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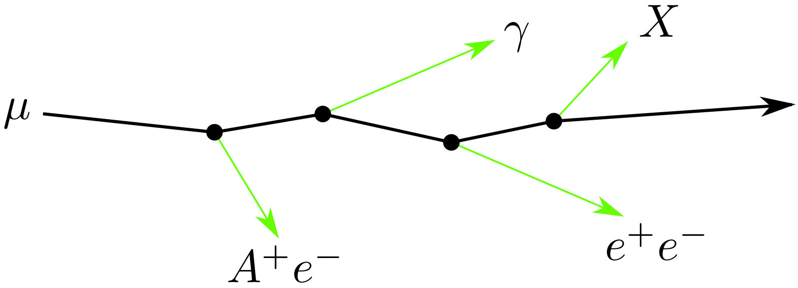

Comparisons of 10 TeV showers

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General information

- Comparison of 500 showers, initiated by 10 TeV e^-
- ParticleCut of 5 MeV
- CORSIKA 8: `radio` branch, commit `22dd19d8`
- PROPOSAL version `7.1.1`
- No magnetic field for CORSIKA 8, minimal magnetic field for CORSIKA 7 (0.001 μT along shower axis)

- **C8**: No argon in atmosphere, Highland scattering
- **C8 Argon**: 0.9 $\%$ argon in atmosphere, Molière scattering

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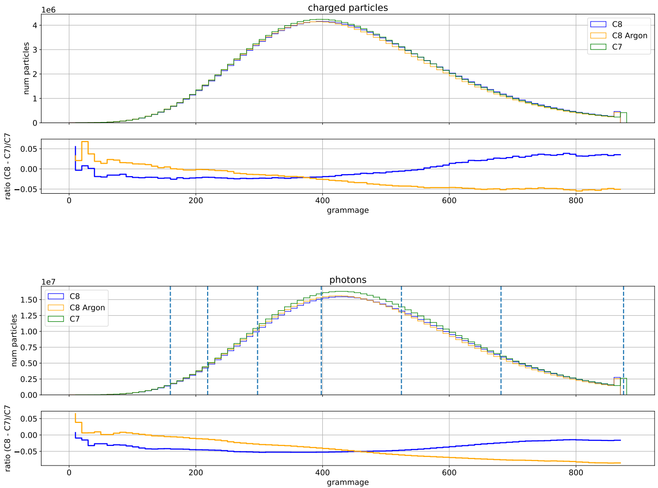
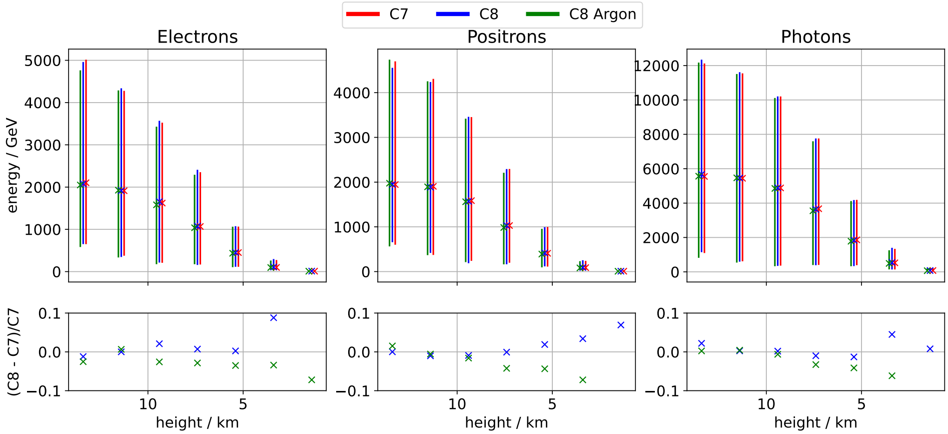
Longitudinal comparisons



