BLAST

Balloon-borne **L**arge-**A**perture **S**ubmillimeter **T**elescope

Antarctica 2006:
First Extra-galactic Survey Results

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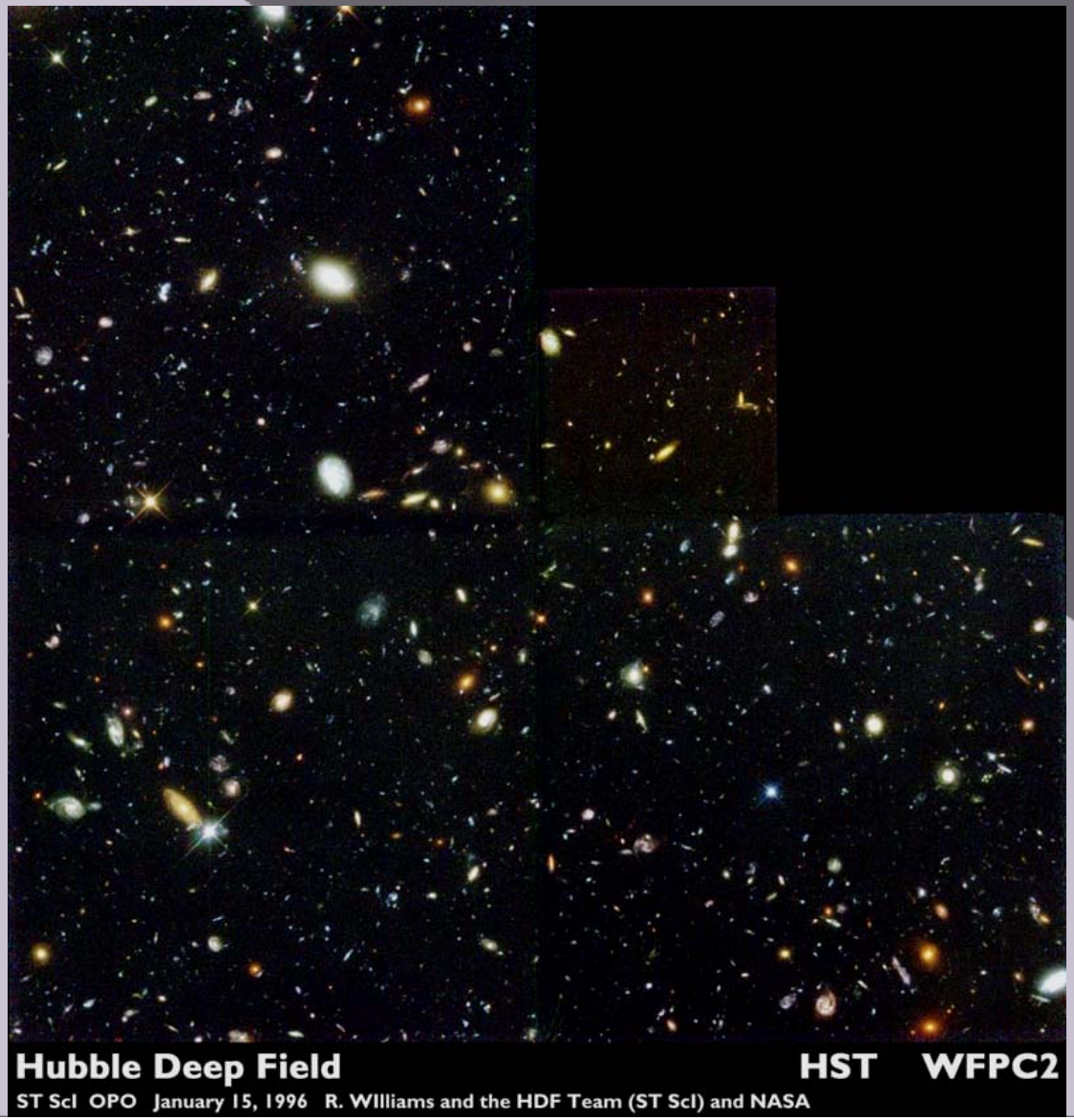
Peter Hargrave
Phil Mauskopf
Carole Tucker
Enzo Pascale

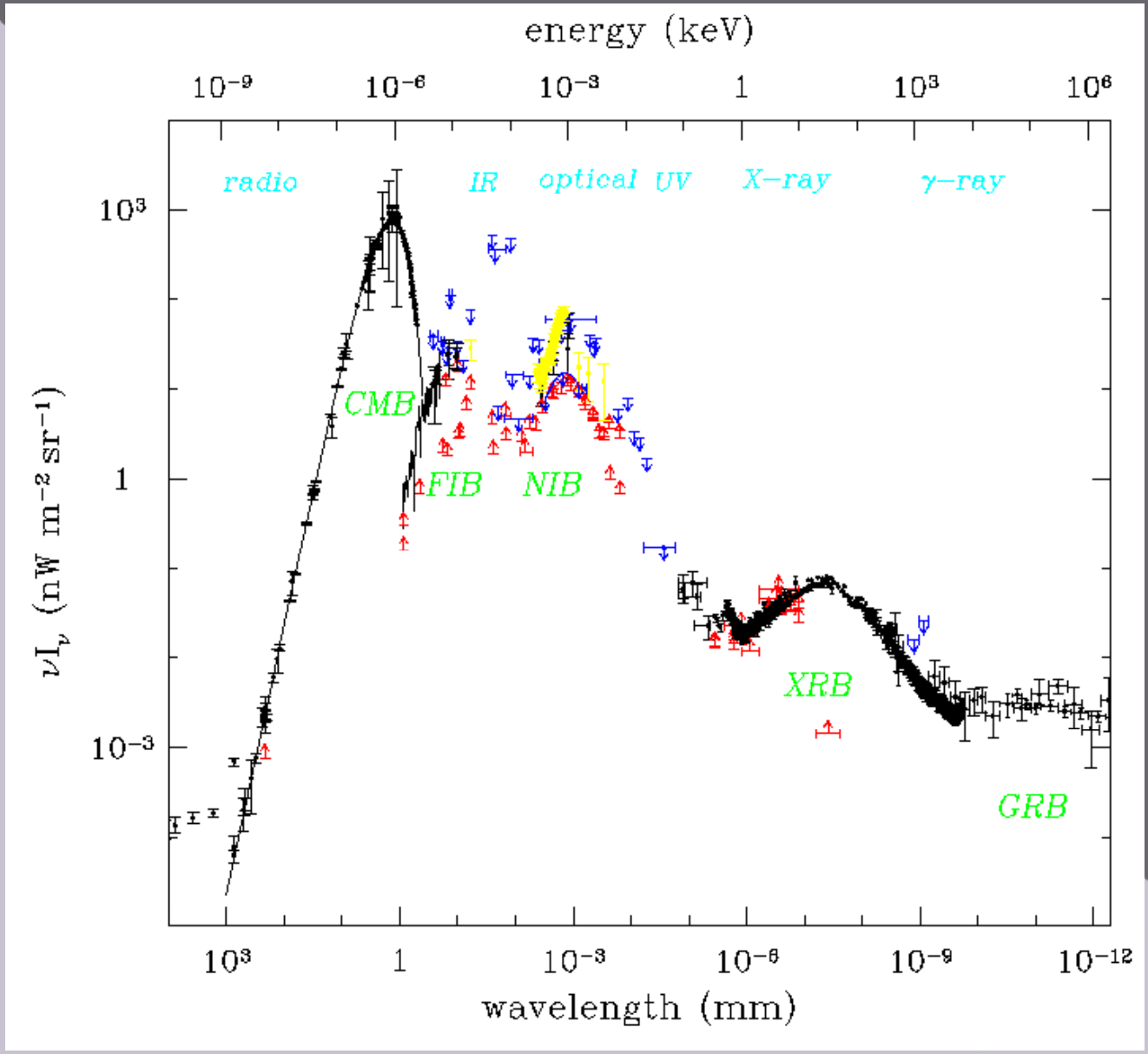
Photo: Mark Halpern

Lot's of Galaxies Out There

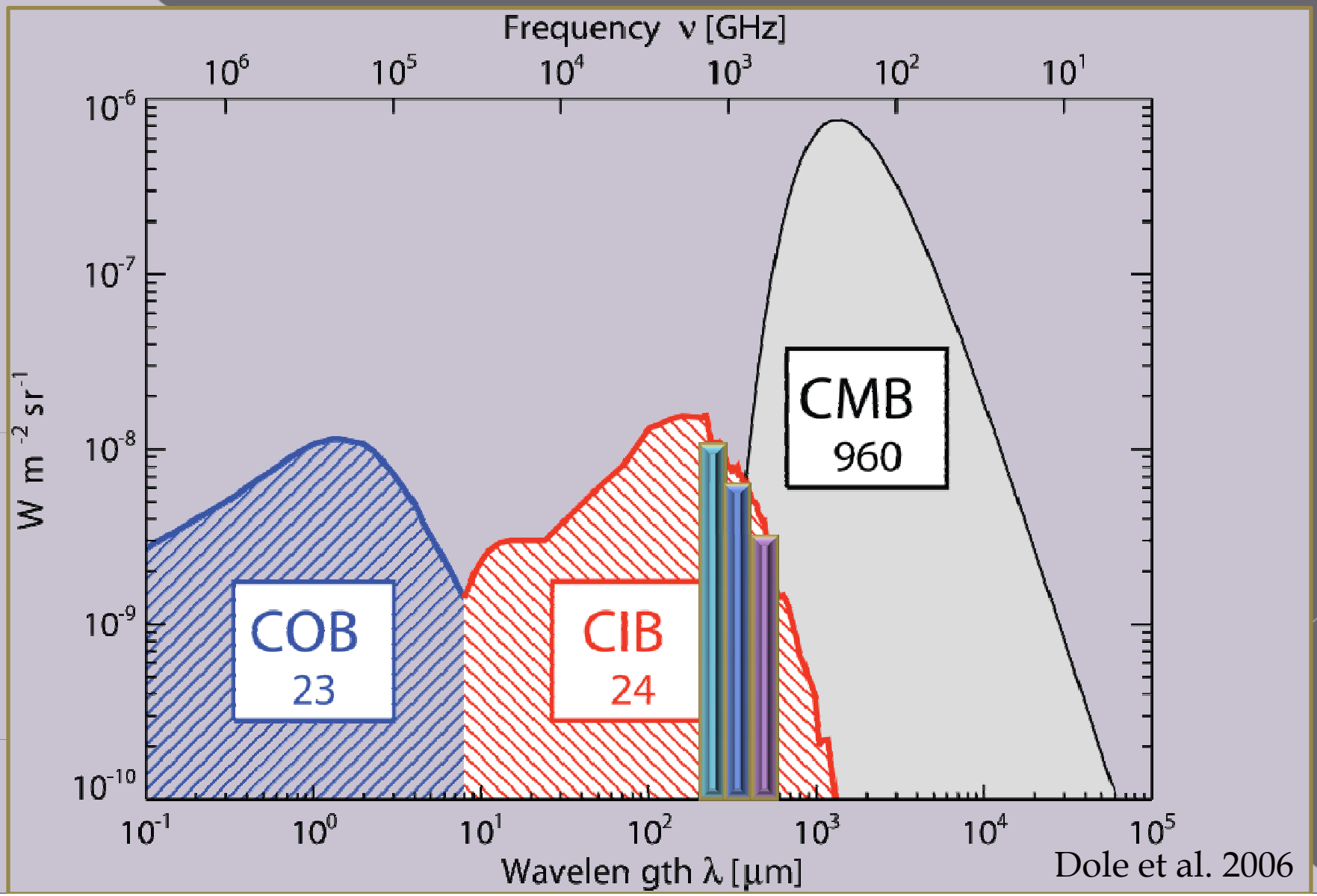


Where is the **ENERGY** going?

