BIRKELAND CENTRE FOR SPACE SCIENCE

Particle Detector

- Bounce Loss Cone Fluxes

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UNIS The University Centre in Svalbard

NTNU Det skapende universitet

Outline

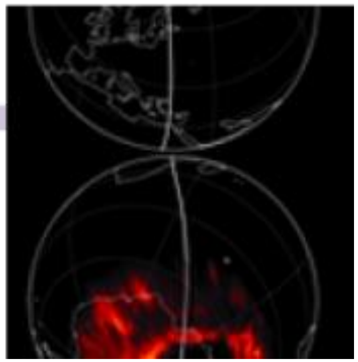
- **Scientific Objectives**
  Primary Science objective:
  A solid quantification of the energetic electron precipitation

- **NorSat particle detector**
  Design and placement of detector houses

- **Wider Impacts**
  EISCAT 3D

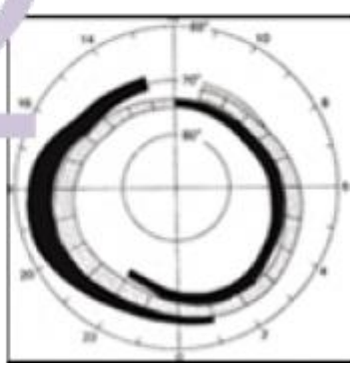
How is Earth connected to space?

1



When and why is the aurora in the two hemispheres asymmetric?

2



How do we get beyond the large-scale static picture of the ionosphere?

3

What are the effects of particle precipitation on the atmospheric system?

4

What is the role of energetic particles from thunderstorms on geospace?

What are the effects of particle precipitation on the atmospheric system?

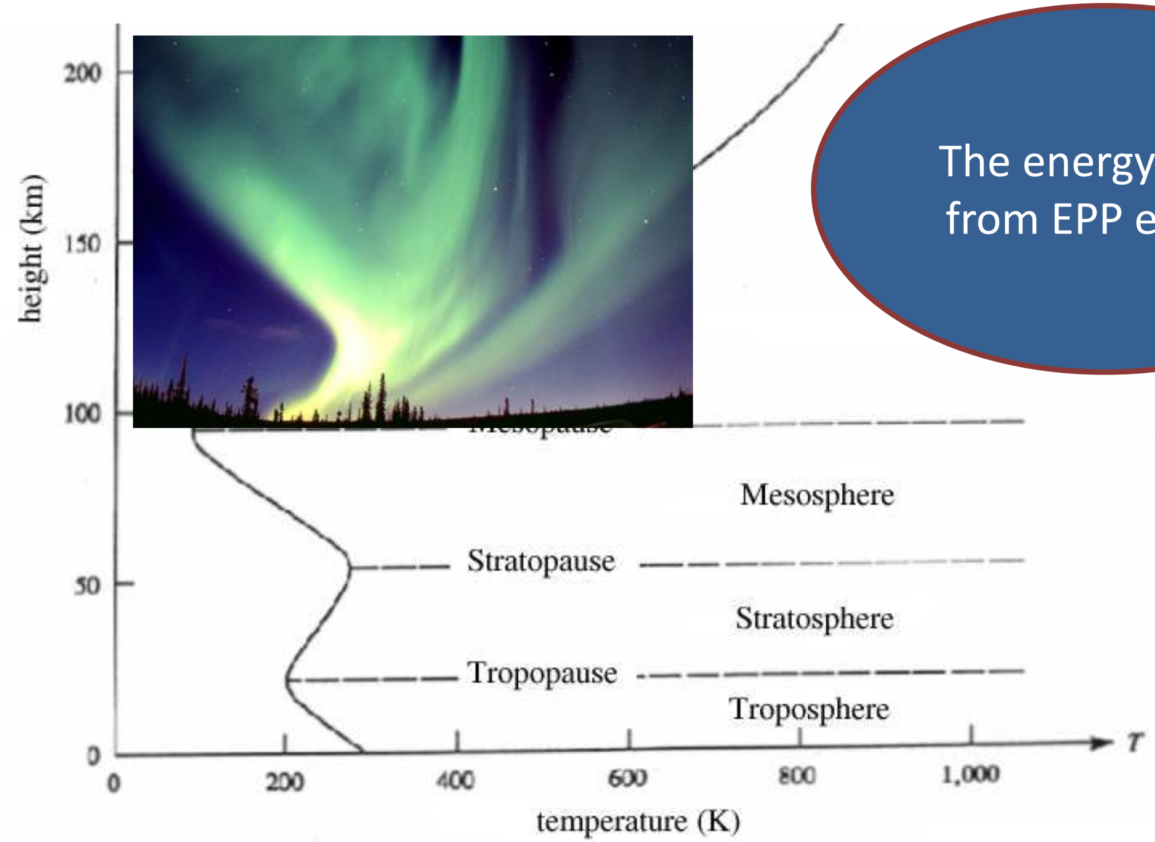
Our team:

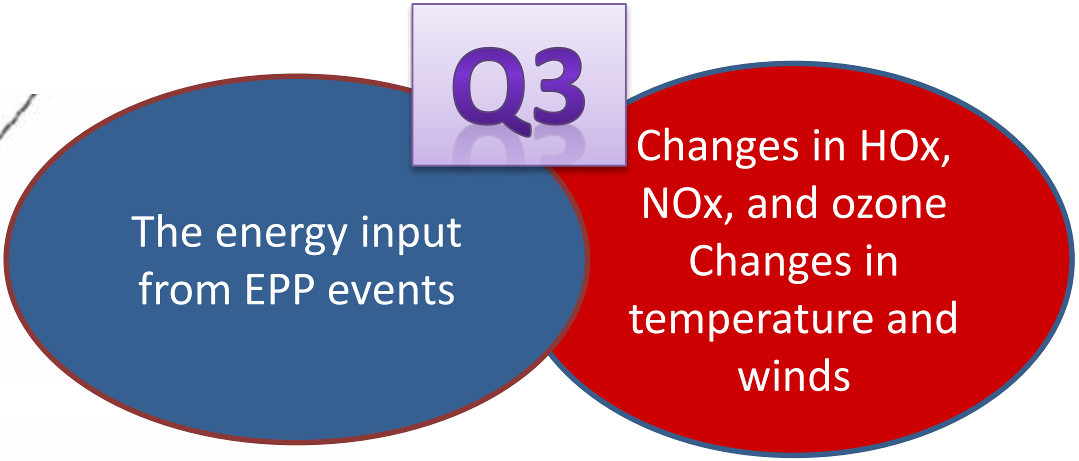
Annet Eva Zawedde
Kishore Kumar Grandhi

Noora Partamies

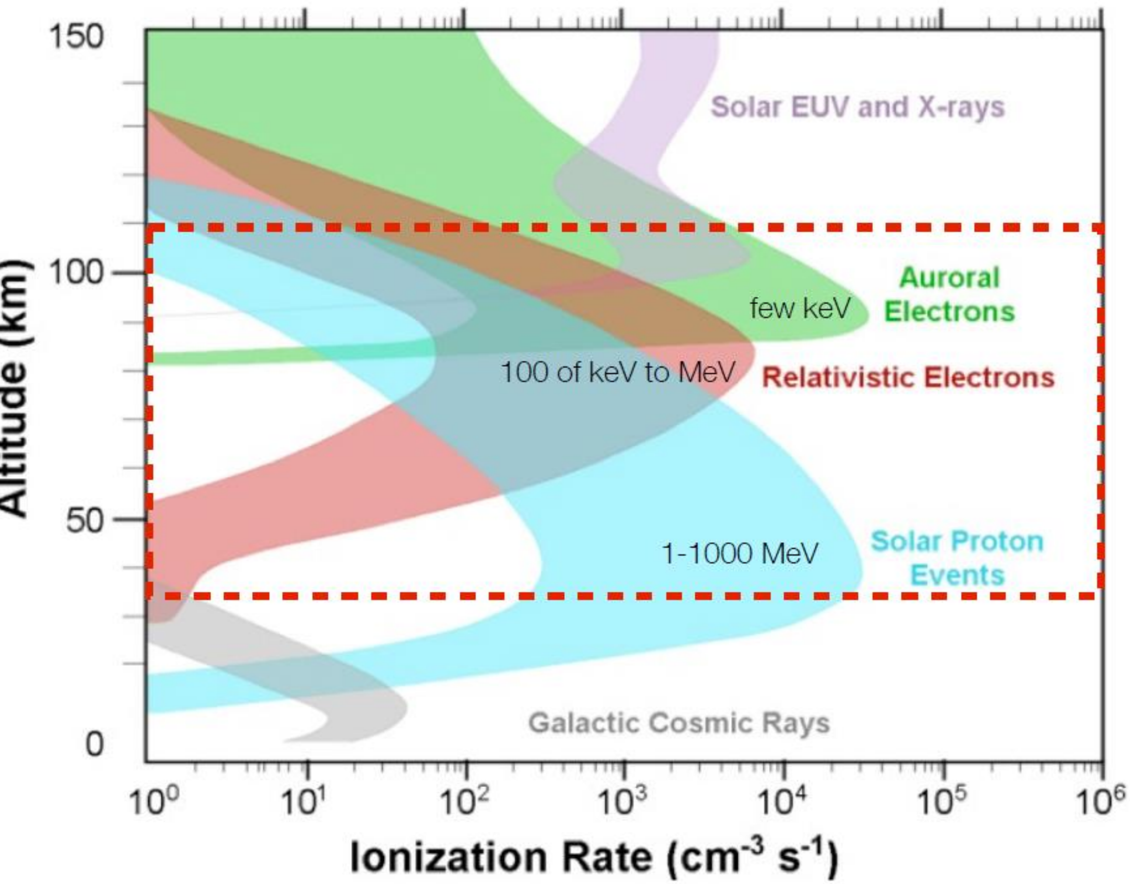
Sven Kühl
+ PhD

What are the effects of particle precipitation on the atmospheric system?





The impact of particle precipitation into the atmosphere – Outstanding questions



- Direct impact of electron precipitation on chemistry?
  At and above 70 km: Yes
  Below 70 km: Few evidence
- Indirect impact of electron precipitation on the chemistry?
  Yes, but most studies do not include middle or high energy electrons.
- Quantification of the impact?
  No, most studies use indices as a proxy for the electron precipitation.

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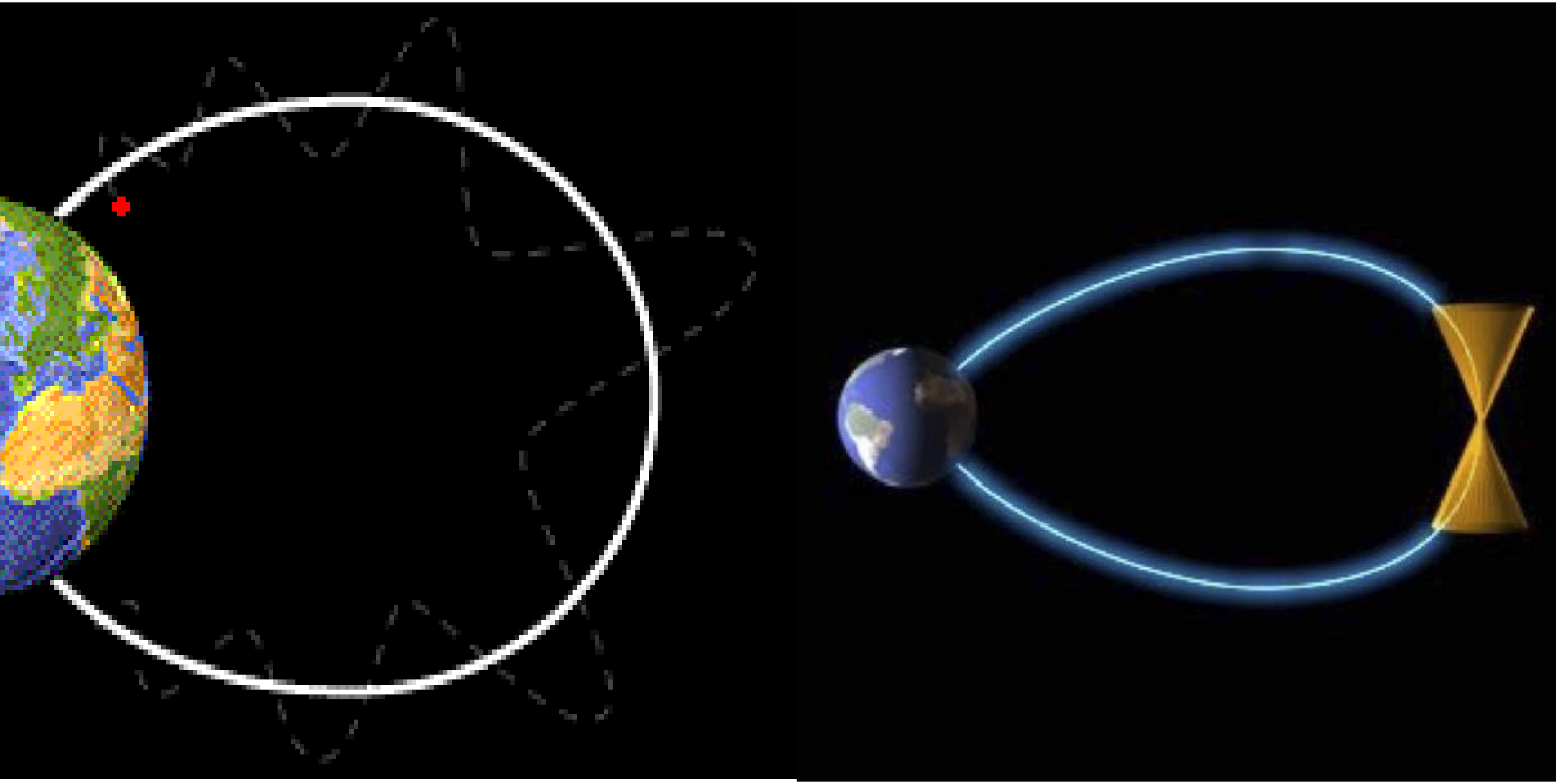
Anisotropic electron fluxes – pitch angles and loss cone

