Optical Tracking of Deep-space probes and Space Debris:

small telescope rebirth for Space Situational Awareness activities

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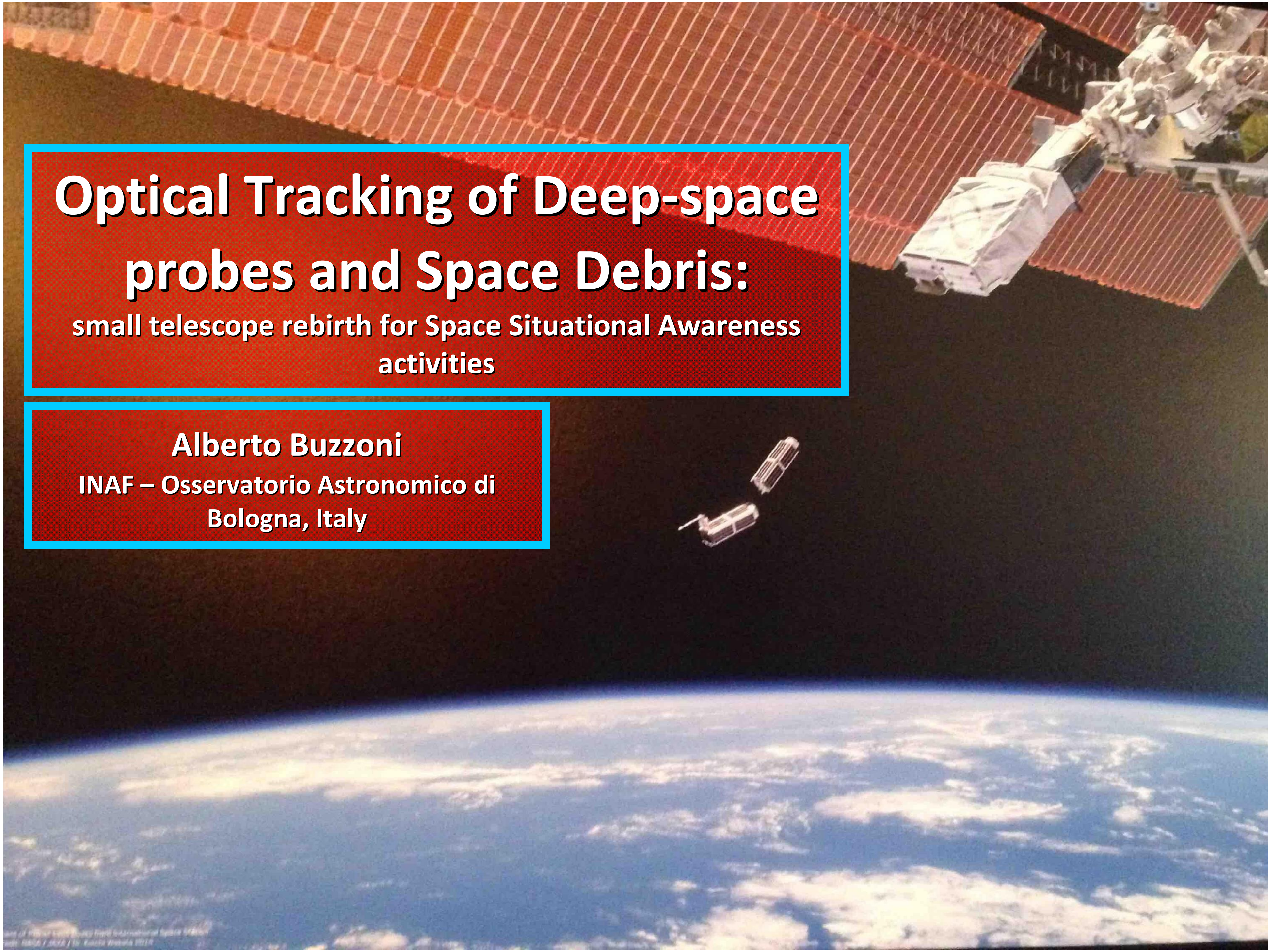
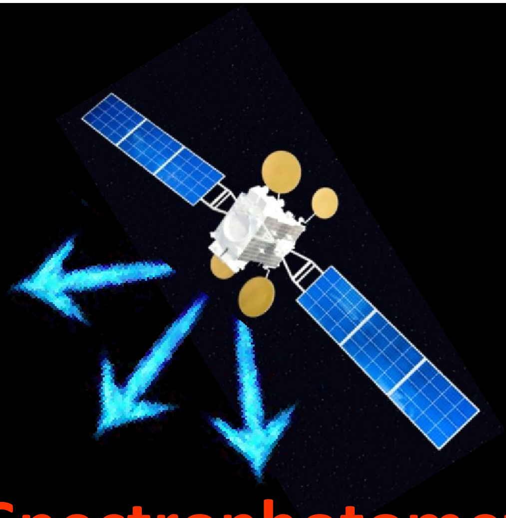


Two main tasks



Optical tracking

Spectrophotometric characterization

The advantage of optical tracking

$$\frac{D_{radio}}{D_{opt}} = \frac{\nu_{opt}}{\nu_{radio}} \cong \frac{10^{15}}{10^{10}} \Rightarrow 10^{5}$$

1. so, a 1m optical telescope matches the angular resolution of a ~100km radiotelescope/interferometer

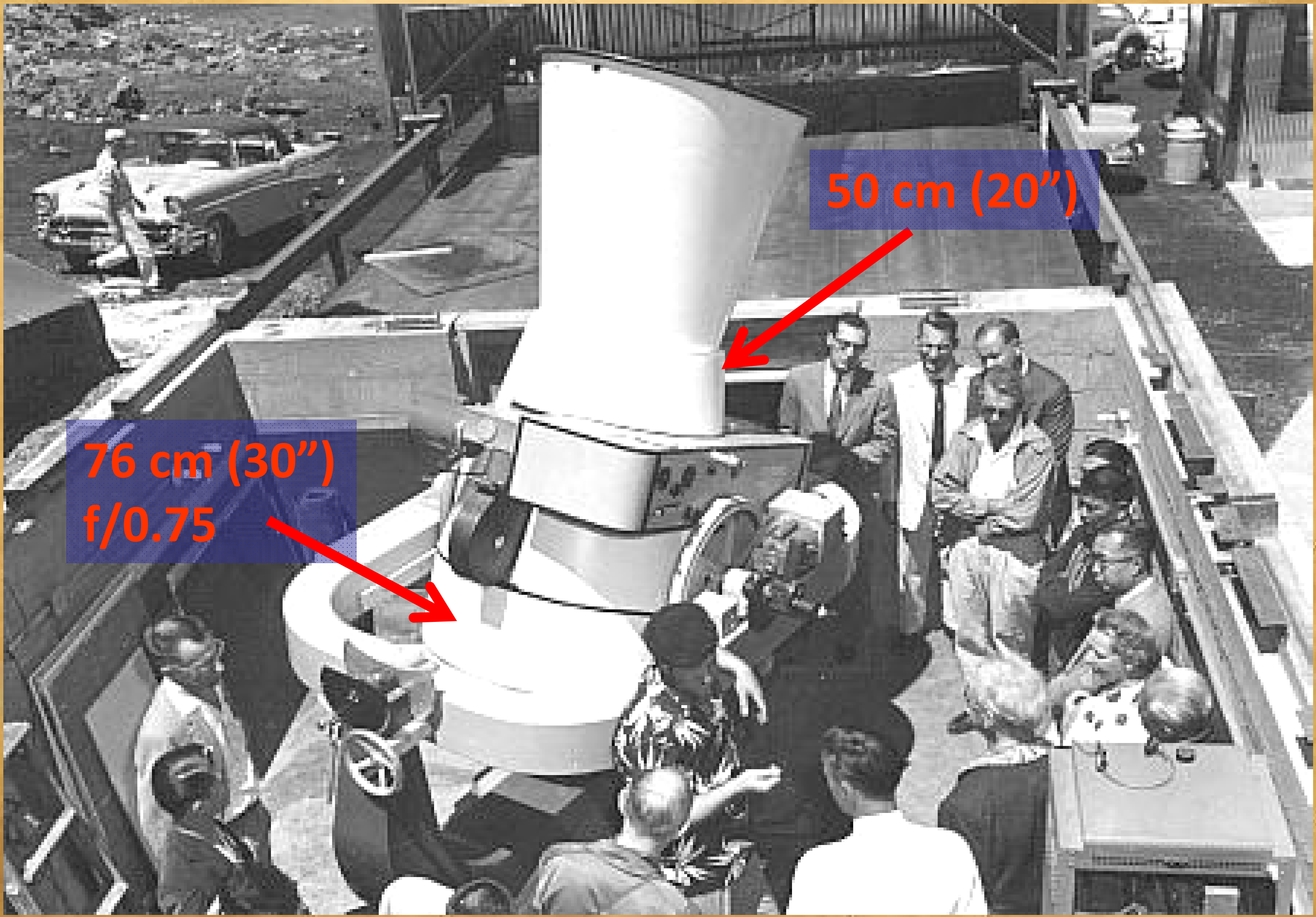
$$f_{radio} = \left(\frac{L_{in}}{d^2}\right)\left(\frac{1}{d^2}\right) \Rightarrow \quad f_{radio} \propto d^{-4} \quad \text{while} \quad f_{opt} \propto d^{-2}$$

2. so, an optical telescope is more efficient than a bistatic antenna, with increasing distance

3. operating costs for a 1m optical telescope are far less than costs for a LBI interferometer

