γγ collider using FCCee

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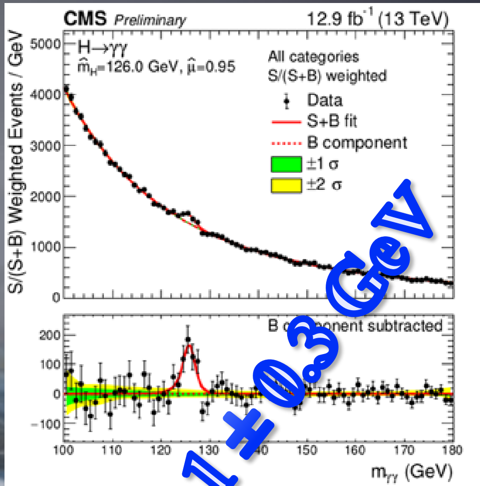
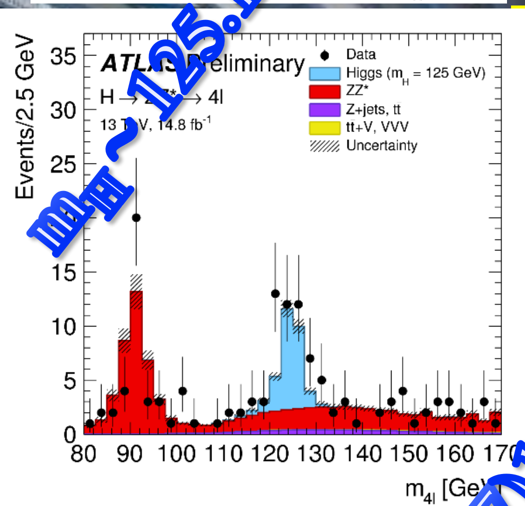
- Introduction
- FCC-γγ collider Concept
- Parameters and performance
- Challenges
- Conclusion

Introduction

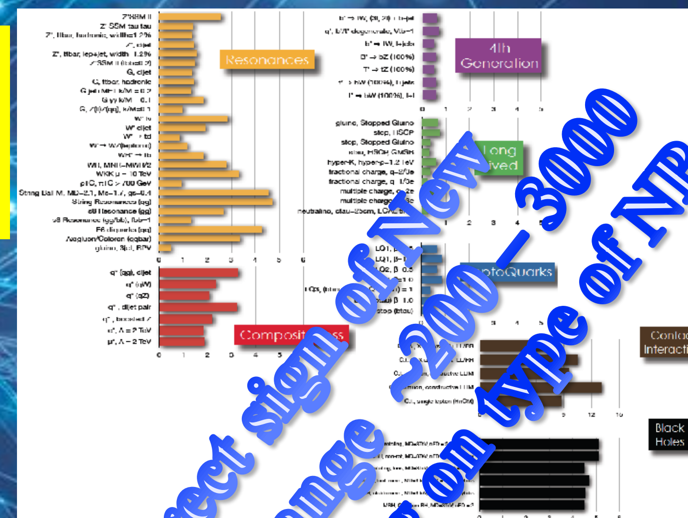
All SM particles observed
No additional particles observed
No indication of deviation from SM predictions



