PLANCK

Physics of the hot gas in the Coma cluster

The Planck Collaboration presented by
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(University of Roma Tor Vergata and CfA)

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The scientific results that we present today are the product of the Planck Collaboration, including individuals from more than 50 scientific institutes in Europe, the USA and Canada

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cnes

agenzia spaziale italiana

NASA

cnrs

DTU Space
National Space Institute

Science & Technology Facilities Council

INAF ISTITUTO NAZIONALE DI ASTROFISICA

CSIC
Consejo Superior de Investigaciones Científicas

National Research Council of Italy

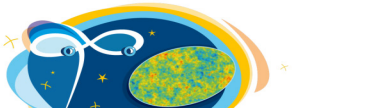
GOBIERNO DE ESPAÑA · MINISTERIO DE CIENCIA E INNOVACIÓN

CSA ASC

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.

UK SPACE AGENCY

MAX-PLANCK-GESELLSCHAFT



HFI PLANCK

PLANCK LFI

IAS orsay

IAP

INAF - IASF BO
ISTITUTO NAZIONALE DI ASTROFISICA
ISTITUTO DI ASTROFISICA SPAZIALE E FISICA COSMICA DI BOLOGNA

Aalto University

Kavli Institute for Cosmology Cambridge

Cavendish Astrophysics

University of Cambridge

Cardiff University
Prifysgol Caerdydd

irfu
saclay
energie atomique • energies alternatives

CESR

CITA–ICAT

cnrs IN2P3
Les deux infinis

ipac Infrared Processing and Analysis Center

Helsinki Institute of Physics

Instituto de Física de Cantabria

Imperial College London

Università degli Studi di Milano

NÉEL institut

IPAG
Institut de Planétologie et d'Astrophysique de Grenoble

ISDC
Data Centre for Astrophysics

JPL

Laboratoire de l'Accélérateur Linéaire

l'Observatoire de Paris — LERMA

LPSC Grenoble
Laboratoire de Physique Subatomique et de Cosmologie

The University of Manchester

MilliLab

Max-Planck-Institut für Astrophysik

NUI Maynooth

INAF Osservatorio Astronomico di Padova

University of Oxford

Dipartimento di Fisica Sapienza Università di Roma

Science & Technology Facilities Council
Rutherford Appleton Laboratory

Tor Vergata

Osservatorio Astronomico di Trieste

UBC

UC Universidad de Cantabria

UCSB

SISSA

ALMA

ESO

US University of Sussex

esa

University of Helsinki

Université de Genève

University of Toronto

Université de Paris-Sud XI

asdc
ASI Science Data Center

"Conclusions"

- 1) Global Radial Profile
  - Planck detects SZ signal at Radii
  - "Where no man has gone before"
- 2) From the Planck image we identify two regions with interesting rapid pressure variation
  - radial pressure jumps?
- 3) We show interesting y-radio relations:
  - quasi-linear scatter and radial relations that puts constraints on models of magnetic field and the production of cosmic ray electrons

Some parameters of the Coma Cluster

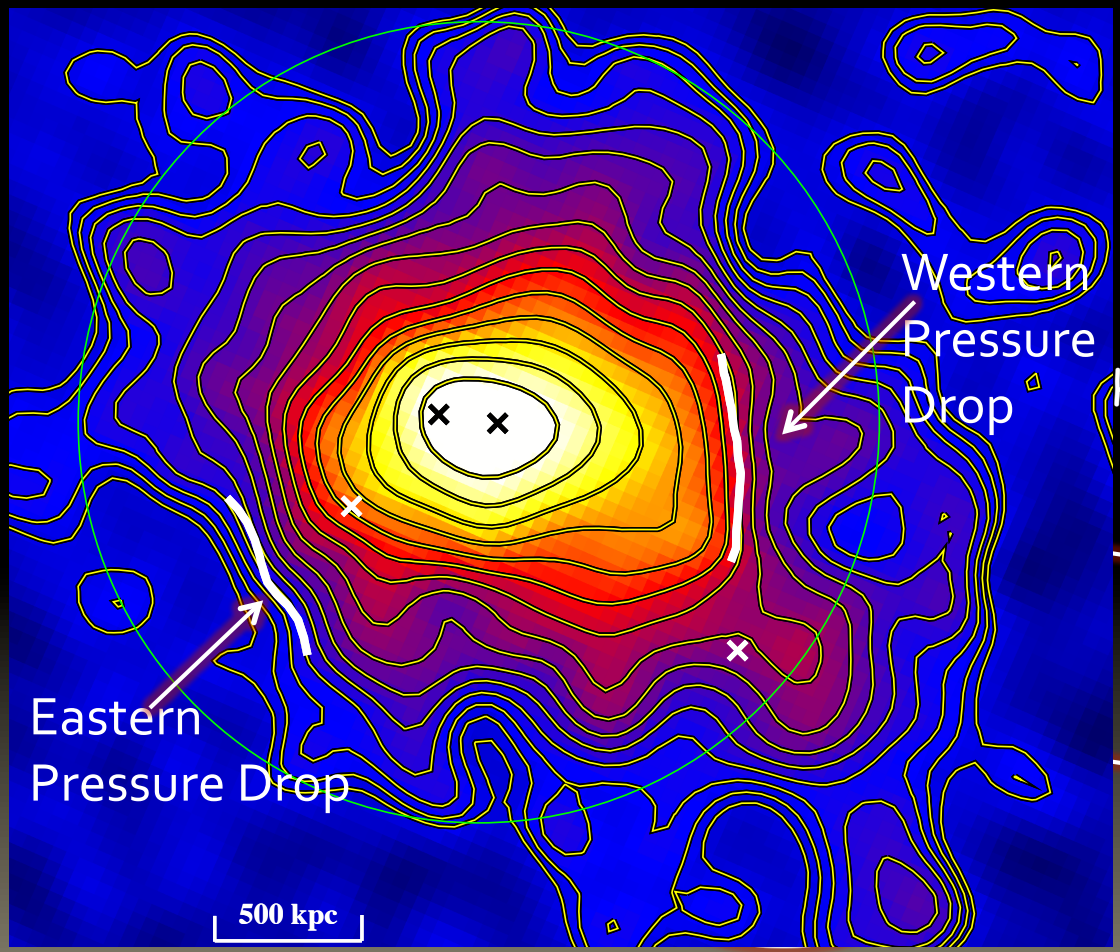
- The Coma cluster is the strongest SZ source of the Planck sky
- It is a massive nearby (z=0.023) cluster
- T=7.66 ±0.2 kev
- $M_{500}=(7.33\pm1)\times10^{14}\ M_{sun}$
- $R_{500}=(1.31\pm 0.06)$Mpc (Bourdin et al. 2012)

Spatially resolved by Planck, 10' = 278 kpc

Observations of Coma

- it has been extensively observed at different wavelengths
- Previous best SZ profile from 7 year WMAP data (Komatsu et al. 2011), with detection at S/N=3.6
- Planck detection S/N>22

