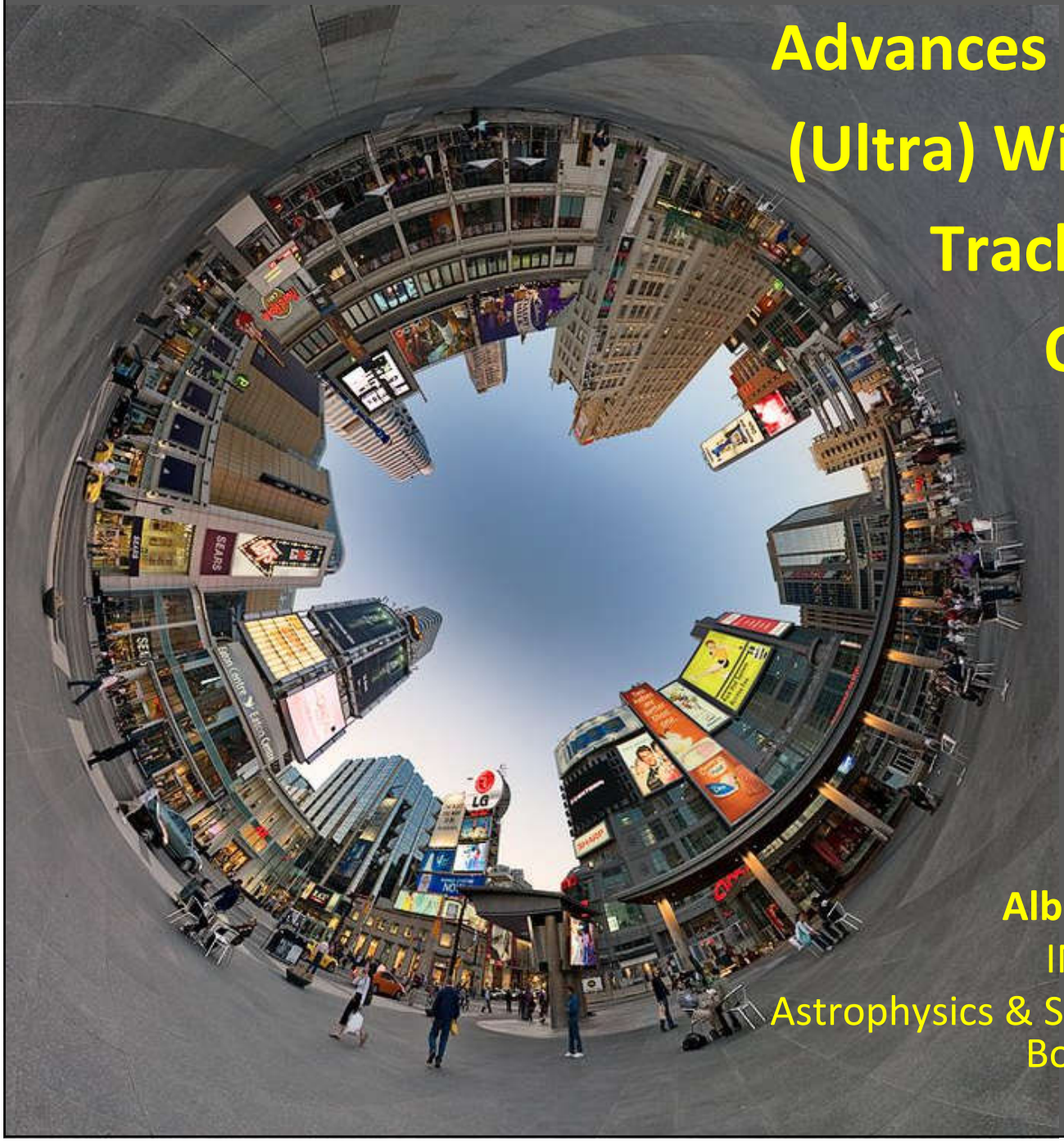

Advances and Synergies in (Ultra) Wide-field Optical Tracking of LEO Objects

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Bologna, Italy

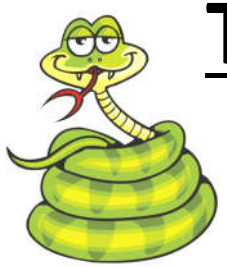
Telescope
Array
e**N**abling
DEbris
Monitoring

