

Kalibrierung von Photomultipliern im Rahmen des JEM-EUSO Fluoreszenzteleskops

Schule für Astroteilchenphysik 2012 - Obertrubach

Michael Karus | Oktober 2012

INSTITUT FÜR KERNPHYSIK (IKP)

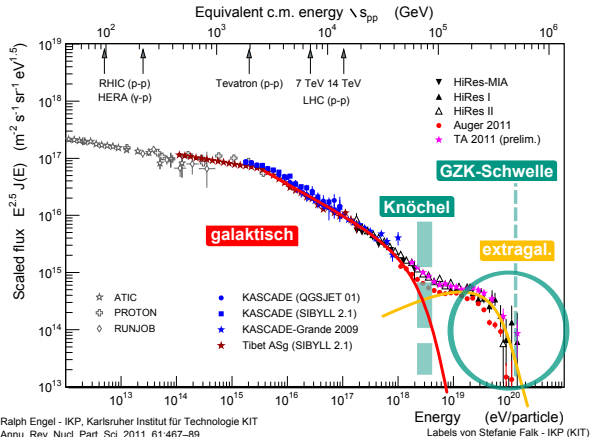


Extreme Universe Space Observatory onboard Japanese Experiment Module

<http://jemeuso.riken.jp/en/index.html>

Motivation - Ziele

- Messung hoch-energetischer kosmischer Strahlung $E > 10^{19}$ eV
- Identifikation von Quellen und Quellregionen



Detektionsprinzip

UV-Photonen

- Fluoreszenzlicht
- Cherenkovlicht

Sichtfeld (FOV)

- 60° Öffnungswinkel
- drei Fresnellinsen

Detektorfläche

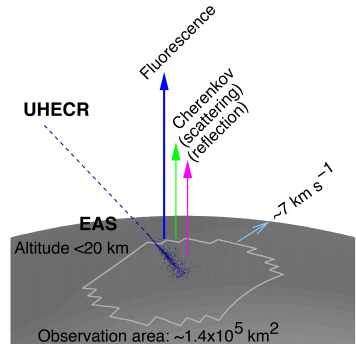
- $1,4 \cdot 10^5 \text{ km}^2$ (Nadir-Modus)
- bis 10^6 km^2 (geneigter Modus)

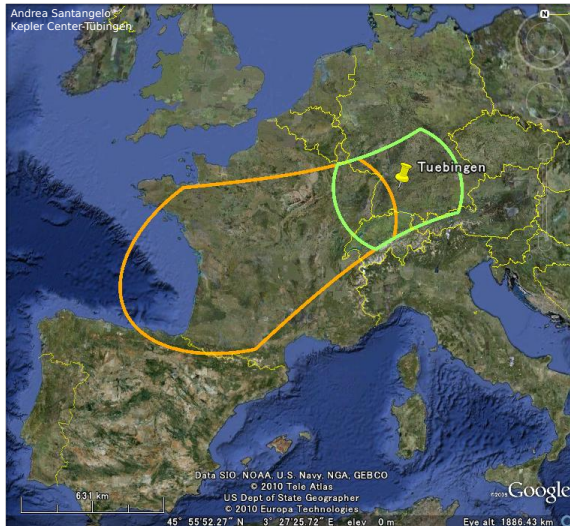
Markus Roth
IKP Karlsruhe (KIT)

