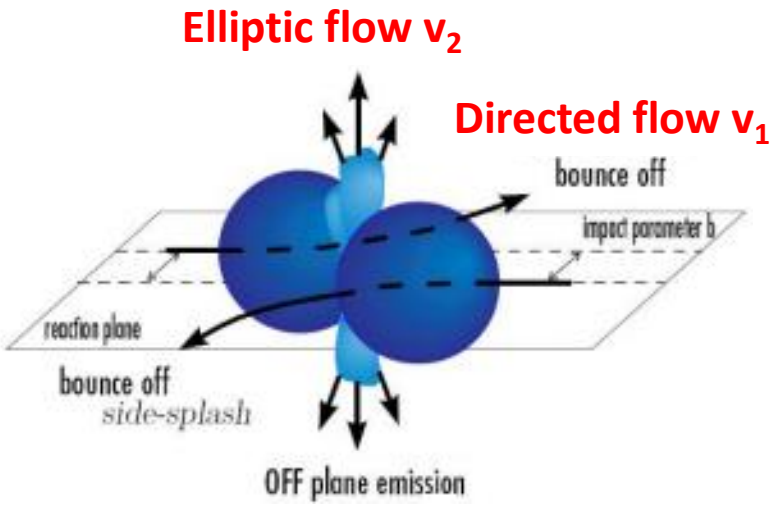
Outline

1) Introduction of SπRIT
2) TPC Readout
3) Noise
4) Dynamic Range
5) Conclusion

SπRIT and EOS



HIC results in compressed matter which undergoes collective expansion

Information for EOS can be extracted by measuring the momentum and angular distribution of isospin pairs (π^+, π^-) (n,p) (^{3}H, ^{3}He)..

Time Projection Chamber: A 3D Particle Tracker

- Charged fragments ionise detector gas
- E-field drifts (vertical) electrons to charge readout pads
- 2D (x-y) position information from pads
- 1D (z) info from time of arrival
- Particle ID from energy loss and mag. Rigidity
- Momentum from curvature of path in B-field

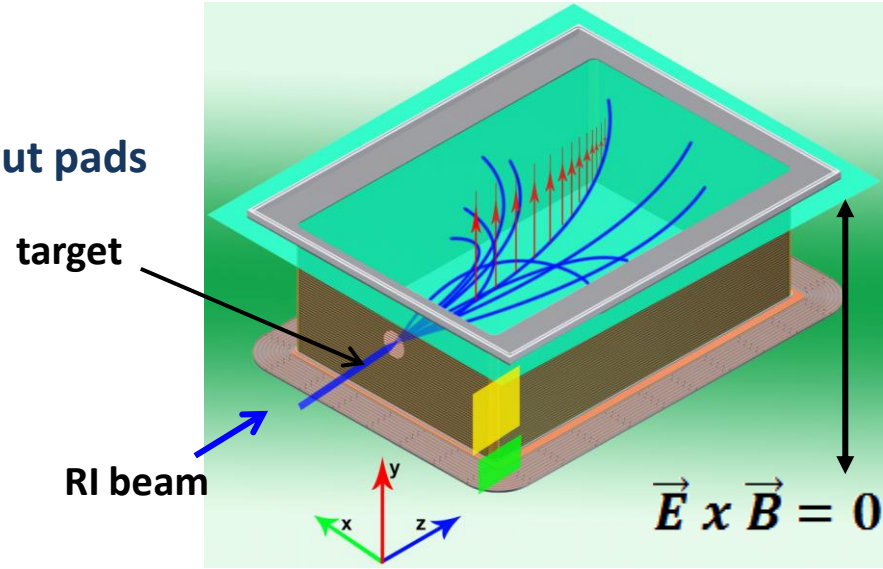
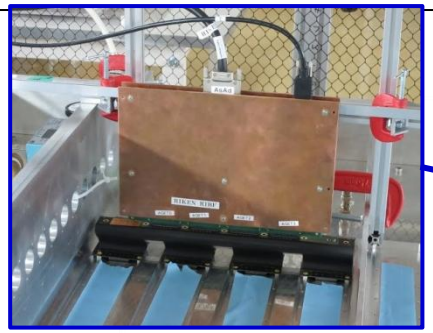