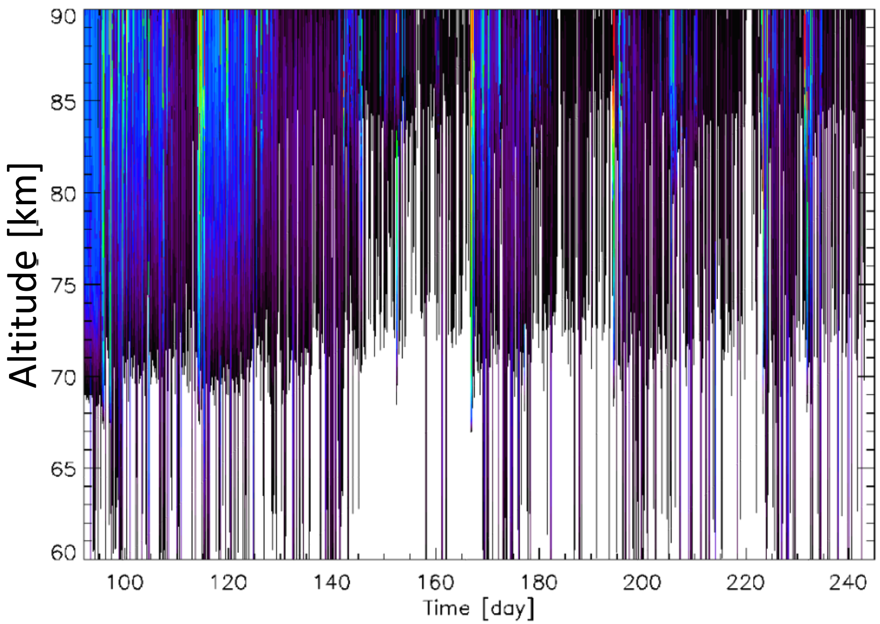


Mirror point < ~100km: Particle lost in the atmosphere

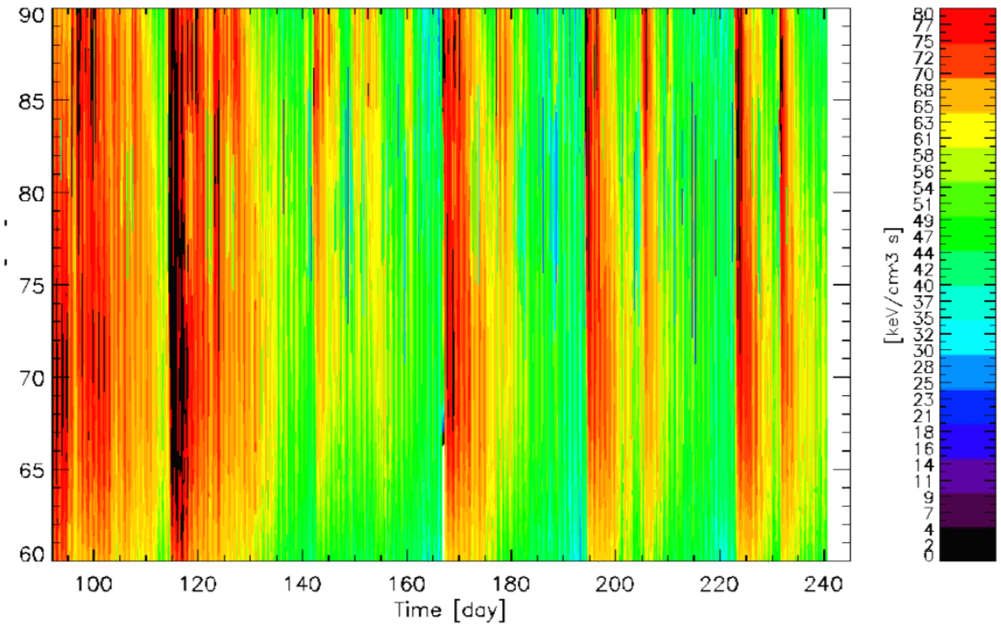
Today: Large uncertainties in the particle energy being deposited in the atmosphere

The MEPED instrument on board NOAA/POES satellites:

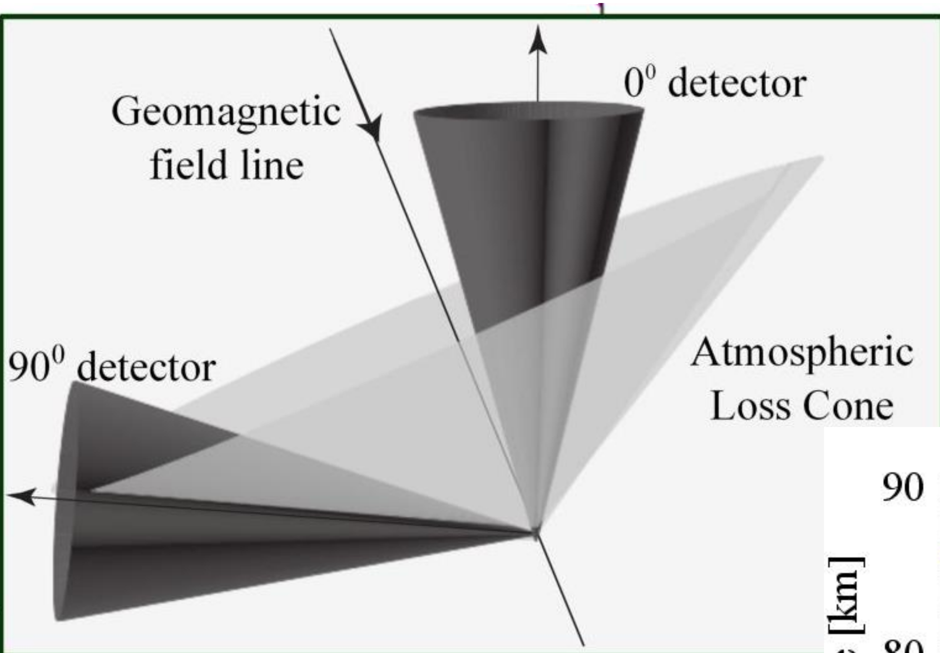
0^0 detector

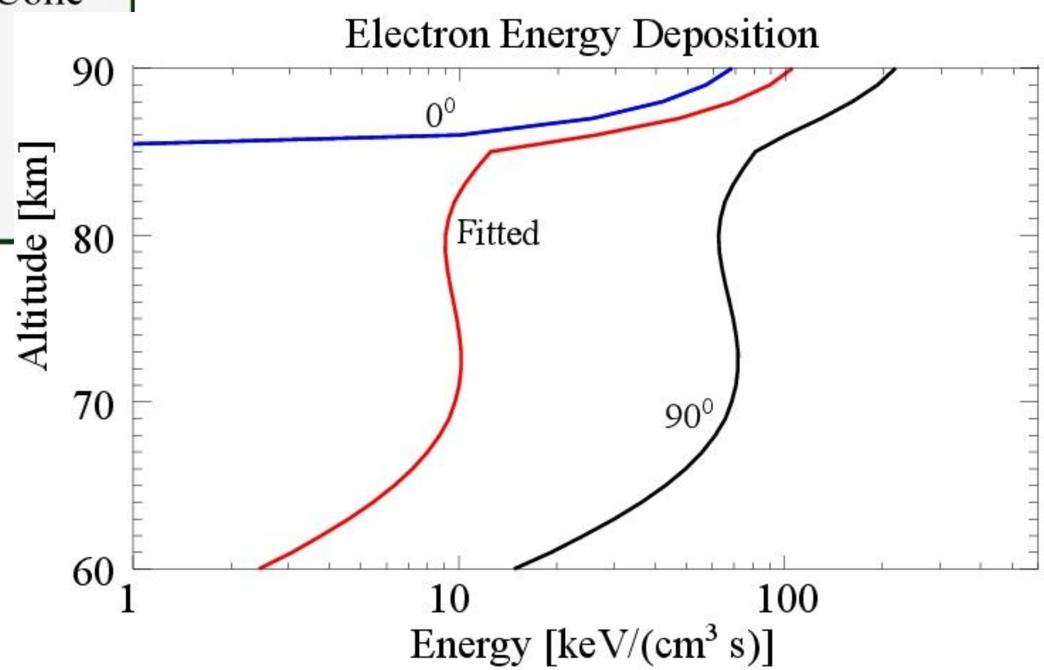


90^0 detector



Electron Energy Spectra and Energy Deposition





BLC particle data
- An unique and attractive data product

- **Variability of the Sun and Its Terrestrial Impact**

  The **VarSITI** program is the ongoing scientific program of **SCOSTEP** (2014-2018)

  → **ROSMIC** (**R**ole **O**f the **S**un and the **M**iddle atmosphere/thermosphere/ionosphere **I**n **C**limate)
- EU COST project: "Towards a sounder assessment of the impact of solar variability on the Earth's climate“
- +++

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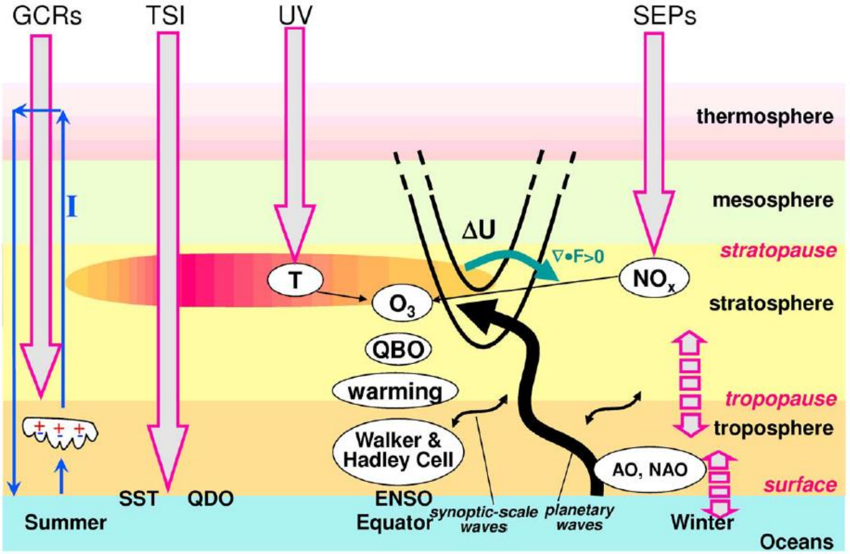
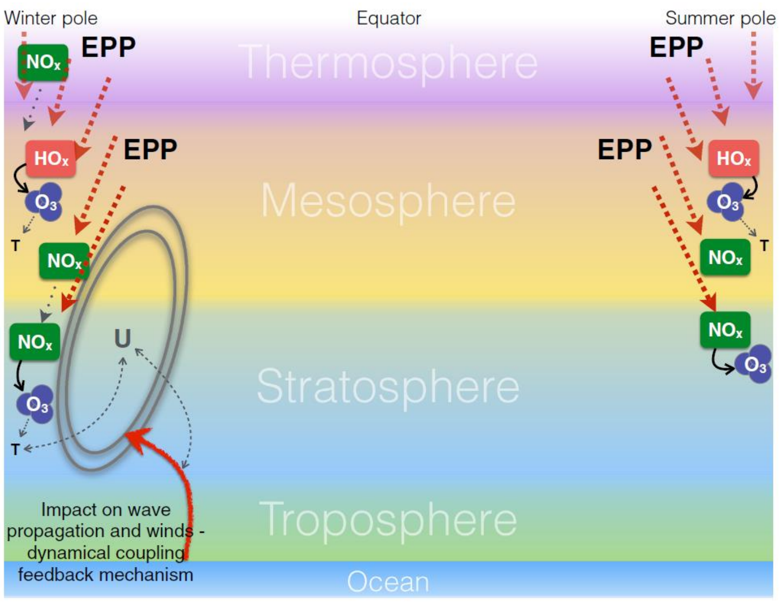
Why now?

