Jens Kauffmann
California Institute of Technology

Why Airships?

Comparisons of Airships to other Science Platforms

Astronomical Constraints

need to detect and resolve objects in space

Practical Constraints

need to build and maintain telescope on a budget

Astronomical Constraints

High Angular Resolution

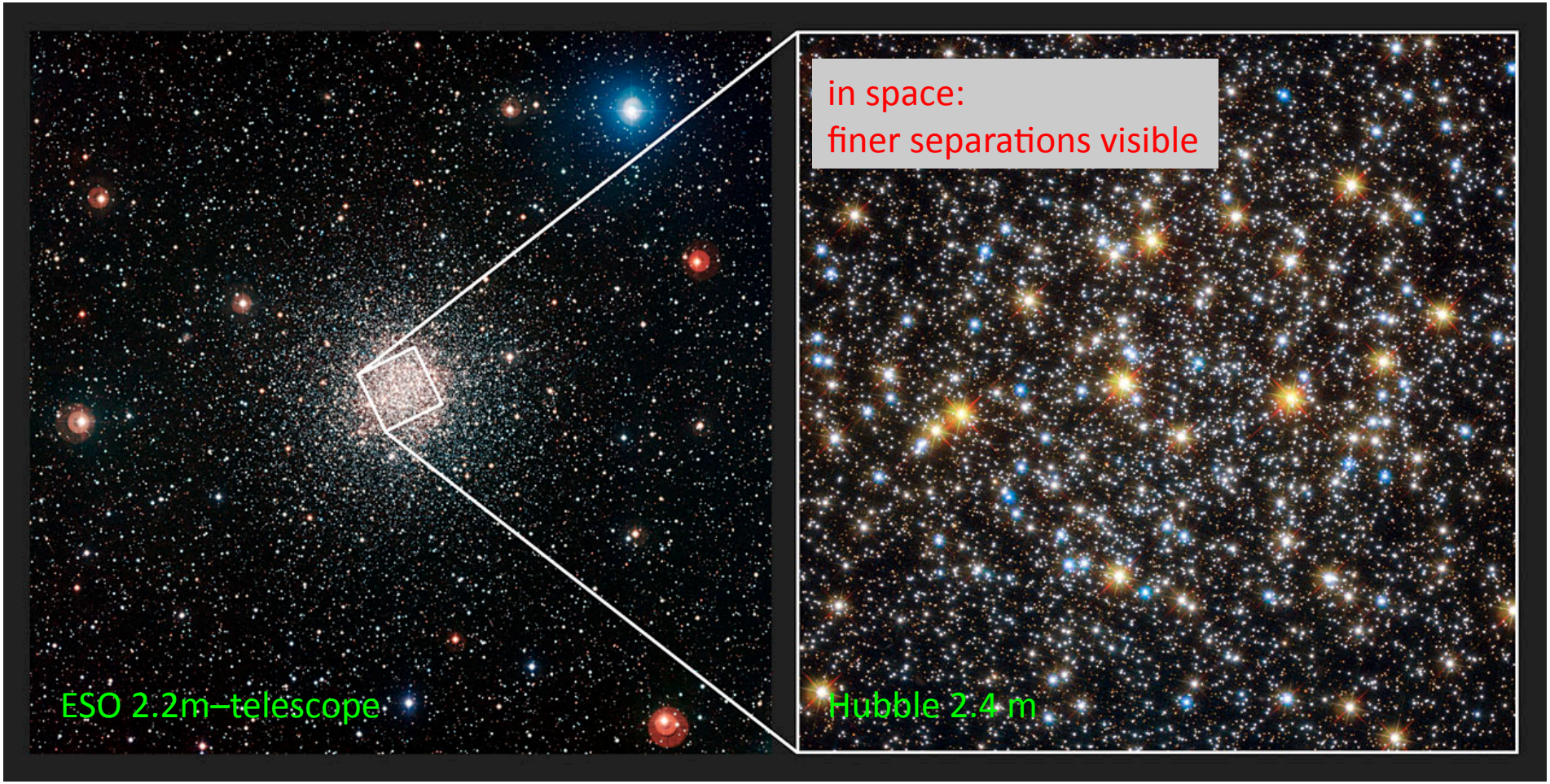
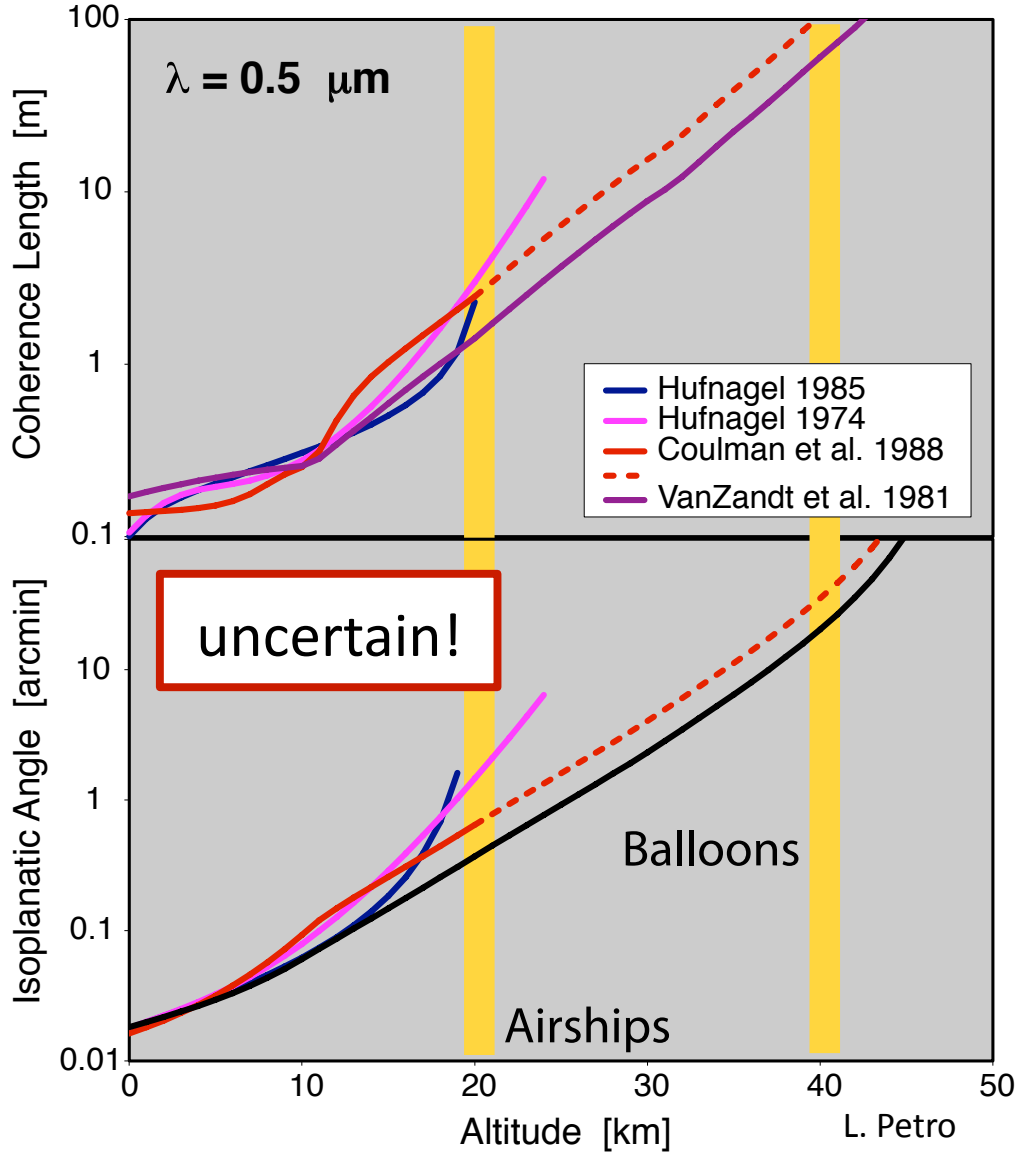
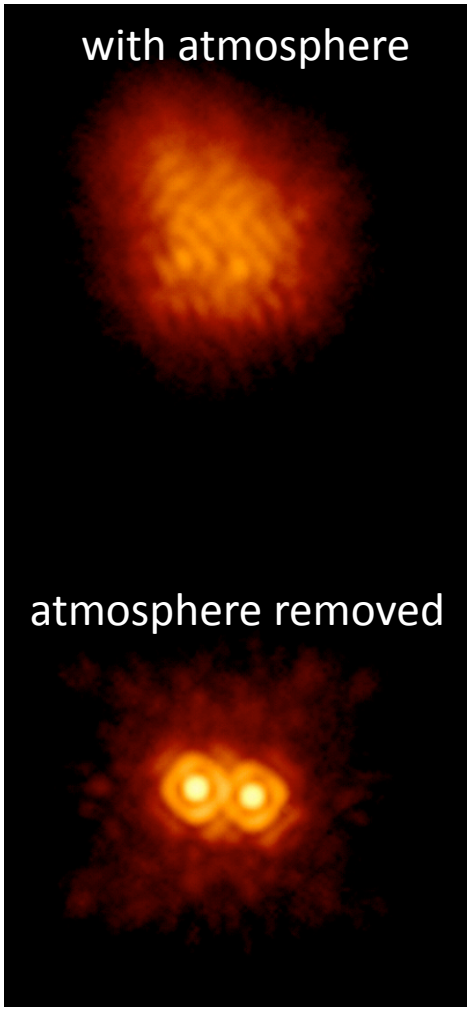