JEM-EUSO

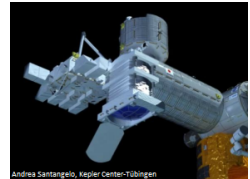


Orbit altitude: 400km

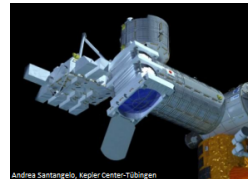


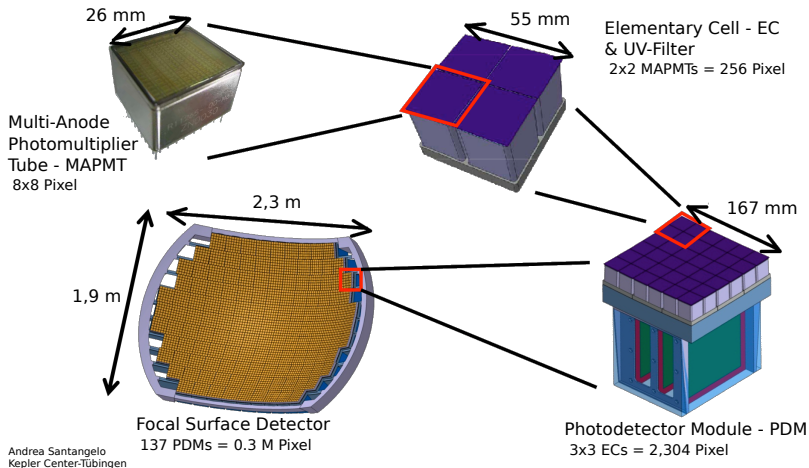


Nadir-Modus



Geneigter Modus

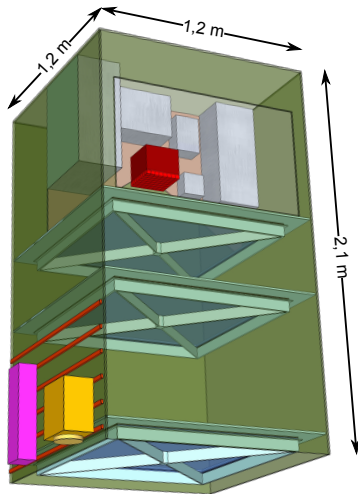




EUSO-Balloon

- UV-Teleskop in ≈ 40 km Höhe
 - 1 PDM
 - Elektronik
 - Optik: 3 Linsen
- Messungen von Luftschauern und Untergrund
- Voraussichtlich 2014

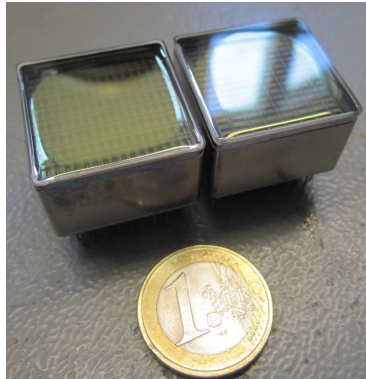
**Ziel: Mechanik- und Elektroniktest
Untergrundmessungen**

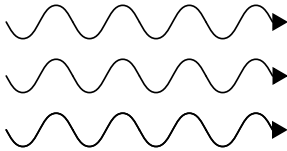


Andrea Santangelo, Kepler Center-Tübingen

<http://apod.nasa.gov/apod/ap120305.html>

Kalibrierung von Photomultipliern





$$N \cdot \gamma$$

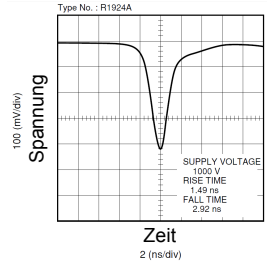
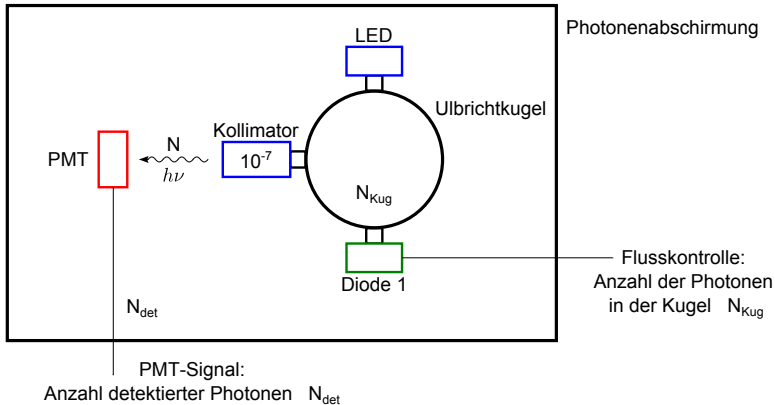


Figure 4-17: Output waveform

Hamamatsu Photonics - Photomultiplier Tubes
Basics and Applications; 3. Auflage 2006

$$\Rightarrow \text{Quanteneffizienz des PMTs} = \frac{\text{Anzahl detektierter Photonen } N_{\text{det}}}{\text{Gesamtzahl auftreffender Photonen } N}$$



