



UNIVERSITY OF
LIVERPOOL

LEVERHULME
TRUST

Flash talk – Riccardo

**Leverhulme Physics Retreat
Caer Beris Manor, 18 September 2025**

What I've done in the past 2 years



MONE

The image shows a stylized logo for the word "MONE" on a black background. The letter "M" is a solid blue color. The letter "O" is a white outline, with a blue lightning bolt shape above it and an orange lightning bolt shape below it. The letter "N" is a solid white color. The letter "E" is a solid orange color.

What I intend to do in the upcoming year



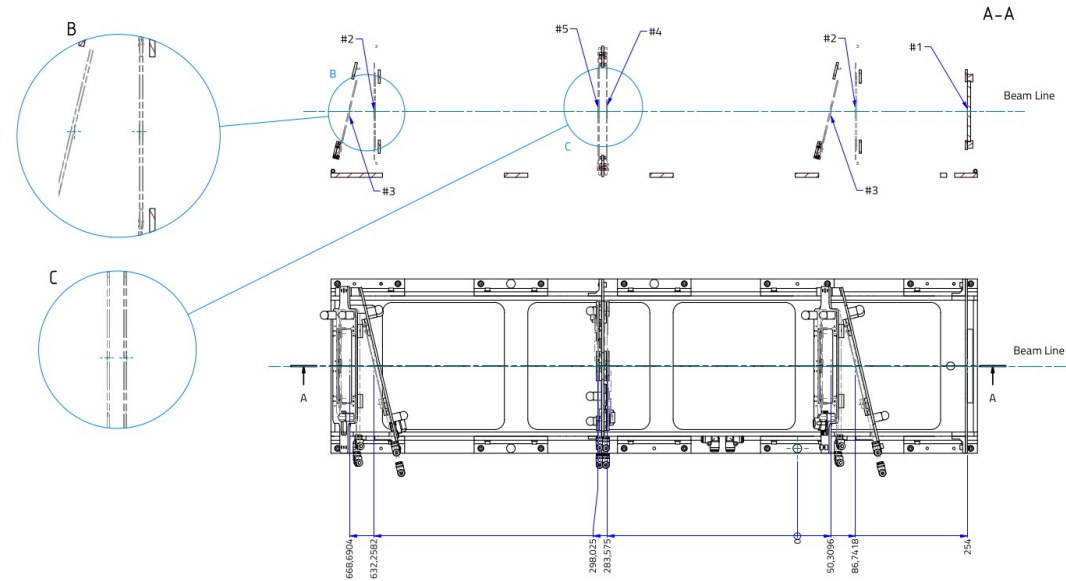
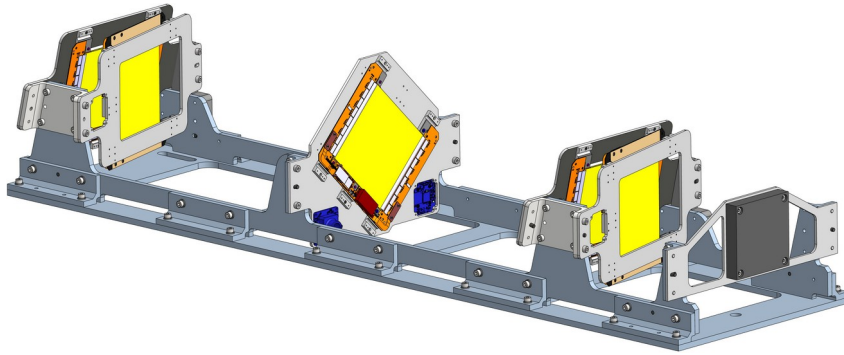
Thanks for the attention

...a bit more in detail...

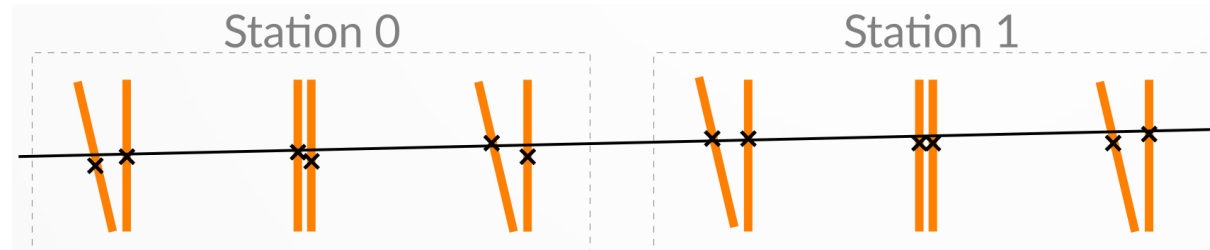
- Develop an alternative method to extract $a_{\mu}^{\text{HVP,LO}}$ from MUonE data
- MUonE analysis
 - Detector alignment
 - Tracking detectors efficiency and resolution
- Test Run 2023-24
 - DQM expert
 - Data taking shifts
- Test Run 2025
 - Run Coordinator
 - Coordinator of the BMS installation and operations

