Futuri acceleratori (RD_FCC): attività nella sezione INFN-Bari e richieste finanziarie per 2021

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

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

Bari
Luglio 2020

Organizzazione

- **Diverse aree di interesse ed attività:**
  - Misure di precisione per acceleratori e^+e^- (FCC-ee, CepC)
  - Misure di precisione per acceleratori pp (FCC-hh) e SppC
  - Prospettive di scoperta di nuova fisica
  - Infrastruttura di calcolo (BARI Tier 2 for RD_FA/FCC)
- **Sono coinvolti fisici teorici e sperimentali**
- **Contributi forniti per CDR per CepC e FCC**
- **Decisioni della European Strategy for Particle Physics:** 19 Giugno 2020

Decisioni della European Strategy

European Strategy Update

2020 Strategy Statements

3. High-priority future initiatives

It is essential for particle physics in Europe and for CERN to be able to propose a new facility after the LHC

- There are two clear ways to address the remaining mysteries: Higgs factory and exploration of the energy frontier
- Europe is in the privileged position to be able to propose both: CLIC or FCCee as Higgs factory, CLIC (3 TeV) or FCChh (100 TeV) for the energy frontier
- The dramatic increase in energy possible with FCChh leads to this technology being considered as the most promising for a future facility at the energy frontier.
- It is important therefore to launch a feasibility study for such a collider to be completed in time for the next Strategy update, so that a decision as to whether this project can be implemented can be taken on that timescale.

a) An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy. Accomplishing these compelling goals will require innovation and cutting-edge technology:

- *the particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors;*
- *Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update.*

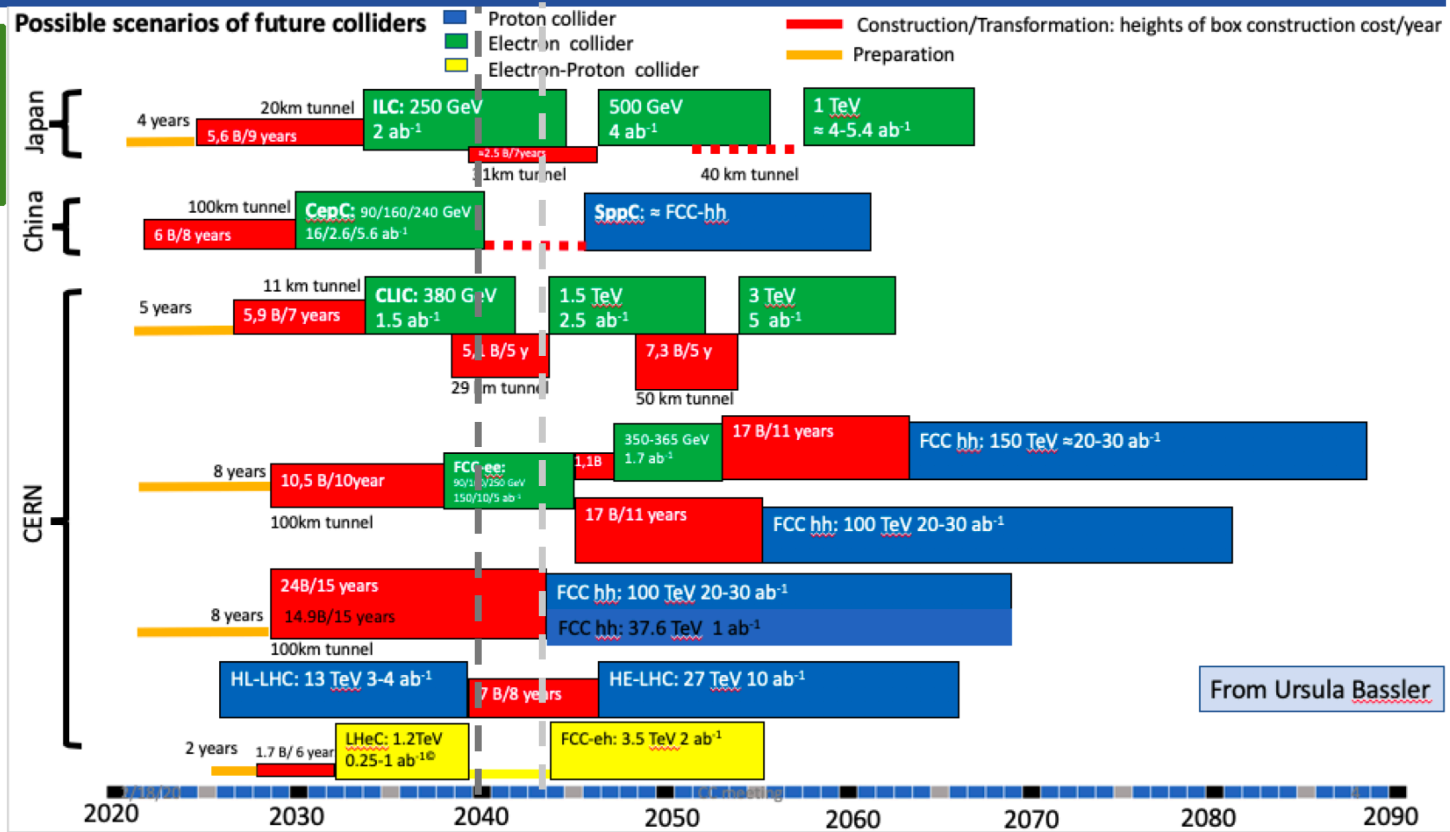
The timely realisation of the electron-positron International Linear Collider (ILC) in Japan would be compatible with this strategy and, in that case, the European particle physics community would wish to collaborate.

Timeline

2020 Strategy Update

3. High-priority future initiatives

Map of possible future facilities submitted as input to the Strategy Update



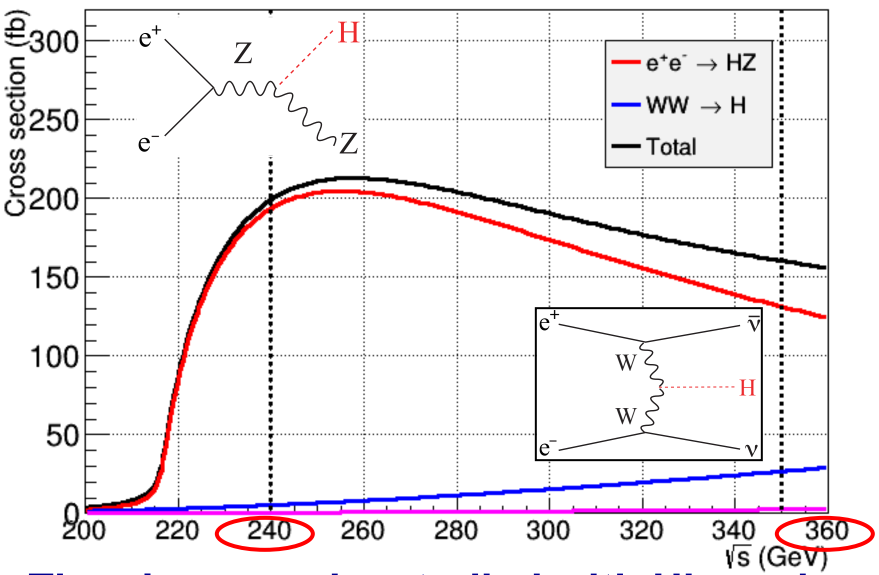
From Ursula Bassler

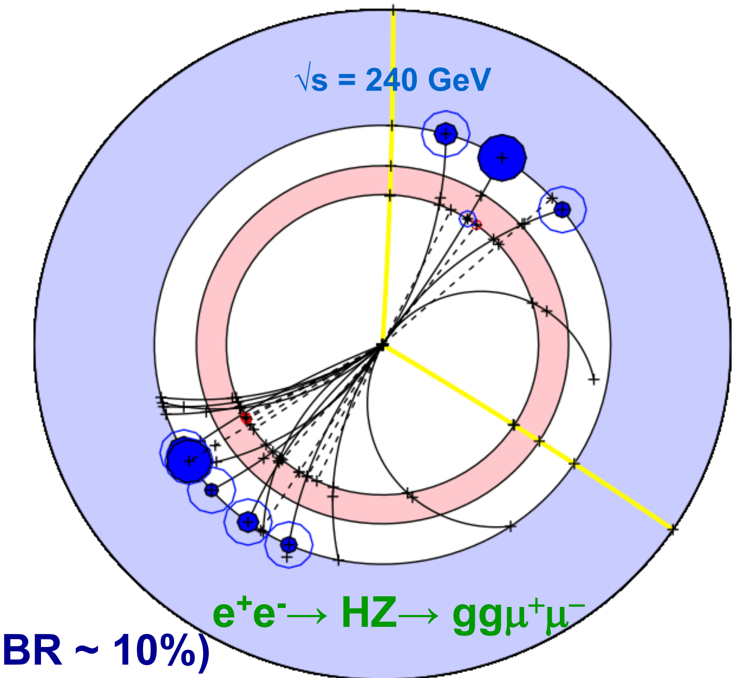
FCC-ee/CepC motivation

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 → 10^6 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)**



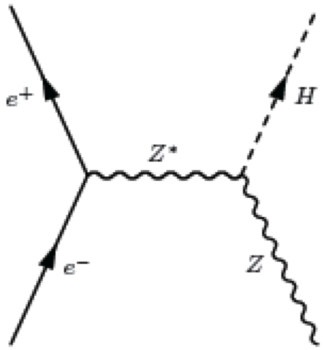


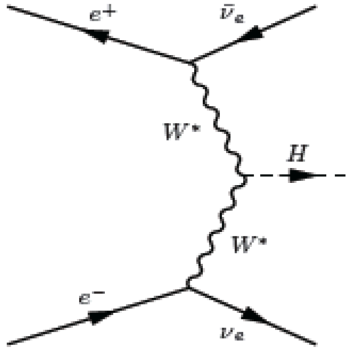
- **The gluon can be studied with Higgs decays (BR ~ 10%)**

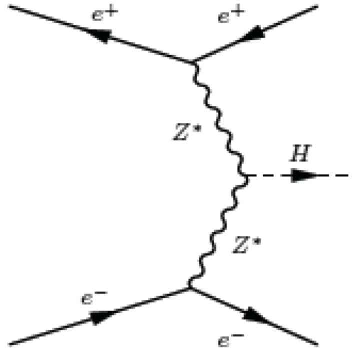
Higgs production at FCC-ee/CepC

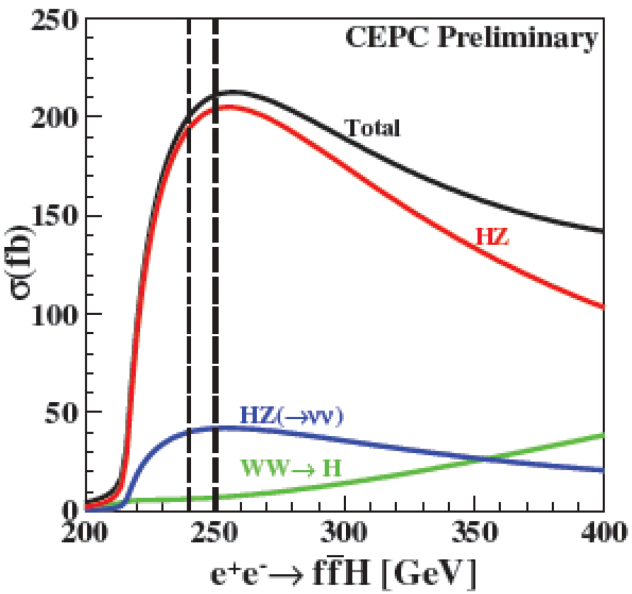
Higgs-strahlung or $e^+e^- \rightarrow ZH$

VBF production: $e^+e^- \rightarrow \nu\nu H$ (WW fus.), $e^+e^- \rightarrow He^+e^-$ (ZZ fus.)

