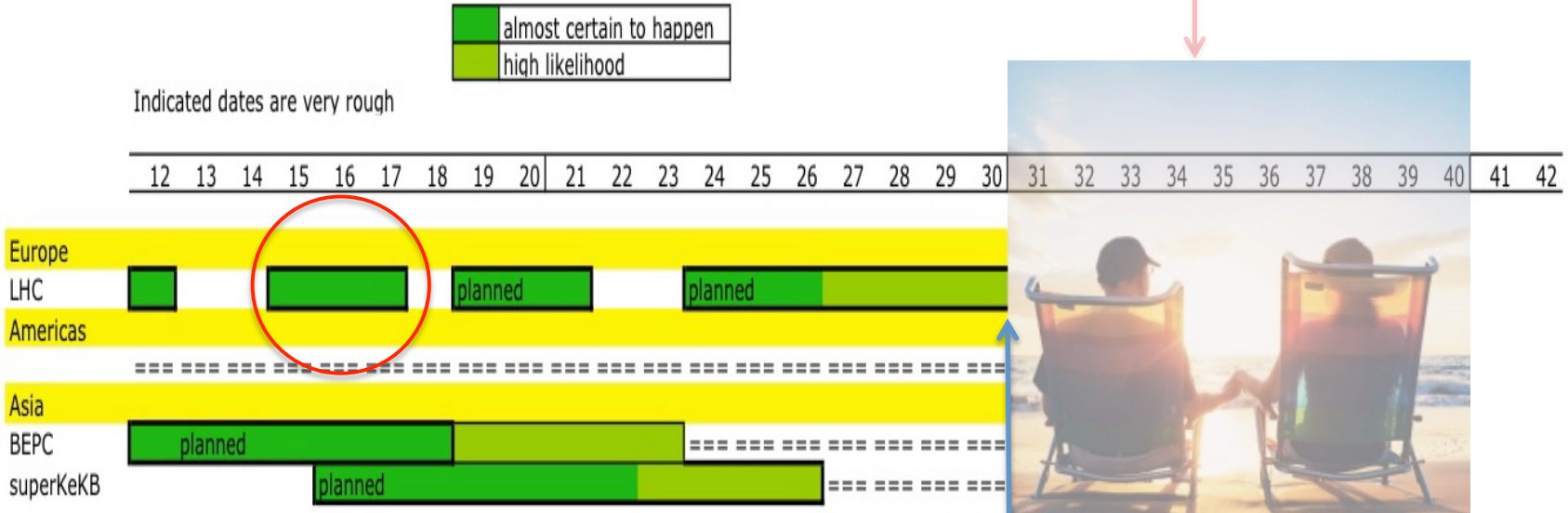

Francois Le Diberder
Clermont-Ferrand, March 2013
A la croisée des chemins (?)

The future must be prepared well in advance

otherwise

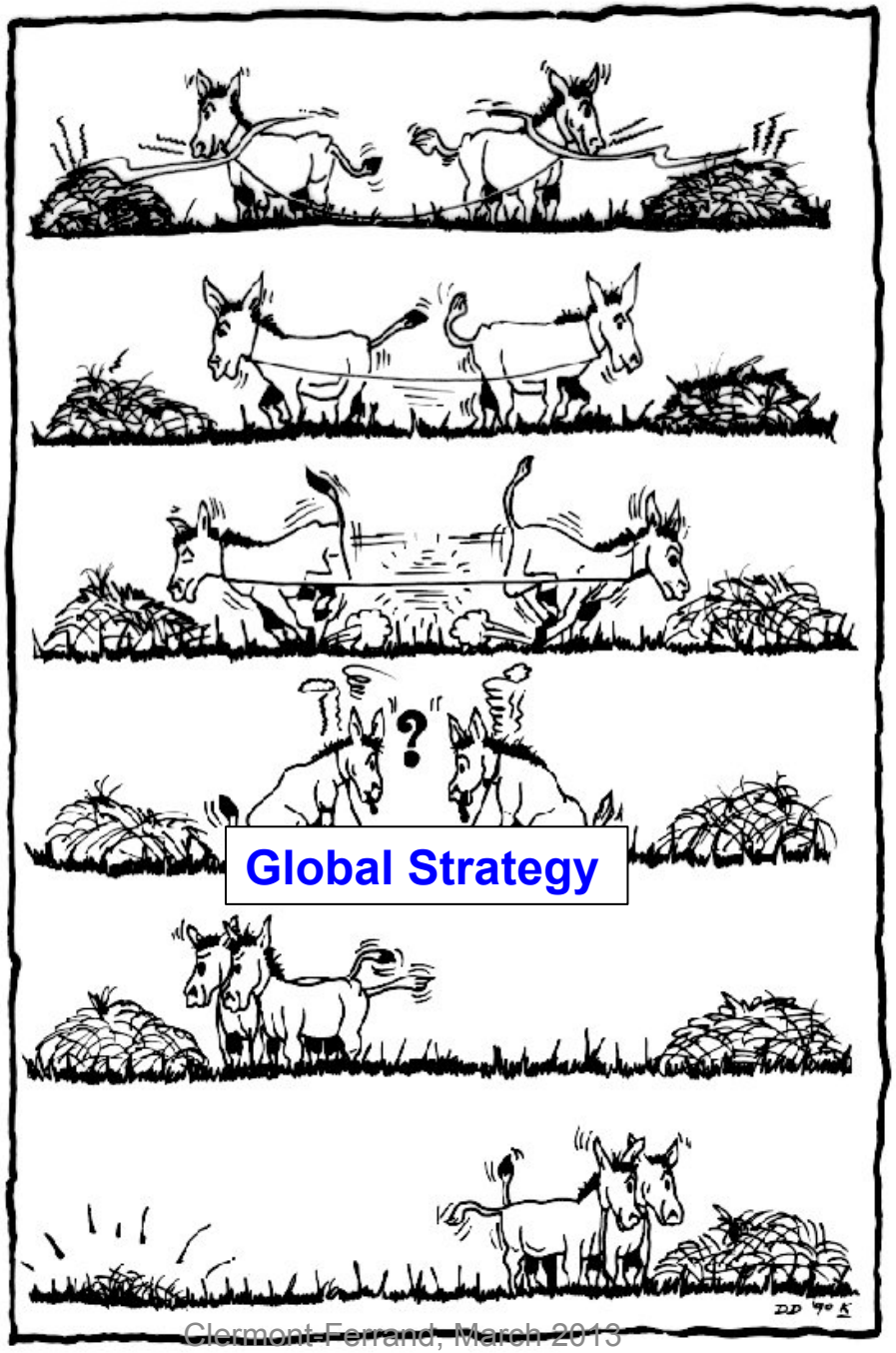
DESY !
SLAC !
FNAL ?

The BIG question for High Energy Frontier



The LHC case (2023++) is crystal clear.
It needs not be discussed (I assume) :
It is at the top of the top of all priorities, Worldwide.

European Strategy
beyond HL-LHC next
CERN based collider to
be pondered in 2018.


?
Global Strategy

And avoid this

European Strategy
(update-1)

High-priority large-scale scientific activities 2

The discovery of the Higgs boson is the start of a major programme of work to measure this particle's properties with the highest possible precision for testing the validity of the Standard Model and to search for further new physics at the energy frontier. The LHC is in a unique position to pursue this programme. *Europe's top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design, by around 2030. This upgrade programme will also provide further exciting opportunities for the study of flavour physics and the quark-gluon plasma*.

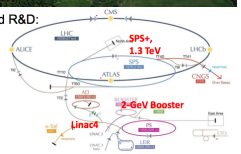
Europe will be pretty busy with the LHC for sometime.

High-priority large-scale scientific activities 3

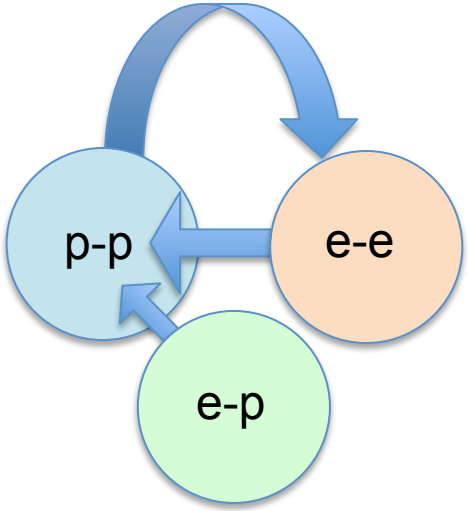
- To stay at the forefront of particle physics, Europe needs to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update, when physics results from the LHC running at 14 TeV will be available. *CERN should undertake design studies for accelerator 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.*

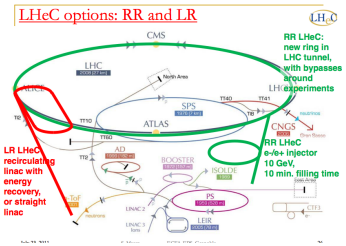
Next large facility in Europe needs physics guidance: the next Strategy update for making a decision: R&D to be ready for the decision

HE-LHC – main Issues and R&D:



- High-field 20T dipole magnets based on Nb_3Sn, Nb_3Al, and HTS
- High-gradient quadrupole magnets for arc and IR
- Fast cycling SC magnets for ~1.3 TeV injector
- Emittance control in regime of strong SR damping and IBS
- Cryogenic handling of SR heat load (first analysis; looks manageable)
- Dynamic vacuum





History tought us that the interplay between
p-p & e-e & e-p colliders is intrumental
in allowing progresses
in our understanding of Physics

Just entering a new world with a potential for many big surprises

We need the right tool

Best–fit Higgs mass m_H :
126.0 ± 0.4 (stat) ± 0.4 (syst) GeV

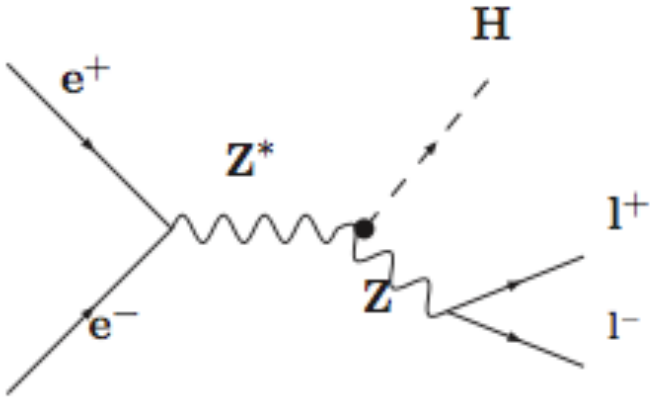
- M=125.8 ±0.4 (stat) ± 0.4 (syst) GeV

We should stay open-minded and filled with intense curiosity:
Exploration of Planet Higgs just began.

- σ/σ_{SM}=0.88±0.21

Physics Case for e+e- Collider (linear or circular)

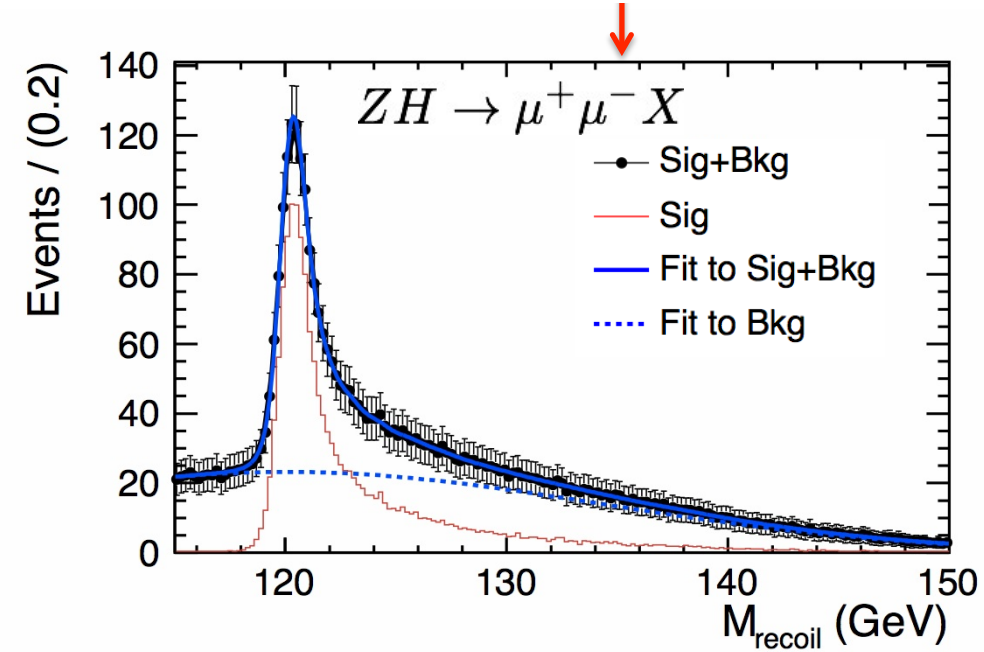
Higgs-strahlung Process:



$$M_H^2 = (\sqrt{s} - E_Z)^2 - P_Z^2$$

$$g_{ZZH}^2 \propto \sigma = N/L\epsilon$$

Allows absolute measurements

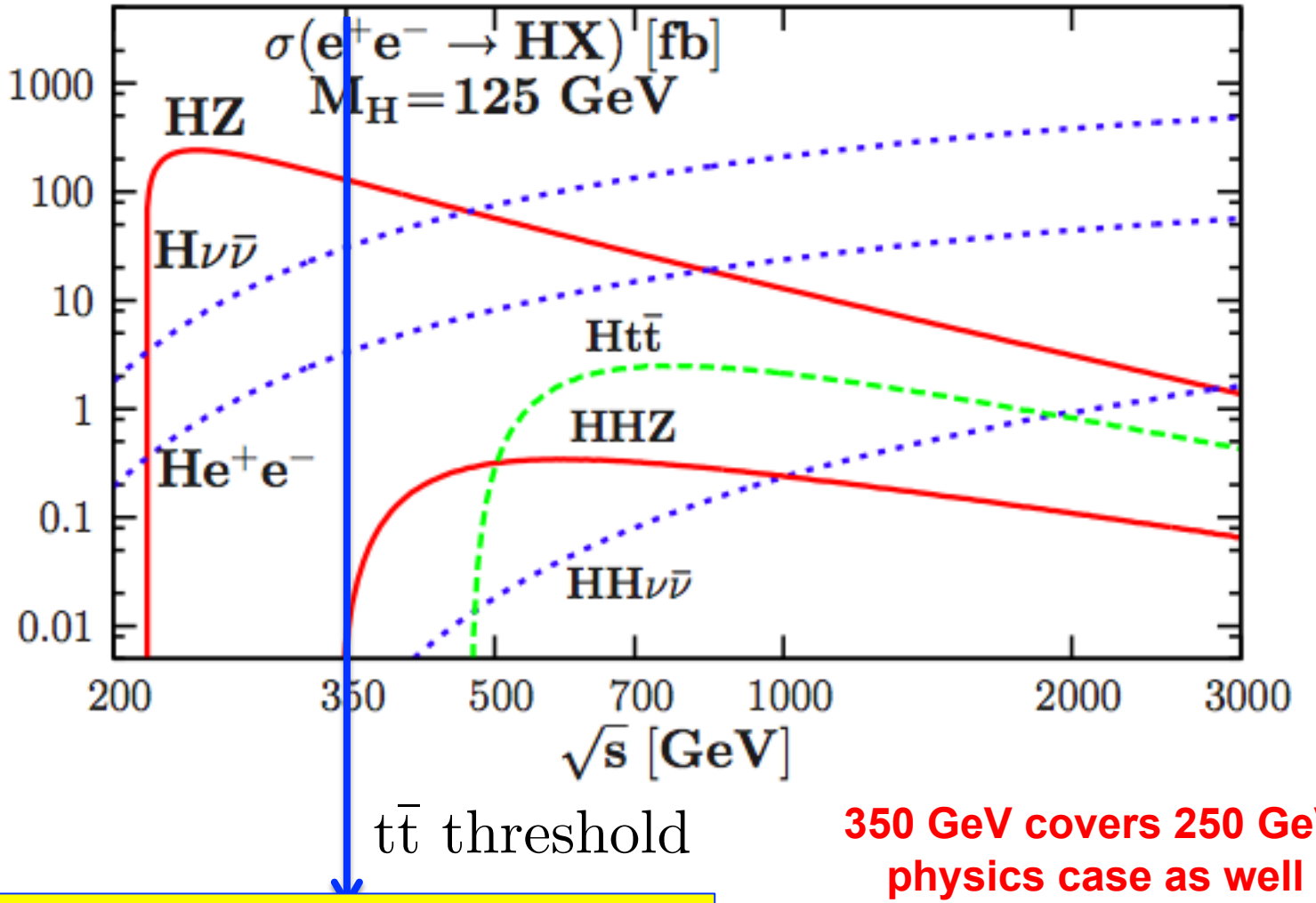


250 GeV is the entrance to Higgs world

Invisible Higgs decays are made visible!

