XCC: XFEL Compton $\gamma\gamma$ Collider Higgs Factory

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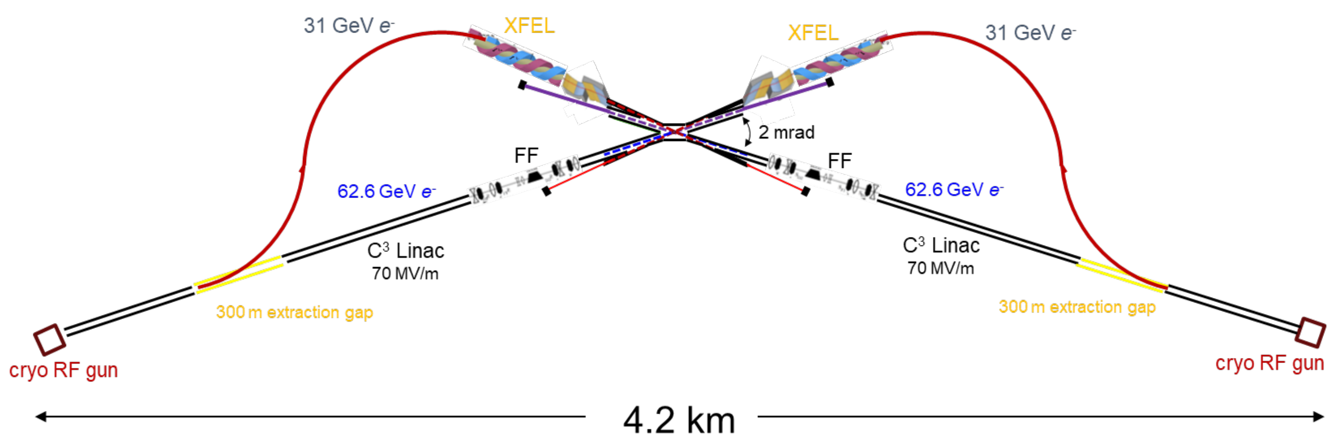
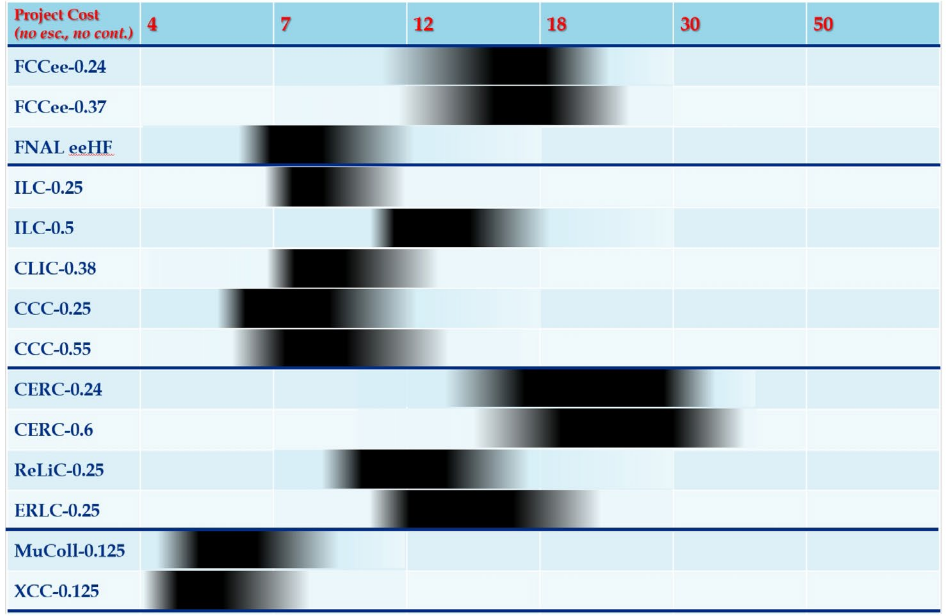
XCC s-channel $\gamma\gamma \to H$ @ $\sqrt{s} = 125$ GeV



