FPF Theory Workshop

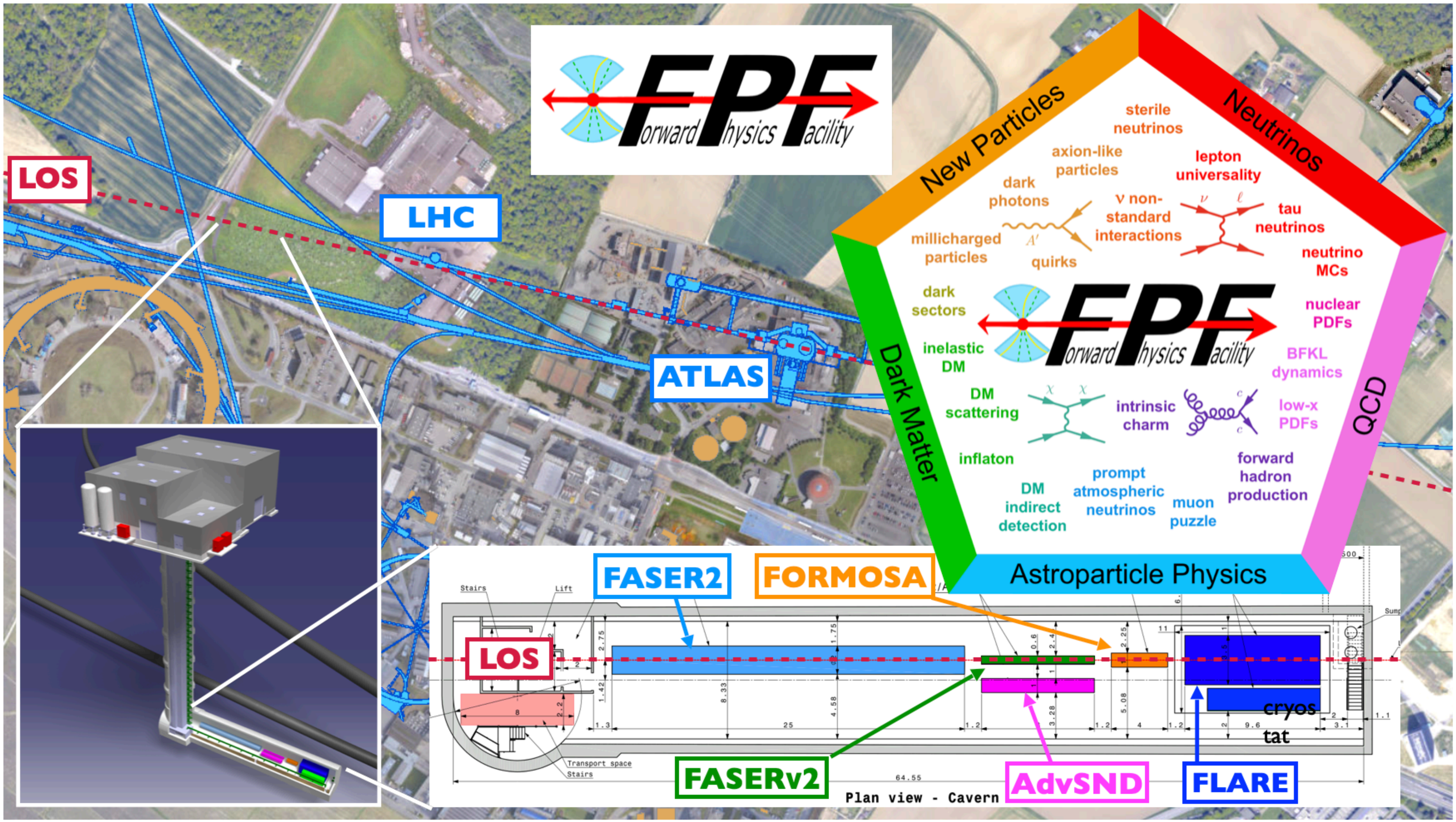
Introduction and Welcome

September 18th 2023

Felix Kling

The Forward Physics Facility

The FPF is a proposed facility that would house a suite of experiments to fully exploit the LHC's physics potential in the forward direction.