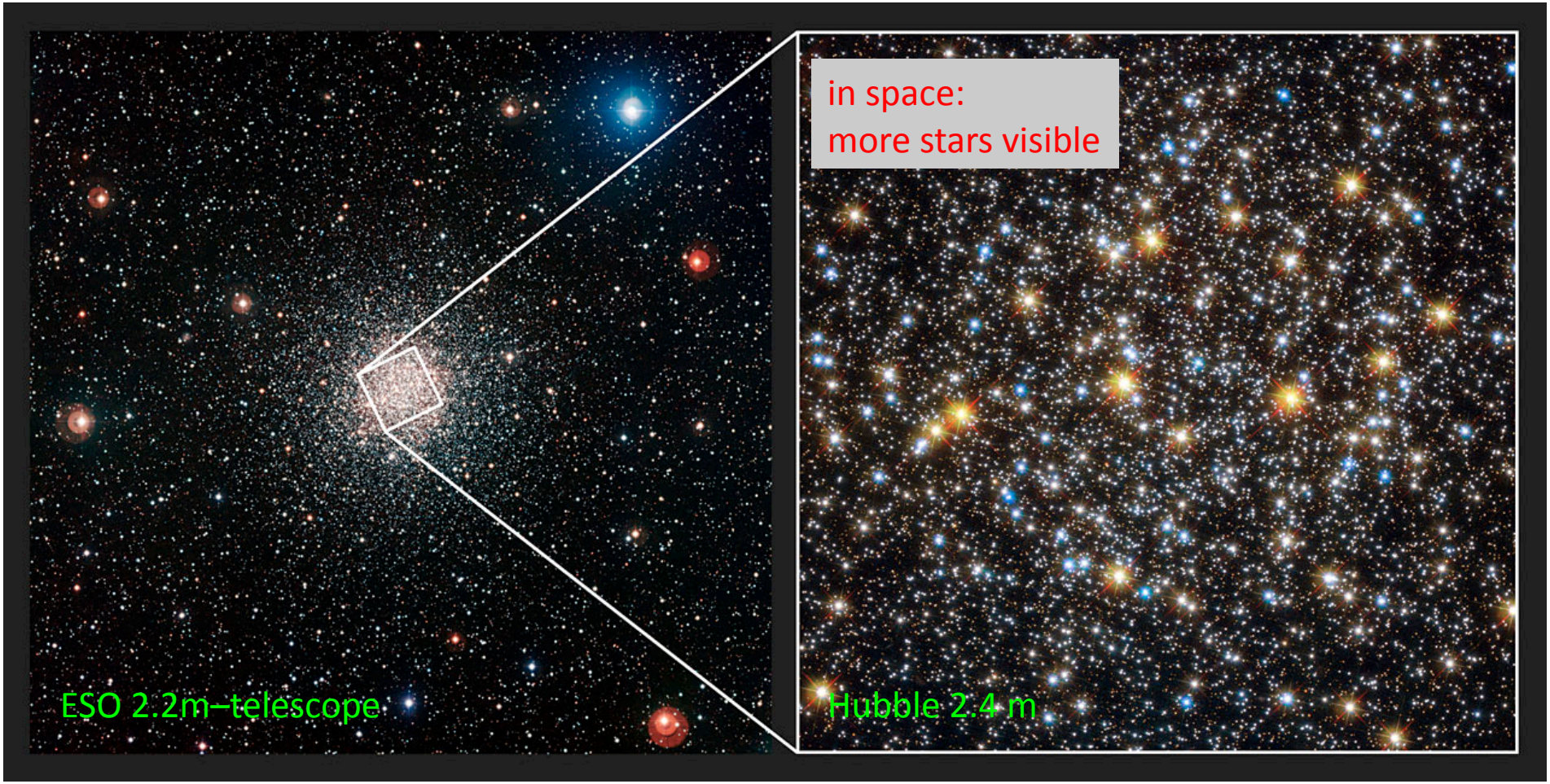
Image Quality



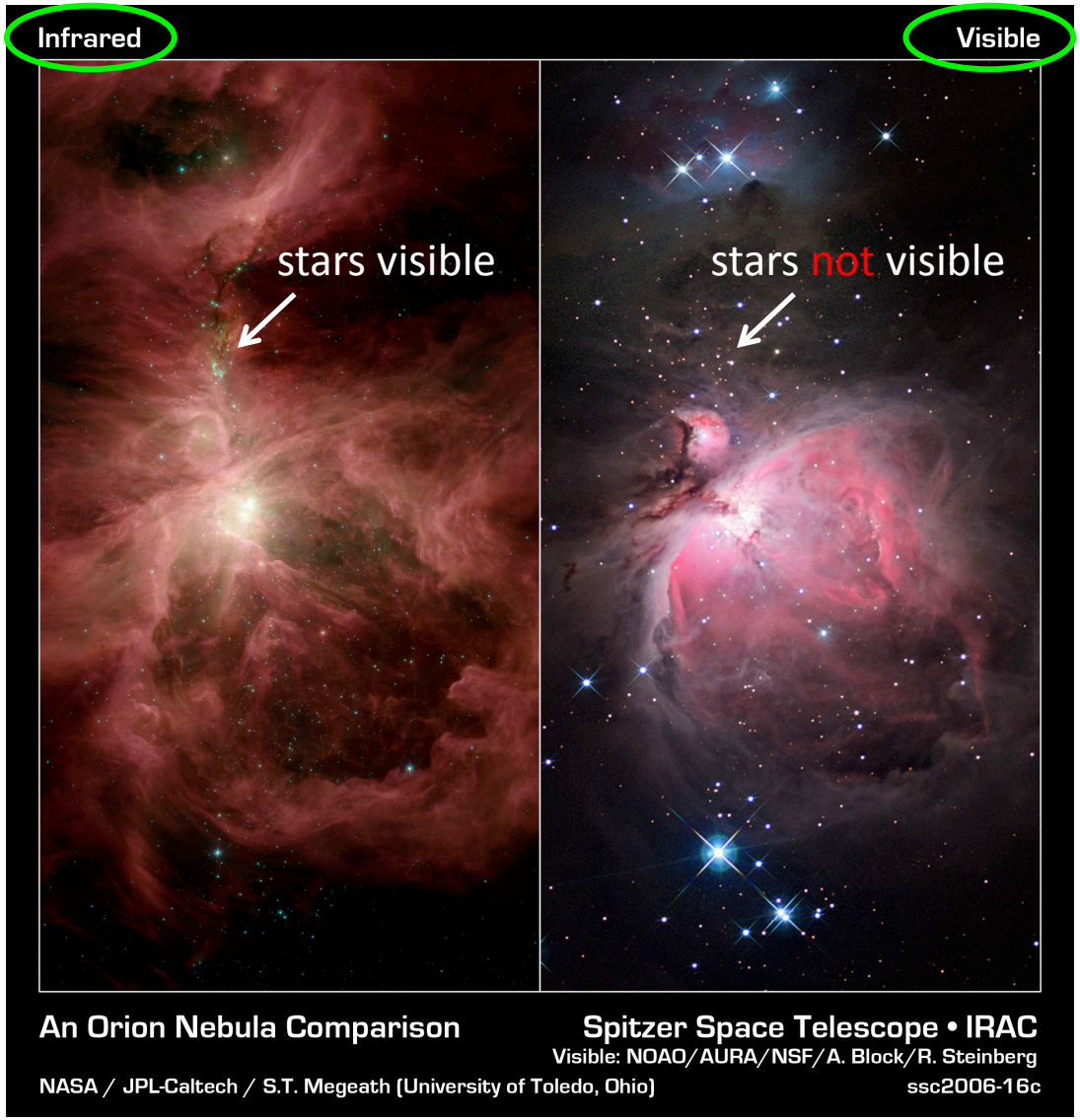


IW Tau: Beichman & Tanner

High Sensitivity

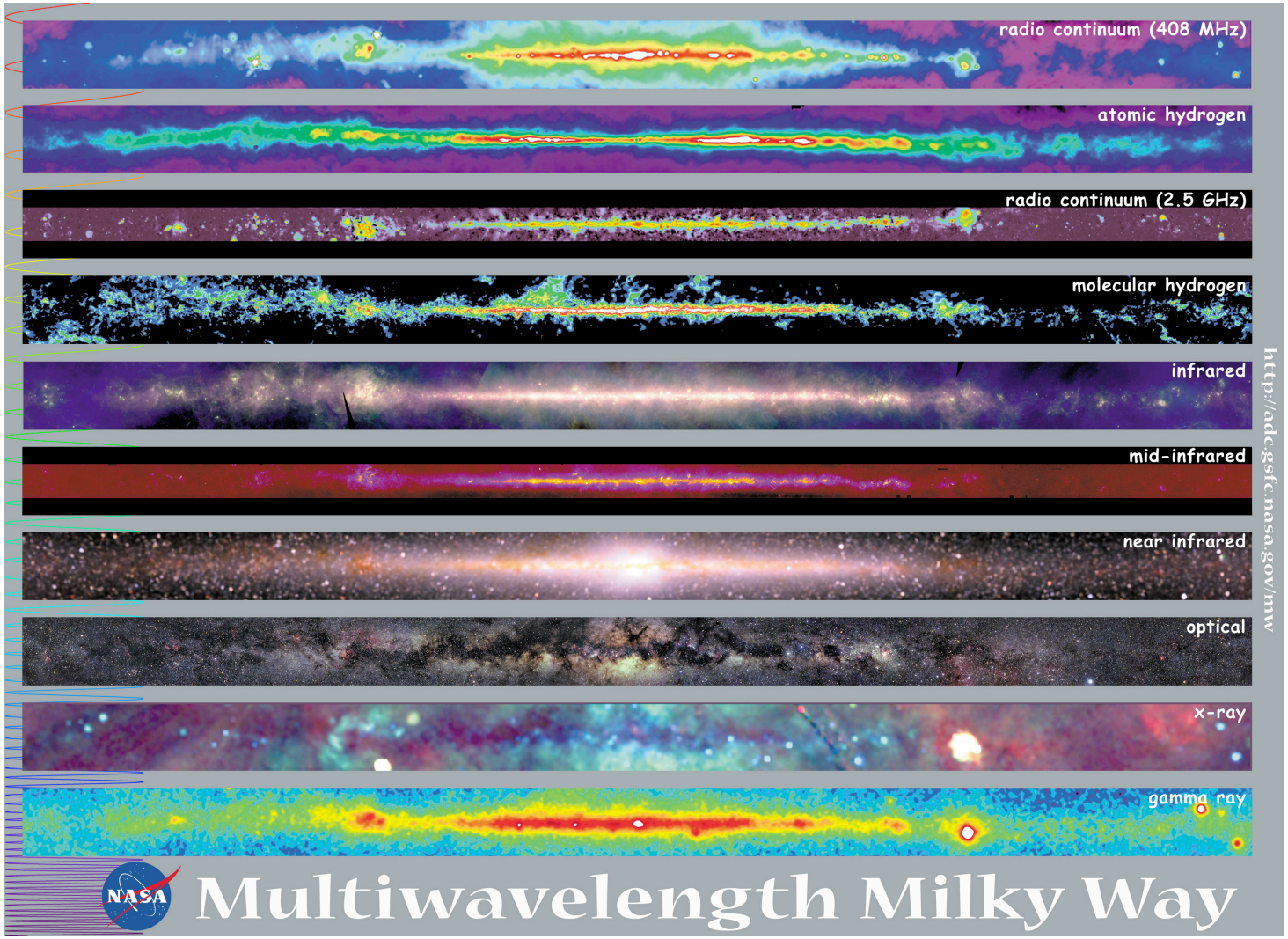


Wide Spectral Range I

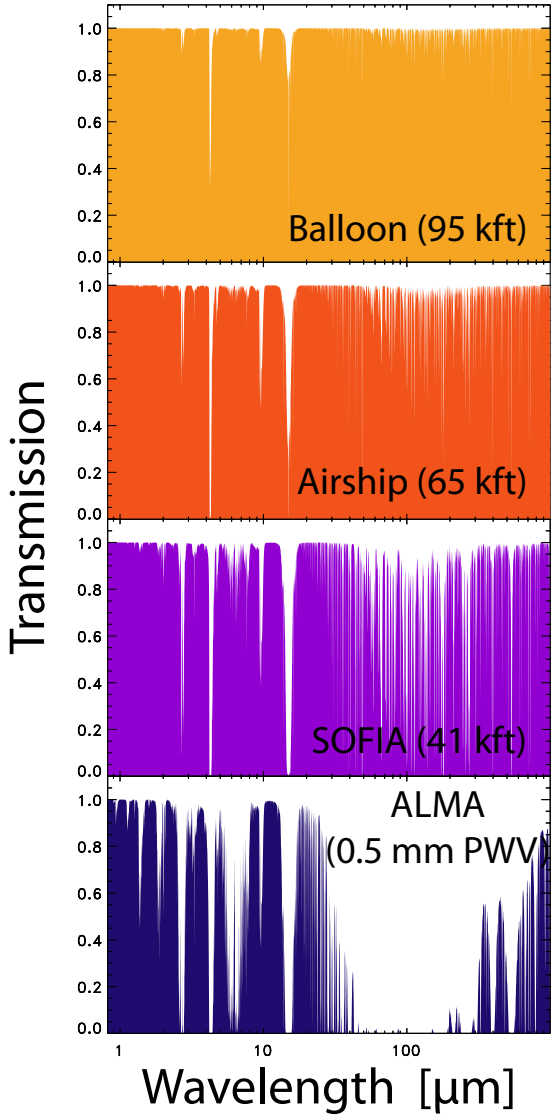


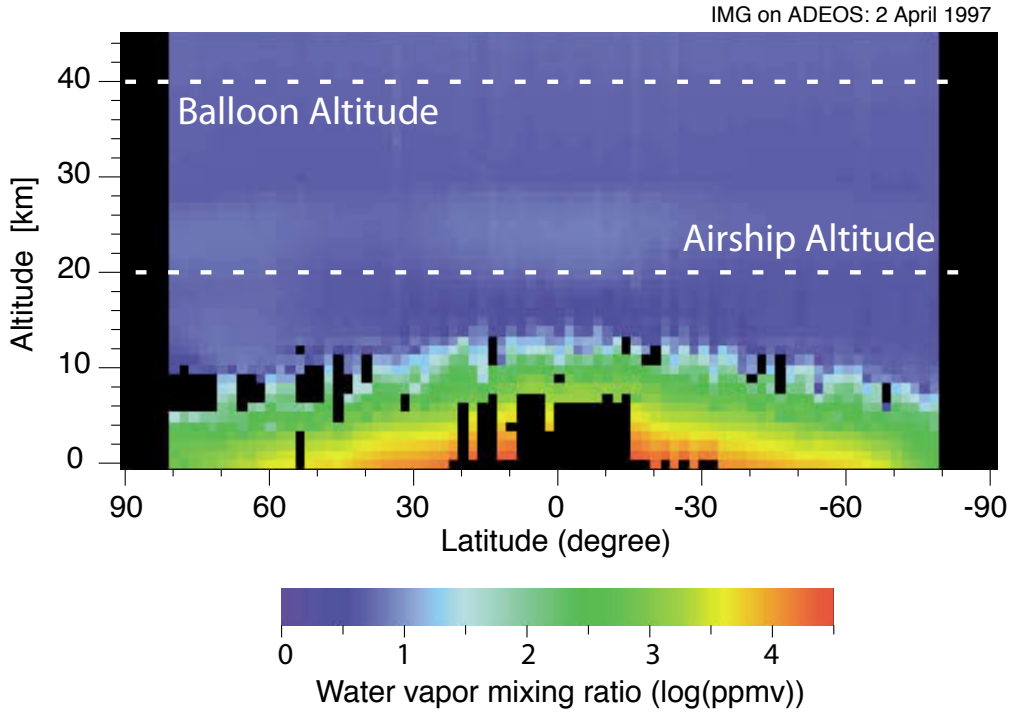
Wide Spectral Range II

