Commissioning of the MEG II tracker system

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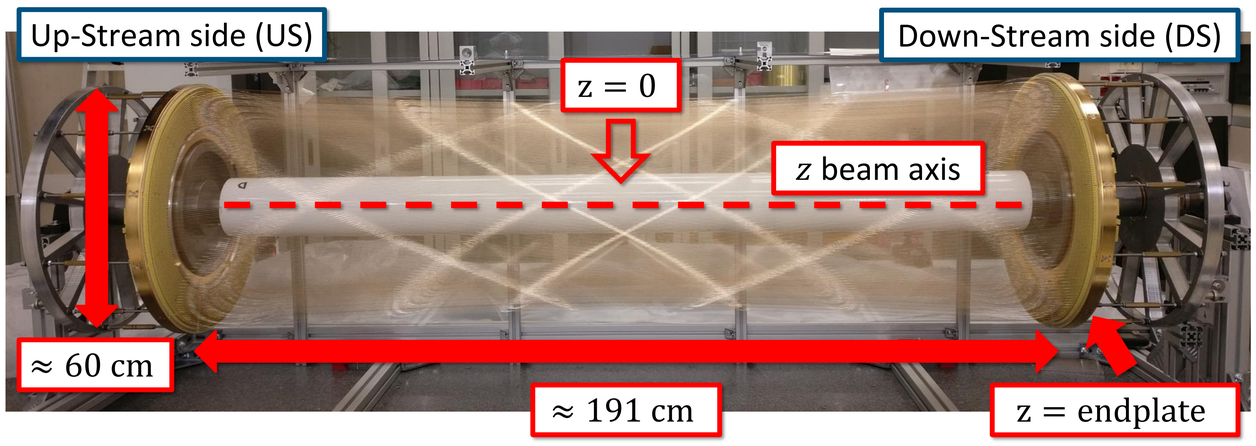
The final MEG results and its upgrade MEG II

The MEG experiment, with its first phase of operations at the Paul Scherrer Institut (PSI), **set the most stringent constraint on the Charged Lepton Flavour Violating (CLFV) $\mu^+ \to e^+\gamma$ decay**. The analysis of the 2009-2013 full data set, corresponding to $\approx 7.5 \times 10^{14}$ μ^+ stopped in the target at a stopping rate of 3×10^7 μ^+/s, resulted in the new best upper limit on the $\mathbf{BR}(\mu^+ \to e^+\gamma) \leq \mathbf{4.2 \times 10^{-13}}$ (90% C.L.), imposing one of the tightest constraints on models predicting LFV-enhancements through New Physics Beyond the Standard Model. The MEG experiment has practically reached its ultimate level of sensitivity, limited by the resolutions on the measurement of the kinematic variables of the two decay products. Therefore an **upgrade** (**MEG II**) **of the experimental apparatus** has been approved and is presently in the **commissioning phase at PSI**. MEG II aims at reaching a **sensitivity enhancement of about one order of magnitude** compared to the final MEG result, by **improving the detector figures of merit and the muon stopping rate** ($\times$ 2 factor on both). The 3 years physics data taking with all the upgraded detectors and the complete DAQ electronics is expected to start in 2020.

The MEG II Cylindrical Drift CHamber (CDCH)

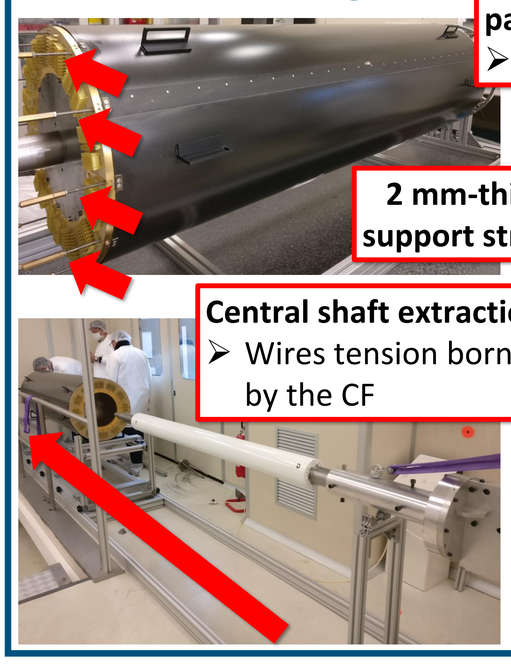
The new Cylindrical Drift CHamber (CDCH) is a key detector for the phase 2 of MEG. CDCH has been built by the INFN groups of Pisa, Lecce and Rome and is **designed to overcome the limitations of MEG e^+ tracker and guarantee the proper operation at high rates with long-term detector stability**.