All
Sky
TR**acking**
Array

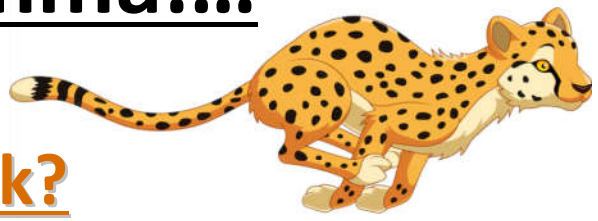
WG1
Debris measurements

EUSST

European Space Surveillance & Tracking Network

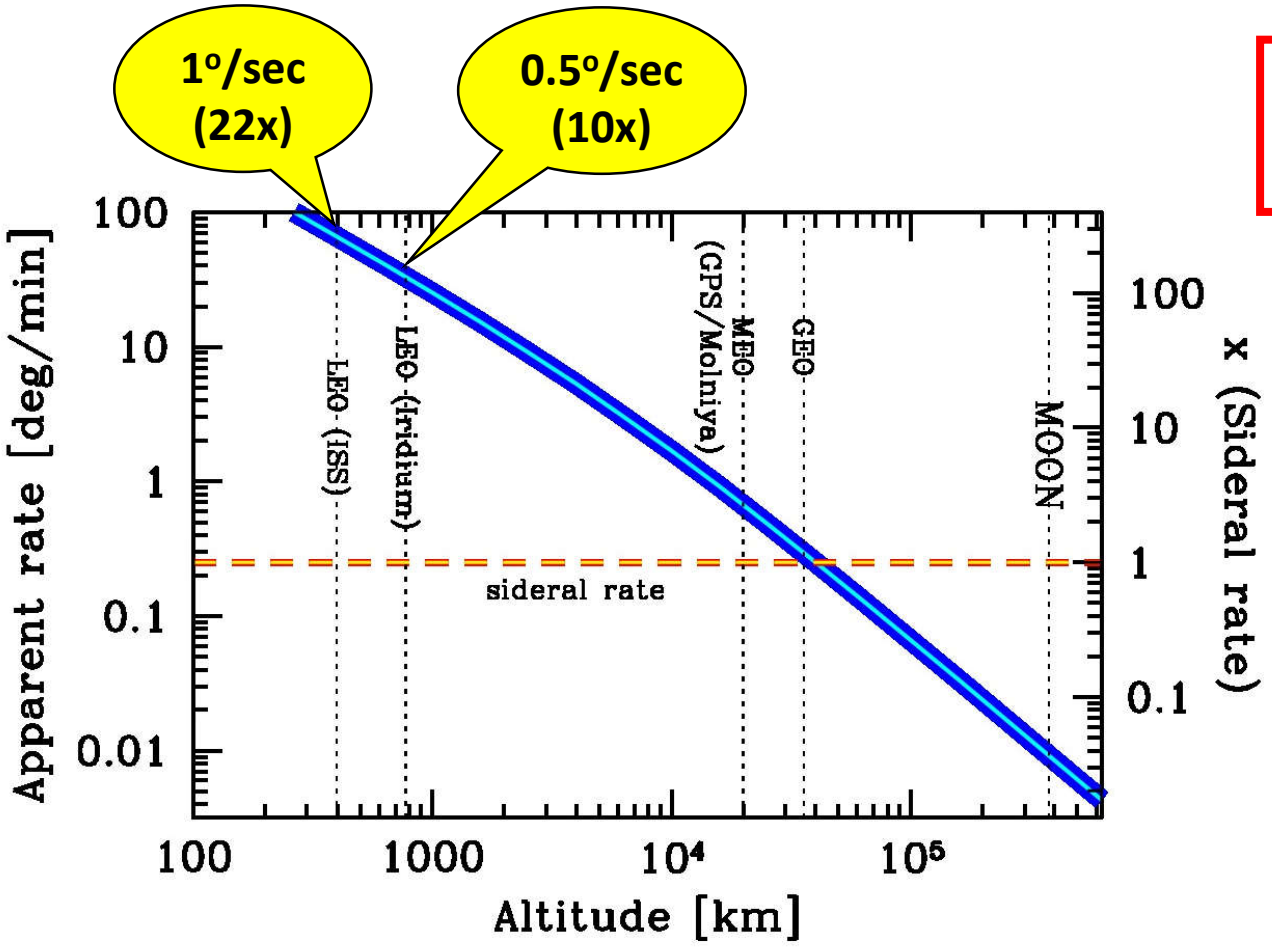


The "snake-cheetah" dilemma:…

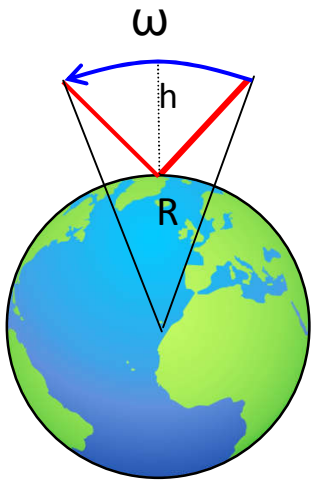


