Current capabilities and first results with CORSIKA 8

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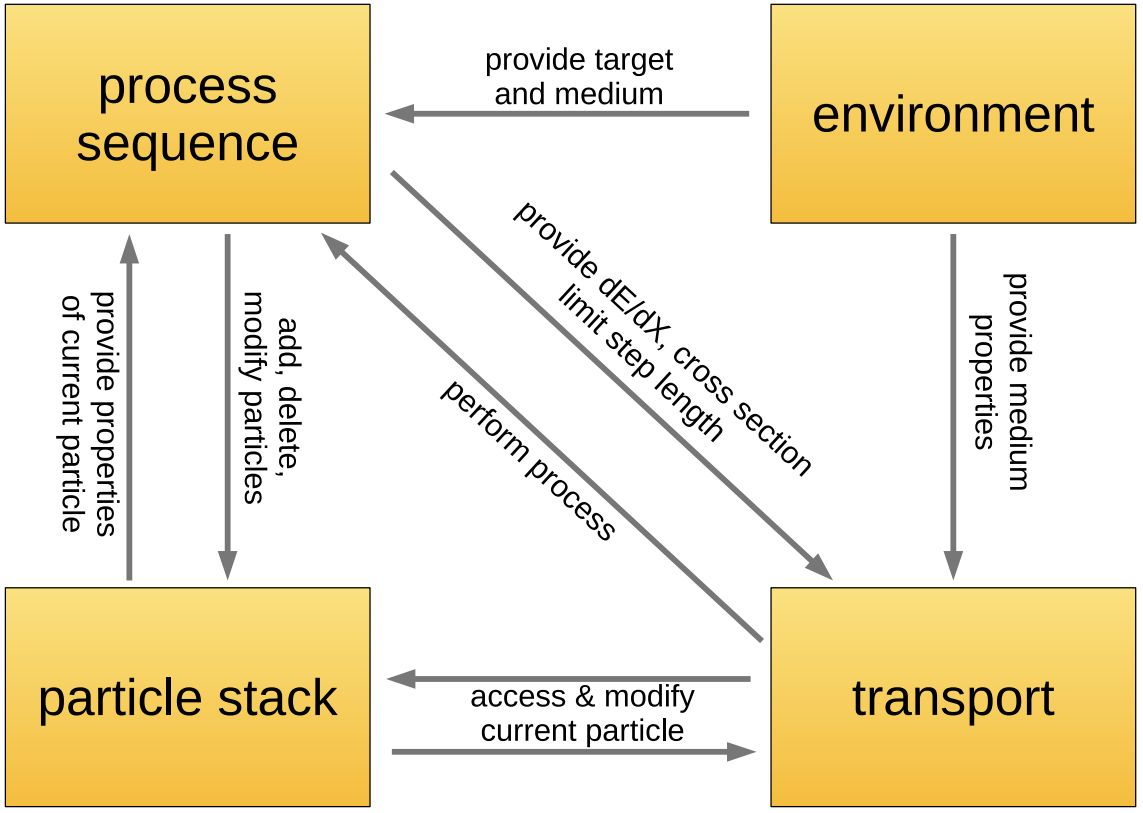
ITeDA

Part I: Current status of the project

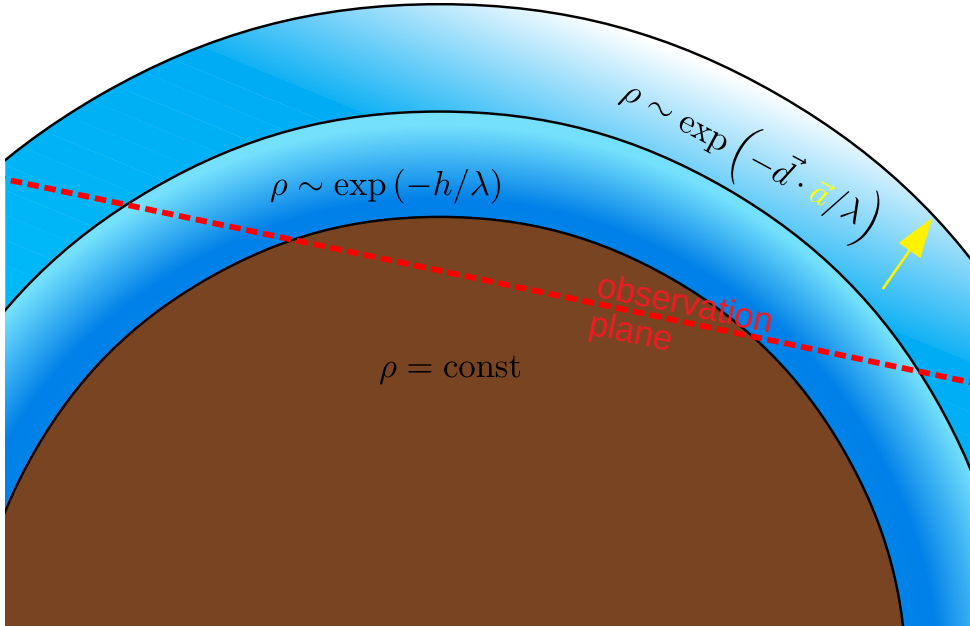
Building blocks of C8



Worldbuilding

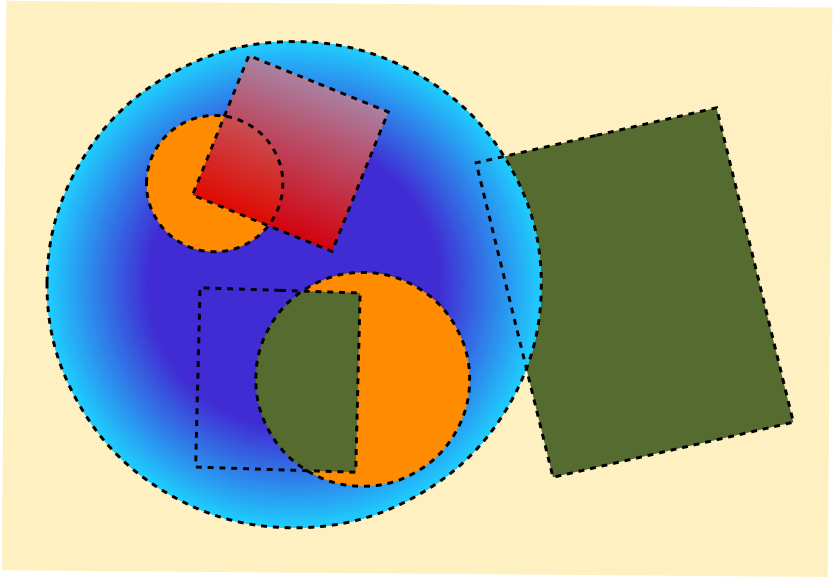
- world entirely composable by user
- different materials/density models in different regions of space
- currently available:
  - homogeneous density
  - exponential flat & curved (“sliding planar approximation”)
- easily extensible by own models