Alignment of the MUonE tracker

Ideal world: all the detector elements are placed *exactly* where they are supposed to be (based on the technical drawings)



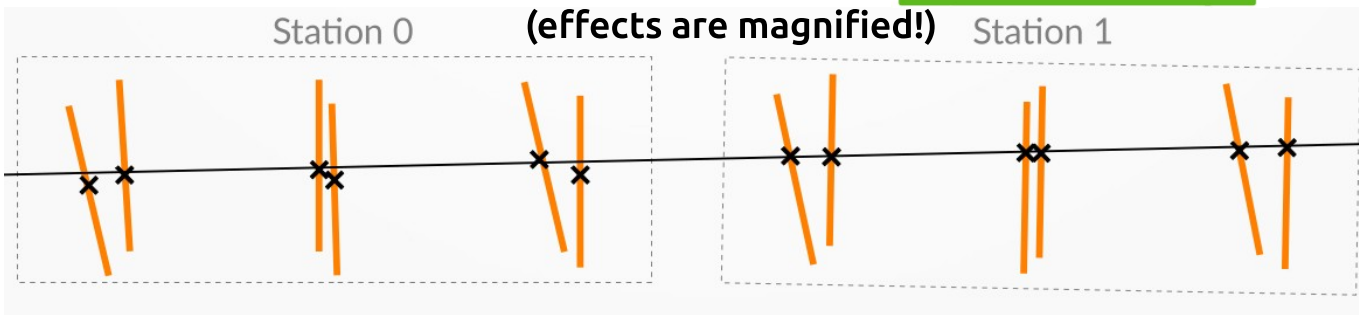
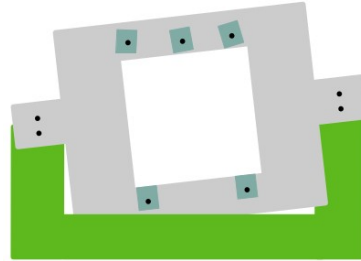
Each detector is already where it is supposed to be → no need of applying any correction in the track reconstruction



Alignment of the MUonE tracker

Real world:

- Tolerances in the components manufacturing and assembly
- The MUonE stations are independent rigid bodies: can have different angles one relative to the other



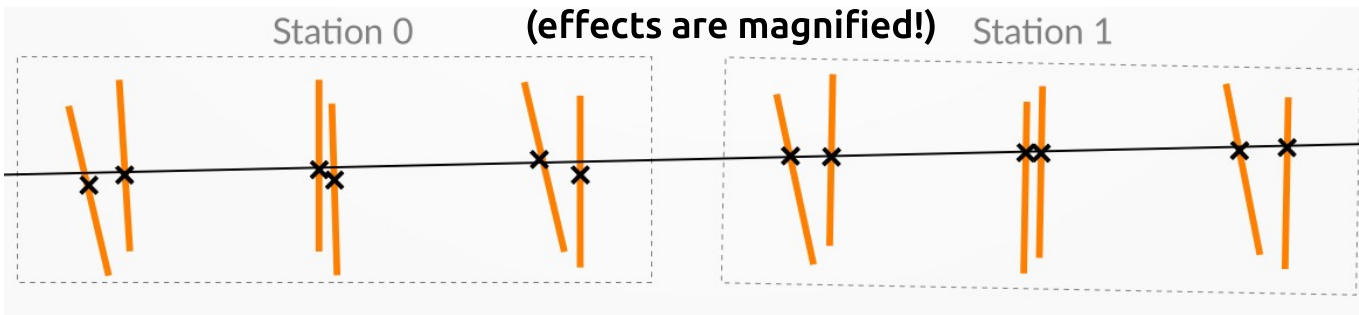
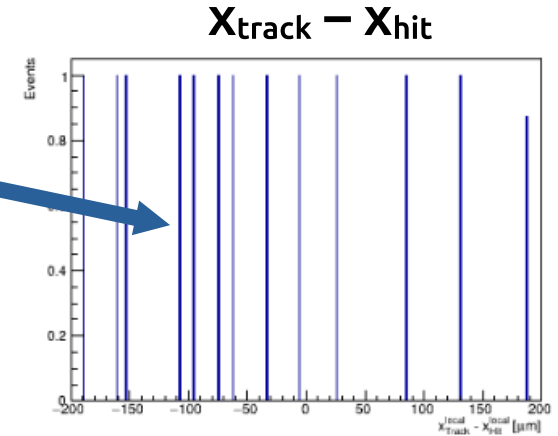
Alignment of the MUonE tracker

