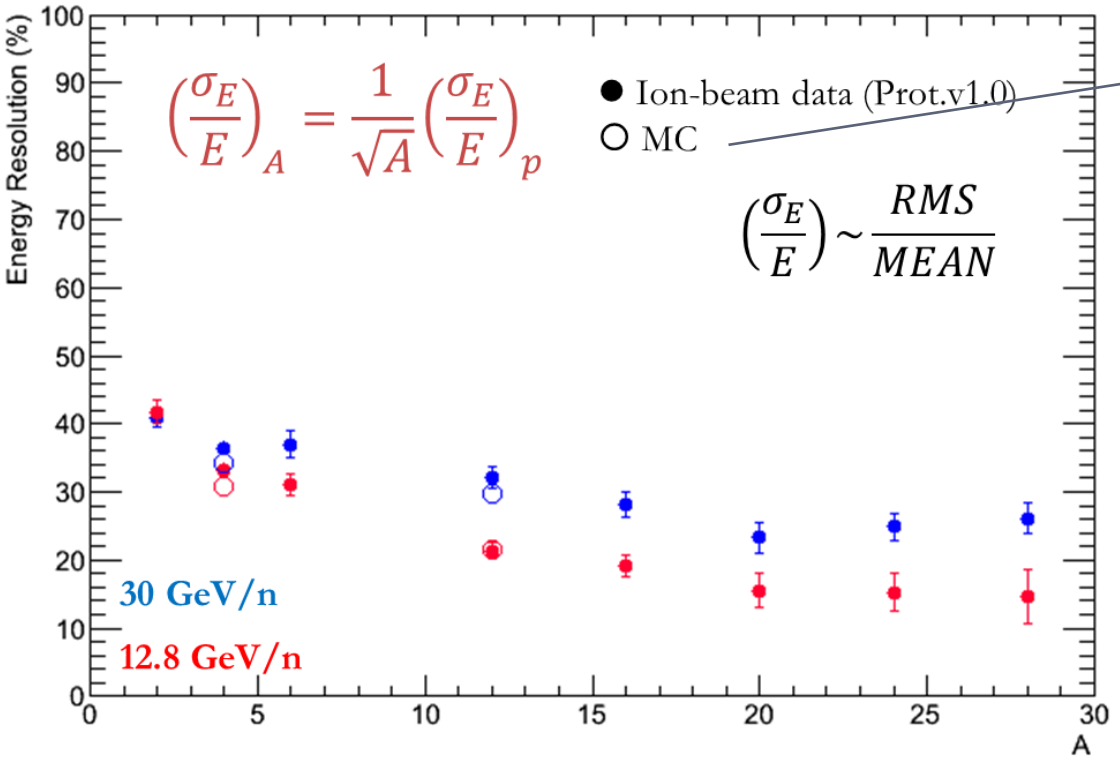
SPS 2013-02

Energy resolution for showers induced by ions

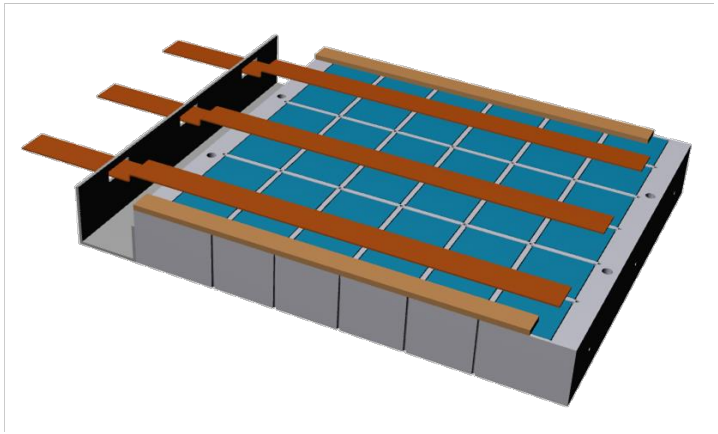


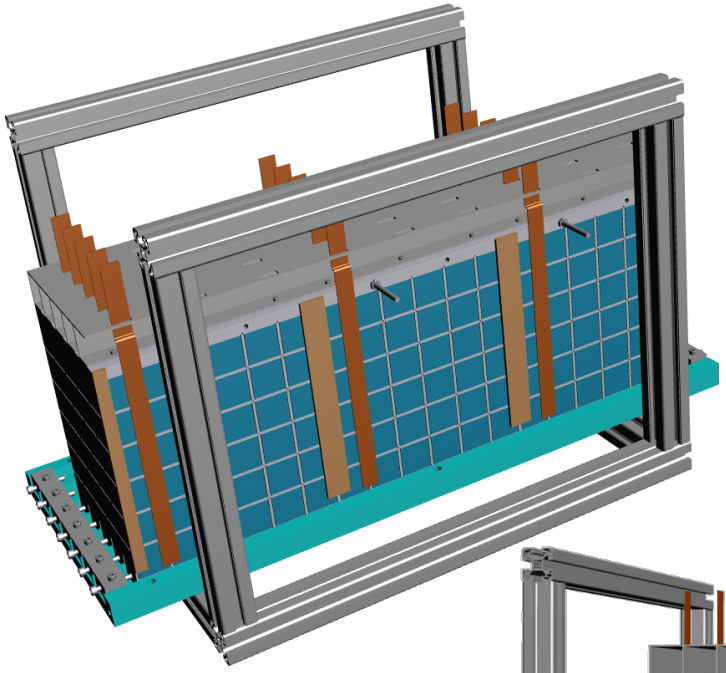
Showers starting on layer 3

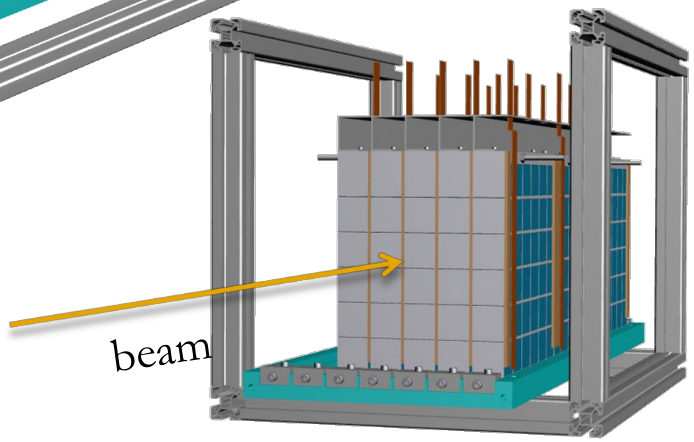
- Prot. v1.0 affected by instrumental effects → MC fine tuning:
  - 14% optical cross talk
  - 4.5% additional gaussian spread to single-crystal signal

- Agreement with MC prediction at few % level
- Measured energy resolution systematically worse than expected
- Instrumental effects understood and fixed:
  - CASIS-time effect
  - optical cross-talk

Prototype upgrade (v2)



