A new cylindrical drift chamber for the MEG II experiment

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Frontier Detectors for Frontier Physics
13th Pisa Meeting on Advanced Detectors
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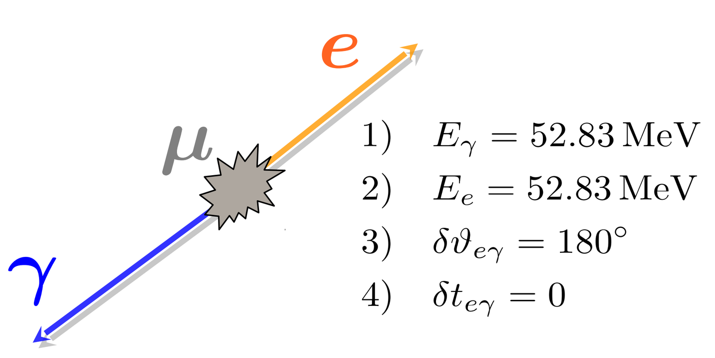
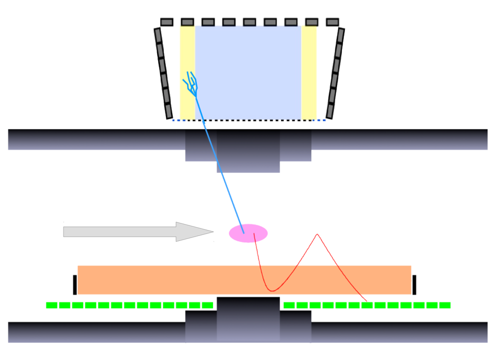
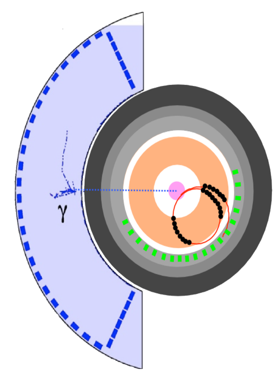
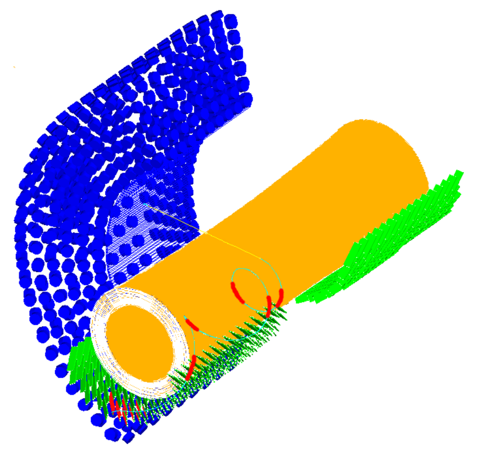
The MEG experiment searches for the **μ → eγ** decay at the Paul Scherrer Institut (PSI) near Zurich, Switzerland. With the analysis of half of the collected statistics, a new upper limit on the branching ratio has been set BR(μ → eγ) < **5.7×10^{-13}** at 90% CL. MEG has recently ended taking data and the final result will be published within 2015. However a substantial improvement of MEG results requires an improvement of detector performances, in order to reject the **background** contributions which limit the signal sensitivity. This will be carried out by a short-term upgrade of the apparatus, that will reach a sensitivity of **$\sim 5 \times 10^{-14}$** on the branching ratio at 90% CL. In MEG II 7×10^{7} μ^+/s will be stopped in a thin target. The four-momentum of photons exiting the target is measured by means of a liquid **Xenon detector**; positrons are tracked by a magnetic spectrometer composed of a **drift chamber** and two **pixelated timing counters** and immersed in a **non uniform magnetic field**.





