News from CORSIKA 8

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bw|HPC

CORSIKA 8

- modern (C++17) framework for Monte Carlo simulation of particle cascades
- open source project with collaborators worldwide
- design rationale:
  - modularity
  - flexibility
  - performance
- domains of applications:
  - workhorse for everyday needs by astroparticle experiments
  - “explorative research”: new physics, hadronic interactions, …

Timeline

Computing and Software for Big Science (2019) 3:2
https://doi.org/10.1007/s41781-018-0013-0

ORIGINAL ARTICLE

Towards A Next Generation of CORSIKA: A Framework for the Simulation of Particle Cascades in Astroparticle Physics

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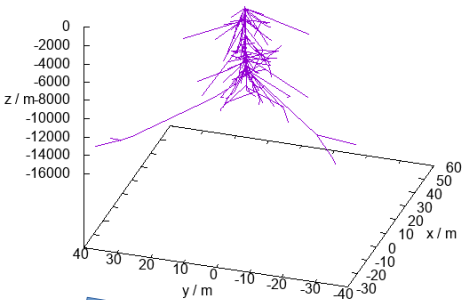
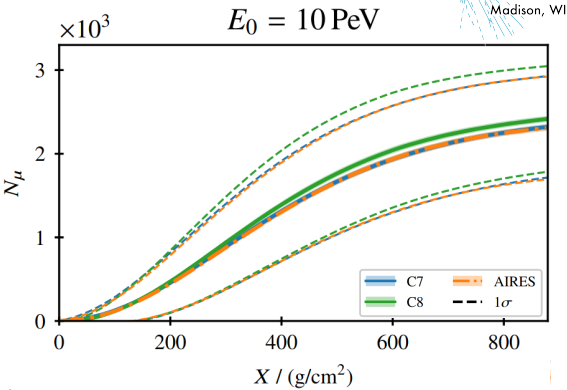
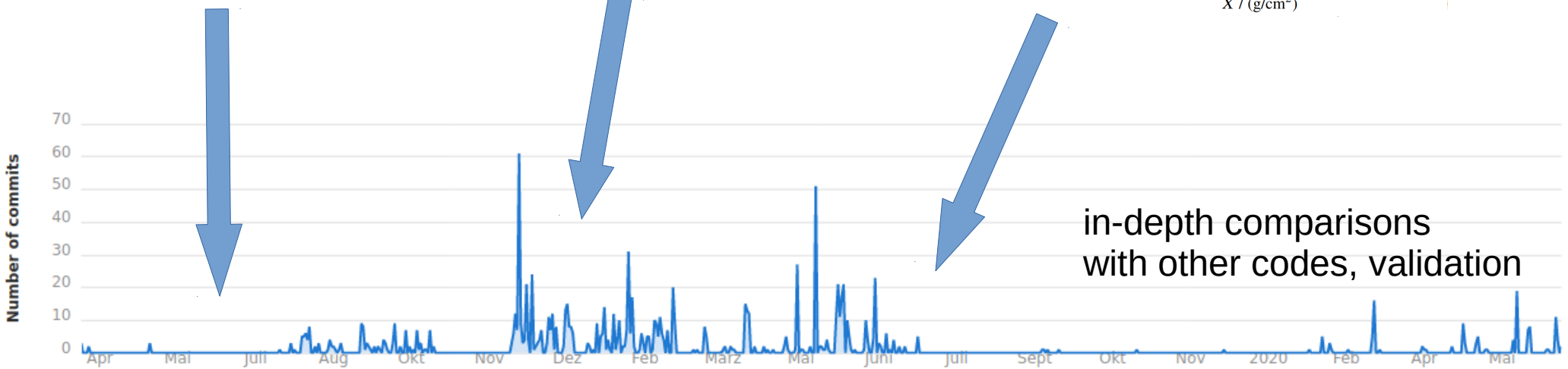
First hadronic cascades



