

# Astrometry

Research Seminar Fall 2018

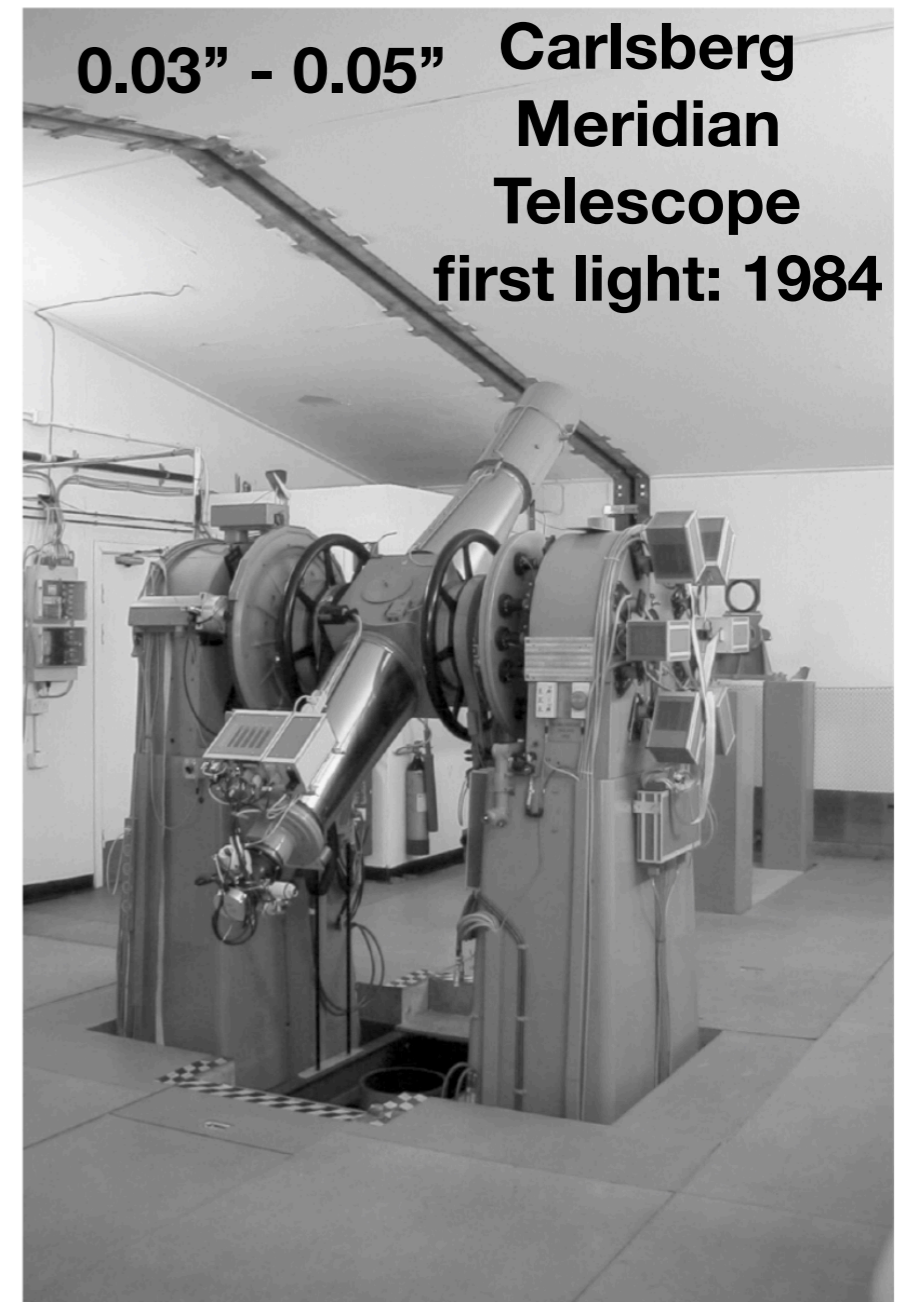
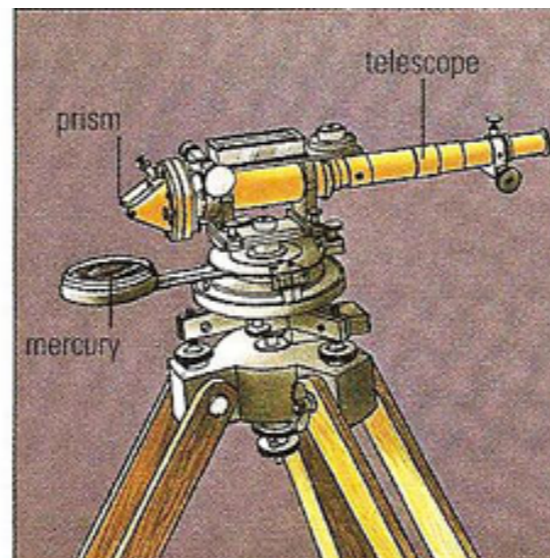
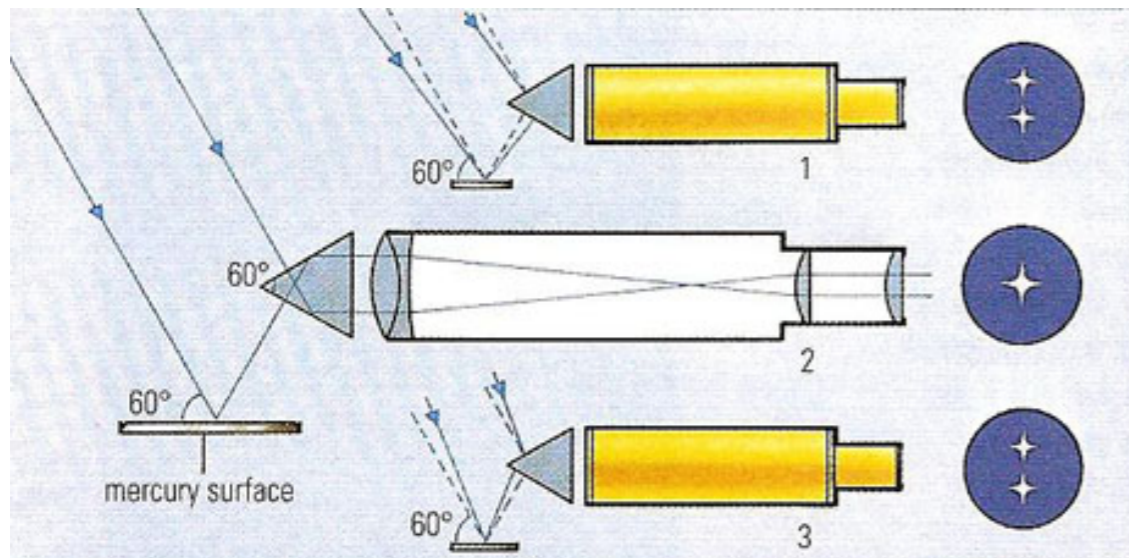
# Ground-based Astrometry

## Meridian circle / transit telescope

- Single positional dof, usually oriented along meridian
- Use time of star's crossing to measure RA
- CMT used in conjunction with Hipparcos

## Astrolabe / zenith tubes

- Use mercury to accurately determine zenith position
- Reflected/nonreflected light meet when star is at given latitude (here 60 degrees)



