

# A summary of the Forward Physics Facility kickoff meeting

The screenshot shows the Indico event page for the "Forward Physics Facility - Kickoff Meeting". The event dates are 9-10 November 2020, with a time zone of Europe/Zurich. The page includes a navigation menu on the left with options like "Overview", "Scientific Programme", "Call for Abstracts", "Timetable", "Contribution List", "Registration", "Book of Abstracts", "Participant List", "Author List", "My Conference", and "My Contributions". The main content area displays the event start and end times (9 Nov 2020, 16:00 to 10 Nov 2020, 21:00), the location (Europe/Zurich), and a list of participants: Jonathan Lee Feng, Maria Vittoria Garzelli, and Felix Kling. A document titled "Snowmass\_LOL\_FPF.pdf" is also listed. A detailed description of the workshop is provided, stating it aims to present the status of the proposal for a forthcoming Forward Physics Facility at the Large Hadron Collider, discuss related physics opportunities, and serve as a basis for a forthcoming Letter of Interest and White Paper. It notes that the event will be held online and that Zoom links will be communicated via email. Abstracts for contributing talks can be submitted until October 25th. The page also provides the Zoom link and meeting ID (921 3182 0665, Passcode: 573869).

Indico Page: <https://indico.cern.ch/event/955956/>  
Snowmass LOI: <https://zenodo.org/record/4059893>

Felix Kling

**SLAC** NATIONAL  
ACCELERATOR  
LABORATORY

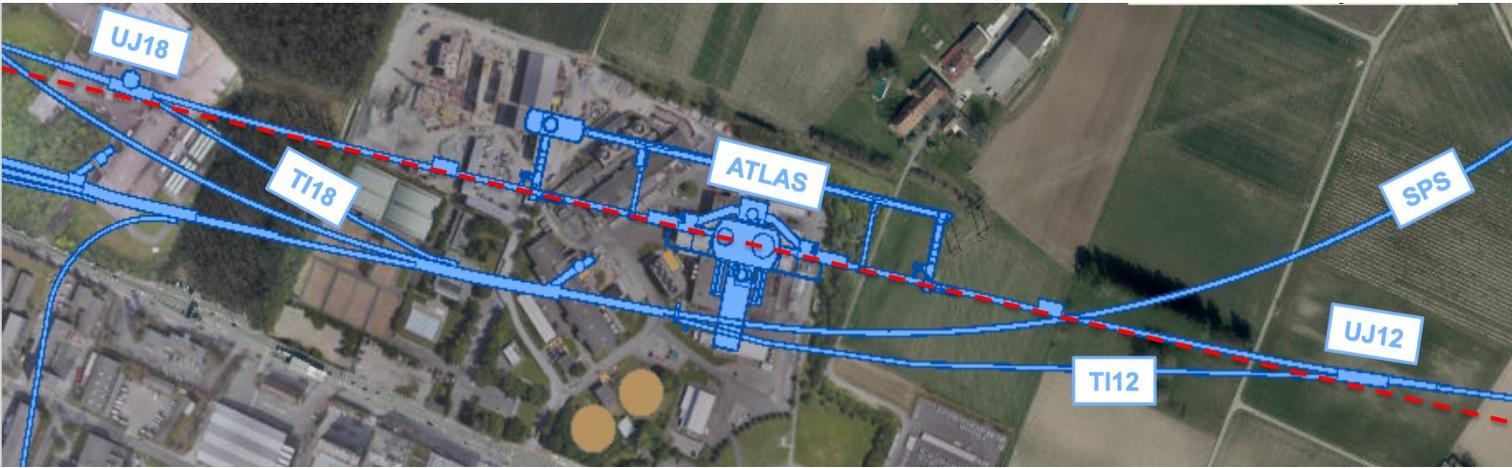
# The Forward Physics Facility

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In recent years, it has become clear that there is a rich SM and BSM physics program that remains to be explored in the far forward region.

The proposal: create a Forward Physics Facility for the HL-LHC to house a suite of experiments that will greatly enhance the LHC's physics potential for **neutrinos**, **LLP searches**, **QCD**, **dark matter and dark sectors**, and **cosmic ray** physics.

Two promising locations: caverns UJ12 and UJ18, each ~500 m from ATLAS and shielded from the ATLAS IP by ~100 m of rock, creating extremely quiet environments.