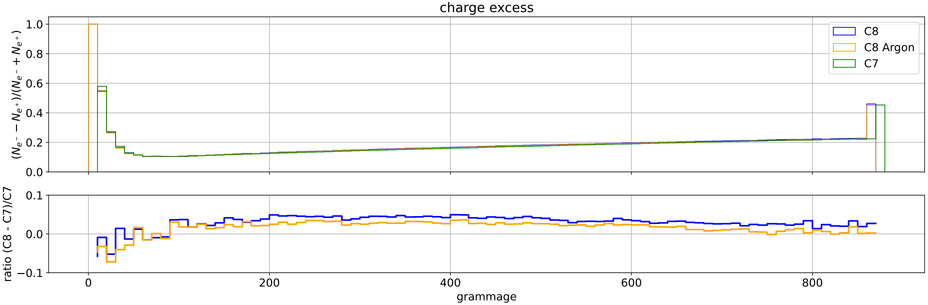
- Most profiles agree within 5 %.
- Introducing argon lets the shower develop significantly earlier
- There is an overall lack of photons in the C8 showers

Longitudinal comparisons



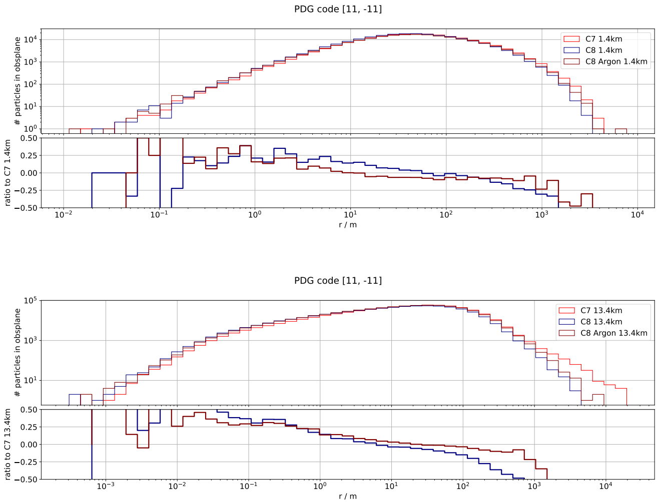
- Crosses indicate median, errorbars indicate 68.2 % central quantile
- Agreement of particle energy per observation plane also within 5 %

Longitudinal comparisons



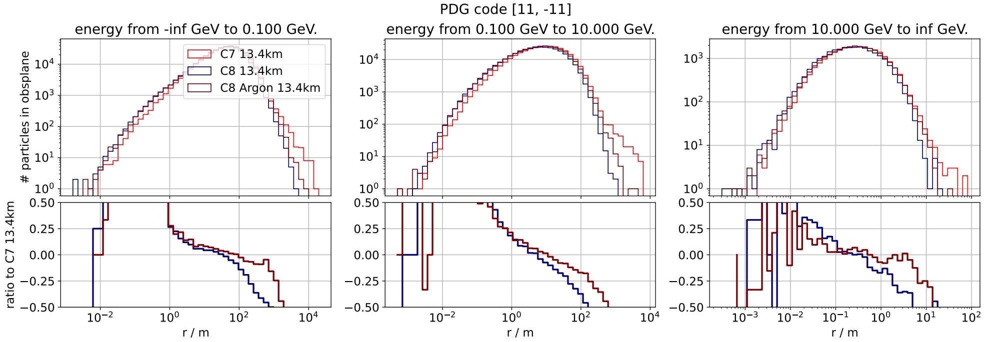
- Charge excess agrees within 5 %
- More charge excess in C8
- Introducing argon slightly improves agreement

Lateral comparisons



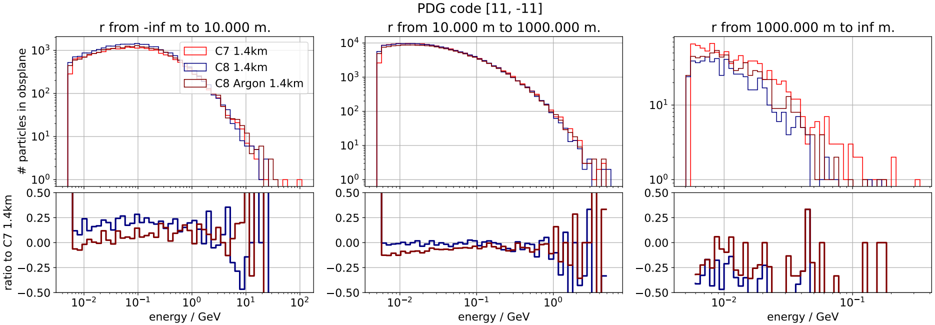
- With Argon/Molière, the distributions are improving
  - → Mainly due to Molière scattering
- For the early shower development, there are already a lot of particles far away from the shower axis that are not simulated in C8!

