ESBO DS
Stratospheric Observatory

Why (and how to) do astronomy from balloons?

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The ESBO *DS* Project

ESBO DS
Stratospheric Observatory

- What?
  - Design study for European Stratospheric Balloon Observatory
  - 3-year H2020 project (Mar 2018 – Feb 2021)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 777516.

- Goals:
  - Regularly flying balloon observatory, long-term: 5 m FIR telescope (5-15 years perspective, feasibility study)
  - 0.5 m UV prototype (launch foreseen for Sept. 2021)

- Who?

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See poster by S. Bougueroua & talk by L. Hanke

- Who?

University of Stuttgart Germany Institute of Space Systems
SSC
EBERHARD KARLS UNIVERSITÄT TÜBINGEN
MPE
INSTITUTO de ASTROFISICA de ANDALUCIA CSIC I·A·A

Content

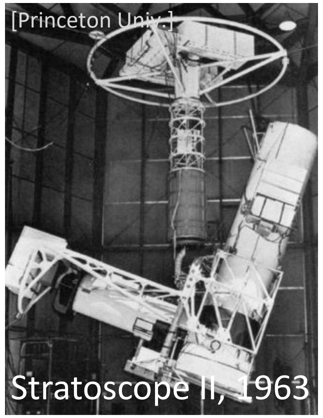
1. Why do Astronomy from Balloons – Opportunities and limitations
2. Current Capabilities
3. Achievements and capabilities ahead
4. Observational Conditions
5. What is Missing? – The idea behind ESBO

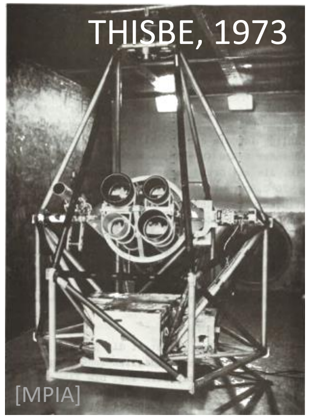
1. Why balloon-borne astronomy?

Historically: because there was nothing else.

- 1912: Experimental confirmation of cosmic rays by V.F. Hess on a manned balloon (few kg?)
- 1957: Stratoscope I, a 0.3 m aperture solar telescope (USA, 0.8 t)
- 1963: Stratoscope II, a 0.9 m aperture telescope (USA, 3.6 t)
- Early development in Germany as well:
  - 1973: THISBE (UV-FIR; MPIA)
  - 1975: Spektro-Stratoskop (KIS)
  - 1977: MPE Compton Teleskop
  - 1978: IAAT/MPE X-ray experiment
  - 1980: Golden Dragon (FIR; MPE)
  - 1980: HEXE (X-rays; MPE & IAAT)


V.F. Hess, 1912

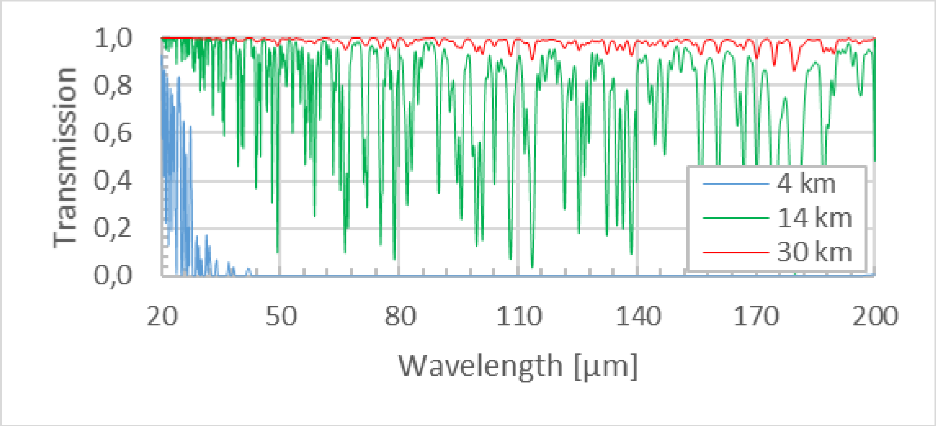

[Princeton Univ.]
Stratoscope II, 1963


THISBE, 1973
[MPIA]

