Un trajectographe de recul pour particules basse énergie à CLAS12

ALERT: A Low Energy Recoil Tracker

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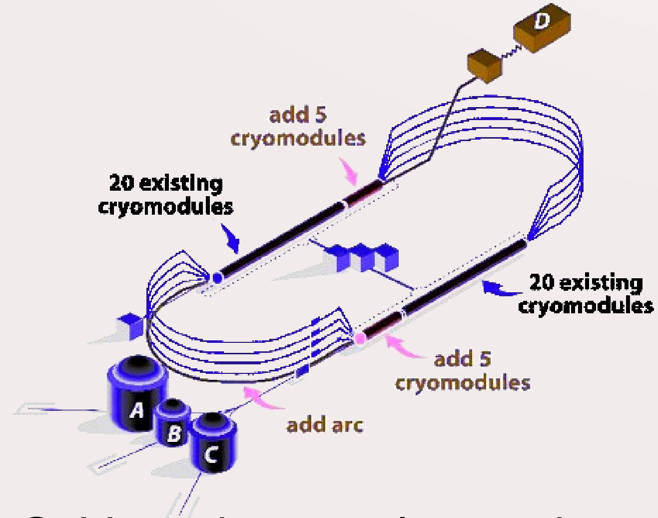
IPNO

Journée d'instrumentation de P2IO

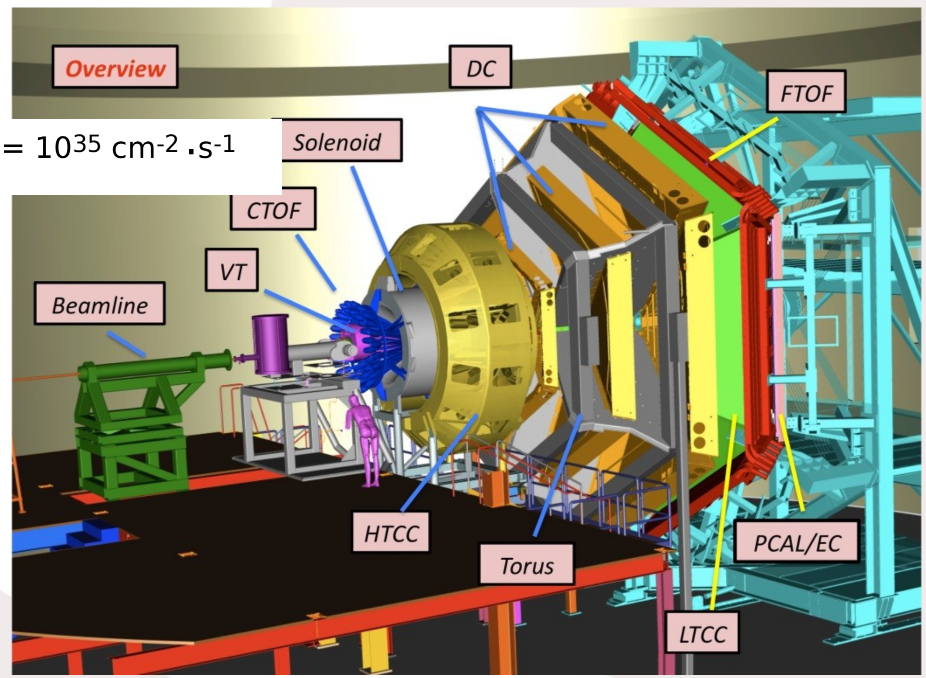
20/11/2015

Jefferson Laboratory, Virginia, USA



12 GeV continuous electron beam

$L = 10^{35}$ cm^{-2}.s^{-1}



Scheme of CLAS12 (Hall B)

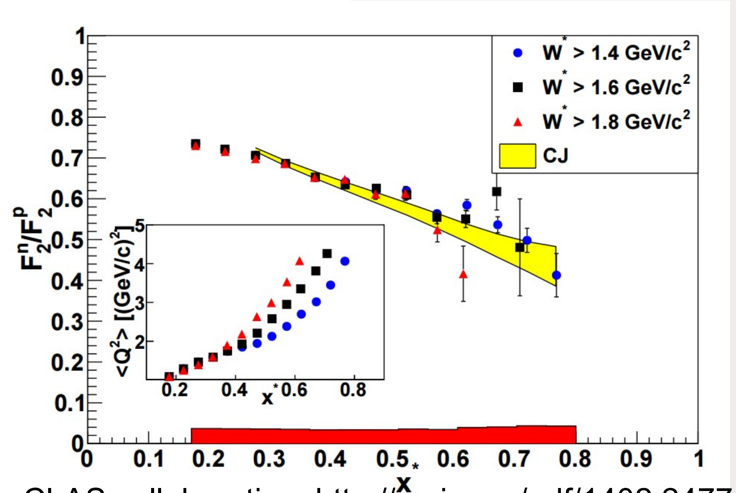
The Hall B will adress the following questions:

- What is the longitudinal and transverse structure of the nucleon?
- What is the 3D structure of the nucleon?
- What is the hadronic spectrum?
- What can we learn about hadrons and cold nuclear matter?

