

Non-thermal phenomena in Large-Scale-Structure: overview and INAF contribution

Gianfranco Brunetti



Small numbers...

6 full time staff
(IRA, OAC)

10+ coll. staff/associate

5+ post doc

4 PhD

~15 refereed PAPERS/yr (+LColl)

~10 /yr INVITED talks/review

AWARDS @ INAF:

Bessel Research Award,

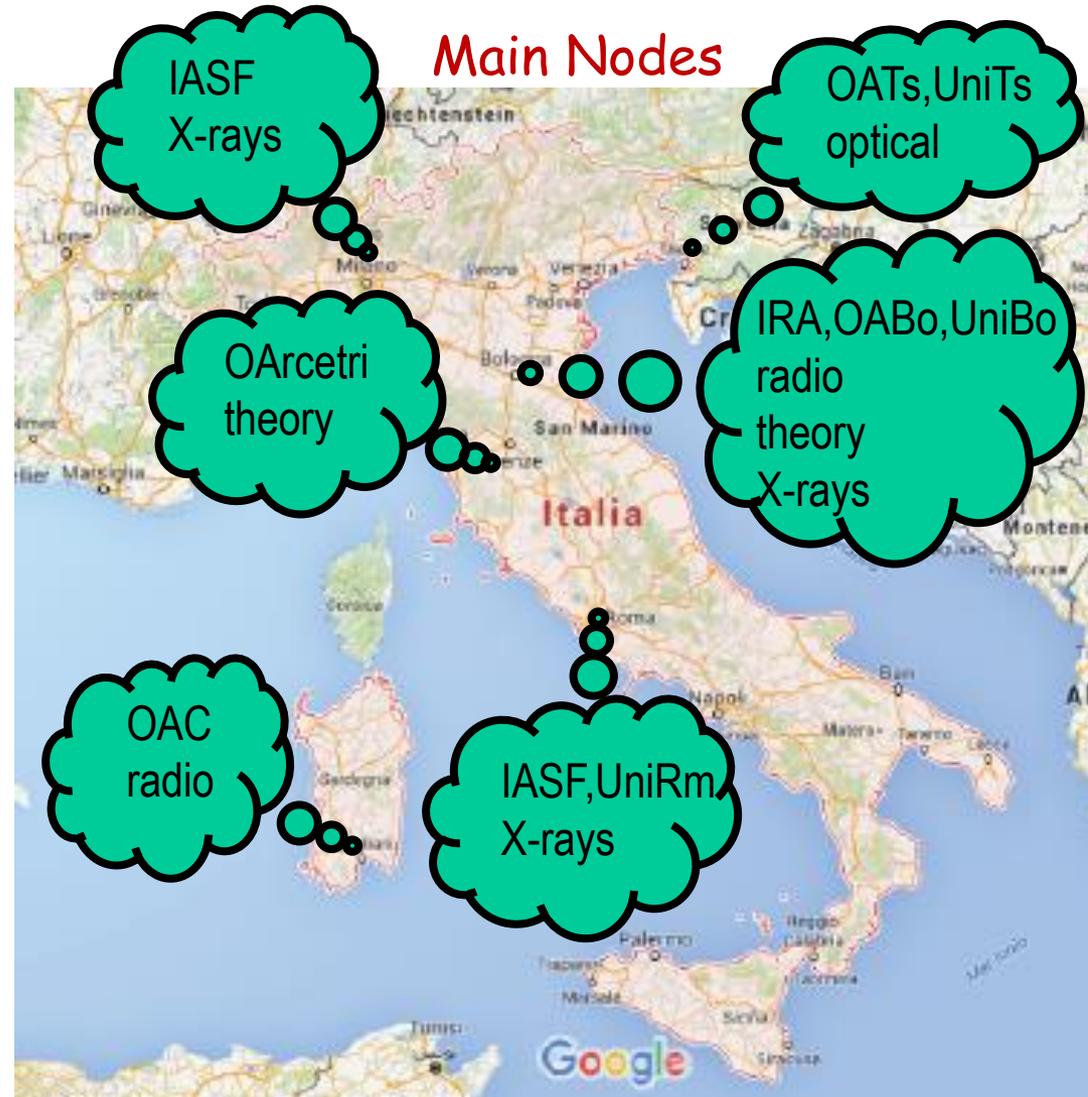
...

Shakti Duggal Award,

Giuseppe Borgia Prize,

...