Meetings and Documentation

FPF workshop series:
FPF1, FPF2, FPF3,
FPF4, FPF5, FPF6

FPF Paper:
2109.10905
~75 pages, ~80 authors

Snowmass Whitepaper:
2203.05090
~450 pages, ~250 authors

FPF in Snowmass

The FPF was prominently featured in many Snowmass Reports
(Thanks to the efforts of many of you!)

Additionally, auxiliary experiments and facilities are proposed to take advantage in far forward kinematic regions. Forward physics facilities allow to further extend the breadth of the HL-LHC physics: they can study regions of parameter phase space for BSM, for example in LLPs and DM searches, that would otherwise remain uncovered, and can perform novel QCD and neutrino measurements in the very forward region

Vision Section of Energy Frontier Report

Auxiliary forward-physics facilities will further extend the physics potential of the HL-LHC both for SM measurements and BSM discoveries. In view of all these considerations, the EF supports continued strong U.S. participation in the success of the LHC, and the HL-LHC construction, operations, and physics programs, including auxiliary experiments.

Energy Frontier Section of Snowmass Summary Report

FPF in Snowmass

Executive Summary (10 pages)

LHC

The Energy Frontier (Science Drivers 1 – 3 & 5): The Energy Frontier currently has a top-notch program with the Large Hadron Collider (LHC) and its planned High Luminosity upgrade (HL-LHC) at CERN, which sets the basis for the Energy Frontier vision. The fundamental lessons learned from the LHC thus far are that a Higgs-like particle exists at 125 GeV and there is no obvious and unambiguous signal of BSM physics. This implies that new physics either occurs at scales higher than we have probed, must be weakly coupled to the SM, or is hidden in backgrounds at the LHC. The immediate goal for the Energy Frontier is to continue to take and analyze the data from LHC Run 3, which will go on for about three more years, and carry out the 2014 P5 recommendations to complete the HL-LHC Upgrade and execute its physics program. The HL-LHC will measure the properties of the Higgs Boson more precisely, probe the boundaries of the SM further, and possibly observe new physics or point us in a particular direction for discovery.

A new aspect of the proposed LHC program is the emergence of a variety of auxiliary experiments that can use the interactions already occurring in the existing collision regions during the normal LHC and HL-LHC running of the ATLAS, CMS, LHCb, and ALICE experiments to explore regions of discovery space that are not currently accessible. These typically involve observing particles in the far forward direction or long-lived particles produced at larger angles but decaying far outside the existing detectors. These are mid-scale detectors in their own right and provide room for additional innovation and leadership opportunities for younger physicists at the LHC. The EF supports continued strong U.S. participation in the success of the LHC, and the HL-LHC construction, operations, and physics programs, including auxiliary experiments.

future collider

New colliders are the ultimate tools to extend the EF program into the next two decades thanks to the broad and complementary set of measurements and searches they enable. With a combined strategy of precision measurements and high-energy exploration, future lepton colliders starting at energies as low as the Z-pole up to a few TeV can shed substantial light on some of these key questions. It will be crucial to find a way to carry out experiments at higher energy scales, directly probing new physics at the 10 TeV energy scale and beyond. The EF supports a fast start for the construction of an e^+e^- Higgs Factory (linear or circular), and a significant R&D program for multi-TeV colliders (hadron and muon). The realization of a Higgs Factory will require an immediate, vigorous, and targeted accelerator and detector R&D program, while the study towards multi-TeV colliders will need significant and long-term investments in a broad spectrum of R&D programs for accelerators and detectors.

Finally, the U.S. EF community has expressed renewed interest and ambition to develop options for an energy-frontier collider that could be sited in the U.S., while maintaining its international collaborative partnerships and obligations with, for example, CERN.