Real world:

- Tolerances in the components manufacturing and assembly
- The MUonE stations are independent rigid bodies: can have different angles one relative to the other

Difference between the hit position on a given module and the position predicted by the track fitting
(you are expected to see a peak around 0 μm)

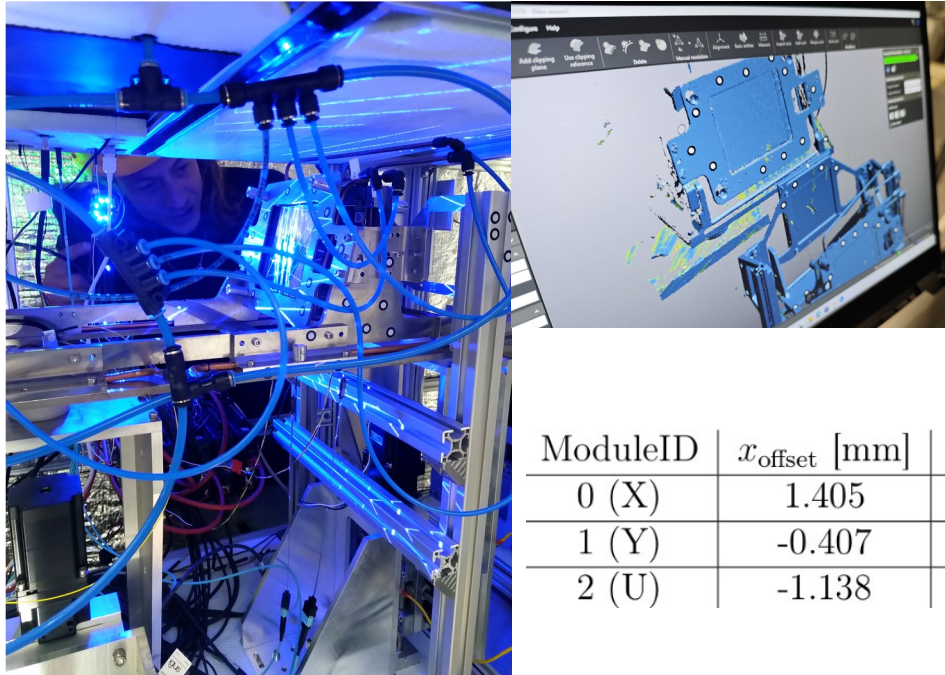
When no corrections are applied to the track reconstruction:



Alignment of the MUonE tracker

2 steps procedure to recover the alignment

- 1) take dedicated measurements of the apparatus
(laser survey / 3D scanner photogrammetry)
to determine the actual detector position @80 μm



I worked on the analysis of these measurements, to extract a (x,y,z) position of each module + parameterise the orientation of the module (3 angles needed)