Tacchini, Livio Gratton



Main Nodes

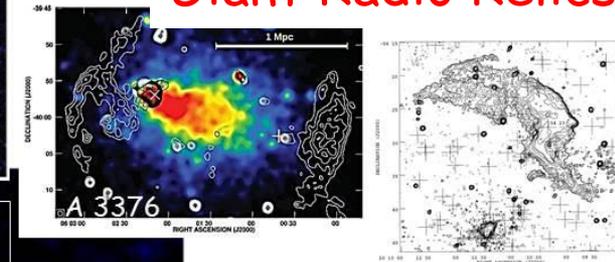
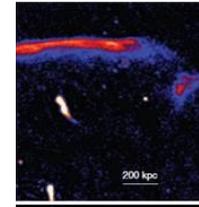
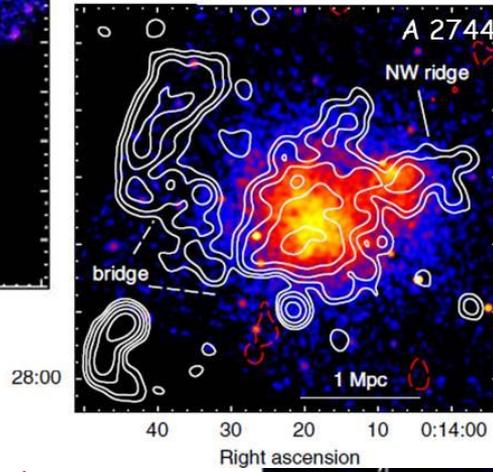
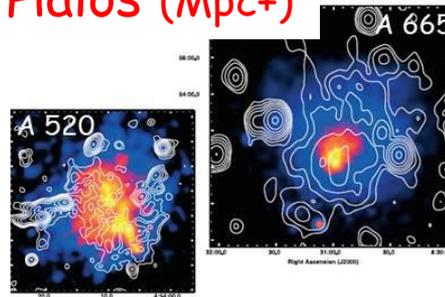
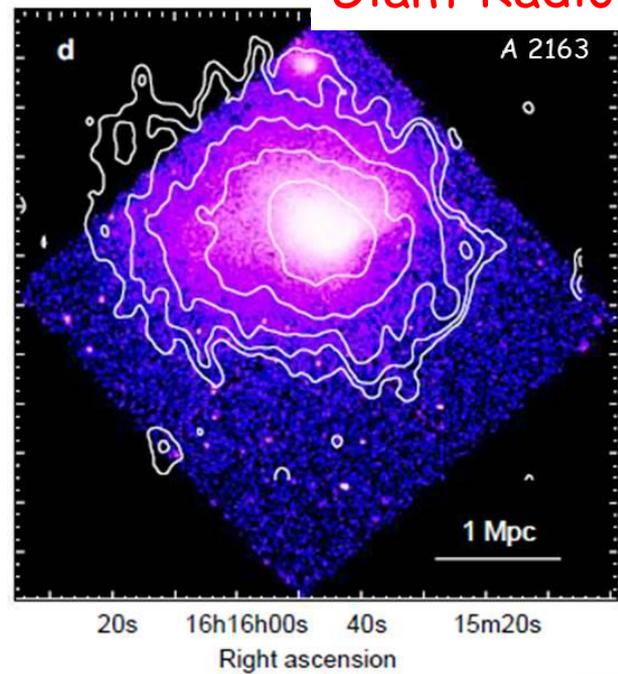
Giant Radio Halos (Mpc+)

Cluster-scale radio emission

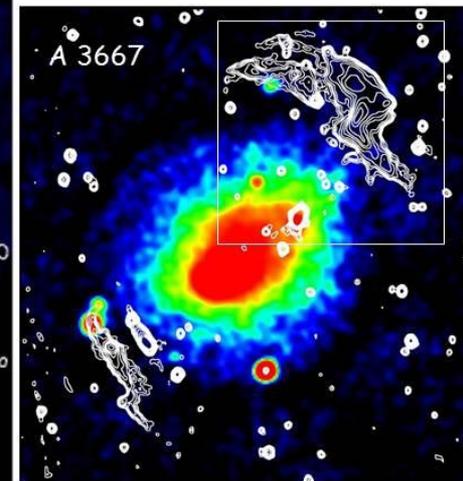
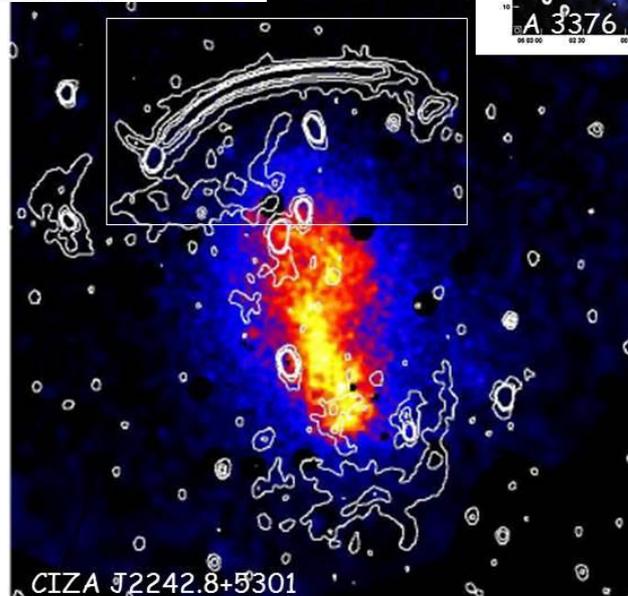
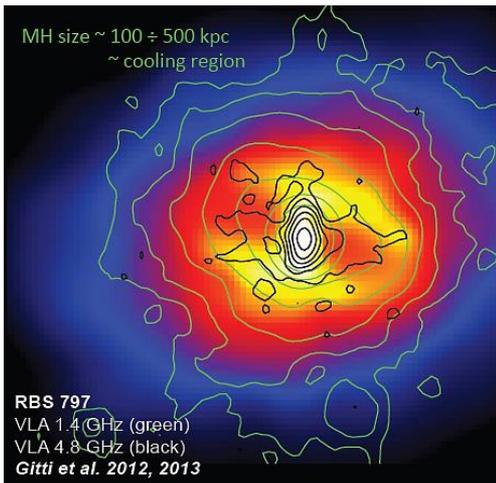
- GeV+ CR electrons
- $\mu\text{G}+$ level magnetic fields
- Origin of CRs and B ?
- Impact on ICM physics ?
- Impact on cluster dyn/evol ?

