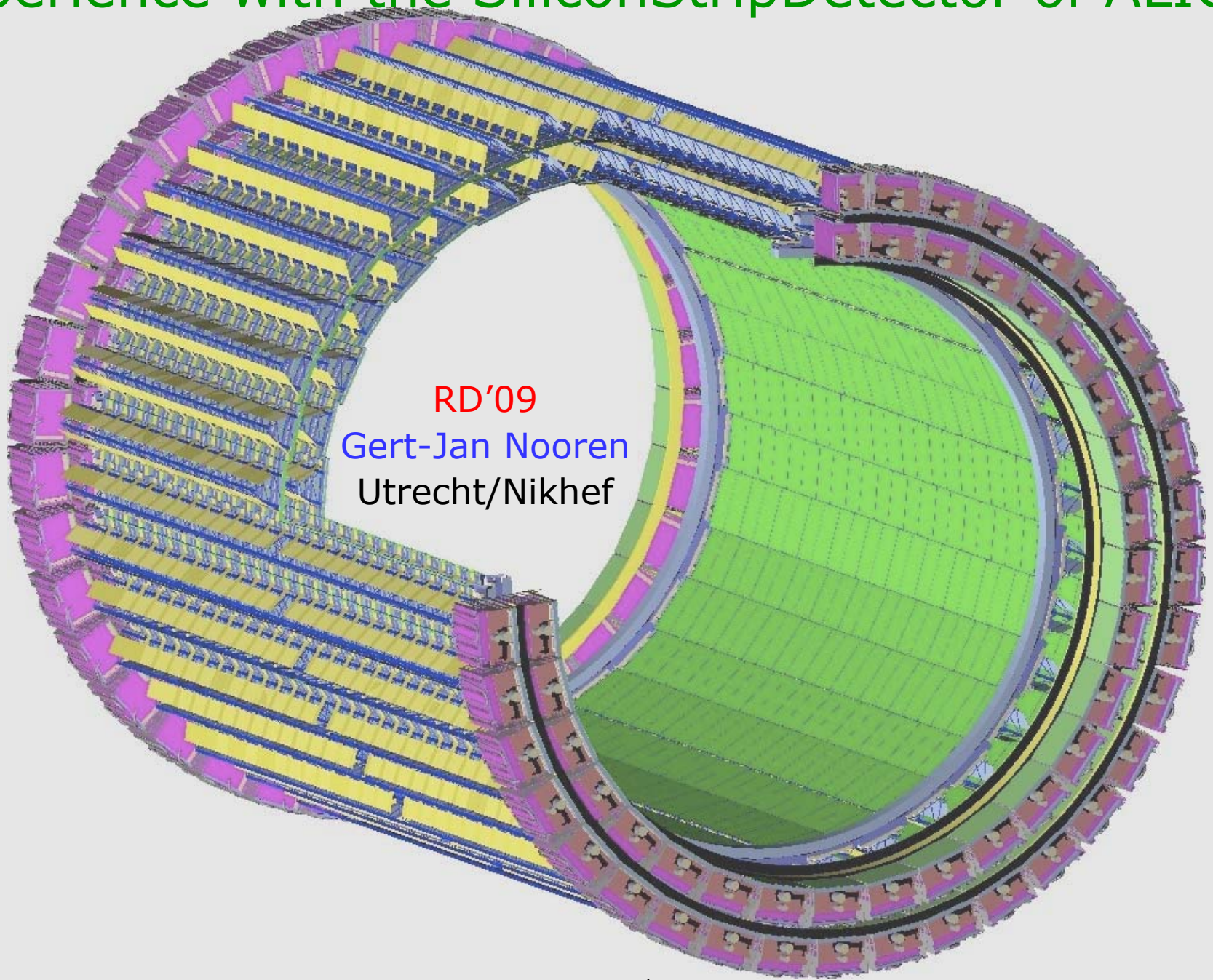
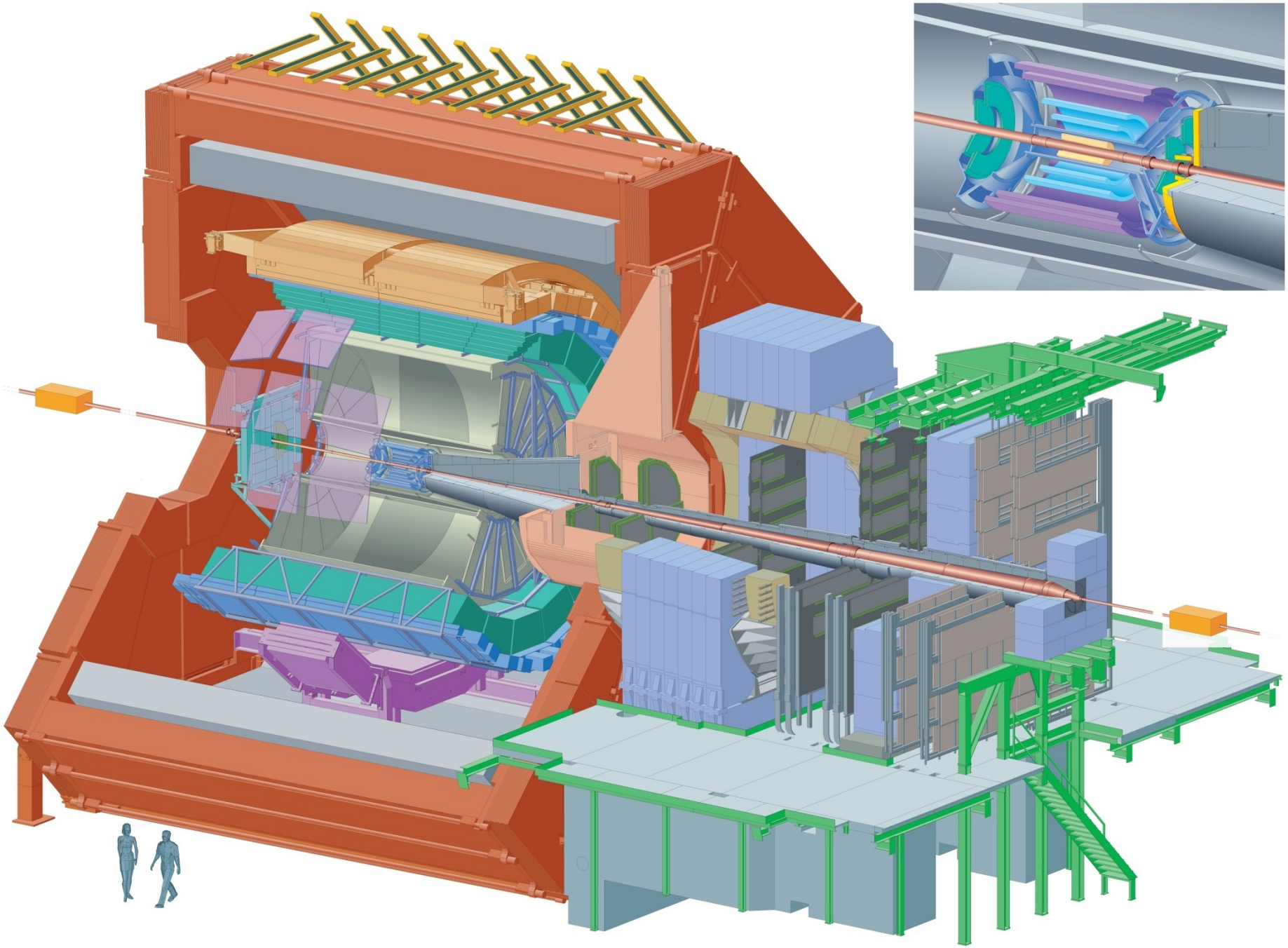
Experience with the SiliconStripDetector of ALICE

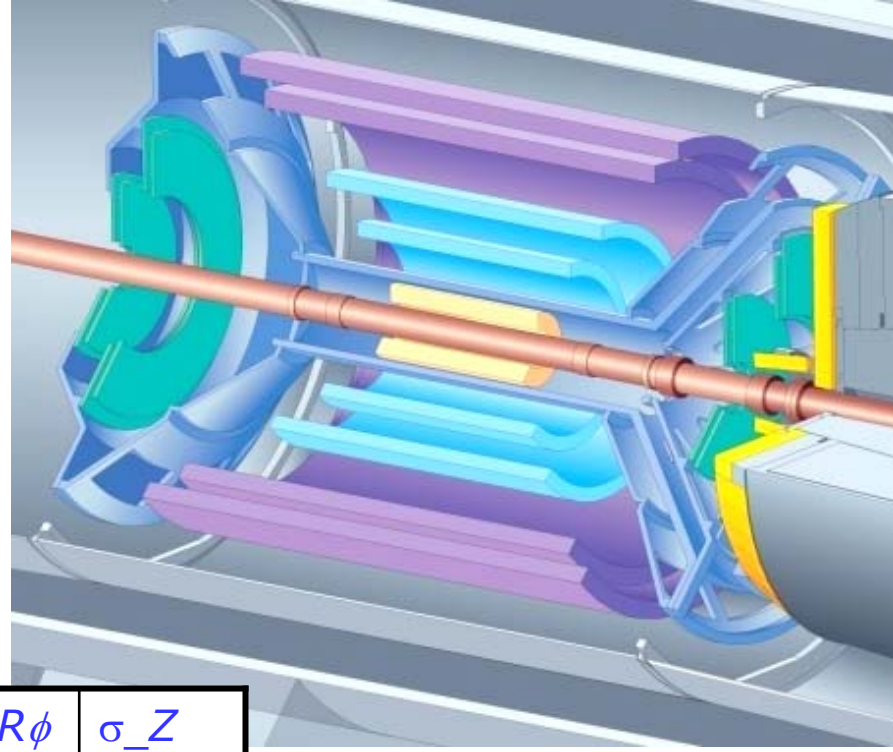


RD'09

Gert-Jan Nooren
Utrecht/Nikhef



The Inner Tracking System



low mass: 8 % X_0

SPD 2.3 %

SDD 2.4 %

SSD 1.7 %

structure 1.3 %

all silicon, 6 layers

layer	type	R [cm]	area [m^2]	chan-nels	occu-pancy	$\sigma\_R\phi$	σ_Z
1	pixels SPD	4	0.07	3.3 M	2.1	12 μm	100 μm
2		8	0.14	6.6 M	0.6		
3	drift SDD	15	0.42	43 k	2.5	35 μm	25 μm
4		24	0.89	90 k	1		
5	double sided strip SSD	38	2.2	1.1 M	4	20 μm	830 μm
6		43	2.8	1.5 M	3.3		

