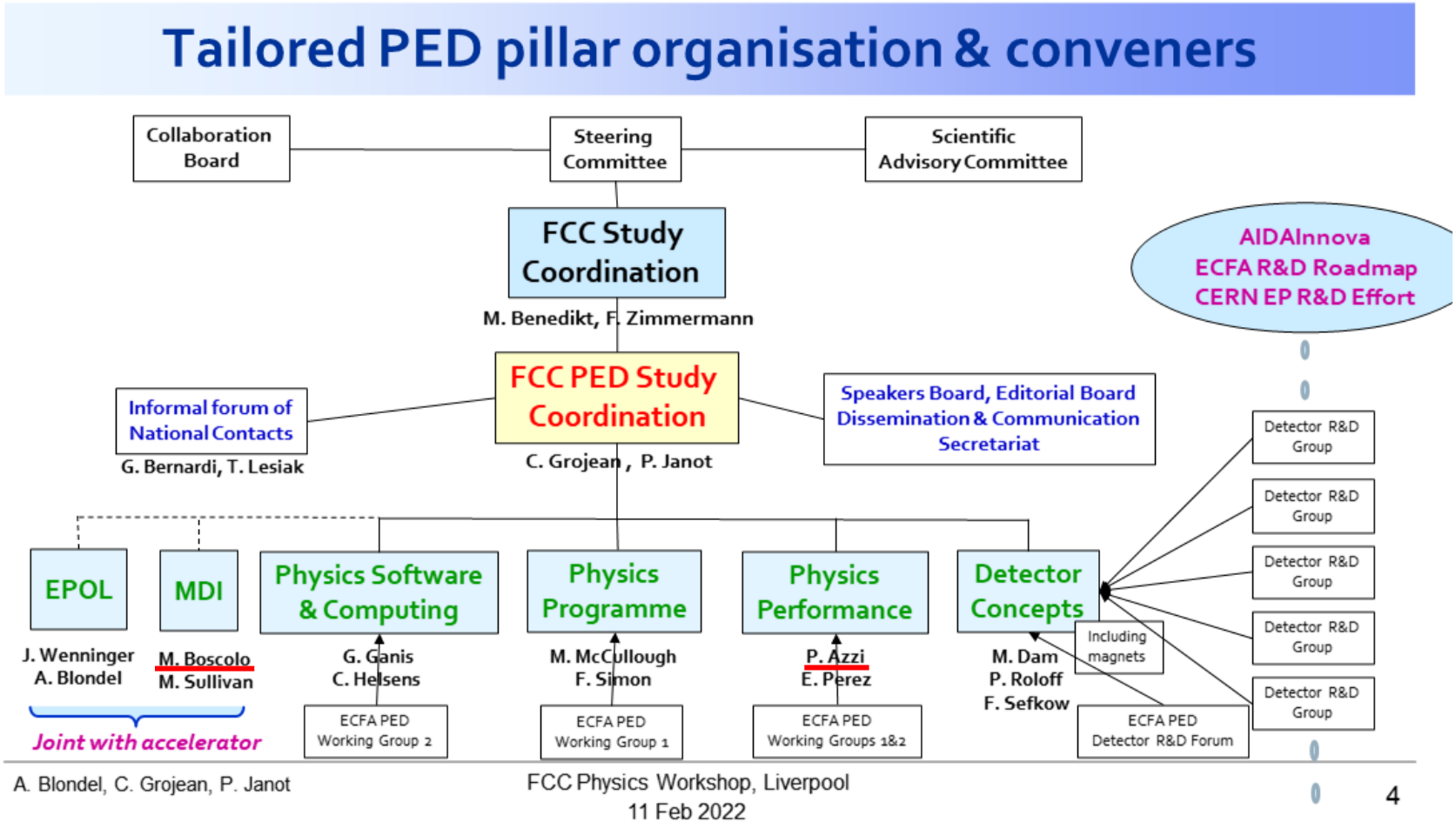
RD_FCC: attività, anagrafica e richieste finanziarie per 2023

