Annual Variation of the Atmosphere in Malargüe and the Implication on Auger FD Observables

setup in the Pampa Amarilla

field PC in FD building Coihueco

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Paris, May 2003

data acquisition

PIERRE AUGER OBSERVATORY

- Auger Fluorescence Detector measures **longitudinal shower development**
- **Atmospheric parameter** affect the development and detection at every height

Knowledge of **atmospheric profiles** is required

Radiosonde measurements in each season are performed:

- 44 launches in total
- average reached altitude ~ 20 km a.s.l. (maximum was 27.5 km a.s.l.)
- roughly every 20 m a set of data (**h, p, T, u, wind**)
- used DFM-97 GPS sondes (www.graw.de)
- accuracy: T < 0.2 K
  p < 1.0 hPa (range 200 hPa to 1080 hPa)
  < 0.5 hPa (range 5 hPa to 200 hPa)
  u < 5%

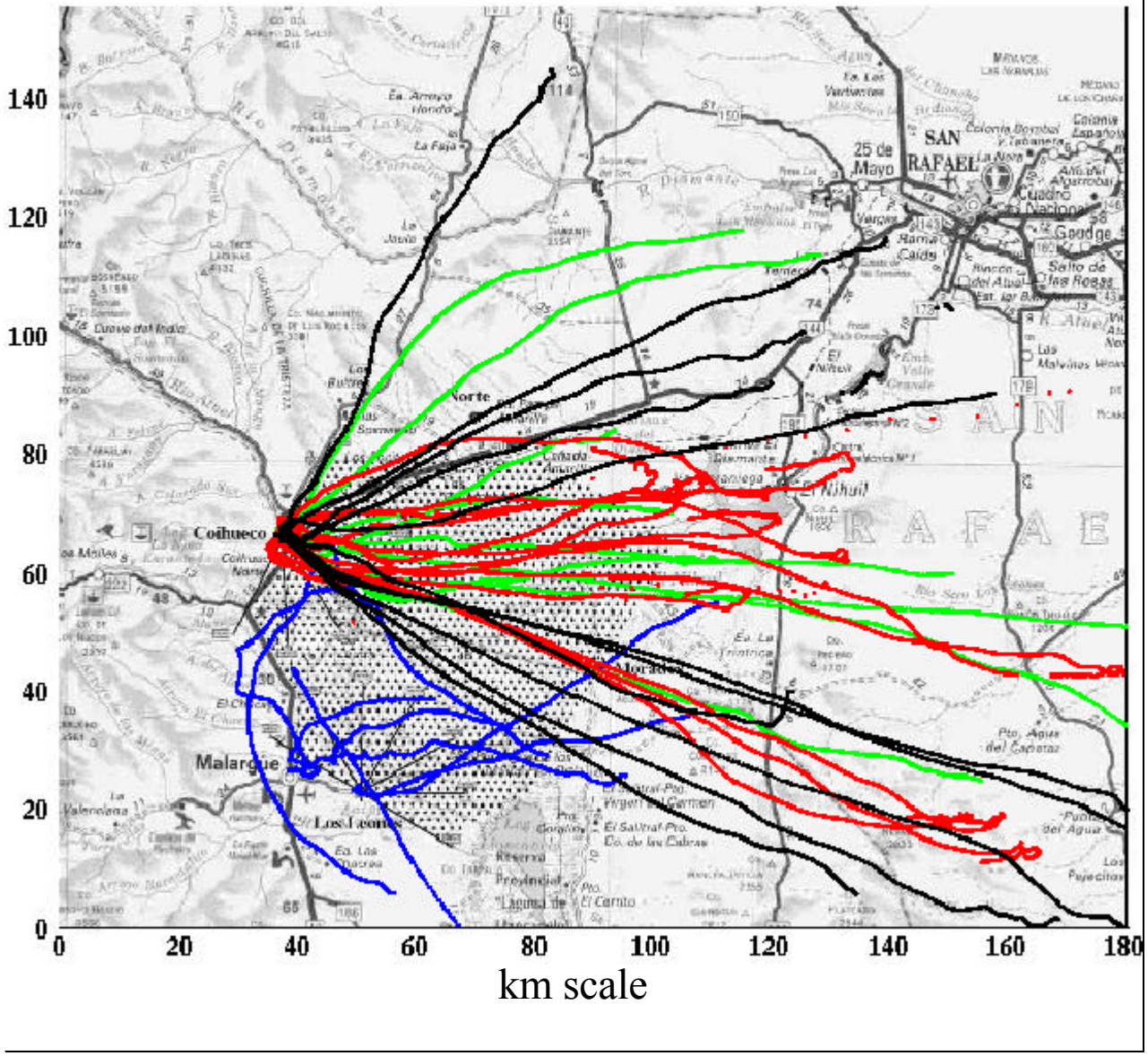
all balloon pathes

blue: winter, Aug. 2002

green: spring, Nov. 2002

red: summer, Jan./Feb. 2003

black: autumn, Apr./May 2003



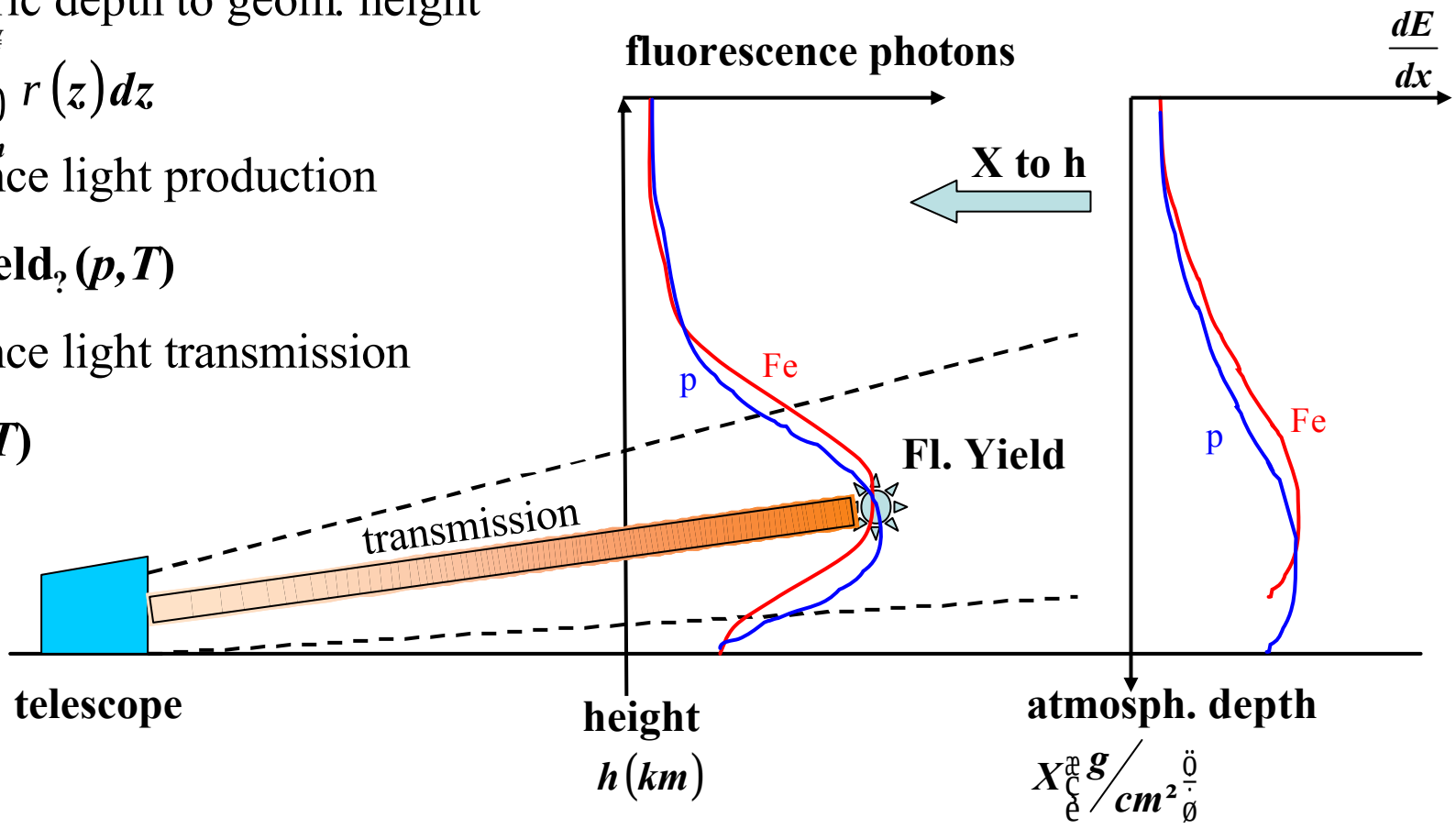
Launches per campaign:

- winter – 9
- spring – 9
- summer – 15
- autumn - 11

important effects of atmospheric profiles

on the Auger FD shower data

1. atmospheric depth to geom. height
   - $X = \int_0^h r(z)\,dz$
2. fluorescence light production
   - **fl. yield, (p,T)**
3. fluorescence light transmission
   - **t (p,T)**



temperature variation

- summer and winter -

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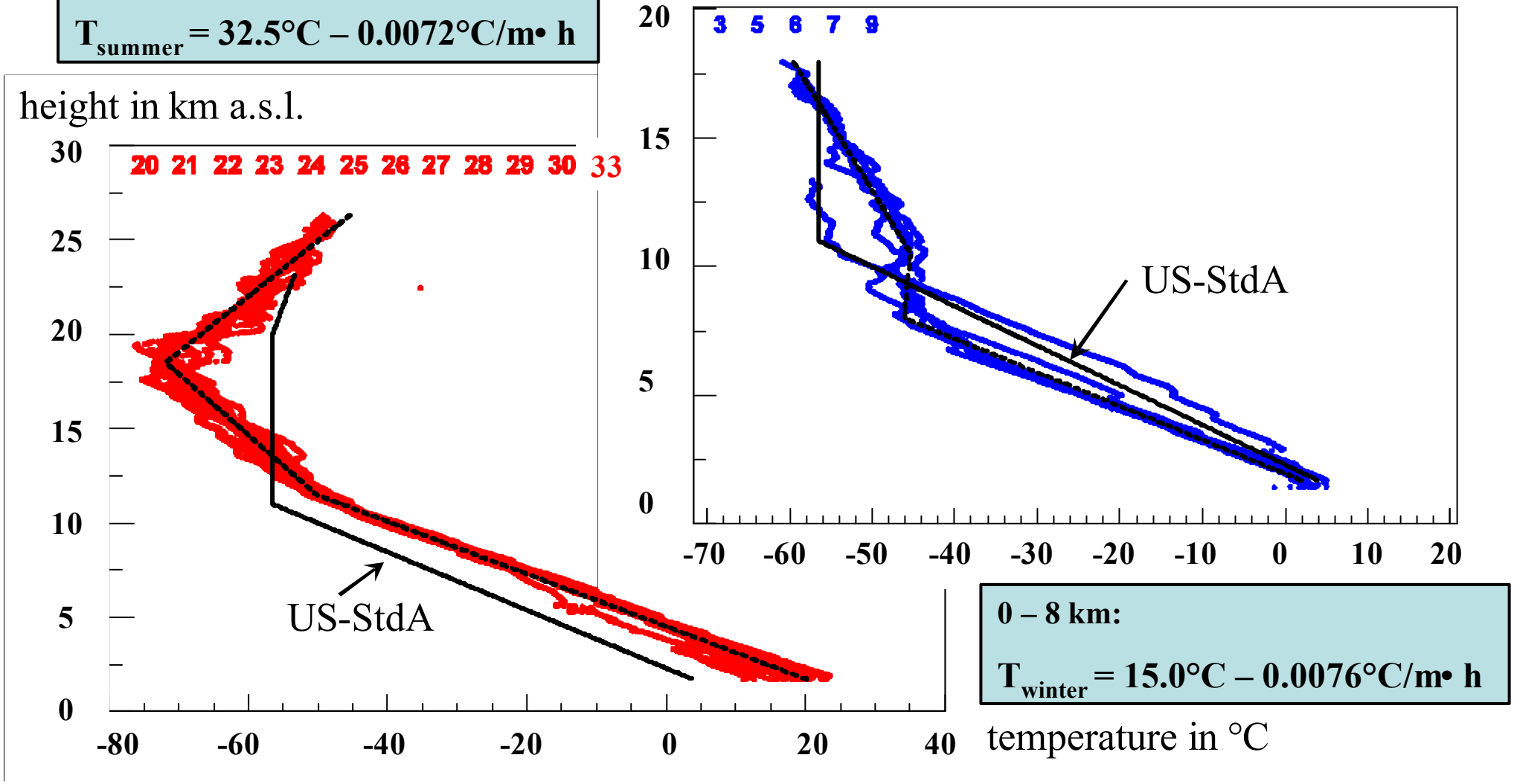
0 – 11.5 km:

$T_{summer} = 32.5°C – 0.0072°C/m \bullet h$



0 – 8 km:

$T_{winter} = 15.0°C – 0.0076°C/m \bullet h$

temperature variation

- spring and autumn -

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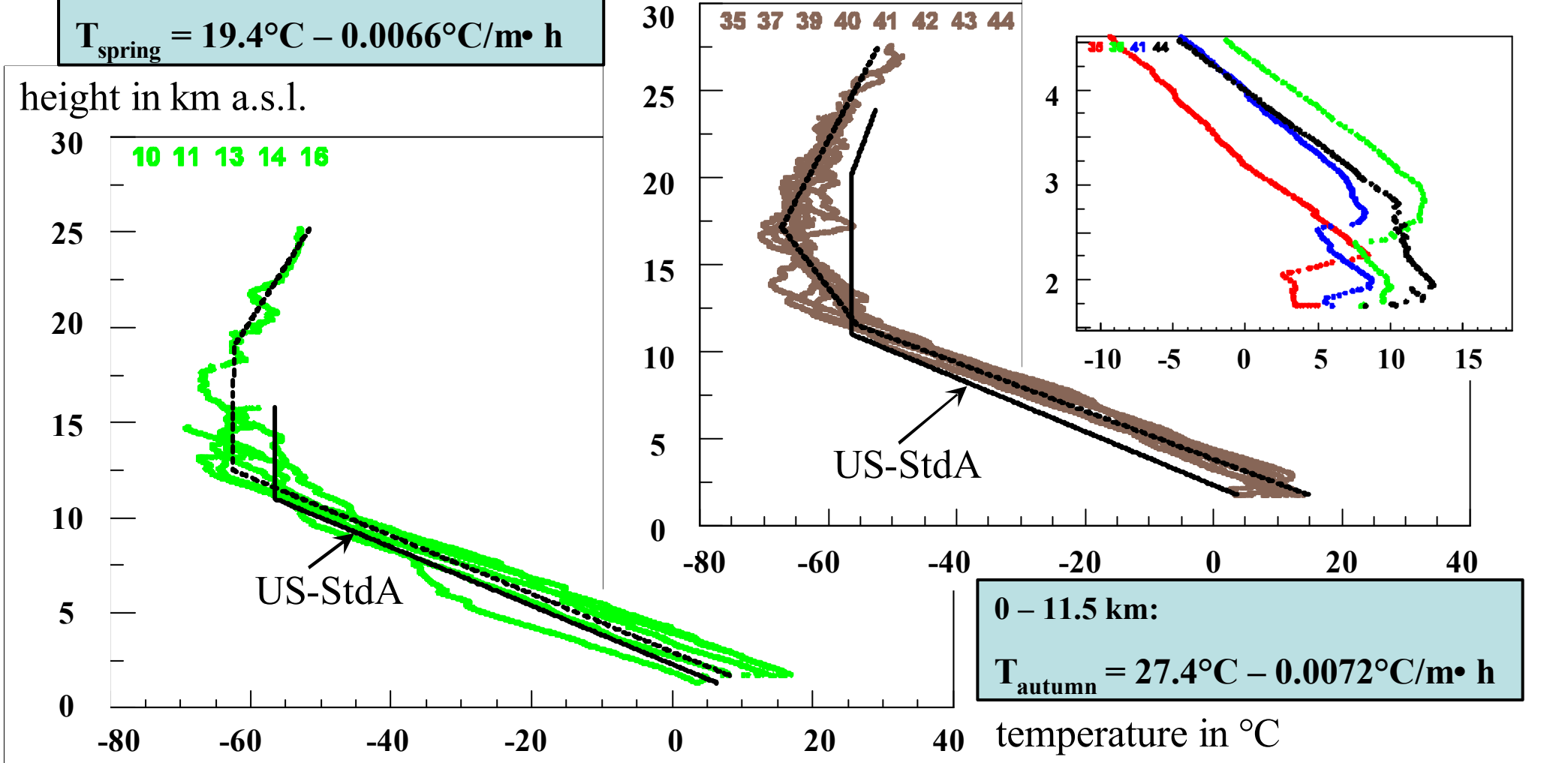
0 – 12.5 km:

T_{spring} = 19.4°C – 0.0066°C/m• h

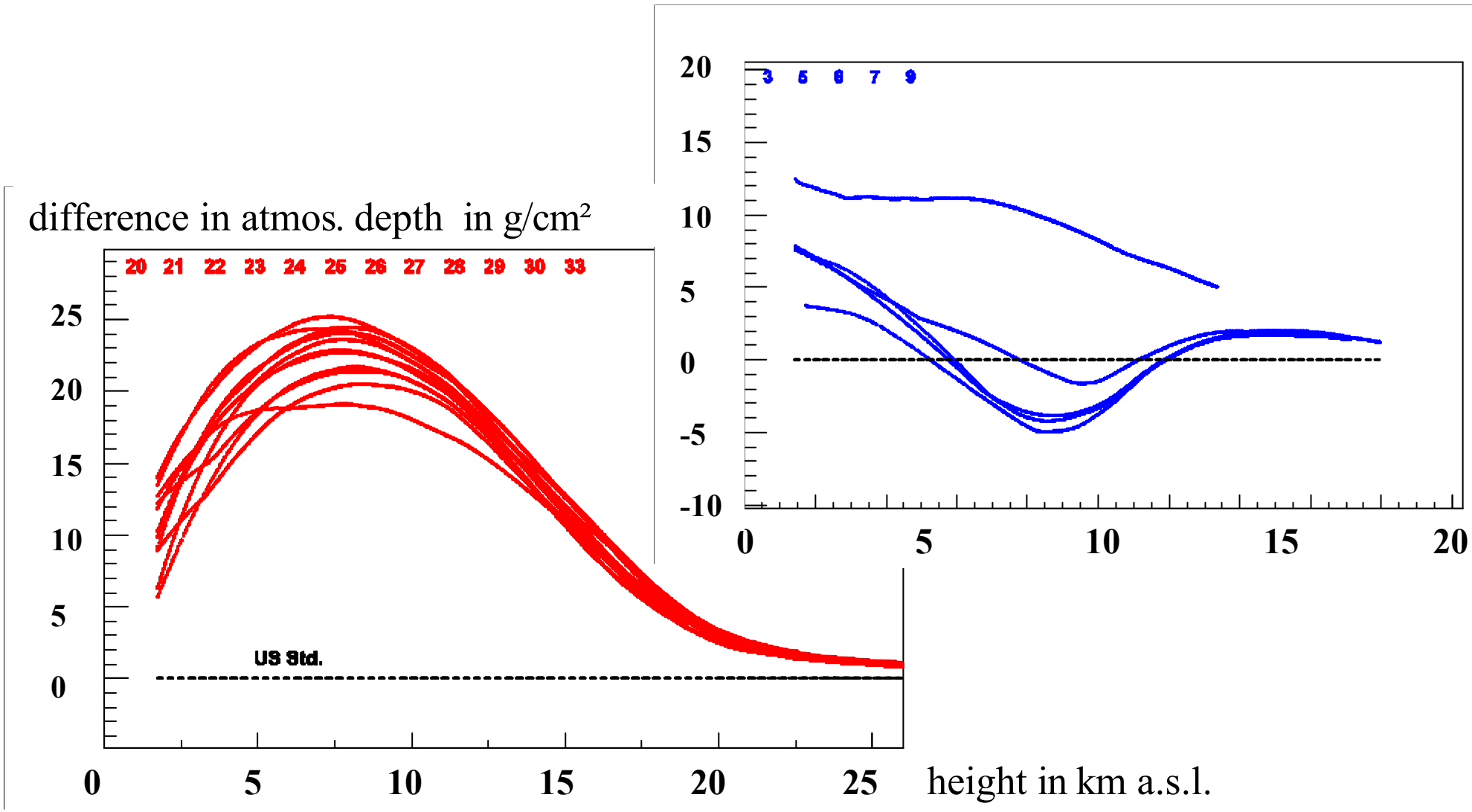


0 – 11.5 km:

T_{autumn} = 27.4°C – 0.0072°C/m• h

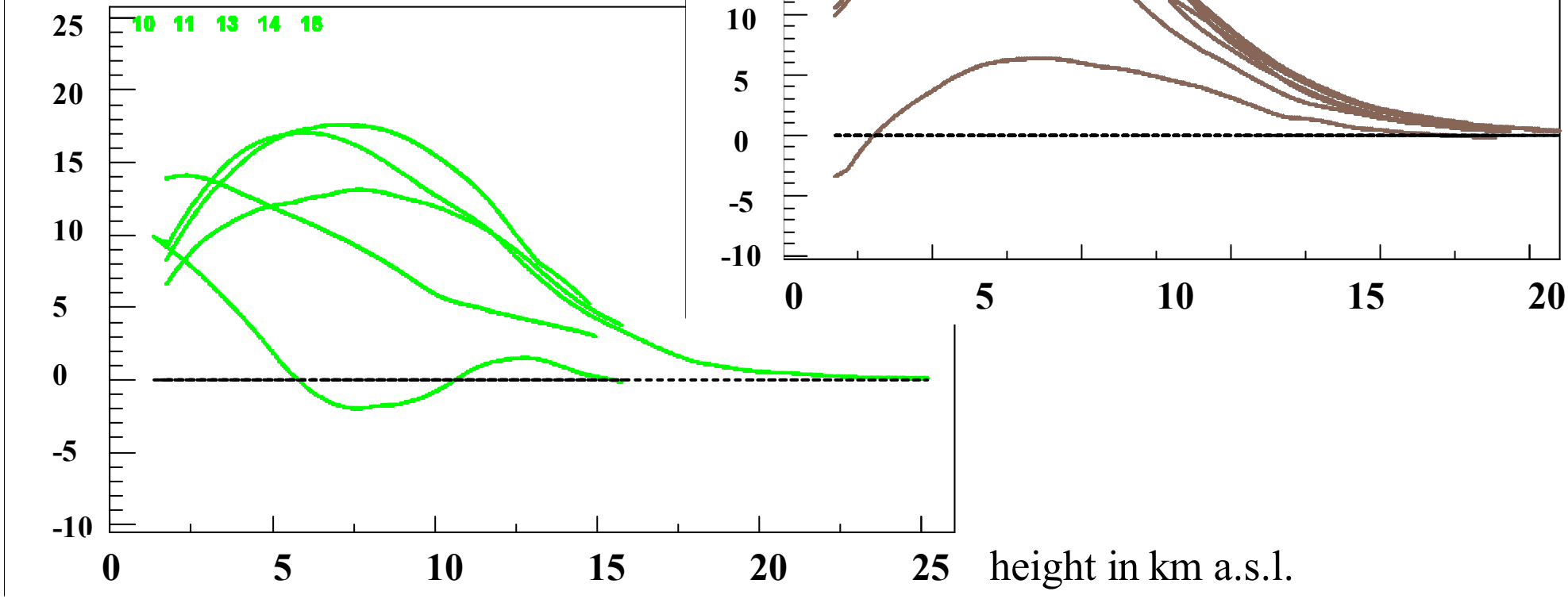
grammage variations

- summer and winter -

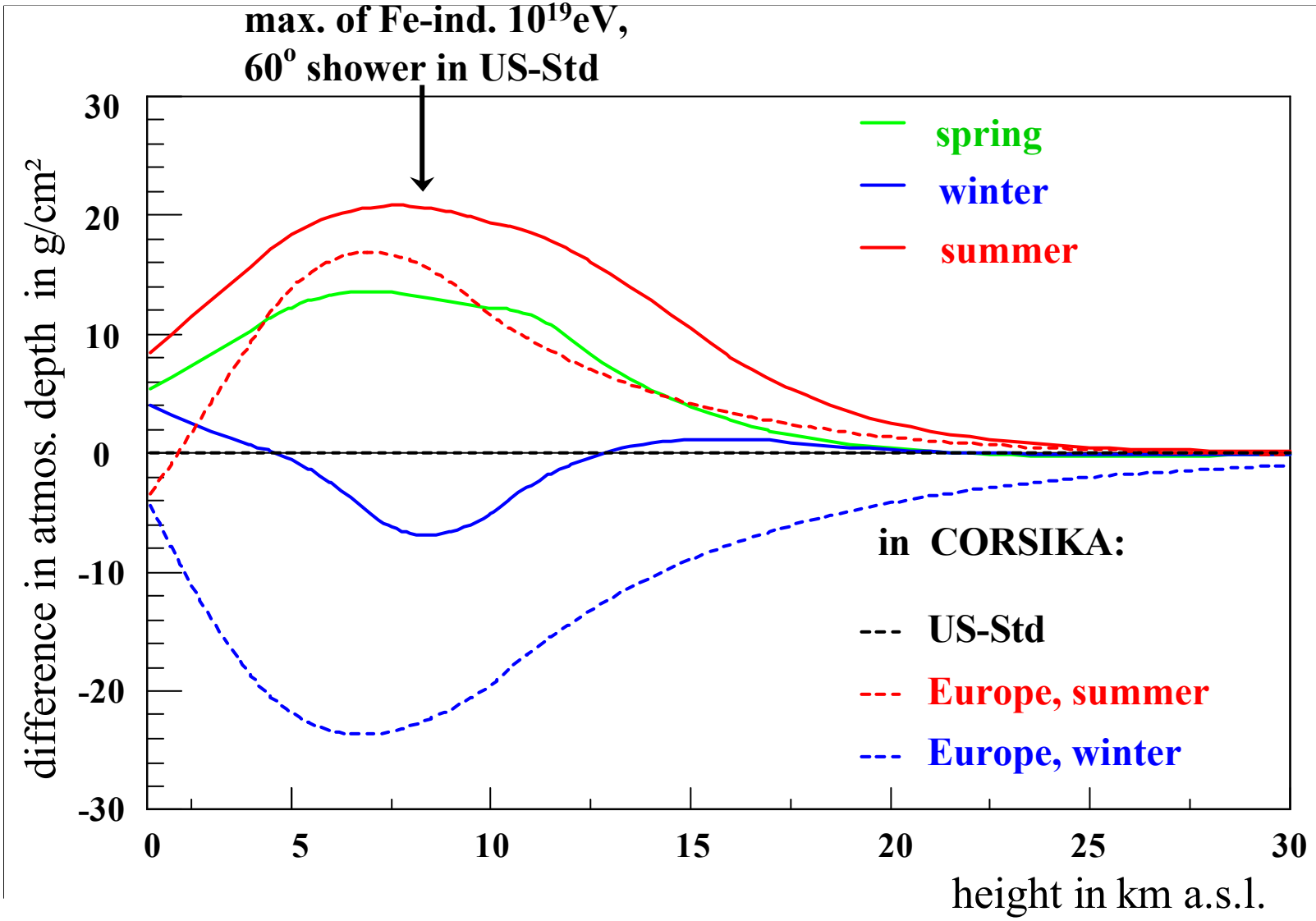


grammage variations

- spring and autumn -

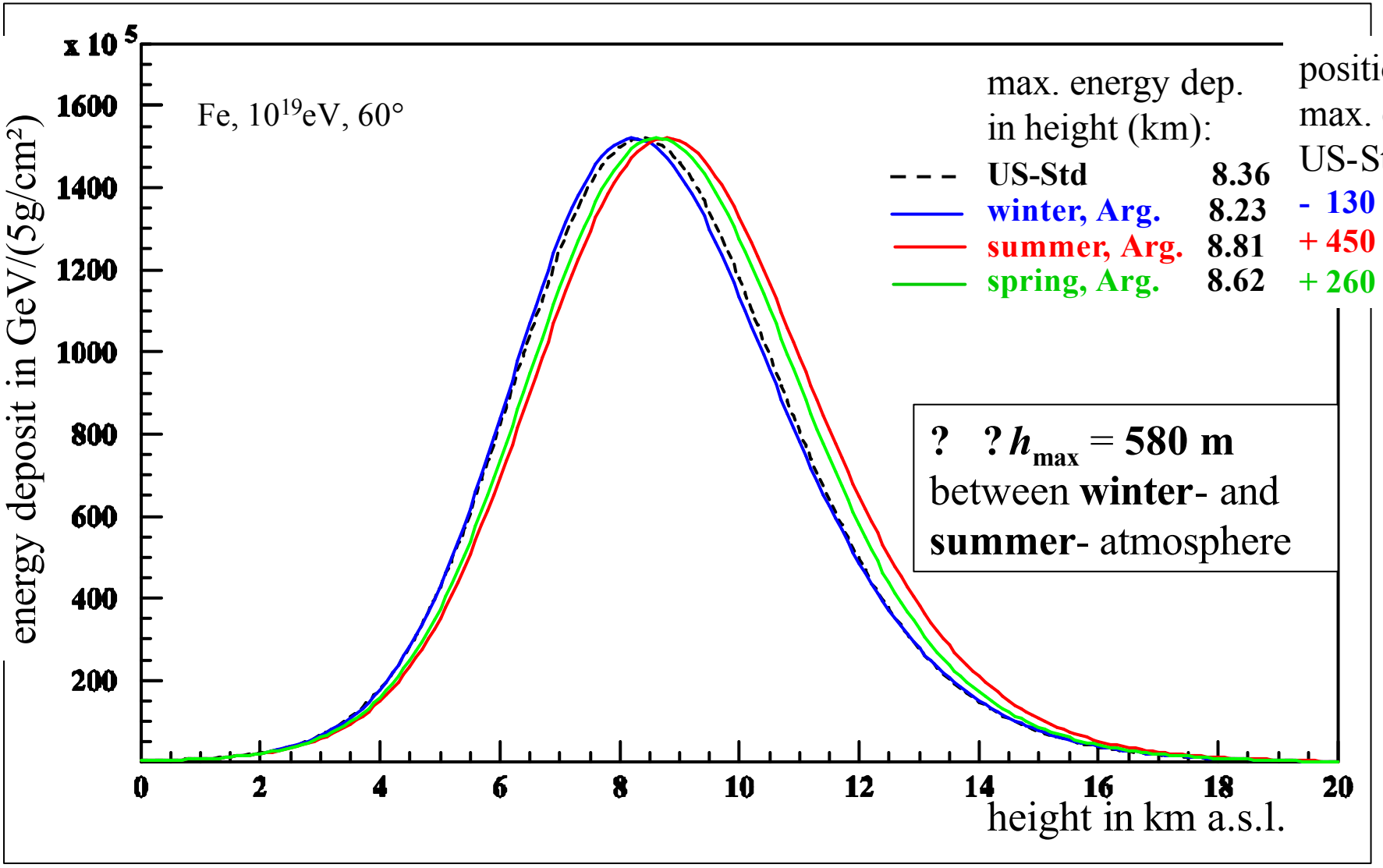