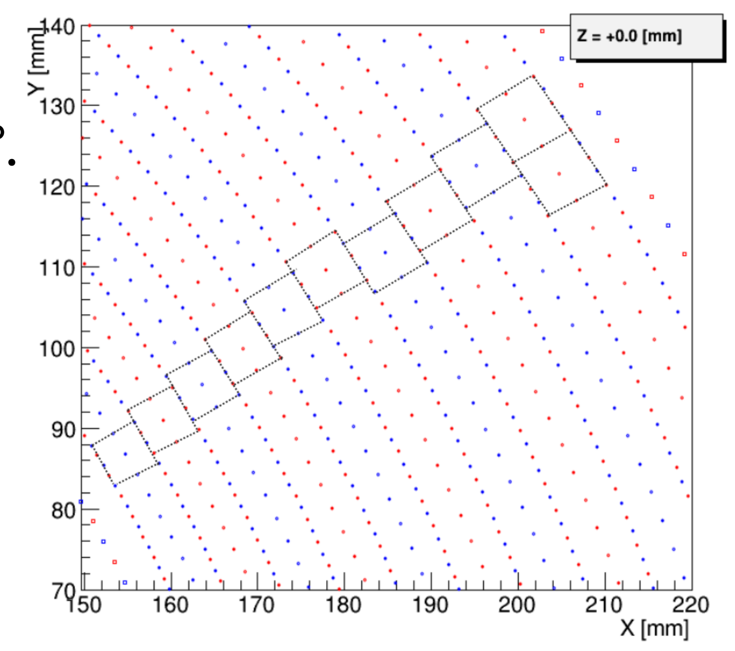




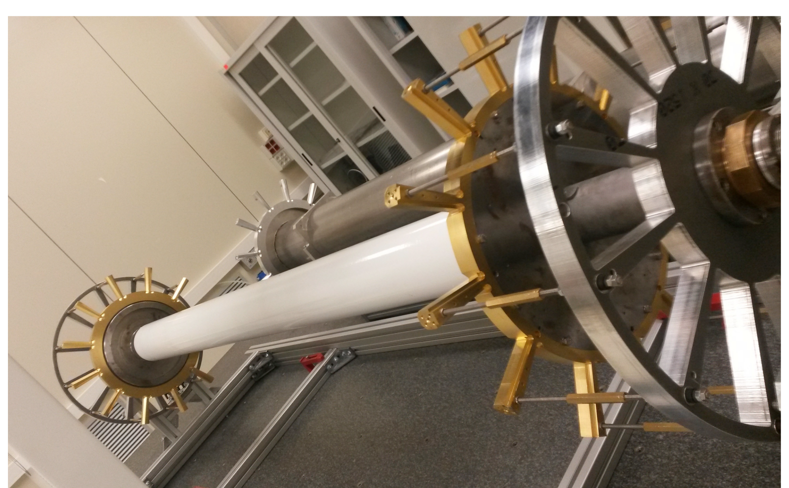
The detector

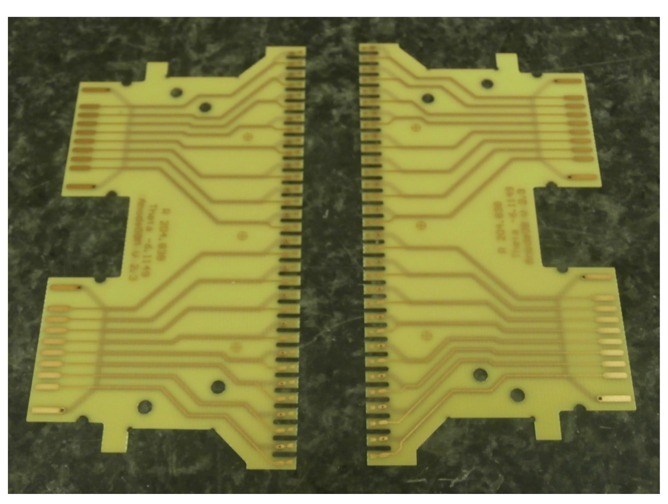
The MEG II tracker is a single-volume cylindrical drift chamber with:

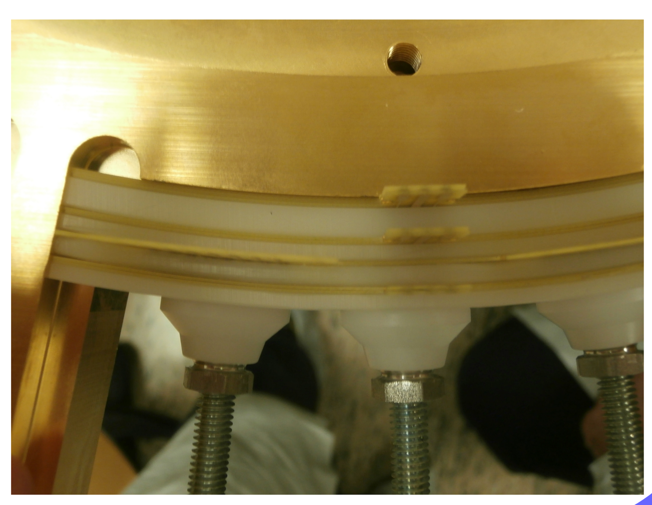
- 10 layers of drift cells with anodes at alternating **stereo angles** 7°-8°.
- drift cells having an approximately **squared** shape 7×7 mm².
- an **ultra-low mass gas** mixture with helium and isobutane 85:15, yielding **less than 2×10^{-3} radiation lengths** per track.
- 20 μm gold-plated tungsten wires as anodes.
- 40-50 μm silver-plated aluminum wires as cathodes and guard wires.
- 2π coverage for a length of 193 cm.
- **double readout** for longitudinal coordinate estimate.



