European Strategy Update

European View on Long-Range Plans for HEP Experiments and Facilities

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The European Strategy for Particle Physics 2006

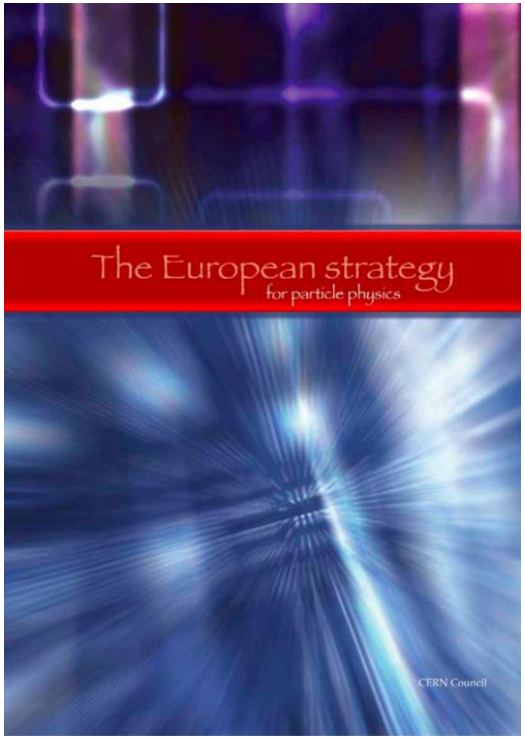
European Strategy Update

First strategy approved by the CERN Council 14th July2006
It contains 17 statements on scientific and organizational matters.

In 2006 the LHC was still under construction,
no hint for a Higgs at the Tevatron,
no prediction for the energy scale of interest for an ILC,
no country to proposing to host ILC,…

- Obviously, completion of the LHC machine was the highest priority !

- Decision to update the strategy based on proposals and observations from a dedicated scientific body that Council shall establish for this purpose.



Time Line of the Update

European Strategy Update

- The update process started in 2011 by setting up the European Strategy Group (ESG) and the Preparatory Group by Council
- February 2012, Call for scientific input from the community
- September 2012: **Open Symposium** (Kracow,PL)
- December 2012: **Scientific Briefing Book** by the Preparatory Group based on the community input (Open Symposium + written submissions) http://europeanstrategygroup.web.cern.ch/europeanstrategygroup/Briefing_book.pdf (> 200 pages)
- January 2013**: Strategy Group drafting session** (Erice, I) Draft of European Strategy Update written and submitted to Council
- March 2013: Council agreed on final draft with minor wording amendments
- May 30 2013: The Council formally adopted the Strategy Update in a special European Strategy Session of the Council in Brussels

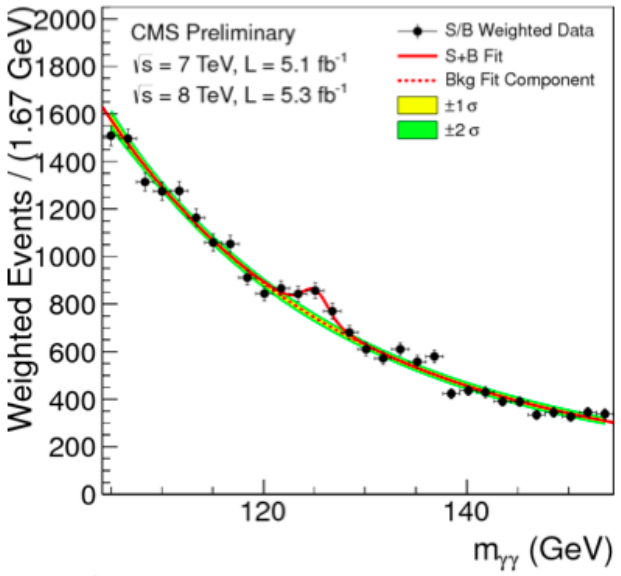
Scientific Input

European Strategy Update

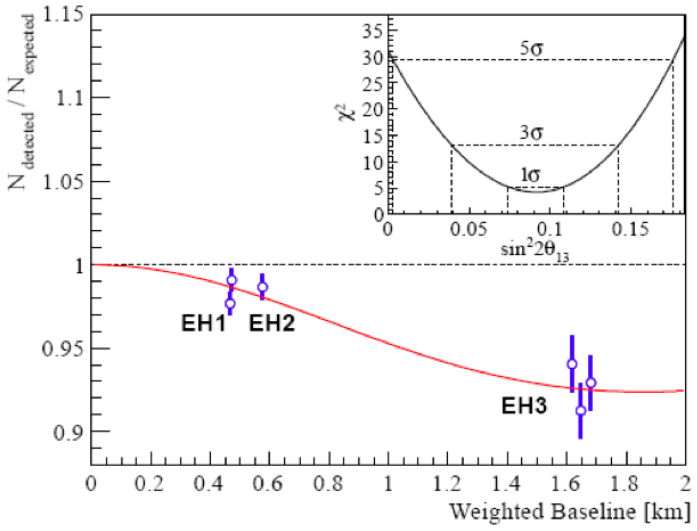
- ~160 written contribution received from individuals, collaborations, national institutes, countries.
- Large attendance during the open symposium (~500 participants)

A plethora of projects, facilities, new ideas were proposed and described. Many triggered by the two discoveries in 2012 (just in time).