stars and different components of gas visible at different wavelengths



Transparency of the Atmosphere

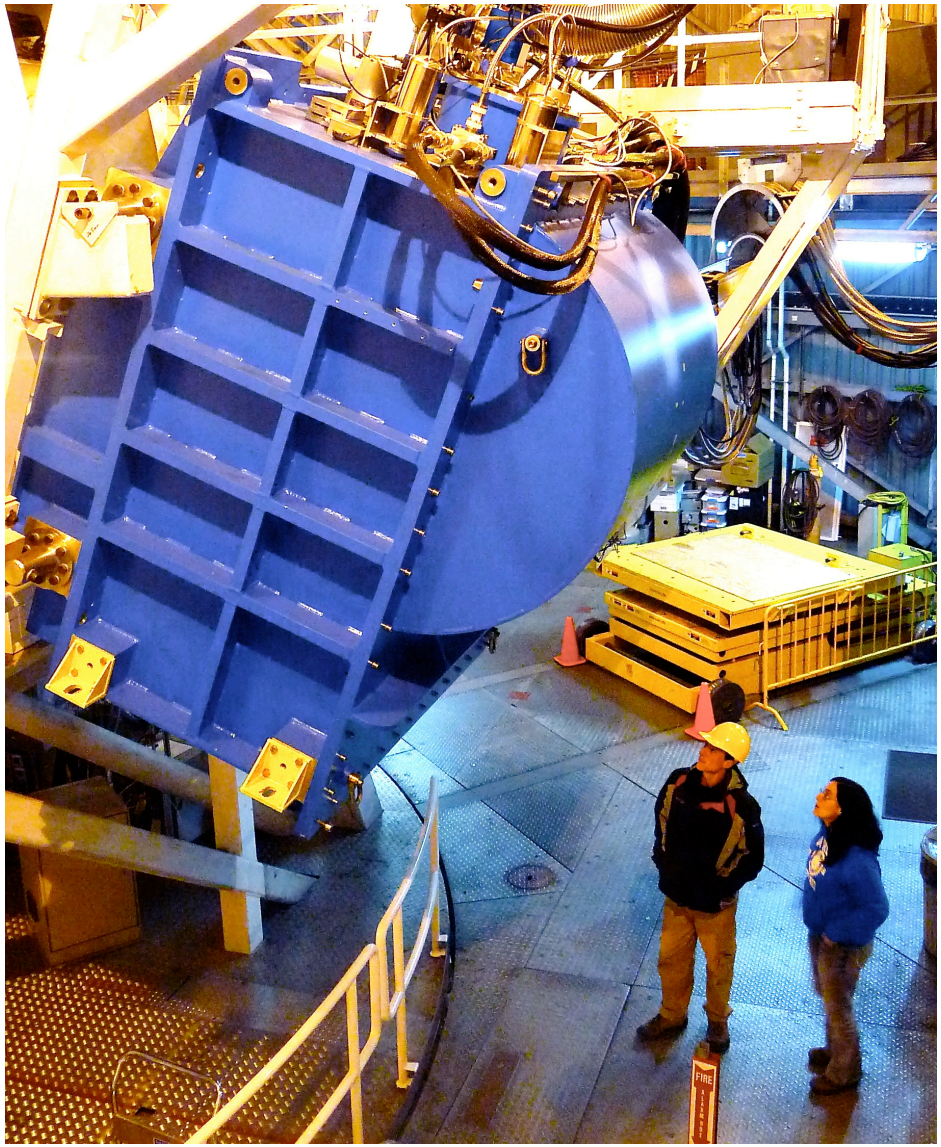




Steven Lord, Caltech

Practical Constraints

Astronomical Instruments are Large and Complex



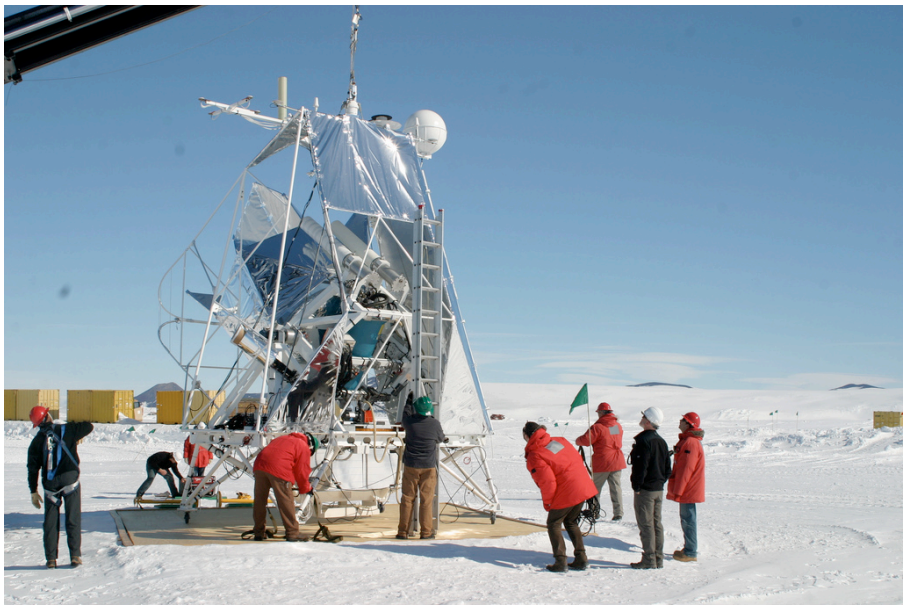
SCUBA2 on the JCMT

Building and Maintaining Telescopes