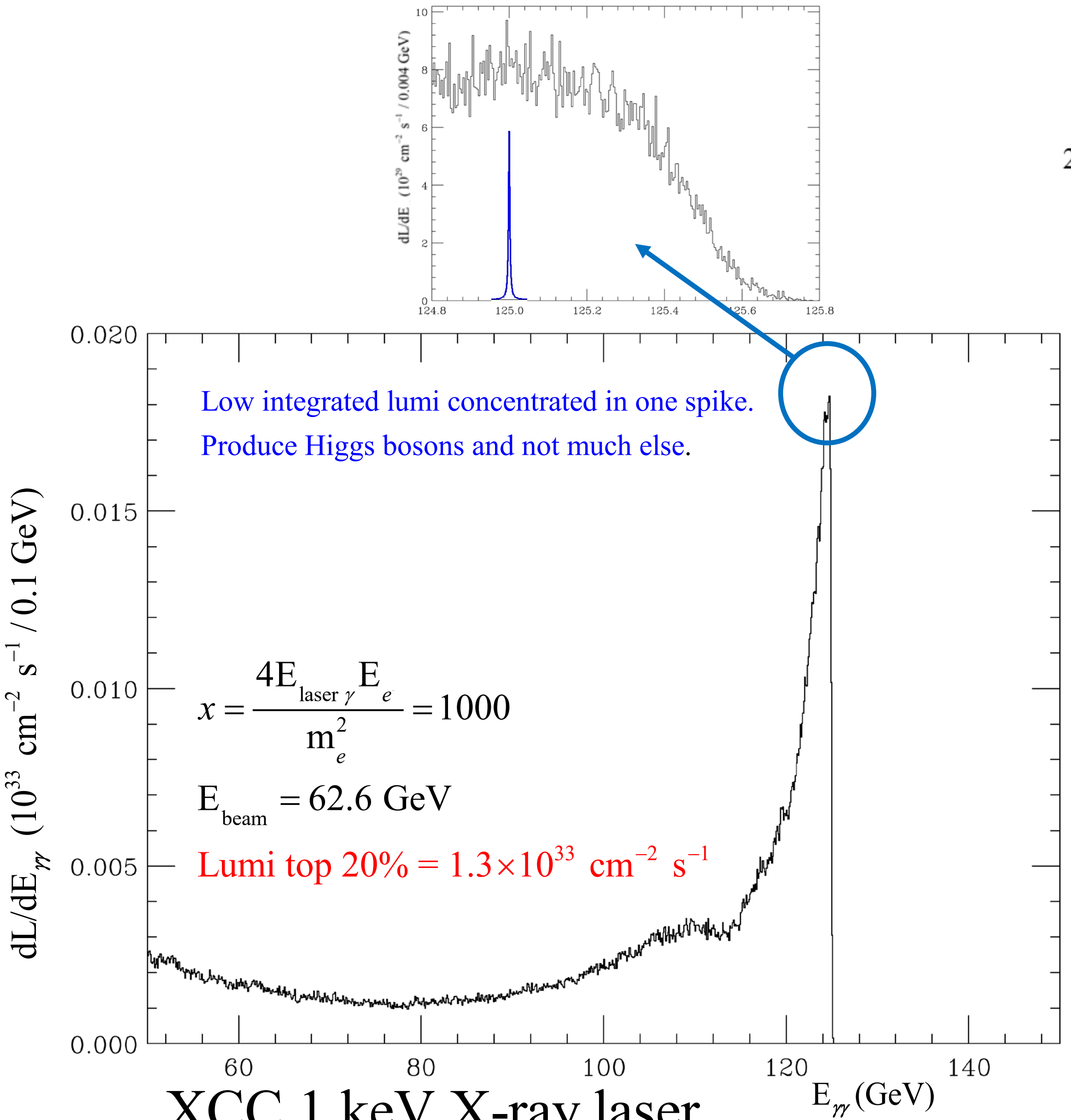


ITF

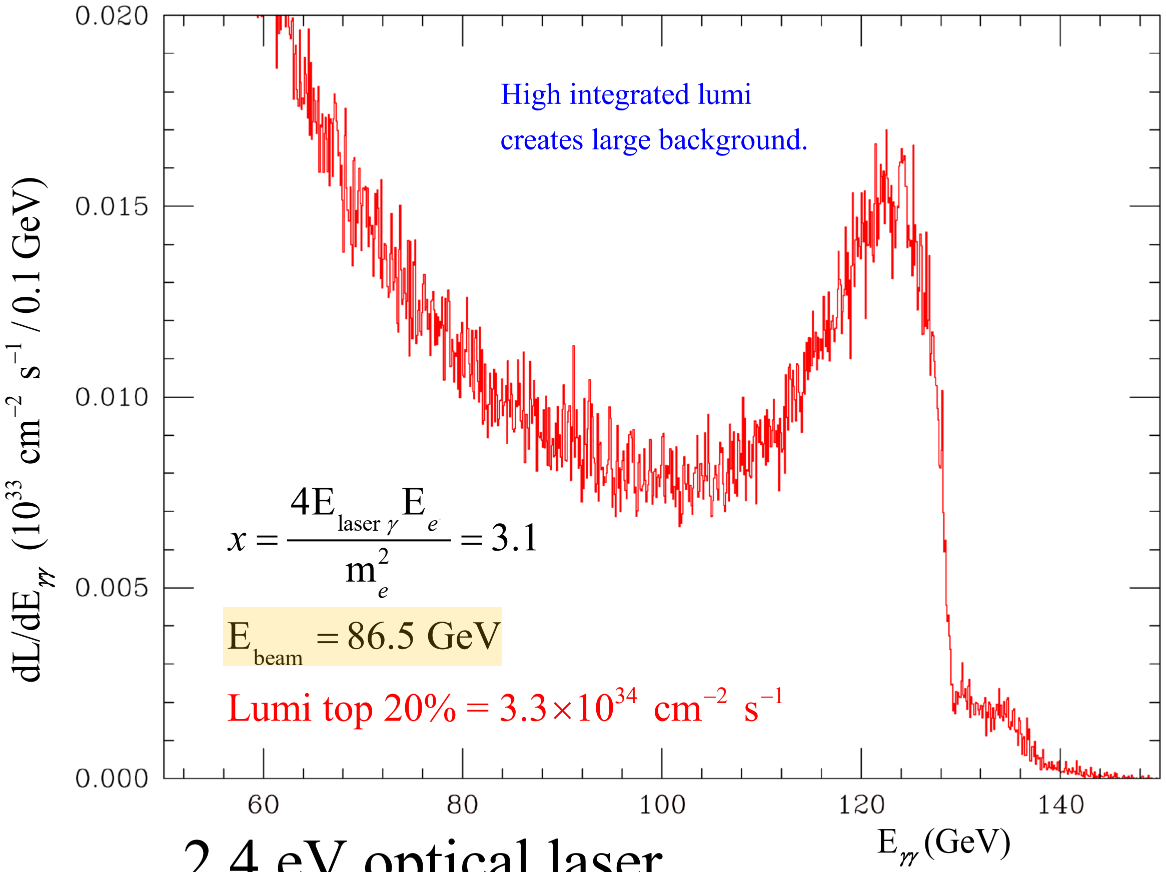
- Staging an e^+e^- collider with an intial $\gamma\gamma$ collider at the Higgs resonance is not a new idea. Such a suggestion by H. Sugawara in 2009 for the ILC was rejected in part due to a weak physics case.
- With an X-ray laser in place of an optical laser, the physics case for a 1st stage $\gamma\gamma$ collider Higgs factory is strengthened considerably. The optimum 2nd stage could again be a $\gamma\gamma$ collider, at $\sqrt{s}$=380 GeV to produce $\gamma\gamma \to H^* \to HH$.
- The XCC could begin operation on an earlier time scale than an e^+e^- Higgs factory due to its lower cost and smaller footprint.