First semi-realistic showers with muons

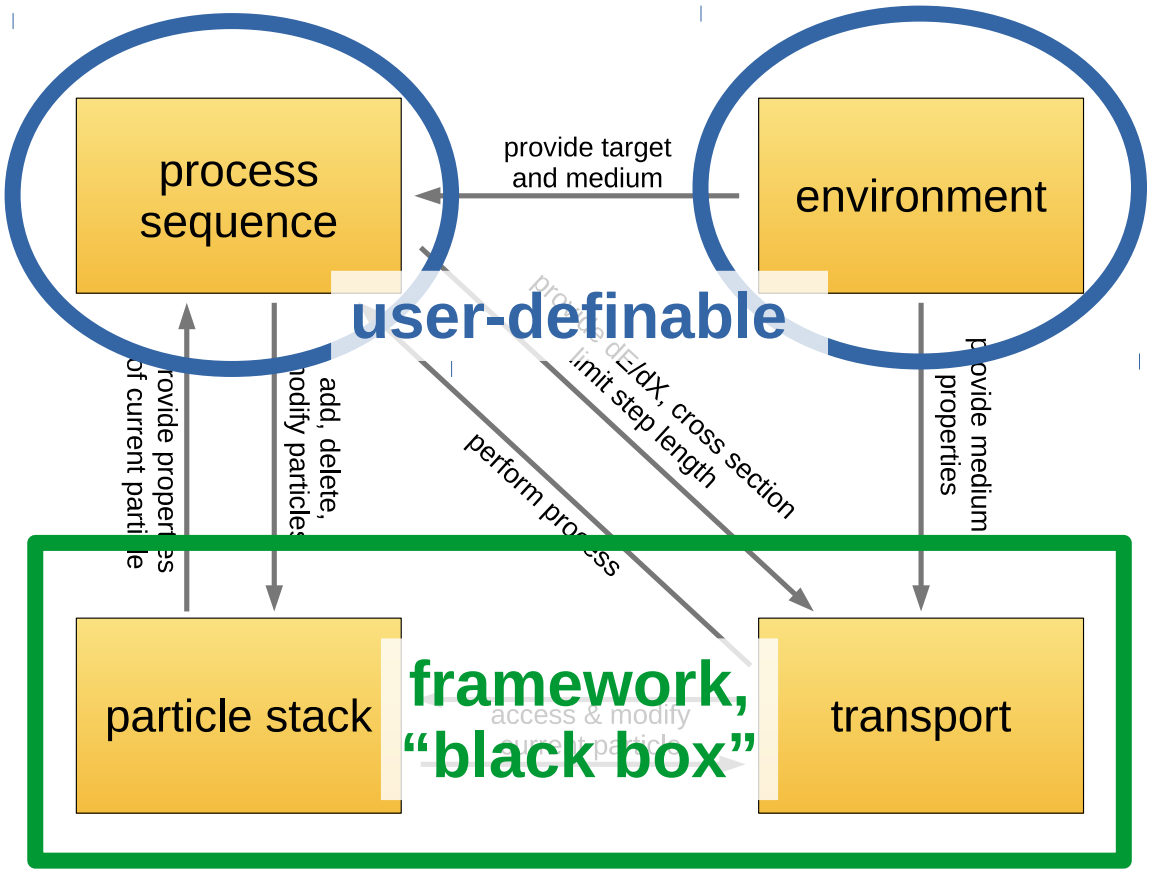


ICRC2019
Madison, WI, USA

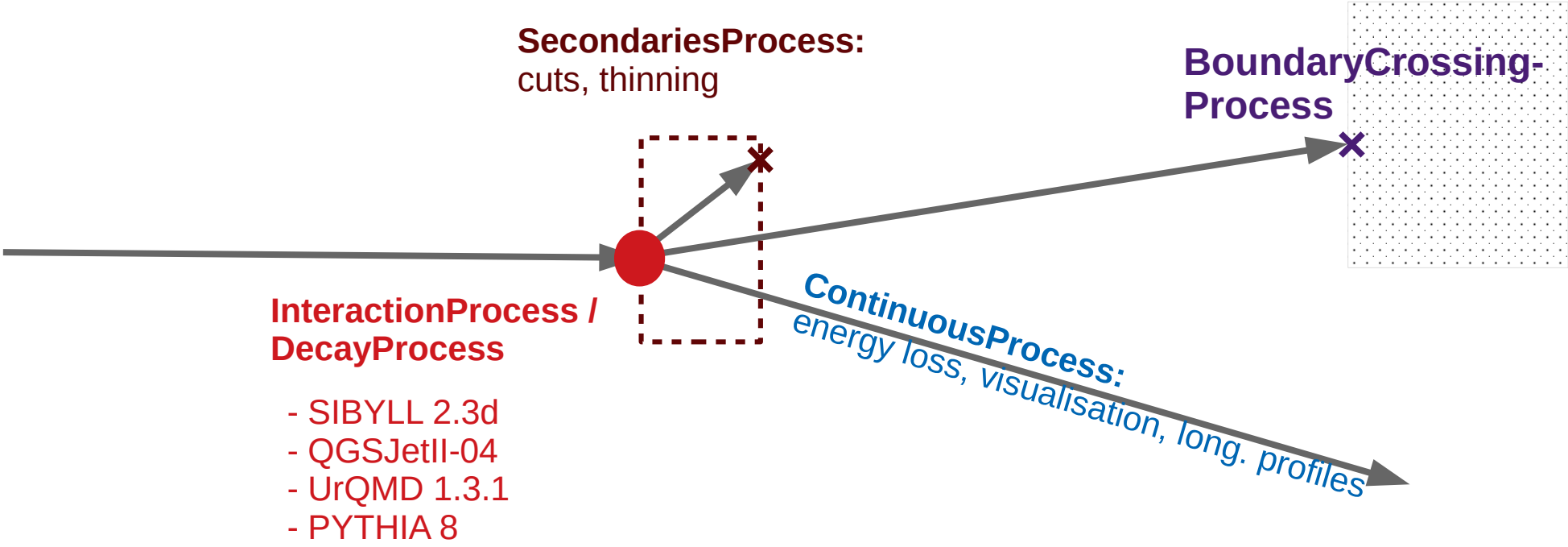


in-depth comparisons
with other codes, validation

Building blocks

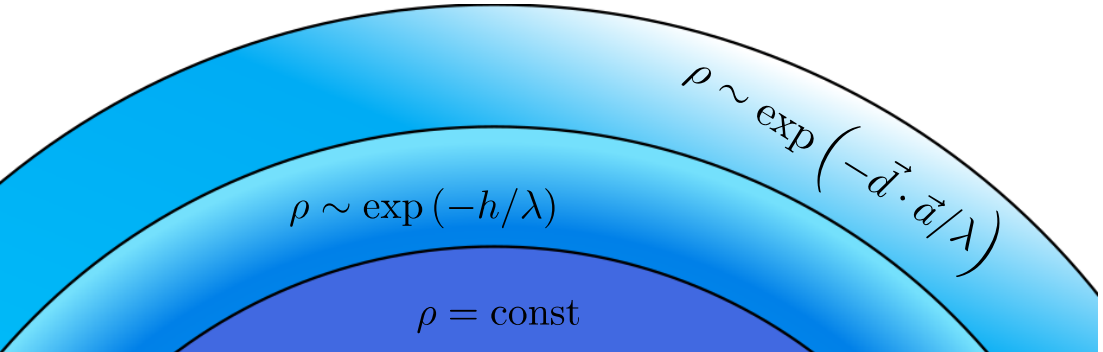


Process classes

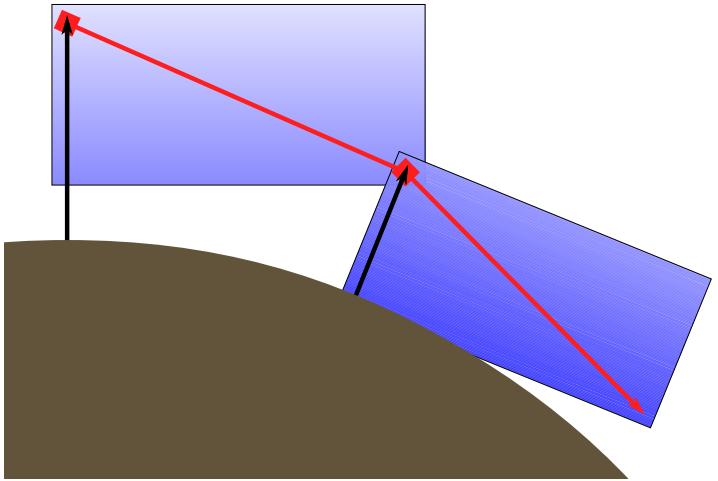


Atmospheric models

- arbitrary number of layers with distinct models
- not necessarily concentric
- provided density models:
  - constant
  - flat exponential
  - spherical exponential
- extensible according to your needs
- chemical composition limited only by physics models
  → not just air

