HEAT – Studien zur Ausrichtung der Teleskope

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PIERRE AUGER OBSERVATORY

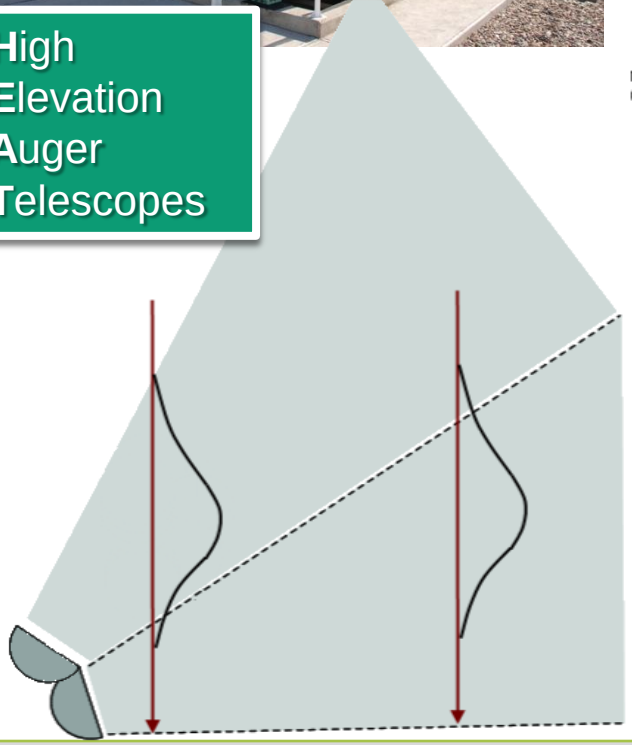
Karlsruhe Institute of Technology

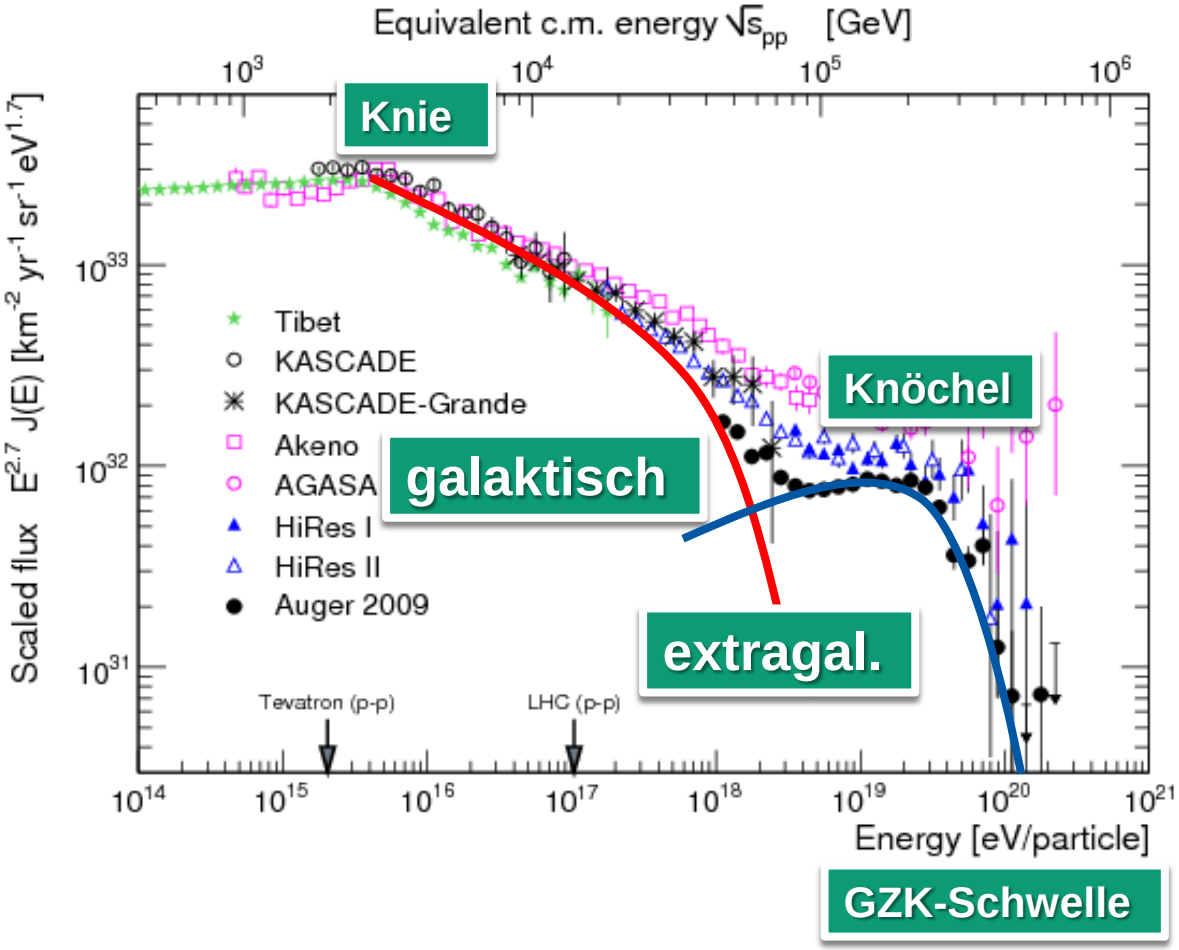
Pierre-Auger-Observatorium

- Malargüe, Argentinien
- Datennahme seit 2004
- Hybrid-Technik
  - 1600 Oberflächen-detektoren
  - 24 Fluoreszenz-teleskope
- Primärteilchen-energie $> 10^{18}$eV

