Prospects for BSM Higgs* Boson Searches at Future Colliders

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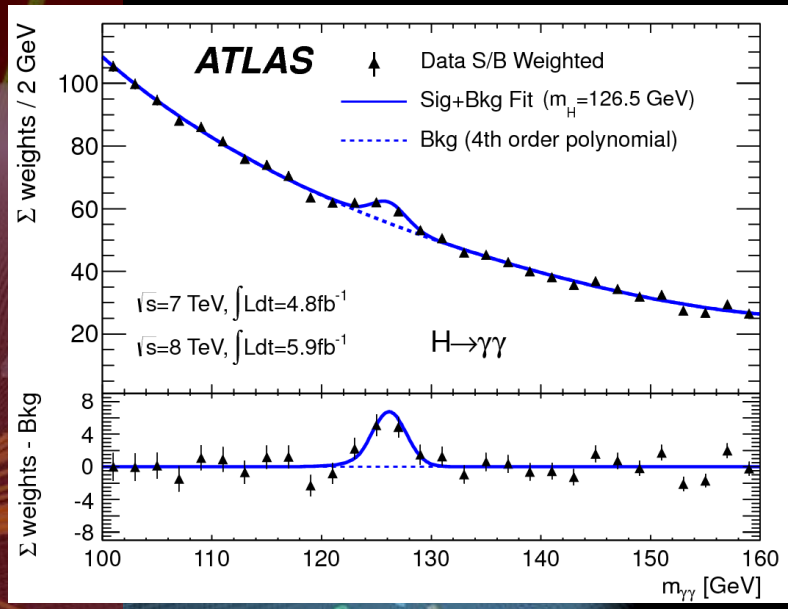
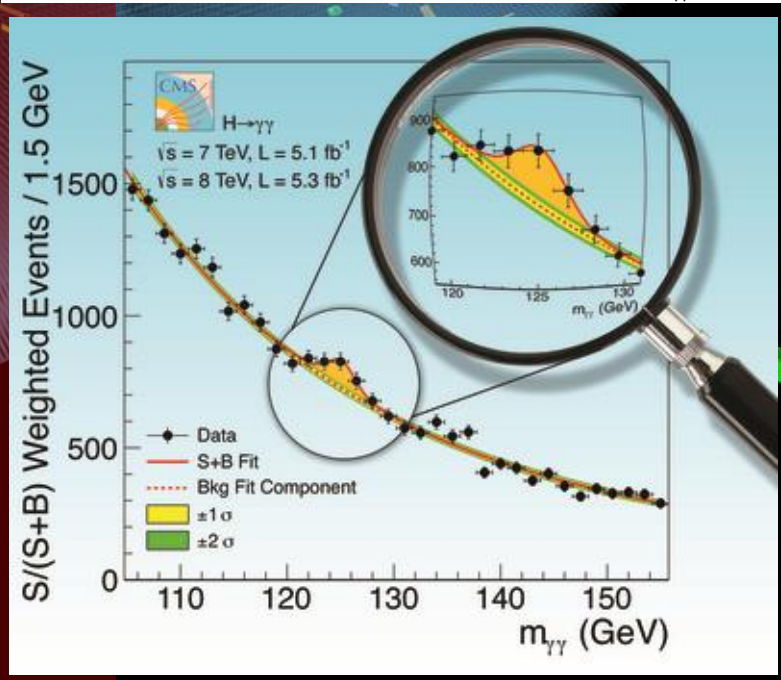
*‘Higgs’ =BEHGHK (Brout-Englert-Higgs-Guralnik-Hagen-Kibble)

Outline

- Introduction
- Upgraded LHC Upgrades calendar, experimental challenges and plans, assumptions, methods and scenarios, SM Higgs prospectives covered by Flera
  - BSM-related property measurements of the observed Higgs boson:
    - Invisible Branching Fraction and Higgs-Portal Interpretation
    - Field Strength Tensor Structure
  - Search for additional (BSM) Higgs bosons:
    - Indirect from coupling measurements
    - Direct from
      - H/A→μμ
      - H→ZZ→4ℓ
      - A→Zh→ℓℓbb
- Future Colliders Introduction to the machines and physics
  - 2HDM couplings deviation reinterpretation
  - Search for additional (BSM) Higgs bosons:
- Summary and Conclusion
- Acknowledgements

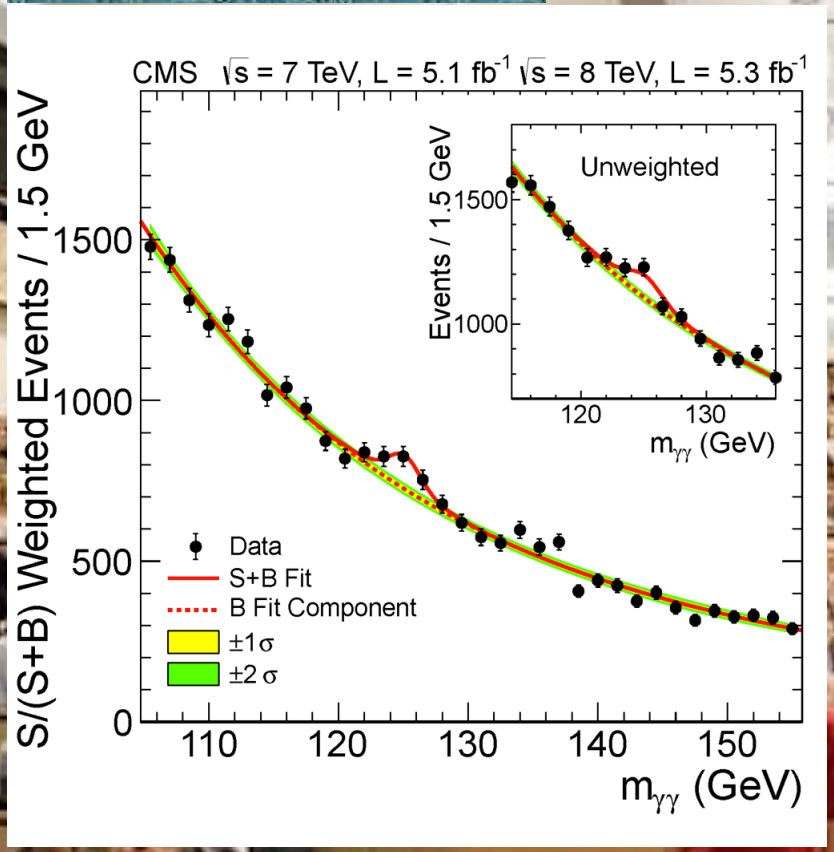
Phys. Lett. B716 (2012)



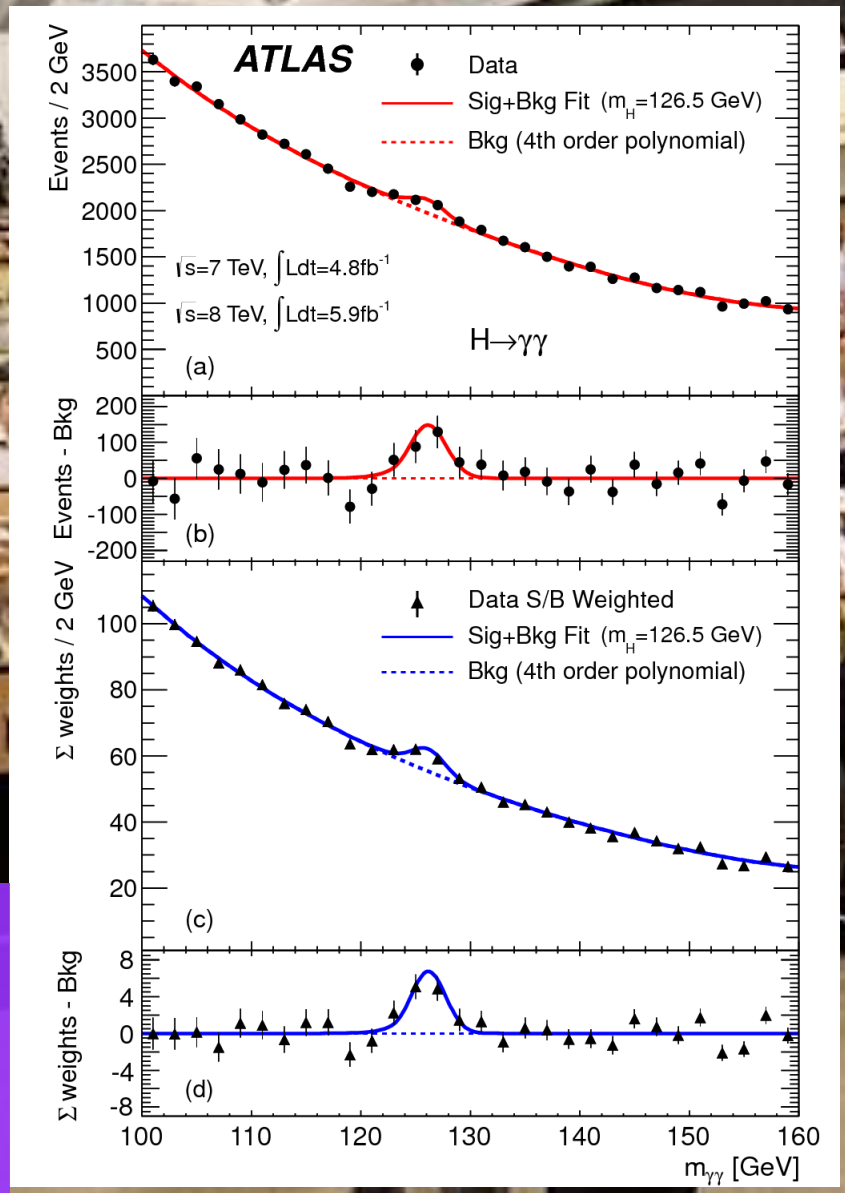


Introduction: July 4 2012, 9:30 AM…..

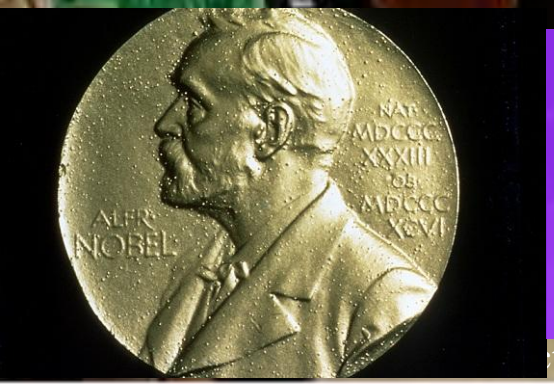
Phys. Lett. B716 (2012)



- "This result constitutes evidence for the existence of a new massive state that decays into two photons."



- "Clear evidence for the production of a neutral boson …is presented."



- In Runs 2-3-4-5 of the LHC…and future machines
  - Continue to measure its properties
  - Is it alone?

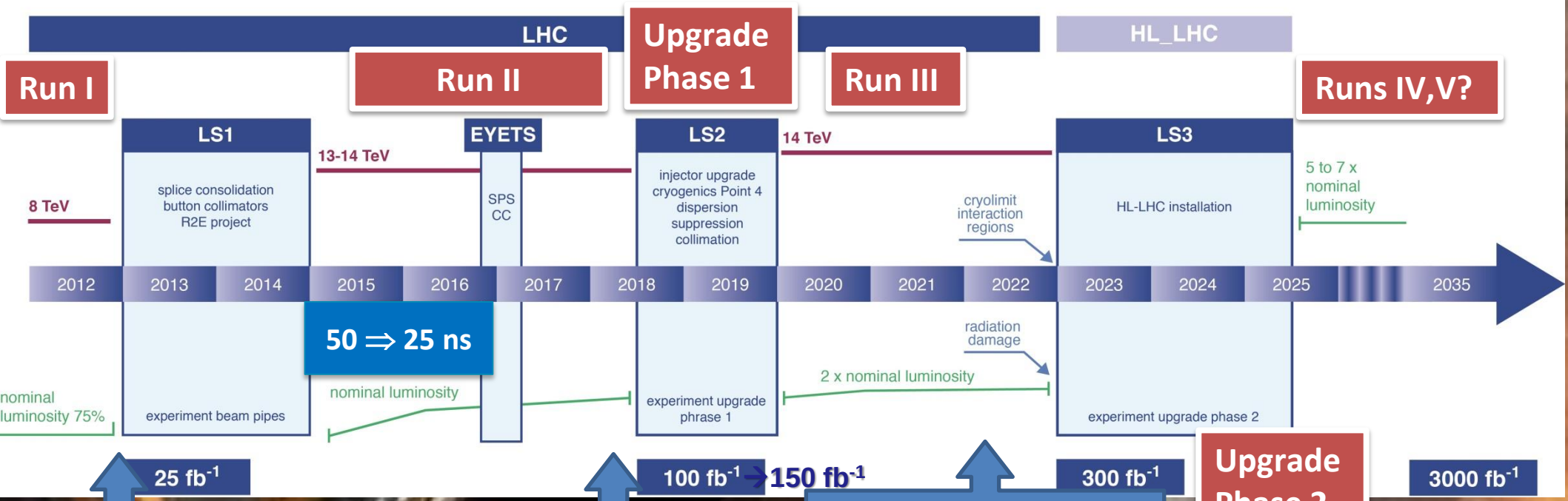
LHC Upgrades Calendar and experimental challenge

Phase 1 Upgrade→Run 3 (2020-2022): twice LHC design luminosity
Event pileup reaches ~50-60 collisions per beam crossing (@ 25 ns)
Factor 5 increase in trigger rates relative to 2012 run
Phase 2 Upgrade→HL-LHC Runs 4,5,..(2025-2035+…): 5-7x LHC design luminosity
Event pileup reaches ~140 collisions per beam crossing (@ 25 ns)
Need solutions to cope with very high rates (10-15 x 2012), radiation and pileup

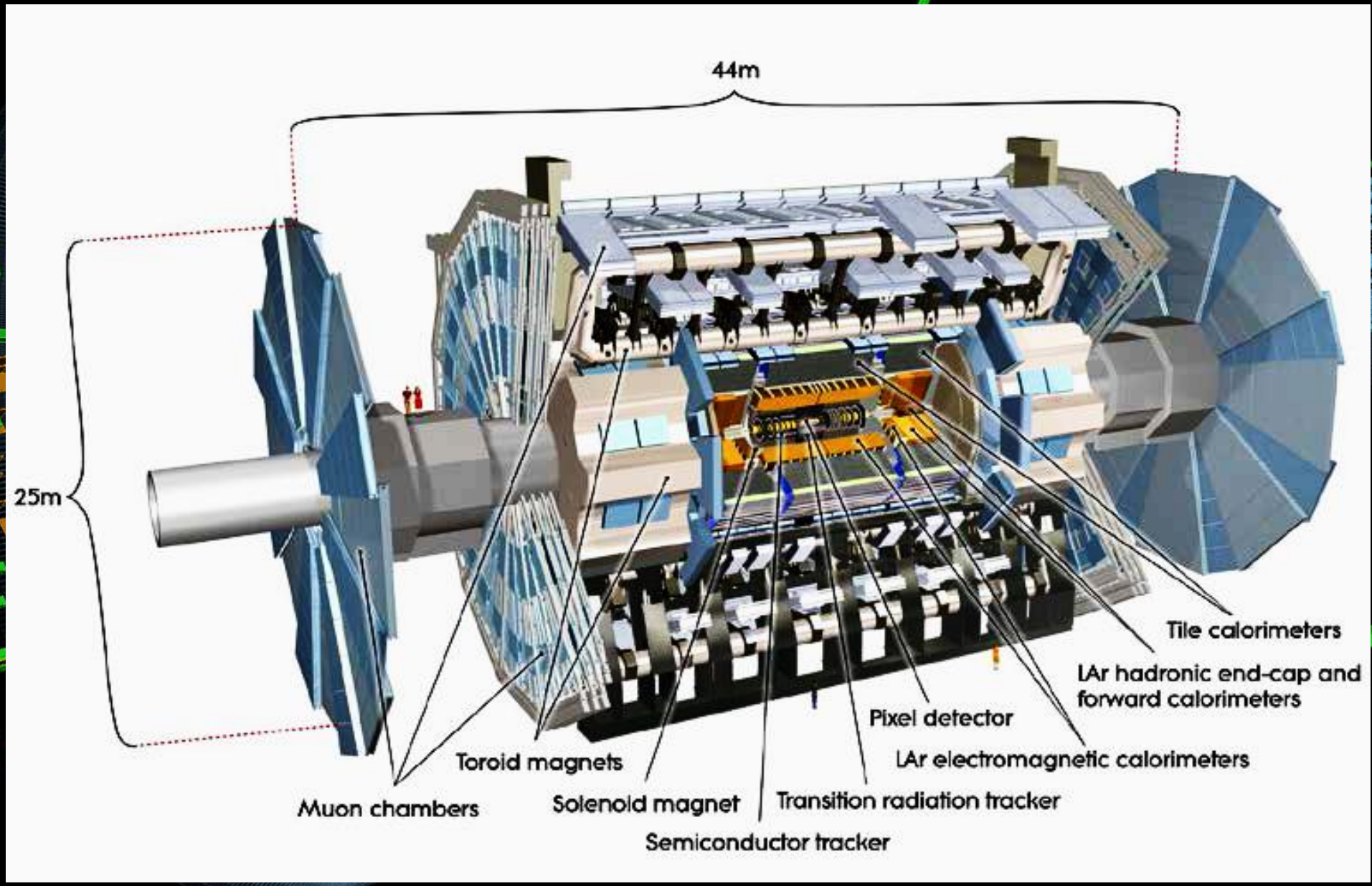
with design L= 1-2 x10^{34} cm^{-2}s^{-1}

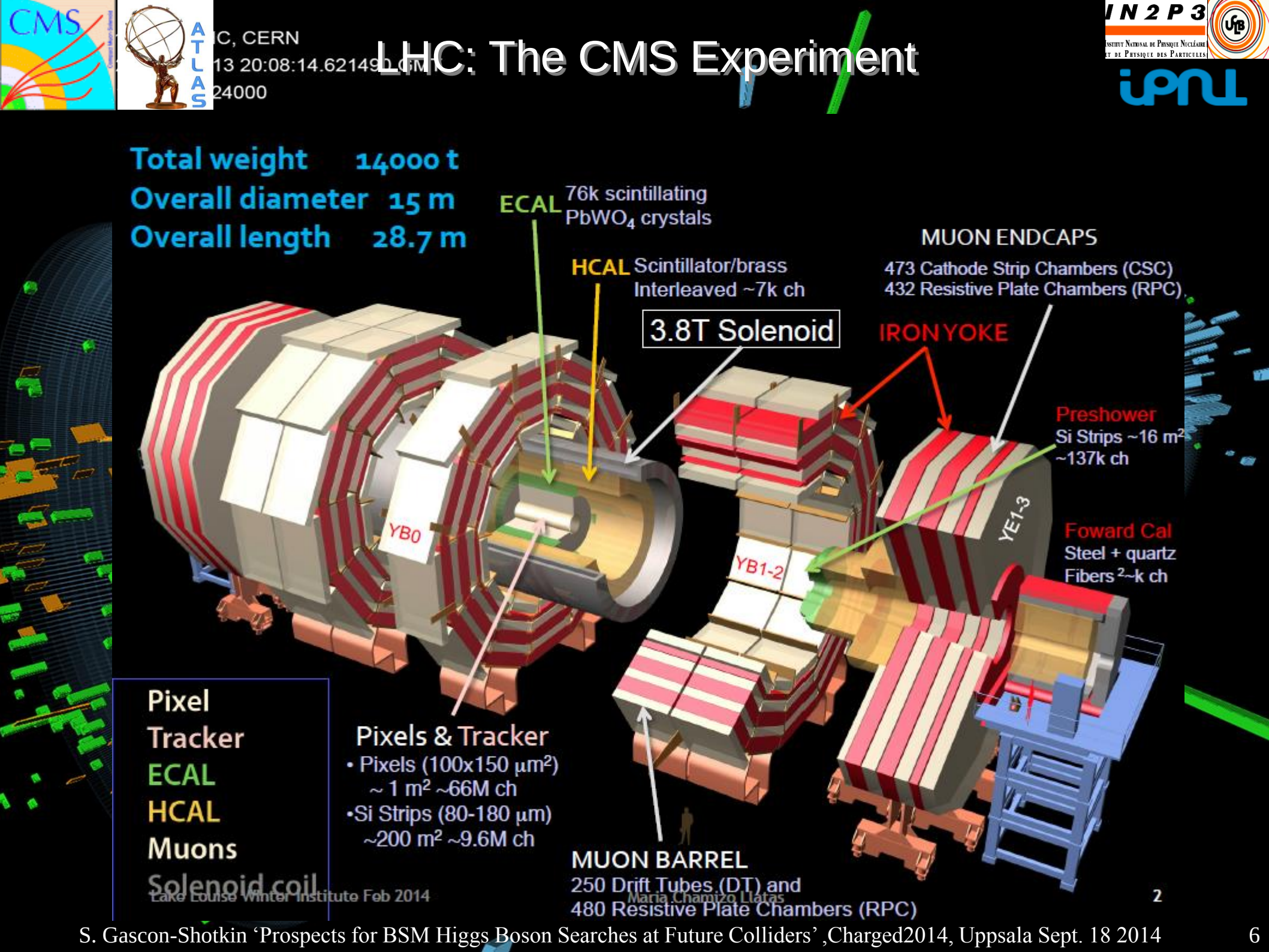
CERN,L. Rossi, HL-LHC Project

New LHC / HL-LHC Plan

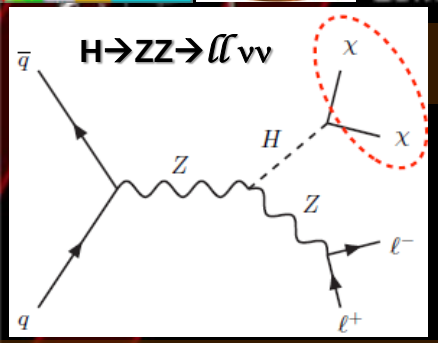


LHC: The ATLAS Experiment




LHC: The CMS Experiment
Total weight 14000 t
Overall diameter 15 m
Overall length 28.7 m
ECAL 76k scintillating PbWO4 crystals
HCAL Scintillator/brass Interleaved ~7k ch
3.8T Solenoid
MUON ENDCAPS
473 Cathode Strip Chambers (CSC)
432 Resistive Plate Chambers (RPC)
IRON YOKE
Preshower
Si Strips ~16 m2
~137k ch
Foward Cal
Steel + quartz
Fibers 2~k ch
YB0
YB1-2
YE1-3
Pixel
Tracker
ECAL
HCAL
Muons
Solenoid coil
Pixels & Tracker
• Pixels (100x150 μm2)
~ 1 m2 ~66M ch
•Si Strips (80-180 μm)
~200 m2 ~9.6M ch
MUON BARREL
250 Drift Tubes (DT) and
480 Resistive Plate Chambers (RPC)
Lake Louise Winter Institute Feb 2014
Maria Chamizo Llatas
2

Higgs Boson Properties: Invisible Branching Fraction and Higgs-Portal Interpretation

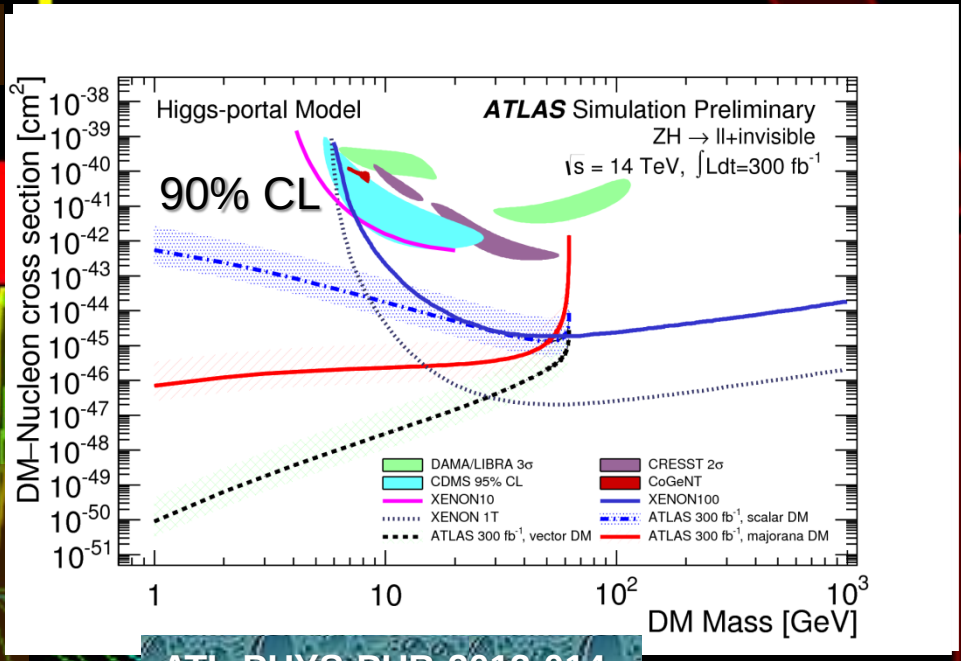


- Maximum LH fit to E_{Tmiss}

H→ZZ→ℓℓνν	ATLAS	CMS
300 fb^{-1}	[23,32]%	[17,28]%
3000 fb^{-1}	[8,16]%	[6,17]%

Ind. couplings	ATLAS	CMS
300 fb^{-1}	[25,28]%	[14,18]%
3000 fb^{-1}	[12,15]%	[7,11]%

- 95% UL on Br_{inv} [real., cons.]:
- Exclusion in σ (DM-nucleon) –m_{DM} plane: sensitivity up to $m_H/2$, complementary to direct detection DM experiments



