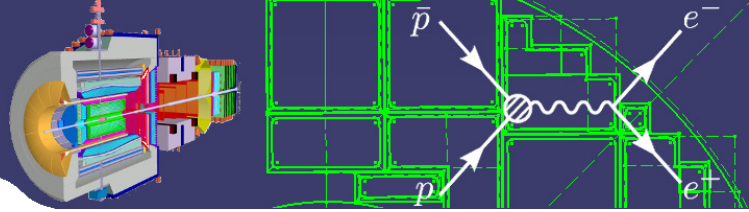
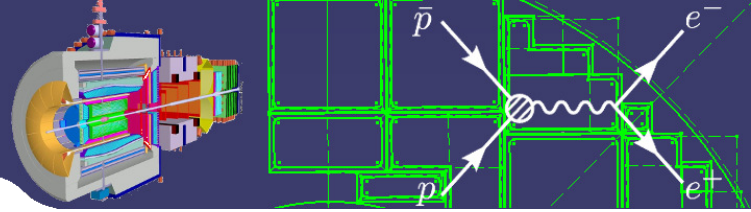


Single Crystal (APD) Energy Threshold

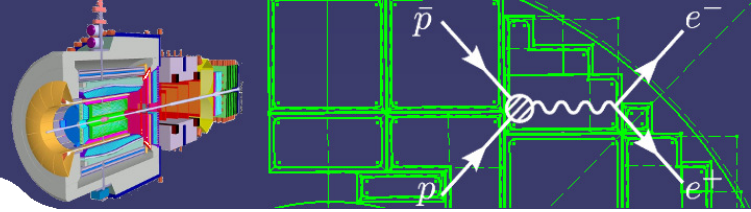
S. Ahmed, L. Capozza, A. Dbeyssi, D. Izard, F. Maas,
O. Noll, D. Rodríguez

PANDA Meeting March 2016

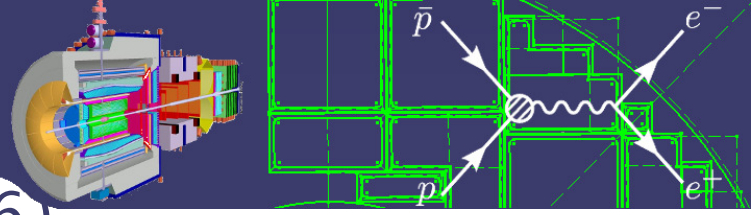
1. March 2016



1. The Backward EMC Prototype (PROTO16)
2. Tests of PROTO16 at the Mainz Microtron Facility
3. Analysis Update



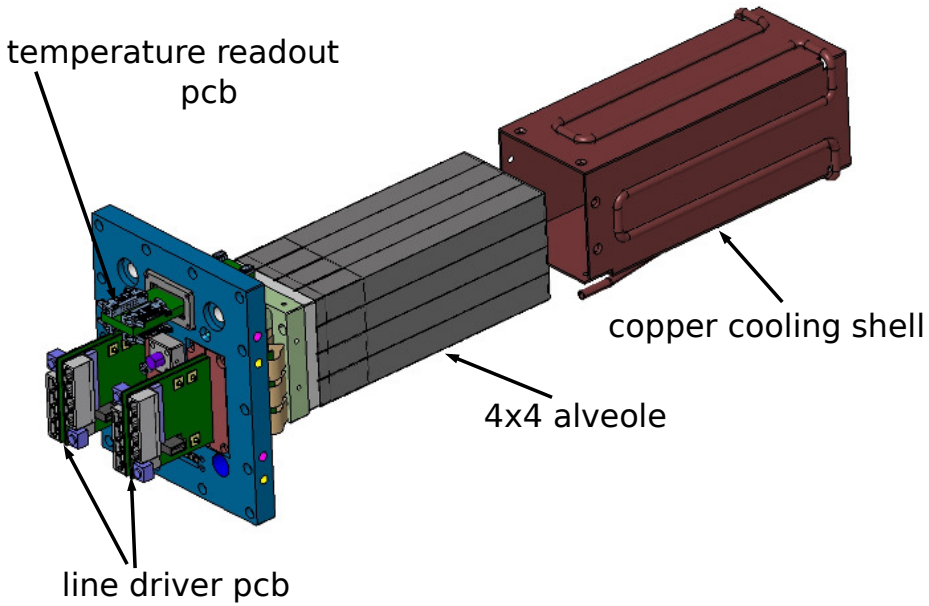
The Backward EMC Prototype (PROTO16)

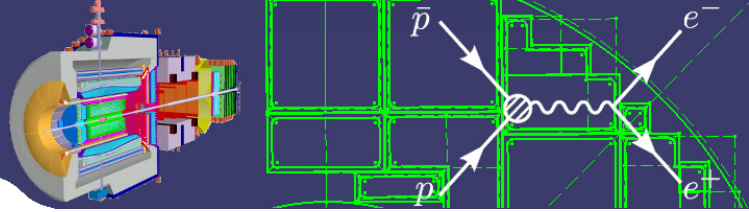


Backward EMC Prototype (PROTO16)

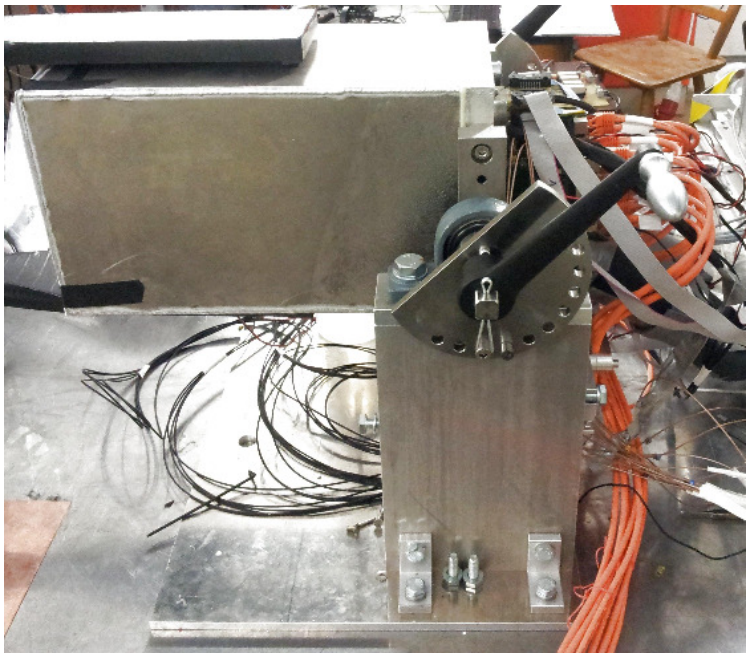
PROTO16

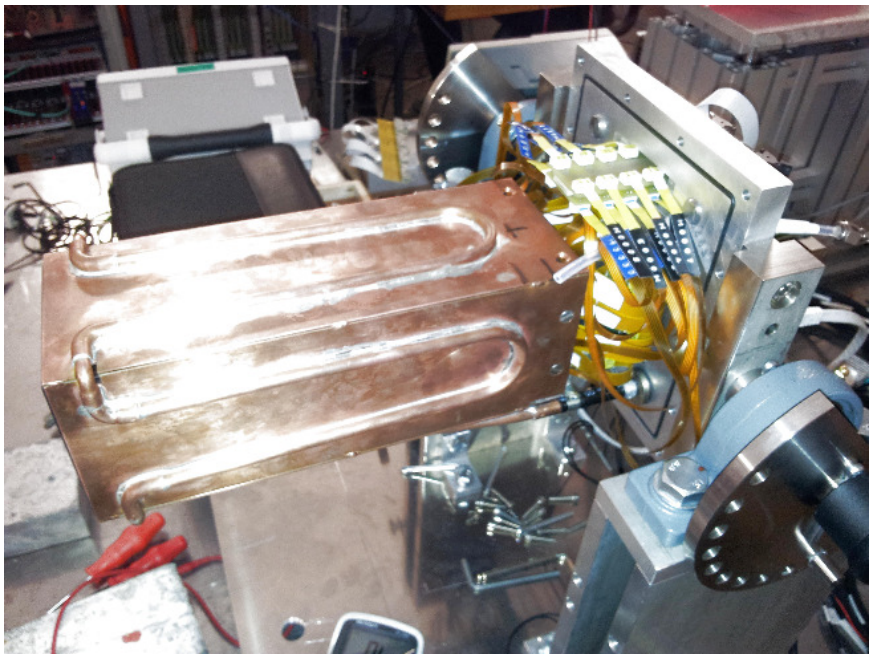
- Mechanics
  - Carbon fibre alveole with 16 $PbWO_4$ crystals
  - Two mounting plates separated with glass fibre feet
  - optical fibre to every crystal
- Cooling
  - Cooling shell
  - Insulated with VIP
  - Nitrogen supply
- Monitoring
  - Flat thermal sensors
  - THMP
- Readout
  - Two APD per crystal
  - APFEL ASIC
  - Line driver





EMC Prototype (PROTO16)





