

Futuri acceleratori: attività nella sezione INFN-Bari e richieste finanziarie per 2022



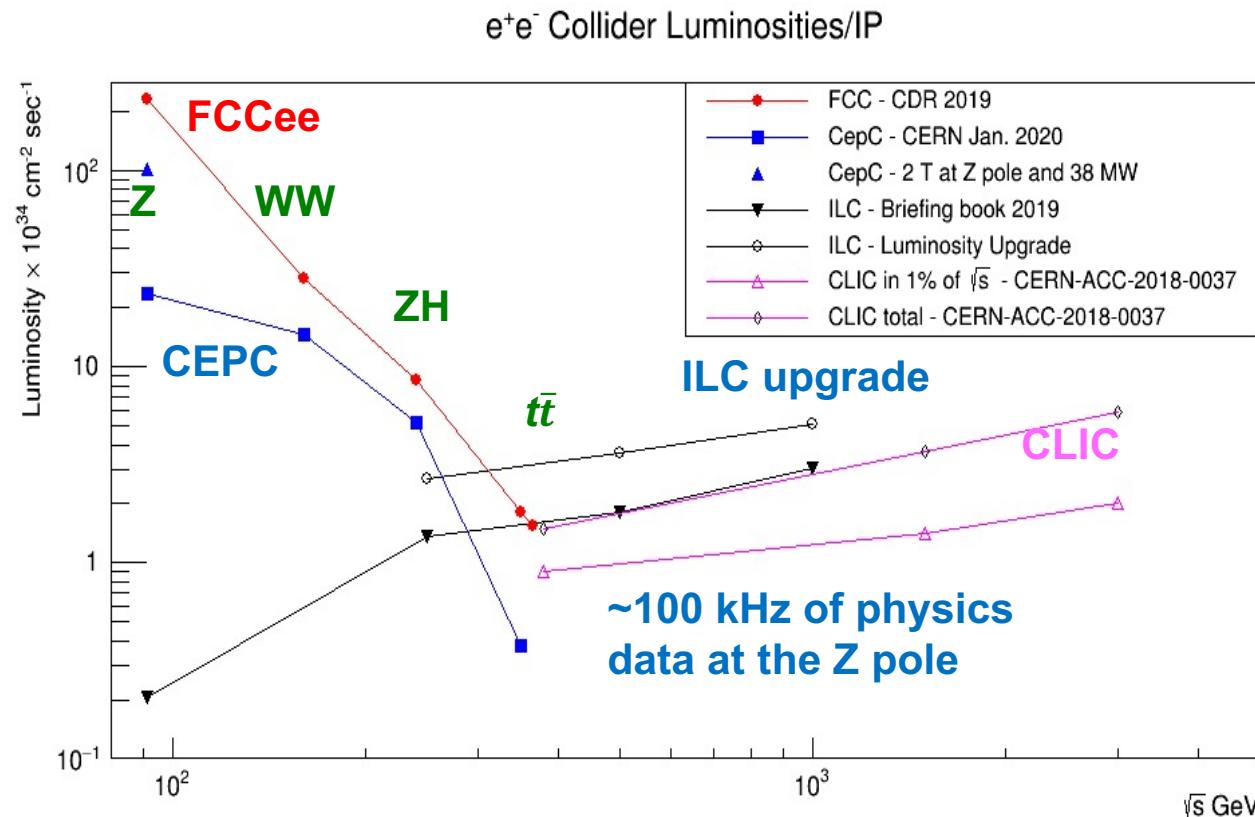
N. De Filippis
Politecnico/INFN Bari
(per gruppo RD_FCC)



in sinergia con **INFN Lecce** e **Università del Salento**

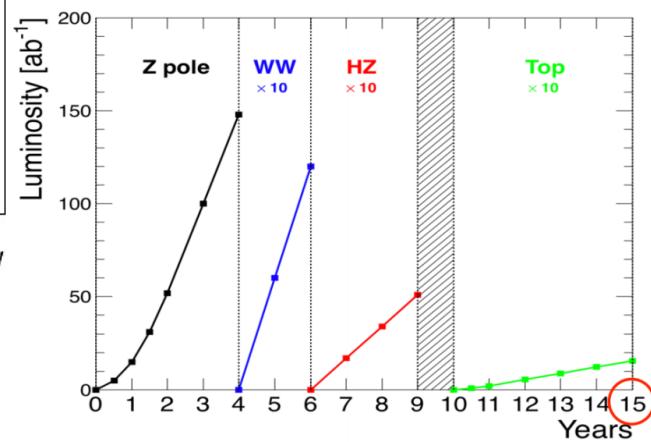
Bari
Luglio 2021

Machine luminosity for physics at e^+e^- colliders



- Flavor factory:
 - $5 \times 10^{12} e^+e^- \rightarrow bb, cc$
 - $10^{11} e^+e^- \rightarrow \tau^+\tau^-$
- Potential discovery of NP

- Higgs factory:
 - $10^6 e^+e^- \rightarrow ZZ$
- EW & Top factory:
 - $3 \times 10^{12} e^+e^- \rightarrow Z$
 - $10^8 e^+e^- \rightarrow W^+W^-$
 - $10^6 e^+e^- \rightarrow t\bar{t}$



FCC week in corso questa settimana

FCC-ee/CepC motivation

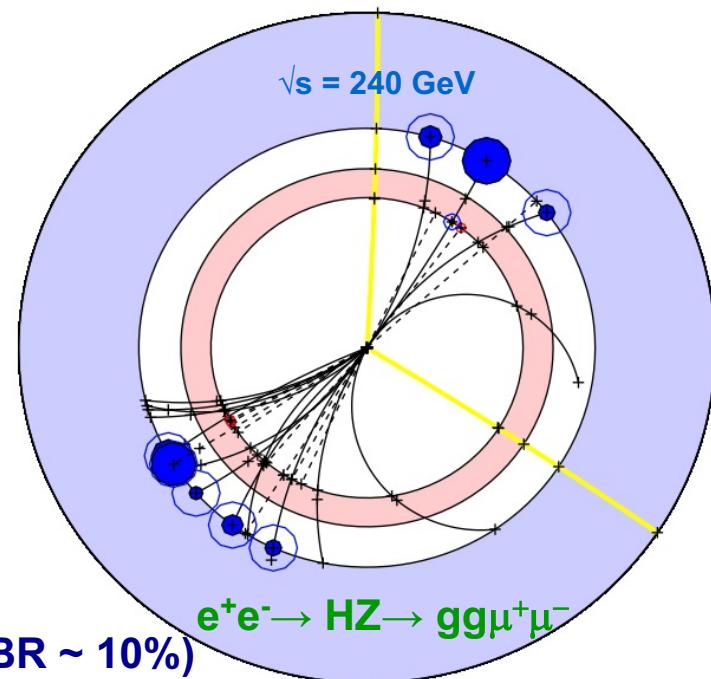
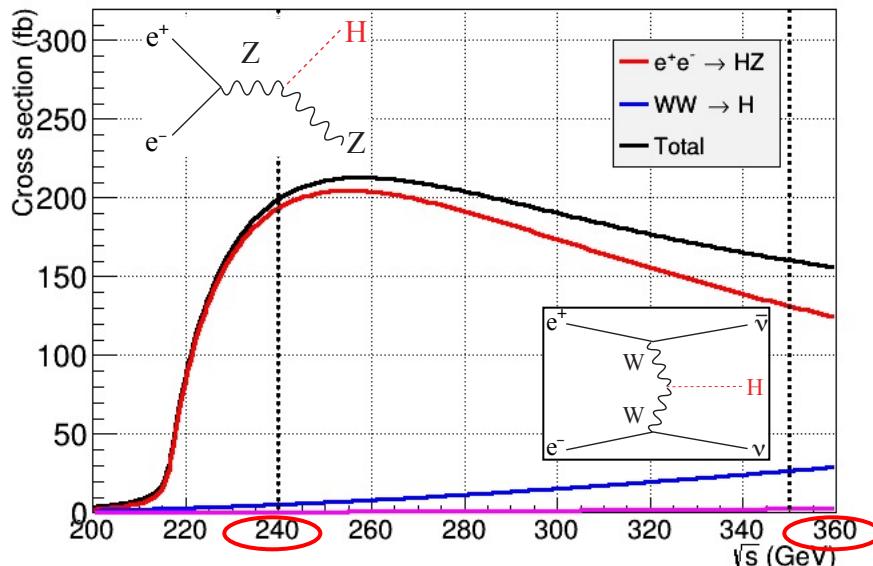
e) There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision and whose energy can be

FCC-ee/CepC: focus on a 90-250 GeV e^+e^- machine (100 km circumf.)

