

# Discussion: Energy Frontier Report preparation

(result presentation, e.g. plots, tables etc.)

## Focus on Accelerator Scenarios

Sep 3, 2021

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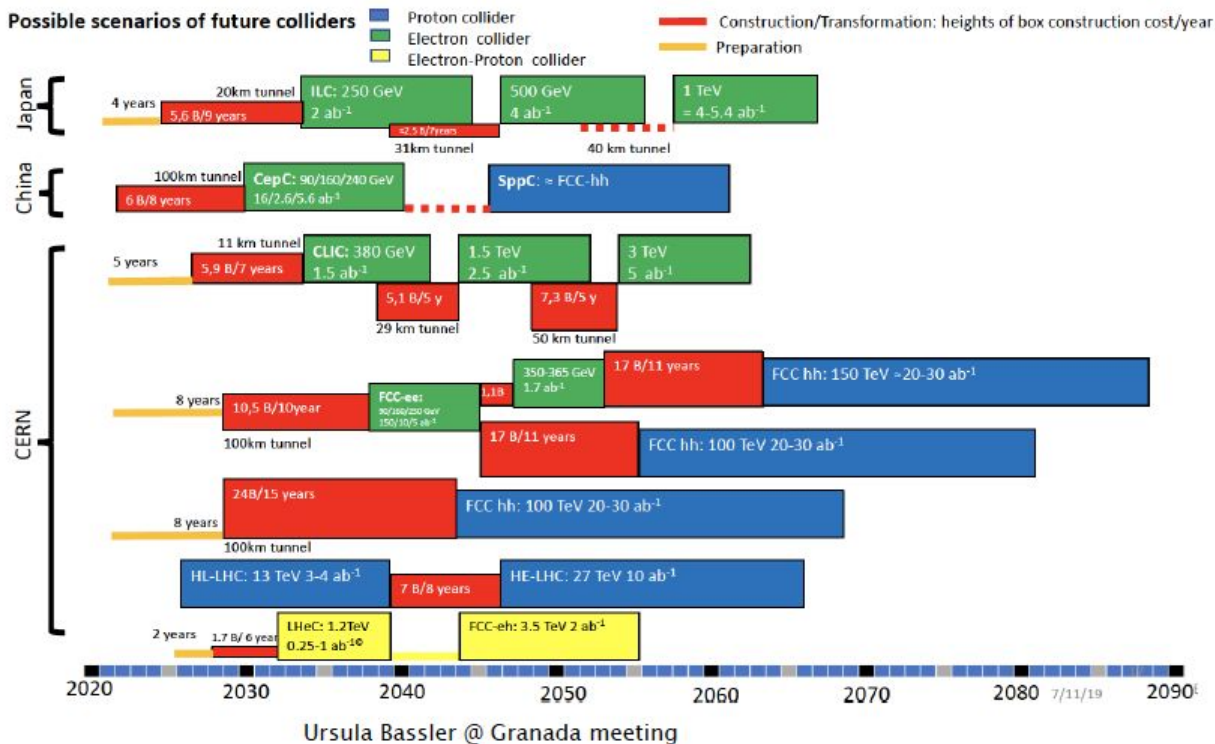
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# Energy Frontier Report

1. **Frontier Summary:** < ~50 pages (including “Subgroup” summaries)
  - **FOR EF:** “subgroup” summaries according to broad themes: for example: Higgs, EWK, Strong Interactions, BSM and Heavy Ions, addressing the overlaps across them.
  - **Authors:** EF conveners and EF-TG conveners
2. **Subgroup Group Reports**
  - Plan for report from each of the 10 TOPICAL GROUPs
  - Each report no longer than a few tens of pages.
  - **Authors:** EF, TG Conveners and Community contributors
  - **Content:**
    - Key Questions
    - Physics landscape leading up to Snowmass CSS
    - New ideas and updates from contributed papers
    - [summary comment by collider type?]
    - outlook

# Future Collider Scenarios & Timelines



- Will add **EIC** and **Muon Collider** to this chart.
- Will consider **new proposals** that have come up during Snowmass 2021.
  - e.g. initiatives for gamma-gamma and plasma colliders etc.

