A novel wiring technique to build ultra-low mass high-wire density drift chambers

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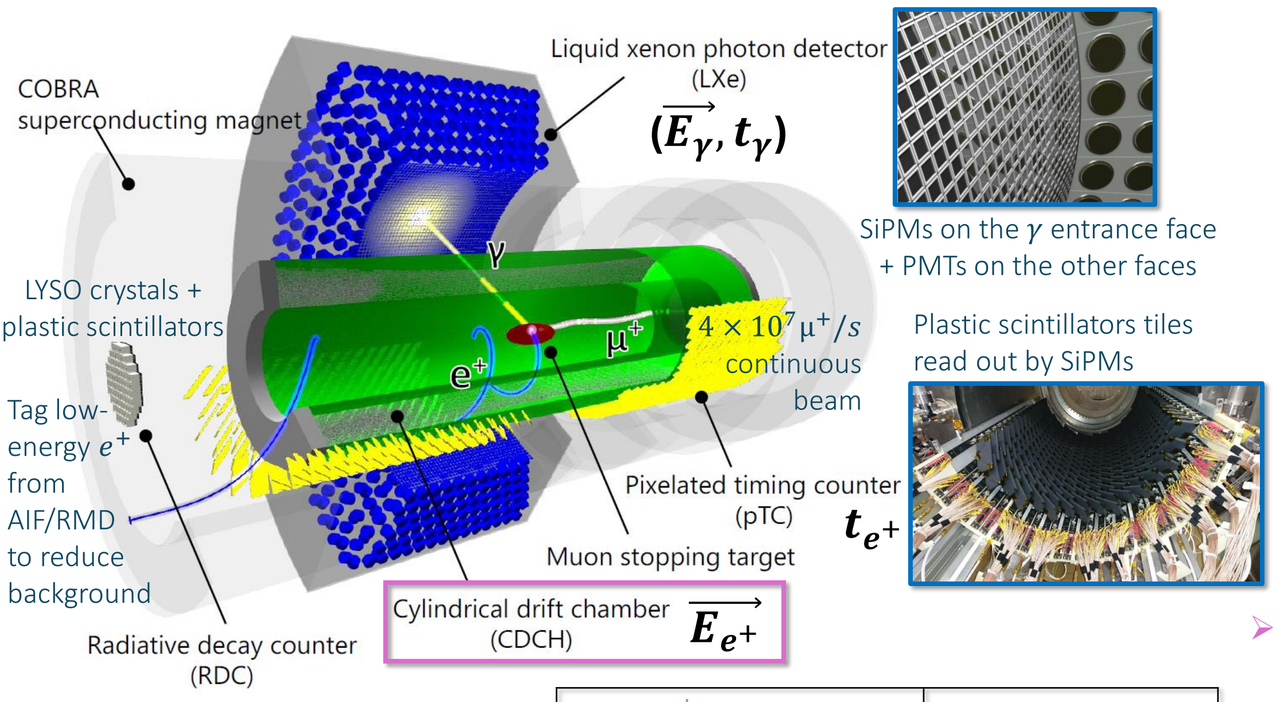
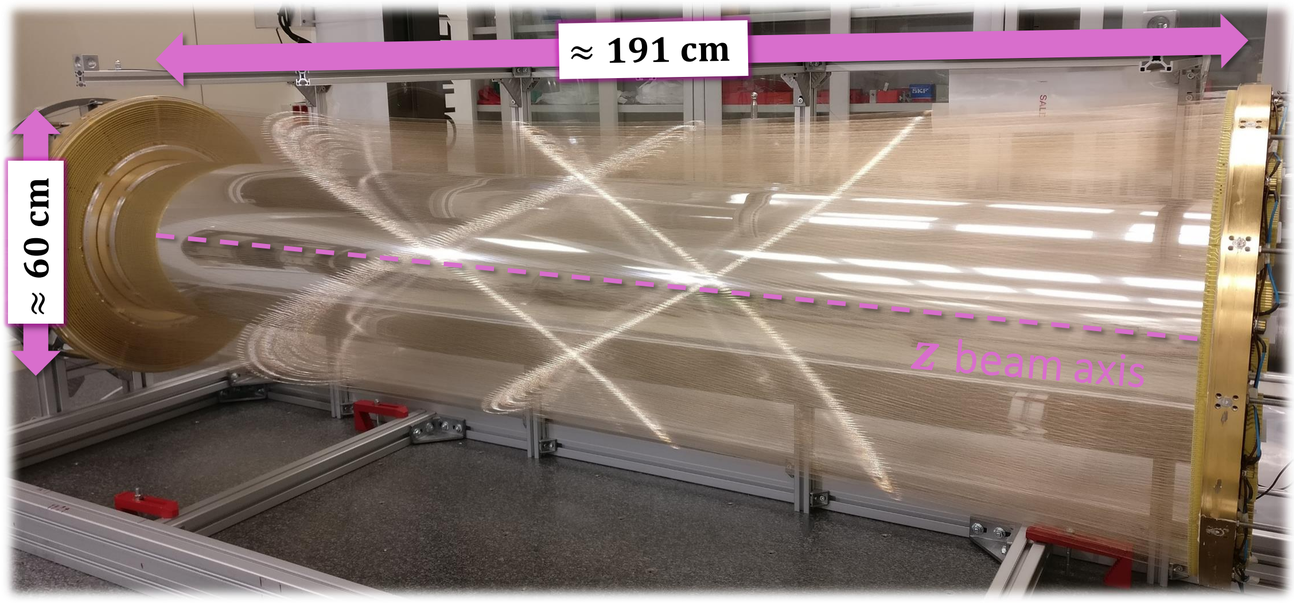
Physics context: the Mu-E-Gamma II experiment at PSI



