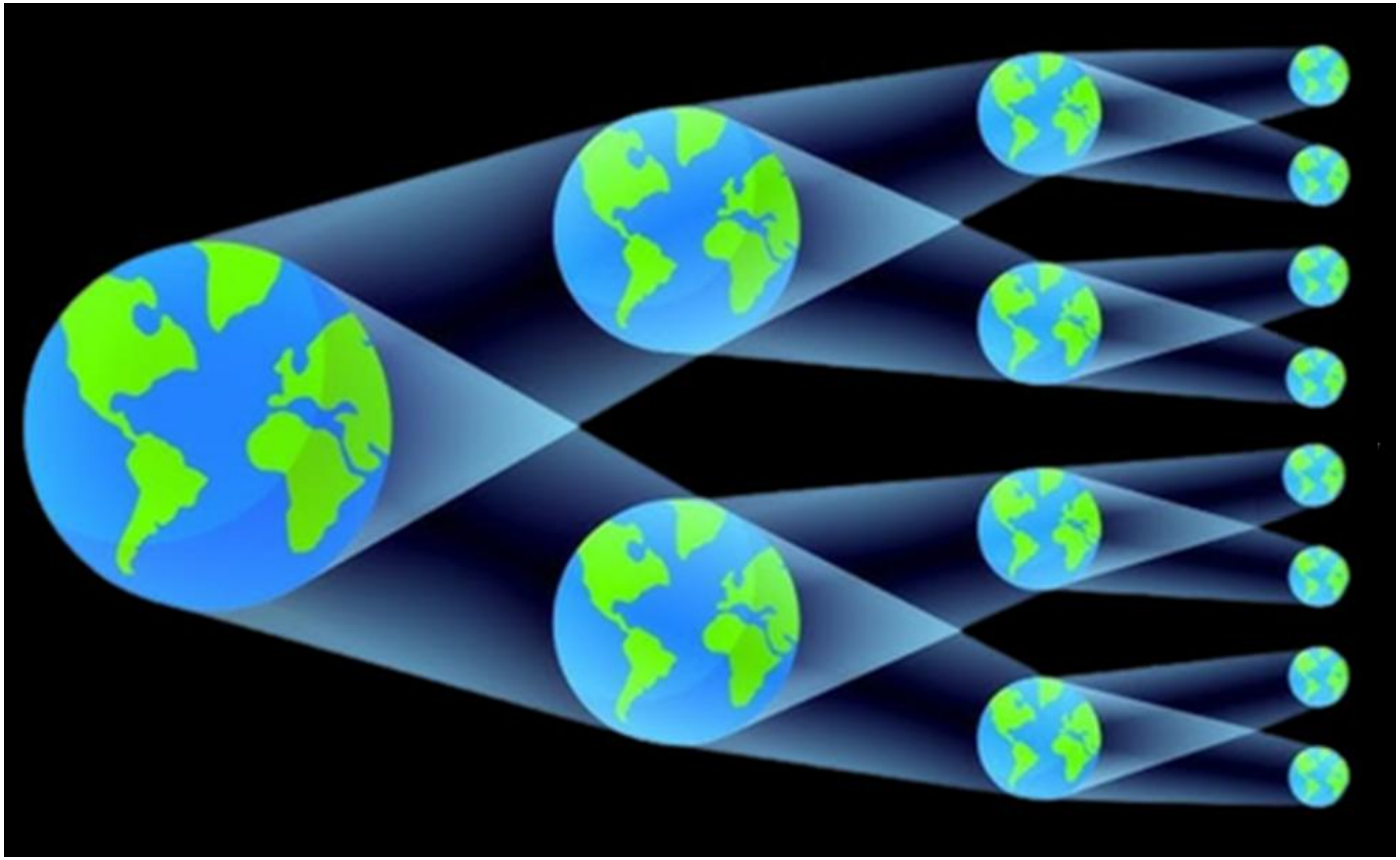
Future colliders

PPAP Community Meeting
University of Birmingham, 17/7/26

Guy Wilkinson
University of Oxford

Many worlds, many colliders

During ESPPU many possible lepton colliders were considered, which have different strengths and weaknesses. Work on many of these continues.



FCC-ee

ILC

LCF

C^3

CLIC

HALHF

LEP3

MuCOL

However, in the world branch we find ourselves, one option now demands essentially full attention (at least for now) – FCC-ee.

International consensus

Outcome of ESPPU was very clear, and has now been adopted through a resolution by CERN Council. Situation has been well articulated by CERN DG, most recently in plenary ECFA meeting in Amsterdam last week [link].

FCC was a key topic of the update of the ESPP

The key points from the European Strategy Group (ESG) report regarding FCC:

- Overwhelmingly strong endorsement of the physics and strategic case for FCC-ee as the next flagship collider at CERN
  - Consensus within the particle physics communities in CERN's Member States
- *A* descoped/staged FCC-ee is preferred to other options as **the** alternative
- **FCC-ee is far ahead of other concepts**

Will return to this later

The update of ESPP, endorsed FCC-ee as CERN's scientific vision for the future:

- CERN **strongly** supports this objective
- ***Our clear aim is to be ready* for a decision on FCC-ee in 2028**
- CERN's highest objective for the long-term future is to be in a position in 2028 to propose to Council FCC-ee as CERN's next flagship collider
- Seeking a decision on FCC-ee, not a choice between options, that choice has been made in the European Strategy update

Status of FCC-ee and opportunities for involvement (with ~zero resources)

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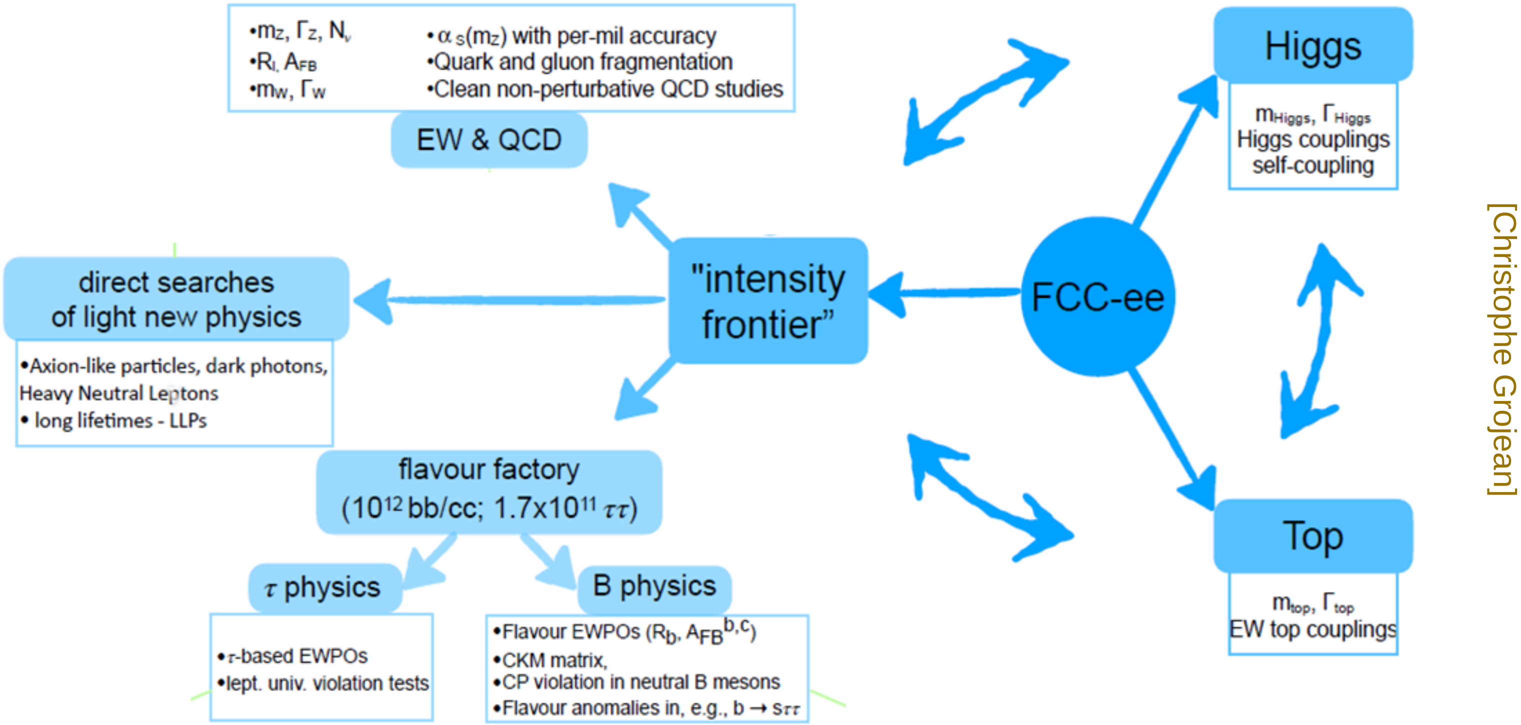
Why did community choose FCC-ee ?

No time, or need, to re-state the physics case of FCC-ee. But as well as being a superlative Higgs factory it has an immensely broad physics programme.

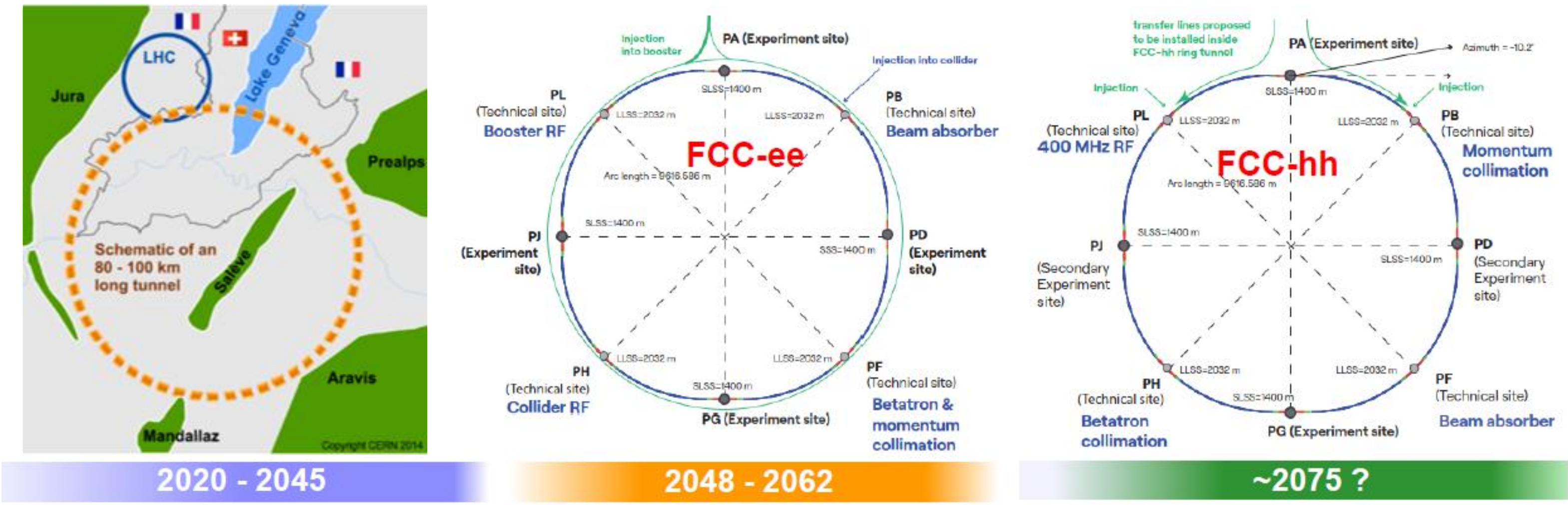


This is important to keep in mind when it comes to the detector challenges.

What about FCC-hh ?

The community retains the ultimate goal of a 10 TeV pCM energy-frontier machine with the ~100 TeV FCC-hh being the leading candidate (alongside a muon collider).

