

Charge excess comparison for electron-induced showers in ice

Corsika 8 vs ZHAireS

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Corsika 8 call, 08.08.24

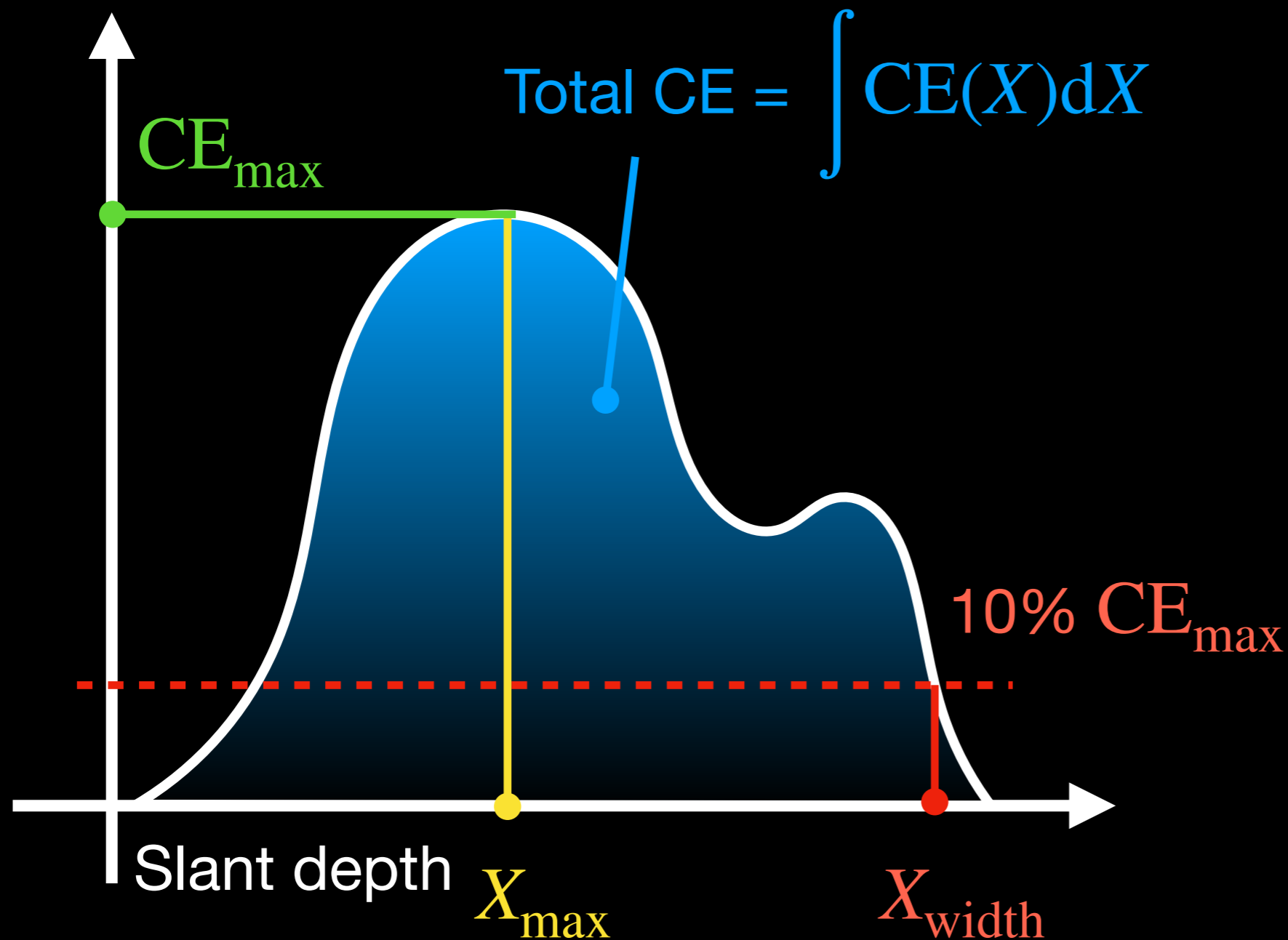
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Part 1

**Electron-induced showers
comparison: Corsika 8 vs ZHAireS**

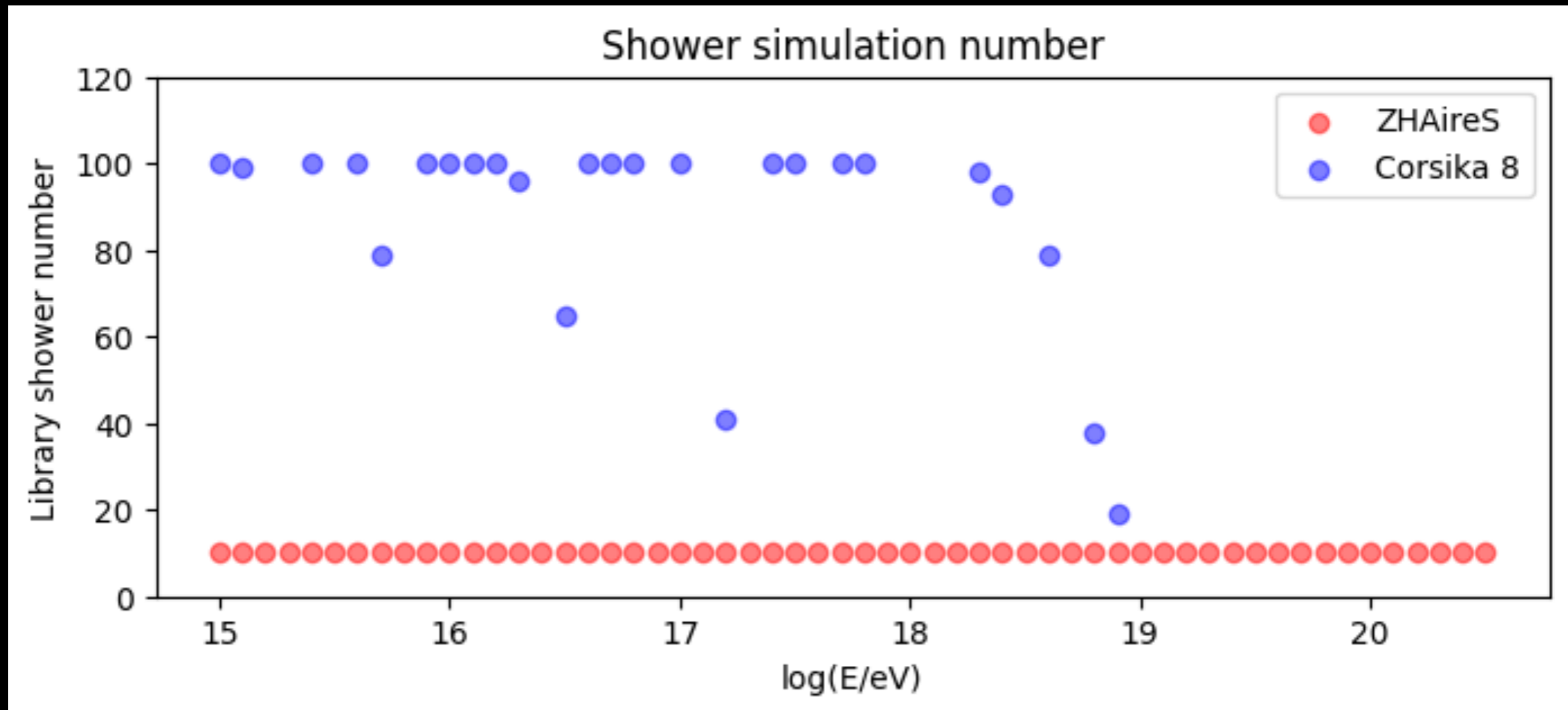
How to compare with different libraries

Charge excess (CE)



- X_{max}
- Total CE
- CE_{max}
- X_{width}
- N sub-shower ?
- ...

