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Balloon-borne opportunities for FIR observations

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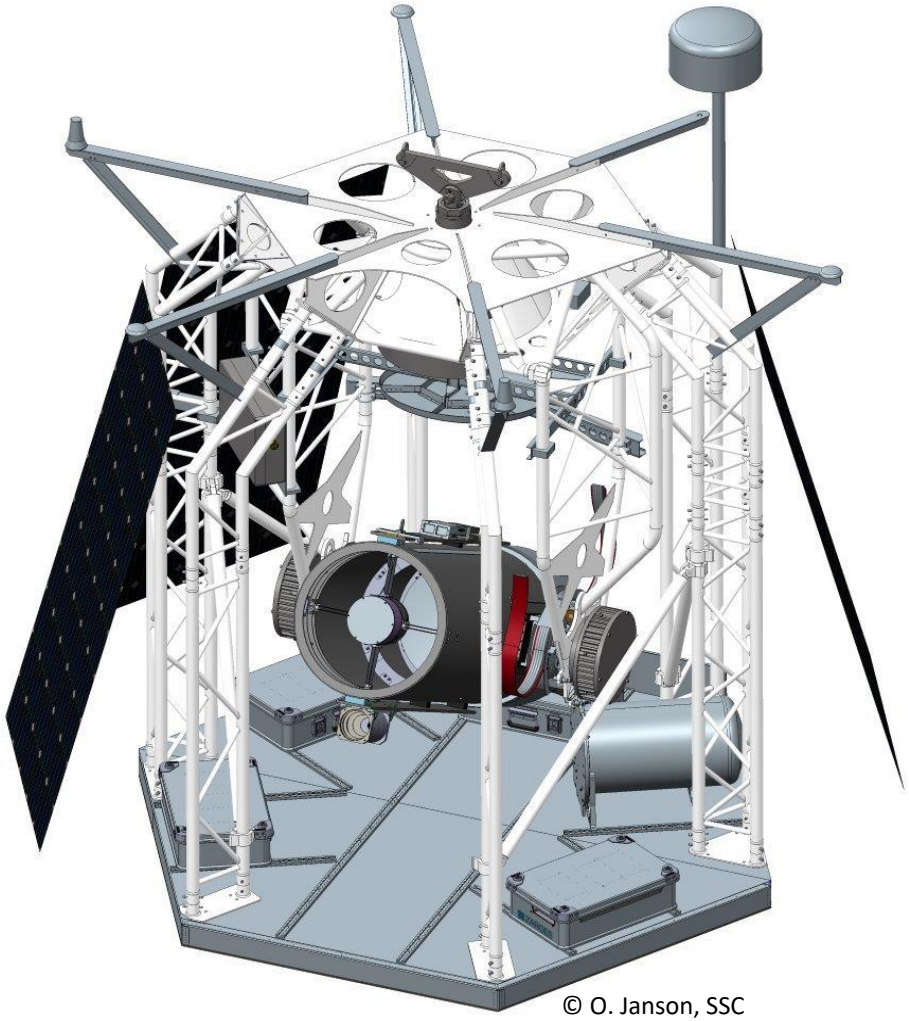
2. Observing Conditions (FIR)
3. Costs & Funding
4. Other Opportunities



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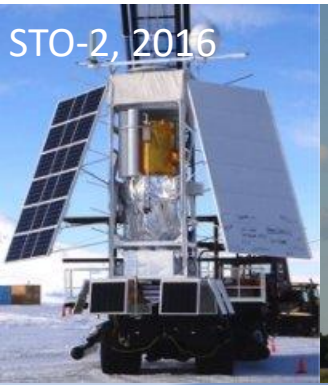
1. Balloon Capabilities

Current Scientific Balloon Flights, Snapshot

- ~ 25 large flights (> 1 t) per year
- Typically > 50% of them are astronomy + astrophysics
- Typically 3-4 over Antarctica
- Mostly NASA, some CNES / CSA, some SSC, some JAXA