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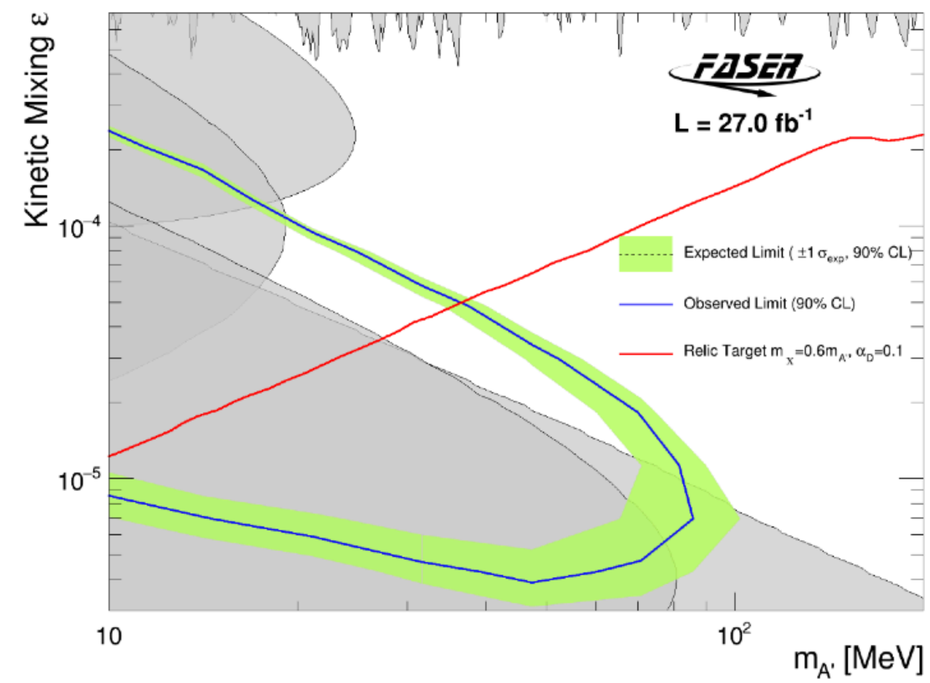
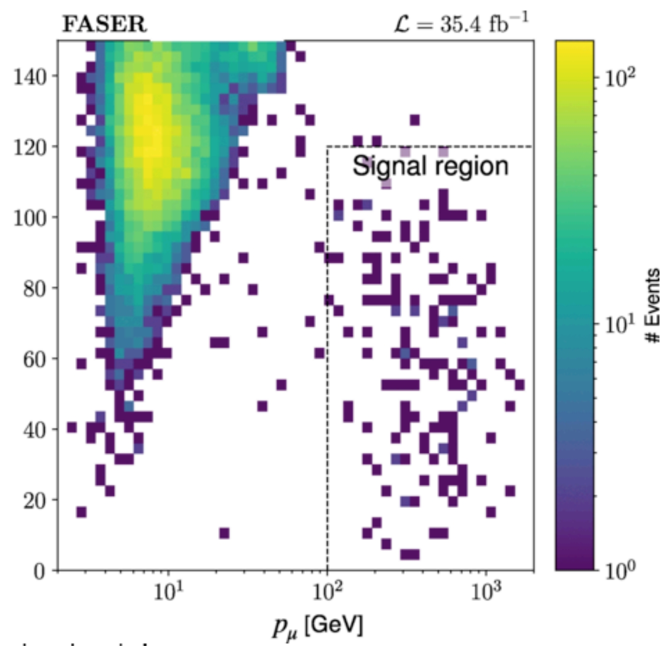
News since FPF Whitepaper

