Atmospheric shower simulation studies with CORSIKA

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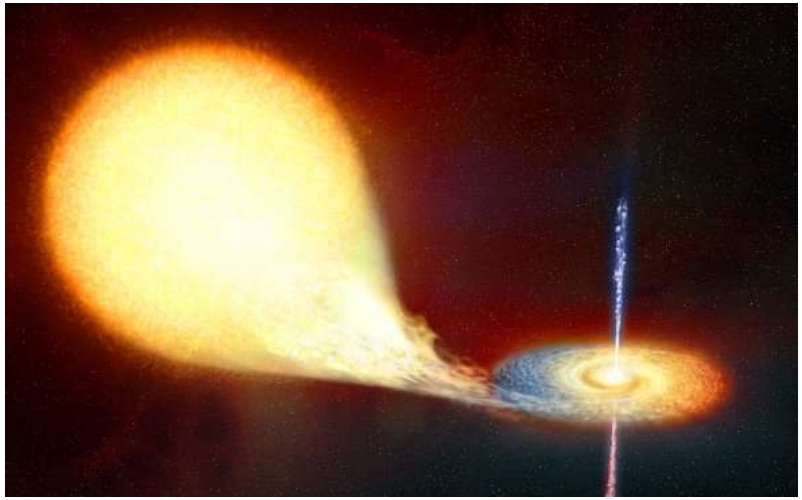
High energy gamma ray astronomy at 100 GeV - 100 TeV



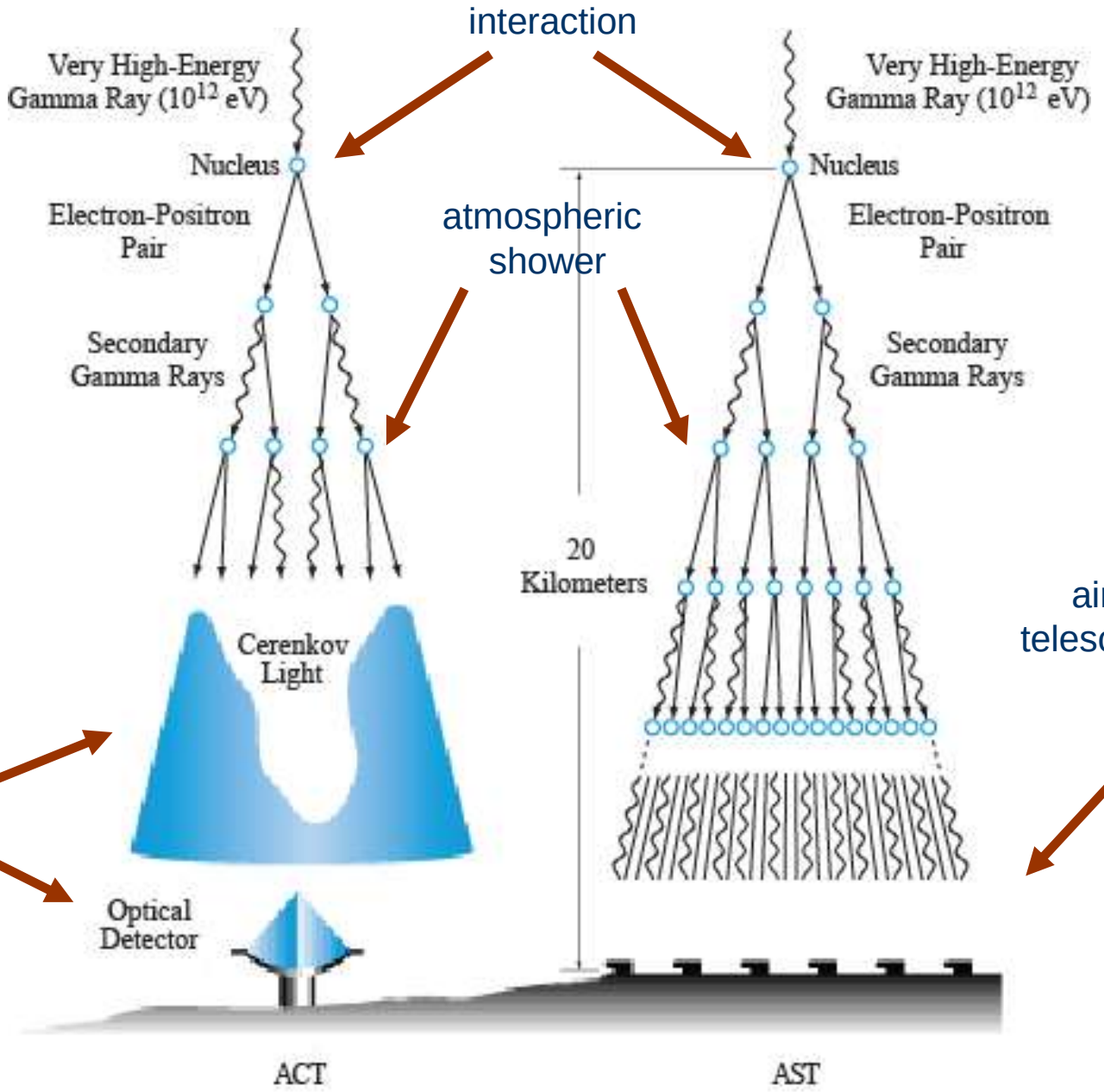
- ✓ High energy gamma rays photons.
- ✓ Coming from a distant source outside the Earth.
- ✓ Energies beyond those achievable in man-made accelerators.

- ✓ When a VHE gamma-ray enters the Earth's atmosphere, it generates an atmospheric shower.

✓ secondary charged particles

✓ Cherenkov light

Detection – Air showers



Atmospheric shower simulation with Corsika

- Primary particle – gamma ray photon.
- Three sets of showers. Every set consists of 10 showers.
- The primary particle energy is.

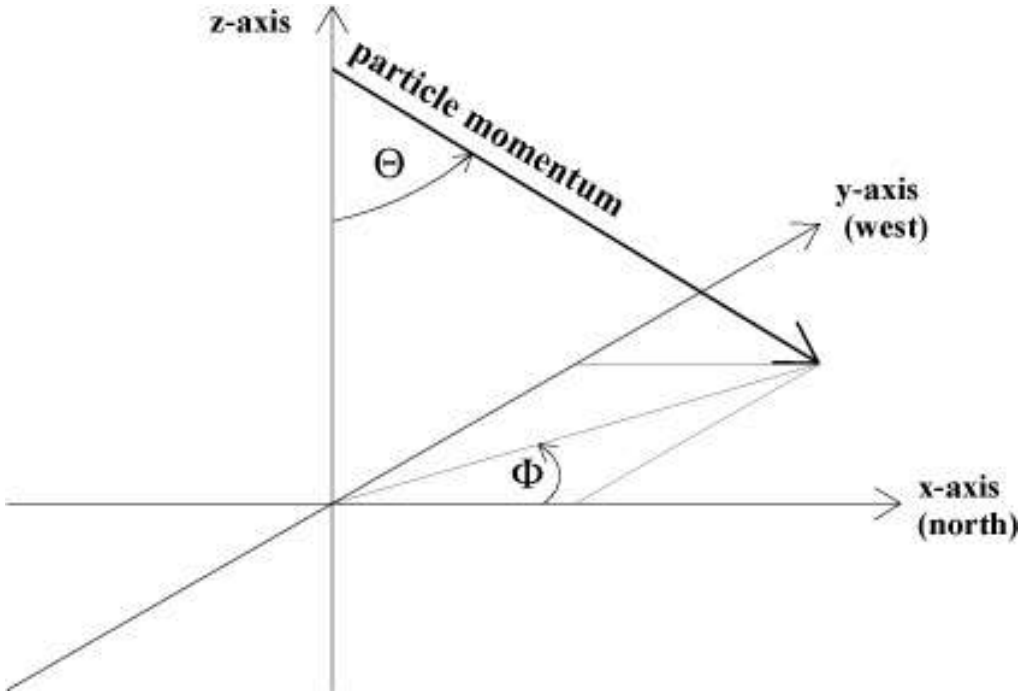
First set $\rightarrow$	10 TeV
Second set $\rightarrow$	40 TeV
Third set $\rightarrow$	70 TeV

- Zenith angle $\rightarrow$ 20 deg.
- Azimuth angle $\rightarrow$ from -180 to 180 deg.
- Observation level $\rightarrow$ 110m above sea level.
- The results are average values for each set of shower.