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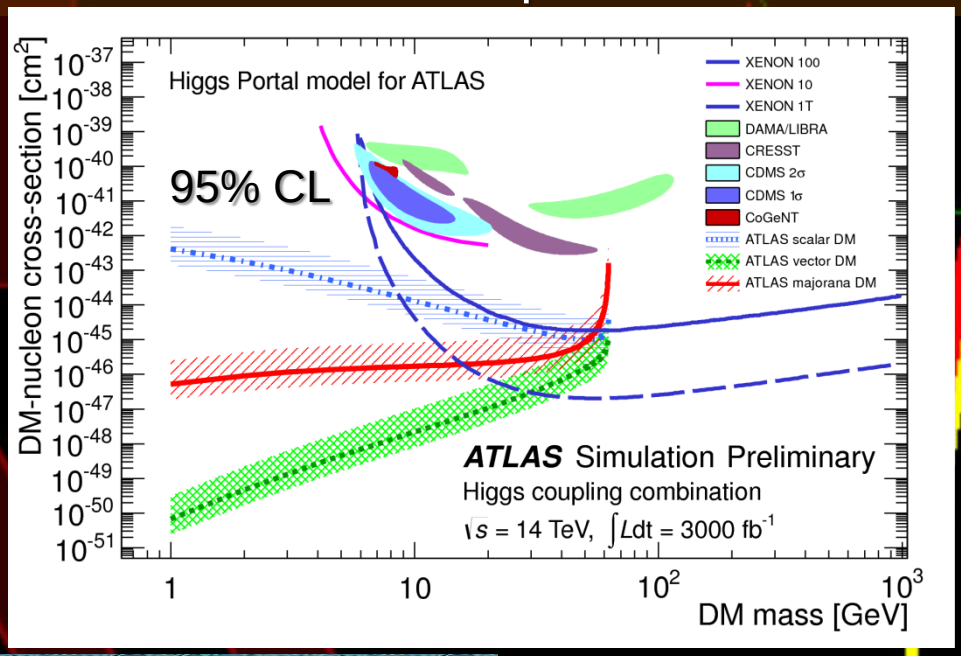

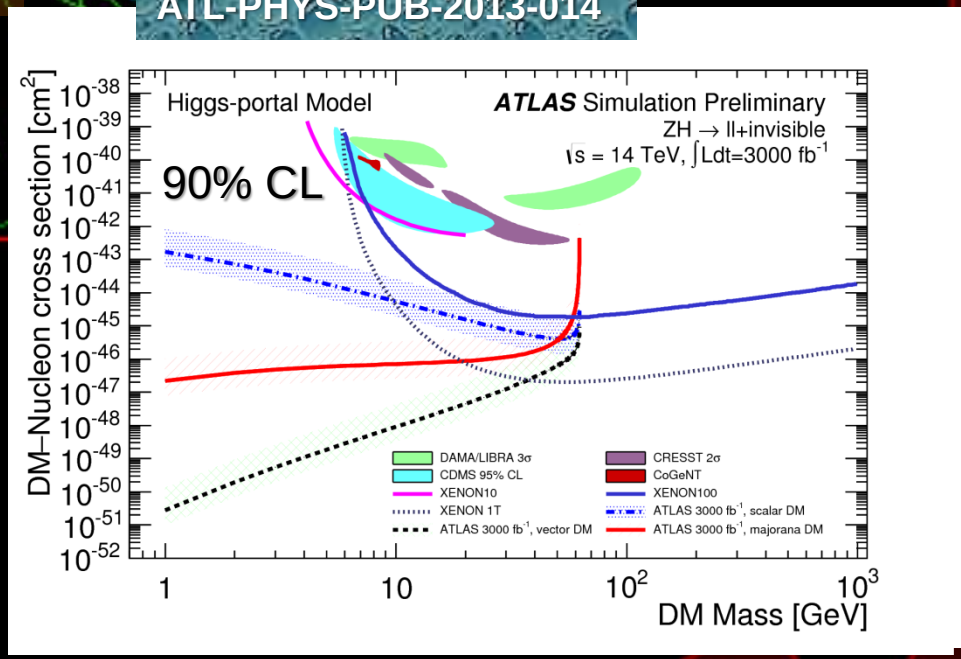

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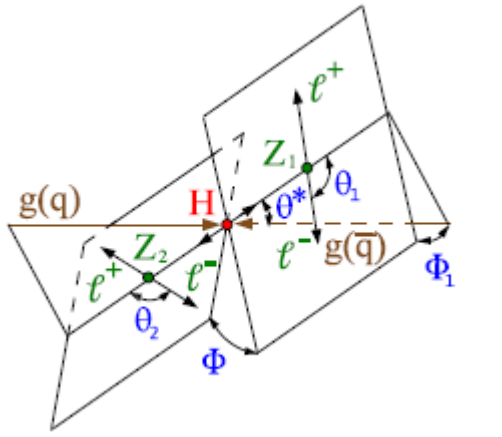
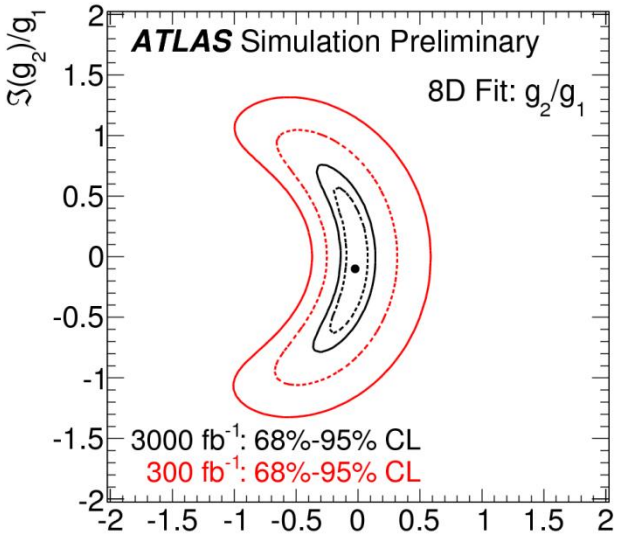
Higgs Boson Properties: Field Strength Tensor Structure via H→ZZ*→4ℓ

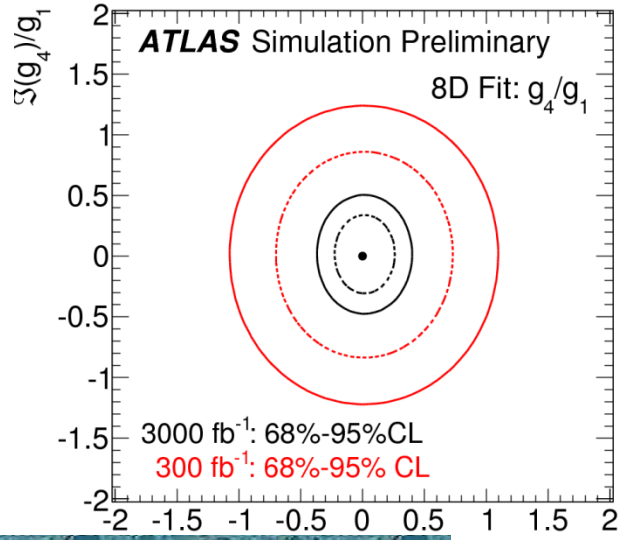
$$A(H \to ZZ) = v^{-1}\left(\underbrace{a_1 m_Z^2 \epsilon_1^* \epsilon_2^*}_{\text{SM tree process}} + \underbrace{a_2 f_{\mu\nu}^{*(1)} f^{*(2),\mu\nu}}_{\text{loop CP-even contributions}} + \underbrace{a_3 f_{\mu\nu}^{*(1)} \tilde{f}^{*(2),\mu\nu}}_{\text{CP-odd contributions (BSM)}}\right)$$



$(m_{4l}, m_{Z_{1,2}}, \theta_{1,2}, \varphi, \varphi_1, \theta^*)$

- Test for presence of extra anomalous CP-even (coupling $a_2 \leftrightarrow g_2$) and CP-odd (coupling $a_3 \leftrightarrow g_4$) components
- 8D fit involving kinematical variables sensitive to a_2 and a_3 with free parameters $Re(a_i)/a_1$ and $Im(a_i)/a_1$, i={2,3}





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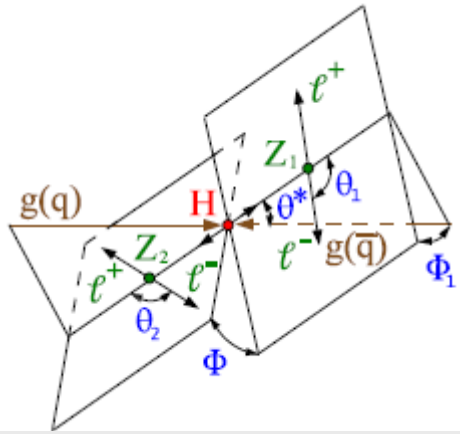
- 95% CL limits: (0,0) corresponds to pure CP-even '0+' SM state
- Factor ~2-3 improvement in precision between 300 and 3000fb-1

Luminosity	$\lvert g_4\rvert/g_1$	$\Re(g_4)/g_1$	$\Im(g_4)/g_1$	$\lvert g_2\rvert/g_1$	$\Re(g_2)/g_1$	$\Im(g_2)/g_1$
300 fb-1	1.20	(-0.88, 0.91)	(-1.02, 1.05)	1.02	(-0.84,0.44)	(-1.19, 1.18)
3000 fb-1	0.60	(-0.30, 0.33)	(-0.39, 0.42)	0.60	(-0.30,0.11)	(-0.71, 0.68)

Higgs Boson Properties: Field Strength Tensor Structure via H→ZZ*→4ℓ

$$A(H \to ZZ) = v^{-1}\left(a_1 m_Z^2 \epsilon_1^* \epsilon_2^* + a_2 f_{\mu\nu}^{*(1)} f^{*(2),\mu\nu} + a_3 f_{\mu\nu}^{*(1)} \tilde{f}^{*(2),\mu\nu}\right)$$

SM tree process | loop CP-even contributions | CP-odd contributions (BSM)



$(m_{4l}, m_{Z_{1,2}}, \theta_{1,2}, \varphi, \varphi_1, \theta^*)$

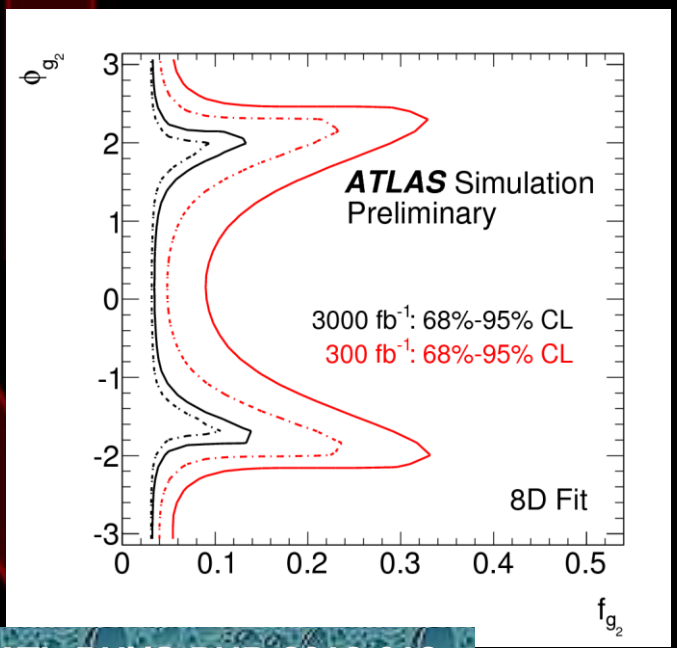
- Alternative method: Fit fraction of events f_{ai} and phases ϕ_i in 0- contribution to kinematic discriminant distribution
- 95% CL limits:

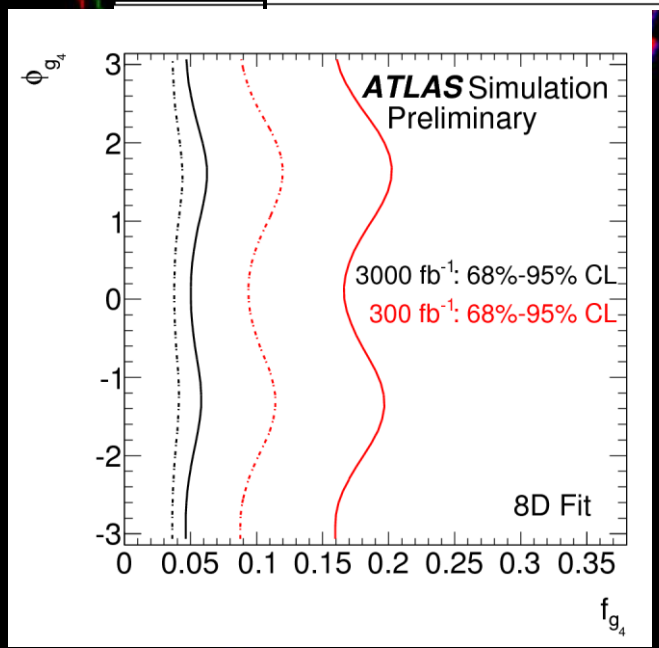
$$f_{a_i} = \frac{|a_i|^2\sigma_i}{|a_1|^2\sigma_1 + |a_i|^2\sigma_i} \qquad \phi_{a_i} = \arg\left(\frac{a_i}{a_1}\right)$$

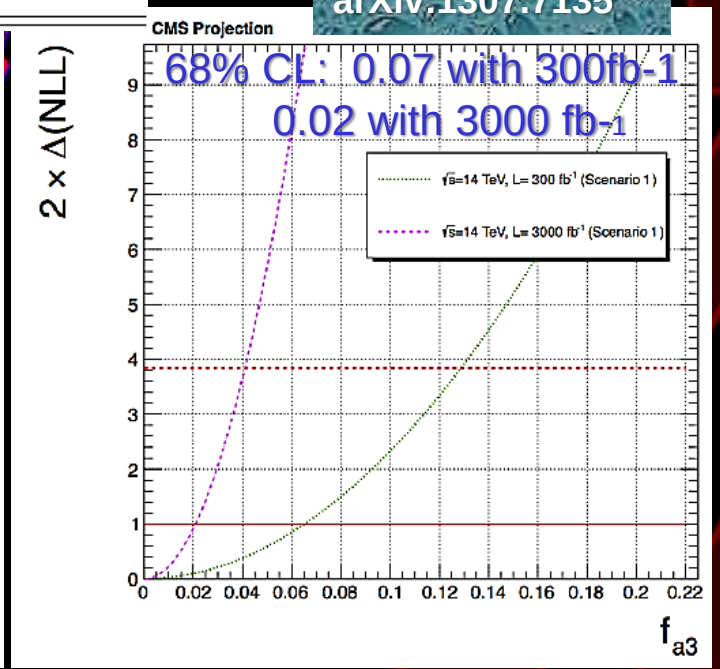
CMS 95% CL ATLAS

f_{g4}	Luminosity	f_{g4}	f_{g2}
0.13	300 fb^{-1}	0.20	0.29
0.04	3000 fb^{-1}	0.06	0.12

CMS-FTR-13-013, arXiv:1307.7135



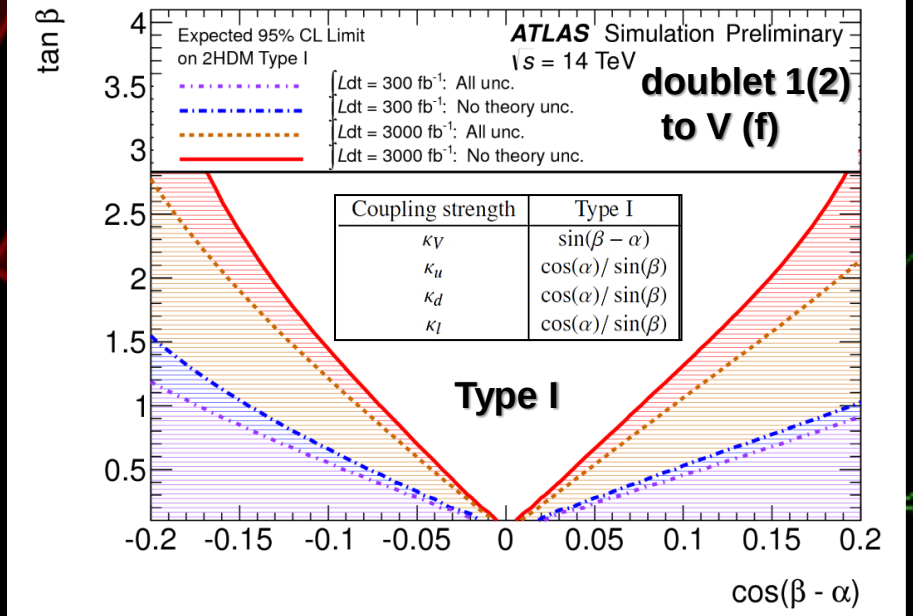


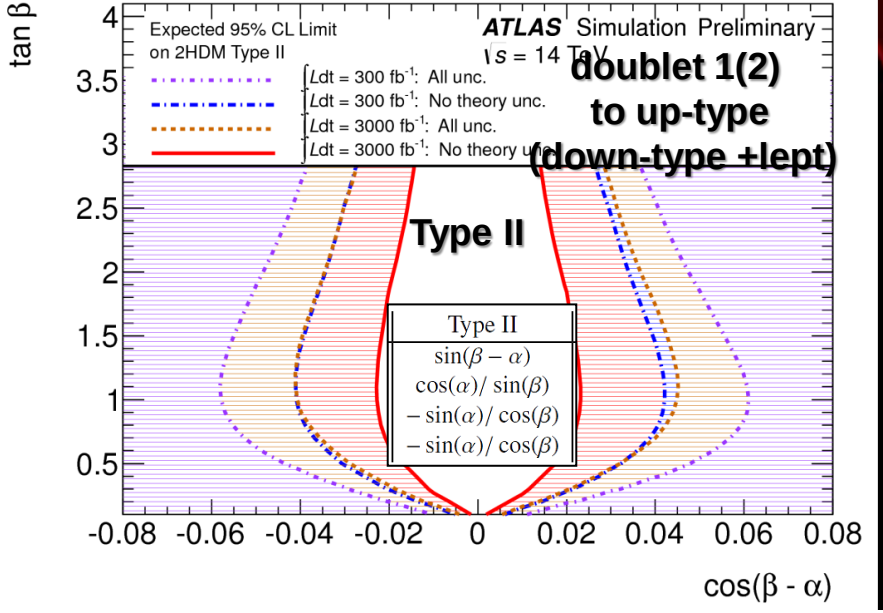


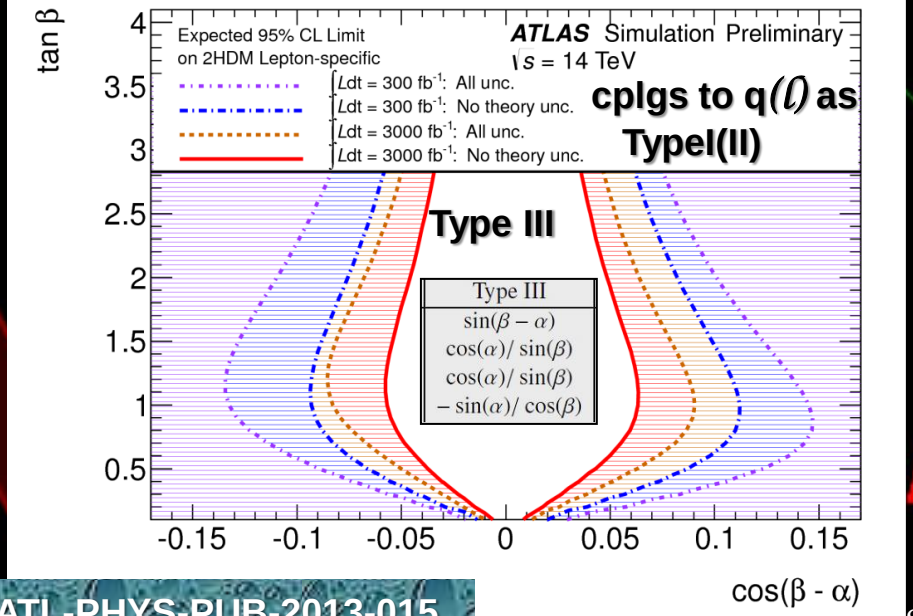
ATL-PHYS-PUB-2013-013

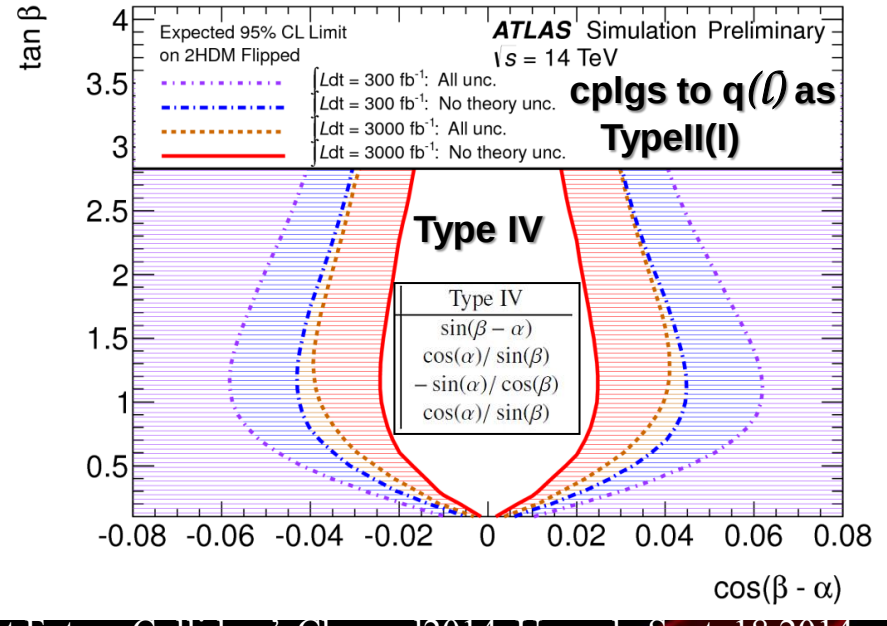
Search for additional (BSM) Higgs bosons: from coupling measurement reinterpretation

- Rescale production and decay rates as functions of the couplings κV, κu, κd, and κℓ



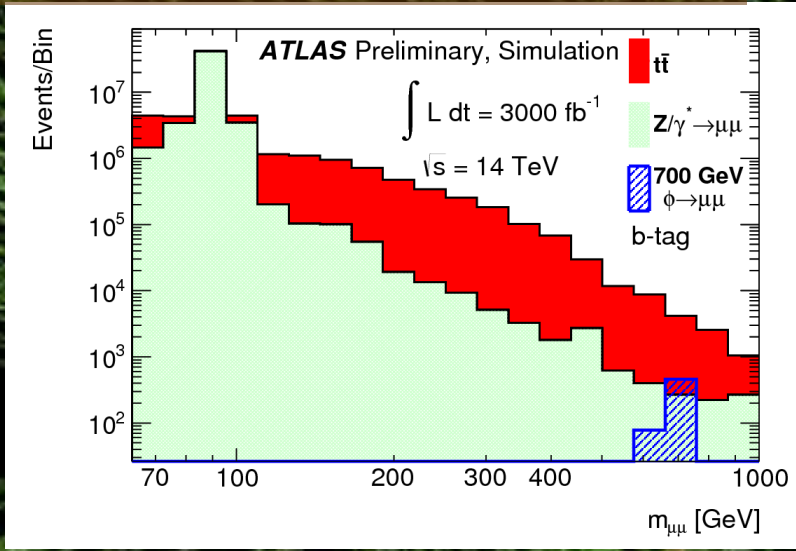


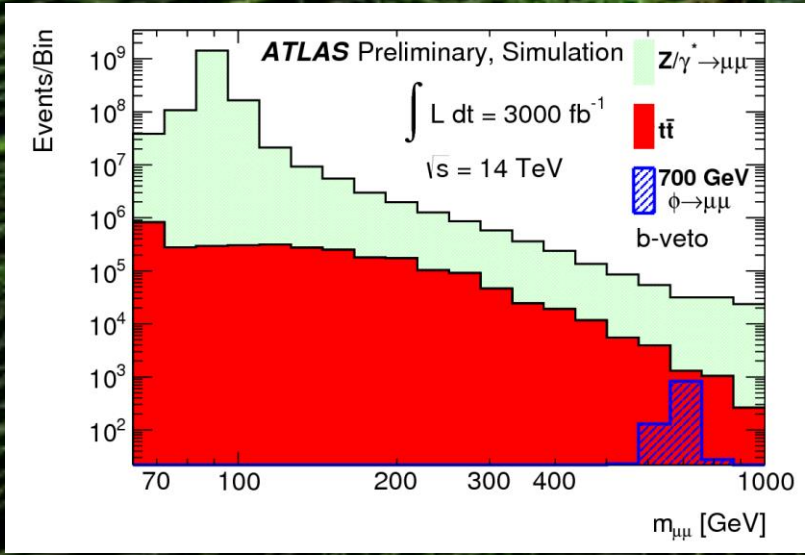




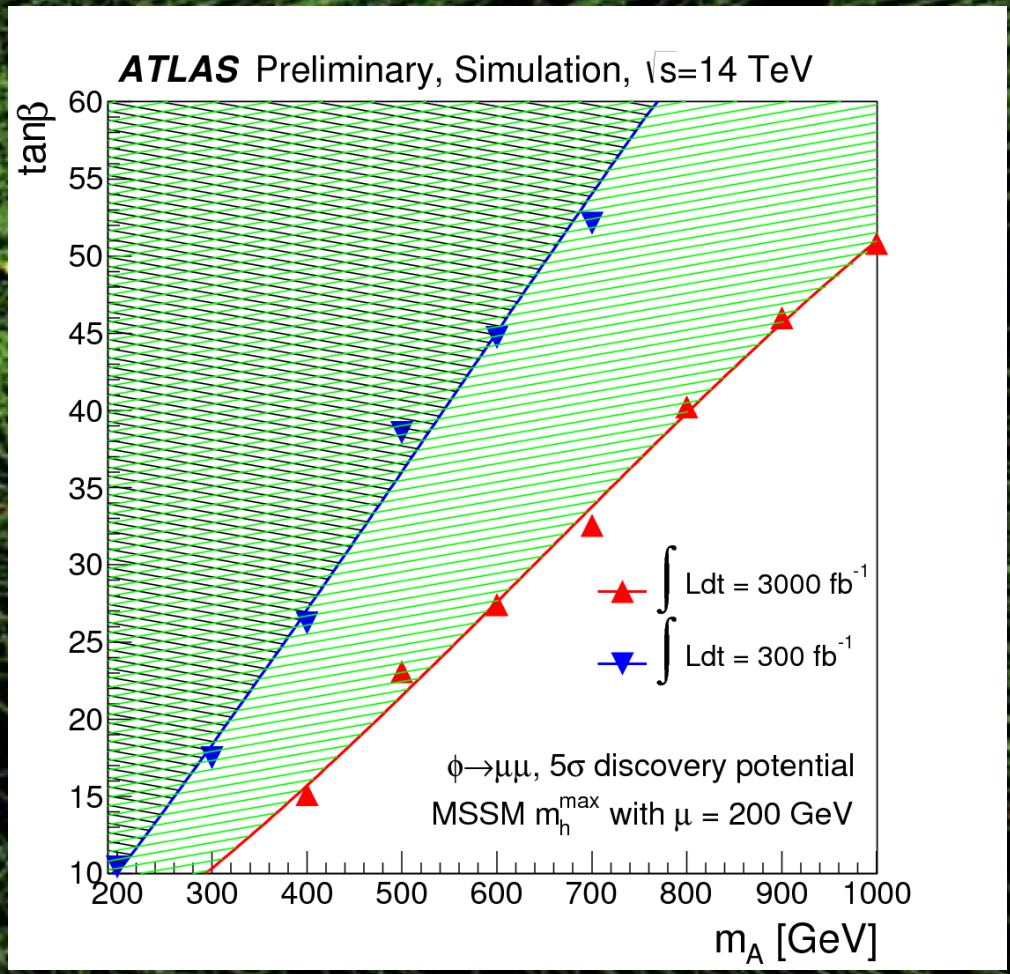
Search for additional (BSM) Higgs bosons: via H/A→μμ

