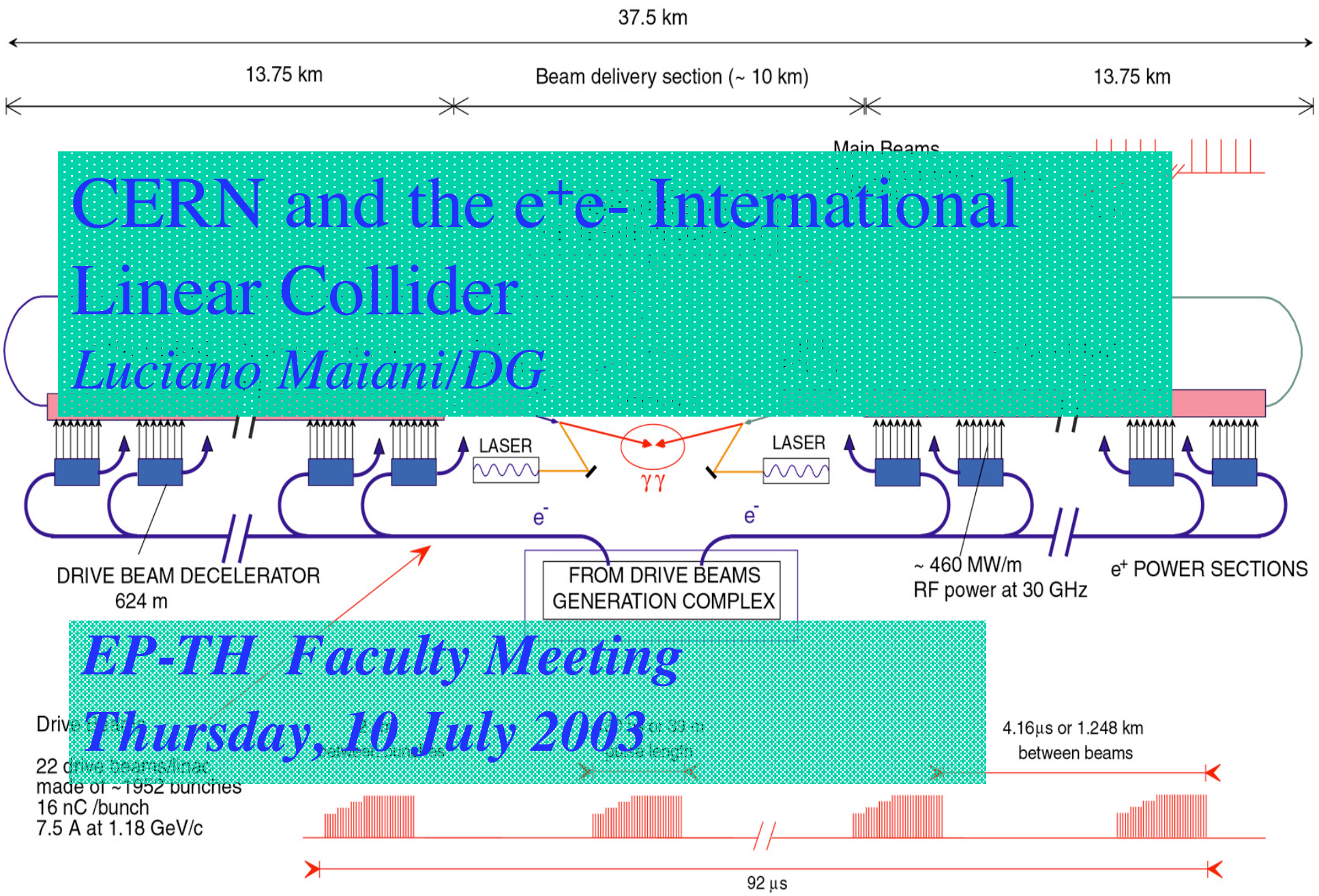
Overall Layout of the CLIC complex at 3 TeV c.m.



CERN and the e+e- International Linear Collider

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EP-TH Faculty Meeting

Thursday, 10 July 2003

1. INTRODUCTION

- While the Large Hadron Collider is in construction at CERN, the High Energy Physics community is discussing the launch of a new project
- electron-positron linear collider (LC) with c.m. energy 0.4 to 1 TeV.
- The LC is to be constructed and operated by an international collaboration and to get into function during the time LHC is still operating, around 2015 if we allow for 10 years construction of the LC.

CERN long-term directions

- The CERN Long-Range Planning Committee, in 1985, studied the LC potential and feasibility
- While the LHC was recommended, Council agreed to continue R&D for linear colliders at a low level
- CERN has cooperated with other major laboratories in the framework of the (rather informal) International Linear Collider Collaboration.
- In line with the earlier decision and with a more recent recommendation of the SPC, the latest Base Line Plan 2003-2010 foresees that CERN continues to develop, in an International Collaboration, a high-gradient electron acceleration technology (CLIC), aiming at a Linear Collider in the Multi TeV energy region, with a physics reach beyond the LHC.

Accelerator R&D in the present MTP

- Budget for R&D during the period 2004-2007 :
  - 3.8 MCHF/year (material)
  - 6.4 MCHF/year (manpower)
- a moderate increase is foreseen later.

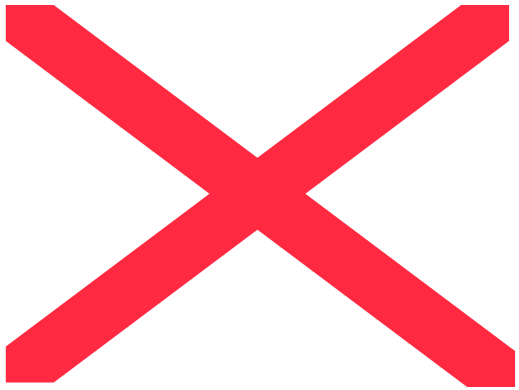
CTF3/CLIC:

- about 90% of the accelerator R&D material budget and a large part of the manpower;
- collaborations with LNF (INFN), Orsay (IN2P3), RAL and Strathclyde University (UK), Uppsala University and SLAC (USA).

SPL:

- work on components for the front-end of a Superconducting Proton Linac (SPL)
- collaboration for high intensity H^- sources among European laboratories developing a RFQ device, IPHI, to be installed at CERN mid-2006 for a 3 MeV pre-injector test station.

