Low momentum proton identification in p+A interaction at SPS energies

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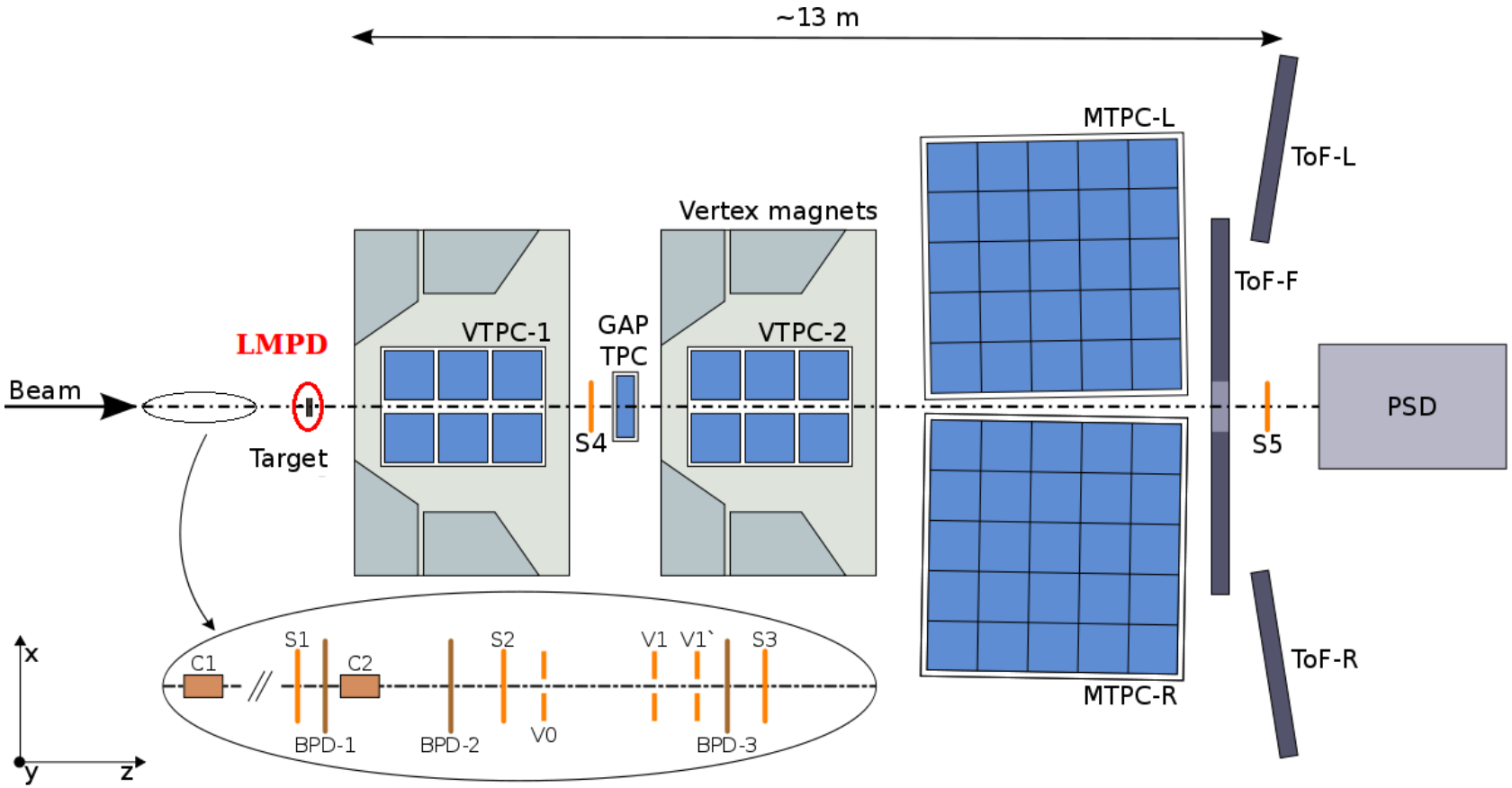
Outline

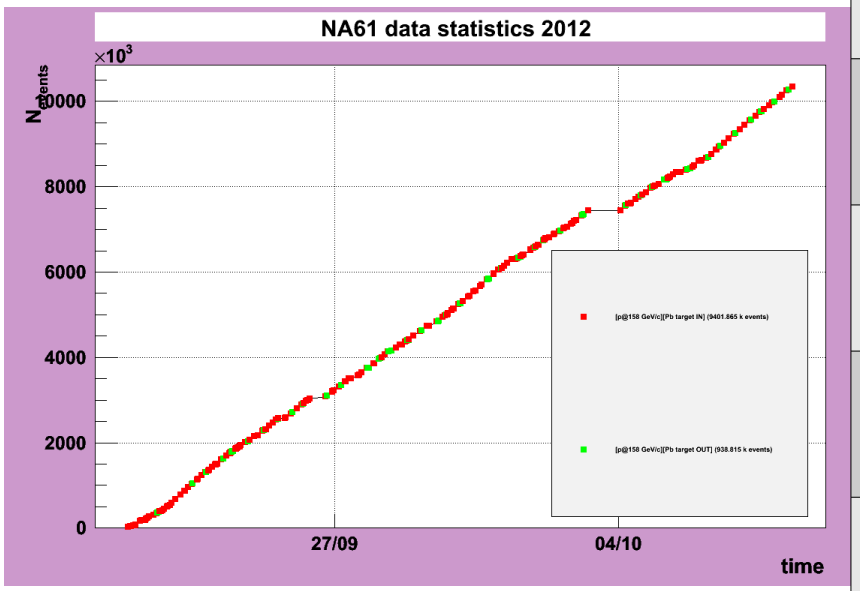
- NA61/SHINE Experiment
- Low momentum particles in h+A collisions
- Low Momentum Particle Detector (LMPD)
  - Detector construction
  - Calibration
- Identification of slow protons with LMPD

NA61/SHINE at CERN SPS



- Fixed-target experiment at the CERN SPS
- Physics program: measurement of hadron productions in p+p, **p+A**, h+A and A+A collisions

NA61 data statistics 2012



	Magnet	event Target in	event Target out
158 GeV p+Pb	30 GeV field	0.80M	0.02M
158 GeV p+Pb	**158 GeV field**	**4.13M**	**0.41M**
120 GeV p+C	Only VTX2	2.60M	0.27M
158 GeV h-+C	Only VTX2	0.93M	0.35M
158 GeV K-+C	Only VTX2	0.95M	0.19M
158 GeV p+Pb	**158 GeV field**	**9.40M**	**0.93M**
Krypton VTX1		4.26M	
Krypton GTPC		1.43M	
Krypton LMPD		**1.59M**	

Low momentum particles in h+A collisions

- Early emulsion experiments → number of "heavy tracks" (ß < 0.7) is correlated to the number of hadron-nucleon collisions inside the nucleus
- Black tracks (ß < 0 .3)
  - isotropic angular distribution
  - associated with the last stage, the evaporation of the final nucleus
  - number Nb measures the nuclear excitation energy
- Grey particles (0.3 < ß < 0.7)
  - angular distribution forward peaked
  - originate from the intranuclear cascade

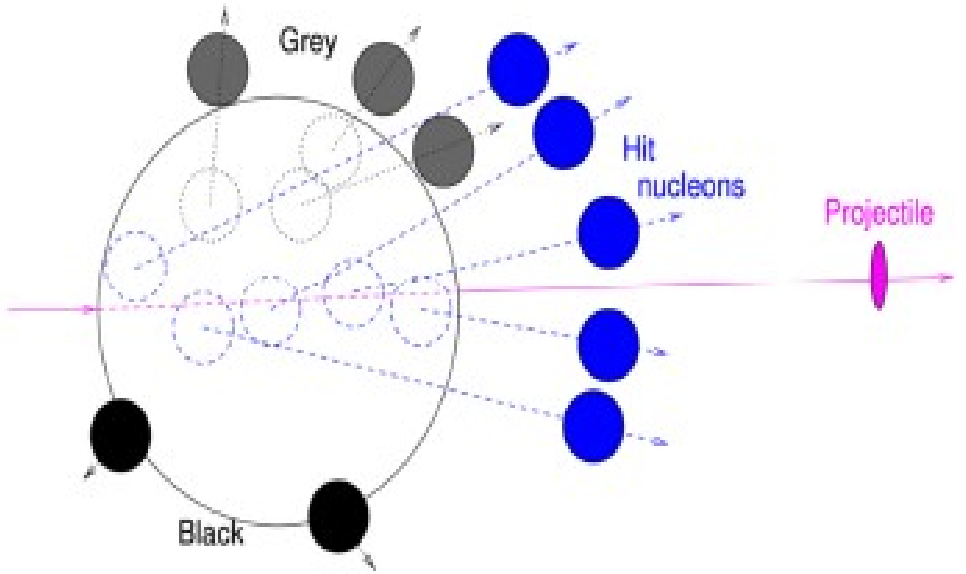
Low momentum particles in h+A collisions

- Angular distributions of grey protons
  - significant dependence on A (the target mass number), stronger forward-peaked for lighter targets than for heavier ones
  - shape and height of the angular distributions do not depend on the incoming energy
  - at fixed A the dependence on the projectile is only weak

The number of slow particles measures the centrality or peripherality of a hadron-nucleus collision.

