

(Ultra) Wide-field Optical Systems
for Space Surveillance Activities:
the TANDEM and ASTRA Projects

Alberto Buzzoni

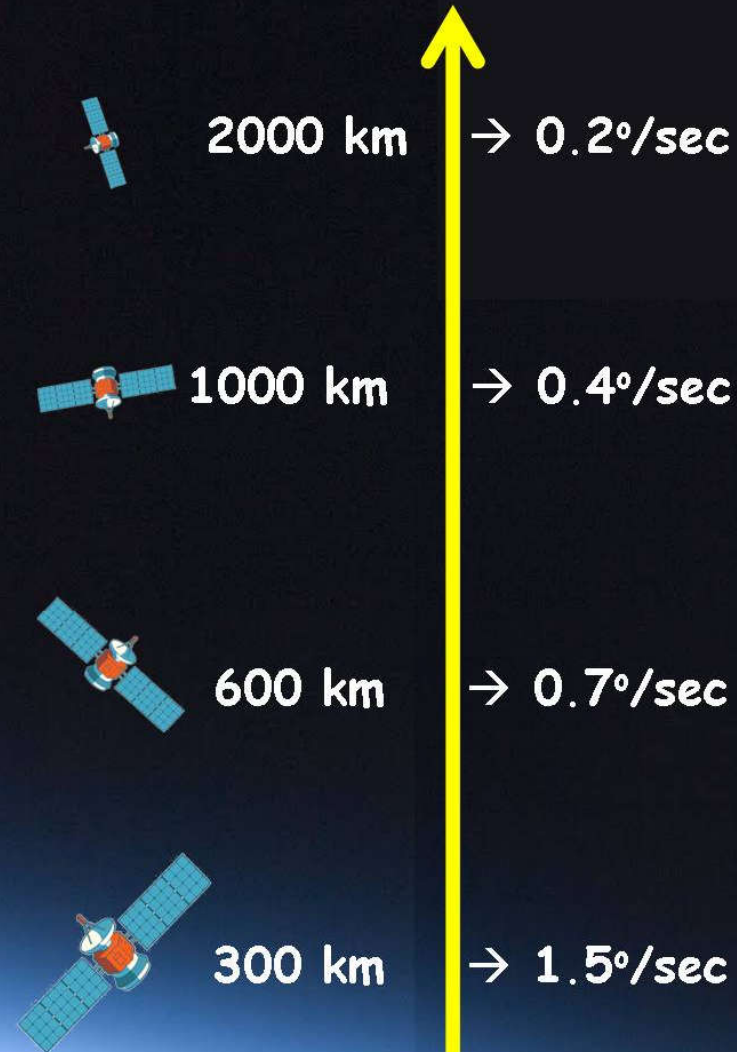
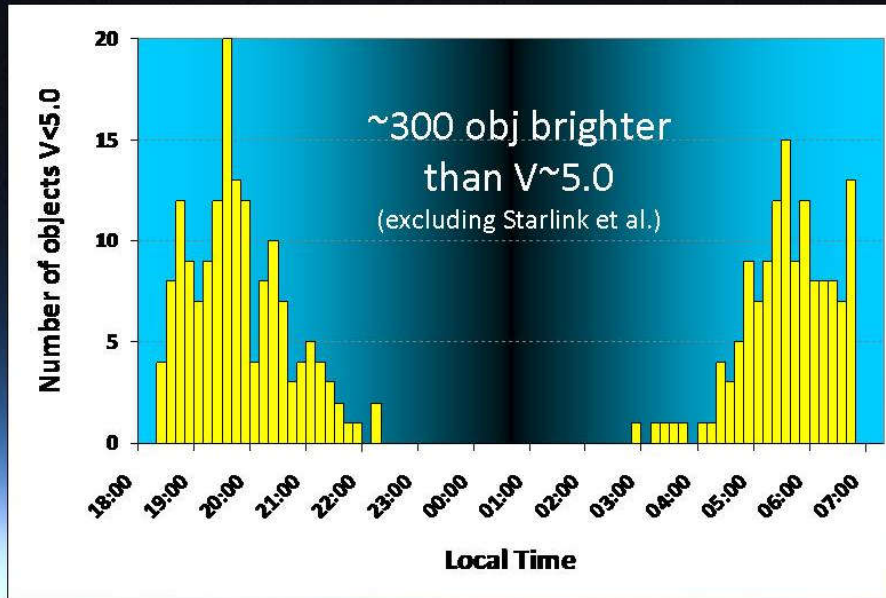
INAF - OAS

Astrophysics & Space Science Obs.

