Mission Envelope from ESA

- Spacecraft launch mass < 300kg
- Payload mass < 60kg
- Total power < 200 W
- Payload power < 65W
- Payload technology readiness:
  - TRL ≥ 6 (ISO scale) for all payload elements
- Platform technology readiness:
  - TRL ≥ 7 (ISO scale) for platform equipment
- Development schedule: < 4 years
- Lifetime in orbit: 2-3 years

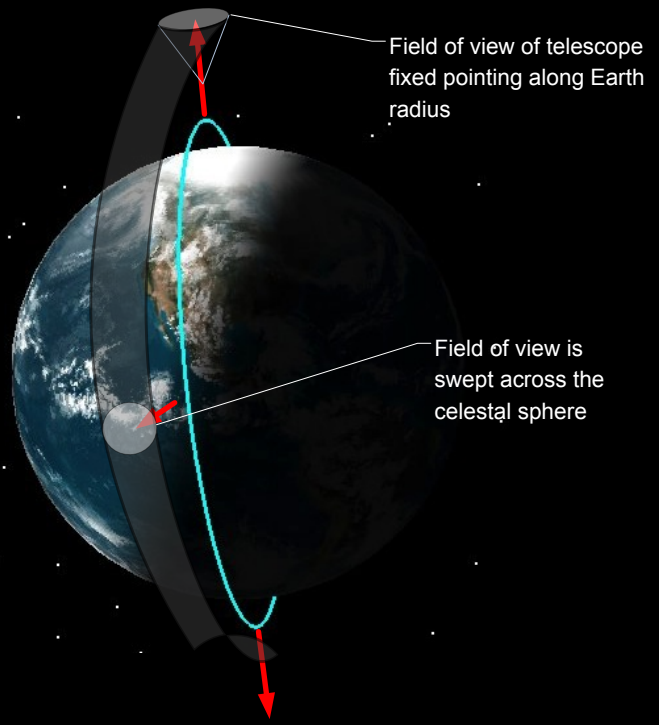
- "Compliance with the constraints deriving from the joint mission profiles will be strictly enforced during the evaluation of the proposals"

Mission Envelope from ESA

- Potential launchers:
  - From Kourou:
    - Soyuz as passenger
    - VEGA as passenger or shared launch
  - From China:
    - Long March 2C or 2D possibly as passenger
- Orbit: No a priori limitation, provided compatibility with launchers and schedule constraints
- Additional requirements:
  - Compatible with the applicable debris regulations
  - **Free from ITAR restrictions**
- For planning purposes a launch in 2021 is envisaged
  - START no later than January 2016!