Coordinate system in Corsika

- The coordinates in CORSIKA are defined with respect to a Cartesian coordinate system.

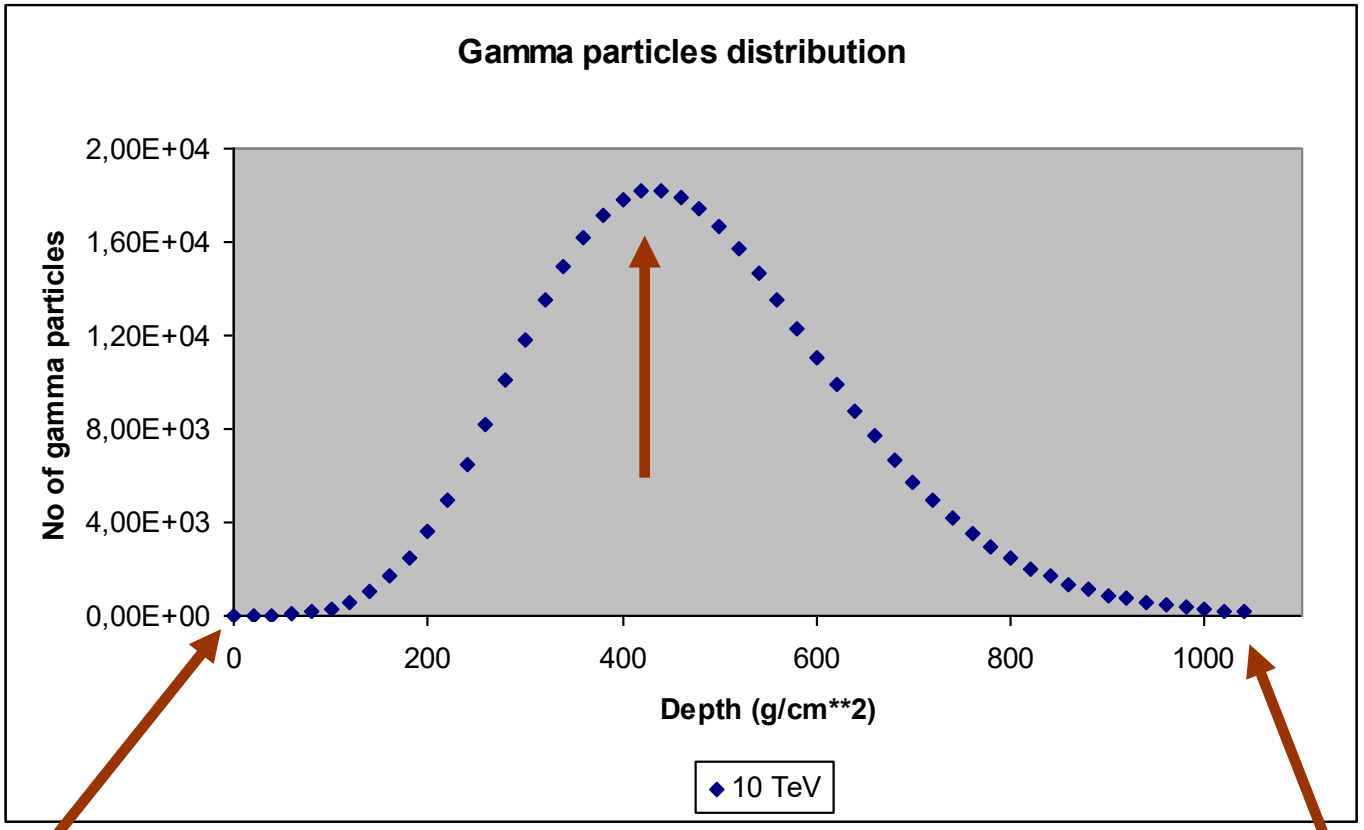
- The positive *x*-axis points to the magnetic North.
- The positive *y*-axis points to the West.
- The *z* axis points upwards.
- The origin is located at sea level.



Θ → Zenith angle.

Φ → Azimuth angle.