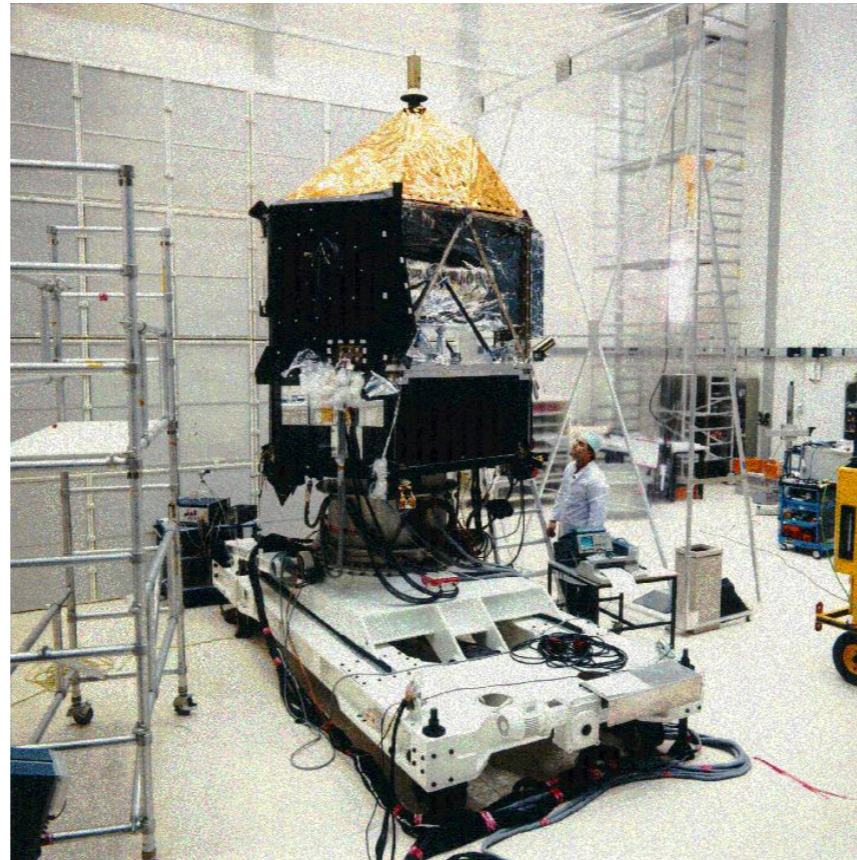
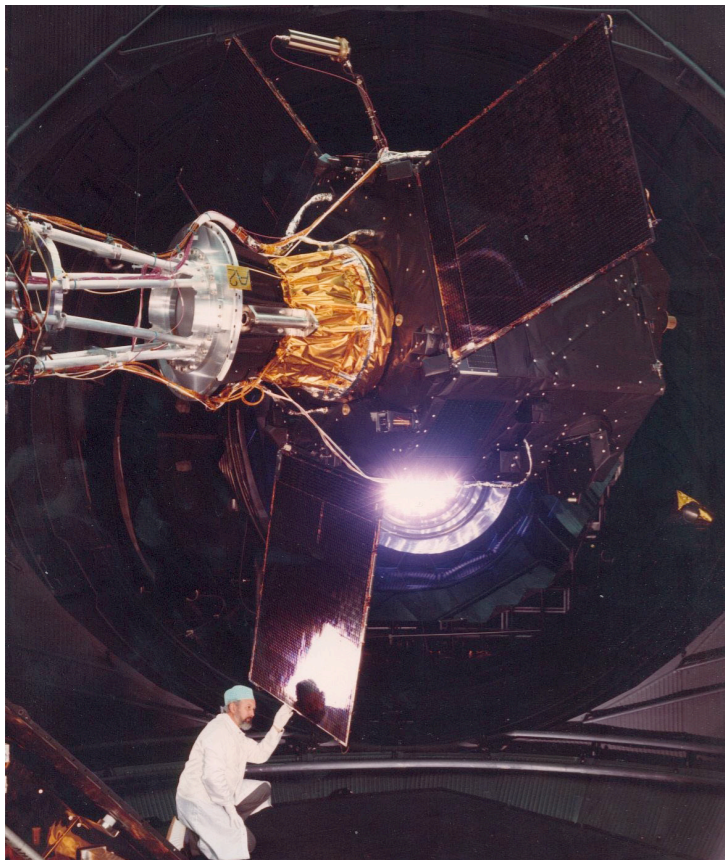


# hipparcos

(High Precision Parallax Collecting Satellite)

- November 1989 to March 1993
- Supposed to be geostationary, but stuck on transfer orbit

(Hipparchos)

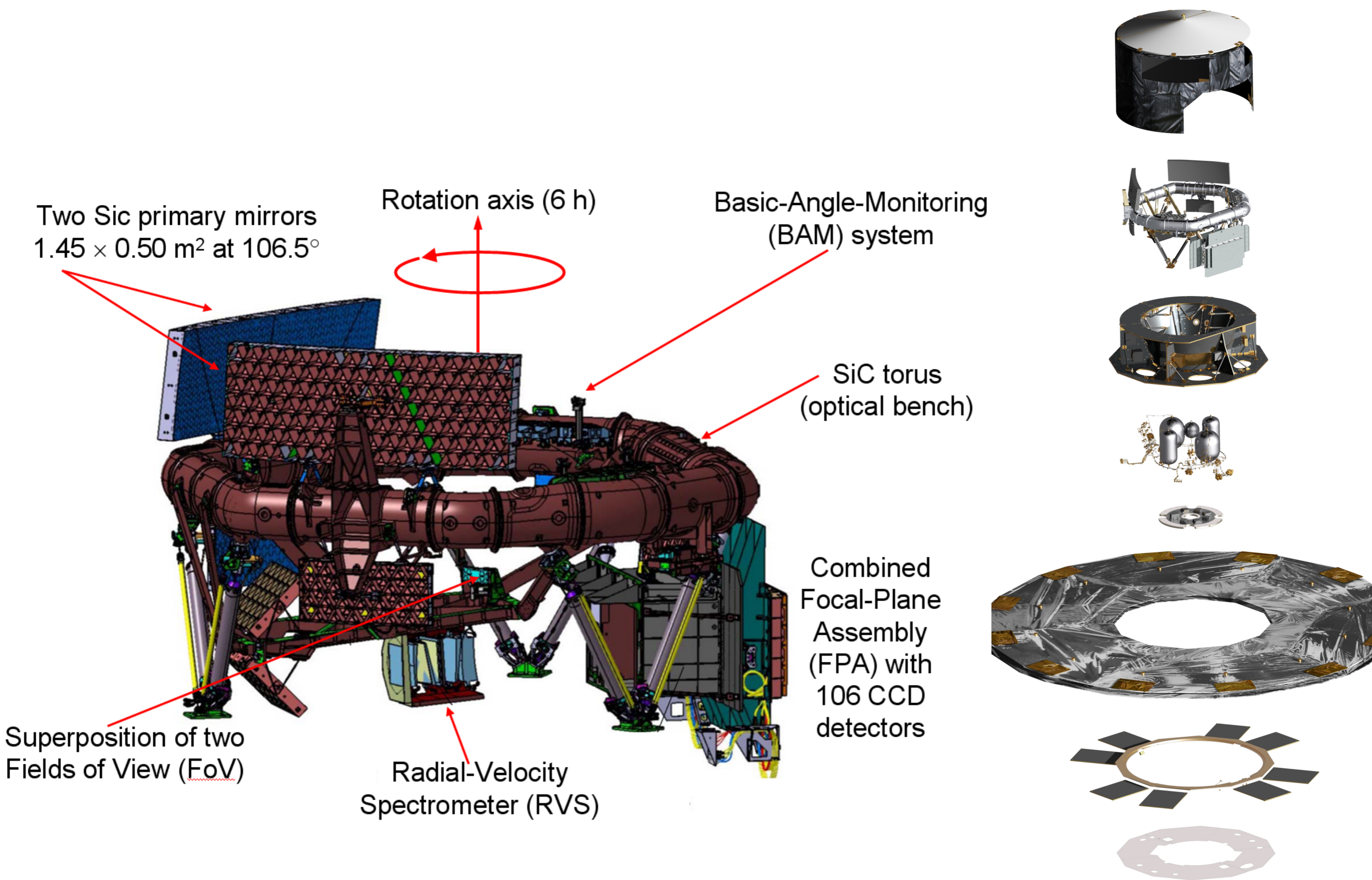


Produced a catalog of 1080 stars, each labelled “bright” or “small”



