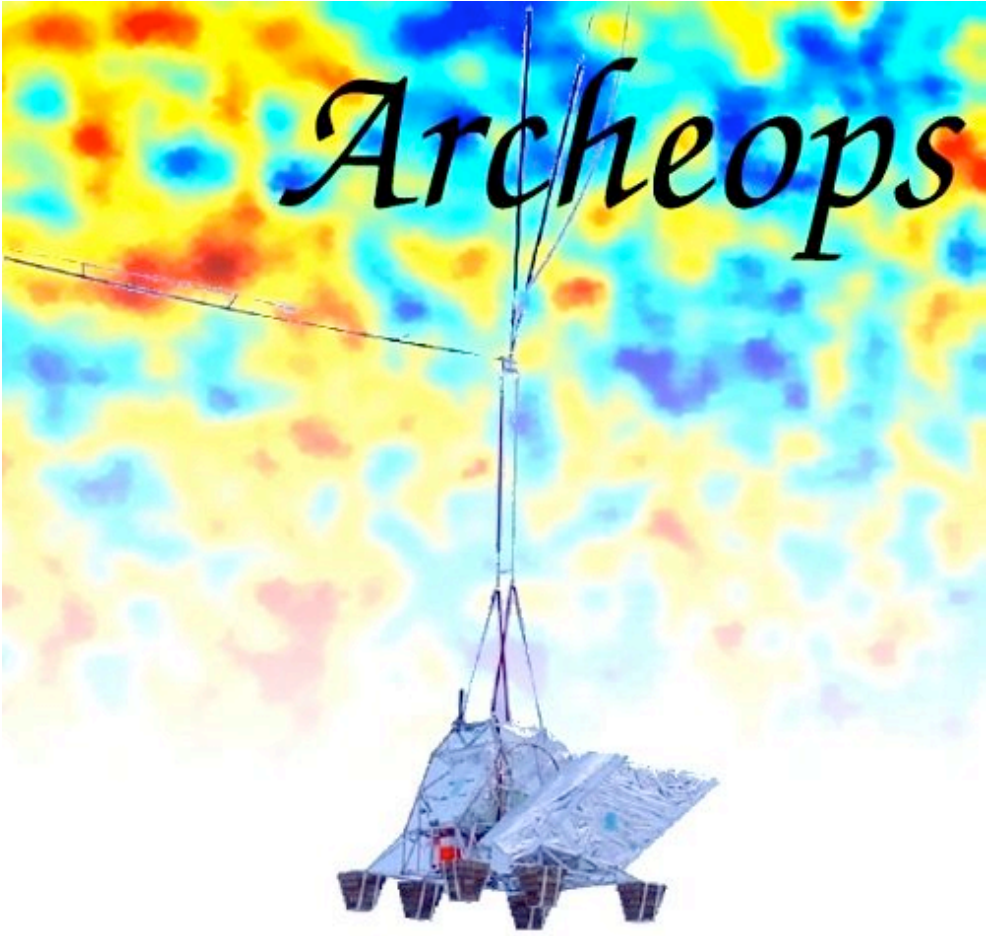


PI: Alain **Benoit** (Grenoble)

FRANCE

LPSC, CRTBT, LAOG (Grenoble), IAS, LAL, (Orsay), SPP-Saclay, IAP, CDF (Paris), CESR, LATT (Toulouse)

ITALY

Univ. La Sapienza (Roma), IROE-CNR (Firenze)

UK

Cardiff Astrophysics Group

USA

CALTECH, JPL, University of Minnesota

RUSSIA

Landau inst. theoretical physics

And also,

CNES

www.archeops.org

Archeops

main points

- Same concept as Planck HFI
  - Off-axis Gregorian telescope
  - Spider web bolometers at 100 mK

→ Testbed for Planck

- Large sky coverage : 30%
  - Large circles on the sky during night-time
  - 19 hour flight during Arctic night

→ Constraints on low ℓ (>10)

- High angular resolution
  - 10-12 arcmin

→ Constraints on high ℓ (<700)

- Multiband photometer
  - 22 bolometers
  - 4 frequency bands : 143, 217, 353, 545 GHz

→ Good redundancy foreground sep.