depends on location of telescope

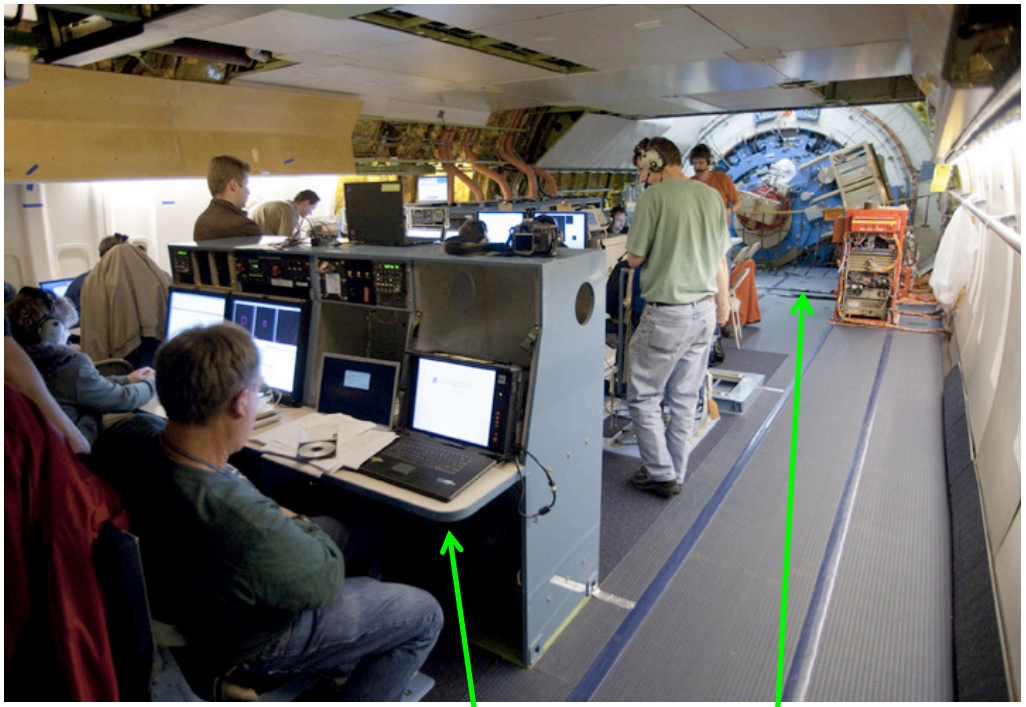
Costs are a Limiting Factor

Herschel Space Telescope
> $1,000M



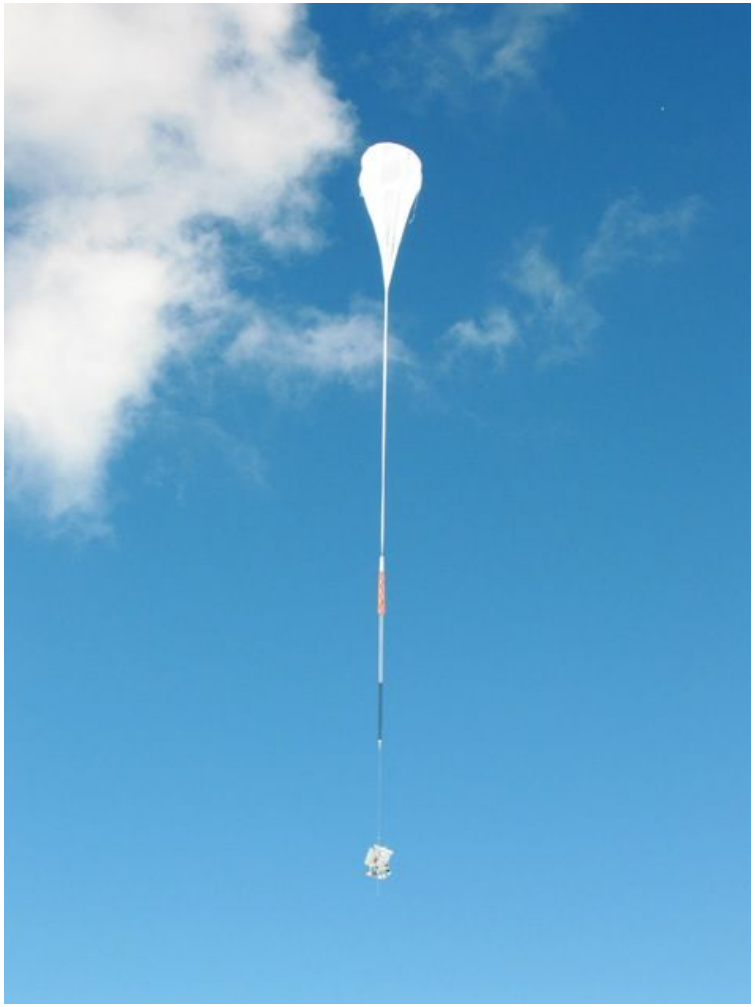
BLAST
few $1M

Controlling the Telescope



SOFIA

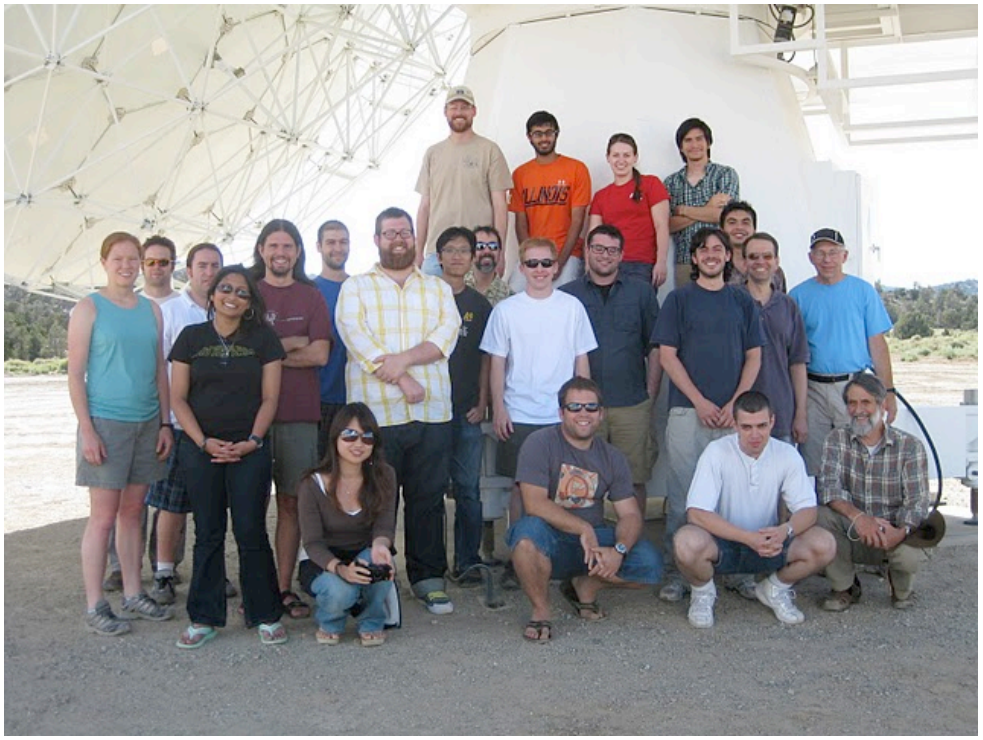
direct control of observations and hardware