# gaia

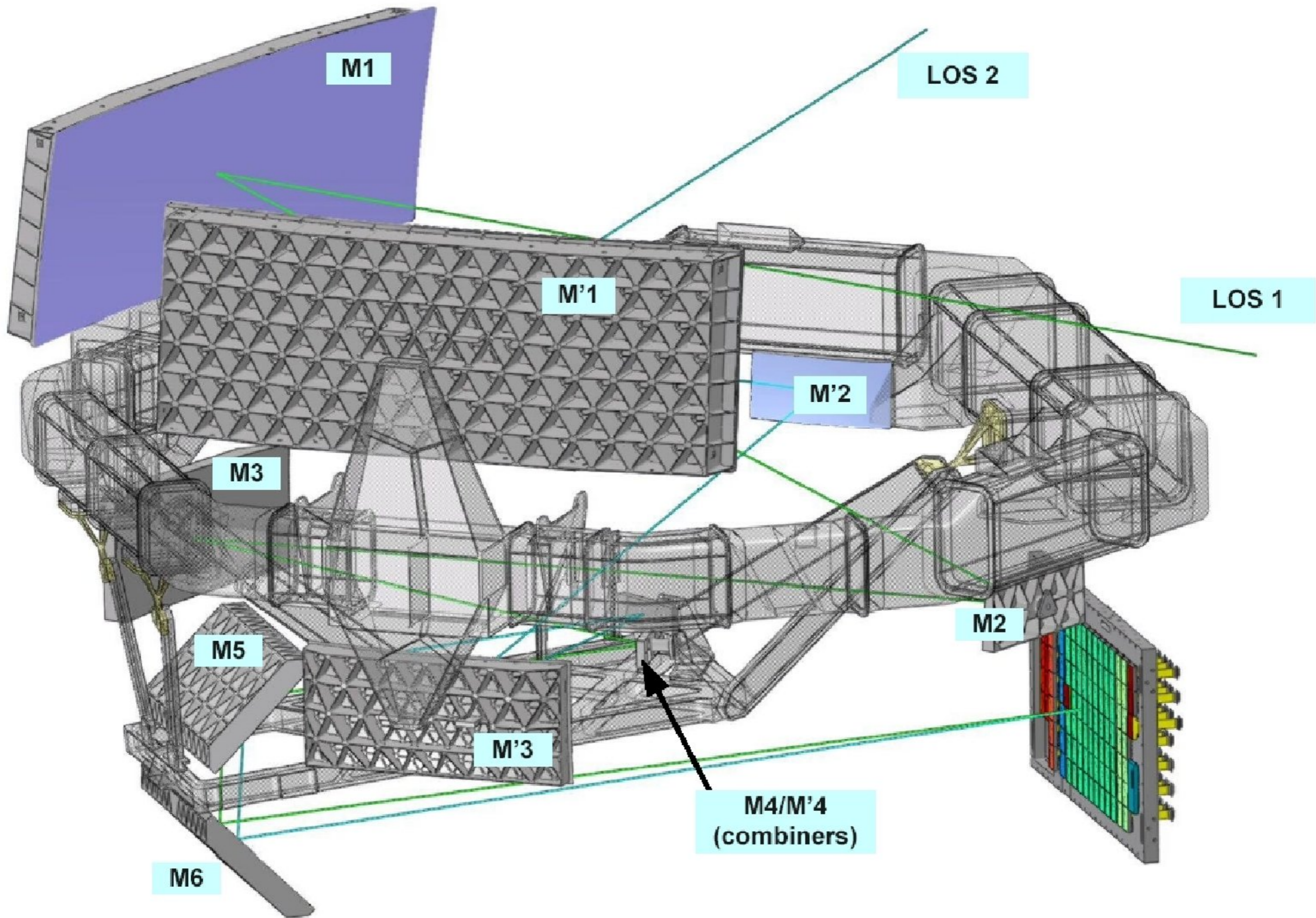
	<b>Hipparcos</b>	<b>Gaia</b>
Magnitude limit	12 mag	20 mag
Completeness	7.3 – 9.0 mag	20 mag
Bright limit	0 mag	3 mag (assessment for brighter stars ongoing)
Number of objects	120,000	47 million to G = 15 mag 360 million to G = 18 mag 1192 million to G = 20 mag
Effective distance limit	1 kpc	50 kpc
Quasars	1 (3C 273)	500,000
Galaxies	None	1,000,000
Accuracy	1 milliarcsec	7 $\mu$ arcsec at G = 10 mag 26 $\mu$ arcsec at G = 15 mag 600 $\mu$ arcsec at G = 20 mag
Photometry	2-colour (B and V)	Low-res. spectra to G = 20 mag
Radial velocity	None	15 km s <sup>-1</sup> to G <sub>RVS</sub> = 16 mag
Observing	Pre-selected	Complete and unbiased