Planck y Map of Coma



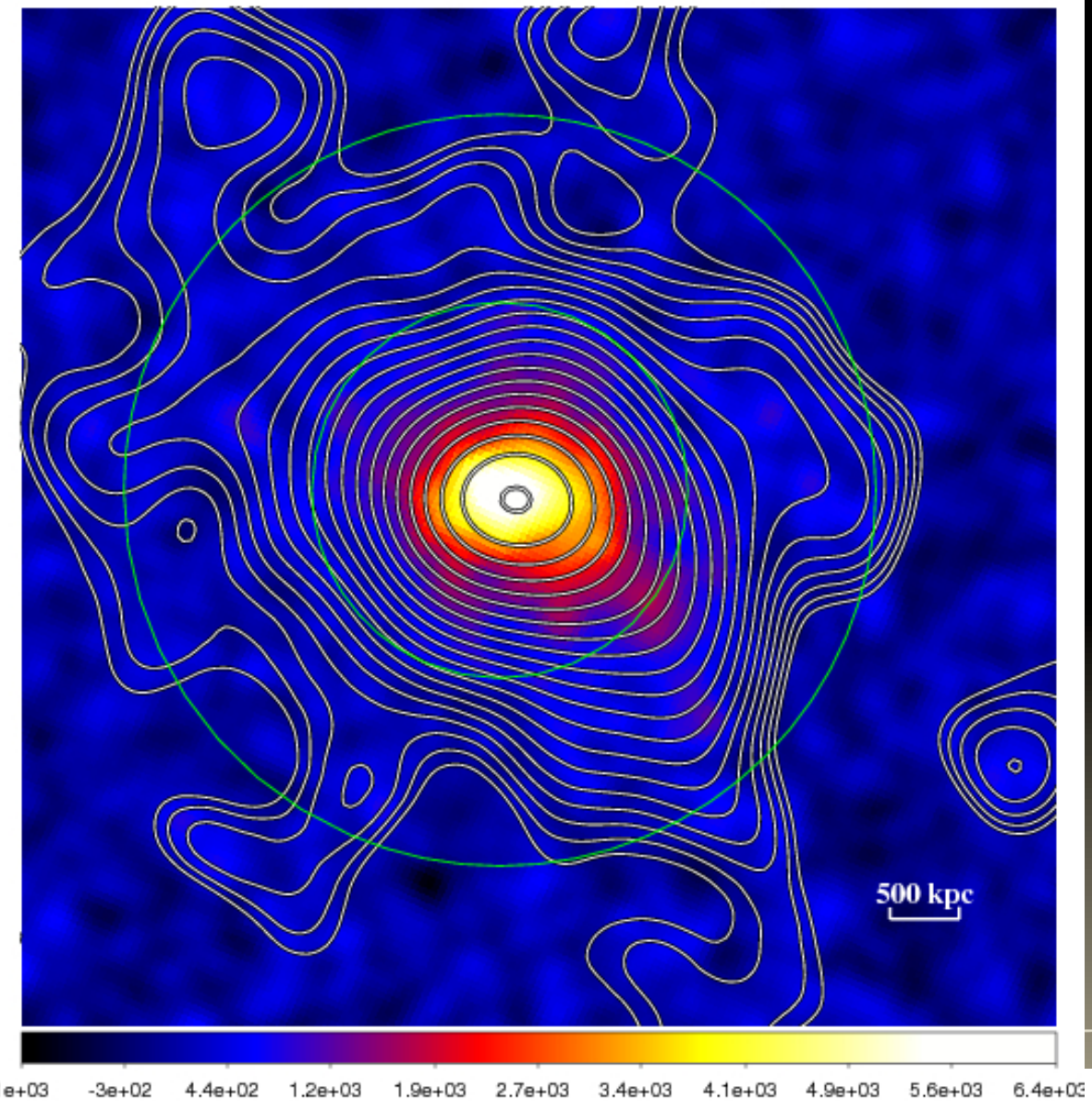
MILCA 10 arcmin
Levels> 2*σ
σ= 2.13x10^{-6}
Levels log equispaced by $2^{1/4}$
Green circle = R_{500}

HFI from 100 GHz to 857 Ghz

Y map extended in the East-West direction

extended Y emission

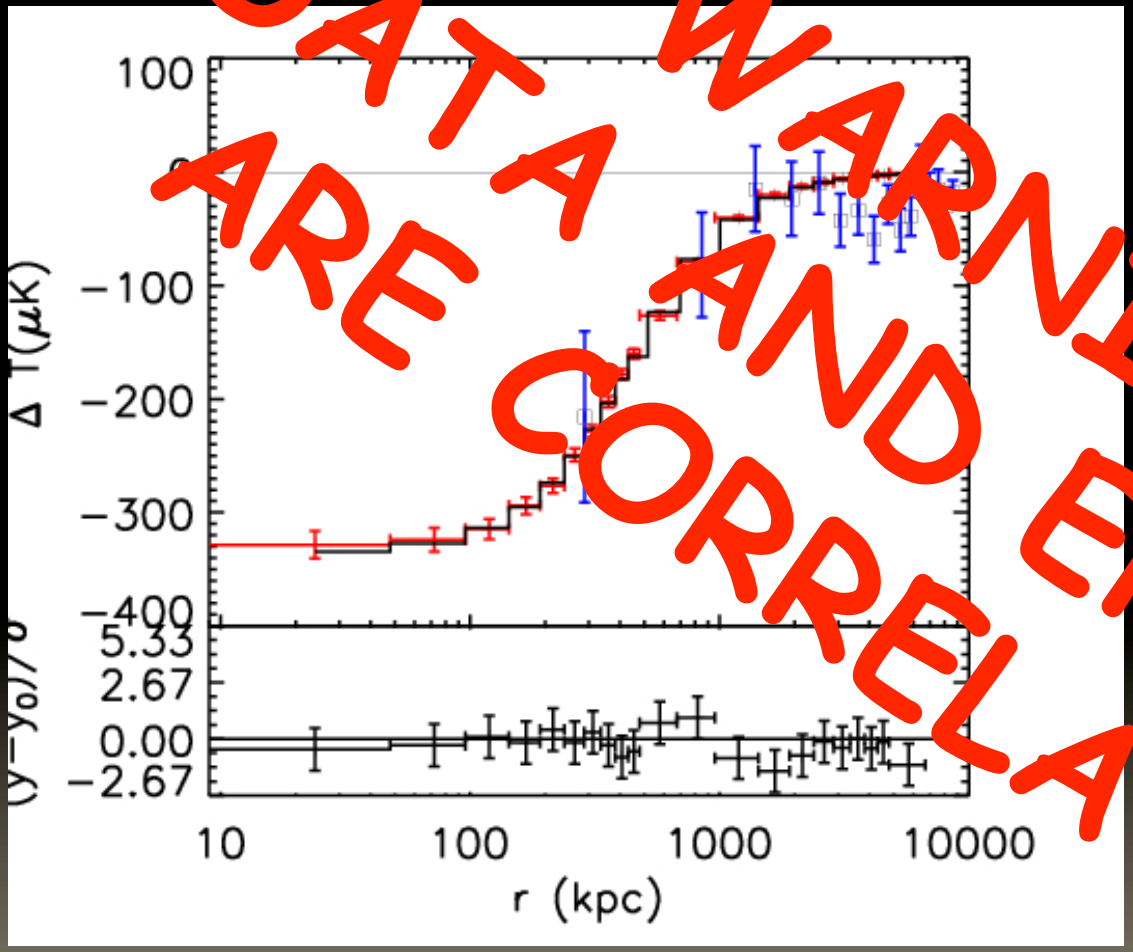
Coma y map



MILCA **30** arcmin
Levels> 2*σ
σ= 6.7e-07
Levels log equispaced by $2^{1/4}$
Green circles = R_{500} and R_{200}