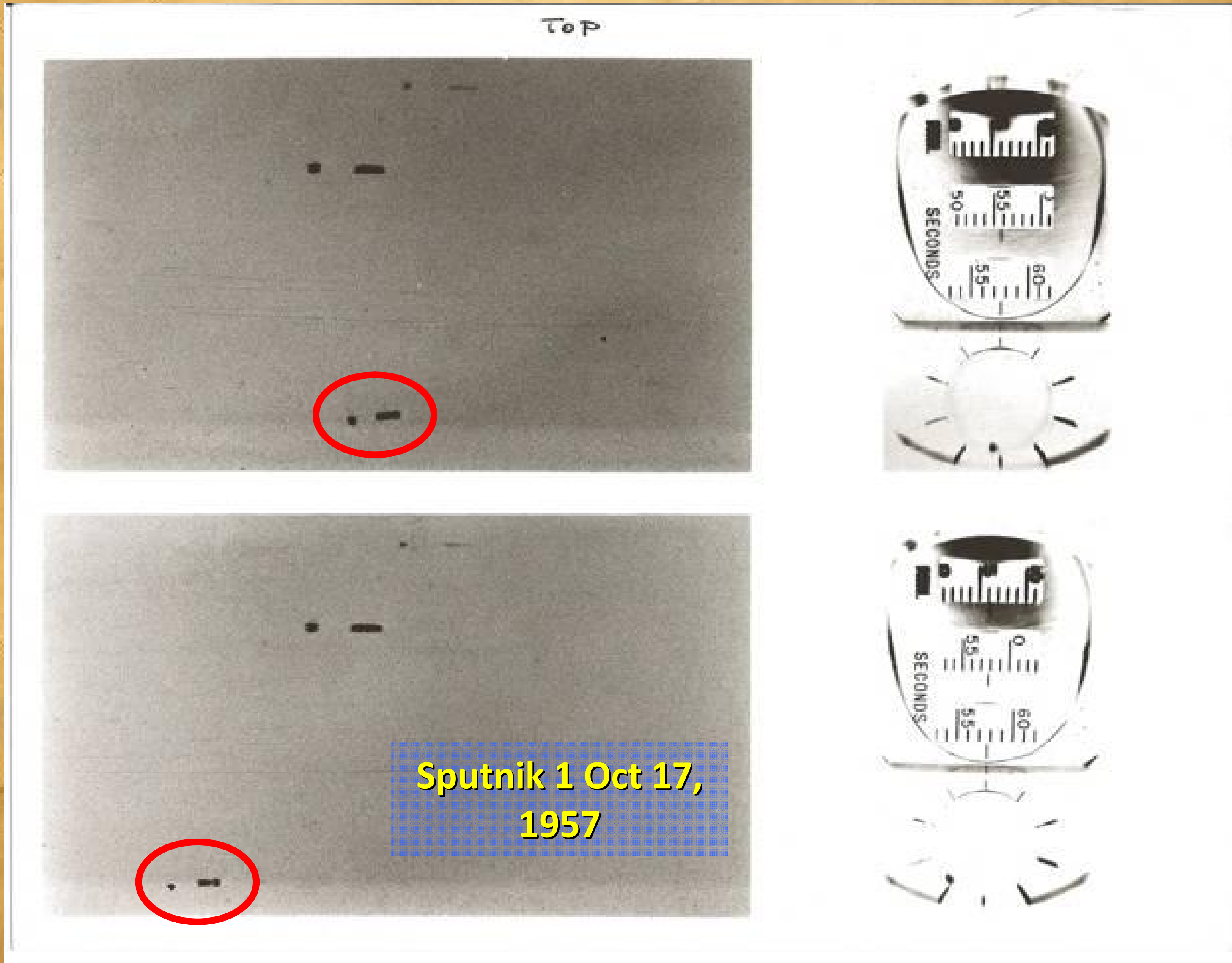
The Baker-Nunn Cameras

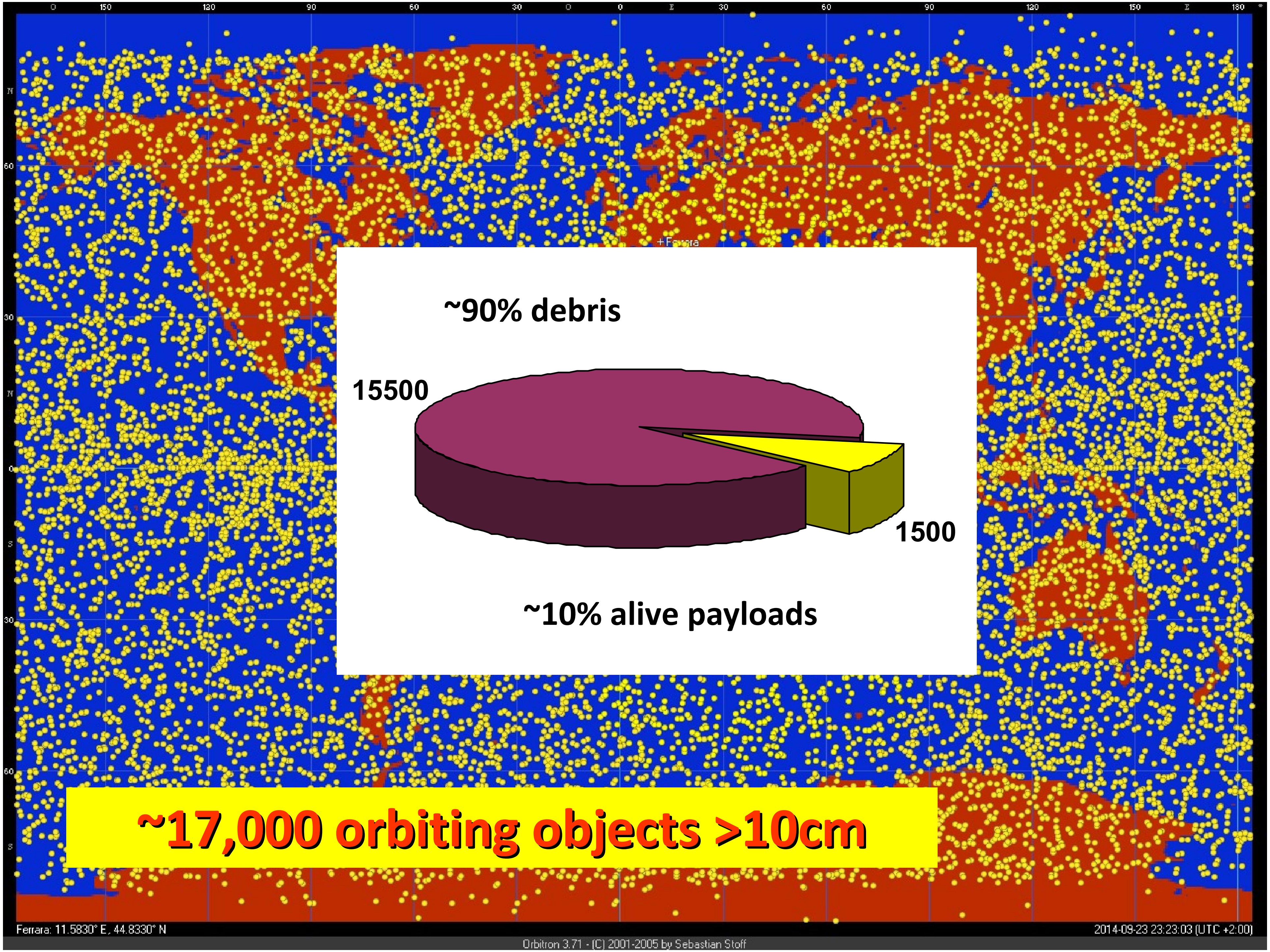
(12 telescopes around the world)



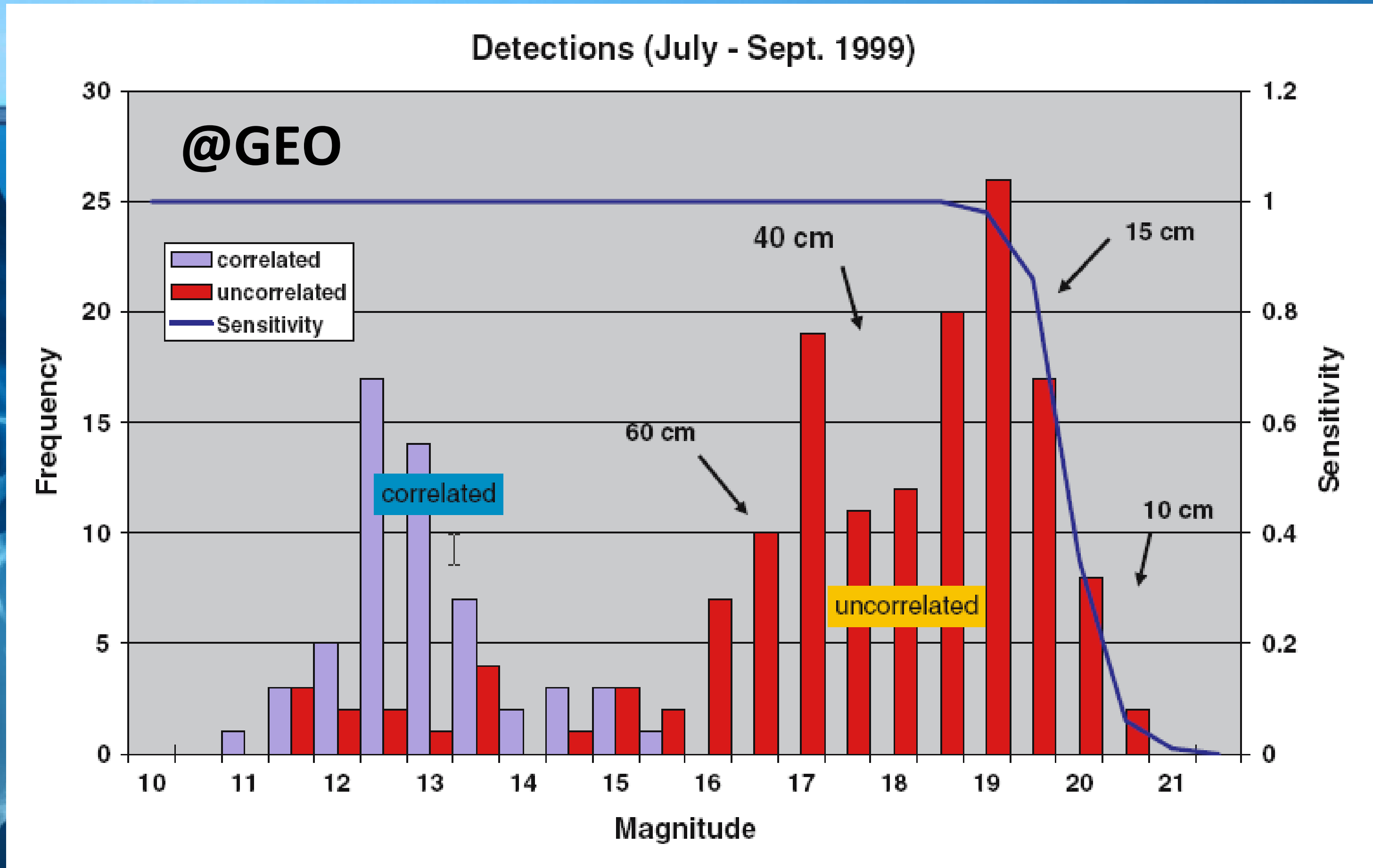
The Baker-Nunn Cameras

(12 telescopes around the world)



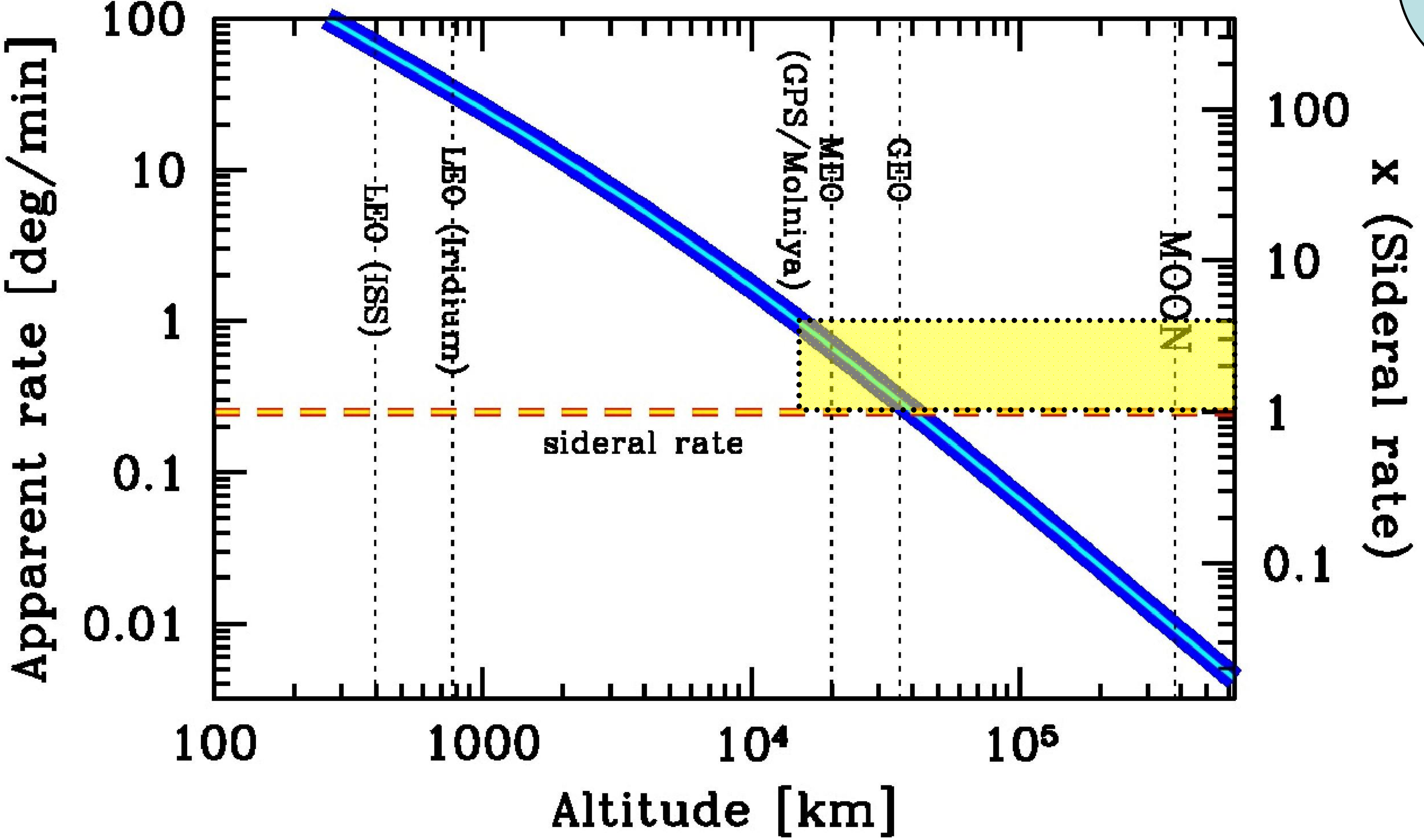

~90% debris
15500
1500
~10% alive payloads
~17,000 orbiting objects >10cm
Ferrara: 11.5830° E, 44.8330° N
2014-09-23 23:23:03 (UTC +2:00)
Orbitron 3.71 - (C) 2001-2005 by Sebastian Stoff

