WG3: Working Group for Light Hadron Production

FPF5 Meeting, CERN

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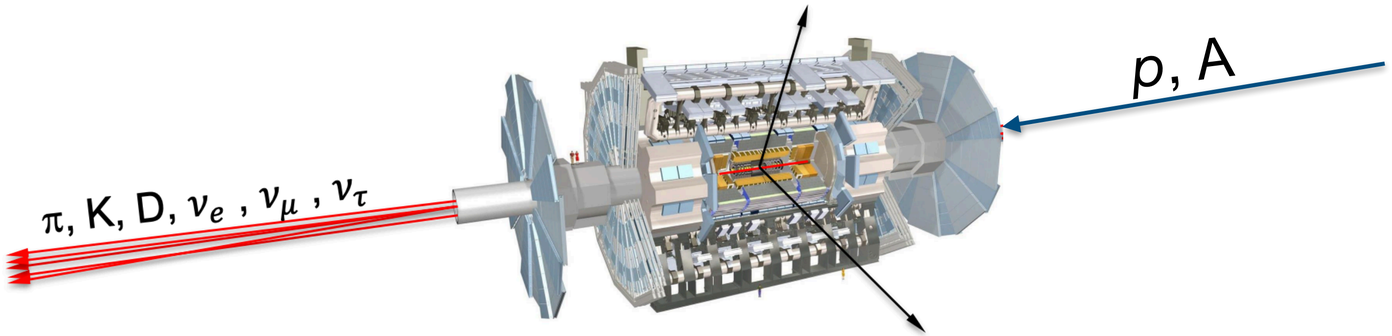
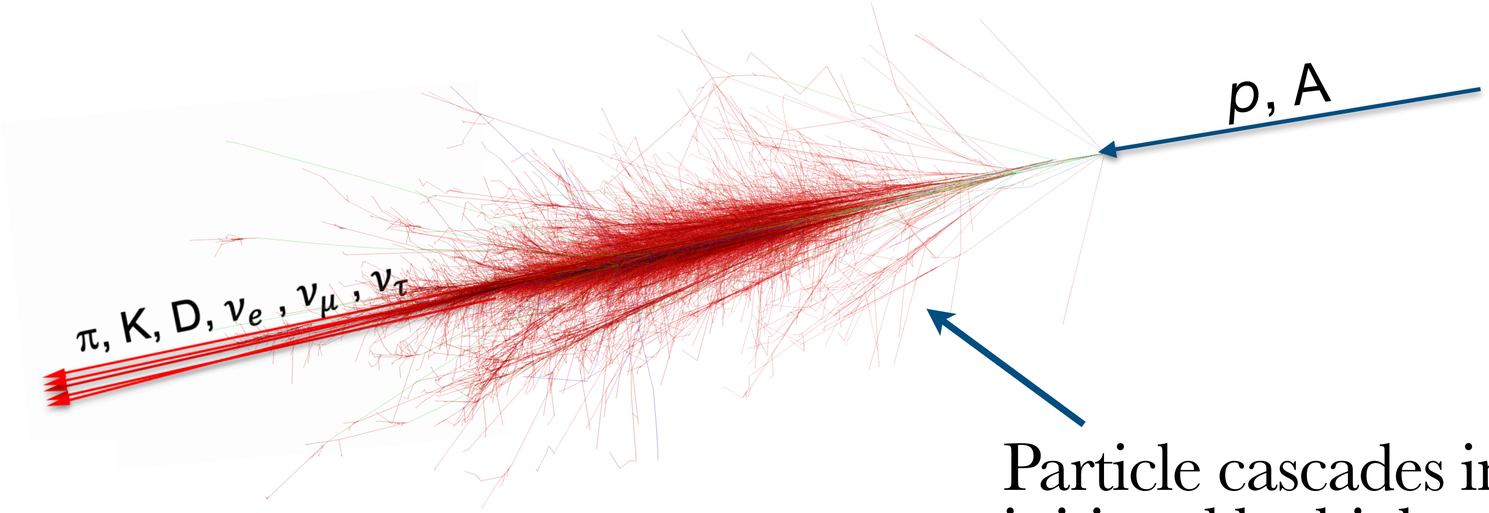
LEHMAN COLLEGE

