Impressions: Strategy Meeting@Granada

personal view by Gudi

LINEAR COLLIDER COLLABORATION

Technical Overview and Challenges of Proposed Higgs Factories

D. Schulte

Rationales

CLIC:
Ultimate goal: Achieve multi-TeV electron-positron collisions
- Linear collider with high gradient normal-conducting acceleration
- Overcome the challenges with technologies
- Now: do it in stages for physics and funding

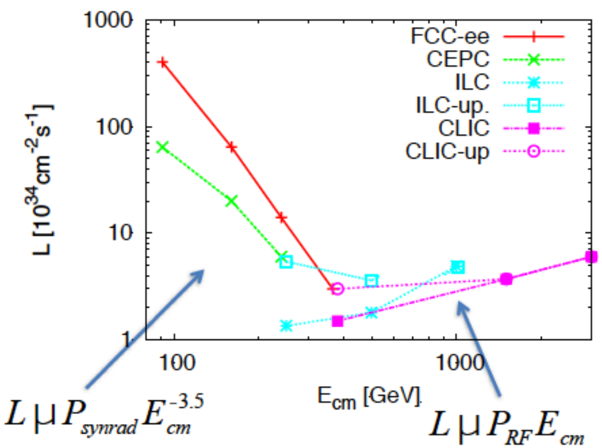
ILC:
Ultimate goal: Reach energies of originally 0.5-1 TeV
- Use high gradient superconducting technology
- Now reduce cost to obtain funding

FCC-hh + FCC-ee
Push the energy frontier with protons
- Large ring with high field magnets

Use the FCC-hh tunnel for an electron-positron collider
- The layout and cost is not optimised for FCC-ee proper

CEPC:
Build a higgs factory with limited energy with a tunnel that could house a hadron collider afterwards

Luminosity per facility



Energy dependence:

At low energies circular colliders trump
- Reduction at high energy due to synchrotron radiation

At high energies linear colliders excel
- Luminosity per beam power roughly constant

Technical Overview and Challenges of Proposed Higgs Factories

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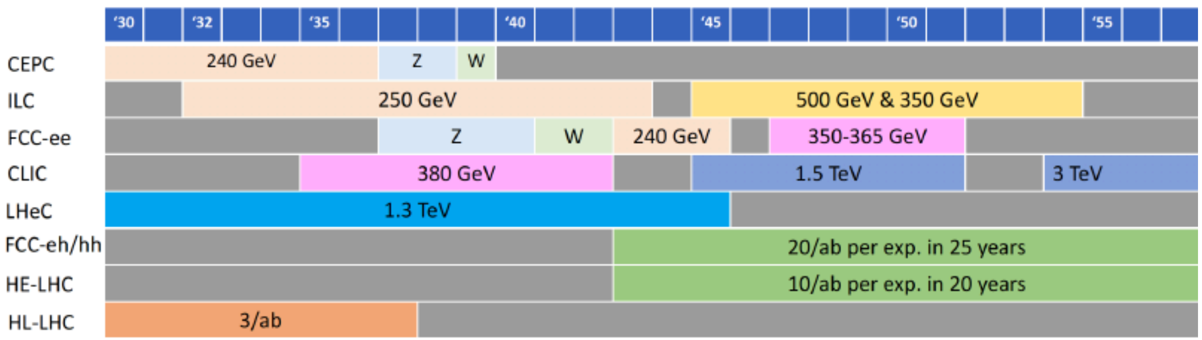
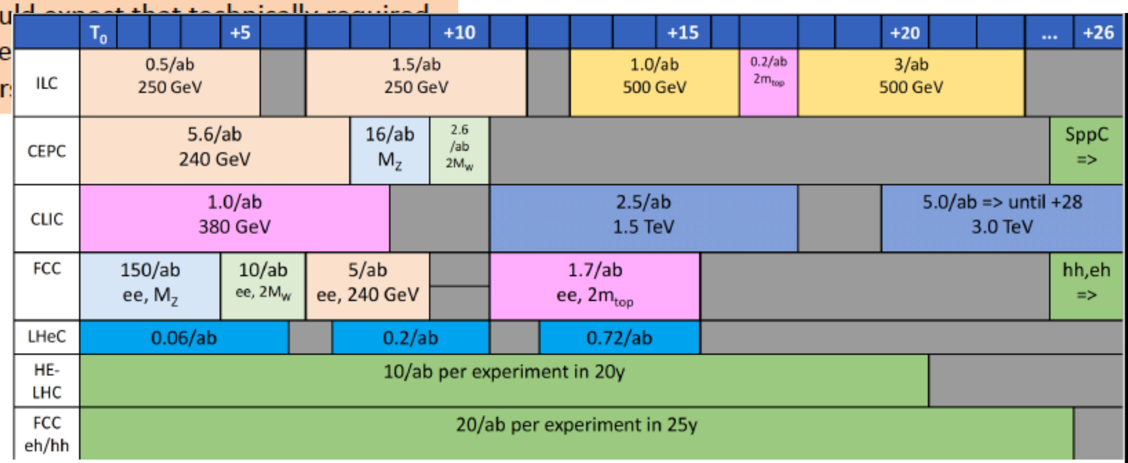