In 2010:

Medium energy/ Relativistic electrons not considered



Gray et al. 2010: Solar Influences on Climate



Seppälä et al. 2014: Solar Influences on Climate

In 2014:

«… one of the **key issues** has turned out to be **how to estimate the electron input** at these energies (approximately 100 keV to few MeV) into the atmosphere.»

Other scientific objectives

Magnetospheric souces

Precise measurements of the angular and energy distribution of the electron and proton fluxes will help to reveal sources and loss processes in the magnetosphere

Microbursts

A sampling frequency of 20 measurements per second will enable us to study small scale features, such as electron microbursts lasting less than one second

Solar Proton Events (SPEs)

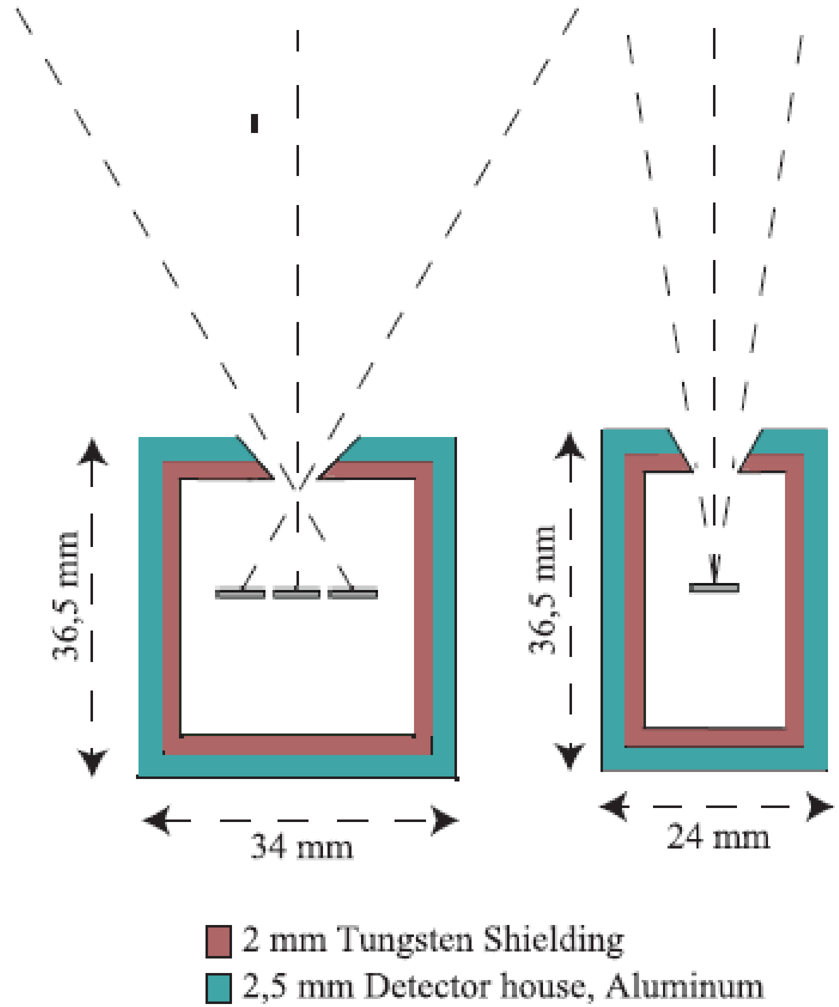
Solar Proton events are major space wheather phenomena that can produce hazardous effects in the near-Earth environment

Energetic Neutral Particles (ENA)

The proton detectors will allow us to detect neutral atoms which will give information on the Earth's ring current loss processes and symmetry

Electron detector - design

- Energy range: 30-500 keV
- Field of view: ~180°
- Units: 9 (divided between three detector houses)
- Sensors: silicon surface-barrier detectors on a strip
- Total mass: 600 g

