The H.E.S.S. II Telescope



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Gamma Ray Astronomy with H.E.S.S.





- particle velocities > speed of light
 - → Cherenkov light emission
- Cherenkov Telescopes collect this light with large mirrors and image the shower onto segmented cameras



- H.E.S.S. : 4 telescopes in Namibia
- Stereoscopic System:
 - reduction of trigger rate by coincidence requirement
 - better resolution of direction of incident gamma ray

H.E.S.S. II



- addition of a very large telescope to the existing array (600 m² mirror area compared to 100 m² for the existing telescopes)
- higher sensitivity with 5 telescopes in stereo mode
- larger mirror area reduces energy threshold (20 GeV compared to 100 GeV in mono mode)



The Optical System of H.E.S.S II





- approx. 600 m² mirror area
- parabolic dish, focal length 36 m
- 850 individual mirrors of hexagonal shape
- spherical mirrors of same focal length
- individual motors for remote alignment



Point Spread Function

(R. Cornils for the H.E.S.S. Collaboration, ICRC2005)



- 2 simulations:
 - each mirror with individual focal length (red)
 - one common focal length for all mirrors (green)
- → Common focal length for all mirrors!

FEM Calculations

- mirror deforms under the influence of gravity
- deviations of surface from ideal curvature
- influence on Point Spread Function



Specifications for H.E.S.S. II Mirrors



- no. of mirrors: 900 (incl. spares)
- type: spherical mirrors
- shape: hexagon, 900 mm flat-to flat
- focal length: 36 600 mm
- material: glass with Al coating or other, protective coating (SiO₂ or other)
- weight: < 25-30 kg
- reflectivity: > 80% (300 600 nm)
- spot-size: > 80% of reflected light within 1 mrad

"Traditional" Glass Mirrors

- grinding to desired curvature
- polishing to obtain surface quality
- coating with Al for reflectivity
- coating with SiO_2 for protection

Filter	300 nm	400 nm	470 nm	600 nm
R [%]/W [mrad]				
A3	65.5/1.2	67.5/0.9	84.7/1.0	70.5/1.0
A4	64.6/1.2	76.6/1.1	81.0/1.1	73.8/1.2
#1	57.5/0.7	69.0/0.7	68.7/0.74	73/0.74
#2	44.4/0.5	70.9/0.5	77.2/0.5	81/0.5
#3	53.9/0.74	70/0.7	74.5/0.74	79/0.74
#4	59/0.65	78.8/0.63	82.2/0.65	82/0.63
#5	42.8/0.71	54/0.71	62/0.71	74.4/0.71
#6	40.5/1.34	67.2/1.34	72.1/1.34	74.3/1.34
#7	52.6/0.57	77.7/0.54	81.2/0.57	82/0.54
#8	-	>70/>1.46	-	-
#9	46.4/0.45	70.8/0.49	76.3/0.45	79.6/0.49
#10	79/0.4	83.3/0.4	82.1/0.34	84.0/0.43



- 10 sample mirrors have been tested (E. Schreiber, Diploma Th., MPI-K)
- reflectivity of 80% not reached
- process has to be improved
- same supplier has delivered mirrors for H.E.S.S. I within specs

Slumped Glass Mirrors

- production process without grinding and polishing
- float glass is heated in a mould to form to correct curvature
- Al and SiO₂ coating



Aluminum Sandwich Mirrors

- mirrors constructed completely from aluminum
- aluminum sheet ("Alanod") supported by aluminum honeycomb structure
- spherical shape produced using a precise mould
- first samples had problems with Point Spread Function and low reflectivity at short wavelengths





Glass/Aluminum-Sandwich Mirrors

- 2 glass foils (1.1 mm), Al honeycomb (20 mm)
- spherical shape produced using precise mould
- first test piece: square mirror with silver reflective layer, f = 34.8m)
- measurement by the developers: 80% of reflected light within 0.5 mrad





The Test Setup for H.E.S.S Mirrors



- a light source at distance 2f is imaged at 2f
- the image is scanned using a photodiode mounted on a precise scan-table
- a reference measurement of light emitted by the source provides the normalization



Review of Results for H.E.S.S I Mirrors

(K. Bernlöhr et al., Astropart.Phys. 20 (2003) 11)

- glass mirrors with Al coating produced by two companies
- measured at 300,400,470,600 nm
- spot-size 0.5 mrad or below for most mirrors
- reflectivity criterion of 80% not always reached



Extended Setup to Accelerate Tests





- CCD picture of light-spot
- only one point measured with diode for absolute normalization
- no scan \rightarrow less time needed



Summary

- the H.E.S.S. Atmospheric Cherenkov Telescope Array will be extended by a 5th telescope of increased size to lower the energy threshold
- 900 spherical mirrors are needed
- different types of mirrors are under investigation:
 - ground glass with Al coating
 - slumped glass with Al coating
 - sandwich Al sheet / Al honeycomb
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- mirrors will be tested for reflectivity and resolution
- an accelerated test method is under development
- prototype production and testing will take place within the next months
- an order for mass-production will be placed in early 2007
- production should be completed in spring 2008