Lateral comparisons



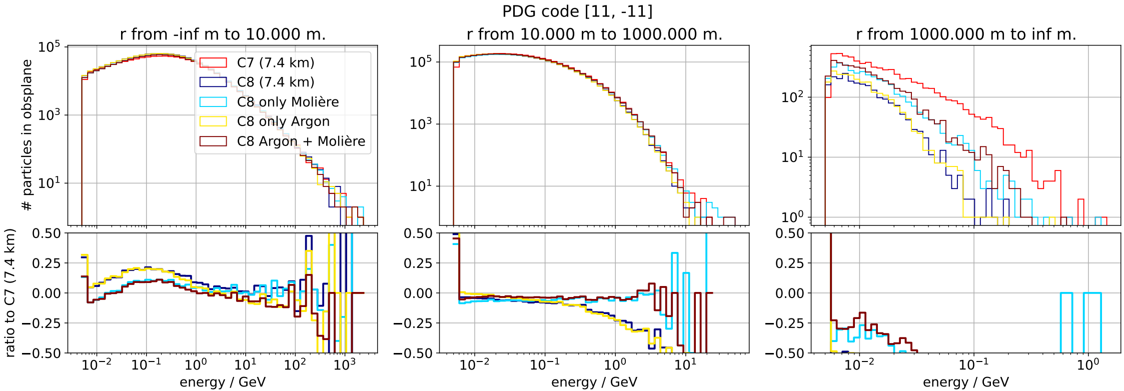
- Lateral distribution is already off early during the shower development

Energy distribution comparisons



- With Molière, the range $r < 10$ m looks slightly better
- Without Molière, the range $r > 10$ m looks slightly better

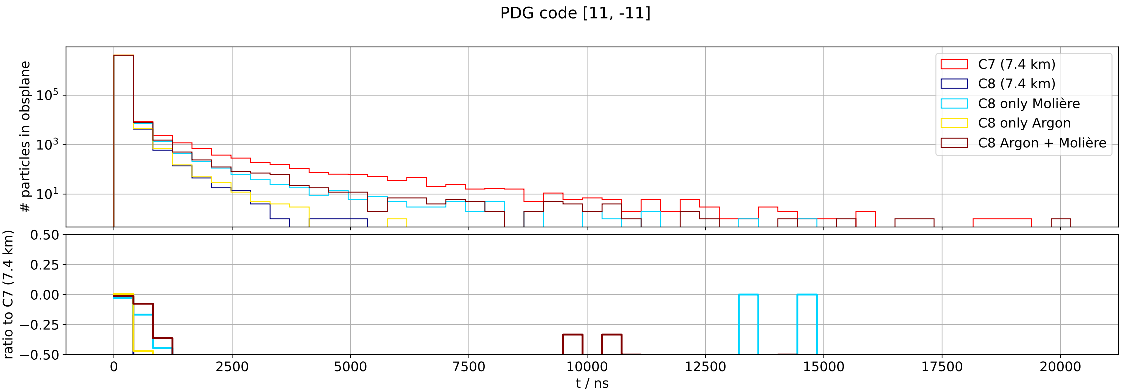
Energy distribution comparisons



Energy distributions show interesting results around shower maximum:

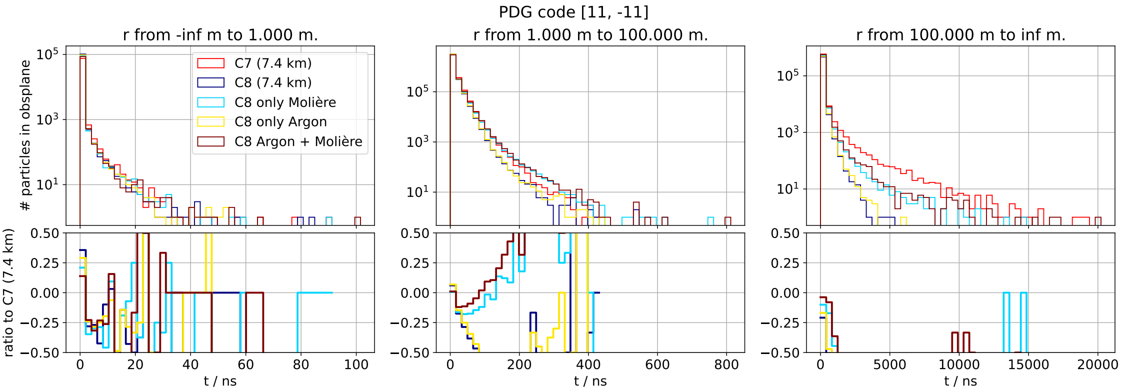
- A "hump" at 0.1 GeV for particles close to the core is clearly visible
- Here, using Molière shows a clear improvement for $r > 10$ m
- There are still much more particles far away from the shower axis in C7

Time comparisons



- There are still significantly more late particles in C7
- Using Molière scattering improved description of the tail of the distribution

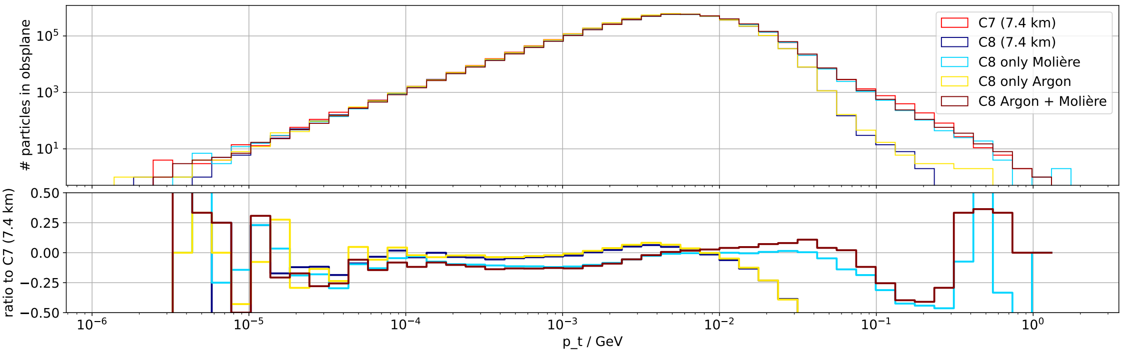
Time comparisons



- The disagreement is most significant for particles far away from the shower axis ($r > 100$ m)
- However, there are more late particles in the intermediate r range (1 m to 100 m)
  - → The disagreement in the time distribution is likely a consequence of the disagreement in the lateral distribution

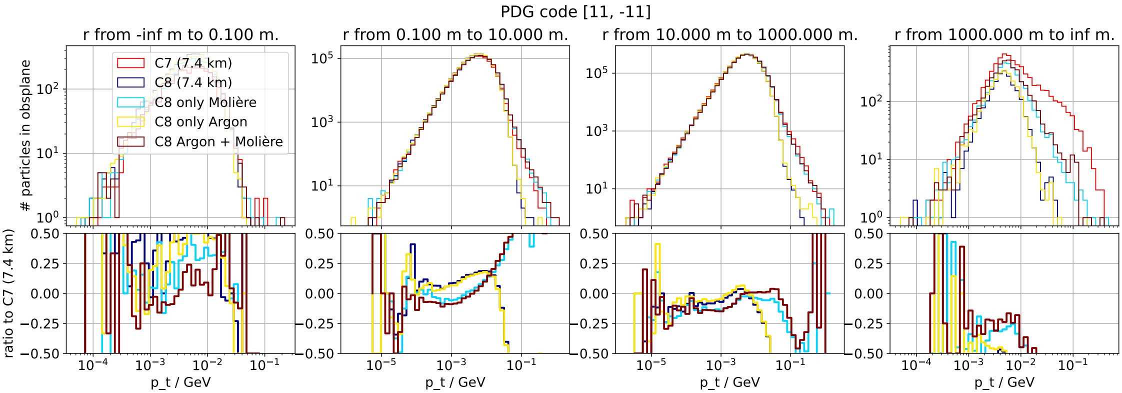
p_t distributions

PDG code [11, -11]



