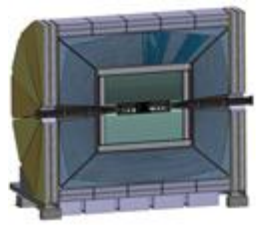
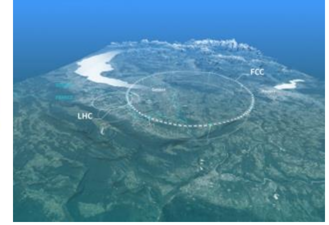
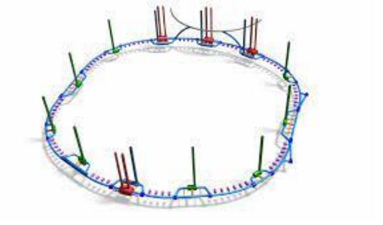


FCC: Status and prospective

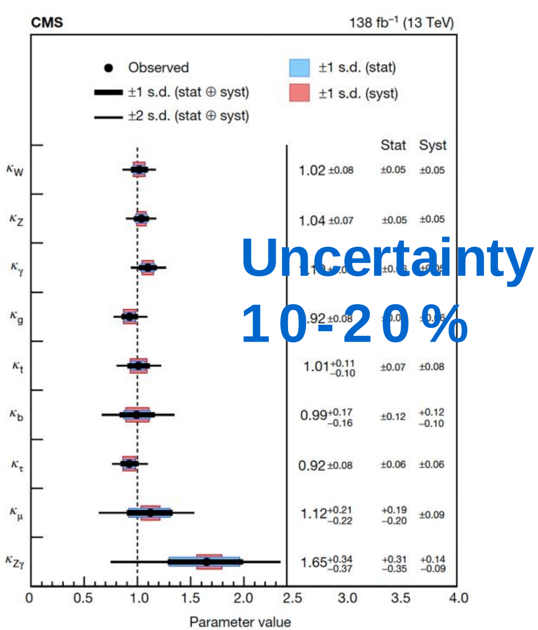
Nicola De Filippis
Politecnico and INFN Bari

21 Nov. 2024

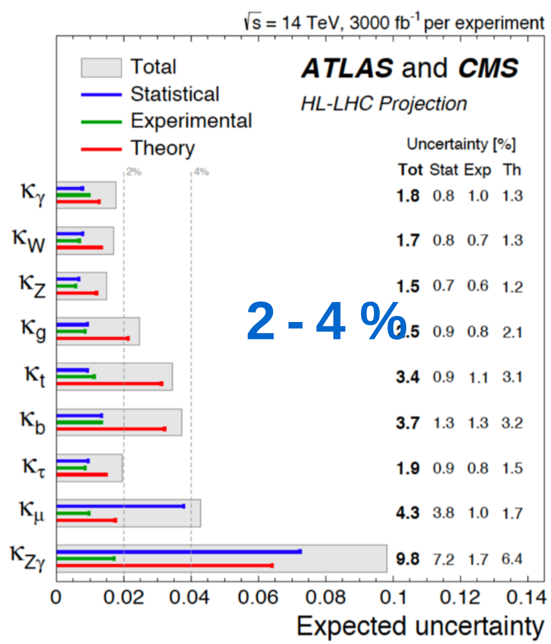
Landscape of the Higgs physics

So far many questions still open for Higgs physics:

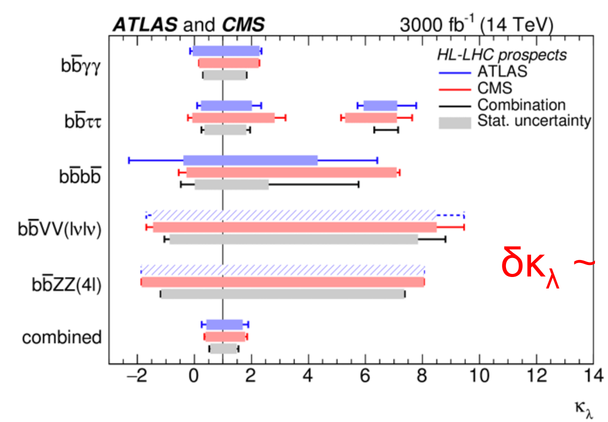
- ✓ How well the Higgs boson couplings to fermions, gauge bosons and to itself be probed at current, HL-LHC and future colliders?
- ✓ How do precision electroweak observables provide us information about the H properties and/or BSM physics?
- ✓ What progress is needed in theoretical developments in QCD and EWK to fully capitalize on the experimental data?
- ✓ What is the best path towards measuring the Higgs potential ?
- ✓ To what extent can we tell whether the Higgs is fundamental or composite?



Uncertainty 10-20%



2 - 4 %



$\delta\kappa_\lambda \sim 50\%$

➢ **Beyond HL-LHC:**

- ✓ Couplings to fermions to %-level, to bosons to per-mil
- ✓ self-coupling
- ✓ Invisible decays, BSM Higgses

N. De Filippis

FCC long-term program

2020 ES for HEP:

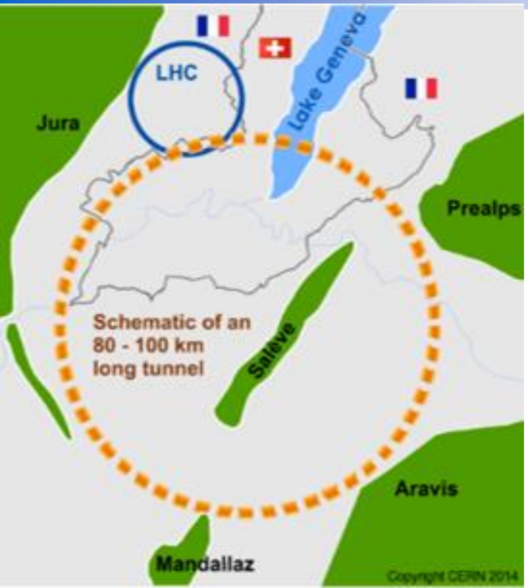
*"**An electron-positron Higgs factory is the highest priority next collider**. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy."*

"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."

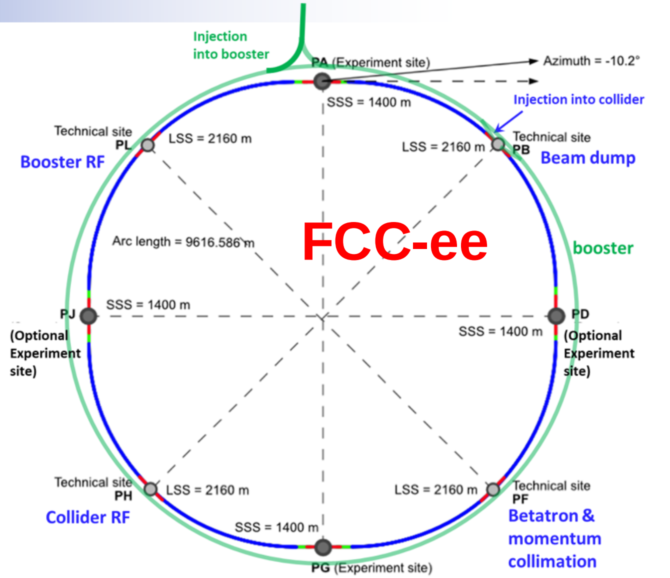
FCC@CERN: comprehensive program maximizing physics opportunities

- **stage 1: FCC-ee (Z, W, H, $t\bar{t}$) as Higgs factory, electroweak & top factory at highest luminosities**
- **stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, pp & AA collisions; e-h option**
- highly synergetic and complementary programme boosting the physics reach of both colliders
- FCC integrated project allows the start of a new, major facility at CERN within a few years of the end of HL-LHC