Credit: D. Berry, NASA GSFC



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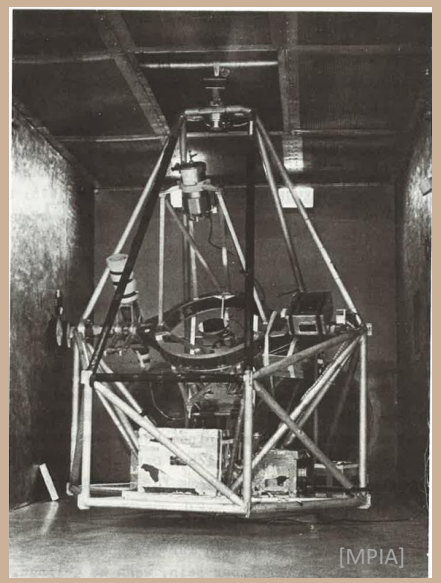
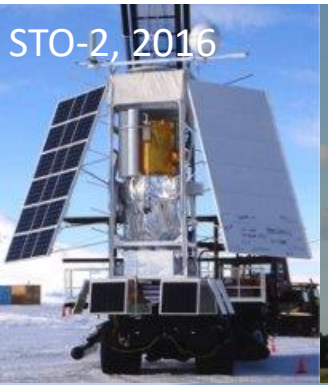
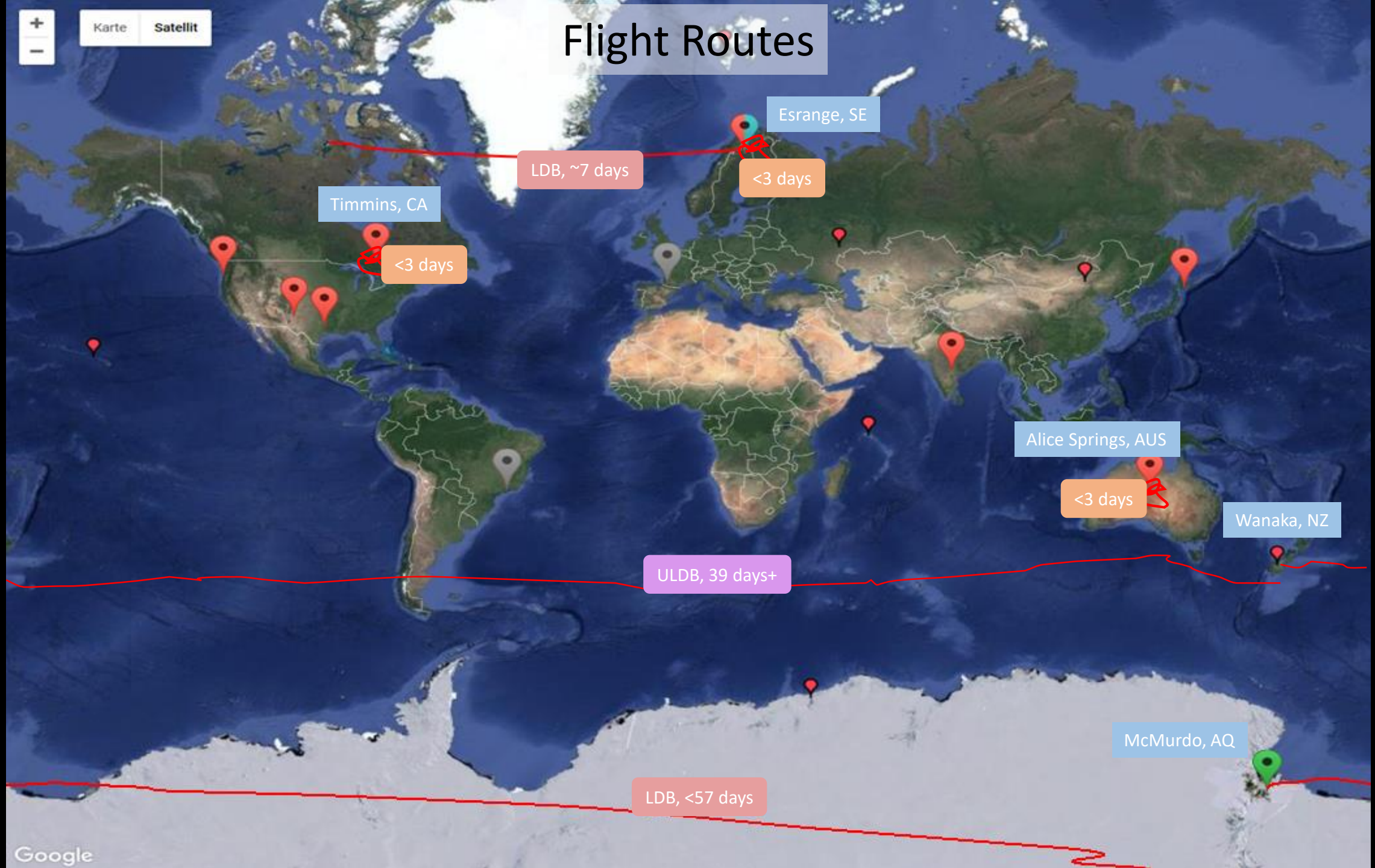
Sidenote: early German FIR missions