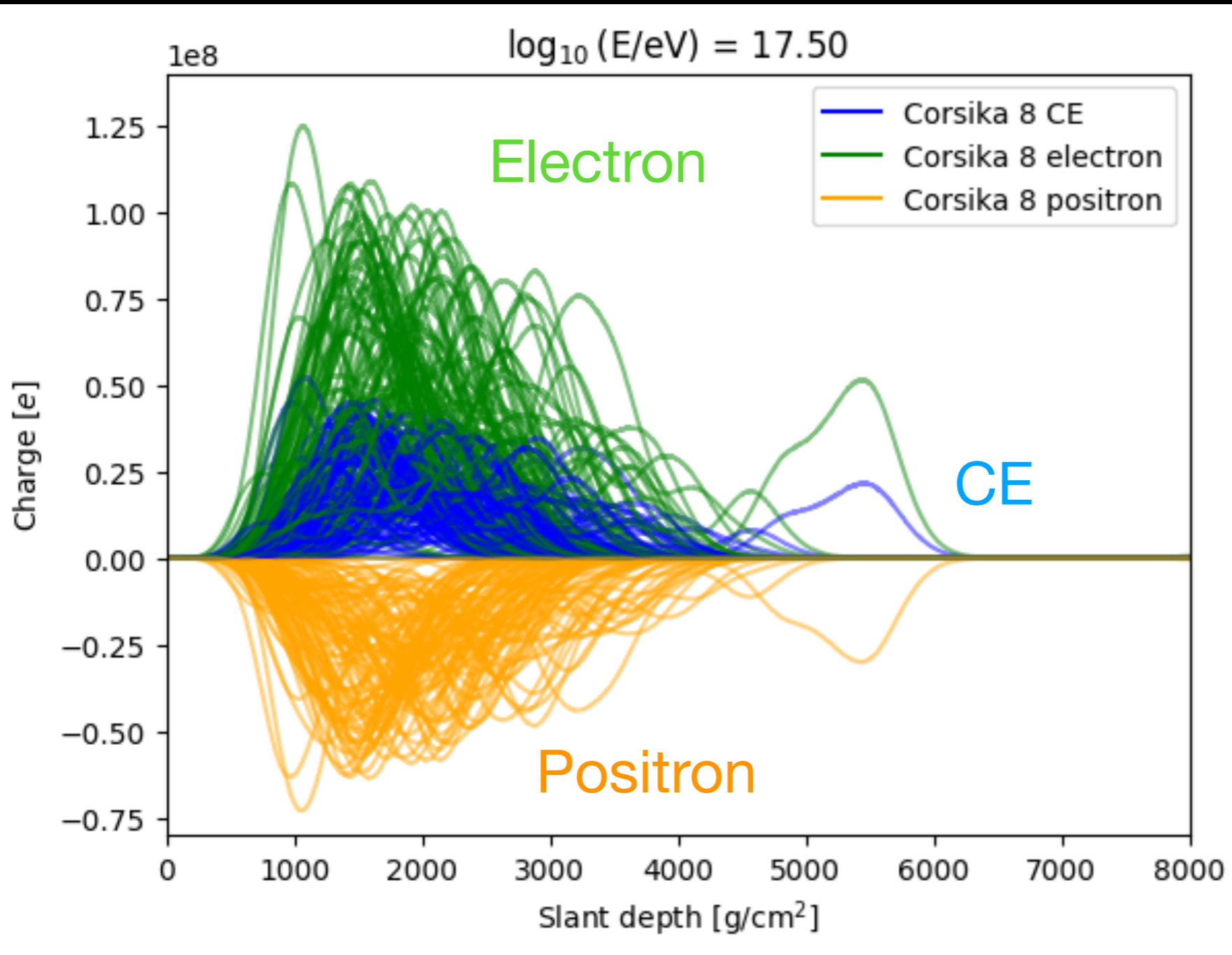
Libraries



- ZHAireS: https://rnog-data.zeuthen.desy.de/shower_library/library_v1.2.pkl
- Corsika 8: Christian
- Corsika 8 failure file: no summary.yaml file

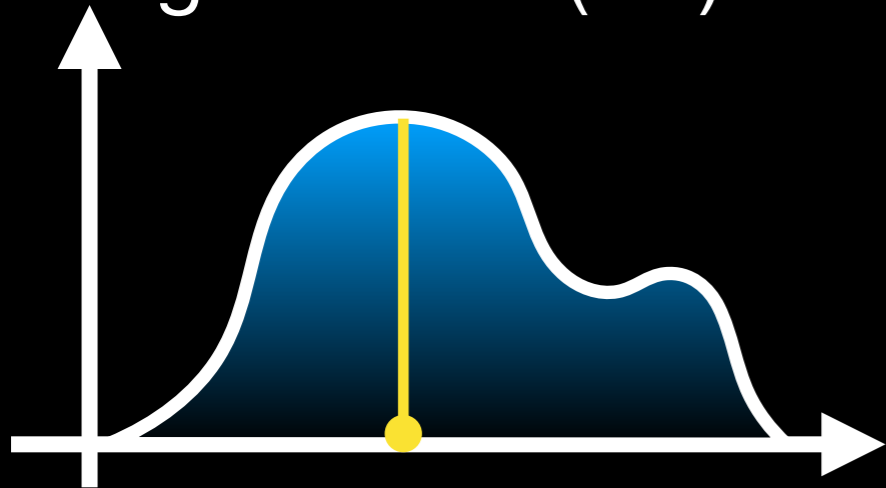
```
outputs/  
  config.yaml  
  summary.yaml  
  particles/  
    config.yaml  
    summary.yaml  
    particles.parquet
```