Higgs Boson at 125 GeV:



Large θ_{13} neutrino mixing angle:



European Strategy Update

A quick tour through the most discussed (fascinating) projects:

Proton-Proton Colliders

European Strategy Update

	Years	E_{cm} TeV	Luminosity $10^{34}cm^{-2}s^{-1}$	Int. Luminosity 300 fb^{-1}
Design LHC	2014-21	14	1-2	300
HL-LHC	2024-30	14	5	3000
HE-LHC	>2035	26-33*	2	100-300/y
V-LHC**	>2035	42-100		

* 16-20 T dipole field
** 80 km Tunnel

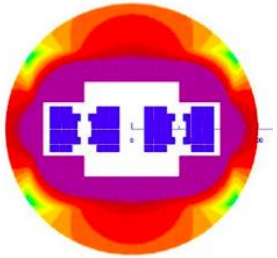
HE-LHC: LHC Energy Doubler

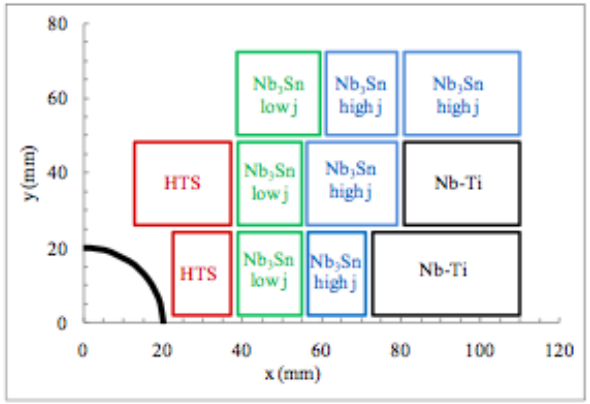
26 TeV c.m. ➔ 16 T magnets with classical low temperature superconducting magnets (Nb_3Sn)

33 TeV c.m ➔ 20 T using high temperature superconductors (YBCO-123, BSCCO-2212).

A possible 20 T design:
(CERN-ATS-2012-237)

Replace SPS by >1 TeV SC ring, etc…



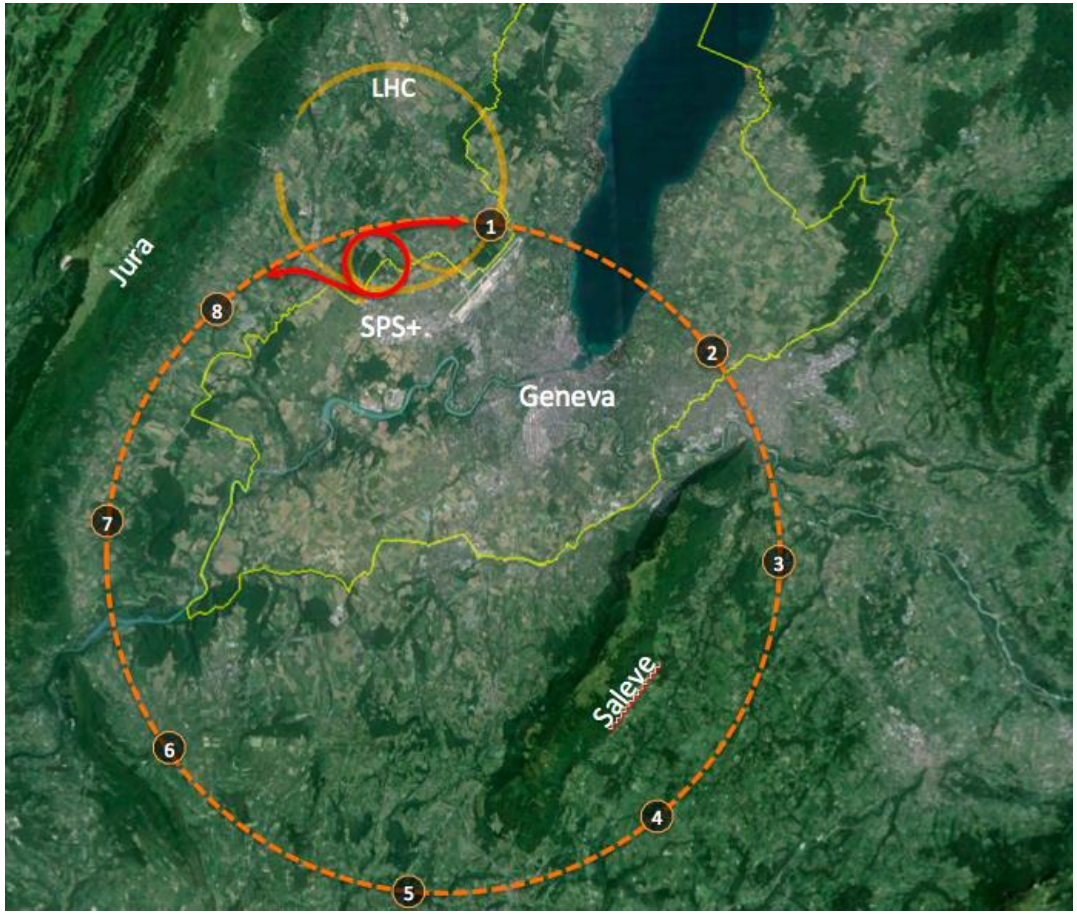


Proton Proton Colliders

European Strategy Update

V-LHC: Very Large LHC

New 80 km tunnel (100 km), early stage of discussion, geological feasibility study:



In an 80 km tunnel:

- 42 TeV with 8.3 T
  (present LHC dipoles technology)
- 80 TeV with 16 T
  (high field based on Nb_3Sn)
- 100 TeV with 20 T
  (very high field based on HTS)

If tunnel diameter is larger than LEP/LHC (3.8 m) dipoles could be larger and 20 T is no hard limit.

Injection energy > 3 TeV

Electron-Positron Colliders

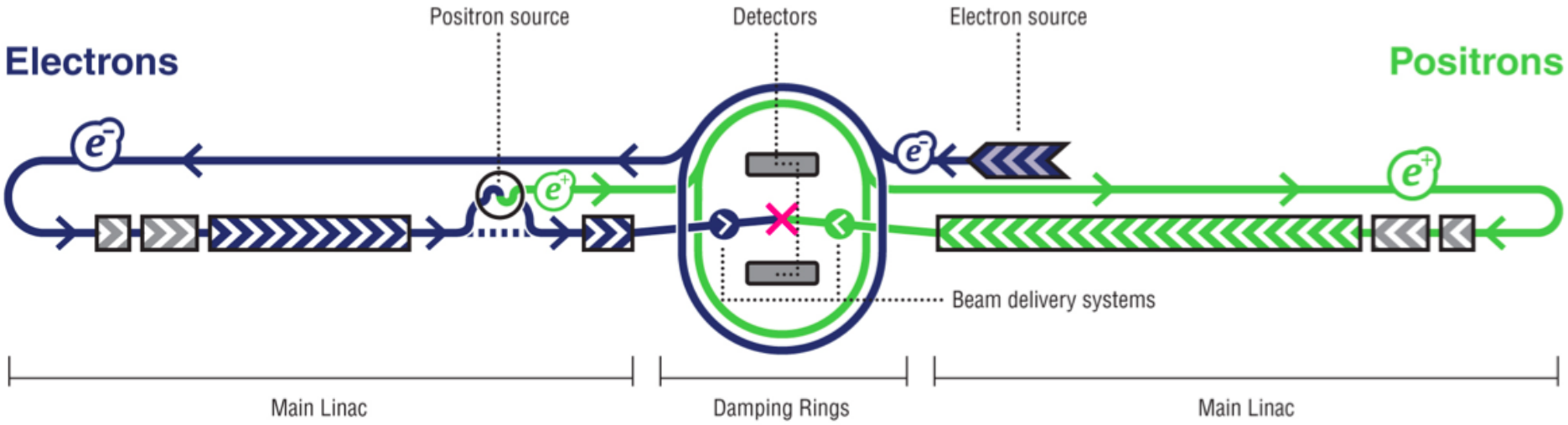
European Strategy Update

	Years	E_{cm} GeV	Luminosity $10^{34}cm^{-2}s^{-1}$	Tunnel length km
ILC 250	<2030	250	0.75	
ILC 500		500	1.8	~30
ILC 1000		1000		~50
CLIC 500	>2030	500	2.3(1.3)	~13
CLIC 1400		1400(1500)	3.2(3.7)	~27
CLIC 3000		3000	5.9	~48
LEP3	>2024	240	1	LEP/LHC ring
TLEP	>2030	240	5	80 (ring)
TLEP		350	0.65	80 (ring)

International Linear Collider

European Strategy Update

Two single beam linacs with superconducting RF cavities (31.5 MV/m)

