Astroparticule et Cosmologie
Université Paris 7 - Denis Diderot

The Planck Cluster Survey

James G. Bartlett

Laboratoire Astroparticule et Cosmologie (APC)

Department of Physics, Université Paris 7 - Denis Diderot

Members of the Planck WG5

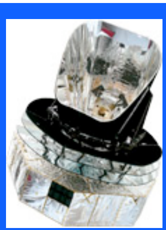
The Planck Cluster Survey

- Clusters & the Sunyaev-Zel'dovich (SZ) effect

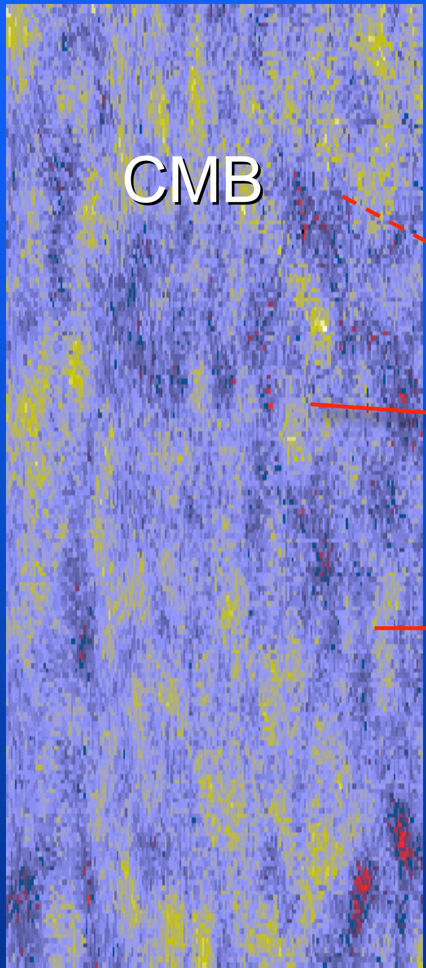
- The Planck catalog **Volume!**

- Science with Planck/XMM-Newton

Cosmology with massive clusters at high z



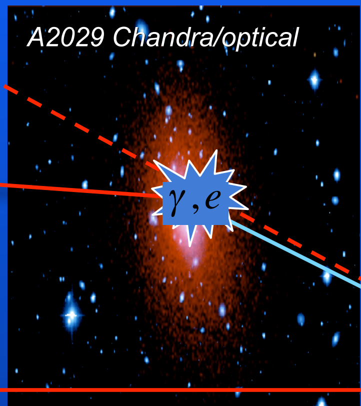
Thermal SZ Effect



Cluster

$T \sim 5keV$

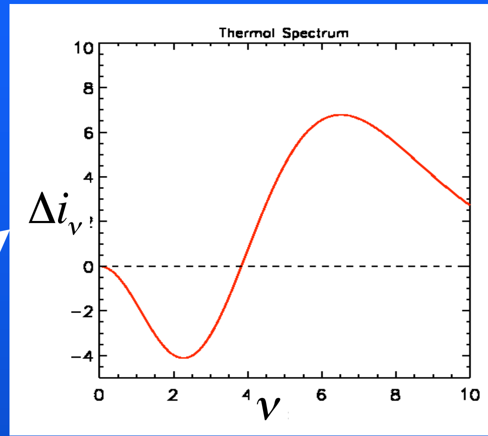
$\tau \sim 0.001 - 0.01$



i_ν^C

i_ν^O

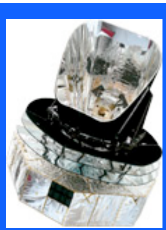
Planck



$$\Delta i_\nu = i_\nu^O - i_\nu^C = y \cdot j_\nu$$

$$y = \int_{los} \frac{kT_e}{m_e c^2} n_e \sigma_T \, dl$$

No redshift dependence!