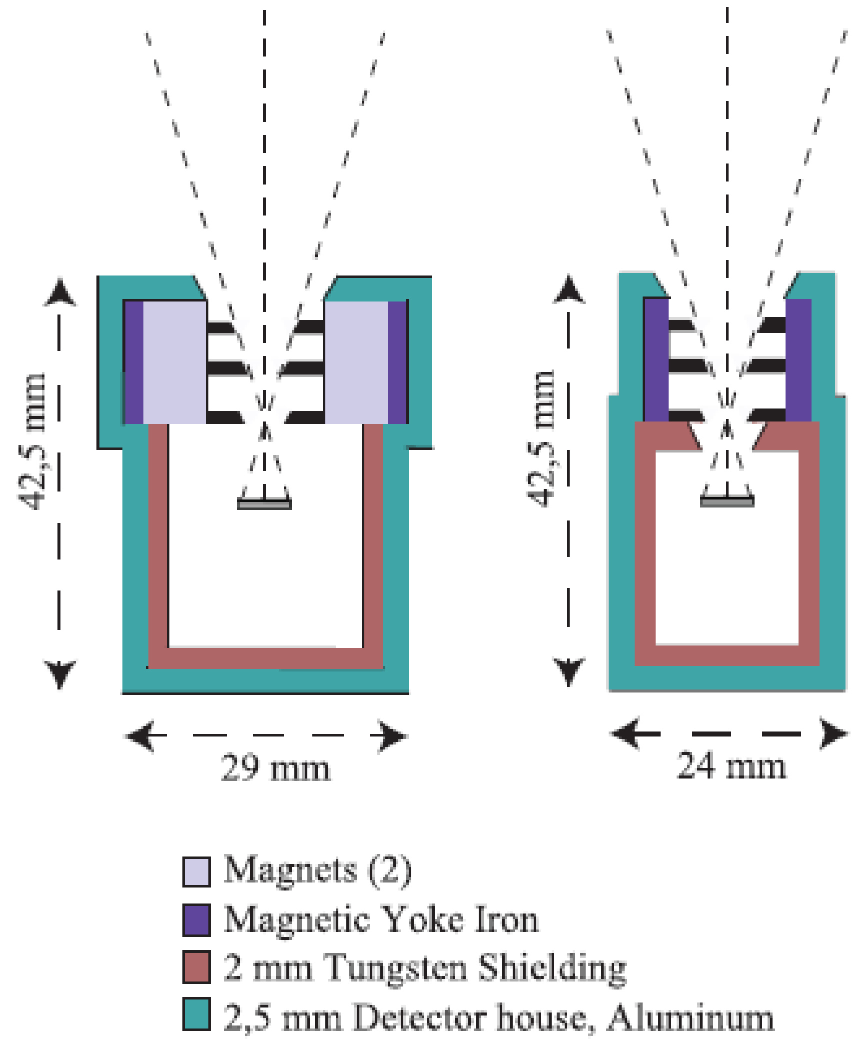


Detector houses: side views

Proton detector - design

- Energy range: 30 keV-10 MeV
- Field of view: ~180°
- Units: 3

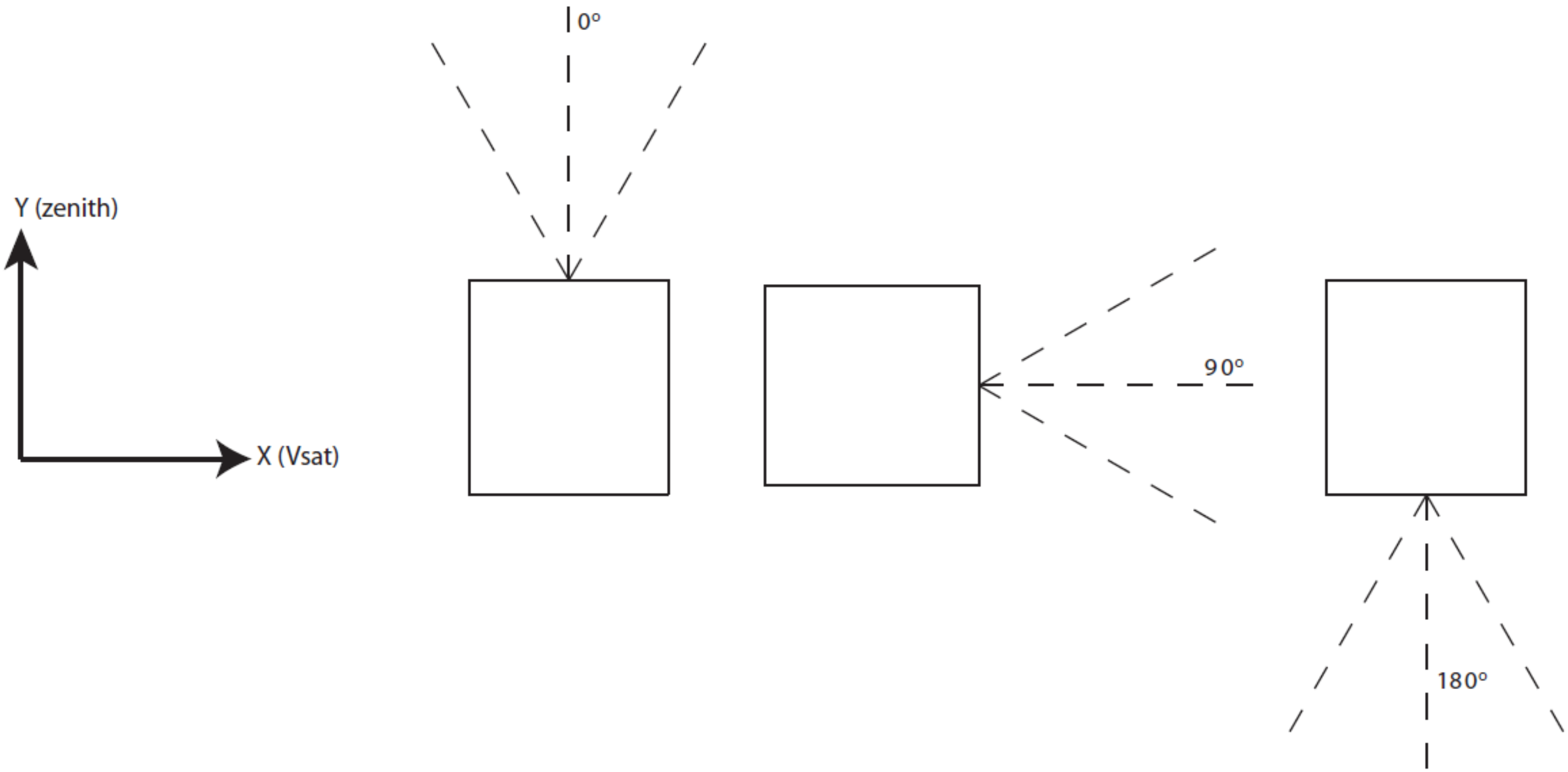
  (three detector houses)
- Sensors: silicon surface-barrier detectors
- Total mass: 600 g