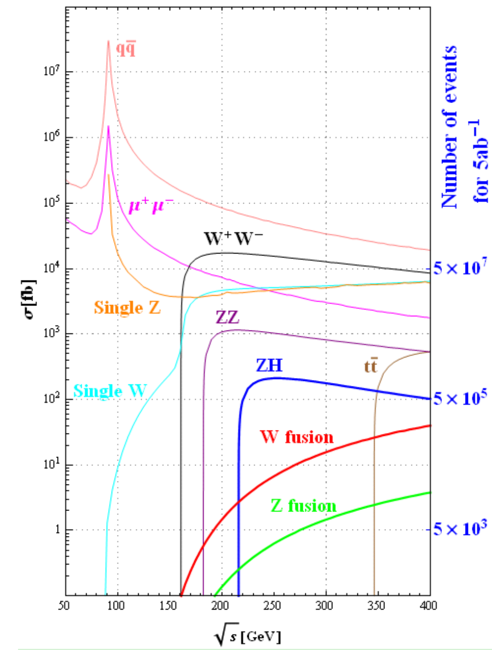








Process	Cross section	Events in 5 ab^{-1}
Higgs boson production, cross section in fb		
$e^+e^- \to ZH$	212	1.06×10^6
$e^+e^- \to \nu\bar{\nu}H$	6.72	3.36×10^4
$e^+e^- \to e^+e^-H$	0.63	3.15×10^3
Total	219	1.10×10^6
Background processes, cross section in pb		
$e^+e^- \to e^+e^-$ (Bhabha)	25.1	1.3×10^8
$e^+e^- \to q\bar{q}$	50.2	2.5×10^8
$e^+e^- \to \mu\mu$ (or $\tau\tau$)	4.40	2.2×10^7
$e^+e^- \to WW$	15.4	7.7×10^7
$e^+e^- \to ZZ$	1.03	5.2×10^6
$e^+e^- \to eeZ$	4.73	2.4×10^7
$e^+e^- \to e\nu W$	5.14	2.6×10^7

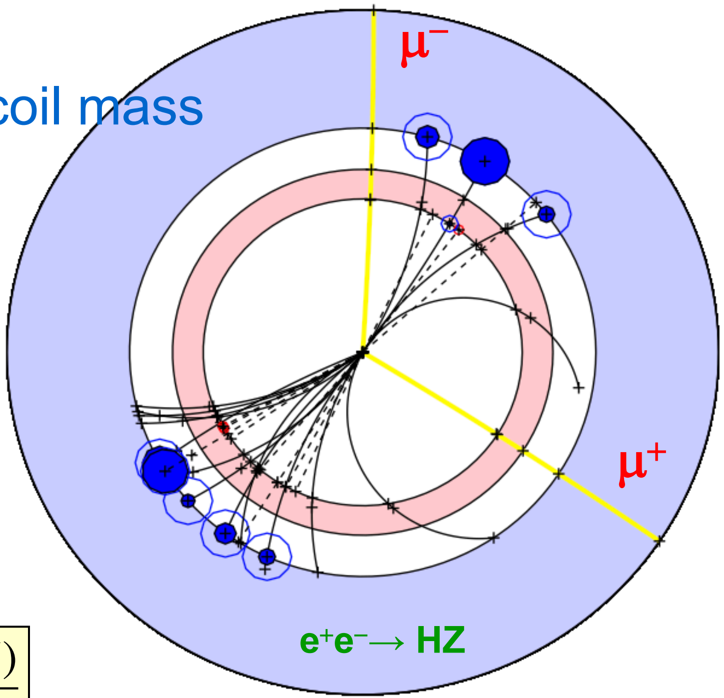


FCC-ee/CepC: Higgs factory at $\sqrt{s}$=240 GeV

Model-independent precision measurements

- A Higgs boson is tagged by a Z and the recoil mass

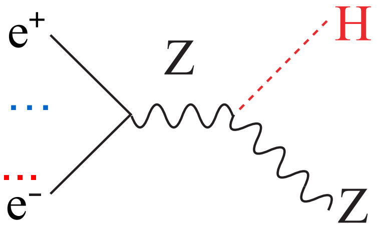
$$m_H^2 = s + m_Z^2 - 2\sqrt{s}(E_+ + E_-)$$



  - Measure σ(e^+e^- → HZ)
  - Deduce g_{HZZ} coupling
  - Infer Γ(H→ZZ)
  - Select events with H→ZZ*
  - Measure σ(e^+e^- → HZ, with H→ZZ*)

$$\sigma(e^+e^- \to HZ \to ZZZ) = \sigma(e^+e^- \to HZ) \times \frac{\Gamma(H \to ZZ)}{\Gamma_H}$$

  - Deduce the total Higgs boson width Γ_H
  - Select events with H → bb, cc, gg, WW, ττ, γγ, μμ, Zγ, …
  - Deduce g_{Hbb} , g_{Hcc} , g_{Hgg} , g_{HWW} , $g_{H\tau\tau}$, $g_{H\gamma\gamma}$, $g_{H\mu\mu}$, $g_{HZ\gamma}$, …
  - Select events with H → "nothing"
  - Deduce Γ(H→invisible)



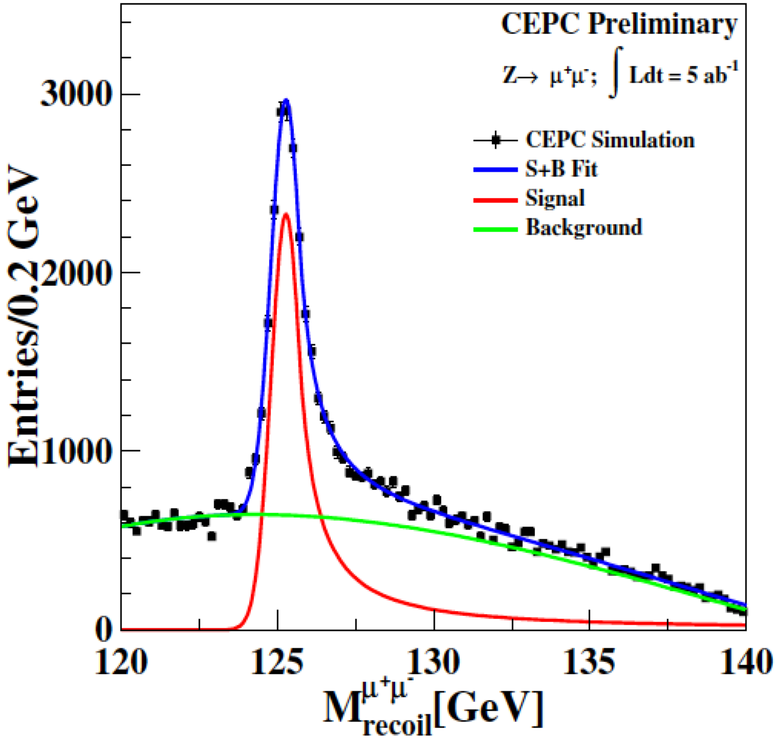
Higgs from recoil mass method

$$m^2_{\mathrm{recoil}} = (\sqrt{s} - E_{f\bar{f}})^2 - p^2_{f\bar{f}} = s - 2E_{f\bar{f}}\sqrt{s} + m^2_{f\bar{f}}$$

- Best mass precision can be achieved with the Z→ll (ee,μμ) decays
- Cross section, ZH and the Higgs-Z boson coupling g(HZZ), can be derived in a model-independent way
- g(HZZ) and Higgs decay branching ratios can be used to derive the total Higgs boson decay width.

- A relative precision of 0.9% for the inclusive cross section has been achieved.
- The Higgs mass can be measured with a precision of 6.5 MeV; the precision is limited by the beam energy spread, radiation effect and detector resolution
- A relative precision of 0.51% on σ(ZH) by combining ee,μμ and qq channels
- g(HZZ) can be extracted from σ(ZH) with a relative precision of 0.25%

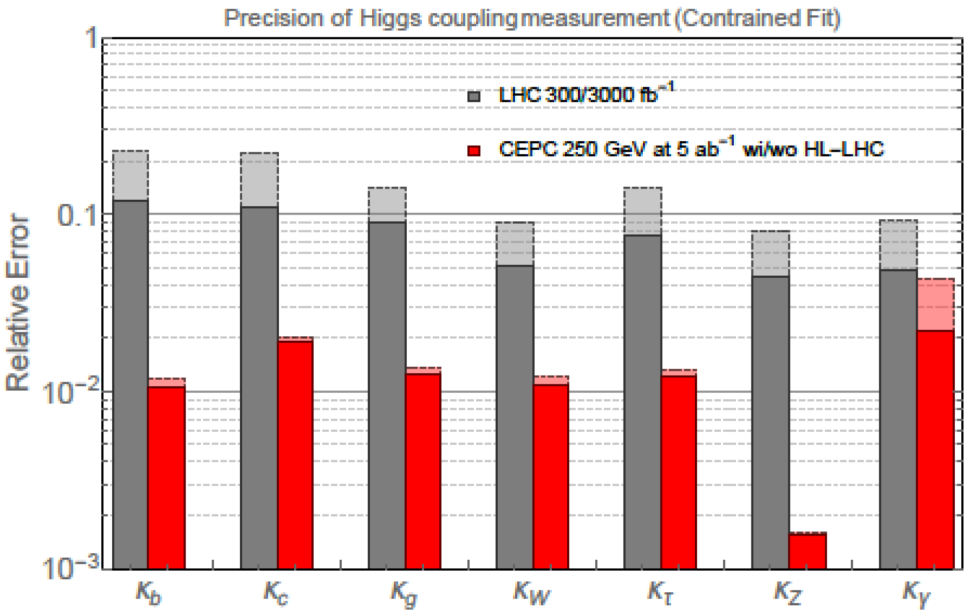
Z decay mode	ΔM_H (MeV)	$\Delta\sigma(ZH)/\sigma(ZH)$	$\Delta g(HZZ)/g(HZZ)$
ee	14	2.1%	
$\mu\mu$	6.5	0.9%	
$ee+\mu\mu$	5.9	0.8%	0.4%
$q\bar{q}$		0.65%	0.32%
$ee+\mu\mu+q\bar{q}$		0.51%	0.25%