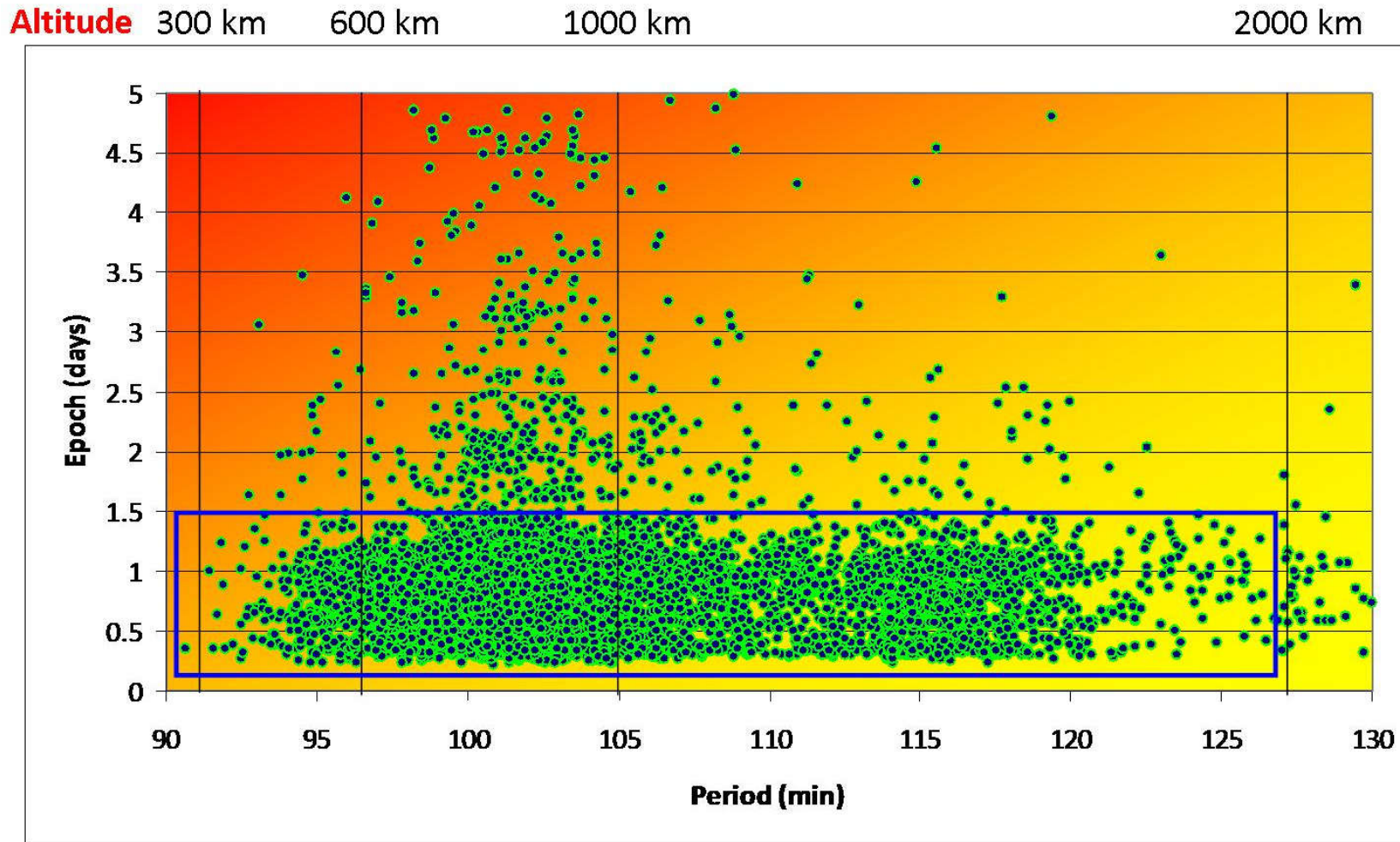
Bologna, Italy



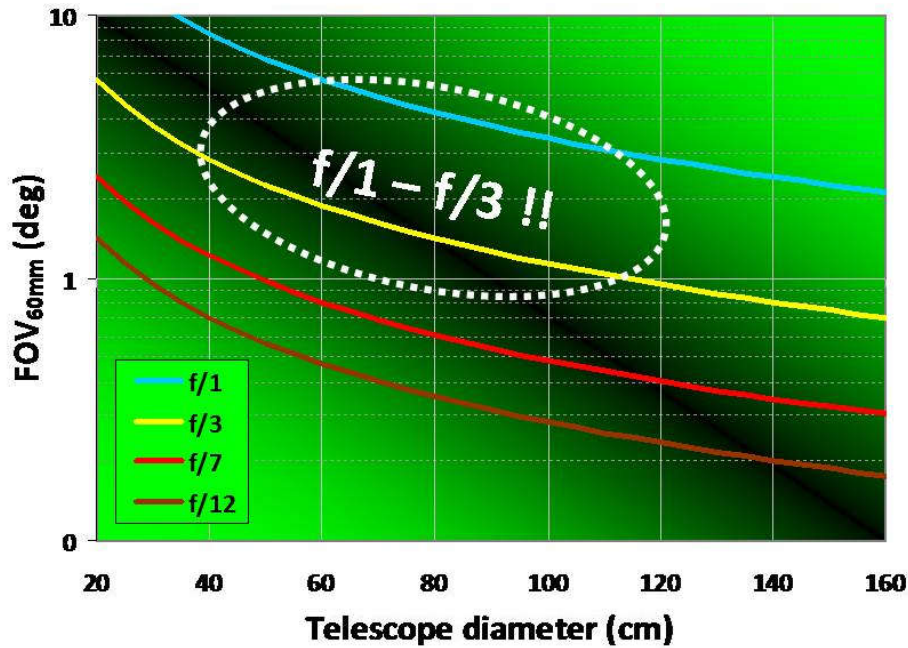
Shadowing and Crossing time



Timeliness!



