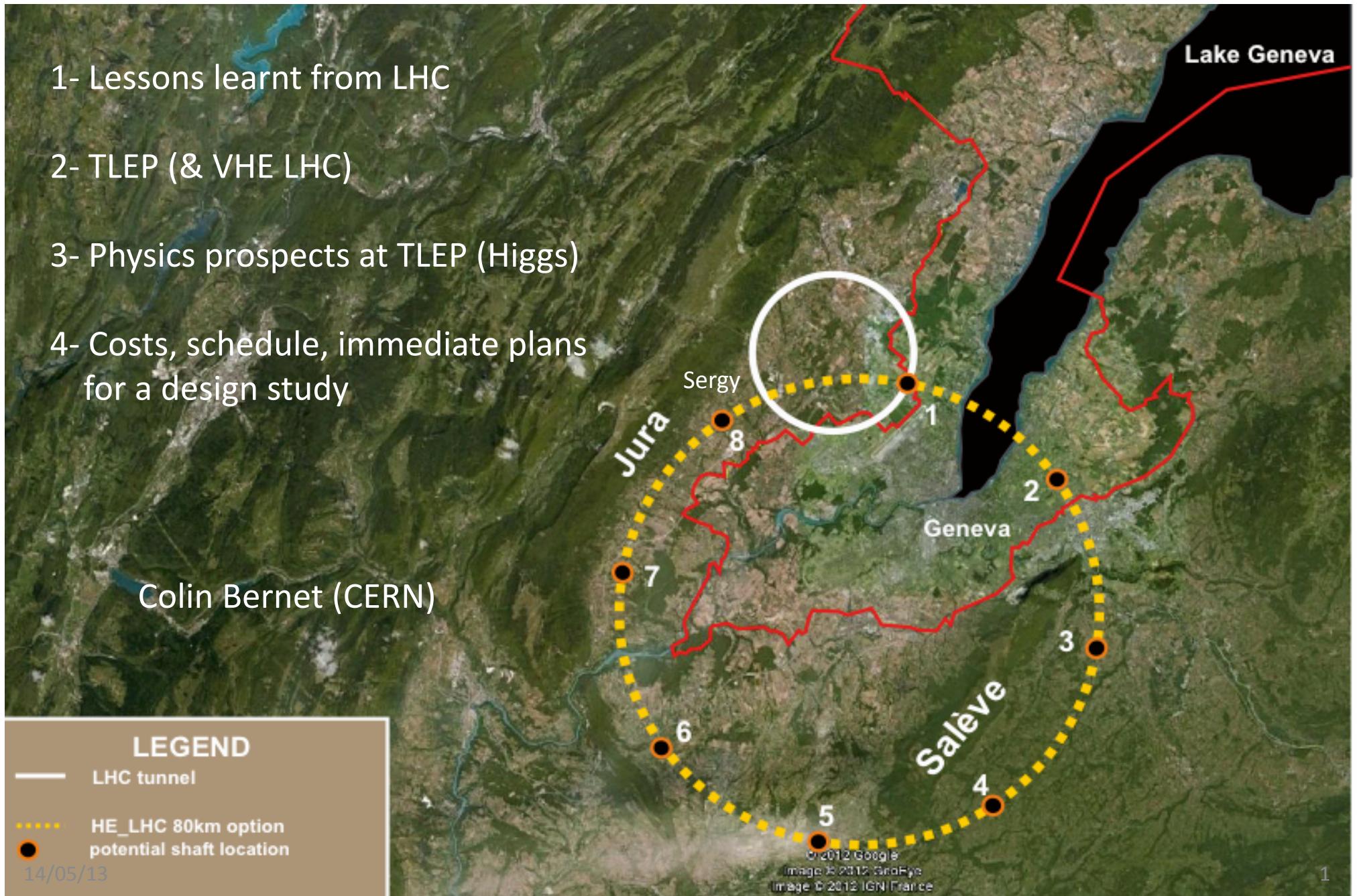
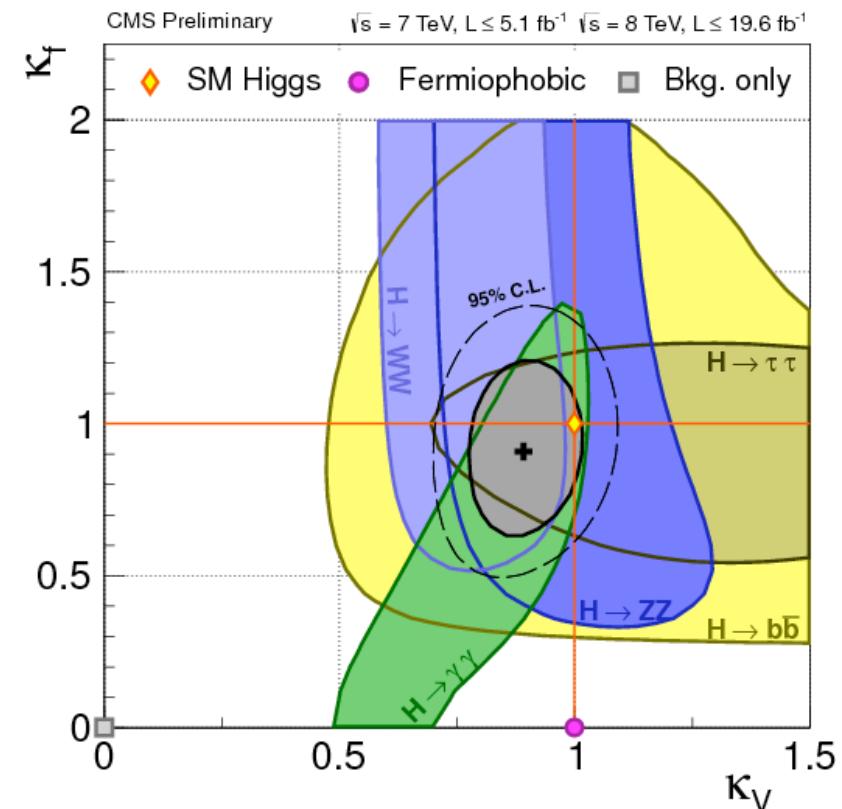
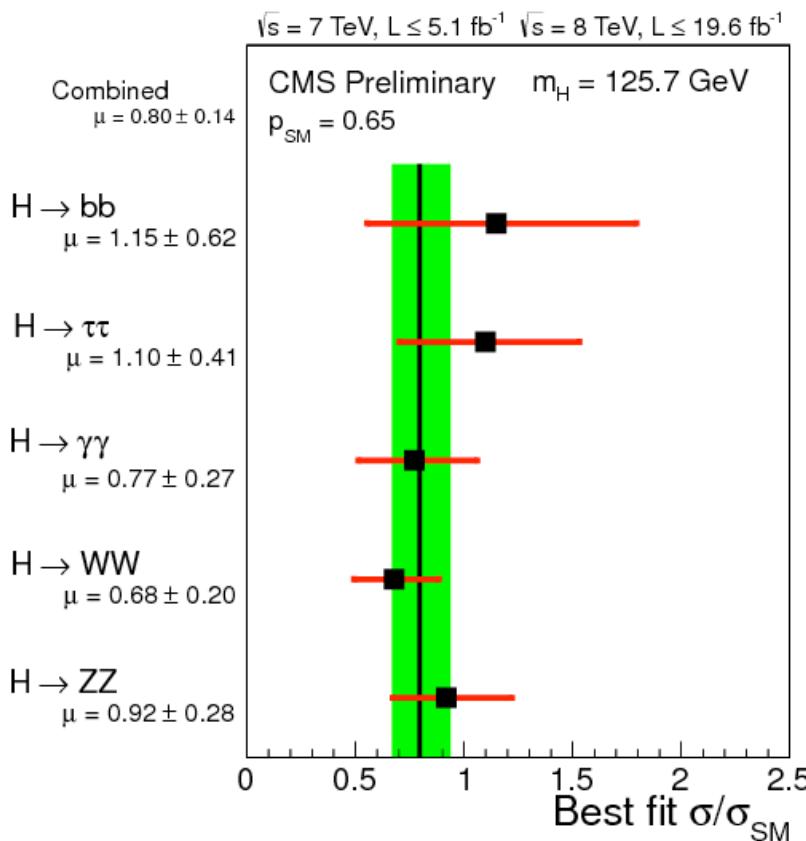


# TLEP, a long term vision for HEP

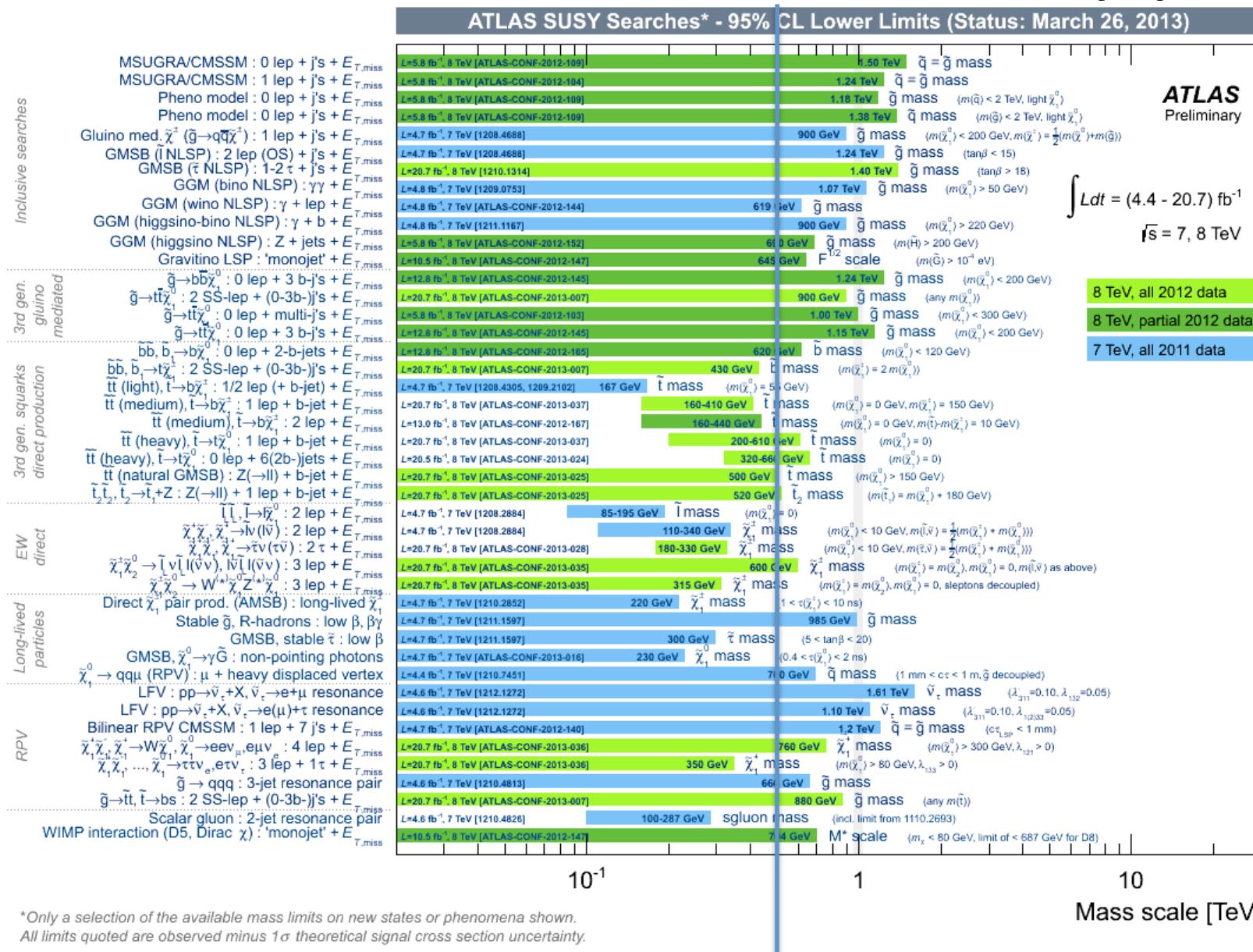


# Discovery of a Higgs boson at LHC



- $\sigma \times \text{BR}$  compatible with Standard Model
  - Suggests SM-like couplings
  - $HZ$  and  $HW$  couplings non zero
    - good news for an  $e^+e^-$  collider
- What to do now?
  - Look for new physics:
    - direct searches
    - precision measurements