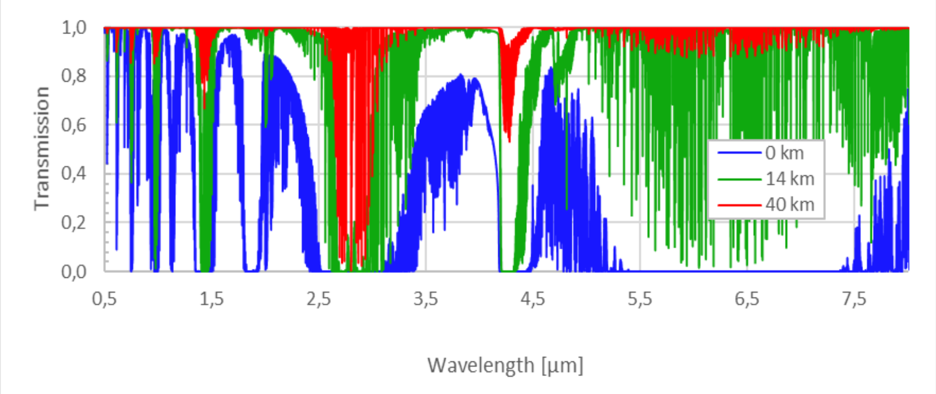

HEXE, 1980
[MPE]

And today? – Observational Conditions

FIR Atmospheric Transmission



Vis/NIR Atmospheric Transmission



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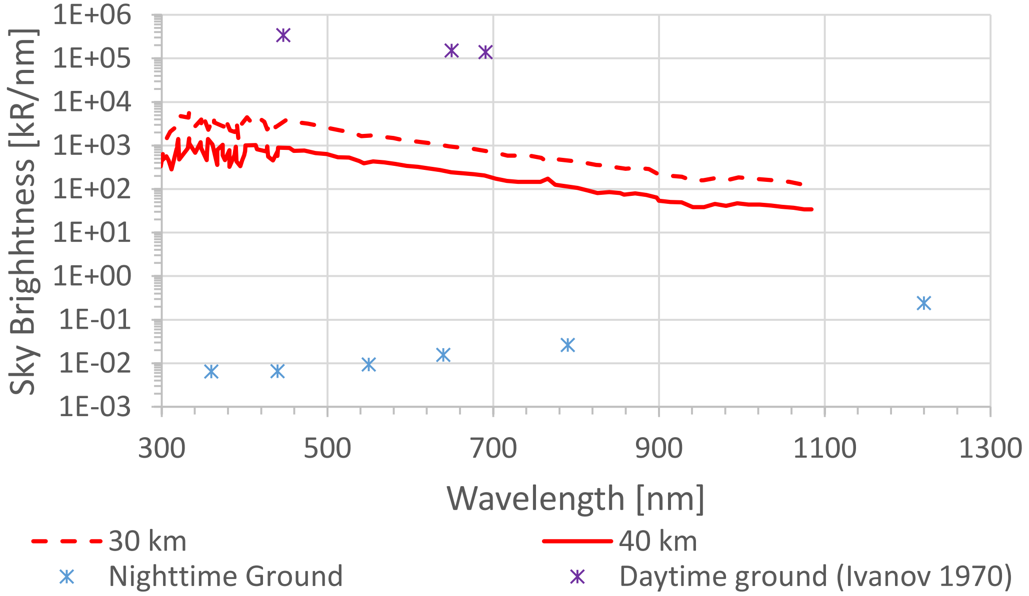
Day-/nighttime differences

