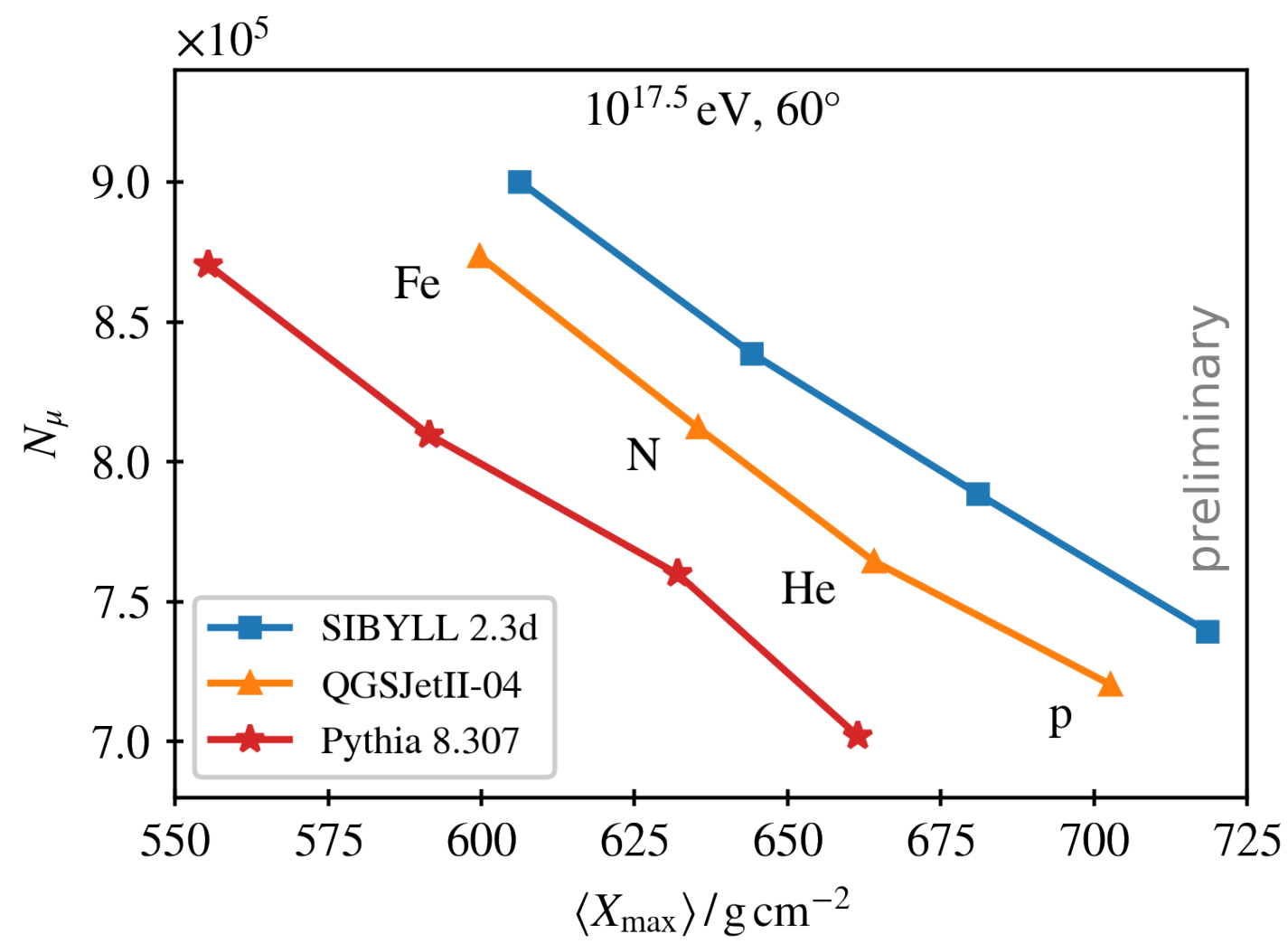


The CORSIKA 8 project and Pythia 8 as hadronic interaction model in air shower simulations