LFI 70Ghz plus HFI from
100 GHz to 857 Ghz

A Simple Performance Test



DATA WARNING
ARE CORRELATED AND ERRORS

SZ radial Profile of Coma
Planck v.s. Wmap

Blue points WMAP data
Optimal V and W band
from Komatsu et al 2011

Red points Planck: the
data quality of the Coma
cluster is spectacular"

RESULT 1

Global Radial Profile

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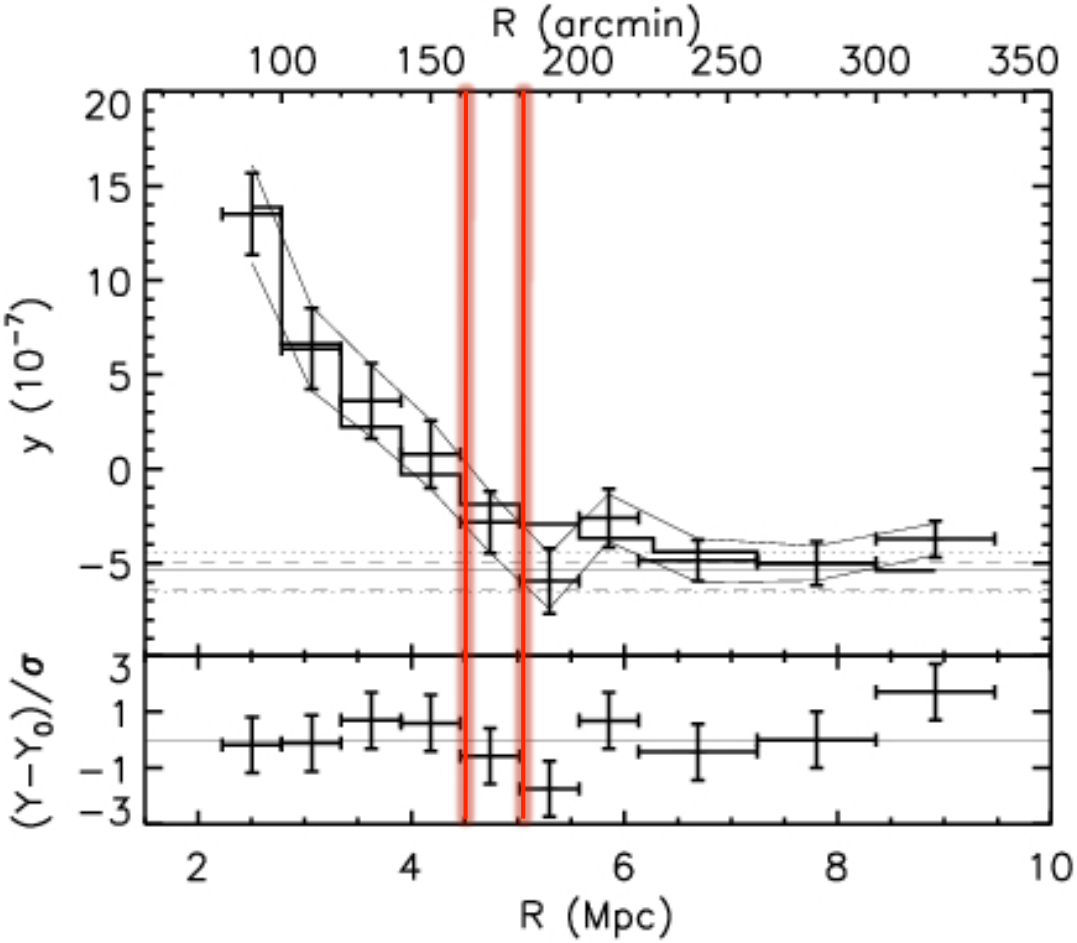
Zero Level and SZ detection limit

SZ radial profile extracted out to 6deg from the cluster center

This allow to find the zero level of the y signal

It also shows that Planck Detects, on average, SZ signal up to 4.5-6 Mpc (4-5 R_{500})

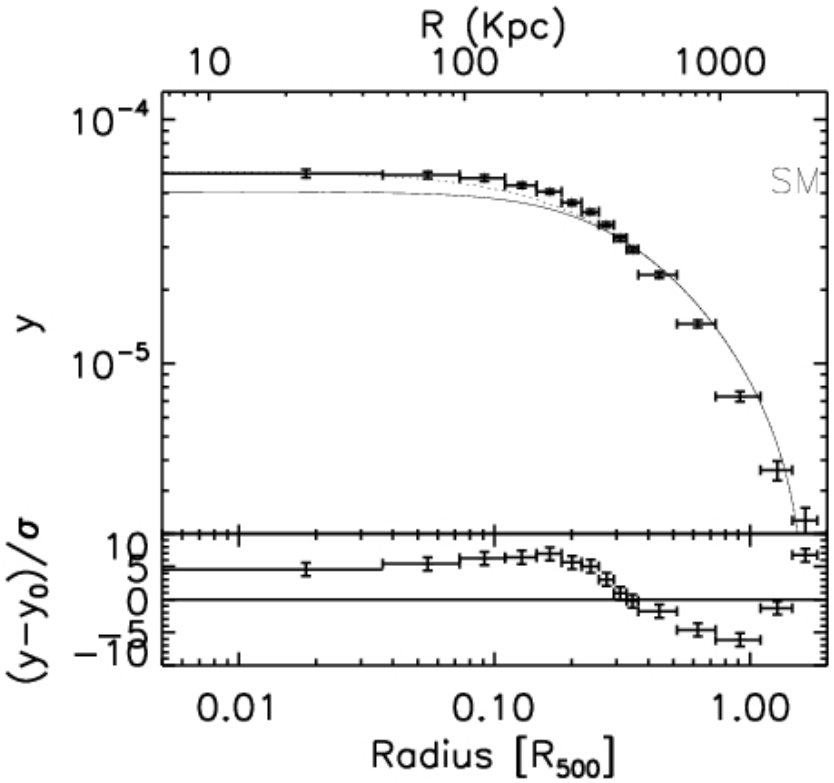


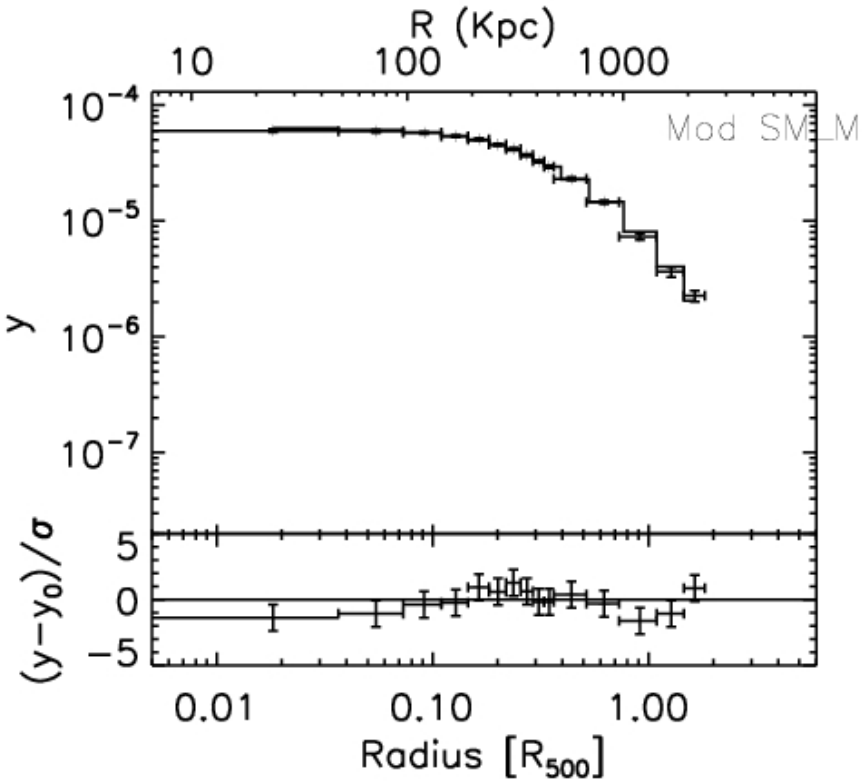
Coma Pressure Profile

Comparison with the SM (Cavaliere et al 2009)
We limit the comparison to the maximum R allowed by the model ($\approx 2 \times R_{500}$)