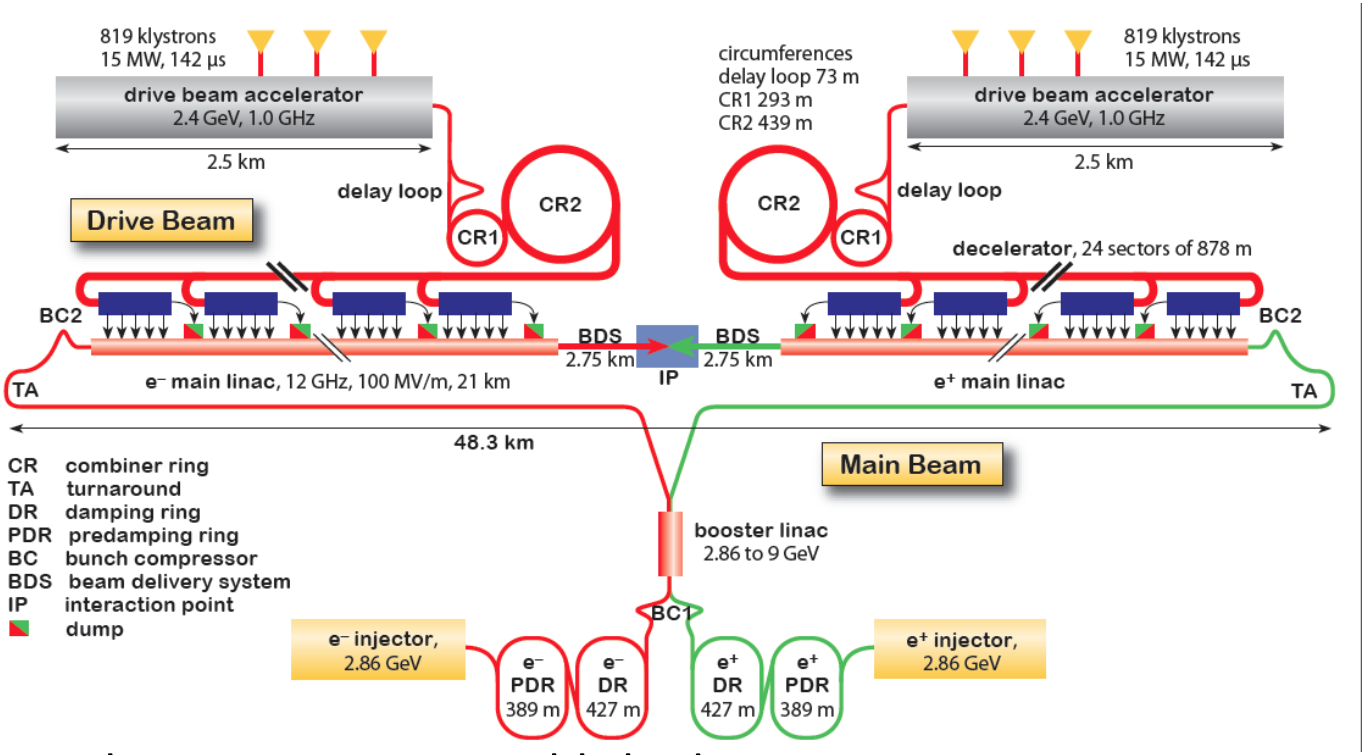


Project at TDR level, key technologies in hand after extensive R&D,
Industrial production of cavities established (e.g. XFEL – 5% of ILC),
For 500 GeV c.m. length of facility is ~ 30 km
Strong Japanese initiative to host ILC.
http://www.linearcollider.org/ILC/Publications/Technical-Design-Report

Compact Linear Collider

European Strategy Update

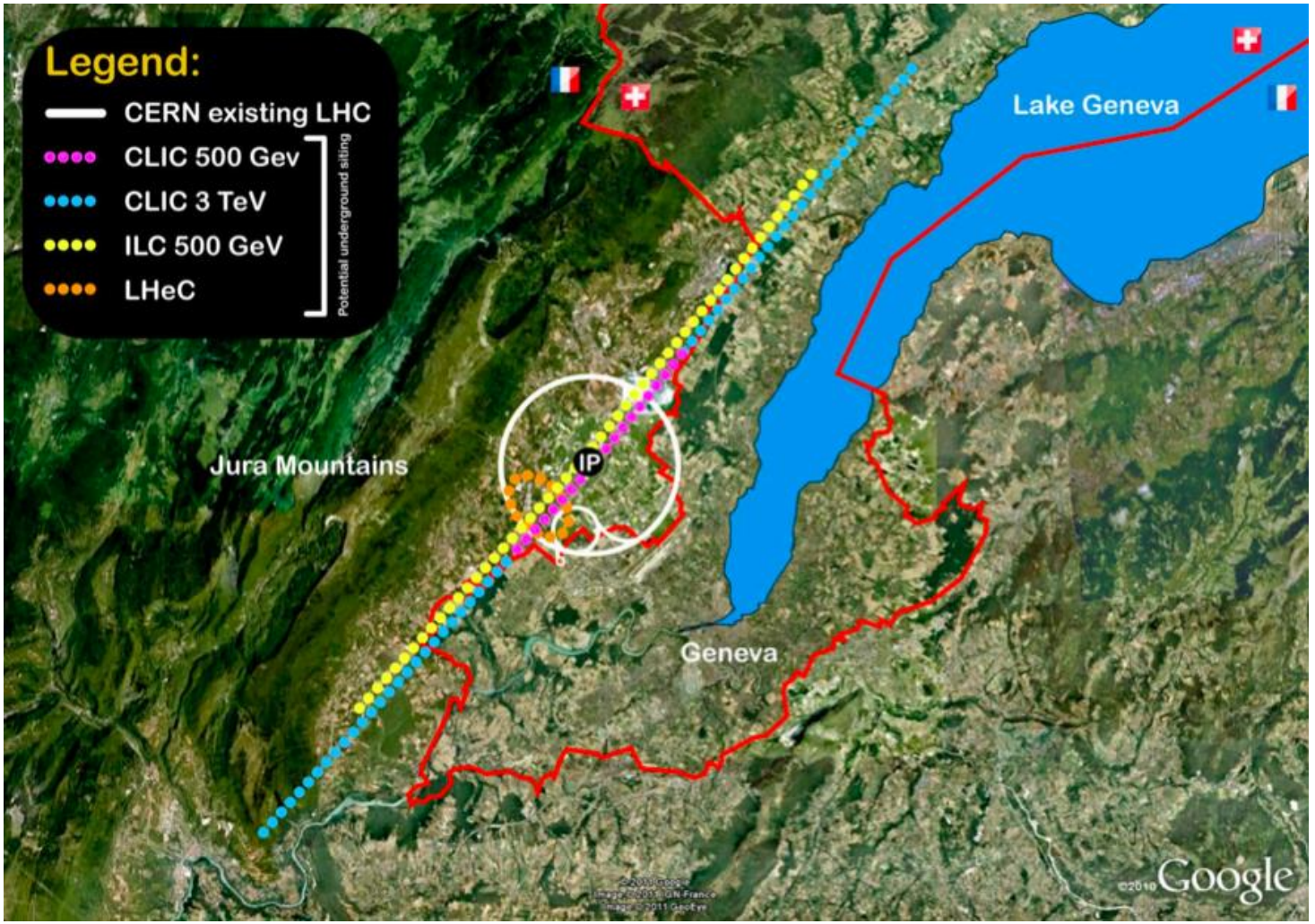
Two beam acceleration: low energy, high current drive beam powers RF cavities of main linac (cavities ~100 MV/m), energy up to 3 TeV c.m. in stages.