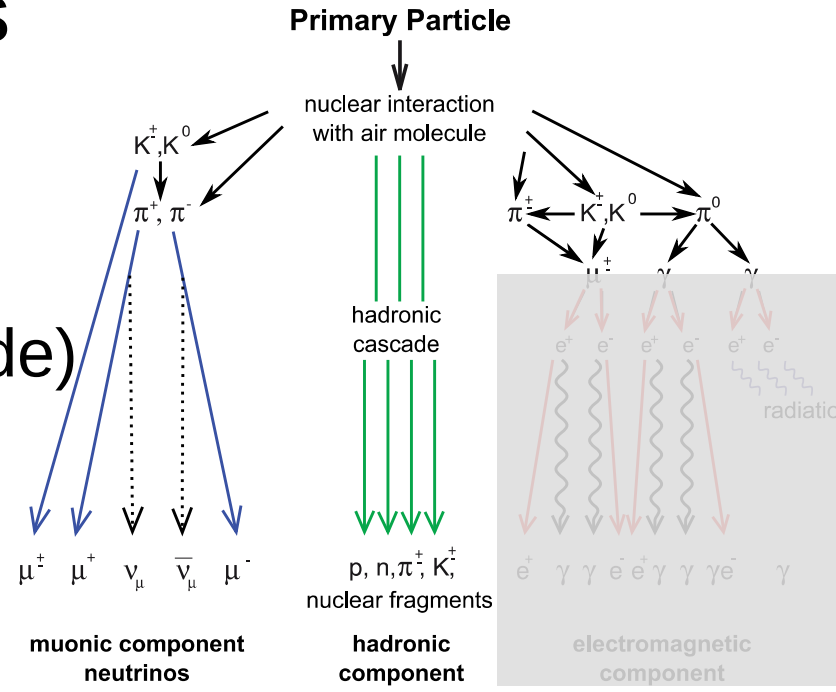


sliding planar atmosphere
similar to AIRES and CORSIKA 7

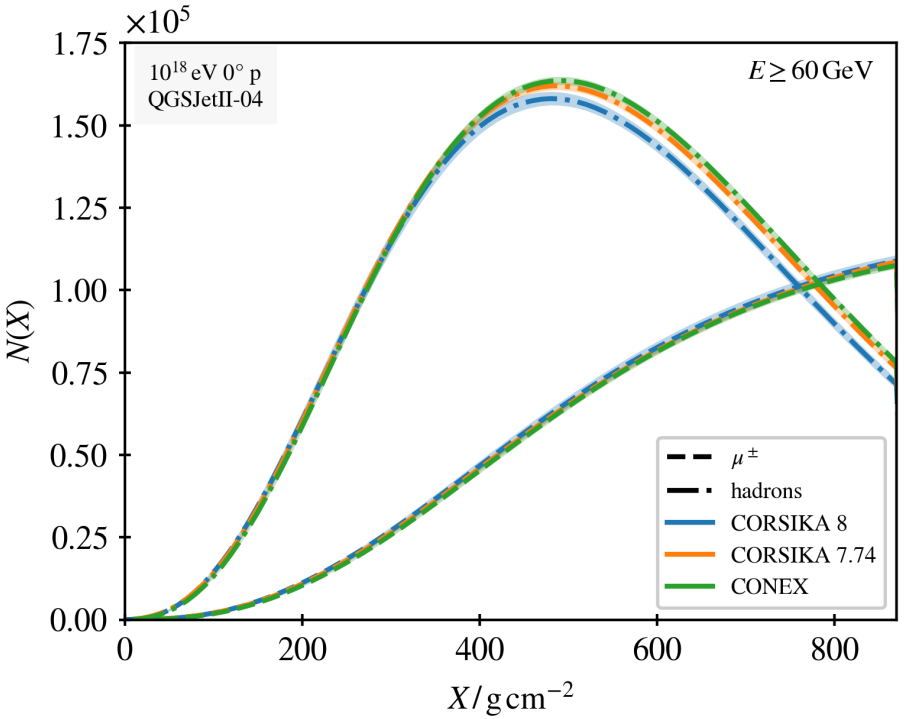


Validation

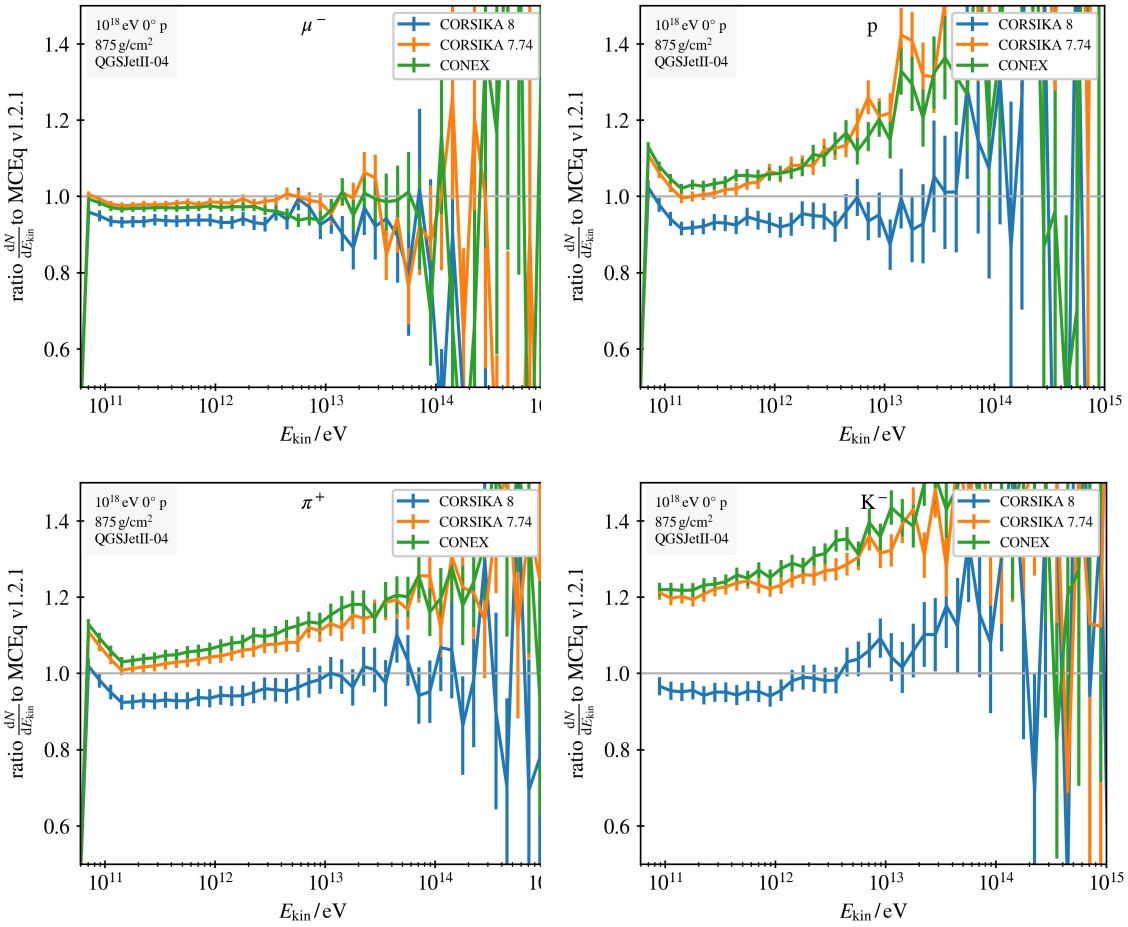
- several codes, latest versions
  - CORSIKA 7.74 MC
  - CONEX MC
  - MCEq 1.2.1 CE (air shower mode)
- only hadron/muon cascade
- UHE vertical proton showers