- Binned LH fit to the $\mu^+ \mu^-$ mass distribution, 2 categories (with and without b-tag)



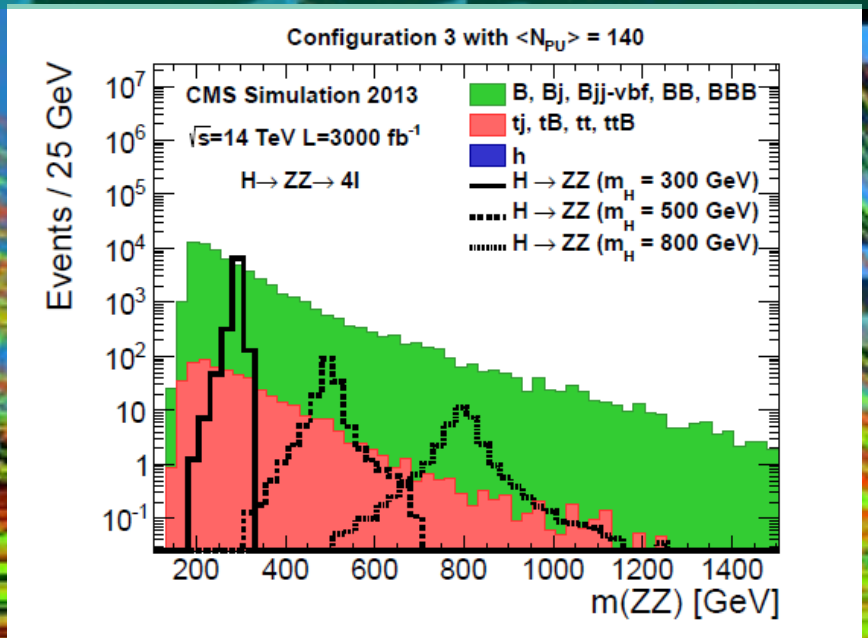


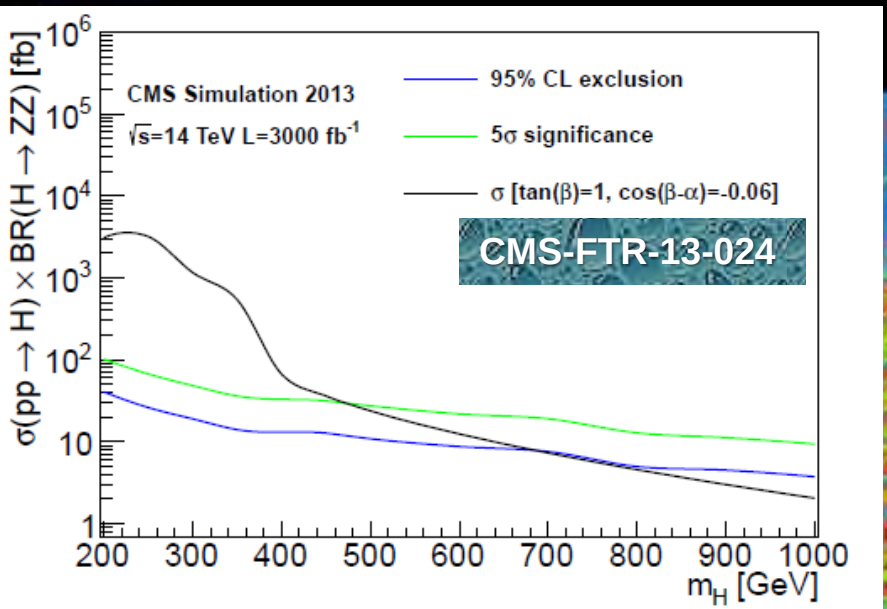
- 5σ contours in the tanβ-mA plane in MSSM, mhMax scenario:

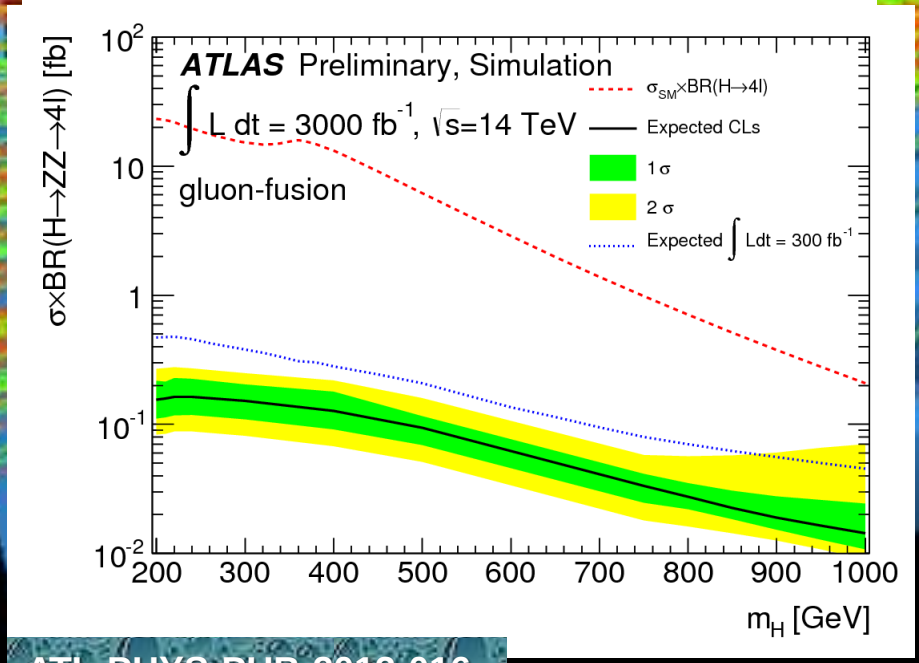


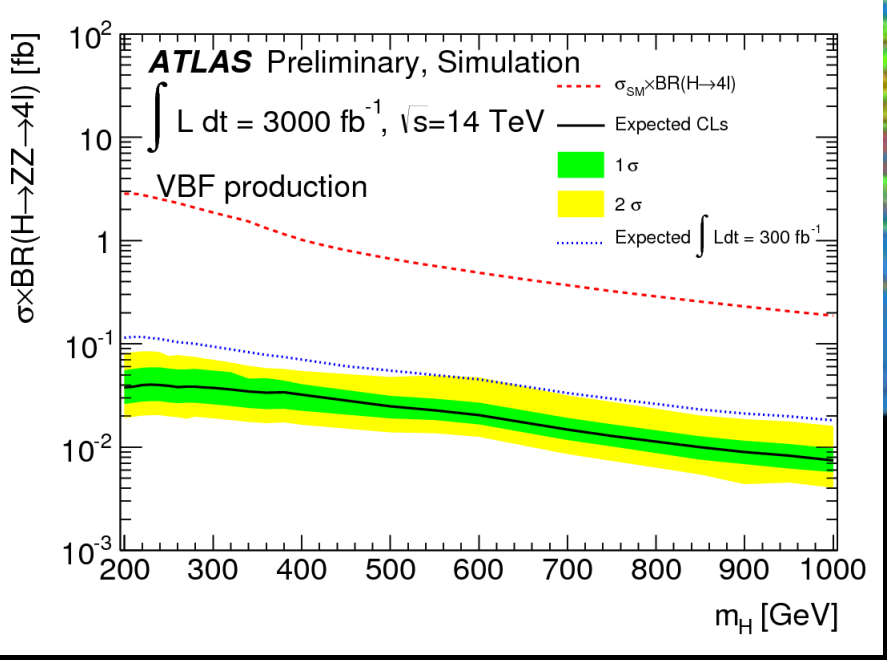
Search for additional (BSM) Higgs bosons via H→ZZ→4ℓ

- σ X BR limits as function of m_H 3000fb-1 (ATLAS includes BR to 4ℓ), probe up to factor 40 below SM





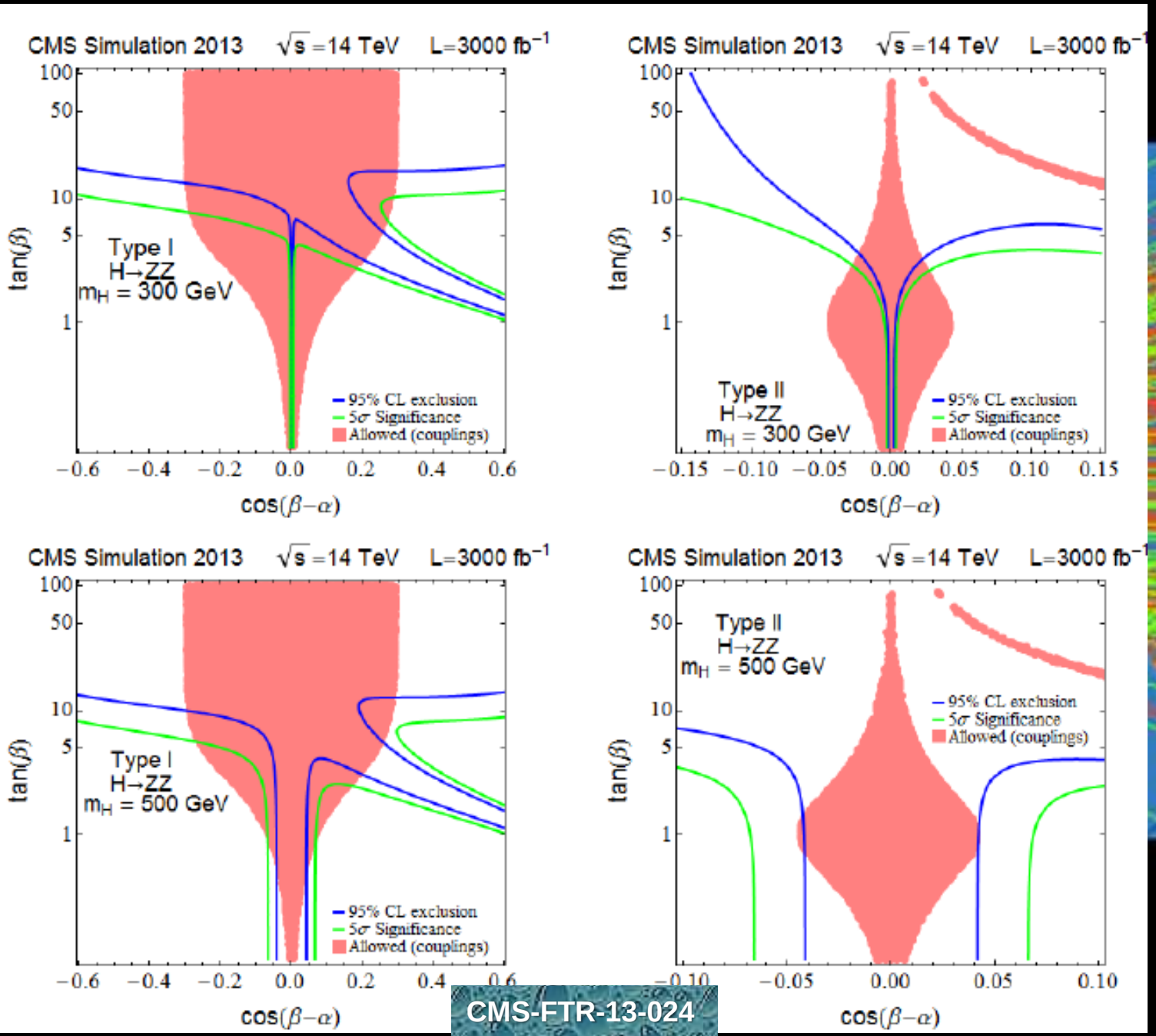




ATL-PHYS-PUB-2013-016

Search for additional (BSM) Higgs bosons via H→ZZ→4ℓ

- CMS: 5σ (green) and 95% exclusion (blue) contours in the tanβ-cos(β–α) plane, 2HDM Types I, II for 3000fb-1
- Compare to zone allowed by non-observation of deviations from the SM in coupling measurements (pink) [white zones in slide 10]

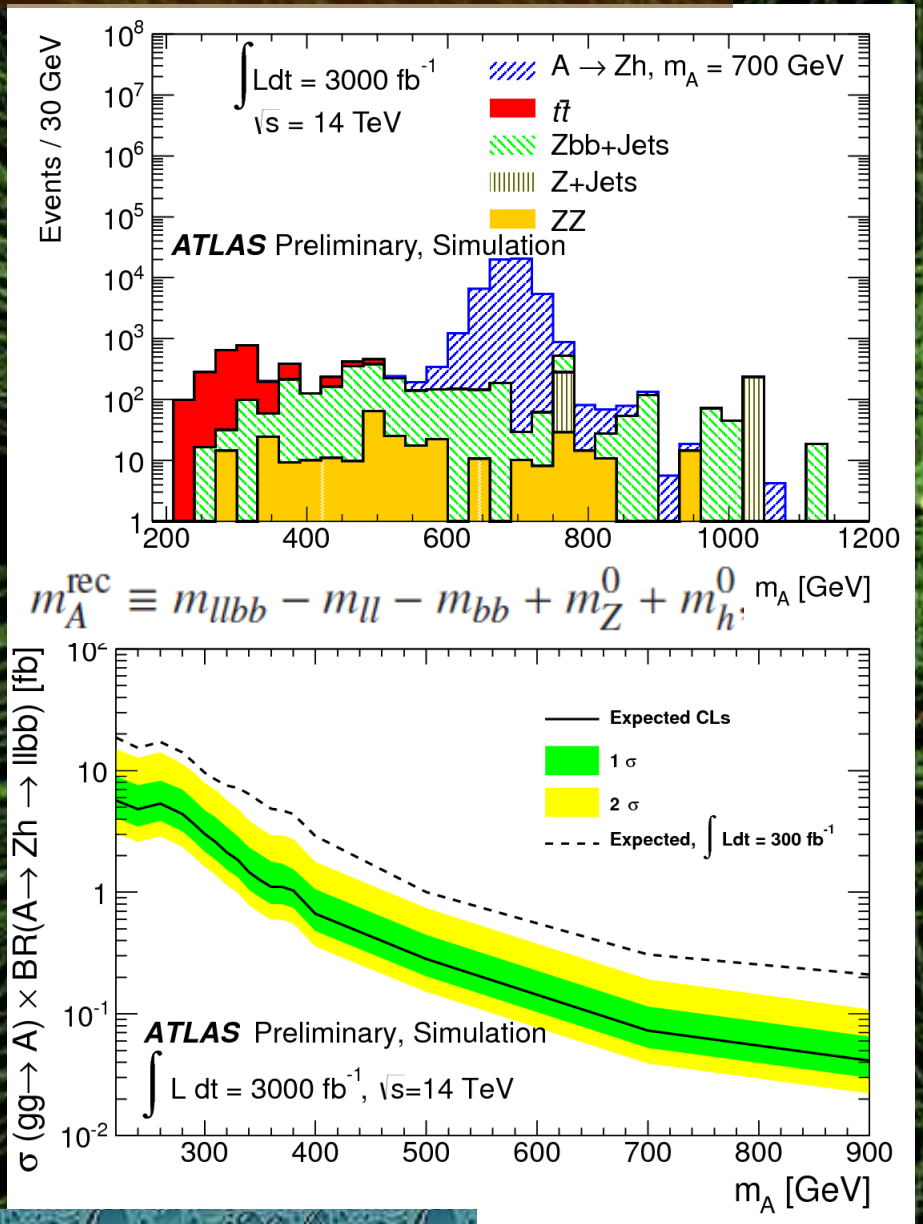


CMS-FTR-13-024

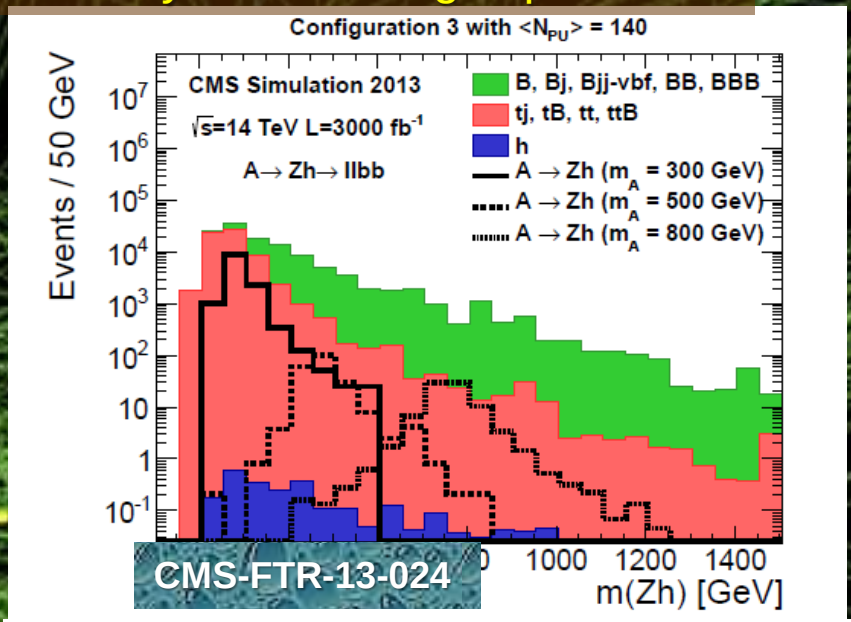
Search for additional (BSM) Higgs bosons via A→Zh→ℓℓbb

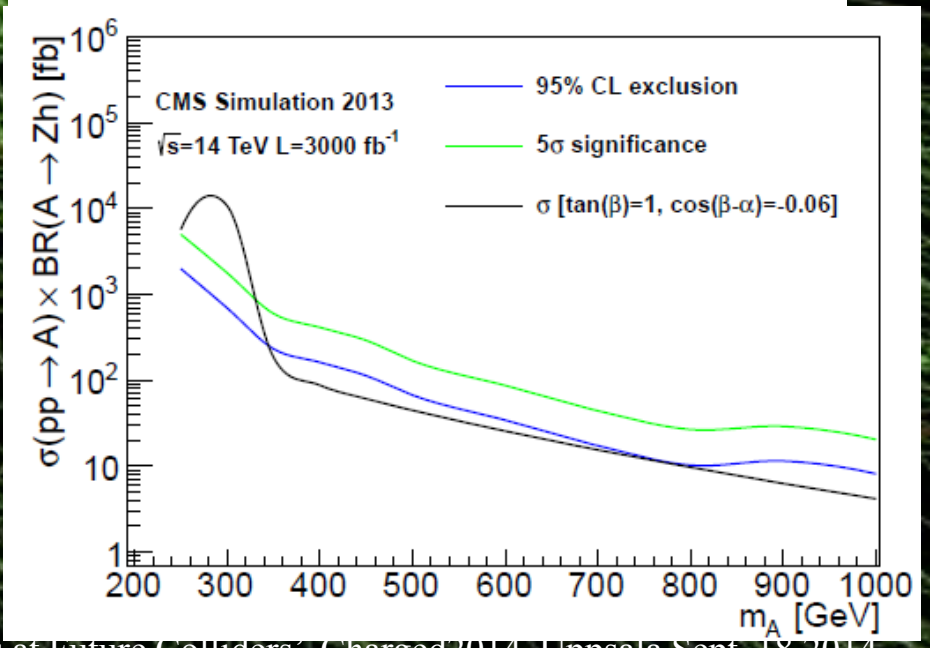
- σ X BR limits as function of m_A 3000fb-1 (ATLAS includes BR to ℓℓbb)

Binned LH fit to m_A



Bin-by-bin counting experiment





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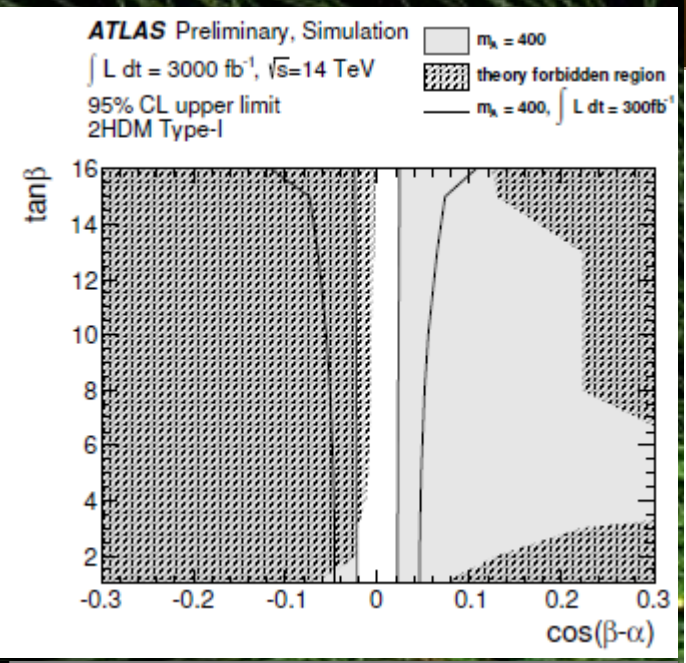
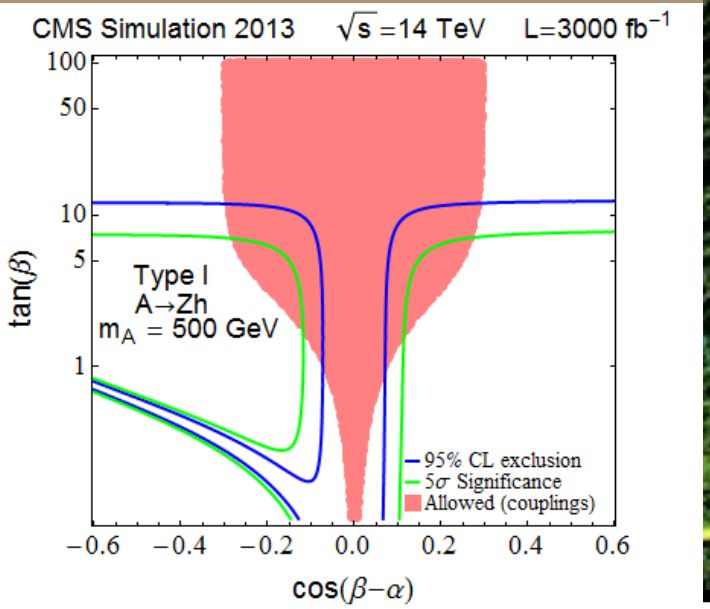
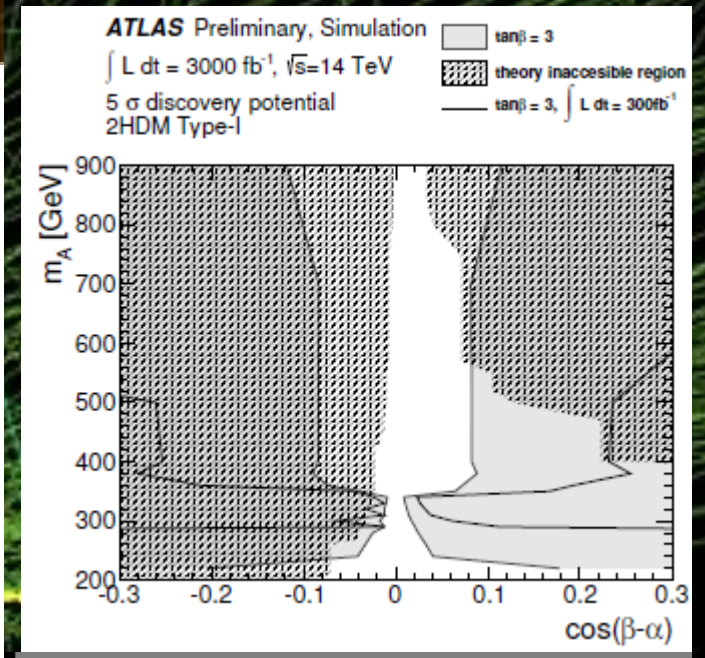
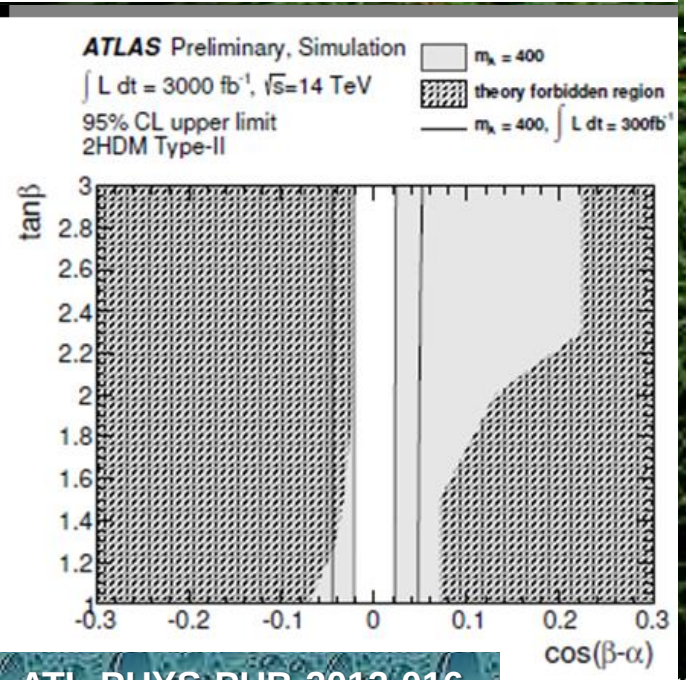
Search for additional (BSM) Higgs bosons via A→Zh→ℓℓbb