Physics motivation

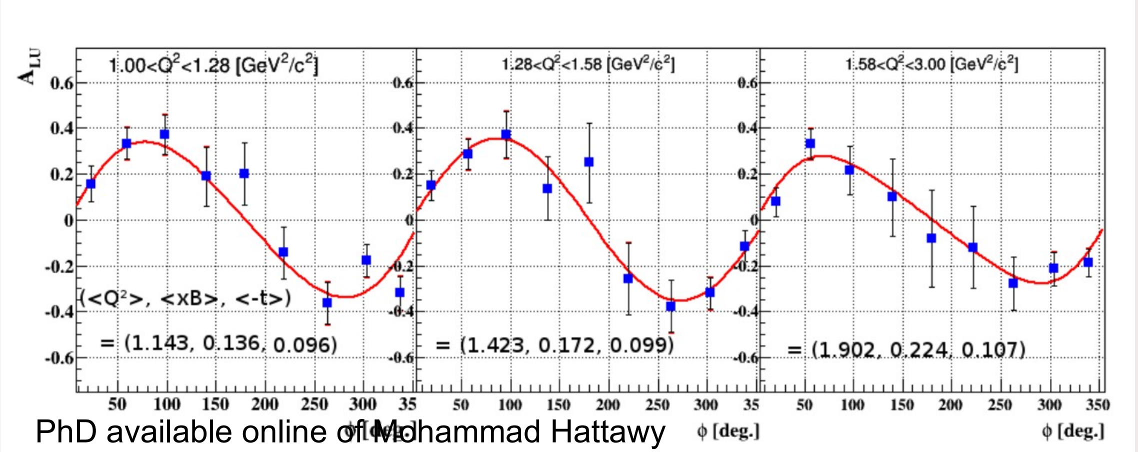
First generation of experiments measuring nuclei fragments at CLAS has given results in the recent years. They used a rTPC.

Tagged proton at low energy



CLAS collaboration: http://arxiv.org/pdf/1402.2477.pdf

DVCS on Helium 4

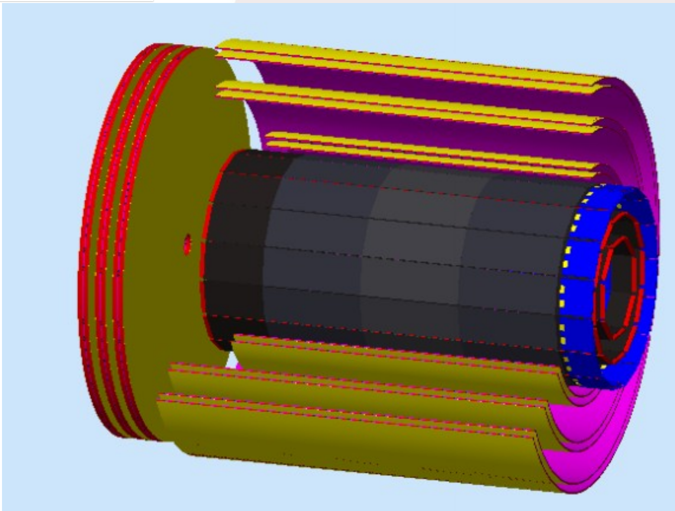


PhD available online of Mohammad Hattawy

A collaboration has started to perform the second generation of measures requiring low momentum particle measurements at JLab

Coherent phi production on He4 (Temple University)
DVCS on He4 (Argonne, JLab, Orsay)
DVCS on N (Argonne, UTFSM)
Tagged EMC (Argonne, JLab, Orsay)

Central detector



The planned central detector for CLAS12:

- 4 layers of silicon detector
- 6 layers of central cylindrical Micromegas
- 6 layers of forward Micromegas
- CTOF
- Neutron detector
- 5 T magnetic field
- Separate protons, kaons, pions
- Detect neutrons
- Momentum threshold 200-300 MeV/c

Momentum threshold needs to be reduced for certain experiments

+

Keep the possibility to be included in the trigger

+

Separate protons, deuterium, tritium, alpha, helium 3

Which detectors?

After a comparison between existing detectors a **drift chamber and an array of scintillators** have been chosen.

It has the following advantages:

- Low material tracker
- Fast detector if wires are not too far and gas well chosen
- Both detectors can be included in the trigger
- Separate protons, deuterium, tritium, alpha, helium 3

