Status of the TPG

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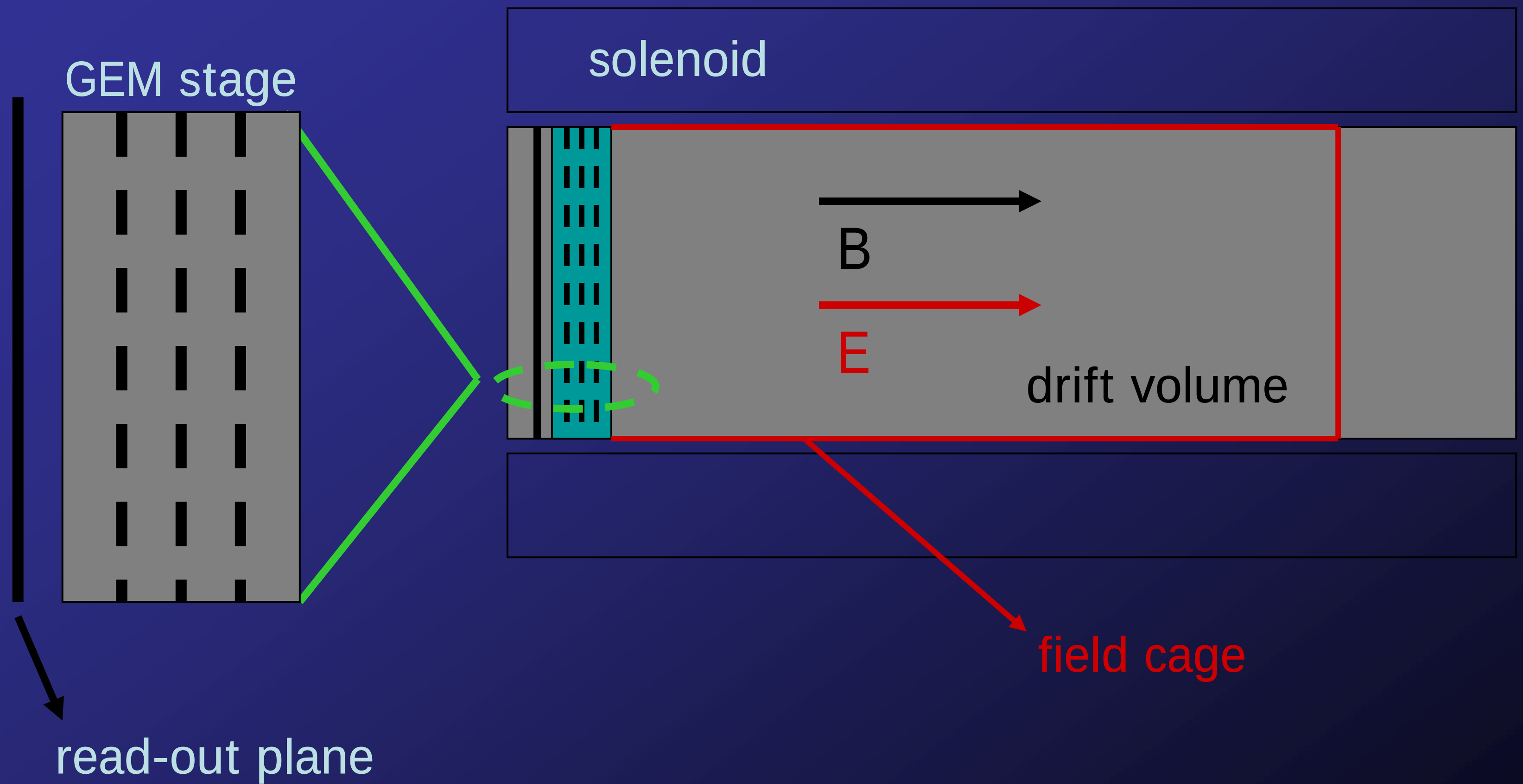
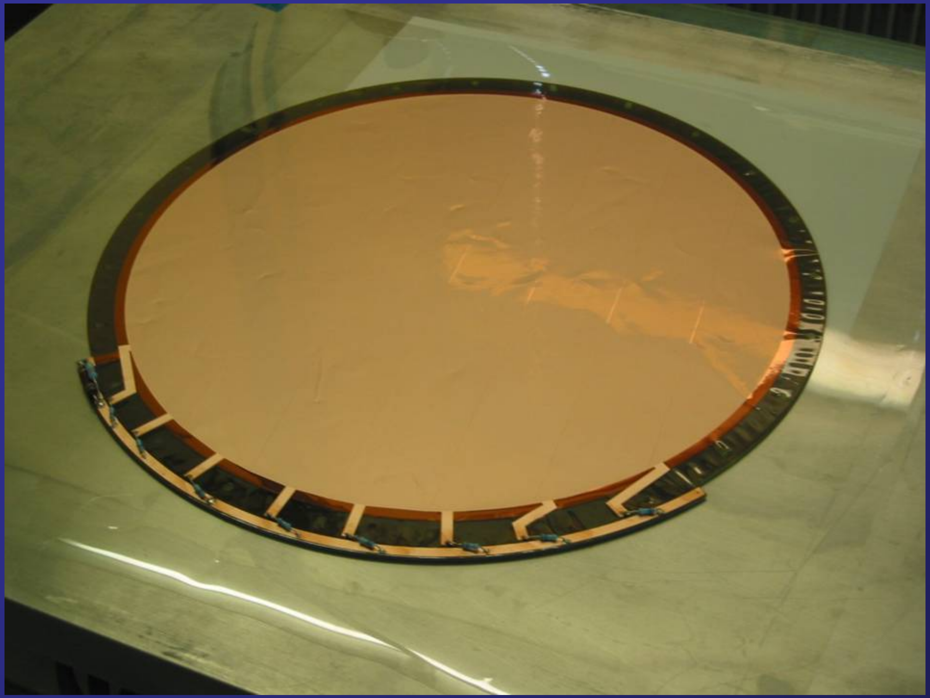
Outline

- Construction and operation
- Update on performances
- Design aspects
  - Electronics
  - Field-cage
  - Gas choice
- Outlook