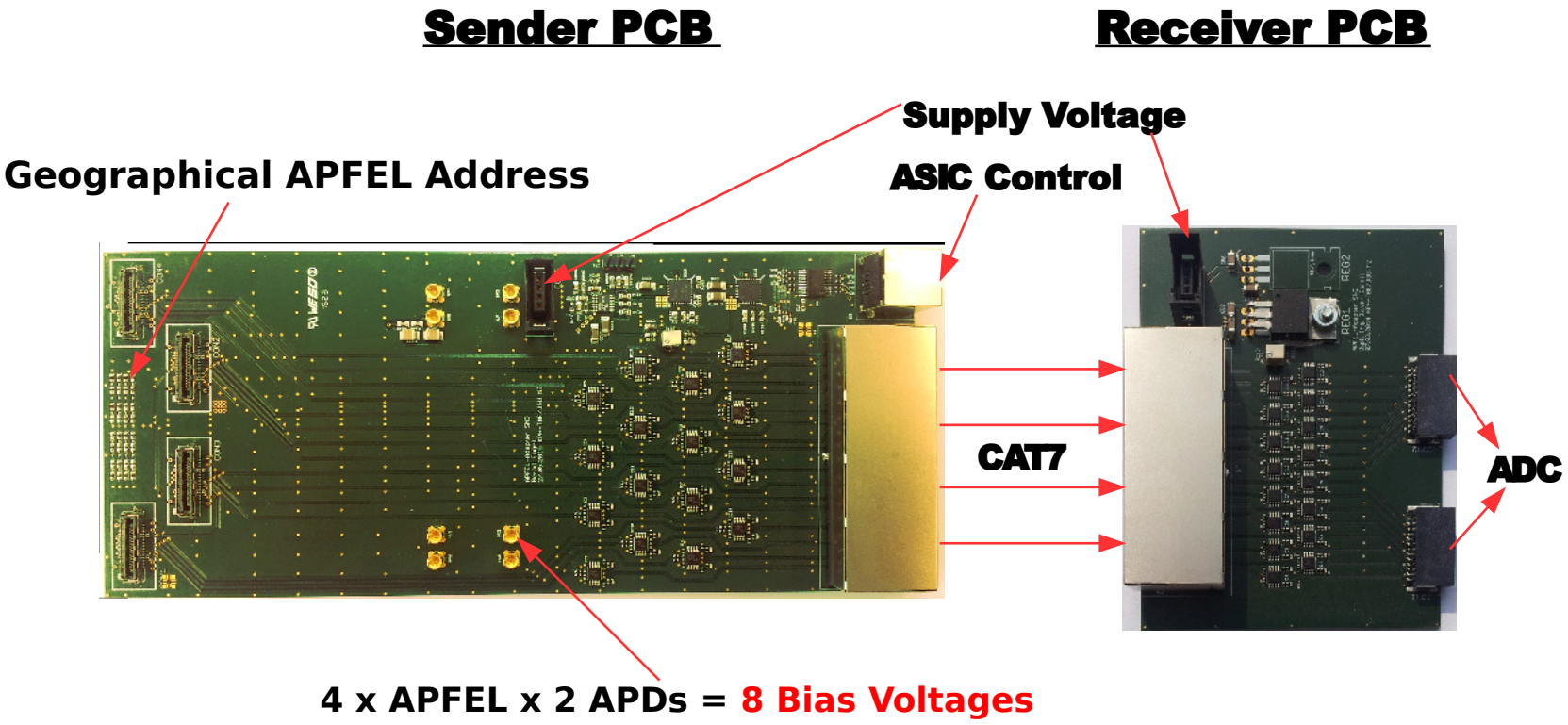
Latest Version of APFEL ASICs

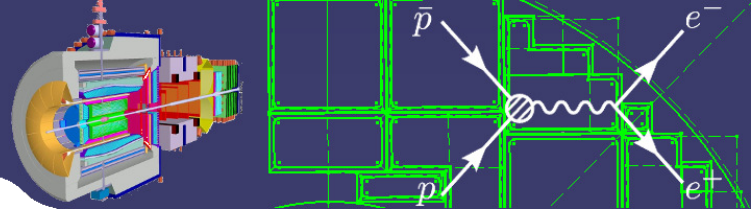
APFEL V. 1.5

- Reads out 2 APDs
- Charge sensitive preamplifier
- 2 main amplifiers (2 gains)
- 4 differential output channels
- HV line for each APD
- Geographical addressing

Developer: P. Wieczorek, H. Flemming (GSI)

Line Drivers



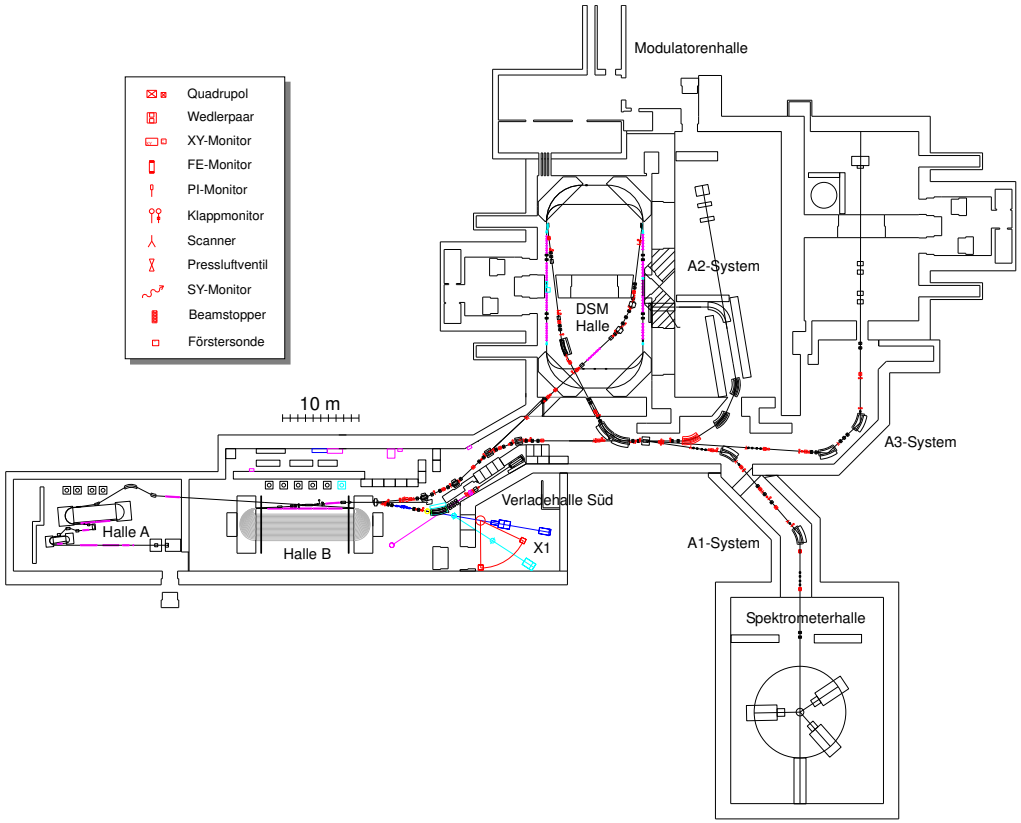


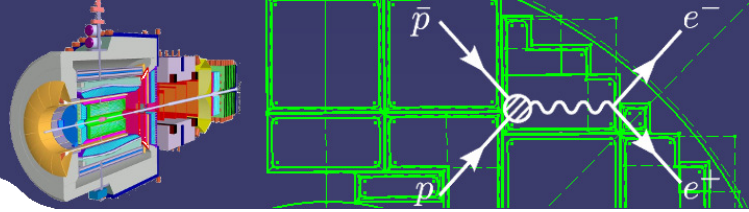
Beam Test of PROTO16 at Mainz (MAMI)

Tests at the Mainz Microtron

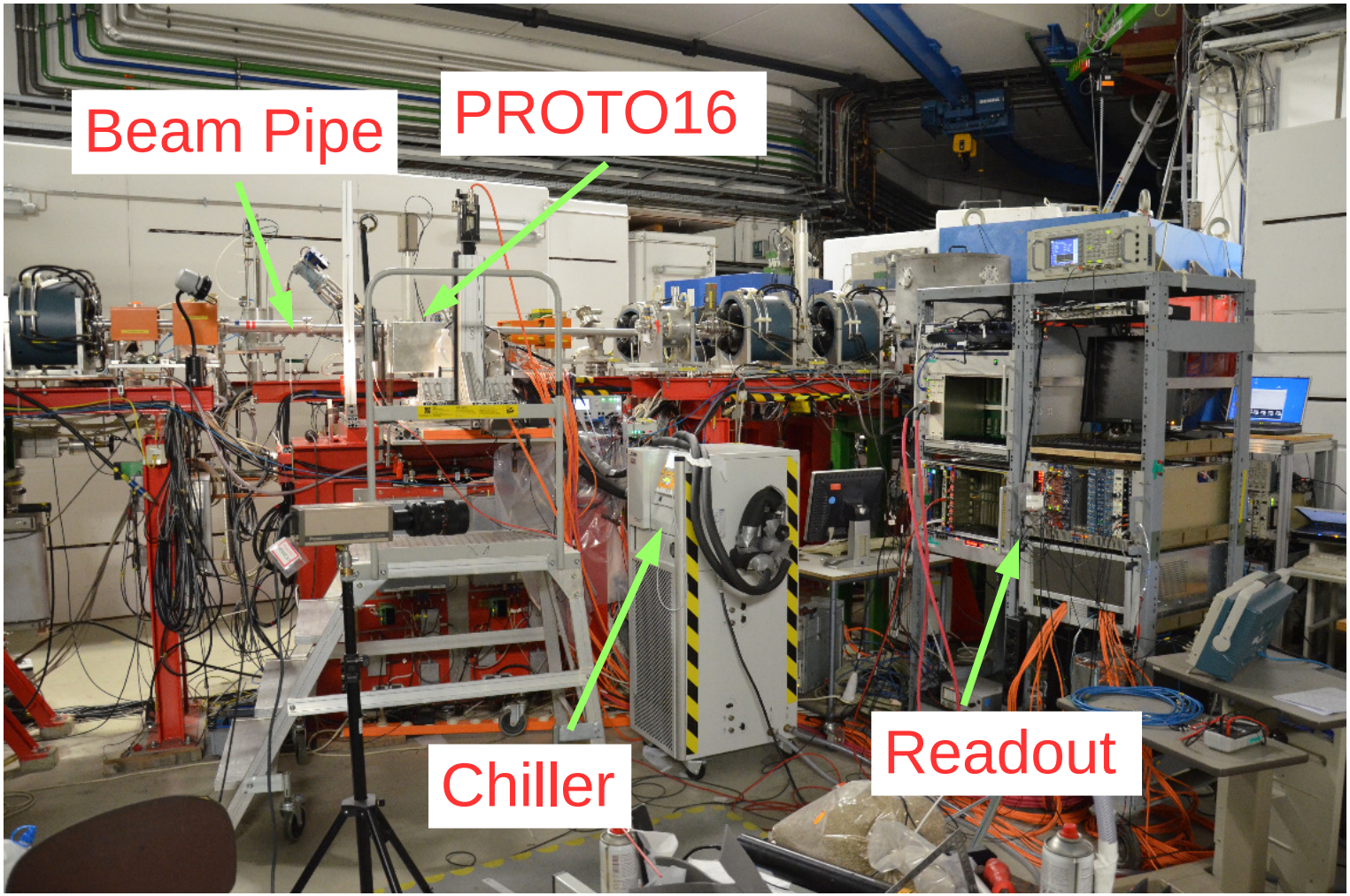
Test Beamtime

- July 2015
- 48 hours
- Electron beam
- Used energies:
  - 195 MeV
  - 315 MeV
  - 450 MeV
  - 600 MeV
  - 855 MeV