A Conceptual Design Report is published,
Prove of principle of two beam acceleration demonstrated!
(Proposal for a Clystron version for start up at low energy)
CERN-2012-003, arXiv:1202.5940, CERN-2012-005, arXiv:1209.2543

Compact Linear Collider

European Strategy Update



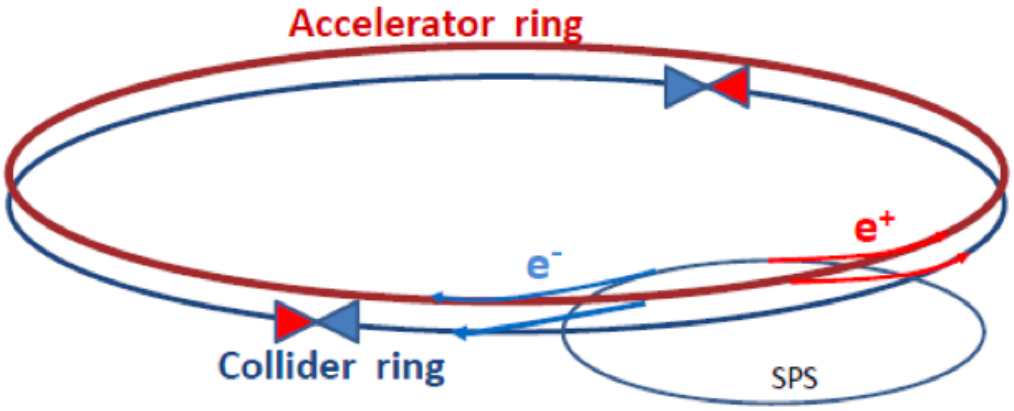
Circular e^+e^- Colliders

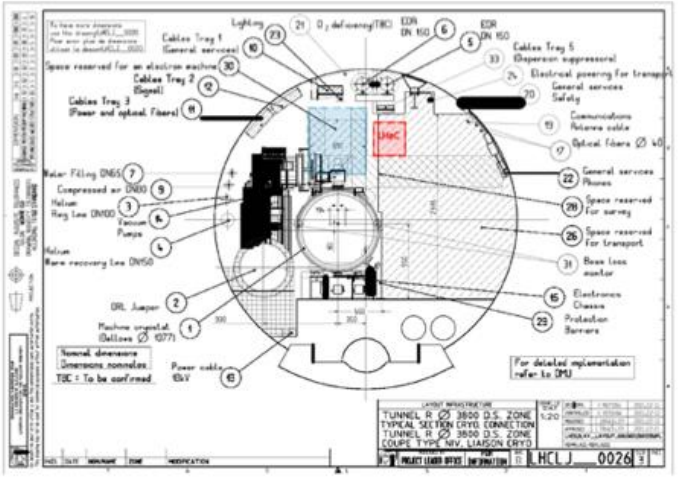
European Strategy Update

Advantages: very high luminosity achievable, more than one IP, mature technology
Disadvantages: Beamstrahlung limits beam life time, limited energy reach – not upgradable

Two rings needed: first ring accelerates e^+e^- to operating energy, injection every few minutes into low emittance collider ring,

LEP3: 240 GeV c.m., proposal to install LEP3 before or just after HL-LHC and use ATLAS and CMS as detectors.