Detector schematics

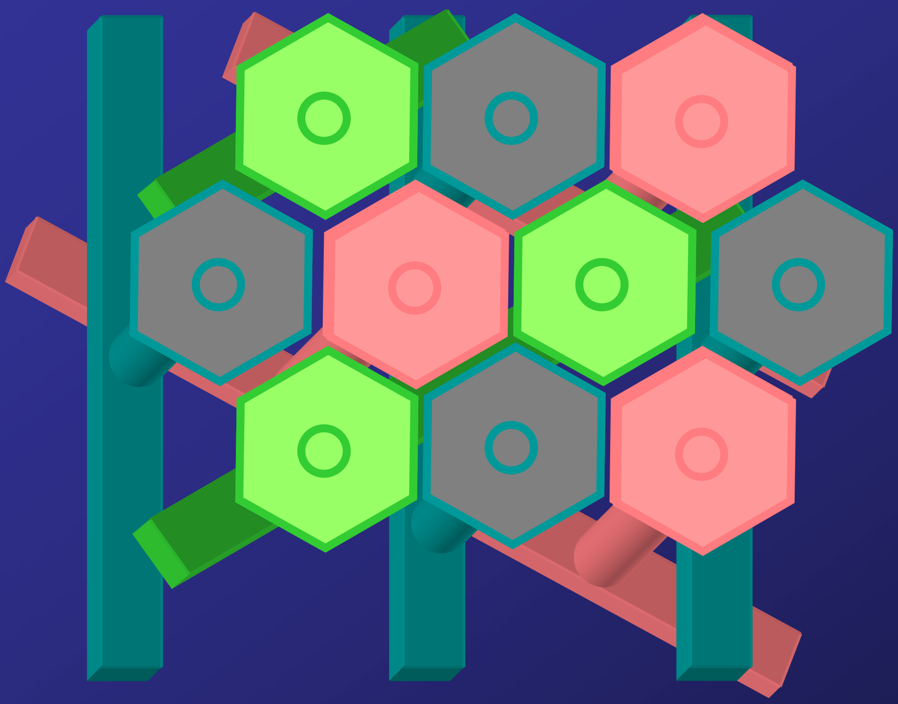


The GEM foil

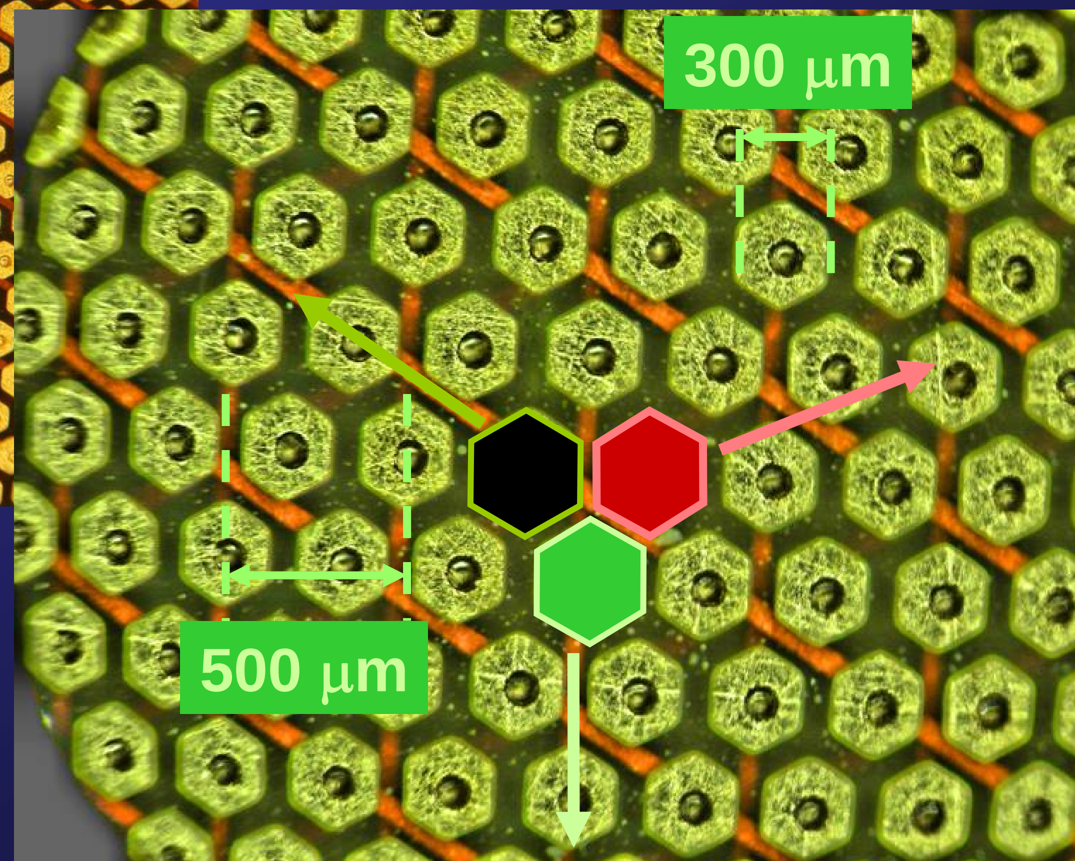


- Triple-layer structure
- Each layer divided in 8 regions, independently powered
- Max amplification depends on gas and HV. With good gas it can be as high as 10^6.\

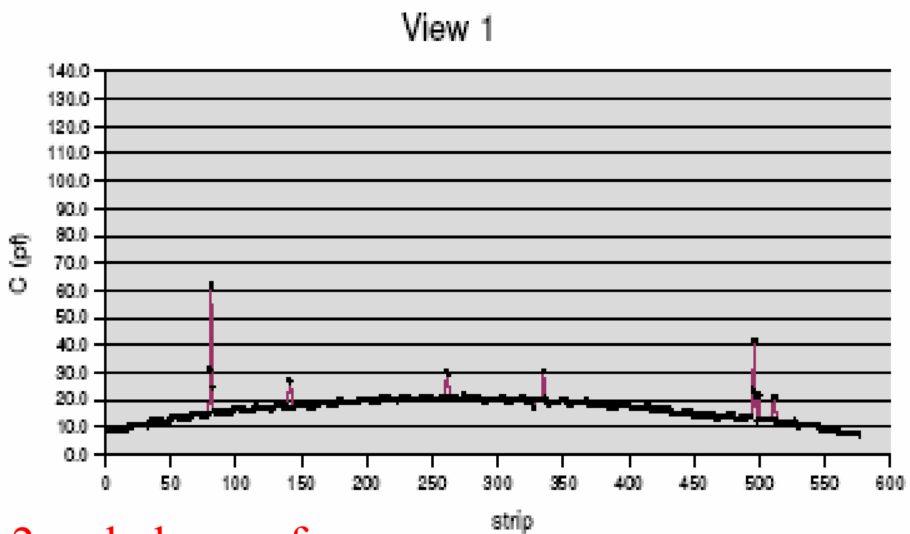
The hexaboard

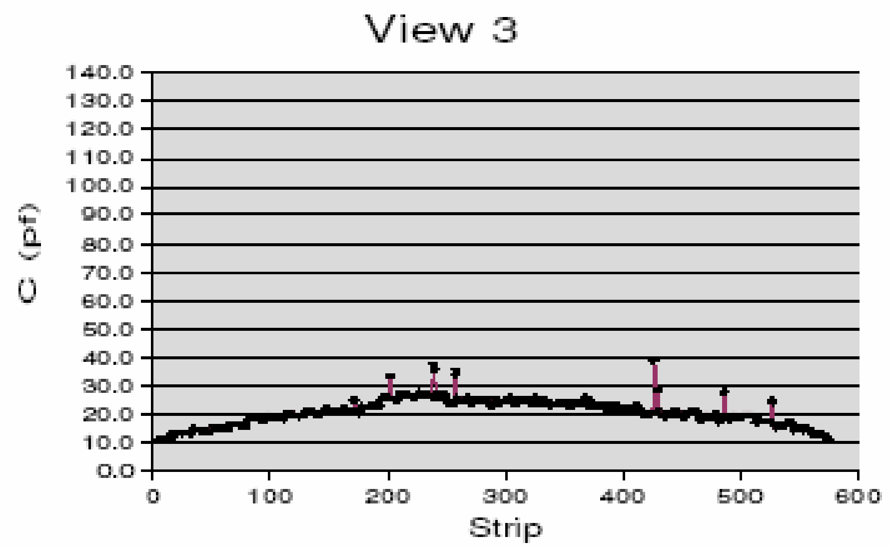


- ~710000 hexagonal pads
  - size: 300 µm
  - pitch: 500 µm
- grouped into strips along 3 coordinates at 120 degrees (u, v, w) running at different depths