SiPMs on the γ entrance face + PMTs on the other faces

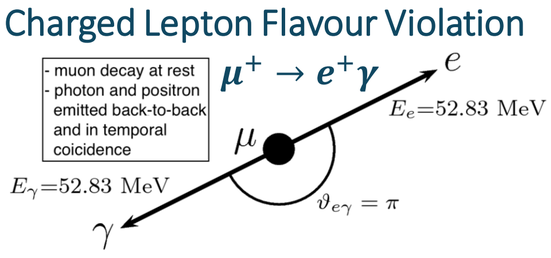
Plastic scintillators tiles read out by SiPMs

Application: the Cylindrical Drift CHamber (CDCH)



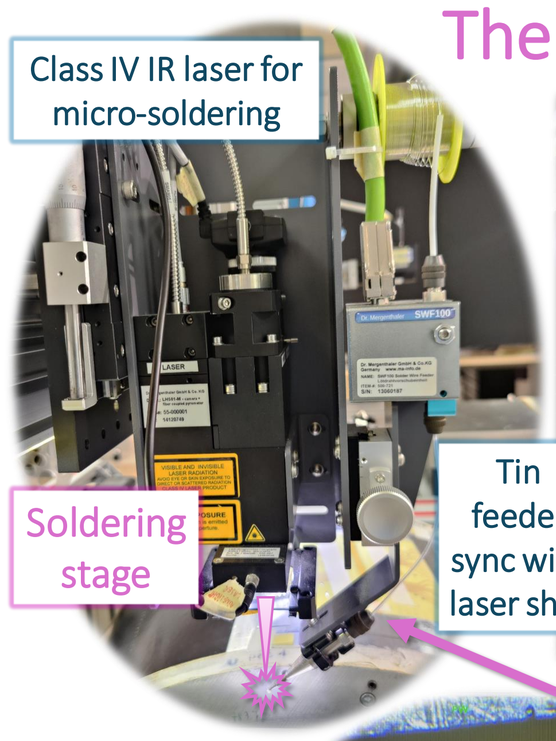
- Low-mass single volume detector with high granularity filled with He:iC$_4$H$_{10}$ 90:10 gas mixture
  - + additives to improve the operational stability: 1.5% isopropyl alcohol + 0.5% Oxygen
  - 9 concentric layers of 192 drift cells defined by ≈12000 wires
  - Small cells few mm wide: occupancy of ≈1.5 MHz/cell (center) near the stopping target
  - High density of sensitive elements: ×4 hits more than MEG phase 1 Drift CHamber (DCH)
- Total radiation length $\mathbf{1.5 \times 10^{-3}\ X_0}$: less than $\mathbf{2 \times 10^{-3}\ X_0}$ of MEG DCH or ≈150 µm of Silicon
  - MCS minimization and γ background reduction (bremsstrahlung and Annihilation-In-Flight)
- Single-hit resolution (measured on prototypes): $\sigma_{hit} < 120\ \mu m$
- Extremely high wires density (12 wires/cm^2) → modular design and assembly