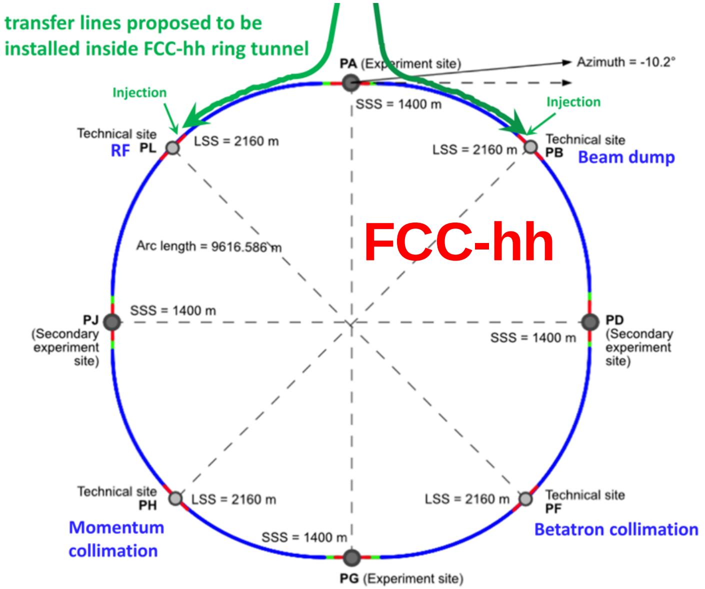
FCC long-term program



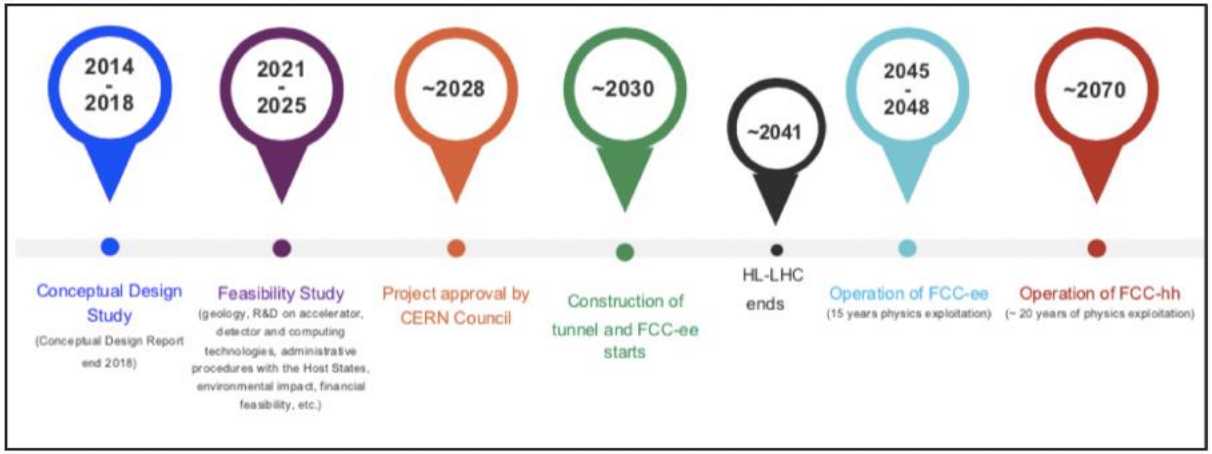
2020 - 2045

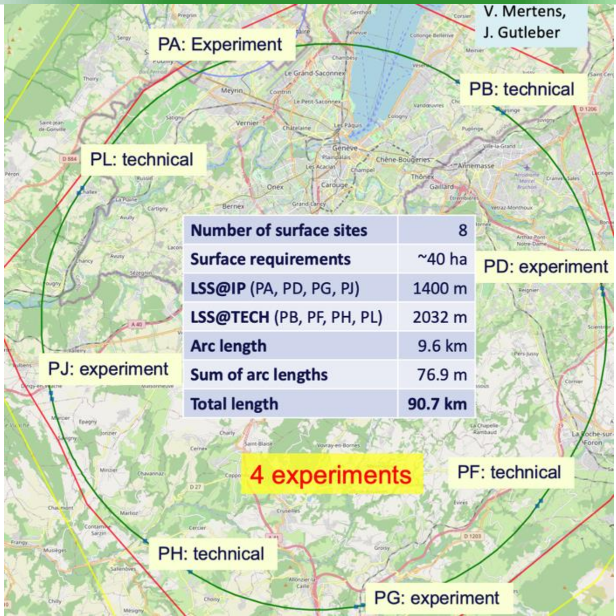


2045 - 2065



2070 -



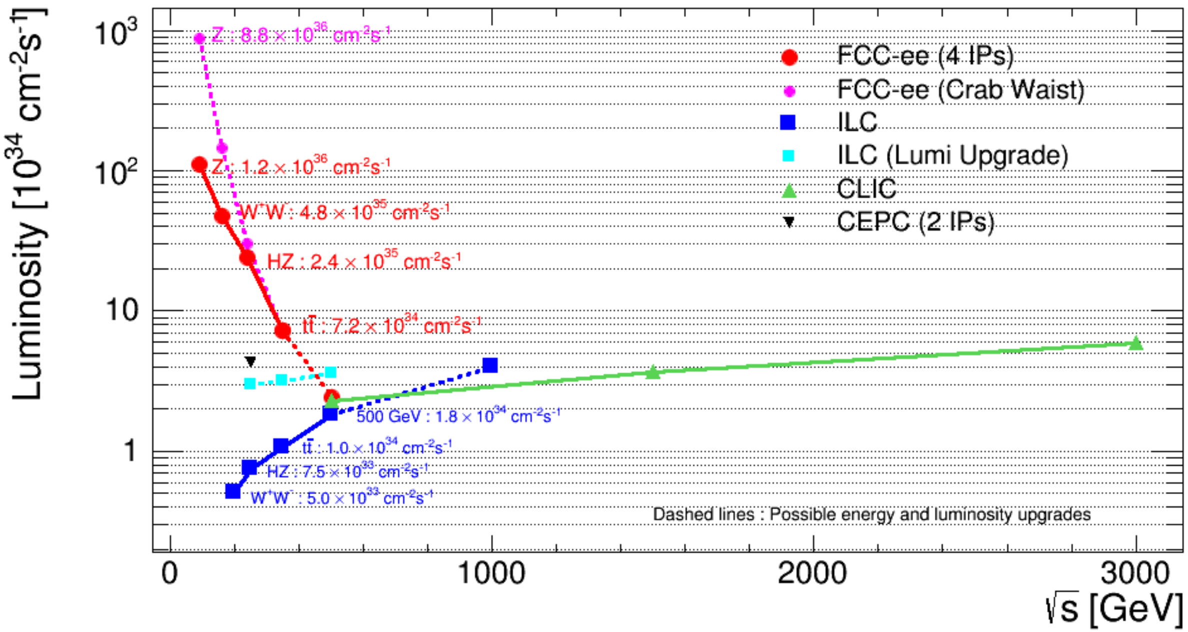


Number of surface sites	8
Surface requirements	~40 ha
LSS@IP (PA, PD, PG, PJ)	1400 m
LSS@TECH (PB, PF, PH, PL)	2032 m
Arc length	9.6 km
Sum of arc lengths	76.9 m
Total length	**90.7 km**

Final closest deliverable is a **Feasibility Study Report by March 2025**.

N. De Filippis

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



- Higgs factory:
  - 10^6 $e^+e^- \to HZ$
- EW & Top factory:
  - 3×10^{12} $e^+e^- \to Z$
  - 10^8 $e^+e^- \to W^+W^-$
  - 10^6 $e^+e^- \to tt$
- Flavor factory:
  - 5×10^{12} $e^+e^- \to bb, cc$
  - 10^{11} $e^+e^- \to \tau^+\tau^-$

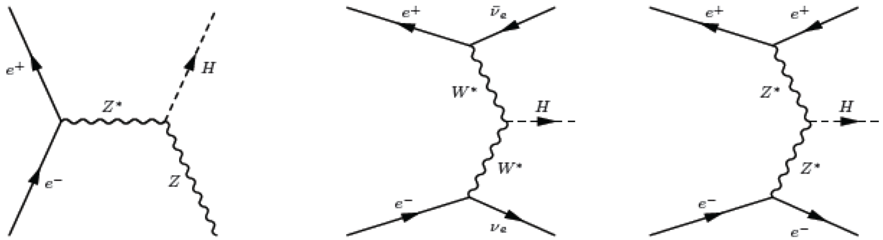
~100 kHz of physics data at the Z pole

Phase	Run duration (years)	Center-of-mass Energies (GeV)	Integrated Luminosity (ab^{-1})	Event Statistics	Extracted from FCC CDR
FCC-ee-Z	4	88-95 ± <100 KeV	150	3×10^{12} visible Z decays	LEP * 10^5
FCC-ee-W	2	158-162 <200 KeV	12	10^8 WW events	LEP * 2.10^3
FCC-ee-H	3	240 ± 2 MeV	5	10^6 ZH events	Never done
FCC-ee-tt	5	345-365 ± 5 MeV	1.5	10^6 $t\bar{t}$ events	Never done
s channel H	?	125 ± 2 MeV	10?	5000 events	Never done

$$\approx \frac{\Delta_{LEP,Stat}}{500}$$

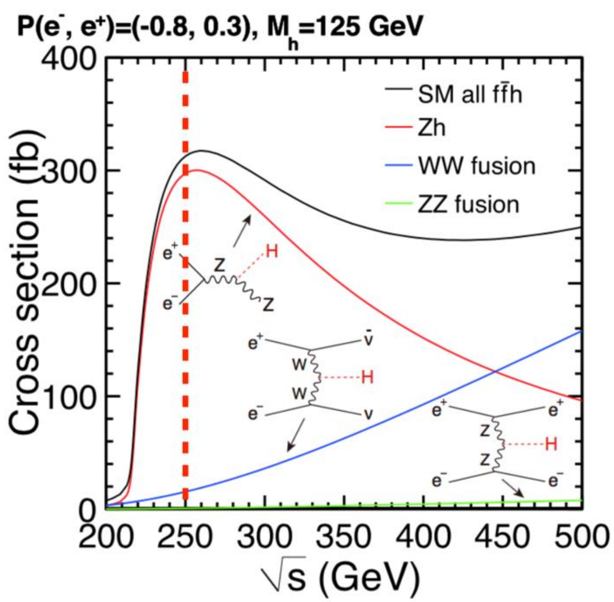
Higgs production at FCC-ee

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

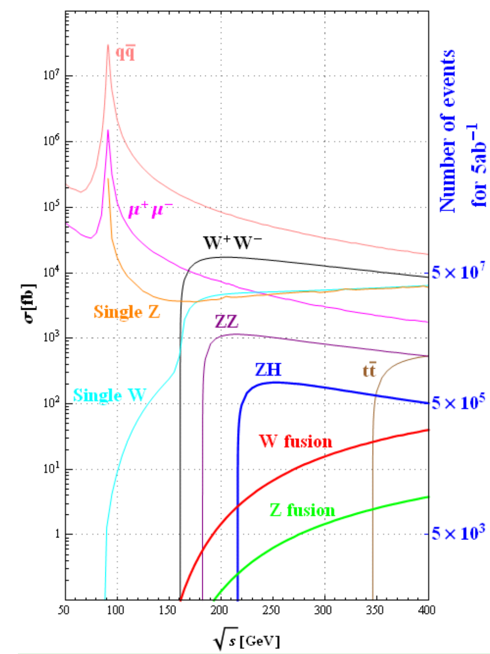


Higgs production @ FCC-ee		
Threshold	ZH production	VBF production
240 GeV / 5 ab^{-1}	1e6	2.5e4
365 GeV / 1.5 ab^{-1}	2e5	5e4

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

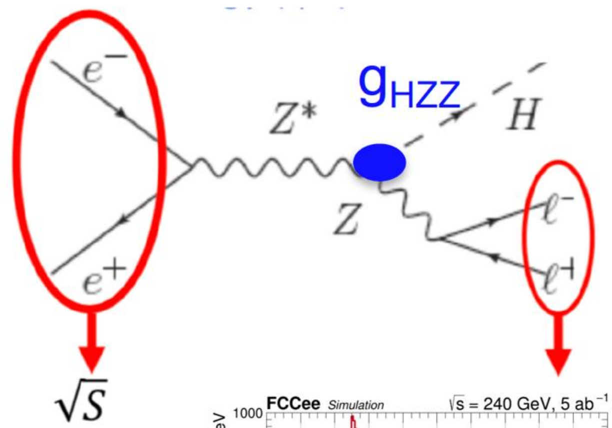


Process	Cross section	Events in 5 ab^{-1}
Higgs boson production, cross section in fb		
$e^+e^- \rightarrow ZH$	212	1.06×10^6
$e^+e^- \rightarrow \nu\bar{\nu}H$	6.72	3.36×10^4
$e^+e^- \rightarrow e^+e^-H$	0.63	3.15×10^3
Total	219	1.10×10^6
Background processes, cross section in pb		
$e^+e^- \rightarrow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



Global strategy for Higgs measurements

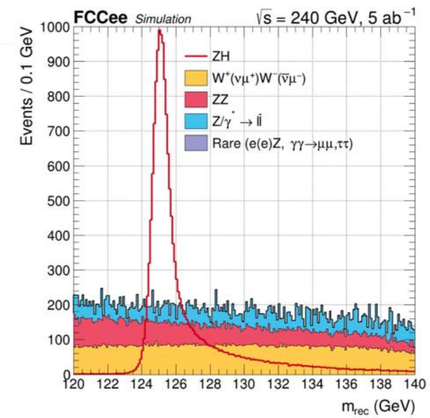
$\sigma(e^+e^- \rightarrow HZ) \,\alpha\, g^2_{HZZ}$



ZH events tagged by the Z, without reconstructing the Higgs decay. Unique to lepton colliders.

e.g. when Z → leptons : $m^2_{\mathrm{recoil}} = s + m^2_{\ell\ell} - 2\sqrt{s}(E_{\ell^+} + E_{\ell^-})$

