RD_FCC referee meeting

report of Bari and Lecce groups activities

OUTLINE

➢ Simulation of the cluster counting technique with Garfield++ and Geant4 to prove the improvement in the particle identification by using the dN/dx with respect to the traditional method of dE/dx

➢ Integration of the IDEA Geant4 full sim

➢ Development of a new type of field wires based on carbon monofilaments coated with a thin metal sheet to allow for ease of soldering

➢ Development of a fast digitizer coupled to a FPGA for fast filtering and pre-analysis of the signal spectra, aiming at strongly reducing the amount of data transfer

➢ Development and construction of a drift velocity monitoring chamber with a sensitivity of 10^{-3}

➢ Status of a laboratory for drift chamber activities at INFN Bari

➢ Under evaluation the possibility to join a test beam activity

other details: https://agenda.infn.it/event/23950/

Simulation of the cluster counting technique with Garfield++ and Geant4

We are investigating the potential of the cluster counting technique using Garfield++ and Geant4 software tools.
In details:

- We studied the performances of a single drift cell filled with a gas mixture of 90% helium and 10% isobutane, by using Garfield++ and Geant4.
- We developed **three different algorithms** that reproduce in Geant4 the number of clusters distribution and the cluster size distribution .
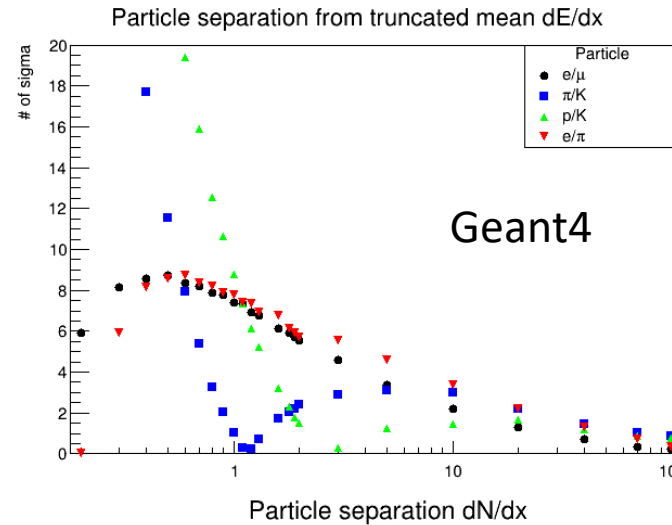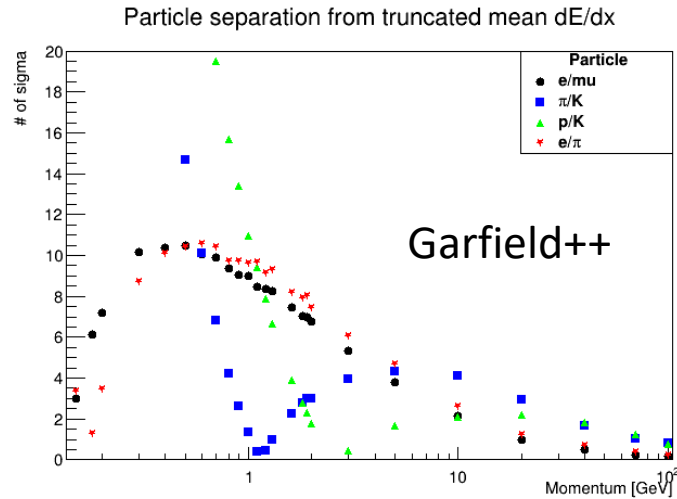
Talks & Proceedings:
Talk presented at International Workshop on Future Linear Colliders, LCWS 2021, 15-18 March 2021
Title "*Simulation of particle identification with cluster counting technique*", with proceeding publication on *SPIRES*.
Arxiv number:*2105.07064*
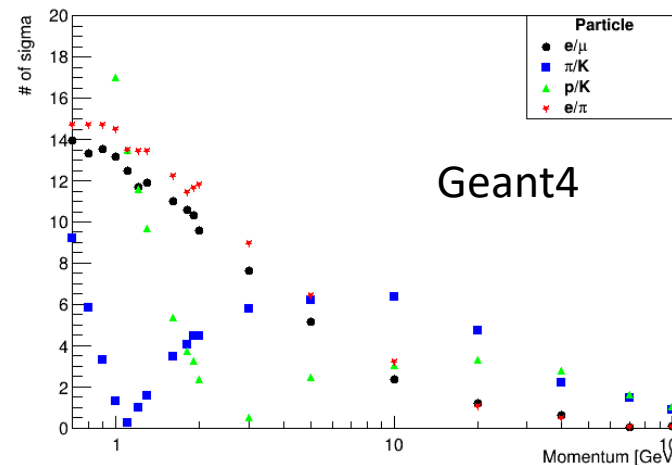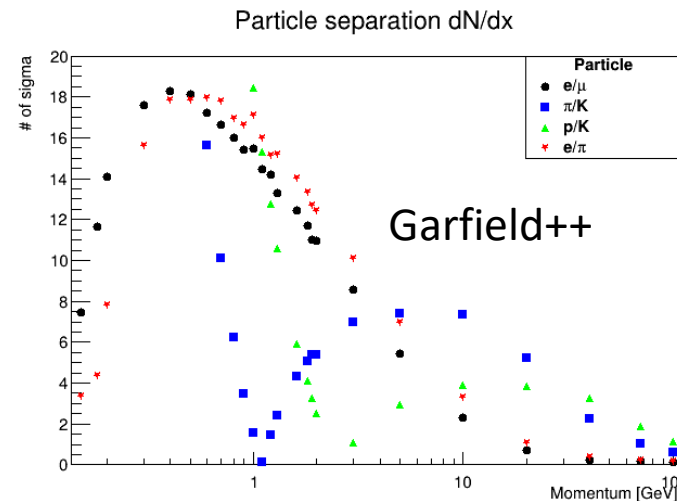
Talk presented at Workshop of the CEPC Physics, Software, and New Detector Concept 14-17 April 2021
Title "*Simulation of PID with cluster counting technique*"