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for the CORSIKA 8 Collaboration

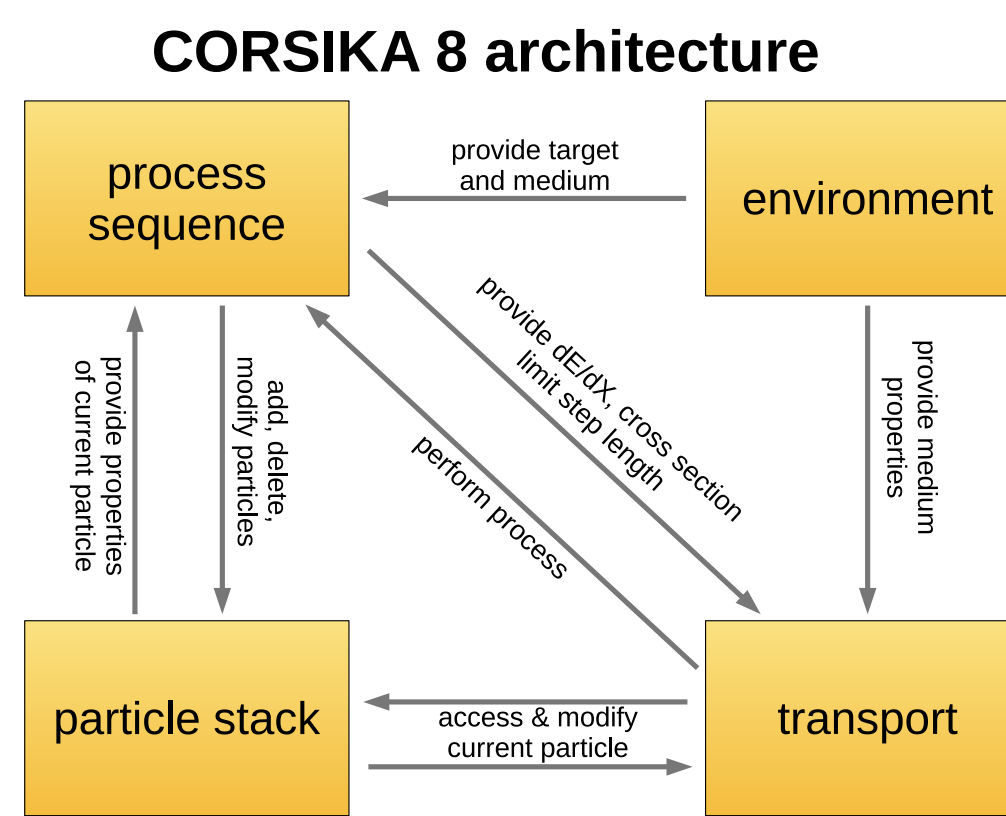


Summary

- Pythia 8.307 available in CORSIKA 8 as new high- and low-energy interaction model
- first realistic simulations of hadron showers with Pythia 8
- longitudinal development compressed due to higher hadron-oxygen cross-sections
- work in progress
- offers new perspective on muon puzzle

The CORSIKA 8 Project

- modern C++ framework for (air) shower simulations
- open source project developed by international collaboration
- flexible, user-defined geometry, media, physics processes
- unique features not available in other codes: cross-media showers, complete particle ancestry
- current status: usable by developers and early adopters, most important physics models implemented (hadronic interaction models, EM model, radio & Cherenkov emission)



Get in touch with us!