Gains from SZ Surveying

<u>SZ ‘flux’ limited survey:</u>

$$S_{sz} = \int_{cluster} d\Omega \, \Delta i_\nu \propto Y f_\nu$$

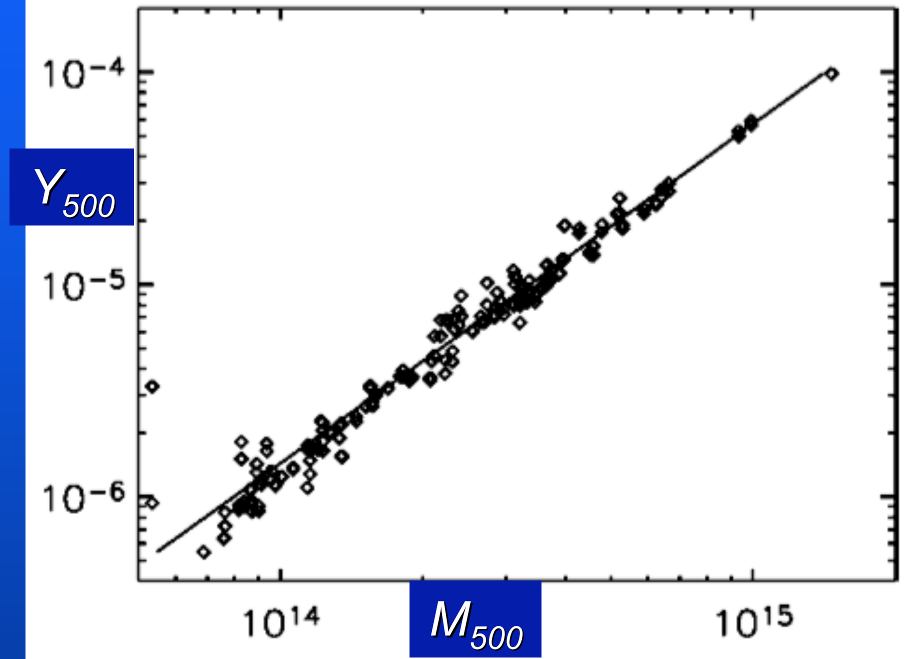
$$Y = \int_{cluster} d\Omega \, y \propto \frac{f_{gas} M_{tot} T_e}{D^2_{ang}(z)}$$ Gas thermal energy

- Tight correlation to MASS

  Intrinsic scatter $\sim 5\%$

  Insensitive to mergers, thermal structure, etc

Motl et al. 2005, ApJ 623, L63

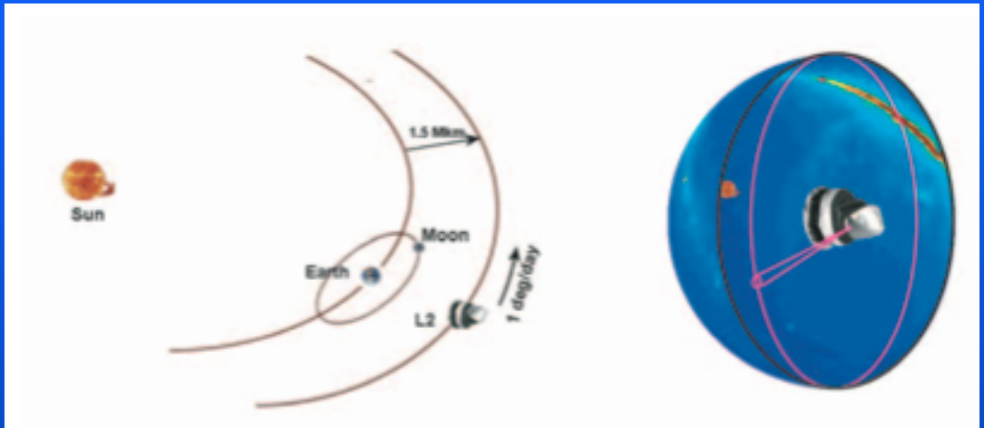


See also: da Silva et al. 2004, Hallman et al. 2006, Kravtsov et al. 2006, Nagai 2006

The *Y-M* relation needs to be empirically calibrated (e.g., normalization)

The Planck Mission

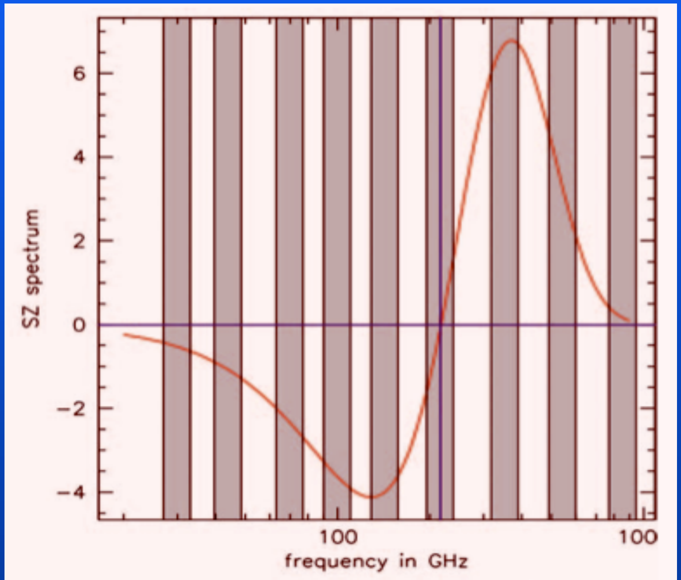
Ref: Planck Blue Book



- Launch: July 2008
- Transfer to orbit: 3-4 months
- 2 full-sky surveys: 14 months
- Data release: + 2 years