5 ab⁻¹ integrated luminosity to two detectors over 10 years → 10⁶ clean Higgs events

→ FCC-ee/CEPC measure the Higgs boson production cross sections and most of its properties with precisions far beyond achievable at the LHC

◆ Higgs-strahlung ($m_H = 125$ GeV)



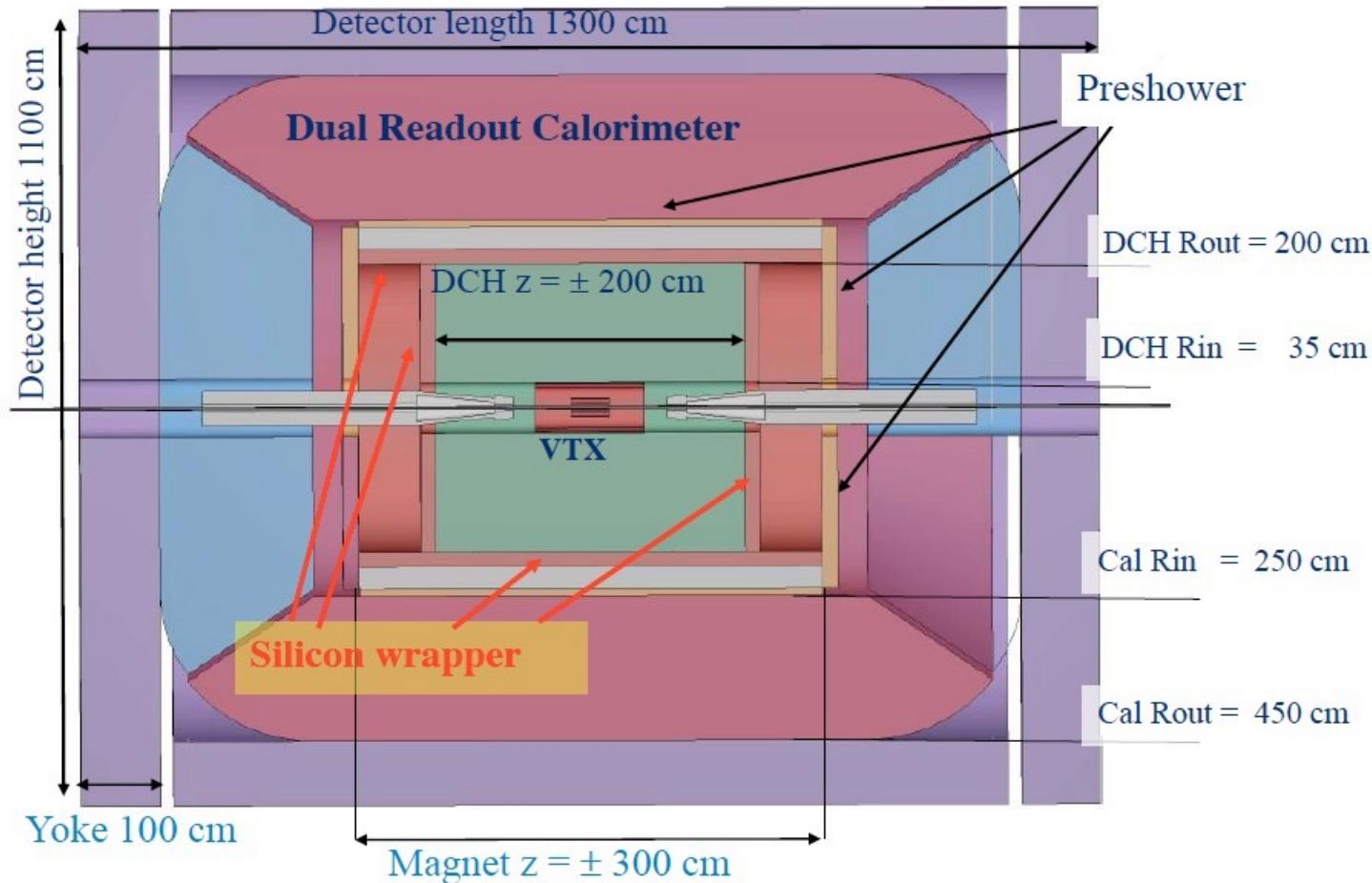
◆ The gluon can be studied with Higgs decays (BR ~ 10%)

The IDEA experiment at FCC-ee/CepC

**IDEA: proposta di
esperimento INFN**

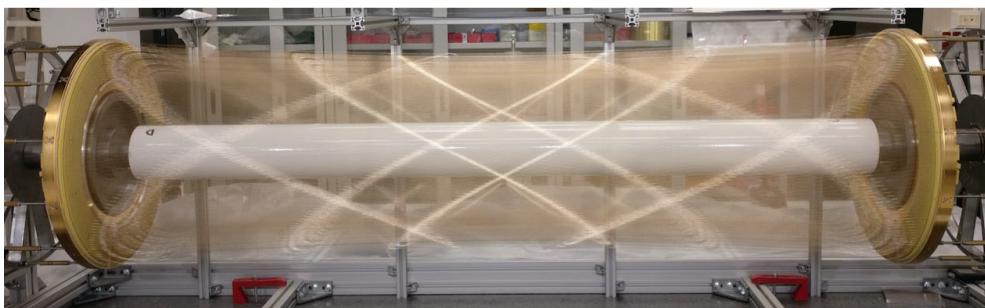
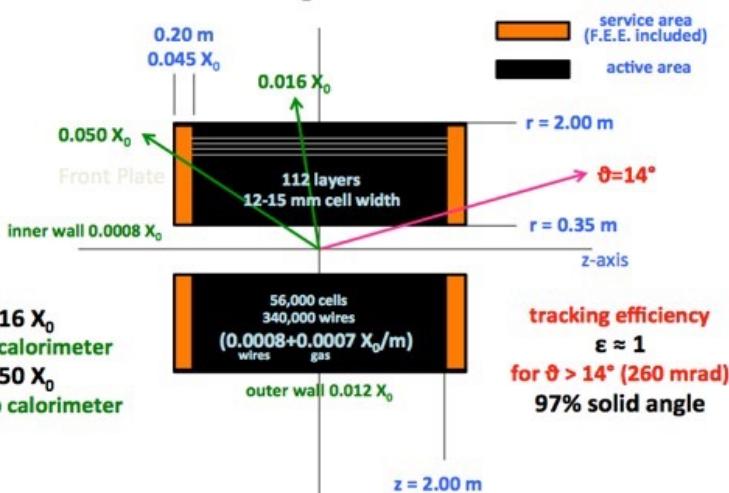
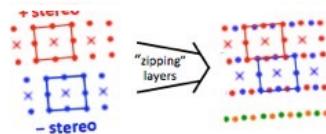
FCC-ee at CERN

CEPC at IHEP-China

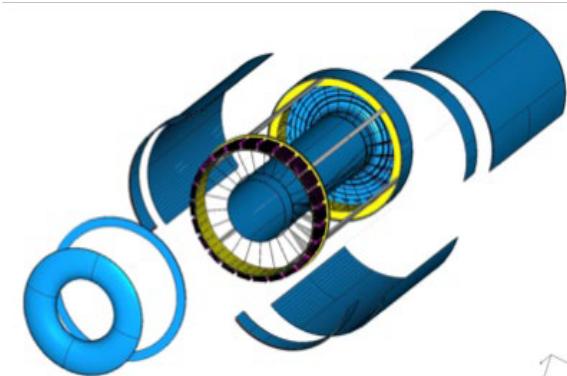


Design guideline: the Drift Chamber

Drift Chamber



sense wires:	20 mm diameter W(Au) =>	56448 wires
field wires:	40 mm diameter Al(Ag) =>	229056 wires
f. and g. wires:	50 mm diameter Al(Ag) =>	58464 wires
	343968 wires in total	



New concept of construction allows to reduce material to $\approx 10^{-3} X_0$ for the barrel and to a few $\times 10^{-2} X_0$ for the end-plates.

The wire net created by the combination of + and - orientation generates a more uniform equipotential surface

- High wire number requires a non standard wiring procedure and needs a feed-through-less wiring system.
- A novel wiring procedure developed for the construction of the ultra-light MEG-II drift chamber

Attività svolta da INFN Bari nel 2020-2021

Attività

La partecipazione alle attività relative alla progettazione, simulazione e costruzione della camera a deriva per IDEA (FCC-ee/CepC/SCT) ha richiesto numerosi passi:

- test e caratterizzazione di una camera di monitoraggio della velocità di deriva
 - simulazione della camera
 - misure della v drift in laboratorio (da fare)
- simulazione della camera a drift con Geant4 ed integrazione in IDEA
- studi di PID: tecnica di “cluster counting”
- contributo alla progettazione meccanica per nuovo prototipo per SCT →IDEA
- realizzazione di un laboratorio per studi su prototipi di camera a deriva
 - In corso completamente line del gas/sistema di distribuzione
 - In corso ordini per strumentazione

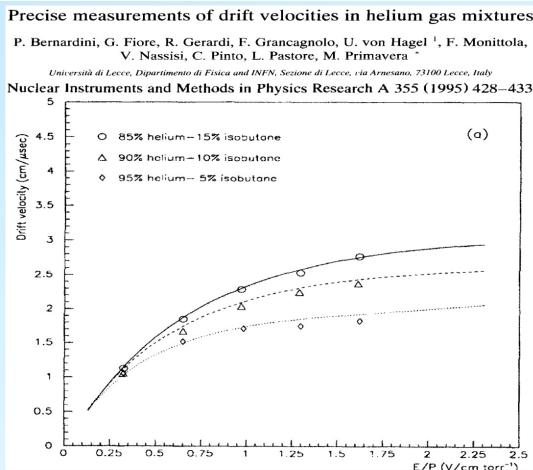
Camera di monitoraggio della velocità di drift

Motivazioni:

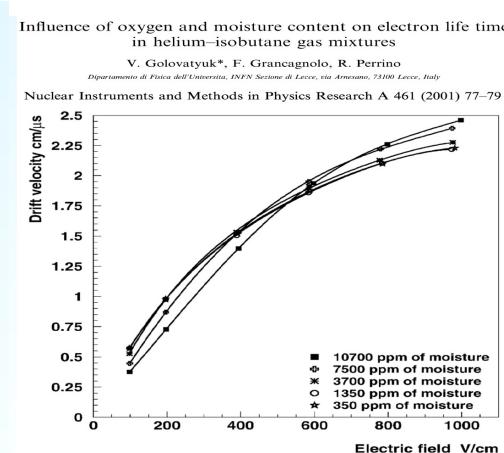
Variazioni dell'ordine del percento della velocità di drift incidono, su una distanza di drift di 5 mm, con un non trascurabile contributo di 50 µm alla risoluzione spaziale.