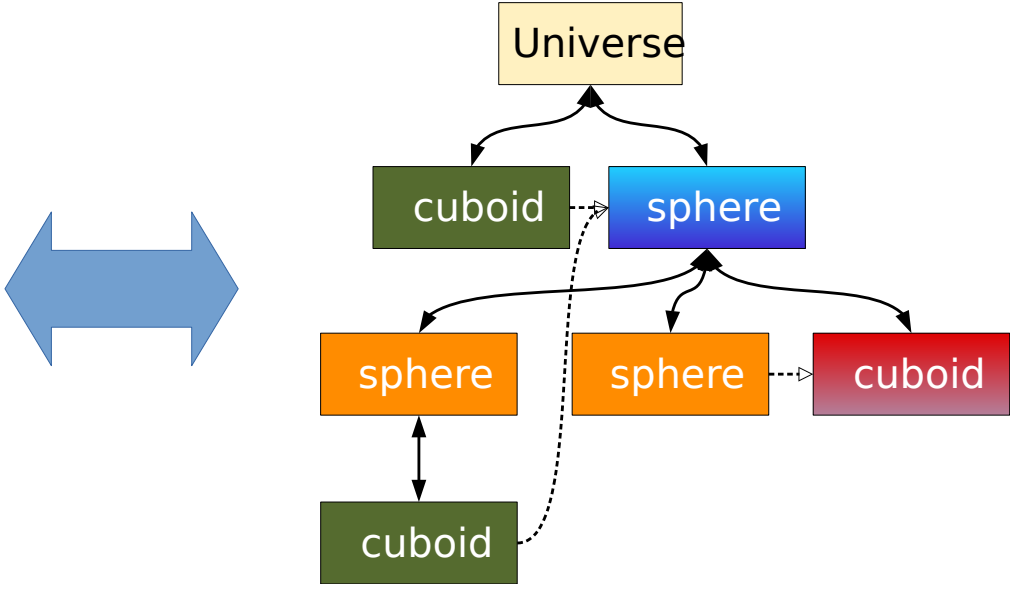
→ see my second talk



Worldbuilding

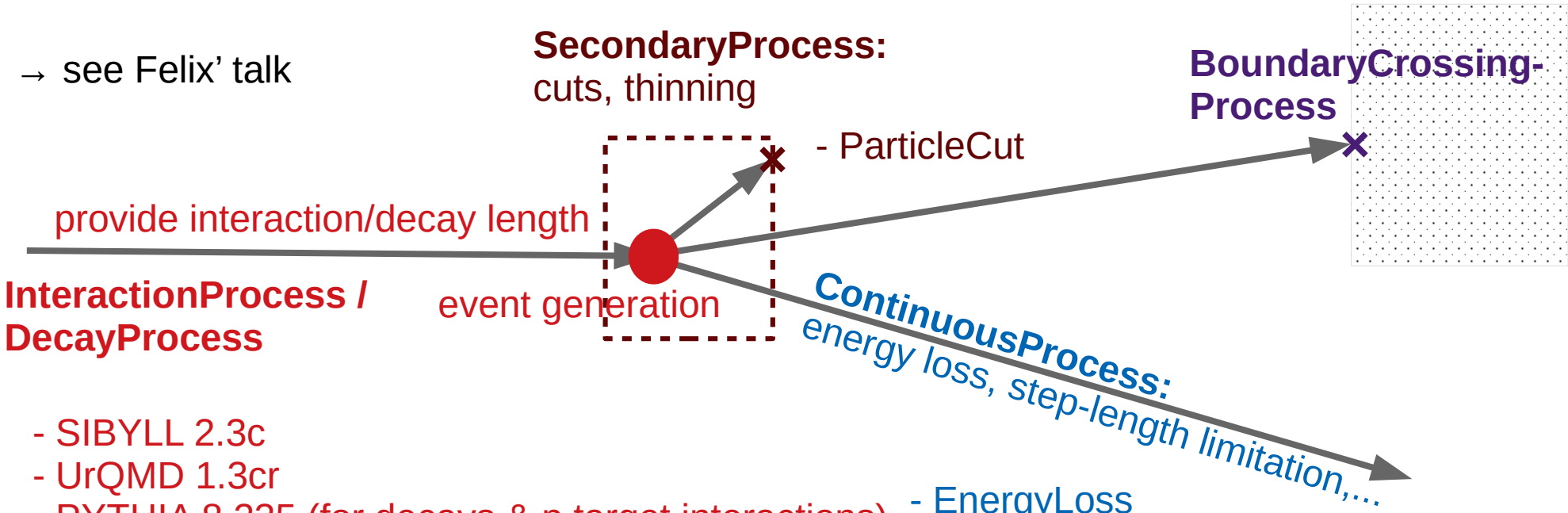
- geometric primitives furnished with models of the material
- assembled in a tree representing containment





