Introduction

- **TLEP / FCC-ee**
  - **Physics, Experiments, Detectors break-out session**
    - **Conveners: Alain Blondel, Patrick Janot**
      - ➨ **Follows six LEP3 / TLEP workshops**
      - ➨ **Towards Design Study organization**

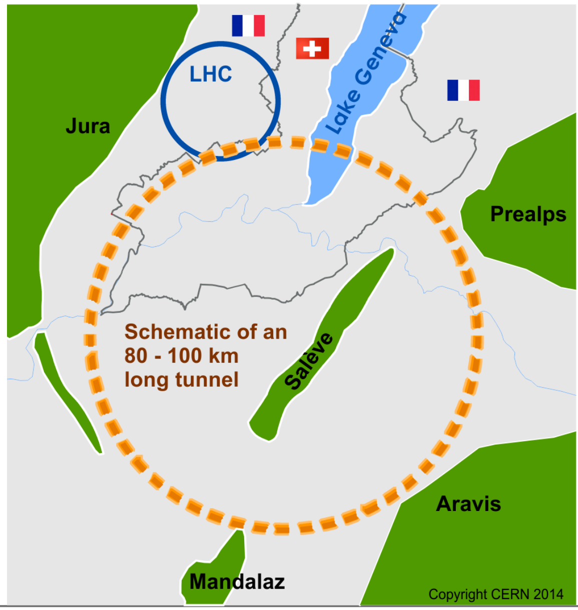
FCC: Strategy/Motivation

- **European Strategy Statement**
  - **Approved by CERN council in May 2013, see here**

d) To stay at the forefront of particle physics, Europe needs to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update, when physics results from the LHC running at 14 TeV will be available. *CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines.*

- **Study a 100 TeV machine in a 80-100 km tunnel**

FCC-hh



Can also host a 90-400 GeV e^+e^- collider as an intermediate step

FCC-ee

TLEP/FCC-ee : Physics case

- **European Strategy Statement**
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e) There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision

FCC-ee?

TLEP/FCC-ee : Physics case

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FCC-ee?

FCC-ee, FCC-hh?

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FCC-ee?

FCC-ee, FCC-hh?