Visible



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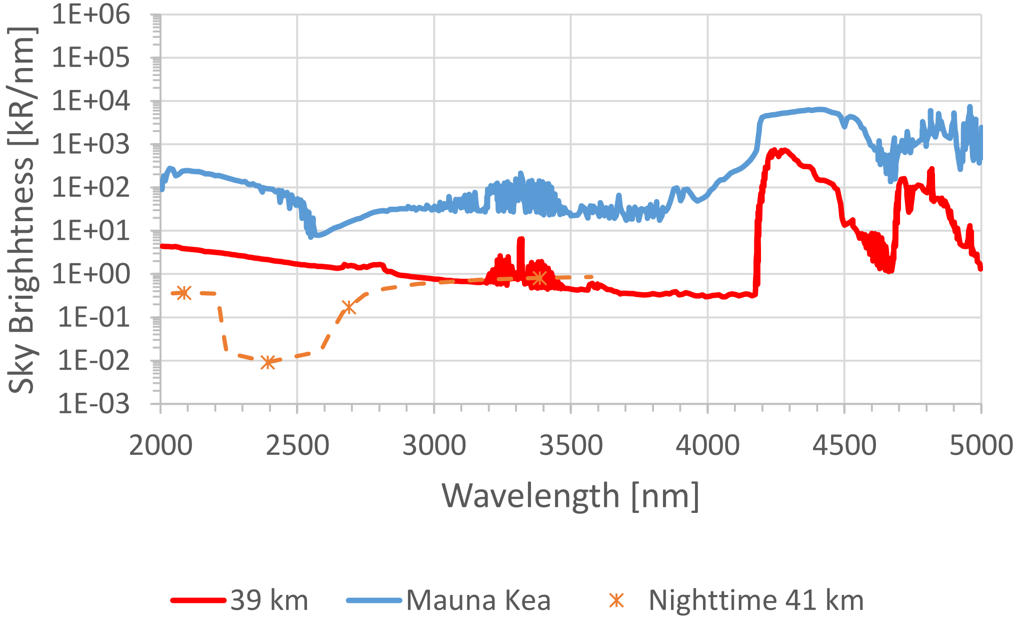
Near-infrared



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Operational conditions compared to space

	Balloon	Space
Launch costs	0.4 – 3 MEUR	> 70 MEUR
Shape and size restrictions:	Flexible	Launcher payload fairing
Available data retrieval rates:	> 100 GB/day avg.	2 GB/day (Herschel)