Compact Linear Collider studies@ CTF3

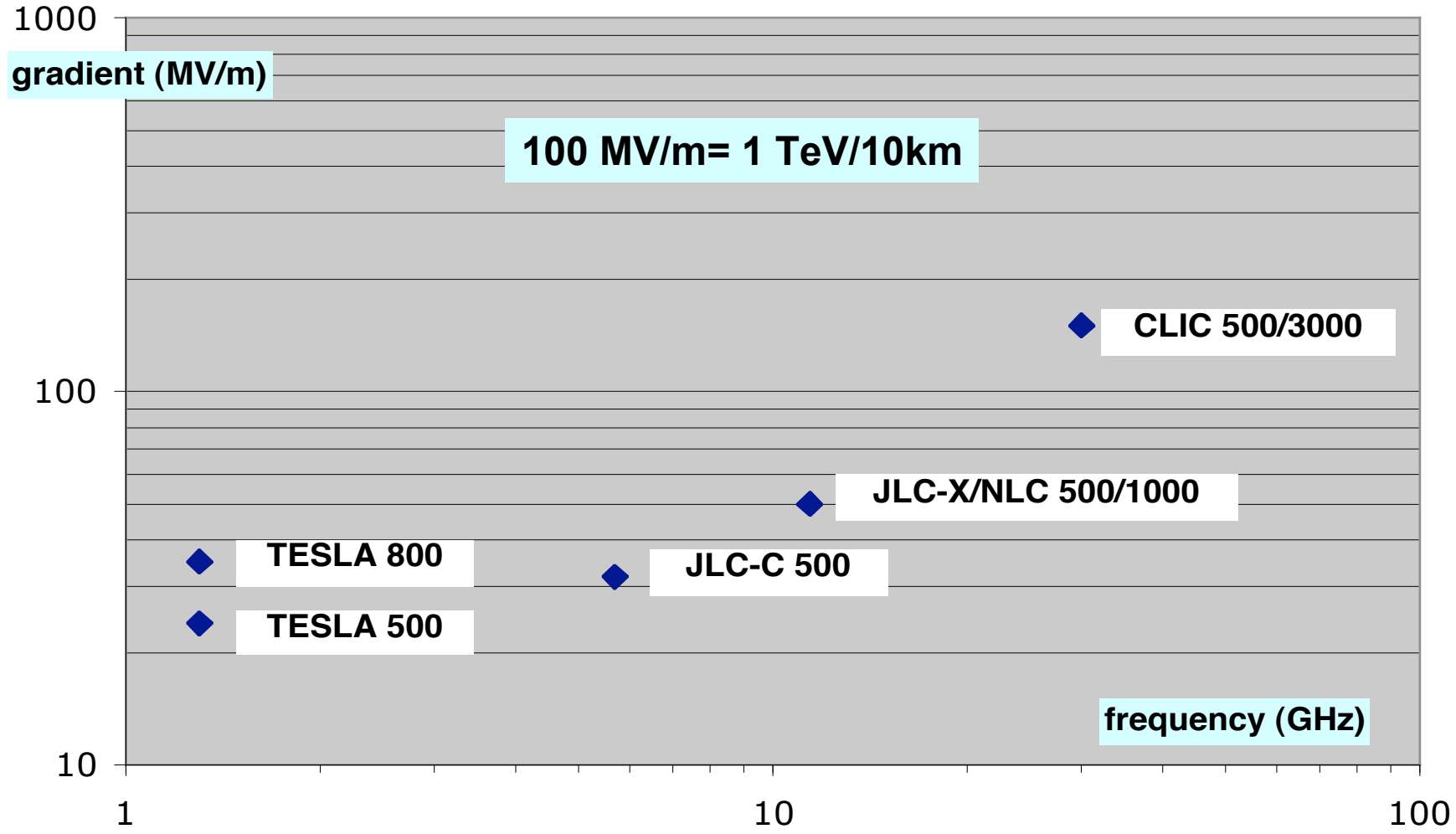


Nov 28, 2002
Average gradient
150 MV/m

(= 1.5 TeV/10km!)

2. WHICH LINEAR COLLIDER?

Loaded accelerating gradients vs. RF frequency in present LC designs



Cost Estimates

TESLA (500 GeV)

- material cost.= 4.8 BCHF
- 7200 man x years are required for the construction;
- the material cost of a detector approx. 450 MCHF;
- the extension to 800 GeV would entail replacing of the sc cavities (not included in the cost) but no additional infrastructure.

JLC (500 GeV)

- material cost = 495 BY (approx. 5.8 BCHF)
- minimum staff would be 165 FTEs (contract work included in material cost);
- the material cost of a detector 30 to 40 Billion Yen (approx. 350 to 460 MCHF);
- extension to 1000 GeV would entail the installation of addition copper cavities, not included, but no additional infrastructure.