Process classes

→ see Felix' talk



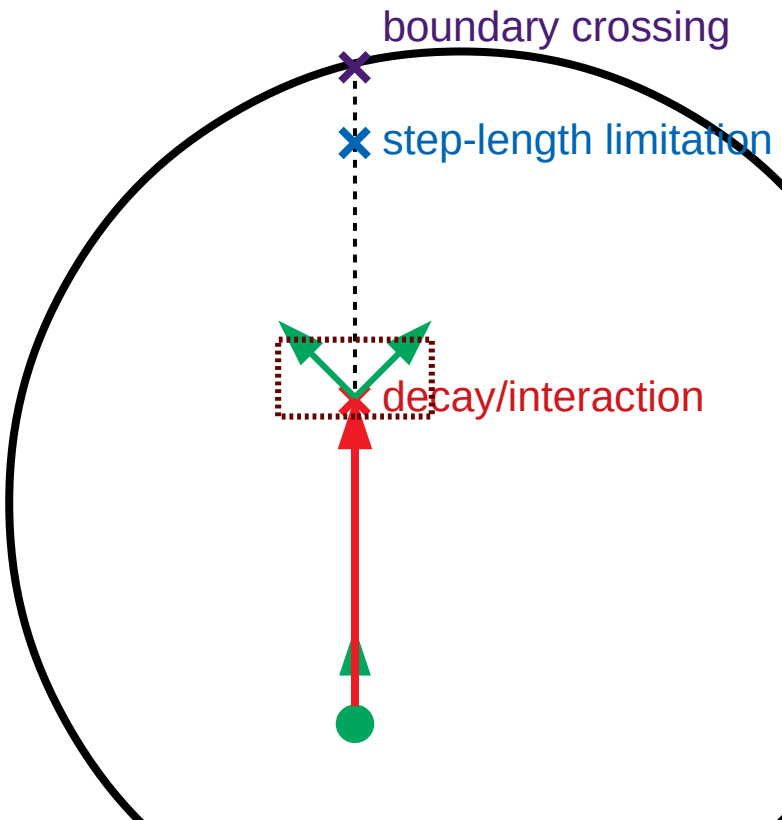
- SIBYLL 2.3c
- UrQMD 1.3cr
- PYTHIA 8.235 (for decays & p target interactions)
- SwitchProcess(LEModel, HEModel, E_{th})

can be SwitchProcesses themselves...

- EnergyLoss
- TrackWriter
- ObservationPlane

Cascade step

- determine step-length
- apply continuous processes
- perform interaction/decay
- apply secondary processes



under the hood

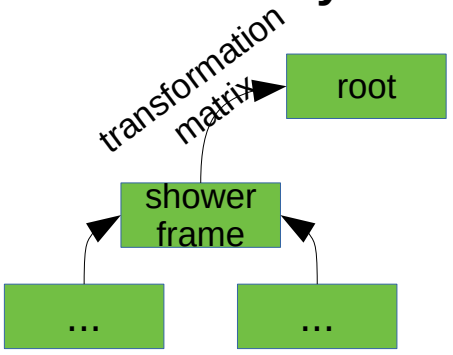
statically typed units

→ compile-time dimensional analysis

```
MassDensityType rho = 4_g /
                      cube(cm);
auto length = 5.4_m;
auto X = length * rho
// → GrammageType
```

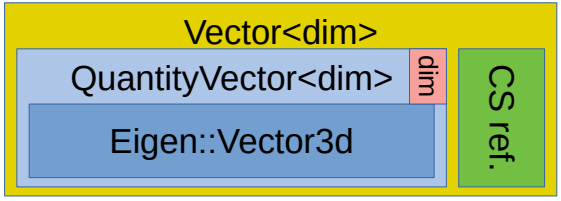
conversion between
SI & natural units provided!

coordinate systems



Definition of new CS by:
- rotation and/or translation
- reference CS

Vectors & points



automatic transformations into common CS when necessary:

```
Vector<length> v(cs1,…),
               w(cs2,…);
auto u = v + w;
```

Part II: First results & comparison

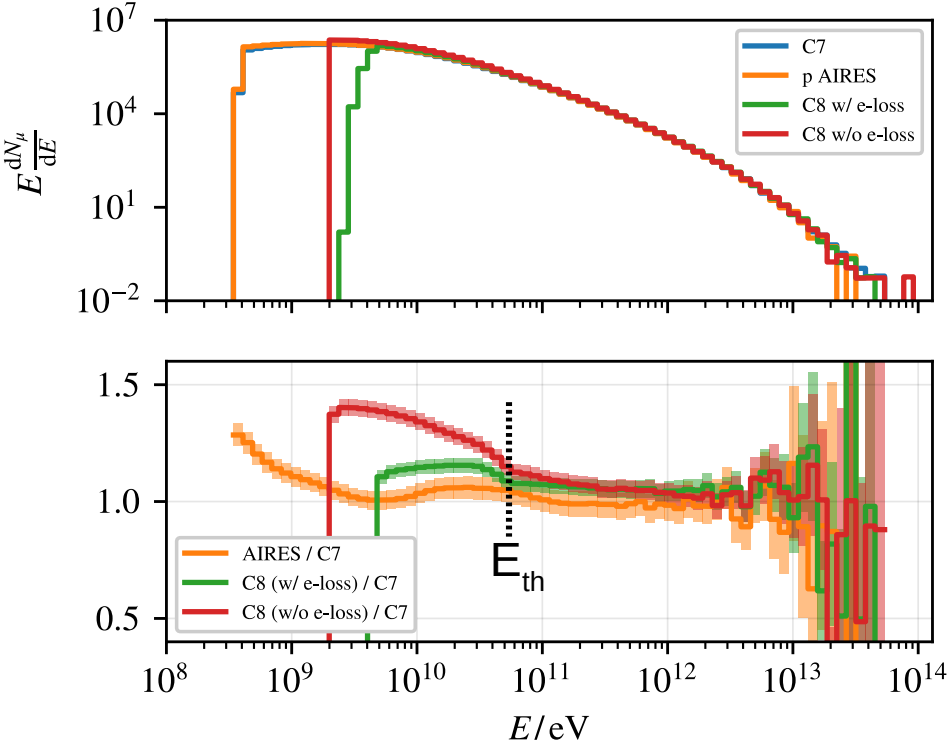
based on ongoing work with D. Melo, F. Riehn and R. Ulrich