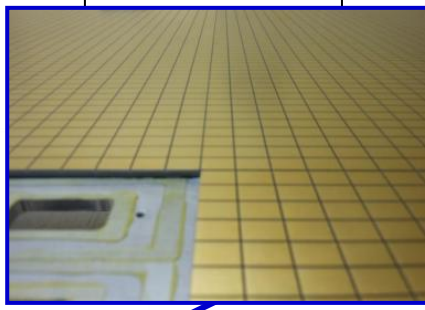
Figure courtesy of J. Estee

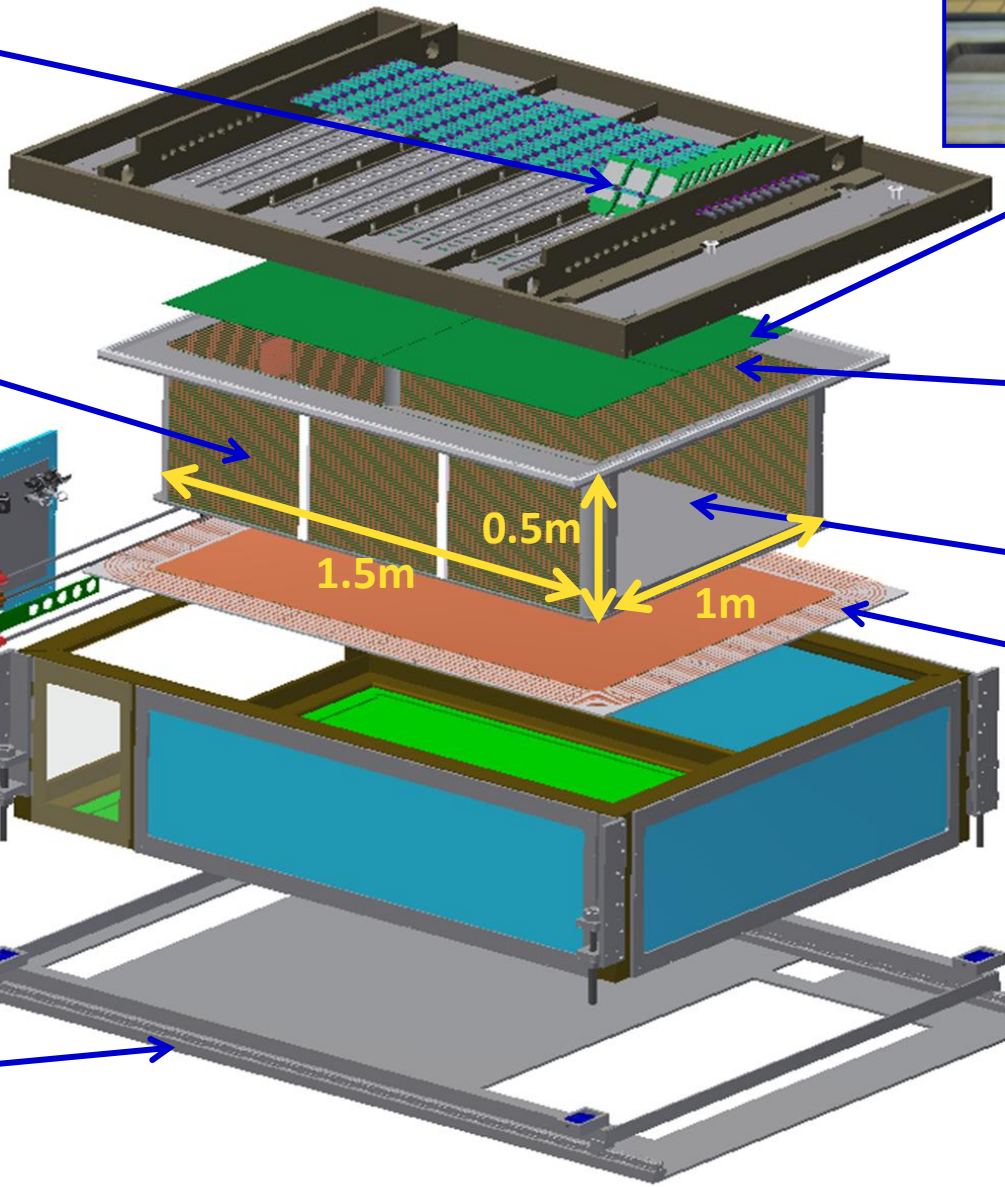
SπRIT

Front End Electronics



Pad Plane





Field Cage

Wire Planes

Beam

Cathode

Laser Optics

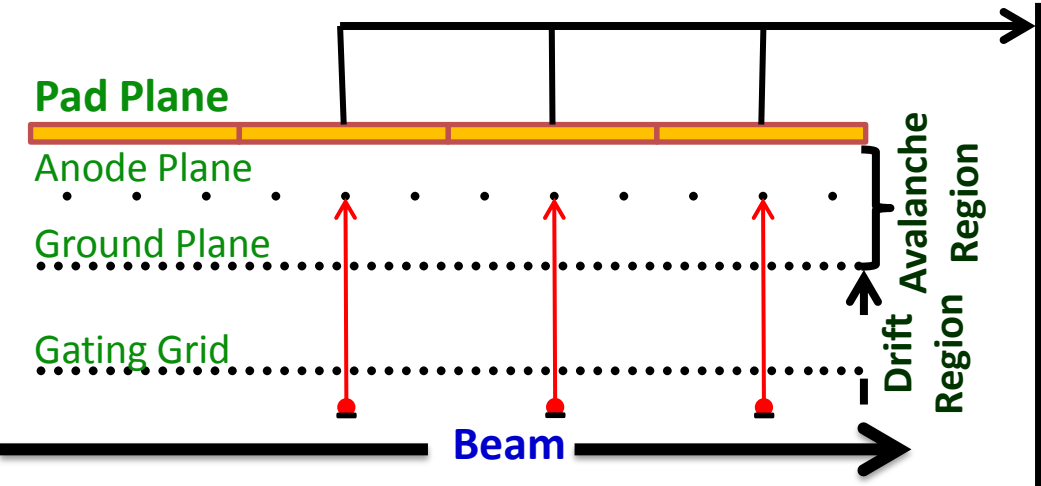
Voltage Step-Down

Target Mechanism

Rails

TPC Readout

Wire planes act as MWPC to amplify signal
Charge is induced on pads which are connected to GET electronics



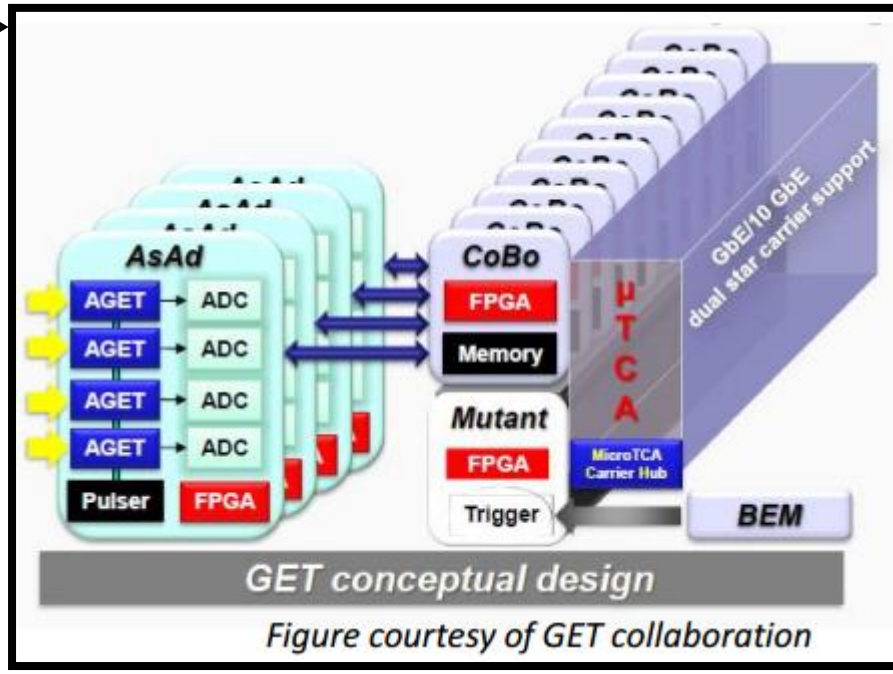


Figure courtesy of GET collaboration

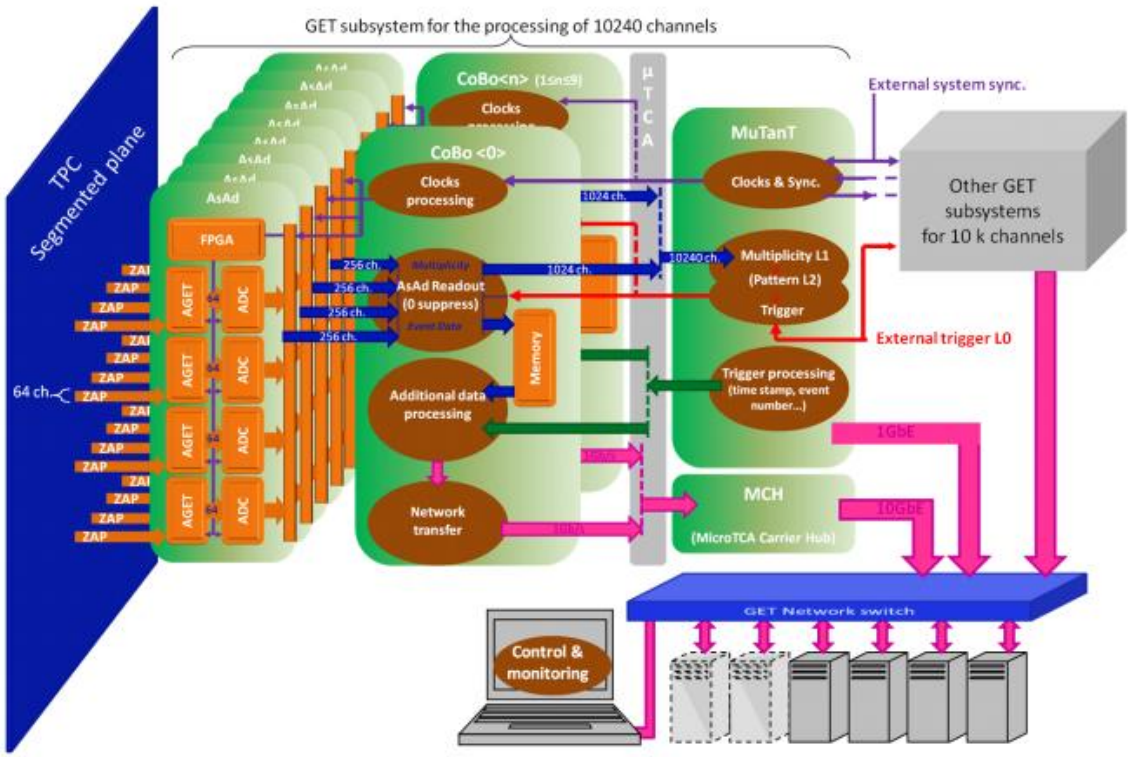
- Total number of pads = 12096
- 1 pad = 1 channel
- 1 channel: preamp, shaper, discriminator, 512-sample analog memory (SCA)