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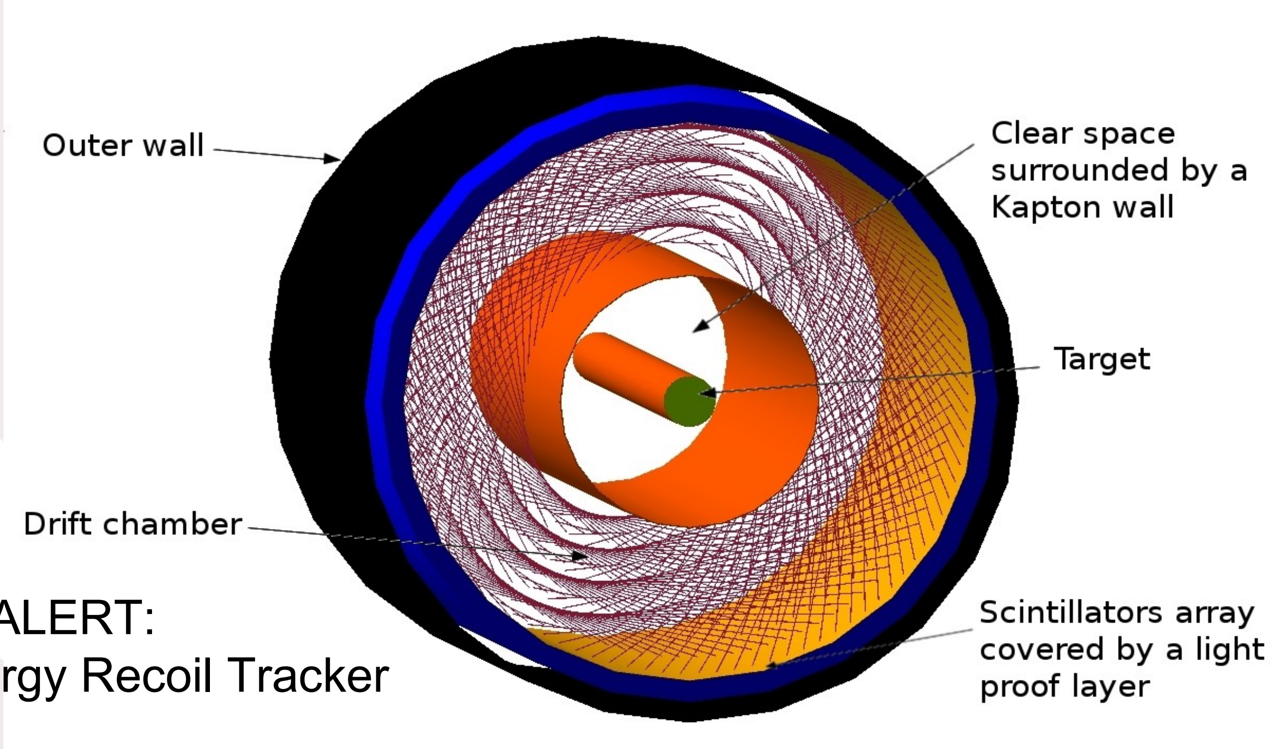
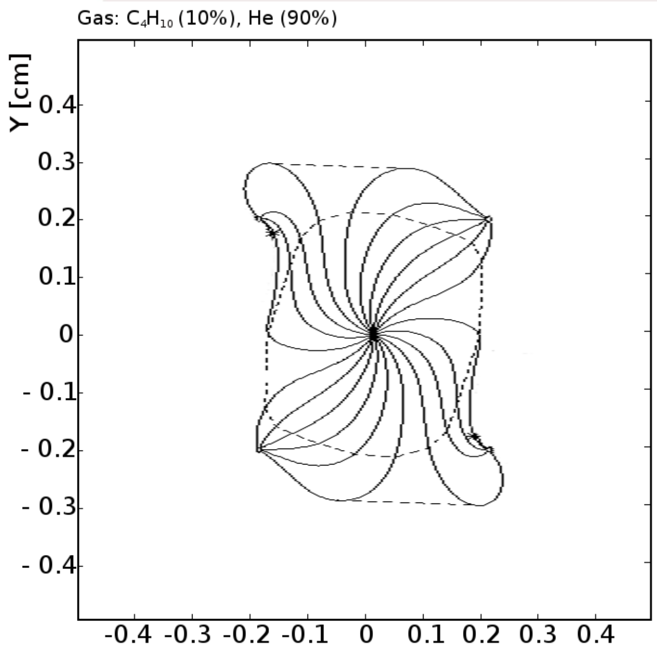


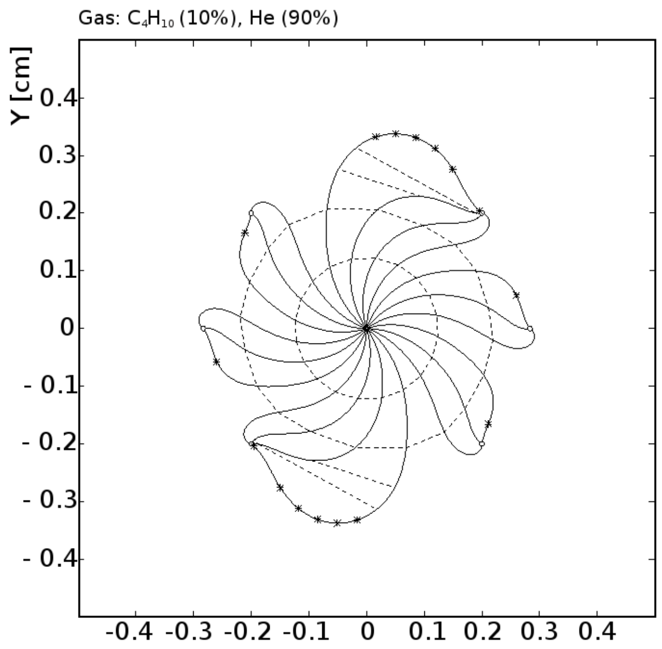
ALERT:
A Low Energy Recoil Tracker

Drift chamber layout (1/2)

Use stereo angle to determine the position along the beam axis
Space between two wires of different potential: 2 mm

Layout of the wires (elementary cell)