better to stare and wait…

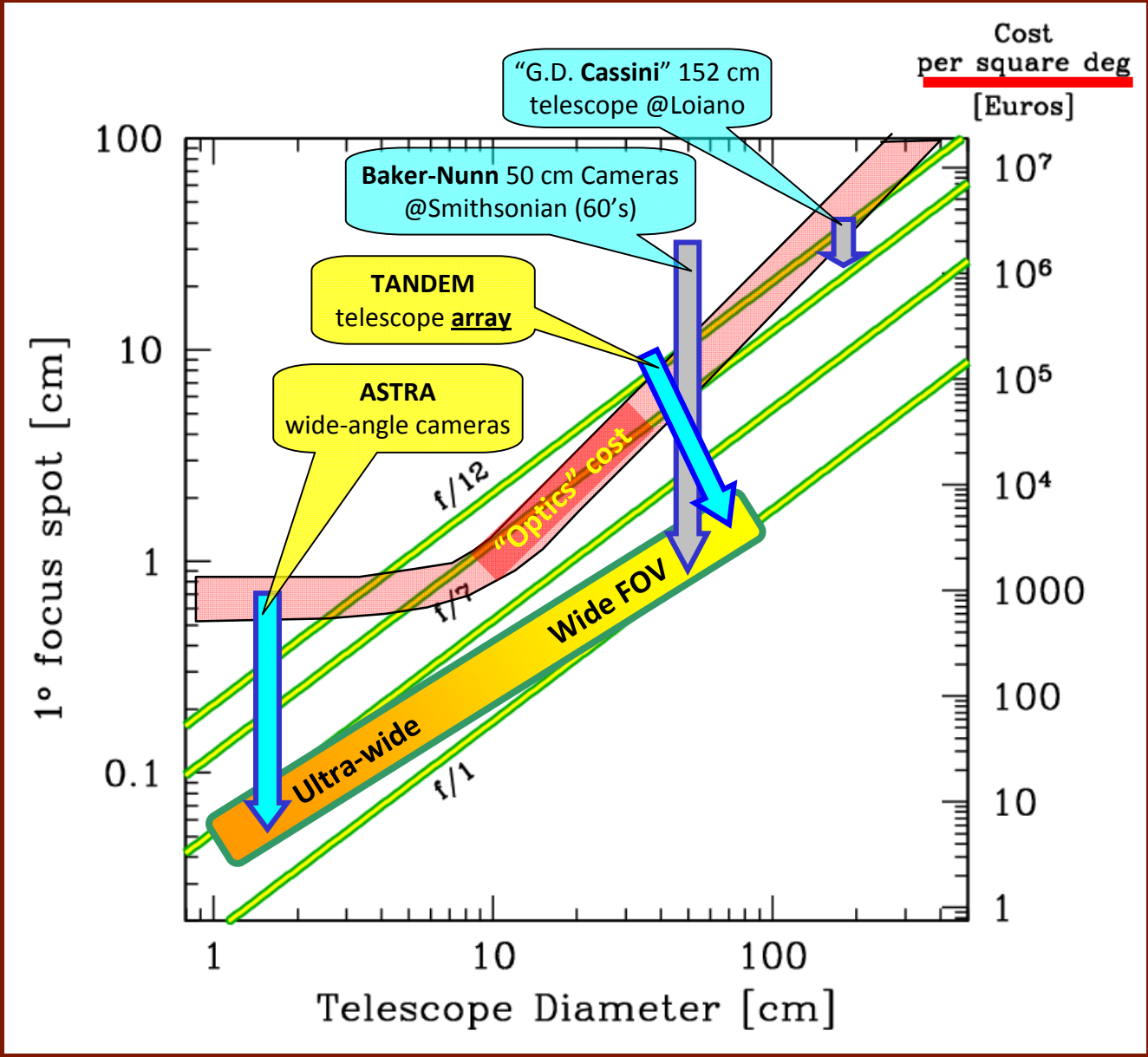
…or to move and track?



$$Zoom(\omega) = \left(\frac{h+R}{h}\right)$$



Pay per view...



Assume to be mosaicing w/ 4k²CCD @30K€

Standard cost of the "telescope" according to Meinel (1982)