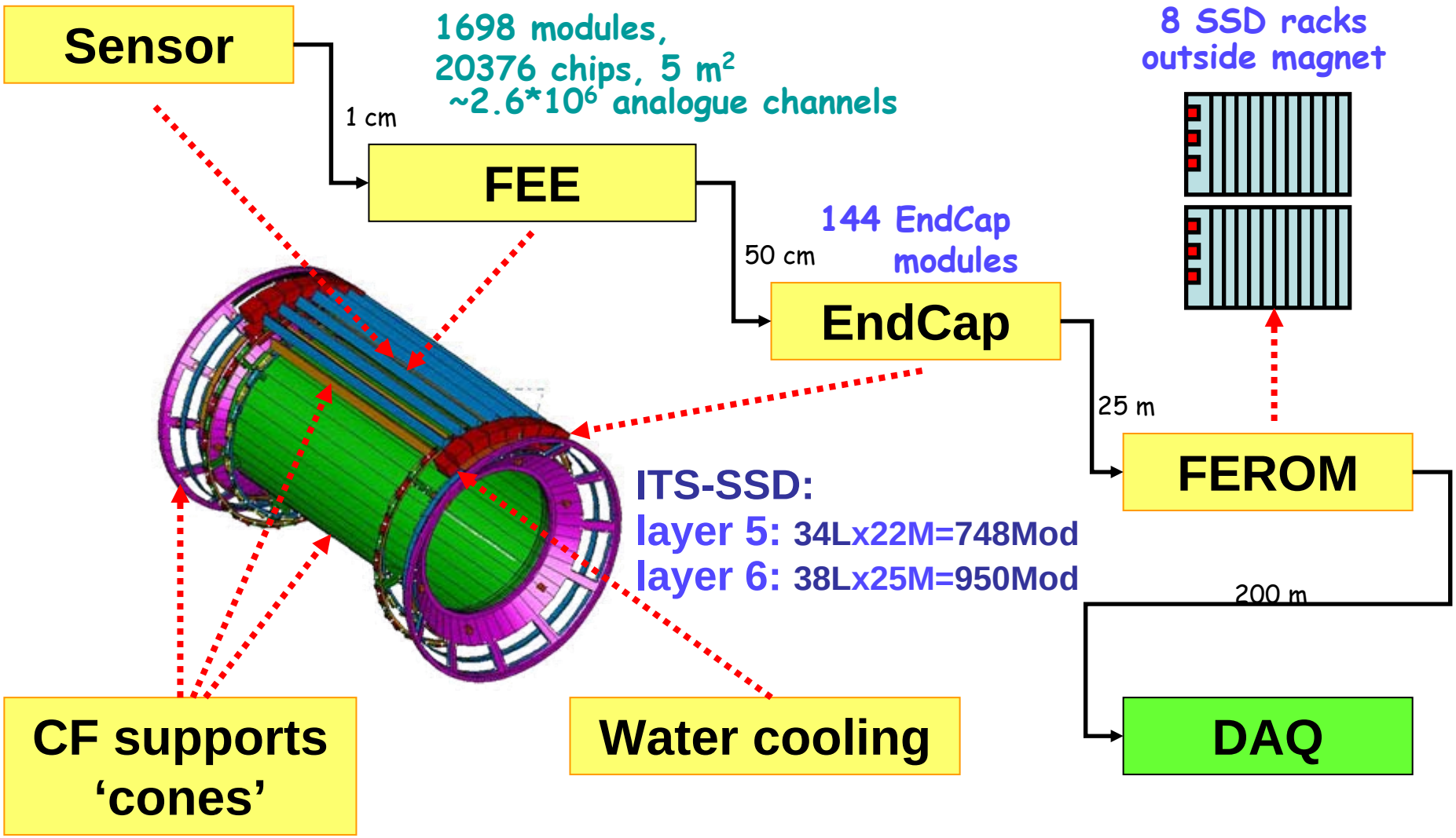
specials

SPD: fastOR trigger

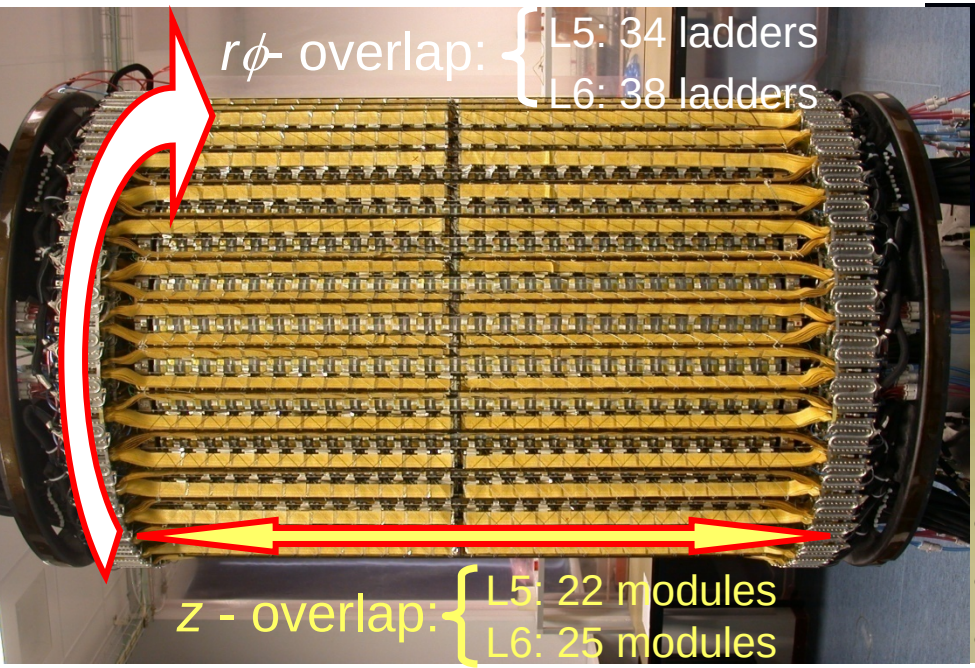
SDD: ΔE signal

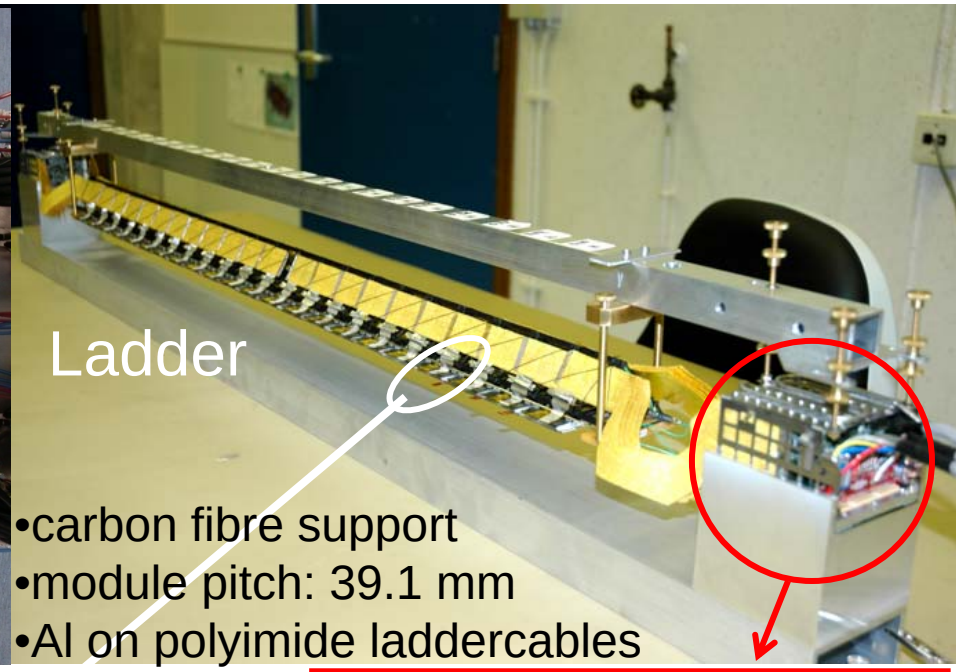
SSD : ΔE signal

SSD: Silicon Strip Detector



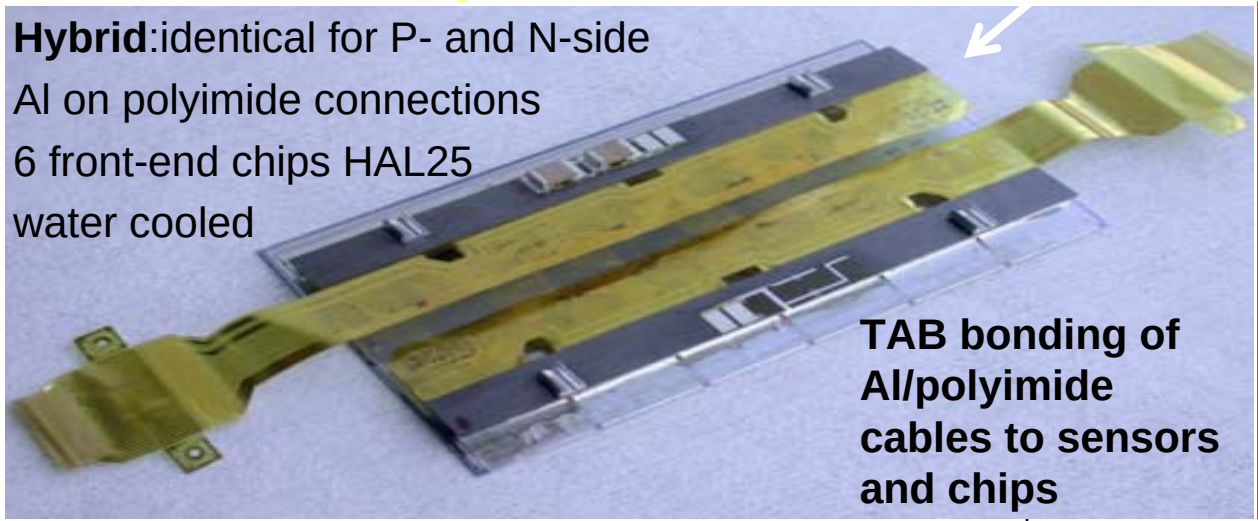
SiliconStripDetector



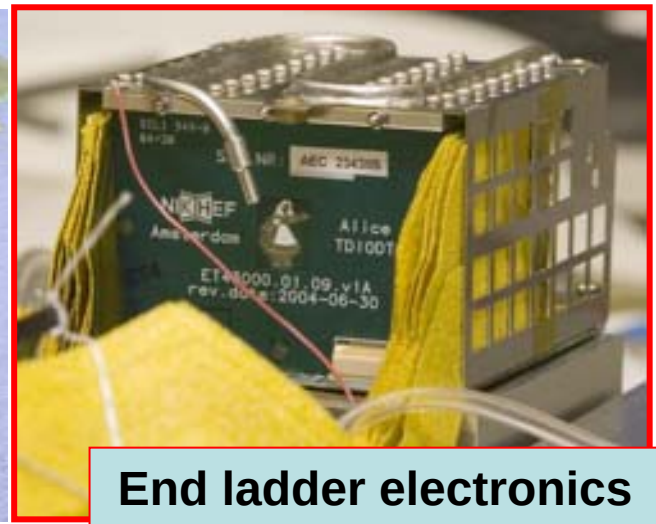


- carbon fibre support
- module pitch: 39.1 mm
- Al on polyimide laddercables

Hybrid:identical for P- and N-side
Al on polyimide connections
6 front-end chips HAL25
water cooled



TAB bonding of Al/polyimide cables to sensors and chips

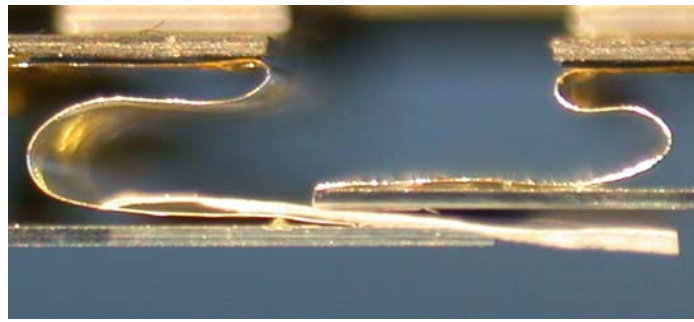


End ladder electronics

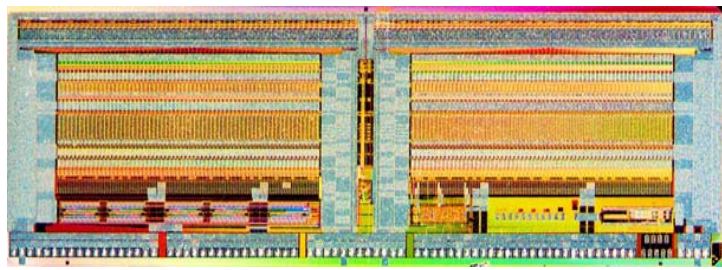
a bit more detail…

- resolution 20 μm *Rφ* 820 μm *Z*
