TLEP Design Study: (some) Main Questions

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Fully part of

Multiprobe Collider Complex

TLEP : e^+e^-, up to $\sqrt{s}$ ~350 GeV (possibly 450-500 GeV)

VHE-LHC : pp, $\sqrt{s}$ ~ 100 TeV in same tunnel including possibly ep collisions and/or $\gamma\gamma$ collisions if needed

(CERN implementation capitalizing on existing infrastructures

Why ?

High-priority large-scale scientific activities in European Strategy

Recommendation #2

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. These design studies should be coupled to a vigorous accelerator R&D programme, including high-field magnets and high-gradient accelerating structures, in collaboration with national institutes, laboratories and universities worldwide.

Possible Strategy for Future Large Scale Accelerator

When

What

after LHC @14 TeV

Standard Higgs and nothing else

Non standard Higgs and/or new physics

Decision in 2018

e^+e^- Collider : e.g. TLEP, ILC

Depending of NP scale e^+e^- and/or pp : CLIC or TLEP+VHE-LHC or VHE-LHC directly

VHE-LHC (pp 100 TeV) or μμ collider (if new physics hints <5 TeV)

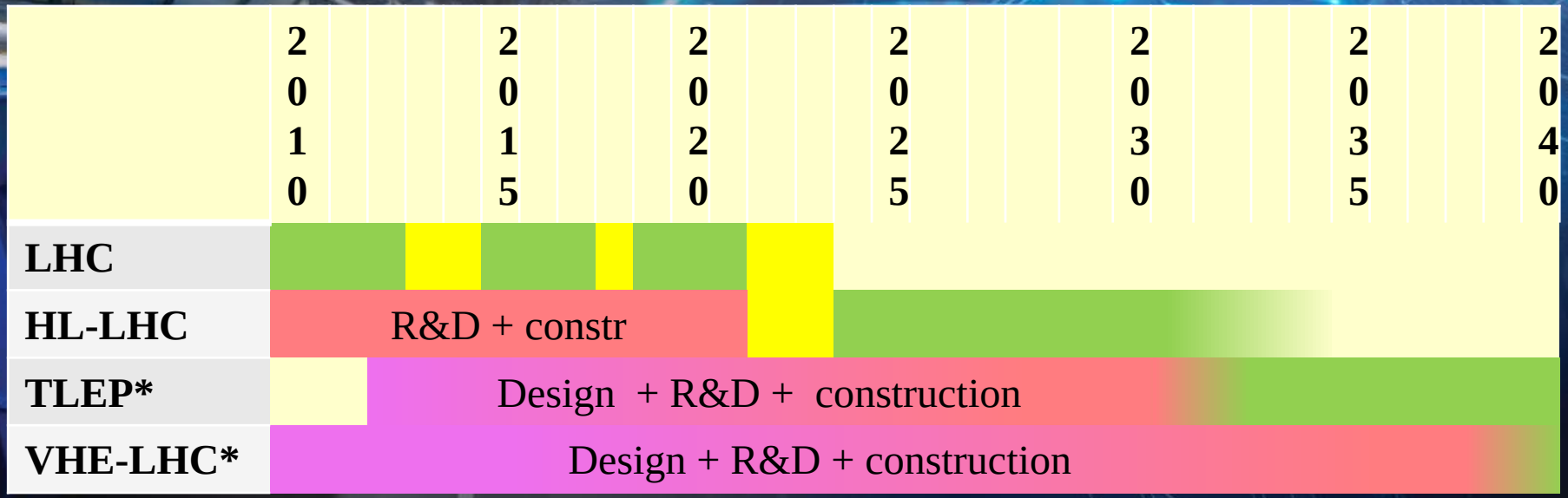
We should develop a strategy toward very High Energy …

…possibly with the same complex?

Can TLEP come timely?