The TANDEM project @ INAF

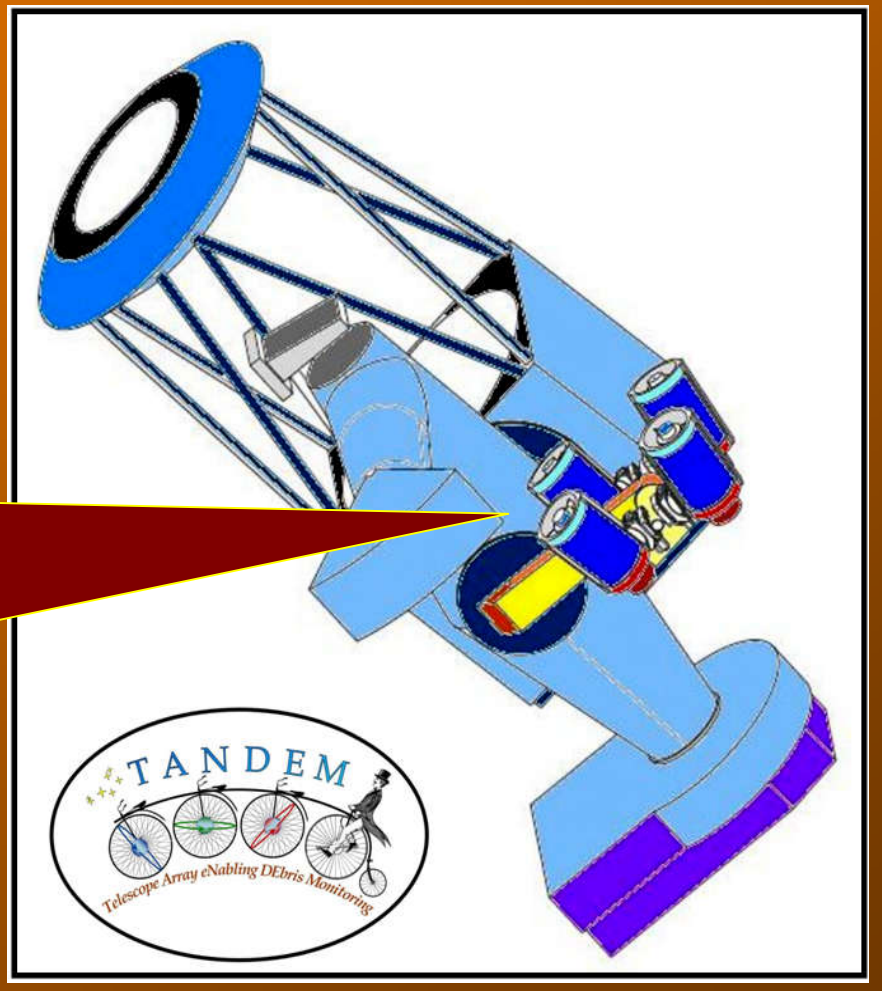
4x telescopes Ø 35 cm f/2.2

FOV = 20 □^{2} V_{lim} ~ 18

≈

1 monolithic tel. Ø 70 cm f/1.1

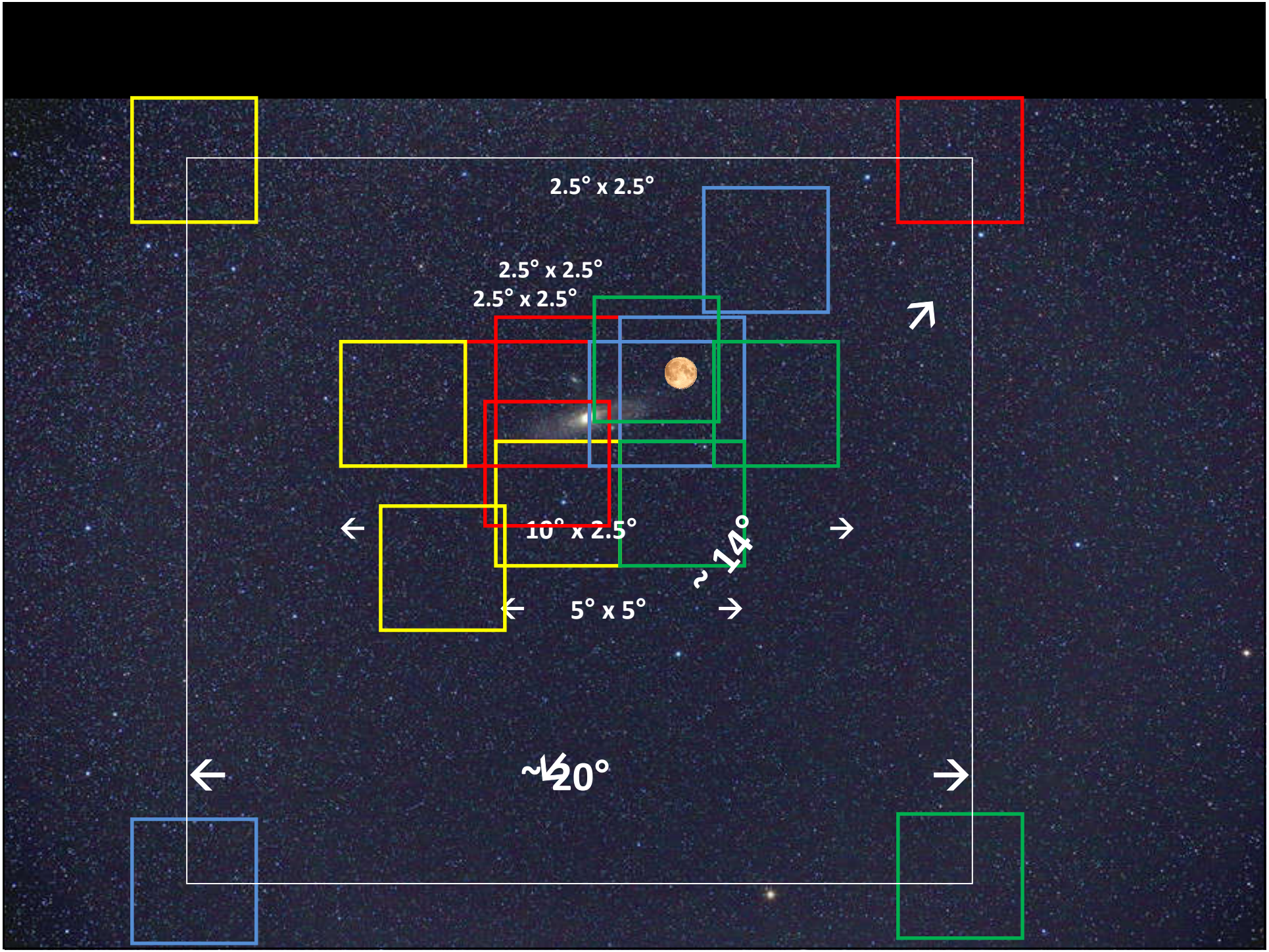
FOV = 2.5° x 2.5° V_{lim} ~ 20



Expected operational by Summer 2023

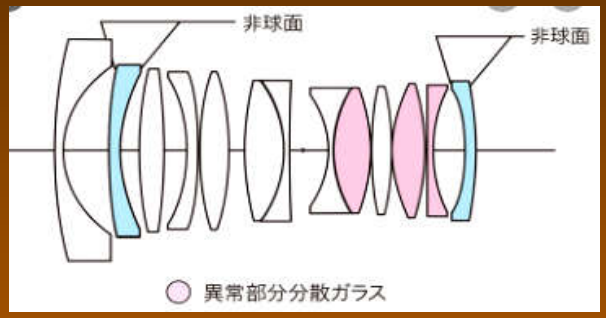
Max Collecting area (4x35cm = Ø 70 cm)