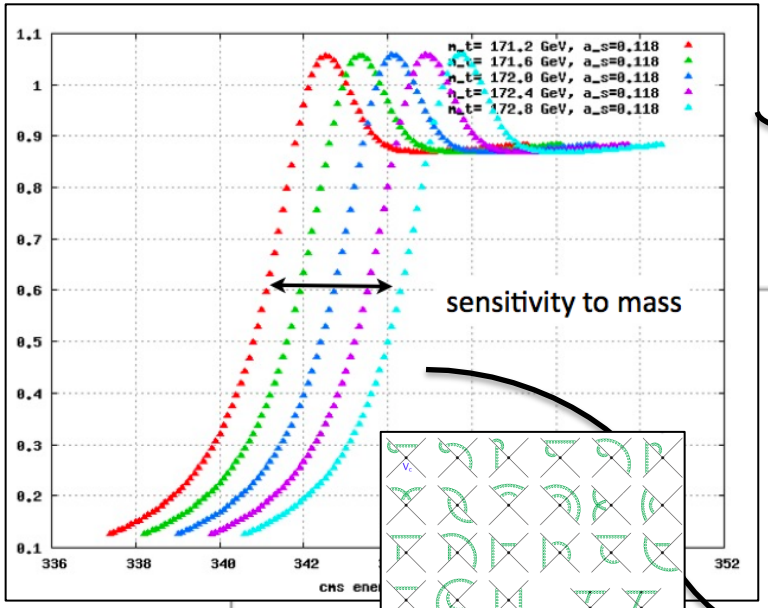
At 250 GeV, sensitivity to invisible and all unexpected decay modes of the Higgs to the 1% level.

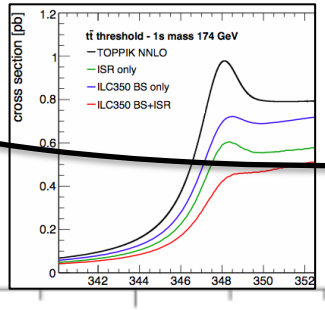
Two simultaneous thresholds : $t\bar{t}$ and HHZ



350 GeV is the entrance to top world

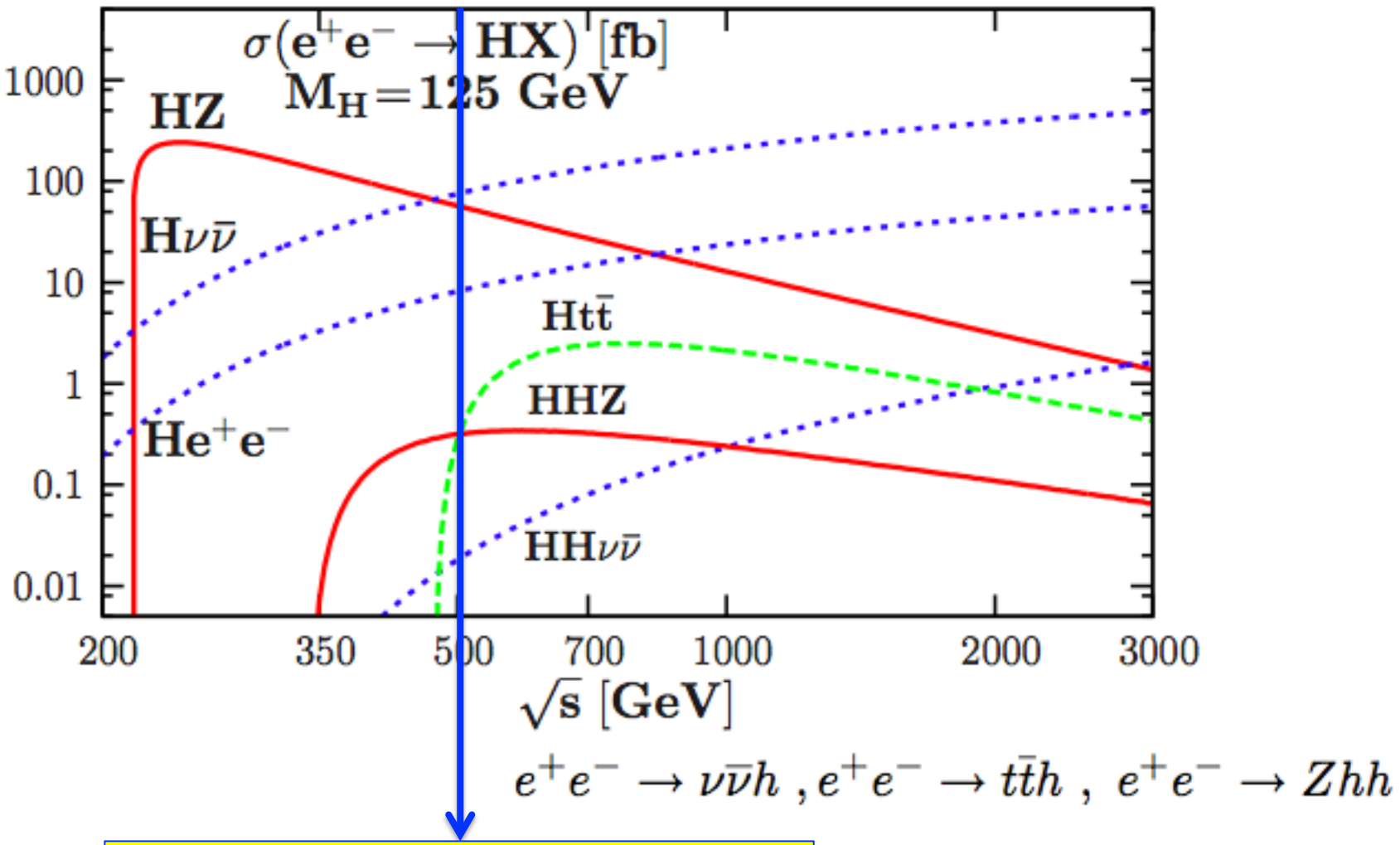
350 GeV covers 250 GeV physics case as well





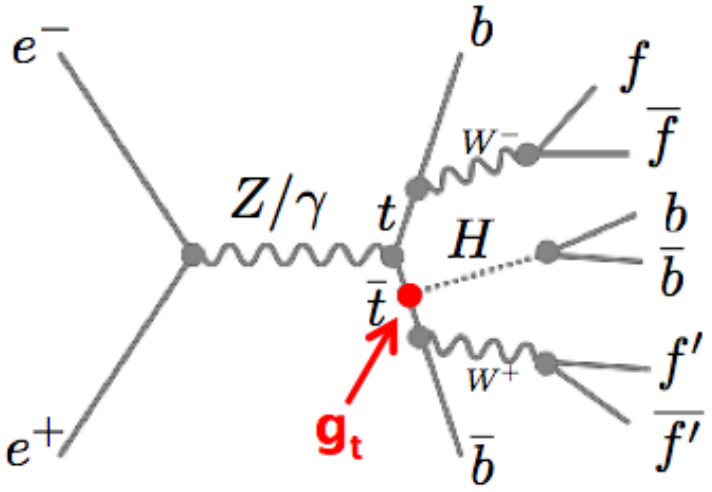
Tour de force

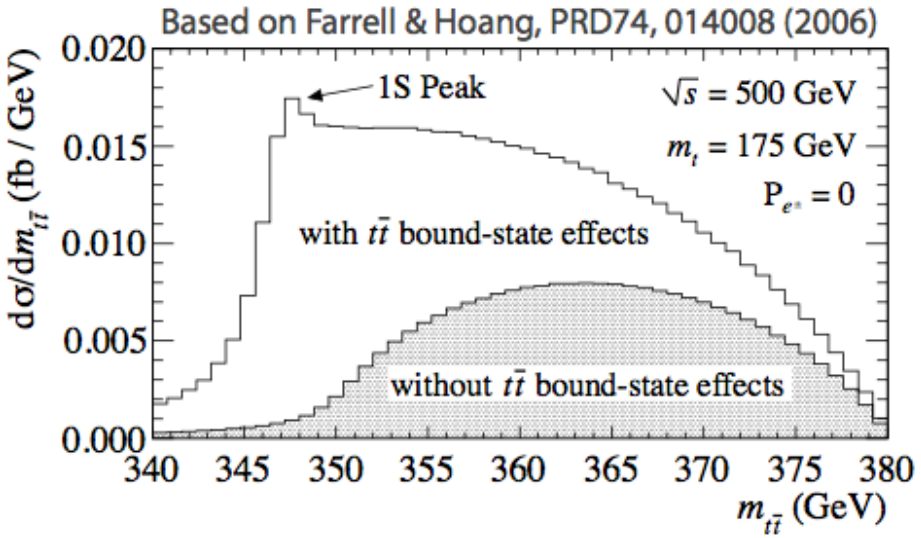
Much cleaner relation to $m_t^{\overline{\rm MS}}(m_t)$



500 GeV is the portal to the whole SM

base line energy

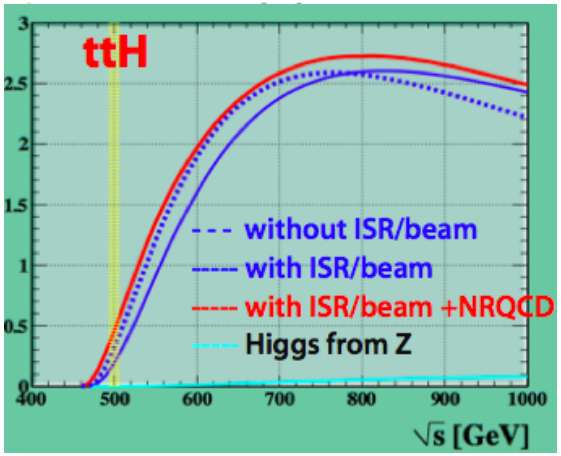




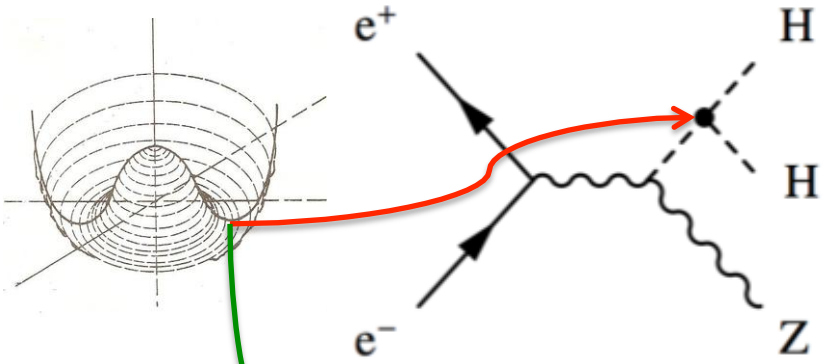
6-jet + lepton cut flow

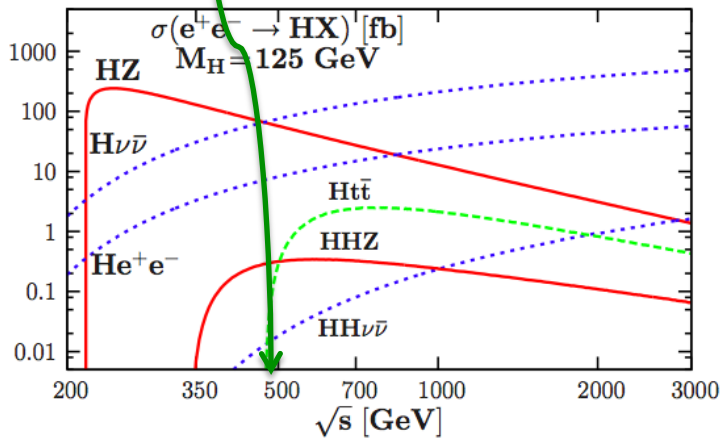
L = 1 ab^{-1}, polarized beams

cut \ sample	ttH (6J)	ttH (8J/4J)	tt	ttZ	ttg*-> ttbb	significance
no cuts	282.	358.	980739.	2407.	1160.	0.3
# isolated lepton = 1	180.	49.0	340069.	791.	398	0.3
thrust < 0.77	146.	37.7	144999.	617.	266.	0.4
$Y_{5->4}$ > 0.005	126.	25.8	12298.	416.	114.	1.1
4x btag	49.0	4.2	173.	53.3	37.8	2.8
mass cuts	39.5	1.6	23.0	33.9	13.2	3.7