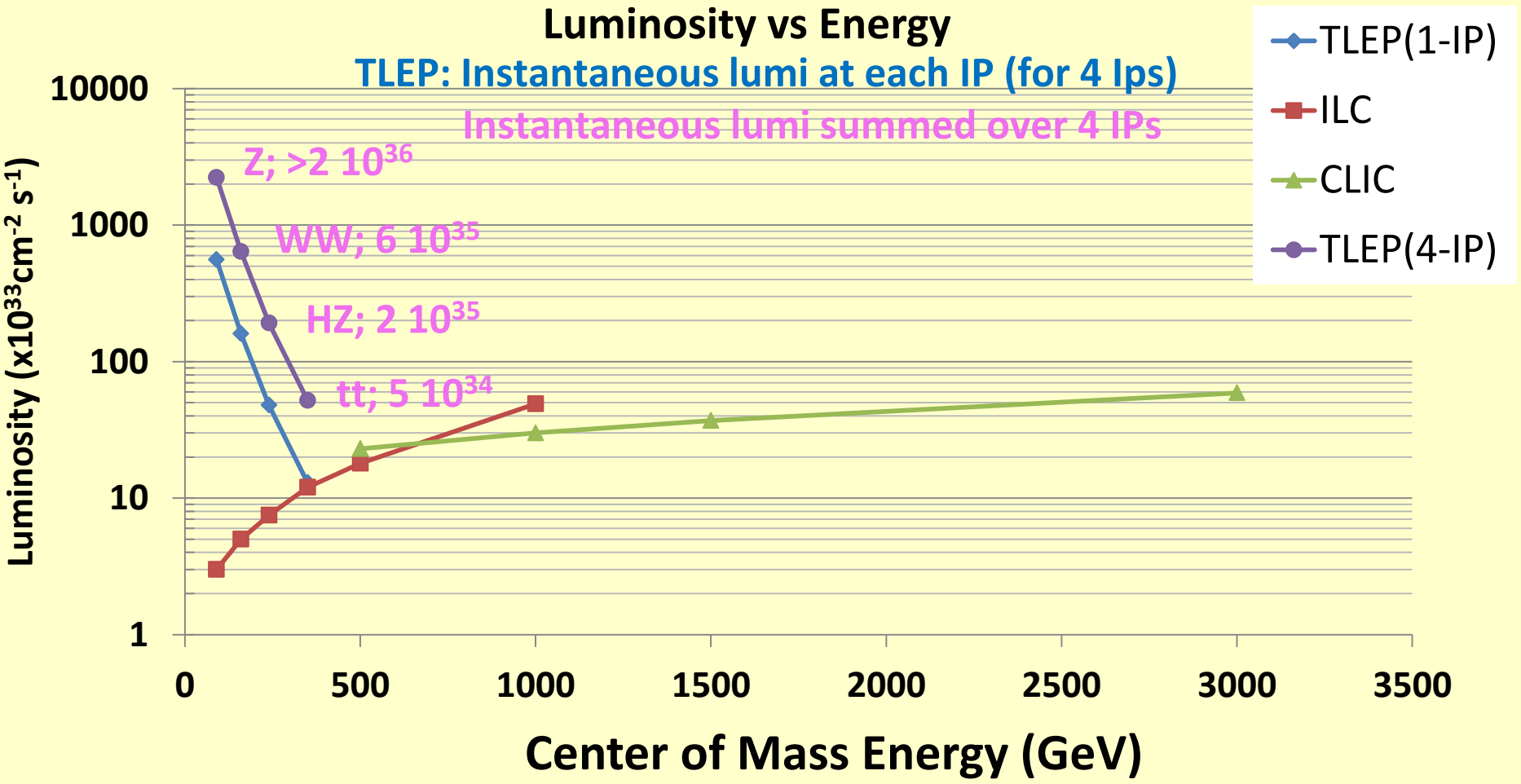
⇨ **Enough inputs is needed to decide PP-direction in 2018**

- **Ambitious milestones have to be set up**
  - **STEP 1: Interim CDR in ~2 years**
  - **STEP 2: a-CDR in 5 years, in a timely fashion with an update of the European Strategy in 2017-18**
- **A technically possible timeline (to be confirmed by the DS) ?**



Is a start in early 2030's realistic?

What is the TLEP maximum luminosity?



Luminosity is THE key parameter for TLEP programme!

STEP1: Main general parameters need to be established by interim report (~end 2015)

Many sub-question to be answered

Amongst which

- ⇨ Main critical accelerator parameters (emittance, ratio, BB tune shift…)
- ⇨ Initial lattice
- ⇨ Polarization feasibility (transv., longit.) vs energy
- ⇨ Beam energy measurement and spread
- ⇨ Frequency of RF system and max. feasible CW gradient
- ⇨ Number of rings (Injection ring + 2 separate collider arcs ?
  - ➢ Can one use common strait sections for high energy (>340 GeV)
  - ➢ Where is the injector ring located at the IR?
- ⇨ Injection complex (can one reuse existing infrastructures?)