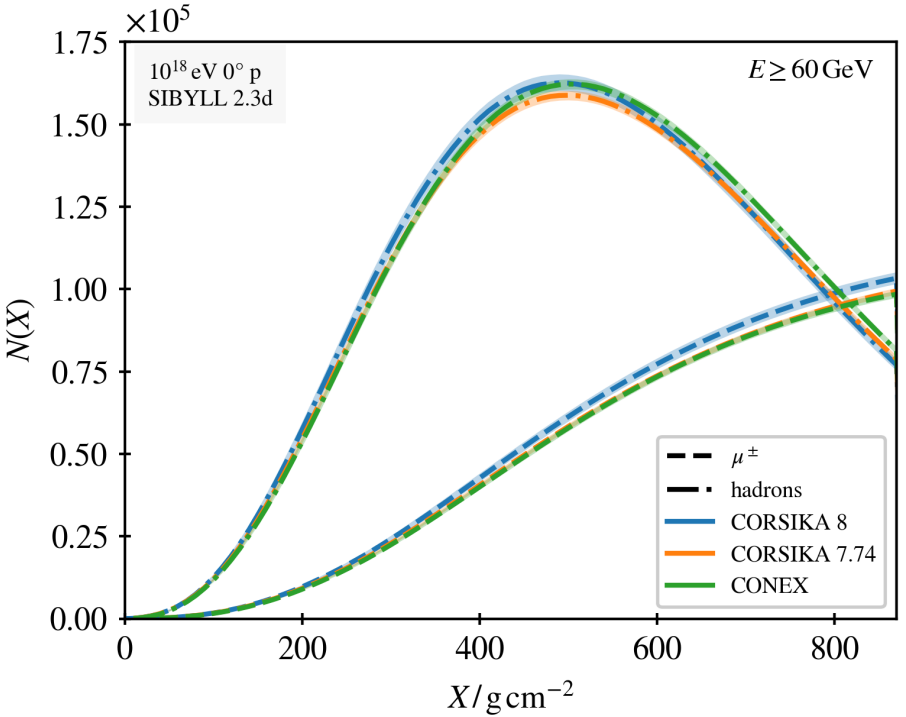
QGSJetII-04

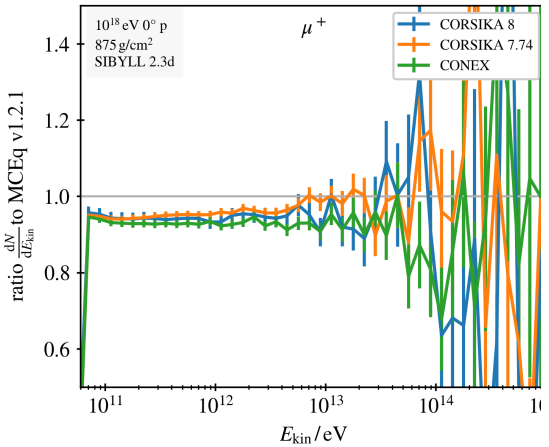


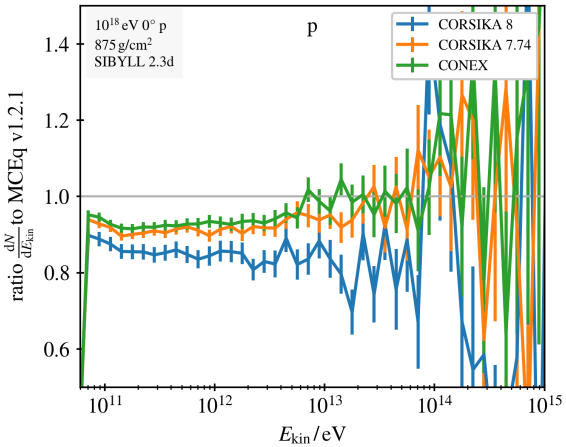
- same “projectile mappings” in C8 and MCEq
- source of systematic uncertainty

