FCAL R&D towards a prototype of very compact calorimeter

Yan Benhammou

Tel Aviv University

On behalf of the FCAL collaboration

outlook

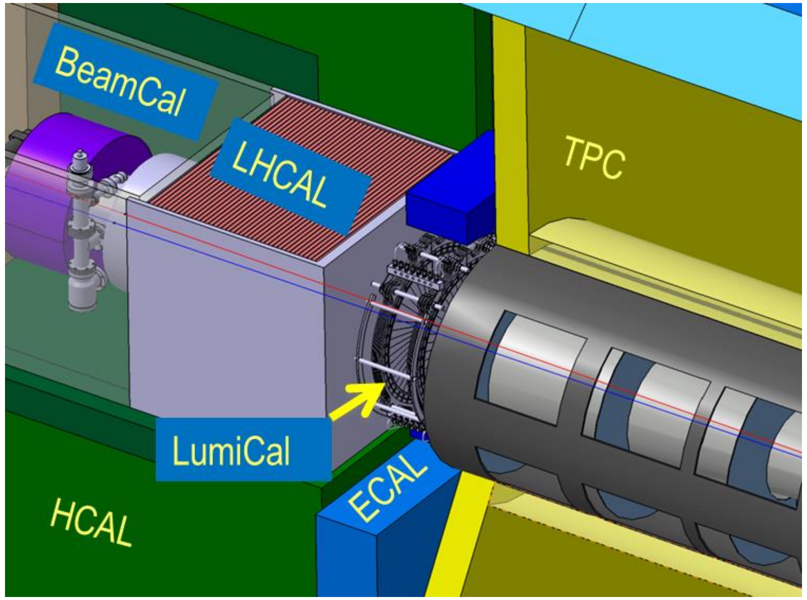
- Lumical
- 2016 test beam set up
- Signal extraction
- Energy calibration
- Noise study
- Electron photon identification
- conclusion

PRELIMINARY RESULTS !

LumiCal in the Forward Region

Goals:

- Precise integrated luminosity measurements;
- Extend a calorimetric coverage to small polar angles. Important for physics analysis.



LumiCal:

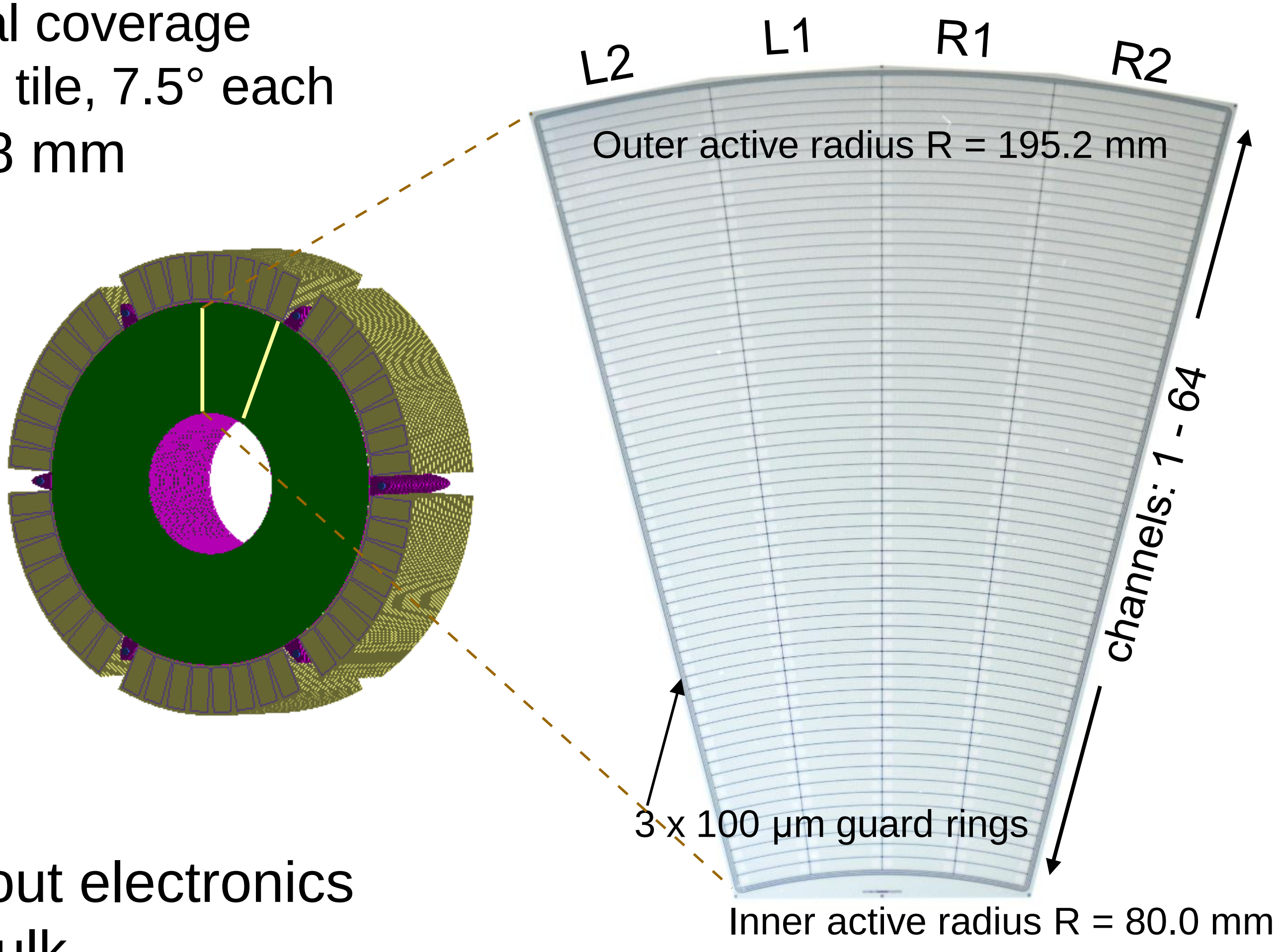
- electromagnetic calorimeter;
- 30/40 layers (ILC/CLIC) of 3.5 mm thick tungsten plates with 1 mm gap for silicon sensors;
- symmetrically on both sides at ~2.5m from the interaction point.

The integrated luminosity is measured by counting number N_B of Bhabha events in a certain polar angle (θ) range of the scattered electron.

LumiCal Design

- 12 tiles make full azimuthal coverage
- 4 azimuthal sectors in one tile, 7.5° each
- 64 radial pads, pitch 1.8 mm

4 sectors:



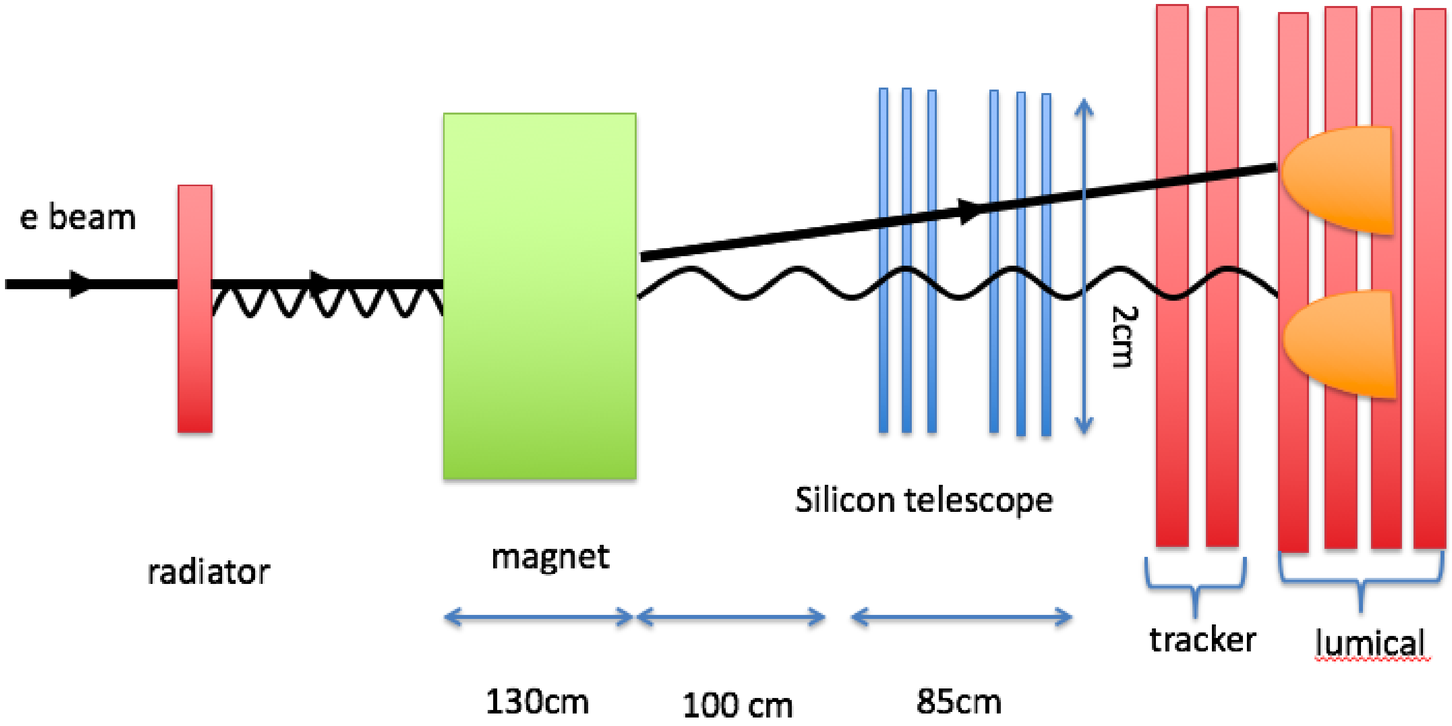
- Silicon sensor
- thickness 320 µm
- DC coupled with read-out electronics
- p+ implants in n-type bulk

FCAL Collaboration
High precision design

Test beam setup & aims

Aims
1. Use a tracker in front of lumical to identify electron/photon
2. Add more W layers than in 2015 TB
3. Verify new bonding technology

- 8 **rotated** silicon planes (1/2 TAB bonding)
  - 2 planes with W : tracker
  - 6 planes starting with 3W: calo (use of charge divider)
- A lot of tungsten planes
- 16 ASD chip (2048 channels)
- DAQ system
- Mechanical box
- Telescope (six planes)
- targets