2.5° x 2.5°


2.5° x 2.5°
2.5° x 2.5°
2.5° x 2.5°
10° x 2.5°
~ 14°
5° x 5°
~20°

The ASTRA project

Voigtlander E 21mm f/1.4 Nokton



Sony α 7 III Full Frame 24.2 MP CMOS back-illuminated

FOV: 82° x 59° (100° diag)
Full Frame format:
6000 x 4000 px back-illuminated CMOS
Platescale: 50 arcsec/px
Latency: 0.01 sec (LEO)

The ASTRA project

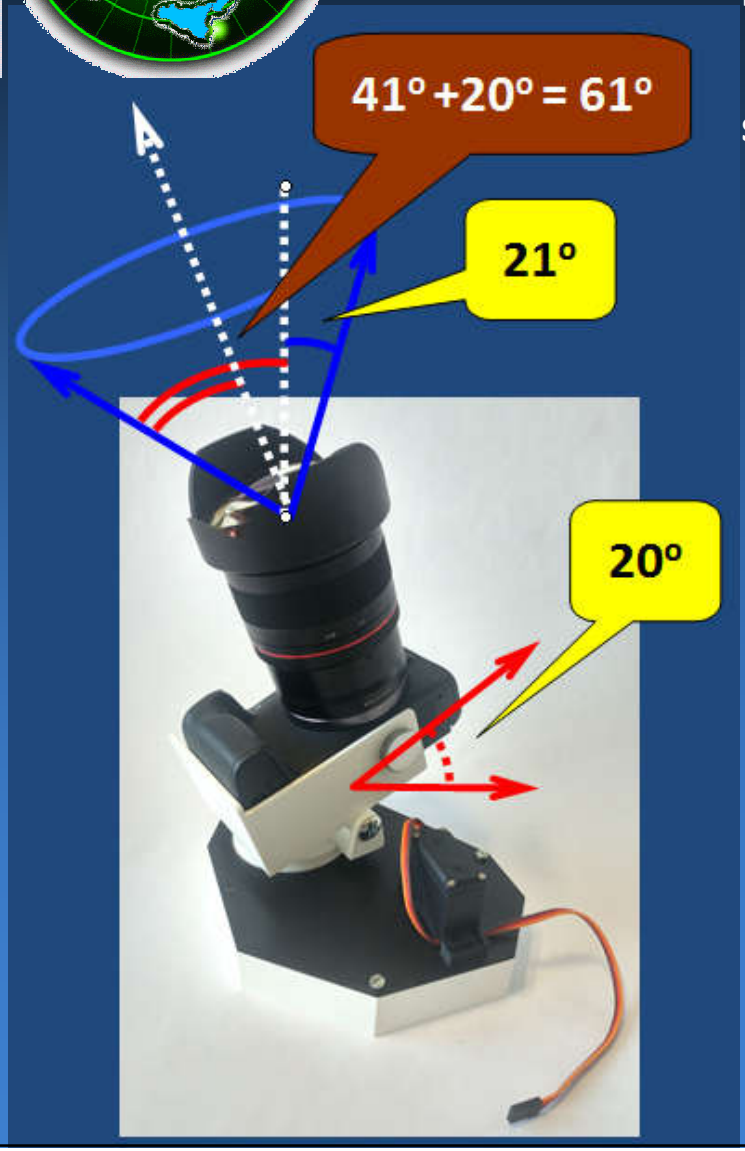