Project	Start construction	Start Physics (higgs)
CEPC	2022	2030
ILC	2024	2033
CLIC	2026	2035
FCC-ee	2029	2039 (2044)
LHeC		

Proposed dates from projects

Wou… time… year…

2019



Technical Overview and Challenges of Proposed Higgs Factories

D. Schulte

Maturity (Personal View)

- CEPC and FCC-ee
  - Do not see a feasibility issue with technologies or overall design
  - But more hardware development and studies essential to ensure that the performance goal can be fully met
    - E.g. high power klystrons, strong-strong beam-beam studies with lattice with field errors, ...

- ILC and CLIC
  - Do not see a feasibility issue with technology or overall design
  - Cutting edge technologies developed for linear colliders
    - ILC technology already used at large scale
    - CLIC technology in the process of industrialisation
  - More hardware development and studies required to ensure that the performance goal can be full met
    - e.g. undulator-based positron source, BDS tuning, ...

Perspective on the European Strategy from Asia

Geoffrey Taylor
CoEPP and University of Melbourne,
AUSTRALIA

ILC or CLIC?

See S. Stapnes talk this Symposium

- **“We need a linear collider!”**
- **Both are capable of providing the essential “Higgs Factory”:**
  - ***240-250GeV e+e- Collider***
  - ***Extending to high energy:***
    - CLIC initial capability already at 380GeV - top quark threshold
      - ILC up to ~800 -1000GeV - Future upgrade, more $
      - CLIC to multi-TeV - Future upgrade, more CHF

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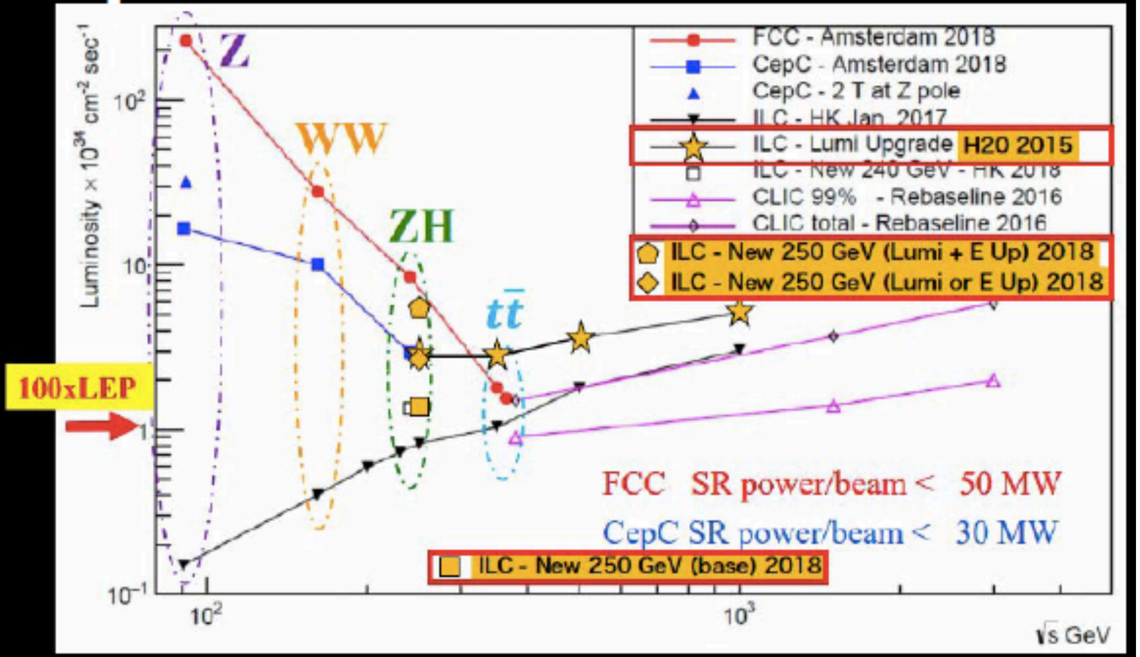
e+e- Lumi Comparison

- Apparently significant difference at the overlap region (~250GeV) quite a range of luminosities
- See D Schulte's talk: differences should not be taken too seriously at this stage!