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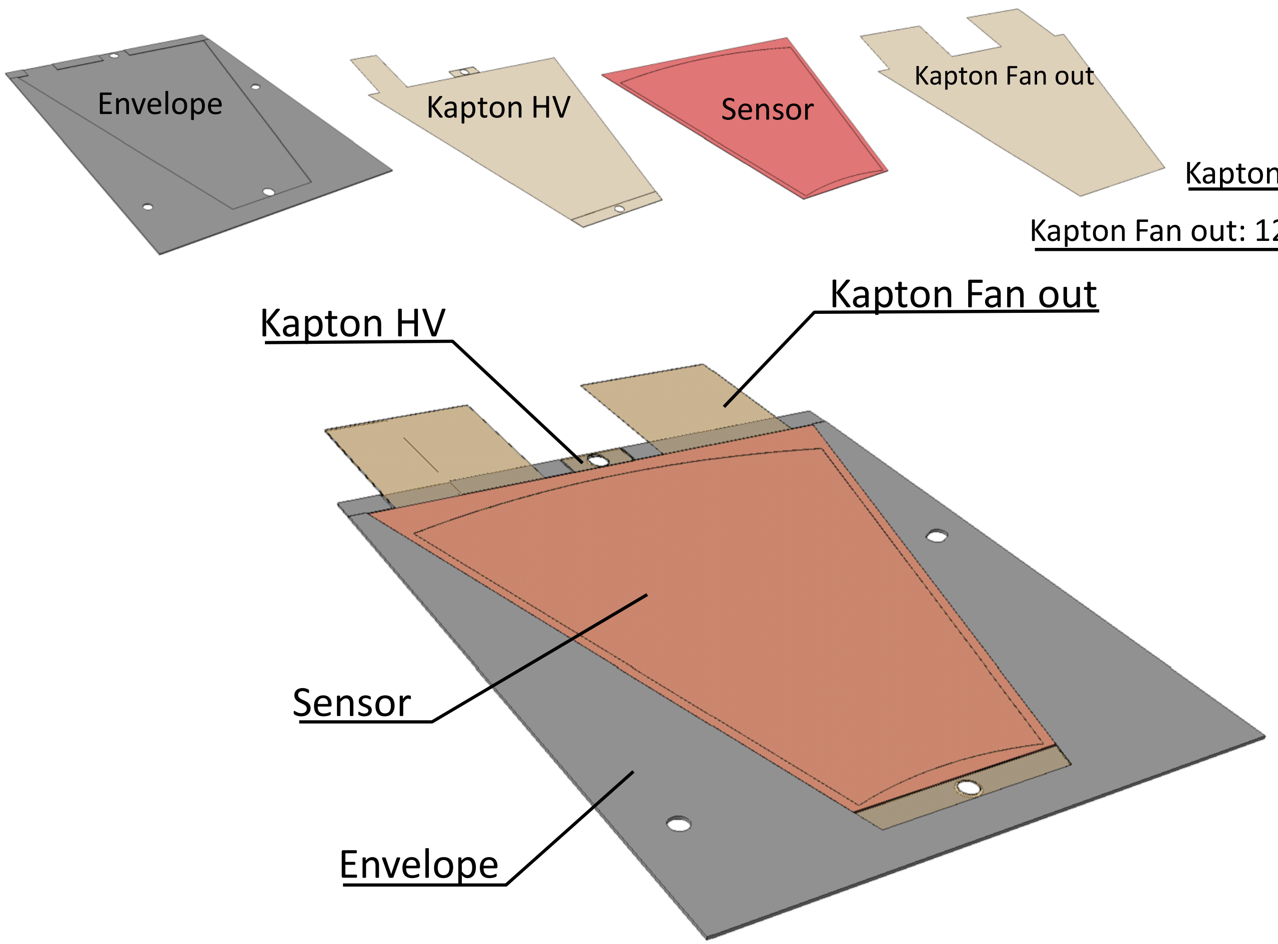
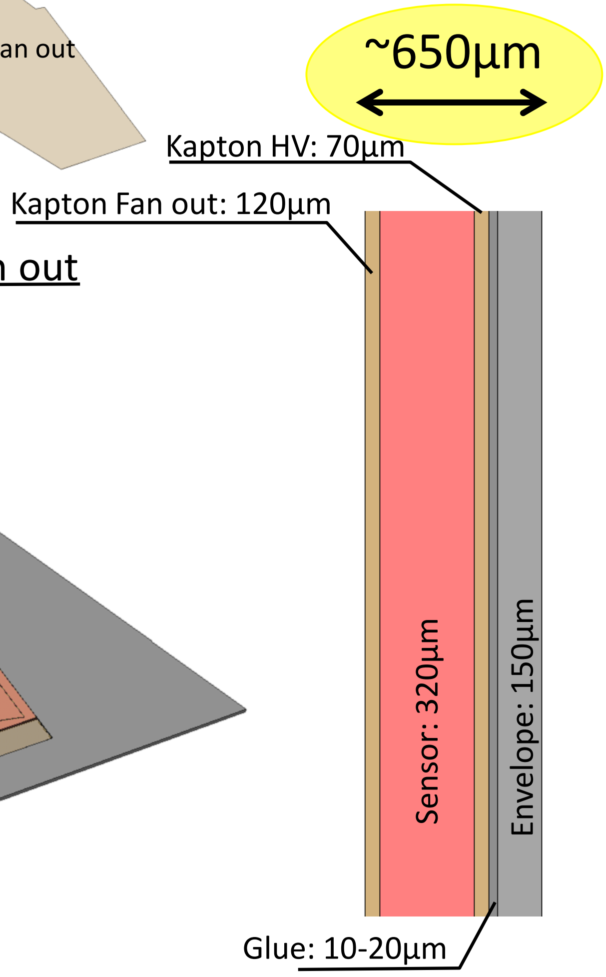
Design of the Thin LumiCal Module



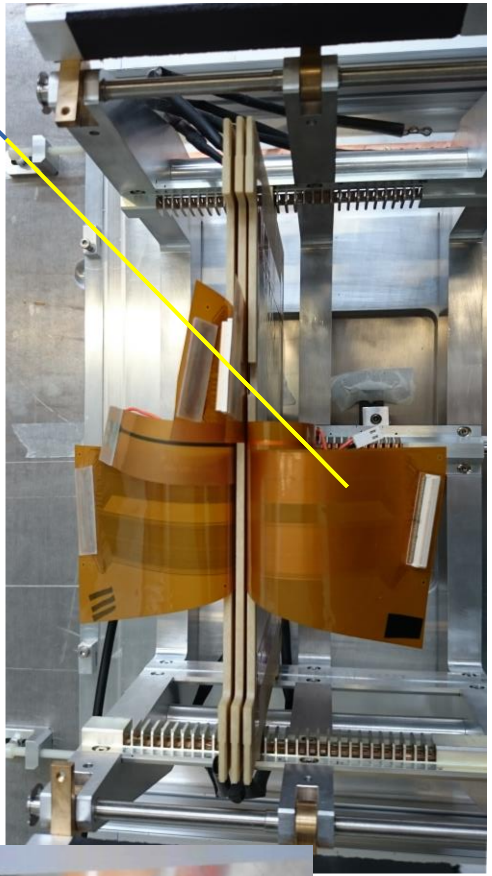


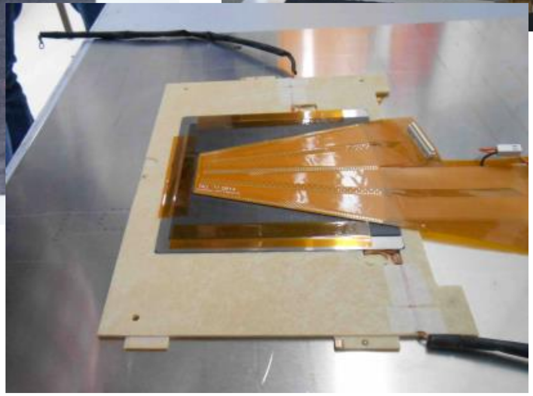
Thin LumiCal Module in Mechanical Frame

Kapton fanout

130 pin Panasonic connectors provides interface to APV-25 hybrid and SRS DAQ system.

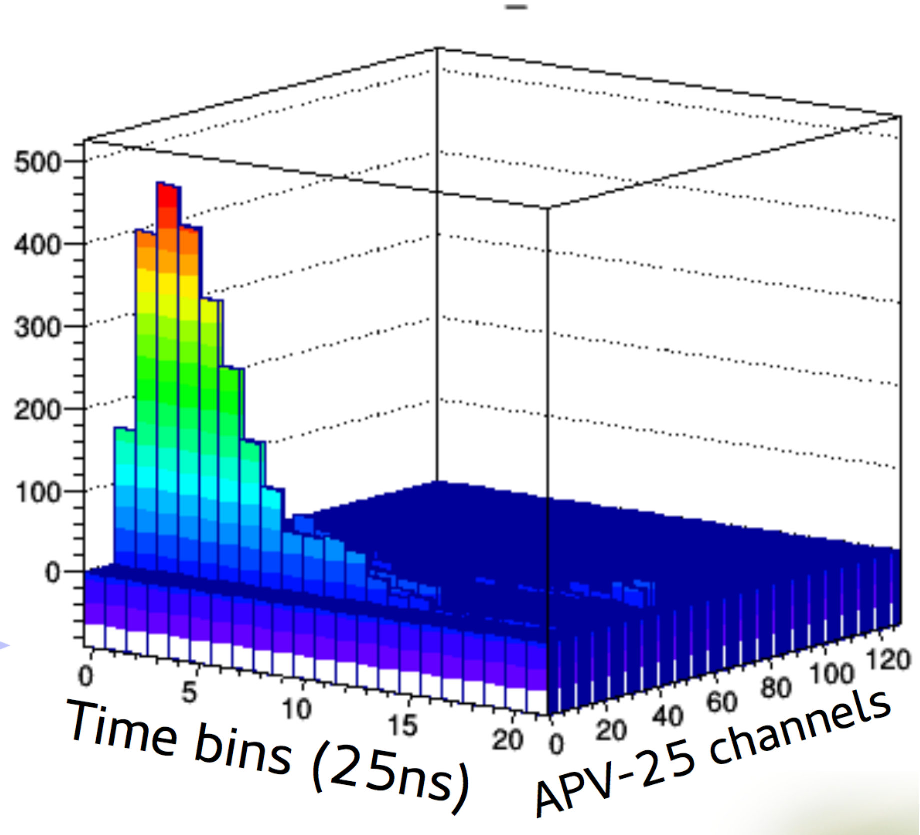
Carbon fiber supporting structure ("envelope") provides mechanical stability and easy stack assembly.