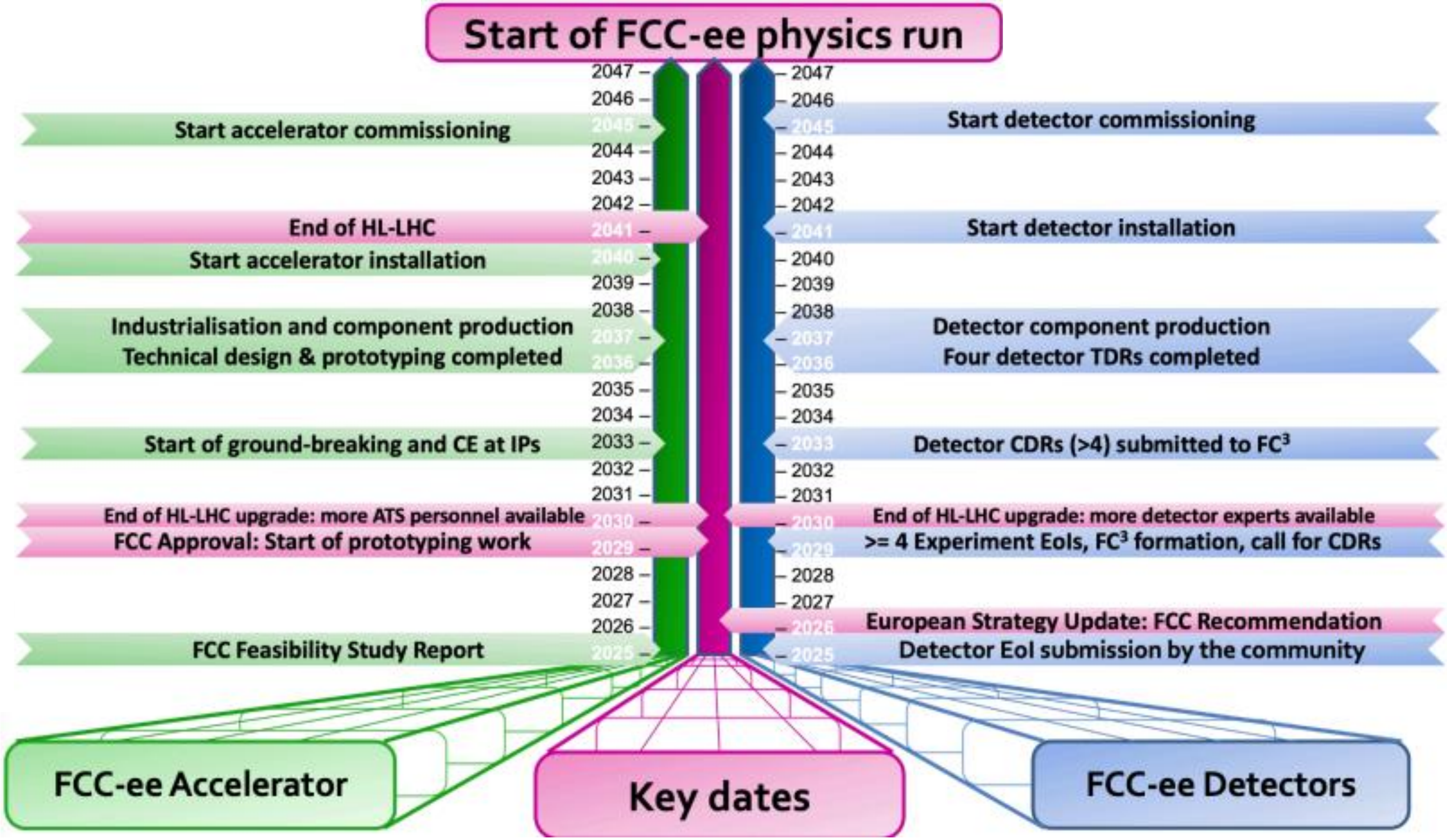
The tunnel & much of the infrastructure needed for FCC-ee, can be reused for FCC-hh, & so CERN views FCC-ee & FCC-hh as part of an *integrated programme*.



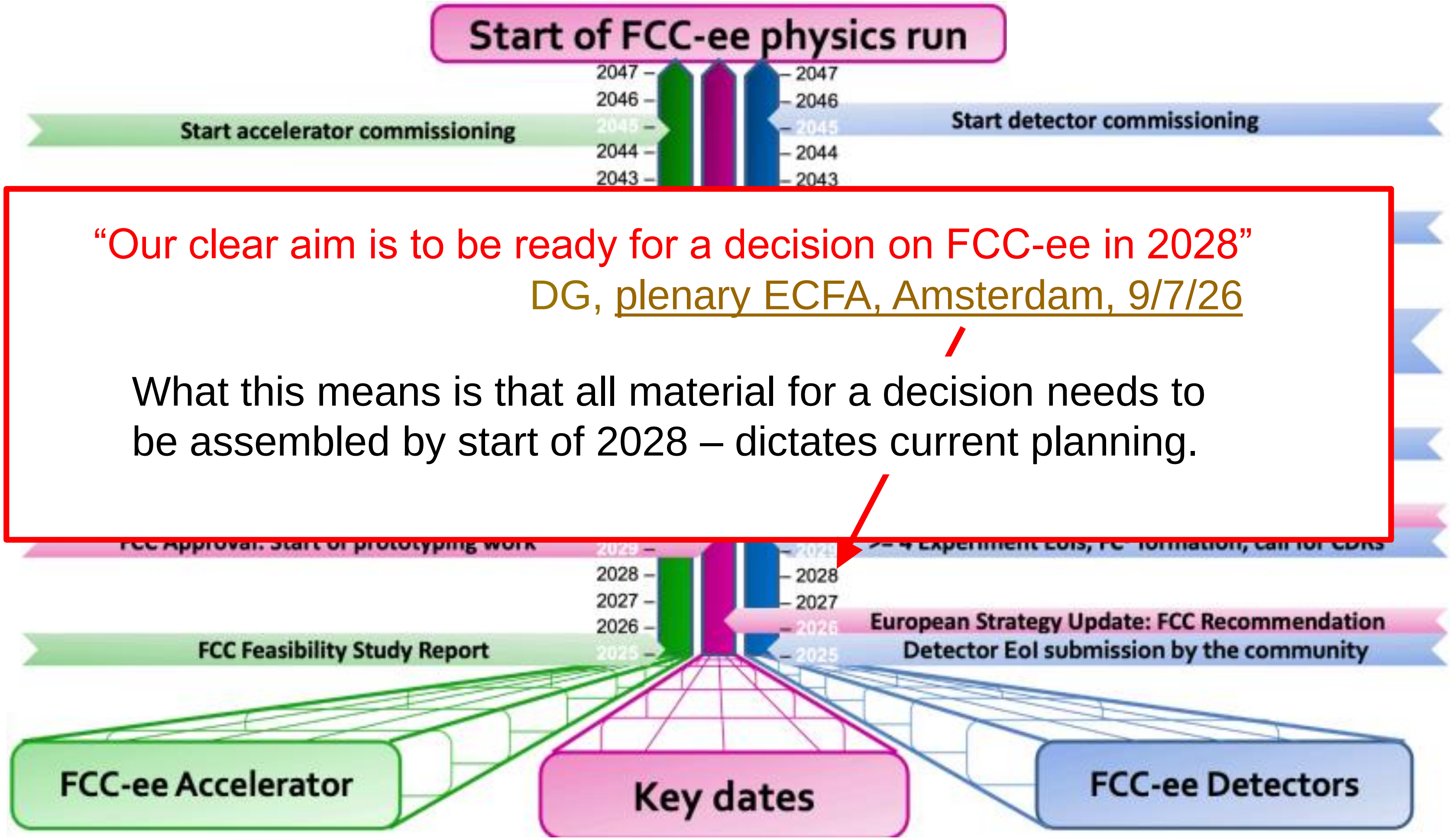
Post ESPPU one will hear less mention of this – a strategic decision while the focus is on getting FCC-ee over the line. However:

- Physics arguments for FCC-hh remain unchanged (S. Williams, T. You).
- FCC-hh compliance remains a critical boundary condition in all FCC-ee planning.
- Work towards FCC-hh and high-field magnets continues.

Countdown to physics



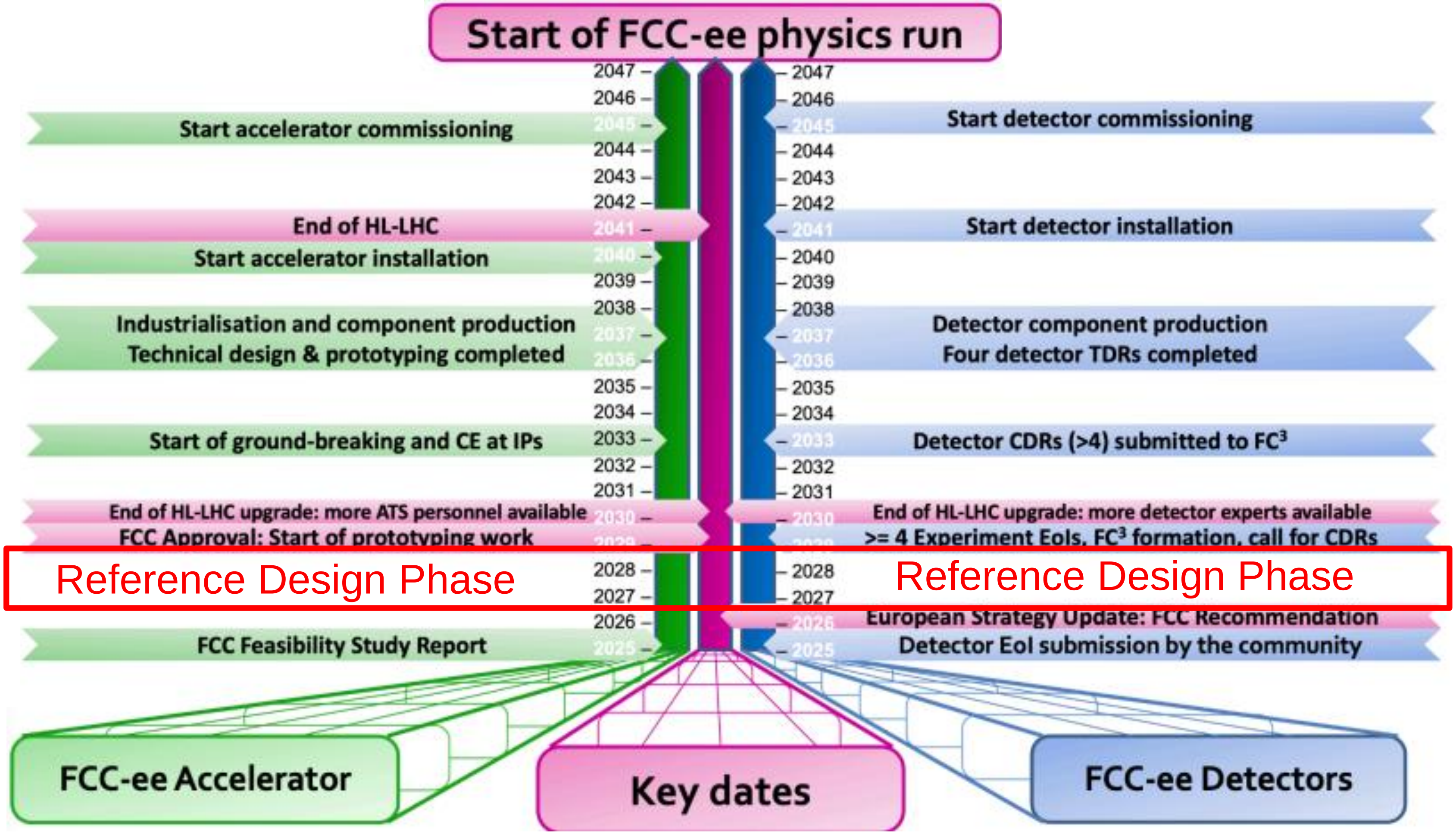
Countdown to physics



"Our clear aim is to be ready for a decision on FCC-ee in 2028"
DG, plenary ECFA, Amsterdam, 9/7/26

What this means is that all material for a decision needs to be assembled by start of 2028 – dictates current planning.

Countdown to physics



What is Reference Design Phase (RDP) and selected developments

Goals of Reference Design Phase (RDP)

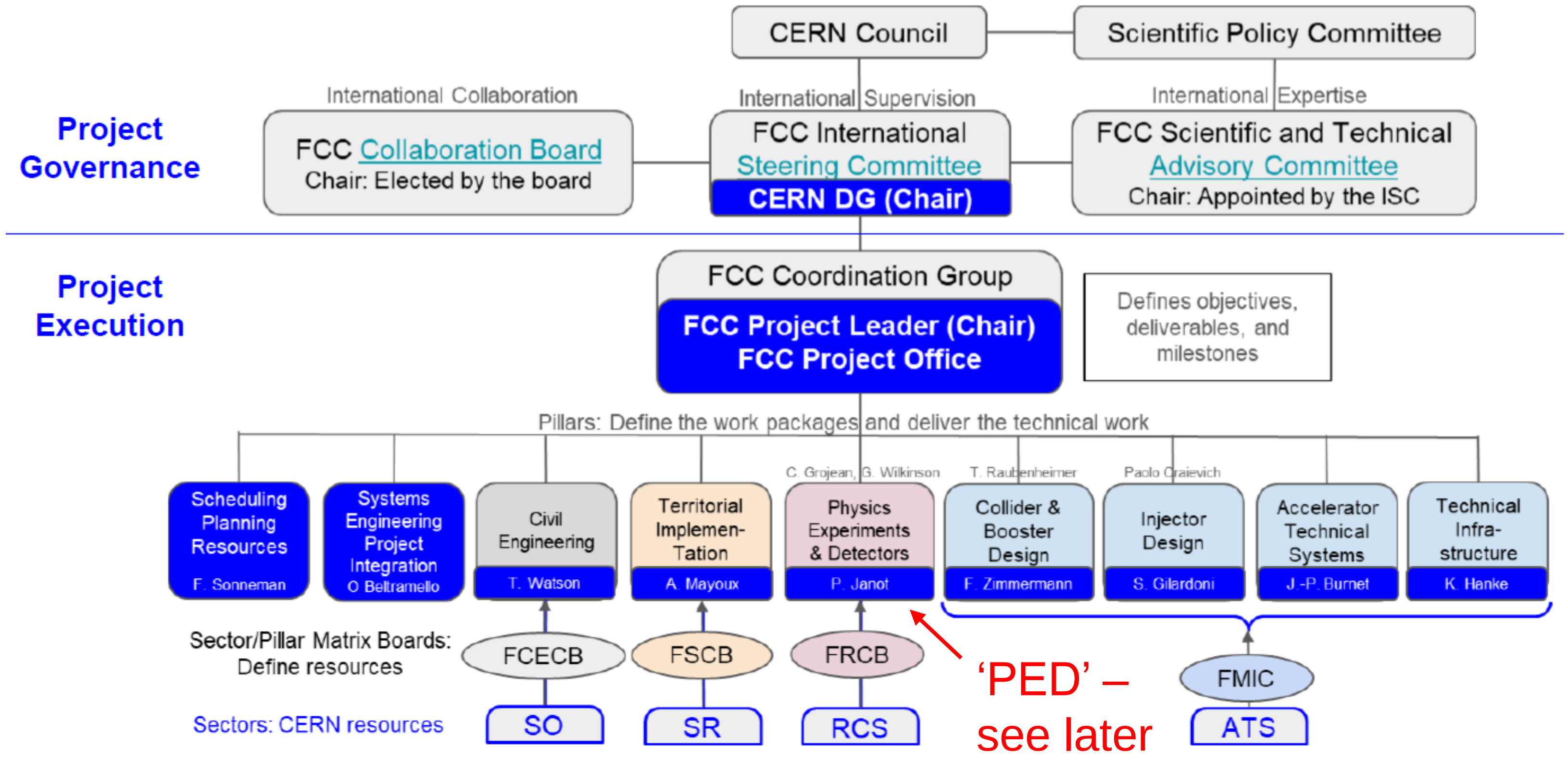
From Frank Zimmermann (for PED aspects see later):

- **Increase maturity** of technical design.
- Overall **project integration** and **requirements on civil engineering (CE)** sufficiently detailed to enable subsequent launch of CE tender post approval
- Project design sufficiently detailed to **allow advancing with environmental impact assessment** for project authorisation processes in Host States
- Reducing project risks via:
  - Integrated planning across all domains and interface management;
  - Prototyping of critical systems;
  - Build up cost / performance contingency by design optimisation;
  - CE refinement;
  - Coordination with Host States on territorial implementation aspects;
  - Reinforcing collaboration as basis for global support for the project.