A fit to the recoil mass distribution allows:



- measurement of σ(ZH) independent of the Higgs decay mode with O(%) uncertainty. Hence an absolute determination on g_{HZZ}

  → **$\delta g_{HZZ}/g_{HZZ}$ ~ 0.2 %** (also including Z→had)

- a precise meas. of the **Higgs mass → $\delta m_H/m_H$ ~ O(MeV)**

$$\sigma_{ZH} \times \mathcal{B}(\mathrm{H} \rightarrow \mathrm{X\overline{X}}) \propto \frac{g^2_{\mathrm{HZZ}} \times g^2_{\mathrm{HXX}}}{\Gamma_{\mathrm{H}}}$$

- H → ZZ* provides Γ_H
- H → XX provides g_{HXX}

H → ZZ* provides Γ_H :

$$\frac{\sigma(e^+e^- \rightarrow ZH)}{\mathrm{BR}(H \rightarrow ZZ^*)} = \frac{\sigma(e^+e^- \rightarrow ZH)}{\Gamma(H \rightarrow ZZ^*)/\Gamma_H} \simeq \left[\frac{\sigma(e^+e^- \rightarrow ZH)}{\Gamma(H \rightarrow ZZ^*)}\right]_{\mathrm{SM}} \times \Gamma_H$$

→ **$\delta\Gamma_H/\Gamma_H$ ~ several %**

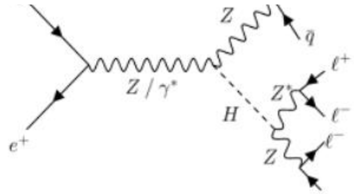
Selecting events with H → bb, cc, gg, WW, tt, γγ, μμ, Zγ, …

→ derive g_{Hbb}, g_{Hcc}, g_{Hgg}, g_{HWW}, g_{Htt}, $g_{H\gamma\gamma}$, $g_{H\mu\mu}$, $g_{HZ\gamma}$, … → **$\delta g_{XX}/g_{XX}$ ~ 1 %**

Selecting events with H → "nothing" → derive Γ(H→invisible)

ZH, Z→(qq/νν) H→ZZ*→4l studies

Yehia Mahmoud and Nicola De Filippis



Samples:

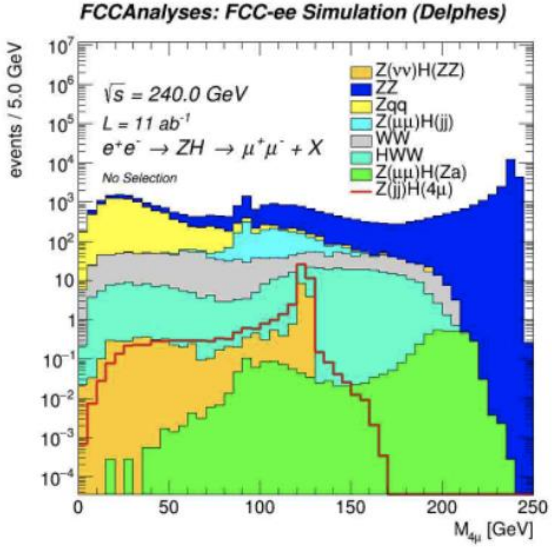
Produced by WHIZARD+PYTHIA for event generation and Delphes (IDEA detector card) for detector simulation. FCCee Winter 2023 Samples. Events produced at $\sqrt{s}$ = 240 GeV and L = 10.8 ab^{-1}.

Backround -> ZZ/ WW/ Zqq/ HWW/ Hjj/ HZa

Lepton Selection criteria (Same for hadronic and invisible channels):

- First pair of leptons (From On-shell Z)
  - Oppositely charged leptons
  - The pair which minimises $|M_{ll} - M_Z|$
- Second Pair of leptons (From off-shell Z)
  - Oppositely charged leptons
  - Highest momentum oppositely charged pair of the remaining

- Additional cut for 2e2mu: On-shell Z mass > 60 GeV. This is to remove contribution from Off-Shell Z leptons.

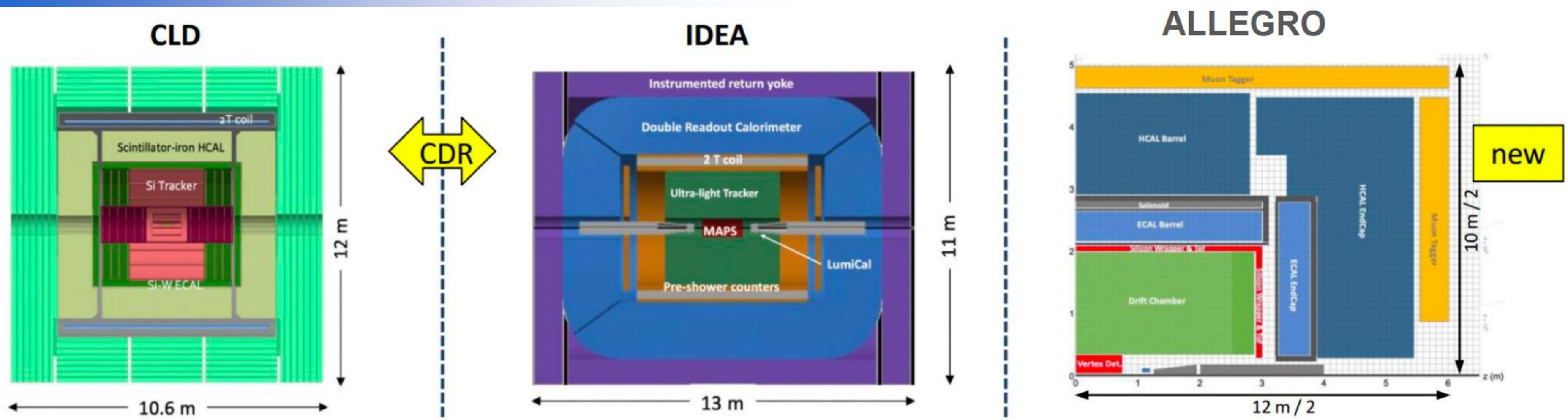


Analysis cuts:

- Momentum of the softest lepton
  P_{min} > 5 GeV.
- Missing momentum cut:
  P_{miss} < 40 GeV for Z(jj), P_{miss} > 100 GeV for Z(vv)
- Visible energy of all the reconstructed particles excluding the 4 leptons
  E_{vis} > 30 GeV
- Invariant mass of dimuon pair from the Off-shell Z*
  10 < M_{Z^*} < 65 GeV
- Invariant mass of the 4 leptons:
  124 < M_{4l} < 125.5 GeV

Channel	Signal yield	Total Bckg	s/√(s+b)
Z(jj)H(4μ)	26	3	4.82
Z(jj)H(4e)	19	8	3.6
Z(jj)H(2e2μ)	20	5	4.0
Z(vv)H(4μ)	9	4	2.496
Z(vv)H(4e)	6	2	2.12
Z(vv)H(2e2μ)	7	3	2.21

FCC-ee detector concepts - IDEA



Imported from CLIC
- Full Si tracker
- SiW Ecal HG
- SciFe Hcal HG
- Large coil outside

FCCee specific design
- Si Vtx + wrapper (LGAD)
- Large drift chamber (PID)
- DR calorimeter
- Small coil inside
- μ-WELL technology for muon chambers

FCCee specific design
- Tracker as IDEA
- LAr EM calorimeter
- Coil integrated
- Hcal not specified

INFN Bari strongly involved in the design, construction and operation of an ultra-light drift chamber for a high performance tracking and particle ID

- recent interest on using RPC technology for muon chambers

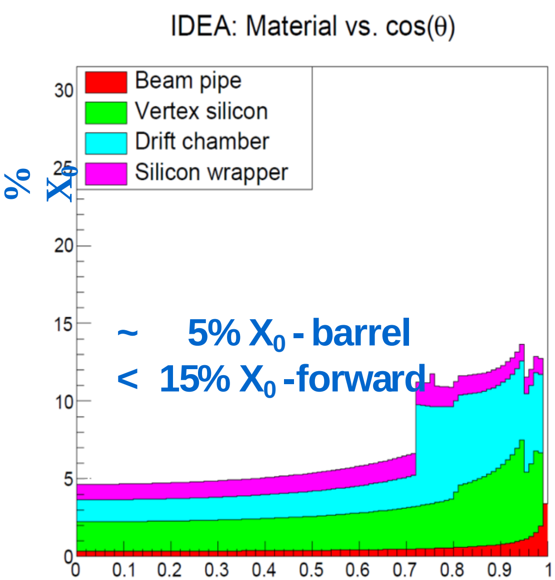
Requirements on track momentum resolution

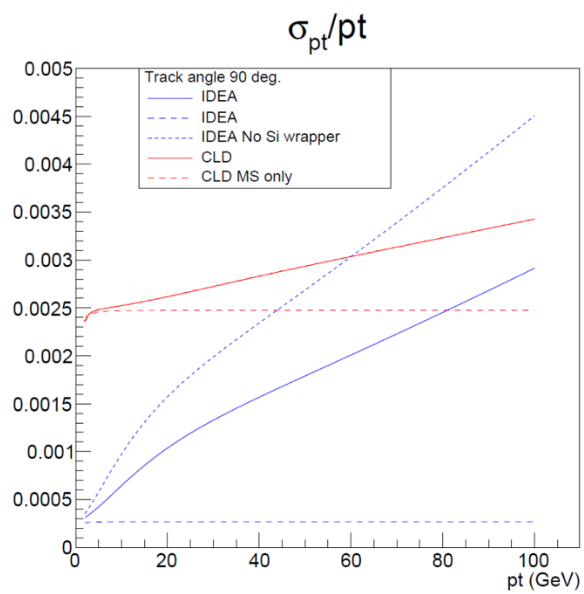
The IDEA Drift Chamber is designed to cope with transparency

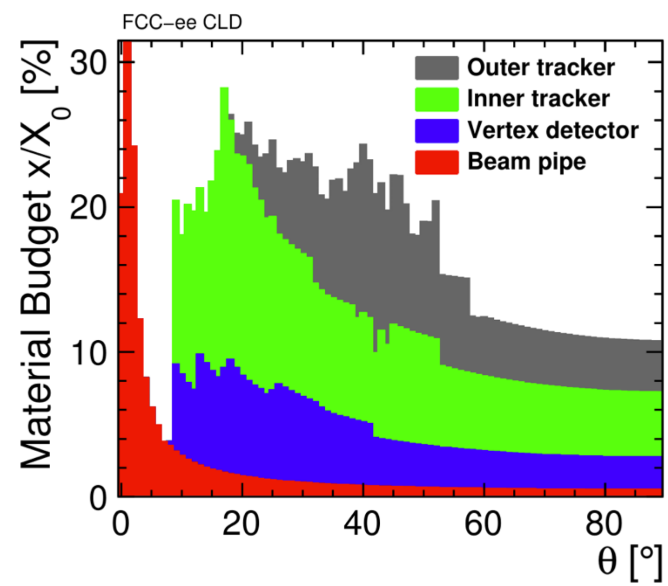
- a unique-volume, high granularity, fully stereo, low-mass cylindrical
- gas: He 90% - iC_4H_{10} 10%
- inner radius 0.35m, outer radius 2m
- length L = 4m