The XCC is very different from previous γγ collider concepts

Machine	E_{e^-} (GeV)	Polarization	$N_{\rm H}$/yr	$N_{\rm Bgnd}/N_{\rm H}$	$N_{\rm minbias/BX}$
XCC	62.8	90% e^-	80,000	170	9.5
2.4 eV laser	86.5	90% e^-	70,000	540	50
ILC	125	-80% e^- +30% e^+	98,000	140	1.3
ILC	125	+80% e^- -30% e^+	65,000	60	1.3



XCC 1 keV X-ray laser



2.4 eV optical laser

ILC/C^3 vs. XCC Physics Comparison

Stage I & II Parameters

Colliding Particles	ILC/C^3 e^+e^-	XCC $\gamma\gamma$
Stage I:		
$\sqrt{s}$ (GeV)	250	125
Luminosity (fb^{-1})	2000	460
Beam Power (MW)	5.3 / 4.0	4.0
Run Time (yr)	10	10
# Single Higgs	0.5×10^6	1.3×10^6
Stage II:		
$\sqrt{s}$ (GeV)	550	380
Luminosity (fb^{-1})	4000	4900
Beam Power (MW)	11 / 4.9	4.9
Run Time (yr)	10	10
# Single Higgs (I+II)	1.5×10^6	1.3×10^6
# Double Higgs	840	1800
# $t\bar{t}$	2.0×10^6	2.9×10^6

Stage I, 10 years

κ framework $\quad BR_{BSM} = 0$

coupling a	HL-LHC† Δa (%)	ILC/C^3 Δa (%)	XCC Δa (%)
HZZ	2.4	0.46	0.83
HWW	2.6	0.44	0.84
Hbb	6.0	0.83	0.85
$H\tau\tau$	2.8	0.98	0.89
Hgg	4.0	1.6	1.1
Hcc	-	1.8	1.2
$H\gamma\gamma$	2.9	1.1	0.10
$H\gamma Z$	-	-	1.5
$H\mu\mu$	6.7	4.0	3.5
Γ_{tot}	5	1.6	1.7

† S1 from Table 36 in arXiv:1902.00134 [hep-ph]

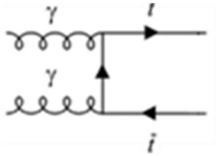
Stage I+II, 20 years

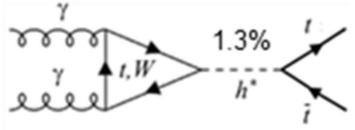
Model Independent EFT

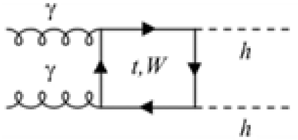
coupling a	ILC/C^3 Δa (%)	XCC Δa (%)
HZZ	0.38	0.94
HWW	0.37	0.94
Hbb	0.60	0.95
$H\tau\tau$	0.77	0.99
Hgg	0.96	1.2
Hcc	1.2	1.2
$H\gamma\gamma$	1.0	0.44
$H\gamma Z$	4.0	1.5
$H\mu\mu$	3.8	3.5
Htt	2.8	4.6
HHH	20	14*
Γ_{tot}	1.6	2.4
$\Gamma_{inv}{}^\dagger$	0.32	–
$\Gamma_{other}{}^\dagger$	1.3	1.5

