OLIMPO : an update

S. Masi, P.A.R. Ade, E. Battistelli, A. Boscaleri, P. Camus, S. Colafrancesco, A. Coppolecchia, A. Cruciani, G. D' Addabbo, G. D' Alessandro, P. de Bernardis, S. De Gregori, G. Di Stefano, M. De Petris, M. Gervasi, K. Irwin, L. Lamagna, P. Marchegiani, P. Mauskopf,, L. Nati, F. Nati, F. Piacentini, R. Puddu, G. Romeo, A. Schillaci, C. Tucker, D. Yvon, A. Wuensche, M. Zannoni.

Dipartimento di Fisica, Università La Sapienza, Roma
Department of Physics and Astronomy, University of Cardiff, UK
IFAC-CNR, Firenze, Italy
Institut Neel, Grenoble, France
Istituto Nazionale di Geofisica, Roma, Italy
Osservatorio Astronomico di Roma, INAF, Italy
Dipartimento di Fisica, Università di Milano Bicocca, Italy
NIST Boulder CO. USA
CEA Saclay, France
INPE Brasil

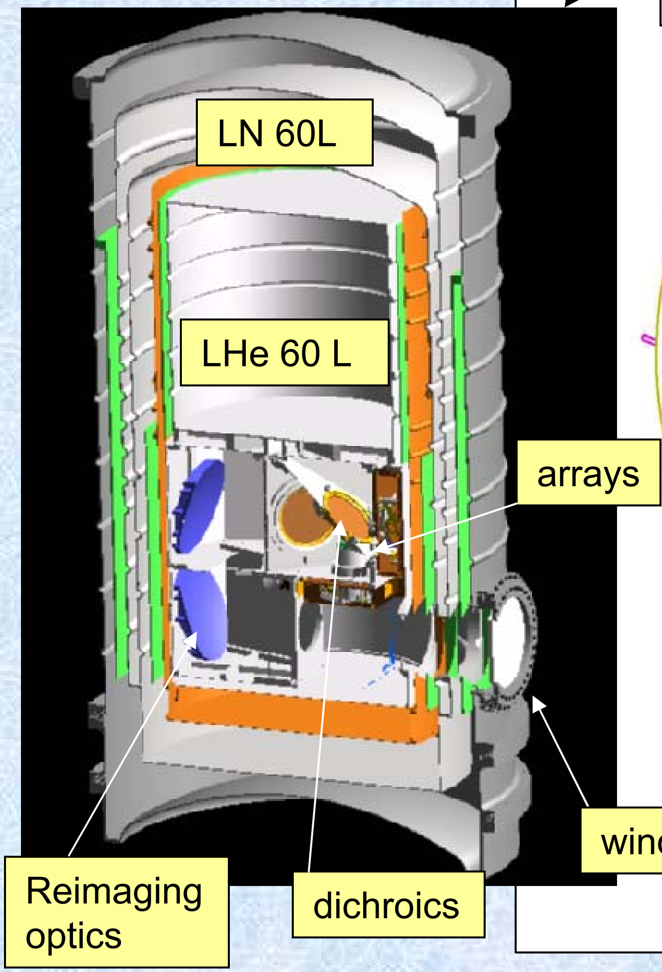
The OLIMPO experiment is a mm-wave balloon-borne telescope, optimized for high-frequency measurements of the Sunyaev-Zeldovich effect. The instrument uses four bolometer arrays, for simultaneous observations at 150, 210, 350, 480 GHz, coupled to a 2.6 m diameter Cassegrain telescope, achieving a resolution of 4,3,2,2 arcmin FWHM respectively.