Motivation

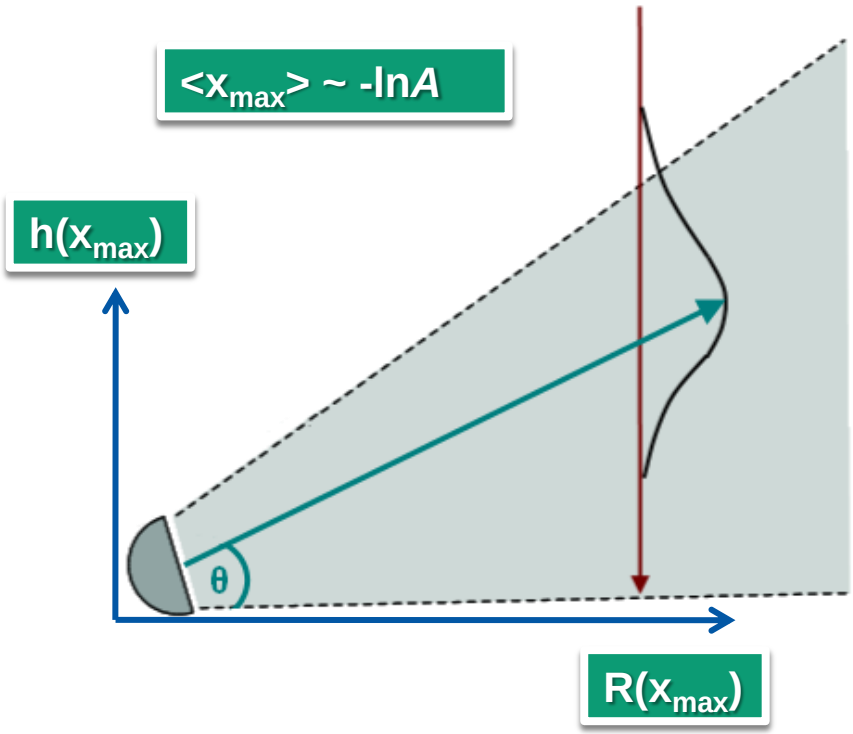
High
Elevation
Auger
Telescopes



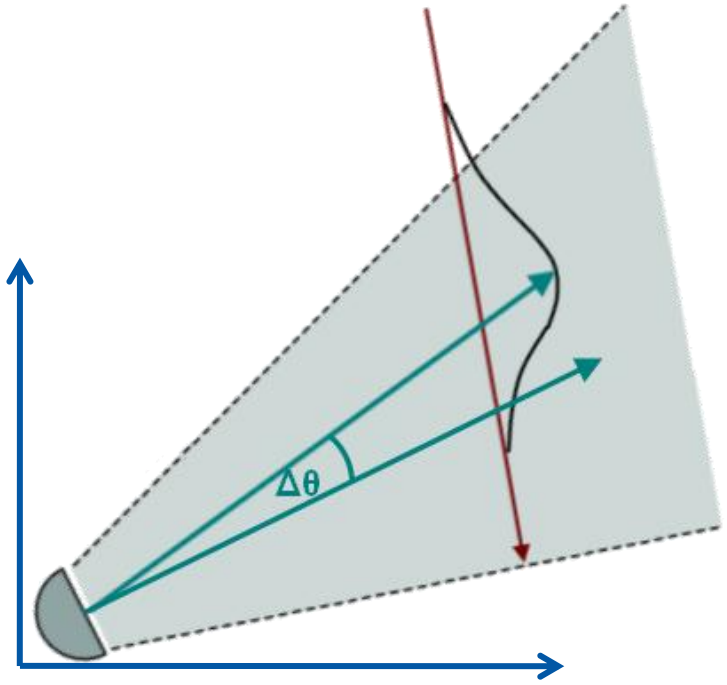


Einfluss der Teleskopausrichtung

