FCC-ee: input to EPPSU drafting day

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21/10/24

Data sets and baseline operation plan

Current baseline plan, assuming four IPs and 15 years of operation (one year required to install RF required for ttbar). Order of Z, WW, ZH running is flexible. Time spent at each energy can be adjusted according to physics priorities.

Run	Energies [GeV]	# years	Integrated lumi [ab^{-1}]	Key physics goals
Z	88, 91, 94	4	40, 125, 40	Z lineshape, flavour, QCD, $\alpha_{QED}(m_Z^2)$, rare decays, dark sector
WW	157.5, 162.5	2	19.2	W mass and width, N_ν, α_{QCD}, flavour
ZH	240	3	10.8	Higgs couplings, σ_{ZH}
ttbar	340,360,365	5	0.4, 2.7	m_{top}, top EW couplings, Higgs couplings via VBF production

Other runs under consideration:

- Run at 125 GeV (Higgs pole) for electron Yukawa;
- Run at 217 GeV for 'threshold' Higgs mass + x-section info valuable for κ_λ;
- Short runs below Z for precision QCD studies.

Five key physics deliverables

FCC-ee physics programme is extremely broad. Below table constructed on arbitrary principle of taking only one measurement from a single physics area. Even then, the limit of five means that certain topics are excluded (m_{top}, QCD, spectroscopy…)

Z, electroweak	Z width	17 keV	125x more precise than LEP
Z, direct searches	Heavy neutral leptons	m_N up to ~80 GeV and $\|U_{\mu N}\|^2$ down to 10^{-11}	Probes space unconstrained by astrophysics + cosmology. Approaches seesaw limit.
Z, heavy flavours	BF($B \rightarrow K^* \tau\tau$)	$\sim 10^{-7}$	Example of unique ability to probe b decays to 3rd generation leptons. Sensitivity 10^3 better than current limits.
HZ, Higgs coupling	HZZ	0.14%	10x higher precision than expected at end of HL-LHC, and model independent.
WW, electroweak	m_W	300 keV	30x higher precision than current best measurement.

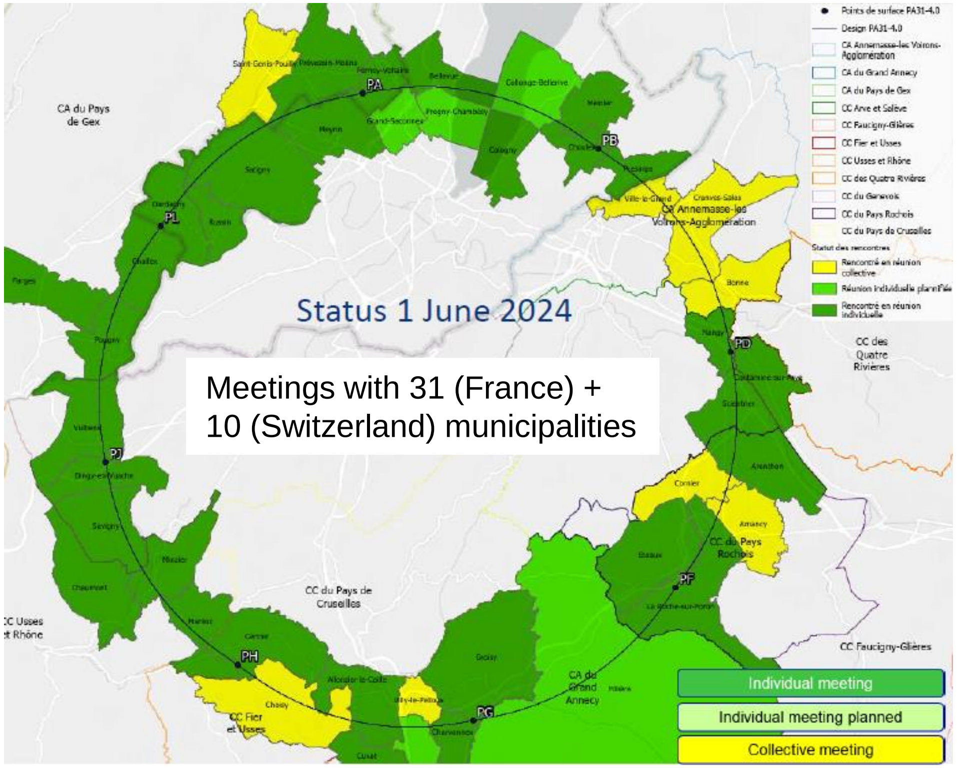
Easy to generate *very many* alternative lists, where FCC-ee impact would be similar ! (NB also the rich programme of non-HEP science possible with injector & booster).

Status of project

Final report of Feasibility Study to be released early next year. Culmination of ~10 years work, of which physics & accelerator studies have been only one aspect.

For example, reference ring layout chosen from ~100 initial variants. Input considerations:

- Geology (test drillings underway);
- Surface constraints;
- Environment;
- Infrastructure;
- Machine performance.



Continual and ongoing engagement with local communities.

Technical, scientific and financial feasibility carefully scrutinised.
Verdict on Mid-Term Report very positive.

Timeline, costs and path to FCC-hh

Current timeline considered very realistic, based on past CERN experience.

- Previous e^+e^- machine at CERN (*i.e*. LEP) took 8 years from approval to physics.
- No alternative project at CERN could start earlier, because of HL-LHC !

Costing from Mid-Term report

Will be updated to ``category 3" (-20%, +30%) for Final Report, and final update prior to approval.

Tunnel and much of infrastructure can be re-used for FCC-hh.

Accelerators (with Z, WW and ZH running)	3847 MCHF
Injectors and transfer lines	585 MCHF
Civil engineering (with 2 IPs)	5538 MCHF
Technical infrastructure (with Z, WW and ZH running)	2490 MCHF
Experiments (CERN contribution only, 2 IPs)	150 MCHF
Territorial development	191 MCHF
Total	12,801 MCHF
Total with 4 IPs	13,511 MCHF
Total with 4 IPs and running at 350 + 365 GeV	14,976 MCHF

Timeline, costs and path to FCC-hh

Current timeline considered very realistic, based on past CERN experience.

Baseline project covers all energy points.
No upgrade needed (FCC-hh *is* the upgrade).

If necessary, however, approval of ttbar operation could be deferred to later date (though the physics arguments for ttbar are extremely strong).

If FCC-hh were delayed, FCC-ee could readily take the opportunity to explore new measurements (*e.g.* electron Yukawa).

Additional cost of going from 2 to 4 IP is relatively modest, and the benefits are substantial (more statistics, more opportunities for community, robustness…)

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Environmental considerations

Sustainability and environmental considerations have been central throughout FCC Feasibility Study. Many gains in efficiency already achieved w.r.t. CDR.

Independent experts have been tasked with estimating carbon footprint of all tunnel, shafts and surface site construction [*e.g.* D. Mauree, FCC Week 2024].

Baseline: 1.17 $MtCO_2$ (eq)

Possibilities identified for reducing by 50% (but must tension vs costs)

Tunnel is foreseen to house accelerators over ~50 years (FCC-ee + FCC-hh).

Wall power will vary between 222 and 357 MW, depending on energy. annual power budget for running at 240 GeV will be 1.0 TWh.

Extensive consultation and discussion with local communes to minimise Impact and maximise benefits [*e.g.* J. Gutleber, FCC Week 2024]. Examples:

- Supply >30% of generated heat (300-400 GWh/yr) to local users;
- Modifications in water supply to be made in manner to benefit local farmers;
- Aim to make excavated molasse into fertile soil suitable for agriculture;
- < 4 km of new roads required.