typical grammage profiles



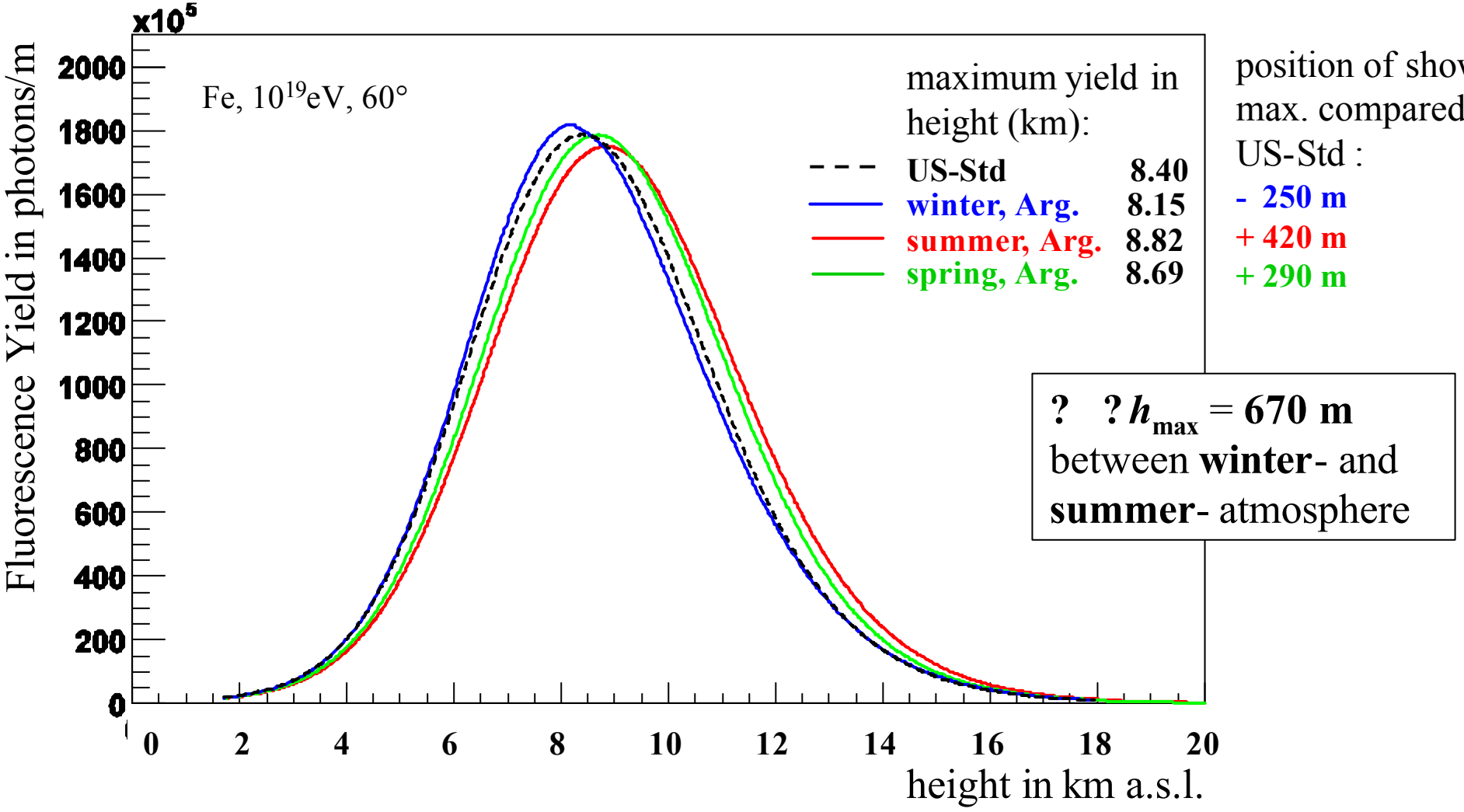
longitudinal shower development

- energy deposit -



longitudinal shower development

- fluorescence yield -



position of shower max. compared to US-Std :