- Polarized 353 GHz Channel

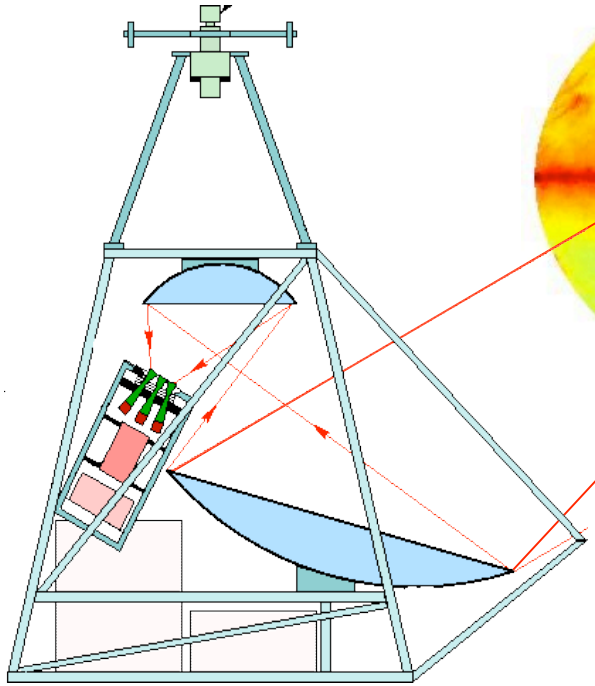
→ Polarized Foregrounds

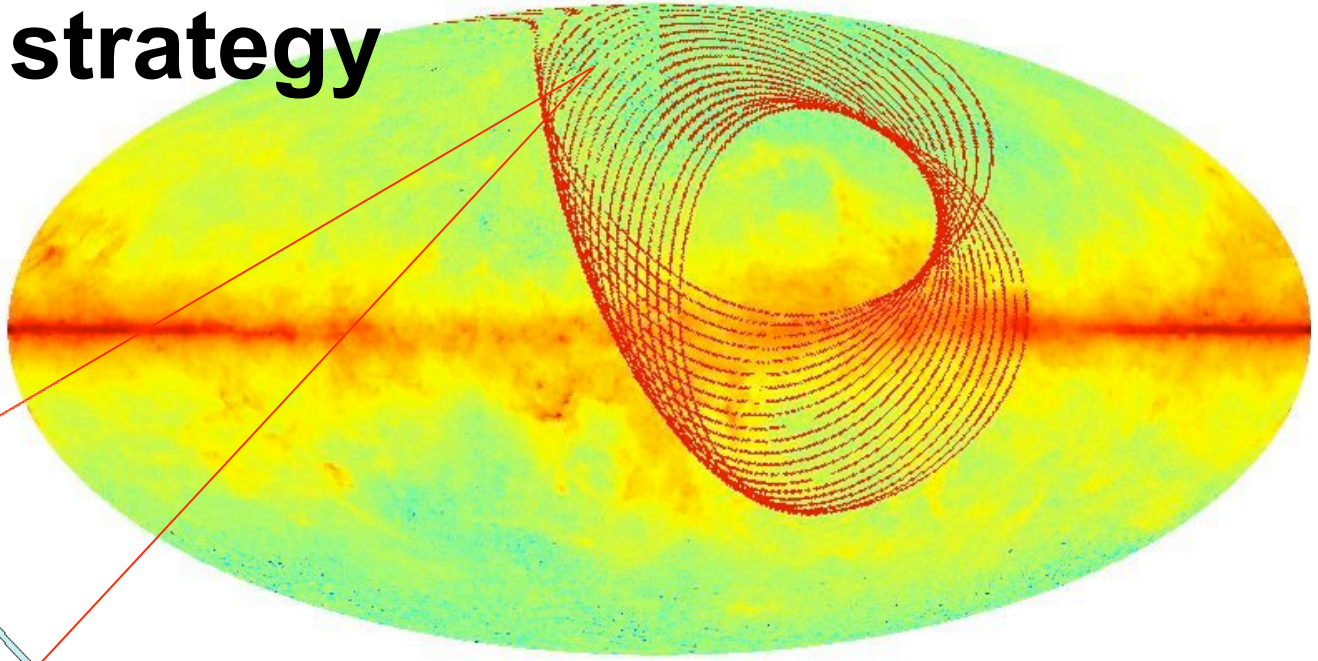
Archeops
flights

Flight	Trapani	KS1	KS2	KS3
date	july 1999	jan 2001	jan 2002	feb 2002
duration	4h	7.5h	2h	12h
location	Trapani (Italy)	Kiruna (Sweden)	Kiruna (Sweden)	Kiruna (Sweden)

scanning strategy

Planck-like





only real example of Planck Telescope being used on the sky

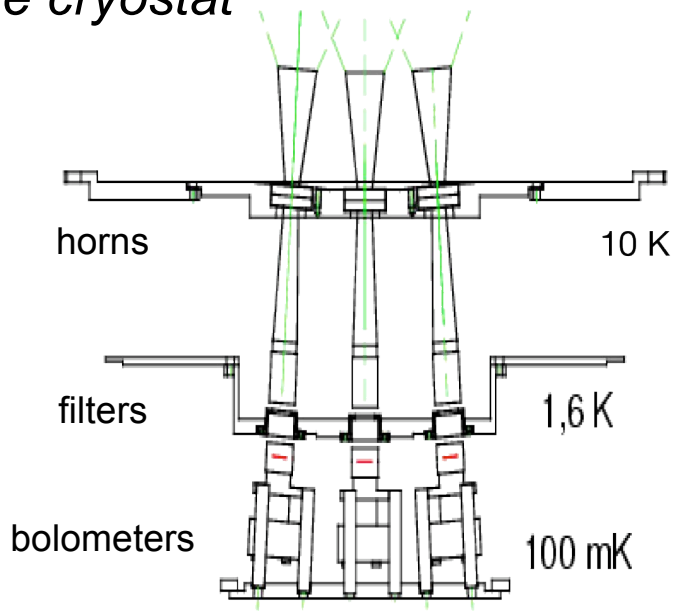
used for early tests by Alcatel (ground sidelobe measurements)

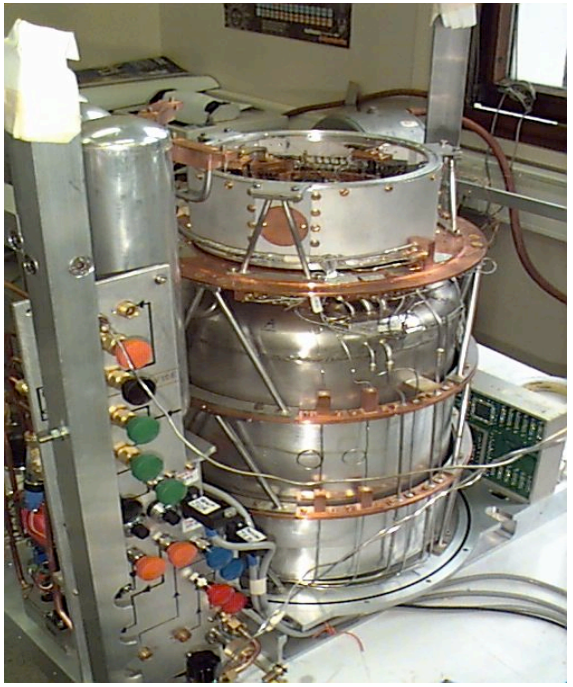
- flight during arctic night
- the optical axis sweeps the sky at 2 rpm describing large circles on the sky
- constant elevation (41°) allowing observation of Jupiter & Saturn
- ~ 30% of the sky in 12 hours
- pointing reconstruction using stellar sensor (rms < 1.2 arcmin)

instrument

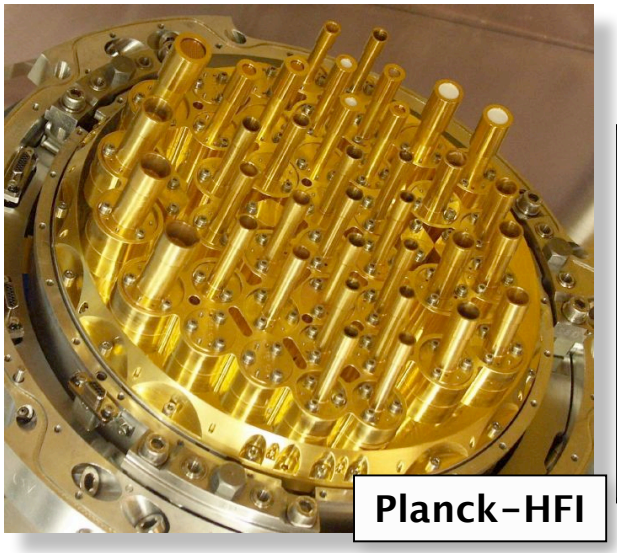
open cycle ^{3}He-^{4}He cryostat

classical He cryostat for 10 K stage
(different from Planck)





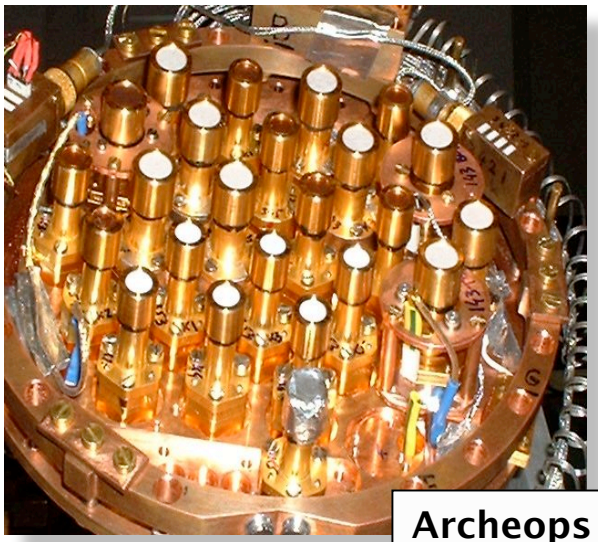
100 mK



Planck-HFI

resolution (goal) [arcmin]

