How to Cover 40000 km^2 with FD?

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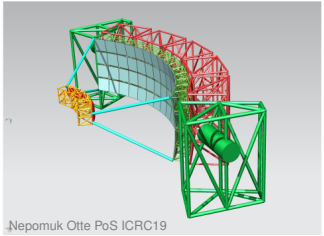
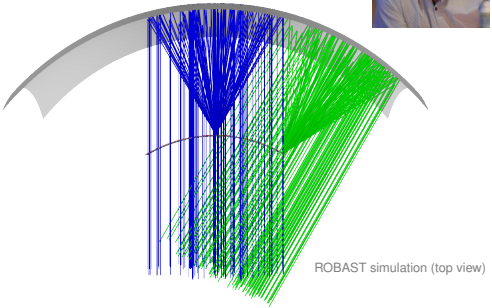
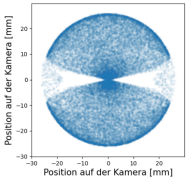
Reminder: “Cyclops” Design

- 10° elevation coverage
- large aperture / small pixels
- based on MACHETE/Trinity design

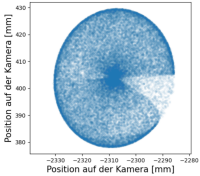


- Optimization for GCOS at UHE*:
  - 10° × 60° telescpes
  - effective aperture 15 m^2
  - pixel diameter 5.2 cm / 0.6°
  - camera with ∼1500 SiPMT pixels





(a) PDV (0°,0°)



(g) PDV (5°,30°)

*Bachelor Thesis Lukas Scherne (KIT) Simulation des Fluoreszenzdetektors des Global Cosmic-Ray Observatory

Cyclops vs. Auger/TA vs. FAST/CRAFFT

Signal-to-noise ratio: $(S/N)_{\text{FD}} \propto \sqrt{A/\Omega_{\text{pix}}}$
(effective aprture A and pixels size Ω_{pix})

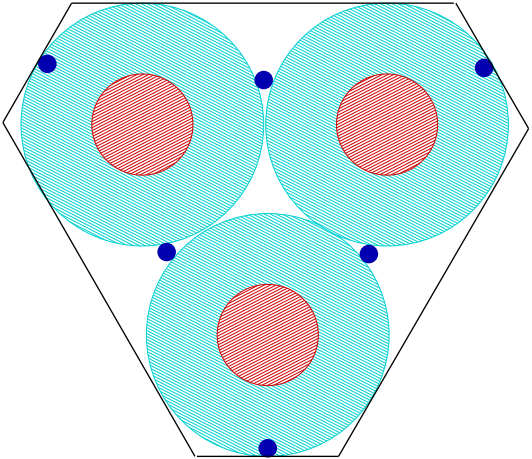
	$\sqrt{A/\Omega_{\text{pix}}}$/(m/deg)	R_{max}/km at 10^{20} eV	stations for GCOS	cost/station/M$	total cost/M$
Cyclops	13	60	3.5	2	7
Auger	1.2	45	6.3	2.4	15
FAST	0.07	25	20.4	0.4	8

$\rightarrow$ similar cost for Cyclops and FAST
$\rightarrow$ simplified maintenance for 3 vs 25 sites
$\rightarrow$ but additional atmospheric monitoring efforts needed for Cyclops

cost estimates based on Pech+UHECR18 for FAST and arXiv:1907.08727 for cyclops

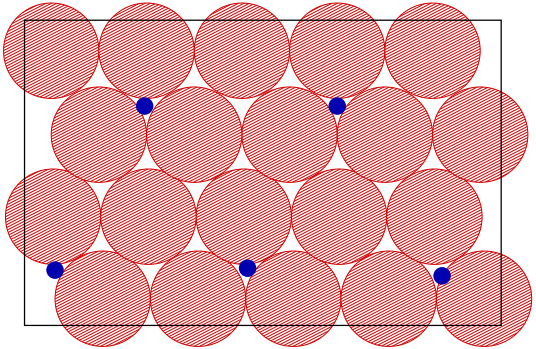
Possible Site Layouts (40 000 km^2)

"superman"



$\sim$ equilateral triangle, 300 km side length
3 sites with one FAST and cyclops each
$\gtrsim$ 6 laser facilities