- 12-bit ADC → 10.5 bit dynamic range
- Shaping time: 70ns – 1014ns
- Sampling rate: 1-100 MHz

1 AsAd = 272 channels

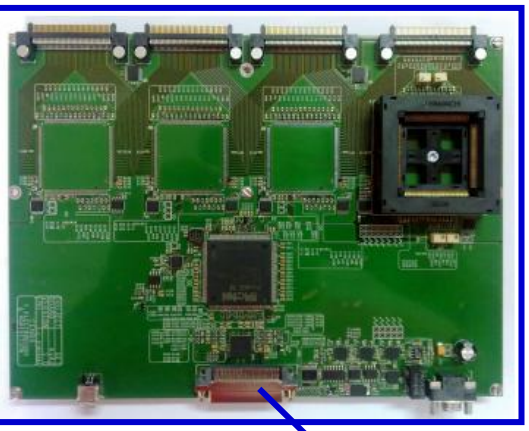
GET Architecture

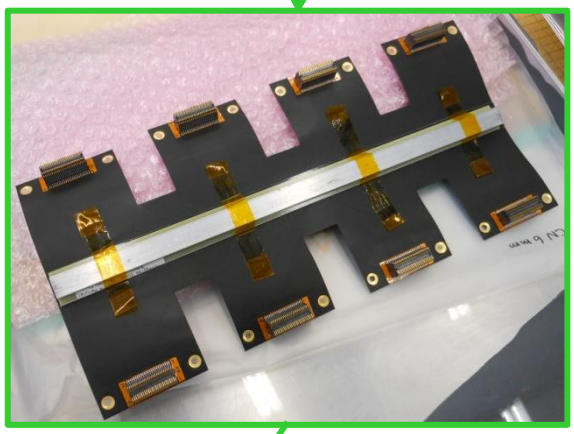
- GET consists of AsAd ↔ CoBo ↔ Mutant
- AsAd = ASIC with ADC CoBo = Concentration Board
- AsAd connects to TPC pads via a flexible circuit-protection board (ZAP)
- 1 AsAd board has 4 AGET chips → 256 channels per AsAd
- 48 AsAd required in total