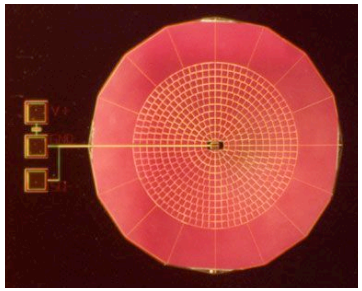
channel	Archeops	Planck-HFI
143	~12' (8')	7.1'
217	~14' (8')	5.0'
353	~12' (8')	5.0'
545	~20' (8')	5.0'

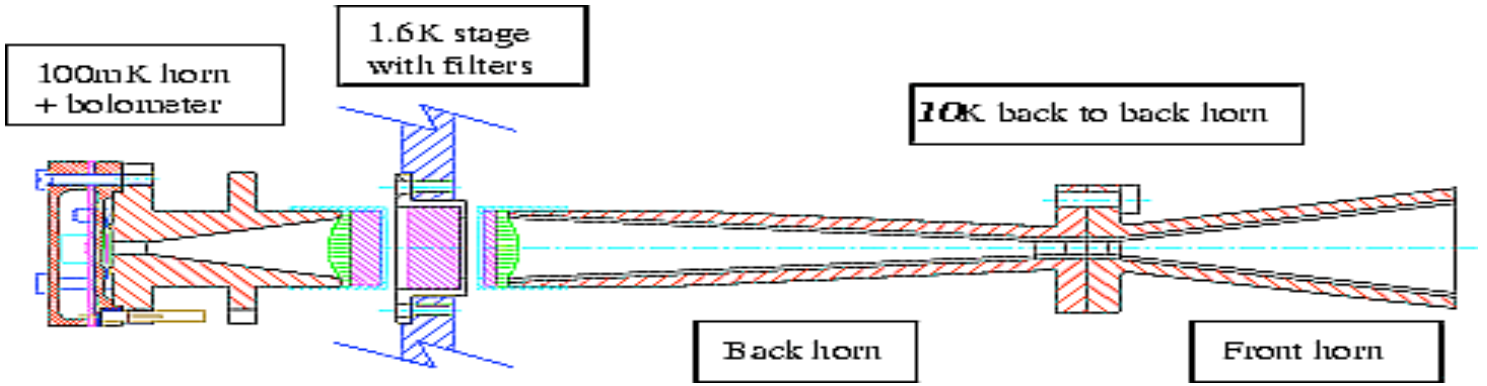


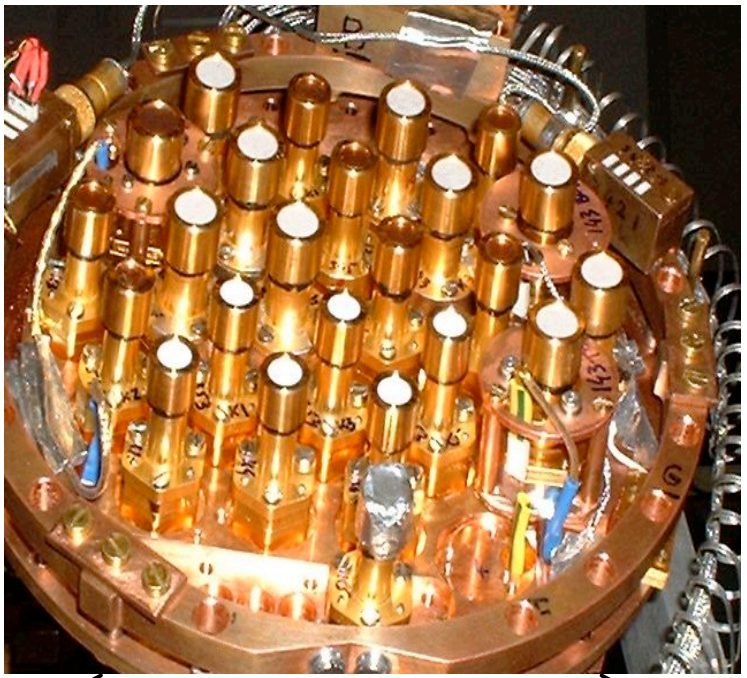
Archeops

bolometers and cold optics

clone of Planck-HFI







- Spider-web bolometers
  - 6 @ 143 GHz
  - 8 @ 217 GHz
  - 6 @ 353 GHz (OMT) polarization
  - 1 @ 545 GHz
- some 217 and 545 multimode
- 4 blind
- 7 thermometers (0.1, 1.6, 10 K)

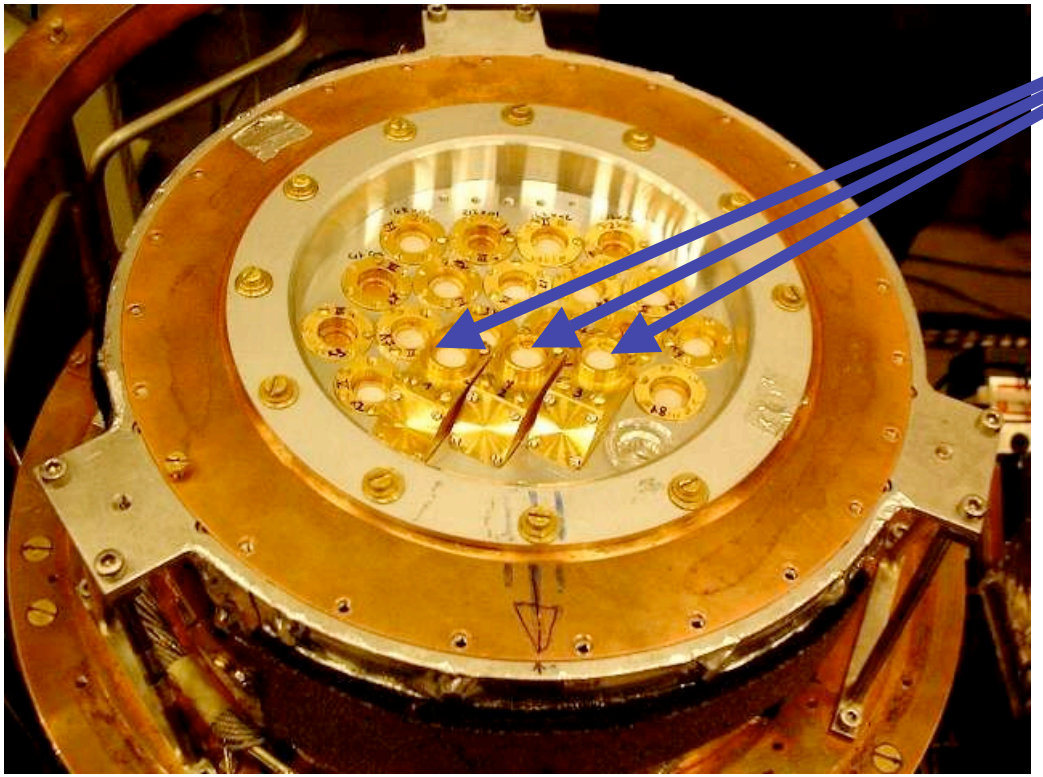
- best sensibility **90 $mK_{CMB}.s^{1/2}$**