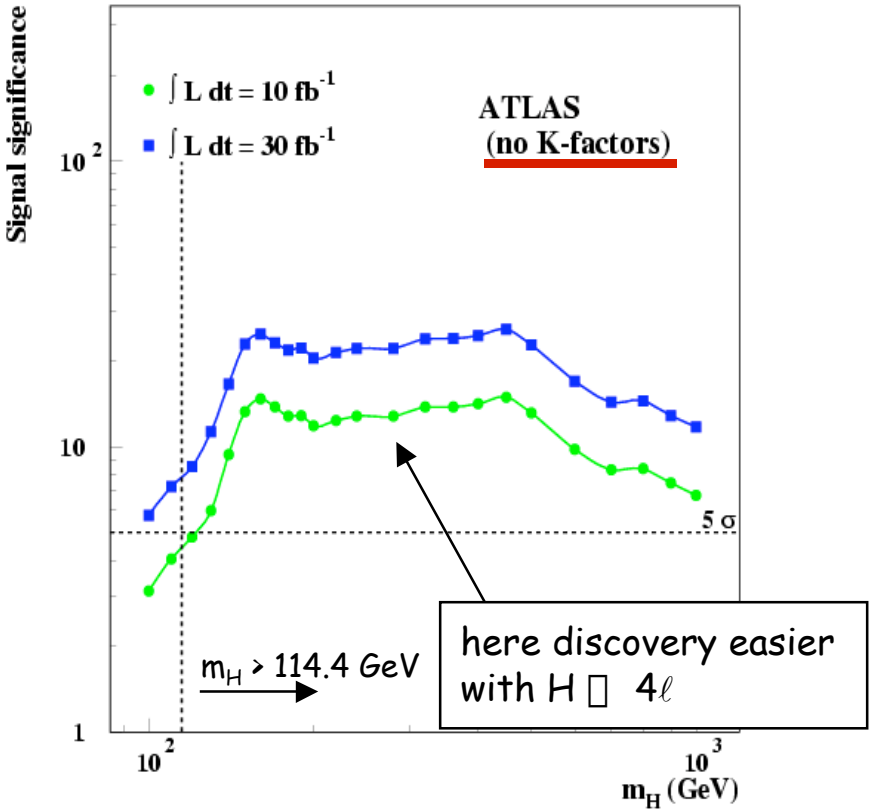
NOTE

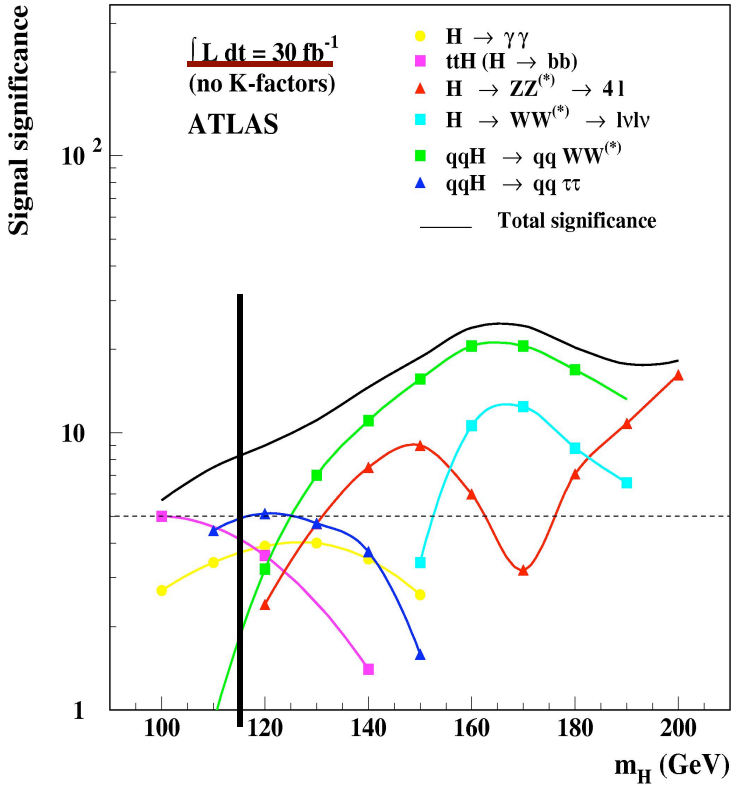
- estimates **do not** include contingency **nor** contract cost escalation.
- Under similar assumption, CERN Baseline Plan (Tabs 1A and 6a) gives 3.43 BCHF +1.3 BCHF for the total material of the LHC machine and detectors.

LC belongs to a similar cost category as the LHC

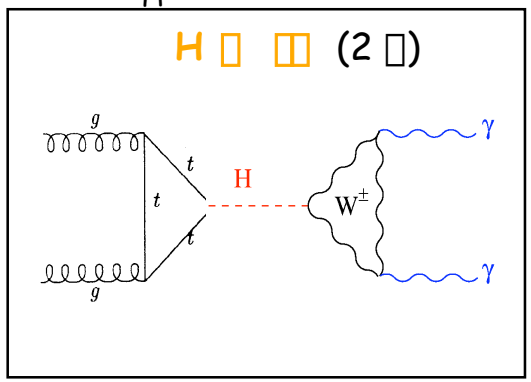
3. WHY AN e+e- LINEAR COLLIDER?