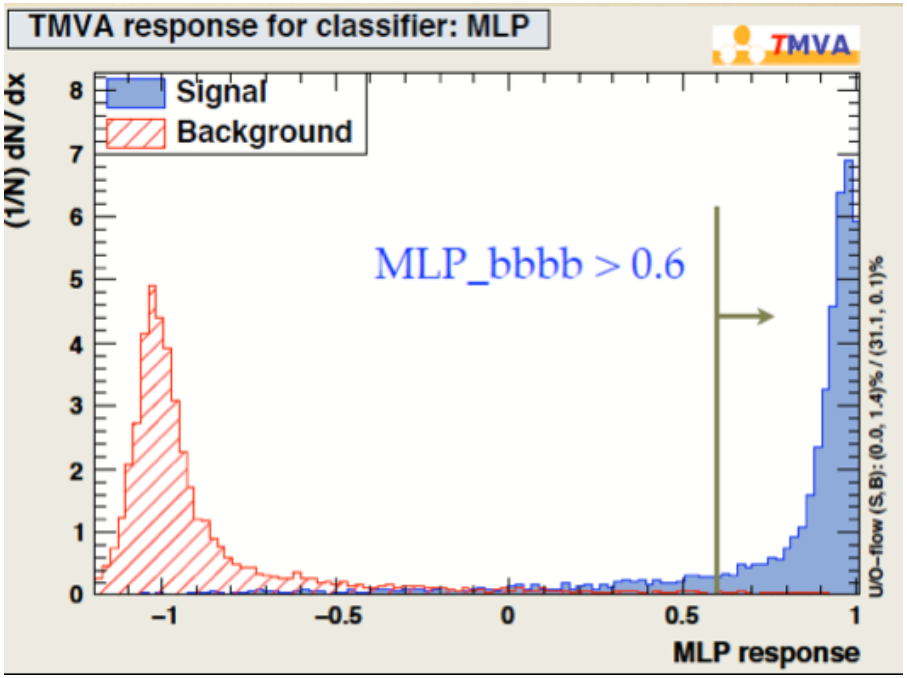


Coupling Htt at about 5%



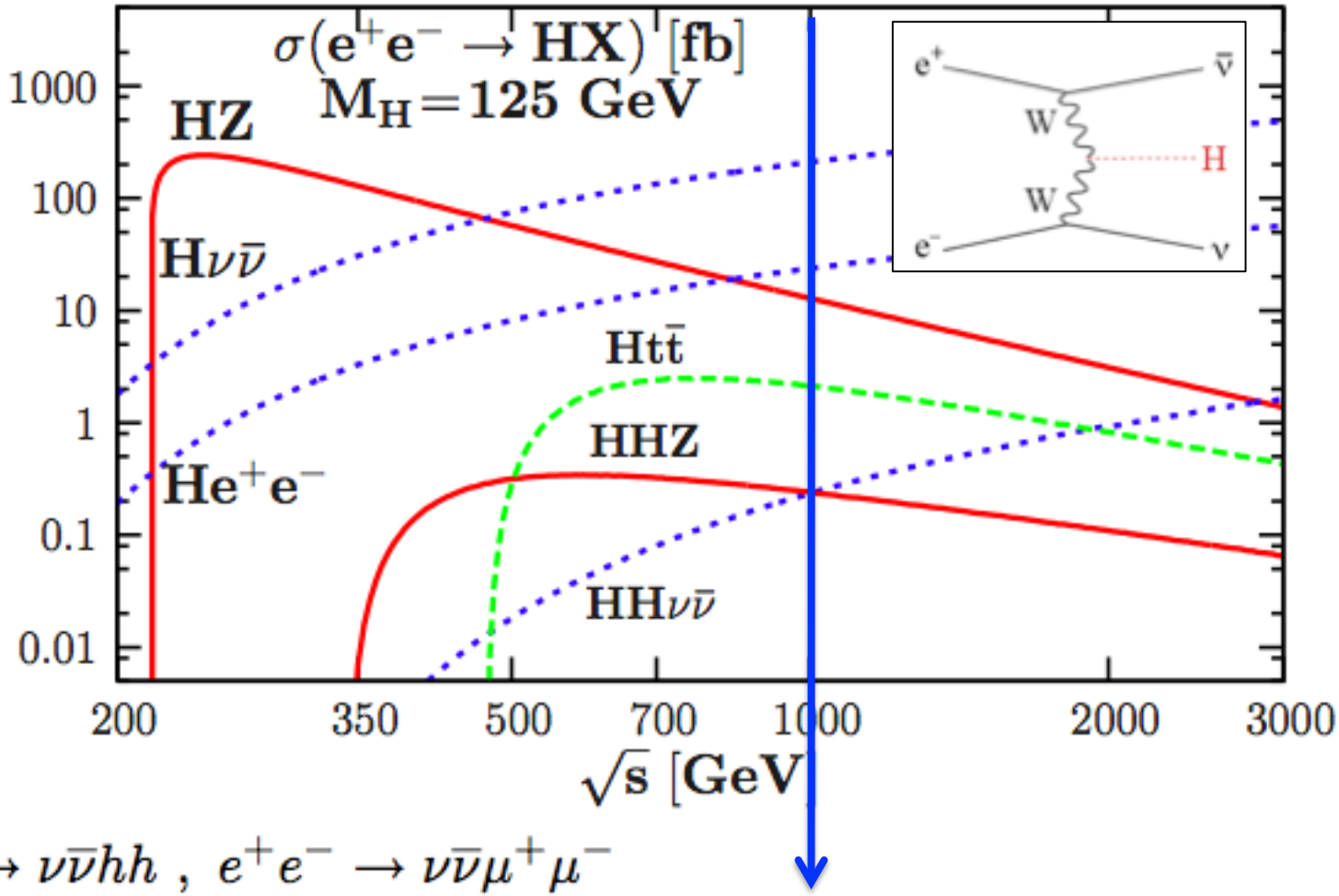


Decay mode	BR.	# events in 1 ab^{-1}
qqbbbb	32%	146
vvbbbb	9%	42
qqbbWW*->qqbbqqqq	6%	28
llbbbb	4%	19
qqbbWW*->qqbbqqlv	3%	14
qqbbWW*->qqbblvqq	3%	14
others	43%	194
tt -> bbqqqq		~800,000
ZZZ, ZZH -> qqbbbb		~600



Energy (GeV)	Modes	signal	background	significance	
				excess (I)	measurement (II)
500	$ZHH \to (l\bar{l})(b\bar{b})(b\bar{b})$	6.4	6.7	2.1σ	1.7σ
500	$ZHH \to (\nu\nu)(b\bar{b})(b\bar{b})$	5.2	7.0	1.7σ	1.4σ
500	$ZHH \to (q\bar{q})(b\bar{b})(b\bar{b})$	8.5	11.7	2.2σ	1.9σ
		16.6	129	1.4σ	1.3σ

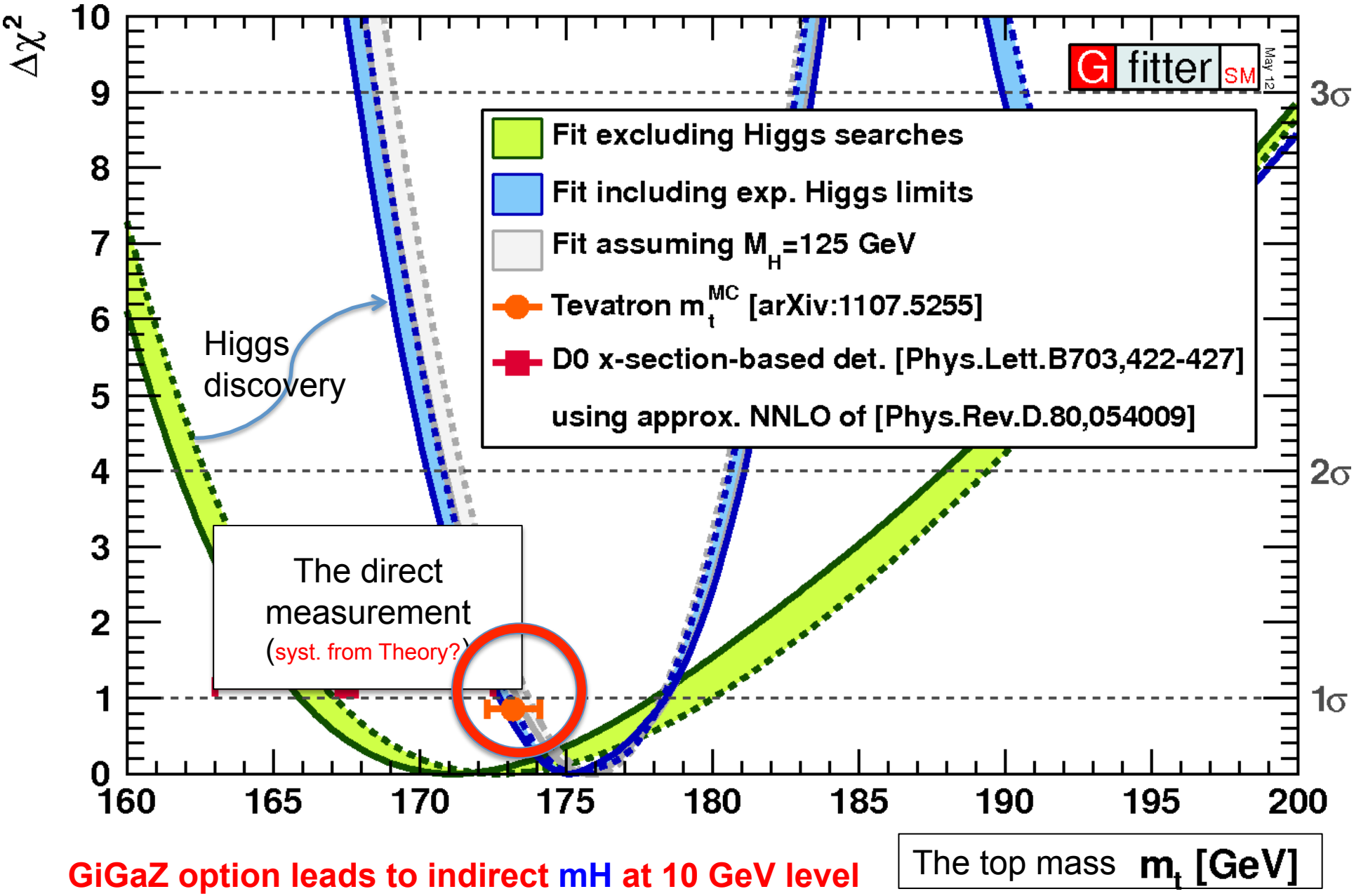
Coupling HHH: LC similar to LHC



$e^+e^- \to \nu\bar{\nu}hh$, $e^+e^- \to \nu\bar{\nu}\mu^+\mu^-$

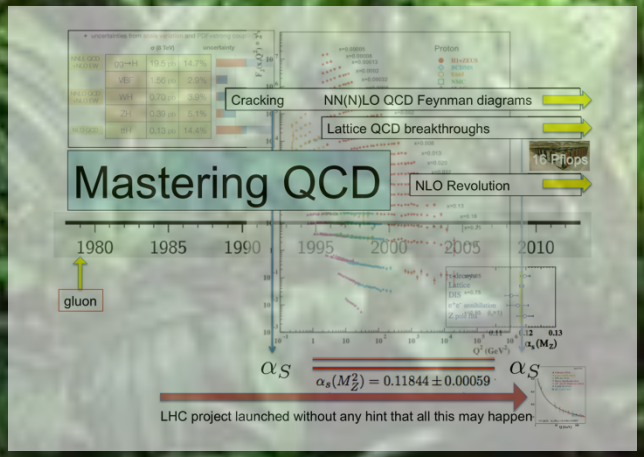
A new regime for Higgs studies

1000 GeV is the Vector-Vector world



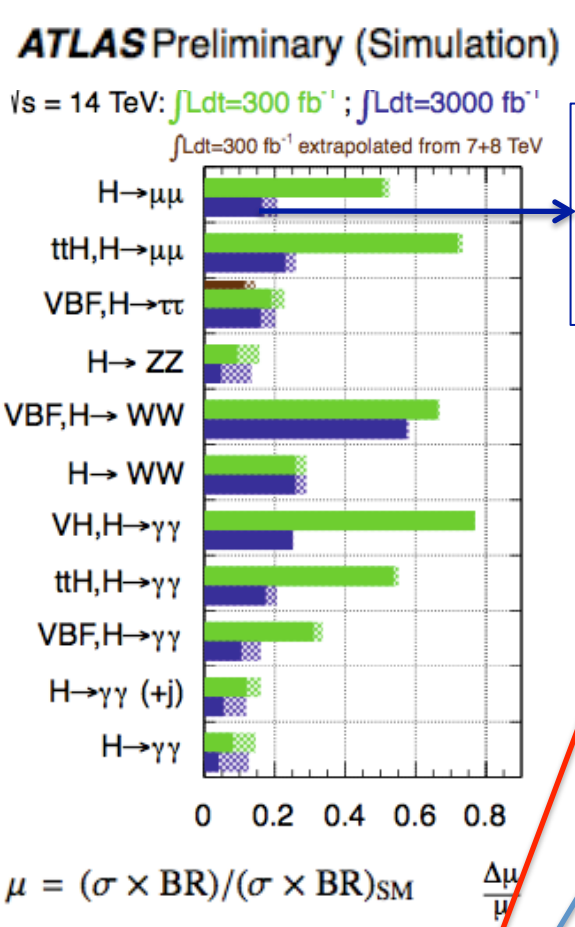
GiGaZ option leads to indirect mH at 10 GeV level

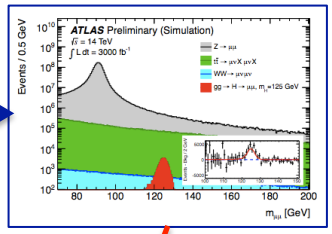
Physics at actual Collider

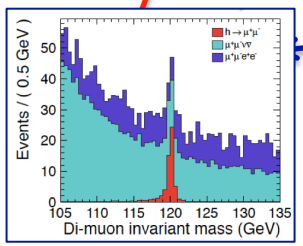


- Now 8 but 13 TeV soon
- Higher Luminosity
- Detectors upgrades
- Know-how improving

HL-LHC/LC comparison

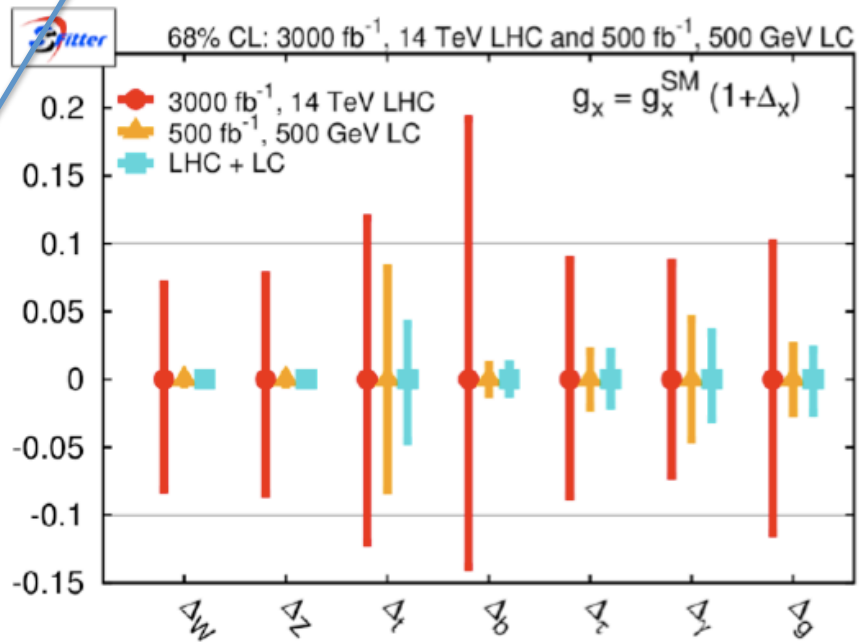




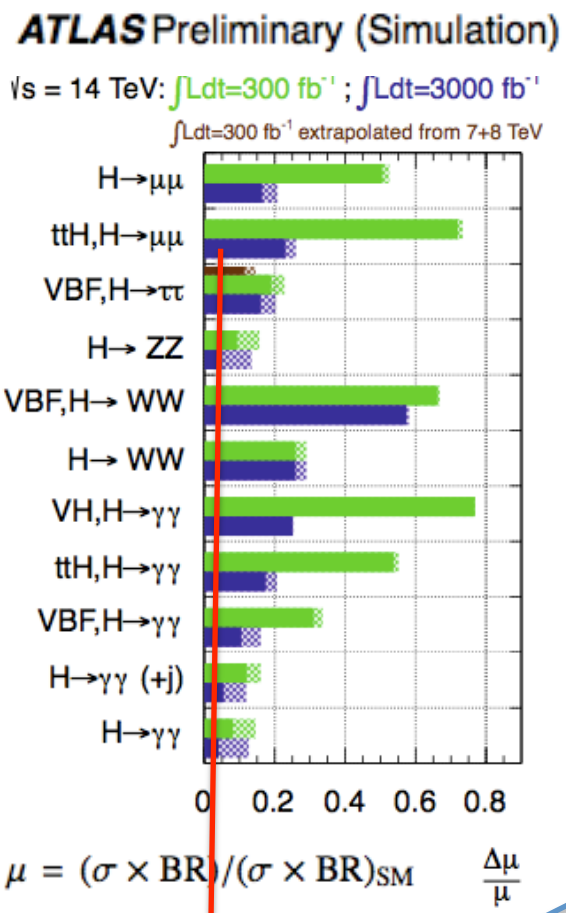


20% at 1000 GeV

	250/350 GeV	500 GeV	3 TeV
g_{Hbb}	1.6/1.4%		2%
g_{Hcc}	4/3%	2%	2%
$g_{H\tau\tau}$	3/3 %	2.5 %	
g_{HWW}	4/3%	1.4%	<2%
$g_{H\mu\mu}$	–	–	7.5%
g_{HZZ}	1.5–2%		
g_{HWW}/g_{HZZ}			<1%
g_{ttH}	–	15%	
g_{HHH}	–	30–40%	20%
Γ_H	11/7%	5%	