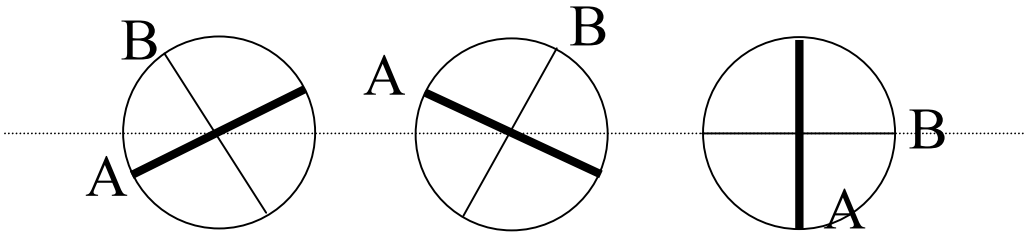
(planck-HFI requirement)

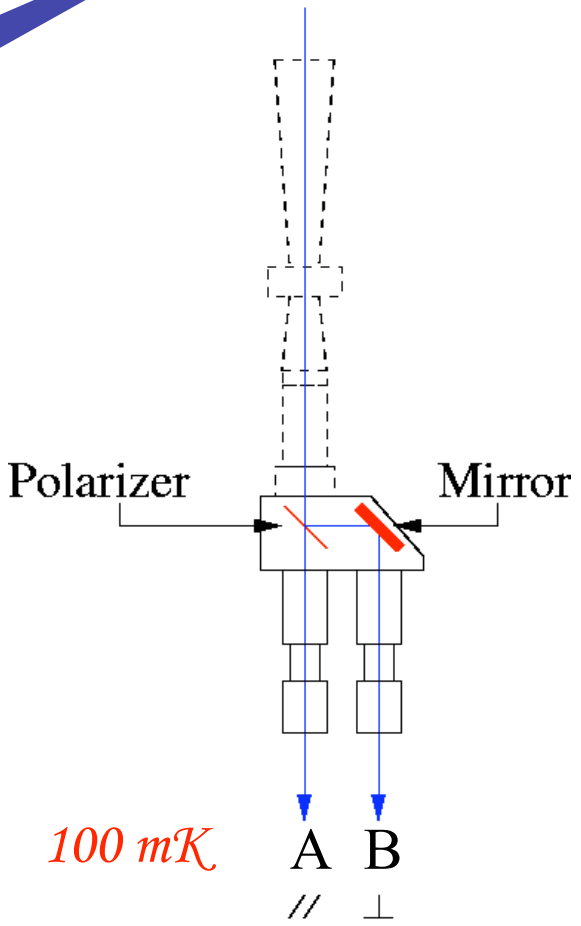
Polarized bolometers OMT

original design for Planck-HFI polarized measurements (before PSB)

353 GHz (6 = 3 OMT pairs)





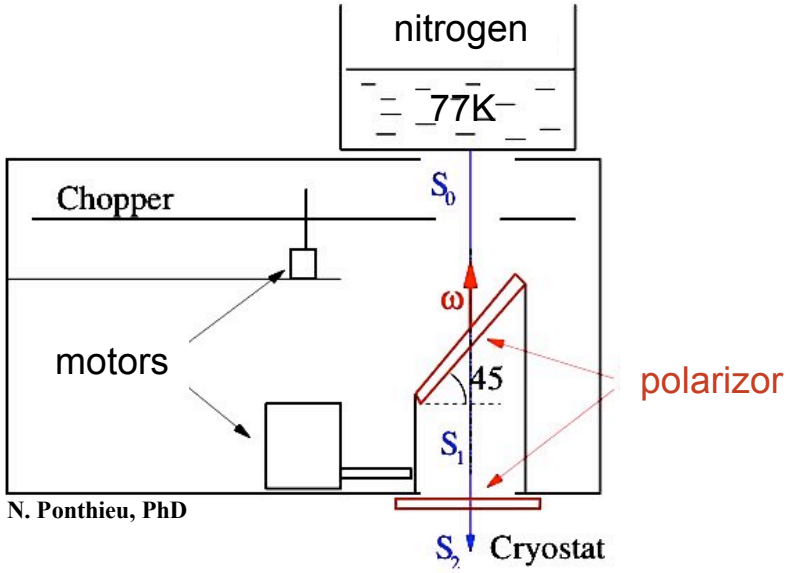


Ground-based calibration

polarized calibration

laboratory measurements

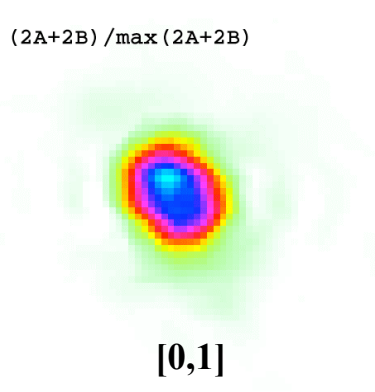
- transmission
- cross polarization (< 1%)
- angle of OMT grids determined to within 3°

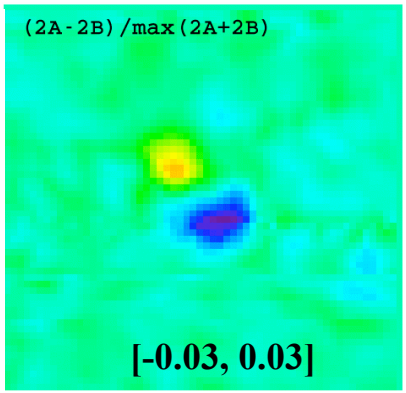


Radar Hill

linearly polarized blackbody source for an additional pre-flight polarization calibration

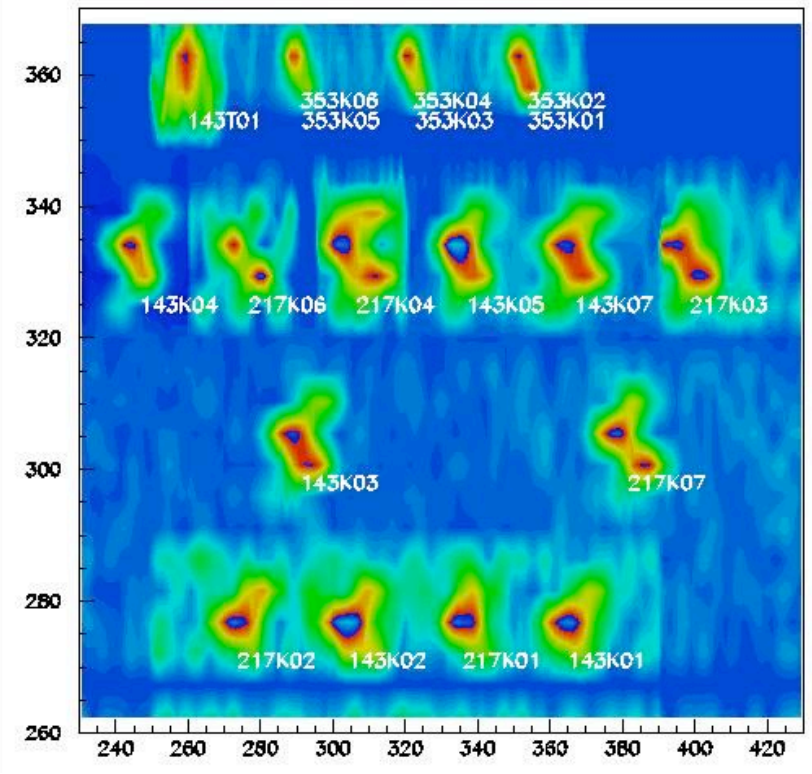
- verification of angles
- I,Q,U beams measurements (agreed within 20%)