Monolithic vs. Telescope Array

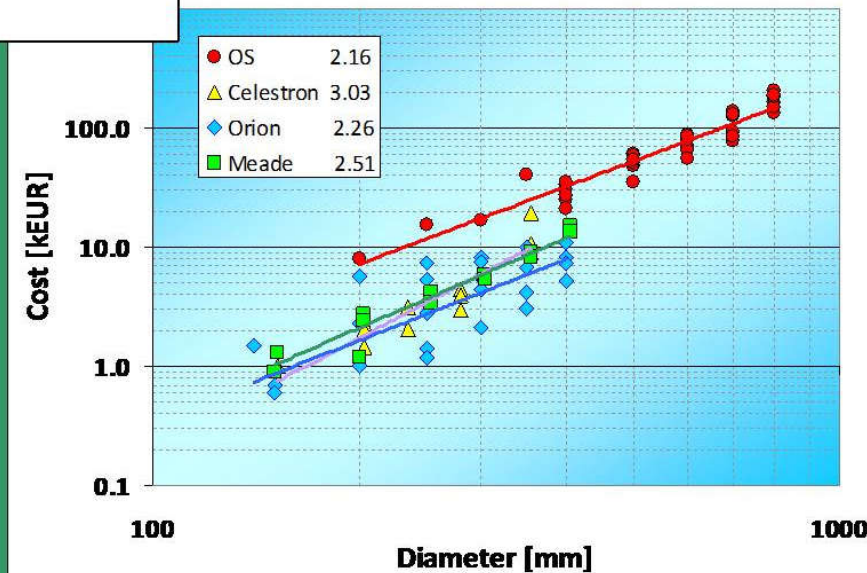


$$n \times T \Rightarrow \begin{aligned} D &= d_{array} \sqrt{n} \\ f / \# &= f_{array} / \sqrt{n} \end{aligned}$$

$$\text{Cost} \propto d^{2.4} \longrightarrow$$

$$\frac{C_{array}}{C_{mono}} = \frac{n \times d^{2.4}}{(d\sqrt{n})^{2.4}} = n^{\left(\frac{2-2.4}{2}\right)} \approx n^{-0.2}$$

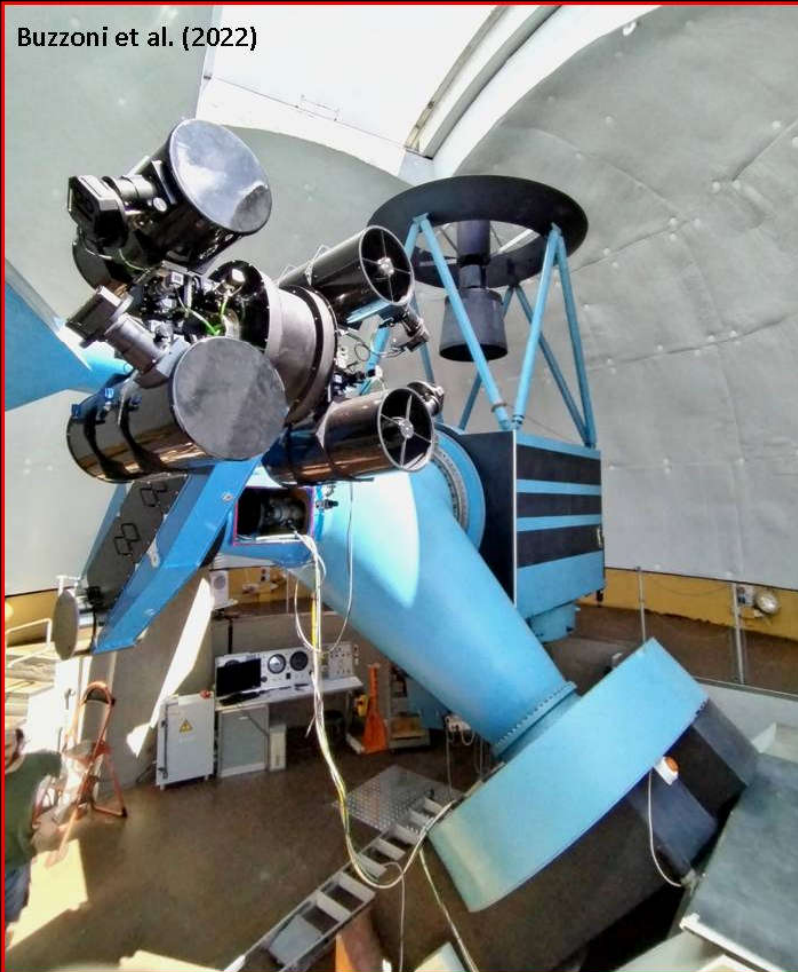
Buzzoni et al. (2024)