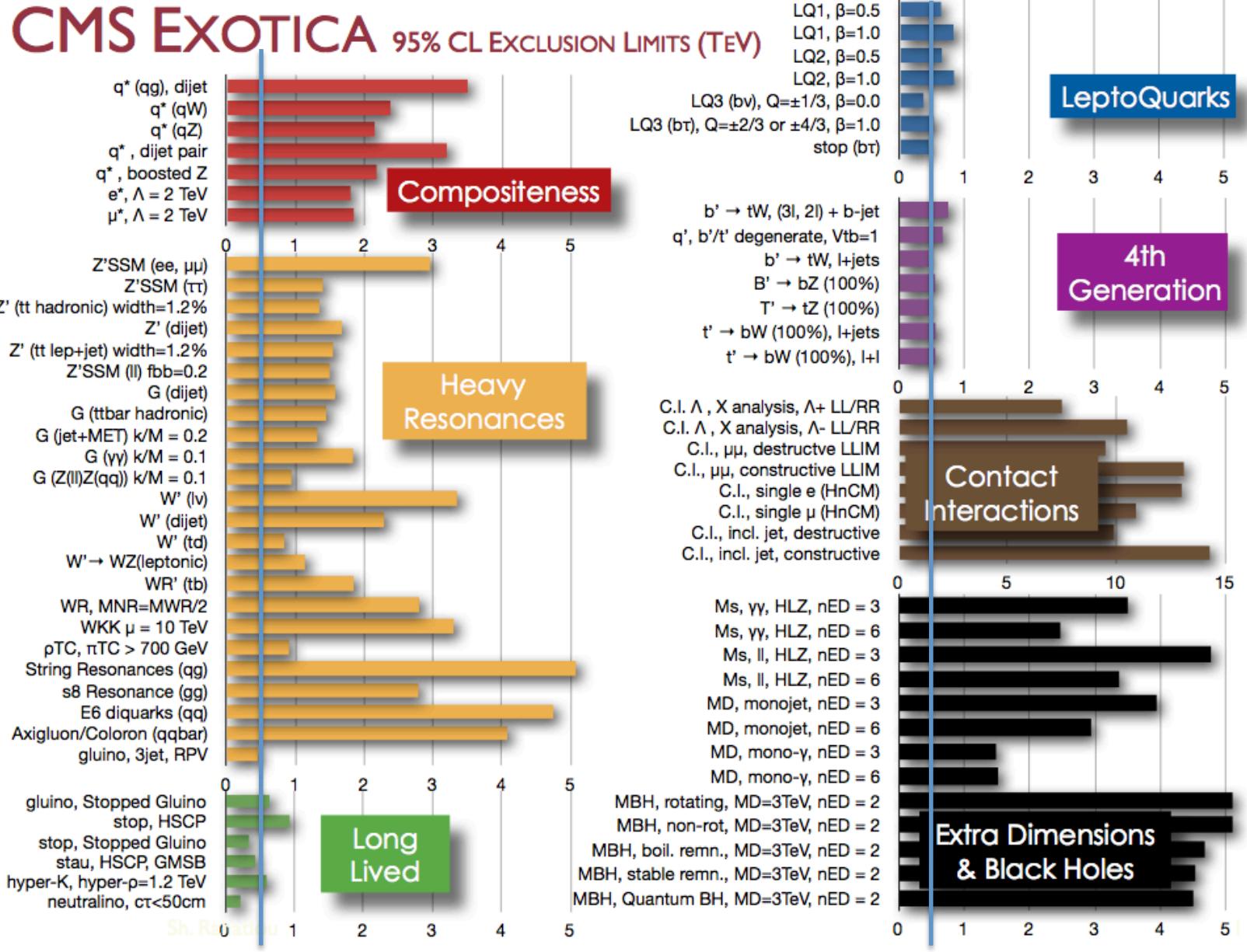
# Direct searches at LHC: no susy yet



Caveat: non exhaustive, model dependent

pair production possible at  $e^+e^-$  collider with  $V_s=1 \text{ TeV}$  only if  $m < 500 \text{ GeV}$

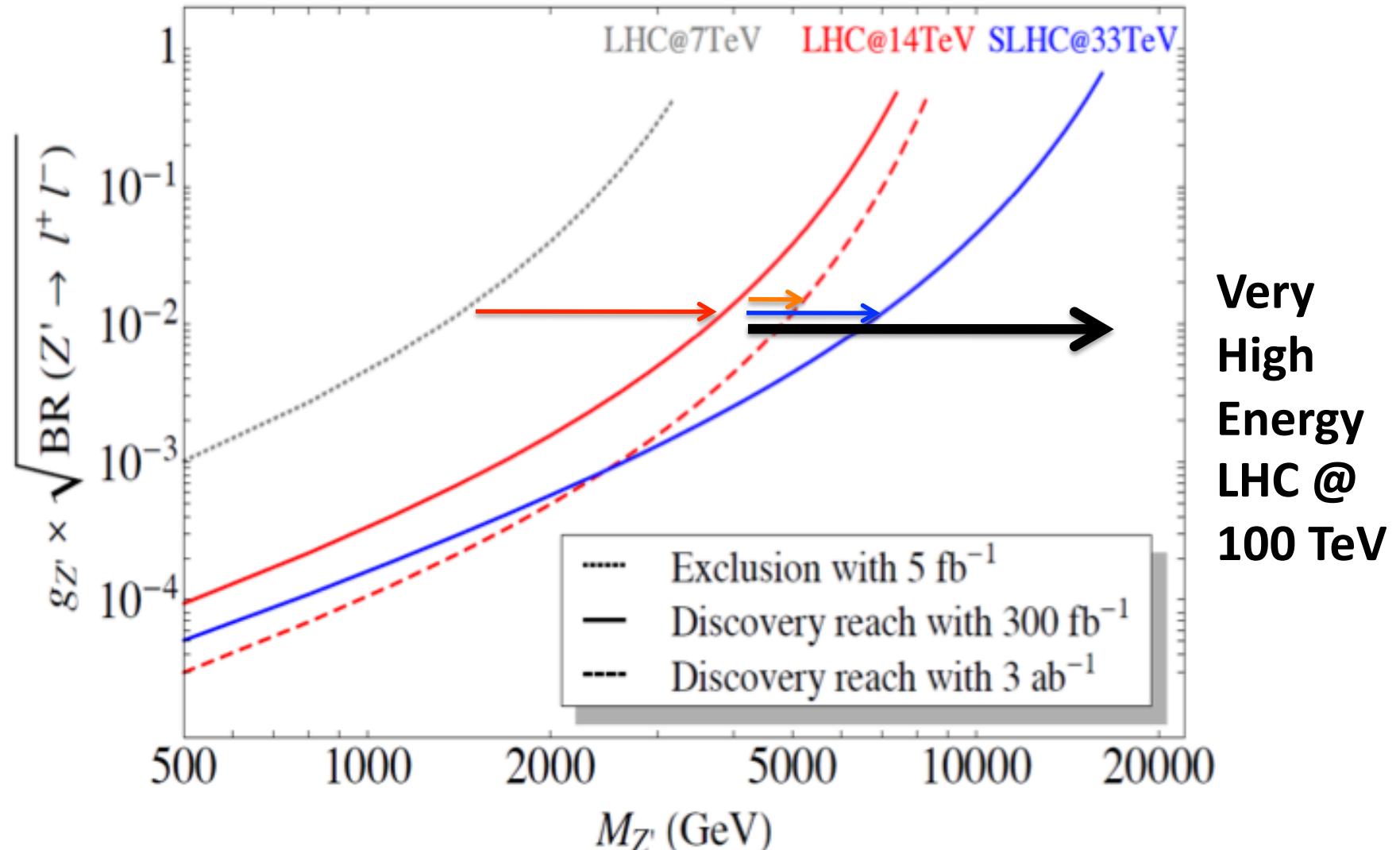
# Direct searches at LHC: no exotism yet



Caveat: non exhaustive, model dependent

# Direct searches at LHC: Future

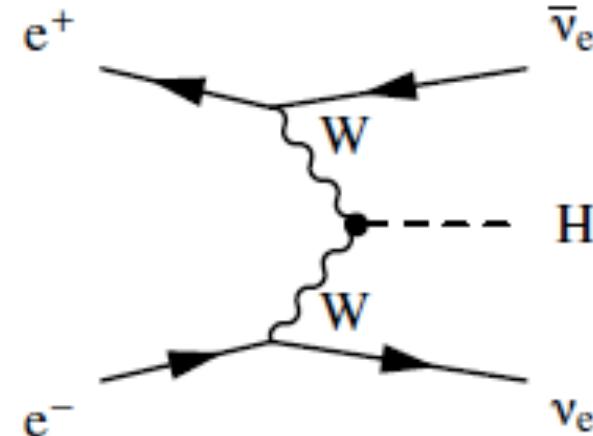
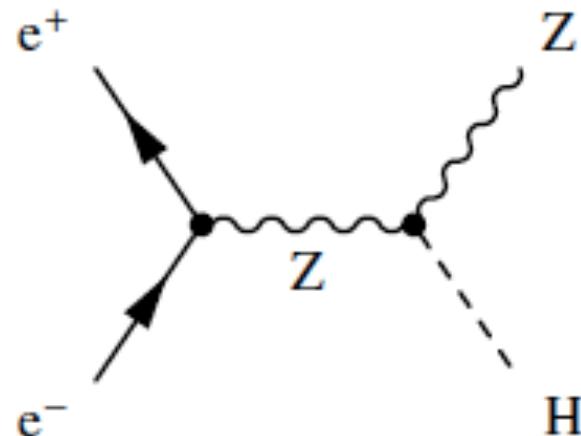
ref. in J. Alcaraz' talk, LHC France 2013



- LHC 300  $\text{fb}^{-1}$  @ 13 TeV can discover new particles with  $m \sim \text{few TeV}$
- mass range  $\times 2$  wrt LHC 5  $\text{fb}^{-1}$  @ 7 TeV
- HL LHC 3000  $\text{fb}^{-1}$  won't help
- SLHC extends the range to several TeV
- **What about higher vs?**

# Goal of an e+e- collider

- Indirect search for new physics through precise measurements involving known particles:
  - Higgs boson
  - W and Z boson
  - top quarkrequires large luminosity
- Discover & study new particles requires large energy (1 TeV is not enough)



# What precision on Higgs couplings?

- Example : Precision for Higgs couplings
  - Maximal deviations with respect to SM couplings, as a function of new physics scale
    - SUSY  $\frac{g_{hbb}}{g_{h_{\text{SM}}bb}} = \frac{g_{h\tau\tau}}{g_{h_{\text{SM}}\tau\tau}} \simeq 1 + 1.7\% \left(\frac{1 \text{ TeV}}{m_A}\right)^2$  for  $\tan\beta = 5$  H. Baer, M. Peskin et al.
    - Composite Higgs  $\frac{g_{hff}}{g_{h_{\text{SM}}ff}} \simeq \frac{g_{hVV}}{g_{h_{\text{SM}}VV}} \simeq 1 - 3\% \left(\frac{1 \text{ TeV}}{f}\right)^2$
    - Top partners  $\frac{g_{hgg}}{g_{h_{\text{SM}}gg}} \simeq 1 + 2.9\% \left(\frac{1 \text{ TeV}}{m_T}\right)^2, \quad \frac{g_{h\gamma\gamma}}{g_{h_{\text{SM}}\gamma\gamma}} \simeq 1 - 0.8\% \left(\frac{1 \text{ TeV}}{m_T}\right)^2$
  - Other models may give up to 5% deviations with respect to the Standard Model
  - Maximal deviations for the new physics scale still allowed by LHC results