- 250 m
+ 420 m
+ 290 m

? ? h_{max} = 670 m between **winter**- and **summer**- atmosphere

position of shower maximum

- fluorescence yield -

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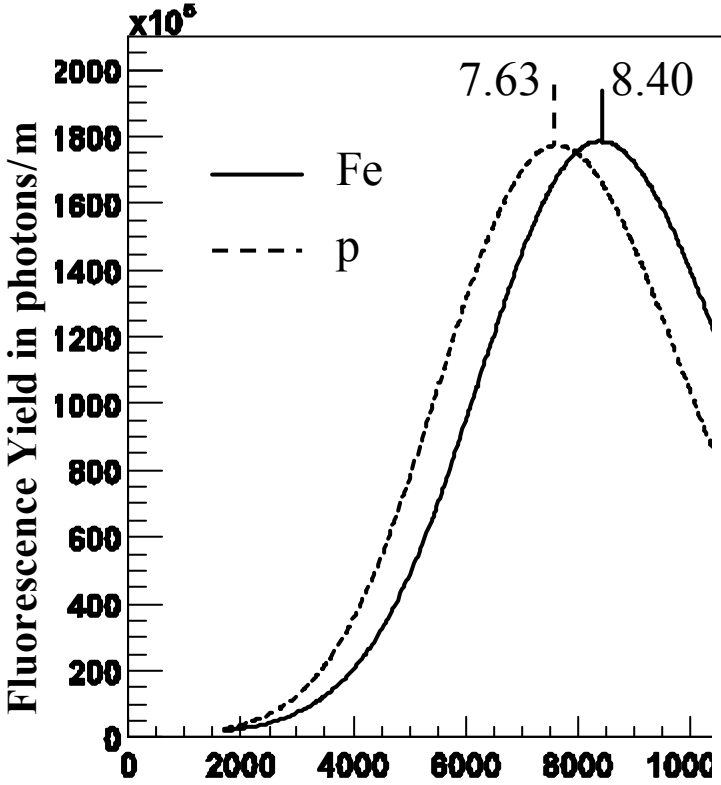
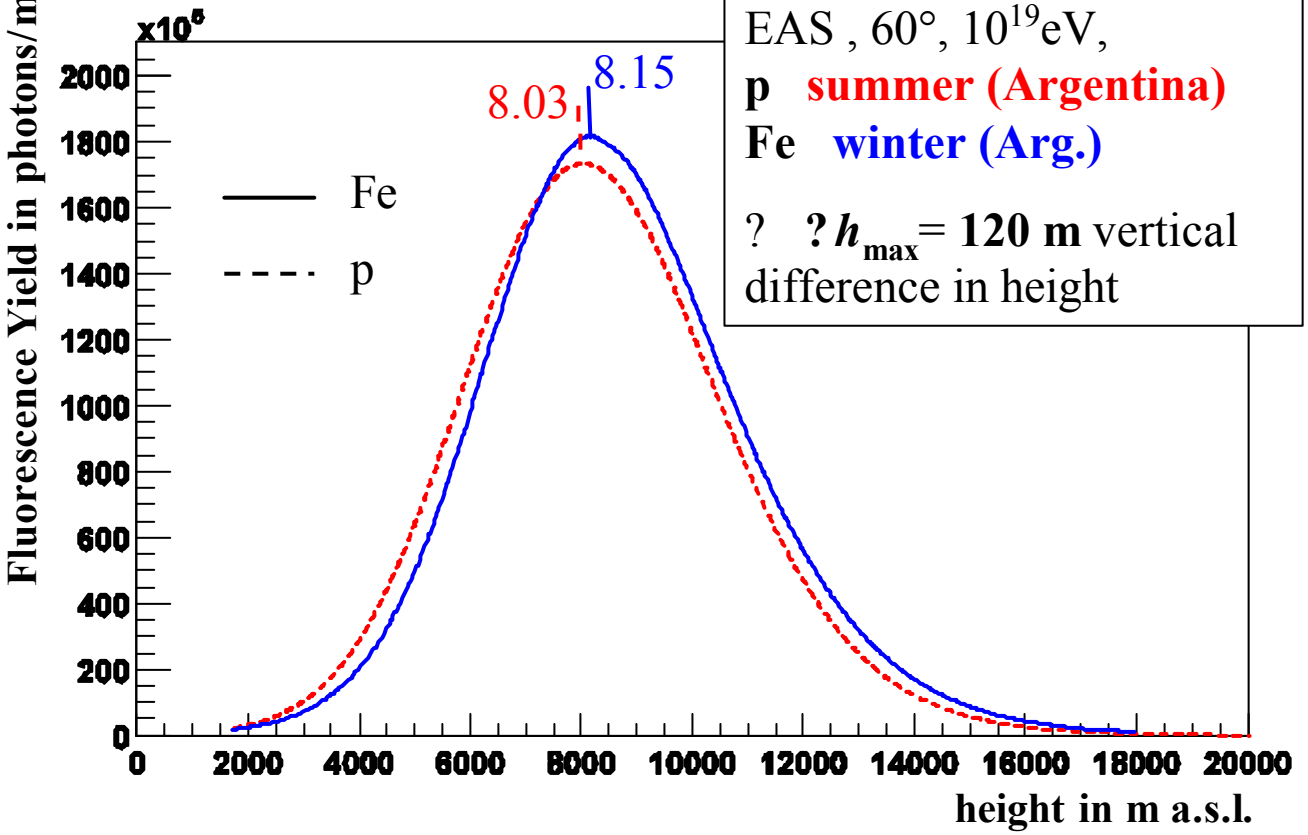


both EAS in **US-Std**, 60°, 10^{19}eV:

? ? h_{max} = **770 m** vertical difference in height



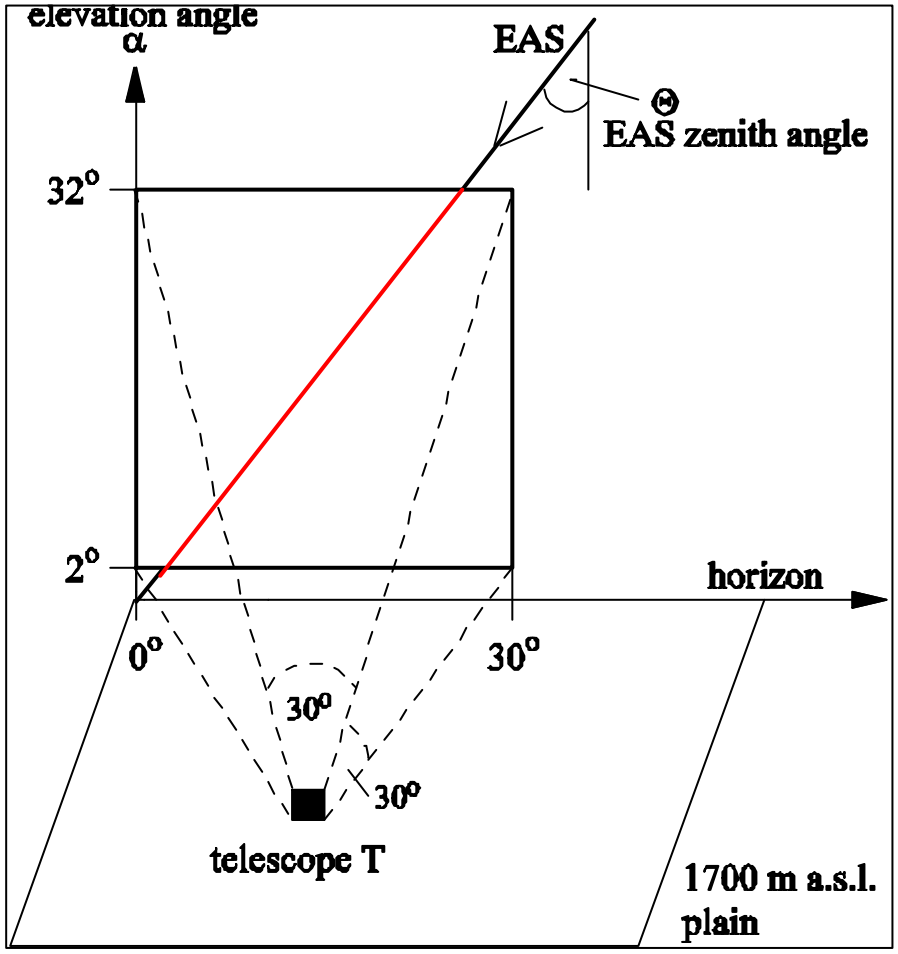
EAS , 60°, 10^{19}eV,

p **summer (Argentina)**

Fe **winter (Arg.)**

? ? h_{max} = **120 m** vertical difference in height

Rayleigh transmission - geometry



visible part of the shower

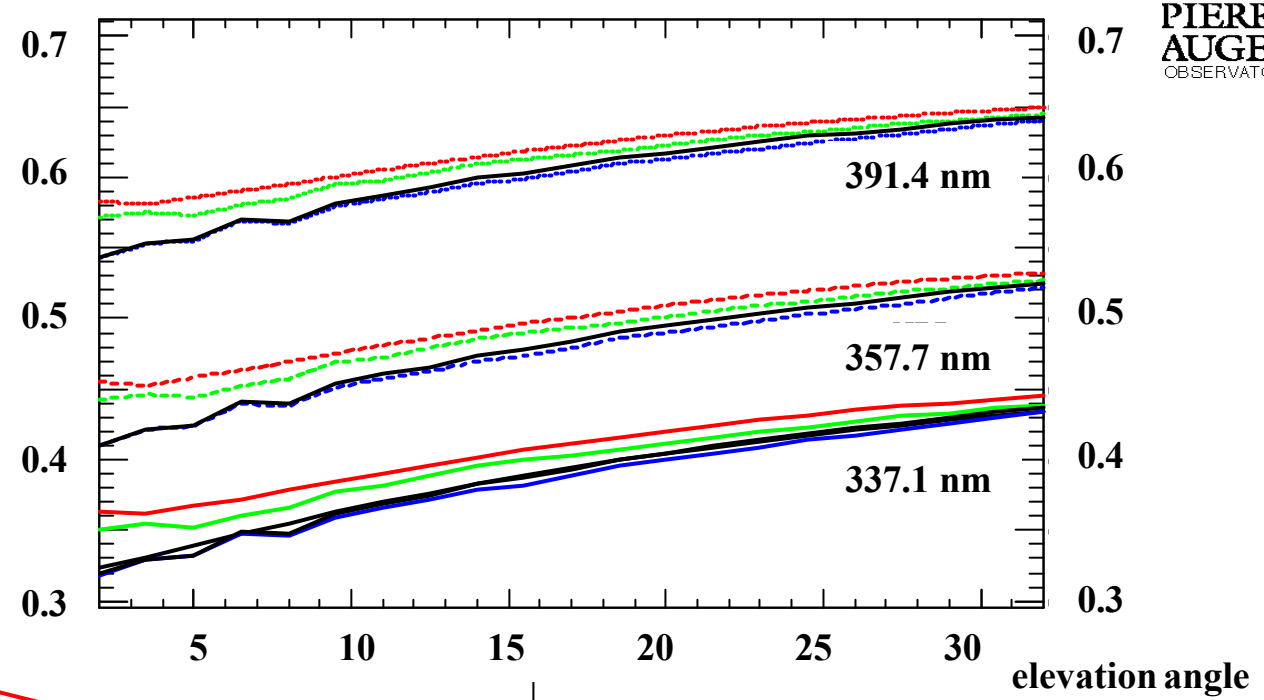
typical distance (shower, telescope):