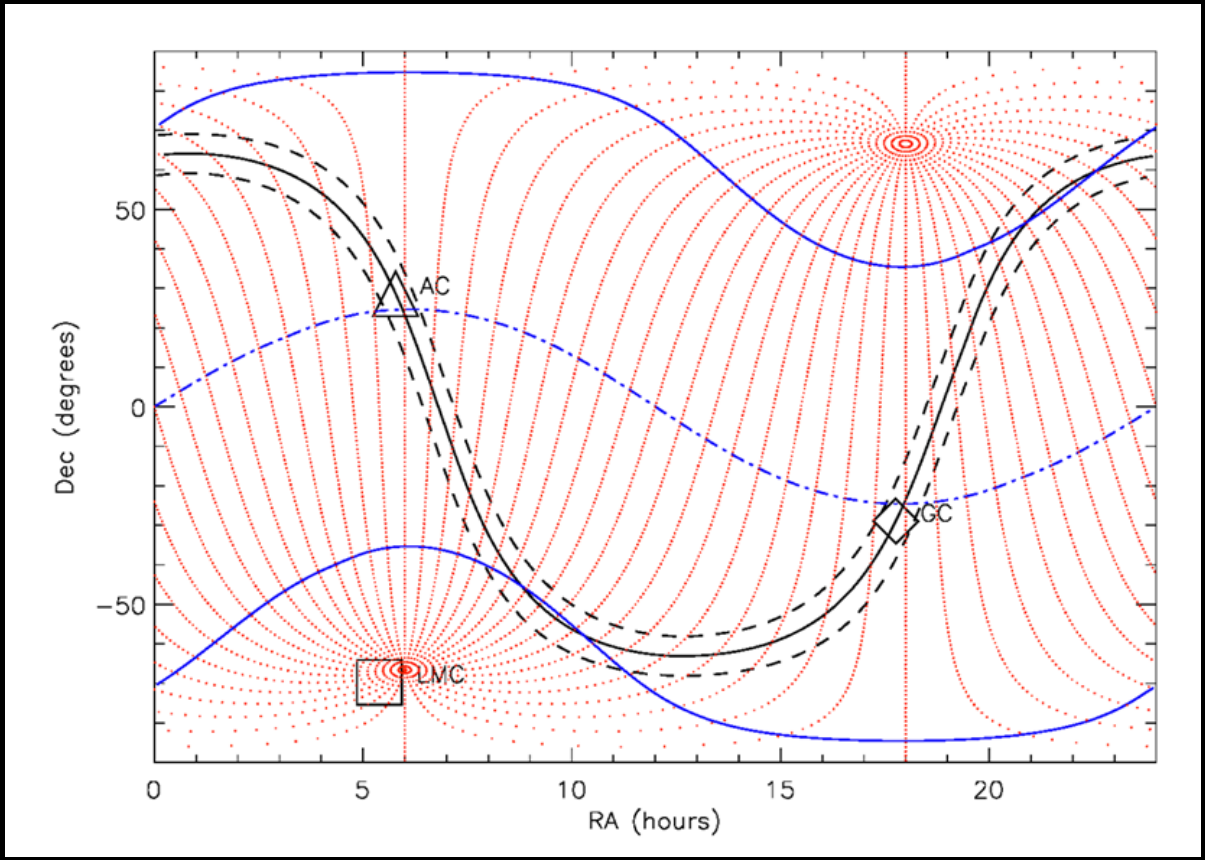
Proposed Mission Configuration

- Orbit is proposed as sun synchronous orbit at ~600 km – ensures re-entry <25 yrs without thruster
- Viewing direction is anti-Earth
- Solar panels constantly illuminated
- Radiators constantly face deep space
- Eclipses are an issue – thermal stability
- Full survey in 6 months with multiple passes over sky “bins”
- Will also require ability to off scan direction point during survey
- Will need to have “pointed” mode capability as well



Sky Coverage

Crude assessment based on assumption of covering 360 degrees ecliptic latitude per orbit – no eclipses or Moon constraint!



Sampling

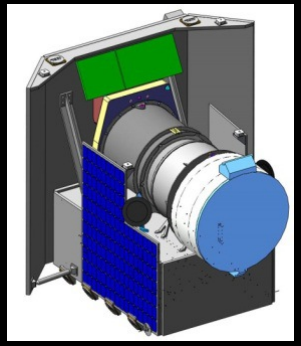
- 600 km orbit equivalent to 96.5 minutes period
- Cover 3.7 arcmin/sec along the scan direction
- Orbital orientation wrt celestial sphere changes as year progresses at rate of 360/365 deg/day or 3.7 arcmin per orbit at the ecliptic plane (EP).
- As ecliptic latitude changes this varies as ~cos(latitude) – full overlaps at the poles.
- If we take a ~0.85 m (Spitzer size) aperture the beam sizes will be approximately as given in table (next slide)
- So at the EP there will be minimal sampling in the low frequency bands and gaps in the high frequency coverage
- Repoint as cross galactic plane to ensure full sampling
- Sensitivity needs to be as great as possible – looking at 4 seconds
- In scan direction would need take up to ~16 arcmin “pixels” in full scan mode to do this

Channel Parameters

- Based on Tsys from Brian Ellison presentation at 300K and 100K
- Using 85 cm aperture
- Using 4 second integration
- Unresolved Line Sensitivity (ULS) Assumes 1 MHz resolution – will scale as rt(BW) for resolved lines
- Only need modest resolution as galaxy rotation curves ~10's-100's km/s in width
- Omnisys autocorrelator provides 1024 channels for 6 W. If we take 4 MHz then BW is 4 GHz per band (they developing this for JUICE SWI – no TRL issues)
- We could use one per channel – 24 W total for WBS plus 6 W/channel for receiver, 6W control electronics and 15 W for cooler and 20% margin. 83 W total.