[rev Brunetti & Jones 14, Feretti et al 12]

Giant Radio Relics

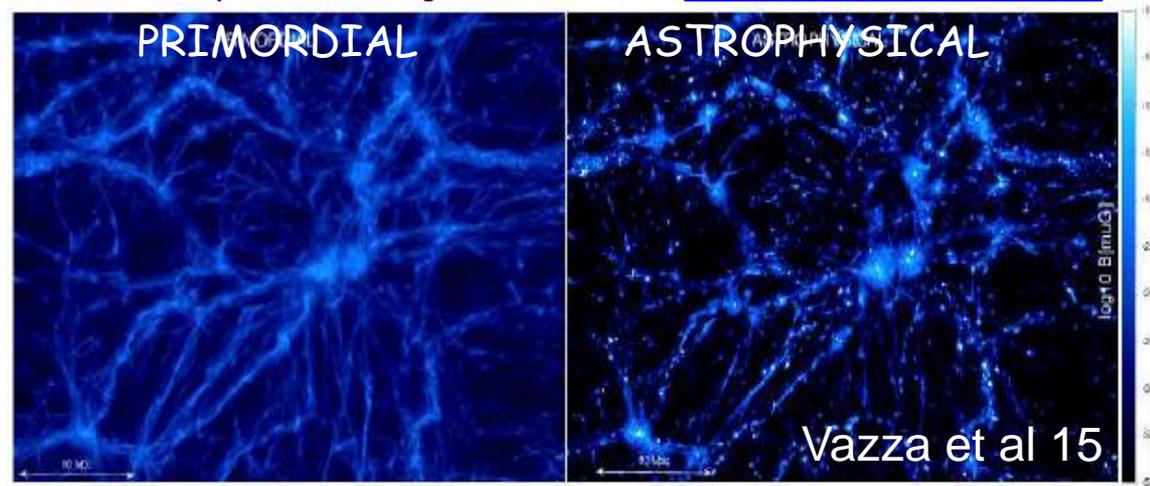
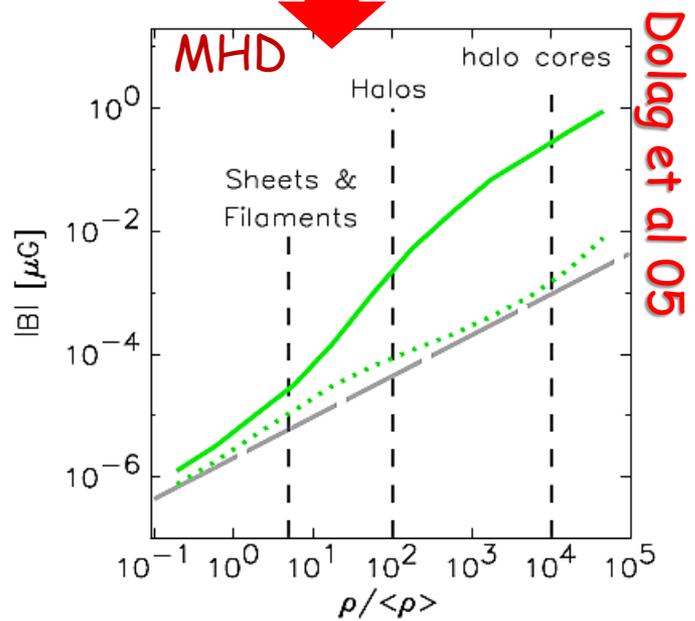
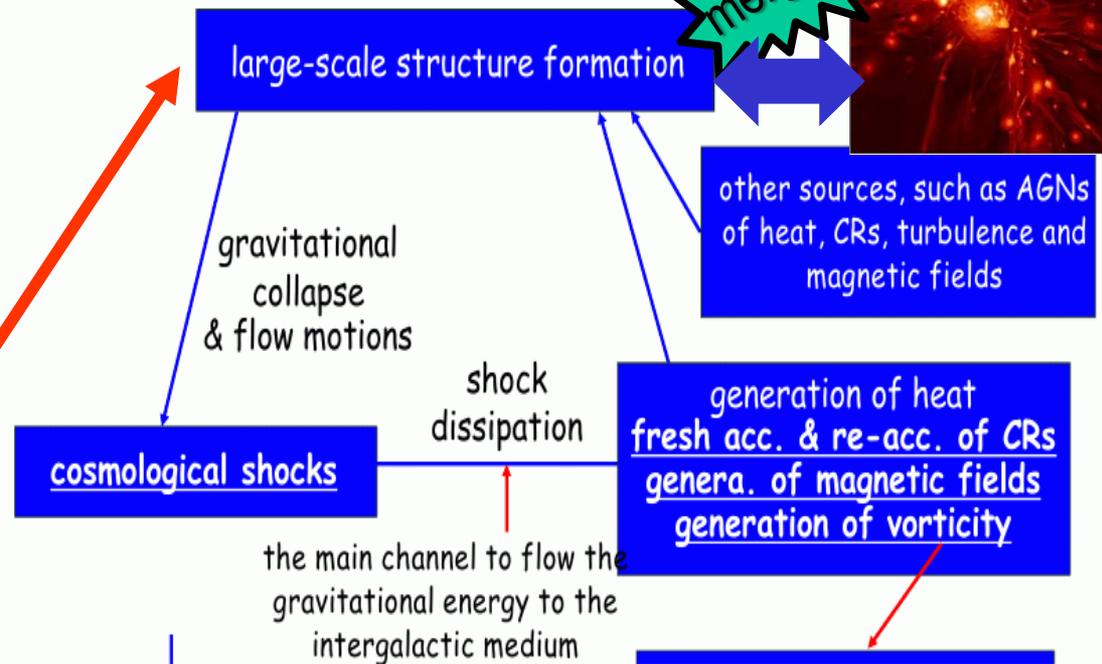
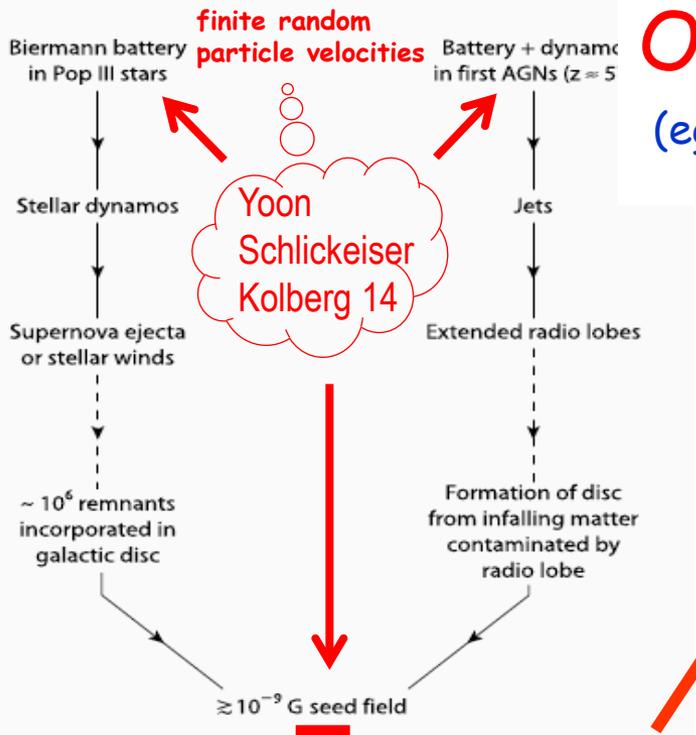