Charge excess



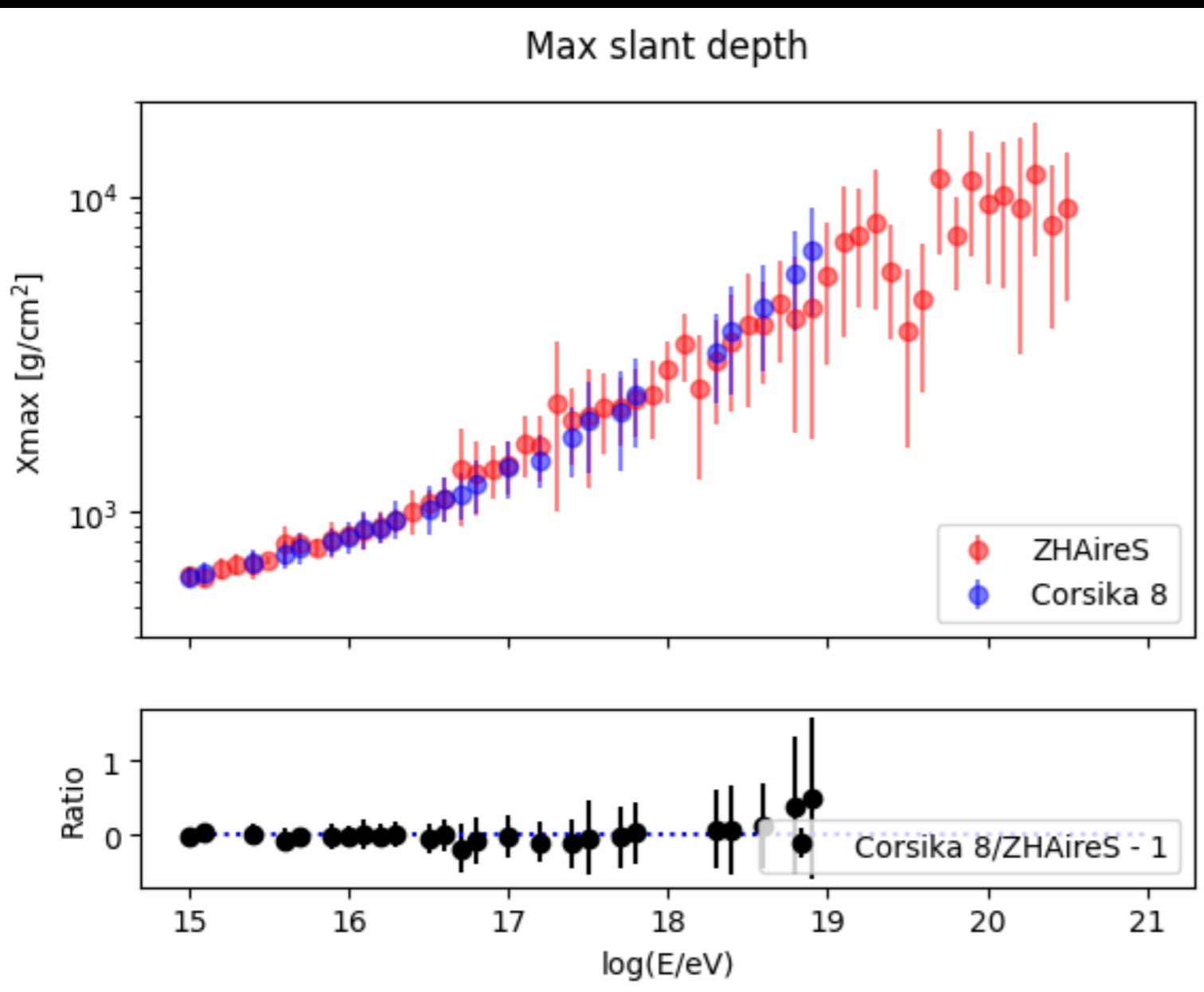
- $CE = e^- - e^+$

Charge excess (CE)



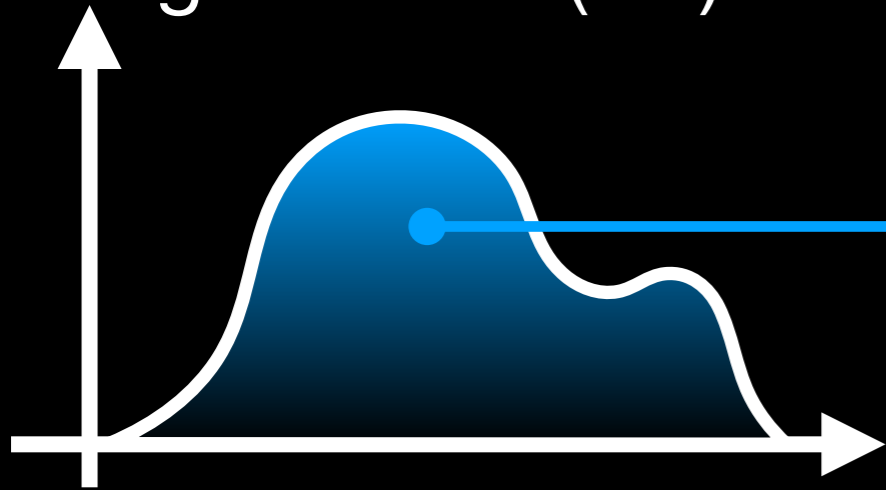
X_{max}

X_{max} Slant depth



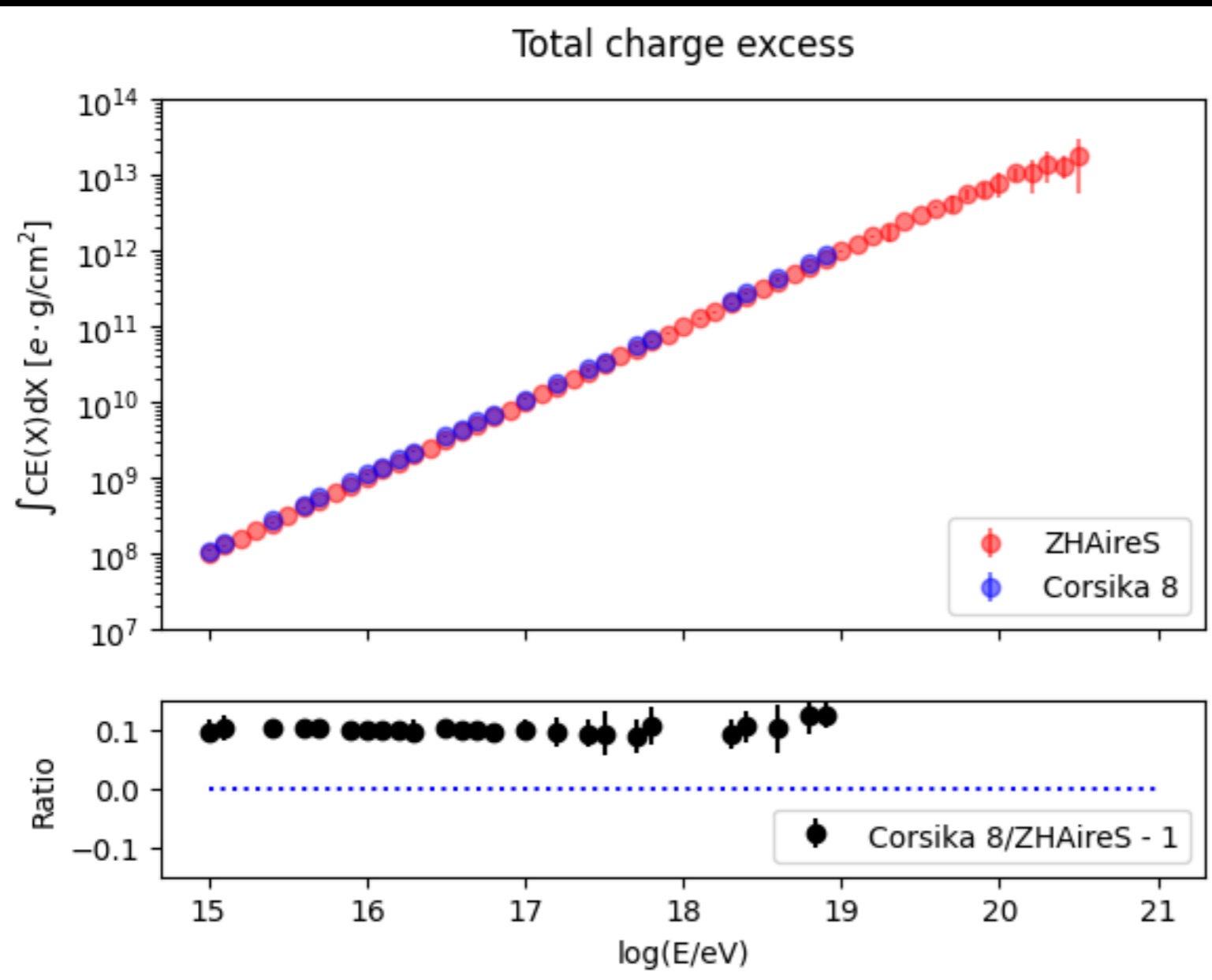
- Mean values are consistent
- X_{max} large variations for higher energy

Charge excess (CE)