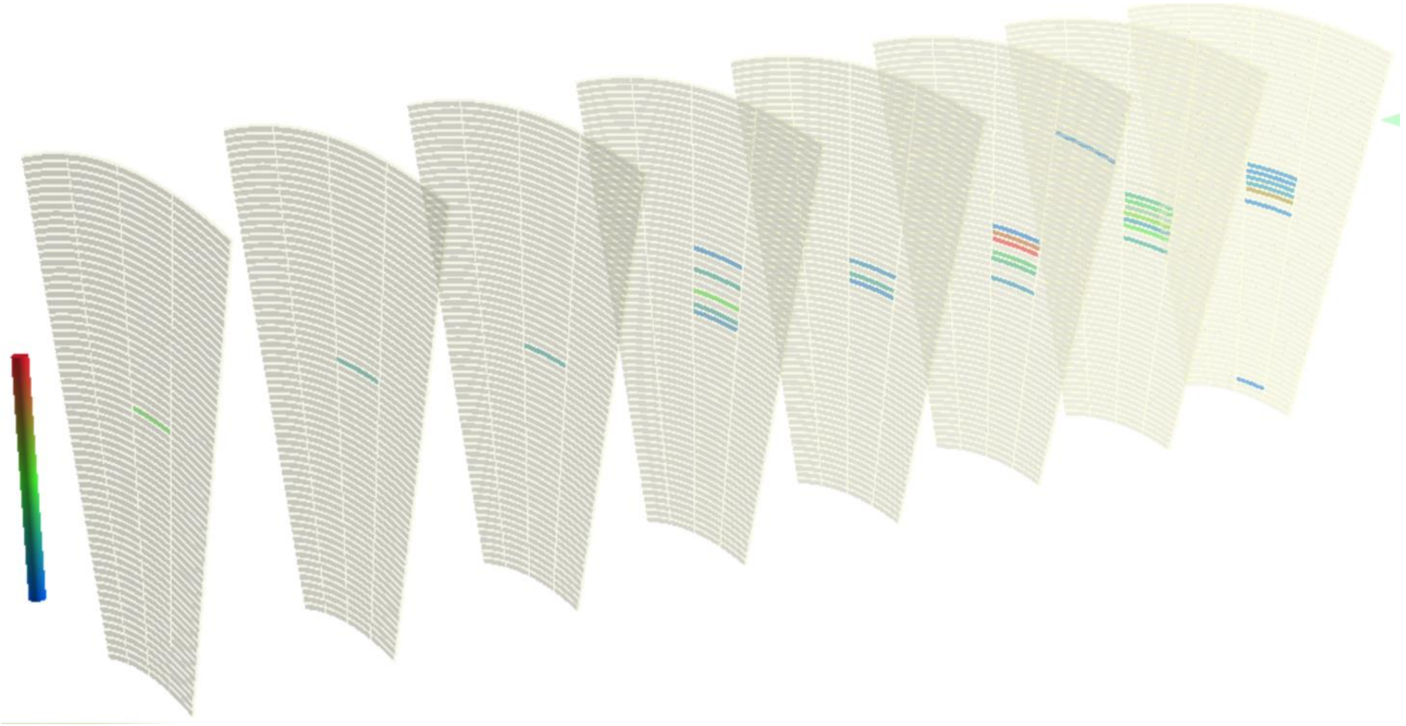




- 4 modules were successfully tested with e- beam at DESY in October 2015.
- 4 additional modules were prepared for the beam test in August 2016 including one assembled with TAB bonding technology.
- 2 APVs per detector

Event example



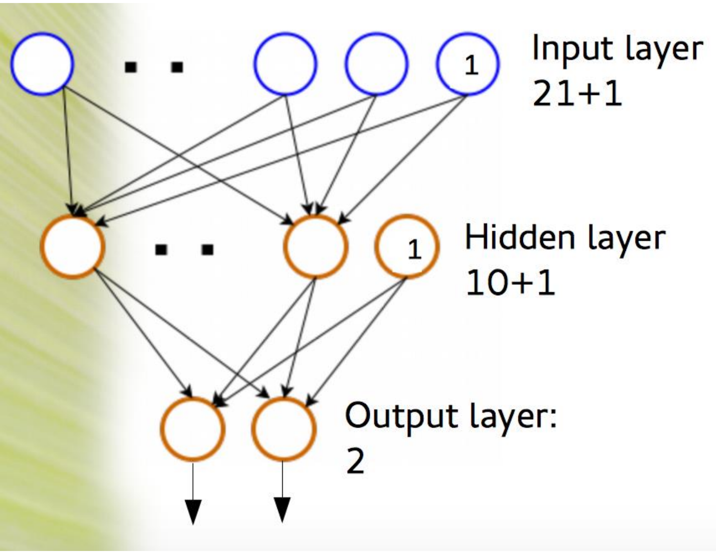


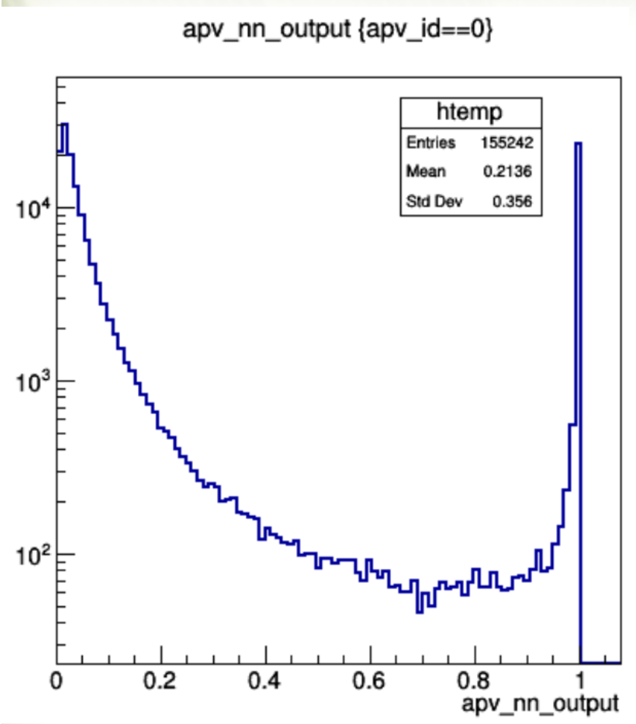
Typical signal event with APV

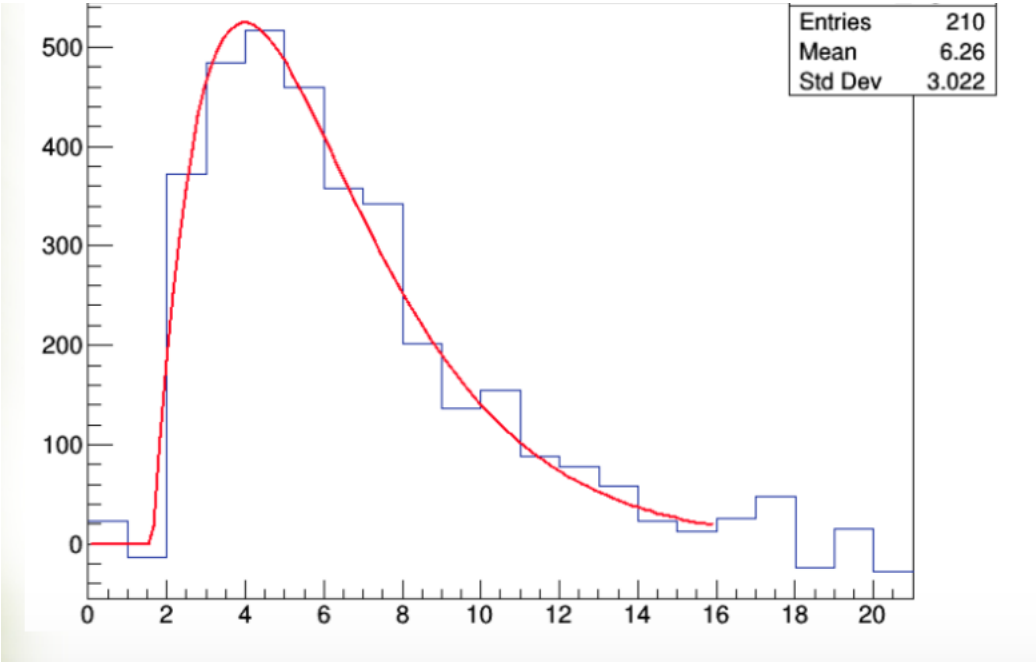
Signal extraction optimization

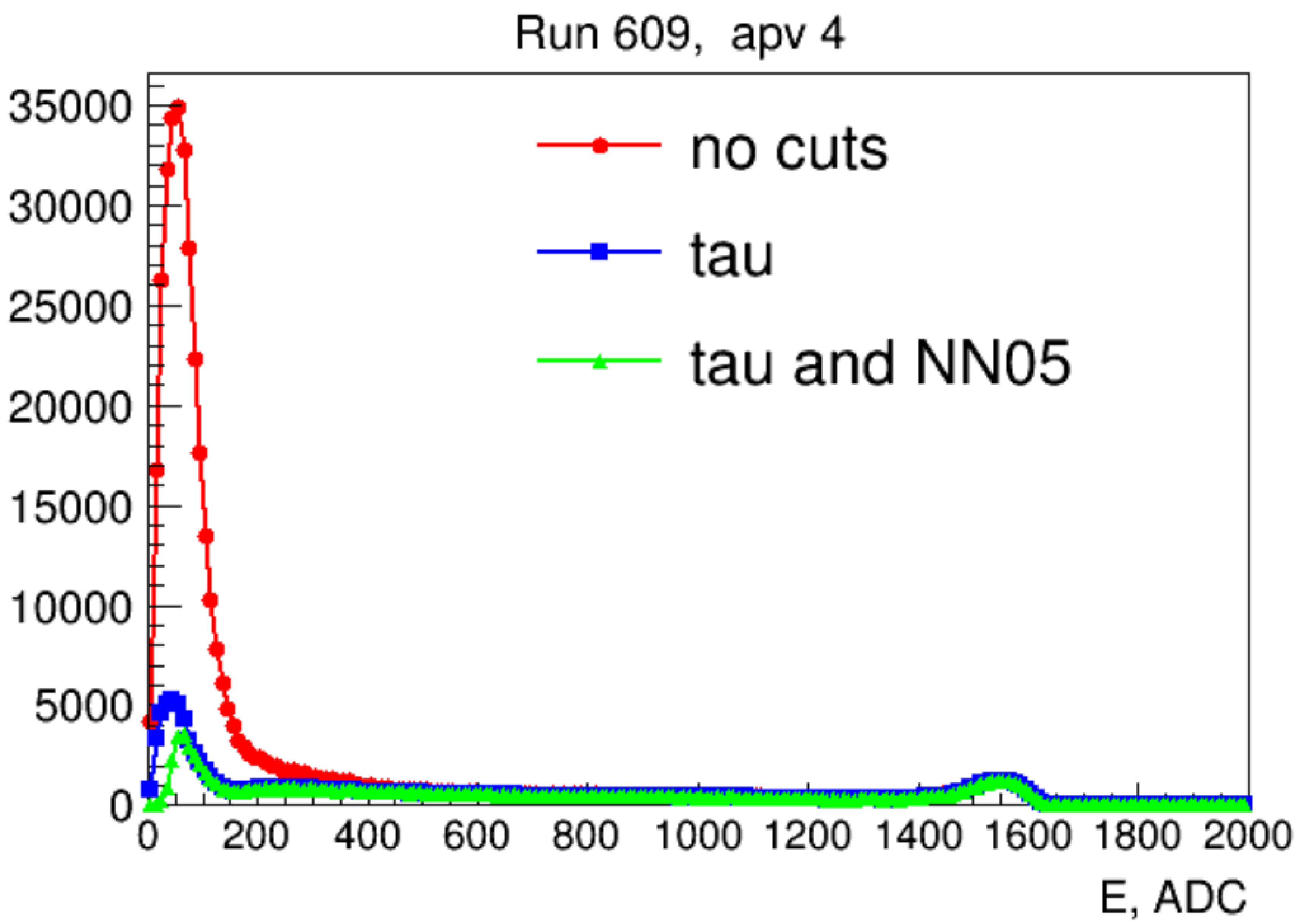
$$V = \frac{e^{\frac{t0-t}{\tau}}(t-t0)P0}{\tau}$$

