First Results on Dec 2015 Proto120 Beam Test

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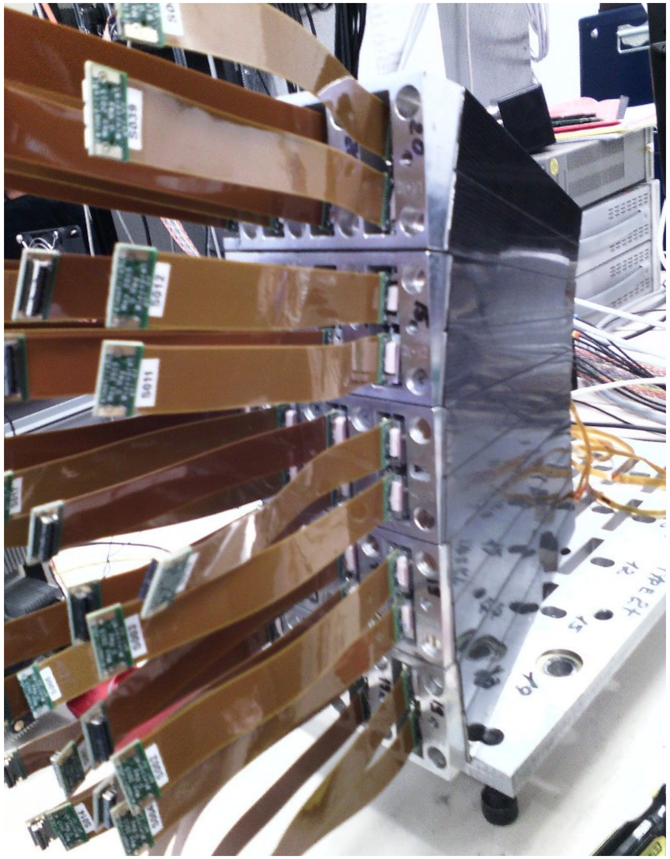
Proto120

- ASIC flex PCBs v6 with left- and right-hand connector configuration



- Assembly of 2 crystal blocks (type 2 and 3)
- 80 crystals equipped with matched pairs of APDs based on information from APD database

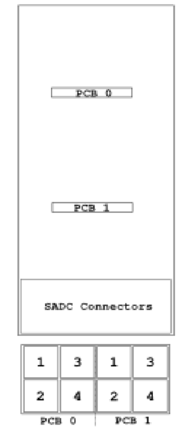
Proto120

R A S P B E R R Y 1				R A S P B E R R Y 4				
C20 : 4 S037 A1, B1 **366** 5 <0> 364,86	C20 : 2 W040 A2, B2 **368** 5 <0> 362,90	C10 : 4 S030 A3, B3 **353** 60 5 <1> 362,73	C10 : 2 W043 A4, B4 **379** 1 5 <1> 344,33	A10 : 4 S007 A5, B5 **324** 2 10 <1> 369,69	A10 : 2 W054 A6, B6 **317** 3 10 <1> 345,94	A11 : 4 S008 A7, B7 **176** 4 10 <0> 345,21	A11 : 2 W001 A8, B8 **321** 5 10 <0> 370,13	R
C20 : 3 S038 A9, B9 **275** 5 <0> 345,98	C20 : 1 W038 A10, B10 **273** 5 <0> 377,30	C10 : 3 S020 A11, B11 **271** 59 5 <1> 367,41	C10 : 1 W059 A12, B12 **270** 6 5 <1> 343,89	A10 : 3 S039 A13, B13 **223** 7 10 <1> 345,58	A10 : 1 W055 A14, B14 **226** 8 10 <1> 371,48	A11 : 3 S009 A15, B15 **220** 9 10 <0> 374,58	A11 : 1 W005 A16, B16 **224** 10 10 <0> 369,78	L
C21 : 4 S032 A17, B17 **360** 4 <0> 362,59	C21 : 2 W036 A18, B18 **370** 4 <0> 362,16	C11 : 4 S031 A19, B19 **367** 58 4 <1> 365,03	C11 : 2 W042 A20, B20 **364** 11 4 <1> 345,73	A20 : 4 S012 A21, B21 **332** 12 9 <1> 345,10	A20 : 2 W020 A22, B22 **333** 13 9 <1> 344,60	A21 : 4 S019 A23, B23 **315** 14 9 <0> 344,52	A21 : 2 W004 A24, B24 **335** 15 9 <0> 344,80	R
C21 : 3 S035 A25, B25 **292** 4 <0> 373,42	C21 : 1 W034 A26, B26 **287** 4 <0> 363,90	C11 : 3 S021 A27, B27 **274** 57 4 <1> 369,74	C11 : 1 W044 A28, B28 **255** 16 4 <1> 345,48	A20 : 3 S011 A29, B29 **571** 17 9 <1> 345,52	A20 : 1 W031 A30, B30 **246** 18 9 <1> 345,41	A21 : 3 S018 A31, B31 **569** 19 9 <0> 344,72	A21 : 1 W006 A32, B32 **243** 20 9 <0> 344,99	L
F20 : 4 S034 A33, B33 **381** 3 <0> 347,75	F20 : 2 W030 A34, B34 **352** 3 <0> 367,10	F21 : 4 S022 A35, B35 **375** 56 3 <1> 366,69	F21 : 2 W041 A36, B36 **390** 21 3 <1> 344,94	F21 : 4 S010 A37, B37 **331** 22 8 <1> 369,47	F21 : 2 W058 A38, B38 **316** 23 8 <1> 358,20	F20 : 4 S017 A39, B39 **216** 24 8 <0> 345,67	F20 : 2 W002 A40, B40 **177** 25 8 <0> 368,25	R
F20 : 3 S047 A41, B41 **261** 3 <0> 367,03	F20 : 1 W035 A42, B42 **289** 3 <0> 368,40	F21 : 3 S029 A43, B43 **259** LED 55 3 <1> 350,29	F21 : 1 W047 A44, B44 **280** 26 3 <1> 375,72	F21 : 3 S003* A45, B45 **250** 27 8 <1> 363,17	F21 : 1 W032 A46, B46 **570** 28 8 <1> 363,46	F20 : 3 S043 A47, B47 **252** 29 8 <0> 373,28	F20 : 1 W063 A48, B48 **237** 30 8 <0> 361,03	L
S046 A49, B49 **371**	W039 A50, B50 **382**	F11 : 4 S028 A51, B51 **386** LED 54 2 <1> 367,71	F11 : 2 W045 A52, B52 **363** 31 2 <1> 355,20	F11 : 1 S0002 A53, B53 **323** 32 7 <1> 360,20	F11 : 3 W060 A54, B54 **349** 33 7 <1> 356,68	F10 : 1 S005* A55, B55 **341** 34 7 <0> 357,80	F10 : 3 W062 A56, B56 **327** 35 7 <0> 354,14	R
S045 A57, B57 **291**	W033 A58, B58 **285**	F11 : 3 S023 A59, B59 **254** LED 53 2 <1> 374,72	F11 : 1 W046 A60, B60 **278** 36 2 <1> 366,33	F11 : 2 S004 A61, B61 **234** 37 7 <1> 361,77	F11 : 4 W052 A62, B62 **238** 38 7 <1> 361,21	F10 : 2 S042 A63, B63 **248** 39 7 <0> 373,22	F10 : 4 W003 A64, B64 **247** 40 7 <0> 366,37	L
A21 : 4 S044 A65, B65 **355** 1 <0> 376,68	A21 : 2 W029 A66, B66 **378** 1 <0> 367,22	A20 : 4 S025 A67, B67 **362** LED 52 1 <1> 364,10	A20 : 2 W050 A68, B68 **369** 41 1 <1> 364,05	C20 : 1 S006 A69, B69 **325** 42 6 <1> 374,32	C20 : 3 W053 A70, B70 **343** 43 6 <1> 353,77	C21 : 1 S014 A71, B71 **322** 44 6 <0> 364,43	C21 : 3 W061 A72, B72 **337** 45 6 <0> 370,67	R
A21 : 3 S036 A73, B73 **258** 1 <0> 377,96	A74, B74 **266**	A20 : 3 S026 A75, B75 **262** LED 51 1 <1> 374,12	A20 : 1 W048 A76, B76 **256** 46 1 <1> 345,89	C20 : 2 S013 A77, B77 **232** 47 6 <1> 374,49	C20 : 4 W057 A78, B78 **218** 48 6 <1> 360,90	C21 : 2 S024 A79, B79 **251** 49 6 <0> 371,30	C21 : 4 W064 A80, B80 **241** 50 6 <0> 359,39	L
top T Y P E 3 bottom				top T Y P E 2 bottom				

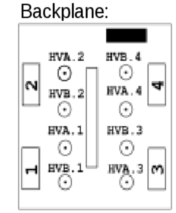
Backpl. : Link ASIC
HV cable A, B
Crystal
Signal cable
Buff.-Board <PCB> APD

- Depolished crystals
- Polished crystals
- Crystals + blue led

Buffer board:

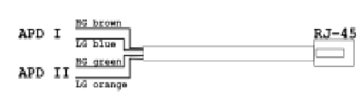


Backplane:



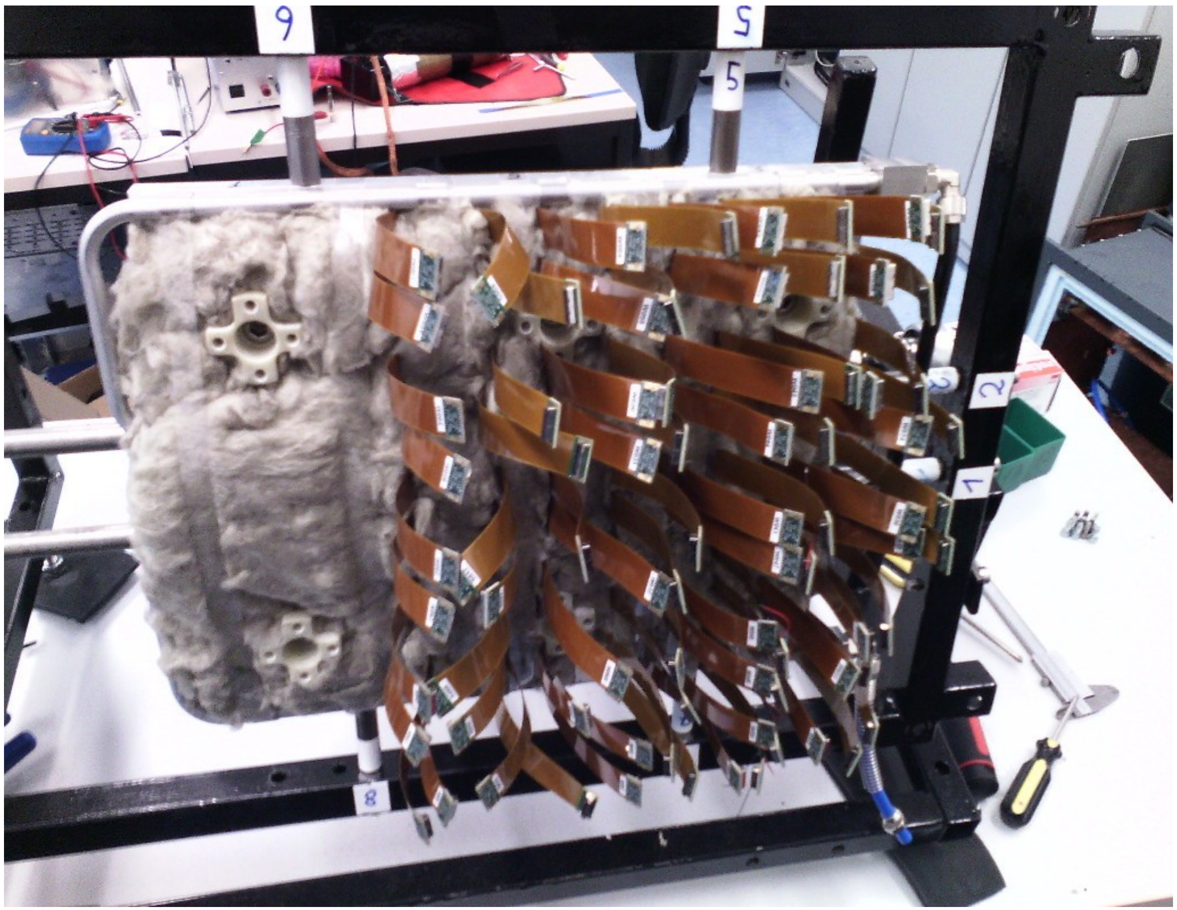
GEO:	
Orange	4
Green	3
Blue	2
Brown	1

Board ID (green 0 and red 1)
FEE-ID: 000-0-0110
Cable ID Geo



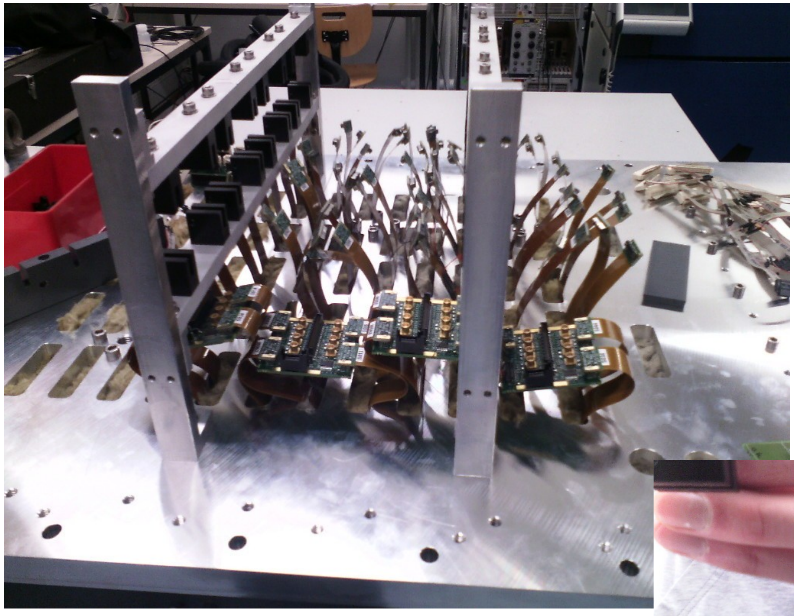
Proto120

- new design of cooling plate, spacers and intermediate plate
- feed-through of ASIC cables into the warm part – now unproblematic

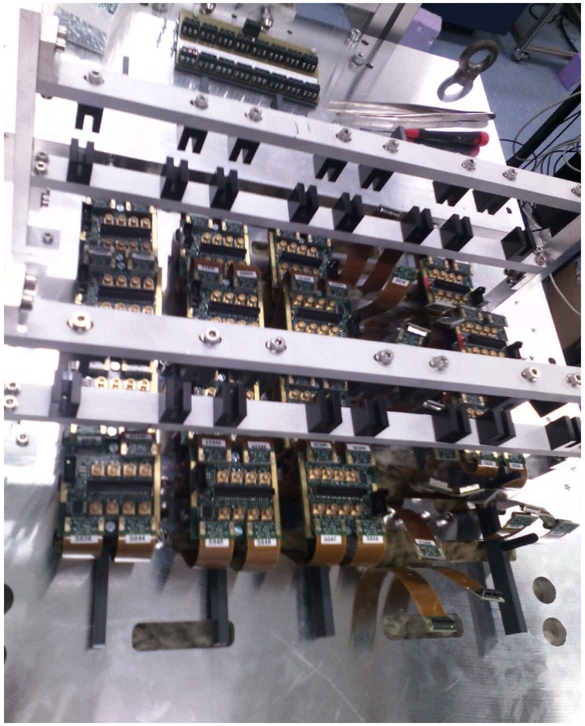


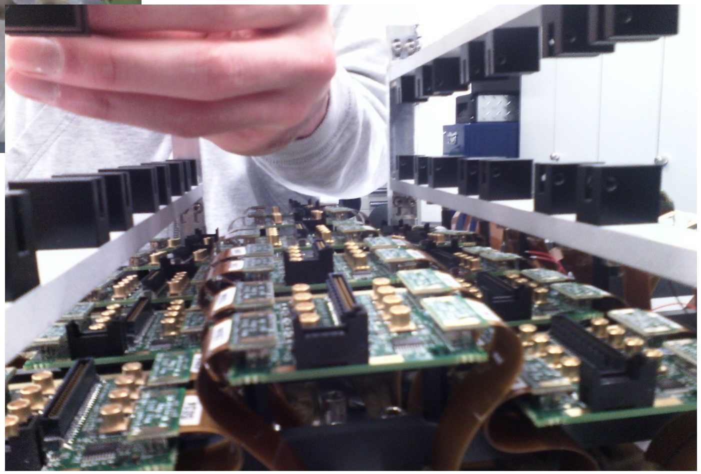
Proto120

- ASIC cables still relatively stiff – problematic dense packing of backplane PCBs



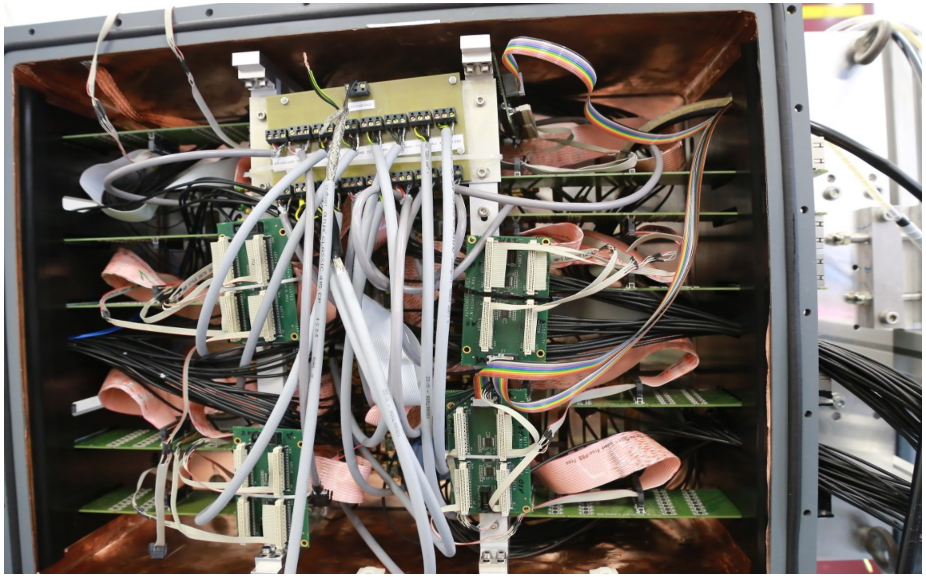
- solution: staggered configuration of BPL at two different heights





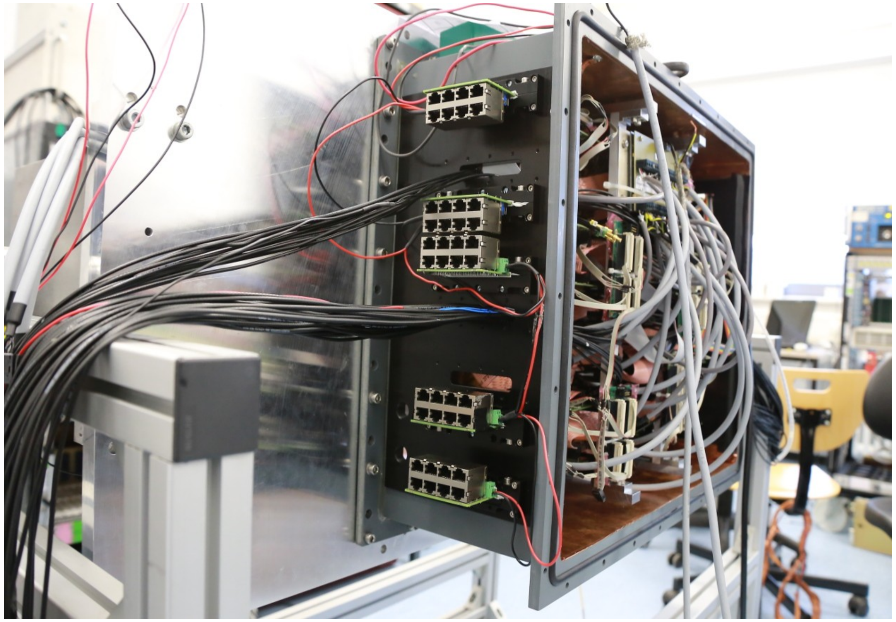
Ok for Proto120. But not for slice design due to limited clearance to inner edge of magnet

Proto120



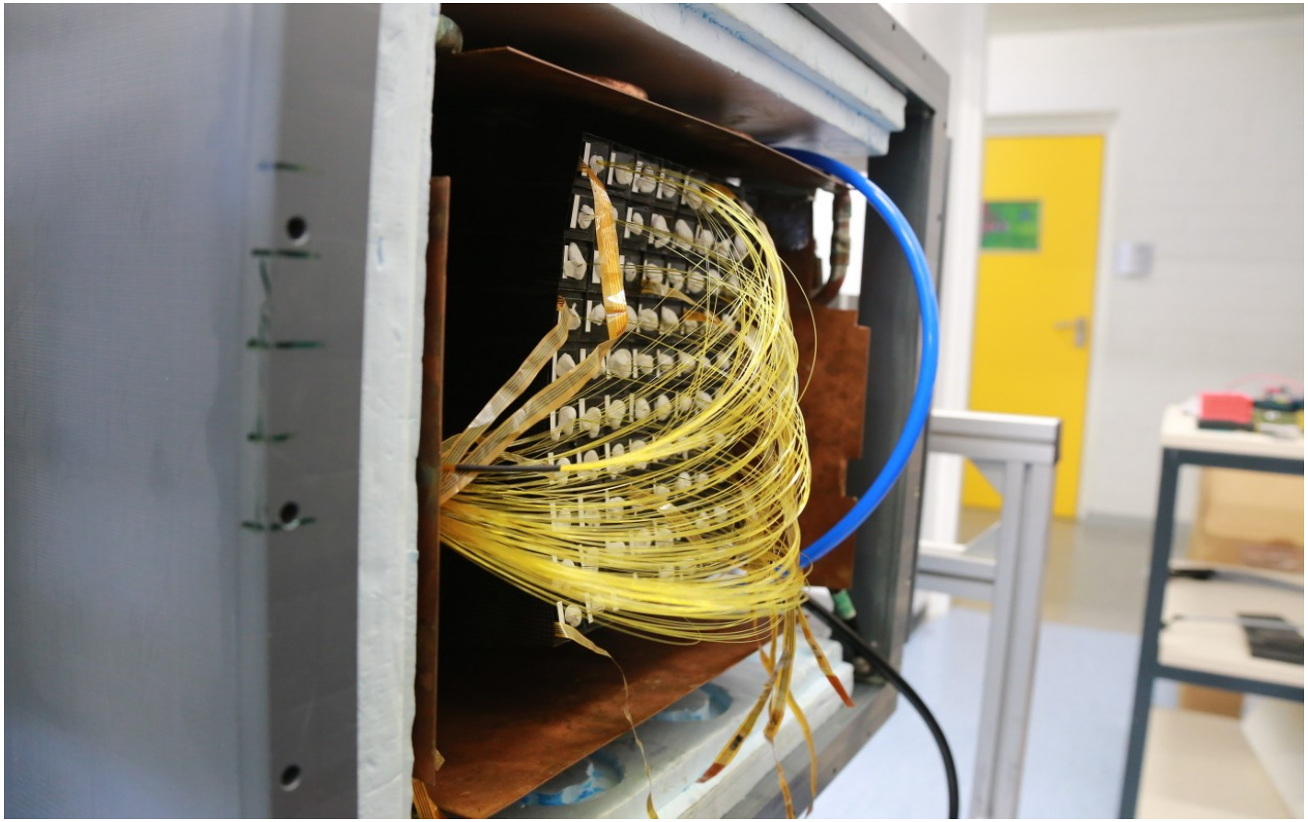
- integration of remaining electronics critical: several faulty connections due to dense cabling
- contact problems mainly in ribbon cables for signals but also in new cable scheme for ASIC slow control