Background Light in the Universe



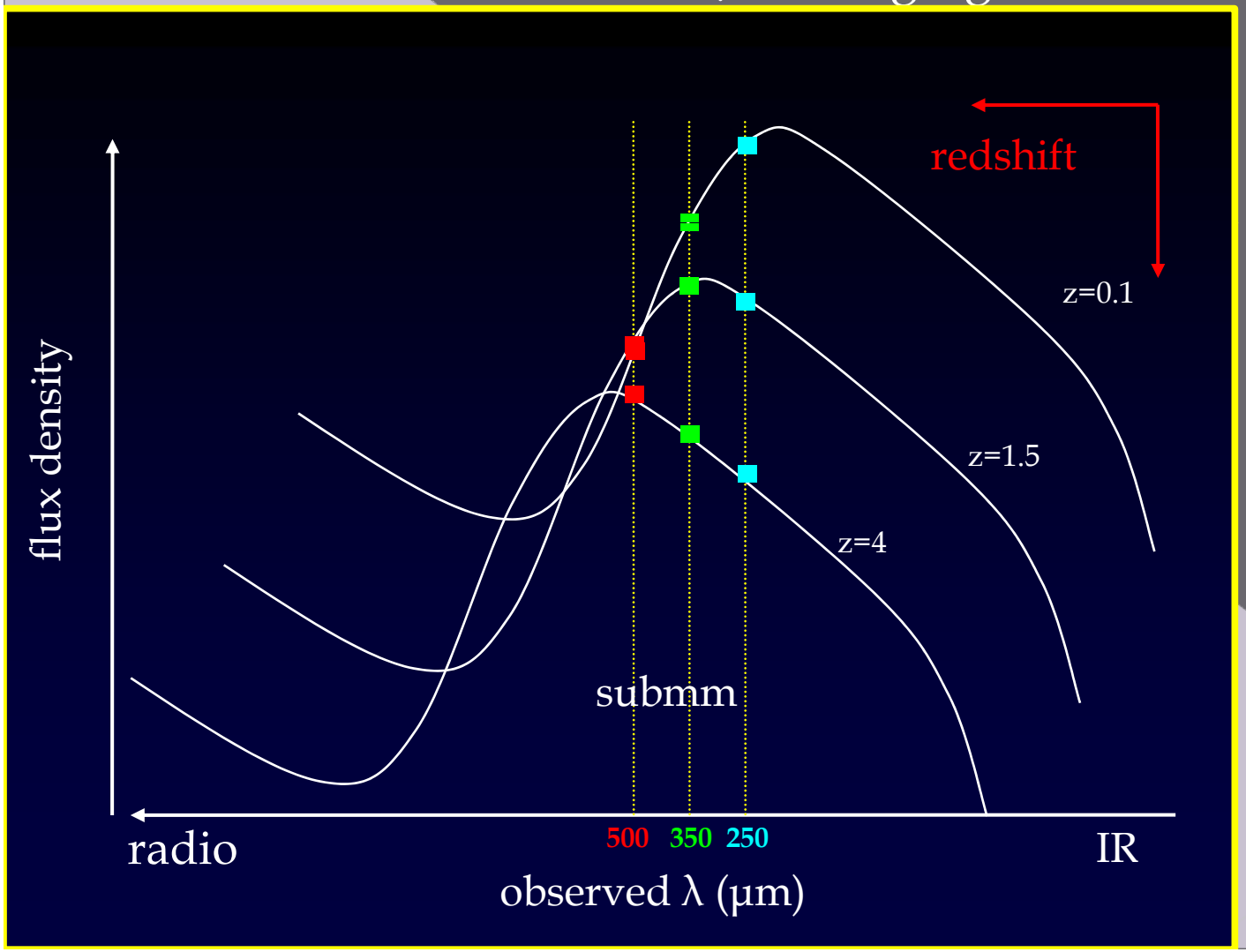
Cosmic Infrared Background



Dole et al. 2006

Submillimeter Photometry

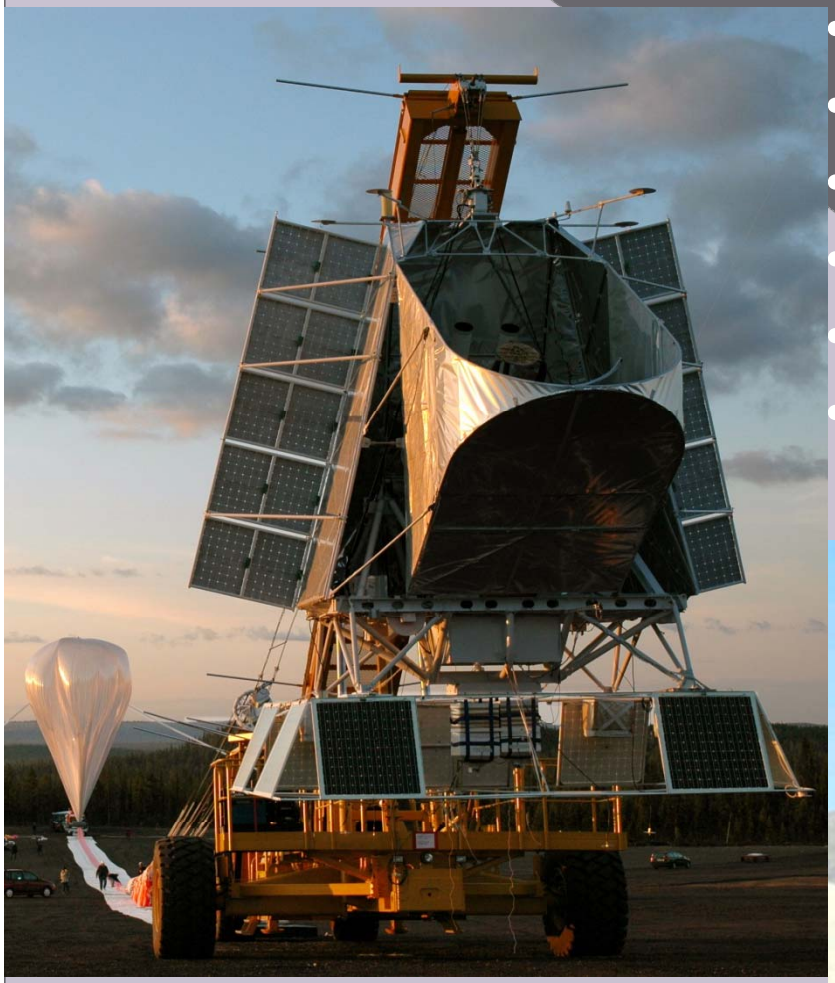
Simultaneous 500, 350, 250 μm imaging



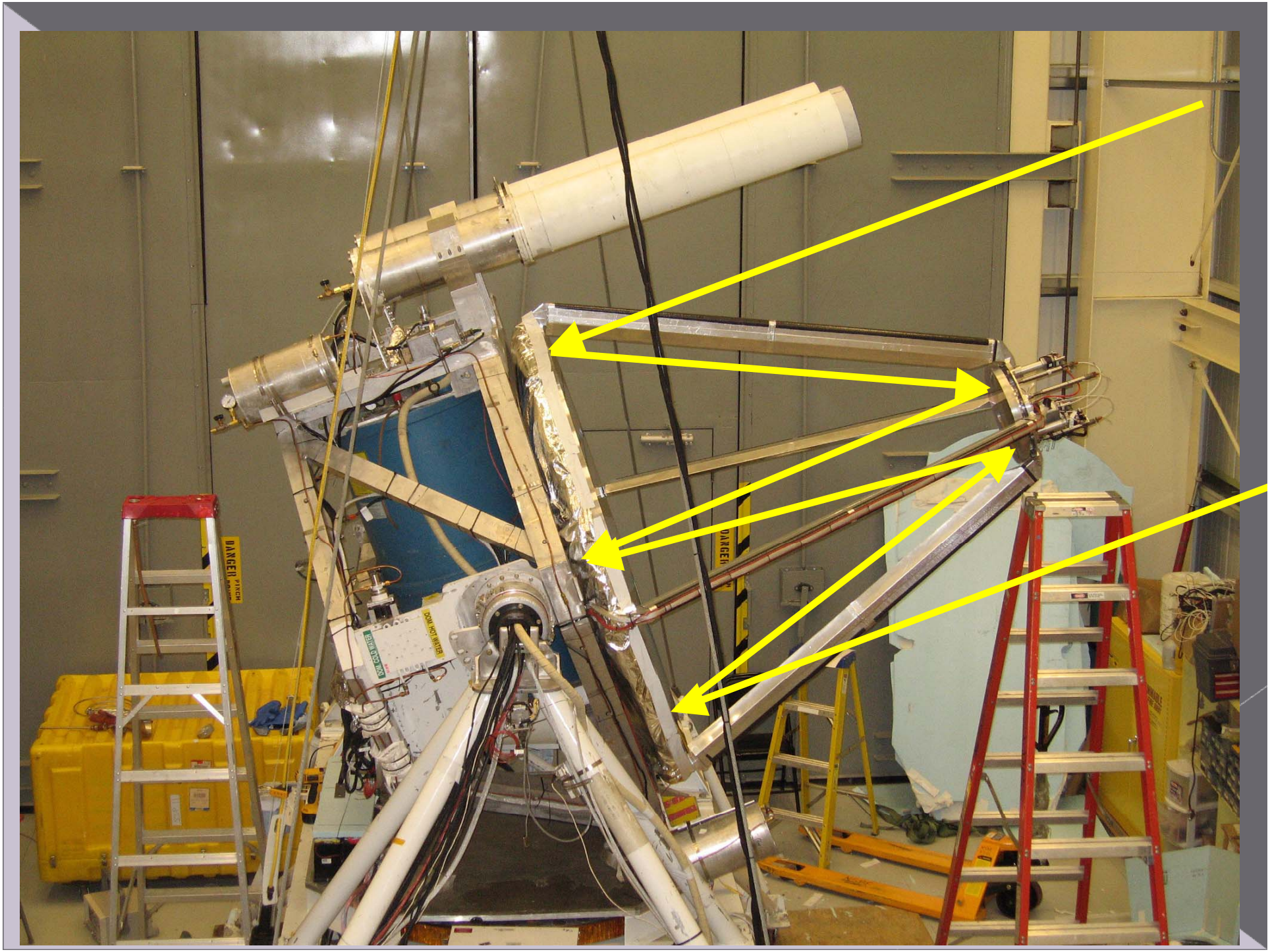
BLAST filters: sensitive to **bolometric flux** colours function of **redshift**

bolometric luminosity (SFR)

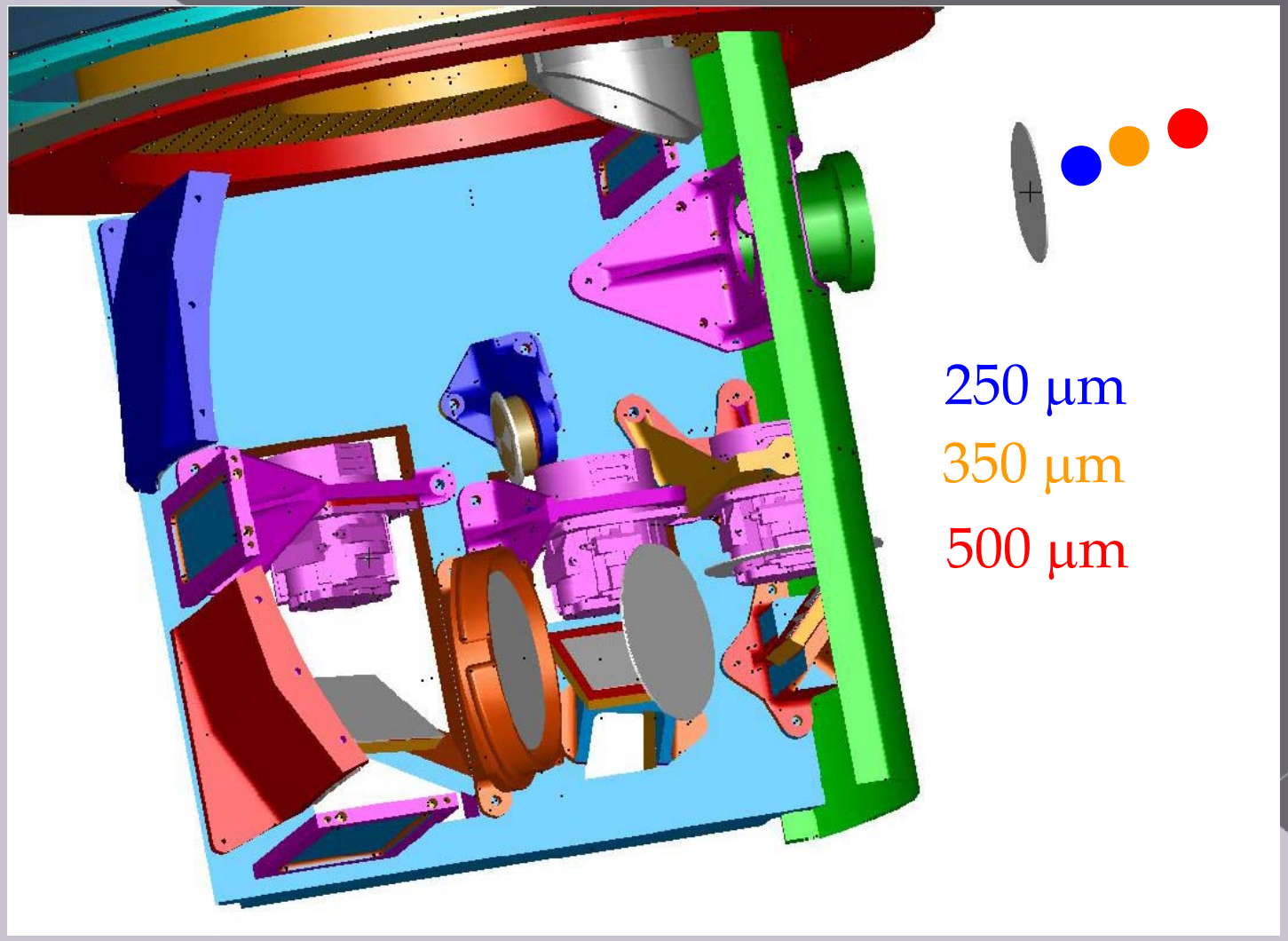
The BLAST Telescope vs. The HUMMER



- Approximately the same size and weight
- Both available in RED
- Hummer: 0-100 km/hr in 9 seconds
- BLAST: GPS *and* Star Navigation
- Circumpolar in 11 days
- BLAST sub-mm sensitivity exceeds that of the Hummer

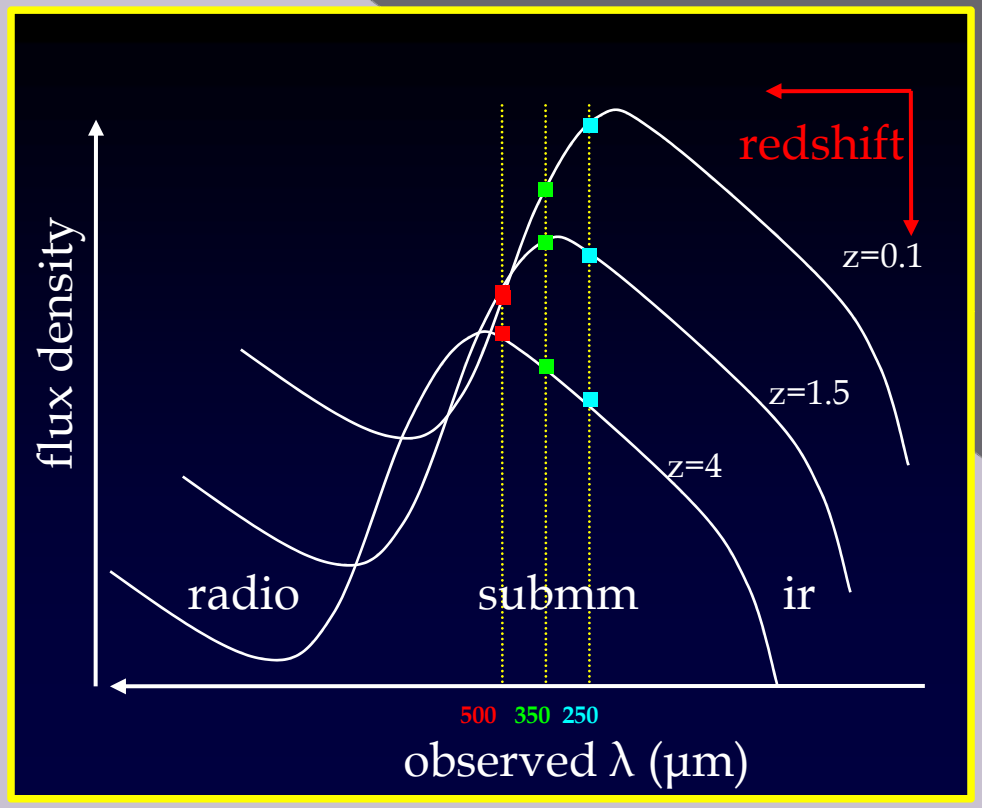


Cold Re-imaging Optics



BLAST/HERSCHEL SUB-MM SURVEYS

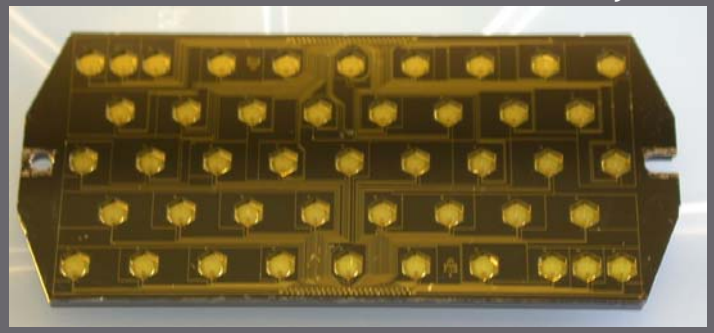
Simultaneous 500, 350, 250 μm imaging

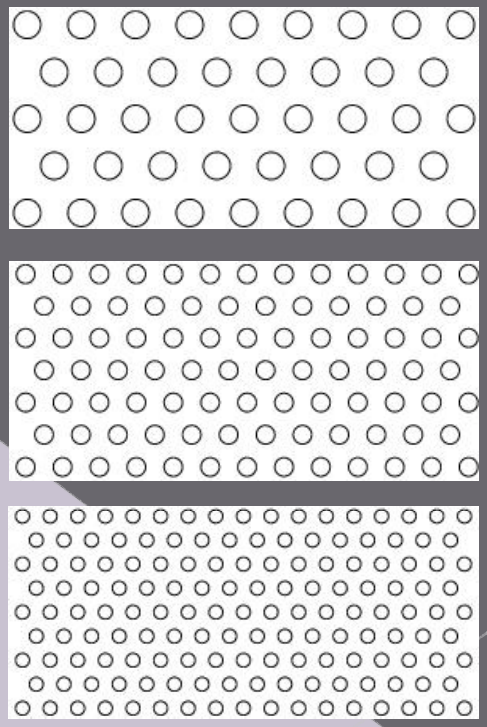


BLAST filters: sensitive to **bolometric flux**
colours function of **redshift**

bolometric luminosity (SFR)