SM model from Fusco Femiano et al. 2011 that fits the Rosat Suf. And XMM T profiles

SM fit to Planck leaving c, kc, and a free Parameters (R_{500} fixed to XMM)





Coma Pressure Profile

Fit of the radial SZ profile with an analytic pressure profile

A) Universal Pressure Profile (Arnaud et al.)

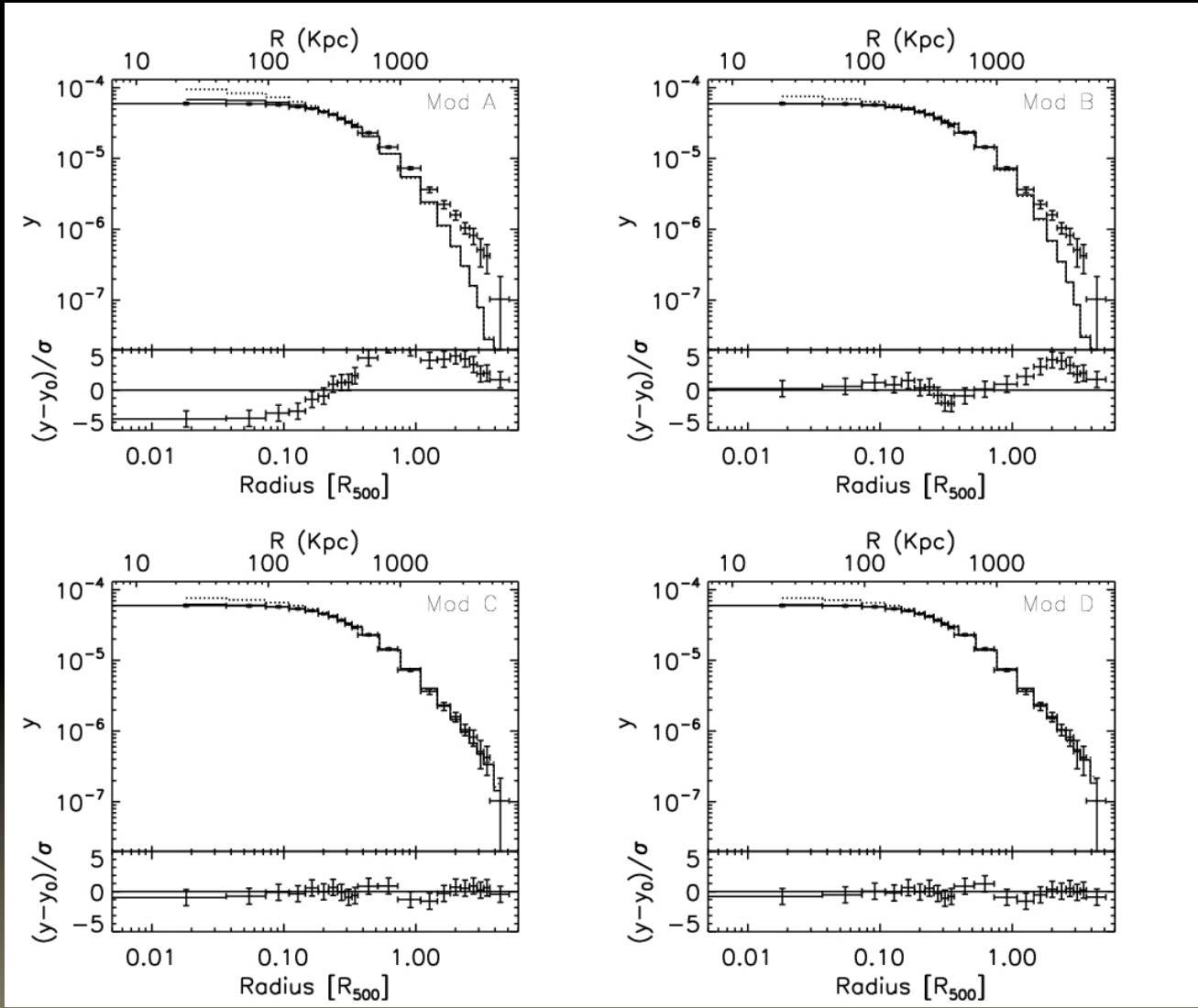
B) Pressure Profile for merging systems

Model B provide a good fit up to R_{500} but it is too steep at large radii

C) Modified Pressure Profile