Setup

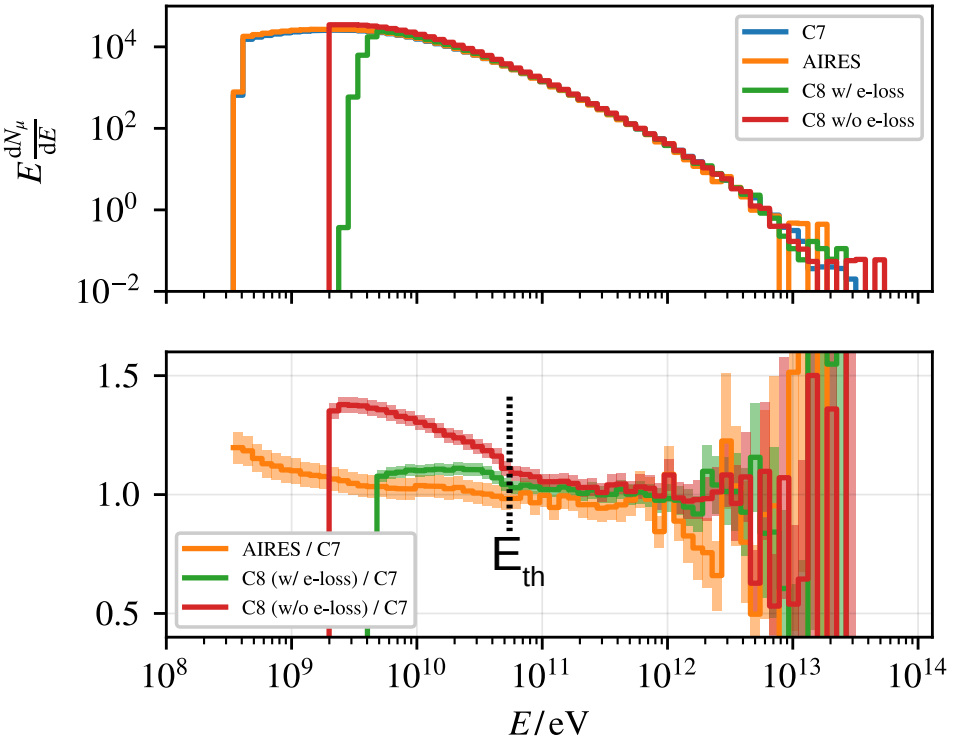
- mostly equivalent setups for C8, C7.64, AIRES 18.09
- single-layer exponential atmosphere 878 g/cm²
- C8: 78.5 % N, 21.5 % O, no Ar
- SIBYLL 2.3c + UrQMD 1.3cr / HSA for AIRES
- propagation of hadrons & muons
- vertical proton showers @ 10 PeV & 1 EeV

```
auto sibyllSeq = sibyll23 << sibyll23Nuc;
process::switch_process::SwitchProcess hadronicSwitch(urqmd, sibyllSeq, 55_GeV);
auto sequence = hadronicSwitch << decay << eLoss << cut << observationLevel
                << trackWriter;
```