Balloon

no control after launch

Easy Access to Hardware



- train the next generation
- develop new instruments

Current Observatories

Ground–Based Observatories

Pros:

- relatively easy access
- large structures possible
- relatively cheap

Cons:

- limited spectral range
- limited sensitivity

Space–Based Observatories

Pros:

- perfect transmission
- very stable
- very efficient

Cons:

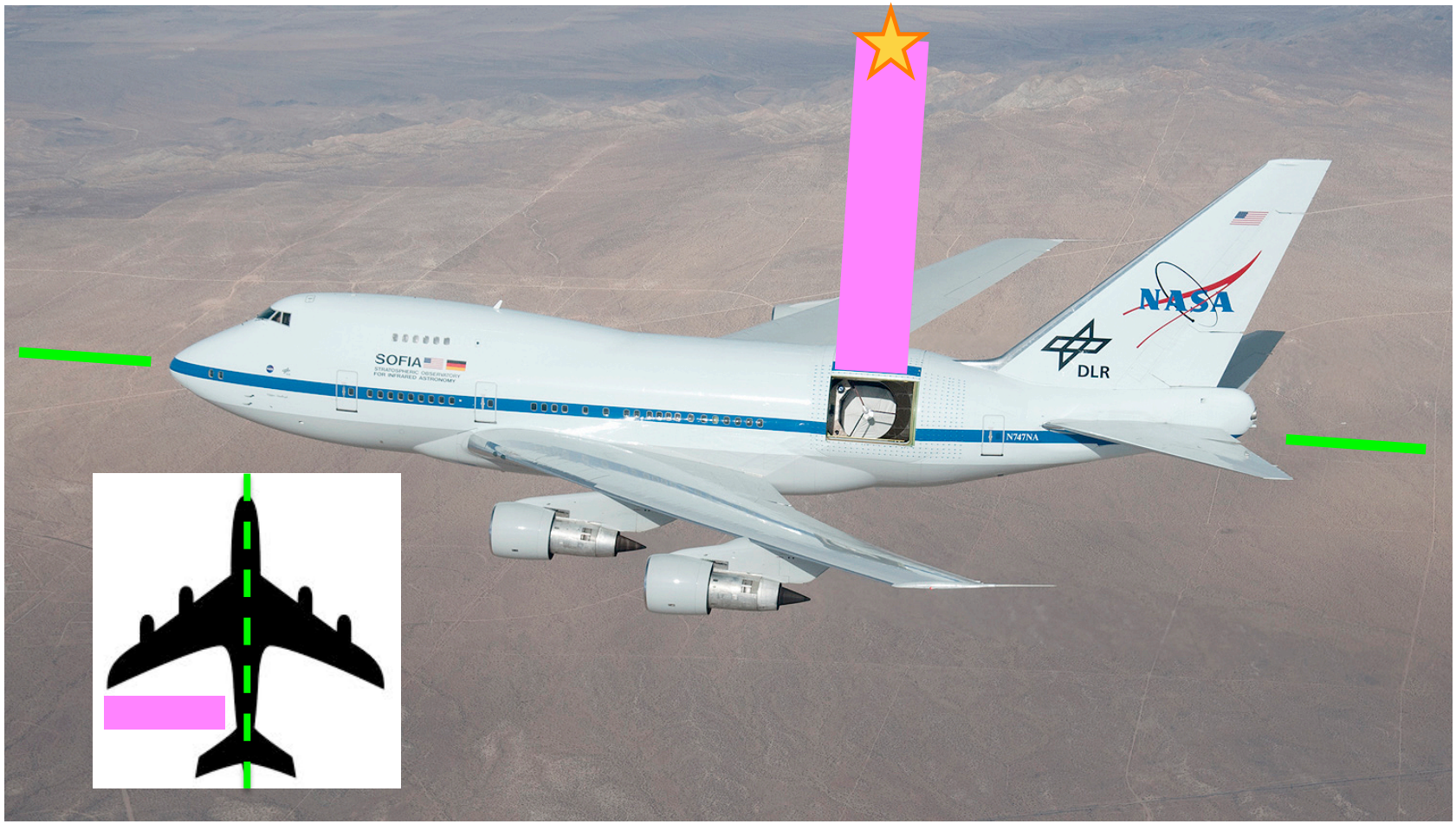
- very expensive
- not accessible
- very inflexible (w.r.t. technology)
- limited control (not for observers)

Fixed Wing Aircraft: SOFIA

Stratospheric Observatory for Infrared Astronomy

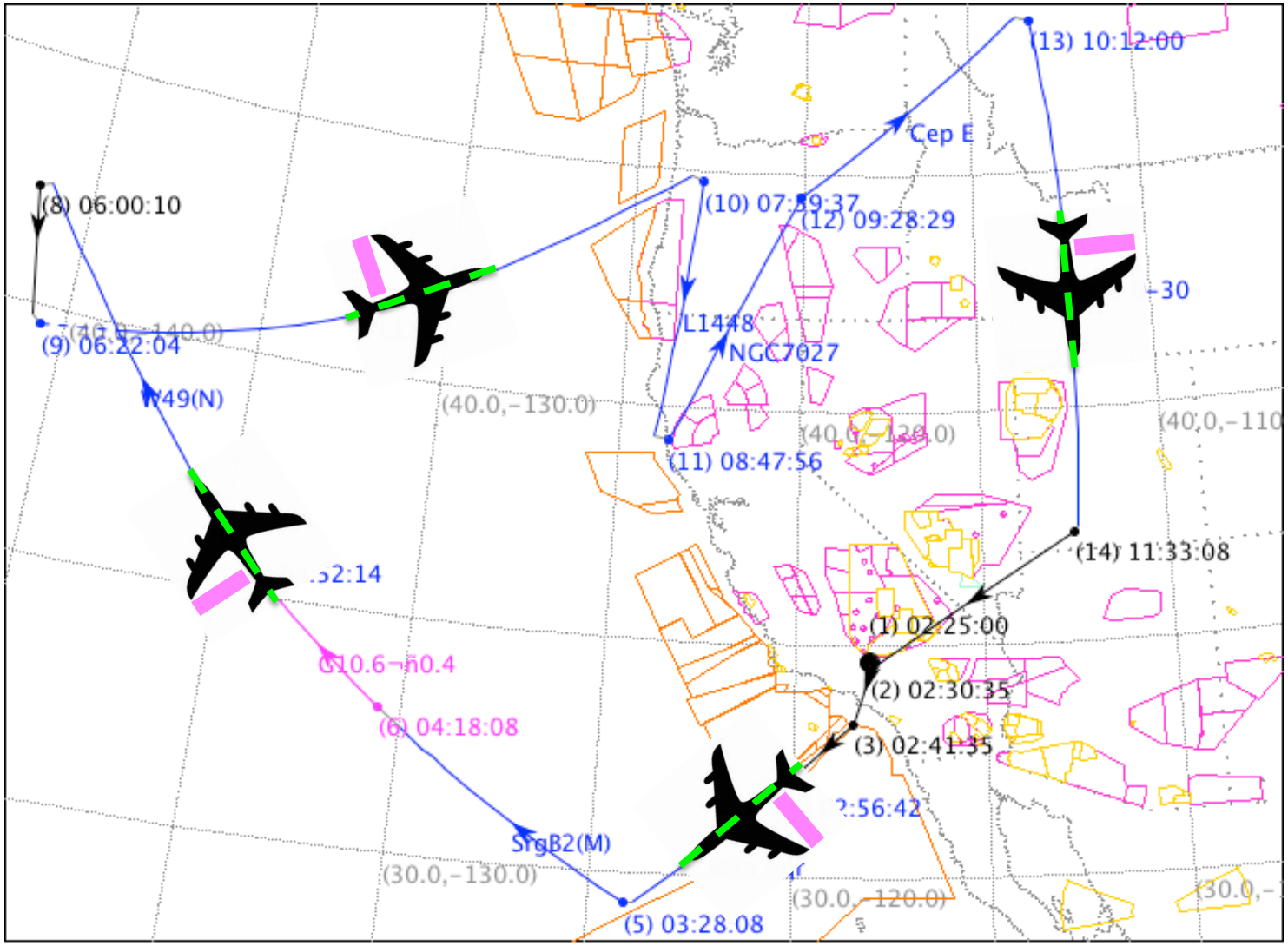
- operates at ~40,000 ft
- flies out of Palmdale, CA
- 2.5 m telescope
- plan to fly 3 or 4 nights per week