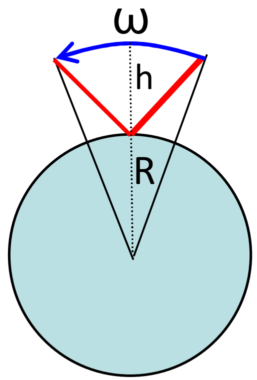
Uncovering the iceberg



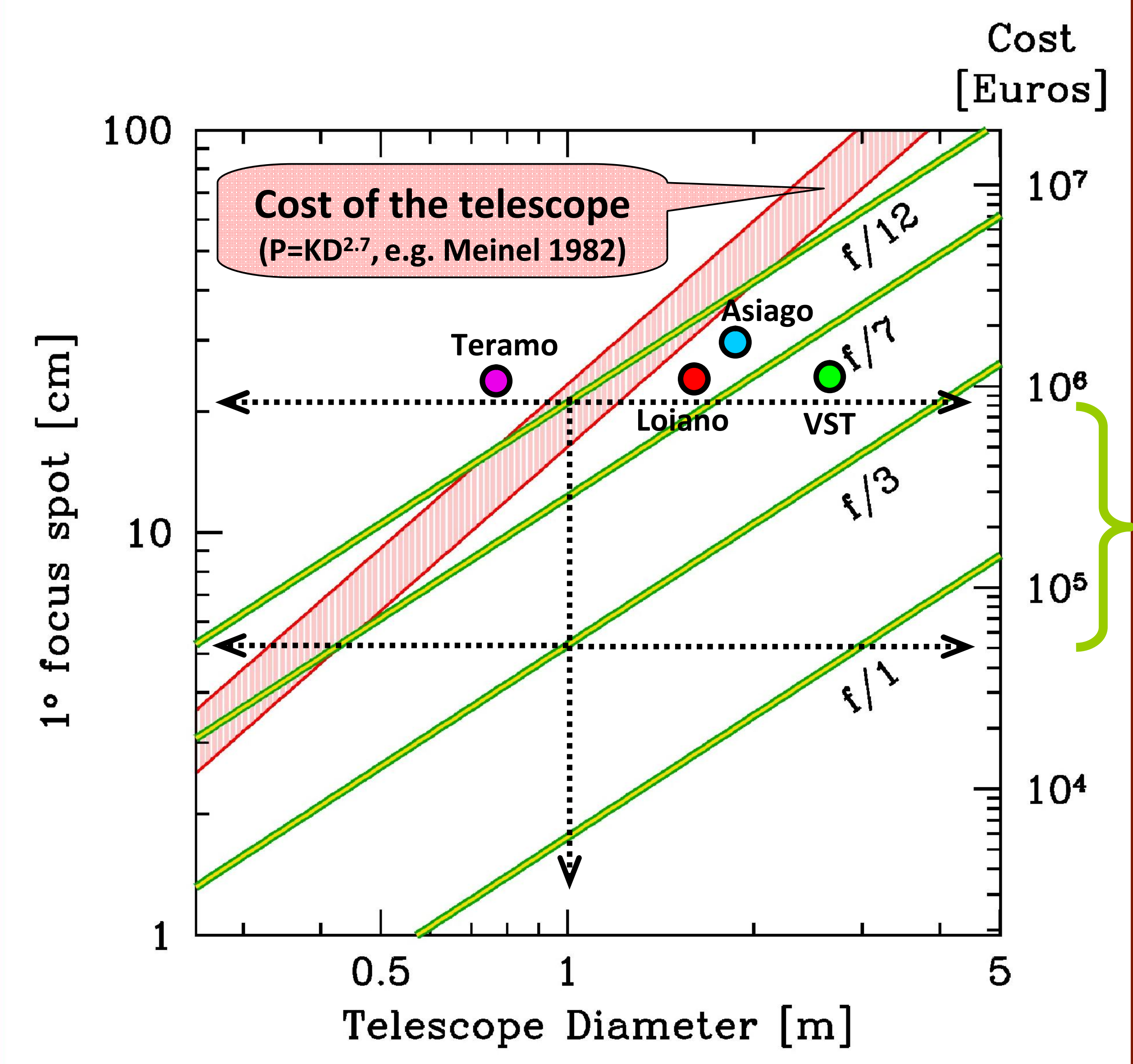
Schildknecht et al. (2004)

Tuned strategies for a technical challenge





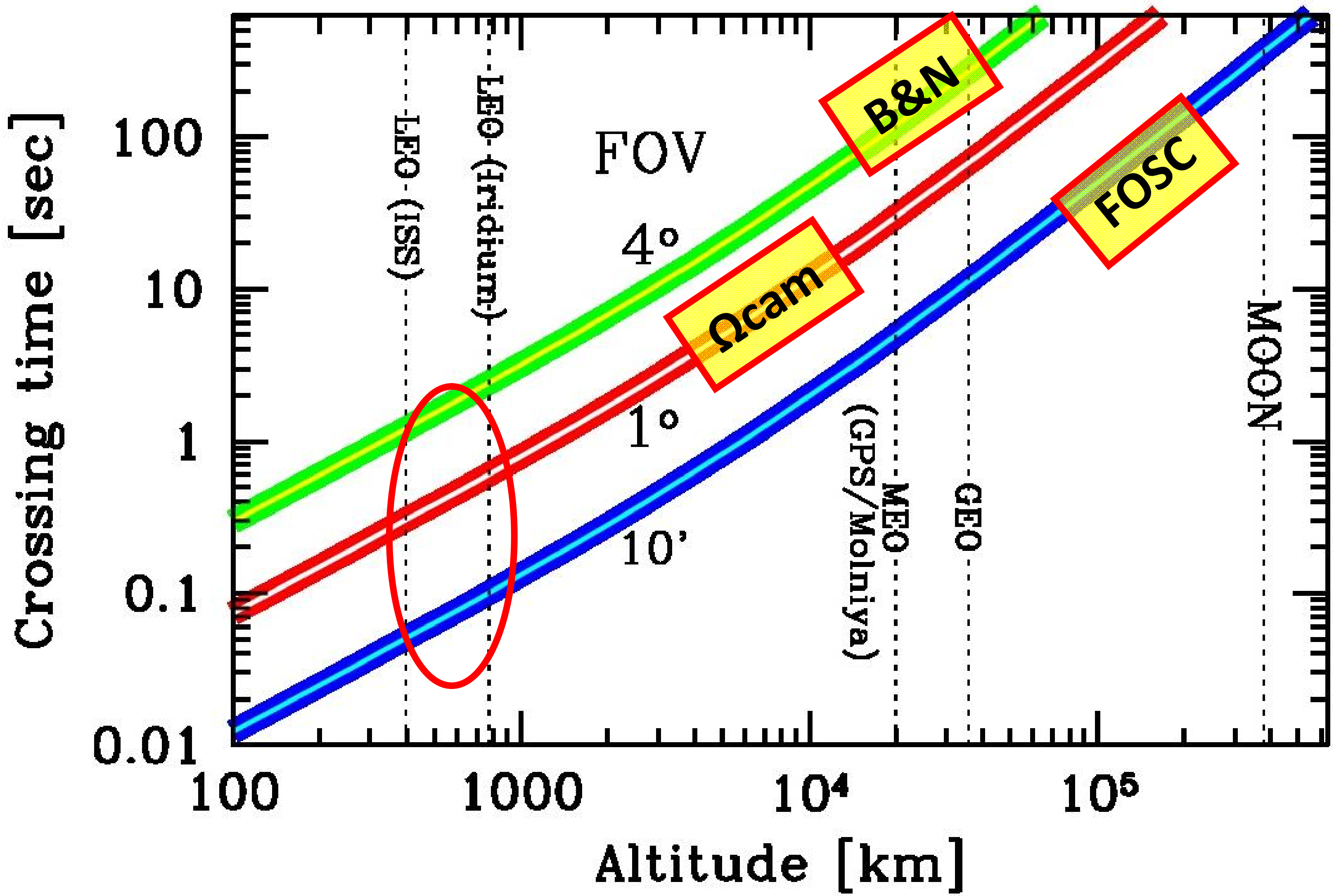
Pay per view...



Cost of the CCD coverage, $P=k(fD)^2$

(Assume to be mosaicing w/ $4k^2$CCD @30K€)

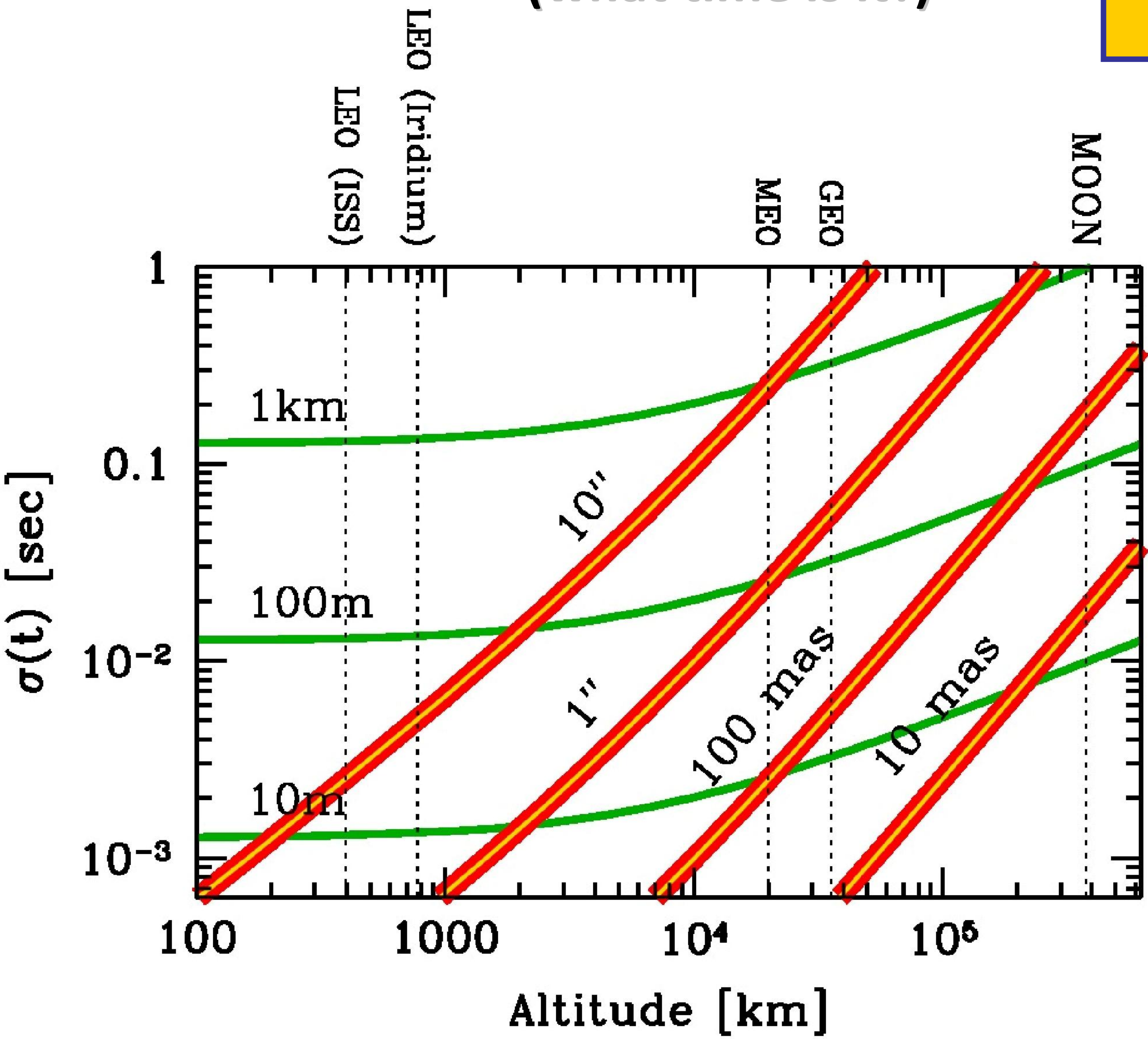
Catching the "road runners"

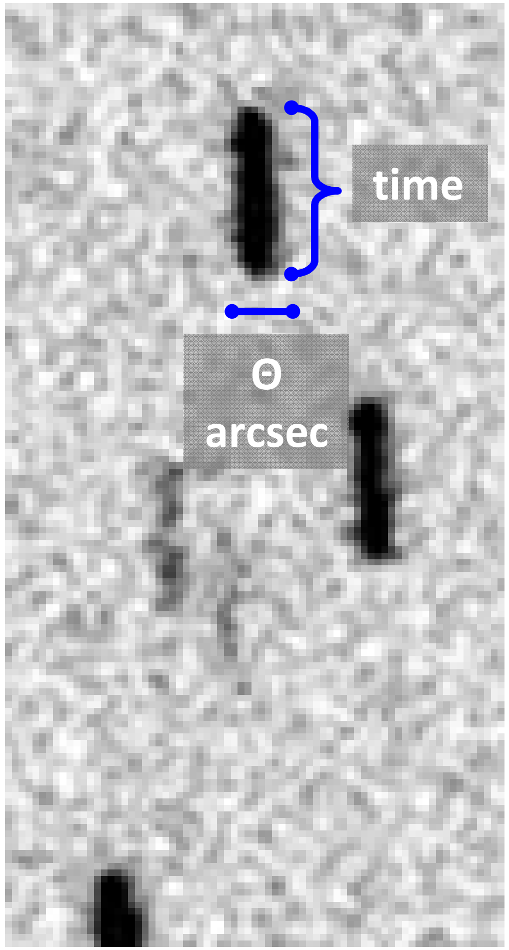


The clock bias

(what time is it?)

