

Accelerator Frontier : *“Pause” and “Restart”*

Snowmass Day (“Restart”), Sept. 24, 2021

Stephen Gourlay, Tor Raubenheimer,
Vladimir Shiltsev



Accelerator Frontier at a Glance

- **7 Topical Groups + Implementation Task Force**
 - 30 conveners + dozen liaisons to 8 Frontiers
 - 329 LoI → expect some 60 White papers
- **Most active over the “Pause” and in Aug.-Sep.:**
 - AF1 “Beam Physics” – “Ultimate Beams/Colliders” Workshop series
 - AF4 “Multi-TeV Colliders” – workshops and discussions with IMCC, EF, TF
 - AF6 “Advanced Concepts” – discussions with EF, TF
 - AF7 “Technology” – three topical workshops
 - Implementation Task Force – continued regular meetings in 4 subgroups
- **Effective interactions with**
 - Muon Collider Forum
 - AF4+D.Li and D.Stratakis + EF + TF + IF + CERN/IMCCollaboration
 - Fermilab Booster replacement Group (PIP-III)
 - mix of accel, theory and detector people
 - Fermilab Collider Group
 - led by P.Bhat - mix of accel, theory and detector people
- **All AF Topical Groups plan workshops and meetings before converging on White papers by March 15, 2022**
 - Today’s AF breakout session = *liaison-led cross frontier discussions*

AF1: “Physics Limits of Ultimate Beams”

- A total of five Zoom workshop sessions (joint with AF4 and AF6) was held between Dec. 3, 2020 and April 6, 2021.
(<https://indico.fnal.gov/category/1120/>)
 - Leading physicists from particle physics presented various discovery physics potentials with e+e-, gamma, muon and proton colliders.
 - Discussions on pushing for the ultimate beams that the ongoing plasma wakefield acceleration or other disruptive acceleration technology could have the potential to reach the ultimate beams at the quantum limit.
 - The conventional RF acceleration-based beams so far are still limited by the either the engineering limit or social sustainability limits
- **Plan to restart the workshop series with focuses on test facilities and education.**
- **Also, two US PAS sessions on colliders Jan’22 - <https://uspas.fnal.gov/>**
- **Plan to have 3-4 white papers covering physics limits, test facilities, and education topics.**

Mei Bai, Zhirong Huang, Steve Lund

AF4 (Multi-TeV Colliders): Work with proponents on White Papers and the Topical Group Report



TG4: Issues to be Addressed in White Papers and Final Report for Multi-TeV Colliders

The Snowmass 2021 Accelerator Frontier Topical Group no. 4 – Multi-TeV Colliders, in collaboration with the Energy Frontier colleagues aims to explore the potential machine routes, timelines, R&D requirements, and common issues at the very high energy scale such as energy efficiency and cost.

This document outlines the proposed structure of White Papers and key aspects that will be summarized in the final working group report. The information gathered during the preparation of these reports will also assist in the communication with other Topical Groups on synergistic matters.

We expect that the bulleted lists below may not be comprehensive, so each whitepaper team can add topics that they view as relevant to their proposal.

Structure of White Papers

- 1. Design Overview**
 - 1.1. Status of Design
 - 1.2. Performance Matrix
 - 1.3. Design Summary
 - 1.4. Design Challenges
- 2. Technology Requirements***
 - 2.1. Technology Readiness Assessment
 - 2.2. Required R&D
 - 2.3. Required and Desirable Demonstrators
- 3. Staging options and upgrades**
 - 3.1 Energy upgrades
 - 3.2 Luminosity upgrades
 - 3.3 Experimental system upgrades
- 4. Synergies with other concepts and/or existing facilities**
 - 4.1 Synergies on machine technologies
 - 4.2 Synergies on detector technologies
 - 4.3 Synergies on conventional facilities and green power

*Notes: A list of technology R&D LOIs related to each machine concept is included. We ask the machine coordinators to integrate inputs from these LOIs into section 2 of the document.