Higgs coupling measurements

- **10 parameters** $\kappa_b,\ \kappa_c,\ \kappa_\tau,\ \kappa_\mu,\ \kappa_Z,\ \kappa_W,\ \kappa_\gamma,\ \kappa_g,\ \mathrm{BR}_{\mathrm{inv}},\ \Gamma_h.$
- **assuming lepton universality → 9 parameters** $\kappa_b,\ \kappa_c,\ \kappa_\tau = \kappa_\mu,\ \kappa_Z,\ \kappa_W,\ \kappa_\gamma,\ \kappa_g,\ \mathrm{BR}_{\mathrm{inv}},\ \Gamma_h.$
- **assuming the absence of exotic and invisible decays →7 parameters:**

$$\kappa_b,\ \kappa_c,\ \kappa_\tau = \kappa_\mu,\ \kappa_Z,\ \kappa_W,\ \kappa_\gamma,\ \kappa_g$$



Projections for CEPC at 250 GeV with 5 ab^{-1} integrated luminosity and 7 parameters fit

	CEPC				CEPC+HL-LHC			
Luminosity (ab^{-1})	0.5	2	5	10	0.5	2	5	10
κ_b	3.7	1.9	1.2	0.83	2.3	1.5	1.1	0.78
κ_c	5.1	3.2	1.6	1.2	4.0	2.3	1.5	1.1
κ_g	4.7	2.3	1.5	1.0	2.9	1.9	1.3	0.99
κ_W	3.8	1.9	1.2	0.84	2.3	1.6	1.1	0.80
κ_τ	4.2	2.1	1.3	0.94	2.9	1.8	1.2	0.90
κ_Z	0.51	0.25	0.16	0.11	0.49	0.25	0.16	0.11
κ_γ	15	7.4	4.7	3.3	2.6	2.5	2.3	2.0

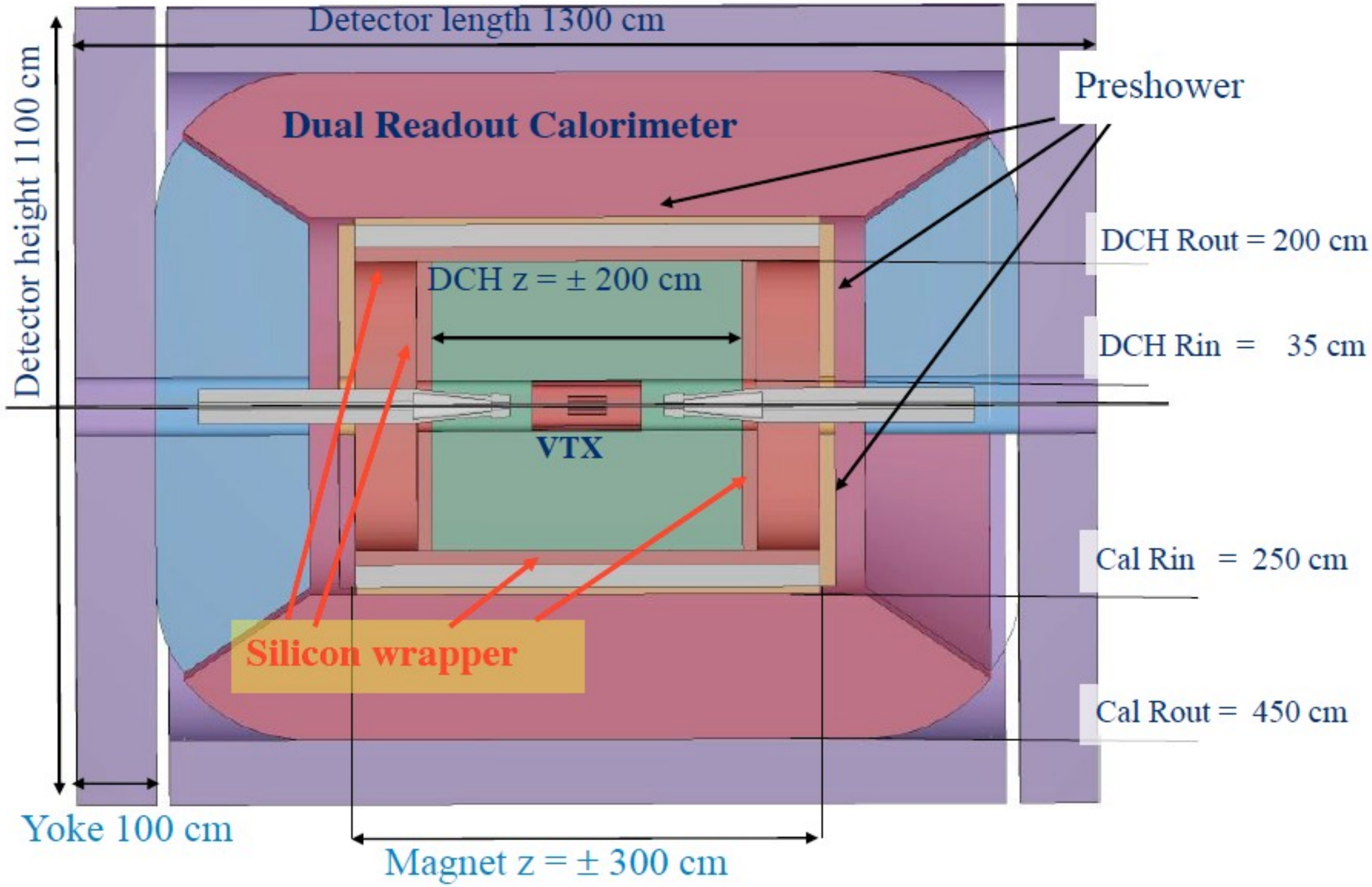
Concerning $\mathrm{BR}_{\mathrm{inv}}$ a high accuracy of 0.25%, while the HL-LHC can only manage a much lower accuracy of 6-17%.

The IDEA experiment at FCC-ee/CepC

IDEA: proposta di esperimento INFN

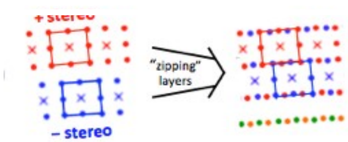
FCC-ee at CERN

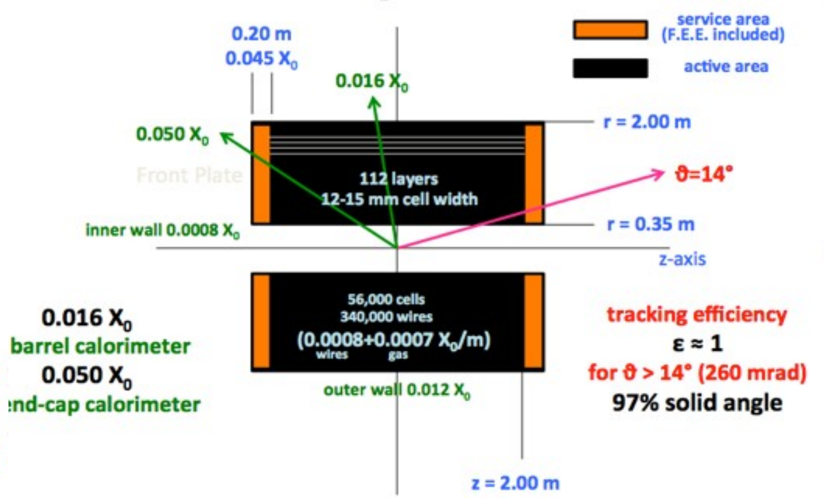
CEPC at IHEP-China



The Drift Chamber for the IDEA experiment

Drift Chamber





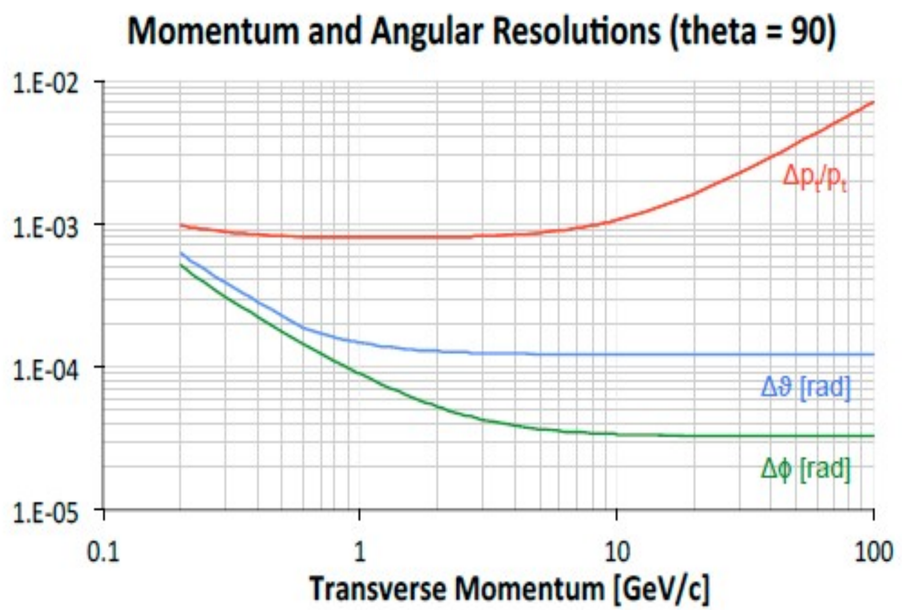
	R_{in} [mm]	R_{out} [mm]	z [mm]
drift chamber	350	2000	±2000
service area	350	2000	±(2000÷2250)

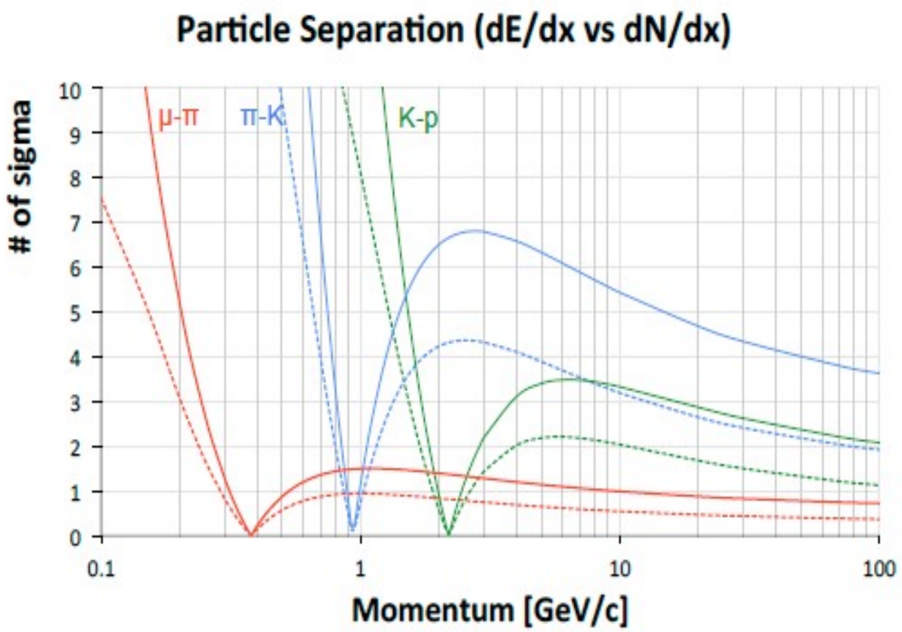
	inner wall	gas	wires	outer wall	service area
thickness [mm]	0.2	1000	1000	20	250
X_0 [%]	0.08	0.07	0.13	1.2	4.5