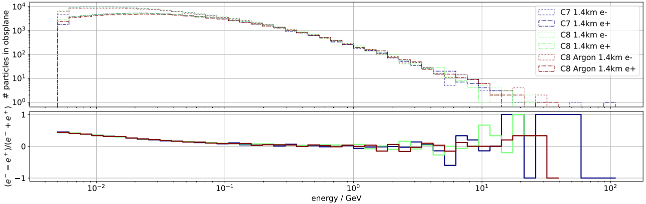
- Defined here as the transversal momentum in the observation plane: $p_\mathrm{t} = \sqrt{p_x^2 + p_y^2}$
- Distribution mostly influenced by the scattering model
- Tail of distribution is described much better using Molière

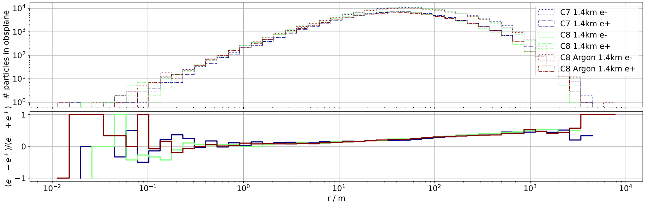
p_t distributions



- There is still a significant disagreement far away from the shower axis

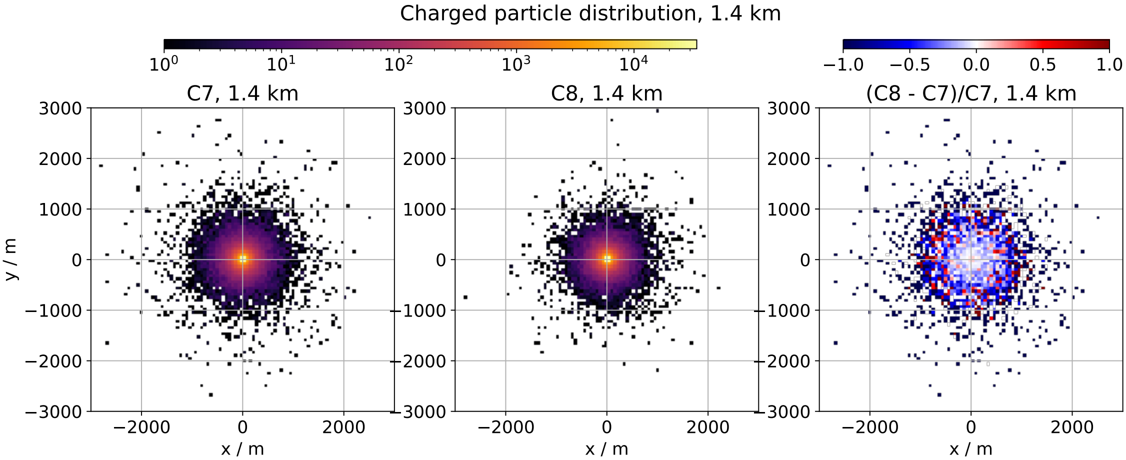
Charge excess





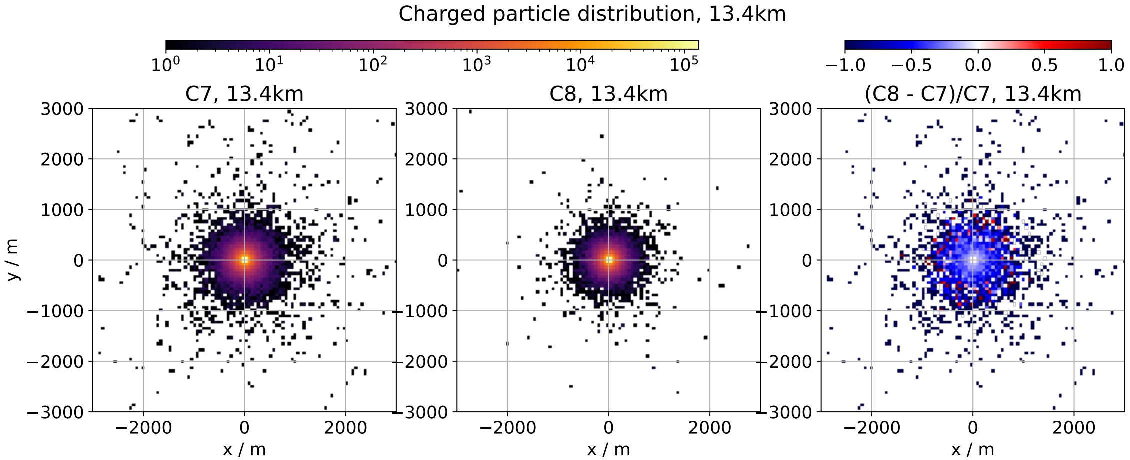
- Good agreement in charge excess, also for other observation heights
- Although the lateral distribution is off, the charge excess looks compatible for all lateral bins