If approval is given, a Technical Design Phase (2029-2032) will follow.

FCC organisation for RDP

FCC structure has been re-organised for RDP:



Pro: looks much more like something designed by a Project Planning expert
Con: looks much more like something designed by a Project Planning expert
Pro: more direct contact with CERN departments and sectors
Con: more CERN-centric than previously

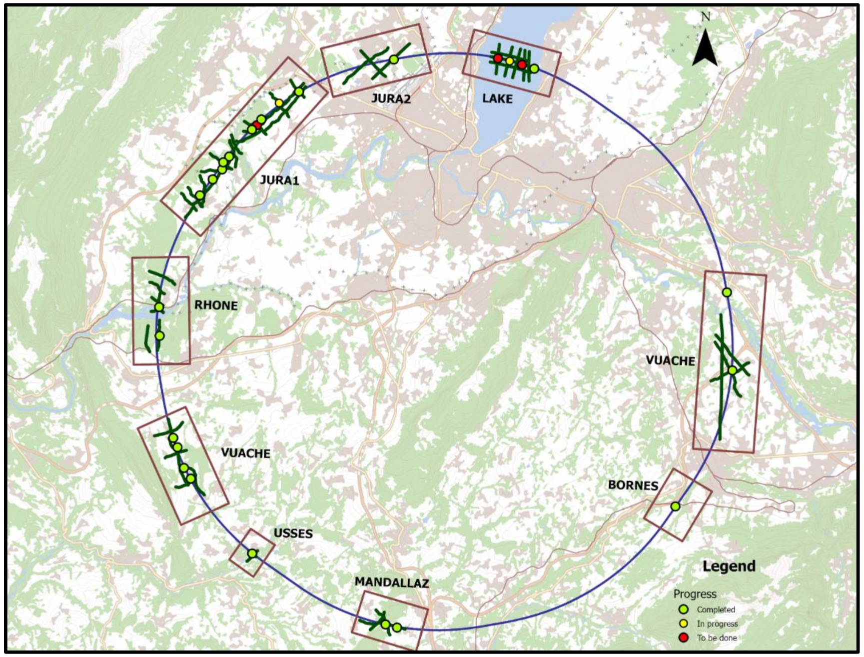
Civil Engineering – site investigations

First phase of site investigations will be completed by the end of 2026 (1 land and 3 lake locations remain out of total of 27 drillings).

Current results confirm initial geological model, and indicate that the tunnel will remain largely with the molasse rock (very suitable for digging).

Update geological model for Q1 2027, to enable adjustment of tunnel depth and tilt.

RDP: follow-up campaigns, plus detailed drilling at experimental sites.

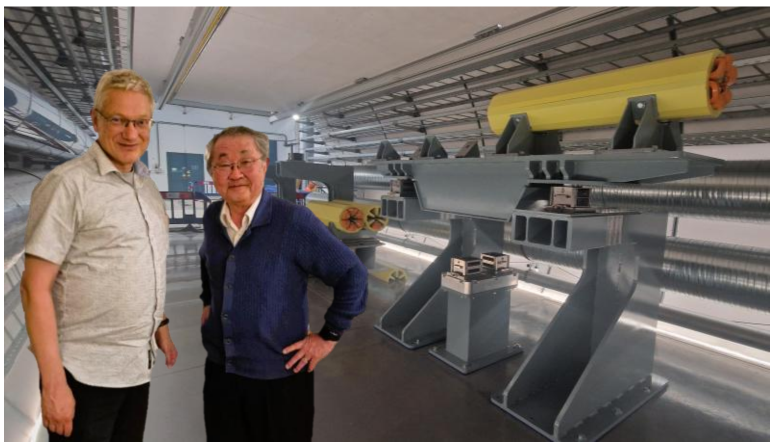


Important developments: change of lattice

Global Hybrid Chromaticity (GHC)

Katsunobu Oide

Pursued through 2016 to 2026



Backbone for all FCC-ee studies until now. High level of maturity, building on SuperKEKB experience.

Local Chromatic Correction (LCC)

Pantaleo Raimondi

Adopted for the RDP (2026-)

Newer concept with final focus design with both horizontal and vertical chromaticity correction sections and modular design of technical insertions.

Important developments: change of lattice But why should we care ?

LCC optics has 10% lower synchrotron-radiation energy loss per turn

→ either reduce power requirements from 50 MW to 45 MW and save money, or increase luminosity

Fewer power converters needed; shorter quadrupoles and sextupoles

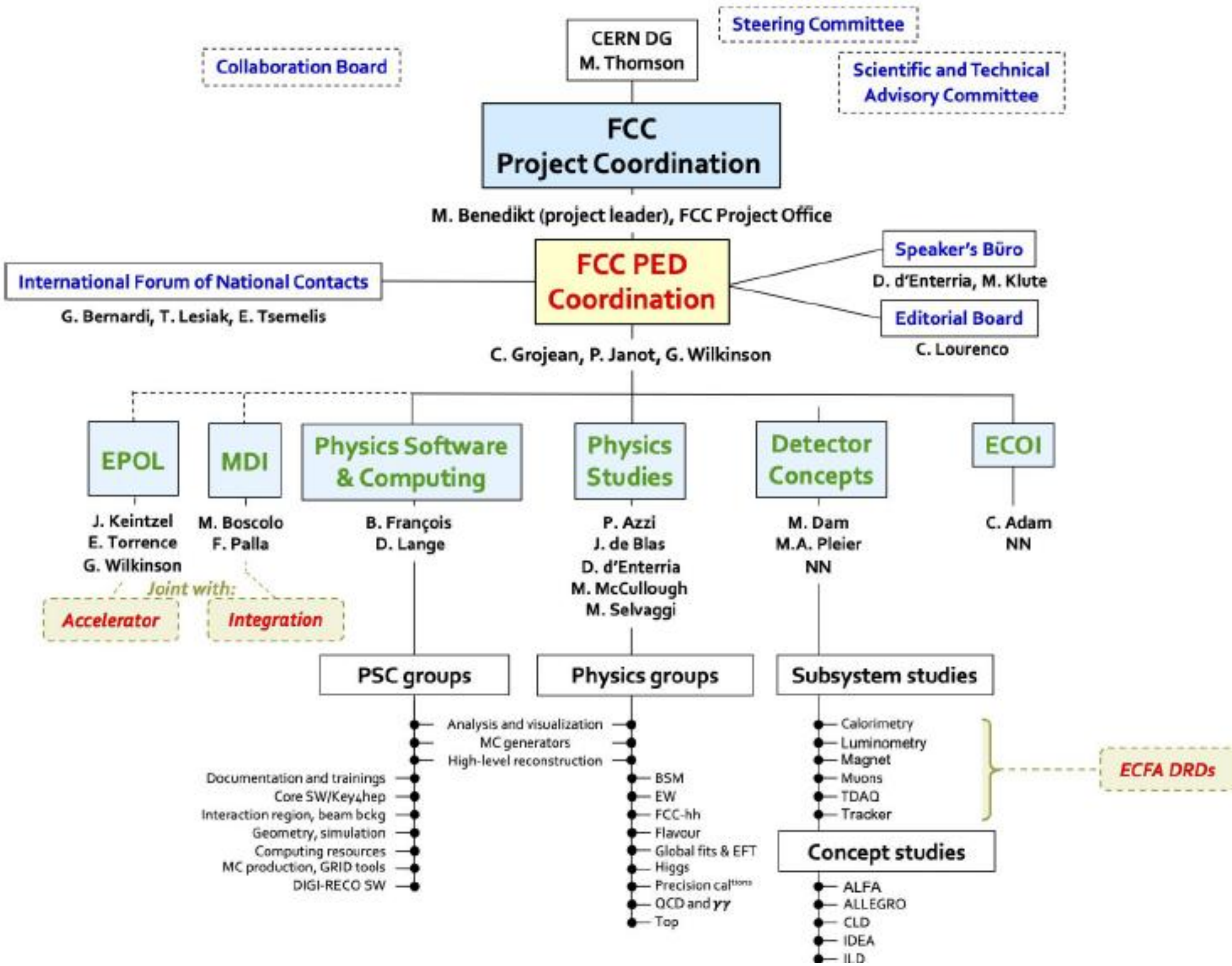
→ cost savings, and
→ higher machine availability, and increased integrated luminosity

Higher dynamic and momentum aperture, and more flexibility

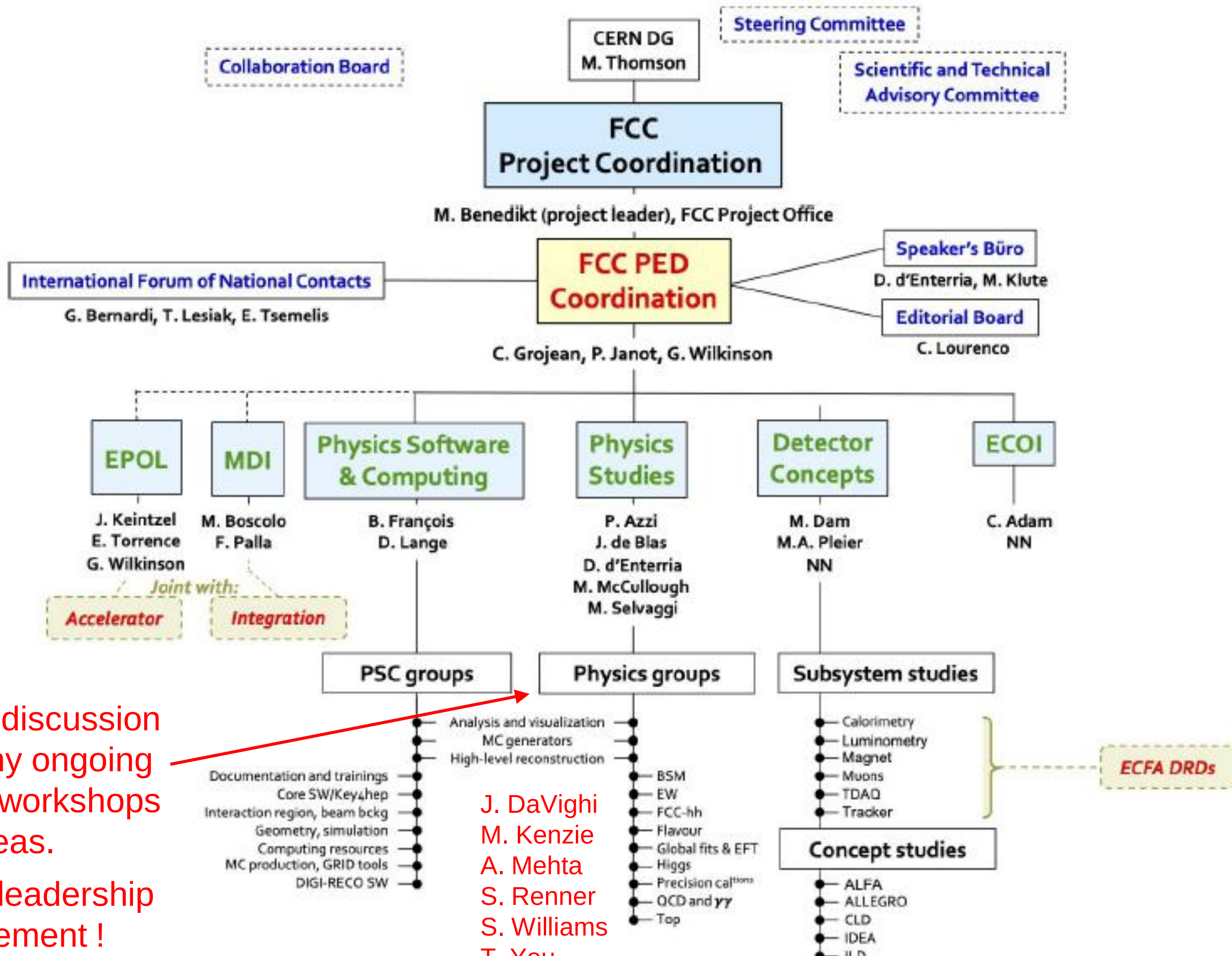
→ this, and other factors, opens the possibility of changing the RF frequency (from 400 MHz to 600 MHz), which may bring several benefits, including cost. Discussion ongoing.