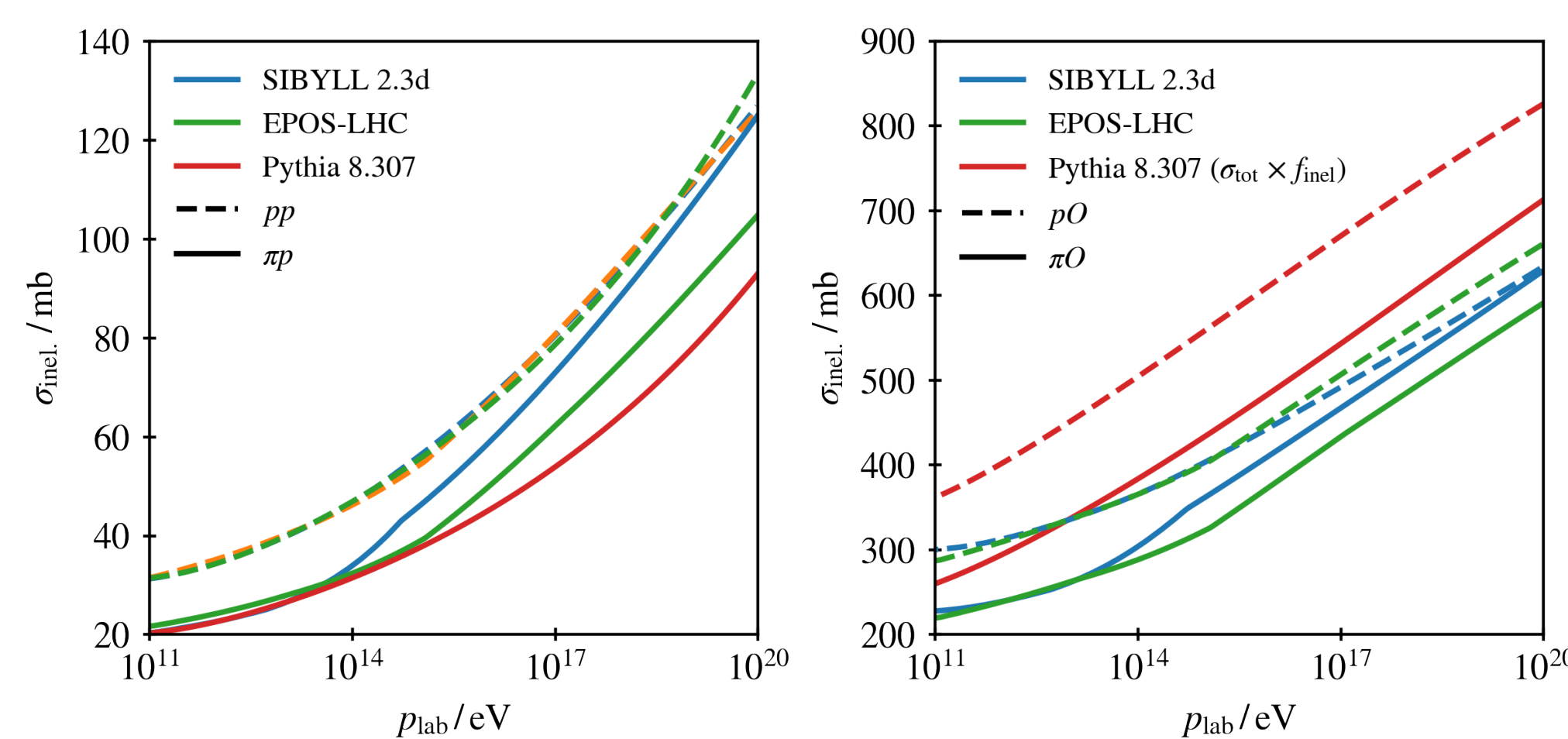


gitlab.iap.kit.edu/AirShowerPhysics/corsika
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Pythia 8

- general-purpose event generator, popular in high-energy physics, in particular at LHC
- new features for CR applications since latest release (8.307):
 - arbitrary hadron species
 - random collision energy $E > 0.2$ GeV
 - also useful as low-energy model
 - simplified nuclear interaction model:
 - 1) generate hadron-nucleon collision
 - 2) continue with probability $1 - 1/(n_{\text{sub}})$
 - a) select secondary with highest p_{\perp}
 - b) generate collision with nucleon
 - c) go to 2)
- now interfaced to CORSIKA 8 for shower simulations