- double-sided silicon strip sensor 73 * 40 mm^2 active area, 0.3 mm
  - 768 strips 95 μm pitch, integrated capacitors
  - stereo angle 35 mrad: 7.5 mrad (P) 27.5 mrad (N)
  - punch-thru biasing, depletion voltage < 70 V, operation up to 90 V

- overlap of active sensor area
  - in *Z,* along ladder: high/low sensors 0.6 mm
  - in *φ,* between ladders: high/low ladders 6 mm



- Al/polyimide cables
  - sensor (95 μm pitch) – chip (80 μm pitch): 14 μm Al on 10 μm polyimide
  - hybrid flex 30 μm Al on 20 μm polyimide
  - ladder cable 30 μm Al on 30 μm polyimide

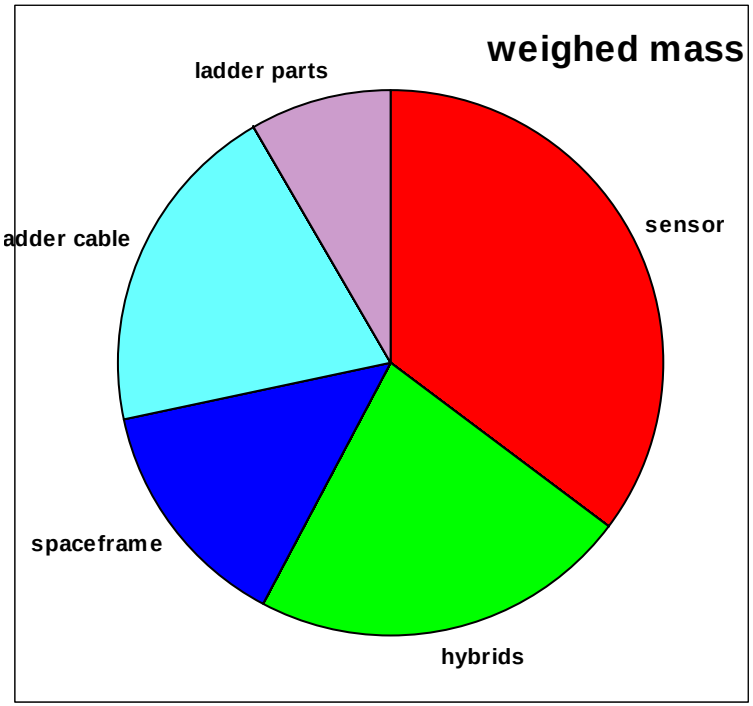


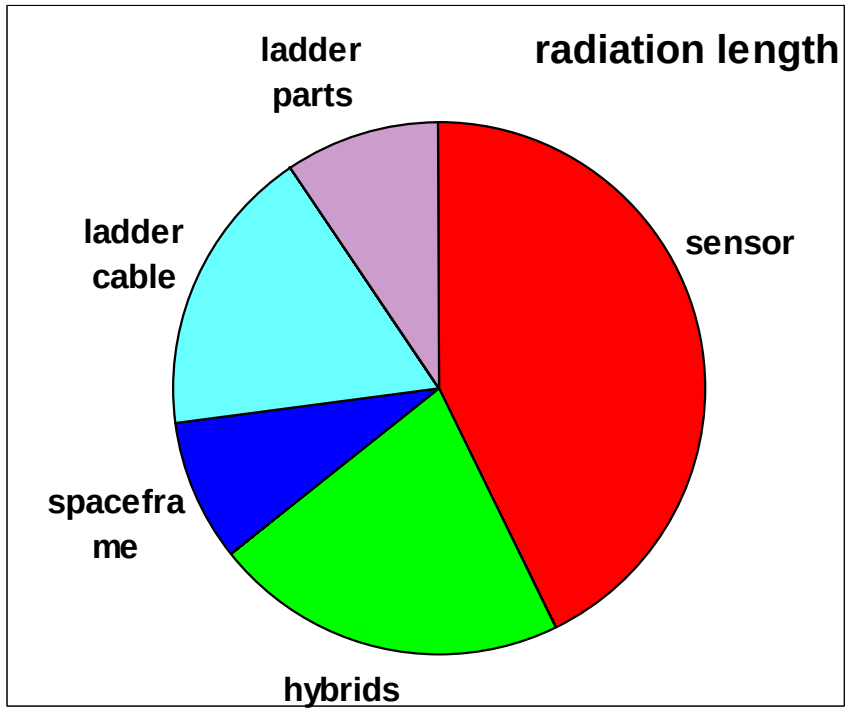
- HAL25 front-end
  - 128 channels CSA, shaper, sample&hold
  - sequential read out at 10 MHz
  - thinned to 0.15 mm