The TANDEM project

Buzzoni et al. (2022)



4x telescopes \varnothing 35 cm f/3
 $FOV = 16 \square^2 \quad V_{lim} \sim 19$
 \approx
 1 monolithic tel. \varnothing 70 cm f/1.5
 $FOV = 2.0^\circ \times 2.0^\circ \quad V_{lim} \sim 20$



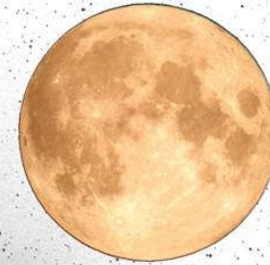


"First light" @TANDEM
Loiano, June 28, 2023 @21:11 UT



**exp. time 20 microsec
(i.e. 0.00002 sec!!)**

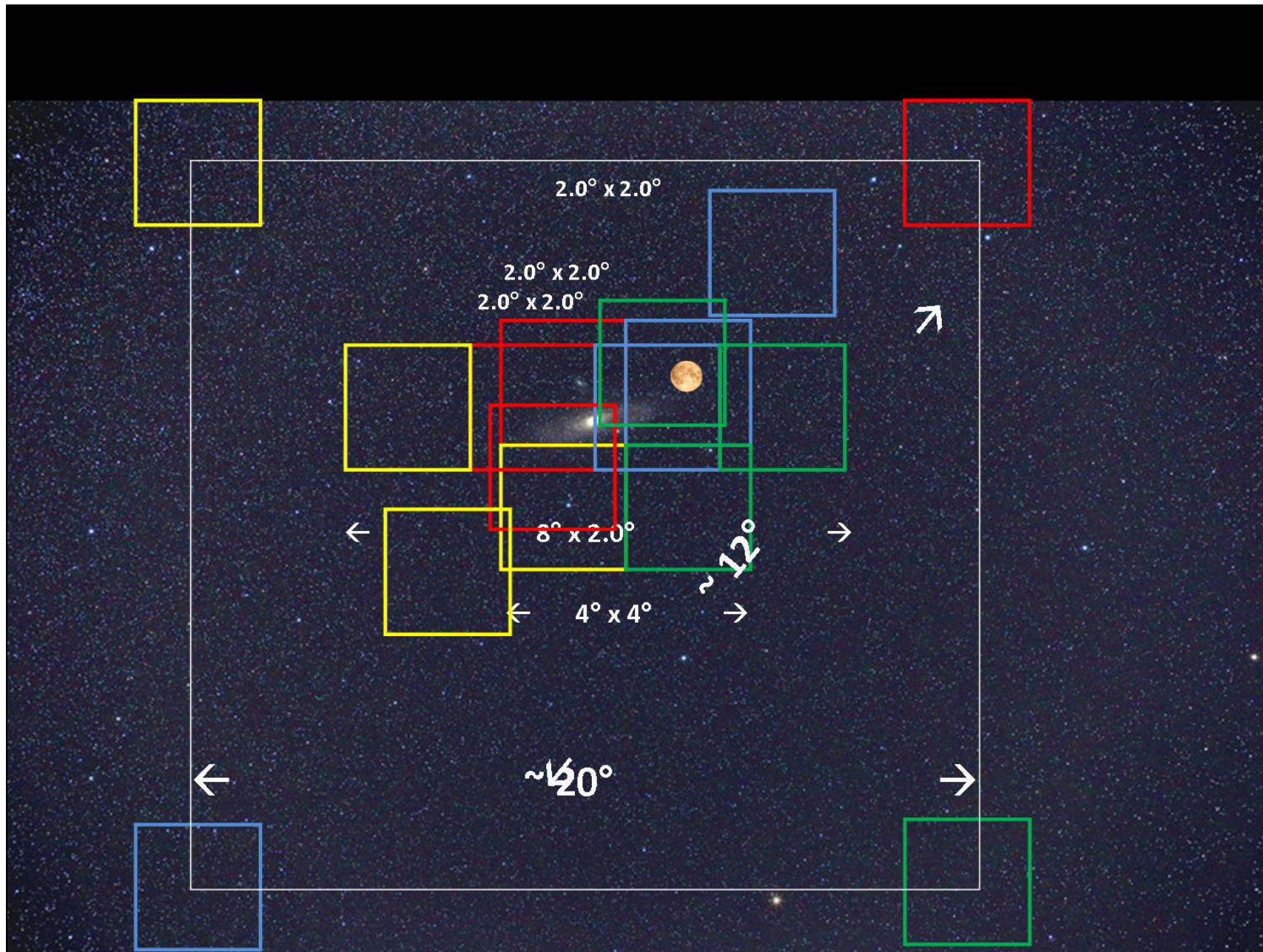
FOV 2°x2°

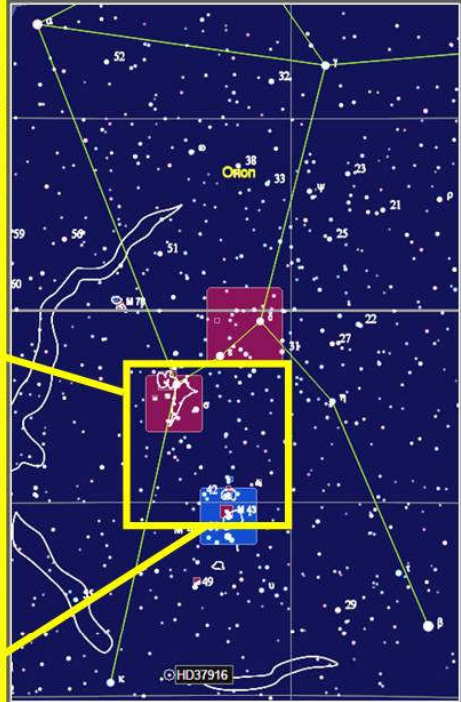
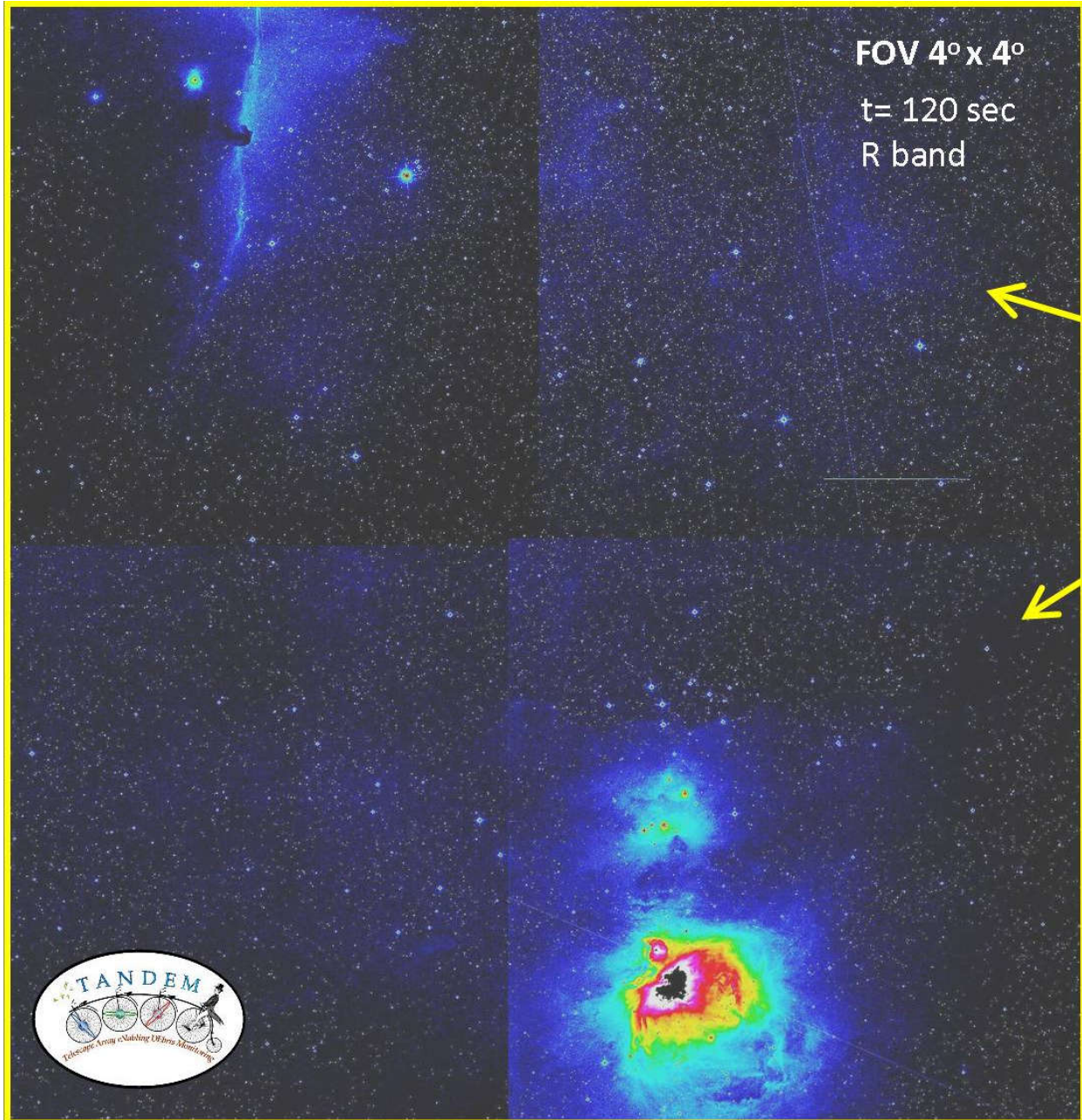