E' necessario:

- monitorare tutti i parametri (campo elettrico, miscela di gas, pressione, vapori d'acqua) che possono indurre variazioni di velocità di drift al livello di qualche per-mille
- test in letteratura dimostrano che un continuo monitoraggio della velocità di drift al livello del $\pm 1 \times 10^{-3}$ in tempi dell'ordine di poche decine di secondi consente di apprezzare:
 - variazioni di campo elettrico di 2V/cm;
 - variazioni relative di contenuto di isobutano del 4.3×10^{-3} ;
 - variazioni della pressione della miscela di 0.8 mbar;
 - **variazioni nel contenuto di vapore acqueo del 150 ppm** .



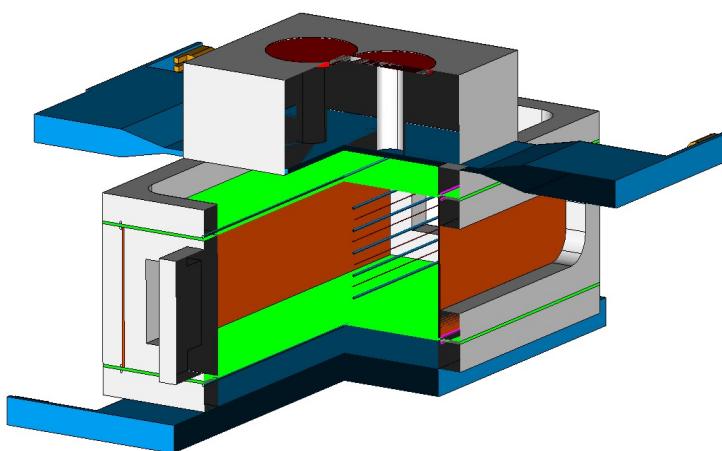
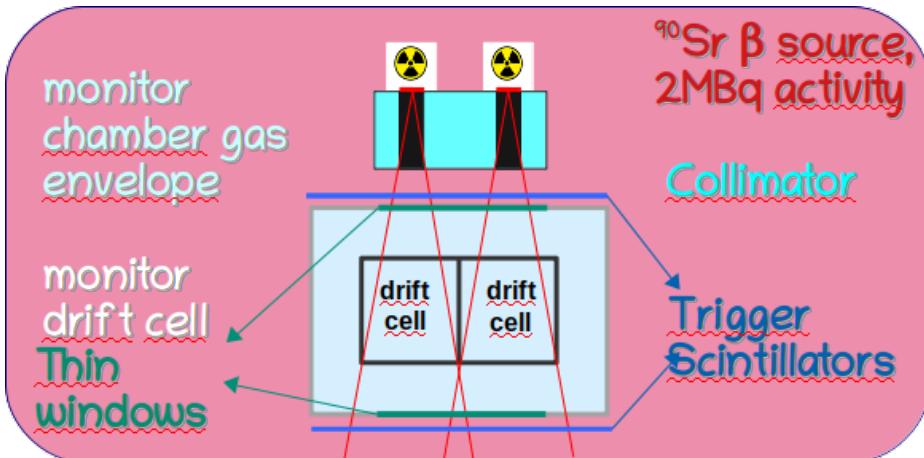
For a 90/10 mixture, at normal pressure, variations of the electric field, around the operating value of 1 V/cm/torr, of about 2 V/cm induce drift velocity variations of 1×10^{-3} .



To mitigate the ageing effect, sometimes it is useful to introduce small quantities of water vapors in the gas mixtures, but it is important to control the consequent variations of drift velocity.

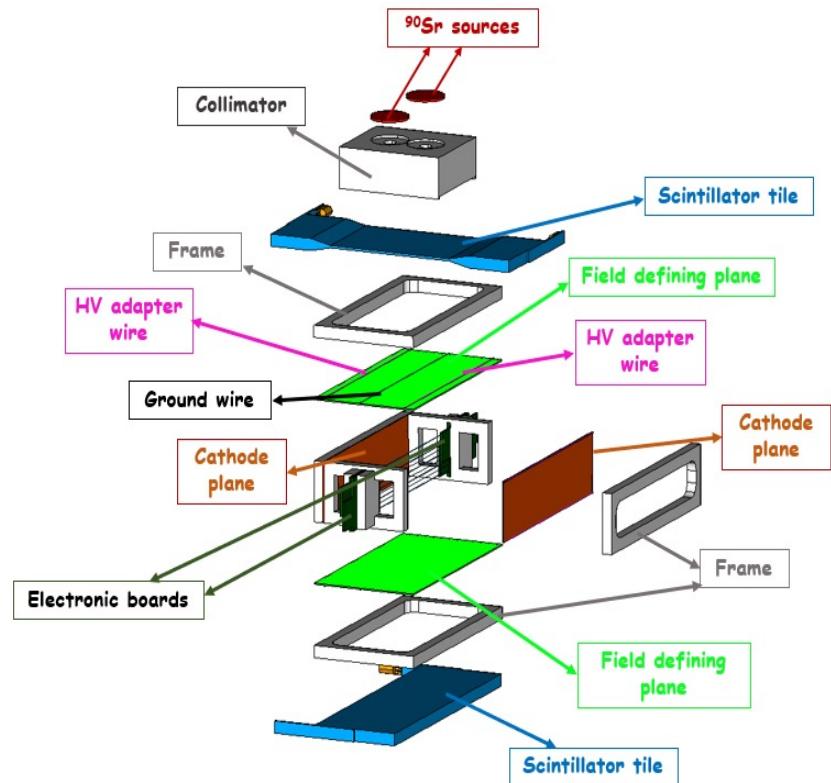
E.g. at the operating value of the electric field of about 1 V/cm/torr, variations of ≈ 150 ppm leads to an increase of 10^{-3} in drift velocity.

Camera di monitoraggio della velocità di deriva



- Struttura meccanica realizzata, scheda di elettronica pronta
- Filatura della camera in corso a INFN Lecce
 - presto a Bari