Pointing restrictions	Southern/Northern hemisphere 24-h cycle wrt ecliptic for mid-latitudes	None / 90-min cycles, depending on orbit

PoGO+ (2013, 2016)
- PI: KTH (SE)
- X-ray telescope

Sunrise (2009, 2013,…)
- PI: MPS (D)
- 1 m UV solar telescope

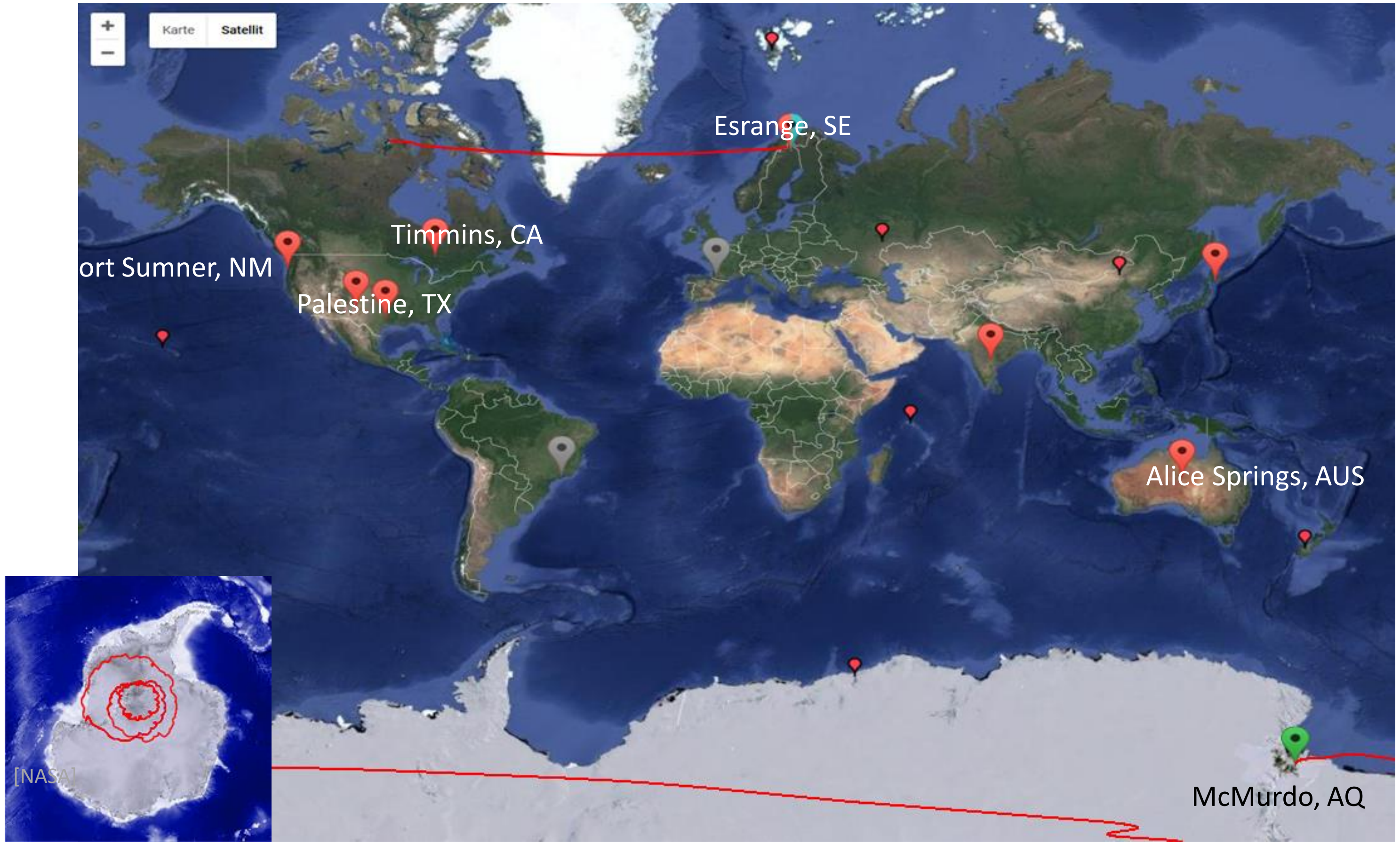
OLIMPO (2014, 2018)
- PI: Univ. La Sapienza (IT)
- 2.6 m CMB telescope