D) Vikhlinin Fitting Formula

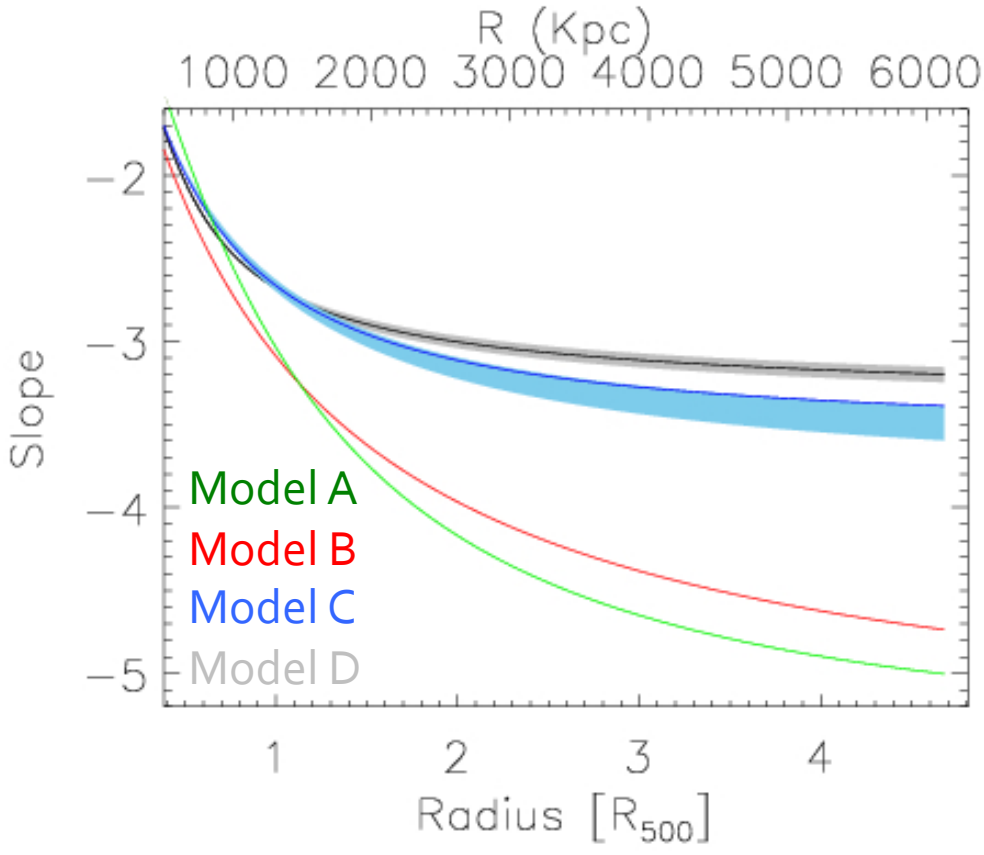
Model C is a good fit



External Slope of the Pressure profile of Coma

Coma External Slope = 3.5±0.3

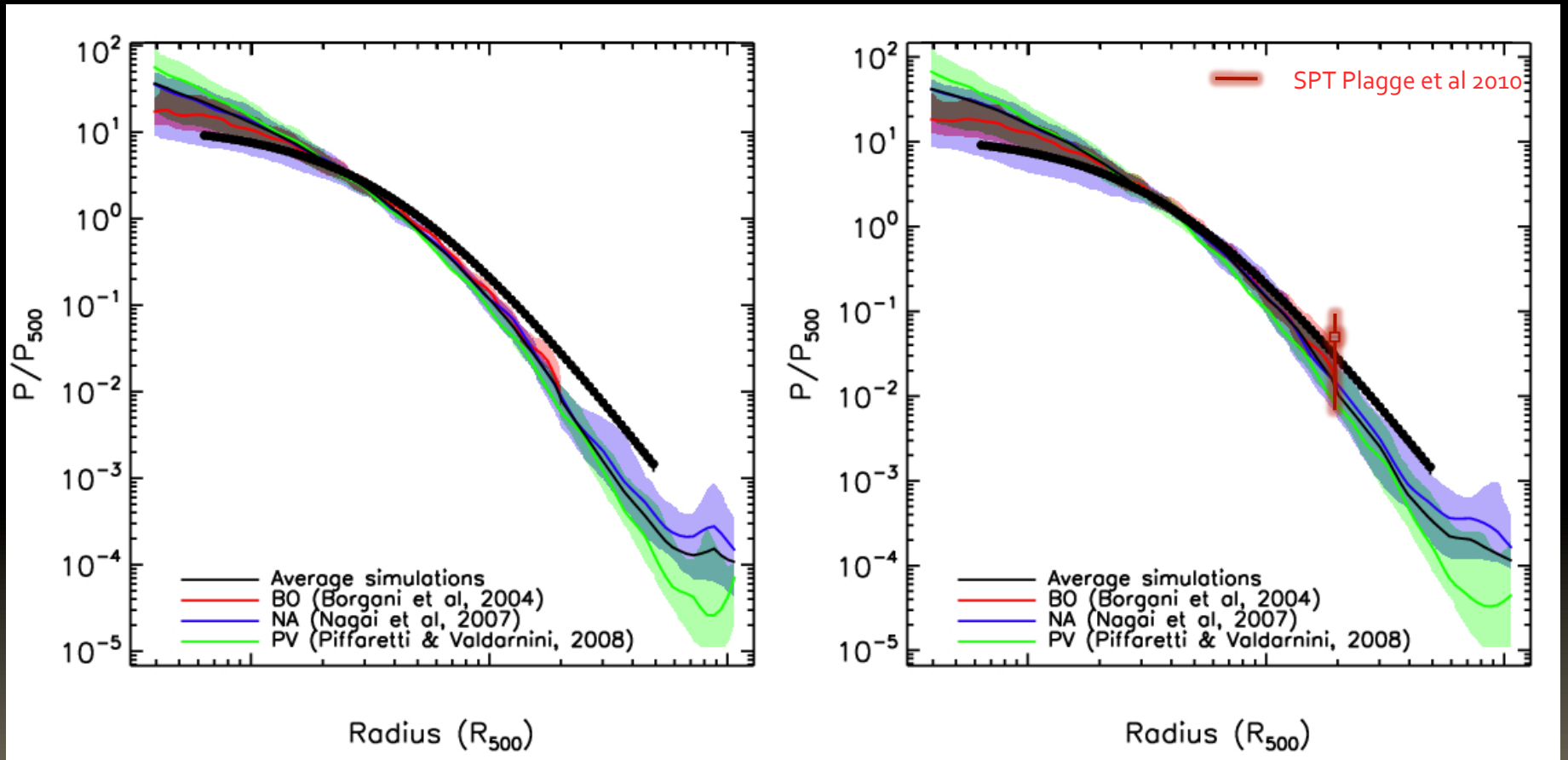
Mean Slope from simulation=5.49



Pressure Profile

Renormalized to the true mass

Renormalized to the HE mass

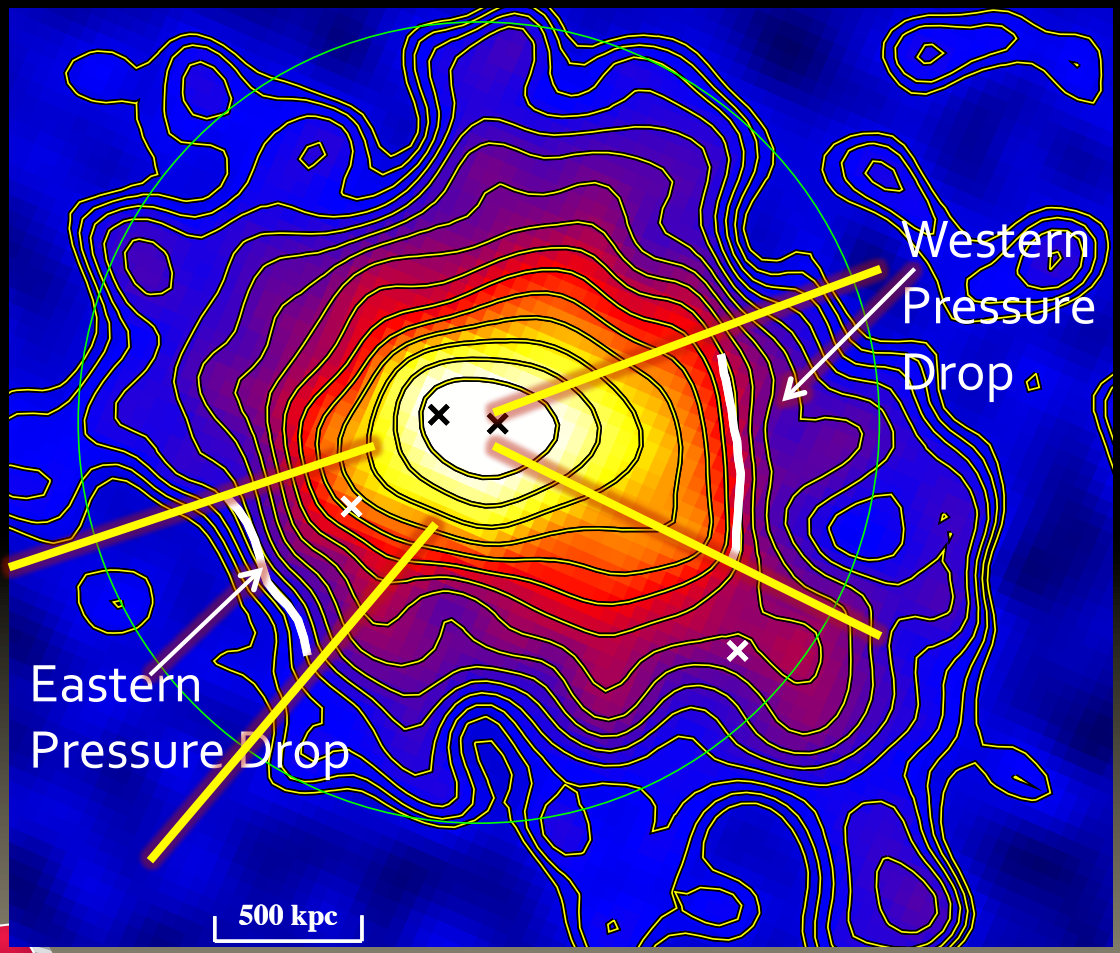


Coma Pressure Profile

RESULT 2

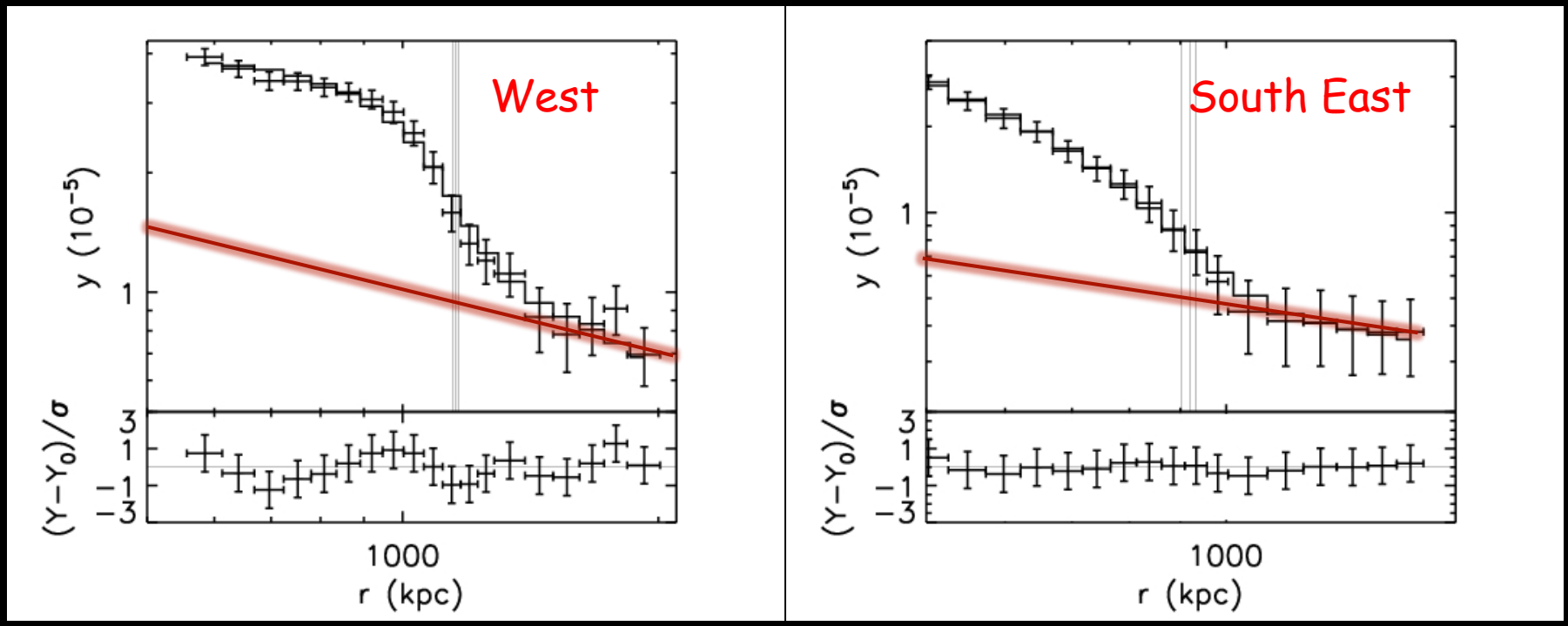
Radial Pressure Drops

Pressure drops in the y Map