module mass & radiation length

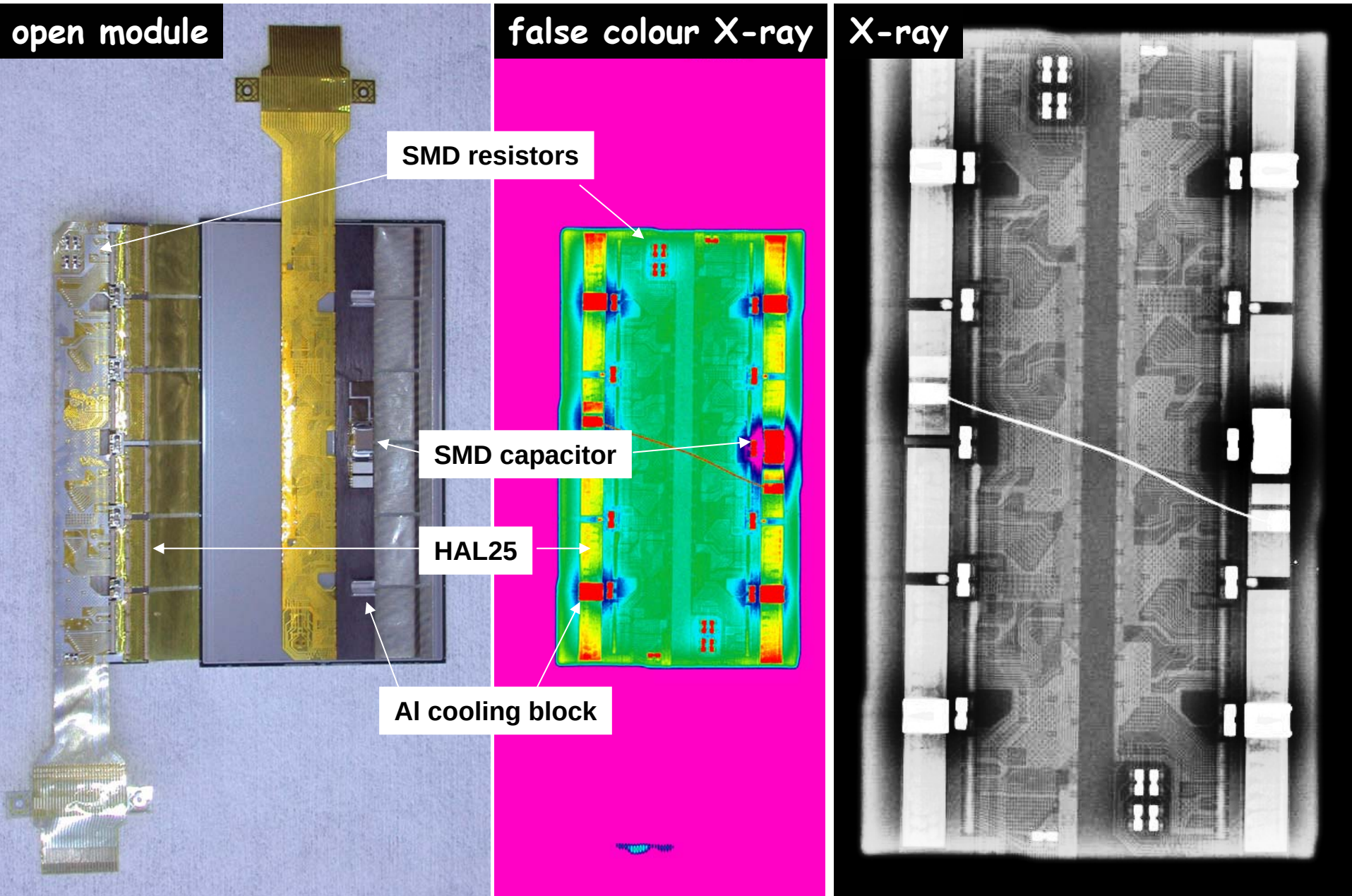
	mass [g]	radiation length [% X_0]
sensor	2.2	0.36
module on ladder	6.3	0.85

as installed mass of SSD on TPC 111 kg





radiation length



radiation hardness

- expected radiation dose at the SSD 10 krad
- front-end ASICS in rad hard (Mrad) 0.25 micronIBM
- latch-up protection in end ladder electronics
- sensor tested up to 100 krad
- read-out electronics
  - standard components -> FPGA memories may fail
    - remote upload possible, under test
    - partially redundant logic possible, not implemented
- power supplies
- magnetic field at racks up to 100 Gs
  - VME crates: Wiener Marathon
  - low-voltage and bias voltage: CAEN EASY

power and grounding

full symmetry P – N around analog ground

- separate bias supplies for P and N side
- floating low-voltage power supplies for P and N hybrids

analog signals via LVDS shielded twisted pair (one per module)

double shielding

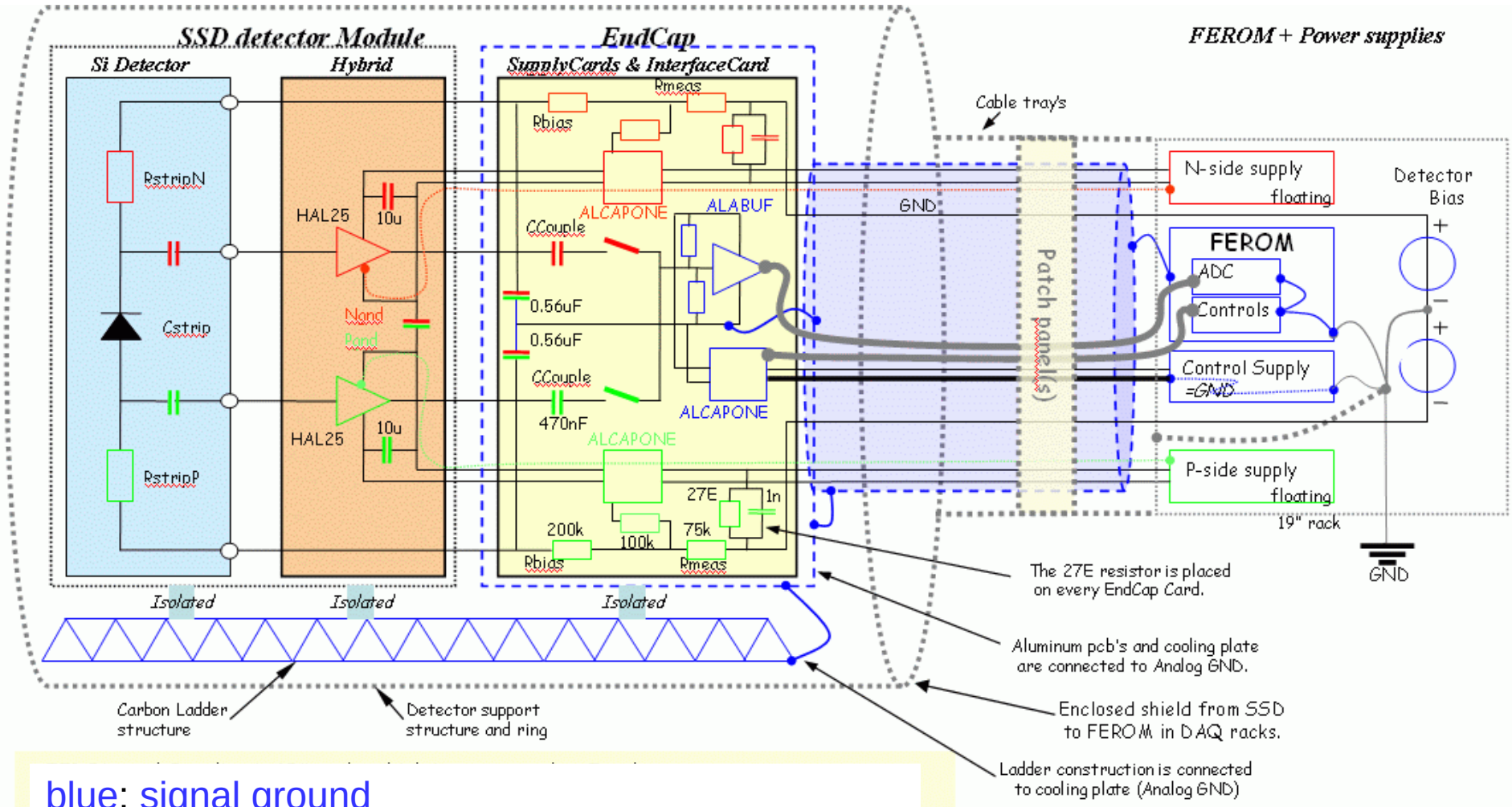
inner shields connect to electronics ground

includes carbon fibre of ladders

outer shields connect to mechanical structures

carry ground currents via carbon frame across detector

ground and power connections



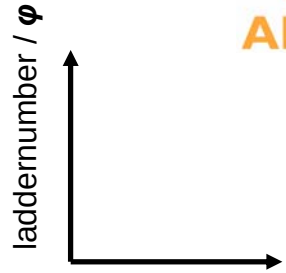
blue: signal ground
red: at positive bias
green: at negative bias
grey: dirty ground