The CLD silicon tracker is made of:

- six barrel layers, at radii ranging between 12.7 cm and 2.1 m, and of eleven disks.
- the material budget for the tracker modules is estimated to be 1.1 − 2.1% of a radiation length per layer







For 10 GeV (50 GeV) μ emitted at an angle of 90° w.r.t the detector axis, the p_T resolution is

- about 0.05 % (0.15%) with the very light IDEA DCH
- about 0.25% (0.3%) with the CLD full silicon tracker, being dominated by the effect of MS

The Drift Chamber of IDEA

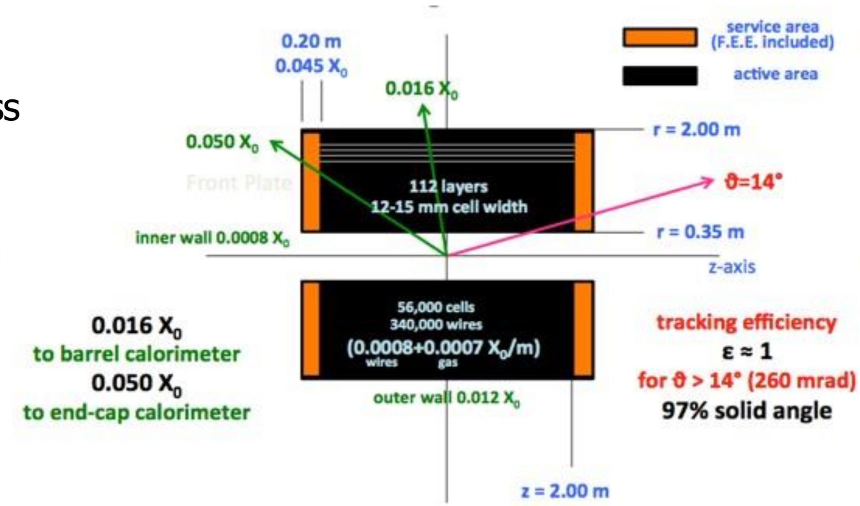
The DCH is:

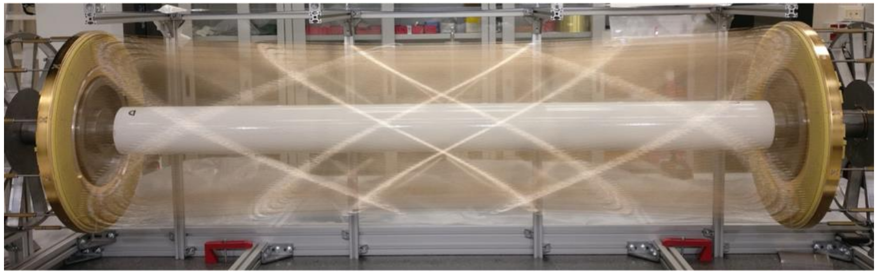
- a unique-volume, high granularity, fully stereo, low-mass cylindrical
- gas: He 90% - iC_4H_{10} 10%
- inner radius R_{in} = 0.35m, outer radius R_{out} = 2m
- length L = 4m
- drift length ~1 cm
- drift time up to 400ns
- σ_{xy} < 100 μm, σ_z < 1 mm
- 12÷14.5 mm wide square cells, 5 : 1 field to sense wires ratio
- 112 co-axial layers, at alternating-sign stereo angles, arranged in 24 identical azimuthal sectors, with frontend electronics
- 343968 wires in total:

  sense vires: 20 μm diameter W(Au) => 56448 wires

  field wires: 40 μm diameter Al(Ag) => 229056 wires

  f. and g. wires: 50 μm diameter Al(Ag) => 58464 wires





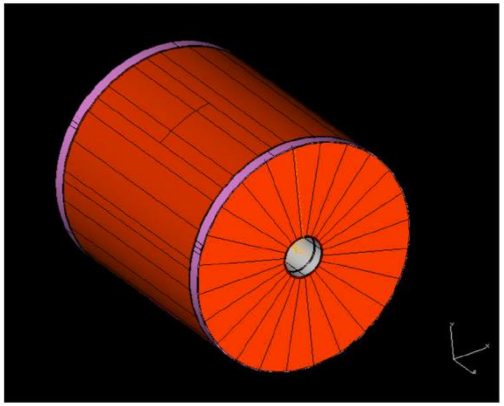
- the wire net created by the combination of + and – orientation generates a more uniform equipotential surface → better E-field isotropy and smaller ExB asymmetries)

- thin wires → increase the chamber granularity → reducing both multiple scattering and the overall tension on the endplates

Mechanical structure of the DCH

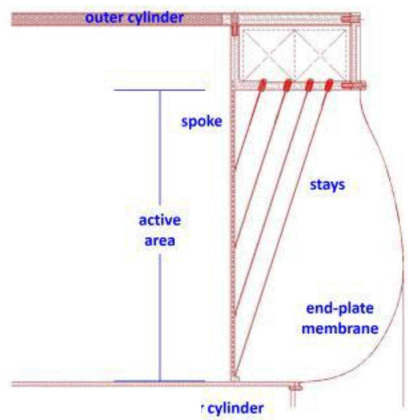
Miccoli (INFN Lecce)
F. Procacci (Ph. D. Poliba and INFN Bari)

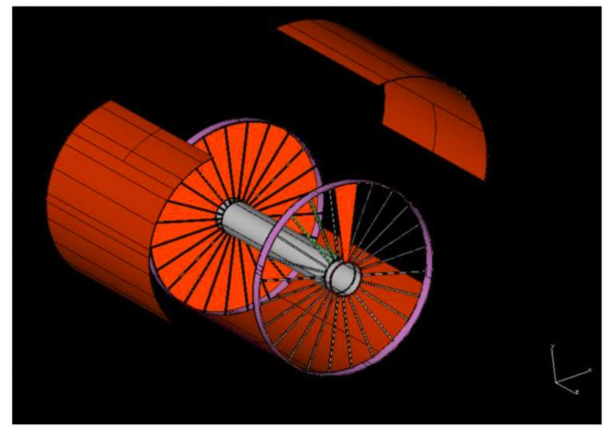
IDEA Drift Chamber



- Inner radius $\mathbf{R_{in}}$ **= 35 cm**, outer radius $\mathbf{R_{out}}$ **= 200 cm**
- Length **L = 400 cm**
- Inner wall thickness **200 μm** Carbon fiber
- Outer wall thickness **2cm** composite material sandwich (honeycomb structure)

tension recovery system



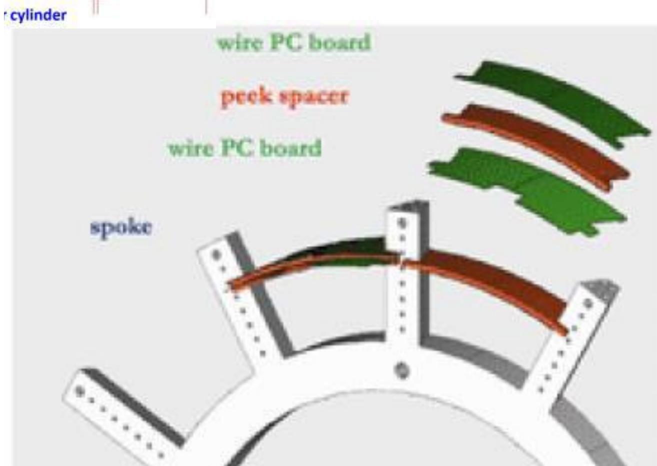


- **Inner cylinder** and **Outer cylinder** are connected with 48 **Spokes** (24 per endcap) forming 24 azimuthal sectors.
- Each spoke is supported by 15 **Cables.**
- Spoke length **l = 160cm**

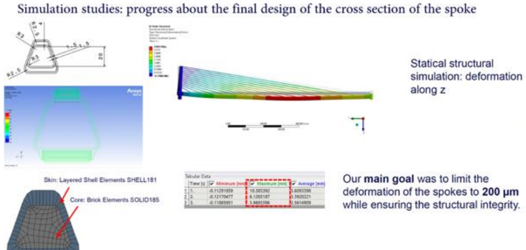
Big Problems to manage!

- σ_{xy} < **100 μm** → accuracy on the position of the anodic wires < **50 μm**.
- The anodic and cathodic wires should be parallel in space to preserve the constant electric field.
- A 20 μm tungsten wire, 4 m long, will bow about 400 μm at its middle point, if tensioned with a load of approximately 30 grams.

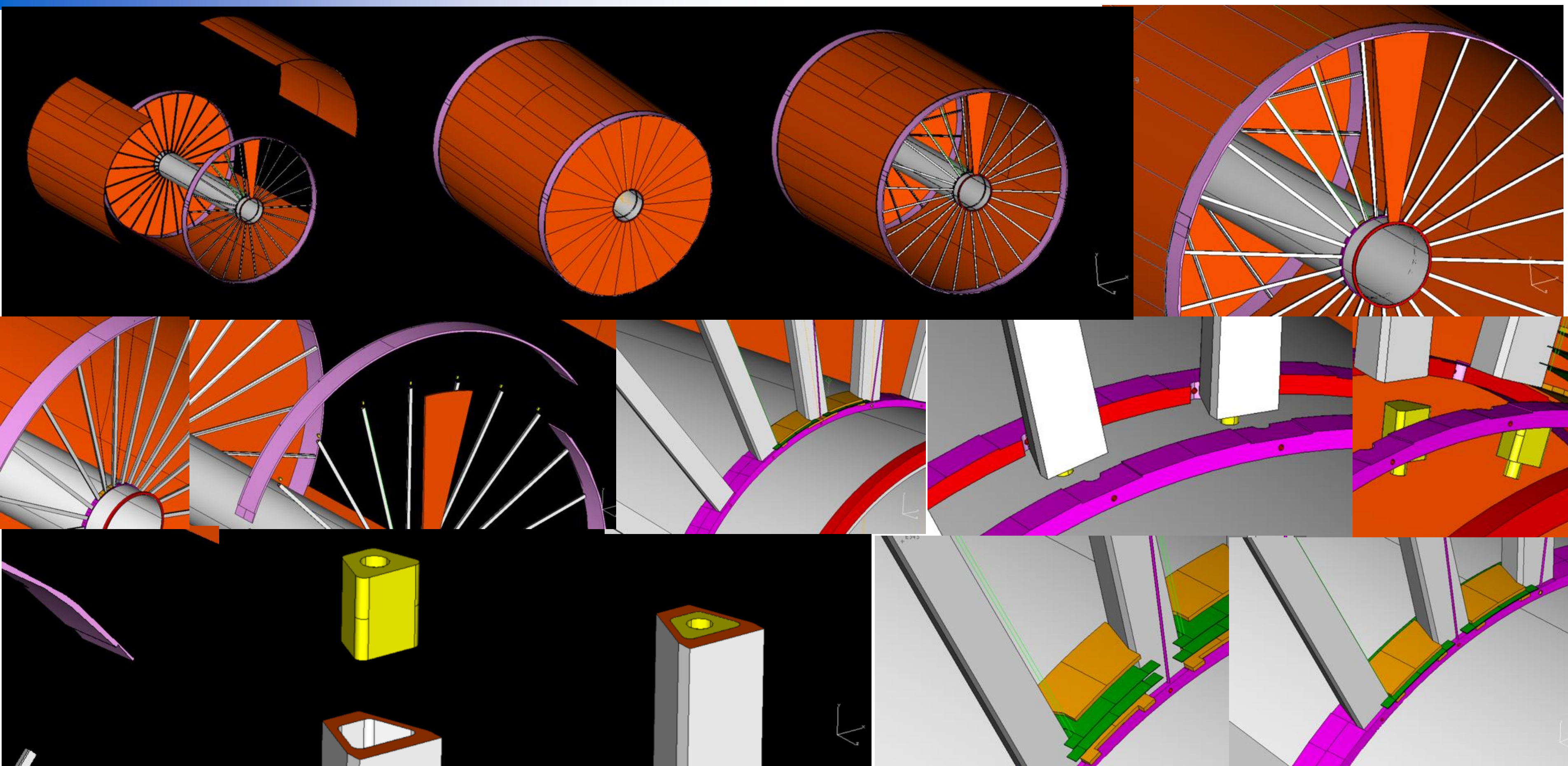
30 gr tension for each wire → **10 tonnes** of total load on the **endcap**