We Extracted SZ profiles from two cluster sectors containing the pressure drops

Rapid pressure drops in Coma

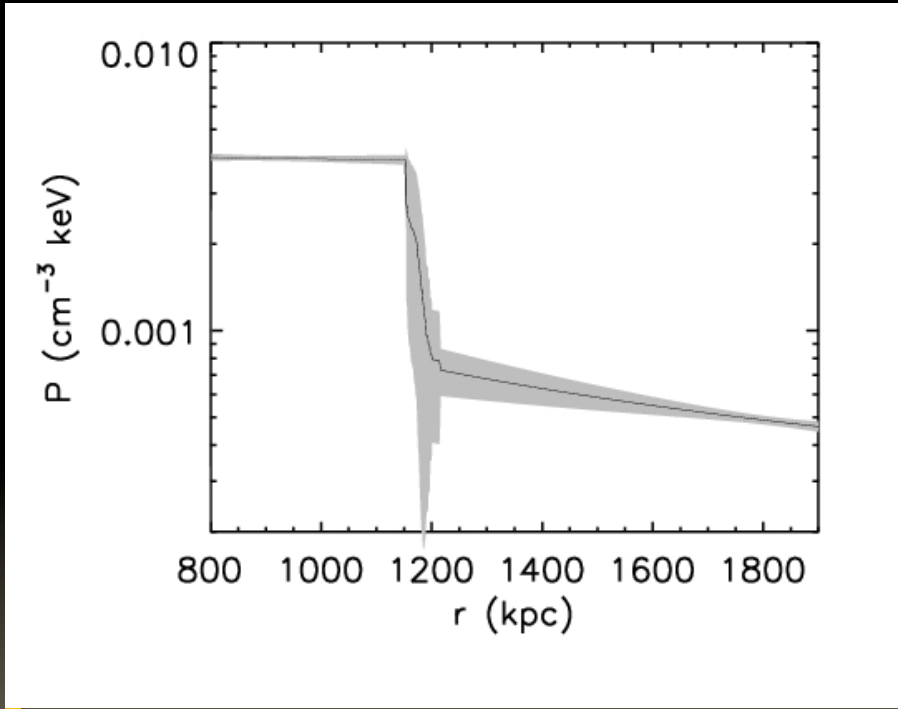


- The profiles confirm the presence of pressure drops to the West and the South East
- The west pressure variation has been noticed by Markevitch 2010 and it shows a correspondent radio edge (Brown and Rudnik 2011)
- Observed pressure drops are consistent with being discontinuous
- With this assumption we tried to measure the corresponding pressure jumps