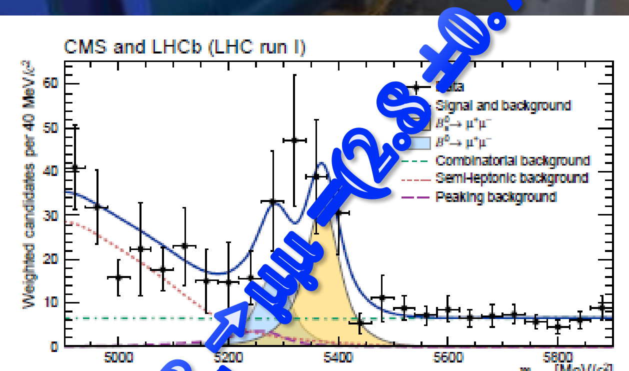


$m_H = 125.1 \pm 0.3$ GeV

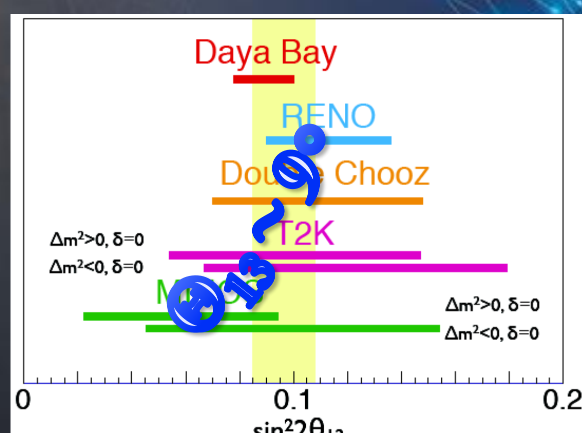
High Precision Measurements
Very High Energy Reach
High Intensity ν Beams



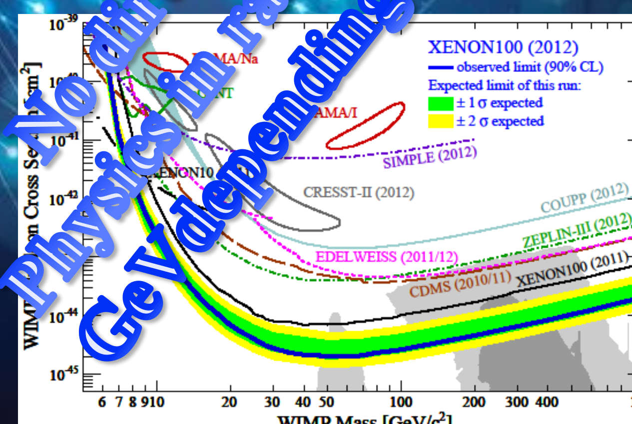
No direct sign of New Physics in range ~200 – 3000 GeV depending on type of NP



$B_s \to \mu\mu = (2.8 \pm 0.7)\,10^{-9}$



$\Theta_{13} \sim 9°$



Possible Scenarii (cont'd)