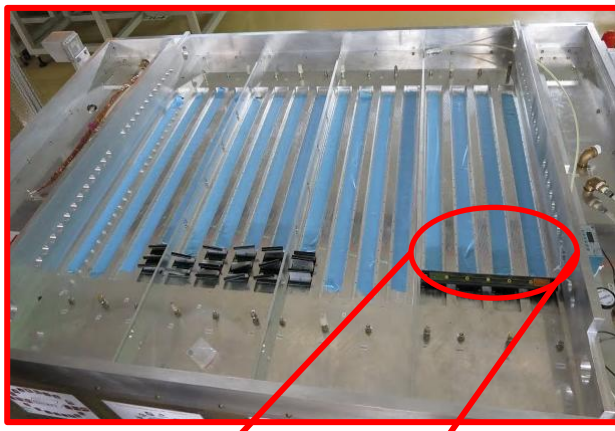


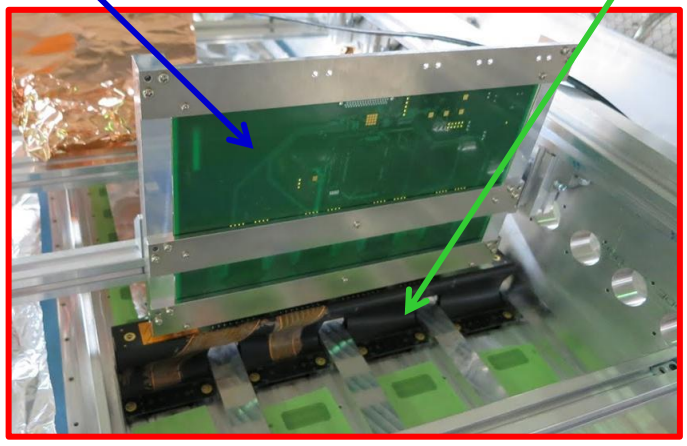
TPC Noise

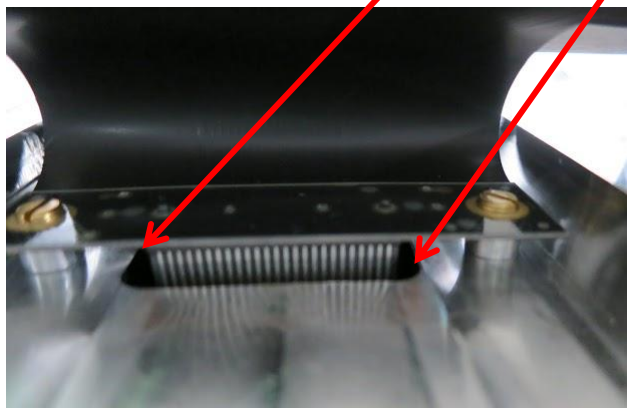
GET→ZAP→TPC









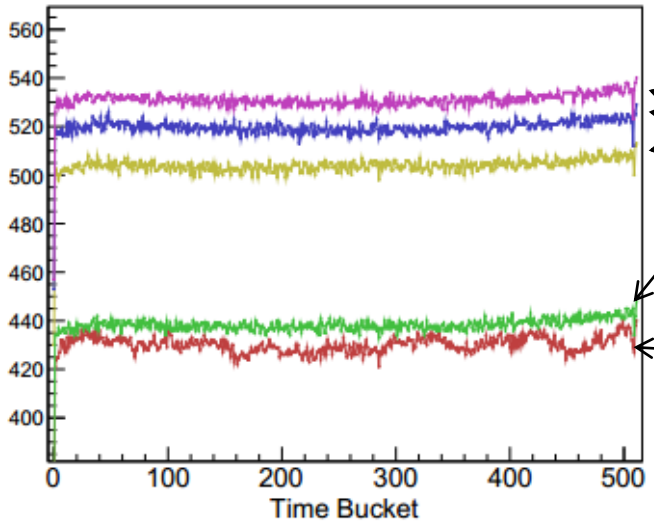


Digitised signal leaves AsAd

Noise contribution is from AsAd, ZAP and TPC

Noise Analysis

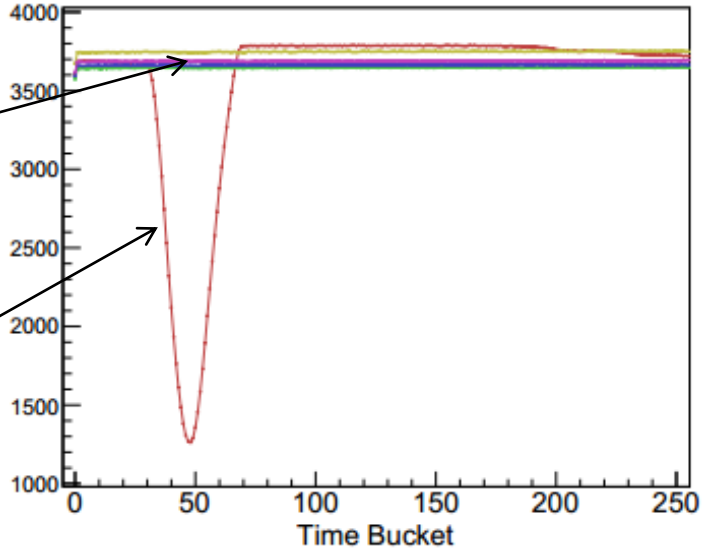
Pedestal: 1 Event 5 Channels



Unconnected

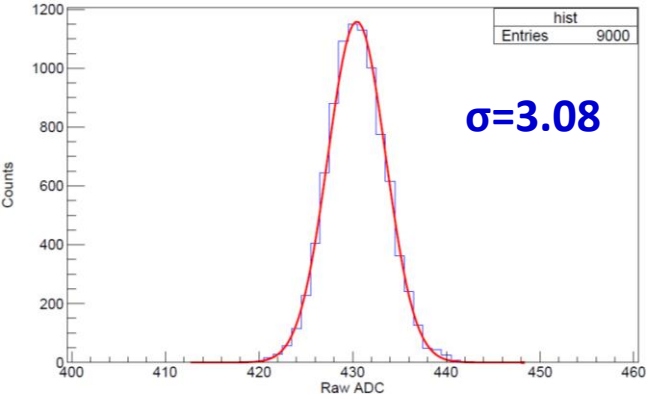
Connected

Pulser: 1 Event 5 Channels

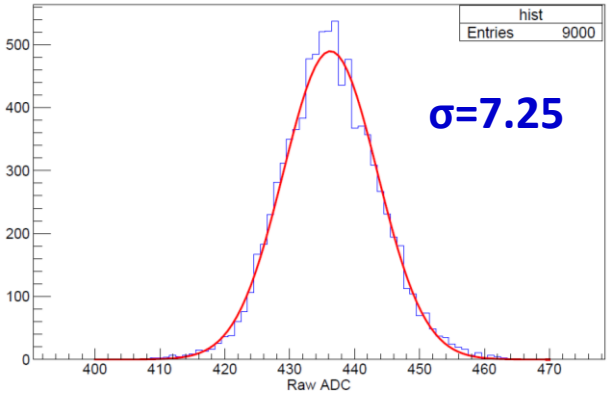


Channel 0

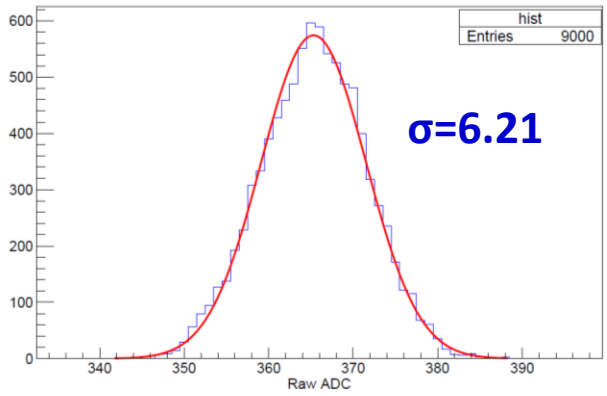
GET



GET+ZAP

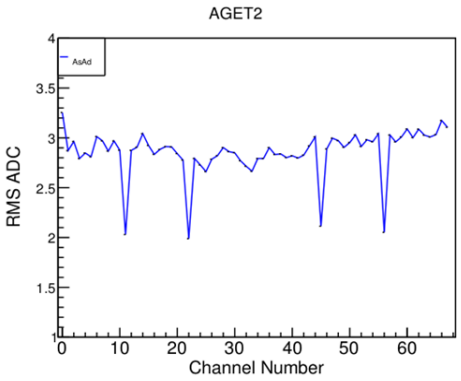


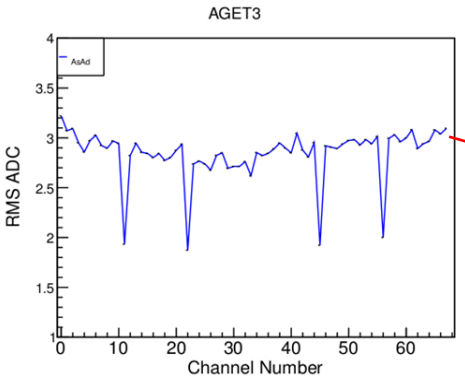
GET+ZAP+TPC



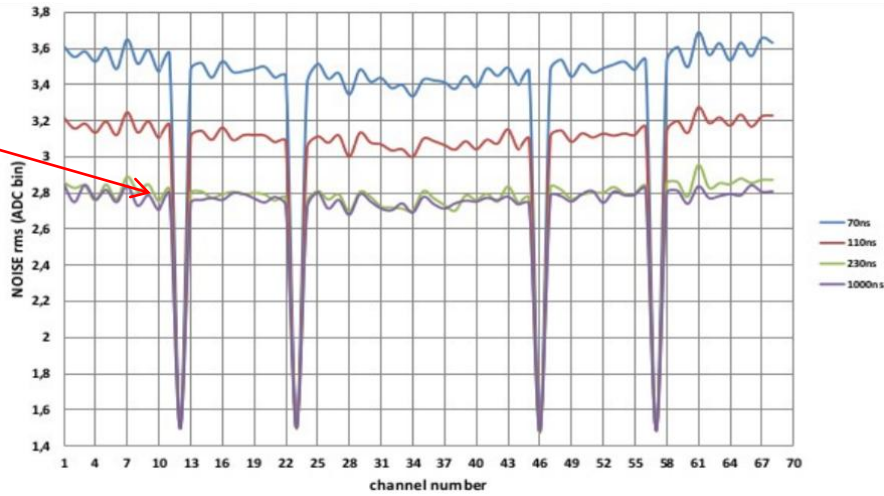
Noise Evaluation: AsAd

- As well as 64 data channels; each AGET has 4 FPN channels
- 10.5 bit equates to rms noise = 2.8 ADC counts





From GET Manual



No FPN subtraction

	Avg RMS
AGET0	2.92
AGET1	2.91
AGET2	2.91
AGET3	2.90

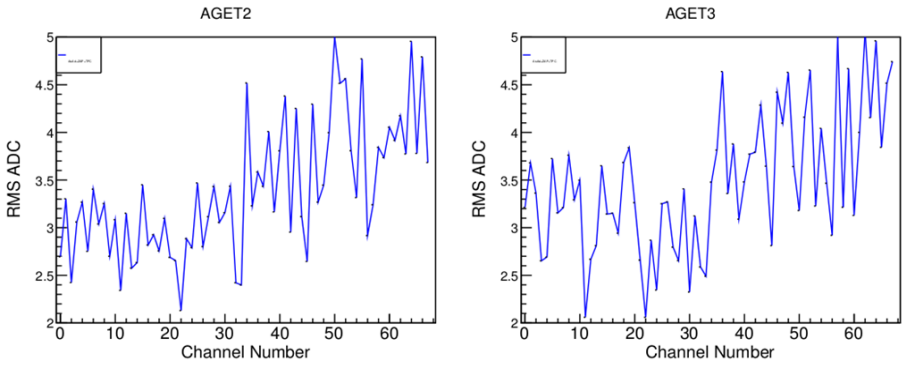
Results are in agreement with GET specification