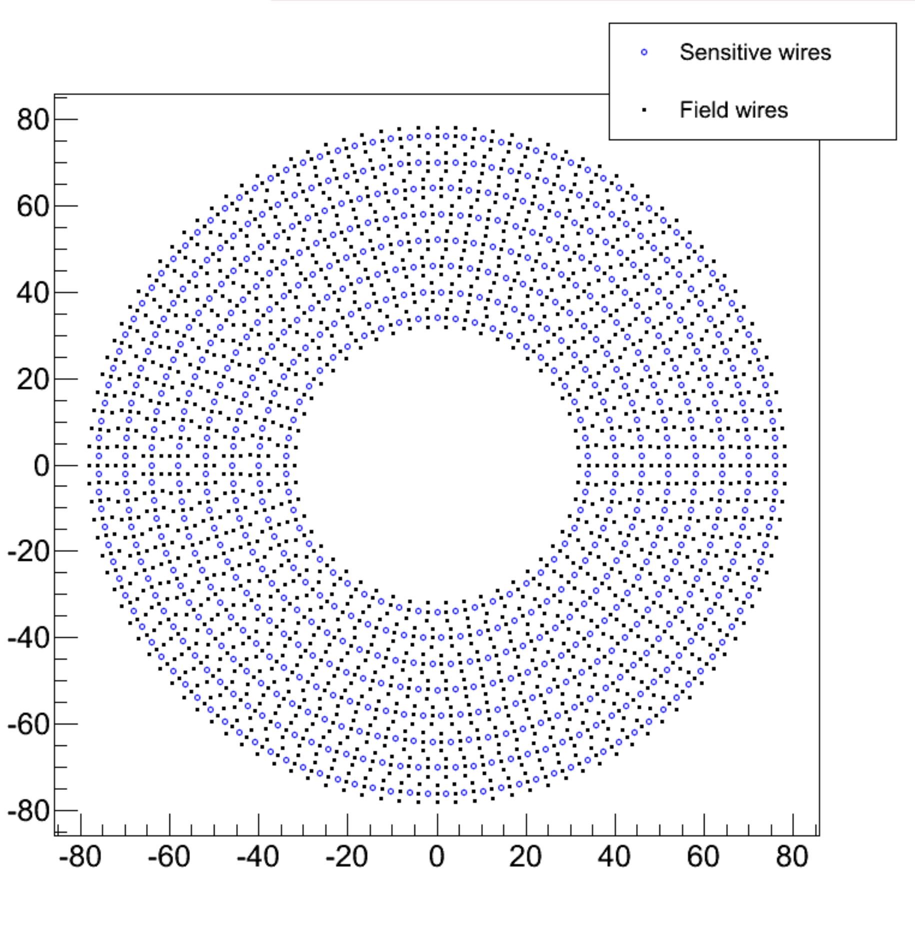


GARFIELD simulations of the electron drift lines, G. Dodge

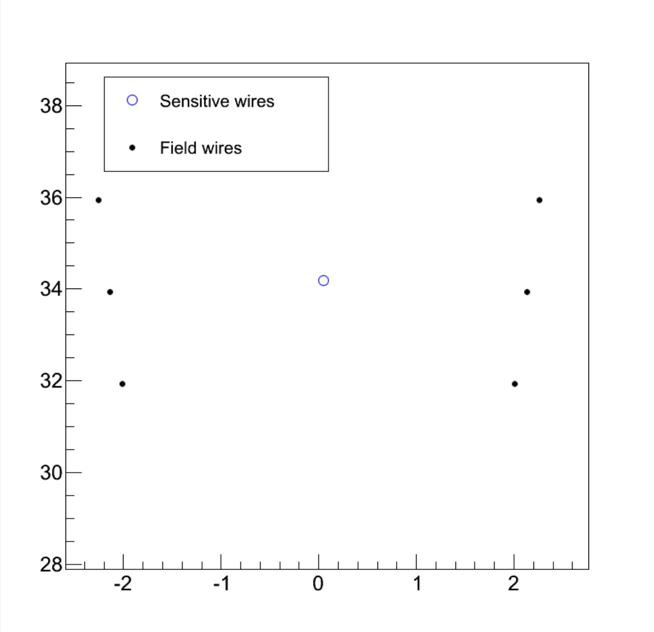
Maximum drift time estimated to be 200 ns

A prototype with different cell configuration is being designed.

Drift chamber layout (2/2)



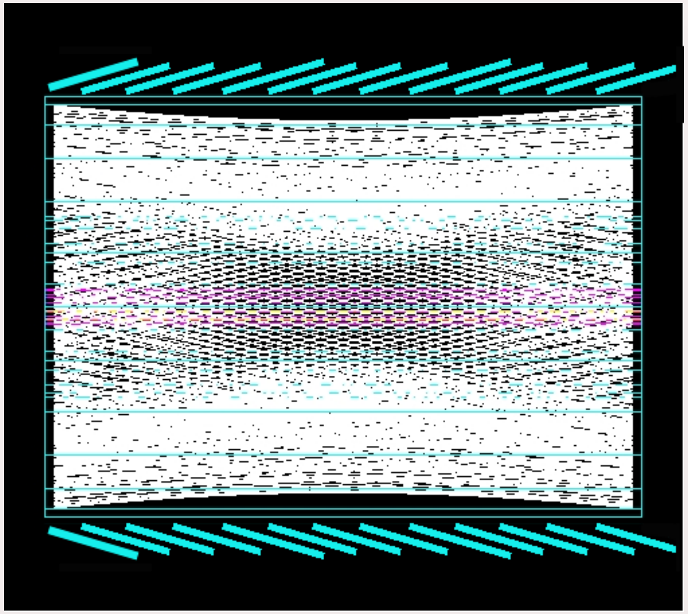
Example of a layout. In this configuration there are 662 sensitive wires and 1986 field wires



View of one cell

To ensure a 20 microns sag, the total weight on the end plate due to the tension is about 600 kg.
Tests will be performed to use lighter wires.

Scintillators layout



Configuration under study, signal readout by APDs

Several layers are superimposed which allow to measure dE/dx and help to identify particles.

The granularity needs to be determined.
It depends on:
- the time resolution
- the rate
- matching with the drift chamber.

The scintillators must also have the ability to detect particles from alphas to protons. A multi-layer scintillator may be needed.

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ORSAY

Simulation software

or trying to understand what to expect from ALERT

Software status

Developed in pure Geant4, available in a Git repository.

Three post-docs implied in its implementation:
- everything about scintillators is done at Argon
- everything about the drift chamber geometry, reconstruction algorithm and fitting algorithm is done at Orsay

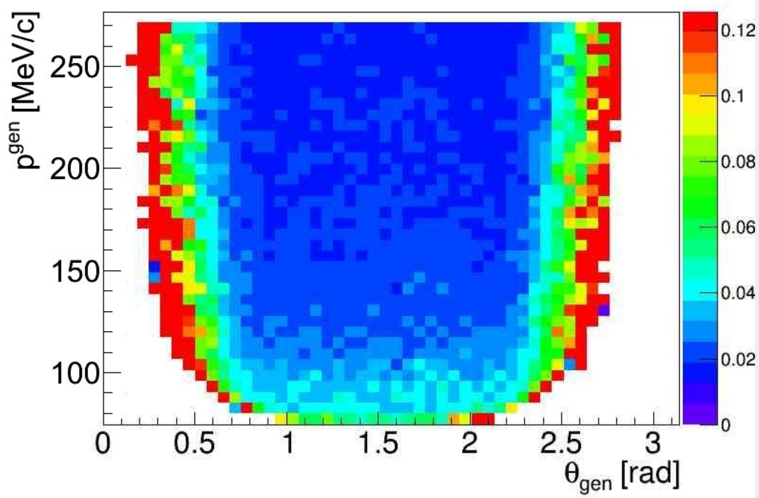
Definition of the scintillators geometry has just started.