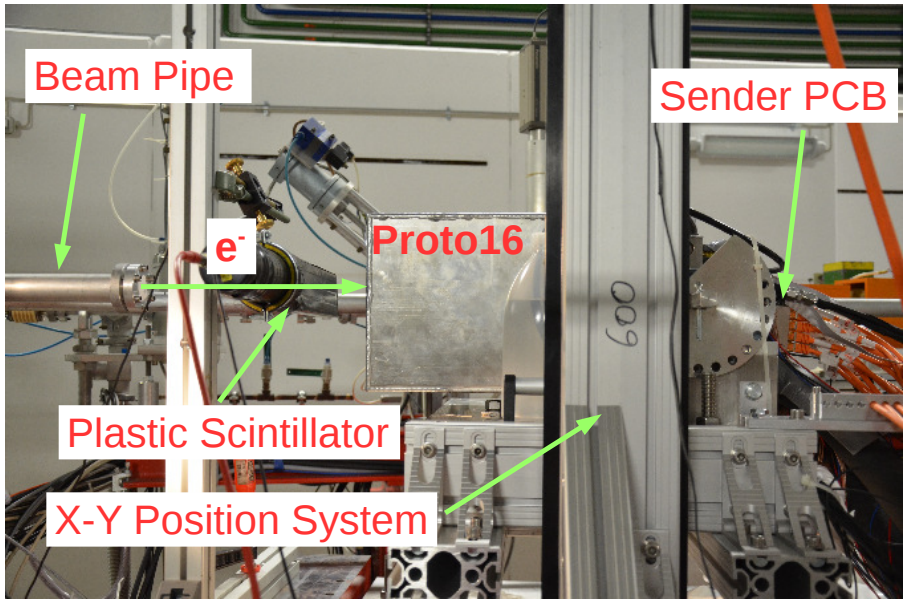


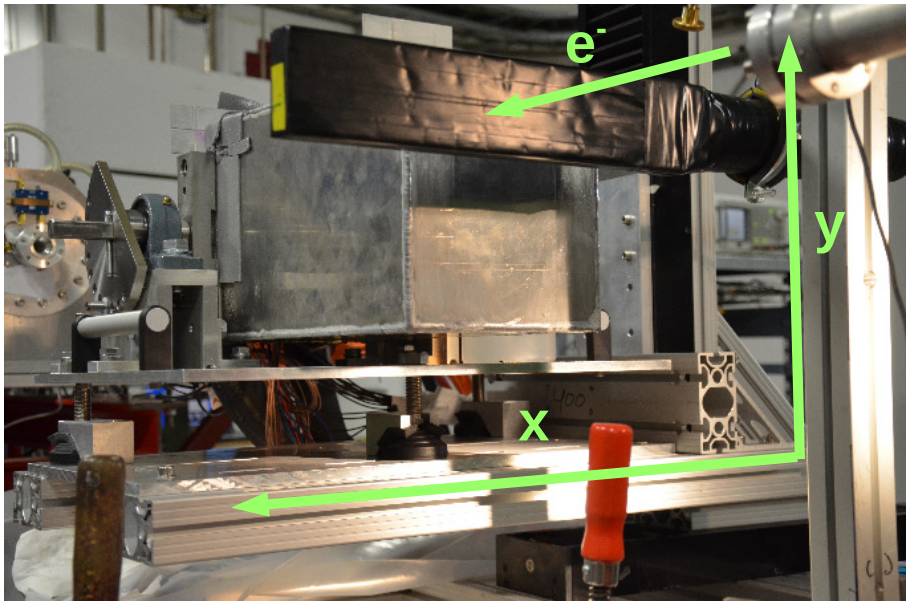


PROTO16 in MAMI Hall B

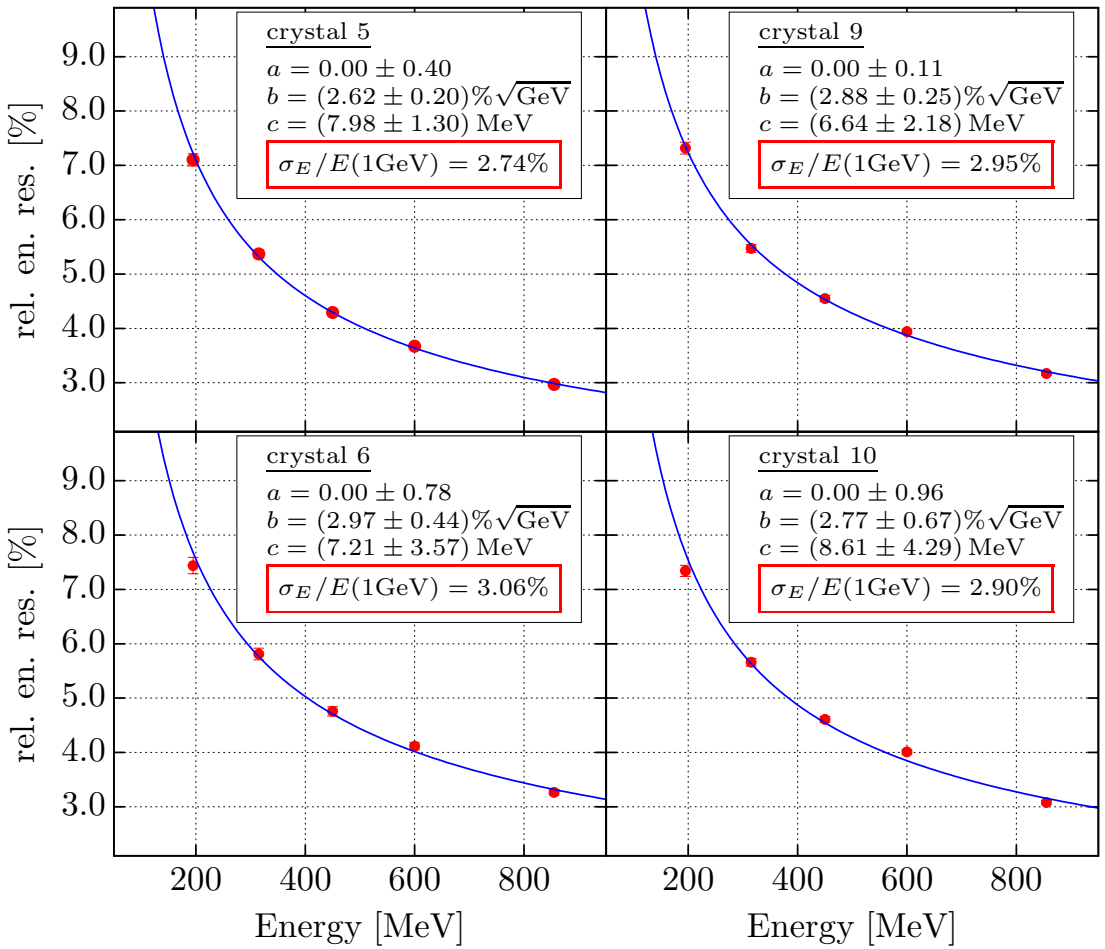


PROTO16 in MAMI Hall B



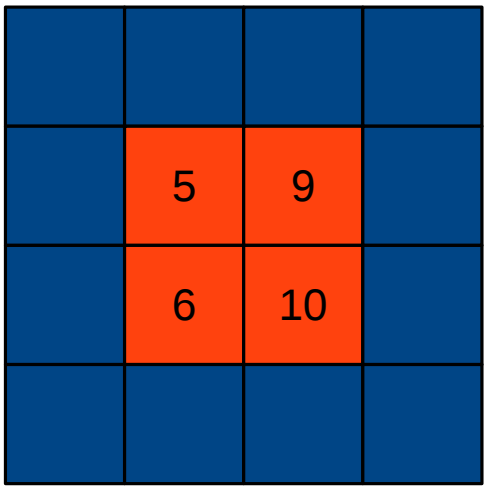


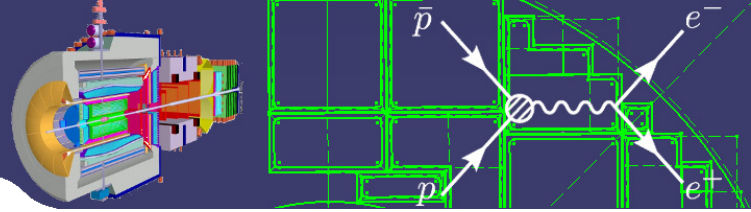
Energy Resolution (Low Gain)



Energy Resolution

- $\frac{\sigma_E}{E} = a \oplus \frac{b}{\sqrt{E}} \oplus \frac{c}{E}$





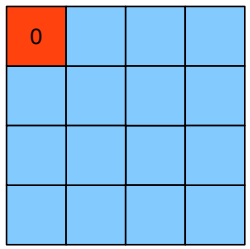
Analysis Update

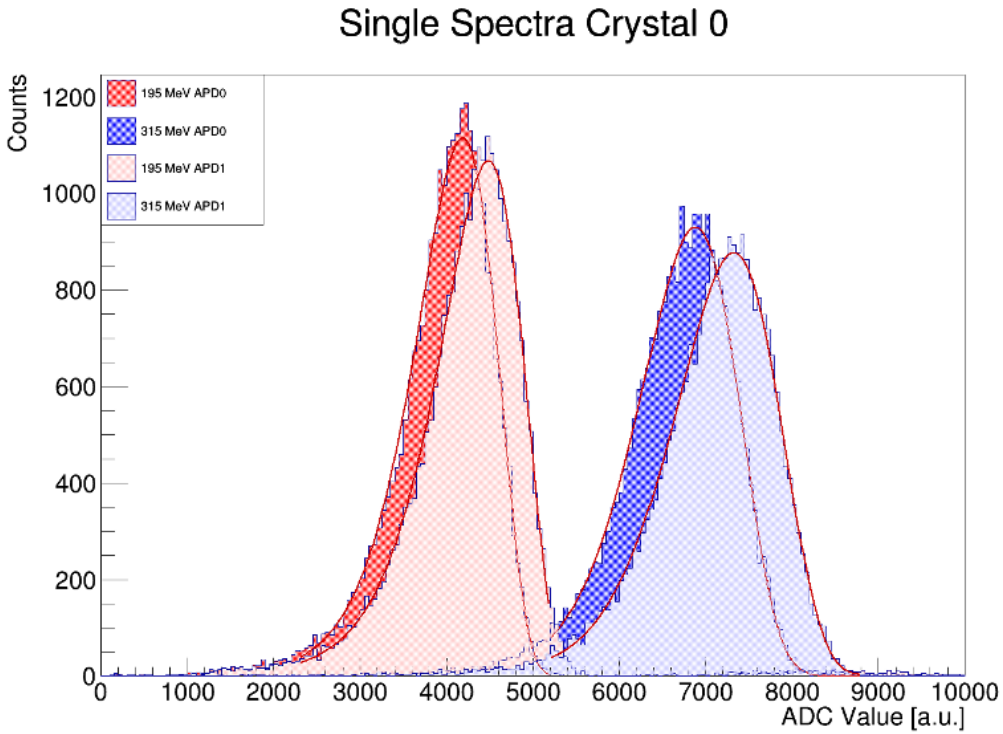
- Energy Calibration
- Hit Detection
- Threshold Scan $\rightarrow$ Single Crystal Energy Threshold