Gamma particles distribution

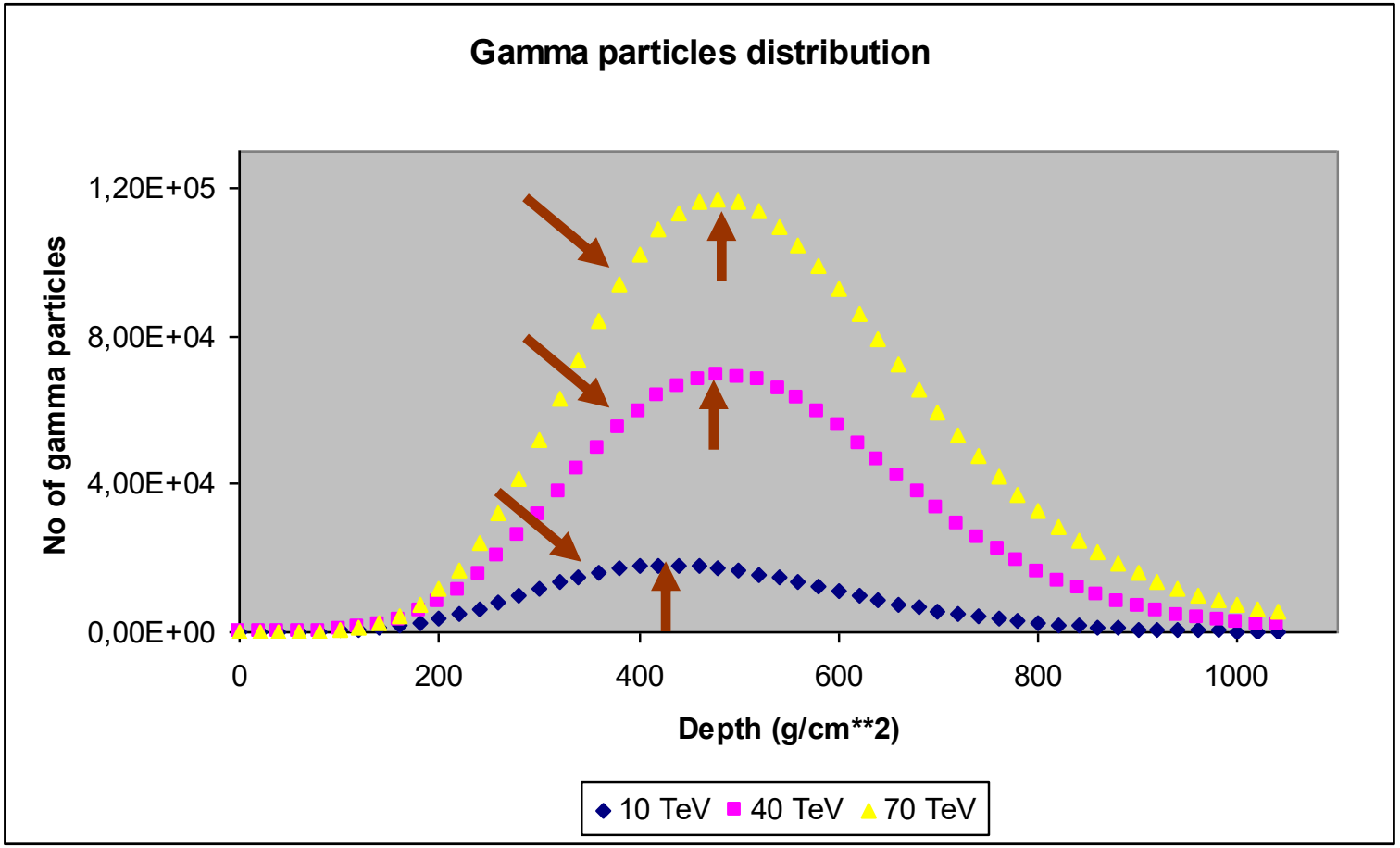


Starting point.
The top of the atmosphere.

Shower maximum
at a depth of 420 g/cm^2.

Observation level.
110 m above sea level.

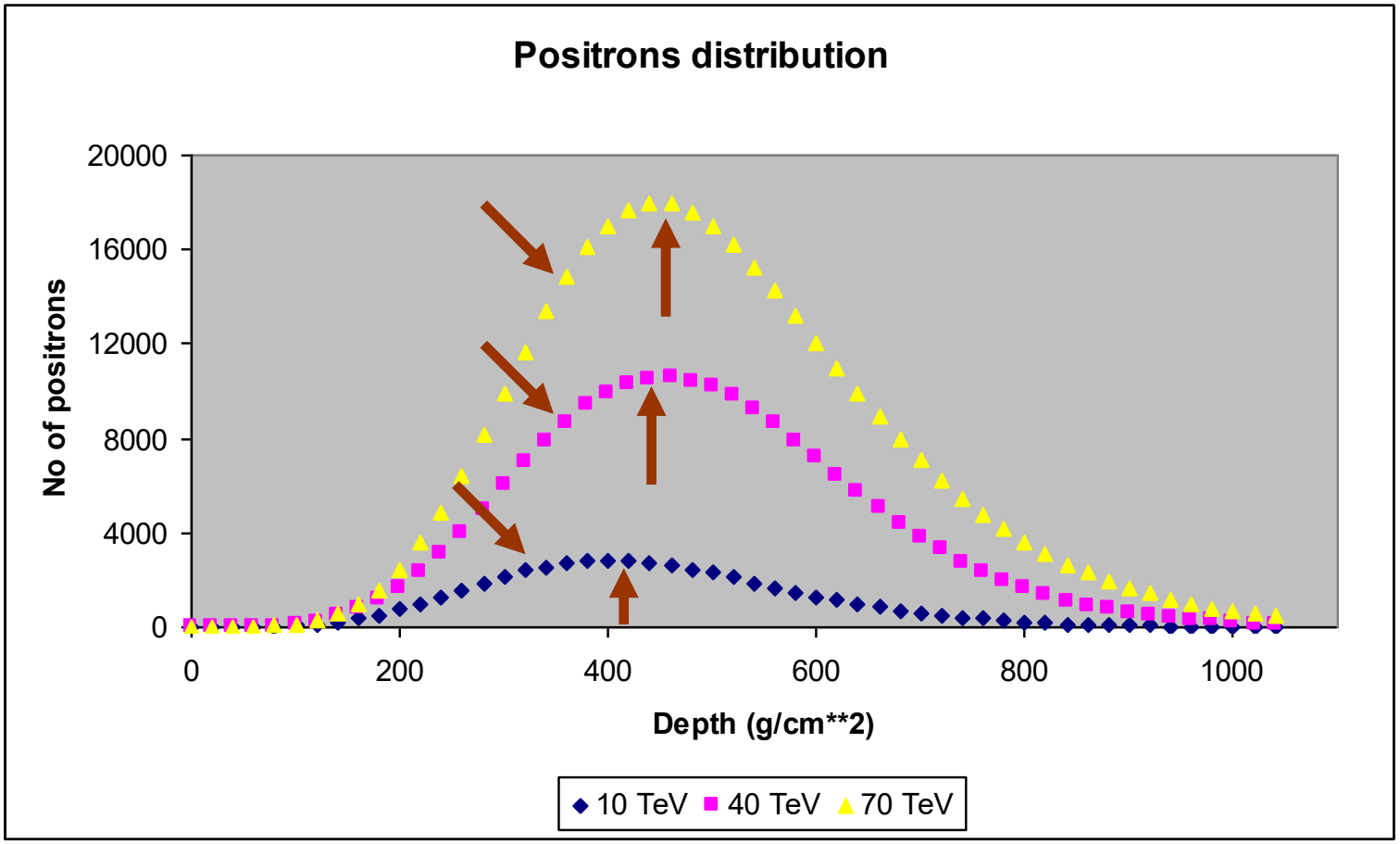
Gamma particles distribution



✓ Big primary energy → more gamma particles.

✓ Shower maximum → goes deeper.