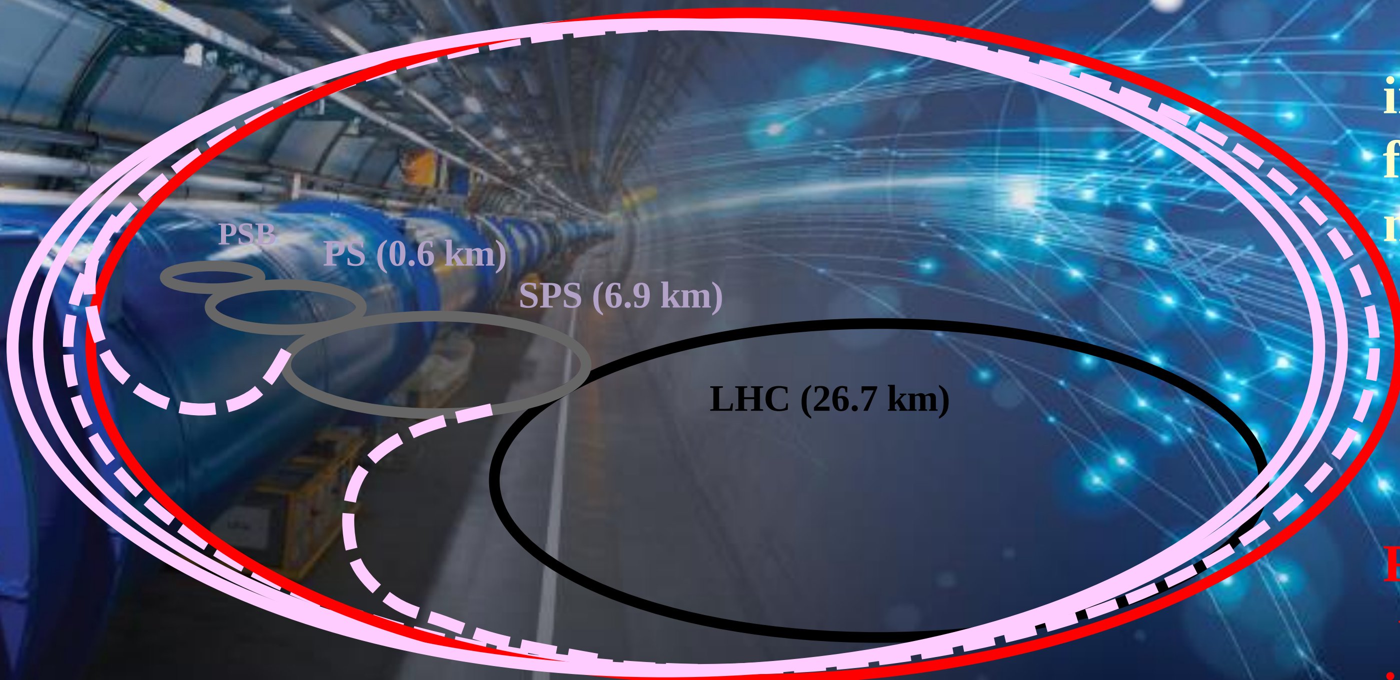
When | **What**

When	What: Standard Higgs	What: Non-standard Higgs
after LHC @14 TeV	Standard Higgs and nothing else	Non standard Higgs and/or new physics
Decision in 2019-20	High precision e^+e^- Collider : e.g. FCCee…	Depending of NP scale e^+e^- and/or pp : FCCee+FCChh or CLIC or FCChh directly
	FCChh (pp 100 TeV)	

A strategy toward very High Energy should be developed… …possibly with multiple probes and with the same complex?

FCC

97 km tunnel



(CERN implementation
capitalizing on existing infrastructures

FCCee: e^+e^-, up to $\sqrt{s}$ ~350 GeV including possibility for γγ collisions if needed

FCChh : pp, $\sqrt{s}$ ~ 100 TeV in same tunnel including possibly ep collisions if needed

Possible Strategy (if present situation prevails)

1. Mesuring the electroweak sector with the HIGHEST possible precision with e^+e^- collisions
2. Observation of deviations from the SM providing indications on the scale of New Physics
3. Exploring this New Physics directly with pp collisions
4. If needed, complement the studies with other types of collisions
   - $e^{+/-}p$ collisions
   - $\gamma\gamma$ collisions
   - $\mu^+\mu^-$ collisions

A « >50-year » programme !

Several proposal have been made for $\gamma\gamma$ colliders e.g.