# The Forward Physics Facility

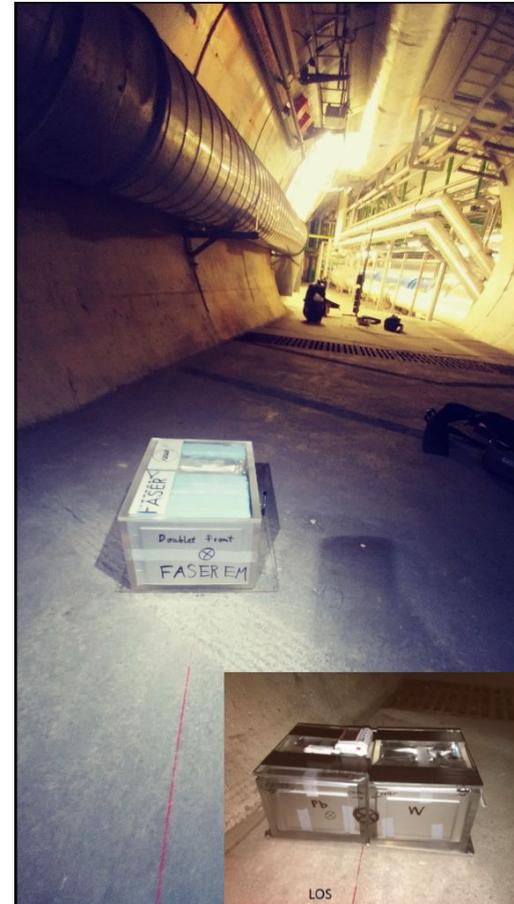
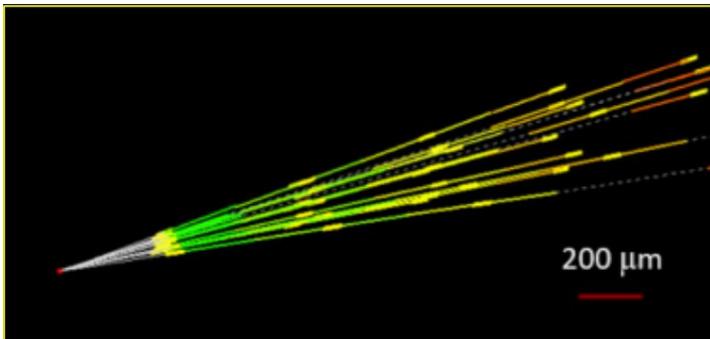
## Example: Neutrinos

No neutrino has ever been detected at the LHC.

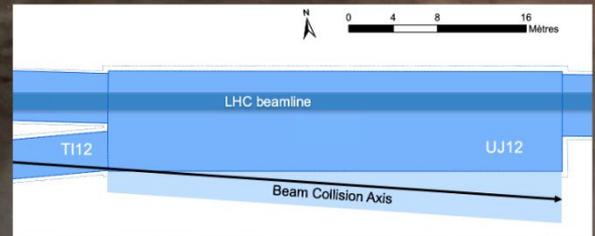
But there is a huge flux of TeV neutrinos in the far forward direction. De Rujula et al. (1980s)

In 2018, the FASER collaboration placed  $\sim 30$  kg pilot emulsion detectors in the far forward region for a few weeks (inserted and removed in TSs).

Expect  $\sim 10$  neutrino interactions. Several neutral vertices have been identified, likely to be neutrinos. Analysis ongoing.