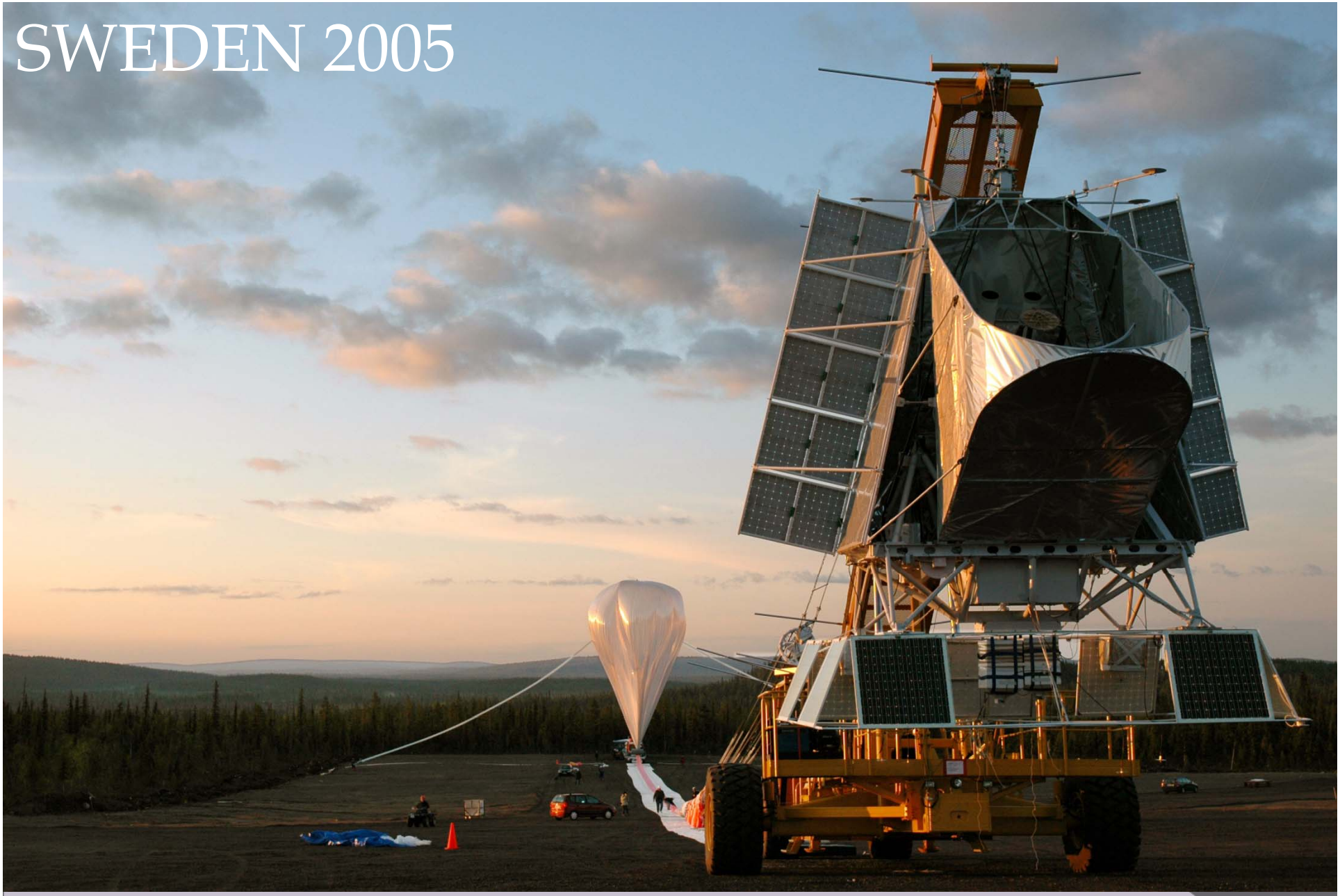
JPL

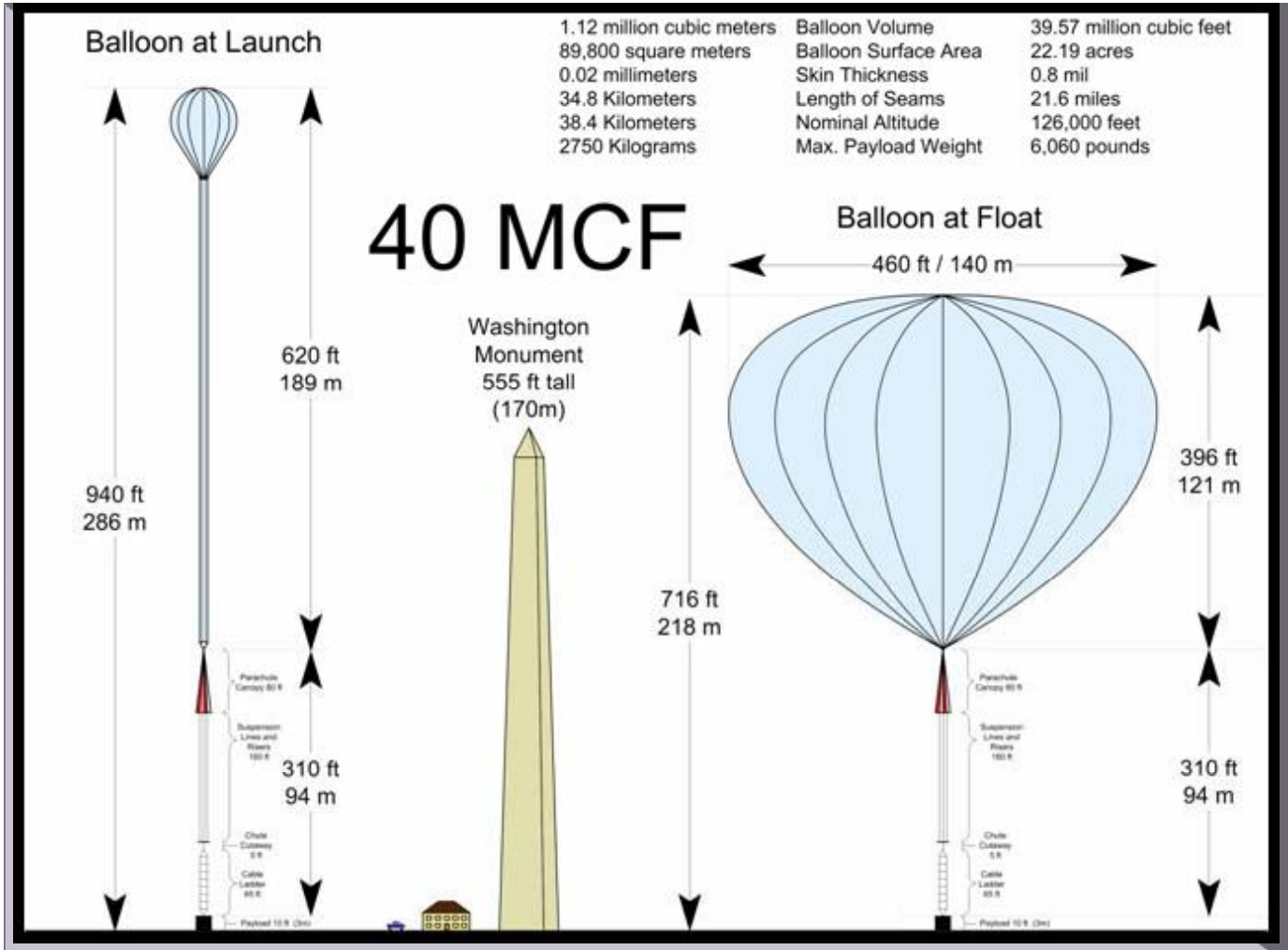




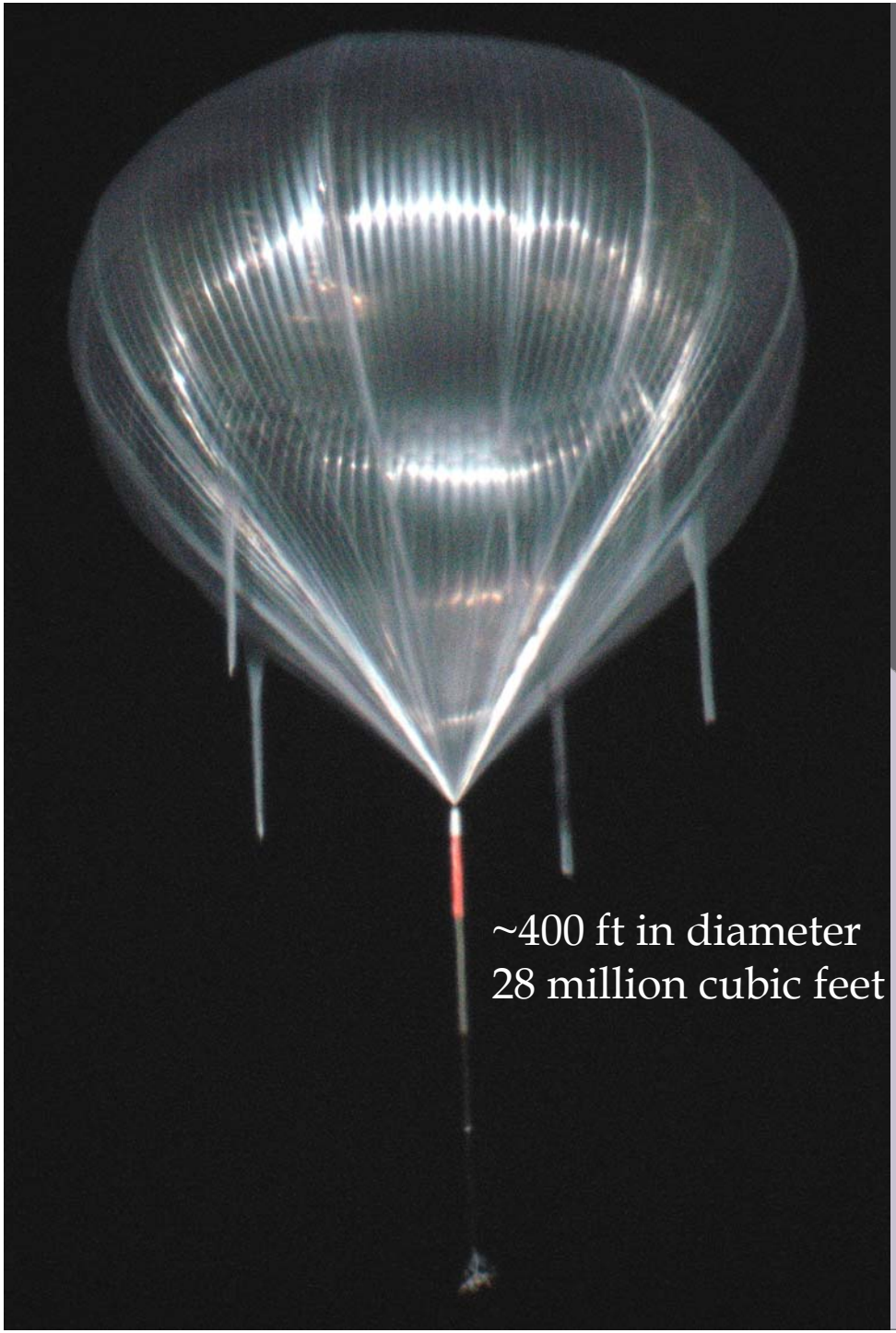
13' BLAST, 7' SPIRE

SWEDEN 2005




Balloon at Launch
1.12 million cubic meters
Balloon Volume
39.57 million cubic feet
89,800 square meters
Balloon Surface Area
22.19 acres
0.02 millimeters
Skin Thickness
0.8 mil
34.8 Kilometers
Length of Seams
21.6 miles
38.4 Kilometers
Nominal Altitude
126,000 feet
2750 Kilograms
Max. Payload Weight
6,060 pounds
40 MCF
Balloon at Float
460 ft / 140 m
Washington Monument
555 ft tall
(170m)
940 ft
286 m
620 ft
189 m
310 ft
94 m
716 ft
218 m
396 ft
121 m
310 ft
94 m

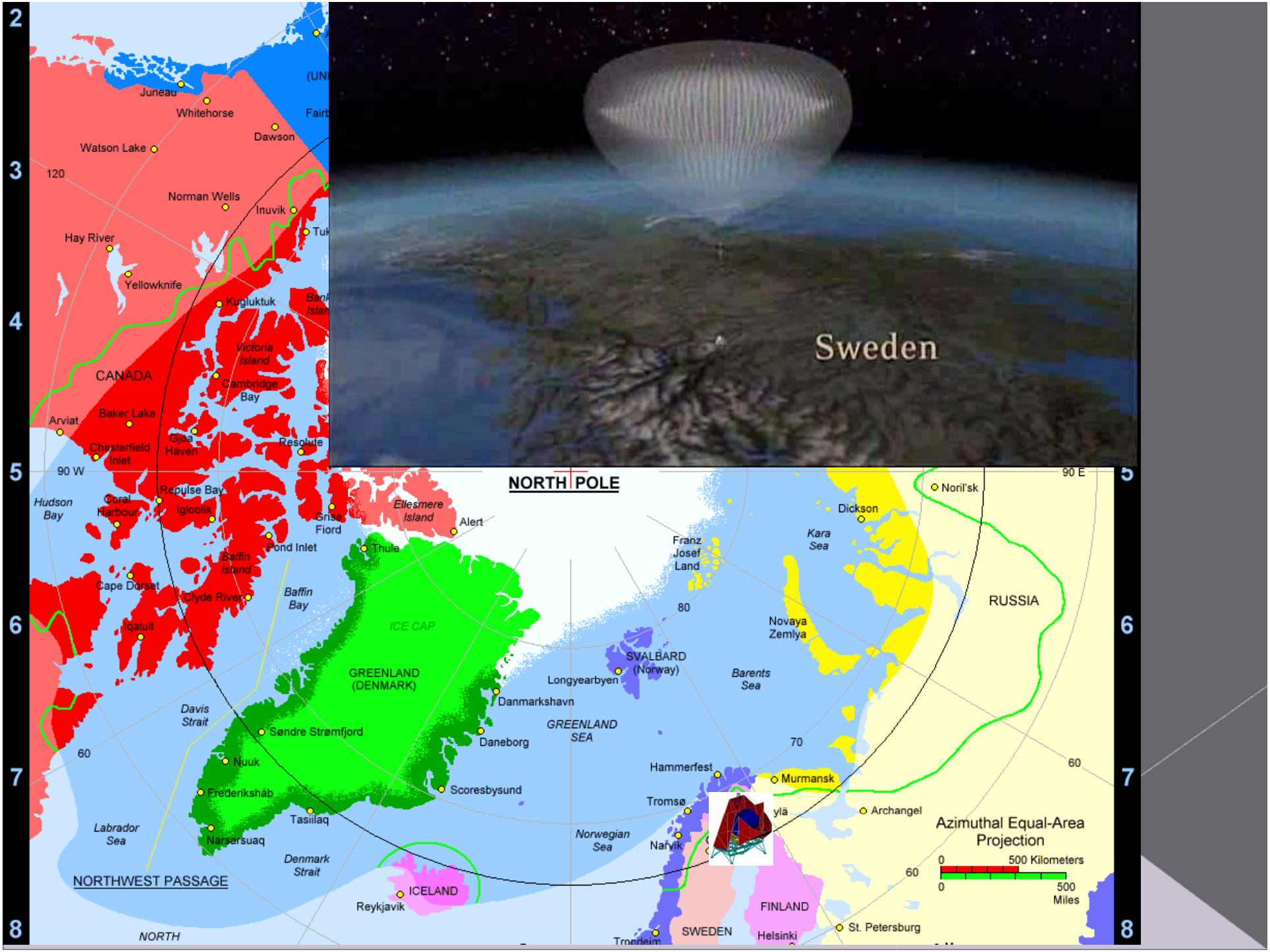
High Altitude Balloons Take BLAST Above 99.5% of the Atmosphere for 11 Days



~400 ft in diameter
28 million cubic feet

At 120,000 ft

Photo: Joe Martz


Sweden
NORTH POLE
Juneau
Whitehorse
Dawson
Watson Lake
Norman Wells
Inuvik
Hay River
Yellowknife
Kugluktuk
Victoria Island
CANADA
Cambridge Bay
Baker Lake
Arviat
Gjoa Haven
Resolute
Chesterfield Inlet
Repulse Bay
Coral Harbour
Igloolik
Hudson Bay
Grise Fiord
Ellesmere Island
Alert
Pond Inlet
Thule
Baffin Island
Cape Dorset
Clyde River
Baffin Bay
Iqaluit
ICE CAP
GREENLAND (DENMARK)
Davis Strait
Søndre Strømfjord
Nuuk
Frederikshåb
Labrador Sea
Narsarsuaq
Tasiilaq
Denmark Strait
NORTHWEST PASSAGE
ICELAND
Reykjavik
NORTH
Danmarkshavn
Daneborg
GREENLAND SEA
Scoresbysund
Longyearbyen
SVALBARD (Norway)
Franz Josef Land
Barents Sea
Kara Sea
Novaya Zemlya
RUSSIA
Noril'sk
Dickson
Hammerfest
Murmansk
Tromsø
Archangel
Norwegian Sea
Narvik
FINLAND
SWEDEN
Helsinki
St. Petersburg
Trondheim
Azimuthal Equal-Area Projection
0 500 Kilometers
0 500 Miles
90 W
90 E
120
80
70
60
2
3
4
5
6
7
8

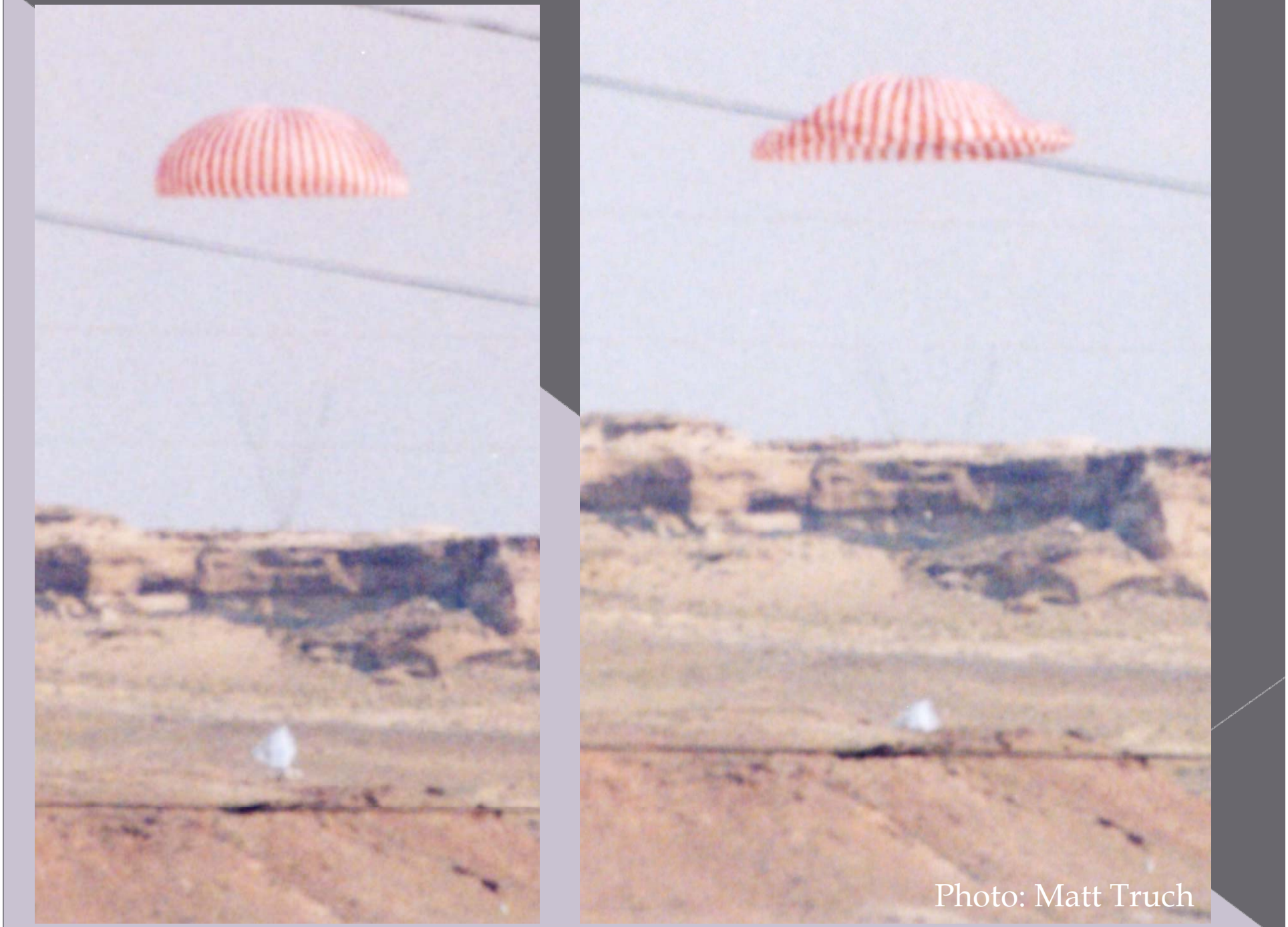


Photo: Matt Truch

Not a Scratch!