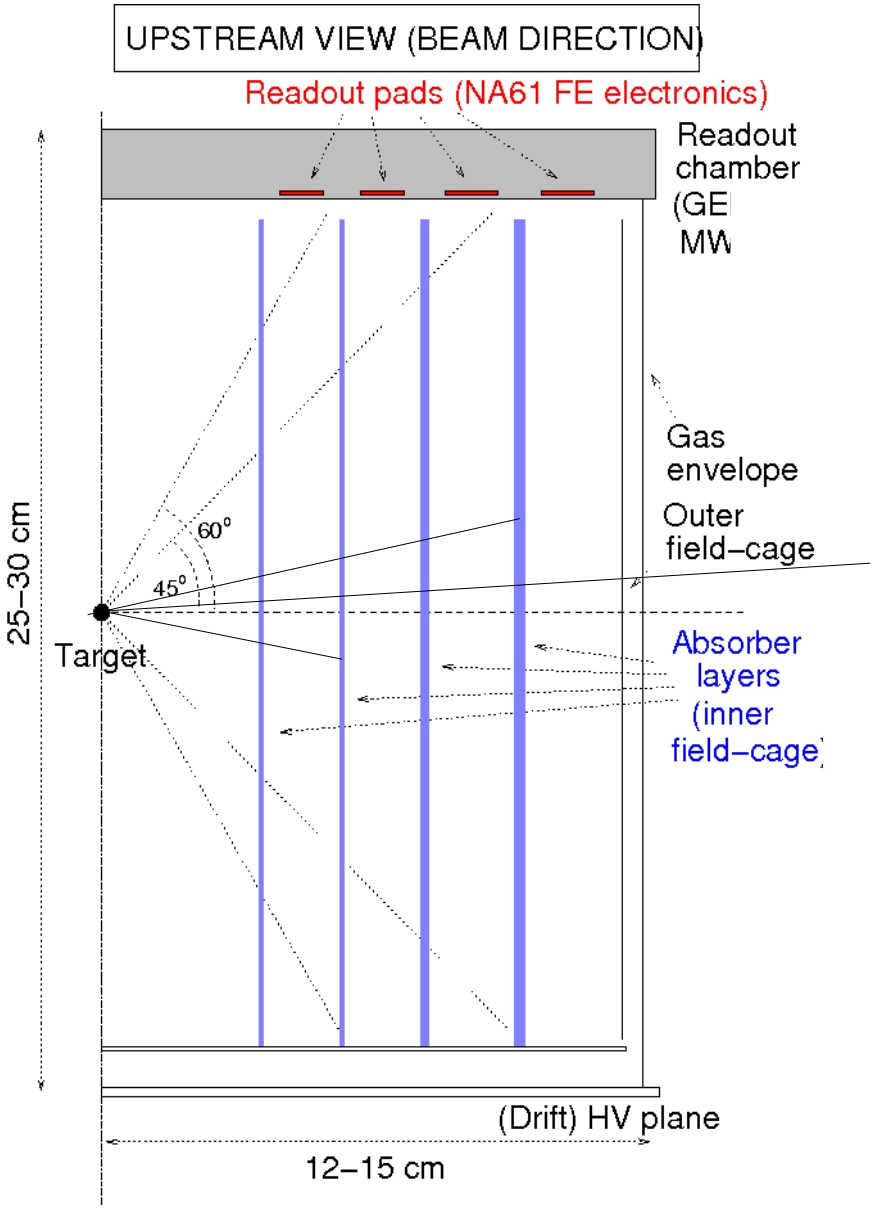
LMPD - *Physics objectives*

- Centrality of h+A collision is correlated to the number of slow (“gray”) nucleons (produced by the “break-up” of the nucleus)

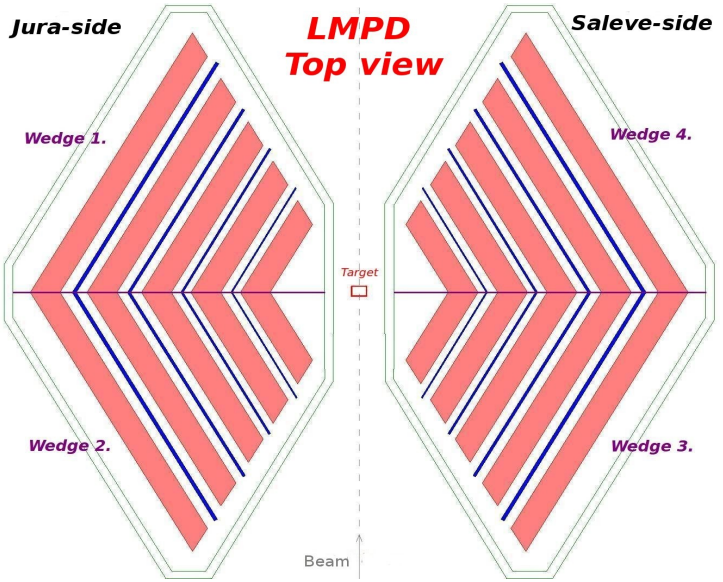


LMPD → identification and energy measurement of low momentum particles in p+A collisions → *Centrality Detector*

LMPD - *Operation principle*



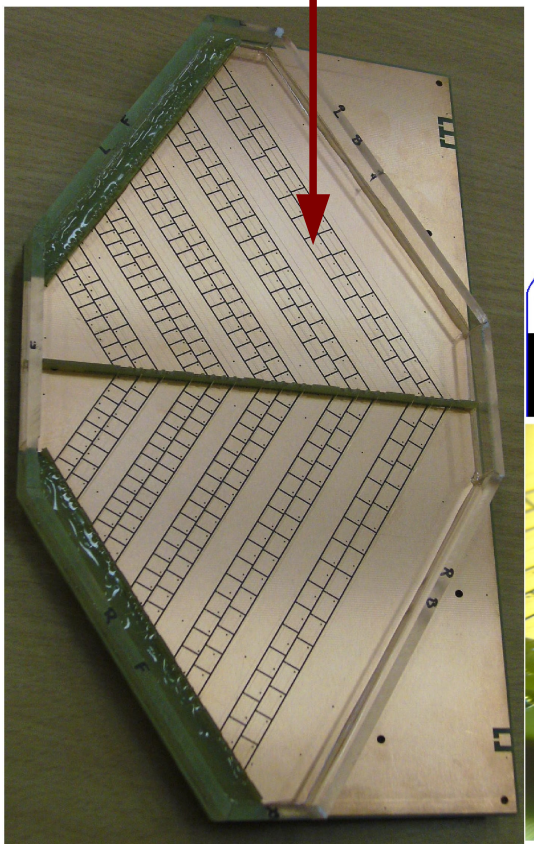
- TPC, intervals in particle range defined by absorber layers
- Simultaneous measurement of dE/dx and range: energy and identification

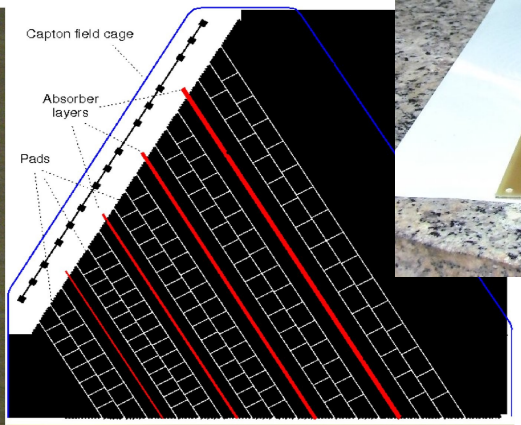


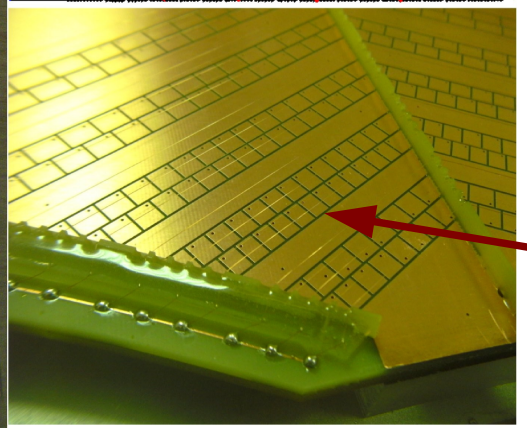
Low Momentum Particle Detector

Readout chamber (MWPC)