N. De Filippis
Politecnico/INFN Bari

Bari
Luglio 2022

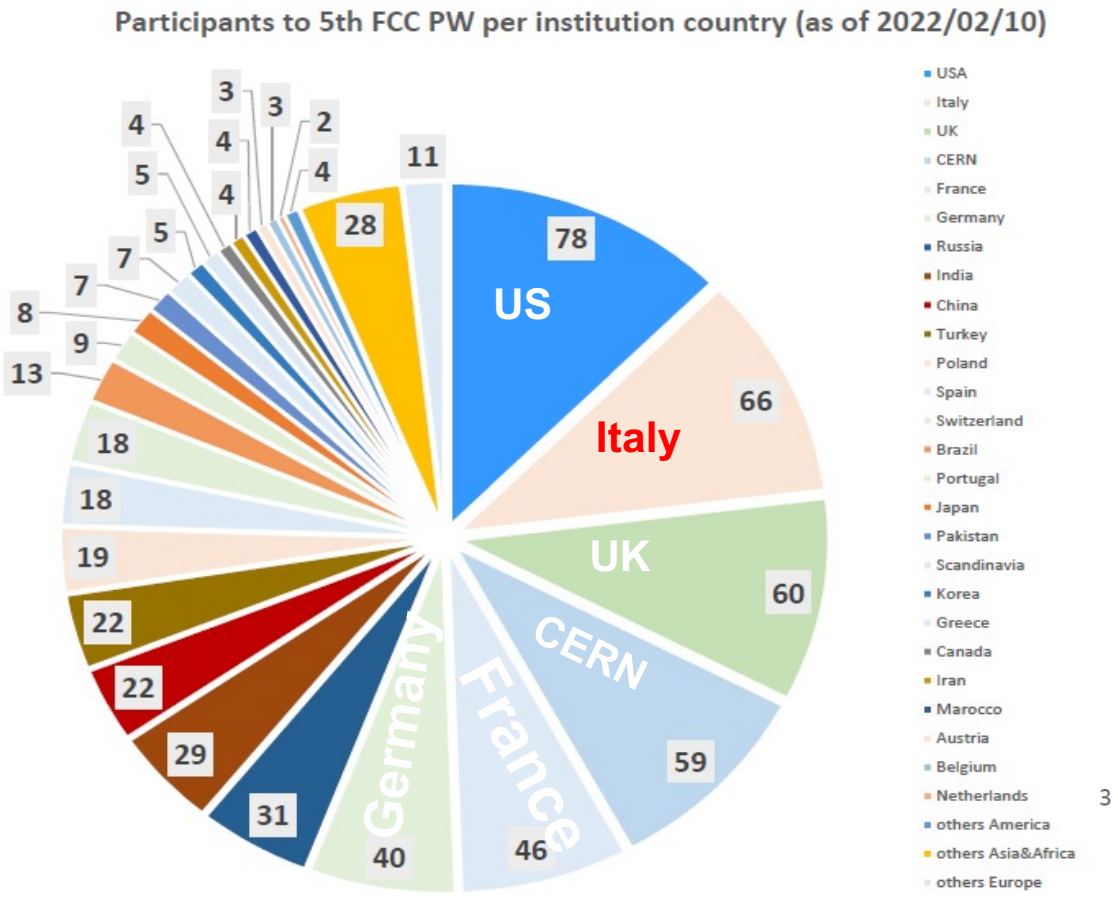
FCC Organzation

- FCC organization approved by CERN Council June ‘21
  - CERN/3566/Rev. CERN/ 3588)



INFN effort

- Fall 2016: line of research on future accelerators created in



- **More resources**
  - **CSN5 grants**
    - **ARCADIA**
    - **Hidra2**
  - **EU grants:**
    - **EuroCirCol**
    - **FCC-IS**
    - **Attract**
    - **AidaInnova**
    - **EuroLabs**
    - **Cremlin+, FEST**

2021 schedule

The PED Pillar Objectives in 2025

- **Mostly defined by the general (tight) timeline of the FCC project**

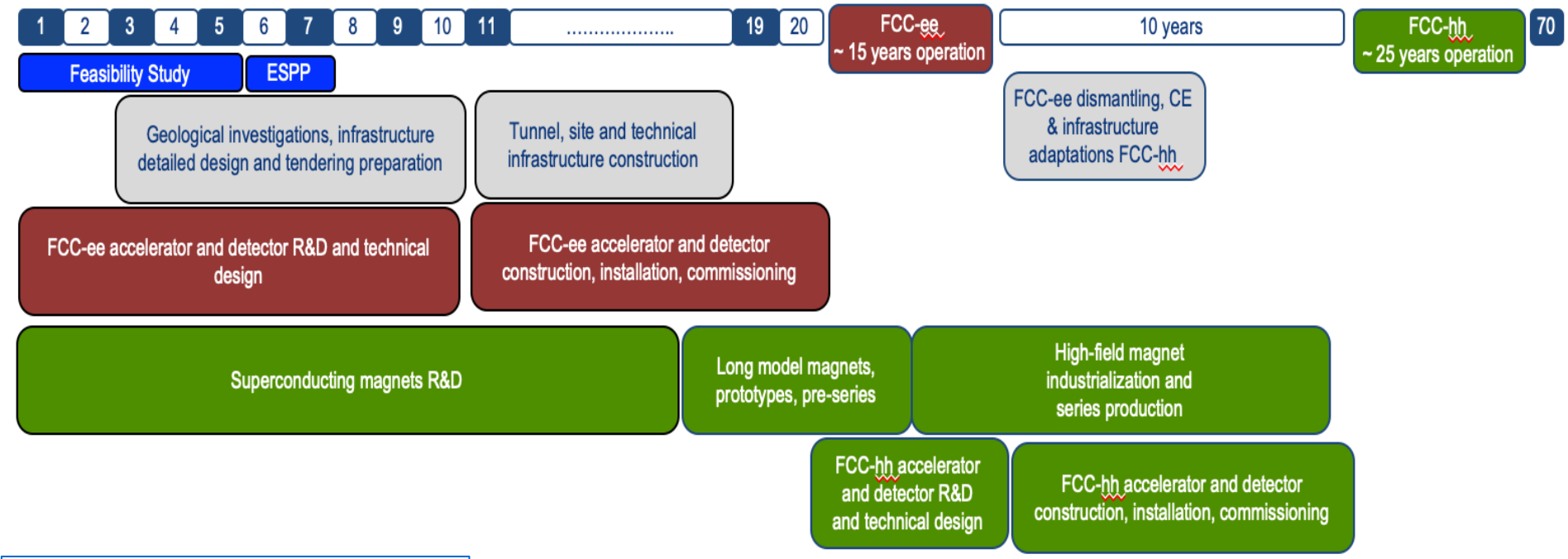
Infrastructure and accelerator **Physics, Experiments, and Detectors**

Milestone / activity	Target date	Possible timeline
First e^+e^- collisions in FCC-ee	Early 2040's	FCC-ee detector commissioning
Start machine installation	2037	Start FCC-ee detector installation
Tunnel completion	2035/36	
Start tunnel construction	2030	Start FCC-ee detector construction
Project approval	2028/29	FCC-ee Detector TDR's and approvals
Next European Strategy Update	2026/27	Next European Strategy Update (ESU)
Key prototypes (feasibility proof)	2026	FCC-ee Proto-collaborations and EoI's
FSR(*) (feasibility proof)	End 2025	PED FSR, includes enough common material and knowledge for FCC-ee proto-collaborations

