



INTRODUCTION AND GOALS

5th Forward Physics Facility Meeting

Jonathan Feng, UC Irvine, 15 November 2022



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INTRODUCTION

- The FPF will greatly enhance the HL-LHC physics program
 - Neutrinos: Neutrino blind → Neutrino factory, insights into neutrinos, QCD, astroparticle physics.
 - BSM: Modest extension of weak-scale searches → New sensitivity to MeV-GeV FIPs, LLPs, milli-charged particles, quirks, light dark matter, and many other groundbreaking discoveries.
- Many of these opportunities rely essentially on the LHC's high center-of-mass energy, are therefore inaccessible at fixed target experiments and unique to the FPF, and will disappear for decades (or forever) if not explored at the HL-LHC.
- The FPF is well-aligned with the recommendations of EPPSU and Snowmass:

2020 EPPSU 1st Recommendation

The successful completion of the high-luminosity upgrade of the machine and detectors should remain the focal point of European particle physics, together with continued innovation in experimental techniques. The full physics potential of the LHC and the HL-LHC, including the study of flavour physics and the quark-gluon plasma, should be exploited.

2022 Snowmass Energy Frontier Summary

Our highest immediate priority accelerator and project is the HL-LHC, the successful completion of the detector upgrades, operations of the detectors at the HL-LHC, data taking and analysis, including the construction of auxiliary experiments that extend the reach of HL-LHC in kinematic regions uncovered by the detector upgrades.

Resource needs and plan for the 5-year period starting 2025:

1. Prioritize HL-LHC physics program, including auxiliary experiments.

CERN NEWS

- CERN and PBC support for the FPF (and for FASER, FASERnu, SND@LHC) has been generous and essential.
- Jamie Boyd and I had a first meeting about the FPF with CERN Directors Fabiola Gianotti, Joachim Mnich, and Mike Lamont in June 2022. The meeting was encouraging and very useful, and we planned to meet again 8 months after that meeting (~Feb, Mar 2023).
- LHCC Minutes, Sept 2022 (following discussions with LHCC Chair Frank Simon)
 - A proposal on the Forward Physics Facility (FPF), a large underground experimental facility, well shielded in the line of sight of the ATLAS interaction point, is being put forward. First informal discussions about the next steps with this proposal have taken place between the proponents and the LHCC chair.
 - Given the scope of the proposed facility and the scientific overlap with projects that fall into the responsibility of other committees, the LHCC proposes to discuss the FPF together with other proposals, in an appropriate forum such as the Physics Beyond Colliders study group, prior to moving towards reviews by the scientific committees to ensure a comprehensive and aligned view of the strategy for CERN moving forward. Considering the implications for the long-term scientific strategy and the future development of the CERN infrastructure, a discussion in the SPC may be appropriate to help define priorities prior to further steps.
- Takeaway: FPF will be discussed with other proposals, particularly HIKE + SHADOWS and SHiP@ECN3, in the coming year. We understand that details of this discussion and its timing are currently being discussed.

CERN NEWS

- FPF and other projects were discussed at length at the PBC Annual Workshop, held last week at CERN (<https://indico.cern.ch/event/1137276>). From Claude Vallee's summary talk (for more, see also the next talk):

FORWARD PHYSICS FACILITY

Good progress in the conceptual design of the infrastructure and decoupling from LHC operation constraints

Strong support from Snowmass HE group to HL-LHC auxiliary detectors

LHCC statement in September recommending to further study the FPF in the global PBC context

Next steps:

- **CDR expected in 2023 with more details on detector technical aspects, physics complementarity and Collaboration structure**
- **Relevant information on physics reach (sensitivity curves, etc...) to be provided to FPC, BSM and QCD WGs to address comparison with other projects**