A reconstruction algorithm is nevertheless already available using a global helix fit for the drift chamber. A Kalman Filter will be used in the future.

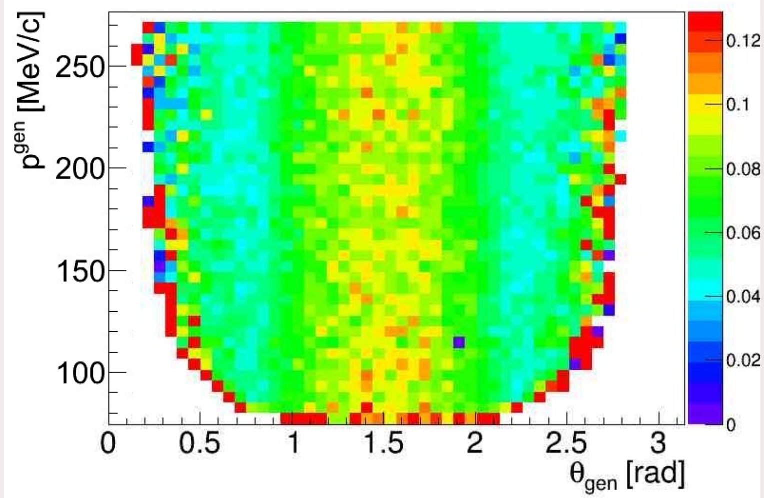
Simulated resolutions for protons

(based on a simplified simulation)

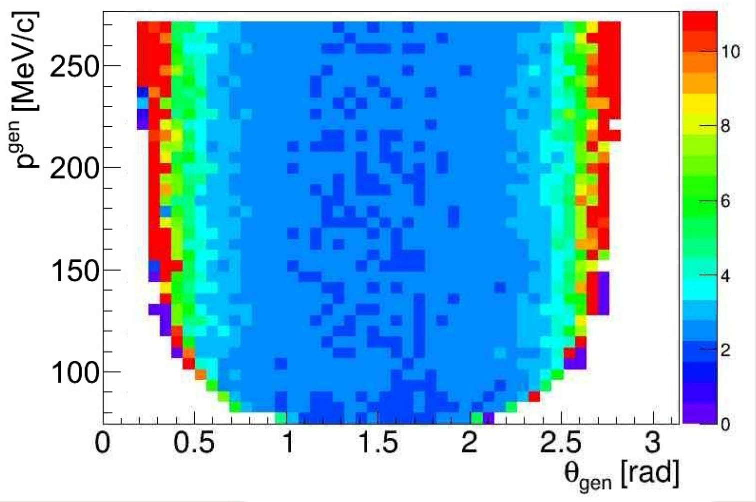
Phi [rad]



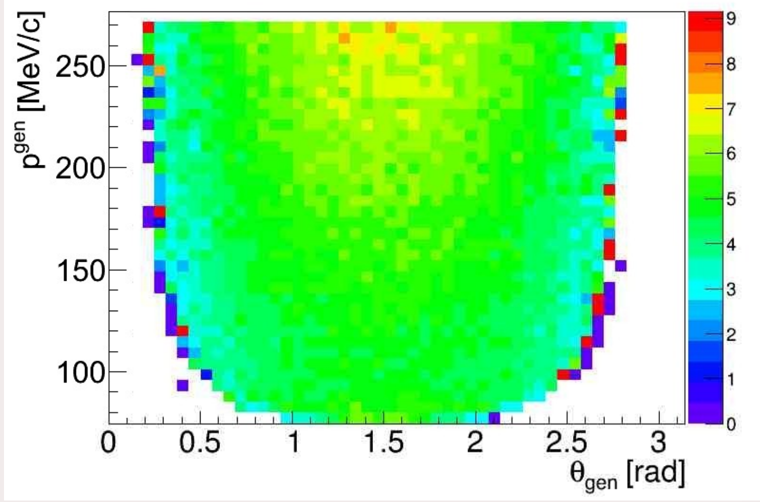
Theta [rad]



Z [mm]

