Ultra-low mass drift chambers: the experience of the MEG II positron tracker

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Seminario di Sezione

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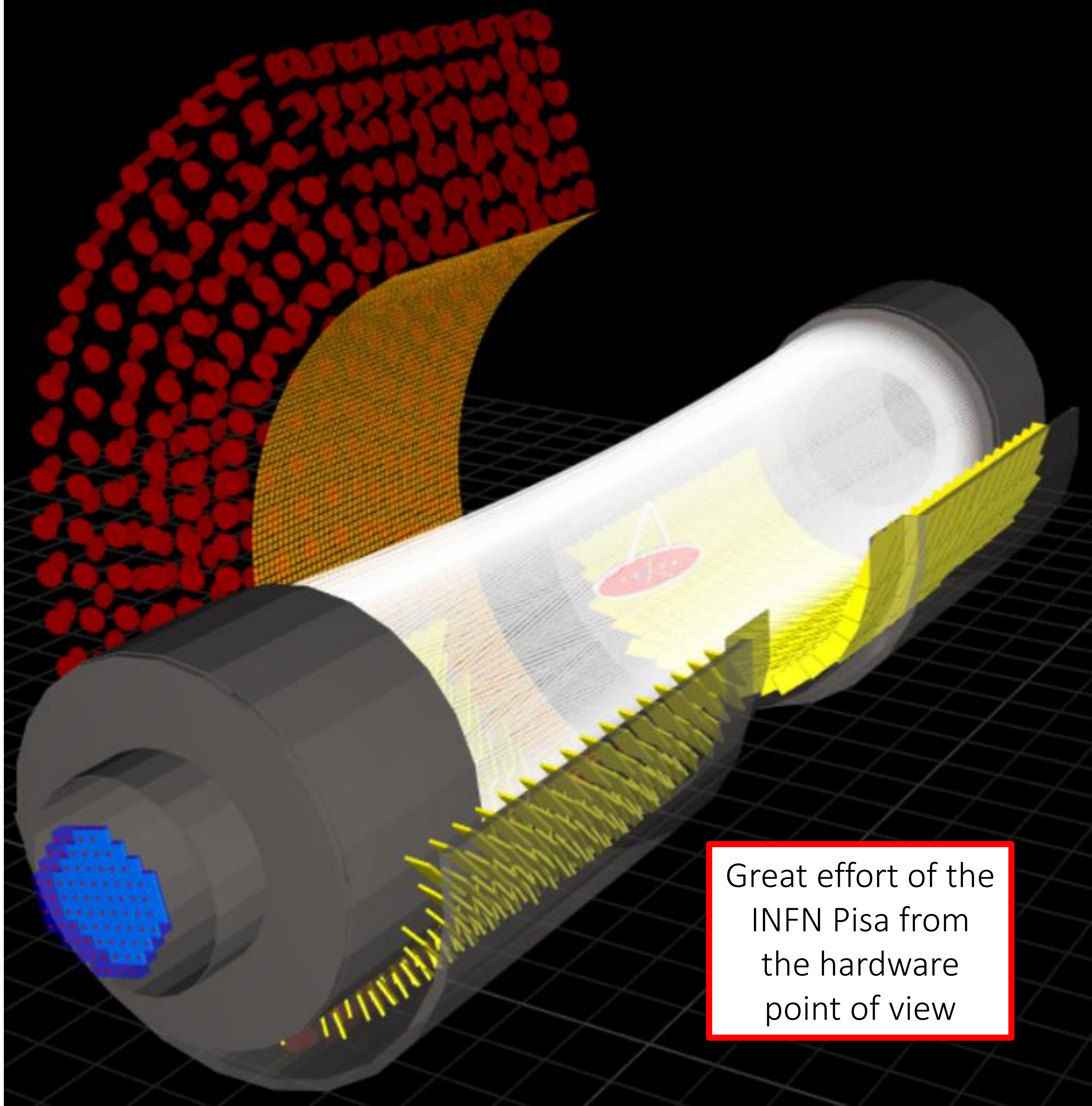
Useful links:
- https://www.pi.infn.it/?p=9603
- https://agenda.infn.it/event/28894/

Outline

- Introduction to MEG II experiment
- The MEG II Cylindrical Drift CHamber (CDCH)
    - Detector performance
    - New design concept and wiring
    - Assembly in Pisa
    - Commissioning phase at the Paul Scherrer Institut (PSI)
    - Integration into the experimental apparatus
- Investigations on wire breakages
- Investigations on anomalous currents
- Conditioning with beam
- Start of the physics data taking
- Conclusions and prospects



Great effort of the INFN Pisa from the hardware point of view

Introduction

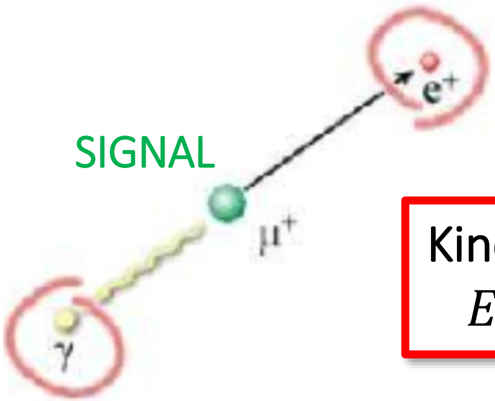
CLFV and $\mu^+ \to e^+\gamma$ decay

European Physics Journal C (2016) 76:434

- Lepton Flavour Violation (LFV) processes experimentally observed for neutral leptons
  - Neutrino oscillations $\nu_l \to \nu_{l'}$
- LFV for charged leptons (CLFV): $l \to l'$???
- If found → definitive evidence of New Physics

- In this context the MEG experiment represents the state of the art in the search for the CLFV $\mu^+ \to e^+\gamma$ decay
  - **Final results** exploiting the **full statistics** collected during the 2009-2013 data taking period at **Paul Scherrer Institut** (PSI, Switzerland)
  - $BR(\mu^+ \to e^+\gamma) < 4.2 \times 10^{-13}$ (90% C. L.) world best upper limit

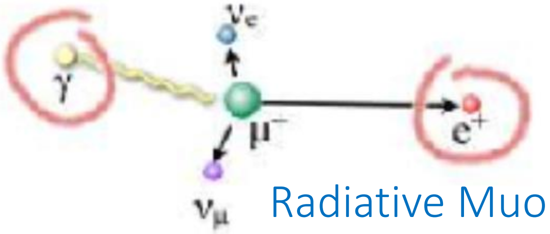
SIGNAL



Kinematic variables

$E_e, E_\gamma, t_{e\gamma}, \theta_{e\gamma}$

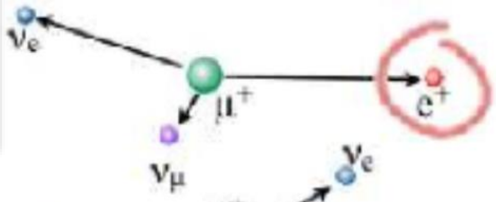
- $28\ \mathrm{MeV/c}\ \mu^+$ continuous beam stopped in a $130\ \mu\mathrm{m}$-thick polyvinyl toluene target ($15°$ slant angle)
- Most intense DC muon beam in the world at PSI: $R_\mu \approx 10^8\ \mathrm{Hz}$
- μ^+ decay at rest: 2-body kinematics
- $E_\gamma = E_e = 52.8\ \mathrm{MeV}$
- $\theta_{e\gamma} = 180°$
- $t_{e\gamma} = 0\ \mathrm{s}$



Radiative Muon Decay (RMD)

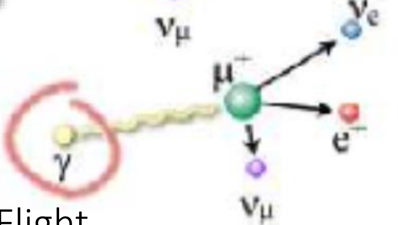
- $E_\gamma < 52.8\ \mathrm{MeV}$
- $E_e < 52.8\ \mathrm{MeV}$
- $\theta_{e\gamma} < 180°$
- $t_{e\gamma} = 0\ \mathrm{s}$

Standard μ decay
≡
Michel decay



BACKGROUNDS

From RMD, Annihilation-In-Flight or bremsstrahlung



Accidental

- $E_\gamma < 52.8\ \mathrm{MeV}$
- $E_e < 52.8\ \mathrm{MeV}$
- $\theta_{e\gamma} < 180°$
- $t_{e\gamma} = \mathrm{flat}$

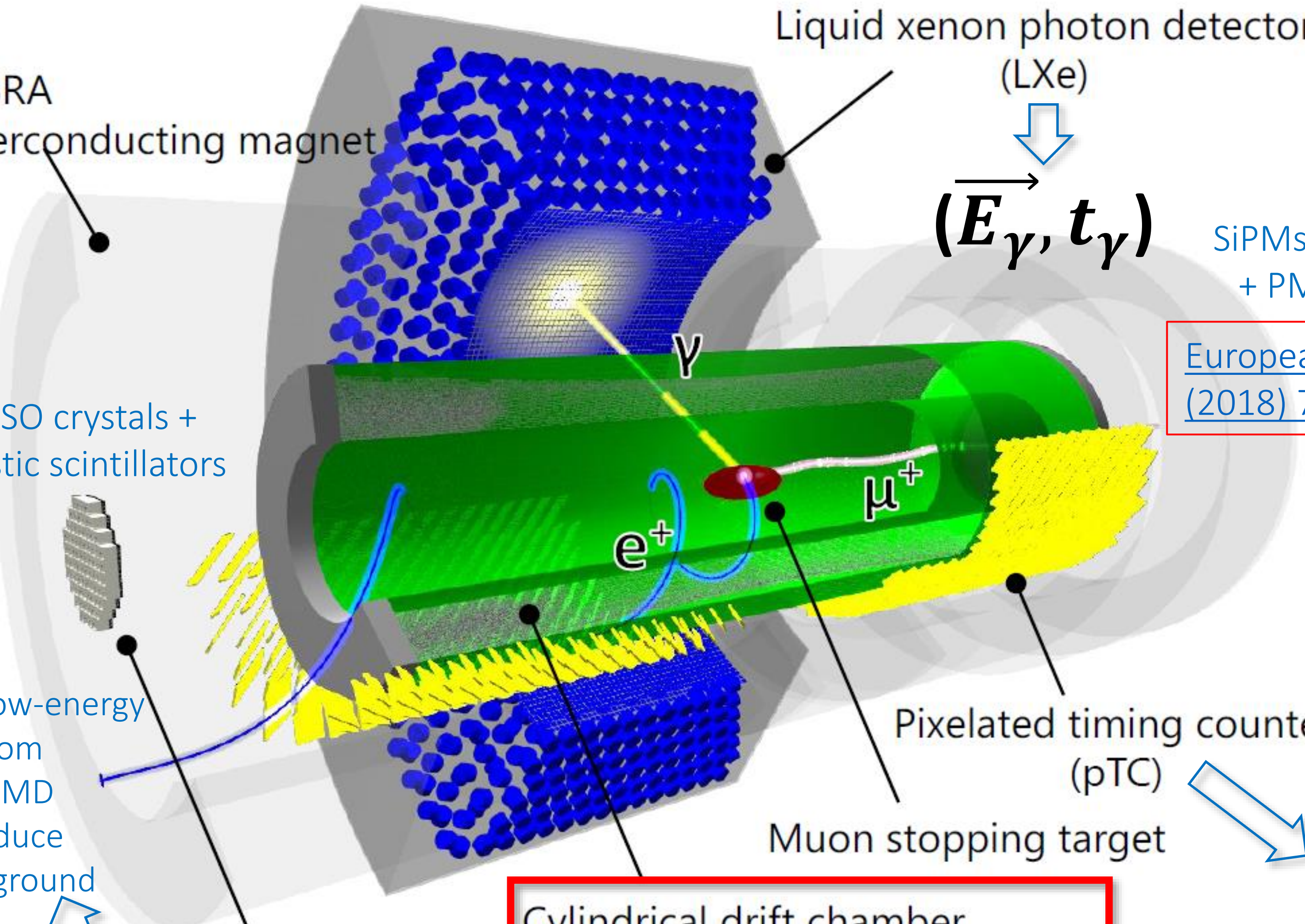
- $BKG_{ACC} \propto R_\mu \Delta E_e \Delta t_{e\gamma} \Delta E_\gamma^2 \Delta\theta_{e\gamma}^2$ ➜ DOMINANT in high rate environments
- $BKG_{RMD} \approx 10\% \times BKG_{ACC}$

The MEG II experiment

COBRA superconducting magnet

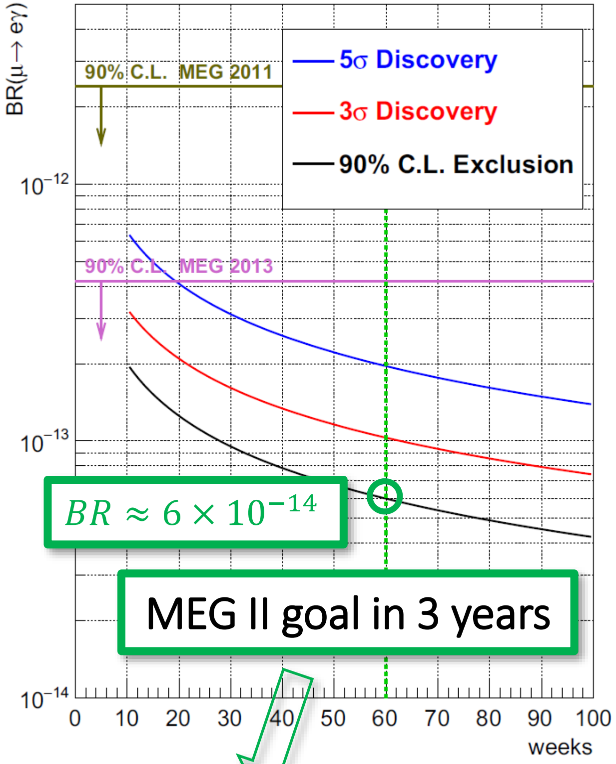
Liquid xenon photon detector (LXe)

$(\overrightarrow{E_\gamma}, t_\gamma)$



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

European Physics Journal C (2018) 78:380



$BR \approx 6 \times 10^{-14}$

MEG II goal in 3 years

- Increasing the μ^+ stopping rate
- Improving the detectors figures of merit
  - $\times$ 2 factor than MEG

LYSO crystals + plastic scintillators

Tag low-energy e^+ from AIF/RMD to reduce background

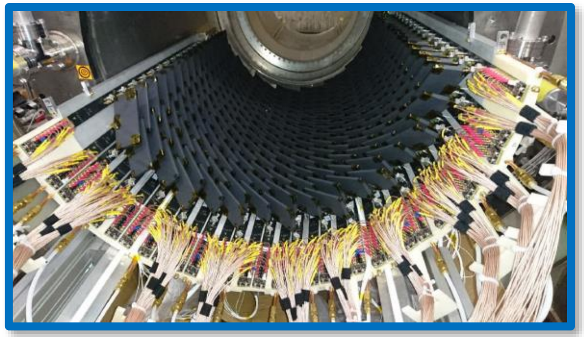
Radiative decay counter (RDC)

Cylindrical drift chamber (CDCH) $\overrightarrow{E_{e^+}}$

Muon stopping target

Pixelated timing counter (pTC)

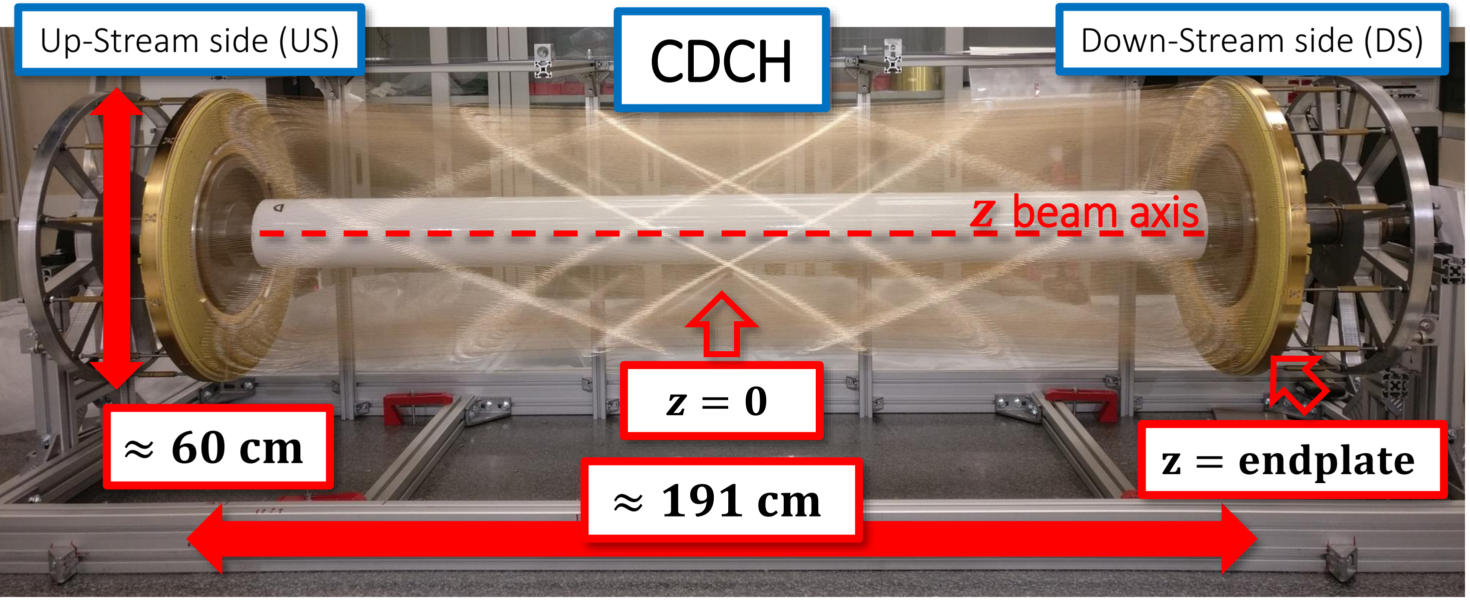
t_{e^+}

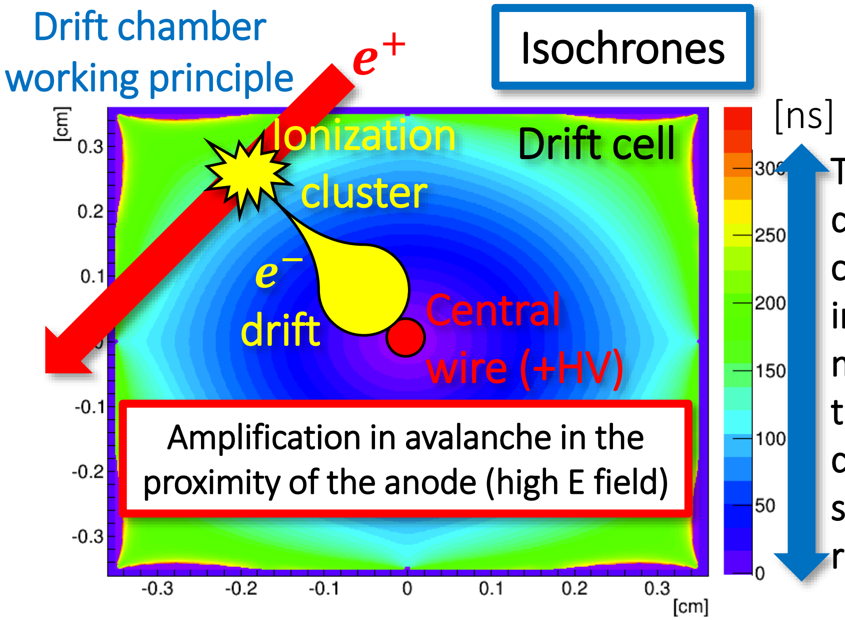


Plastic scintillators tiles read out by SiPMs

The MEG II Cylindrical Drift CHamber (CDCH)

Detector performance





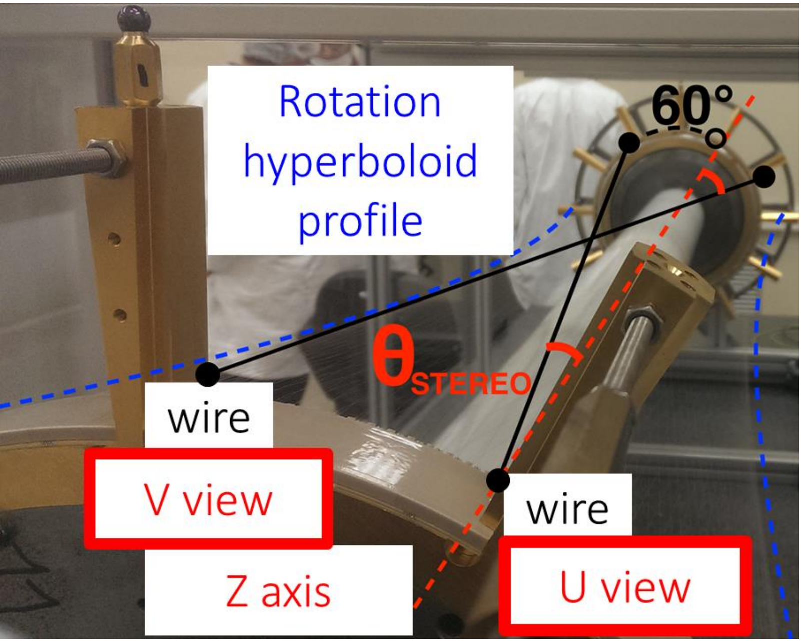
The measured drift time is converted into a position measurement through dedicated space-time relations

- Low-mass single volume detector with high granularity filled with He:Isobutane 90:10 gas mixture
  - 9 concentric layers of 192 drift cells defined by 11904 wires
  - Small cells few mm wide: occupancy of ≈1.5 MHz/cell at CDCH center near the stopping target
  - High density of sensitive elements: ×4 hits more than MEG drift chamber (DCH)
- Total radiation length 1.5×10^{-3} X_0: less than 2×10^{-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): $\sigma_{hit} < 120$ µm
- 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 design is based on the experience gathered with the KLOE drift chamber

Currently most updated reconstruction algorithms with full MC simulations

e^+ variable	MEG	MEG II
ΔE_e (keV)	380	100
$\Delta\theta_e$, $\Delta\varphi_e$ (mrad)	9, 9	6.7, 6.7
Efficiency$_e$ (%)	40	65

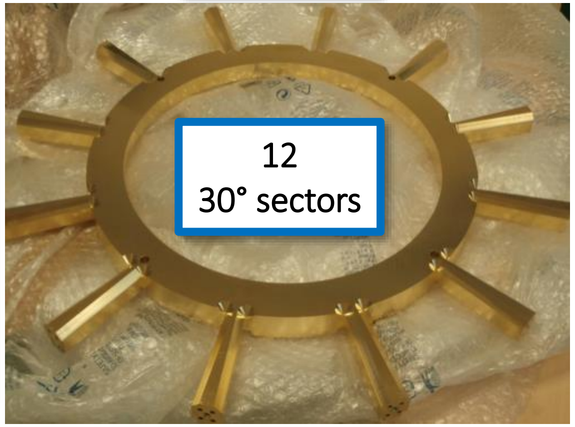
Design and wiring

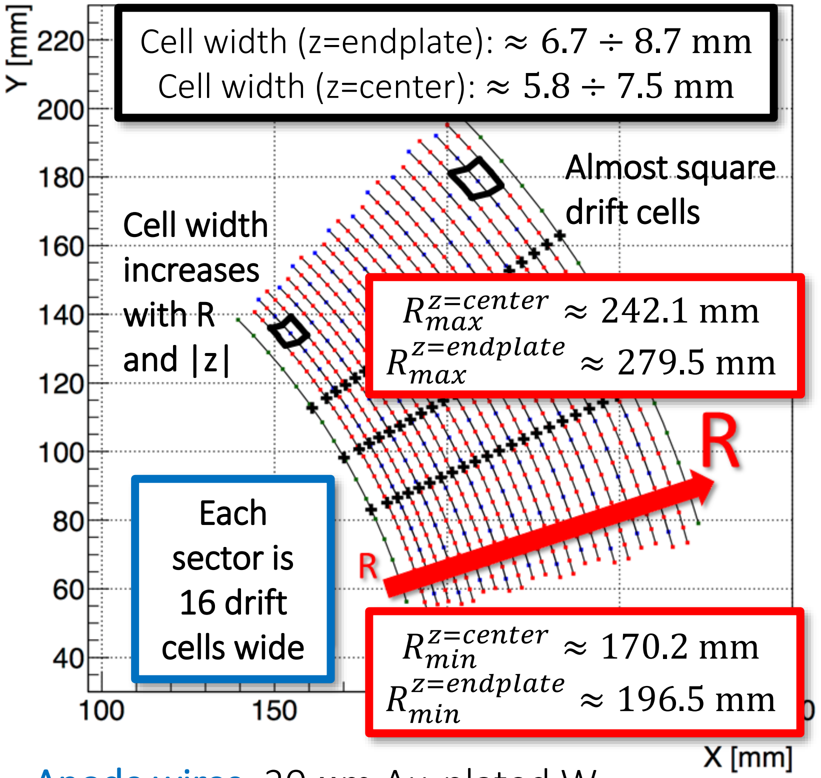


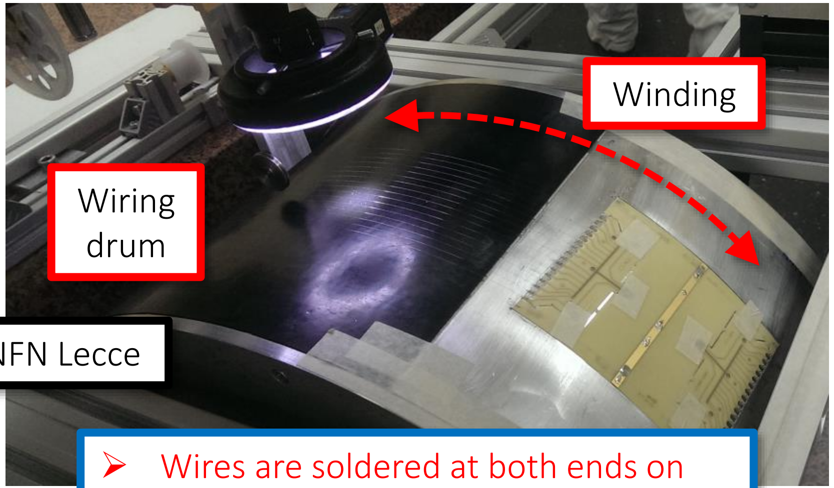
Stereo wires geometry for longitudinal hit localization