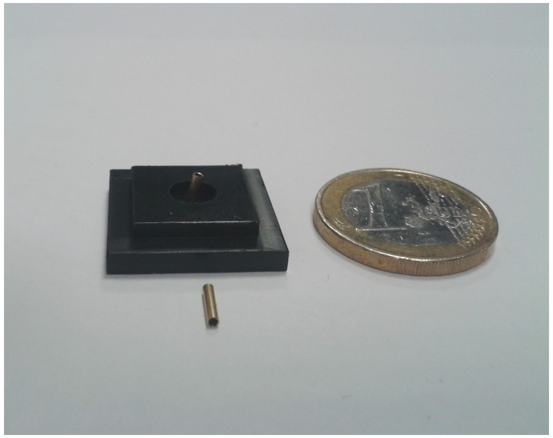
! conclusion: re- and new design of entire electronics from BPL PCB on (including HV distribution)



Proto120

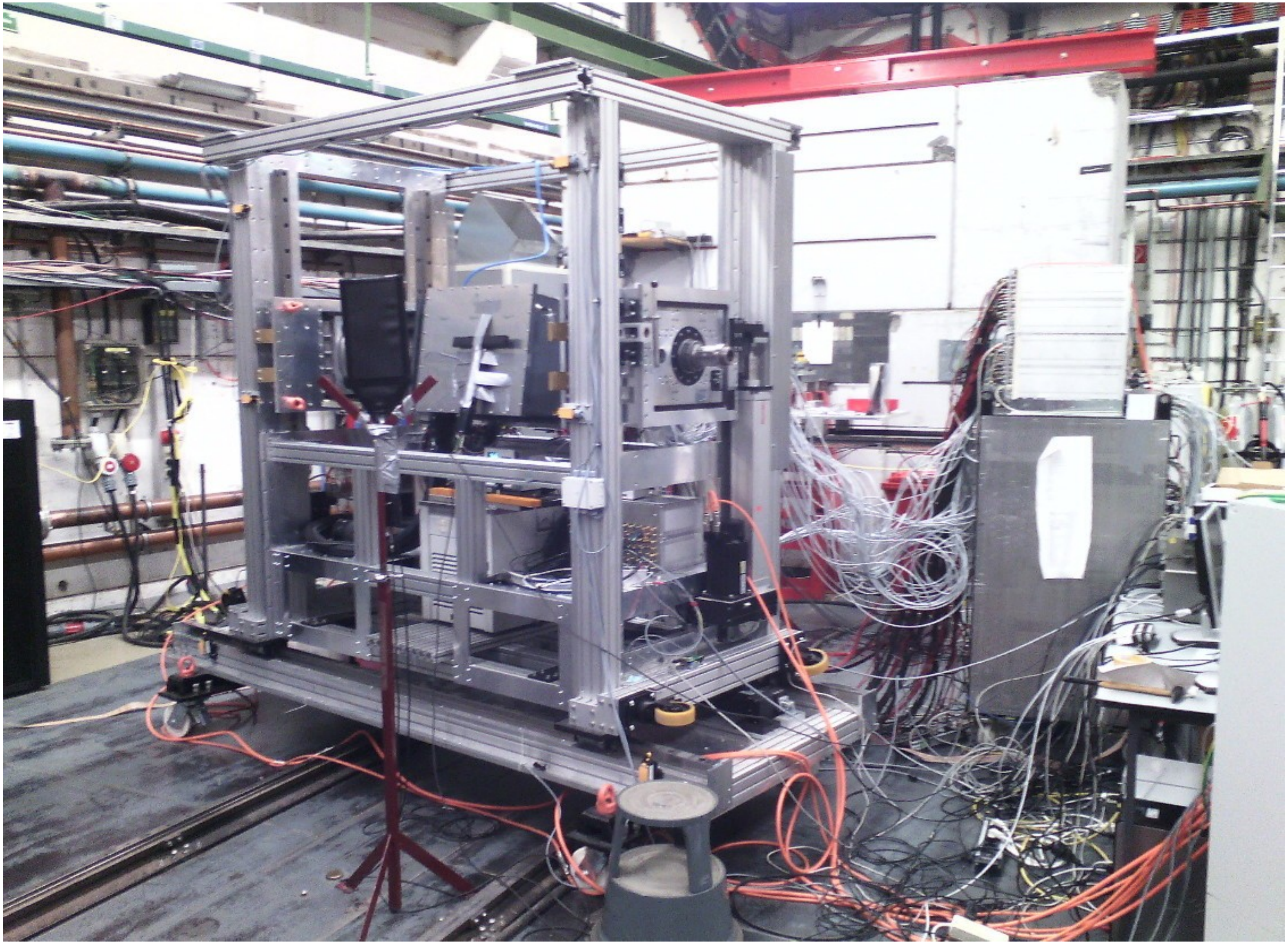
- all crystals equipped with monitoring light fibers fed into the crystal by a new (but not final) front stopper





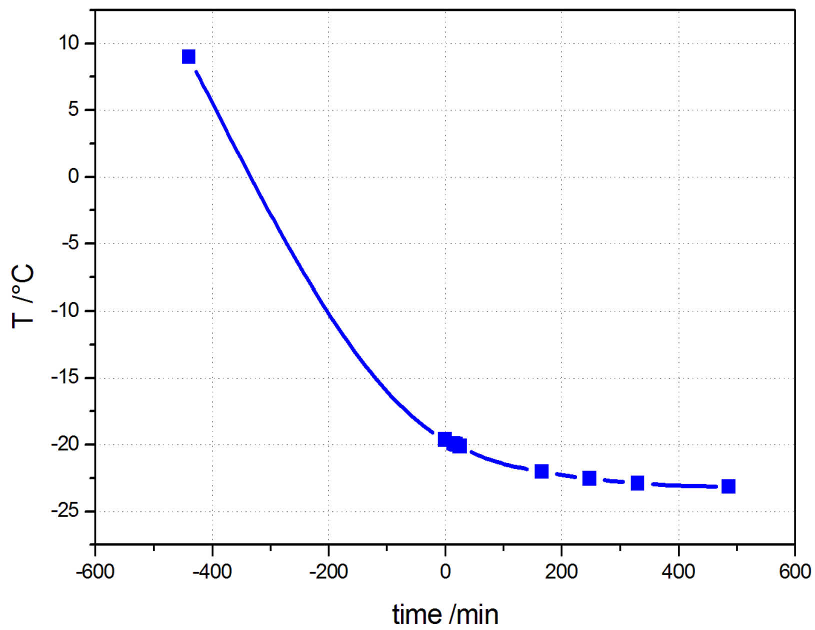
Data taking with pulser performed – Analysis not started yet

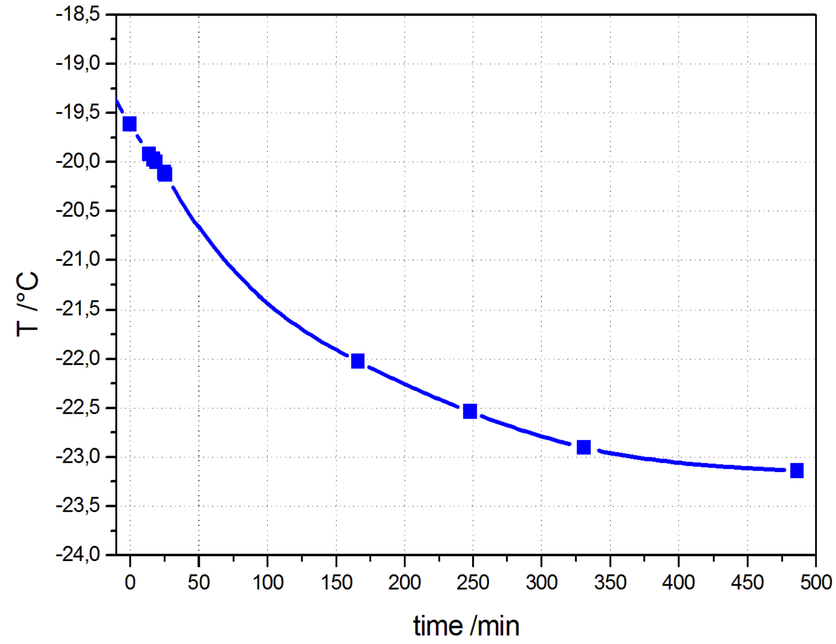
Proto120



Observations

- Cooling down to -25 °C took longer than in previous tests (~ 18h vs 12h)

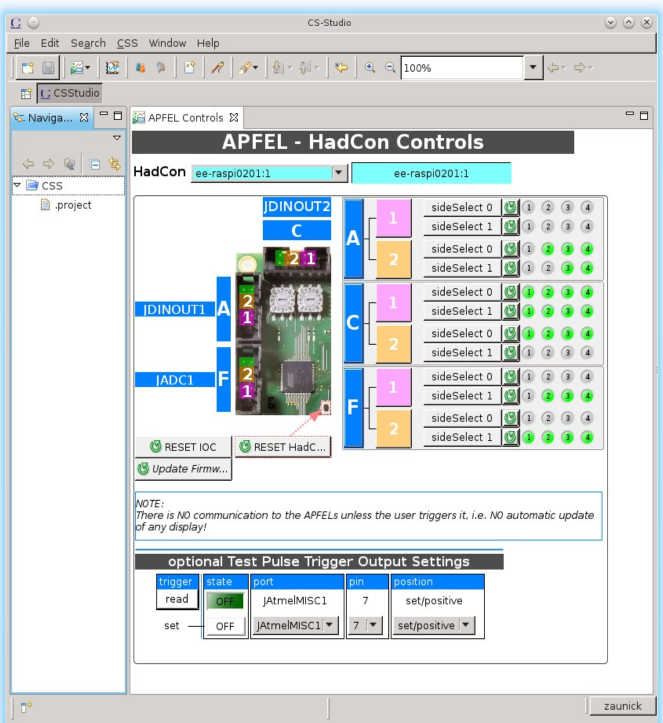


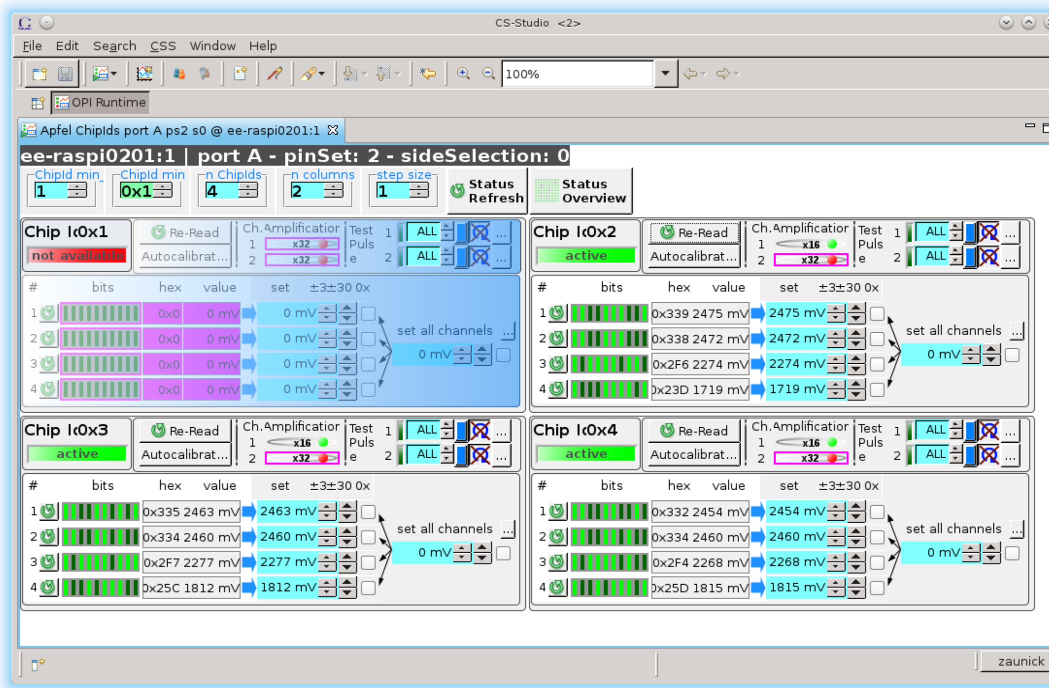


→ improve thermal Insulation (not under focus for this beam test)