The detector geometry will be realised by the stacking of FR4 wire PCBs with PEEK spacers in each sector of the endplate. A carbon fiber support structure will guarantee the proper wire tension. In the inner side an aluminated mylar foil will tight the gas volume. All the mechanical compatibilities and the insertion in the MEG II apparatus will be checked with a mock-up chamber.





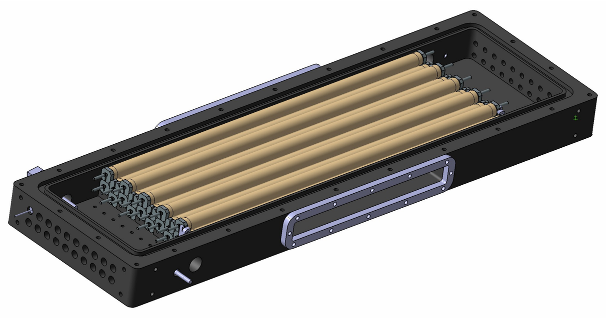


HV system

- ISEG boards with high resolution and stability
- Low noise in a GHz bandwidth

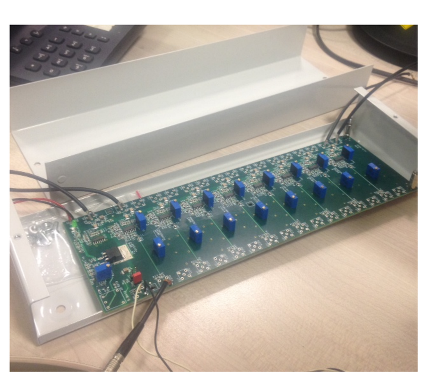
Gas system

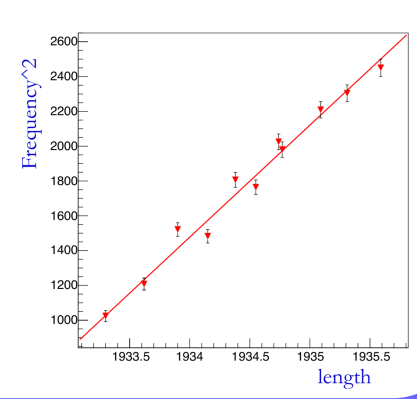
- Good control of the gas quality (oxygen, moisture, hydrocarbons)
- Drift tube chamber for real time gas monitoring with radioactive sources



Wire strain measurement

The tension of the drift chamber wires will be measured with an **acoustic method.** Mechanical oscillations are induced by acoustic bursts on wires at high voltage. The change of the capacitance of the cell induces an electric signal.





Readout

Differential drift chamber signals are digitised by DRS4 chip at a (programmable) speed of 2 GSPS with an analog bandwidth of 1 GHz. This is necessary for ionisation cluster identification.

Presented by S.Ritt in the Front-end, Trigger, DAQ and Data Management session

Expected performance

The MEG II drift chamber will track ~50 MeV positrons in a very harsh environment (~30 kHz/cm hit rate).

Resolutions	MEG	MEG II
p_e (keV)	306	130
ϑ_e(mrad)	9.4	5.3
φ_e(mrad)	8.7	4.8
e^+ efficiency (%)	40	88

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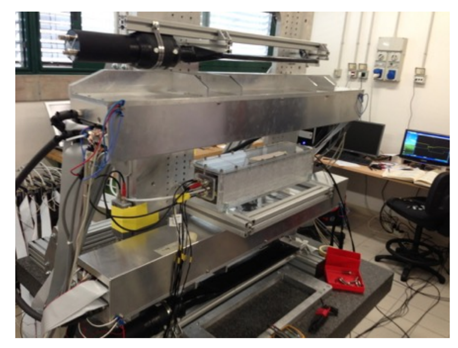
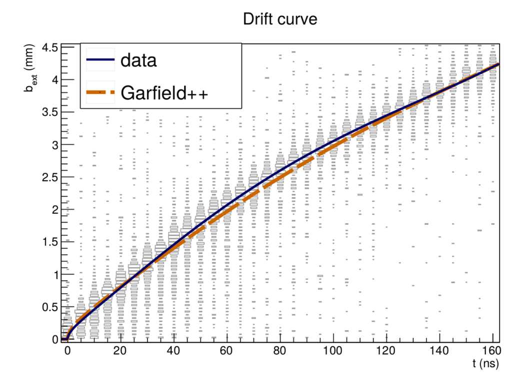
Do not miss the related contributions in the poster sessions!!!