# The Forward Physics Facility



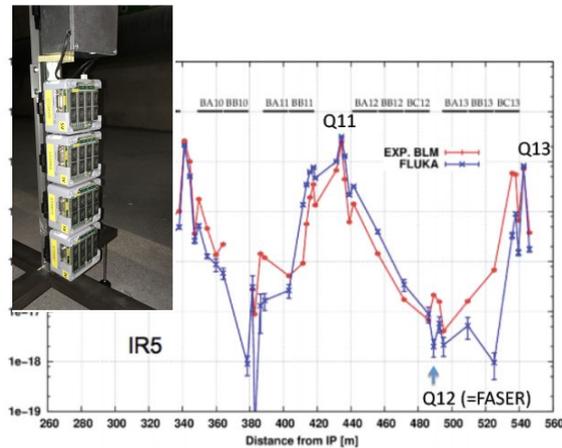


# Environment and Services

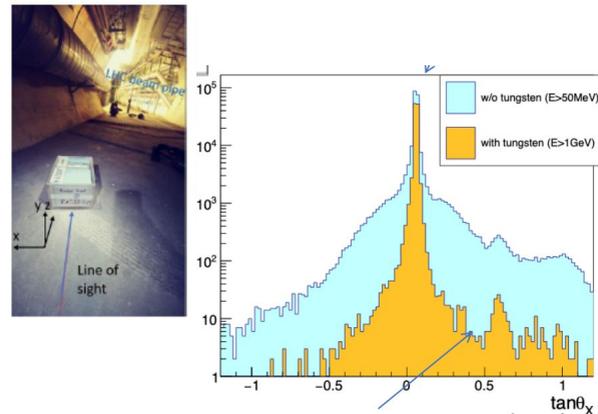
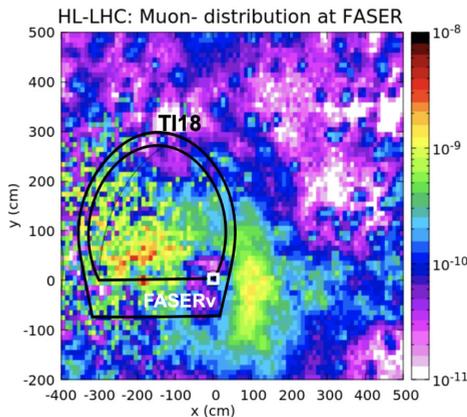
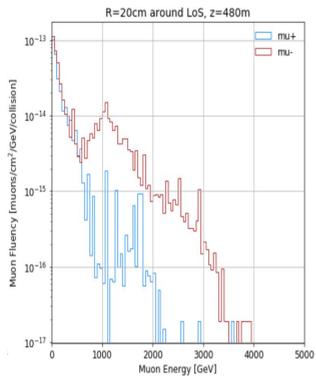
In preparation for FASER, particle fluxes and radiation were studied in TI12/TI18 with simulations and measurements

TI12 /TI18 are ideal to place experiments – and the FPF in UJ12 / UJ18 would likely be similar

The installation of common services for the FPF would be a big advantage for preparing the experiments