Mini-Halos (100+ kpc)

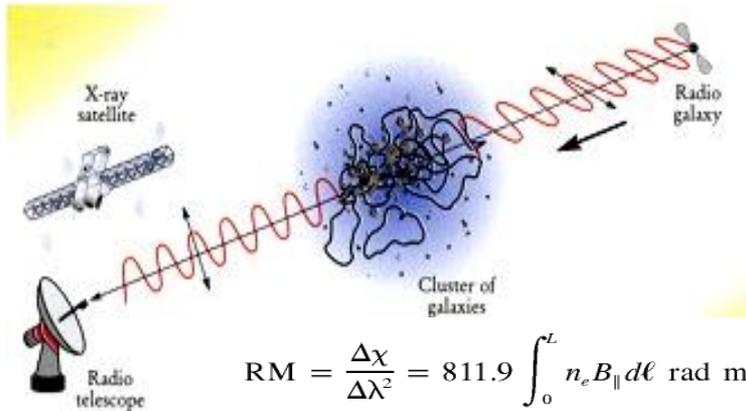


Origin of LS Magnetic Fields

(eg Rees 04 Gaensler et al 04)



Seminal contributions from INAF in measuring LF Fields



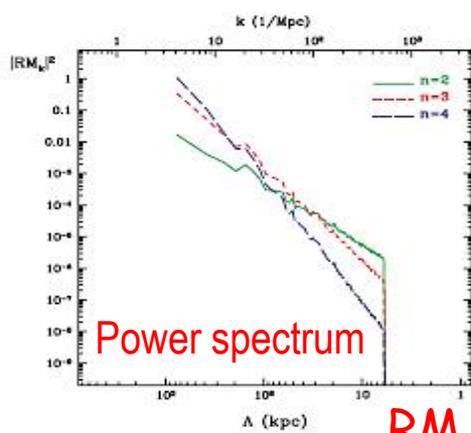
Feretti et al 95

...
Murgia et al 04

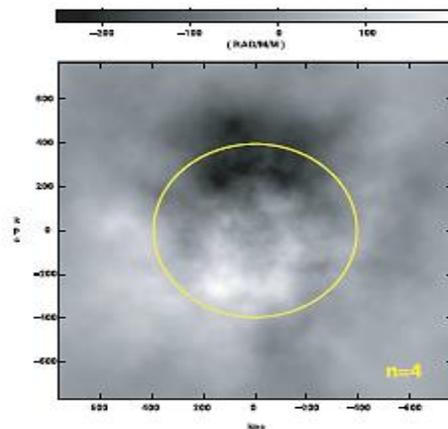
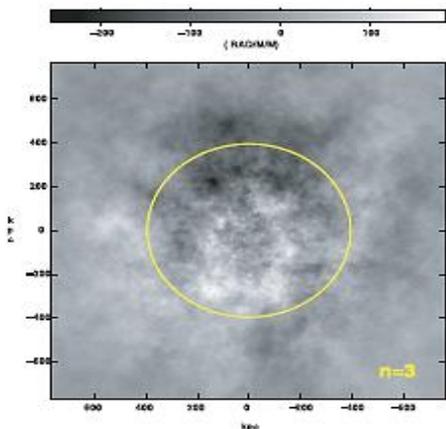
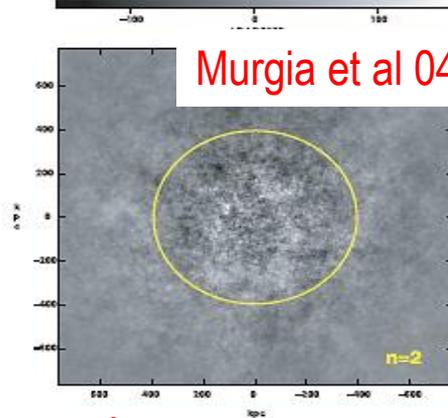
Govoni et al 05

...
Bonafede et al 10, 13 ...

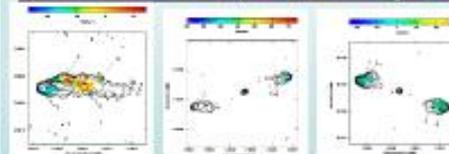
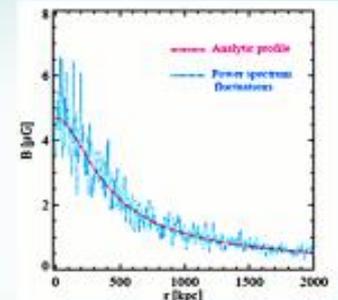
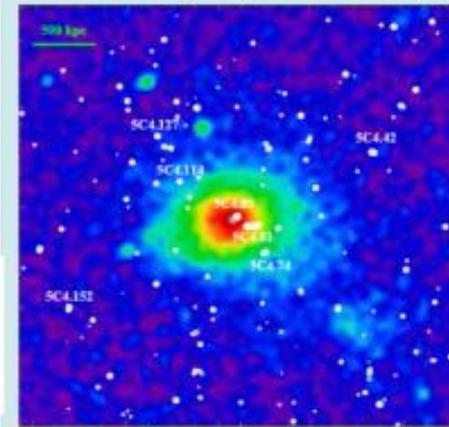
Talk by
Feretti