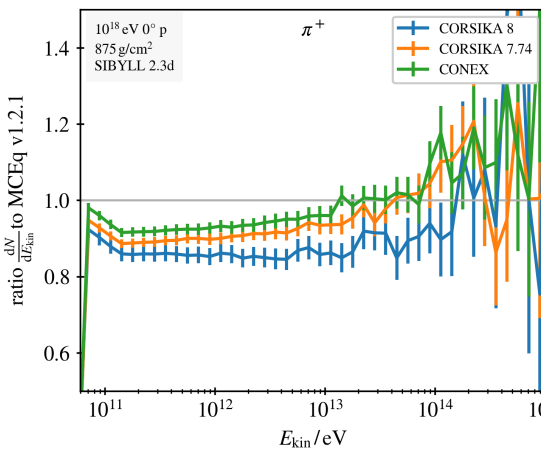


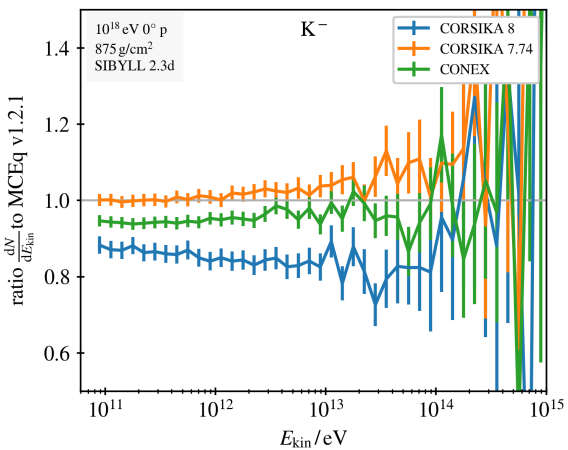
SIBYLL 2.3d


×10^5
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
N(X)
10^18 eV 0° p
SIBYLL 2.3d
E ≥ 60 GeV
μ±
hadrons
CORSIKA 8
CORSIKA 7.74
CONEX
0
200
400
600
800
X / g cm^−2

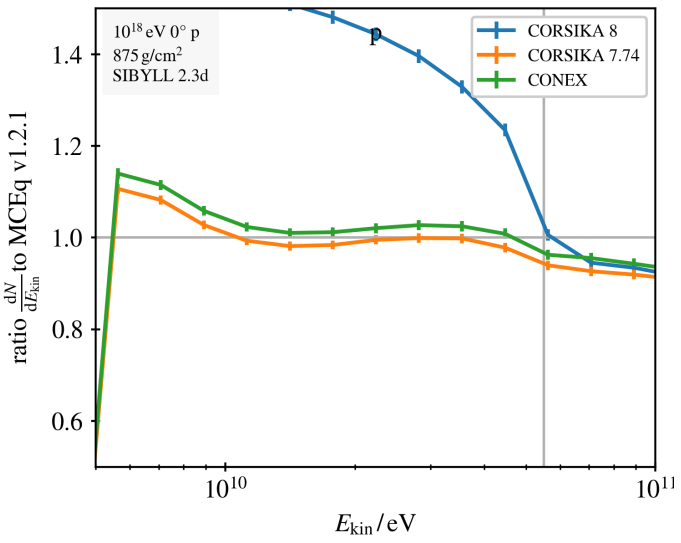

10^18 eV 0° p
875 g/cm^2
SIBYLL 2.3d
μ+
CORSIKA 8
CORSIKA 7.74
CONEX
ratio dN/dE_kin to MCEq v1.2.1
1.4
1.2
1.0
0.8
0.6
10^11
10^12
10^13
10^14
E_kin / eV