THISBE, 1973

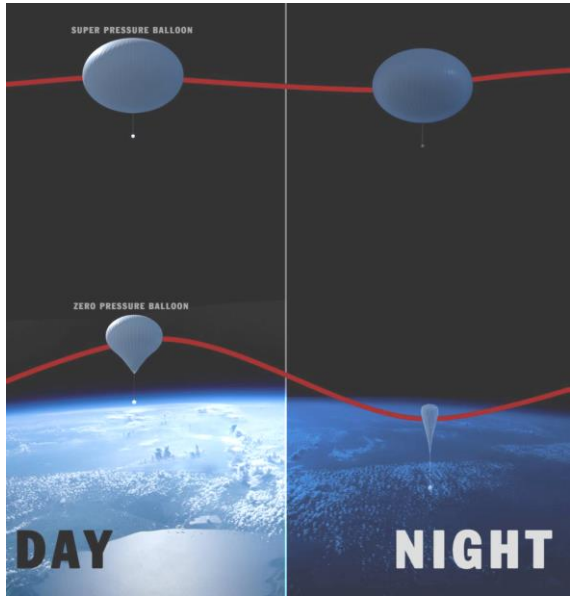
Goldener Drache, ~1980




Flight Routes
Karte
Satellit
Esrange, SE
LDB, ~7 days
<3 days
Timmins, CA
<3 days
Alice Springs, AUS
<3 days
Wanaka, NZ
ULDB, 39 days+
McMurdo, AQ
LDB, <57 days
Google