Total CE

Slant depth

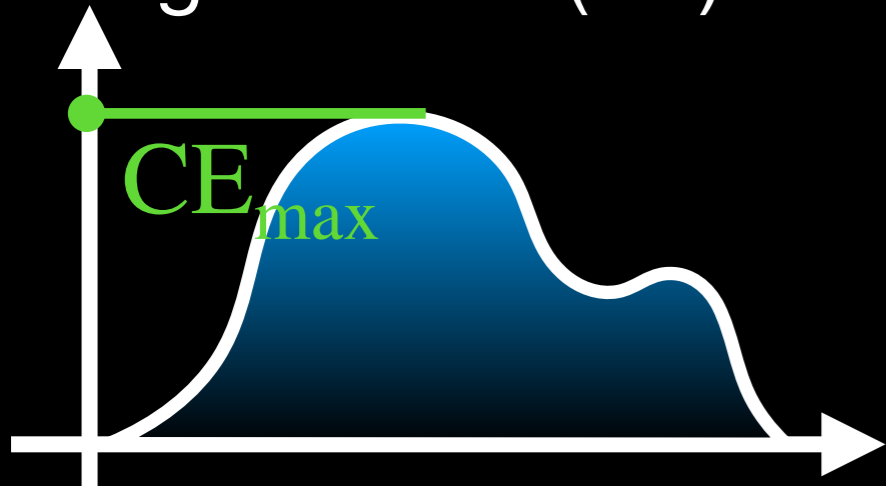


- $\int CE(X)dX$

- Corsika 8 has 10% total CE more than ZHAireS

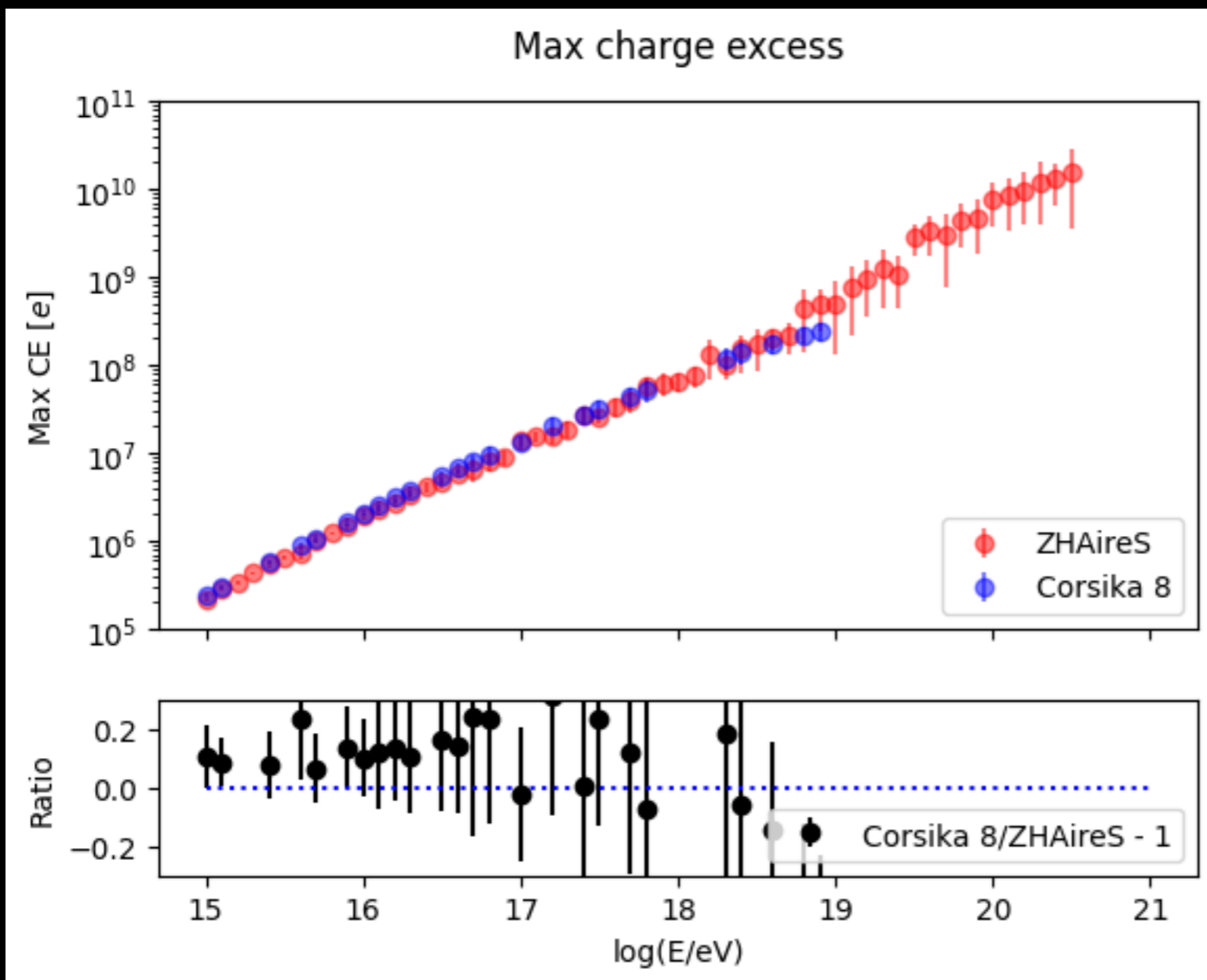
- Total CE small variations

Charge excess (CE)



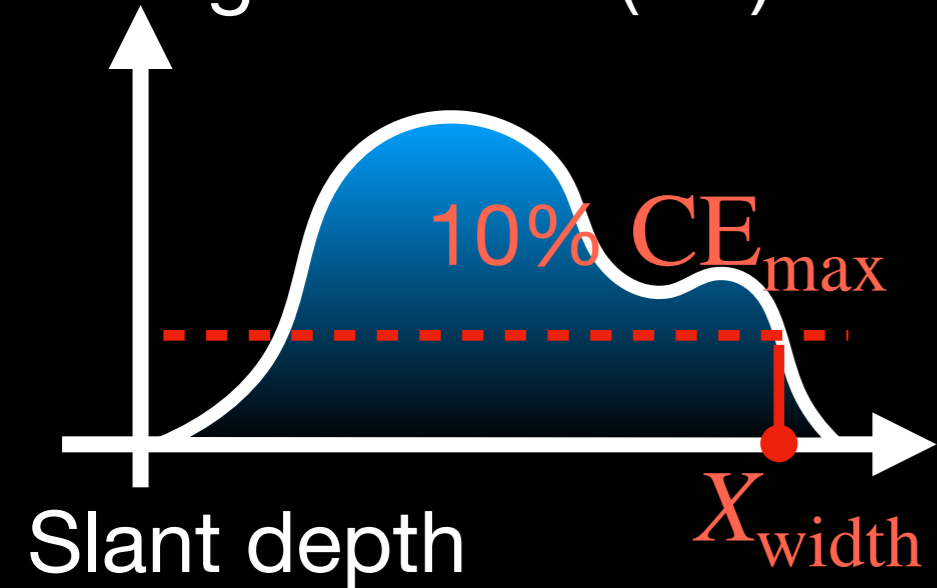
CE max

Slant depth



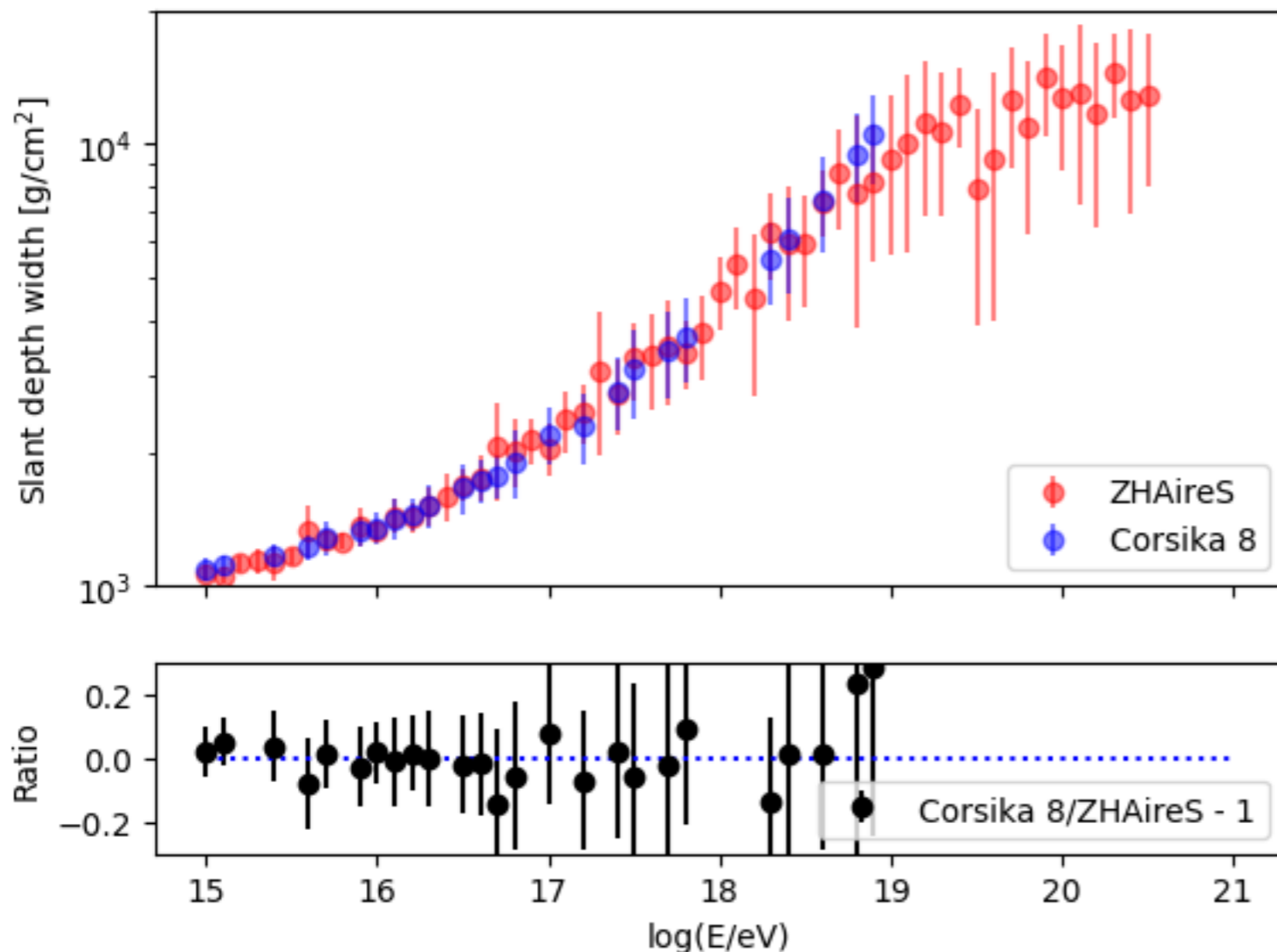
- Corsika 8 has larger CE maximum than ZHAireS
- CE maximum has large variations for higher energy

