Some basic thoughts on possible target setups

A single thick target induces multiple scattering (MS) on the scattered muon and electron,
degrading the precision of the measurement,
but a thin target reduces the integrated number of events to be collected per run period,
increasing the statistical uncertainty of the measurement

It is therefore important to see how to best balance the systematic and statistical uncertainties:
retain a long target, to maximize the rate of interactions,
while minimizing the uncertainty induced by the material thickness

A possible option is to split the target into many thin slices, spread along the beam axis

Carlos Lourenço, CERN
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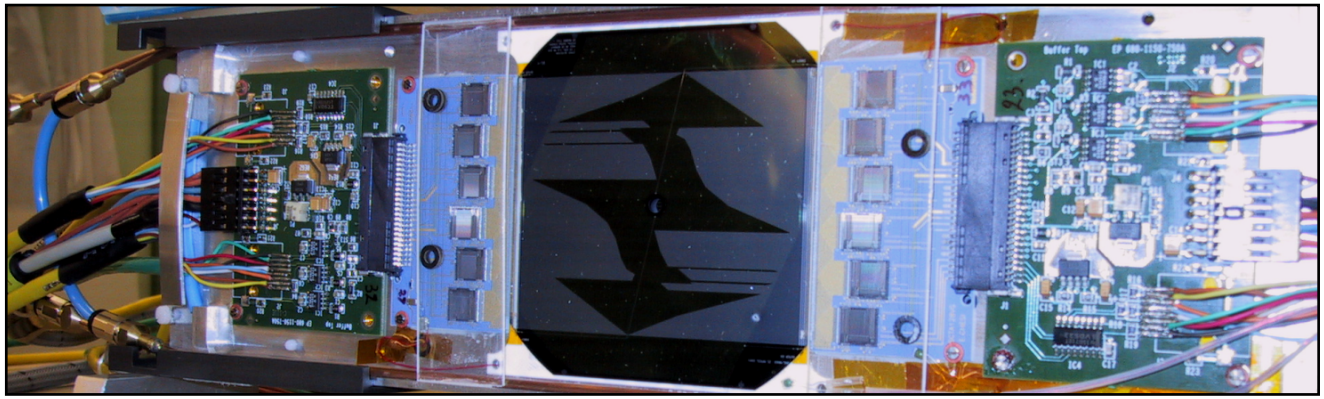
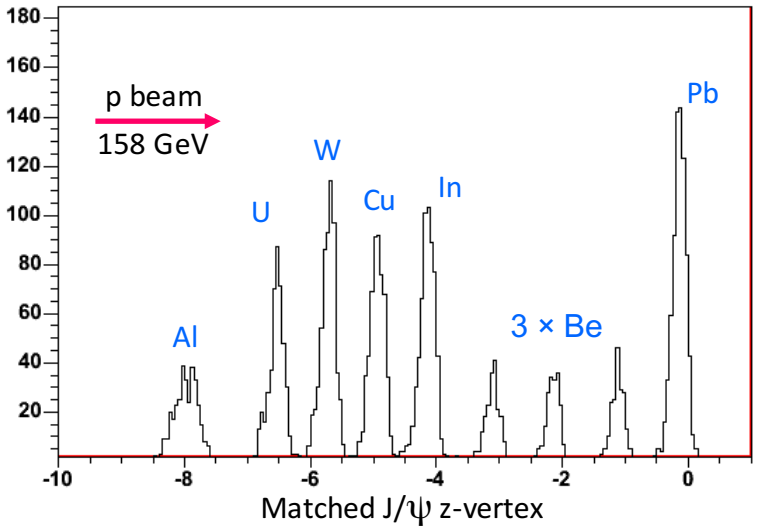
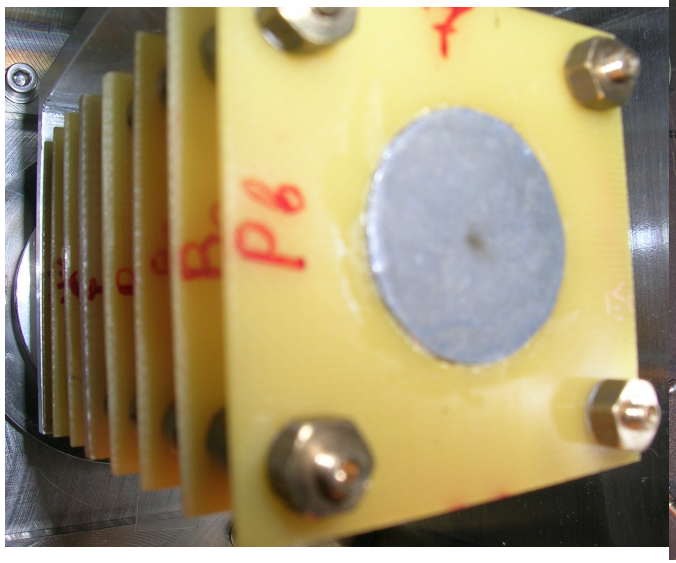
Previous experience