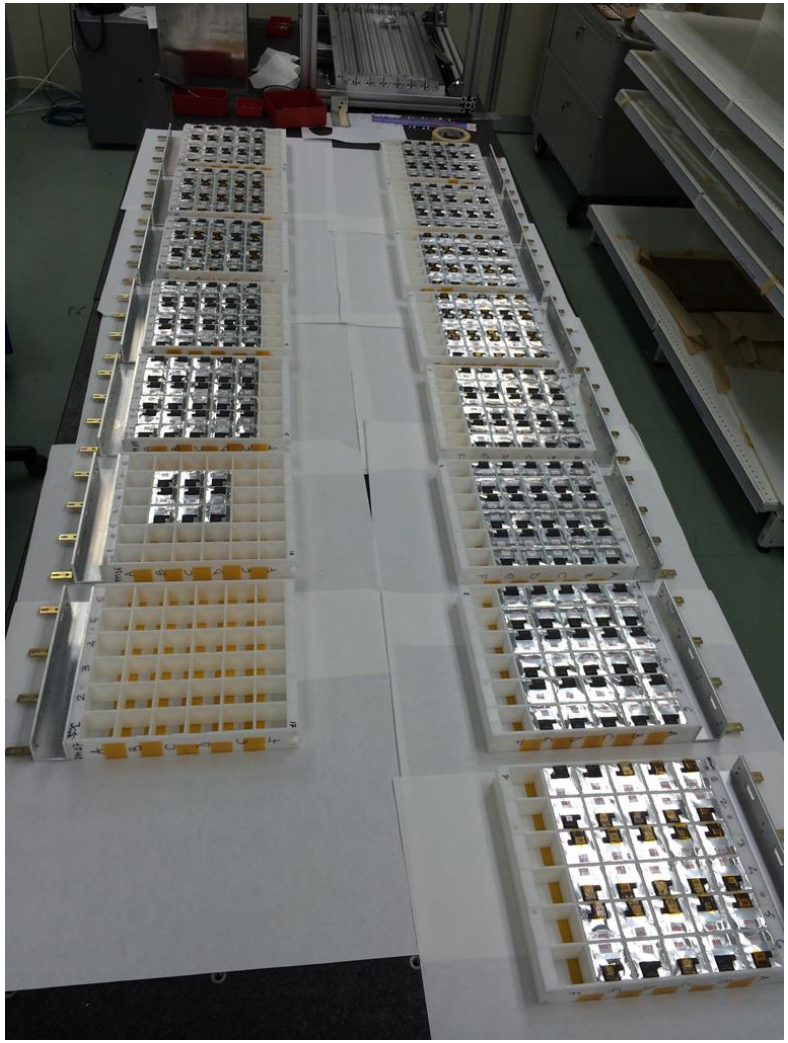


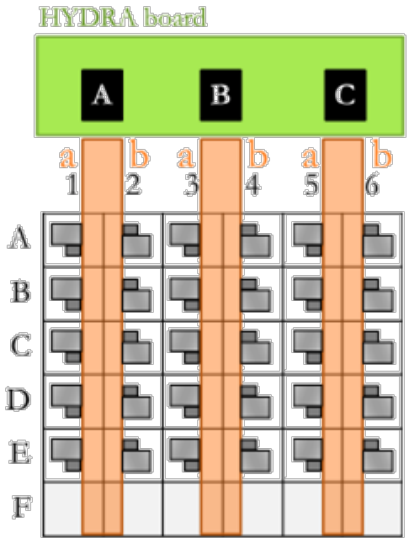


- Prototype mechanics completely redesigned
  - Sensor placed sideways!
  - Up to 18 trays × 36 crystals each
  - active depth **35.0 X_0 → 1.6 λ_I**

• Mechanics: INFN Pisa

Prototype upgrade (v2)





- First version of HYDRA chip (28 channels)
- Two-PD redout
- V2.0 → 5×5×18 instrumented elements

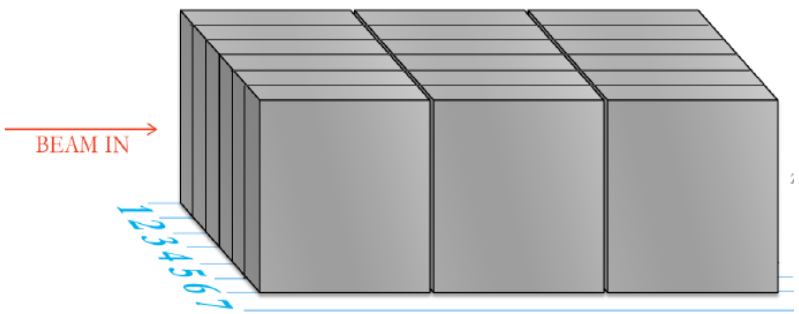
Sep 2016	v2.0	μ,π,e 50÷200 GeV
Oct 2016	v2.0	(3÷40000) e 300MeV

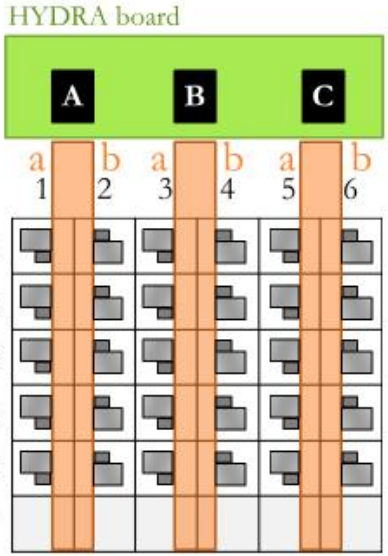
• Data analysis: INFN Florence+Pisa, CIEMATMadrid