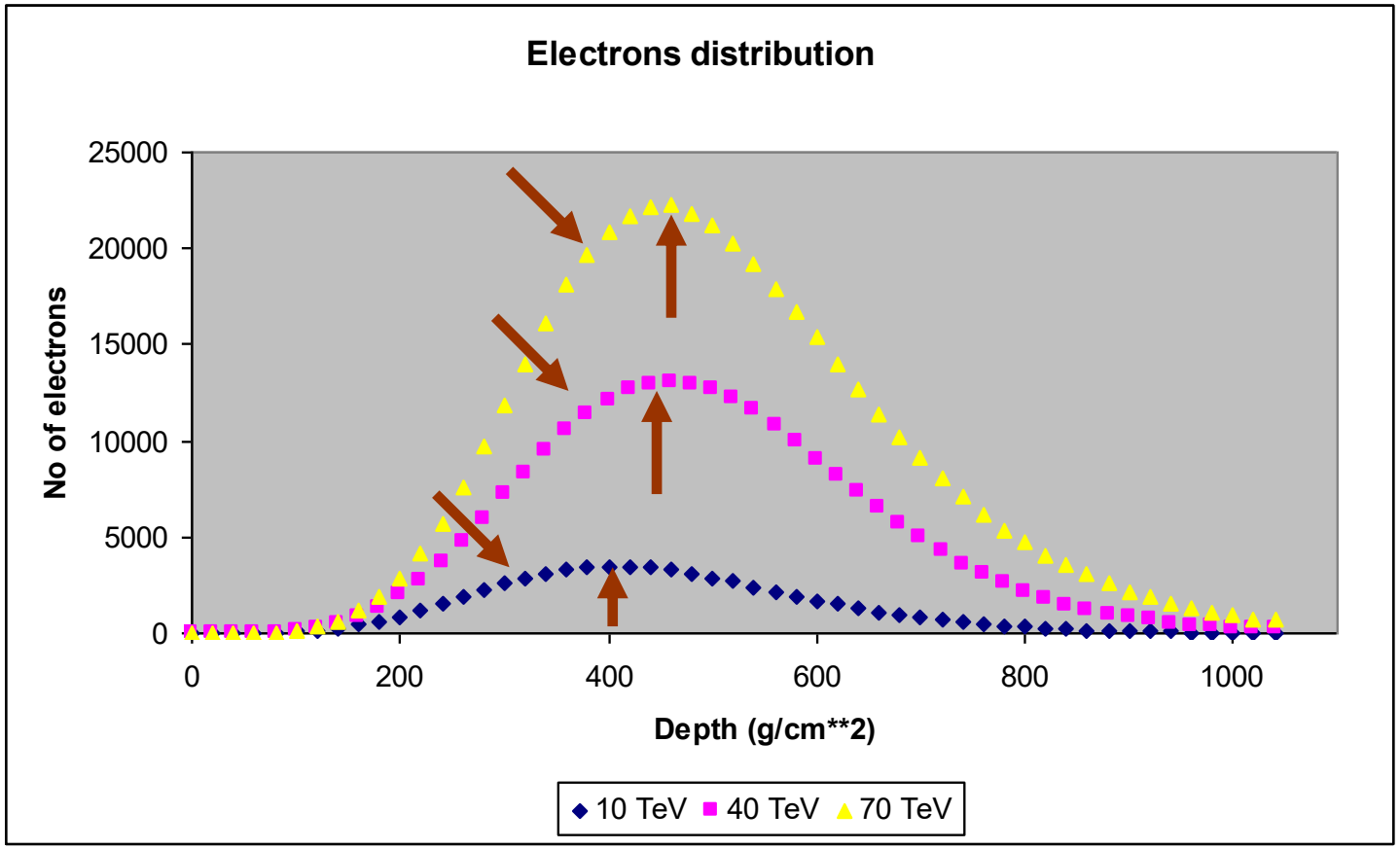
Positrons distribution



✓ Big primary energy → more positrons.

✓ Shower maximum → goes deeper.

Electrons distribution



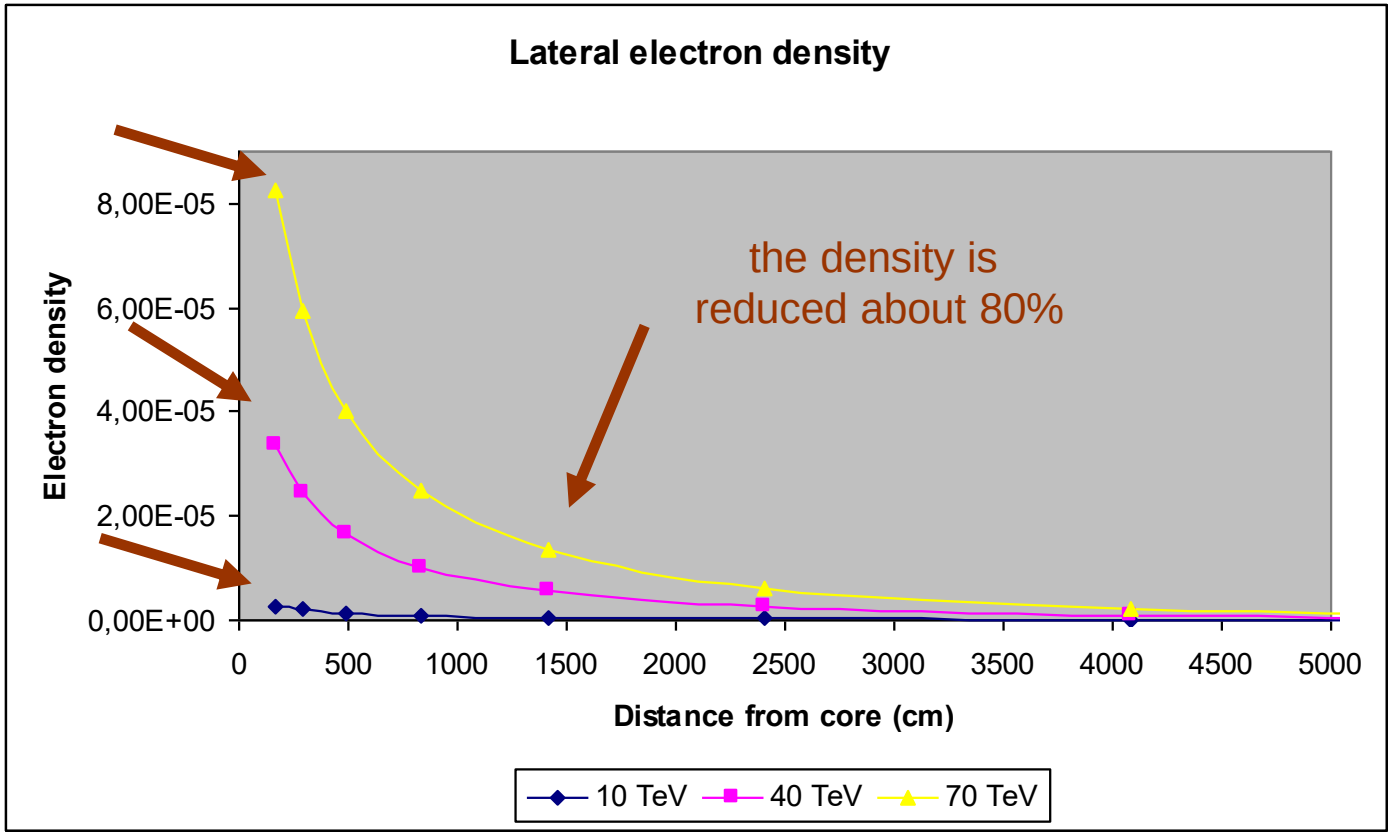
✓ Big primary energy → more electrons.

✓ Shower maximum → goes deeper.