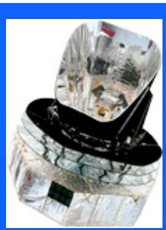
Two instruments: HFI & LFI

9 bands: 30 → 5 arcmins

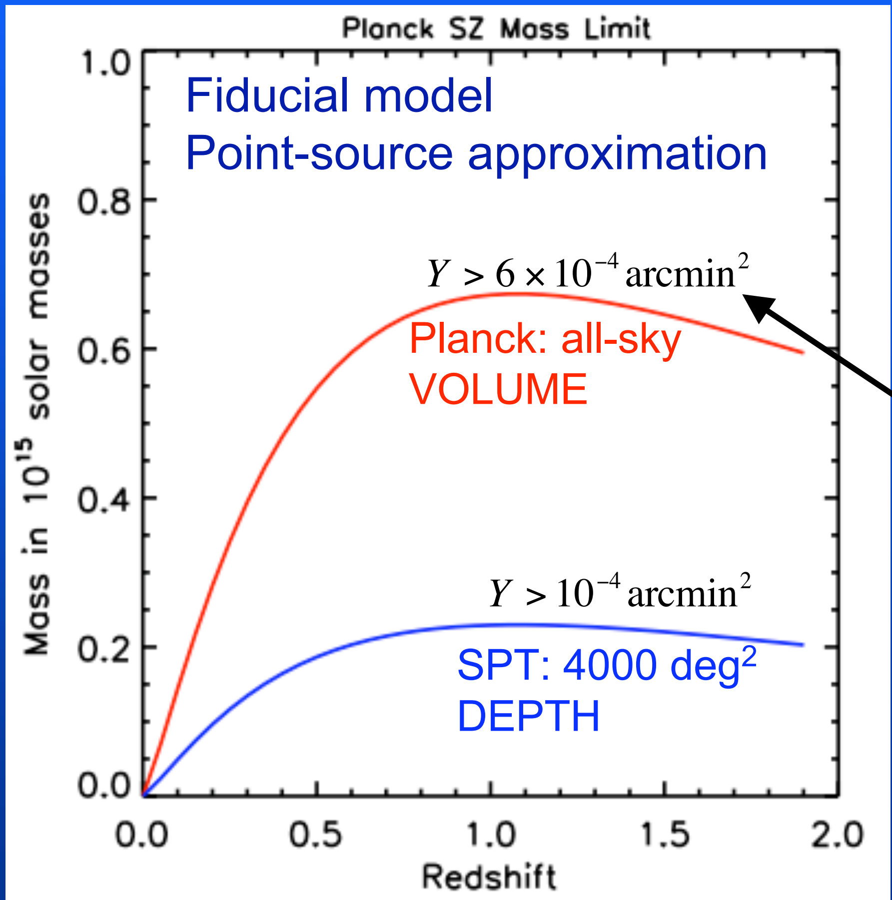


7 → 5 arcmins

Most clusters unresolved



Gains from SZ Surveying



Close to a mass selected catalog, uniform in redshift at *z>0.5*

Important for evolutionary studies
- *same kind of object observed at different epochs*

Under study by Planck WGs 2 & 5

An SZ Survey:
- **Efficient at high z**
- **Mass selected**
- **Universal spectrum**