Initial Assessment of maximum reachable luminosity vs energy?

STEP 2: advanced Conceptual Design (2017-2018)

Technical feasibility demonstration of critical components

Would require R&D work on critical issues

- ⇨ **RF system**
  - ⇨ **Cavity structures and CW maximum gradient reach**
  - ⇨ **RF source (Klystrons, IOT, SSD) and efficiency**
- ⇨ **Magnet system**
  - ⇨ **Low cost technology (~200km may be needed)**
  - ⇨ **Is it a dream to think of wide range of field (70-14000G)**
- ⇨ **Vacuum system (100MW not worse than LEP 8W/cm)**
  - ⇨ **Issue is the cost and time for coating**
- ⇨ **Efficient Energy management**
  - ⇨ **Can one recuperate energy**
  - ⇨ **Can one optimize its use ⇨ operation flexibility**

Assessment of reference maximum reachable luminosity vs energy and critical technical component feasibility

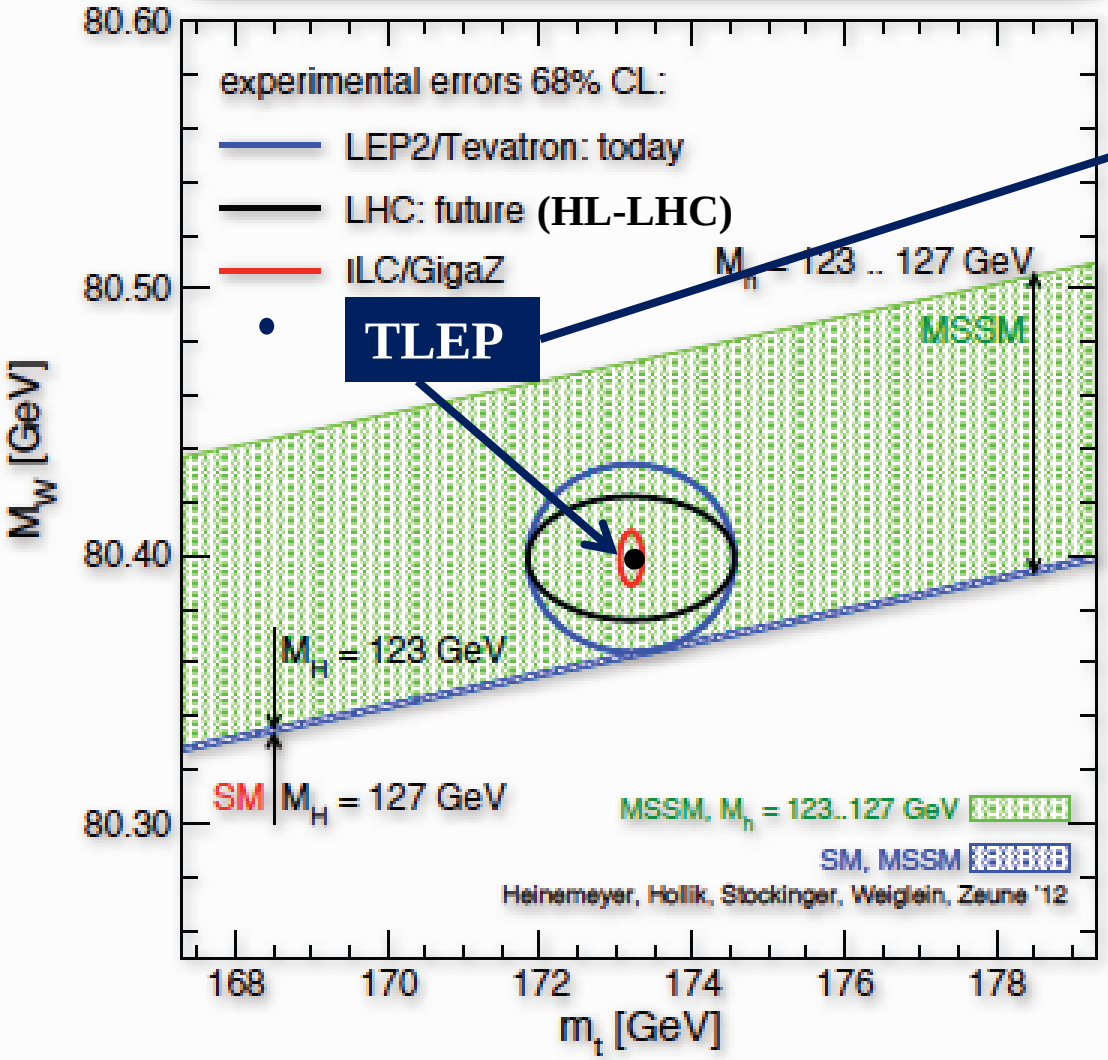
Is it useful to have concurrent or simultaneous TLEP and LHC operation?