Struttura della camera



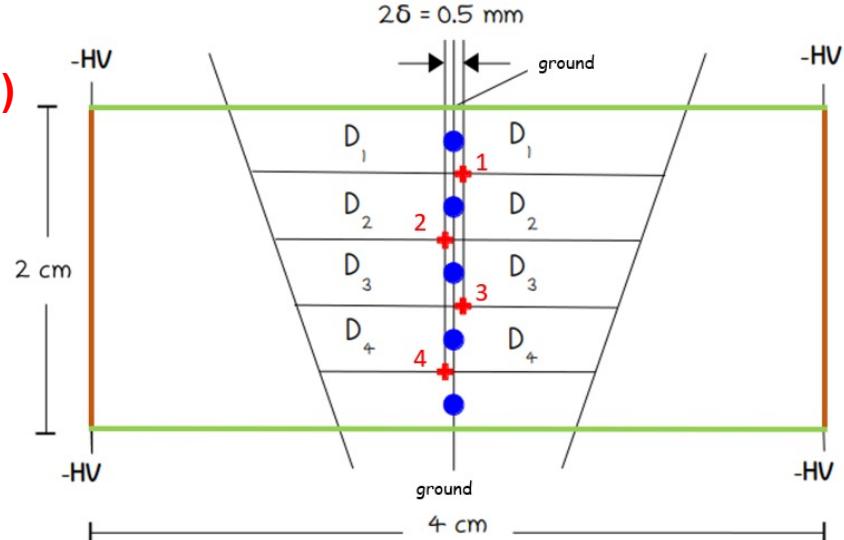
Dark box
realizzata a Bari

Camera di monitoraggio della velocità di deriva

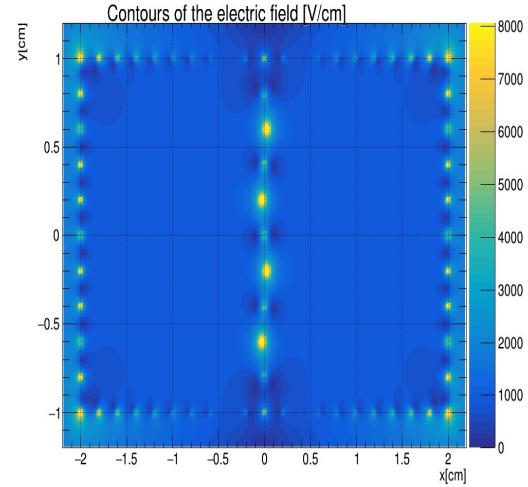
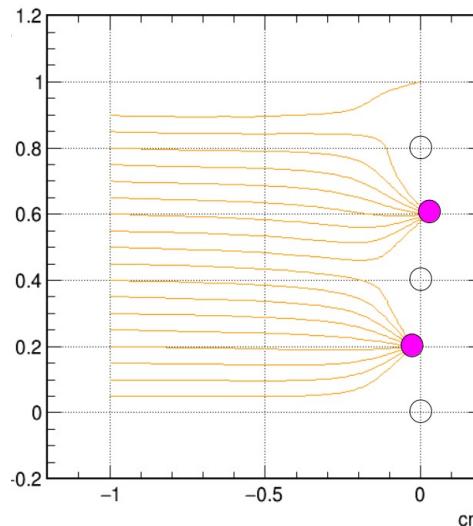
Cuna (Lecce), Margjeka (Bari)

Simulazione della camera:

- Simulation program Garfield++ (v. 2017)
- Simulation different gas-mixtures
- Simulation of electric field configuration and
- Tracks through the chamber
- Simulation of the measurement
- Scope: to determine the optimized value for V_s and V_g to ensure a high and uniform electric field in the two drift cells.



Electric field configuration with
 $V_g = -350V$, $V_s = 925V$



PREPARED FOR SUBMISSION TO JINST

INTERNATIONAL CONFERENCE ON INSTRUMENTATION FOR COLLIDING BEAM PHYSICS

24 - 28 FEBRUARY, 2020

BUDKER INSTITUTE OF NUCLEAR PHYSICS, NOVOSIBIRSK, RUSSIA

A 10^{-3} drift velocity monitoring chamber

F. Cuna ^{a,b,1}, G. Chiarello^d, A. Corvaglia^a, N. De Filippis^{c,f}, F. Grancagnolo^a, M. Manta^b, I. Margjeka^{c,c}, A. Miccoli^a, M. Panareo^{a,b}, G. F. Tassielli^{a,1}

^aIstituto Nazionale di Fisica Nucleare, Lecce, Italy

^bUniversità del Salento, Italy

^cUniversità degli Studi di Bari, "Aldo Moro", Italy

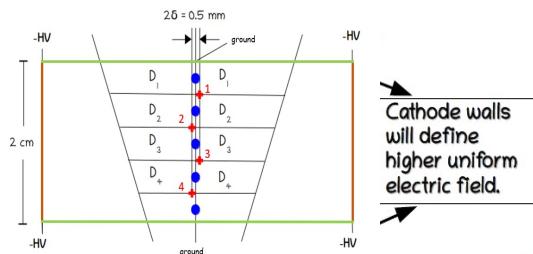
^dIstituto Nazionale di Fisica Nucleare, Roma, Italy

^eIstituto Nazionale di Fisica Nucleare, Bari, Italy

^fPolitechnico di Bari

Camera di monitoraggio della velocità di deriva

Principio della misura



Drift velocity can be measured using the shift on wire positions, starting by time relations:

$$t_2 = \frac{t_1 + t_3}{2} \pm \frac{2\delta}{v_d}$$

Subtracting $t_3 - t_2$

$$t_3 = \frac{t_2 + t_4}{2} \pm \frac{2\delta}{v_d}$$

Sense wires are staggered in the planes $x = \pm\delta$ to allow drift velocity measurements.

$$v_d = \frac{16\delta}{\Delta\Theta} \quad \sigma_{v_d} = \sqrt{\left(\frac{16}{\Delta\Theta}\right)^2 \sigma_\delta^2 + \left(\frac{-16\delta}{\Delta\Theta^2}\right) \sigma_{\Delta\Theta}^2}$$

For tracks on left side
 $\Theta = +8\delta/v_d$
 For tracks on right side
 $\Theta = -8\delta/v_d$

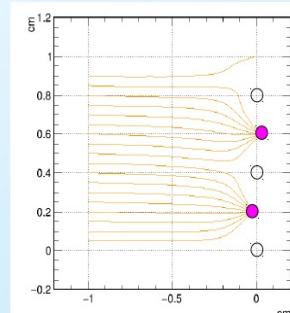
- Θ will have double gaussian distribution.
- The distance between the two peaks is related to drift velocity

Simulation results for electric field

We made simulations using Garfield++. First step was the optimization of electric field inside the two drift cells. We fixed the voltage on cathode plane at -2000V and varied the voltage on field wires from 0V to -800 V and on the sense wires from 0 V to 1200 V.

The optimized values are:

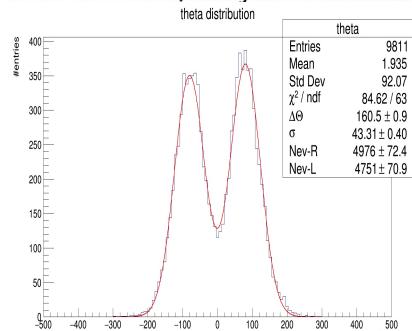
- 925 V for sense wires
- -350 V for field wires



Simulation results for electron tracks

We simulated 2000 tracks on left side and 2000 on the right side.

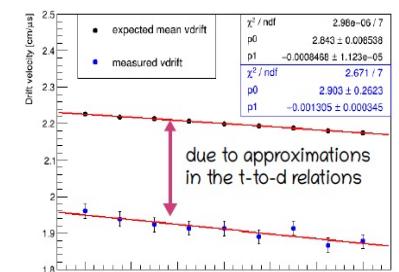
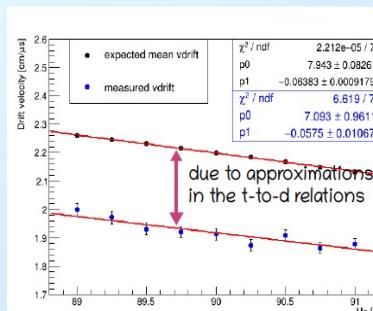
After ionization, every electron from cluster drifted to the sense wire. Saving drift times and total charges produced, we obtained the double peak distribution.



$$\Delta\Theta = (209.1 \pm 2.2) \text{ ns} \quad v_d = (1.91 \pm 0.02) \text{ cm}/\mu\text{s}$$

An increment in the number of event of a factor of 100 increases the sensibility at 10^{-3} level.

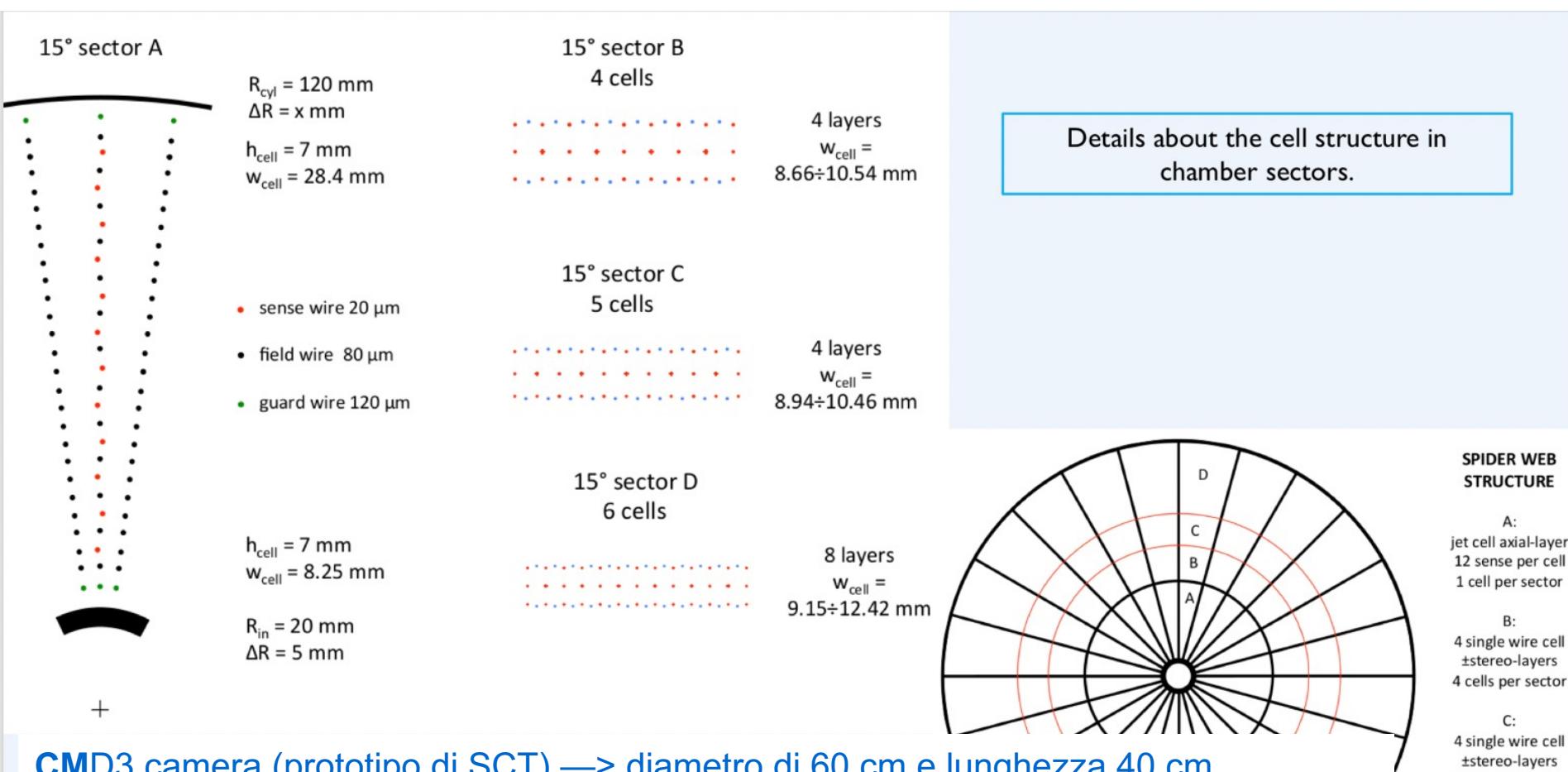
The number of tracks necessary to obtain this sensibility is 4×10^5 and it will be obtained with the radioactive source and the experimental set-up chosen.