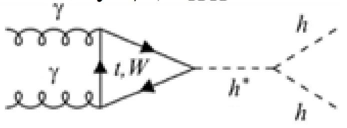
† 95% C.L. limit

*assumes XCC error is ILC/C^3 value scaled by $1/\sqrt{N_{HH}}$









XCC Technical Challenges and P5 Ask

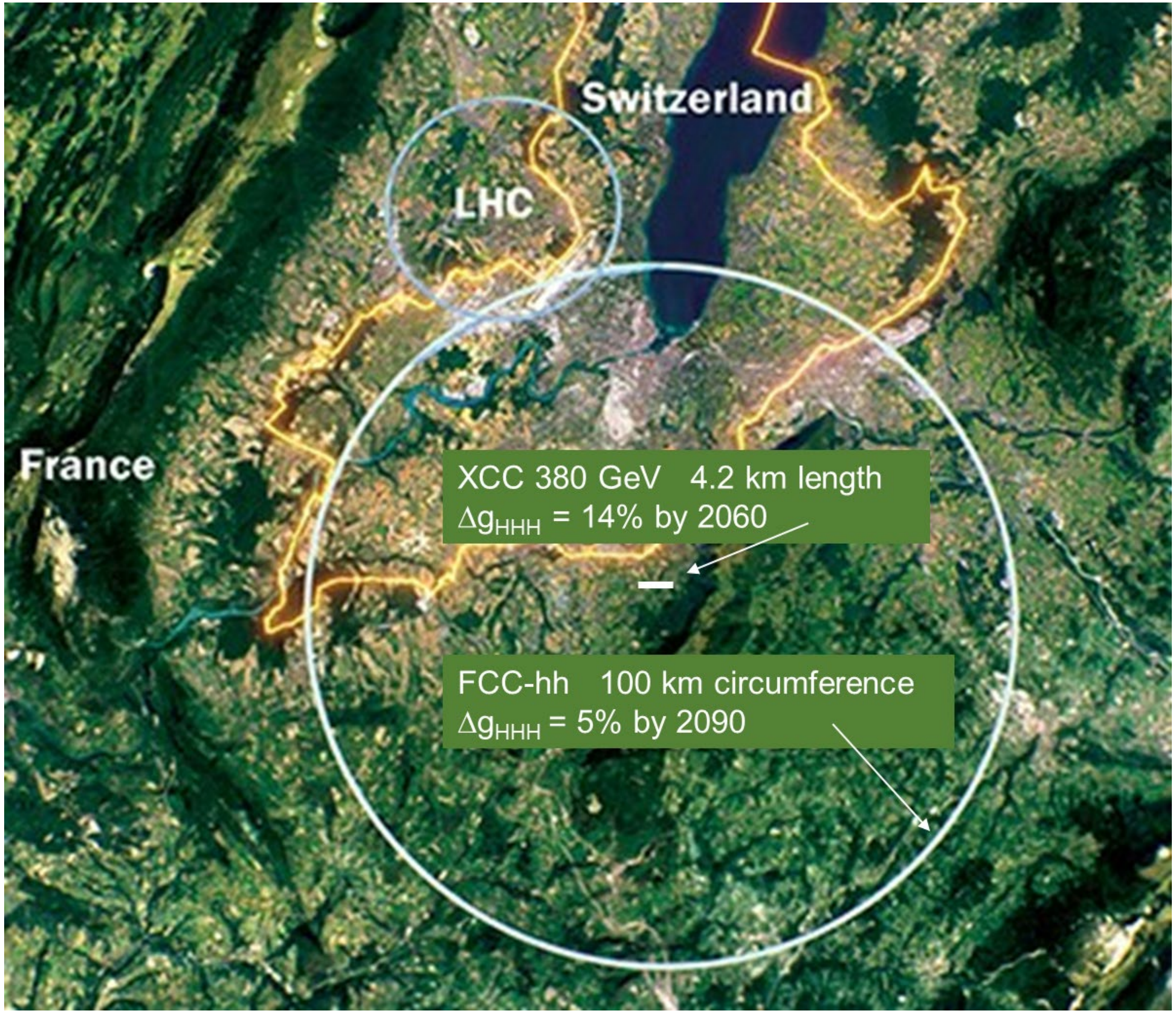
Technical Challenges

- e^- accelerator with $70-120$ MV/m (common with C^3 e^+e^- collider)
- Focusing of round e^- beams to $\sigma_{x,y} = 5.5$ nm
- Focusing of 1 keV γ XFEL with 700 mJ/pulse to 70 nm FWHM waist
- XFEL and e^- beamline layouts around the IP
- Timing stability of the XFEL laser beam and e^- beam at Compton IP.

P5 Ask

- Support for 5 to 6 FTE's for a few years to write a CDR.
- Due to common accelerator technology, we propose that the XCC CDR be incorporated into the C^3 CDR as a 2nd collider configuration option, with the choice between e^+e^- and $\gamma\gamma$ to be made at a later date (much like a CDR might contain several site options).

XCC vs. FCC-hh


Switzerland
LHC
France
XCC 380 GeV 4.2 km length
Δg_{HHH} = 14% by 2060
FCC-hh 100 km circumference
Δg_{HHH} = 5% by 2090