- $\theta_{stereo} \approx 6° \div 8.5°$ as R increases

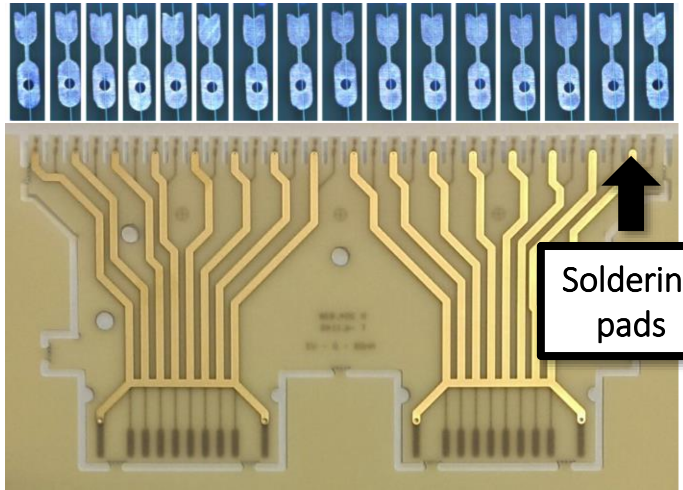
Endplate



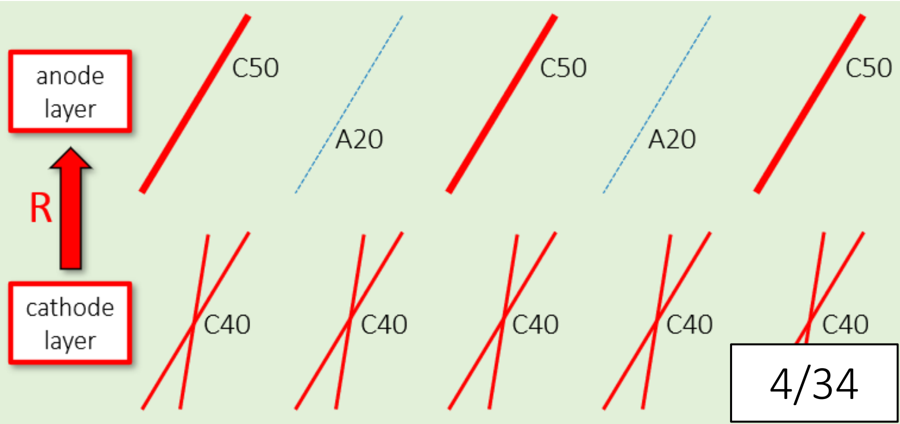




- Anode wires: 20 μm Au-plated W
- Cathode wires: 40/50 μm Ag-plated Al
  - 40 μm ground mesh between layers
- Guard wires: 50 μm Ag-plated Al
- **Field-to-Sense wire ratio 5:1**



- Wires are soldered at both ends on the pads of 2 PCBs (wire-PCBs) which are then mounted on CDCH endplates
- Wiring inside a cleanroom

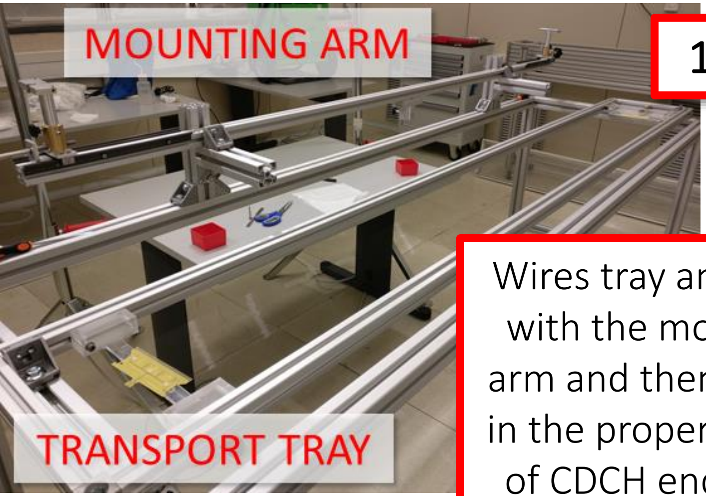


CDCH assembly

Modular assembly

San Piero a Grado (INFN Pisa) facility

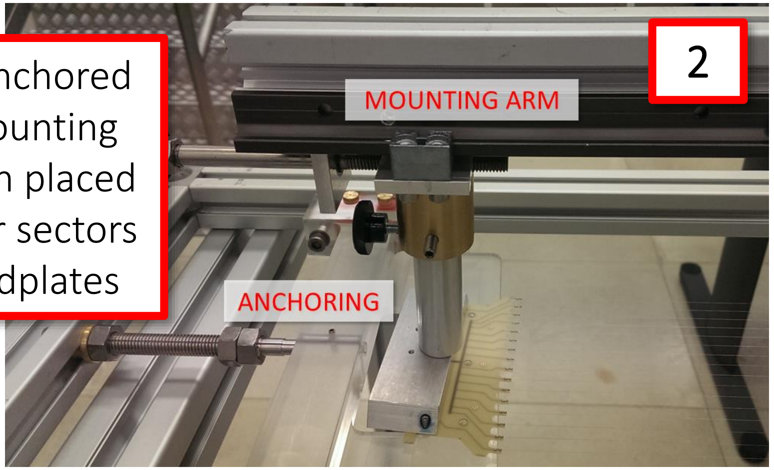
1

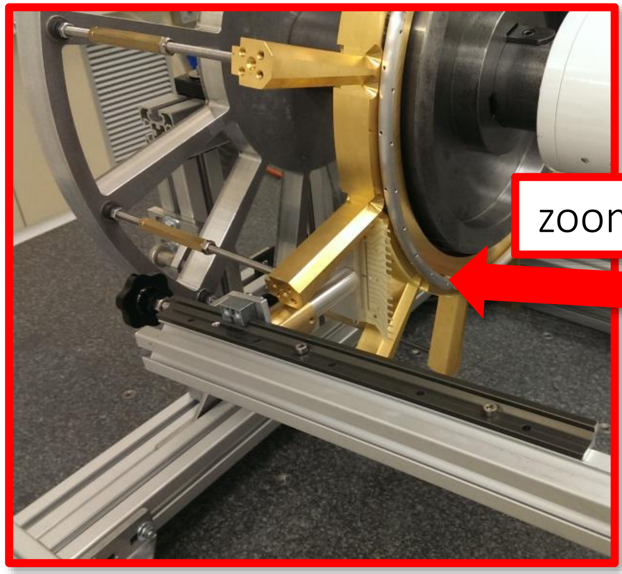


This operation is repeated for the 12 sectors in one layer and for all the wires layer

Wires tray anchored with the mounting arm and then placed in the proper sectors of CDCH endplates

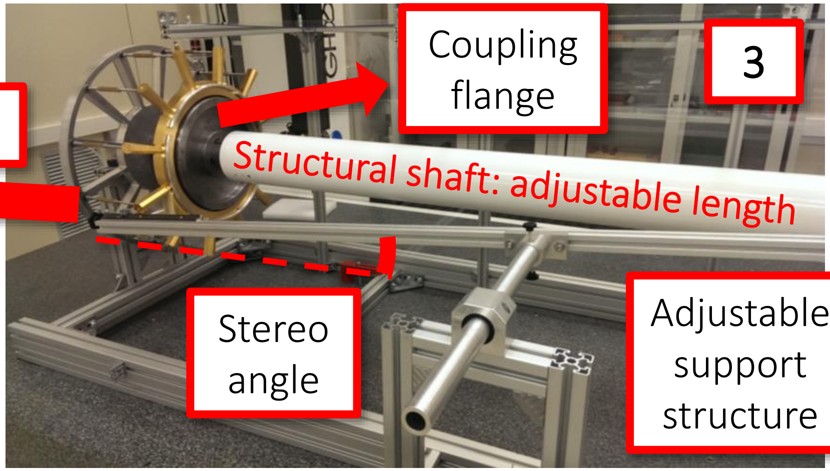
2



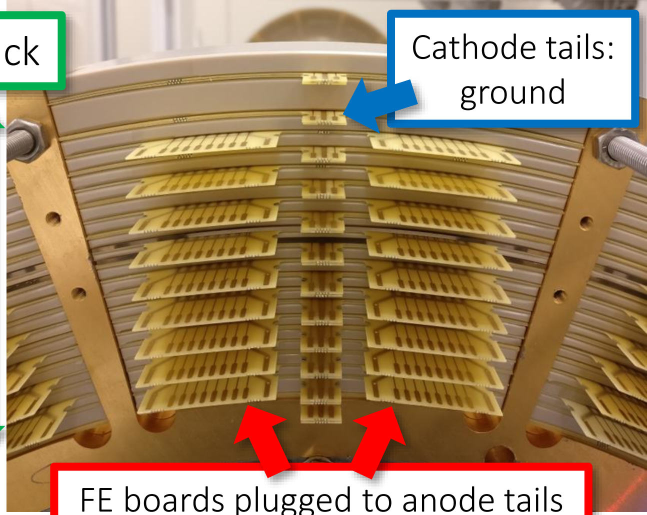


zoom

3



Final wire-PCBs stack

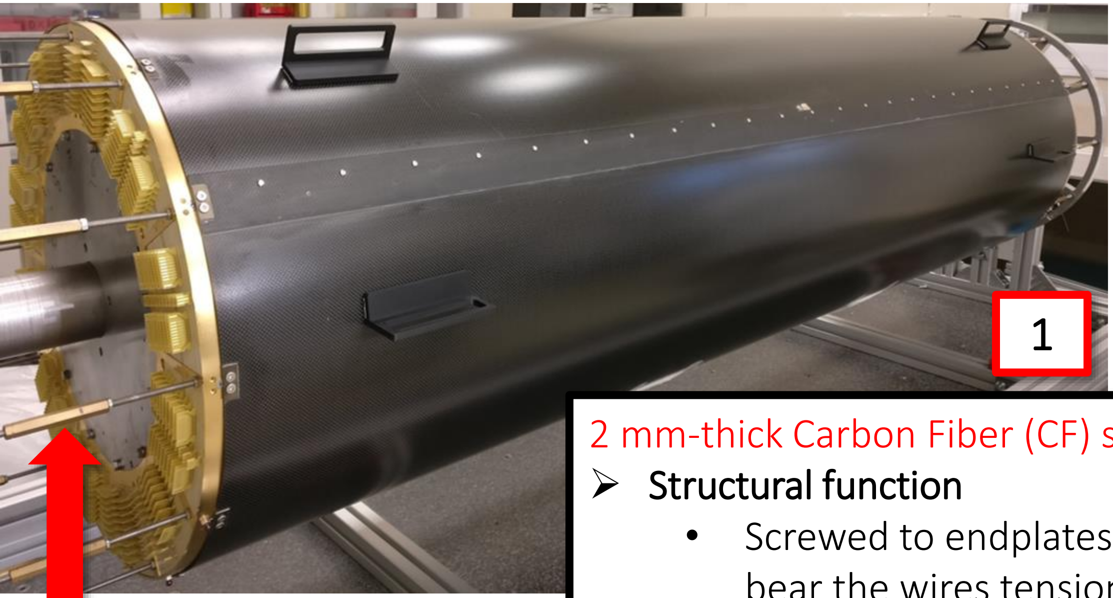


PEEK spacers to mount the PCB at the correct radius

- Once each wires layer is mounted a geometry survey campaign with a Coordinate Measuring Machine (CMM) is performed to record the mounting position of each wire-PCB ($\approx$ 20 μm accuracy)
- **Thickness of the PEEK spacers adjusted** to minimize the discrepancy from the nominal mounting radius

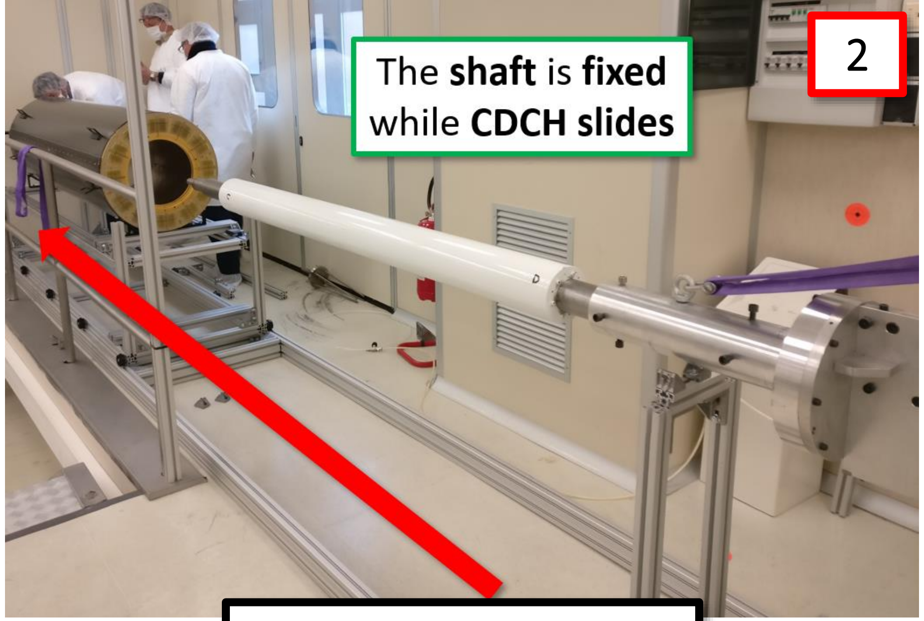
Sealing

San Piero a Grado
(INFN Pisa) facility



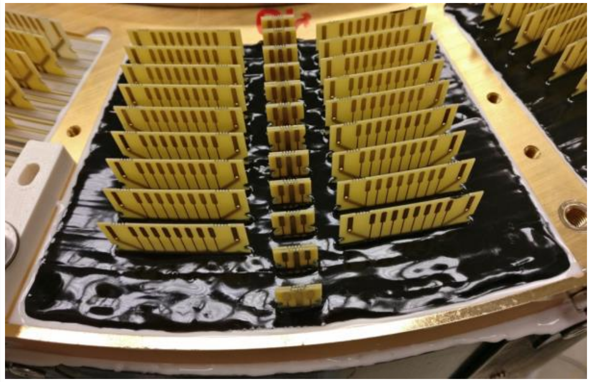
- Fine geometry tuning by adjusting the positions of each individual spoke by acting on the 12 turnbuckles per side
- Endplate planarity and parallelism at a level better than 100 μm thanks to the CMM

2 mm-thick Carbon Fiber (CF) shell
- Structural function
  - Screwed to endplates to bear the wires tension and keep the CDCH length
- Gas mixture tightness
  - Sealing of CF perimeters and wire-PCBs stack with special encapsulants and adhesives



Central shaft extraction

20 μm-thick aluminized Mylar foil insertion
- To separate the inner target volume filled with pure He from the wires volume filled with He:Isobutane 90:10 mixture
- Glued at the endplate inner radius



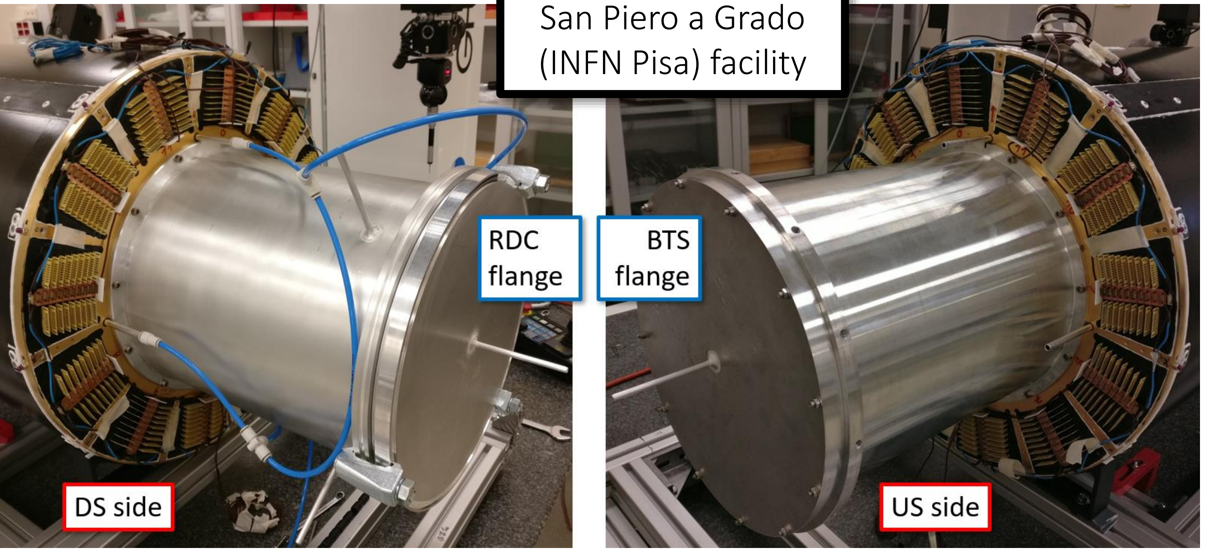
Assembly and sealing performed inside a cleanroom with a strict monitoring of temperature and relative humidity

At this point CDCH was locked into a handling cage with a dumping system and transported to PSI for the commissioning activities

CDCH commissioning

External mechanical structures

San Piero a Grado
(INFN Pisa) facility



Aluminum inner extensions to
connect CDCH to the MEG II beam line

Endplate planarity check
in the DAQ configuration

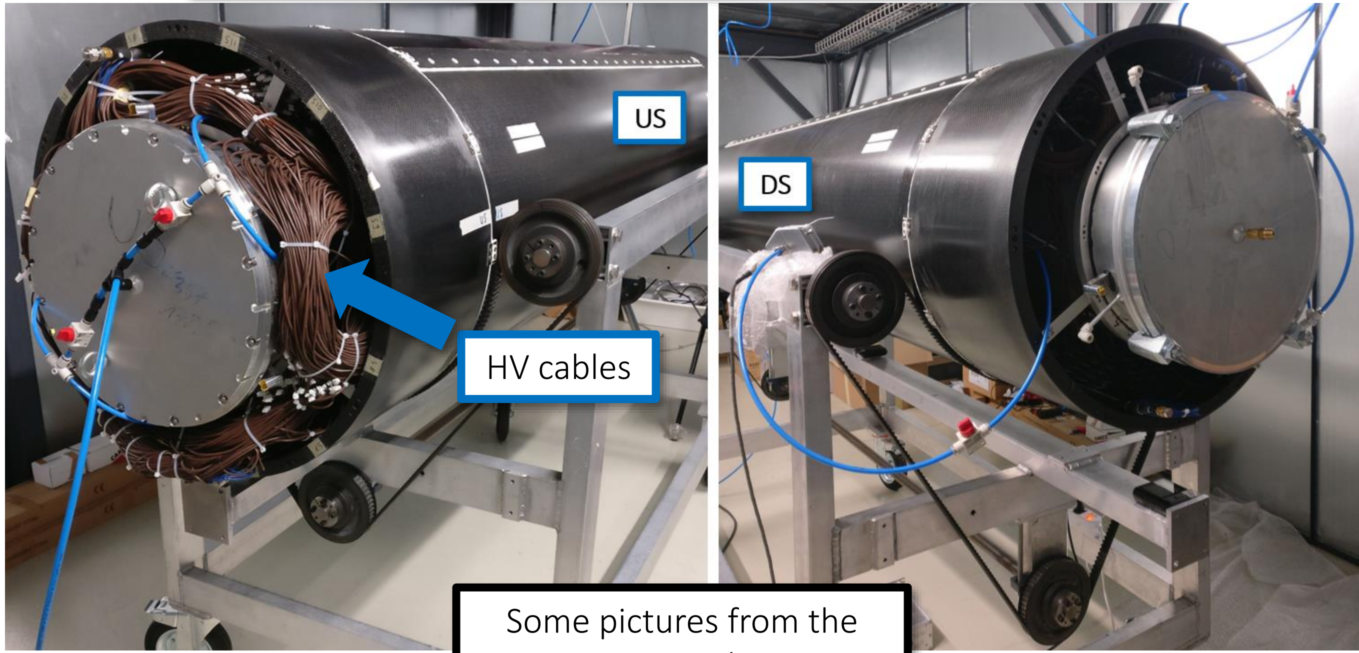
US

Mag (mm)
0.037
-0.010
-0.012
-0.019
-0.007
0.009
0.043
0.017
-0.020
-0.007
-0.013
-0.018

DS

Mag (mm)
0.007
-0.000
-0.011
0.009
0.001
-0.004
-0.001
-0.003
0.005
-0.010
0.003
0.005

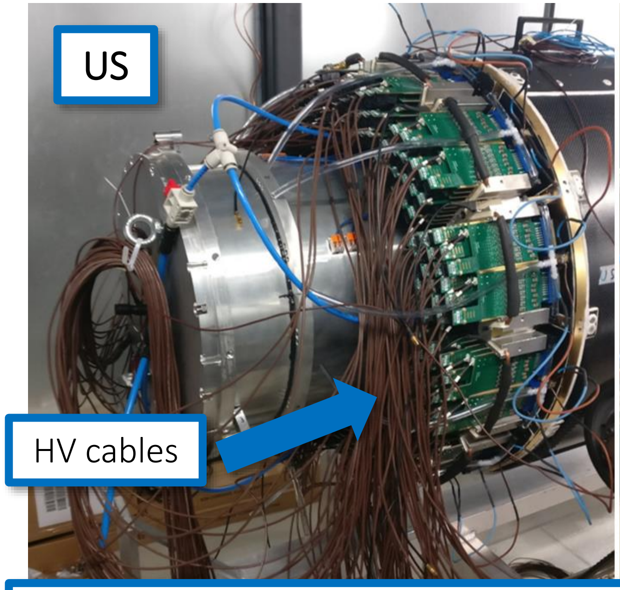
- External CF structure
  - Structural + gas tightness function
- CDCH mechanics proved to be stable and adequate to sustain a full MEG II run and multiple handling operations during the maintenance periods
  - Survey measurements before/after a run show total agreement at the 10 µm level

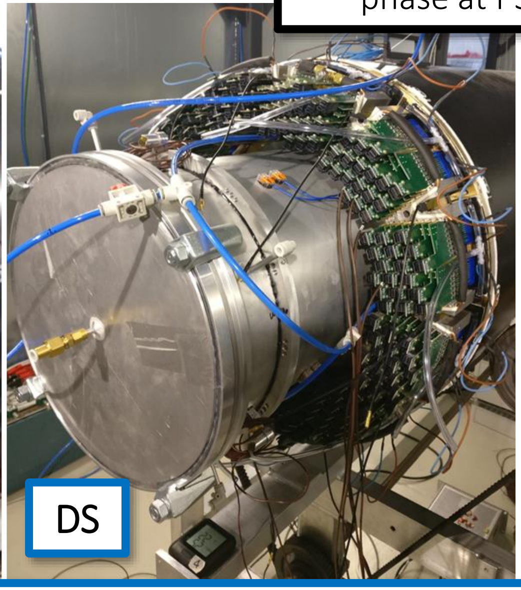


Some pictures from the
commissioning phase at PSI

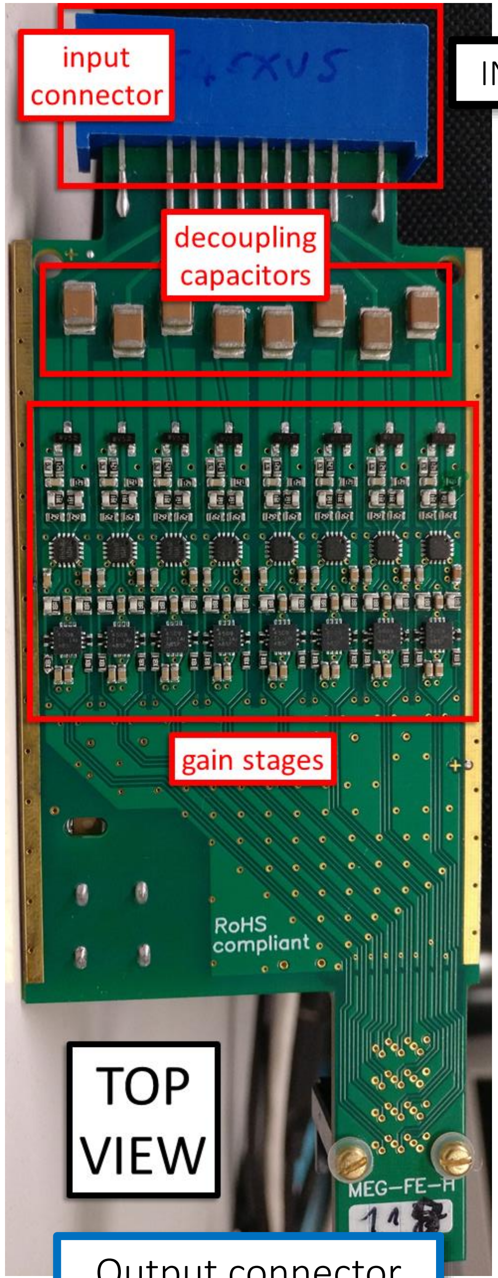
FE electronics

Some pictures from the commissioning phase at PSI



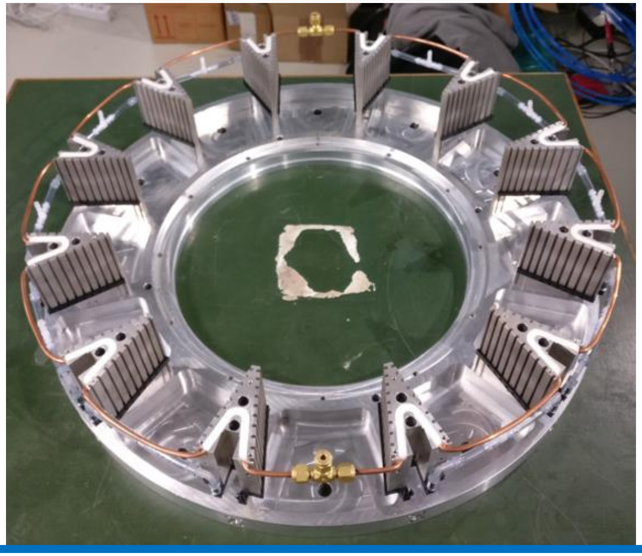


- 216 FE boards per side
    - 8 differential channels to read out signal from 8 cells
    - Double amplification stage with low noise and distortion
    - High bandwidth of nearly 400 MHz
        - To be sensitive to the single ionization cluster and improve the drift distance measurement (cluster timing technique)
- Signal read out from both CDCH sides
- HV supplied from the US side