Motivation I (Snowmass)

- Large motivation to study light hadron production at the FPF arises from observations of extensive air showers (EAS)
- <u>LHC:</u>



- <u>EAS:</u>

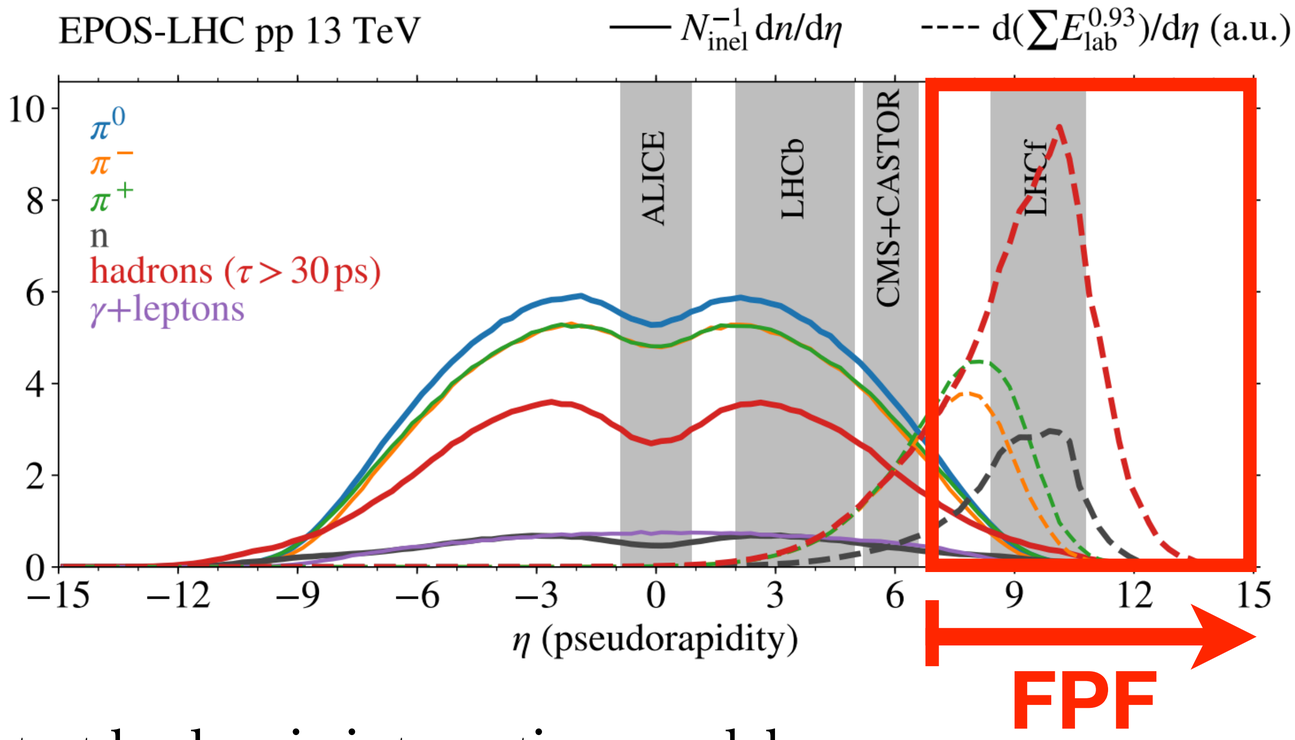


Particle cascades in the atmosphere initiated by high-energy cosmic rays

Motivation I (Snowmass)

- Extensive air showers:
  - Particle production in the far-forward region
  - Low momentum transfer
  - Non-perturbative regime
  - Complex particle composition
  - Energies range over many orders of magnitude
- Modeling of particle interactions based on phenomenological models developed for EAS simulations

