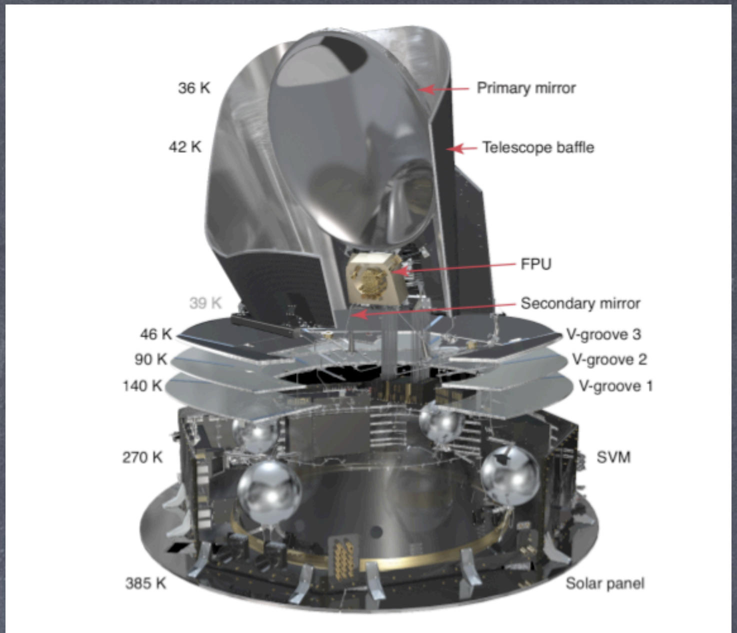
CMB experiments

The Planck example

Tauber et al. 2010
Planck collaboration 2011
Planck collaboration 2013

Planck satellite

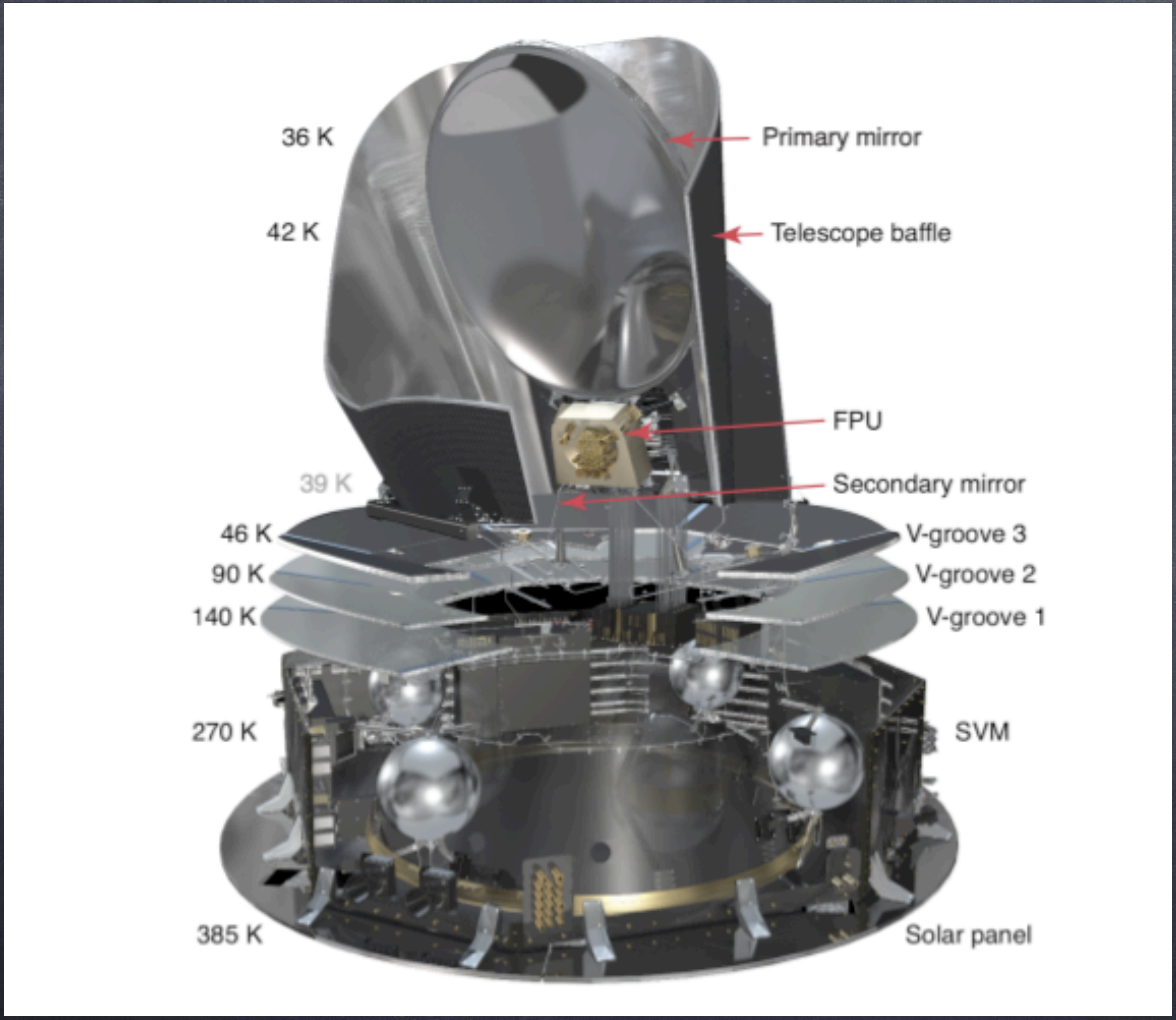


- 3rd generation of satellites for CMB (after COBE and WMAP)
  Launched by ESA 14th May 2009 (L2 Lagrange point)
- Scanning strategy based on large circles on the sky (1 rpm, 40 minutes)
  Full sky coverage in about 6-7 months
- Hors-axe gregorian telescope of 1.5 m
- Two instruments:
  - LFI : radiometers (OMT) cooled down to 18 K
    30 [4], 44[6] et 70 [12] GHz
  - HFI : bolometers (SW and PSB) cooled down to 100 mK
    100 [8], 143 [8+4], 217 [8+4], 353[8+4], 545 [4] et 857 [4] GHz + 2 Dark
- Complex cryogenic system:
  50 (V-grooves), 18 (H sorption cooler), 4 (JT ^4He), 1.4 et 0.1 K (dilution ^3He-^4He)

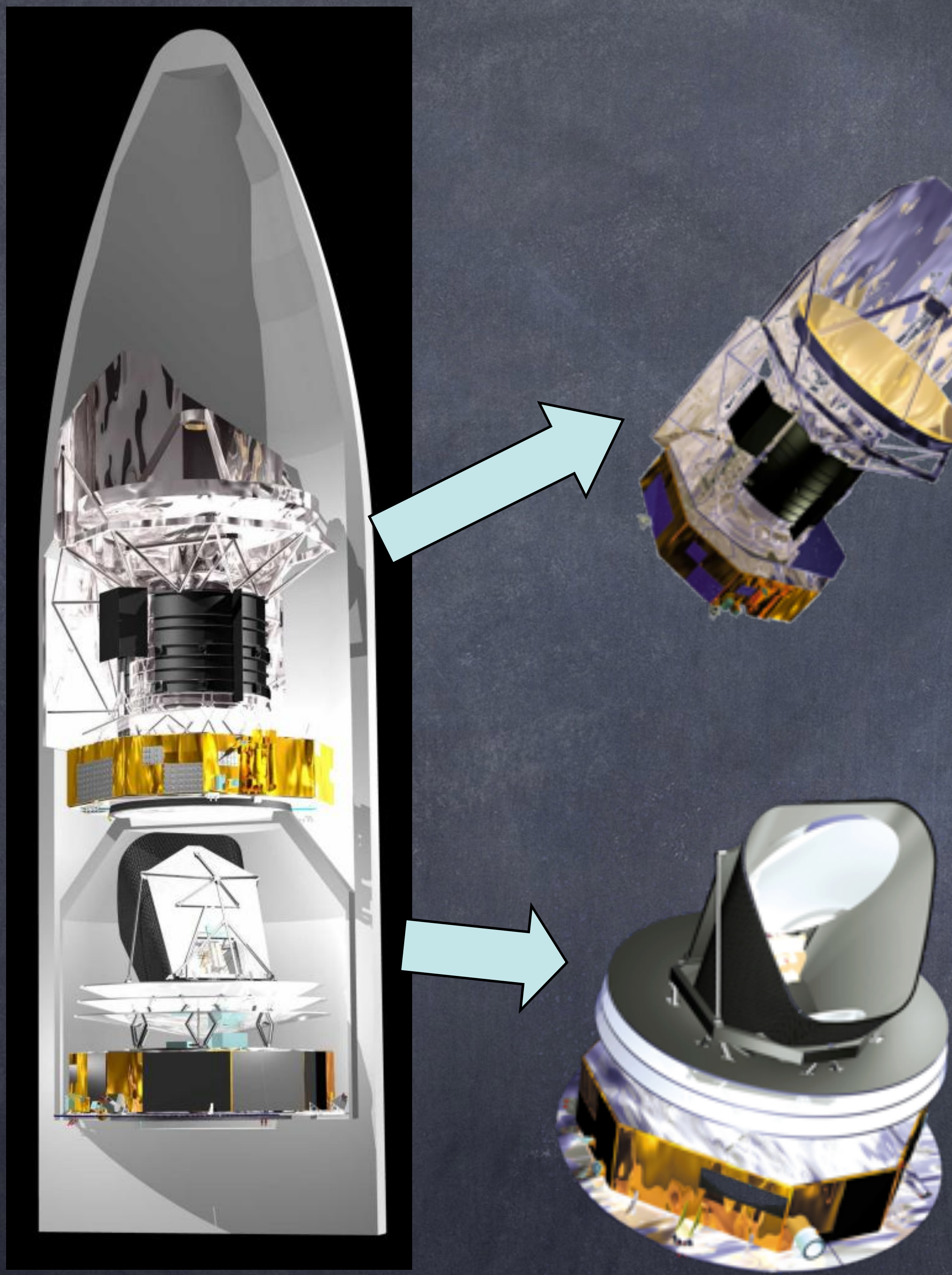
	30	44	70	100	143	217	353	545	857
Resolution (arcmin)	32	27	13,4	9,6	7,2	4,9	4,8	4,3	4,3
Sensibility (μ	146	173	152	23	20	28	116	814	23798

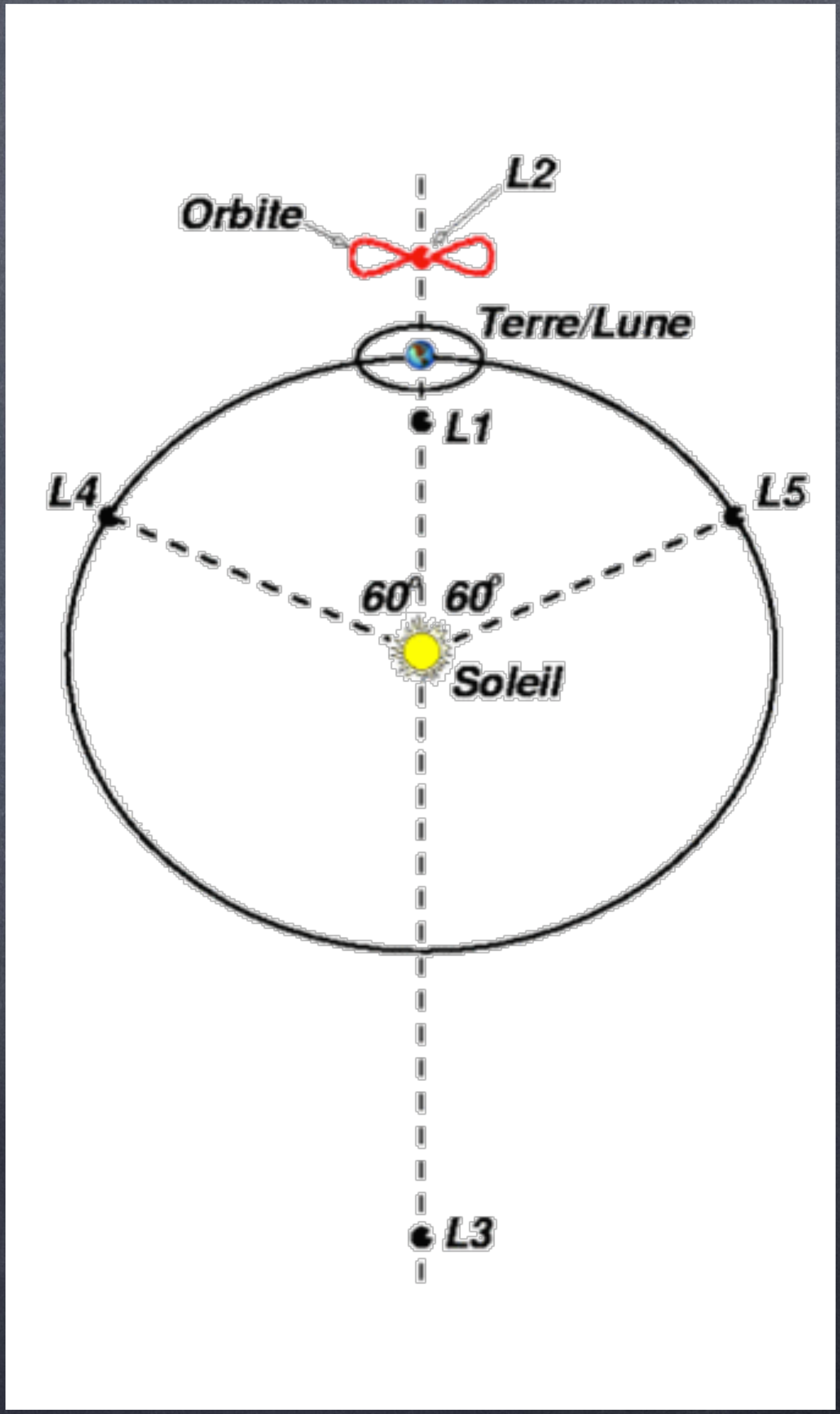
Bersanelli & Mandolesi 2000
Planck HFI Core Team 2011
Lamarre et al. 2003