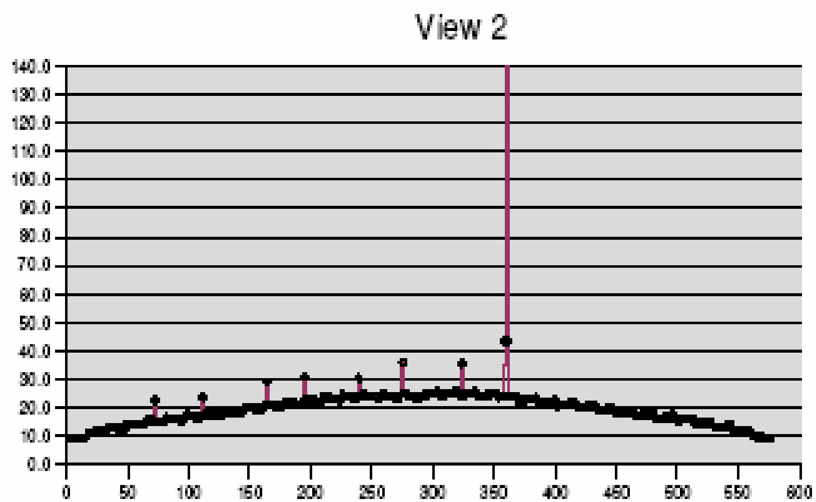

300 μm
500 μm

… to this:



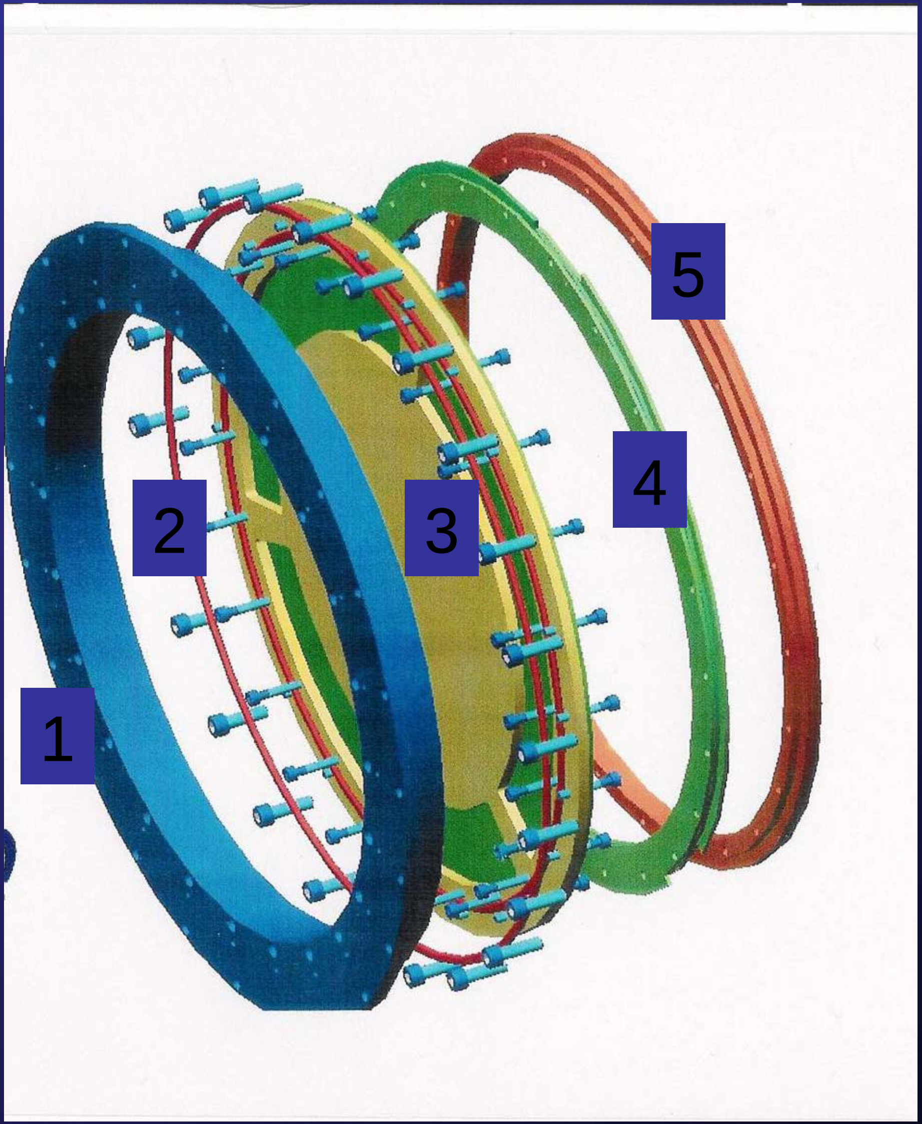


- 2 pad planes of same quality are available
- < 10 anomalies over 576 strips
- all layers have similar production quality

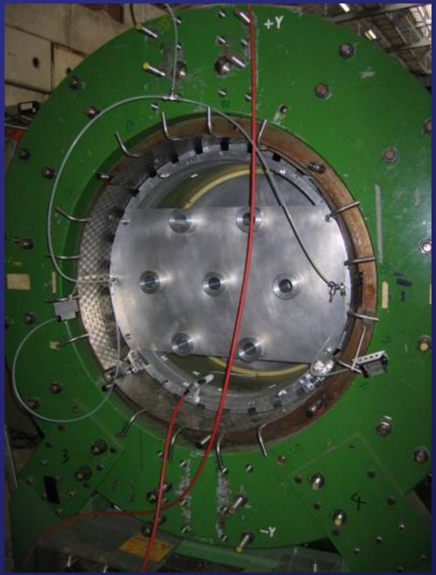


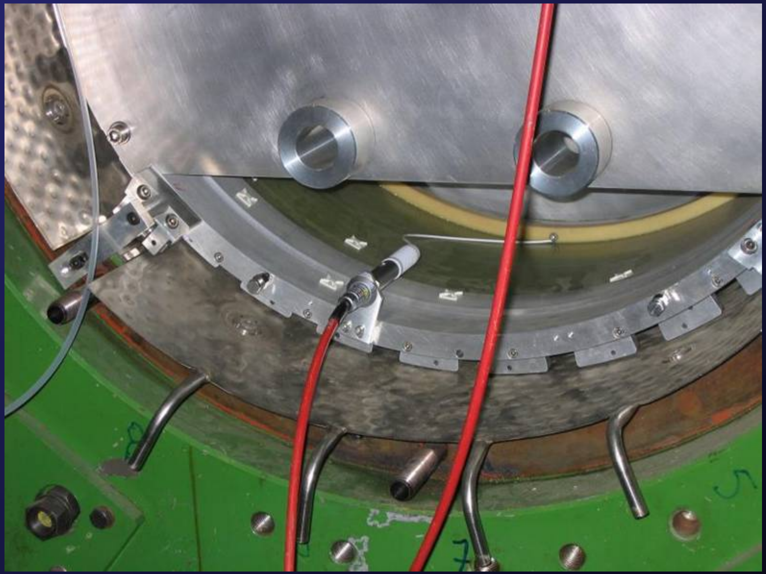
Support structures

1. outer metal ring
2. o-rings for gas tightness
3. stiffener plate
4. GEMs support rings
5. guard ring