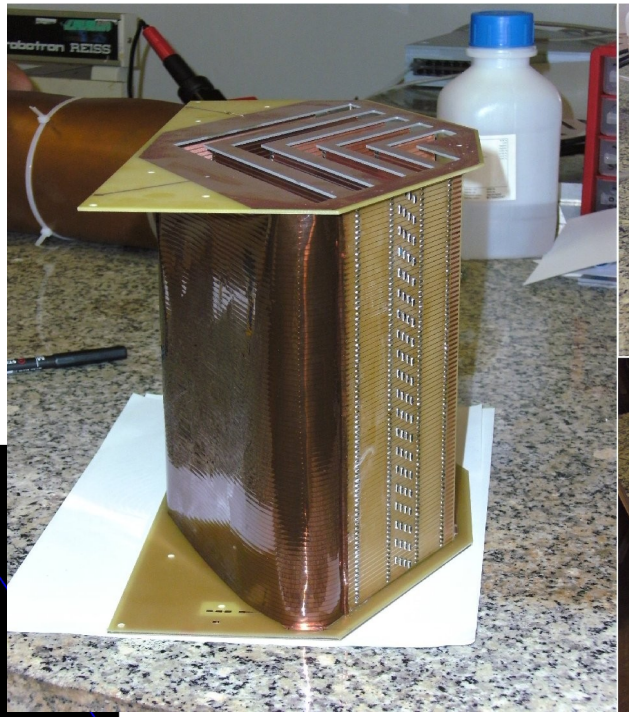
Cathode plane

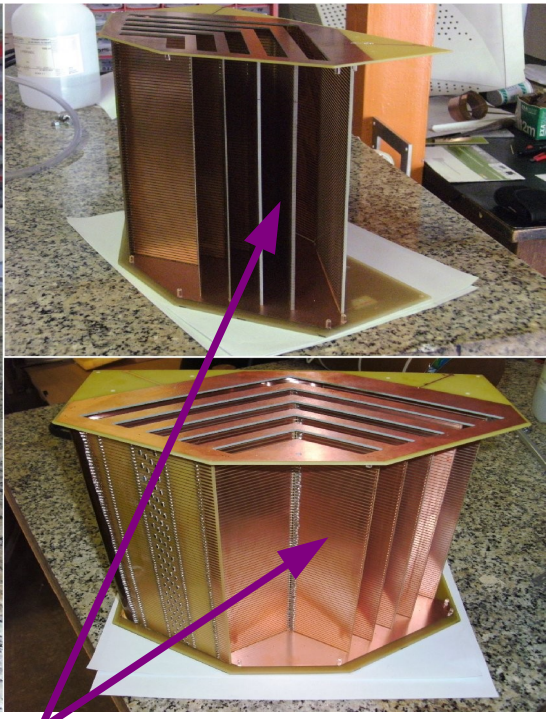






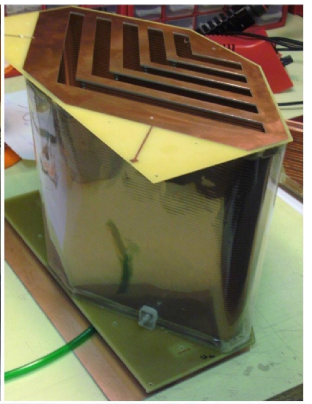
Wires

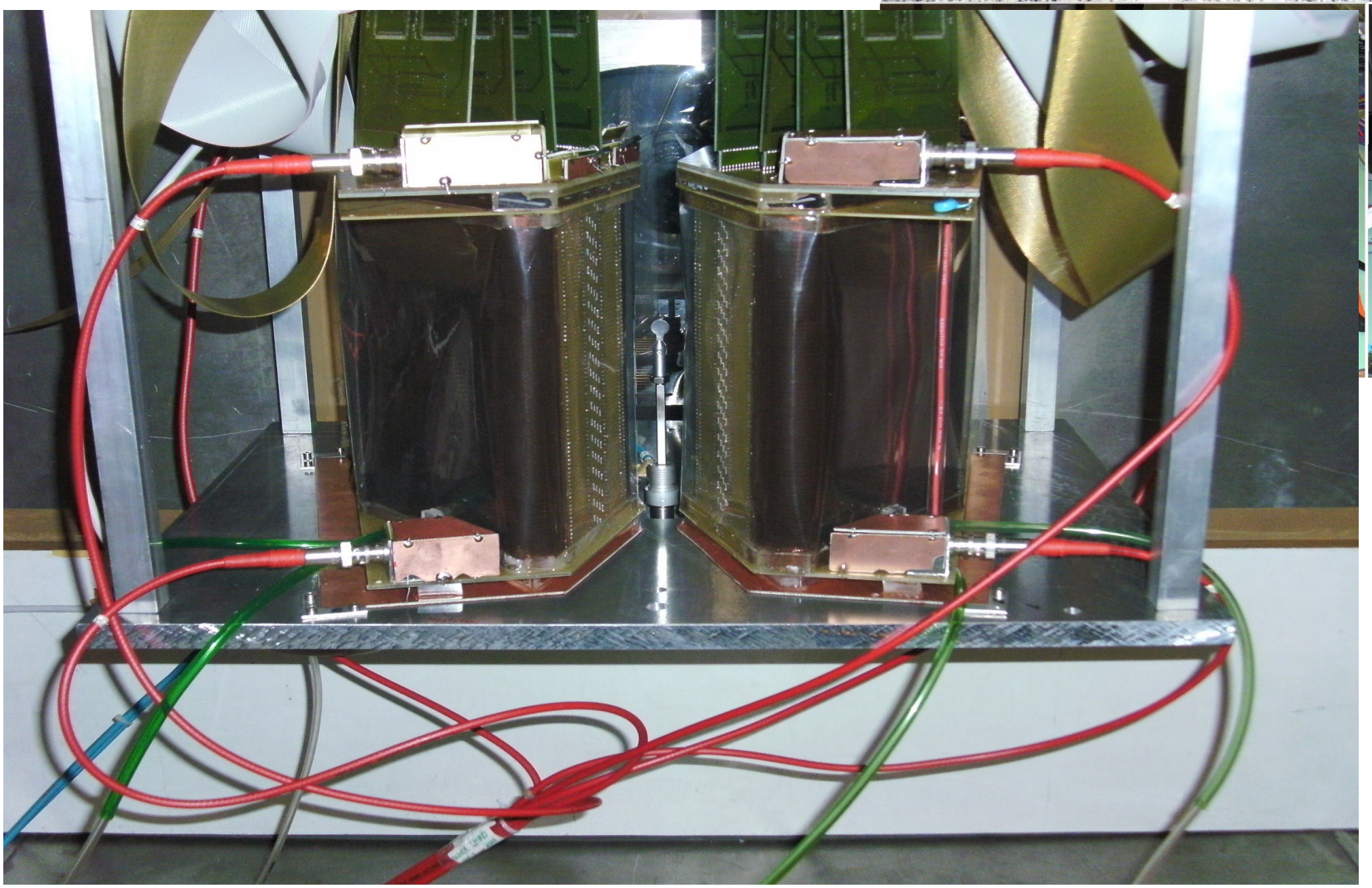


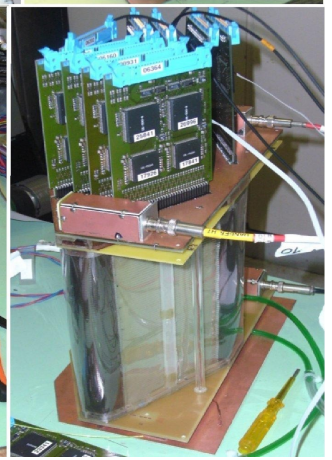


Absorber layers

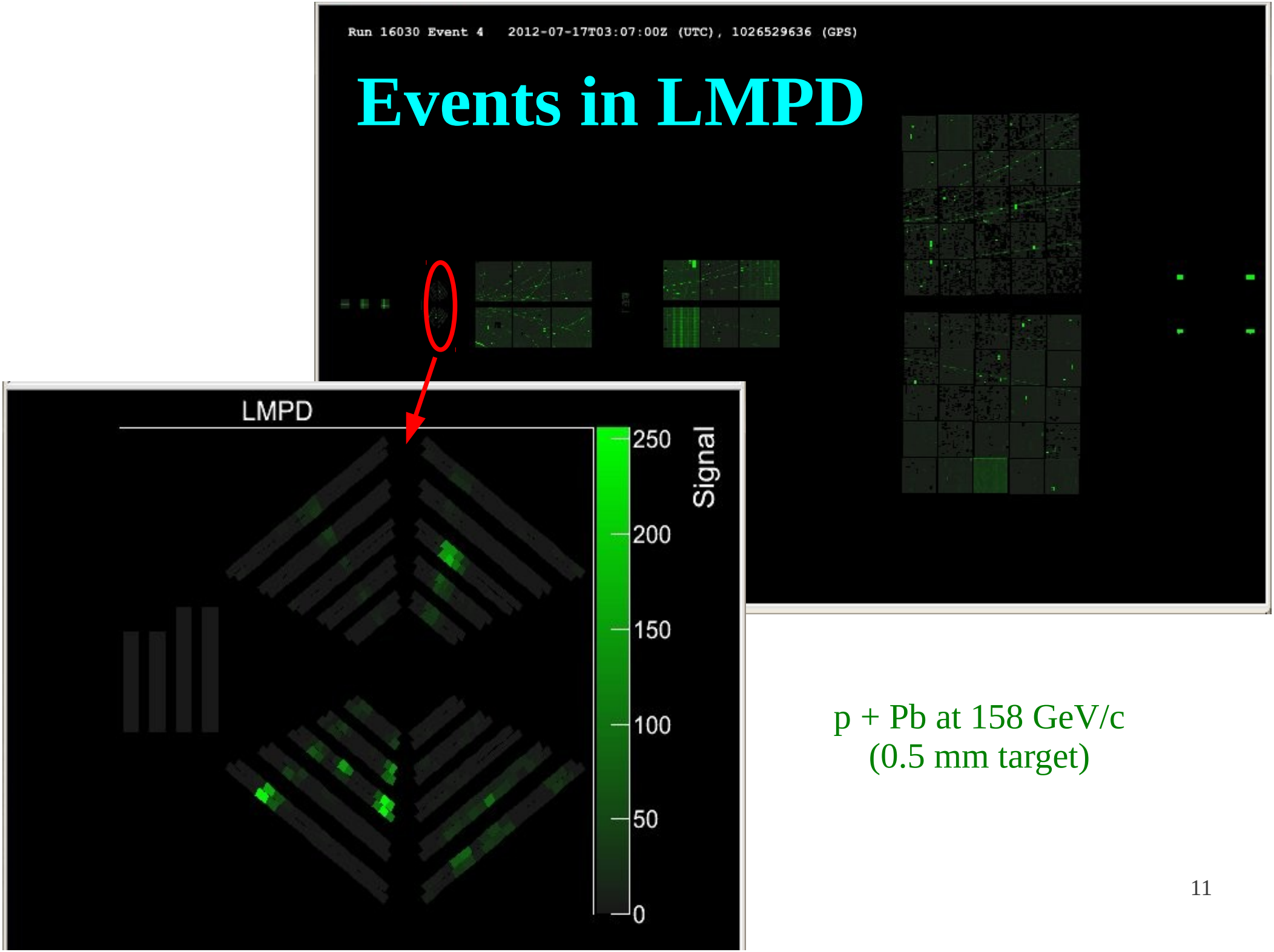
Low Momentum Particle Detector





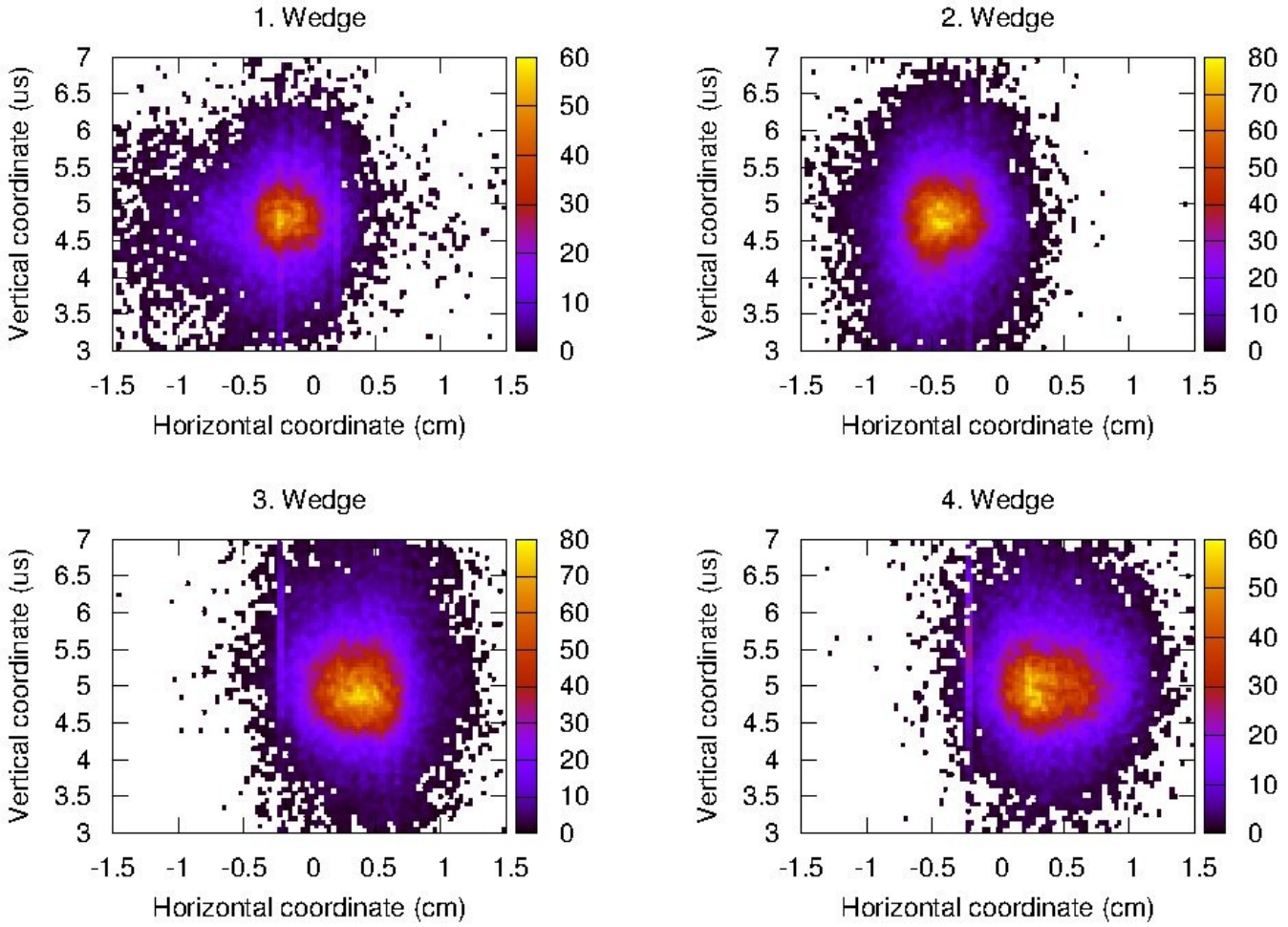


Events in LMPD



p + Pb at 158 GeV/c
(0.5 mm target)

Tracking performance



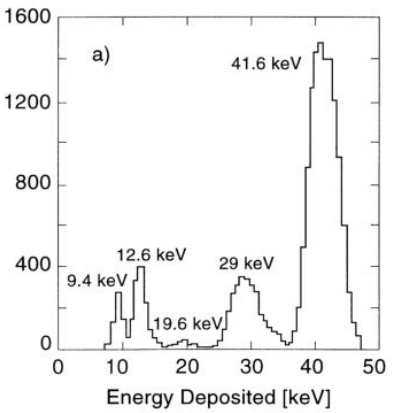