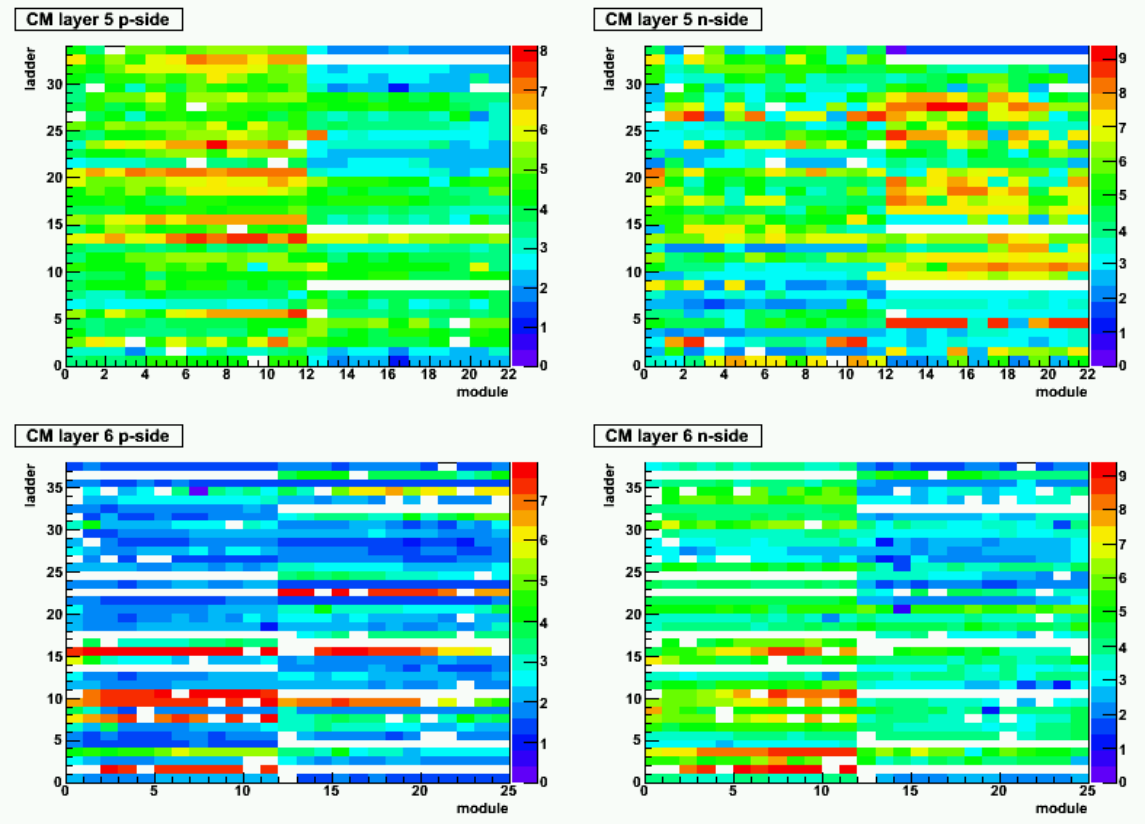
A and C side are independent, but grounds are interconnected via ladderframe

R.Kluit ALICE SSD EndCap
NIKHEF Amsterdam
2-3-2006

results

- intrinsic noise typ. 3 mV, MIP signal 100 mV
- common mode
  - amplitude up to 10 mV
  - major contributor: LV power supply



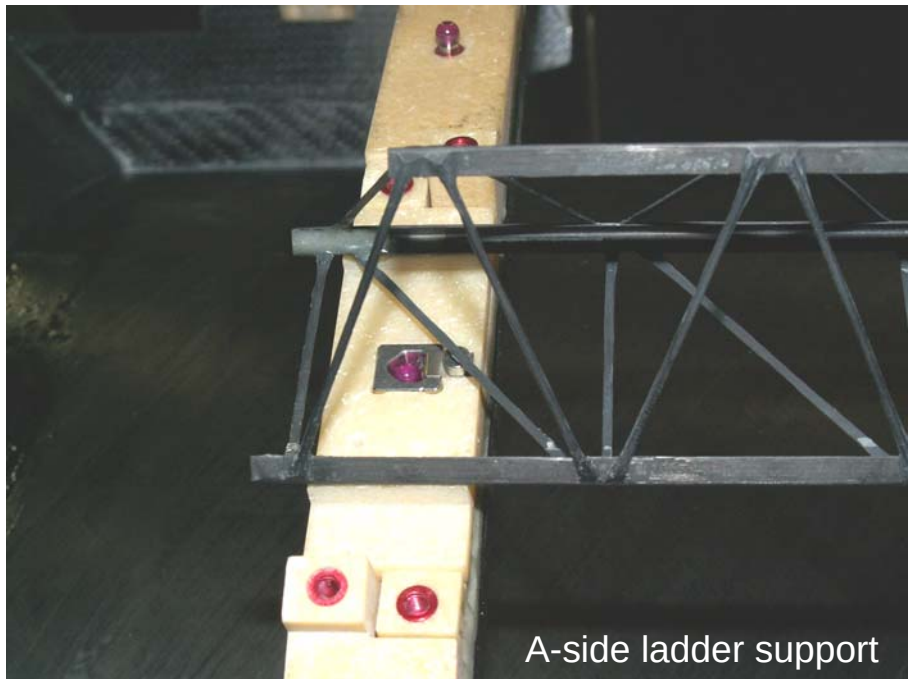


needs to be corrected before zero suppression
on-the-fly during read-out

alignment - principle

after assembly, survey is not possible: no access to fiducials on the sensors, but:

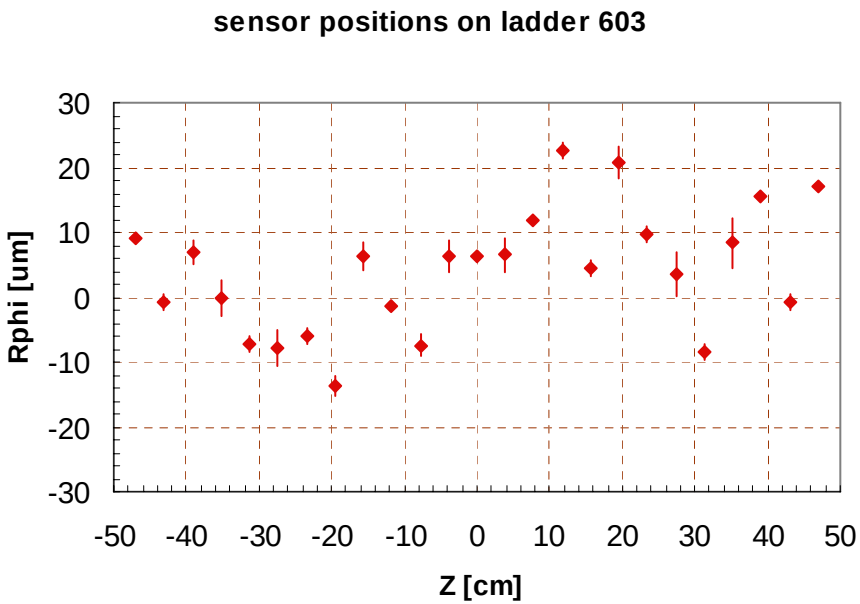
1. design guarantees no movements during transport and installation
   - stress-free mechanics
   - no overdetermined positioning:
     - determine ladder position (*Rφ, Z, R)* at A-side
     - determine ladder orientation (rotations around *Rφ, Z, R)* via C-side

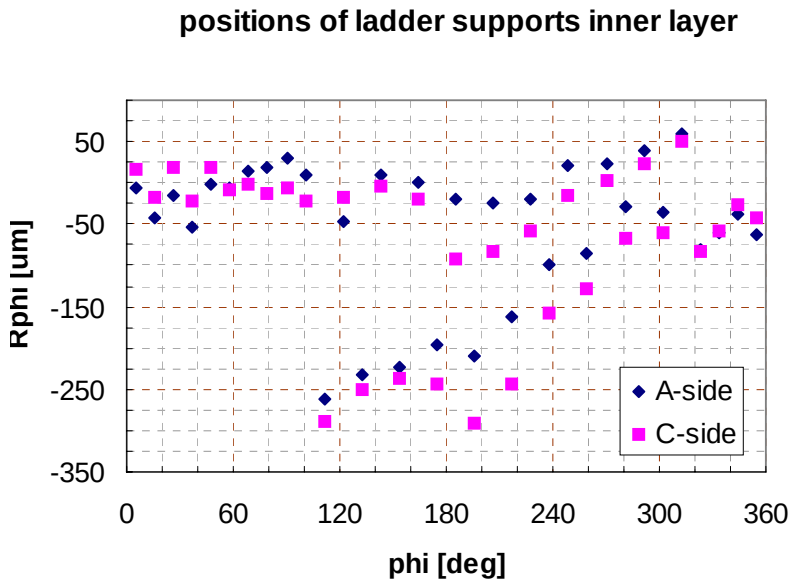

A-side ladder support

alignment - survey

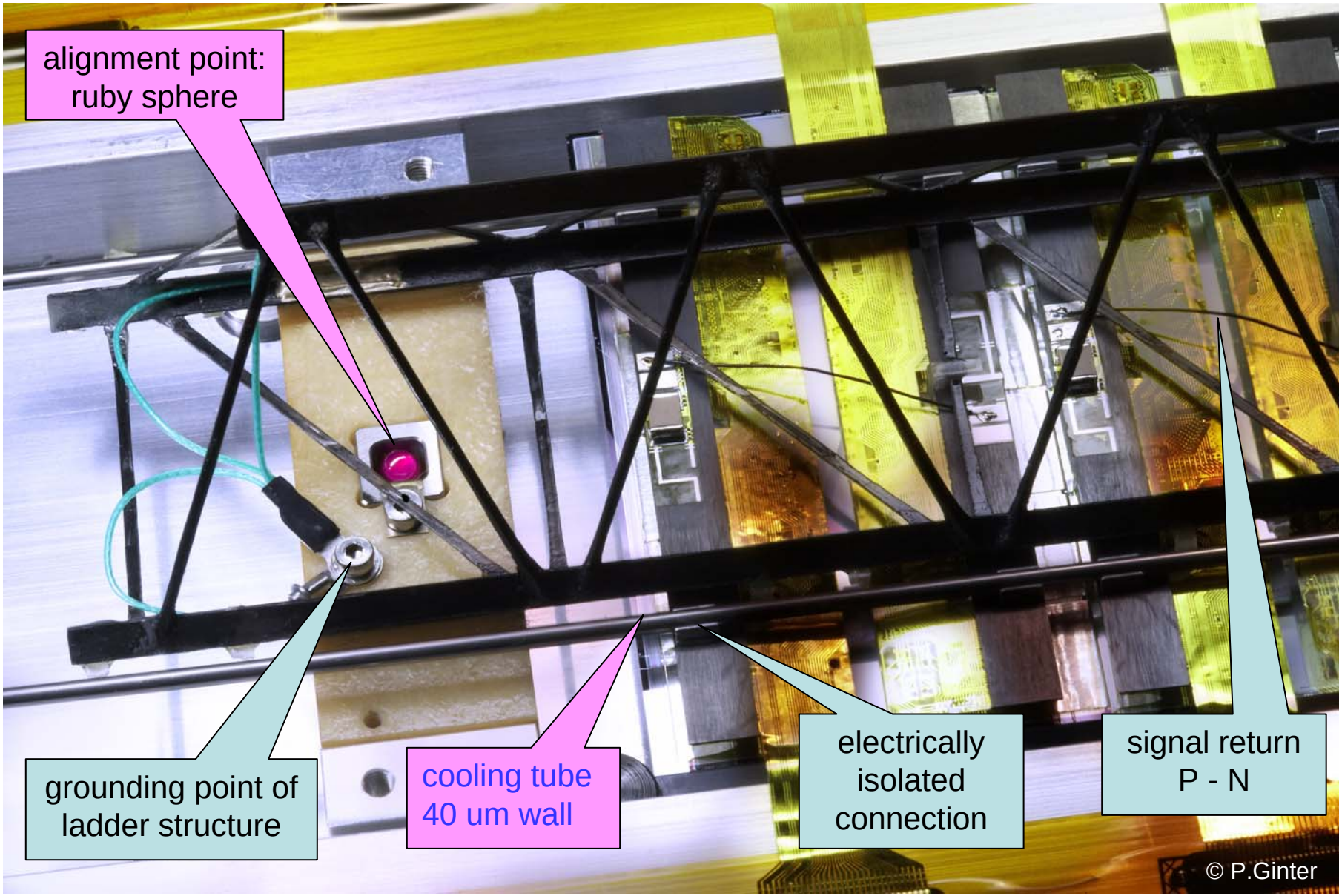
after assembly, survey is not possible: no access to fiducials on the sensors, but:

1. design guarantees no movements during transport and installation
2. survey sensors after assembly on the ladders
3. survey support points for ladders on the cones



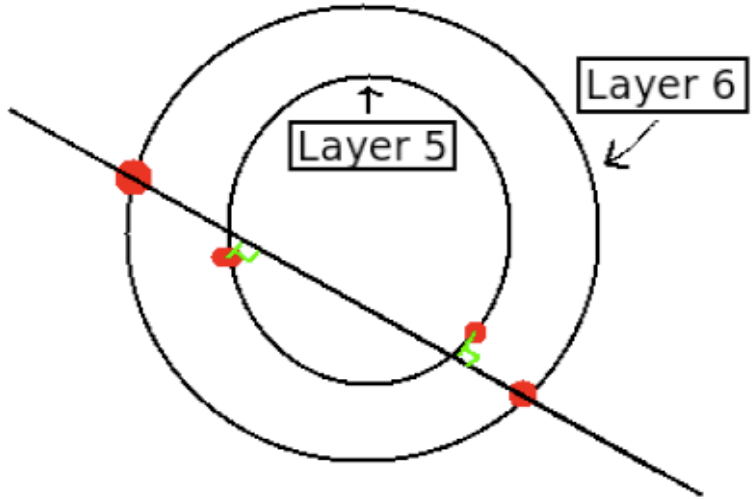


details of a ladder, C-side

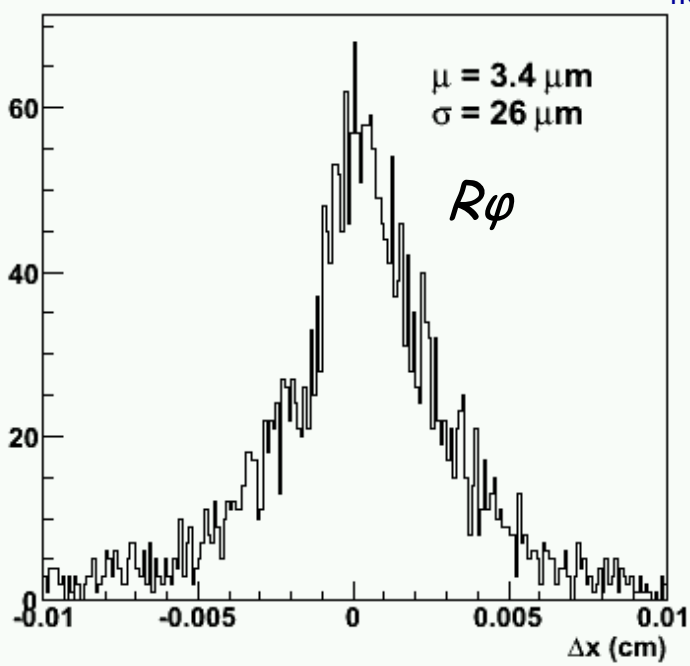


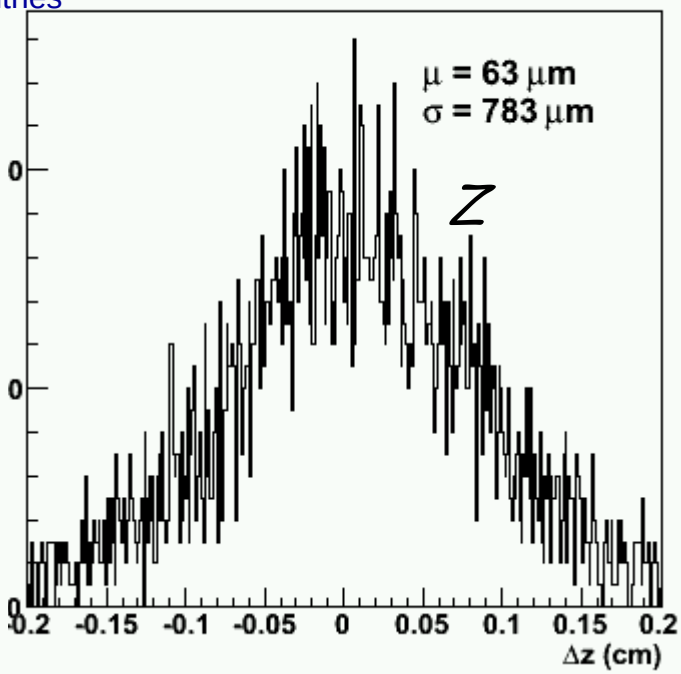
alignment - result

1. use cosmics without field
2. apply pre-installation survey data
3. straight line fit to points on layer 6, measure distance to hit on layer 5