Best Scenario: AsAd+ZAP+TPC rms ~ 3.0 ADC

With average FPN subtraction Avg RMS ~ 2.5 ADC counts

Noise Evaluation: AsAd+ZAP+TPC

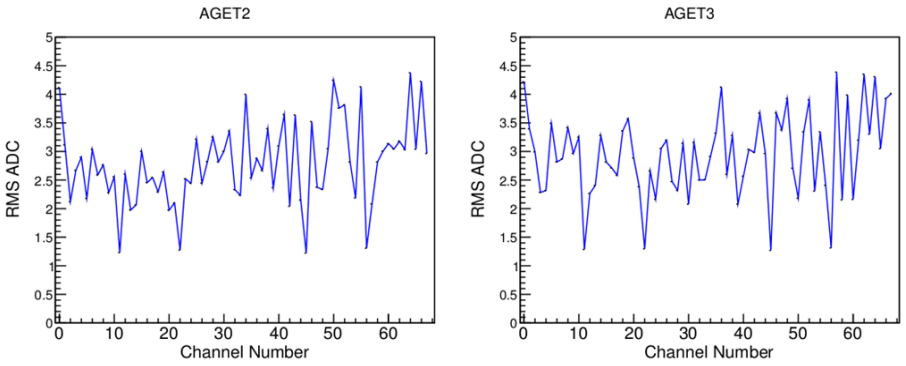
No FPN Subtraction



	AGET2	AGET3
Ch0-33	2.96	3.10

Initial goal was ~ 3.0 ADC counts

FPN Subtraction

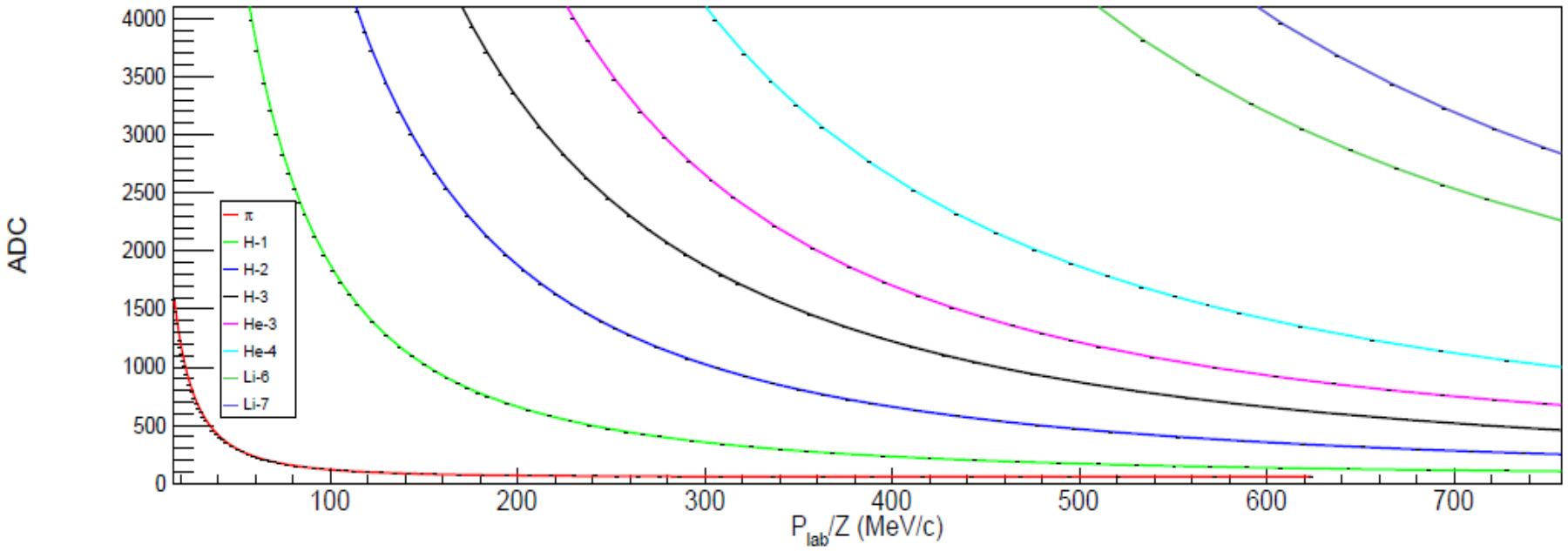


	AGET2	AGET3
Ch0-33	2.62	2.84

Initial goal was ~ 2.5 ADC counts

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



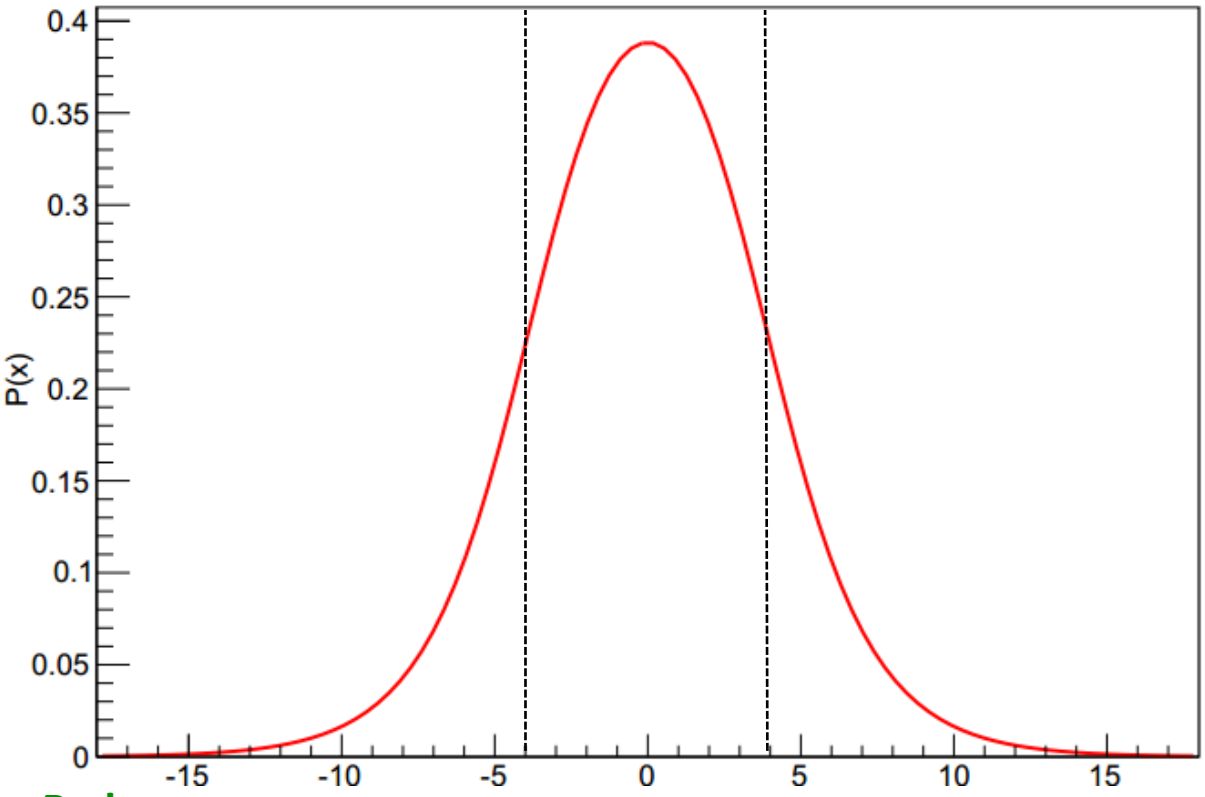
Conclusion

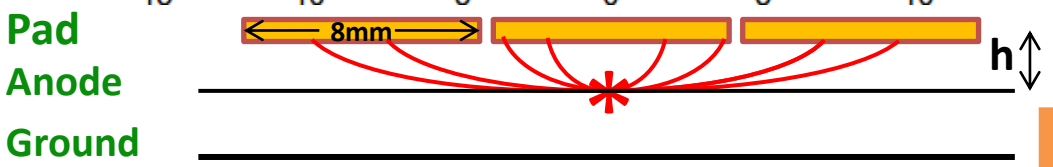
- Noise is under control and at a suitable level to operate TPC
- Charged particles up to He-4 should be achievable
- Detect and track cosmics later this year
- Use the induced-charge-distribution to determine discriminator settings

Thank You For Your Attention

W. Powell, R. Shane, A. McIntosh, T. Isobe, J. Barney, J. Estee, G. Jhang, N. Nakatsuka, S. Tangwanchaeron, H. Baba, Z. Chajecki, M. Chartier, M. Famiano, R. Lemmon, F. Lu, W.G. Lynch, T. Murakami, H. Sakurai, A. Taketani, M.B. Tsang, R. Wang, S. Yennello