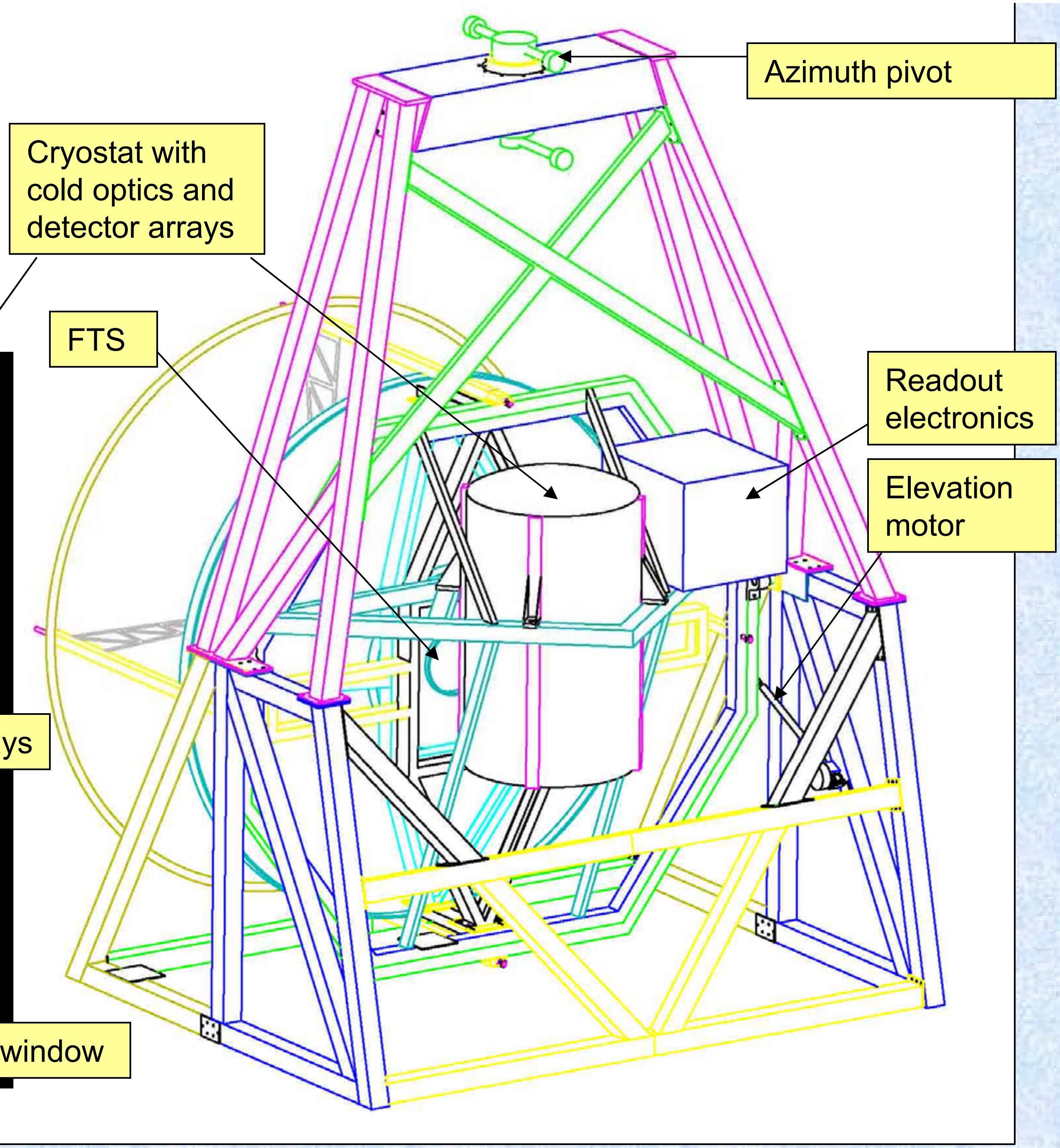
We describe the instrument, the observation strategy, and the mission, which is a polar long-duration flight launched from Svalbard islands. The current observation plan includes deep integrations on a selected sample of 40 clusters, plus a wide blind survey of an empty sky area.

We have recently upgraded the instrument adding ***spectroscopic capabilities*** *within the 4 bands above, and discuss here the scientific potential of this innovative configuration.*

- In fig. 1 we show the OLIMPO balloon payload (Masi et al. 2008), with solar panels, ground shield and sun shield removed.
- Note the tiltable 2.6m primary mirror and the lightweigth secondary.
- Pointing is obtained rotating the payload around an azimuth pivot and changing the elevation of the inner frame, including the telescope, the FTS and the detector’s cryostat
- The total mass of the payload is 1.5 tons.