Integration of the IDEA Geant4 full sim.

We are developing a full simulation for the IDEA detector (for the moment not in the FCC framework).
The current status of the software is:

- Simplified Vertex and Si detectors are present: geometry, hits and reconstruction;
- Drift Chamber is present : geometry, hits and reconstruction;
- DR Calorimeter is present : geometry, hits;
- Pre-shower: a preliminary geometry, hits and fitting;

Comparison of Calorimeter energies between integrated simulation and the proper calorimeter simulation
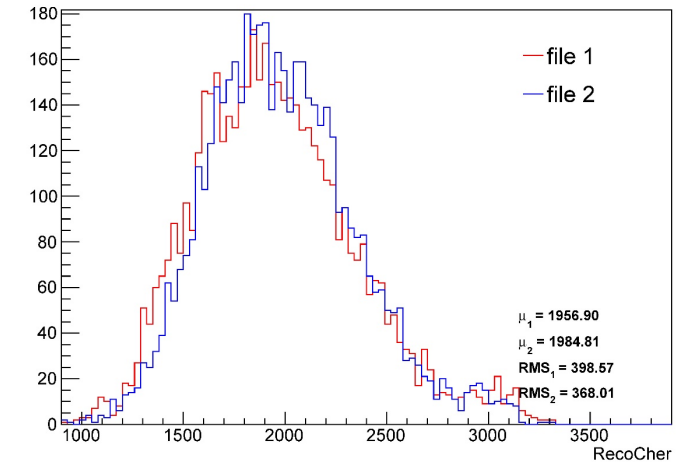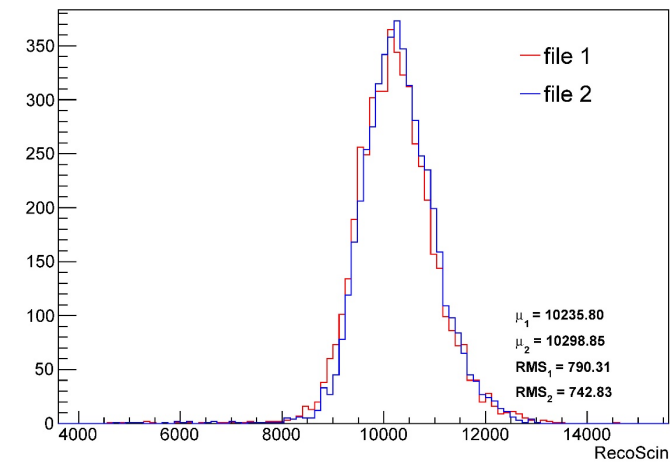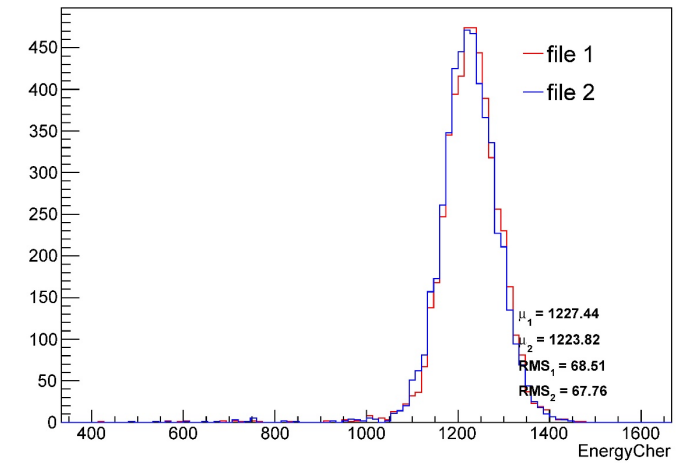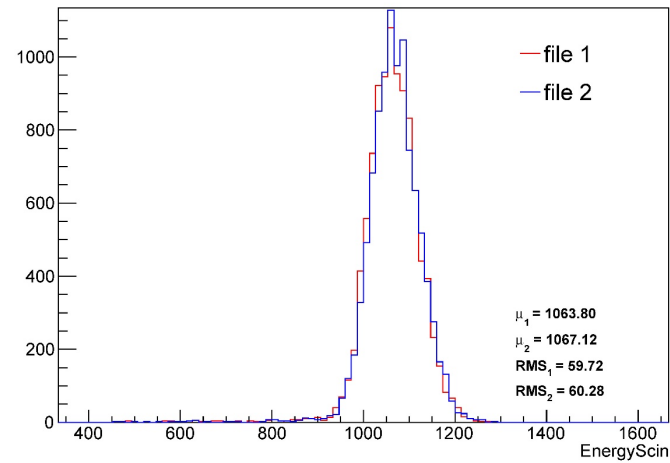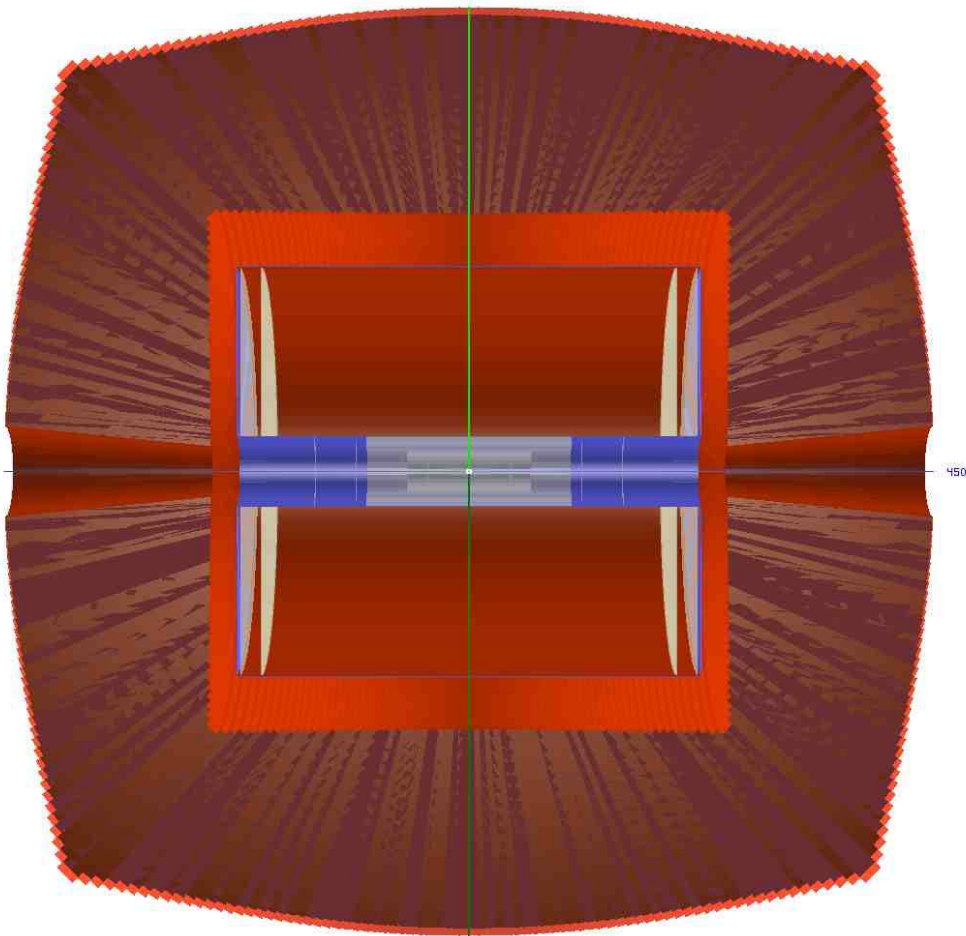
Development of a new type of field wires