Assembling the detector

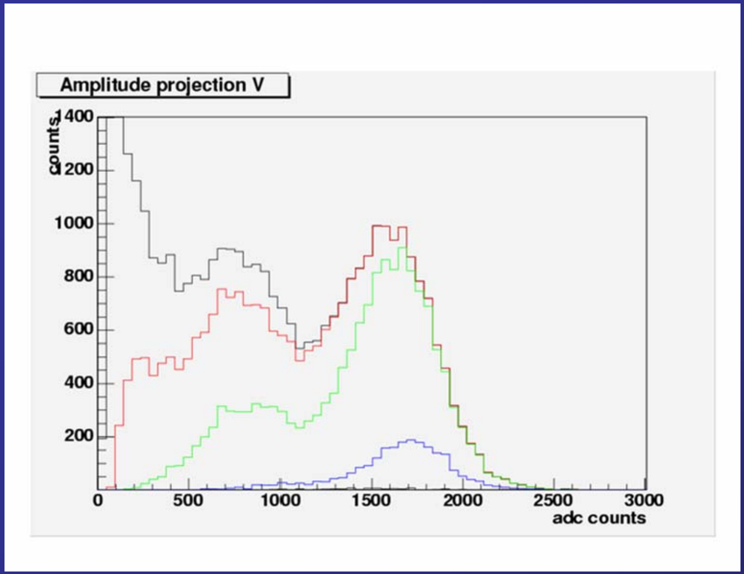




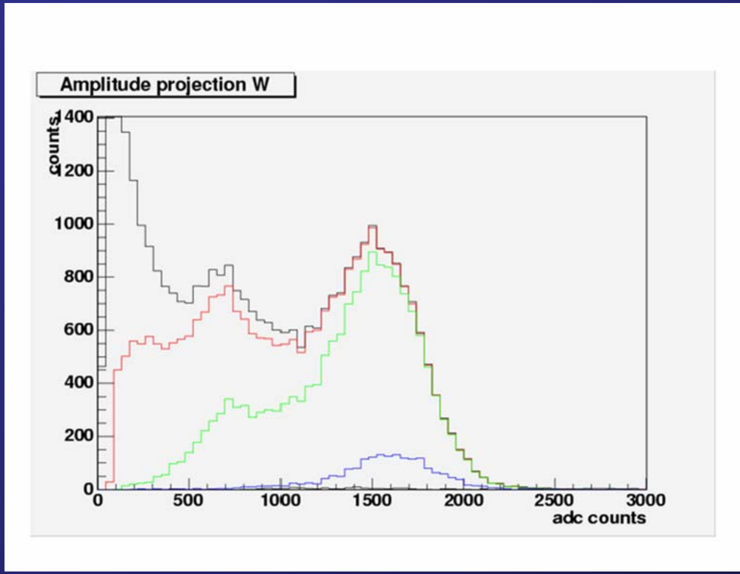
^{55}Fe source calibration

- Absolute energy, equalization
- Preamp gain calibration is not included yet
- First indications are
  - Despite the lack of gain equalization, the energy resolution is already quite good
  - The plots are very sensitive to the cuts on cluster size, as expected from a properly working detector

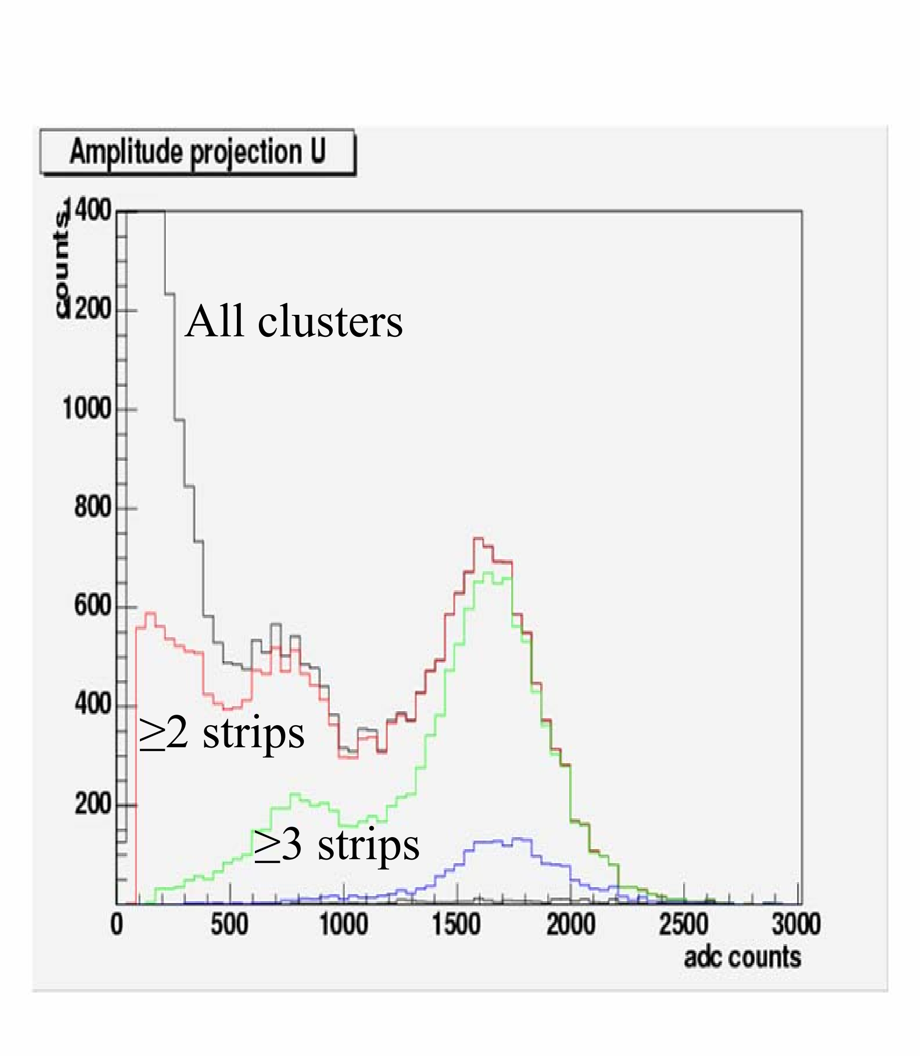
^{55}Fe source



Amplitude projection V
counts
1400
1200
1000
800
600
400
200
0
500
1000
1500
2000
2500
3000
adc counts



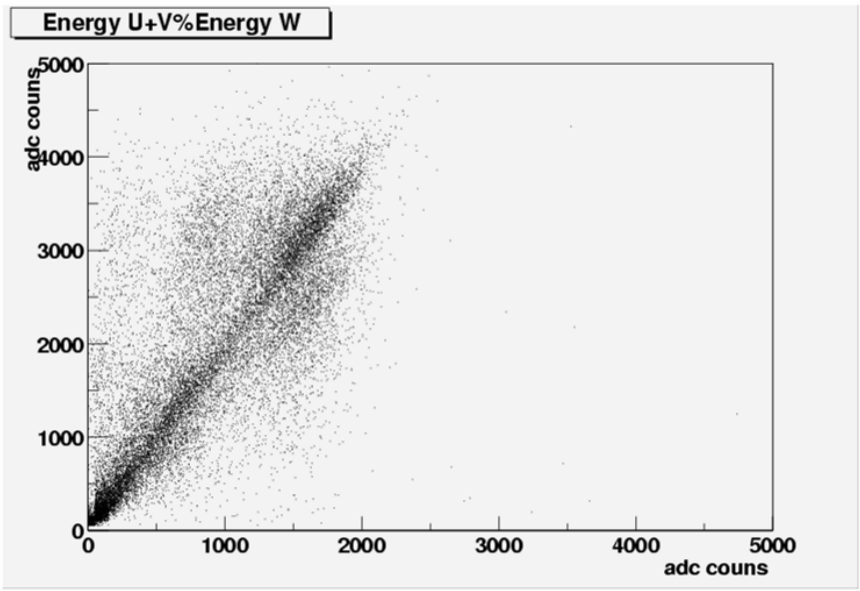
Amplitude projection W
counts
1400
1200
1000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000
adc counts



Amplitude projection U
counts
1400
1200
1000
800
600
400
200
All clusters
≥2 strips
≥3 strips
0
500
1000
1500
2000
2500
3000
adc counts