Angenommene Ausrichtung

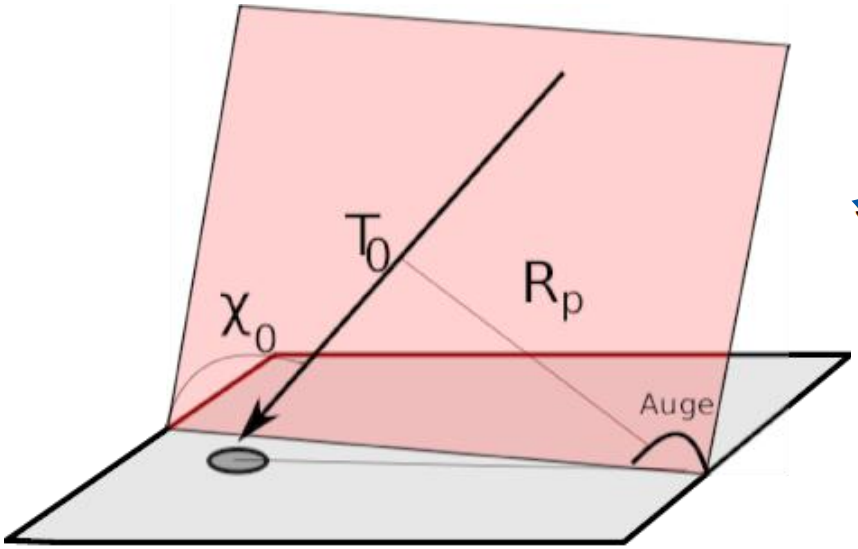


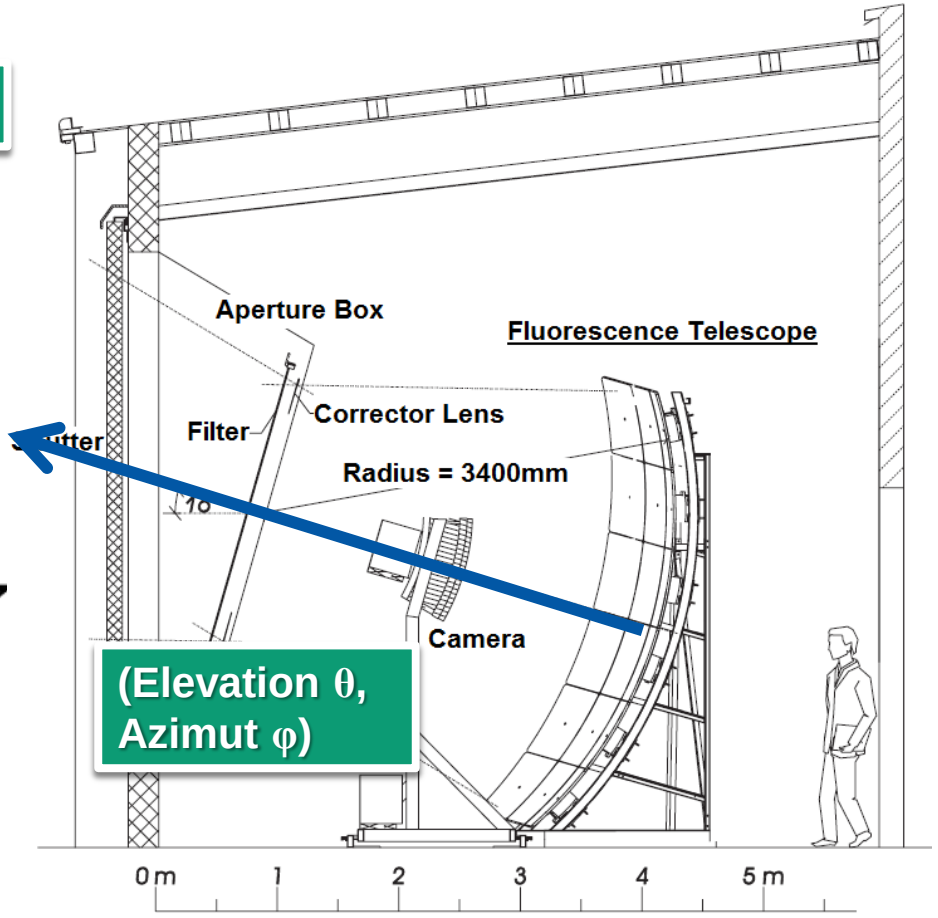
Tatsächliche Ausrichtung



Geometrie

Shower Detector Plane (SDP)