The Planck SZ Catalog

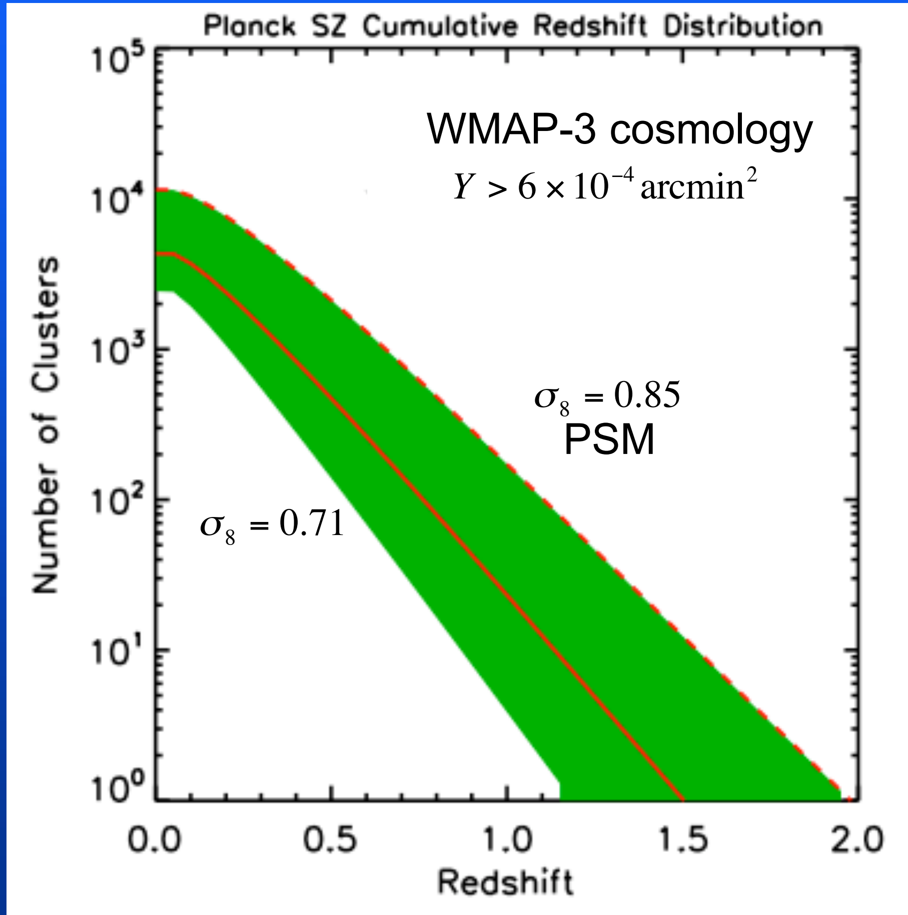
Large modeling uncertainty:
σ_8, *Y-M* calibration & Y_{lim}

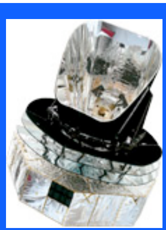
WMAP-1: $\sigma_8 = 0.9 \pm 0.1$
WMAP-3: $\sigma_8 = 0.76 \pm 0.05$

Solid red line consistent with:
- WMAP-3 (Spergel et al. 2007)
- M-T (Vikhlinin et al. 2006, Arnaud et al. 2005)
- Fit to local cluster abundance (Chamballu & Bartlett 2007)

(See also: Barbosa et al. 1996, Aghanim et al. 1997, Diego et al. 2002, Battye & Weller 2003, Gueshbusch et al. 2005, Melin et al. 2006, Schaefer & Bartelmann 2006)

|b|>20 (30,000 deg^2)