(*) FSR = Feasibility Study Report

Adapted from schedule in M. Benedikt's presentation

Timeline of the FCC integrated programme
FCC week, Paris - May 30, 2022

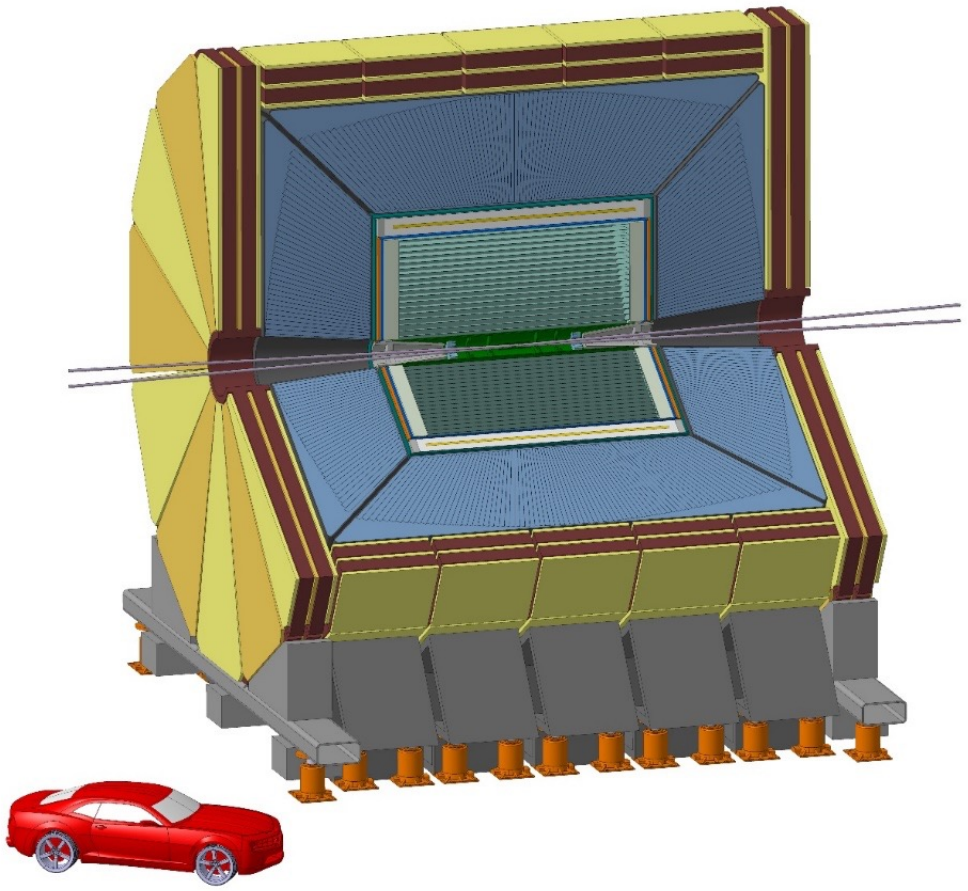


- Feasibility Study: 2021-2025
- If project approved before end of decade → construction can start beginning 2030s
- FCC-ee operation ~2045-2060
- FCC-hh operation 2070-2090++

F. Gianotti

CEPC/FCC: INFN detector R&D

- IDEA detector concept
  - Vertex detector
    - ARCADIA
  - Drift chamber
    - Cluster counting
  - Silicon wrapper
    - ATLASpix3
  - Dual Readout calorimeter
    - Also with crystals
  - μRwell muon chambers
    - Pre-shower



R&Ds presented to IDRC

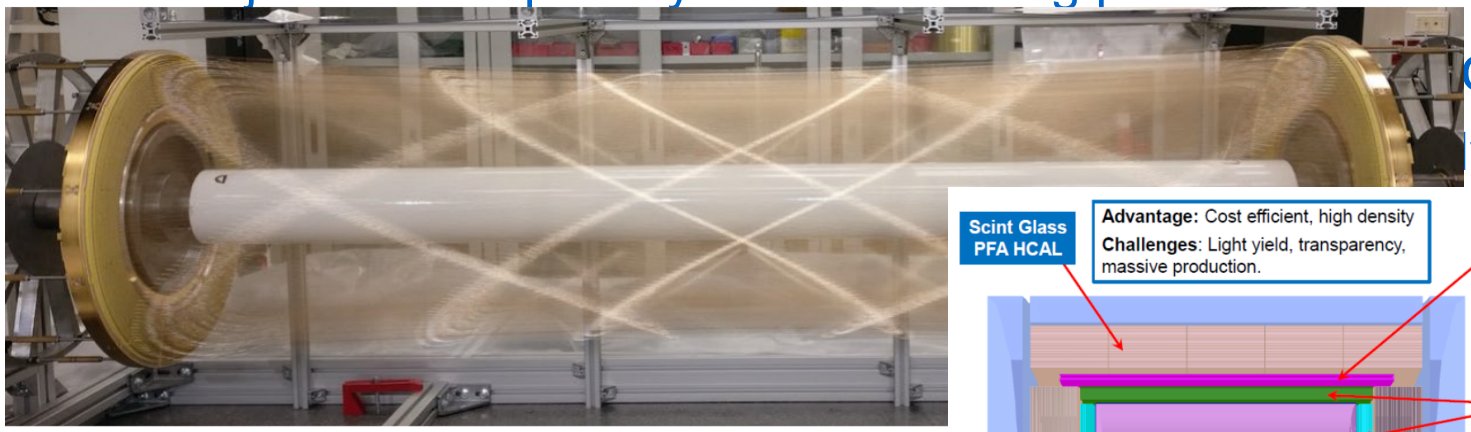
1. Vertex
   - 1.1 MOST2
   - 1.2 ARCADIA
2. Tracker
   - 2.1 TPC
   - 2.2 Silicon Tracker
   - 2.3 Drift chamber
3. Calorimeter
   - 3.1 ECAL Calorimeter
     - 3.1.1 Crystal
     - 3.1.2 SiW
   - 3.2 HCAL Calorimeter
     - 3.2.1 DHCAL
     - 3.2.1 AHCAL
   - 3.3 DR Calorimeter
4. Muons
   - 4.1 Scintillator
   - 4.2 µRwell
5. Solenoid
   - 5.1 NiTi
   - 5.2 HTS
6. MDI
7. TDAQ
8. Software