# of layers	112	min 11.8 mm – max 14.9 mm
# of cells	56448	192 at first layer – 816 at last layer
average cell size	13.9 mm	min 11.8 mm – max 14.9 mm
average stereo angle	134 mrad	min 43 mrad – max 223 mrad
transverse resolution	100 µm	80 µm with cluster timing
longitudinal resolution	750 µm	600 µm with cluster timing

active volume	50 m^3	0.9 He-0.1 iC_4H_{10}
readout channel	112,896	r.o. from both ends
max drift time	400 ns	800 × 8 bit at 2 GHz

The Drift Chamber for the IDEA experiment





$\Delta p_t/p_t = (0.7p_t + 8.3) \times 10^{-4}$

$\Delta\vartheta = (1.1 + 9.4/p) \times 10^{-4}$ rad

$\Delta\varphi = (0.33 + 9.4/p) \times 10^{-4}$ rad

dE/dx = 4.3 %

dN/dx = 2.2 % (at ε_N = 80 %)

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

call H2020-INFRASUPP-2018-2020 progetto ”CREMLIN+” iniziato

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

- “Development and design of Particle Identification and tracking systems” per la SCT

call AIDAinnova: proposta accettata

- “Cluster Counting/Timing: data reduction and pre-processing of drift chamber signals sampled at high rates” finanziato con soli 20kE per INFN Lecce

Partecipazione a progetti

Progetto per outreach "PhysicsInvolvingPeople" – finanziato

- 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.

Proposta per Call H2020-MSCA-RISE-2020 "NEPHTHYS" – sottomesso

"New Frontier for experimental particle physics and technology scouting"

Obiettivi:

- the EFT modeling for new physics and the interpretation of the Higgs and Dark Matter measurements provided by the LHC experiments within the EFT framework;
- the development of new technologies for silicon and gas detectors for charged particle detection and identification in future collider experiments;
- the development of applications for data analysis, data mining and scouting using machine learning techniques.

FEST (1)

Horizon 2020

Call: H2020-MSCA-RISE-2019

(Marie Skłodowska-Curie Research and Innovation Staff Exchange)

Topic: MSCA-RISE-2019

Type of action: MSCA-RISE

Proposal number: 872901

Proposal acronym: FEST

Deadline Id: H2020-MSCA-RISE-2019

Approvato con valutazione 90.4/100 per un totale di 2,106,800€ (100% di quanto richiesto) di cui

1,426,000€ all'INFN

- 8 nazioni, europee e non
- 11 istituti e industrie
- 14 sezioni INFN

Call: H2020-MSCA-RISE-2019
Type of action: MSCA-RISE
Proposal number: 872901
Proposal acronym: FEST
Duration (months): 48
Proposal title: Future Experiments seek Smart Technologies
Activity: PHY

N.	Proposer name	Country	Total Cost	%	Grant Requested	%
1	ISTITUTO NAZIONALE DI FISICA NUCLEARE	IT	1,426,000	66.81%	1,426,000	67.69%
2	JOHANNES GUTENBERG-UNIVERSITAT MAINZ	DE	294,400	13.79%	294,400	13.97%
3	RUHR-UNIVERSITAET BOCHUM	DE	115,000	5.39%	115,000	5.46%
4	THE UNIVERSITY OF SUSSEX	UK	36,800	1.72%	36,800	1.75%
5	UPPSALA UNIVERSITET	SE	110,400	5.17%	110,400	5.24%
6	WESTFAELISCHE WILHELMS-UNIVERSITAET MUENSTER	DE	46,000	2.16%	46,000	2.18%
7	INSTITUTE OF HIGH ENERGY PHYSICS CHINESE ACADEMY OF SCIENCES	CN	27,600	1.29%	0	0.00%
8	EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH	CH	4,600	0.22%	4,600	0.22%
9	COSTRUZIONI APPARECCHIATURE ELETTRONICHE NUCLEARI CAEN SPA	IT	36,800	1.72%	36,800	1.75%
10	Eltos S.p.A.	IT	9,200	0.43%	9,200	0.44%
11	Technology Transfer Agency Techtra Sp. z o.o.	PL	27,600	1.29%	27,600	1.31%
	Total:		2,134,400		2,106,800	

Abstract:
Future Experiments (FE) in Particle Physics face new challenges both in terms of large areas and high rates. Extended R&D activities on existing detectors such as GEM, MicroMegas, micro-RWell, silicon detectors, large volume drift chambers, as well as detectors still to be fully developed like Dual Readout Calorimeters, are the ingredients to build any experiment at future accelerators (as CepC, FCC, ILC or Muon Collider).

The very large scales of future detectors require new and improved production techniques. Their industrialization would allow for: a plethora of non-academic applications such as homeland security, monitoring devices as well as medical imaging applications; a better production yield and a reduced construction time; a significant cost reduction. This is one of the main goals of our intersectorial activities within the Project.

FE will face unprecedented experimental conditions, with strong magnetic fields and extremely high luminosities. New Front End Electronics (FEE), and new digitization, clustering and tracking algorithms must be developed and optimized. An ideal playground for such processes is the BESIII Cylindrical GEM Inner Tracker (CGEM-IT) that is being built and will be installed at IHEP, Beijing, within 2021. This will be the first time that a GEM is operated in a 1 T magnetic field being readout in micro-TPC mode and exploiting the TIGER, a fully custom ASIC for MPGD readout.

Another aim of the project is to develop a new generation of general purpose ASICs, capable of interfacing with several different detector types.

FEST also aims to perform MonteCarlo simulations of FE, improving and updating event generators to the new experimental scenarios. All these activities require a large computing power. A possible approach involving cloud and HPC techniques on micro infrastructures will be investigated; special care will be devoted to applications that could ease the access of SMEs to local cloud technologies.

Evaluation Summary Report

Evaluation Result
Total score: 90.40% (Threshold: 70/100.00)

FEST (2)

Table B1 – Work Package (WP) List

Work Package No	Work Package Title	Activity Type (e.g. Research, Training, Management, Communication, Dissemination…)	Number of person-months involved	Beneficiary leading	Start Month	End month
1	BESIII CGEM-IT detector and Physics	Research, Training	211	INFN	1	48
2	Detectors for future experiments	Research, Training	118	INFN	1	48
3	Readout electronics for future experiments	Research, Training	55	INFN	1	48
4	Medical applications	Research, Training	10	INFN	1	48
5	Future accelerators Physics	Research, Training	56	INFN	1	48
6	Data Challenge	Research, Training	14	INFN	1	48
7	Dissemination and Outreach	Dissemination, Outreach	0	INFN	1	48
8	Management	Management	0	INFN	1	48

An *ultra-low mass drift chamber* could represent the ideal solution for a general purpose central tracking detector, making use of: low mass gas mixtures; new materials for wires and for mechanical supports; new assembly techniques for high granularity layouts; new reconstruction techniques to improve particle identification capability by more than a factor of two w.r.t. the traditional method of charge integration; cluster timing, to improve the spatial resolution by correcting the bias in the impact parameter definition. The FEE must evolve to match the specific requirements of these innovations; task T3.4 is coping with such requirements in WP3.

Task 2.1 Drift Chamber [M1-48] [HM 12/18,0/0] [INFN,IHEP] New solutions involving polymeric fibers or Carbon monofilaments, coated with easy to solder light metals, like tin, zinc, copper or their common alloys, will represent a breakthrough in the drift chamber technology and must be pursued with feasibility studies. Moreover, the adoption of new composite materials for the drift chamber gas containment and for the electrostatic and radiofrequency shielding of the active chamber volume, suitably shaped to minimize stresses and deformations, will contribute to further lowering the overall tracking system material budget in front of the remaining sub-detectors. Prototypes will be developed to test both new wires and smart enclosure/shielding technologies. This task will lead to D2.1.

Task 3.4 Develop specific Front-End and Post-Processing Electronics [M28-40] [HM 18/18,0/0] [INFN,IHEP] Front-end electronics for high density drift chambers will be designed for a gain which must produce a suitable read-out signal for further processing, low power consumption, a bandwidth adequate to the expected signal spectral density and a fast pulse rise time response, to exploit the cluster counting/timing technique. Identifying both the amplitude and the arrival time of each peak associated with each individual ionization cluster is the minimum requirement on the data transfer for storage. The possibility of being programmed to perform "ad hoc" functions, optimizing its performance in relation to the task to be performed, suggests the possibility of using FPGAs for the real-time analysis of the data generated by a drift chamber and successively converted by an ADC. This task will lead to D3.4.

Description of Deliverables:

2.1 Report on the technical characteristics of a full scale prototype [M48] [T2.1]

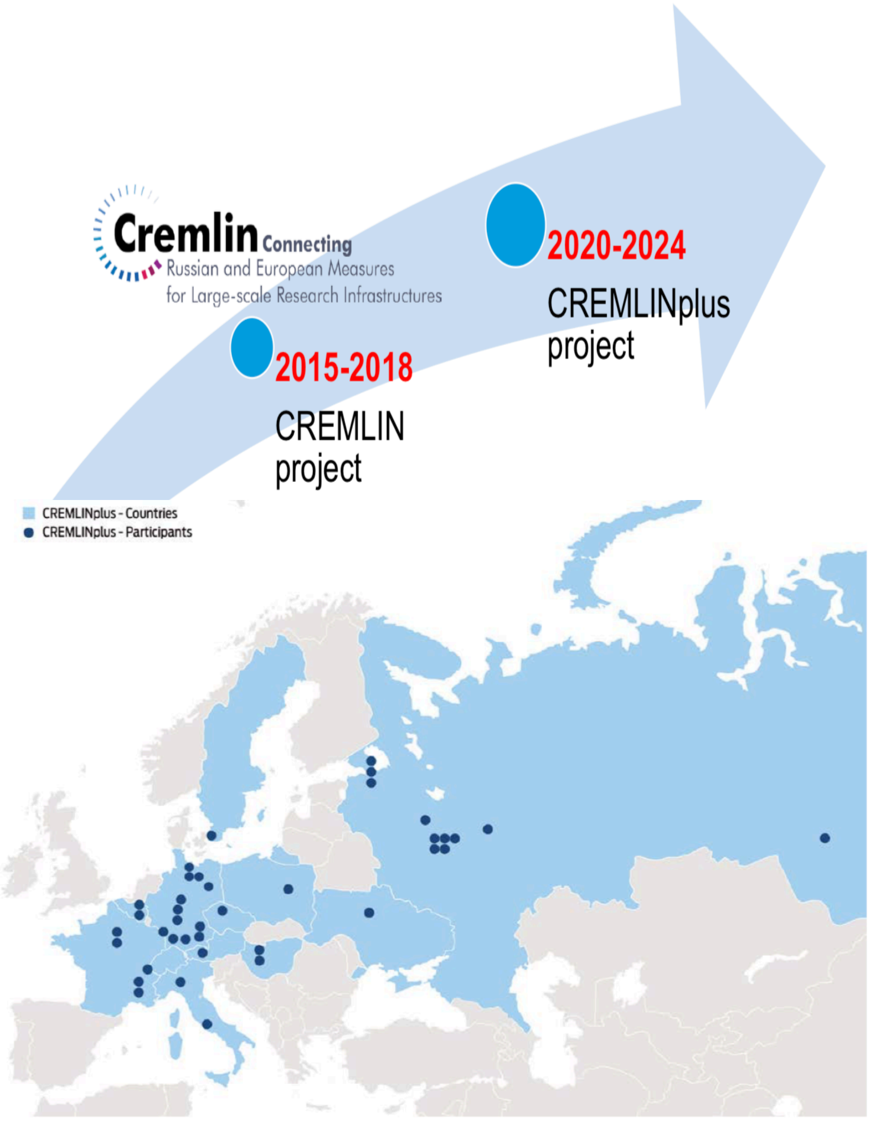
D3.4 Report with the definition of a suitable FPGA and implementation of the peaks finding algorithm on the FPGA through the related evaluation board [M36] [T3.4]

M2.2	DCH: choice of materials for wires and gas containment	**WP2**	**INFN**	**M36**	Results of mechanical tests

CREMLIN+ (1)

CREMLIN PLUS
Connecting Russian and European Measures for Large-scale Research Infrastructures

- ✓ Funded under EU´s Research and innovation Programme Horizon 2020
- ✓ CREMLINplus is a Research and Innovation Action (RIA), following INFRASUPP-01-2018-2019
- ✓ Project duration: 4 years, 01.02.2020-31.01.2024
- ✓ Budget: 25 million EUR
- ✓ Consortium: 35 partners
- ✓ Coordinator: DESY



CREMLIN+ (2)

CREMLIN PLUS

Connecting Russian and European Measures for Large-scale Research Infrastructures

BINP	Budker Institute of Nuclear Physics of SB RUS
IAP	Institute of Applied Physics, Russian Academy of Sciences
ICISTE	International Centre for Innovations in Science, Technology and Education
INR RAS	Institute for Nuclear Research of the Russian Academy of Sciences
JINR	Joint Institute for Nuclear Research
MEPhI	National Research Nuclear University "MEPhI"
NRC KI	National Research Center "Kurchatov Institute"
NUST MISIS	National University of Science and Technology MISIS
PTI	IOFFE Physico-Technical Institute of the Russian Academy of Sciences
SPSU	Saint Petersburg State University

10 Russian partners

DESY	Deutsches Elektronen-Synchrotron
EKUT	Eberhard Karls Universität Tübingen
European XFEL	European X-Ray Free-Electron Laserfacility GmbH
FAIR	Facility for Antiproton and Ion Research in Europe GmbH
FZJ	Forschungszentrum Jülich GmbH
GUF	Johann Wolfgang Goethe-Universität Frankfurt am Main
HZG	Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH
JLU	Justus-Liebig-Universität Giessen
TUM	Technische Universität München
CEA	Commissariat à l'Énergie Atomique et aux Énergies Alternatives
ESRF	European Synchrotron Radiation Facility
ILL	Institut Max von Laue - Paul Langevin
CNRS	Centre National de la Recherche Scientifique
UCA	Université Clermont Auvergne
ELI-DC AISBL	Association Internationale Extreme-Light-Infrastructure Delivery Consortium
NPI CAS	Nuclear Physics Institute, Czech Academy of Science
MTA EK	Magyar Tudomanyos Akademia Energiatudomanyi Kutatokozpont
Wigner RCP	Magyar Tudomanyos Akademia Wigner Fizikai Kutatokozpont
INFN	Istituto Nazionale di Fisica Nucleare
UNIMIB	Università degli Studi di Milano-Bicocca
ADSI (LTP*)	Austrian Drug Screening Institute GmbH
CERN	European Organization for Nuclear Research
WUT	Politechnika Warszawska
ESS	European Spallation Source ESS ERIC
INR NASU	Institute for Nuclear Research of NAS of Ukraine
LLE-AISBL	Laserlab-Europe AISBL

25 European partners

INFN
FE, LNF→Task 5.4: Development and design of Inner Tracker for the SCT detector→ full cylindrical IT based on the innovative μ-RWELL technology
BA, LE →Task 5,3, 5.5

Budget amount: 292 K€ (Lecce+ Bari) + ~70 Keuro overhead

CREMLIN+ (3)

CREMLIN PLUS
Connecting Russian and European Measures for Large-scale Research Infrastructures

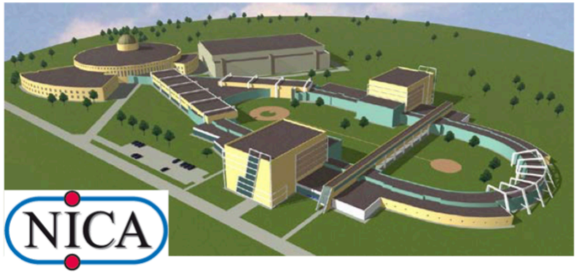
- **Consortium BINP & CERN (coordinating partners); and JLU; CNRS_LAL; INFN**
- **Budget 2.19 MEUR**

10 WPs, WP5: Joint technology development around SCT and future lepton colliders

5 Russian megascience projects

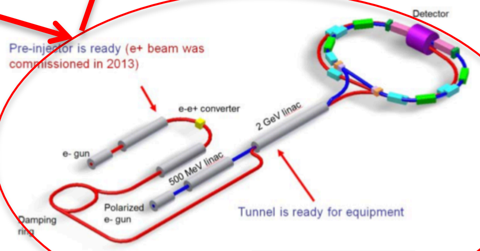
- **NICA**: Superconducting accelerator complex („Nuclotron-based ion collider facility"); Dubna
- **PIK**: High-flux research reactor (International Centre for Neutron Research, ICNR); Gatchina
- **USSR**: Ultima Synchrotron Storage Ring; Protvino **synchrotron radiation source**
- **SCT**: Lepton Collider „Super Charm-Tau Factory"; Novosibirsk
- **XCELS**: High power laser „Exawatt Center for Extreme Light Studies"; Nizhniy Novgorod

High lumi e+e- collider (10^{35}), 4-6 GeV CM energy

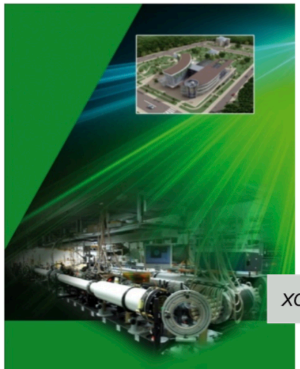


PIK

USSR sketch, NRC KI



SCT sketch



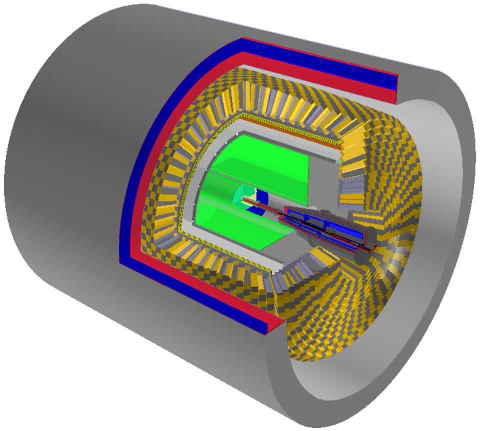
XCELS

CREMLIN+ (4)

CREMLIN PLUS

Connecting Russian and European Measures for Large-scale Research Infrastructures

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 (TraPId) 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

Attività svolta da INFN Bari nel 2019 e 2020

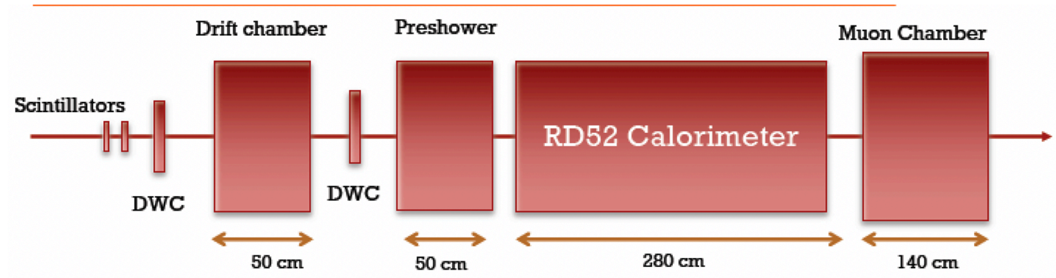
Strategia delle attività

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

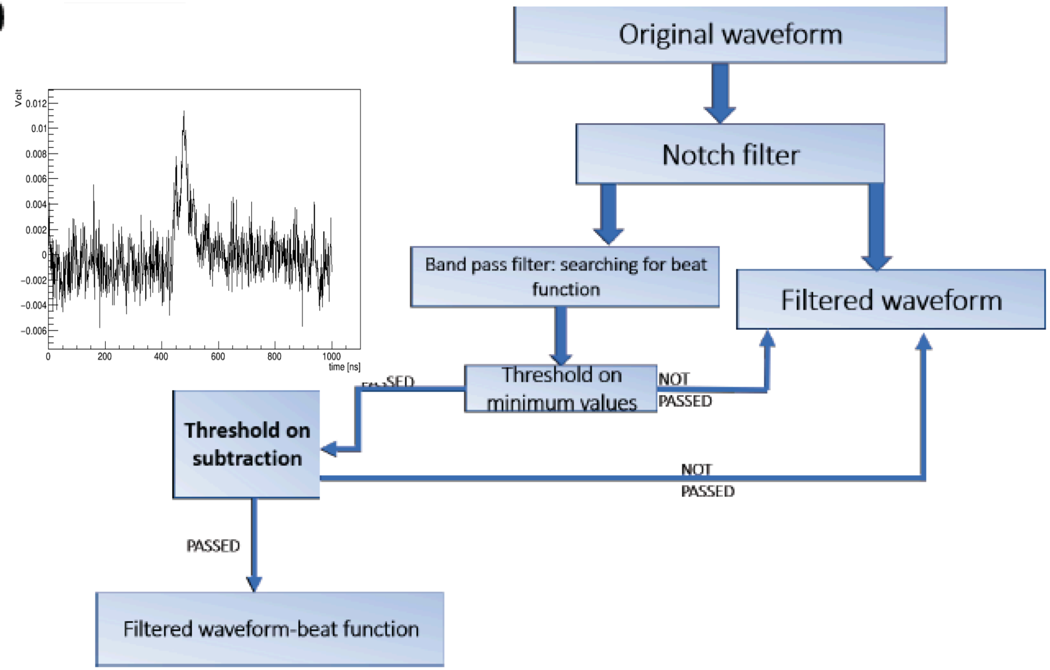
- Test e caratterizzazione di un prototipo di camera a deriva
  - analisi dati del Test Beam 2018
- Test e caratterizzazione di una camera di monitoraggio della velocità di deriva
  - simulazione della camera
- Simulazione della camera a drift con Geant4 ed integrazione in IDEA
- Contributo alla progettazione meccanica per nuovo prototipo per SCT →IDEA