Muon spectra



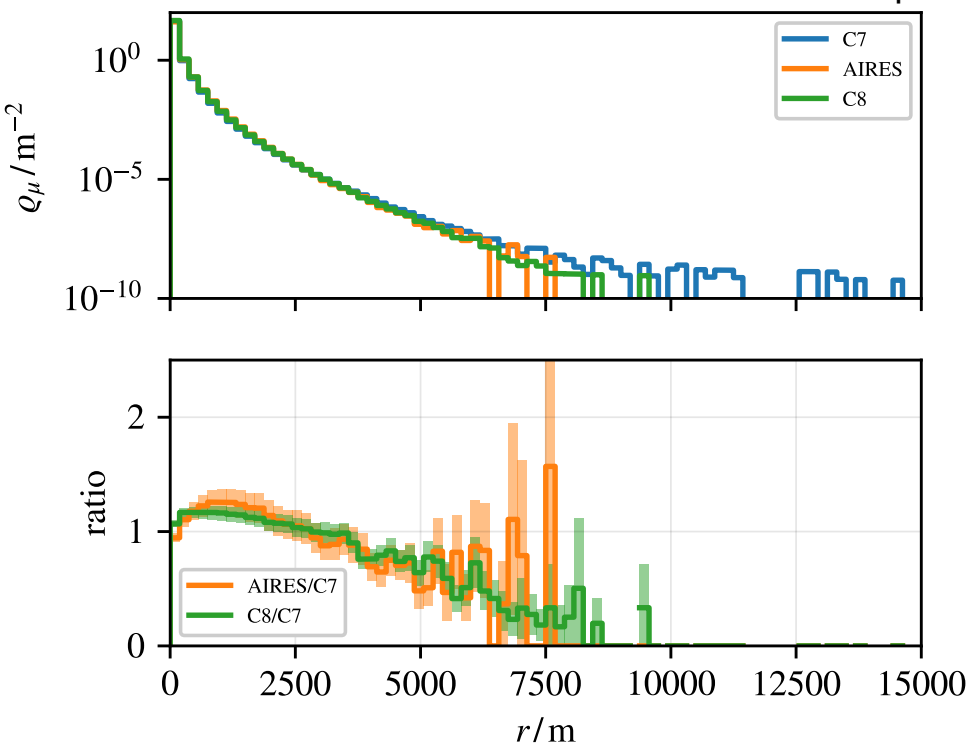
1 EeV



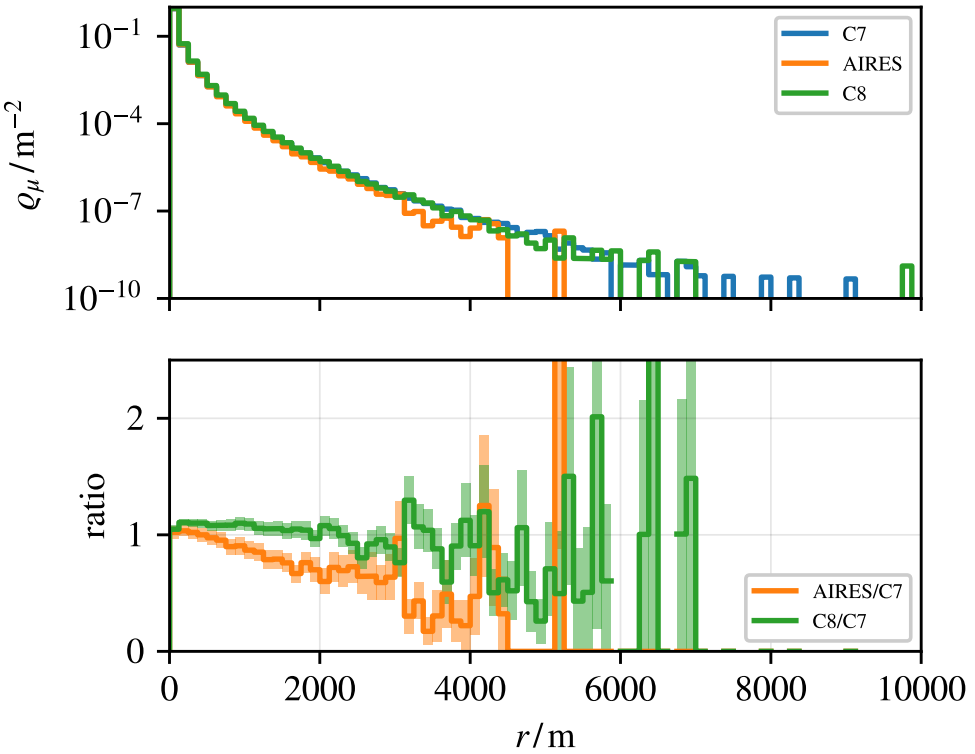
10 PeV

Muon LDF

$E_\mu > 5$ GeV



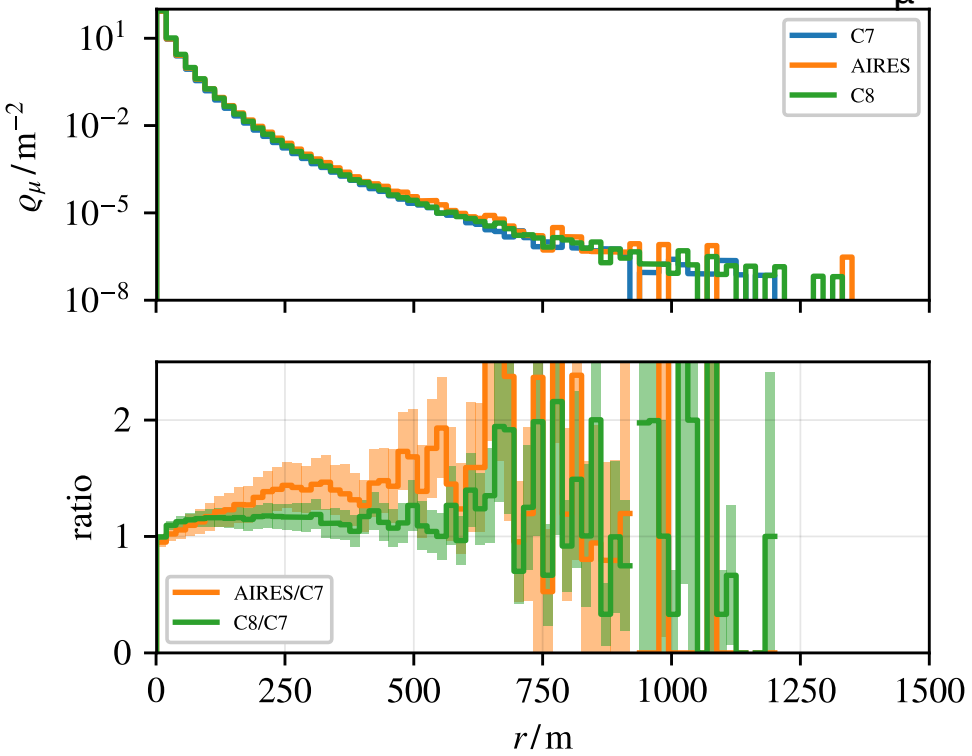
1 EeV