Observations

- Reliability of internal signal and slow-control connections very bad. Box had to be warmed up and reopened during beam test due to connection faults
- New slow control distribution hardware (SC Multiplexer boards) not working as intended. Workaround with hand-tinkered cables
- New slow control CSS macros (GSI) utilized. Usability ok. Stability to be improved + features to be added



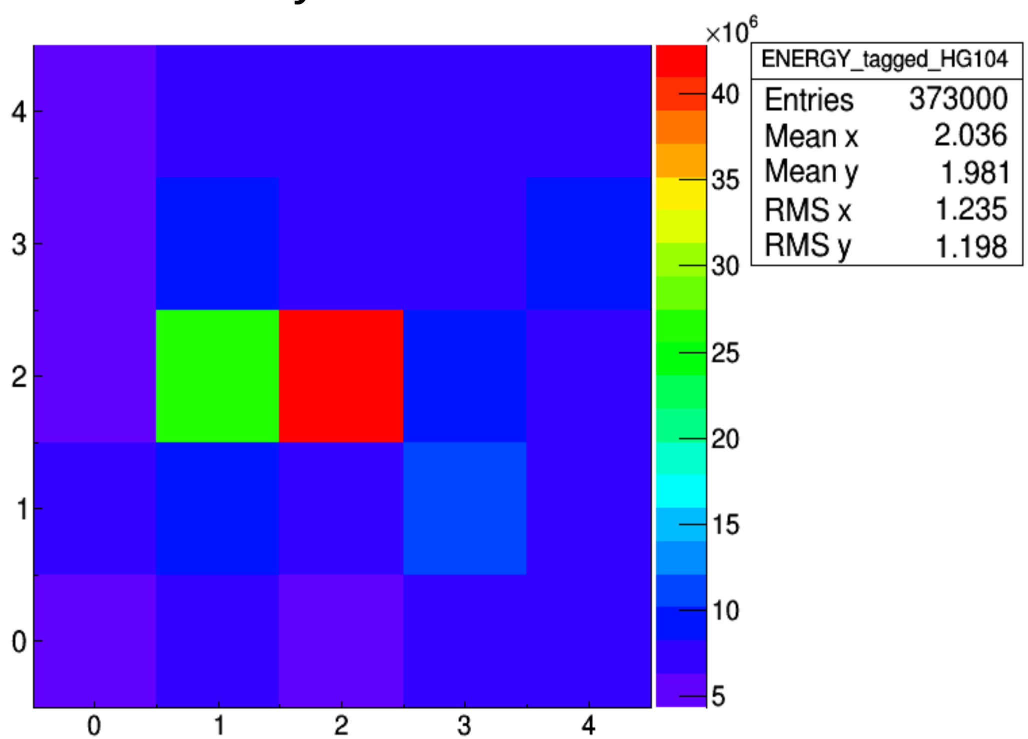


Observations

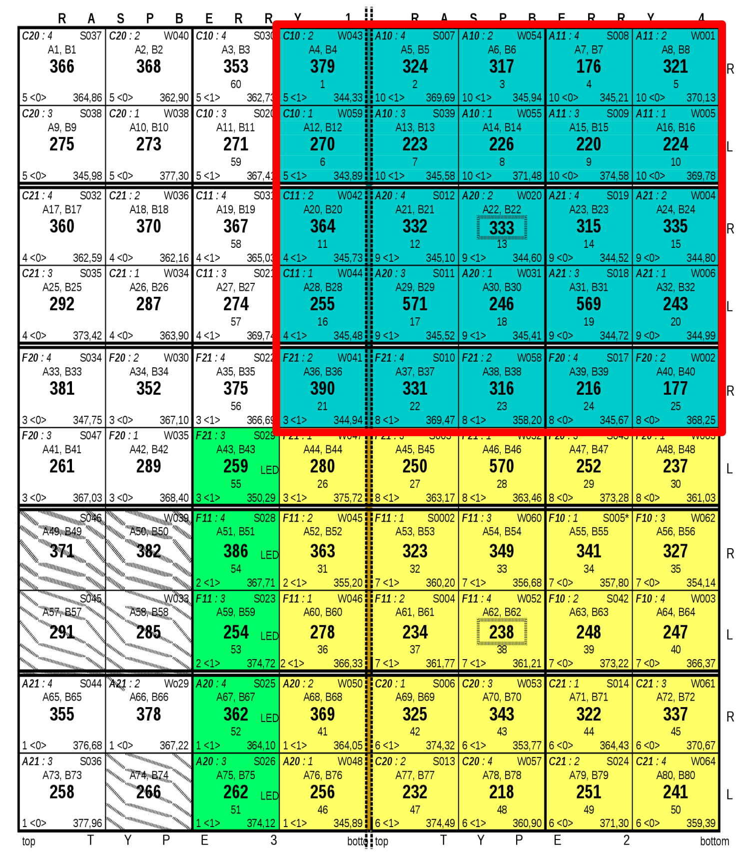
- Noise and pick-up appeared to be higher compared to previous beam tests. But due to limited preparation time no focus on optimal grounding/shielding

Data Analysis

- Started analysis of data set for depolished crystal matrix
- Detector was aligned to incorporate beam into the central crystal exclusively

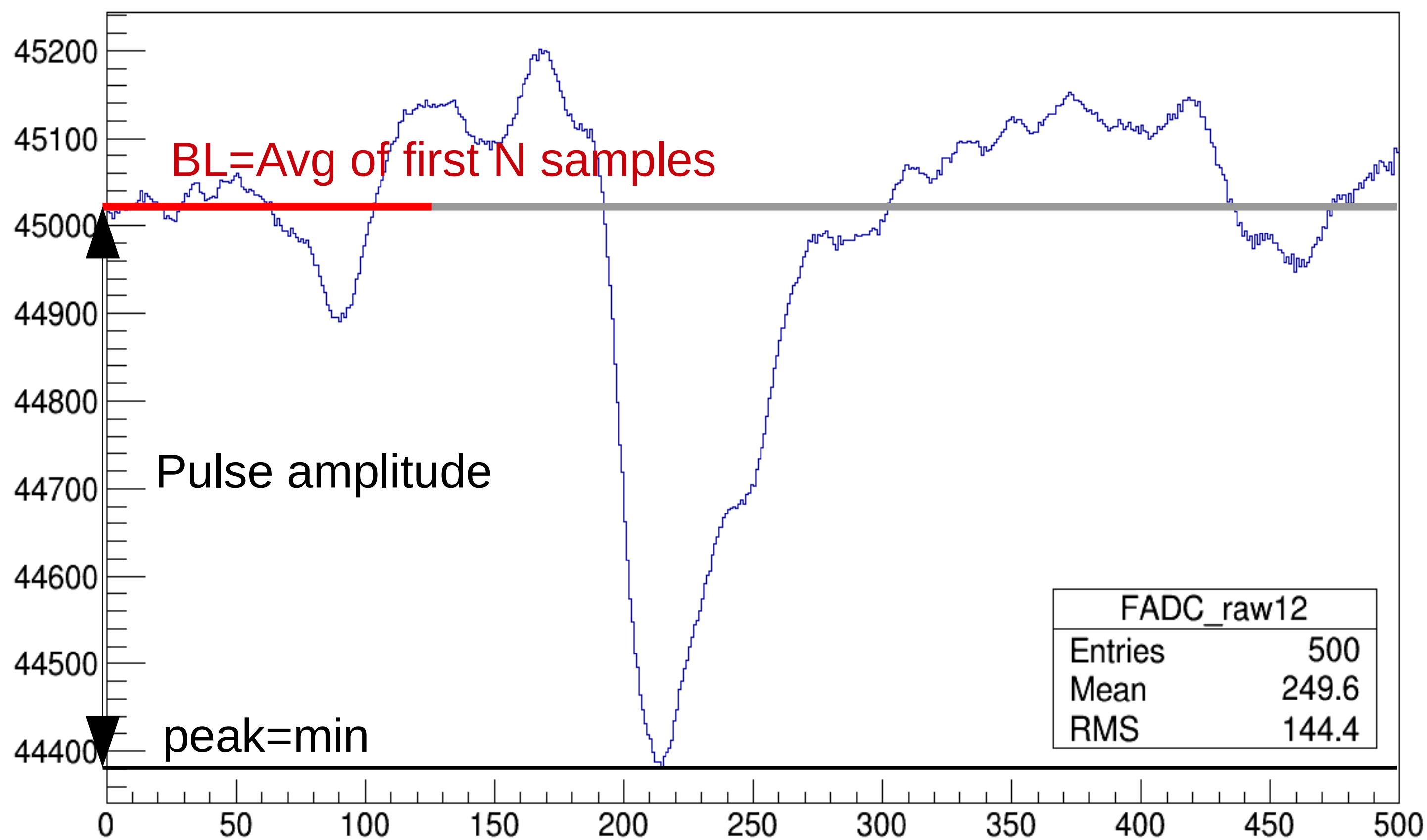


Mean deposited energy in 5x5 matrix during one run (a.u.)

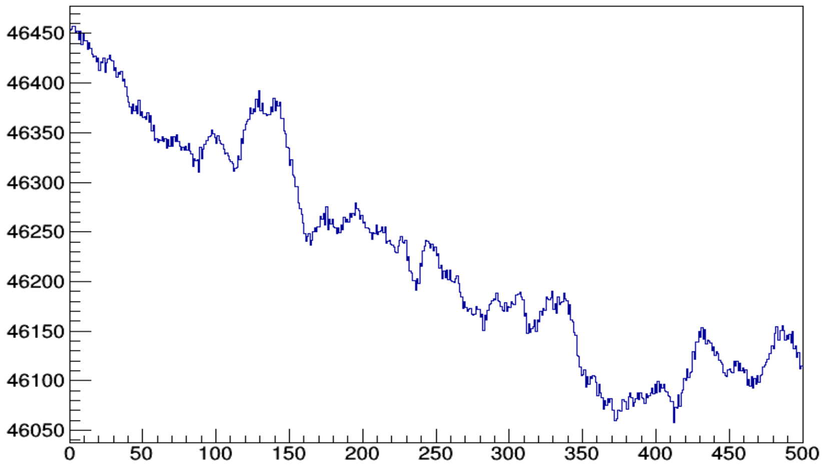


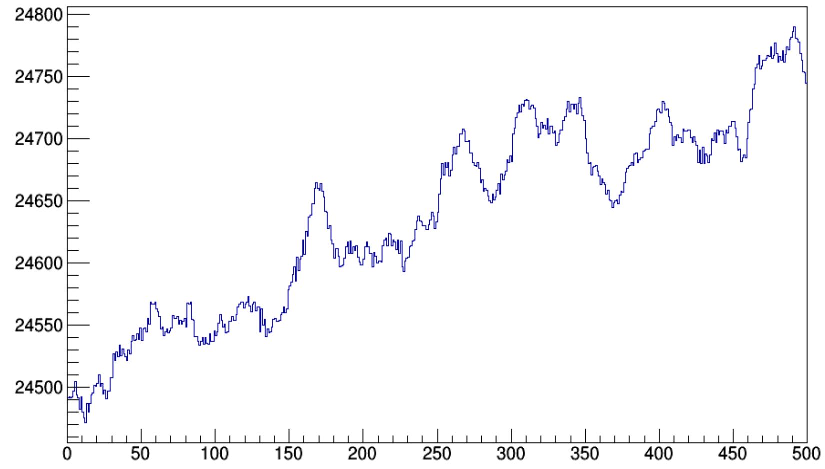
Data Analysis

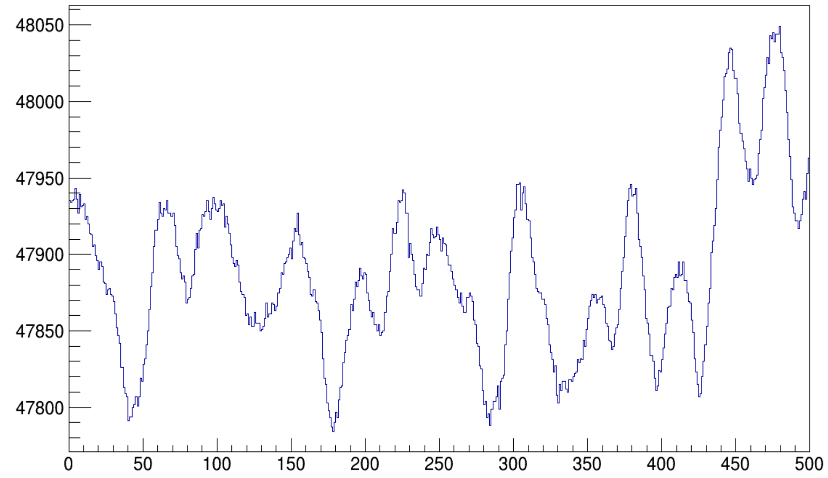
- Simple peaking algorithm with adaptive base line
- For each channel and event extract mean(BL) and RMS(BL)
- Define pulse amplitude = Max (bl-min, max-bl)