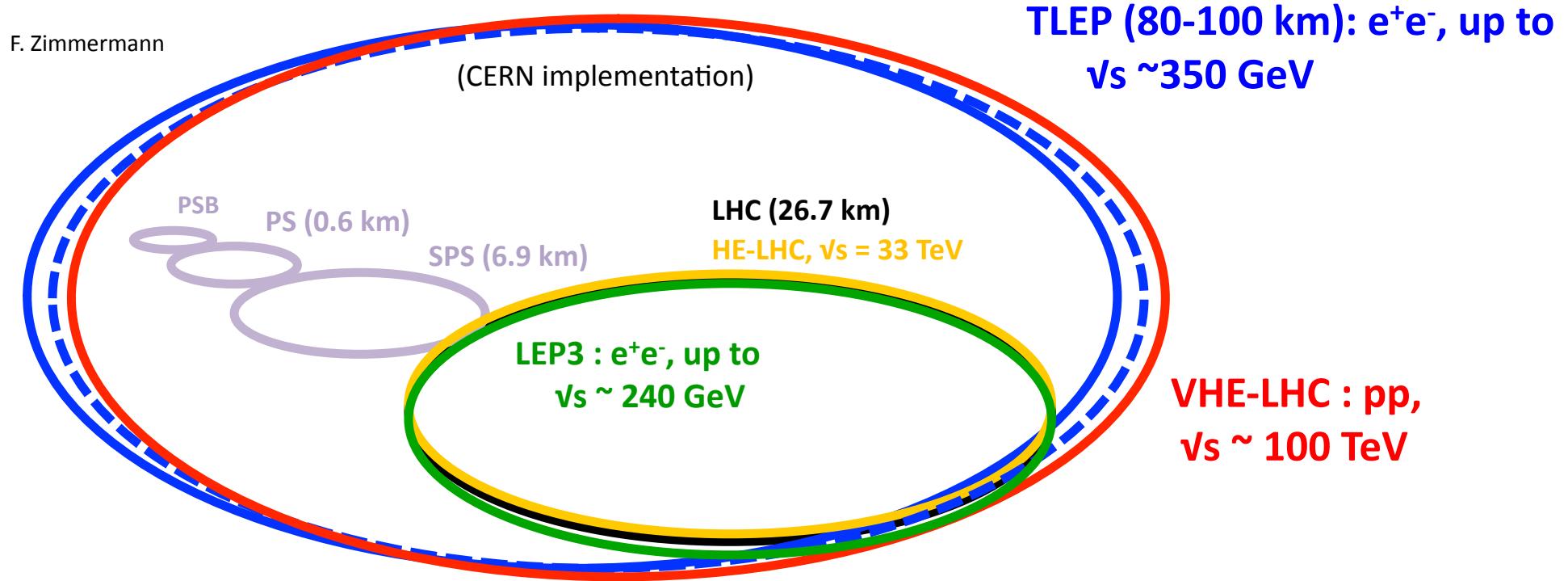
	$\Delta hVV$	$\Delta h\bar{t}t$	$\Delta hbb$
Mixed-in Singlet	6%	6%	6%
Composite Higgs	8%	tens of %	tens of %
Minimal Supersymmetry	< 1%	3%	10% <sup>a</sup> , 100% <sup>b</sup>

J.D. Wells et al.

- Strongly influences the strategy for Higgs factory projects
  - Need at least a per-cent precision on couplings for a  $5\sigma$  “observation”
    - And **sub-percent precision** if new physics is at the (multi-)TeV scale

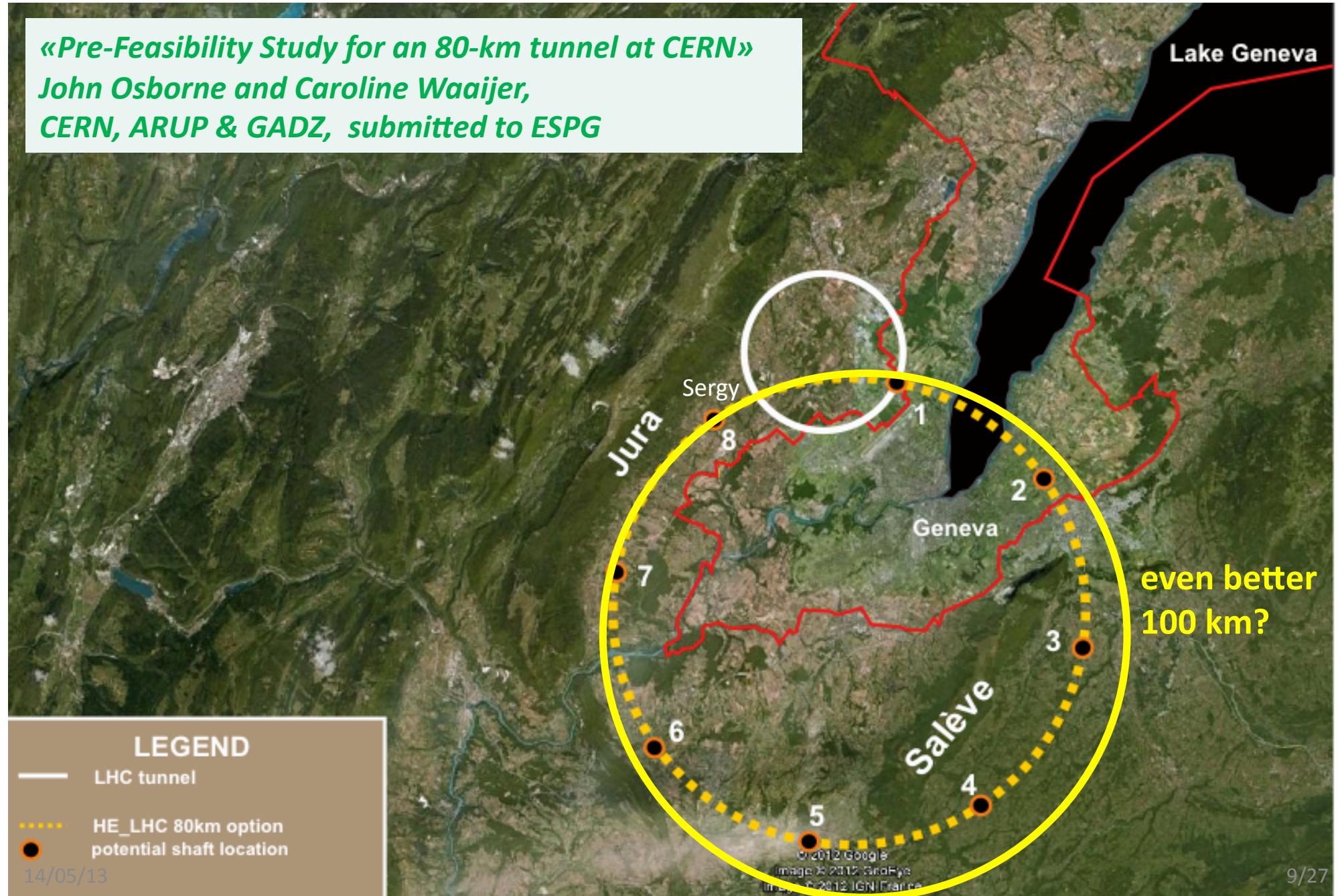
# The solution : TLEP + VHE-LHC

(Worst case solution : LEP3+HE-LHC)

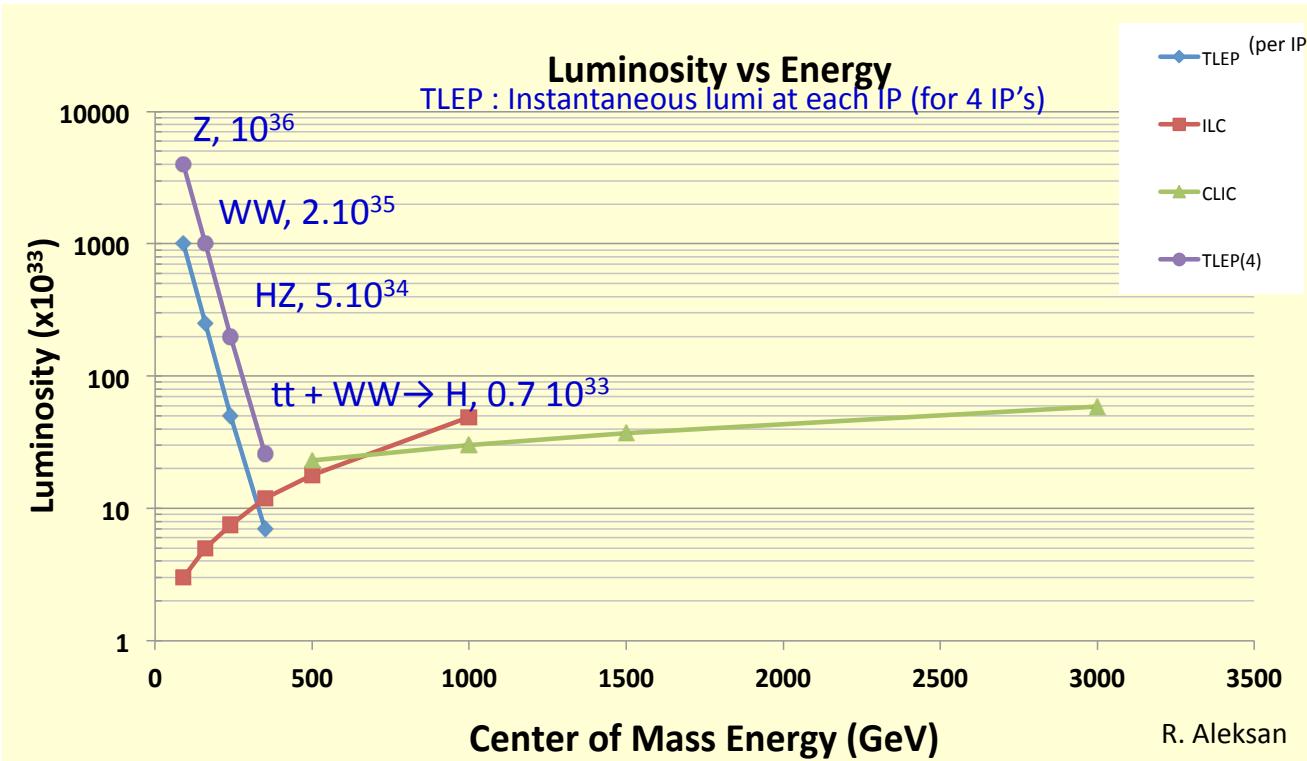


- **TLEP Physics case : Precision measurements sensitive to multi-TeV New Physics**
  - TeraZ ( $\sqrt{s} \sim m_Z$ ), MegaW ( $\sqrt{s} \sim 2m_W$ ), Higgs Factory ( $\sqrt{s} \sim 240$  GeV), top ( $\sqrt{s} \sim 350$  GeV)
- **Followed by VHE-LHC : Direct search for New Physics in the 10-100 TeV range**
  - $\sqrt{s} \sim 100$  TeV with 20T magnets
  - Also allows the HHH coupling to be measured to a few %

# 80-km tunnel in Geneva area – “best” option



# Luminosity at e+e- colliders



LHeC-inspired  
optics/parameter

$\nu_s$ (GeV)	# Bunches
91	2625
240	80
350	12

Circular collider:

- Can use more than one detector at the same time (here 4)
- Luminosity increases when  $\nu_s$  decreases
  - because saved RF power is used to collide more bunches when synchrotron radiation decreases ( $1/E^4$ )
- Ultimate precision measurements
  - Crossing point with linear colliders  $\sim 400$  GeV
    - Luminosity upgrade ( $\times 3$ ) now envisioned at ILC : luminosity is the key !

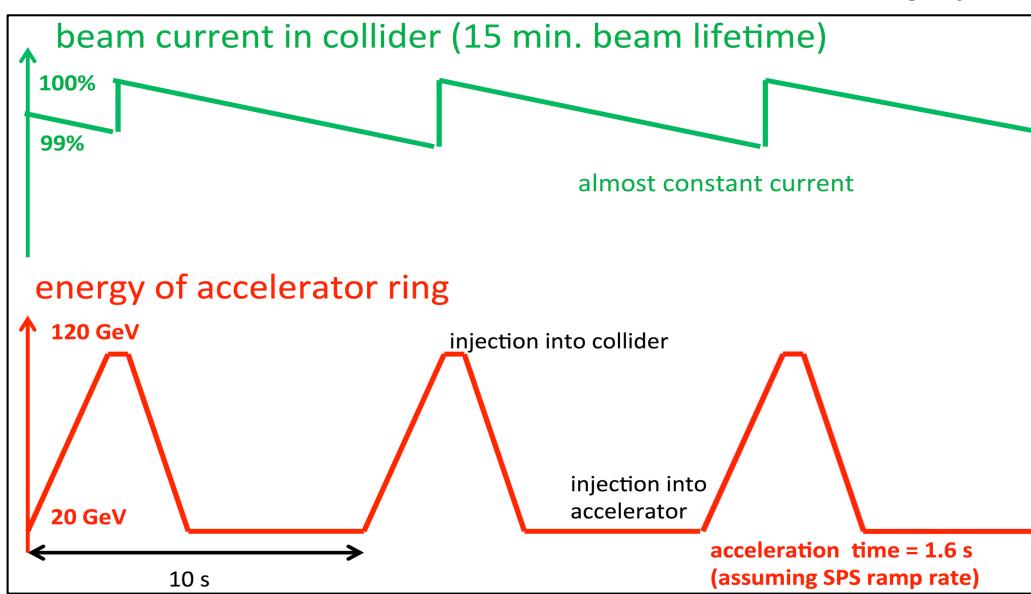
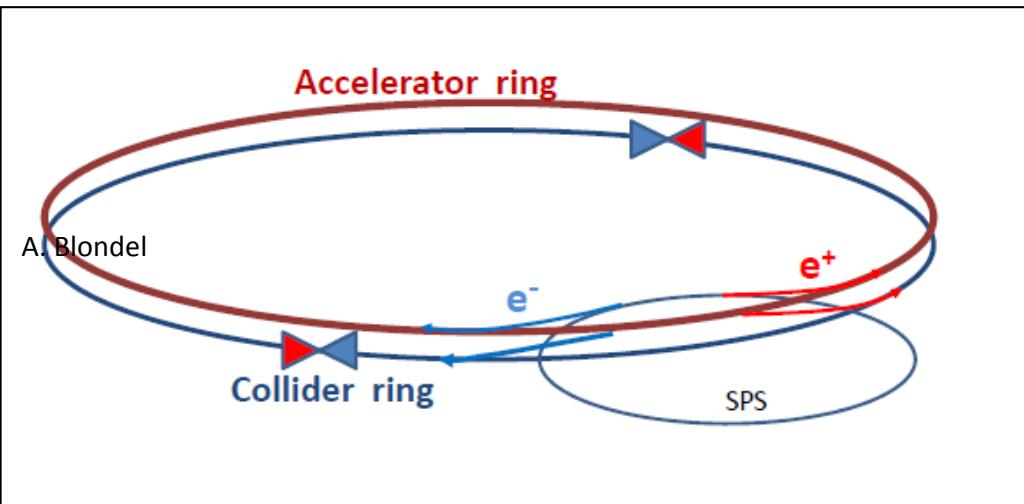
# Luminosity at TLEP: beam size & Beamstrahlung