- ❑ INFN driven
- ❑ INFN participation

Highlights: Drift Chamber

- Highly transparent tracker with excellent PID
- Joint INFN-BINP development
  - Synergy with MEG-II, CDM3 and tau-charm factory R&D
  - Additional support from EU grants: CREMLIN+ → Eurizor
  - Major R&D to quantify cluster counting performance

AIDA innova



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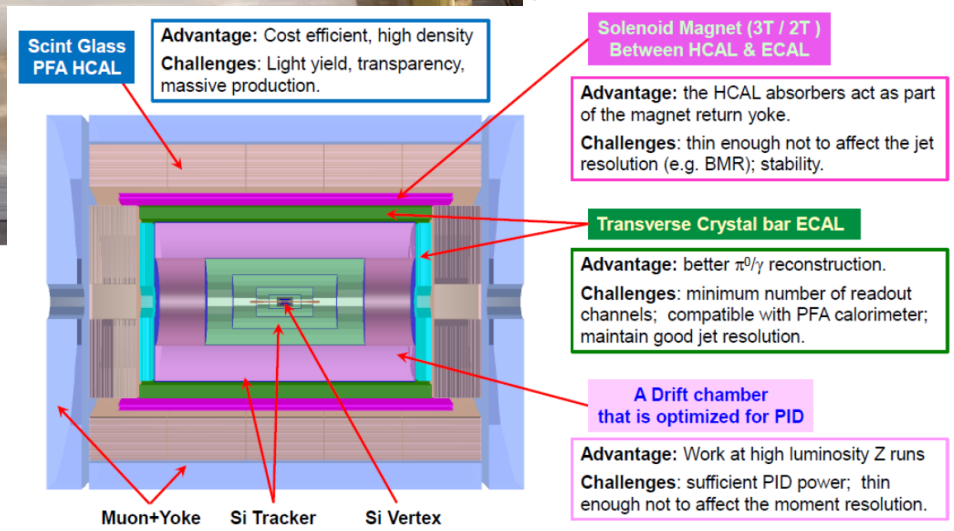


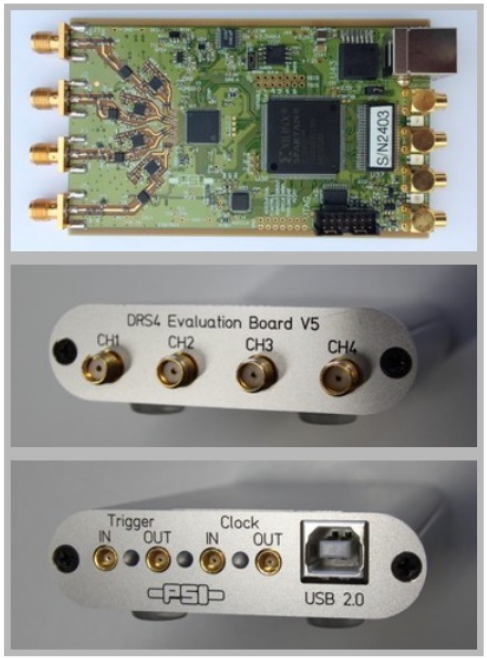
Attività RD_FCC Bari

Responsabilità:
N. De Filippis: Fisica, Simulazione e Software di RD_FCC Italia

INFN Bari Laboratory

New equipment:

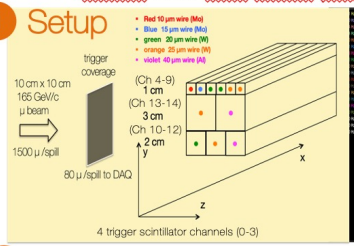
- gas bottle: He, CO_2
- high voltage power supply
- scintillators (+siPM)
- pc desktop for DAQ
- 1GHz oscilloscope
- Digitizer/Amplifier DRS

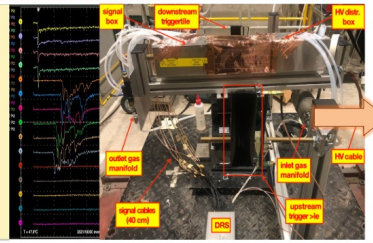


2021 test beam results

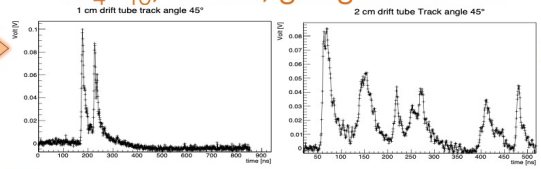
A beam test has been performed during November 2021 at CERN on the H8 line in a parasitic mode to validate the simulations results by using a muon beam.

1 Setup

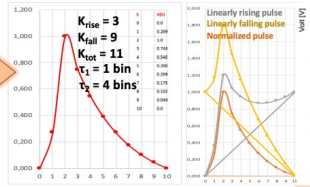


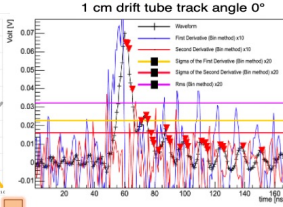


2 1.2 GSPS (853.33 ns), 90%He10% iC_4H_{10}, 10 bits, gas gain ≈ $2 \cdot 10^5$



3 Electron peak finding algorithms

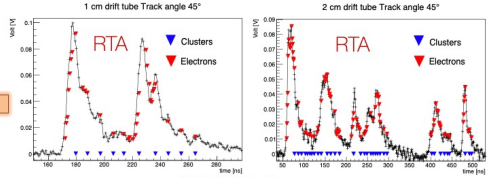


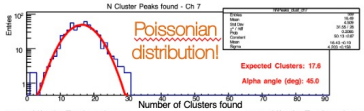


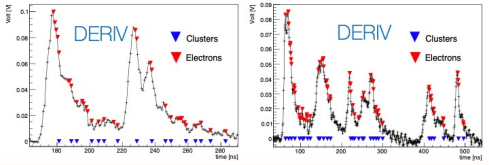
Running Template Algorithm (RTA)