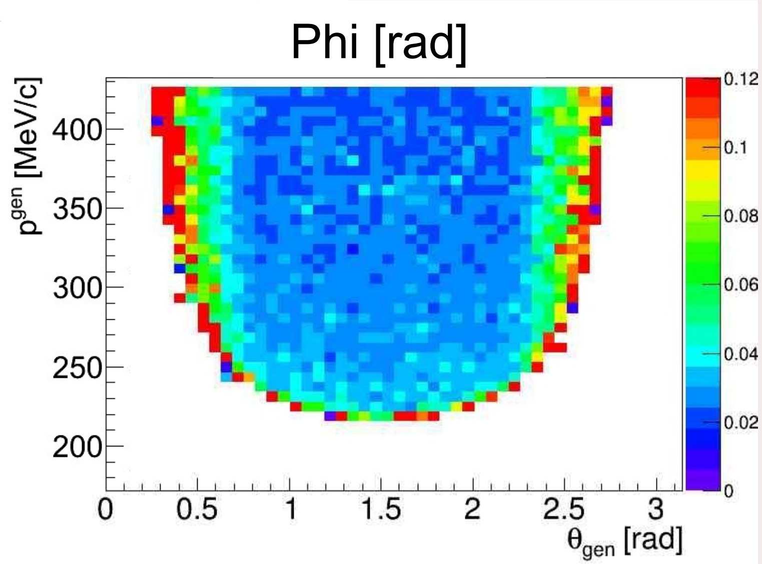


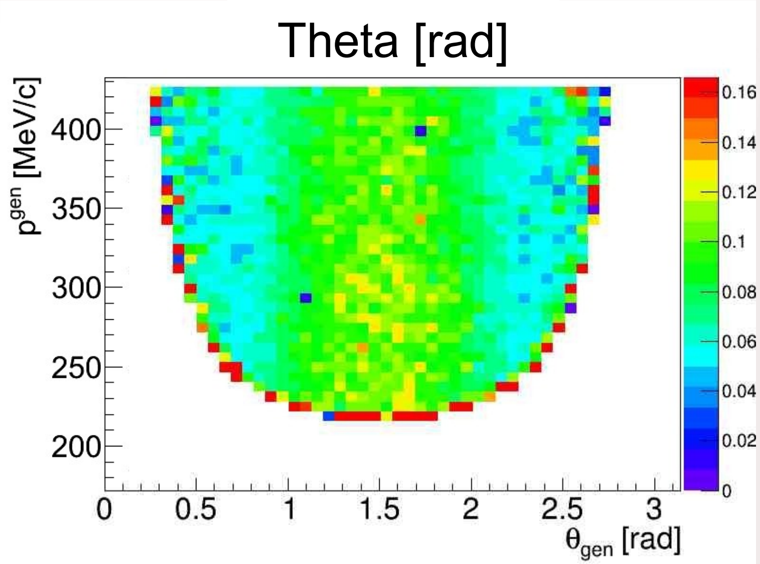
Pt [%]

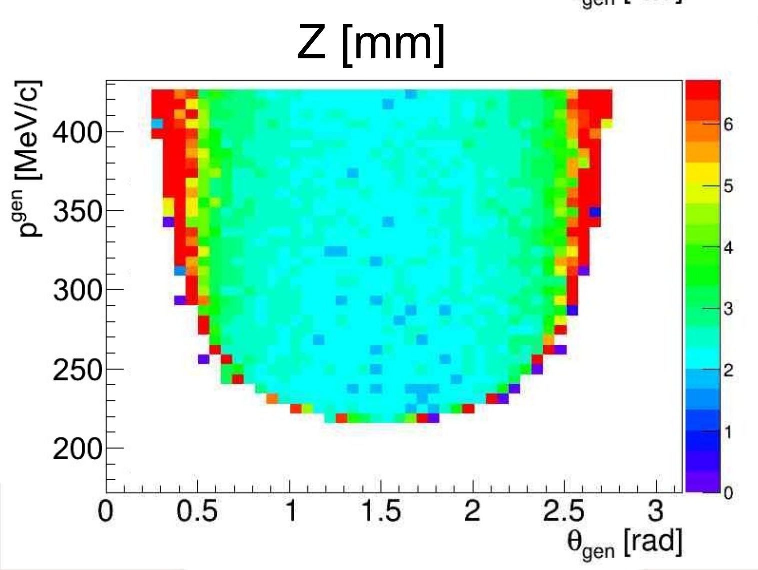


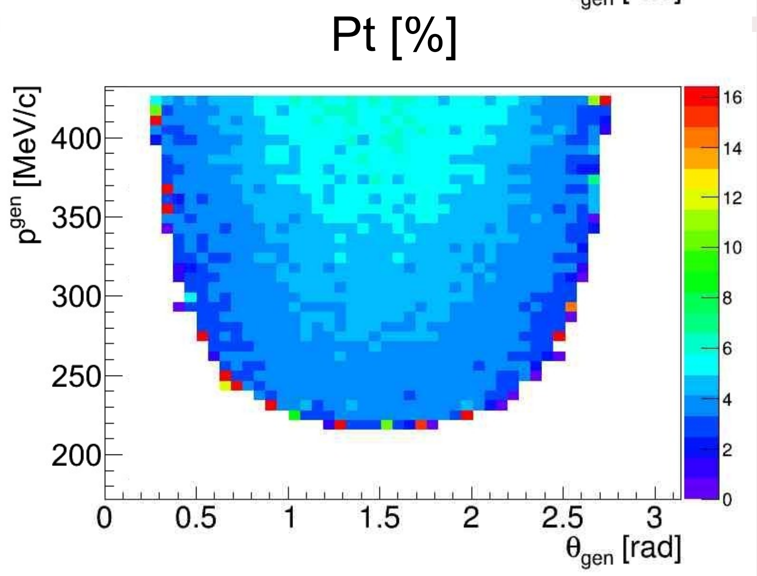
Simulated resolutions for alphas

(based on a simplified simulation)