- **Low-mass unique volume detector with high granularity** filled with He:Isobutane 90:10 gas mixture
  - 9 concentric layers: 192 drift cells, few mm wide, defined by 11904 wires
  - 20 μm Au-plated W anode wires, 40/50 μm Ag-plated Al cathode wires
  - High density of sensitive elements: $\times$ 4 hits more than MEG
  - Stereo wires geometry ($6.5° \div 8°$) for longitudinal hit localization
- **Total radiation length $\mathbf{1.5 \times 10^{-3}}$ $\mathbf{X_0}$** (less than 1.7×10^{-3} X_0 of MEG)
  - MCS minimization and γ background reduction
- **Single-hit resolution** (measured on prototypes): $\sigma_{hit} < 120$ μm
- **Momentum and angular resolutions** (full MC simulation of the MEG II experimental apparatus): $\sigma_P \approx 90$ keV, $\sigma_\theta \approx 6$ mrad, $\sigma_\varphi \approx 5.5$ mrad
- **Extremely high wires density** (12 wires/cm^2) → the classical technique with wires anchored to endplates with feedthroughs is hard to implement
  - **CDCH is the first drift chamber ever designed and built in a modular way**

CDCH sealing

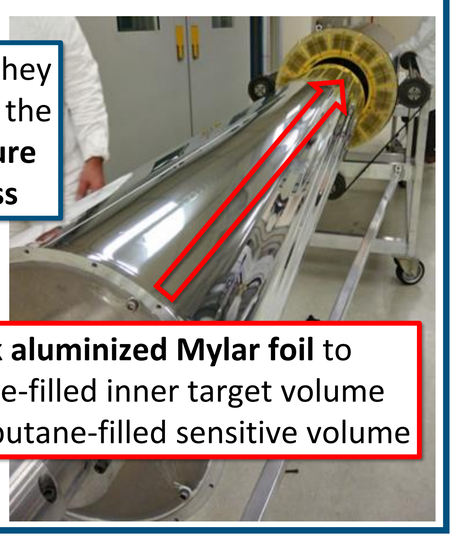
Fine tuning of the endplates distance, planarity and parallelism at a level better than 100 μm
- 12 turnbuckles per side connected to the endplates



2 mm-thick CF support structure

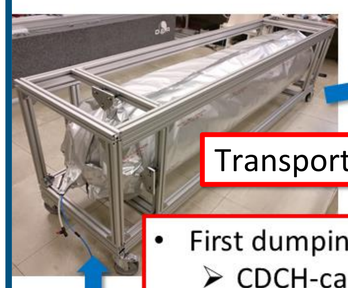
Central shaft extraction
- Wires tension borne by the CF

Together they guarantee the **gas mixture tightness**



20 μm-thick aluminized Mylar foil to separate the He-filled inner target volume from the He:Isobutane-filled sensitive volume

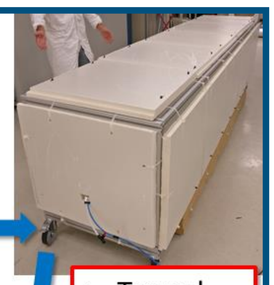
CDCH packing and transport to PSI



Transport cage

- First dumping system
  - CDCH-cage silent blocks
- First wrapping

- Second dumping system
  - Cage-floor rubber pillows
- Number of layers optimized to dump low frequency oscillations typical of a car travel



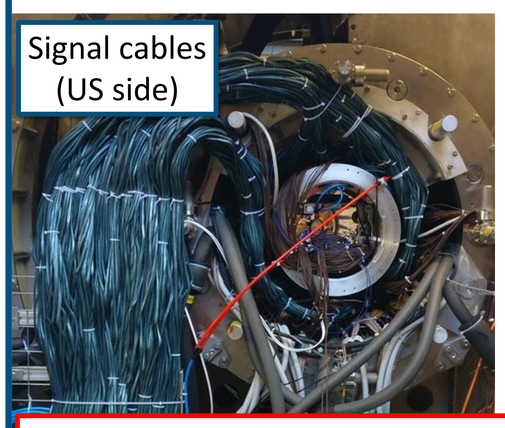
- Termal insulation panels

Nitrogen inside

- Second wrapping

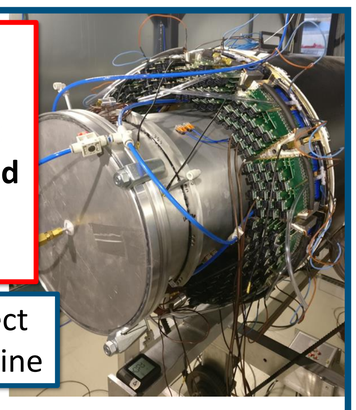
Used truck with air-conditioned load compartment

CDCH commissioning at PSI



Signal cables (US side)