Physics, Experiments and Detectors (PED) during RDP

Organisation of Physics, Experiments and Detectors in Reference Design Phase



Organisation of Physics, Experiments and Detectors in Reference Design Phase



J. DaVighi
M. Kenzie
A. Mehta
S. Renner
S. Williams
T. You
…

Limited further discussion today, but many ongoing and upcoming workshops in all areas.

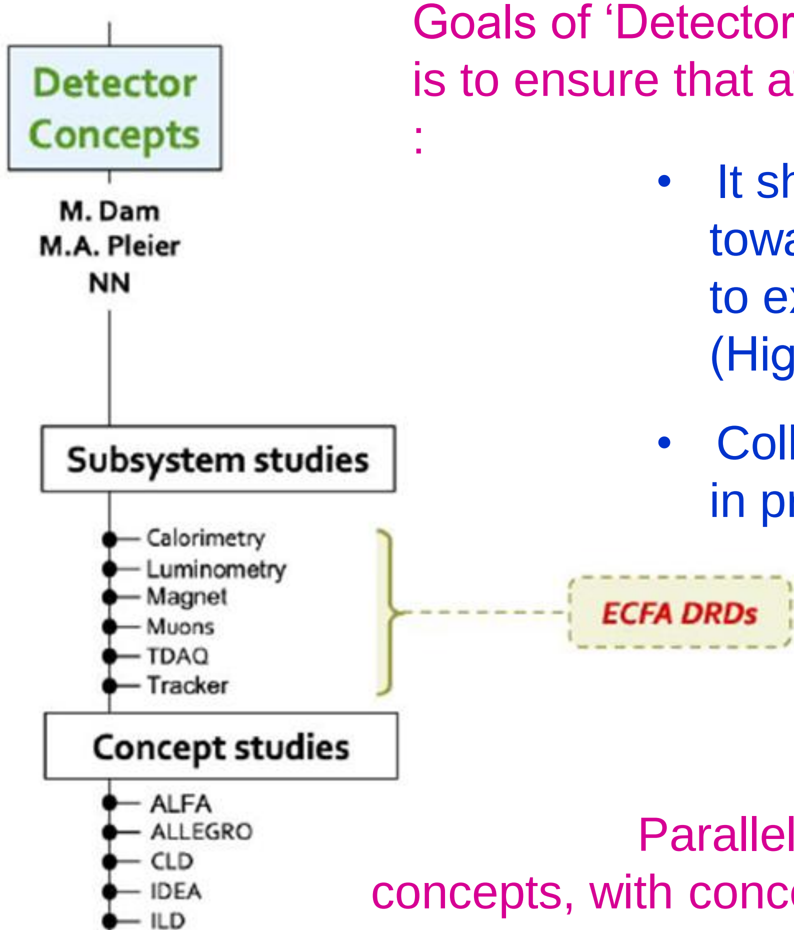
Significant UK leadership and engagement !

PED objectives during the RDP

Below is the list of key PED objectives during RDP. UK physicists are encouraged to engage with any of these & more. Today will say a little more about selected topics.

- Continuation of the development of specific conceptual detector designs with the international HEP community;
- Consolidation of IP region layouts & detector integration;
- Background mitigation strategies & machine-detector interface (MDI) optimisation;
- Development of a common computing architecture model & finalisation of a common software/analysis framework;
- Realistic implementation of some of the algorithms needed to confirm the experimental systematic uncertainties on EW precision observables;
- Coordination of the theory community to address the corresponding theory challenges for the FCC-ee;
- Assessment of the physics case, feasibility, and schedule implications for different centre-of-mass energy stages;
- Streamlining & optimisation of the procedures for centre-of-mass energy calibration & for possible monochromatic operation at 125 GeV to explore the electron Yukawa coupling;
- Proposal for staging implementation & improvements of the (staged/descoped) FCC-ee.

Detector activities



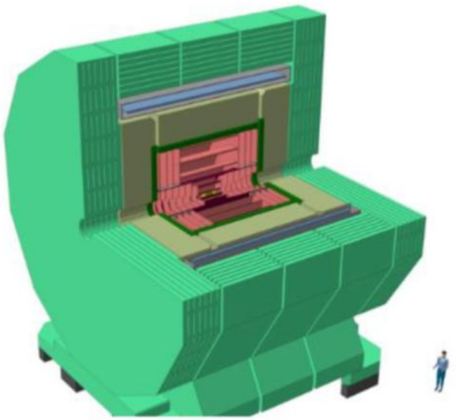
Goals of ‘Detector Concepts’ WP in Reference Design Phase is to ensure that at time of decision on project approval:
:

- It should be clear that there is a path towards detector solutions that will be able to exploit fully the physics opportunities (Higgs, EW, flavour, LLP…);
- Collaborations are ready to form immediately, in preparation for down-select of experiments.

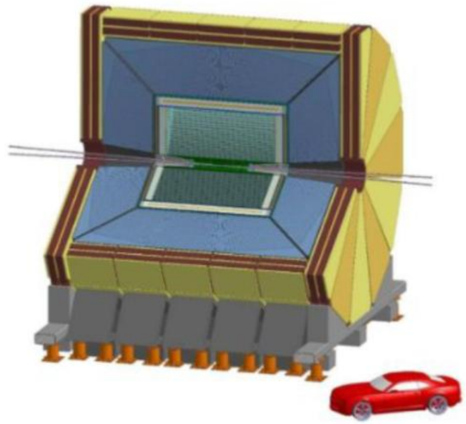
Parallel work on both subsystems and on individual concepts, with concept advocates contributing to the subsystem activities, and vice versa – too early for collaborations or competition !

Emerging detector concepts

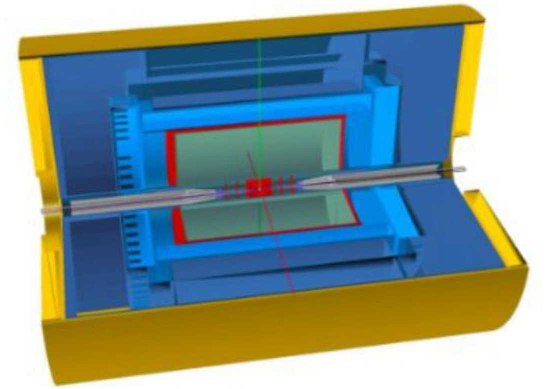
CLD



IDEA

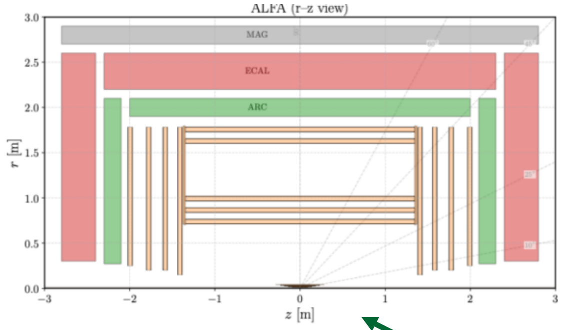


ALLEGRO

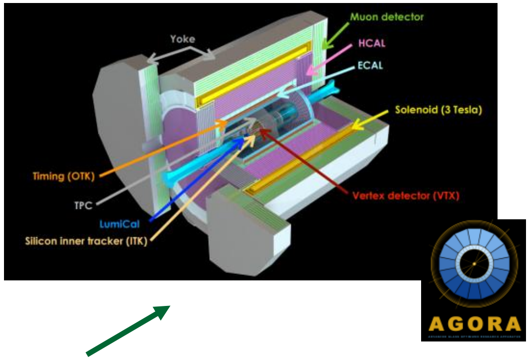


ILD (being ported from ILC)

ALFA



AGORA (being ported from CEPC)



New additions

Not yet collaborations ! These will only form after project approval.

Detector concepts: distinguishing features

	Tracker	PID	ECAL
CLD [FCC week link]	Si based (precise technology under review)	Option for RICH ('ARC')	Silicon tungsten
IDEA [FCC week link]	Drift chamber, plus Si wrapper	dE/dx, dN/dx, plus TOF	Crystal dual readout
ALLEGRO [FCC week link]	Drift chamber or straw tube or SciFi, plus Si wrapper	dE/dx, dN/dx (if available), plus TOF	Noble-liquid
ILD [FCC week link]	TPC	dE/dx, dN/dx, possibly plus TOF	Silicon tungsten
ALFA [FCC week link]	MAPS	RICH ('ARC')	GRAiNITA (novel crystal-based), better than 2%/sqrt(E) + 1%
AGORA [FCC week link]	TPC (for now)	dE/dx, dN/dx Possible forward RICH	BGO crystal 2%/sqrt(E) + 1%

Vertex Detectors

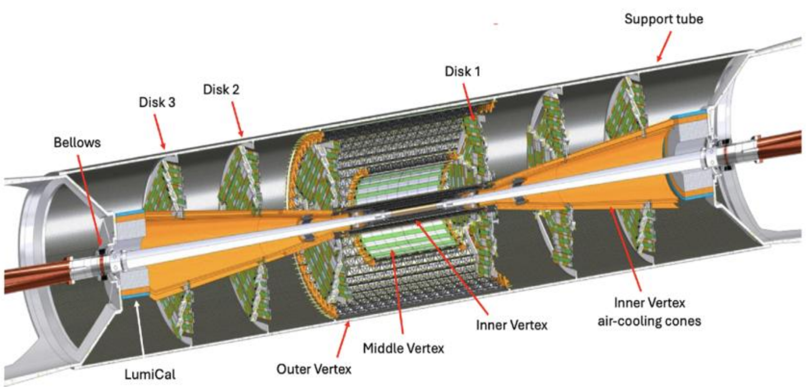
Vertex detector developments highly inspired by ALICE ITS2 and ITS3 designs

- All based on thinned and stitched MAPS
- Ultra-low material, micron precision, low power, efficient cooling, lightweight mechanics, all ~1cm from IP

[Workshop, Oct. 2025]

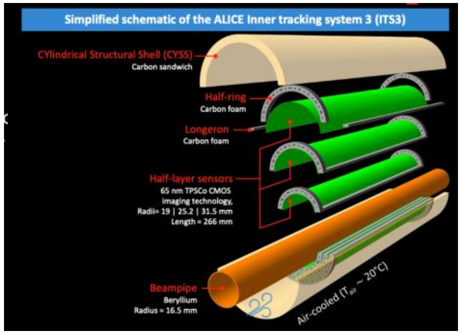
IDEA Vertex Detector (INFN Pisa, Frascati)

- Fully integrated in MDI design
- All sensors are 50 μm MAPS
- Three inner barrel layers: 25 x 25 μm^2, 50 mW/cm^2, air cooling
- Middle + outer layers: 150 x 50 μm^2, water cooled
- Three disks both forward and backward
- Hit resolution: ~3 μm; material: 2.5% X_0 at 90°



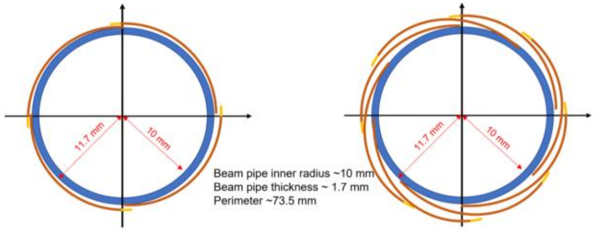
FCC-SEED: curved sensors wrapping around beam pipe (French institutes)

ALICE ITS3 with air cooling under development



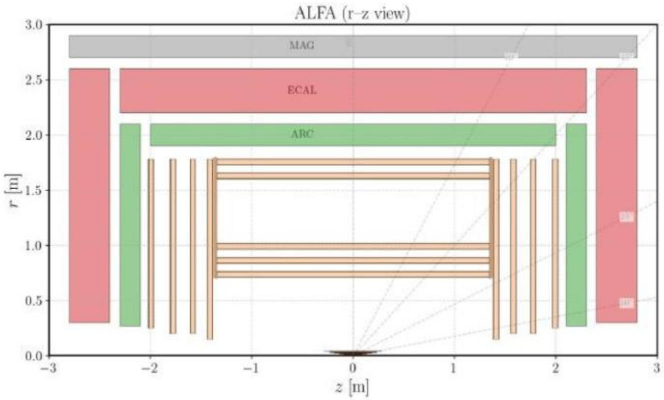
12-mm curvature reached

FCC-SEED



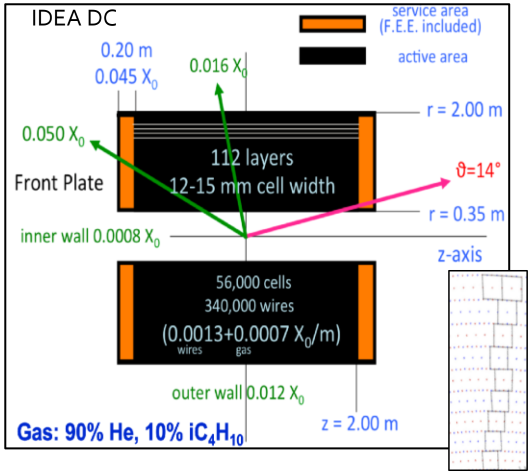
Central Trackers

Tracking is one of the places where the relevant design space remains widest.