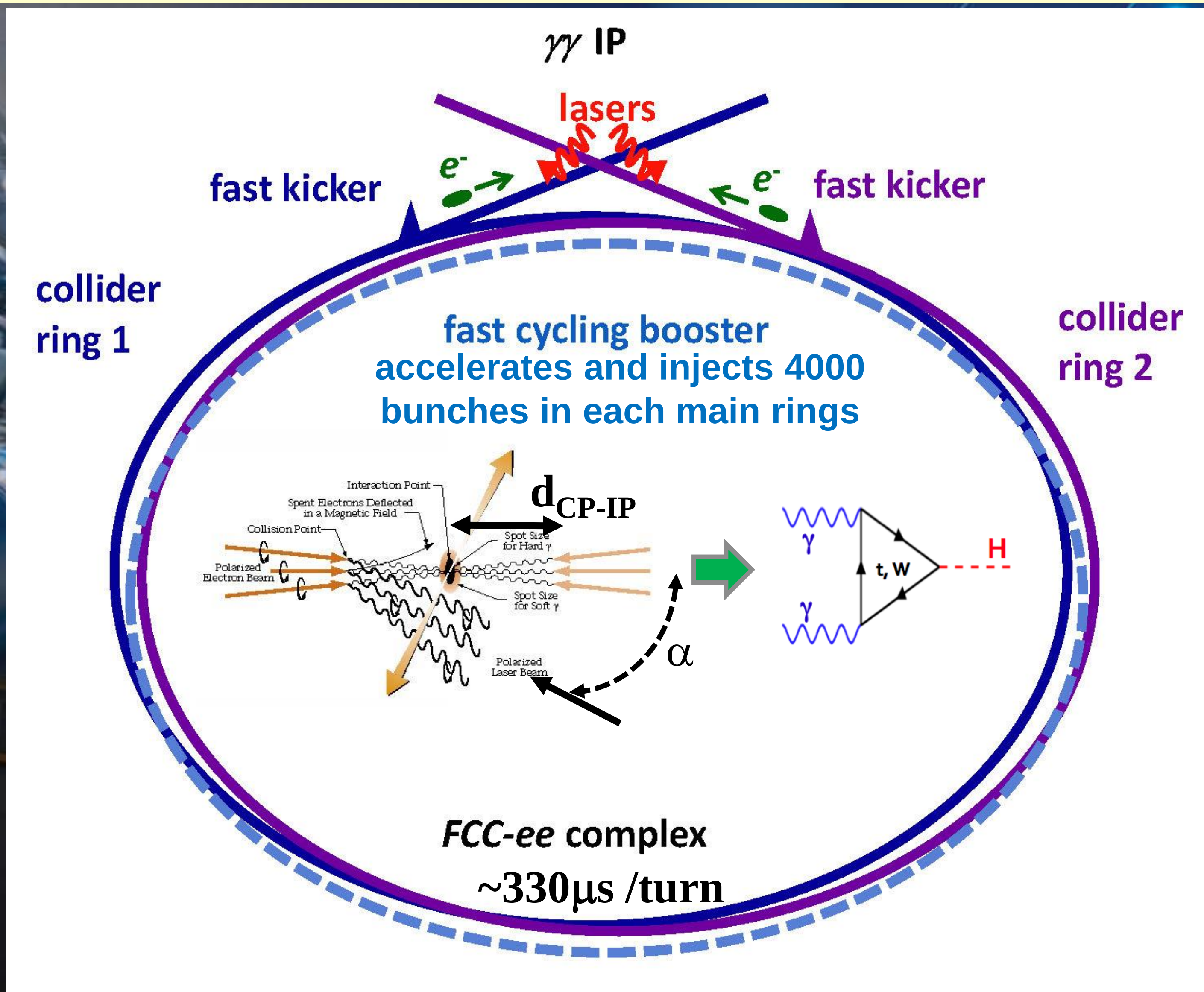
- Using recirculating linacs (SaPPHIRE)
- Using linear colliders (CLIC, ILC)

Can one use the FCC infrastructure to make $\gamma\gamma$ collisions?

Note: $\gamma\gamma$ collider is also a e^-e^- and $e^-\gamma$ collider

FCC–γγ collider Concept

"Scenarios for circular γ–γ Higgs Factories", R. A., A. Apyan,Y. Papaphilippou, F. Zimmermann, **Proceedings of IPAC2015, Richmond, VA, USA**