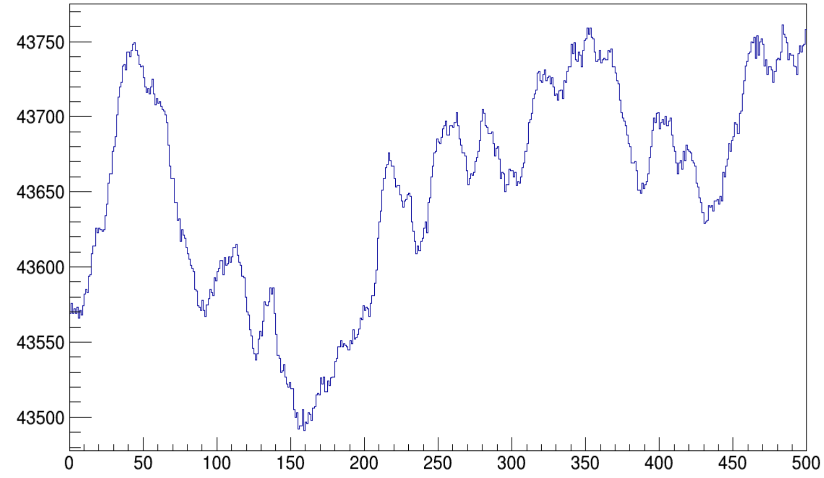


Noise


46450
46400
46350
46300
46250
46200
46150
46100
46050
0 50 100 150 200 250 300 350 400 450 500


24800
24750
24700
24650
24600
24550
24500
0 50 100 150 200 250 300 350 400 450 500

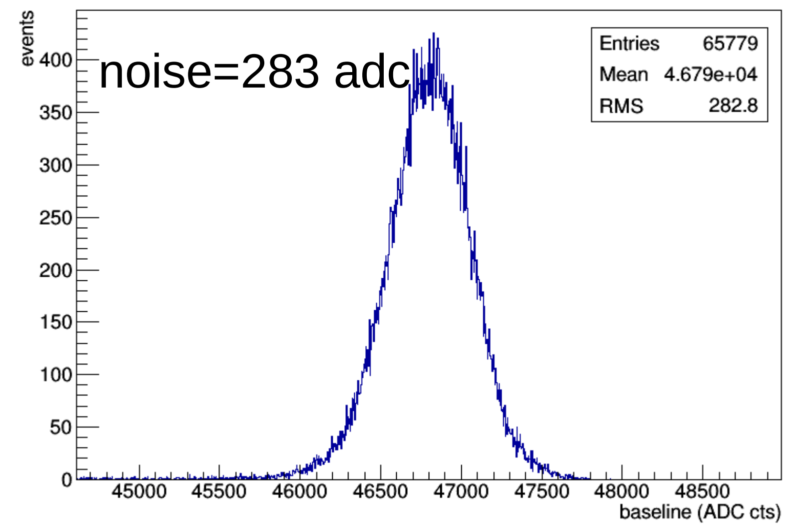

48050
48000
47950
47900
47850
47800
0 50 100 150 200 250 300 350 400 450 500


43750
43700
43650
43600
43550
43500
0 50 100 150 200 250 300 350 400 450 500

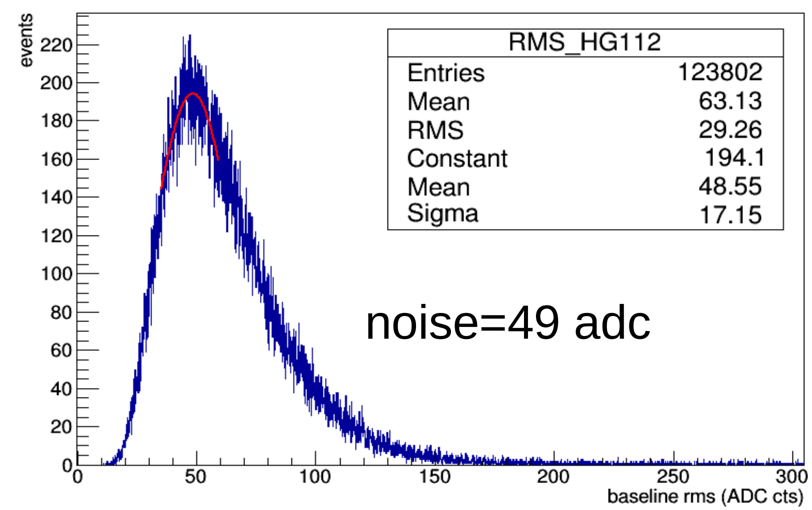
Noise

Two types of relevant noise definitions:

- Distribution of baseline mean values
  - Indicates the presence of low frequency fluctuations (EMI, pick-up etc.)
  - Less relevant for event-by-event reco due to adaptive BL



- Distribution of baseline rms values
  - characterizes the noise relevant at signal timing and sampling frequencies
  - Determines the lower bound of the signal noise



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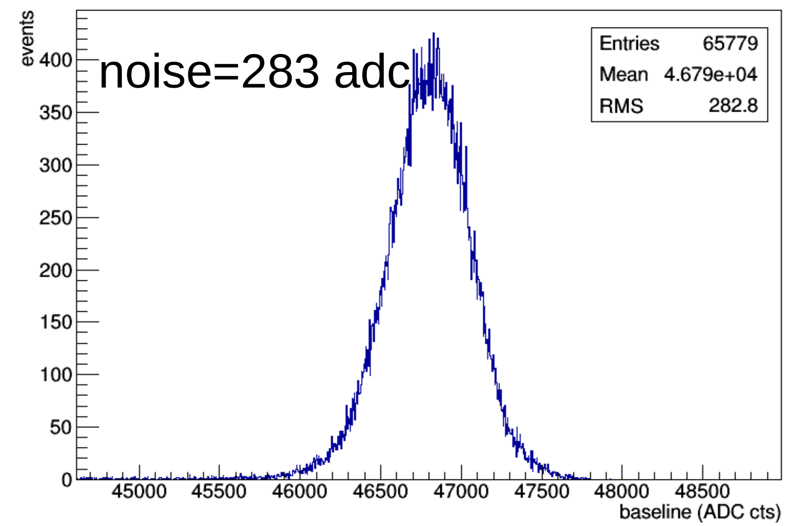

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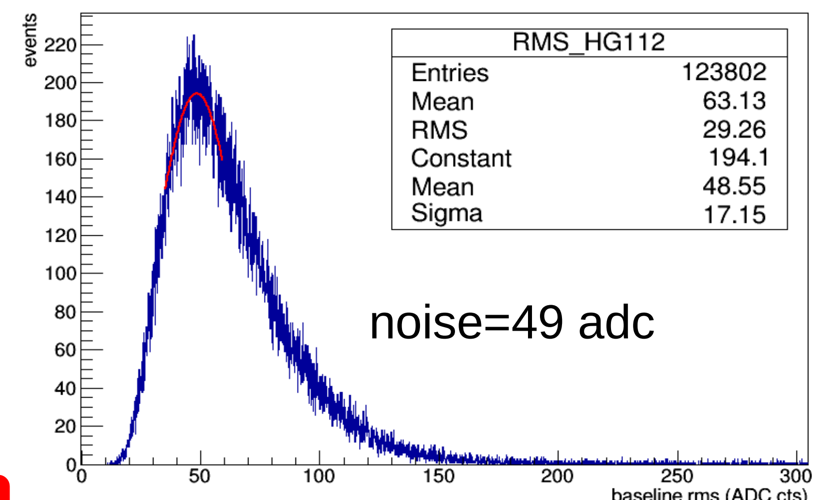


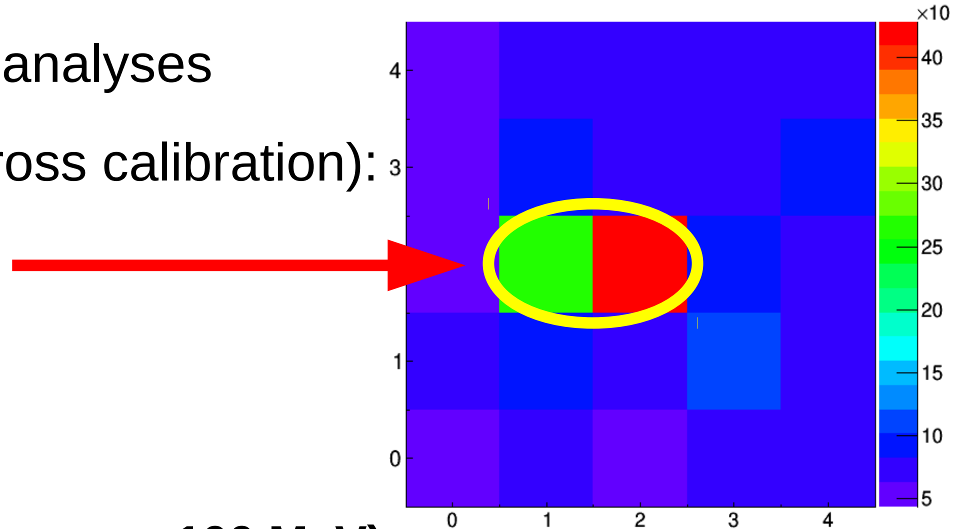
coarse energy calibration coefficient ~ 40 ch/MeV:

sigma(Noise) ~ 1.2 MeV and E_{thr} ~ 3.6 MeV

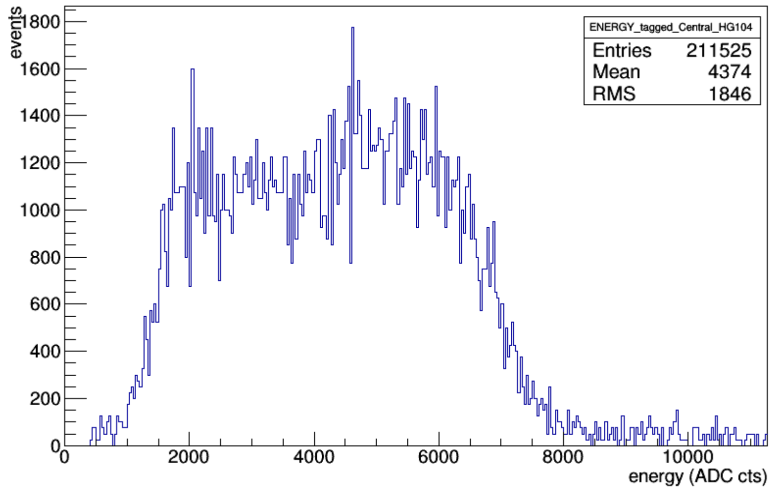
Energy Extraction

- Detector misalignment: e-deposit never in only one crystal
- Clustering required – even for simple analyses
- Start with Poor-man clustering (w/o cross calibration):