Sagem Défense Sécurité

Final check of one of Gaia's primary mirrors



**Tension between  
parallactic precision and  
solar radiation**

SUN

EARTH

L2

SGE ANGLE

GAIA



45°

rotation axis of  
the spacecraft

precession of axis  
in 63 days

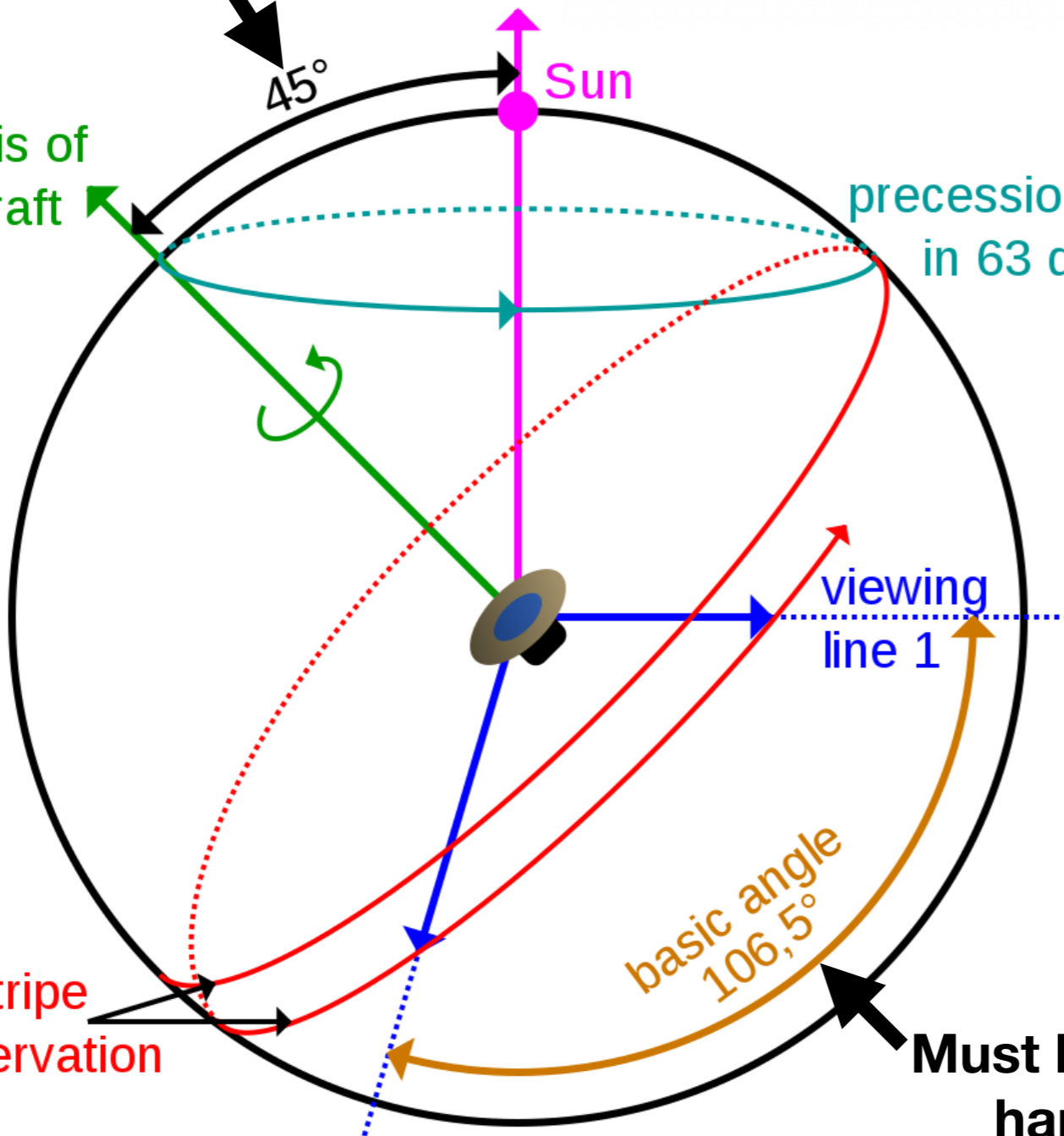
viewing  
line 1

basic angle  
106,5°

continued stripe  
of observation

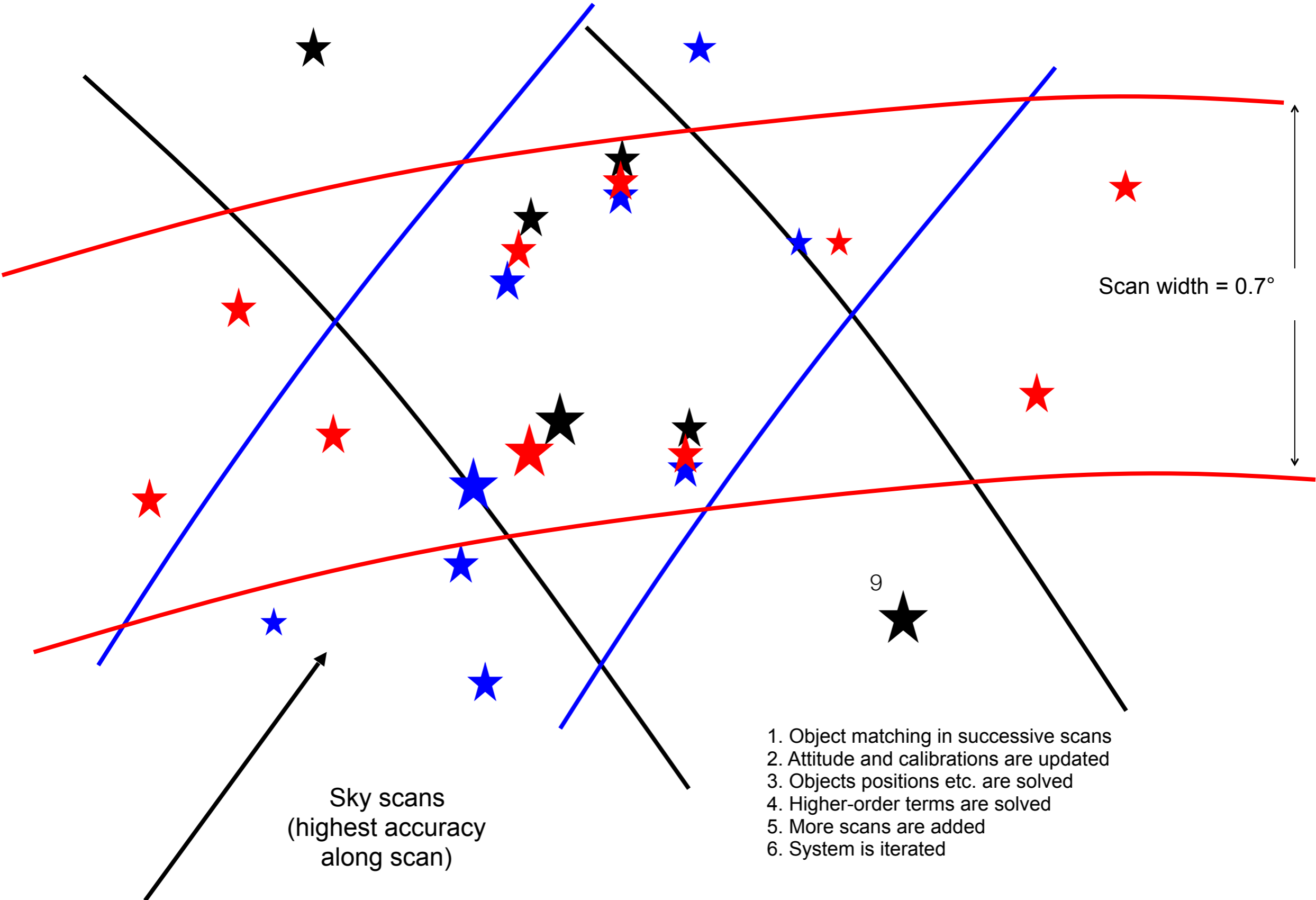
viewing line 2

**Must be wide, can't be  
harmonic of 360**





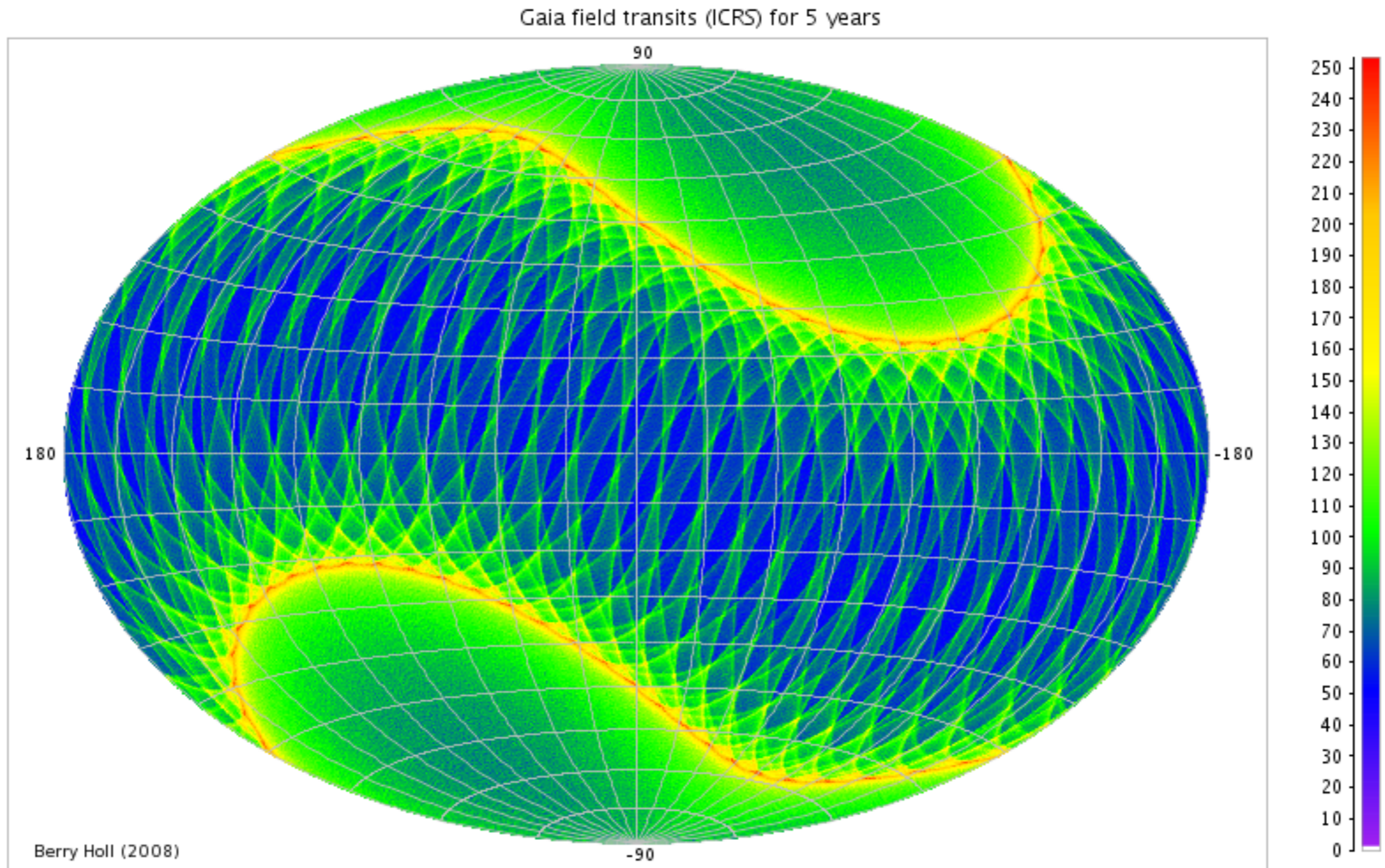
# Successive observations yield proper motion / parallax