## Muon flux: FLUKA



# BSM Physics

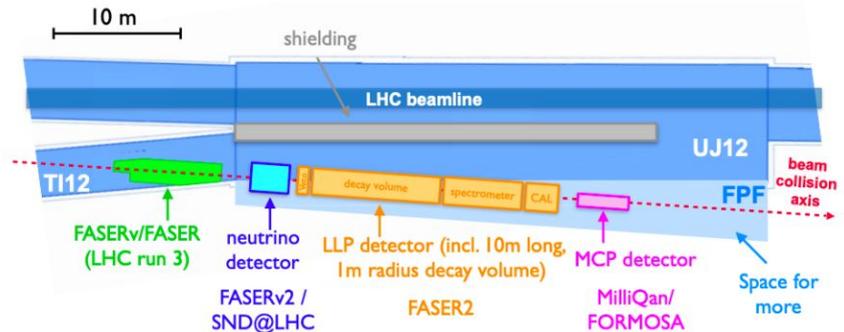
## Myriad probes of BSM physics

Long-lived particles

Neutrinos

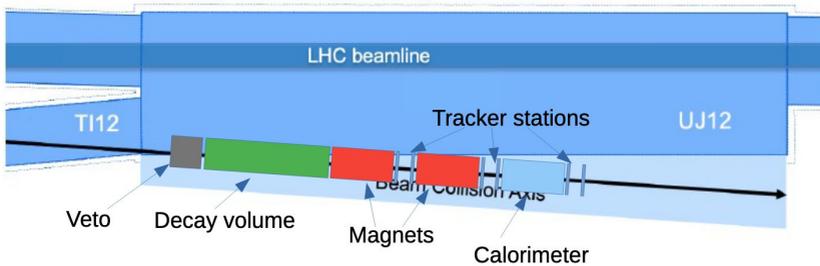
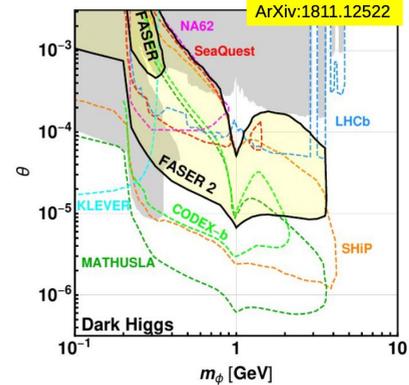
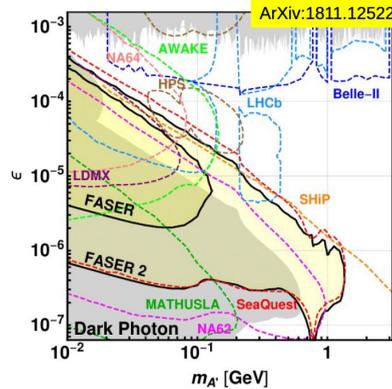
Dark matter

Millicharged particles



# Long-Lived Particles @ FPF

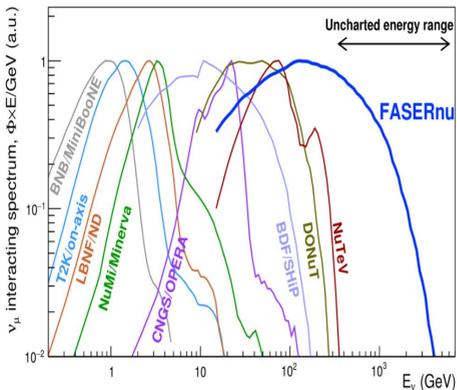
FASTER 2 would be sensitive to a large range of LLP models. Its sensitivity mostly complements or matches other proposed LHC and fixed target experiments



