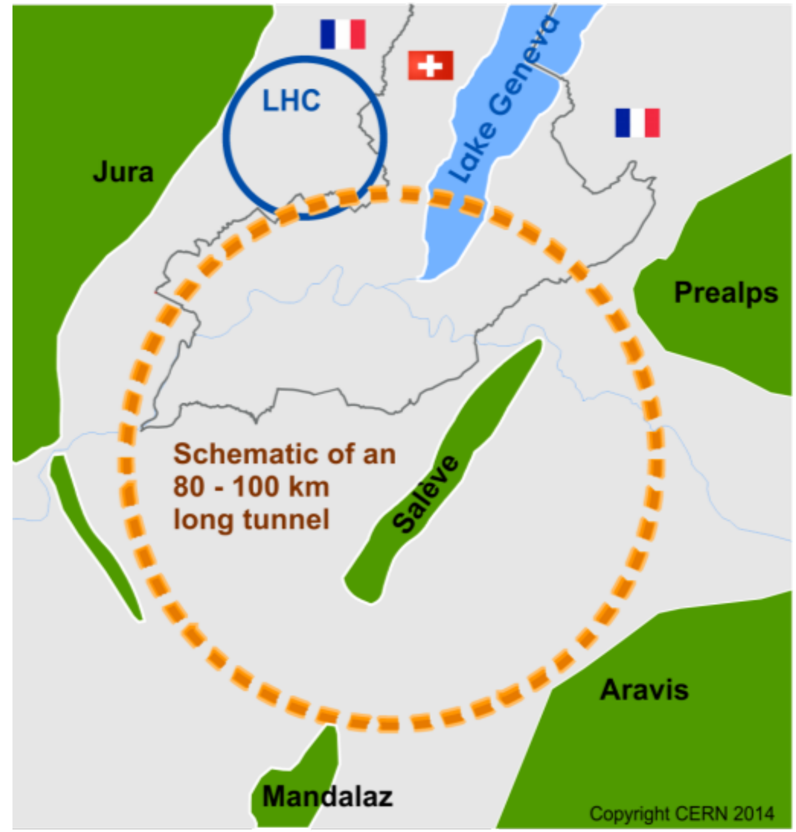
(NUOVA) SIGLA FCC

The FCC Design Study

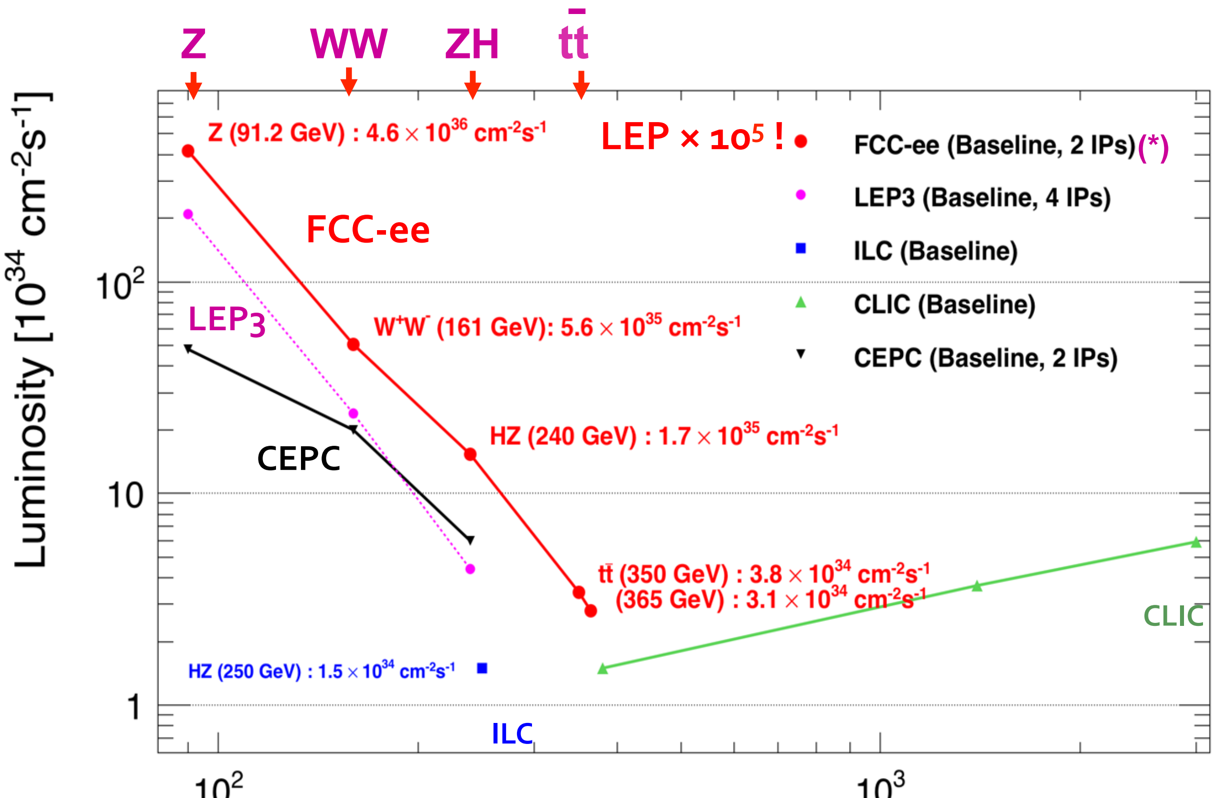
- **Requested from European Strategy (2013)**
  - "Ambitious post-LHC accelerator project"
    - Study kicked off in Geneva in Feb. 2014
- **International collaboration to study circular colliders (111 institutes)**
  - Fitting in a new 100 km infrastructure, in the Geneva area
- **Ultimate goal: 100TeV pp collider (FCC-hh)**
  - Requires R&D for 16T magnets
  - Defines the infrastructure
- **Possible first steps**
  - e^+e^- collider (FCC-ee) at the intensity frontier
    - High luminosity, $\sqrt{s}$ = 90-400 GeV
  - pp collider (HE-LHC) in the LEP/LHC tunnel
    - With FCC-hh technology (16T $\rightarrow$ 28 TeV)
- **Possible add-on**
  - e-p option (FCC-eh)



- **European Strategy update (2019)**
  - Conceptual design report (CDR)
  - Cost review for tunnel and each collider
  - Schedules and operation models

Energies and luminosities at the FCC-ee

- The FCC-ee offers the largest luminosities in the 88 → 365 GeV √s range



(*) A study for a 4 IPs FCC-ee has been requested by the CERN management and is foreseen to be conducted this year (2019)

- Ultimate precision:
  - 100 000 Z / second (!)
    - 1 Z / second at LEP
  - 10 000 W / hour
    - 20 000 W at LEP
  - 1 500 Higgs bosons / day
    - 10 times ILC
  - 1 500 top quarks / day

  in each detector

... in a clean environment:

- No pileup
- Beam backgrounds under control
- E,p constraints

PRECISION and SENSITIVITY to rare or elusive phenomena

- The FCC-ee precision for the study of the Higgs boson is multiplied by the presence of the four heaviest SM particles (Z, W, H, and top) in its energy range

CEPC proposal in China very similar (no top threshold): community trying to optimizie the software and detector development effort