Similar, but LC gives an absolute measurement



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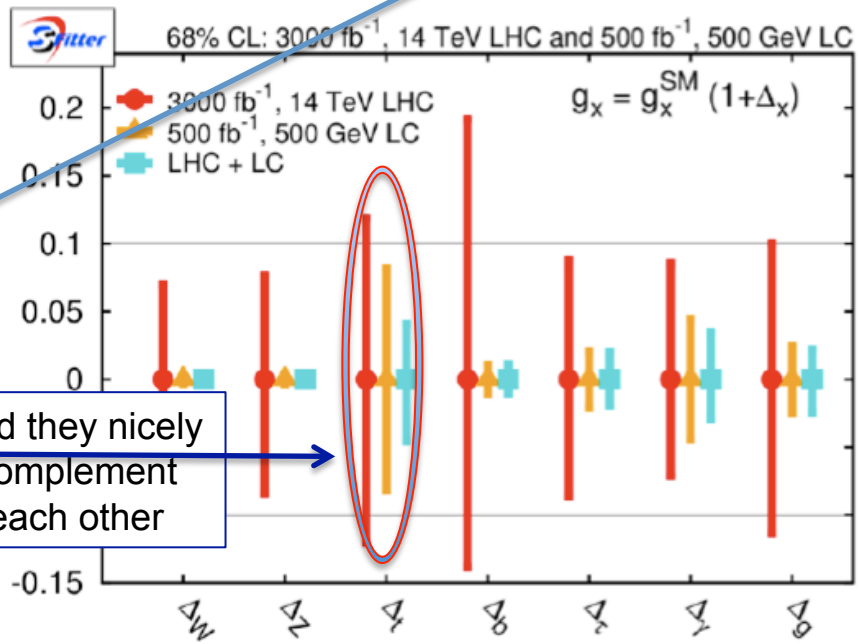
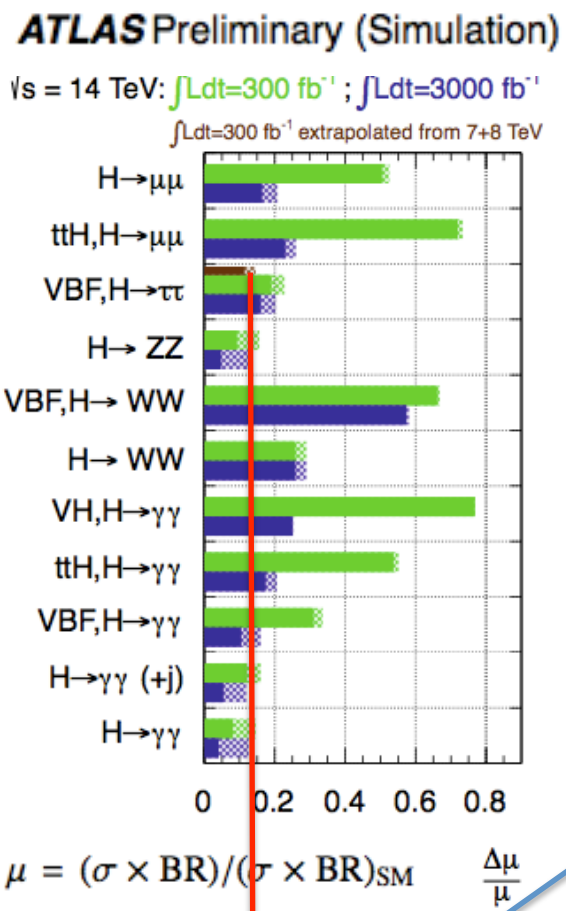
20% at 1000 GeV



Similar, but LC gives an absolute measurement

Above 500 GeV LC much better

And they nicely complement each other



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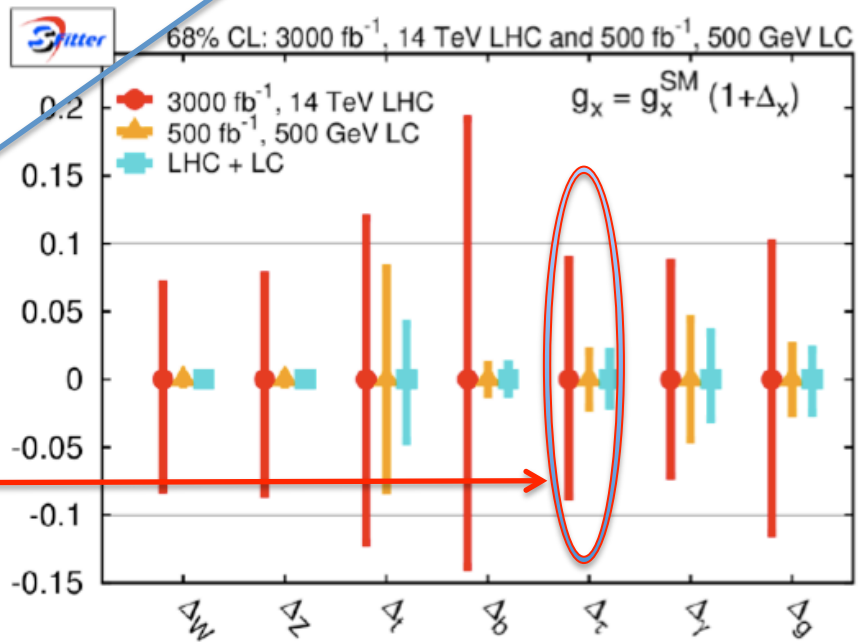
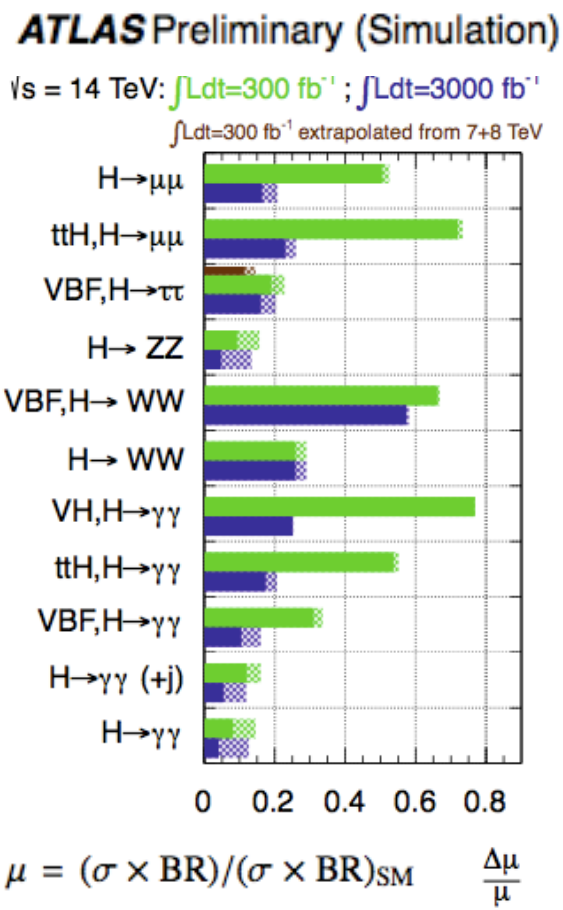


LC much better and gives an absolute measurement



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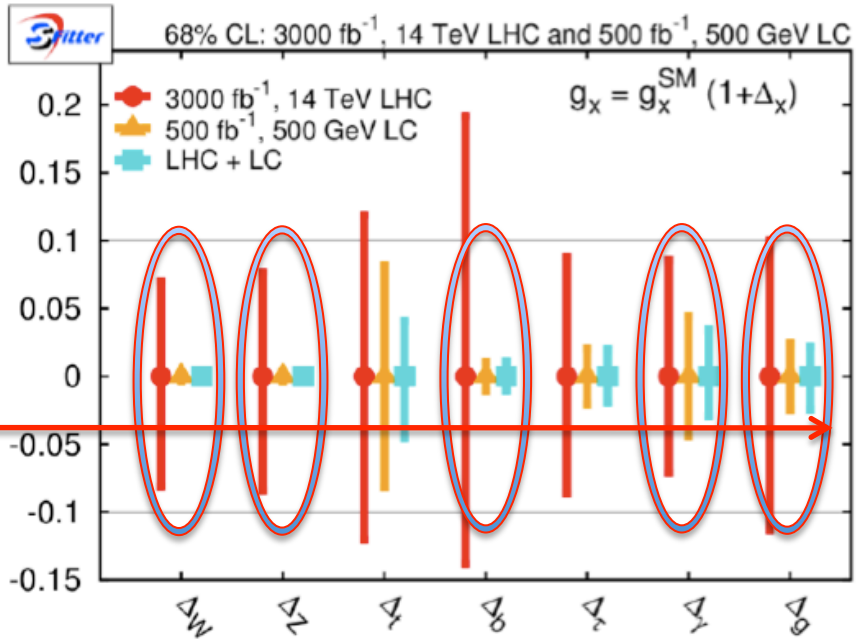


Similar statement for these 5

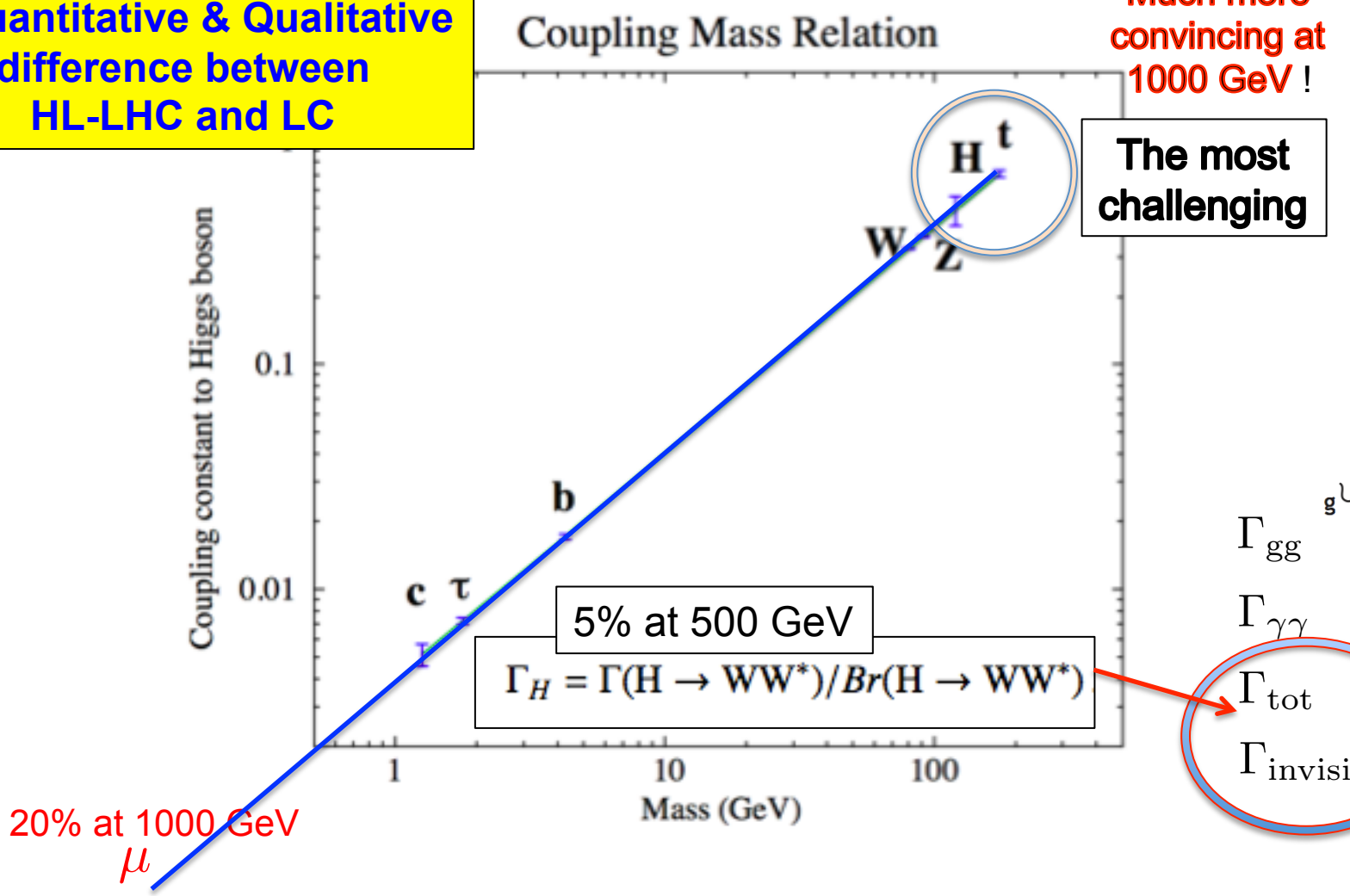
LC much better and gives an absolute measurement

The dream-machine

A 500+ GeV Electron Collider can cover
most accessible Higgs couplings

A Quantitative & Qualitative difference between HL-LHC and LC

Much more convincing at 1000 GeV !



LHC projections are realistic, but are:
1) dealing only with subset of channels, yet,
2) preliminary (more important things to do :-),
3) cannot really assess experimental limitations to come,
4) cannot foresee theoretical progresses (20 years from now!)