FORWARD PHYSICS FACILITY

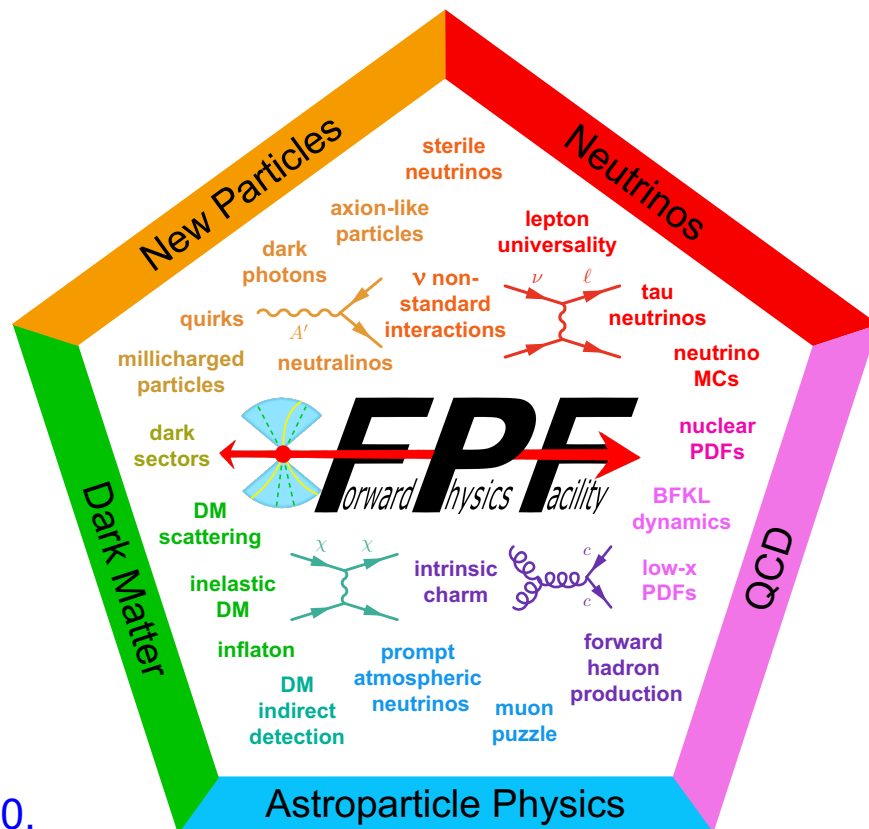
- The rich physics program in the far-forward region has been developed in a series of meetings and papers – thanks to all participants and authors!

- FPF Meetings

- [FPF Kickoff Meeting](#), 9-10 Nov 2020
- [FPF2 Meeting](#), 27-28 May 2021
- [FPF3 Meeting](#), 25-26 Oct 2021
- [FPF4 Meeting](#), 31 Jan-1 Feb 2022
- [FPF5 Meeting](#), 15-16 Nov 2022
<https://indico.cern.ch/event/1196506>

- FPF Papers

- FPF “Short” Paper: 75 pages, 80 authors, Phys. Rept. 968, 1 (2022), [2109.10905](#).
- FPF White Paper: 429 pages, 392 authors+endorsers representing over 200 institutions, J. Phys. G (2022), [2203.05090](#).



- Excellent progress in a short time, but much work to be done to prepare for CDRs and anticipated prioritization and funding decisions in 2023.

ORGANIZATIONAL INFRASTRUCTURE

- New working group structure established to organize the work and provide contact names for new people interested in the FPF.

Steering Committee: Jamie Boyd, Jonathan Feng, Felix Kling

WG0 Facility: Jamie Boyd

WG5 FASER2: Josh McFayden

WG6 FASERnu2: Aki Ariga, Tomoko Ariga

WG7 FLArE: Jianming Bian, Milind Diwan

WG8 AdvSND: Giovanni De Lellis

WG9 FORMOSA: Matthew Citron, Chris Hill

Physics WGs

WG1 Neutrino Interactions: Juan Rojo

WG2 Charm Production: Hallsie Reno

WG3 Light Hadron Prod: Luis Anchordoqui, Dennis Soldin

WG4 BSM: Brian Batell, Sebastian Trojanowski

Detector WGs

WG Liaisons	WG5 FASER2	WG6 FASERnu2	WG7 FLArE	WG8 AdvSND	WG9 FORMOSA
WG1	Josh McFayden	Aki Ariga, Tomoko Ariga	Steve Linden, Wenjie Wu	Antonia Di Crescenzo	Matthew Citron
WG2	Josh McFayden	Aki Ariga, Tomoko Ariga	Steve Linden, Wenjie Wu	Antonia Di Crescenzo	Matthew Citron
WG3	Josh McFayden	Aki Ariga, Tomoko Ariga	Steve Linden, Wenjie Wu	Antonia Di Crescenzo	Matthew Citron
WG4	Josh McFayden	Aki Ariga, Tomoko Ariga	Steve Linden, Wenjie Wu	Cristovao Vilela	Matthew Citron

WG GOALS

- Each Physics WG has established goals for FPF5, February 2023, and the CDRs, with detector WG liaisons providing detector performance input.
- To join, contact the WG leaders and join the (free) Slack workspace.