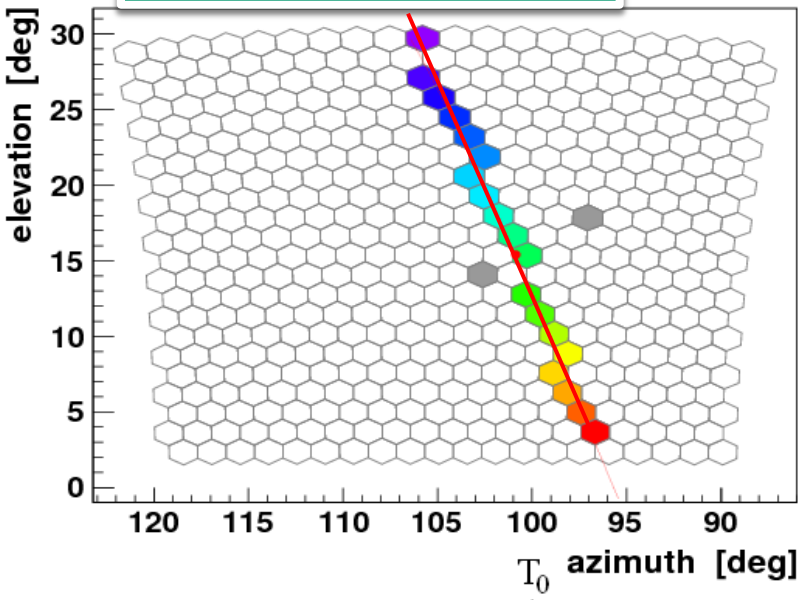


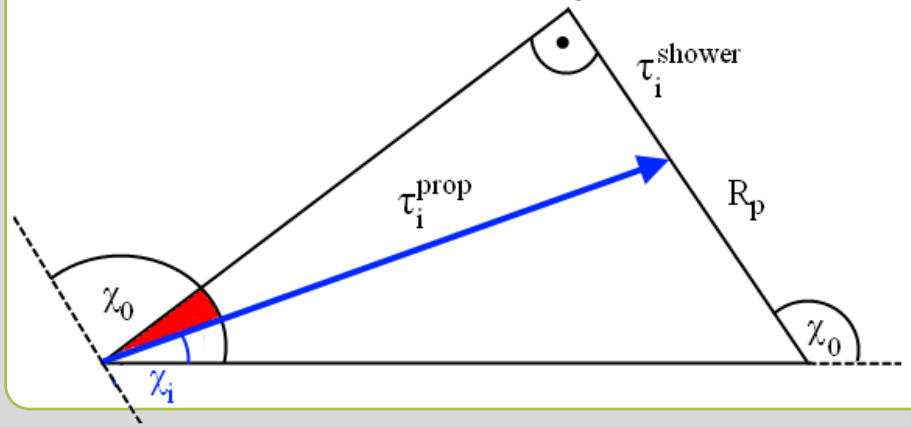


Augensystem

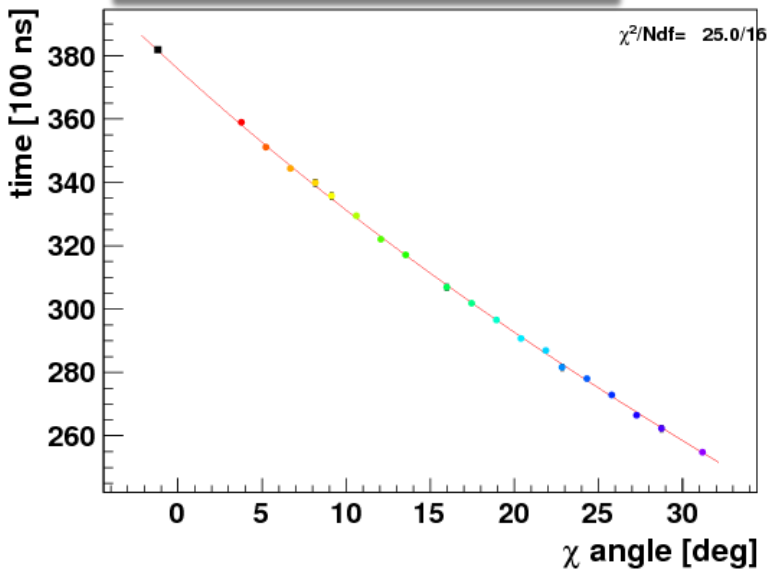
Schauerrekonstruktion

SDP-Fit



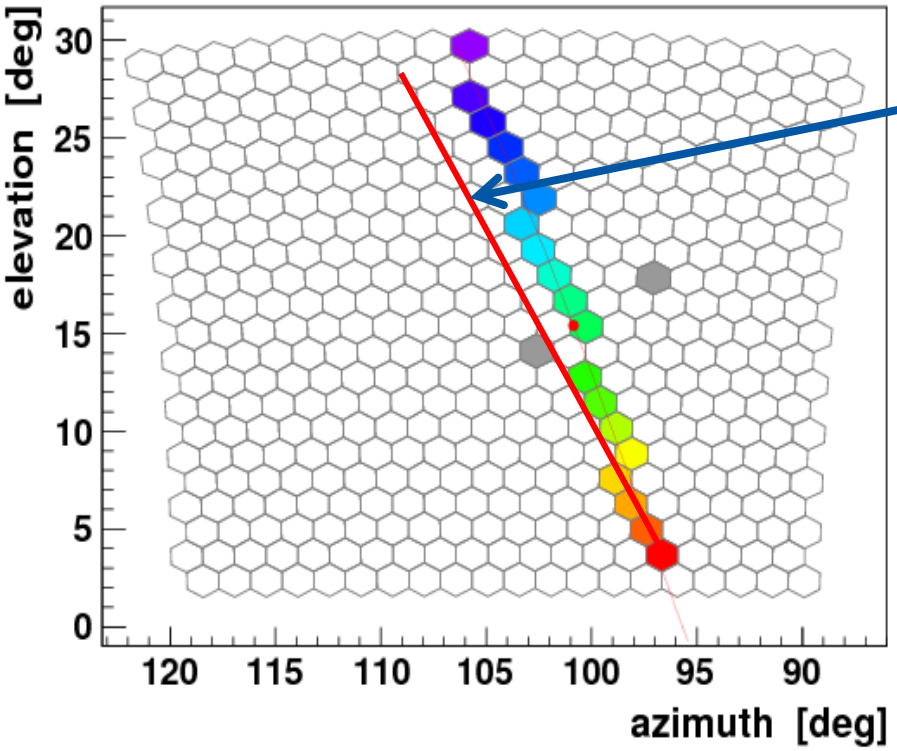


Time-Fit



$$
\begin{aligned}
t_i^{\mathrm{exp}} &= t_0 - \tau_i^{\mathrm{shower}} + \tau_i^{\mathrm{prop}} \\
&= t_0 + \frac{R_p}{c}\left(\frac{1}{\sin(\chi_0 - \chi_i)} - \frac{1}{\tan(\chi_0 - \chi_i)}\right) \\
&= t_0 + \frac{R_p}{c}\tan\left(\frac{\chi_0 - \chi_i}{2}\right)
\end{aligned}
$$