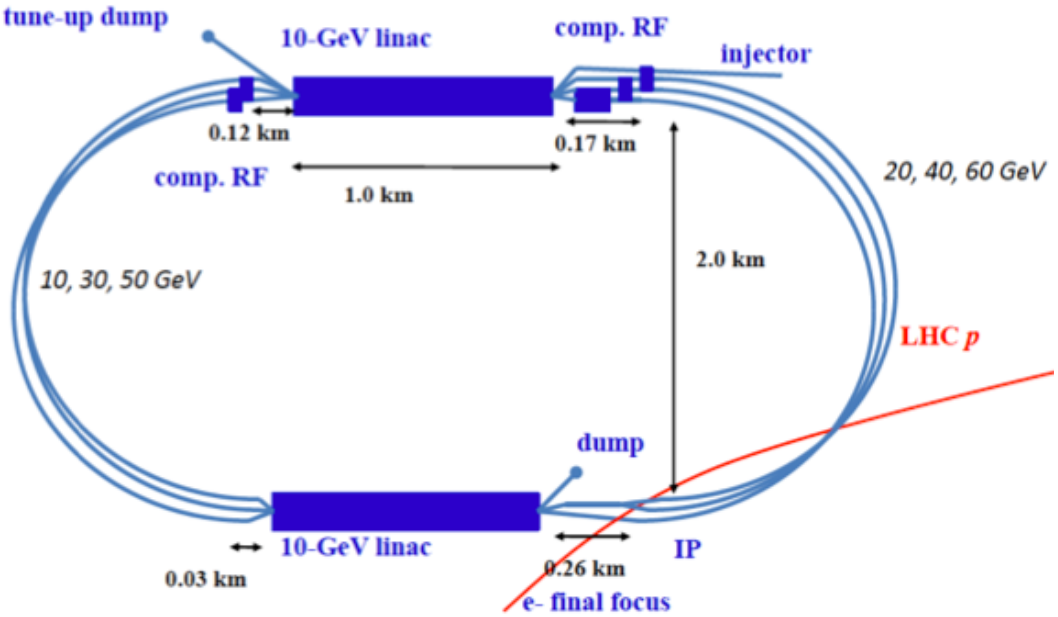


TLEP: Circular e^+e^- collider in new 80 km tunnel, to be used later for pp collision (as with LEP, LHC), achievable energy 350 GeV (ttbar threshold).
More info at: http://tlep.web.cern.ch

Electron-Proton Collider

European Strategy Update

LHeC: 10 GeV linear accelerator with energy recovery,
"Race track" configuration: 10 GeV x2 x3 = 60 GeV e^-, e^+
$Q^2_{max} \sim 1$ TeV^2, additional eA option
Only practicable interaction point is IP2 (ALICE)



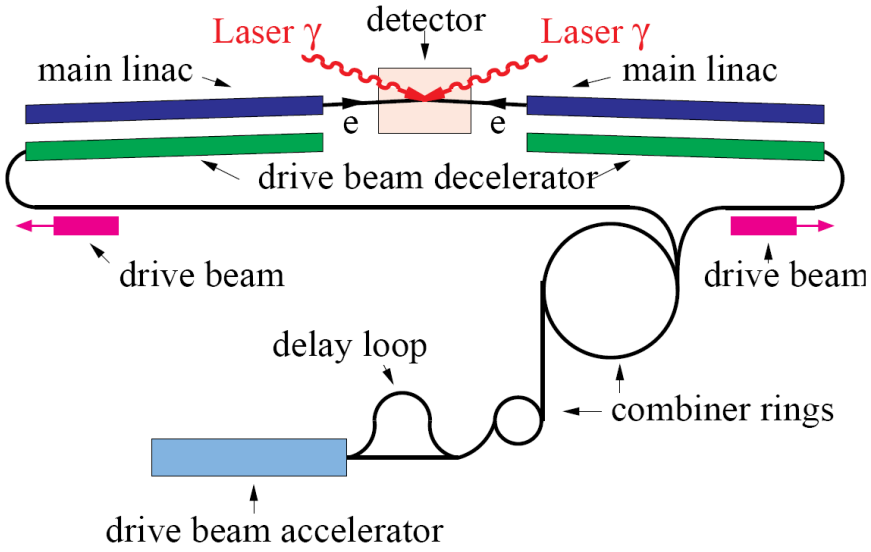
Very detailed CDR published (J. Phys. G: Nucl. Part. Phys. 39 (2012) 075001).

Photon-Photon Colliders

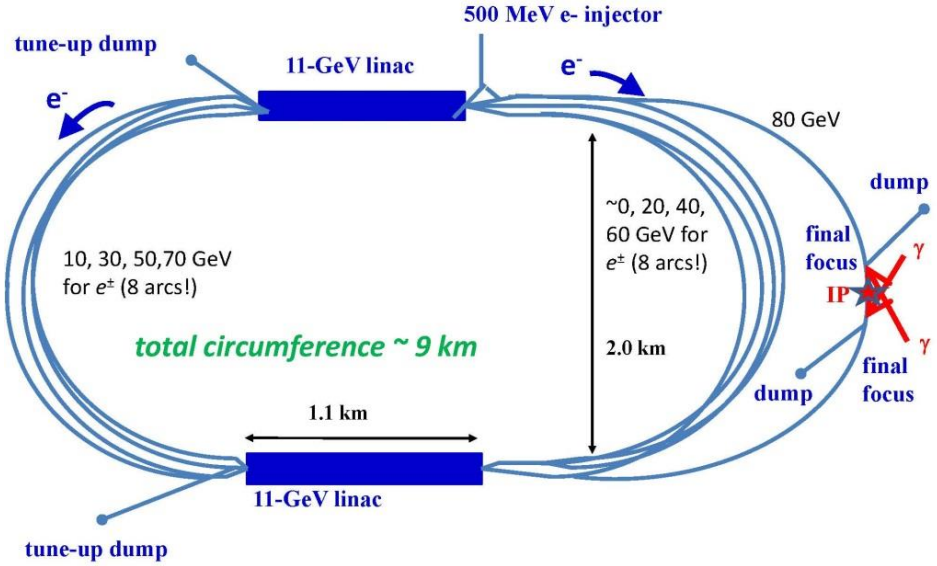
European Strategy Update

Photon-Photon collisions at √s = 125 GeV to produce Higgs (s-channel)
Advantages: lower beam energy (80 GeV), no positron source needed
High power laser back-scatter system (6 x 10^{21} Wm^{-2})