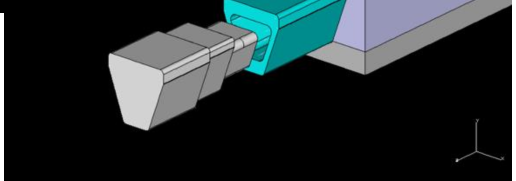


Simulation studies: progress about the final design of the cross section of the spoke



Mechanical structure: a complete model





Plan to start the construction of a DCH prototype full lenght, three sectors

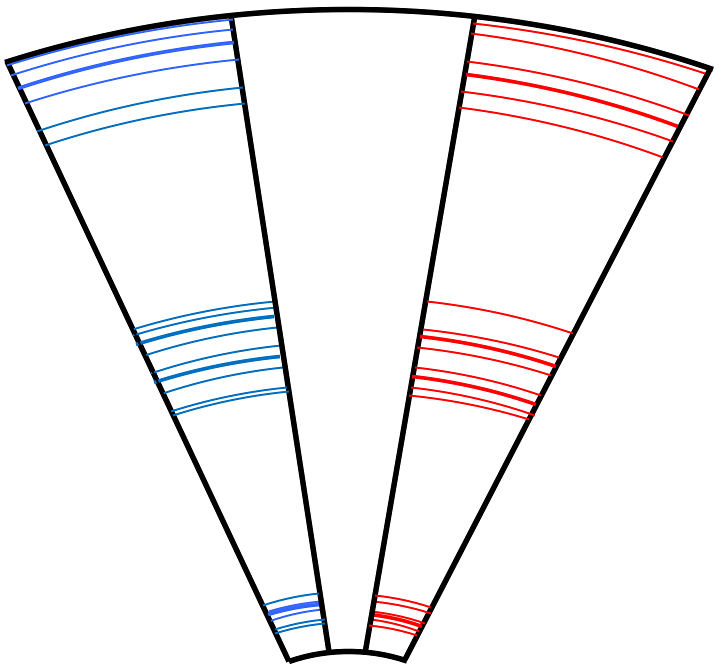
A realistic complete model ready:

- mechanically accurate
- precise definition of the connections of the cables on the structure
- connections of the wires on the PCB
- location of the necessary spacers
- connection between wire cage and gas containment structure

2025 full-length prototype: Configuration

Target: a full length DCH prototype with 3 sectors per endcap

- 8 spokes (4 per endcap)
- Internal ring
- part of the outer ring
- part of the cylindrical panel



First two layers of superlayer #1
V and U guard layers (2 x 9 guard wires)
V and U field layers (2 x 18 field wires)
U layer (8 sense + 9 guard)
U and V field layers (2 x 18 field wires)
V layer (8 sense + 9 guard)
V and U field layers (2 x 18 field wires)
V and U guard layer (2 x 9 guard wires)

Last two layers of superlayer #7
V and U guard layers (2 x 21 guard wires)
V and U field layers (2 x 42 field wires)
U layer (20 sense + 21 guard)
U and V field layers (2 x 42 field wires)
V layer (20 sense + 21 guard)
V field layer (42 field wires)

First two layers of superlayer #8
U field layer (46 field wires)
U layer (22 sense + 23 guard)
U and V field layers (2 x 46 field wires)
V layer (22 sense + 23 guard)
V and U field layers (2 x 46 field wires)
V and U guard layer (2 x 23 guard wires)

Last two layers of superlayer #14
V and U guard layers (2 x 35 guard wires)
V and U field layers (2 x 70 field wires)
U layer (34 sense + 35 guard)
U and V field layers (2 x 70 field wires)
V layer (34 sense + 35 guard)
V and U field layers (2 x 70 field wires)
V and U guard layer (2 x 35 guard wires)

TOTAL LAYERS: 8
Sense wires: 168
Field wires: 965
Guard wires: 264

PCBoards wire layers: 42
Sense wire boards: 8
Field wire boards: 22
Guard wire boards: 12
HV values: 14

Readout channels: 8+8 +16+16+16+16 + 16+16 = 112

2025 full-length prototype: Goals

- **Check the limits of the wires' electrostatic stability at full length and at nominal stereo angles**

- **Test different wires**: uncoated Al, C monofilaments, Mo sense wires, …, of different diameters
  - Test different wire anchoring procedures (soldering, welding, gluing, crimping, …) to the wire PCBs
  - Test different materials and production procedures for spokes, stays, support structures and spacers
  - Test compatibility of proposed materials with drift chamber operation (outgassing, aging, creeping, …)

- Validate the **concept of the wire tension recovery scheme** with respect to the tolerances on the wire positions
  - Optimize the layout of the wires' PCBs (sense, field and guard), according to the wire anchoring procedures, with aim at minimizing the end-plate total material budget

- Starting from the new concepts implemented in the MEG2 DCH robot, **optimize the wiring strategy**, by taking into account the 4m long wires arranged in multi-wire layers

- Define and validate **the assembly scheme** (with respect to mechanical tolerances) of the multi-wire layers on the end plates
  - Define the front-end cards channel multiplicity and their location (cooling system necessary?)

- **Optimize the High Voltage and signal distribution** (cables and connectors)

- Test performance of **different versions of front-end, digitization and acquisition chain**

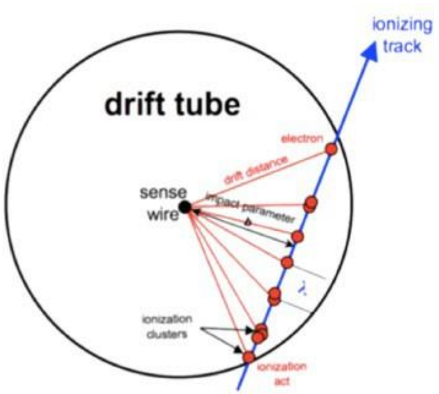
▸ ***Full-length prototype necessary***

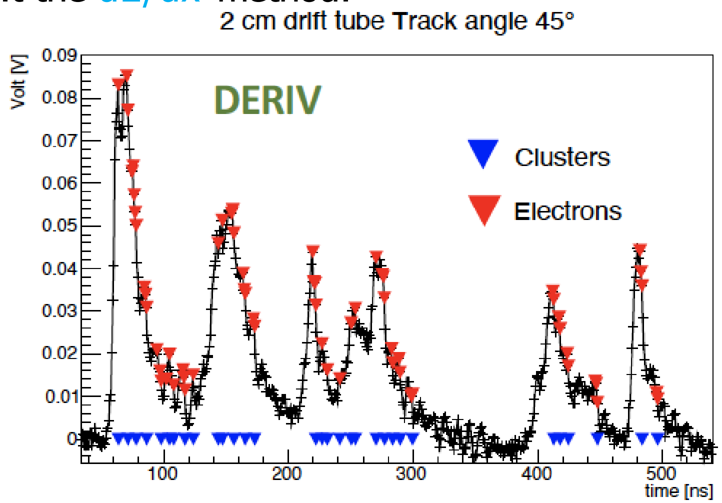
○ ***Can be done in parallel on small prototypes***

The Drift Chamber: Cluster Counting/Timing and PID

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.





- collect signal and identify peaks
- record the time of arrival of electrons generated in every ionisation cluster
- reconstruct the trajectory at the most likely position

Requirements
fast front-end electronics
(**bandwidth ~ 1 GHz**)
high sampling rate digitization
(**~ 2 GSa/s, 12 bits, >3 KB**)

- Landau distribution of dE/dx originated by the mixing of primary and secondary ionizations, has large fluctuations and limits separation power of PID → primary ionization is a Poisson process, has small fluctuations

- 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:

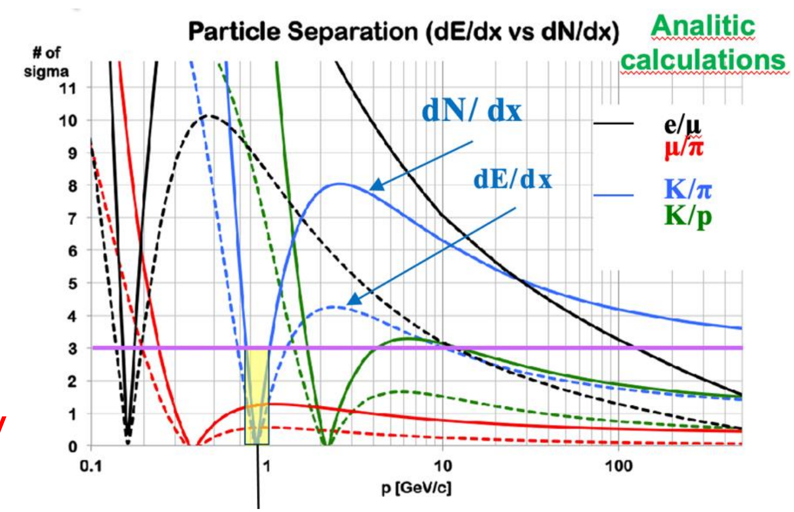
dE/dx: truncated mean cut (70-80%), with a 2m track at 1 atm give $\sigma \approx$ 4.3%