Output connector and HV stage on the bottom side

Several T and RH sensors are placed inside the endcaps for monitoring

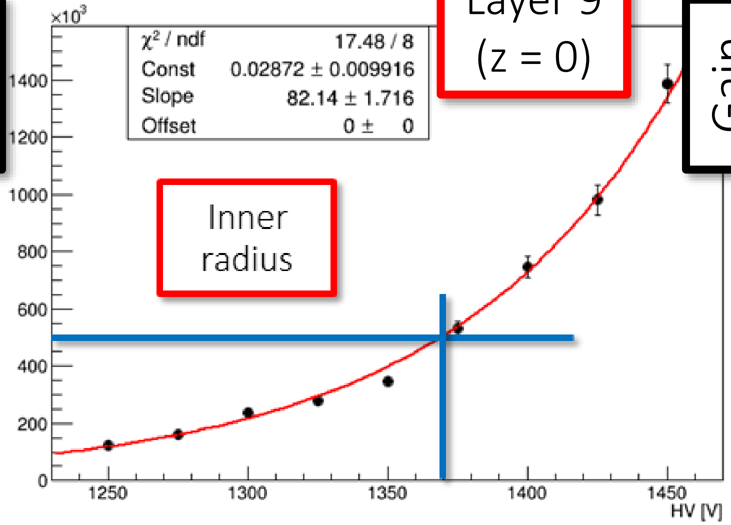


- FE electronics cooling system embedded in the board holders
    - Power consumption for each channel: 40 mA at 2.2 V
    - Heat dissipation capacity granted by a **1 kW chiller system**: 300 W/endplate
- Dry air flushing inside the endcaps to avoid water condensation on electronics and dangerous temperature gradients

HV working point

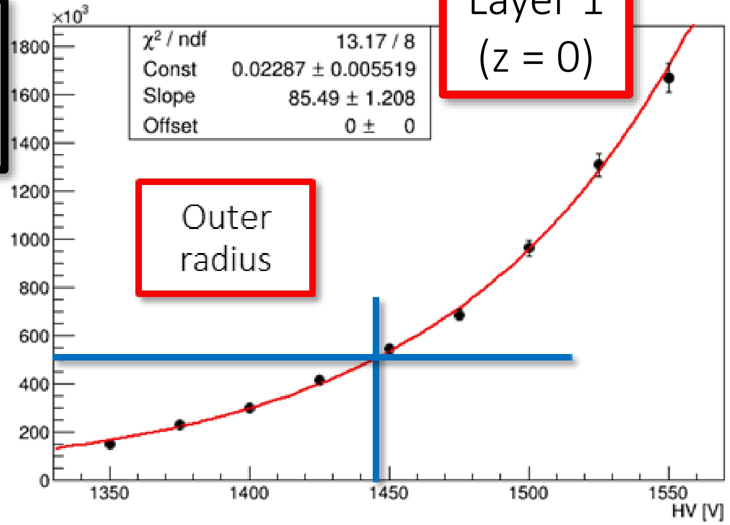
Gain

Layer 9 (z = 0)

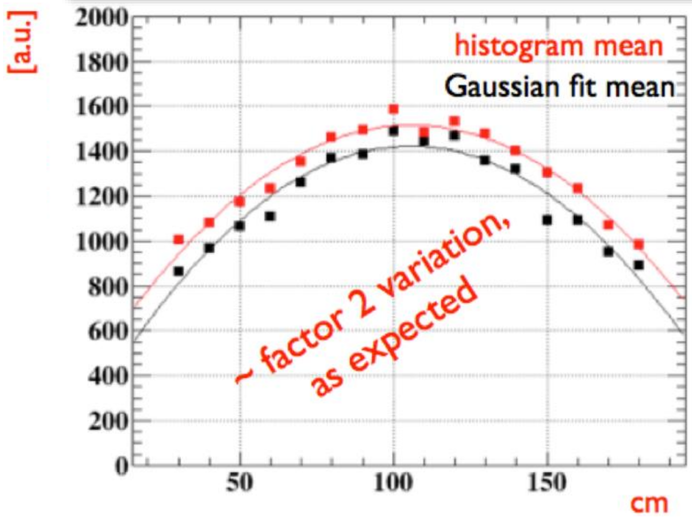


Gain

Layer 1 (z = 0)



Expected **gain variation vs. longitudinal coordinate *z*** given the CDCH hyperbolic shape



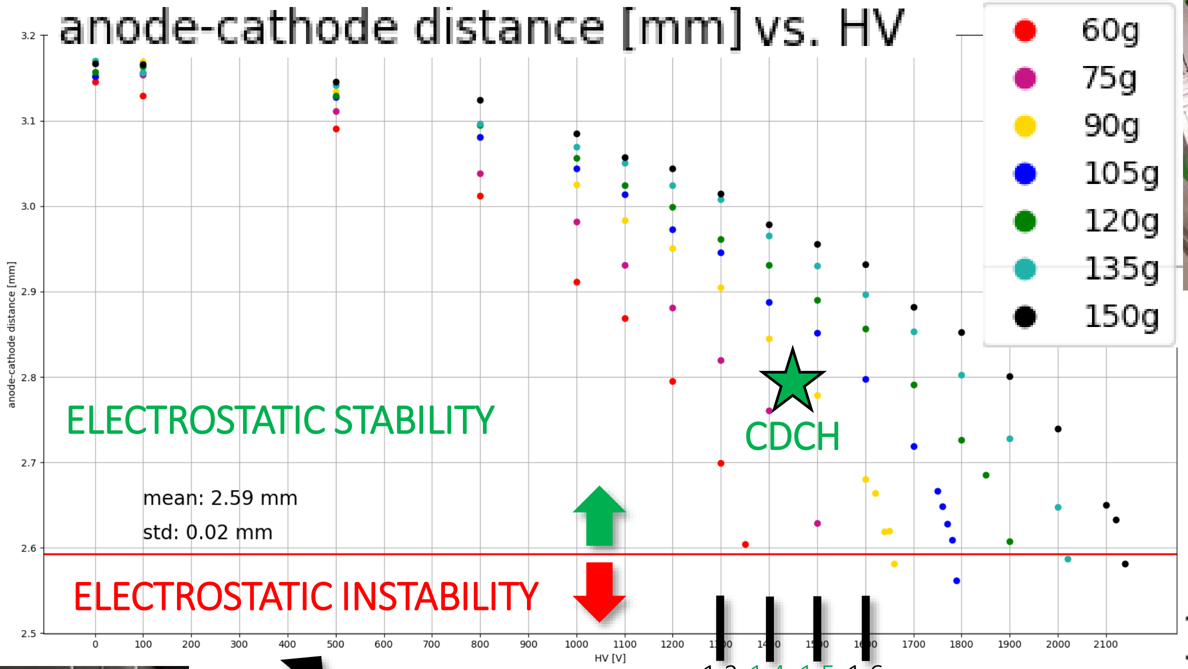
- **Garfield simulations on single electron gain**
  - Gas mixture He:Isobutane 90:10 and P = 970 mbar (typical at PSI)
- Working point → HV for gas gain $G = 5 \times 10^5$
  - To be sensitive to the single ionization cluster

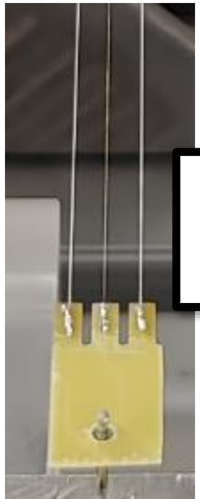
HV tuning by 10 V/layer to compensate for the variable cell dimensions with radius and *z*

L1	L2	L3	L4	L5	L6	L7	L8	L9
1480 V	1470 V	1460 V	1450 V	1440 V	1430 V	1420 V	1410 V	1400 V

Average HV Working Point (WP) as a function of the layer

Working length

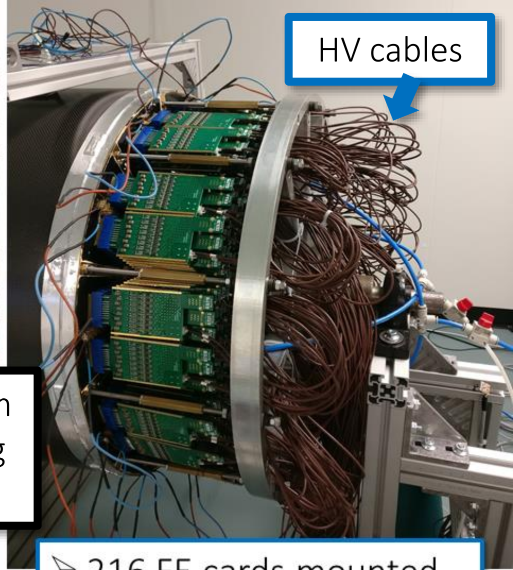




2 m-long 3-wires prototype in the MEG lab at INFN Pisa

Cell inefficiency experimentally measured

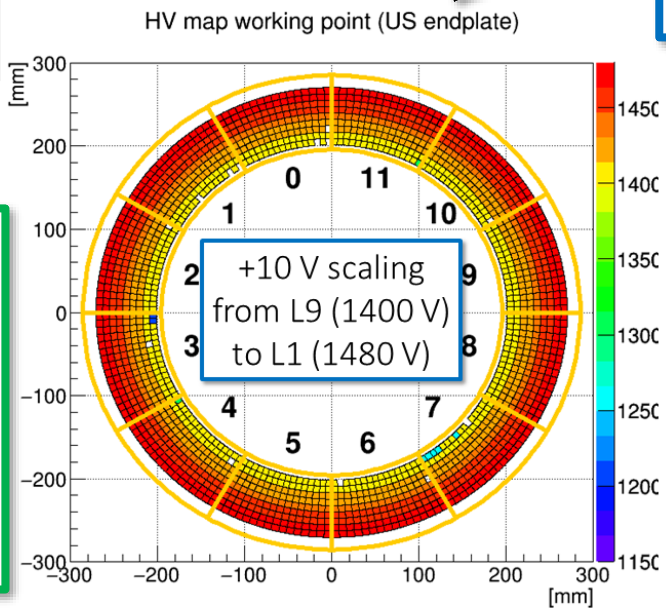
- Negligible in e^+ reconstruction
  - 0.5% worsening in resolutions
- Tests with high statistics full MC



Some pictures from the commissioning phase at PSI

- CDCH temporarily sealed with CF + Al tape
- Nitrogen flux

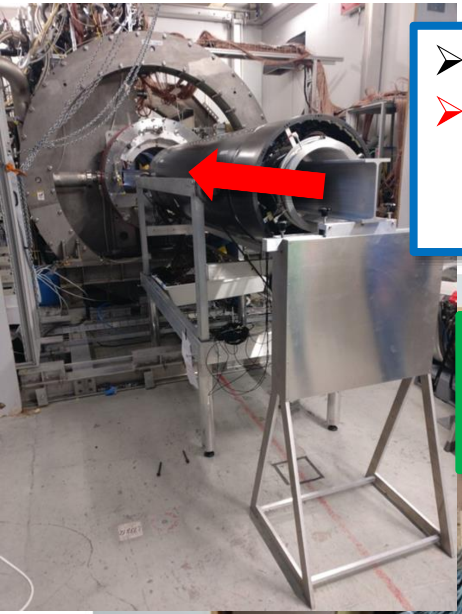
- 216 FE cards mounted on the US side



Final CDCH length experimentally found through systematic HV tests at different lengths/wires elongations

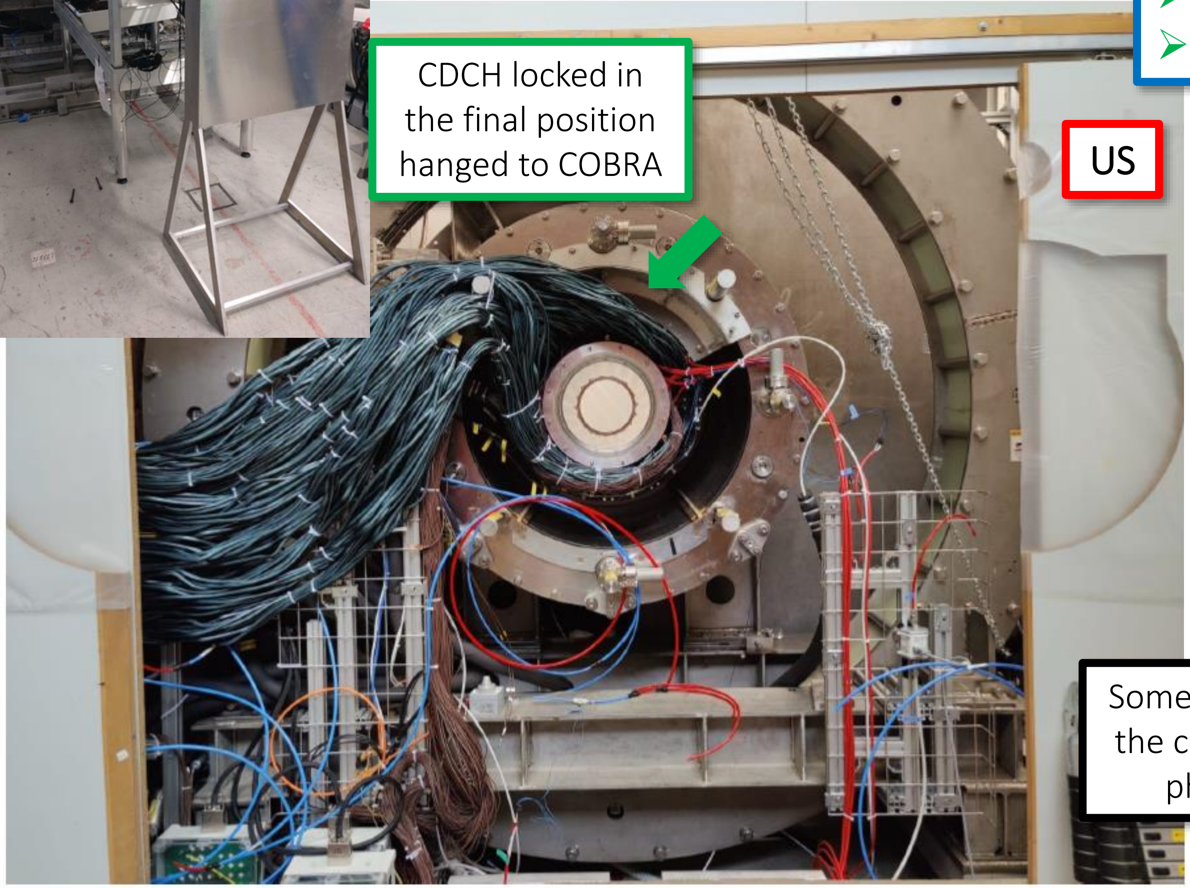
- Tests performed in 2019 and 2020 at PSI inside a cleanroom
- CDCH length adjusted through geometry survey campaigns with a laser tracker (20 μm accuracy)
- Final length set to +5.2 mm of wires elongation
  - 65% of the elastic limit

Integration into the MEG II apparatus

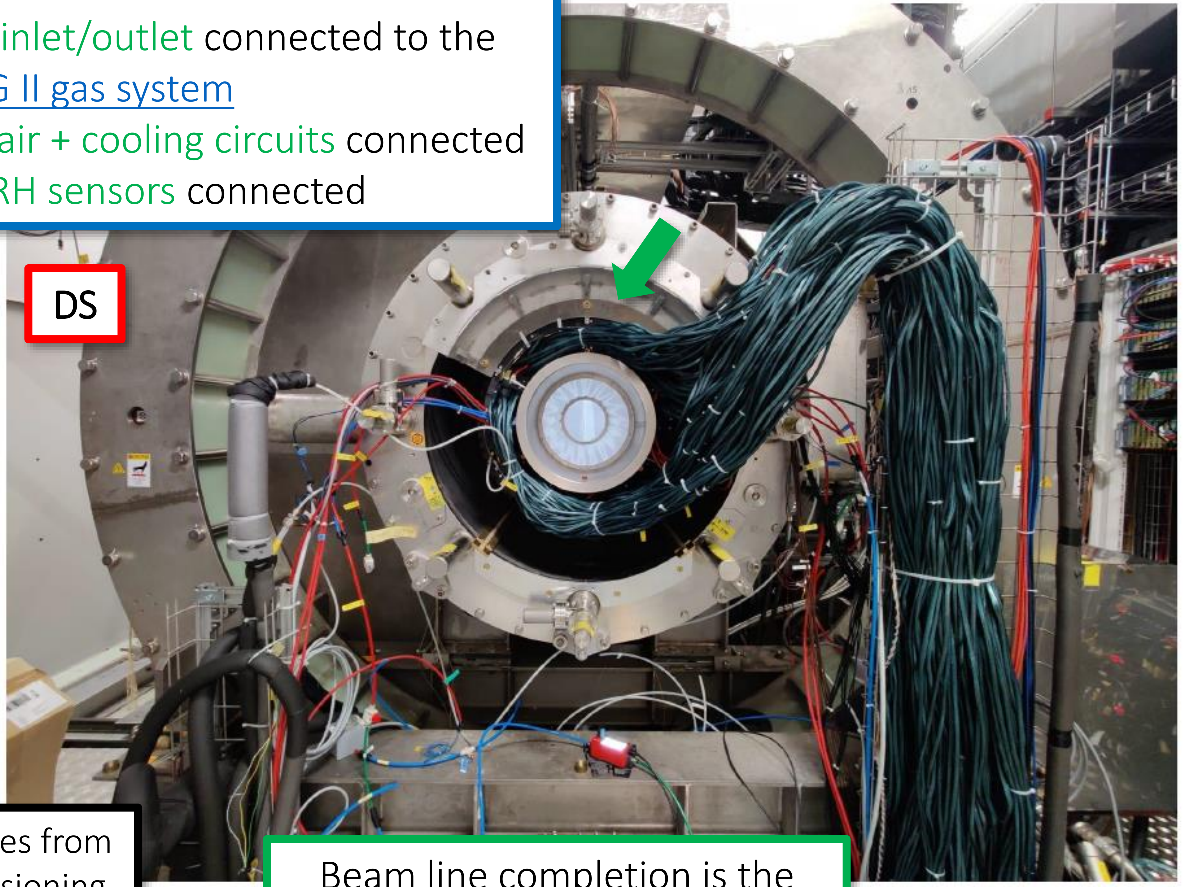


- CDCH inside the experimental area
- Insertion rail through the inner volume to slide CDCH inside the COBRA magnet

CDCH locked in the final position hanged to COBRA



- HV + signal cabling completed for the possible 2π read out
- Gas inlet/outlet connected to the MEG II gas system
- Dry air + cooling circuits connected
- T + RH sensors connected



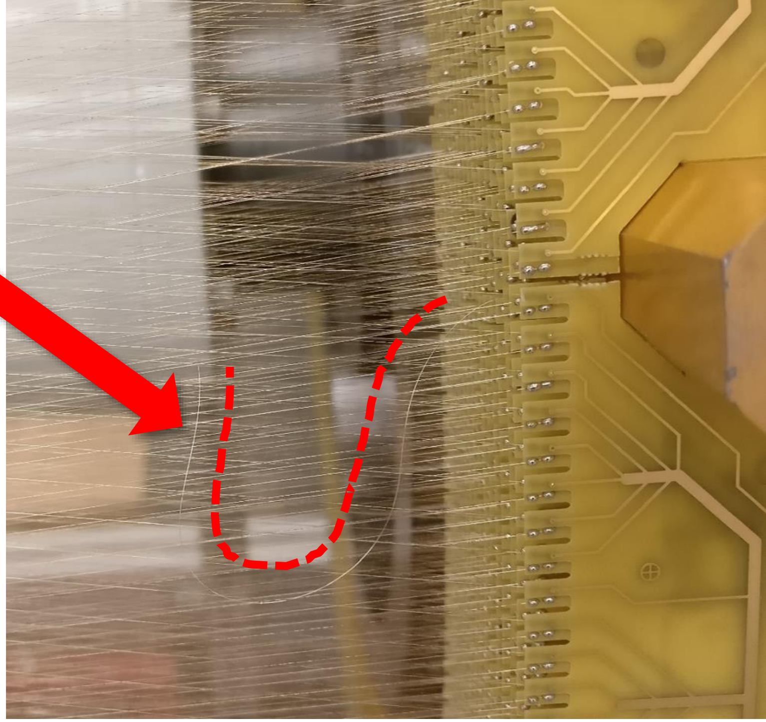
Some pictures from the commissioning phase at PSI

Beam line completion is the last operation (not shown here)

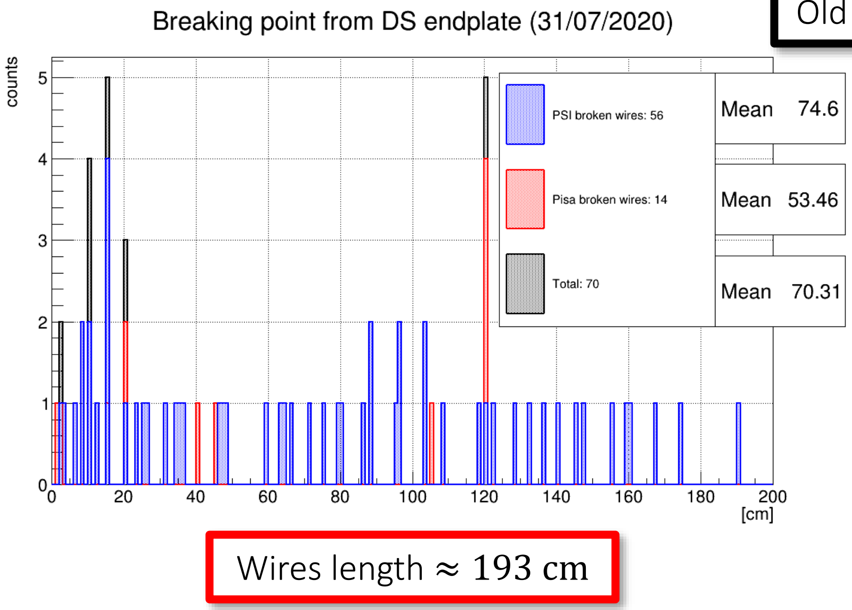
Investigations on wire breakages

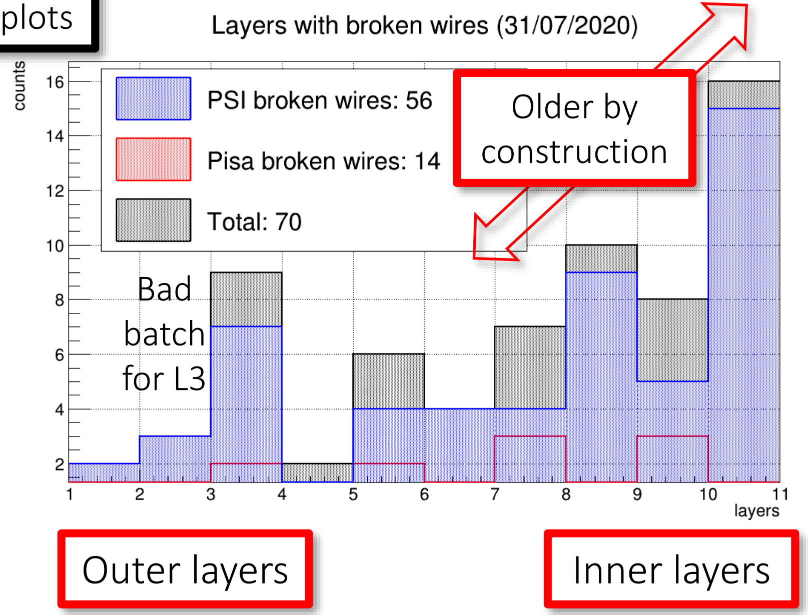
Wire breakages

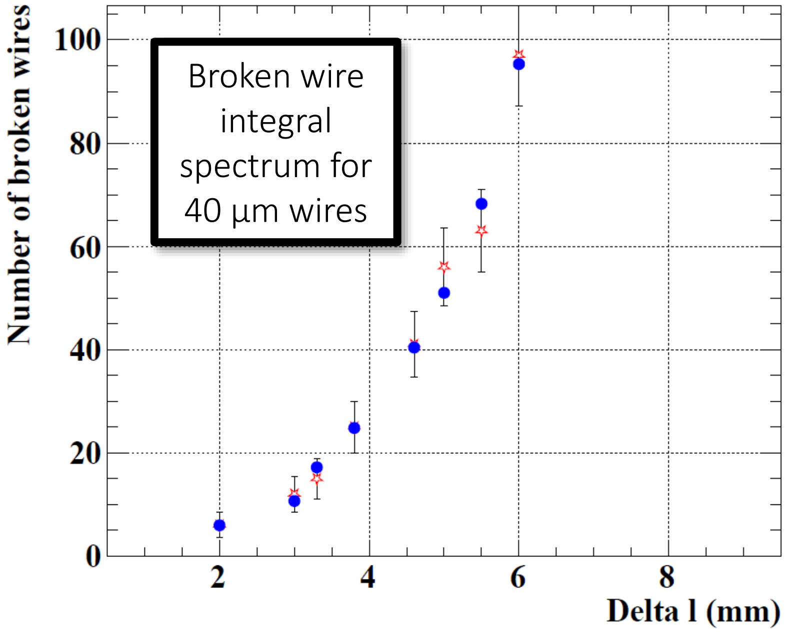
- During assembly at Pisa and the final lengthening operations at PSI we experienced the breaking of aluminum wires in the chamber
  - Mainly the 40 μm cathodes were affected
  - A few 50 μm cathodes and guards
- **107 broken wires in total during CDCH life** (14 at Pisa)
  - 97 broken 40 μm cathodes (90%)
- **Consequent delay in construction and commissioning**