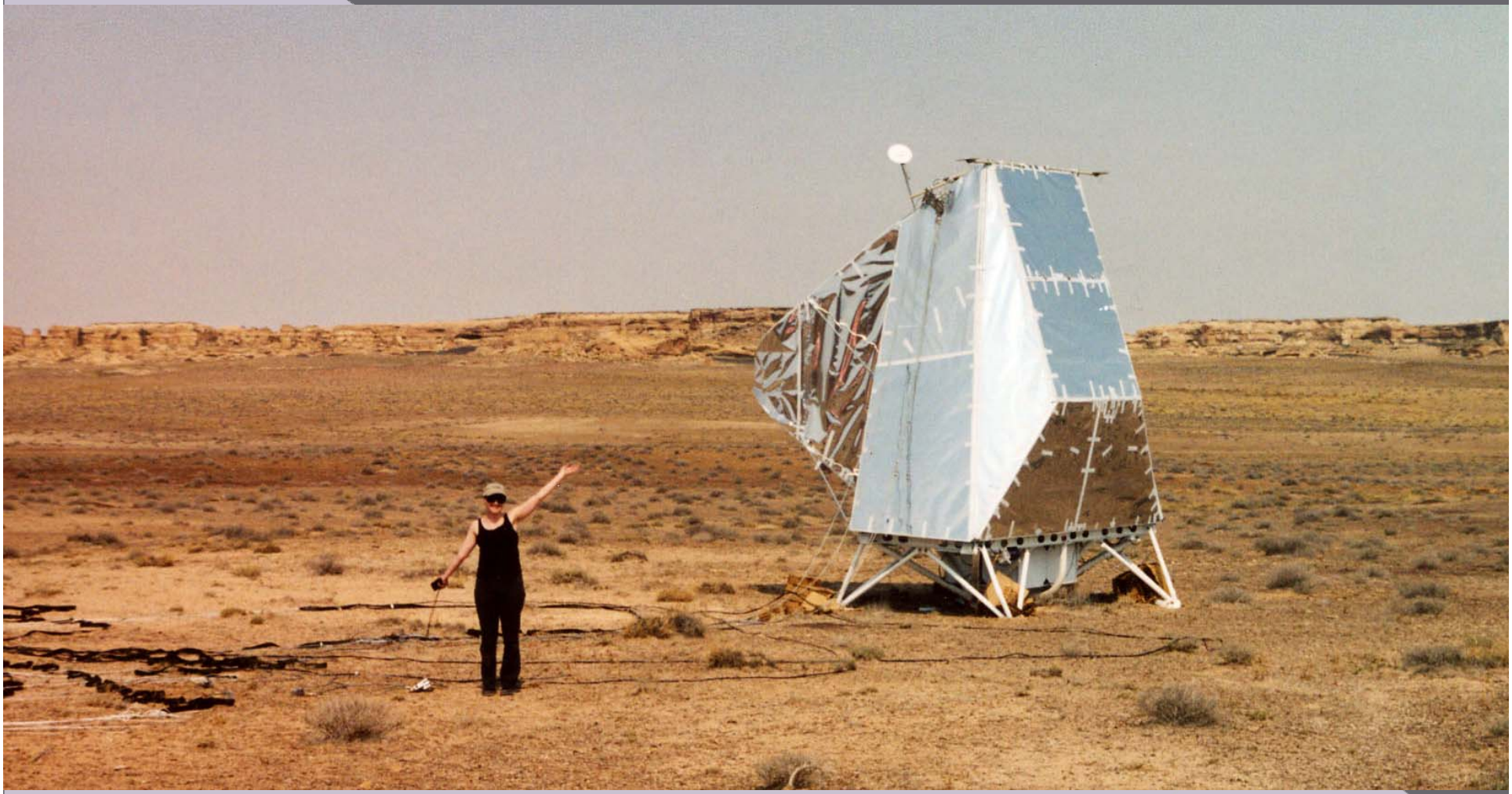


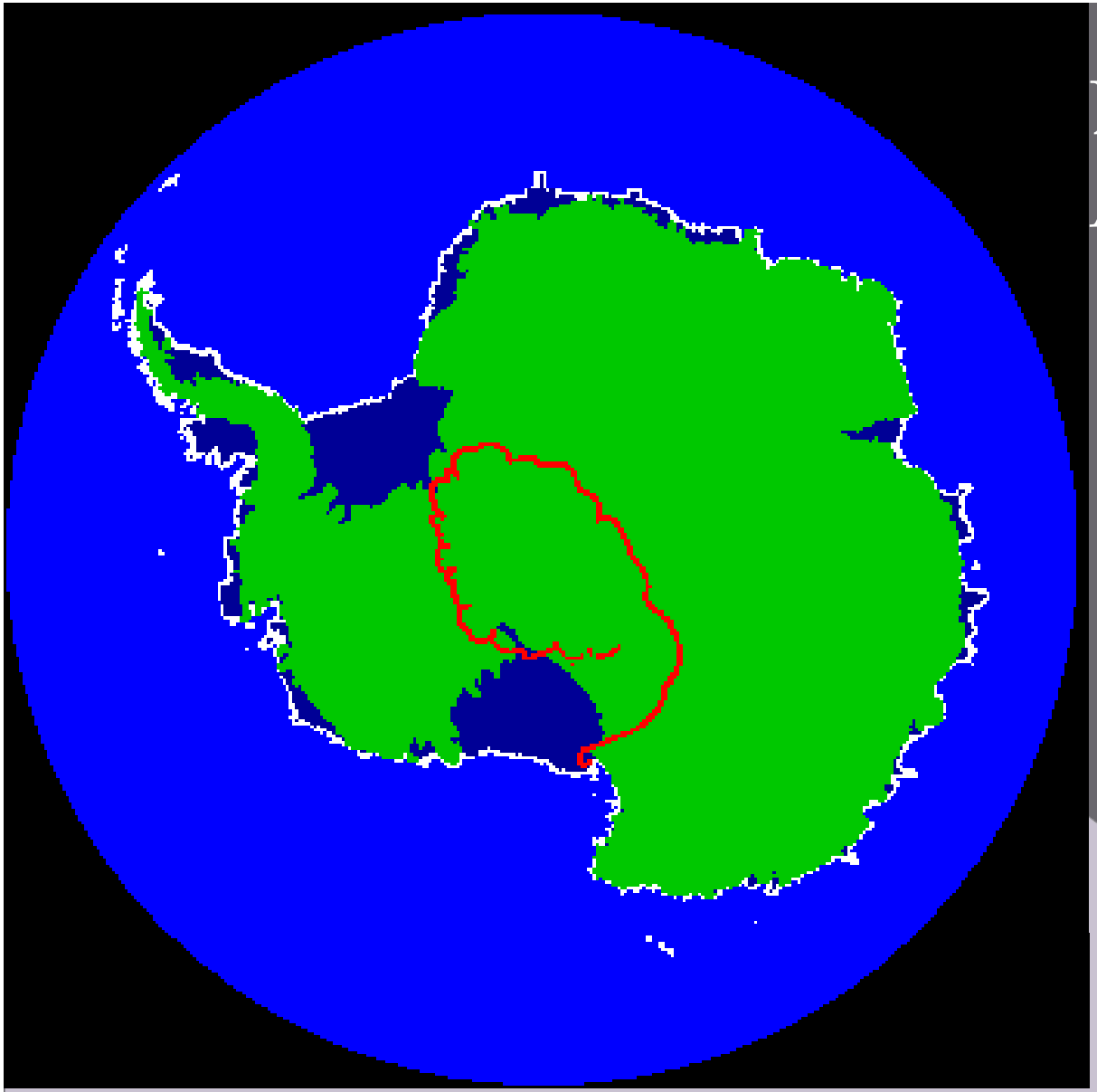
Photo: Matt Truch

This is a GREAT Landing!!!.... But did it Work?

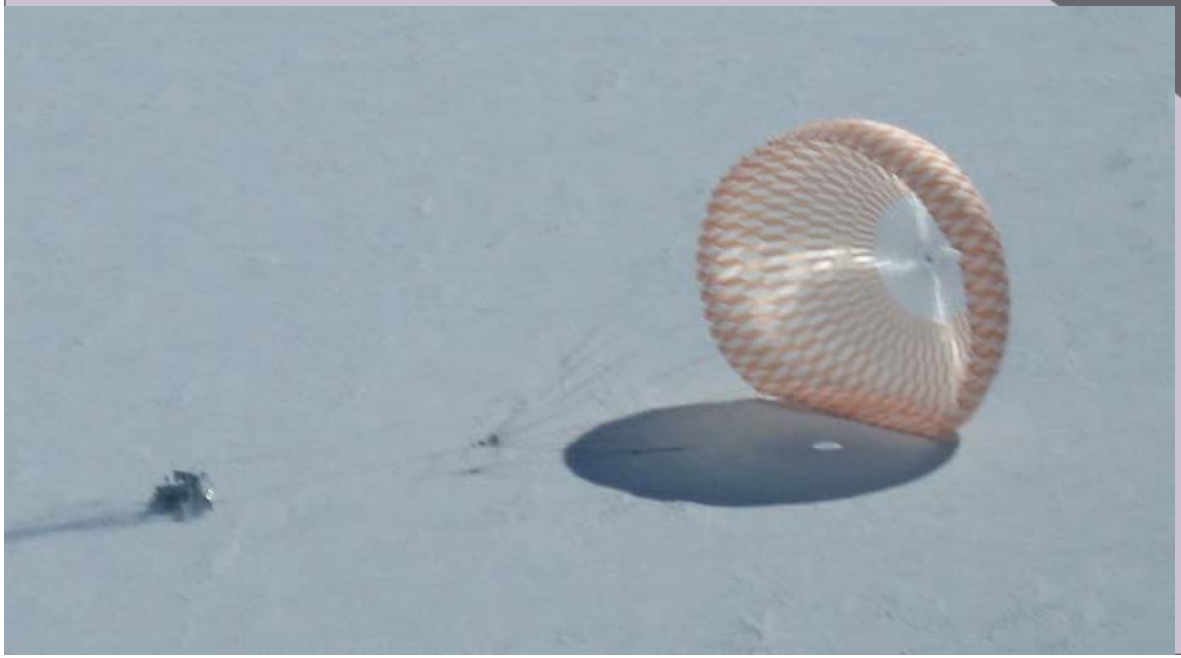
Antarctica

BLAST

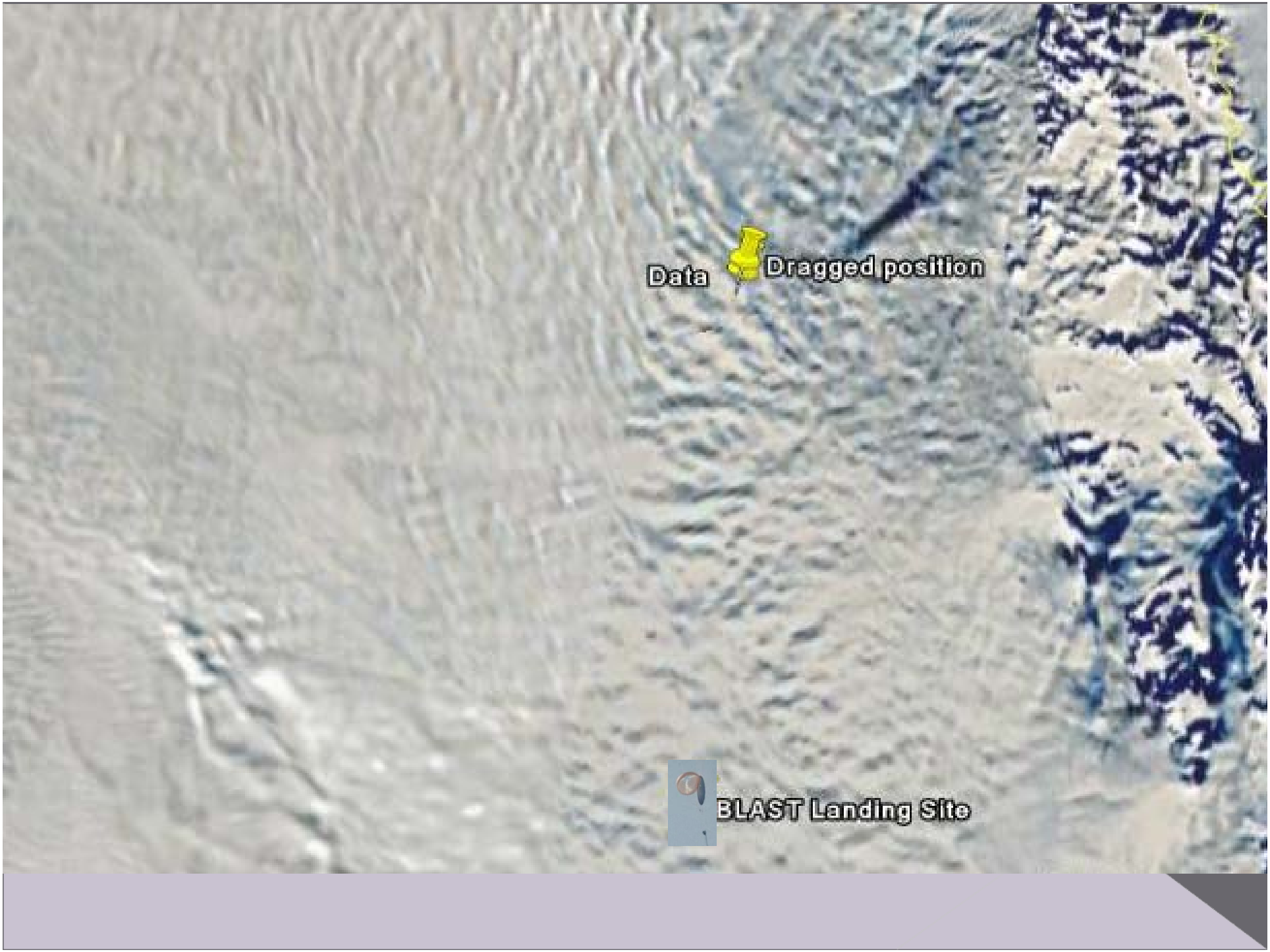
Just before Launch

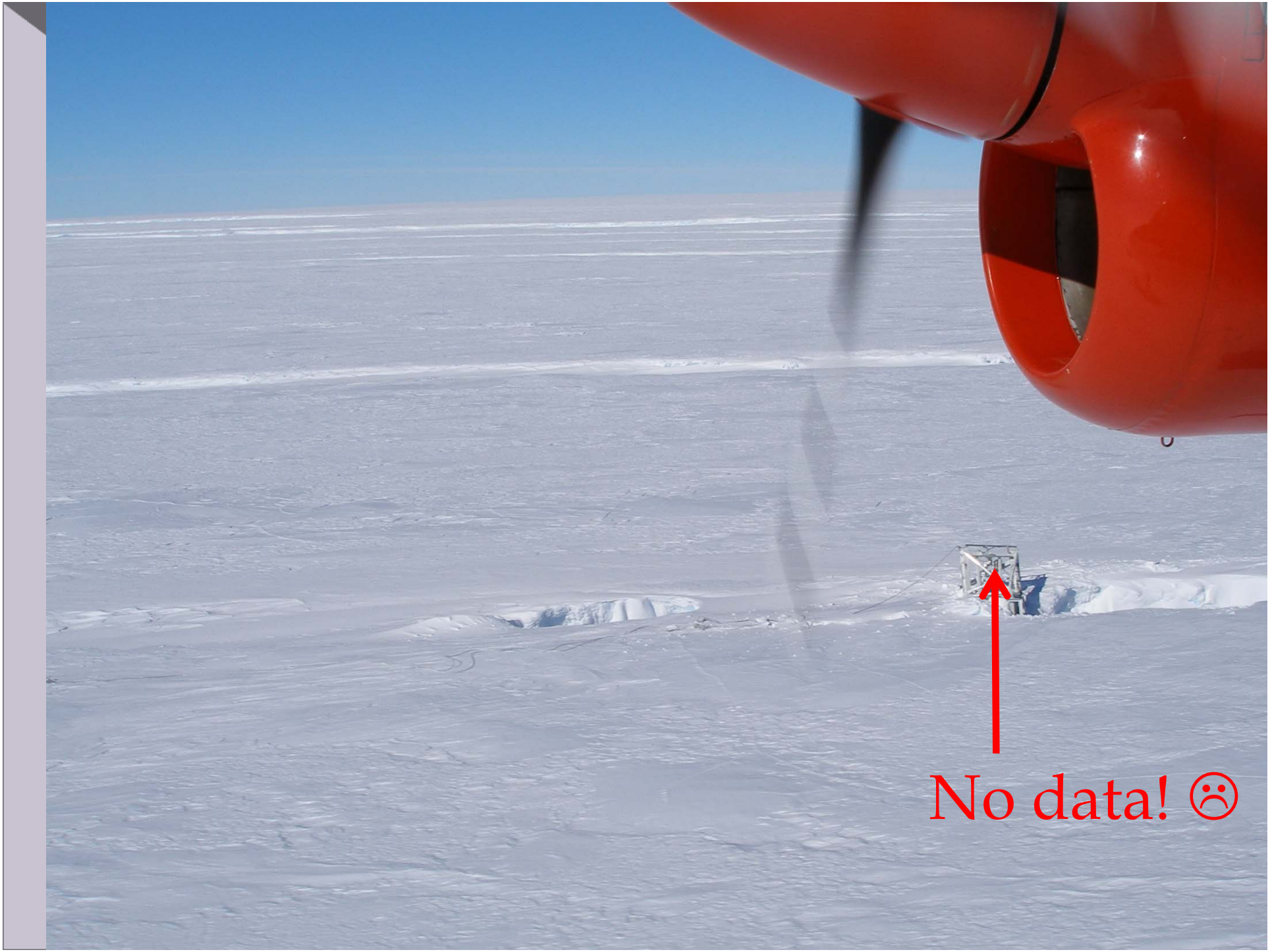


BLAST Flight Path
Antarctica 2006

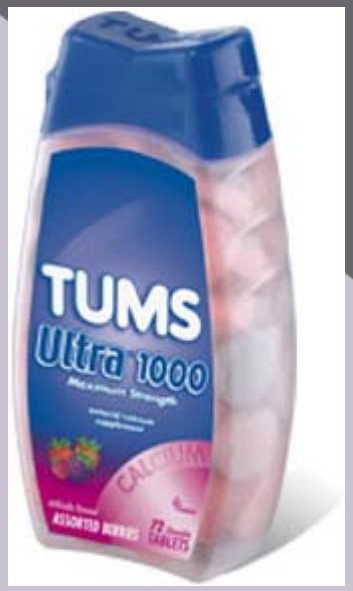


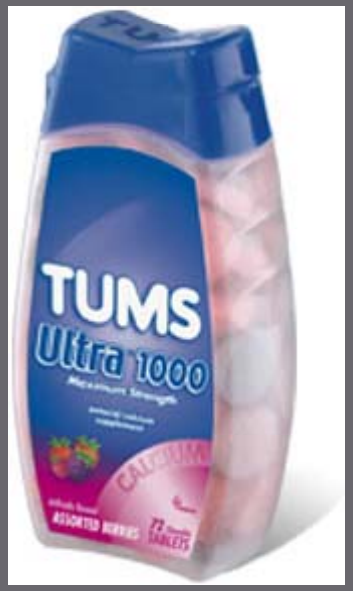
ONE DAY PASSES….