- Different technics :
  - Standard fit using the CR-RC shaper cut on χ^2
  - Neural network







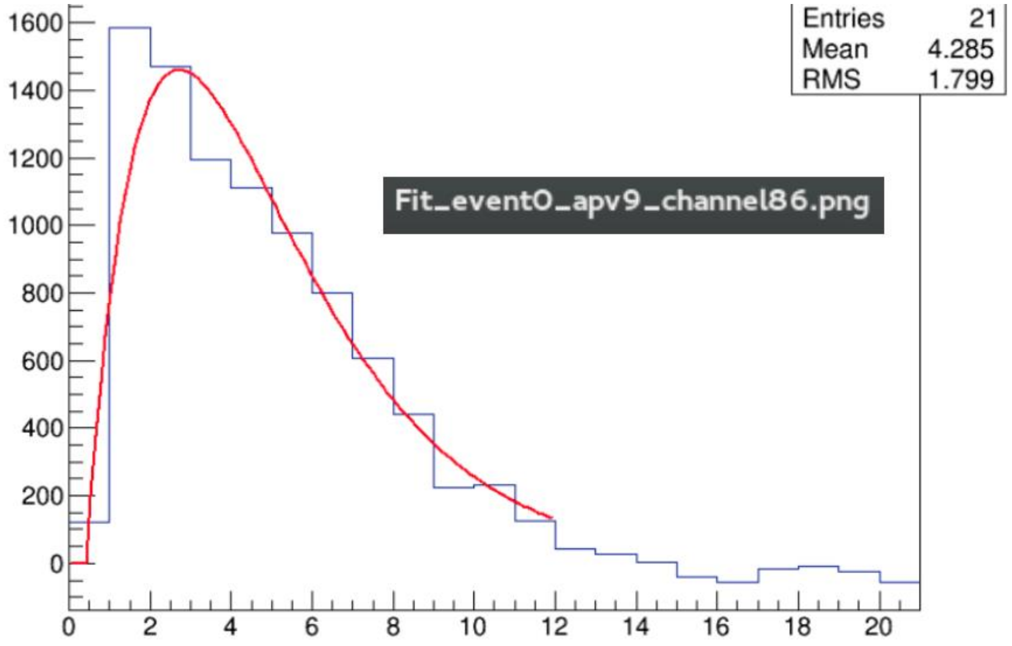


Run 609, apv 4
no cuts
tau
tau and NN05
35000
30000
25000
20000
15000
10000
5000
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
E, ADC

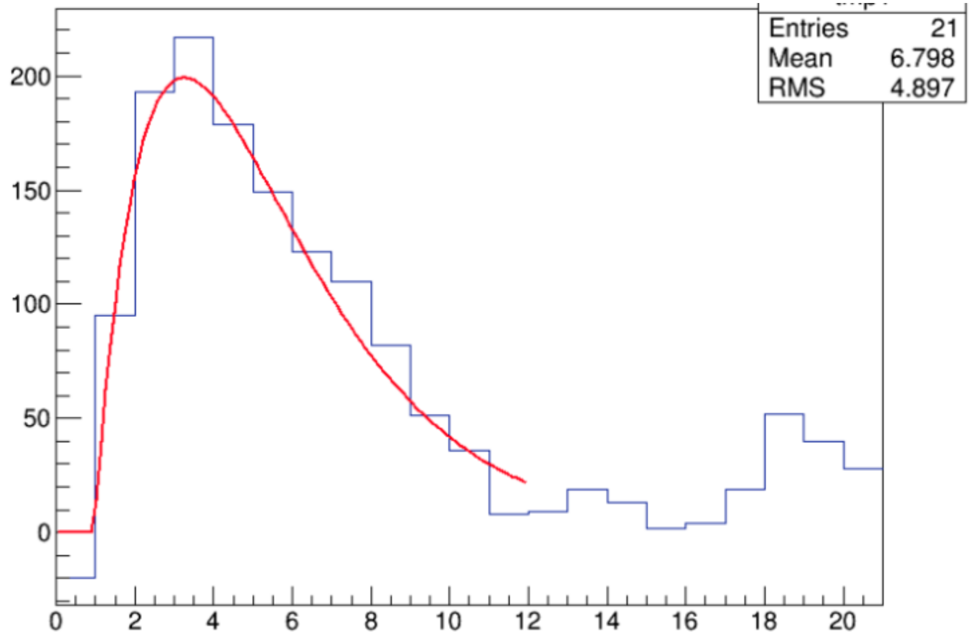
Saturation

- The APV is saturating for a charge greater than ~8MIP so saturation due to the e.m. shower

Satured pulse



Non satured pulse



When saturation occurs the signal reaches maximum earlier : started to study the time bin differences to reject/recover some signals

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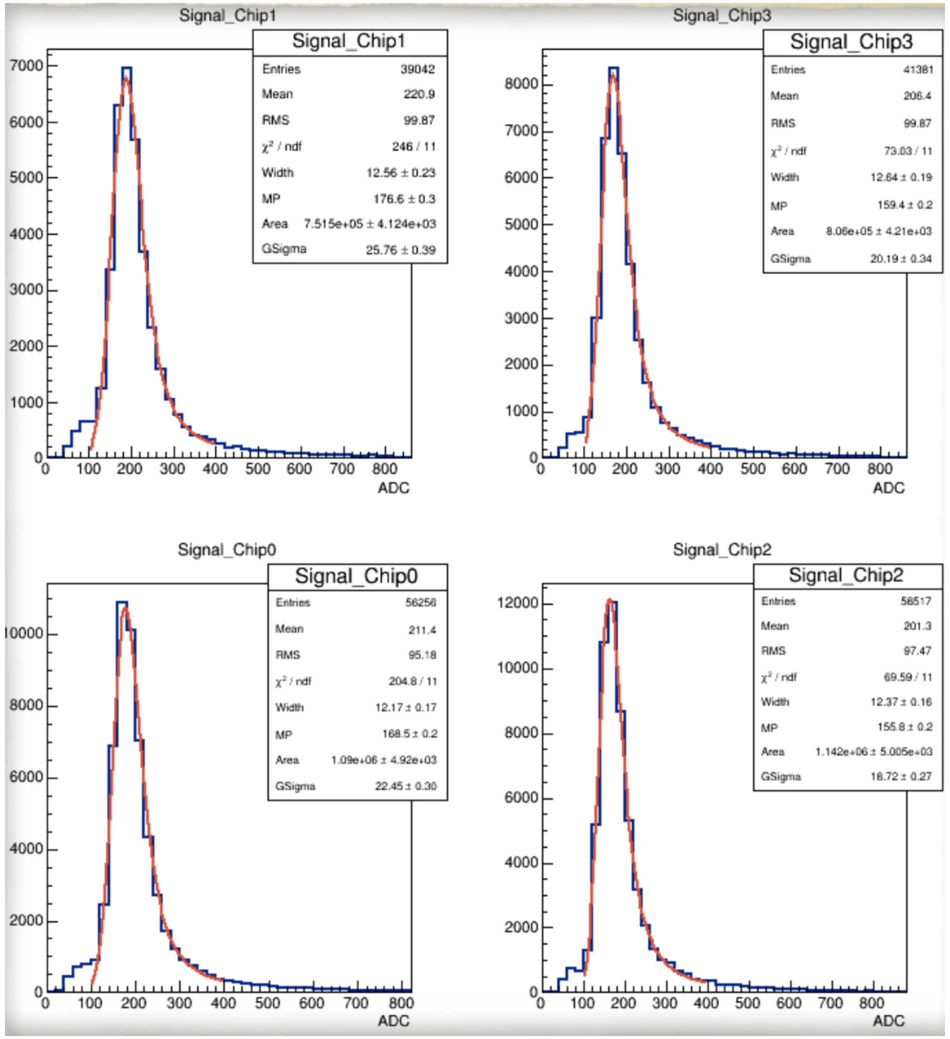
Energy calibration

- Use the two first detectors (without W) to calibrate the energy
- Fit with landau-gauss function