# Snowmass 2021: EF Benchmark Scenarios

Snowmass 2021 Energy Frontier Collider Study Scenarios

Collider	Type	$\sqrt{s}$	P [%] $e^-/e^+$	$L_{int}$ $ab^{-1}$
HL-LHC	pp	14 TeV		6
ILC	ee	250 GeV	$\pm 80 / \pm 30$	2
		350 GeV	$\pm 80 / \pm 30$	0.2
		500 GeV	$\pm 80 / \pm 30$	4
		1 TeV	$\pm 80 / \pm 20$	8
CLIC	ee	380 GeV	$\pm 80 / 0$	1
		1.5 TeV	$\pm 80 / 0$	2.5
		3.0 TeV	$\pm 80 / 0$	5
CEPC	ee	$M_Z$		16
		$2M_W$		2.6
		240 GeV		5.6
FCC-ee	ee	$M_Z$		150
		$2M_W$		10
		240 GeV		5
		$2 M_{top}$		1.5

Snowmass 2021 Energy Frontier Collider Study Scenarios

Collider	Type	$\sqrt{s}$	P [%] $e^-/e^+$	$L_{int}$ $ab^{-1}$
FCC-hh	pp	100 TeV		30
LHeC	ep	1.3 TeV		1
FCC-eh	ep	3.5 TeV		2
muon-collider (higgs)	$\mu\mu$	125 GeV		0.02
High energy muon-collider	$\mu\mu$	3 TeV		1
		10 TeV		10
		14 TeV		20
		30 TeV		90

Note for muon-collider: It is important to note that the plan is not to run subsequently at the various c.o.m etc. These are reference points to explore and assess the physics potential and technology. The luminosity can be varied to determine how best to exploit the physics potential.

## Other options to explore:

- Muon collider at a very high energy ( >30 TeV?)[Need to consolidate gro list of c.o.m. energies]
- FCC pp >200 TeV? and ~75 TeV documenting sensitivity loss
- Very high energy e+e- collider
- Other emerging ideas:  $\gamma\text{-}\gamma$  collider,  $C^3 e^+e^-$  collider [C3=Cool Copper Collider]

# Accelerator Scenarios for Baseline Study

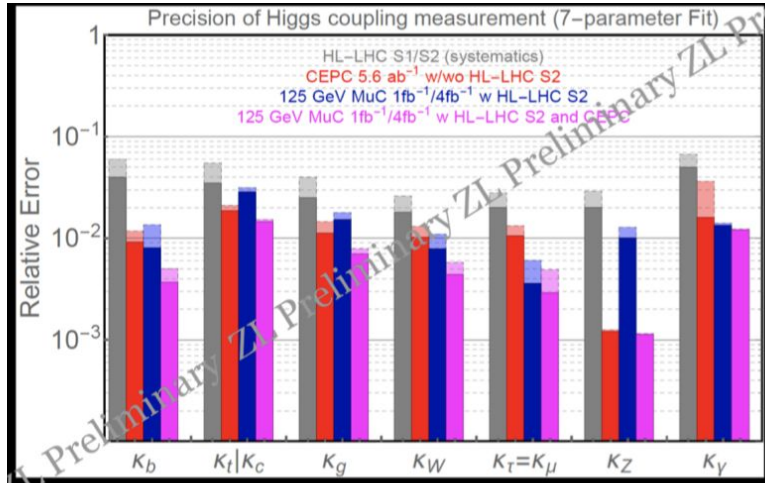
- Converge on “other options to explore” since Oct 2020!  
[discussion got slowed down due to Snowmass pause!]
- Muon collider at a very high energy
  - Need to consolidate growing list of c.o.m. energies
- FCC pp @ 300 TeV?
- Very high energy e+e- collider
  - C<sup>3</sup> @250 and 550 GeV
  - gamma-gamma collider - [energy?]
- Any other options?
- For all the above need to understand the luminosity scenarios
- Other parameters ? e.g. beam polarization for HE e+e- coll.?

# Accelerator Scenarios for Baseline Study

- Start from ESG Briefing book summary plots as the baseline
  - Need to connect with colleagues who produced the plots.
- Snowmass 2022 updates
  - Come up with a “frozen list” of accelerator scenarios to consider in the main report, by Sep 24th “Restart Community meeting”
  - Shall we only add, or also drop any accelerator scenarios?