Threshold Scan - Energy Calibration

Energy Calibration

- ADC Channel → Energy
  - Single APD Spectra
  - 195 MeV, 315 MeV
  - Novosibirsk function
  - (85±5)% deposited Energy (Geant4)

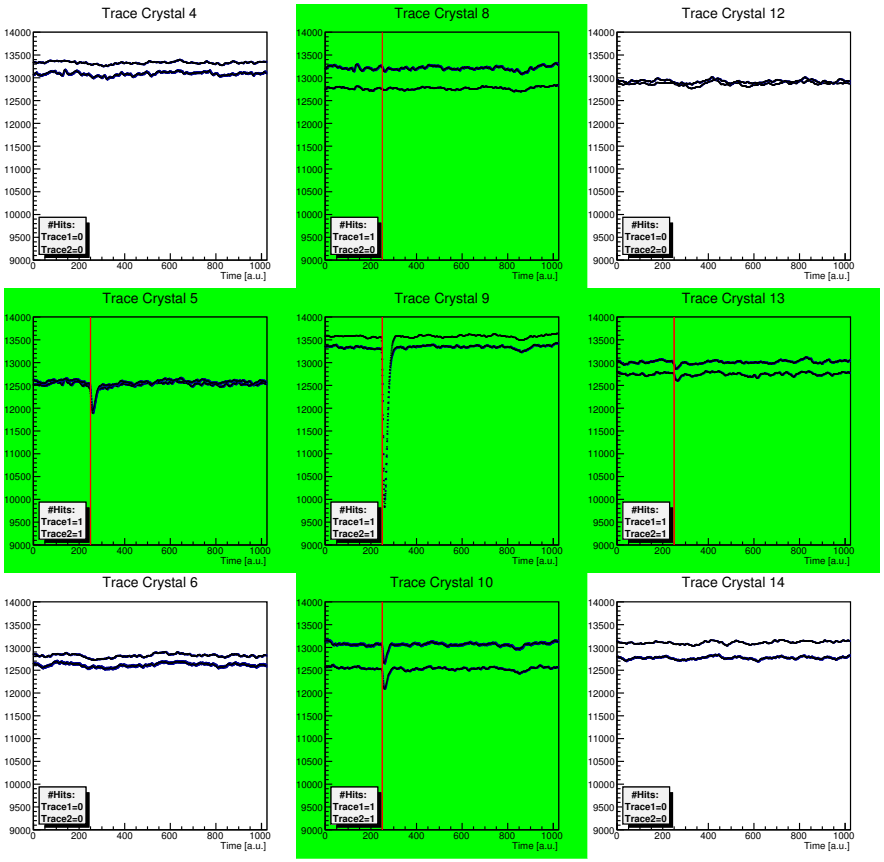




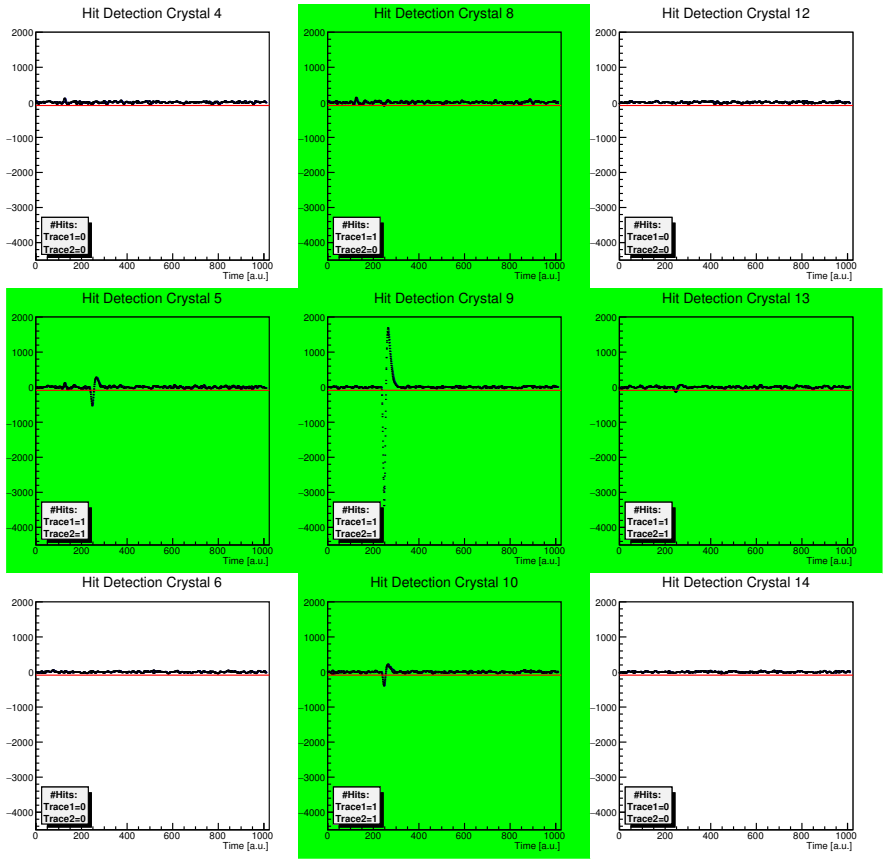
APD0: 0.038±0.002 MeV/CH
APD1: 0.036±0.002 MeV/CH

Hit Finder Algorithm

Raw signal (195 MeV)



Hit Finder (Threshold = -90 a.u.)

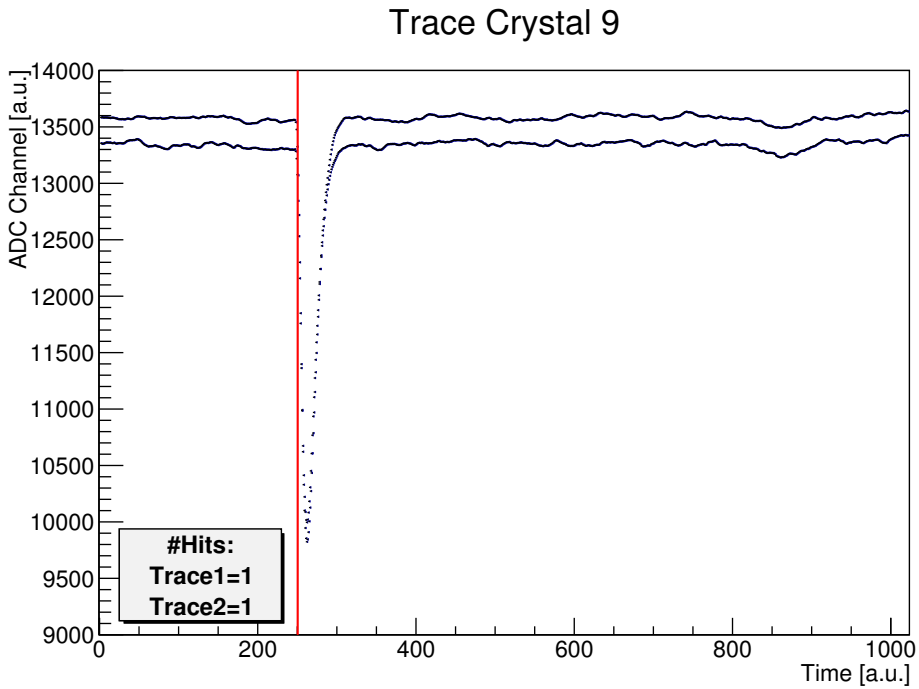


- Simple moving Average (SMA)
- filt[i]=trace[i+w]-trace[i]

Threshold Scan

Lowering the Threshold

- E=195 MeV
- Central crystal
- High Gain
- Hit finder on traces off the trigger pulse
- Hit finder threshold scan
  - -120 a.u. $\rightarrow$ 0 a.u.
  - 3 a.u. steps
  - Count number of hits

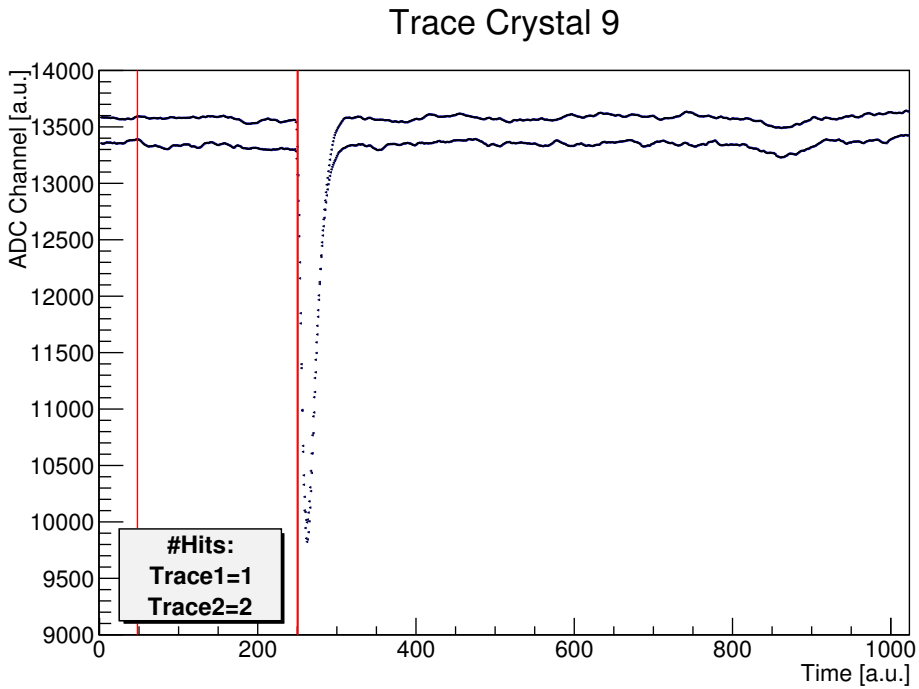


Threshold = -90 a.u.