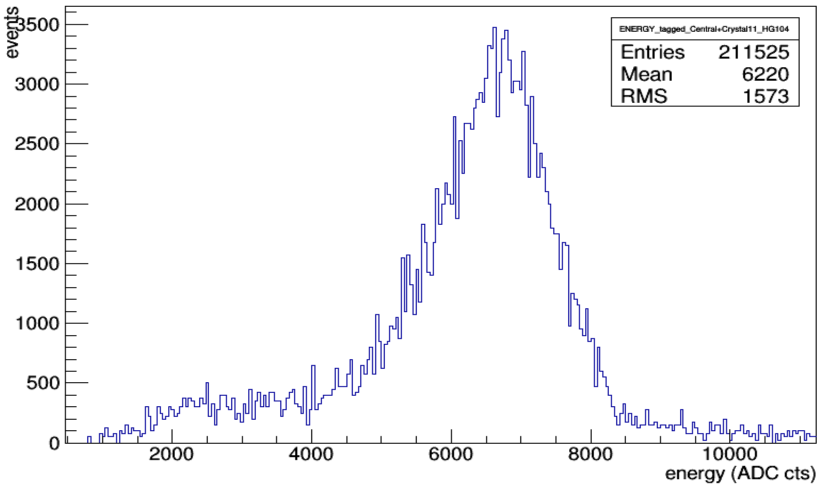
  energy sum of central and neighbor



Energy spectrum (photon energy 100 MeV)

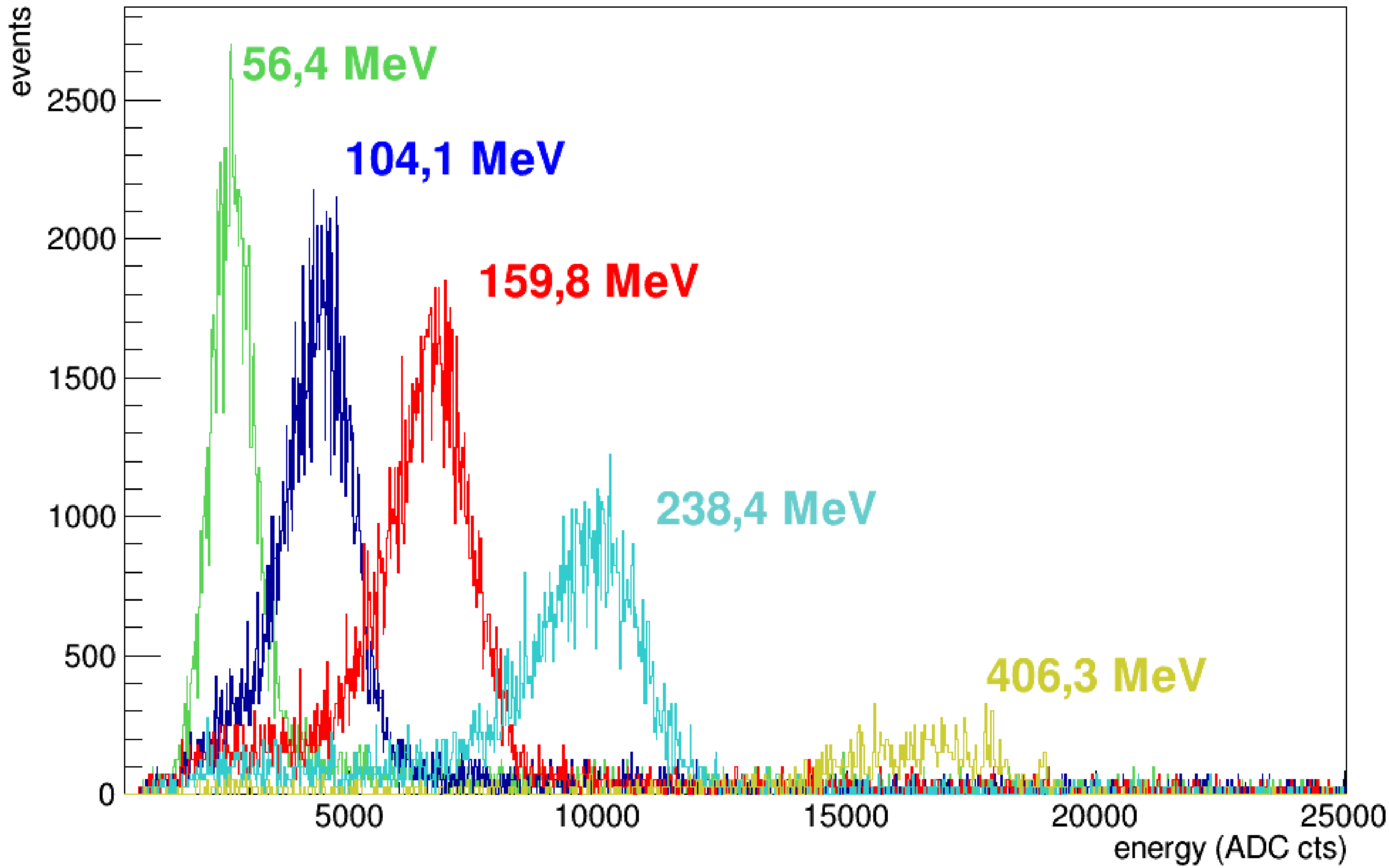


Central crystal only



Central crystal + left neighbor

Energy Extraction

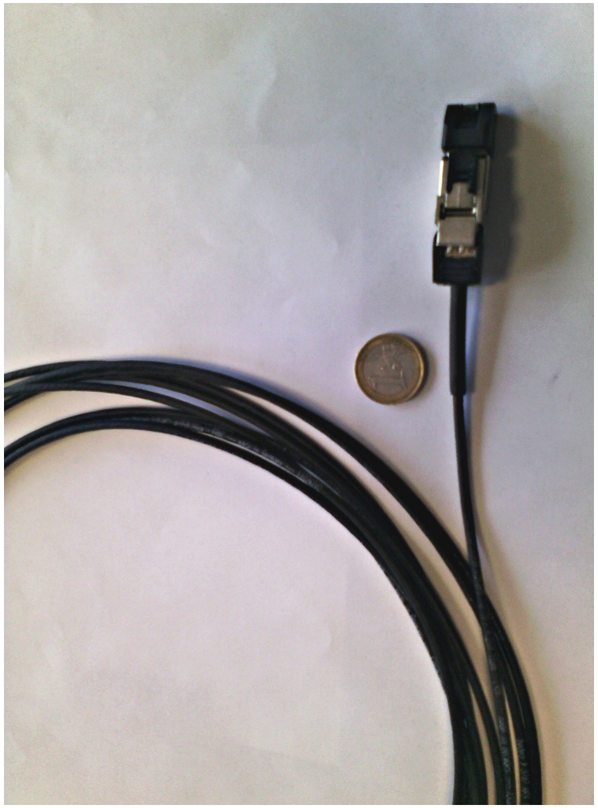


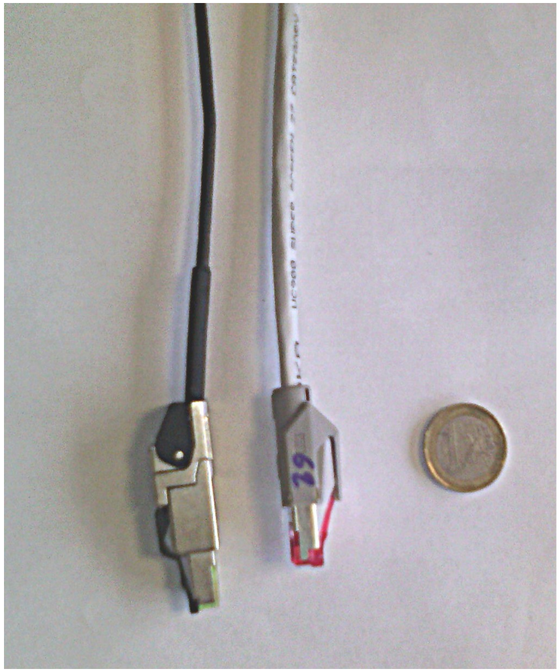
- Reasonable energy spectra for low energies
- Higher photon energies get spread over larger crystal number

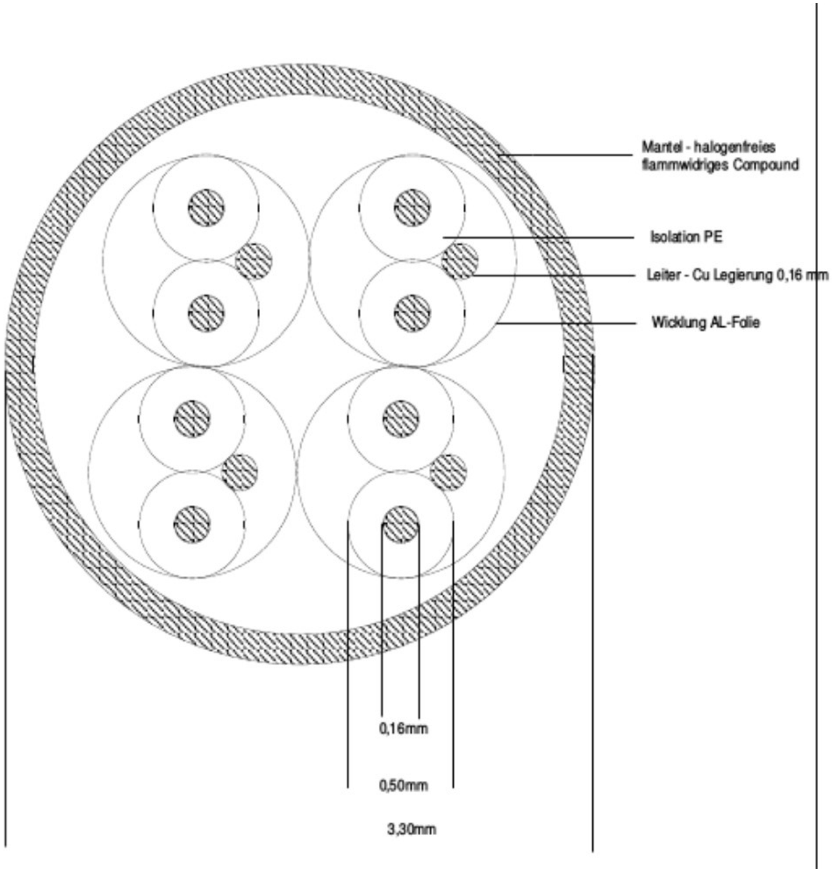
→ full clustering + cross calibration required