Charge excess (CE)



X width

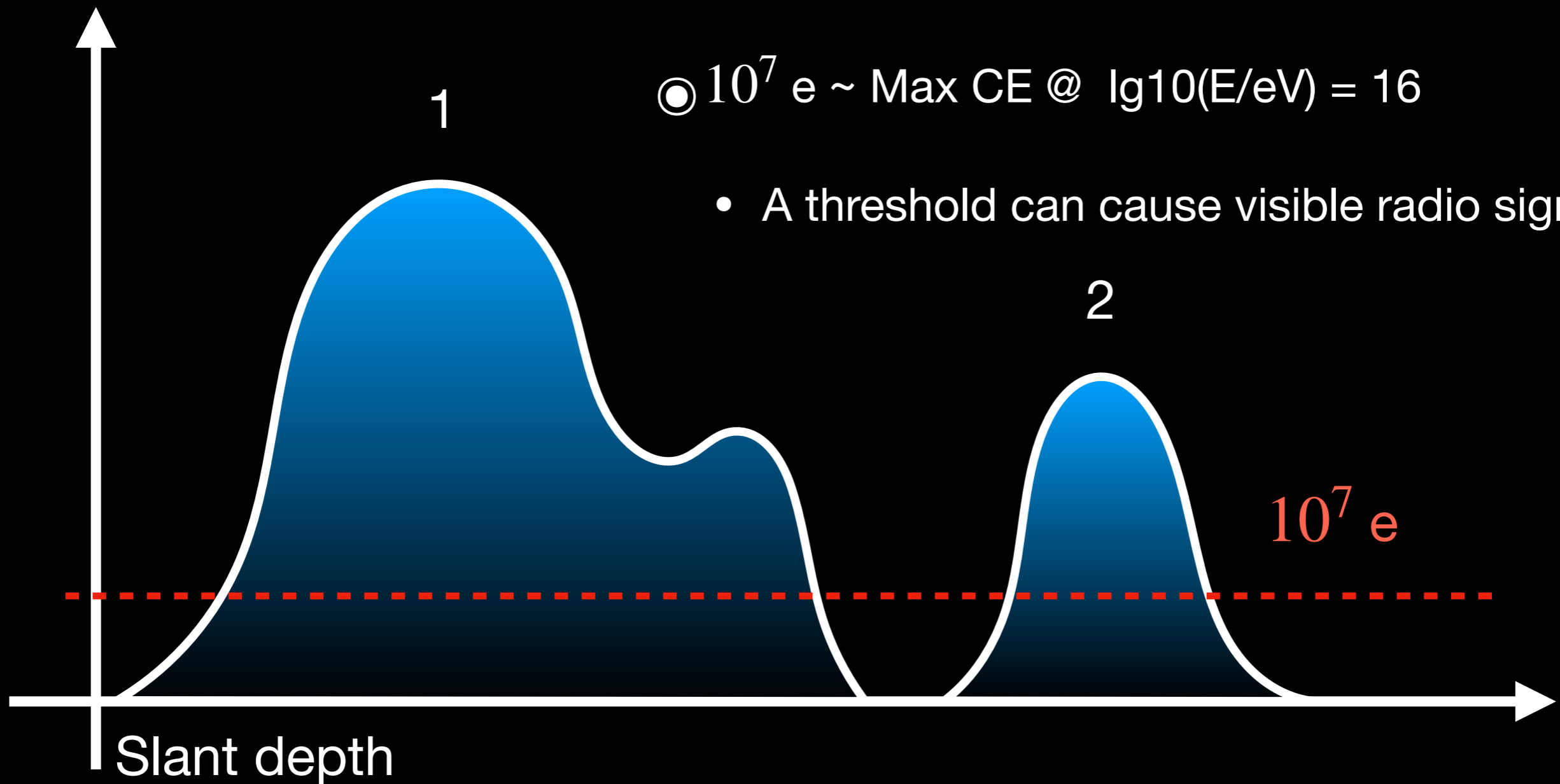
Slant depth width (CE < CE_{max} × 10%)



- 10% CE max as threshold
- Corsika 8 and ZHAireS have consistent X width if the threshold is 10% CE max
- W width has large variations for higher energy

How to quantify sub-shower

Charge excess (CE)

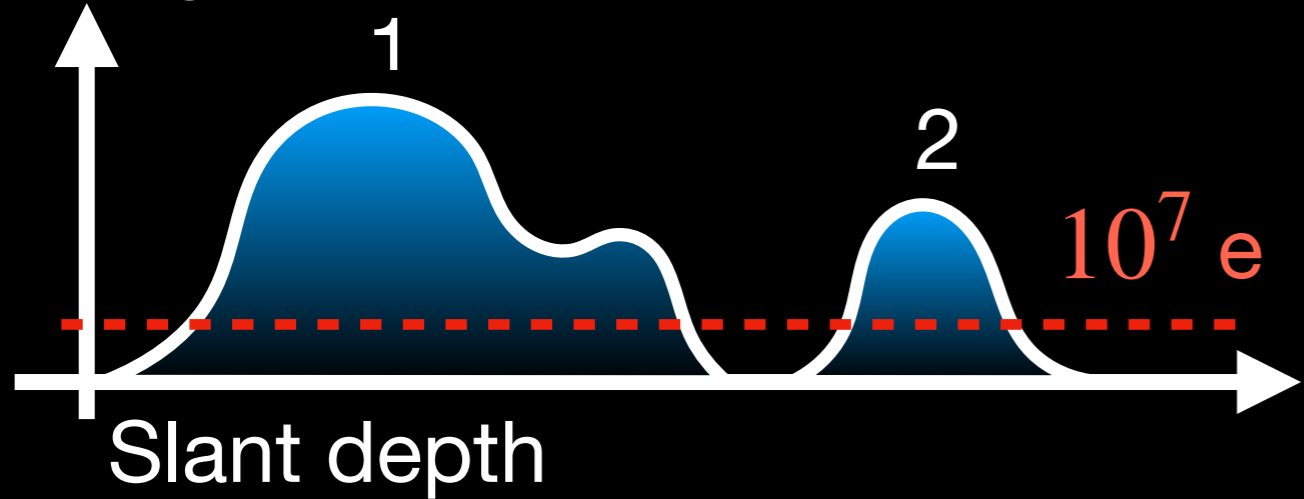


⊙ N sub-shower ?