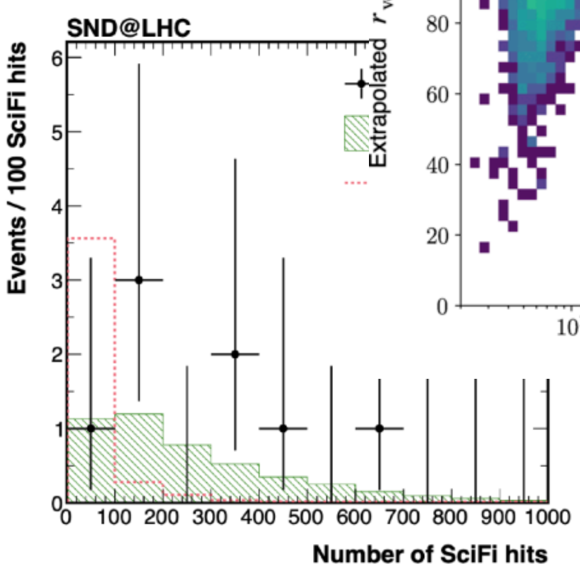
First experimental results from pathfinder experiments!

First search results on dark photons: 2308.05587



2303.14185





2305.09383

First observation of collider neutrinos:
153 events (FASER) + 8 events (SND@LHC)

Received lot's attention:
see here for viewpoints article

VIEWPOINT

The Dawn of Collider Neutrino Physics

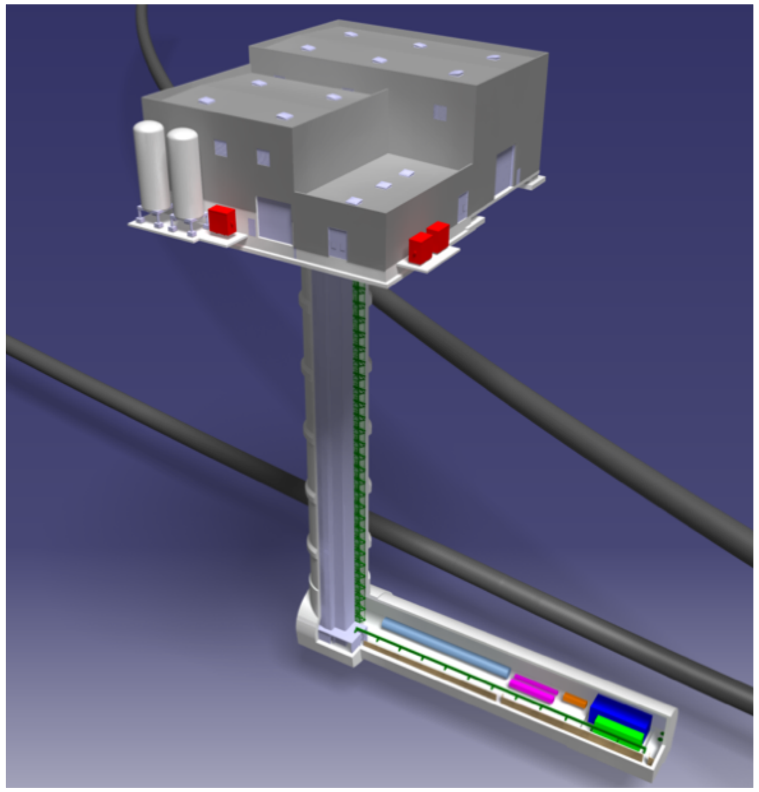
Elizabeth Worcester
Brookhaven National Laboratory, Upton, New York, US

July 19, 2023 • *Physics* 16, 113

The first observation of neutrinos produced at a particle collider opens a new field of study and offers ways to test the limits of the standard model.