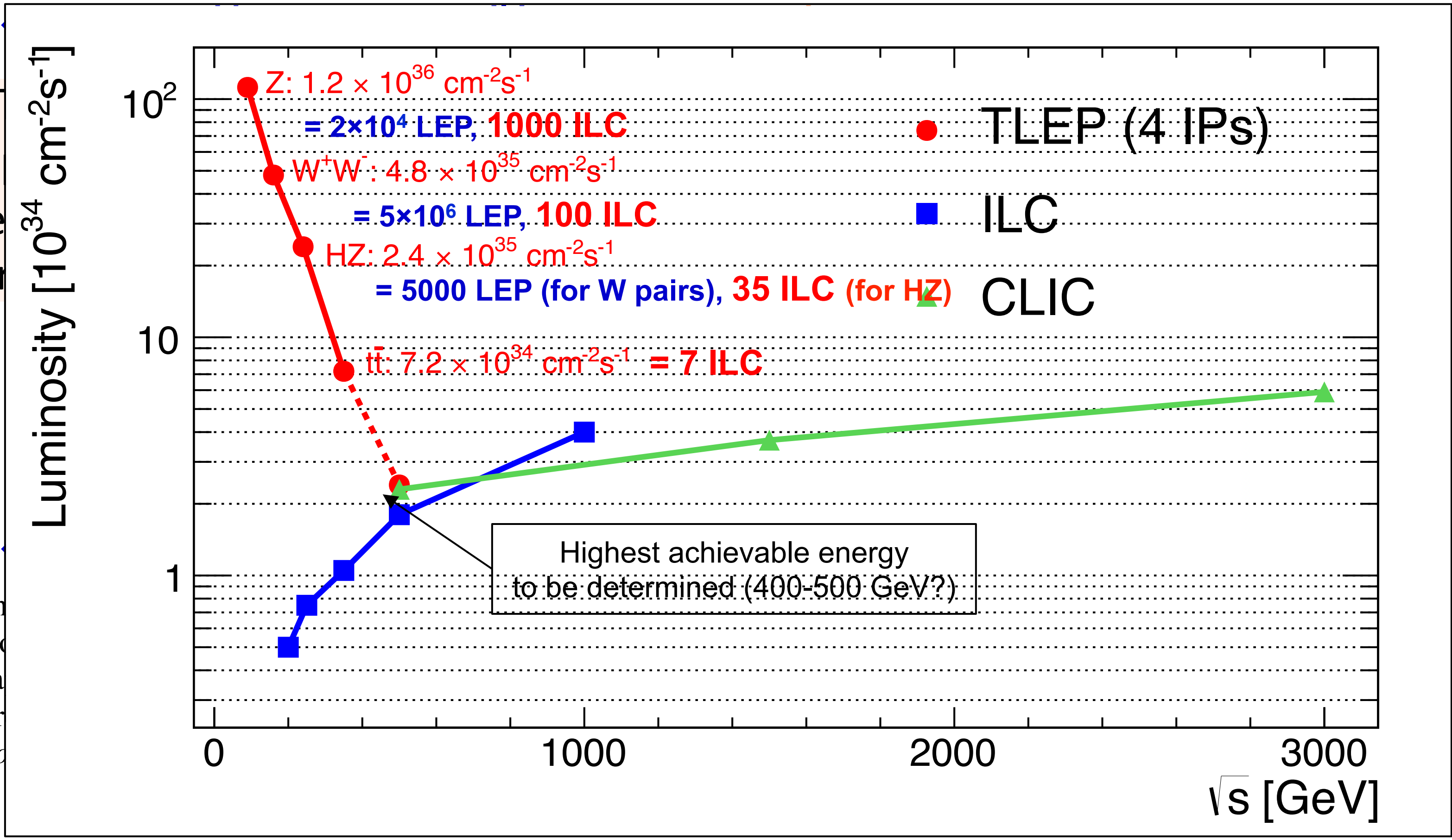
  - **Additional comment in the European Strategy statement**

The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation. The initiative from the Japanese particle physics community to host the ILC in Japan is most welcome, and European groups are eager to participate. *Europe looks forward to a proposal from Japan to discuss a possible participation*.

