HIGHLIGHTS DA RD_FCC CSN1 FEBBRAIO 2022 PARTE 1

Manuela Boscolo

FUTURE CIRCULAR COLLIDER Innovation Study

INFN LNF

CERN

Sommario

- Novita’ organizzazione progetto FCC
- Evoluzione italiana
- News Activities: focus sul nuovo layout con 4IPs e MDI design (WP2)

ESPP Update 2020 “High-priority future initiatives”

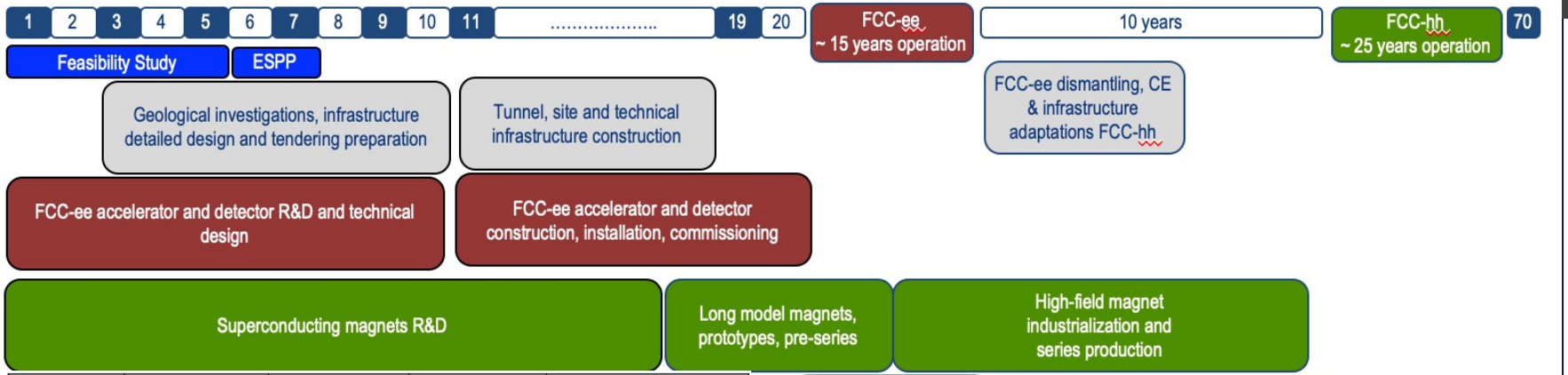
- An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy.

- “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..”

→ launch of Future Circular Collider Feasibility Study in summer 2021

Timeline of the FCC integrated programme

Technical schedule



	√s	L /IP ($cm^{-2}\,s^{-1}$)	Int. L /IP(ab^{-1})	Comments
e^+e^- FCC-ee	~90 GeV Z 160 WW 240 H ~365 top	230 x10^{34} 28 8.5 1.5	75 5 2.5 0.8	2-4 experiments Total ~ 15 years of operation
pp FCC-hh	100 TeV	5 x 10^{34} 30	20-30	2+2 experiments Total ~ 25 years of operation
PbPb FCC-hh	$\sqrt{s_{NN}}$ = 39TeV	3 x 10^{29}	100 nb^{-1}/run	1 run = 1 month operation
ep Fcc-eh	3.5 TeV	1.5 10^{34}	2 ab^{-1}	60 GeV e- from ERL Concurrent operation with pp for ~ 20 years
e-Pb Fcc-eh	$\sqrt{s_{eN}}$ = 2.2 TeV	0.5 10^{34}	1 fb^{-1}	60 GeV e- from ERL Concurrent operation with PbPb

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

F. Gianotti

FCC FS Council Documents, June '21

Organisational Structure of the FCC Feasibility Study

http://cds.cern.ch/record/2774006/files/English.pdf

CERN/SPC/1155/Rev.2
CERN/3566/Rev.2
Original: English
21 June 2021

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		*Voting Procedure*
For decision	**RESTRICTED COUNCIL** 203rd Session **17 June 2021**	Simple majority of Member States represented and voting

FUTURE CIRCULAR COLLIDER FEASIBILITY STUDY:

PROPOSED ORGANISATIONAL STRUCTURE

This document sets out the proposed organisational structure for the Feasibility Study of the Future Circular Collider, to be carried out in line with the recommendations of the European Strategy for Particle Physics updated by the CERN Council in June 2020. It reflects discussion at, and feedback received from, the Council in March 2021 and is now submitted for the latter's approval.