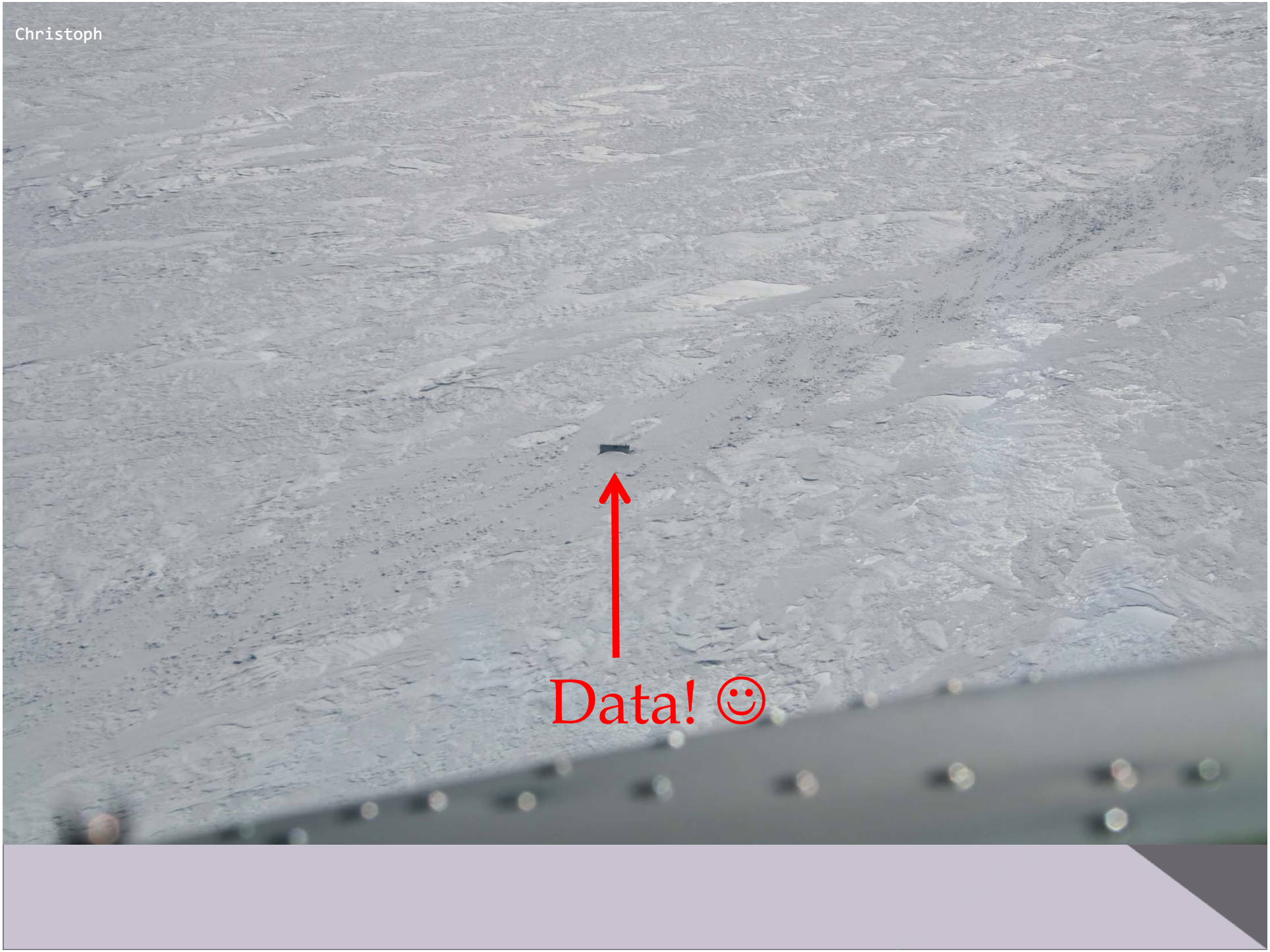

Data
Dragged position
BLAST Landing Site


No data! ☹

TWO DAYS PASS…..






Christoph
Data! ☺

TWO DAYS PASS…..


RECOVERD
JANUARY 07TH, 2007
@ 7600'MSL 1600 LT.
BLAST
Data Hard Drives
Highest Recovery Priority

BLAST: By the Numbers:

Altitude: 39 km
Days at float: 12

Colors: 3 (250, 350, 500 microns)
Detectors: 260
Beams: 32, 45, 62 arcseconds

Amount of Data Collected: 120 GB
Number of Samples: 24 billion

Mass: 2000 kg
Mirror Diameter: 1.8 meters
Motors: 3
Actuators: 4
Pointing Sensors: 11
Power consumption: 500 W

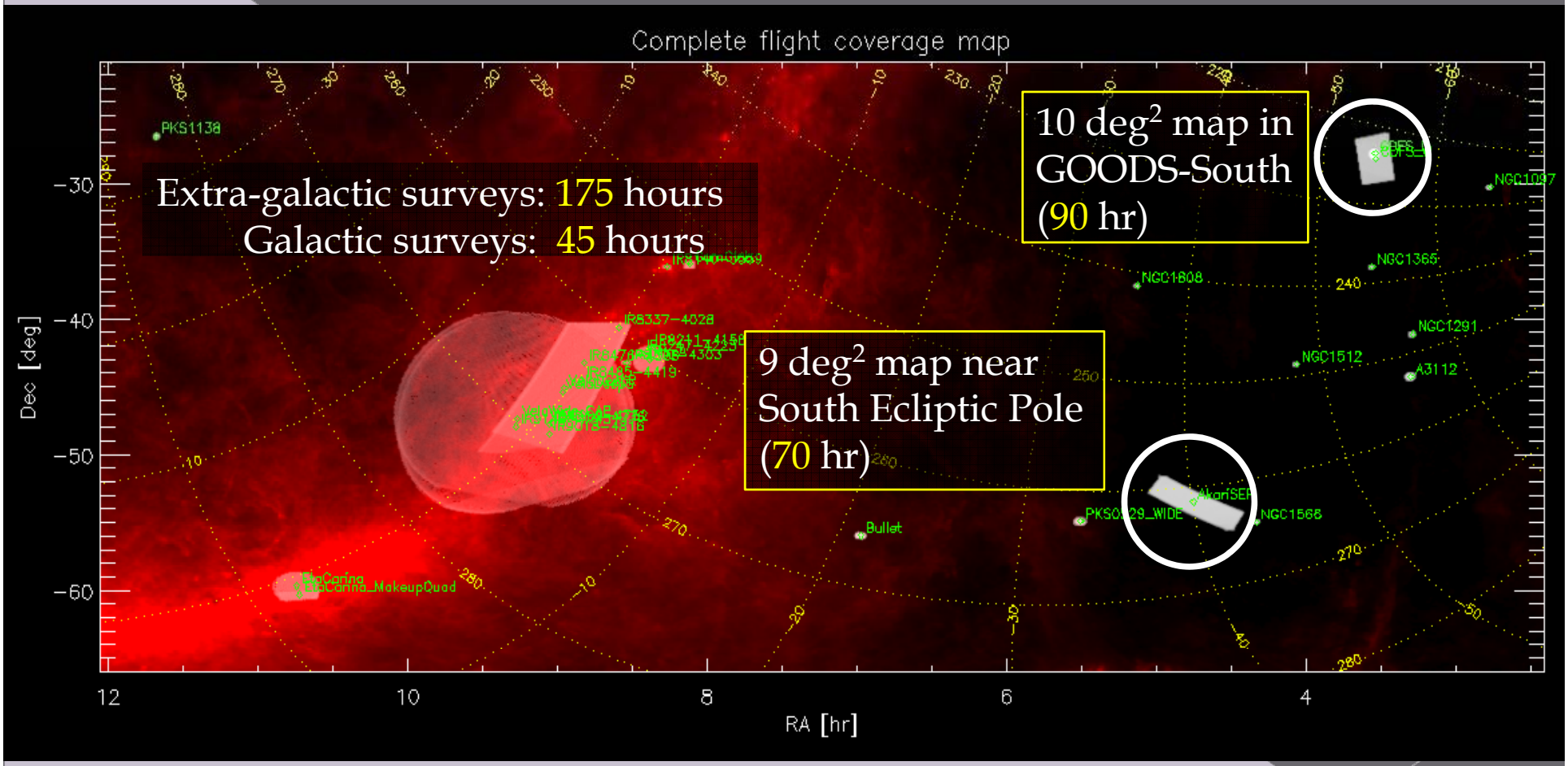
Computers: 5
Processors: 43
110,000 lines of code

Number of People to Build and Fly: 25
Total number including analysis: 42
Total Effort: > 2 working lifetimes

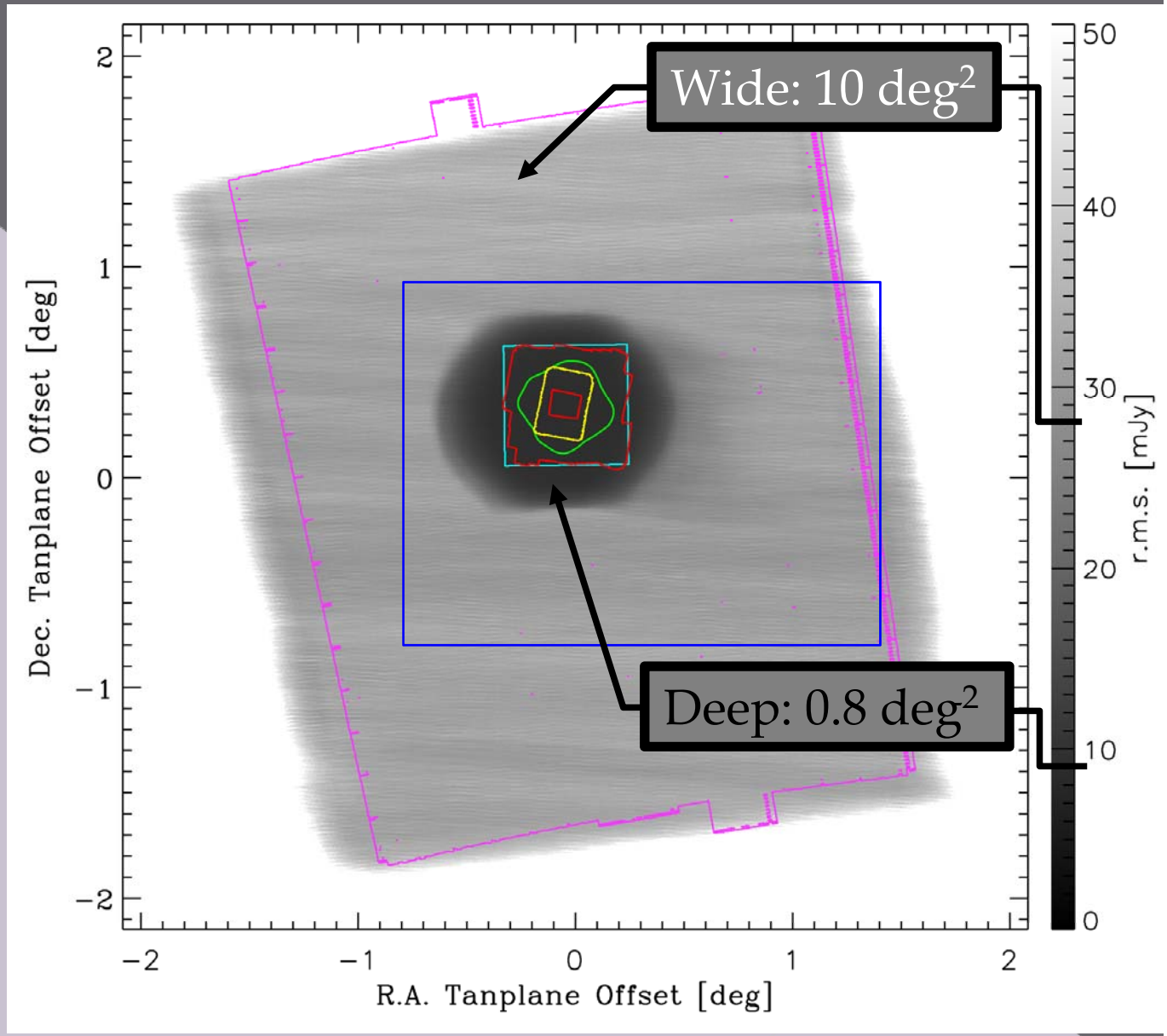
Lowest Telescope Temp: -55C
Highest Telescope Temp: 50C
Cryogens: 35 l Nitrogen
40 l Helium
Bolometer temperature: 300 mK

SWAG orders: 5 Mugs, mouse pads, t-shirts, stickers, tattoos

BLAST 2006: 11-day circumpolar flight from McMurdo, Antarctica



BLAST COVERAGE IN GOODS-SOUTH



BLAST COVERAGE IN GOODS-SOUTH

SWIRE (shallow Spitzer):
MIPS 24, 70, 160 μm
IRAC 3.6, 4.5, 5.8 and 8 μm

ATCA (1.4 GHz, shallow)

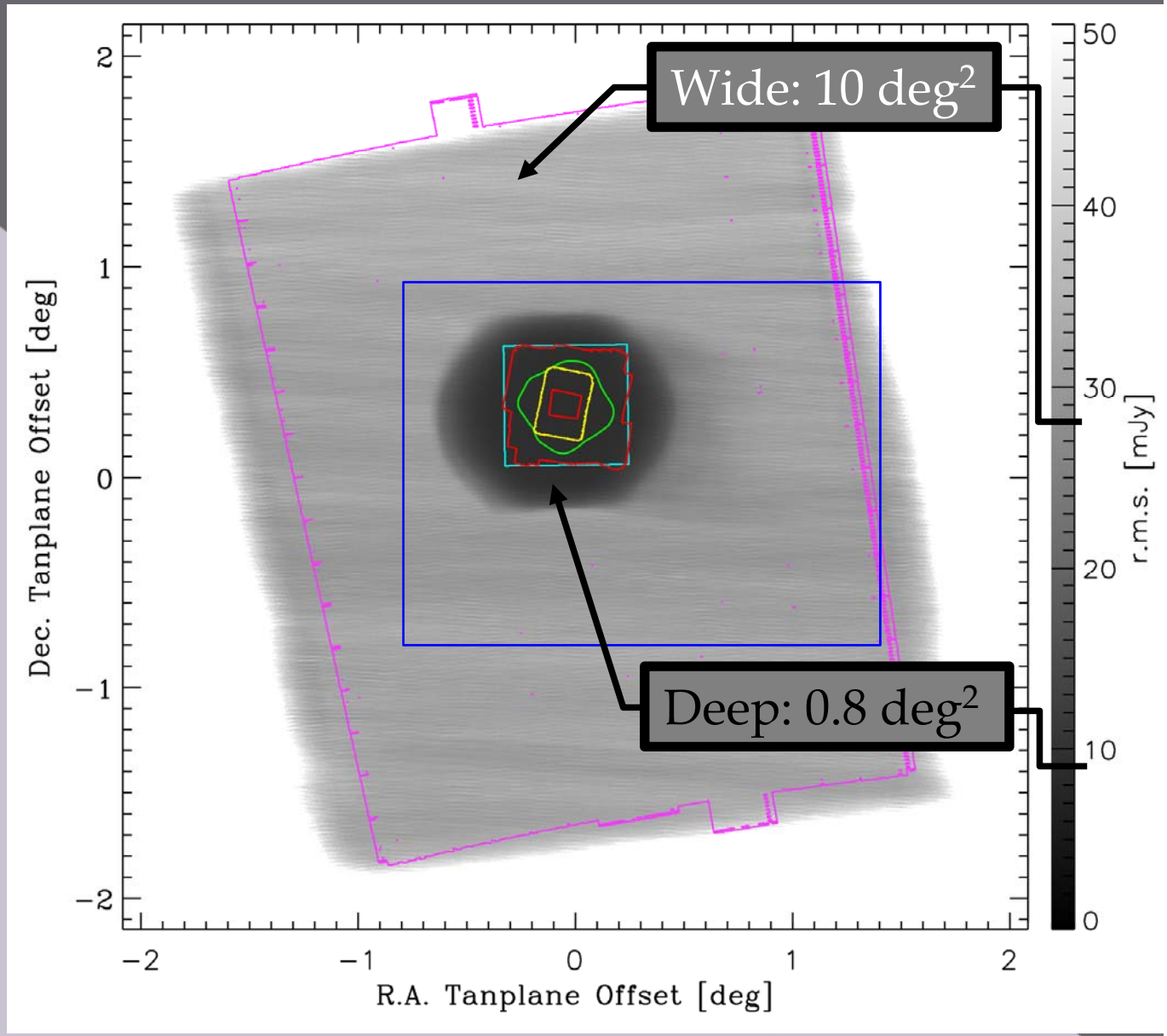
VLA (1.4 GHz, deep)

FIDEL (deep Spitzer):
MIPS 24, 70 μm

Chandra (1 Ms exposure)

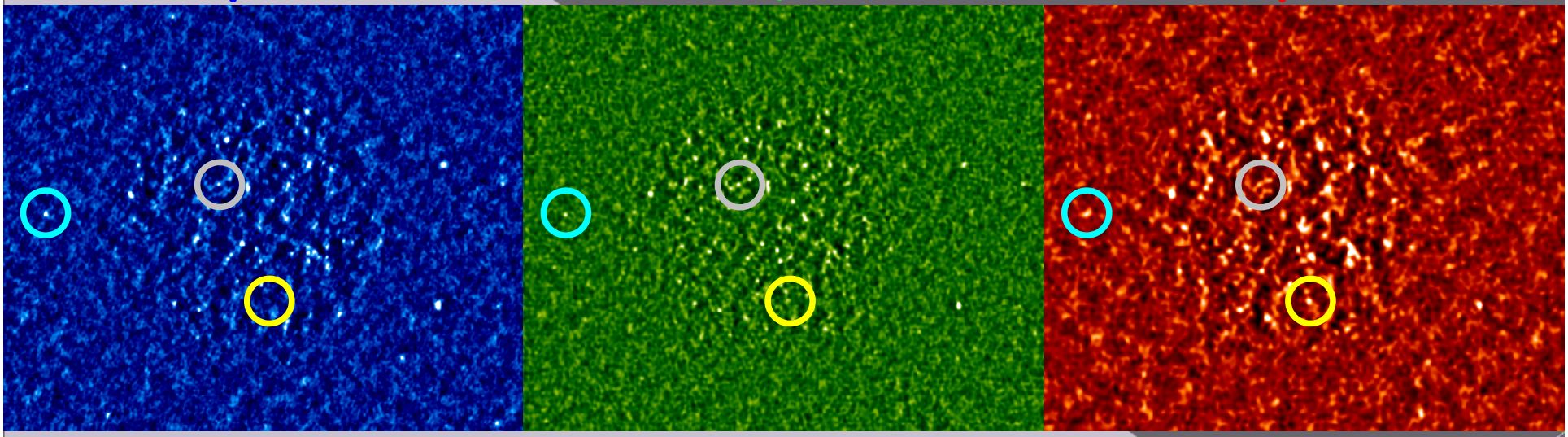
GOODS-S (super deep):
Spitzer MIPS 24 + IRAC
Hubble ACS
ESO imaging+spectroscopy
KPNO+Subaru Imaging

ALSO:
Hubble UDF South
GEMS
...