- 40 μm and 50 μm "bare" (uncoated) Al5056 (1000 m, 2700 €): bought from CFW, to be shipped to BINP;

- 35 μm Carbon monofilament (about 1000 m, 3000 €): ordered from Specialty Materials;

- TRUMPF Hüttinger TruPlasma DC 3002 air-cooled power supply (10000 €): bought, to be shipped to BINP (under investigation how to do it);

- Ceramic screws (about 2000 €): order in progress.

Development of a fast digitizer coupled to a FPGA

FPGA XILINX KCU105 + ADC AD9689

- FPGA XILINX KCU105 + ADC AD9689: bought with 2019 (CSN1 + DOT1) funds;

- Workstation (i7, 32Gb, 1Tb): bought with 2020 DOT1 funds;

Nexys Video Artix-7 FPGA board

- Nexys Video Artix-7 FPGA: bought with CREMLIN+ funds
(to test the ASoC chip from Nalu Scientific);

task AIDAInnova

- Texas Instrument ADC32RF45: *waiting for unlock SJ* (2500 €)

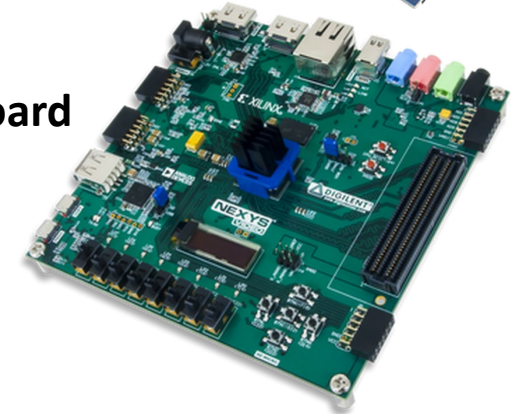- Travel funds for CAEN collaboration: *waiting for unlock SJ* (2000 €)
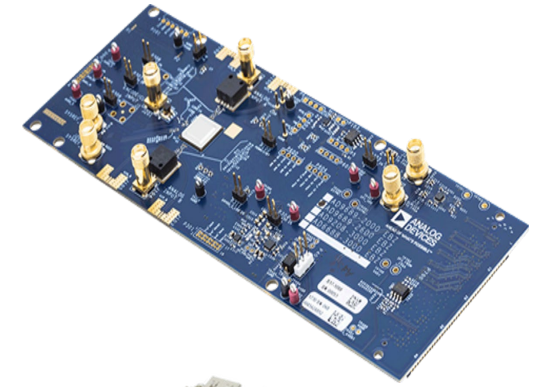
ADC32RF45

KCU105

Development and construction of a drift velocity monitoring chamber

It is crucial to control the purity of the gas injected in a drift monitoring chamber because uncontrolled fluctuations of the gas composition and contaminations by impurities could deteriorate spatial and momentum resolution of the candidate signal track.