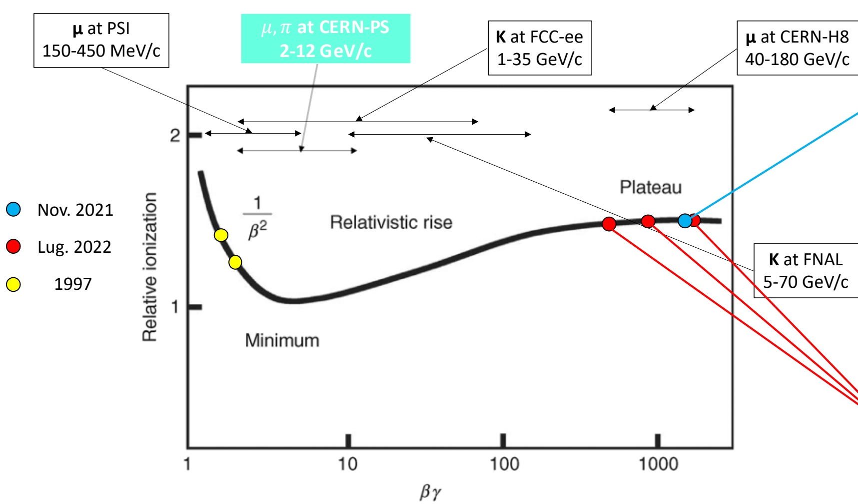
dN_{cl}/dx: for He/iC_4H_{10}=90/10 and a 2m track gives $\sigma_{dN_{cl}/dx}$ **/(dN_{cl}/dx)** < 2.0%

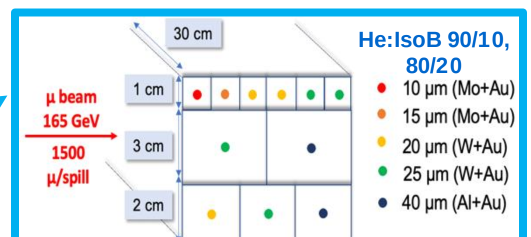
Beam tests in 2021,2022, 2023 and 2024

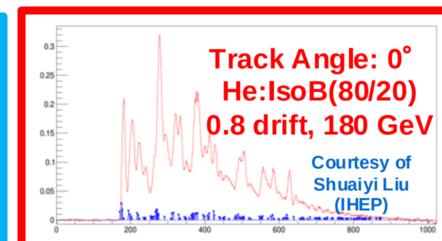
Beam tests to experimentally asses and optimize the **performance of the cluster counting/timing** techniques:

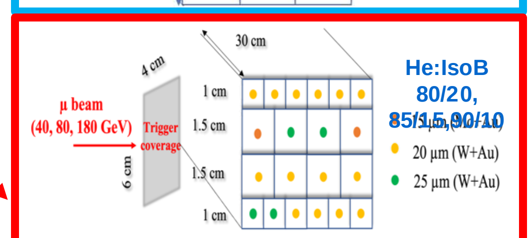
- two **muon beam tests** performed at **CERN ($\beta\gamma$ > 400)** in Nov. 2021 and July 2022 (p_T =165/180 GeV).
- a **muon beam test** (from 4 to 12 GeV momentum) in 2023 performed at **CERN**. A new testbeam with the same configuration done on July 10, 2024
- Ultimate test at **FNAL-MT6** in 2025 with □ and **K ($\beta\gamma$ = 10−140)** to fully exploit the relativitic rise.

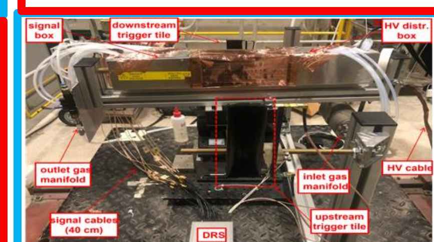








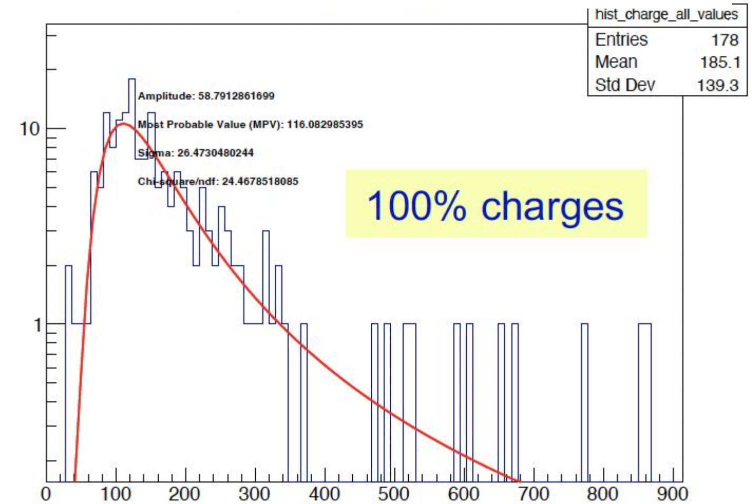




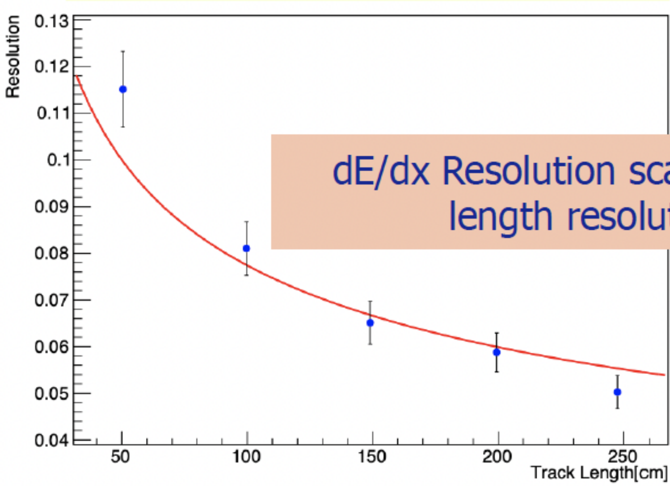
2021/2022 beam test results: resolutions

W. Elmetenawee (INFN Bari), M. Louka (Ph.D. Poliba and INFN Bari)

- Landau distribution for the charge along a track
- Selected the distribution with 80% of the charges for the dE/dx truncation, to be compared with dN/dx
- **NEW results**

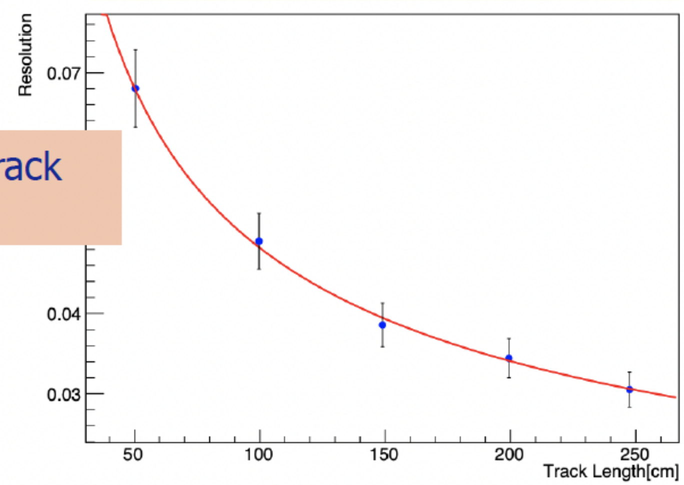


dE/dx Resolution



dE/dx Resolution scan vs track length resolution

dN/dx Resolution



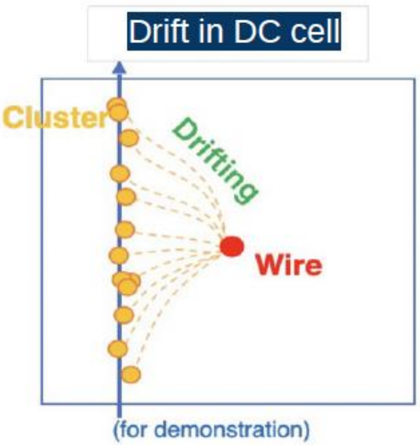
dE/dx resolution dependence on the track length $L^{-0.37}$

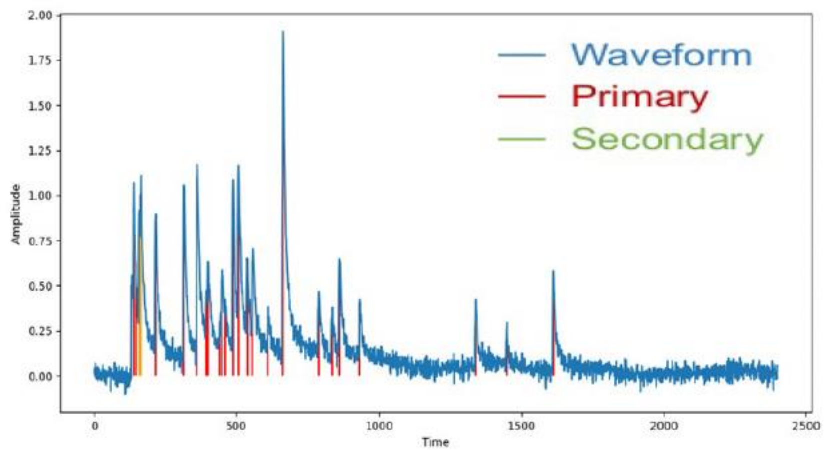
dN/dx resolution dependence on the track length $L^{-0.5}$

~ **2 times** improvement in the resolution using dN/dx method

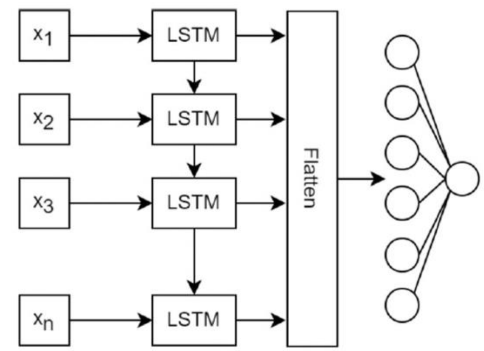
Simulation of Cluster Counting: GARFIELD + NN

M. Anwar (Ph. D. Poliba and INFN Bari)





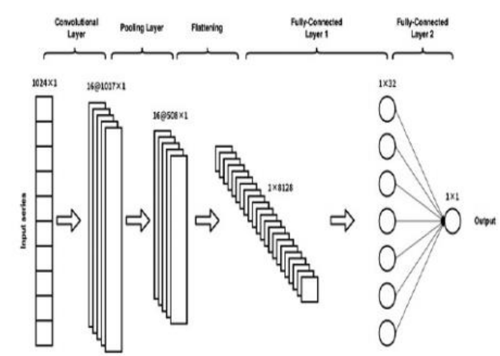
Digitizer in place → to be exported in Key4HEP for DCH full sumulation