First and Second Derivative Algorithm (DERIV)

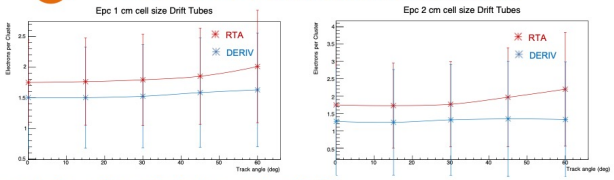
4 Same cluster counting algorithm







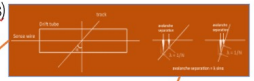
5 Independent compatible results

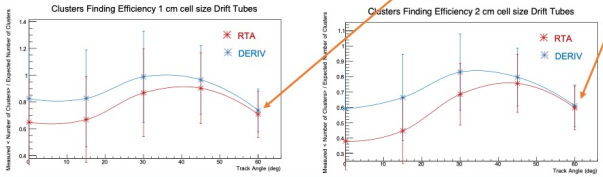


Expected number of electron peaks [5,6] = δ cluster/cm (M.I.P.) · drift tube size [cm] · 1.3 (relativistic rise) · 1.6 electrons/cluster · 1/cos(α)

- α = angle of the muon track w.r.t. normal to sense wire
- δ cluster/cm (mip) = 12 (18) for 90%(80%) He gas mixtures)
- drift tube size = 0.8 (1.8 cm) for 1 cm (2 cm) drift tube

Space charge + attachment + recombination effects affect the experimental CC efficiency!





6 Beam test conclusions and plans

1. Establish the limiting conditions for an efficient CC: Nov 2021
   - gas gain saturation
   - cluster density (by changing the gas mixture)
   - space charge (gas gain, sense wire diameter, track angle)
2. Demonstrate the ability to count clusters:
   - at a fixed βγ (muons at a fixed momentum) count the clusters by doubling the track length, changing the track angle and the gas mixture
3. In optimal configuration, measure the relativistic rise as a function of βγ, both in dE/dx and in dN_C/dx, by scanning the muon momentum from the lowest to the highest value (from a few GeV/c to about 250 GeV/c at CERN/H8) to define the particle identification capabilities of the cluster counting approach over the full range of interest for all future lepton machines. July 2022

References

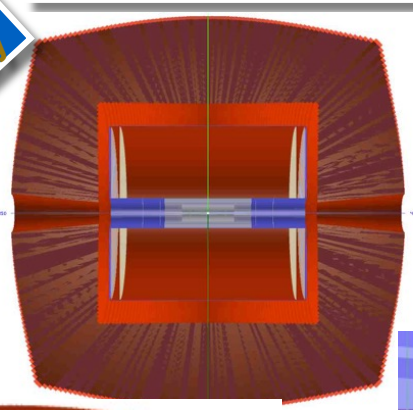
[1] M. Benedikt et al., FCC-ee The Lepton Collider : Future Circular Collider Conceptual Design-Report Volume 2. Eur. Phys. J. Spec. Top.228(2019) 261(623)
[2] F.Bedeschi, A detector concept proposal for a circular e+e- collider,Vol. ICHEP2020, PoS, (2021) 819
[3] G.F. Tassielli on behalf of the IDEA Collaboration, A proposal of a drift chamber for the IDEA experiment for a future e+e- collider Vol. ICHEP2020, PoS, (2021) 877
[4] F.Cuna, N.De Filippis, F.Grancagnolo, G.F.Tassielli, Simulation of particle identification with the cluster counting technique, proceeding at LCWS2021
[5] R. G. KEPLER, C. A. D'ANDLAU, W. B. FRETTER and L. F. HANSEN, Relativistic Increase of Energy Loss by Ionization in Gases IL NUOVO CIMENTO VOL. VII, N. 1 - 1 Gennaio 1958
[6] H. Fischle , J. Heintze and B. Schmidt Experimental determination of ionization cluster size distributions in counting gases Nuclear Instruments and Methods in Physics Research A301 (1991) 202-214

Geant4 full simulation of IDEA

The integration of the **Calorimeter geometry** description with IDEA **Silicon Vertex (SVX), Drift Chamber (DCH)** has been performed. The code is available in the HEP-FCC github area: https://github.com/HEP-FCC/IDEADetectorSIM

(calorimeter+Drift chamber)

Visualization for the Integrated Geometry

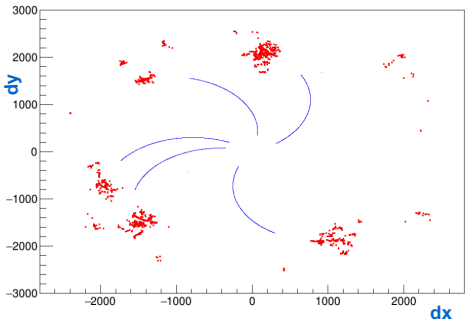


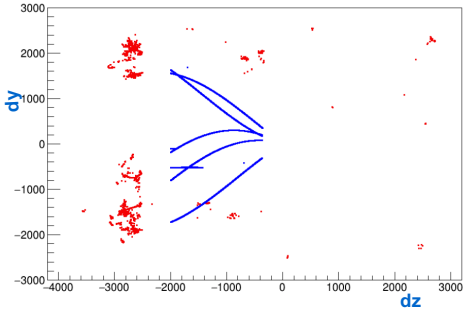
Phi volume (barrel)

Phi volume (Endcap)

Hits display

Simple display for the hits of negative energy pions of 870 MeV as seen in the different detectors (DCH & DR calo).