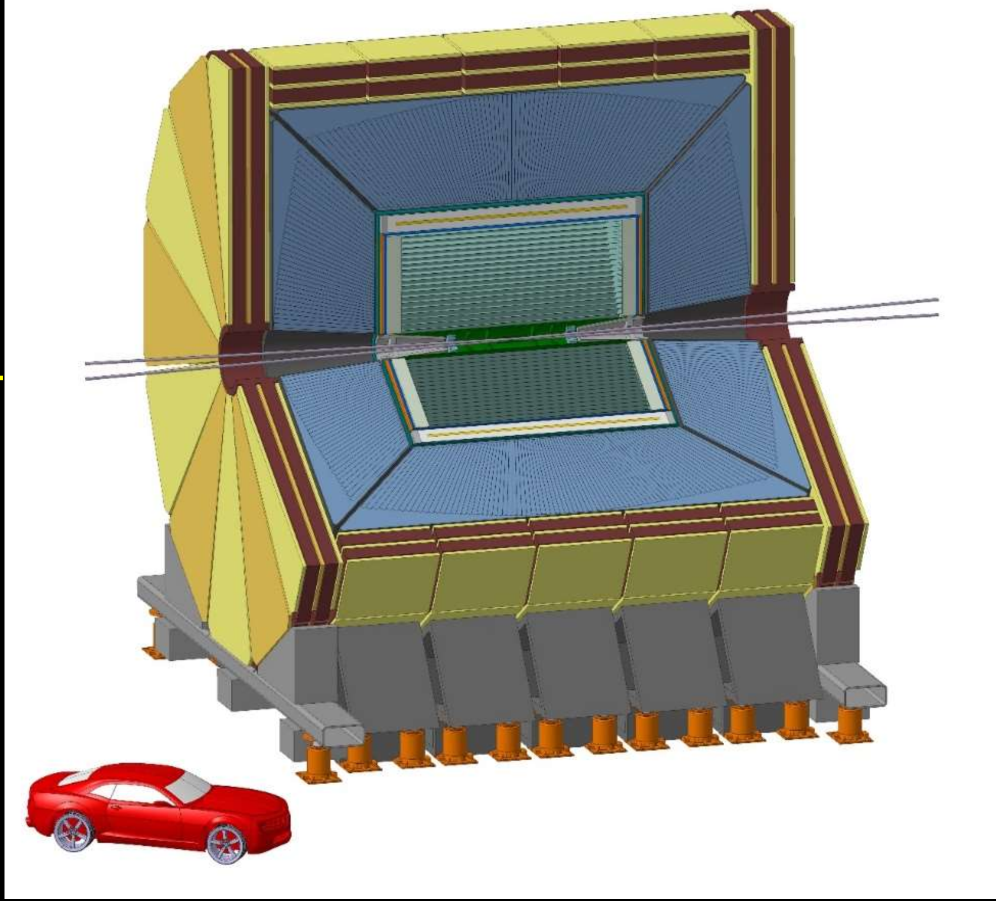
FCC-ee Discovery machine and more

- **EXPLORE** the 10-100 TeV energy scale region with precision measurements of the properties of the Z,W,Higss and top particles
  - 20-50fold improved precision on EWK observables
  - 10 fold more precise and model-independent Higgs coupling measurements
- **DISCOVER** that the Standard Model does not fit
  - Existence of extra-weakly-coupled and Higgs-coupled particles
  - Understanding of the underlying physics structure
- **DISCOVER** a violation of flavour conservation/universality
- **DISCOVER** very weakly coupled particles in the 5-100 GeV mass range
  - Such as right handed neutrinos, dark photons,ALPS …
- **DISCOVER** dark matter as invisible decays of the Z or Higgs

Detector concept IDEA

- Si pixel vertex detector
  - 5 MAPS layers
    - R = 1.7 – 34 cm
- Drift chamber (112 layers)
  - 4m long, r = 35 – 200 cm
- Si wrapper: strips
- Solenoid: 2 T - 5 m, r = 2.1-2.4
  - 0.74 X_0, 0.16 λ @ 90º
- Pre-shower: μRwell
- Dual Readout calorimetry
  - 2m deep/8 λ
- Muon chambers
  - μRwell