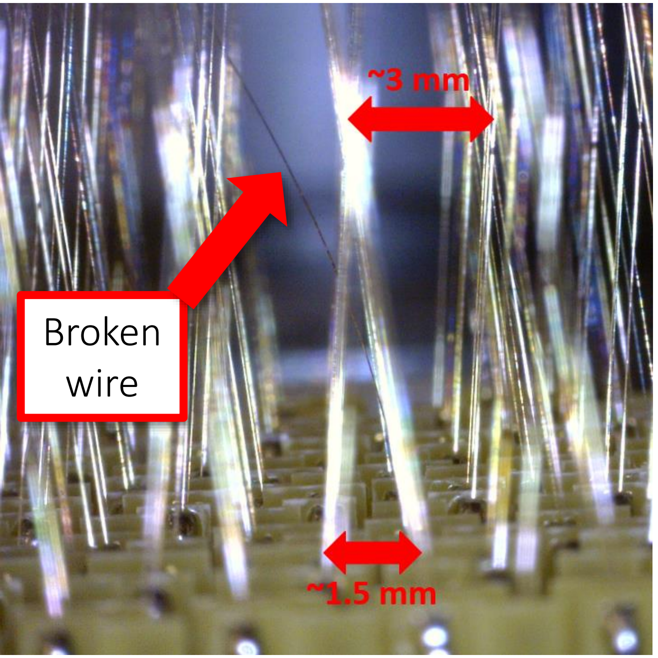
Old plots



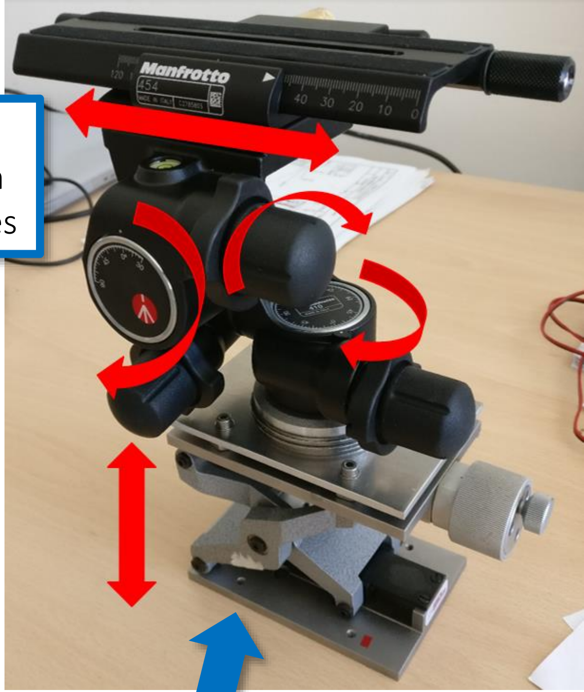




Broken wires extraction

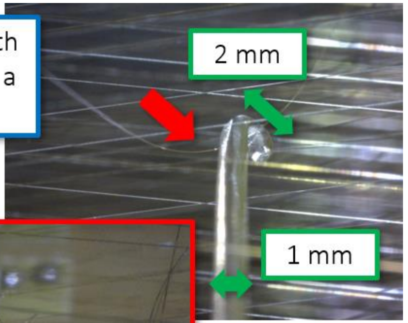


- Each broken wire piece can randomly put to ground big portion of the chamber
- They must be removed from the chamber
  - Very delicate and time-consuming operation
- We developed a safe procedure to extract the broken wires from inside CDCH
  - Exploiting the radial projective geometry given by the stereo wire configuration

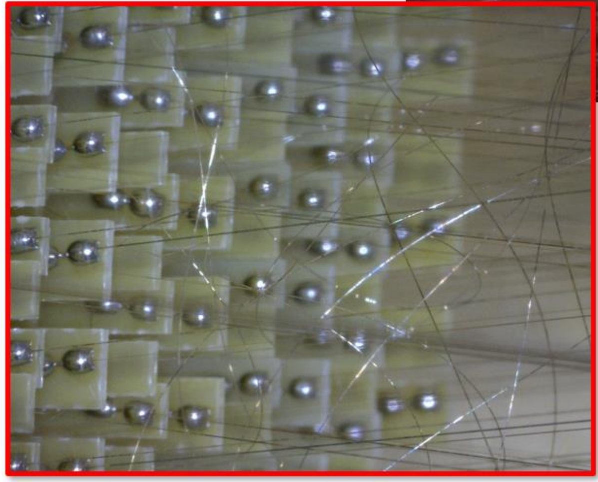


Commercial camera mount with precision movements for all axes

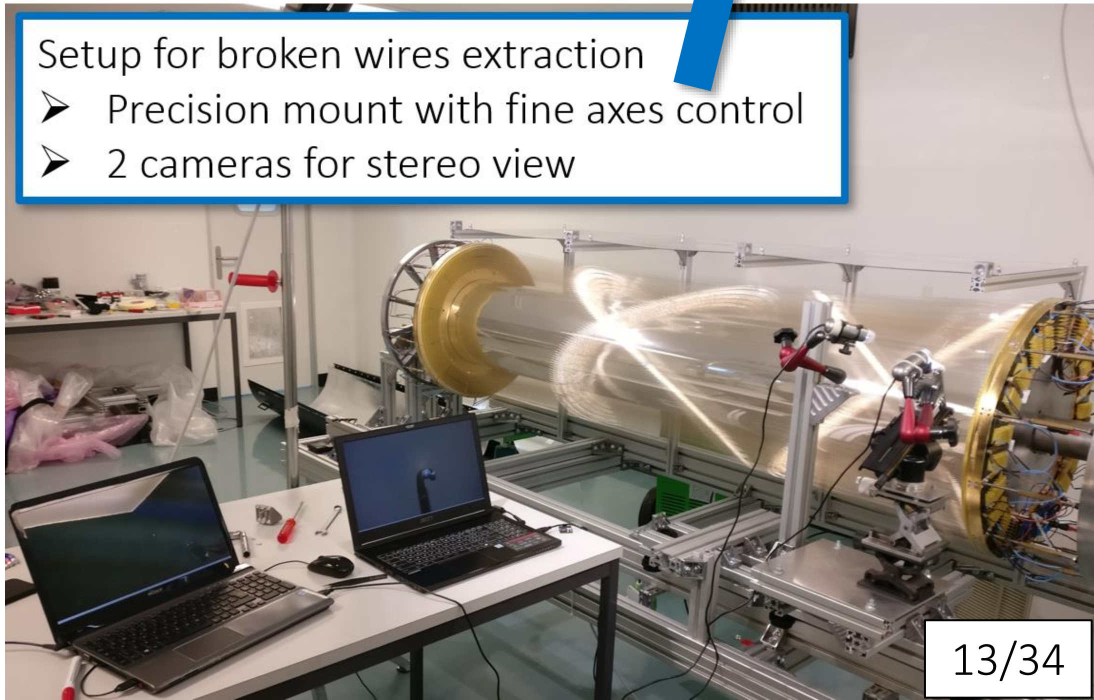
Example of extraction with a broken wire hooked by a stainless steel rod



1. Enter with a small tool inside the chamber (few mm space)
2. Hook the wire piece as close as possible to the wire-PCB
3. Extract the wire segment
4. Pull it perpendicularly in the radial direction to break it at the soldering pad

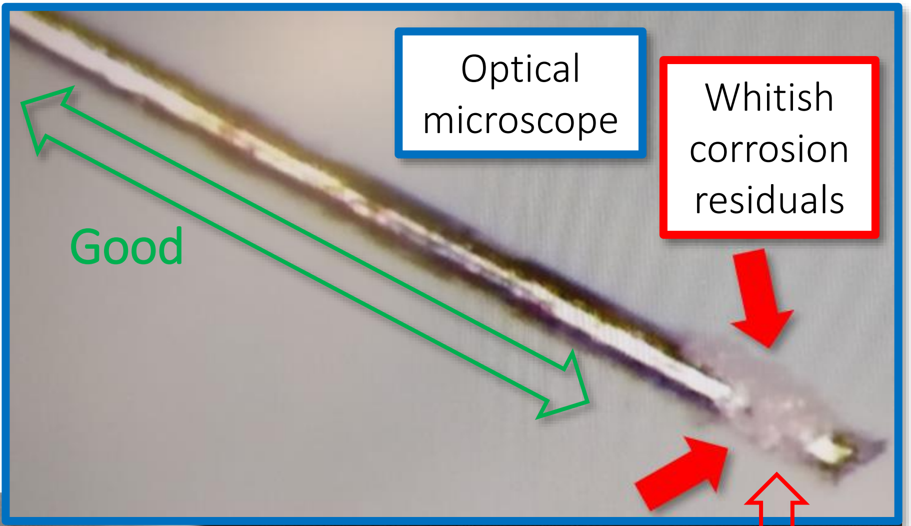


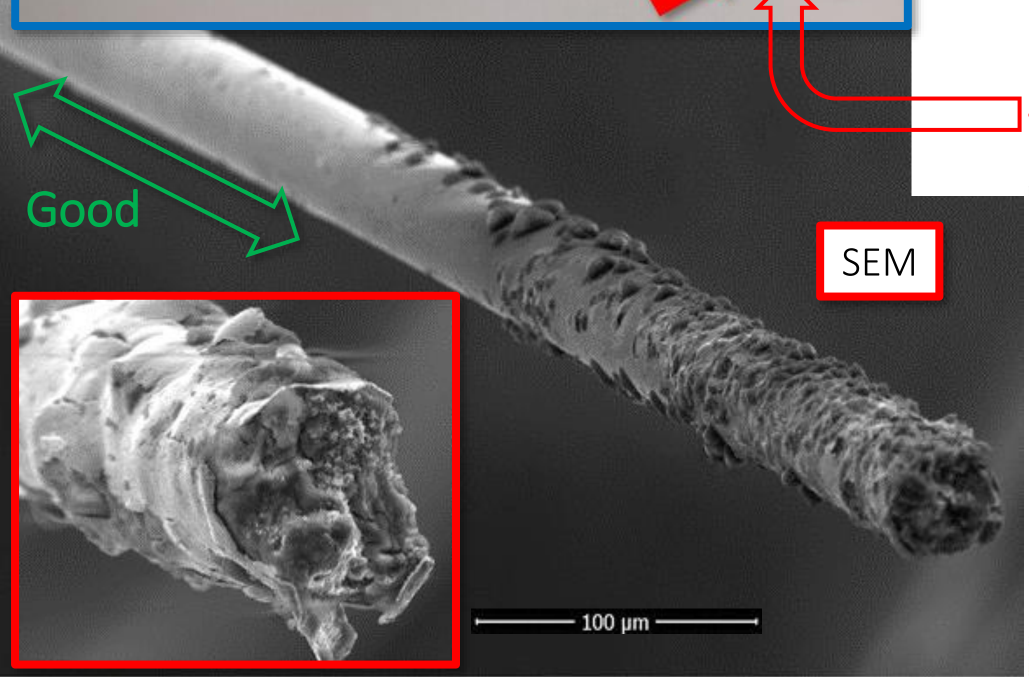
One of the worst case…



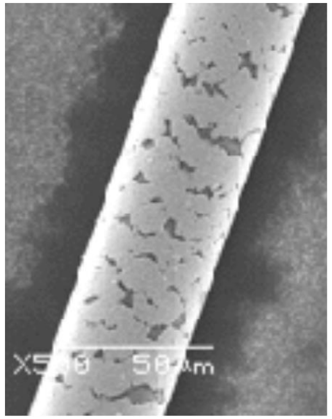
Setup for broken wires extraction
- Precision mount with fine axes control
- 2 cameras for stereo view

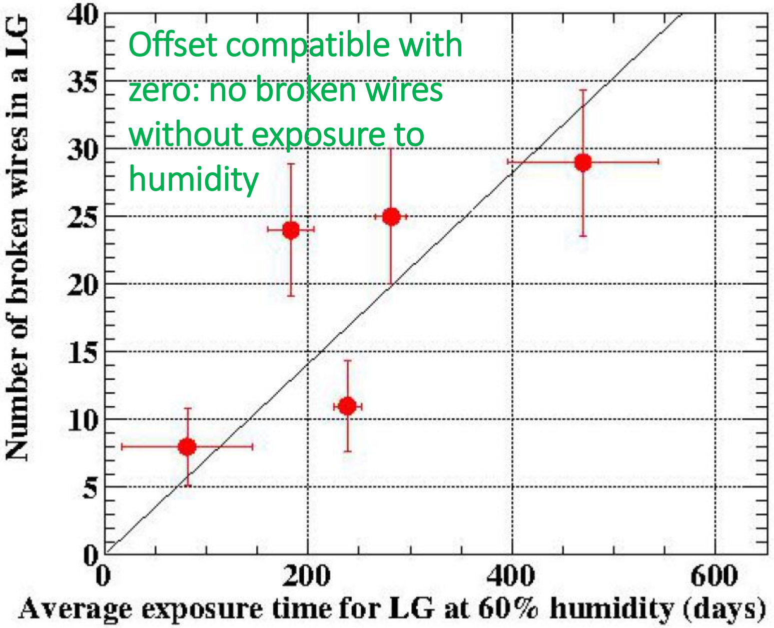
Investigations on wire breakages

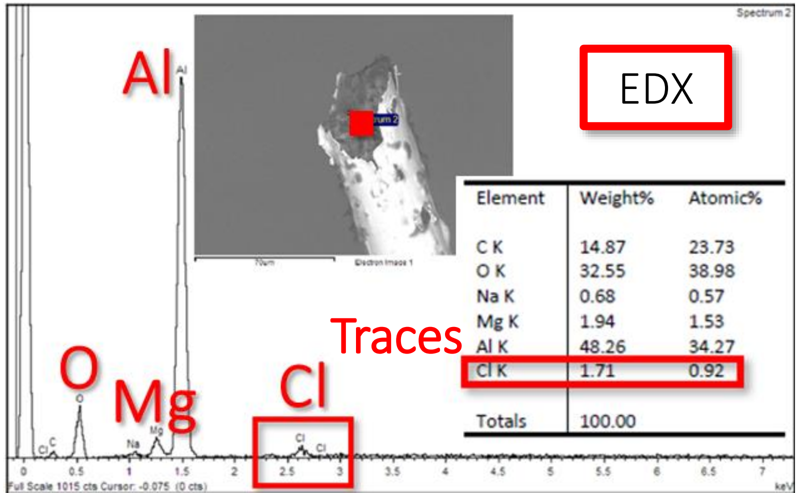




- Breakings due to corrosion of the aluminum wire core
- Two hypotheses
  1. Galvanic process between Al and Ag coating
  2. Al corrosion by Cl
- Both imply water as catalyst
  - Air moisture condensation inside cracks in the Ag coating even at low Relative Humidity (RH) levels $< 40\%$
  - Al oxide or hydroxide deposits







Element	Weight%	Atomic%
C K	14.87	23.73
O K	32.55	38.98
Na K	0.68	0.57
Mg K	1.94	1.53
Al K	48.26	34.27
Cl K	1.71	0.92
Totals	100.00	

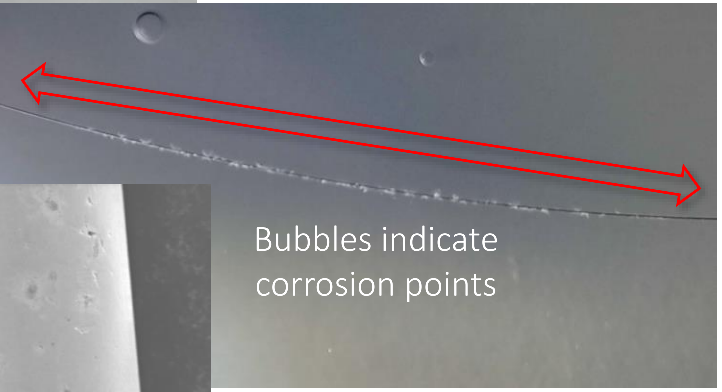
- Found a good linear correlation between number of broken wires and exposure time to humidity
- The only way to **stop the corrosion** is to keep the **wires in an inert atmosphere**
- No more broken wires due to corrosion since CDCH was flushed with Nitrogen or Helium once sealed

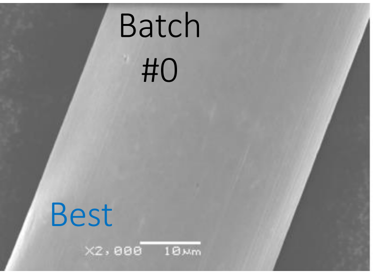
Al(Ag) wires: CDCH vs. CDCH2

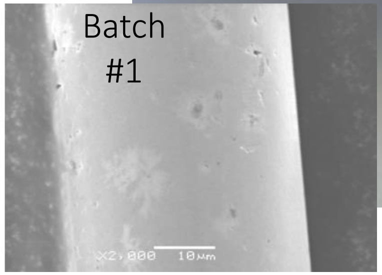
CDCH: 40 µm (75.5%) + 50 µm (24.5%) Al(Ag) wires

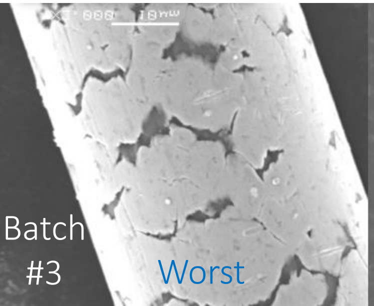
50 µm wire samples (1 meter each) immersed in distilled water

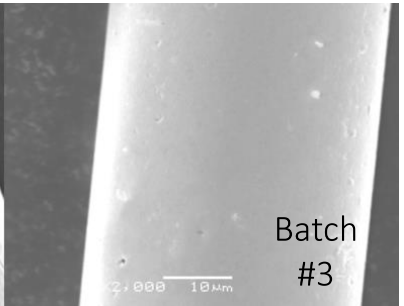
- ➢ Continuous corrosion points
- ➢ Breakings with no stress
- ➢ 40 µm wire samples completely destroyed







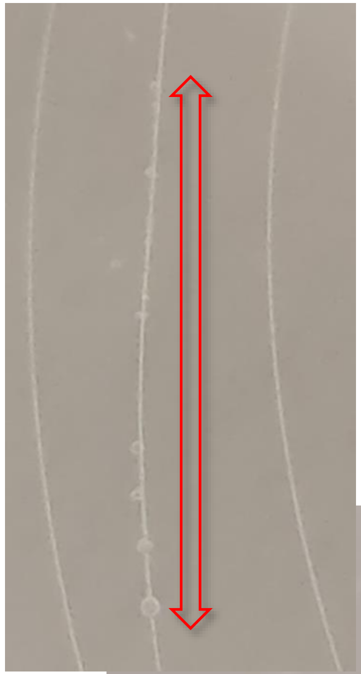


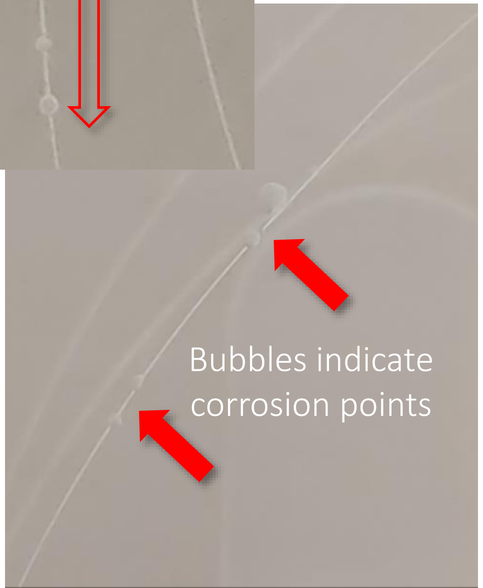


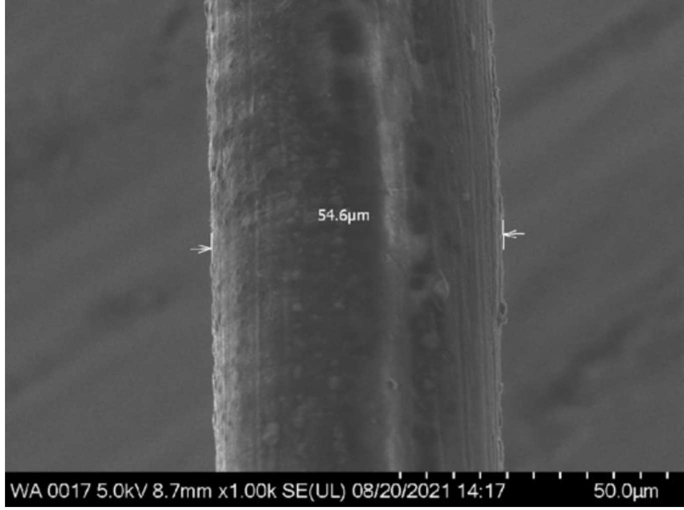
Production batch-dependent wire surface quality

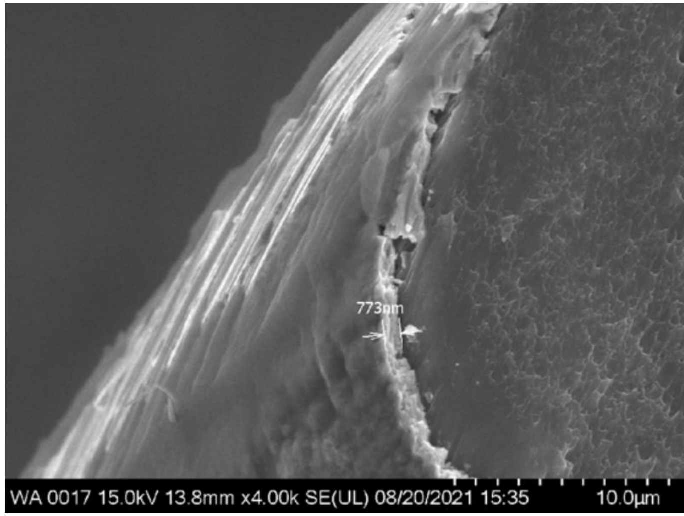
- ➢ Final drawing process (polish) on plated wires
- ➢ Cracks on the surface
- ➢ Weak points prone to corrosion

CDCH2: 50 µm (100%) Al(Ag) wires









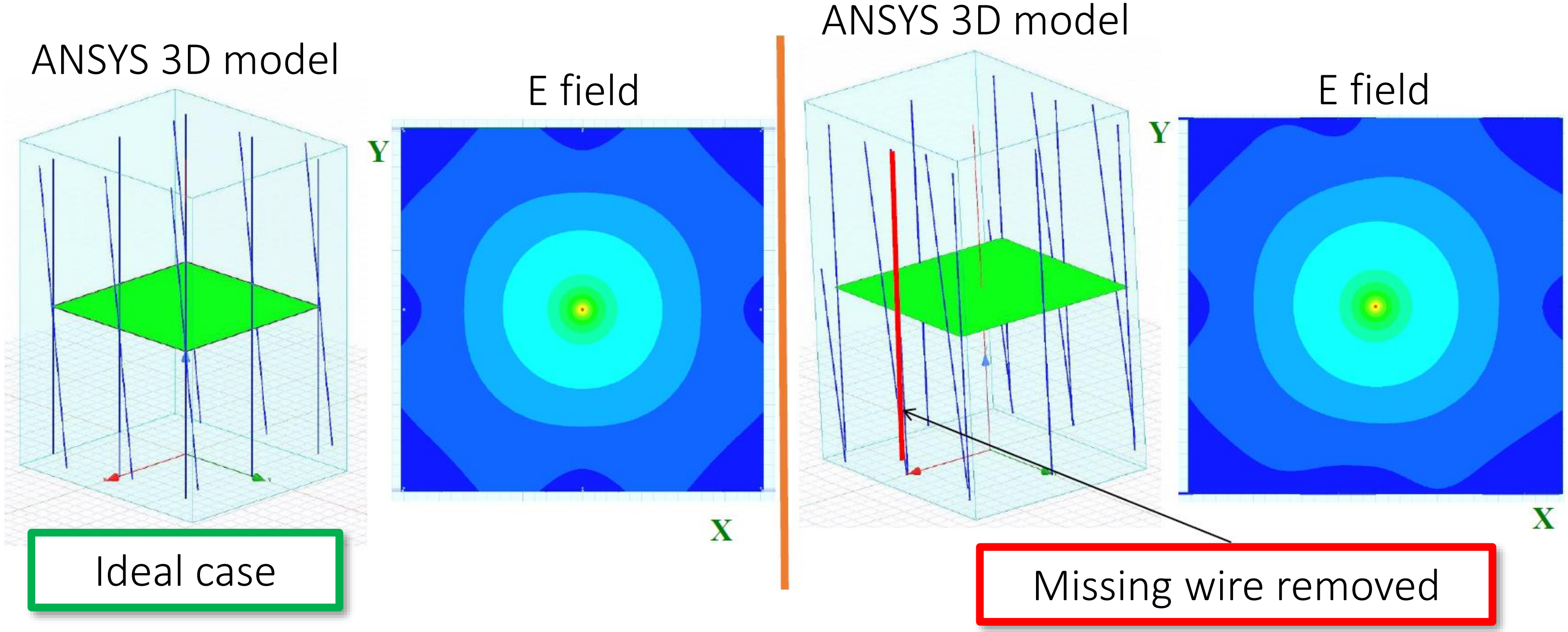
Uniform and thicker Silver coating

- ➢ No final drawing process
- ➢ No cracks on the surface

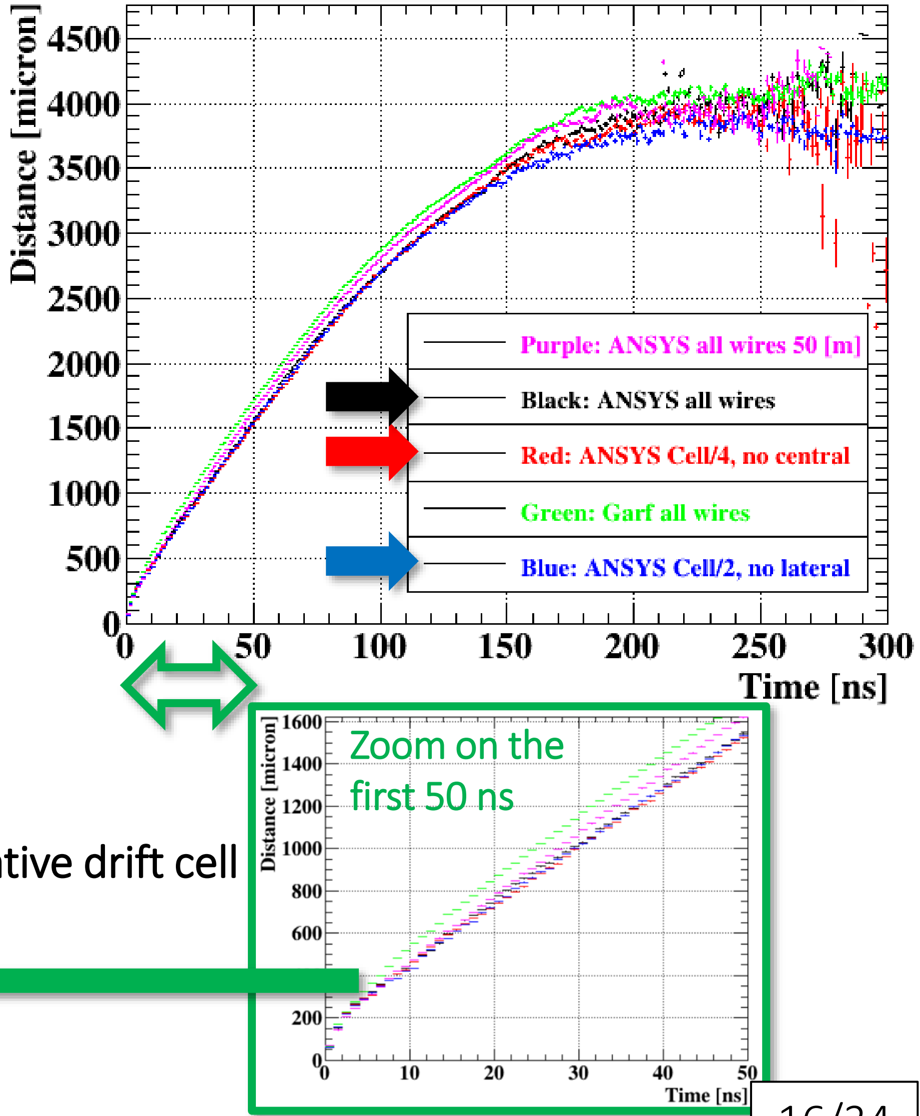
50 µm wire samples (1 meter each) immersed in distilled water