Analisi dati test beam 2018

- The chamber consists of 12 x 12 cell
- Each cell is 1 cm x 1 cm
- the wire length is 60 cm
- The voltage applied to each wire is about 1475V (depends by the runs)
- The gas used is 90% He 10 % i-C4H10



Trattamento del rumore



Pubblicazione: «*First test-beam results obtained with IDEA, a detector concept designed for future lepton colliders*», Nucl. Instrum. Methods Phys. Res., A 958 (2020) 162088

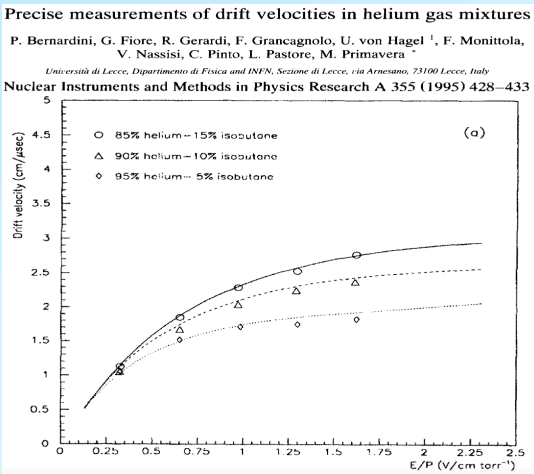
Camera di monitoraggio della velocità di deriva

Motivazioni:

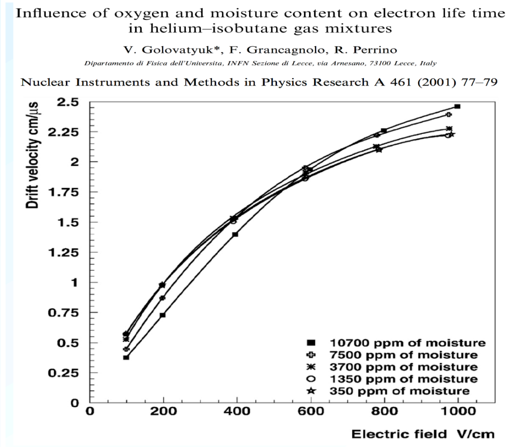
Variazioni dell'ordine del percento della velocità di drift incidono, su una distanza di drift di 5 mm, con un non trascurabile contributo di 50 μm alla risoluzione spaziale.

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 di contenuto di vapori d'acqua di $_{-150}^{+80}$ 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.

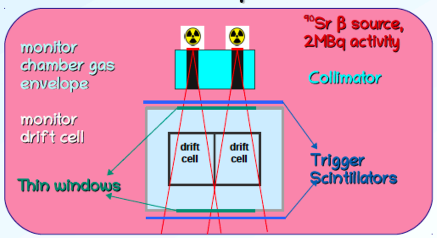
E.g. at the operating value of the electric field of about 1 V/cm/torr, variations of ≈ 150 ppm leads to an increase of 10^{-3} in drift velocity.

Camera di monitoraggio della velocità di deriva

Struttura della camera

Monitoring chamber structure

Schematic set up

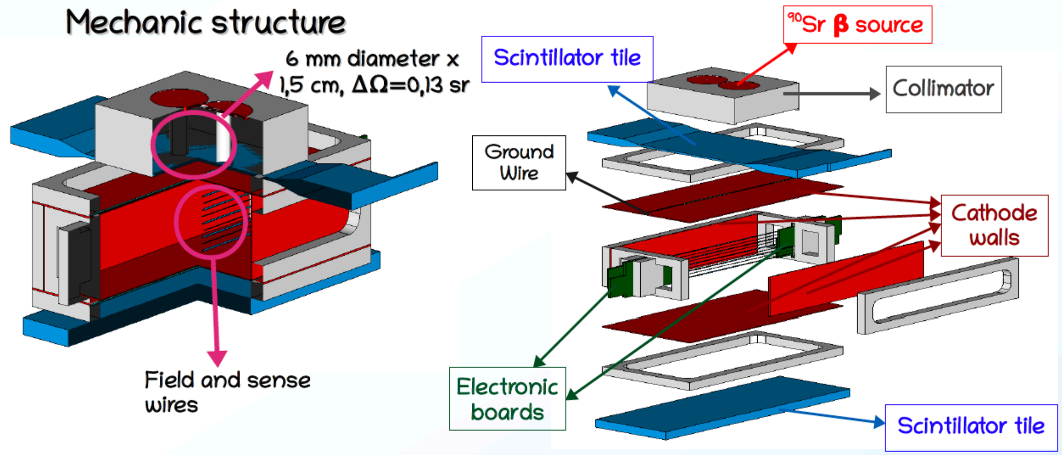


The chamber can be supplied with gas coming from the inlet and the outlet of the detector.

We will determine if gas contaminations originate inside the main chamber or in gas supply system.

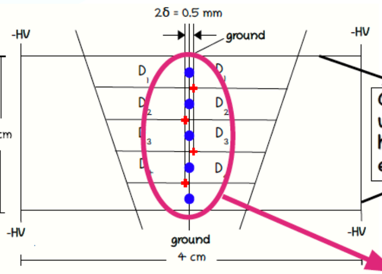
We will use two ^{90}Sr weak calibration radioactive source placed on top of two thin scintillator tiles telescope.
To select electrons that pass through the chamber, the two sources will be collimated, so that the number of decays that can be used will be around $4{\times}10^3$ per second.
This set-up allows to measure variations of drift velocity at 10^{-3} level within a minute.

Mechanic structure



Camera di monitoraggio della velocità di deriva

Principio della misura



Cathode walls will define higher uniform electric field.

Sense wires are staggered in the planes x= ±δ to allow drift velocity measurements.

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

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

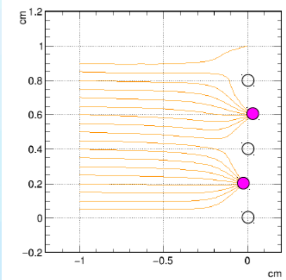
Subtracting t_3-t_2 → $\Theta=(t_1+t_3-2t_2)-(t_2+t_4-2t_3)$ →

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

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



Simulation results for electric field

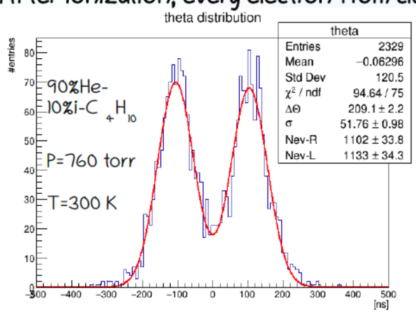
We made simulations using Garfield++. First step was the optimization of electric field inside the two drift cells. We fixed the voltage on cathode plane at -2000V and varied the voltage on field wires from 0V to -800 V and on the sense wires from 0 V to 1200 V. →

The optimized values are:
- 925 V for sense wires
- -350 V for field wires

Simulation results for electron tracks

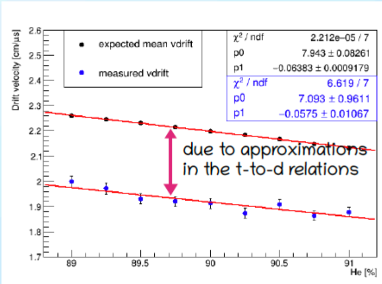
We simulated 2000 tracks on left side and 2000 on the right side.

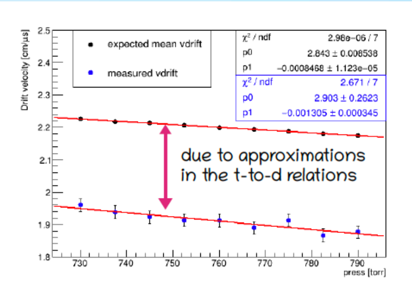
After ionization, every electron from cluster drifted to the sense wire. Saving drift times and total charges produced, we obtained the double peak distribution.



$\Delta\Theta=(209.1\pm2.2)\,ns\qquad v_d=(1.91\pm0.02)\,cm/\mu s$

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 $4{\times}10^5$ and it will be obtained with the radioactive source and the experimental set-up chosen.

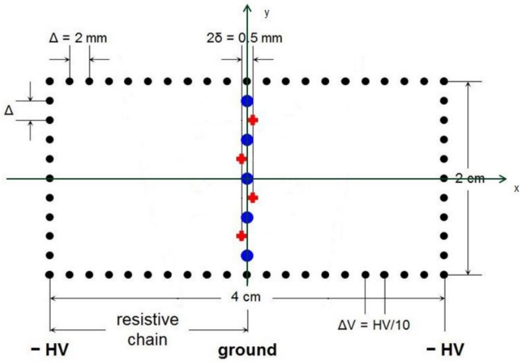




Camera di monitoraggio della velocità di deriva

Simulazione della camera:

- simulation program Garfield
- 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.