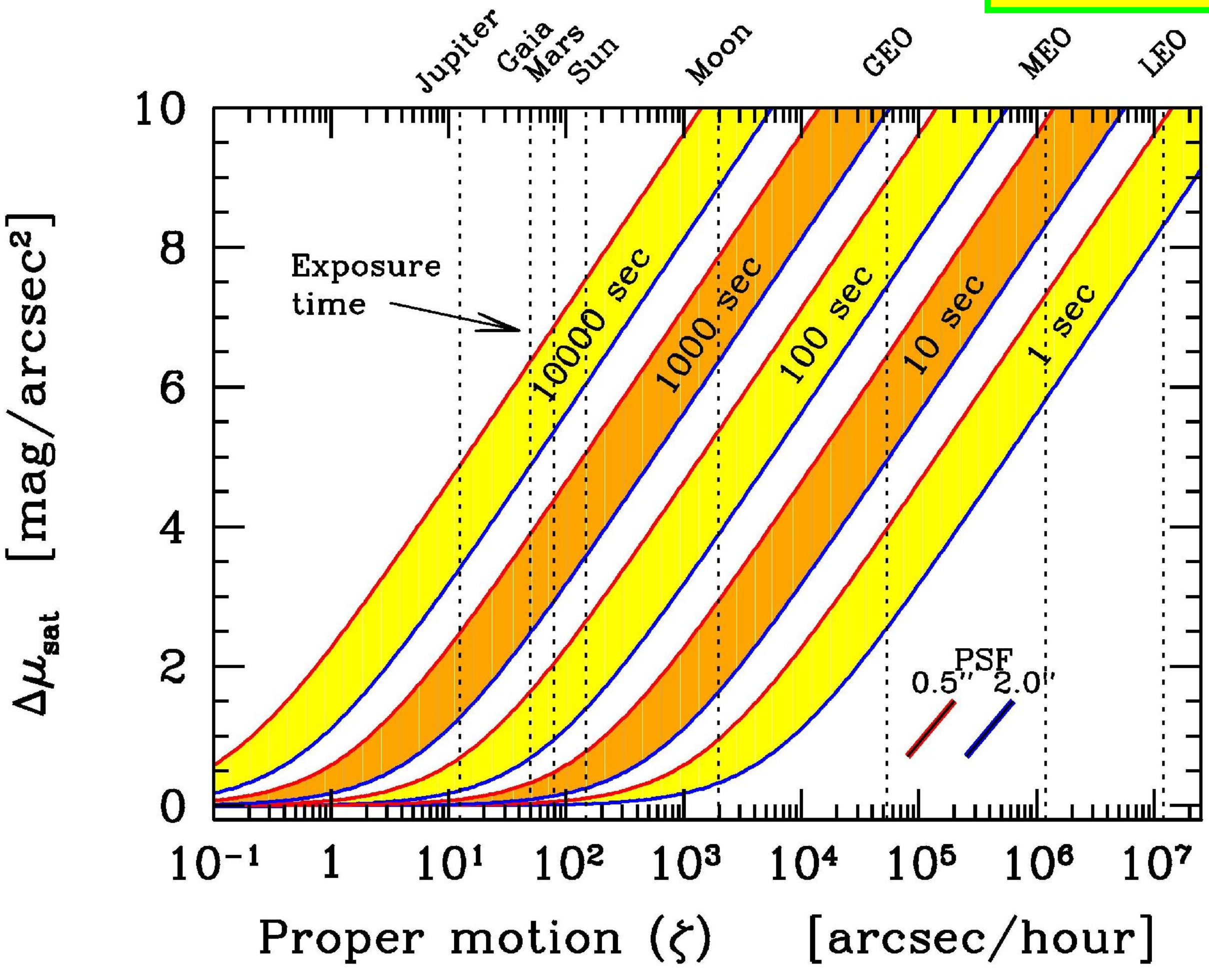
$$\sigma(t) \cong \frac{3.6\theta_{mas}}{\zeta}[\text{sec}]$$





Motion Dimming

$$\Delta\mu = 2.5\log\left(1+\frac{4t_{\exp}\zeta}{\pi FWHM}\right)$$

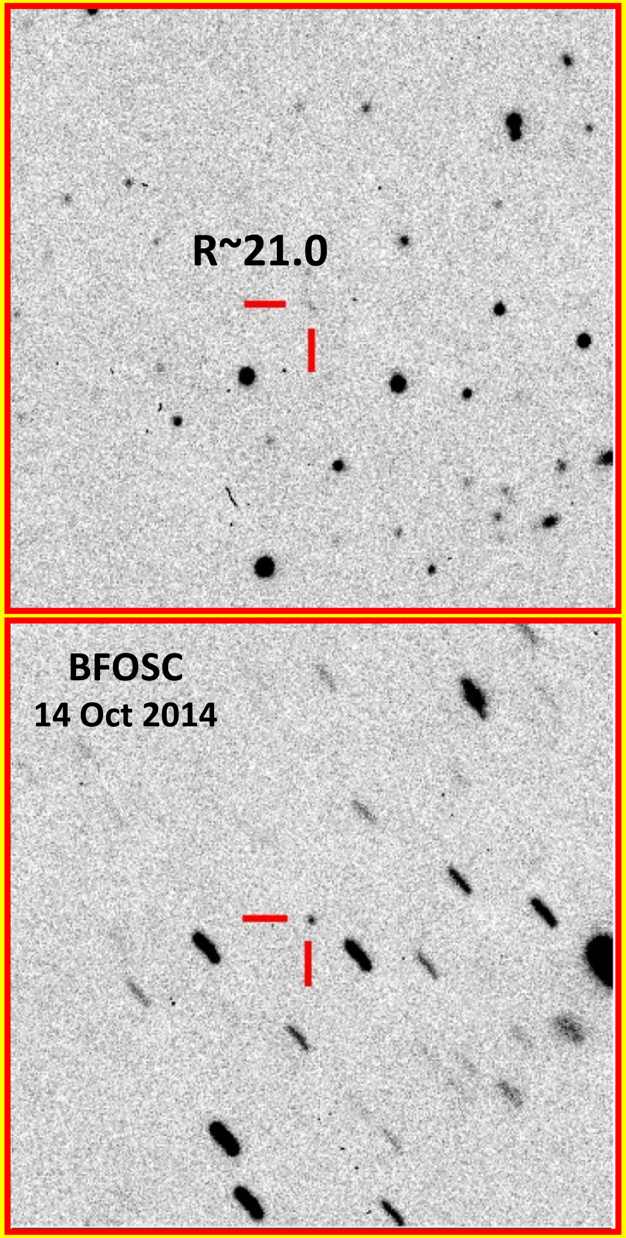


$$(S/N)_{track} = (S/N)_{trail}10^{+0.2\Delta\mu}$$

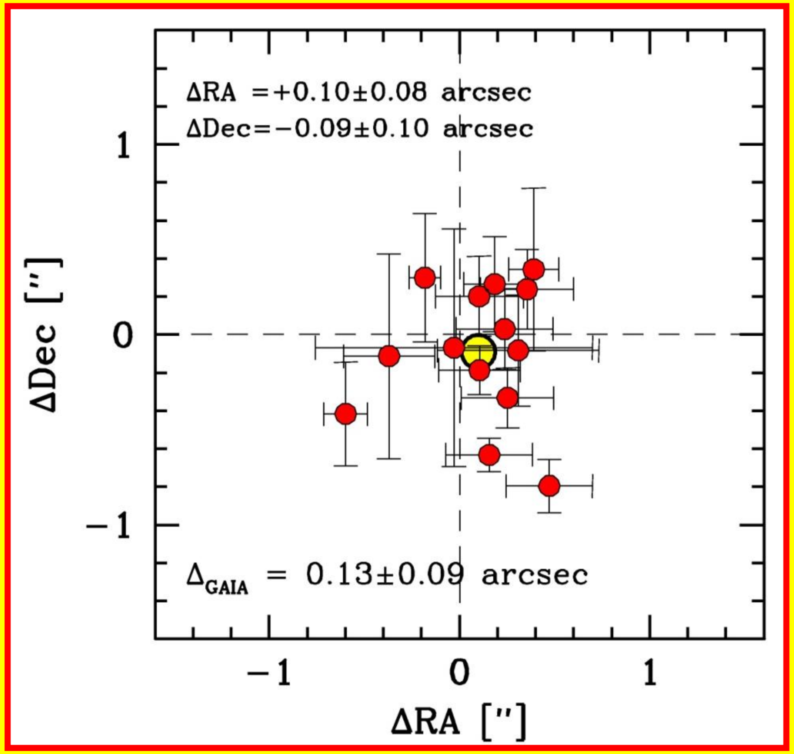
A cutting-edge experiment: spotting GAIA in its Halo L2 orbit

A. Buzzoni, G. Altavilla, S. Galleti, I. Foppiani, R. Gualandi

σ = 90 m.a.s.
600 meters @ 1.5 million km!!



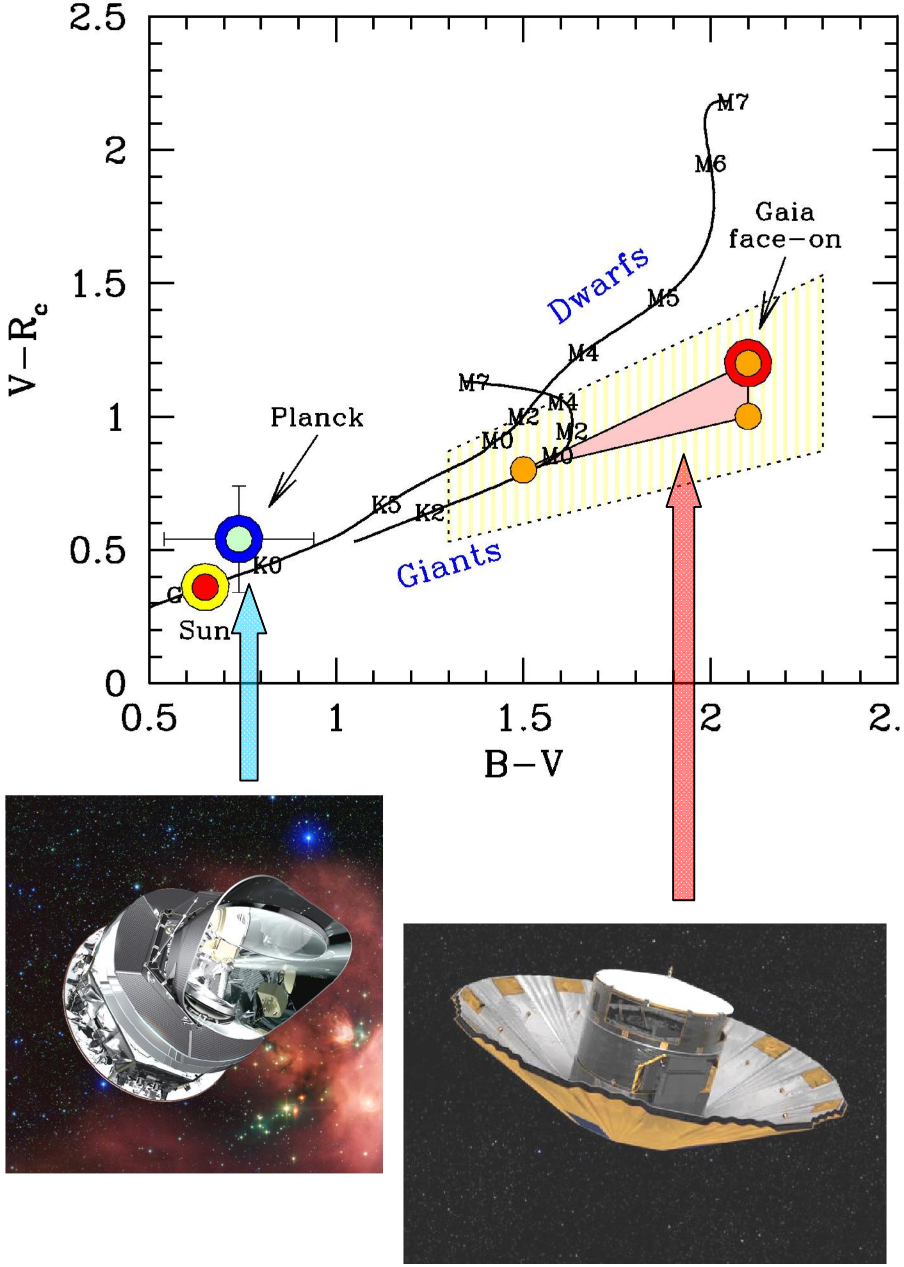
Buzzoni et al. (2016)

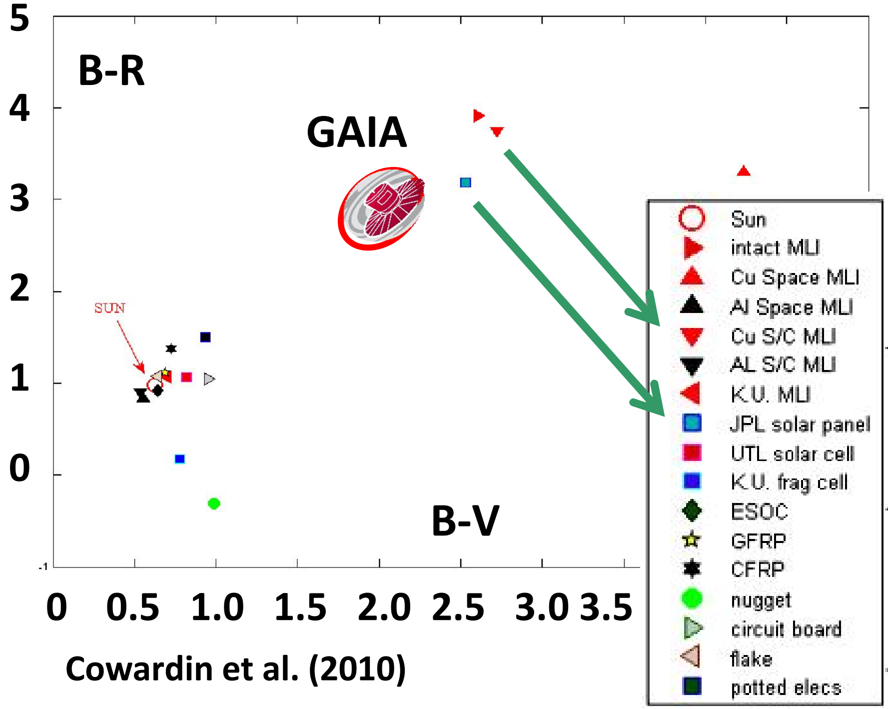


Spectrophotometric characterization

(What is made of?)