Example FASER 2 layout in FPF

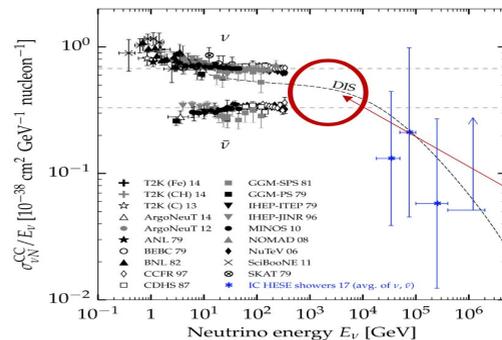


# Physics with neutrino detectors @ FPF

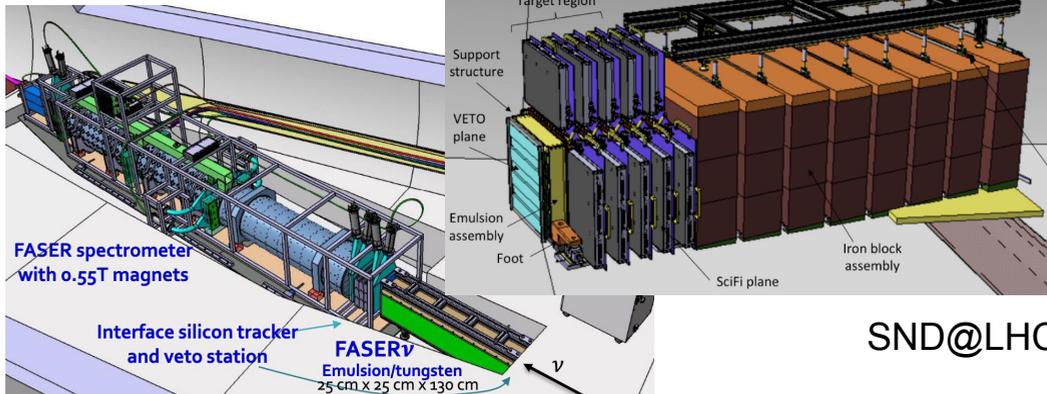


LHC provides high energy neutrino beam

2 collaborations propose experiments



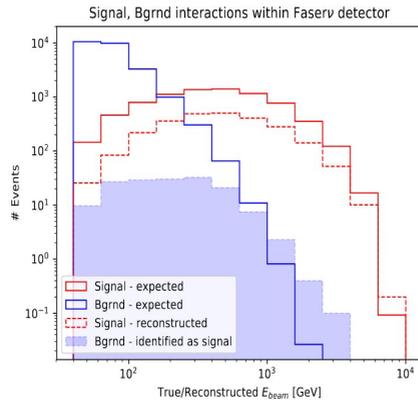
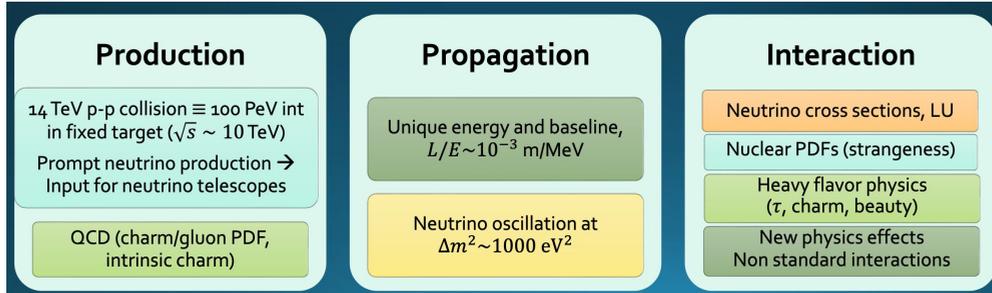
## FASERnu



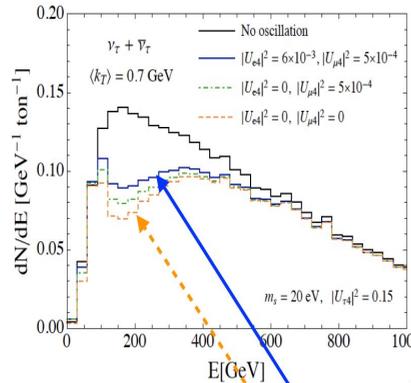
SND@LHC

# Physics with neutrino detectors @ FPF

broad spectrum of possible neutrino physics probed



neutral currents & NSI

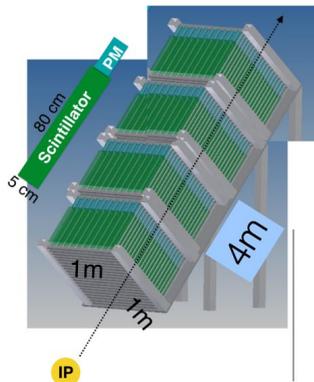
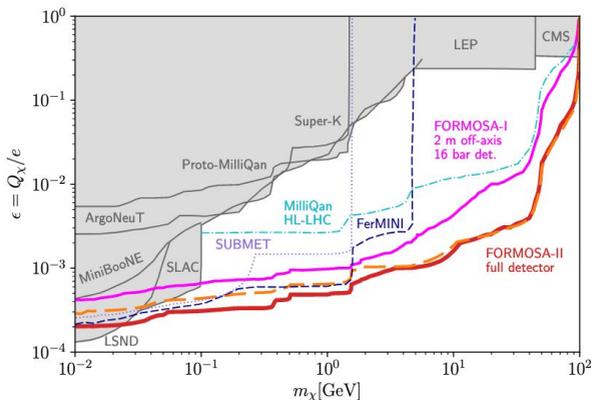


neutrino oscillations

16:00	QCD for inclusive forward charm production at the LHC	Pinel Lathiotis
16:00 - 16:15		
16:15	IPDF: issues and opportunities at the Forward Physics Facility	Maria Vittoria Ciuchini
16:20 - 16:35		
	Further thoughts... & Discussion	Dr. Giorgina Chiarenza
16:40 - 17:00		
17:00	Forward Physics in PFTBA 8	Isidoro Gonzalez et al.
17:00 - 17:15		
	General Purpose MC Forward Physics	Felix Meier-Krausz
17:20 - 17:35		
	Further thoughts... & Discussion	Dr. Roger Entler
17:40 - 18:00		
18:00	Forward production in MC generators: constraints from other observables and relevance for high energy cosmic ray st.	Sergiy Ostapchenko
18:00 - 18:15		
	Forward hadronisation: the key of muon production in air showers	Dr. Tengfei Feng
18:20 - 18:35		
	Further thoughts... & Discussion	Ralph Richard Engel
18:40 - 18:50		
18:50	FastCode and Forward Charm Production	Fabrizio Galassi
19:00 - 19:15		
	Muon and Neutrino Fluxes in IceCube	Oliver Scharf
19:20 - 19:35		
	Further thoughts... & Discussion	Mary Hall Newson
19:40 - 20:00		
20:00	Summary and conclusions	Felix Kling
20:00 - 20:10		