W. Elmetenawee

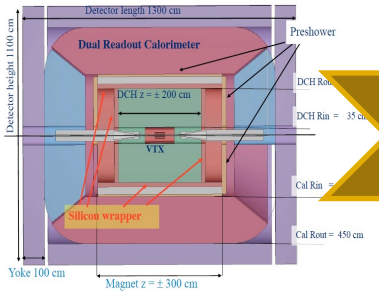
The Migration to EDM4hep and Key4hep

Goal: port the simulation and the algorithms to a common FCC framework to develop studies, physics analysis and algorithms in the standard/final environment.

Standalone

Geant4 Monte Carlo hits (possible other data structures) reconstructed tracks

simulation + reconstruction



done

Covert to

FCC framework

EDM4HEP

In progress

geometry port the algorithms port the data

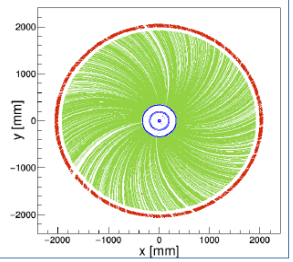
Key4HEP

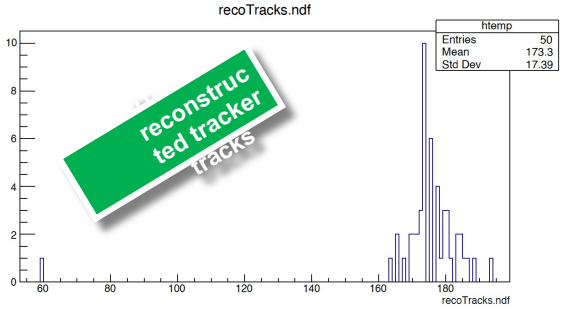
The converted tracker hits: silicon vertex tracker, drift chamber, pre–shower

Example of simulation

particle
- 1090 events
- 1 muon/event
- theta in [88.5, 90.5] deg
- energy = 1 GeV

geometry
- Beam pipe
- SVX
- DCH
- PSHW
- magnetic field = 2.0 T

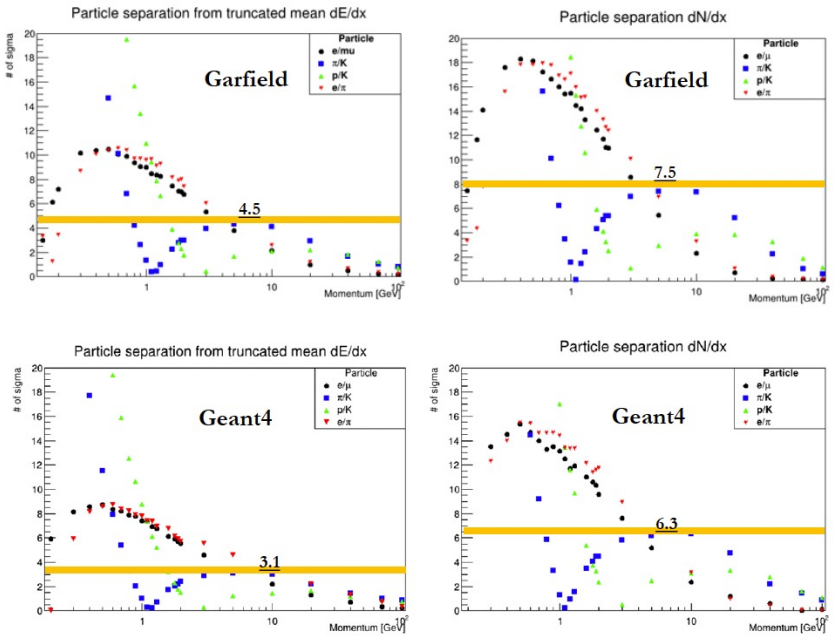




W. Elmetenawee

Cluster Counting/Timing and P.Id.

- A simulation of the ionization process in 1 cm long side cell of 90% He and 10% iC4H10has been performed in Garfield++ and Geant4.
- Geant4 software can simulate in details a full-scale detector, but the fundamental properties and the performances of the sensible elements have to be parameterized or an "ad hoc" physics model has to be implemented.
- Three different algorithms have been implemented to simulate in Geant4, *in a fast and convenient way*, the number of clusters and clusters size distributions, using the energy deposit provided by Geant4.



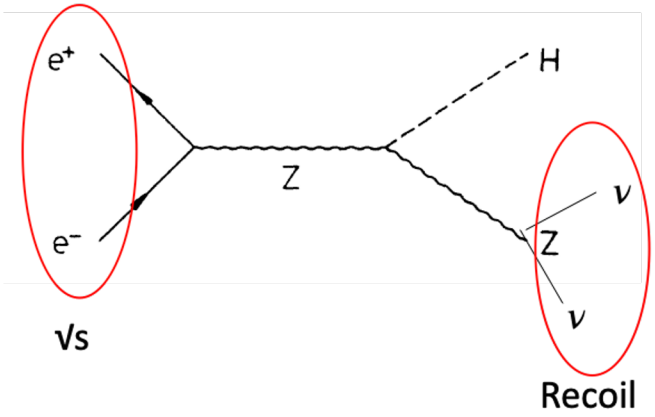
We are assuming a cluster counting efficiency of 100%.