Buzzoni et al. (2016)

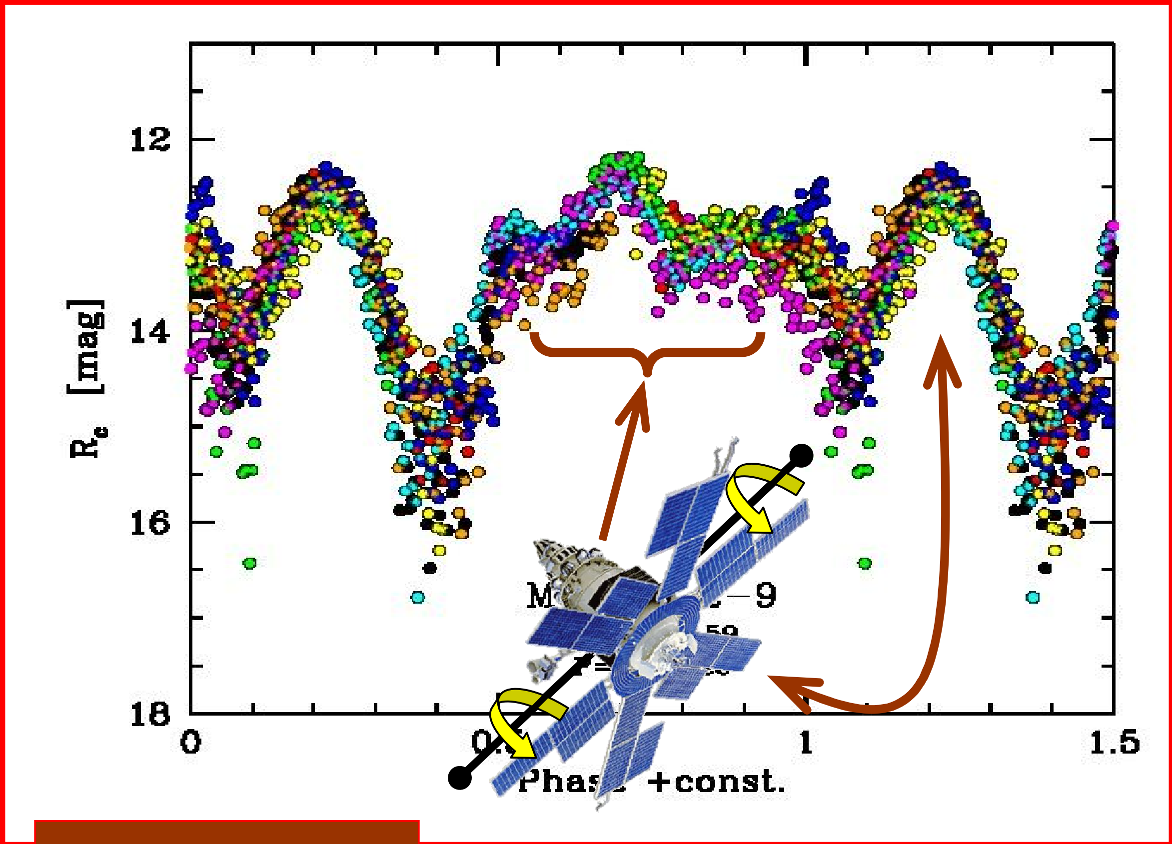




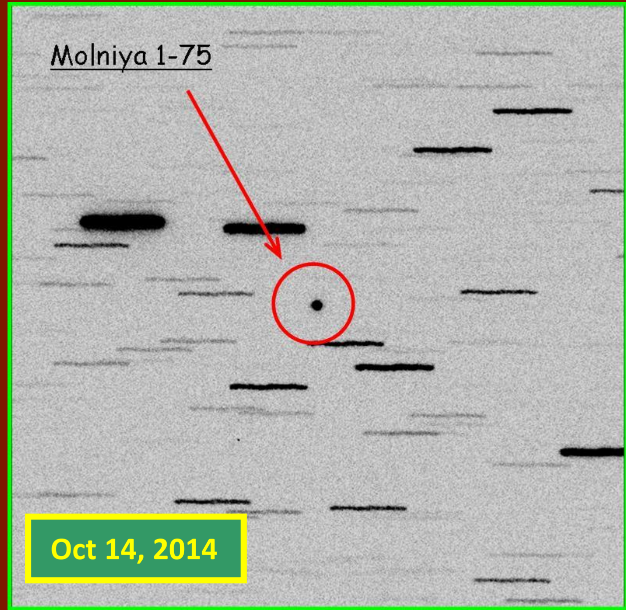
Cowardin et al. (2010)

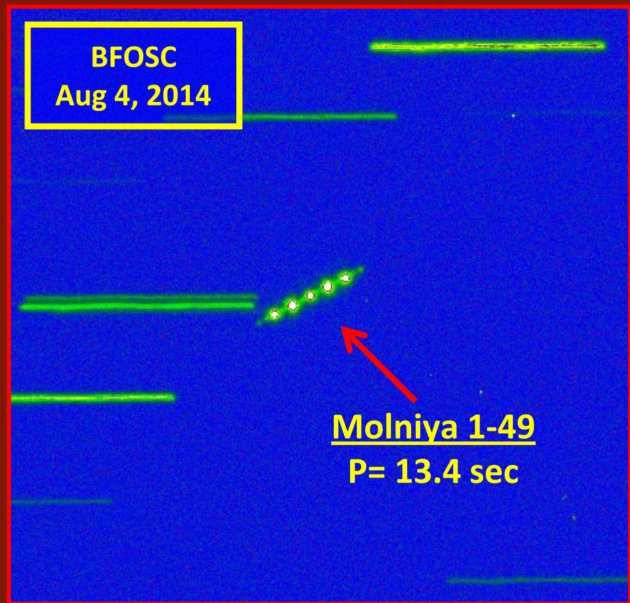
Tracking & Trailing

A. Buzzoni, G. Altavilla, F. Matassoni (OABo),
J. Guichard, S. Camacho-Lara (Mex) A. Figer (Fra)



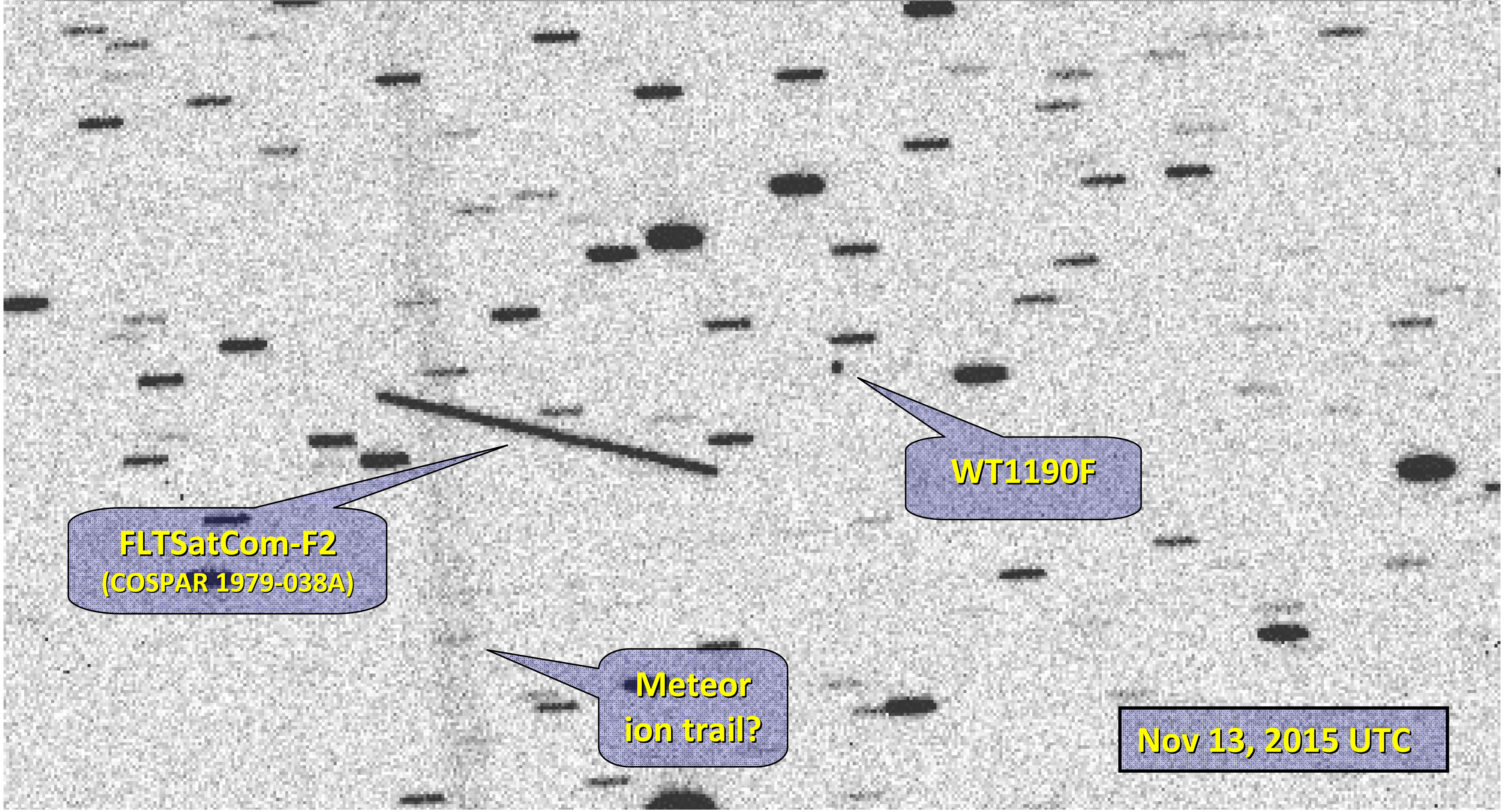
Molniya 2-09
(COSPAR 1974-026A)
P= 14.5 sec





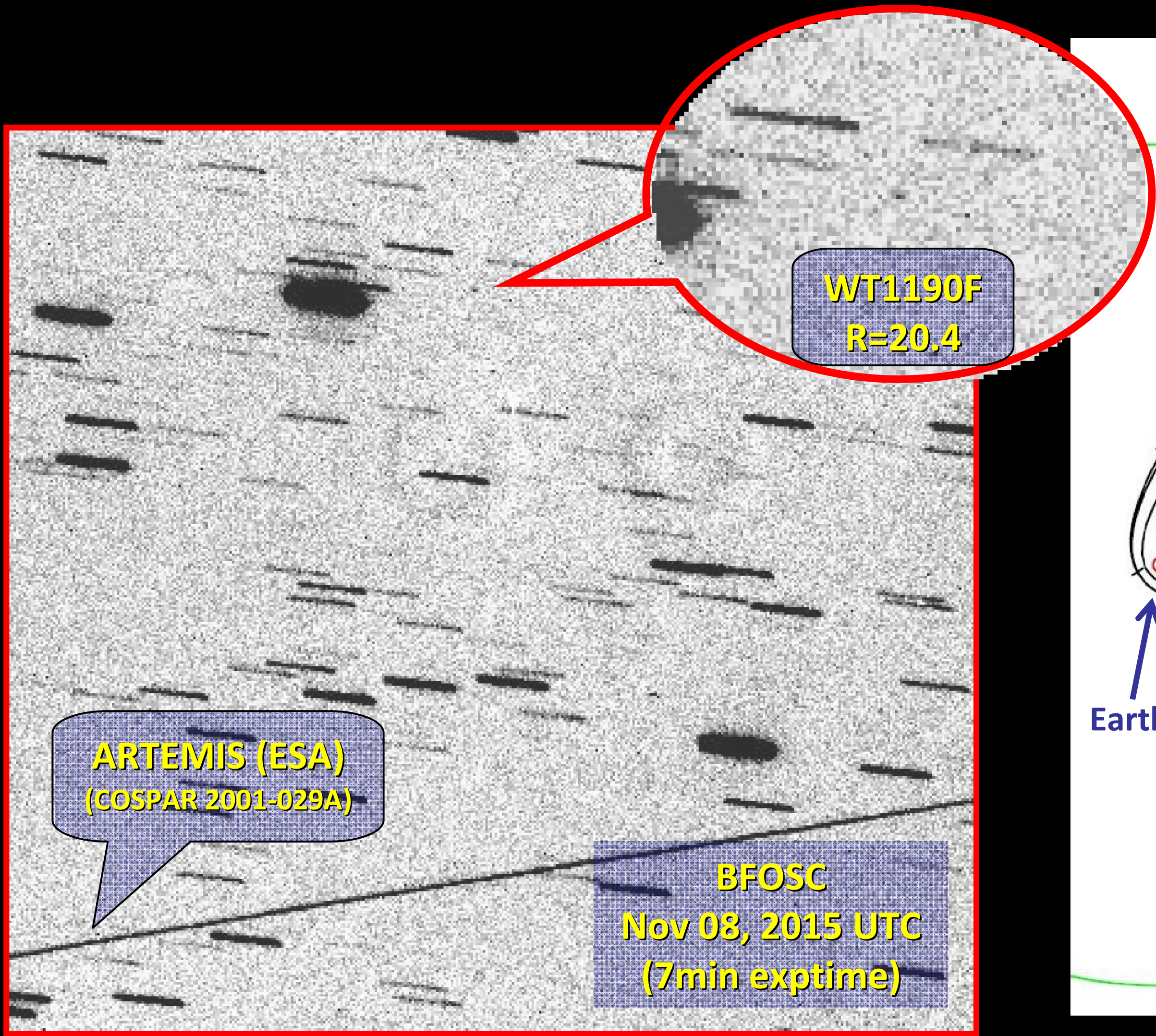
Rehearsal of the Armageddon: the deep-space debris WT1190F