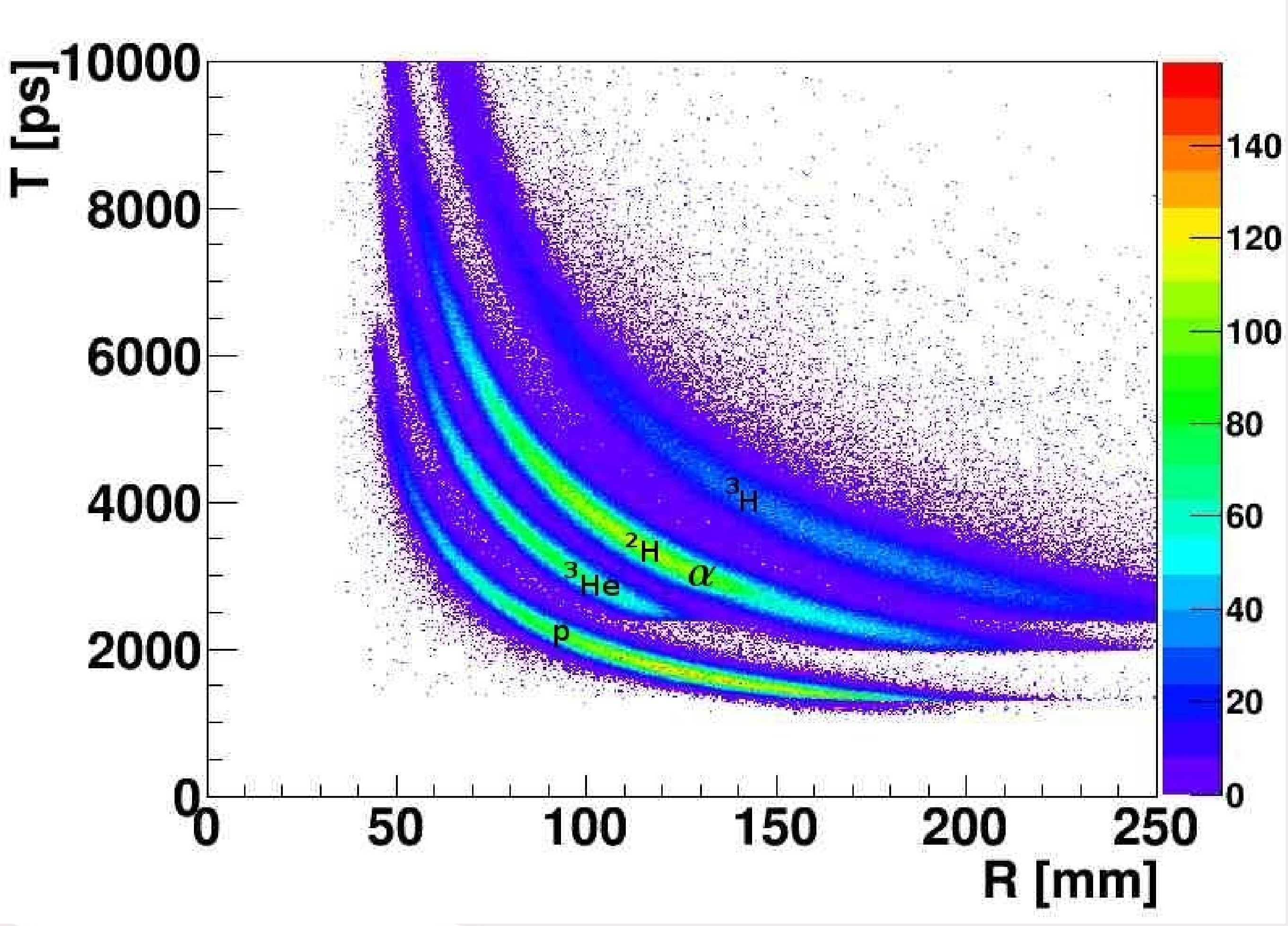






Particle identification

Using the reconstructed radius in the wire chamber and the time of arrival in the scintillator, protons, helium 3 and hydrogen 3 can be separated.



Particle identification: results

In an experiment where ALL 5 species would be present.

With a 150 ps time resolution and a 10% energy resolution of the scintillator

99% of protons identified are protons
92% for helium 3
98% for hydrogen 3

85% for deuterium
88% for alphas

With a 200 ps time resolution and a 10% energy resolution of the scintillator

97% of protons identified are protons
89% for helium 3
97% for hydrogen 3

83% for deuterium
86% for alphas

Can be improved using the information carried by the energy deposition in the drift chamber and fine tuning the parameters.

FastMC available and being used by collaborators.

Hardware

or trying to understand how to build ALERT

Electronics

Main requirements:
- interfaces with CLAS12 readout structure
- has a 10 ns or less time resolution
- stands a few MHz of particle flux
- can be included in the trigger
- can work in magnetic field or can be deported

Use existing electronics DREAM of the **CLAS12 Micromegas developed at Irfu:**
- only a few updates necessary
- fulfill all the requirements above
- will already be in place

Tests will be performed using a small drift chamber between January and March 2016.

Wires

In order to reduce the weight on the end plate and increase the acceptance, we want to use **carbon wires**.

Trying to mount them is the very first step to check the possibility to use carbon wires.

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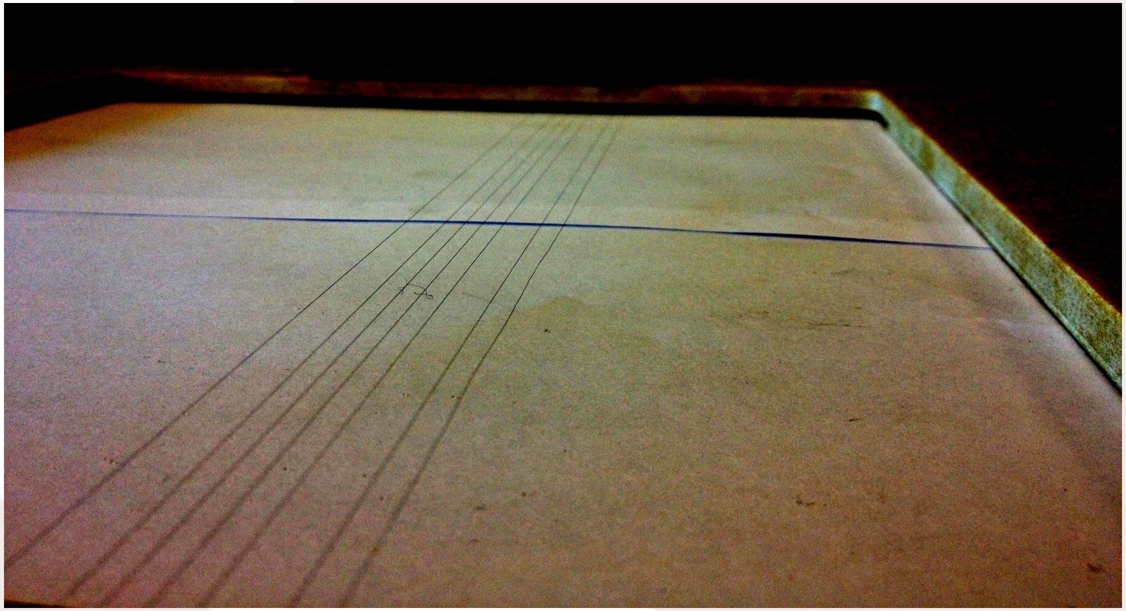
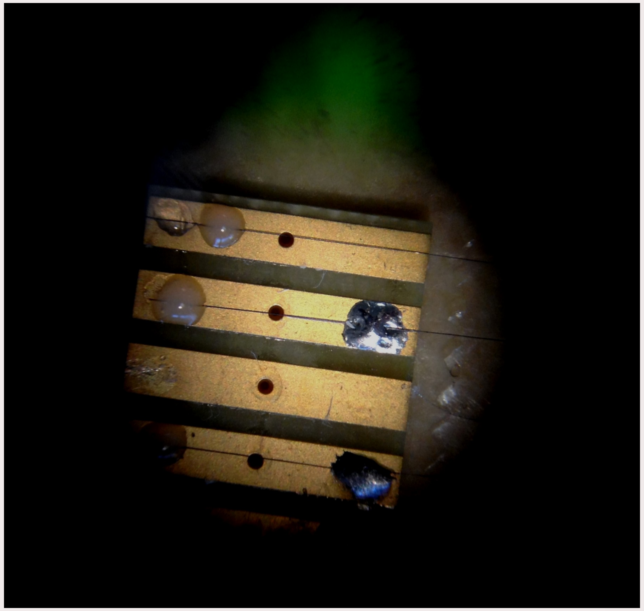
M. Imre and A. Maroni were able to stretch 34 microns diameter carbon wires over 300 mm.