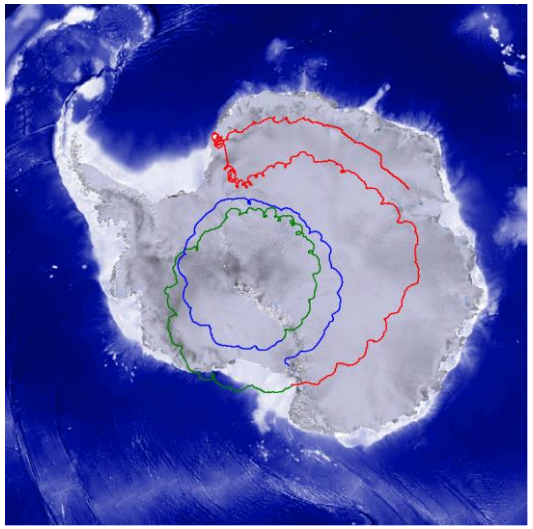
1. Balloon Capabilities

Flight Duration	- 2-3 days (April & Aug./Sept.) - 7 days (transatlantic) - Up to 57 days (Antarctica)	Zero Pressure Balloons
	- Up to 46 days (goal: 100 days), Super Pressure Balloons	
Suspended Mass	- Up to ~3600 kg for Zero Pressure Balloons - Up to ~ 2300 kg for Super Pressure Balloons	
Flight Altitude	- Up to ~ 38.7 km for Zero Pressure Balloons - Up to ~ 34 km for Super Pressure Balloons	
Pointing	- „Single stage“: < 5“ (1 σ)	
Instrument Mass	- Up to ~400/450 kg (excluding telescope)	
Power	- Up to ~500 W for instrument	
Communication	- ~ 12 Mbit/s line of sight - ~ 134 Kbit/s via Iridium Certus (over-the-horizon) - **4-30 Mbit/s via Starlink at mid-latitudes (over the horizon)** - **100-200 Kbit/s via Starlink over Antarctica (over the horizon)** - Exotic option: „Data drops“ - Optical communication in the future?	



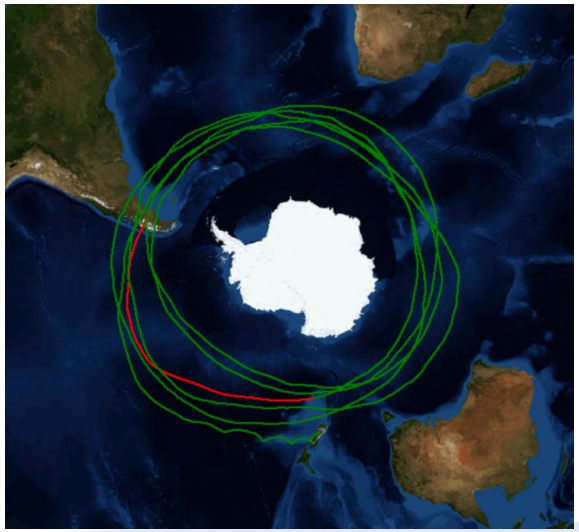
1. Balloon Capabilities

Trajectories



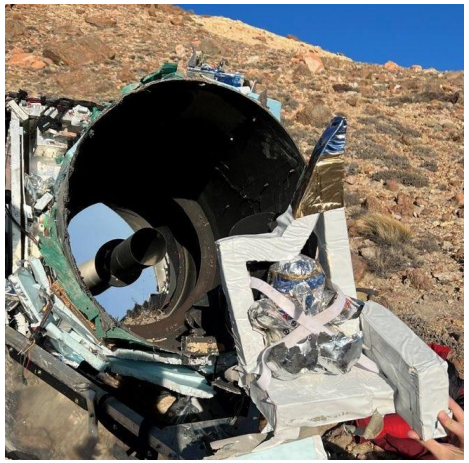
GUSTO, 2024 (57 days)

SuperBIT 2023 (37 days)