1 GeV e-



Extract calibration value :
MIP/ADC channel

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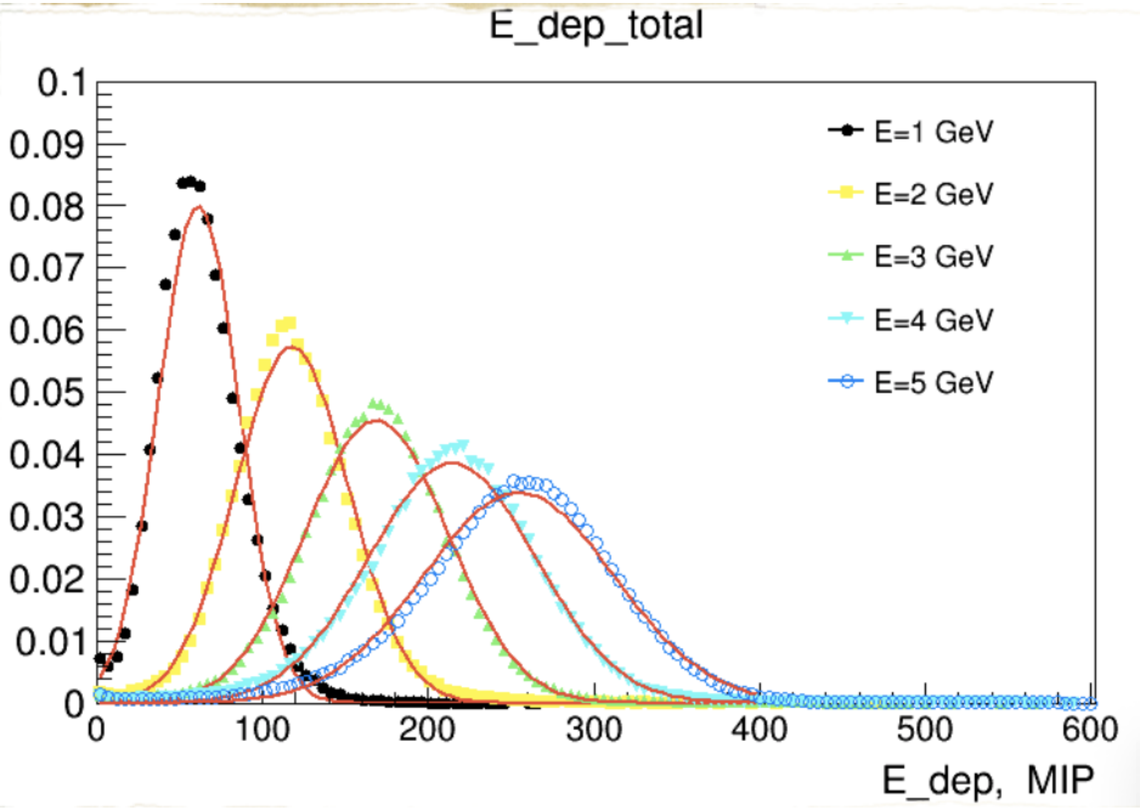
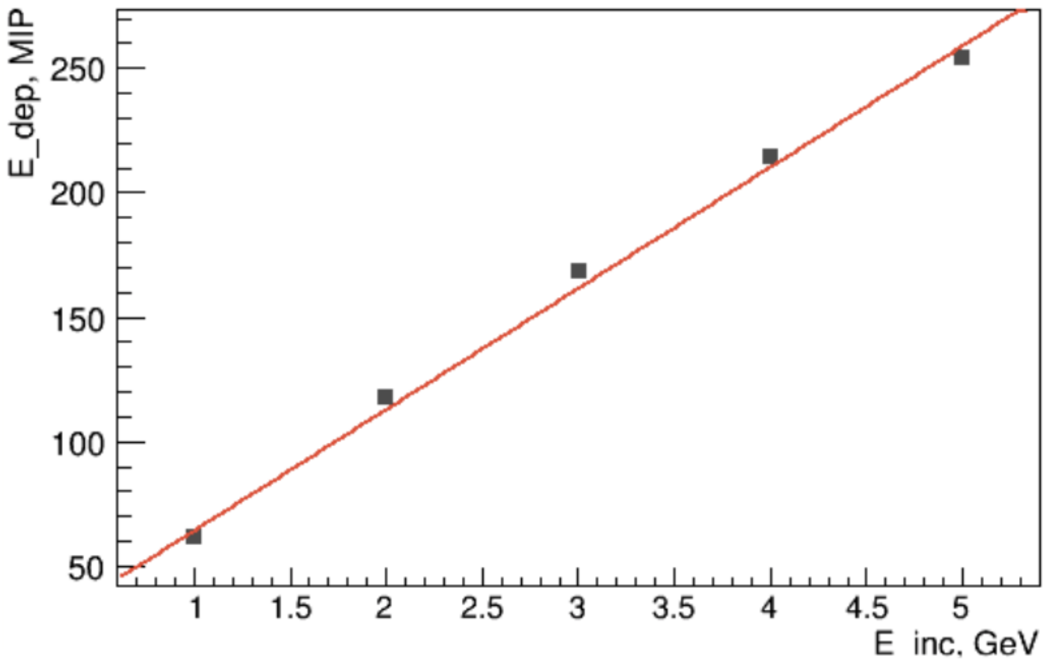
Total energy deposited with charge divider





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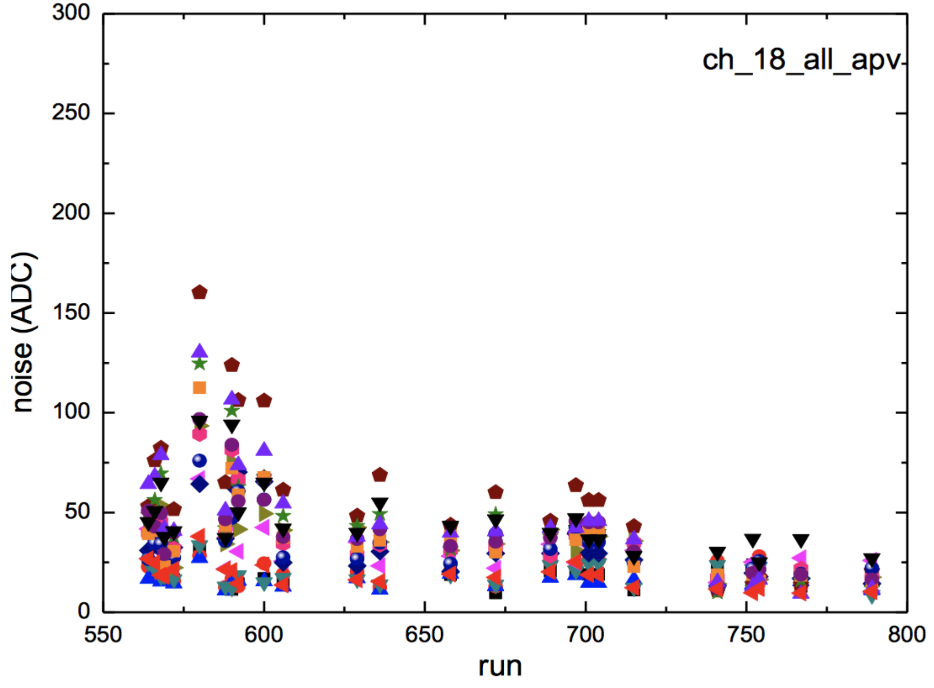
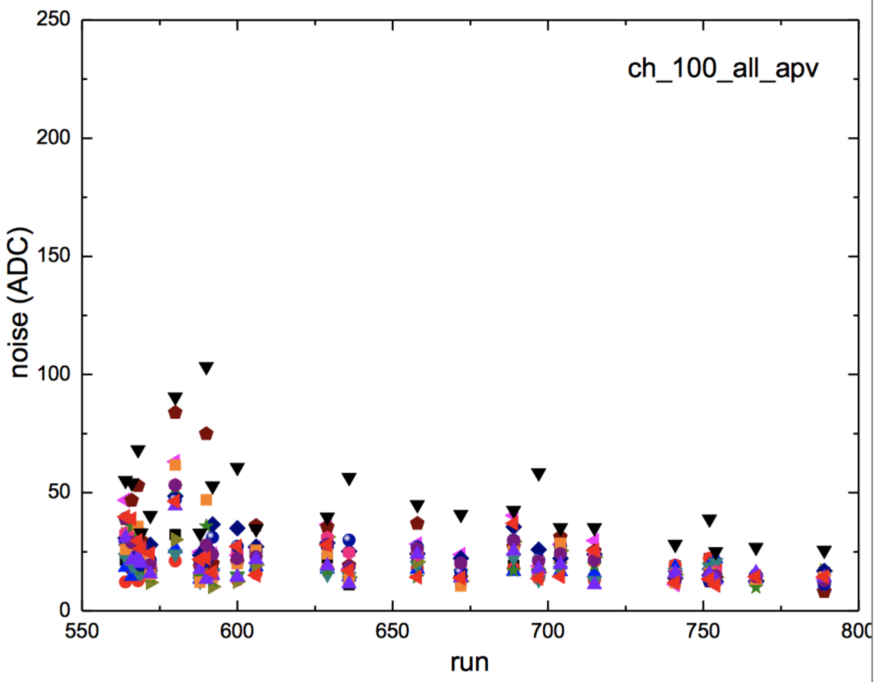
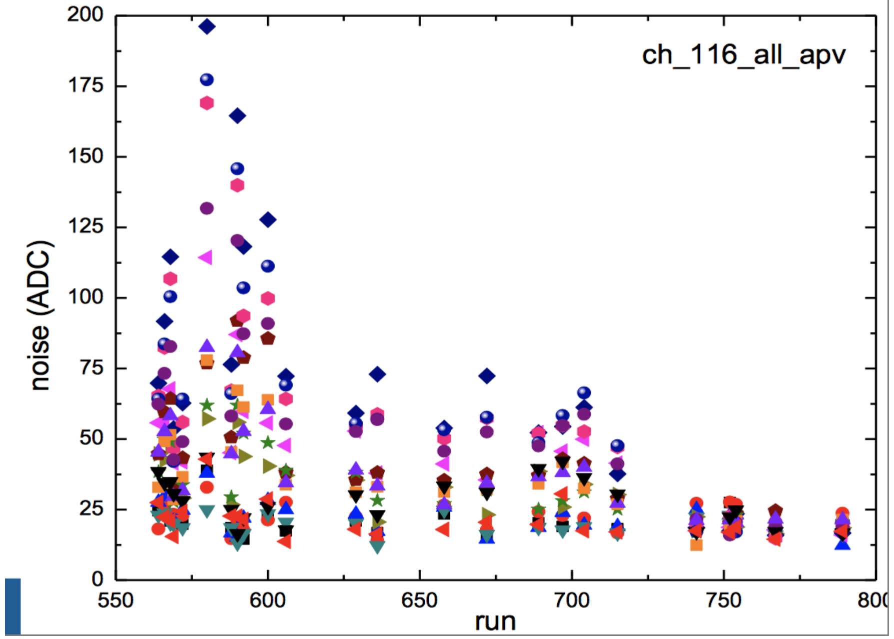
Noise study

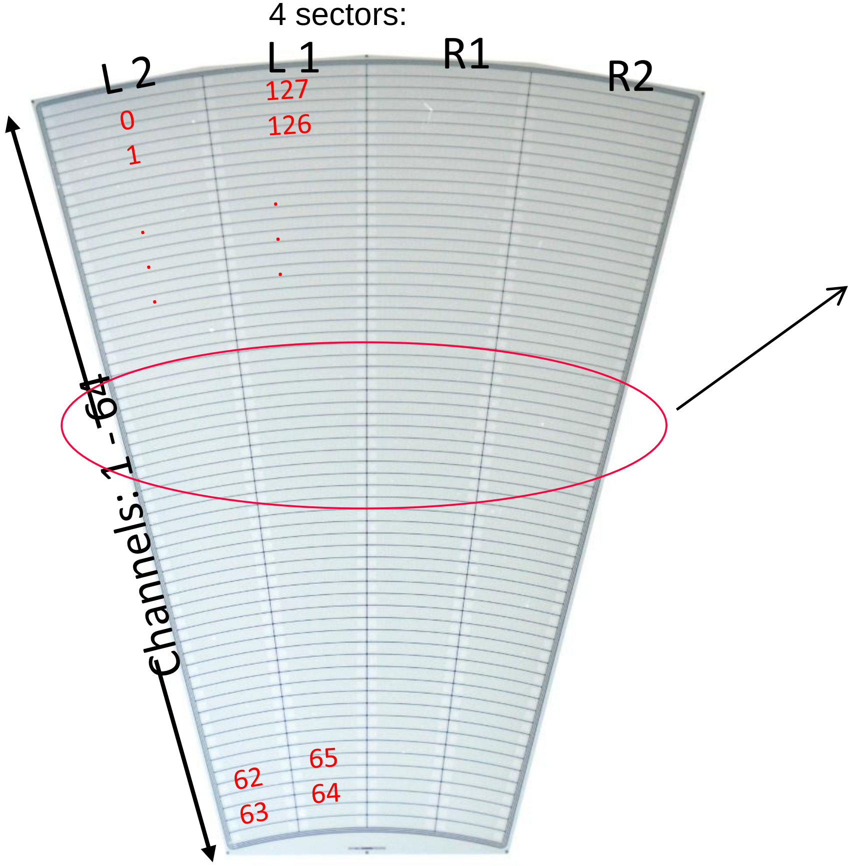
- Study the noise for each channels and each run.