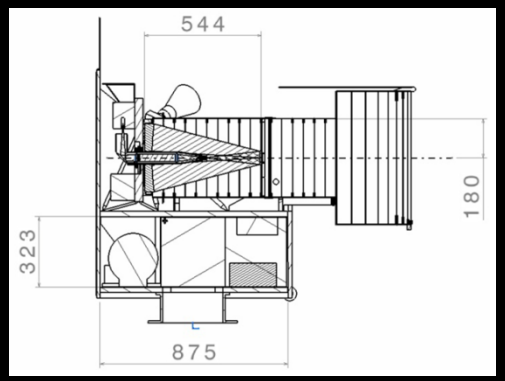
Species	Freq (GHz)	Wavel (µm)	Beam FWHM (arcmin)	50 km/s in MHz	Tsys SSB (K) @100 K	ULS ($W\ m^{-2}$) @100 K	Tsys SSB (K) @300 K	ULS ($W\ m^{-2}$) @300 K
CO (6-5)	691.0	433.9	2.1	115	800	4.9E-17	1500	9.1E-17
CI[609]	809.0	370.6	1.8	135	950	5.8E-17	2000	1.2E-16
NII[205]	1450.0	206.8	1.0	242	3000	1.8E-16	4500	2.7E-16
CII[158]	1900.0	157.8	0.8	317	5000	3.0E-16	7500	4.6E-16

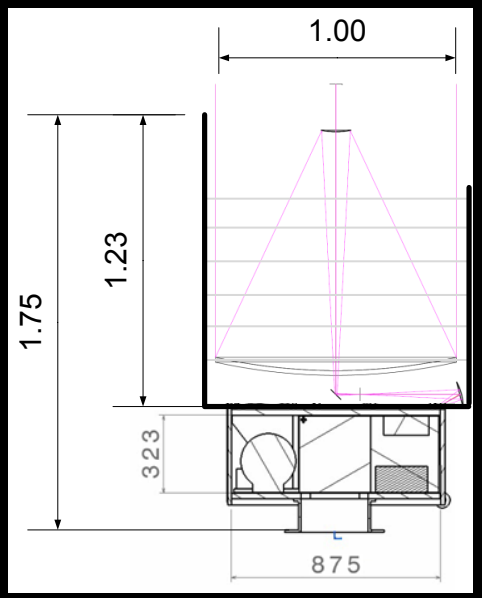
Possible Spacecraft approach

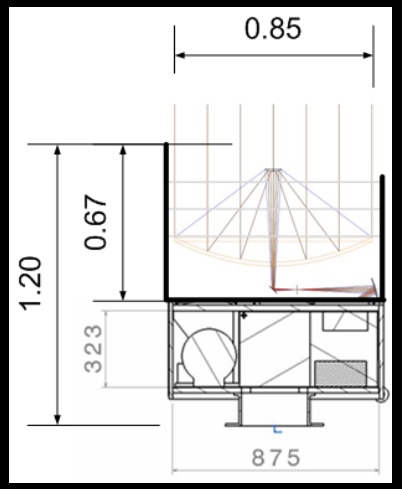


Start from SSTL concept for CHEOPS
(35 cm optical telescope)
Mass (S/C+payload) ~ 200 kg