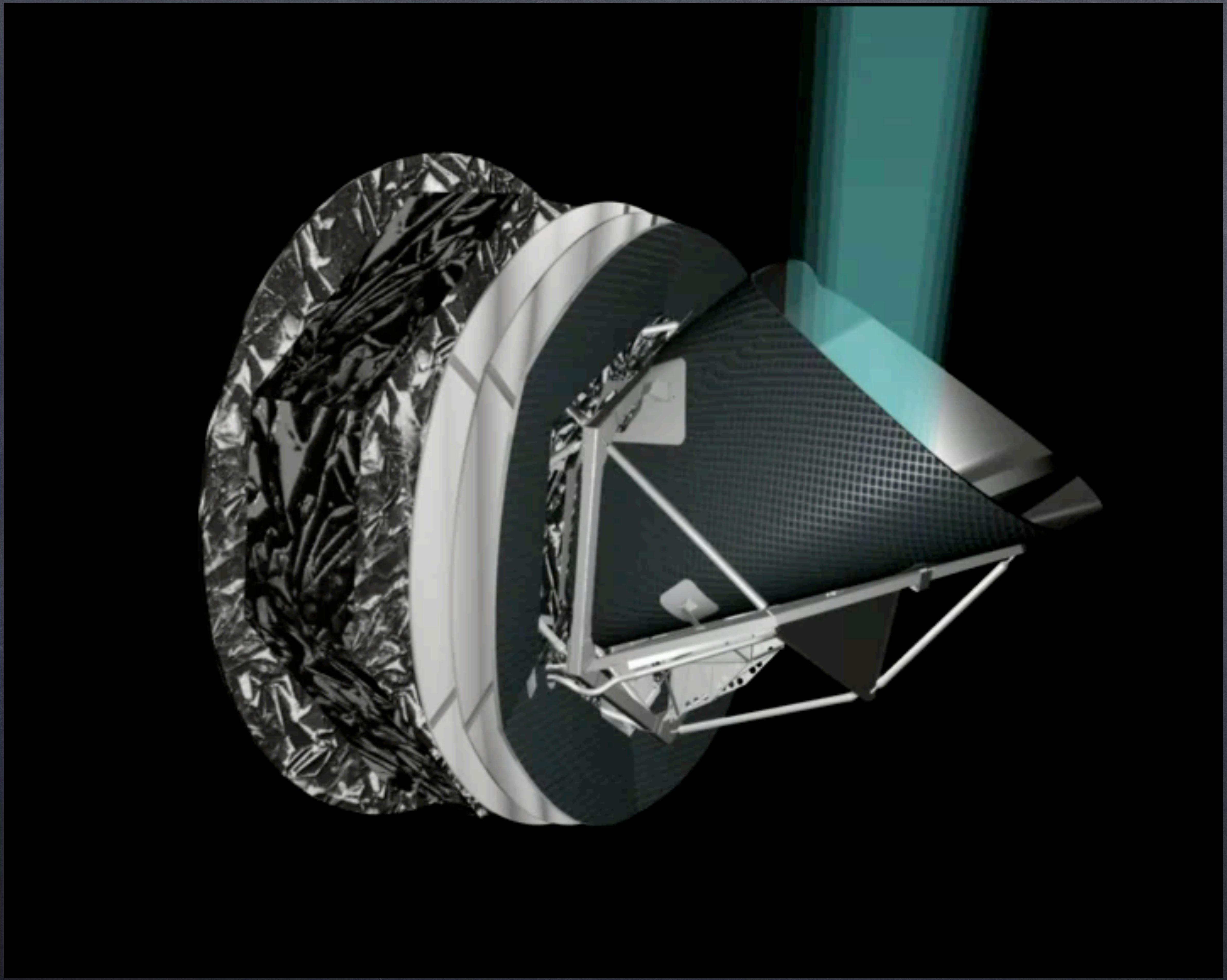
Planck satellite



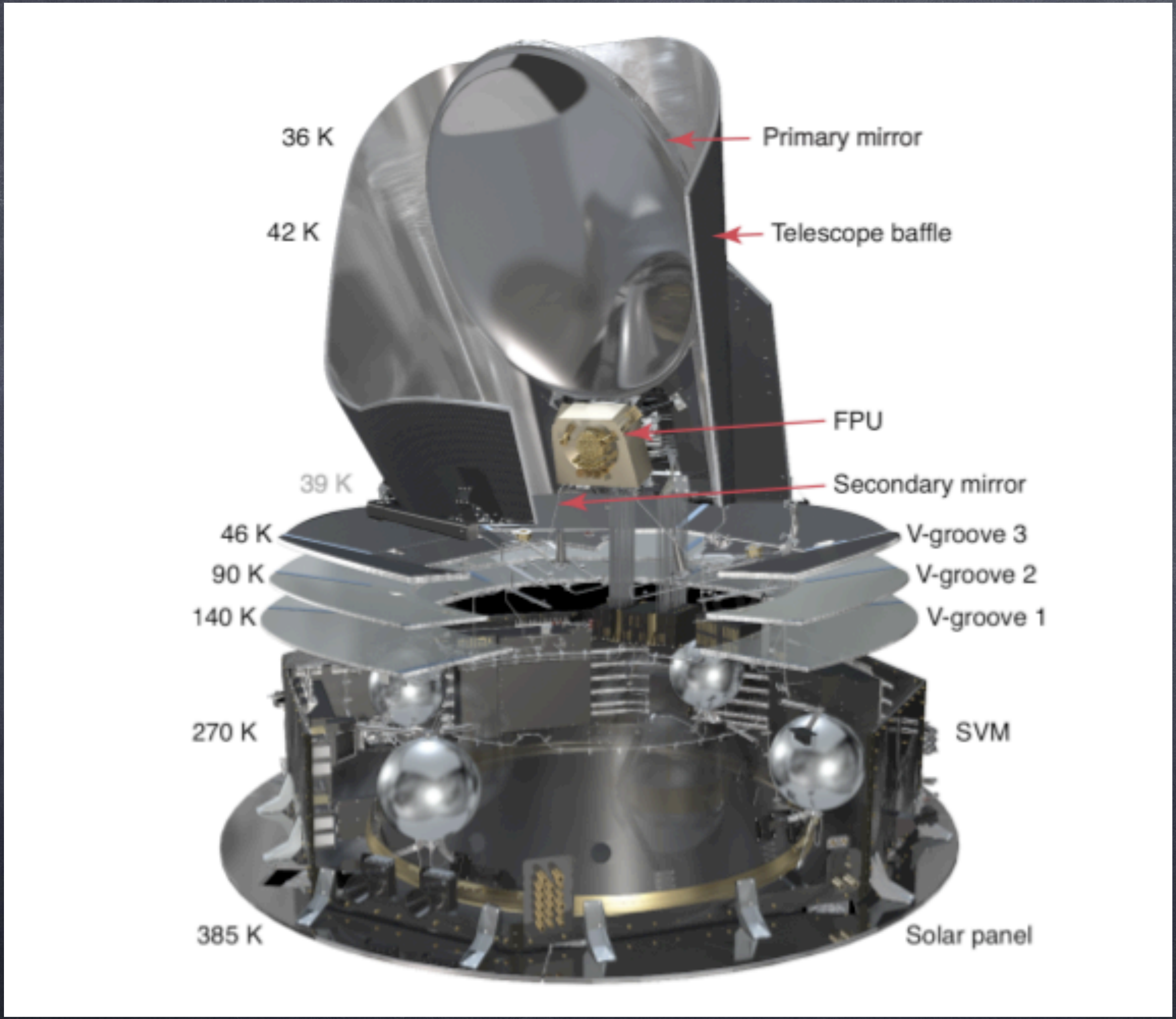
Launch and orbit



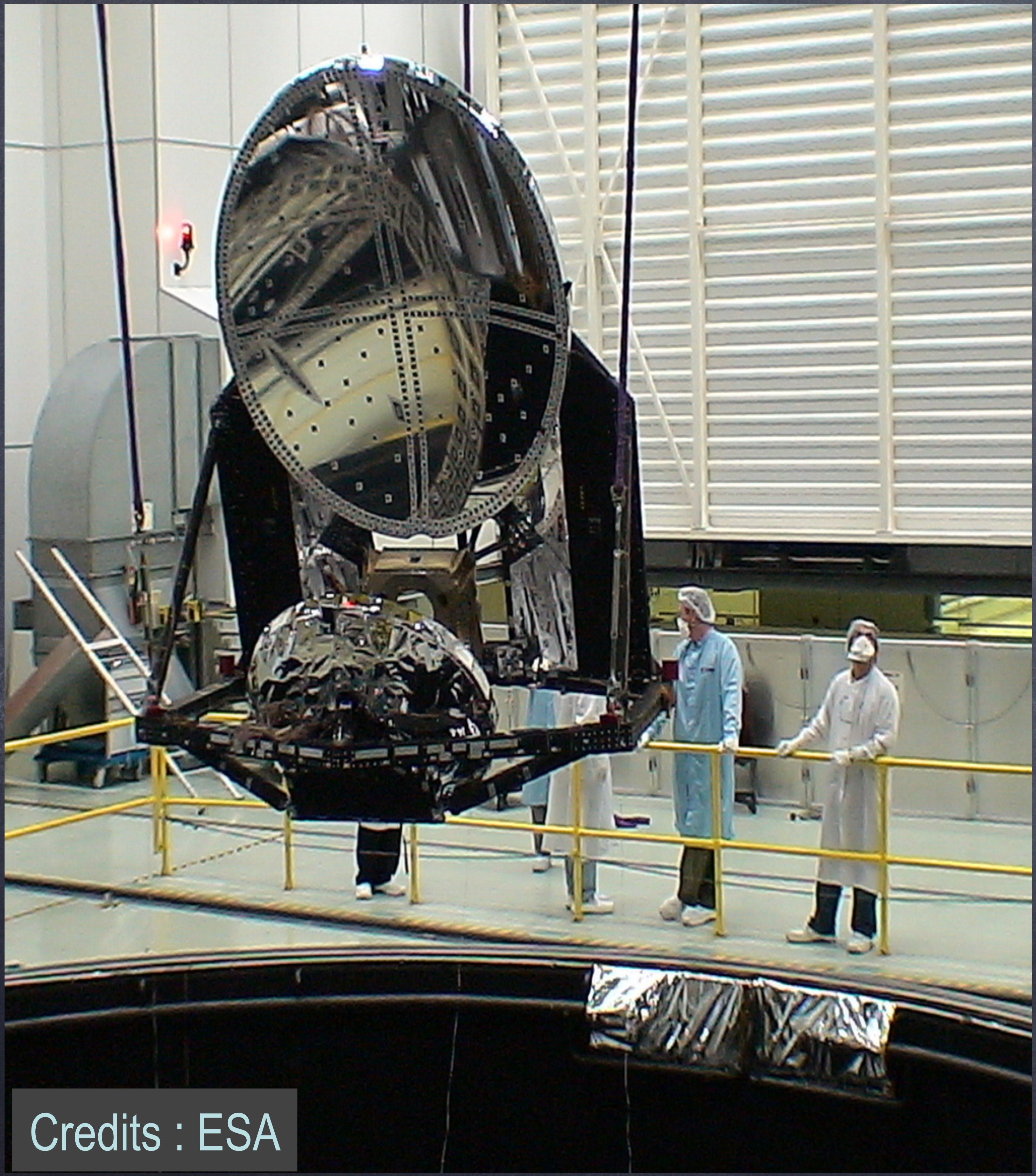




Planck satellite



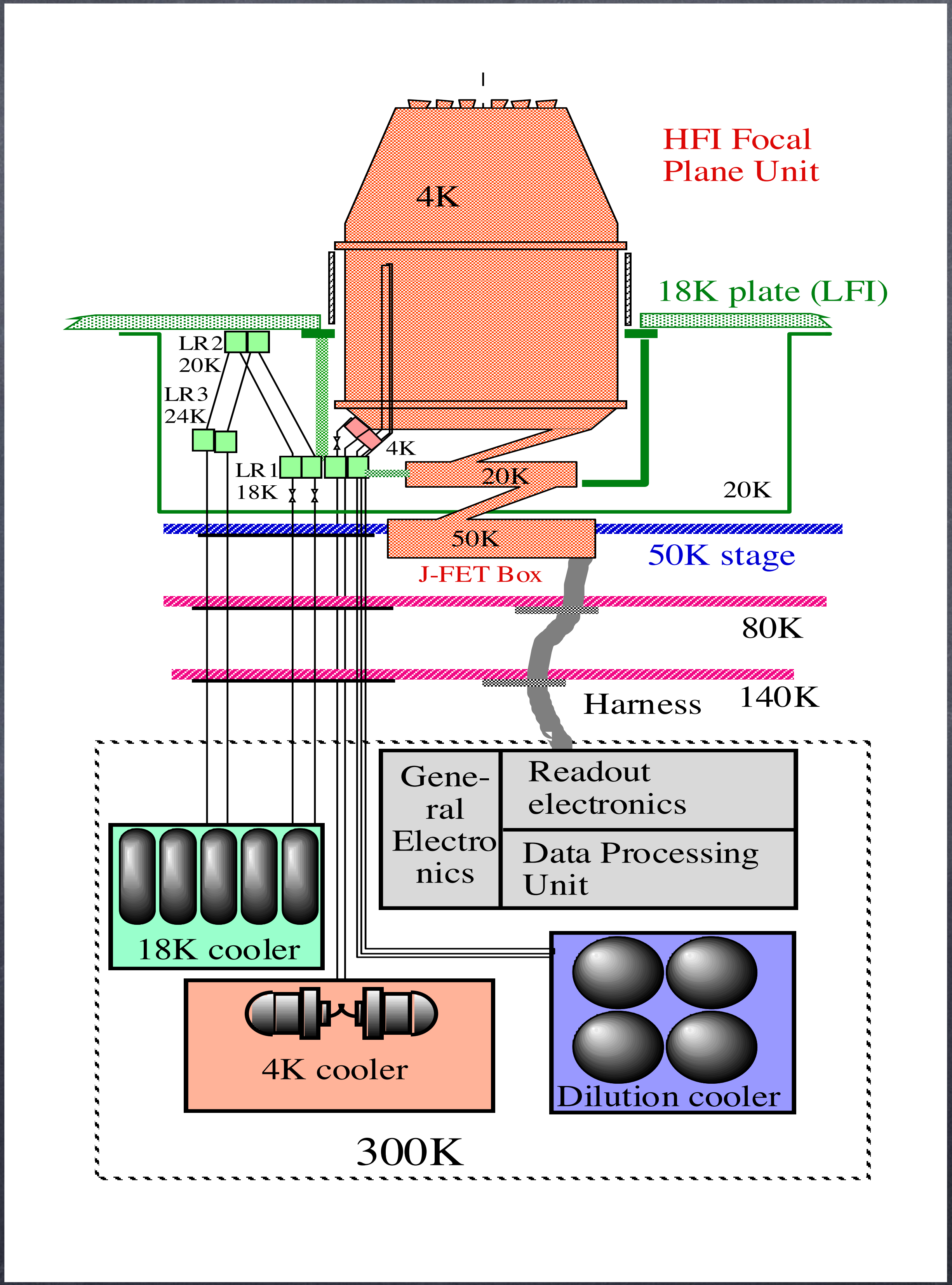
The telescope



- Hors-axe gregorian telescope
- 1.5 m diameter
- 2 reflectors
- Works at 50 K
- Minimize instrumental polarization