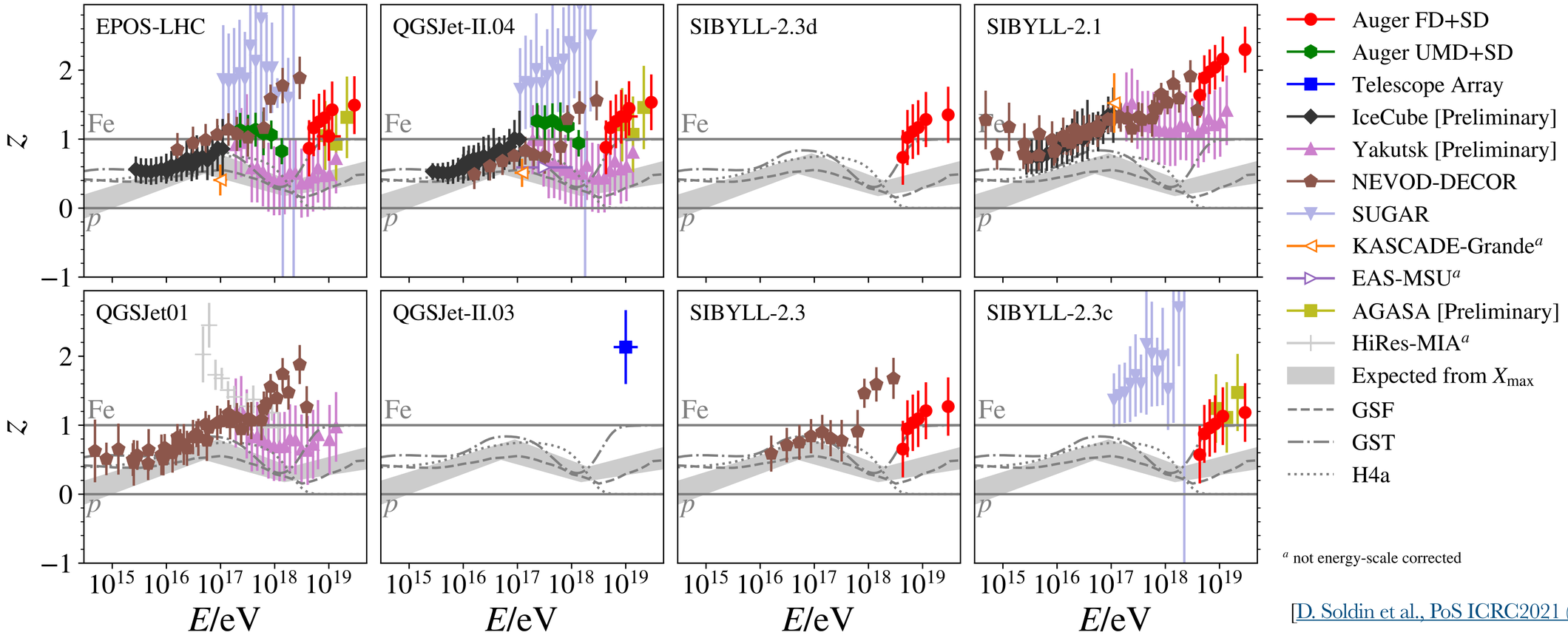
[J. Albrecht et al., Astrophys. Space Sci. 367 (2022)]



- FPF will provide unique opportunities to test hadronic interaction models

Motivation I (Snowmass)

- Large discrepancies between data and MC observed in extensive air showers (EAS)