Lateral electron density

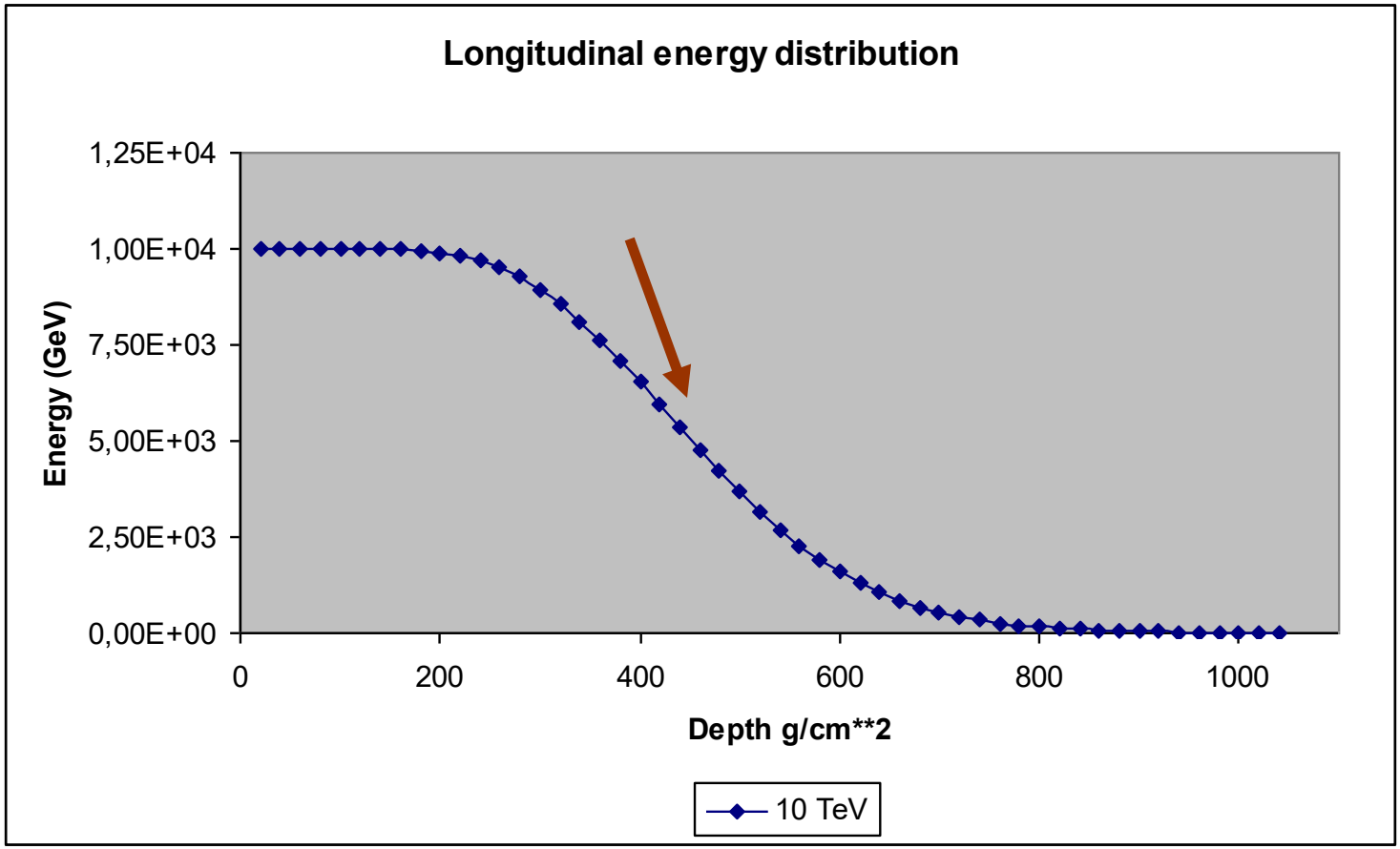
at observation level

for the three primary energies



at a distance of 14 m from the core

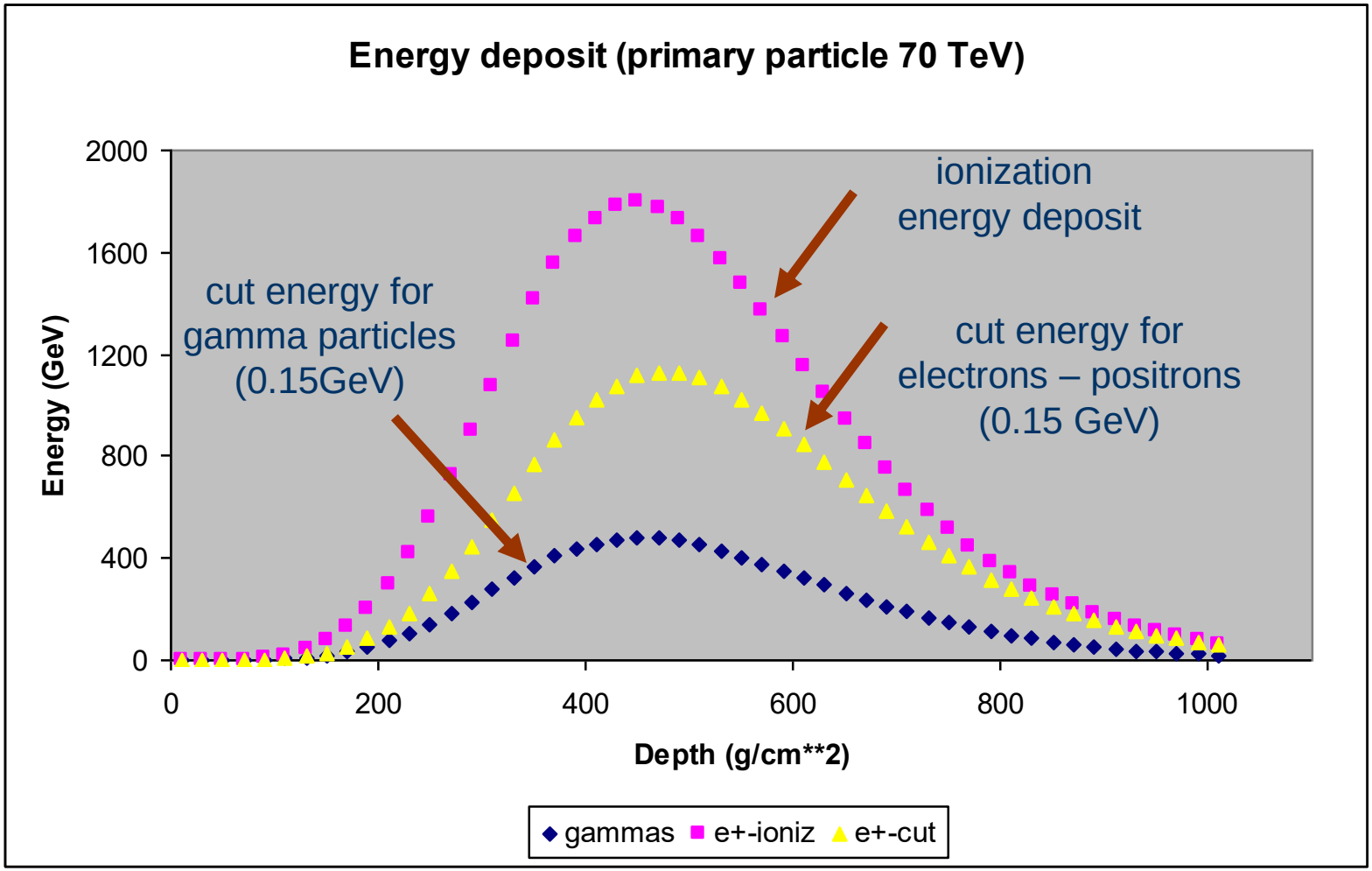
Shower energy distribution



✓ Continuing reduction in the shower energy.