2. Current Capabilities

And today?

Launch Sites:

- Short-duration flights ca. 30 h
  (3 h to ~ 40 h, April & Aug/Sept)
- Mid-duration flights ca. 130 h
  (~ 7 days, May-Aug)
- Long-duration flights ca. 1000 h
  (up to 55 days, Nov-Jan)
- Inactive

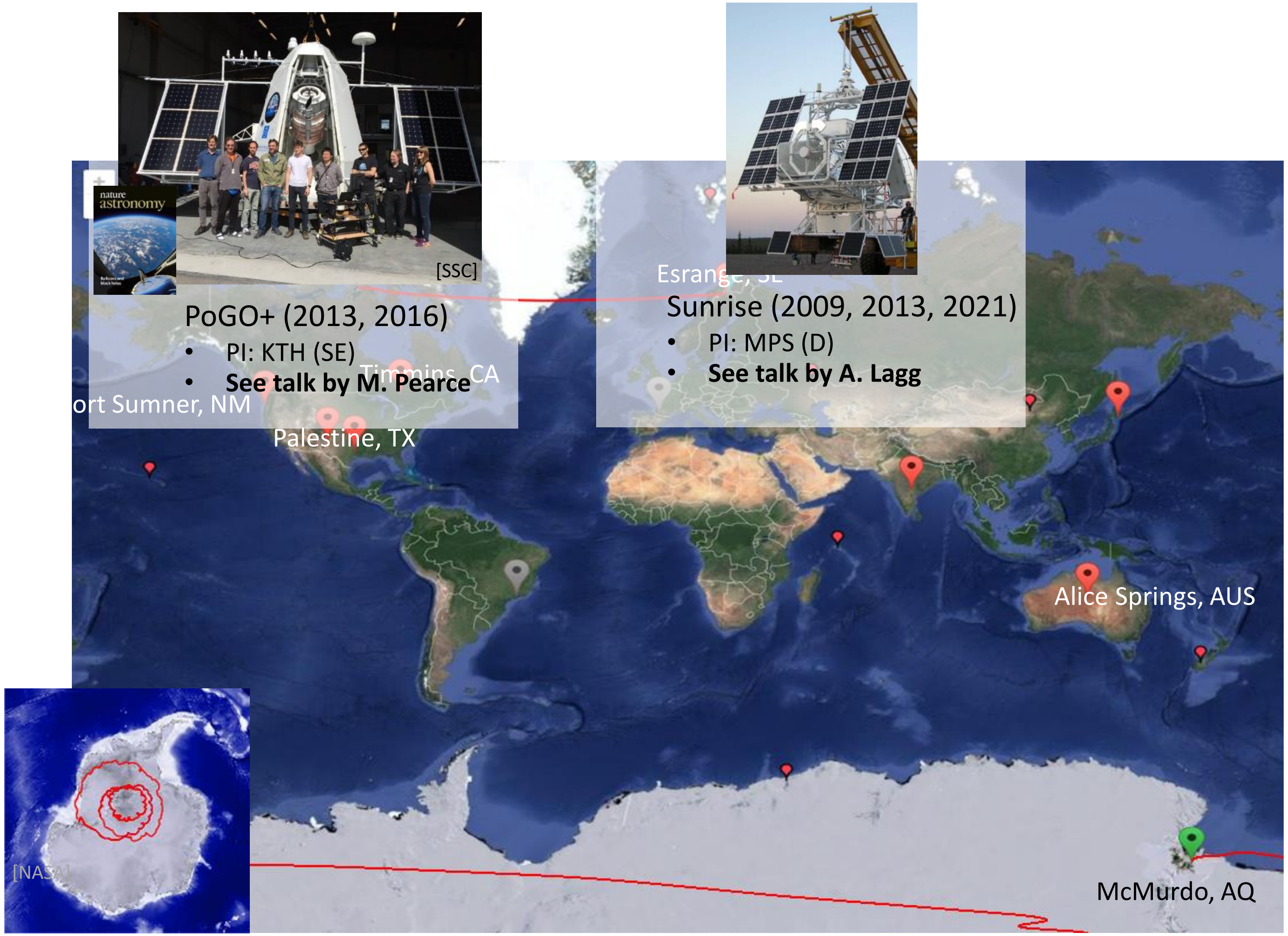


Generally:

- 30 to 40 km altitude (above 99.9 % of atm. Mass)
- Up to 3.6 t payload
- Image stabilisation: < 0.1“

3.4 t
Herschel

And today?



Launch Sites:

- Short-duration flights (3 h to ~ 40 h, April & Aug/Sept) — ca. 30 h
- Mid-duration flights (~ 7 days, May-Aug) — ca. 130 h
- Long-duration flights (up to 55 days, Nov-Jan) — ca. 1000 h
- Inactive

Generally:

- 30 to 40 km altitude (above 99.9 % of atm. Mass)
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Herschel

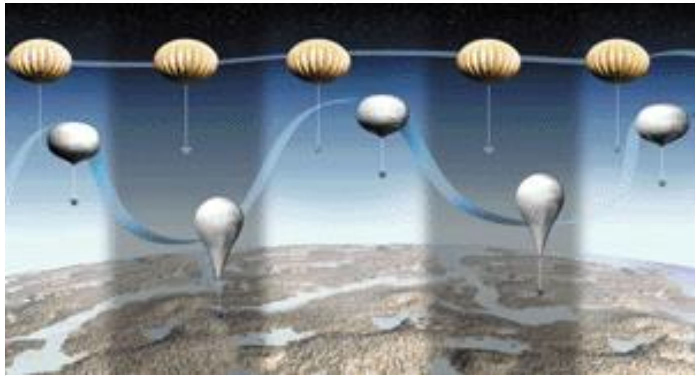
Content

1. History of BBA
2. Current Capabilities in stratospheric ballooning
3. **Achievements and capabilities ahead**
4. A regular observatory – the ESBO vision

ESBO Stratospheric Observatory

Ultra Long Duration flights

- Based on Super Pressure balloons
- Flight durations of 100 days and more
- 1000 – 2000 h of observation per flight
- Launch sites: McMurdo (AQ), Wanaka (NZ)



[NASA]

[NASA]

Trajectory of
ULDB Flight 2016 (COSI):
Wanaka (NZ) –> Peru
46 days afloat

Reliable landing technology

Current situation:

- Unsteered parachutes
- No opening shock damping

Future improvements: soft landings

- Automated steered parafoils
- Opening shock damping
- Subject to work under ESBO *DS*

[WorldView]

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Challenges

- Experiment vs. observatory
- Resources for instrument + telescope + platform
- Too much effort on technology + platform
  -> smaller percentage of focus on science return
- Reliability of flight opportunities (part. Antarctica)
- „Something always breaks“