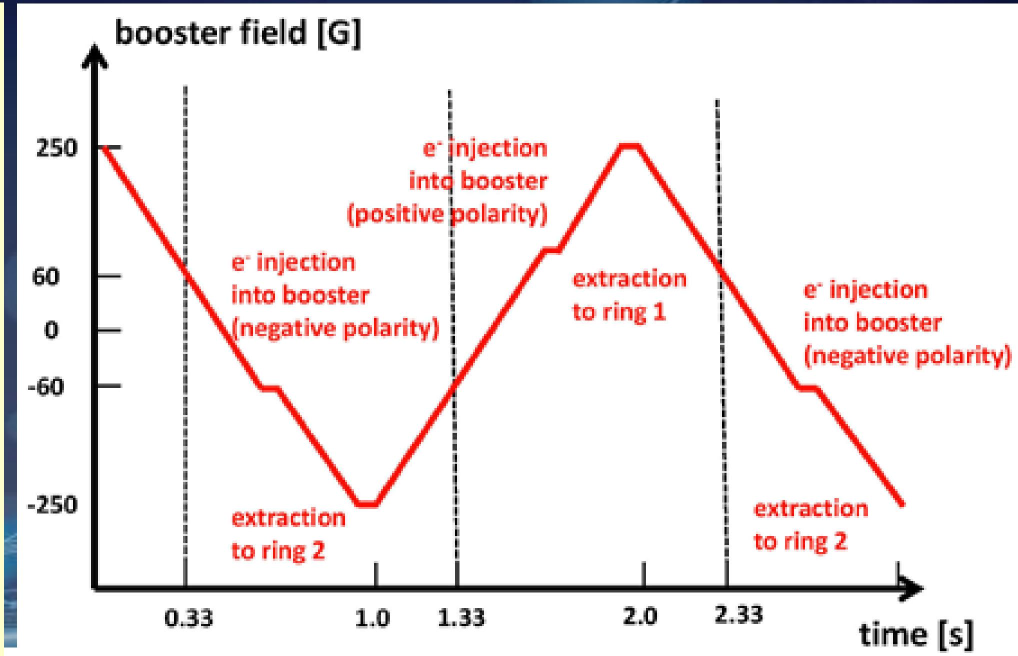
FCC–γγ collider Concept

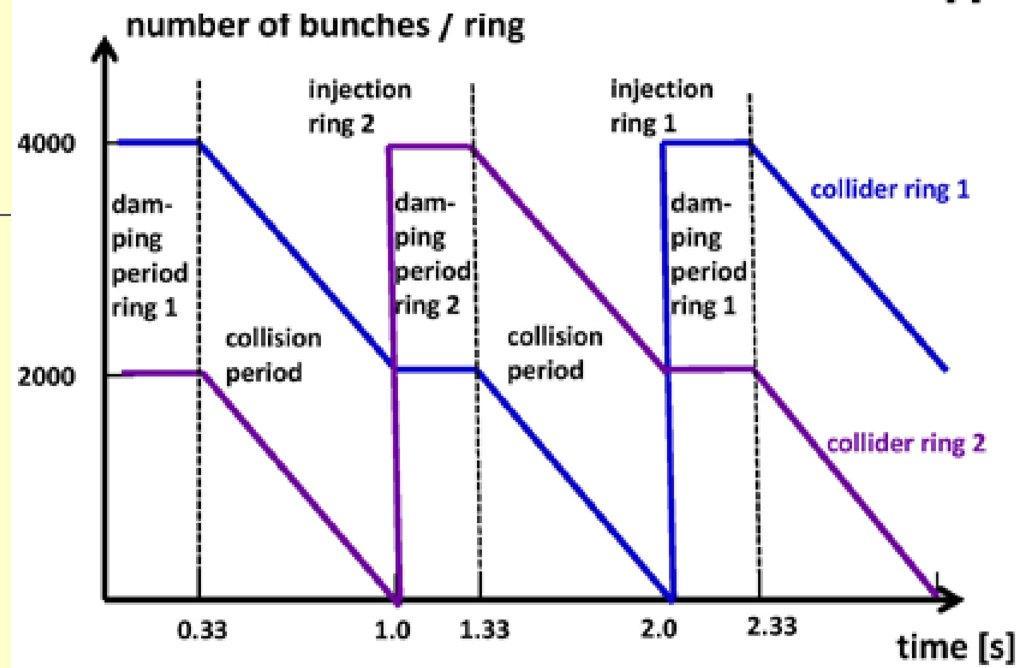
Booster cycle :

1. Inject 4000 bunches from booster in ring 1
2. Ramp down booster, inverte polarity to get 4000 bunches from injector in booster
3. Ramp up and inject 4000 bunches in ring 2
4. Ramp down booster, inverte polarity to get 4000 bunches from injector in booster
5. Ramp up and inject 4000 bunches in ring 1

Main rings' cycle :