- Original Plot, F. Bedeschi , CEPC Workshop, Rome, May 2018
- Updates Private communication, Keisuke Fujii, IPNS, KEK

Perspective on the European Strategy from Asia

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CoEPP and University of Melbourne,
AUSTRALIA

International WG initiated by KEK, MEXT

- Members: 2 (Europe), 2 (North America), 2 (Asia incl. Japan)
- Update ILC-PIP to describe:
  - *International share of the remaining technical development*
  - *Organization and governance of the ILC Laboratory*
  - *Model of international cost-sharing for construction and operation*
- Will report to MEXT and other government agencies as a recommendation from the international ILC community ~ September 2019
- Draft report will be presented at the LCB meeting in August 2019

ILC/CepC Advantage for Europe

- Allows concentration on proton, high energy future
  - *CERN essential for the energy frontier.*
  - *Proton and high-field magnet expertise*
  - *The ONLY laboratory capable of attempting very difficult projects, thus should be setting a "high bar"*
- CERN infrastructure in protons beams outlays the fear of a second 100km tunnel.
  - *Possible to see a new proton collider at CERN by mid-2040s (not mid 2060s, but also not 100TeV)*

Perspective on the European Strategy from Asia

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The Needs of Particle Physics

- A e+e- collider higgs factory ASAP
  - *and, yes, in time, t-tbar, ttH, HH, ..*
- A new energy frontier facility following HL-LHC
  - *even without a specific physics driver, as yet*
  - *pp, ion-ion and ep all possible*
- An active field, with multiple activities in parallel:
  - *particle physics data taking and analysis*
  - *accelerator physics, including μμ colliders and plasma acc'n*
  - *detector development*
  - *advanced computing techniques*

Asian (and personal) View

- Diversity is Critical to thrive in all environments, including HEP.
  - *Big and small facilities/experiments, at various stages of development and operation*
- Push for e+e- colliders, both Linear and Circular, as soon as possible.
  - *Linear Collider: ILC*
    - 1 Collision point
  - *Circular Collider: CepC*
    - 2 Collision points
- Push for FCC tunnel to be ready at completion of HL-LHC
  - *Stage the energy frontier with best option magnets available for early 2040's*
  - *?? Default: ~8T LHC magnets optimised for price*
    - Minimum energy: >50TeV
    - Magnet upgrade foreseen.
  - *ep and ion-ion options available*
  - *4 collision points*
  - *Upgrade path to higher energy after 20 years operation?*

See A. Yamamoto, S. Rossi, V. Shiltzev talks this symposium

S. Bethke (MPP Munich):

overview of

"national inputs"

submitted to the 2020 ESPP

disclaimer (1)

- "national" inputs from 18 CERN MS
  and from 4 NMS (CDN, J, RUS, USA)
  (some nations submitted >1 …)
- here: concentrate on analysing
  - inputs from particle physics commun.
  - priority future HEP (collider) projects
  - selection of general policy statements
- not include statements on running and on approved projects (LHC, hl-LHC, KEKb,.

disclaimer (2)

- sometimes difficult to separate priorities from possibly unsorted lists of topics (assign priority levels or check marks?)
- interpretation of statements sometimes difficult
- multiple inputs not always consistent
- margin between priority levels sometimes feeble

–> there is a certain "degree of freedom" for interpretation, classification and assignment of priority levels

- some "national inputs" not really based on community input; representation of number of scientists different by up to 1-2 orders of magnitude…