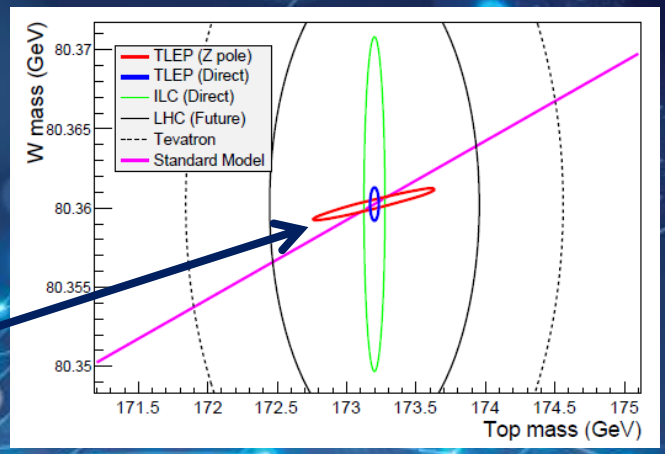
Can one operate TLEP and LHC simultaneously?
Energy management?
Achievable luminosities?

Even more challenging
Can one operate TLEP and VHE-LHC simultaneously?
Energy management?
Achievable luminosities?

How and Which New Physics Energy scale can be probed?

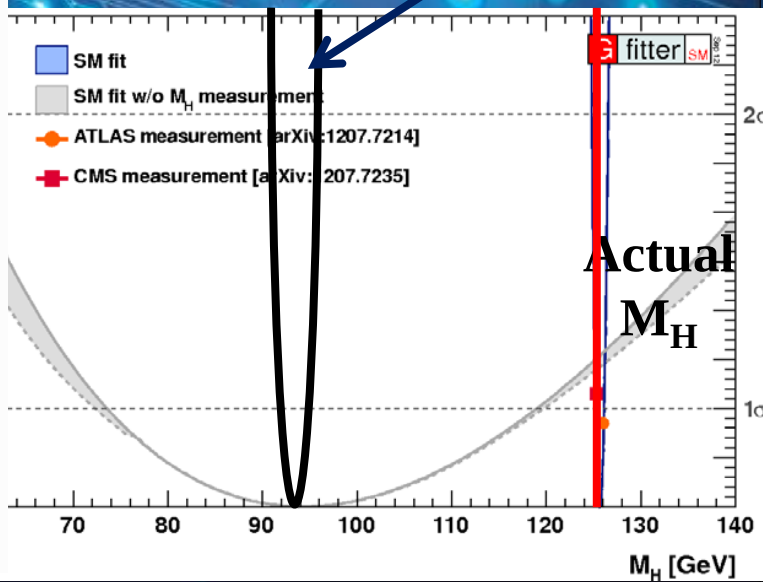
Extending the concept to a BSM framework, and projections:





Indirect: M_H=94.0 ± 1.4

Direct: M_H=125.500 ±0.007



…but also Higgs properties

	LHC(300)	LHC (3000)	TLEP (240+350)
Δm_H (MeV)	~100	~50	~7
$\Delta\Gamma_H/\Gamma_H$ ($\Delta\Gamma_{inv}$)	--(14)	--(7)	1.0(0.45)%
H spin	✓	✓	✓
Δm_W (MeV)	~10	~10	<0.5
Δm_t (MeV)	800-1000	500-800	~0
$\Delta g_{HVV}/g_{HVV}$	4-7%*	2%*	0.15-1%
$\Delta g_{Hff}/g_{Hff}$	6-13%*	4-7%*	0.2-0.7%
$\Delta g_{Htt}/g_{Htt}$	14%*	7%*	~13%
$\Delta g_{HHH}/g_{HHH}$	~30%*	~30%?	--