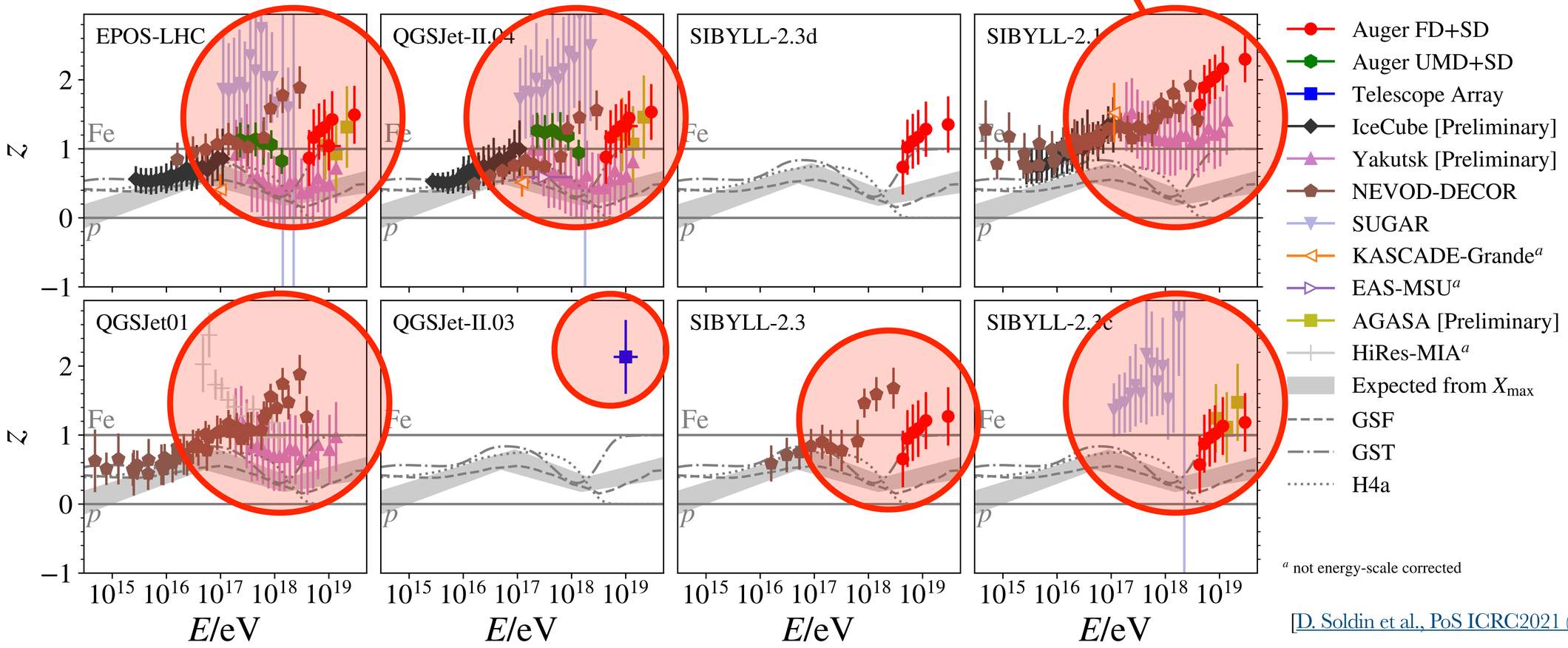
[D. Soldin et al., PoS ICRC2021 (2021) 349]

- Muon measurements and models indicate composition heavier than iron at high energies!

Motivation I (Snowma

Muon Puzzle

- Large discrepancies between data and MC observed in extensive air showers (EAS)