- **What about FCC-ee ?**

TLEP/FCC-ee : Physics case

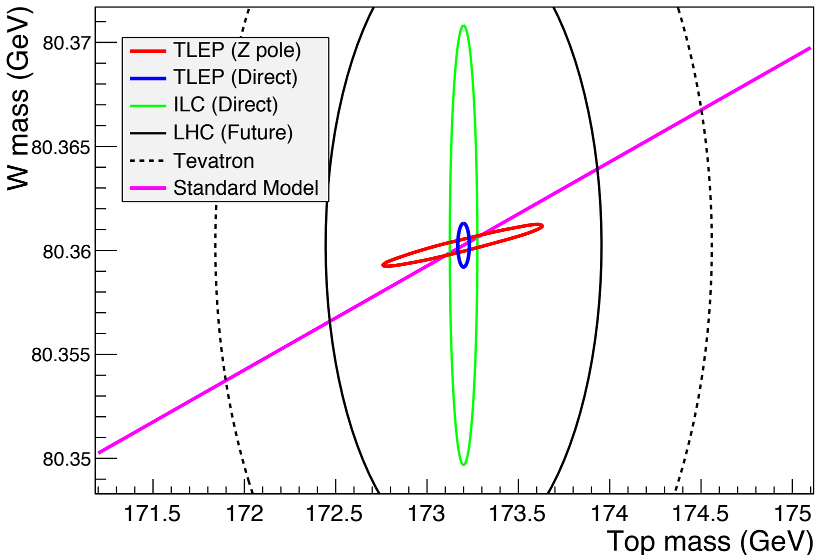
- **European Strategy Statement**

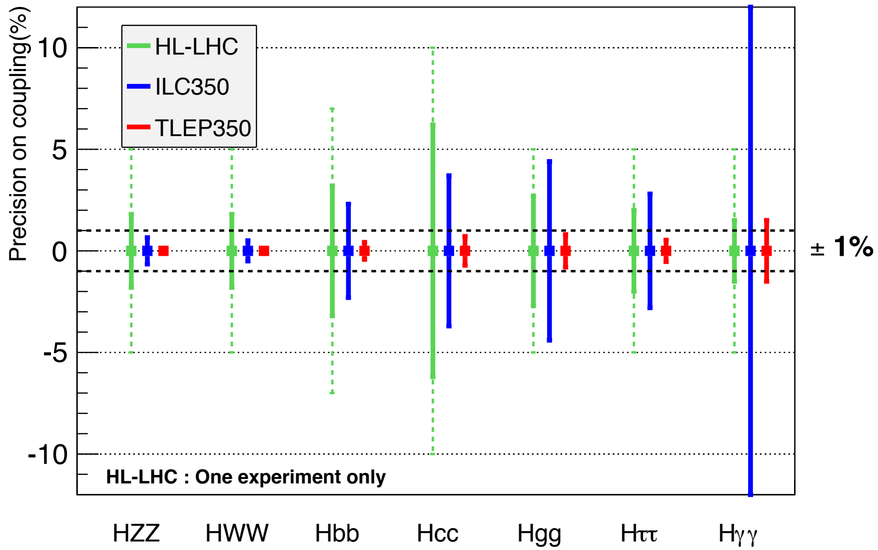


"The FCC-ee / FCC-hh combination offers, for a great cost effectiveness, the best precision and the best search reach on the market", see JHEP01(2014)164

TLEP/FCC-ee : Physics case

- **Examples of what unequalled precision buys at FCC-ee:**
  - **Sensitivity to weakly-coupled new physics up to 30 TeV (via Z, W, top properties)**
    - **Complementary to FCC-hh: direct sensitivity to coloured new physics up to 30 TeV**
  - **Sensitivity to new physics coupled to the Higgs sector up to 5-10 TeV**
    - **Via measurements of Higgs couplings and width down to 0.1% precision**





  - **Sensitivity to other new physics through rare decays (Z, W, H, t, b, c, τ, …)**
  - **Sensitivity to the (heavy, sterile) neutrino sector through invisible decays**
  - **Direct searches for rare processes**

TLEP/FCC-ee Design Study: Physics

- **Experimental Physics Programme**
  - Study the properties of the Higgs and other particles with unprecedented precision

Electroweak Physics at the Z pole	Di-boson Physics m_W measurement	H(126) Properties	Top Quark Physics
QCD and $\gamma\gamma$ Physics	Flavour Physics	Exp'tal signatures of New Physics	

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  - Set constraints on the possible detector designs to match statistical precision

Detector Designs

TLEP/FCC-ee Design Study: Physics

Experimental Physics Programme

- Study the properties of the Higgs and other particles with unprecedented precision

Electroweak Physics at the Z pole

Di-boson Physics m_W measurement

H(126) Properties

Top Quark Physics

QCD and γγ Physics

Flavour Physics

Exp'tal signatures of New Physics

- Develop the necessary tools

Understand the experimental conditions

Offline Software and Computing

Online Software and Computing

Exp'tal Environment

- Set constraints on the possible detector designs to match statistical precision

Detector Designs

TLEP/FCC-ee Design Study: Physics

Phenomenology/Theory Programme

- Set up a long-term programme to match theory predictions to experimental precisions