- **Italian Network: 5 stations**

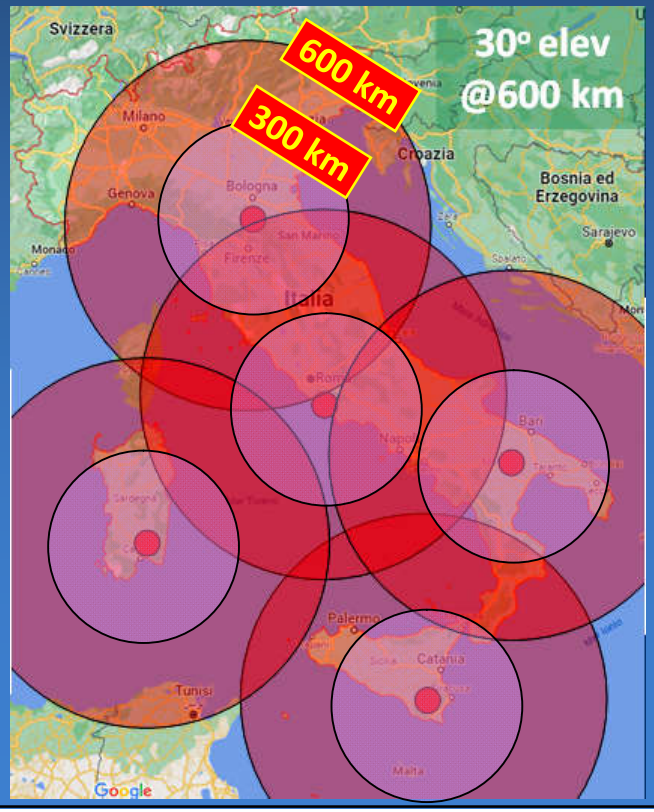
remotely operated from Loiano

- **FOV: 82° x 59° (100° diag)**

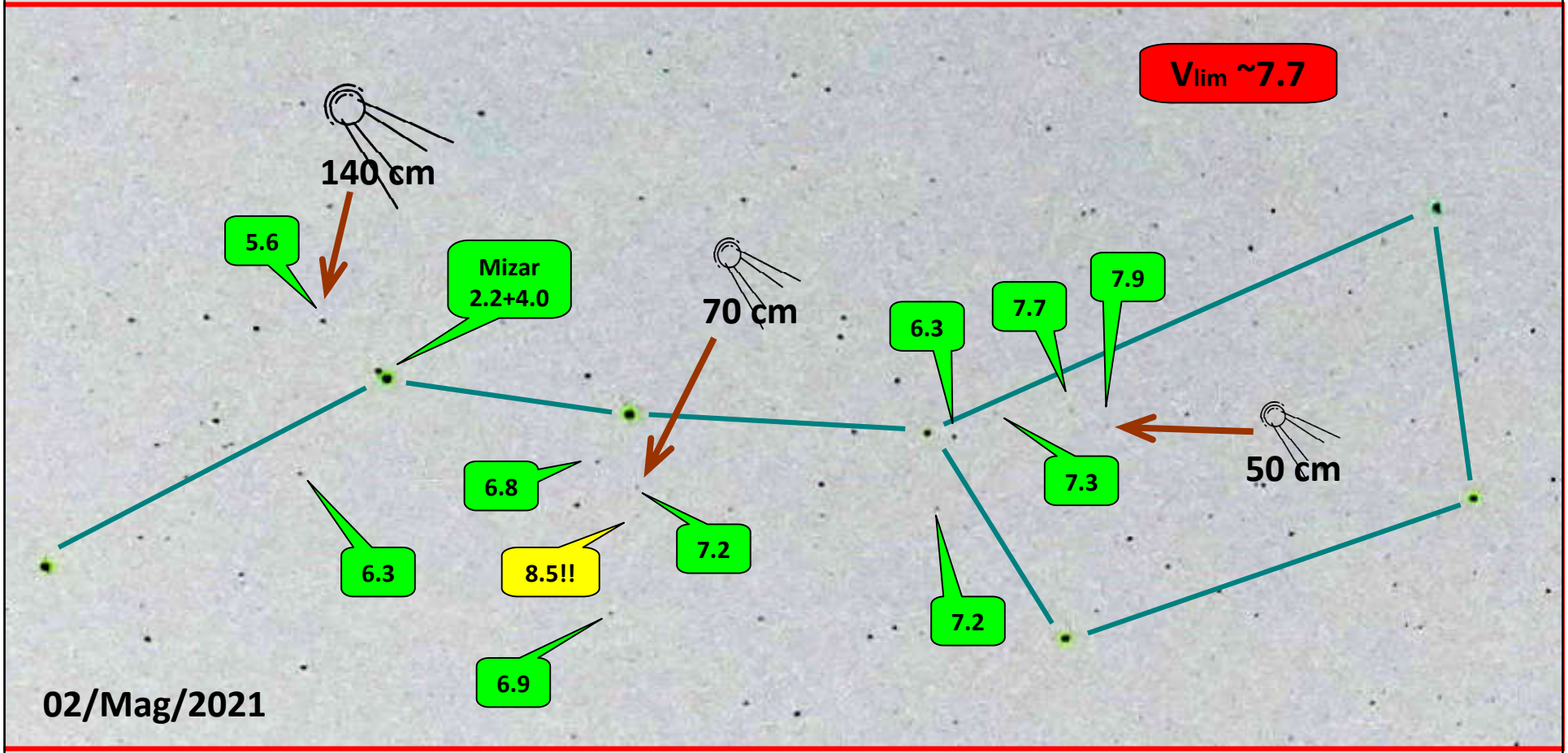
steerable in azimuth

- **Mag limit @latency exp: 6.5**
- **Expected operational by Spring 2023**





Voigtlander E 21mm f/1.4
Nokton



t_{exp} = 0.1 sec (ISO 25000)