- A muon particle is passed through mixture of gases (90% He and 10% C_4H_{10}) generate electron-ion pairs causing a read out signal (induce current). The simulation package creates analog induced current waveforms from ionizations (HEED). The digitization package incorporates electronics responses taken from experimental measurements and generates realistic digital waveforms

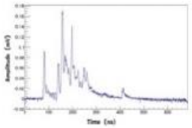
• Two Step Reconstruction Algorithm:

- **Peak finding**: Find all peaks (primary and secondary) in the waveform
- **Clusterization**: Determine the primary peaks from the founded peaks in step 1



Challenge: Data reduction and pre-processing

The excellent performance of the **cluster finding** algorithms in offline analysis, relies on the assumption of being able to transfer the full spectrum of the digitized drift signals.
However ...



according to the **IDEA drift chamber operating conditions**:
- 56448 drift cells in 112 layers (~130 hits/track)
- maximum drift time of 500 ns
- cluster density of 20 clusters/cm
- signal digitization 12 bits at 2 Gsa/s

... and to the **FCC-ee running conditions at the Z-pole**
- 100 KHz of Z decays with 20 charged tracks/event multiplicity
- 30 KHz of $\gamma\gamma \longrightarrow$ hadrons with10 charged tracks/event multiplicity
- 2.5% occupancy due to beam noise
- 2.5% occupancy due to hits with isolated peaks

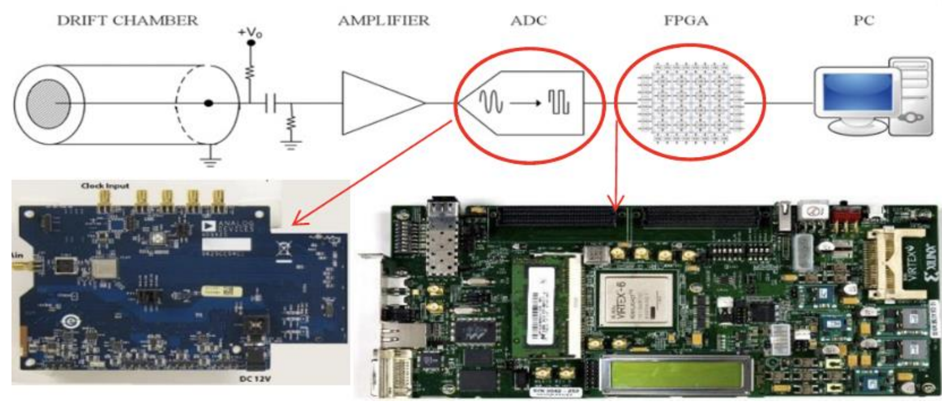
Reading both ends of the wires, ⇨ data rate ≥ 1 TB/s !

Solution consists in transferring, for each hit drift cell, instead of the full signal spectrum, only the minimal information relevant to the application of the **cluster timing/counting techniques**, i.e.:

the amplitude and **the arrival time** of each peak
associated with each individual ionisation electron.

G. De Robertis, F.Loddo and a Ph.D (INFN Bari)

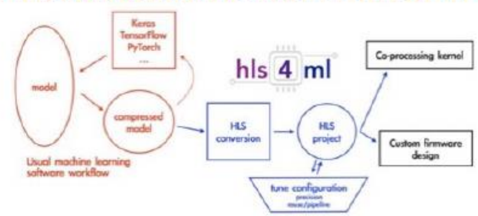
This can be accomplished by using a **FPGA** for the **real time analysis** of the data generated by the drift chamber and successively digitized by an ADC.

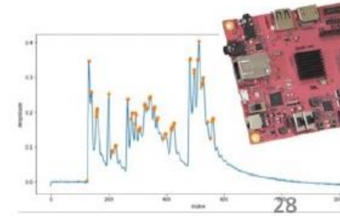


Single channel solution has been successfully verified.
G. Chiarello et al., The Use of FPGA in Drift Chambers for High Energy Physics Experiments May 31, 2017
DOI: 10.5772/66853

With this procedure **data transfer rate is reduced to ~ 25 GB/s**
Extension to a 4-channel board is in progress. Ultimate goal is a multi-ch. board (128 or 256 channels) to **reduce cost** and complexity of the system and to gain flexibility in determining the **proximity correlations** between hit cells for track **segment finding** and for **triggering** purposes.

Implementing ML algorithms on FPGA for peak finding





International collaboration

INFN Bari + Lecce

INFN Pisa joining with MEG DCH experts

INFN Perugia joining for tracking studies

G. Iakovidis group from BNL (US): wire procurement

A. Jung group from Purdue U. (US):

- coating / manufacturing facility at composite center Purdue would allow manufacturing all kinds of materials
- existing supported R&D on US side
  - composite R&D for thicker high TC / electric C CFs
  - reconstruction / tracking for FCC folded GEANT work of implementing CF into sim
  - prototype of CF and reference of tungsten being constructed in lab

G. Charles group from IJCLAB (France)

- any test with wire material, choice for the prototype chosen but new ones could be tested. Produce charaterization of strength, maybe with a micrometric motor. Test different kind of wires
- test also of anchoring the wire (crimp, gluing, soldering)
- activity on mechanical design and realization of prototypes
- Garfield simulation studies, participation to testbeam campaigns
- Activity on electronics to be verified with IN2P3

IHEP (China): Effort to build a international collaboration enforced

- ➢ well established collaboration with IHEP for NN-based cluster counting algorithm

Summary/Conclusions

Good progress reported on:

- mechanical structure design
- on going effort to build a full-length prototype next year
- testbeam data analysis → NEW results on cluster counting

Plenty of areas for collaboration (also in the context of DRD1 WP2):

- detector design, construction, beam test, performance
- local and global reconstruction, full simulation
- physics performance and impact
- etc.

Effort to build a national and international collaboration

Backup

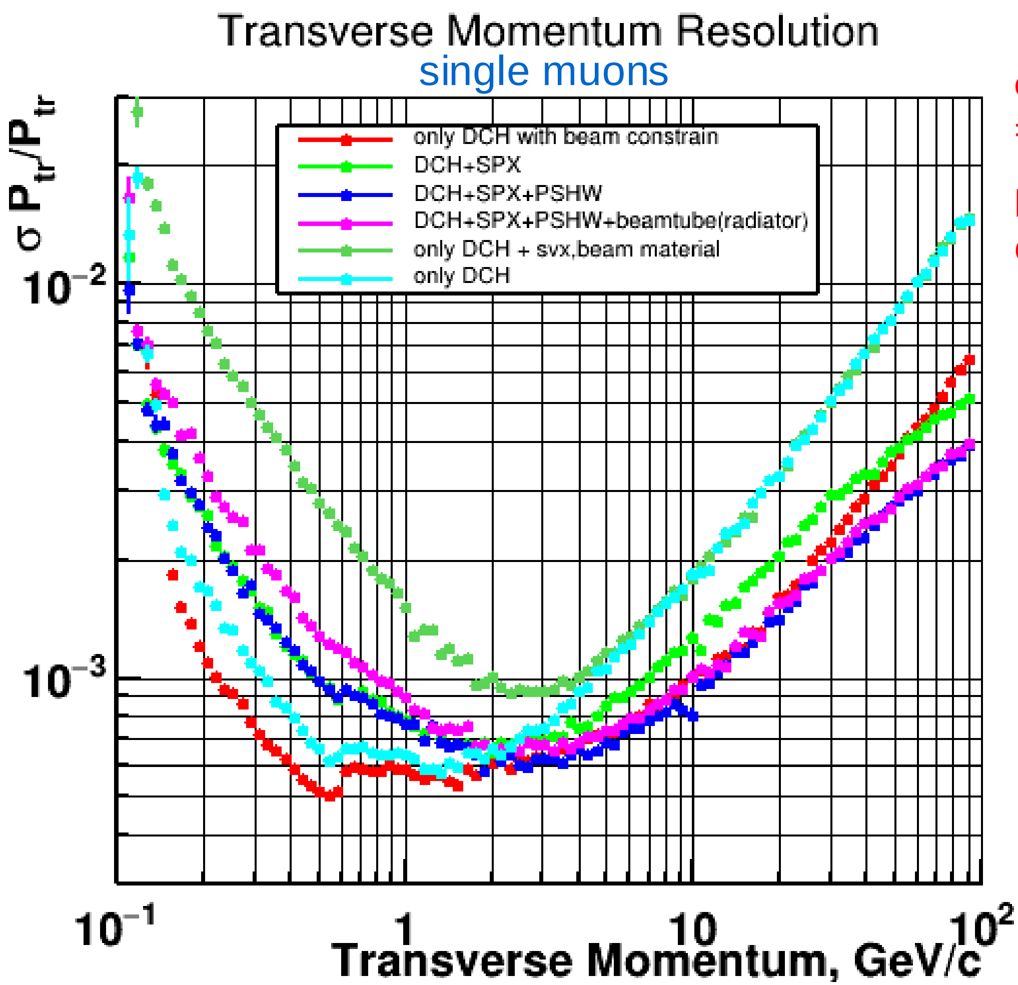
Full simulation of IDEA: performance of the IDEA (old) + tracking + background studies

For the Geant4 based simulation framework code:

$$\frac{\Delta p_T}{p_T}\Big|_{res.} = \frac{\sigma_{r\phi}\, p_T}{0.3\, B_0 L_0^2}\sqrt{\frac{720 N^3}{(N-1)(N+1)(N+2)(N+3)}}$$

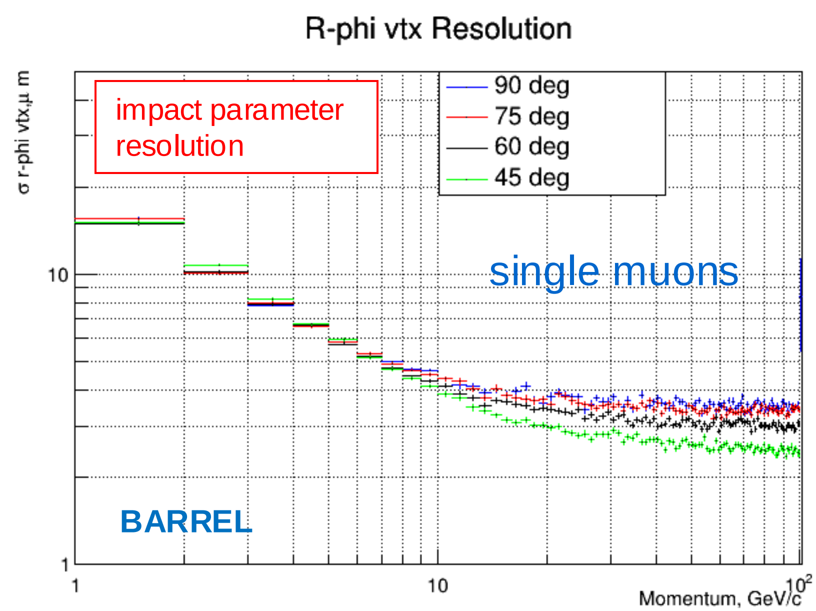
$$\approx \frac{12\, \sigma_{r\phi}\, p_T}{0.3\, B_0 L_0^2}\sqrt{\frac{5}{N+5}}$$

$$\frac{\Delta p_T}{p_T}\Big|_{m.s.} = \frac{N}{\sqrt{(N+1)(N-1)}}\,\frac{0.0136\,\mathrm{GeV/c}}{0.3\beta\, B_0 L_0}\sqrt{\frac{d_{tot}}{X_0\,\sin\theta}}\left(1 + 0.038\ln\frac{d}{X_0\,\sin\theta}\right)$$