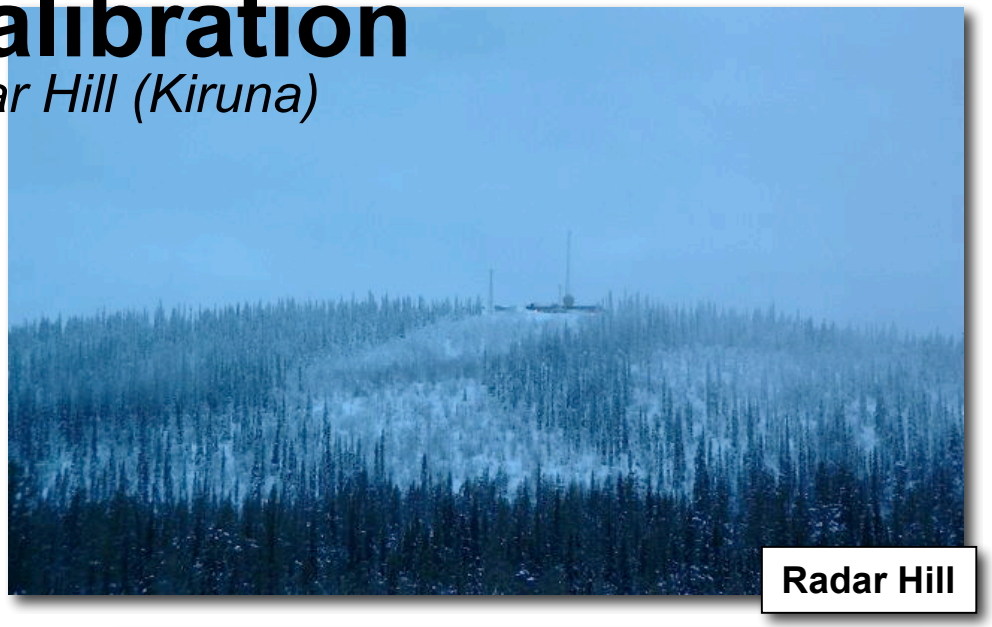


Ground-based calibration

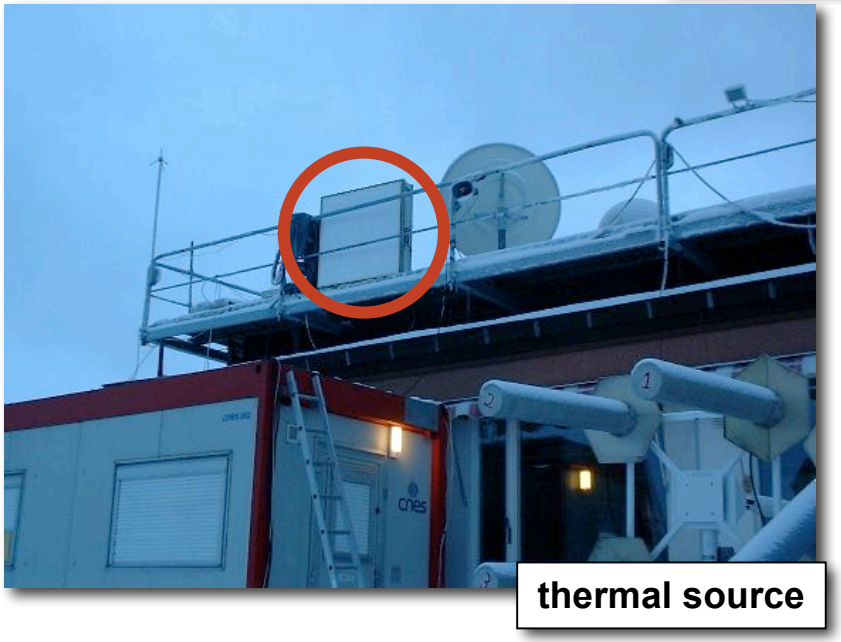
beam measurements from Radar Hill (Kiruna)



S.Henrot-Versillé (Archeops Meeting 02/26/2001)