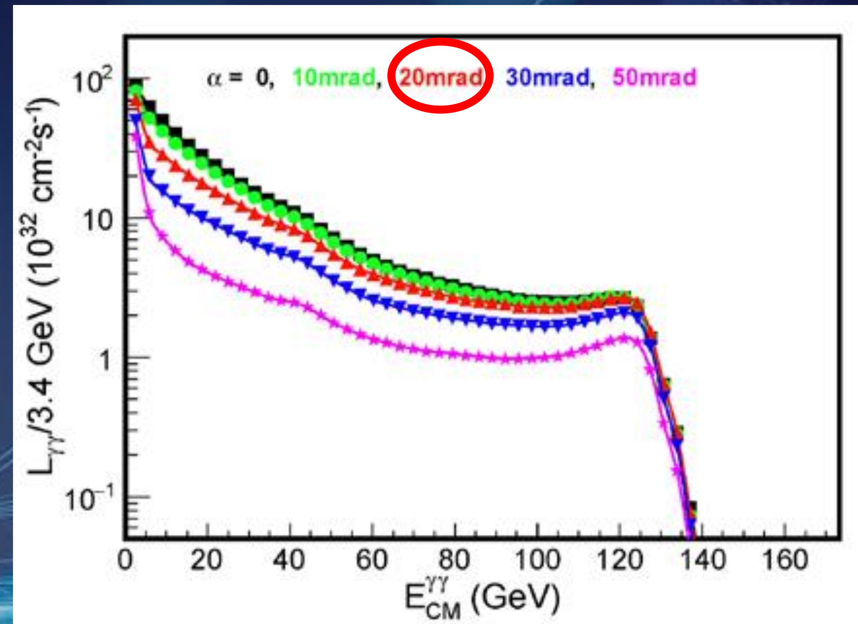
1. Damp the beams during 0.33 s
2. Extract and collide 2000 bunches during 0.66 s (1 bunch/turn)
3. Damp the beams during 0.33 s
4. Extract and collide 2000 bunch