- Independent track reconstruction inside wedges
- Main vertex (target) visible after tracking

Calibration of LMPD

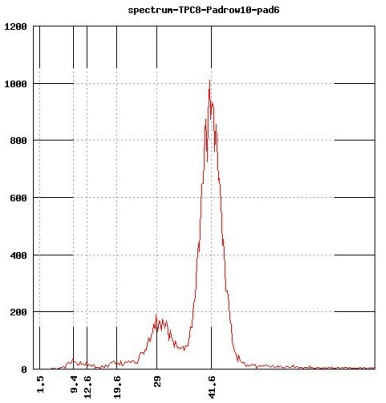
- Krypton calibration

  → Relative gain calibration of pads
  (3D cluster finding, 3 iteration)

Kr spectra at NA49



Kr spectra in LMPD

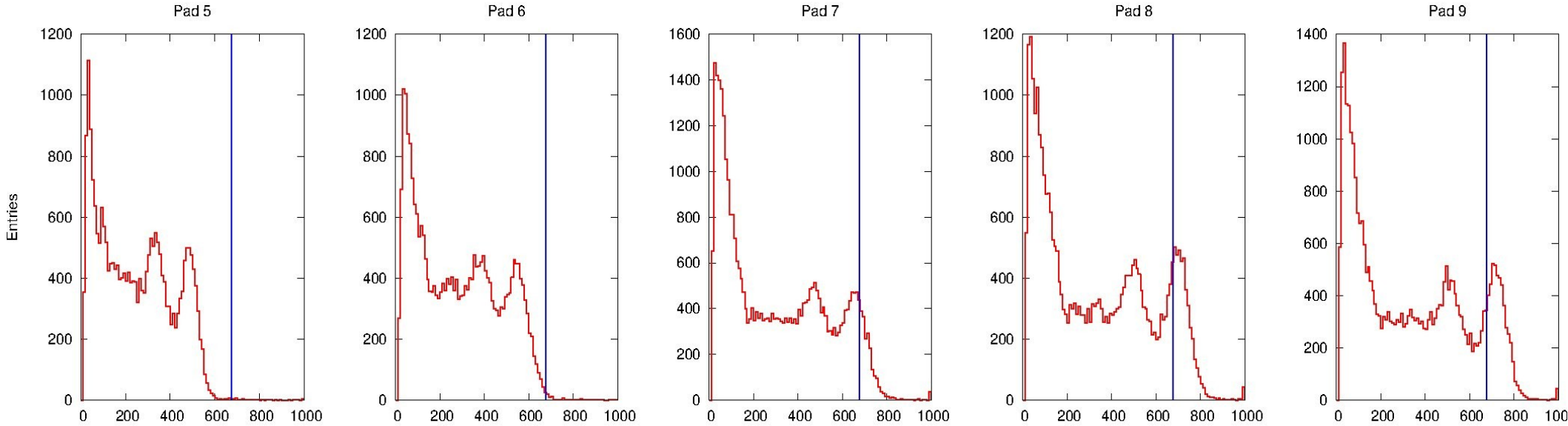


  → For absolute gain calibration:

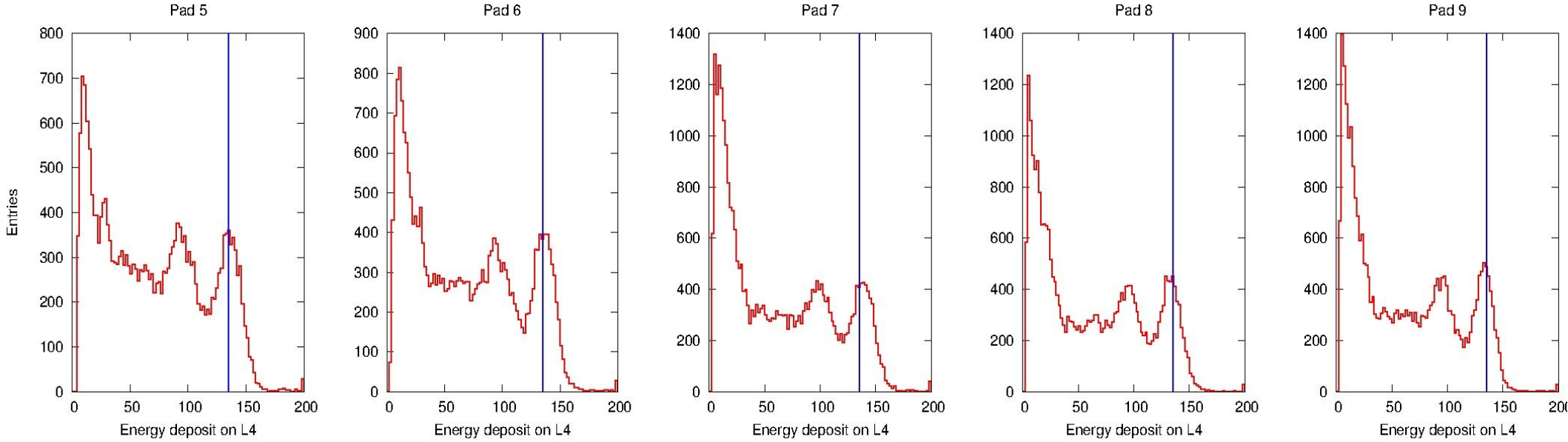
    - Different HV settings
    - Gradually increasing gain towards outer pad-rows