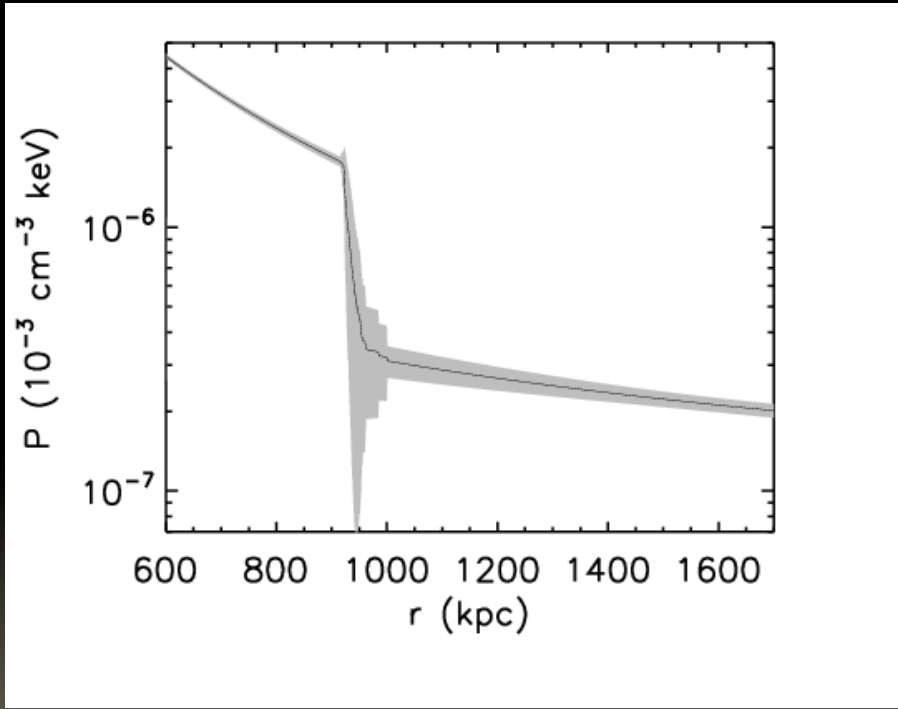
Rapid pressure drops in Coma

We fitted the observed profiles using a 3D pressure profile composed of two powerlaws with a pressure jump

West



South East



$D_j=4.5^{+1.4}_{-0.08}$

$D_j=4.9\pm1.6$

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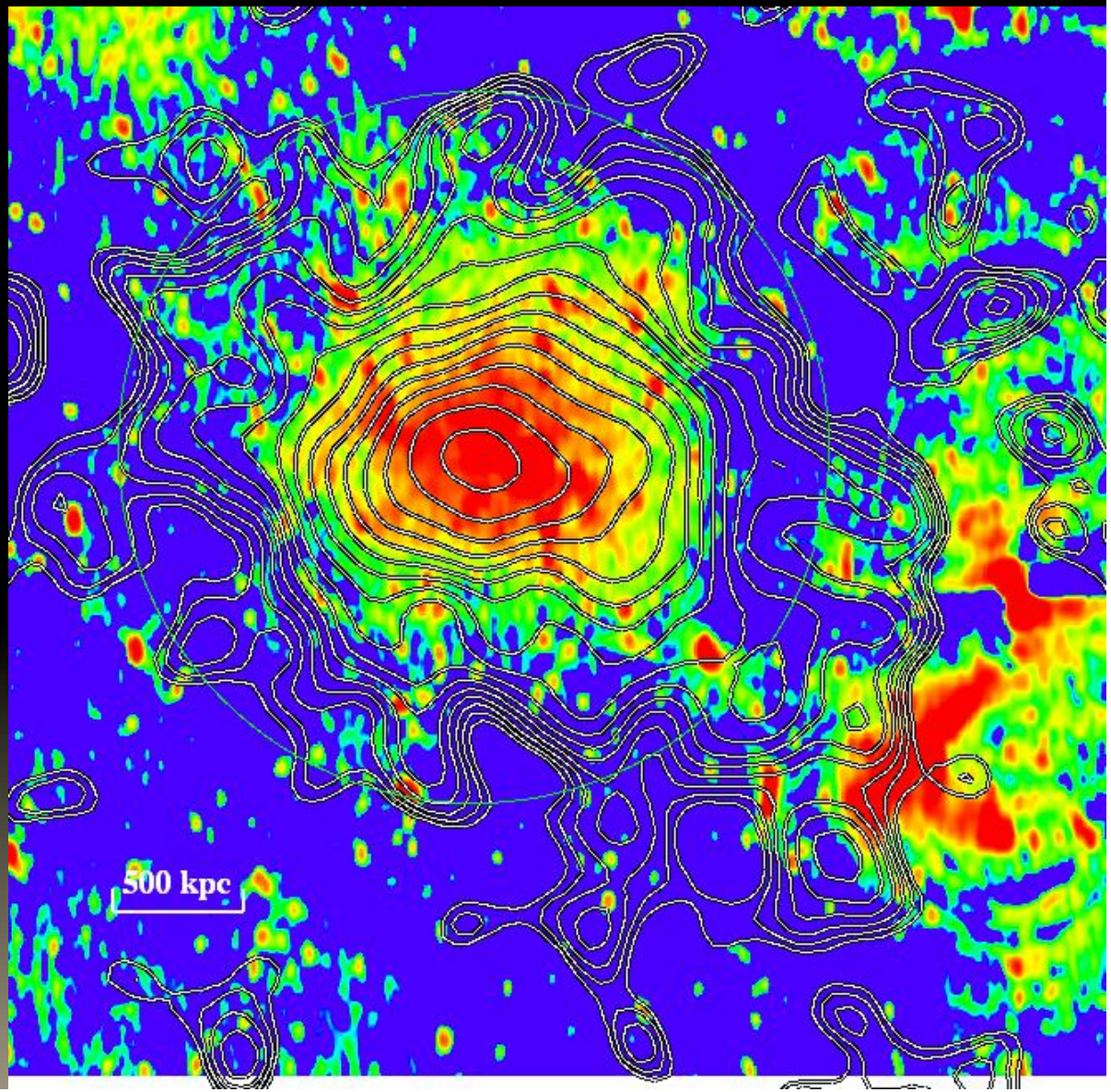
RESULT 3
Y-RADIO RELATIONSHIP

Y-RADIO RELATIONSHIP

Westerbork Synthesis Radio Telescope total intensity at 350 MHz (Brown and Rudnick, 2011) overplayed to the Planck isocontours