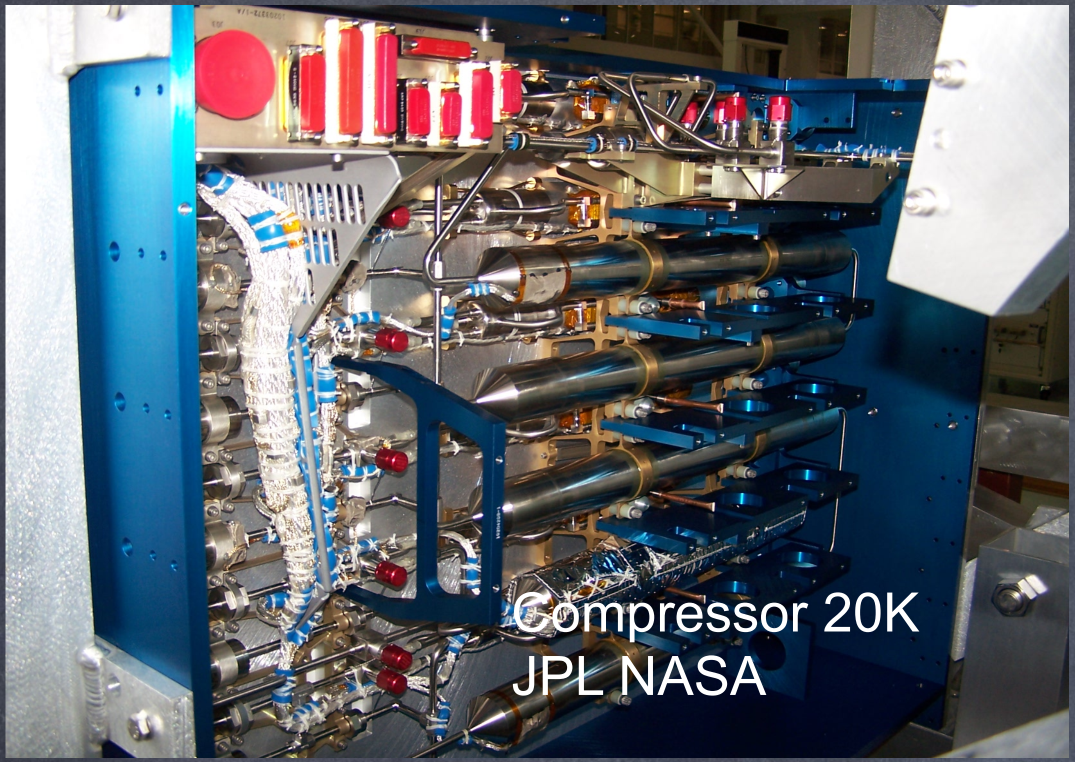
Active cryogenic system

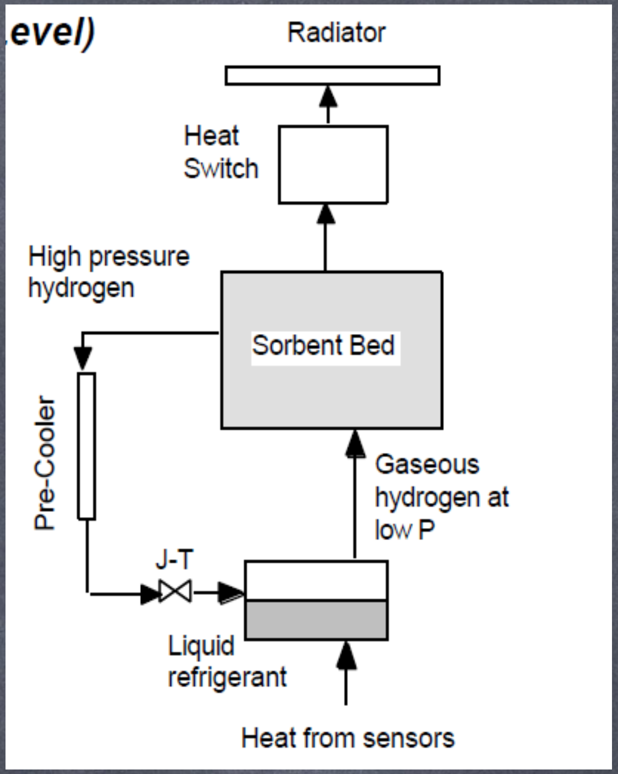
LFI @ 18 K - HFI @ 0.1 K

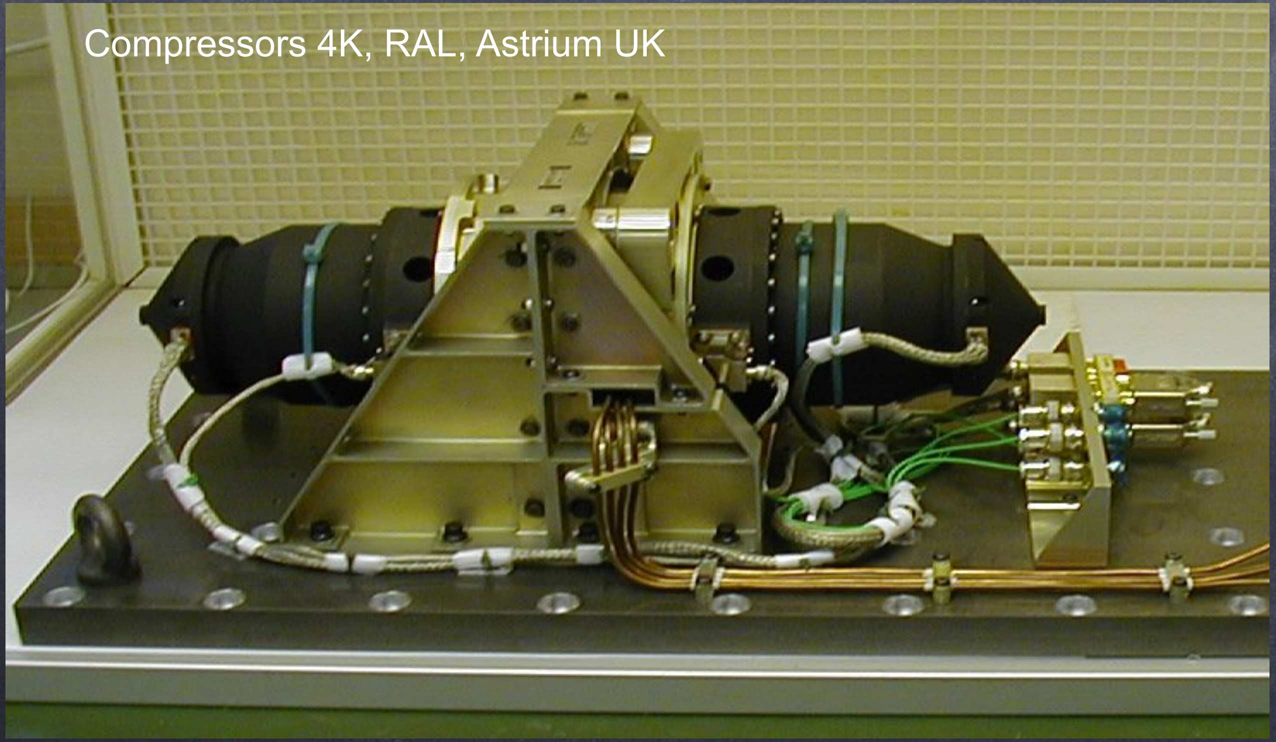


Cryogenic system

Sorption cooler 20 K

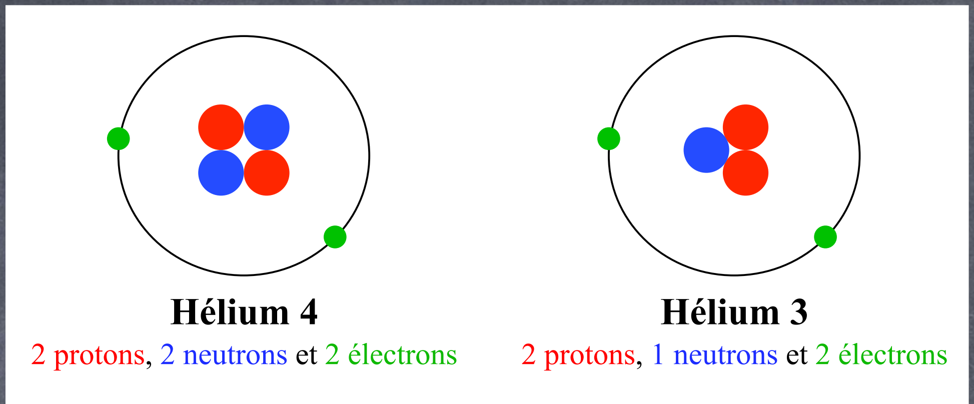




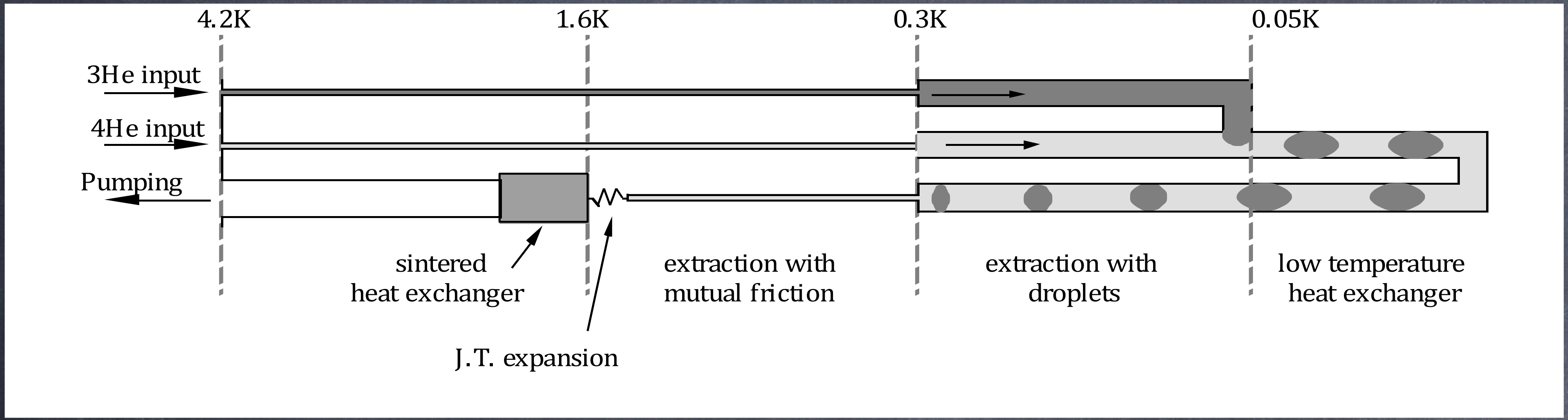


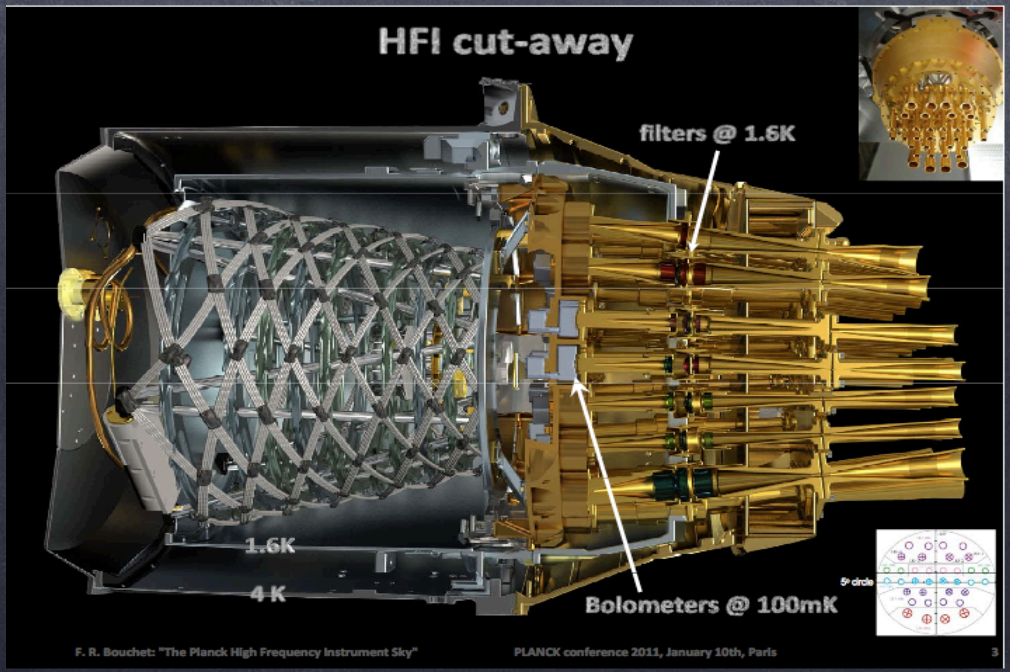
Dilution

He has 2 isotopes
He keeps liquid at 0 K

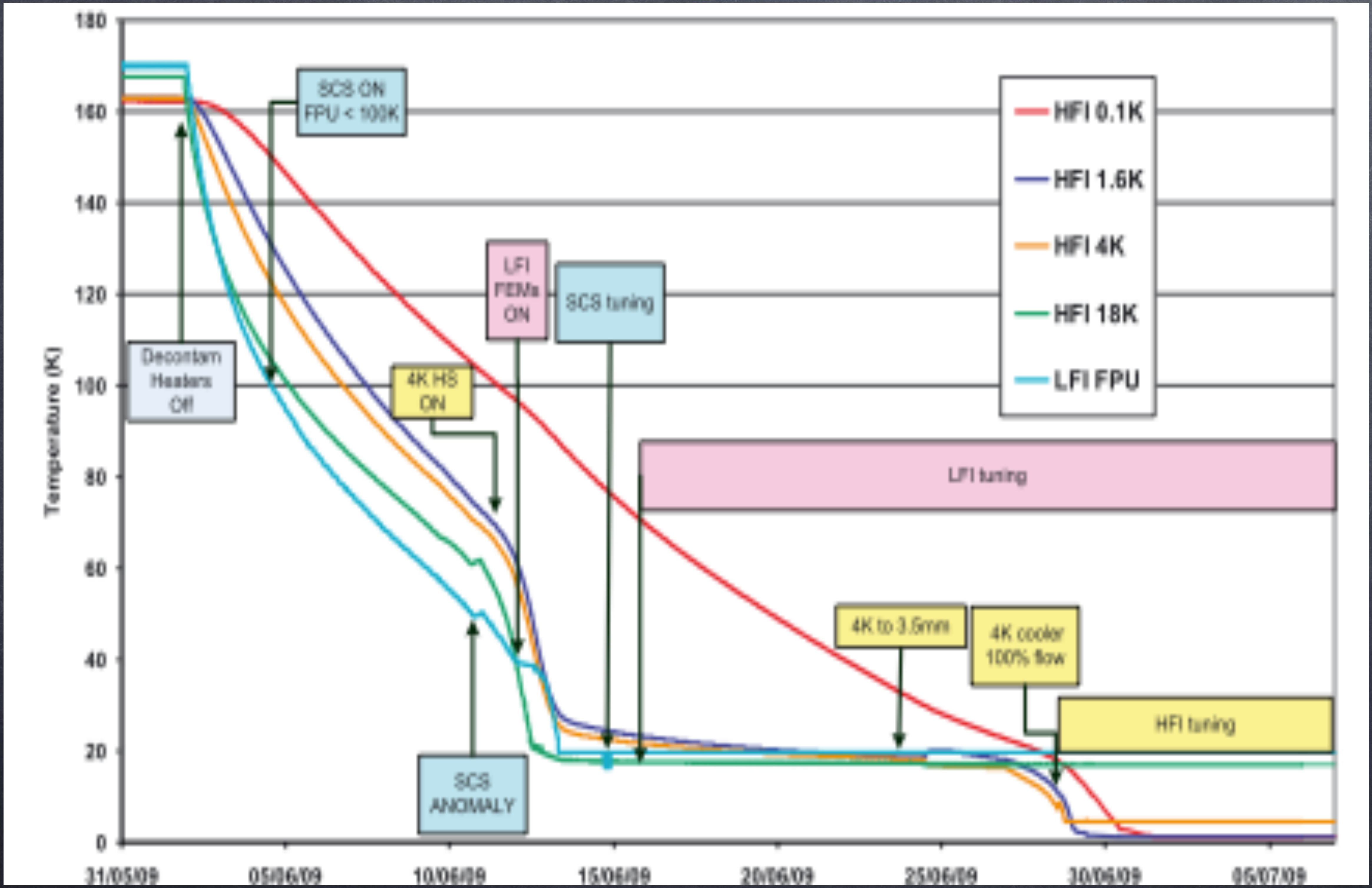


Spacial 3He-4He dilution (Benoit et al.)