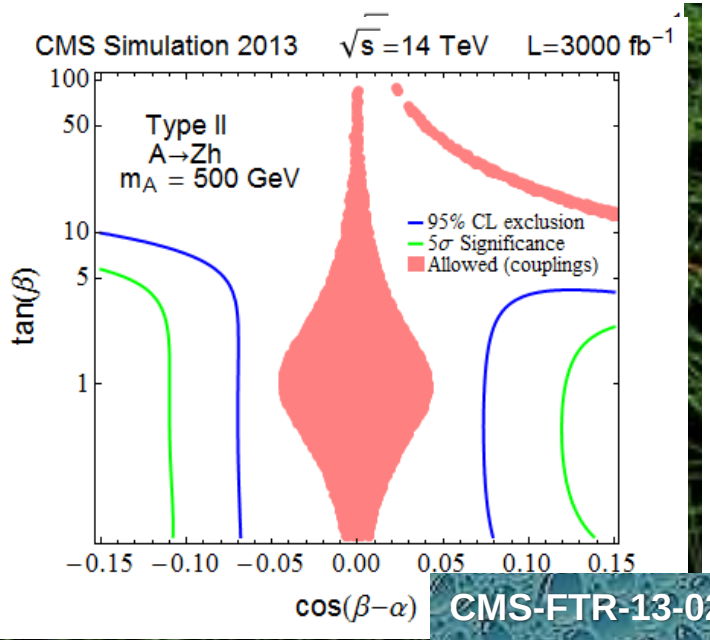
Interpretation in 2HDM I, II

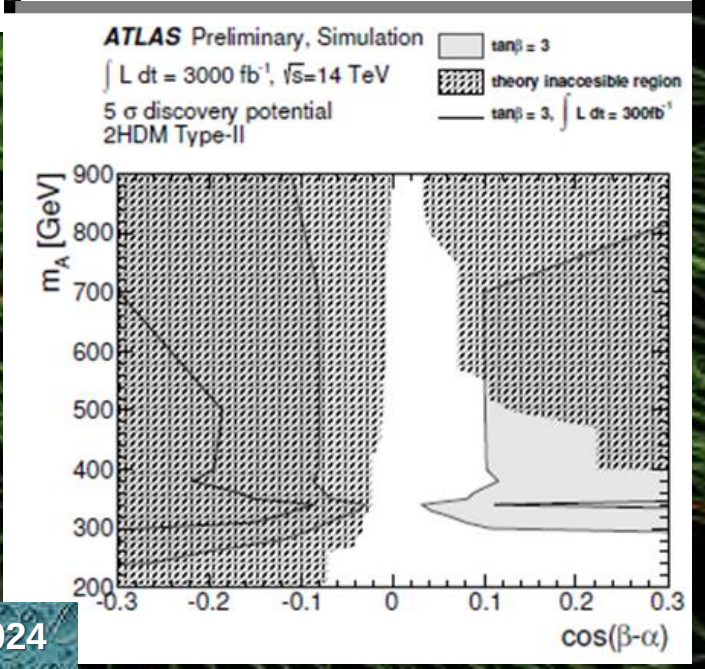












CMS-FTR-13-024

ATL-PHYS-PUB-2013-016

Future e+e- H Physics program/ILC timetable

Integrated Luminosity (ab^{-1})

K. Kawagoe (modified)

Existing Physics :

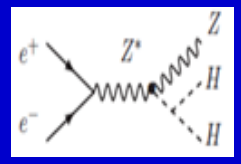
→ Higgs and Top Quark

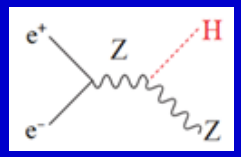
- Learn "everything" about H (125)
- Probe dynamics of EWSB

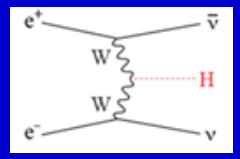
New Physics beyond SM:

- Direct or indirect DM searches
- Evidence for BSM physics
- Hints of a new mass scale

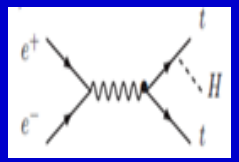
HHZ







HZ $\bar{\nu}\nu H$ $\bar{t}t$



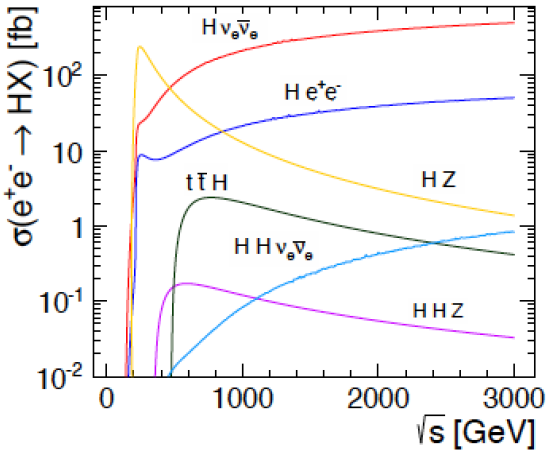
$\bar{t}tH$

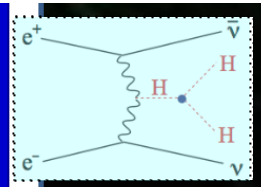
E cm (GeV)

2 1

200 300 400 500 600

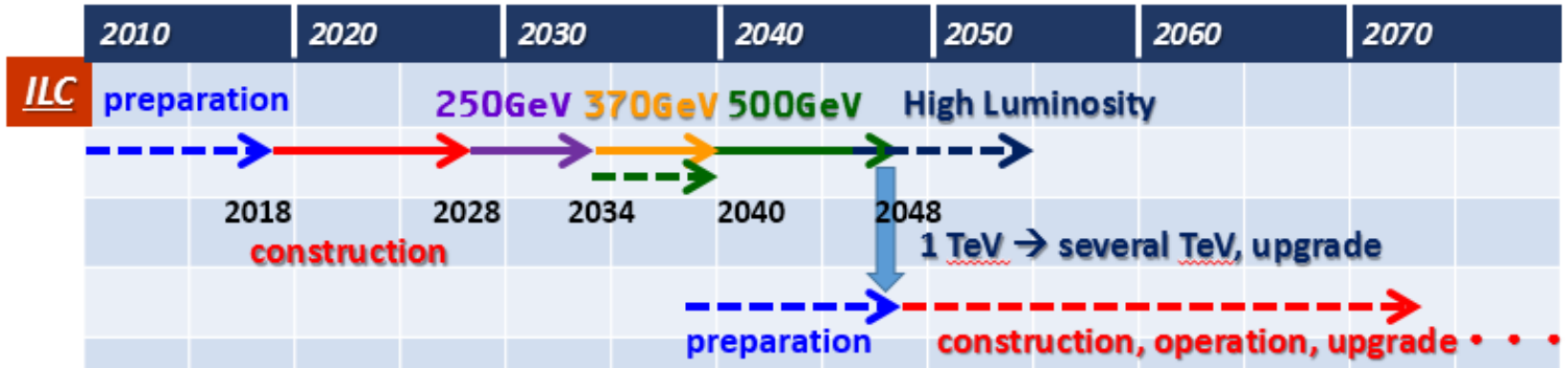
Production xsects.





ILC timetable

A. Yamamoto, ICHEP14



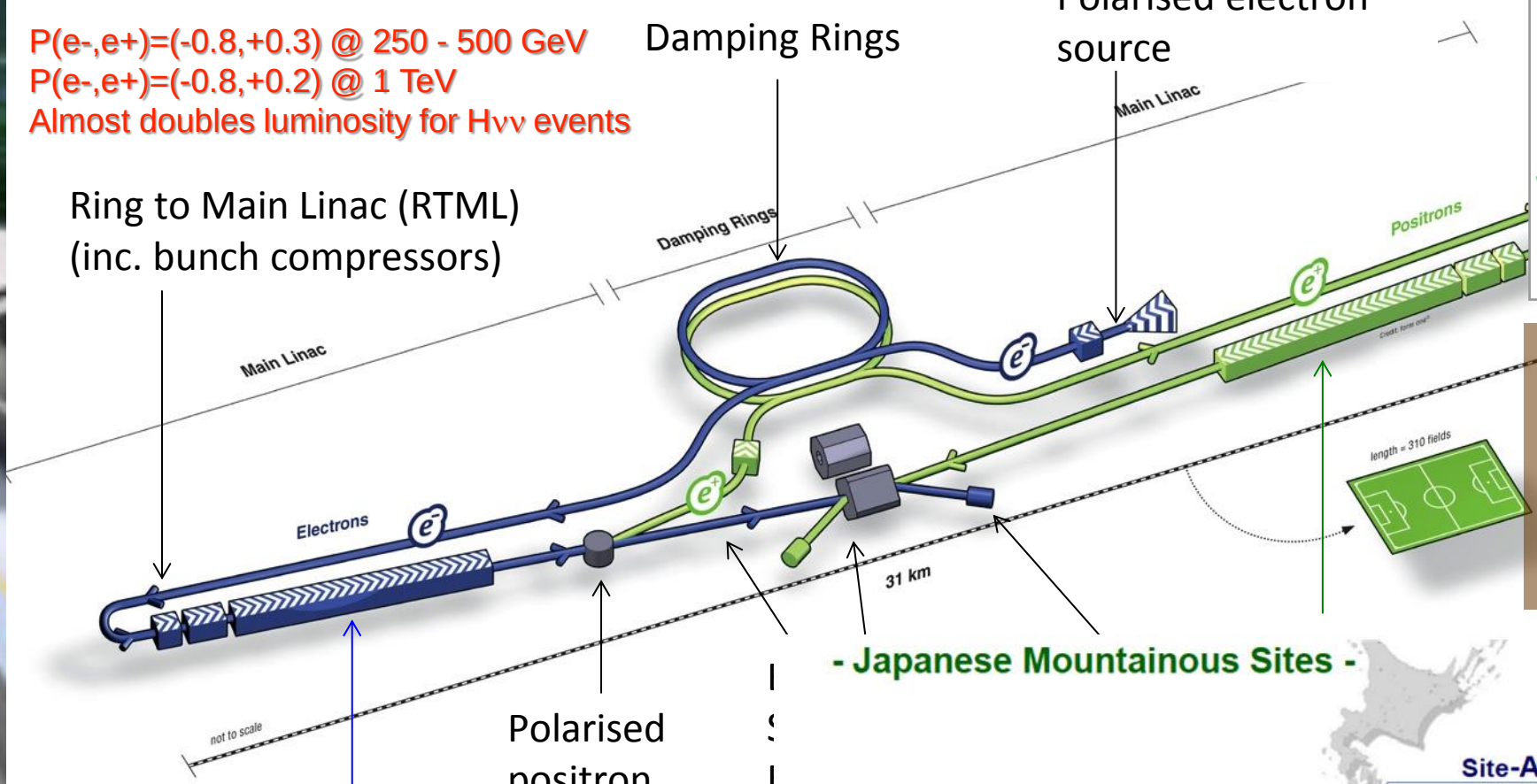
The International Linear Collider (ILC)

P(e-,e+)=(-0.8,+0.3) @ 250 - 500 GeV
P(e-,e+)=(-0.8,+0.2) @ 1 TeV
Almost doubles luminosity for Hνν events

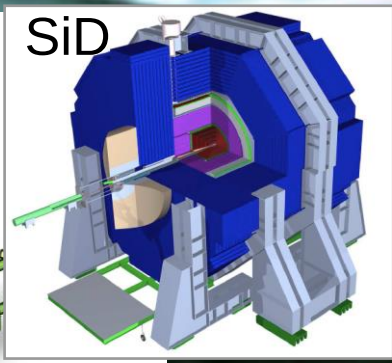
Damping Rings

Polarised electron source

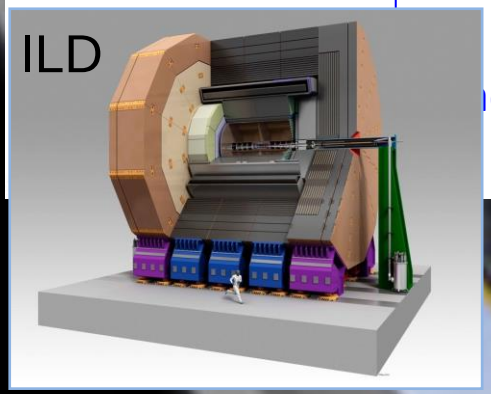
Ring to Main Linac (RTML)
(inc. bunch compressors)



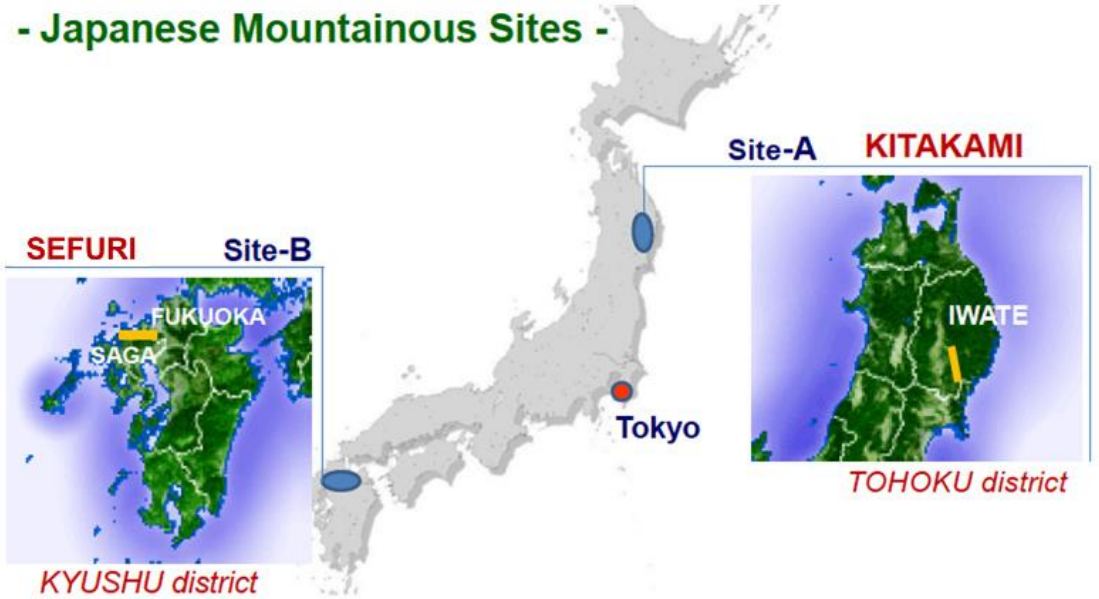
Polarised positron source



TDR finished June 2013 (http://www.linearcollider.org/ILC/Publications/Technical-Design-Report)



- Japanese Mountainous Sites -



The Compact Linear Collider (CLIC)

CERN existing LHC

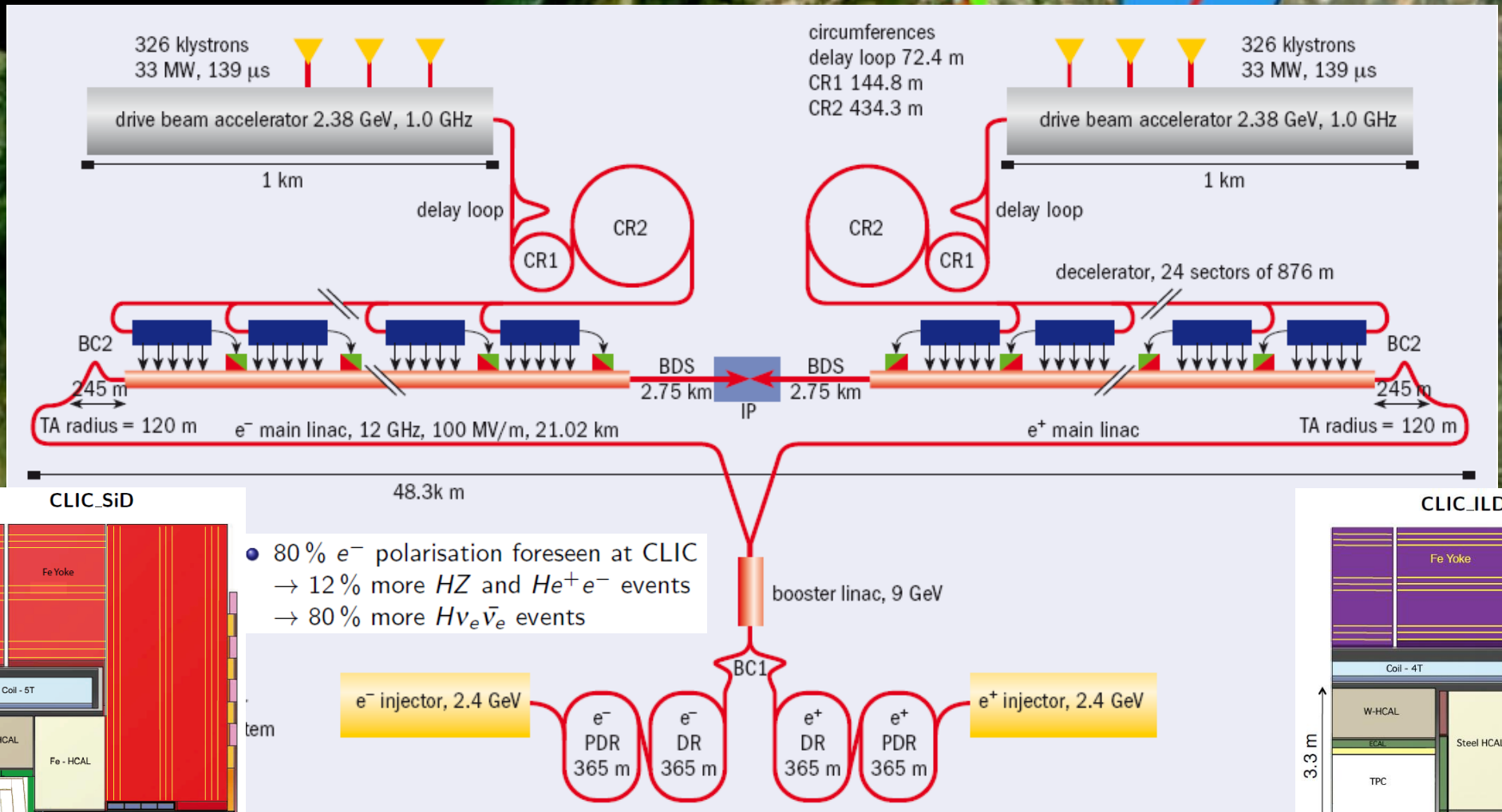
Potential underground siting :

- CLIC 500 Gev
- CLIC 1.5 TeV
- CLIC 3 TeV

CLIC

- e+e- 500 - 3000 GeV
- x-band accelerator technology
- 2-beam acceleration
- $\mathscr{L} \sim 2\text{-}6\times10^{34}$

- Envisioned lower bound on CoM is now 350 GeV
- Physics ~2033



- 80 % e^- polarisation foreseen at CLIC
  → 12 % more HZ and He^+e^- events
  → 80 % more $H\nu_e\bar{\nu}_e$ events

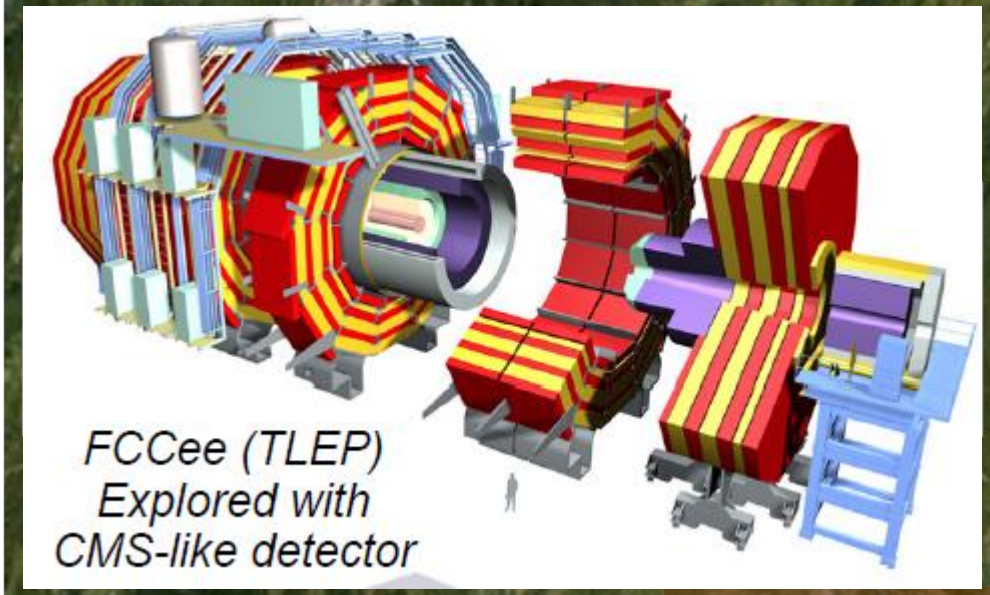
CLIC_SiD

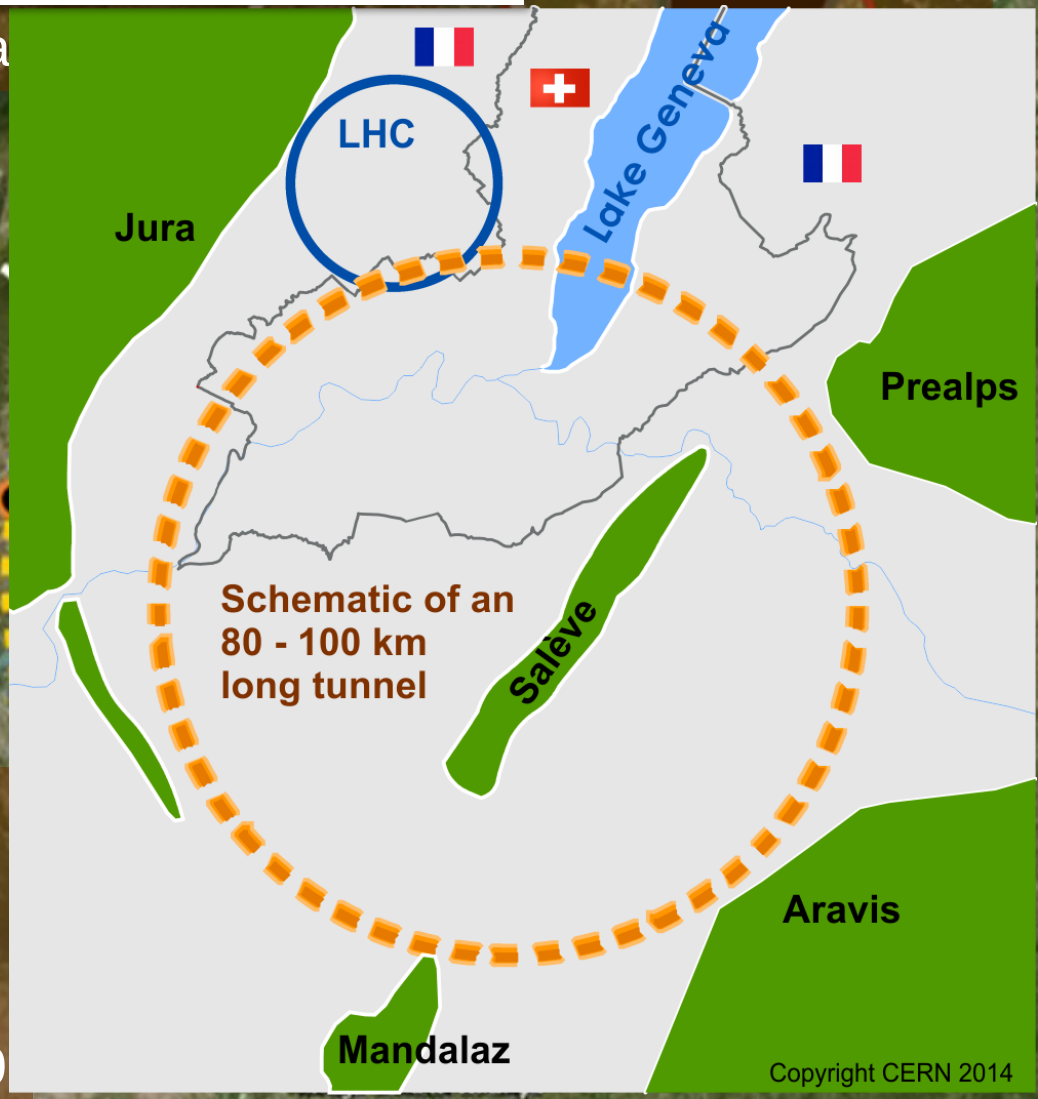
CLIC_ILD

The Future Circular Collider (FCC)