Prepared for submission to JINST

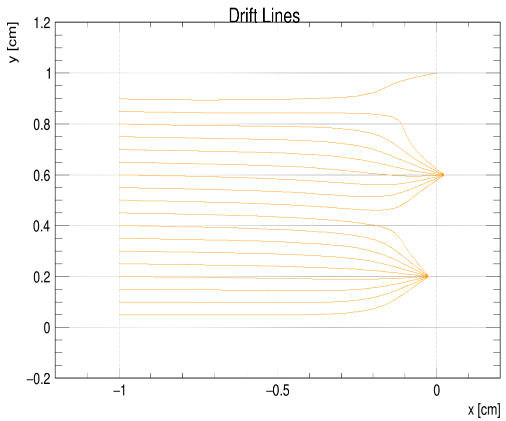
International Conference on Instrumentation for Colliding Beam Physics
24 - 28 February, 2020
Budker Institute of Nuclear Physics, Novosibirsk, Russia

A 10^{-3} drift velocity monitoring chamber

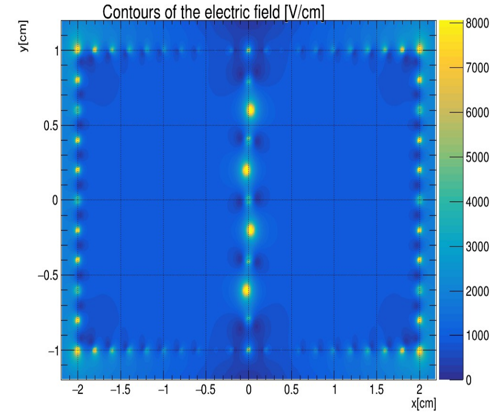
G. Chiarello[d] , A. Corvaglia[a] , F. Cuna [a,b,1] , N. De Filippis[e,f] , F. Grancagnolo[a] , M. Manta[b] , I. Margjeka[c,e] , A. Miccoli[a] , M. Panareo[a,b] , G. F. Tassielli[a]

[a] Istituto Nazionale di Fisica Nucleare, Lecce, Italy
[b] Università del Salento, Italy
[c] Università degli Studi di Bari, "Aldo Moro", Italy
[d] Istituto Nazionale di Fisica Nucleare, Roma, Italy
[e] Istituto Nazionale di Fisica Nucleare, Bari, Italy
[f] Politecnico di Bari

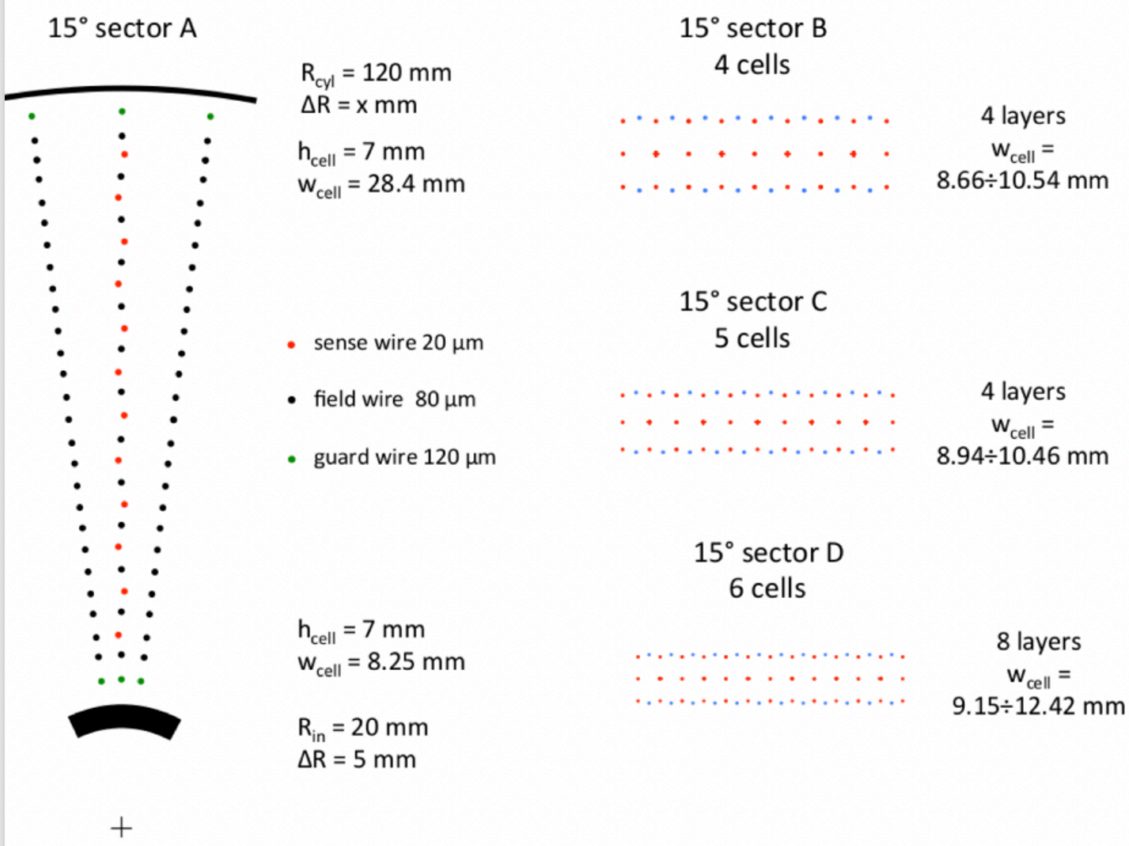
proceeding



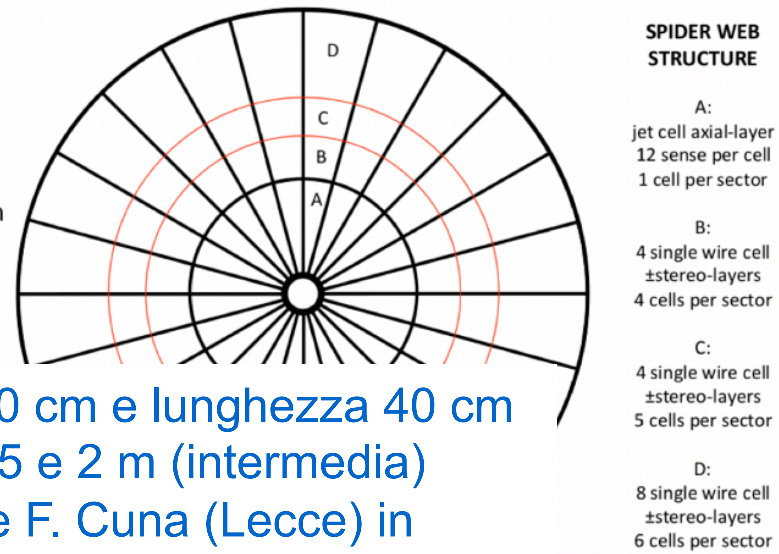
Electric field configuration with
Va* = −350*V* . *Vs* = 925*V



Progettazione meccanica camera a deriva per SCT

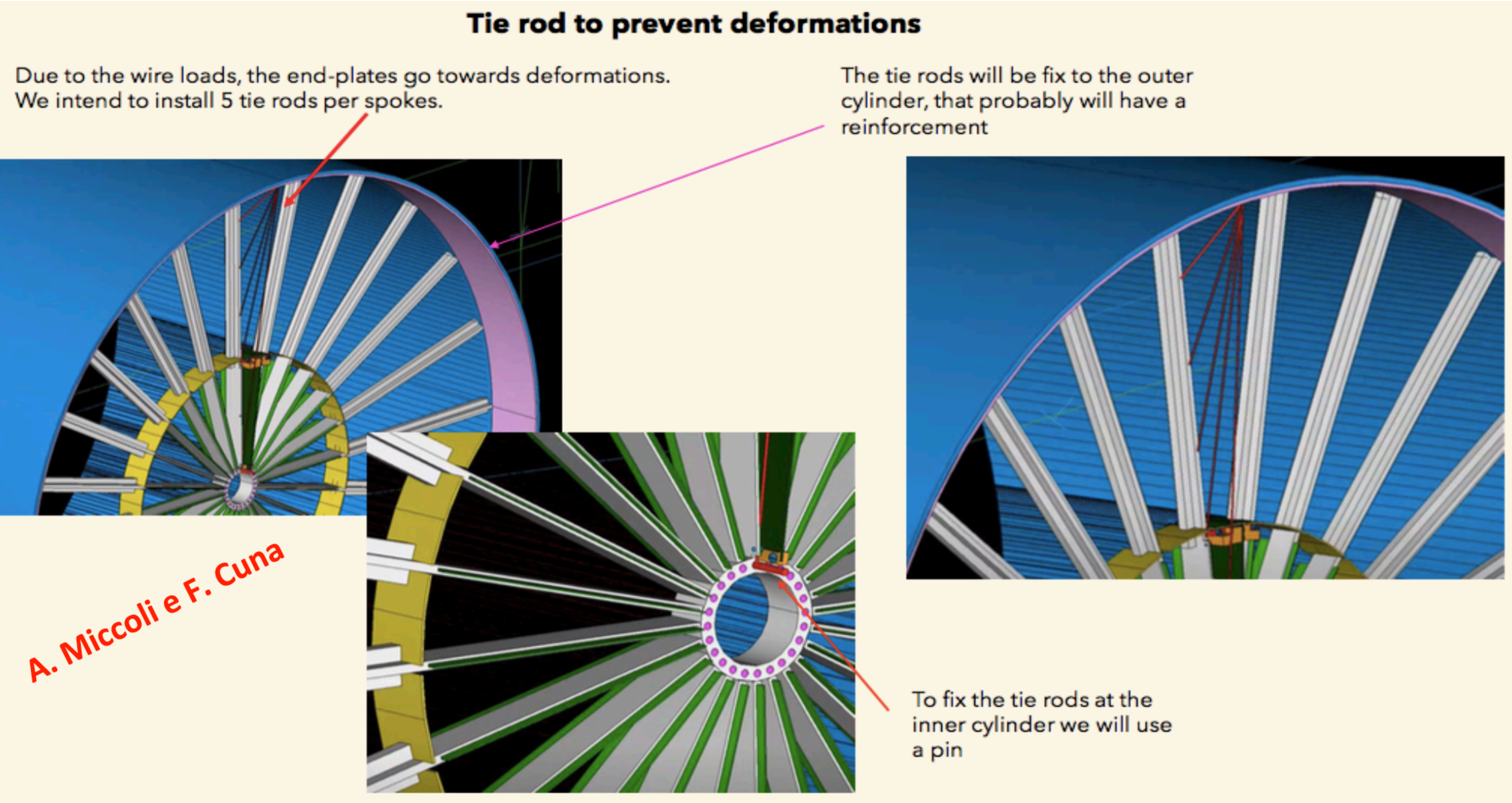


Details about the cell structure in chamber sectors.



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, V. Valentino)

Progettazione meccanica camera a deriva per SCT



- Contenimento delle deformazioni dei raggi mediante alcuni stralli.
- Soluzione preferita ad una aletta di rinforzo solidale ad ogni raggio.

Calcolo per RD_FCC

- E' essenziale che il programma di futuri acceleratori sia supportato dall'evoluzione del calcolo scientifico

- E' stata creata una "virtual organization" **rdfa** per attività RD_FA in GRID:
  - una coda del CNAF associato alla VO e 10TB di disco

- Il centro ReCaS Bari è il primo Tier2 che supporta la VO rdfa quanto:
  - ci sono le risorse per ospitare le simulazioni per RD_FCC
  - c'è il know-how su strumenti di calcolo
  - Il ranking come Tier2 di CMS (ed Alice) è buono

- I dati del testbeam del 2018 sono storati a Bari ed accessibili via grid da chiunque sia sottoscritto alla VO rdfa

- Simulazione della camera a deriva con programma GARFIELD a Bari

- Partita l'attività di simulazione di eventi di fisica, simulazione del rivelatore IDEA ed uso di risorse per il machine learning

Anagrafica e richieste 2021

Anagrafica RD_FCC/CREMLIN+ 2021

INFN- Bari	2020
N. De Filippis (Assoc. Prof.)	30%
M. Abbrescia (Assoc. Prof.)	15%
R. Aly (PhD)	30%
I. Margjeka (PhD)	20%
W. Elmetenawee (PhD)	30%
M. Maggi (1+ ricerc. INFN)	20%
G. Iaselli (Full prof.)	10%
TOT	**1.55 FTE**
Officina meccanica	1 m.u.
Servizio Progettisti Meccanici	1 m.u.