- ➢ Just a few isolated corrosion points
- ➢ A factor of 3 better than the best CDCH production batch

Missing wire effect



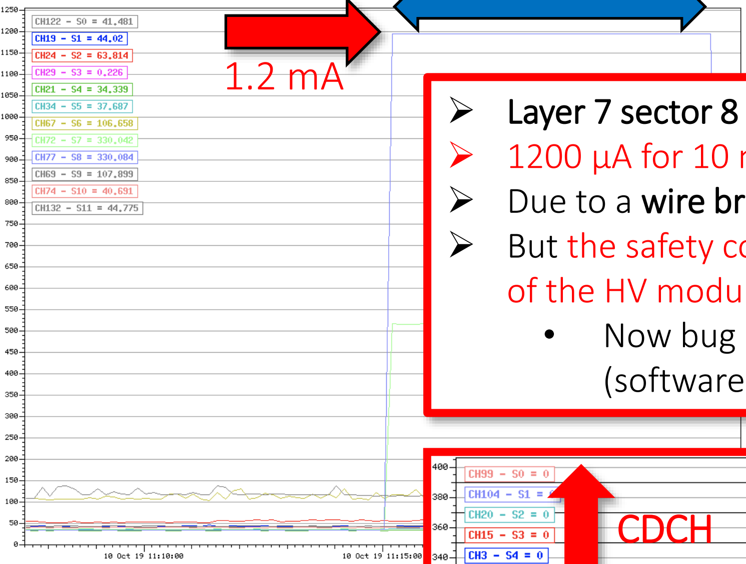
Drift distance vs. drift time relations computed with **Garfield**



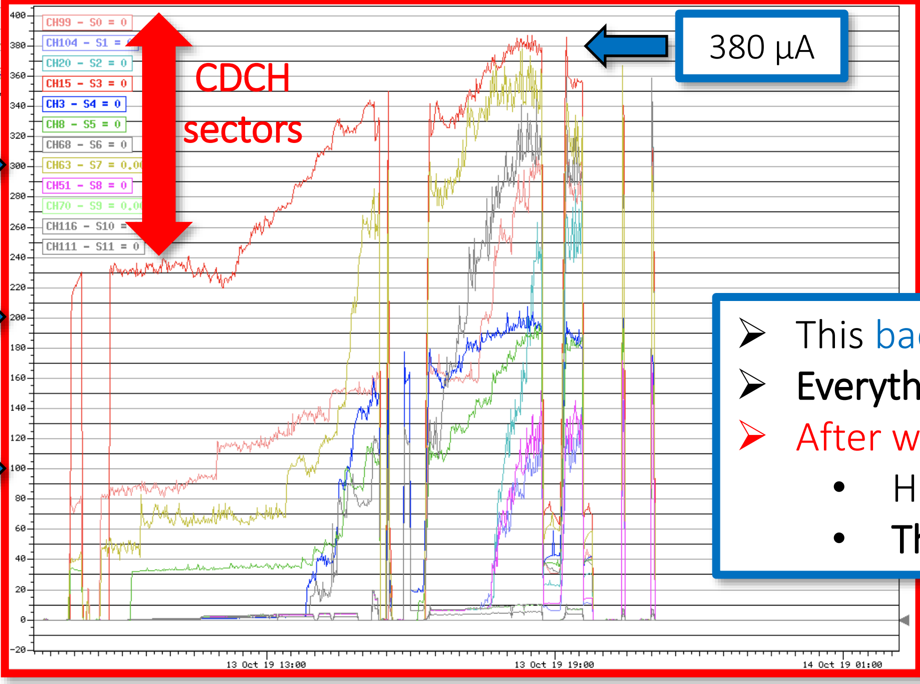
- Study the effect of a missing cathode on isochrones → e^+ reconstruction
- Used **Garfield** and **ANSYS** to **simulate the electric field in a** $\mathbf{6 \times 6\ mm^2}$ **representative drift cell**
  - Single-hit resolution $\sigma_{hit} < 120\ \mu m$
  - Difference between different curves → $\approx 10\ \mu m$
- **Missing wire effect negligible**

Investigations on anomalous currents

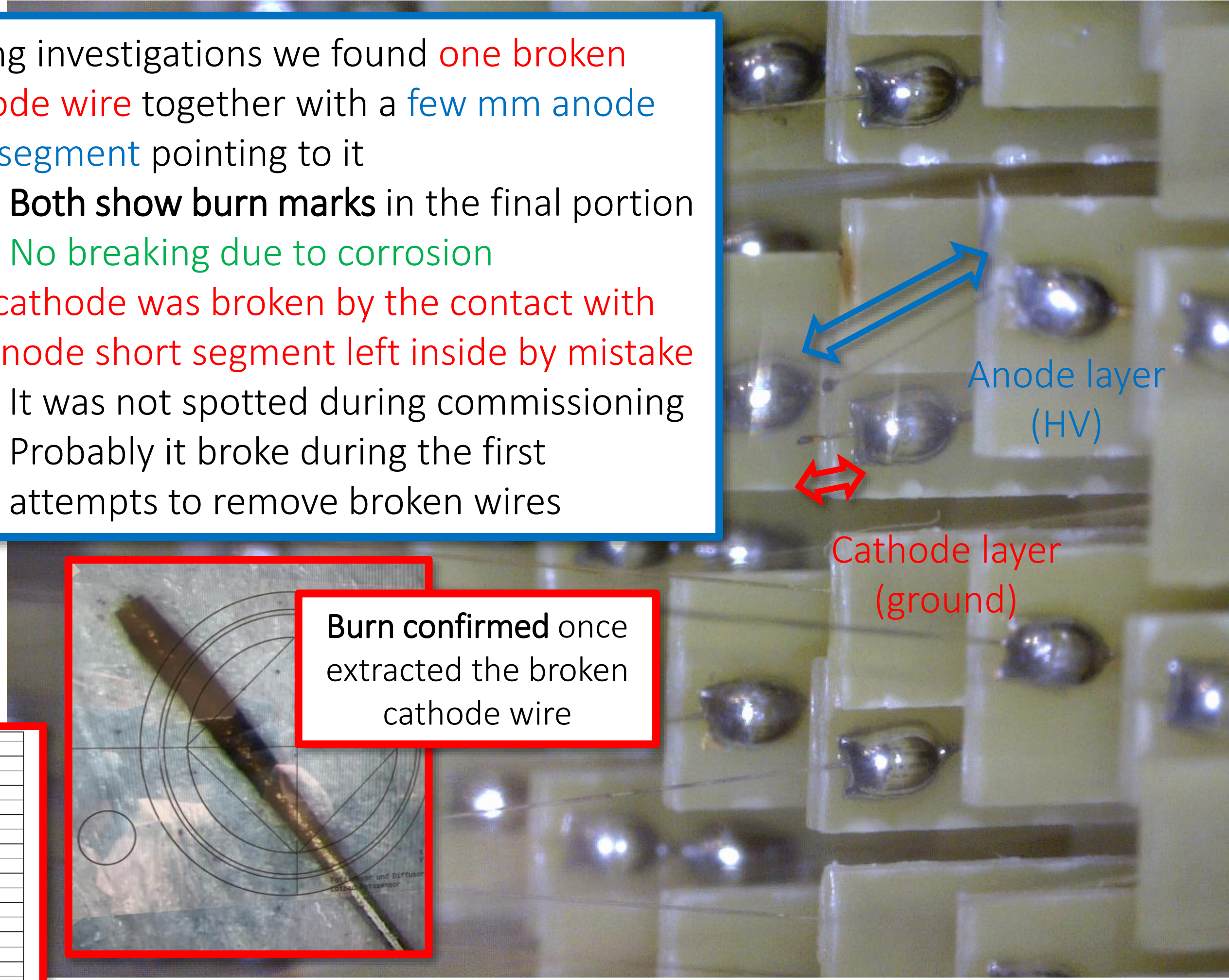
Bad event in 2019



- Layer 7 sector 8
- 1200 µA for 10 minutes
- Due to a **wire breaking**
- But the safety control (firmware) of the HV module did not work
  - Now bug solved + extra (software) safety systems



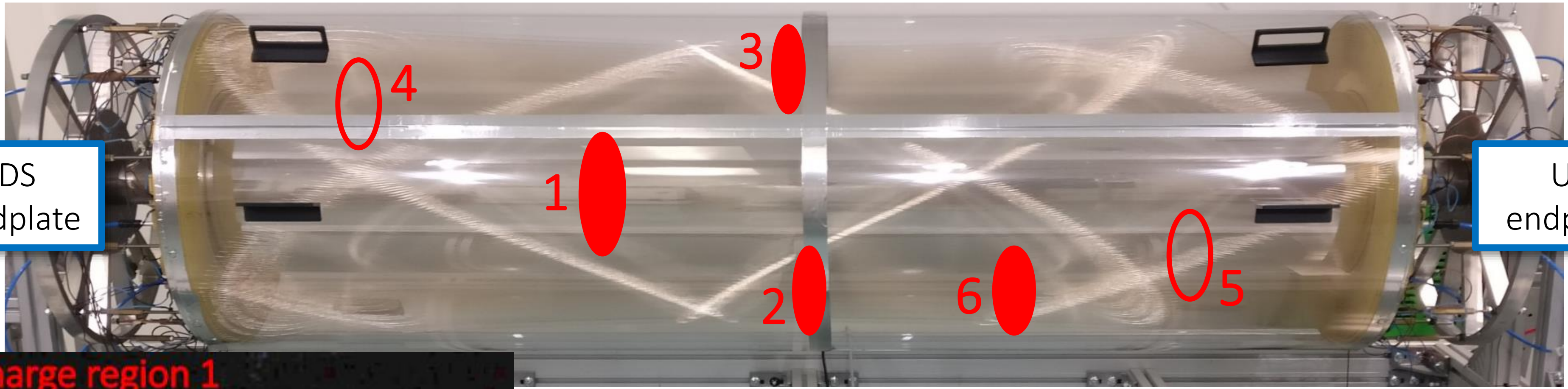
- During investigations we found one broken cathode wire together with a few mm anode wire segment pointing to it
  - **Both show burn marks** in the final portion
  - No breaking due to corrosion
- This cathode was broken by the contact with the anode short segment left inside by mistake
  - It was not spotted during commissioning
  - Probably it broke during the first attempts to remove broken wires

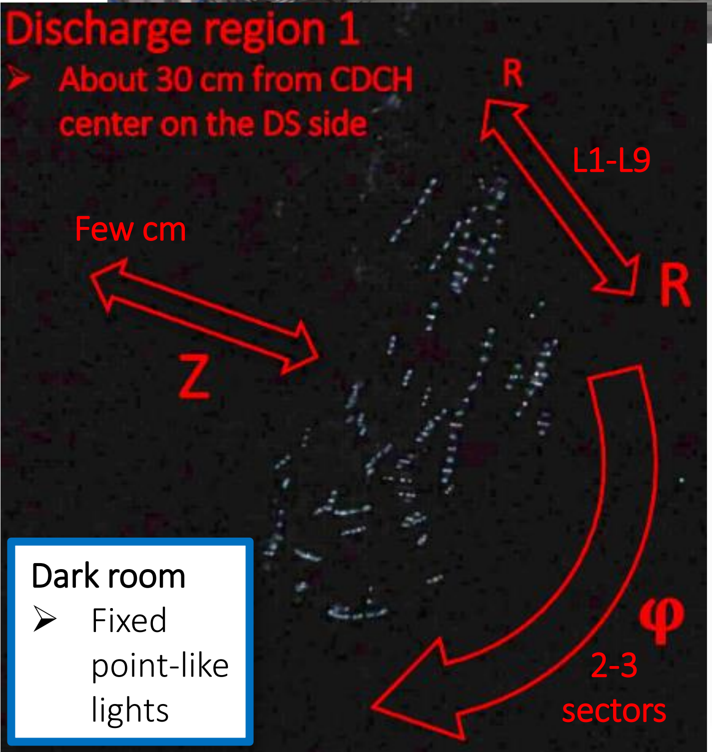


Burn confirmed once extracted the broken cathode wire

- This bad event occurred during the Michel e^+ data taking with μ^+ beam
- **Everything was good up to this moment**
- After we experienced anomalously high currents is several sectors/layers
  - Here an example for layer 2 at the HV working point + beam ON
  - **The problem has been investigated**

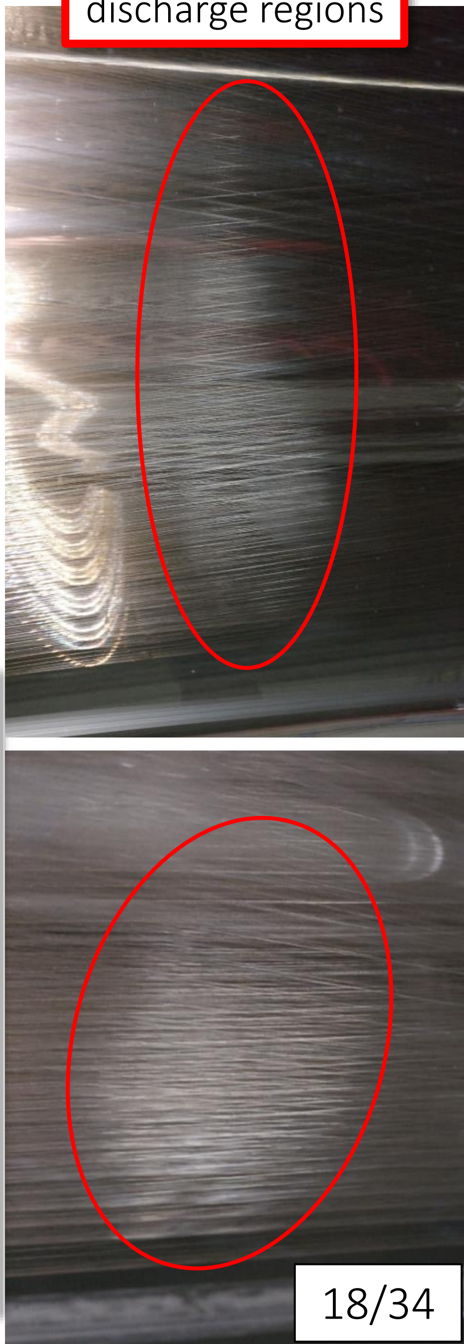
Investigations on high currents





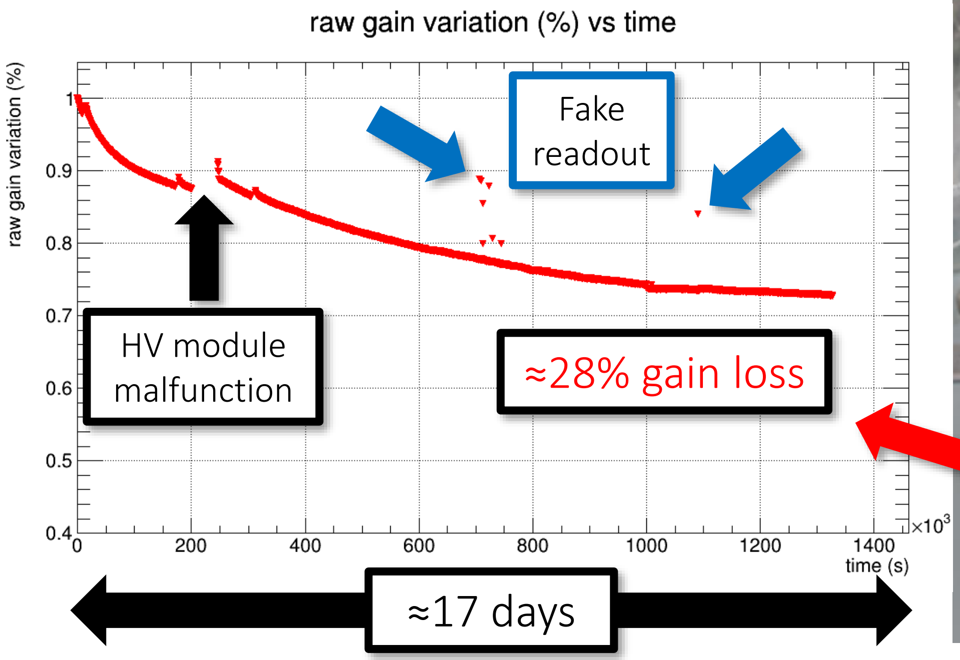
- ➢ We performed HV tests with CDCH closed with a transparent shell and filled with the standard He:IsoB 90:10 gas mixture to spot the discharges
- ➢ We saw corona-like discharges in correspondence of 6 whitish regions
- ➢ Gas mixture optimization: different additives to the standard mixture to **test the CDCH stability** and **try to recover the normal operation**
  - Up to 5% CO_2 and 10% synthetic air (80% Nitrogen + 20% Oxygen)
  - 2000-4000 ppm of H_2O (≈10% Relative Humidity inside CDCH)
  - 1-1.5% Isopropyl alcohol
  - From 500 ppm to 2% of O_2
    - Also in combination with H_2O and Isopropyl alcohol
- ➢ Oxygen proved to be effective in reducing high currents (plasma cleaning?)
- ➢ Isopropyl alcohol crucial to keep stable the current level

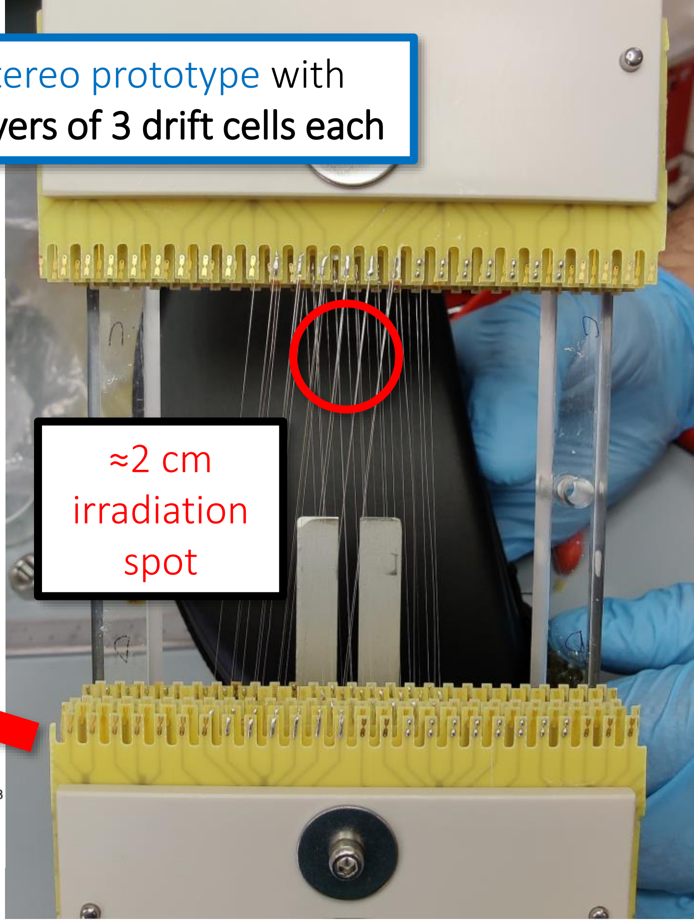
Two of the discharge regions



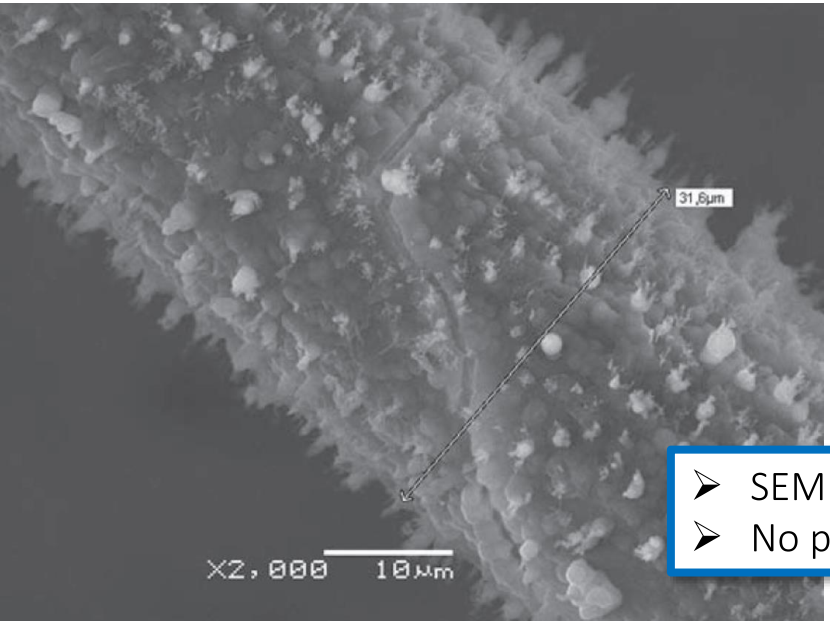
Ageing tests on prototypes

- Accelerated ageing tests on different prototypes were performed
- Prototypes with increasing complexity
  - From a 1-cell prototype to a **small 2-layer stereo prototypes** (6 cells)
  - This latter is presented here and it featured the **same geometry and materials of the CDCH endplates**

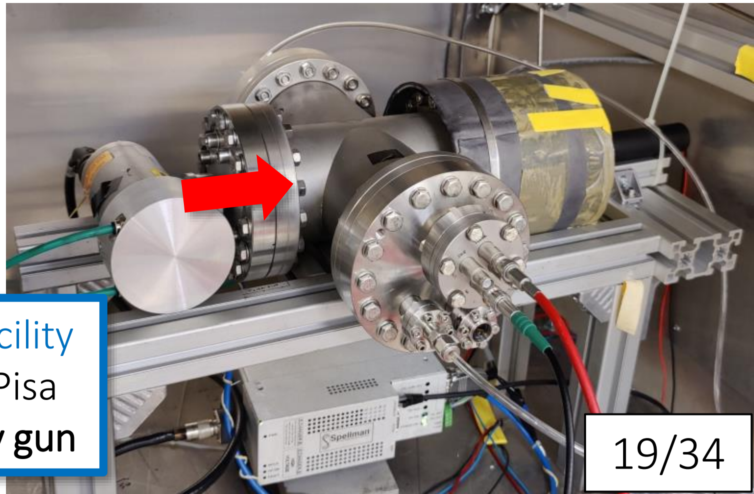




- Total **ageing acceleration factor 10 < *A* < 100**
  - Accumulated charge comparable to the total MEG II life ≈0.5 C/cm
- No issues/discharges observed



- SEM image of an aged anode wire
- No problems on cathode wires

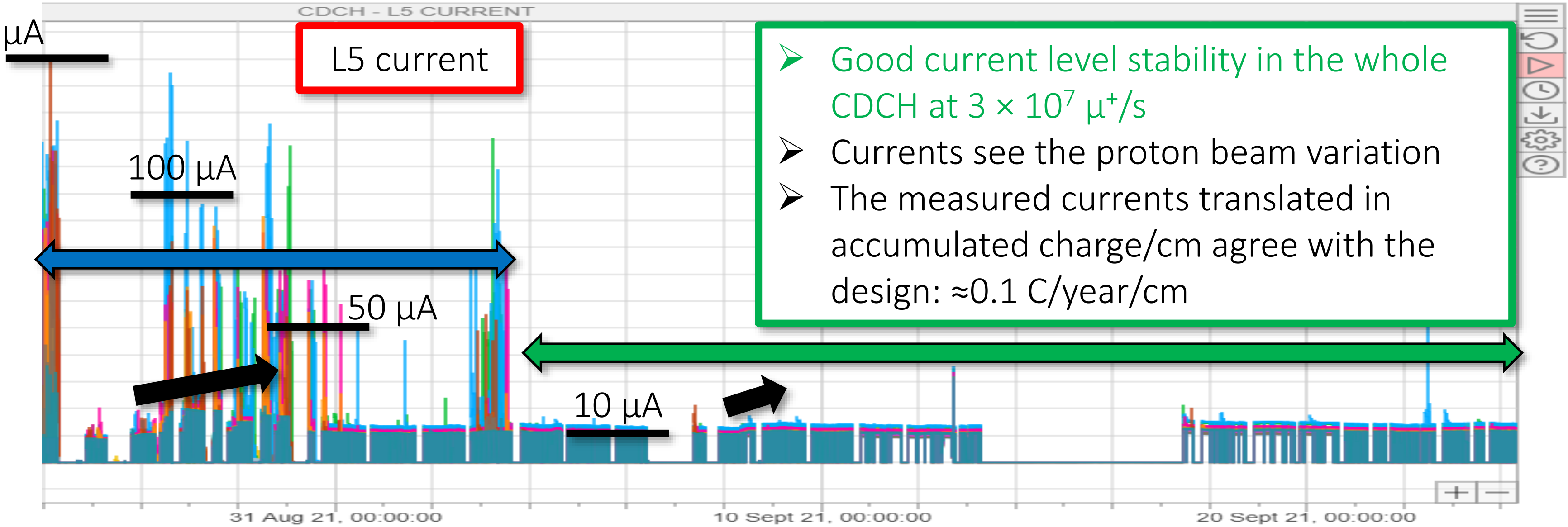


Ageing facility at INFN Pisa with **X-ray gun**

CDCH conditioning with μ^+ beam

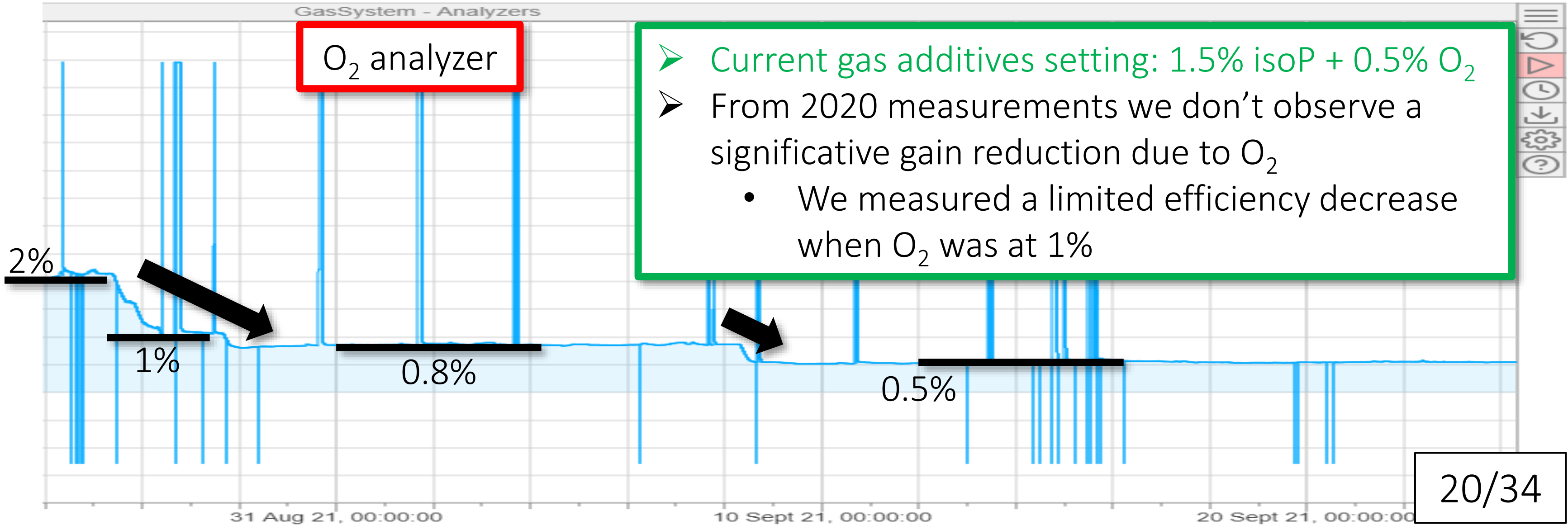
Conditioning with μ^+ beam

- Example of conditioning period with current discharges
- HV up to WP+40V to speed up the O_2 cleaning