- Luminosity achieved by reducing the vertical  $\beta^*$ 
  - From 5 cm (LEP2) to  $\sim 1$  mm (TLEP)
    - Note : 0.3 mm soon to be realized at SuperKEKB
  - Vertical beam size  $\sigma_y \sim 200$  nm
    - Note : 1 to 5 nm for Linear Colliders
- $\sigma_y$  not too small  $\rightarrow$  negligible Beamstrahlung (BS) for Physics
  - beam energy well known  $\rightarrow$  can use energy conservation

	TLEP-H (240)	TLEP-t (250)	ILC (250)	ILC (350)
beam energy [GeV]	120	175	125	175
number of BS $\gamma$ /collision	0.50	0.51	1.17	1.24
mean energy lost / collision [MeV]	42	61	1265	2670
RMS energy lost / collision [MeV]	65	95	1338	2760

F. Zimmermann

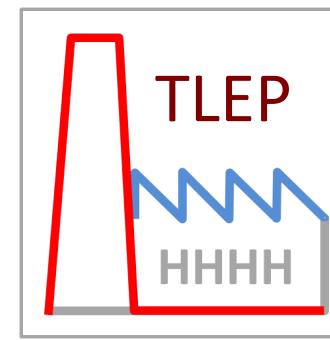
# Luminosity at TLEP: Top-up injection



- At these luminosities, beam lifetime  $\sim 15$  minutes (Bhabha)

- Solution : double ring and continuous top-up injection, as at PEP-II

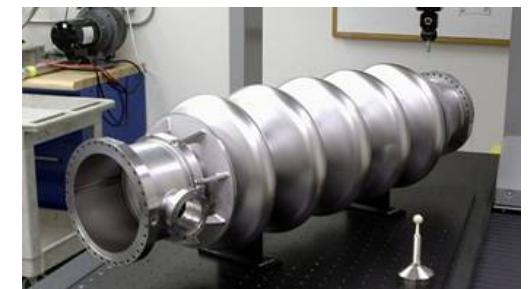
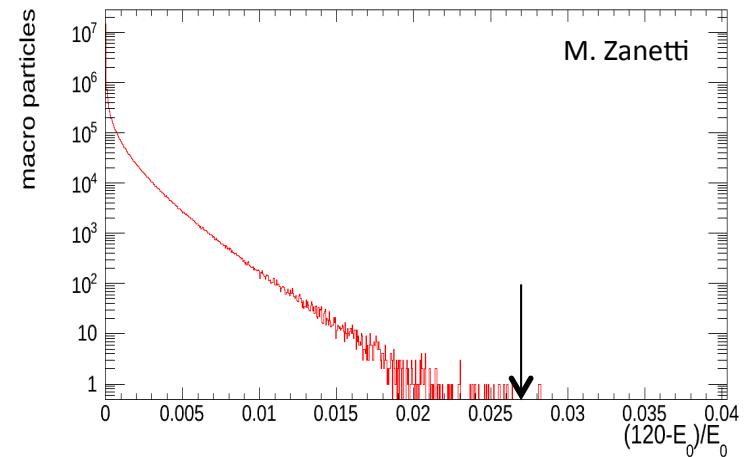
- Note : Soon to be realized at Super-KEKB, beam lifetime  $\sim 5$  minutes



First logo proposal  
M. Koratzinos  
Contest open!

# Challenges (a subset)

- Beamstrahlung
  - Radiating  $e^\pm$  pushed outside the acceptance
    - Reduces the beam lifetime significantly
  - Need to design an achromatic optics at the IPs
    - with 2-3% momentum acceptance
- Efficient RF system
  - Need 12 GeV/turn at 350 GeV
    - ~900 m of SC RF cavities @ 20 MV/m
      - LEP2 had 850 m at 7 MV/m
    - Very high power : up to 200 kW / cavity in the collider ring
      - Power couplers similar to ESS – 700-800 MHz preferred
- Small vertical emittance
  - Can/should further reduce beamstrahlung by minimizing  $\sigma_y/\sigma_x$ 
    - Aim is to reach 0.1% (LEP2 had 2%, SuperKEKB plans 0.2%)



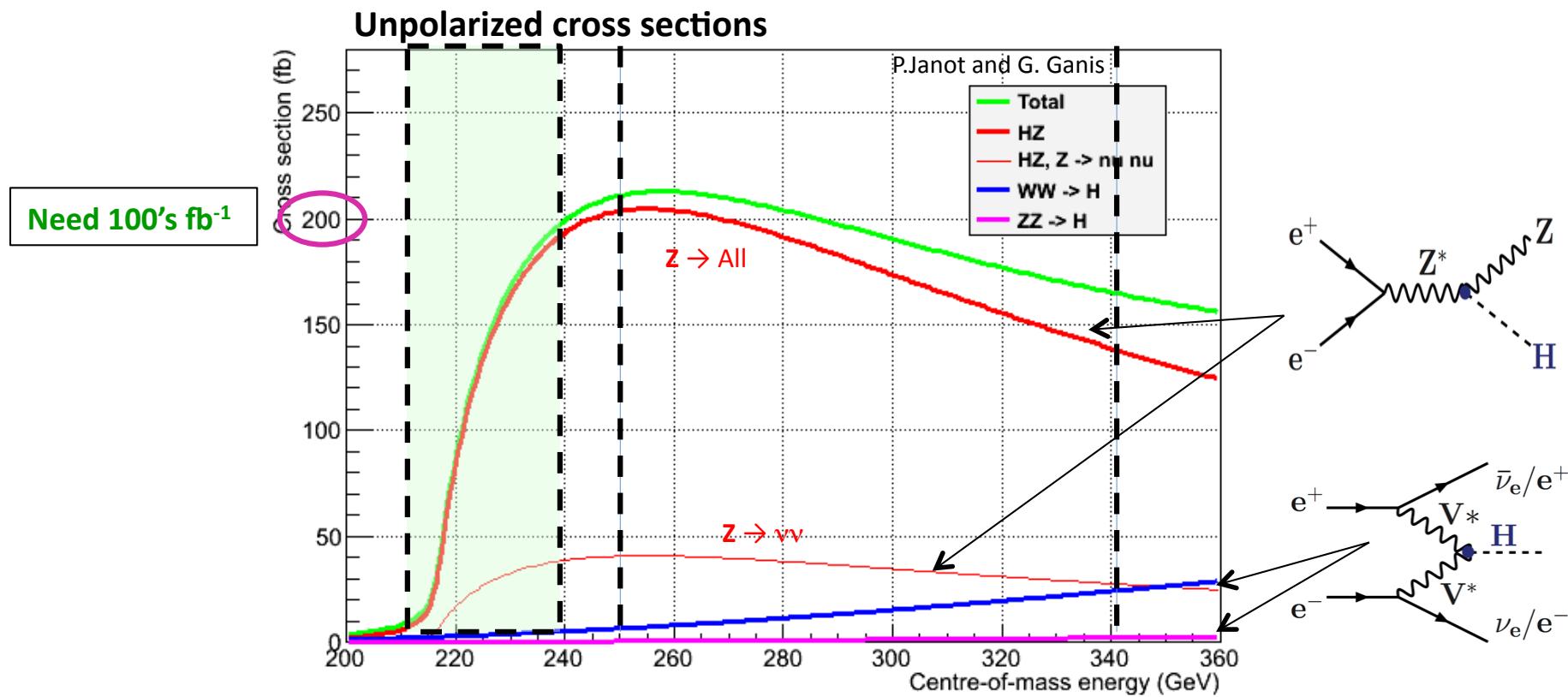
BNL 5-cell 700 MHz cavity



RF Coupler  
(ESS/SPL)

# TLEP as a Higgs factory (1)

- Physics case not driven by the fact that the collider is linear or circular
  - Scan of HZ threshold :  $\sqrt{s} = 210\text{-}240 \text{ GeV}$  Spin
  - Max of HZ cross section :  $\sqrt{s} = 240\text{-}250 \text{ GeV}$  Mass,  $\sigma_{HZ}$ , BRs, Width, Decays
  - Just below  $t\bar{t}$  threshold :  $\sqrt{s} \sim 340\text{-}350 \text{ GeV}$  Width



# TLEP as a Higgs factory (2)

	ILC-250	LEP3-240	TLEP-240
Lumi / IP / 5 years	<b>250 fb<sup>-1</sup></b>	<b>500 fb<sup>-1</sup></b>	<b>2.5 ab<sup>-1</sup></b>
# IP	<b>1</b>	<b>4</b>	<b>4</b>
Lumi / 5 years	<b>250 fb<sup>-1</sup></b>	<b>2 ab<sup>-1</sup></b>	<b>10 ab<sup>-1</sup></b>
Beam Polarization	<b>80%, 30%</b>	—	—
L <sub>0.01</sub> (beamstrahlung)	<b>86%</b>	<b>100%</b>	<b>100%</b>
Number of Higgs	<b>70,000</b>	<b>400,000</b>	<b>2,000,000</b>
Upgradeable to	ILC 1TeV CLIC 3 TeV	HE-LHC 33 TeV	VHE-LHC 100 TeV

- Higgs coupling precisions scale like
  - e.g., for  $g_{HZZ}$  : 1.5% for ILC : 0.65% for LEP3 : 0.2% for TLEP
    - Five years of TLEP = 75-150 years of ILC (at 240 GeV)
  - Note : measure total Higgs boson width  $\Gamma_H$ 
    - At 240 GeV : With  $\sigma_{HZ}$  ( $\sim g_{HZZ}^2$ ) and  $\sigma_{HZ} \times \text{BR}(H \rightarrow ZZ)$  ( $\sim g_{HZZ}^4/\Gamma_H$ )
    - At 350 GeV : With  $\sigma_{WW \rightarrow H}$  ( $\sim g_{HWW}^2$ ) and  $\sigma_{HZ} \times \text{BR}(H \rightarrow WW)$  ( $\sim g_{HZZ}^2 g_{HWW}^2/\Gamma_H$ )

# TLEP as a Higgs factory (3)

- A slide from M. Peskin at the 3rd TLEP/LEP3

The 80 km tunnel envisioned for TLEP can also host a hadron collider (**TLHC**). This might well be the future of particle physics in Europe.

I will now discuss the estimates of Higgs measurement capabilities of these machines and the conversion of those estimates to measurement errors on the Higgs couplings.

It will be obvious that - weighting all claims equally - TLEP has the best capabilities. It has the highest luminosity, can plausibly support multiple detectors, and can reach energies well above the Higgs threshold. In the following, I will omit the comparison with TLEP in the figures. The final errors would in any event be tiny on the graphs that I will show. These are given in a table at the end of the lecture.