LC projections realistic but are:
1) dealing with (full) Monte Carlo only,
2) often preliminary (lack of manpower),
3) not boosted by real data in hand

But, undoubtly

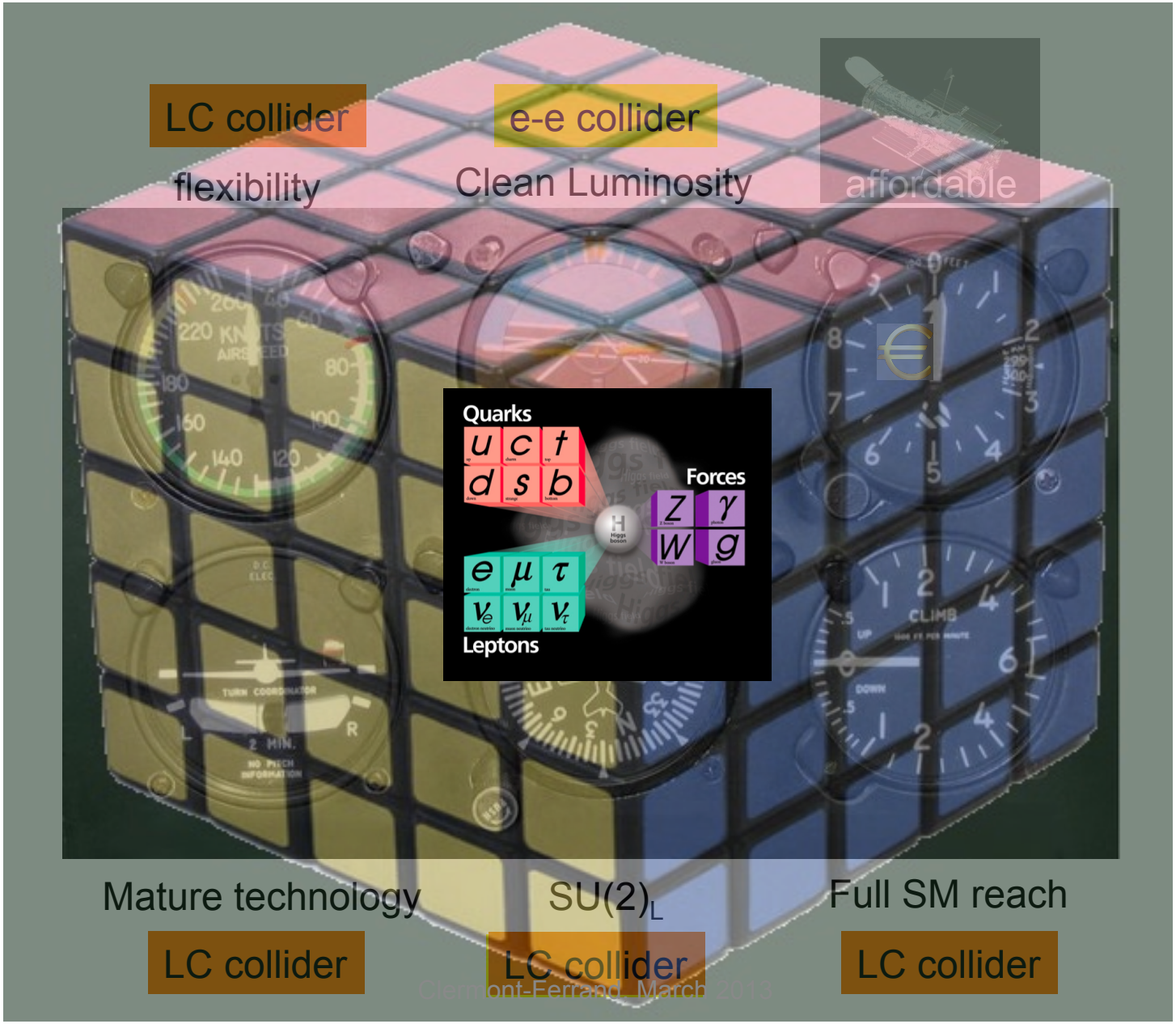
A Quantitative & Qualitative difference between HL-LHC and LC

exp&the systematics limited

exp-statistically limited (but high stat.)

The dream-machine

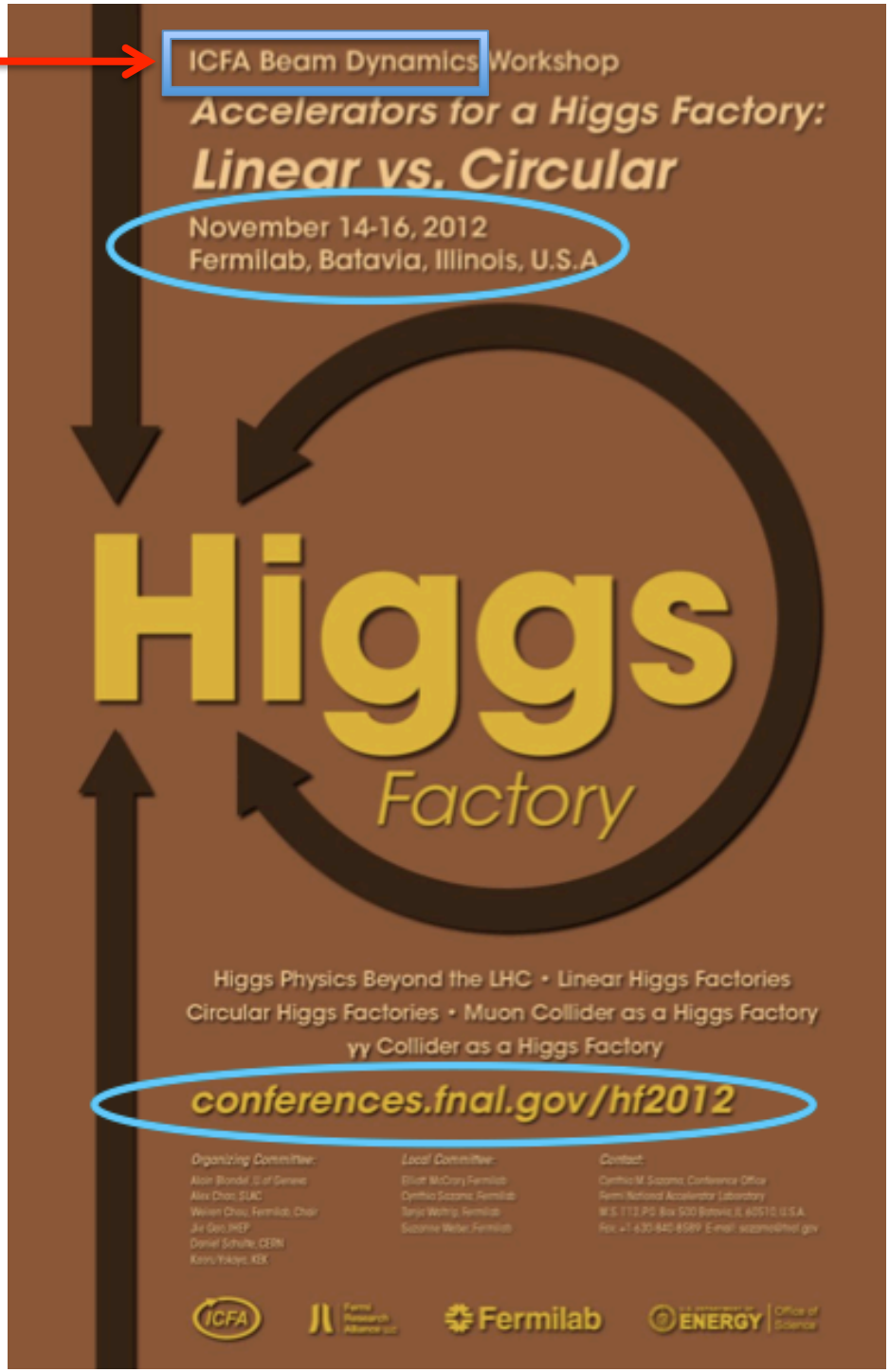
http://ific.uv.es/~fuster/DBD-Chapters



The Lepton Collider machines

Beam Dynamics is a panel from ICFA, It may hold whatever workshop it wishes.

But these workshops are not “ICFA workshops” because there is no mandate from ICFA to do so.



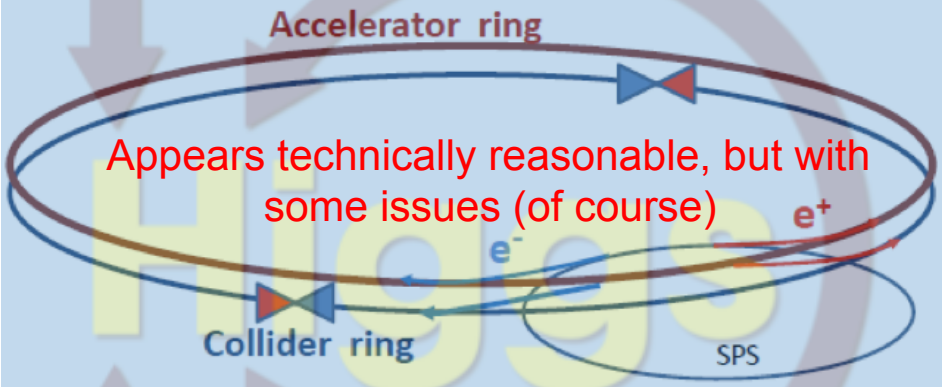
- Linear e+e- collider:
  - ILC
  - CLIC
  - X-band klystron based
- Circular e+e- collider:
  - a) ~~LEP3~~
  - TLEP
  - b) ~~SuperTRISTAN~~
  - ~~Fermilab site-filler~~
  - c) ~~China Higgs Factory (CHF)~~
  - ~~SLAC/LBNL big ring~~
- Muon collider
  - ~~Low luminosity~~
  - ~~High luminosity~~
- γγ collider:
  - ~~ILC-based~~
  - ~~CLIC-based~~
  - ~~Recirculating linac-based (SAPPHiRE)~~
  - ~~SLC type~~

No "political "support

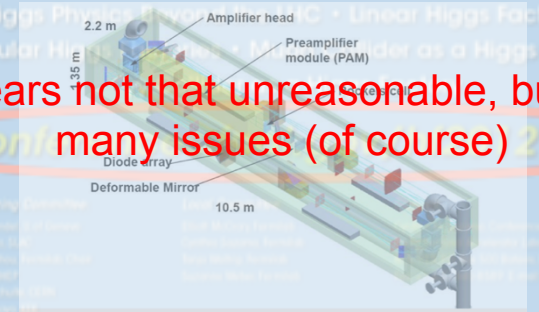
ICFA Beam Dynamics Workshop

Accelerators for a Higgs Factory: Linear vs. Circular

Facts Finding Workshop



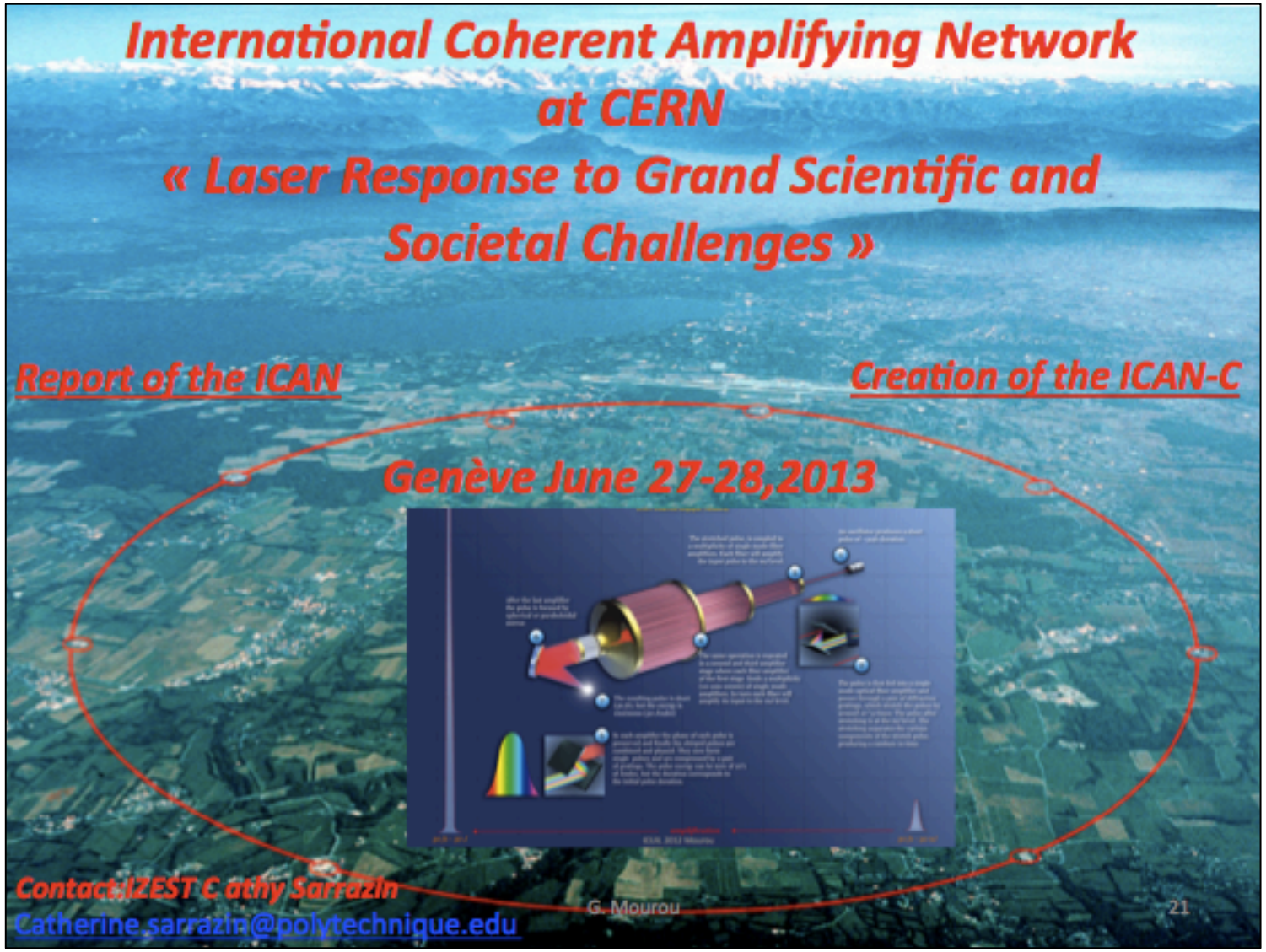
Appears technically reasonable, but with some issues (of course)



Appears not that unreasonable, but with many issues (of course)

Livermore fusion project LIFE will have 384 laser boxes
One would be enough for γγ collider

By the way, a revolution might be under way for High power High Rep Rate Lasers

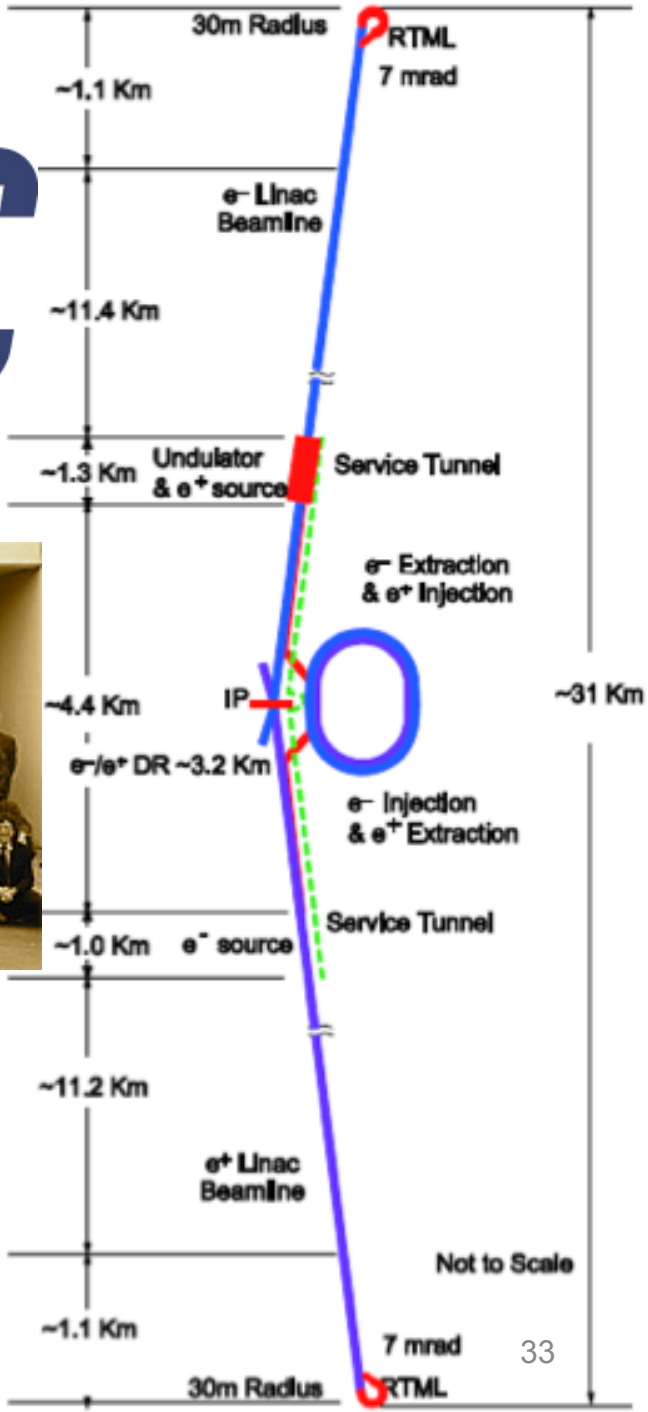


Linear Collider ?