⊙ $10^7 e \sim \text{Max CE @ } \lg_{10}(E/eV) = 16$

- A threshold can cause visible radio signal

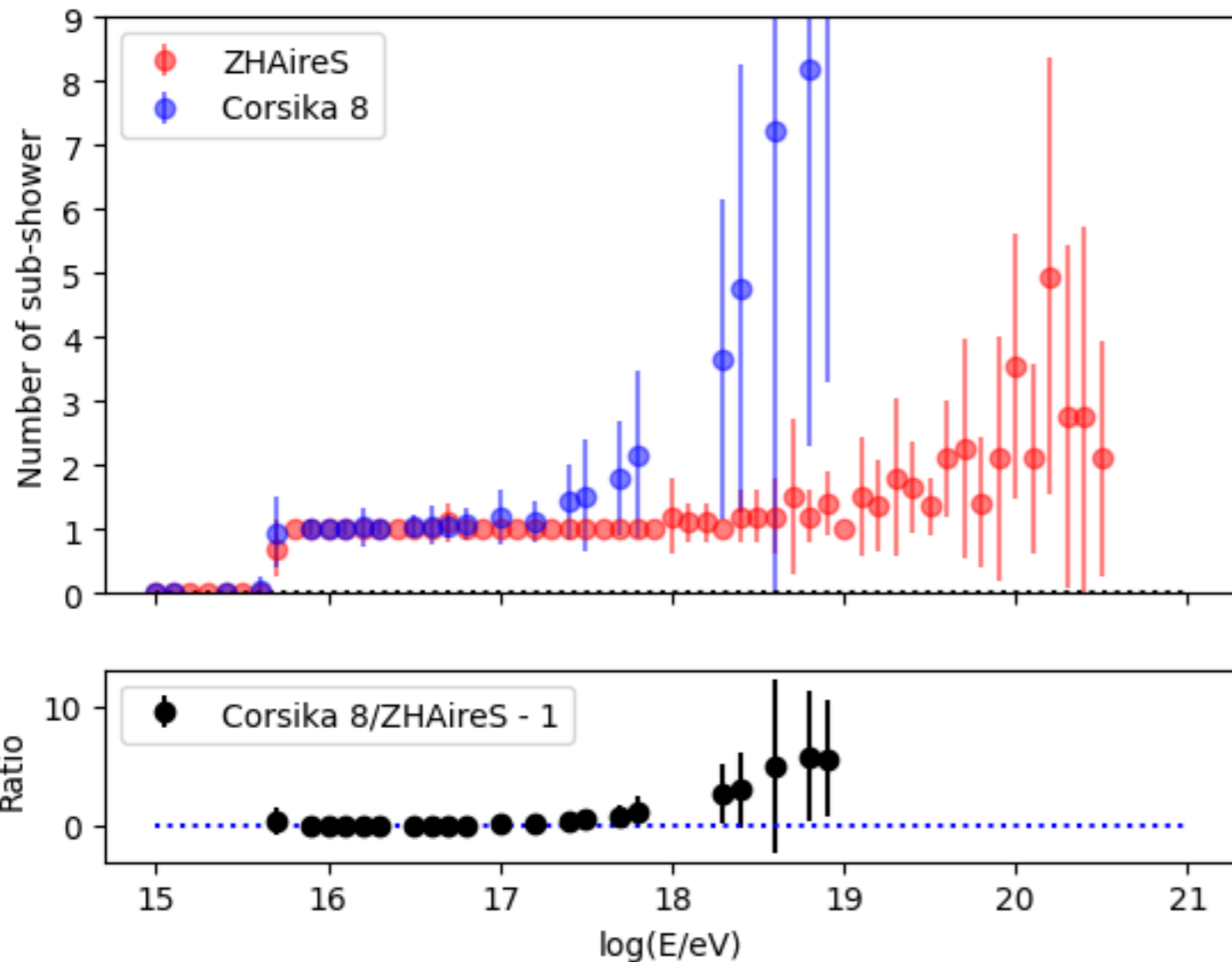
Charge excess (CE)



sub-shower

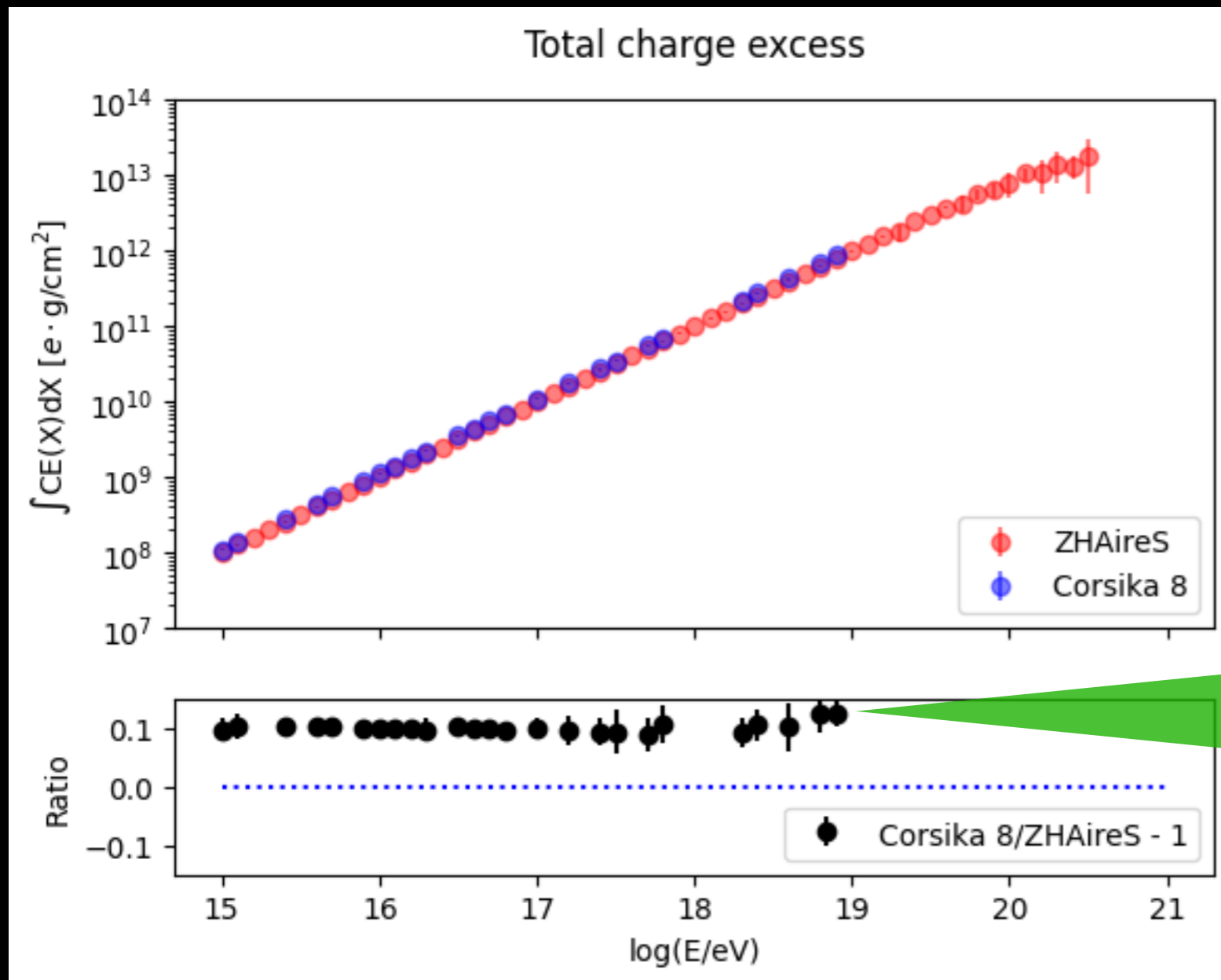
- Corsika 8 has more sub-shower than ZHAireS when $\log_{10}(E/eV) > 17$
- ZHAireS has more than 2 sub-showers when $\log_{10}(E/eV) > 18$
- $\log_{10}(E/eV) > 19$, max slant depth is not enough for the simulations

Number of sub-shower (CE > $10^6 e$)