Main Deliverables and Timeline of the FCC Feasibility Study

http://cds.cern.ch/record/2774007/files/English.pdf

CERN/SPC/1161
CERN/3588
Original: English
21 June 2021

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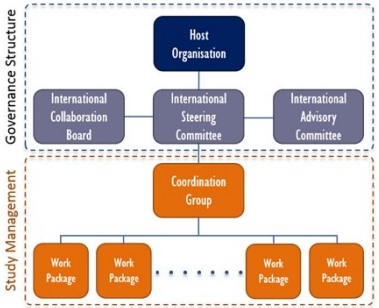
FUTURE CIRCULAR COLLIDER FEASIBILITY STUDY:

MAIN DELIVERABLES AND MILESTONES

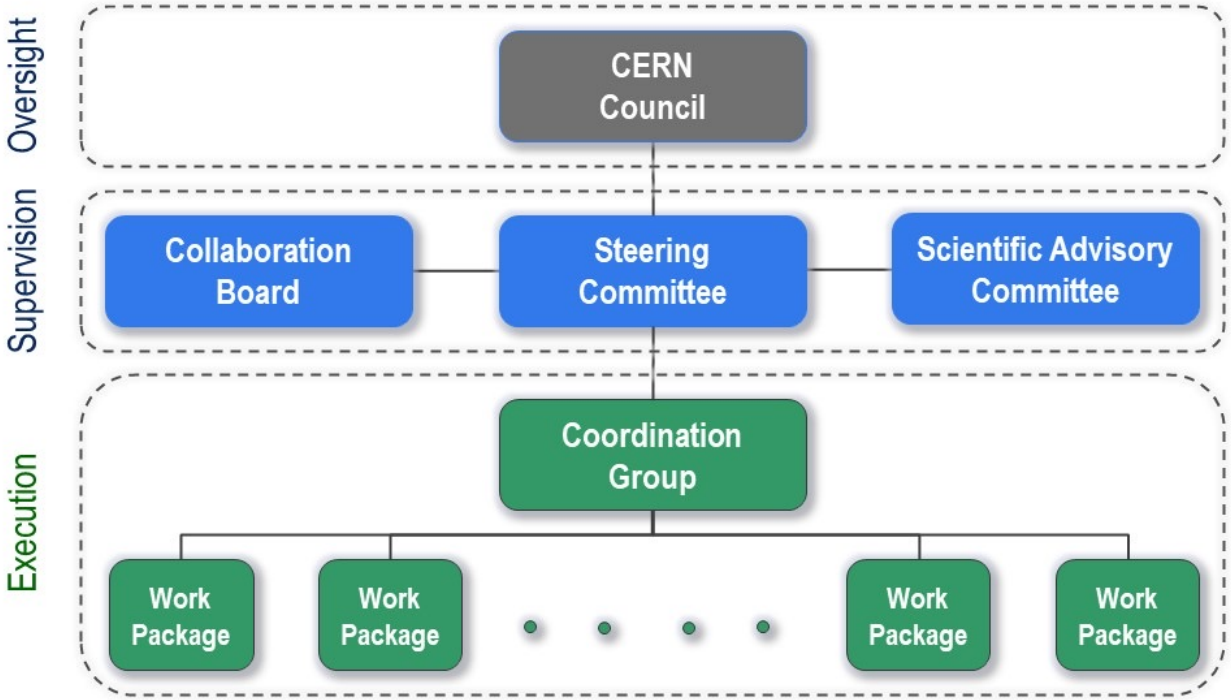
This document describes the main deliverables and milestones of the study being carried out to assess the technical and financial feasibility of a Future Circular Collider at CERN. The results of this study will be summarised in a Feasibility Study Report to be completed by the end of 2025.

FCC Feasibility Study - organisational structure

- New structure very similar to the first phase of the FCC Study (2014-2020), leading to the Conceptual Design Report as input to the ESPPU.



- Classical structure common to CERN projects.



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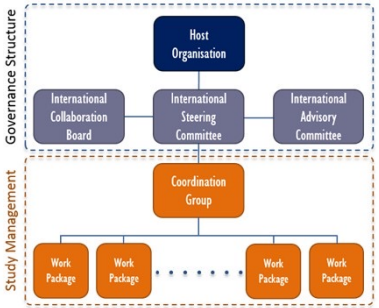

