Demokritos
National Centre for Scientific Research

Institute of Nuclear and Particle Physics

A Micromegas TPC Polarimeter

George Fanourakis

Institute of Nuclear and Particle Physics

NCSR "Demokritos"

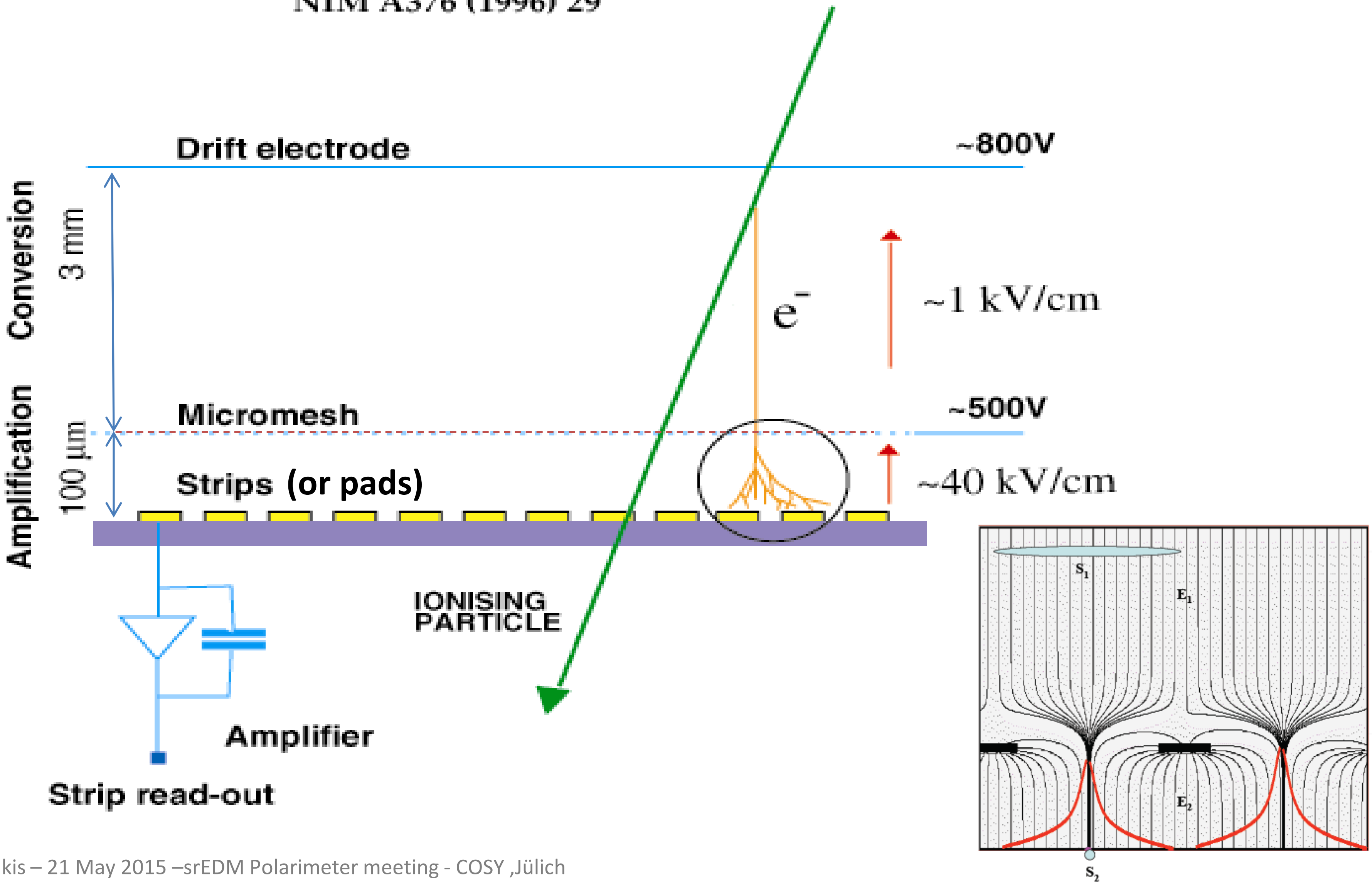
Technology choice: Micromegas

Justification

- A mature technology for tracking, calorimetry, UV, X-ray, neutron, polarimetry … applications
- Robust, stable operation
- Very good energy resolution
- Very good linearity
- Very good position resolution
- Fast signals
- High radiation resistance
- Industrial fabrication process
- Many application fields (Particle Physics, Nuclear Physics, Medicine, Industry…)