Test of new signal cable

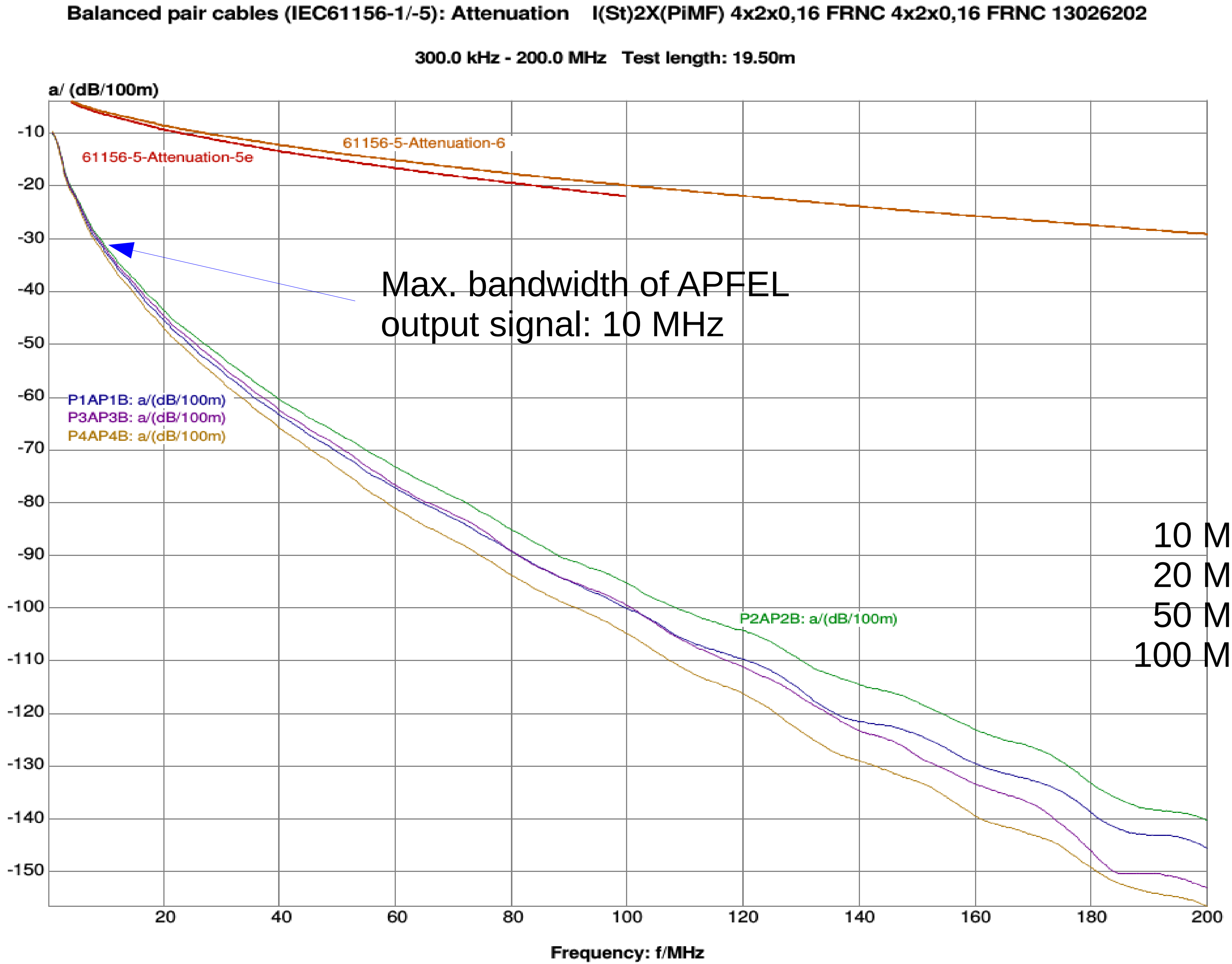
- Development of ultra-thin differential cables started with company BEDEA (Asslar/Germany)
- First prototype with stainless steel cores (0.1mm): attenuation too high
- Second prototype produced in May 2015 with copper cores (.16mm) and improved mechanical stability







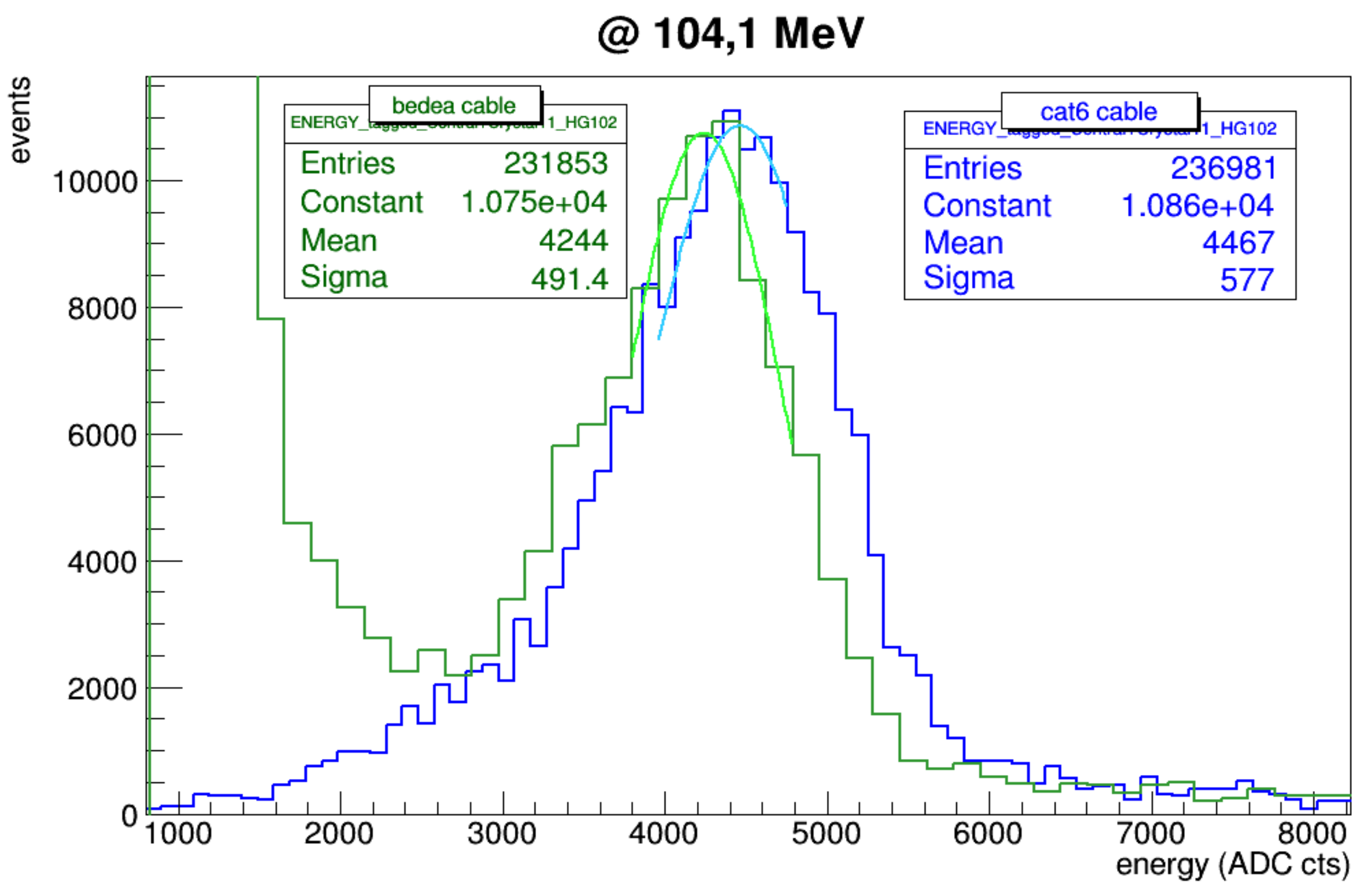
New signal cable - Attenuation



10 MHz: .32 dB/m
20 MHz: .45 dB/m
50 MHz: .7 dB/m
100 MHz: 1.0 dB/m

Test of new signal cable

- Comparison of 2-crystal-sum between standard cable (cat6) and Bedea cable measured at the same channel under equal conditions

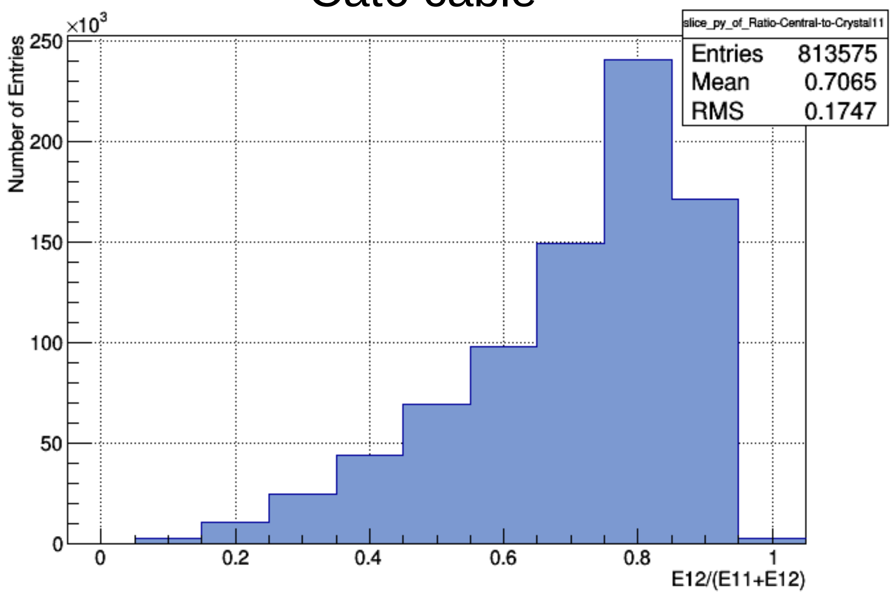


- Due to summation no direct comparability between the cables

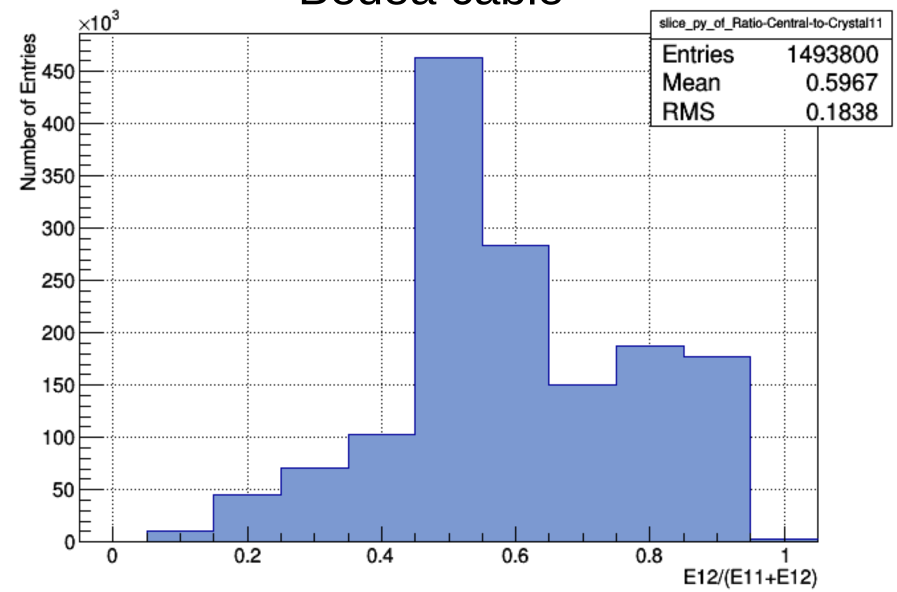
Test of new signal cable

- Better observable: ratio of energy deposit between test channel and (2-crystal) energy sum