Detector houses: side views

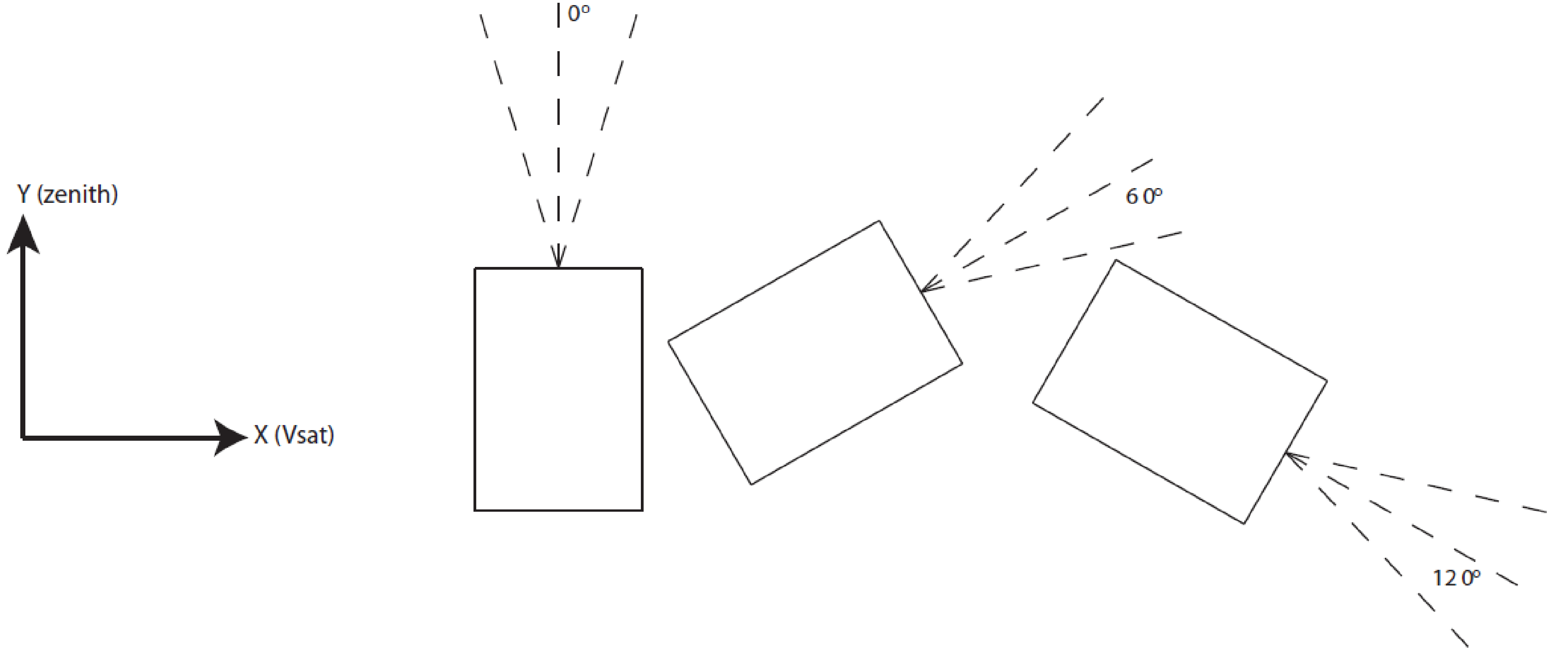
Viewing angles – Electron Detector

In a XYZ-coordinate system for the satellite, where the X-axis is along the velocity direction, and the Y-axis towards zenith:



Viewing angles – Proton Detector

In a XYZ-coordinate system for the satellite, where the X-axis is along the velocity direction, and the Y-axis towards zenith:



The detectors should not look directly into the sun

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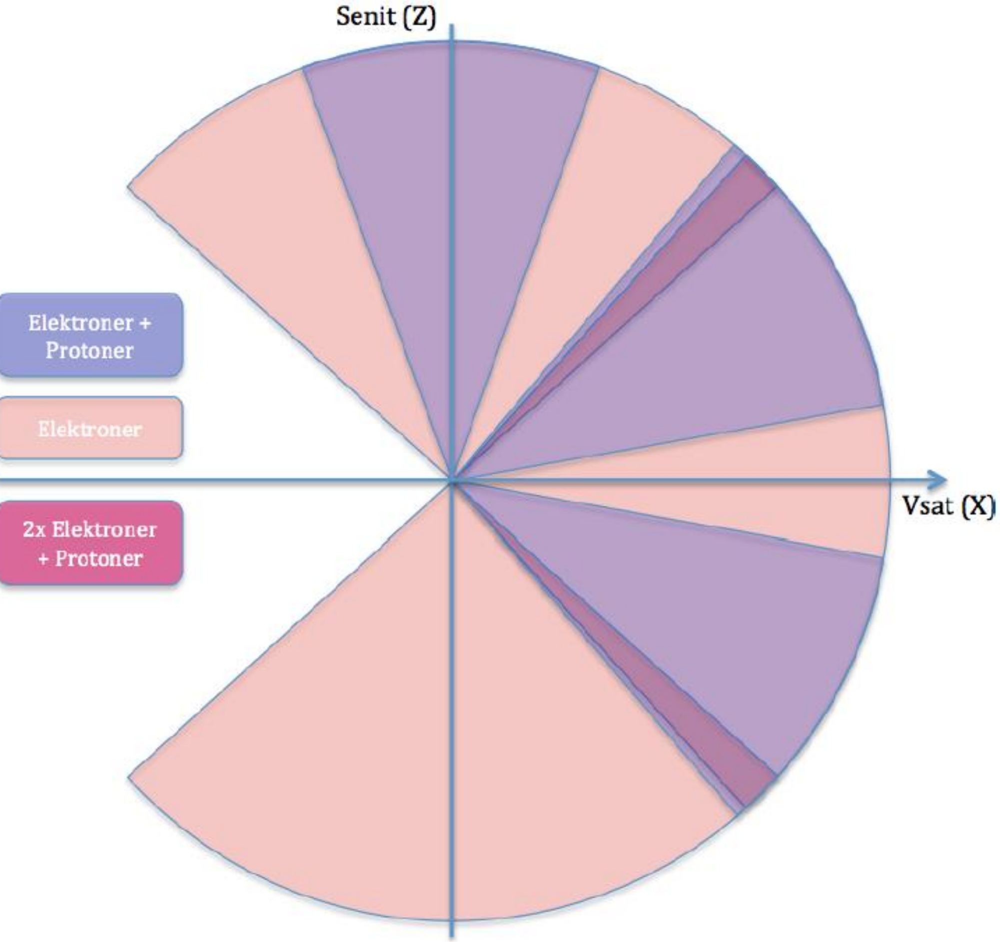
Summary



Viewing directions in the XZ-plane

	Electron detector	Proton detector
Energy range	30 - 500 keV	30 keV – 10 MeV
Detector houses	3	3
Sensors per detectors	3	1
Sensor type	Silicon Surface Barrier	Silicon Surface Barrier
Mass: detectors	~ 600 g	~ 600 g
Mass: electronics	~ 800 g	
Mass: total	~ 2 kg	
Power	~ 5W	
Stability	2^{o}	
Data	30-60 Mbit/orbit	

Technological development

- Silicon Surface Barrier Detectors:
  Sintef Microsystems and Nanotechnology

- Electronics:
  Front end electronics from IDEAS?