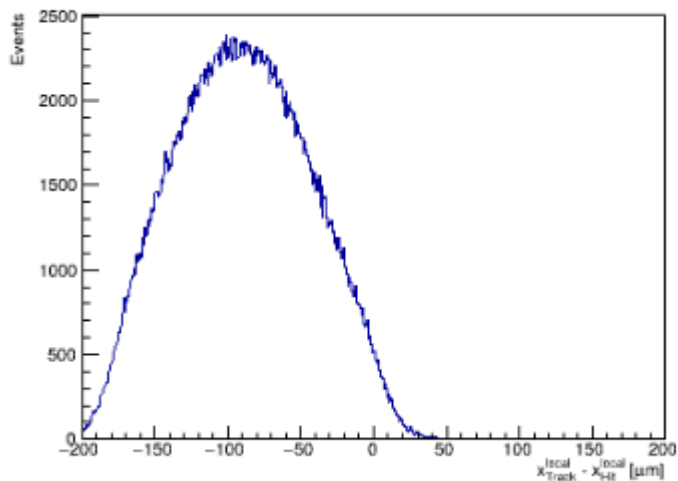
ModuleID	x_{offset} [mm]	y_{offset} [mm]	z_{module} [mm]	θ_{offset} [mrad]	γ_{offset} [mrad]	α_{offset} [mrad]
0 (X)	1.405	0.094	166.420	4.564	-4.403	0.800
1 (Y)	-0.407	0.970	204.743	1.146	-0.020	1.019
2 (U)	-1.138	0.231	537.205	2.353	-2.034	4.009

Alignment of the MUonE tracker

2 steps procedure to recover the alignment

- 1) take dedicated measurements of the apparatus
(laser survey / 3D scanner photogrammetry)
to determine the actual detector position @80 μm

$x_{\text{track}} - x_{\text{hit}}$ improves...



Alignment of the MUonE tracker

2 steps procedure to recover the alignment

2) software alignment: use a sample of events where a single non-interacting muon passes through all the detectors to determine precisely their position (the outcome of step 1 is the starting point)

Numerical minimisation of the residuals $x_{\text{track}} - x_{\text{hit}}$.

The fit parameters are the corrections to apply to the position of each module in order to take into account his misalignments in the track reconstruction

$$\chi^2_{\text{align, module-}j} = \sum_{i=0}^{N_{\text{tracks}}} \left(\frac{x_{\text{Track}}^{ij}(\vec{p}_j) - x_{\text{Hit}}^{ij}}{\sigma_{\text{Hit}}^j} \right)^2$$

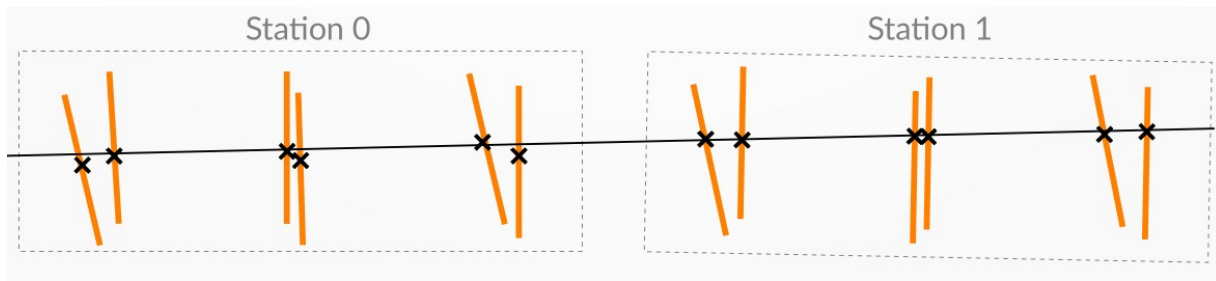
Fit parameters:

(x, y) position of the module

2 angles for the module orientation

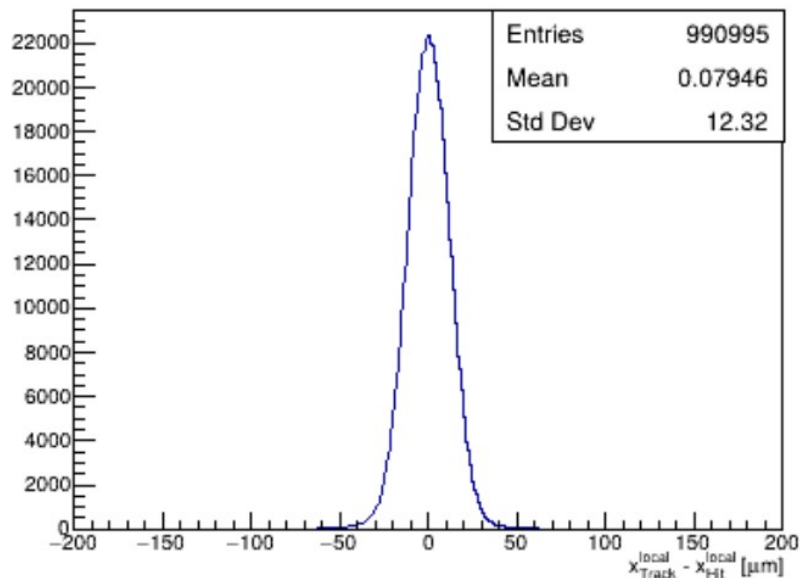
The z position and the 3rd angle are still not included