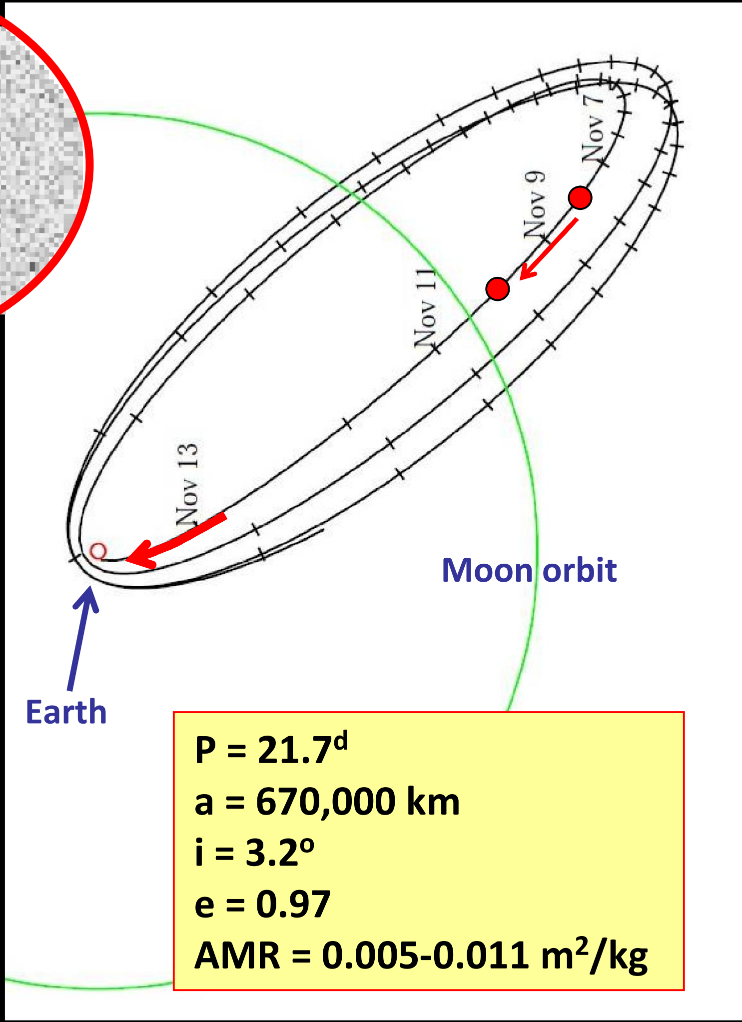
A. Buzzoni, G. Altavilla, I. Foppiani, R. Gualandi, I. Bruni (OABo), C. Frueh, S. Fan (Purdue U. USA), M. Micheli (ESA/NEO), N. Sánchez-Ortíz, J. Nomen (DEIMOS Space, Spain)



Probing the WT1190F final approach to Earth

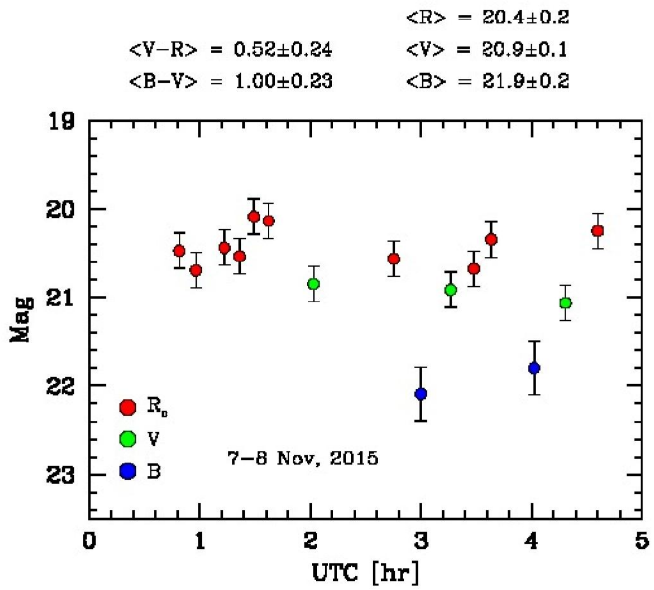
(Nov 07-13, 2015)

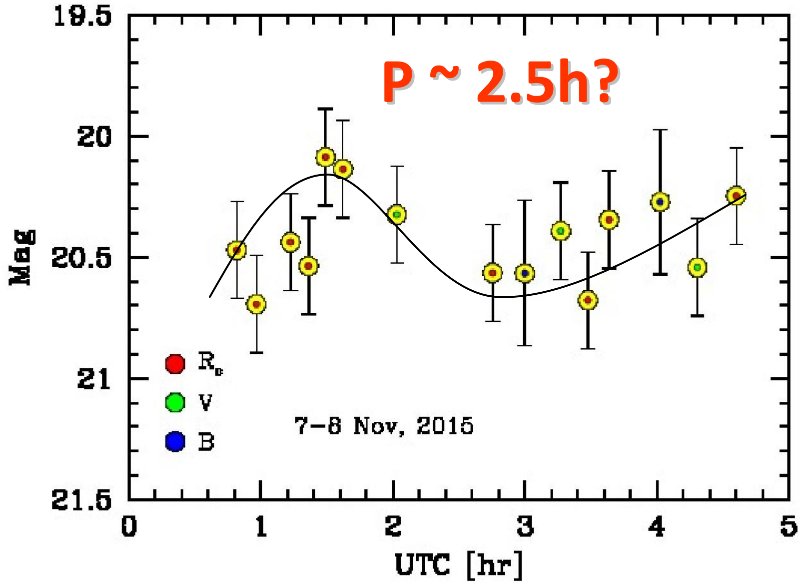


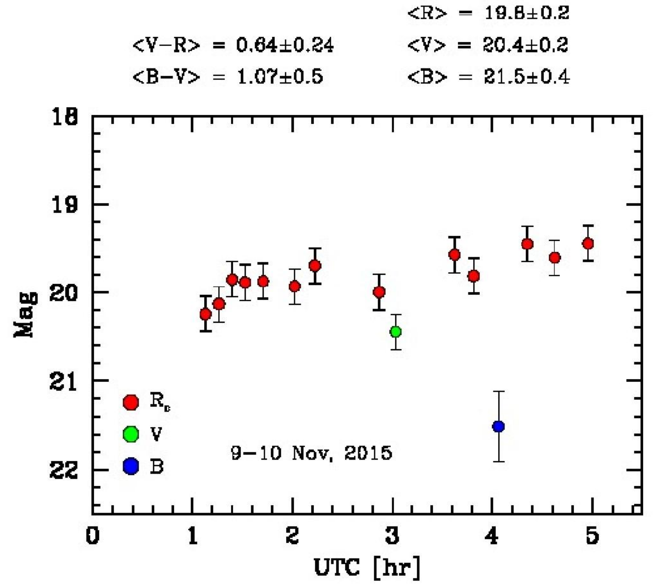


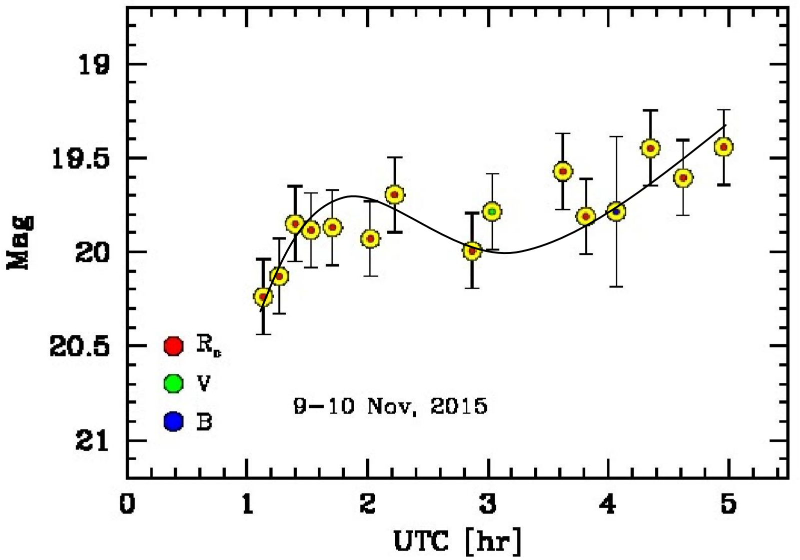
P = 21.7^d
a = 670,000 km
i = 3.2^o
e = 0.97
AMR = 0.005-0.011 m^2/kg

A precessing body?