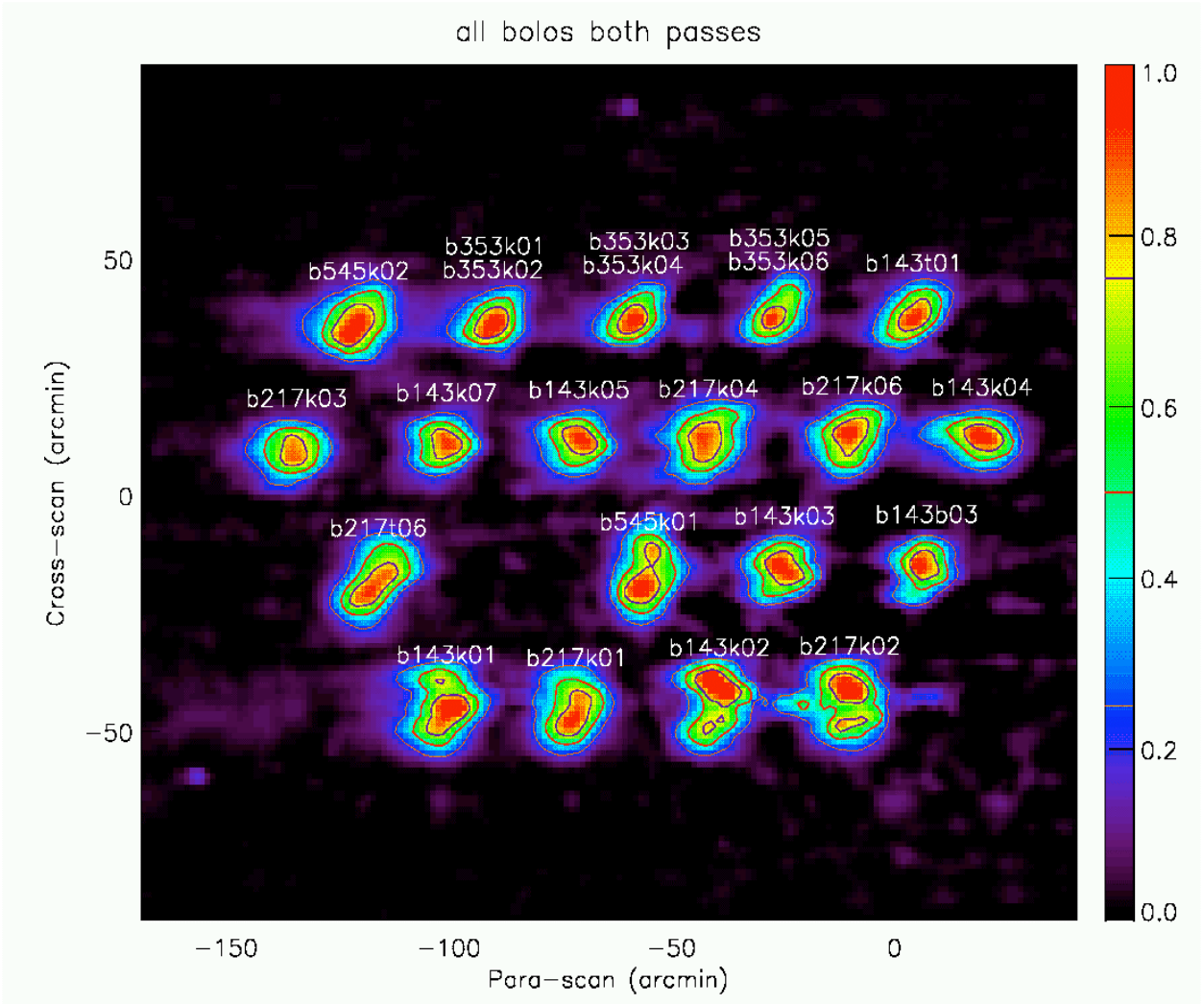
Radar Hill



thermal source

Focal Plane KS1

Reconstruction of the Archeops Focal Plane with Jupiter crossings



Channel	<FWHM>
143 GHz	~11’
217 GHz	~12’
353 GHz	~10’
545 GHz	~12’

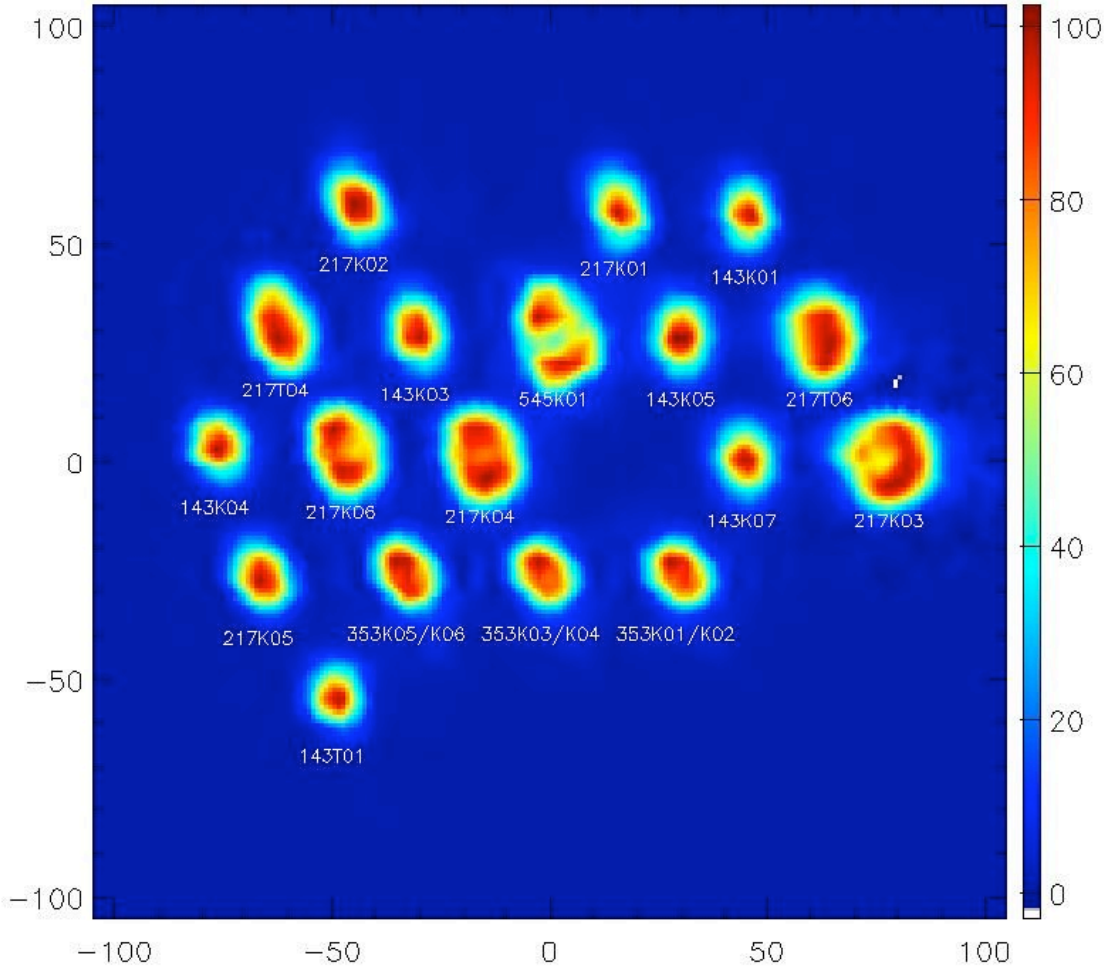
KS2 Crash

deformation of the gondola structure ⇒ defocusing

no time to retune between KS2 and KS3

Focal plane KS3

Reconstruction of the Archeops Focal Plane with Jupiter crossings



mono-mode =
elliptical Gaussian beam

multi-mode =
more structured beam

Channel	<FWHM>
143 GHz	10'x13'
217 GHz	12'x16'
353 GHz	10'x14'
545 GHz	15'x22'