# TLEP as a Higgs factory (4)

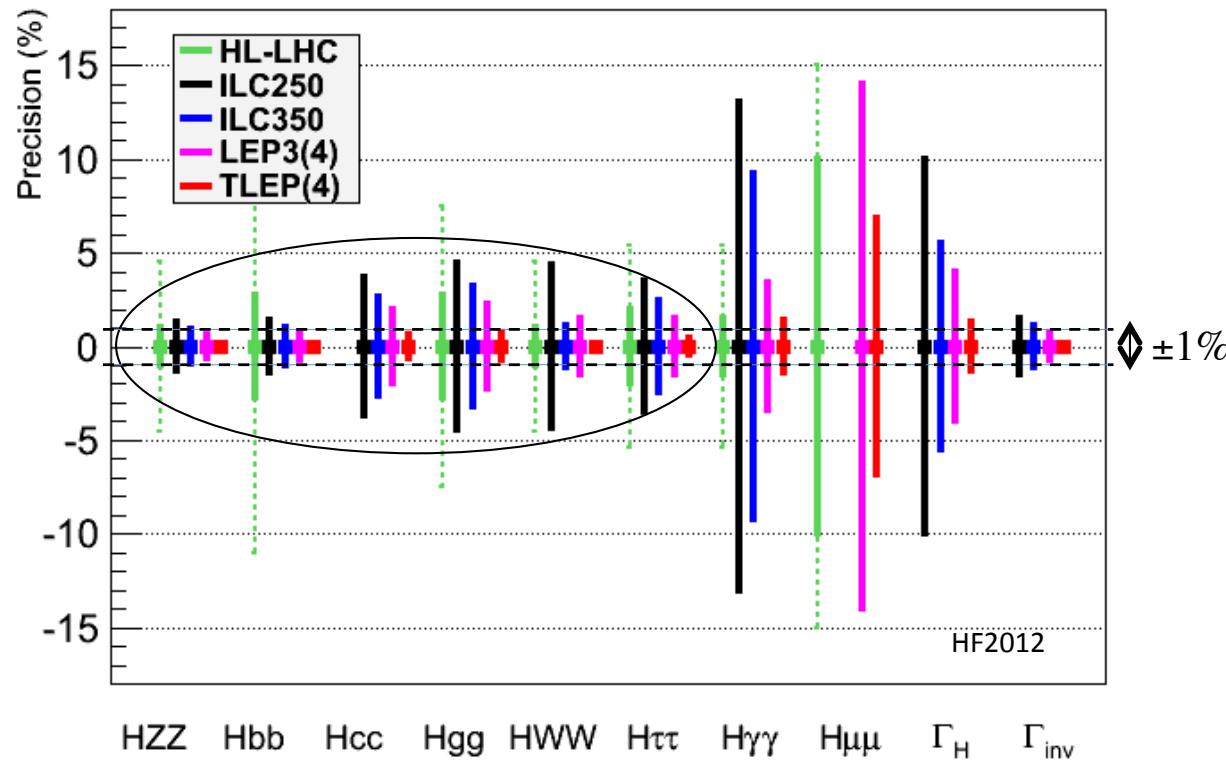
## Summary of the ICFA Higgs Factory Workshop (FNAL, Nov. 2012)

Accelerator →	LHC	HL-LHC	ILC	Full ILC	CLIC	LEP3, 4 IP	TLEP, 4 IP
Physical Quantity ↓	300 $\text{fb}^{-1}$ /expt	3000 $\text{fb}^{-1}$ /expt	250 GeV 250 $\text{fb}^{-1}$ 5 yrs	250+350+ 1000 GeV 5 yrs each	350 GeV (500 $\text{fb}^{-1}$ ) 500 GeV (500 $\text{fb}^{-1}$ ) 1.4 TeV (2 $\text{ab}^{-1}$ ) 5 yrs each	240 GeV 2 $\text{ab}^{-1}$ (*) 5 yrs	240 GeV 10 $\text{ab}^{-1}$ 5 yrs (*) 350 GeV 1.4 $\text{ab}^{-1}$ 3 yrs (*)
$N_H$	$1.7 \times 10^7$	$1.7 \times 10^8$	$6 \times 10^4$ ZH	$10^5$ ZH $1.4 \times 10^5$ Hvv		$4 \times 10^5$ ZH	$2 \times 10^6$ ZH
$m_H$ (MeV)	100	50	35	35	~70	26	7
$\Delta\Gamma_H / \Gamma_H$	--	--	10%	3%	6%	4%	1.3%
$\Delta\Gamma_{\text{inv}} / \Gamma_H$	Indirect (30%?)	Indirect (10%?)	1.5%	1.0%	--	0.35%	0.15%
$\Delta g_{H\gamma\gamma} / g_{H\gamma\gamma}$	6.5 – 5.1%	5.4 – 1.5%	--	5%	N/A	3.4%	1.4%
$\Delta g_{Hgg} / g_{Hgg}$	11 – 5.7%	7.5 – 2.7%	4.5%	2.5%	N/A	2.2%	0.7%
$\Delta g_{Hww} / g_{Hww}$	5.7 – 2.7%	4.5 – 1.0%	4.3%	1%	1%	1.5%	0.25%
$\Delta g_{HZZ} / g_{HZZ}$	5.7 – 2.7%	4.5 – 1.0%	1.3%	1.5%	1%	0.65%	0.2%
$\Delta g_{HHH} / g_{HHH}$	--	< 30% (2 expts)	--	~30%	~20%	--	10%
$\Delta g_{H\mu\mu} / g_{H\mu\mu}$	< 30%	< 10%	--	--	15%	14%	7%
$\Delta g_{H\tau\tau} / g_{H\tau\tau}$	8.5 – 5.1%	5.4 – 2.0%	3.5%	2.5%	3%	1.5%	0.4%
$\Delta g_{Hcc} / g_{Hcc}$	--	--	3.7%	2%	4%	2.0%	0.65%
$\Delta g_{Hbb} / g_{Hbb}$	15 – 6.9%	11 – 2.7%	1.4%	1%	2%	0.7%	0.22%
$\Delta g_{Htt} / g_{Htt}$	14 – 8.7%	8.0 – 3.9%	--	15%	3%	--	< 1%

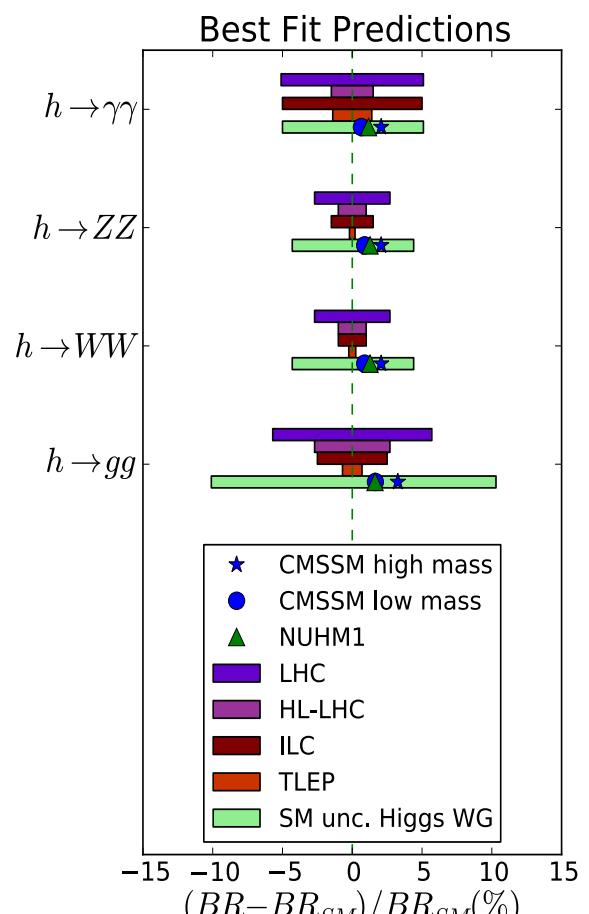
VHE LHC

# TLEP as a Higgs factory (5)

- Need sub-percent precision for a sensitivity to multi-TeV New Physics
  - Compare (LHC), HL-LHC, ILC, (LEP3), TLEP –  $\Gamma_H$  fixed



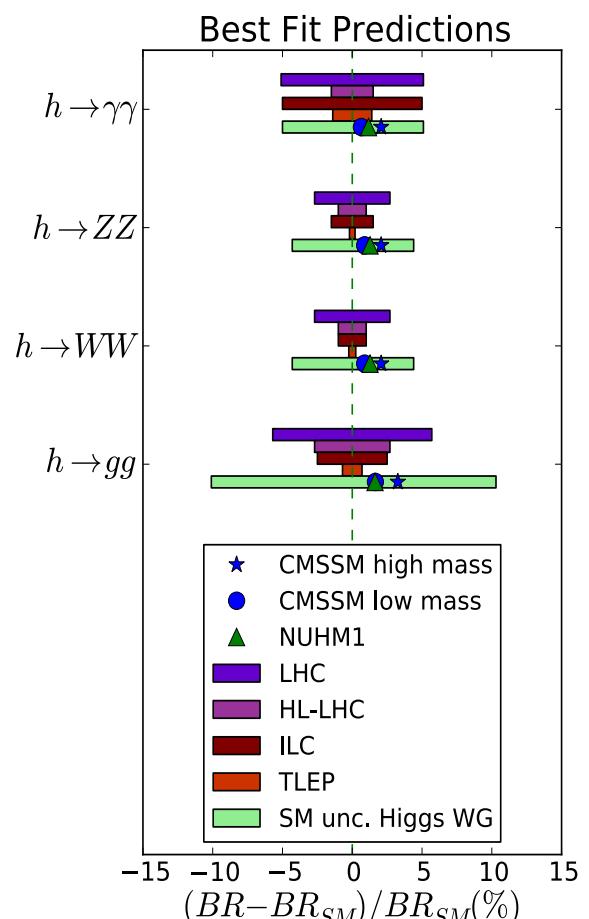
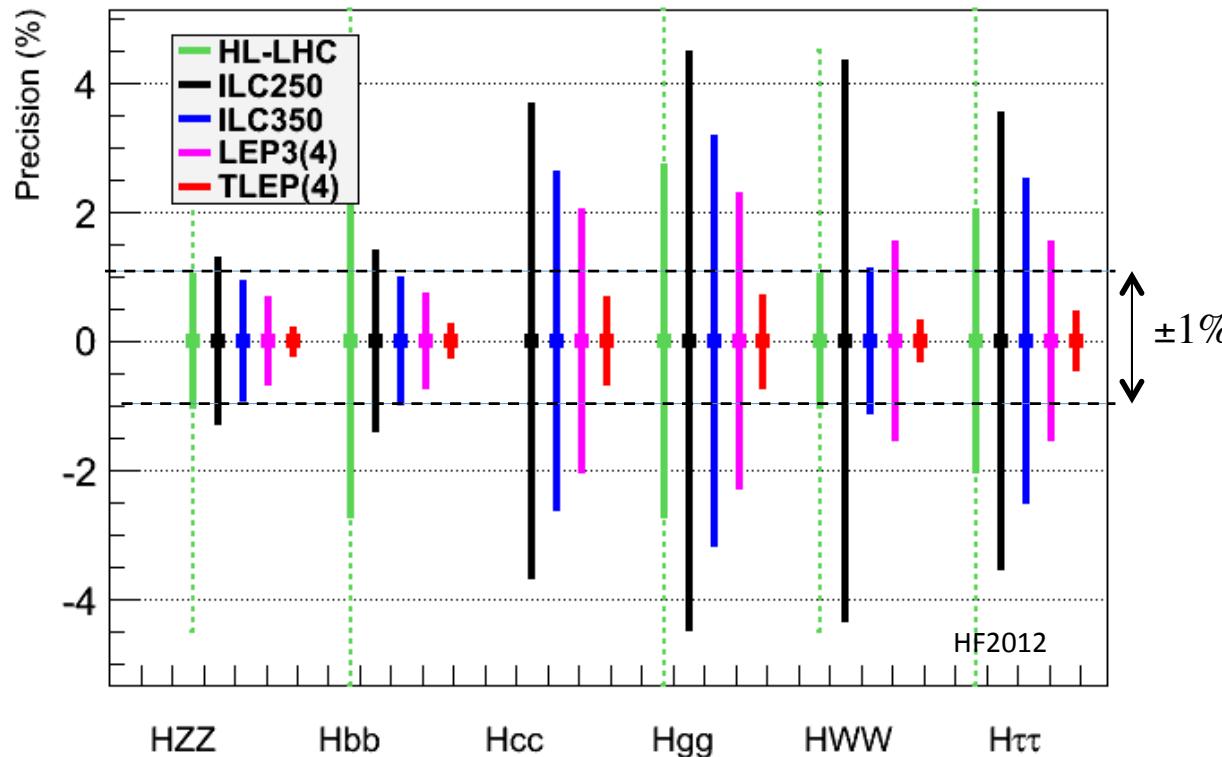
- Summary : TLEP reaches the needed accuracy
  - ILC prospects similar to HL-LHC's
- Much theoretical work also needed