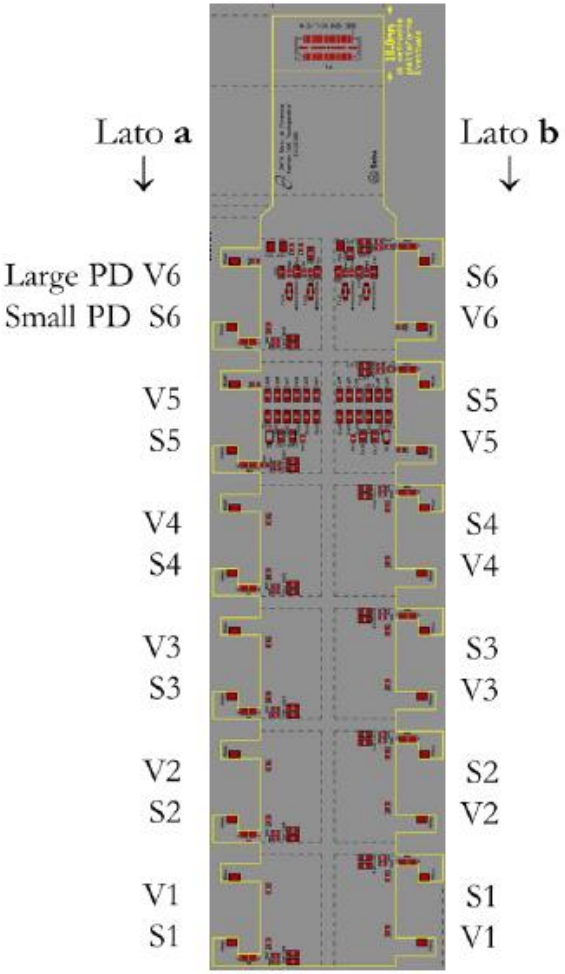
Test	Particles	Energy (GeV)	CaloCube	Notes	Results
SPS 2013-02	Ions Pb+Be	13×A - 30×A	v1.0 3×3×14	• Optical cross-talk • No CASIS time correction • MC model (fine tuning)	Energy resolution $H_2 \div Si_{28}$ <40%
BTF 2014-xx	1÷22 e 50÷400 e	0.491 0.295	v1.0 3×3×5		
SPS 2015-03	Ions (Ar+Poly) Ar	19×A - 30×A 648 -1080	v1.1 3×3×14	• No optical cross-talk • Time-correction	(work in progress)
SPS 2015-09	μ π e	150 50-100-150-180 50-75-180	v1.2 3×3×14	• Sensors along the beam • Few crystals with double-PD readout	Energy resolution (LPD) e @50-75 GeV
SPS 2016-09	μ π e	150 50-100-150-300 50-100-150-200	v2.0 5×5×18	• Full double-PD readout • Lateral sensors • Incomplete μ calibration scan • Anti-	Energy resolution (LPD+SPD) e @50÷200 GeV (work in progress)
BTF 2016-10	1÷40000 e	0.300	v2.0 5×5×18	• Full dynamic range scan	(work in progress)

h ⇒ ~ 10 MIP/GeV
e ⇒ ~ 40 MIP/GeV
High/low gain @ ~32 kMIP
LPD saturation @ ~70÷80 kMIP
SPD ~ LPD/100