NGC 205

M 32



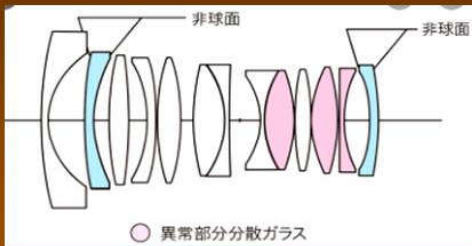






The ASTRA project

Voigtlander E 21mm f/1.4
Nokton

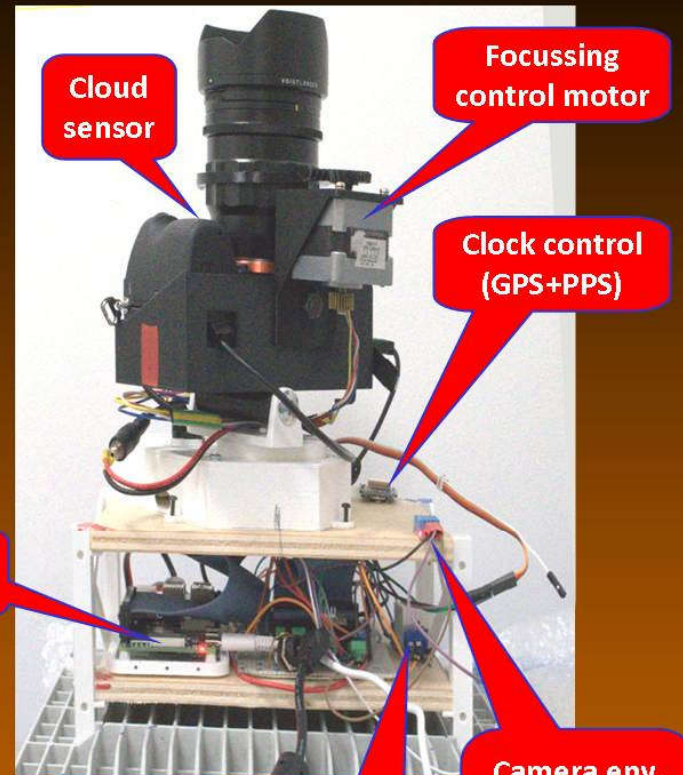


5x

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



FOV: $82^\circ \times 59^\circ$ (100° diag)
Full Frame format:
6000 x 4000 px CMOS
Platescale: 50 arcsec/px
Latency: 0.02 sec (LEO)



Cloud sensor

Focussing control motor

Clock control (GPS+PPS)