- Drift velocity calibration, correction for tracks direction, etc. in progress

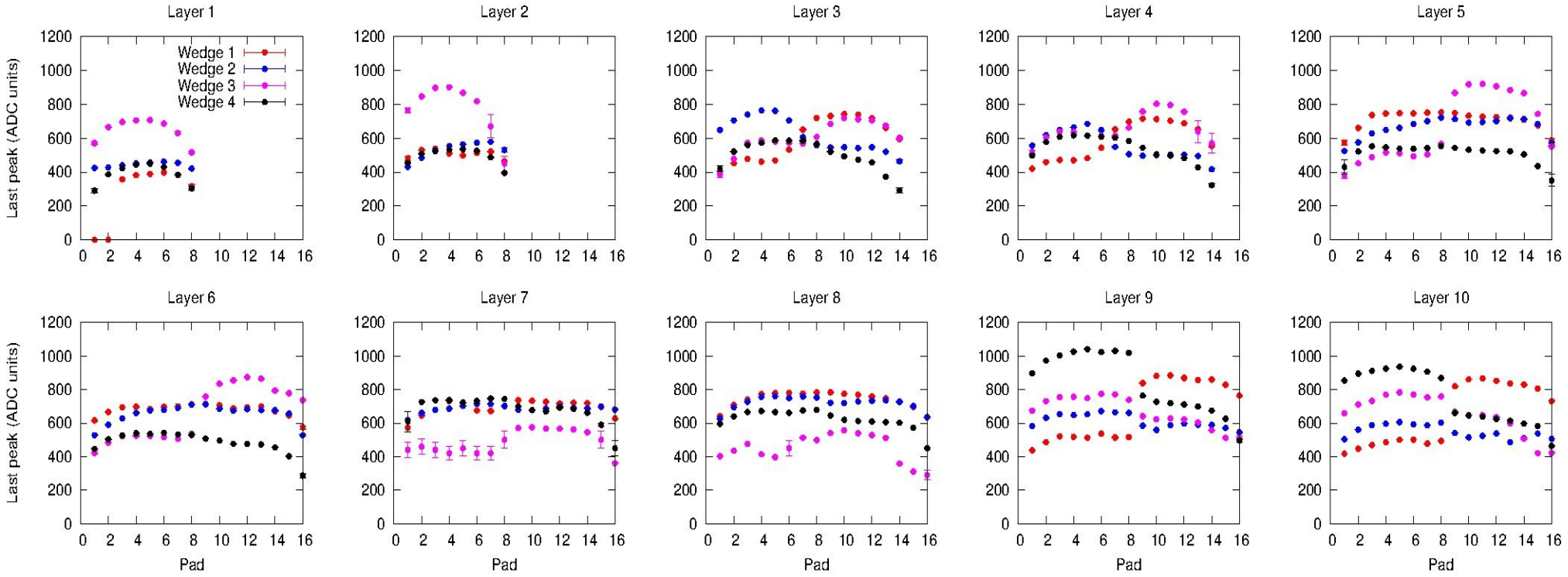
Krypton spectra – before calibration



Krypton spectra – after calibration



Krypton calibration: Position of last peak (41.6keV), before calibration



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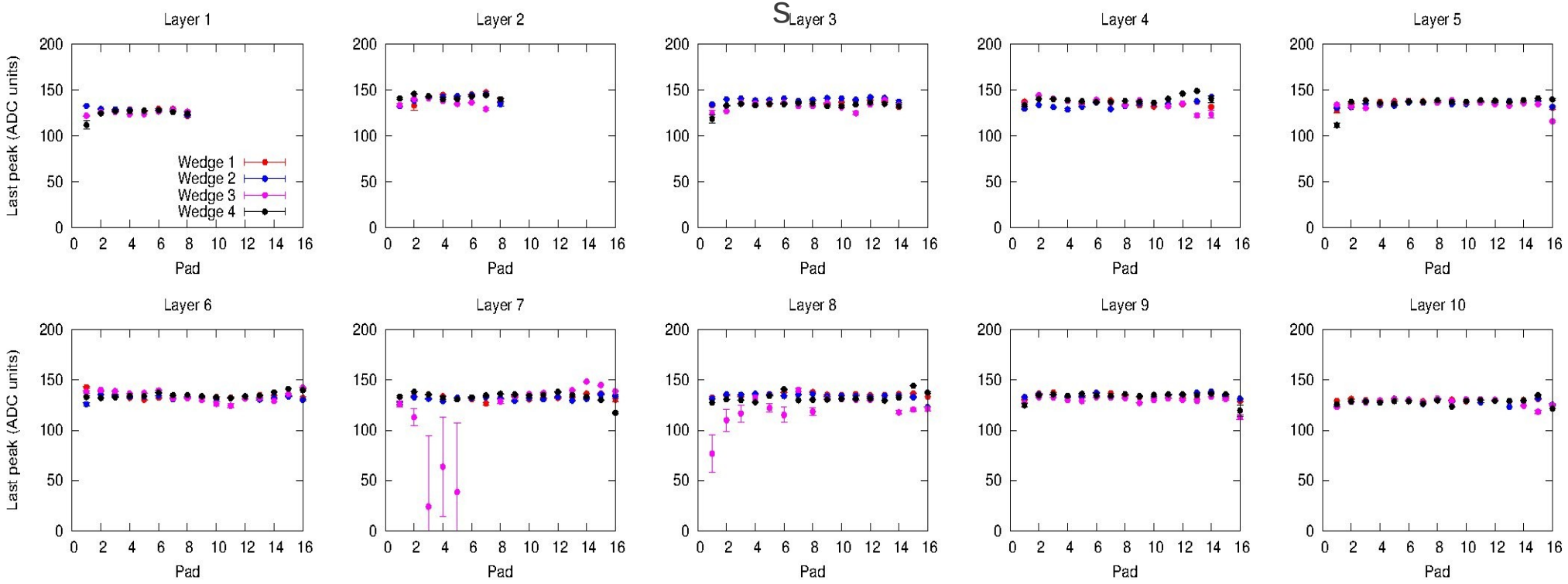
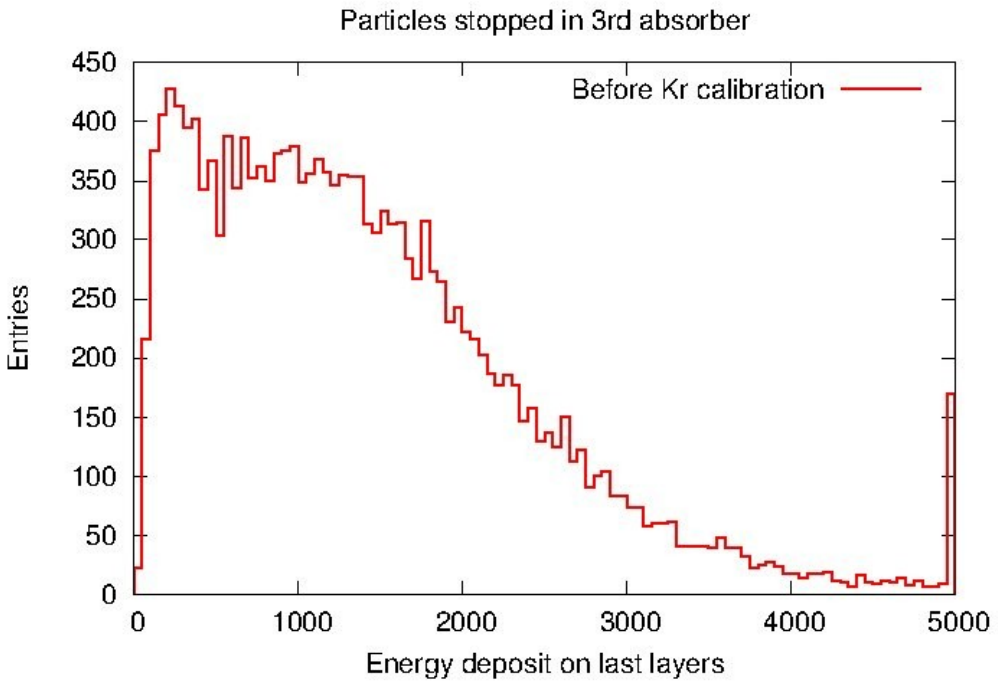
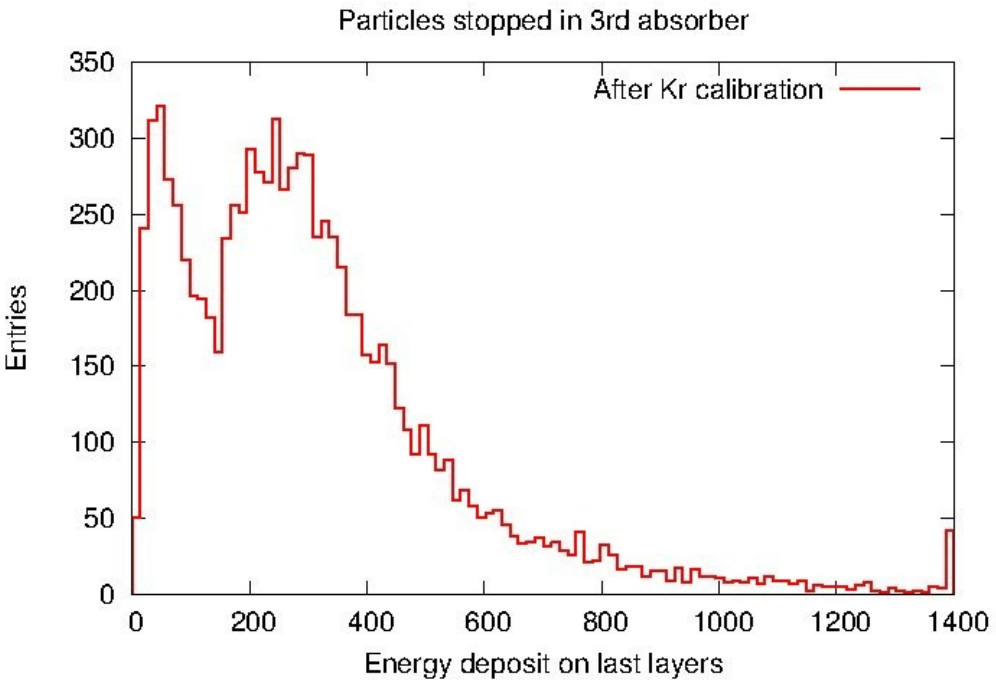