Physics Working Group 1: Neutrino Interactions and Deep-Inelastic Scattering with High-Energy Neutrinos

Scientific Goals. This Working Group includes topics related to high-energy neutrino interactions at the FPF and using these high-energy neutrinos in the Deep-Inelastic Scattering process to constrain proton and nuclear structure. Topics include how well we can measure the neutrino cross-section at TeV energies and what we can learn from this, and how well we can constrain proton and nuclear DIS with the FPF neutrino beam. Also, we'd like to understand given the measurements of neutrino structure functions, how well the incoming neutrino flux can be constrained.

To begin with, we assume a perfectly known neutrino flux and a perfect detector (with finite acceptance) for our projections. Subsequently, we model detector simulation and the fact that the incoming neutrino flux carries large uncertainties.

This Working Group is closely related with WG2, in that measuring the incoming neutrino flux imposes constraints on charm meson and light hadron production in the far forward region at the LHC and in turn on the small-x and large-x PDFs of the colliding protons. We also plan to assess PDF sensitivity in "production" (as opposed to in "scattering") at some point in this WG studies.

In the following we indicate some possible **goals for this WG**. We consider three timescales: the FPF5 meeting, a February 2023 deadline (internal, FPF proponents have been asked to report on the progress by then), and the Conceptual Design Report (CDR) deadlines. These goals are not written in stone and can be discussed once the working group is formed.

FPF5 goals:

- Assemble a group of interested people and make an initial work plan.
- Collect the available tools and results and agree on which ones will be used.
- First estimate of how detector acceptance constraints (x,Q) range accessible.
- First discussion of key observables: inclusive structure functions, dimuon production, what else?
- First discussion of physics interest in neutrino cross-section measurement at TeV energies.
- Start an overleaf document summarizing our ideas, plans, and initial results.

February goals:

- Produce first set of FPF pseudo-data on neutrino inclusive and charm structure functions, including estimate of experimental uncertainties

Forward Phys... Search Forward Physics Facility

wg1_neut... Physics WG: N... 100

Twiki WG1 Description

@Tanjona Rabemananjara Tuesday, November 8th

...s. Also it can be used in some different combination of the xsec is needed

<https://yadism.readthedocs.io/en/latest/theory/intro.html>, without having to rerun jadism from the beginning, and it allows to access results for individual structure functions.

@Tanjona Rabemananjara will push the input lhpdf grid once available. Once there it is also trivial to compute the PDF error on these observables if necessary

Tanjona Rabemananjara 1:28 AM
Thanks @Tommaso Gianni, I will include the script as part of the package.

Juan Rojo 1:33 AM
Thanks Tommaso!

This is very useful

B I [link] [list] [code] [image]

Message #wg1_neutrino_interactions

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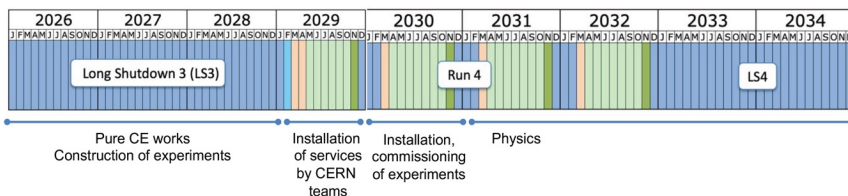
FPF5 TUESDAY

- Morning
 - CERN Welcome
 - Introduction and Goals
 - CERN Context
 - Relationship to other PBC projects, including ECN3, HIKE/SHADOWS, SHiP
 - Facilities Talks
 - New site investigation plans
 - Studies to understand the experimental environment better
- Afternoon
 - FASER2
 - FORMOSA
 - WG4: BSM
 - BSM Exp/Th Discussion
 - New models that merit attention
 - New foci, e.g., complementarity with other CERN projects