# Some EXAMPLES

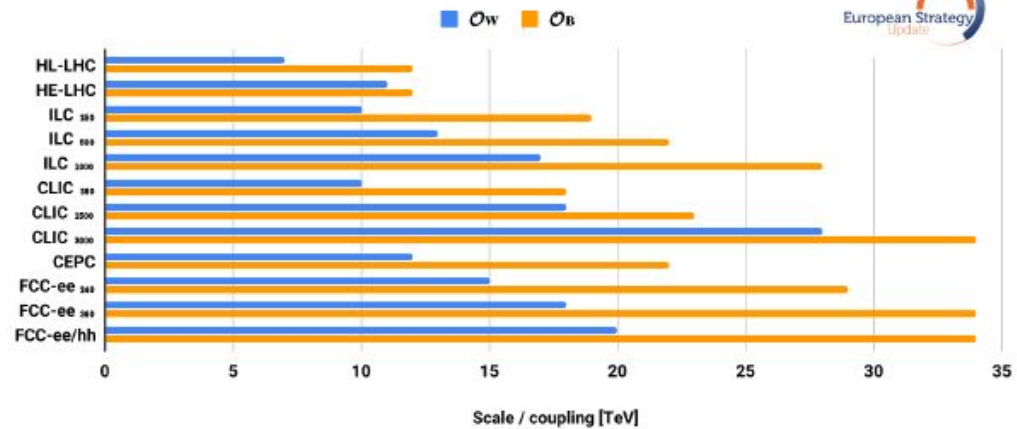
## Higgs Couplings



Adding sensitivity studies from Muon Colliders

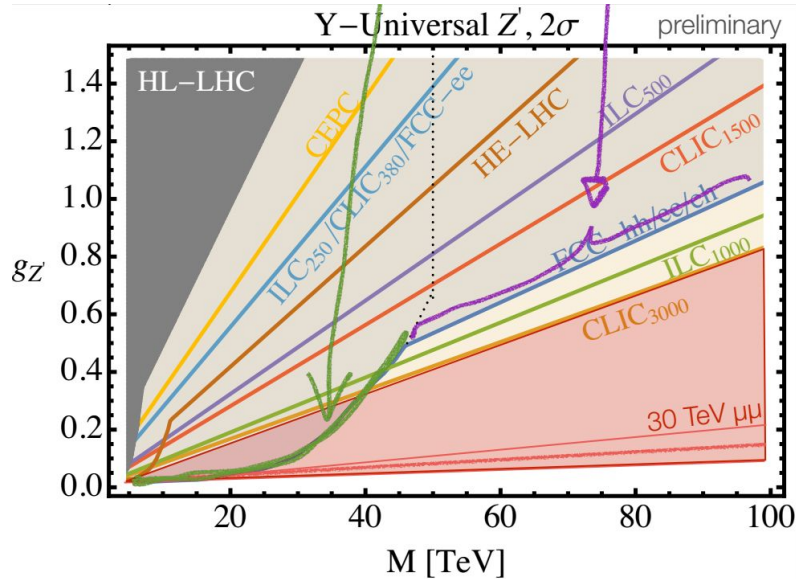
## C.I. scale

95% CL scale limits on 2-fermion 2-boson contact interactions



Add other colliders,  
but would it be better in 2D?

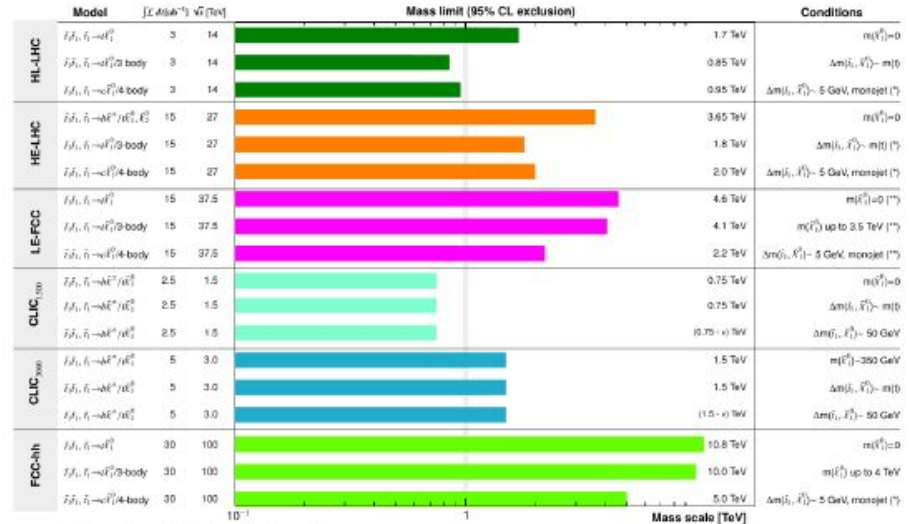
# Some EXAMPLES: New Particle Searches



- Added muon collider
- Focus on 5 sigma discovery reach scenarios
- 95% CL constraints are welcome too.

## All Colliders: Top squark projections

(R-parity conserving SUSY, prompt searches)



(\*) indicates projection of existing experimental searches

(\*\*) extrapolated from FCC-hh prospects

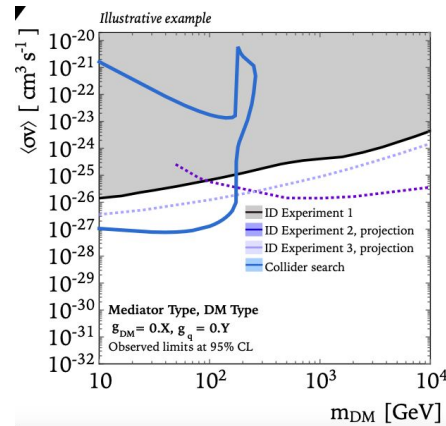
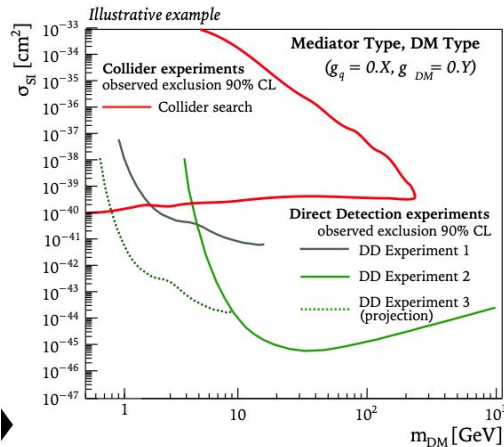
ILC 500: discovery in all scenarios up to Kinematic limit  $\sqrt{s}/2$