Kollimatorabschwächung:

$$R = \frac{N}{N_{\text{Kug}}}$$

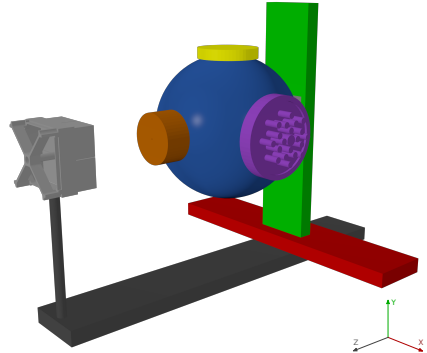
Quanteneffizienz:

$$\eta = \frac{N_{\text{det}}}{N} = \frac{N_{\text{det}}}{R \cdot N_{\text{Kug}}}$$

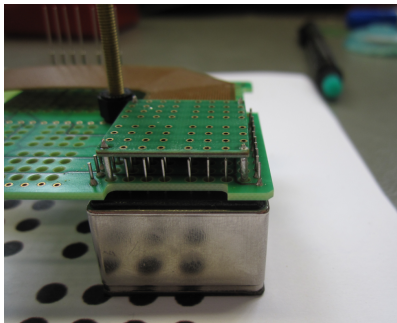
Michael Karus

Gwenaëlle Lefevre PhD-Thesis 2006
Université Paris 7 - Denis Diderot

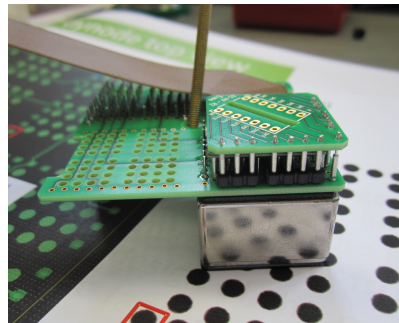
- Absorbierende
Photonenabschirmung
- Uniforme Lichtquelle
 - UV-LED-Array
 - Ulbrichtkugel
- Photodioden
 - Messung der Photonenflüsse
- Kollimator
 - Reduktion des
Photonenflusses am PMT
- Messcomputer zur
Datenerfassung