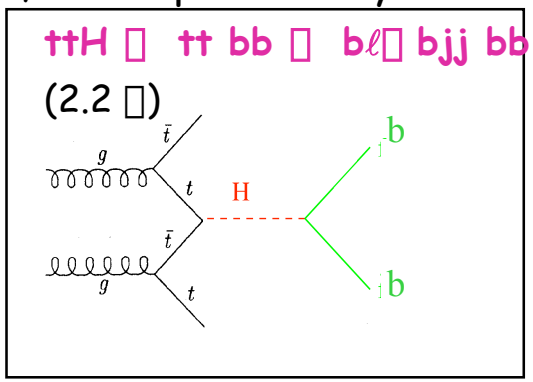
Standard Model Higgs

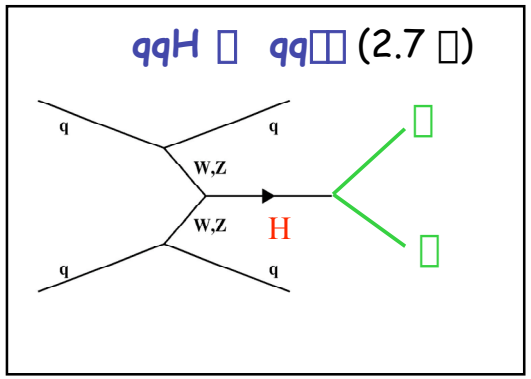




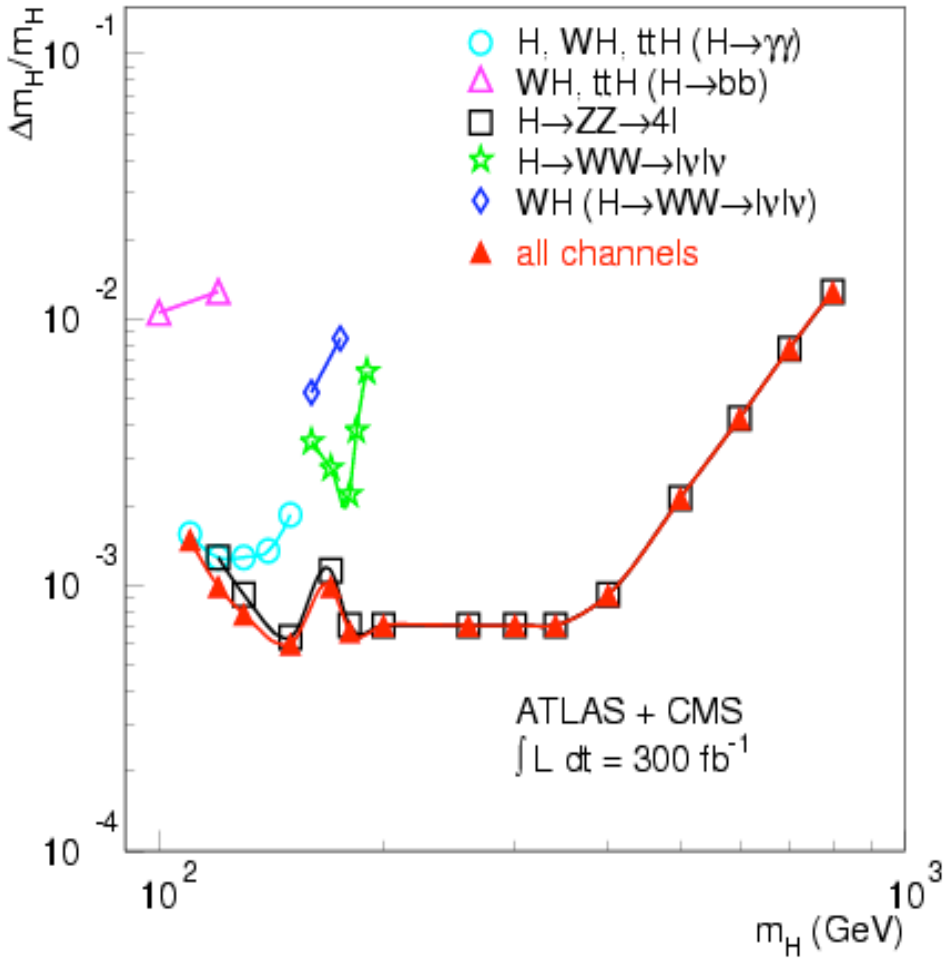
For m_H ~ 115 GeV and 10 fb^{-1}, 3 complementary channels accessible:





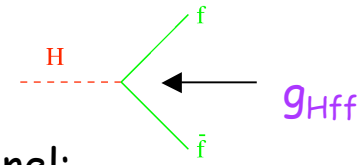


Measurement of the SM Higgs mass at the LHC



Expected experimental
Systematic errors included.
No theoretical uncertainty

Measurement of the SM Higgs couplings

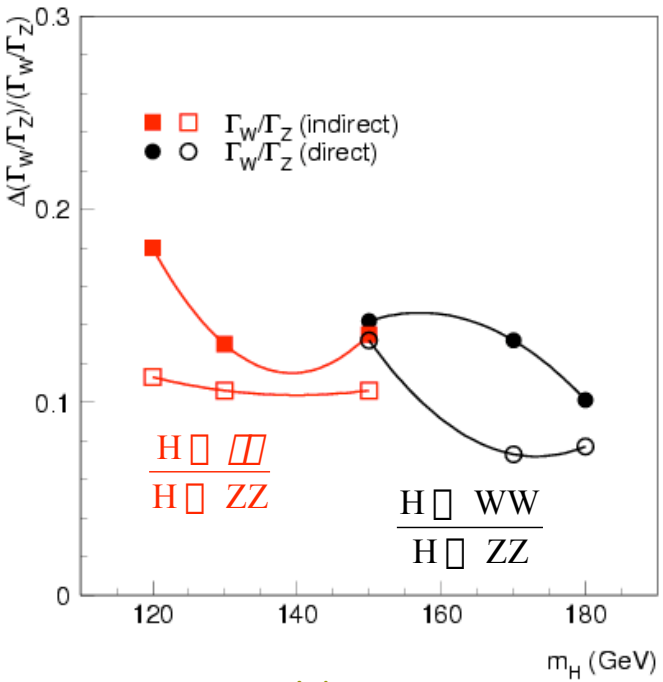


Couplings can be obtained from measured rate in a given production channel:

$$R_{ff} = \int L\,dt \cdot \sigma(e^+e^-, pp \to H + X) \cdot BR(H \to ff) \qquad BR(H \to ff) = \frac{\Gamma_f}{\Gamma_{tot}}$$

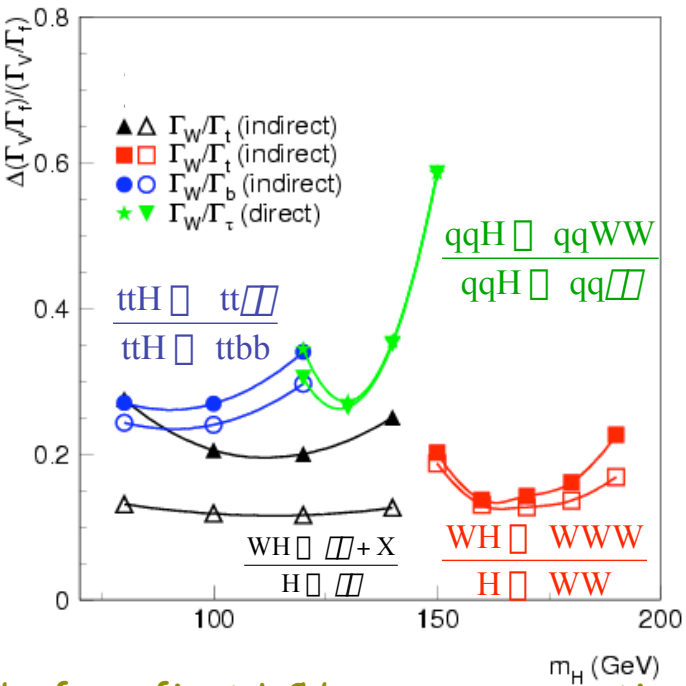
⇒ deduce $\Gamma_f \sim g^2_{Hff}$

Γ_{tot} and σ(pp → H+X) from theory ⇒ without theory inputs measure ratios of rates in various channels (Γ_{tot} and σ cancel) ⇒ $\Gamma_f/\Gamma_{f'}$ ⇒ several theory constraints