(weak effect on the track reco)



Alignment of the MUonE tracker

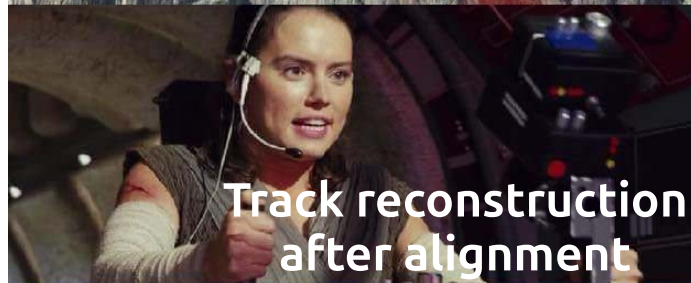
$x_{\text{track}} - x_{\text{hit}}$
after the full procedure



Particle hits in
the detector



Track reconstruction
after alignment

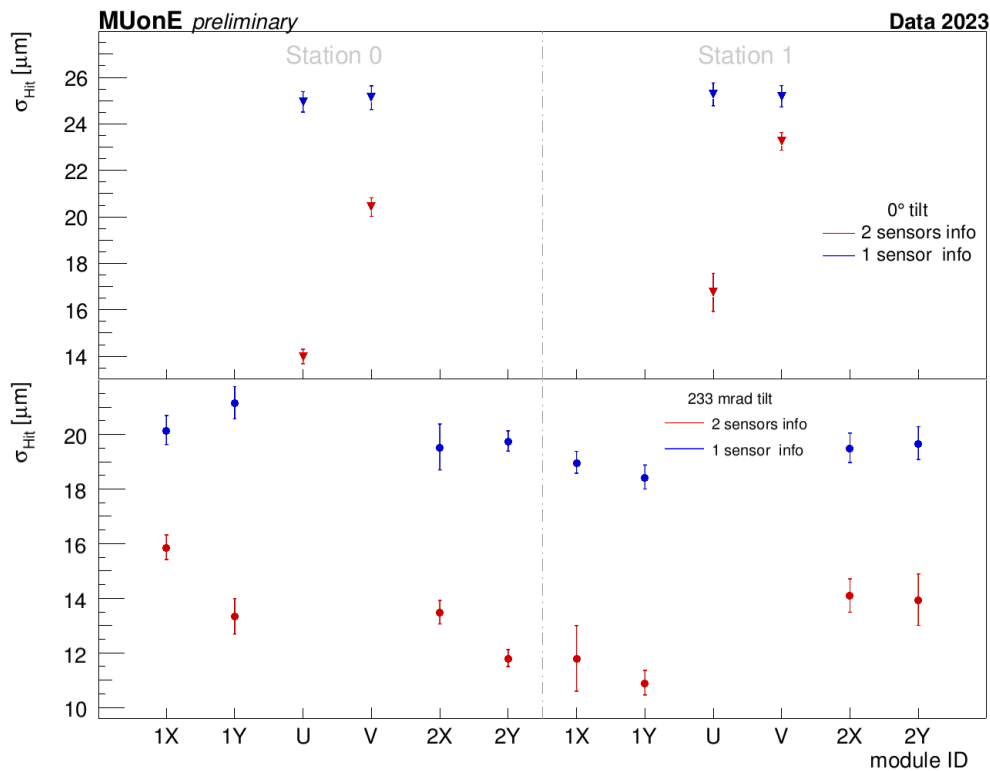


The fit



2S modules resolution

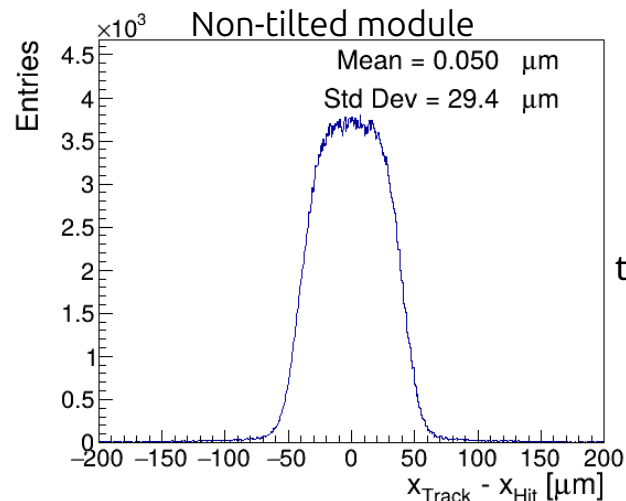
2023



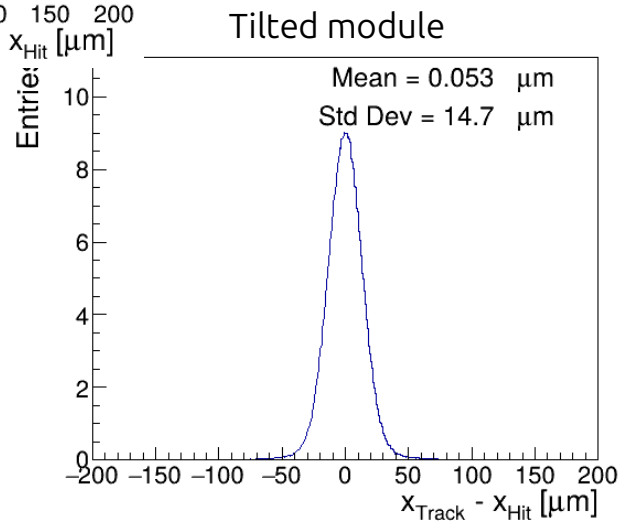
Difference between tilted and non tilted modules