U,V vs. W correlations

TPG



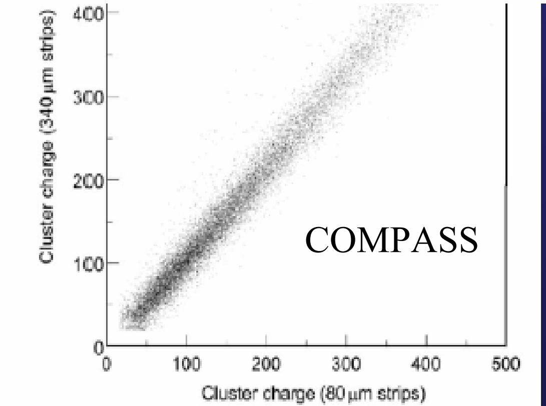
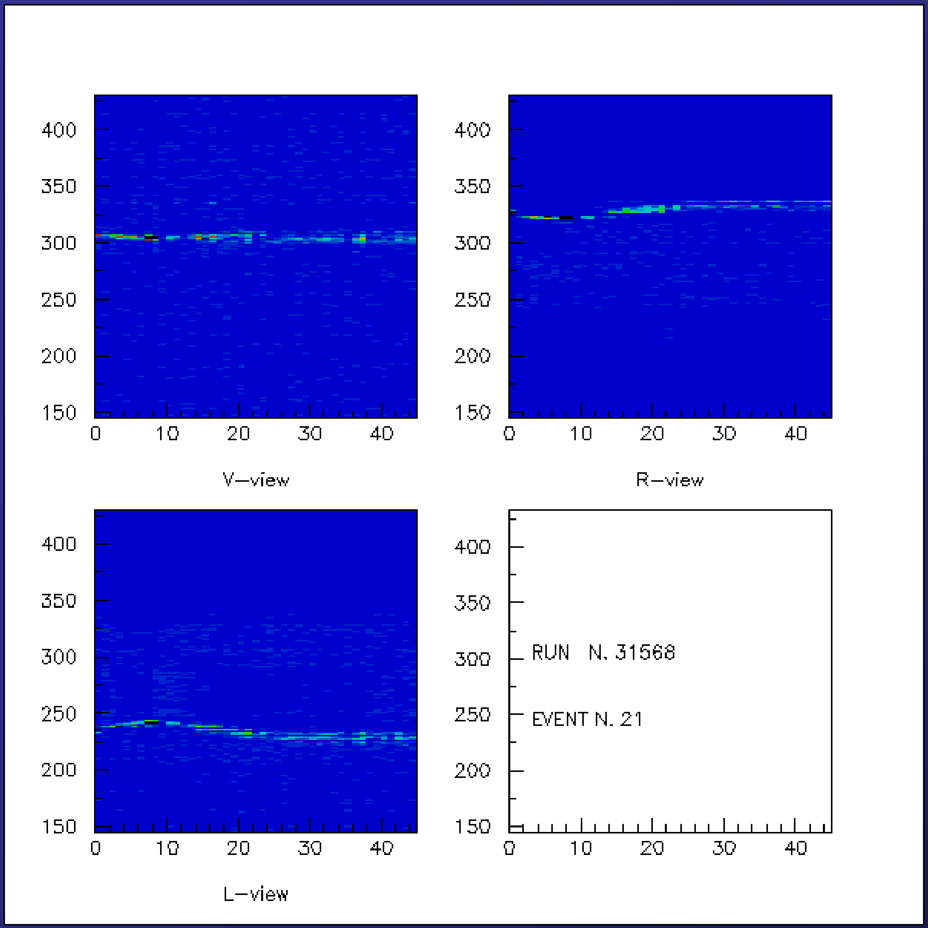


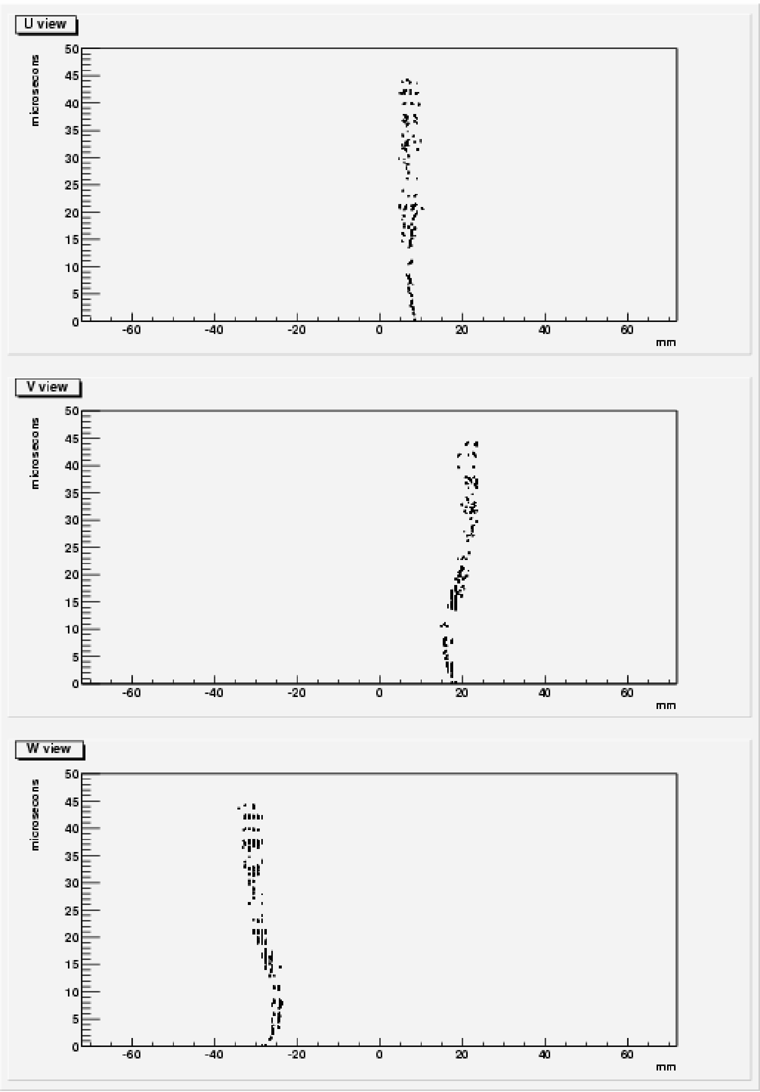
Fig. 42. Cluster charge correlation between the two coordinates.

- out-of-line events are due to lack of gain calibration
- Correlation is important: it can be exploited as an additional tool for getting rid of fake combinations
  - In addition to the use of the 3rd projection
- Compass is able to reject (almost all) fakes by this technique