Cat6 cable



Bedea cable

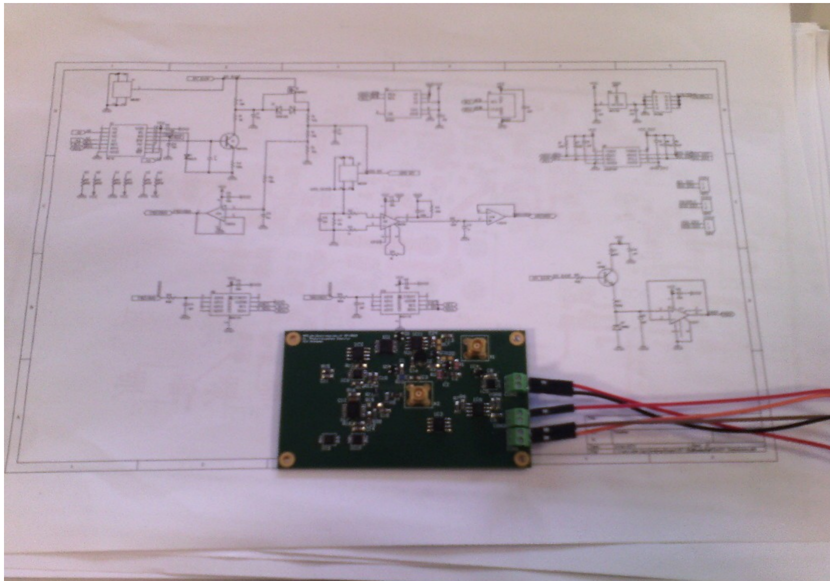


- Derive amplitude ratio of test channel between both cables

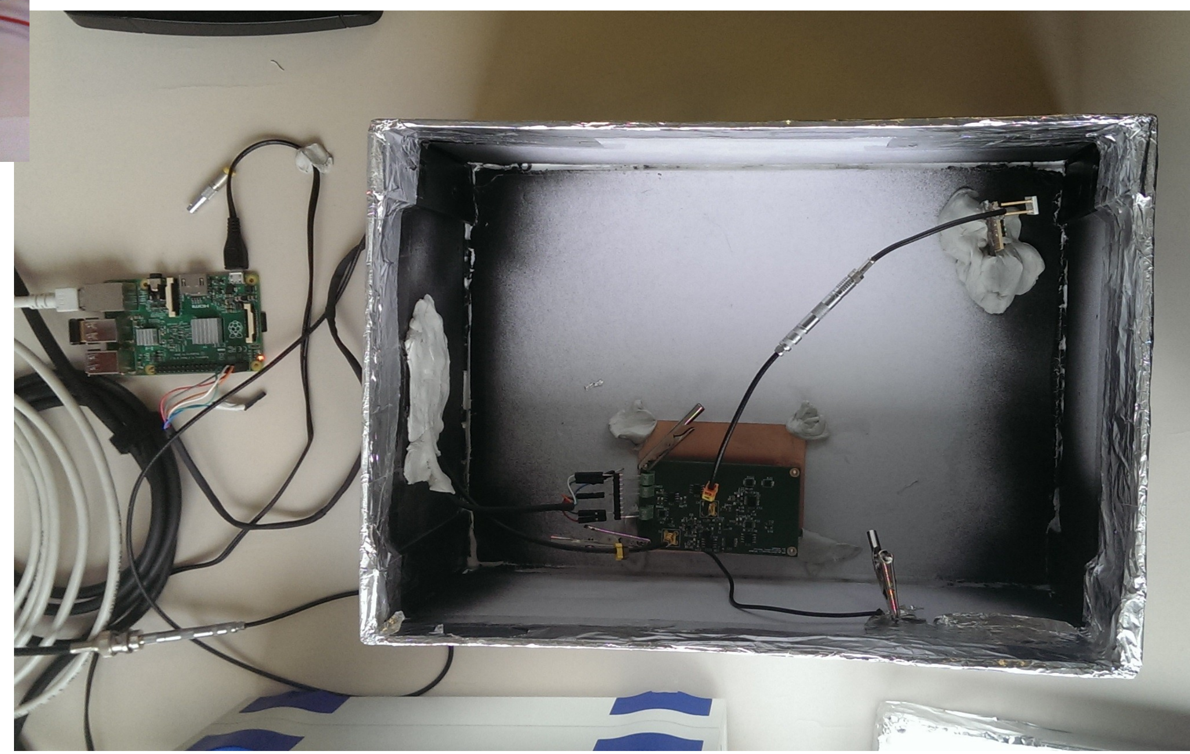
  E_{bedea}/E_{cat6} ~ 64% = -2 dB (i.e. 2 dB higher Attenuation than cat6 cable)

- **Attenuation of 2 dB within specs**
- **Compensation by modification of line driver gain**

HV Distribution



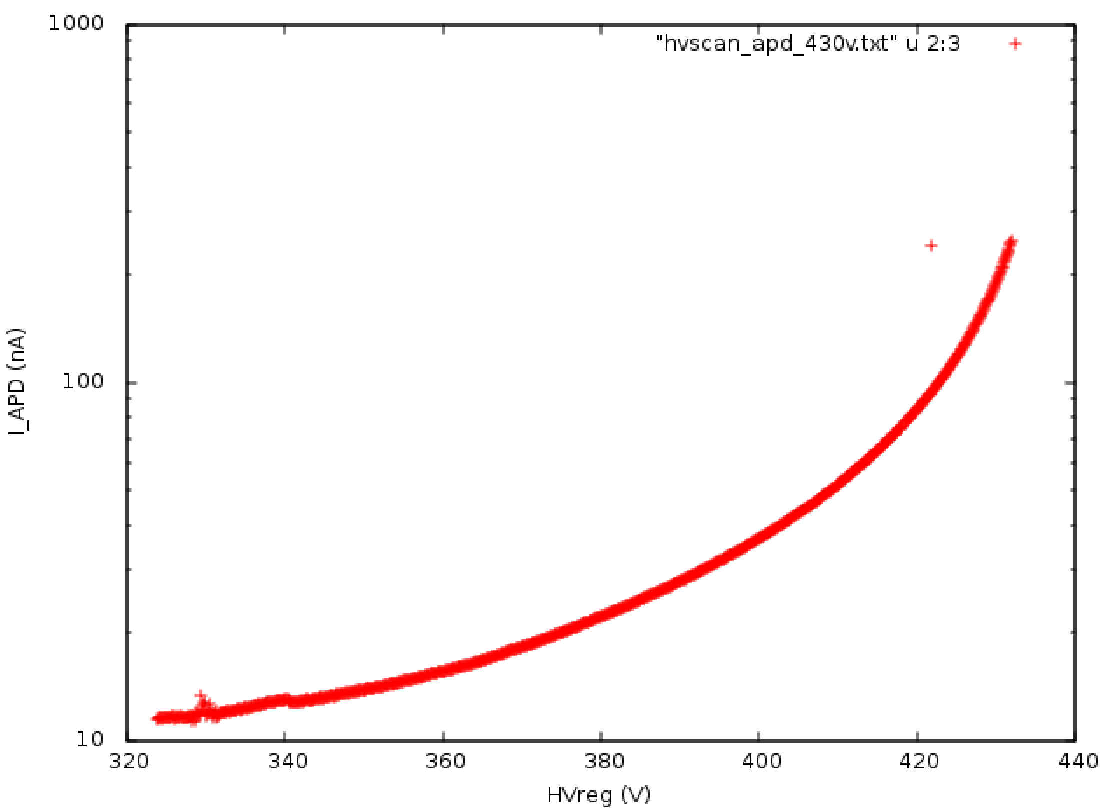
- Distribution of APD bias voltage from one HV cable to 4(8) APDs
- Close to detector → compact, rad hard
- High side shunt regulators for voltage control of individual outputs



- Proof-of-concept prototype with one regulated channel
- Test setup in shielded lighttight box with one reference APD
- Irradiation-characterization test cycles

HV Distribution

- Regulation of a single channel from HV(In) down to HV(In)-100V with 10bit resolution (0.1V/LSB) I2C Potentiometer
- Measurement of actual APD voltage (17mV LSB, 530V FS) and current (30pA LSB, ca. 1uA FS)
- Scan of HV by stepping through all potentiometer (wiper) settings

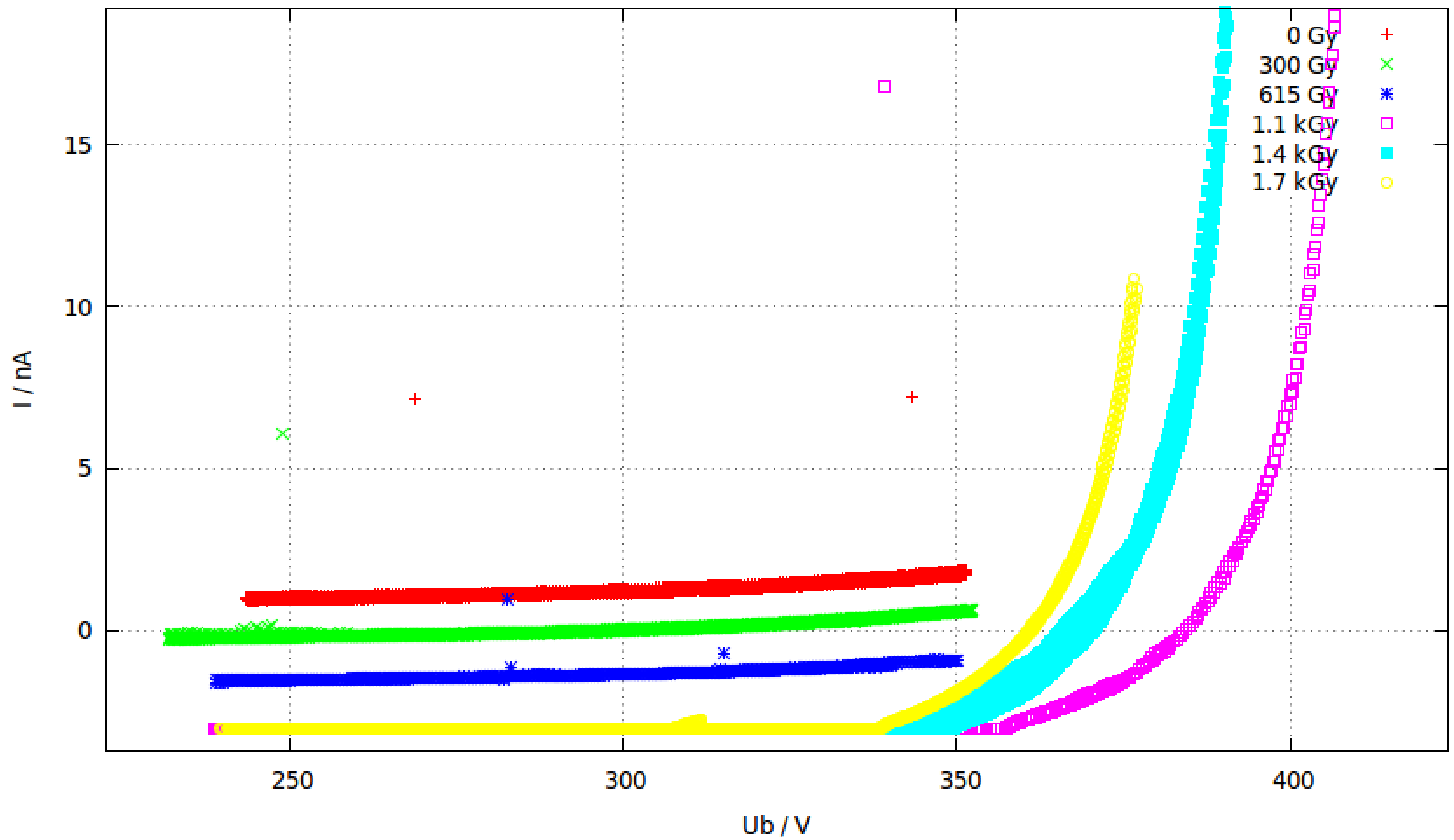



```
#ADC1 ch 0: 25129
#ADC2 ch 0: 9368
#Voltage(1) ch 0: 3.141221 V
#Voltage(2) ch 0: 1.171036 V
#******************************
#HV :     431.68 V
#Current:  249.2 nA
#******************************
#RMeas: 1732.56 MOhm
#LM75 temperature:   20.5 C
#X9119 WCR 0: 0
#Wiper  HV (V)  I (nA)  R (MOhm)
0    431.917   249.81  1729.013
1    431.826   246.16  1754.255
2    431.742   243.16  1775.572
3    431.670   240.25  1796.737
4    431.594   236.97  1821.282
5    431.501   234.24  1842.103
6    431.433   231.73  1861.829
7    431.340   228.46  1888.039
8    431.276   226.36  1905.284
9    431.166   223.01  1933.399
10   431.108   221.07  1950.115
11   430.996   218.00  1977.083
.............

1014   324.898   11.63  27928.194
1015   324.781   11.66  27848.119
1016   324.695   11.64  27904.390
1017   324.582   11.59  28003.459
1018   324.462   11.57  28038.121
1019   324.365   11.59  27991.208
1020   324.262   11.62  27911.845
1021   324.166   11.60  27935.542
1022   324.043   11.57  28014.777
1023   323.939   11.52  28109.280
```

HV Distribution

- Several irradiation-measurement cycles done up to 1.7 kGy with ^{60}Co source
- I/V Characteristic shows shift of measured current towards lower values
- Shift in measured APD voltage towards lower values
- Current clipping at low ADC range limit



Conclusions

- Beam test in Dec 2015 yielded minimal goal – data for depolished 5x5 matrix w/ non-central beam spot
- Data analysis ongoing, currently only ½ FTE
- New design of backend electronics required: stability and space issues
- Concept of HV distribution verified: saving of 7/8 of HV cables

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