News since FPF Whitepaper

Progress on design of FPF experiments

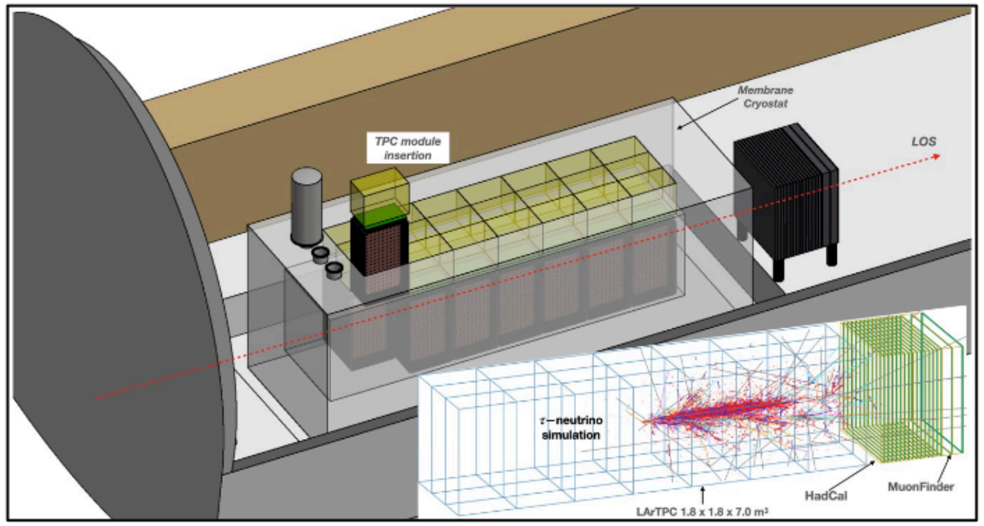


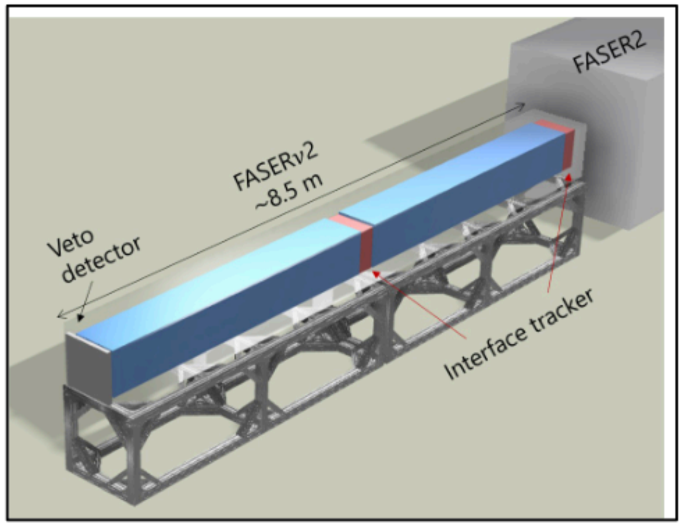
New results on civil engineering, ventilation, background particle rate, radiation protection studies, vibration studies: CDS: 2851822

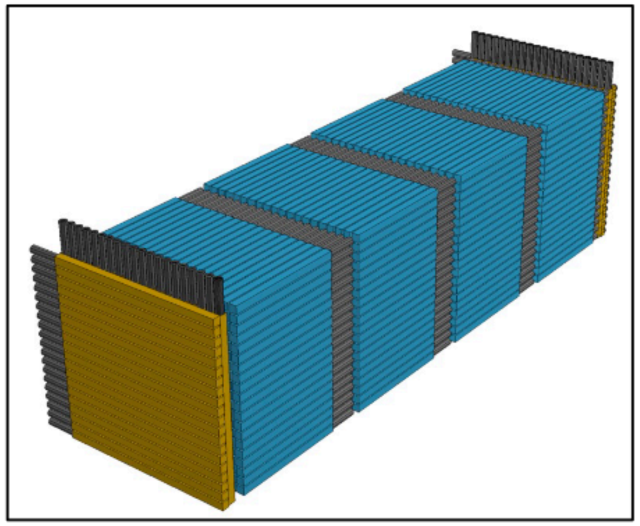
100 m-deep core sample taken to study geology at the site