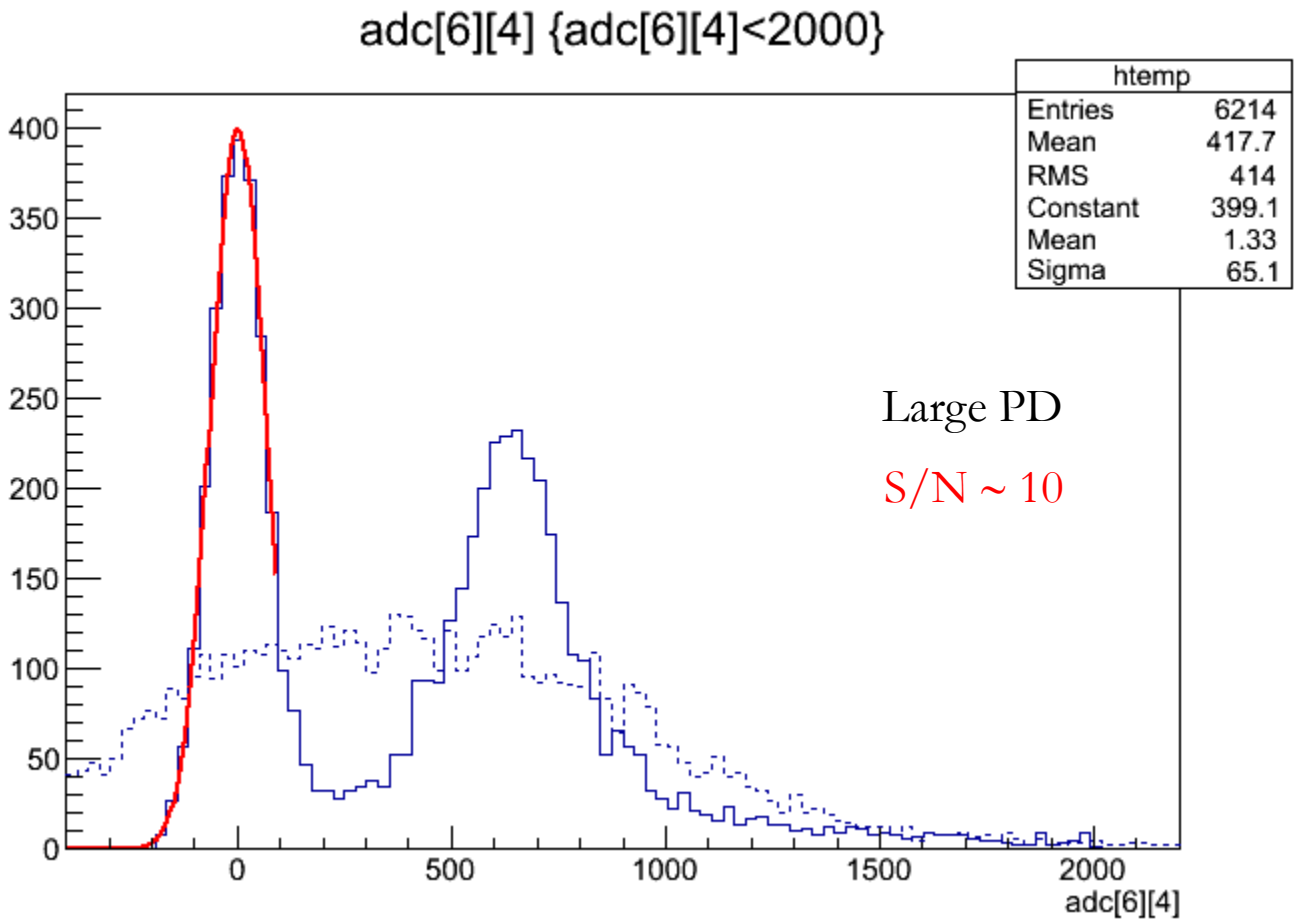
Readout board







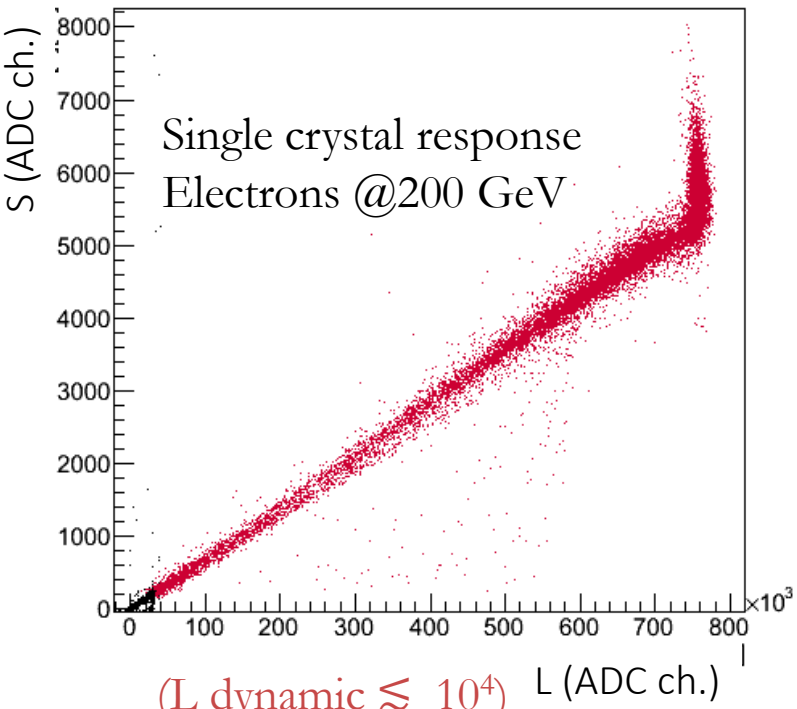
HYDRA Channel	PD
1	-
2	CNa
3	V6a
4	V5a
5	V4a
6	V3a
7	V2a
8	V1a
9	S1a
10	S2a
11	S3a
12	S4a
13	S5a
14	S6a
15	S1b
16	S2b
17	S3b
18	S4b
19	S5b
20	S6b
21	CNb
22	V6b
23	V5b
24	V4b
25	V3b
26	V2b
27	V1b
28	-



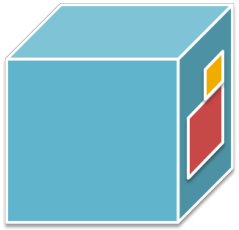
Muons 150 GeV

Single-crystal calibration

- Signal induced by MIPs used to equalize crystal responses
  - v2.0 setup: noise~60÷80 ADCch. $\Rightarrow \langle S/N \rangle_{1MIP} \lesssim 10$
- Signal induced by showers used to equalize relative sensor responses R=L/S



(L dynamic $\lesssim 10^4$)