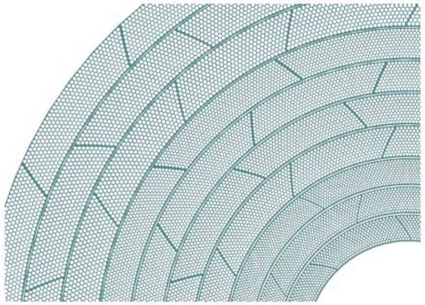


Full silicon tracker
- CLD
- ALFA

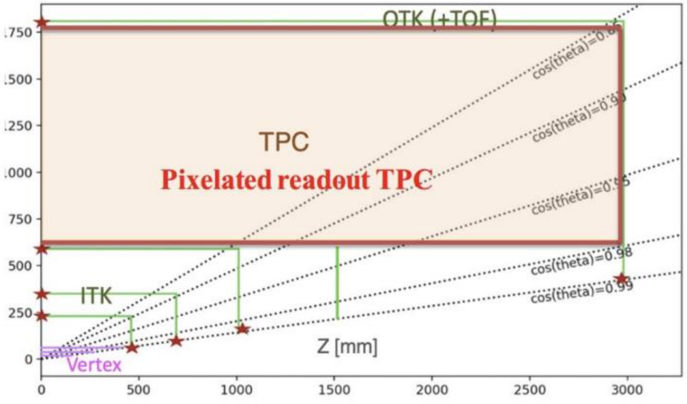
Drift Chamber
- IDEA
- ALLEGRO



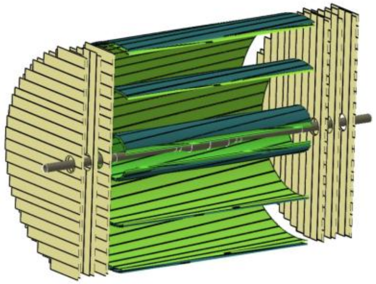
Straw Tracker (ALLEGRO ?)
Robust alternative to DCH?



Time Projection Chamber
- ILD and AGORA



Scintillating Fibre (SciFi) Tracker
- studied for ALLEGRO



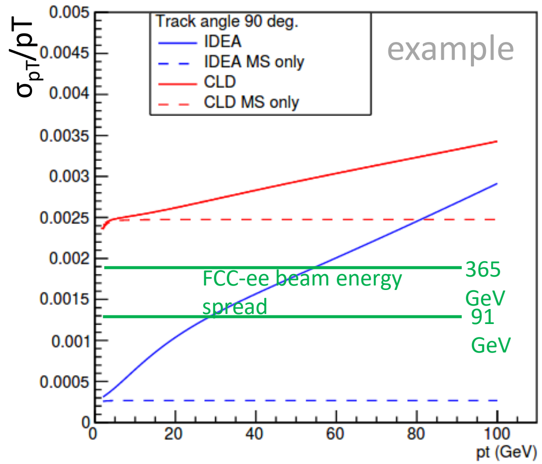
Central Trackers: gaseous or Si ?

At FCC-ee energies, momentum resolution in the CLD Si Tracker limited by multiple scattering.

$$\sigma(p_{\mathrm{T}})/p_{\mathrm{T}}^2 = a \oplus \frac{b}{p\sin\theta}$$

mult.scat

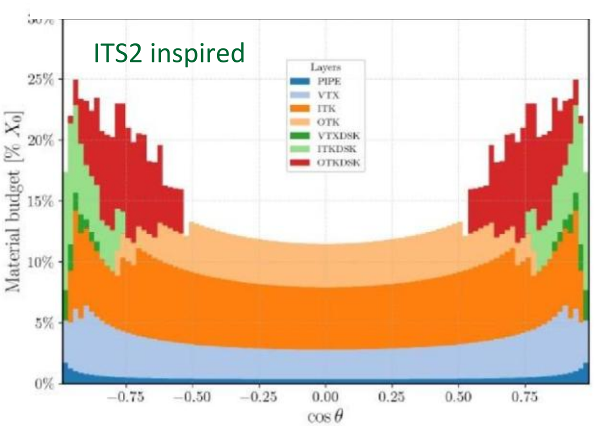
point resolution



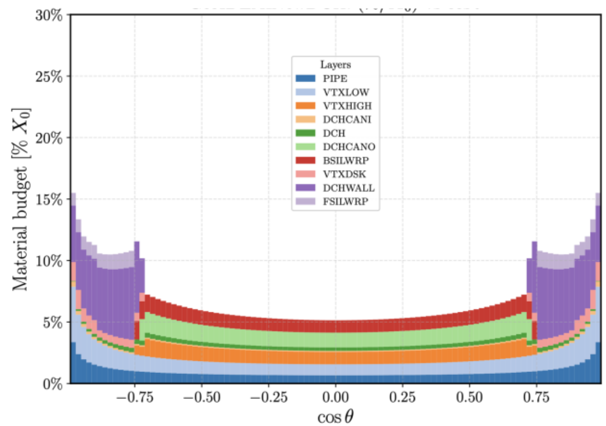
There used to be a strong case for gaseous trackers.

ALFA all-MAPS tracker has a competitive material budget !

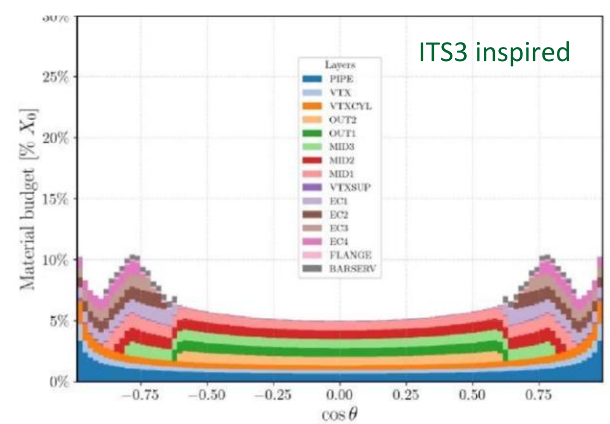
CLD Si pixels + strips



IDEA Drift Chamber + Si



ALFA full Si MAPS



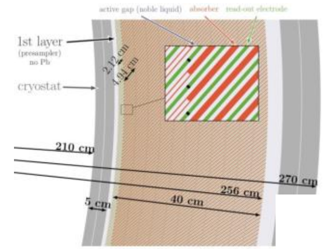
Calorimetry

All concepts aim at Particle Flow reconstruction
- with different emphasis on granularity, energy resolution, stability
- R&D activities concentrated within DRD6 (DRDcalo)

Noble Liquid ECAL + Tile HCAL:

- fine longitudinal sampling (w.r.t. ATLAS, 4 → 12 layers)
- Pb+LAr or denser W+LKr; cold (or warm) electronics
- CALICE or ATLAS style scintillating tile HCAL

EM: $\sigma(E)/E \simeq$ 8-10%/$\sqrt{E}$
Jet: $\sigma(E)/E \simeq$ 4% @ 50 GeV

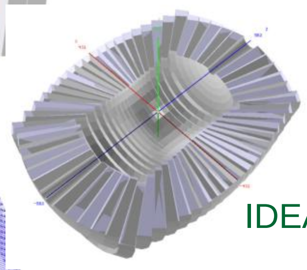


Allegro

Fibre-based Dual Readout :

- copper or steel matrix; Cherenkov and scintillating fibres, SiPMs
- very fine transverse granularity, (some) longitudinal inf. via timing

EM: $\sigma(E)/E \simeq$ 11%/$\sqrt{E}$
Jet: $\sigma(E)/E \simeq$ 3-4% @ 50 GeV

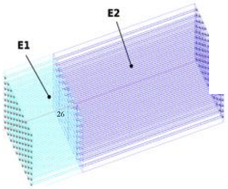


IDEA

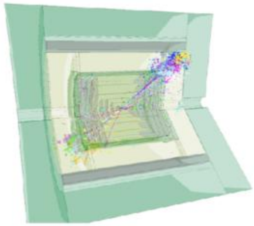
Segmented crystals with Dual Readout:

- Fine transverse segmentation, two longitudinal layers; SiPMs
- Excellent EM energy resolution of ~3%/√E
- Combined with fibre-based DR calorimeter as HCAL

EM: $\sigma(E)/E \simeq$ 3%/$\sqrt{E}$
Jet: $\sigma(E)/E \simeq$ 3-4% @ 50 GeV



CLD,ILD



CALICE-style sandwich with embedded front-end electronics:

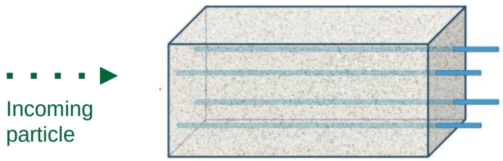
- Tungsten-silicon ECAL; extremely fine segmentation: $(0.5\ \mathrm{cm})^3$
- Steel-scintillator HCAL; SiPM-on-Tile; fine segmentation: $(2.5\ \mathrm{cm})^3$

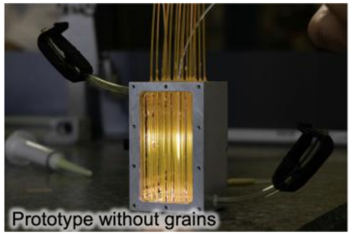
EM: $\sigma(E)/E \simeq$ 16%/$\sqrt{E}$
Jet: $\sigma(E)/E \simeq$ 3-4% @ 50 GeV

Calorimetry – new additions

ALFA: Grainita ECAL concept

- 1mm crystal grains ($ZnWO_4$) immersed in heavy liquid (sodium-tungstate-water solution) or resin
- Emitted light collected by WLS fibres



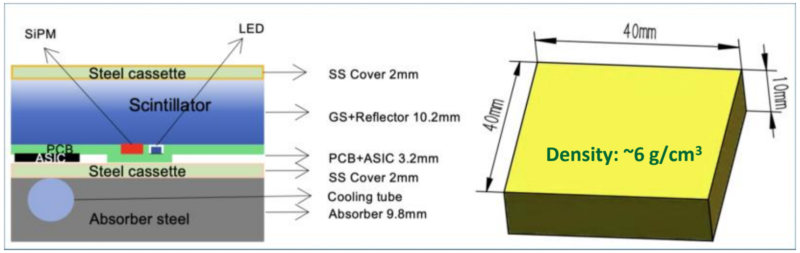


- Excellent energy resolution
- High transverse granularity
- Cost-effective compared to homogenous crystals
- First (small) prototype: 28x28x55 mm^3

ALFA: Dual-Readout Tile HCAL ?

- For example, CALICE-style Steel / Quartz / Scintillator Tile HCAL
- Also to function as a yoke
- To be studied as an extension of AHCAL (DRD6) ?

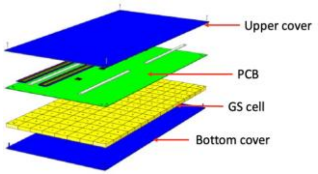
AGORA: Glass Scintillator HCAL



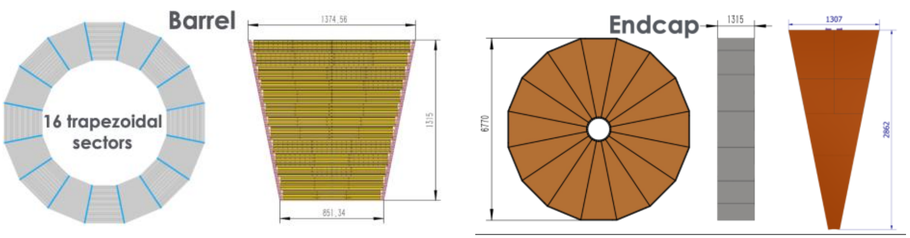
Single layer structure

Total of 85 m^3 glass scintillator

- High sampling fraction (~30%)
- Resolution of ~30%/√E



48 layers stacked per module

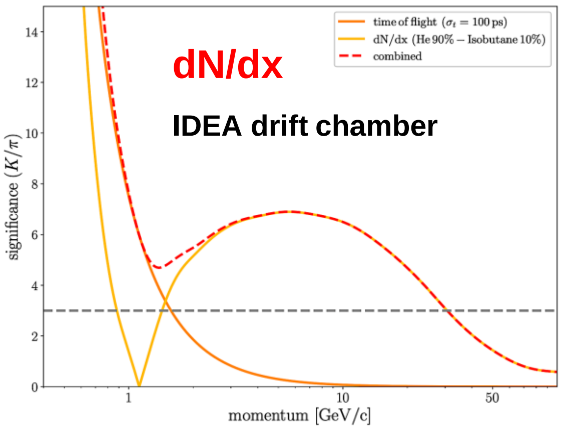


Charged-particle identification

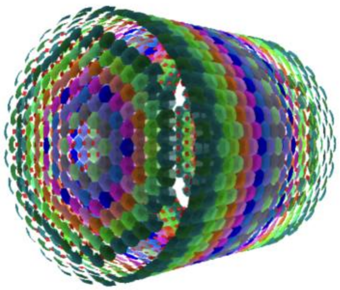
Essential for flavour physics, over a wide momentum range (up to 50 GeV).
Useful also for flavour-tagging jets in Higgs, W and top physics.