Low energy tracks

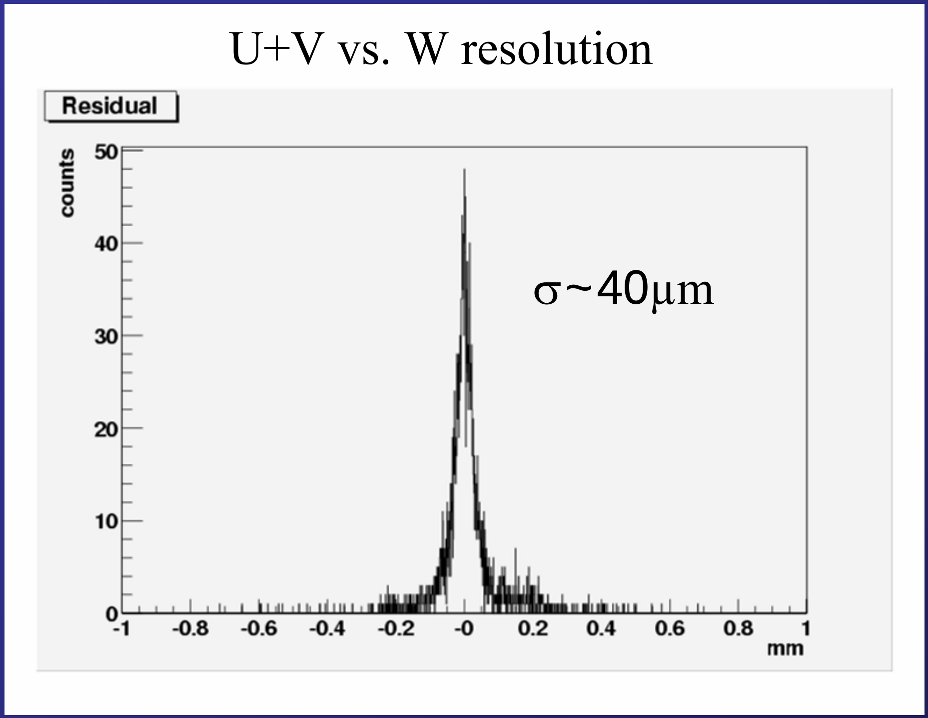


- 500 samples @10MHz
- Ar/CO_2 90/10, 10cm/µs ➔ total 50cm drift path
- e- from Sr source
- B=0.07T (1/10 nominal)
- Color code gives charge amplitude



- 2 MeV/c electron in B=0.07T
- Transverse diffusion spreads the charge

Intrinsic resolution



- ^{55}Fe X-ray conversion position can be determined by 2 projections, then cross-checked with the 3rd one.
- The intrinsic resolution is VERY promising
- This has been obtained with a 3cm drift cell.
- Actual resolution over longer drift depends on gas properties.

Design improvements

- Electronics
- Ingredients for good resolution
- Gas choice
- Discussion on overall parameters
- A compact emittometer, alias TPG ?

Electronics

- New electronics from ALICE
- Higher integration
- Total (including DAQ) 10 CHF / channel
- Digitization is close to detector (less noise)
- Data get out from the detector on a few optical fibers (elegant, simple)
- Large range of possible sampling frequencies up to 40 MHz.

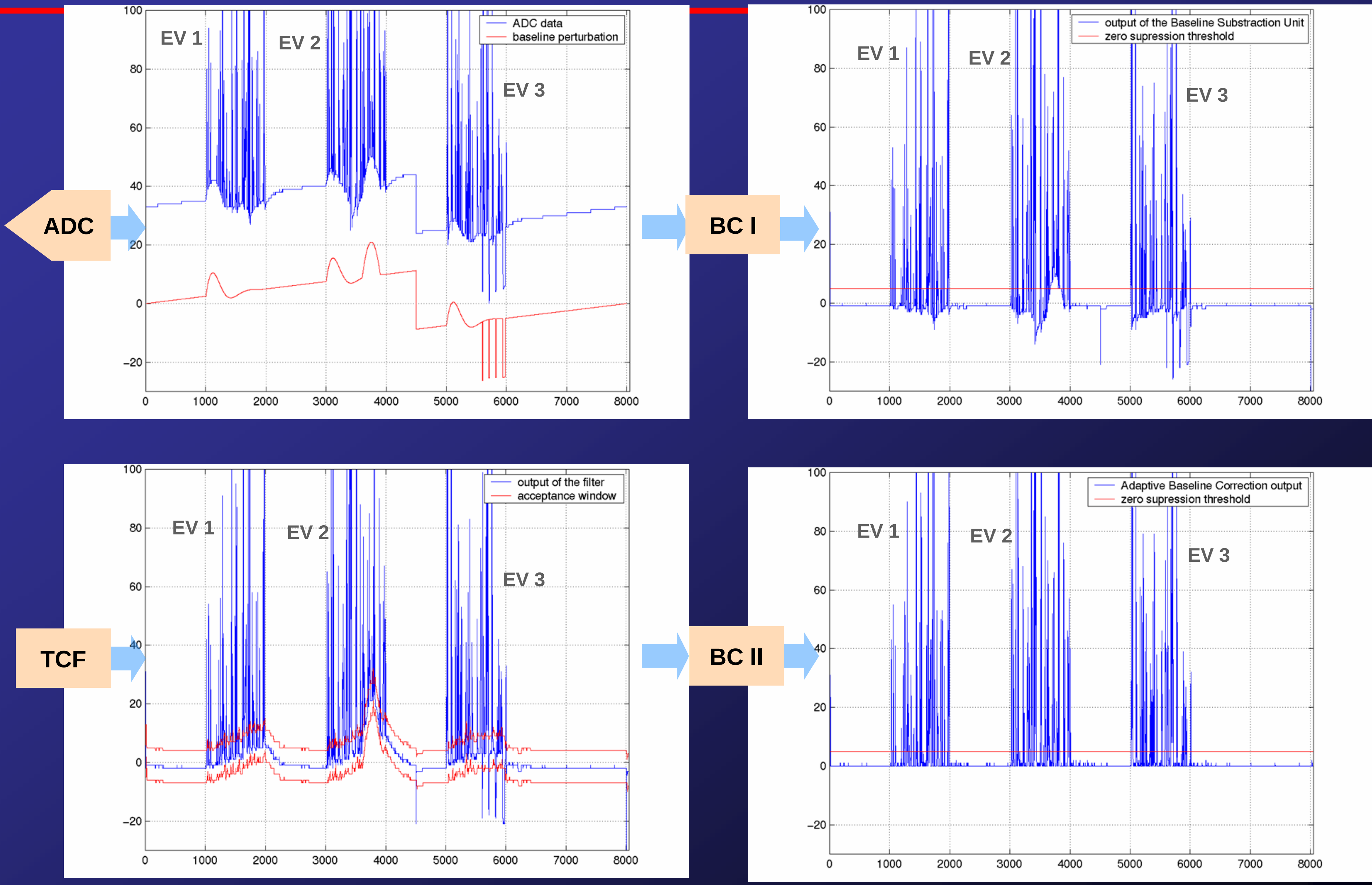
ALTRO EVOLUTION

1998
CHANNELS / CHIP: 1
POWER / CH: 120mW
PRICE / CH: 50CHF

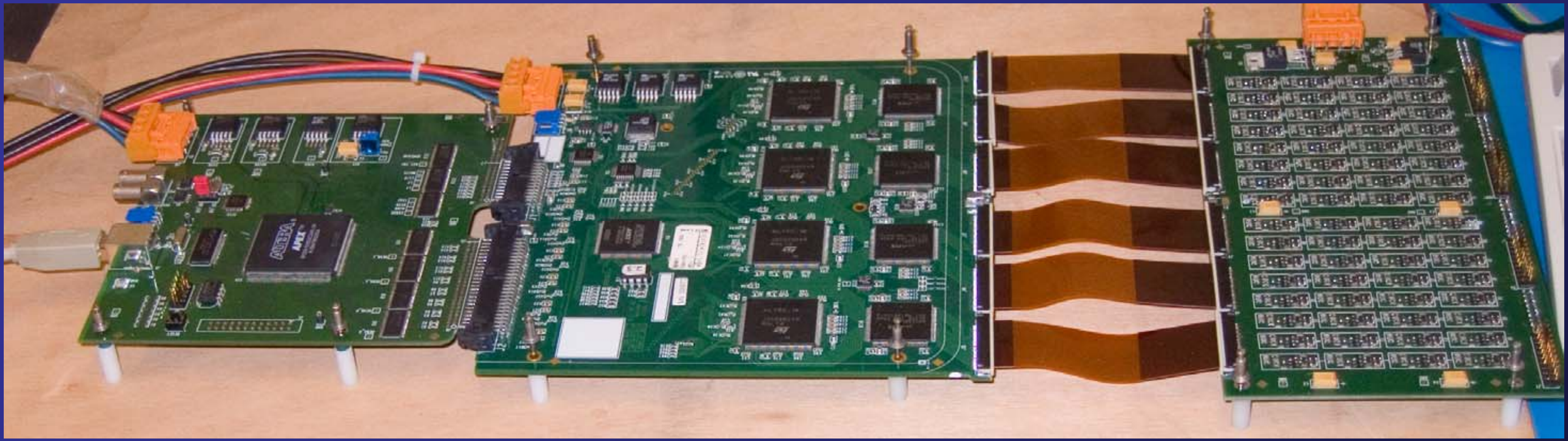
1999
CHANNELS / CHIP: 4
POWER / CH: 80mW
PRICE / CH: 8CHF