- Good current level stability in the whole CDCH at 3×10^7 μ^+/s
- Currents see the proton beam variation
- The measured currents translated in accumulated charge/cm agree with the design: ≈0.1 C/year/cm

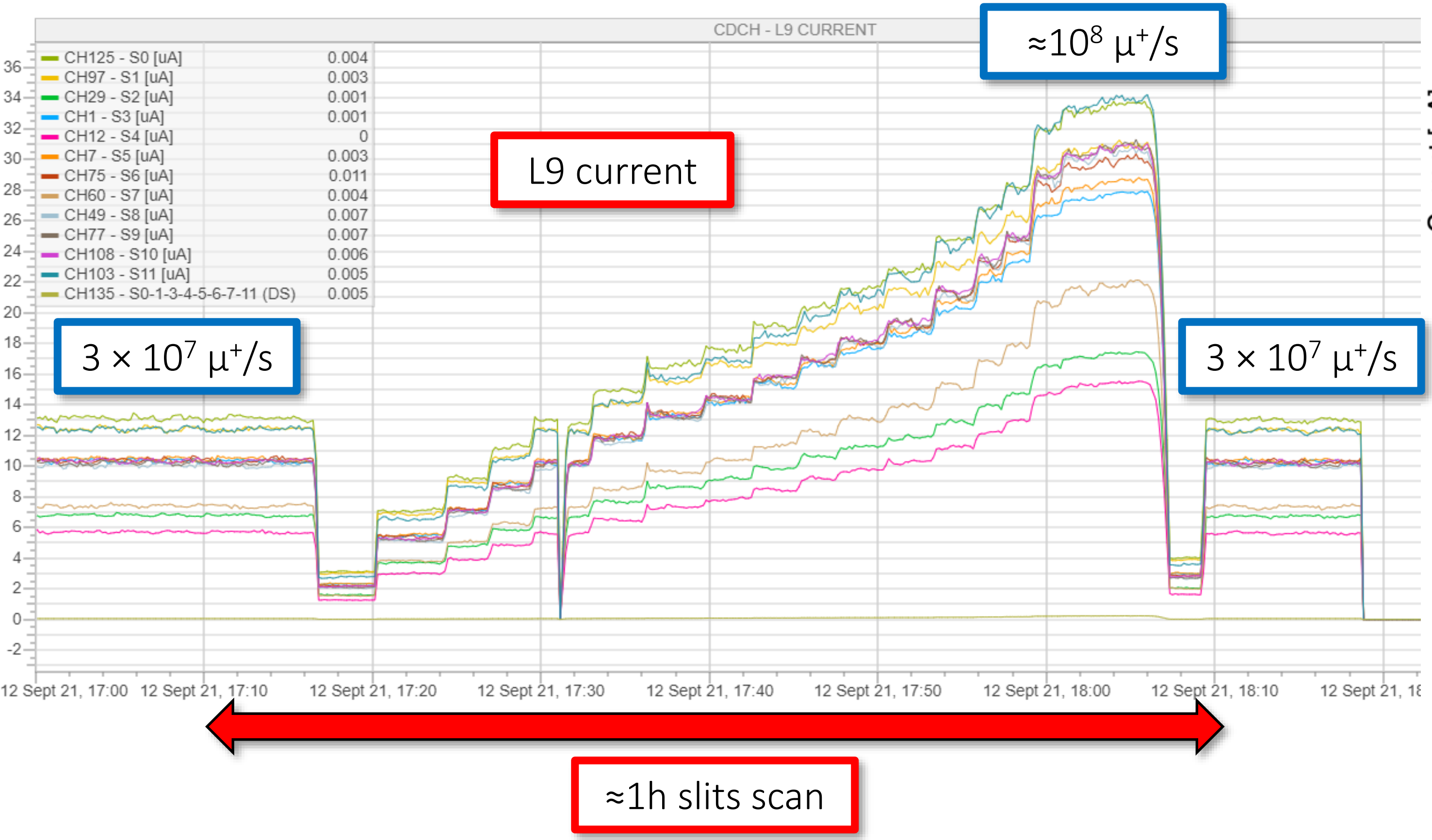
- We are very sensitive to the isopropyl alcohol concentration
- We experienced that 1-1.5% isoP concentration is crucial to keep the stability

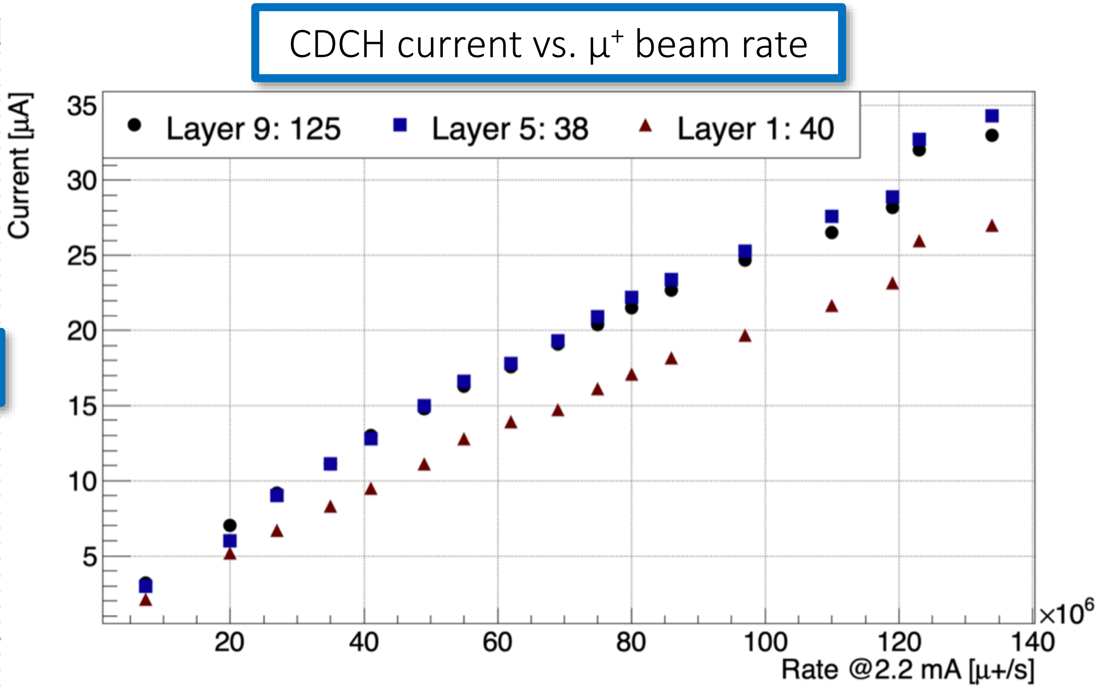


- Current gas additives setting: 1.5% isoP + 0.5% O_2
- From 2020 measurements we don't observe a significative gain reduction due to O_2
  - We measured a limited efficiency decrease when O_2 was at 1%

CDCH currents vs. μ⁺ beam intensity

- ➢ Quick test but the CDCH currents followed reasonably well the beam intensity up to intensities never reached before
- ➢ The proportionality to the μ⁺ rate is good

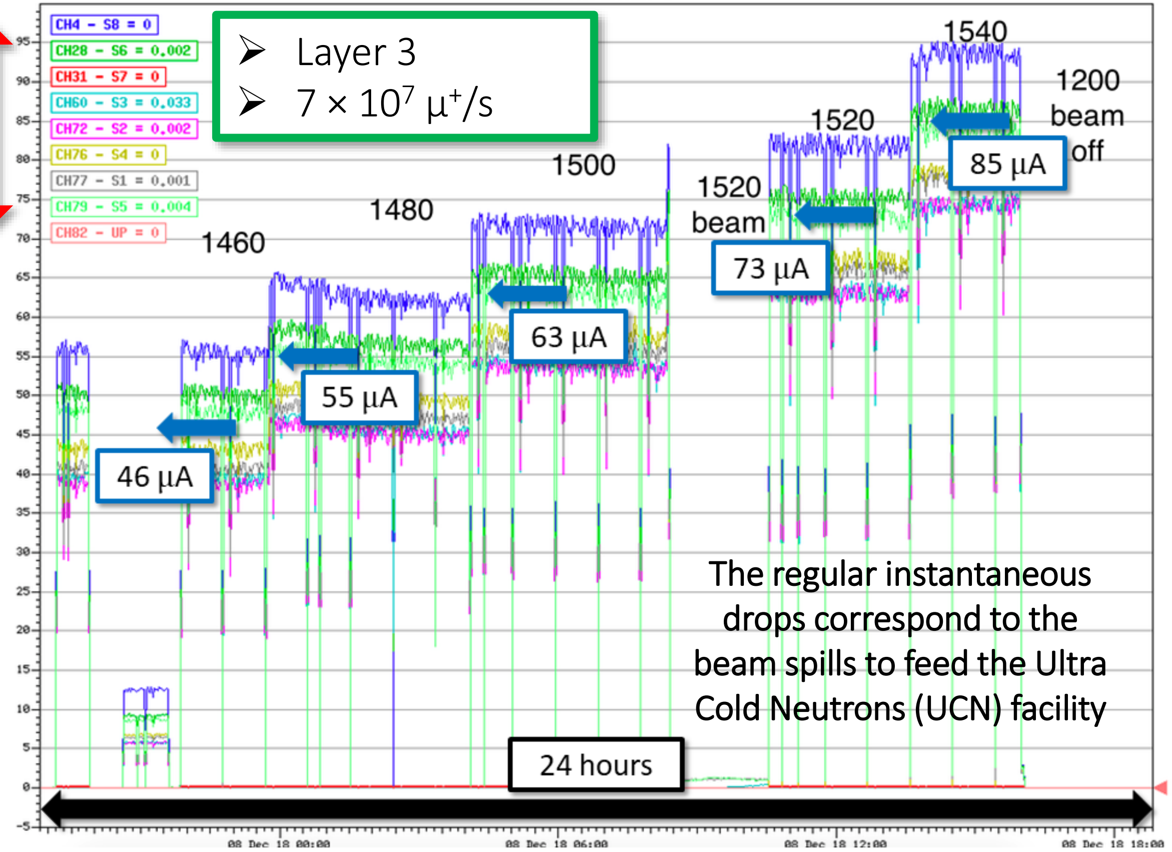


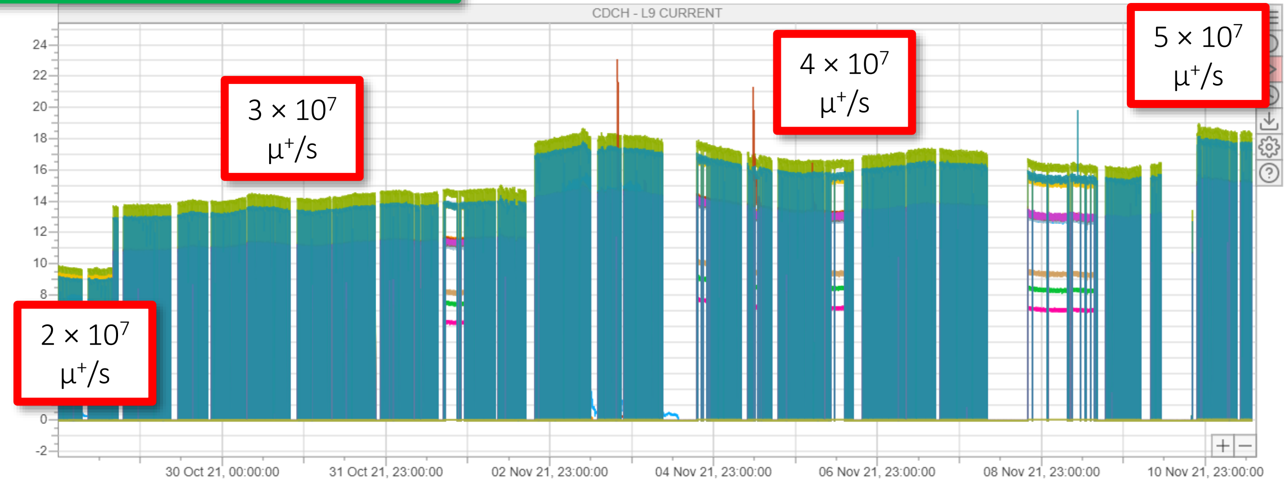


Example of gain curves with CDCH stable

Different colors correspond to different CDCH sectors

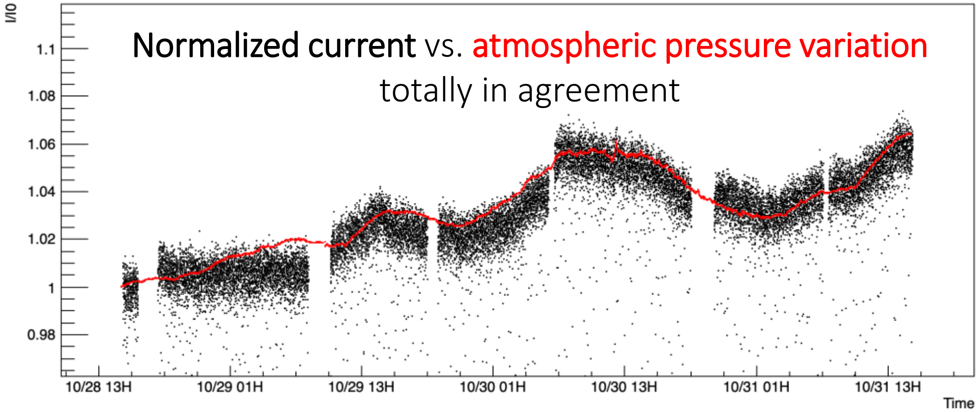
CDCH current level vs. (HV or μ⁺ beam intensity)





- Currents correctly follow the beam intensity
- Gas gain is also sensitive to the variations of the atmospheric pressure

$$\frac{\Delta G}{G} = -k\,\frac{\Delta P}{P}$$

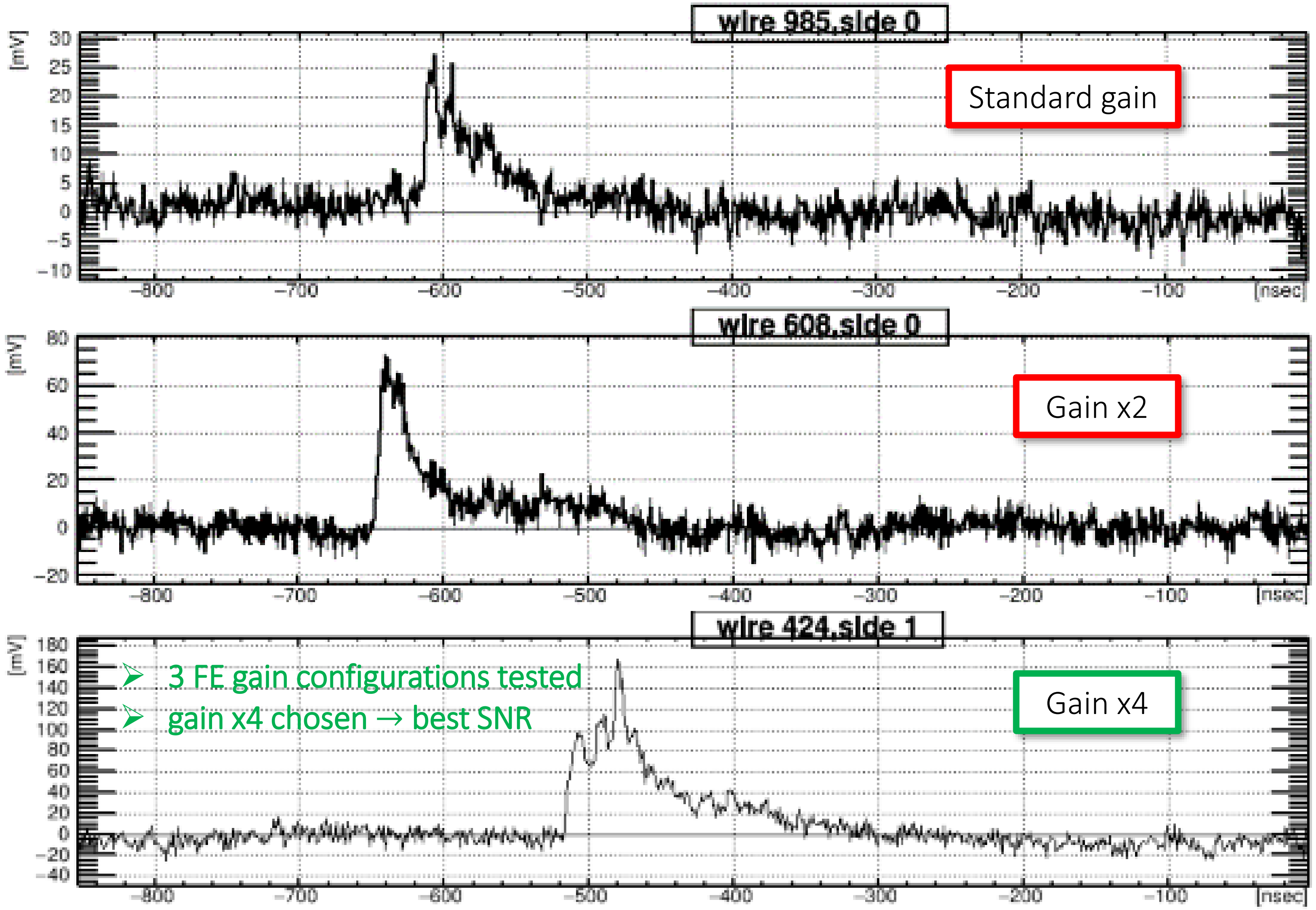


$$\frac{I}{I_0} = 1 - 5\,\frac{\Delta P}{P}$$

$$k = 5$$

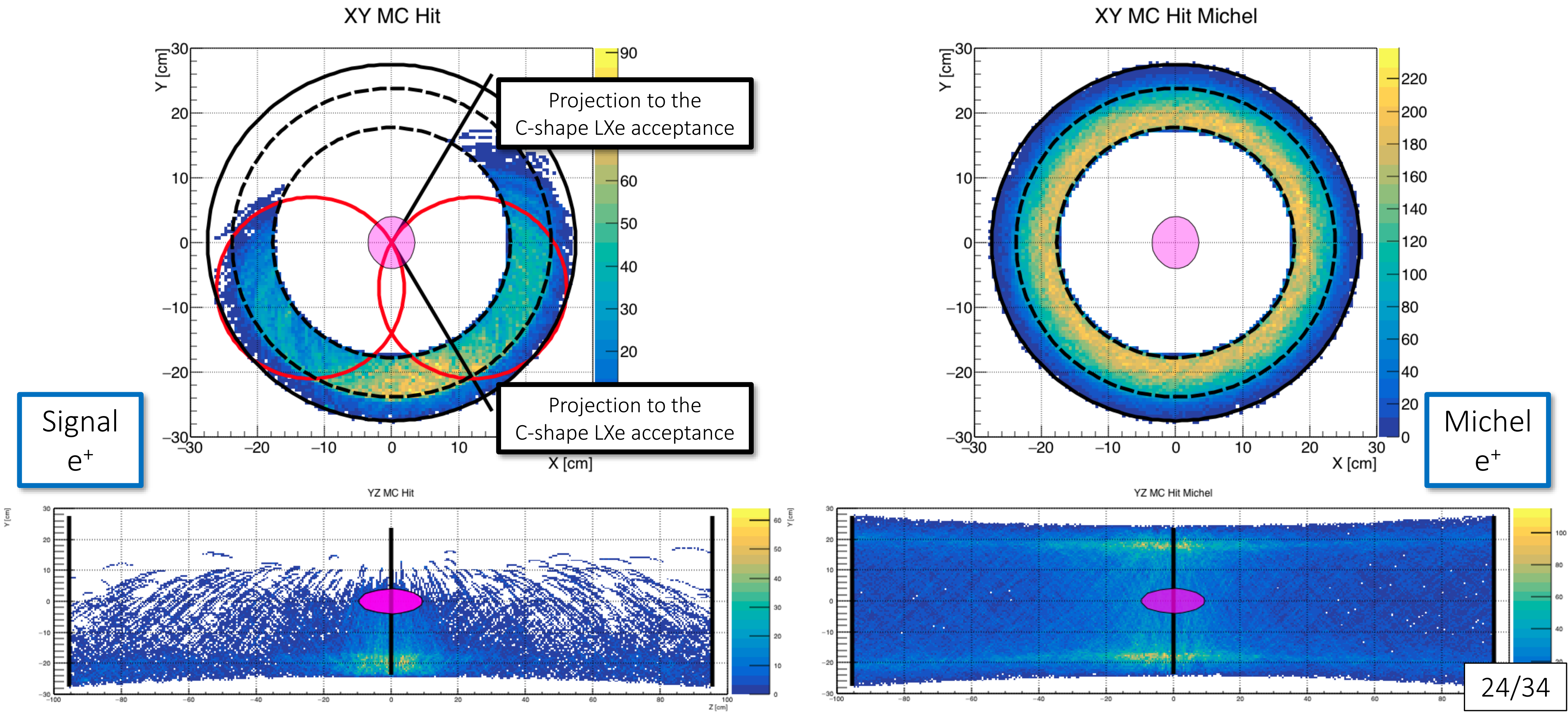
Start of the physics data taking

Example of signal Waveforms

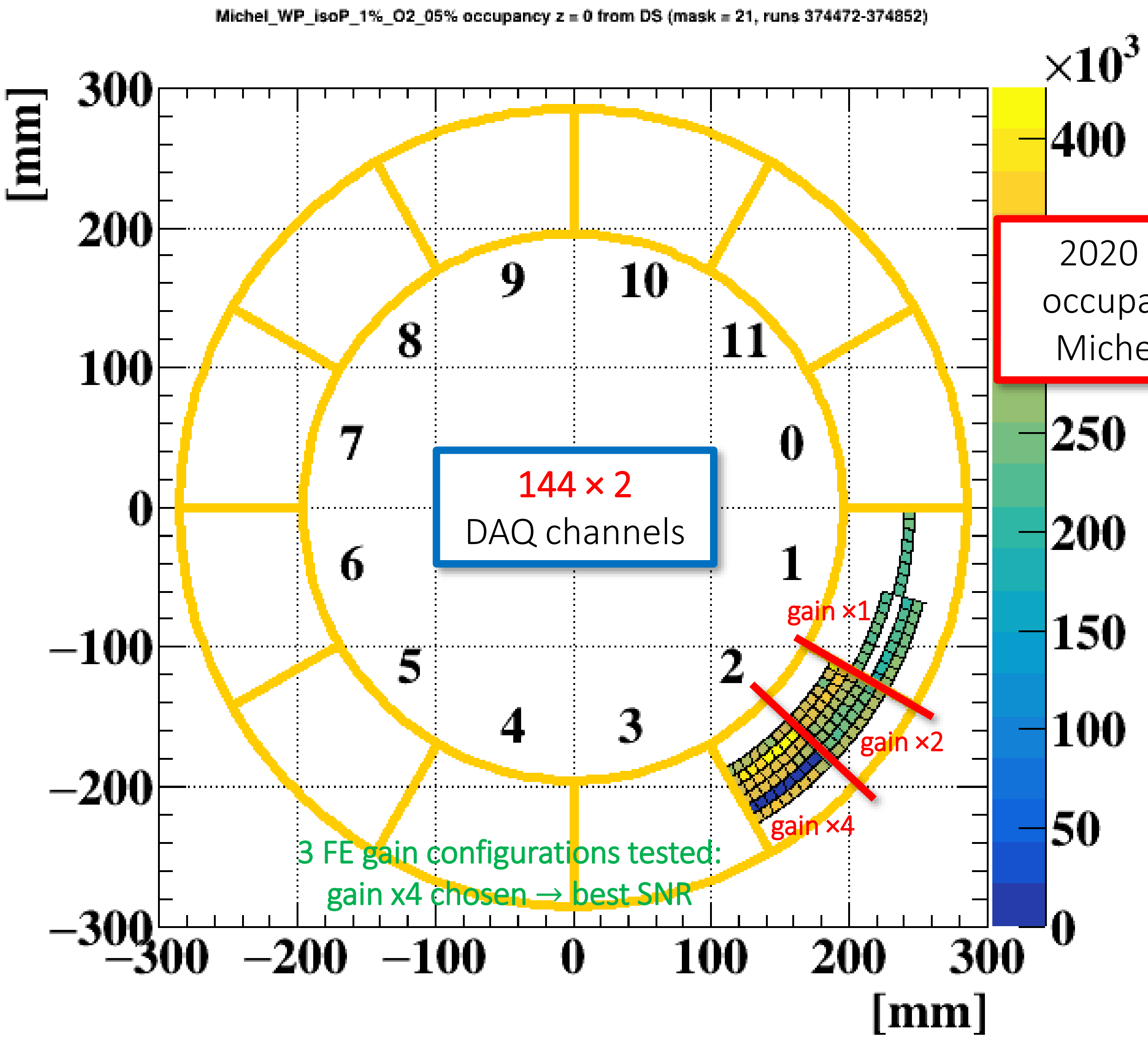


- ➢ In MEG all the signal WF is recorded
- ➢ Then a fine analysis is made offline to get the hit information
  - Timing
  - Signal amplitude
  - Signal integral
  - Position