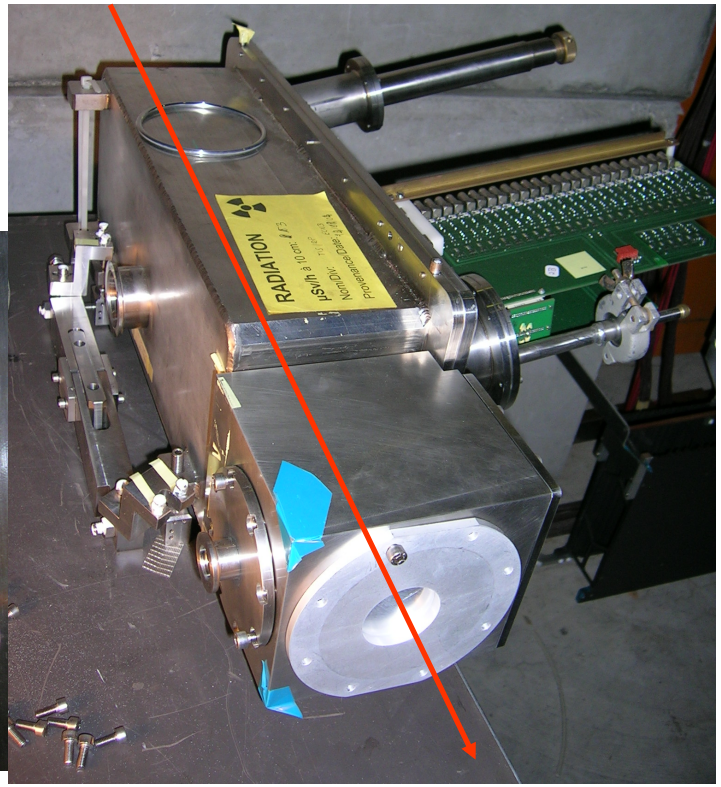
Past fixed target experiments,
using proton beams and
looking for inelastic collisions,
could easily identify the interaction target
with a suitable tracking system.

For instance, NA60 used several targets,
typically 2 mm thick with 8 mm interspacing









Thoughts targeting the MuOnE setup

To keep the MS effect under control, reducing its systematic uncertainty,
it is important to minimize the dependence of the measurement on GEANT corrections

This can be done through a joint analysis of several data samples,
collected with different MS conditions, everything else being identical

We can have several targets of different thicknesses, such as 1, 5, 10 and 20 mm,
and of different materials, such as Be, C and Si (using the silicon sensors as targets)

The joint analysis of all those data samples provides a **data-driven** procedure
to derive the physics result in the ideal limit of no MS effect (zero target thickness)

While the detector effects depend on the characteristics of the target,
the physics mechanism we are studying does not

The target depends on the beam

The M2 muon beam is broad in the transverse plane and has a non-negligible divergence
(relative to the long extension of MuOnE along the beam axis)

It is necessary to track the beam muons upstream of the targets,
to precisely measure of the deflection angles between the incoming muon and the two outgoing leptons

The easiest solution might be to track the incoming muons
with the same tracking stations as the ones used to track the scattered muons and electrons

The setup would be composed of a series of disks (thin in z and broad in x,y to cover the full beam profile)

To distribute the events in several samples depending on the MS they suffer
we need tracking interspersed between the different thin targets

The silicon tracking planes are anyway in the path of the incident muons;
using them as targets partly compensates for the MS they introduce

A few silicon tracking planes per module add a non-negligible fraction of scatterings

Summary

These are just a few thoughts, based on “intuition” and on a few discussions with Umberto, Graziano and Clara

If they survive your critical scrutiny, the setup needs to be simulated to optimize all the numbers

A starting point could be:

= Beam with broad transverse profile, as parallel as possible (negligible divergence)

= Four targets per 50 cm, two of Be, 5 and 10 mm thick, and two of C, 1 and 10 mm thick

= Four silicon tracking planes per 50 cm, 410 micron thick each, also serving as targets, interspersed between the targets

= We also need a beam tracking station upstream of the first target of the first module;
three planes, given the high rate of the incoming muons: 5 x 10^8 mu/spill; spill = 4.8 s; 100 MHz = 1 mu / 10 ns

Basic message for further discussion

= The "independent modules" setup :

50 modules, each one 50 cm long and including a single 10 mm C target and 4 tracking planes (plus the beam tracker)

That leads to an effective target of 50 cm length and 200 tracking planes

= The "overlapping modules" setup :

N targets interspersed with N+4 tracking planes (plus the beam tracker)

Each target, i = 1,N is "covered" by 4 downstream tracking planes, k = i,i+3

With four targets per 50 cm, of 26 mm total thickness, we can

a) keep the experiment extending over 25 m and have 2.6 times more events per running period, or

b) reduce the number of tracking planes from 200 to 80, and the total length from 25 m to 10 m