IDEA concept



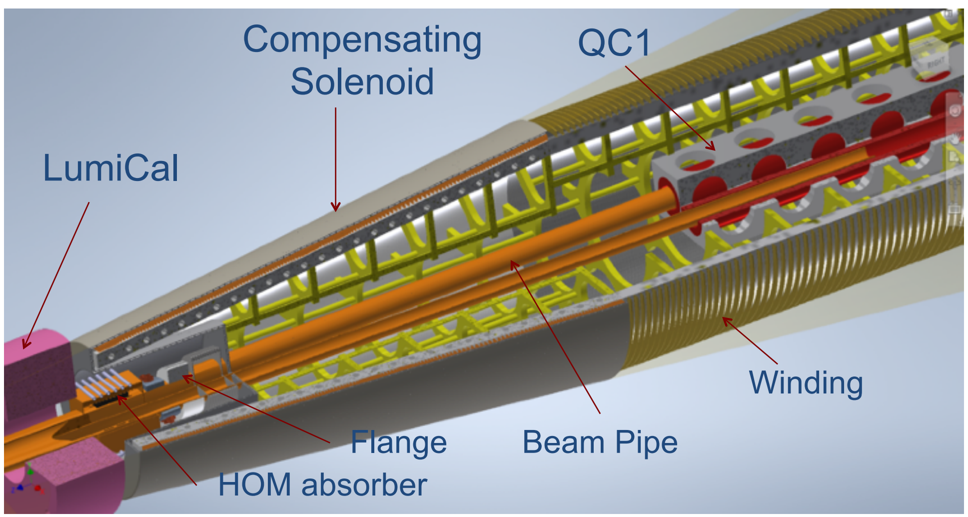
Detector concept driven by INFN that can be deployed at FCC-ee or CEPC

FCC-ee: Machine Detector Interface *(M.Boscolo, N.Bacchetta)*

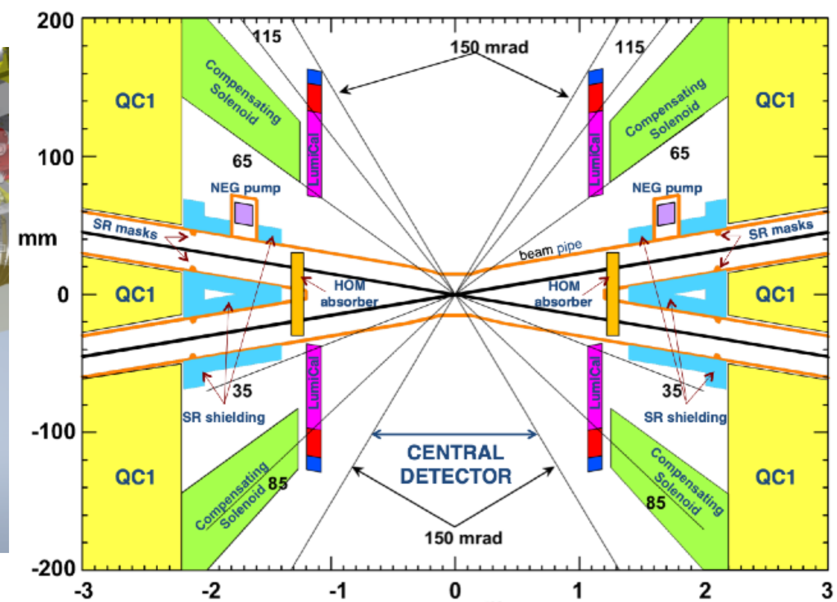
- Concentrate our efforts on 4 main areas:

a. Beam physics (optics, beam dynamics, collective effects)
b. Experimental environment, beam induced backgrounds & luminosity measurement
c. Software for simulation tools
d. Engineering (mechanical, magnets, diagnostics, vacuum, cooling, ...)

Our goal is to have a feasible and well engineered design of the Interaction Region that meets optics, beam dynamics and high current requirements, foresees tolerable radiation and achieves as well the mechanical requirements in terms of integration, stability and assembly.



3D modeling effort: compensating solenoid, cryostat, beampipe



Sketch of the FCC-ee Interaction Region

FCC-ee: Machine Detector Interface *(M.Boscolo, N.Bacchetta)*

- Next steps (towards the TDR) will cover the following macro-areas:

  1. Beam physics (optics, beam dynamics, collective effects)
  2. Experimental environment & Luminosity measurement
  3. Simulation software
  4. Engineering (mechanical, magnets, diagnostics, vacuum, cooling, ...)