Improvement if hits from both the 2S modules are used

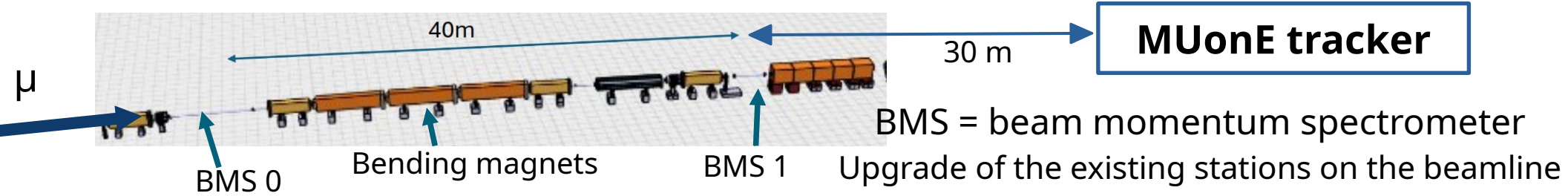
2025



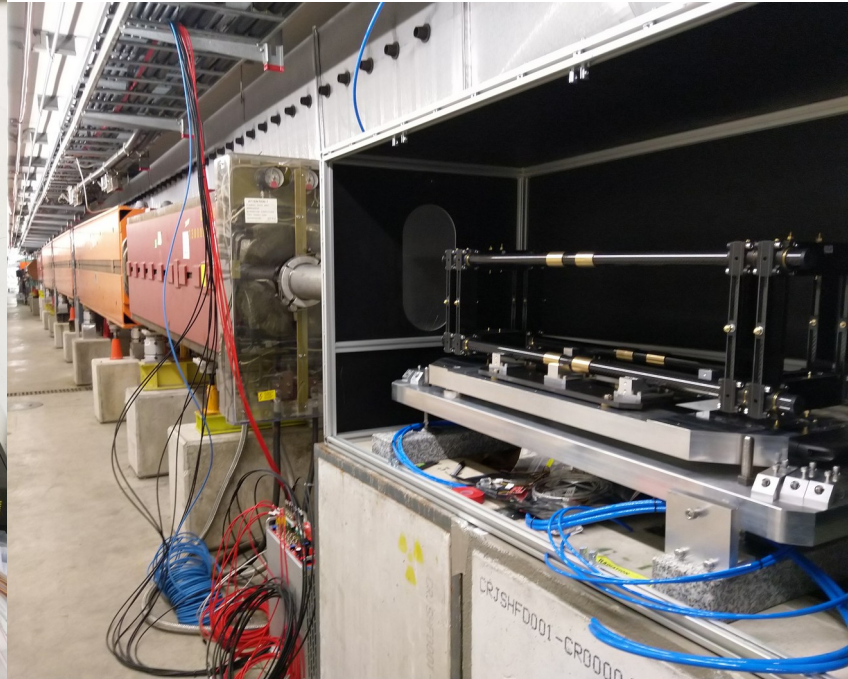
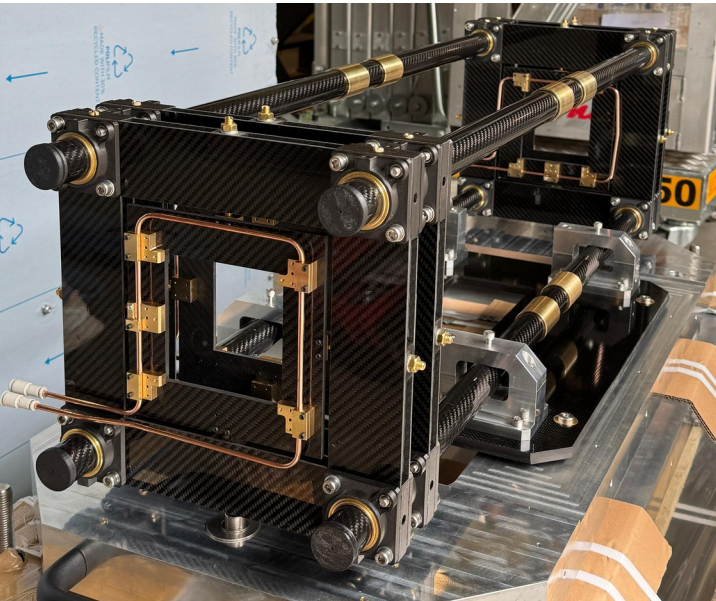
*Std Dev is not (yet)
the hit resolution:
track fit error to be subtracted