The Payload


LN 60L
LHe 60 L
arrays
window
Reimaging optics
dichroics

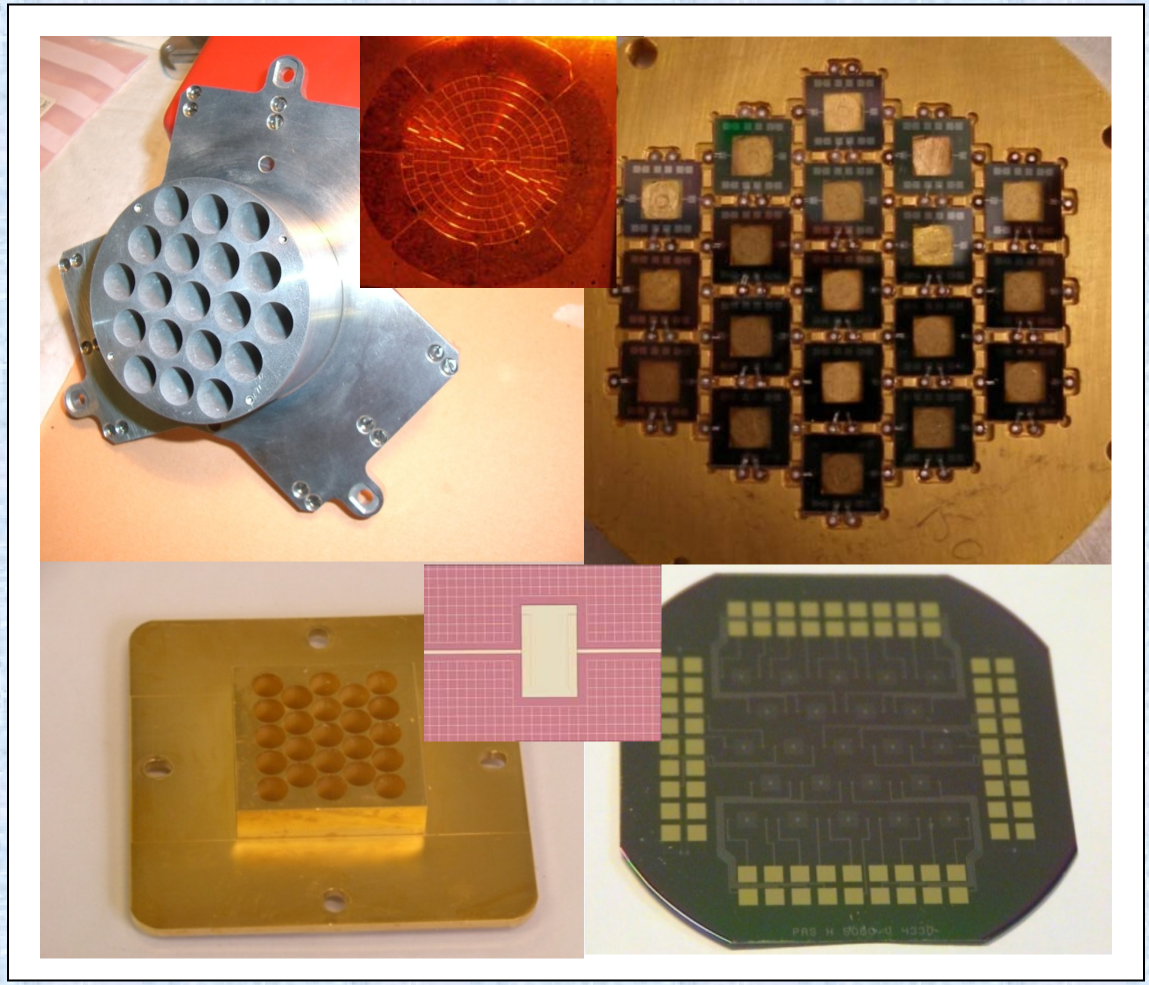

Cryostat with cold optics and detector arrays
FTS
Azimuth pivot
Readout electronics
Elevation motor

Low frequency arrays (TES

- Buffer: Si_3N_4
- Thermistor: Ti (60nm) + Au (10/20 nm)
- Absorber/heater: spiderweb T (10 nm) + Au (5 nm), filling factor 5%
- NET150GHz=145 μK√s
- NET220GHz=275 μK√s
- Univ. Of Cardiff (Mauskopf)

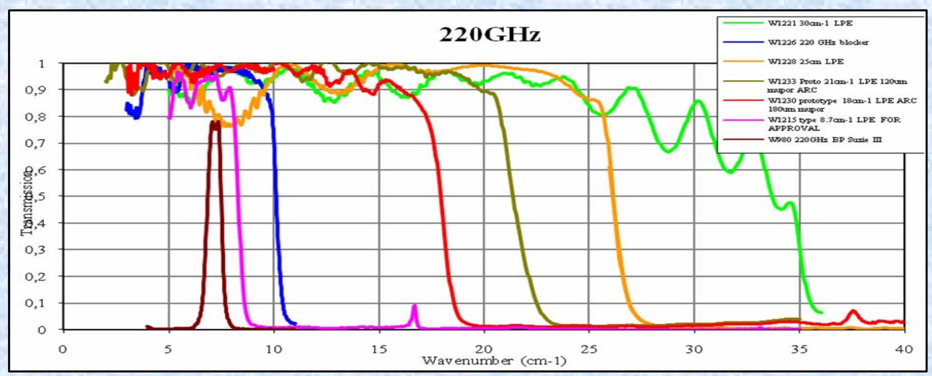
High frequency arrays

- NbxSi1-x (x=0.085)
- SiN 3x3 mm2
- Palladium absorber
- NET340GHz=430 μK√s
- NET450GHz=4300 μK√s
- Inst. Neel Grenoble (Camus)