The drift velocity monitoring chamber will give a prompt response (few minutes) about drift velocity variations at the 10^{-3} level!
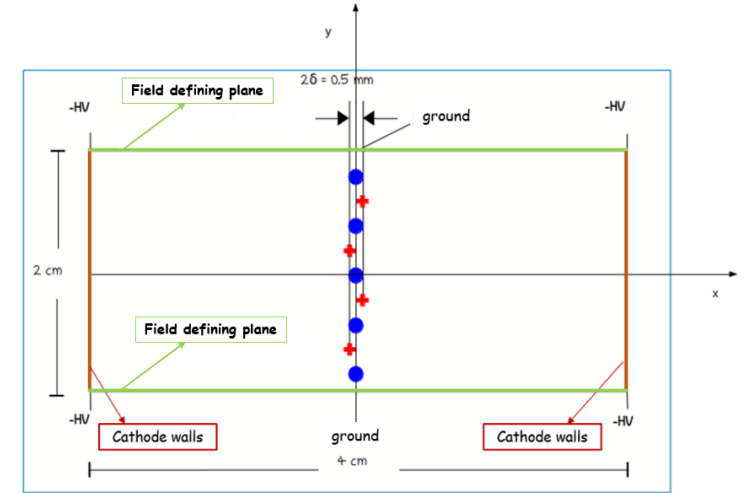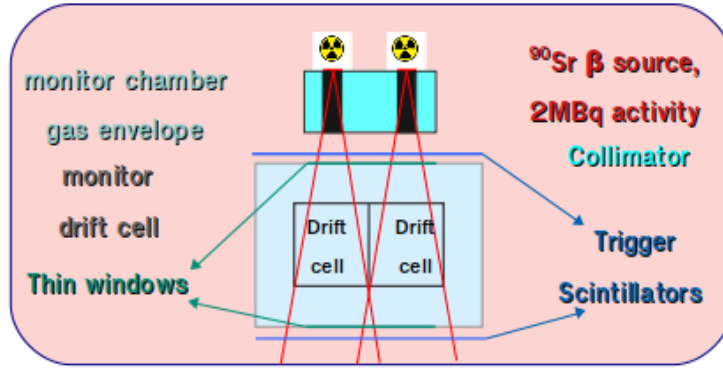
Front end chamber+PCB for wires staggering
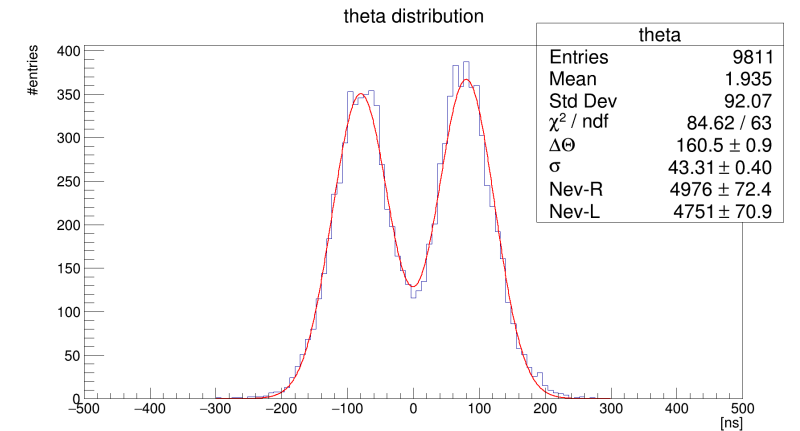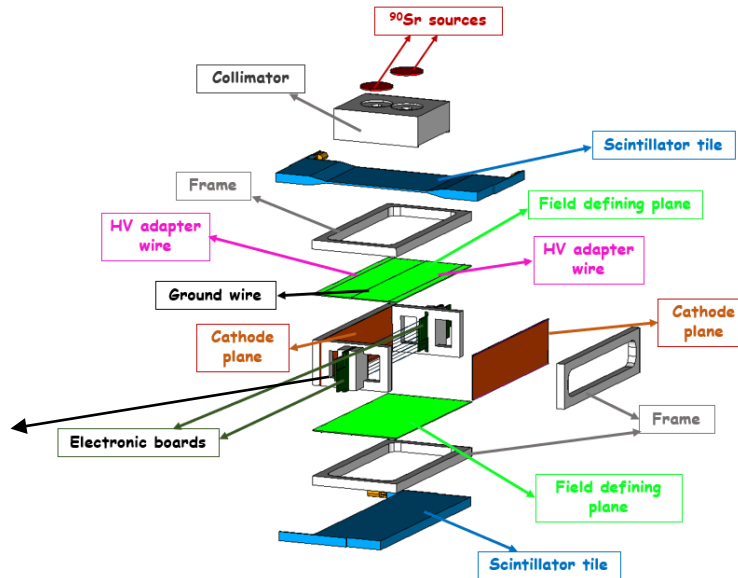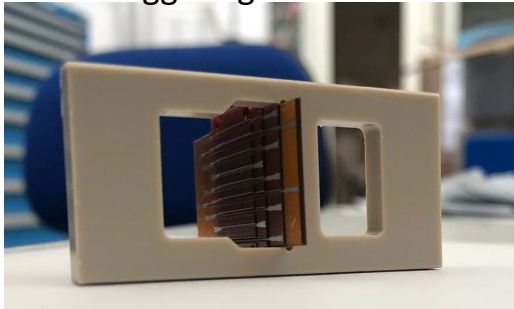
Simulations prove that the system allows for the required sensitivity.