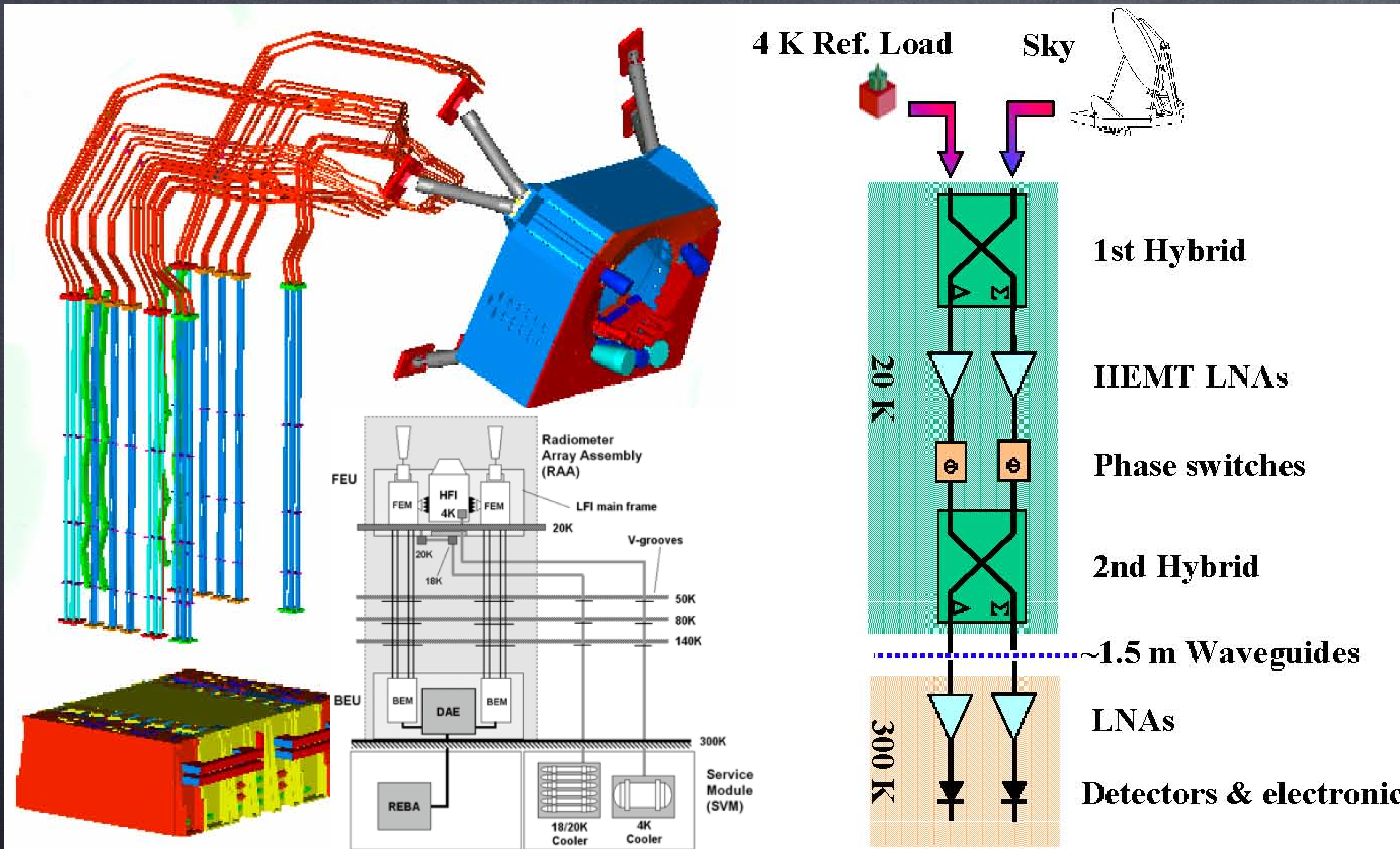




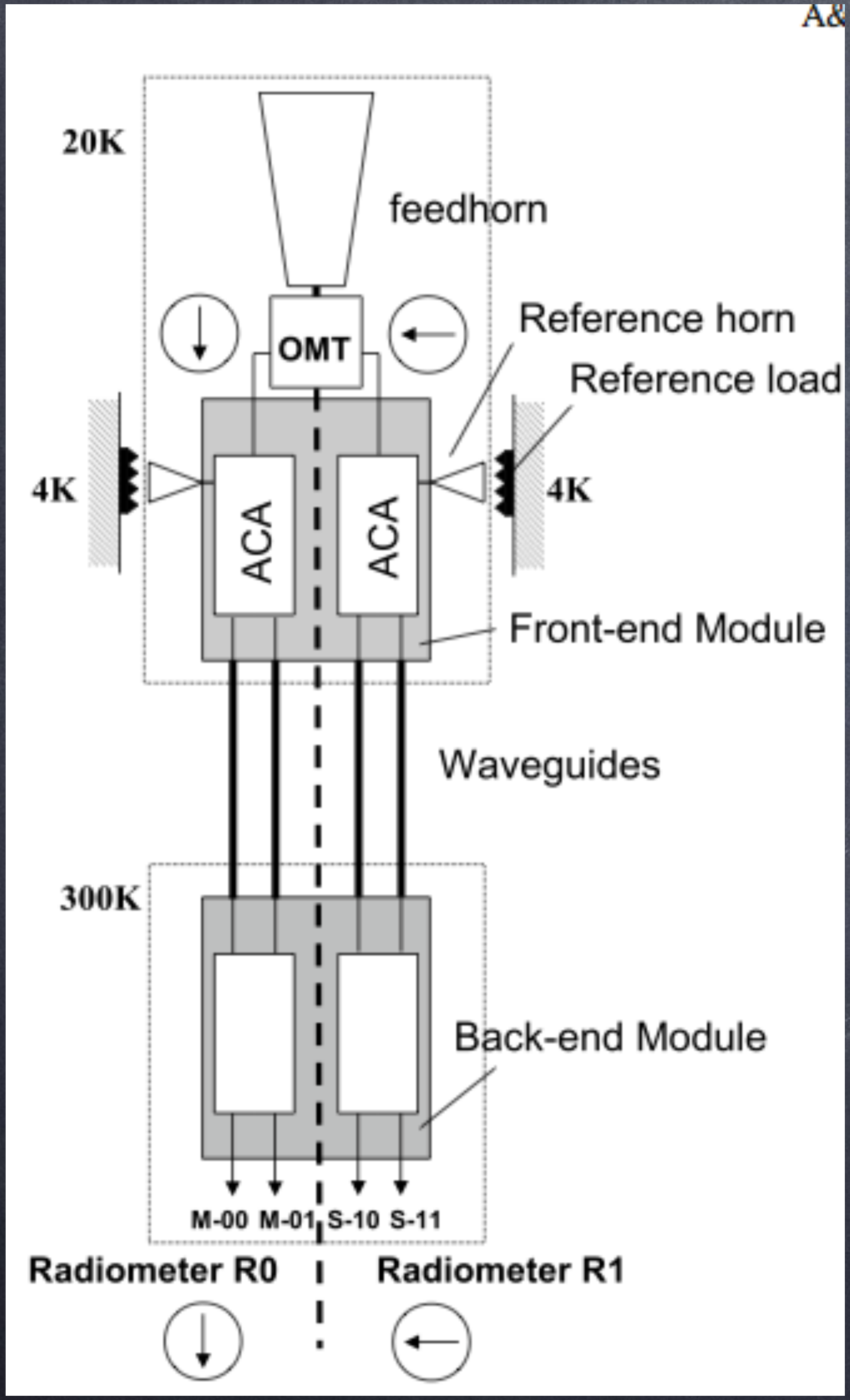
Planck cooling down

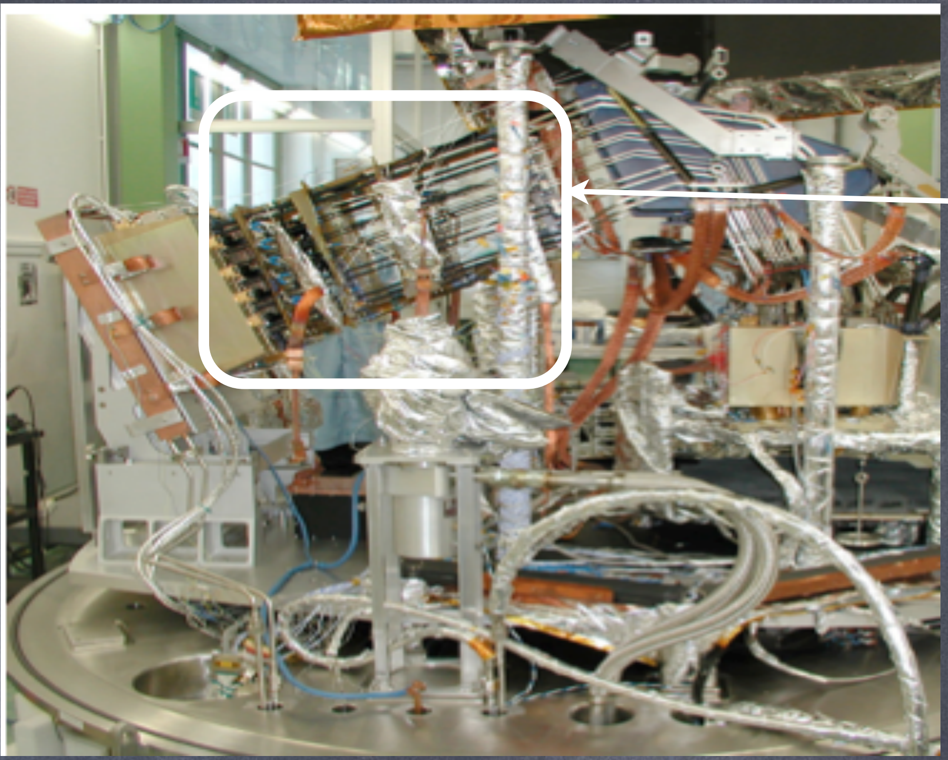


LFI instrument

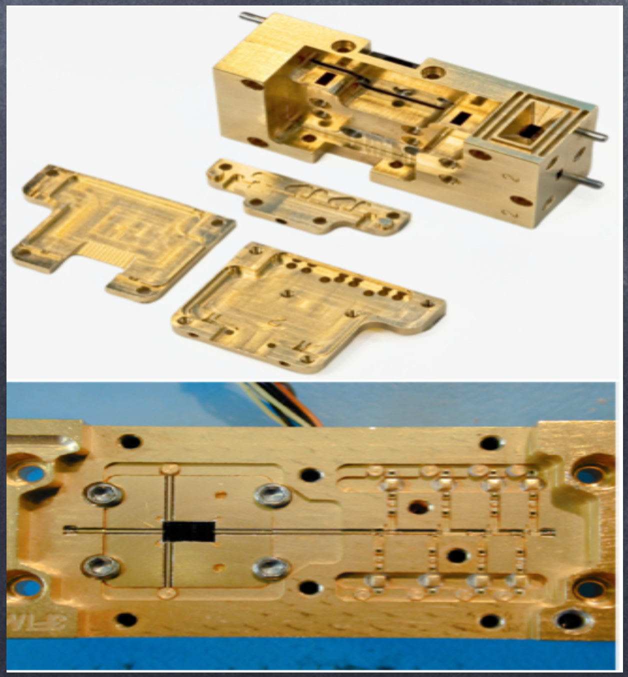


LFI instrument

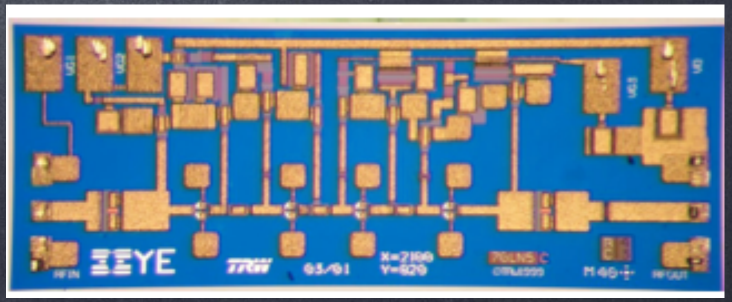




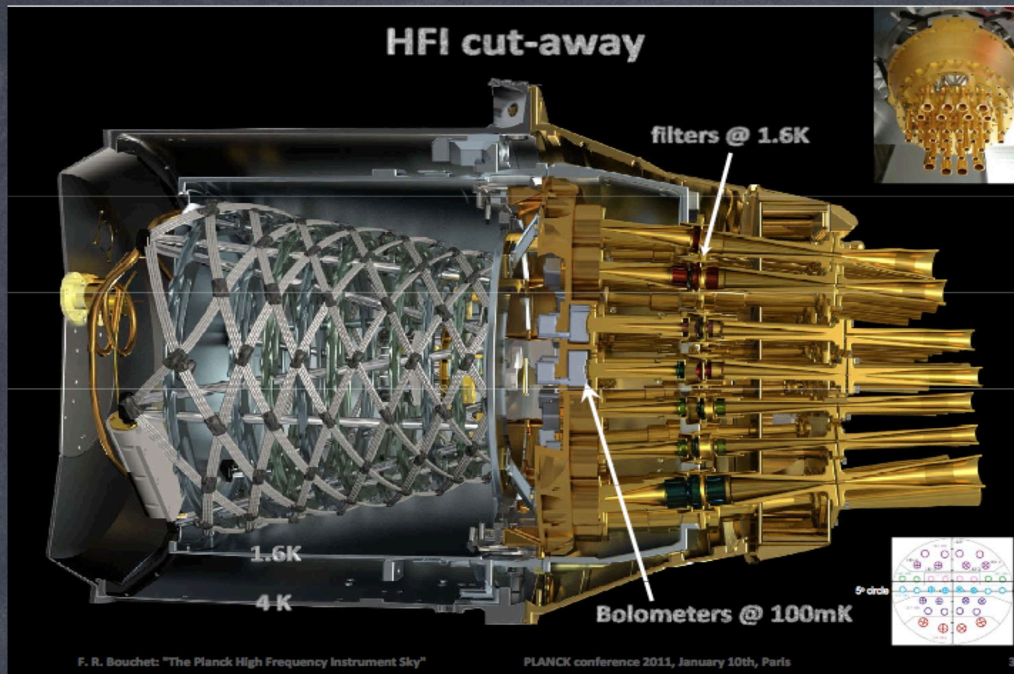
Waveguides

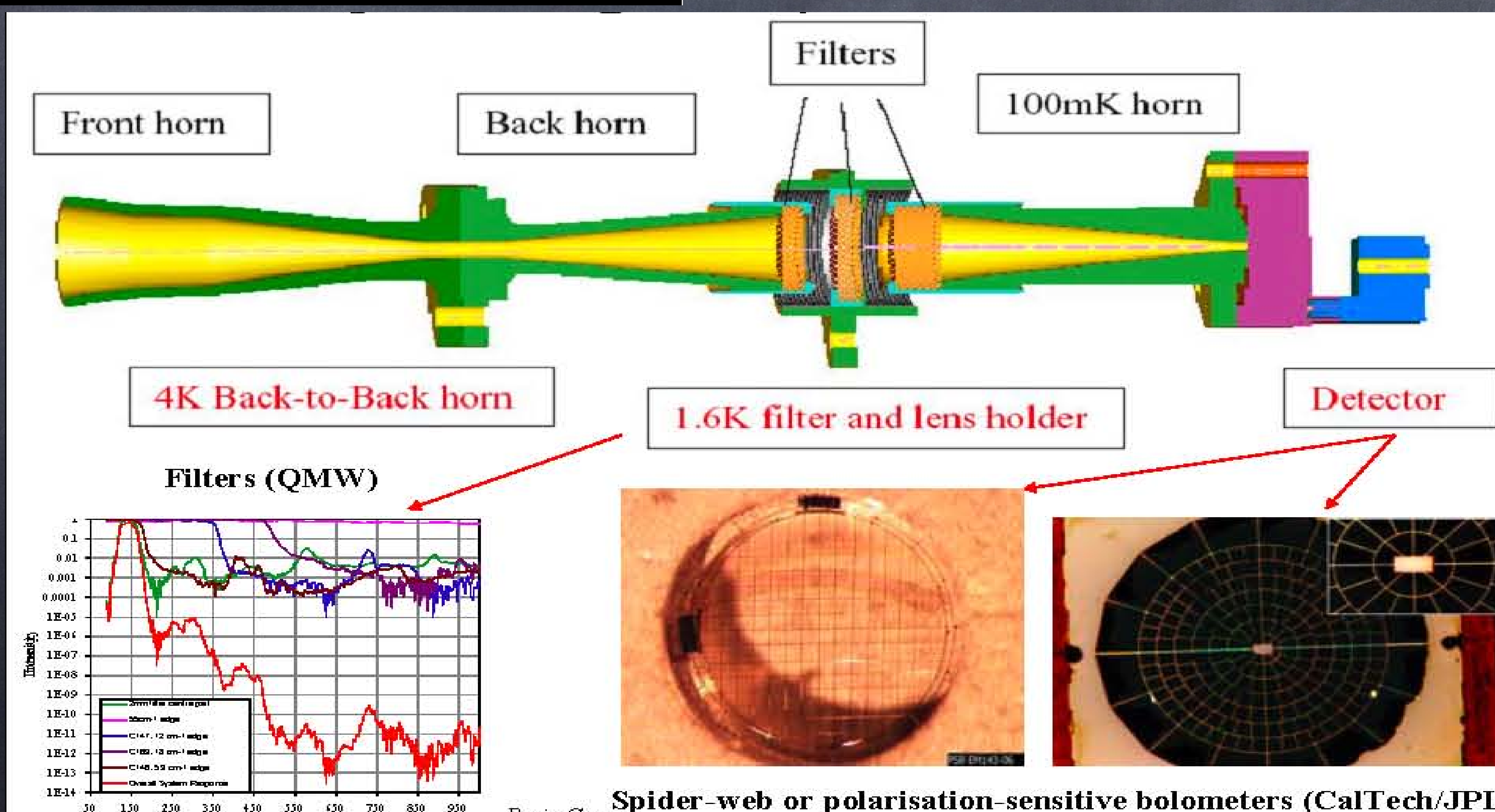


Low Noise amplifier

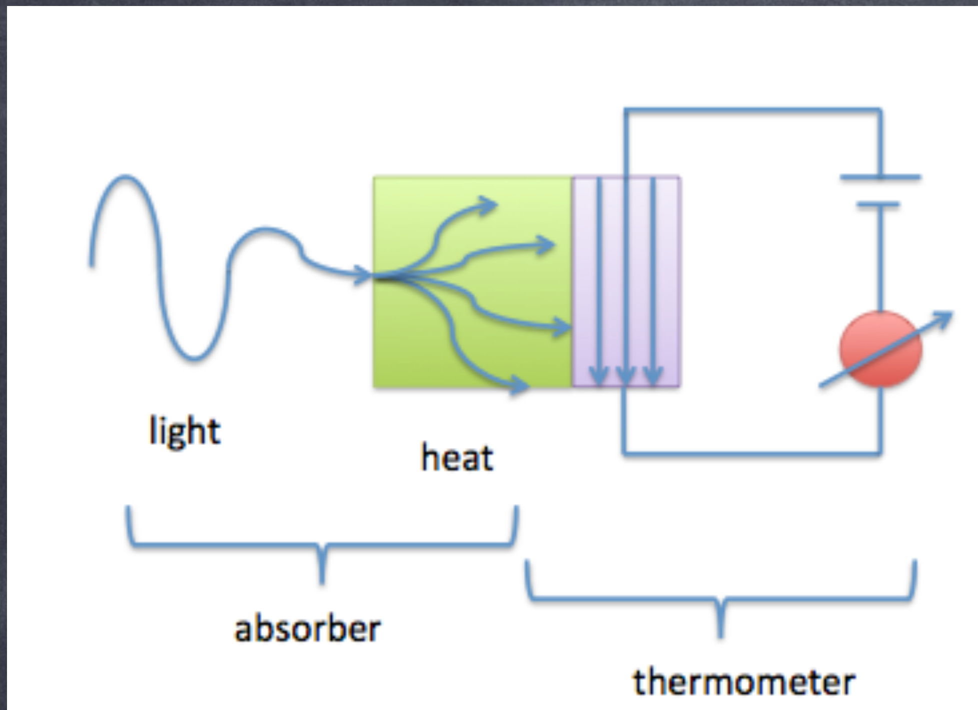


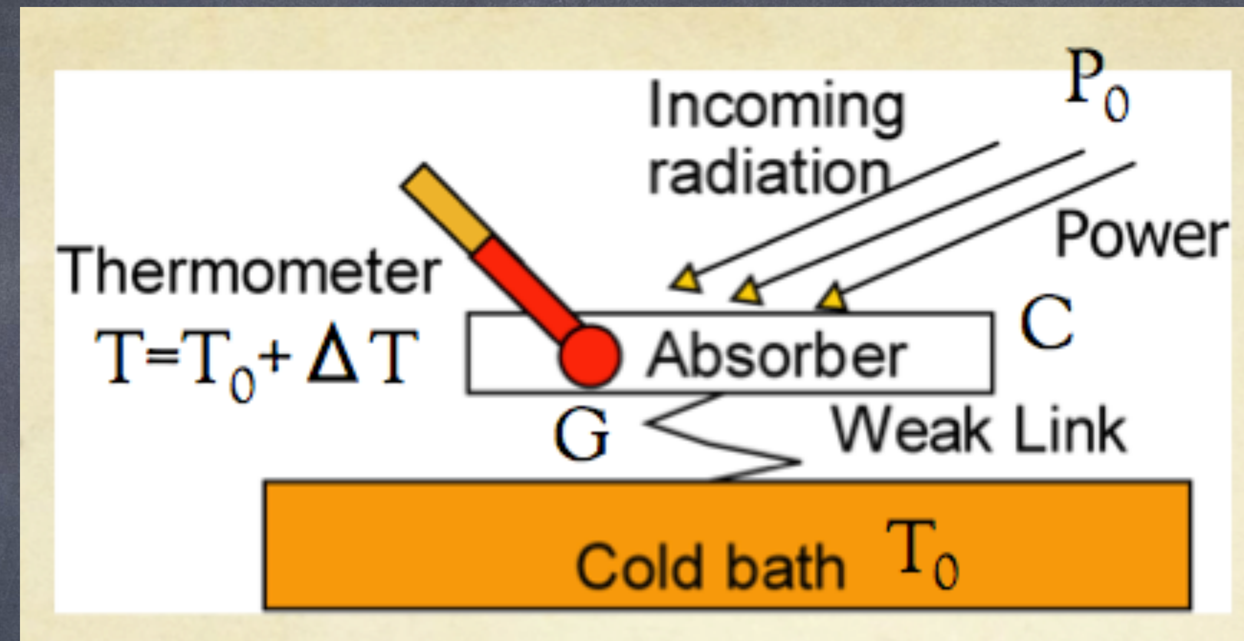