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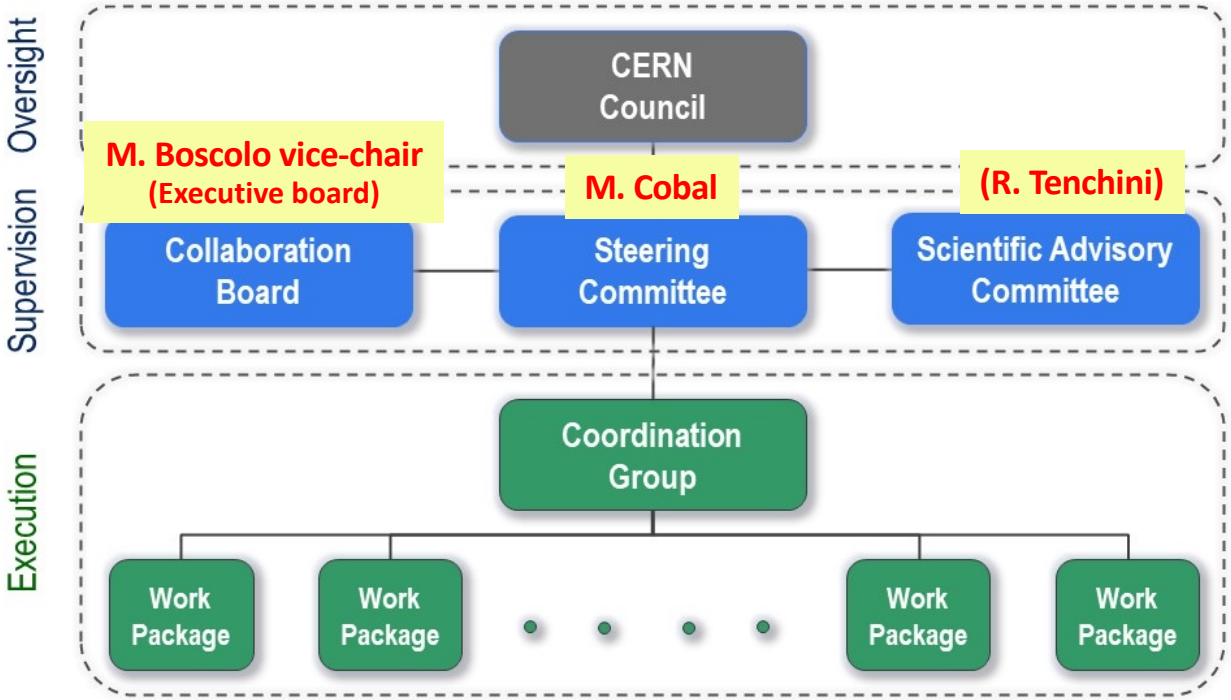


Situazione italiana

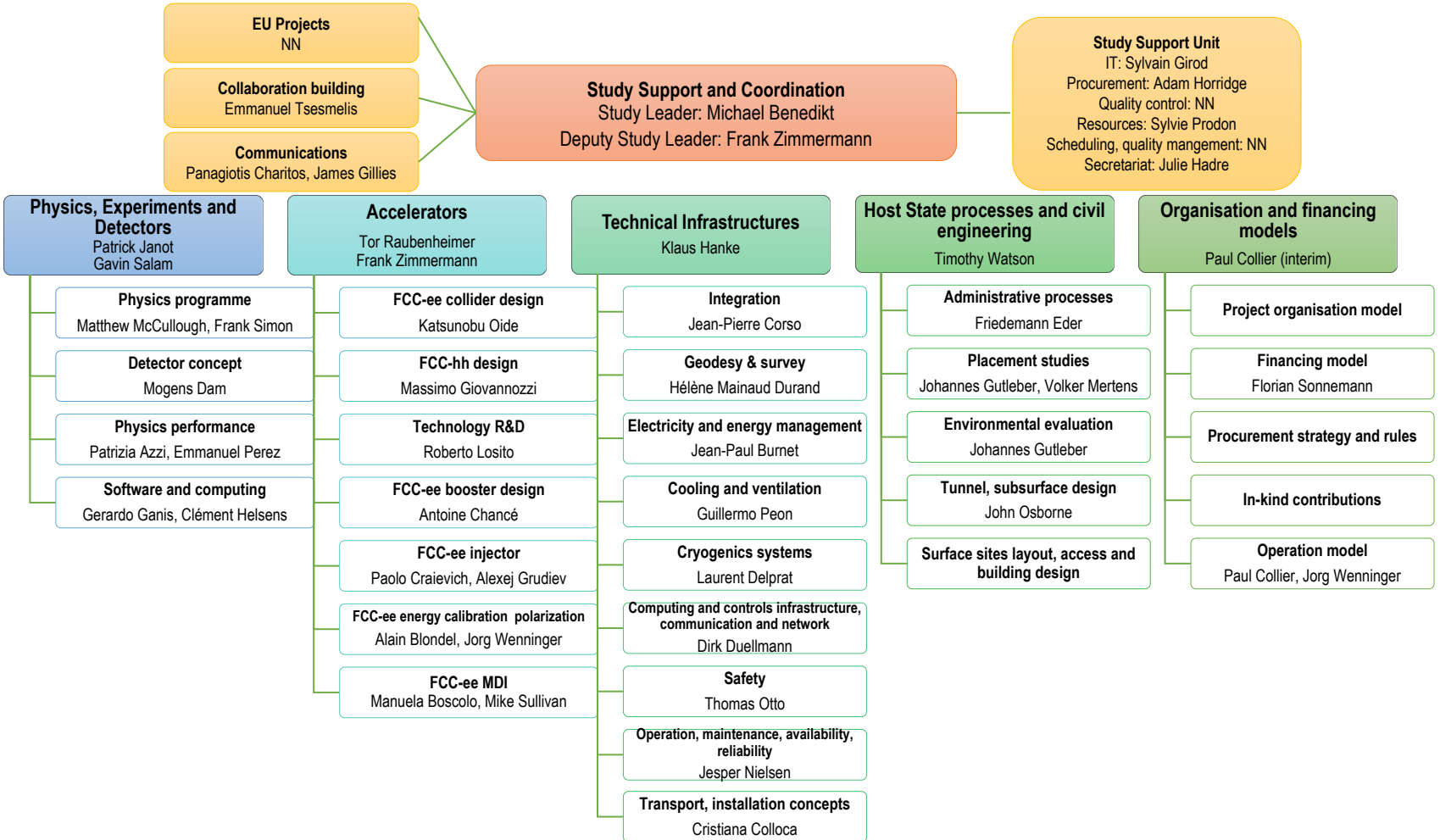
Forte impulso a consolidare posizione italiana da Presidente e Giunta INFN