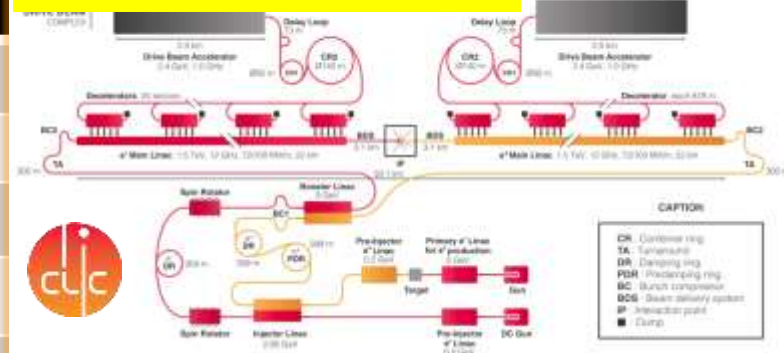
Mark Palmer, Nadia Pastrone, Jingyu Tang,

Alexander Vaishev and Marlene Turner

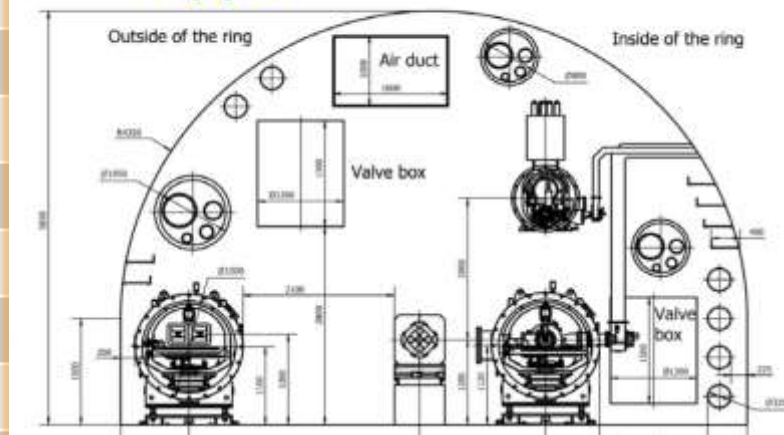
17 (!) High Energy Collider Concepts/Proposals

Name	Details
Cryo-Cooled Copper linac	e^+e^- , $\sqrt{s} = 2$ TeV, $L = 4.5 \times 10^{34}$
High Energy CLIC	e^+e^- , $\sqrt{s} = 1.5 - 3$ TeV, $L = 5.9 \times 10^{34}$
High Energy ILC	e^+e^- , $\sqrt{s} = 1 - 3$ TeV
FCC-hh	pp , $\sqrt{s} = 100$ TeV, $L = 30 \times 10^{34}$
SPPC	pp , $\sqrt{s} = 75/150$ TeV, $L = 10 \times 10^{34}$
Collider-in-Sea	pp , $\sqrt{s} = 500$ TeV, $L = 50 \times 10^{34}$
LHeC	ep , $\sqrt{s} = 1.3$ TeV, $L = 1 \times 10^{34}$
FCC-eh	ep , $\sqrt{s} = 3.5$ TeV, $L = 1 \times 10^{34}$
CEPC-SPPpC-eh	ep , $\sqrt{s} = 6$ TeV, $L = 4.5 \times 10^{33}$
VHE-ep	ep , $\sqrt{s} = 9$ TeV
MC – Proton Driver 1	$\mu\mu$, $\sqrt{s} = 1.5$ TeV, $L = 1 \times 10^{34}$
MC – Proton Driver 2	$\mu\mu$, $\sqrt{s} = 3$ TeV, $L = 2 \times 10^{34}$
MC – Proton Driver 3	$\mu\mu$, $\sqrt{s} = 10 - 14$ TeV, $L = 20 \times 10^{34}$
MC – Positron Driver	$\mu\mu$, $\sqrt{s} = 10 - 14$ TeV, $L = 20 \times 10^{34}$
LWFA-LC (e+e- and $\gamma\gamma$)	Laser driven; e^+e^- , $\sqrt{s} = 1 - 30$ TeV
PWFA-LC (e+e- and $\gamma\gamma$)	Beam driven; e^+e^- , $\sqrt{s} = 1 - 30$ TeV
SWFA-LC	Structure wakefields; e^+e^- , $\sqrt{s} = 1 - 30$ TeV