Poster at INSTR20 " *A 10^{-3} drift velocity monitoring chamber* " and publication on "Journal of Instrumentation " of the proceeding "*A 10^{-3} drift velocity monitoring chamber*".

Status of a laboratory for drift chamber activities at INFN Bari

A physical laboratory space was assigned by the INFN Bari director to carry on the activities related to drift chamber developments and test.

The laboratory has been equipped with a gas distribution system including pipes for He, Ne, CO_2, C_4H_{10} and sensors for safety.

Order for mass flow control, gas mixing unit, gas pressure controller is going to be delivered within few days (with the budget assigned in September).

Gas bottles, radioactive sources, electronics boards and logical units are already available for data acquisition.

Very short term plan: to operate a drift velocity monitoring chamber under construction at INFN Lecce. Measurement of the drift velocity when varying several parameters is foreseen.

Medium term plan: to operate drift tubes for studies about the cluster counting technique and bring them at test beam facilities

The INFN Bari mechanical lab and the mechanical designers are involved in the project for construction and design of prototypes:
*   realized the dark box for the monitoring chamber and are going to construct the endcaps
*   started to contribute to the design of the large prototypes for SCT and FCC-ee.

Mechanical engineers from Bari Politecnico invited to work with us about simulation of drift chamber mechanics
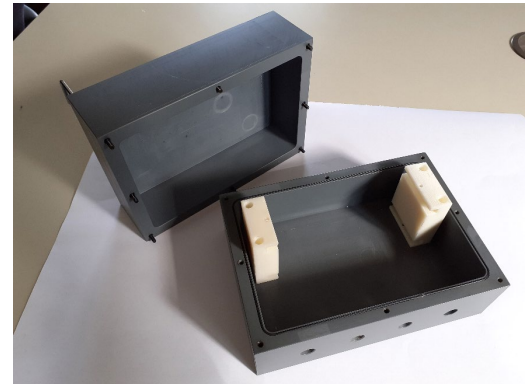
Under evaluation: join a test beam with simple drift tubes October-November 2021

We intend to join, in a parasitic mode, a test beam to perform with simple drift tubes set-up. The goal is to compare simulations results with experimental results for the relativistic rise of the dN/dx: that is of utmost importance for a complete validation of the cluster counting technique.
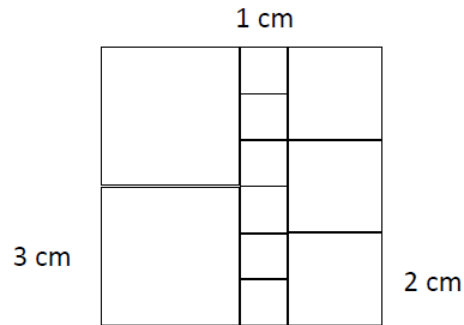