- pp collider (FCC-hh, protons or ions) – 100 TeV CoM – defines infrastructure.
- e+e- collider (FCC-ee/TLEP) – 80-350 GeV CoM – as potential intermediate step.
- e-p option (FCC-eh)
- Organized as an international collaboration, Infrastructure in Geneva area

Reference: TLEP/FCC-ee physics
1308.6176, JHEP 01 (2014) 164

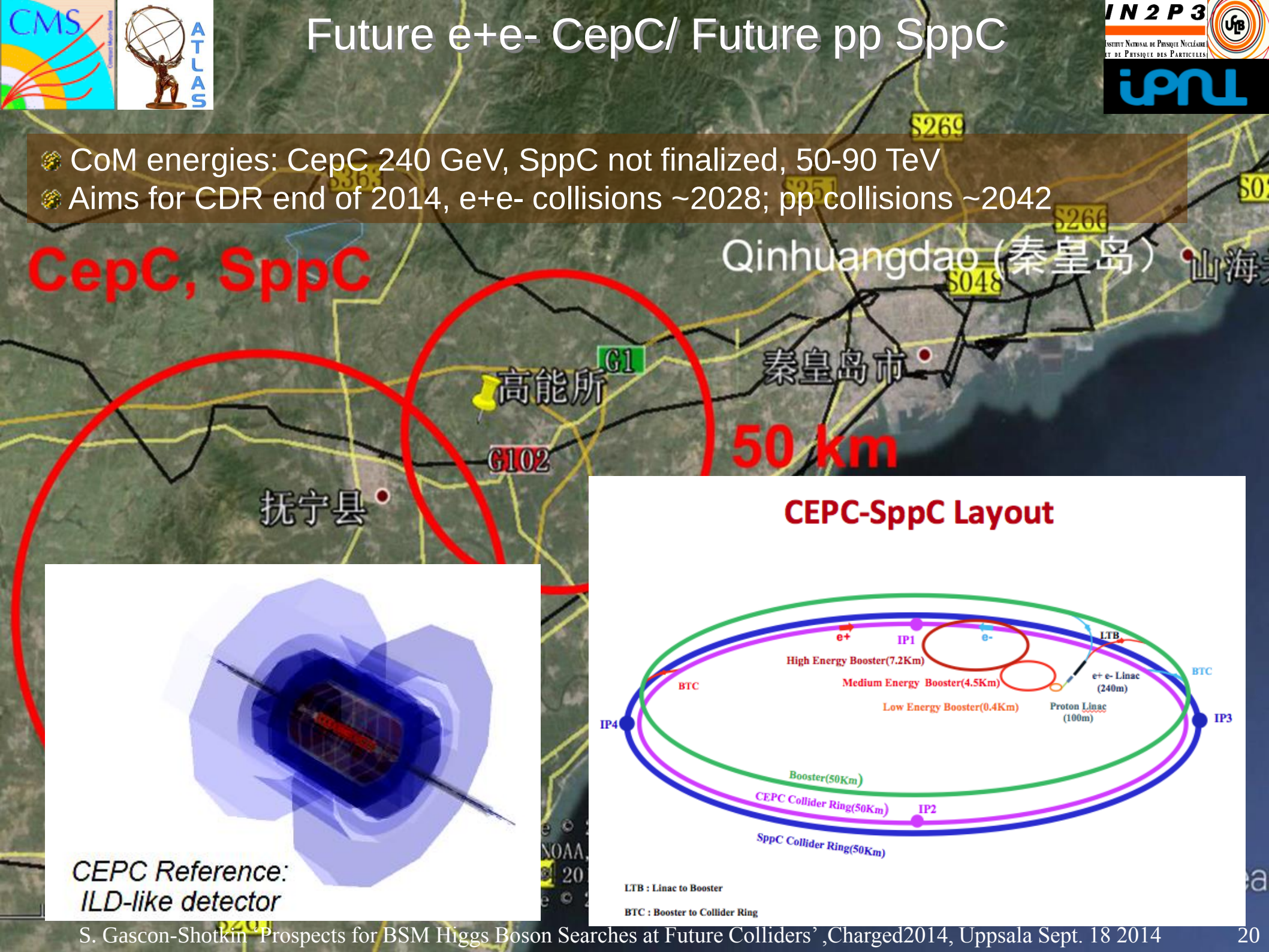




- Aim for CDR/Cost Review for next ESG (2018)
- Physics ~2040

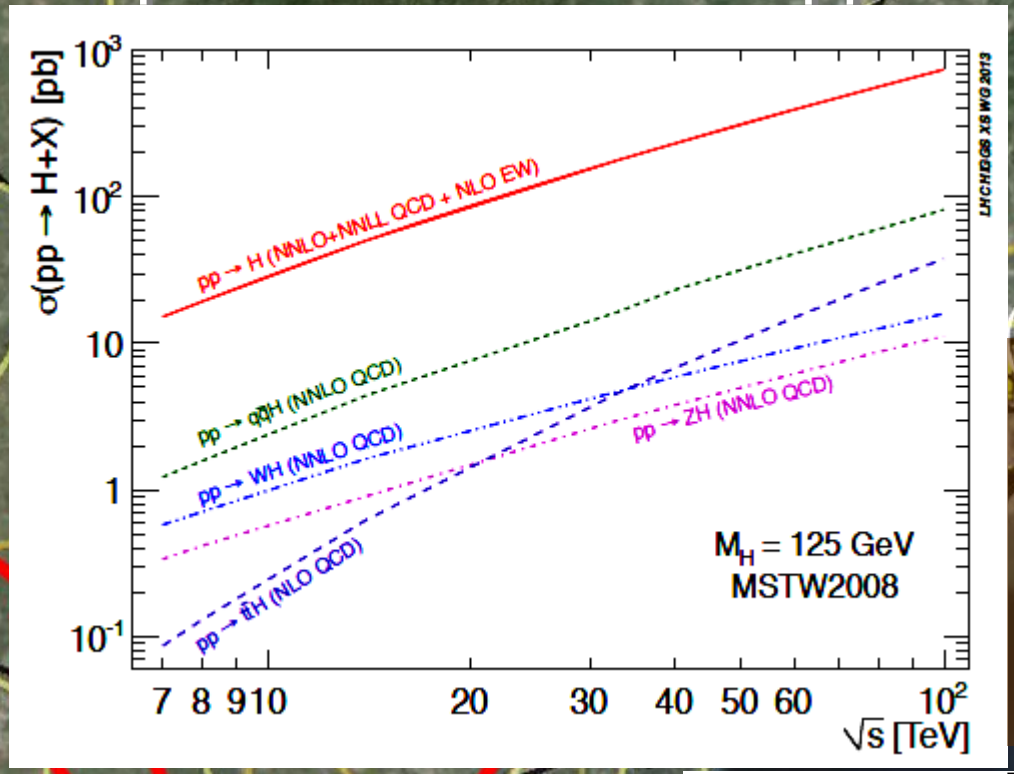
Future e+e- CepC/ Future pp SppC

- CoM energies: CepC 240 GeV, SppC not finalized, 50-90 TeV
- Aims for CDR end of 2014, e+e- collisions ~2028; pp collisions ~2042



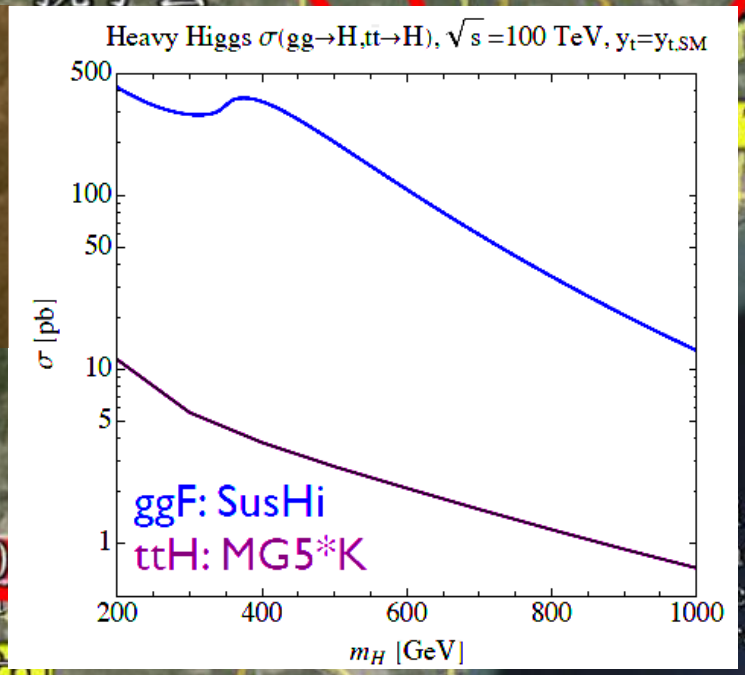
Higgs boson production at future pp Colliders

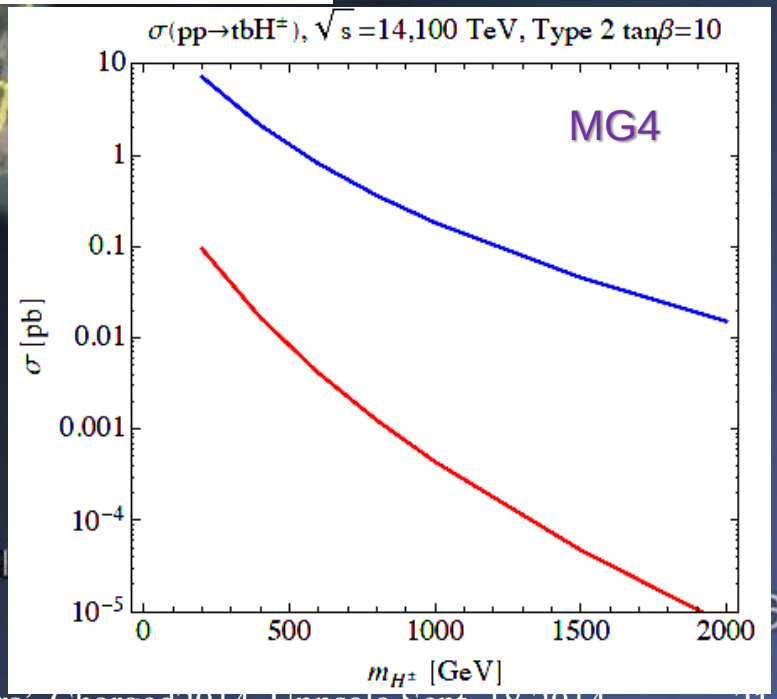
- ttbarh overtakes VH in importance at CoM of ~40 TeV



- H+/- coproduction with tb 2 orders of magnitude higher at 100 than at 14 TeV CoM

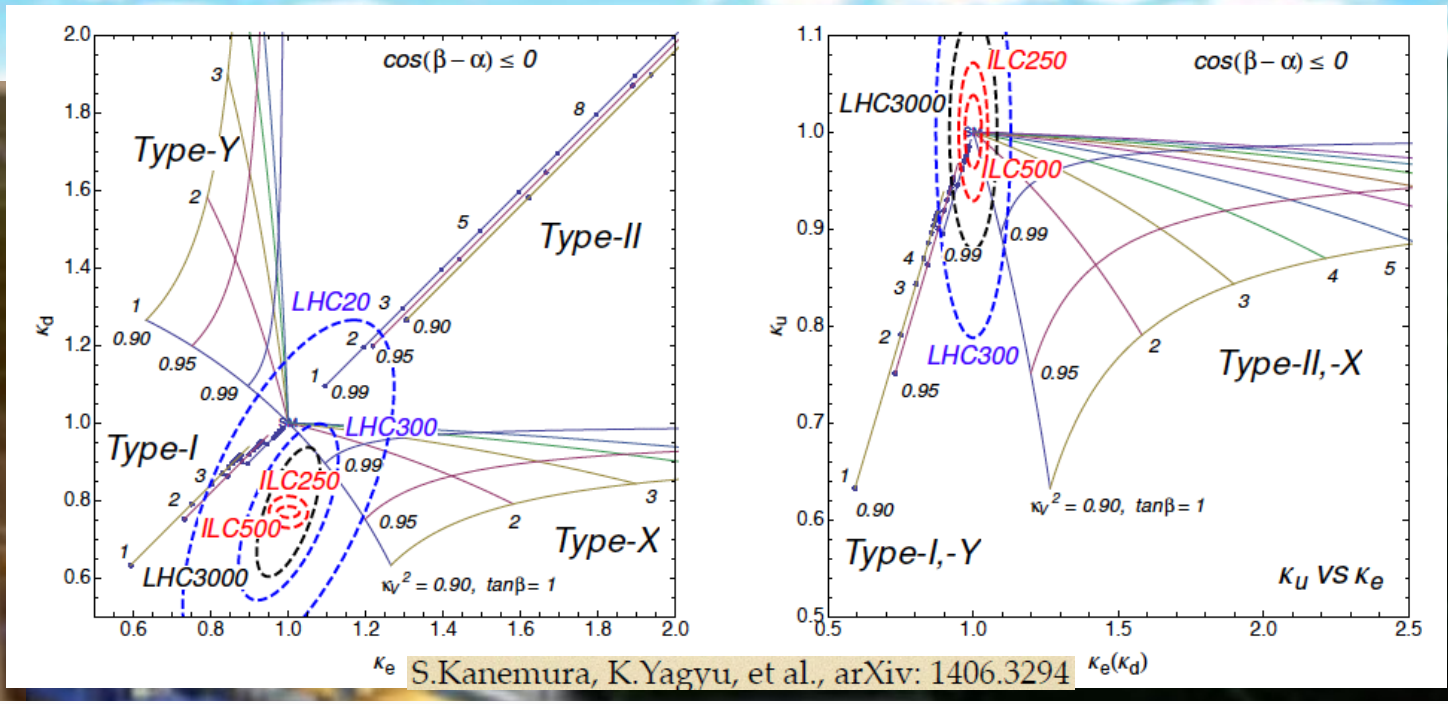
- Production of a 2nd heavy Higgs boson at CoM of 100 TeV



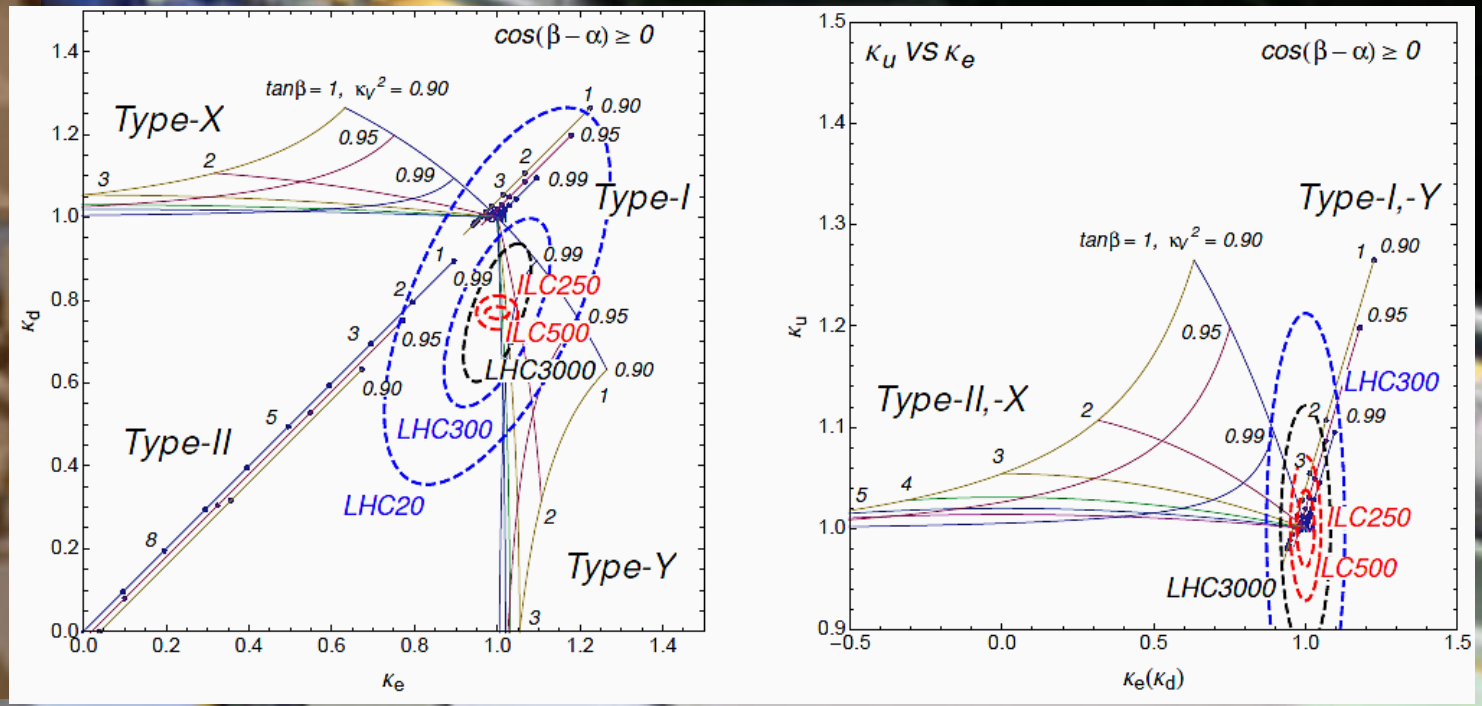


LHC/ILC: Couplings "Fingerprinting" in 2DHM

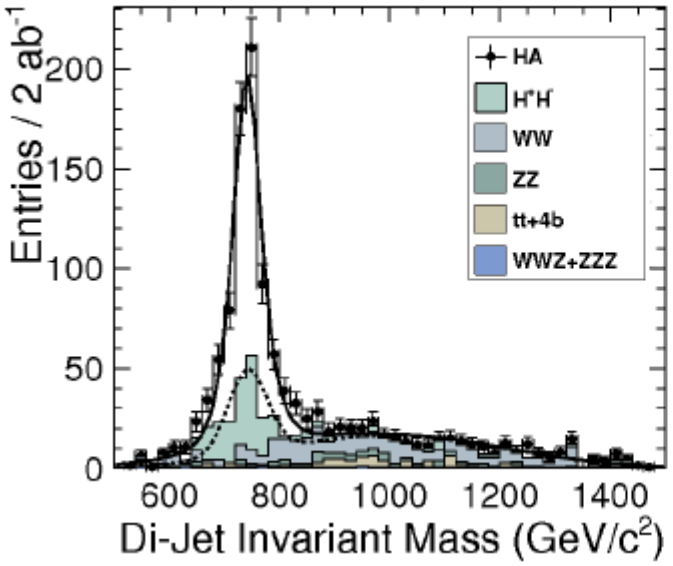
- Interpretation of precision measurements of SM-like Higgs boson coupling constants $\kappa_{u,d,\ell}$ (slide 10) to disambiguate 2HDM 'Type'
- 'Type X (Y)=TypeIV(III)
- Experimental sensitivities from Snowmass HWG (1310.8361v2)

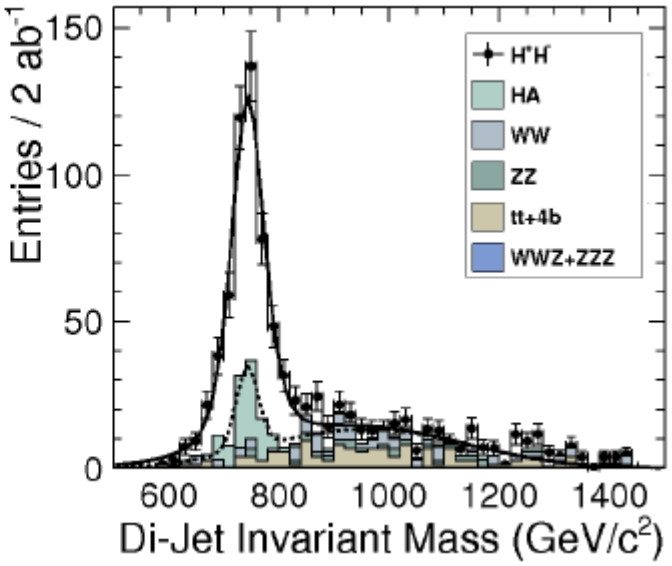


S.Kanemura, K.Yagyu, et al., arXiv: 1406.3294



CLIC BSM Higgs Prospects

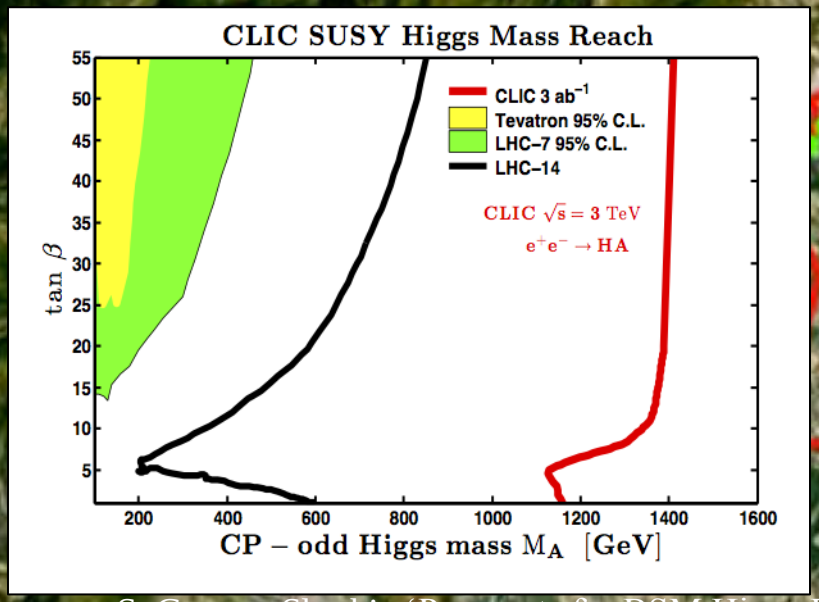




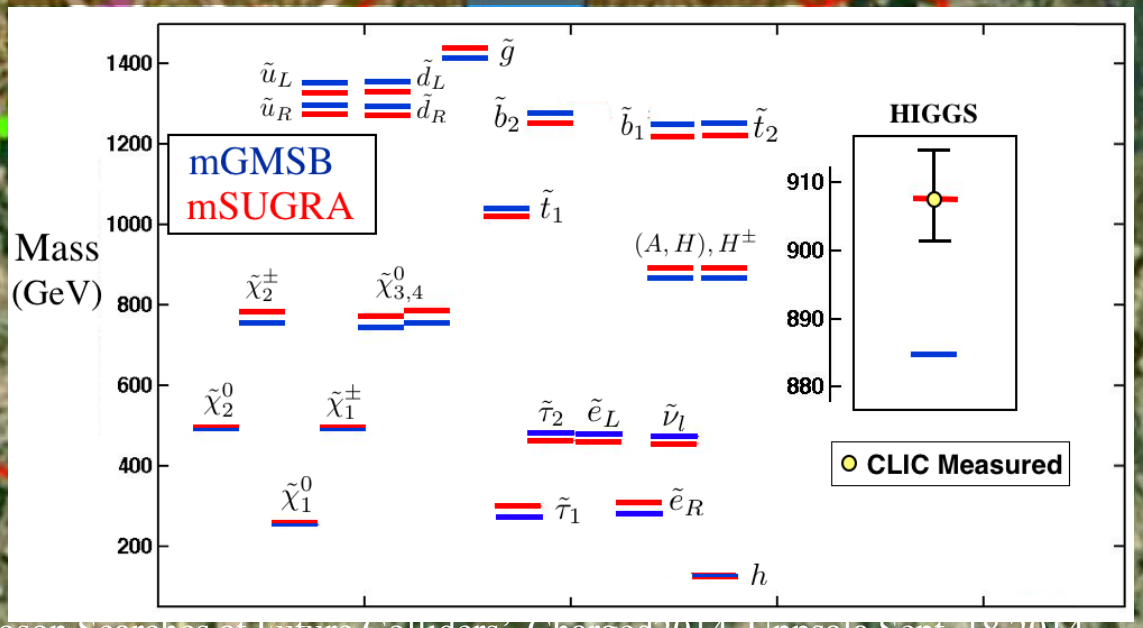
- 'SUSY Model II→mA=742 GeV
- e+e-→HA
- e+e-→H+H-
- bbbb, tbtb final states, tanβ large
- b, t tagging + constrained kin. fit