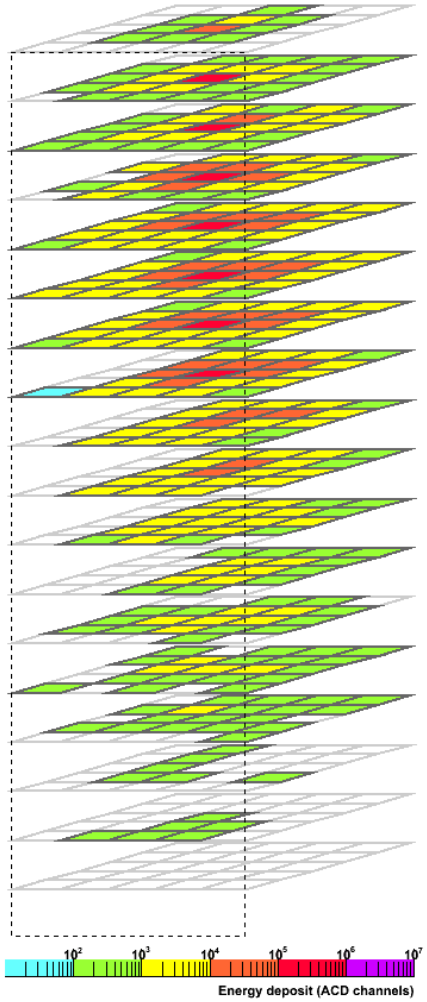
SPD
LPD

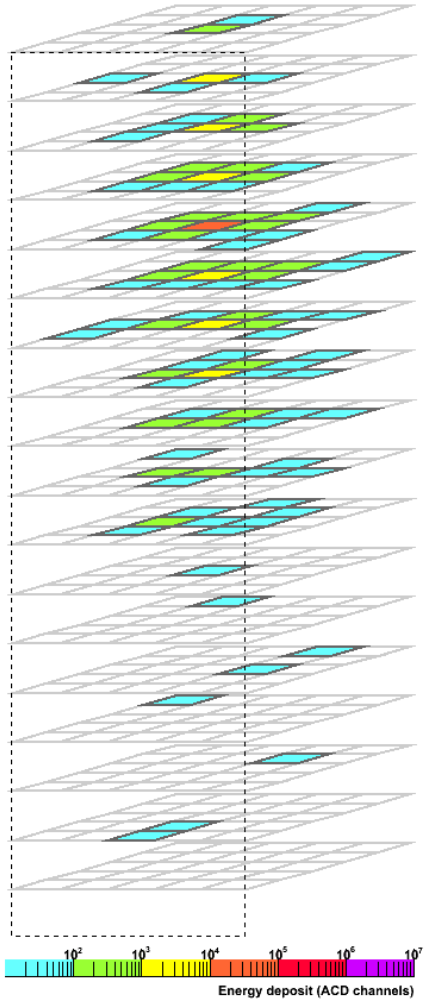
Study of S-vs-L correlation

- Straight-line fit → $S = L/P_0$
- Indipendent fit for low- and high-gain
  - Check systematics
- Cumulative electron sample to cover the full dynamic range
  - 50 +100 + 150 + 200 GeV