Control Unit Raspberry Pi4

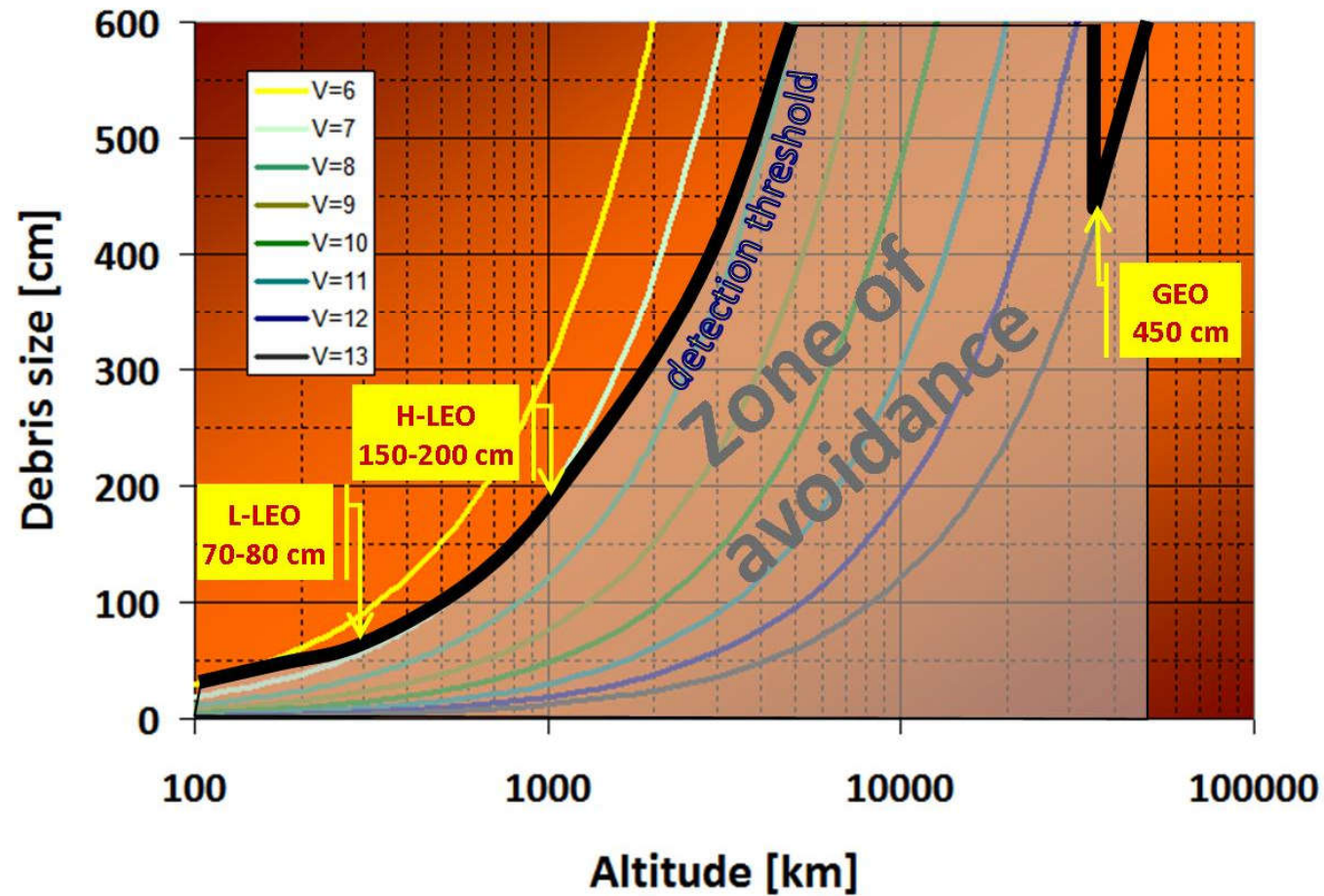
Stepper driver & Solid-state relay

Camera env. sensors (humidity & temperature)

Magnitude vs. Size

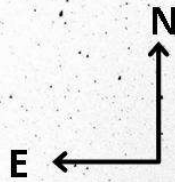
$$V \cong -5\log(s_{cm}) + 5\log h_{km} - 2.5\log(\alpha / 0.1) + 3.40$$

(Buzzoni et al. 2014)