References:
CLIC CDR and
http://arxiv.org/pdf/hep-ex/0112004.pdf

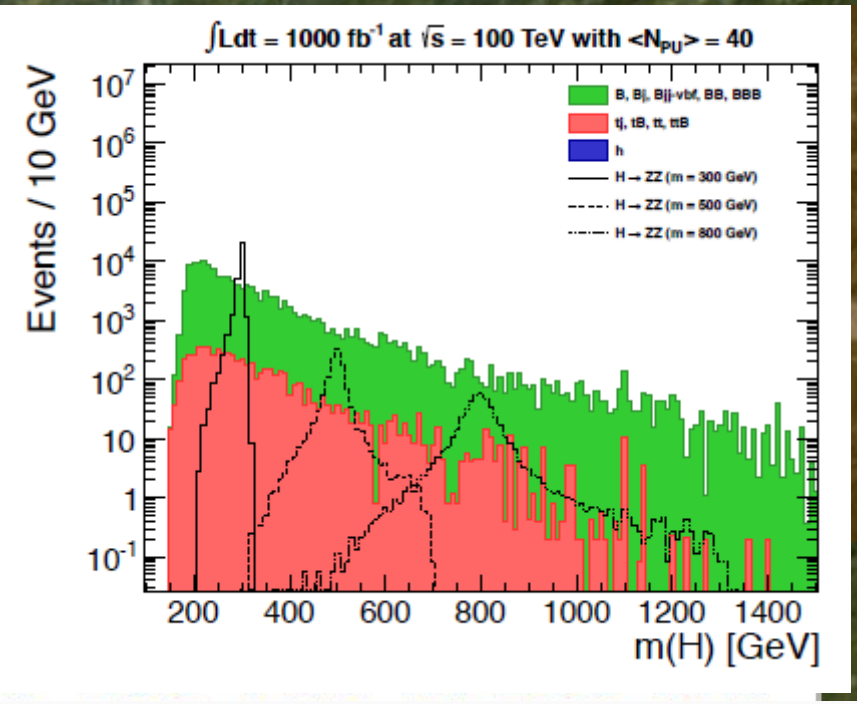
- mH,mA,mH^{+-} measurable to %-level



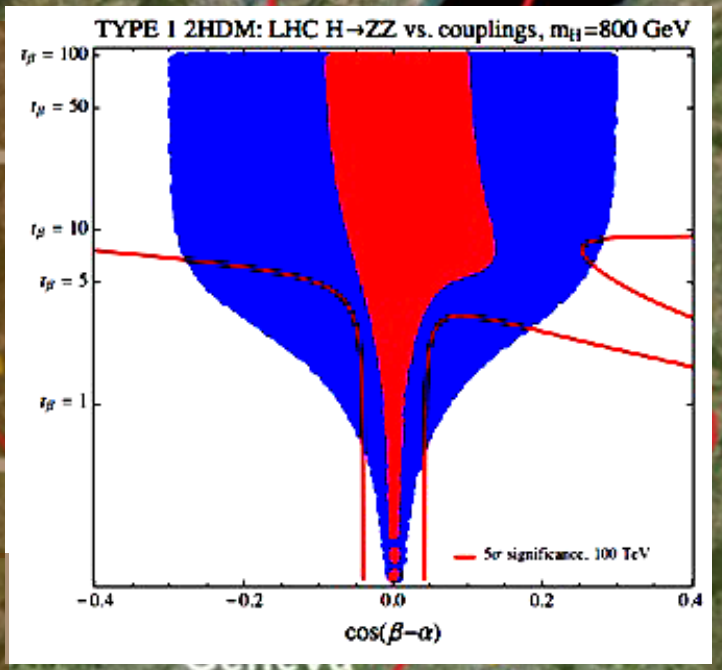
- Ability to resolve quasi-degenerate mass spectra

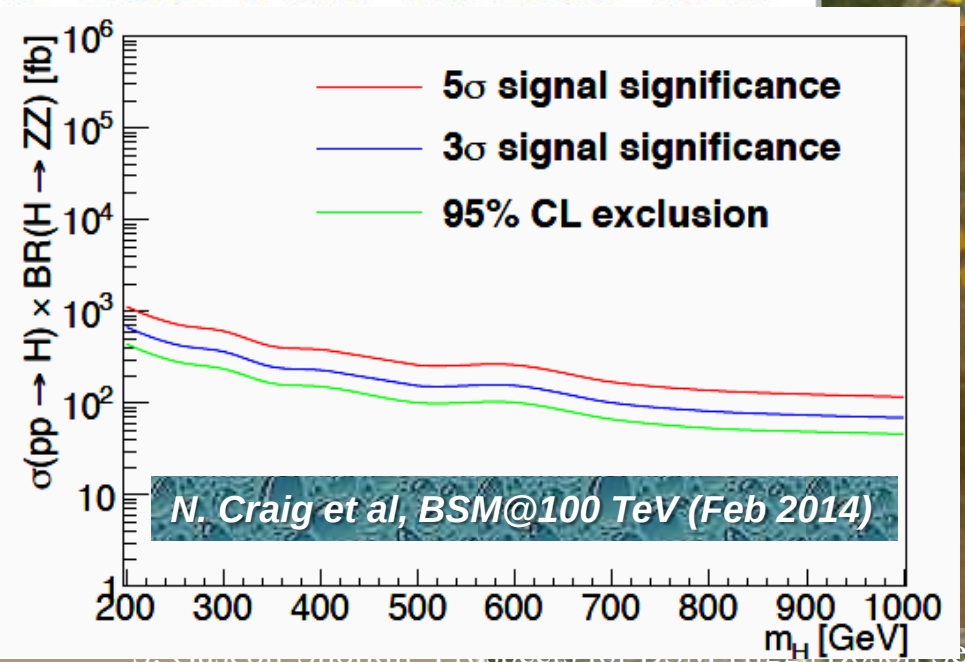


FCC-hh BSM Higgs prospects

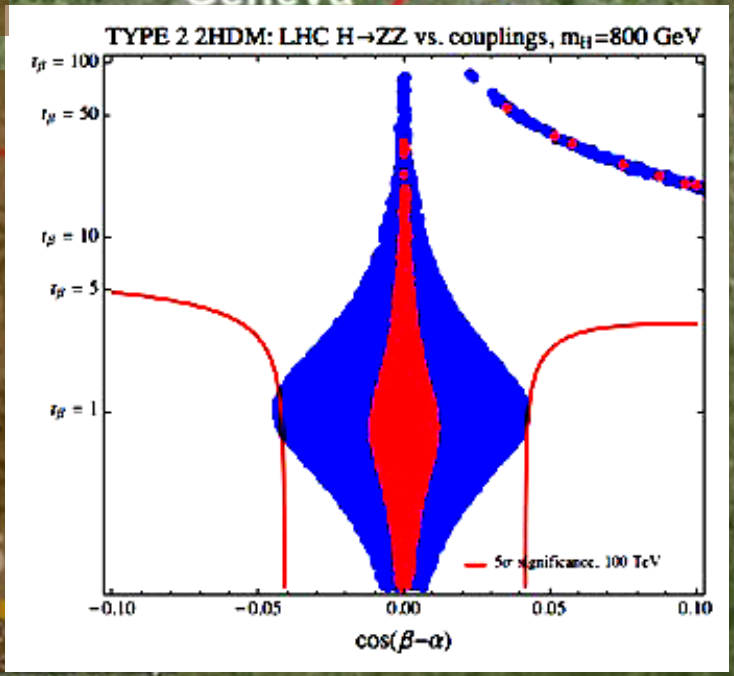


- 2HDM: Heavy neutral H→ZZ→4ℓ (shown) & A→ Zh→ℓℓ+{bb,ττ}
- Backgrounds: VV, ttV, VVV
- σ x BR sensitivity to 100s of fb



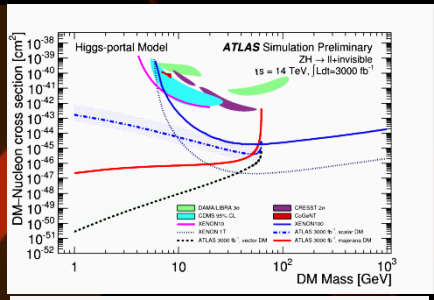


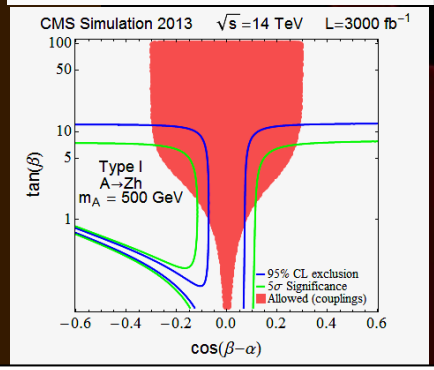
- H→ZZ→4ℓ: 5σ discovery contour in the tanβ-cos(β–α) plane, probes zone allowed by couplings (mH=800 GeV,1000fb^{-1})

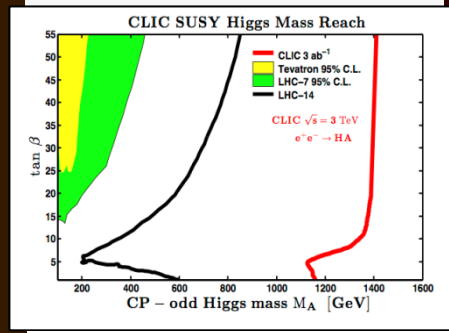


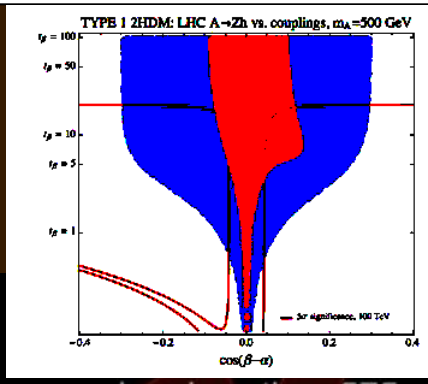
Summary and Conclusion

- Upgraded LHC:
  - Prospects for BSM-related measurements of properties of the observed Higgs boson:
    - Invisible branching fraction: similar for indirect and direct techniques, < ~30% after 300fb-1 ~15% after 3000fb-1
    - Field strength tensor structure: fraction of CP-odd contribution <~20% after 300fb-1, <10% after 3000fb-1
  - Prospects for searches for additional (BSM) Higgs bosons:
    - Indirect from coupling measurements and direct: In both cases could probe large portions of 2HDM phase space starting even in Run 3
- Future Colliders:
  - Prospects for searches for additional (BSM) Higgs bosons:
    - Indirect: from interpretations of coupling deviations and precision mass measurements for model disambiguation
    - Direct: ~Doubling of phase space probeable
  - Complementarity (between lepton and hadron machines) An exciting road lies before us!









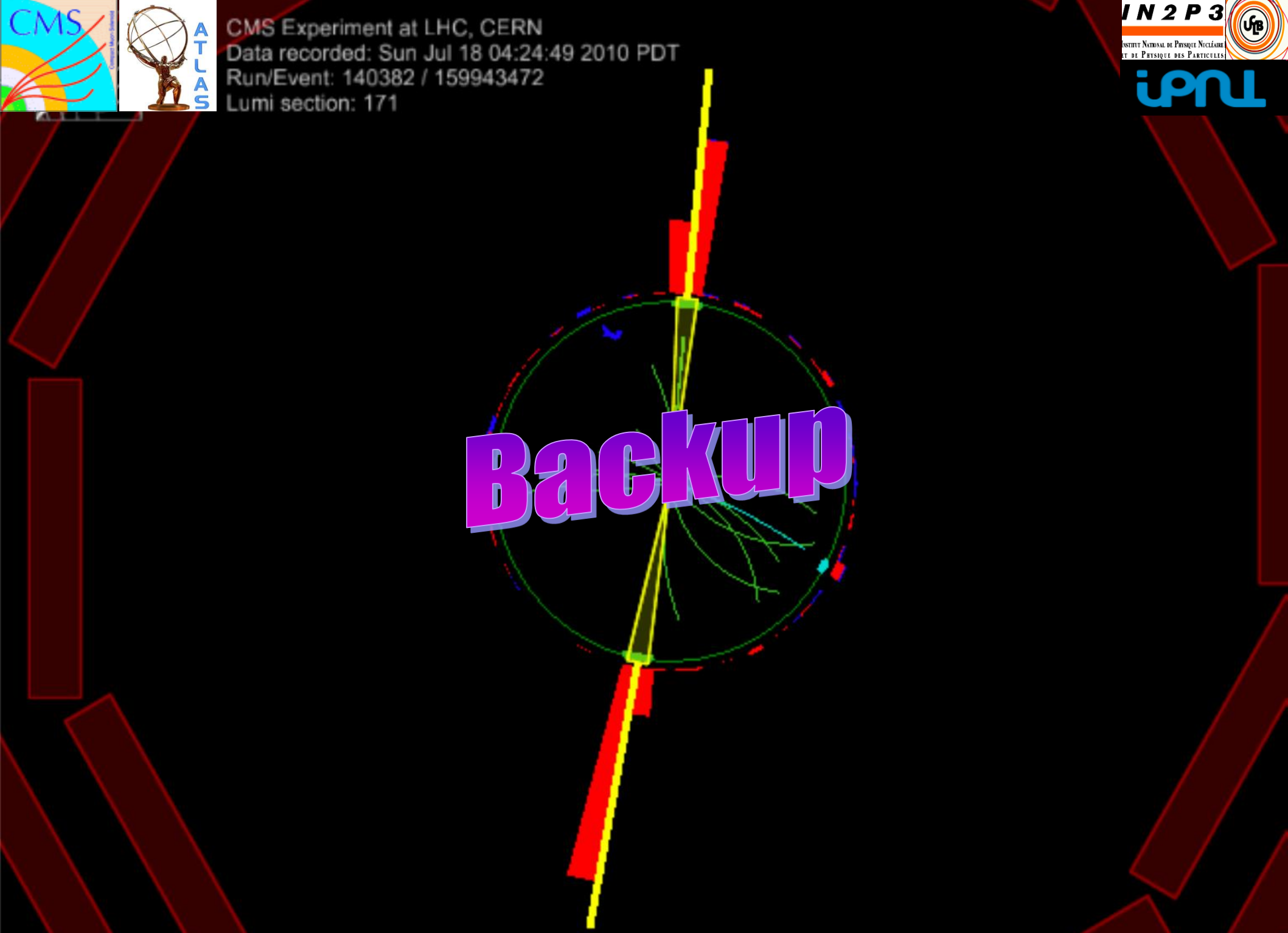
Acknowledgements

- Thanks to :

T. Behnke, M. Klute, Y. Yamazaki, G. Gomez-Ceballos, F. Rizatdinova, F. Bordry, M. Kado, P. Savard, O. Arnaez, F. Monticelli, J. Baglio, A. Nisati, J. Olsen, M. Pieri, P. Giacomelli, H. Kroha, H. Okawa, M. Zanetti, P. Vankov , F. Gianotti, M. Mangano, A. Blondel, L. Linssen, I. Laktineh, J. Wenniger, L. Rossi, N. Walker, S. Chattopadhyay, Y. Wang, A. Yamamoto, J. Gao, J. Tian, E. Sicking, M. Ruan, A. Holzner, M. Chamizo, Y. Enari, J. Rojo, J. Long, N. Craig

And of course the workshop organisers and sponsors …. :

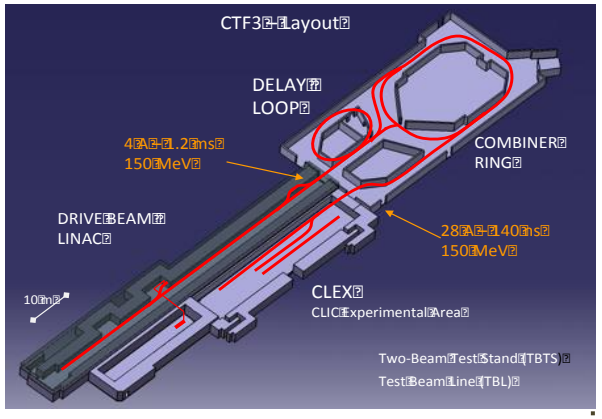
Thank you !


CMS Experiment at LHC, CERN
Data recorded: Sun Jul 18 04:24:49 2010 PDT
Run/Event: 140382 / 159943472
Lumi section: 171
Backup

CLIC Timeline

2013-18 Development Phase

Develop a Project Plan for a staged implementation in agreement with LHC findings; further technical developments with industry, performance studies for accelerator parts and systems, as well as for detectors.



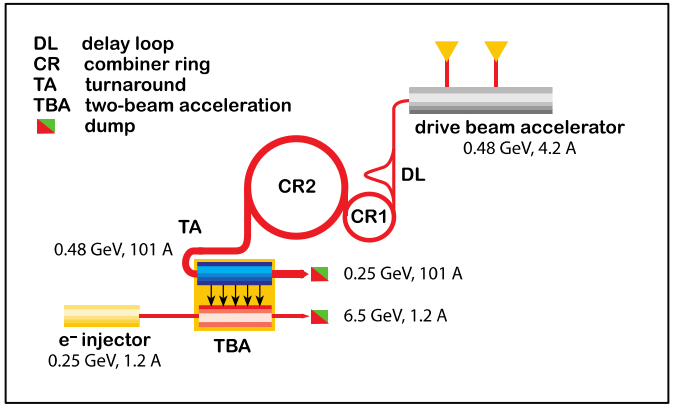
2018-19 Decisions

On the basis of LHC data and Project Plans (for CLIC and other potential projects as FCC), take decisions about next project(s) at the Energy Frontier.

4-5 year Preparation Phase

Finalise implementation parameters, Drive Beam Facility and other system verifications, site authorisation and preparation for industrial procurement.

Prepare detailed Technical Proposals for the detector-systems.



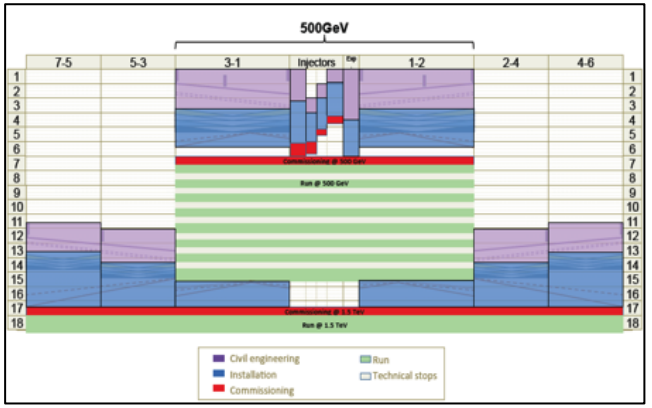
2024-25 Construction Start

Ready for full construction and main tunnel excavation.

Construction Phase

Stage 1 construction of CLIC, in parallel with detector construction.

Preparation for implementation of further stages.



Commissioning

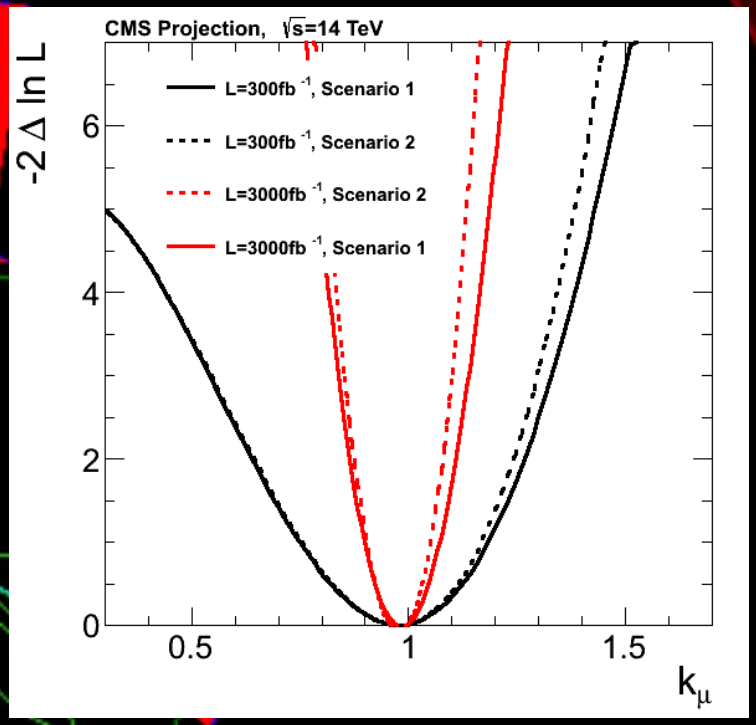
Becoming ready for data-taking as the LHC programme reaches completion.

LHC XS WG Coupling Fit Details

Global fits targeting the *k* factors

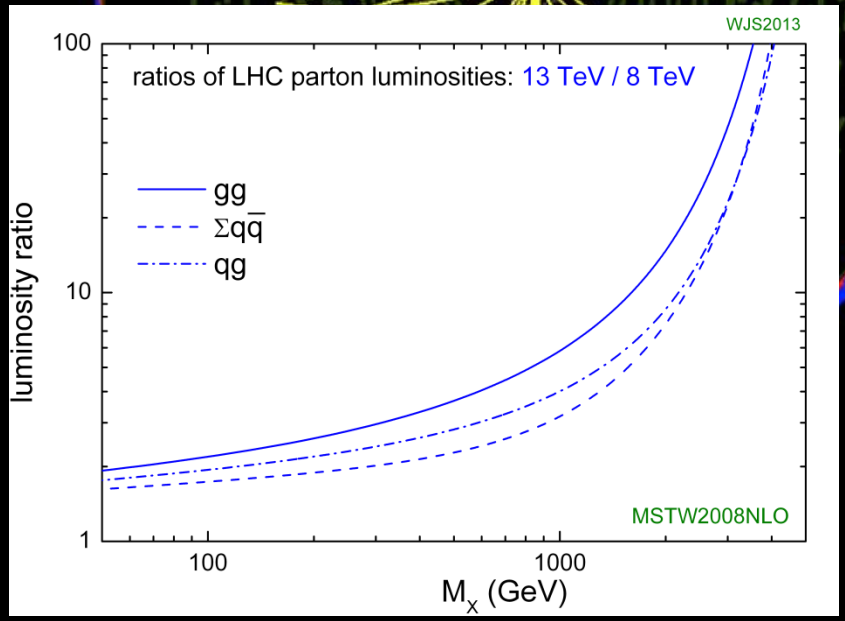
- Assign a modifier to each coupling constant
  - Do not resolve loops, effective coupling instead (k_g, k_g and k_{Zg})
- Results reported in terms of 68% uncertainties (-2DLnL=1) on k

$$\sigma \cdot BR(ii \to H \to ff) = \sigma_{SM} \cdot BR_{SM} \frac{\kappa_i^2 \cdot \kappa_f^2}{\kappa_H^2}$$



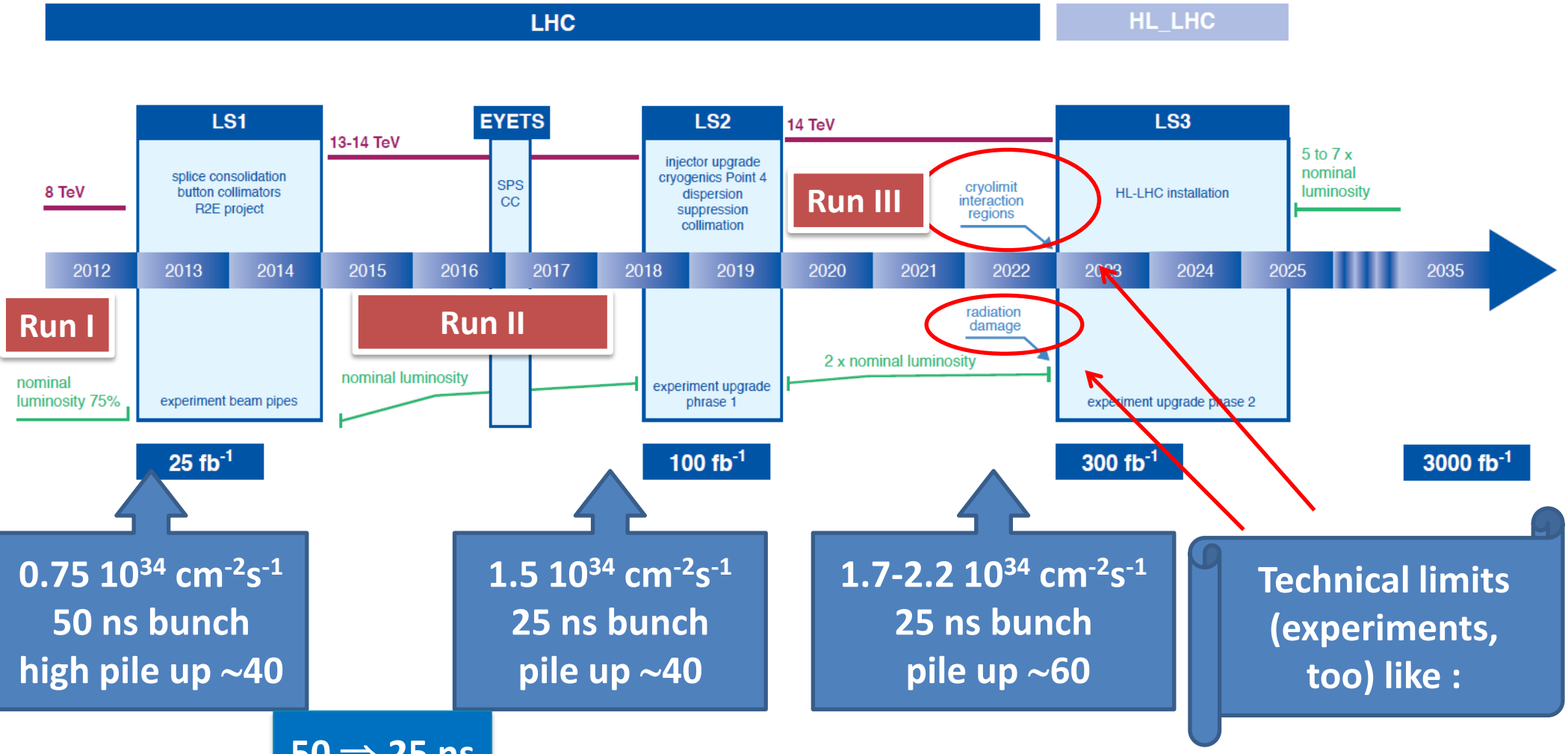
Challenges for low-mass searches in Run 2

- The increase in center-of-mass energy from 8 to 13 or 14 TeV is usually accompanied by a sizeable increase in production cross sections (in general X2 for SM Higgs)
- However the LHC experiments will be dealing with greatly increased pileup (number of interactions per beam crossing will go from ~15 to 40)
- This will affect the efficiency to identify 'physics objects' (electrons, photons, muons, jets…) . The experiments are currently reevaluating and reworking the relevant algorithms.
- In particular, for analyses searching for relatively low-mass resonances, triggering will be a major challenge.