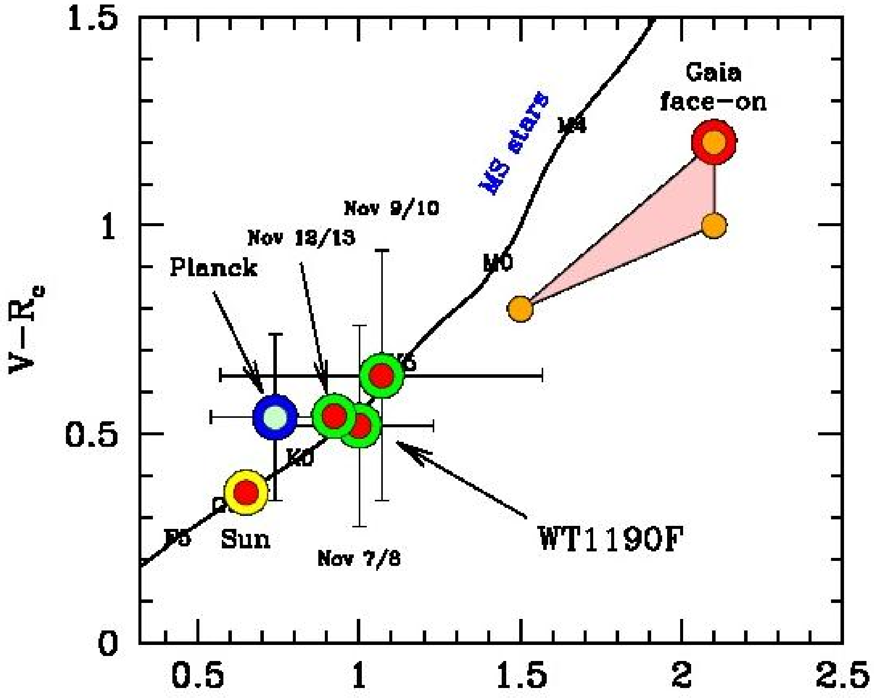


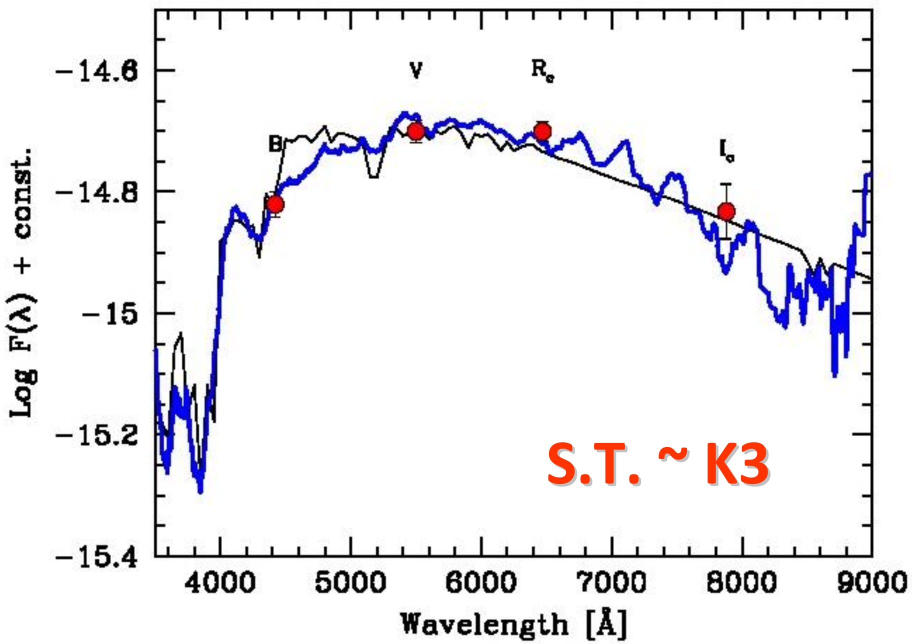


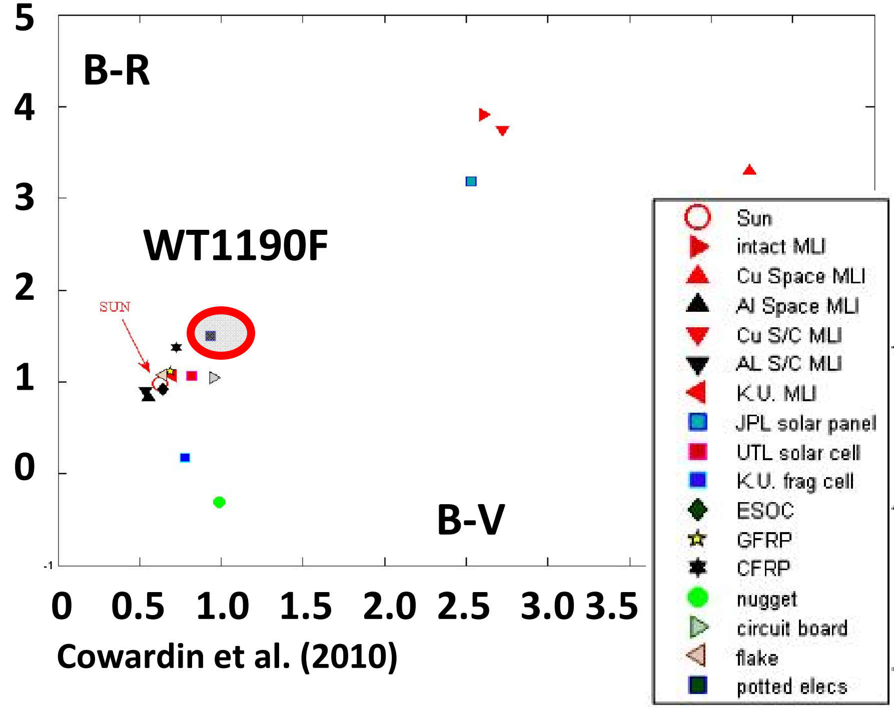




Probing the color properties of WT1190F





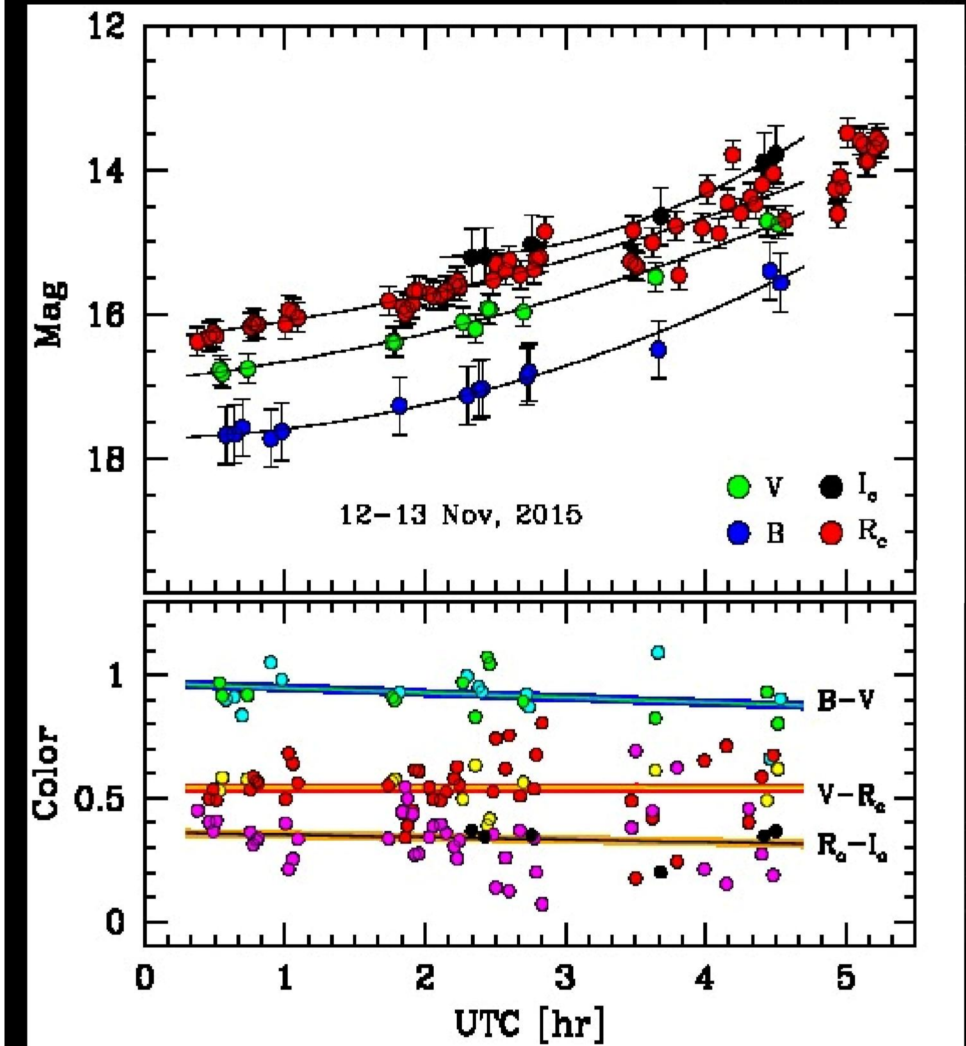


Cowardin et al. (2010)

≈ ?

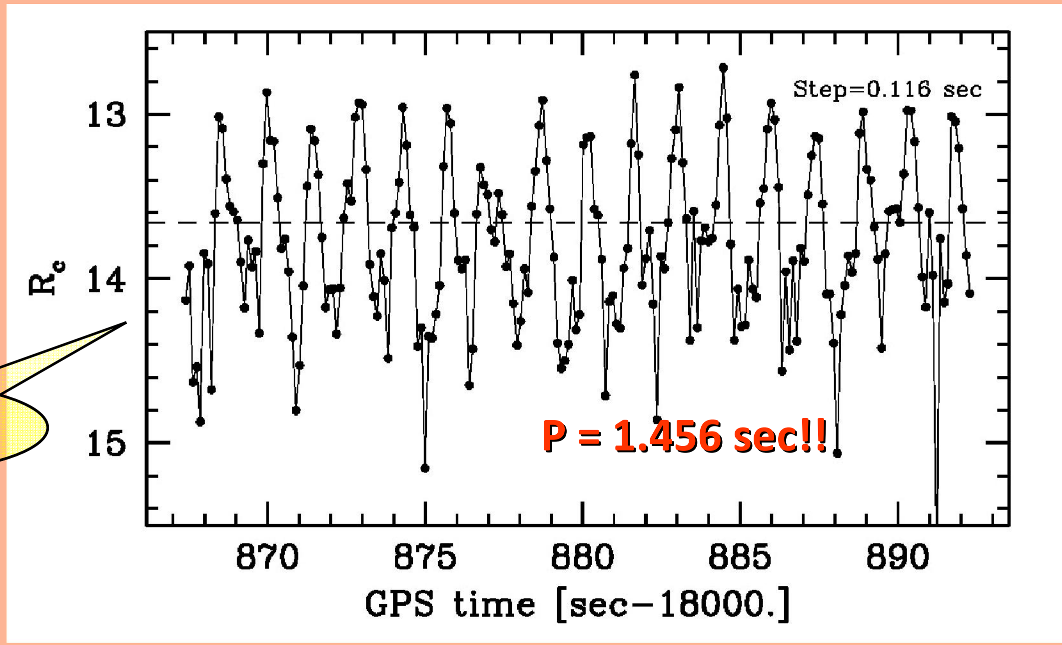
WT1190F

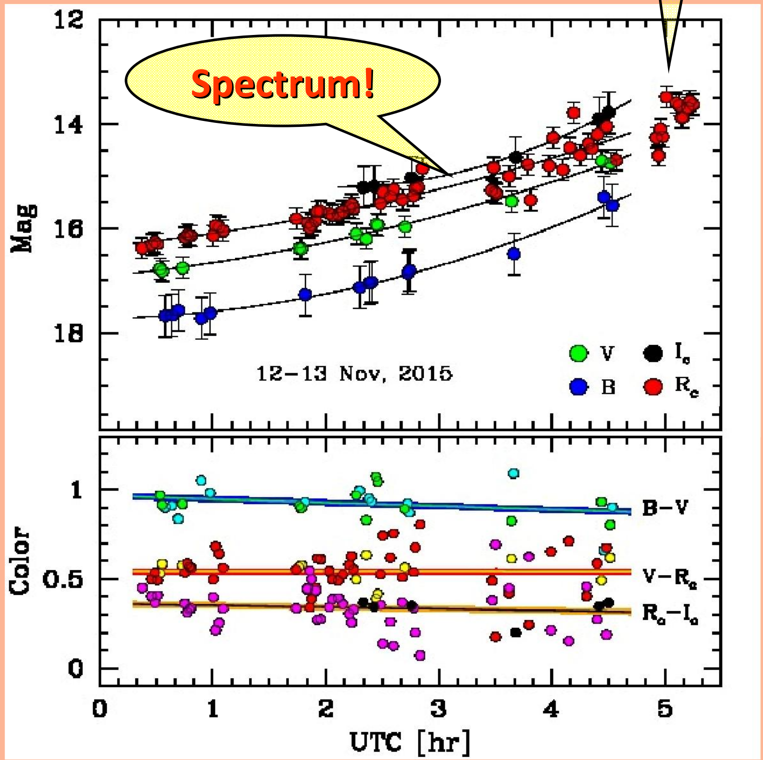
The entry phase

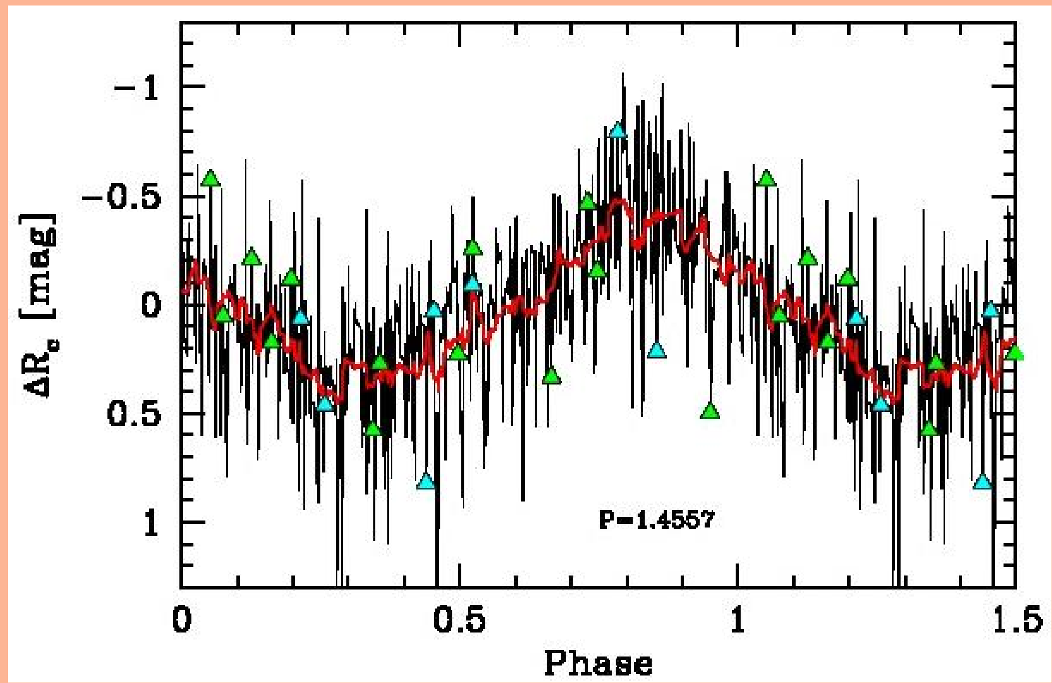


A fast-spinning debris!

Trailing!