½ x t_{exp} → = +0.4 mag

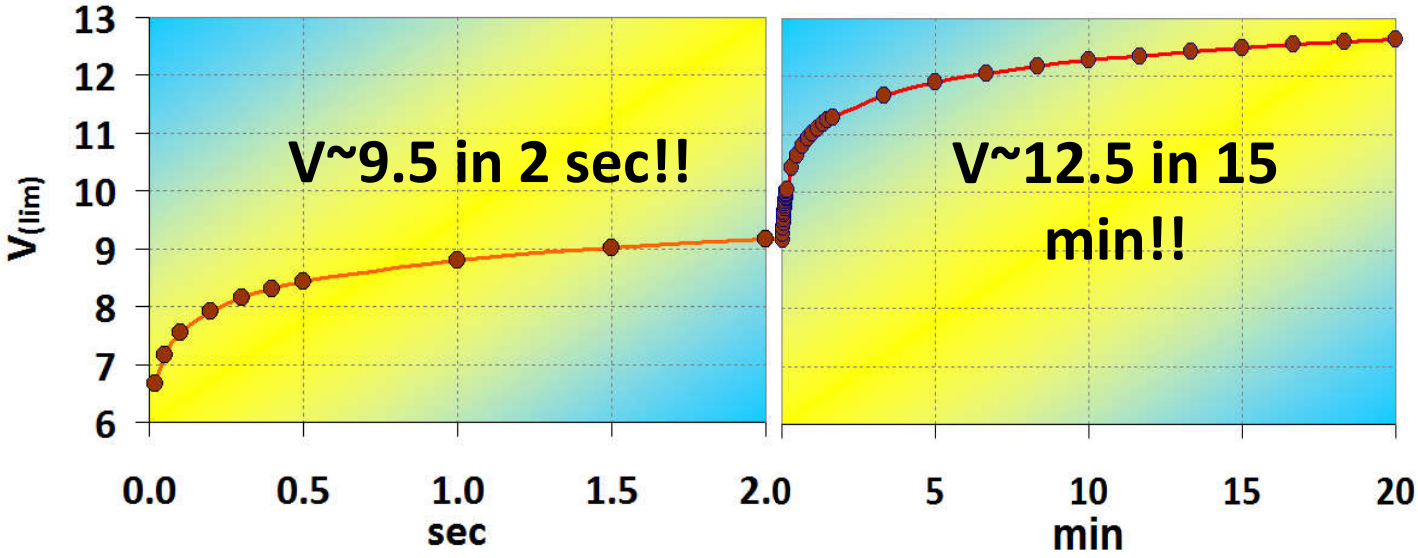
2 x t_{exp} → = -0.4 mag

Accuracy figures

$$V_{lim} \approx 1.25 \log(t''_{exp}) + 8.8$$

aka ~70-80 cm in L-LEO

- Debris size limit → Magnitude limit (V_{lim})



- Inclination (i) → Heading angle (H) →

$$d\,i \le \frac{dH}{\sin\,i} \approx \frac{}{\sin\,i}\left(\frac{5\ arc\,\sec}{30\ \deg}\right) \approx 0.005\ \deg$$

- Semi-major axis (a) →

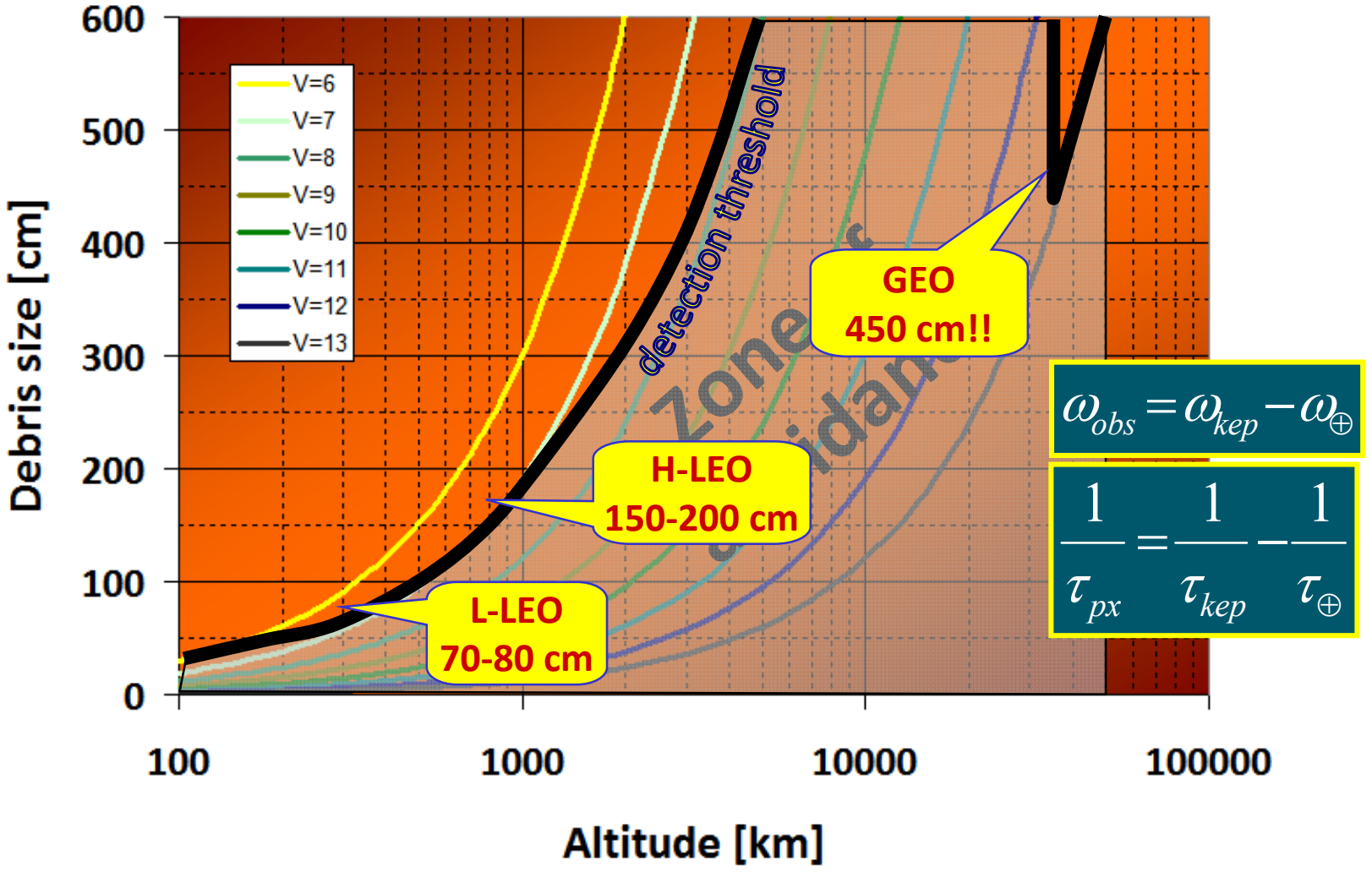
$$\frac{d\,a}{a} \equiv \left(\frac{2}{3}\right)\frac{d\,P}{P} \le \left(\frac{2}{3}\right)\frac{dt}{t} \approx \left(\frac{2}{3}\right)\frac{1.4\ px}{30\ \deg\ arc} \approx \left(\frac{2}{3}\right)\frac{70\ arc\,\sec}{30\ \deg} \approx 1/2000$$