QCD and $\gamma\gamma$ Physics	Precision EW calculations	Flavour Physics

- Understand how new physics would show up in precision measurements, and in searches for rare decays (Z, W, t, H, b, c, τ, …) and rare processes

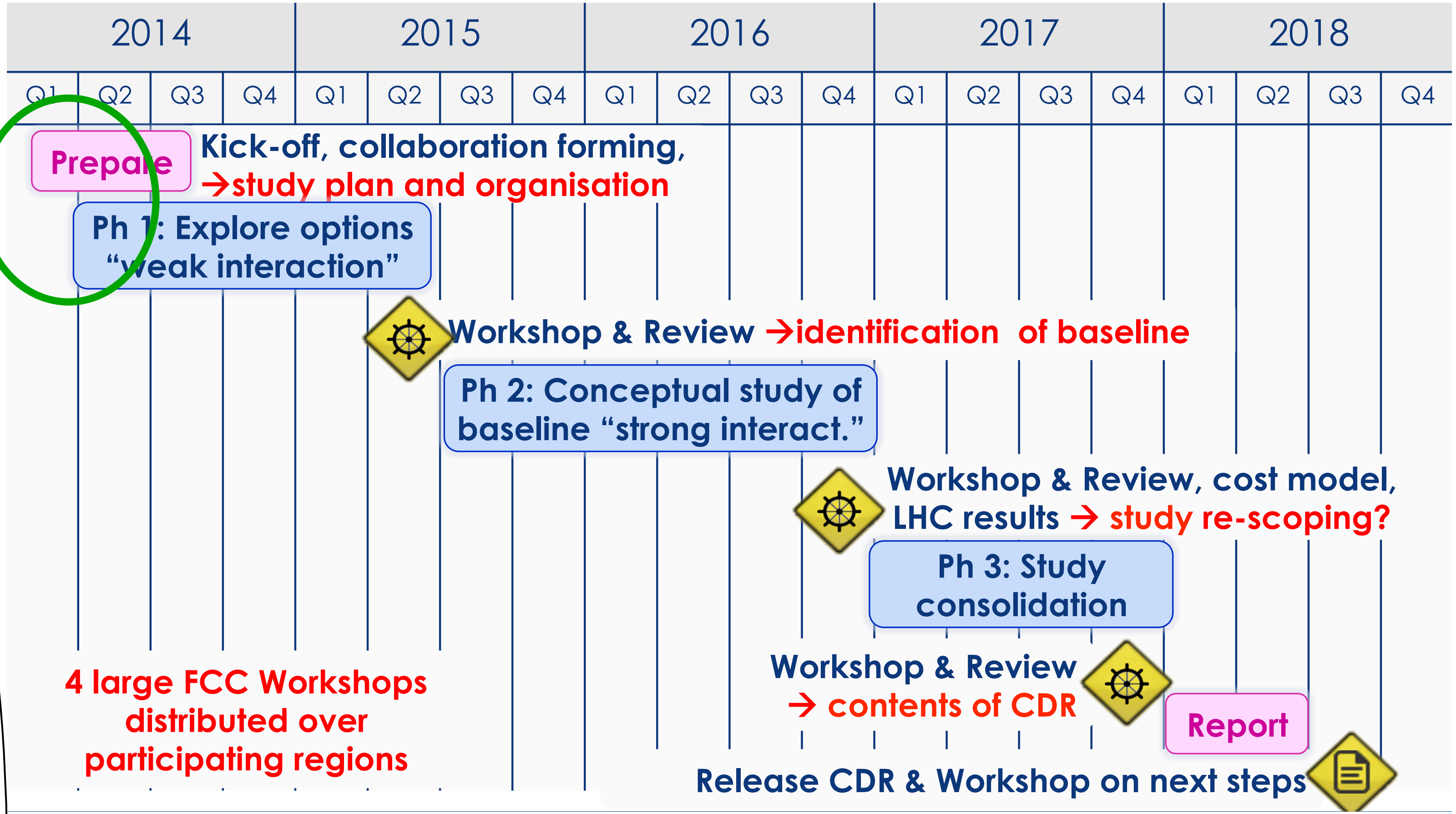
Model Building and New Physics

- Set up the framework for global fits and understand the complementarity with other colliders (LHC, FCC-hh, in particular)