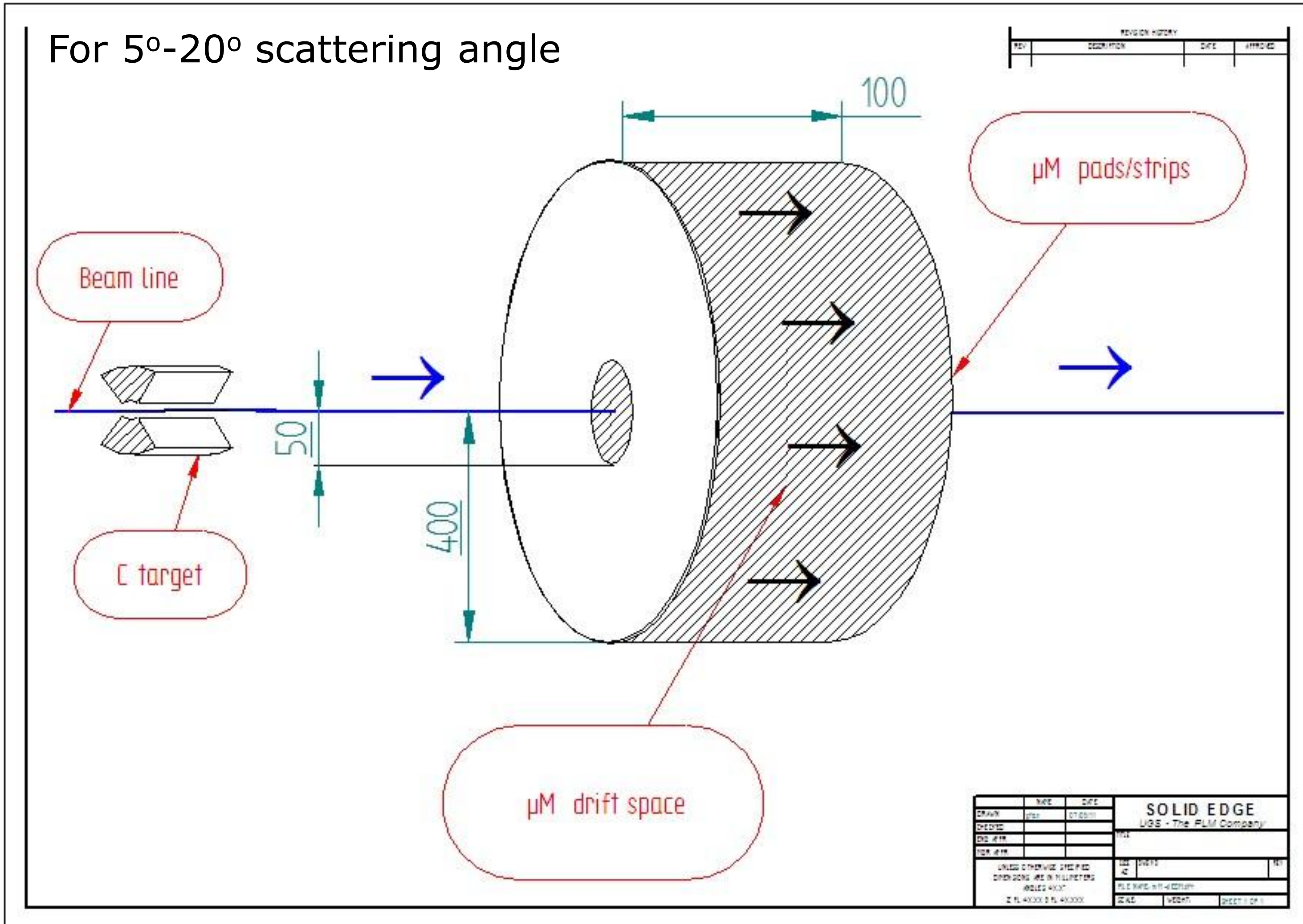
Micromegas principle of operation

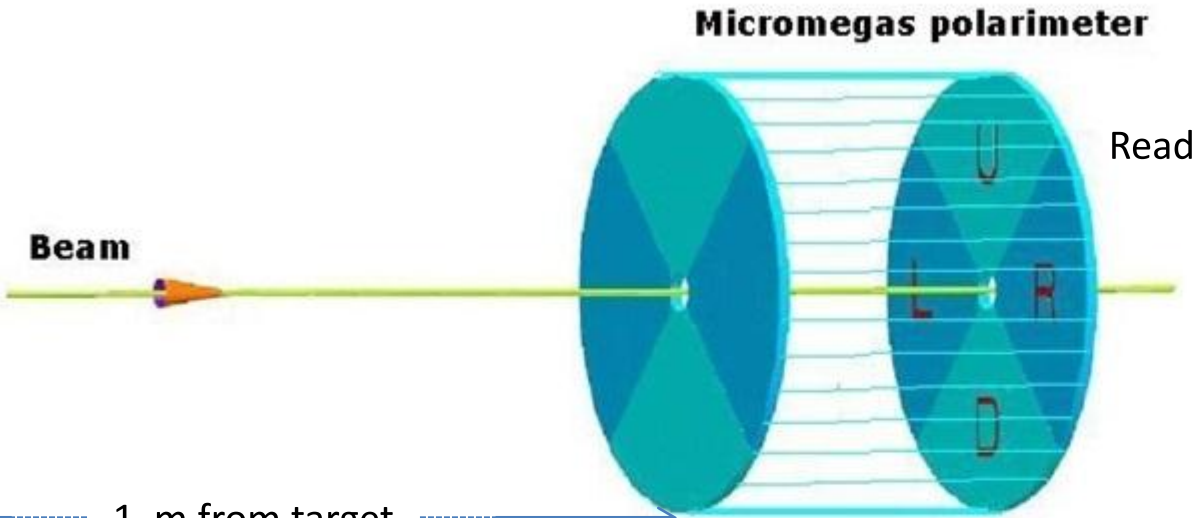
Y.Giomataris, Ph. Rebourgeard, J.P Robert and G. Charpak
NIM A376 (1996) 29