due to approximations in the t-to-d relations

due to approximations in the t-to-d relations

Progettazione meccanica camera a deriva per SCT



CMD3 camera (prototipo di SCT) —> diametro di 60 cm e lunghezza 40 cm

camera di SCT—> diametro 1 m e lunghezza fra 1.5 e 2 m (intermedia)

Ottimizzazione del progetto meccanico (A. Miccoli e F. Cuna (Lecce) in contatto con C. Pastore, M. Mongelli)

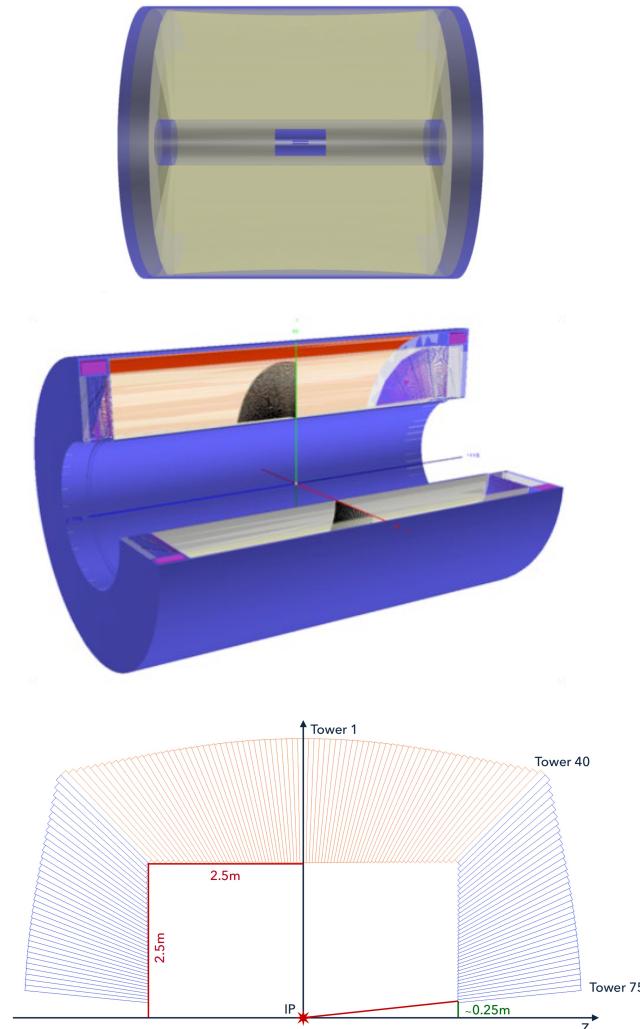
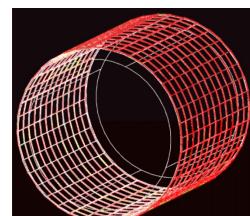
Gruppo Ingegneri Meccanici, Politecnico di Bari interessati alle simulazioni ad elementi finiti con ANSYS → Prof. C. Pappalettere, Prof. C. Casavola, C. Barile (RTDB)

Geant4 full simulation of IDEA

A full standalone geant4 simulation of the **IDEA Silicon Vertex (and Si wrapper), DriftChamber, DR Calorimeter (and Muon)**

- The **DCH** is simulated at a good level of geometry details, including detailed description of the endcaps; hit creation and track reconstruction code available
- **SVX** and **Si wrapper** are simulated as simple layer or overall equivalent material
- **Dual readout** calorimenter simulated with geant4 too
 - Towers are trapezoidal physical volumes with slightly different shapes changing with θ .
 - Fibers are 1mm diameter tubes, 0.5 mm of absorber material (copper) between two adjacent
 - \rightarrow 130 milion fiber for the whole IDEA detector
- **Muon detector**

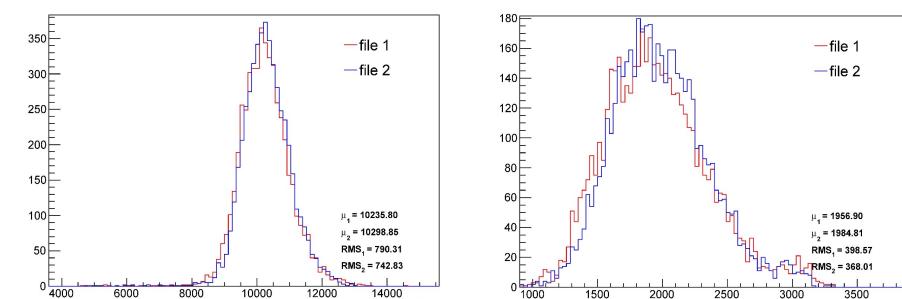
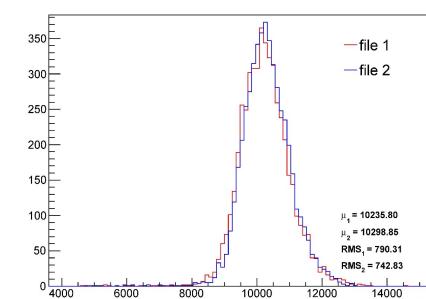
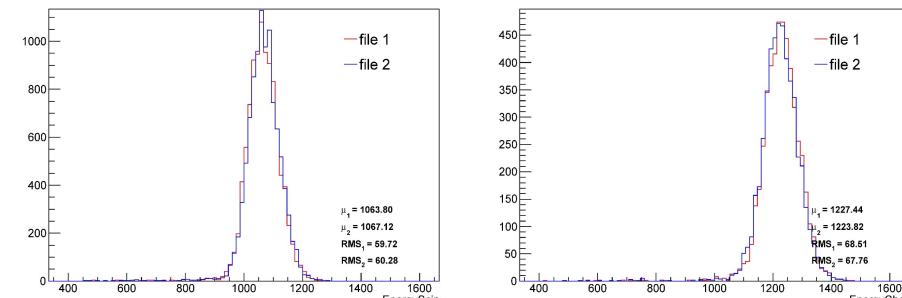
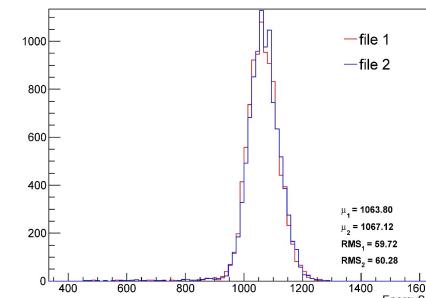
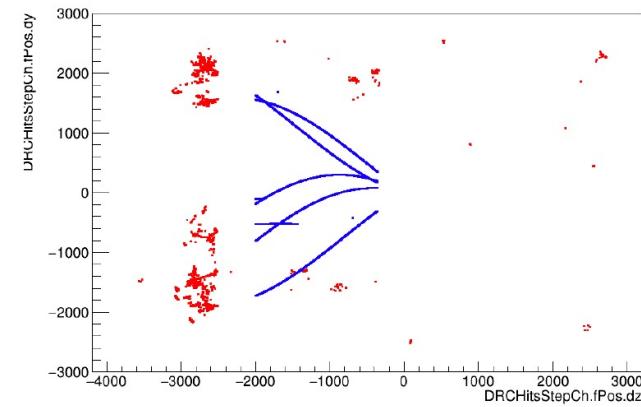
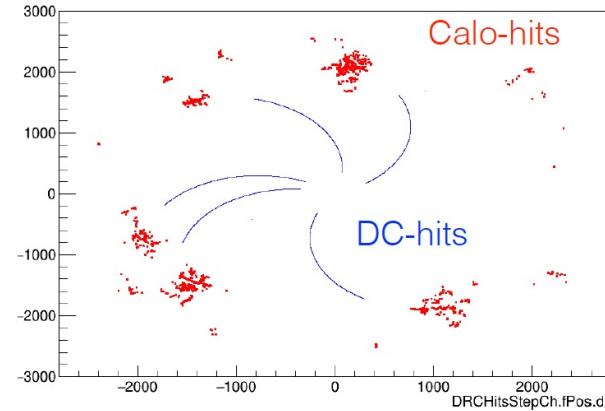
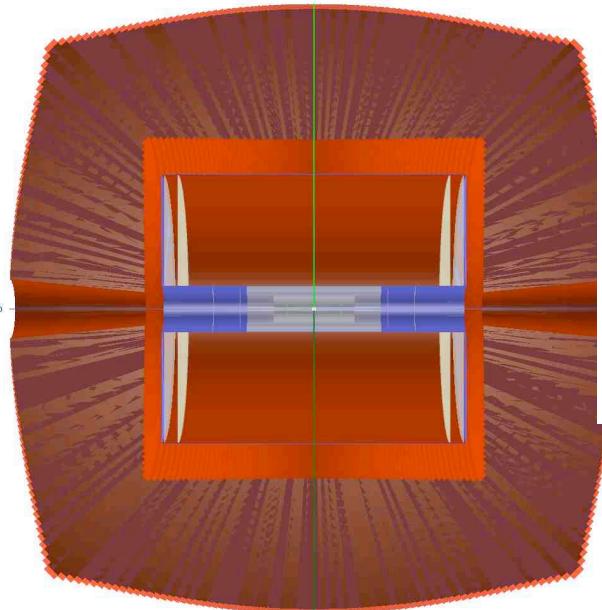
Integration of all the detectors on going