Landings

Sunrise 2013



SuperBIT 2023

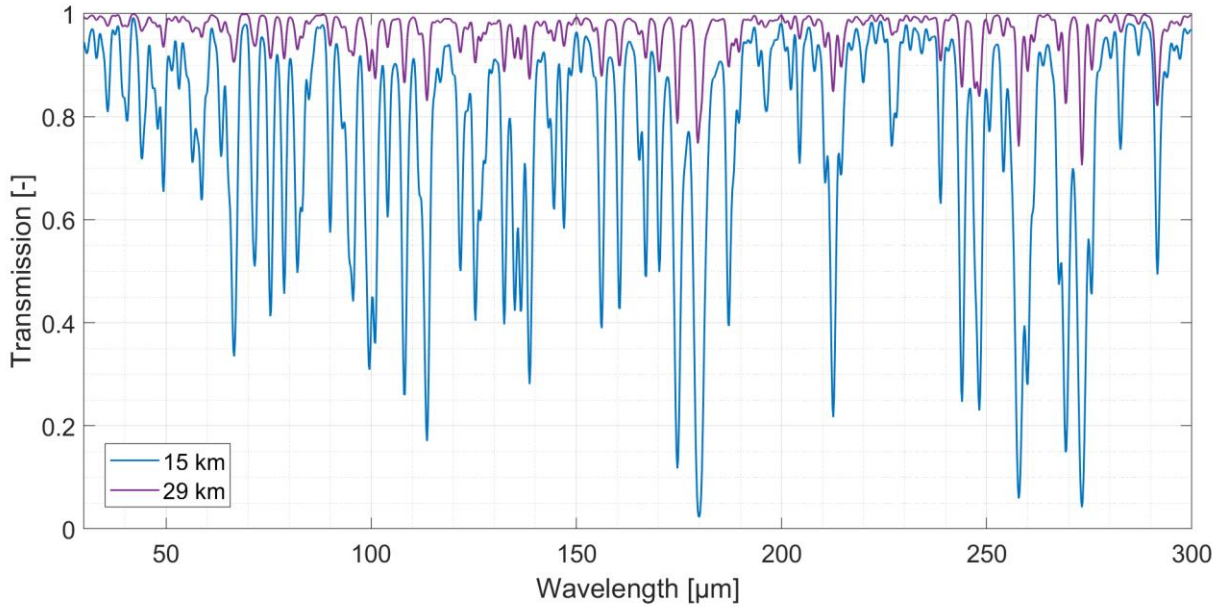
2. Observing Conditions

Atmospheric overburden

- Above ~99% of atmospheric mass (60% at 14 km)
- PWV column: < 0.5 µm

Other aspects

- Reduced pressure broadening of telluric lines -> less dynamic separation between telluric & astronomical lines needed
- (Passively cooled) optics temperatures approx. -20°C to -30°C



		Average transmission [-]	
Species / Line	**Wavelength [µm]**	**14 km**	**29 km**
[OI]	63.184	0.89	1.00
[OI] (LMC)	63.239	~0.7	1.00
[NII]	121.8	0.03	0.92
HD	58.770	0.09	0.96

3. Costs & Funding

- Exemplary flight cost

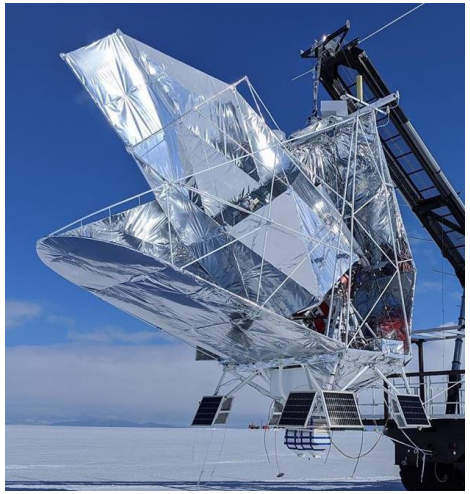
Gondola	1.1 MEUR
Launch campaign (Sweden)	700 kEUR - ~150 kEUR balloon - ~150 kEUR helium - Site rental - Personnel

- Funding opportunities
  - U.S. primarily through NASA ROSES
    - APRA: < $10M
    - Pioneer missions: up to $20M (PUEO)
    - *Explorer missions (GUSTO)*
  - Europe
    - France: flight opportunities through CNES
    - Sweden: SNSB / Swedish Research council
    - Germany: opportunities only really as precursors for space misssions
    - Previously: (smaller) flight opportunities funded through H2020 project „HEMERA“
      - No direct follow on, current related proposal: HE „AIRLIFTS“

4. Other Opportunities

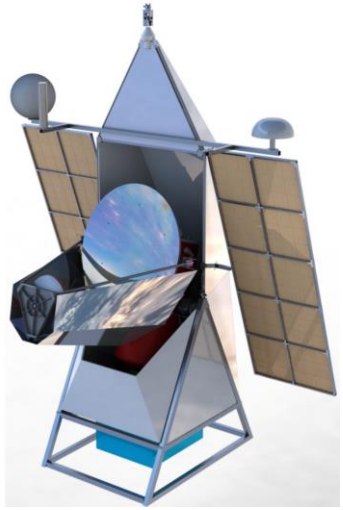
Open time observations on balloon borne telescopes