RM images



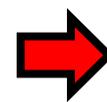
Magnetic field in Coma Cluster :
Strength, structure, radial profile with
RM from 7 sources



Bonafede et al. 2010

With SKA :
~1000 sources

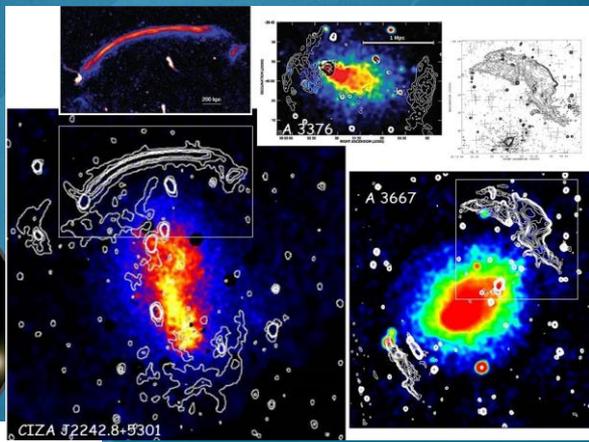
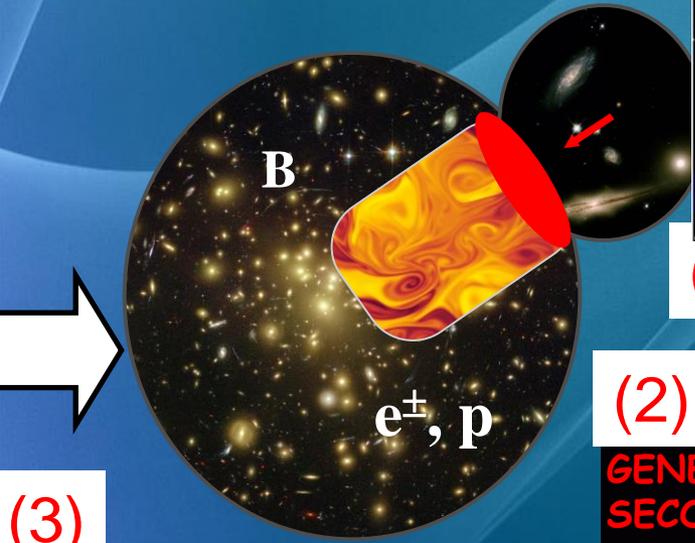
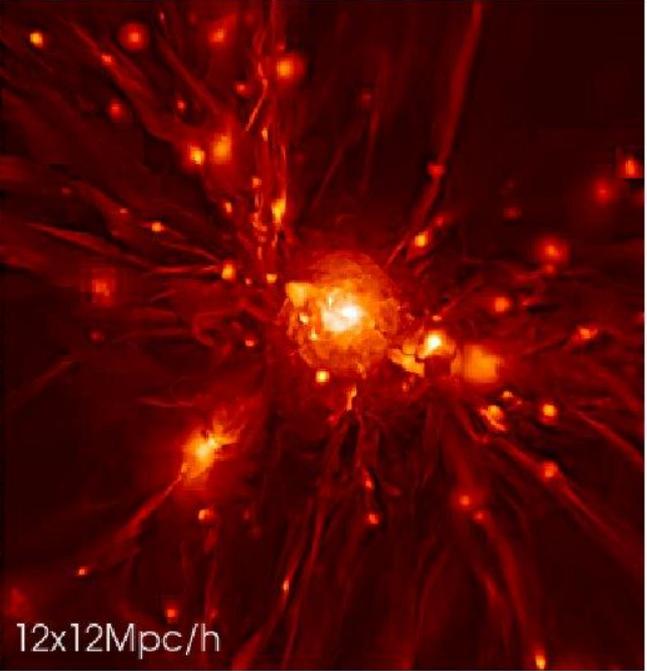
→ Many clusters
→ Distant clusters