J. Ellis et al.

# TLEP as a Higgs factory (6)

- Need sub-percent precision for a sensitivity to multi-TeV New Physics
  - Compare (LHC), HL-LHC, ILC, (LEP3), TLEP –  $\Gamma_H$  fixed



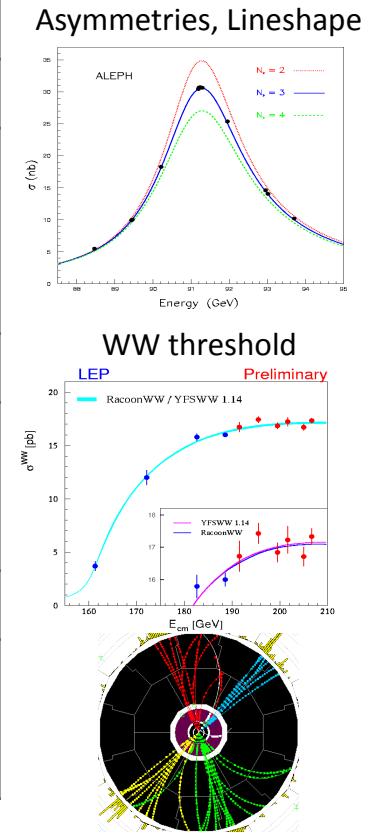
- Summary : TLEP reaches the needed accuracy
  - ILC prospects similar to HL-LHC's
- Much theoretical work also needed

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# Impact of TeraZ and MegaW (1)

- Revisit and improve the LEP precision measurements
  - TLEP can do the entire LEP1 physics programme in 5 minutes

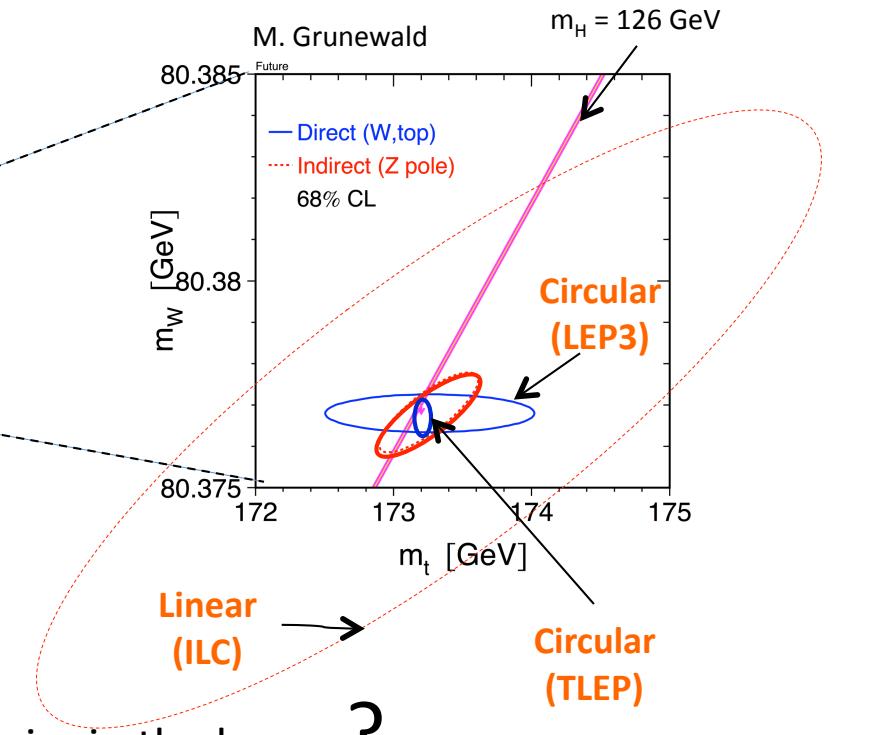
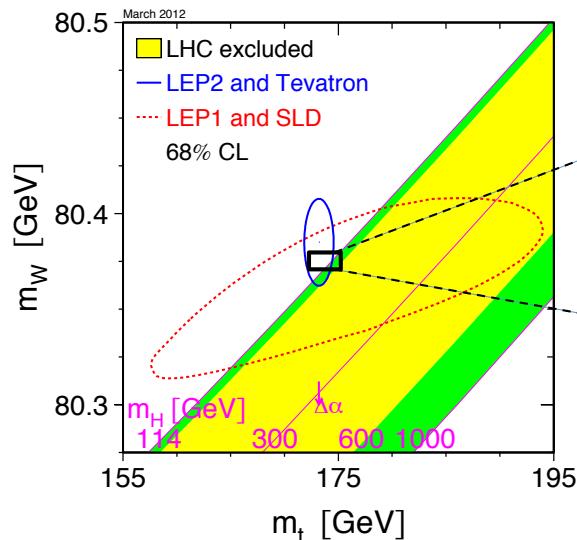
	LEP	ILC	LEP3	TLEP
$\sqrt{s} \sim m_Z$	MegaZ	GigaZ	~TeraZ	TeraZ
Lumi ( $\text{cm}^{-2}\text{s}^{-1}$ ) #Z / year Polarization vs LEP1	Few $10^{31}$ $2 \times 10^7$ no <b>1</b>	Few $10^{33}$ $\text{Few } 10^9$ easy <b>~5-10</b>	Few $10^{35}$ $\text{Few } 10^{11}$ yes (T, L) <b>~50</b>	$10^{36}$ $10^{12}$ yes (T,L) <b>~100</b>
$\sqrt{s} \sim 2m_W$				
Lumi ( $\text{cm}^{-2}\text{s}^{-1}$ ) Lumi / IP / year Error on $m_W$	Few $10^{31}$ $10 \text{ pb}^{-1}$ <b>220 MeV</b>	Few $10^{33}$ $50 \text{ fb}^{-1}$ <b>7 MeV</b>	$5 \times 10^{34}$ $500 \text{ fb}^{-1}$ <b>0.7 MeV</b>	$2.5 \times 10^{35}$ $2.5 \text{ ab}^{-1}$ <b>0.4 MeV</b>
$\sqrt{s} \sim 240 \text{ GeV}$				
Lumi ( $\text{cm}^{-2}\text{s}^{-1}$ ) Lumi / IP / 5 years Error on $m_W$	$10^{32}$ $500 \text{ pb}^{-1}$ <b>33 MeV</b>	$5 \times 10^{33}$ $250 \text{ fb}^{-1}$ <b>3 MeV</b>	$10^{34}$ $500 \text{ fb}^{-1}$ <b>1 MeV</b>	$5 \times 10^{34}$ $2.5 \text{ ab}^{-1}$ <b>0.4 MeV</b>



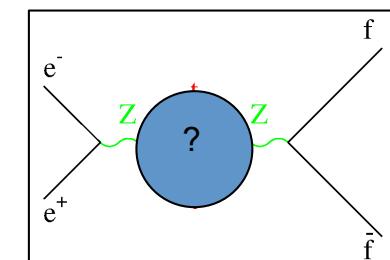
- Important : Polarization up to the WW threshold with TLEP
  - Very precise beam energy determination (10 keV) : unique to circular colliders
    - Measure  $m_Z$ ,  $\Gamma_Z$  to  $< 0.1 \text{ MeV}$ ,  $m_W$  to  $< 1 \text{ MeV}$ ,  $\sin^2\theta_W$  to  $2.10^{-6}$  from  $A_{LR}$

# Impact of TeraZ and MegaW (2)

- Case 1 : Only SM physics in EW Radiative Corrections – Stringent SM Closure test
  - Set stringent limits on weakly interacting new physics ( $m_H$ ,  $m_W$  and  $m_{top}$  known)
    - Much theoretical work also needed



- Case 2 : Some weakly interacting new physics in the loops ?
  - Will cause inconsistency between the various observables
    - Become sensitive to multi-TeV WINP
      - LEP1 was sensitive to  $\sim 200$  GeV ( $m_{top}$ )



# Preliminary cost estimates

- TLEP cost: 7.1 Giga-CHF

Bare tunnel	3.1 <sup>(1)</sup>
Services & Additional infrastructure (electricity, cooling, service cavern, RP, ventilation, access roads ...)	1.0 <sup>(2)</sup>
RF system	2.1 <sup>(3)</sup>
Cryo system	0.2 <sup>(4)</sup>
Vacuum system & RP	0.5 <sup>(5)</sup>
Magnet system for collider & injector ring	0.8 <sup>(6)</sup>
Pre-injector complex SPS reinforcements	0.5
<b>Total</b>	<b>7.1</b>

Note: detector costs not included – can count 0.5 per detector (CMS/ATLAS)

- About 4.5 kCHF / Higgs boson  
(less if tunnel + magnets + cryo are in VHE-LHC price)
- ILC cost (2012 re-evaluation) : 7.8 Giga-\$
  - Many items not included:  
site construction, infrastructure engineering, detectors, coming R&D, ...
  - About 150 k\$ / Higgs boson

(1): J. Osborne, Amrup study

(2): Extrapolation from LEP

(3): B. Rimmer, SRF cost per GeV or per Watt for CEBAF upgrade, 2010

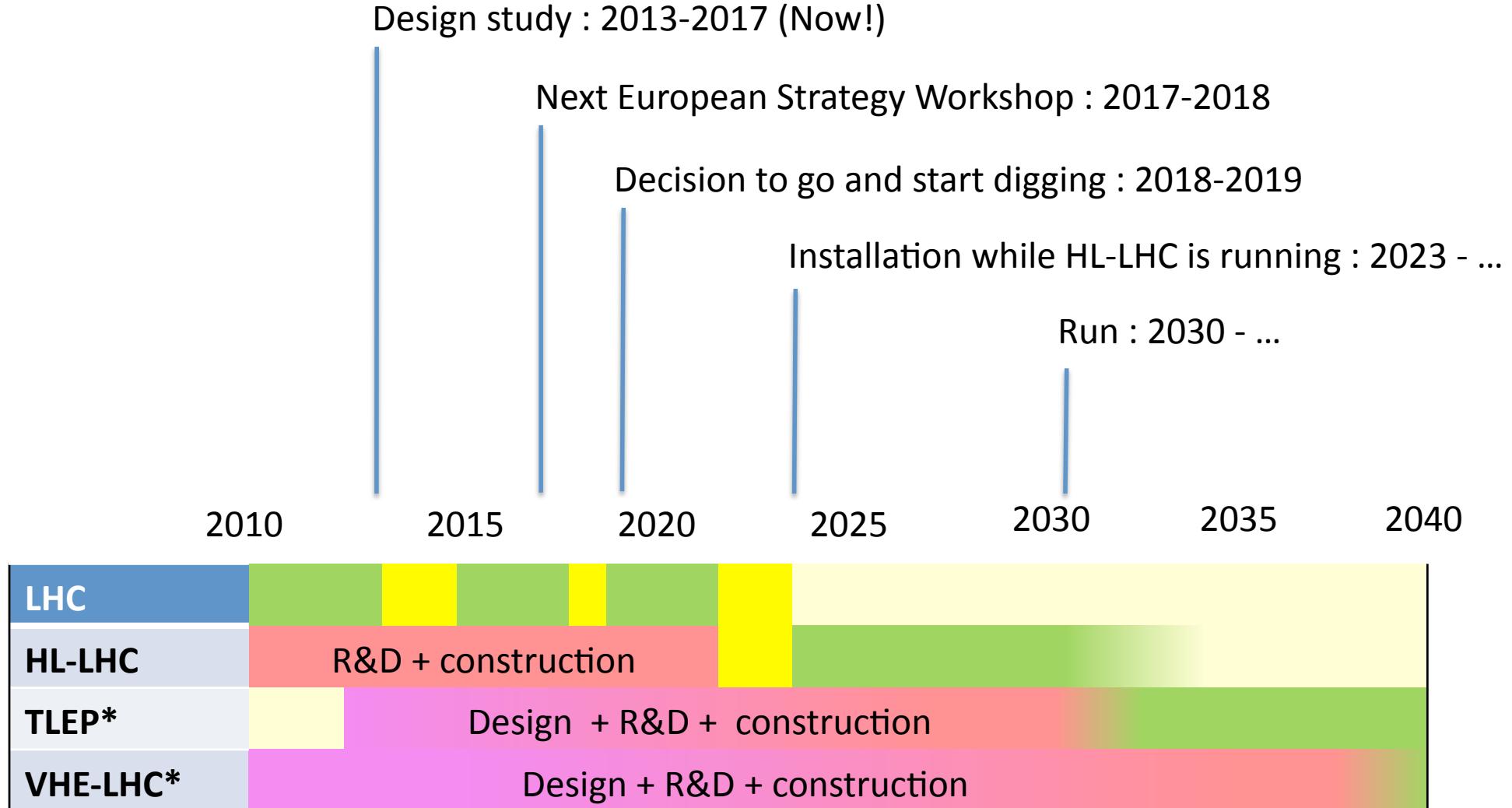
(4): F. Haug, 4<sup>th</sup> TLEP Days, 5 April 2013