In contatto con:
- C. Pastore (OM)
- M. Mongelli (SPM)
- V. Valentino (SPM)

Richieste finanziarie per RD_FCC 2021

Missioni: meetings/workshops (escludendo missioni su FEST)

INFN- Bari	k€
N. De Filippis	2
M. Abbrescia	1
R. Aly	1
I. Margjeka	1
W. Elmetenawee	1
M. Maggi	0,5
G. Iaselli	0,5
TOT	7k€

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 finanziarie per consumi RD_FCC 2021

Si richiede supporto per strumentazione di laboratorio per il funzionamente per "v_{drift} monitoring chamber" in costruzione presso INFN Lecce.

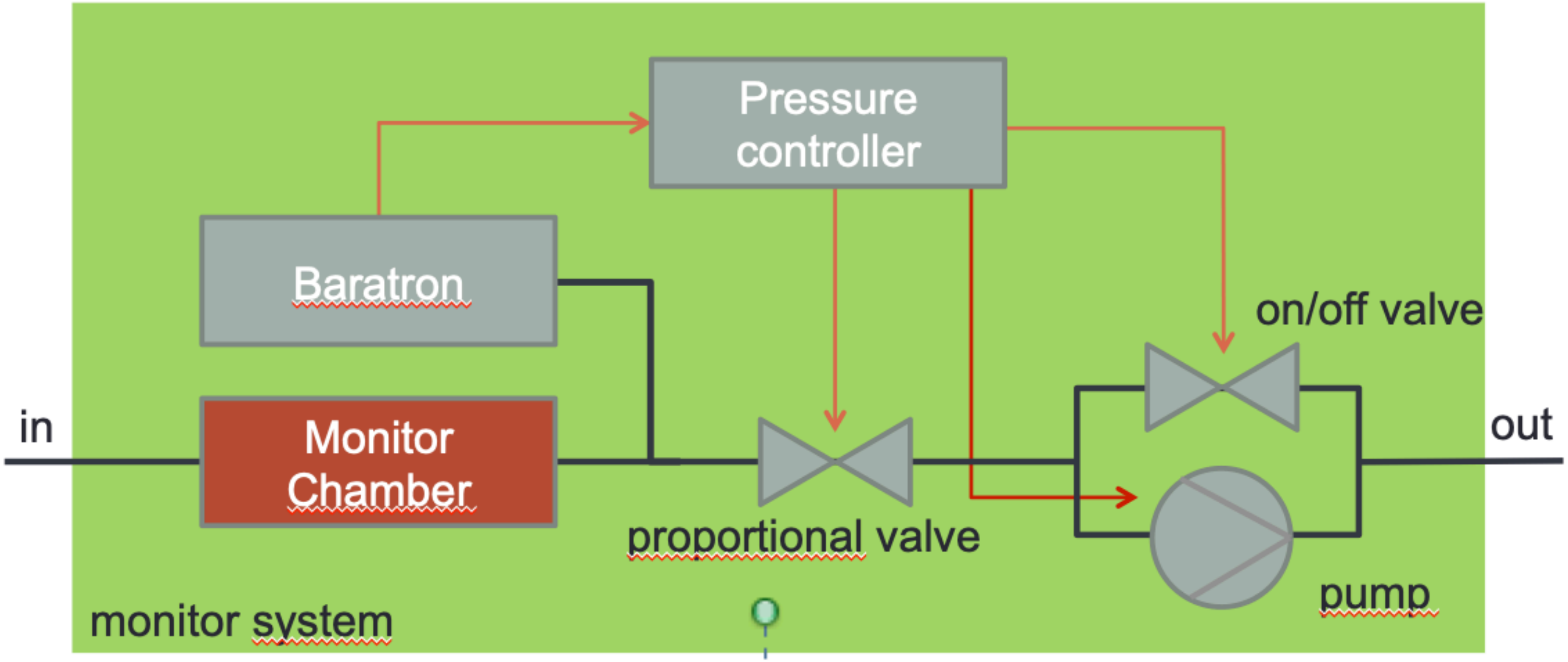
La raccomandazione della CSN1 nel 2019 è stata di continuare la attività formazione del personale con i colleghi di Lecce per poi procedere quest'anno alla valutazione della proposta.

Essa include:

- sorgente
- bombola di gas
- sistema di monitoraggio pressione del gas
- elettronica di lettura
- alimentazione e circuiti di alimentazione

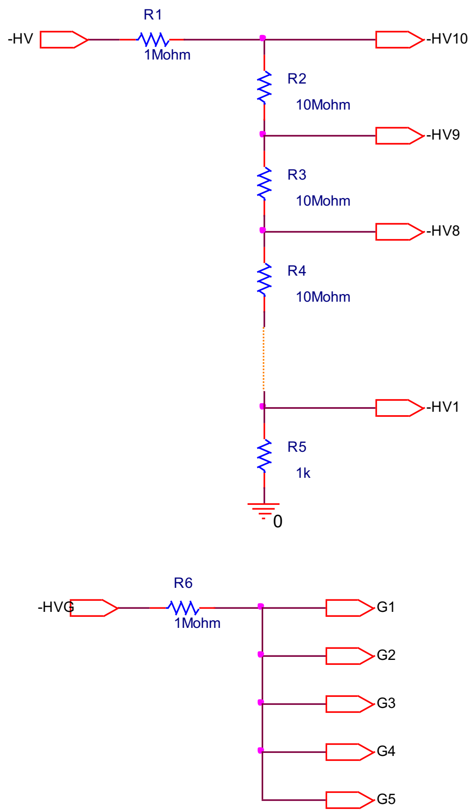
(vedi prossime 3 slide per i dettagli)

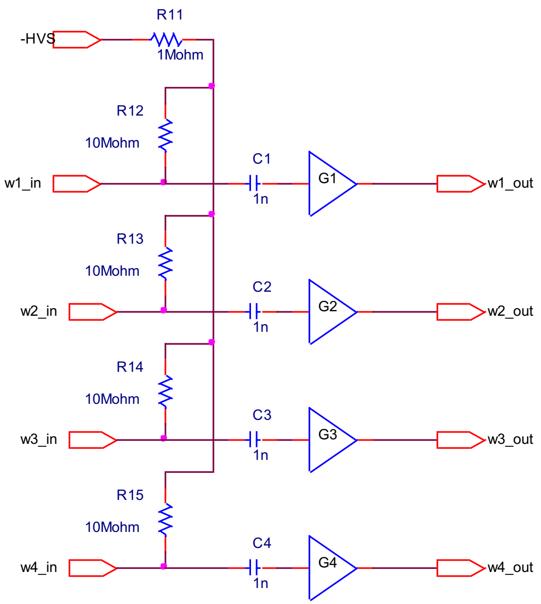
Monitor chamber: monitoring system

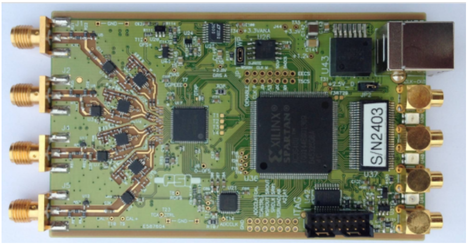


- Baratron: MKS mod. 631D range 0.1÷1000Torr (1383.00)
- Pressure controller: MKS mod. 250E-1D (2950.00)
- Proportional valve: MKS mod. 248D (832.00)
- Pump: 5l/min 120kPa (17.70)

Monitor chamber: biasing/amplifying - DC

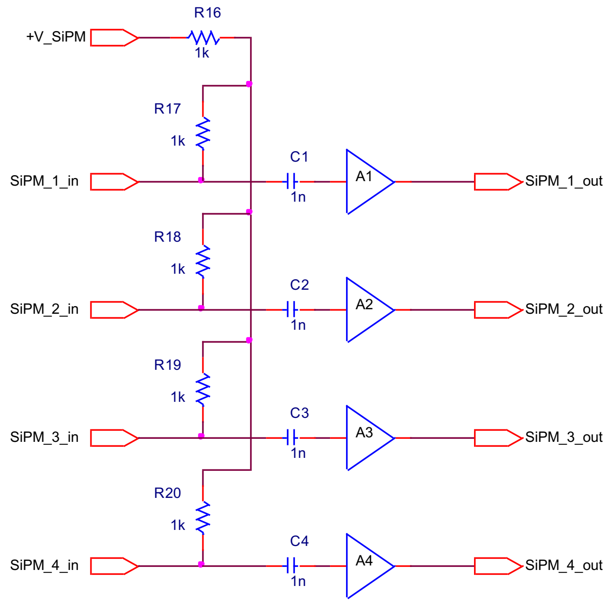






- Biasing
  - 20 (2x10) precision resistors for wires biasing
  - 1 resistor for guards wires biasing
  - 5 resistors for sense wires biasing
- Amplifing
  - 4 low-noise/distortion gain (~10) channels
- Digitizing
  - 4-channels WaveDream board

Monitor chamber: biasing/amplifying - SiPM



- Biasing
  - 30V dc
- Amplifing
  - 4 low-distortion gain channels

Richieste finanziarie per RD_FCC 2021

Consumi: supporto lab per “v_{drift} monitoring chamber”

Quantità	Descrizione	Modello	costo unitario	costo totale
gas				
1	Baratron	MKS mod. 631D	€ 1.383,00	€ 1.383,00
1	Pressure controller	MKS mod. 250E-1D	€ 2.950,00	€ 2.950,00
1	Proportional valve	MKS mod. 248D	€ 832,00	€ 832,00
1	Pump	5l/min 120kPa	€ 17,00	€ 17,00
1	Valvole per switch, raccordi, ecc		€ 600,00	€ 600,00
totale gas + IVA				€ 7.054,04
biasing				
2	convertitore DC/DC HV	CAEN A7502N, -2.1kV	€ 180,00	€ 360,00
2	alimentazione per SiPM		€ 200,00	€ 400,00
40	Resistenze HV	HVC2512-1G0JT18	€ 1,53	€ 61,20
8	wire pcb		€ 120,00	€ 960,00
totale biasing + IVA				€ 927,20
elettronica				
4	canali FE per fili		€ 70,00	€ 280,00
4	canali formazione SiPM		€ 50,00	€ 200,00
1	connettori, pcb		€ 200,00	€ 200,00
1	4-ch's WaveDream Board		€ 1.345,00	€ 1.345,00
totale elettronica + IVA				€ 2.470,50
totale				€ 10.451,74

Conclusioni

- Nell’arco del 2019 e 2020 sono partite molte attività relative al nostro impegno sui futuri acceleratori
- Le attività per FCC/CepC trovano ampio supporto e considerazione nelle decisione della European Strategy
- Abbiamo due progetti di ricerca ufficialmente approvati ed uno di *outreach*
- L’impegno è destinato a crescere nel breve e lungo termine