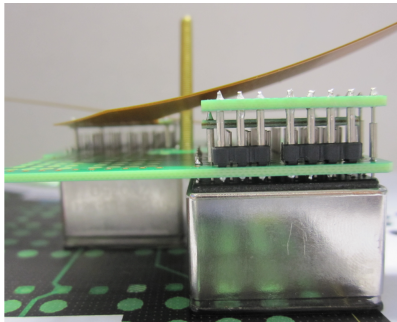
Prototyp Elementary Cell



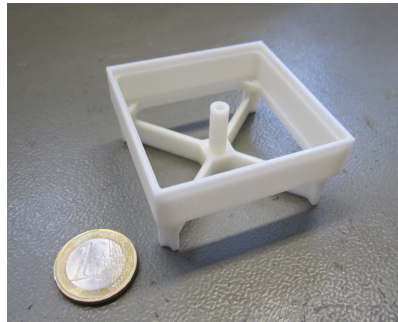
EC-Anoden-Board mit MAPMTs



EC-HV-Board

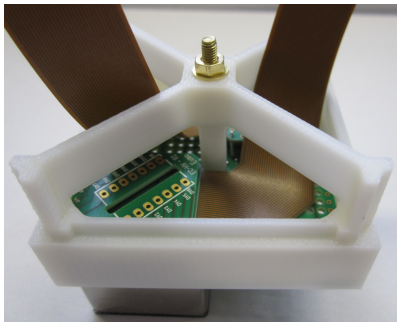


Abstände EC-Boards

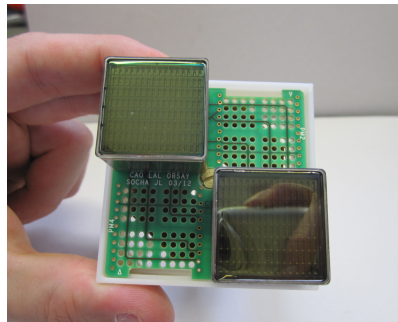


EC-Halterung 3D-Druck

Prototyp Elementary Cell



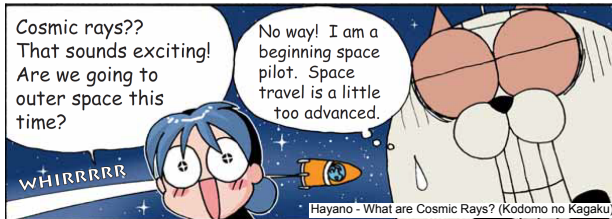
EC-Prototyp von unten



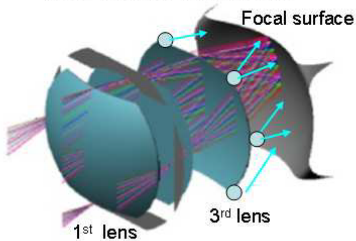
EC-Prototyp von oben

- JEM-EUSO
 - Testexperiment EUSO-Balloon
- PMT-Kalibrierung
- Teststand
- Prototyp EC

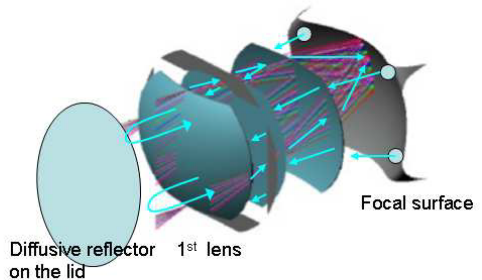
Start vorraussichtlich 2017!



(a) Detector calibration



(b) Optics (+detector) calibration



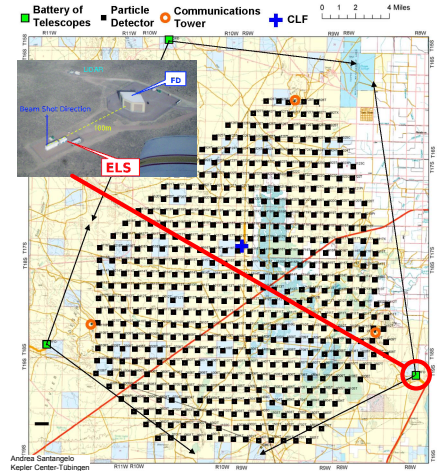
ICRC 2011 - Calibration of JEM-EUSO photodetectors
P. Gorodetzky, N. Sakaki, M. Christl

Uniforme Lichtquellen im Teleskop

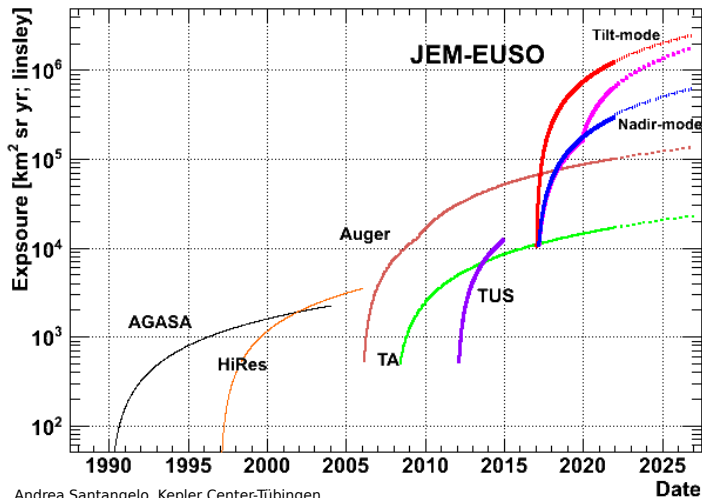
Telescope-Array-EUSO

- Black Rock Mesa FD Station (Utah - USA)
- Absolute Kalibrierung
 - Electron Light Source (ELS)
 - LIDAR
- PDM mit Optik (8° FOV)
- Anfang 2013

Ziel: Kalibrierung mit dem vorhandenen FD-Teleskop



Backup - Exposure



Backup - Photomultiplier

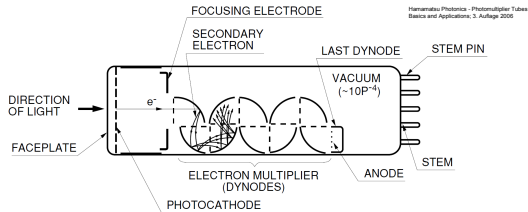


Figure 2-1: Construction of a photomultiplier tube

(1) ALKALI PHOTOCATHODE