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summary of national priorities and interests:

country	item #	e+e- e-w,H,.. (ILC, ...)	e+e- incl. ttbar (FCC-ee)	e+e- incl. HH (ILC+,CLIC)	hh beyond LHC	hh he-LHC	hh FCC	eh	accel. R&D	R&D magnets FCC,he-LHC	R&D novel PWA,μ+μ-	non-accelerator (DM,ndbd)	neutrino physics	intensity frontier	nuclear (FAIR,EIC...)	astro-particle
A	108	1			3				2			√			√	√
B	122	1														
CH	142	1	1		3		3		2	2	3		√	√	√	√
CZ	88	3		3	2	2	2		1	1	1		√		4	
D	33	1		1	3	3	3		2	2	2	4	√	√	√	√
DK	61	3	3		3		3		2	2	2	1	√	√	√	√
E	31	1	3	1	3	3	3		2	2	4		√		√	√
F	15,116,155	1	√	√	3		3	√	2	2	√	√	√	√	√	√
FIN	55	1		1									√		√	√
I	26,138	1	1		3		3		2	2	2	√	√	√		√
IL	34	√			√							√	√	√		
N	43	1		1					3		3	√			√	√
NL	166	1	3	2	3		3		2	2	3	√	√	√		√
PL	125	1	√	√					2							
RO	73												√	√		
S	127	1		1					2	2	√	√	√	3		√
SLO	78															
UK	134,144	1		1	2		2	2	3	3	√	√	√		√	
total score:		13,67	3	6,83	3,67	1,17	3,33	0,5	6,67	5,33	3,75					

MS

1...4: priority 1 to priority 4;
√: mentioned without (clear) assignment of priority
total score: =Σ(1/priority) where given; √ not counted

- 18 MS and 4 NMS submitted national inputs on HEP
- 3 MS and 3 NMS provided no explicit priorisation
- –> "total scoring" based on 15 MS
- total score defined as Σ(1/priority)

country	item #	e+e- e-w,H,.. (ILC, ...)	e+e- incl. ttbar (FCC-ee)	e+e- incl. HH (ILC+,CLIC)	hh beyond LHC	hh he-LHC	hh FCC	eh	accel. R&D	R&D magnets FCC,he-LHC	R&D novel PWA,μ+μ-	non-accelerator (DM,ndbd)	neutrino physics	intensity frontier	nuclear (FAIR,EIC,...)	astro-particle
CDN	157	√	√	√	√	√	√					√	√			
J	63	1							4			3	2			
RUS	40								√			√	√	√	√	√
USA	149;150	√	√	√	√	√	√		√	√	√	√	√	√		√
total score:																

NMS

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future HEP project priorities:

- highest priority for a (general) e+e- collider as next big project : total score of 13,67 out of 15 max.
  - score of 3,00 for upgradeability to include ttbar and/or explicitly for FCC-ee
  - score of 6,83 for upgradeability to include HH or ttH and/or explicitly for linear colliders (i.e. ILC+ or CLIC)
- second priority for (general) accelerator R&D : score of 6,67
  - score of 5,33 for R&D of high-field s.c. magnets (he-LHC, FCC)
  - score of 3,75 for R&D of novel accel. techniques (PWA, μ-coll.)
- third priority for a hadron collider beyond the LHC: score of 3,67
  - score of 1,17 for the he-LHC
  - score of 3,33 for the FCC-hh
  - score of 0,50 for e-h collider (LHeC or FCC-eh)

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overview of

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summary:

- clear preference for an e^+e^- collider as the next h.e. collider:
  - as H-factory and for precision e.w. measurements (ILC, CEPC, FCC-ee, CLIC)
  - significant demands for upgradeability to access $t\bar{t}$ (ILC, CEPC, FCC-ee, CLIC) and also HH and ttH final states (ILC+; CLIC)
- second priority: R&D for future h.e. collider: h.f. s.c. magnets for hadron colliders, and also novel accelerator techniques (PWA, μ-collider)
- third priority: future hadron collider beyond LHC (FCC-hh; fewer demands for he-LHC and eh-collider)
- large diversity of other, "smaller" projects (PBC, neutrino, DM searches, precision/intensity frontier, astro-particle, …

Conclusions (personal view)

- ***Large support for an e+e- machine a.s.a.p.***
    - ***Z-factory seems to be important***
  - **therefore only Asia can do it**
    - ***ILC at Japan***
    - ***CepC at China: practically the same physics case as FCC-ee……!***
- ***Future of CERN is important for the field***
  - **maybe next pp a.s.a.p. after HL-LHC: FCC**
    - ***first stage: just with cheaper LHC magnets? (about 50 TeV)***
    - ***FCC-ee before FCC would cause 20y without data! (Lyn Evans!)***
    - ***would provide an 'upgrade' possibility for FCC with 16T magnets***

very substantial that Japan goes ahead very soon !