(5): K. Oide : factor 2.5 higher than KEK, estimated for 80 km ring

(6): 24,000 magnets for collider & injector;  
cost per magnet 30 kCHF (LHeC);  
10% added; no cost saving from mass production assumed

**preliminary – not endorsed by anybody**

# Possible timescale



# Conclusion

- TLEP (& VHE LHC):
  - best precision, largest discovery reach, cost effective
- The design study is starting:
  - creating the working groups
  - setting up collaborative tools
  - defining the software framework
    - how about ILC/CLIC?
  - first results within 6 months
- To get more information, manifest your interest, or get in the loop:

<http://tlep.web.cern.ch/>

# Backups

# "TLEP RF Power is unacceptable (600 MW?!)"

- RF parameters and total power consumption at 350 GeV

- RF Parameters : TLEP RF ~ LHeC RF

	LHeC	TLEP collider	TLEP inj.
beam energy [GeV]	60	175	175
frequency [MHz]	720 or 800		
total voltage [GV]	20	12	9
av gradient [MV/m]	20	20	20
eff. RF length [km]	1	0.6	0.6
#cavities	1000	600	600
Efficiency (wall→beam)	55%	55%	55%
power throughput [MW]	17	110	10 (peak)
power / cavity [kW]	17	183	17

- F. LeDiberder : 55% should be 17% (like ILC)
    - LEP2 already reached 42%
    - CLIC Drive Beam foresees 55%
    - CEBAF enjoys 55%
- ⇒ Difference between CW and Pulsed

E. Jensen, A. Butterworth, F. Zimmermann, M. Koratzinos

## Total Power Consumption (MW)

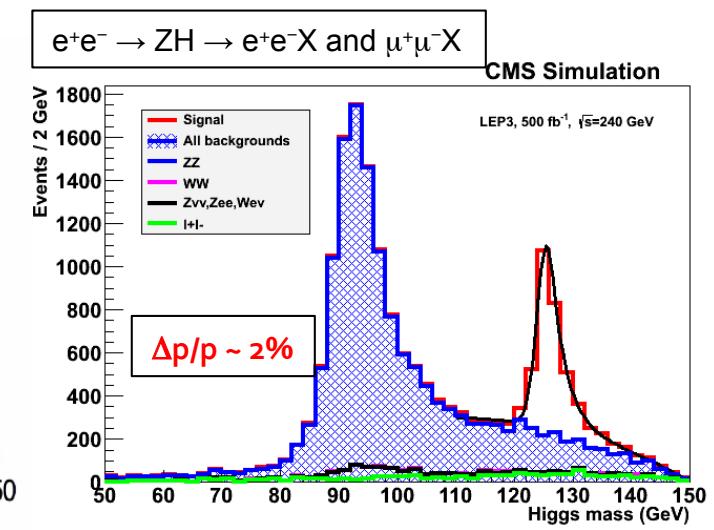
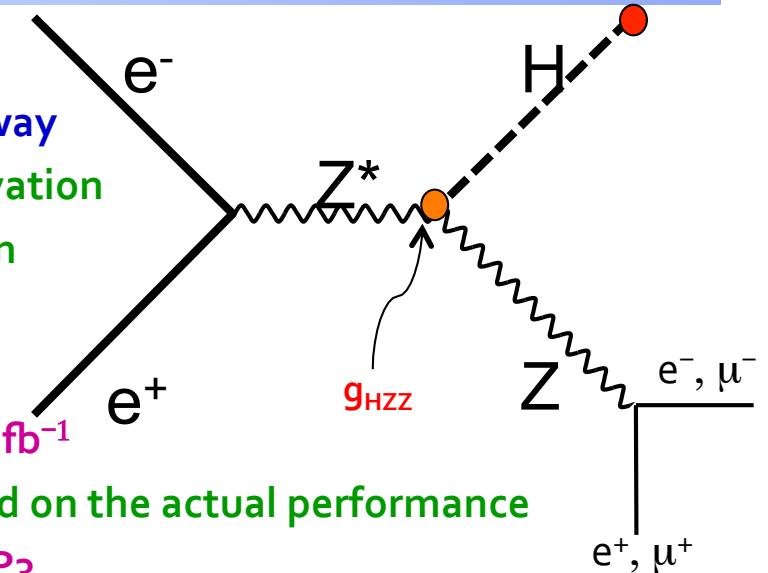
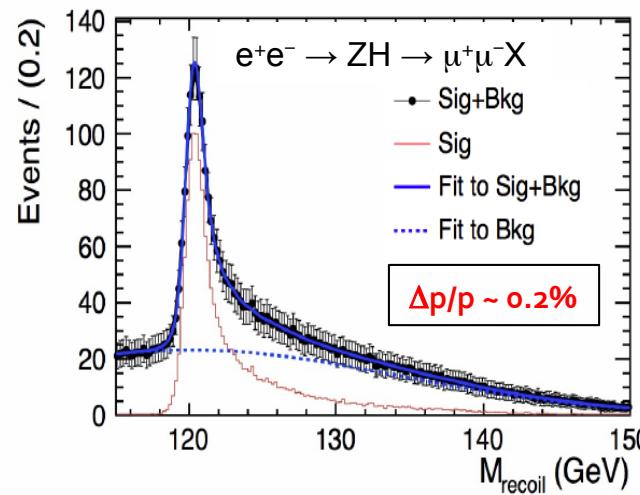
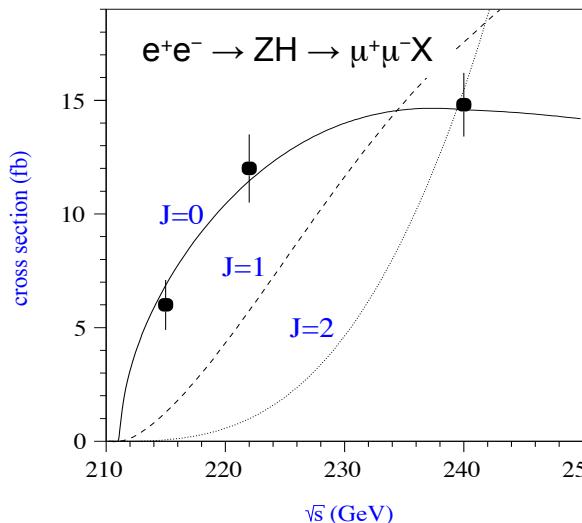
	TLEP
Wall-plug RF power	181
RF cryo power	24
Magnet system power	6
Cooling and ventilation	60
Experiments	25
General services	15
SPS & PS as pre-injectors	5
e-/e+ source & pre-pre-injector	1
<b>Total</b>	<b>318</b>

# Higgs measurements at $\sqrt{s} \sim 240$ GeV (1)

- With  $e^+e^- \rightarrow ZH \rightarrow e^+e^-X$  and  $\mu^+\mu^-X$  events

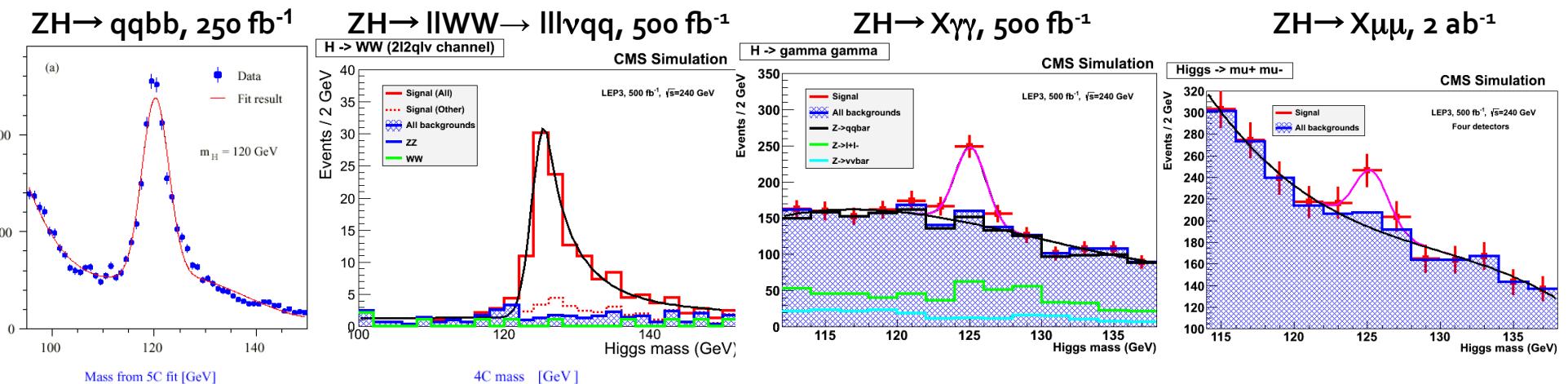
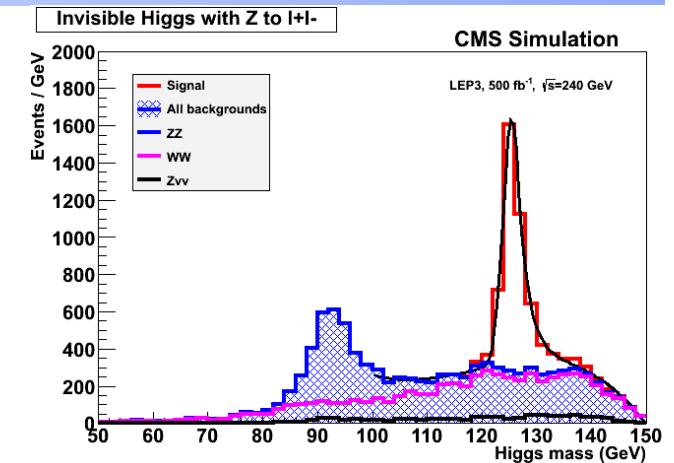
- Measure HZ cross section in a model independent way
  - Find  $m_H$  peak from the leptons and  $E, p$  conservation
  - Determine spin with three-point threshold scan  
→  $10 \text{ fb}^{-1}$  / point suffice
  - Determine  $\sigma_{HZ}$  and  $g_{HZZ}$  coupling at 240 GeV  
→ 3% (1.5%) precision on  $\sigma_{HZ}$  ( $g_{HZZ}$ ) with  $250 \text{ fb}^{-1}$
  - Good tracker needed, but details mildly depend on the actual performance
  - Plots below with ILD@ILC and CMS@LEP3

[9,10,11]



# Higgs measurements at $\sqrt{s} \sim 240$ GeV (2)

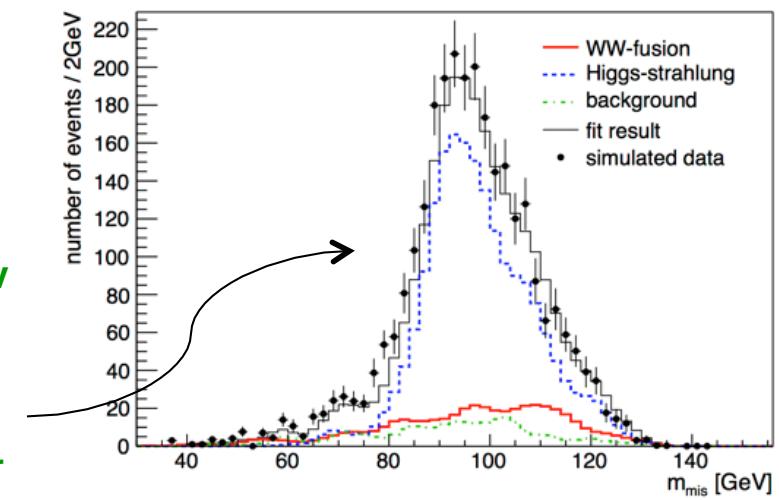
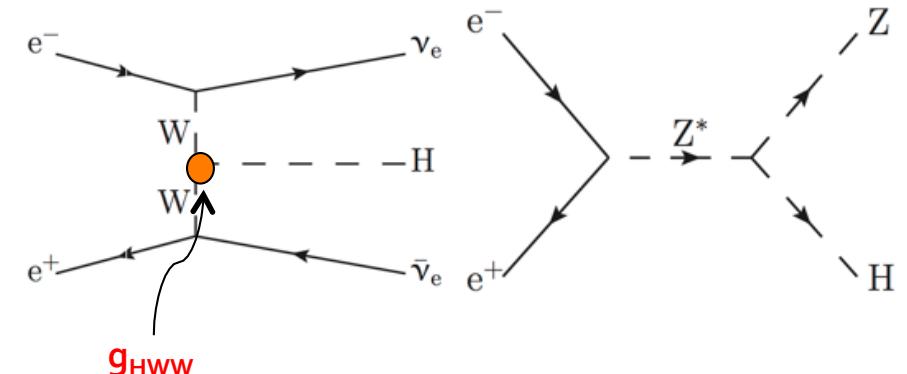
- With  $ZH \rightarrow e^+e^-X$  and  $\mu^+\mu^-X$  events (cont'd)
  - ◆ Measure invisible decay branching ratio ( $X = \text{nothing}$ )
    - Precision on  $\text{BR}_{\text{INV}} \sim 1\%$  with  $250 \text{ fb}^{-1}$
    - Or exclude  $\text{BR}_{\text{INV}} > \sim 2\%$  at 95% C.L.
  