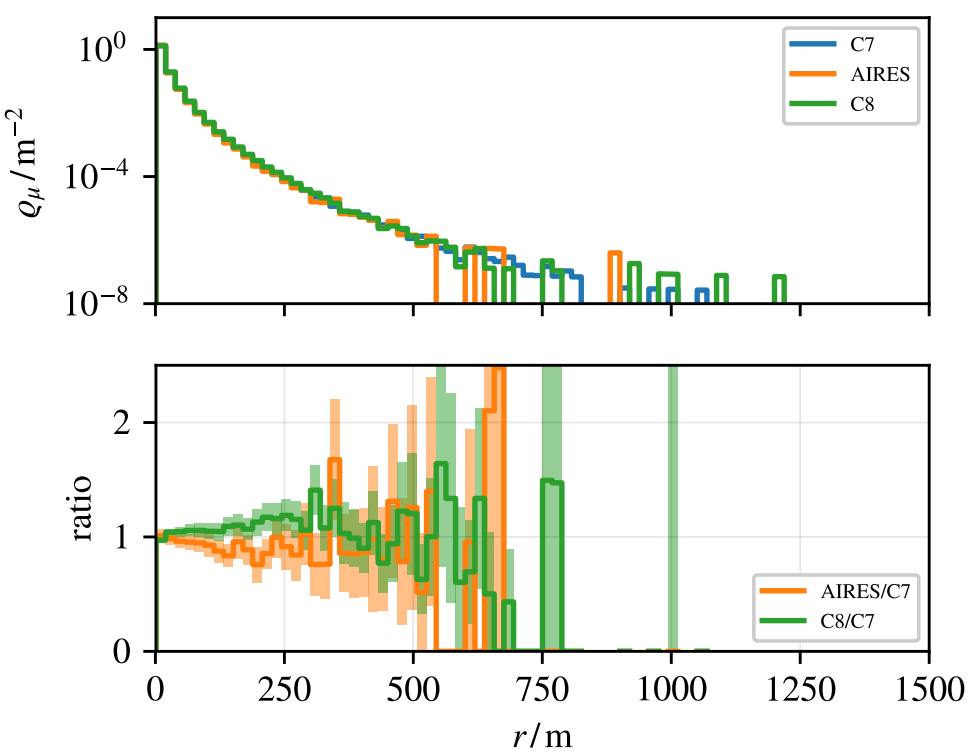
10 PeV

Muon LDF

E_μ > 55 GeV

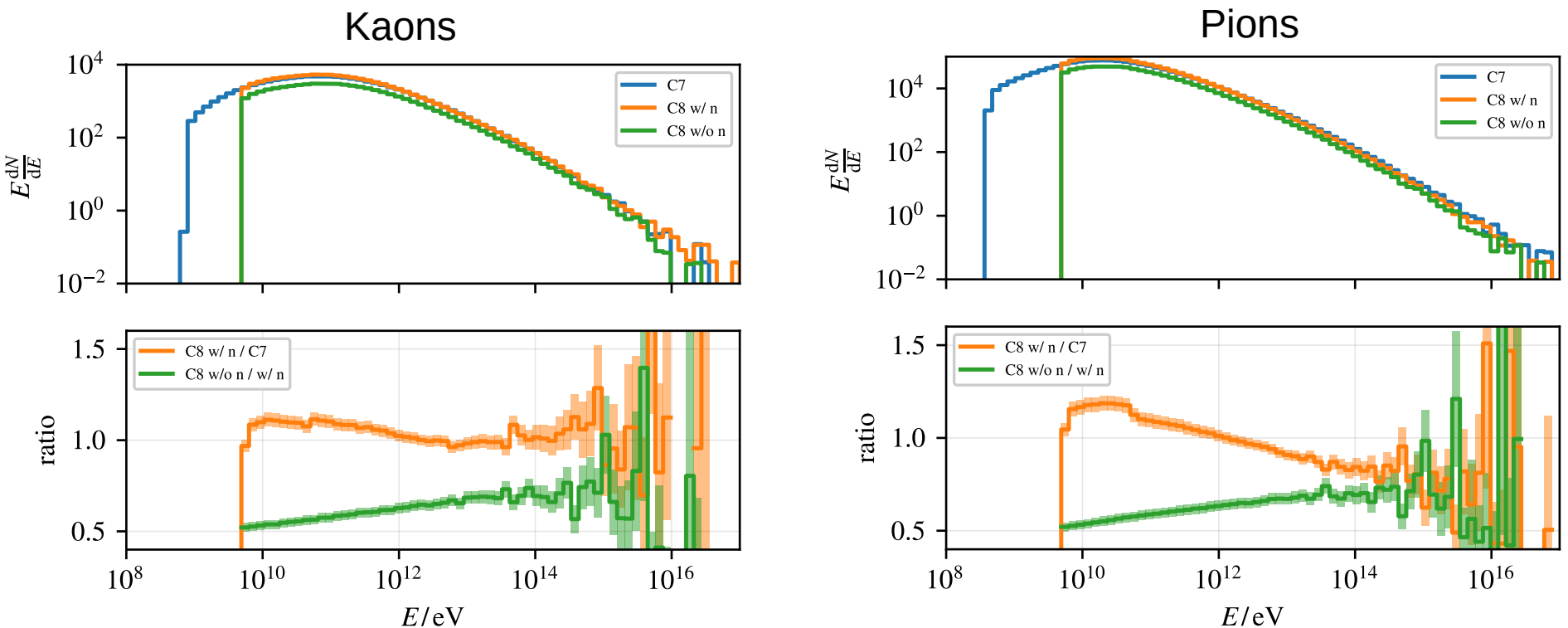


1 EeV



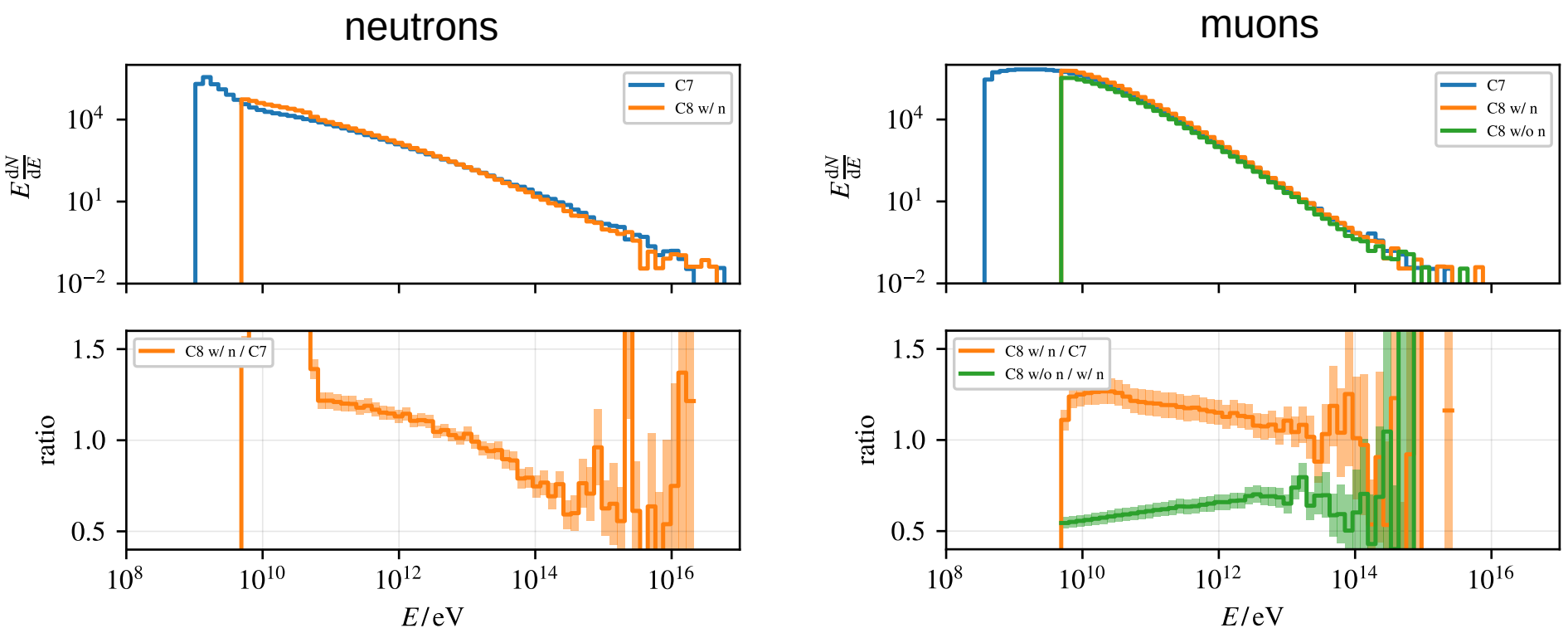
10 PeV

Energy spectra @ 7 km a.s.l.