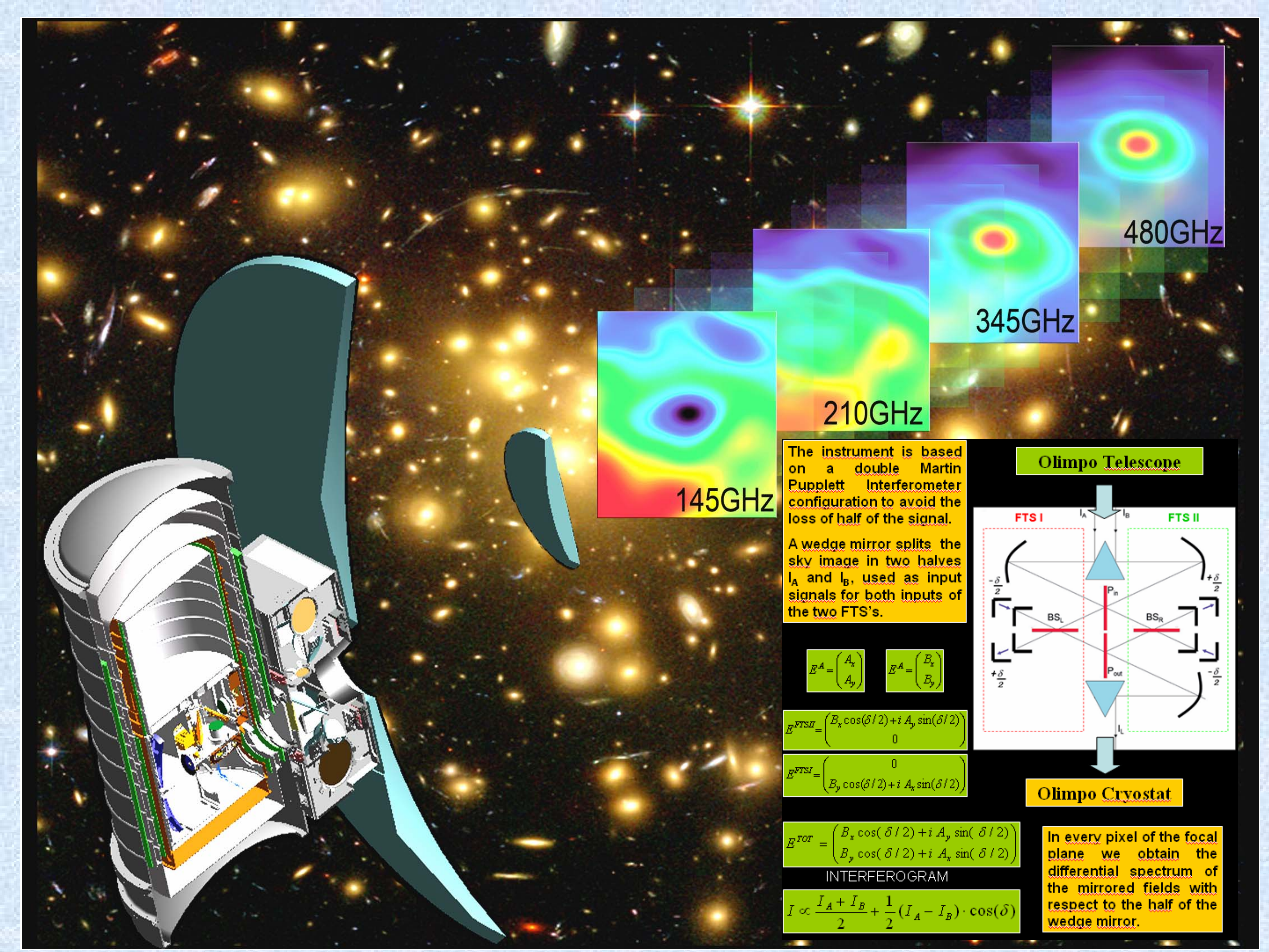
Filters Stacks (Ade, Tucker, Cardiff)

Bol.	ν_{eff} [GHz]	$\Delta\nu_{FWHM}$ [GHz]	Res. [‘]
19	148.4	21.5	4.2
19	215.4	20.6	2.9
23	347.7	33.1	1.8
23	482.9	54.2	1.8