In future : fundamental info for
(plasma)physics of the ICM

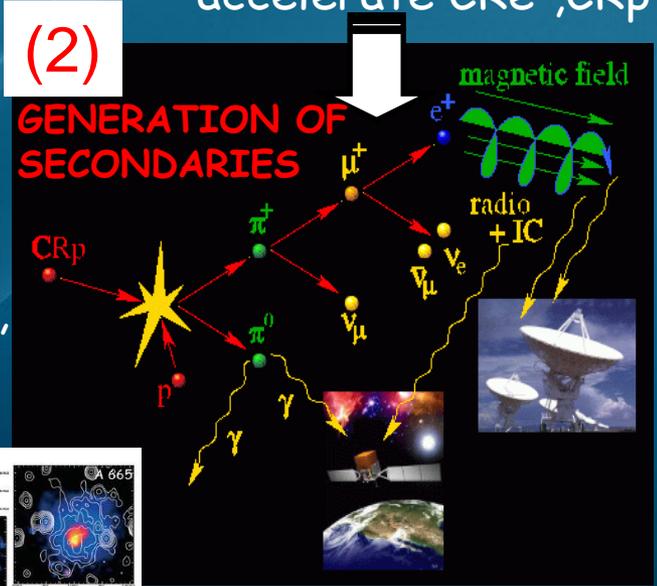
CR-acceleration

Mergers guide CRe acceleration/dynamics and/or amplify B

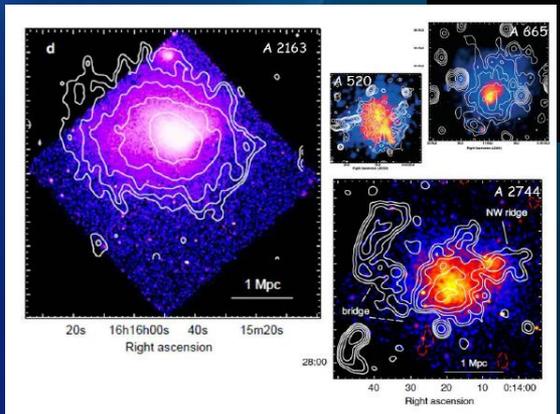


(1) SHOCKS
accelerate CRe^\pm, CRp

(3) TURBULENCE
reaccelerates fossil CRe^\pm ,
 CRp and secondaries CRe^\pm

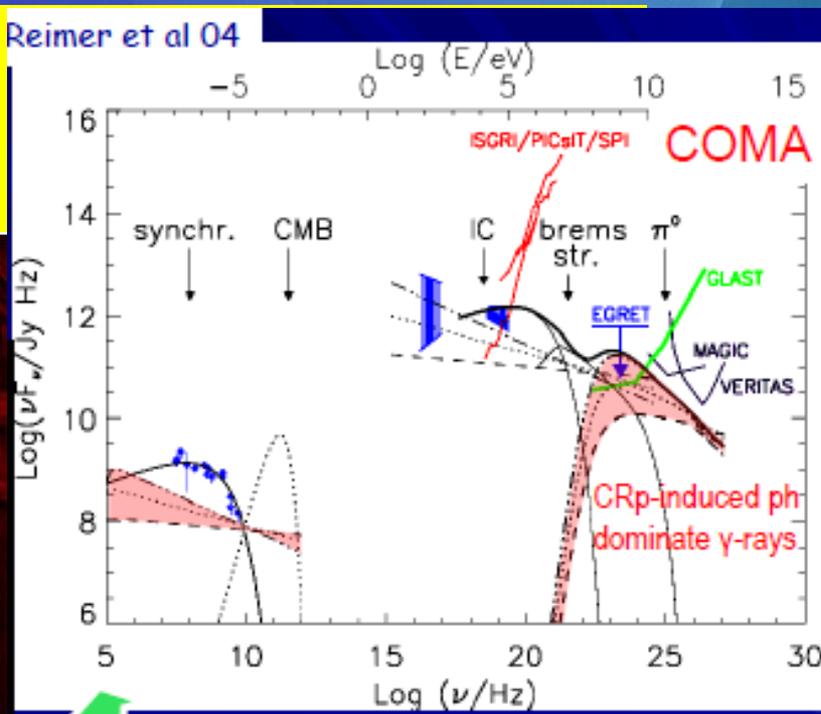


(eg Blasi + 07, Brunetti + Jones 14)



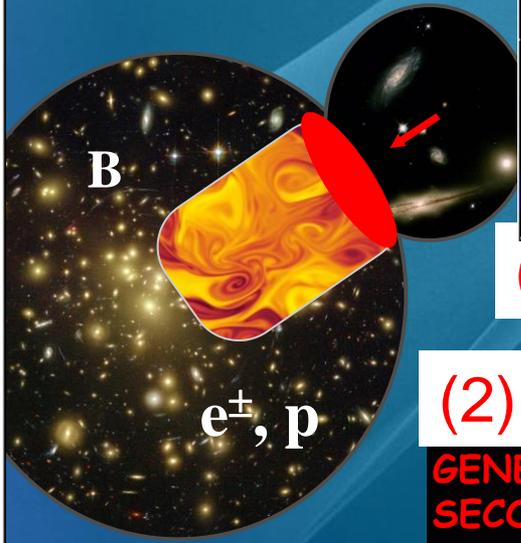
(4) MAGNETIC RECONNECTION

CR-acceleration & emission

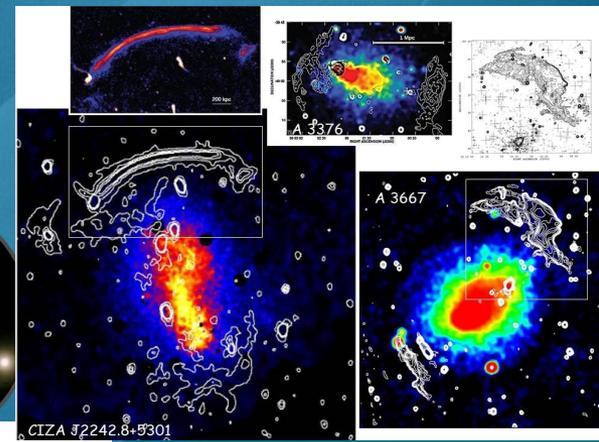


Miniati et al 01, Brunetti & Blasi 05, Blasi et al 07, Pfrommer et al 08, Brunetti & Lazarian 11

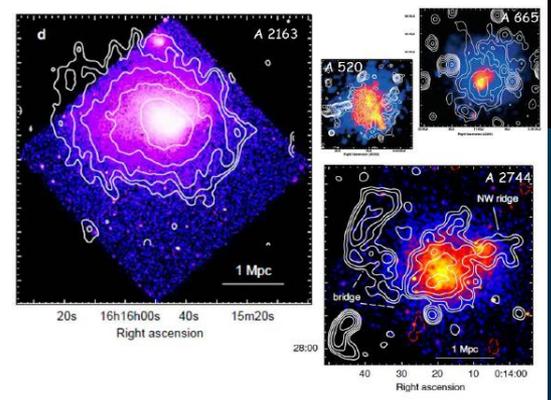
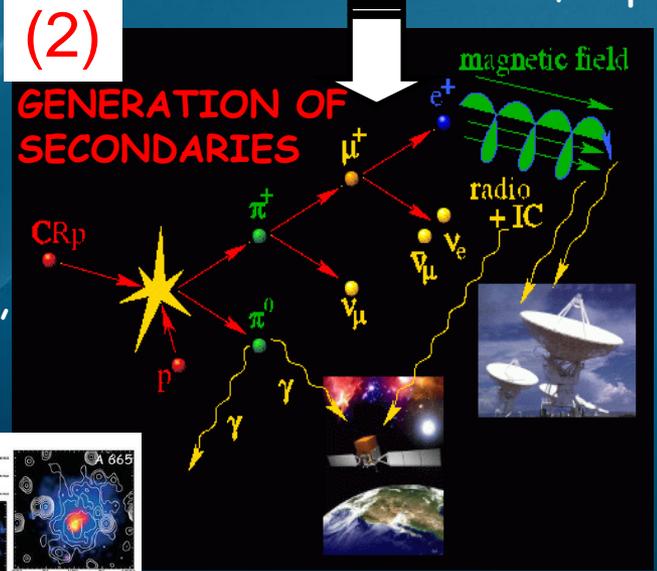
(eg Blasi + 07, Brunetti + Jones 14)