E_0 = 1 EeV

Energy spectra @ 7 km a.s.l.



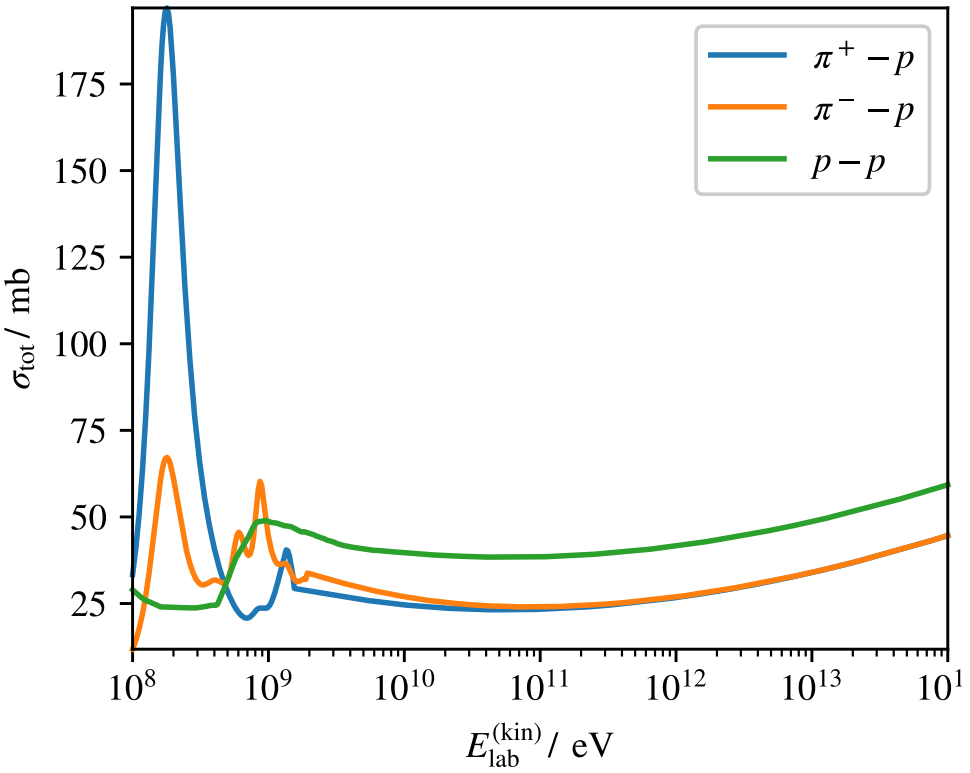
E_0 = 1 EeV

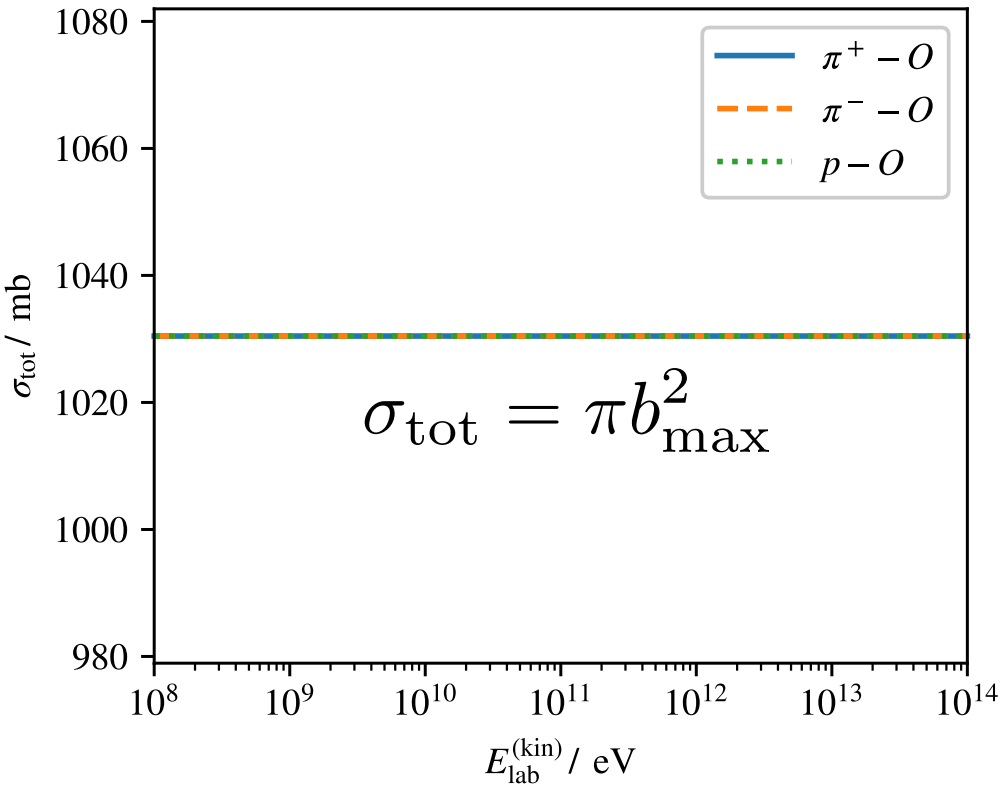
Summary

- basic structure available and working
- ongoing work in physics implementation & improvement
- first showers with hadron & muon propagation look promising...