CLIC based:



SAPPHiRE:

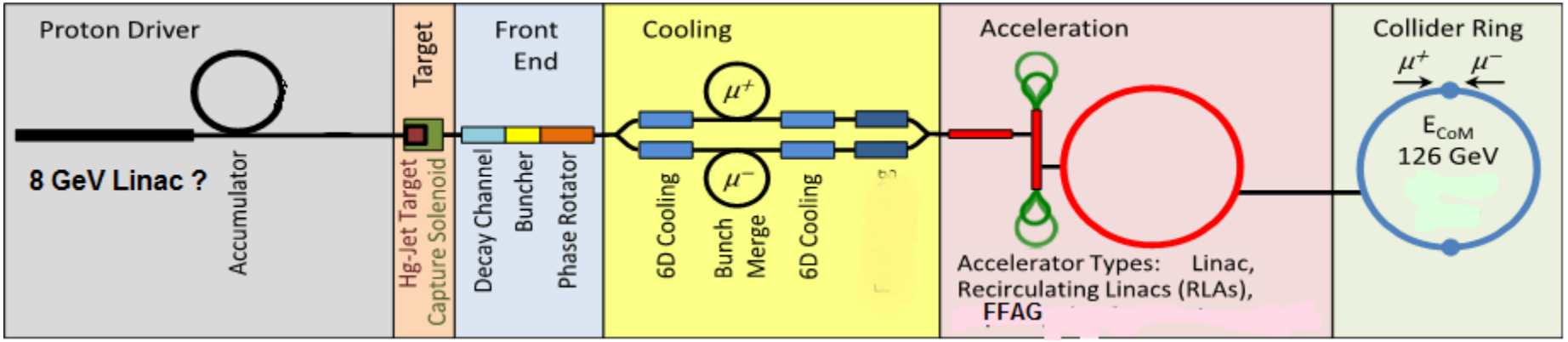


Eur. Phys. J. C 28 (2003) 27

Muon Collider

European Strategy Update

Advantages of μ over e: smaller facility, very low synchrotron radiation, smaller energy spread, s-channel Higgs production ~m^2



Muon collider as Higgs factory, precursor or follow-on of neutrino factory.

Neutrino Experiments

European Strategy Update

- **Long Baseline Neutrino Experiment with conventional beams**

Discovery potential for CP violating,
Precision for δ measurement
and sensitivity to Mass Hierarchy:
Europe: LBNO
CERN ➔ Pyhäsalmi 2300 km
US: LBNE
FNAL ➔ Homestake 1300 km
Japan: T2HK
JPARC ➔ Hyper-K 295 km