Designing the MM polarimeter

Units in mm - Not to scale

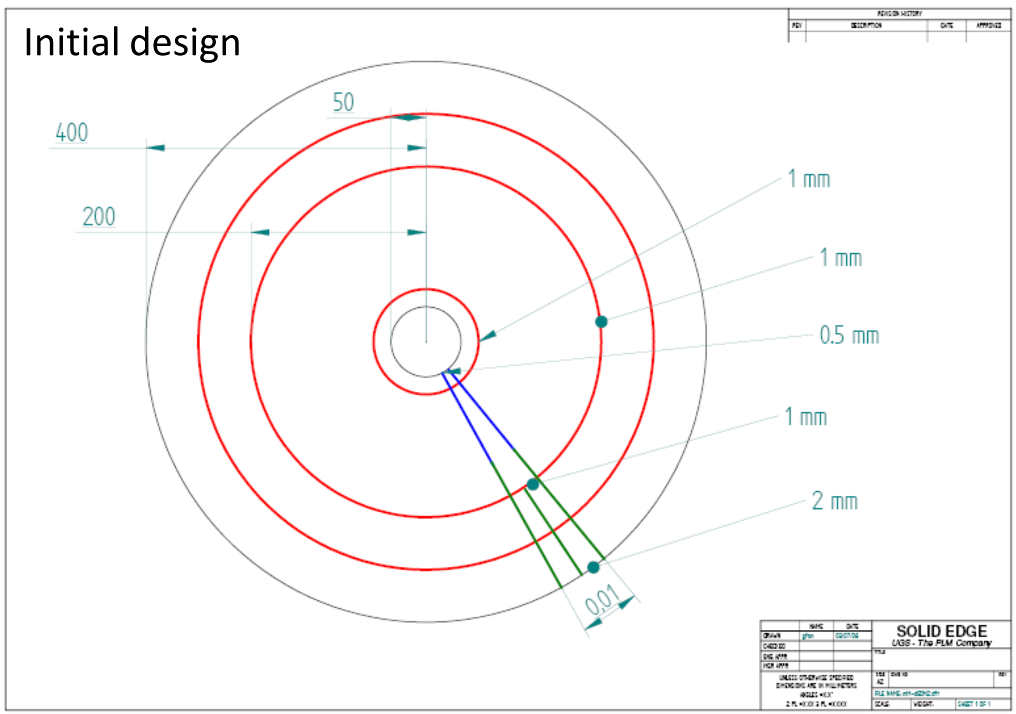




Readout divided in 16 sectors

1 m from target

10 cm drift



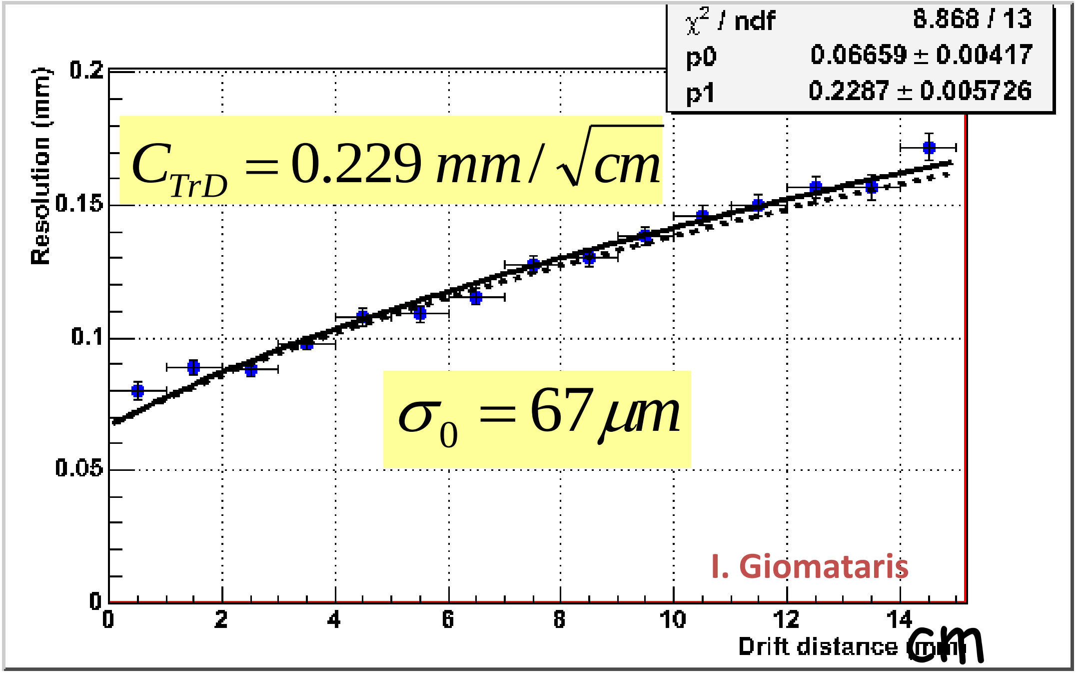
Diffusion issues

$$\sqrt{\sigma_0^{\;2} + \frac{C_{TrD}^{\;\;2}}{N_{eff}} z}$$

σ_0: resolution at zero drift, C_{TrD}: Transverse Diffusion constant, z: drift distance,

N_{eff}: the effective number of electrons over the pad size

Micromegas Ar + 10% CO2



Parameters

Worst case scenario

Gas: C_{TrD}=500μm/sqrt(cm)

Track coming at 5° → 9mm transverse dimension for a 10 cm drift

(for a 20° track it is ~36mm)

N_{eff} ~ 100 for 1mm pad/strip

↓

Longitudinal or transverse diffusion < 150μm

↓

If the track (mip) is sampled over 9 strips:

→ Transverse resolution < 150μm/3*10cm = 500 μrad

But much better for a proton or deuteron

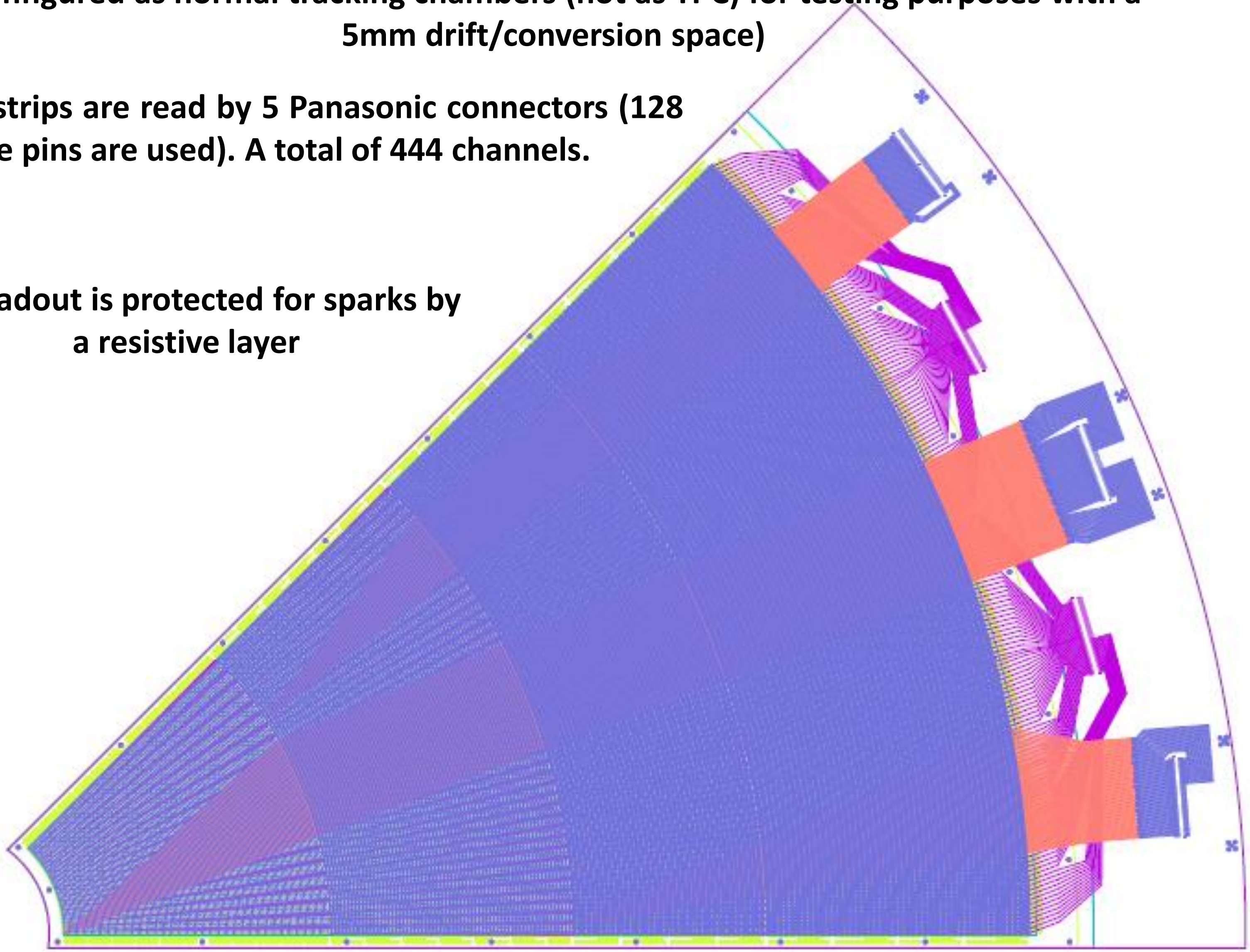
However, we do not need that much accuracy, since the multiple scattering raises the achievable angular resolution more than 1-2 mrads.

A prototype octant design

Configured as normal tracking chambers (not as TPC) for testing purposes with a 5mm drift/conversion space)

The r and phi strips are read by 5 Panasonic connectors (128 pins, not all the pins are used). A total of 444 channels.