- Consolidate baseline of the MDI design for FCC-ee including now more mechanical details:
  - try to converge on a design of the IR with enough details to constitute a real engineering baseline
  - understand installation procedures, mechanical detector interfaces, detector and machine elements accessibility for maintenance/upgrades
  - mechanical stability and position precisions of some detector elements (i.e. Lumical) is a relevant element to consider in the design
  - define better the general strategy for services in and out of the detector

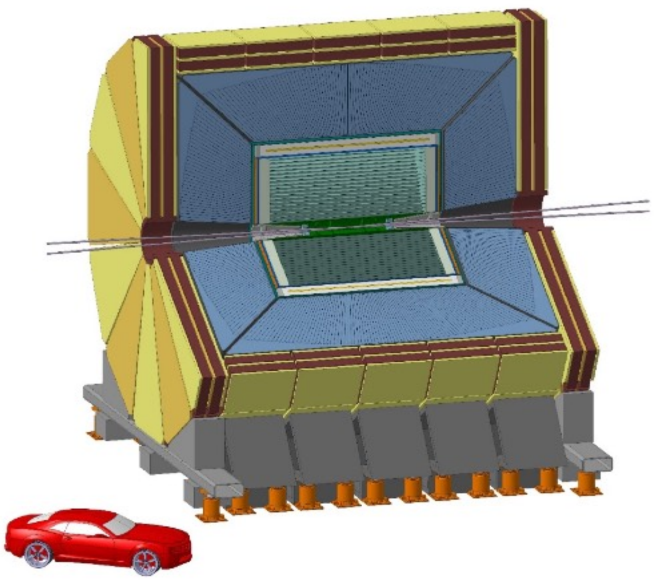
- Much work continues in order to complete a full simulation tool (MDIsim/GEANT) that allow us to have detailed background studies (Synch. Radiation)

Software for IDEA detector concept

Azzi (PD), Braibant, Fontanesi(BO), Pezzotti(PV)

- IDEA is a detector concept for a high-luminosity high-precision ee circular collider. INFN is a driver of the proposal for the hardware and software development.
- Software development: *goal to develop the full and fast simulation of the IDEA concept detector (characterized in particular by a drift chamber tracker and a dual-readout calorimeter) and study its performance for physics.*

IDEA concept



Current development focusing on:
* GEANT standalone simulation of a complete detector concept (vertex, DC and DR Calo)
* Performance and optimization studies
* Porting the simulation code in the official new framework for Future Colliders, Key4Hep/FCCSW

FCC-ee: Case studies & detector requirements from Physics

- To prepare for the next step of the project, a TDR in a 5 year time, FCC-ee study group has started to elaborate a set of « Case studies » to be performed.
- Each study contains a physics measurement goal and a requirement on detector performance, reconstruction/identification tool or theory work

- This list is also currently used in the context of the USA « Snowmass Process »
- It's a starting point for newcomers to join the effort with a clear working framework
- It will be presented also at the next « INFN FCC physics and simulation » meeting (next Thursday) to encourage new involvement in Italy

P. Azzi in Padova following in particular the detector and reconstruction requirements using:

— top quark at threshold and above

— FCNC for top $e^+e^- \to tq \quad q = u, c$ at √2=240GeV

— Development of tracking for long lived particle signatures (such as Heavy Neutral Lepton, Sterile neutrinos)

FCC-ee: Draft Document

Contents

- « living » document listing physics case studies that are unique to the FCC-ee context

PD participation in FCC-INFN

- Two main activities involving PD in FCC project:
  - **Physics and Simulation, WP1:** Simulations and physics studies for FCC-ee/CEPC,
    - P. Azzi, WP convener
  - **MDI, WP2:** Design of Interaction Region for FCC-ee and FCC-hh
    - N. Bacchetta, WP convener

Cognome	Nome	%
Azzi	Patrizia	20
Bacchetta	Nicola	10

- As roles in the FCC Project Study Group:
  - P. Azzi: FCC-ee « Top Physics » convener and member of the Steering Group
  - N. Bacchetta: FCC-ee MDI group convener