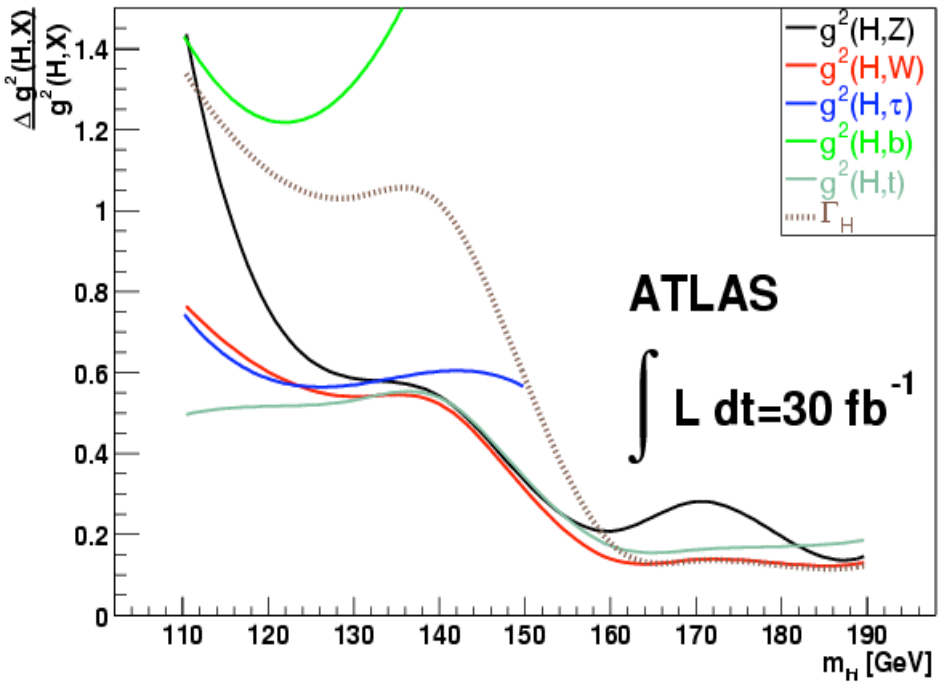
Closed symbols:
LHC 600 fb^{-1}

Open symbols:
SLHC 6000 fb^{-1}



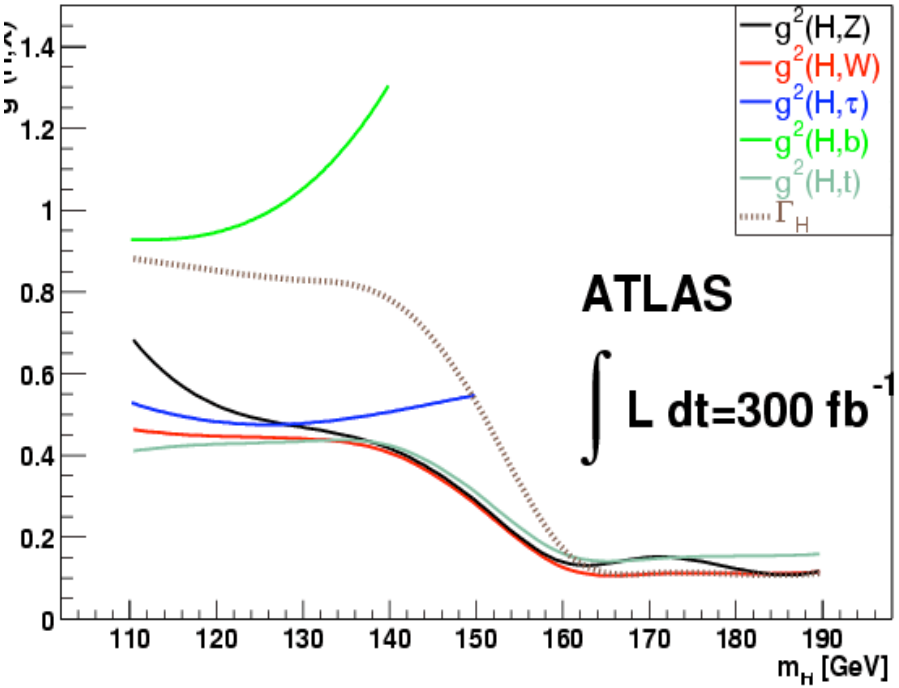
-- SLHC could improve LHC precision by up to ~ 2 before first LC becomes operational

-- Not competitive with LC precision of ~ %



Improved performance on Higgs couplings and width from global fit to all channels
(and from using some theory inputs)

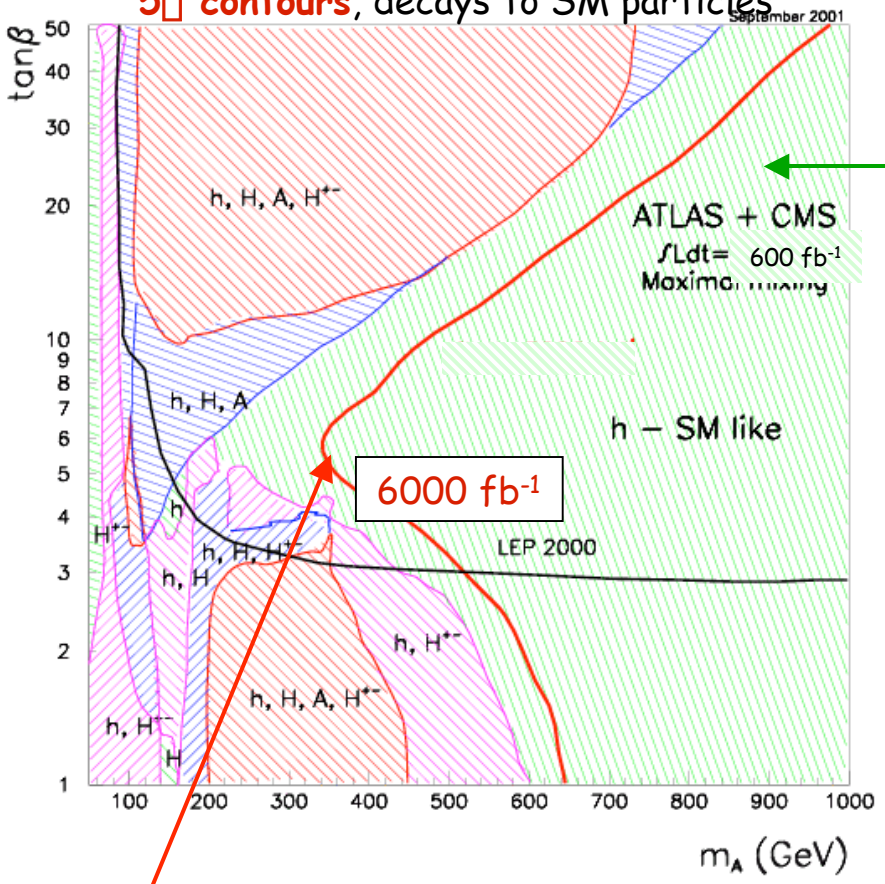
Systematic uncertainties included



MSSM Higgs sector : h, H, A, $H^{\pm}$

$m_h < 135$ GeV , $m_A \approx m_H \approx m_{H^{\pm}}$

5σ contours, decays to SM particles



In the green region only SM-like h observable, unless A, H, $H^{\pm}$ decay into SUSY particles
→ LHC can miss part of MSSM Higgs spectrum