Pads Induced Charge Distribution





$$\Gamma(\lambda) = K_1 \frac{1 - tanh^2 K_2 \lambda}{1 + K_3 tanh^2 K_2 \lambda}$$

$$K_3\,(s, h, ra)$$

ra = anode wire radius (10µm)

s = anode pitch (4mm)

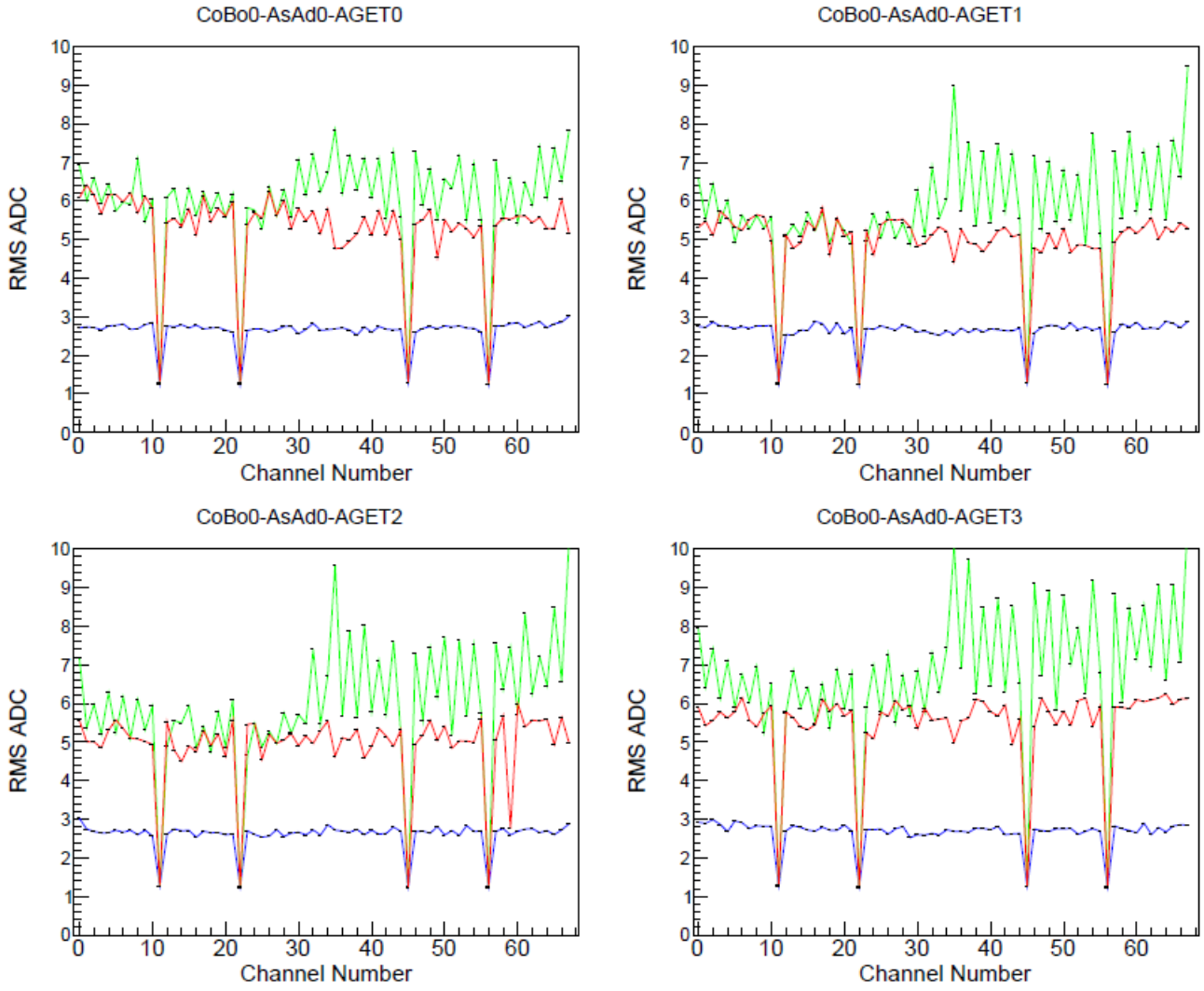
h = anode-pad (4mm)

P(x) obtained by integrating Γ(λ) over pad width

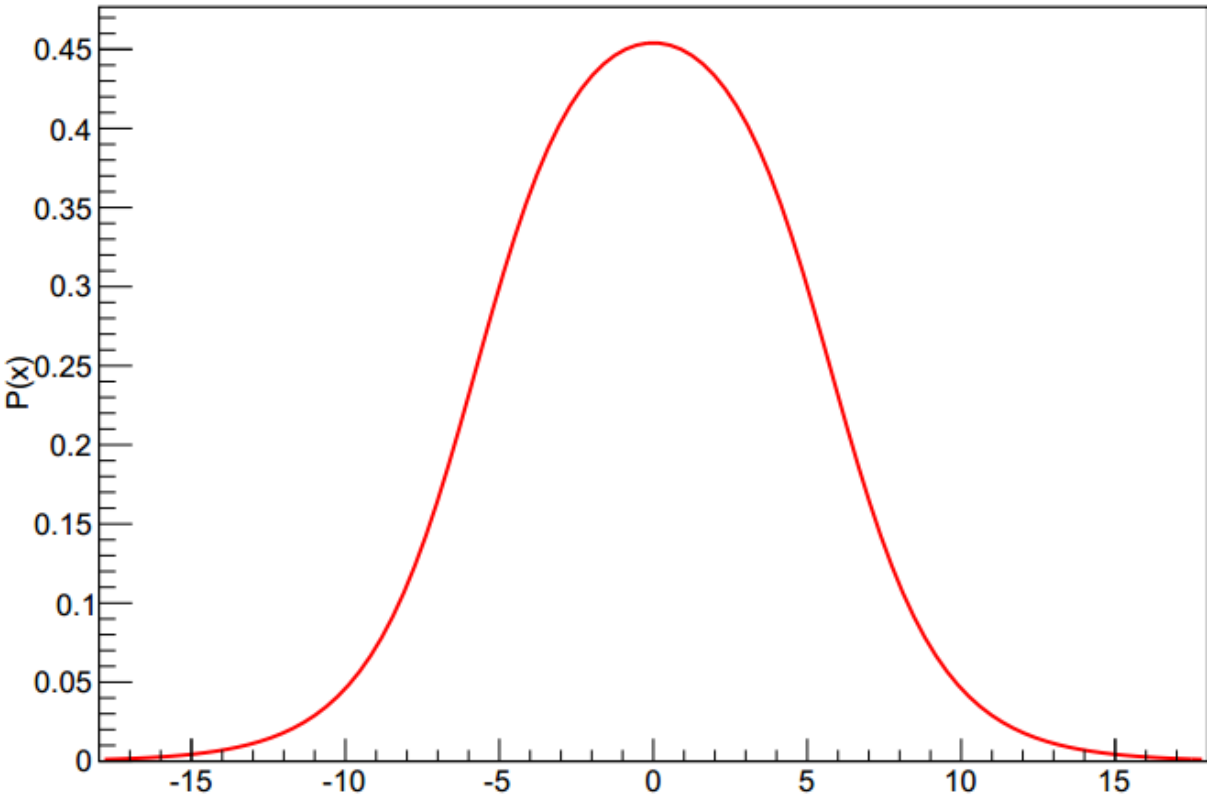
Pad Number	P(x)
0	0.777
1	0.086
2	0.086

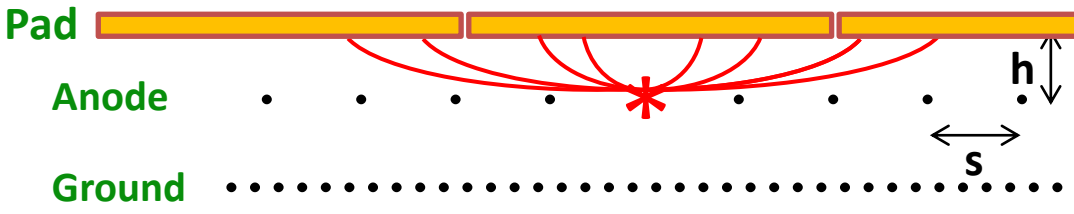
95% of the charge is distributed over 3 pads