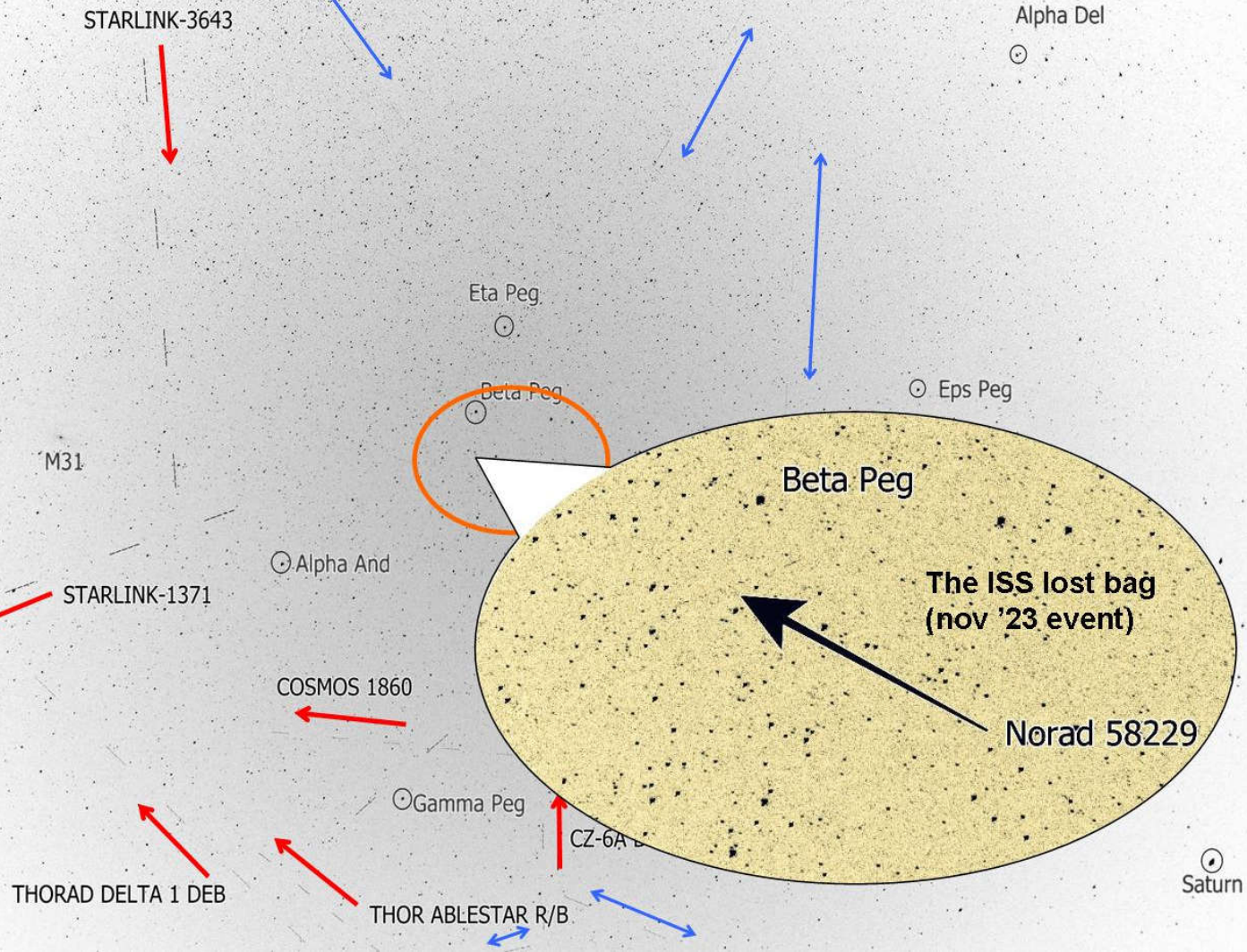




Astra Project, space debris detection test
Nov 19, 2023, 16:57 UT
6400 ISO, 21 mm, F/1.4, exposure: 20 x 0.5 s

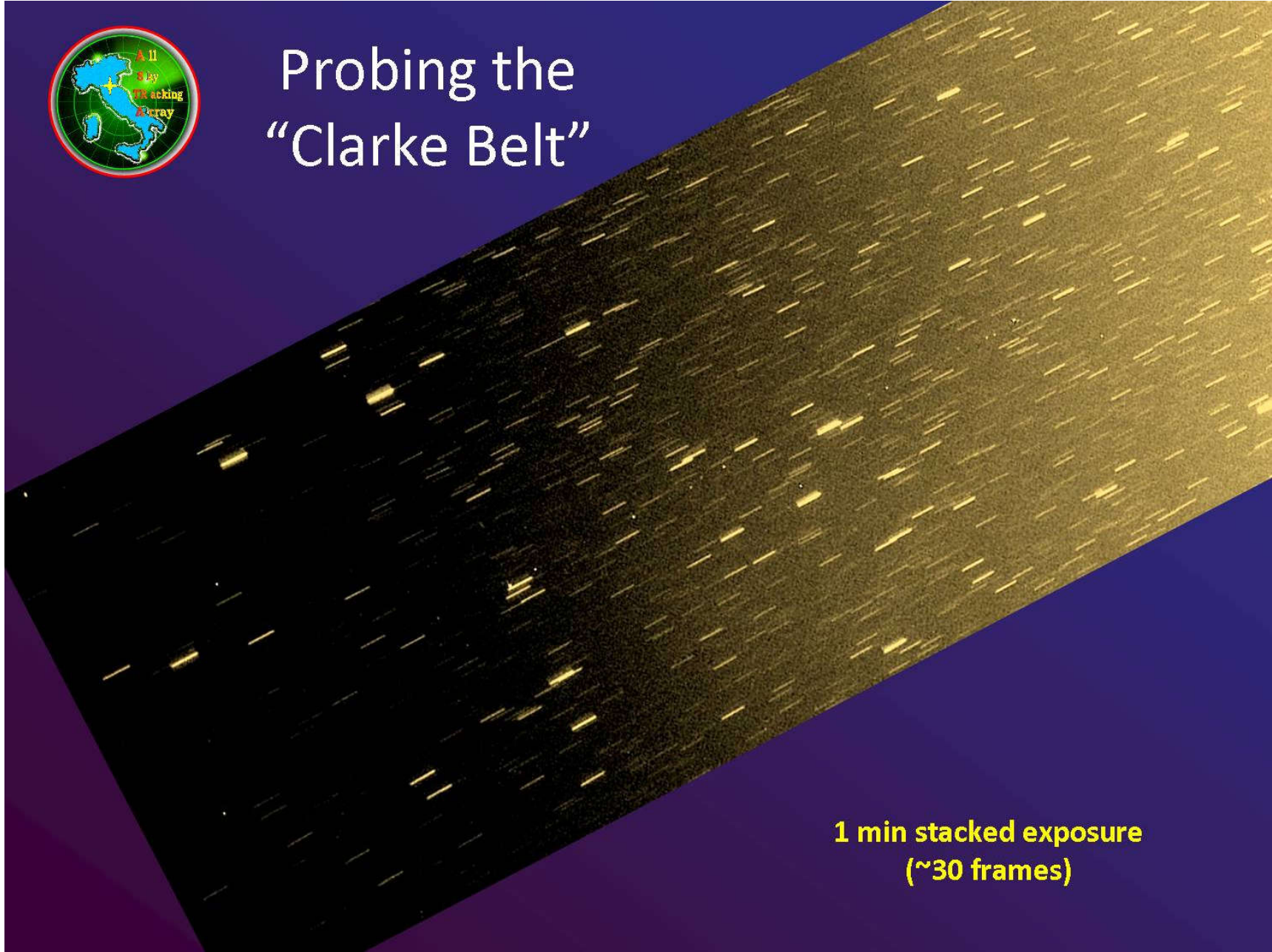


FOV: 82° x 59°
(100° diag)





Probing the “Clarke Belt”



**1 min stacked exposure
(~30 frames)**