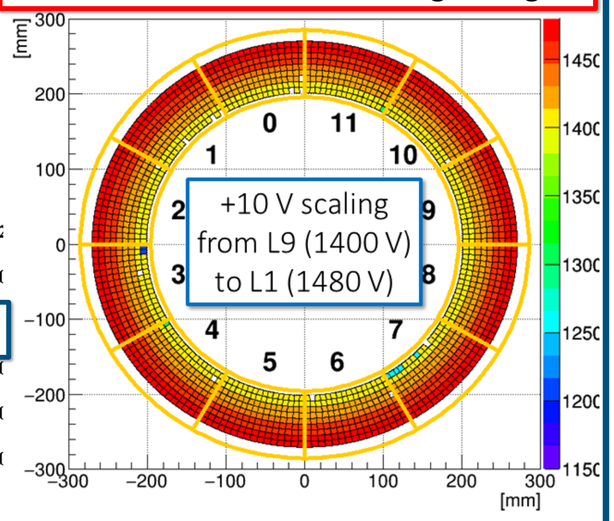
ENDCAPS PREPARATION
- **216 FE boards per side**
  - Double-side read out
- **Cooling pipes embedded in the FE cards holders**
  - T and RH sensors

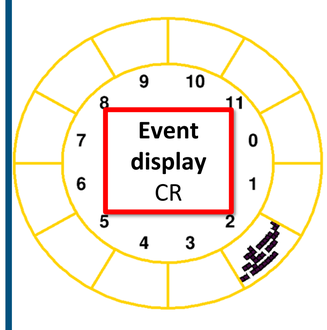


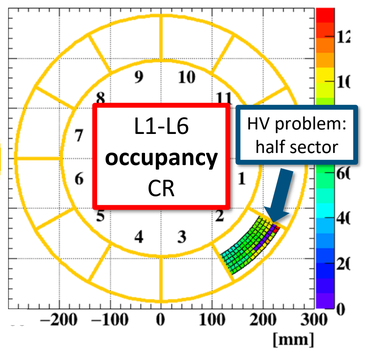
Inner extensions to connect CDCH to the MEG II beam line

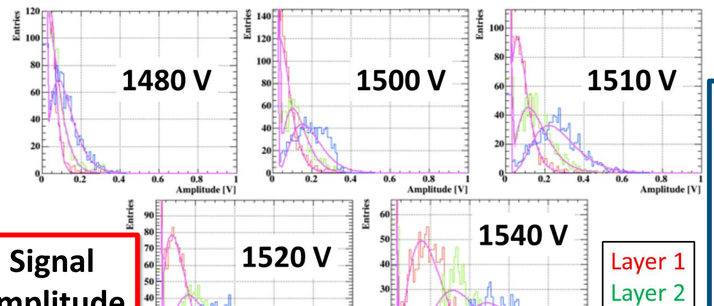
CDCH integrated into the MEG II apparatus
- 192 DAQ channels available
- **2018 and 2019 data taking runs** with
  - **Cosmic Rays** (CR) for gain studies
  - **Muon beam** at different intensities

HV MAP AT THE WORKING POINT (WP)
- **HV for gas gain $G = 5 \times 10^5$**
- Garfield simulations on single e^- gain





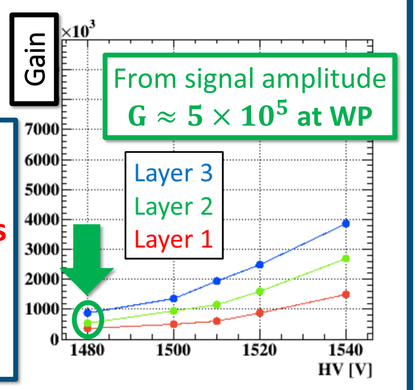




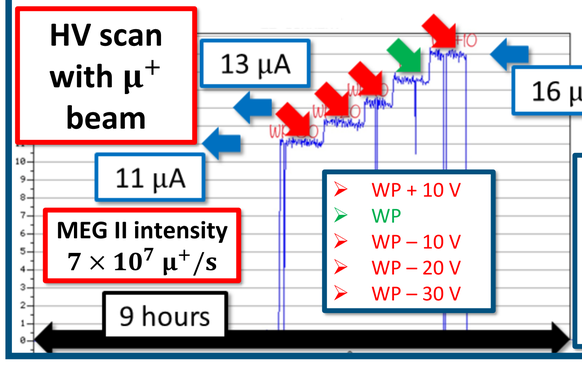
Signal amplitude vs. HV

Layer 1
Layer 2
Layer 3

First gain studies from CR data

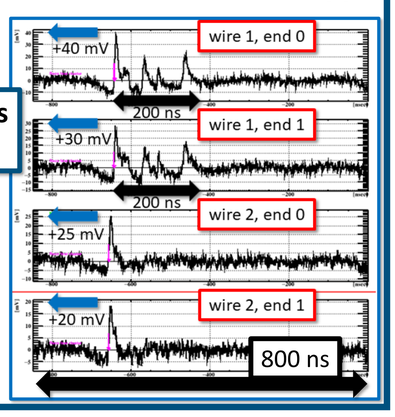


HV scan with μ⁺ beam



Example of **gain curve**
- Current vs. HV
- ~ **exponential behaviour with the HV increase**

Typical **waveforms from Michel e^+**



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- **M. Chiappini PhD thesis**: https://meg.web.psi.ch/docs/theses/chiappini_phd.pdf

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