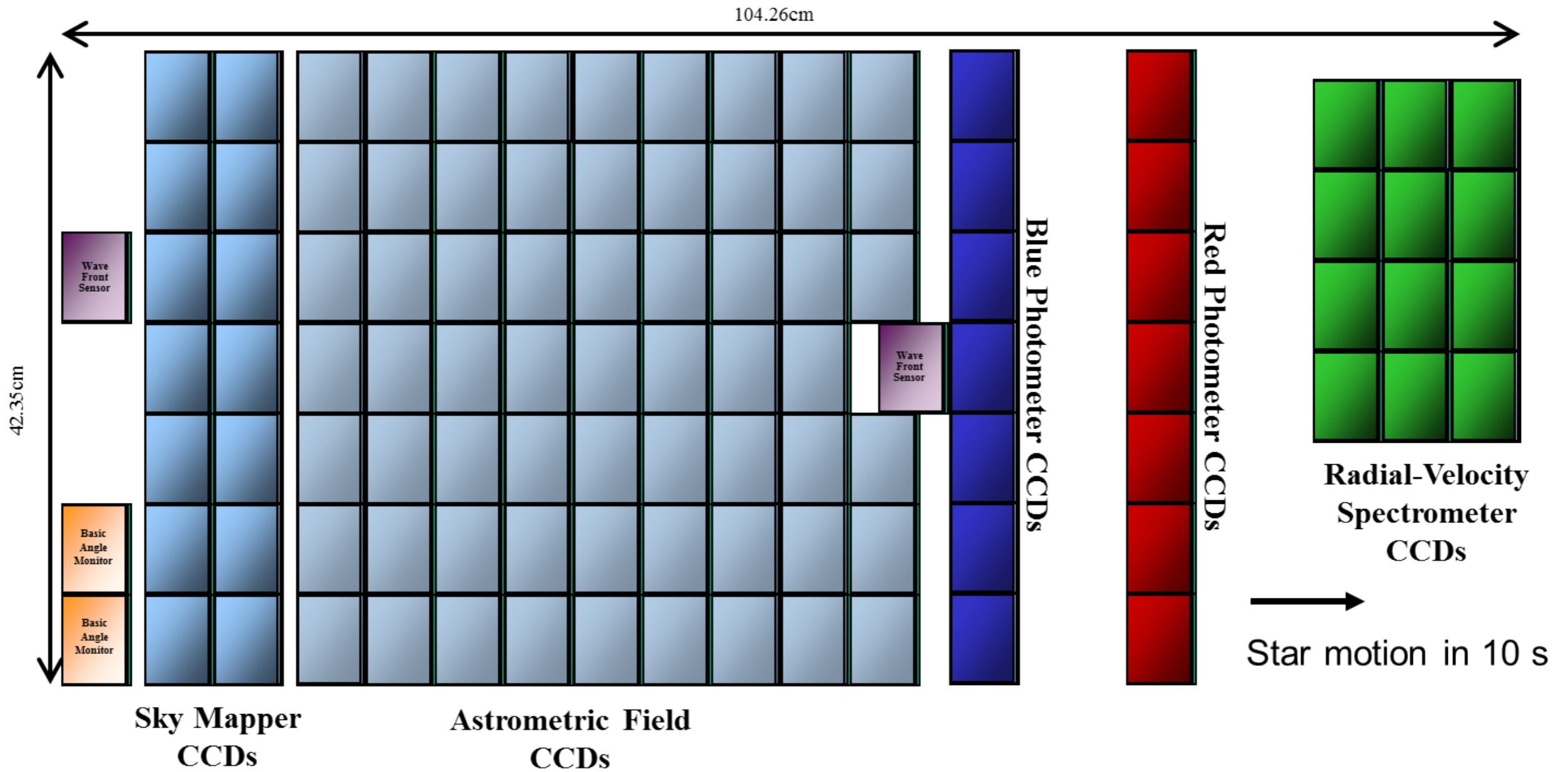
1. Object matching in successive scans
2. Attitude and calibrations are updated
3. Objects positions etc. are solved
4. Higher-order terms are solved
5. More scans are added
6. System is iterated