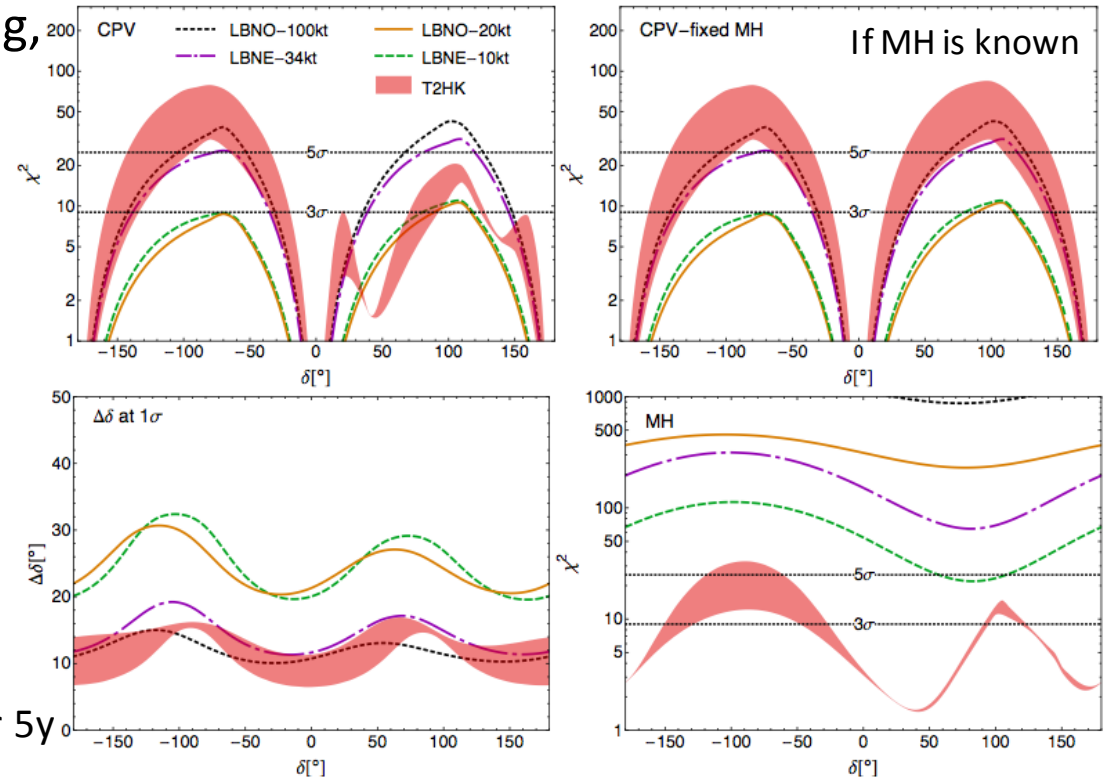


Figure shows values for
LBNO, LBNE for 10y, T2HK for 5y

- **Experiments to address (answer?) the question of sterile Neutrinos**:
vSTORM, ICARUS/NESSIE (possibly at CERN)

The Update of the European Strategy 2013

Excerpt from the Strategy Update

Official text highlighted, interpretations are my own, however trying to reflect the consensus.

Scientific Activities

European Strategy Update

After careful analysis of many possible large-scale scientific activities requiring significant resources, sizeable collaborations and sustained commitment, the following four activities have been identified as carrying the highest priority.

The strategy update must strike a balance between maintaining the diversity of the scientific program and setting priorities since the available resources are limited.

- Only large scale projects are prioritized
- Competitive small and medium size projects (national, regional) are important to keep the diversity of our field, since a breakthrough often emerges in unexpected areas

A priori these 4 activities are not prioritized, it is meant that all 4 should be pursued – there is a logical time line!

High-Priority Large-Scale Scientific Activities

European Strategy
date

LHC and HL-LHC:

> c) ... *Europe's top priority should be the exploitati… …he LHC, including the high-luminosity upgrade … …s with a view to collecting ten times more data th… …round 2030.*
> ...

The strategy recommen… …e, i.e. 3ab^{-1}, without compromises!

The work and i… …ments (ALICE, ATLAS, CMS and LHCb) have ma… …d target integrated luminosity of 3ab^{-1}.

This … Huge work ahead, upgrade of LHC and upgrade of the detec… …be secured, etc.

It is the … challenge for particle physics world-wide ➔ contributions from oth… regions than Europe are crucial.

Program for the near future!

High-Priority Large-Scale Scientific Activities

European Strategy Update

Design studies and R&D for post-LHC projects:

d) … *CERN should undertake design stud… …jects in a global context, with emphasis on proton… …high-energy frontier machines …*

Long time program !
Prepare now for >2035

Europe has a vision fo… …the forefront of particle physics. T… …**he energy frontier**. Possible ma… …EP (in connection with V-LHC)

More s… …one can decide on a next large machine at CERN.

The strateg… …ccelerator R&D for **proton-proton and electron-positron colli…** …d consequently mentions explicitly **high-field magnets and high-gradient accelerating structures.**

High-Priority Large-Scale Scientific Activities

European Strategy Update

International Linear Collider:

e) There is a strong scientific case for an electron-po… groups are eager to participate. *Europe looks fo… to discuss a possible participation.*

This is a strong statement in favor … the Japanese initiative.

The strategy supports … nergy of 250 GeV to perform Higgs studies and … lity of the ILC as major asset!

Many Eu… ested in participating in the ILC project. Exp… comes forward with a clear plan for hosting the ILC… on for Europe to participate.

Intermediate Program !

High-Priority Large-Scale Scientific Activities

Neutrino Programme:

f) … *CERN should develop a neutrino* … *for a substantial European role in future lo* … *urope should explore the possibility of major* … *g-baseline neutrino projects in the US and Japa*…

Simultaneous Program!

It is importa… …o physics activity at CERN, in order to provid… …rt and focus for Europe to play a leading r… …iments – not necessarily hosted in Europe.

Not… …"long baseline"!

Other Scientific Activities

European Strategy Update

Statements g) to k) define other scientific activities which are essential for HEP, but do not need a prioritization. These are:

- Theory
- Small and mid-size experiments studying quark flavour physics, dipole moments, precision measurements at lower energies with neutrons, muons and antiprotons, etc.
- **Instrumentation**, state-of-the-art infrastructure at CERN, large scale data-intensive computing
- Non-accelerator experiments at the overlap with astroparticle physics.
- Research at the boundary between particle and nuclear physics.

Summary

The Strategy Update is the result of a systematic and exhaustive discussion involving the whole particle physics community in Europe and elsewhere.

In all the discussions science was placed first!

Four high-p

- High-Lu
- R&D for
- Participa
- Support

The "Big 3" future projects:

- **HL-LHC in Europe**
- **ILC in Asia**
- **LBNE in America**

Europe has a c

The program is challenging, but not unrealistic.

Europe supports the global effort in our field.

The next update of the European strategy will take place in about 5 years.

European Strategy Update

Thank You!