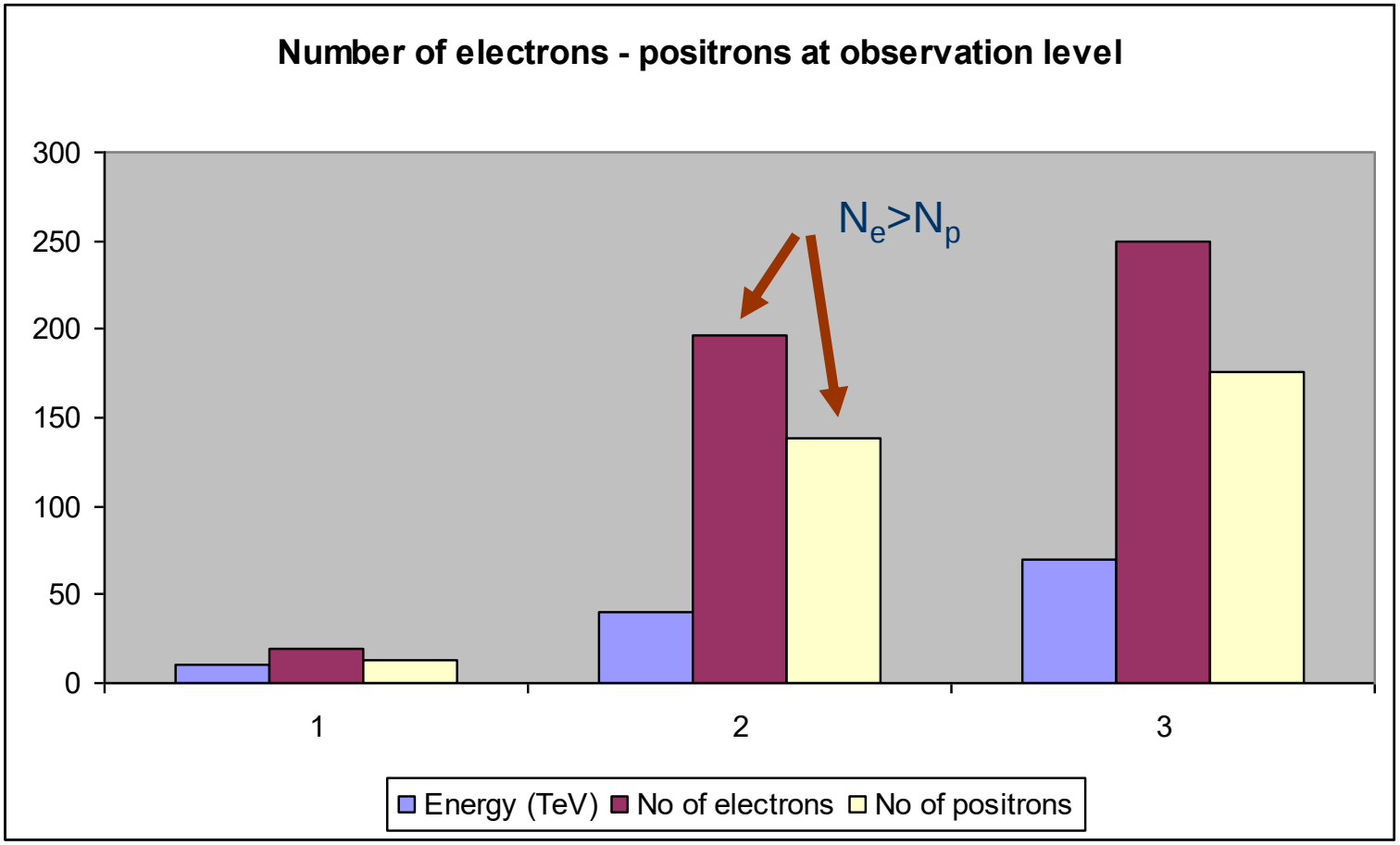
✓ Energy loss → energy deposit into air.

Energy deposit into air



Number of charged particles at observation level

Observation level →110 m above sea level

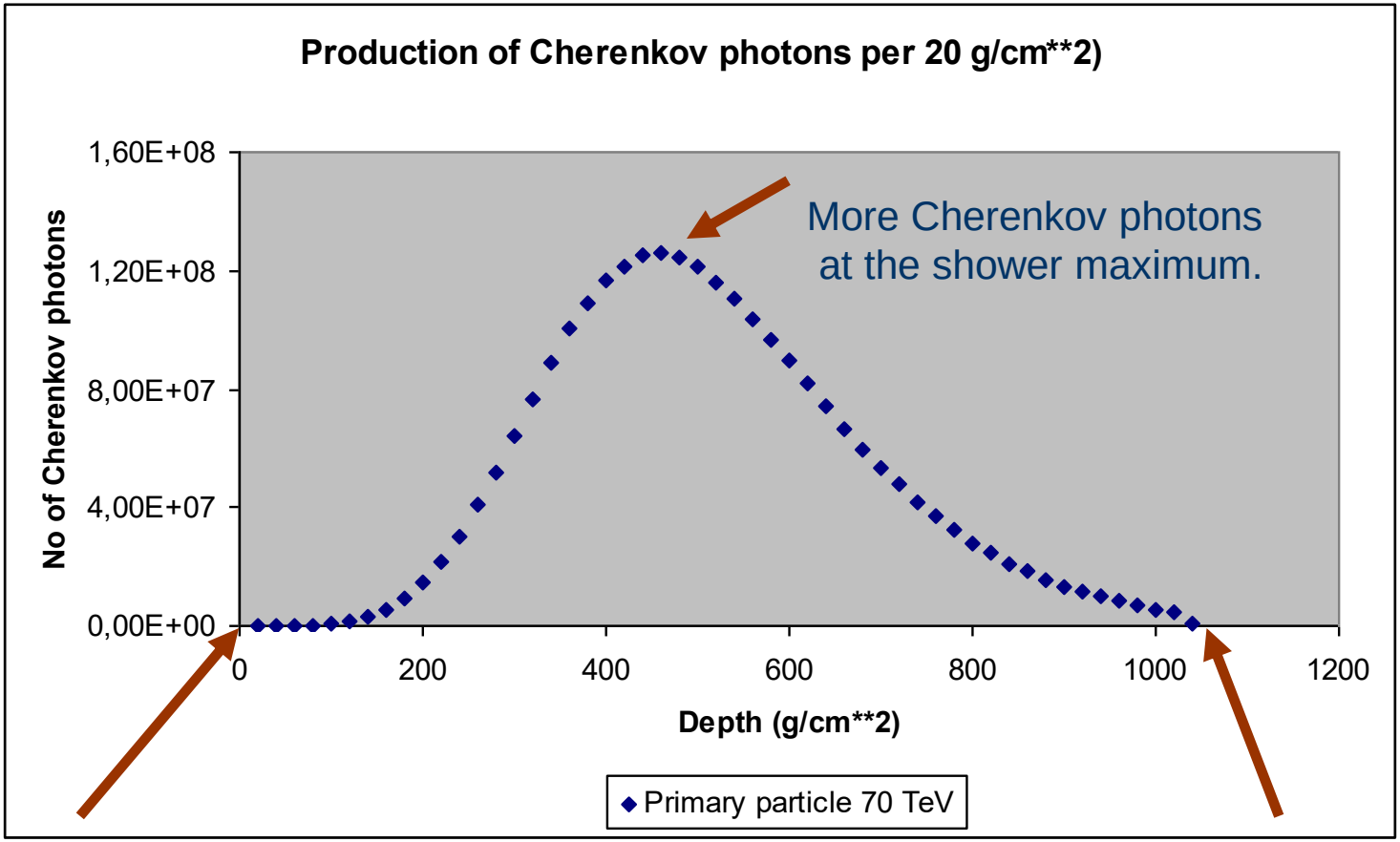


More primary energy → more particles at observation level.

Locations of Cherenkov detectors in the simulation

- ✓ Number of Cherenkov detectors in x direction→10
- ✓ Number of Cherenkov detectors in y direction →8
- ✓ Distance of detectors in x direction→1200 cm
- ✓ Distance of detectors in y direction →1500 cm
- ✓ Length of the detector in x direction →80 cm
- ✓ Length of the detector in y direction →50 cm.