In Progress to be ported to the the full SIM Framework simulation

W. Elmetenawee

ZH analysis with Higgs to hadron & Z invisible at FCC-ee detector performance studies

Reham Aly Mohamed
(Bari)



"Case study" to determine the requirements on the calorimeter performance.
Study performed in the context of the FCC-ee "Higgs Physics group. "

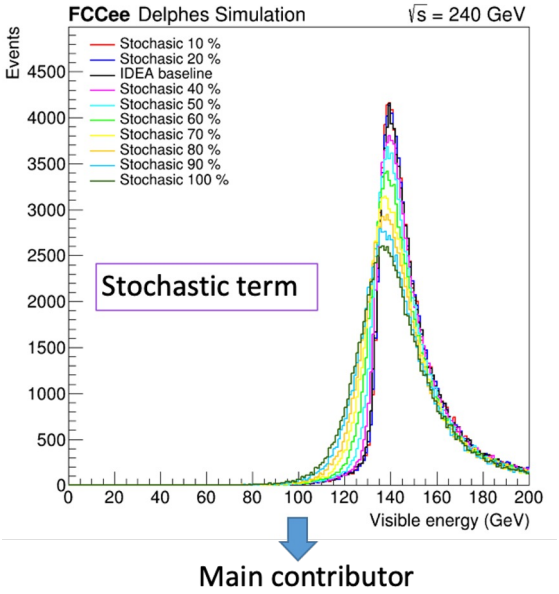
Since the calorimeter energy resolution playing an important role in the jet energy measurement, we are studying the effect of

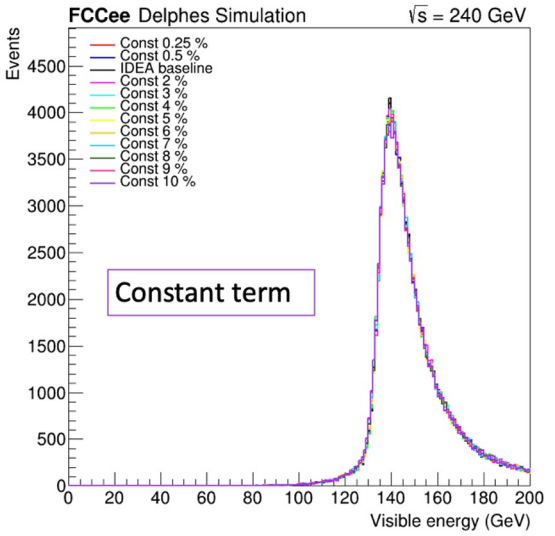
1- Tuning HCAL energy resolution parameters:
Tuning the stochastic, constant terms in Delphas cards
Adding Noise term to energy resolution calculation
2- Tuning the minimum energy threshold
3- Tuning the energy significance
4- Studying the calorimeter granularity impact on the analysis
5- Comparing with the full simulation

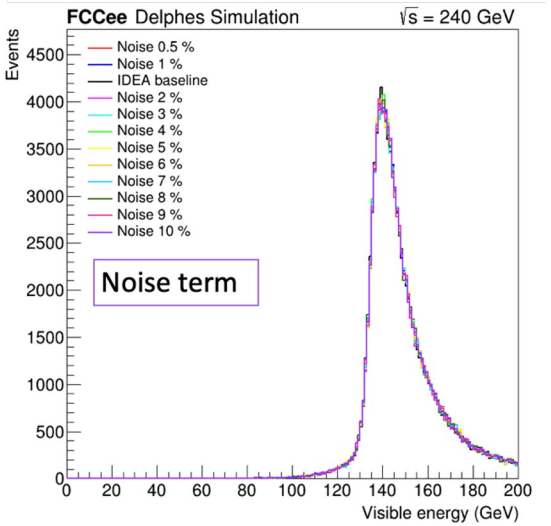
Signal samples:
Z)$\nu\nu$(H(bb)
Z)$\nu\nu$(H(cc)
Z)ν(H(gg)
Z)$\nu\nu$(H(qq)

Some preliminary plots

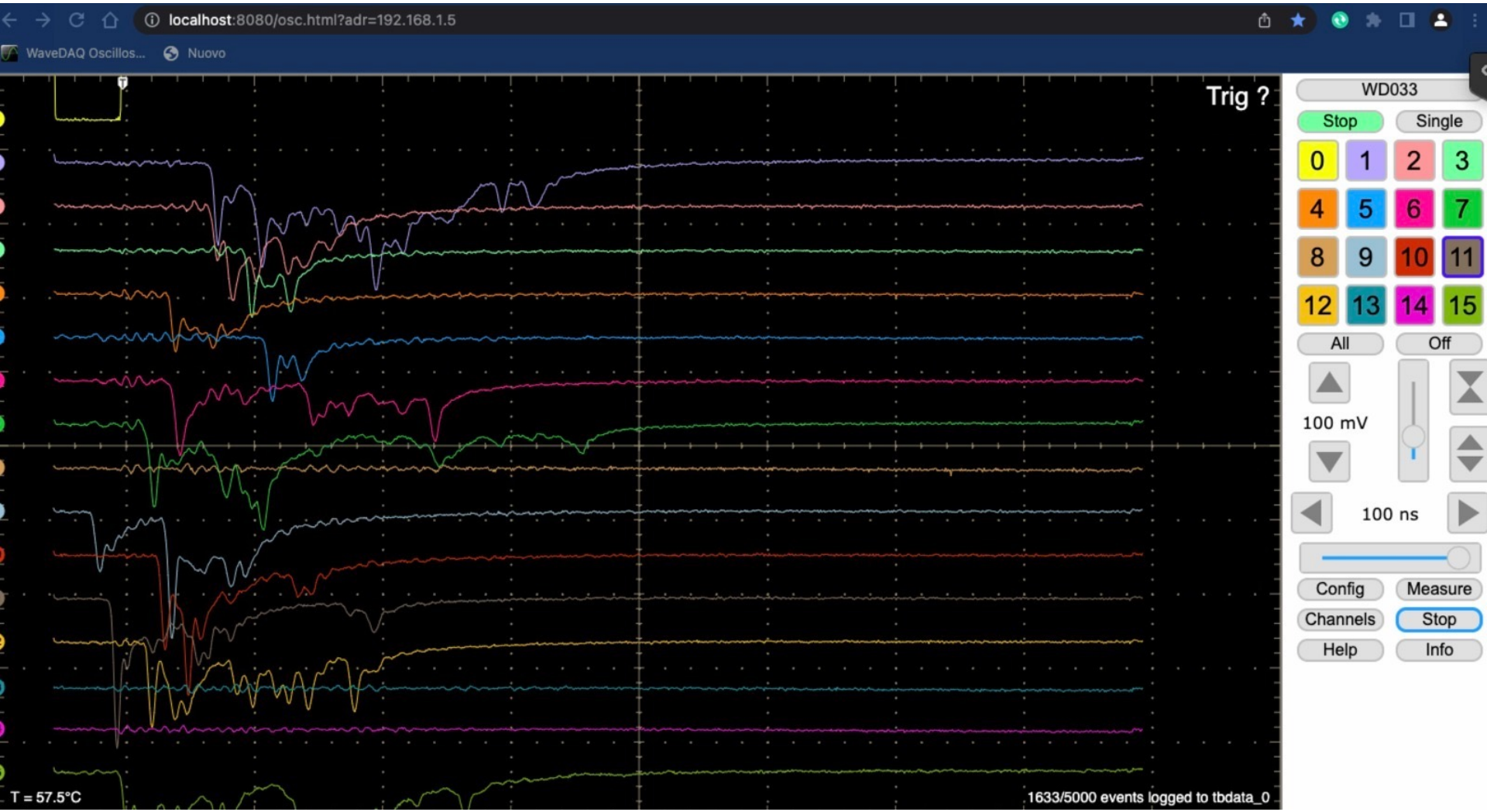
- ZH(gg) signal sample.
- Distribution of Particle Flow candidates visible energy