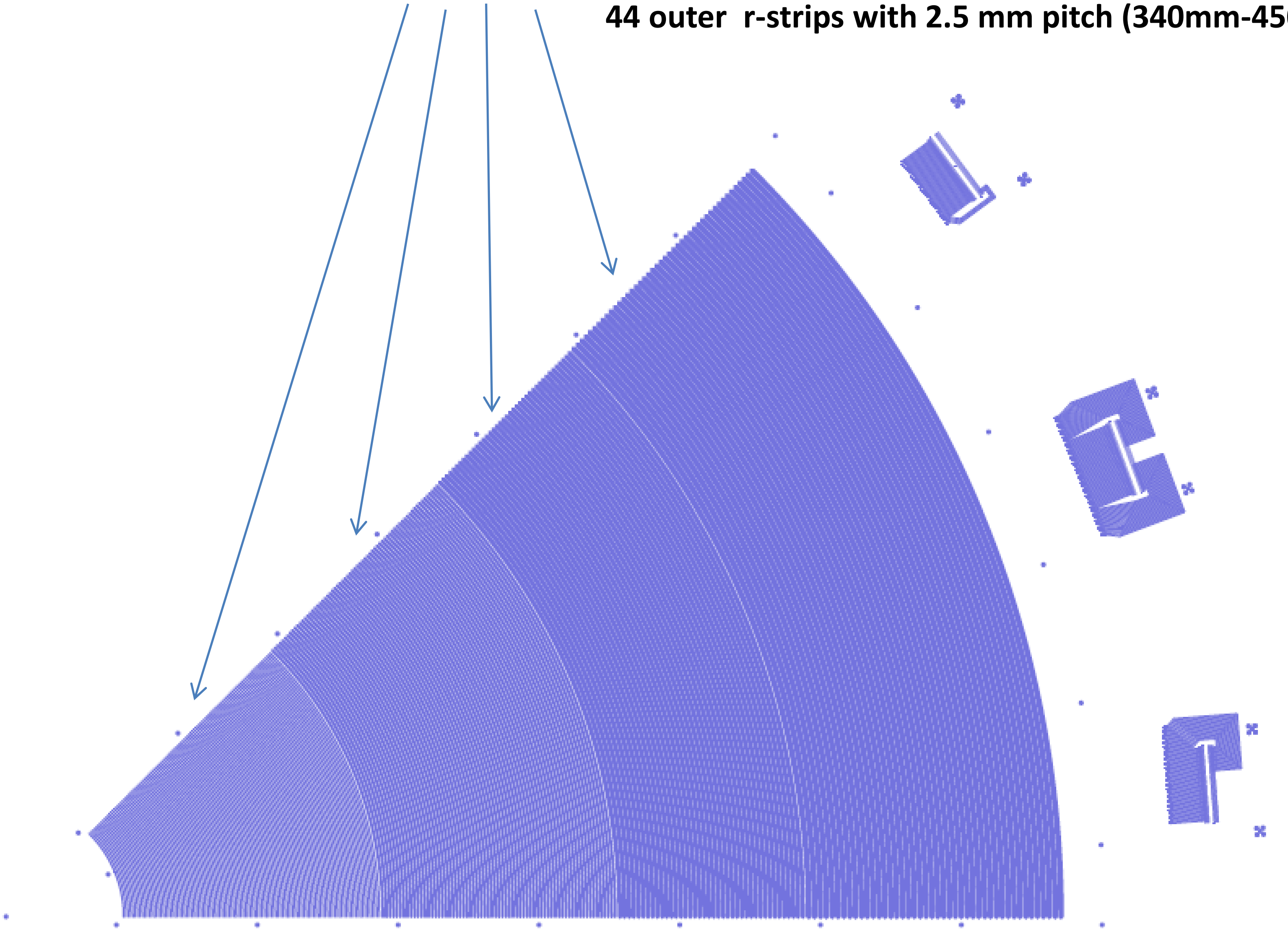
The readout is protected for sparks by a resistive layer



r-strips

260 r-strips,
4 sections

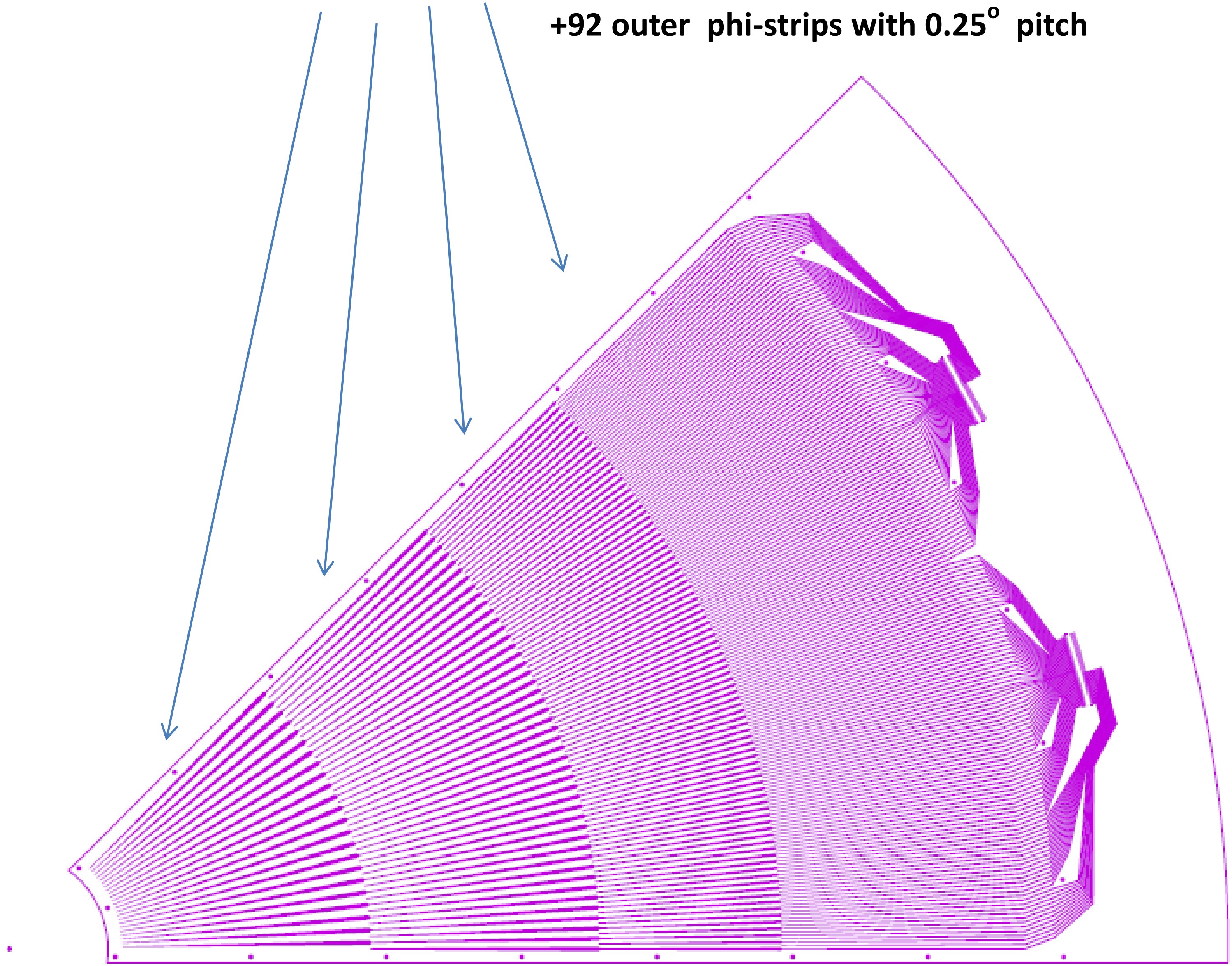
110 inner r-strips with 1 mm pitch (49mm-160mm)
66 next r-strips with 1.5 mm pitch(160mm-260mm)
40 next r-strips with 2 mm pitch (260mm-340mm)
44 outer r-strips with 2.5 mm pitch (340mm-450mm)