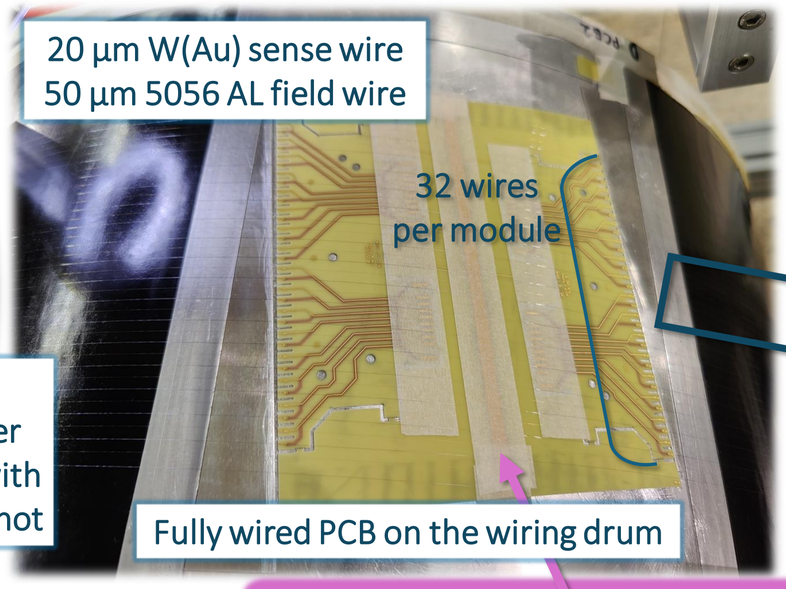
Charged Lepton Flavour Violation

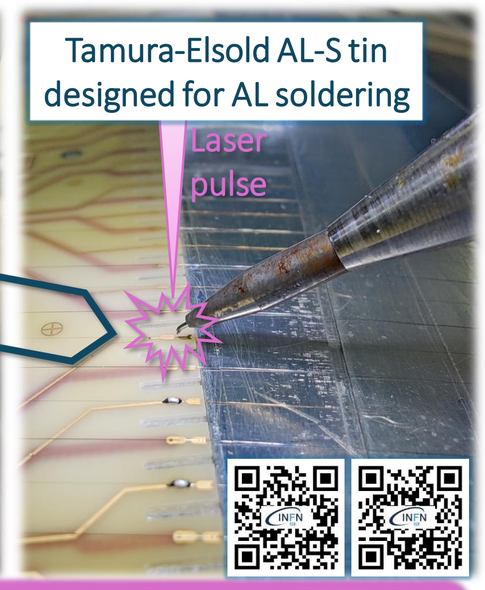


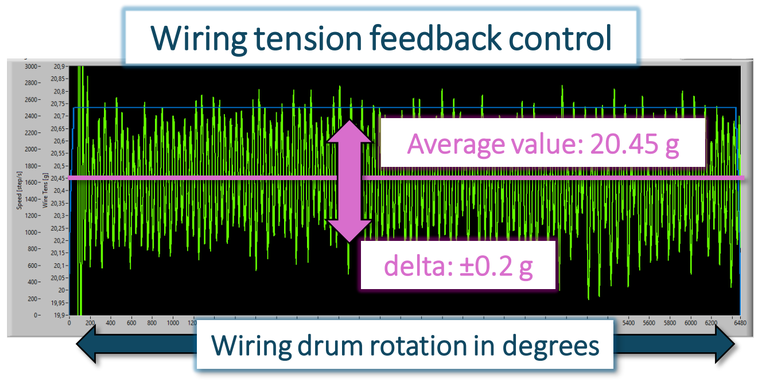
e^+ variable	Measured on data
ΔE_e (keV)	89
$\Delta\theta_e$, $\Delta\varphi_e$ (mrad)	7.2, 4.1
ΔZ, ΔY (at target, mm)	2.0, 0.7
ε_e (%)	67