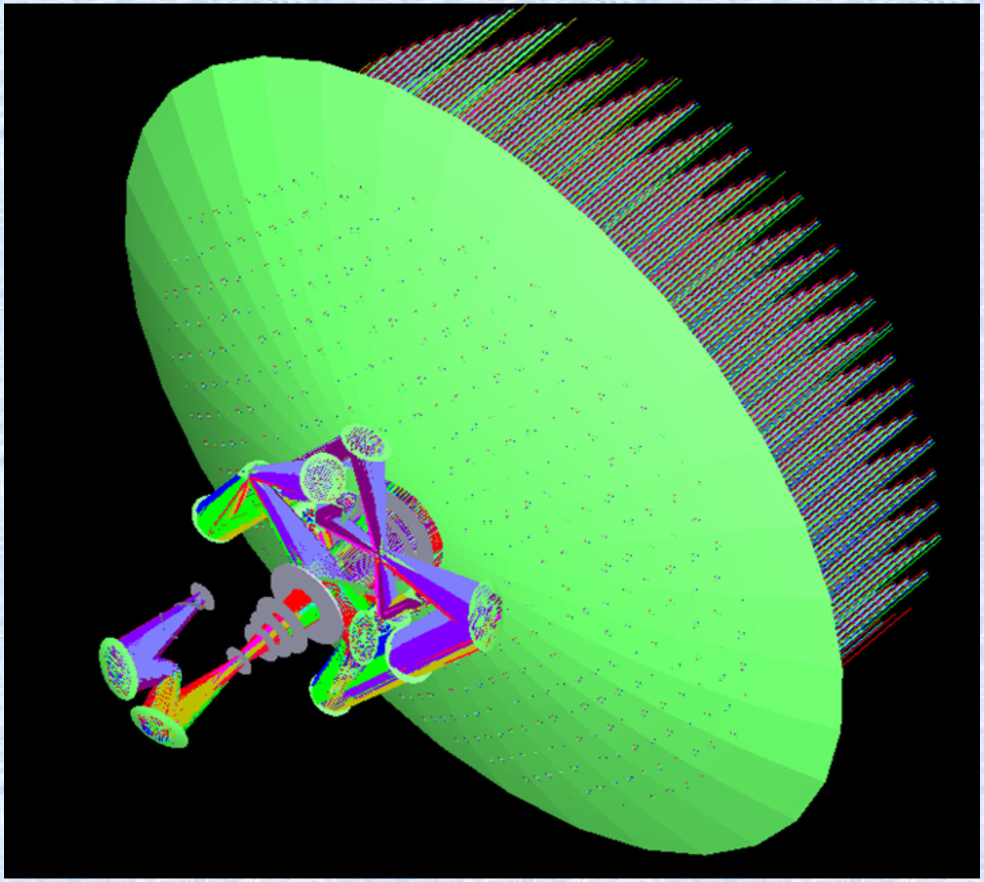


The spectroscopic instrument

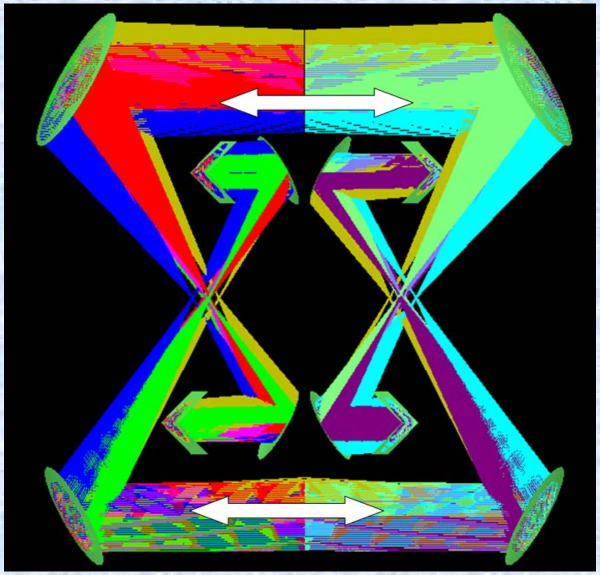
- SZ studies can benefit significantly from spectroscopic measurements, which are required to break degeneracies between the parameters describing cluster and foreground emissions along the line of sight (see below).
- In 2008 we have studied for ASI a spectroscopic SZ space-mission (SAGACE, see de Bernardis et al. 2010).
- As a pathfinder, we are building a plug-in **D**ifferential **FTS** for OLIMPO (see the companion poster from Schillaci et al.).
- The **DFTS** configuration offers
  - an imaging spectrometer with very high throughput,
  - wide spectral coverage,
  - medium to high spectral resolution,
  - rejection of common-mode signals, like instrument emission and most of the ground pickup.
- The main problem is the high radiative background on the bolometers, which is solved splitting the observed frequency range in several bands with independent detector arrays. In the case of OLIMPO, this was already implemented in the 4-bands photometer.



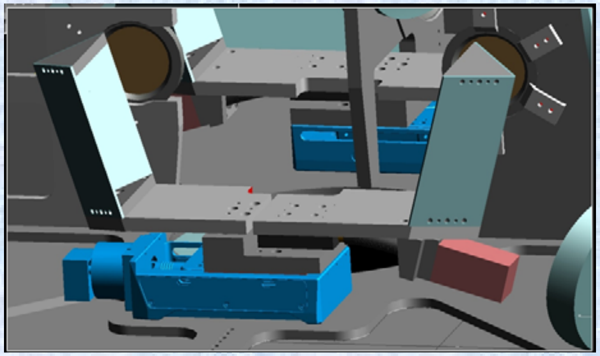
480GHz
345GHz
210GHz
145GHz
The instrument is based on a double Martin Pupplett Interferometer configuration to avoid the loss of half of the signal.
A wedge mirror splits the sky image in two halves I_A and I_B, used as input signals for both inputs of the two FTS's.
Olimpo Telescope
FTS I
FTS II
I_A
I_B
$-\frac{\delta}{2}$
$+\frac{\delta}{2}$
P_{in}
BS_L
BS_R
P_{out}
$+\frac{\delta}{2}$
$-\frac{\delta}{2}$
I_L
Olimpo Cryostat
$E^A = \begin{pmatrix} A_x \\ A_y \end{pmatrix}$
$E^A = \begin{pmatrix} B_x \\ B_y \end{pmatrix}$
$E^{FTSII} = \begin{pmatrix} B_x \cos(\delta/2) + i\, A_y \sin(\delta/2) \\ 0 \end{pmatrix}$
$E^{FTSI} = \begin{pmatrix} 0 \\ B_y \cos(\delta/2) + i\, A_x \sin(\delta/2) \end{pmatrix}$
$E^{TOT} = \begin{pmatrix} B_x \cos(\delta/2) + i\, A_y \sin(\delta/2) \\ B_y \cos(\delta/2) + i\, A_x \sin(\delta/2) \end{pmatrix}$
INTERFEROGRAM
$I \propto \frac{I_A + I_B}{2} + \frac{1}{2}(I_A - I_B) \cdot \cos(\delta)$
In every pixel of the focal plane we obtain the differential spectrum of the mirrored fields with respect to the half of the wedge mirror.