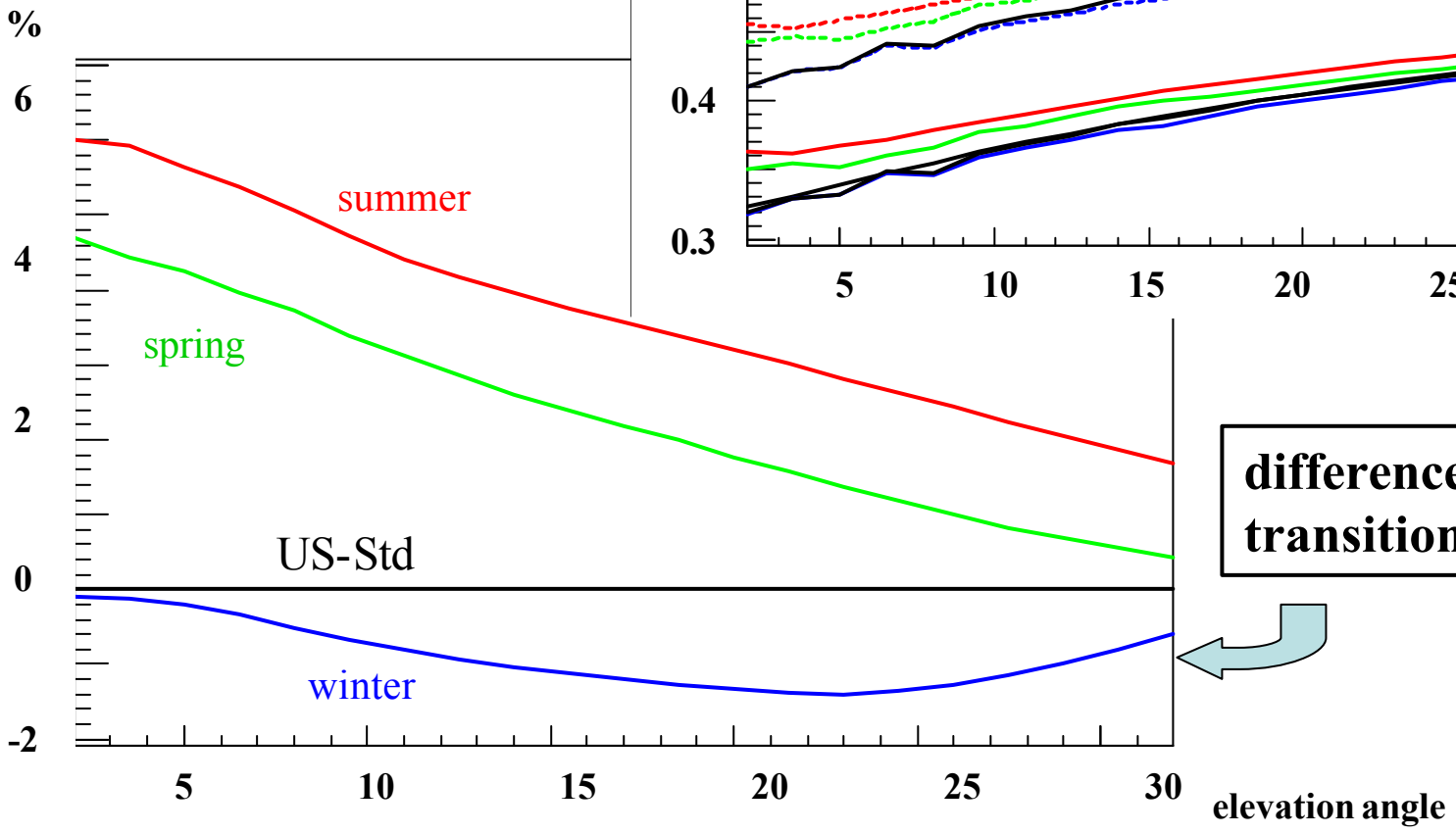
~ 15 km

Rayleigh transmission

realistic atmospheres

- at three wavelengths

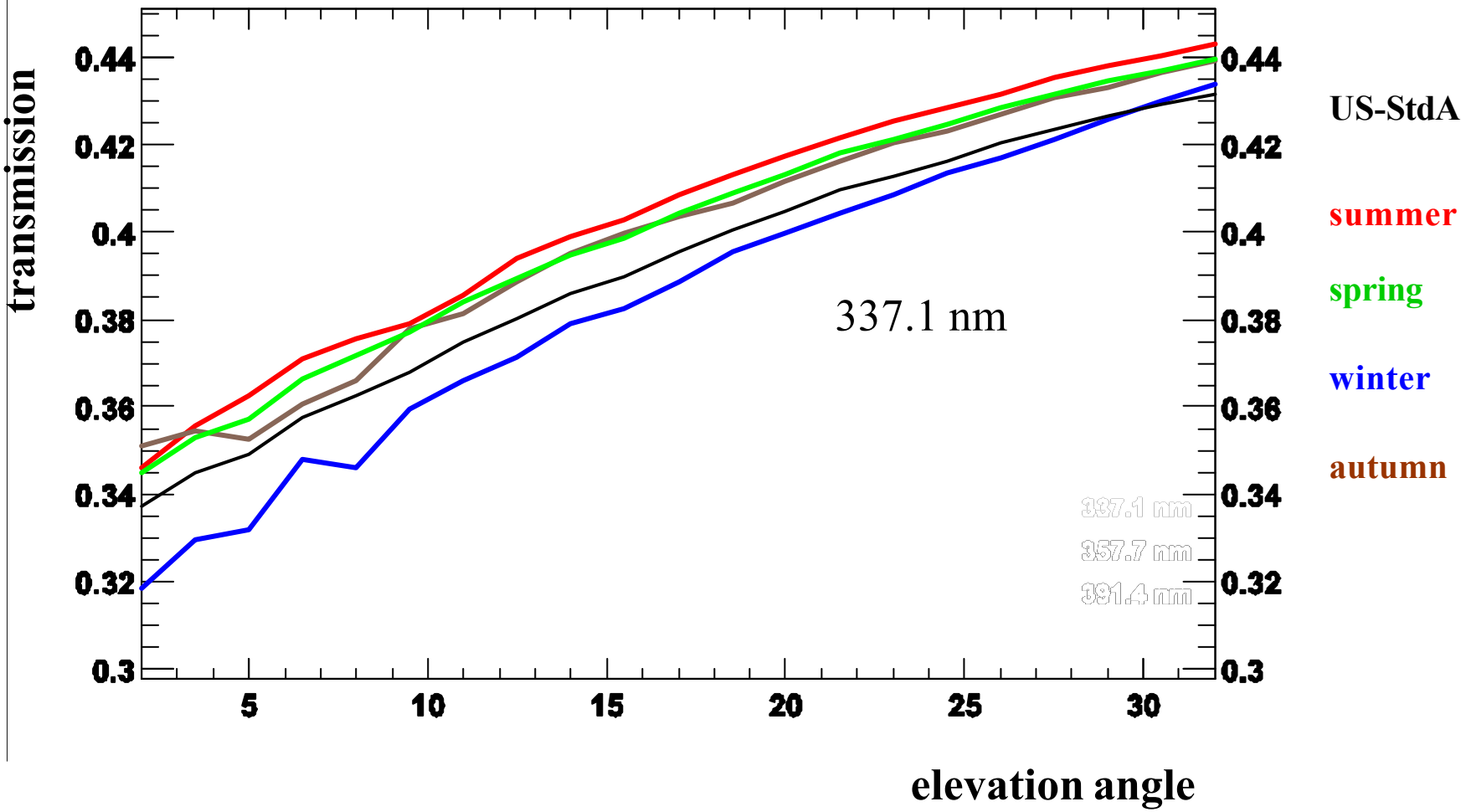




differences in Rayleigh transition at 337.1 nm

Rayleigh transmission

with correction for ground parameter



summary

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- **three important effects of the atmospheric profiles :**
  1. longitudinal shower development according to geometrical height
     (? $h_{max,Fe}$ (summer ? winter) up to 580 m)
  2. fluorescence light production
     (**?** *Fl.Yield* from measured data ~ 4 %, with constant E_{dep} ;
     ? $h_{max,Fe}$ (summer ? winter) up to 670 m)
  3. fluorescence light transmission to the telescope (Rayleigh)

  good data on the atmospheric profiles is necessary for the accurate reconstruction of EAS

  (? h_{max} up to (30 g/cm²)/*cos* T ? h_{max} (p to Fe) ~ 80 g/cm²)

- **first radiosonde data from Malargüe, Argentina :**
  1. large differences from the US Standard atmosphere
  2. seasonal variations shifted compared to Europe data