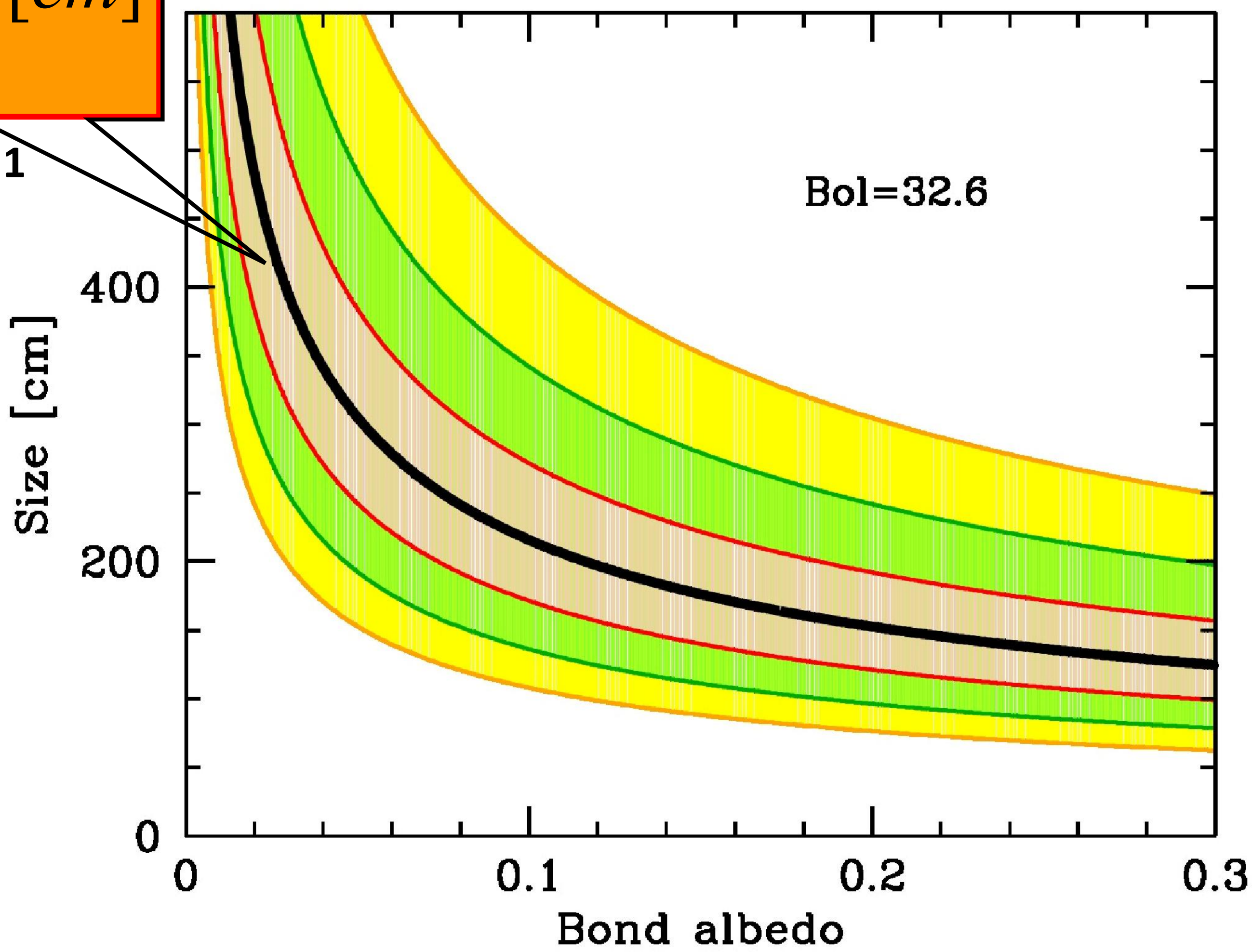




What's the origin of WT1190F?

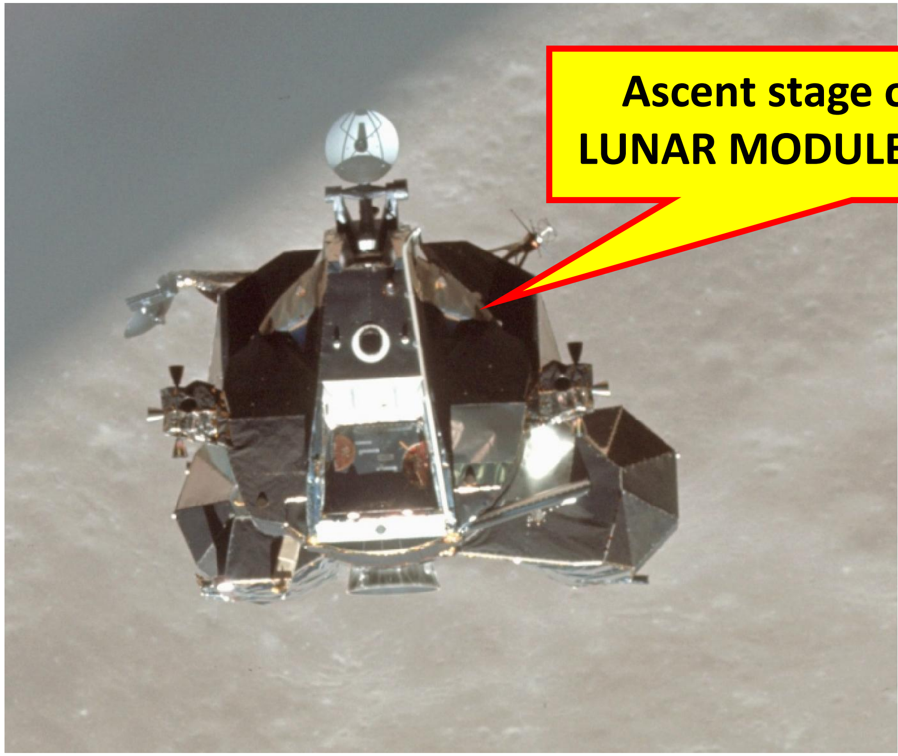
$$s = \frac{216}{\sqrt{\alpha_{10}}}[cm]$$

with $\alpha_{10} = \alpha/0.1$



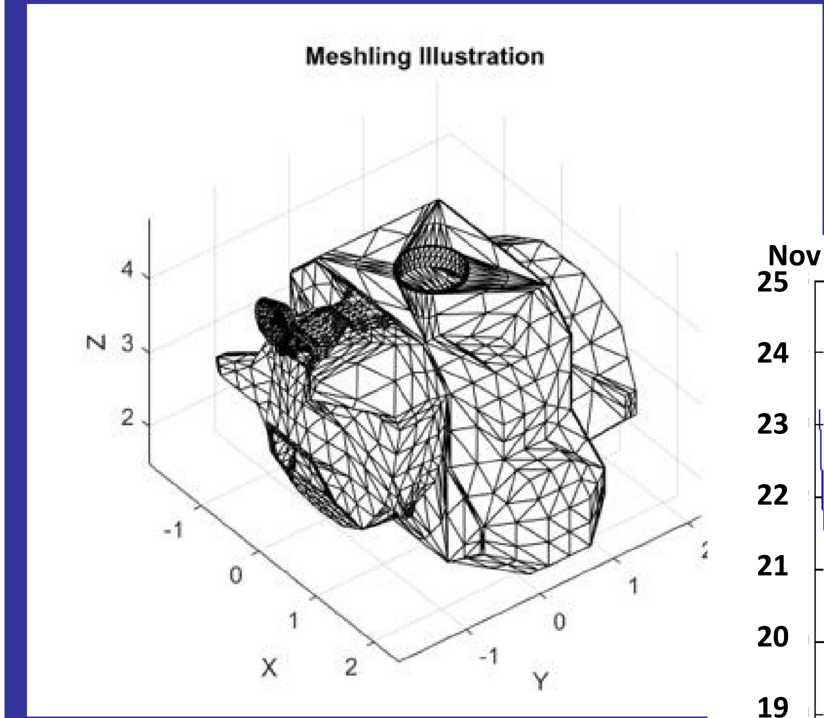
Upper stage Athena II rocket
carrying the
LUNAR PROSPECTOR (1998)

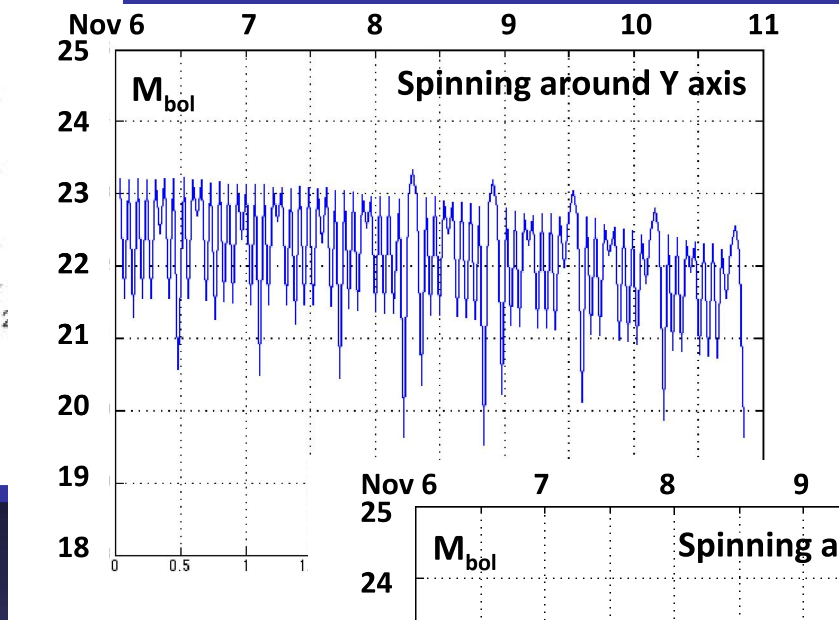
What's the origin of WT1190F?

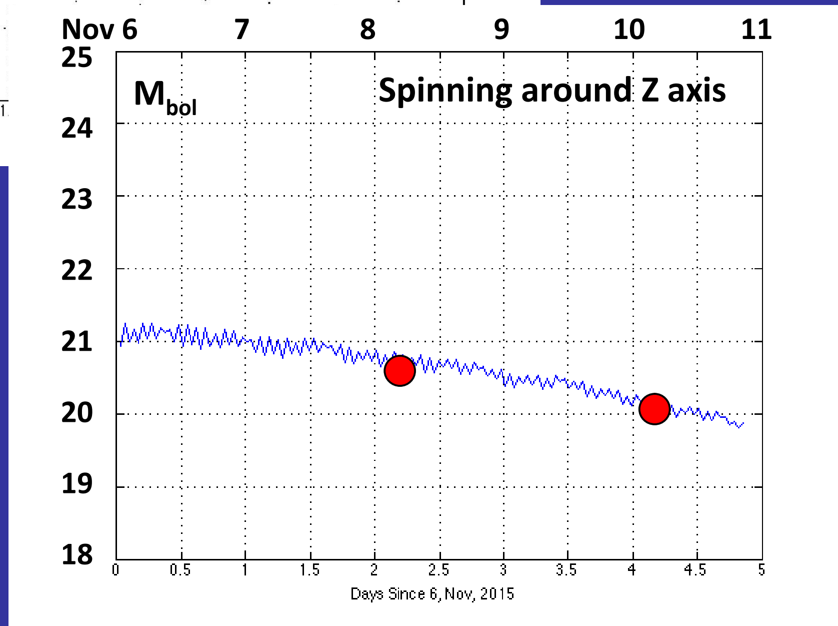


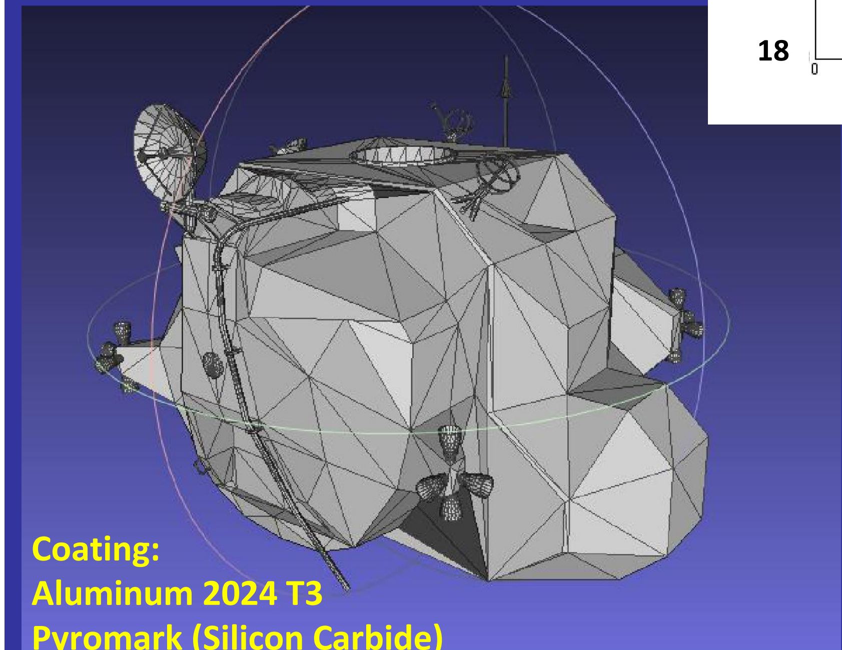
Ascent stage of the Apollo 10
LUNAR MODULE "Snoopy" (1969)

Toward assessing the "Snoopy" hypothesis









Fan, Frueh, & Buzzoni (AIAA Space Conf., 2016)