- Measure other  $\sigma_{HZ} \times \text{BR}(H \rightarrow ff, VV)$ 
  - ◆ With exclusive selections of Z and H decays
    - Precision of 1.5% to 8% with  $250 \text{ fb}^{-1}$  for the copious decays ( $bb$ ,  $WW$ ,  $gg$ ,  $\tau\tau$ ,  $cc$ )
    - Need more luminosity for rare decays ( $\gamma\gamma$ ,  $Z\gamma$ ,  $\mu\mu$ )
      - Particle flow, b and c tagging, lepton and photon capabilities needed



# Higgs measurements at $\sqrt{s} \sim 240$ GeV (3)

- Higgs width from the  $H\nu\nu$  final state

- ◆ From  $\sigma_{WW \rightarrow H}$  and  $BR(H \rightarrow WW)$ 
  - $\sigma_{WW \rightarrow H} \sim g_{HWW}^2$
  - $BR(H \rightarrow WW) = \Gamma_{H \rightarrow WW} / \Gamma_H \sim g_{HWW}^2 / \Gamma_H$   
 $\Rightarrow \Gamma_H \sim \sigma_{WW \rightarrow H} / BR(H \rightarrow WW)$
- ◆ Contribution to  $H\nu\nu$  from  $HZ \sim 40$  pb
  - Known from  $ZH \rightarrow e^+e^-X$  and  $\mu^+\mu^-X$
- ◆ Contribution from WW fusion  $\sim 6$  pb
  - To be measured
- ◆ Select  $\nu\nu bb$  events from  $ZH$  and WW fusion
  - Needs adequate b tagging and particle flow
- ◆ Fit the missing mass distribution for  $N_{WW \rightarrow H \rightarrow bb}$ 
  - $\sigma_{HZ} \times BR(H \rightarrow bb)$  known to  $\sim 1.5\%$  or better
  - $\sigma_{WW \rightarrow H} = N_{WW \rightarrow H \rightarrow bb} / BR(H \rightarrow bb)$ 
    - ⇒ Precision on  $\sigma_{WW \rightarrow H} \sim 14\%$  with  $250 \text{ fb}^{-1}$
    - ⇒  $\Gamma_H \sim \sigma_{WW \rightarrow H} / BR(H \rightarrow WW)$ , measured up to  $15\%$  precision with  $250 \text{ fb}^{-1}$

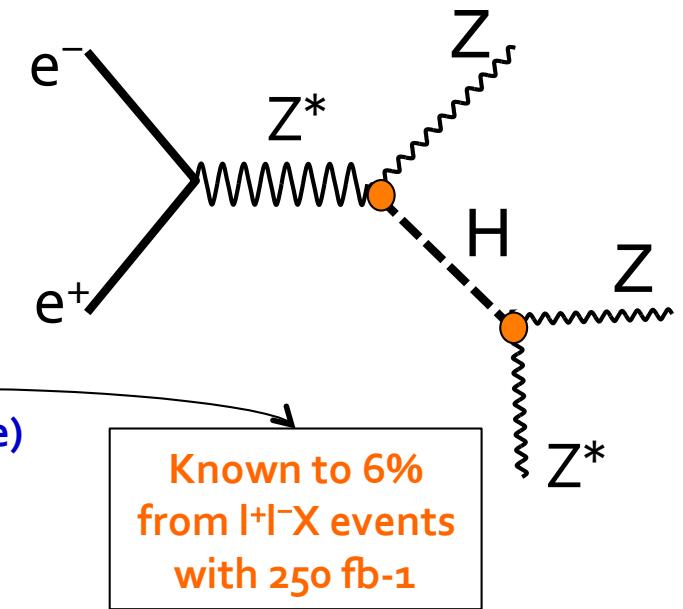


[17]

# Higgs measurements at $\sqrt{s} \sim 240$ GeV (4)

- Higgs width from the ZZZ final state

- ◆ Number of ZZZ events  $\sim \sigma_{HZ} \times BR(H \rightarrow ZZ)$ 
  - $\sigma_{HZ} \sim g^2_{HZZ}$
  - $BR(H \rightarrow ZZ) = \Gamma_{H \rightarrow ZZ} / \Gamma_H \sim g^2_{HZZ} / \Gamma_H$ 
    - ⇒ Number of ZZZ events  $\sim (g^4_{HZZ}) / \Gamma_H$



- ◆ Select  $l^+l^- l'^+l'^-$   $X$  events (~ background and  $H \rightarrow WW$  free)

- Number of events in  $250 \text{ fb}^{-1}$  @ 240 GeV :
  - ⇒  $250 \text{ fb}^{-1} \times 200 \text{ fb} \times BR(H \rightarrow ZZ) \times BR(Z \rightarrow ll)^2 \times 3$
  - About 40 events, of which ~25 selected

- ◆ Hence measure the total width  $\Gamma_H$  with a precision of 21%

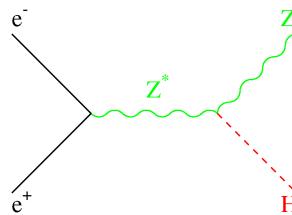
- Reduced to 12% in combination with WW fusion measurement
  - ⇒ Could be further reduced with other  $Z$  decays

(Need full simulation and WW/ZZ simultaneous fit)

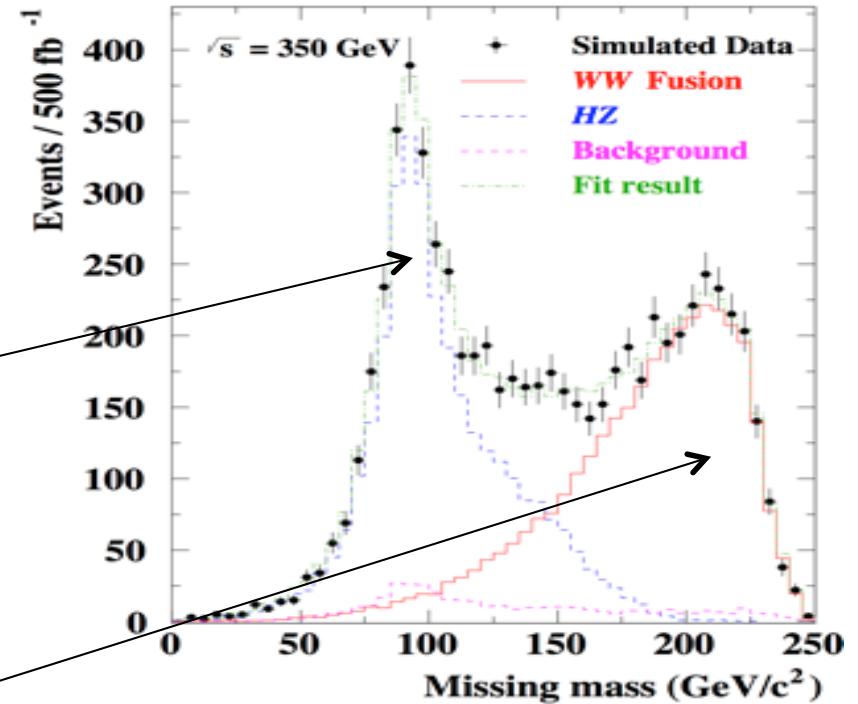
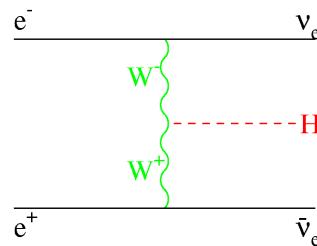
- ◆ Note : Precision of a few % can be reached on  $\Gamma_H$  if one assumes no exotic Higgs decays

# Measurements at $\sqrt{s} \sim 350$ GeV (ILC/TLEP) [1]

- Luminosity similar for ILC and TLEP
  - ◆ At each IP :  $350 \text{ fb}^{-1}$  over 5 years
    - With possibly 4 detectors at TLEP
  - ◆ More study of the  $H\gamma\gamma$  final state with  $H \rightarrow bb$ 
    - Contribution from  $HZ$  :  $\sim 25 \text{ fb}$



- Contribution from  $WW \rightarrow H$  :  $\sim 25 \text{ fb}$



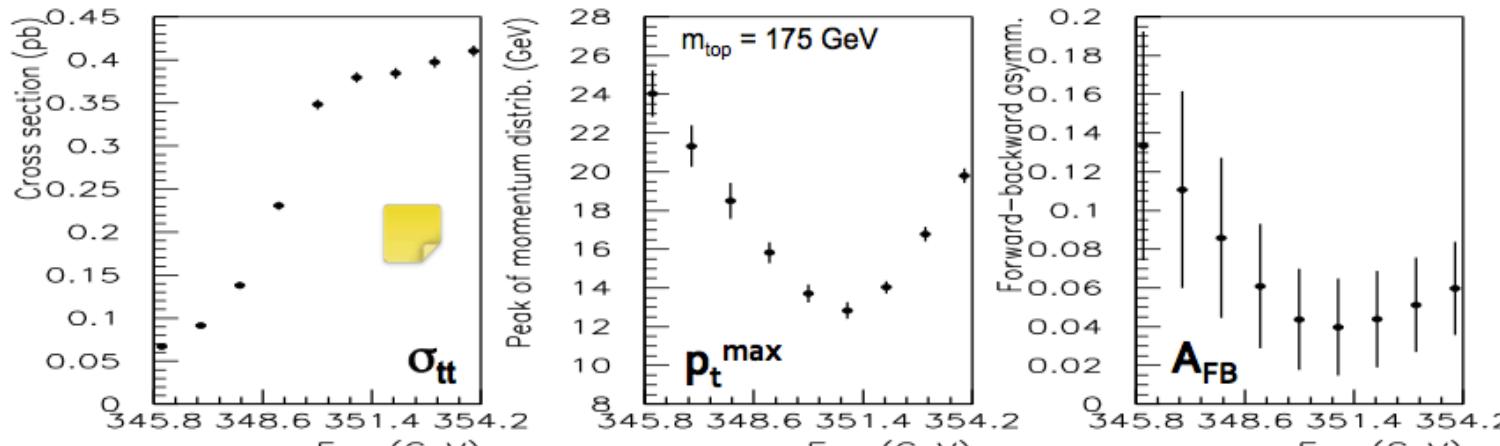
	ILC (250+350)	TLEP (240+350)
$\sigma_{WW \rightarrow H}$	$12\% \rightarrow 4\%$	$2.2\% \rightarrow 1.5\%$
$\Gamma_H$	$10\% \rightarrow 5.5\%$	$1.8\% \rightarrow 1.3\%$

- Improves precision on  $\Gamma_H$  and  $HWW$  coupling
- Smaller improvement of other  $\sigma \times \text{BR}$  measurements

# Top Measurements at $\sqrt{s} \sim 350$ GeV (1)

## □ Scan of the tt threshold

- ◆ Observables  $\sigma_{tt}$ ,  $A_{FB}$  and  $\langle p_t^{\max} \rangle$  sensitive to  $m_{top}$ ,  $\Gamma_{top}$ , and  $\lambda_{top}$  (ttH Yukawa coupling)
  - Experimental precision (for ILC)
    - No beamstrahlung at TLEP is an advantage



- Sensitivity with  $300 \text{ fb}^{-1}$  for ILC (expected to be better for TLEP)

$\Delta m_{top}$	$\Delta \Gamma_{top}$	$\Delta \lambda_{top}/\lambda_{top}$
30 MeV (0.02%)	35 MeV (3%)	30%

- Studies of rare top decays

M. Martinez and R. Miquel, 2003