Geant4 full simulation of IDEA

W. Elmetenawee, N. De Filippis

The full simulation for the IDEA detector (for the moment not yet in the FCC framework).

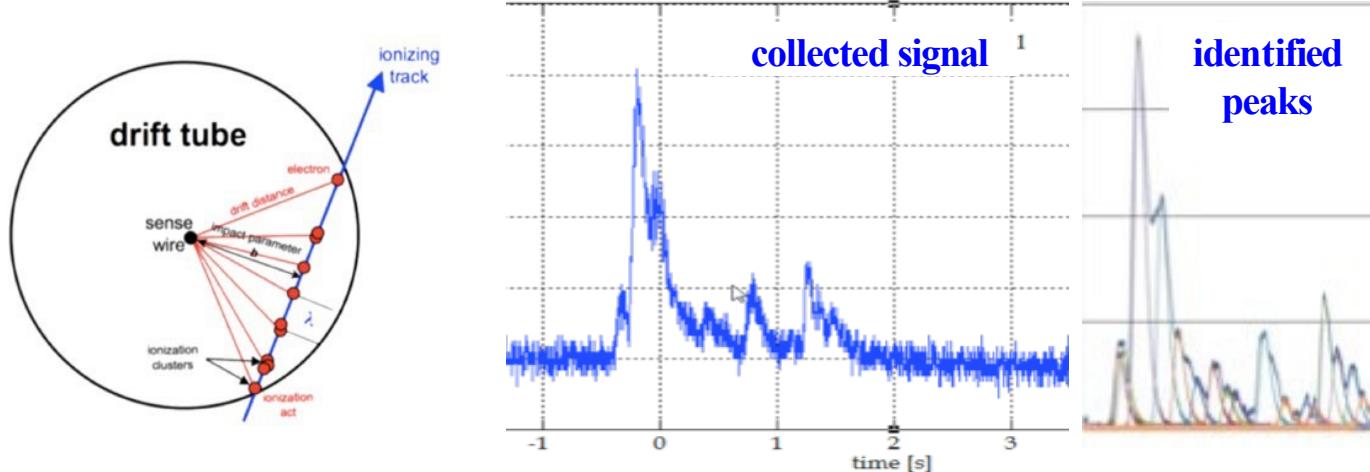


Comparison of Calorimeter energies
between integrated simulation and the
proper calorimeter simulation

Cluster Counting/Timing and P.Id. principles

Principle: In He based gas mixtures the signals from each ionization act can be spread in time to few ns. With the help of a **fast** read-out electronics they can be identified efficiently.

- By counting the number of ionization acts per unit length (dN/dx), it is possible to identify the particles (P.Id.) with a **better resolution** w.r.t the dE/dx method.



- record the time of arrival of electrons generated in every ionisation cluster ($\approx 12\text{cm}^{-1}$)
- reconstruct the trajectory at the most likely position

The cluster counting is based on replacing the measurement of an **ANALOG** information (the [truncated] mean dE/dX) with a **DIGITAL** one, the number of ionisation clusters per unit length:

$$dE/dx$$

Truncated mean cut (70-80%) reduces the amount of collected information. $n = 112$ and a 2m track at 1 atm give $\sigma \approx 4.3\%$

$$dN_c/dx$$

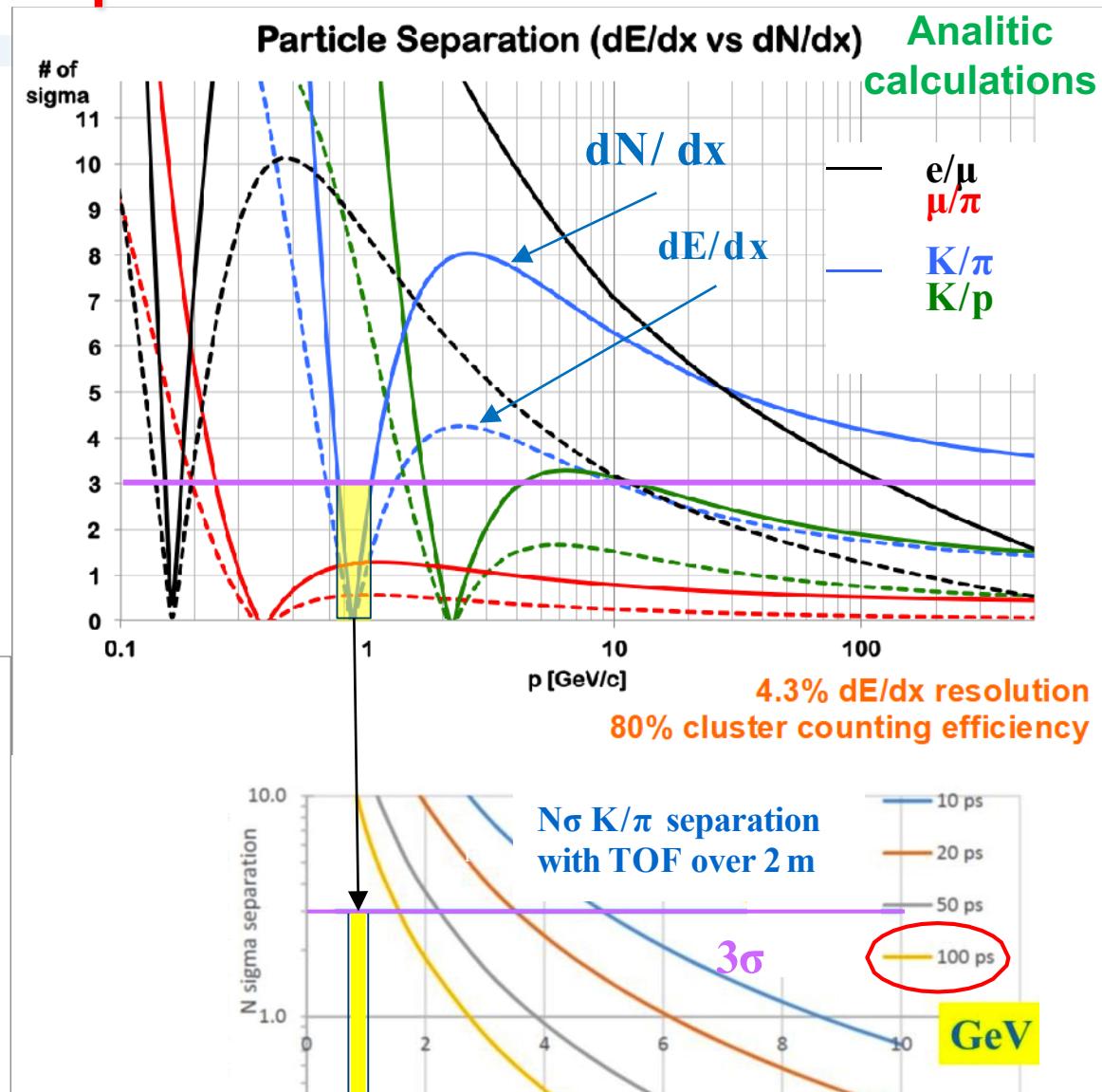
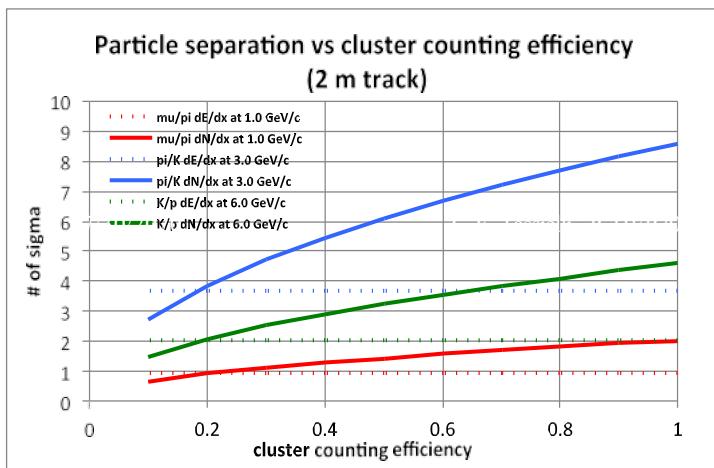
$\delta_d = 12.5/\text{cm}$ for $\text{He/iC}_4\text{H}_{10}=90/10$ and a 2m track give $\sigma \approx 2.0\%$