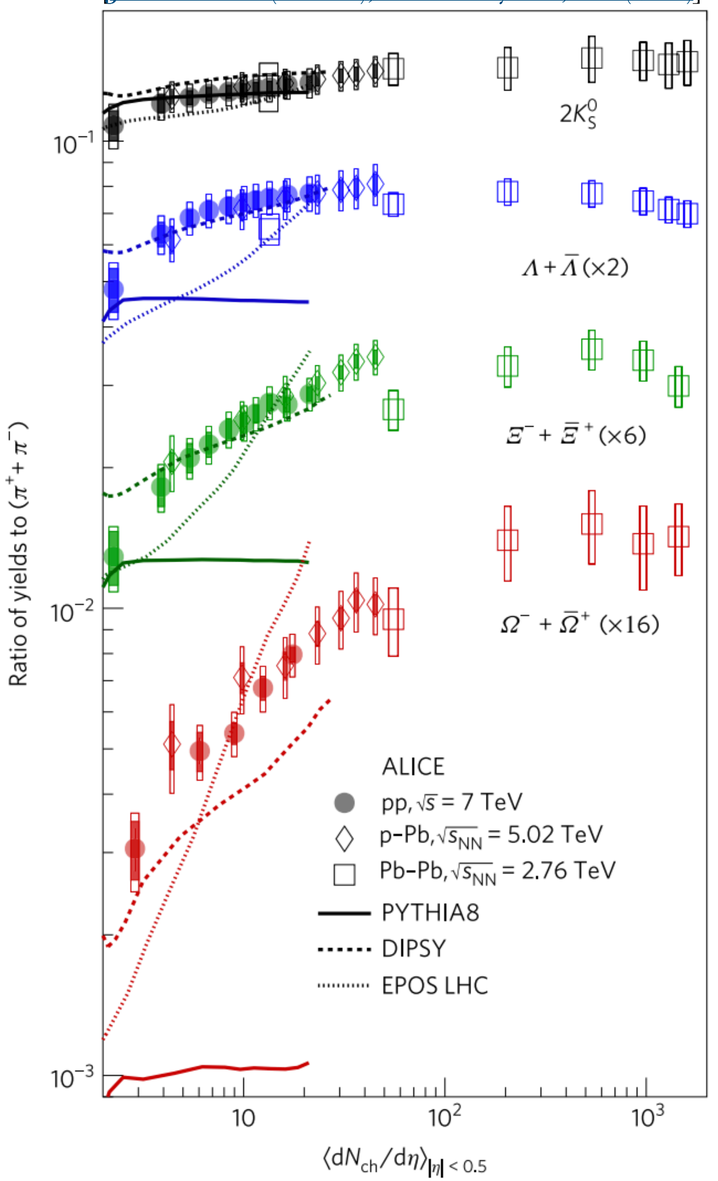
[D. Soldin et al., PoS ICRC2021 (2021) 349]

- Muon measurements and models indicate composition heavier than iron at high energies!

Motivation II (Snowmass)

- Evidence for strangeness enhancement reported by ALICE
- Universal enhancement of strangeness production in high-multiplicity events at mid-rapidity ($|y| < 2$)
- Depends on the multiplicity of the event at mid-rapidity, not on the details of the collision system!
- Can this effect also be seen in hadrons produced at forward rapidities?
- Possible explanation for the Muon Puzzle in EAS…
- <u>FPF provides unique opportunities for testing the forward rapidity region!</u>

[J. Adam et al. (ALICE), Nature Phys. 13, 535 (2017)]



WG3 Organization

- First kickoff meeting on October 10
- Sign-up sheet for WG3:
  - https://docs.google.com/spreadsheets/d/1SKCB0uE_EX2sWJNPaJjPXg9xohsX6SqjDeUS-ypYICk/edit?usp=sharing
- So far 21 people signed up for WG3, please feel free to contact/add interested candidates!
- Next WG3 meeting: End of November / beginning of December

	First Name	Last Name	Affiliation	Email Address	Comments
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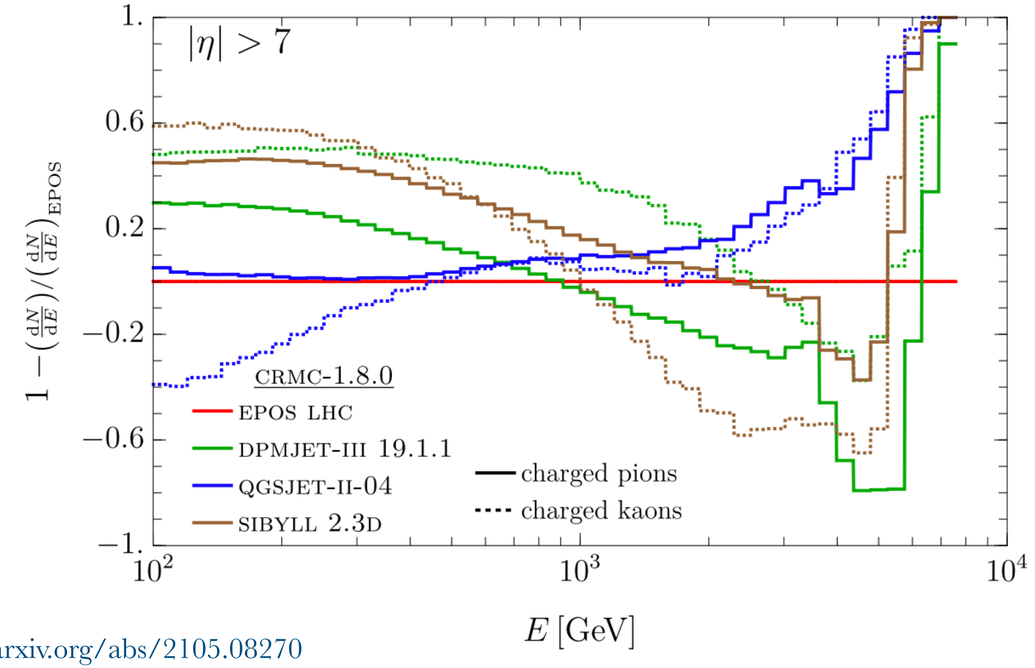
21	Tom	Paul	Lehman College, City University of New York		