A Tour of Some BLAST Sources

250μm 350μm 500μm



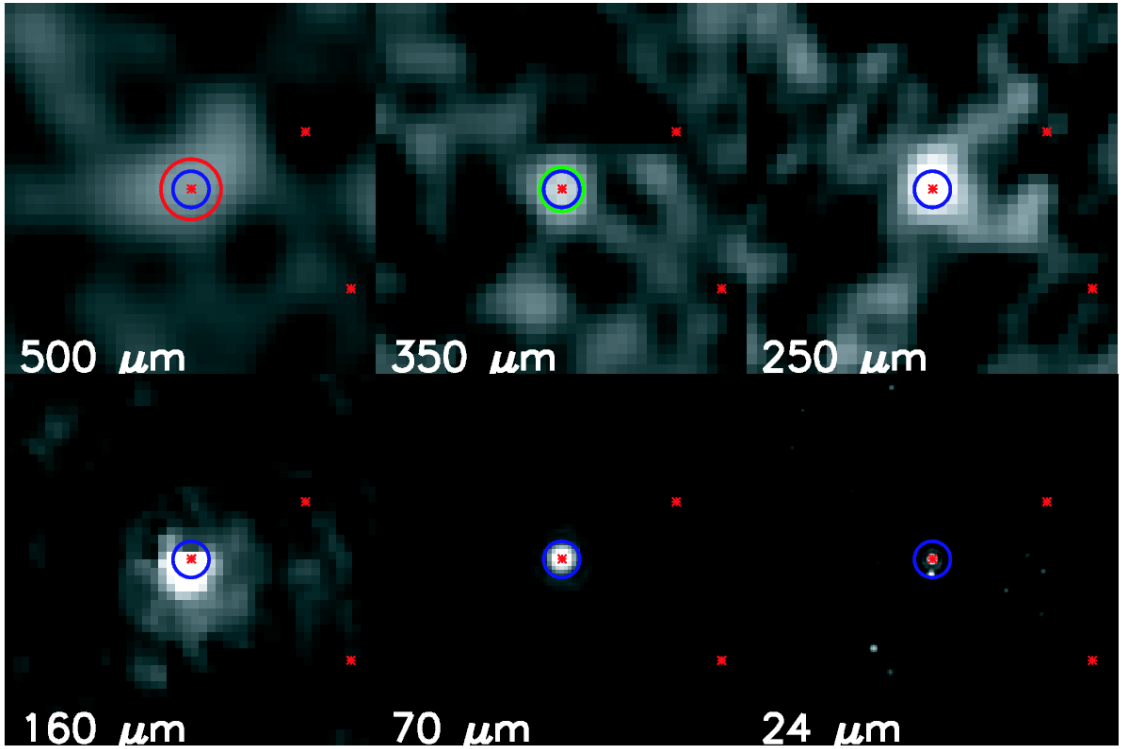
z=0.169 IRAS galaxy (IR 03337-2759)

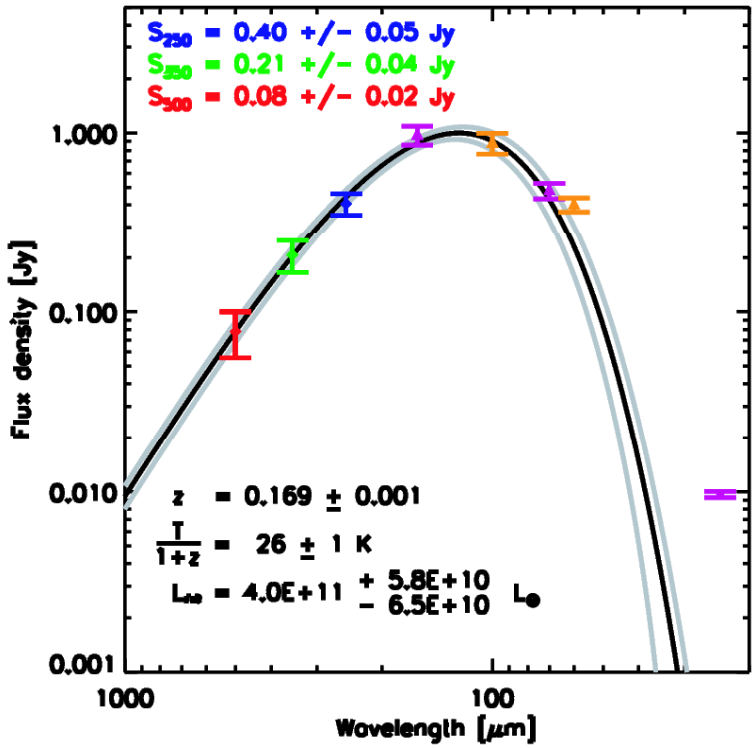
z=1.1 galaxy from the SWIRE survey (J033259.19-274325.3)

z~3 galaxy selected by strong BLAST 500μm emission

z=0.169 IRAS galaxy (IR 03337-2759)

Clear radio detection (ATCA survey)
Detected in all Spitzer & IRAS bands
BLAST data constrain Rayleigh-Jeans tail



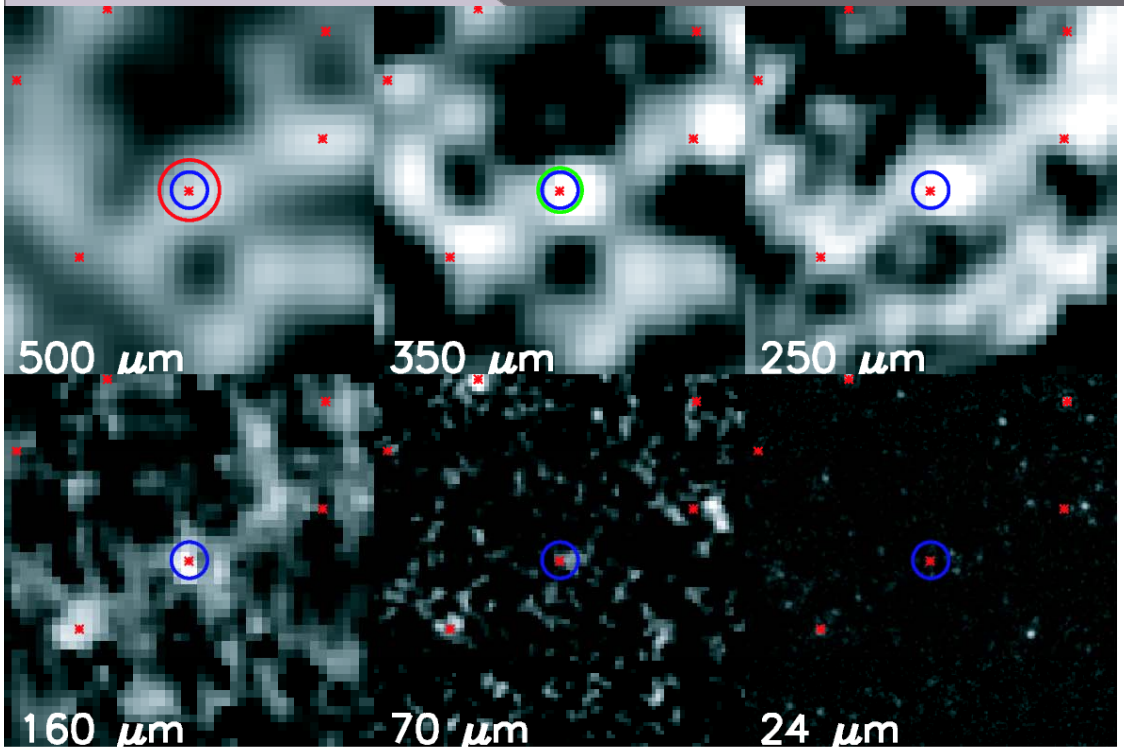


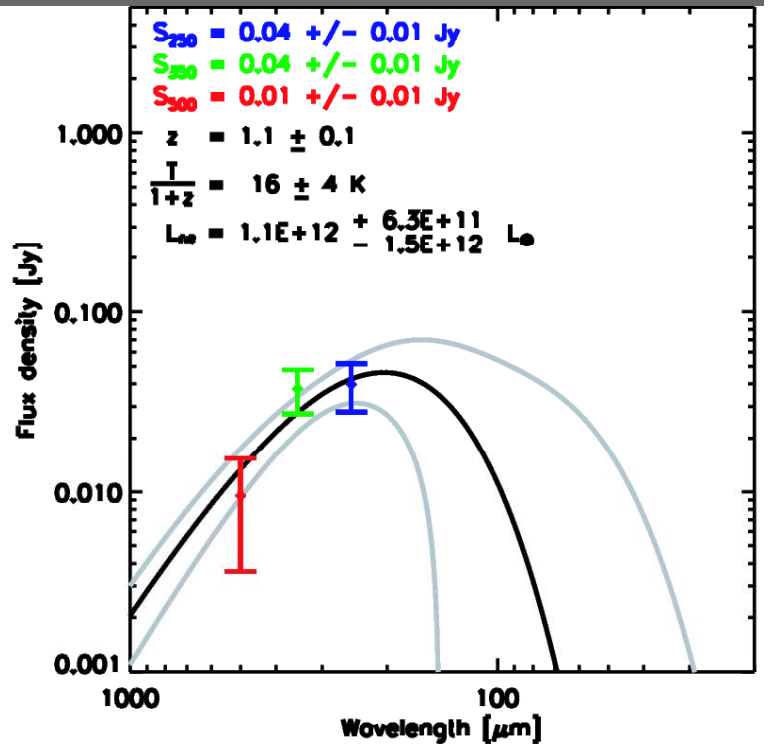
T_{OBS} = 26 K
T_{REST} = 30 K

$L_{BOL} = 4 \times 10^{11} L_{SUN}$
SFR ~ 70 M_{SUN} yr^{-1}

z=1.1 galaxy (SWIRE J033259.19-274325.3)

Clear radio detection (ATCA Survey)
Spitzer 24μm + IRAC, faint at 160 and 70 μm
BLAST detects SED *peak*, constrains temperature



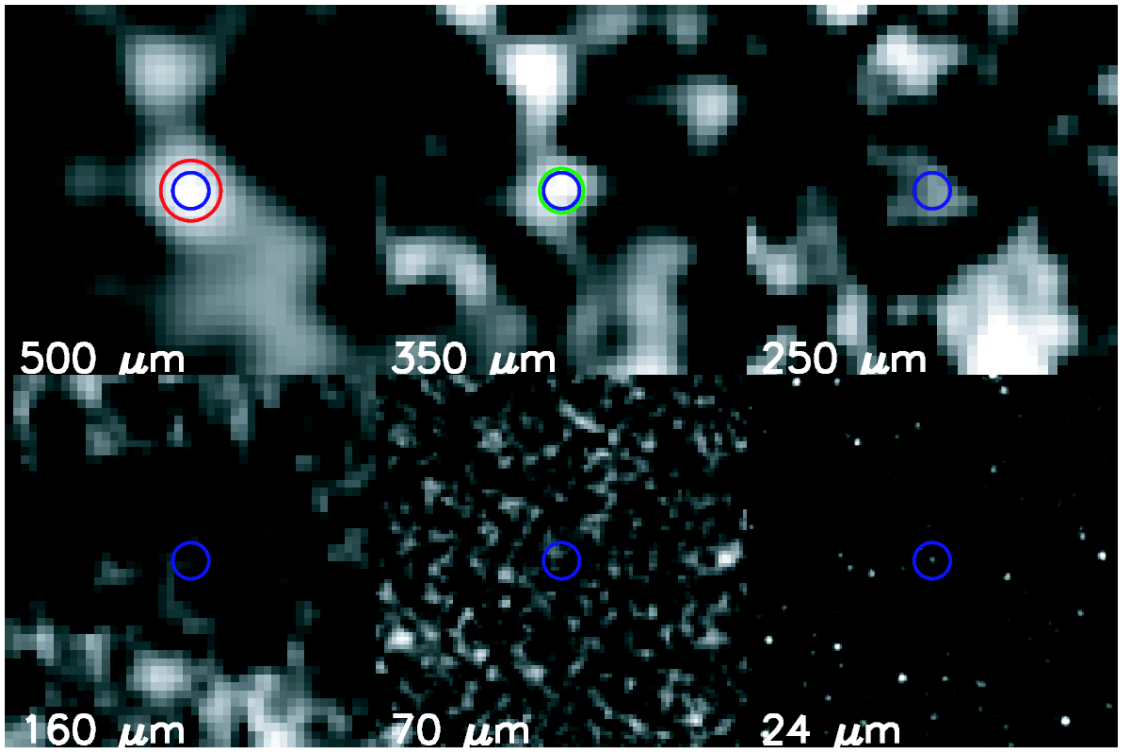


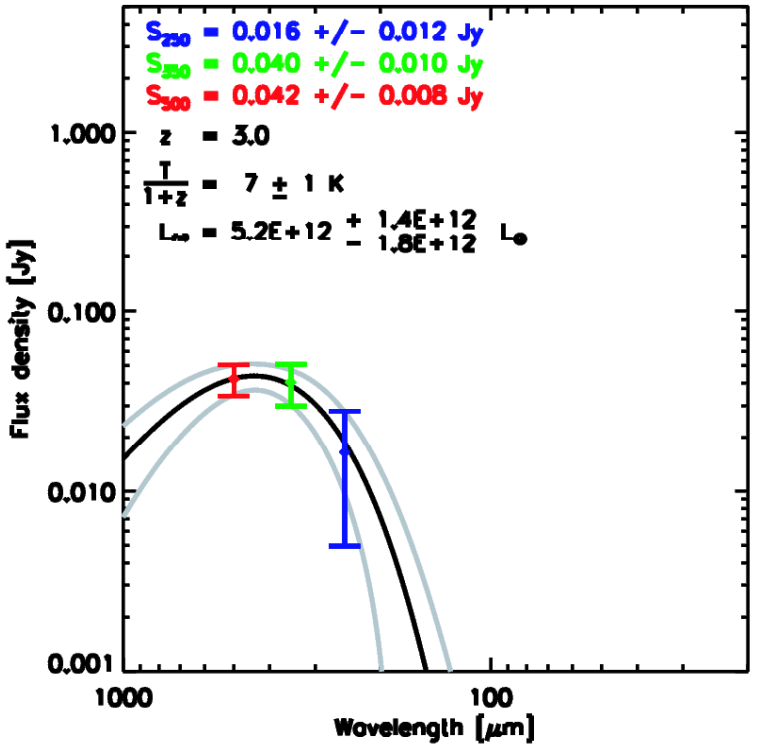
T_{OBS} = 16 K
T_{REST} = 34 K

$L_{BOL} = 1.1 \times 10^{12} L_{SUN}$
SFR ~ 200 M_{SUN} yr^{-1}

z~3 galaxy selected by strong BLAST 500μm emission

BLAST detects SED *peak*, constrains temperature
Expected 850 μm flux density ~20 mJy – a bright SCUBA galaxy?



