The Double Donut Schmidt Camera concept for UHECR observation from space

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ABSTRACT--The DDSC (Double Donut Schmidt Camera) is a wide field, moderate resolution, telescope concept developed for the detection of UHECR from space. Since the design is fully scalable we propose the extension of the concept, originally developed for EUSO-FF, to fit the detector in the currently available class of large launchers (Arianne 4-5). This will allow a substantial increase (a factor 3) of the UHECR detection rate with respect to EUSO.FF. This system will also act as precursor for a space-based observatory of UHE neutrinos. The optics dimensions, evaluated for two possible diameters (7m and 10m) of the entrance pupil, can guarantee the observation of several cosmogenic neutrino events from proton interactions with the CMB of the universe. This system could be scaled to even larger dimensions for the detection of cosmogenic neutrinos from interaction of nuclei with CMB or the study of other hypothetical neutrino sources.

I - Introduction

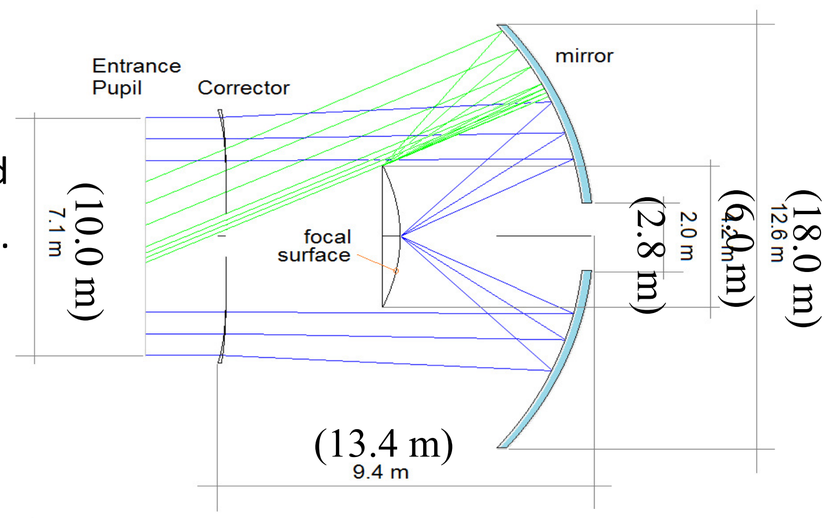
- Rate of detected UHECRs from space increases:
  with mass of observed atmosph. (→ orbit altitude)
  decrease of Energy threshold (→ increase of pupil)

-Progress in lightweight deployable mirrors for space:
JWST(Nasa) large mirror composed Be segments(1)
ALC(ESA) Advanced LIDAR Concept (2-5)
LATT(ESA) Large Aperture Telescope Techn.(6-7)
the thin glass active mirror technology makes possible the construction of virtually unlimited deployable mirrors
with the mechanisms for large mw antenna
- Projects: EUSO-like for UHE ν's(8), K-EUSO(9)

II - Double Donut Schmidt Camera (DDSC)(10)

DDSC concept: optimizes FoV
maximizes pupil diameter
geometrically scalable

Fig.1
geometry for 7m (and 10m) diameter pupils.



III -Design and performance of 50° FoV and 7 m pupil 'active mirror' Double Donut Schmidt Camera (11)

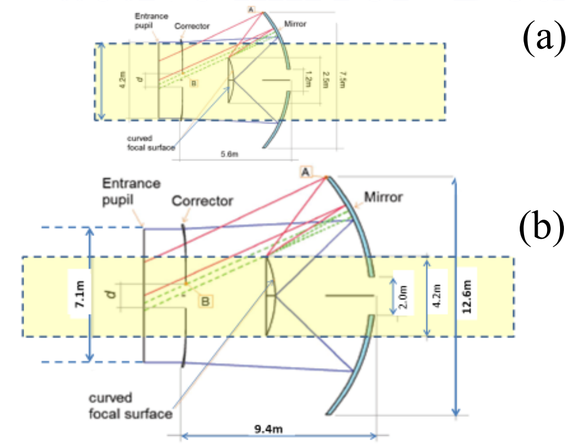


Fig.2 (a) DDSC for EUSO-FF.; (b) DDSC with detector scaled to diam. of the fairing.