Figure courtesy Michael Perryman

# ~70 transits per target over 5 years

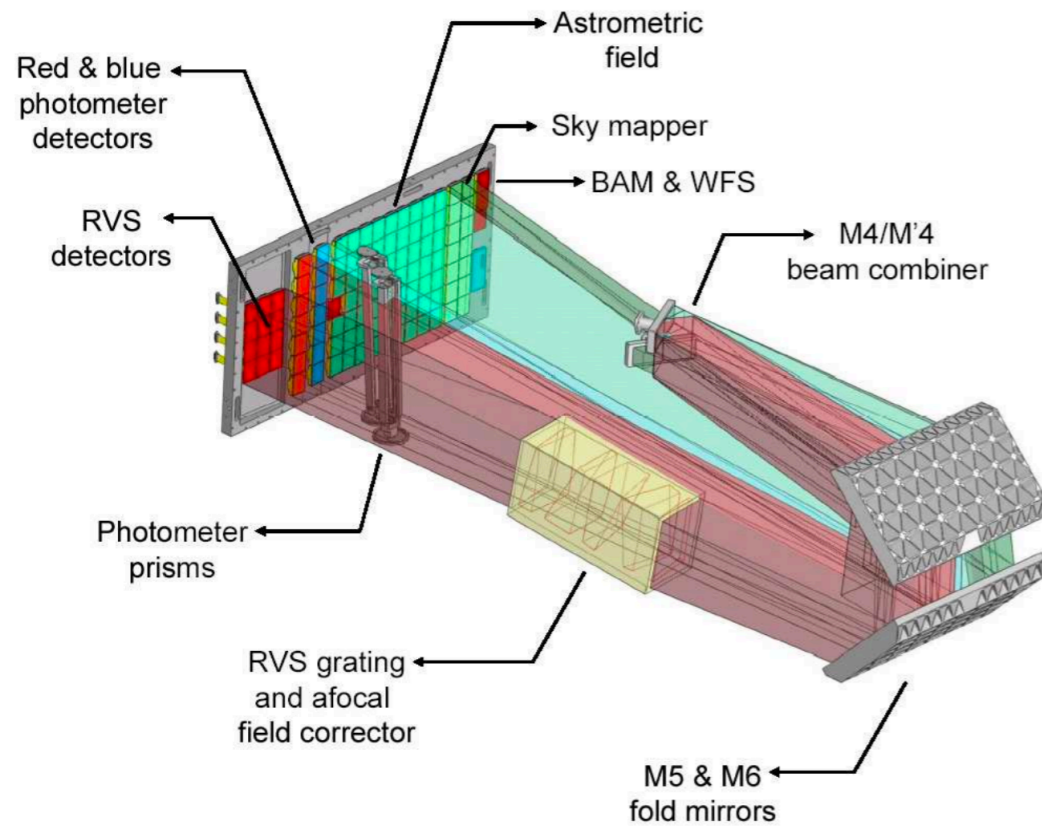


# Focal Plane

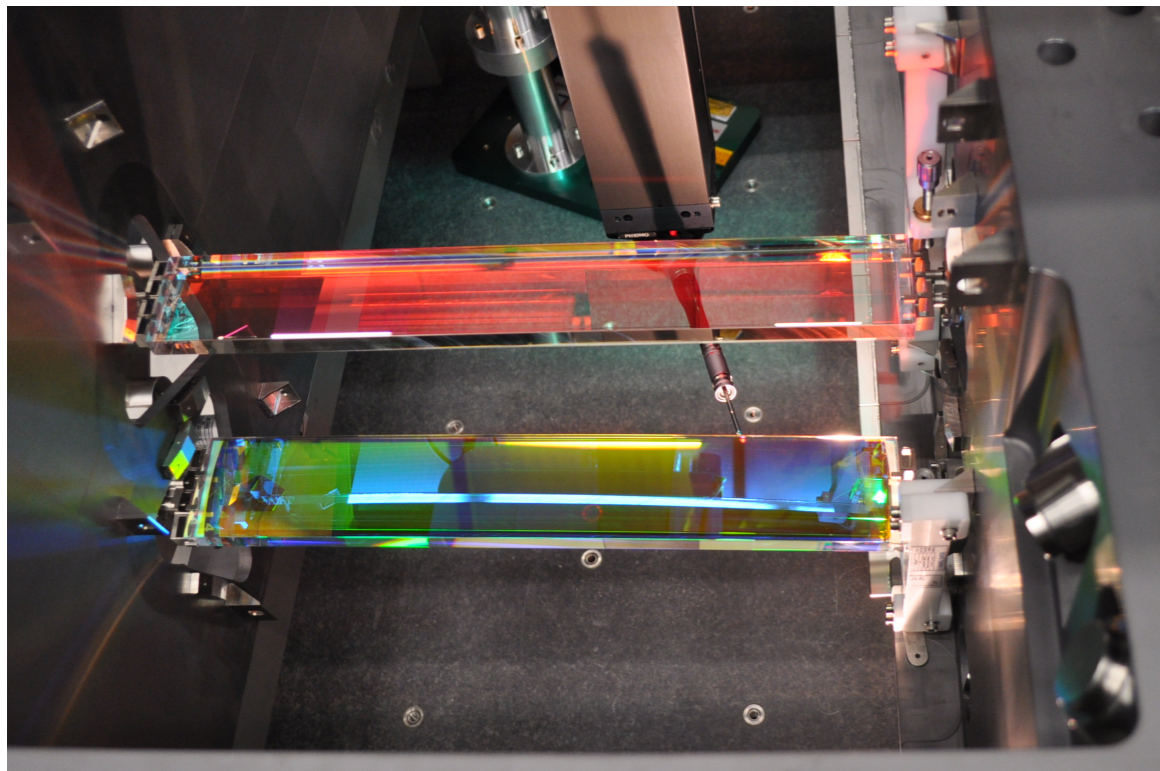
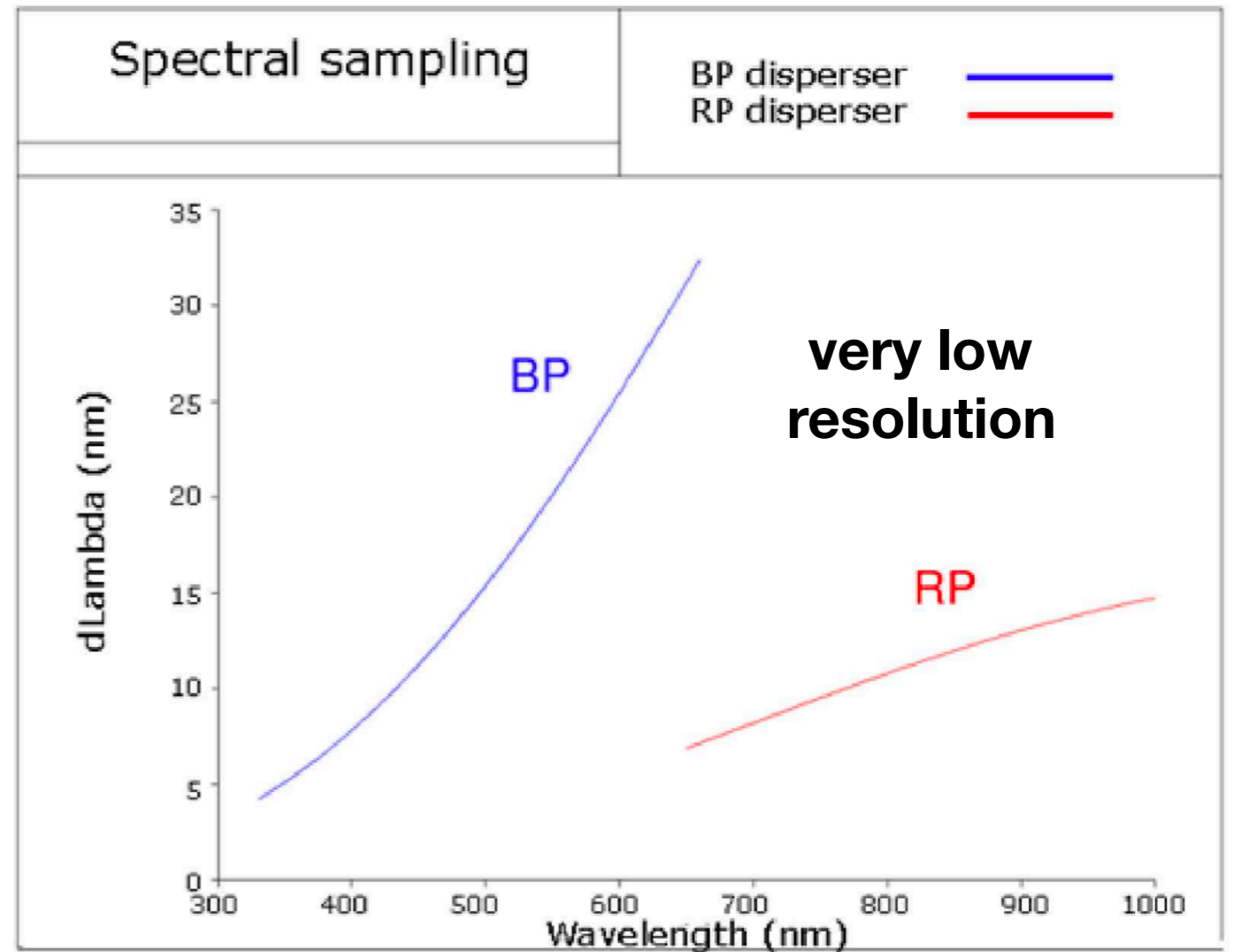