ellipticities

time constants have been deconvolved iteratively

Macias-Perez et al., 2006, A&A, submitted

beam pattern

for CMB and dust emission analysis

CMB

6 bolometers @ 2 frequencies

4 @ 143 GHz and 2 @ 217 GHz

sensitivity

93 < s < 210 $\mu K_{CMB}.s^{1/2}$

Tristram et al., 2005, A&A, 436, 785

Dust

6 bolometers @ 353GHz

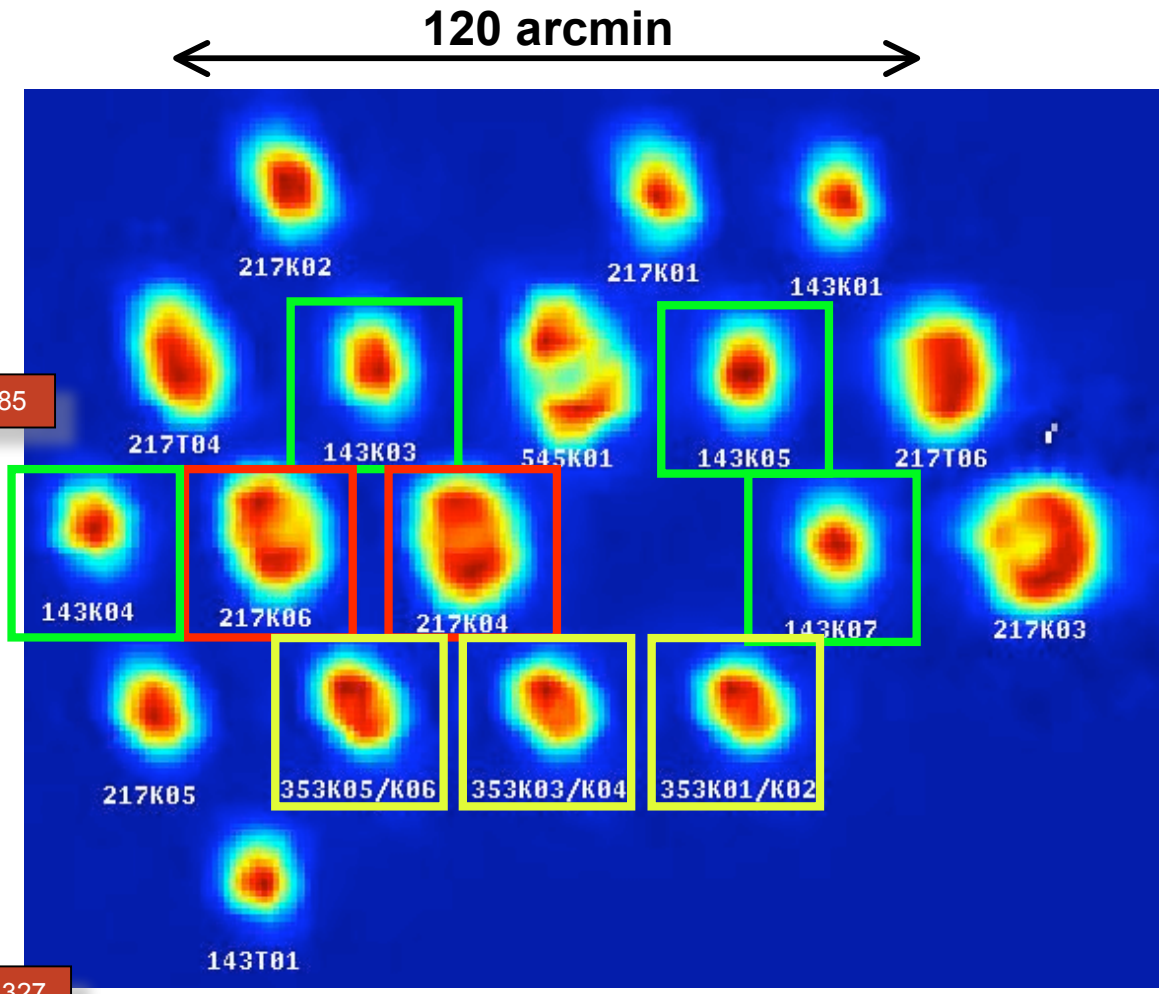
3 OMTs pairs

sensitivity

s ~ 48 $\mu K_{RJ}.s^{1/2}$

(noise level : 82 $\mu K_{RJ}.s^{1/2}$ in temperature
and 105 $\mu K_{RJ}.s^{1/2}$ in polarization)

Ponthieu et al., 2005, A&A, 444, 327



Asymfast
main beam modelization

Tristram et al., 2004, PRD, 69, 123008

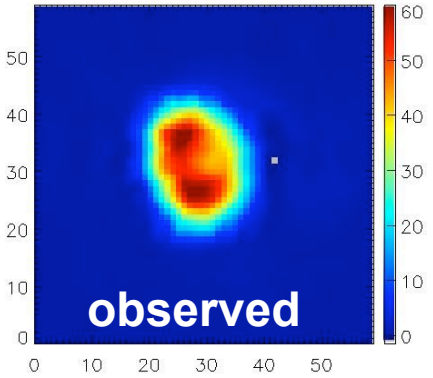
takes into account the asymmetry of the beams projected through the scanning strategy

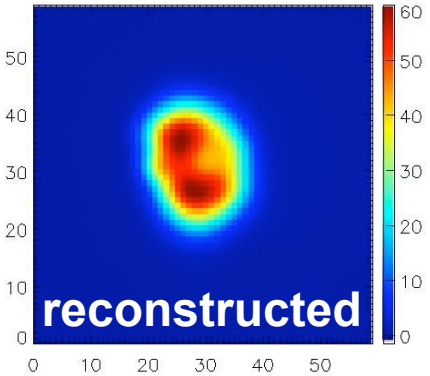
method

- decomposition of the asymmetric beam into a sum of Gaussians
- convolution in the spherical harmonic space

$$B_\ell$$

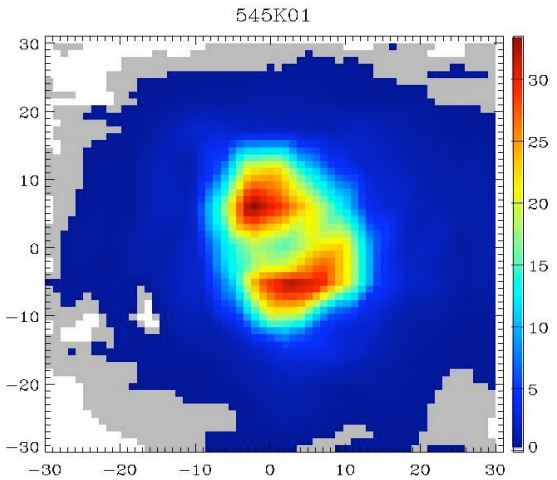
asymmetric beam smoothing effect in multipoles





decomposition in 10 Gaussians

beam modelisation

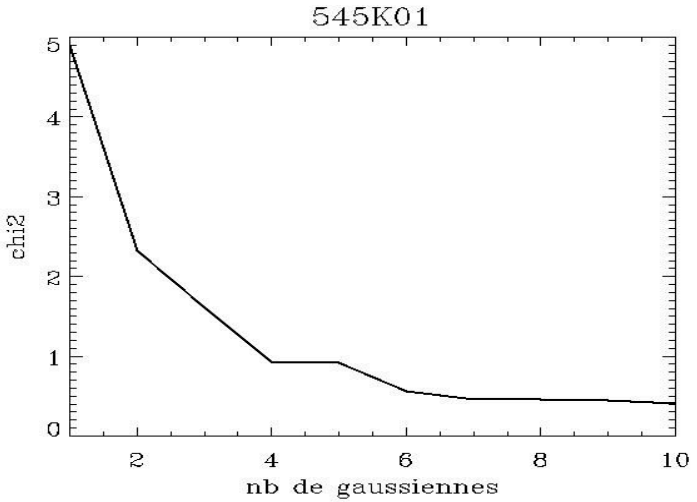


- **goal**

accurate reproduction of all beam shapes with Gaussian functions for map-making purposes

- **mean**

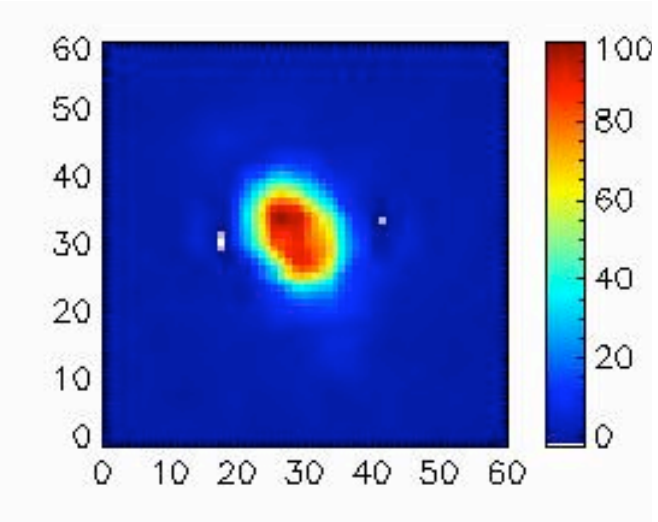
simultaneous fit of 10 symmetric Gaussians