→ could improve also the **spatial resolution**

Design guidelines: particle identification

Cluster Counting/Timing in DCH for good P.Id. performance

- Expected excellent K/ π separation over the entire range except $0.85 < p < 1.05$ GeV (blue lines)
- Could recover with timing layer



Partecipazione di INFN Bari a progetti

Progetti internazionali e nazionali

call H2020-MSCA-RISE-2019: progetto "FEST" iniziato

“Future Experiments seek Smart Technologies (FEST)”

- bloccato per il COVID-19
- riprenderà a fine anno

call H2020-INFRASUPP-2018-2020 progetto "CREMLIN+" al 2° anno

“Connecting Russian and European Measures for Large-scale Research infrastructure”

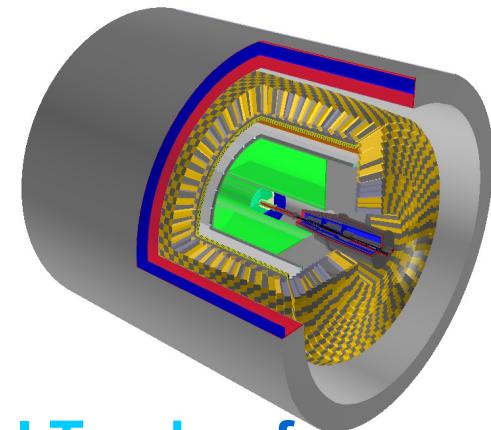
- “Development and design of Particle Identification and tracking systems” per la SCT
 - 6 mesi di ritardo per COVID-19

call AIDAinnova: iniziata

- “Cluster Counting/Timing: data reduction and pre-processing of drift chamber signals sampled at high rates” finanziato per INFN Lecce

Task 5.3 Development of software for the design of an SCT detector

- SCT detector software framework AURORA
 - <https://git.inp.nsk.su/sctau/aurora>
- Synergy with the Key4HEP (turnkey software) initiative
 - <https://github.com/key4hep>
- Work in progress for
 - Event generators, Detector geometry description, Reconstruction algorithms, Event selection tools



Task 5.5 Development and design of Central Tracker for the SCT detector

- An ultra-low mass Tracking Chamber with Particle Identification capabilities (TraPlId) concept (INFN Lecce and Bari)
 - Low material
 - Improved identification with cluster counting
 - Synergy with MEG2 DC and the IDEA DC project for FCC-ee and CEPC
 - New drift chamber for the CMD3 experiment as a prototype for the SCT central tracker

*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*

→ Deliverables early next year

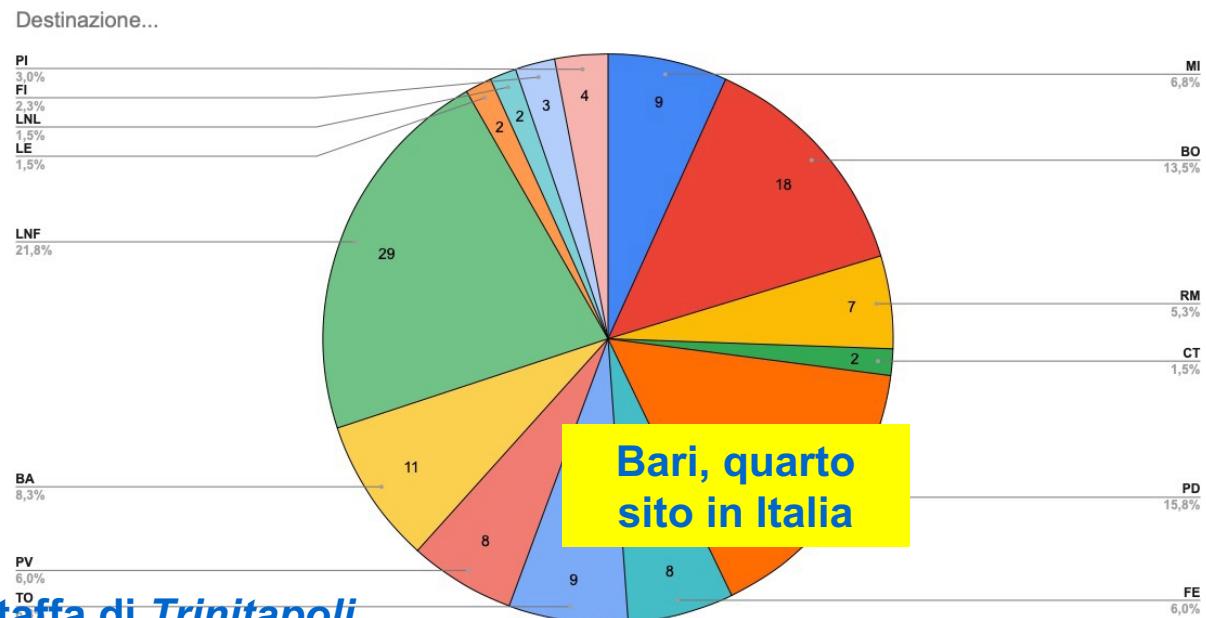
Partecipazione a progetti

Progetto di outreach per Call PhysicsInvolvingPeople "What Next? Il futuro spiegato ai giovani" – iniziato

- Da Bari: N. De Filippis, M. Abbrescia, L. Silvestris, G. Iaselli
- organizzazione, attraverso il coinvolgimento di studenti dell'ultimo anno delle scuole superiori, di una giornata evento di divulgazione scientifica in cui gli studenti parteciperanno alla creazione di un cortometraggio che verrà proiettato durante gli eventi finali rivolti a tutta la cittadinanza e che saranno resi disponibili su varie piattaforme web.
- **prima fase iniziata conclusa , partenza delle seconde fasi**



Logo realizzato da:
M. Abbrescia,
Prof. Bufo IIS "Dell'Aquila-Staffa di Trinitapoli"



Proposta PRIN 2020 - RAZOR

Acronym: RAZOR - physics@teRA-Z cOllideR.

Study of the Z-boson couplings to heavy fermions at the Future Circular electron - positron Collider:trillions of Z's for extreme precision to challenge the Standard Model while looking for new physics

- focus of RAZOR is to pave the way to reproduce and improve the measurement of the heavy (b- and c-) quark forward-backward asymmetries and the tau-polarisation, possible only with this huge Z data set
- The tau polarization is measured from so-called optimal observables defined from the decay productskinematics or using neural networks

Bari POLIBA+Milano unit will carry the activities for:

- *WP2: Tau polarization and lepton couplings*

Bari POLIBA unit responsible for:

- *WP4: Particle Identification*
- *WP5: MonteCarlo simulation, software and computing*

Attività per il 2022

Strategia delle attività

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

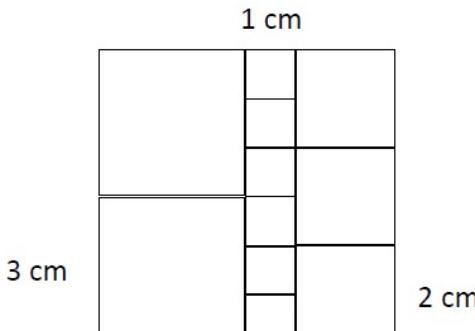
- Test of drift tubes and multi-wire drift chambers prototypes in the local laboratory assigned to us and in test beam areas ← “cluster counting technique”
- Simulazione della camera di monitoring a dei prototipi di camera a drift ed integrazione con gli sottorivelatori in Geant4 → Key4HEP
- Finalizzazione della progettazione meccanica per il prototipo di camera a deriva per SCT (con l'aiuto degli ingegneri POLIBA) → IDEA
- studi su algoritmi di tracciamento sia per IDEA che per CMD3 (task 5.3 di CREMLIN+, con l'uso di strumenti di machine learning)
- Analisi dati per misurare le asimmetrie backward/forward e la polarizzazione del τ al picco della Z → attività PRIN 2020
- Analisi dati per misurare le higgs self-coupling alla soglia di produzione HZ