- 6 copper drift tube 1 cm x 1 cm x 40 cm
- 3 copper drift tube 2 cm x 2 cm x 40 cm
- 2 copper drift tube 3 cm x 3 cm x 40 cm
- *11 preamplifier cards (1 GHz, 20 db)+termin.*
- 5 HV power supply channels
- 11 digitizer (2GSa/s,12 bit) (WBD and oscilloscope)
- Gas mixing and distribution
- 2-3 trigger scintillators (HV, discriminator...)

Test program preliminary
- HV scan at fixed beam momentum (90:10 He/iC$_4$H$_{10}$)
- Gas mixture scan at fixed p beam and HV:
  - ➢ 90:10 He/iC$_4$H$_{10}$
  - ➢ 85:15 He/iC$_4$H$_{10}$
  - ➢ 80:20 He/iC$_4$H$_{10}$
  - ➢ Possibly other mixtures (to be defined)
- Angle scan (φ and θ) at fixed gas gain and p:
  - ➢ φ 0, 30 45 for different track length
  - ➢ Θ 0, 30, 60 for space charge determination
- μ relativistic rise from minimum p to maximum p
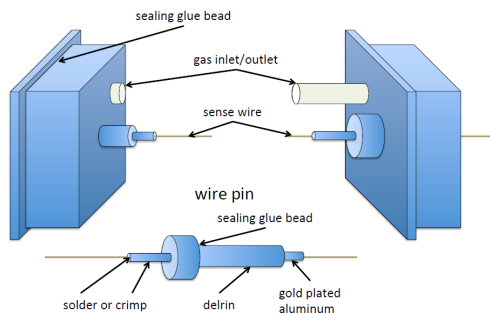
Per il test beam siamo in attesa di una risposta da Barbara Holzer (Nicola ha scritto come responsabile del test). Abbiamo l'accordo di LHCb e del gruppo delle MuRwell, main utilizzatori del fascio, ma ci manca il suggello ufficiale dell'SPS (Barbara Holzer)

Stima preliminare e grossolana: 3 persone per 2 settimane

Note: Design of front-end amplifier is on going (possibly we will use some commercial ones as phillips scientific 794)

backup

On going and future activities.

- Continue the development of the full simulation and perform physics studies:
  - Complete the DR hit integration/debugging
  - Complete the hit/reco conversion to EDM4HEP
  - Check the pre-shower descripton
  - Add the muon spectrometer
- Perform PID studies with the full detector simulation;
- join a test beam with simple drift tubes October-November 2021;
- Complete a drift chamber laboratory at INFN-Ba;
- Complete and test the drift velocity monitoring chamber;
- Progress in designing the mechanical structure of the drift chamber prototype (CMD-3 new drift chamber):
  - complete simulations and stress-strain analysis;
  - build a 1:1 mock-up of three sectors to validate simulations and test materials;
- Build small single-cell drift chamber and drift tubes prototypes to test different wire proposals;
- Progress on two-channels digitizer-FPGA embedded system to refine cluster counting/timing algorithms;
- Build a four-channel board (AIDAinnova program) and study possible extensions to 32/64 channels system;
- Follow closely and contribute to the development of a front-end ASIC for cluster counting/timing.

- June 2021
- July 2021

- July 2021
- December 2021

- December 2021
- June/July 2021
- …
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- …
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Development of the mechanical design for CMD3 drift chamber

The mechanical design for CMD3 drift chamber has been developed traying to combine two main goals:

- The high transparency.
- The mechanical stability of the whole structure.

Simulations of mechanical tension recovery
Three stays loaded with:

- 145 N at ≈10°
- 240 N at ≈14°
- 200 N at ≈21°

max deflection obtained < ±25 μm
The simulations prove the feasibility of the project.
Optimization in progress .

Talk at CREMLINplus WP5 General Meeting: Task 5.5-Drift Chamber Prototyping, 28-29 September 2020

Talk at CREMLINplus WP5 General Meeting: Task 5.5-Drift Chamber Prototyping, 17-18 February 2021