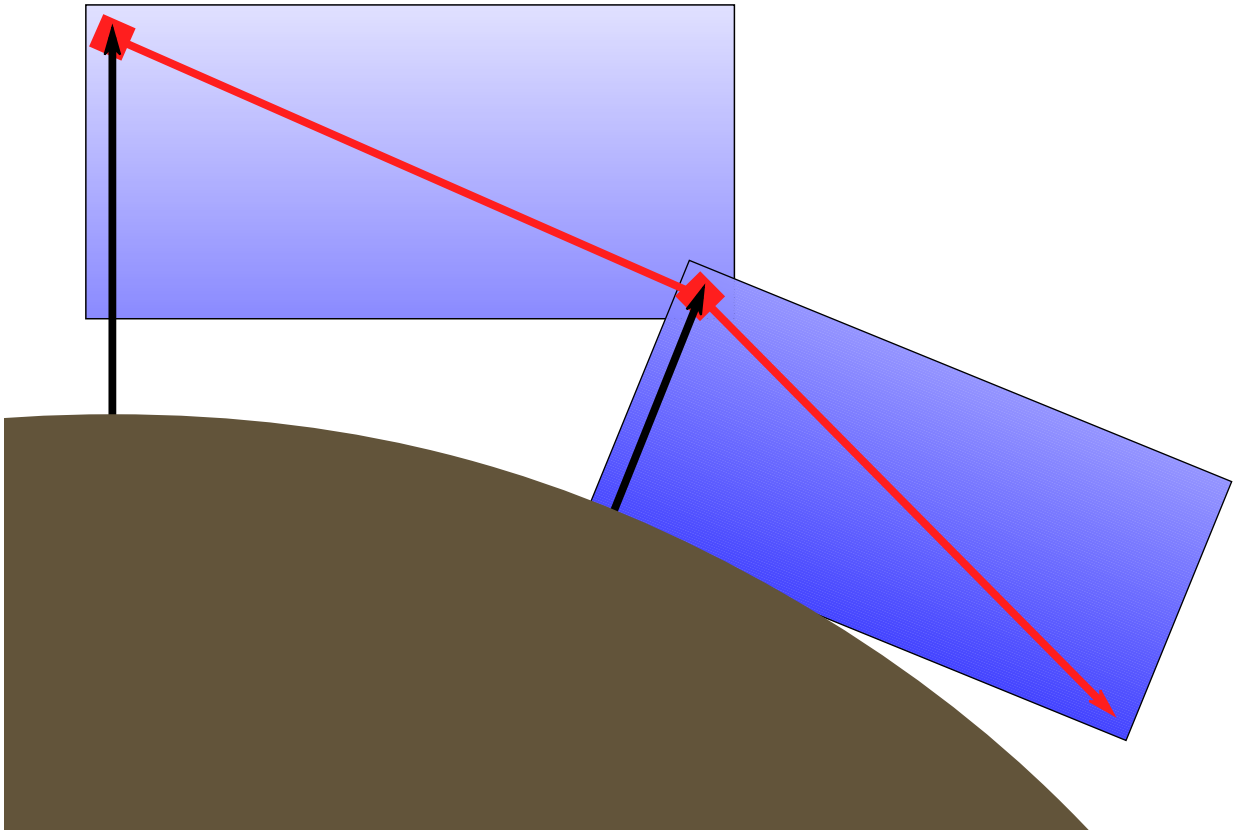
Backup

UrQMD cross-sections

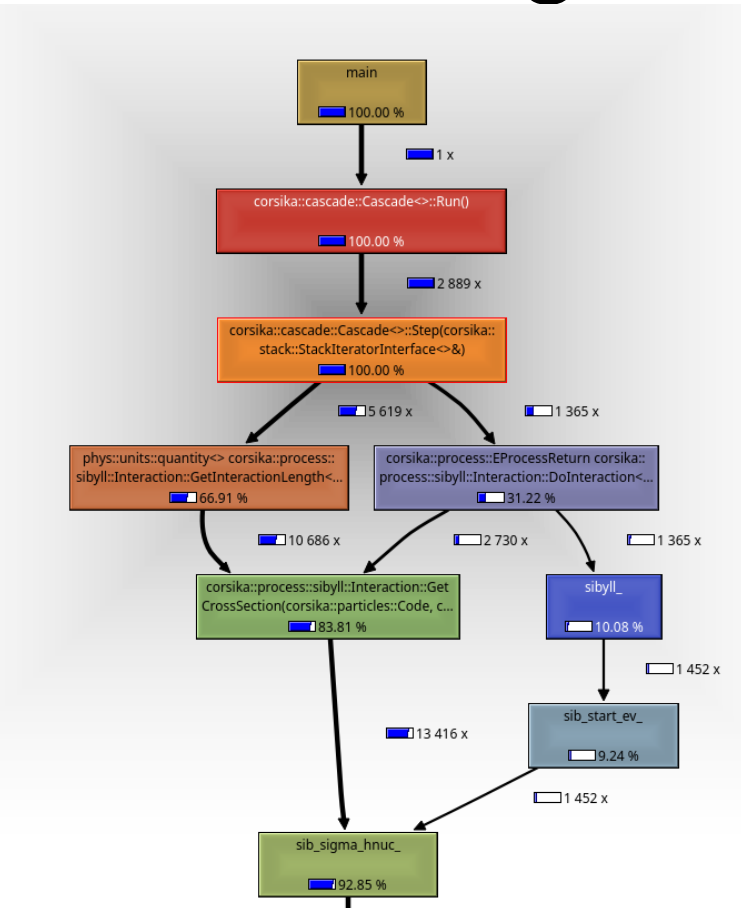




Sliding planar approximation



Profiling


main
100.00 %
1 x
corsika::cascade::Cascade<>::Run()
100.00 %
2 889 x
corsika::cascade::Cascade<>::Step(corsika::
stack::StackIteratorInterface<>&)
100.00 %
5 619 x
1 365 x
phys::units::quantity<> corsika::process::
sibyll::Interaction::GetInteractionLength<...
66.91 %
corsika::process::EProcessReturn corsika::
process::sibyll::Interaction::DoInteraction<...
31.22 %
10 686 x
2 730 x
1 365 x
corsika::process::sibyll::Interaction::Get
CrossSection(corsika::particles::Code, c...
83.81 %
sibyll_
10.08 %
1 452 x
13 416 x
sib_start_ev_
9.24 %
1 452 x
sib_sigma_hnuc_
92.85 %

Units

- Compile-time dimensional analysis based on *PhysUnits C++11*
- Example:

```
MassDensityType rho = 4_g / cube(cm);
auto length = 5.4_m;
auto X = length * rho // → GrammageType
```

  fully integrated into geometry framework: Vector<speed_d>,…

- conversion between SI & natural units provided!