Two-dimensional distributions



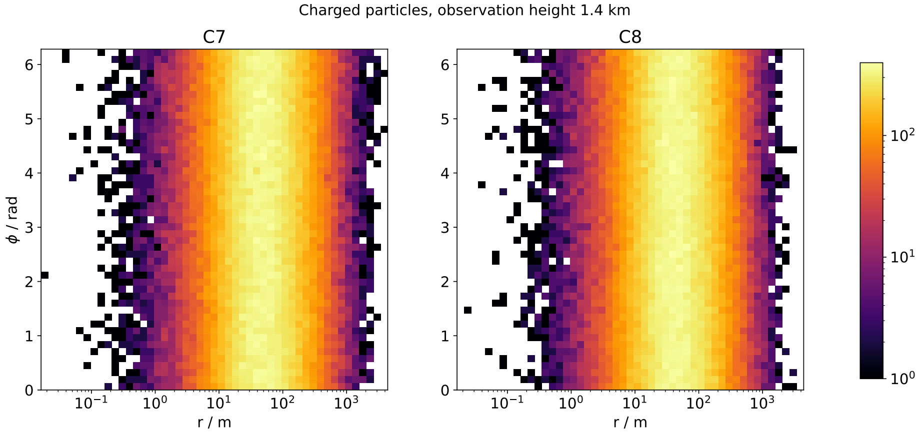
- Overall good agreement for the particle distributions
- As expected: Excess of particles in C7 far away from the shower core

Two-dimensional distributions



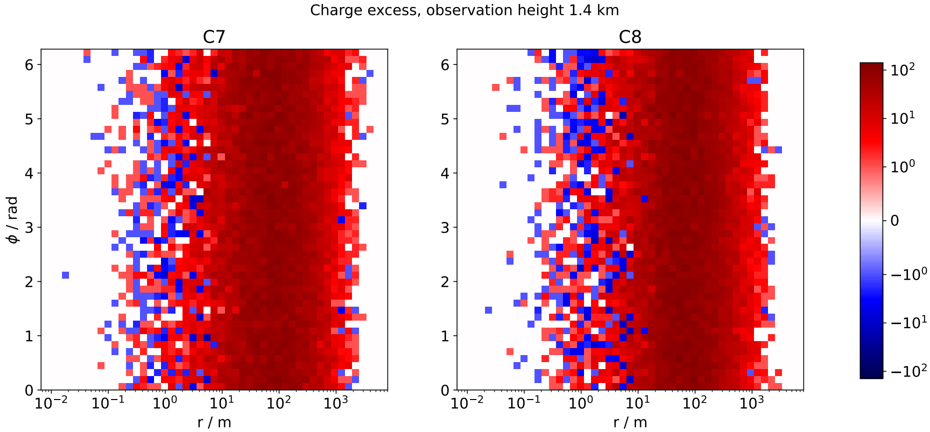
- For early shower development: Missing particles away from shower core become even more visible!

Two-dimensional distributions



- No asymmetries in azimuth visible for charged particle distribution

Two-dimensional distributions



- No asymmetries in azimuth visible for charge excess

conclusions

- Charge excess and longitudinal profiles agree within 5 %
- Argon has a significant impact on the longitudinal distribution
- The differences in the arrival times are mainly due to the differences in the lateral distributions
- We highly recommend to use `Molière` as a scattering model instead of `Highland` for future simulations
  → However, discrepancies in the lateral profile are still visible
- There are no signs of azimuthal asymmetries visible

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