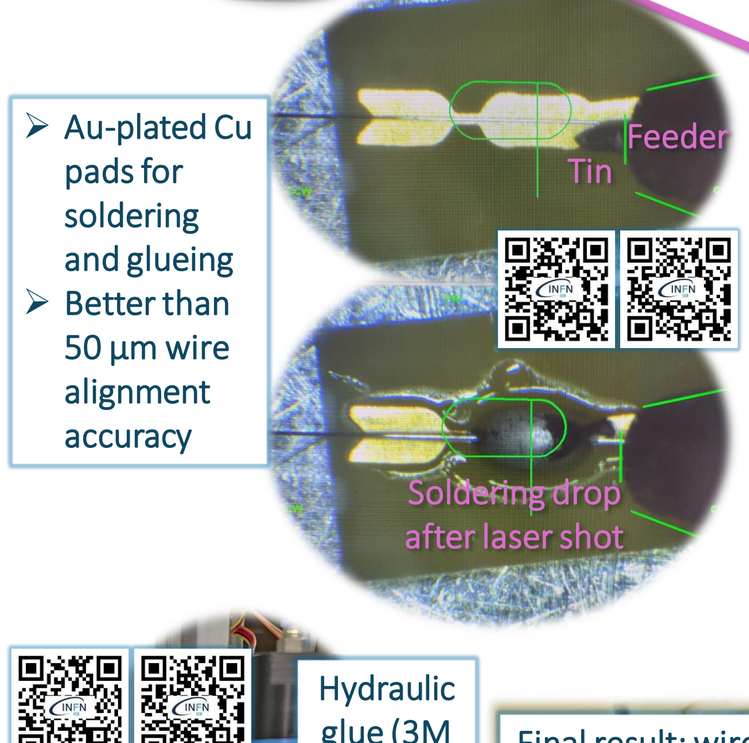
The MEG II wiring machine inside the INFN Pisa cleanroom