Bestimmung der Ausrichtung

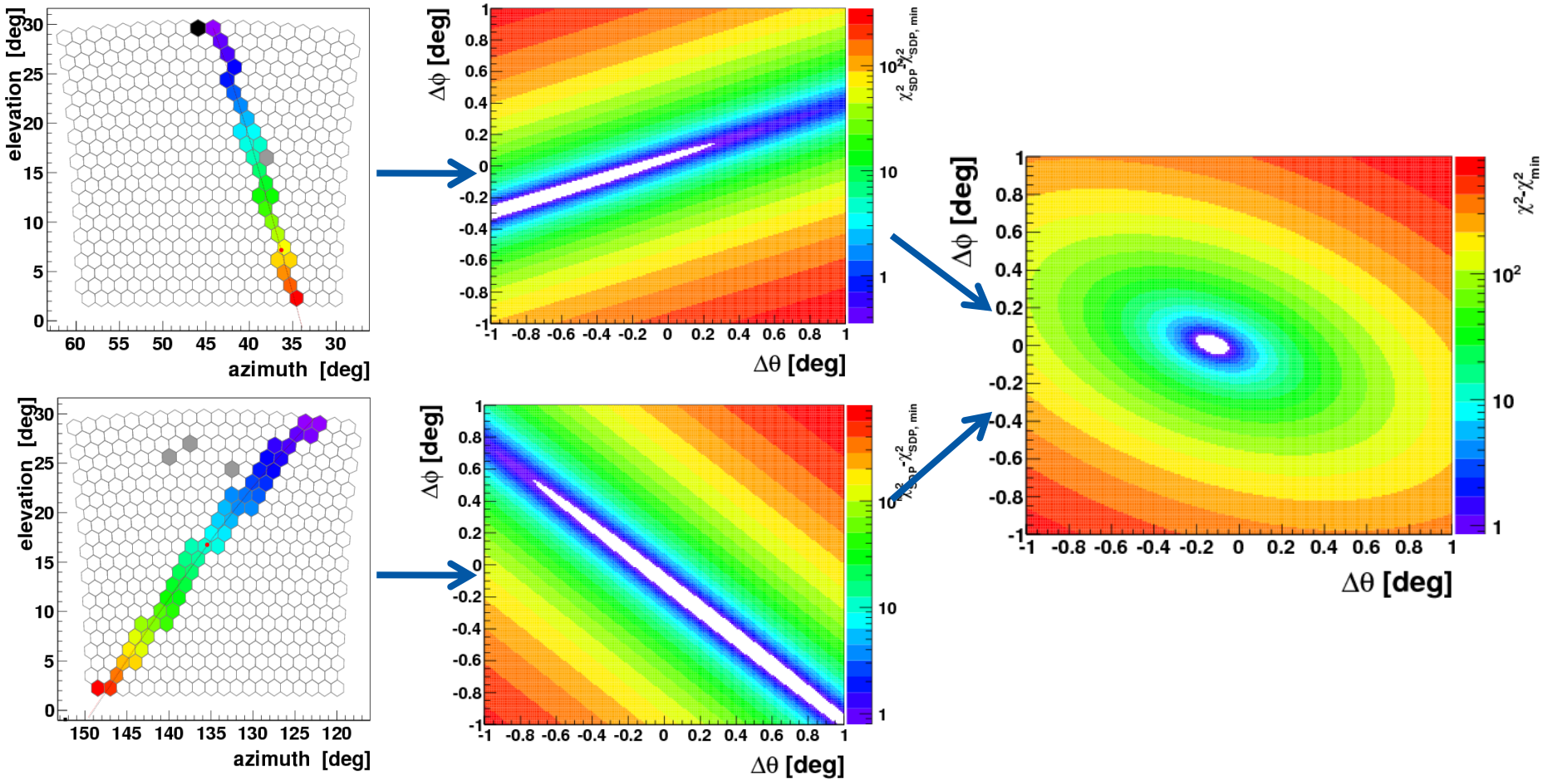


- Verwenden einer Referenzgeometrie

<Ort, Richtung, Zeitpunkt>

  - LASER-Schüsse (CLF)
  - Oberflächendetektor (SD)
  - Fluoreszenzteleskope (FD)
- Projektion in Augensystem
- Minimieren der Pointing-Parameter :
  - Elevation: $\Delta\theta$
  - Azimut: $\Delta\varphi$