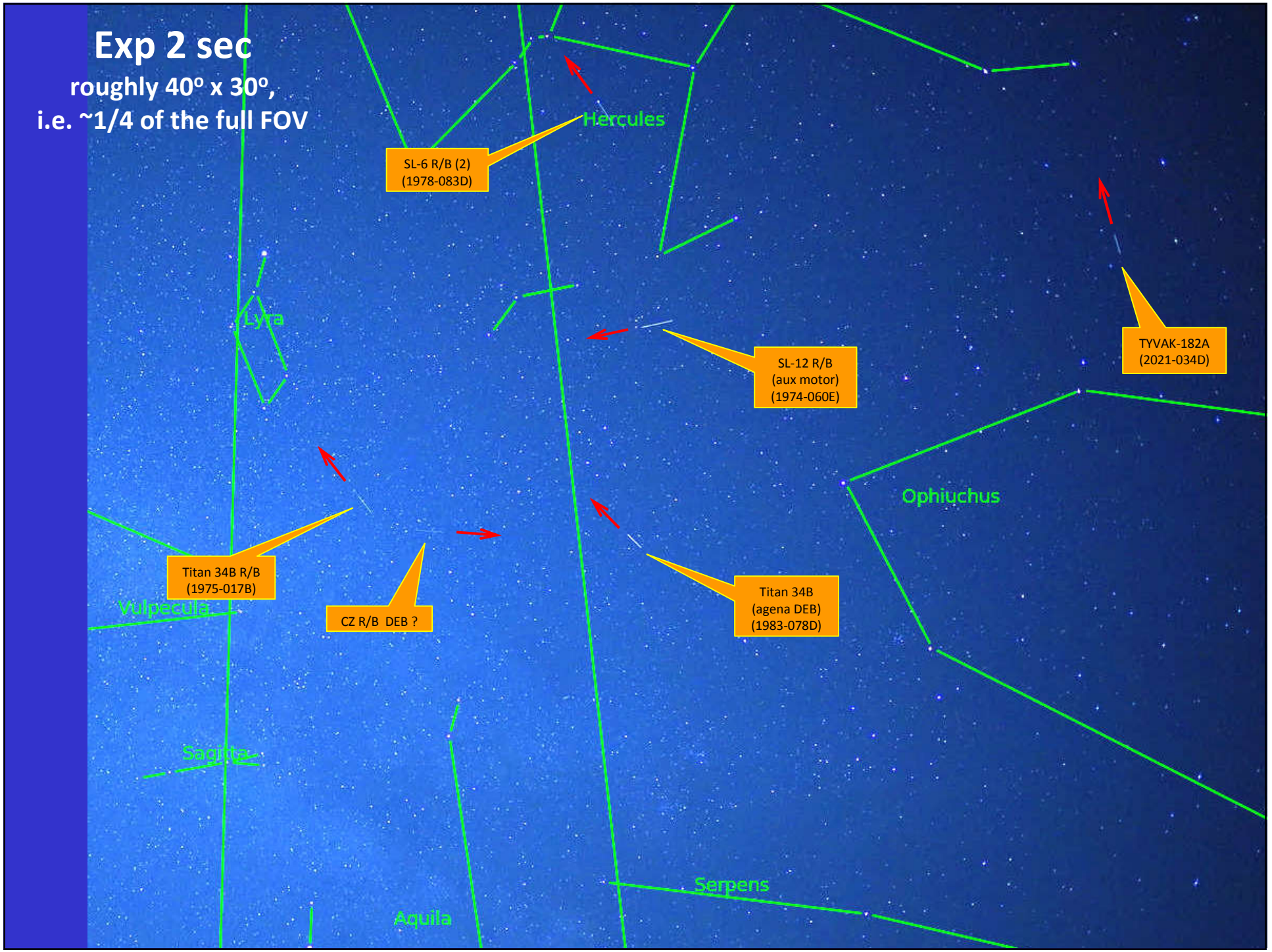
e.g. Macko (1962)

Magnitude vs. Size

$$V \cong -5\log(s_{cm}) + 5\log h_{km} - 2.5\log(\alpha / 0.1) + 3.40$$

(Buzzoni et al. 2014)




Exp 2 sec
roughly 40° x 30°,
i.e. ~1/4 of the full FOV
Hercules
SL-6 R/B (2)
(1978-083D)
Lyra
SL-12 R/B
(aux motor)
(1974-060E)
TYVAK-182A
(2021-034D)
Ophiuchus
Titan 34B R/B
(1975-017B)
Vulpecula
CZ R/B DEB ?
Titan 34B
(agena DEB)
(1983-078D)
Sagitta
Serpens
Aquila