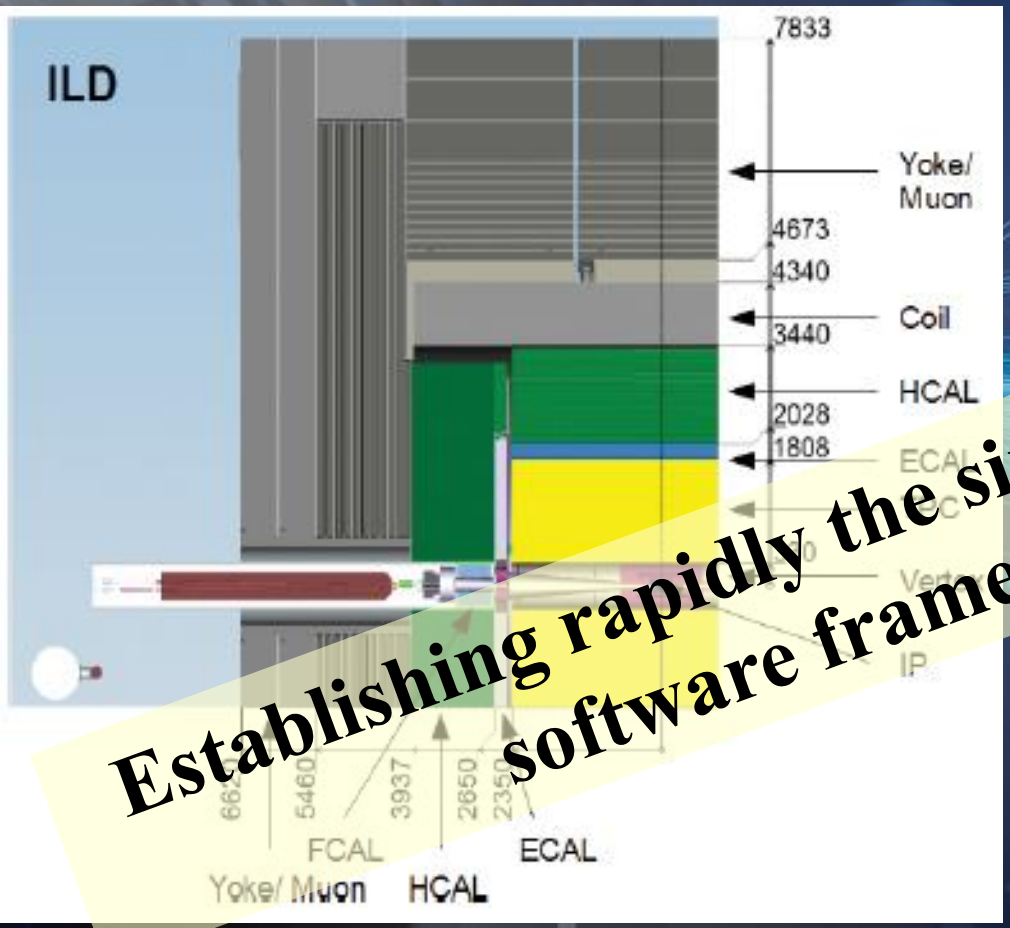
What are the limitation from theory?
How/up to which level can these be overcome?
What specific new physics and scale is TLEP sensitive to?
Is this competitive if LHC does not see new physics?