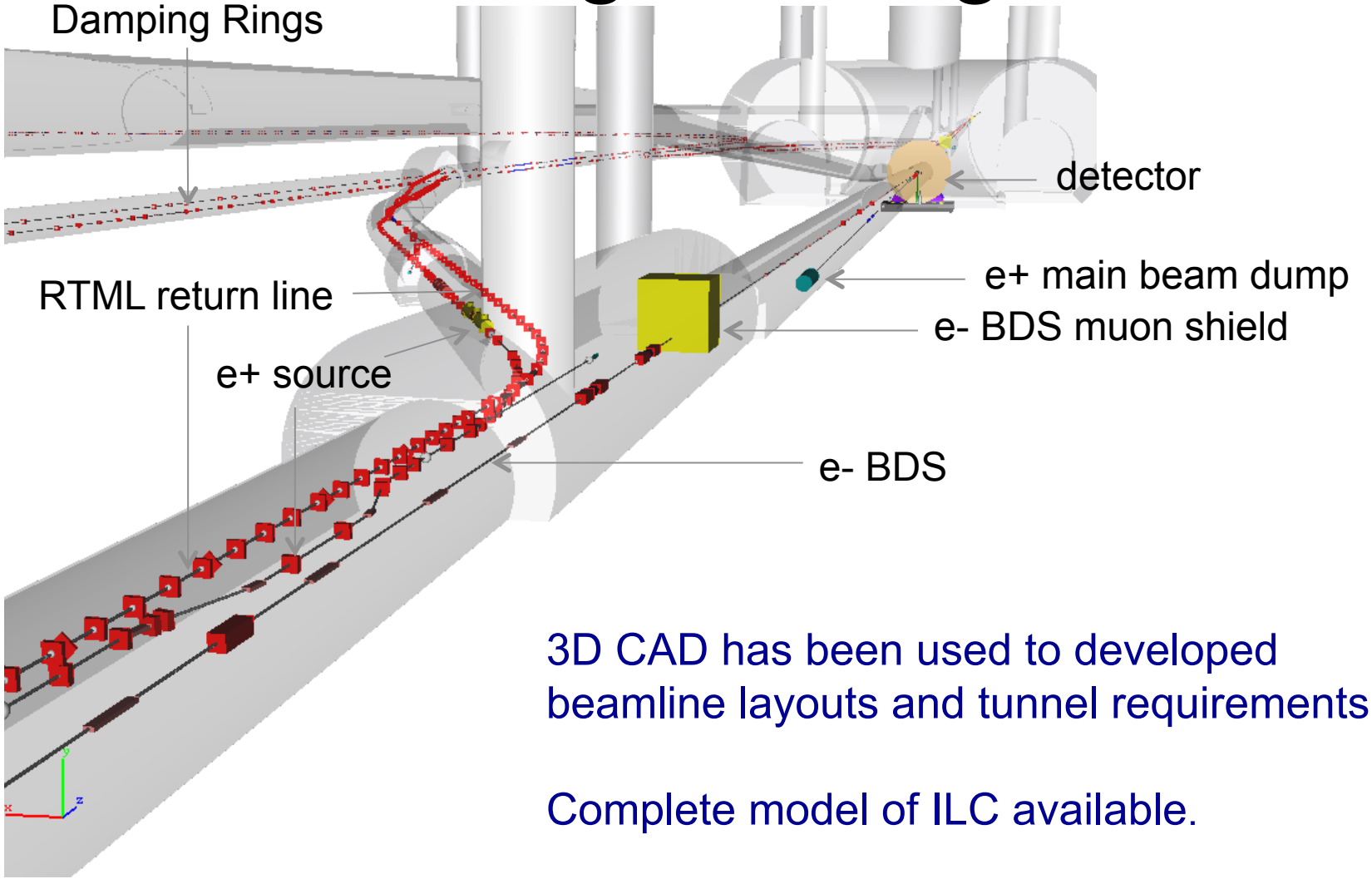
To make a long history short: August 2004

November 2004

March 2005



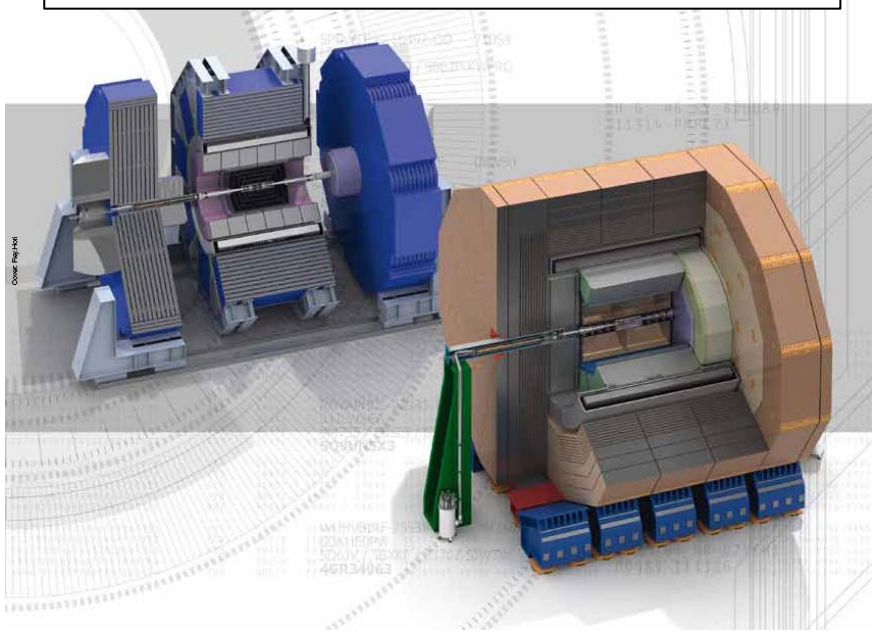
Central Region Integration

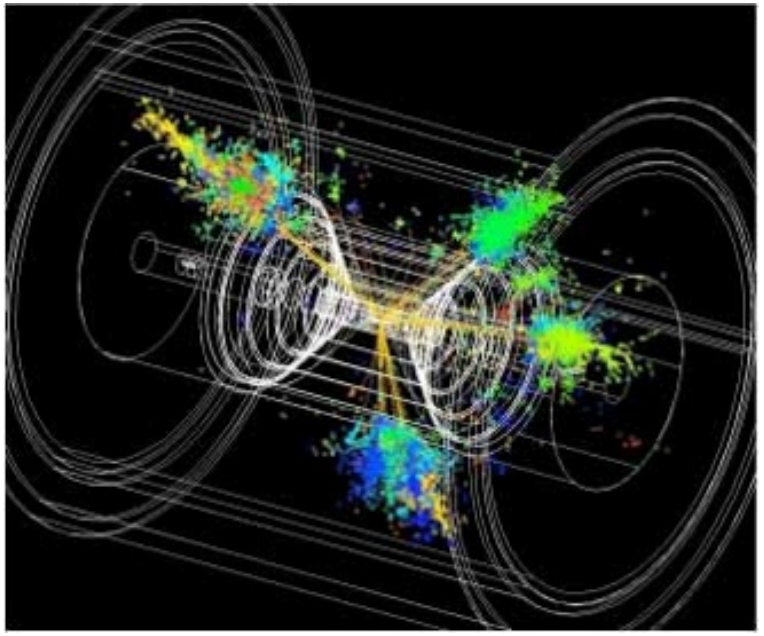


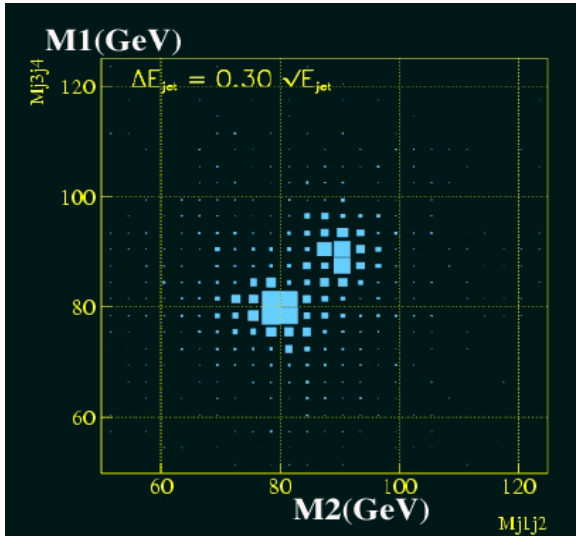
3D CAD has been used to developed beamline layouts and tunnel requirements.

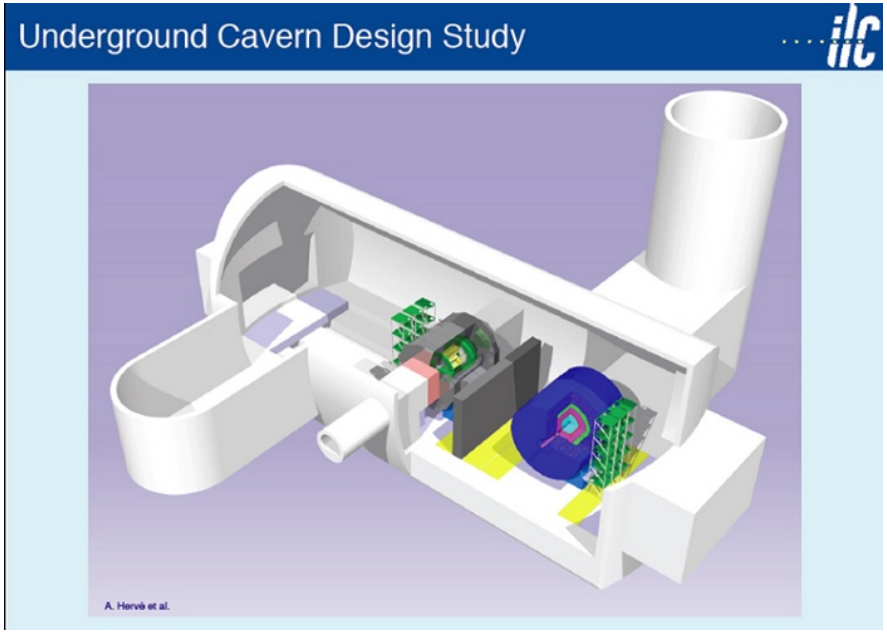
Complete model of ILC available.