Energy deposit distribution for particles stopped in 3rd absorber



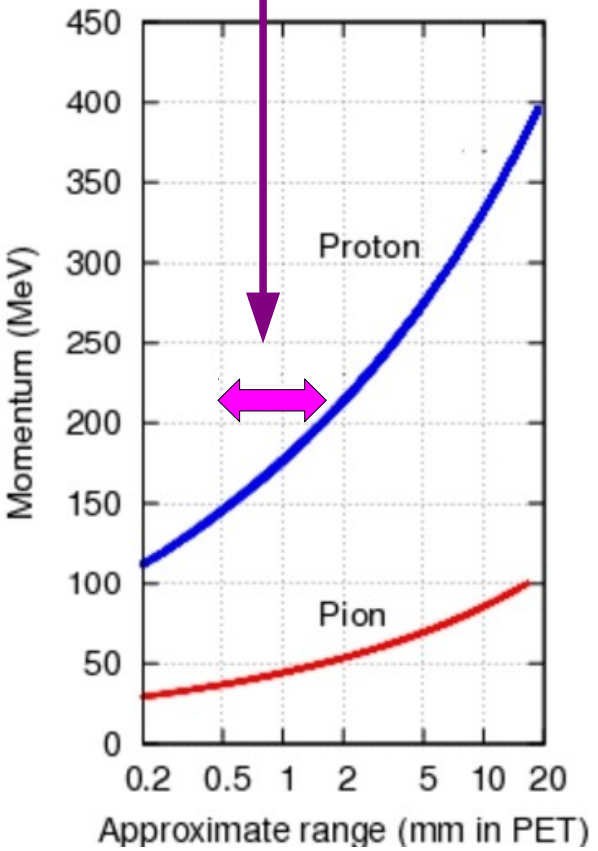


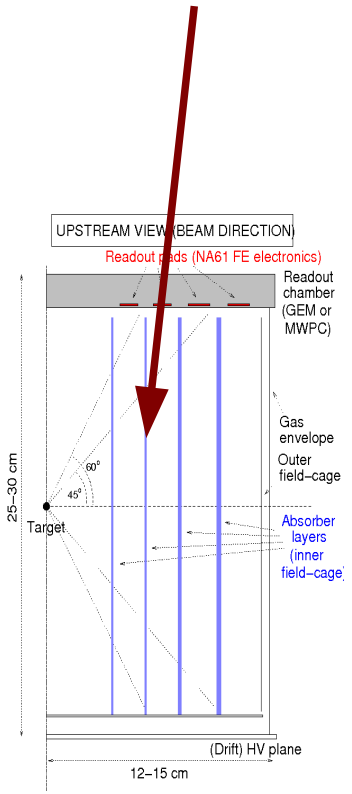
Before Kr calibration

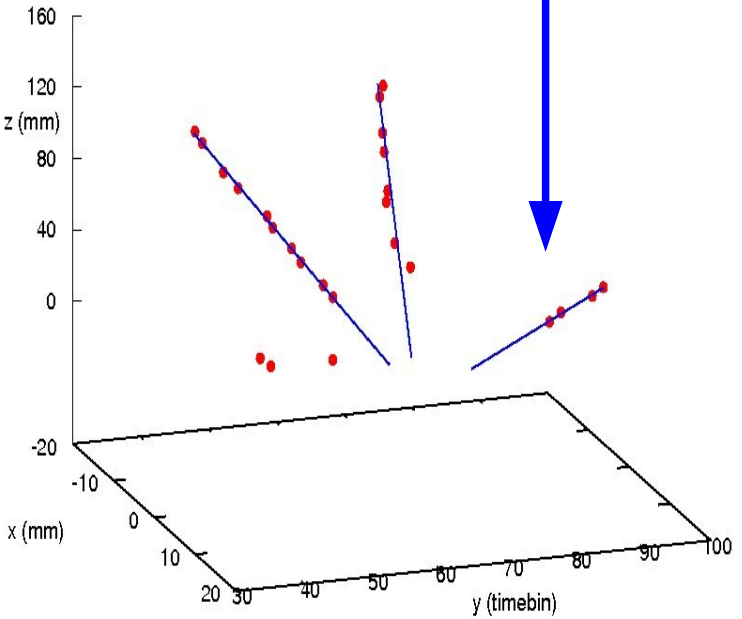
After Kr calibration

Proton identification with LMPD

Particles reconstructed
with range 0.5mm < r < 1.5mm
stop in 2nd absorber

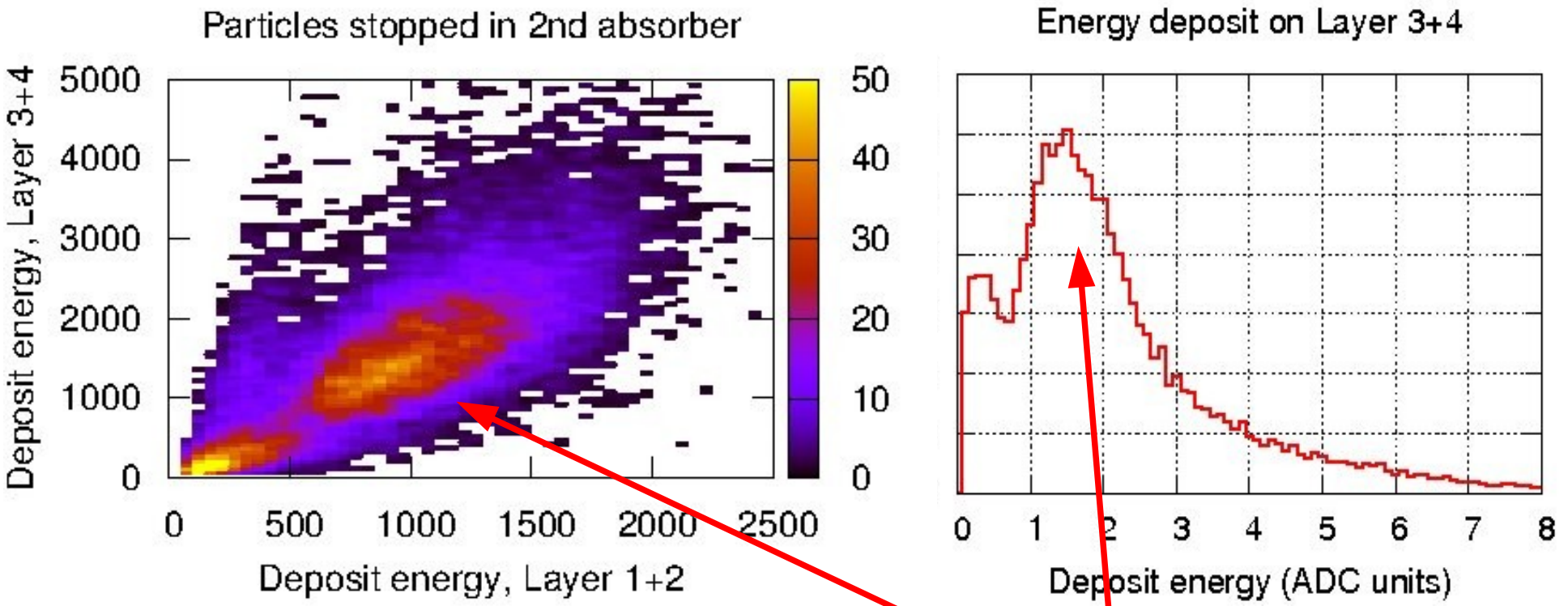






Typical event in LMPD (p+Pb data, 2011)