SM measurements

# Millicharged Particles & MilliQan/FORMOSA



With a more advantageous location and free of spatial constraints, installing a milliQan-like detector in the FPF for HL-LHC is an obvious next step for this type of experiment

- *Baseline design of 1 m x 1 m x 4 m device would easily provide world-leading sensitivity over a large portion of relevant parameter space*
  - **Highly configurable detector, potential to do even better**
- Can confirm understanding of backgrounds by relocating milliQan demonstrator to FASER cavern

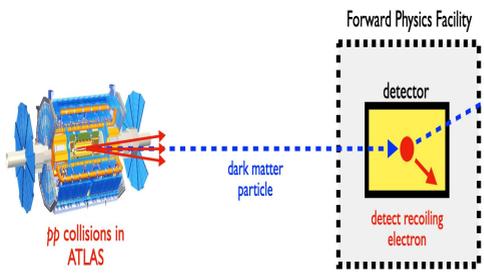
more physics potential:

Heavy Neutrino EDM

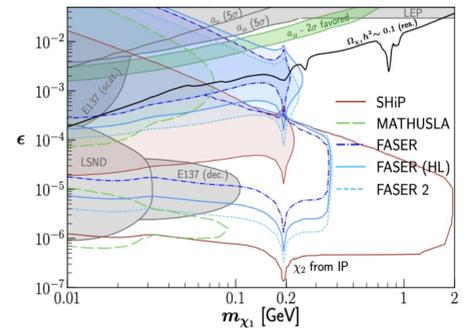
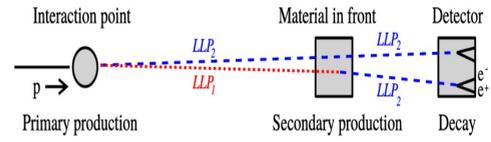
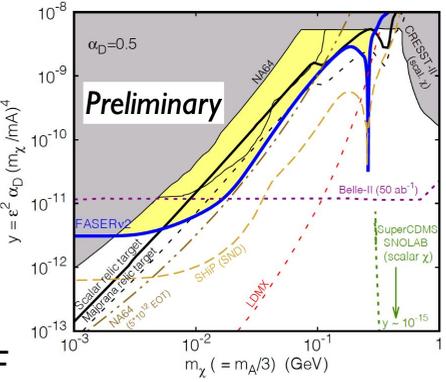
Tau Neutrino MM