Test beam with drift tubes to validate the “cluster counting technique”

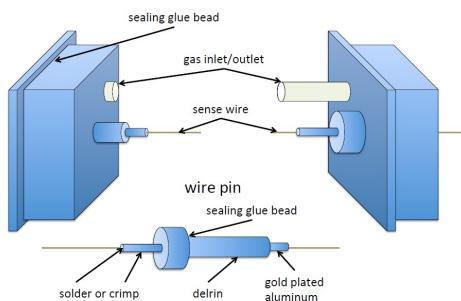
Responsible: N. De Filippis

Under evaluation: join a test beam with simple drift tubes early next year

We intend to perform a test beam with simple drift tubes set-up to compare simulations results with experimental results: 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/iC₄H₁₀)
- Gas mixture scan at fixed p beam and HV:
 - 90:10 He/iC₄H₁₀
 - 85:15 He/iC₄H₁₀
 - 80:20 He/iC₄H₁₀
- 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

Development of the mechanical design for CMD3 drift chamber for the SCT factory

The mechanical design for CMD3 drift chamber has been developed trying 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 $\approx 10^\circ$
- 240 N at $\approx 14^\circ$
- 200 N at $\approx 21^\circ$

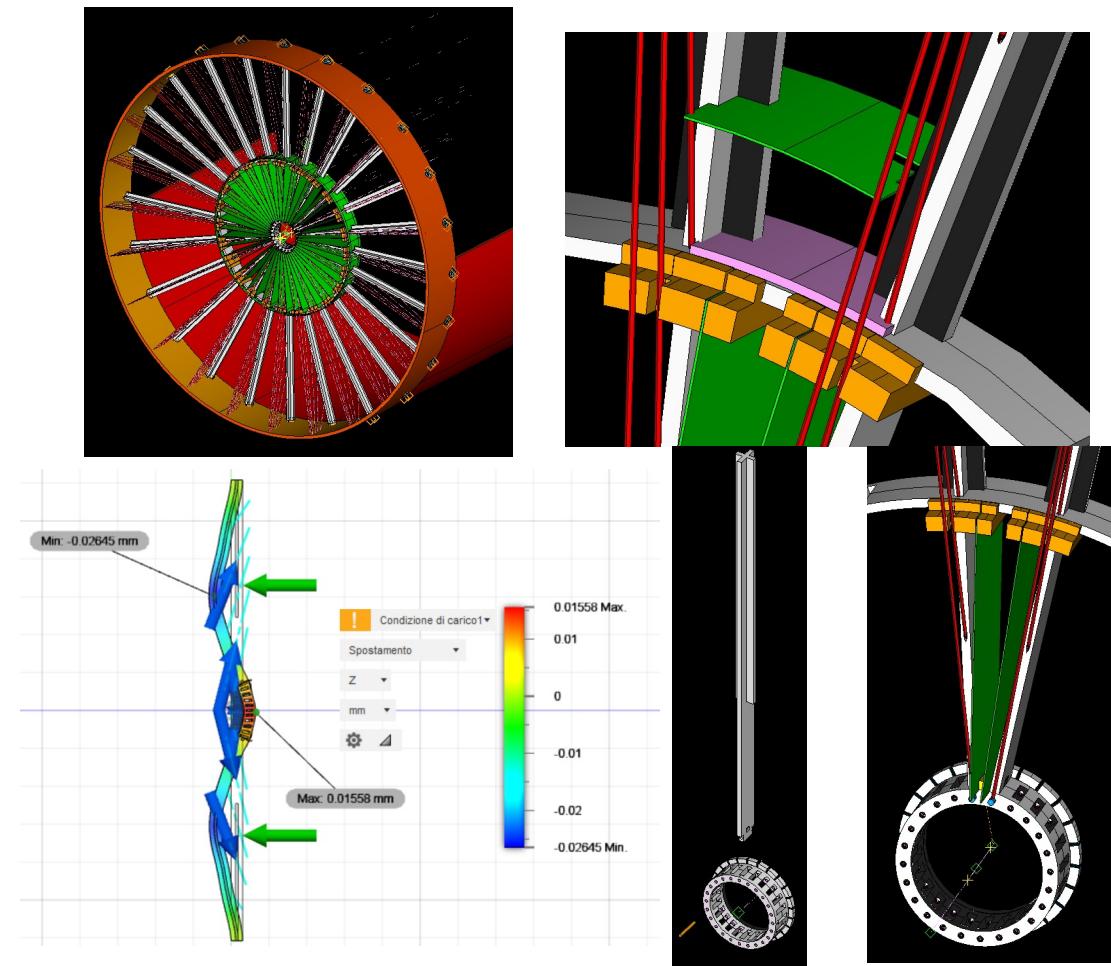
max deflection obtained $< \pm 25 \mu\text{m}$

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



contributo con gli Ingegneri Meccanici, Politecnico di Bari interessati alle simulazioni ad elementi finiti con ANSYS → Prof. C. Pappalettere, Prof. C. Casavola, C. Barile (RTDB)

Anagrafica e richieste 2022

Anagrafica RD_FCC/CREMLIN+ 2022

INFN- Bari	2021
N. De Filippis (Assoc. Prof.)	30%
M. Abbrescia (Assoc. Prof.)	15%
R. Aly (Ass. Ricerca)	30%
G. Tassielli (RTDA)	10%
I. Margjeka (PhD)	30%
D. Paesani (PhD)	10%
W. Elmetenawee (PhD)	30%
M. Maggi (ricerc. INFN)	10%
D. Diacono (Tecn. INFN)	10%
G. Donvito (Tecn. INFN)	5%
V. Spinoso (Tecn. INFN)	15%
TOT	1.95 FTE

PRELIMINARY

F. De Fazio. and P. Colangelo disponibili ed interessati a interagire sulla elaborazione del programma di fisica, ma senza nessuna percentuale.

Anagrafica RD_FCC/CREMLIN+ 2022

INFN- Bari	Sigle sinergiche	RD_FCC	CREMLIN+	AIDA INNOVA
N. De Filippis (Assoc. Prof.)	30%	25%	--	5%
M. Abbrescia (Assoc. Prof.)	15%	15%	--	
R. Aly (Ass. Ric.)	30%	30%		
G. Tassielli (RTDA)	10%	10%	--	
I. Margjeka (PhD)	30%	30%	--	
D. Paesani (PhD)	10%	10%		
W. Elmetenawee (PhD)	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	1.95 FTE	1.8 FTE	0,1 FTE	0,05 FTE

PRELIMINARY

In contatto con:

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

per servizi di officina meccanica e progettazione
meccanica

Richieste finanziarie per RD_FCC 2021

Consumi/Inventariabile:

- tubi a drift, strumentazione da portare alle aree per test beams:
 - preamplificatori da testare;
 - digitizzatori (acquisto DRS o moduli CAEN)
 - strumentazione specifica per il fascio (camerette di tracciamento);
 - sonde ad alta frequenza per oscilloscopio;
 - alimentatori di HV e LV;
 - **RICHESTA: 7-10k€**
- componenti in fibra di carbonio/ltro per gli spoke dell'endcap della camera a drift per SCT → da quantificare
- computer desktop dedicato per simulazioni standalone con Geant4 (molto pesanti), Garfield e ANSYS **2k€**

Missioni: meetings/workshops (escludendo missioni su FEST)

- **RICHIESTA: 6k€**

Richieste su FEST (le stesse dell'anno scorso)

	Diaria Cina	120	E/day	FEST A	2100	E/month	Risparmio CSN1			
	Viaggi Cina	900	E/viaggio	FEST B	1800	E/month	AdR			
Sezione	MU FEST	Diaria tot	Viaggi	Viaggi tot	Totale	FEST A	FEST B	ASS.	SJ	Cost CSN1
INFN-BA	6	21.600	7	6.300	27.900	12.600	10.800	4.500	23.400	15.300

Richieste per personale (AdR) e servizi

- Richiesta di un assegno di ricerca Junior per un anno su fondi Kremlin+
- Richiesta di un borsa post-laurea per un ingegnere meccanico per 6 mesi su fondi Kremlin+ (pagata da INFN Bari o INFN Lecce)

Richiesta di servizio di officina meccanica e progettazione meccanica per realizzazione di pezzi per vari prototipi di camera a drift

In contatto con:

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

Conclusioni

- Nell'arco del 2020 e 2021, nonostante il COVID-19, si sono fatti molti passi avanti sulle attività connesse a RD_FCC:
 - laboratorio, camera di monitoring, simulazione, progettazione meccanica
- Le attività per FCC/CepC trovano ampio supporto e considerazione nelle decisione della European Strategy
- Abbiamo diversi progetti di ricerca ufficialmente approvati ed uno di *outreach* che si concluderà quest'anno
- L'impegno è destinato a crescere nel breve e lungo termine
 - il contributo del personale di sezione è benvenuto