SOFIA: Observing Procedures



observations at right angles to flight direction

SOFIA: Observing Procedures



limited efficiency

SOFIA: Summary

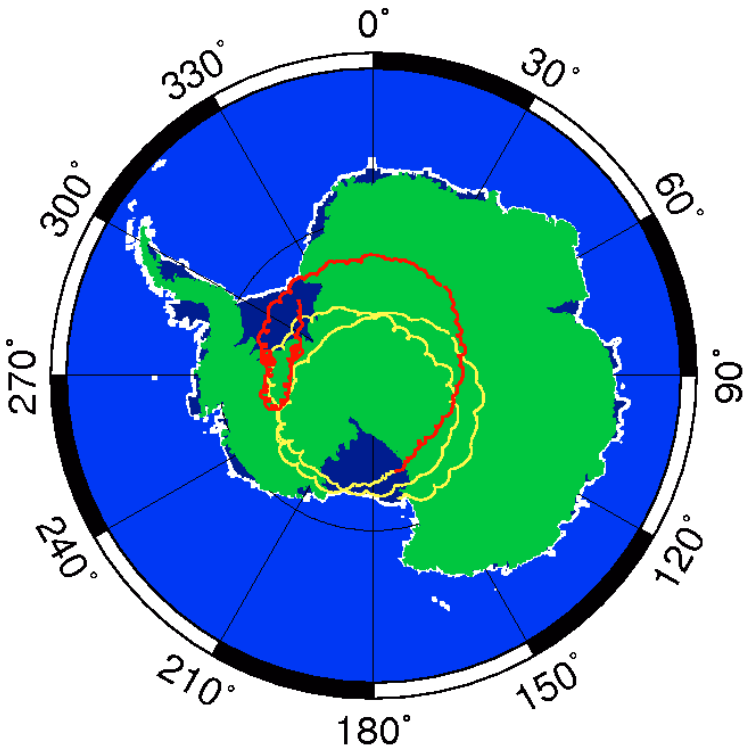
Pros:

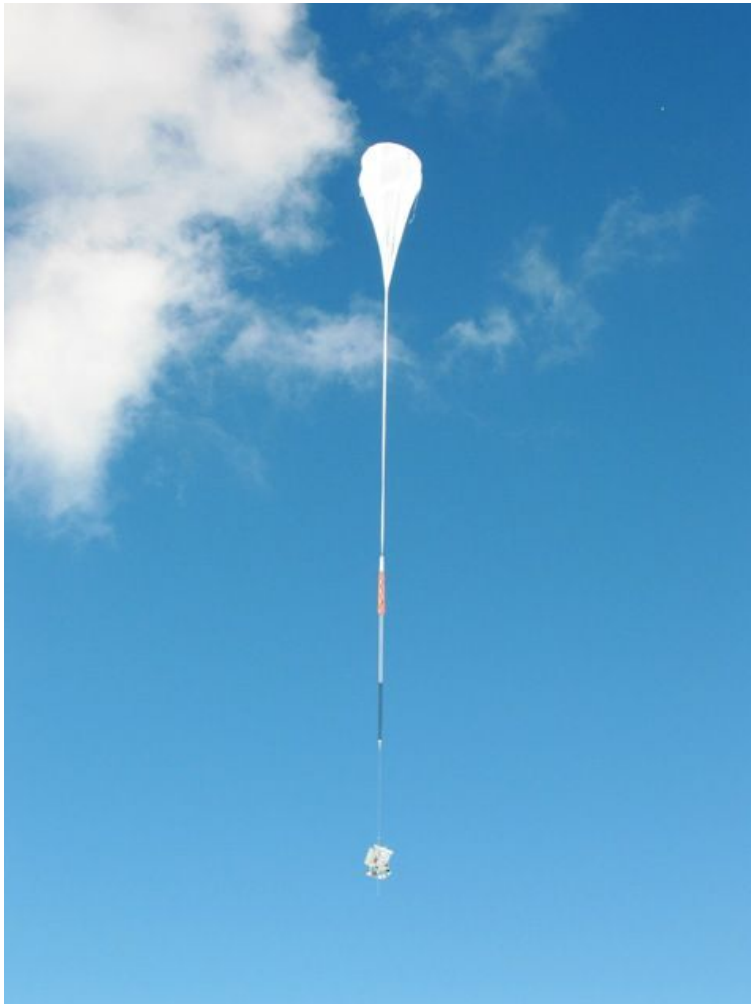
- OK transmission
- easy access
- good for instrument development

Cons:

- inefficient observing procedures
- better transmission (higher altitude) needed for many experiments
- very expensive ($3.75B over 20 yr?)

Stratospheric Balloons

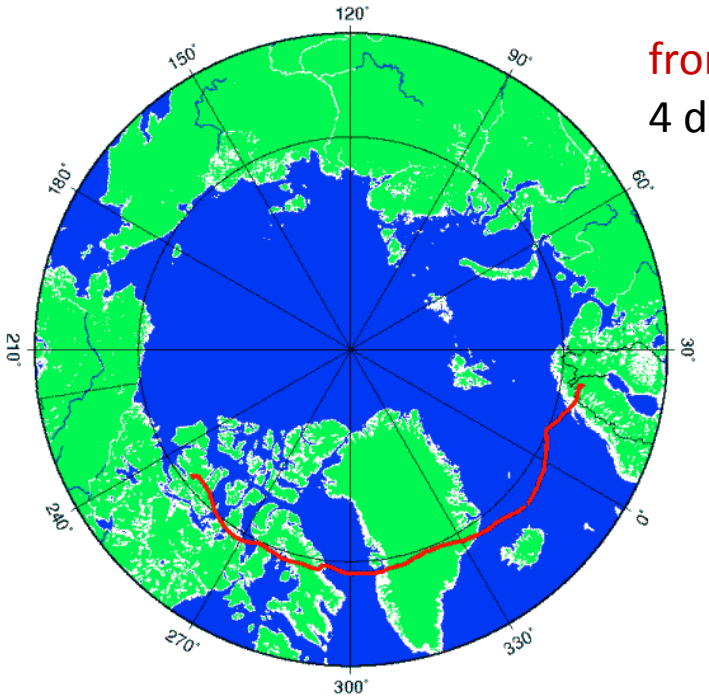




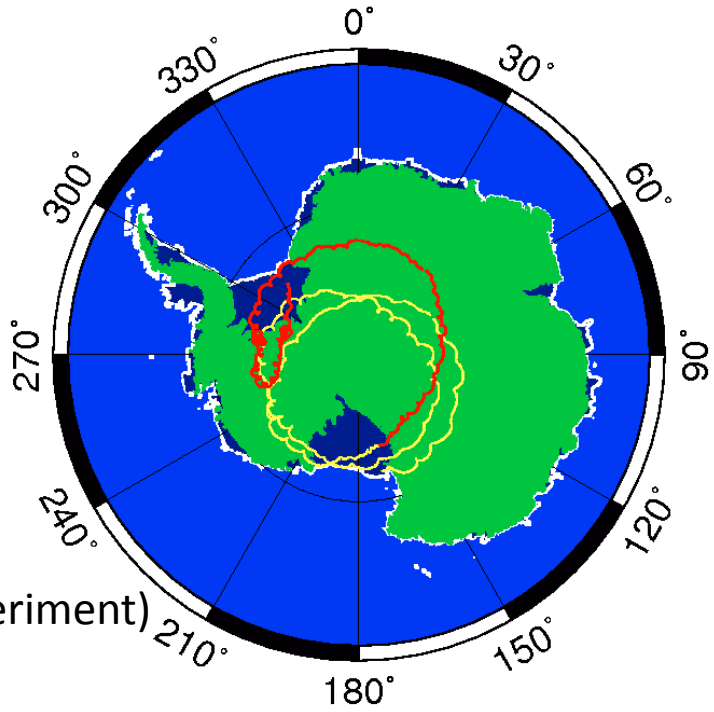
- operates at ~120,000 ft
- payload ~2,000 kg
- recoverable (in ideal circumstances)
- flights of several 10 days

database: http://stratocat.com.ar

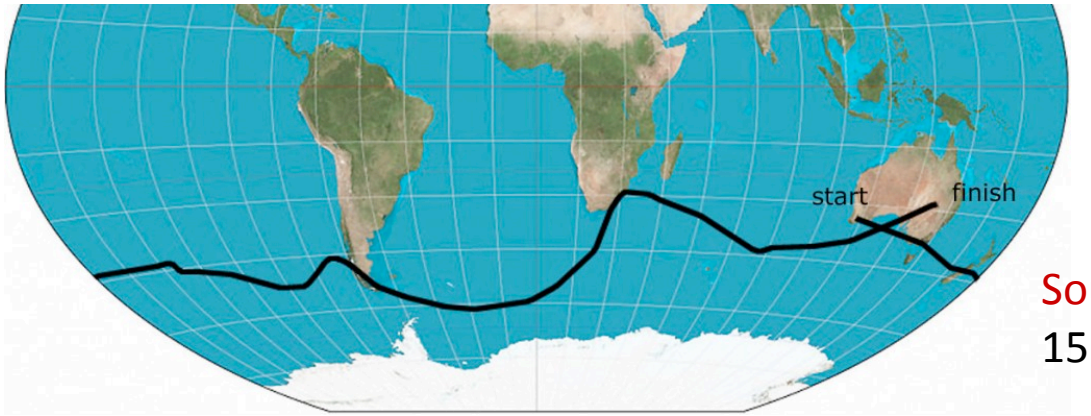
Stratospheric Balloons: Example Flights



from Kiruna:
4 d (BLAST)