10:00	Welcome <i>6/R-012 - conference room, CERN</i>	<i>Joachim Josef Mnich</i> 10:00 - 10:10
	Introduction and Goals <i>6/R-012 - conference room, CERN</i>	<i>Jonathan Lee Feng</i> 10:10 - 10:25
	PBC Landscape and CERN Context <i>6/R-012 - conference room, CERN</i>	<i>Claude Vallee</i> 10:30 - 10:45
11:00	Overview of the FPF Facility Design <i>6/R-012 - conference room, CERN</i>	<i>Kincso Balazs</i> 10:50 - 11:10
	Break <i>6/R-012 - conference room, CERN</i>	11:15 - 11:45
	FLUKA Estimates of the FPF Background Rate <i>6/R-012 - conference room, CERN</i>	<i>Marta Sabate Gilarte</i> 11:45 - 12:00
12:00	Radio Protection Considerations <i>6/R-012 - conference room, CERN</i>	<i>Heinz Vincke</i> 12:05 - 12:20
	Run 3 Data and Implications for FPF Environment <i>6/R-012 - conference room, CERN</i>	<i>Jamie Boyd</i> 12:25 - 12:45
	Discussion <i>6/R-012 - conference room, CERN</i>	12:50 - 13:00
13:00	Lunch	
15:00	FASER2 <i>6/R-012 - conference room, CERN</i>	<i>Josh McFayden</i> 15:00 - 15:50
16:00	Break <i>6/R-012 - conference room, CERN</i>	16:00 - 16:30
	FORMOSA <i>6/R-012 - conference room, CERN</i>	<i>Chris Hill</i> 16:30 - 17:05
17:00	WG4: BSM <i>6/R-012 - conference room, CERN</i>	<i>Brian Thomas Batell et al.</i> 17:15 - 17:35
	BSM Exp/Th Discussion <i>6/R-012 - conference room, CERN</i>	17:40 - 18:00
18:00		

FPF5 WEDNESDAY

- Morning
 - FASERnu2
 - Advanced SND
 - WG1: Neutrino Interactions
 - WG2: Charm Production
 - WG3: Light Hadron Production
- Afternoon
 - FLArE
 - Exp-Th connections, WG liaisons
 - Integration of Experiments Discussion
 - Synergies between experiments
 - Timeline and Physics Planning Discussion
 - Upcoming milestones, next goals



10:00	FASERnu2: Updates on FASERnu, Muon Measurement, and FASERnu2 6/R-012 - conference room, CERN	Tomoko Ariga 10:00 - 10:12
	FASERnu2: Prospects of Emulsion Film Production for FASERnu2 6/R-012 - conference room, CERN	Hiroki Rokujo 10:14 - 10:26
	FASERnu2: Interface Tracker Design and Charge ID Studies 6/R-012 - conference room, CERN	Yosuke Takubo 10:28 - 10:40
11:00	Advanced SND 6/R-012 - conference room, CERN	Antonia Di Crescenzo 10:50 - 11:20
	Break 6/R-012 - conference room, CERN	11:30 - 12:00
12:00	WG1: Neutrino Interactions 6/R-012 - conference room, CERN	Dr Juan Rojo 12:00 - 12:15
	WG2: Charm Production 6/R-012 - conference room, CERN	Mary Hall Reno 12:20 - 12:35
	WG3: Light Hadron Production 6/R-012 - conference room, CERN	Luis Anchordoqui et al. 12:40 - 12:55
13:00	Lunch	
15:00	FLArE: Overview of Organization and Scientific Strategy 6/R-012 - conference room, CERN	Milind Vaman Diwan 15:00 - 15:15
	FLArE: Overview of Simulation and Physics Reach 6/R-012 - conference room, CERN	Prof. Jianming Bian 15:18 - 15:33
	FLArE: Overview of Design and Engineering Choices, and the Road to a Cost and Schedule Estimate 6/R-012 - conference room, CERN	Steven Linden 15:35 - 15:50
16:00	SM Exp/Th Discussion 6/R-012 - conference room, CERN	16:00 - 16:20
	Break 6/R-012 - conference room, CERN	16:20 - 16:50
17:00	Integration of Experiments Discussion 6/R-012 - conference room, CERN	16:50 - 17:20
	Timeline and Project Planning Discussion 6/R-012 - conference room, CERN	Albert De Roeck et al. 17:20 - 18:00
18:00		