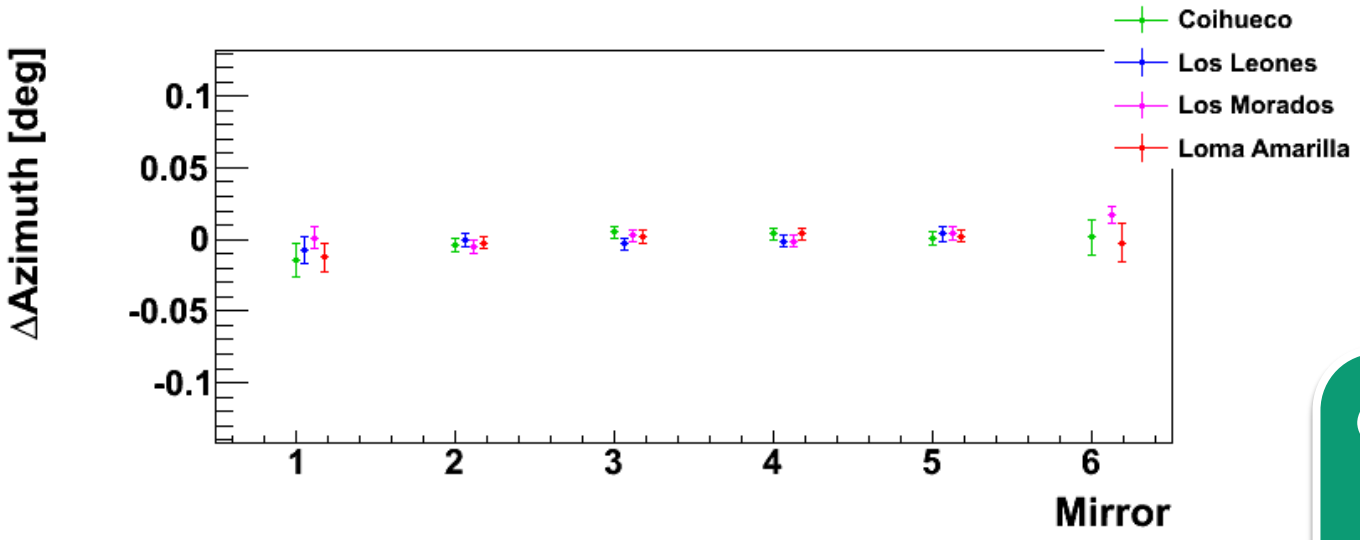
Algorithmus

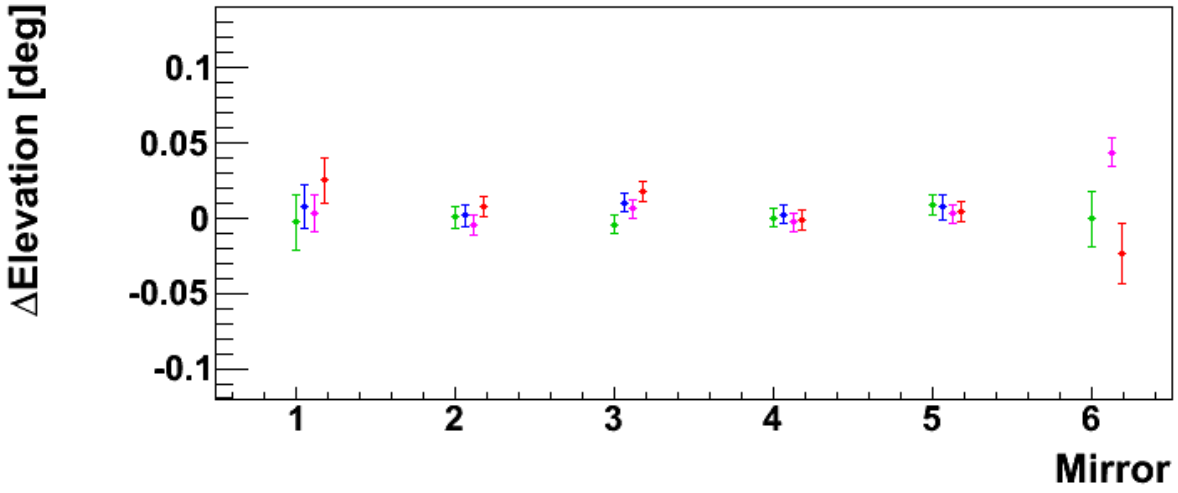


Ereignisse

$$\chi^2 = \chi^2_{SDP} + \chi^2_{SDP}$$

MC: Referenz - wahre Geometrie





$(\Delta\theta, \Delta\varphi)<0.1°$

➢ Algorithmus funktioniert

Ergebnis & Ausblick

Elevation

Teleskop Nr.	Ref: Coihueco	Ref: CLF	default