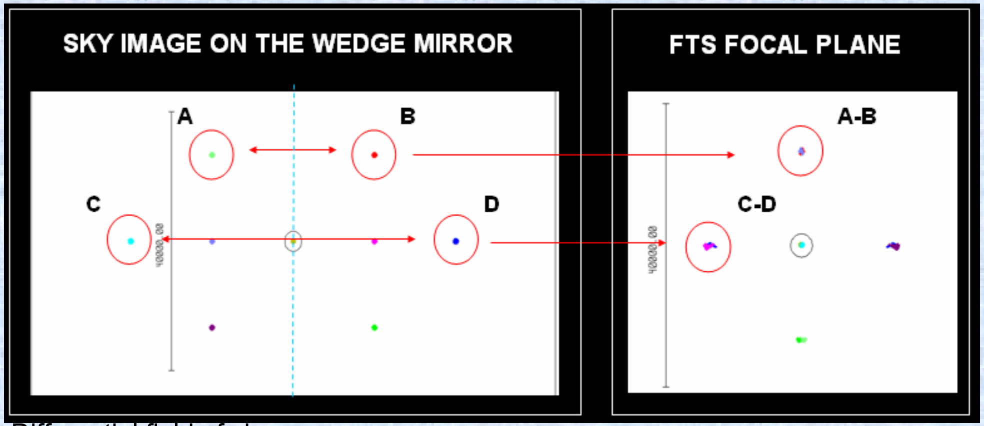
Global design of the optical system



Optical layout of the doublel Martin-Puplett FTS



Mechanical arrangement of the translation stages



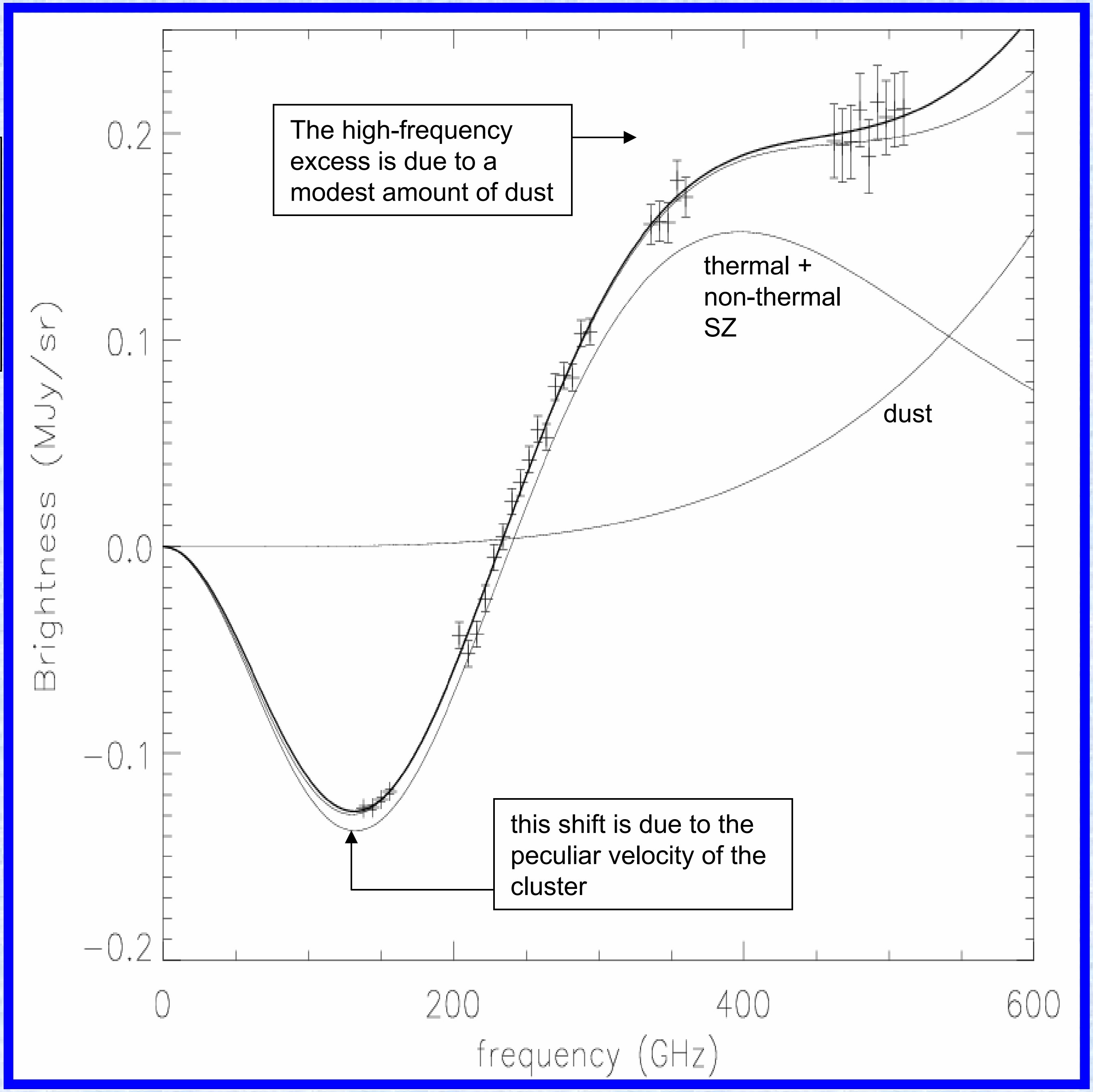
Differential field of view

The OLIMPO Martin-Puplett Differential Fourier Transform Spectrometer

Simulated OLIMPO measurement of a cluster l.o.s. with

τ_{th}=0.005,
T_e=10 keV,
τ_{nonth}=0.0001,
v_{pec}=500 km/s,
I_{dust}=6kJy/sr@150GHz

The data with the error bars are simulated observations from a single pixel of the OLIMPO-FTS, for an integration time of 3 hours. The two lines through the data points represent the input theory (thin) and the best fit for the plotted data realization (thick). The other thin lines represent thermal plus non-thermal SZE, and dust emission.

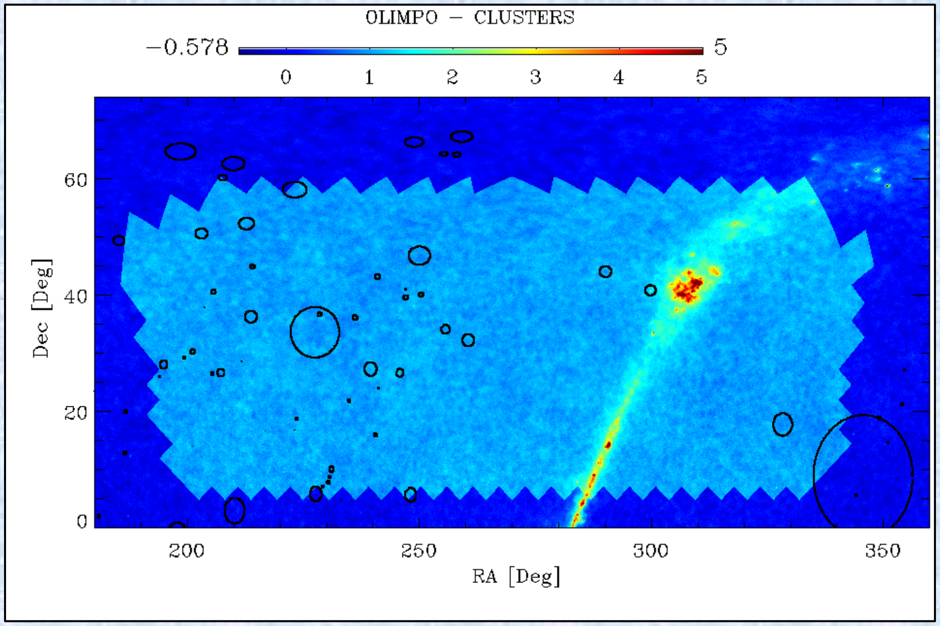


Parameters Determination

- In the presence of peculiar velocities, non-thermal populations (from AGNs in the cluster), and foreground dust, there are simply too many free parameters to be determined with the observation of a few frequency bands.