2001
CHANNELS / CHIP: 1
POWER / CH: 16mW
PRICE / CH: 5CHF

Digital Conditioning of the TPC Signal



A possible TPG electronic chain



- From left to right
  - Signal inverter
  - 128-channels ALICE TPC front-end
  - USB readout card
- Addition of protection diodes possible.
- Electronics noise ~ 1K electrons, depending on cable length
  - Total S/N depends on amplification. Can be quite high with good gas mixture.
- Being designed for a different experiment, straightforward application to TPG

Momentum resolution

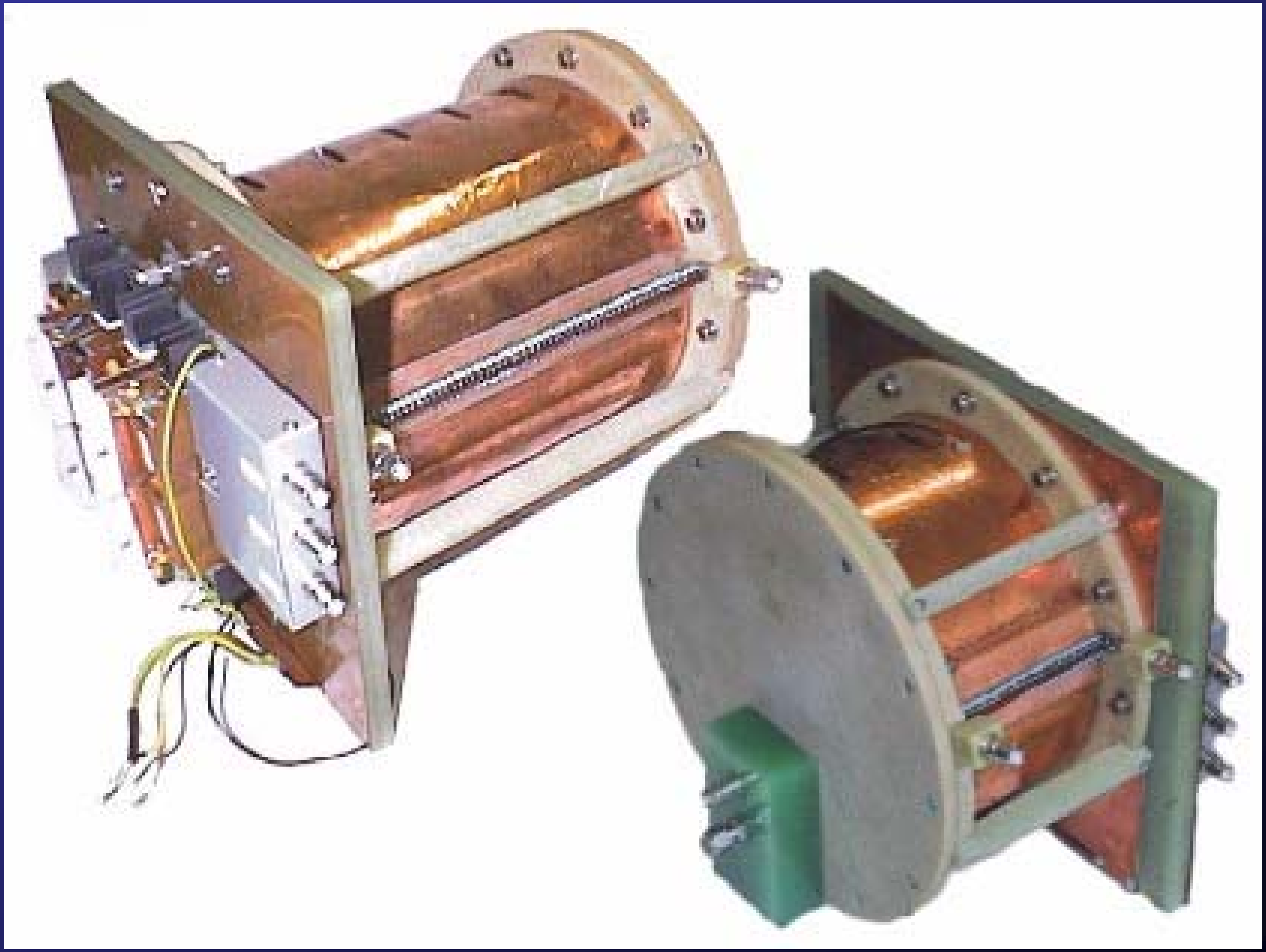
- Position resolution is driven by
  - Readout pitch (fixed)
  - Diffusion in gas
  - Ionization and gain
- Gas choice is a key point: we should look for larger gain and ionization and smaller diffusions.
- Momentum resolution is driven by
  - Position resolution
  - Number of available points
- From the simple Glukstern formula: 50 points give dp/p resolution factor only 1.5 better than 20 points.
- If more distant points are affected by more diffusion, we should really consider limiting the number of points and the drift length.

Shorter field-cage?

	He/CO_2 1m	Ne/CO_2 18cm
E	500 V/cm	300 V/cm
Max HV	50 KV	5.4 KV
Drift time	60 μs	6 μs
Drift velocity	1.68 cm/μm	3 cm/μm
Sampling freq	2MHz	10MHz
Number of samples	118	60
Specific ionization	10 e^-/cm	20 e^-/cm
Usable long. Slices	118	20 (shaper limited)
N. Radiation lenghts	6.6 E-4	5 E-4
X-ray abs. Coeff.	2.5 E-5 cm^{-1}	1.2 E-4 cm^{-1}
X-ray abs. probability	1	0.4
Electronics	HARP	ALICE