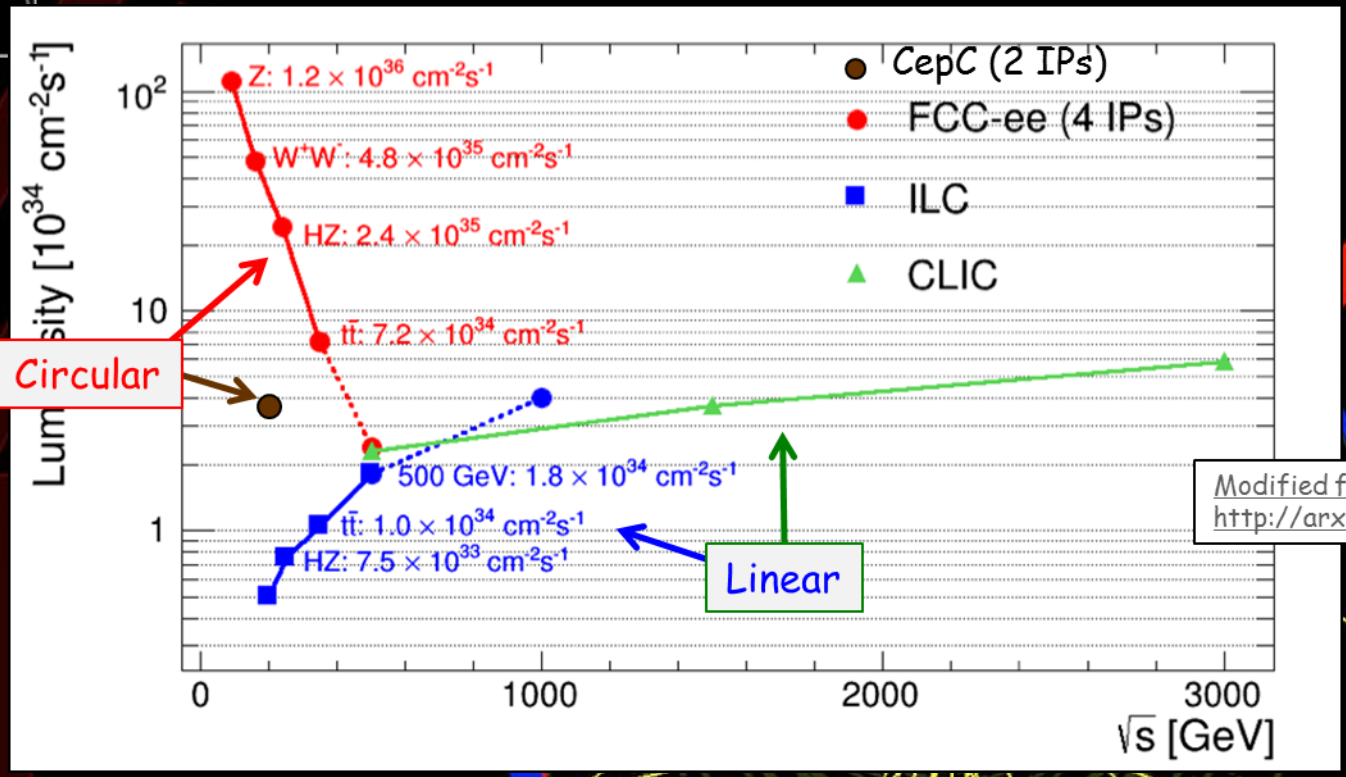


CMS Experiment at
Data recorded: Sun
Run/Event: 194108
Lumi section: 575

New LHC / HL-LHC Plan



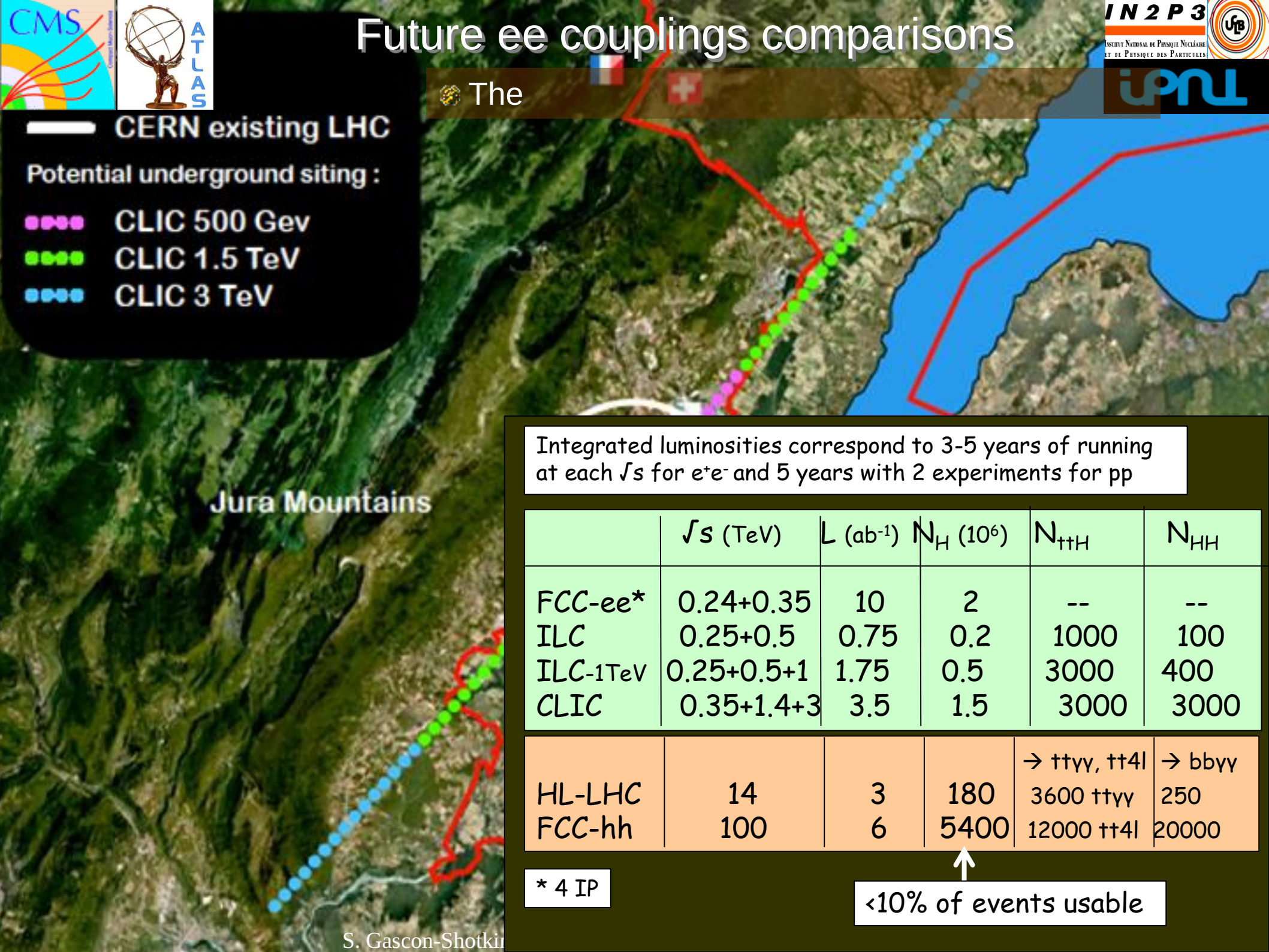
Future ee machines



	Size km	√s GeV	RF MV/m	L per IP 10^{34}	Bunch/train x-ing rate(Hz)	σ_x μm	σ_y nm	Lumi within 1% of √s	Long. polarisation e^-/e^+
CEPC	54	240	20	1.8	$4x10^5$	74	160	>99%	considered
FCC-ee	100	240	20	6	$2x10^7$	22	45	>99%	considered
ILC	31	250	14.7	0.75	5	0.7	7.7	87%	80%/30%
ILC	31	500	31.5	1.8	5	0.5	5.9	58%	80%/30%
CLIC	48	3000	100	6	50	0.04	1	33%	80%/considered

Future ee couplings comparisons

The



Integrated luminosities correspond to 3-5 years of running at each $\sqrt{s}$ for e^+e^- and 5 years with 2 experiments for pp

	$\sqrt{s}$ (TeV)	L (ab^{-1})	N_H (10^6)	N_{ttH}	N_{HH}
FCC-ee*	0.24+0.35	10	2	--	--
ILC	0.25+0.5	0.75	0.2	1000	100
ILC-1TeV	0.25+0.5+1	1.75	0.5	3000	400
CLIC	0.35+1.4+3	3.5	1.5	3000	3000
				→ ttγγ, tt4l	→ bbγγ
HL-LHC	14	3	180	3600 ttγγ	250
FCC-hh	100	6	5400	12000 tt4l	20000

* 4 IP

<10% of events usable

Future ee couplings comparisons

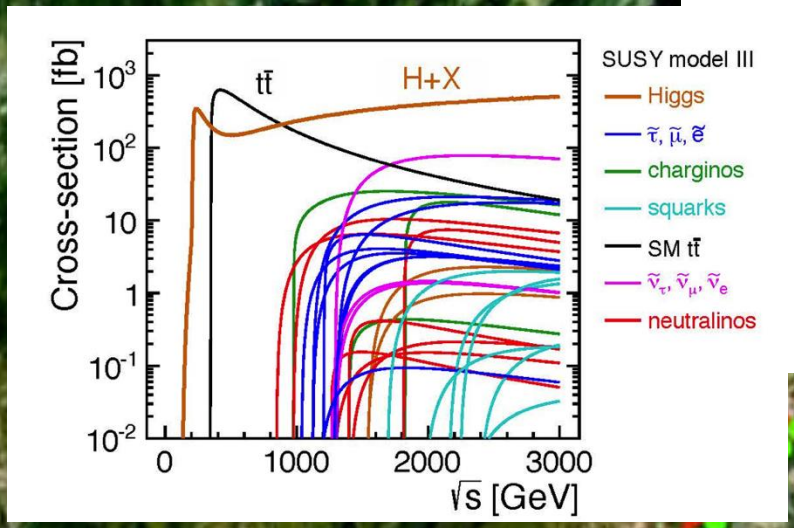
The

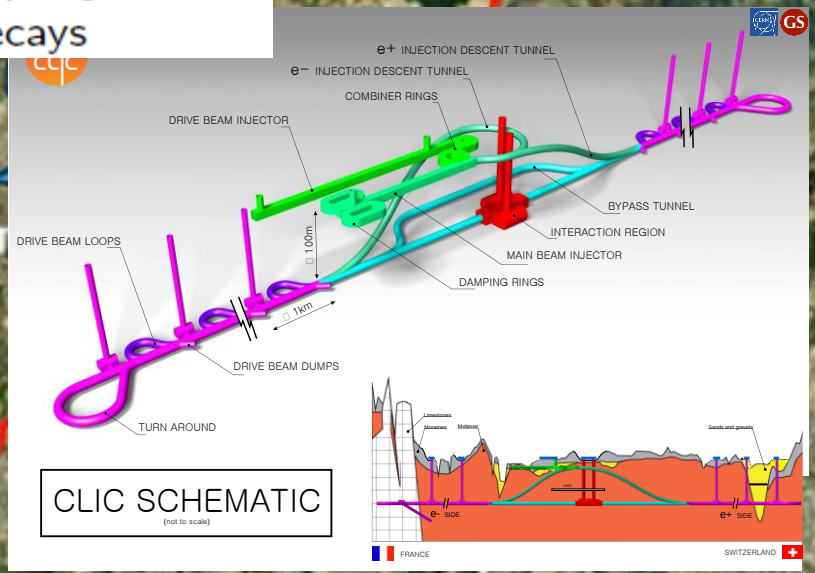
CERN existing LHC

Potential underground siting :

- CLIC 500 Gev
- CLIC 1.5 TeV
- CLIC 3 TeV

- Currently studied scenario
  - $\sqrt{s}$=350 GeV/375 GeV, 500 fb^{-1}
    - SM Higgs physics including total width measurement
    - Top threshold scan
  - $\sqrt{s}$=1.4 TeV, 1.5 ab^{-1}
    - BSM physics
    - $t\bar{t}H$, Higgs self coupling
    - Rare Higgs decays
  - $\sqrt{s}$=3 TeV, 2 ab^{-1}
    - BSM physics
    - Higgs self coupling
    - Rare Higgs decays



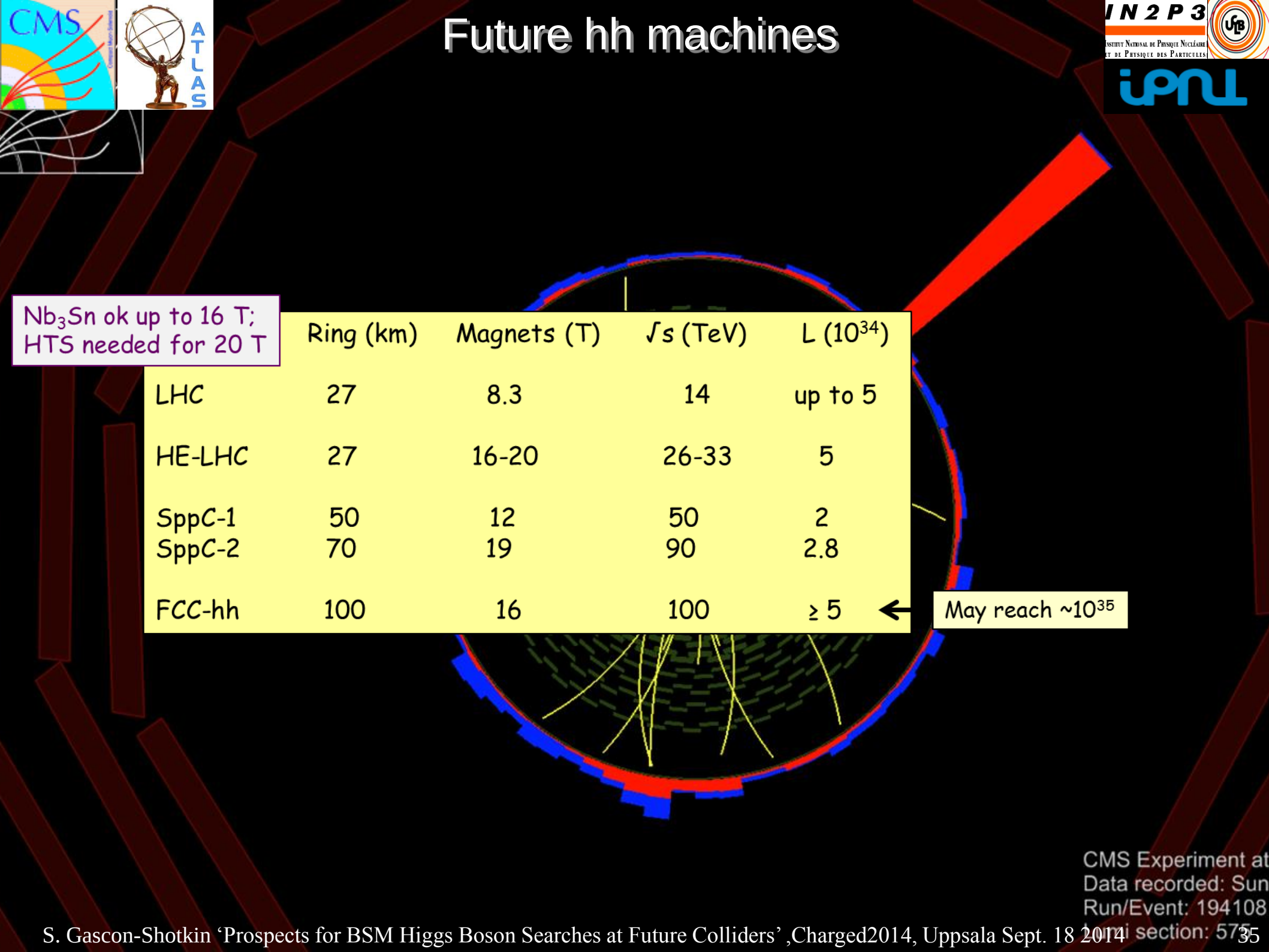


		SUSY model I		*SUSY model II*	
	State	Mass (GeV)	Width (GeV)	Mass (GeV)	Width GeV
Without $\gamma\gamma$	A/H	902.1 ± 1.9	21.4 ± 5.0	742.7 ± 1.4	21.7 ± 3.3
Without $\gamma\gamma$	$H^\pm$	901.4 ± 1.9	18.9 ± 4.4	744.3 ± 2.0	17.0 ± 4.7
With $\gamma\gamma$	A/H	904.5 ± 2.8	20.6 ± 6.3	743.7 ± 1.7	22.2 ± 3.8
With $\gamma\gamma$	$H^\pm$	902.6 ± 2.4	20.2 ± 5.4	746.9 ± 2.1	21.4 ± 4.9

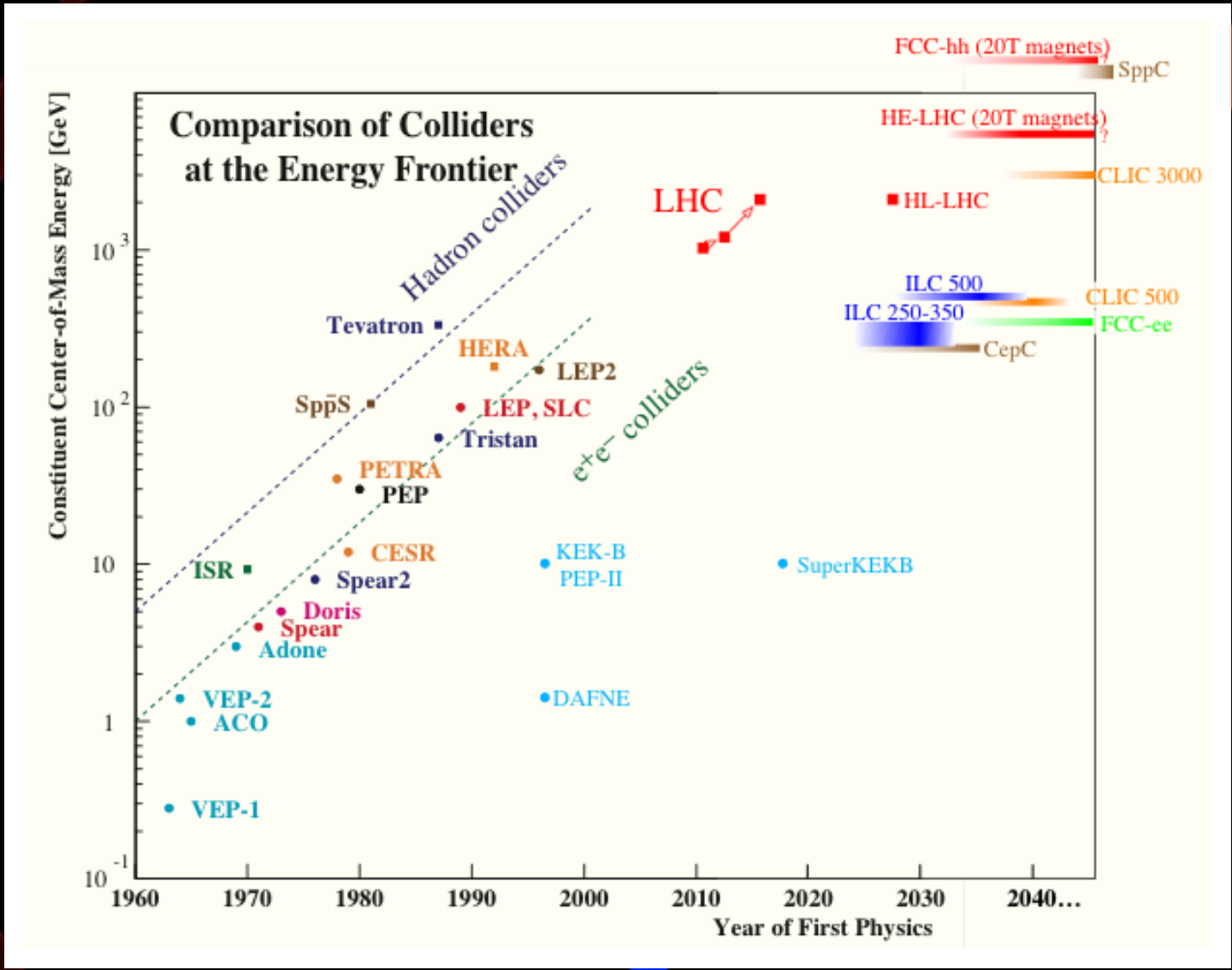
Future hh machines

Nb_3Sn ok up to 16 T;
HTS needed for 20 T

	Ring (km)	Magnets (T)	$\sqrt{s}$ (TeV)	L (10^{34})	
LHC	27	8.3	14	up to 5	
HE-LHC	27	16-20	26-33	5	
SppC-1	50	12	50	2	
SppC-2	70	19	90	2.8	
FCC-hh	100	16	100	≥ 5	← May reach ~10^{35}



Future hh machines

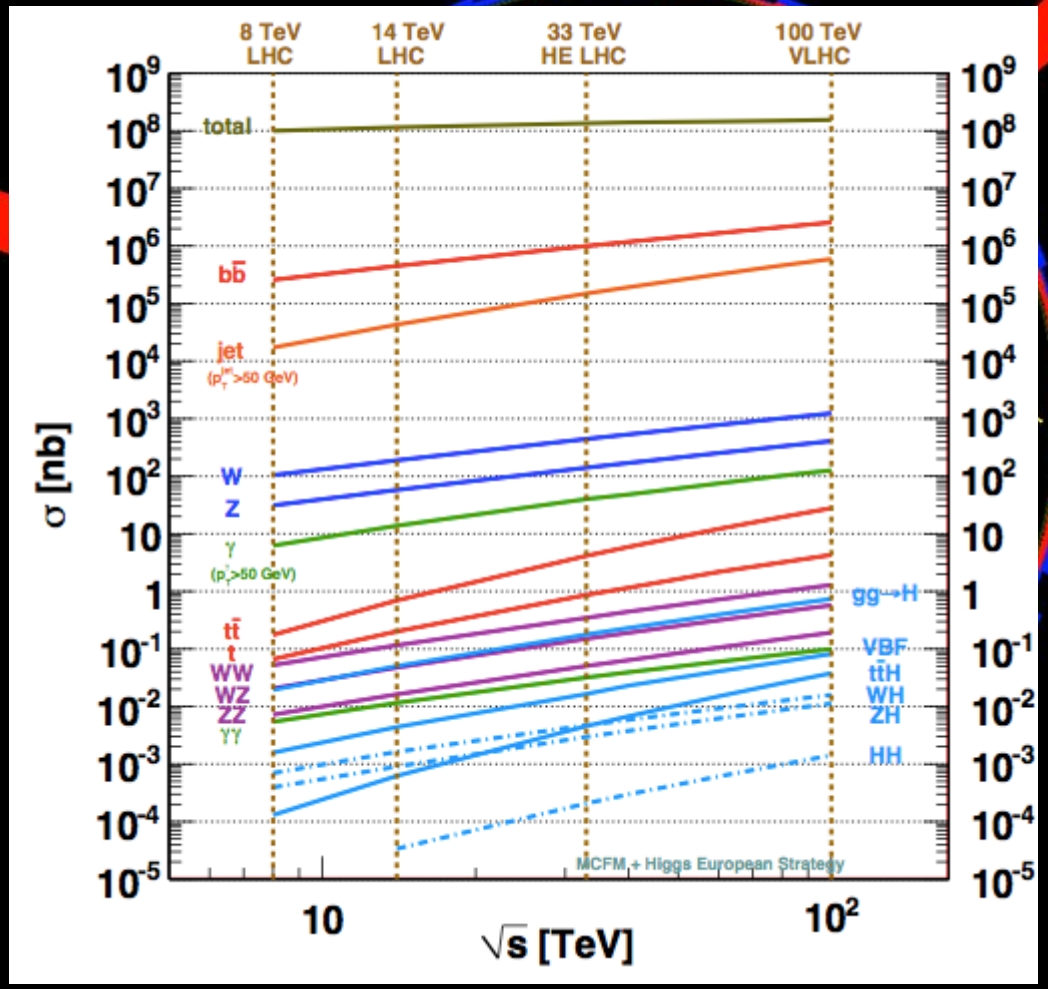


CEPC-SppC Schedule (Preliminary)

- CPEC
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-15 ➔ Pre-CDR by 2014
    - R&D: 2016-2020
    - Engineering Design: 2015-2020
  - Construction: 2021-2027
  - Data taking: 2030-2036