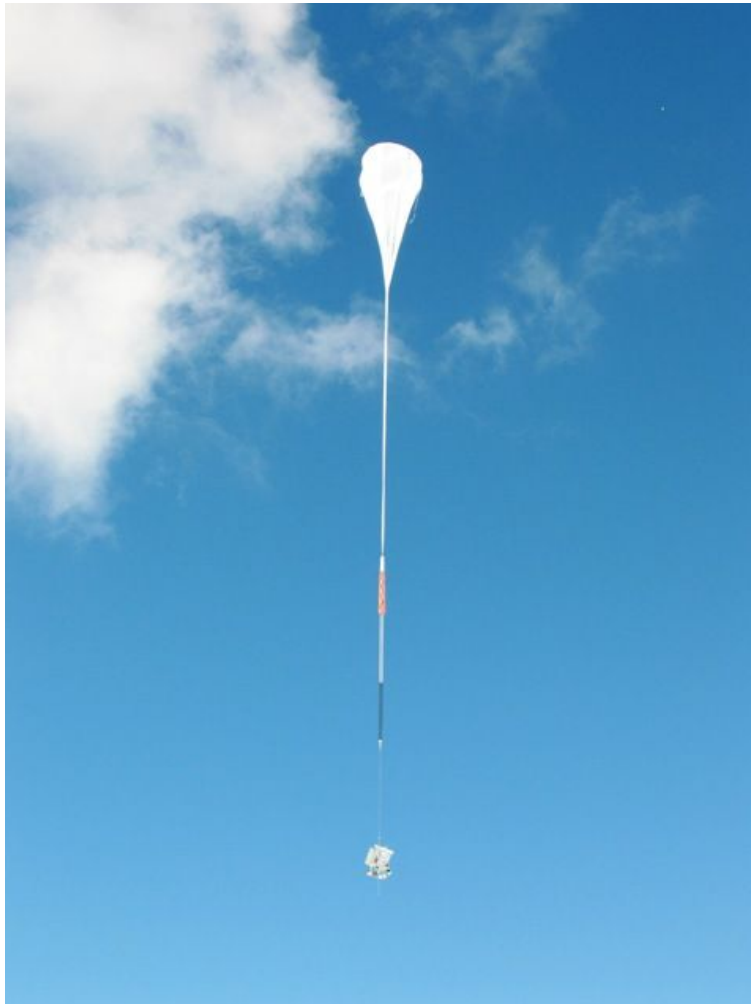


from McMurdo:
54 d (ULDB experiment)



Southern Ocean:
15 d (Steve Fosset)

Stratospheric Balloons: Summary



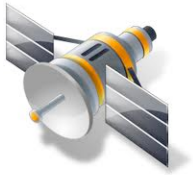
Pros:

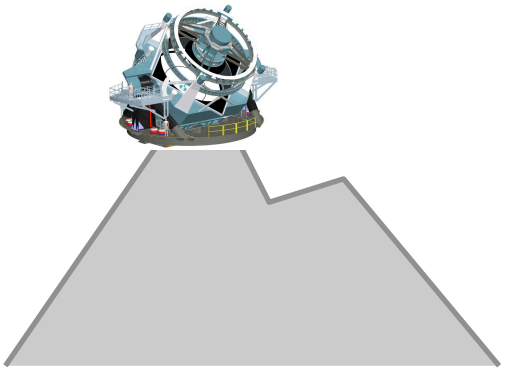
- excellent transmission
- very cheap (few $1M)

Cons:

- no control of experiment
  (for long duration flights)
- very inefficient (few flights per year)
- limited lift (max. ~2,000 kg)
- limited (solar) power

Platform Summary





perfect

difficult

data quality

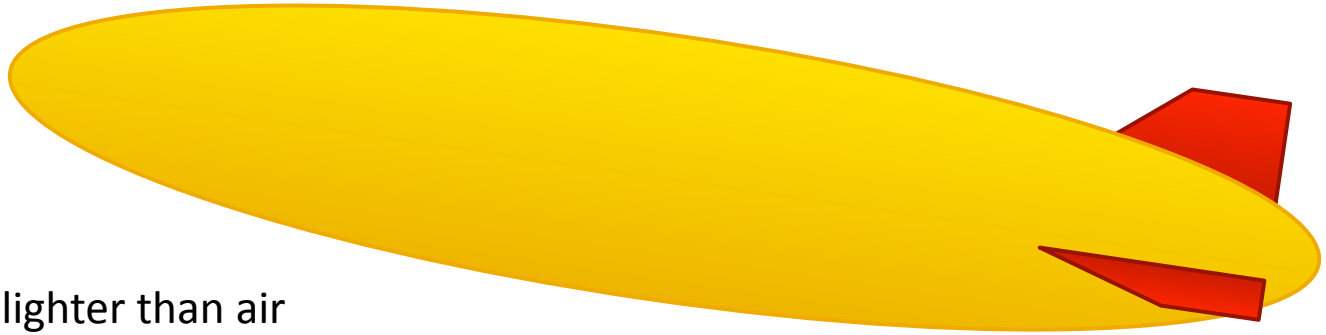
technical challenge

limited

easy

Airships:
Known Properties

Fundamental Concepts



- lift from gasses lighter than air
- should be able to operate above SOFIA (>40,000 ft)
- can lift ~2,000 kg or more
- flies in a controlled fashion
- costs >$100M

different designs possible:

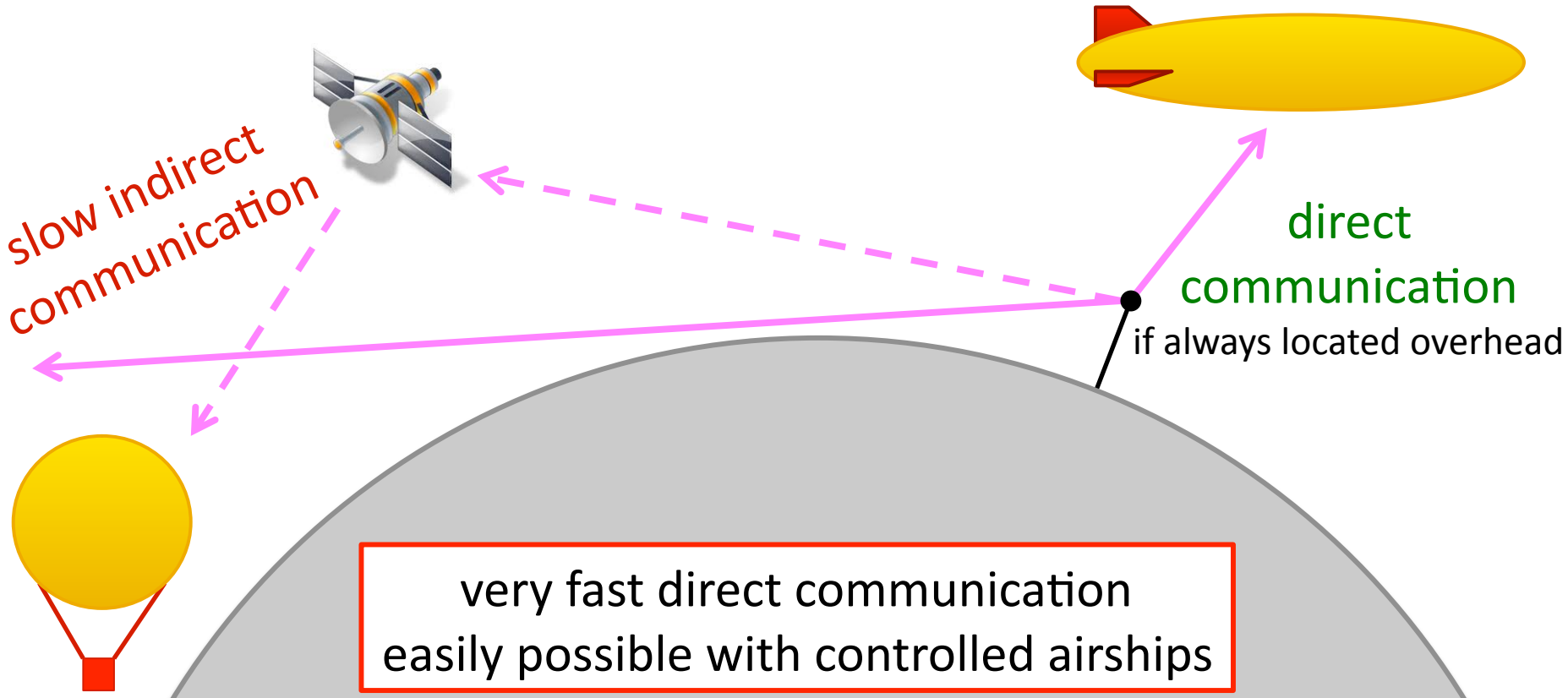
extreme duration vehicles:

- remains airborne for months or years
- recovery not straightforward
- not necessarily reusable
- very high altitude (70,000 ft?)

vehicles with regular flights:

- remains airborne for ~10 days
- straightforward takeoff and landing
- regular flights, just like a plane