1	(44.88 ±0.12)°	(44.90 ±0.03)°	44.0
2	(45.48 ±0.18)°	-	44.0
3	(44.6 ±0.3)°	-	44.0

Vorläufig

To-Do

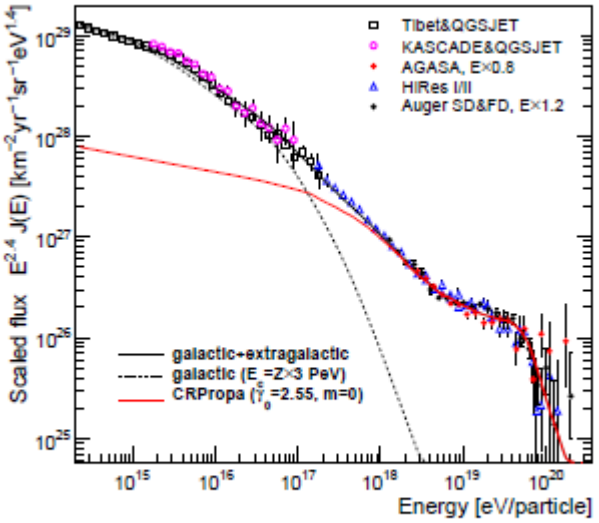
Systematischer Fehler aus Referenzgeometrie Coihueco?

➢ Vergleich mit Geometrie aus SD

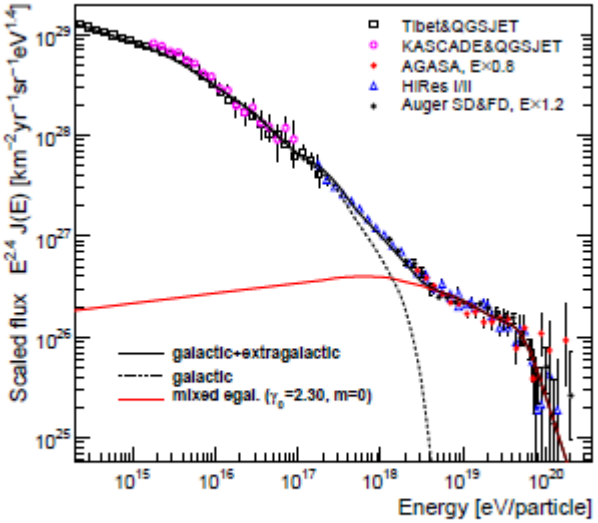
Vielen Dank für Eure Aufmerksamkeit!