phi-strips

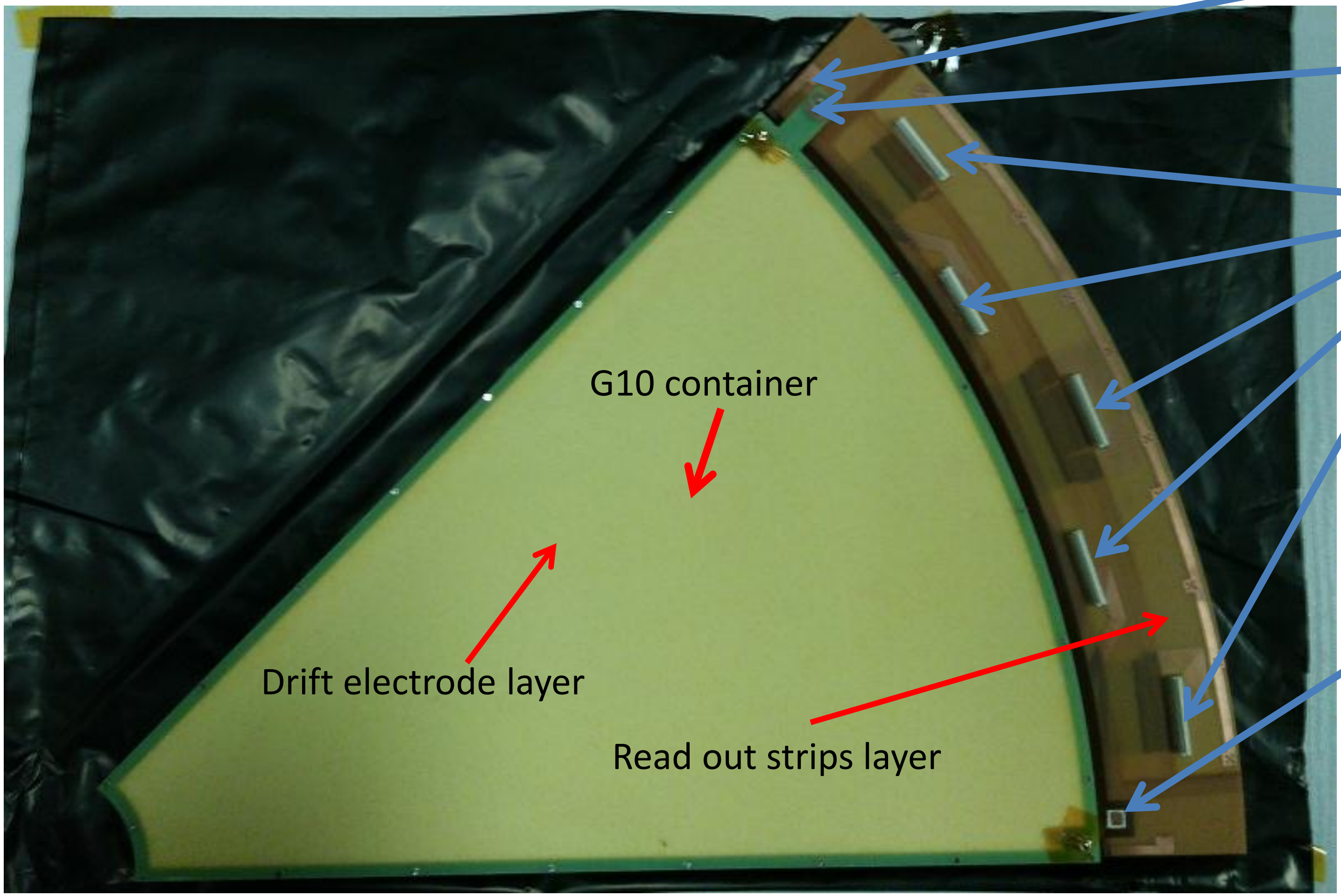
184 phi-strips,
4 sections

23 inner phi-strips with 1.96^{o} pitch (0.2mm-2mm,)
+23 next phi-strips with 0.98^{o} pitch
+46 next phi-strips with 0.49^{o} pitch
+92 outer phi-strips with 0.25^{o} pitch



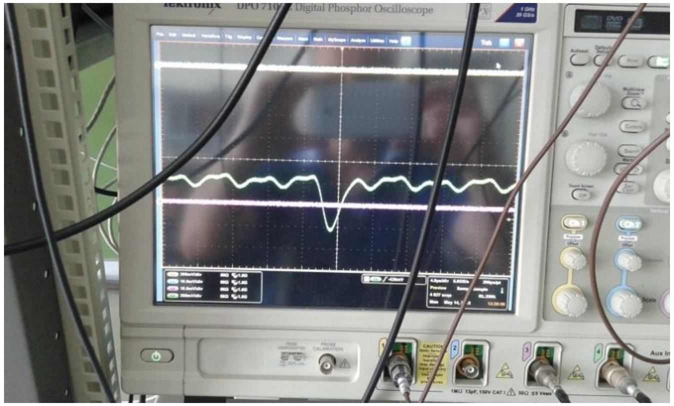
Implementing the prototype octant

Two r-phi prototype octants have been ordered and constructed in the electronics lab of CERN. One with a 10 MOhm/sq and one with a 100MOhm/sq resistivity of the resistive layer, to test the behavior in various beam density situations (fast or less fast operation).