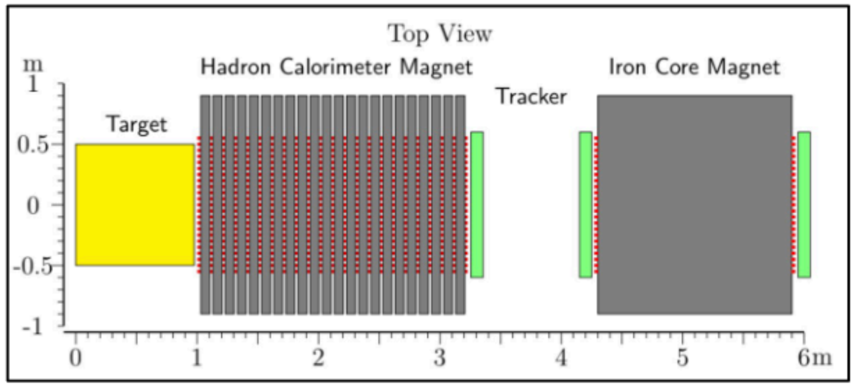
News since FPF Whitepaper

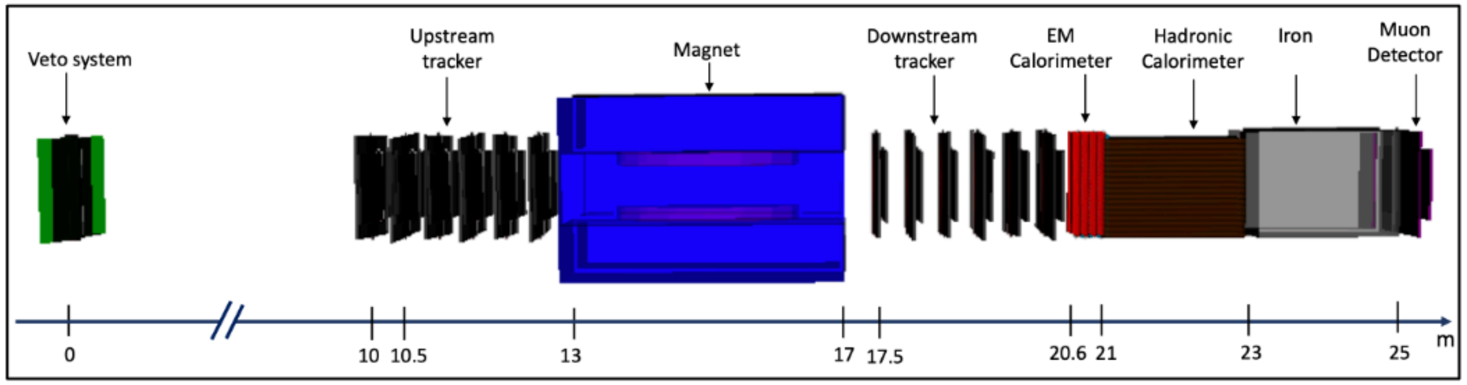
Progress on design of FPF experiments







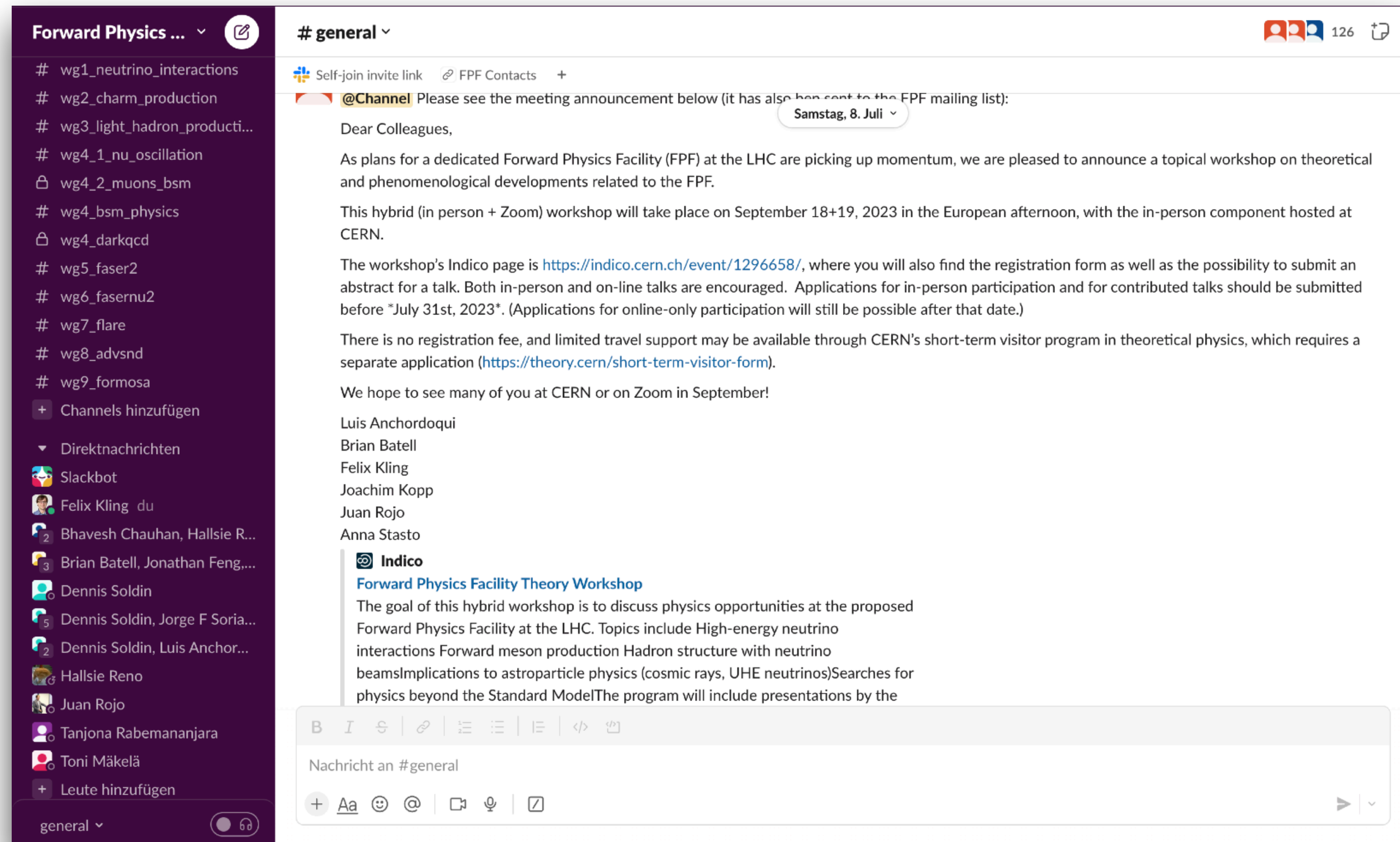




Many recent results also summarized in [FPF P5 Input Document]()

Slack Channel

Much of the organization and communication of the FPF Working Groups takes place in the **FPF Slack Workspace.** To be added to this workspace, contact Juan Rojo (Nikhef).



Organization

Steering Committee: Jamie Boyd, Albert De Roeck, Milind Diwan, Jonathan Feng, Felix Kling

WG0 Facility Jamie Boyd (CERN)

WG1 Neutrino Interactions Juan Rojo (Nikhef)

WG2 Charm Production Anna Stasto (Penn State)

WG3 Light Hadrons /Astroparticle Luis Anchordoqui (Lehman), Dennis Soldin (KIT)

WG4 New Physics Brian Batell (Pittsburgh), Sebastian Trojanowski (Warsaw)

WG5 FASER2 Alan Barr (Oxford), Josh McFayden (Sussex), Hide Otono (Kyushu)

WG6 FASERnu2 Aki Ariga (Chiba), Tomoko Ariga (Kyushu)

WG7 FLArE Jianming Bian (UC Irvine), Milind Diwan (Brookhaven)

WG8 Advanced SND Giovanni De Lellis (Napoli)

WG9 FORMOSA Matthew Citron (UC Davis), Chris Hill (Ohio State)

Physics

Detector

FPF Theory Workshop

Theory and physics have been a main driver of the FPF since the beginning.

With the FPF maturing, the focus of the FPF meetings increasingly shifted towards experimental, technical and organizational discussions.

At the same time, a successful proposal for the FPF requires to further explore and quantify the physics sensitivity studies. In addition, the operating pathfinder experiments will also greatly benefit from further theory input.