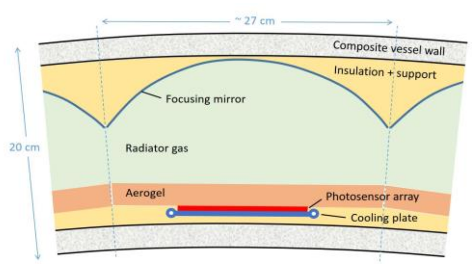
With gaseous tracking chamber, dE/dx,
or even better dN/dx (cluster counting).

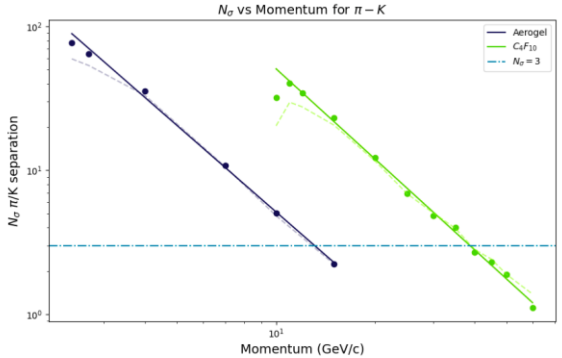
Complemented by TOF at low momentum,
provided by *e.g.* LGADs in Si wrapper.



With Si tracker, there needs to be a
dedicated PID detector, preferably RICH to cover full momentum range, *e.g.* ARC.







UK involvement through DRD4.

The path towards Collaboration formation

From the 'FCC Objectives, Deliverables, Milestones' Council Document:

We intend to arrange proto-EoIs to already be made available as part of the for-approval Council documentation

> These activities are aimed at demonstrating feasibility, integration compatibility and cost realism for the FCC-ee detectors, without committing to a final detector selection or to experiment collaborations forming. Expressions of interest for FCC-ee detectors will be invited after the project approval, with a view to moving towards detector conceptual design reports by 2033.

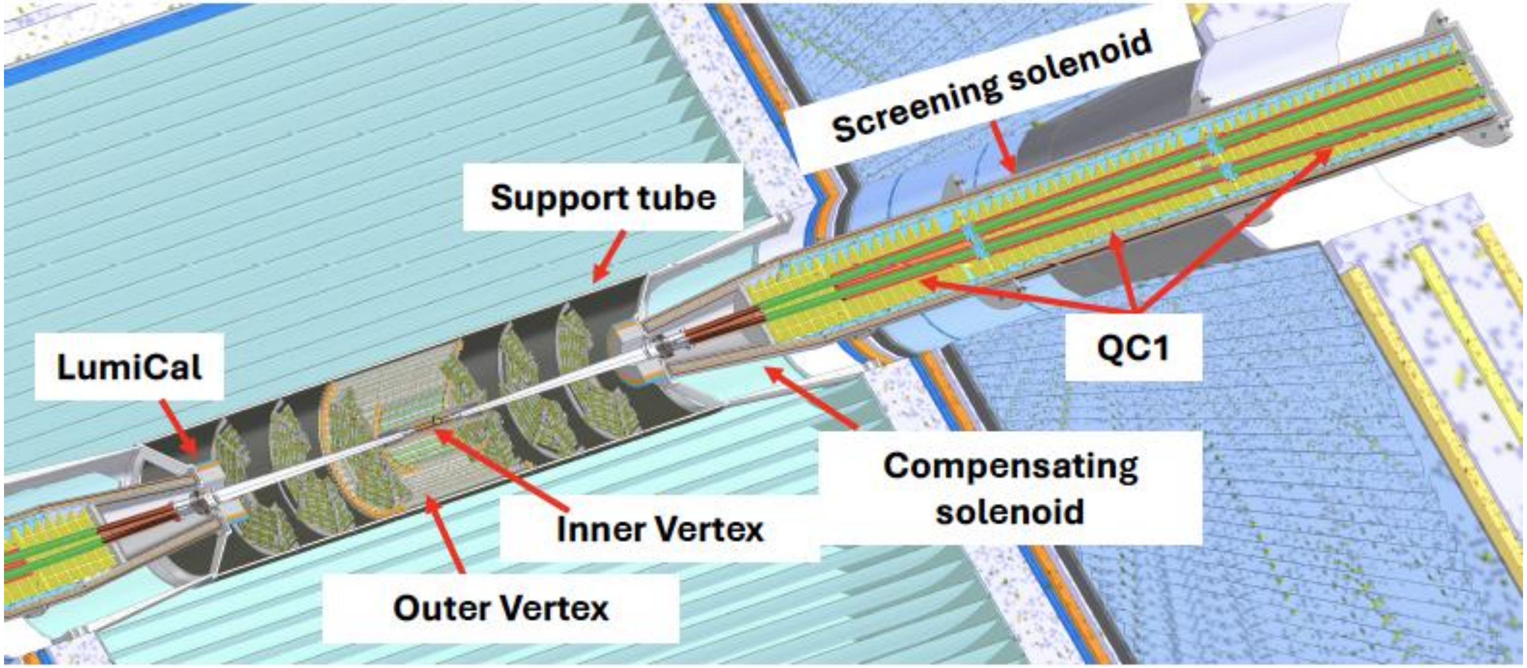
It is suggested (by PED) that a process begin immediately after project approval (assumed 2028) to enable community-wide discussion and synthesis of best elements of existing proposals towards four robust LoIs, and collaborations to form late 2029 / early 2030.

ECFA could facilitate this process through arranging series of \`Evian-like' workshops (recall Evian Meeting of 1992, two years before LHC approval, which considered 12 LHC EoIs and cleared the way to the final configuration).

UK physicists are encouraged to widen their engagement with FCC Detector Concepts so that they can play a central role in these discussions !

Machine-detector interface

FCC-ee interaction region is a highly complex and crowded environment, whose optimisation demands very close cooperation between physicists & machine.



Key topics:

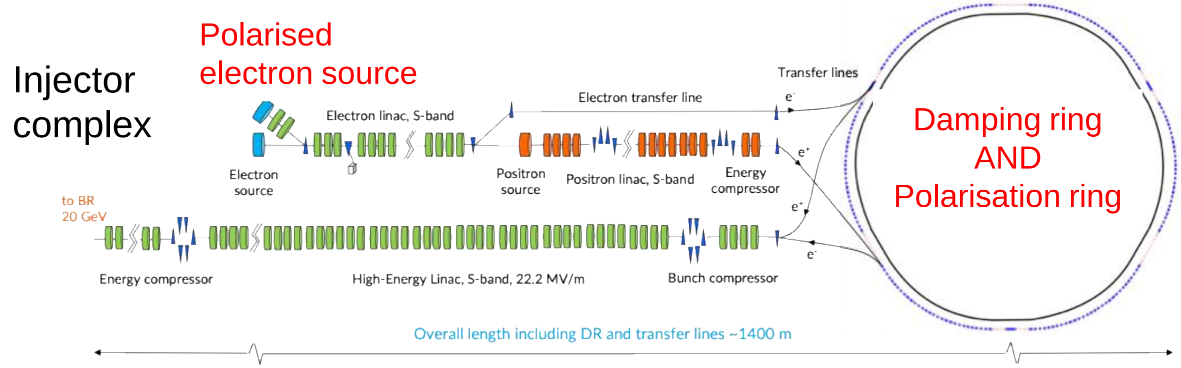
- Design and implementation of lumi cal & vertex detector.
- Beam pipe design, including cooling.
- Optimisation of collimators, masks and shielding.
- Evaluation of all sources of machine background.
- Detector opening strategy and impact on cavern dimensions.

E_{CM} calibration ('EPOL')

Ultra-precise collision energy calibration a unique strength of FCC-ee, and essential for electroweak programme. Programme relies on transversely polarised beams and resonant depolarisation, but plenty of scope for particle physicist involvement

- Polarimeter development (Manchester student [J. Burvill] already active)
- Measurement of E_{CM} related quantities (E_{CM}, crossing angle, longitudinal boost…) with physics events *e.g.* $e^+e^- \rightarrow \mu^+\mu^-$

Interesting developments:

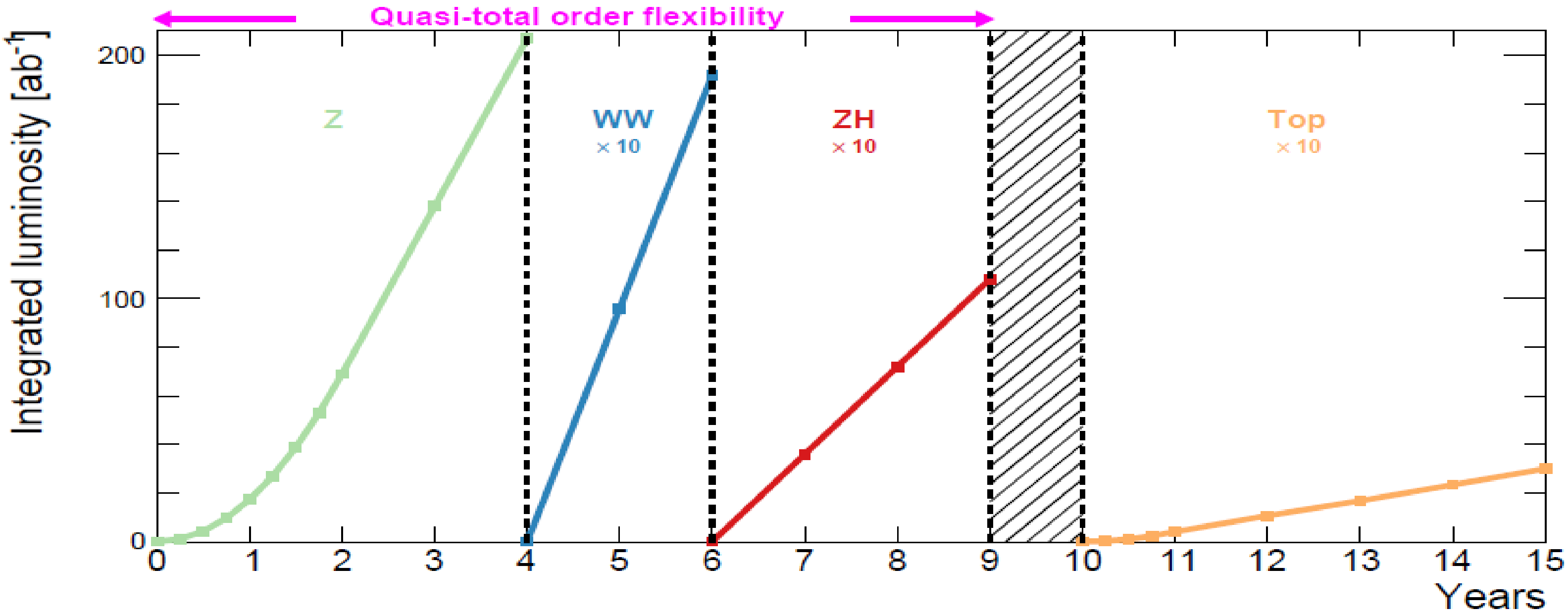


1) Moving towards strategy of injecting polarised beams, rather than 'wasting' ~2 hours at start of fill to wait for polarisation to build up → greater machine availability / more time for physics !

2) New idea: measure dimuon production from collision of beam positrons with electrons in injected gas target. Threshold is very close to E_b = 45 GeV and can be measured very precisely. Again, more help welcome !