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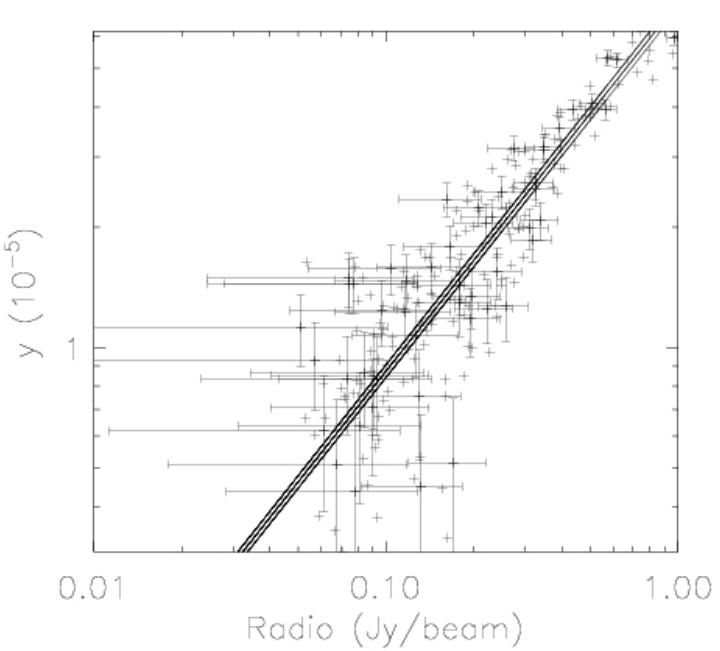
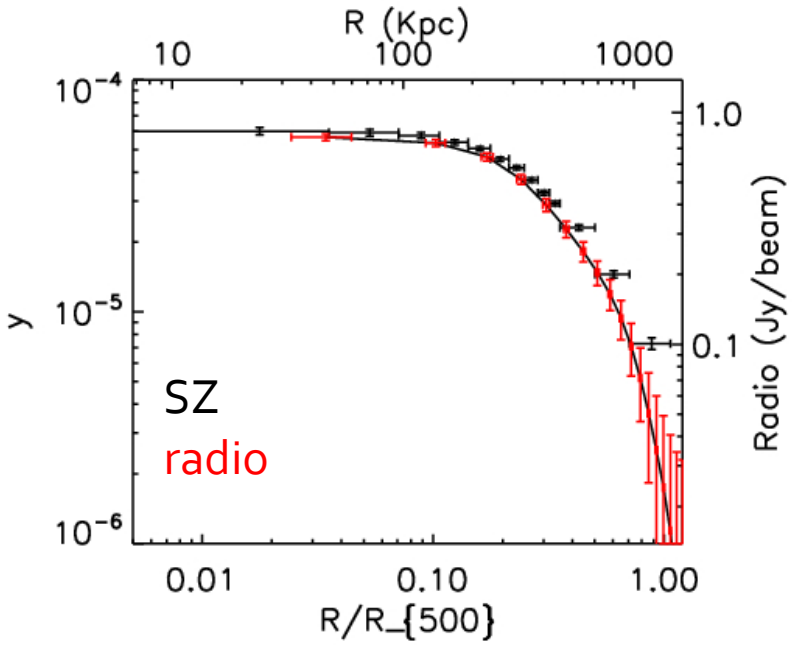
Scatter and radial plots





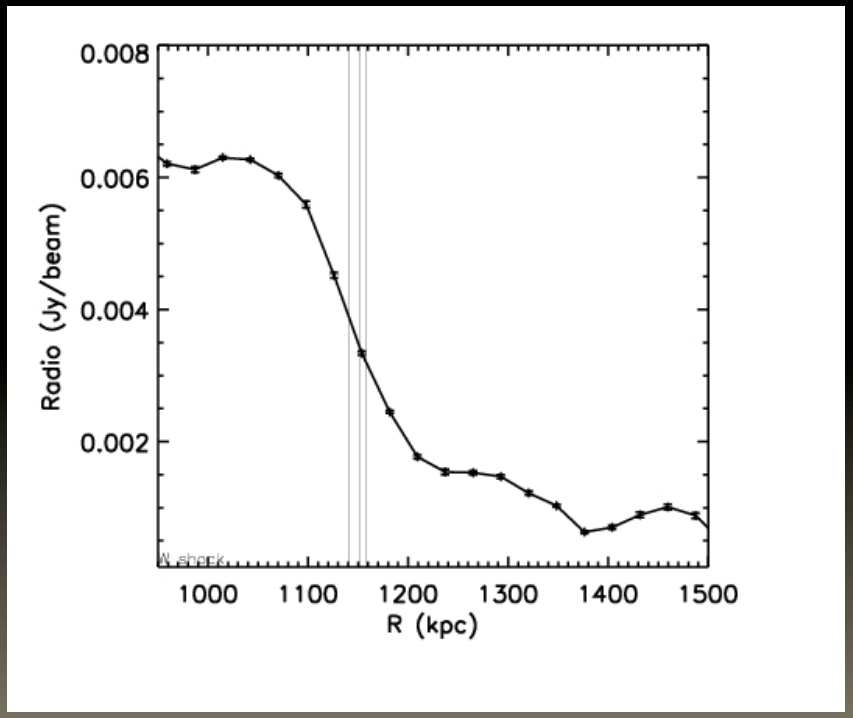
Log $(y/10^{-5})$= c +m Log (Radio)
m=0.92±0.03
C=0.86±0.02

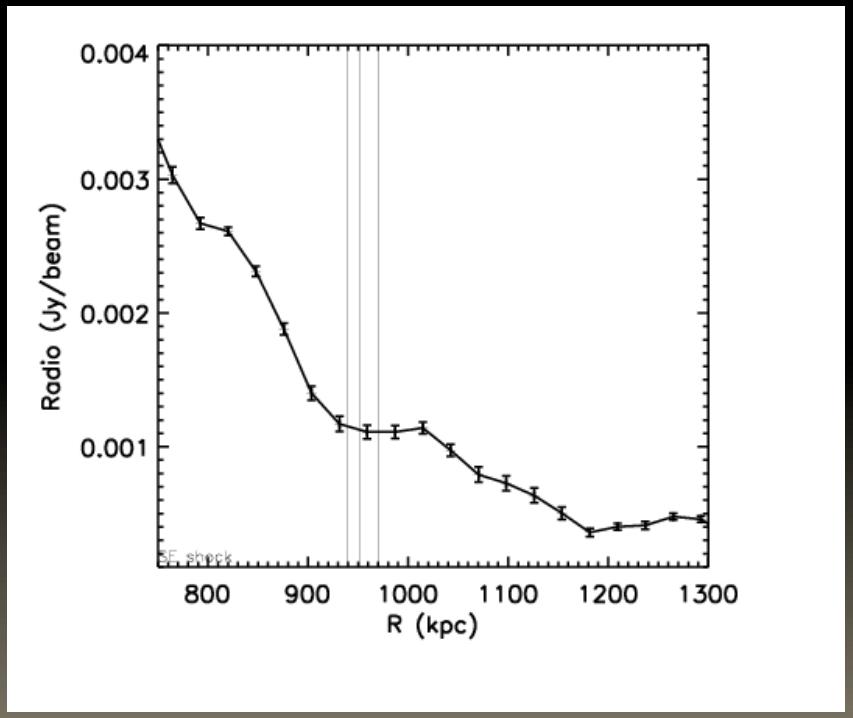
Quasi linear relation

- This puts constraints on models of the cluster magnetic field and the production of cosmic ray electrons
- One or both of these components must be very broadly distributed, i.e., not scaling with the thermal density that produces the Y signal

Radio profiles at the Pressure drops

- The radio data show a rapid drop coincident with the observed y pressure drop in the west, and near the y drop in the southeast
- The radio halo seems to be "confined" within these drops
- If the drops are generated by shocks, this demonstrates the importance of shocks in generating radio halo emission, either directly or through their post-shock turbulence





Radio data from Brown and Rudnick (2011)

Conclusion 1/3

- We presented the data analysis of the Coma Cluster observed in SZ with *Planck*
- Planck detects signal up to 4-5 R_{500}
- We find that the Arnaud et al. pressure profile for merging systems is a good fit up to R_{500} and underestimates P at larger radii
- The observed P slope is shallower than the average predicted by simulations, lying on the very upper side of the distribution

Conclusion 2/3

- We find two rapid pressure drops in Coma that are compatible with the presence of discontinuities in the 3D pressure
- Despite of its angular resolution (10') Planck is effective in detecting and measuring possible pressure jumps in Coma
- Radio data shows similar intensity drops close to the pressure ones

Conclusion 3/3

- Y and radio brightness are strongly correlated, with an approximately linear relationship
- This puts strong constraints on models of the cluster magnetic field and the production of cosmic ray electrons. One or both of these components must be very broadly distributed, i.e., not scaling linearly with the thermal density that produces the Y signal

The End