Prototype tests with an external tracker

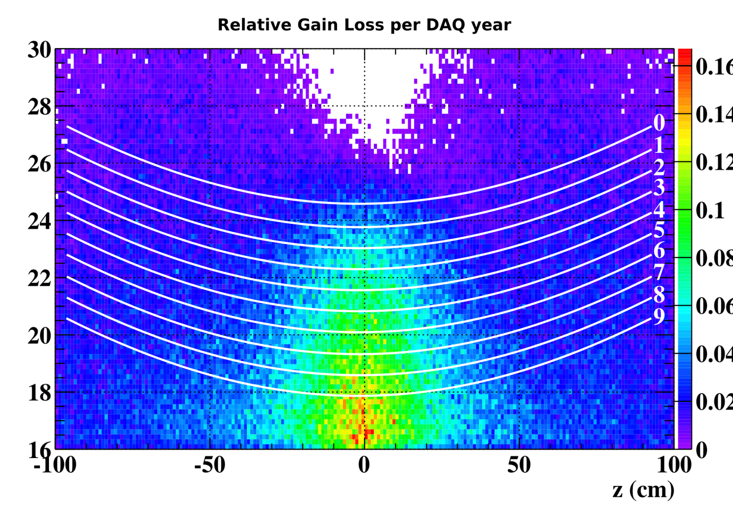
The transparency of the chamber has the drawback of a poor **ionisation statistics** in the detector, which results in a bias and a worsening of resolution in the impact parameter estimate. For a clean measurement of the single-hit resolution we used an **external silicon tracker**. Details shown in the poster by L. Galli.





Ageing tests on prototypes

The extremely **high muon rate** in the MEG II spectrometer results in a huge amount of charge collected in the hottest portion of the innermost wire (**~0.5 C/cm**).



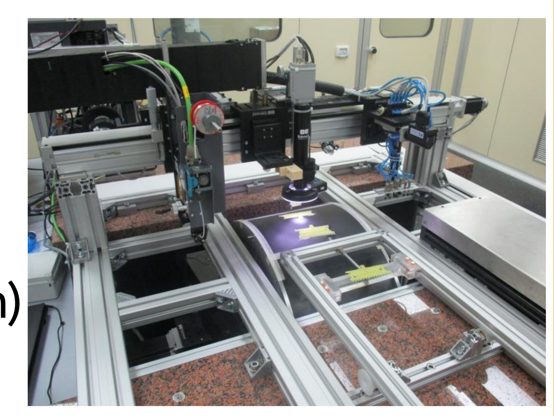
We performed laboratory tests to measure the **robustness** of the chamber to **ageing effects**. See the poster by M. Venturini.

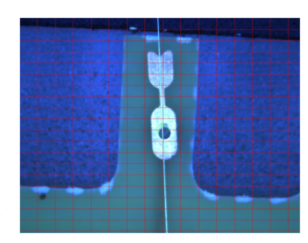
Wiring machine development

A new construction tool has been developed. It consists of:

- a semiautomatic wiring machine with a high precision on wire mechanical **tensioning** (< 0.5g) and on wire **positioning** (~20 μm) for simultaneous wiring of multi-wire layers;
- a contact-less **IR laser soldering tool**;
- an automatic **handling system** for storing and transporting the multi-wire layers.

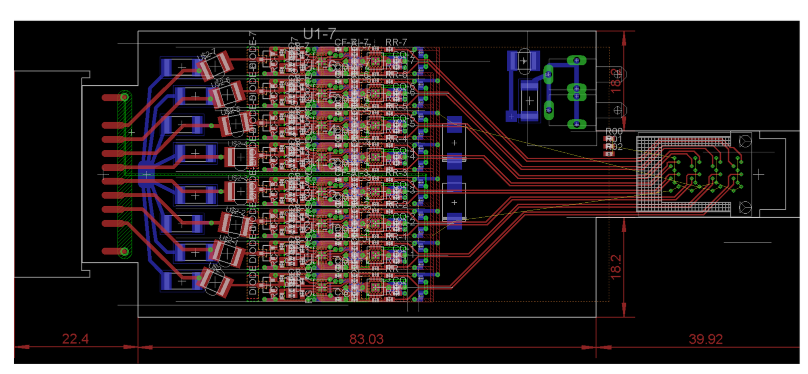
Full description in the poster by G. Chiarello.





High performance Front End Electronics

In order to permit the detection of single ionisation acts, the electronic readout interface has to process high speed signals. For this purpose, a high performance 8-channels **front-end electronics** has been designed and tested. Simulations show a 3dB **bandwidth** around **1GHz** and a voltage gain of ~10. See the poster by A. Pepino.



Front-end, Trigger, DAQ and data management session

Development of cluster timing techniques

Improvement of the single-hit resolution with the timing of **individual ionization encounters** is possible due to:

- High bandwidth FE with large amplification.
- Low ionisation density gas.
- Waveform digitisation in the GSPS region.

Monte Carlo studies shown in a poster by G. Signorelli.