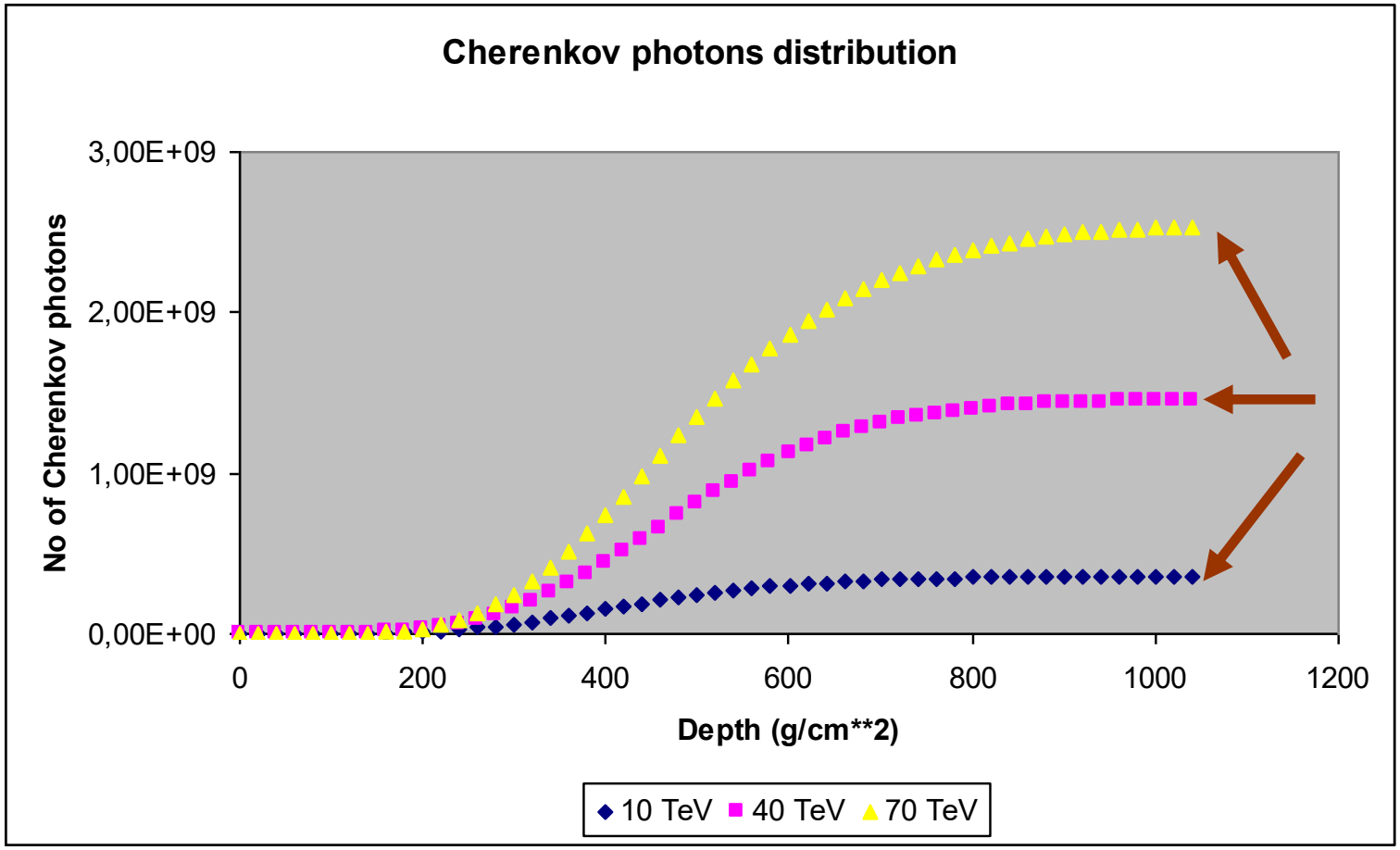
Production of Cherenkov photons per 20g/cm^2



Starting point.
The top of the atmosphere.

Observation level.
110 m above sea level.

Total production of Cherenkov photons



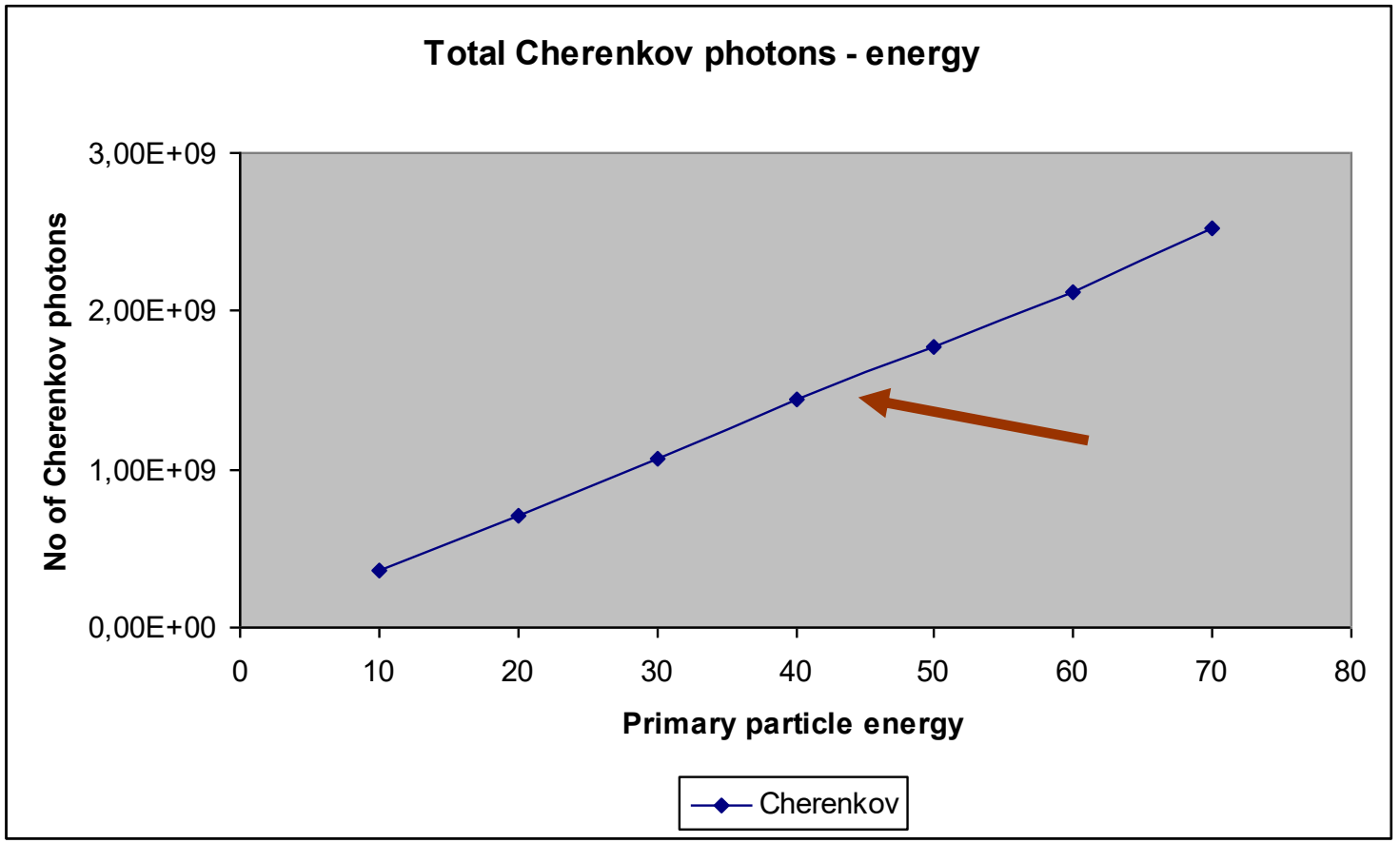
observation level

✓ The Cherenkov photons generated at all depths reach the observation level.