~4k entries

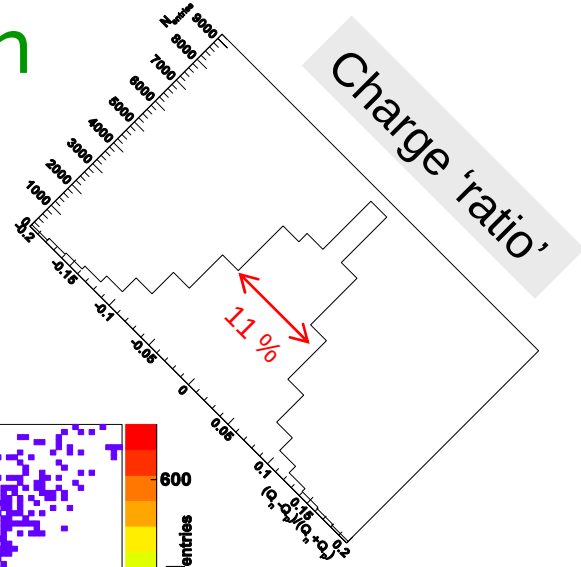




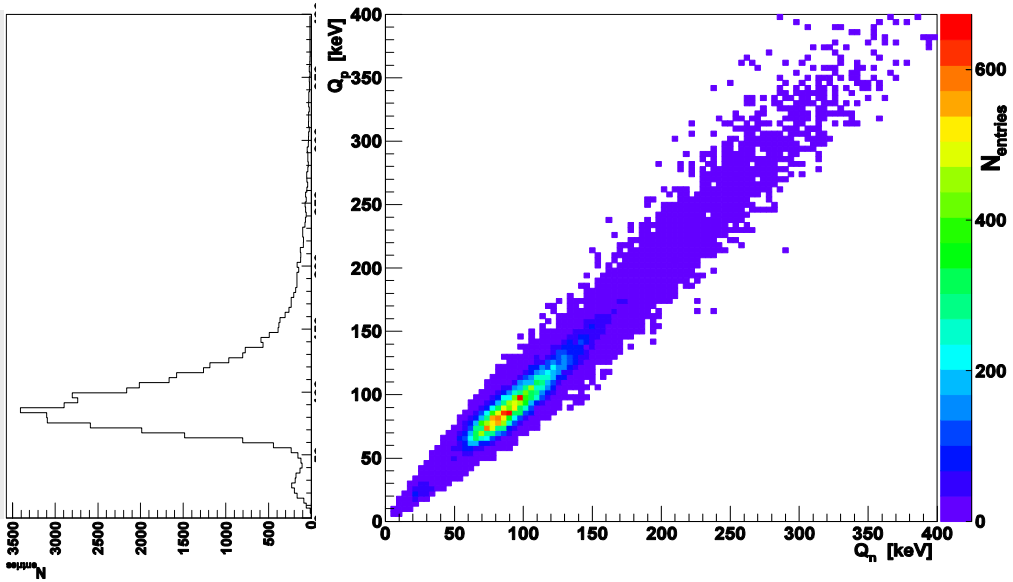
SSD calibration

Charge matching ->
relative calibration

- 46 k cosmic clusters
- Inclined tracks included

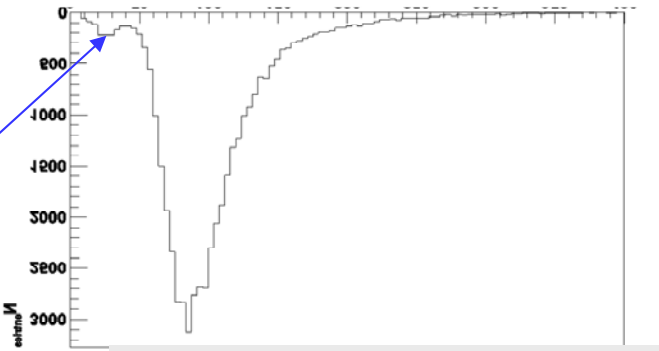


Cluster charge N-side



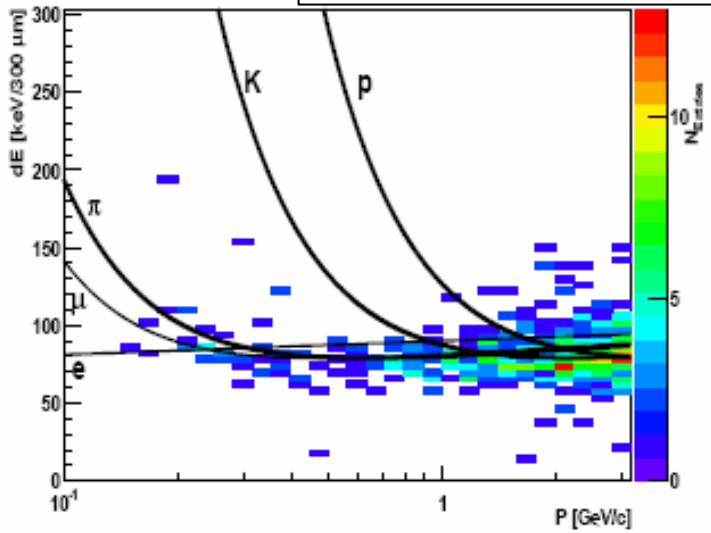
noise level 2 keV
➔ S/N ~ 40

noise hits 10^{-4} per module per event

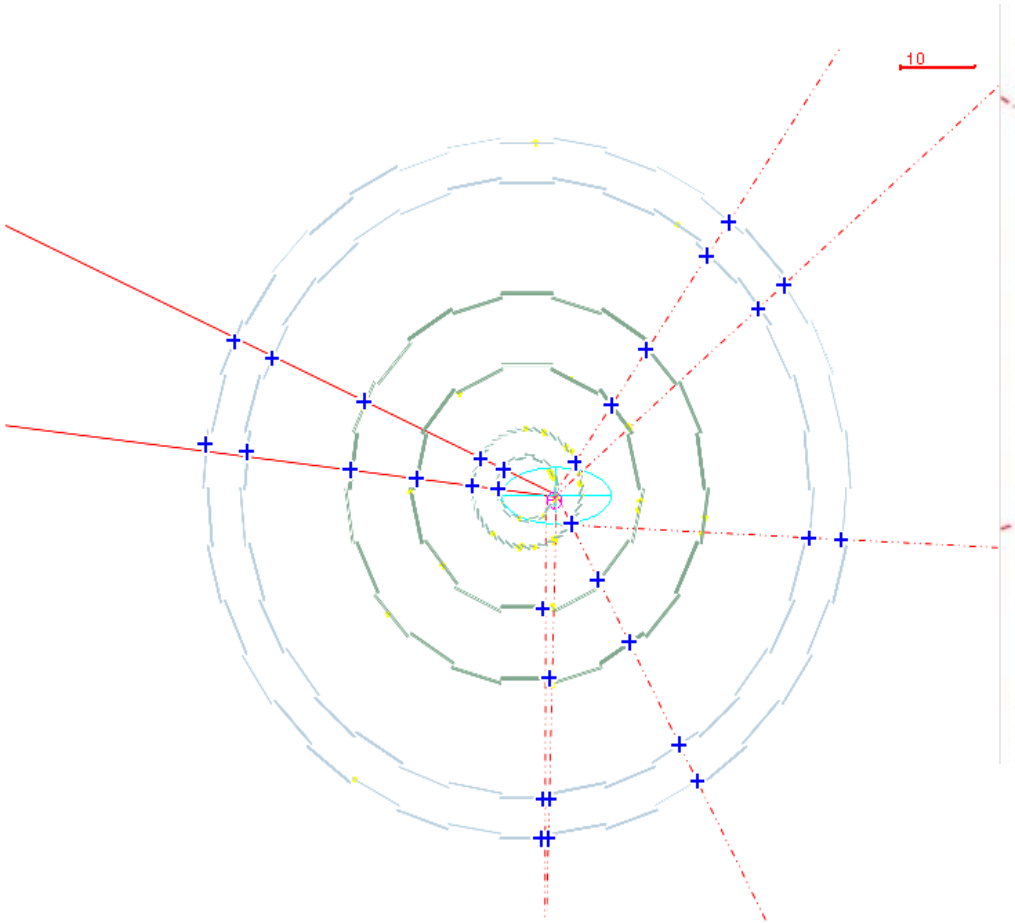


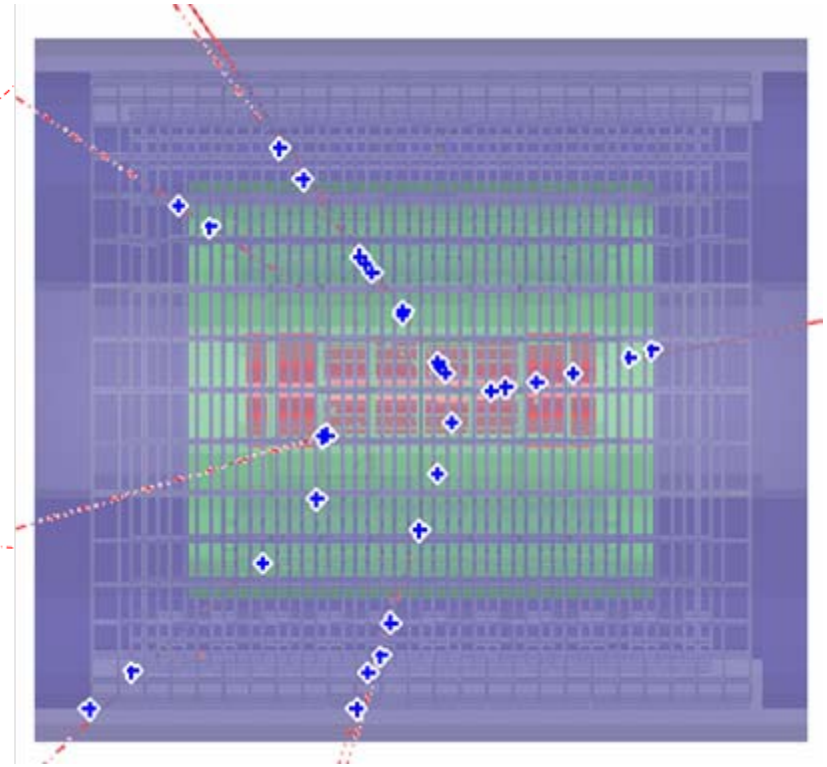
Cluster charge P-side

energy signal vs. *p*



First interactions 11th September 2008





Circulating beam 2 on 11 Sep:
stray particle interacts in SPD

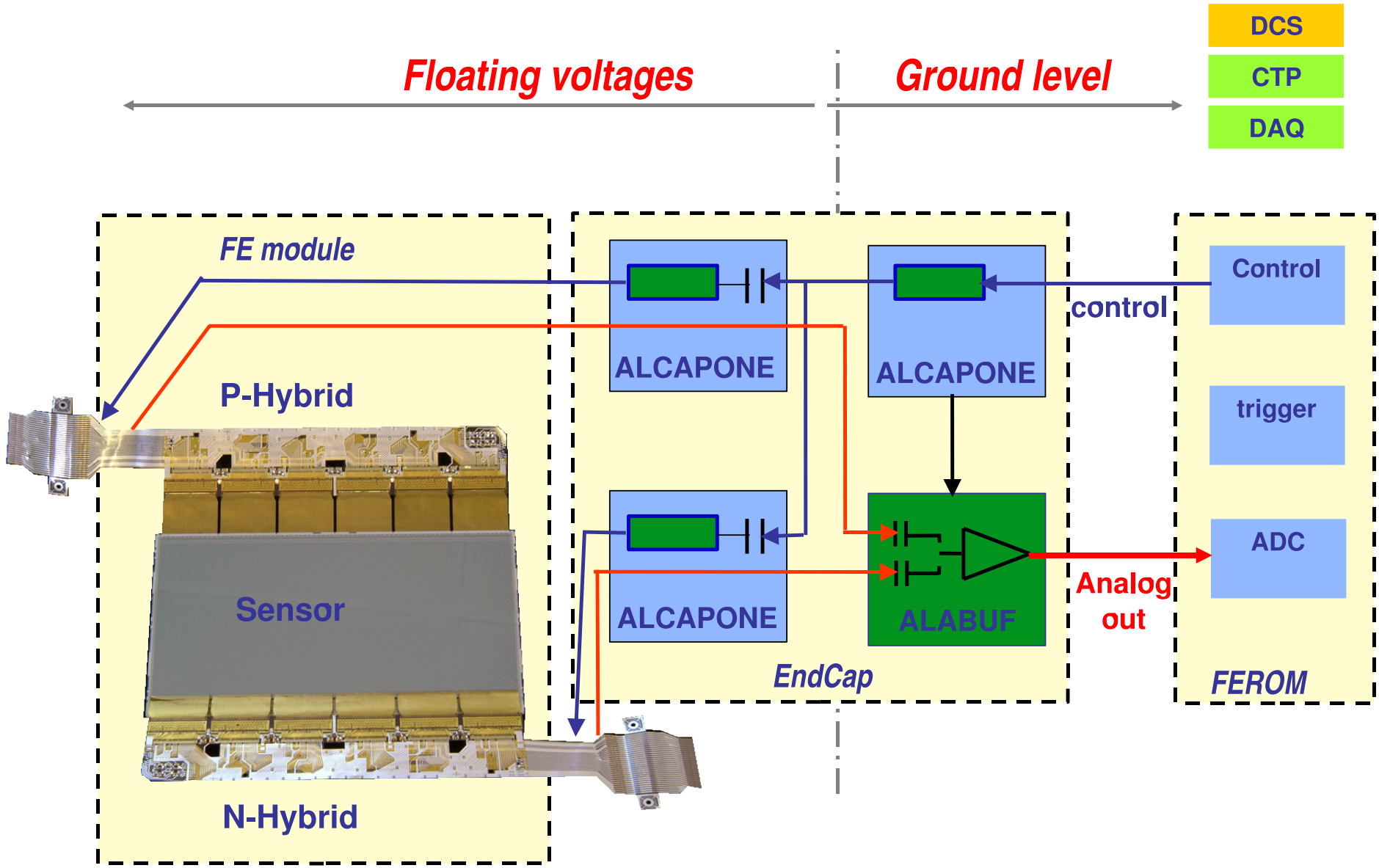
ITS has 7 tracks reconstructed with common vertex