HFI instrument





Bolometers in a nutshell



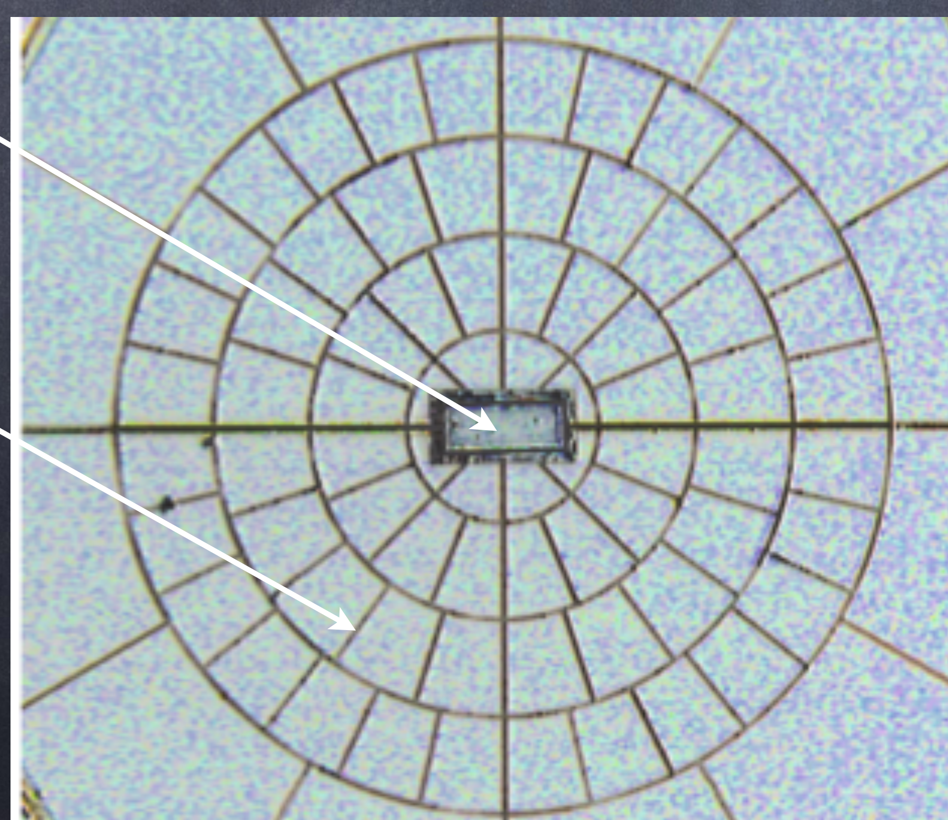


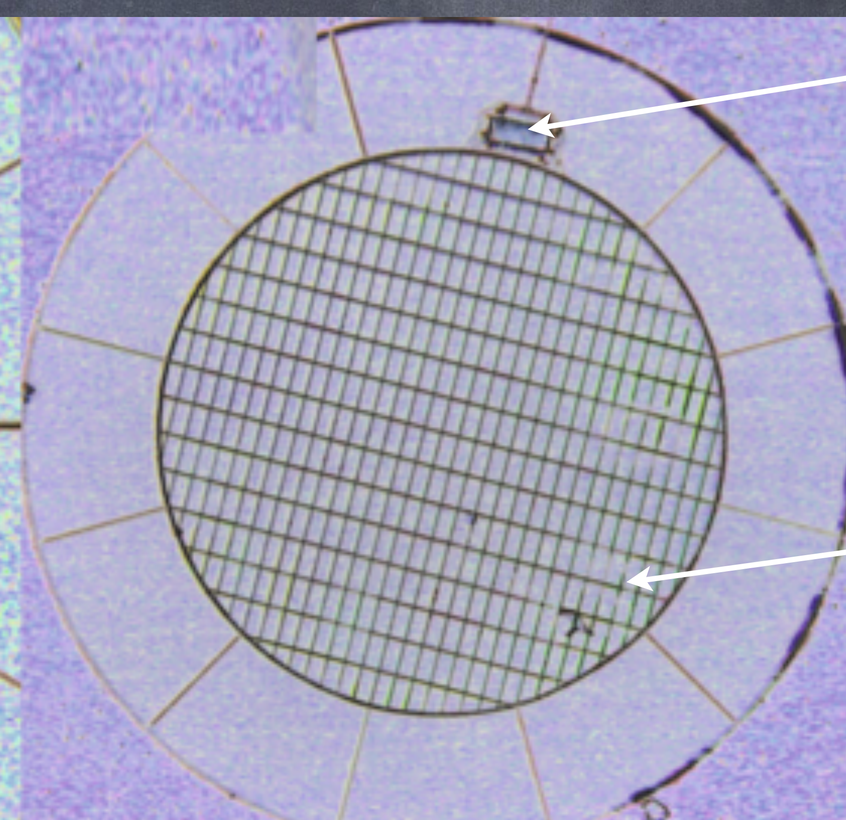
Spider web bolometers

Polarised Sensitive Bolometers (PSB)

Thermistor

Absorbing grid





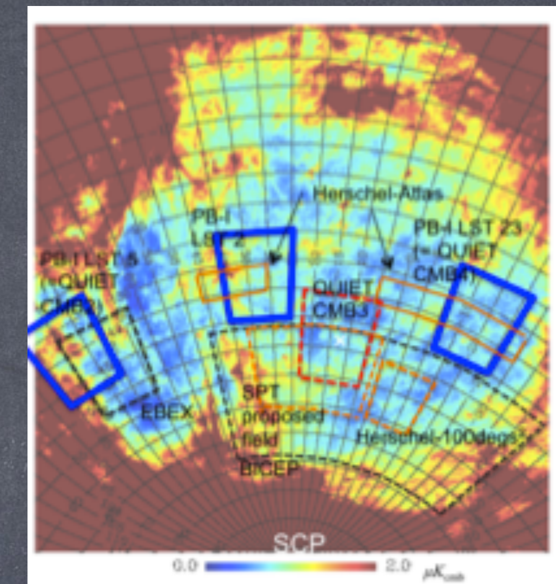
Thermistor

Absorbing grid

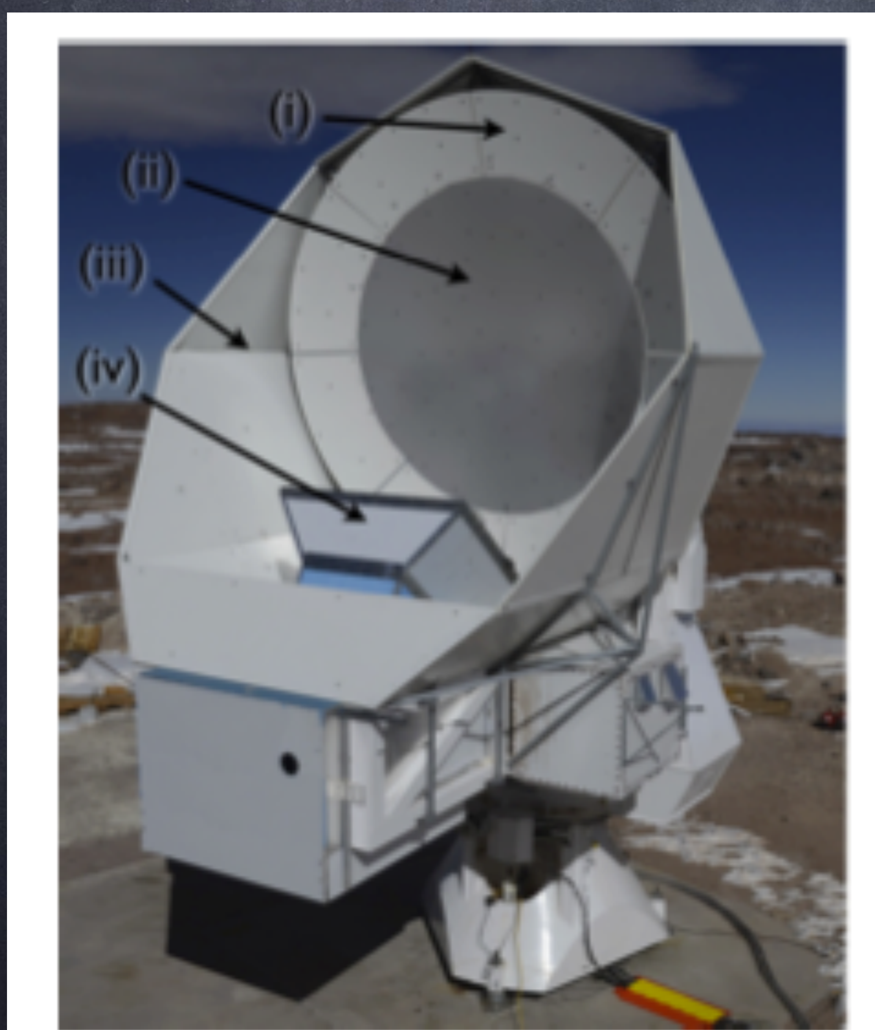
New generation of CMB experiments

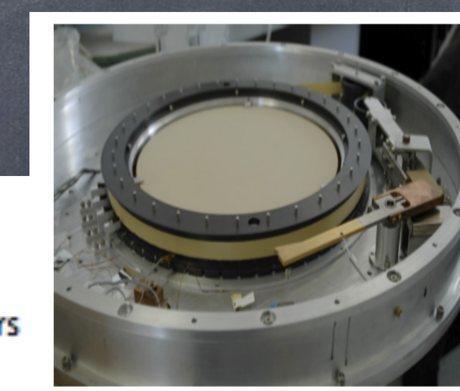
- Two main scientific objectif
  1. Measure CMB polarisation and B modes: 1 or 2 orders of magnitude in sensitivity
  2. High resolution of observation of high redshift objects: large number of compact detectors
- Current detectors photon noise limited, so need to increase the number of detectors in the FOV = arrays of detectors
- Two detector technologies are available: TES (Transition Edge Sensors) bolometers and KID (Kinetic Inductance Detectors)
- Multiplexing (reading more than one detector at the same time) is the key thing