✓ At great depths the number of Cherenkov photons created are small, so the total number tends to become stable.

Increase Cherenkov photons with energy

- Number of Cherenkov photons arriving at the observation level.



✓ The increase in the Cherenkov photons in connection with the energy of the primary particle is almost linear.

Experiments in High Energy Gamma Ray Astronomy

Telescope arrays for the detection of Cherenkov light

- H.E.S.S. experiment

✓ Located in Namibia, near the Gamsberg mountain.

✓ Energies from 100GeV to 100TeV.

- MAGIC experiment

✓ Located in La Palma, one of the Canarian islands.

✓ Energies >100GeV.

✓ Mirror surface 236m^2.

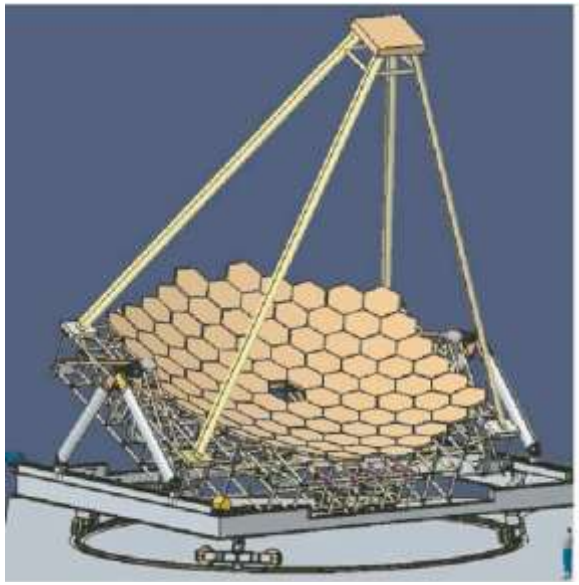
- VERITAS experiment

✓ Located in southern Arizona of the USA.

✓ Energies from 50GeV to 50TeV.

✓ An array of four 12m optical reflectors.

New Experiment - CTA



- Location

✓ Not yet determined.

- Three telescope types

✓ Four 24 m telescopes with 5^o field-of-view.

✓ 23 telescopes of 12 m diameter with 8^o field-of-view.

✓ 32 telescopes of 7 m diameter with a 10^o field-of-view.

- Telescopes distribution

✓ The telescopes are distributed over 3 km^2 on the ground.

✓ The effective collection area of the array is considerably larger than this at energies beyond 10 TeV.

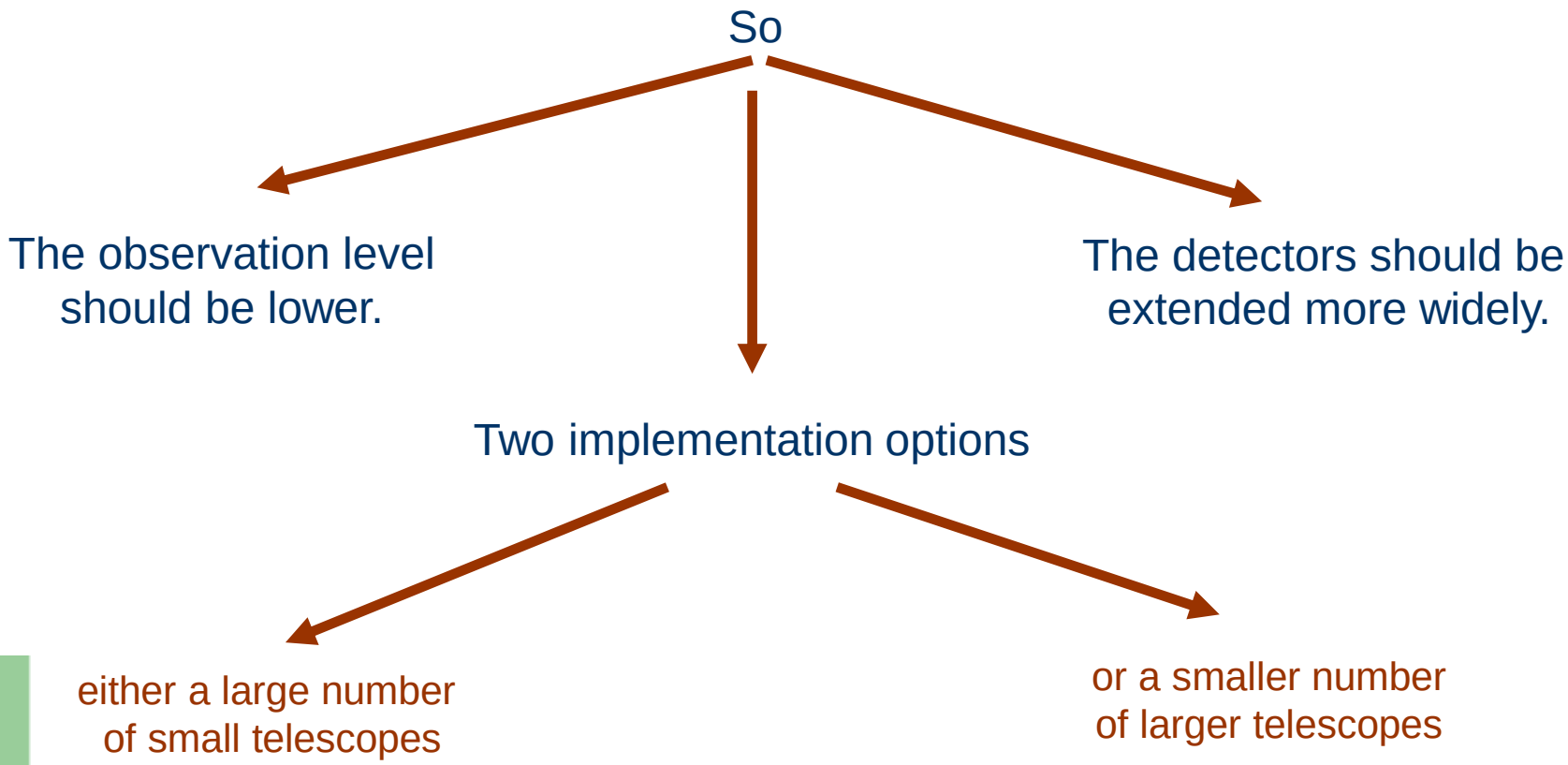
- Cost

✓Array layout has a nominal construction cost of 80 M€ and meets the main design goals of CTA.

Conclusions

The high-energy range above 10TeV

For very high primary particle energy ~100TeV the maximum of the shower goes deeper and the Cherenkov light reaches its ultimate intensity at about 800 g/cm^2 or ~2 km in altitude.



Thank you for your time