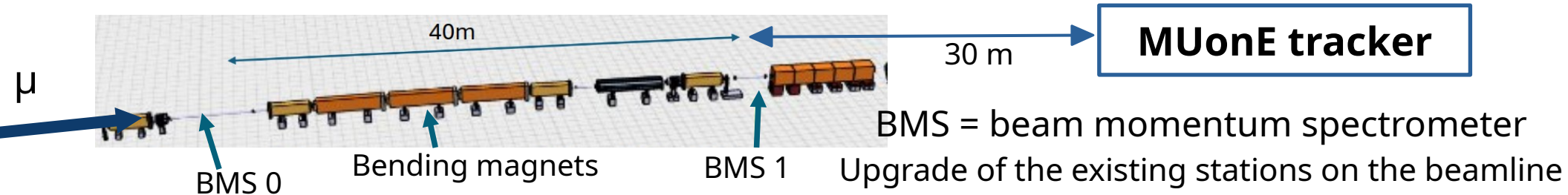
Test Run 2025 – BMS installation



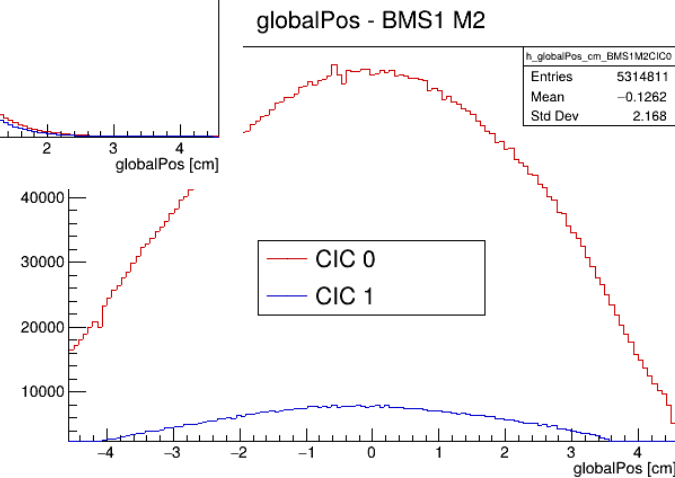
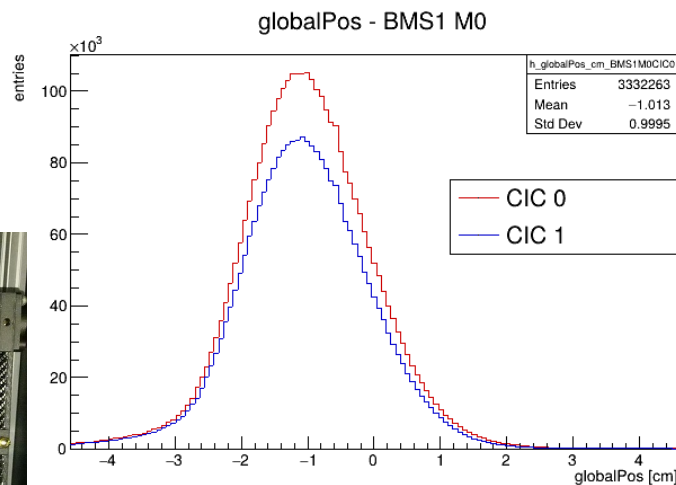
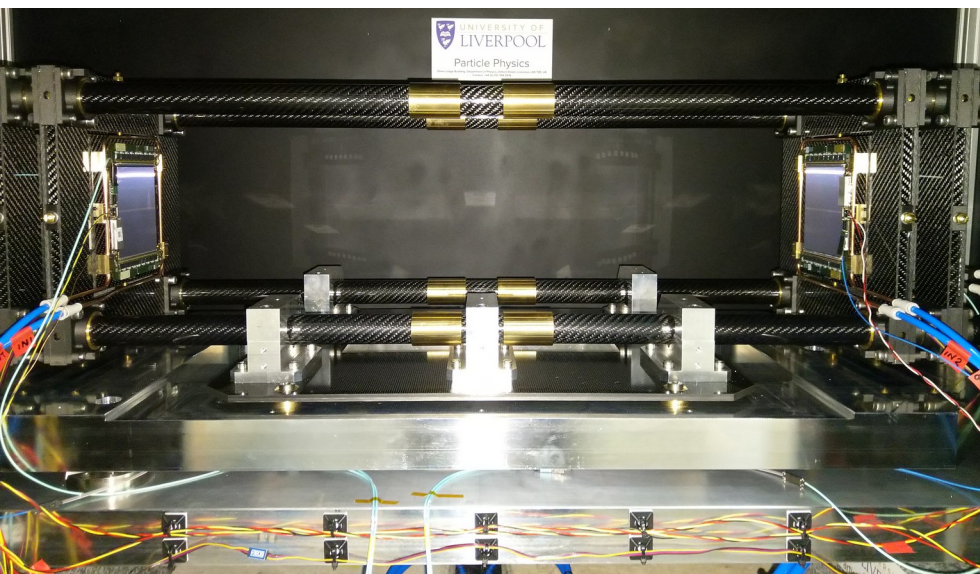
New Carbon Fibre structure



Test Run 2025 – BMS installation



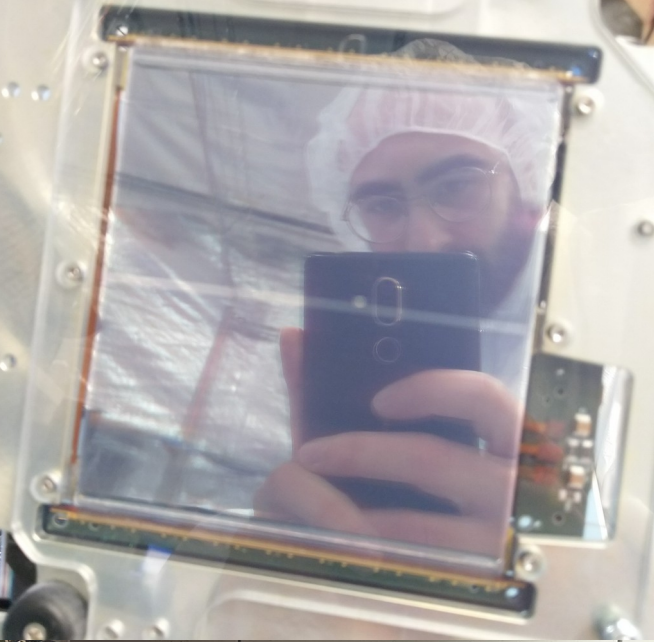
Ready to take data!



...a bit more detailed wishlist for next year...

- Technical publications for the MUonE alignment and detector performance
- Significant progress in the MUonE data analysis
- Preliminary results from the BMS
- Technical publication on the BMS hardware
- Improvements of the BMS hardware

Test Run 2025 – some pictures pretending to do stuff



Plenty of relaxing infusions needed...