Back-ups

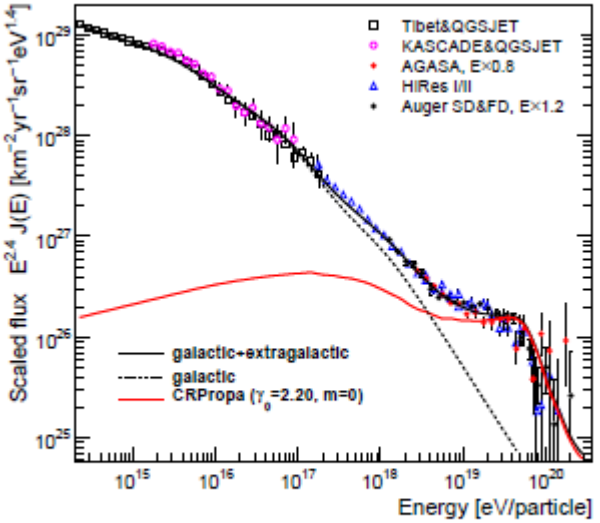
Knöchelmodelle



(a) Extragalactic protons

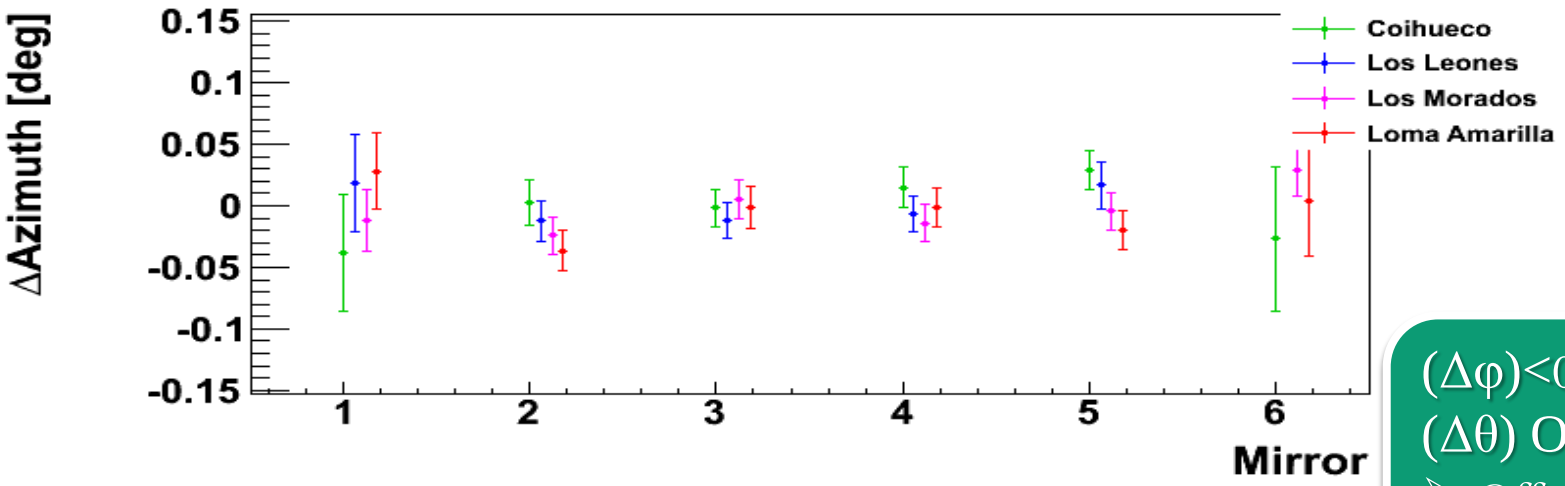


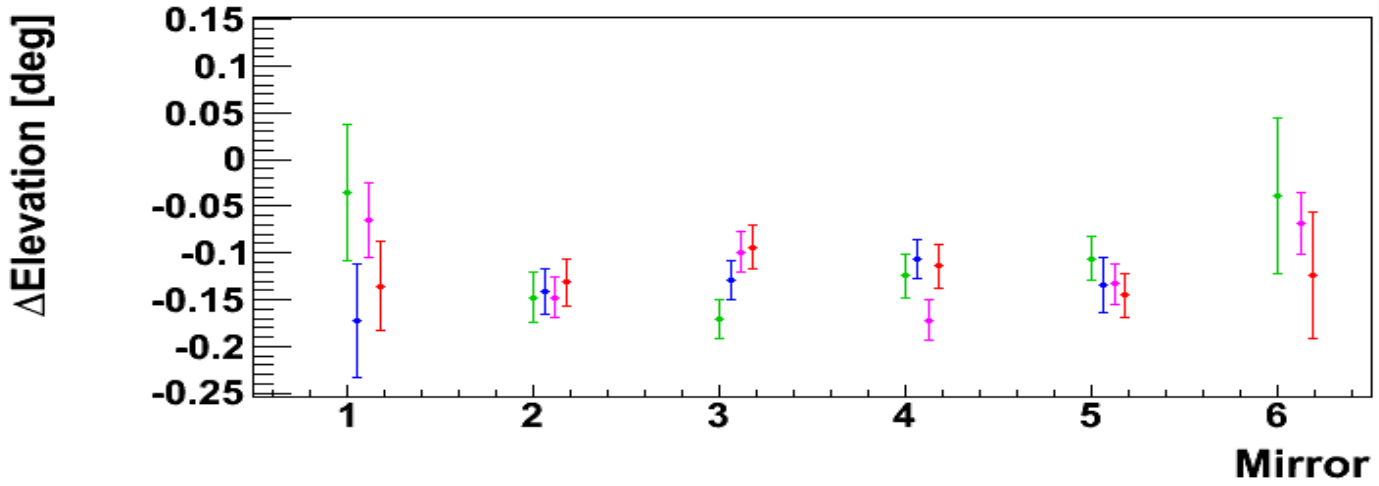
(b) Mixed Composition (adopted from [49])



(c) Transition at the ankle

MC: Referenz SD





$(\Delta\varphi)<0.1°$
$(\Delta\theta)$ Offset 0.16°
➢ Offset zwischen FD und SD