first alignment and calibration is ok

ALICE is ready for beam

.. then, on 19 Sep …

SSD electronics

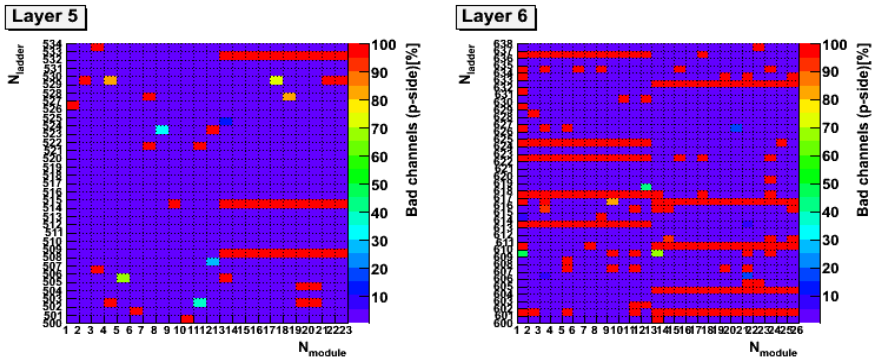


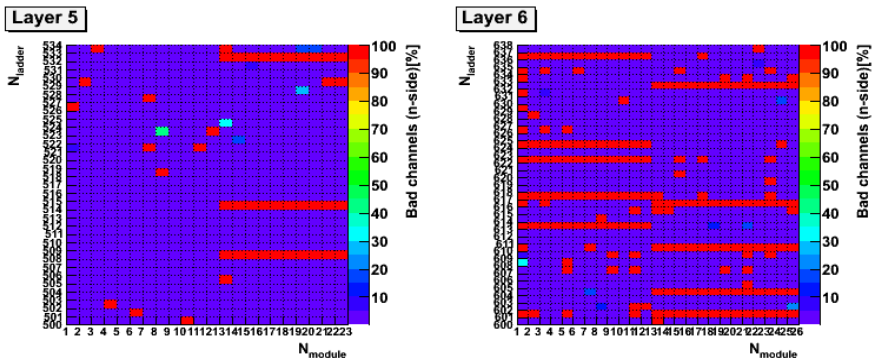
Common mode correction

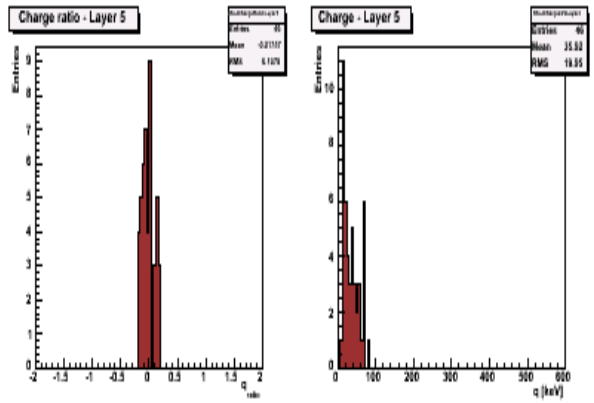
implemented in firmware of FEROM

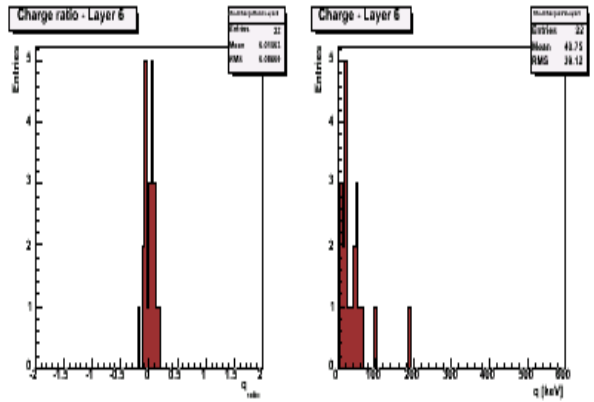
- pedestal corrected with pre-loaded values from pedestal run
- common mode calculated over max. 96 channels per HAL25
  - skip first and last 16 channels
  - skip dead channels
  - skip channels with signal > threshold (particle signal)
- subtract common mode for each event
- zero suppress
  - dead channels
  - channels with adc < pre-loaded threshold
- dead channels
  - static list, edited manually (known dead modules)
  - dynamic list from pedestal run
    - noise out of limits
    - pedestal out of limits

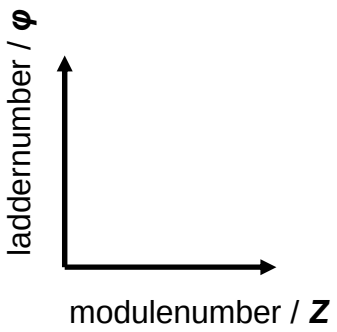
noise hits



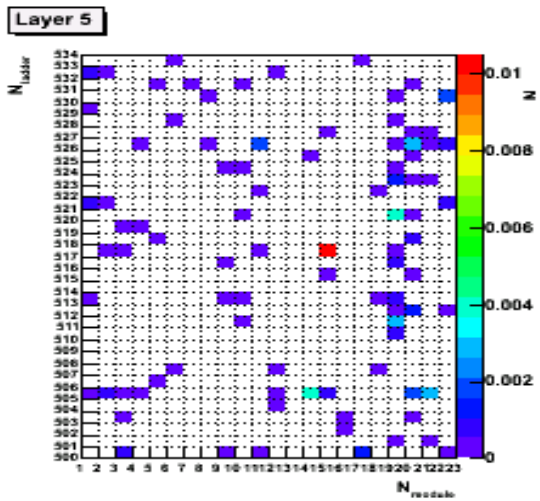


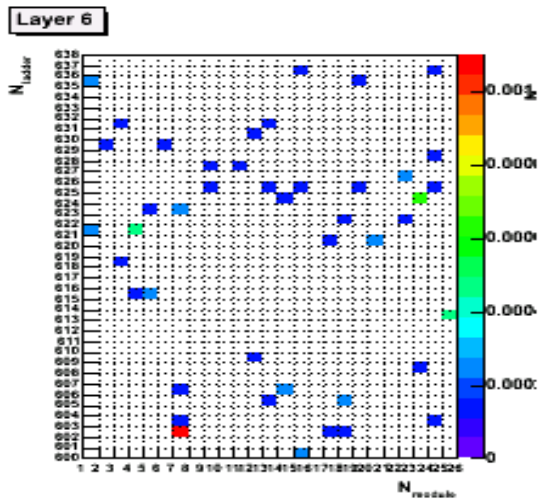




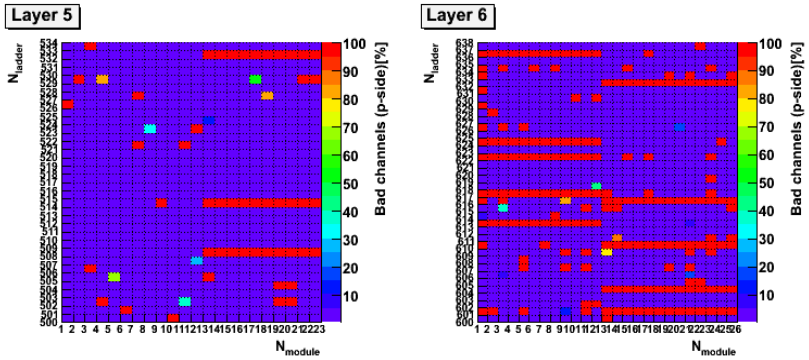


noise hits 10^{-4} per module per event





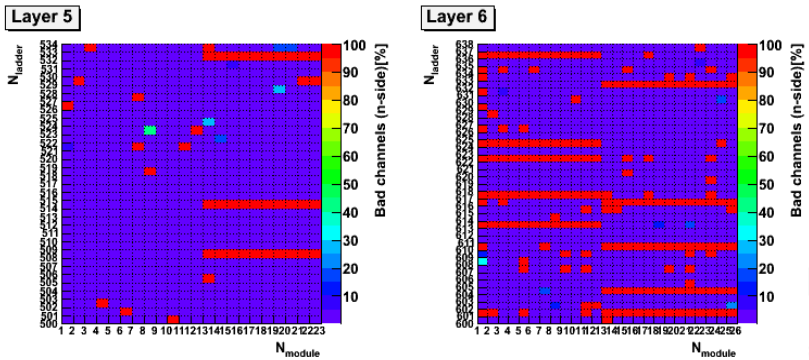
example: cosmics run 60419



dead channels

run 60419 890 events

626 Fast-Or events
1358 clusters in Layer 5
1244 clusters in Layer 6



hit pattern