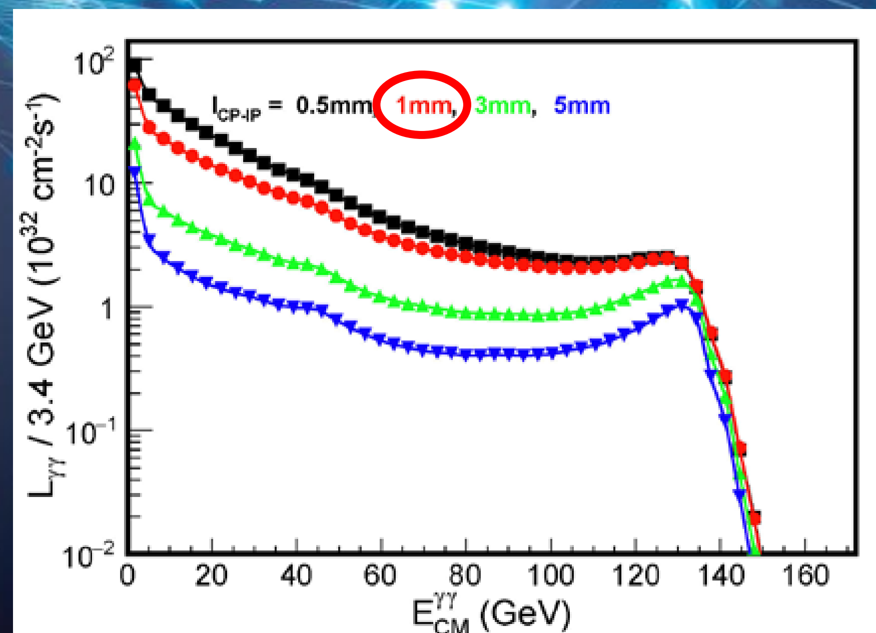




Parameters and Performance from simulations

	symbol	SAPPHIRE	FCC-ee
average el. power	P	100 MW	100 MW
beam energy	E	80 GeV	85 GeV
b. polarization	P_e	0.80	0.80
bunch popul.	N_b	10^{10}	7.7×10^{10}
laser rep rate	f_{rep}	200 kHz	3 kHz
av. collision rate	f_{coll}	200 kHz	2 kHz
laser pulse energy		5 J	5 J
laser power		1000 kW	15 kW
laser wave length	λ	350 nm	350 nm
Rayleigh length	z_R	0.3 mm	0.3 mm
rms laser spot CP	$\sigma_{\gamma;x,y}$	4 μm	4 μm
laser pulse length	σ_λ	0.25 mm	0.15 mm
# bunches / beam	n_b	-	4000
collider period		-	2 s
bunch length	σ_z	30 μm	350 μm
E damping time	τ_E	-	67 ms
energy spread	σ_δ	?	7×10^{-4}
RF frequency	f_{rf}	800 MHz	800 MHz
RF voltage	V_{rf}	2×10 GV	6 GV
$\gamma\gamma$ crossing angle	θ_c	≥20 mrad	≥20 mrad
nor.hor./vert. emit	$\gamma\epsilon_{x,y}$	5, 0.5 μm	69, 0.06 μm
geom. h./v. emit.	$\epsilon_{x,y}$	32, 3 pm	440, 0.4 pm
hor. IP beta funct.	β_x^*	5 mm	1 mm
vert. IP beta funct.	β_y^*	0.1 mm	0.1 mm
hor. rms spot size	σ_x^*	400 nm	700 nm
vert. rms spot size	σ_y^*	18 nm	6 nm
hor. rms CP spot	σ_x^{CP}	410 nm	1000 nm
vert. rms CP spot	σ_y^{CP}	180 nm	60 nm
distance IP – CP		~1 mm	1 mm
e^-e^- geometric luminosity	L_{ee}	2.2×10^{34} $cm^{-2}s^{-1}$	1.3×10^{34} $cm^{-2}s^{-1}$
$\gamma\gamma$ luminosity >125 GeV	$L_{\gamma\gamma}$	6×10^{32} $cm^{-2}s^{-1}$	8×10^{32} $cm^{-2}s^{-1}$





Parameters and Performance from simulations

Physics not discussed in this talk by lack of time, see:

SAPPHiRE: a Small γγ Higgs Factory, S. Bogacz et al., *Submitted to the European Particle Physics Strategy Preparatory Group*

Higgs Physics with a γγ Collider Based on CLIC 1, D. Asner et al., CERN-TH/2001-235.

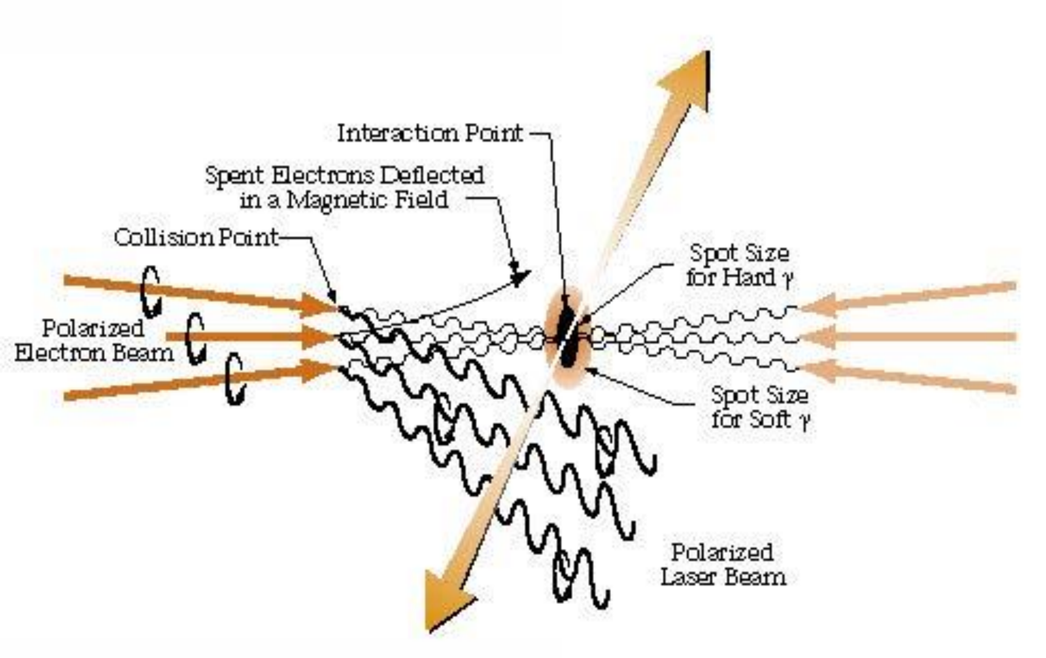
With the parameter above:

$L_{\gamma\gamma}$ (>125 GeV) = ~8 10^{32} cm^{-1} s^{-1} → **~10 000 Higgs/year (10^7 s)**

L_{ee} = ~1.3 10^{34} cm^{-1} s^{-1} → **e.g. ~4 10^8 $e^-e^- \rightarrow e^-e^-$ /year (10^7 s) with θ_{scatt} > 5°**

$L_{e\gamma}$ = ~3 10^{33} cm^{-1} s^{-1} → **~3 10^4 $e^-\gamma \rightarrow W^-\nu$ /year (10^7 s)**

Challenges



A very powerful laser system is necessary

Laser Pulse energy	5 J
Laser repetition rate	3 kHz
Average power	15kW
Laser Wavelength	350nm

Challenges

Design of the Interaction region

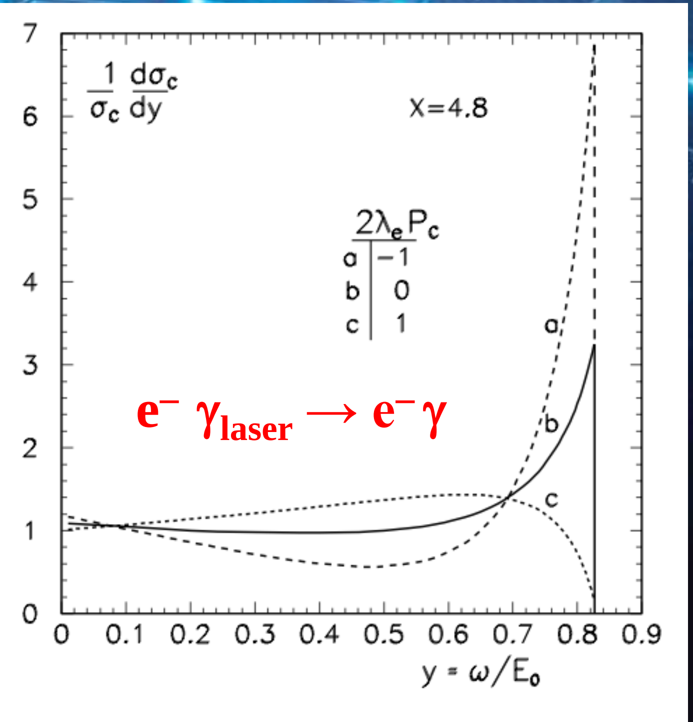
Distance CP-IP	1mm
Laser spot at CP	4-10μm
Laser incident angle	20mrad
Integation of IR in detector	

Polarization of the electron beam

All previous figures were given with:

- Polarized Laser
- Unpolarized electron

If electron polarization (0.8) can be preserved, gain ~x3 on Higgs Xsect.



Conclusions

We have demonstrated the conceptual feasibility of a γγ-collider using the FCCee infrastructure

Several challenges have to be studied concerning the technical implementation of such a facility, amongst which :

- **The laser performance**
- **The design of the interaction region**
- **The possibility to preservation of electron polarization**

A laser with the required specifications is also useful for many other applications, including :

- **Laser drived Plasma Wakefield Acceleration**
- **MultiMeV gamma sources**
- **Low energy γγ collider for study of vaccuum polarization and QED**