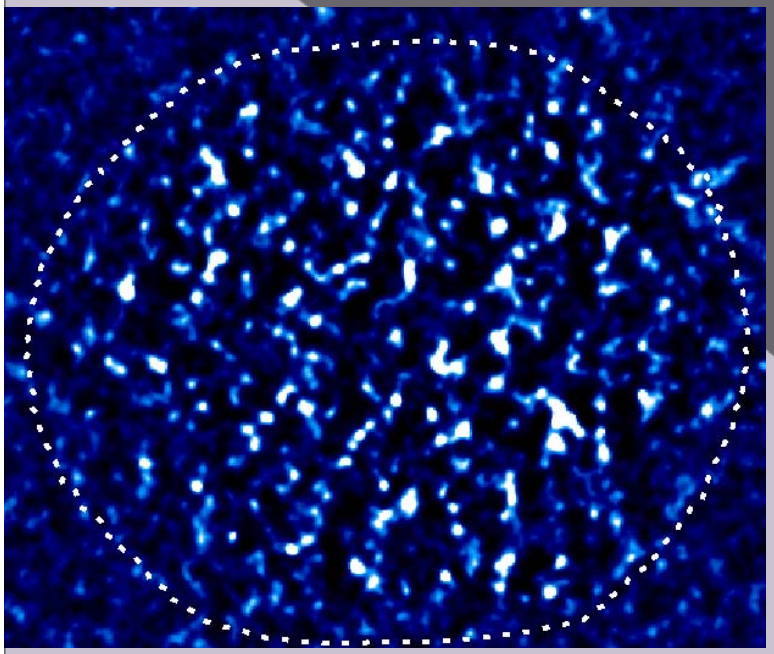


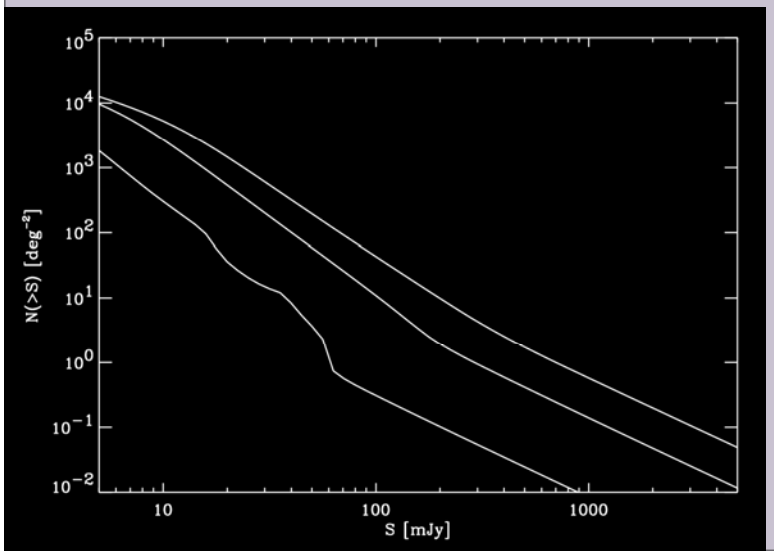
Photometric Redshift:
assume T_{REST} to infer z~3

T_{OBS} = 7 K
T_{REST} = 30 K

$L_{BOL} = 5.2 \times 10^{12} L_{SUN}$
SFR ~ 940 M_{SUN} yr^{-1}

The BLAST Deep Map is Confused





Hopefully We Are Not!

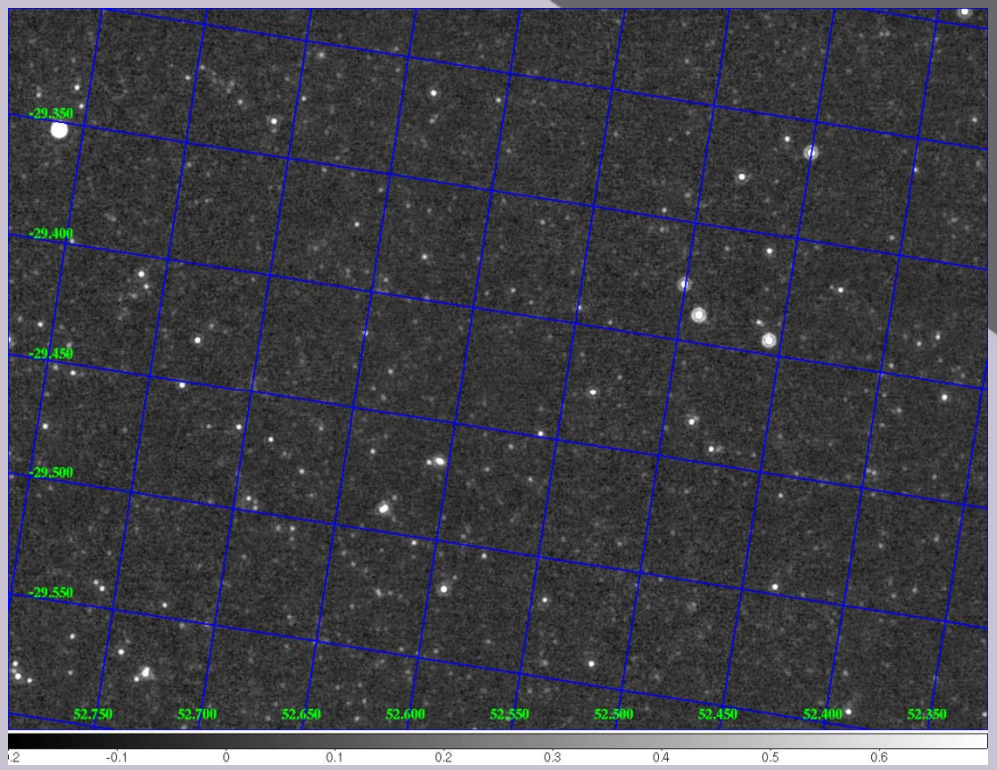
What do you do with a map that has too many sources to resolve them individually?

Why not just add up the flux?

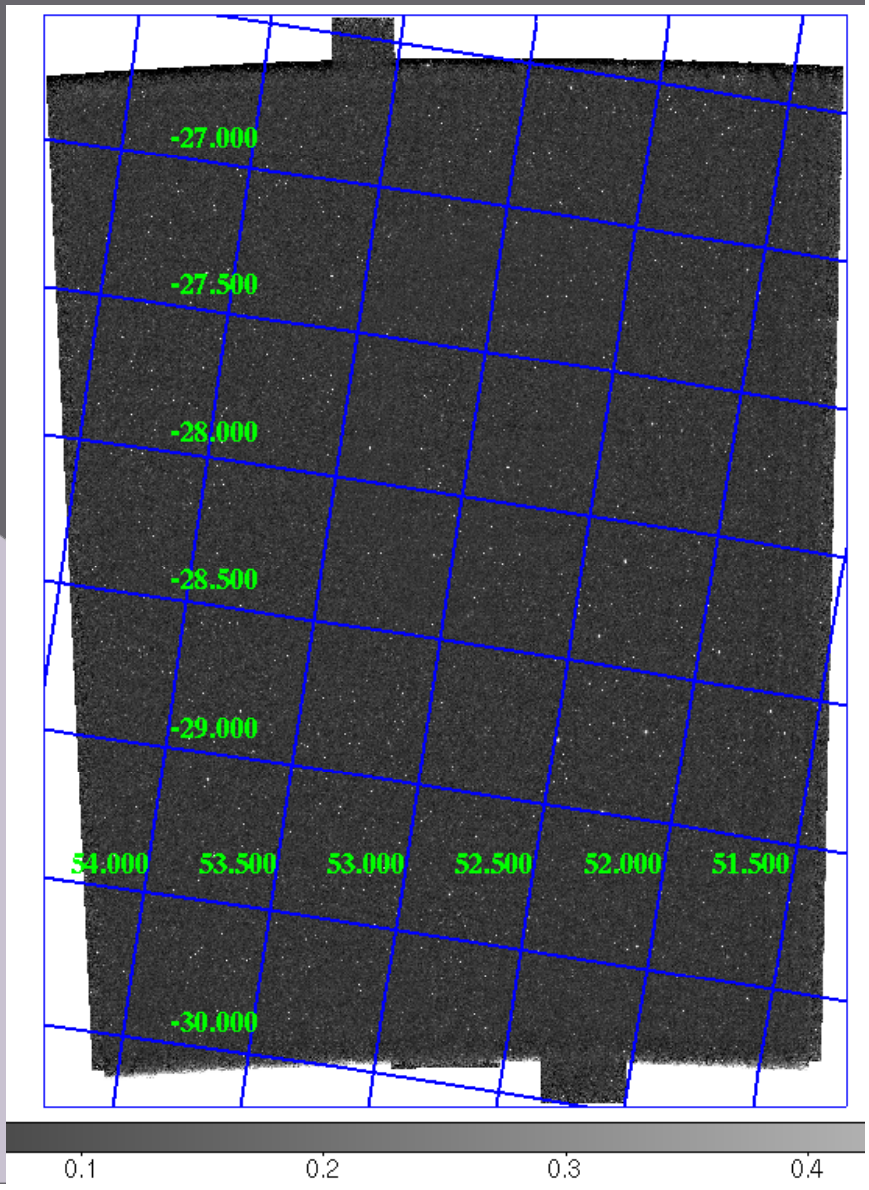
P(D) analysis – looks at the statistics of the signal(noise) to determine the underlying source of the signal

Stacking analysis uses the positions of known sources to extract the flux.

Finding the Source(s) of the Submillimeter Background?

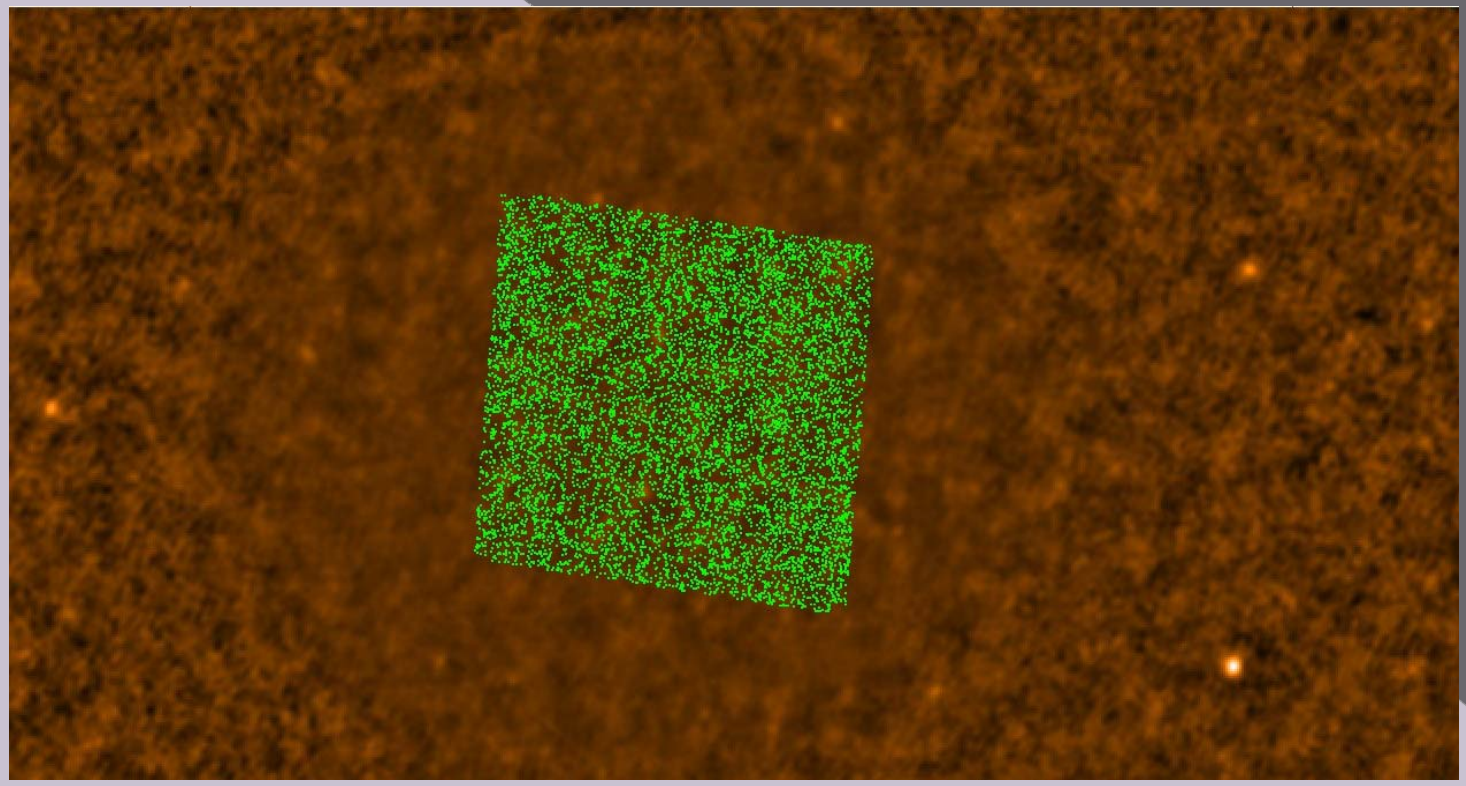


Spitzer 24 micron galaxies in the BLAST field.

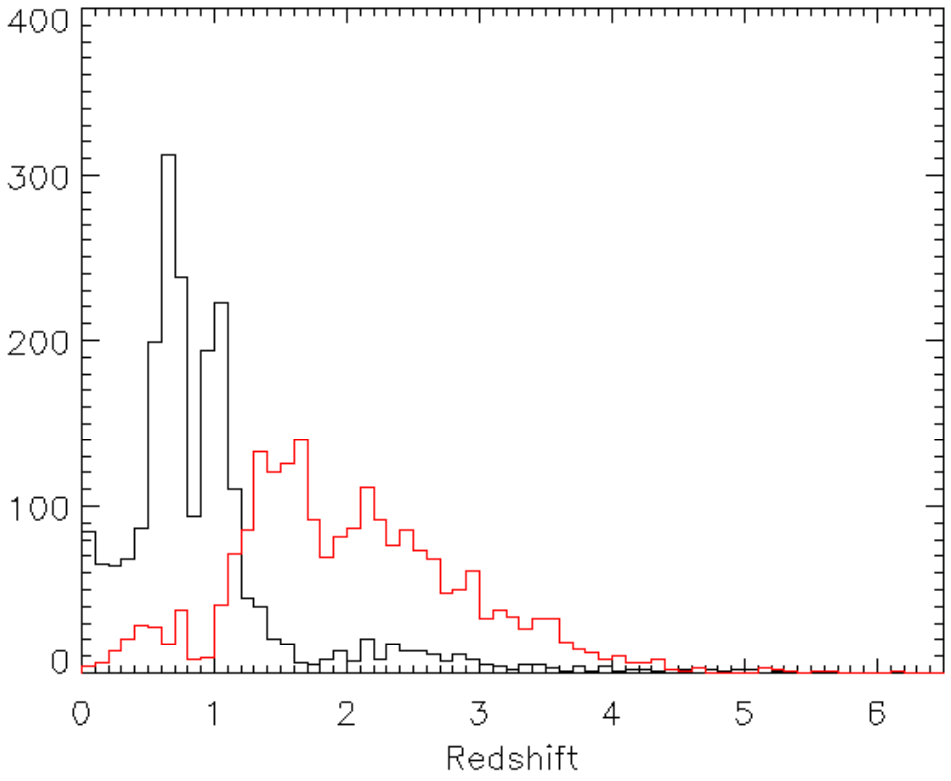


FIDEL 24 micron Catalog

9118 galaxies



SPITZER IRAC Colors provide redshift bins for the FIDEL Stacking



We can separate the catalogue in sources above and below $z > 1.2$.

BLAST – Other Results

- Radio and mid-IR identification of BLAST source counterparts in CDFS
- The Far Infrared History of the Universe
- Stacking Results from CDFS
- Clustering Measurements of the Cosmic Far Infrared Background in GOODS
- The 250-micron selected galaxy population in GOODS-S
- Submillimeter galaxy number counts from P(D) analysis of BLAST maps
- Evolution of the FIR Luminosity Function Revealed by new BLAST 250--500um surveys
- Star Formation in the Carina Nebula
- BLAST dust around Eta Carina BS Cassiopeia A
- Resolved Nearby Galaxies
- Dust to mass ratio in the blast resolved galaxies
- Detection of a Submillimeter Galaxy Behind the Bullet
- Abell 3112 Central Source
- Spitzer SEP maps and source lists
- Catalogs of high confidence sources in SEP
- Cold Cores in Vela – Nature
- The evolutionary state of the dense cores in Vela-D
- Kappa from extinction with Vela emission
- Cygnus X
- Galactic Targeted Sources
- IC 5146
- Aquila

SUMMARY

BLAST surveys in GOODS-S and SEP detect > 1000 sources

Source brightnesses span 2 orders-of-magnitude

Detected a mixture of:

- z<1 lower-luminosity galaxies (not detected by SCUBA!)
- z>1 ultra-luminous "SCUBA" galaxies

Determined the source of the CIB – Spitzer-detected 24 micron galaxies

The BLAST data will be publicly available in 4-6 weeks.