4. What is missing? – The idea behind ESBO

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Goal: Establish an accessible balloon-borne astronomical observatory

- Instrument flight opportunities
- Observation time access
- Exchange, upgrade, refill of instr.
- Regular flights, regular operation
- Fast turnaround times
- Maximum re-use of hardware

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Enablers:

- Modern balloon systems & long flight trajectories
- Soft landing technologies
- Autonomous systems

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Observatory elements under ESBO *DS* / STUDIO Prototype

- Safe landing technologies
- Modular gondola
- Modular / expandable ADCS
- Flexible Mission Control SW
- Instrument-independent image stabilisation
- Qualification procedures

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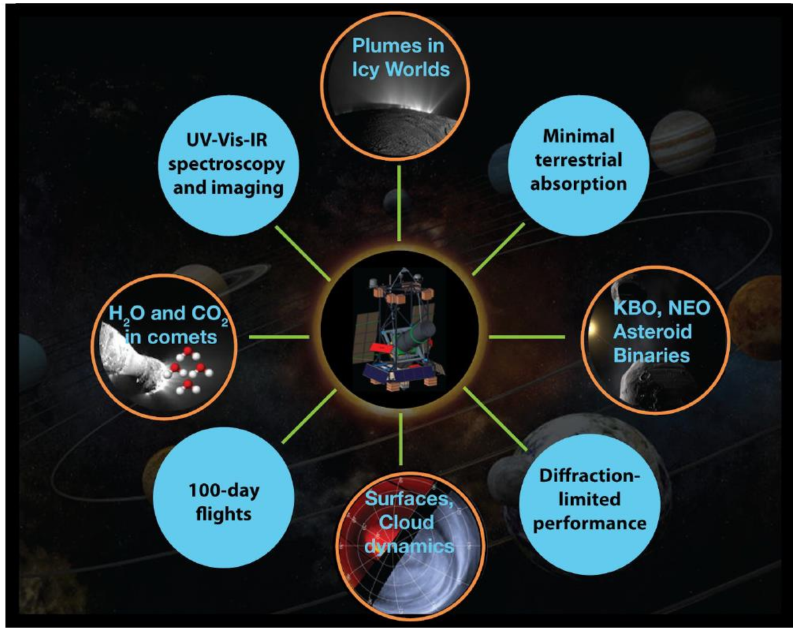
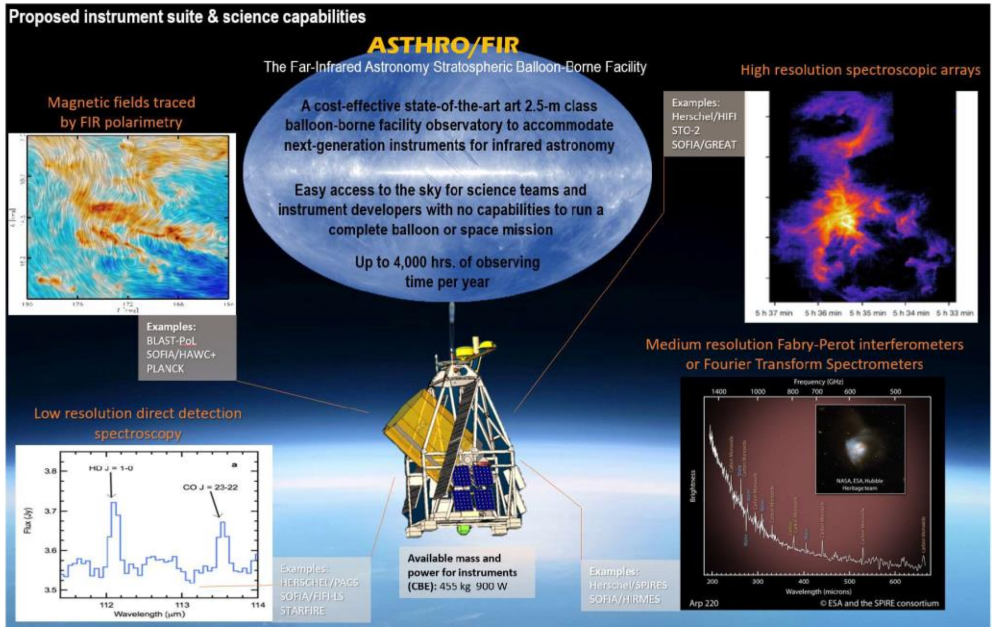
Other observatory facility proposals