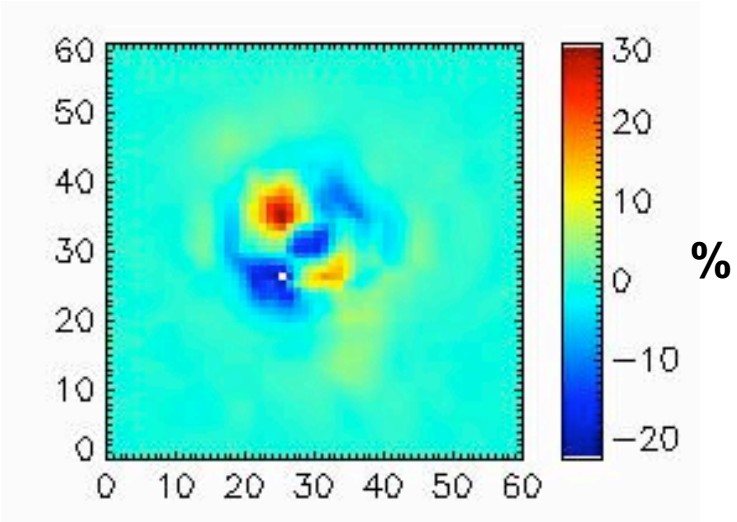


beam modelisation

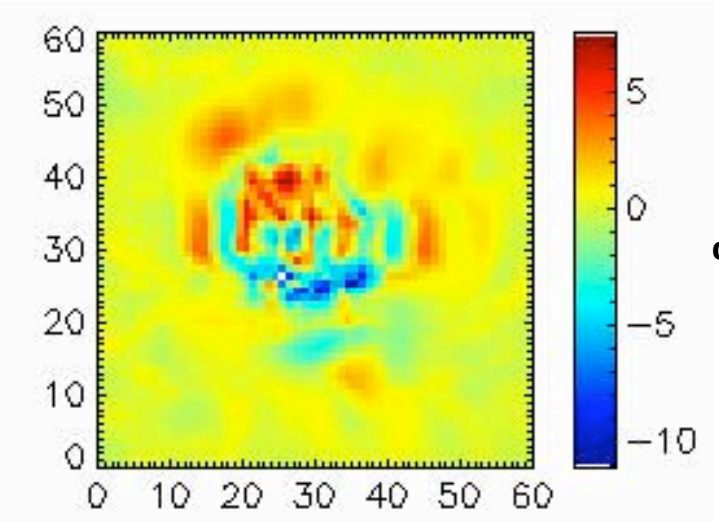
residuals

353K05





with 1 elliptical gaussian



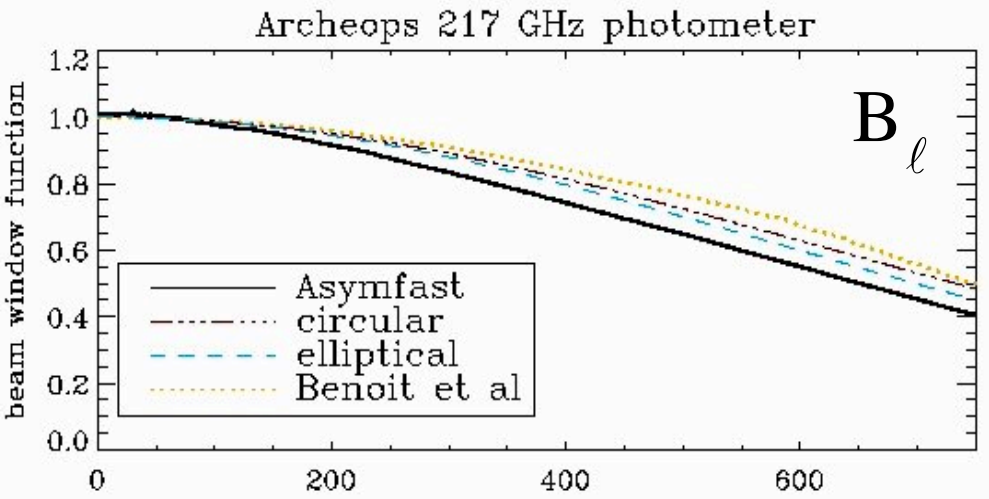
with 10 circular gaussians

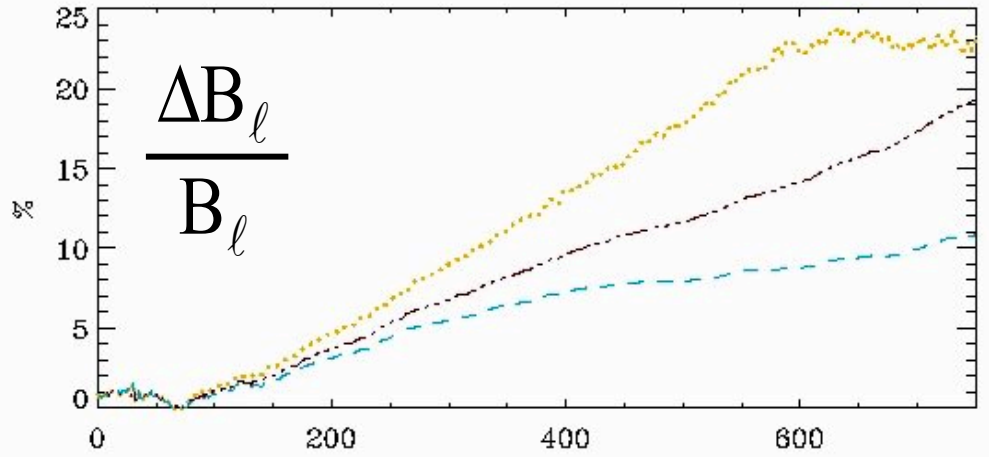
Asymfast

Beam transfer function

Tristram et al., 2004, PRD, 69, 123008

effect on C_ℓ reconstruction





up to 20% on second peak, for most asymmetric beam shapes

Conclusions

- **ground-based calibration**
  difficult challenge.
  We use in-flight measurements for data reduction (except polarizer angle).
  Ground-based measurements more of a check-up.

- **resolution**
  goals not achieved for KS3 flight due to defocusing

→ **alignment procedure is of utmost importance for Planck**

- **beam shape**
  important asymmetry for multimode horns

- **effects on CI**
  We take into account asymmetry using simulations (Asymfast)

→ **needs for a sophisticate main beam analysis**

References

www.archeops.org

- *Archeops: A High Resolution, Large Sky Coverage Balloon Experiment for Mapping CMB Anisotropies*
  Benoit et al., 2002, Astropart. Phys. 17, 101-124
- *First Detection of Polarization of the Submillimetre Diffuse Galactic Dust Emission by Archeops*
  Benoit et al., 2004, A&A 424 571
- *The CMB power spectrum from an improved analysis of the Archeops data*
  Tristram et al., 2005, A&A 436 785
- *Temperature and polarization angular power spectra of Galactic dust radiation at 353 GHz as measured by Archeops*
  Ponthieu et al., 2005, A&A 444, 327
- *Archeops In-flight Performance, Data Processing and Map Making*
  Macías-Pérez et al., 2006, A&A submitted