Threshold Scan

Lowering the Threshold

- E=195 MeV
- Central crystal
- High Gain
- Hit finder on traces off the trigger pulse
- Hit finder threshold scan
  - -120 a.u. $\rightarrow$ 0 a.u.
  - 3 a.u. steps
  - Count number of hits

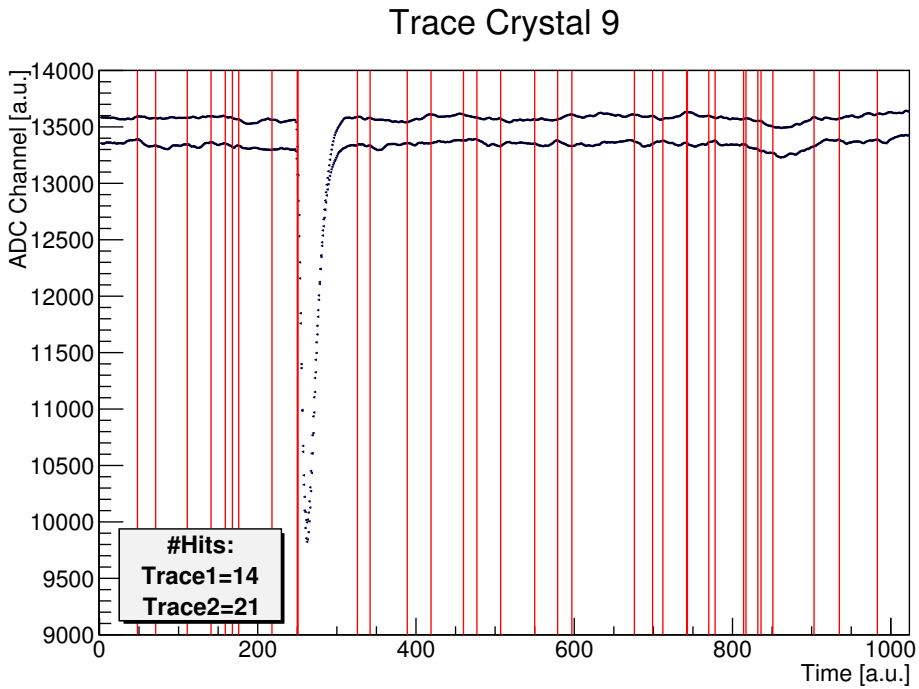


Threshold = -50 a.u.

Threshold Scan

Lowering the Threshold

- E=195 MeV
- Central crystal
- High Gain
- Hit finder on traces off the trigger pulse
- Hit finder threshold scan
  - -120 a.u. $\rightarrow$ 0 a.u.
  - 3 a.u. steps
  - Count number of hits

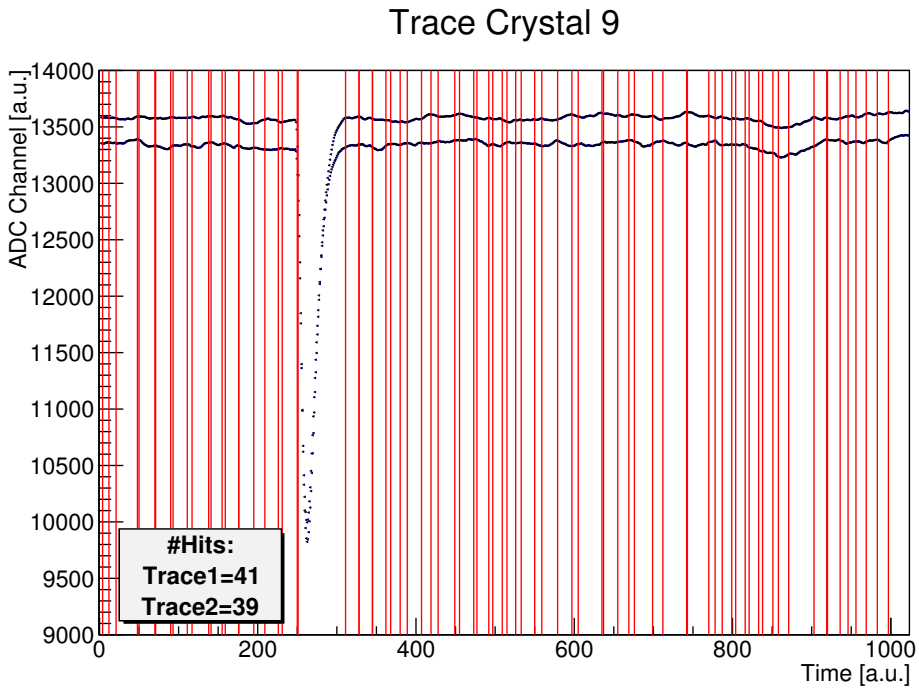


Threshold = -20 a.u.

Threshold Scan

Lowering the Threshold

- E=195 MeV
- Central crystal
- High Gain
- Hit finder on traces off the trigger pulse
- Hit finder threshold scan
  - -120 a.u. $\rightarrow$ 0 a.u.
  - 3 a.u. steps
  - Count number of hits

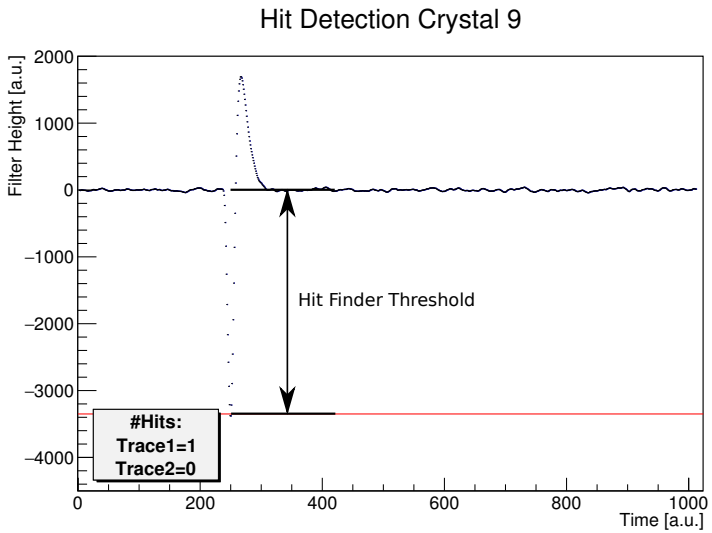


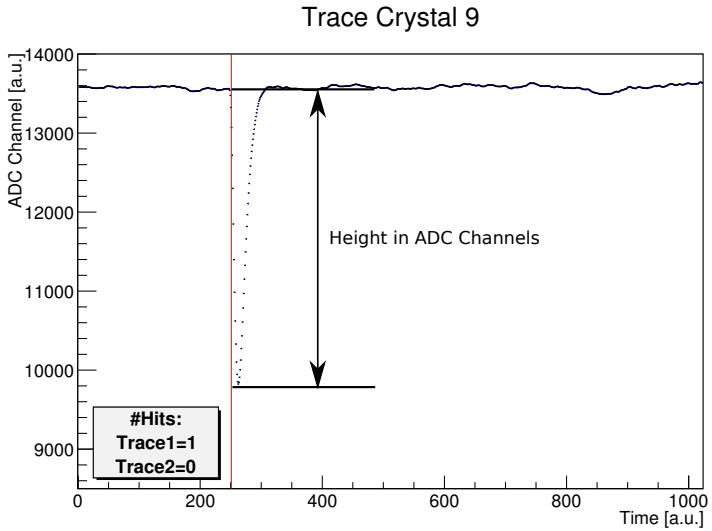
Threshold = 0 a.u.

Threshold Scan - Energy Scale

Energy Scale

- Hit finder threshold → Pulse height (ADC channels)

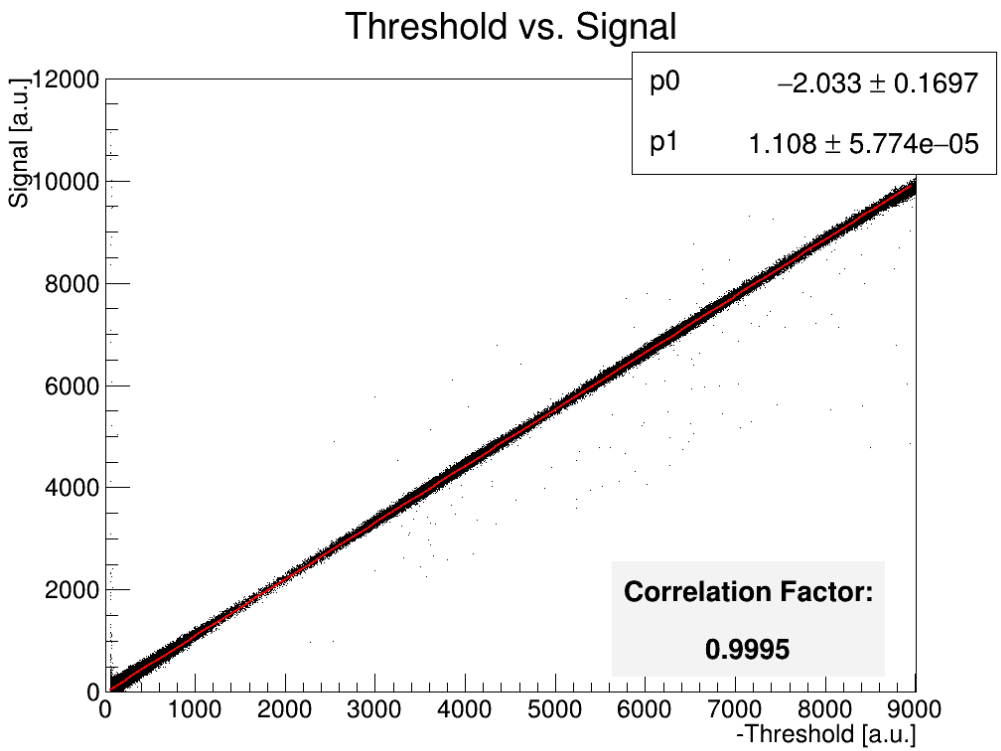




Threshold Scan - Energy Scale

Energy Scale

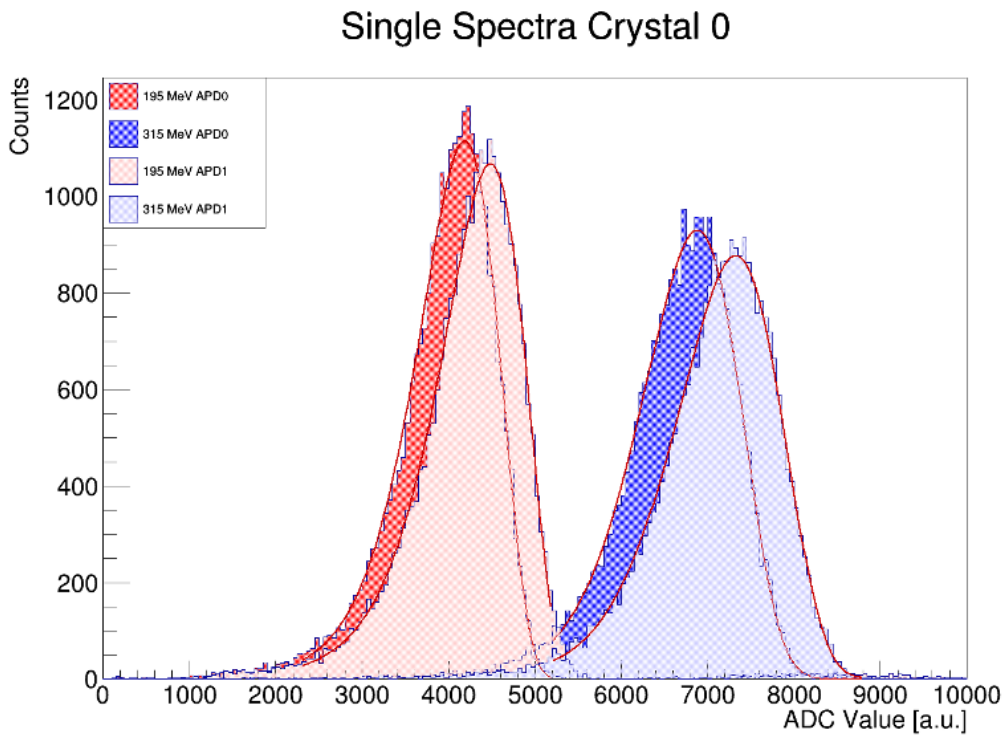
- Hit finder threshold $\rightarrow$ Pulse height (ADC channels)