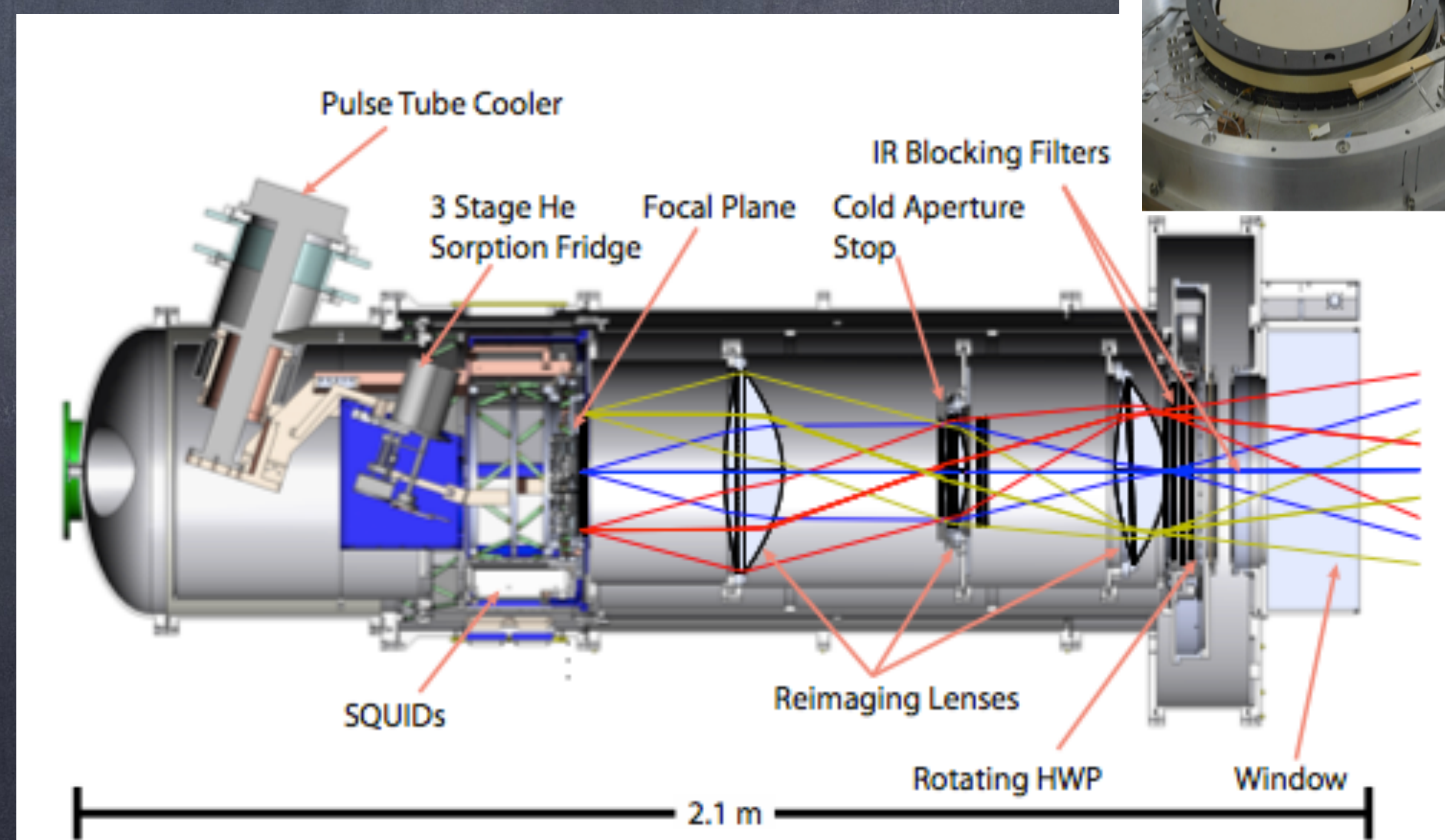
Polarbear experiment



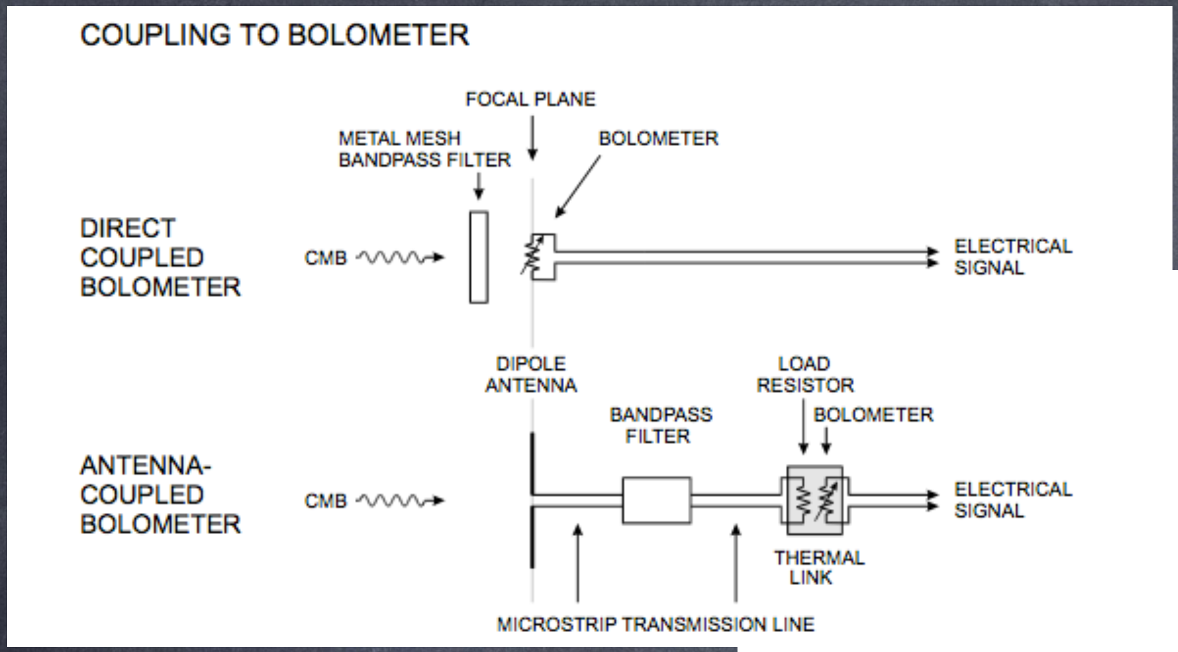
- Designed to measure B-modes CMB polarization
- 3.5 arcmin resolution up to several degrees (fsky = 0.1)
- few thousands TES at 150 GHz and operated at 250 mK
- Operated at the Atacama desert in Chile

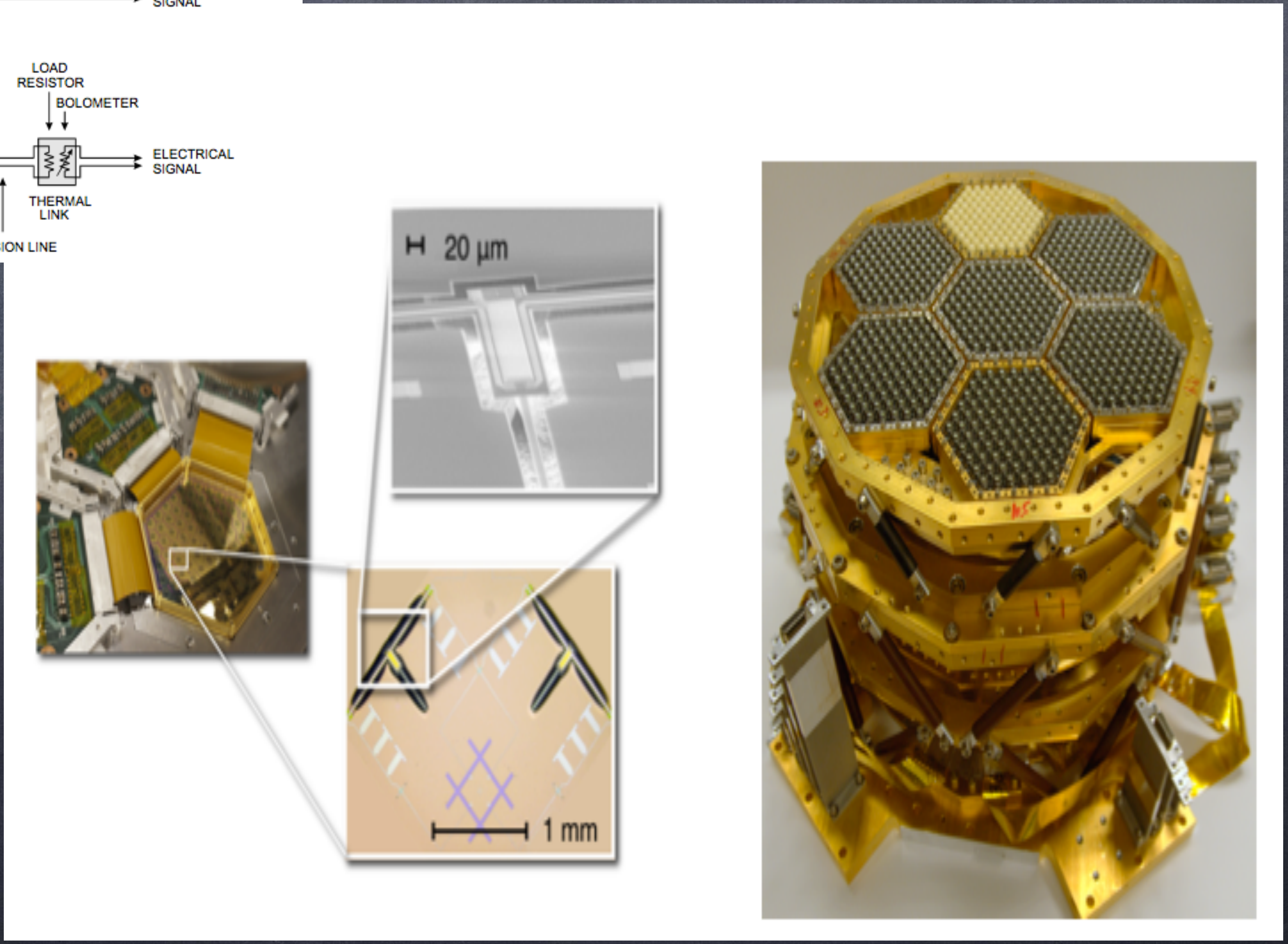






Antenna coupled TES detectors

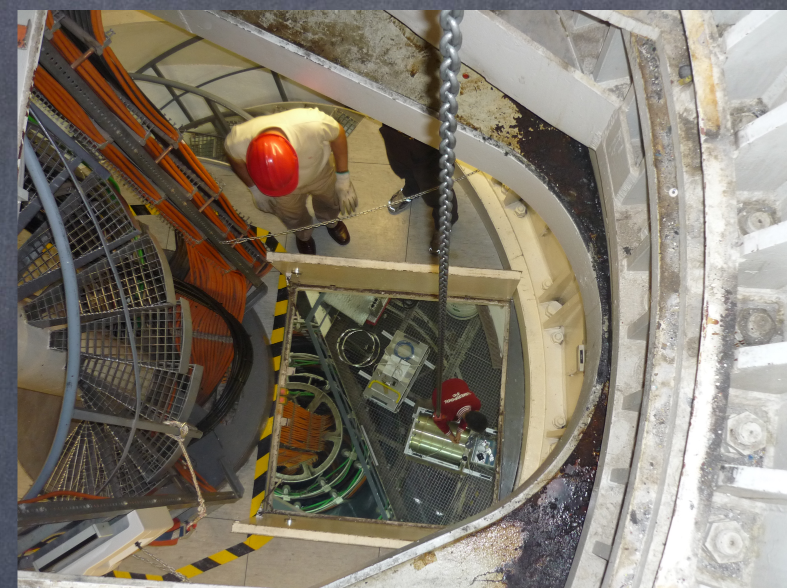




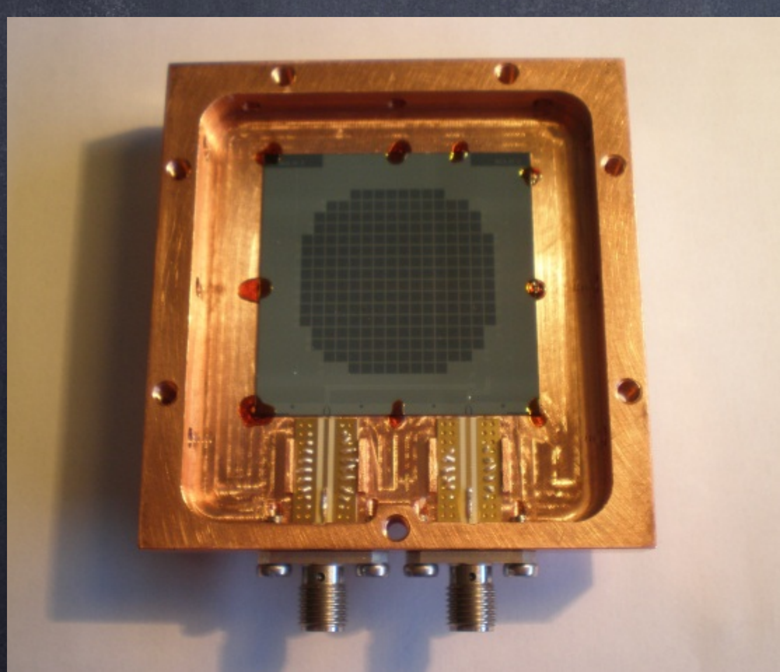
NIKA experiment

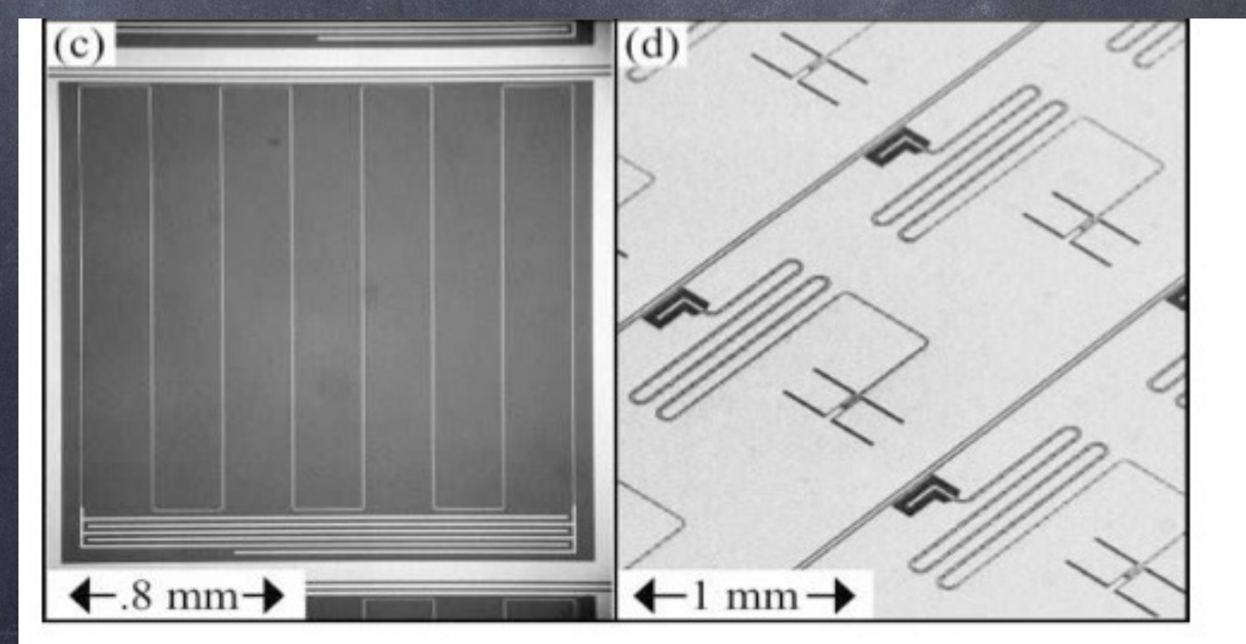
- High resolution (12 arcsec) observations of the SZ effect with the IRAM 30 m telescope
- Dual band camera of KIDs at 140 and 240 GHz operated at 100 mK
- Small patches on the sky (FOV 6.5 arcmin)