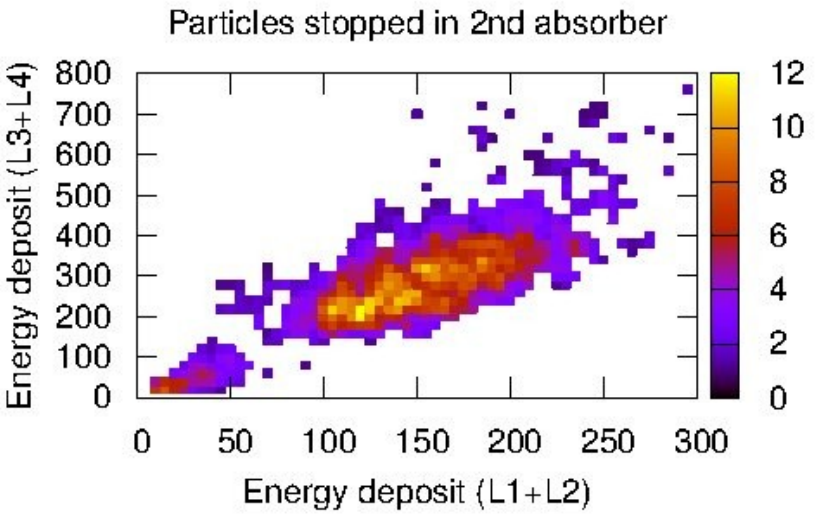
Proton identification with LMPD

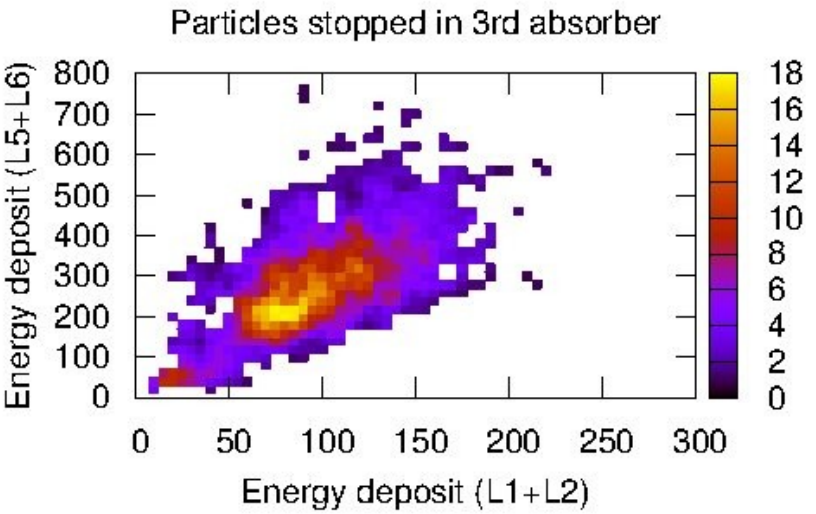


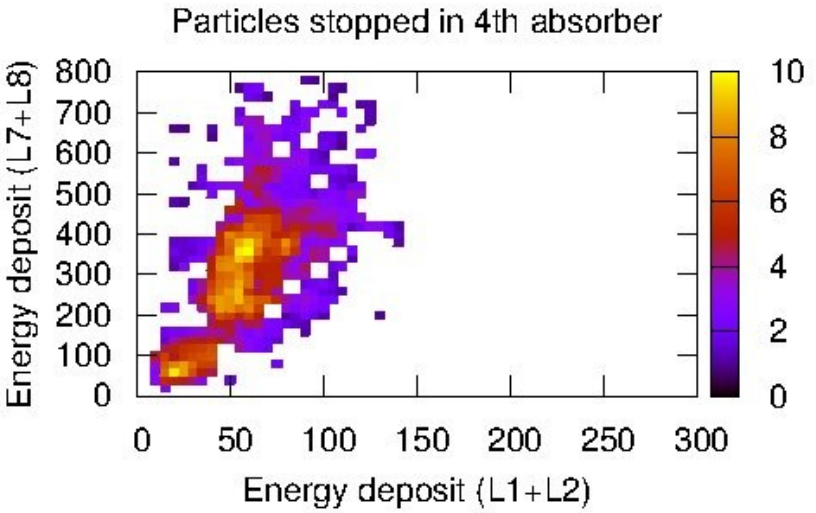
Particles stopped in 2nd absorber → **proton peak** visible
(*2011 data*, ***without calibration***)

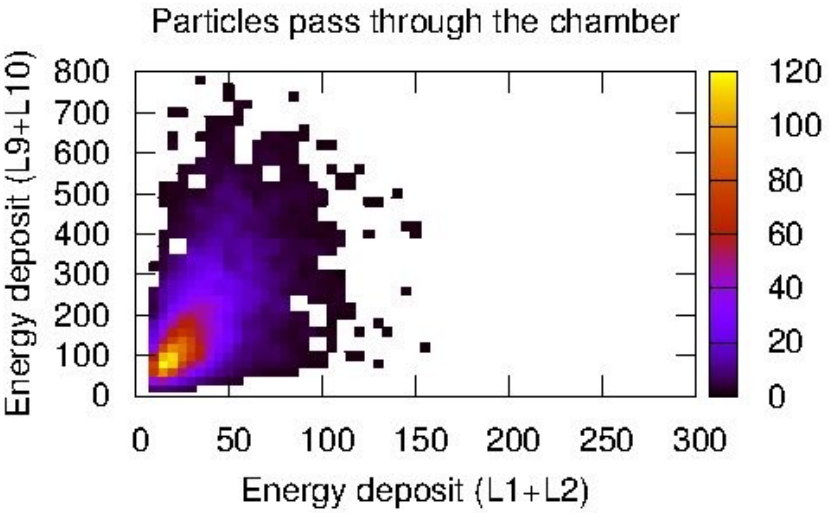
Energy deposit distributions

After Kr calibration, with vertex (and direction) cuts









Summary

- Low Momentum Particle Detector (LMPD) at NA61
    - TPC with absorber layers → range and dE/dx
    - Identification and energy of slow particles
- p+A collisions → centrality is correlated to the number of grey protons
- LMPD ~ Centrality Detector in the p+Pb run at NA61
- Calibration in progress
- **Proton peak is visible**


Thank you
for your attention!