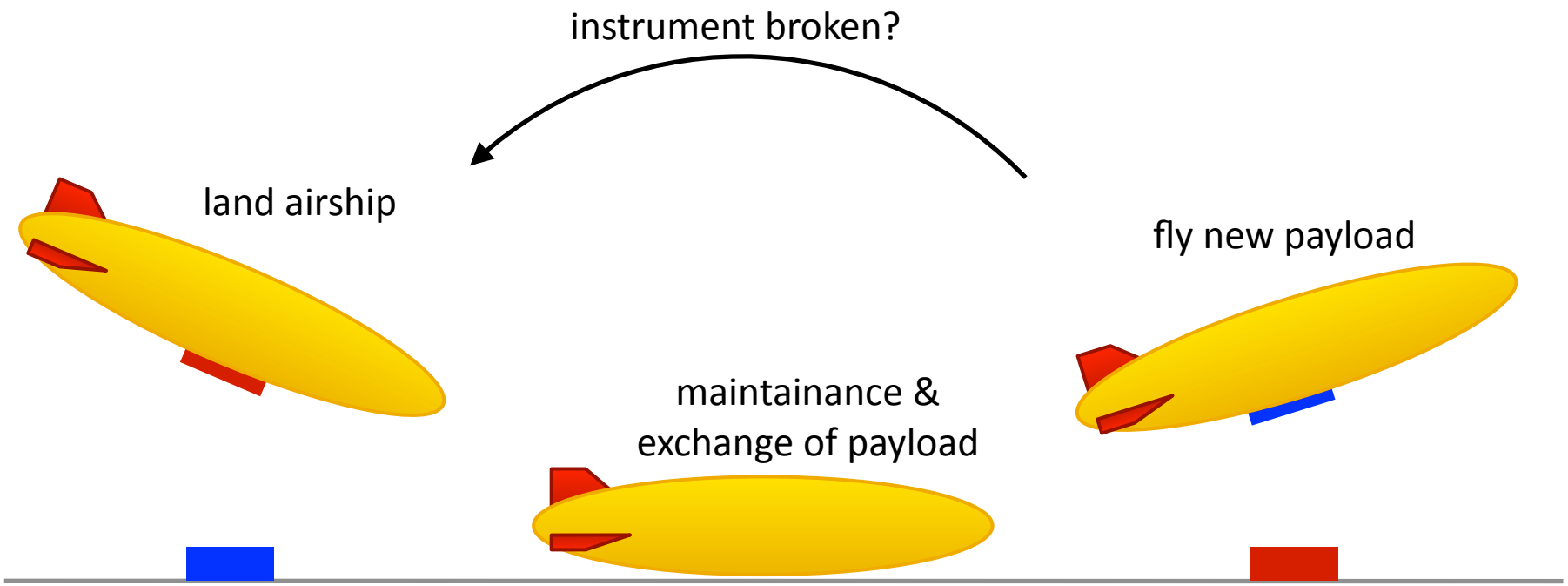
Communications & Control



very fast direct communication
easily possible with controlled airships

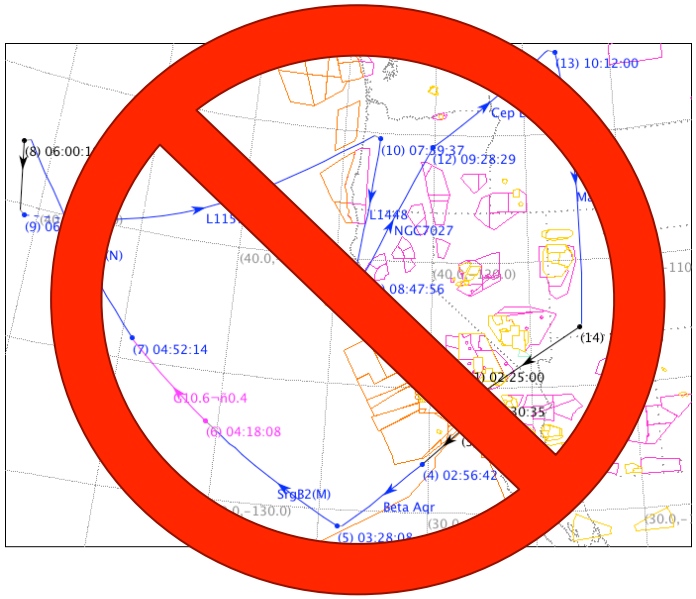
Herschel PACS (raw):
1,500–4,000 kbit/s ~ 1 Gb/hour

Access to Payload & Flexibility

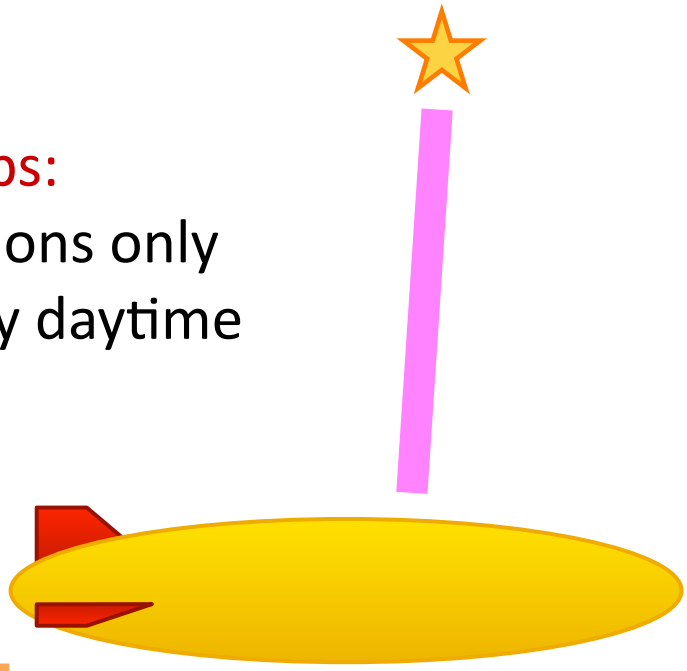


not possible with airships
that cannot be recovered!

Observing Efficiency

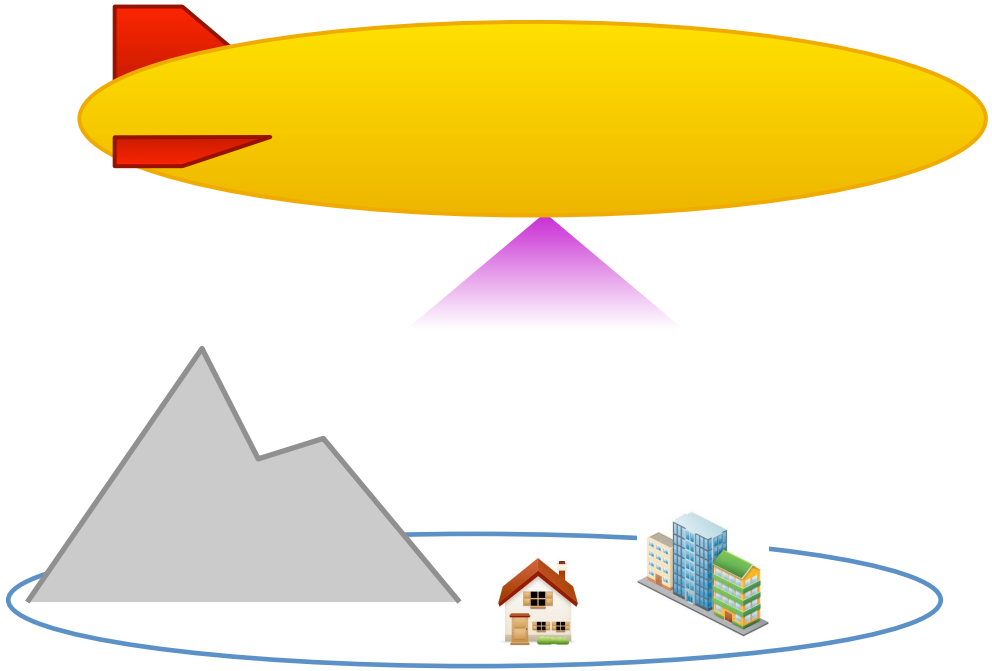


on airships:
observations only
limited by daytime



Telescope	Time per Year
Space	365 days = 8,760 hours
VLT	>340 nights ~ 4,000 hours
SOFIA	<3.5 nights per week = 1,820 hours
Balloon	~30 days = 720 hours
Airship	every second week = 4,380 hours

Synergy with Earth Science



high vantage point
(radius ~500 km at 20 km altitude)

long duration

Airships:
Open Questions

Questions for this Workshop

atmospheric transmission
=> which objects can be studied?

permissible telescope size
+ pointing stability
=> resolution, sensitivity

costs
=> compared to other platforms?
=> earth science partners!

MONEY PER MISSION

Mission	Lifetime cost (US$ billion)	Start of operation	End of operation	Hours of observation	Cost per hour ($ thousand)
Herschel Space Observatory	1.4	2009	2012	20,000	**70**
Spitzer Space Telescope	1.7	2003	2012	54,000	**31**
SOFIA	3.75	2014	2034	16,000	**234**
Chandra X-Ray Observatory	4.4	1999	2014	90,000	**49**
James Webb Space Telescope	5.2	2014	2024	60,000	**87**
Hubble Space Telescope	14.1	1990	2015	60,000	**235**

Nature 466, 428-431 (2010)