Direct observation of whole Higgs spectrum may require $\sqrt{s} \geq 2$ TeV LC

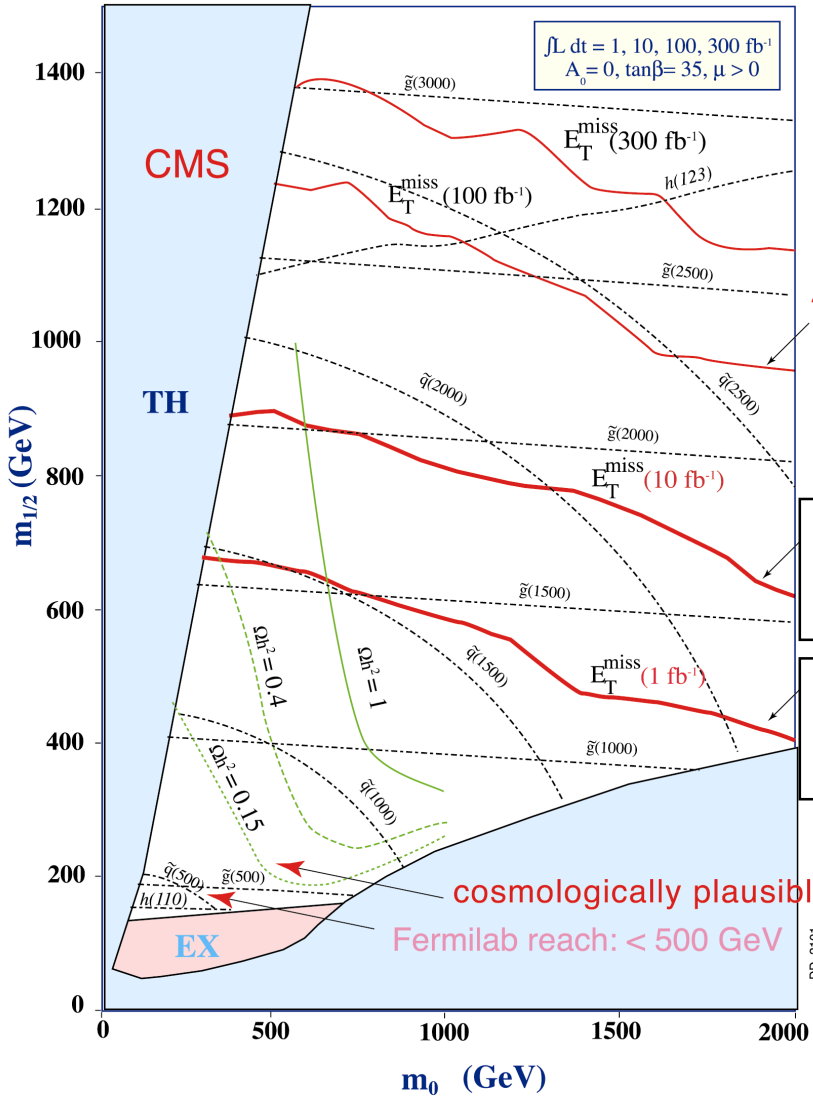
Region where ≥ 1 heavy Higgs observable (at 5σ) at SLHC → green region reduced by up to 200 GeV

Region $m_A < 600$ GeV, where $\sqrt{s} = 800$ GeV LC can demonstrate (at 95% C.L.) existence of heavy Higgs indirectly (i.e. through precise measurements of h couplings), almost fully covered.

SUPERSYMMETRY

Large $\tilde{q}\tilde{q}, \tilde{q}\tilde{g}, \tilde{g}\tilde{g}$ cross-section □ □ 100 events/day at 10^{33} for $m(\tilde{q}, \tilde{g}) \sim 1$ TeV