Initial tests of an octant

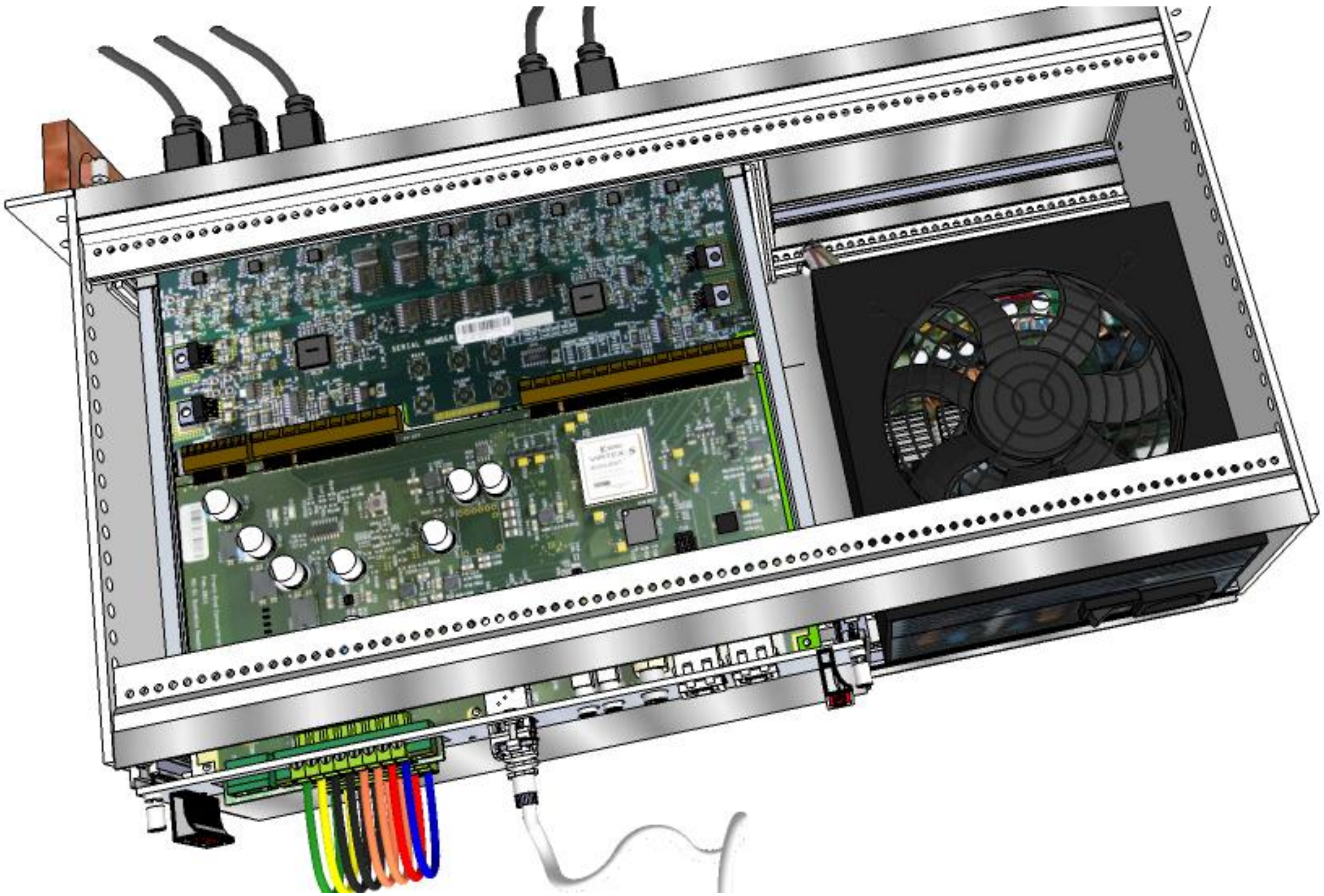
We started testing one of the r-phi octants using the SRS readout system using the APV chips, developed by the RD51 collaboration. This system reads both the charge and the time of the pulse from each strip. We use two big scintillator counters (provided by HOU) to trigger. We use the MMDAQ Software developed by ATLAS.