BLAST TNG *(2020)*



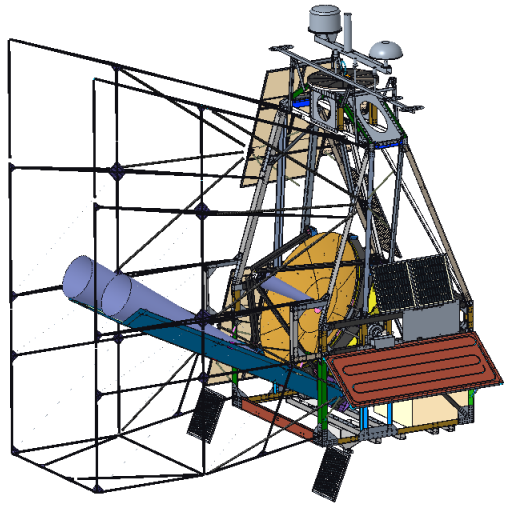
- 2.5 m telescope
- 3 MKID arrays @275 mK:
  - 250, 350, 500 µm
- 30, 41, 59 arcsec resolution
- 25% shared risk time

BLAST Observatory *(proposed)*



- 1.8 m telescope
- 3 MKID arrays @100 mK:
  - 175, 250, 350 µm
- 28, 39, 55 arcsec resolution
- 30% shared risk time (planned)

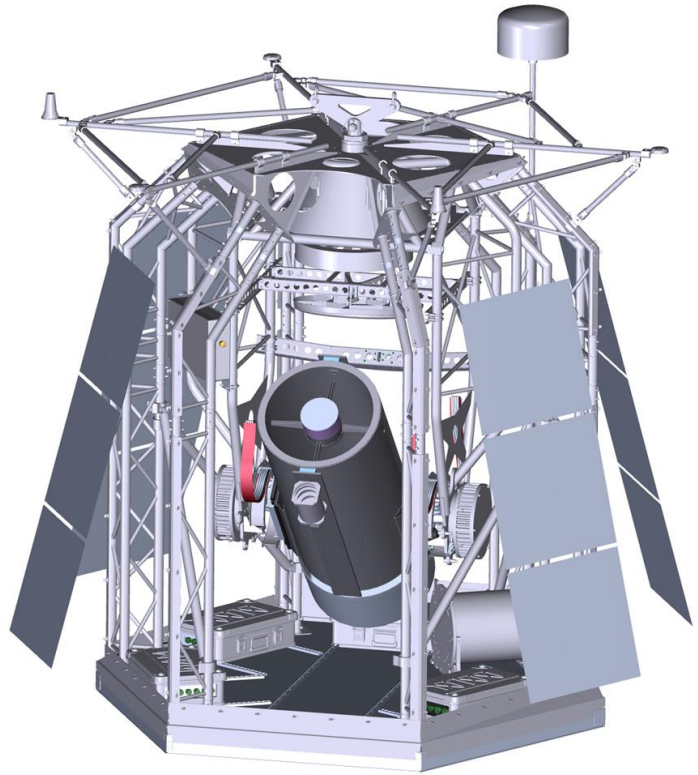
ASTHROS *(Dec. 2024)*



- 2.5 m telescope
- High-resolution spectroscopy @
  - 121.9 µm & 205.2 µm
- 12, 20 arcsec resolution
- (Still?) considering shared risk

4. Other opportunities

- STUDIO gondola
  - 817 kg gondola, currently for telescope mass of approx. 250 kg & 0.5 m aperture
  - Telescope pointing: ± 40 arcsec
  - Scalable design, up to ~ 700 kg telescope & 2 t gondola
  - Extendable for transatlantic flights (7-8 days)



Thank you for your attention!