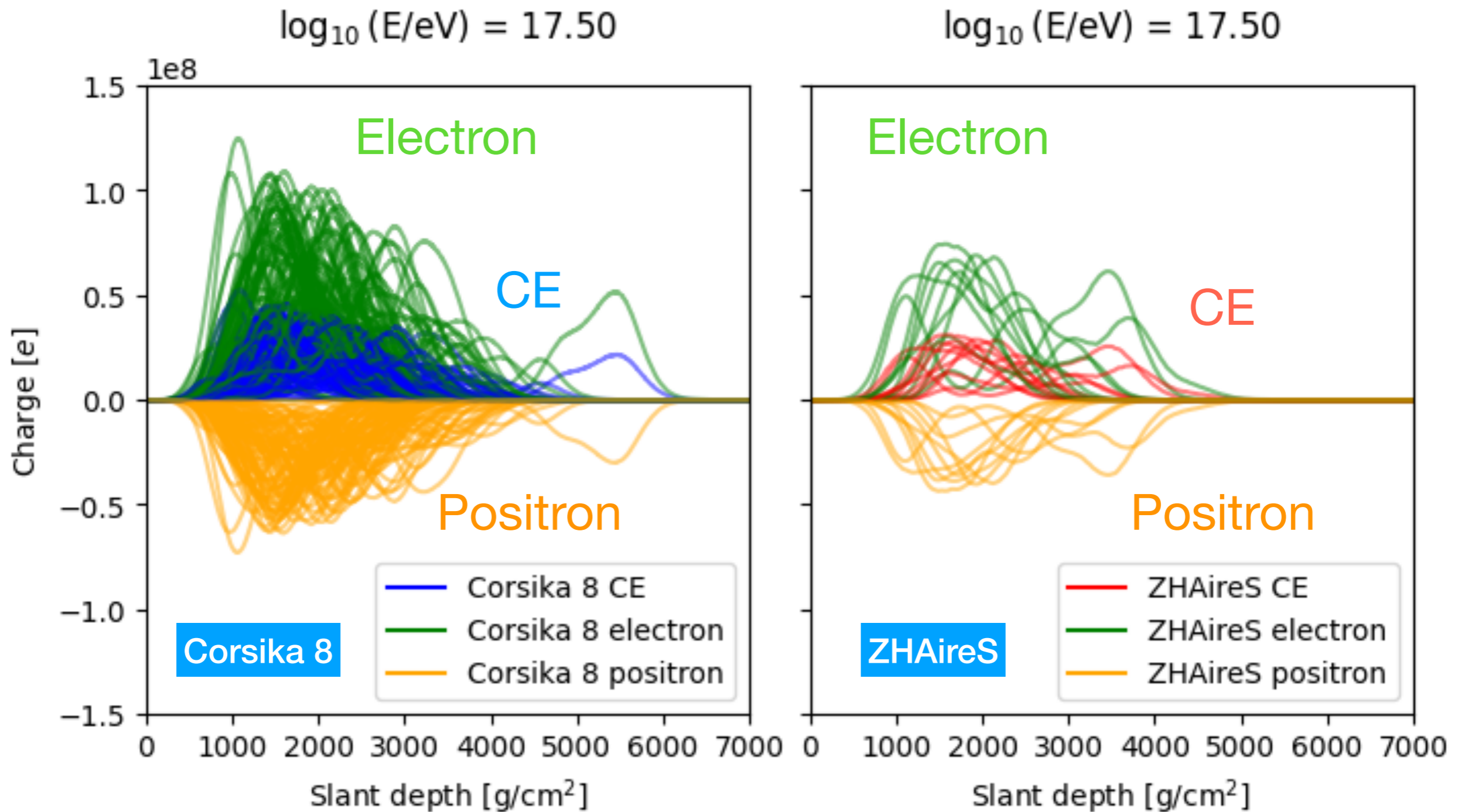
Part 2

Total CE difference

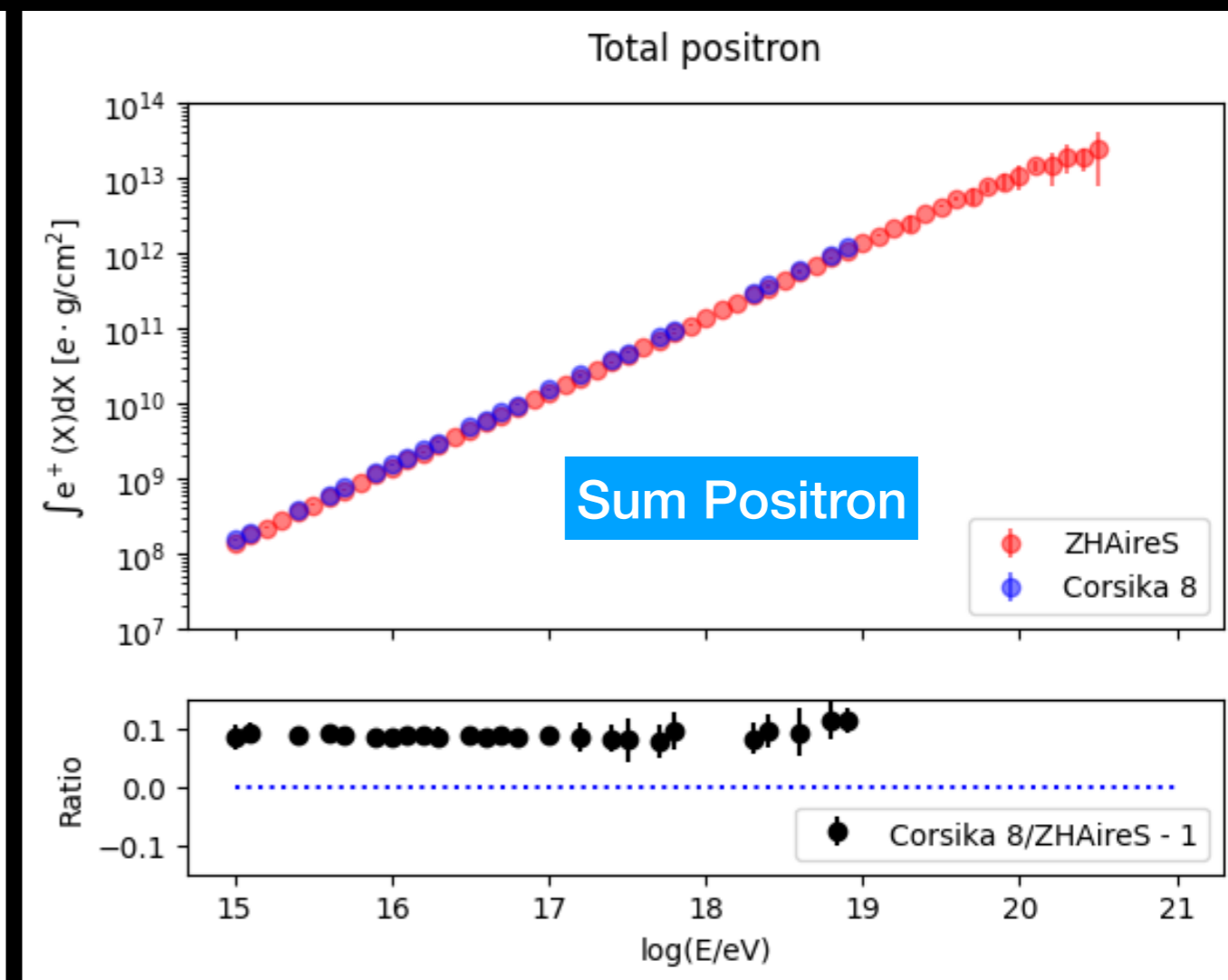
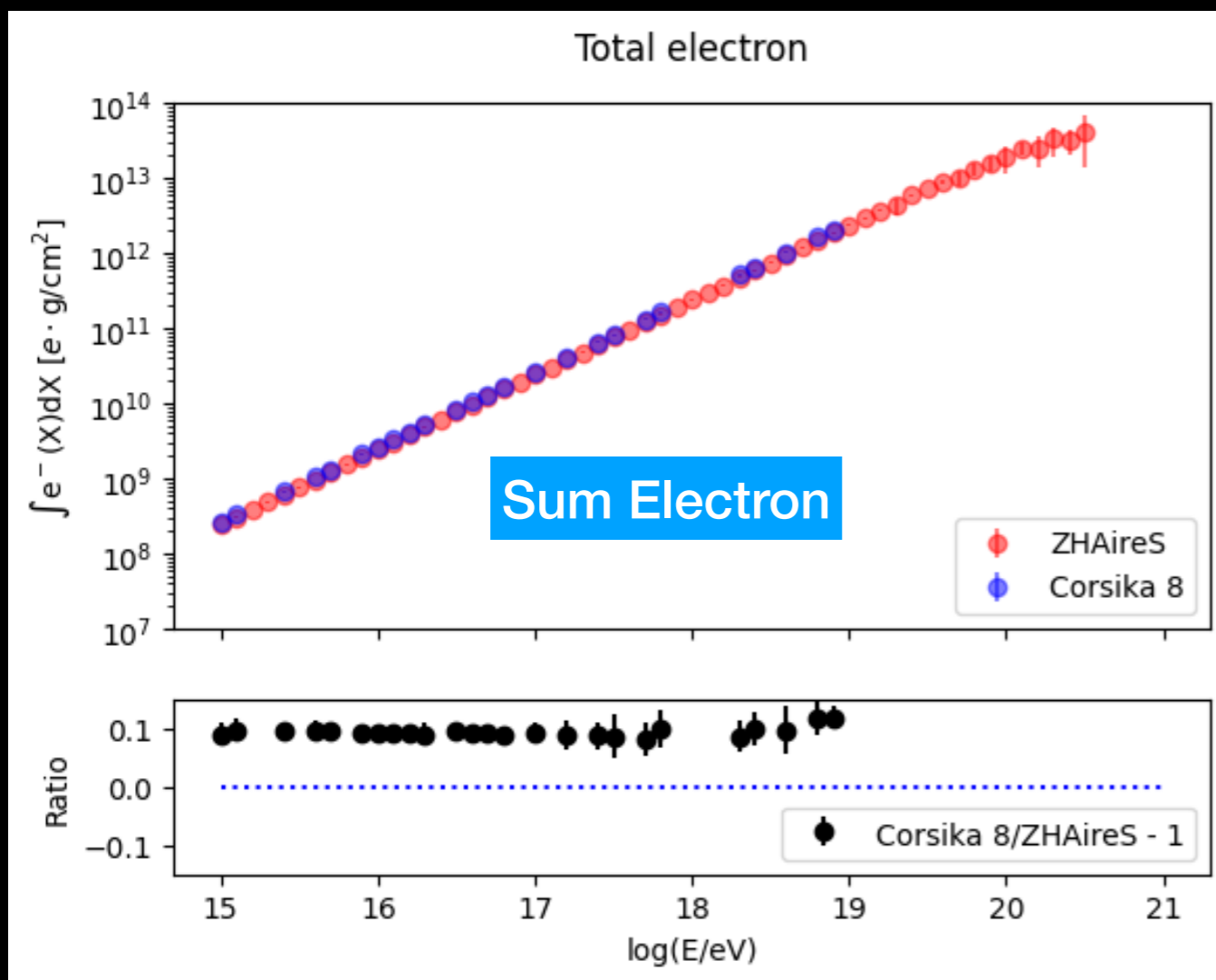