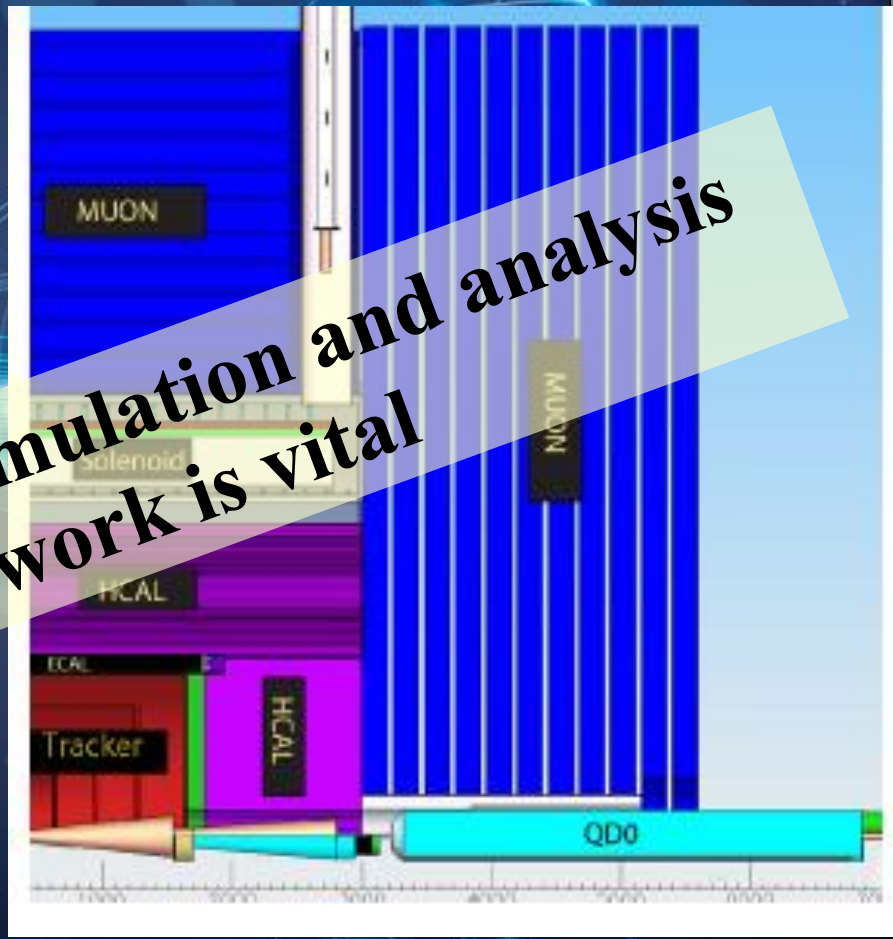
Can we do better?

Could be significantly improved at VHE-LHC?

Channels	Production/year	Physics
$\tau^+\tau^-$	3 10^{10} pairs	Rare decays, conservation laws…
c or b quarks	> 2 10^{11}	CP violation, rare decays…
	e.g. > 3 10^{10} B_s	Large B_s sample with clean environment within SM, > 1000 $B_s \rightarrow \tau^+\tau^-$ detected

What are the main detector characteristics needed? We should benefit from all the work done for ILC detectors!