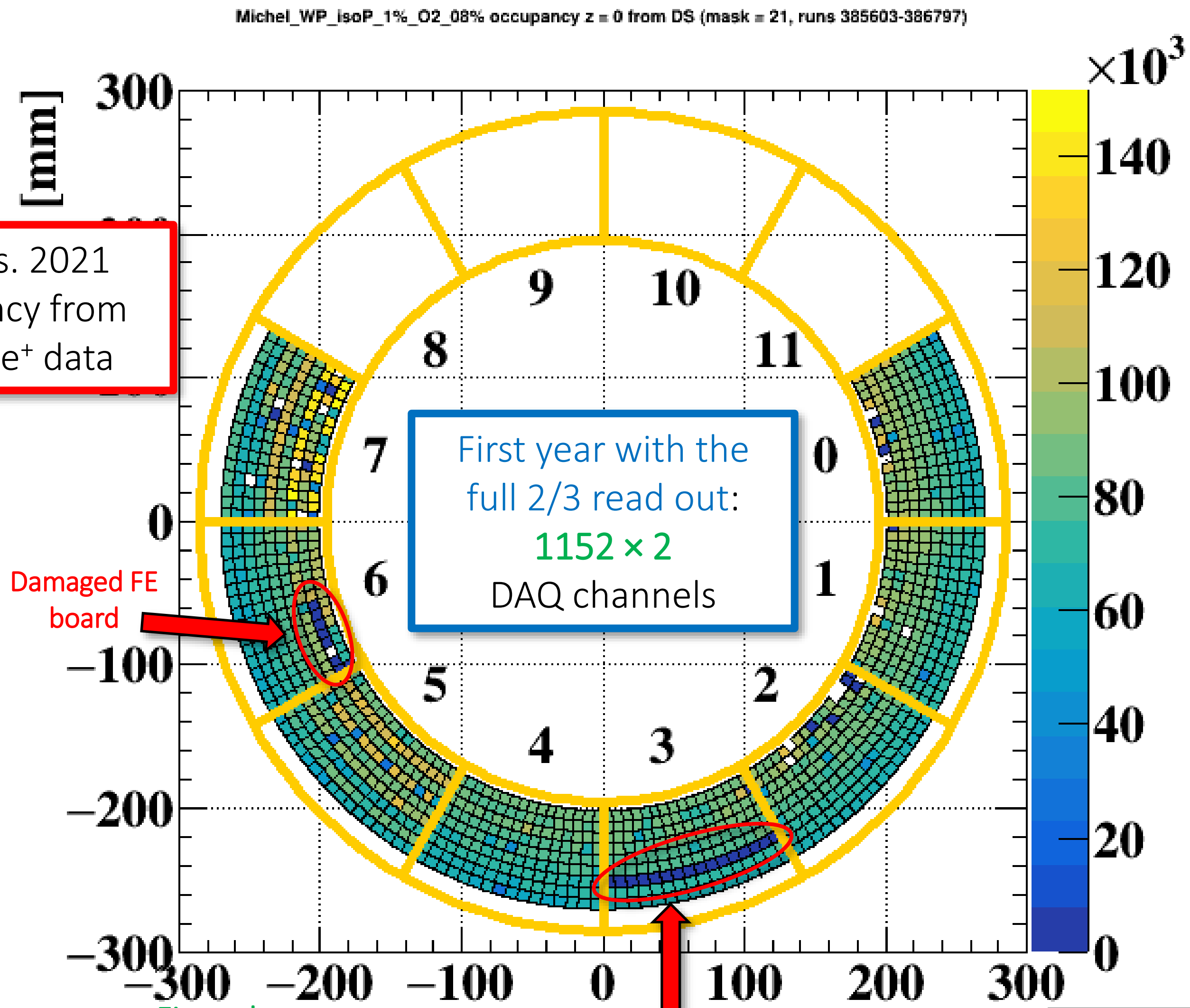
Example of CDCH occupancy from MC



Occupancy from data

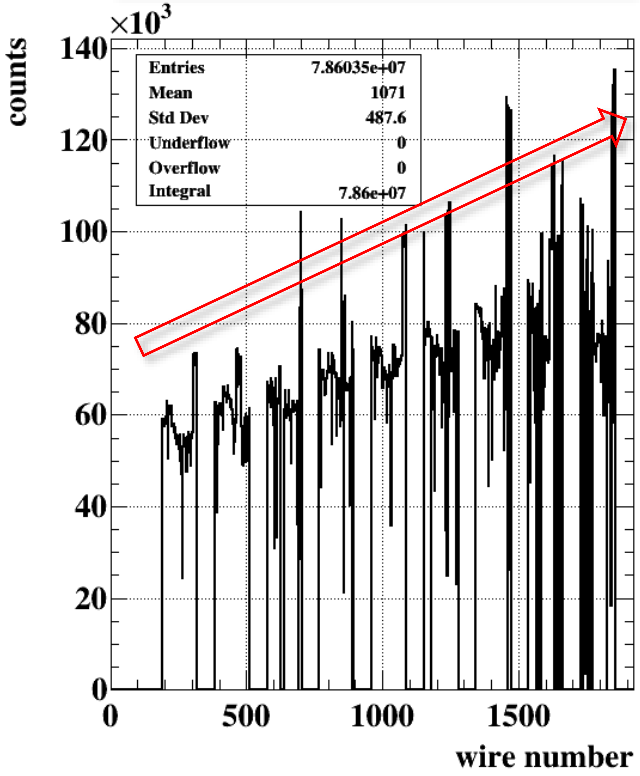


2020 vs. 2021 occupancy from Michel e+ data

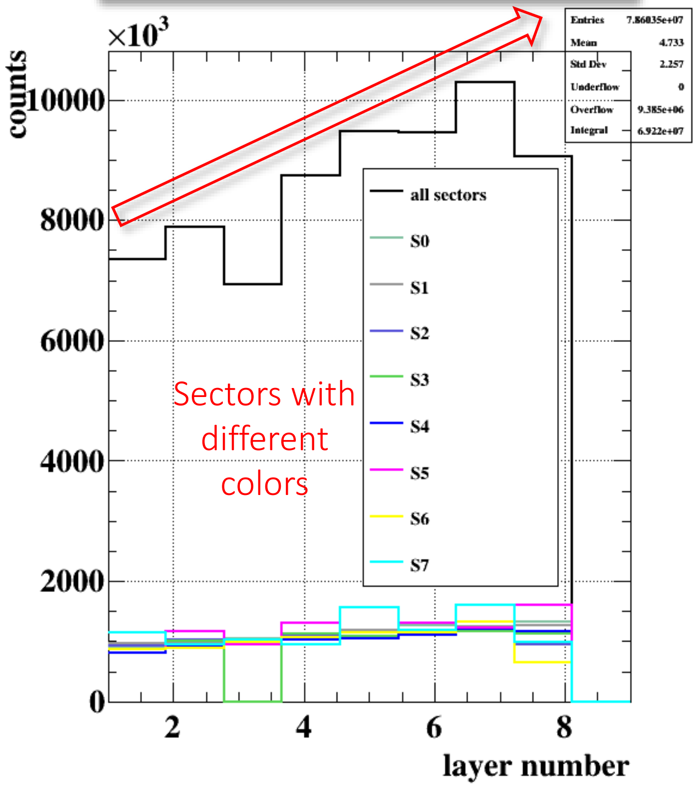


Some diagnostic plots from Michel e^+ data

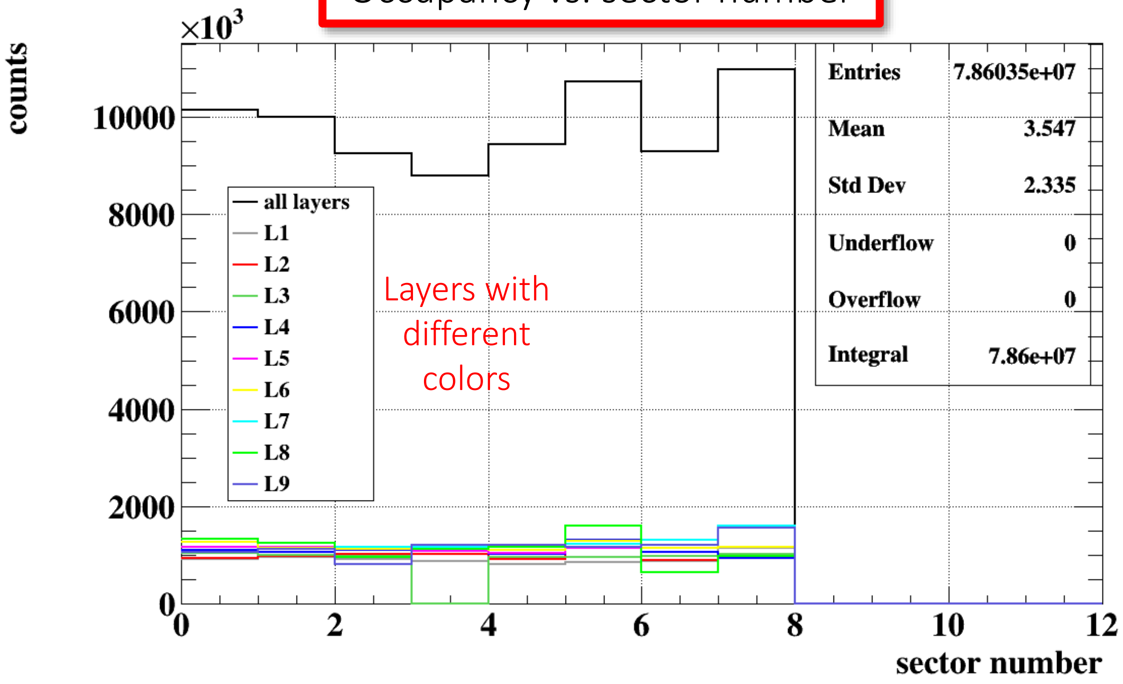
Occupancy vs. wire number



Occupancy vs. layer number



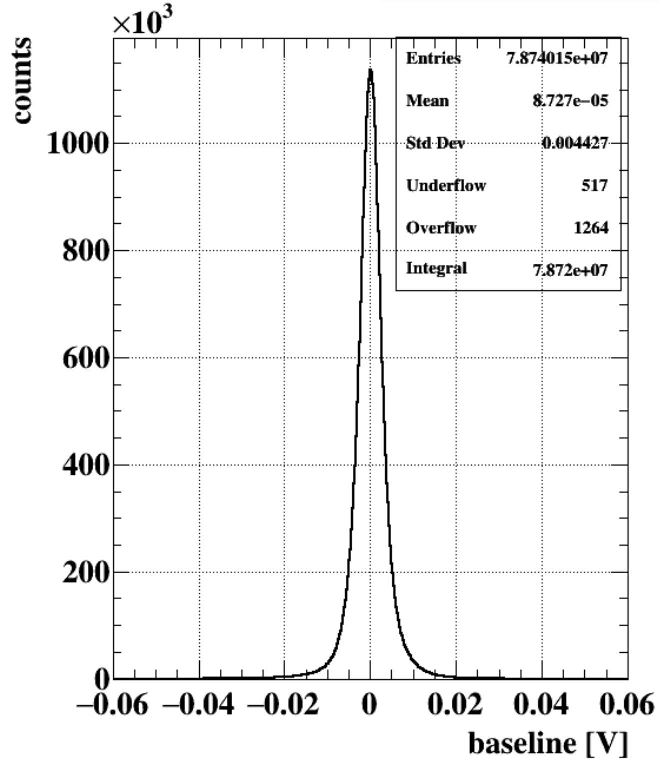
Occupancy vs. sector number

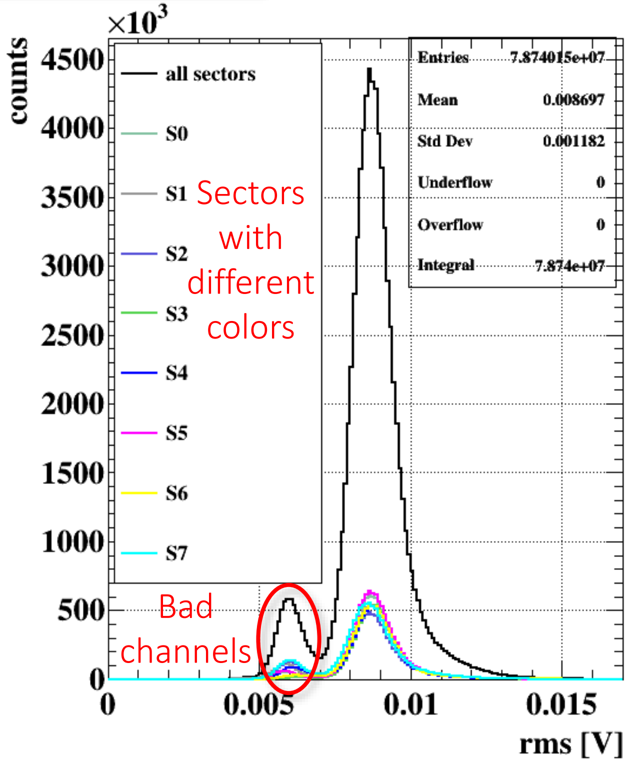


Scaling by radius as expected with Michel e^+ events

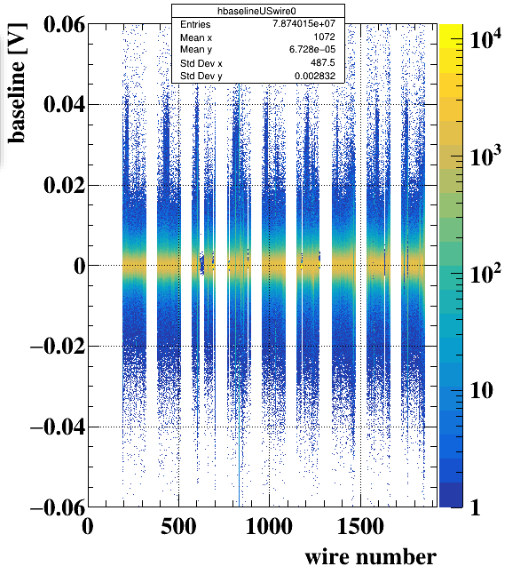
Some diagnostic plots from Michel e^+ data

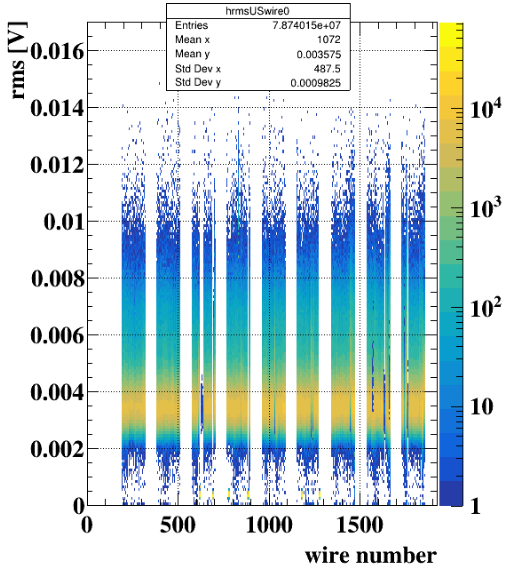
US + DS baseline and RMS levels



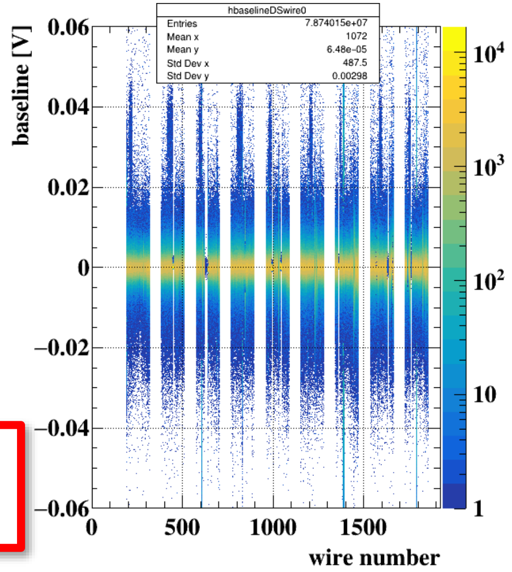


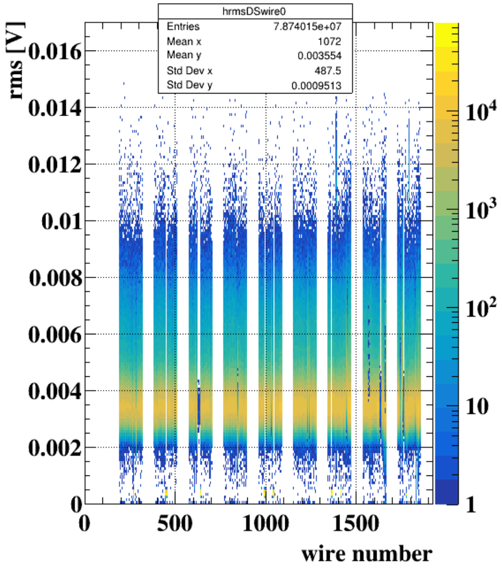
Baseline US wire by wire





RMS US wire by wire





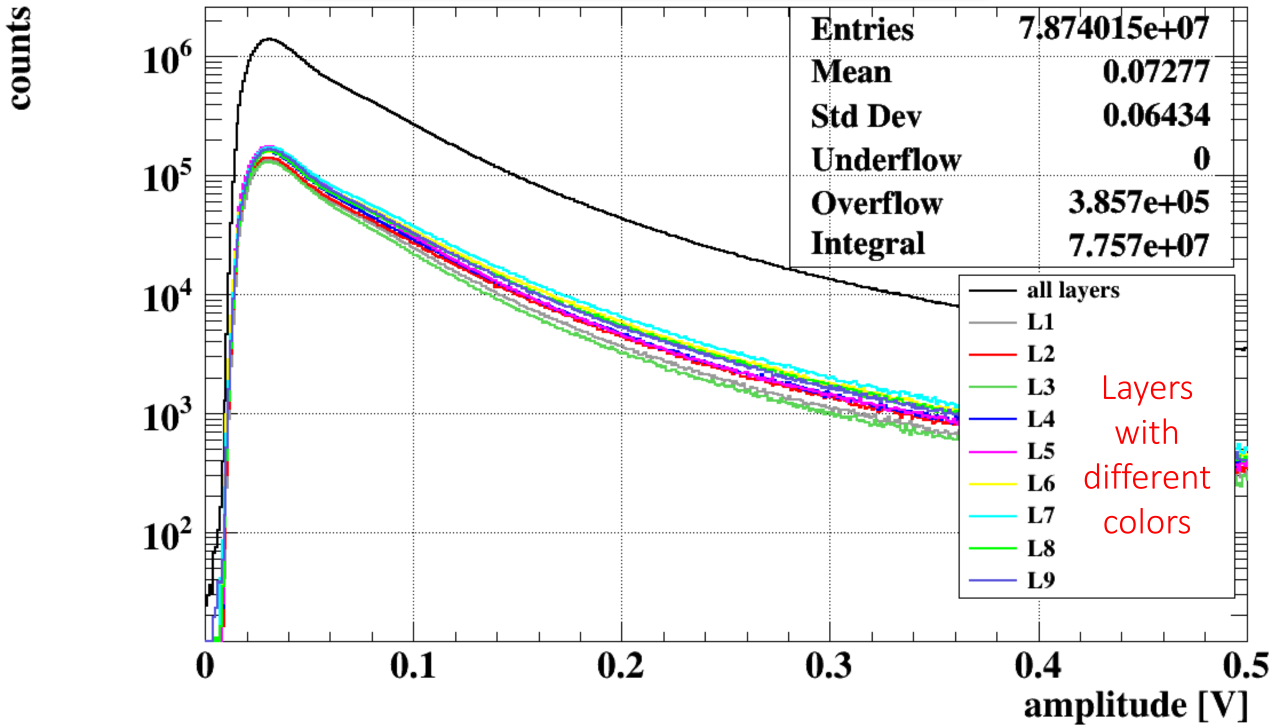
RMS DS wire by wire

Baseline DS wire by wire

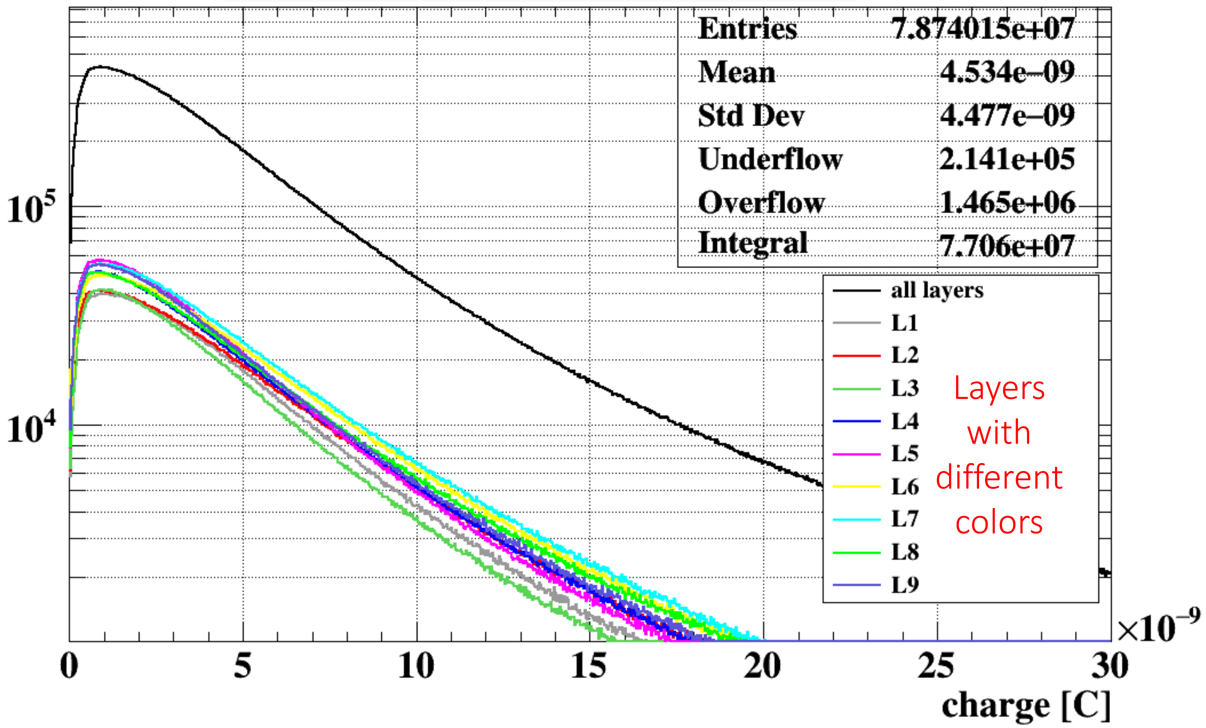
Noise situation is under control

Some diagnostic plots from Michel e^+ data

US + DS signal amplitude distribution

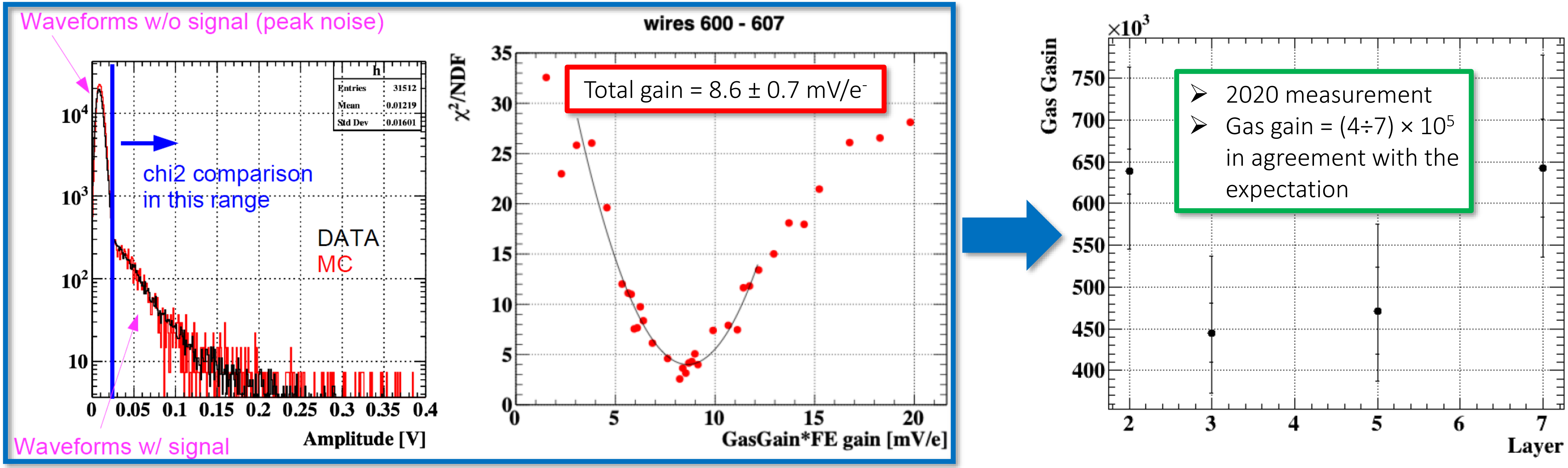


US + DS signal charge distribution



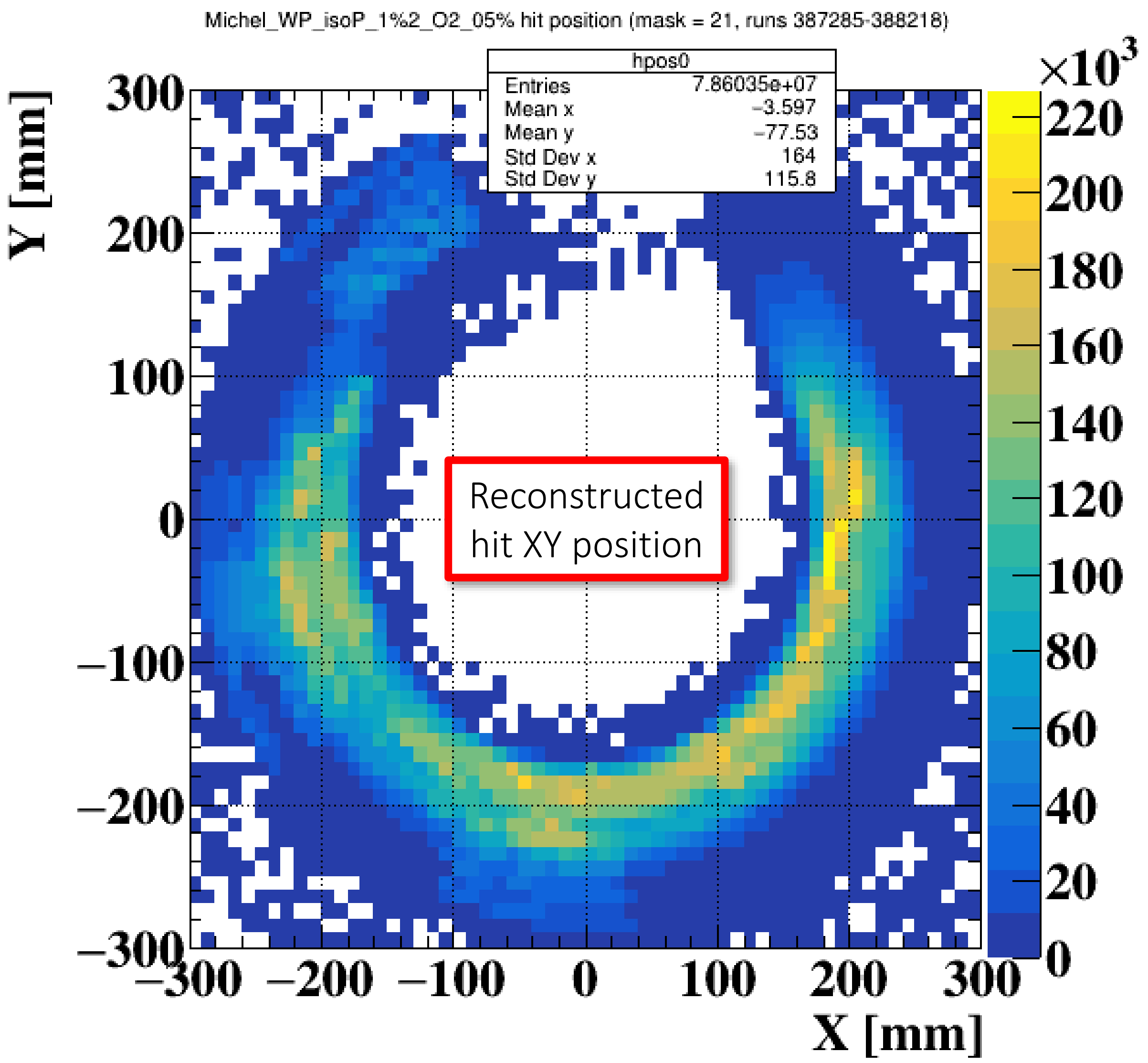
Uniformity by layer thanks to the 10 V scaling of the HV