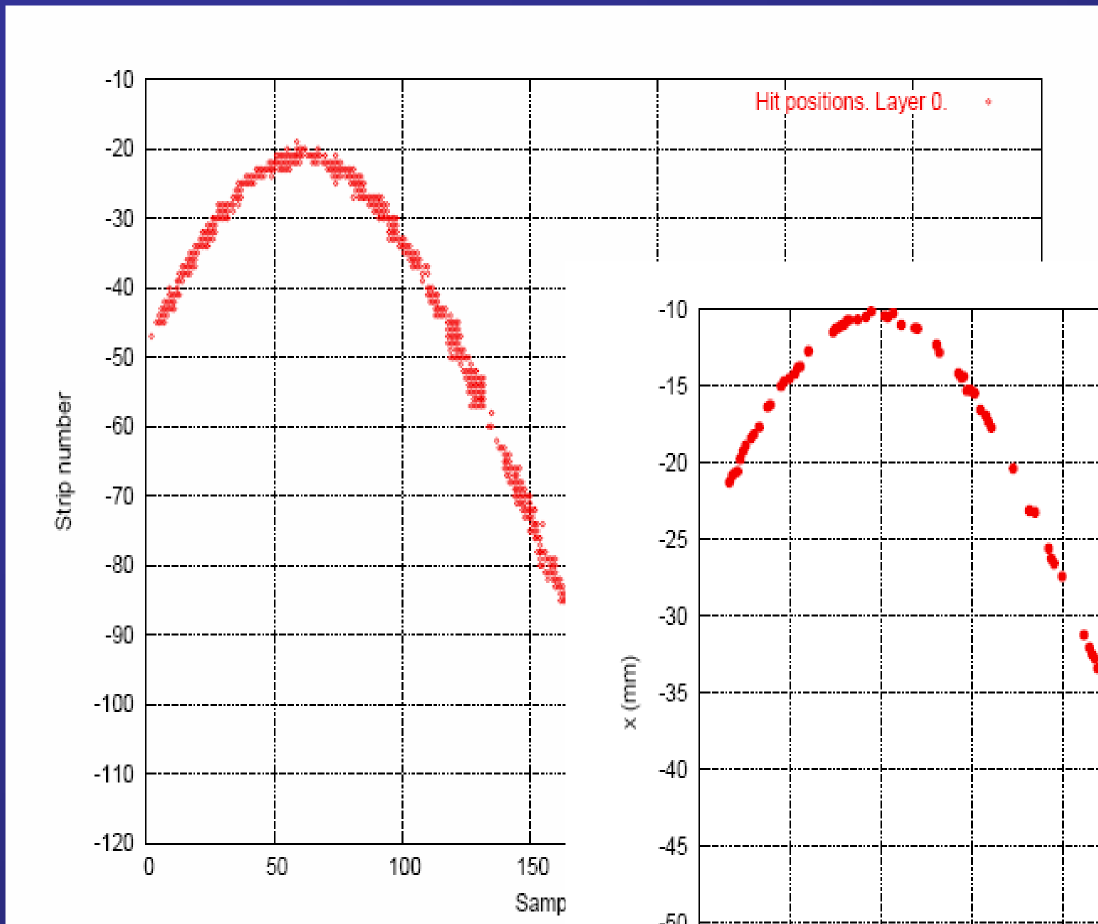
Advantages of a short TPG with Ne

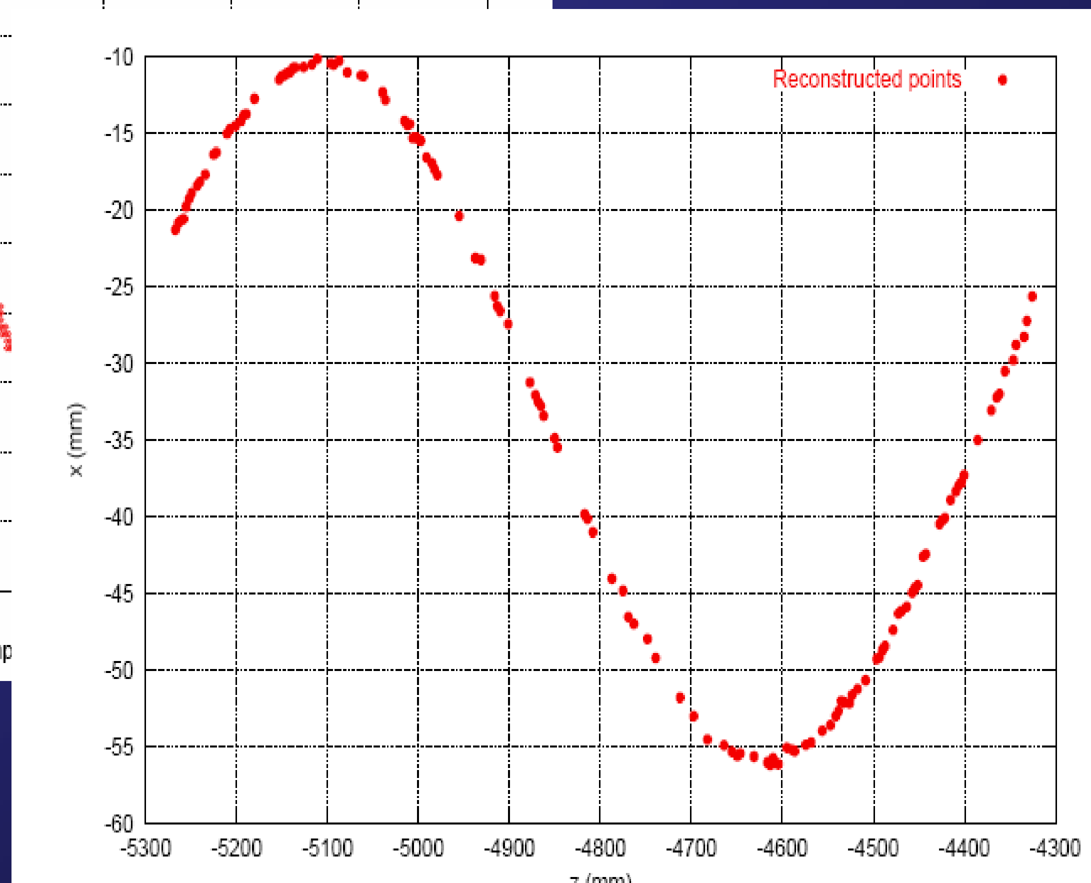
- Straightforward “poor’s man” construction
  - 20 cm field-cage made of a small insulating cylinder internally covered by a Cu-clad Kapton foil.
  - Field shaping strips made by Cu etching
  - Moderate HV
    - Simple insulator
    - More friendly for safety
- Lager ionization
  - Better resolution
- Faster mixture
  - Less sensitive to X-ray background



Simulation / reconstruction

- Short (18cm) and long (1m) Ne/CO_2 TPG have been simulated in G4MICE and reconstructed.
  - Thanks to Rikard and Olena
- Results are very encouraging, even if – for the moment – the experimental resolution is not reproduced in the MC
  - Maybe due to different gas mixture
  - If X-ray background not a problem, one could go to Ar-based mixtures -> even better TPC performance
    - Slightly more material, but TPG starts from <u>very</u> low amount
- Simulation results should be considered as upper limits.


Hit positions. Layer 0.
Strip number
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
50
100
150
Samp


Reconstructed points
x (mm)
z (mm)
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-5300
-5200
-5100
-5000
-4900
-4800
-4700
-4600
-4500
-4400
-4300

	Short	Long
P_t rec – P_t mc	0.53 MeV/c	0.37 MeV/c
P_l rec – P_l mc	1.63 MeV/c	1.27 MeV/c
X residual	0.22 mm	0.26 mm
Y residual	0.23 mm	0.25 mm

- Residuals not in line with measured position resolution (~0.04 mm). Need more studies.
- Notice the better momentum resolution of the longer TPG, compared with the (average) worse residuals
  - “long” is too long, the last part of the track has larger residuals and is practically useless in the fit
- “short” and “long” are extremes
  - Marginal improvement due to 1/sqrt(N) in Gluckstern formula combined by diffusion at long drift path indicates a possible optimum at ~40 point (30 to 35 cm)

Outlook

- New design could allow to build a full detector with simple means and at a very (very) moderate cost
- New electronics has the necessary "grade" for application in the real experiment
  - S/N is OK
  - No rate problems whatsoever (as many muons per spill as you want)
  - More test data taking will be made with the new electronics … But do not expect this for tomorrow
- Simulation/reconstruction is catching up, but needs further study
- TPG is not any more on the critical path, but it keeps moving slowly under the water surface …