Threshold Scan - Energy Scale

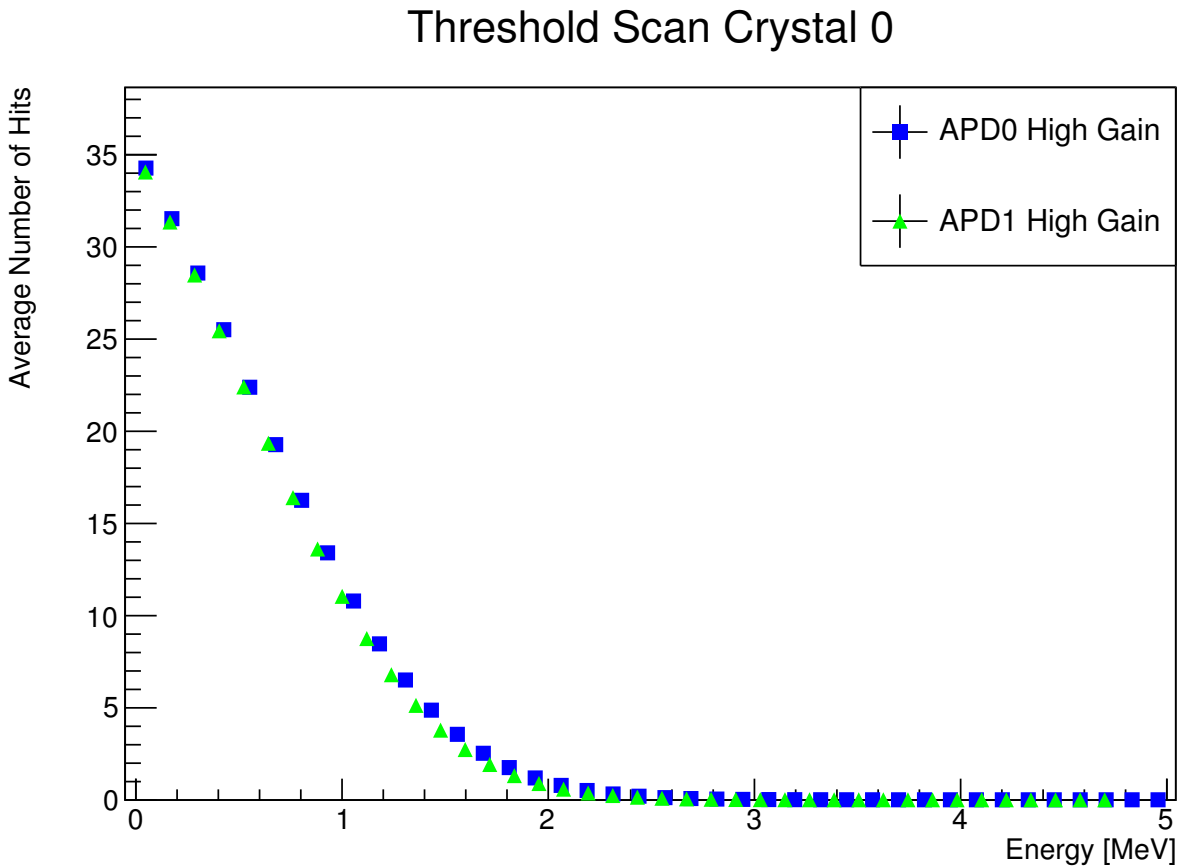
Energy Scale

- Hit finder threshold → Pulse height (ADC channels)
- Pulse height (ADC channels) → deposited energy