WG3 Science Topics

- Neutrino fluxes at the FPF:
  - Ratio of electron and muon neutrinos is a proxy for the ratio of charged pions and kaons
  - Electron and muon neutrino fluxes populate different energy regions which will help to disentangle them
  - Neutrinos from pion and kaon decays have different rapidity distributions which will help to disentangle them
  - Fast simulation package* available! (F. Kling)
  - Further studies needed:
    - MC based on different generators
    - Neutrino fluxes in different detectors
    - Tests of dedicated strangeness (muon) enhancement models

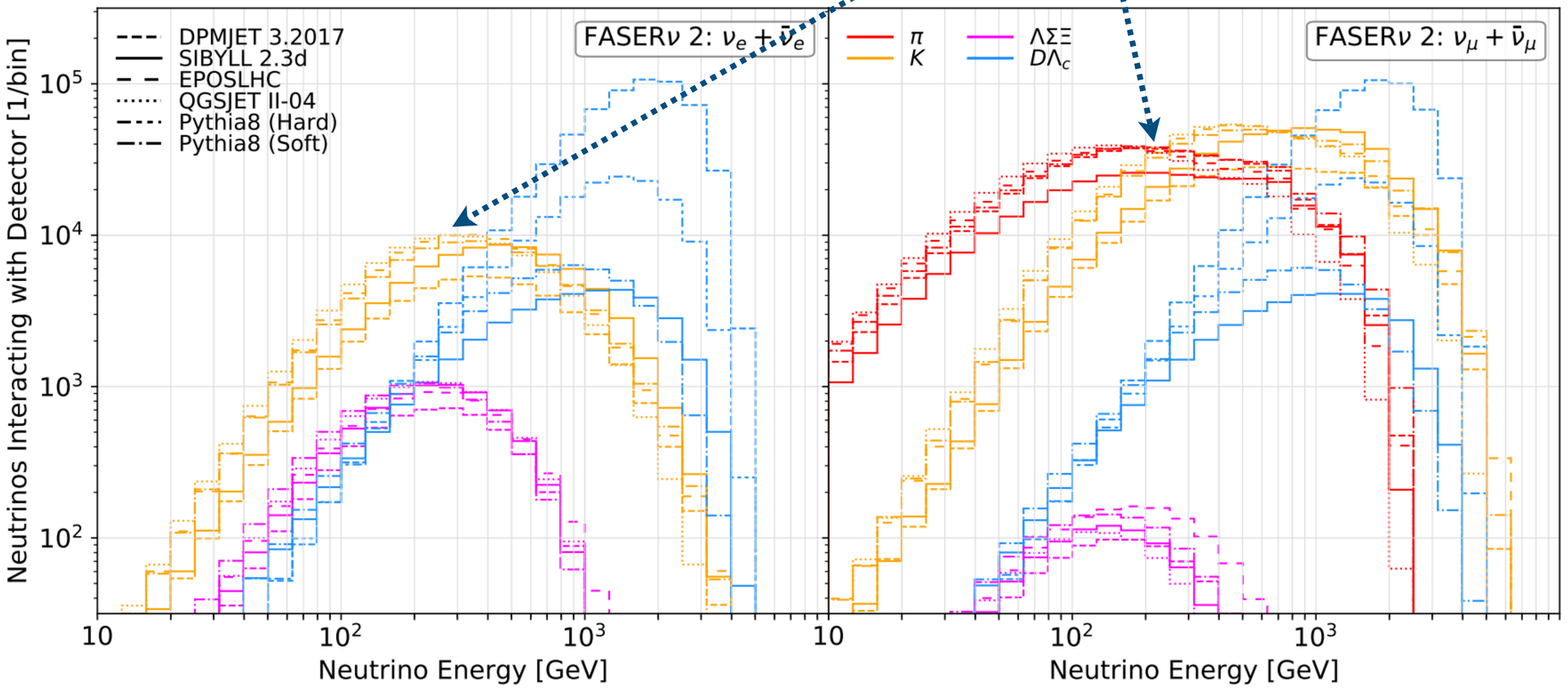


* Simulation code available at: https://github.com/KlingFelix/FastNeutrinoFluxSimulation, see also https://arxiv.org/abs/2105.08270

WG3 Science Topics

- Neutrino fluxes at FASERν2:

low energy region relevant!



- Predictions differ by a factor of up to 2, much bigger than the anticipated FPF uncertainties

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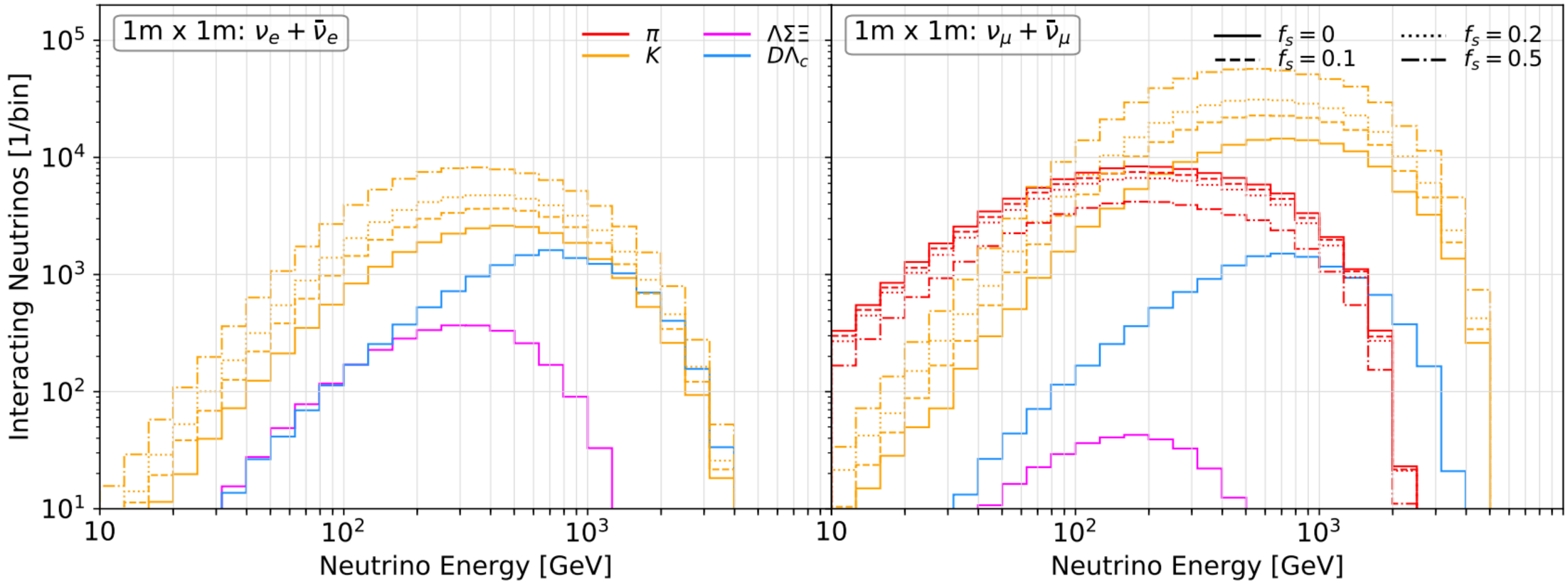
WG3 Science Topics