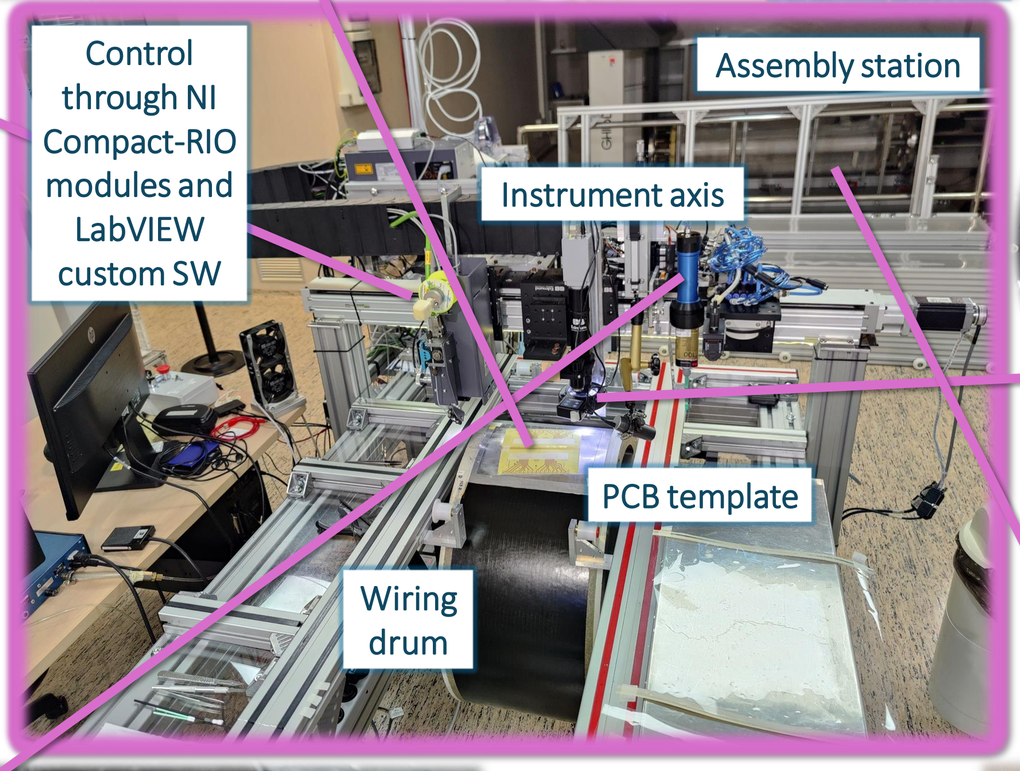


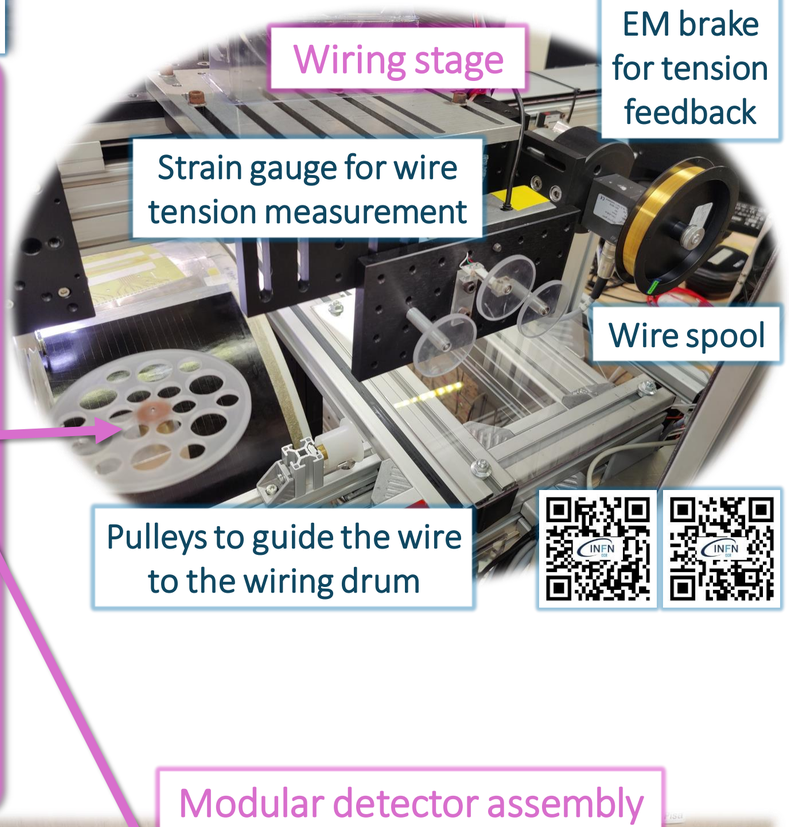


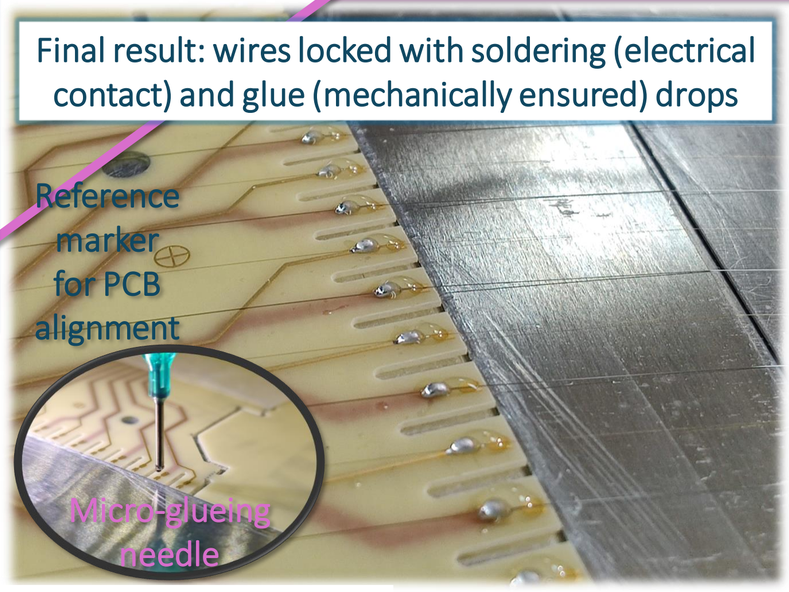


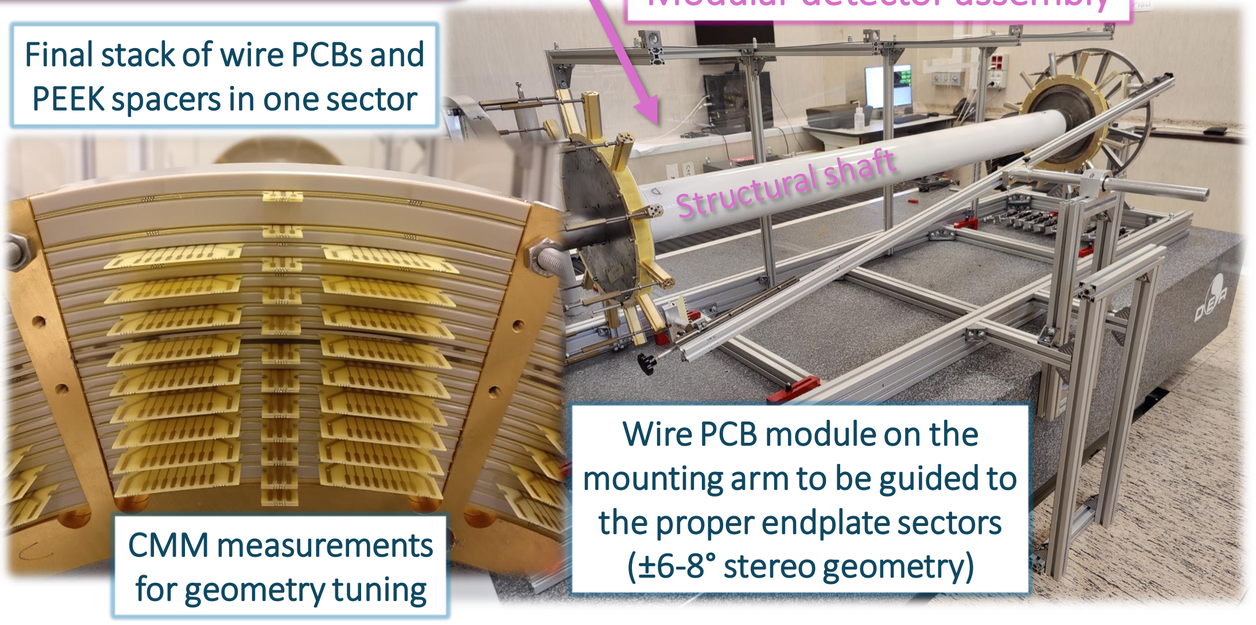


- Au-plated Cu pads for soldering and glueing
- Better than 50 µm wire alignment accuracy









Glueing stage

Since the extreme difficulty to solder very thin AL wire and avoid micro-slipping

References
- Performances of a new generation tracking detector: the MEG II cylindrical drift chamber, A. M. Baldini et al., Eur. Phys. J. C 84 (5) 473 (2024)
- Operation and performance of the MEG II detector, MEG II Collaboration, Eur. Phys. J. C 84 (2) 190 (2024)
- A search for $\mu^+ \to e^+\gamma$ with the first dataset of the MEG II experiment, K. Afanaciev et al., Eur. Phys. J. C 84, 216 (2024)
- The Cylindrical Drift Chamber of the MEG II experiment, M. Chiappini et al., NIMA, Volume 1047 (2023) 167740
- An automatic system for the wiring of Drift Chambers for modern high intensity and high precision particle physics experiments, G. Chiarello et al., JINST 15 (2020) C0703