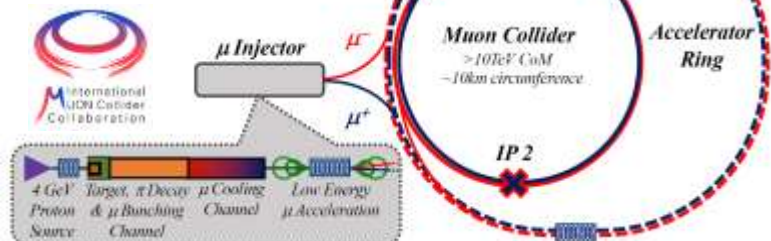
CLIC e^+e^- 3 TeV, 100 MV/m 50 km



pp 100 km : SPPC 75 TeV, 12 T magnets, FCC-hh 100/16 T



$\mu^+\mu^-$ 10-14 TeV cme
10-14 km, 16 T magnets



Implementation Task Force

- The Accelerator **Implementation Task Force** is charged with developing metrics and processes to facilitate a comparison between projects.
- 10 int'l experts and 2 Snowmass Young's
- This year worked in four subgroups:
 - Size, complexity, power, environment
 - Physics reach (impact), beam parameters
 - Technical risk, technical readiness, validation
 - Cost, schedule
- Plan to finish preliminary analysis and start talking to proponents in Dec-Jan, to be ready to submit report (Snowmass WP) by May 2022



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(LBNL)



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Sarah Cousineau
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Marlene Turner
(LBNL)



Spencer Gessner
(SLAC)



EF Restart - AF Discussions

Energy Frontier Workshop - Restart

<https://indico.fnal.gov/event/49756/timetable/>



Aug 30, 2021, 10:00 AM → Sep 3, 2021, 4:30 PM US/Eastern

Alessandro Tricoli (BNL), Laura Reina (Florida State University), Meenakshi Narain (Brown University)

Description **The goal of this EF community workshop is to regroup after the few months of pause of Snowmass activities, assess progress made so far in on-going studies, share new studies that may have been started, identify gaps in our strategies, and update the community with schedule, goals and plans for the upcoming months towards the final reports in spring/summer 2022.**

The workshop will be **virtual** only, and will comprise plenary and parallel sessions, with ample time for discussions with members of the EF community and across Frontiers. Dedicated unstructured discussion sessions are also planned around topical themes.

NO REGISTRATION NEEDED.

The sessions will start at 10:00 am and end at 4:30 pm (US Eastern time), including a one-hour break, and a coffee/tea break of half-an-hour.

The Zoom links will be made available in due course.

Tue 08/31

3:00 PM → 4:30 PM Unstructured Discussions: Joint Discussion with AF (Muon Collider and new ideas)

Conveners: Derun Li (LBNL), Diktys Stratakis (Fermi National Accelerator Laboratory), Fabio Maltoni (Universite' catholique de Louvain), Kevin Black, Patrick Meade (Stony Brook), Sergo Jindariani (FNAL) **MC-Higgs, -3, -6, -10, -14**

Wed 09/01

3:00 PM → 4:30 PM Unstructured Discussions: Joint Discussion with AF (e+/e- and hadron colliders, HL-LHC)

Conveners: Dmitri Denisov (Fermilab), Vladimir Shiltsev (FNAL) **ILC, CLIC, FCC/CepC/SPPS, FNAL site fillers**

Thur 09/02

3:00 PM → 4:30 PM Unstructured Discussions: Joint Discussion with AF: advanced acceleration concepts and the collider options

Conveners: Dmitri Denisov (Fermilab), Vladimir Shiltsev (FNAL) **AAC-colliders, ITF, theory**

Compact (Fermilab Site-Filler) Colliders

Circumference ~16 km

Linear ~7 km



1. e+e- Site Filler, $\sqrt{s} = 90-240$ GeV
2. Muon Collider, $\sqrt{s} = 0.126 - 8$ (10) TeV
3. pp Site Filler Collider, $\sqrt{s} = 24-28$ TeV

1. C³ (Cool Copper Cavity) e+e- Collider, $\sqrt{s} = 90 - 500$ GeV
2. NC RF (CLIC-Klystron) e+e- Collider, $\sqrt{s} = 90 - 500$ GeV
3. SRF-Travelling Wave e+e- Linear Collider, $\sqrt{s} = 90 - 250$ GeV