- Neutrino fluxes at FLArE:



- Example: strangeness enhancement toy model [L. Anchordoqui et al., JHEAp 34 (2022)]

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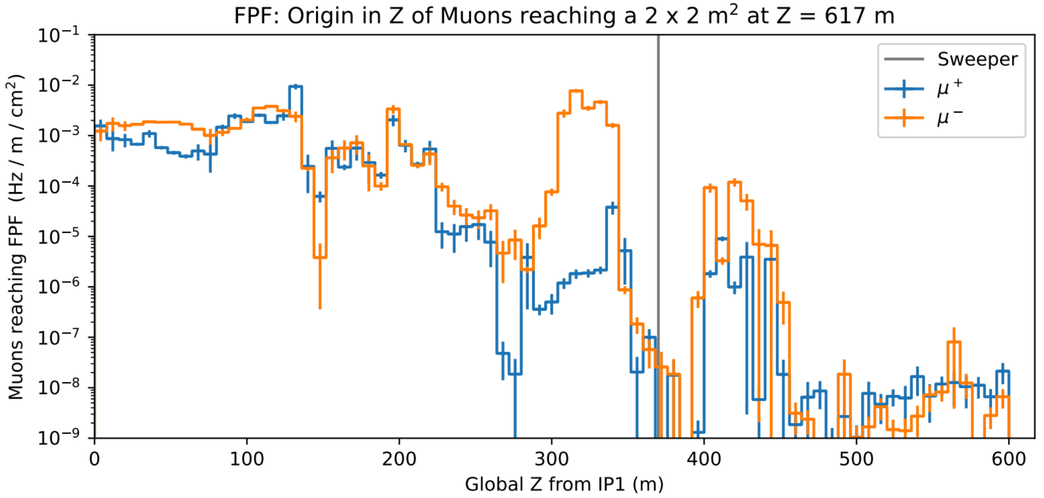
WG3 Science Topics

- Muon fluxes at the FPF:
  - Large muon flux at the FPF, e.g. ~1 Hz per cm^2 in FASER
  - Challenging to study as the origin of production is uncertain…
  - BDSIM/Geant4 simulations available, including full muon history (L. Nevay)
  - Open questions:
    - Can we use muons to study light hadron production?
    - Can we measure the muon charge ratio?
    - Do sweeper magnets help our physics case?
    - What can we learn from muon fluxes measured at FASER and SND@LHC?
  - Dedicated studies of the muon yield at the FPF (incl. full muon history) needed!

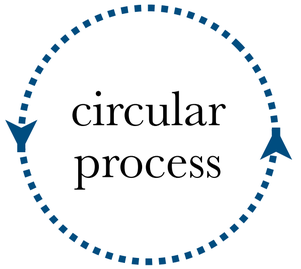


WG3 Goals

- Short-term goals:
  - Identify interested people and organize WG3 ✓
  - Define physics goals (✓)
  - Identify some action items (✓)
  - Finalize statement of scope and goals (✓)
    - Dennis & Luis will draft a first document to be circulated to WG3 for feedback
  - Assign volunteers (students?) to work on specific topics based on the existing simulations ✗
- Any open issues/questions will be discussed during the next WG3 meeting (Nov./Dec.)

WG3 Goals

- Long-term goals (~February):
  - Define analyses of FPF data that can help to understand light hadron production
  - Quantify how well we can test/constrain certain models/generators
  - Define detector requirements, e.g.
    - Rapidity ranges, e.g. $\eta > 7$
    - Energy resolution (i.e. low energy region)
    - Angular/spacial resolution
    - Requirements on flavor ID efficiency
    - …
  - Give feedback to experimentalists about detector requirements
  - Include realistic detector description in simulations



Thanks!