Inelastic cross-sections



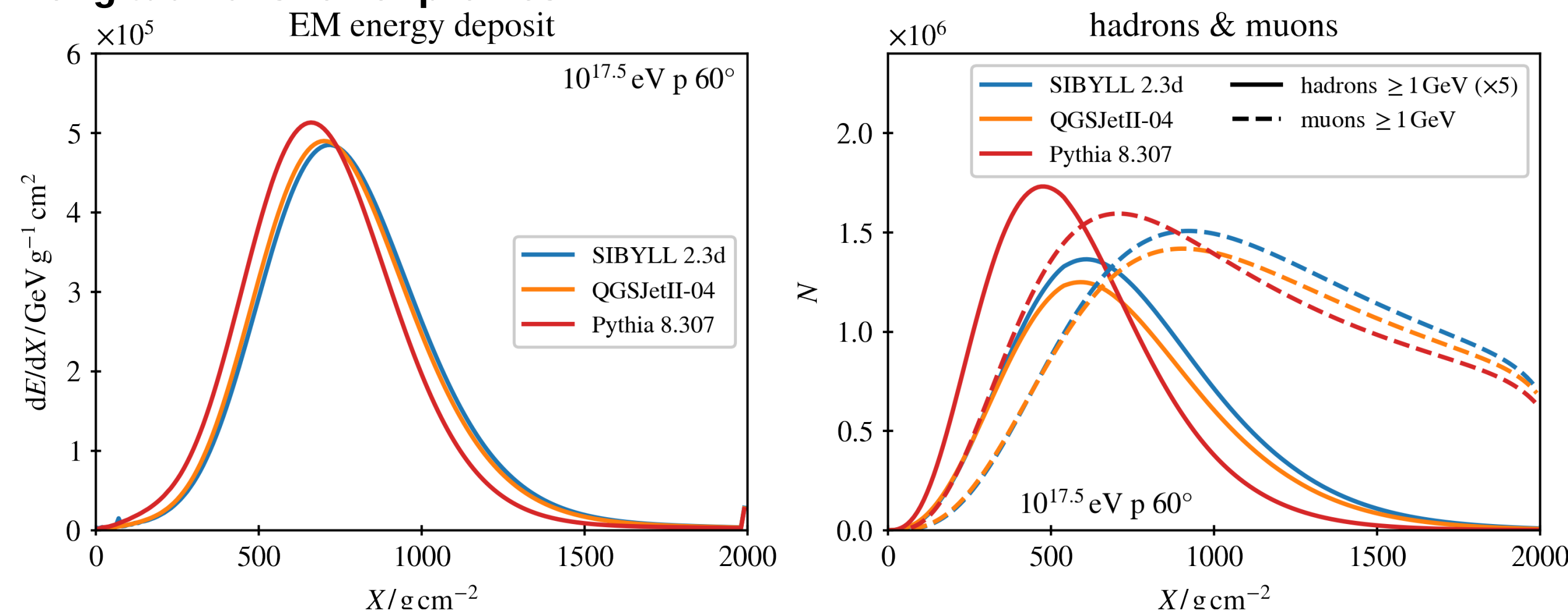
- Pythia nuclear interaction model provides only total cross-section
- fraction of inelastic events f_{inel} via Monte Carlo, approx. constant: πO : 92 %, pO : 90 %
- Pythia cross-sections lowest in hadron-proton but highest in hadron-oxygen

$$\sigma_{\text{tot}}^{(hA)} = \frac{A}{\langle n_{\text{subcoll}} \rangle} \sigma_{\text{tot}}^{(hp)}$$