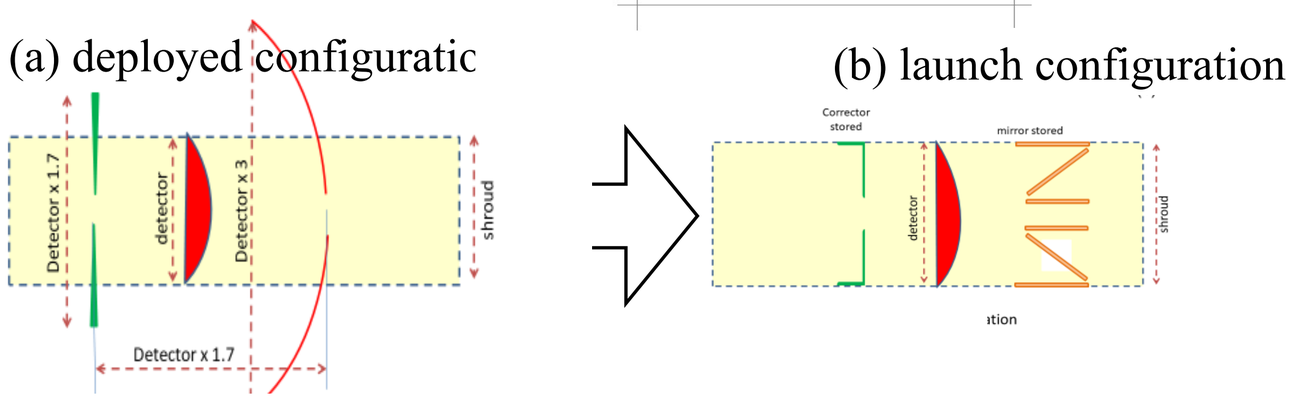


Fig.3 – (a) The deployed DDSC for a detector fitting the shroud; (b) the DDSC system with corrector and mirror stored.

IV- UHECR and cosmogenic neutrino events expected with DDSC telescope

Cosmogenic ν fluxes (by p→CMB)(12)

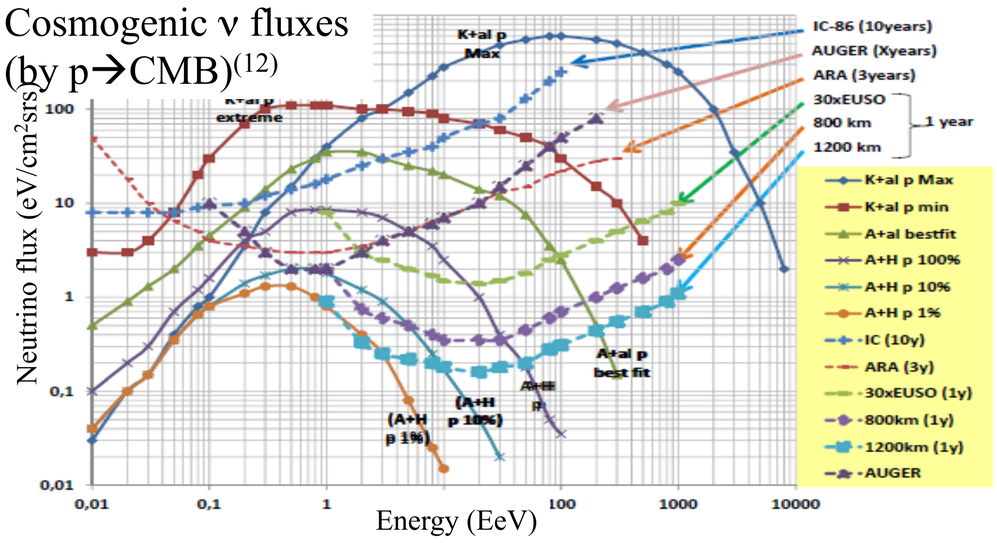


Fig.4 – Cosmogenic ν fluxes for the expectations(13, 14, 15) and sensitivity of IC-86,ARA,AUGER,EUSO observatories.

Altitude (km) (circular orbit)	400	800	1200
Total FoV (°)	50	50	50
Radius of spherical calotte (km)	198	378	580
Area of spherical calotte (10^3km^2)	110	450	1066
Mass of observed atmosphere (10^3t)	1100	4500	10660
Pupil diameter of the optical system (m)	7/10	7/10	7/10
E threshold (EeV)	2.2/1.2	7/4	15/10
Proton events/year (uniform source distrib. + GKZ) (at E_p>100EeV)	**0.3k**	**1.3k**	**2.8k**
Neutrino events/year (Kalashek ≈ min) (ref.13)	**4/0.3**	**1.8/1.3**	**0.8/4.5**
Neutrino events/year (Kalashek ≈ Max) (ref.13)	**15/4**	**12/16**	**9/36**
Neutrino event/year (Ahlers bestfit) (ref.14)	**1.2/.04**	**0.3/0.2**	**0.12/0.4**
Neutrino events/year (A+H p=100%) (ref.15)	**0.2/.002**	**0.03/0.01**	**0.01/.02**
Neutrino events/year (A+H p=10%) (ref.15)	**--**	**0.001**	**0.002**

V Conclusions:

- step forward in the detection of extreme energy cosmic rays and neutrinos from space
- much larger than any existing orbiting telescope, but **moderate optical resolution + new technology = reasonable cost and high probable success**
- telescope specifically designed for extreme low weight and deployability, compatible with the existing class of launchers
- the active LATT (Large Aperture Telescope Technology) guarantees the optical performance also with the variable thermal load in low/medium orbit
- possible further applications: (a) large aperture telescope for LIDAR missions; (b) search of space debris from orbit

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