e^- 200 GeV

Large PDs

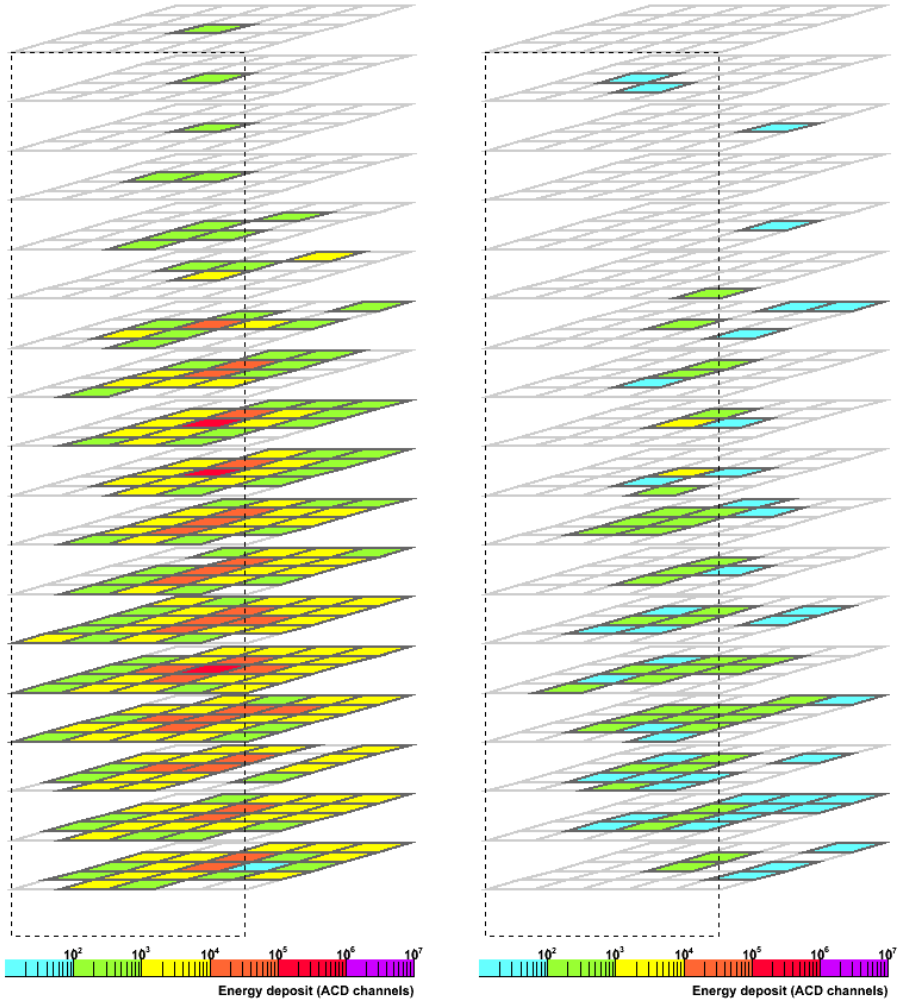




Small PDs

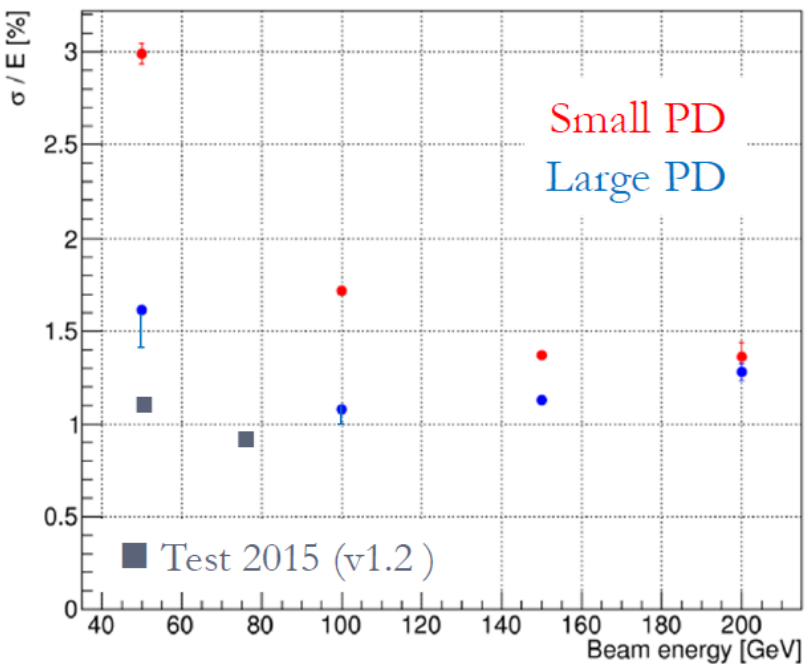
π^- 150 GeV

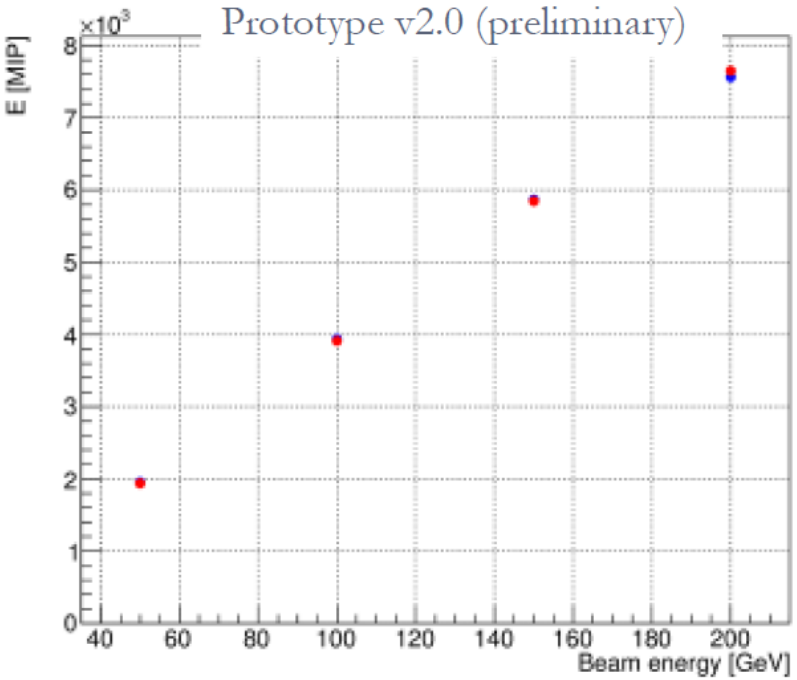
Large PDs



Small PDs

Energy resolution – e.m. showers





Energy resolution for em showers:

- Better that **1.5%** up to 200 GeV with Large PDs
- Comparable performances with Small PD above 200 GeV