Gondola for High Altitue Planetary Science (GHAPS)



FIR Astronomy Stratospheric Balloon Facility *(see talk by J. Pineda)*



Other observatory facility proposals

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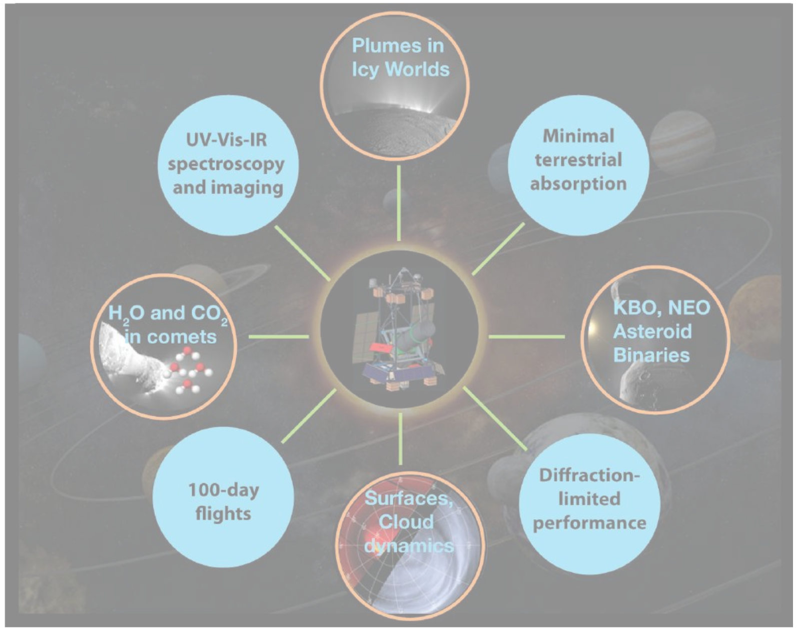

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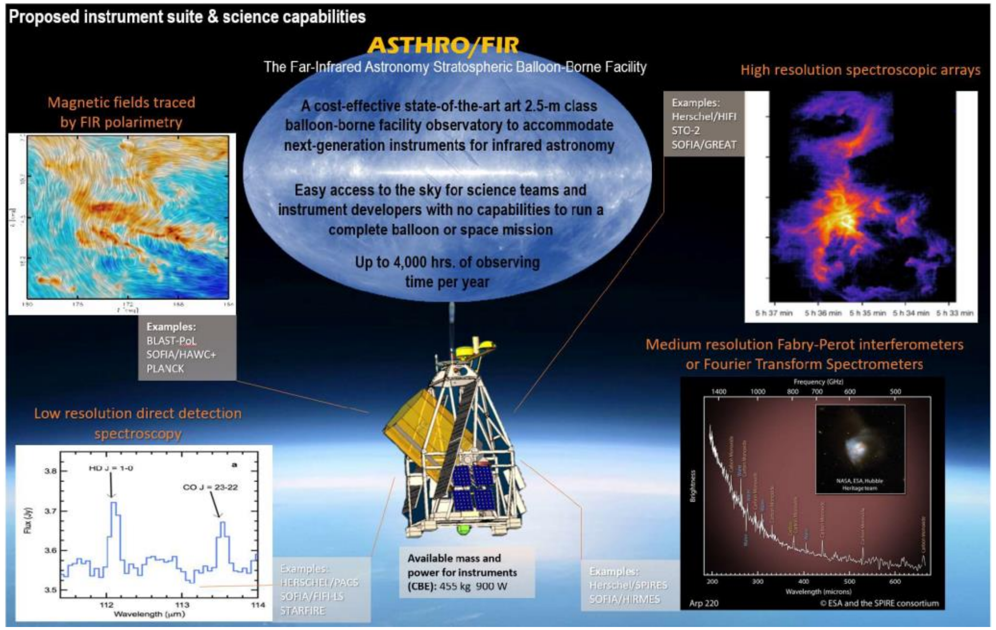

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The other way around: questions to you

- What has to change to increase the attractiveness of balloon platforms / the science return?
- How do you see the roles of space/balloon-/air-borne platforms?