Propagation speed in carbon wires

Setup a small test bench with E. Rauly to evaluate the propagation speed in carbon wires as it could be a complication if it is too low.

After calibration the propagation speed was measured to be **6.6 ns/m.**

For comparison for a coaxial cable, the speed is 5 ns/m.

For our detector, it means the maximum propagation time is 2 ns, that can be added to uncertainty on the position measurement (10 ns) BUT with some work can also probably be reduced once the position along the wire is known. **So it should not be an issue.**

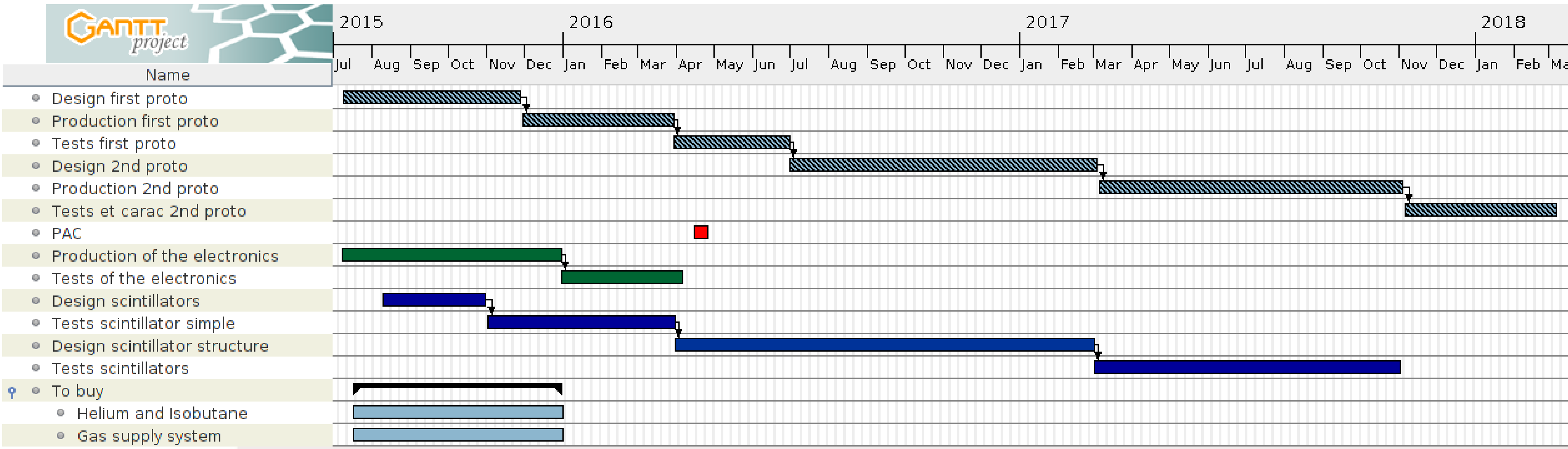
Schedule

or trying to understand when to build ALERT

Schedule

Project granted by P2IO, which will be enough to support the R&D.

Schedule for our R&D:



With the participation of: David Attié (Irfu), Laurent Audouin (IPNO), Pascal Baron (Irfu), Julien Bettane (IPNO), Gabriel Charles (Irfu), Raphaël Dupré (IPNO), Bernard Genolini (IPNO), Michel Guidal (IPNO), Irakli Mandjavidze (Irfu)

- Submission of a proposal to Jefferson laboratory to obtain beam time for at least three experiments that would use ALERT.

Conclusion

The preliminary design for A Low Energy Recoil Tracker (ALERT) has been done

Simulation shows the resolutions for particles with a mass between proton and alpha

ALERT can separate protons, hydrogen 3, helium 3, helium 4 and deuterium

A Fast Monte Carlo implementing the resolutions, acceptance and soon the identification efficiency is available.

The founding provided by P2IO will permit

- to perform the first tests using carbon wires as well as produce a large prototype
- to optimize existing electronics to a wire chamber
- to build a second drift chamber, hopefully using 100% of carbon wires

This research will also benefit to experiments measuring low energy heavy nuclei.