APD0: 0.038±0.002 MeV/CH
APD1: 0.036±0.002 MeV/CH

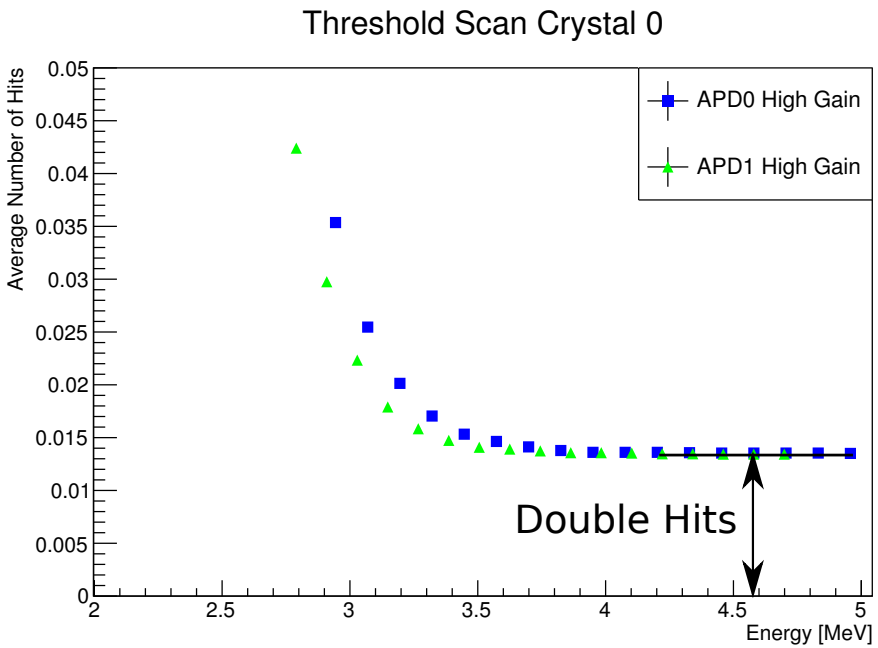
Threshold Scan - Results

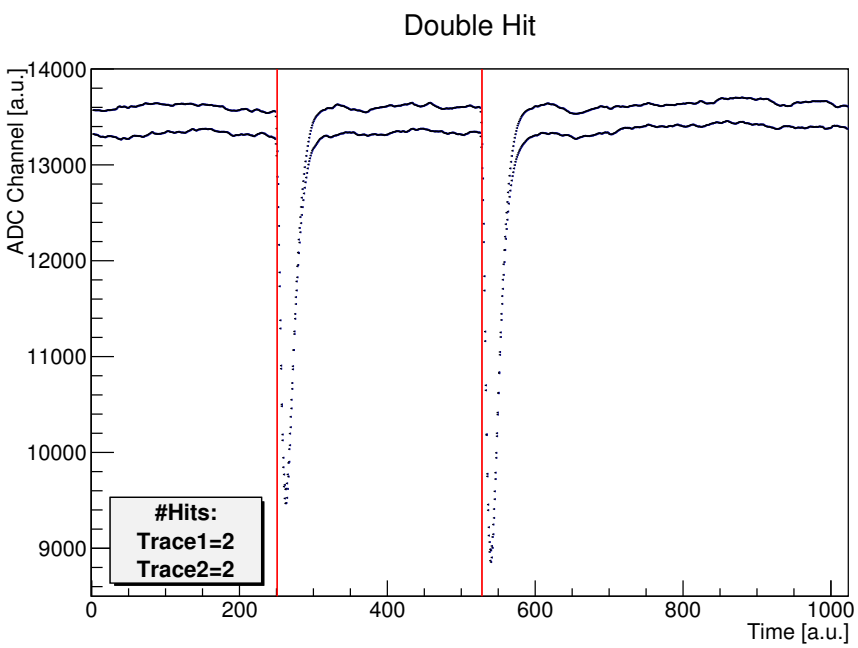


Detector Self Trigger

At least one hit in central crystal $\rightarrow$ $\langle$Hits$\rangle$-1

Threshold Scan - Single APD

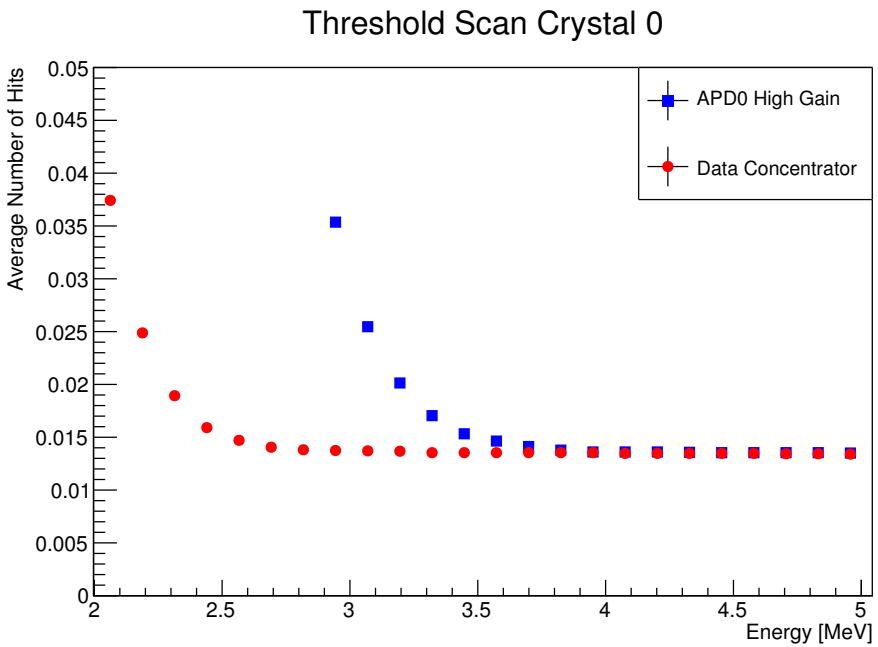


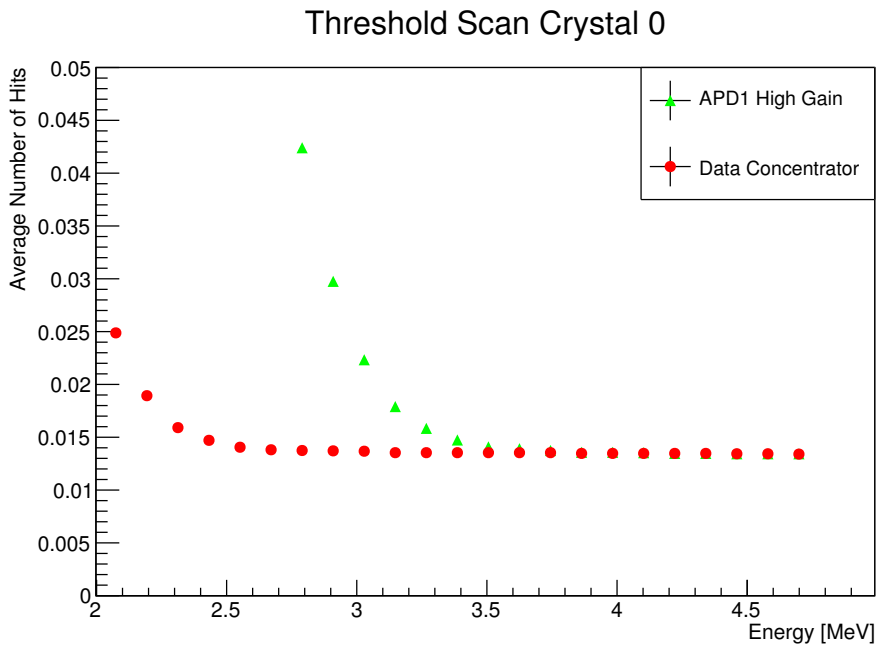


Double Hits

off-pulse time $\sim 17\mu s$, trigger rate $\sim$ 800 Hz $\rightarrow P_{double}$ $\sim$1.3%