<https://www.cosmos.esa.int/web/gaia/focal-plane>

## Photometric Instrument

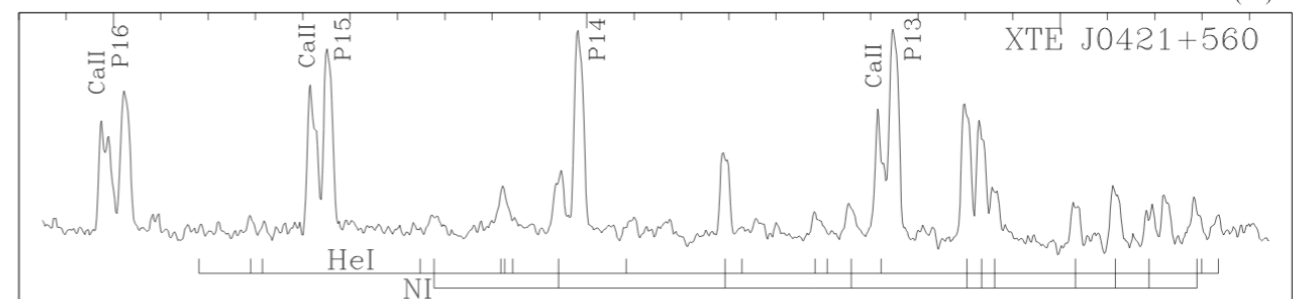
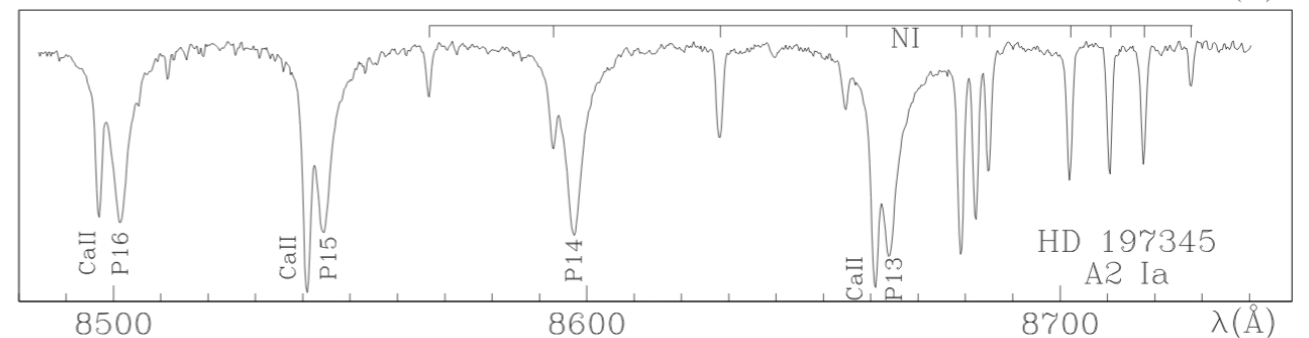
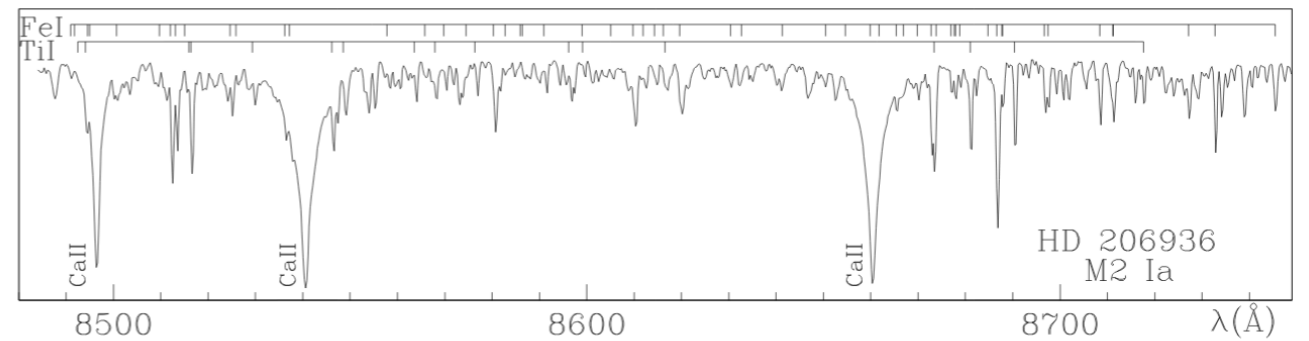
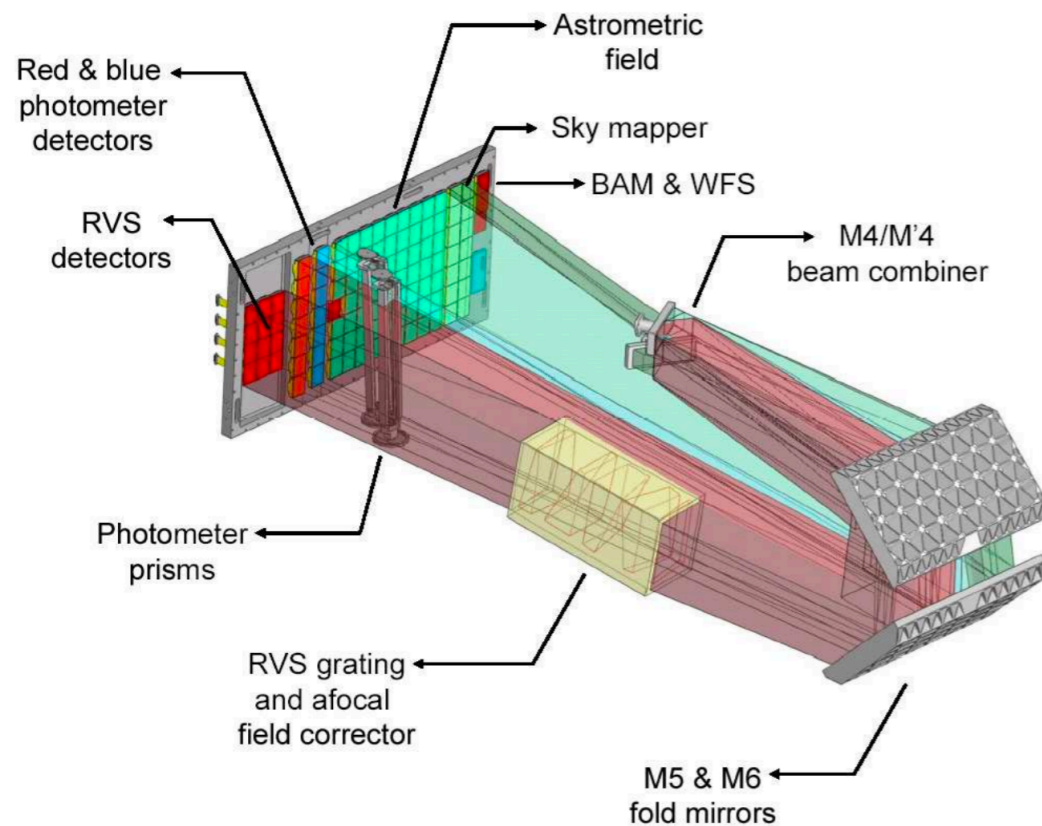


- Goal:  $T_{\text{eff}}$  for all targets
- BP: 330–680 nm
- RP: 640–1050 nm
- Objects are selected for RV instrument by RP