$\sigma(p_t)/p_t$ (100 GeV) $= 3\times10^{-3}$

but new studies ongoing



$\sigma(d_0)$ (100 GeV) = 2μm

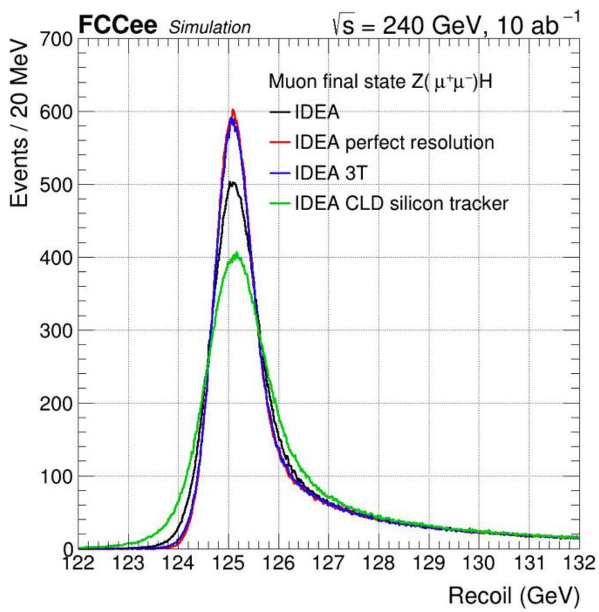
N. De Filippis

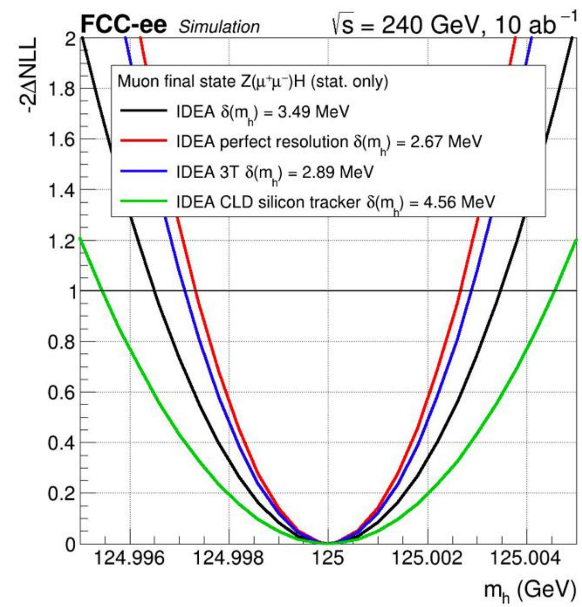
Constraint from Higgs Mass measurement

Higgs boson mass to be measured with a precision better than its natural width (4MeV), in view of a potential run at the Higgs resonance

Higgs mass reconstructed as the recoil mass against the Z, M_{recoil} , and solely from the Z

$$M_{recoil}^2 = (\sqrt{s} - E_{l\bar{l}})^2 - p_{l\bar{l}}^2 = s - 2E_{l\bar{l}}\sqrt{s} + m_{l\bar{l}}^2$$





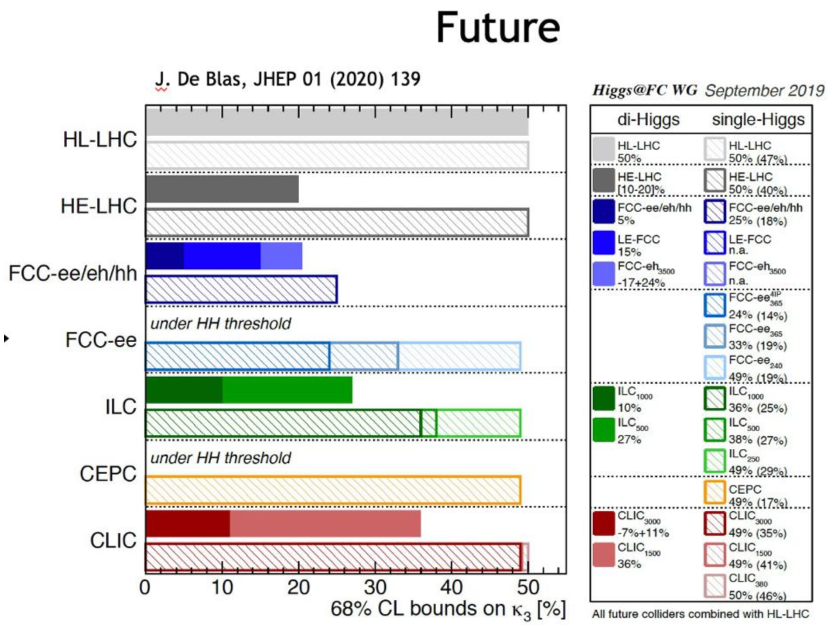
μ from Z, with momentum of O(50) GeV, to be measured with a p_T resolution smaller than the BES in order for the momentum measurement not to limit the mass resolution

- achieved with the baseline IDEA detector → uncertainty of 4.27 MeV with 10 ab^{-1}
- CLD performs less well because of the larger amount of material → larger effects of MS

If the B increased from 2T to 3T → 50% improvement of the momentum resolution
14% improvement on the total mass uncertainty

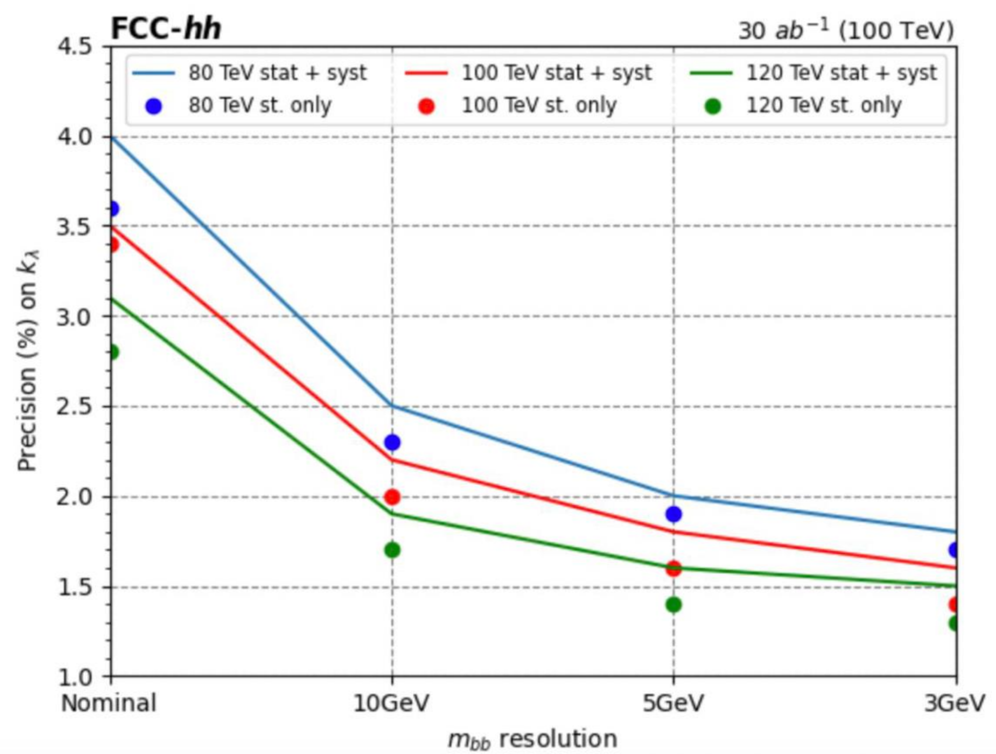
Higgs self couplings at FCC-hh

A, Taliercio, N. De Filippis



Future limits on k_λ

$\bar{b}b\gamma\gamma$ analysis: center of mass energy scan



FUTURE CIRCULAR COLLIDER

Progress on international collaboration

Joint Statement of Intent between The United States of America and The European Organization for Nuclear Research concerning Future Planning for Large Research Infrastructure Facilities, Advanced Scientific Computing, and Open Science

The United States and CERN intend to:

- Enhance collaboration in future planning activities for large-scale, resource-intensive facilities with the goal of providing a sustainable and responsible pathway for the peaceful use of future accelerator technologies;
- Continue to collaborate in the feasibility study of the Future Circular Collider Higgs Factory (FCC-ee), the proposed major research facility planned to be hosted in Europe by CERN with international participation, with the intent of strengthening the global scientific enterprise and providing a clear pathway for future activities in open and trusted research environments; and
- Discuss potential collaboration on pilot projects on incorporating new analytics techniques and tools such as artificial intelligence (AI) into particle physics research at scale.

Should the CERN Member States determine the FCC-ee is likely to be CERN's next world-leading research facility following the high-luminosity Large Hadron Collider, the United States intends to collaborate on its construction and physics exploitation, subject to appropriate domestic approvals.

26 April 2024

White House Office of Science and Technology Policy Principal Deputy U.S. Chief Technology Officer Deirdre Mulligan signed for the United States while Director-General Fabiola Gianotti signed for CERN.

EU Competitiveness Report

edited by Mario Draghi, and officially handed over to Ursula von der Leyen in September 2024

https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en

"One of CERN's most promising current projects, with significant scientific potential, is the construction of the Future Circular Collider (FCC): a 90-km ring designed initially for an electron collider and later for a hadron collider..

Refinancing CERN and ensuring its continued global leadership in frontier research should be regarded as a top EU priority*, given the objective of maintaining European prominence in this critical area of fundamental research, which is expected to generate significant business spillovers in the coming years."*

Supporting statements at CERN’s 70 anniversary

“….No European country alone could have built the world’s largest particle collider. CERN has become a global hub because it rallied Europe and this is even more crucial today.

I am proud that we have financed the feasibility study for CERN’s Future Circular Collider (FCC). This could preserve Europe's scientific edge and could push the boundaries of human knowledge even further. *And as the global science race is on, I want Europe to switch gears. To do so, European unity is our greatest asset. ….”*