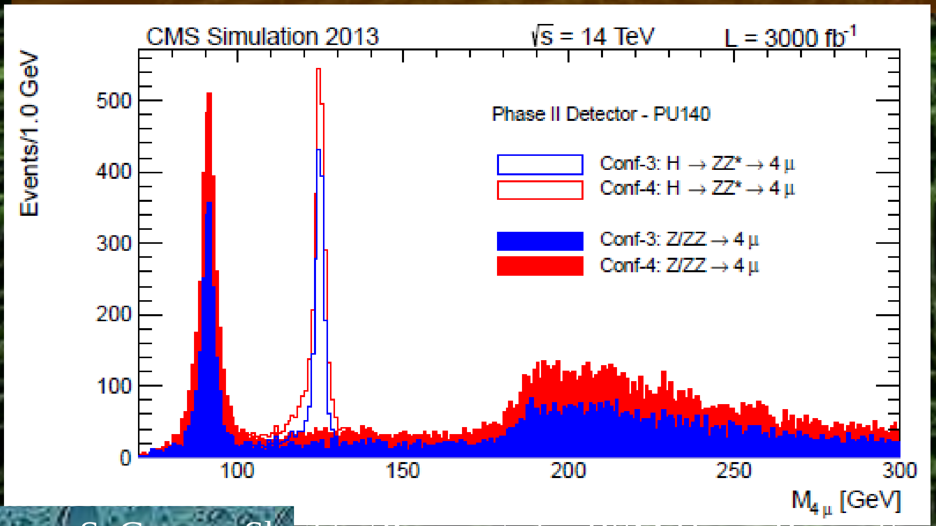
- SPPC
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-2020
    - R&D: 2020-2030
    - Engineering Design: 2030-2035
  - Construction: 2036-2042
  - Data taking: 2042 -

Future hh machines

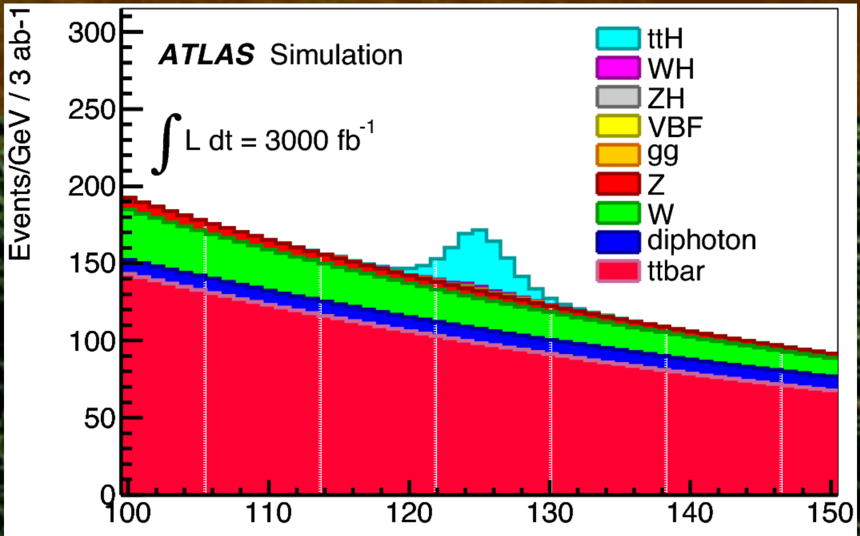


Assumptions, methods and scenarios

- ATLAS: Use fast simulation to mimic the beam effects on momentum and energy resolution, acceptance, identification and reconstruction efficiencies, fake rates, etc. Some rescaling of Run1 results for some analyses.
- CMS: Assume that upgraded detector will compensate the effects of higher pile-up, use three different scenarios:
  - Scenario 1: all systematic uncertainties are kept unchanged with respect to those in current data analyses
  - Scenario 2: the theoretical uncertainties are scaled by a factor of 1/2, while other systematical uncertainties are scaled by 1/√L
  - Scenario 3: set theoretical uncertainties to zero, leave other syst. uncertainties the same as in 2012
  - Some studies with fast simulation



CMS-FTR-13-003

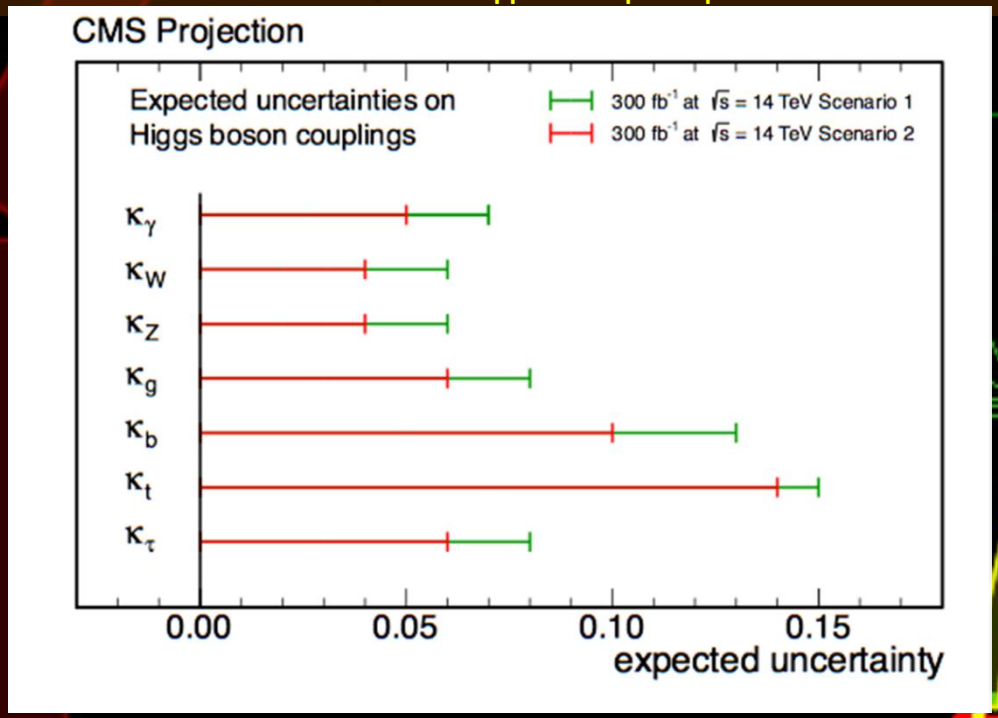


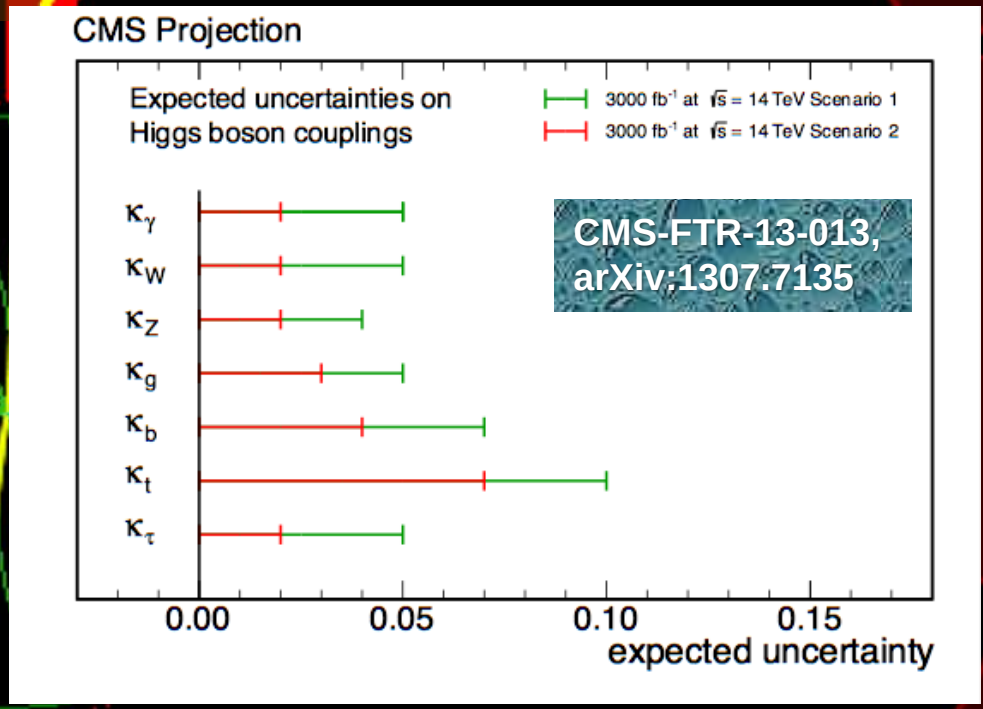
ATL-PHYS-PUB-2013-007

Higgs Boson Properties: Couplings and Coupling ratios (1)

- Global fit procedure of LHC-Higgs XS WG (arXiv:1307.1347), modifier for each κ, effective κ for loops, $\kappa_H=\Sigma\kappa_i BR_i$ for i in SM

$$\sigma \cdot BR(ii \to H \to ff) = \sigma_{SM} \cdot BR_{SM} \frac{\kappa_i^2 \cdot \kappa}{\kappa_H^2}$$





-2ΔLnL=1, (%)		κ_γ	κ_W	κ_Z	κ_g	κ_b	κ_t	κ_τ	$\kappa_{Z\gamma}$	κ_μ
300fb^{-1}	ATLAS	[8,13]	[6,8]	[7,8]	[8,11]	N/a	[20,22]	[13,18]	[78,79]	[21,23]
	CMS	[5,7]	[4,6]	[4,6]	[6,8]	[10,13]	[14,15]	[6,8]	[41,41]	[23,23]
3000fb^{-1}	ATLAS	[5,9]	[4,6]	[4,6]	[5,7]	N/a	[8,10]	[10,15]	[29,30]	[8,11]
	CMS	[2,5]	[2,5]	[2,4]	[3,5]	[4,7]	[7,10]	[2,5]	[10,12]	[8,8]

ATL-PHYS-PUB-2013-014

Higgs Boson Properties: Couplings and Coupling ratios (2)

- Fit coupling ratios to avoid assumption on total width

300fb-1: Ranges from 3-22% (ATLAS), 4-23% (CMS)
3000fb-1: Ranges from 2-10%(ATLAS) , 2-8% (CMS)

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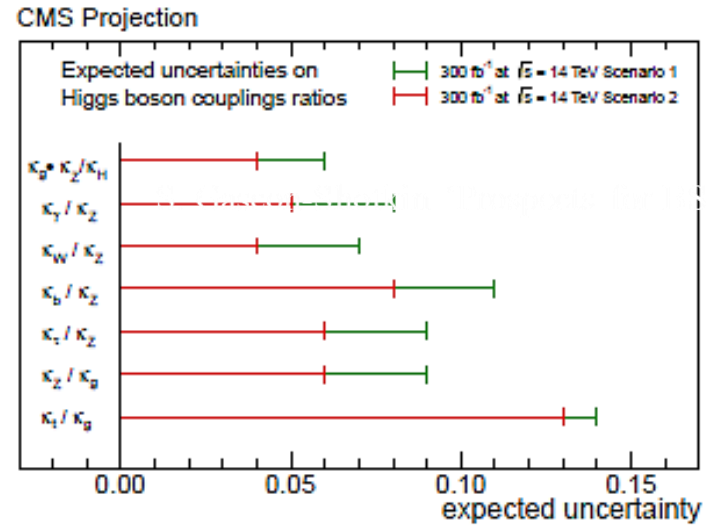
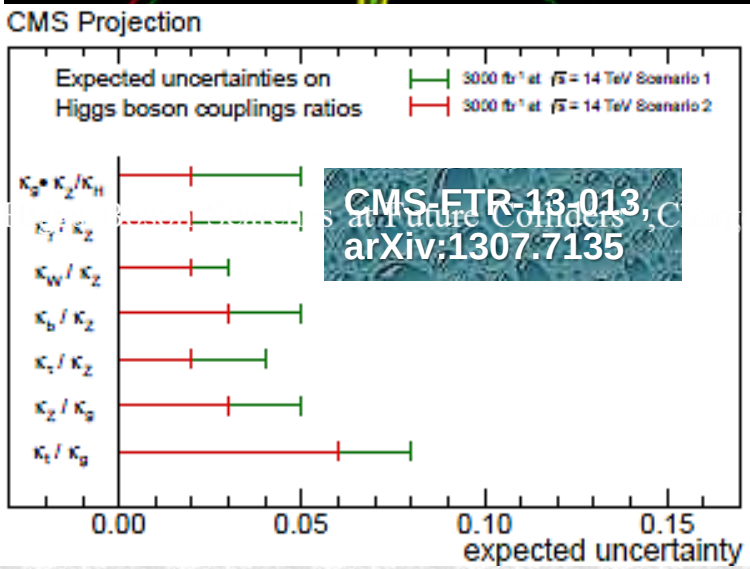
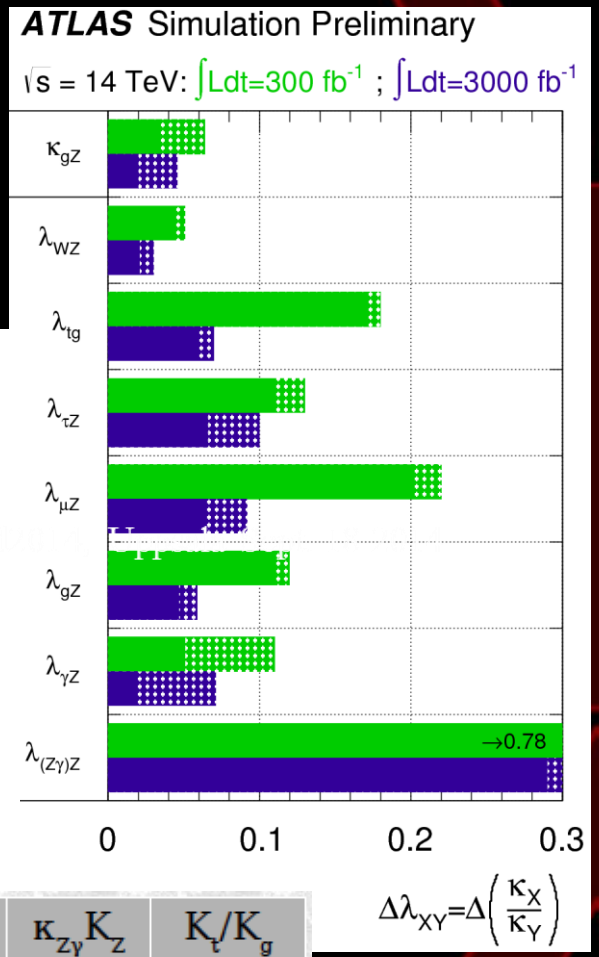


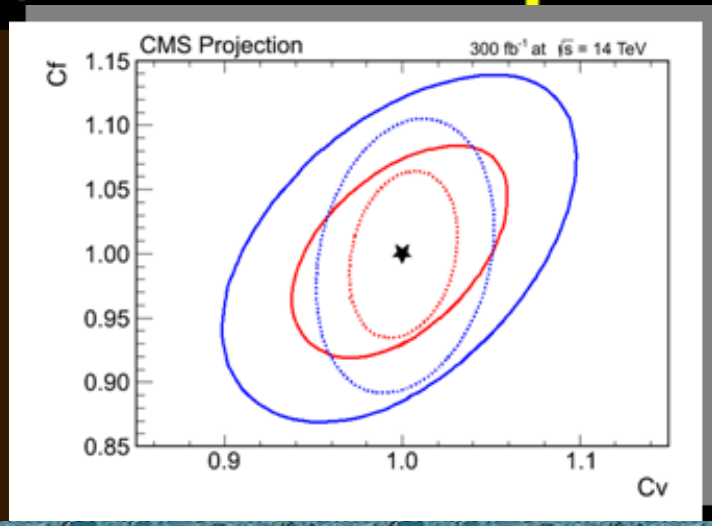


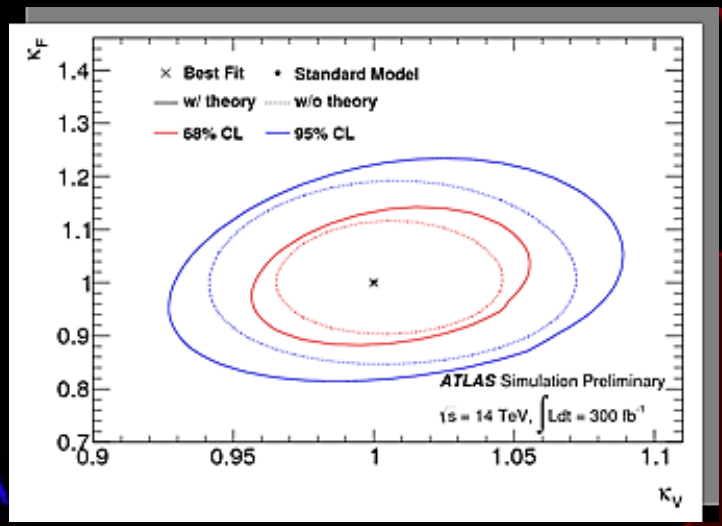


		$K_g K_Z / K_H$	K_W / K_Z	K_γ / K_Z	K_g / K_Z	K_b / K_Z	K_τ / K_Z	K_μ / K_Z	$\kappa_{Z\gamma} K_Z$	K_t / K_g
300fb-1	ATLAS	[3,6]	[4,5]	[5,11]	[11,12]	N/a	[11,13]	[20,22]	[78,78]	[17,18]
	CMS	[4,6]	[4,7]	[5,8]	[6,9]	[8,11]	[6,9]	[22,23]	[40,42]	[13,14]
3000fb-1	ATLAS	[2,5]	[2,3]	[2,7]	[5,6]	N/a	[7,10]	[6,9]	[29,30]	[6,7]
	CMS	[2,5]	[2,3]	[2,5]	[3,5]	[3,5]	[2,4]	[7,8]	[12,12]	[6,8]

Higgs Boson Properties: Couplings and Coupling Ratios (3)

- Precision on universal couplings to fermions (kF) and bosons (kV) at 1/ 2 sigma
- ~5% (10%) precision in Higgs couplings to vector bosons (fermions) with 3000fb-1





http://cds.cern.ch/record/1494600?ln=en

- Mass-scaled coupling ratios

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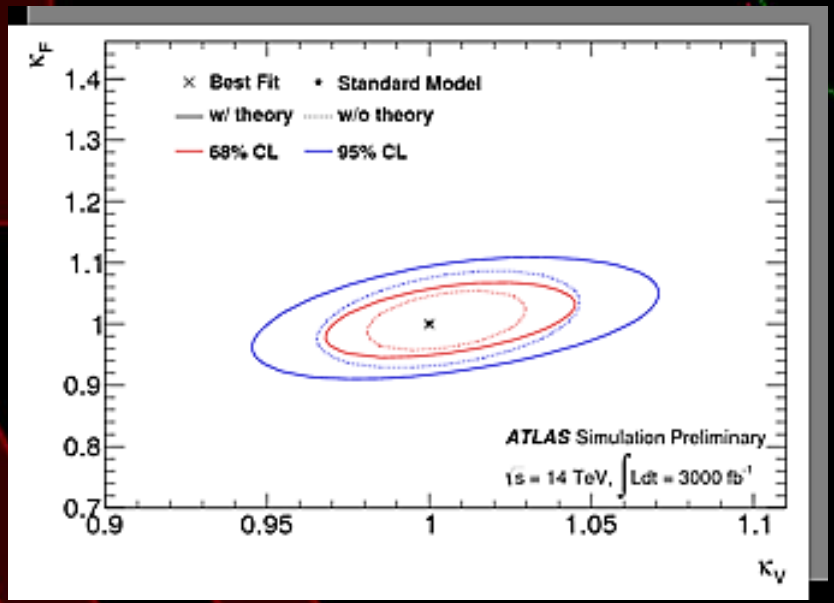
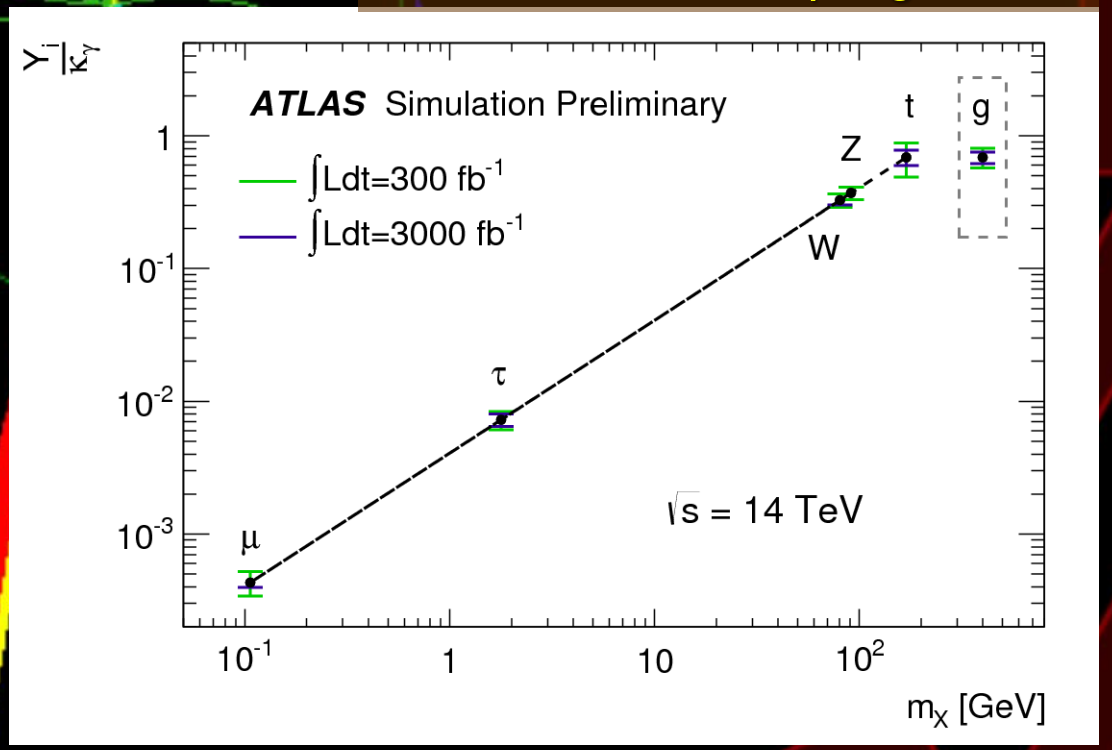
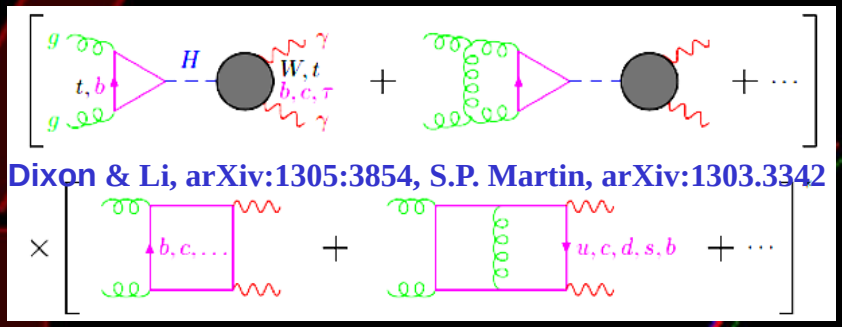
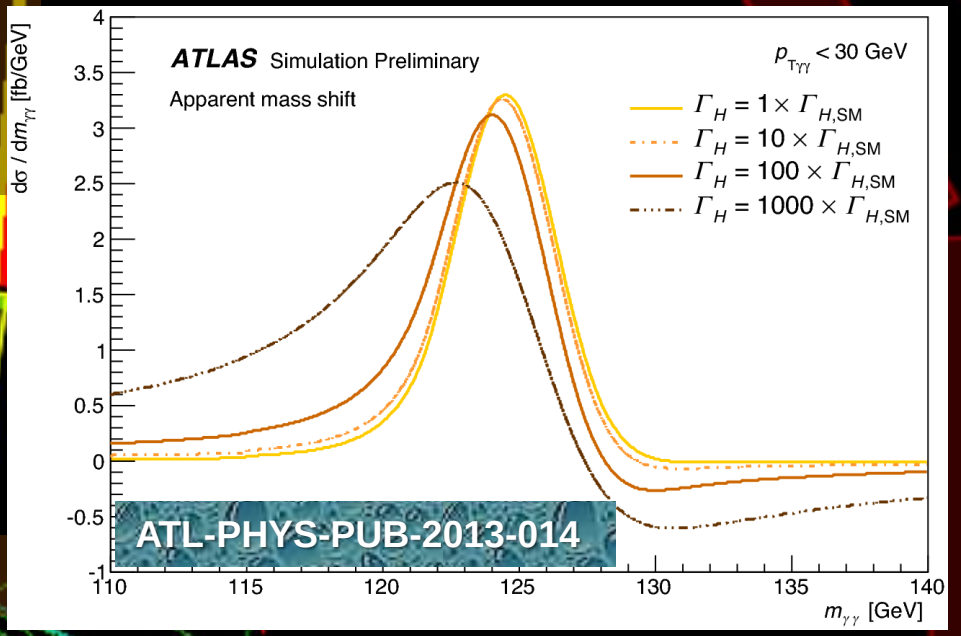




Higgs Boson Properties: Natural Width via H→γγ

- gg→γγ/gg→H→gg interference convoluted with detector resolution shifts mass peak, function of natural width (Γ_{SM}=4.1 MeV), probeable via $pt_{\gamma\gamma}$





- 95% CL Γ_H< 920 (200) MeV for 300(3000)fb-1