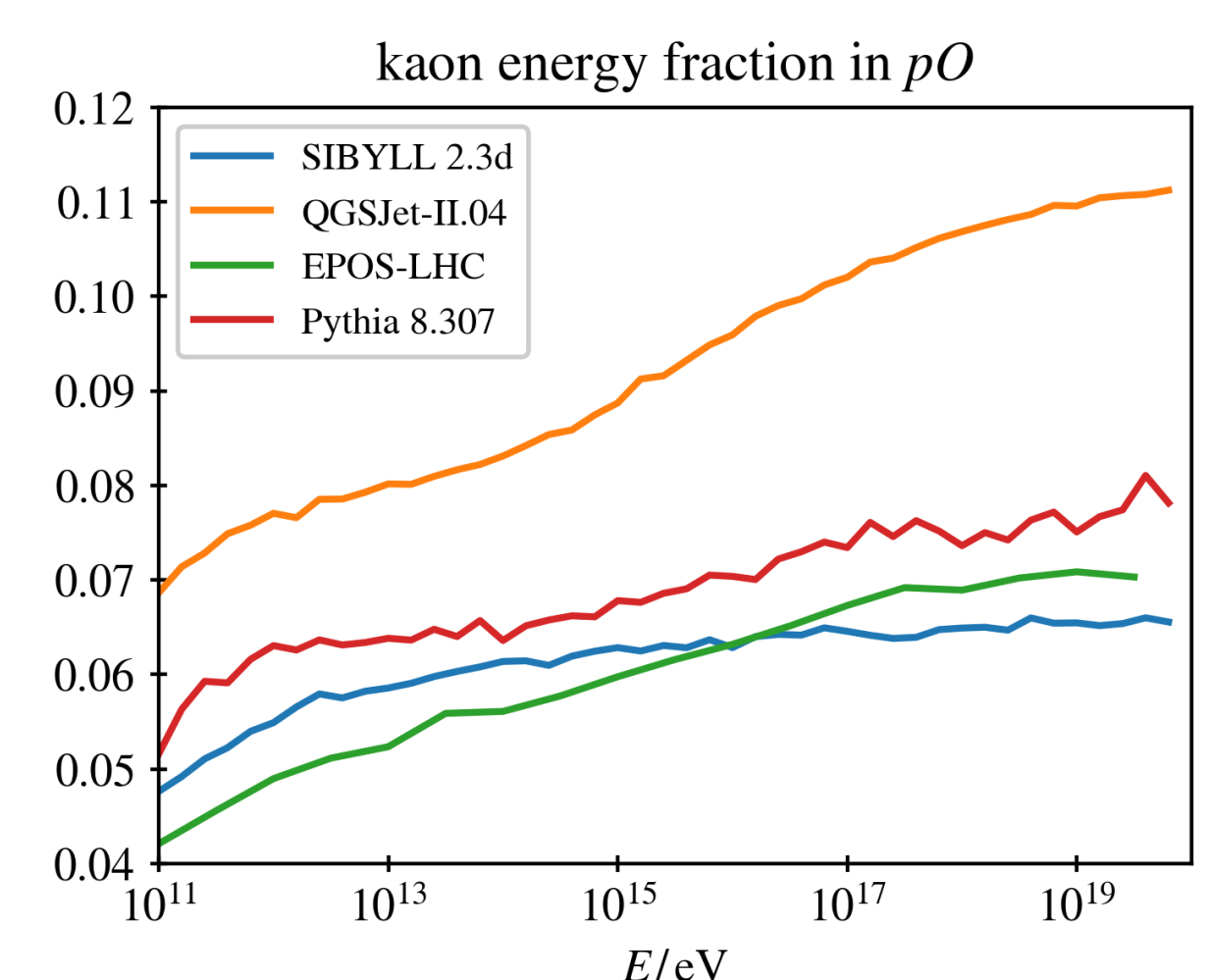
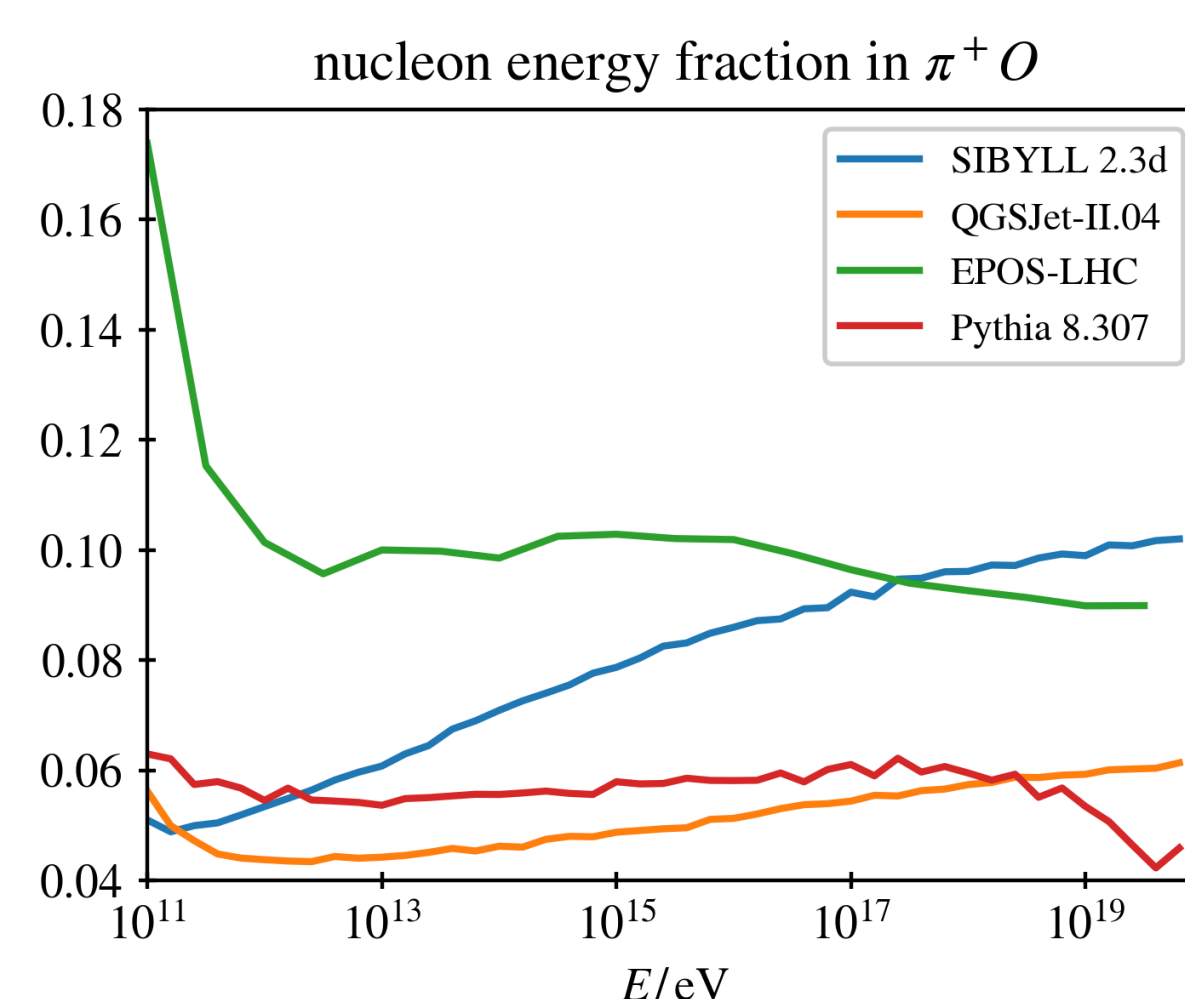
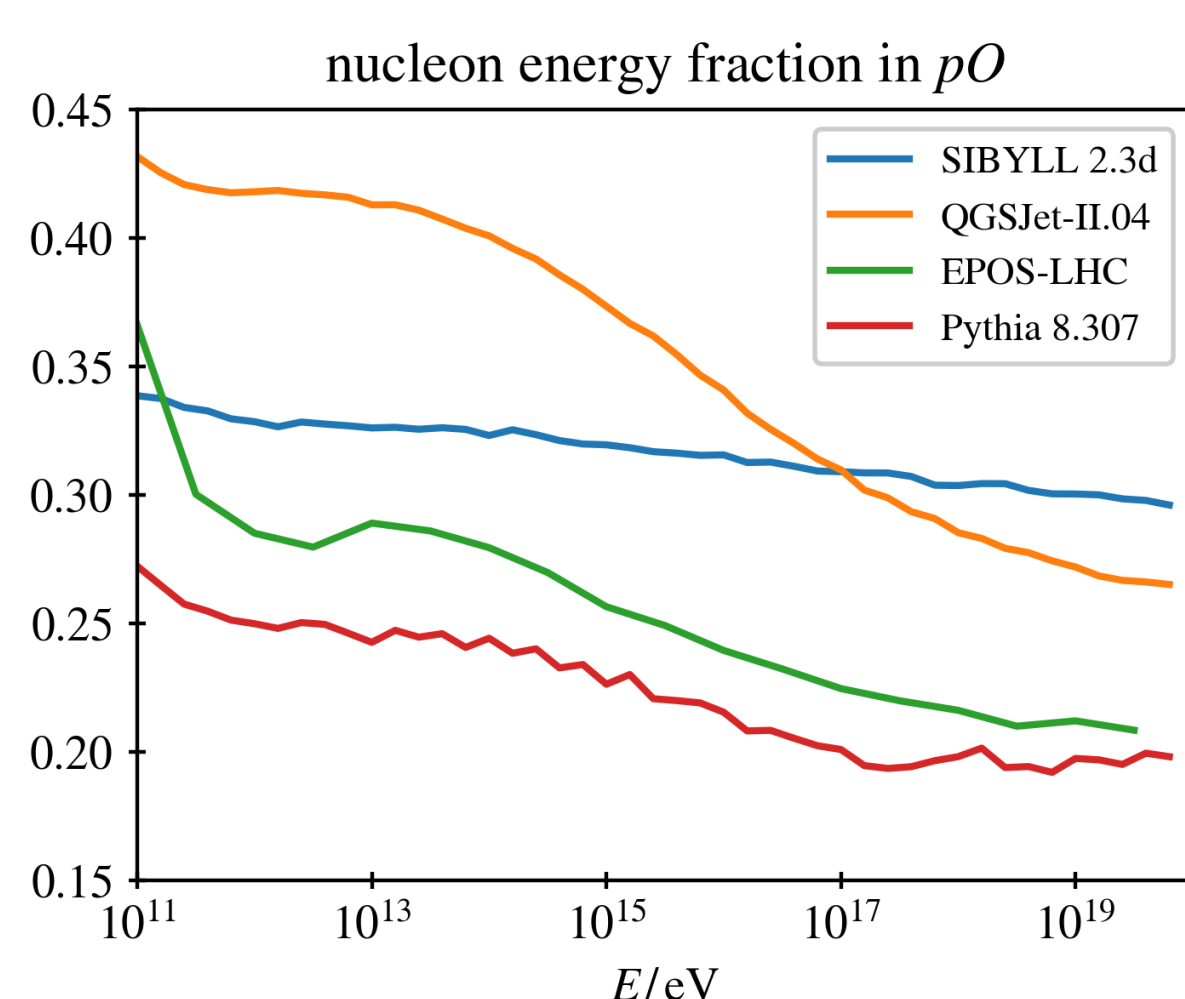
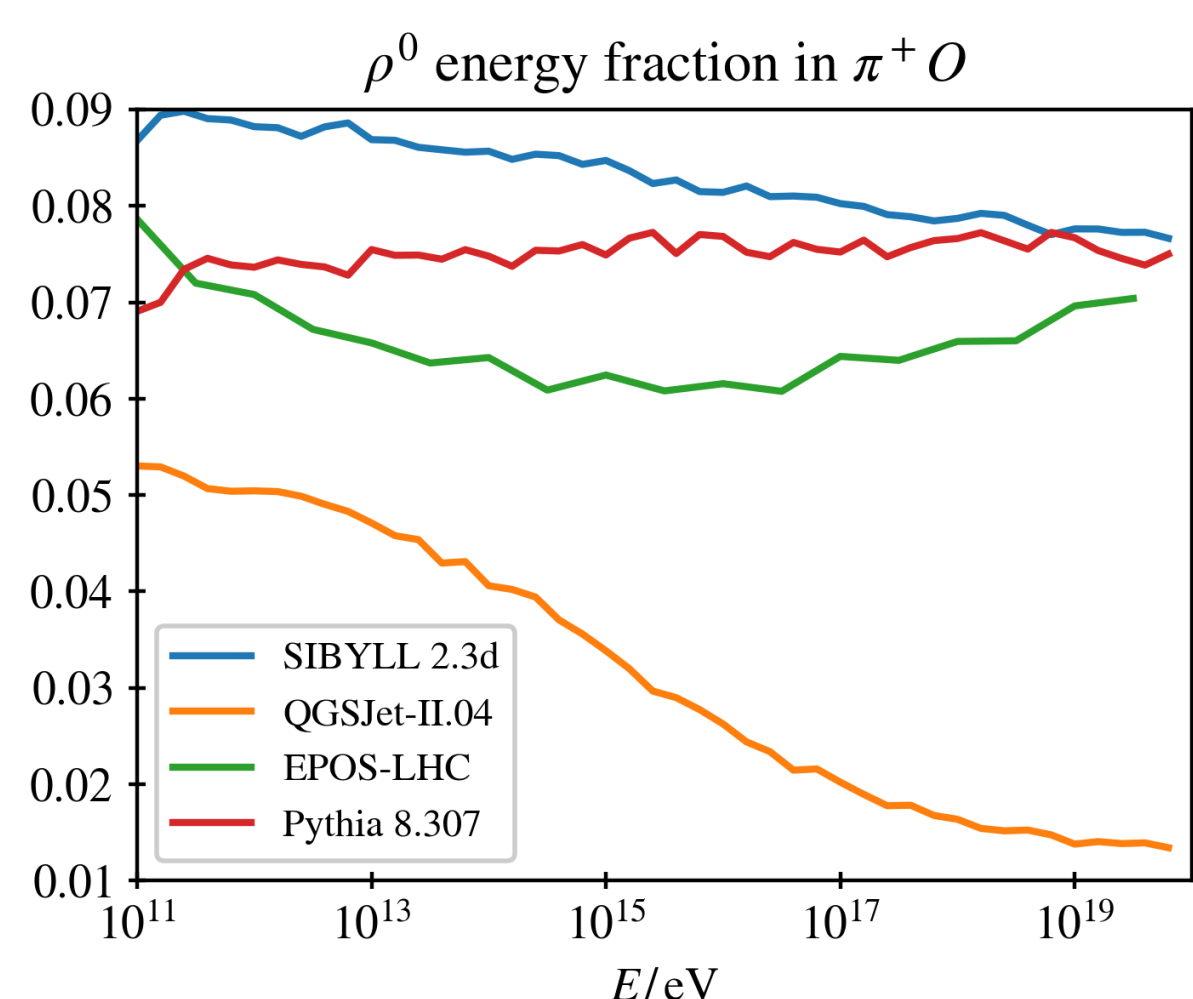
Air shower simulation setup

- hybrid CORSIKA 8/CONEX
- Monte Carlo treatment of hadrons & muons in CORSIKA 8
- semi-superposition of SIBYLL combined with Pythia for nuclear primaries
- cascade equations for EM component with CONEX

Longitudinal shower profiles



- averaged over 600 showers
- showers with Pythia 8 compressed
- effect in hadrons/muons more pronounced than EM component, amplified by number of generations
- Pythia 8 has highest muon content in maximum



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3. T. Sjöstrand, M. Utheim, Eur.Phys.J.C 82 (2022) 1, 21, arXiv:2108.03481
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