Global Analysis, Combination, Complementarity

TLEP/FCC-ee Design Study: Timeline

- From Michael's Benedikt presentation



- We are here at "Phase o" (Preparation)

TLEP/FCC-ee Design Study: Phase 0

- **Preparation has started ahead of the kick-off meeting**
  - With the proposal of a Work Breakdown Structure (WBS): to be discussed together
    - i.e., a number of working groups in "Experiments" and in "Phenomenology"
  - With the nomination of one high-profile convener for each working group
    - To plan and start the Exploration phase (Phase 1)
      - ... and possibly beyond
    - To propose names for working group co-conveners
      - Targeting international collaboration and global effort
    - To propose names for sub-group conveners
      - ibid.
- **We do not start from scratch anyway**
  - Many synergies exist with linear collider studies
    - And possibly with linear collider teams: contacts are more than welcome !
  - Synergies with other circular e^+e^- colliders and with FCC-hh whenever appropriate
  - A first look at the TLEP Physics case [JHEP01(2014)164] has already been given
    - Although many new aspects will come up during the design study
      - What can be done with, e.g., 10^{12} Z is beyond (current) imagination

TLEP/FCC-ee Design Study: Physics WBS

- **Experimental Physics WBS (coordinators A. Blondel, P. Janot)**
  - **Study the properties of the Higgs and other particles with unprecedented precision**

Electroweak Physics at the Z pole
R. Tenchini

Di-boson Physics m_W measurement
R. Tenchini

H(126) Properties
TBA

Top Quark Physics
P. Azzi

QCD and $\gamma\gamma$ Physics
D. d'Enterria

Flavour Physics
S. Monteil

Exp'tal signatures of New Physics
TBA

- **Develop the necessary tools**

Understand the experimental conditions

Offline Software and Computing
TBA
Synergy with FCC-hh

Online Software and Computing
C. Leonidopoulos

Exp'tal Environment
N. Baccheta
Synergy with FCC-hh

- **Set constraints on the possible detector designs to match statistical precision**

Detector Designs
G. Rolandi

Synergy with linear collider detectors

TLEP/FCC-ee Design Study: Physics WBS

- **Phenomenology/Theory WBS (coordinators J. Ellis, C. Grojean)**
  - **Set up a long-term programme to match theory predictions to experimental precisions**

QCD and $\gamma\gamma$ Physics
(Joint exp/th)
P. Skands

Precision EW calculations
S. Heinemeyer

Flavour Physics
(Joint exp/th)
TBA

  - **Understand how new physics would show up in precision measurements, and in searches for rare decays (Z, W, t, H, b, c, τ, …) and rare processes**

Model Building and New Physics
TBA

Synergy with
FCC-hh physics
Linear collider physics,
LEP physics

  - **Set up the framework for global fits and understand the complementarity with other colliders (LHC, FCC-hh, in particular)**

Global Analysis, Combination, Complementarity
TBA

Today's breakout session

- **Preliminary thoughts from (some of) the working group conveners**

14:20 **Plans for Working Groups 1 & 2: EW physics at the Z pole, and di-boson physics** *15'*
Speakers: Roberto Tenchini (Sezione di Pisa (IT)), Alain Blondel (Universite de Geneve (CH))

14:40 **Plans for Working Group 4: Top quark physics** *15'*
Speaker: Patrizia Azzi (INFN Padova (IT))

15:00 **Plans for Working Group 5: QCD and gamma gamma physics** *15'*
Speakers: David d'Enterria (CERN), Peter Skands (CERN)