L'obiettivo di questo Workshop è quello di **espandere la comunità** di persone interessate o già coinvolte nel progetto FCC presentato alla comunità scientifica in occasione dell' aggiornamento dell' European Strategy for Particle Physics (ESPP), ratificata dal Council del CERN nel giugno 2020.
L' Istituto Nazionale di Fisica Nucleare è uno degli artefici principali che ha condotto alla preparazione dell' ultima ESPP e alla preparazione concettuale di FCC. È fondamentale fare il punto della situazione degli studi in corso e **coinvolgere coloro potenzialmente interessati ad unirsi a questo progetto**, sia per ciò che riguarda lo **sviluppo delle macchine acceleratrici (e+e- in particolare, ed hh) che degli apparati sperimentali, includendo gli studi dei processi fisici con esse accessibili.**

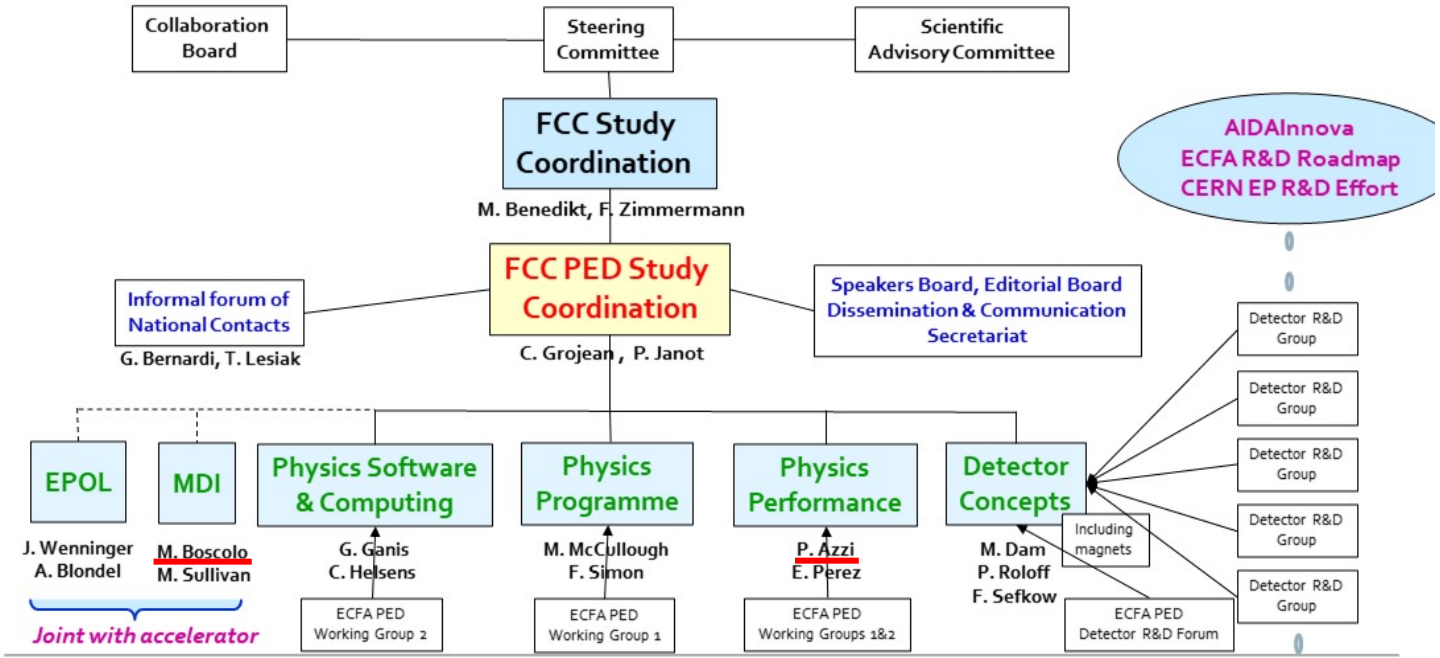
Workshop website: https://agenda.infn.it/event/29752/