The Planck SZ Catalog

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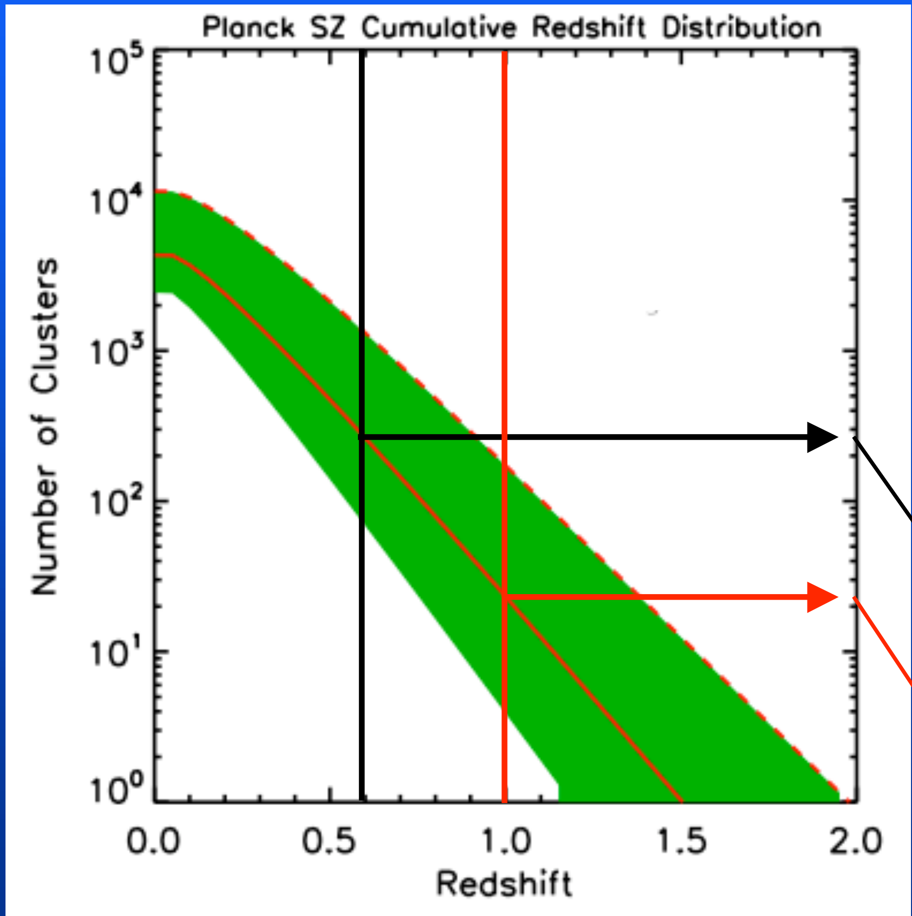
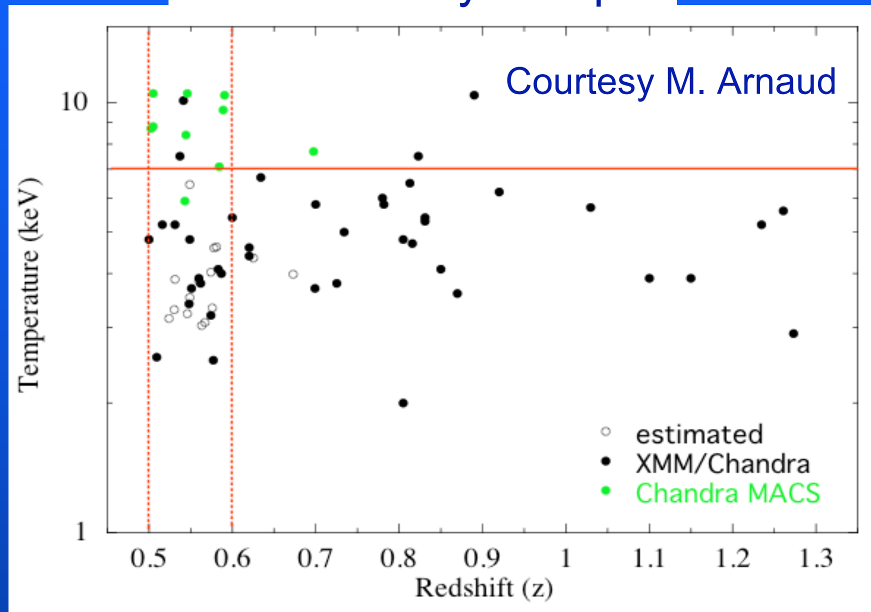


Present X-ray Sample



Planck:

- ~ few 100 clusters at *z>0.6* & with *T>7 keV*
- ~ 10 clusters at *z>1*, *T>8 keV*

An XMM-Planck Sample

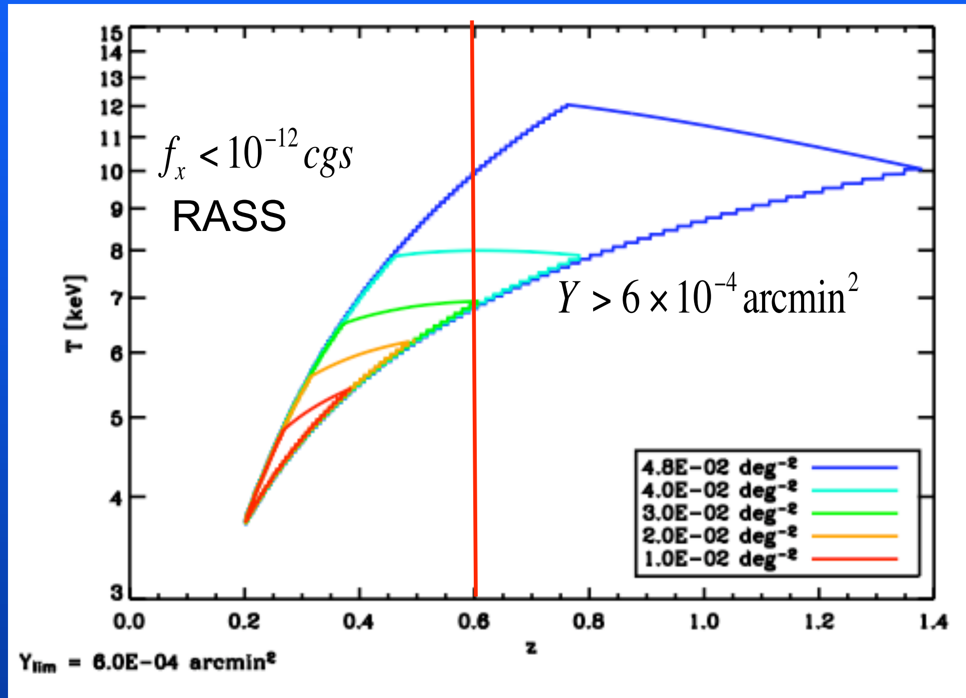
GOAL:

Target the massive clusters at high redshift to do this science with XMM-Newton

~300 clusters
@ z>0.6 & T>7keV

Potential 100-fold increase in sample size!

NEW Planck clusters

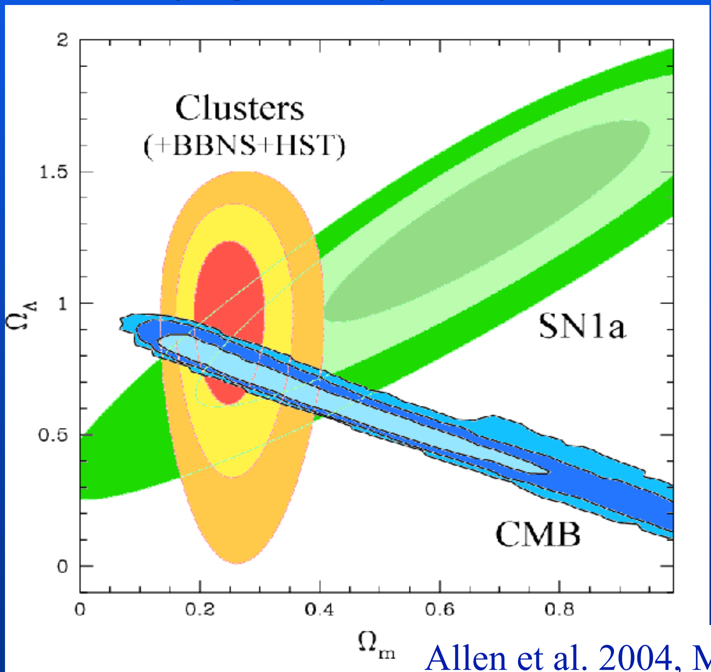


Chamballu, JGB, Melin 2007

Massive Clusters at High z

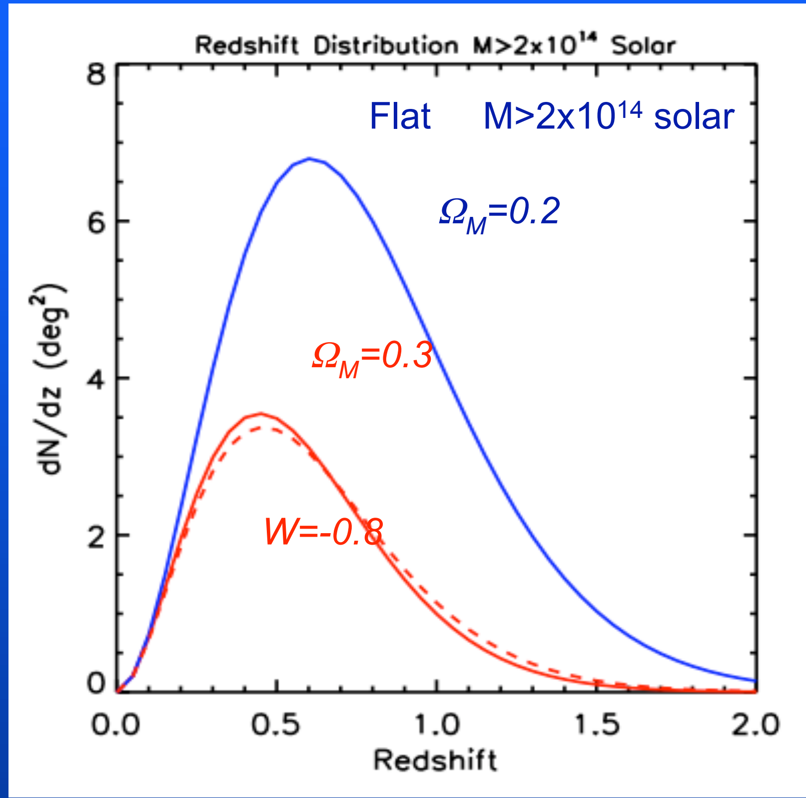
Ideal for cosmology

- Most sensitive to cosmology
- Global properties less affected by galaxy formation