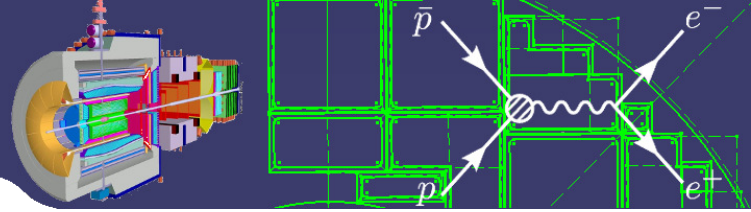
Threshold Scan - Data Concentrator



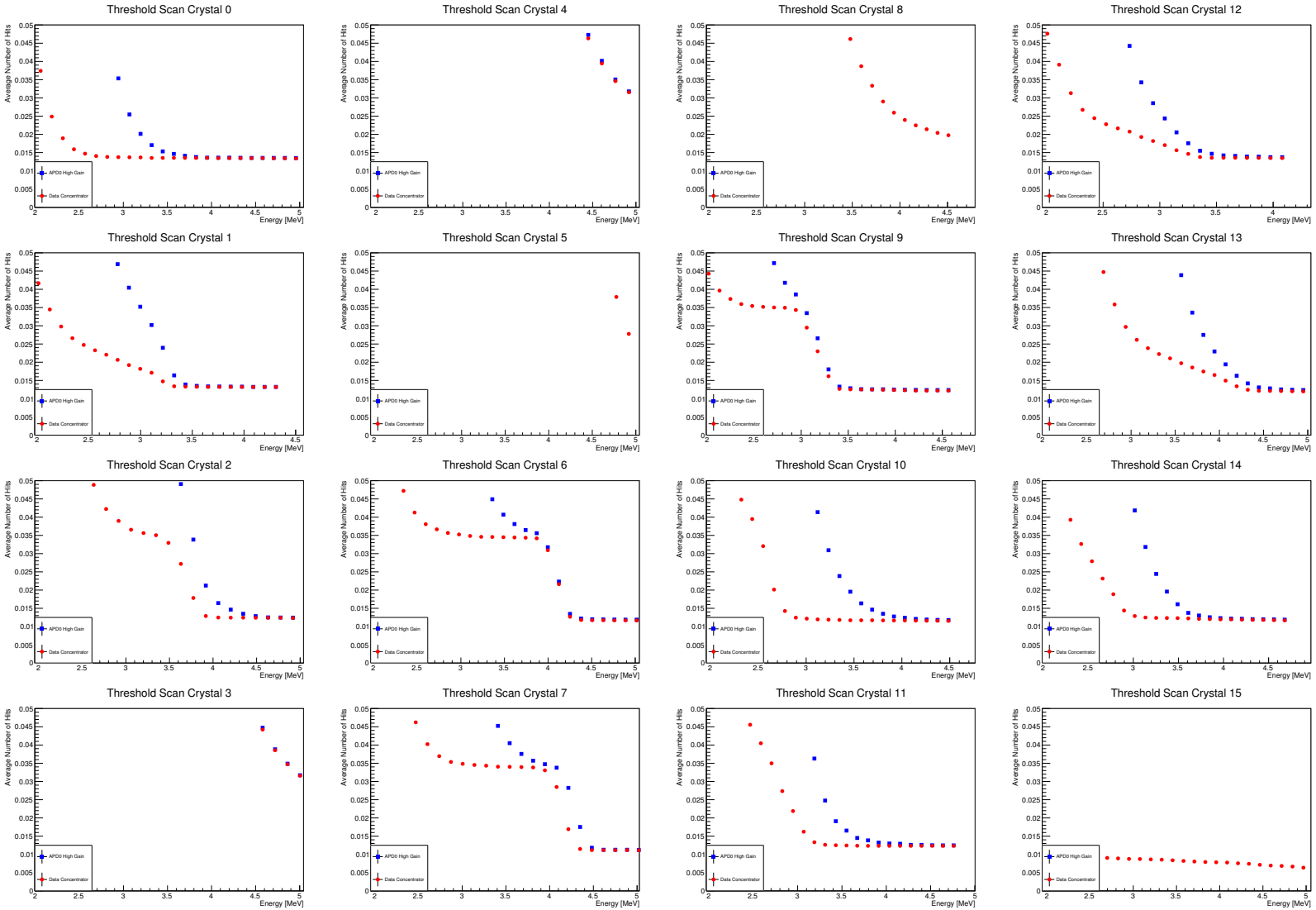


Data Concentrator

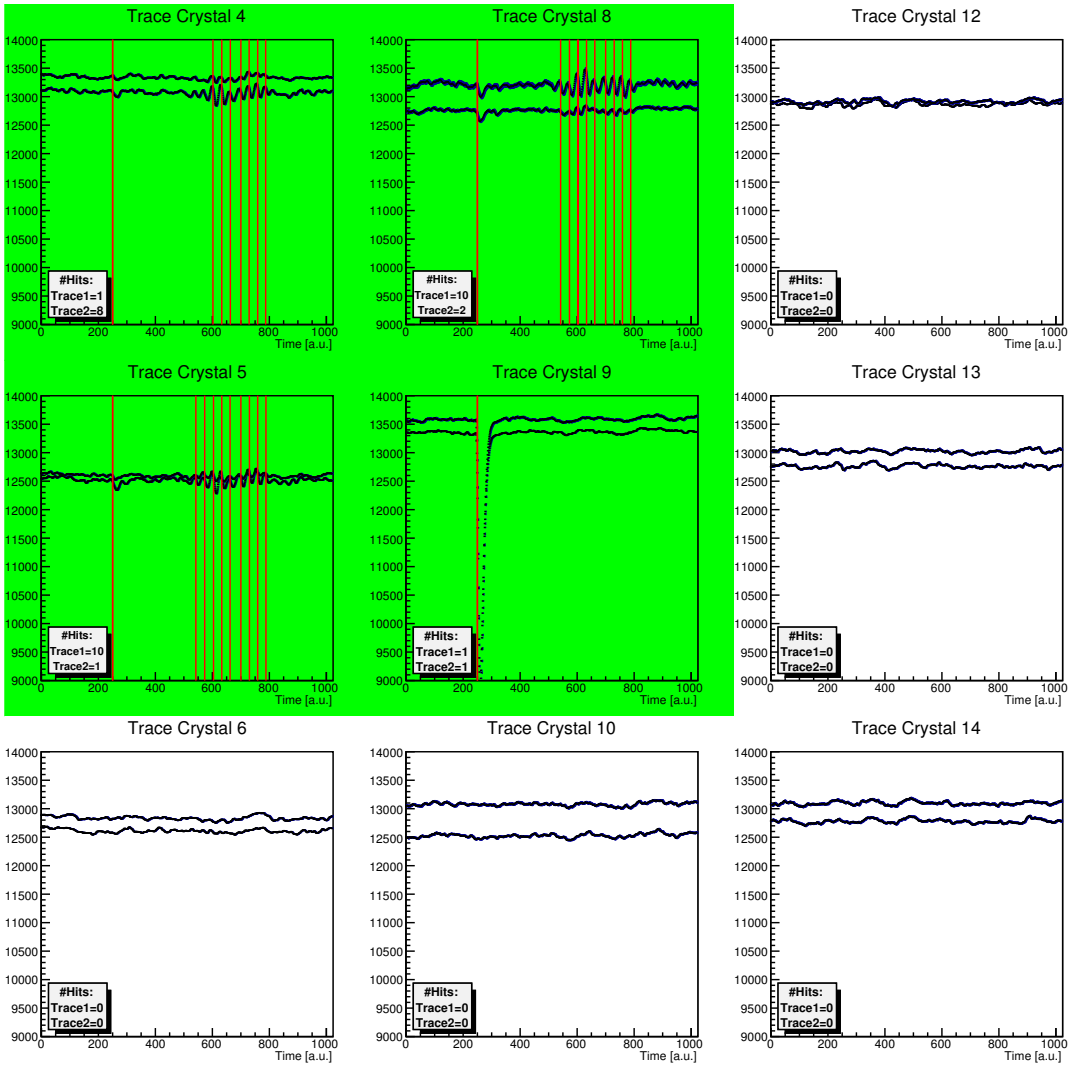
Event has to appear in both APD traces



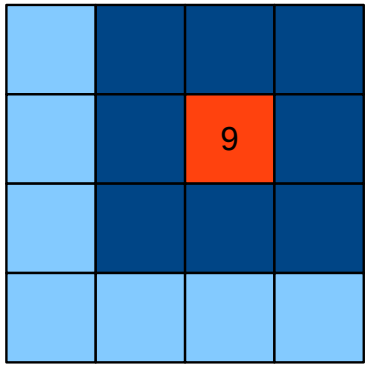
Threshold Scan - All Channels APD0

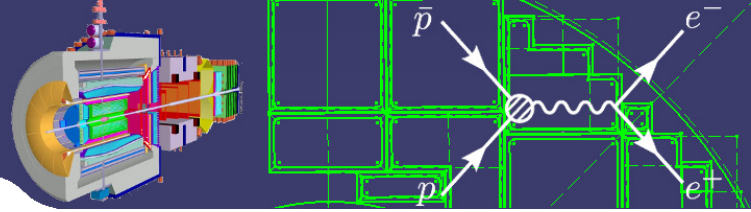


Threshold Scan - Ringing



~1%...5% of events in these APD traces





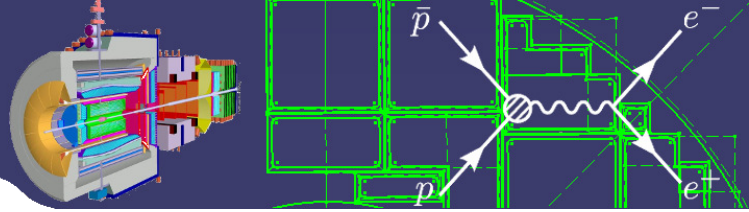
Summary and Outlook

Summary

- Analysis Update with July '15 beamtime data
- Study of single crystal (APD) energy threshold with APFEL ASIC and Mainz line drivers
- 2 MeV single APD threshold and hit required in the other APD at data concentrator level:
  1 noise hit in $\sim$ 3% of the traces
- Noise hit rate: $0.03/17\mu s = 1.76$ kHz
- Can be eliminated by cluster finding algorithm (?)

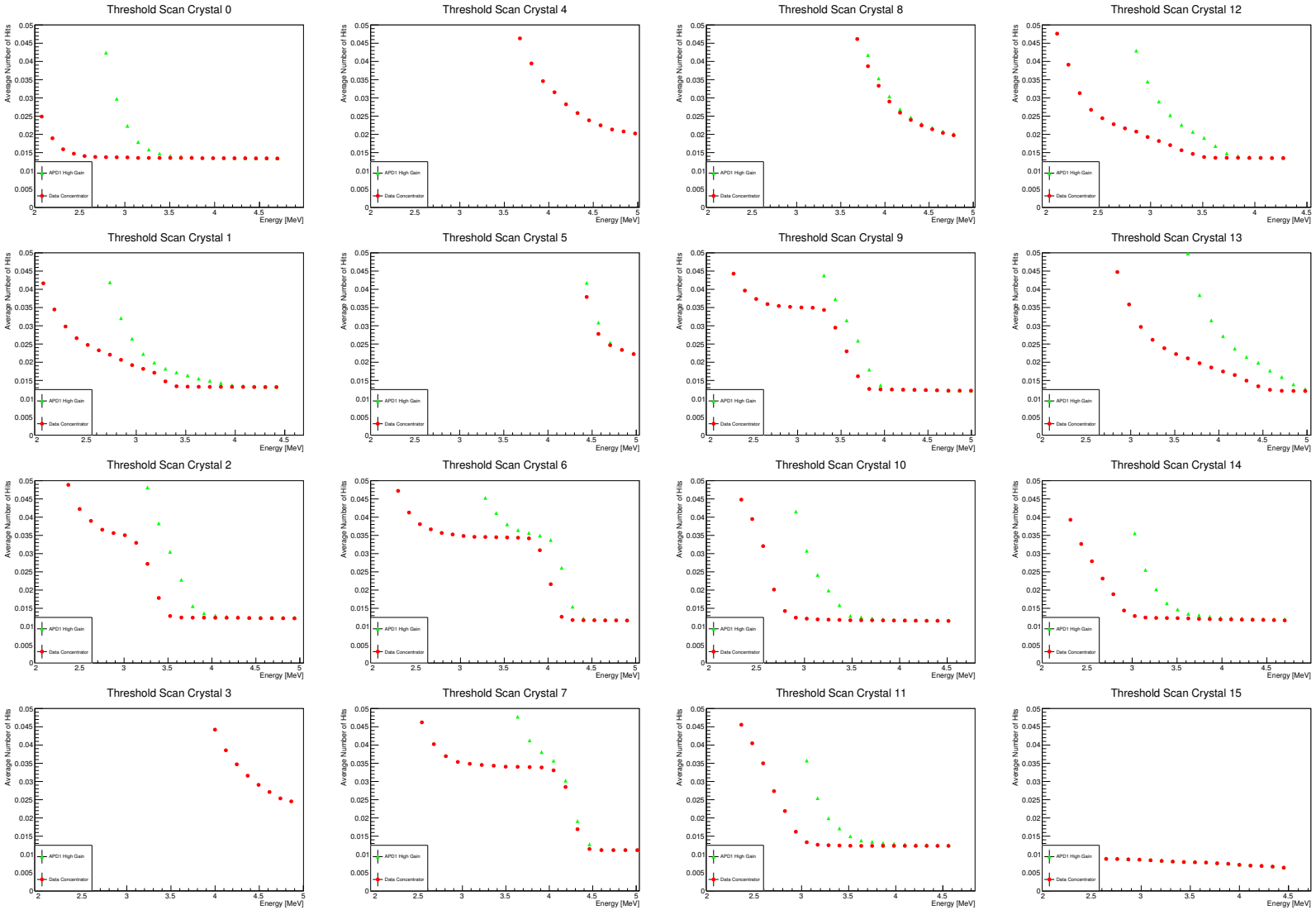
Next Steps

- Study of line driver noise
- Preparing beamtime May '16
- Integration of Uppsala ADC
- Improving feature extraction $\rightarrow$ FPGA



Thank you!

Threshold Scan - All Channels APD1



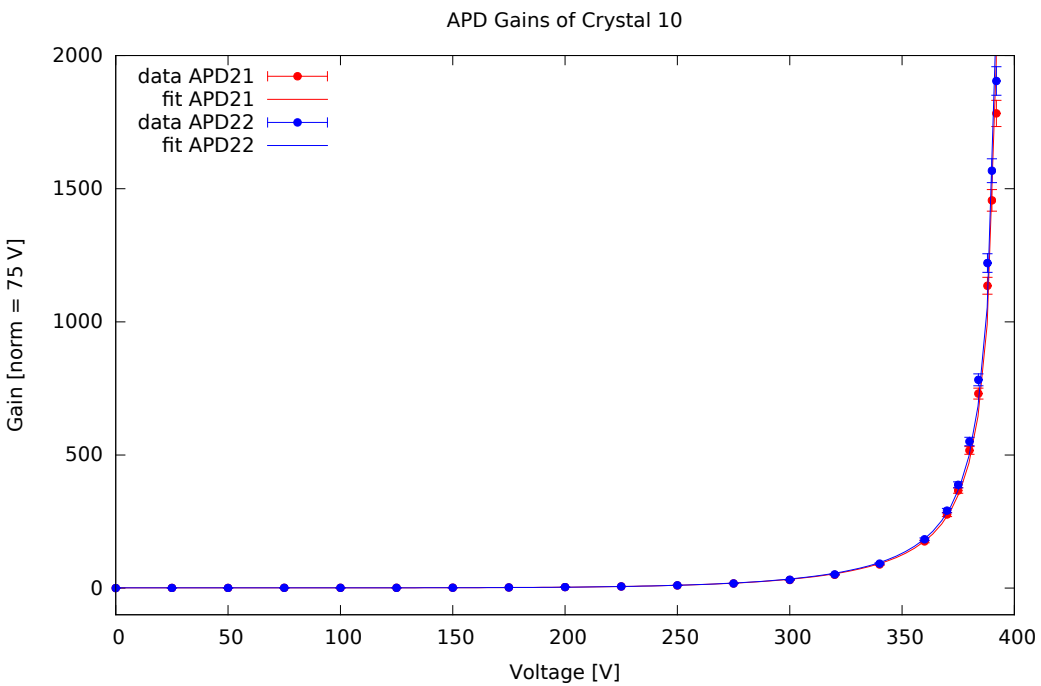
Determination of APD Gain

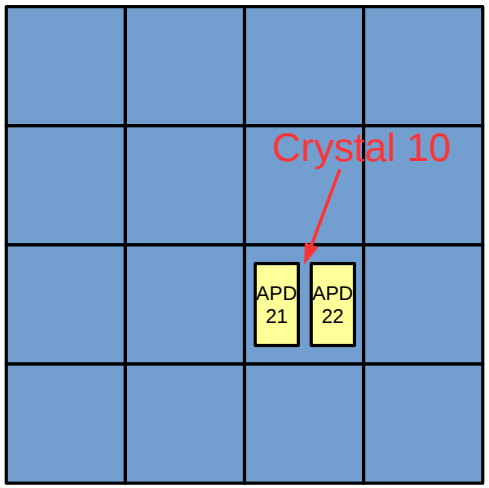
Procedure

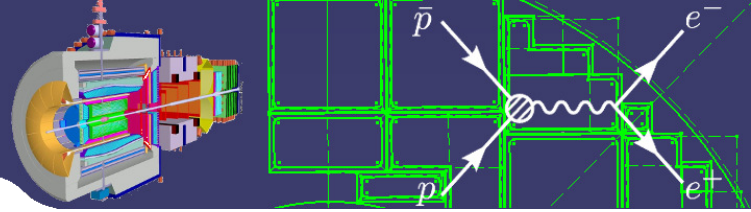
- T = -25 °C
- Constant light pulses
- scan voltages

Fitfunction

- normalized to 75 V
- $G(U) = \frac{A}{1-(U/k)^{k1}} + C$
- k = breakdown voltage
- $k_{APD21} = 396.28 \pm 0.41$ V
- $k_{APD22} = 396.19 \pm 0.43$ V
- $G_{APD21} = 796 \pm 72$
- $G_{APD22} = 845 \pm 81$







Analysis - APD Gain

Crystal	G APD left	ΔG APD left	G APD right	ΔG APD right
0	824	60	1030	177
1	905	62	889	65
2	709	48	784	58
3	429	35	477	51
4	-	-	1162	111
5	790	50	759	42
6	-	-	926	81
7	775	59	802	62
8	897	121	968	98
9	797	76	775	54
10	796	72	845	81
11	446	30	464	37
12	1006	77	1118	91
13	701	41	866	56
14	800	44	1061	60
15	803	44	1201	68