Inoltre, domani 11/3/22 ci sara' un seminario su FCC (seminari nazionali acceleratori) link to FCC seminar

FCC Feasibility Study – coordination team and contact persons



Tailored PED pillar organisation & conveners



F. Gianotti
13/1/2022

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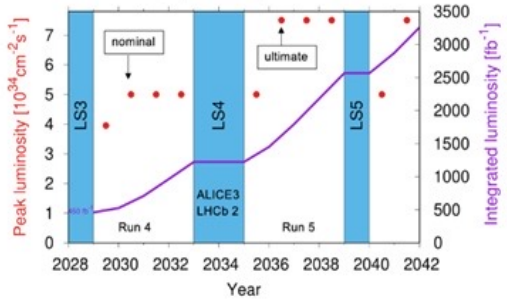
Note on long-term planning

Preliminary (optimistic) schedule of HL-LHC



Shown integrated luminosities include 1 month/year of HI running and no MD or special runs after 2036

LS4 extended from 1 to 2 years (in view of ALICE and LHCb upgrades)

With proposed shift and extension of LS3, and inclusion of HI runs beyond LS3:
- 2500 fb^{-1} are expected by end 2038 (current end-date of HL-LHC)
- 3000 fb^{-1} (int. luminosity goal) would now be reached in ~ 2041

Note: it should not be assumed that future shifts of LS schedules, or new, ambitious upgrades of the experiments, entail an automatic shift/extension of HL-LHC end date, as this has an impact on the future of the field (next collider cannot start before ~ 7 years from end of HL-LHC for technical and financial reasons)

→ next European Strategies will need to optimise the overall planning of the field based on HL-LHC performance and physics results, interest of the community, progress with next facility, etc.

FCC: CERN Council endorsed in June 2021 the FCC feasibility study

A major achievement for CERN and the field!

- approx. 100 MCHF in CERN 5-year Medium Term Plan
- technical, administrative, financial feasibility, consolidation physics case,…

J. Mnich
7/2/2022

Final decision on the long-term HL-LHC schedule will have to be taken at the next (or next-to-next?) strategy update in light of:

- performance and results from the LHC, progress with the next project (FCC), …

- we have to find the right balance between motivation and commitment of the community for the success of the LHC
- and preparing the ground for the future with a visionary project like the FCC

Support from CERN Host States

8 Nov 2021: The **Préfet de la region Auvergne-Rhone-Alpes** was nominated by the **French Prime Minister Jean Castex** as "interlocuteur unique des autorités Suisses et du CERN" **to accompany CERN during the FCC Feasibility Study for all infrastructure related aspects, in concertation with Switzerland** and to ensure the compliance with all relevant rules. In particular, the Prime Minister asked the Préfet to establish, by the end of the year 2021, an organization diagram for the management of his mission, as well as a calendar identifying the actions to be taken in order to respond to CERN's requests, and to report regularly on the progress of the mission and make proposals to allow France to facilitate the execution of the feasibility study.

10 Dec 2021: The **Swiss Federal Council** announced that it will draw up a **federal sectoral plan** in order to clarify and facilitate the administrative procedures for spatial planning and **to improve planning security for all CERN projects, including the FCC** in the event of its implementation. The sectoral plan, which also responds to a request from the Republic and Canton of Geneva, will provide a framework for balancing the objectives of research policy, host-state policy and spatial planning policy.