Optimisation of running strategy

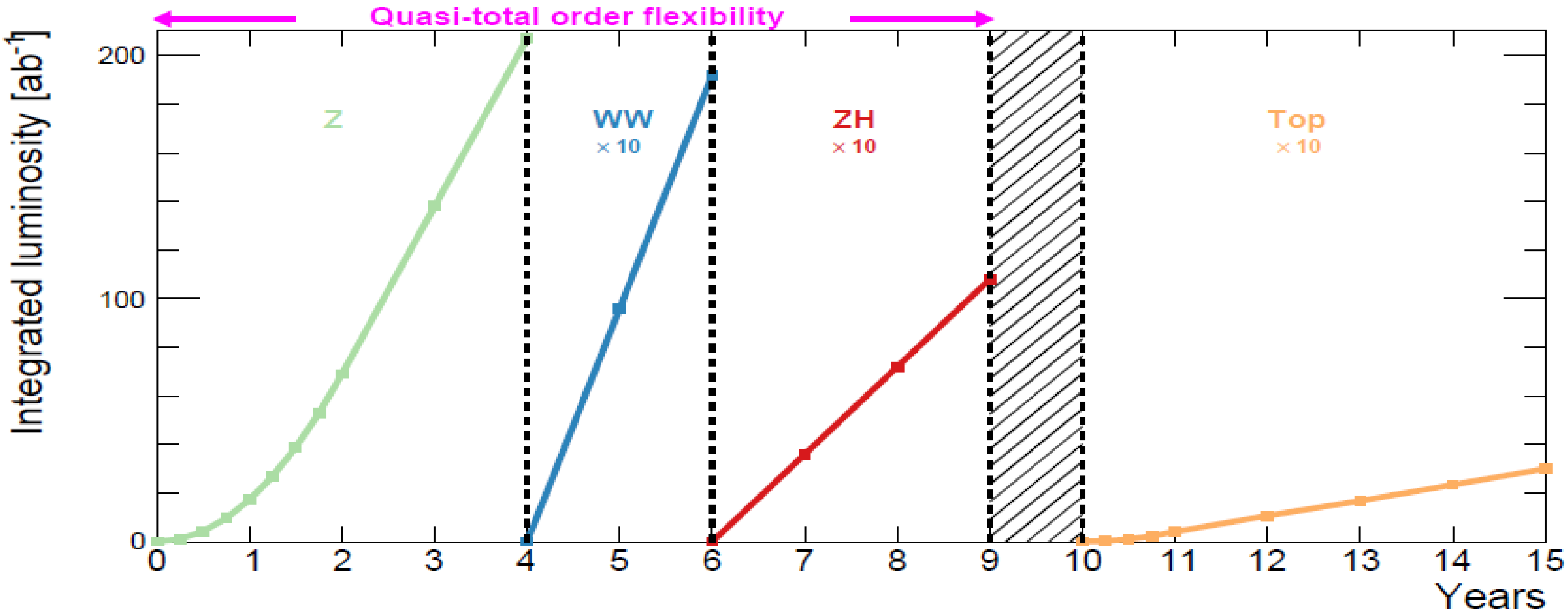
The current baseline plan, which (probably) will be that presented for approval:



Working point	Z pole	WW thresh.	ZH	$t\bar{t}$	
$\sqrt{s}$ (GeV)	88, 91, 94	157, 163	240	340–350	365
Lumi/IP (10^{34} cm^{-2}s^{-1})	140	20	7.5	1.8	1.4
Lumi/year (ab^{-1})	68	9.6	3.6	0.83	0.67
Run time (year)	4	2	3	1	4
Integrated lumi. (ab^{-1})	205	19.2	10.8	0.42	2.70
Number of events	6×10^{12} Z	2.4×10^{8} WW	2.2×10^{6} ZH + 65k WW $\rightarrow$ H	2×10^{6} $t\bar{t}$ + 370k ZH + 92k WW $\rightarrow$ H	

Optimisation of running strategy

The current baseline plan, which (probably) will be that presented for approval:



However, this is not set in stone. Imaginative thinking about how this could be adjusted, or what additional running points could be added, are welcome !

In general, flexibility of operation means no decisions need to be taken now.

Optimisation of running strategy

Possibilities include, changing balance of data at each energy point within same operational time envelope (or, of course, extending overall envelope)...

- Increase the number of Z, by rebalancing off-peak and on-peak, or adding more years of operation - direct benefits for flavour physics and LLP searches.
- More WW threshold data, if theory and E_b systematics on m_W warrant it.
- Re-balance Higgs data at 240 GeV and 365 GeV (*e.g.* for κ_λ sensitivity).

…or instead / in addition taking data at additional energy points

- 'few' year operation at 125 GeV to gain sensitivity to electron Yukawa. Monochromatisation and (possibly) polarisation required, so this is something to understand better before end of RDP [→ backups].
- Threshold HZ run at 217 GeV for alternative measurement of m_H.
- Short runs at energies below Z pole for QCD studies.

Work backing up any of the above, or any new ideas most welcome !

Descoping and staging

Reminder:
EPPSU plan B

B. A descoped FCC-ee is the preferred alternative option for the next flagship collider at CERN.

Descoping scenarios include removing the top-quark run, constructing two rather than four interaction regions and experiments and decreasing the radiofrequency (RF) system power. These measures would reduce the construction cost by approximately 15%. Although this would have a significant impact on the breadth of the physics programme and the precision achieved, the descoped FCC-ee would still provide a very strong physics programme and a viable path towards high energies, compared to the alternative collider options. Should additional resources become available, these descoping scenarios would be reversible.

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Physics community needs to be vocal in what would be lost in a true descoping, and push instead that this option be recast as a staging scenario.

Recoverable descopes:
- lower RF power (probably reversible): *e.g.* 50 MW to 30 MW saves 0.35 BCHF
- *deferred* top run would save 1.26 BCHF from initial bill

Not recoverable, and a false economy:
- excavating only two experimental caverns would save 0.80 BCHF

It is for the community to define how best to satisfy this plan B cost reduction.

Already developments ongoing, *e.g.* optics and RF changes, that will help.

Concluding messages

CERN DG message from plenary ECFA, Amsterdam, July 2026 [link]:

FCC-ee

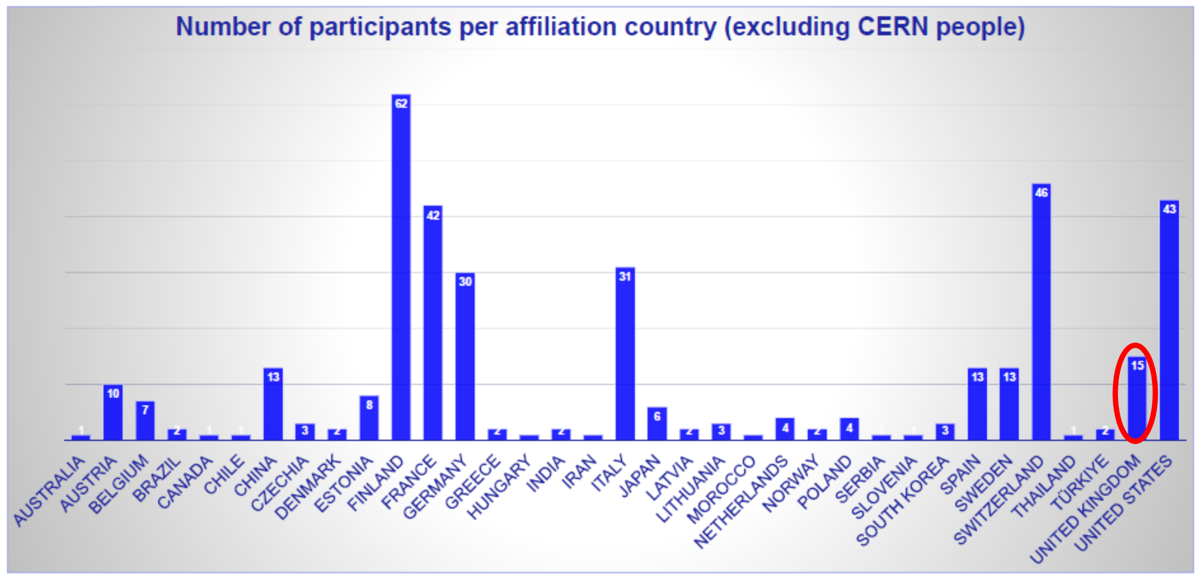
The next two years will be critical to our success

- **FCC-ee** is the clear best option for the future of CERN **and for global particle physics**
  - **the outcome of the European Strategy Update is crystal clear**
- At CERN, we will do everything possible to ensure the realisation of FCC-ee

At this time, it is important that the whole community gets behind our collective goal to secure FCC-ee as CERN's next flagship collider

Concluding messages

FCC is entering a decisive phase – now would be an excellent time for UK to increase its involvement, which until now lags behind other international partners.



FCC Week 2027

Next FCC collaboration meeting will be the FCC Week 2027 in Madrid, this year including an integrated FCC Physics Workshop (previously a separate event).

Entire community invited and welcome !

(warning: I've heard rumours that the dates could still be changed, so check before booking !)

Practical information

E-groups that all can sign up for. The clickable links here will not work, but they will on the version of this list uploaded to indico page of meeting.

= send an email to the full e-group
= link to an open e-group = link to a closed/cumulative e-group
= send an email to the coordinators/conveners

- > **FCC-PED-Physics**
  - FCC-PED-PhysicsCoordinationGroup
  - FCC-PED-PhysicsGroup-BSM
  - FCC-PED-PhysicsGroup-EWPrecision
  - FCC-PED-PhysicsGroup-Flavours
    - FCC-PED-PhysicsGroup-Flavours-Coordination
    - FCC-PED-PhysicsGroup-Flavours-CPC
    - FCC-PED-PhysicsGroup-Flavours-Charm
    - FCC-PED-PhysicsGroup-Flavours-CPV
    - FCC-PED-PhysicsGroup-Flavours-Rare
    - FCC-PED-PhysicsGroup-Flavours-TauEW
  - FCC-PED-PhysicsGroup-GlobalFits
  - FCC-PED-PhysicsGroup-hh
  - FCC-PED-PhysicsGroup-Higgs
  - FCC-PED-PhysicsGroup-HighLevelReco
  - FCC-PED-PhysicsGroup-MCgenerators
  - FCC-PED-PhysicsGroup-PrecisionCalculations
  - FCC-PED-PhysicsGroup-QCD
  - FCC-PED-PhysicsGroup-Top
- > **FCC-PED-SoftwareAndComputing**
  - FCC-PED-SoftwareAndComputing-Coordination
  - FCC-PED-SoftwareAndComputing-Analysis
  - FCC-PED-SoftwareAndComputing-Core
  - FCC-PED-SoftwareAndComputing-DB
  - FCC-PED-SoftwareAndComputing-DigiReco
  - FCC-PED-SoftwareAndComputing-Documentation
  - FCC-PED-SoftwareAndComputing-Full-Simulation
  - FCC-PED-SoftwareAndComputing-Generators
  - FCC-PED-SoftwareAndComputing-LEPdata
  - FCC-PED-SoftwareAndComputing-MCproduction
  - FCC-PED-SoftwareAndComputing-Resource
  - FCC-PED-SoftwareAndComputing-MDI
- > **FCC-PED-DetectorConcepts**
  - FCC-PED-DetectorConcepts-Coordination
  - FCC-PED-DetectorConcepts-Calorimetry
  - FCC-PED-DetectorConcepts-Luminometry
  - FCC-PED-DetectorConcepts-Magnet
  - FCC-PED-DetectorConcepts-Muon
  - FCC-PED-DetectorConcepts-TDAQ
  - FCC-PED-DetectorConcepts-Tracker
  - FCC-PED-DetectorConcepts-ALFA
  - FCC-PED-DetectorConcepts-ALLEGRO
  - FCC-PED-DetectorConcepts-CLD
  - FCC-PED-DetectorConcepts-IDEA
  - FCC-PED-DetectorConcepts-ILD
- > **FCC-ee-MDI**
- > **FCC-ee-PolarizationAndEnergyCalibration**
- > **FCC-PED-ECOI**
- > **FCC-International-Forum-National-Contacts**
- > **FCC-PED-CoordinationGroup**
- > **FCC-PhysicsAndExperiments-SteeringGroup**
- > **FCC-PED-SpeakersBuro**
- > **FCC-PED-EditorialBoard**

FCC-PED =

List of regular meetings on indico: https://indico.cern.ch/category/5251/

Backups

Conclusion of ESPPU and CERN endorsement

Outcome of ESPPU process:

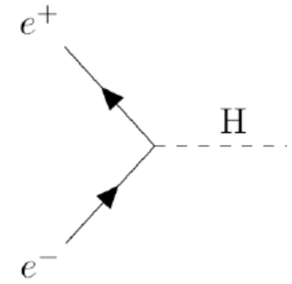
“ The next CERN flagship collider project

A. The e^+e^- Future Circular Collider (FCC-ee) is recommended as the preferred option for the next flagship collider at CERN.

B. A descoped FCC-ee is the preferred alternative option for the next flagship collider at CERN.”

On 22nd May, in Budapest, CERN Council voted to update European Strategy following these recommendations.

Run at 125 GeV ?
s-channel Higgs production

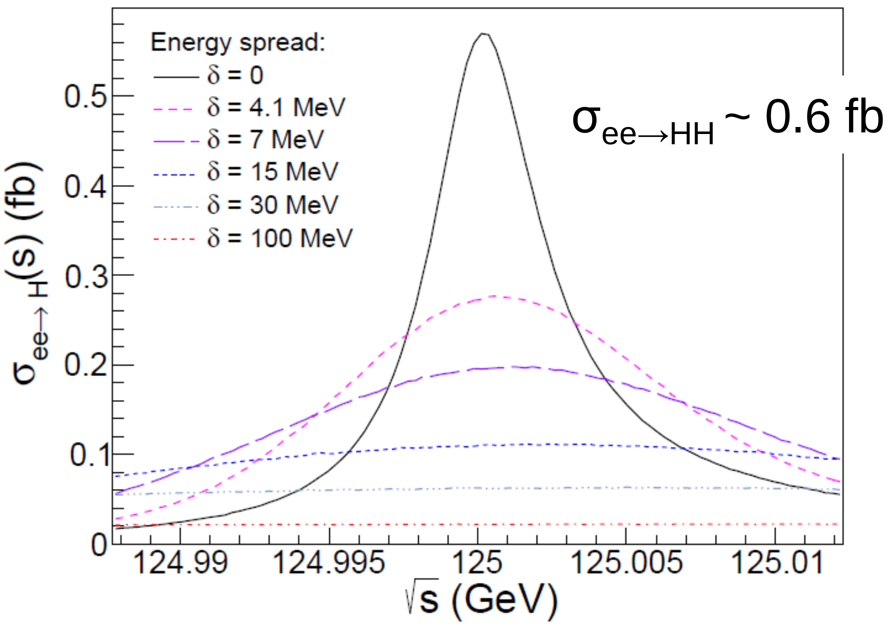


A tantalising possibility, under evaluation and not in FSR baseline, is to devote a few years operation at $E_{CM}=m_H=125$ GeV to measure Yukawa coupling to electrons.