And the detector designs are ready



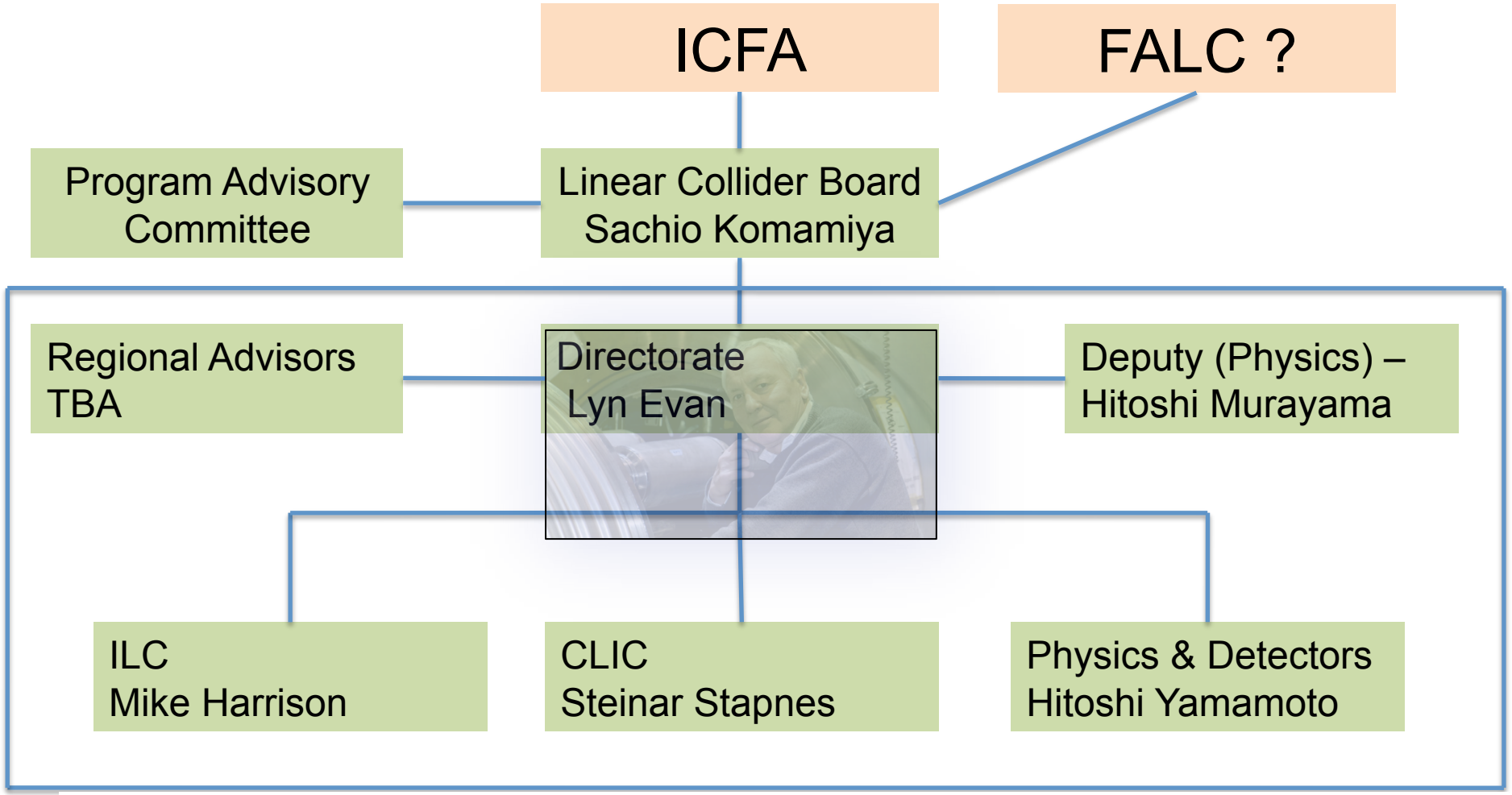






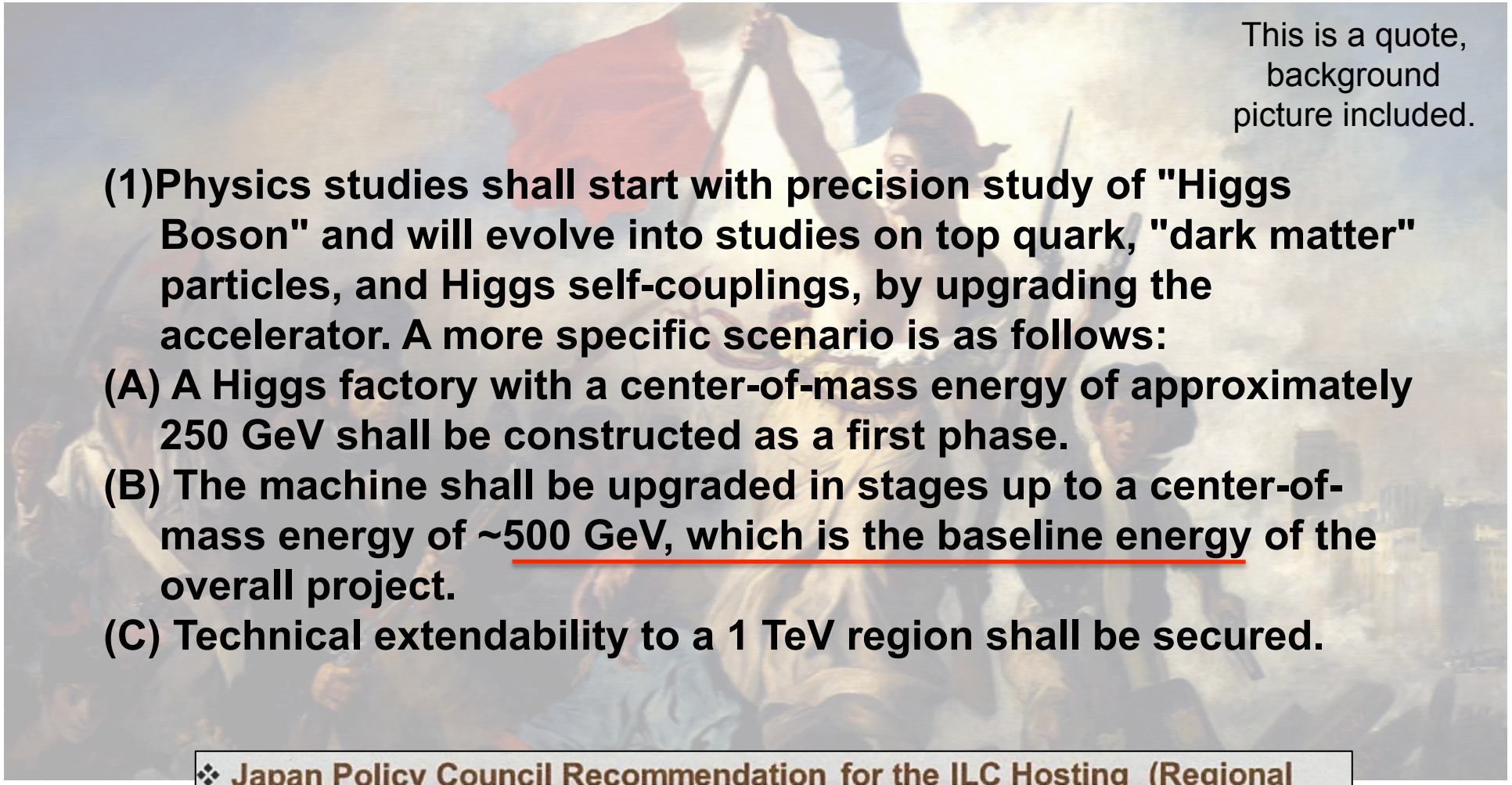
LINEAR COLLIDER COLLABORATION

Designing the world's next great particle accelerator


ICFA
FALC ?
Program Advisory Committee
Linear Collider Board
Sachio Komamiya
Regional Advisors
TBA
Directorate
Lyn Evan
Deputy (Physics) –
Hitoshi Murayama
ILC
Mike Harrison
CLIC
Steinar Stapnes
Physics & Detectors
Hitoshi Yamamoto

An essential element is political

Japan HEP community statement



This is a quote, background picture included.

(1)Physics studies shall start with precision study of "Higgs Boson" and will evolve into studies on top quark, "dark matter" particles, and Higgs self-couplings, by upgrading the accelerator. A more specific scenario is as follows:

(A) A Higgs factory with a center-of-mass energy of approximately 250 GeV shall be constructed as a first phase.

(B) The machine shall be upgraded in stages up to a center-of-mass energy of ~500 GeV, which is the baseline energy of the overall project.

(C) Technical extendability to a 1 TeV region shall be secured.

❖ Japan Policy Council Recommendation for the ILC Hosting (Regional Development through Creation of Global Country inside Japan)

is supported by industry and politicians

Dear Dr. Brinkman,

As members of the Diet and also leading figures of the supporting group for hosting the International Linear Collider (ILC) in Japan, we are writing this letter to express our deep desire to
accelerator-driven basic science, espe
Projects between Japan and the US.

The ILC, whose construction is strongly
discovery at the LHC, represents the fu
fundamental goal of making the next
Universe. The most delicate undertaki
national conditions to build the ILC
internationally structured. We consi
international enterprise would repres
projects in all fields of science, technolog

Sincerely yours,

Kaoru Yosano
A member of the House of Representatives
Previous Ministers of Finance, Education, International Trade and Industry

Takeo Kawamura
A member of the House of Representatives
Previous Chief Cabinet Secretary and Minister of Education, Culture, Sports, Science and Technology

Ryu Shionoya
A member of the House of Representatives
Previous Minister of Education, Culture, Sports, Science and Technology

Hiroya Masuda
Professor of University of Tokyo
Previous Minister of International Affairs and Communications

Japan: observer state of CERN

CC: Dr. Jim Siegrist Director, Office of High Energy Physics U.S. Department of Energy
Dr. Philip Rubin Principle Assistant Director for Science Office of Science and Technology Planning
Dr. Jerry Blazey Assistant Director for Physical Science Office of Science and Technology Planning

A bid-to host activity in Japan

Promoter's Meeting on Industry – KEK Collaboration Council

2008. 02.21

Industry – KEK Collaboration Council

(June 11, 2008)

Advanced Accelerator Association Promoting Science & Technology

Honorary Chairman :
Masatoshi Koshiba
Director General at Heisei Foundation for Basic Science

Advisory Meeting

Chairman:
Takashi Nishioka

Supreme Advisor :
Kaoru Yosano

General Meeting

Board of Directors

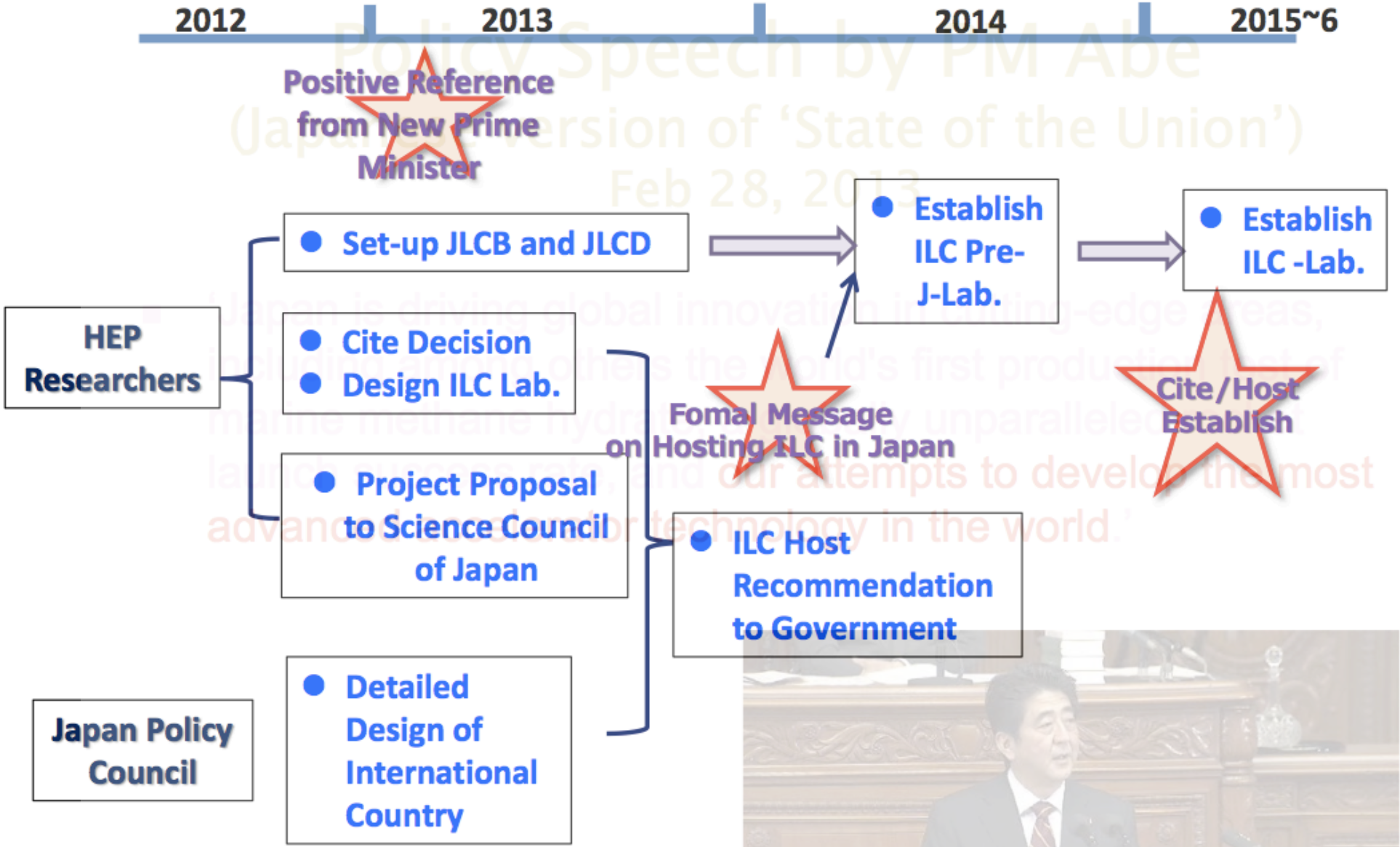
Secretariat

Technology Study Group

Outreach Group

Intellectual Property Study Group

Large Project Study Group


2012
2013
2014
2015~6
Positive Reference from New Prime Minister
HEP Researchers
Set-up JLCB and JLCD
Cite Decision
Design ILC Lab.
Project Proposal to Science Council of Japan
Japan Policy Council
Detailed Design of International Country
Establish ILC Pre-J-Lab.
Establish ILC -Lab.
Fomal Message on Hosting ILC in Japan
Cite/Host Establish
ILC Host Recommendation to Government


March 27th 2013

Statement on a Linear Collider Project in Japan as input to the European Strategy Process

The German Committee for Particle Physics (KET)

25.11.2012

The proposal of the Japanese community to host the ILC as an international project finds enthusiastic support in the German community. In view of the unique capabilities of such a facility for precision measurements of the newly discovered particle, the foreseen expandability to higher energies and the technical readiness of the project as documented in the Global Design Effort [4]) we strongly recommend to contribute actively to the realisation of this project.

And a similar statement was provided by Spain

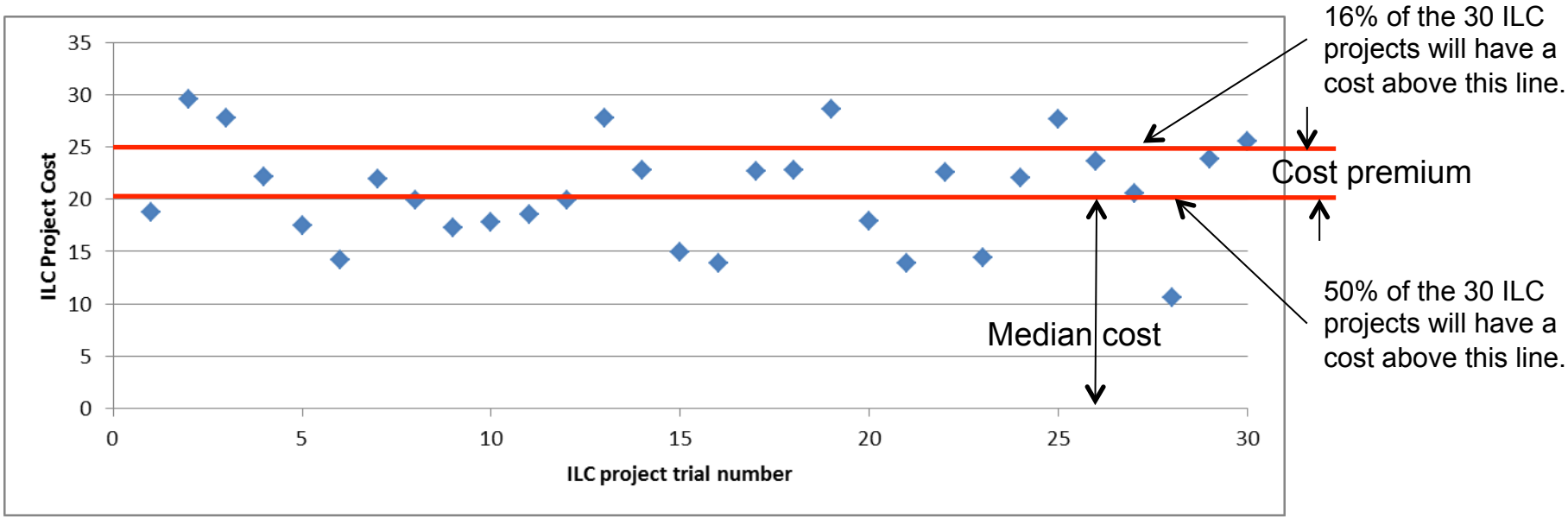
Cost

These are misleading units

(one billion)

Value estimate confidence level

- The Value estimate is a median estimate. In other words, we estimate that the probability that the cost of the ILC construction project will be equal to or less than the Value estimate is 50%.
- Because some regional funding agencies may require an estimate with a higher confidence level, we also provide a “cost premium”.
- The cost premium is our estimate of the additional Value or Labor required to achieve an 84% confidence level.
- Thus, the probability that the cost of the ILC construction project will be equal to or less than the sum of the Value estimate and the cost premium is 16%.



ILC TDR Value estimate

- The Value estimate for the cost of the ILC design as presented in the Technical Design Report, averaged over the three regional sites, is 7,780 MILCU.
- This may be compared with the escalated RDR estimate: 7,266 MILCU.
- The overall cost growth between the TDR and the RDR, not attributable to inflation, is thus 514 MILCU, i.e, an increase of approximately 7%.
- The net cost growth is the sum of
  - A cost **decrease** of approximately 9% in the total project cost, due to value engineering and cost optimization of the machine design, which was carried out after the RDR; and
  - A cost **increase** of approximately 16% of the total project cost, due to a re-estimate of the fabrication cost of cavities and cryomodules, which is based on extensive experience and studies not available at the time of the RDR.

Regional dependence

Region	Value (MILCU)
Americas	7,723
Asia	7,982
Europe	7,634

ILC TDR Labor estimate

- The explicit Labor estimate for the ILC design as presented in the Technical Design Report, averaged over the three regional sites, is 22,613 thousand person-hours.
- This may be compared with the RDR estimate: 24,427 thousand person-hours.
- The overall reduction of about 7% from the RDR to the TDR is due to
  - cost-optimization of the machine design (reduction);
  - re-estimate of the cavity and cryomodule labor (increase); and
  - re-estimate of installation, management, administration, and system integration manpower (reduction).