Corsika 8:
Electron-induced
shower produce
more electron and
less positron?

Electron and positron number

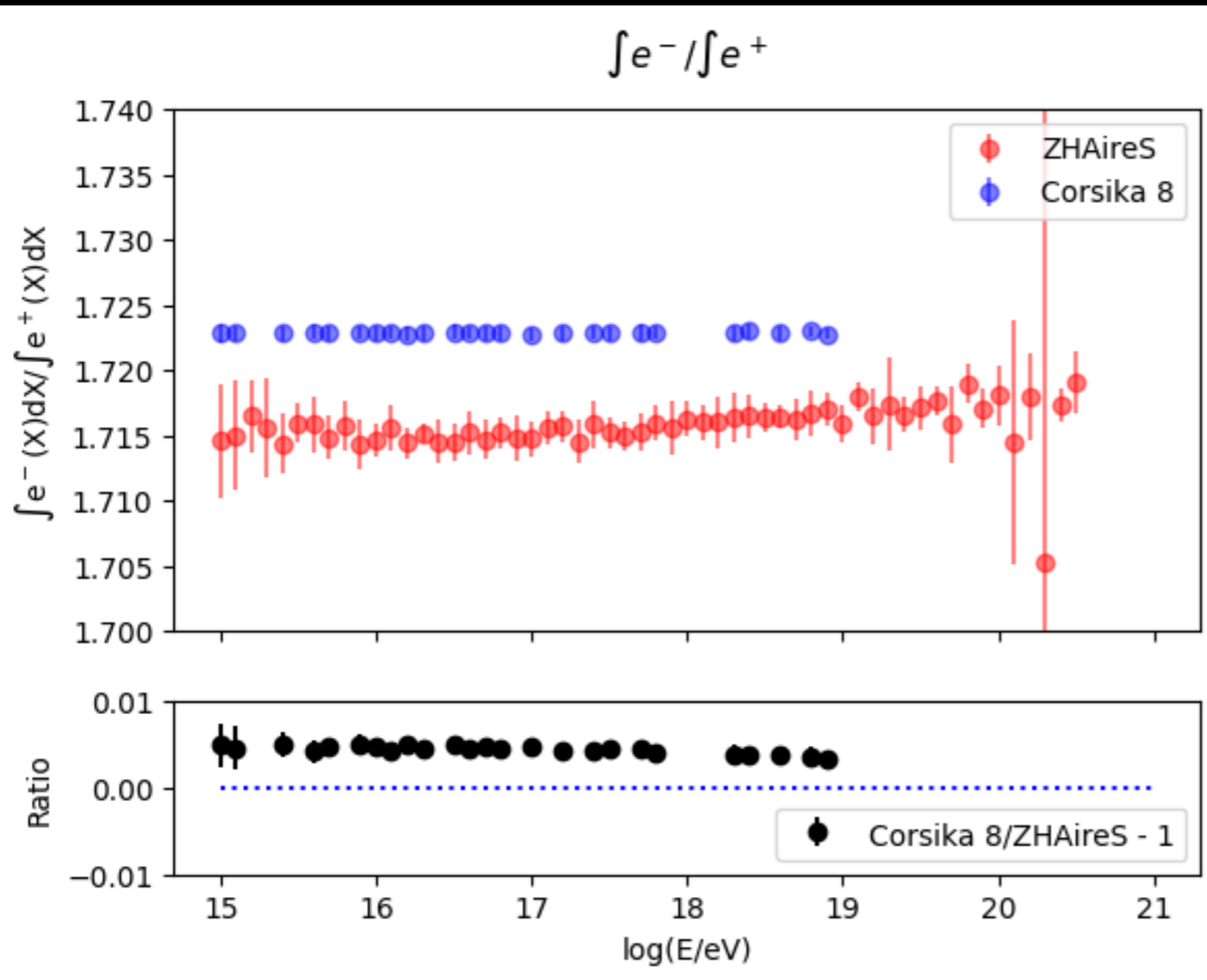


Electron and positron comparisons



- Corsika 8: Electron-induced showers produce more electron and less positron? 
- Corsika 8: More electron and more positron 

Electron positron production ratio comparison



- Total electron/ total positron ~ 1.7
- Less than 1% electron-positron production difference in different libraries

Comparison summary

● Electron-induced shower: CE comparison

- Xmax: consistent
- Total CE: 10% difference
- CEmax: 10% difference when $\log_{10}(E/\text{eV}) < 17$
- Xwidth: consistent
- N sub-shower: Corsika 8 has more sub-shower than ZHAireS when $\log_{10}(E/\text{eV}) > 17$
 - Need to be validated

● Electron-induced shower: electron and positron comparisons

- Corsika 8 produce 10% electron and 10% positron more than ZHAireS, individually

Simulations

- Blue: Corsika 8
- Red: ZHAireS

Thank you!