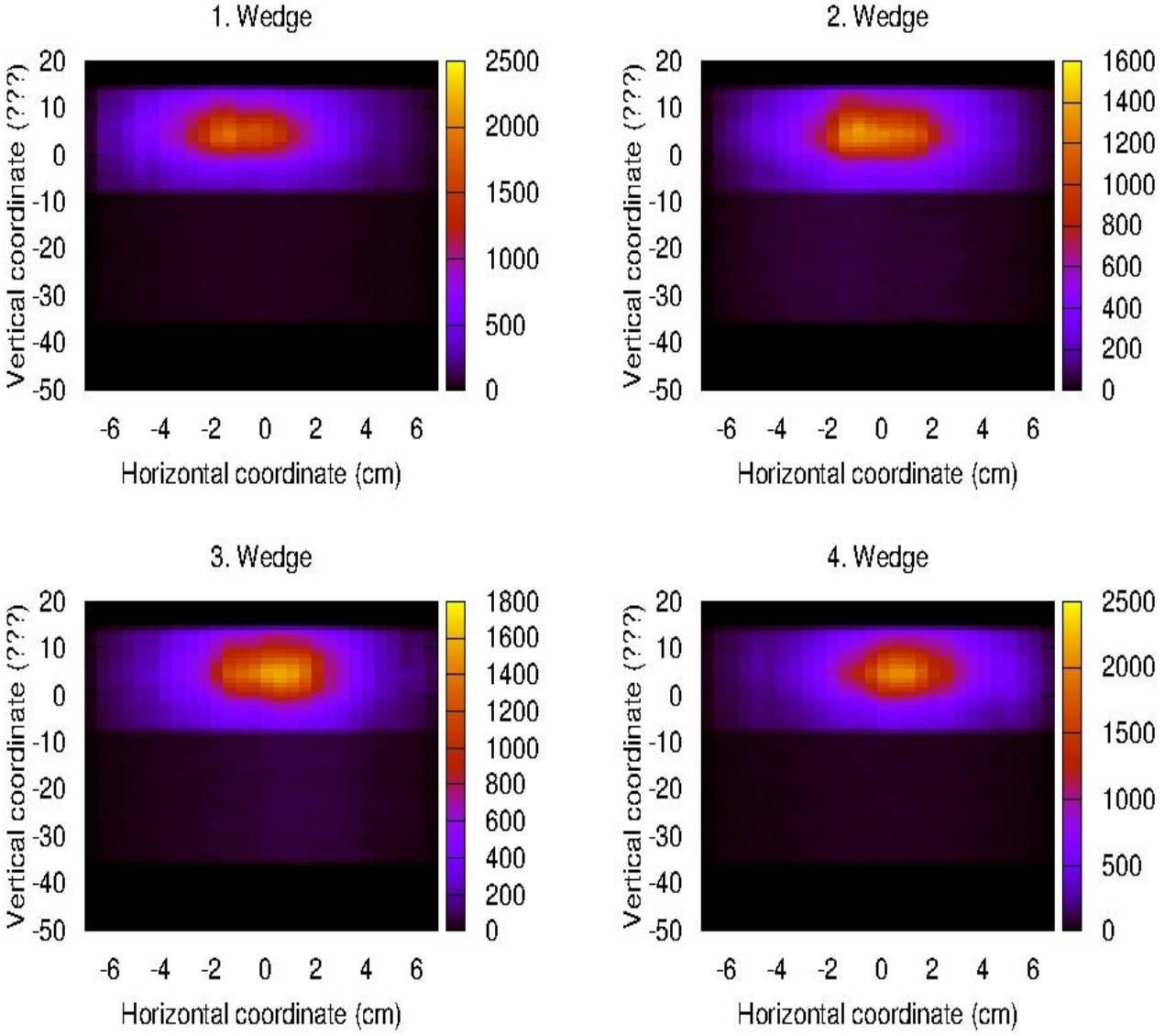
Backup

Data taking with LMPD

2011	Number of events
Pb, 0.5mm	2 442.5 k
Pb, 0.5mm (rotated)	617.5 k
C, 2mm	547.5 k
Al, 1mm	621.9 k
Target Out	263.6 k

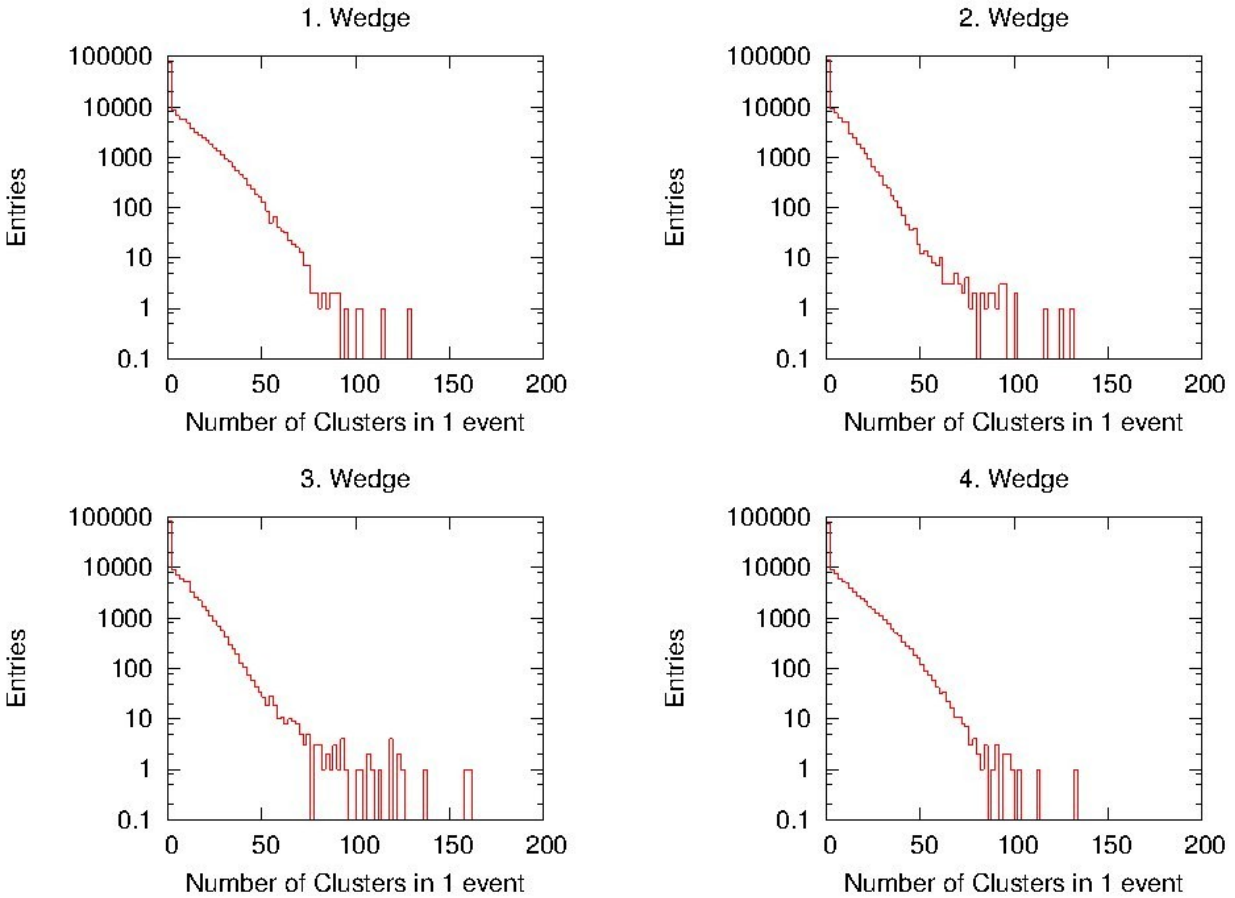
2012	Number of events
Kr calibration	1 593.1 k
Pb, 1mm	8 196.4 k (Sept.)
Target Out	830.6 k (Sept.)

Cluster distributions

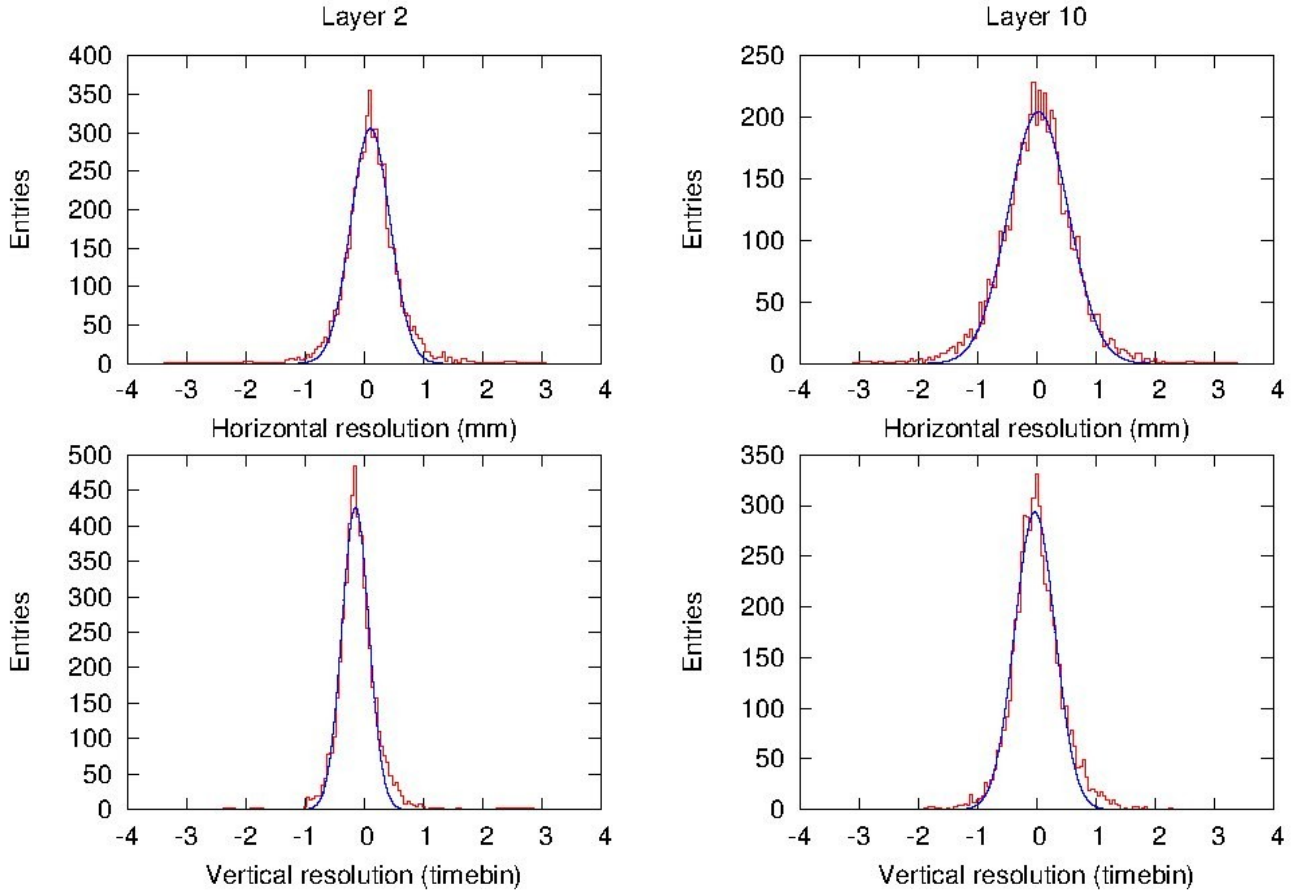


- Horizontal – vertical coordinates of all clusters
- Top and bottom of chamber visible
- Drift velocity: ≈ 0.89 cm/μs

Number of Clusters in 1 event

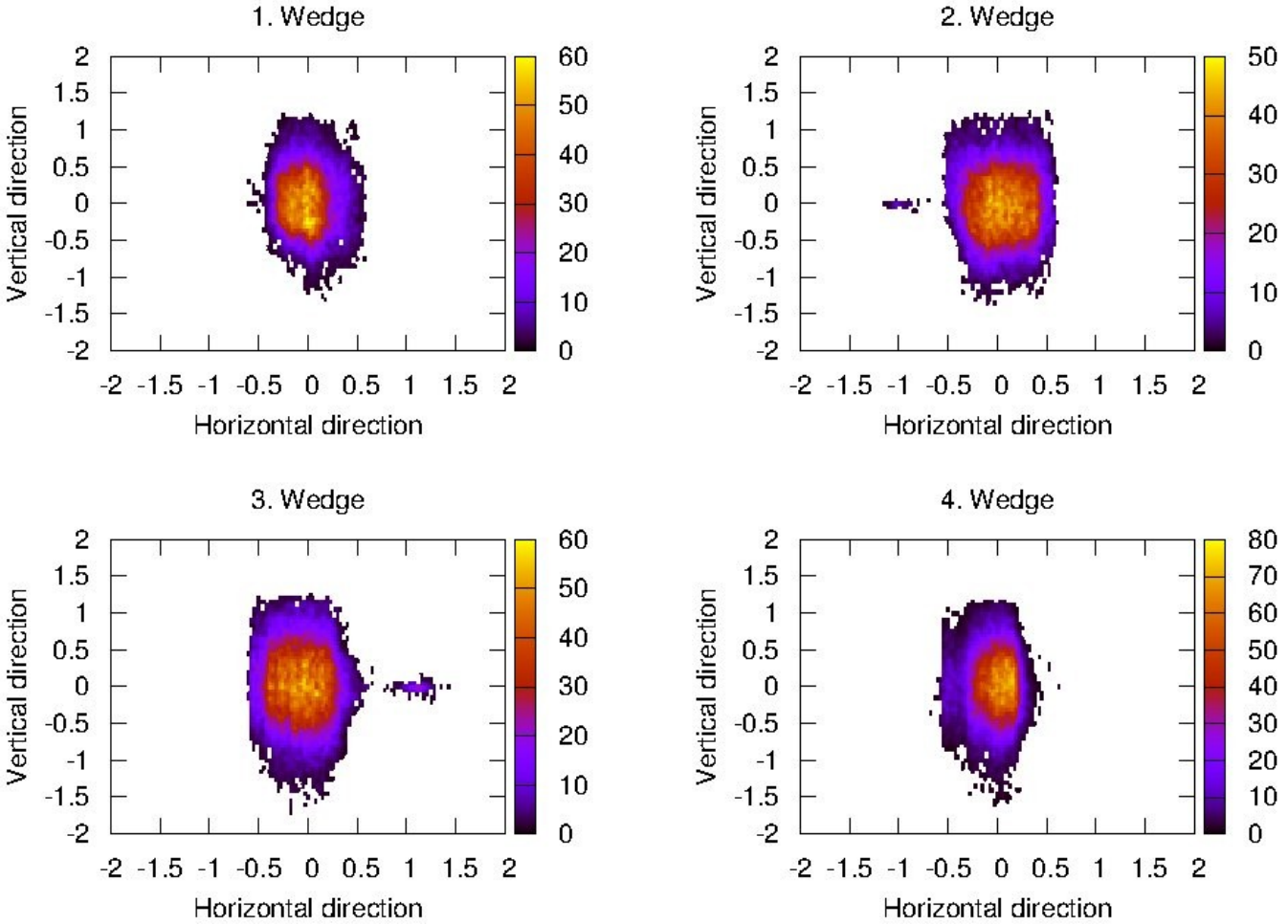


Position resolution



- Position resolution in horizontal direction ~ 1-2 mm
- Position resolution is vertical direction ~ 1timebin ≈ 1.8mm

Tracking performance – direction of tracks



Number of tracks per events
(2011 data)