Neutrino Interactions

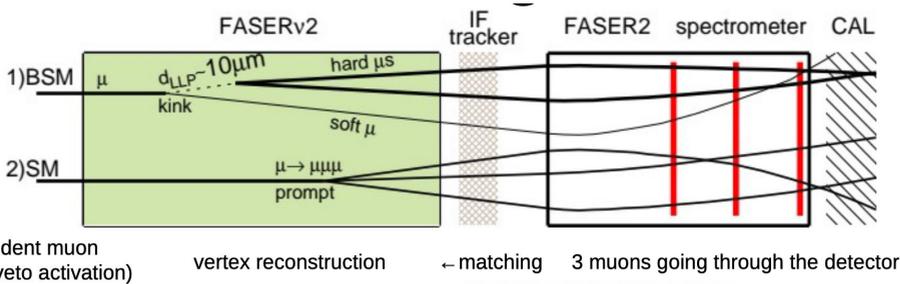
# and even more physics opportunities



Brian Batell  
Dark Matter Scattering @ FPF

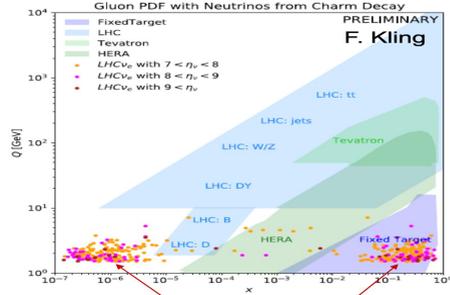


Krzysztof Jodlowski  
secondary particle production



Sebastian Trojanowski  
FASERv as muon beam dump

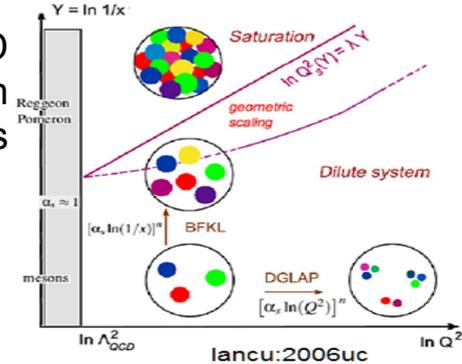
# PDFs and MC Generators @ FPF



Neutrino experiments @ FPF will test QCD in novel kinematic regimes where little or no experimental measurements exist

We don't know which QCD formalism(s) are appropriate in these regimes

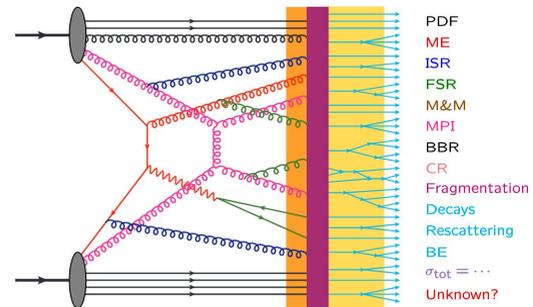
FPF test transition to small-x factorization, higher-twist enhancements in charm production, DIS on heavy nuclei, strange sea PDFs



*“forward physics is extensively modelled, but little tested”*

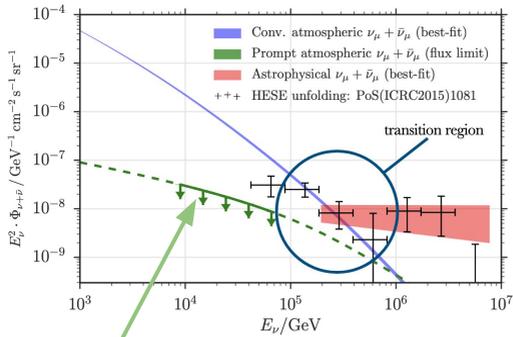
in absence of (quantitative) 1st principles: **need data**

An event consists of many different physics steps to be modelled:



Fragmentation can include clusters, strings, ropes, QGP, shove, ...

# Cosmic Rays and Neutrinos @ FPF



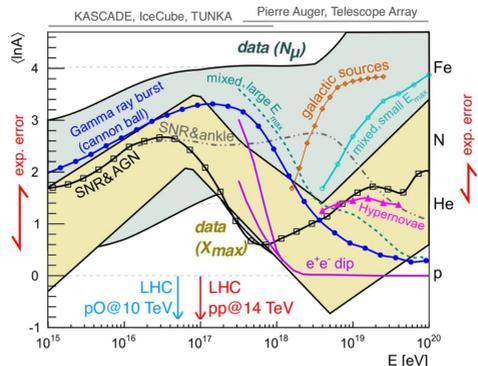
prompt atmospheric neutrinos

In order for IceCube to make precise measurements of the cosmic neutrino flux, we need accelerator measurements of high energy and large rapidity charm production.

neutrinos from charm decay @ FPF

Muon puzzle: CR mass measurements from muon data incompatible with other mass measurements.

New input from LHC crucial to reproduce EAS data consistently: too large uncertainties in model for forward spectra and light ion interactions.



muon charge ratios, neutrino flavor ratios, different energy spectra @ FPF

# Summary

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We would like to thank all speakers for the very interesting presentation.

The FPF opens up many new opportunities for **neutrino physics**, **long lived particle searches**, **milli-charged particle searches**, **PDFs and QCD**, **dark matter and dark sectors**, and **cosmic rays and cosmic neutrinos**, significantly extending the LHC's physics program.

The work discussed in this (and the following) meetings will contribute to a whitepaper for the Snowmass 2021 community study and the FPF proposal.

We would like to invite the LLP@LHC community to help us explore the physics potential of this program.