Take this “bus” and add 1m or 0.85m (very fast) FIR telescope in tube

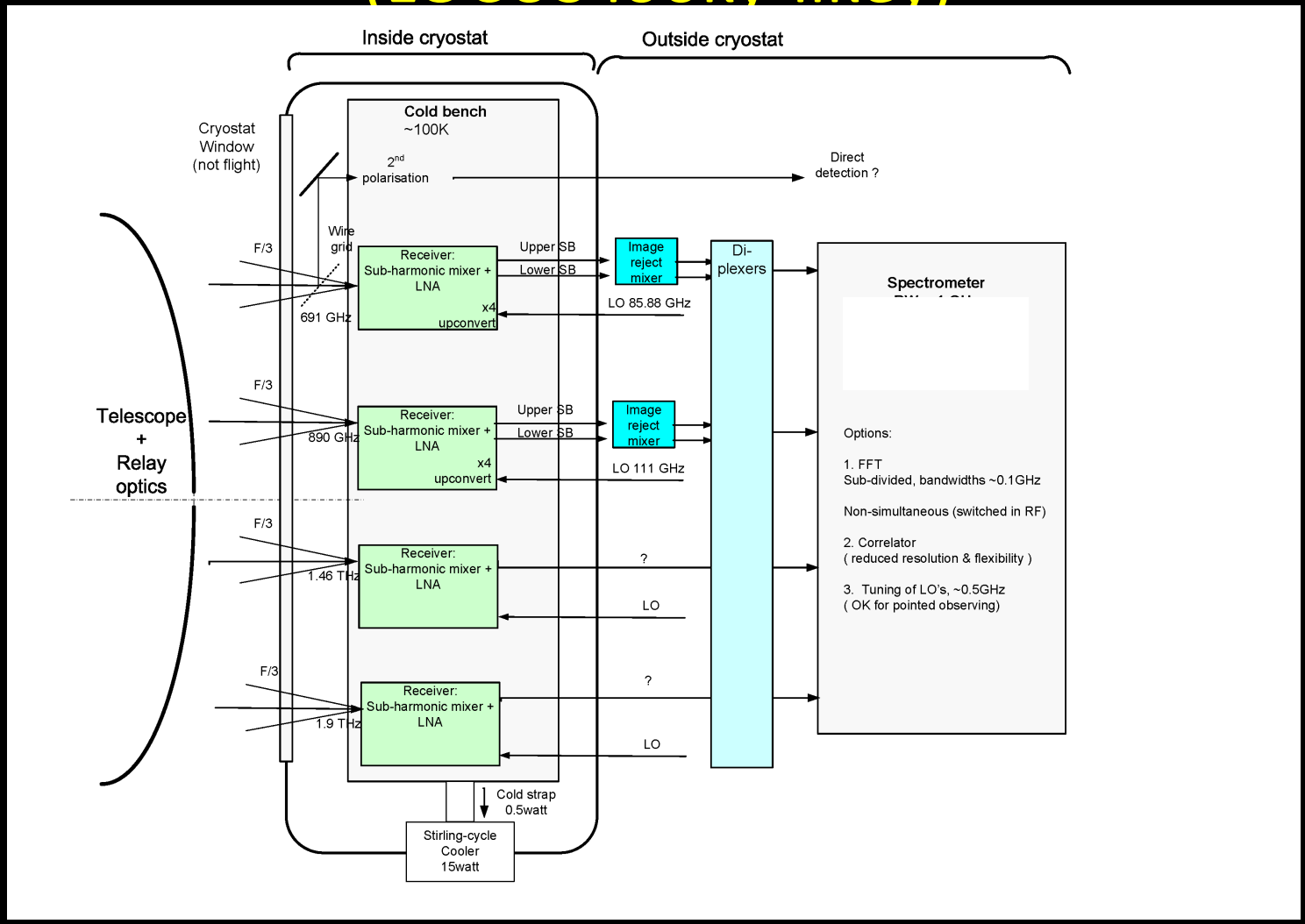




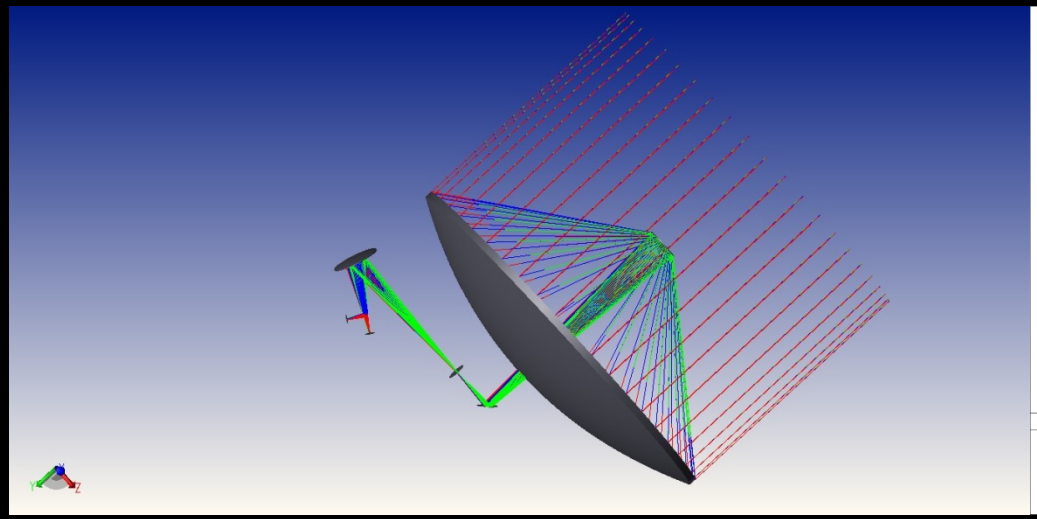


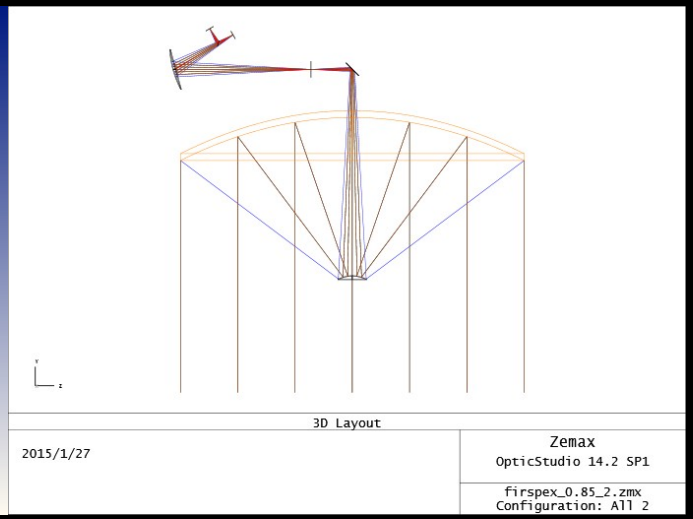
Mass ~250 kg (S/C + payload) assuming SiC mirror @25 kg/m^2

Payload Block Diagram (LOCUS looky-likey)



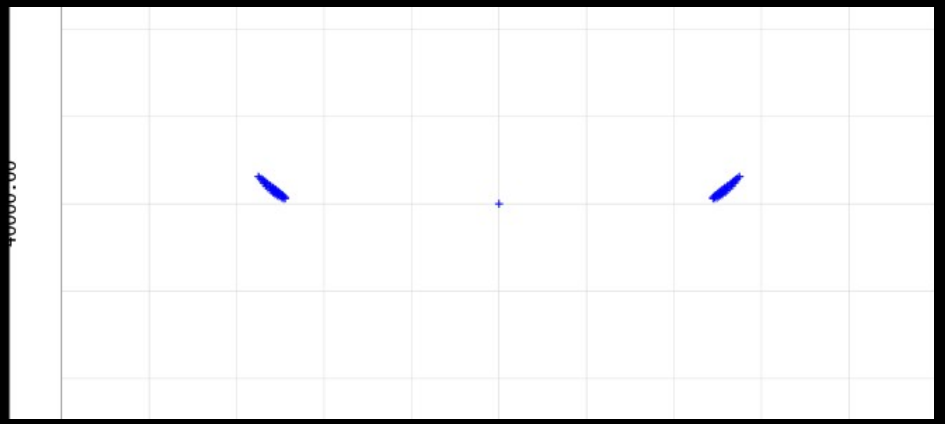
Telescope – initial design





Probably needs to be no larger than 0.85 m

This may be a bit too extreme



Mass estimate

- Based on using SiC for primary and secondary
- CFRP tube
- Aluminium OB cryostat etc….
- Electronics a bit of guess
- Needs to be about this to meet ESA rqmt.

0.425	m radius
25	kg/m2 area dens
Primary Area	0.57
Primary Mass	14.19
Secondary area	0.01
Secondary mass	0.32
Support structure	2.90
Tube (guess)	15.00
Cryostat, receiver and OB	10.00
Electronics	8.00
Net Total	50
Margin	10
Total	60

Mission Summary

- **Proposed Configuration**
  - Low Earth orbit mission sized to ~CHEOPs – satellite ~300 kg power ~200 W with payload ~60 kg and 60 W
    - Rationale – cost and launcher constraint
  - Science requirements dictate all-sky survey and pointed mode – emphasis on all-sky
    - Need to keep both all-sky and pointed mode observations as options
    - CHEOPs orbit suitable for either all sky survey (AKARI like) or anti-Sun pointed CHEOPS like (not preferred)
- **Payload drivers**
  - Telescope size and mass
  - Receiver accommodation
  - Receivers need active cooling
  - Payload needs passive cooling and thermal stabilisation
  - Power
- **Mission drivers**
  - Power – battery sizing for eclipses
  - Thermal stability around orbit especially in/out eclipse
  - Pointing stability during survey
  - Pointed observation mode and (therefore) fuel requirements
  - Data rate?