Establishing rapidly the simulation and analysis software framework is vital

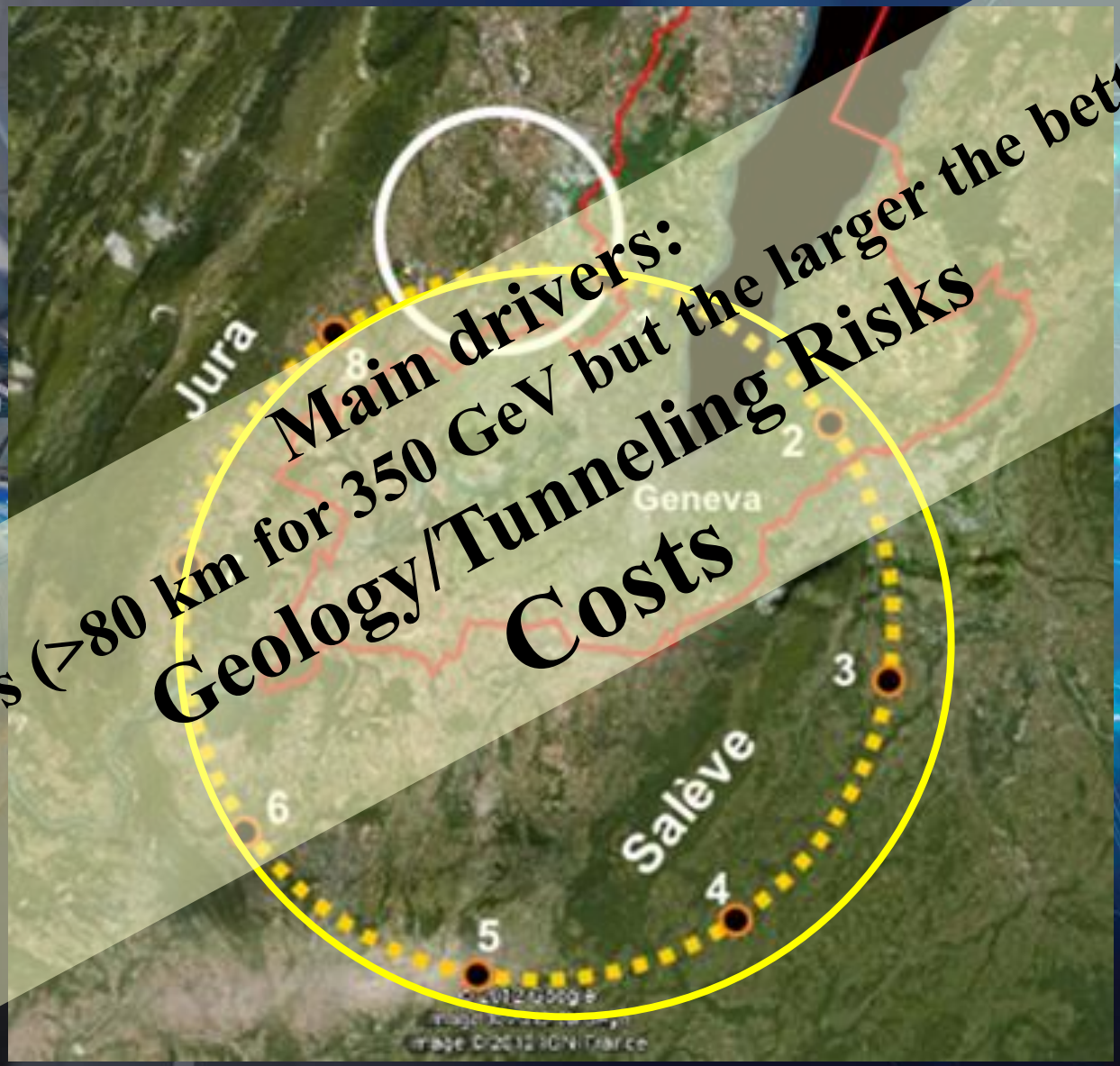
Need to integrate the advantages of TLEP

- **Low Beamstrahlung**
  - ⇨ **Less dilution of Xsections at threshold (WW,ZZ,ZH,tt)**
  - ⇨ **Excellent beam energy knowledge**
  - ⇨ **Beam energy-mometum constraints**
  - ⇨ **Less background**
  - ⇨ **Easier luminosity measurement**

- ➢ **Si Vertex tracker seems unavoidable**
- ➢ **TPC is a great device (see LEP) but is it usable at TLEP ? (ions back flow, heat of electronic (10kW/m^2), …) else all Si Tracker is a viable option**
- ➢ **What is the needed resolution of EM calorimeter? Is W/SiPad calo needed? Is LAr a crazy option?**
- ➢ **Does one need PID?**
- ➢ **Can one reuse magnet systems (CMS)?**

Is there any detector R&D needed specific to TLEP?

Tunnel: What is the optimal size ?



Physics (>80 km for 350 GeV but the larger the better)

Main drivers:

Geology/Tunneling Risks

Costs

Overall Cost is a crucial element, which will make the project possible or not

Personnal opinion :
It should not be much larger than LHC:
Accelerator: (LHC + LEP-tunnel*inflation
(4.2 + 0.7*1.5) = 5.2 BCHF
Detectors: 1.2 BCHF
Cost is likely to drive the number of detectors

Credible Accelerator costing is mandatory

Several costing method should be used to gain confidence (i.e. analogical, parametrical and analytical methods)

- **A preliminary assessment is needed at the interim CDR**
- **A reference cost for the a-CDR is essential**

Setting up a truly international collaboration

Mandatory if we want to succeed in this endeavor

Should be set up at the very beginning of the effort at all levels so that collaborators have ownership

Divide the work in well consistent and well identifiable sub-tasks

Need to have visibility at

- **The scientific level (consensus is vital)**
- **The EC level**
- **The national level**
- **The local (Geneva, Ain, Haute Savoie)**

A lot of work ahead!