→ SUSY could be found quickly



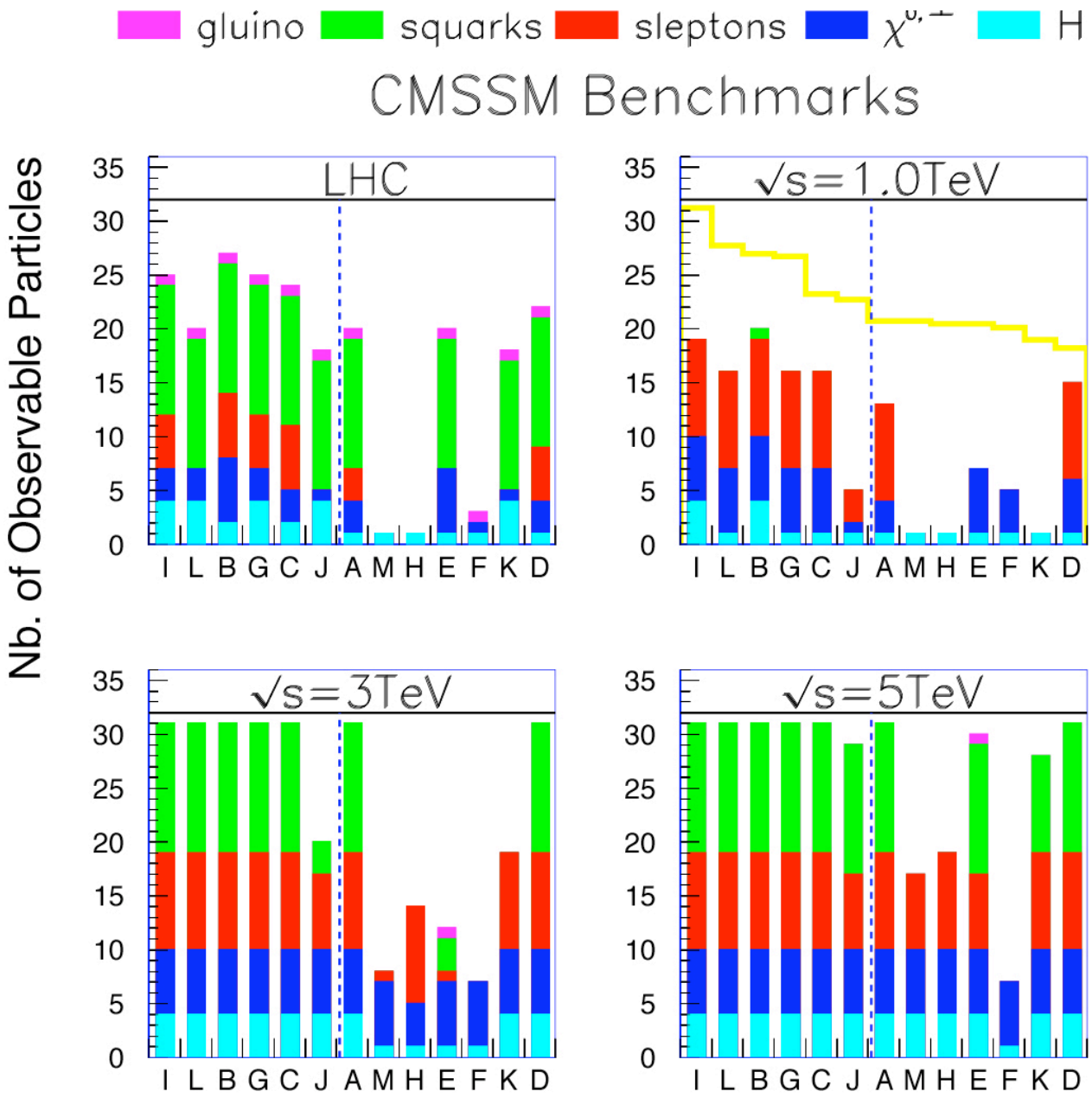
5□ discovery curves

~ one year at 10^{34}: up to 2.8 TeV

~ one year at 10^{33} : up to 2.3 TeV

~ one month at 10^{33} : up to 2 TeV

Reach of Multijet + E_T^{miss} searches (most powerful and model-independent signature if R-parity conserved)



Benchmarking MSSM s compatible with Cosmological Dark Matter

Projet 240 km - Variantes Est et Ouest

VLHC at CERN?
(Circ. = 240 Km)

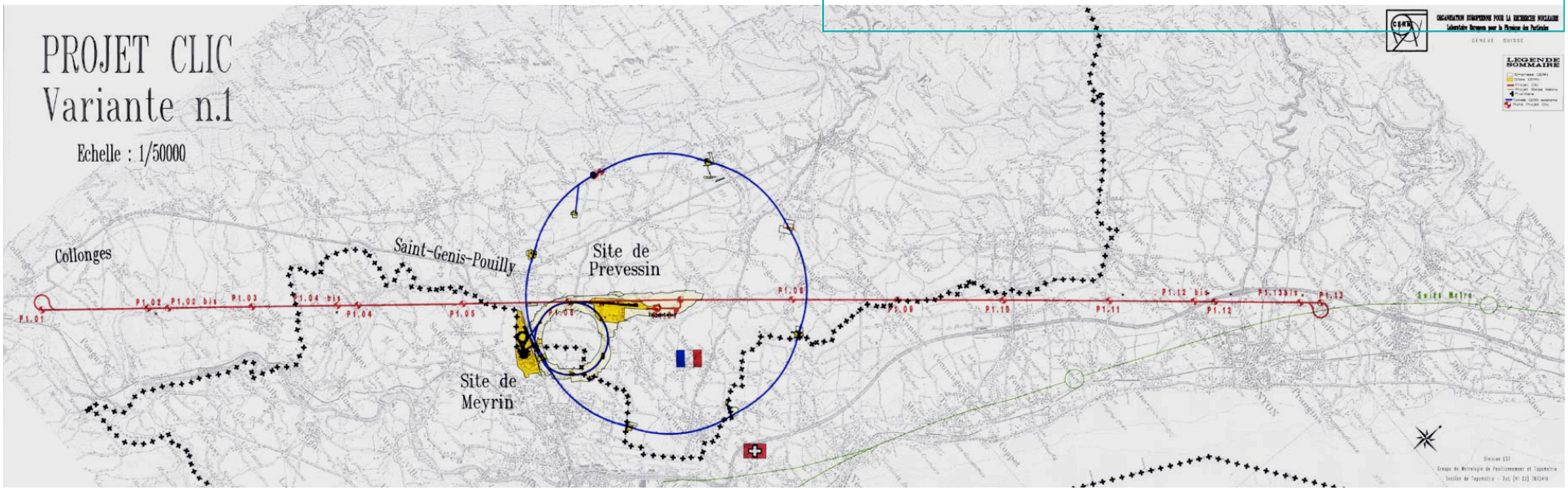
SITUATION

GADZ
GEOTECHNIQUE
APPLIQUEE
DERIAZ S.A..
CH-1213 PETIT-LANCY 2

Exploratory study shows prohibitive tunnel cost

Compact Linear Collider CLIC

Fitting CLIC at CERN



Very personal views

- A sub-TeV collider is needed for precision Higgs boson physics – in case of a light Higgs boson;
- Useful to distinguish SM from Minimal Supersymmetric SM;
- Multi TeV capability needed to really sort out Supersymmetry;
- A Multi TeV LC can reasonably be built in Europe … unlike a VLHC (as far as we know now!)