- We have carried out detailed simulations of OLIMPO observations in the spectroscopic configuration with an extended 200-300 GHz band.
- The spectroscopic configuration has superior performance in converging to the correct estimate of thermal optical depth and dust parameters, while the photometric configuration, *in the absence of priors*, tends to converge to biased estimates of the parameters.
- See de Bernardis et al. 2012 for details

Input parameters	OLIMPO	• No priors	• Prior T=(10$\pm$3) keV
τ_{th} =50x10^{-4}	FTS	τ_{th} =(63$\pm$27)10^{-4}	τ_{th} =(49$\pm$6)10^{-4}
T = 10 keV	3h integ.	T = (9.0$\pm$4.1) keV	T = (9.6$\pm$0.5)keV
τ_{non-th}=1x10^{-4}	one	τ_{non-th}=(14$\pm$9)10^{-5}	τ_{non-th}=(11$\pm$9)10^{-5}
ΔT_{CMB}=22μK	detector	ΔT_{CMB}=(24$\pm$43)μK	ΔT_{CMB}=(22$\pm$43)μK
$\Delta I_{dust150}$=6 kJy/sr		$\Delta I_{dust150}$=(5.7$\pm$1.6)kJy/sr	$\Delta I_{dust150}$=(5.8$\pm$0.9)kJy/sr