Watch our web page:

http://blastexperiment.info/
http://blastthemovie.com/

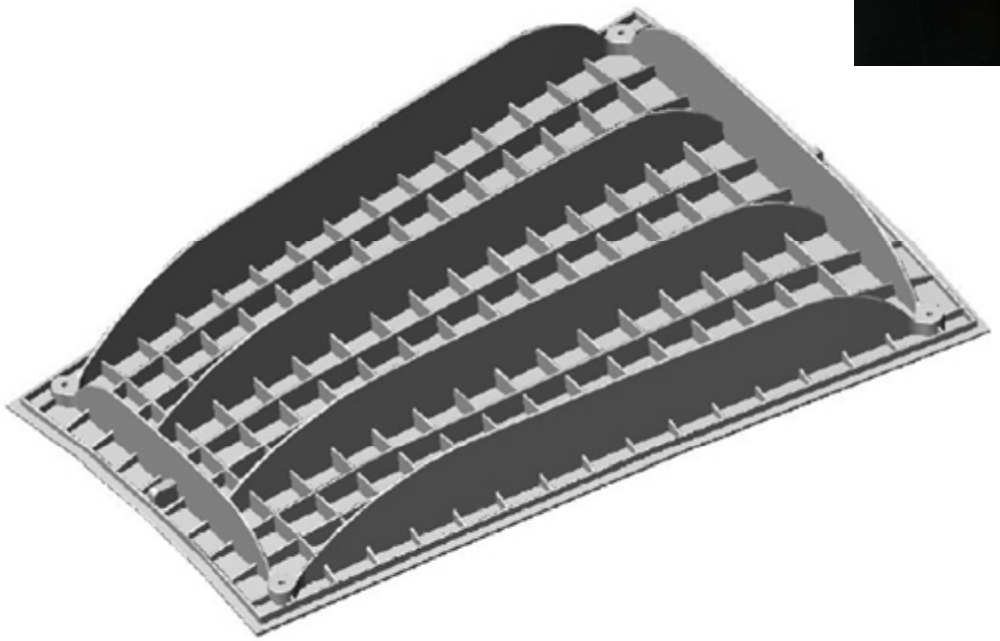
Is There a Future for Ballooning in the FIR/Submm?

- Bigger and better mirrors
- Better pointing
- Longer flights at mid-lattitude
- Detectors

The Future of Submm Ballooning

Large Diameter Lightweight Mirrors

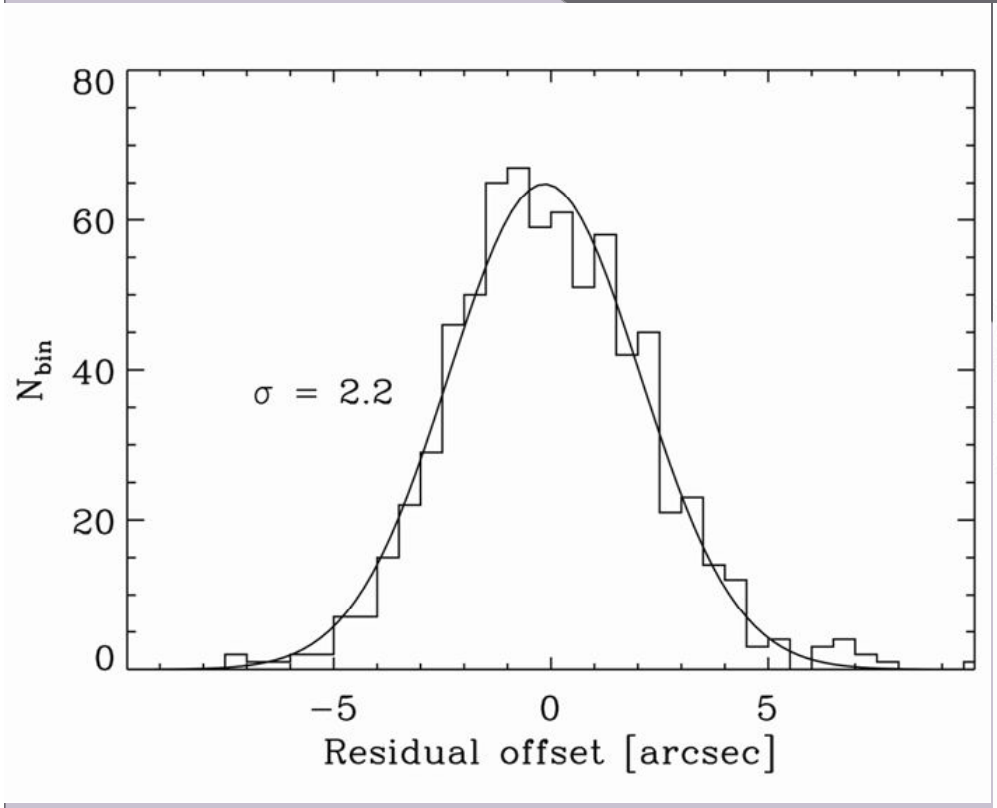
ACT 2 meter diameter secondary

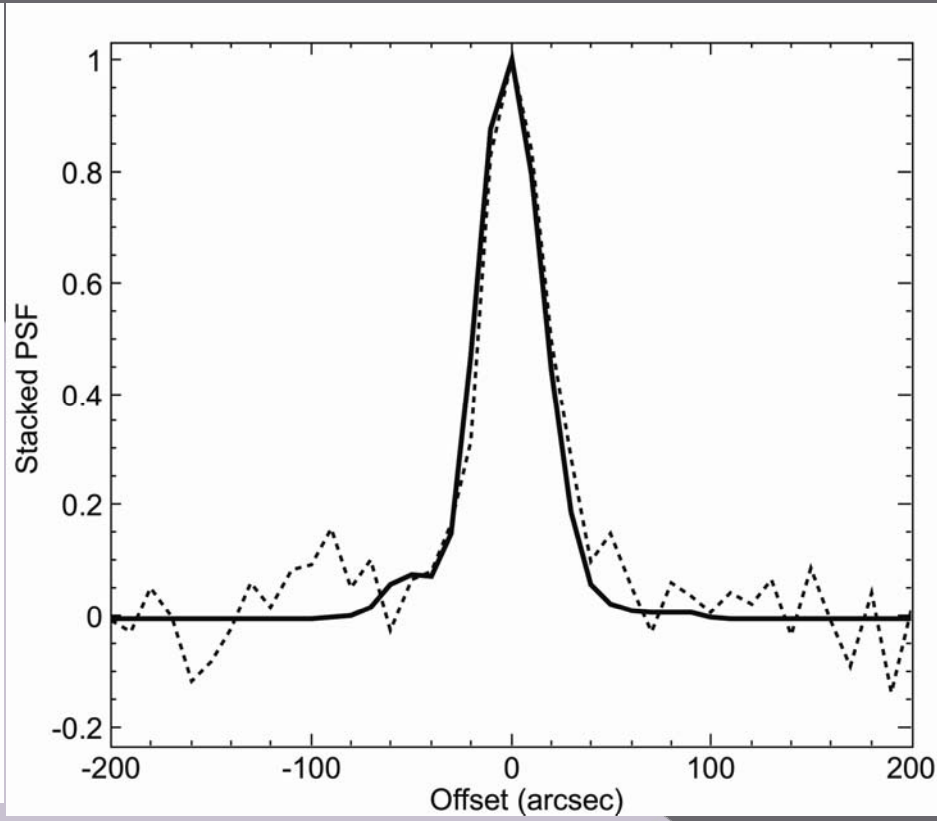


-Make a 3 meter diameter mirror with <3 micron rms surface.
- Weight <350 lbs
- Cost $300-400K

The Future of Submm Ballooning

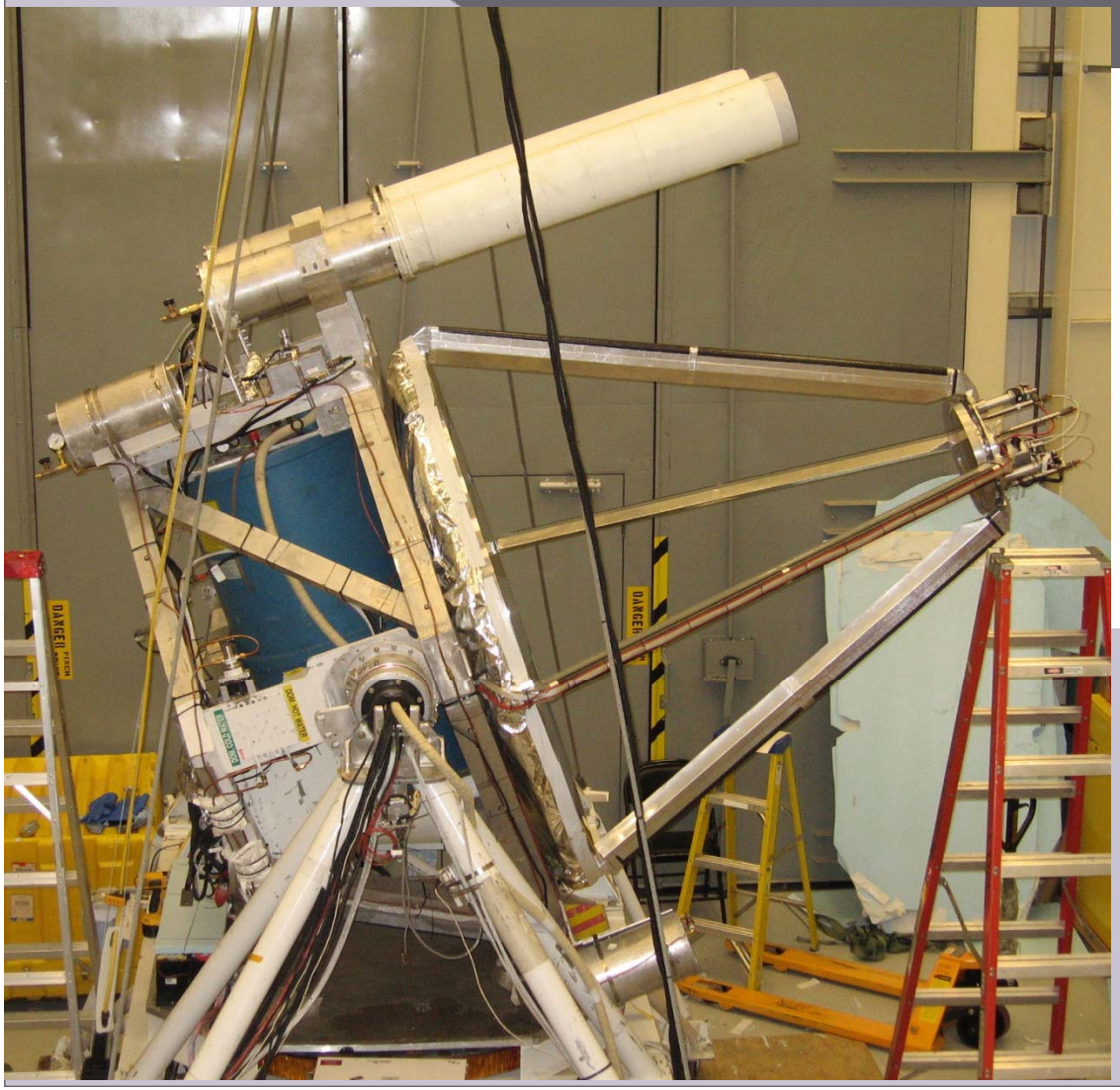
-Pointing – 2 arcsecond pointing reconstruction has already been achieved.
- On-source pointing is a bit harder – Do you need this for spectroscopy?

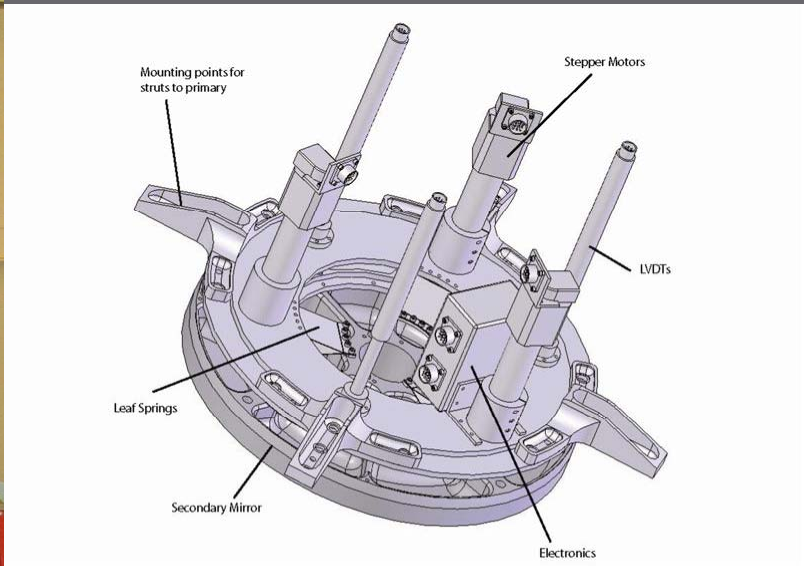




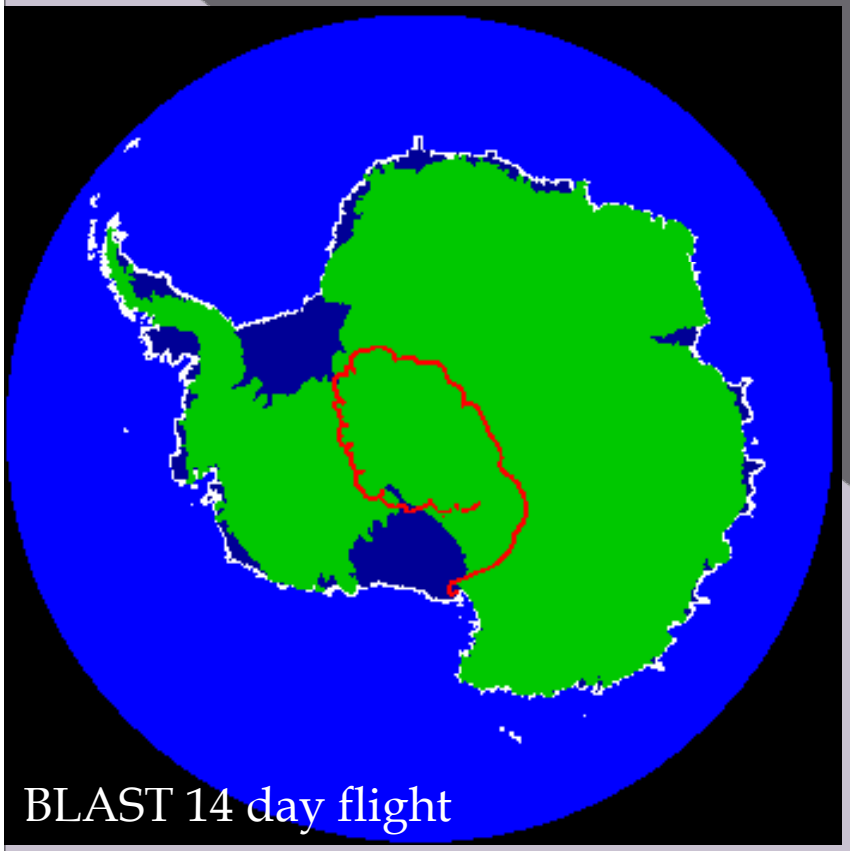
The Future of Submm Ballooning

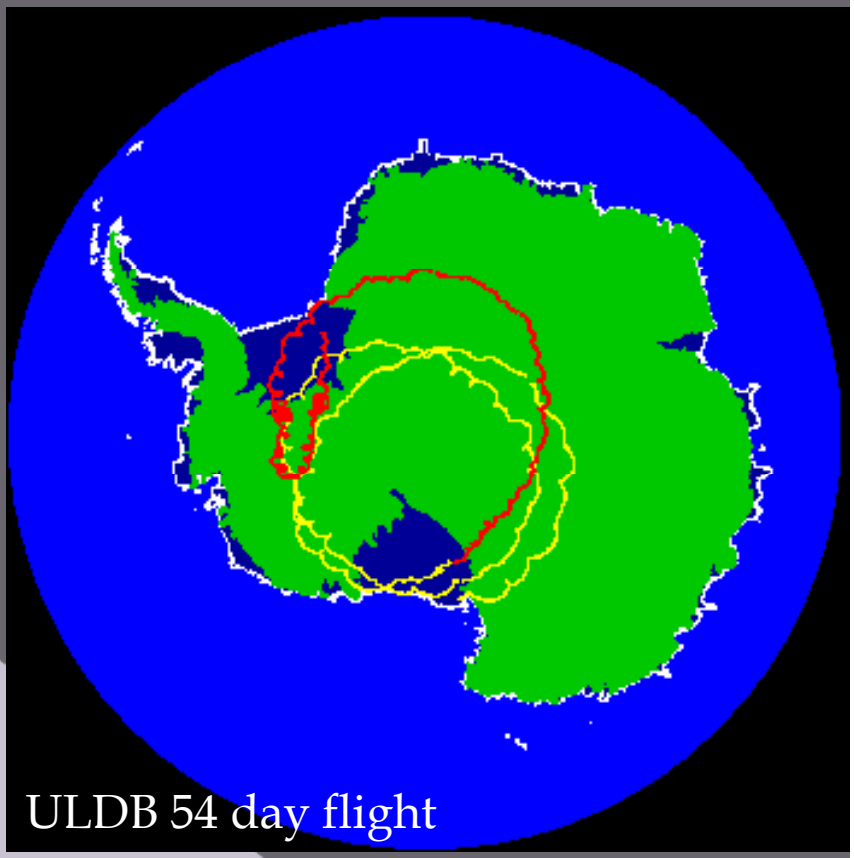
-Fast pointing with a positioning secondary could relieve this problem.





The Future of Submm Ballooning


BLAST 14 day flight


ULDB 54 day flight

-"Conventional" LDB flights – 5000 lbs at 120kft for 40 days
- ULDB flights – 1000 lbs at 120 kft for 100 days (for now!)
    - Mid-latitude flights will allow diverse target selection.

The Future of Submm Ballooning

It's the DETECTORS, STUPID!

-The detectors for BLAST were <10% of the budget.
- Funded on the coat tails of Herschel.
- Detectors for future instruments ~40% of the budget!
- No mission to ride on.
- Balloon program does not have the budget to support detector development

So, What Do You End Up With?

BEST

Balloon-born Extragalactic Spectrometer Telescope

- Off-axis 3 meter primary
  - Cooled to 80K
  - 1% emissivity
- 6000 detectors
  - R = 100-200
  - 60 spatial pixels
- Cover two patches 1 sq. deg. each in a 21 day LDB Flight

Thanks!