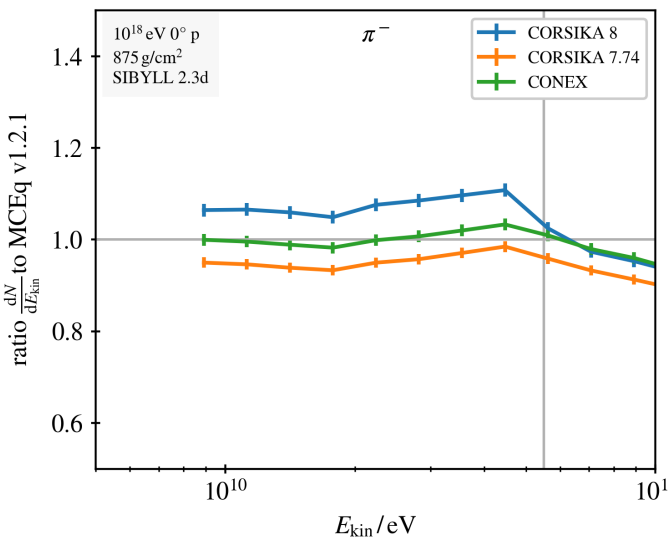

10^18 eV 0° p
875 g/cm^2
SIBYLL 2.3d
p
CORSIKA 8
CORSIKA 7.74
CONEX
ratio dN/dE_kin to MCEq v1.2.1
1.4
1.2
1.0
0.8
0.6
10^11
10^12
10^13
10^14
10^15
E_kin / eV

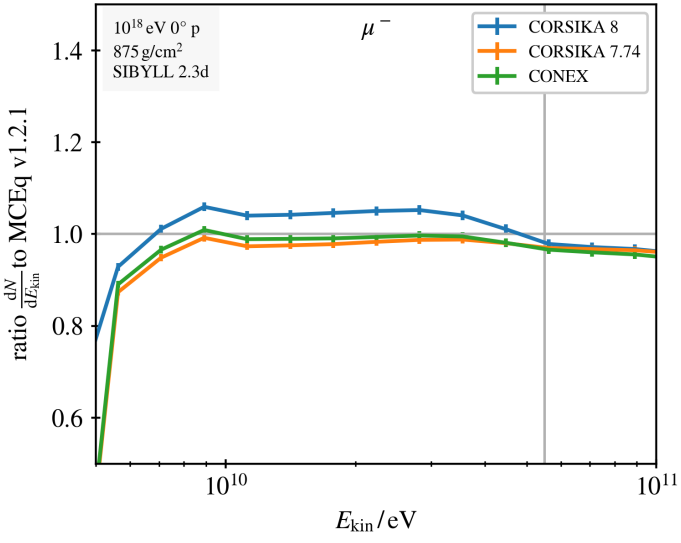

10^18 eV 0° p
875 g/cm^2
SIBYLL 2.3d
π+
CORSIKA 8
CORSIKA 7.74
CONEX
ratio dN/dE_kin to MCEq v1.2.1
1.4
1.2
1.0
0.8
0.6
10^11
10^12
10^13
10^14
E_kin / eV


10^18 eV 0° p
875 g/cm^2
SIBYLL 2.3d
K−
CORSIKA 8
CORSIKA 7.74
CONEX
ratio dN/dE_kin to MCEq v1.2.1
1.4
1.2
1.0
0.8
0.6
10^11
10^12
10^13
10^14
10^15
E_kin / eV

Lower energies: UrQMD







big improvement compared to 2019!

side remark: update appreciated :-)

Next steps @KIT

- CONEX CE for (interim) e.m. long. profile, X_{max}
- tracking in magnetic fields & numerics
- shower genealogy
- general maintenance & improvements

Conclusions

- CORSIKA 8 is an international project with a vision about next-gen EAS simulation
- still under heavy development, lots of features missing
- already usable for specific studies
- comparisons with other codes revealed several bugs in most of them
- now good agreement regarding hadronic component