Snowmass Muon Collider Forum White paper discussion

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EF

AF TF

Lots of white papers will be coming in over the next few months leading up to the Snowmass March deadline

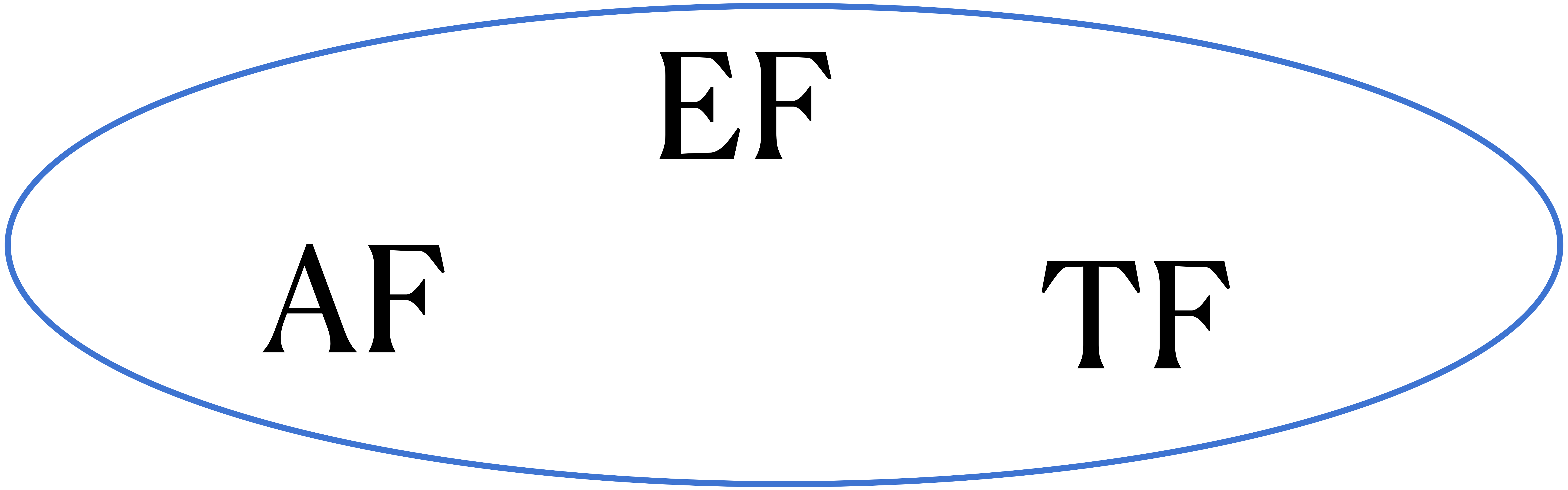
Some will be narrow studies - but in different frontiers talking about vastly different things

Some will be full blown project proposals (International muon collider collaboration)

Some will express potential US interests

AF, EF, TF topical groups will take info from all these white papers to present their relevant TG cases

Our proposal



A white paper that condenses all the info into one place for the status/argument for muon collider R&D

Useful for both as frontier level reference, and for P5 as a centralized document

Is it needed?

Isn't this redundant with international muon collider white paper?
No, the focus is different.

Is this a proposal for a US muon collider project?
No, if there is a white paper for that it is great,
this is just laying the case out and what could be done to get there

Provides a one stop shop for status/capabilities in all frontiers
+ more guidance for US centric possibilities which is not the muCC focus

Contrasting with last Snowmass

EF Report 1401.6081

3.10.6 Muon Collider: 125 GeV, 350 GeV, 1.5 TeV, 3 TeV

A muon collider holds promise as a technique for reaching very high energies in lepton-lepton collisions and for s-channel production of the Higgs boson and possible additional Higgs states. Studies of the muon collider are not yet mature, particularly in designing a detector that can overcome the background from decays of the muons circulating in the ring. However, promising first results on physics analysis including machine backgrounds were reported at Snowmass. A muon collider will:

1. Provide capabilities similar to those of ILC and CLIC described above.
2. Produce the Higgs boson, and possible heavy Higgs bosons, as s-channel resonances This allows a sub-MeV Higgs boson mass measurement and a direct Higgs boson width measurement.