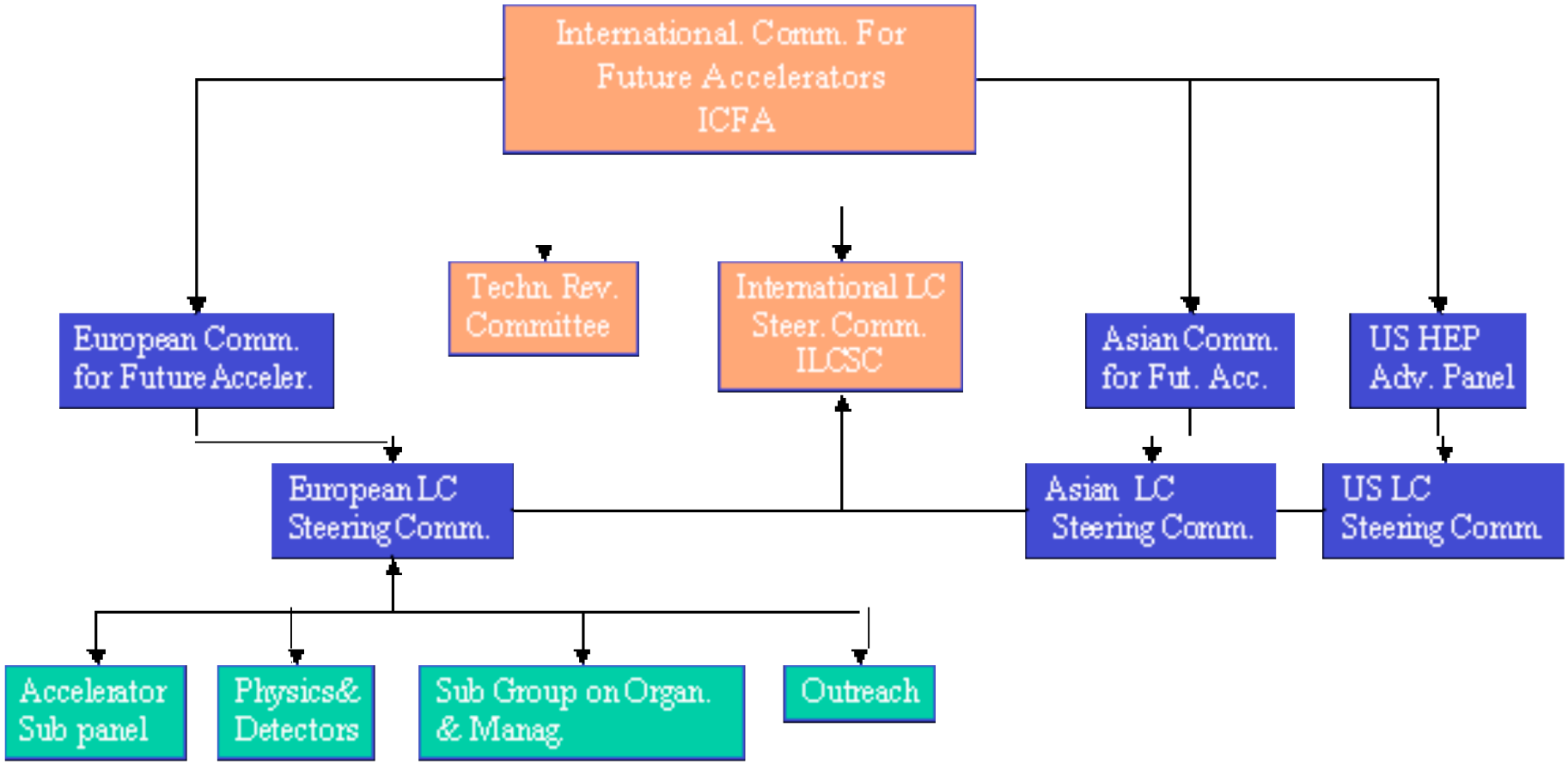
4. ECFA Working Group recommendations (summer 2001)

- "… the allocation of all necessary resources to fully exploit this unique and pioneering facility." (i.e. the LHC)
- "… continued support for ongoing experiments. They promise significant scientific results, provide an optimal physics return on previous investment, and are vital for the education of young physicists."
- "…the realisation, in as timely a fashion as possible, of a world-wide collaboration to construct a high-luminosity e+e- linear collider with an energy range up to at least 400 GeV as the next accelerator project in particle physics. The Working Group urges the appropriate bodies to make decisions concerning the chosen technology and the construction site for such a machine soon. "

ECFA (cont'd)

- "… an improved educational programme in the field of accelerator physics and increased support for accelerator R&D activity in European universities, national facilities and CERN."
- "… A coordinated collaborative R&D effort to determine the feasibility and practical design of a neutrino factory based on a high-intensity muon storage ring. "
- "… a coordinated world-wide R&D effort to assess the feasibility and estimate the cost of a CLIC, a VLHC, and a muon collider. In particular, R&D for CLIC is well advanced and should be vigorously pursued. "
- "The central role of CERN in Europe must continue and will be essential as the fulcrum of the long-term future of particle physics. The Working Group considers it essential that, through CERN, Europe should be able to play a key role in the exploration of the multi-TeV horizon that will open in the post-LHC era."

5. The international promotion scheme for the Linear Collider



6. The discussion in Committee of Council

Questions to Comm. of Council discussed in March 2003

- The way Council and CERN could participate in the discussion with Funding Agencies;
- The extent of the collaboration that CERN may provide to the LC, should the LC project be approved;
- The resources made available to CERN for this collaboration and the forms of coordination deemed necessary with other European accelerator laboratories;
- The way such collaboration can be made compatible with the construction and full exploitation of the LHC and with the future of CERN.

CC conclusions

- ***CERN Council, given its mission, composition and authority, should play a major role in the definition of the European participation to the LC;***
- ***Given appropriate resources, CERN is prepared to participate in any of the present LC projects.***

7. Early LC: actions and roadmap

- This is what is being discussed now in ICFA and related committees
- ***Early = decisions and construction ASAP, E<1 TeV***
- ***Inter-regional discussions on LC organized by UK (Ian Halliday, PPARC). Next meeting in London, 29-30 July***
- ***Europe represented by 4 big countries (DE, UK, FR, IT) and by CERN DG + Presid. of Council to represent the Organisation, in particular the smaller countries not around the table;***
- ***Organizational models worked out in Japan and Europe***

Early LC: actions and roadmap (cont'd)

- Technology choice in 2004, between TESLA and, if available, X-band;
- Site choice and construction startup: 2007
- Commissioning: 2015
- CERN role: conveying European contribution (together with some other EU labs – DESY, RAL, …) much like US Labs with respect to the LHC
- Where? German Government has not offered a site for TESLA, sending decision to discussions on global scale that have to start;
- Who pays? Most CERN MS see a contribution via CERN, probably not on an equal share basis within regions.

8. CONCLUSIONS

- Europe/CERN are doing an enormous effort to build the LHC;
- The exploration of MultiTeV is crucial;
- Europe/CERN should keep their options to contribute to a High Energy Linear Collider, the only viable option to get into Multi TeV in Europe;
- ***This is in line with the recommendations made by the ECFA working group***
- In consequence CERN should:
    - Continue to develop CLIC: we need to know if it is a viable option (by 2007 at the latest);
    - Integrate CLIC in European Linear Collider R&D;
    - Participate in a sub-TeV LC, if done early, on a lower scale of effort than other regions, whatever the technology, with resources made available;
    - Be ready to enter into a Global Organisation, which should coordinate the creation of facilities in the present network of Accelerator Laboratories.
- We see CERN Council as the natural body to coordinate the participation of European Particle Physics in global projects.