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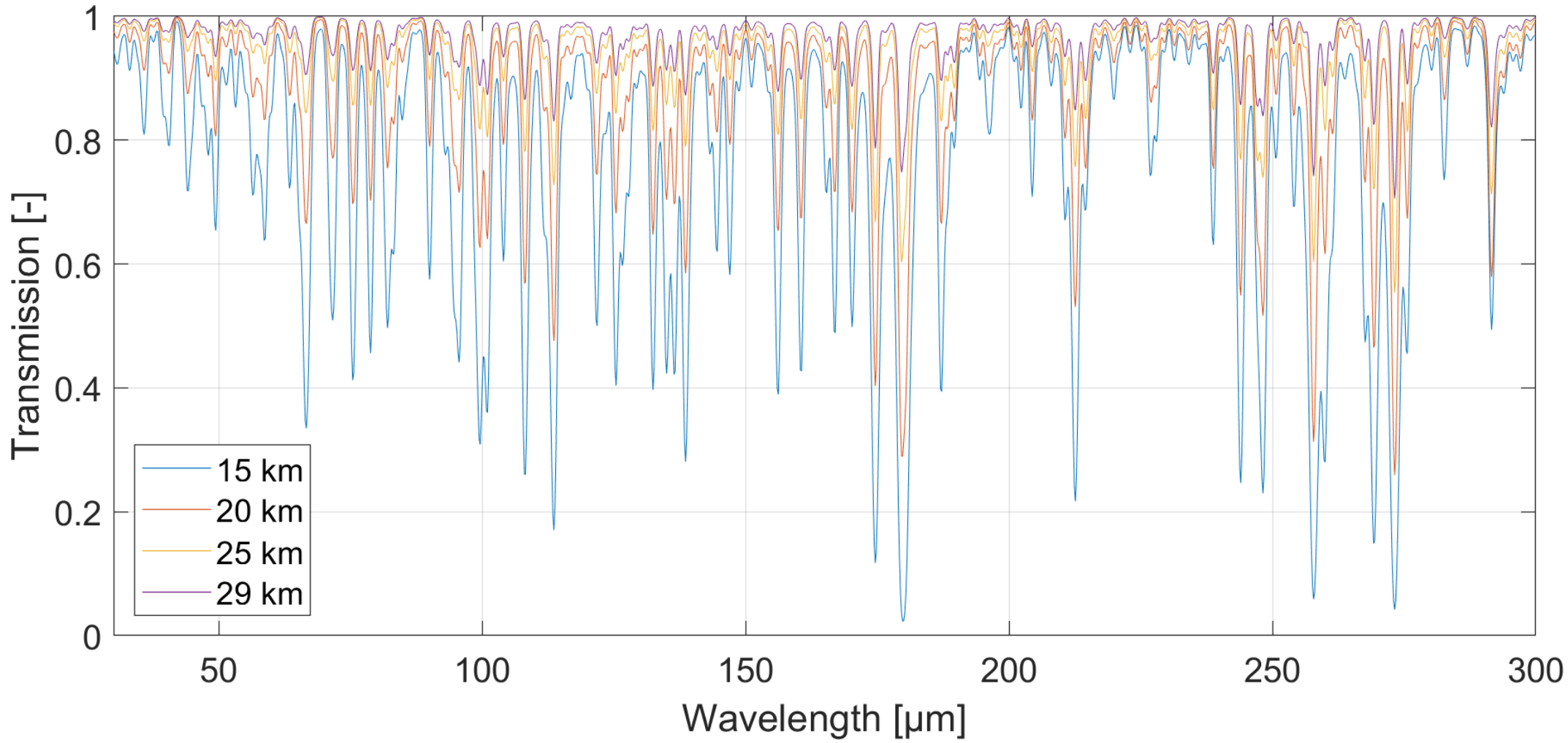
Transmission [-]
1
0.8
0.6
0.4
0.2
0
50
100
150
200
250
300
Wavelength [μm]
15 km
20 km
25 km
29 km