Observation Program

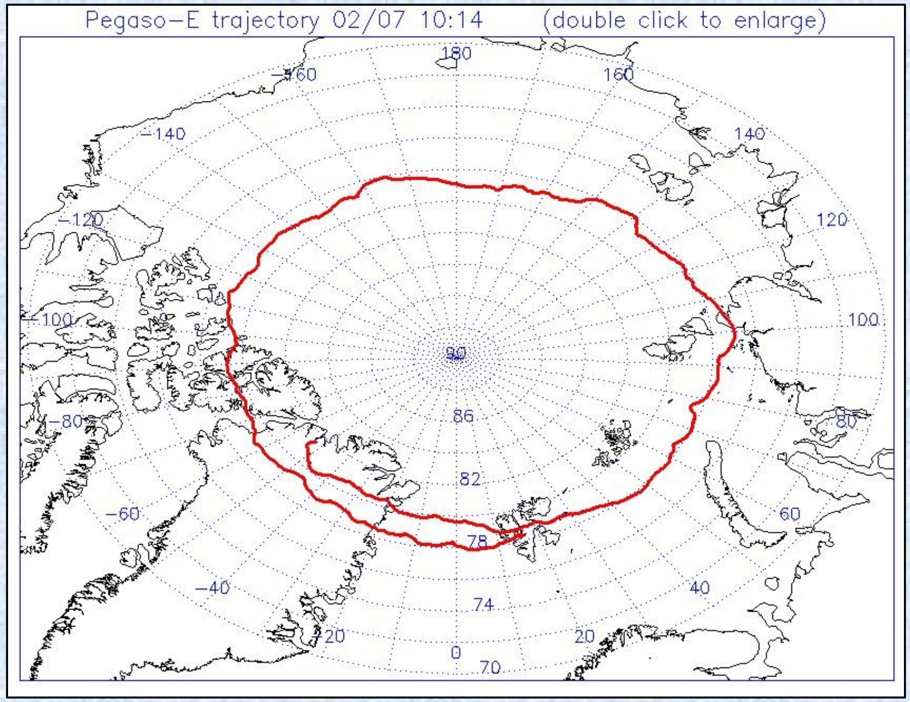


- In a circumpolar summer long duration flight (>200h) we plan to observe 40 selected clusters and to perform a blind deep integration on a clean sky region
- We have optimized the observation plan distributing the integration time among the different targets according to their brightness and diurnal elevation.

ind	ID	RA	Dec	TIME	frac	NAME
0	1	212.83	52.2	18000	1	3C295CLUSTER
1	40	194.95	27.98	3600	0	ABELL1656
2	43	203.13	50.51	3600	1	ABELL1758
3	44	205.48	26.37	3600	1	ABELL1775
4	45	207.25	26.59	3600	1	ABELL1795
5	48	216.72	16.68	18000	1	ABELL1913
6	49	223.18	16.75	11360.88	1.27	ABELL1983
7	50	223.63	18.63	18000	1	ABELL1991
8	51	223.21	58.05	5640.53	1.28	ABELL1995
9	53	227.56	33.53	18000	1	ABELL2034
10	54	229.19	7	3600	1	ABELL2052
11	55	230.76	8.64	3600	1	ABELL2063
12	56	234.95	21.77	3600	1	ABELL2107
13	57	236.25	36.06	18000	1	ABELL2124
14	58	239.57	27.23	3600	1	ABELL2142
15	59	240.57	15.9	3600	1	ABELL2147
16	61	247.04	40.91	18000	1	ABELL2197
17	62	247.15	39.52	3600	1	ABELL2199
18	63	248.19	5.58	3600	1	ABELL2204
19	65	250.09	46.69	3600	1	ABELL2219
20	66	255.68	34.05	7230	1.49	ABELL2244
21	69	260.62	32.15	18000	1	ABELL2261
22	70	290.19	43.96	3600	1	ABELL2319
23	71	328.39	17.67	3600	1	ABELL2390
24	98	241.24	23.92	13045.75	1.1	AWM4
25	100	299.87	40.73	18000	1	CYGNUSA
26	101	201.2	30.19	18000	1	GHO1322+3027
27	102	241.11	43.08	18000	1	GHO1602+4312
28	107	230.46	7.71	3600	1	MKW03S
29	120	228.61	36.61	18000	1	MS1512.4+3647
30	121	245.9	26.56	13147.05	1.1	MS1621.5+2640
31	128	201.15	13.93	18000	0	NGC5129GROUP
32	134	199.34	29.19	18000	1	RDCSJ1317+2911
33	143	231.17	9.96	18000	1	RXJ1524.6+0957
34	150	211.73	28.57	18000	1	WARPJ1406.9+2834
35	151	213.8	36.2	18000	1	WARPJ1415.1+3612
36	161	194.02	25.95	18000	0	[VMF98]128
37	162	203.74	37.84	18000	1	[VMF98]139
38	163	205.71	40.47	18000	1	[VMF98]148
39	164	214.12	44.78	18000	1	[VMF98]158
40	165	250.47	40.03	18000	1	[VMF98]184

Mission Profile

SORA LAUNCH:July 1st 2009 (1.5 ton)



- We will use a long-duration circumpolar flight launched from Svalbard Islands (June 2013).
- We have tested these flights in collaboration with ASI, and demonstrared the feasibility of launching heavy payloads from the Longyearbyen airport, performing 2-3 weeks flights around the north pole during the Arctic summer.

References

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Acknowledgements

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