3He-4He Dilution cryostat



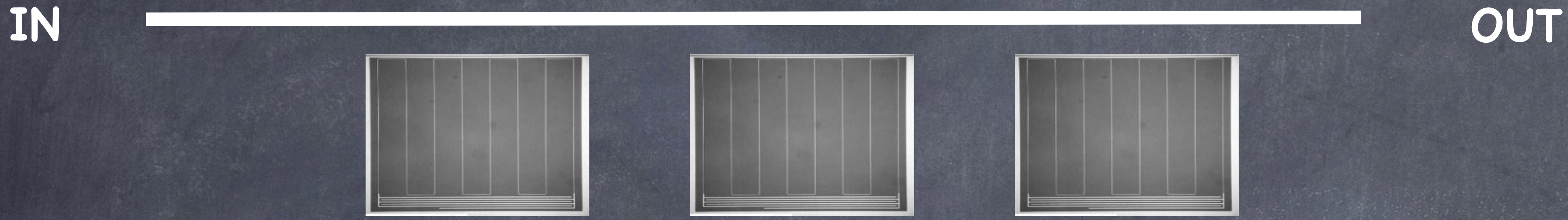
Array of 224 KIDs

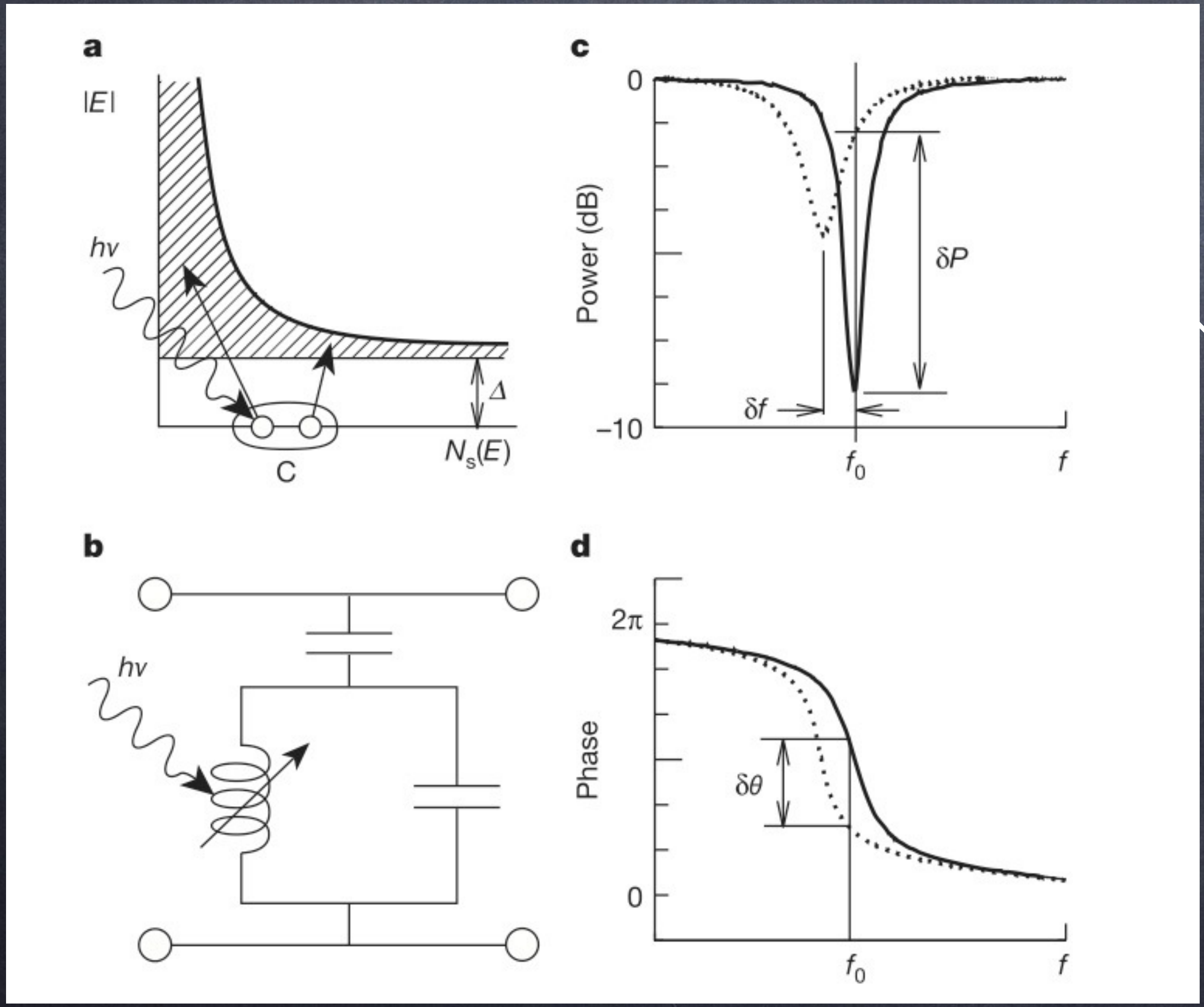




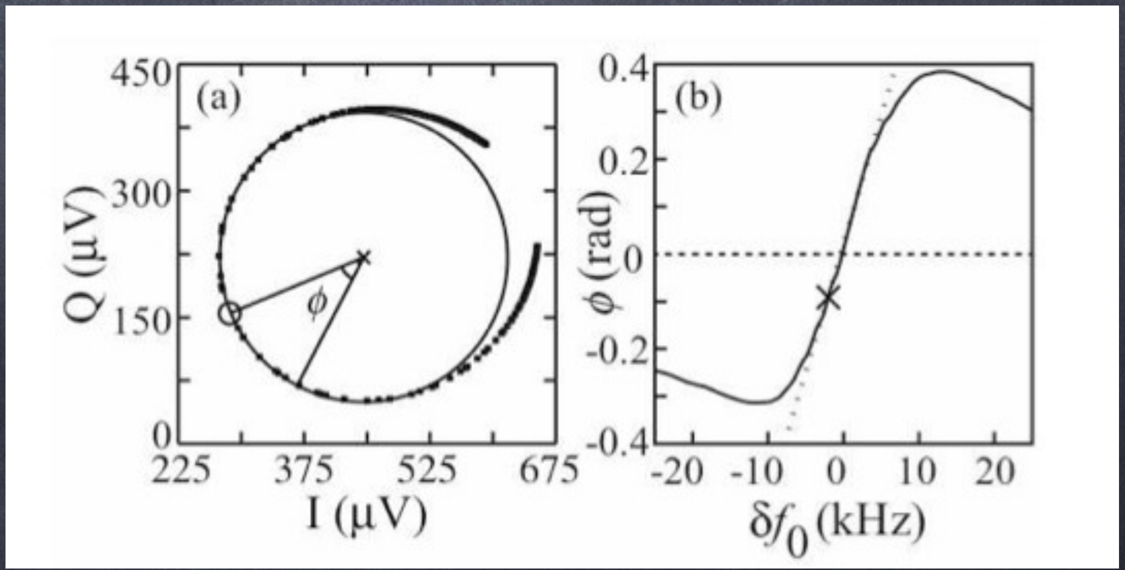
KIDs in a nutshell

Superconducting Microwave Resonators coupled to a feed line





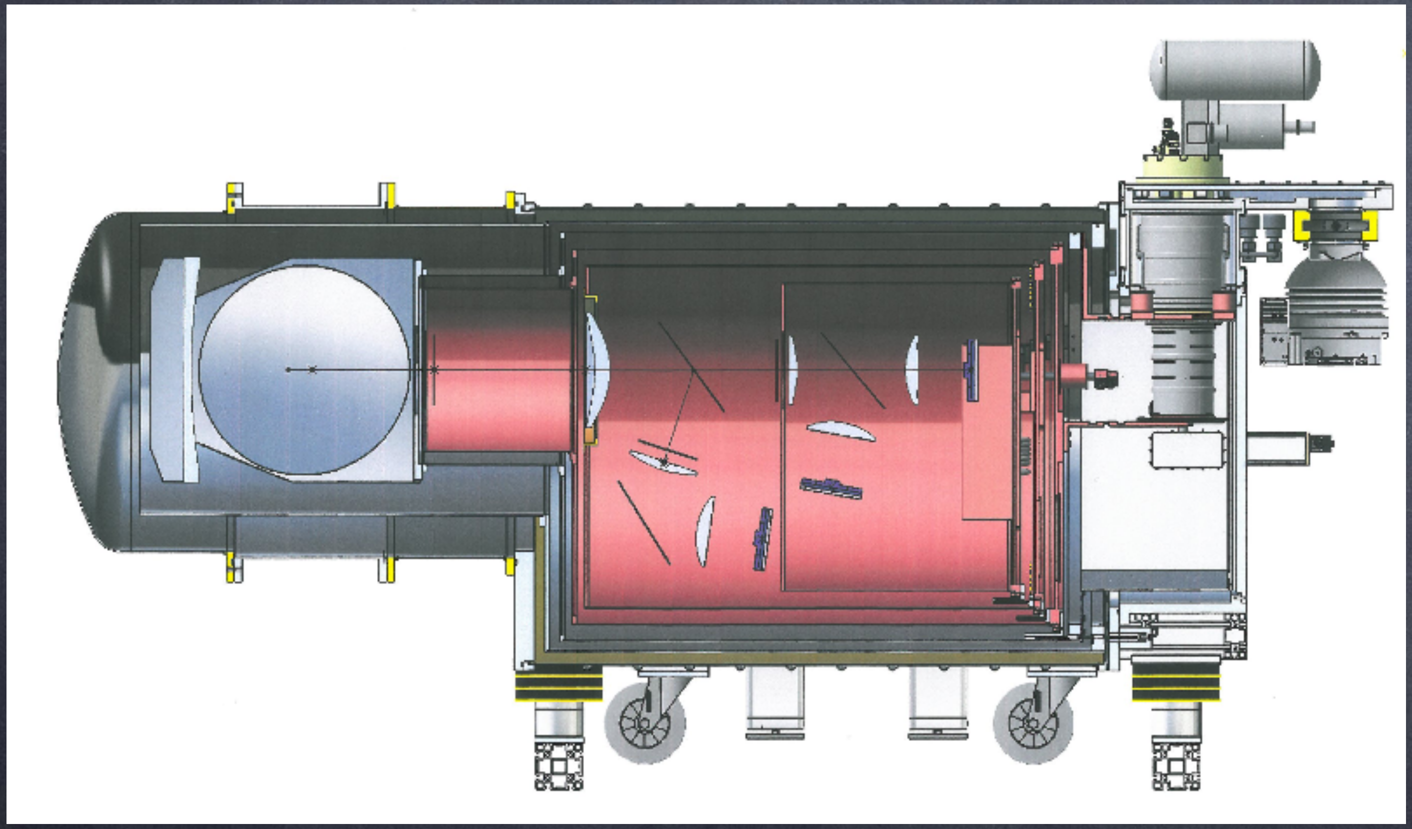
Resonance frequency changes with received power



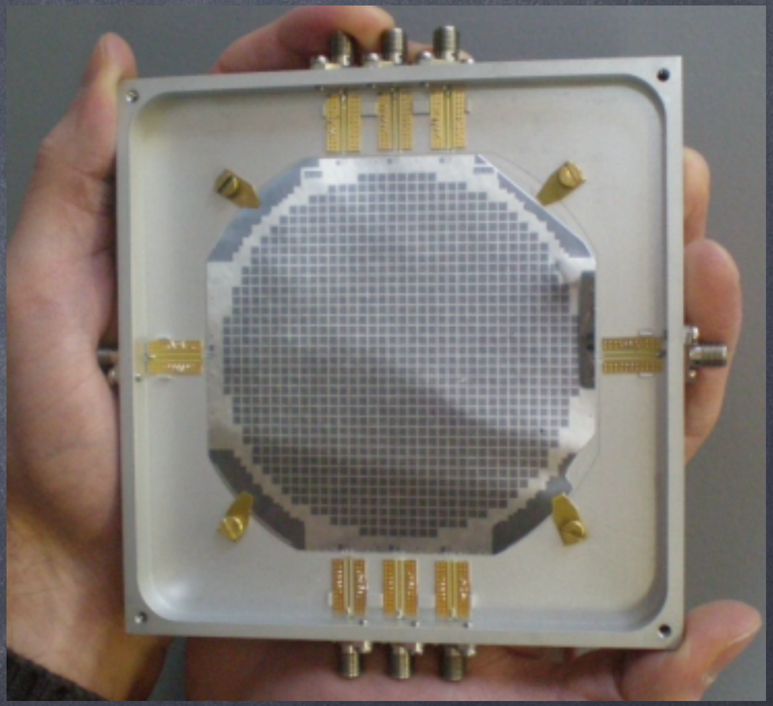
NIKA2 experiment

Upgrade version of NIKA to be installed in 2015

BIG 3He-4He dilution cryostat



Array of 1024 KIDs



Your own experiment

Think about:

Primary Scientific goal
Resolution
Sensitivity
Observation frequency (how many)
Time of observation
Type of experiment (ground, balloon, satellite)
Observation time
Detector technology
Cooling system