MAP contribution 1308.0494

energy. The main advantages of a MC are the ability to study the direct (s-channel) production of scalar resonances, a much better energy resolution (because of the lack of significant beamstrahlung), and the possibility of extending operations to very high energies. At ILC/CLIC, however, significantly greater polarization of the initial beams is possible[22].

What should go in it? What's the scope/size/timeline?

Overall picture - Energy Frontier matters, muon collider is the only option to get there(10+ TeV scale) other than pp on any near term scale relevant for current Snowmass participants.
This is also the only EF(10+TeV) machine the US could potentially host in that timescale.

TF: physics case EF+Higgs
AF: status/r&d needs/timeline
EF: status/r&d needs

2 slides from each frontier for discussion
What needs done before March deadline for "raw data"/recruitment

Synergies with other frontiers (Neutrino) and R&D

AF White Paper (1)

- AF coordinators work closely with EF and TF coordinators on a White paper for Snowmass
- The AF goals for the paper are:
  - Review main accelerators components needed for a Muon Collider
  - Highlight recent developments on accelerator technology that could lead to a Muon Collider
  - Report on the accelerator Muon Collider R&D needs
  - Discuss a timeline and siting options (including US sites)

AF White Paper (2)

- In order to get the best possible input for the paper, our goal is to form a team with accelerator experts
- Pending interest of the accelerator community, we like to organize a workshop to discuss further the accelerator needs (late January 2022)
- Please contact us if you are interested to join

TF: White Paper Content (I)

Objectives of the White Paper from the TF point of view:

- Big questions in physics and how a muon collider would contribute in addressing them.
- What has changed in the theory landscape since the last Snowmass.
- Connect the physics that could be explored through other experiments (neutrino, g-2, flavour factories).

TF: White Paper Content (II)

Physics Potential

- Precision
  - ➡ Higgs physics
  - ➡ Top physics
  - ➡ EW physics
  - ➡ QCD
  - ➡ Interpretational frameworks
- Direct BSM searches
  - ➡New states (s-channel)
  - ➡Dark Matter (missing energy)
  - ➡Light/Weakly interacting

Development in the simulation tools

- Hard Scattering Processes at very high-energy (stability of the predictions)
- Resummation of large logs QED and EW
- Event generators
- Completeness of New Physics models

EF: White Paper Content (1)

Objectives of the White Paper from the EF point of view:

- Highlight physics reach of a high energy Muon Collider
- Demonstrate and benchmark performance of reconstruction and identify bottlenecks
- Identify requirements for the Muon Collider detectors
- Sketch an R&D path towards realization of technologies for such detectors
- The scope of this work is beyond just US – connection/collaboration with IMCC is a must

- Muon Colliders present unique physics opportunities but also face unique challenges:
  - Large Beam-induced-Backgrounds in tracker and calorimetry → large data rates and challenging reconstruction
  - Reduced acceptance due to the shielding nozzles (optimize and instrument?)
  - Radiation doses higher than those at e+e- colliders
  - Resource demanding simulation tools and frameworks

EF: White Paper Content (2)

- Physics performance:
  - Physics objects reconstruction (fullsim and fastsim)
  - Evolution of BIB and MDI
  - Estimates of physics sensitivity in a set of benchmark analyses
  - Identify future needs for Software support and development

- Detectors:
  - Benchmark technologies for trackers, calorimetry, and muon systems
  - Refine Trigger/DAQ strategy
  - Identify promising alternative technologies

- Define the path forward:
  - Identify major steps in R&D for detectors, simulation software and physics studies
  - Estimate level of resources necessary to execute the R&D path
  - Define a timeline with the goal to be ready on the same timescale as the accelerator