Initial Testing All AGET



Rows: Induced Charge Distribution





$$\Gamma(\lambda) = K_1 \frac{1 - tanh^2 K_2 \lambda}{1 + K_3 tanh^2 K_2 \lambda}$$

$$K_3\,(s, h, ra)$$

ra = anode wire radius (10µm)

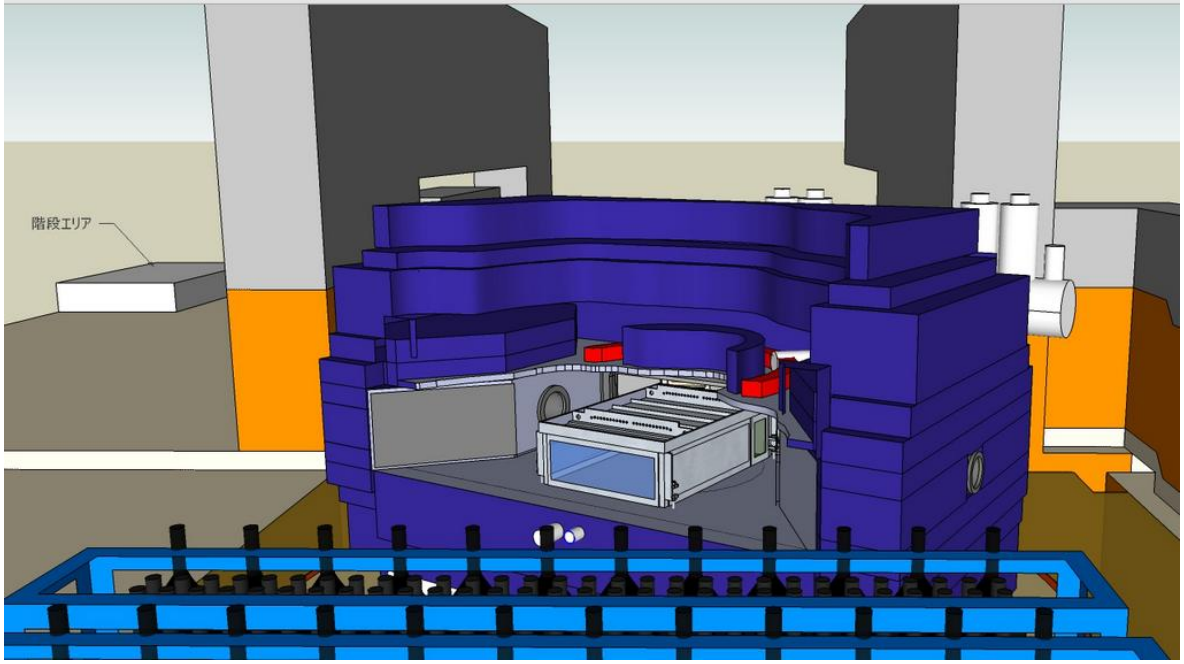
s = anode pitch (4mm)

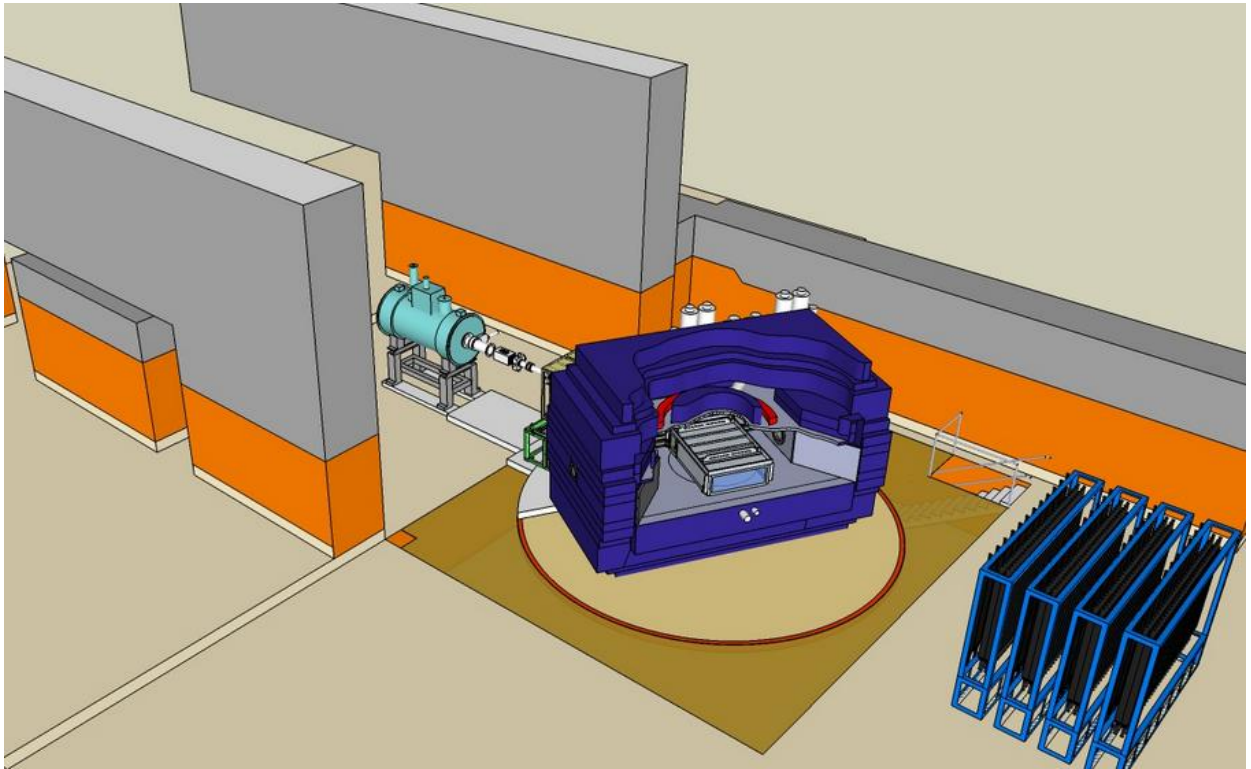
h = anode-pad (4mm)