Regional dependence

Region	Labor (M person-hours)
Americas	22.37
Asia	22.89
Europe	22.58

Very careful cross-evaluation

Response to the ILC International Cost Review (already incorporated into the Value estimate numbers)

Increased test infrastructure cost to 50% of estimated facility capital value

Increased cavity premium by 15%

Table 1: Overall additions to the TDR Value estimate made in response to the review committee's recommendations, in 2012 MILCU

Item number	Description	Value increase	Premium increase
5	Cavity fabrication and processing		111
6	Cavity and cryomodule test infrastructure	59	39
7	Cryomodule test power consumption	20	3
8	Marx modulator	11	3
9	Asian site warehouses	11[a]	3
	Total	101	159

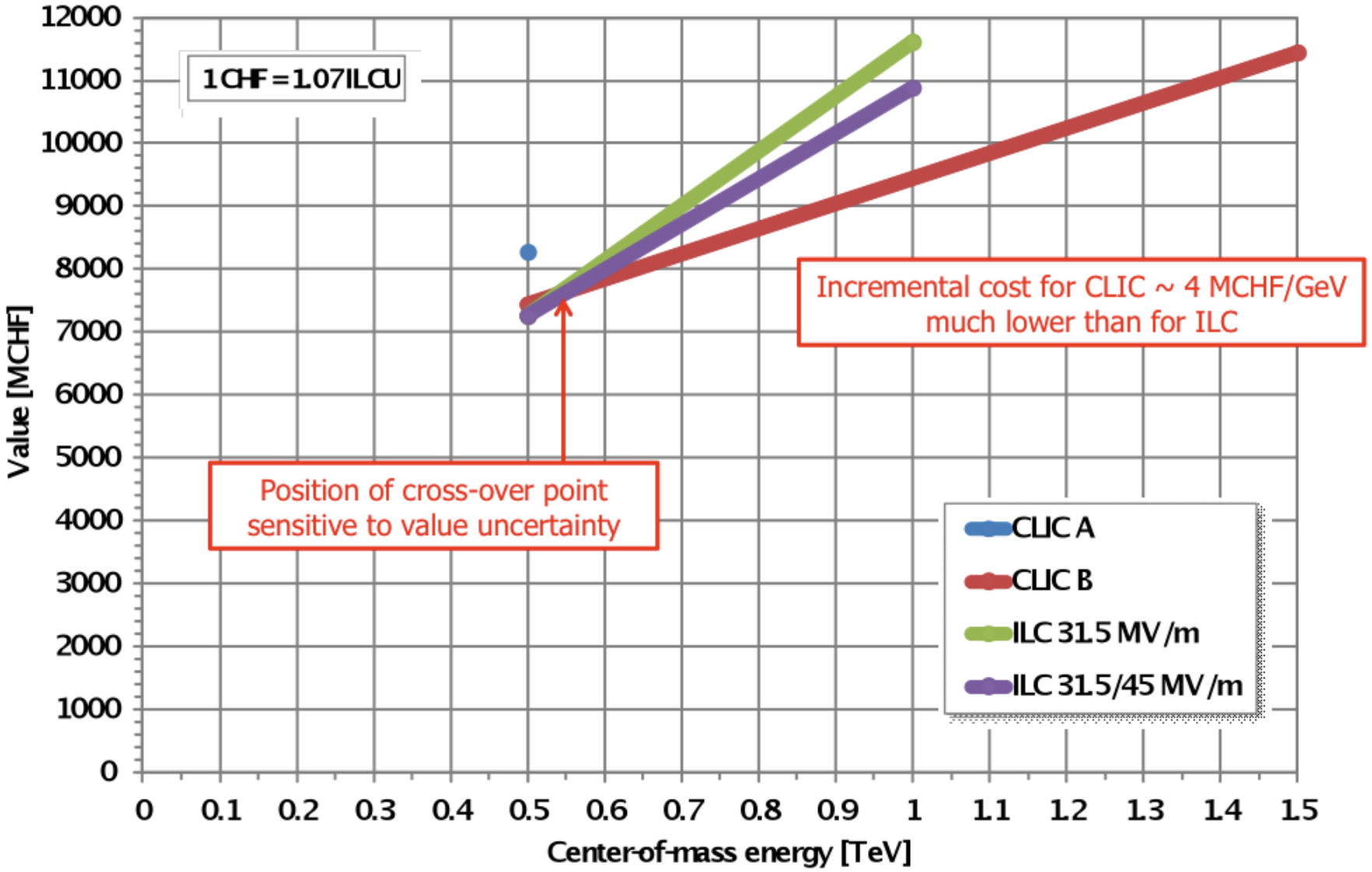
[a]Asian site estimate increases by 31.5 MILCU, but site-average increases by only 11 MILCU

Added Value to Asian civil estimate for warehouses

Add costs of power consumption for CM tests, scaled from AMTF

Increased manpower rate for modulator fabrication

Value vs center-of-mass energy of CLIC and ILC



Serious hope for the long awaited miracle to come

almost certain to happen
high likelihood
unclear

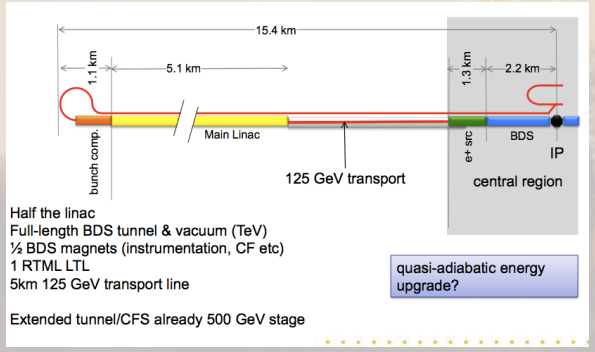
Indicated dates are very very rough

The GAP Zone

12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

Europe
LHC — planned — planned
HL-LHC — considered possibility
HE-LHC
VHLC
HLeC — interfere with HL-LHC
CLIC — staqged CLIC — considered
LEP3 — interfere with HL-LHC
TLEP — synergy with VHLC
Sapphire
LC photon^2
Americas
muColl — considered
muHiggs
Vfiller
SILC
Asia
BEPC — planned
superKeKB — planned
ILC
sTristan(s)
ChinaHF
SppChina

Long standing R&D TDR level Global project



Half the linac
Full-length BDS tunnel & vacuum (TeV)
½ BDS magnets (instrumentation, CF etc)
1 RTML LTL
5km 125 GeV transport line

quasi-adiabatic energy upgrade?

Extended tunnel/CFS already 500 GeV stage

High-priority large-scale scientific activities 4

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 and whose energy can be upgraded. 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*.

ILC in Japan would be an opportunity for all of us.

Organisational issues 1

Future major facilities in Europe and elsewhere require collaboration on a global scale. *CERN should be the framework within which to organise a global particle physics accelerator project in Europe, and should also be the leading European partner in global particle physics accelerator projects elsewhere. Possible additional contributions to such projects from CERN's Member and Associate Member States in Europe should be coordinated with CERN.*

Europe tries to be ready to participate in a large project taking place outside of Europe, if it happens.

Circular Collider ?

(so far just a set of unchecked but nice ideas)

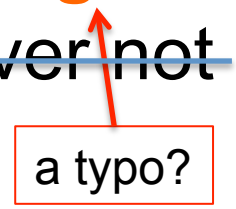
Parameter Table – Circular Higgs Factories

		Circular e+e- collider							
		LEP3		TLEP	Super-TRISTAN	Fermilab Site-filler	IHEP Ring CHF-50km	IHEP Ring CHF-80km	SLAC/LBNL Ring
Top Level Parameters									
Energy (center of mass)	GeV	240	240	350	240	240	240	240	240
Luminosity (per IP)	10^{34} cm^{-2} s^{-1}	1	4.9	0.65	1	0.52	2.5	3.85	1
No. of IP		2 (4)	2	4	1	1	2	1	1
No. of Higgs per year (per IP)	1000	20		100		13	100	200	
Size (length or circumference)	km	26.7	81	81	40	16	49.78	69.88	26.7
P(wall)	MW	200	200	200	100	200	300	300	200
Polarization									
e-		0	0	0	0	0	0	0	0
e+		0	0	0	0	0	0	0	0

Let's pick up one number, and refer to the LEP-3 preprint

(Note that the two rings together produce 50MW of gamma rays above 1.3MeV)

We have limited the total power loss in the ring due to synchrotron radiation to 100 MW (50 MW per beam). This would roughly equate to a wall power consumption of **200 MW** (assuming a 50% power efficiency of the RF system). This figure is high, but not abnormally so. Currently CERN has a 200 MW contract with France's electricity provider EdF. Energy consumption figures of the proposed LHeC project are also similar. Projected linear collider power consumptions **are up to three times higher** (admittedly for higher ECM, ~~which is however not needed for Higgs production~~).



Parameter Table – Linear Higgs Factories

		Linear e+e- collider						
			ILC		CLIC			X-band
					A+	A	A/B	Klystron-based
Top Level Parameters								
Energy (center of mass)	GeV	250	500	1000	250	500	3000	
Luminosity (per IP)	10^{34} cm^{-2} s^{-1}	0.75	1.8	4.9	1.37	2.3	5.9	
No. of IP		1	1	1	1	1	1	
No. of Higgs per year (per IP)	1000	23	49		34	44	446	
Size (length or circumference)	km	21	31	48	13.2	13.2	48.3	
P(wall)	MW	128	162	301	235	272	589	
Polarization								
e-	%	80	80	80	80	80	80	
e+	%	30	30	30	0	0	0	

ILC TDR 163 = 105 (cryo, etc.) + **58 (SCRF)**

ILC MW more than three times **less (not higher)**

At 500 GeV

17% = ILC evaluation (both use ILC cavities)

another typo?

We have limited the total power loss in the ring due to synchrotron radiation to **100 MW** (50 MW per beam). This would roughly equate to a wall power consumption of 200 MW (**assuming a 50% power efficiency of the RF system**). This figure is high, but not abnormally so. Currently CERN has a 200 MW contract with France's electricity provider EdF. Energy consumption figures of the proposed LHeC project are also similar. Projected linear collider power consumptions **are up to three times higher** (admittedly for higher ECM, ~~which is however not needed for Higgs production~~).

Parameter Table – Circular Higgs Factories

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Top Level Parameters									
Energy (center of mass)	GeV	240	240	350	240	240	240	240	240
Luminosity (per IP)	10^{34} cm^{-2} s^{-1}	1	4.9	0.65	1	0.52	2.5	3.85	1
No. of IP		2 (4)	2	4	1	1	2	1	1
No. of Higgs per year (per IP)	1000	20		100		13	100	200	
Size (length or circumference)	km	26.7	81	81	40	16	49.78	69.88	26.7
P(wall)	MW	200	200	200	100	200	300	300	200
Polarization									
e-		0	0	0	0	0	0	0	0
e+		0	0	0	0	0	0	0	0

Should be about 600 MW (SCRF only)

And it doesn't cover the Physics case…

At the same time it is beyond Europe financial capabilities

As of today : no TDR, no CDR, no costing, no external review for a new type of machine.

Luminosity:
(10^34 cm-2 sec-1 unit)

ILC (500 GeV) : 1.5
TLEP (350 GeV(*)) : 0.65 (unrealistic: unaffordable MW)
But 2 (4?) IP's mitigate part of the large reduction to come.

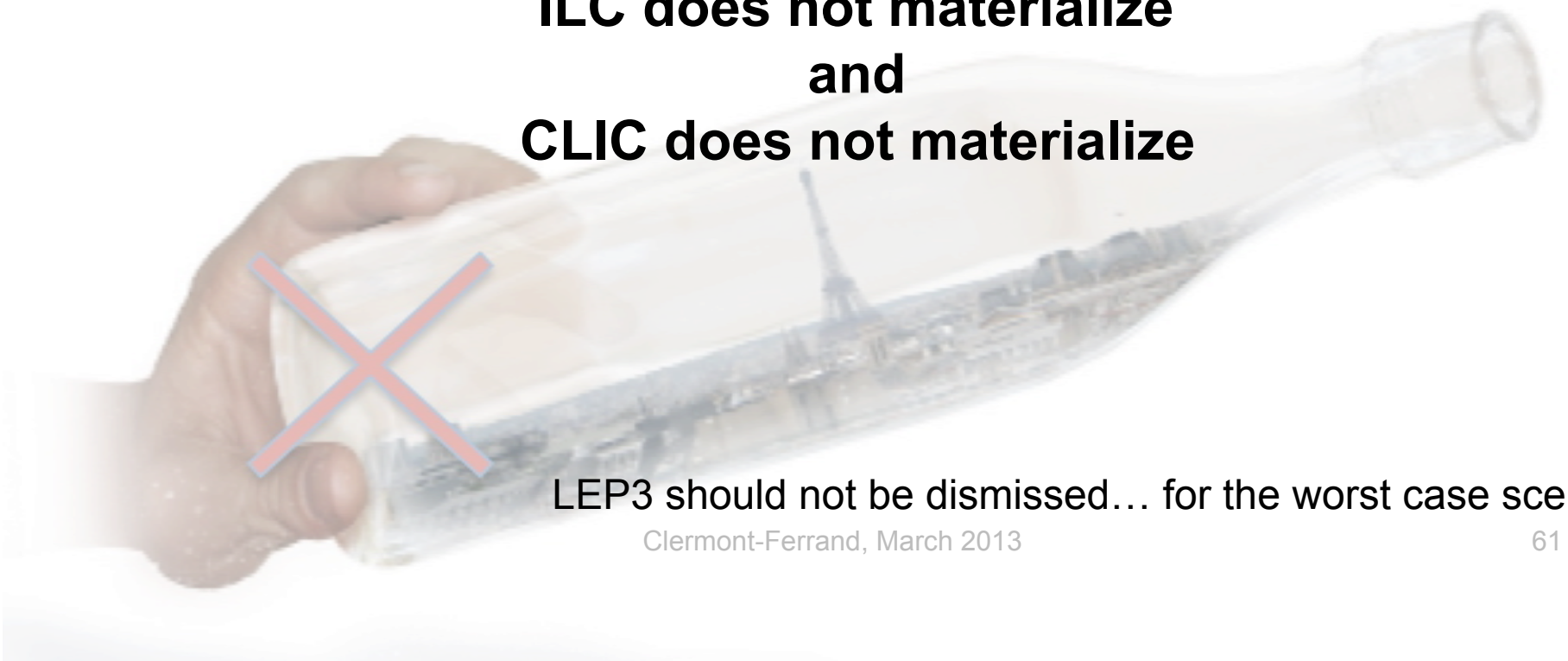
The main point is that TLEP doesn't cover the Physics case…

(*) when running at 350 GeV, ILC luminosity is 0.9

But, it remains a very interesting set of ideas !
TLEP might be technically feasible
and it would provide a link towards
a possible ultra-high energy hadron machine.

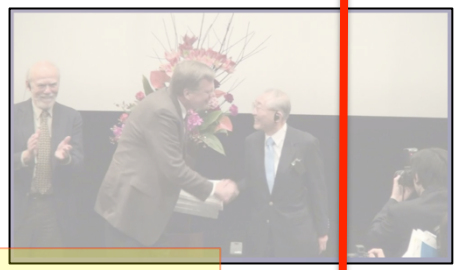
CDR needed (and foreseen)

This link might prove very useful, in case:
New Physics is discovered at LHC
and
ILC does not materialize
and
CLIC does not materialize



LEP3 should not be dismissed… for the worst case scenario

Timeline for HEP Global roadmap: 24 busy months



TDR official release
June 12
World Wide Event
(ask Perrine)

Community Planning Meeting
Oct. 11-13 (FNAL)

ILC TDR and
DBD Reviews
start Dec. 15

eLCWS 2013
May 27-31 DESY

LP2013
June 24-29 (S.F.)

LCB takes charge
Feb. 21 (Vancouver)

Open Symposium
Sept. 10-12 (Krakow)

Community Summer Study
Early August "Snowmass"

HF 2012
Nov. 14-16 (FNAL)

Strategy Group drafting session
January 21-26 (Erice)

LCWS 2012
Oct. 22-26 (Arlington)

draft

LCWS 2013
fall (Japan)

1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

2012 2013

European Strategy
Jan. 21-26 (Erice)

We must dare
to make up
our mind:
time is ripe!