2022 test beam on going



Strategia delle attività 2023

Si intende continuare/consolidare le attività relative alla progettazione, simulazione e test di una camera a deriva per IDEA (FCC-ee/CepC):

- Test of drift tubes and multi-wire drift chambers prototypes in the local laboratory and in test beam areas ← "cluster counting technique"
- Wiring and assembling of drift tubes
- Misure con camera di monitoring o dei prototipi di camera a drift
- Simulazione della camera a deriva in Geant4 → Key4HEP
- studi su algoritmi di tracciamento sia per IDEA FCC con Kalman Filter vs machine learning
- analisi dati per misurare le higgs self-coupling alla soglia di produzione HZ
- analisi dati per misurare le higgs self-coupling per FCC-hh

Beam test plans

We intend to perform test beams with simple drift tubes set-up to compare simulations results with experimental results:

- @CERN with muons with momentum in the range 30-180 GeV
- @Fermilab with muons with momentum in the range 3-20 GeV

1. Establish the **limiting parameters** for an efficient cluster counting:
   - cluster density (by changing the gas mixture)
   - space charge (by changing gas gain, sense wire diameter, track angle)
   - gas gain saturation

2. In optimal configuration, **measure the relativistic rise as a function of βγ**, both in **dE/dx** and in **dN_{cl}/dx**, by scanning the muon momentum from the lowest to the highest value (from a few GeV/c to about 180 GeV/c at CERN/H8).

3. Use the experimental results to fine tune the predictions on performance of **cluster counting** for **flavor physics** and for **jet flavor tagging** both in **DELPHES** and in **full simulation**

Anagrafica e richieste 2023

Anagrafica RD_FCC/Eurizon 2023

INFN- Bari	2023
N. De Filippis (Assoc. Prof.)	30%
M. Abbrescia (Assoc. Prof.)	20%
R. Aly (Ass. Ricerca + PJAS)	50%
M. Louka (PhD)	30%
B. D'Anzi (PhD)	30%
W. Elmetenawee (Ass. Ricerca)	30%
M. Maggi (ricerc. INFN)	10%
D. Diacono (Tecn. INFN)	10%
G. Donvito (Tecn. INFN)	5%
V. Spinoso (Tecn. INFN)	15%
I. Marjeka (Ass. Ricerca)	10%
TOT	**2.4 FTE**

Anagrafica RD_FCC/Eurizon 2023

INFN- Bari	Sigle sinergiche	RD_FCC	Eurizon	AIDA INNOVA
N. De Filippis (Assoc. Prof.)	30%	25%	--	5%
M. Abbrescia (Assoc. Prof.)	20%	20%	--	
R. Aly (Ass. Ric.)	50%	50%		
I. Margjeka (PhD)	10%	10%	--	
M. Louka (PHD)	30%	30%		
B. D'Anzi (PhD)	30%	30%		
W. Elmetenawee (Ass. Ricerca)	30%		30%	
M. Maggi (1+ ricerc. INFN)	10%	--	10%	
D. Diacono (Tecn. INFN)	10%	10%		
G. Donvito (Tecn. INFN)	5%	5%		
V. Spinoso (Tecn. INFN)	15%	15%		
TOT	**2,4 FTE**	**1.95 FTE**	**0,4 FTE**	**0,05 FTE**

In contatto con:

- **C. Pastore (OM)**
- **M. Mongelli (SPM)**

per servizi di officina meccanica e progettazione meccanica

Richieste per personale (AdR) e servizi

- **Richesta di un assegno di ricerca Junior per un anno per FCC**
- **Richiesta di servizio di officina meccanica (1 m.u) e progettazione meccanica (1 m.u) per realizzazione di componenti per vari prototipi di camera a a drift**
- **In contatto con:**
  - **C. Pastore (OM)**
  - **M. Mongelli (SPM)**

Richieste finanziarie per RD_FCC 2023

Consumi/Inventariabile:

- strumentazione per tubi a drift:
  - Aluminium wire (1000 m) - 1000 k€
  - Tungsten wires (1000 m) – 1000 k€
  - Feedthrough - 500 €
  - cap for drift tubes 500 €
  - Crimper machine 1000€
- **RICHESTA: 4** k€

Missioni: meetings/workshops/testbeams

- missioni: 13k€
- responsabilità: 2k€

RICHIESTA: 15k€