array of FDs

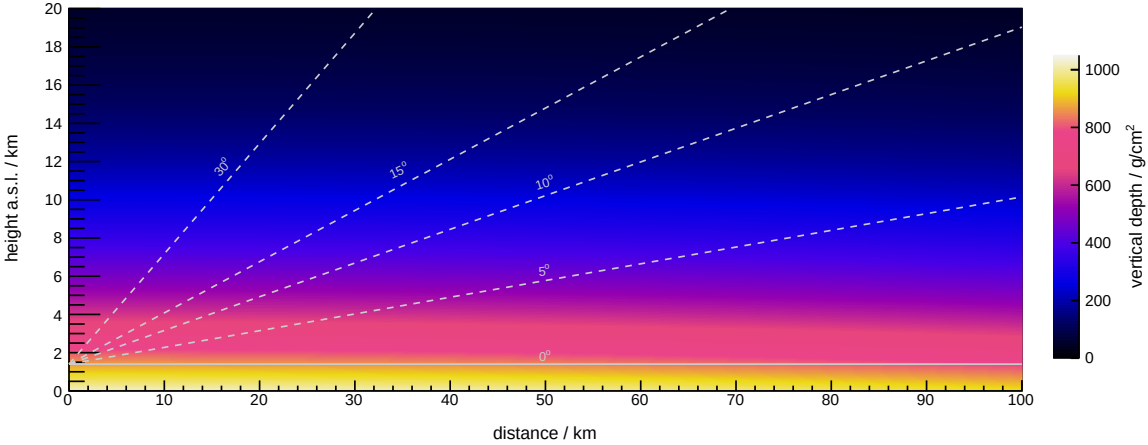


250$\times$160 km^2 rectangle
20 FAST sites
?? laser facilities

color code: FAST, cyclops, laser facility

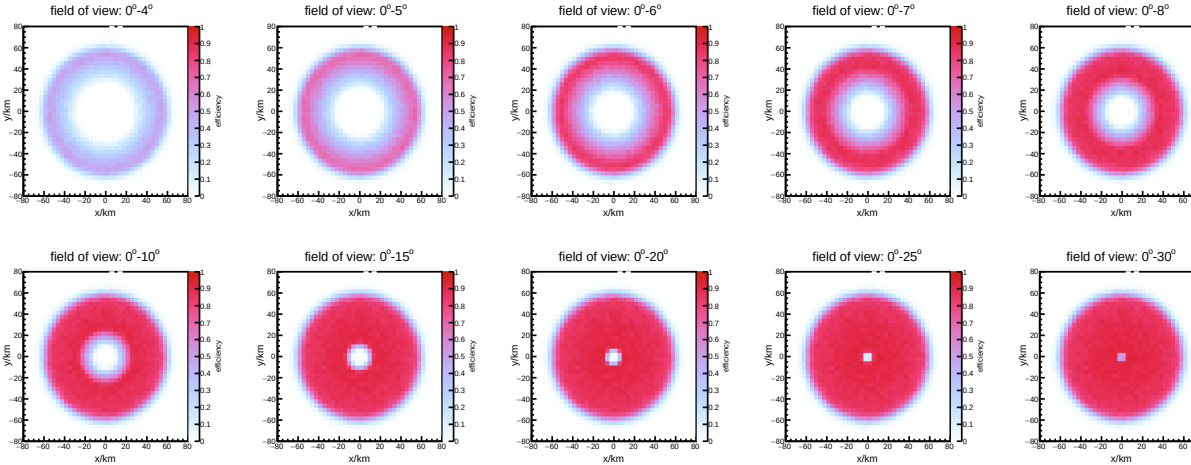
Additional Slides

FD Field of View



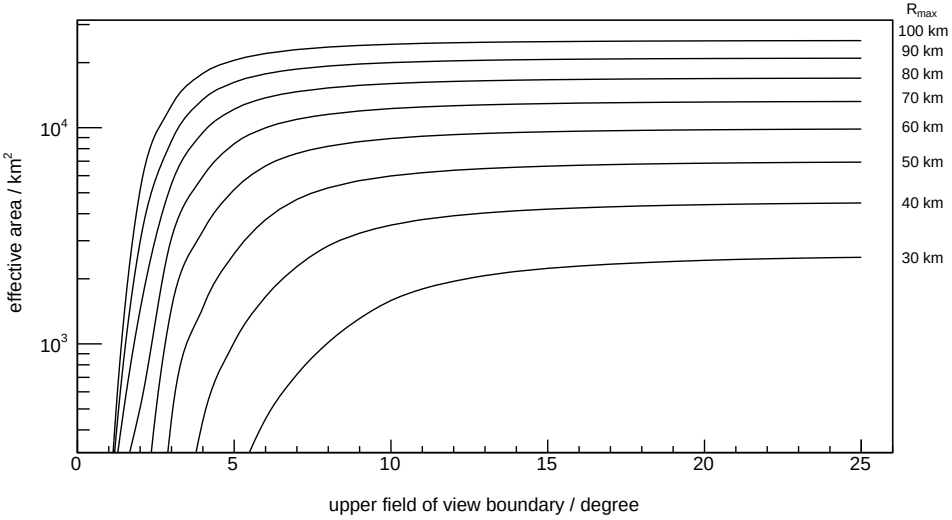
Important range at UHE: $X_{\max} \in (700, 900)$ g/cm^2 (slant depth!)

FD Field of View



Cut on viewable range $X_{\text{low}} < 700$, $X_{\text{up}} > 900$ g/cm^2

Effective Area vs. Upper Field of View Boundary



small field of view needed at UHE (large R_{max}), $\alpha_{\text{max}} \lesssim 10°$

Does GCOS need an FD?

- energy calibration (calorimetric energy)
- mass calibration (direct observation of shower maximum)
- hybrid physics (ground densities and longitudinal profile)