## Spectroscopic Instrument

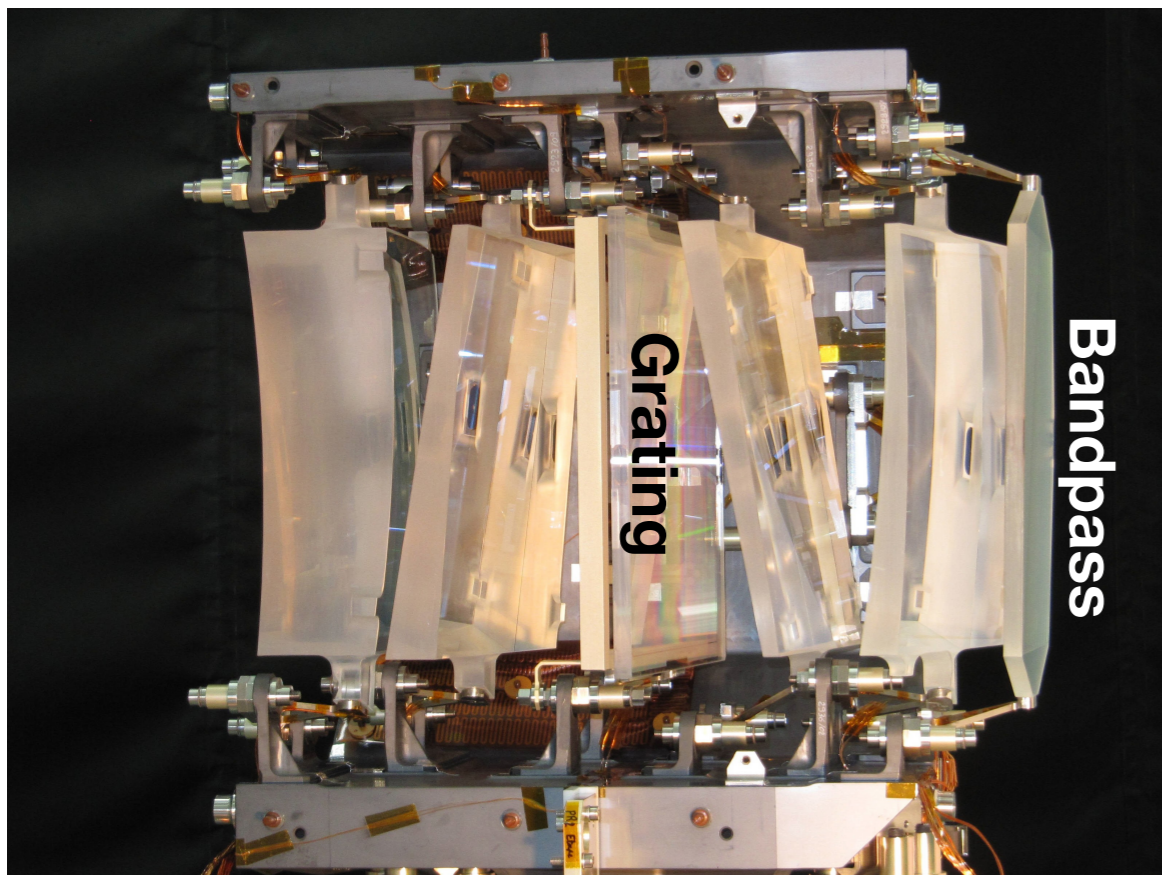
- Goal: radial velocity for stars down to 17th mag, abundances, reddening
- Near-infrared (845–872 nm)
- Medium resolution ( $\lambda/\Delta\lambda \sim 11500$ )
- Will observe 100-150 million stars  $\sim 40$  times each



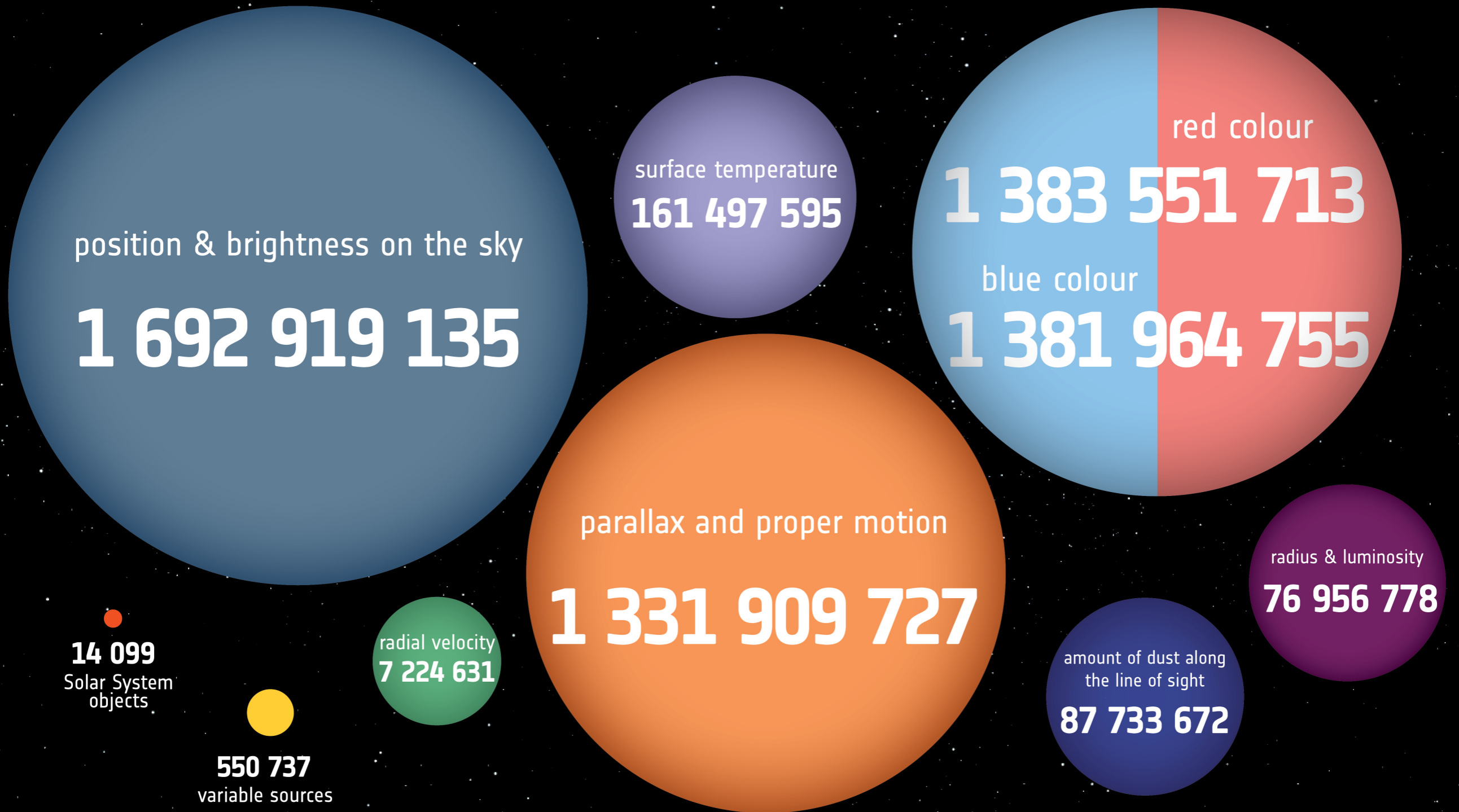
Early

Late

X-ray transient



# → HOW MANY STARS WILL THERE BE IN THE SECOND GAIA DATA RELEASE?



**DR3 (targeting 2021):** improved astrometry, object classification, spectra released, solar-system catalog