P(x) obtained by integrating Γ(λ) over pad width

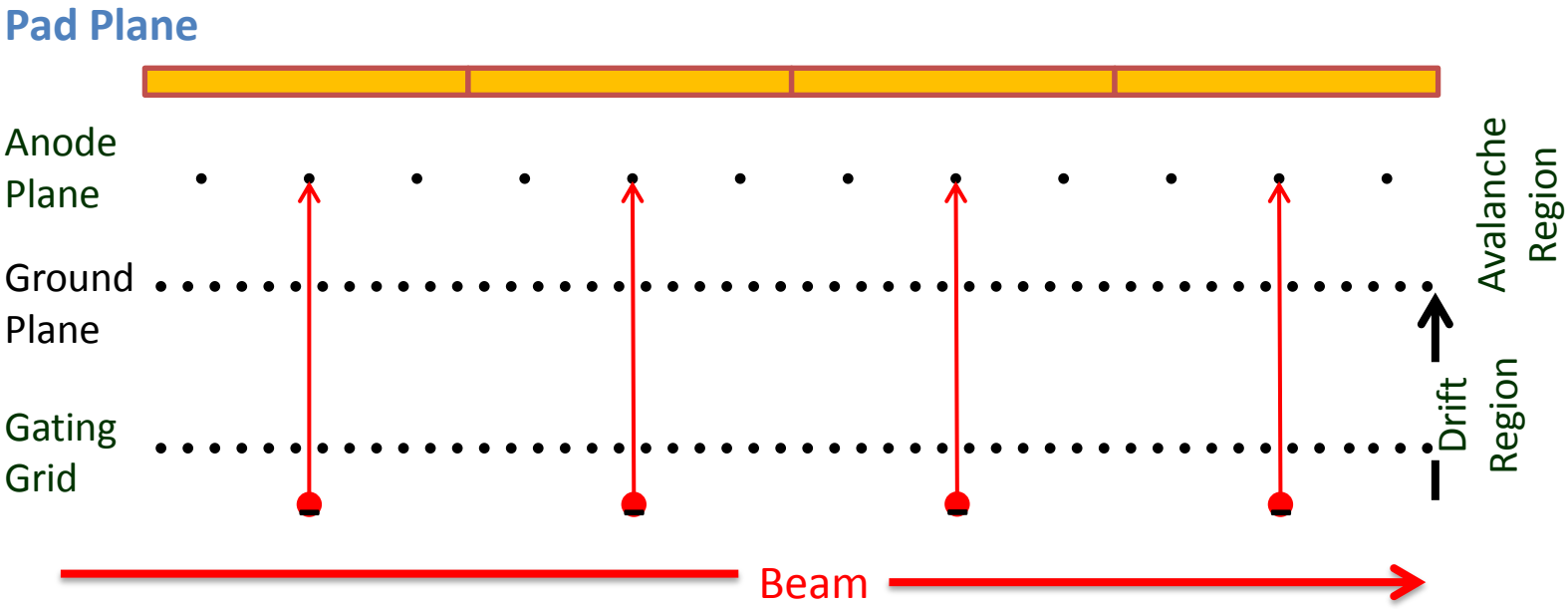
Pad Number	P(x)
0	
1	
2	

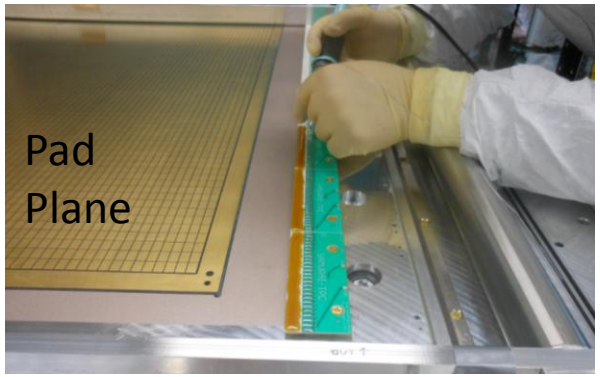
98% of the charge is distributed over 3 pads

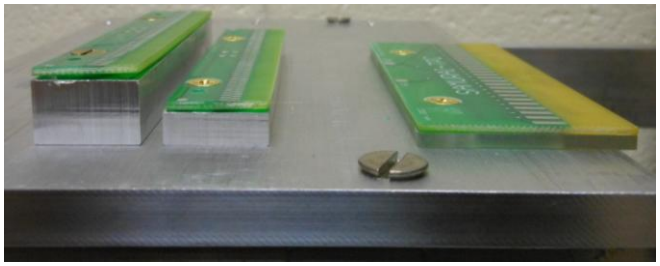

階段エリア



Wire Planes


Pad Plane
Anode Plane
Ground Plane
Gating Grid
Avalanche Region
Drift Region
Beam


Pad Plane



Dynamic Range

- Dynamic range is the ratio of smallest to largest signal
- GET has a 12-bit ADC → Output range from 0-4096 ADC counts
- What is the largest Z that can be detected?

A TPC typically operates with 20:1 signal:noise for a pad

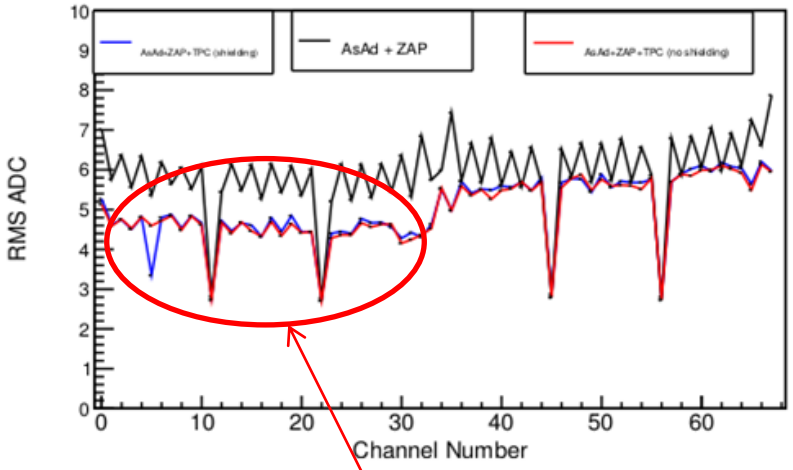
Smallest signal is for pion, what is the largest signal Z_{max} =?

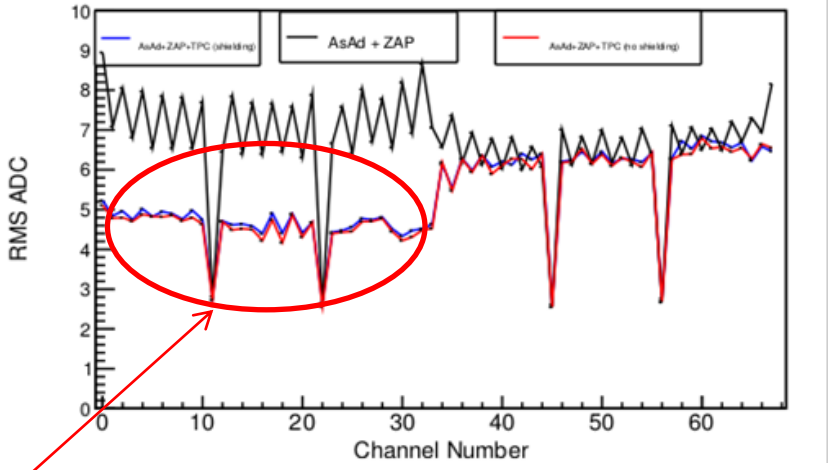
Signal: How many pads is the induced charge distributed over? What fraction of the charge is received by each pad?

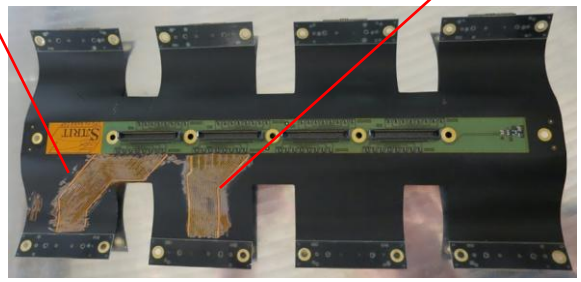
Noise: What is the noise level? What is the main source of the noise? Can it be reduced? (Greater noise = reduced dynamic range)

Noise Evaluation: ZAP

Ch 0-33 have Ag layer removed







	Ch 0-33	Ch 34-67
AGET2	4.6	5.7
AGET3	4.6	6.2