But cross-section is tiny…

…& effectively decreased further through ISR and because Higgs width (~4 MeV) small compared to E_{CM} spread.

Note that natural E_{CM} spread for colliding beams is ~70 MeV. This must be reduced: the monochromatisation challenge !

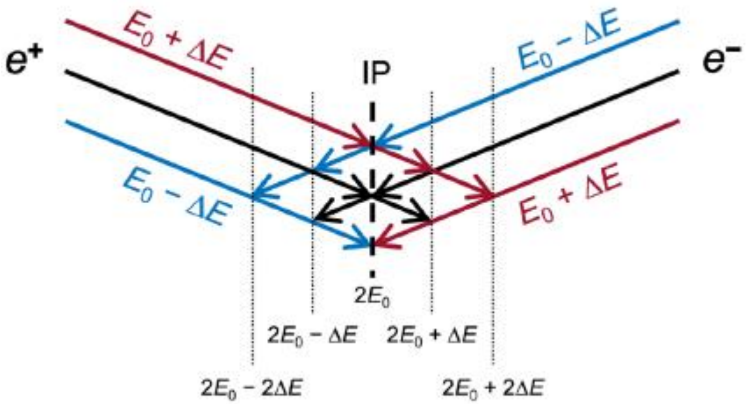


Also need good knowledge of m_H (~ Γ_H), good E_{CM} knowledge, & high E_{CM} stability.

In addition, must develop refined analysis exploiting all Higgs decay modes to separate signal from background (*e.g.* Higgs $\to$gg becomes an important channel).

The monochromatisation challenge

Monochromatisation can be achieved through introduced opposite-sign dispersion.



The problem is that this generally also results in an emittance blow up, and hence a decrease in luminosity. Need to find the sweet spot in $\delta_{\sqrt{s}}$ vs. L plane !

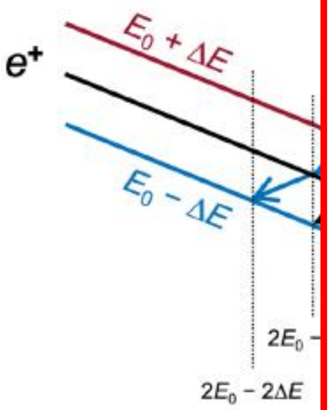
First serious attempt to implement such a scheme [Zhang *et al.*, arXiv:2411.04210] achieves monochromatisation factors of >2. With such a performance, it would be possible to set 95% CL limit of 2.5x SM value in 1 year, ~20-40x better than is foreseeable at HL-LHC. Efforts ongoing to improve further.

Further sensitivity can be enabled through polarised colliding beams [Bughezal *et al.*, arXiv:2407.12975], which may become an option with evolving E_b calibration strategy.

Goal – to reach a clearer idea on feasibility of measurement by end of RDP.

The monochromatisation challenge

Monochromati … -sign dispersion.



… erally also … up, and hence … leed to find the … !

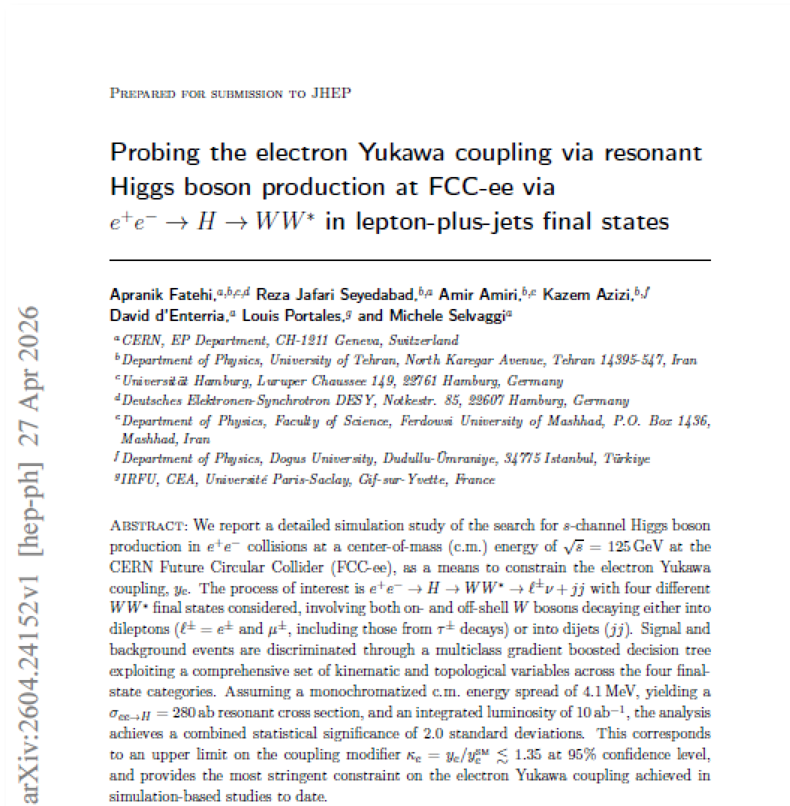
… ement such a … 04210] achieves … of >2. With such

a performanc … M value in 1 year,
~20-40x bett … o improve further.

Further sensi … ms [Bughezal *et al.*, arXiv:2407.1297 … libration strategy.

Goal – to rea … nd of RDP.

Recent developments – a significant (four-fold) improvement in H→WW*→lepton + jets channel, now matching previous golden mode, H→gg.



PREPARED FOR SUBMISSION TO JHEP

Probing the electron Yukawa coupling via resonant Higgs boson production at FCC-ee via $e^+e^- \to H \to WW^*$ in lepton-plus-jets final states

Apranik Fatehi,[a,b,c,d] Reza Jafari Seyedabad,[b,a] Amir Amiri,[b,e] Kazem Azizi,[b,f] David d'Enterria,[a] Louis Portales,[g] and Michele Selvaggi[a]

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[g] IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France

ABSTRACT: We report a detailed simulation study of the search for s-channel Higgs boson production in e^+e^- collisions at a center-of-mass (c.m.) energy of $\sqrt{s} = 125\,\mathrm{GeV}$ at the CERN Future Circular Collider (FCC-ee), as a means to constrain the electron Yukawa coupling, y_e. The process of interest is $e^+e^- \to H \to WW^* \to \ell^\pm\nu + jj$ with four different WW^* final states considered, involving both on- and off-shell W bosons decaying either into dileptons ($\ell^\pm = e^\pm$ and $\mu^\pm$, including those from $\tau^\pm$ decays) or into dijets (jj). Signal and background events are discriminated through a multiclass gradient boosted decision tree exploiting a comprehensive set of kinematic and topological variables across the four final-state categories. Assuming a monochromatized c.m. energy spread of 4.1 MeV, yielding a $\sigma_{ee\to H} = 280\,\mathrm{ab}$ resonant cross section, and an integrated luminosity of $10\,\mathrm{ab}^{-1}$, the analysis achieves a combined statistical significance of 2.0 standard deviations. This corresponds to an upper limit on the coupling modifier $\kappa_e = y_e/y_e^{SM} \lesssim 1.35$ at 95% confidence level, and provides the most stringent constraint on the electron Yukawa coupling achieved in simulation-based studies to date.

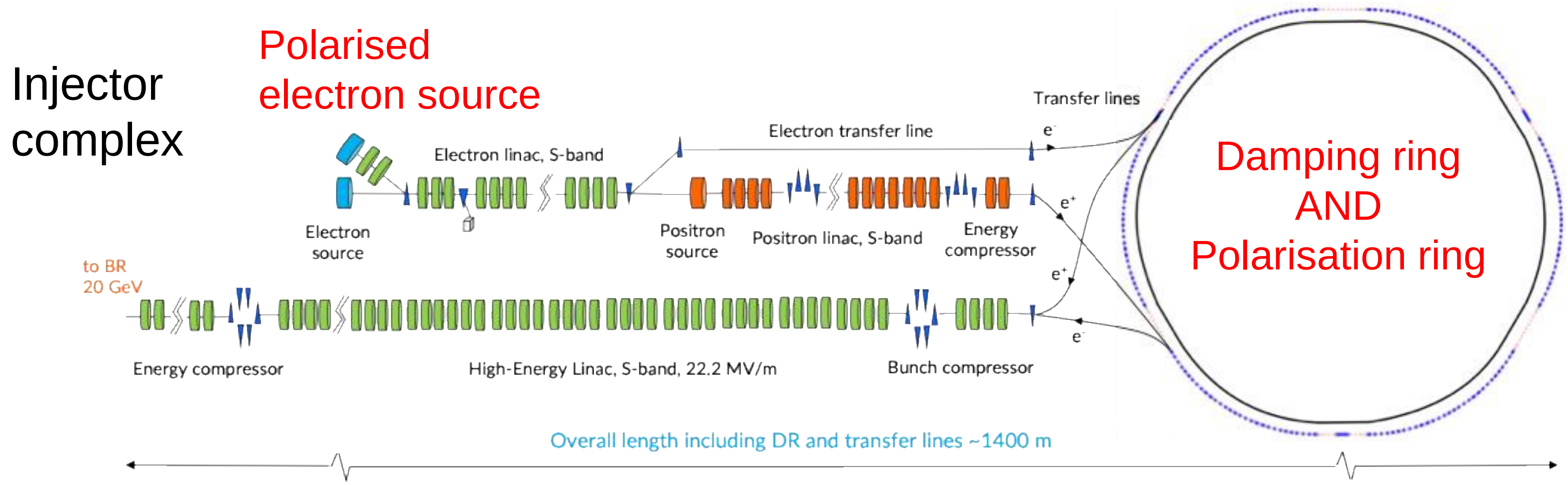
[arXiv:2604.24152]

Important developments: feasibility studies for injection of polarised beams

Transversely polarisation of non-colliding pilot bunches needed for precise calibration of beam energy – vital for EW measurement programme.

Until now, baseline strategy was to inject pilot bunches into collier ring at start of fill, and then spend up to two hours inducing polarisation with wiggler magnets.
→ Impossible to inject colliding bunches during this period – no physics data !

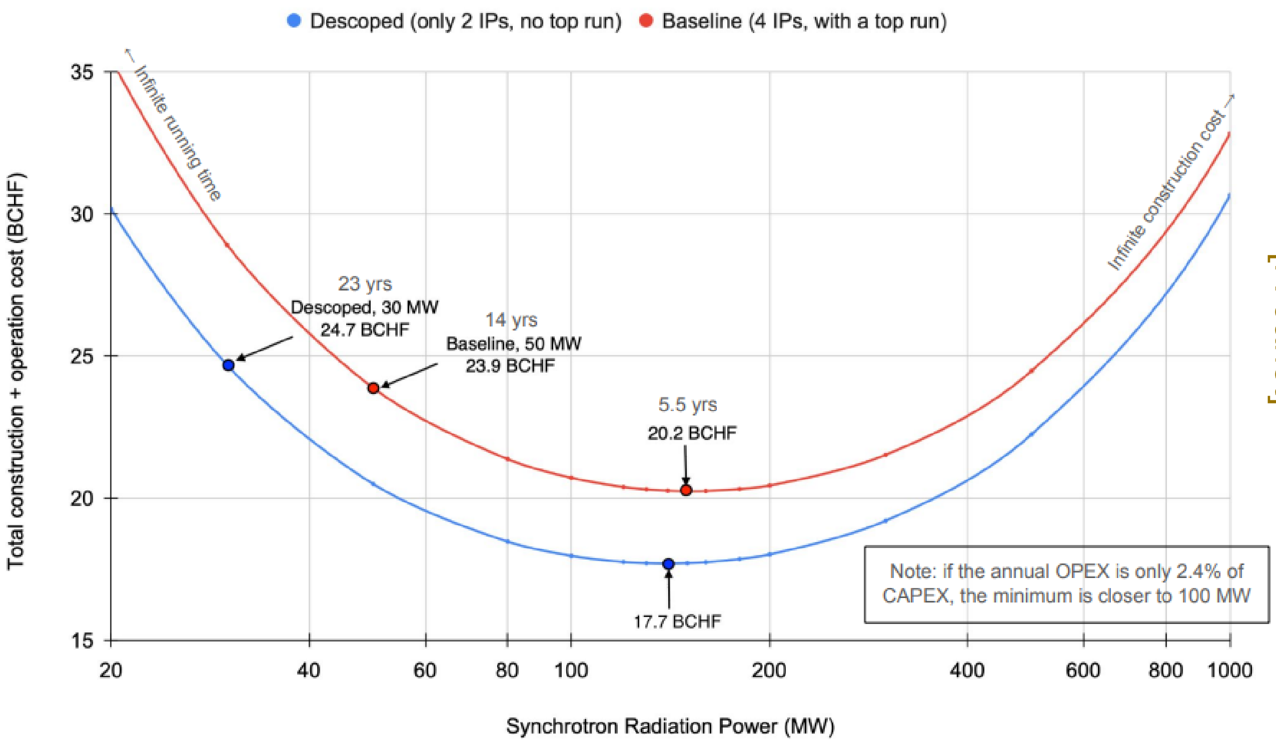
New scheme (not yet baseline, but very likely) – inject already polarised bunches.



Why should a flavour physicist care ? Increases availability by (at least) 10% !

Descoping RF power – a false economy ?

For fixed physics output, it is cheaper (measured in construction + operation costs) to increase RF power rather than decrease it, as latter increases running time.



[P. Janot]

Of course, increased RF power has other consequences, *e.g.* detector backgrounds, so this should not be taken as a proposal, just an observation…