The SRS RD51 scalable readout system

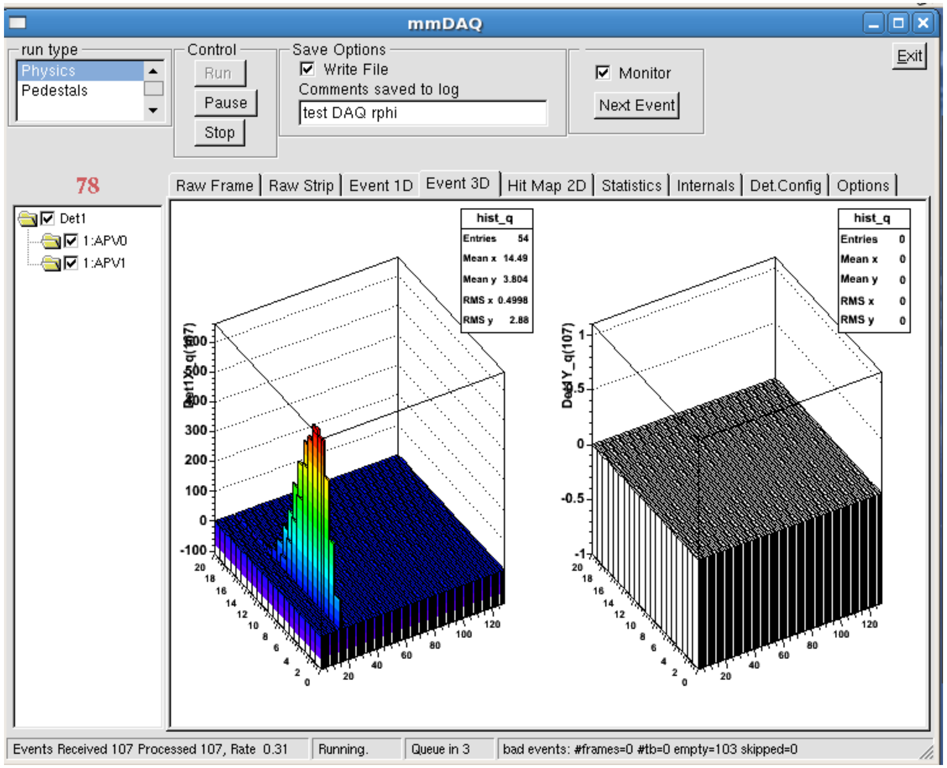
SRS Minicrate

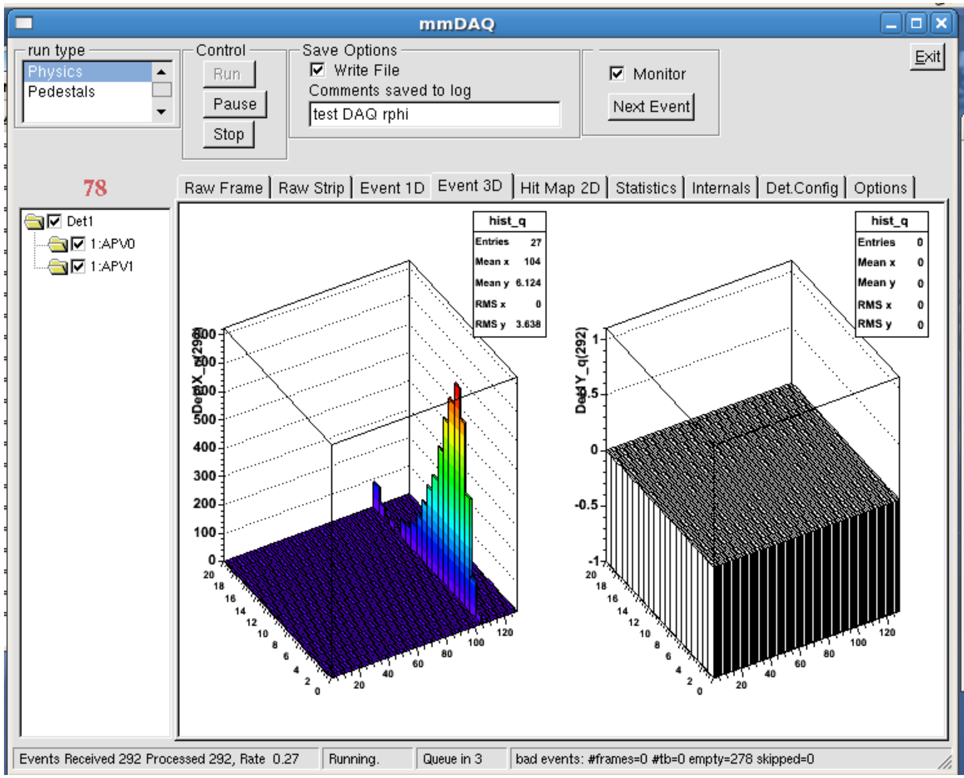
a portable solution for up to 4k channels



FEC card ADC card

APV front end r or phi strip signals





25 ns signal sampling

Sampling and Readout logistics – a solution

Maximum track rate expected: 40 MHz

For a 10 cm drift the ionization e's take 2-3 μs to reach the anode: ~ 120 tracks max present in the TPC at all times.

→ An average of ~ 120/3500 = 0.03 per channel
But each track involves > 9 strips

What matters is to be able to quickly determine the arrival time of the drift electrons at each involved strip. This can be done within 200ns, for each of its 64 channels, with the VMM chip developed by Brookhaven for the ATLAS experiment

The 3rd version of the VMM chip is expected by the end of this summer. Work is being done (by ATLAS and RD51) to use this as a front end (instead of the APV) in the SRS system.

MM Polarimeter costs (Euros)

Full 2π detector:

Design of the readout board: 5K
Construction of the Micromegas board: 25K
Design of detector cylinder, drift plane, field shaper: 2K
Construction of detector cage, drift plane, field shaper: 7K
SUM: 40K

Gas system: 10K

Readout system (VMMs):

60x64 channel VMM front ends: 60x200= 12K
Interfaces: 10K
Power supplies, NIM modules, crate, : 40K

Calibration system: 10K

Estimated total: ~130K (does not include costs of physicists' manpower)

More testing plans and prospects

We plan to continue testing these octants using the SRS/APV readout.

Testing plans

- **Test with cosmic rays at Demokritos**
- **Test with beams at CERN and/or Julich**

Next steps (assuming we obtain further funding)

- **Use the above prototypes in real TPC mode (supply a 10 cm drift space, use the same DAQ electronics initially)**
- **Do further tests in beam lines**
- **MC studies to determine the most efficient r and phi pitch and segmentation**
- **Design a full circle prototype (or maybe 2 halves, or 4 quadrants) with 16 independent octants**
- **construct it and test it.**
- **Design a calibration system**