News varie

- **ECFA R&D roadmap completata**

Implementation plans da discutere al Council dopo discussione con funding agencies (K. Jacobs Feb. 22)

  - **R&D principalmente finalizzato a FCC-ee**

- Percezione diffusa che la comunita' ILC si stia muovendo verso FCC – **ILC** visto come **sempre piu' improbabile**

- **Snowmass**

  Partecipazione alla scrittura di 2 white papers (due mid-March)

  - DR calorimetry e FCC general

Impegni internazionali

2021 Int. Wrksp. On High Energy CEPC – Nov. 9-12, 21
- 5 session conveners, 12 talks da italiani INFN

FCCIS WP2 Workshop 2021 – Nov. 29-Dic. 10
- 2 session conveners, 6 talks da italiani INFN

IAS Program on HEP, HK Gen. 13-19, 2022
- 1 session convener, 3 talks da italiani INFN

ECFA Higgs Fact.: 1st Topic. Meet. on Simulation, Feb. 22
- 2 session conveners, 5 talks da italiani INFN

FCC Physics workshop, Feb. 7-11, 2022
- 1 session convener, 16 talks da italiani INFN

EU programs:
- FCCIS: 1 nov 2020-24 (LNF) progetto esterno che fa capo alla CSN1
  - WP2: FCC-ee Collider Design (INFN-LNF: leads MDI task and collective effects)
- AIDAinnova: From 1st of April 2022
- Euro-Lab: Proposal approved. Project will start on 1st of September 2022. INFN is the coordinating institute

Highlights

Novita’ su attivita’ in corso

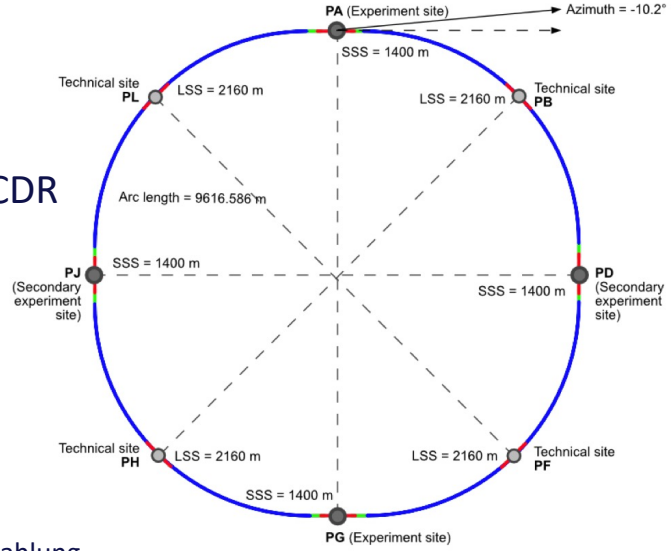
per WP2

Nuova ottica con 4IPs, nuova tabella parametri all'IP

K. Oide link
FCCIS WP2 workshop, 29/11/21

Evolution of optics for FCC-ee after CDR

Circumference = 91.174 km



Same essential boundary conditions for the IR optics as in the CDR

parameters table		Z	W^+W^-	ZH	ttbar
β_x^*	m	0.15	0.2	0.3	1.0
β_y^*	mm	0.8	1.0	1.0	1.6
σ_x^*	μm	6.4	13	13.7	38.2
σ_y^*	nm	28	41	36	68
σ_z	mm	14.5 (12.1)	8.01 (6)	6 (5.3)	2.95 (2.54)
σ_δ	%	0.13	0.154	0.185	0.229
N	10^{11} p/bunch	2.53 (1.7)	2.91 (1.5)	2.04 (1.8)	2.64 (2.2)
bunches/beam		9600	880	248	36

in collision, i.e. with Beamstrahlung
(in parenthesis CDR values)

IR design driven by synchrotron radiation:
$E_{critical}$ <100 keV from 450 m from the IP
(from LEP experience)
-> Asymmetric IR optics

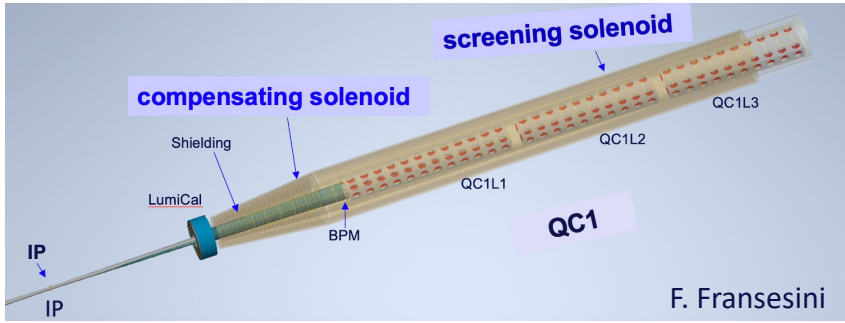
cambiato il numero di particelle/bunch,
il bunch spacing, lunghezza del bunch, energy spread

FUTURE CIRCULAR COLLIDER
Innovation Study

MDI (1)

Nuovo layout con 4 Interaction Points in progress
Disegno camera da vuoto all'IP in progress
Studio dei fondi di macchina in progress
Proposta IP-generated radiation monitor da Beamstrahlung photons proposta
potenza in gioco molto alta, «Instrumented photon beam dump»

Richiesta di verificare la possibilita' di aumentare il detector field a 3 T alla Z
Fast luminosity monitor – very low angle Bhabhas proposta
detector da disegnare, possibile interesse di CSN1?