Additional Modes?  
Additional colliders?  
Model independence



# Some EXAMPLES: WIMP and light DM

- Currently recruiting new members (with the help of SEC Matt LeBlanc and Grace Cummings) to compile list of DM @ collider experiments for summary plots and update European Strategy ones if needed:



Work also will include the planned DMWG whitepaper (and discussion with other Frontiers) on lowering the couplings for the simplified models used by the LHC

# Discussion topics

- Summary plots and inclusion of the baseline collider scenarios highlighting the individual reach of a specific collider at a time
- How to compare different studies and identify gaps?
  - e.g. compare some advanced studies (e.g. ILC, FCC-ee) with very preliminary results (e.g. muon collider).
- Maybe they are on different footing?
  - Study based on full simulation vs fast simulation
  - Background estimations [full vs ideal]?
  - Differences in treatment of systematic uncertainties
  - ... etc..
- As long as the results are robust, propose to add a footnote that clarify the assumptions included in the results [...full sim vs fast sim, or a thorough study of background, etc...]

# Discussion topics

- Format of sensitivity plots by collider:
  - Continue with the ESG format ?
  - Or change to 2D ... sensitivity vs c.o.m? vs collider
- While all of this work is done in different TGs, and Frontiers, **we would like to have some uniform summary plots (if possible) for the overall EF report**
- **Coordination for the summary plots/tables with XFrontier, and XTG need to start now**
  - important for the TGs to come to an agreement of conventions, inputs, etc. starting soon/NOW!
  - otherwise, we may be in a situation where each summary of results will have a series of caveats attached to it.

# Discussion

Google docs for input:

[https://docs.google.com/document/d/1Mm-KQNkmP\\_01dxng9kww4o6YZ5MSRxd6P6CDXdpMSkA/edit](https://docs.google.com/document/d/1Mm-KQNkmP_01dxng9kww4o6YZ5MSRxd6P6CDXdpMSkA/edit)

**Feel free to add - please do include your name and comment. This will help us follow up later in case we have questions and also include interested parties in future discussions**

**A. Community Comments from discussion**

**B. Suggestions for a list of plots or tables which should be included in the reports.**

Backup slides

# Activities and Timeline

- **Broad effort of LOI solicitation through dedicated Topical Group meetings**
  - 376 received - see list [here](#)
  - 268 have EF as primary
  - **Cross-frontier LOIs:** TF (21), AF (20), IF(17), RF (16), CF (14), NF (11), CompF (9)
- **LOIs have contributed to shaping Topical Group activities**
  - see breakout sessions of the [Community Planning Meeting \(CPM\), Oct 5-8, 2020](#)

❖ If you haven't submitted a LOI, you can still contribute!  
just get in touch with your ideas and plans

## Timeline going forward

1/21-6/21	6/30/21	7/12/21	8/30/21	9/24/21	3/15/22	5/31/22	6/30/22	7/22	9/30/22	10/31/22
Activity Slowdown	Restart of Activities	DPF Meeting + Snowmass Townhall	Now, EF restart Workshop	Snowmass day	Deadline Contributed Paper Submission	Prelim. TG Reports	Prelim. Frontier Reports	Community Summer Study (UW-Seattle)	Final Reports	Snowmass Book & ArXiv docs

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- **Sept. 24, 2021: Snowmass Day, <https://indico.fnal.gov/event/50538/>**
  - Plenary session 12:00-2:00pm (eastern time) with short talks from all frontiers
  - EF parallel session 2:30pm-5:00pm (eastern time) with highlights by topical group
  - Early Career (EC) will be chosen as speakers: they will provide their own perspective and highlight EC studies
- **Winter 2021-2022: few one-day virtual EF workshops by topic (SM, Higgs, BSM, Colliders,...)**
  - Check progress towards March deadline for contributed papers
  - Discuss overlap with other frontiers
- **Spring 2022: EF workshop to review contributed papers**
  - Focus on main themes and messages by contributed papers, towards May deadline for TG reports.
  - Converge on summary plots and other contributions involving multiple TGs or multiple frontiers
- **March-July 2022: circulations of preliminary TG and EF reports, then public readings**