- Development of complete instrument at the Institute for Physics and Technology, UiB

- We have extensive in house experience with particle experiments and other space experiments flown on rockets and satellites

Wider impacts:

- EISCAT 3D – D-region and spatial and time resolution!
- Space environment
- Space weather effects

  (radio blackout in polar regions, 10-20 MHz)
- Context to the Langmuir probe and possible a radiometre

EISCAT_3D – Best radar in the world (233 MHz, 10 MW)

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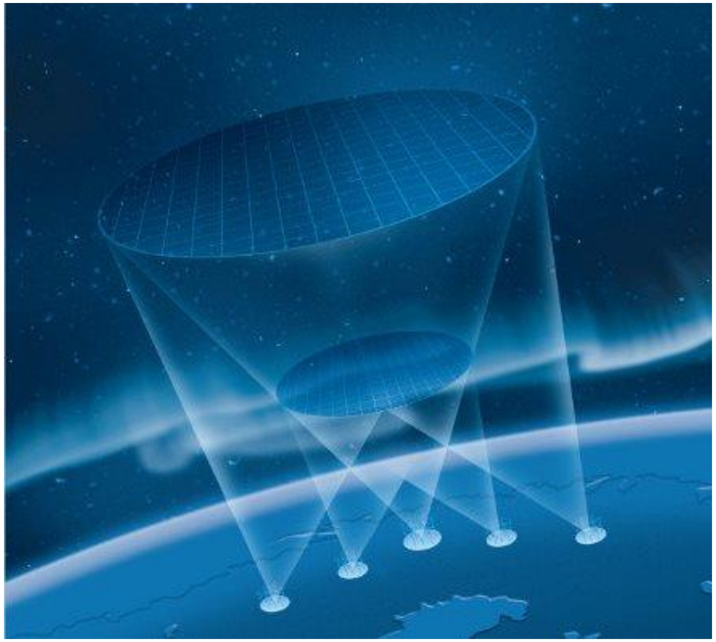
FOR SPACE SCIENCE

- UiT has applied to RCN for 228 MNOK
- Full support from Norwegian universities
- International project on ESFRI roadmap
- Stage 1: starting in 2015, completed in 2020
- **EISCAT_3D will give full 3D-measurements**
- Our instrument will complement EISCAT_3D (similar time/space resolution, but from above)



Particle energies and impact alititudes

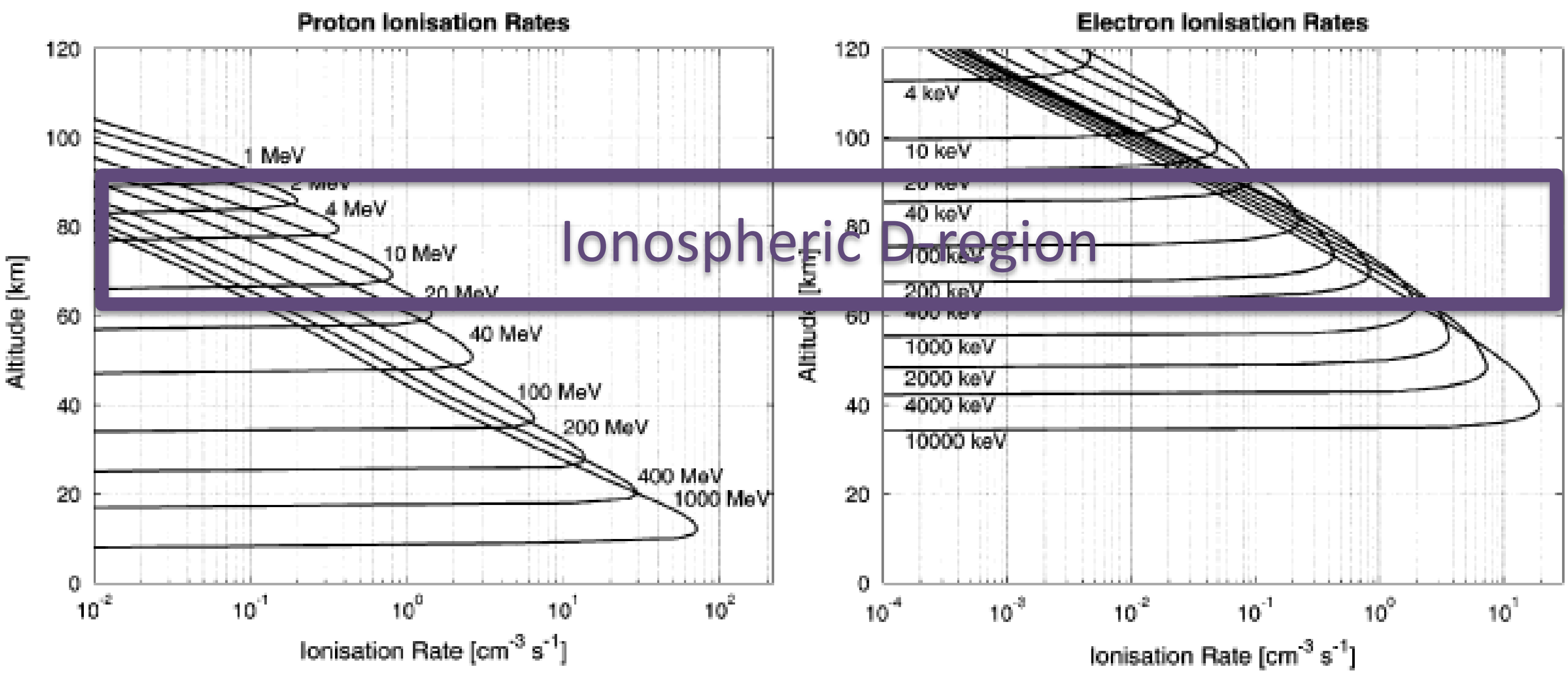


Figure reference: *Turunen et al. (2009)*