Indeed, there have been a large number of interesting developments on the theory side in the last year.

↓

FPF Theory Workshop

FPF Theory Workshop

Mon 18/09 | Tue 19/09 | All days

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Session legend

BSM Physics Parallel Session | SM Physics Parallel Session

14:00

Welcome and Introduction — *Felix Kling et al.*
4/3-006 - TH Conference Room, CERN — 14:00 - 14:20

Talk: FPF Connection to Astro-Particle Physics — *Prof. Subir Sarkar*
4/3-006 - TH Conference Room, CERN — 14:30 - 15:00

15:00

Physics with Muons at the FPF — *Alexander Sandrock et al.*
4/3-006 - TH Conference Room, CERN — 15:00 - 16:00

16:00

BSM Physics Parallel Session	SM Physics Parallel Session
Looking forward to photon-coupled sub-GeV long-lived p... *Krzysztof Jodlowski*	**Investigating the reach of FPF via information geometry ...** *Dr Toni Makela*
Light Scalars at FASER *Huayang Song* *4/3-006 - TH Conference Room, CERN* 16:40 - 16:55	**The Swampland and Neutrino Physics** *Luis Anchordoqui* *4/3-001, CERN* 16:40 - 16:55
Quirks at the Forward Physics Facility *Jonathan Lee Feng* *4/3-006 - TH Conference Room, CERN* 16:55 - 17:10	**Forward Neutrinos from Charm at Large Hadron Collider** *Dr Atri Bhattacharya*
ISR and FSR of Dark Photons *Peter Reimitz* *4/3-006 - TH Conference Room, CERN* 17:10 - 17:25	**Forward D-meson production** *Keping Xie* *4/3-001, CERN* 17:10 - 17:25
Benchmarking Proton Bremsstrahlung for Dark Sector Pr... *Saeid Foroughi-Abari*	**CT18 Fitted Charm: possibilities at the Forward Physics ...** *Dr TIMOTHY J HOBBS*
SensCalc: public and unified calculations of sensitivities t... *Jean-Loup Tastet*	**Tuning Pythia for Forward Particle Production at the FPF** *Max Fieg*
Probing Reheating Cosmology at FORMOSA and FPF: Co *Yu-Dai Tsai*	**Electromagnetic Properties of Neutrinos and the Weak M...** *Roshan Mammen Abraham*

17:00 — 18:00

Mon 18/09 | Tue 19/09 | All days

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Session legend

14:00

Neutrino Cross Sections at TeV Energies — *Dr Tanjona R. Rabemananjara et al.*
4/3-006 - TH Conference Room, CERN — 14:00 - 14:30

Neutrino Interaction Tools for the FPF — *Dr Alfonso Andres Garcia Soto*
4/3-006 - TH Conference Room, CERN — 14:30 - 15:00

15:00

BSM Physics Opportunities with LHC Neutrino Beams — *Kevin James Kelly*
4/3-006 - TH Conference Room, CERN — 15:00 - 15:30

Hadronic Physics in Neutrino Interactions and Complementarities to the EIC — *Dr Ivan Vitev*
4/3-006 - TH Conference Room, CERN — 15:30 - 16:00

16:00

WG1 Summary: Neutrino Interactions and DIS — *Dr Juan Rojo*
4/3-006 - TH Conference Room, CERN — 16:30 - 16:45

WG2 Summary: Forward Charm Production — *Anna Stasto*
4/3-006 - TH Conference Room, CERN — 16:45 - 17:00

17:00

WG3 Summary: Light Hadron Production and Astroparticle Connections — *Dennis Soldin et al.*
4/3-006 - TH Conference Room, CERN — 17:00 - 17:15

WG4 Summary: BSM Physics — *Sebastian Trojanowski*
4/3-006 - TH Conference Room, CERN — 17:15 - 17:30

Discussion and Next Steps — *Felix Kling et al.*
4/3-006 - TH Conference Room, CERN — 17:30 - 18:00

18:00