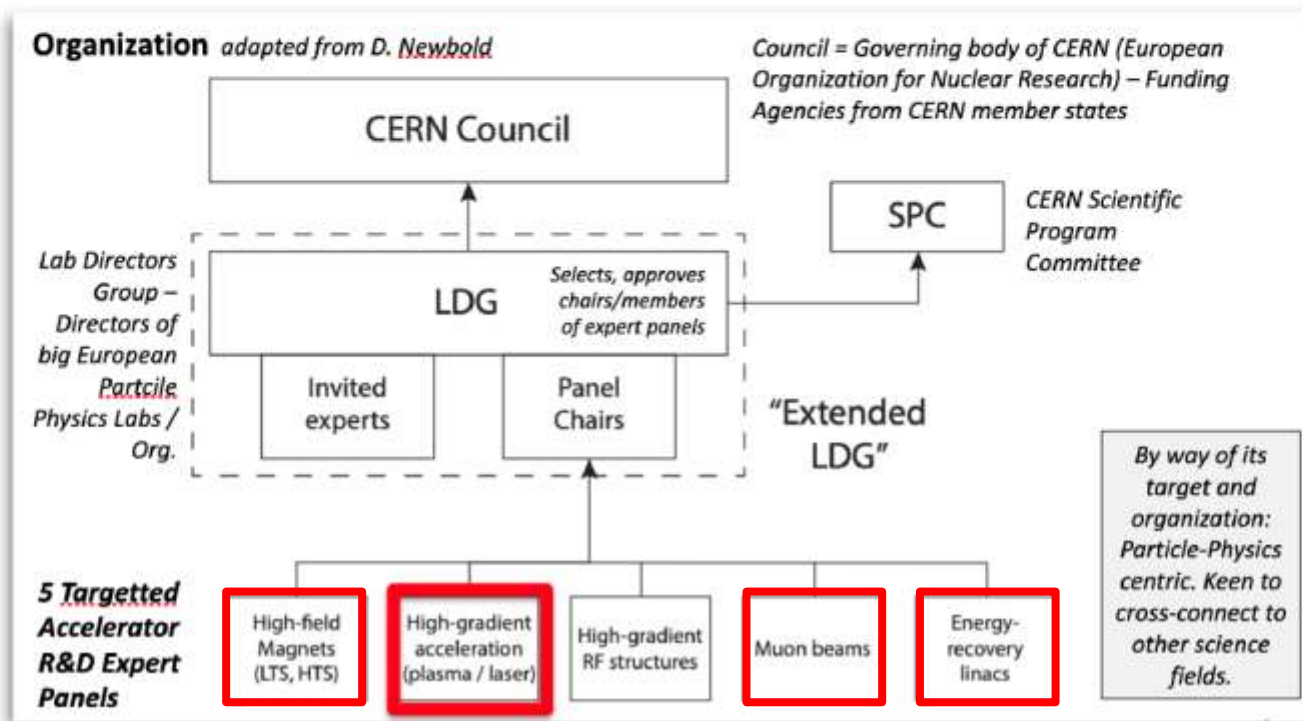
Courtesy P.Bhat (FNAL)



AF6 (Advanced Concepts): Int'l Coordination

Snowmass 2021

- As Snowmass was pausing, a new European effort was ramping up beginning ~ March 2021
- See initial townhall intro by Ralph: <https://indico.cern.ch/event/1017117/> for more information
- Aggressive timeline with interim report September, final October 2021
- Representation from AF, AF6 to coordinate but they are way out in front





Notable AF Workshops/Meetings

- 2021 APS April Meeting:
 - Three well-attended symposia on Muon Colliders
- AF7 – Targetry:
 - Target Simulations Workshop held on 6 April
<https://conference.sns.gov/event/267/>
 - Irradiation Stations and Alternatives Workshop held on 17-18 June
<https://indico.fnal.gov/event/48628/>
 - Joint AF2/AF5/NF/RPF Targetry mini-workshop: Sep. 23
<https://indico.fnal.gov/event/46752/>
- MIT Workshop on Cyclotrons and FFAs (Sep 7-9, 2021)
<https://indico.mit.edu/event/150/>
- Active Snowmass AF participation/presence at :
 - IPAC'21 (Brazil, May 2021)
 - Lomonosov Conference (Moscow, Aug. 2021)
 - ICFA HB2021 – hadron beams (FNAL, Oct. 2021)