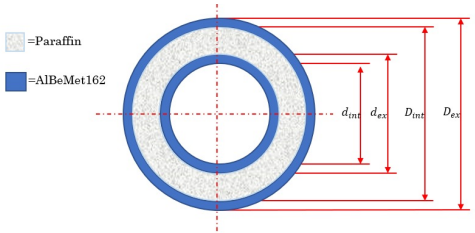


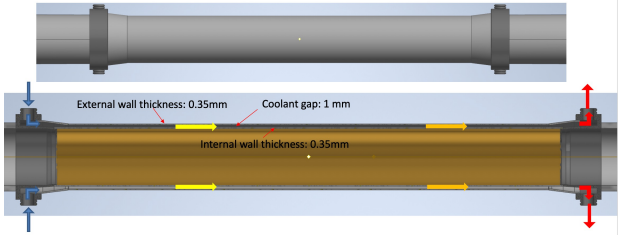
Detector Solenoid compensation scheme
compensating solenoid in front of the first quad, as close as possible to IP, to reduce the ε_y blow-up
screening solenoid to shield the detector field inside the final focus quad

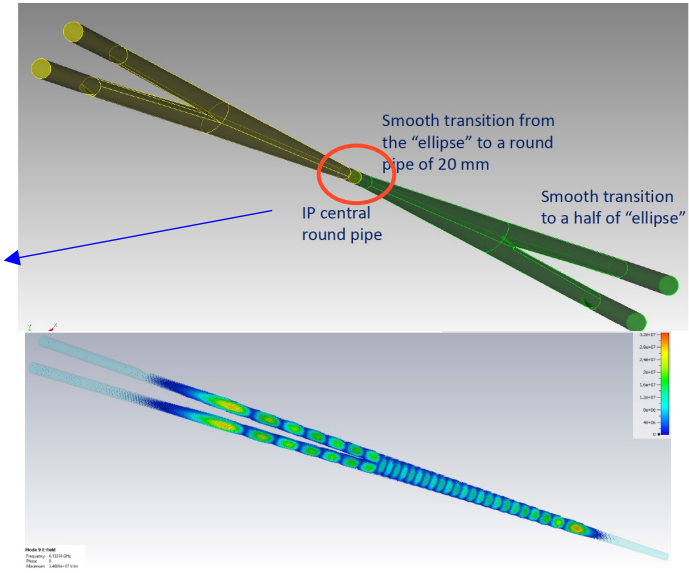
Final Focus Quadrupole QC1 design: CCT Final Focus SC quadrupole, max gradient 100 T/m, 4.2 K (disegno preso da SuperB, stessi constraints di spazio)

MDI (2) Central chamber

warm and cooled
central beam pipe
Inner radius **10 mm**







Material	*thickness*
AlBeMet162	0.35 mm
Paraffin (PF200)	1 mm
AlBeMet162	0.3 mm
Au	5 μm

Thickness 1.7mm (**X/X0=0.59%**)

AlBeMet162: 62% Be and 38% Al alloy

CST wake-filed simulation (A. Novokhatski, SLAC)
Heating power is 260 W for the two beams,
most of this power will travel out away from the IP

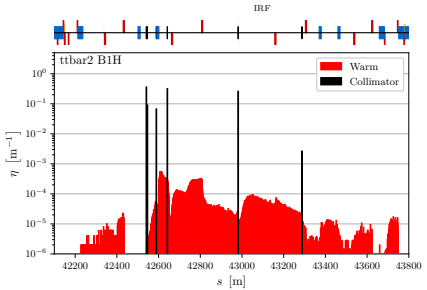
[Vertex resolution vs the first vertex layer radius, Donal Hill, MDI meeting #33]

*Central pipe **CDR** values:*
***inner radius 15 mm** for X/X0=0.47%*

MDI (3)

Lavoro con la collimation team per fornire eventi di background da tracciare nei rivelatori

- Sviluppo di collimation tracking code
- Radiation damping & tapering
- Geant4 e Fluka integrati nella simulazione
- Studio physical aperture →



da discutere nel MDI group con gli esperti del detector:

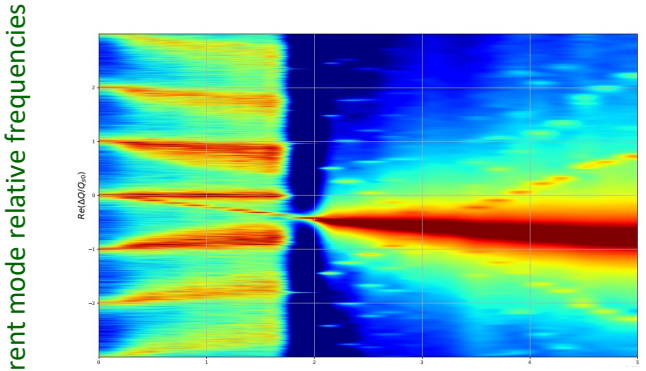
- Interaction Region support system anchoring to (or outside of) the detector
- IR insertion strategy (by one or two sides) – available room for mounting
- Detector components details yet (e.g.: geometry, weight, anchor points)?
- Room allocation in the IR for services

Collective effects

- Impedance budget evaluation with new layout in progress
- Mitigation of electron cloud effects EPJ+ link
- Beam-beam interaction including the longitudinal impedance

Turbulent mode coupling instability (TMCI) including the longitudinal impedance

Both transverse and longitudinal impedances are included



E. Carideo, M. Migliorati, M. Zobov et al., "Transverse and Longitudinal Single Bunch Instabilities in FCC-ee", IPAC2021

FUTURE CIRCULAR COLLIDER Innovation Study

Commenti finali

FCC sta accelerando

- Momento giusto per espandere collaborazioni

Il supporto INFN nella governance di FCC si sta consolidando
Molto lavoro da RD_FCC mostrato a eventi internazionali
Importante workshop a Roma il 21-22 marzo

FCCIS Work Packages

WP1: study management (CERN)

WP2: collider design (DESY)

Deliver a performance optimised machine design, integrated with the territorial requirements and constraints, considering cost, long-term sustainability, operational efficiency and design for socio-economic impact generation.

WP3: integrate Europe (CERN)

Develop a feasible project scenario compatible with local – territorial constraints while guaranteeing the required physic performance.

WP4: impact & sustainability (CSIL)

Develop the financial roadmap of the infrastructure project, including the analysis of socio-economic impacts.

WP5: leverage & engage (IFJ PAN)

Engage stakeholders in the preparation of a new research infrastructure. Communicate the project rationale, objectives and progress. Create lasting impact by building theoretical and experimental physics communities, creating awareness of the technical feasibility and financial sustainability, forging a project preparation plan with the host states (France, Switzerland).

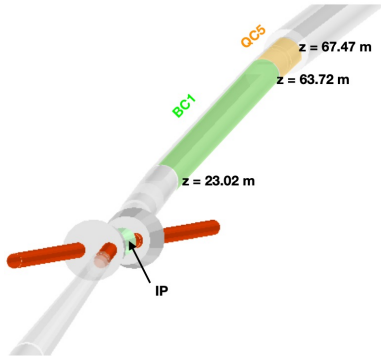
Beamstrahlung Radiation generated at the IP

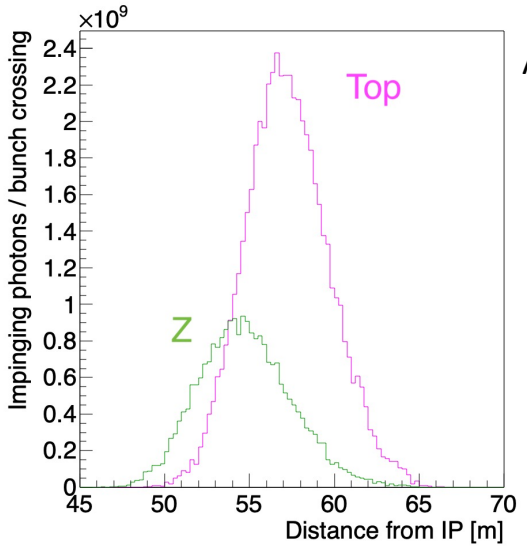
link: IPAC21 MDI

- A significant flux of photons is generated at the IP in the very forward direction by Beamstrahlung, radiative Bhabha, and solenoidal and quadrupolar magnetic fields.
- **Beamstrahlung** interactions produce an **intense source of locally lost beam power**
- The impinging angle of the **Beamstrahlung** photons with the pipe is about 1 mrad for both beam energies.

	Beam energy	Beamstrahlung Radiation power
<Eγ> = 2 MeV	45.6 GeV	387 kW
<Eγ>=67 MeV	182.5 GeV	89 kW

[GuineaPig++]





A. Ciarma

Beamstrahlung photons tracked up to their loss points, at about 50-60 m after the IP