accelerates fossil CRe^{\pm} , secondaries CRe^{\pm}



(1) SHOCKS
accelerate CRe^{\pm}, CRp



(4) MAGNETIC RECONNECTION

IMPORTANT CONTRIBUTION FROM INAF

Reimer et al 04

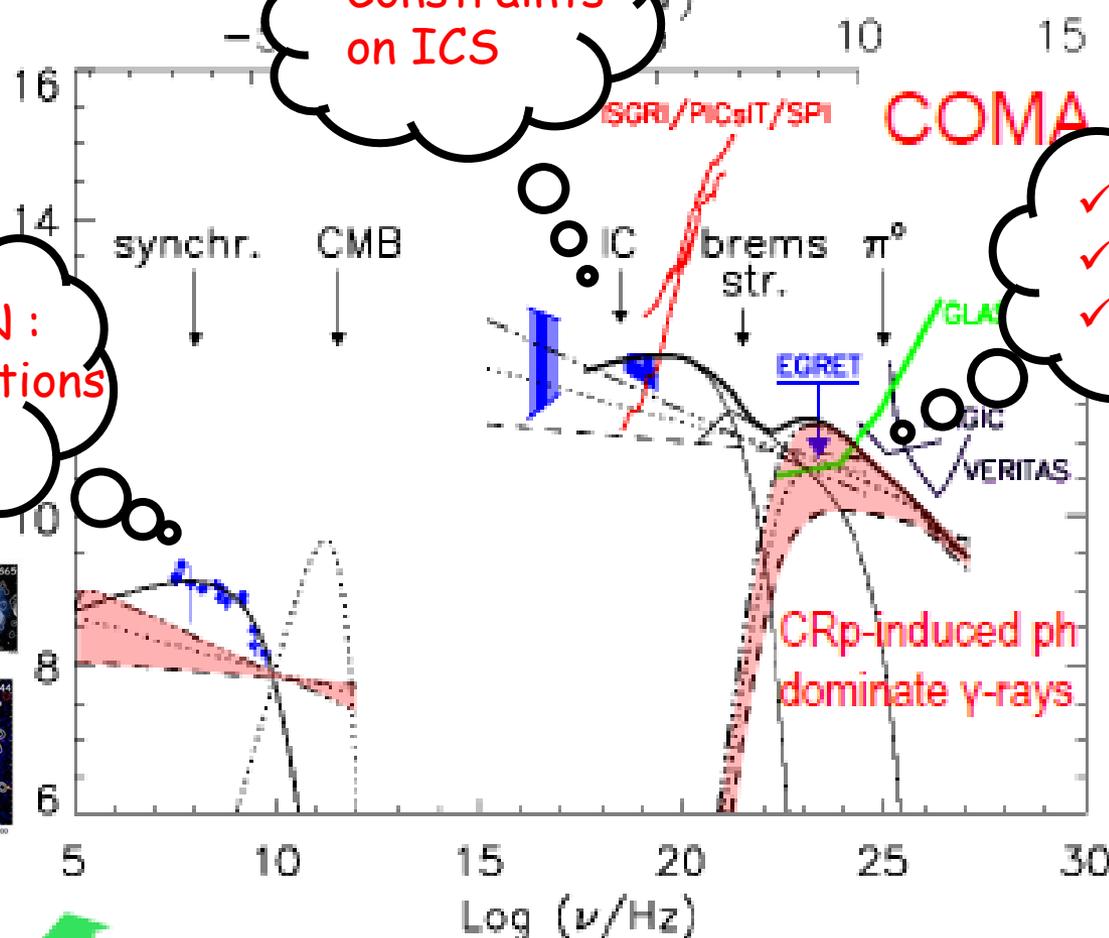
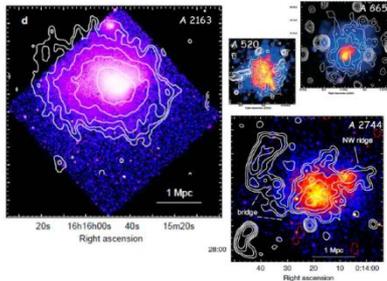
Constraints on ICS

CTA

SKA

LEADER IN:
 ✓ Observations
 ✓ theory

✓ FERMI
 ✓ MAGIC
 ✓ theory



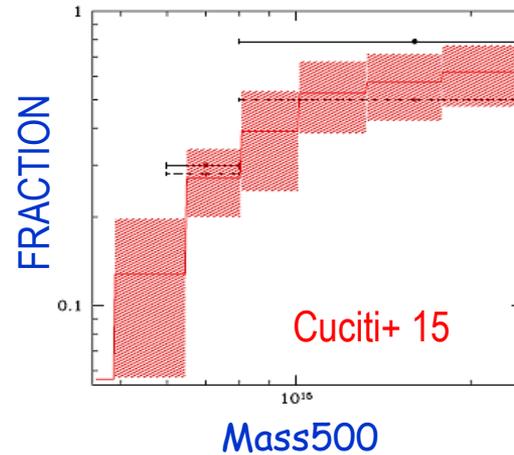
Miniati et al 01, Brunetti & Blasi 05,
 Blasi et al 07, Pfrommer et al 08,
 Brunetti & Lazarian 11