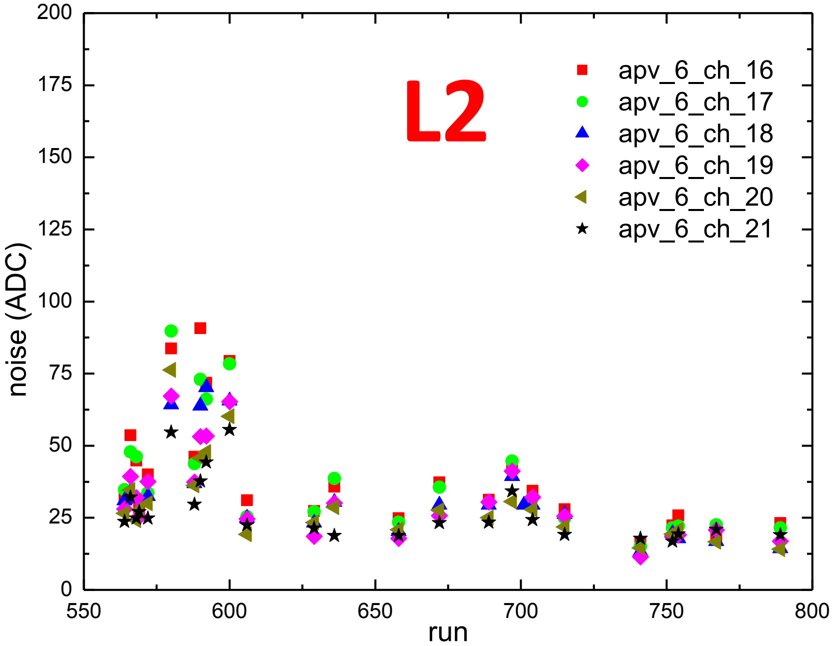


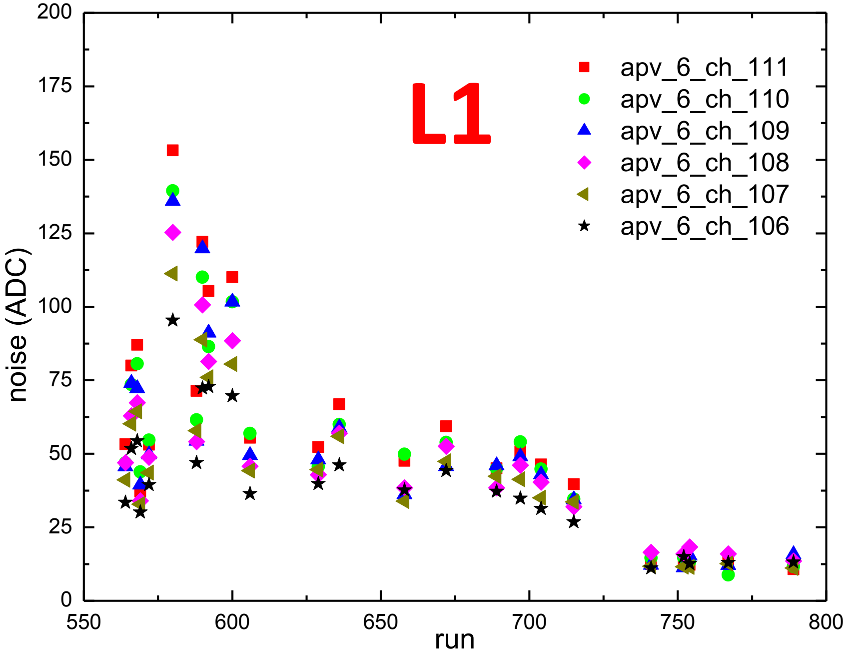
Channel noise comparison

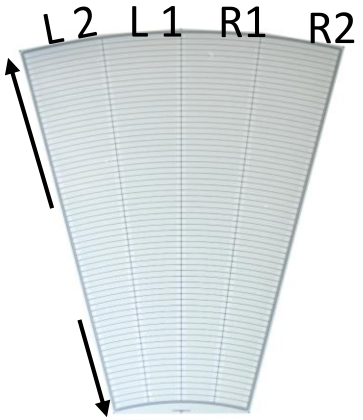


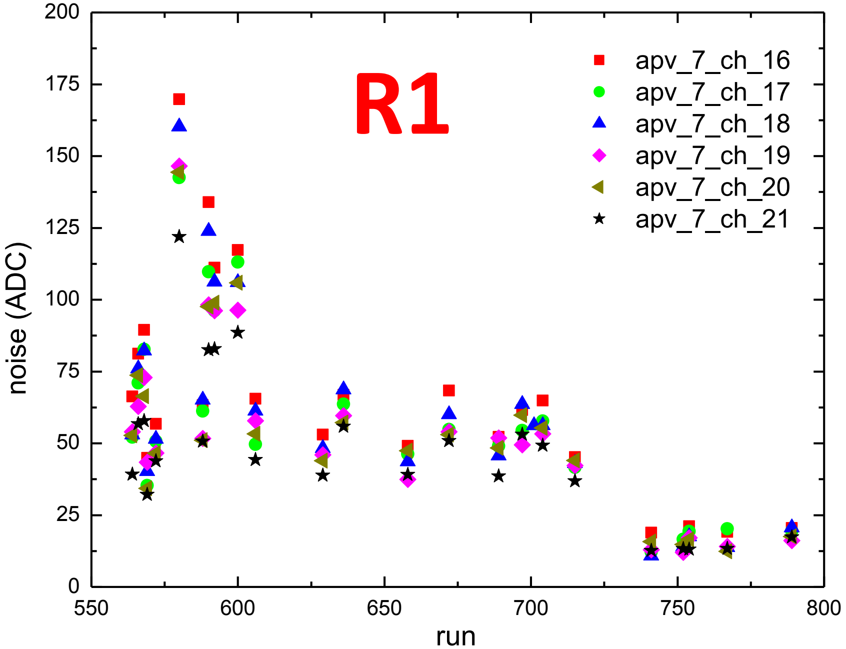
APV_id: 0, 2, 4, 6, 8, 10, 12, 14		APV_id: 1, 3, 5, 7, 9, 11, 13, 15	
L2	**L1**	**R1**	**R2**
16	111	16	111
17	110	17	110
18	109	18	109
19	108	19	108
20	107	20	107
21	106	21	106

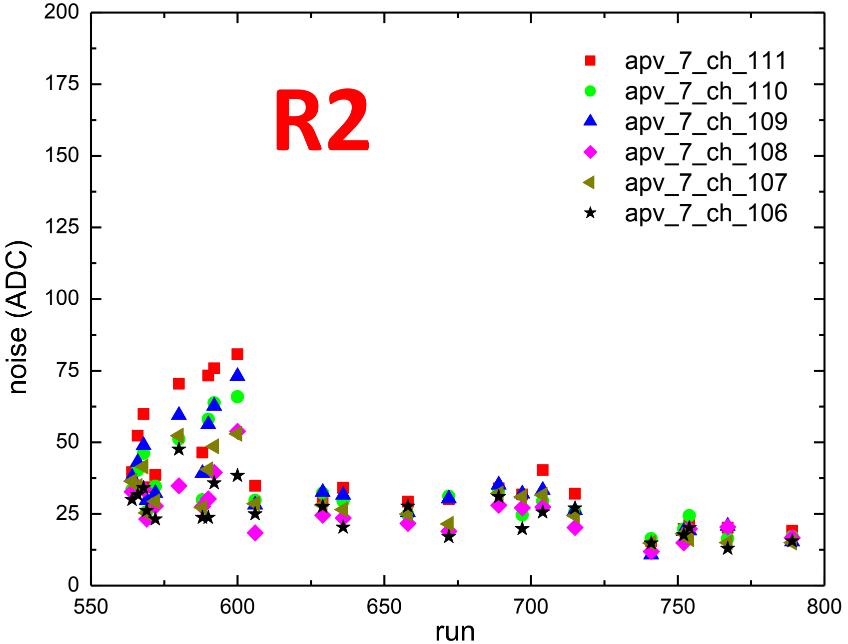
LAYER 4


L2
apv_6_ch_16
apv_6_ch_17
apv_6_ch_18
apv_6_ch_19
apv_6_ch_20
apv_6_ch_21
noise (ADC)
run
0
25
50
75
100
125
150
175
200
550
600
650
700
750
800

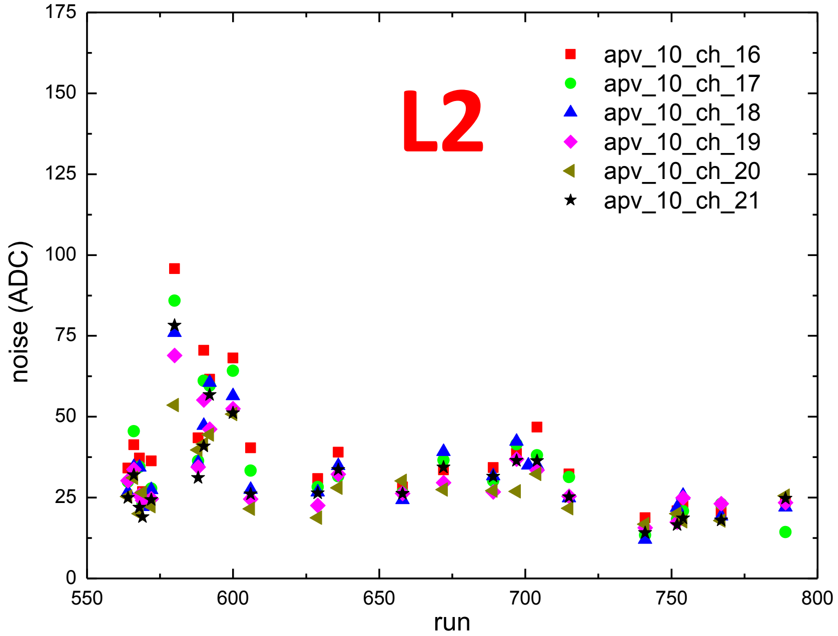

L1
apv_6_ch_111
apv_6_ch_110
apv_6_ch_109
apv_6_ch_108
apv_6_ch_107
apv_6_ch_106
noise (ADC)
run
0
25
50
75
100
125
150
175
200
550
600
650
700
750
800