15:20 **Plans for Working Group 6: Flavour Physics** *15'*
Speaker: Stephane Monteil (Univ. Blaise Pascal Clermont-Fe. II (FR))

15:45 **Coffee break** *30'*

16:15 **Plans for Working Group 8: Experimental Environment** *15'*
Speaker: Nicola Bacchetta (Universita e INFN (IT))

16:35 **Plans for Working Group 10: Online software and computing** *15'*
Speaker: Christos Leonidopoulos (University of Edinburgh (GB))

16:55 **Plans for Working Group 11: Detector Designs** *15'*
Speaker: Gigi Rolandi (CERN)

17:15 **Possible synergies with CLIC detectors** *20'*
Speaker: Lucie Linssen (CERN)

17:40 **A TPC for ee-FCC (TLEP) ? A follow-up.** *20'*
Speaker: Philippe Schwemling (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))

18:05 **MC codes for FCC-ee** *15'*
Speaker: Staszek Jadach (Polish Academy of Sciences (PL))

WG9: Offline software (& computing)

- **Possible synergy with FCC-hh**
  - Common framework
  - Parametric simulation
  - Data format
  - MC Generators
  - Simulation
  - Reconstruction
  - Computing support

a. Establish an end-to-end analysis framework for TLEP physics studies, starting from the comparative merits of what is used by the LHC collaborations and for the linear collider studies (not forgetting older LEP developments, the current use of parallel computing, and the use of modern languages like python), and after an evaluation of the specific needs for TLEP.

b. In this framework, develop a flexible parametric simulation of a typical TLEP detector, where the particle energy and angular resolutions, as well as the various sub-detector granularities, are parameterized. This simulation will serve in early studies to converge on a set of "minimal" detector performance.

c. In this framework, define a compact, particle-based, data format, ready to use by the software tools needed for physics analyses (particle clustering in jets, b tagging, etc.)

d. In this framework, integrate the Monte Carlo event generators needed for physics studies, both for background and signal simulations.

e. In this framework, evaluate the needs and plan for the development of (1) detailed fast simulation; and (2) a GEANT-based (GEANT-V based) simulation; of the TLEP detector designs, which will emerge from the corresponding working group. At this point, organize the event reconstruction software developments.

f. Evaluate the requirements for offline computing support for experiments.

WG3: H(126) Properties

Scientific objectives

- **Couplings**
- **Widths**
- **Mass**

a. Understand the experimental precision with which TLEP could measure all properties of the recently discovered Higgs particle (couplings to light fermions, couplings to gauge bosons, coupling to the top quark, self coupling, total width, invisible width, …) by accumulating over two million Higgs bosons at and above the HZ production threshold.

- **Strategy**

b. Develop a strategy in terms of centre-of-mass energies and integrated luminosities to optimize the TLEP potential in this respect.

- **Detector design**

c. Set constraints on the performance and the relevance of the various sub-detectors, to make the experimental precision match or approach the expected statistical accuracy.

- **Exp'tal limitations**
- **Theory limitations**

d. Understand the external limitations (measurement of other observables, measurement of the beam energy, detector and machine infra-structure, theoretical uncertainties, etc.), and contribute to proposing ways to alleviate them.

- **Larger √s ?**

e. Evaluate the Higgs-related added value of a run above the top-anti-top threshold as a function of its duration and its centre-of-mass energy (say 400 or 500 GeV).

WG7: Exp'tal signatures of new physics

Scientific objectives

- **Rare decays**
- **Rare processes**
- **Direct searches**

a. Evaluate the TLEP potential for new physics sensitivity, be it through direct production, or through rare decays of Z, W, Higgs boson and top quark (in particular), for a variety of new physics models.

- **Generators**

b. Contribute to the development of the pertaining Monte Carlo generators.

- **Detector design**

c. Understand specific requirements on detector performance and infrastructure.

- **Strategy**

d. Develop a strategy in terms of centre-of-mass energies and integrated luminosities to optimize the TLEP potential.