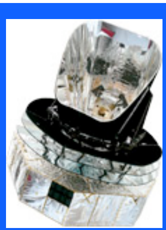


Measuring $f_{gas}(z)$

Allen et al. 2004, MNRAS 353, 457
26 clusters, ONLY 4 above z=0.5



Key: cluster mass



Planck/XMM-Newton Science

XMM-Newton follow-up - sensitivity to get:

- Gas properties: $L(r),\ T\ [\text{some}\ T(r)],\ M_{gas}$
- Total MASS from hydrostatic equilibrium (relaxed)

⇒ Calibration of *Y-M* relation

- *Critical* for cosmological application of cluster counts

⇒ Measure $f_{gas}(z)$

- Cosmological constraints (e.g., Allen et al. 2004)

⇒ Scaling relations between L, T, M_{gas}, M, Y

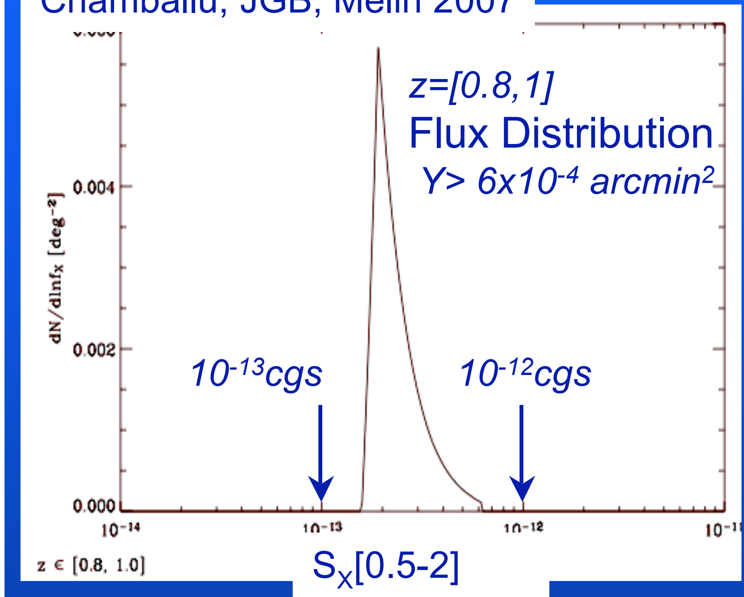
- Cluster properties and evolution

⇒ Mass profiles

- Structure formation and dark matter properties

Observing with XMM

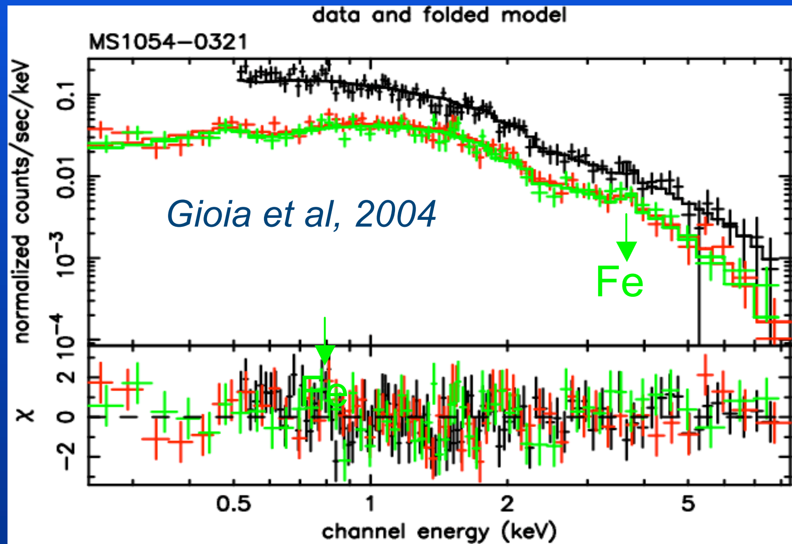
Chamballu, JGB, Melin 2007



Model prediction for flux distribution of Planck clusters at *0.8<z<1*

Example of XMM performance

25 ksec: z=0.83,
S_X[0.5-2]~2.5 10^{-13} cgs



kT = 7.2±0.5 keV

Conclusions

- Planck (2008): a *unique* cluster catalog for cosmology
  - Volume & mass selection (all-sky SZ survey)
  - ~100-fold increase in massive cluster sample (*T>7keV*) at *z>0.6*
- Ideal for XMM-Newton studies
  - An array of exciting cosmology/structure formation studies
  - Phased program cutting in *Y* with 25-50 ks/cluster
  - Whole shebang:

10 Ms program:
~*300* clusters at *z>0.6*, *T>7keV*
with *T±10%*, *T* profile
MASSES

Planck vs ROSAT

ROSAT - RASS based

NORAS - north
REFLEX - south
(Böhringer et al. 00, 04)

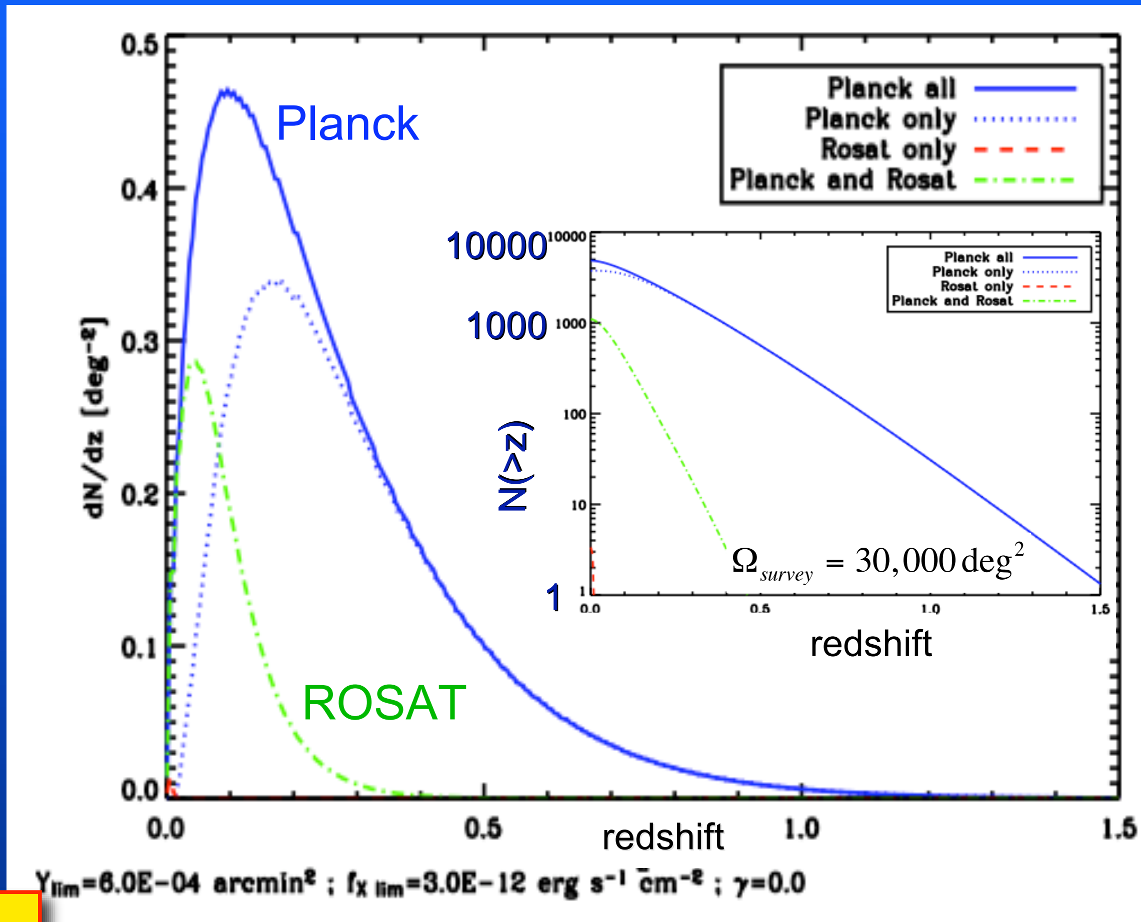
$f_x\left[0.1-2.4keV\right] > 3\times10^{-12}\, ergs/s/cm^2$

(~1000 clusters)

Planck $Y > 6\times10^{-4}\,\text{arcmin}^2$

- Moving out in z
- Volume

⇒ Massive clusters



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