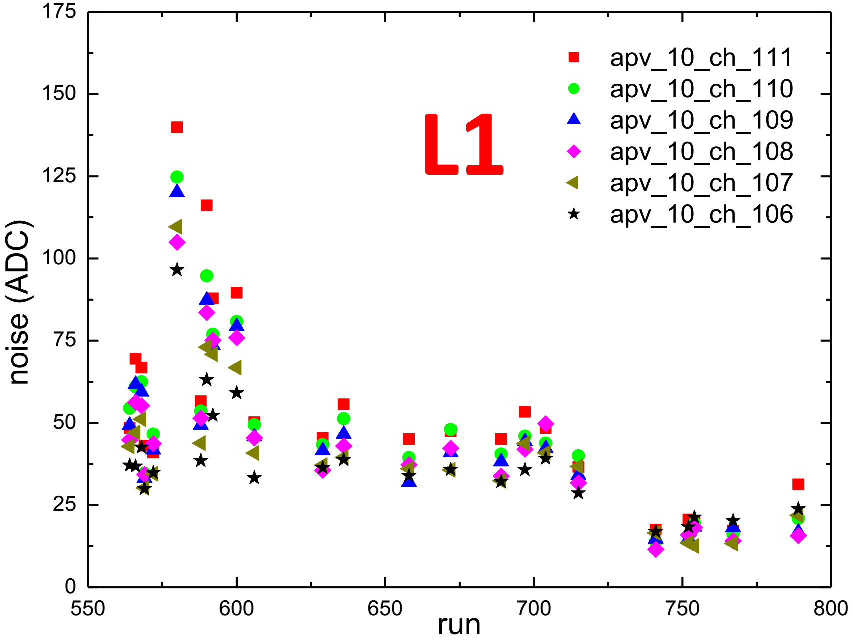

L 2
L 1
R1
R2

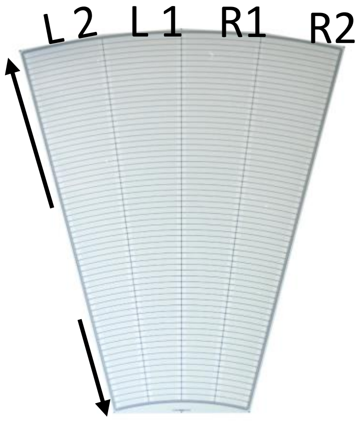

R1
apv_7_ch_16
apv_7_ch_17
apv_7_ch_18
apv_7_ch_19
apv_7_ch_20
apv_7_ch_21
noise (ADC)
run
0
25
50
75
100
125
150
175
200
550
600
650
700
750
800

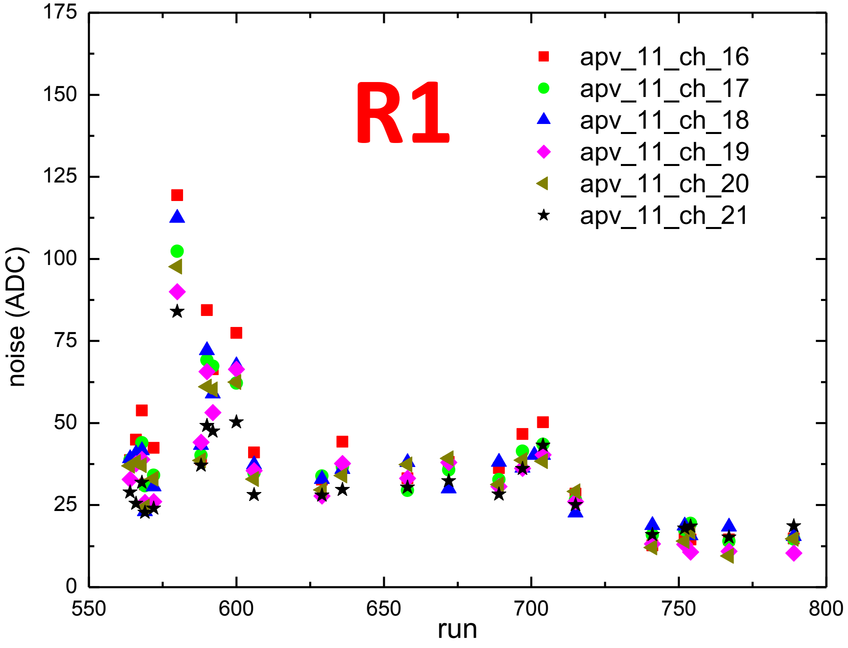

R2
apv_7_ch_111
apv_7_ch_110
apv_7_ch_109
apv_7_ch_108
apv_7_ch_107
apv_7_ch_106
noise (ADC)
run
0
25
50
75
100
125
150
175
200
550
600
650
700
750
800

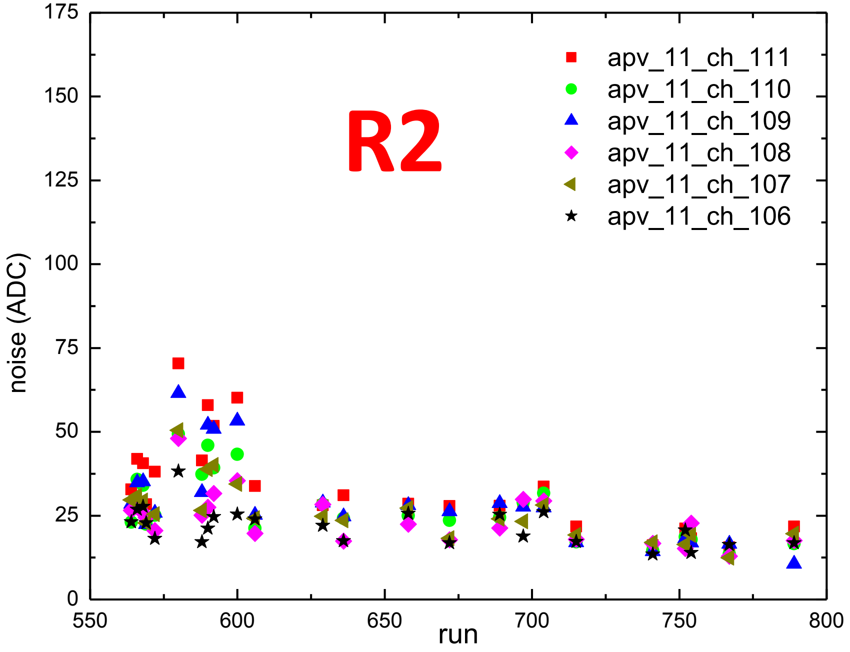
LAYER 6


L2
apv_10_ch_16
apv_10_ch_17
apv_10_ch_18
apv_10_ch_19
apv_10_ch_20
apv_10_ch_21
noise (ADC)
run
0 25 50 75 100 125 150 175
550 600 650 700 750 800


L1
apv_10_ch_111
apv_10_ch_110
apv_10_ch_109
apv_10_ch_108
apv_10_ch_107
apv_10_ch_106
noise (ADC)
run
0 25 50 75 100 125 150 175
550 600 650 700 750 800

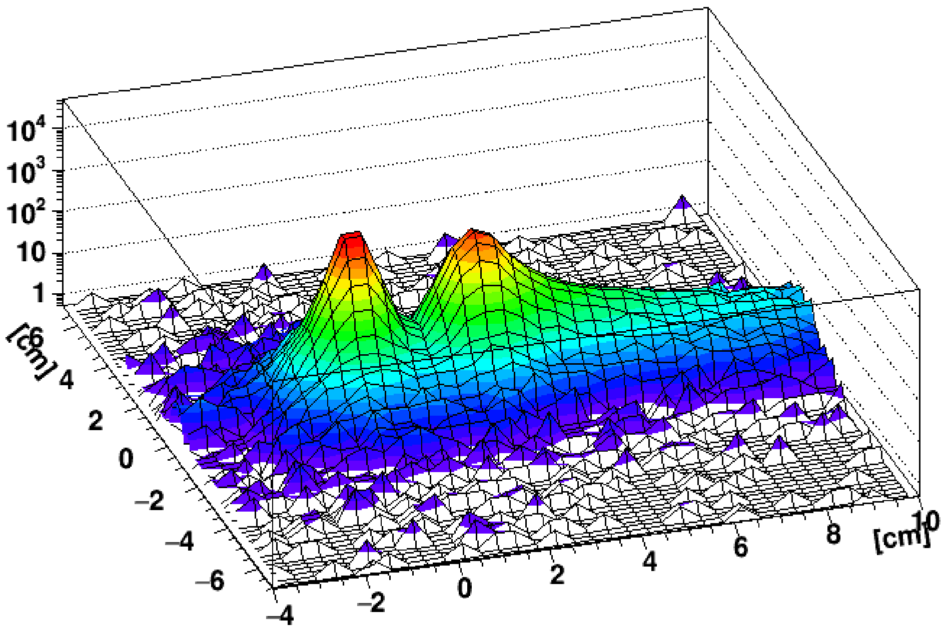

L 2
L 1
R1
R2

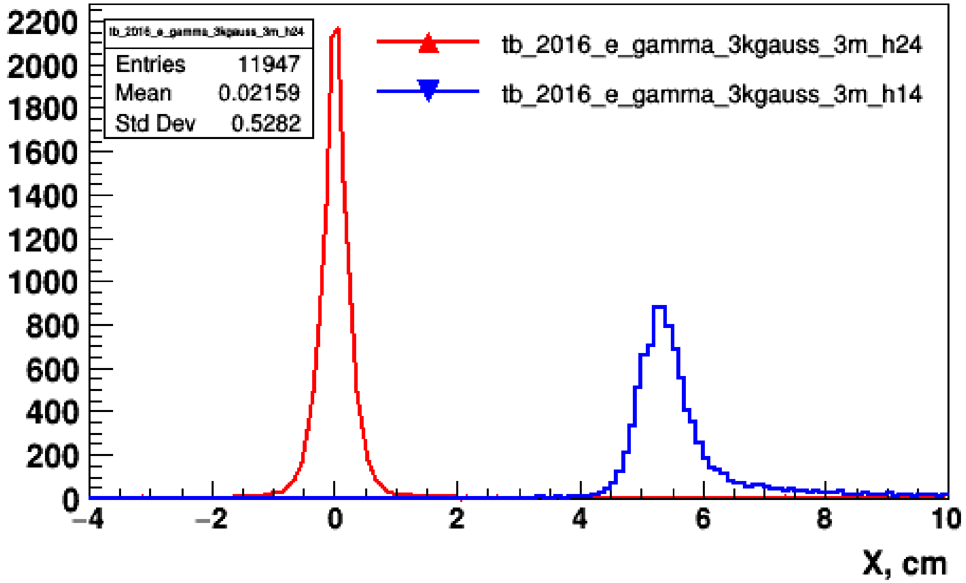

R1
apv_11_ch_16
apv_11_ch_17
apv_11_ch_18
apv_11_ch_19
apv_11_ch_20
apv_11_ch_21
noise (ADC)
run
0 25 50 75 100 125 150 175
550 600 650 700 750 800