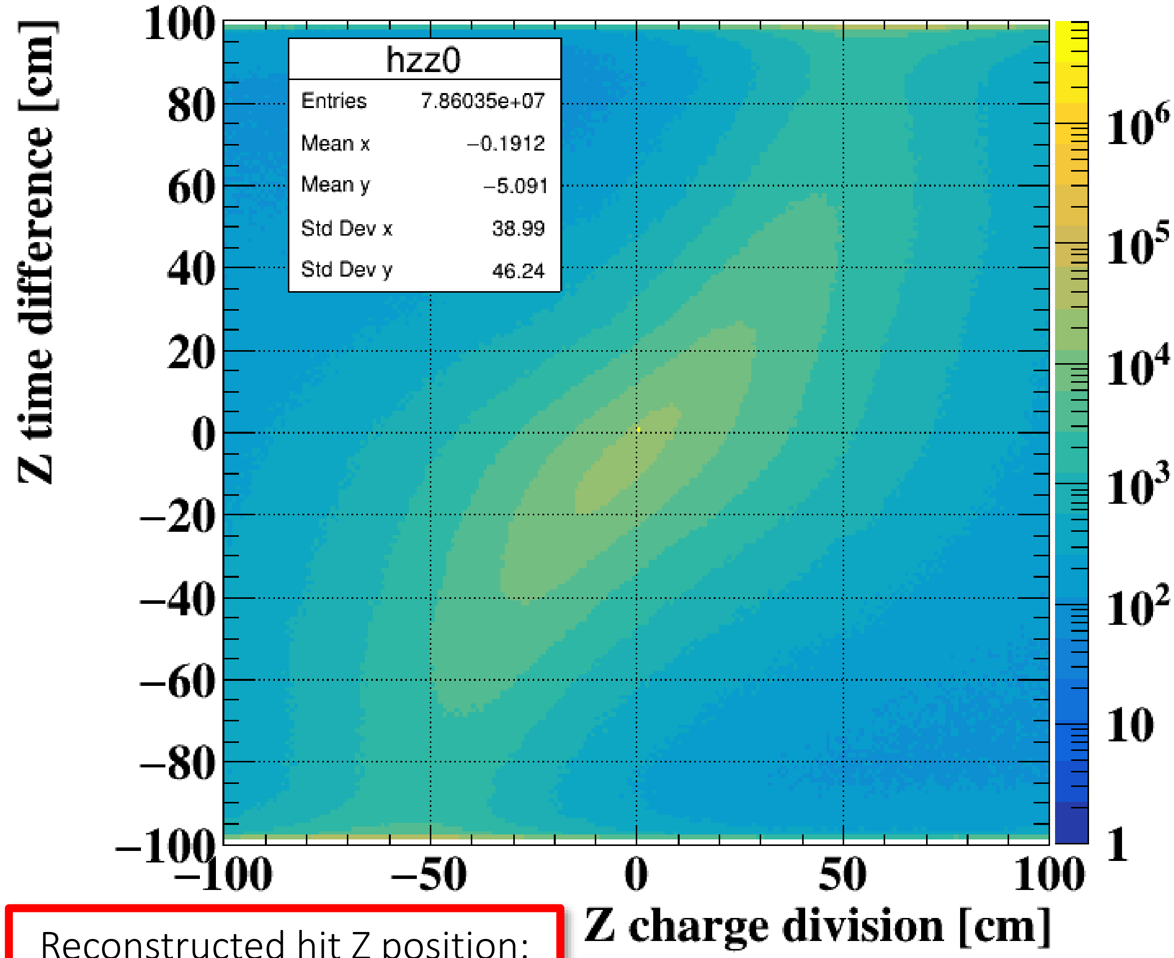
Gain measurement



- **Signal amplitude distribution** from Cosmic Ray events: clean environment
- The only parameter to be tuned in MC to reproduce data is the Total gain = Gas gain × FE gain
- FE gain measured to be 0.120 mV/fC
  - FE response to real single-electron drift chamber signals produced by laser ionization on a prototype
- Gas gain = Total gain / FE gain

Some diagnostic plots from Michel e^+ data

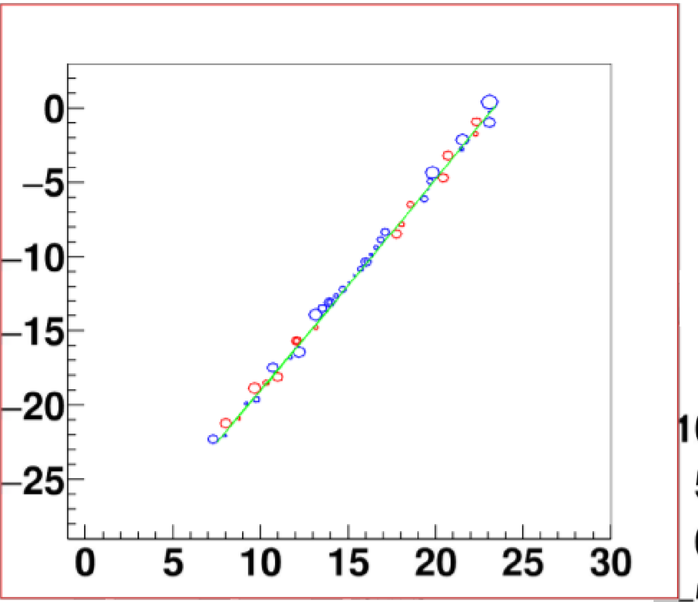




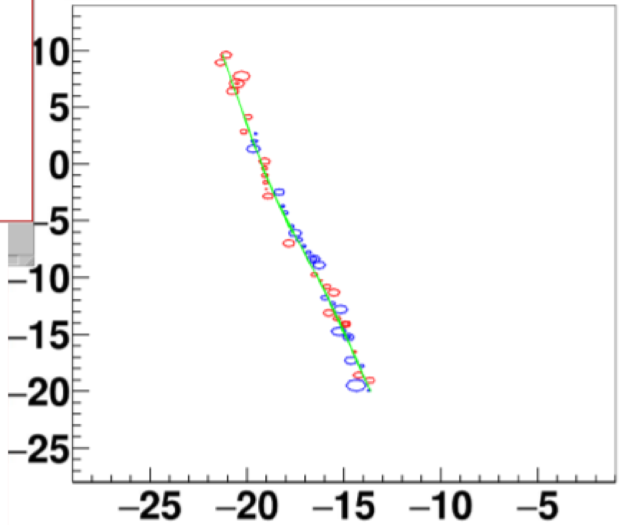
Reconstructed hit Z position:
time difference
vs.
charge division

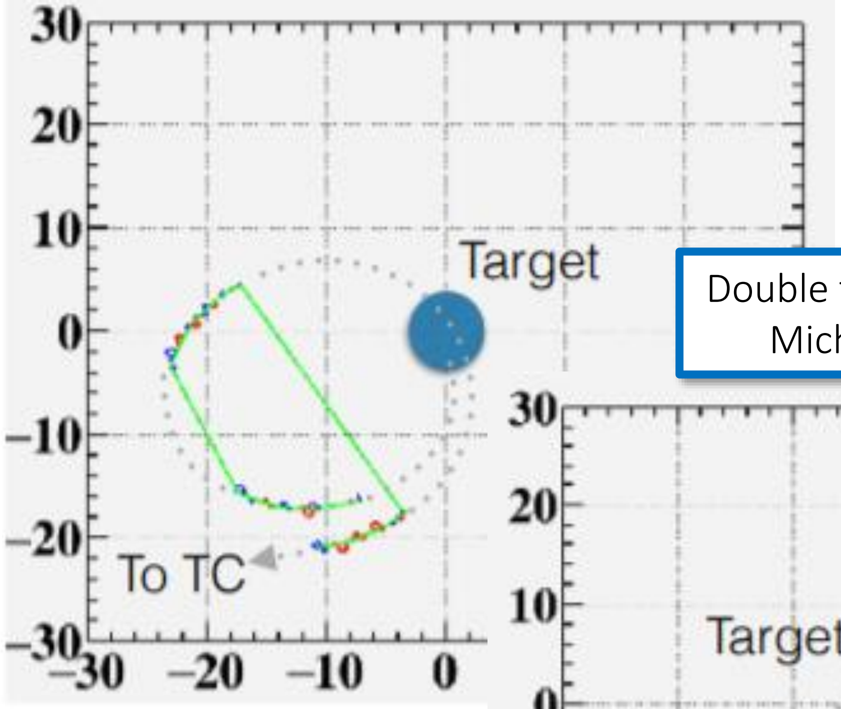
A few event display examples

Data acquisition and analysis ongoing

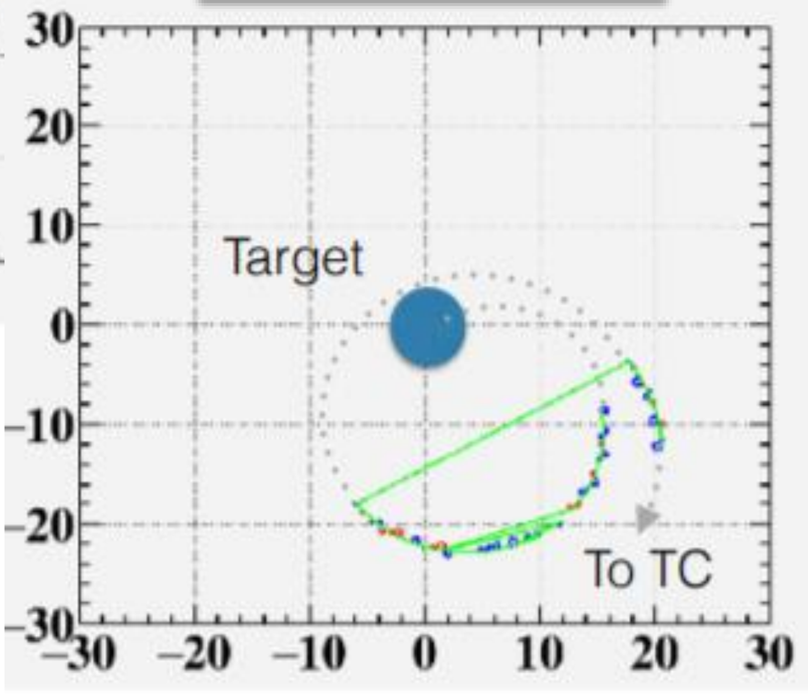


Straight tracks from Cosmic Ray events





Double turn tracks from Michel e^+ events



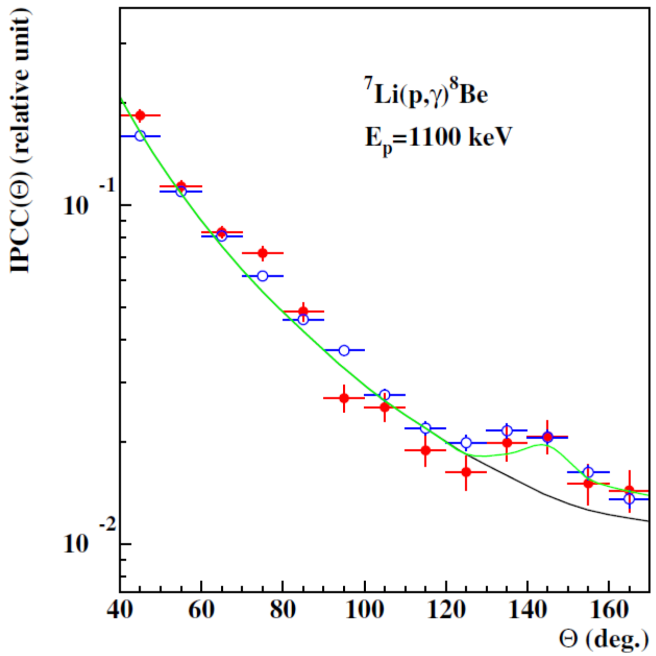
Beyond $\mu^+ \to e^+\gamma$: the X(17) boson search

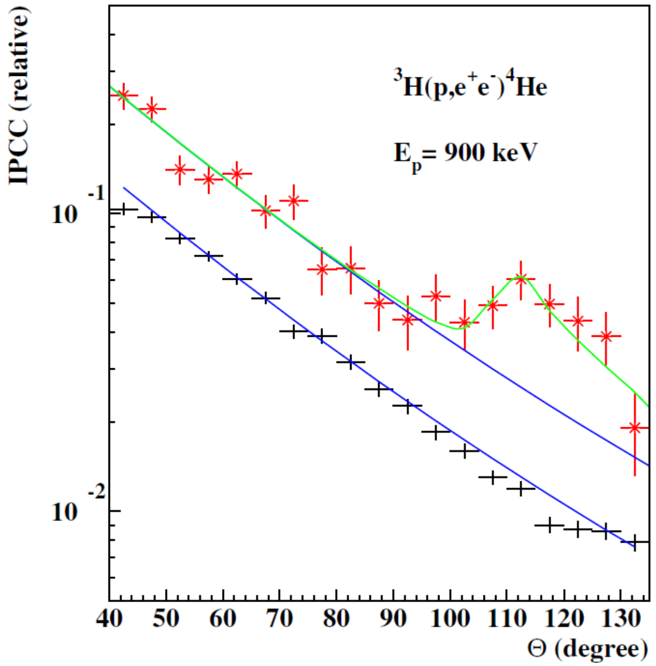
- In 2016 the Atomki collaboration measured an excess in the angular distribution of the Internal Pair Creation (IPC) in the $^7Li(p, e^+e^-)^8Be$ nuclear reaction
- This anomaly was confirmed by further measurements
  - $^3H(p, e^+e^-)^4He$ reaction
- Possible interpretation
  - Production of a new physics boson mediator of a fifth fundamental force that describes the interaction between dark and ordinary matter

  $$p\,N \to N'^* \to N'\,(X \to)\,e^+e^-$$

  - Its mass is expected to be 17 MeV → X(17)
- An independent experiment could confirm or not this results
  - Artifact of the detector geometry???

- MEG II has all the ingredients to repeat the Atomki measurement
  - CW proton accelerator (used for LXe detector calibrations)
  - CDCH for e^+e^- measurement
  - pTC as trigger
  - B field → e^+e^- invariant mass with CDCH + COBRA magnet



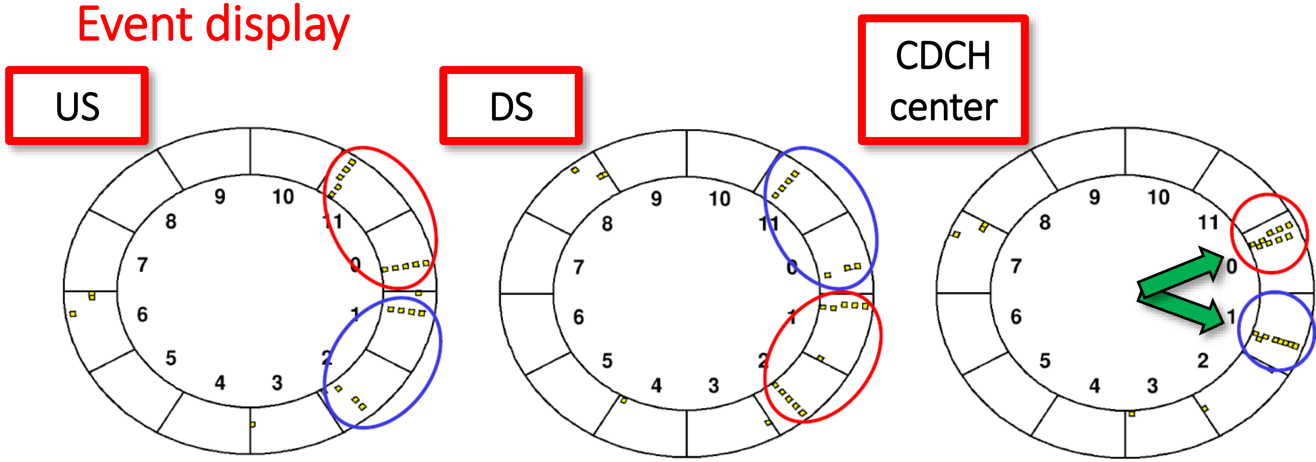


First test with CDCH and B field OFF

- CW Li(p,γ)Be reaction with e^+e^- pairs from γ conversion (likely in the CW beamline)
- **First test with an existing aluminum vacuum chamber**

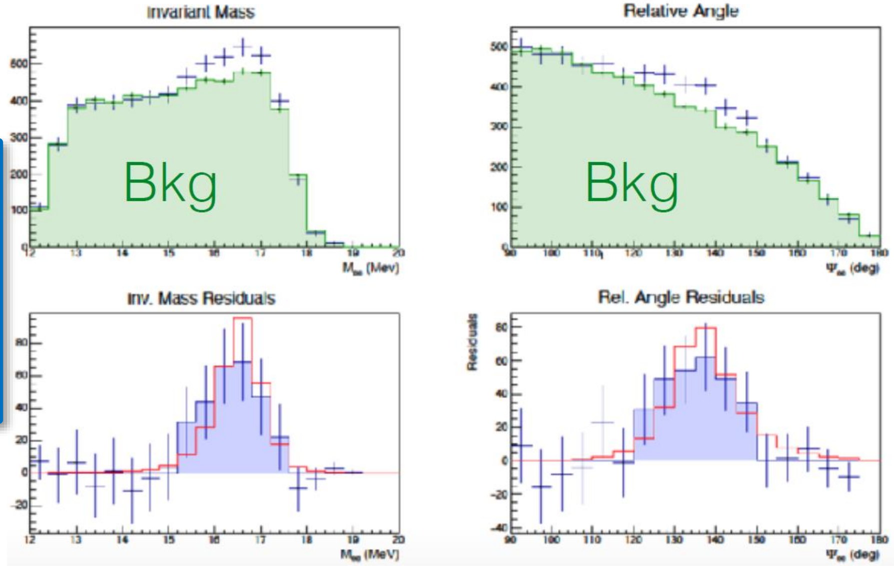
- For the final measurement to minimize the MCS and achieve a better resolution the CW target region was re-design
  - The new setup consists of a 10 μm thick Li_2O layer on a 25 μm thick Cu substrate
  - Connection to the CW beamline by means of a Cu arm
  - Both structures are placed in a CF vacuum chamber

Event display



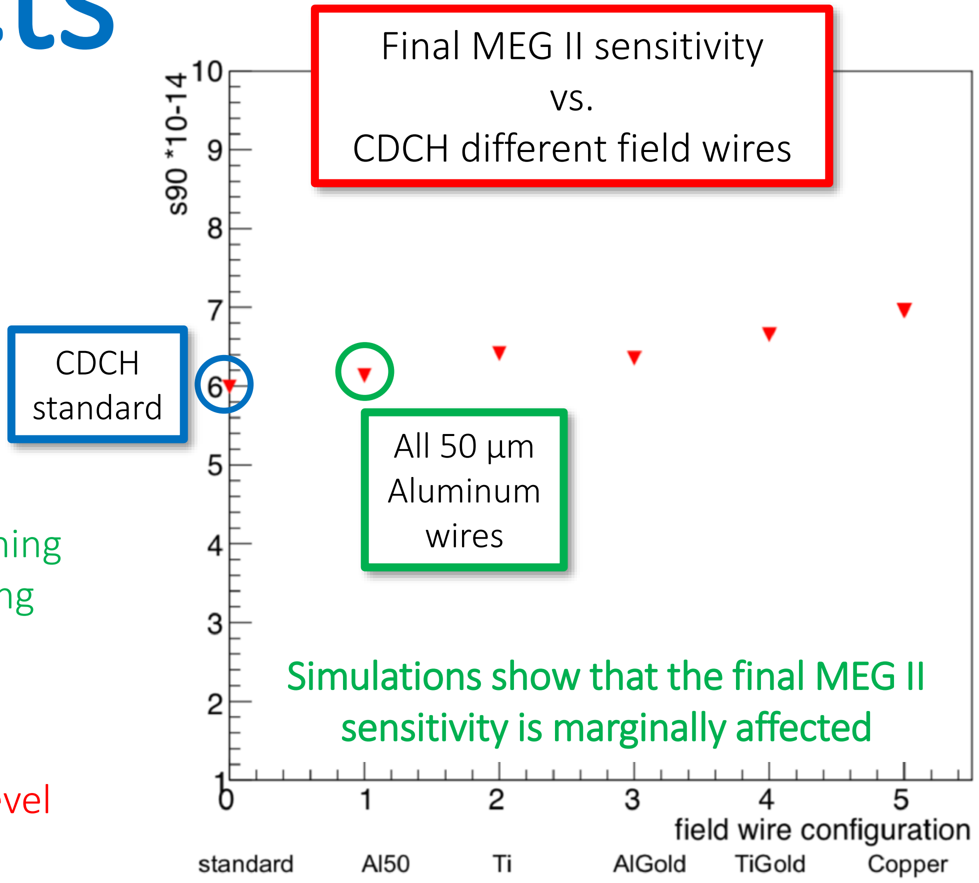
- Events are near Z=0
- 2 particles leave 2 tracks at CDCH center and 4 at Z=endplates due to the stereo angle

MC studies shows that a 5σ significance can be achieved in order 1 week



Conclusions and prospects

- The new drift chamber CDCH of the MEG II experiment has been presented
  - **Full azimuthal coverage** around the stopping target
  - **Extremely low material budget**: low MCS and background
  - **High granularity**: 1728 drift cells few mm wide in ΔR ≈ 8 cm active region
    - Improve angular and momentum resolutions of the e^+ kinematic variables
  - Stereo design concept, modular construction, light and reliable mechanics, fast and low noise electronics
  - Accelerated ageing tests on prototypes pointed out NO design criticalities
- Despite the **COVID-19 situation** we were able to perform the 2020 and 2021 commissioning of all the MEG II subdetectors and the experiment recently started the physics data taking which is expected to go on for the upcoming 3 years
  - **2021 is the first year with the full DAQ electronics available**
- Problems along the path
  - Corrosion and breakage of 107 aluminum wires in presence of 40-65% humidity level
    - Especially 40 µm wires (90%) proved to be prone to corrosion
    - Problem fully cured by keeping CDCH in dry atmosphere
  - Anomalously high currents experienced
    - Probably triggered by a bad event during the 2019 engineering run
    - CDCH operation recovered by using additives (**0.5% O_2 + 1.5% Isopropyl alcohol**) to the standard He:IsoB 90:10 gas mixture
- The construction of a new chamber (CDCH2) is about to start at INFN Pisa
  - CDCH vs. CDCH2 main difference: all 50 µm Al wires with thicker Ag coating and without the final drawing process which caused the cracks on the wire surface → **minimize the wire breaking probability**



THANKS

FOR YOUR ATTENTION