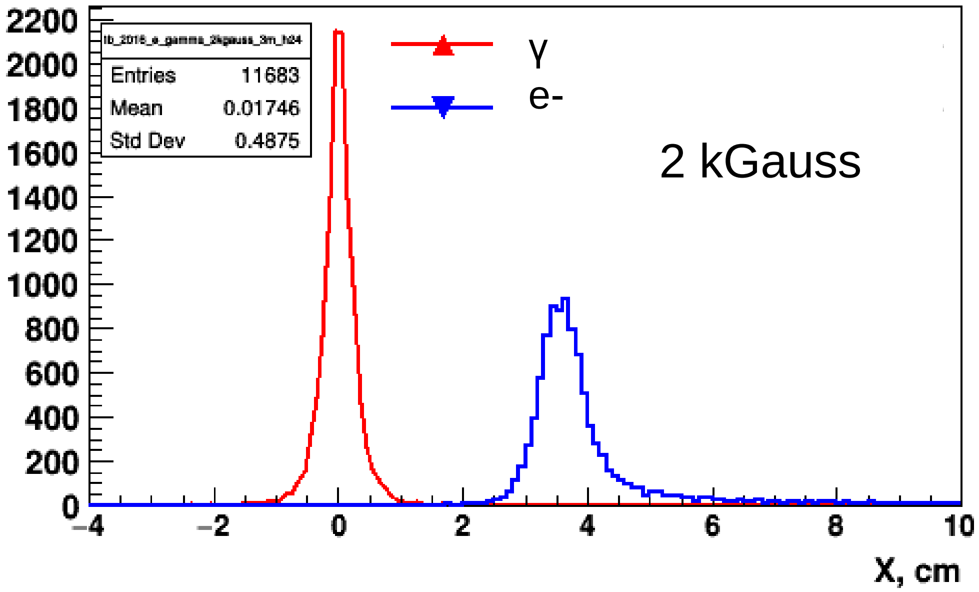

R2
apv_11_ch_111
apv_11_ch_110
apv_11_ch_109
apv_11_ch_108
apv_11_ch_107
apv_11_ch_106
noise (ADC)
run
0 25 50 75 100 125 150 175
550 600 650 700 750 800

Electron photon identification

- We produced photon using a radiator and bent the electron trajectory
- Simulation with different magnetic field value







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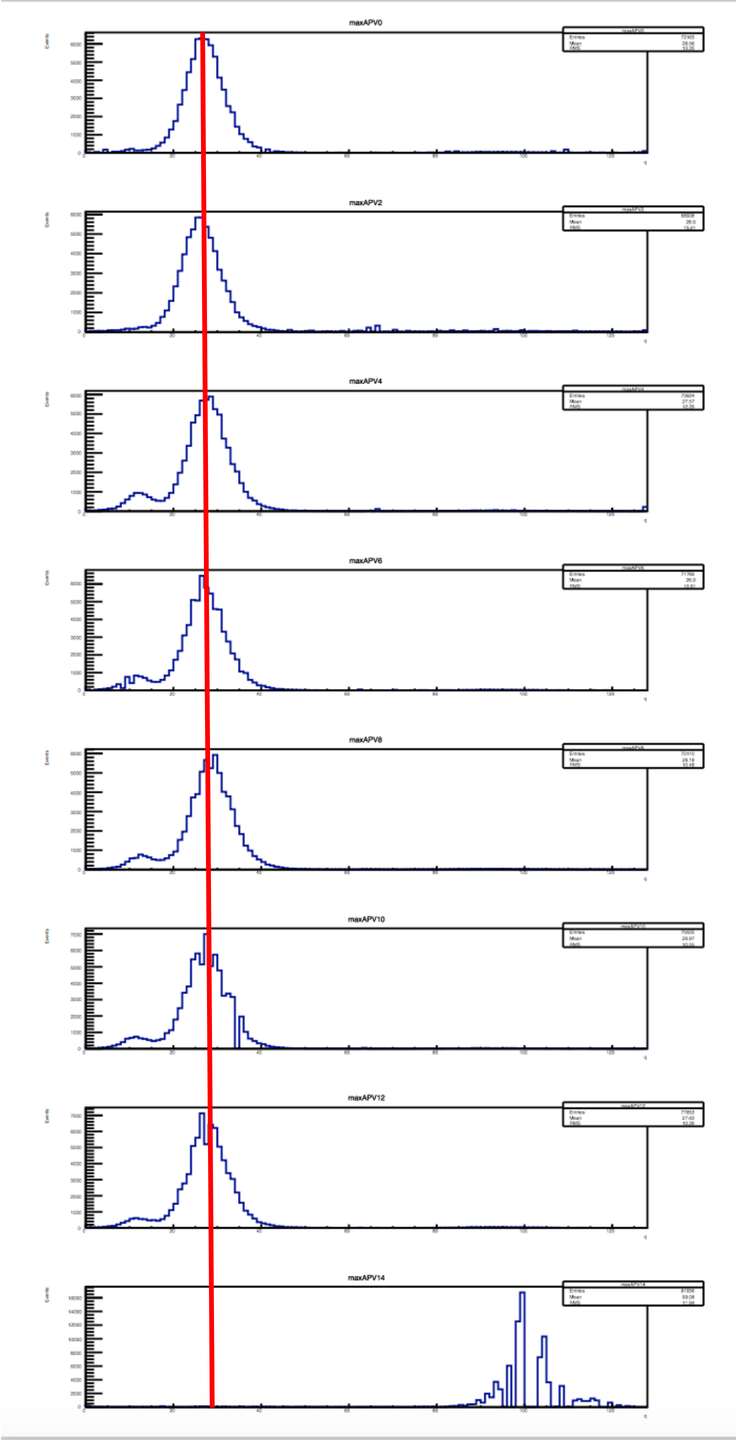
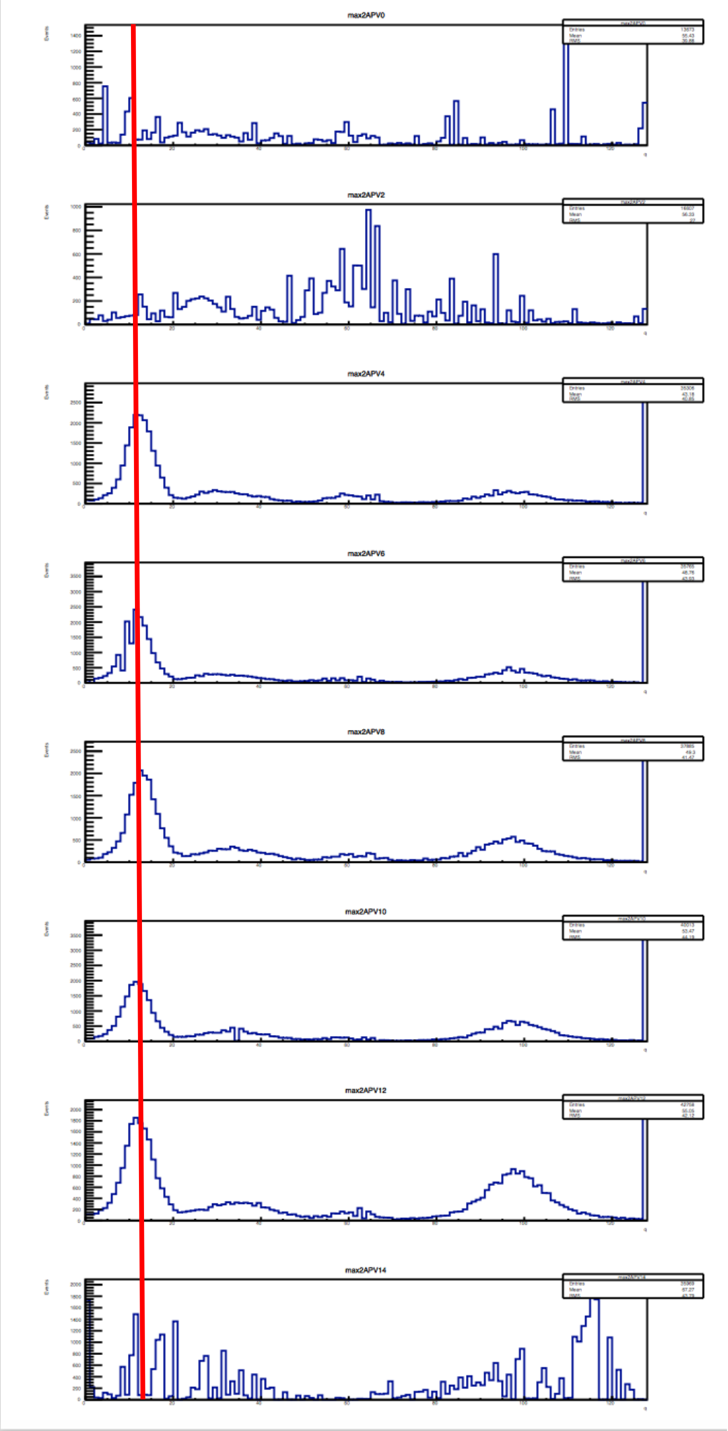
MAX 1 : Electron Channel ~31



MAX 2: Photon Channel ~12



20 channels difference : ~36 mm

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conclusion

- Development of tools to extract the signal and reject the noise
- Energy calibration is on going
- Energy deposited with and without charge divider has been studied
- Extensive noise study : need to check in TAU the L1-R1 vs L2 R2 noise
- Electron photon identification started

Need to continue but first results are encouraging