Properties of Cluster-scale radio emission

- INAF 'pioneered' this field -

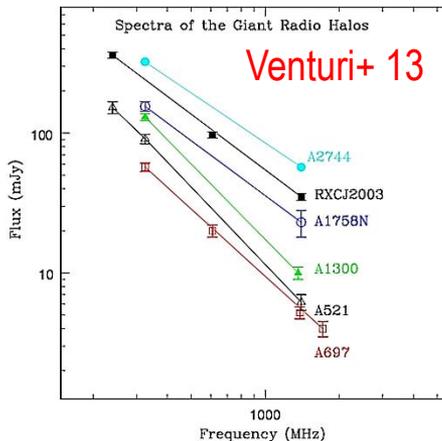
(1)

- How common is cluster-scale radio emission ?



- Connection with thermal properties (dynamics, mass, ...)

- Spectrum of diffuse cluster-scale emission



Statistical studies

Feretti+Giovanini 95

...

Giovanini + 99

NVSS+X-rays

...

...



Surveys with GMRT
+ follow ups 500+ hr

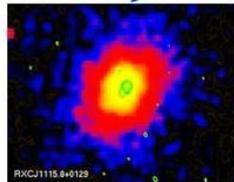
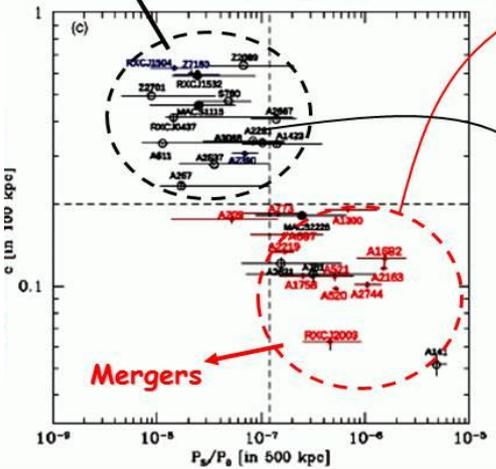
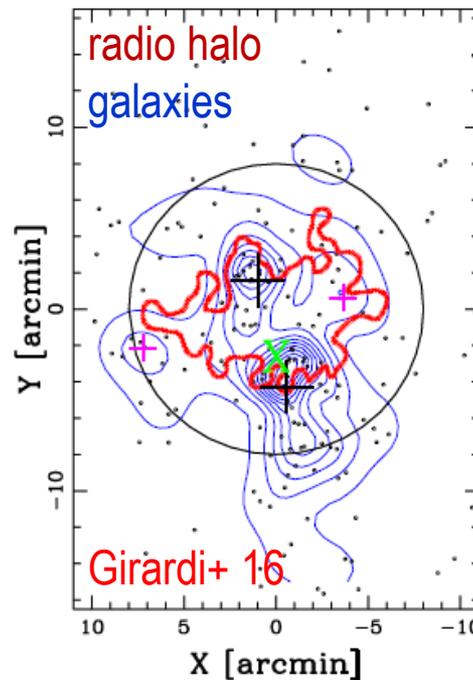
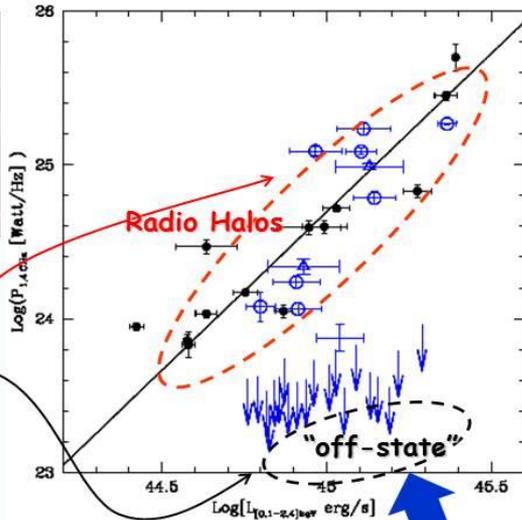
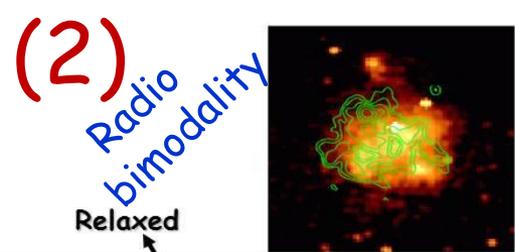
Venturi + 2007

Venturi + 2008

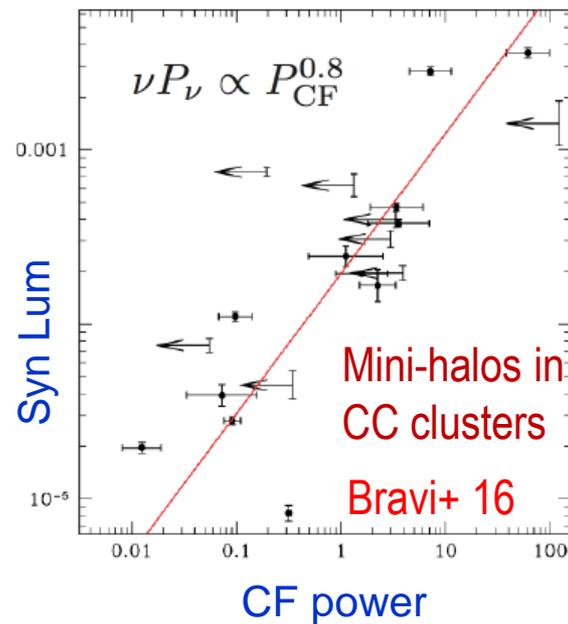
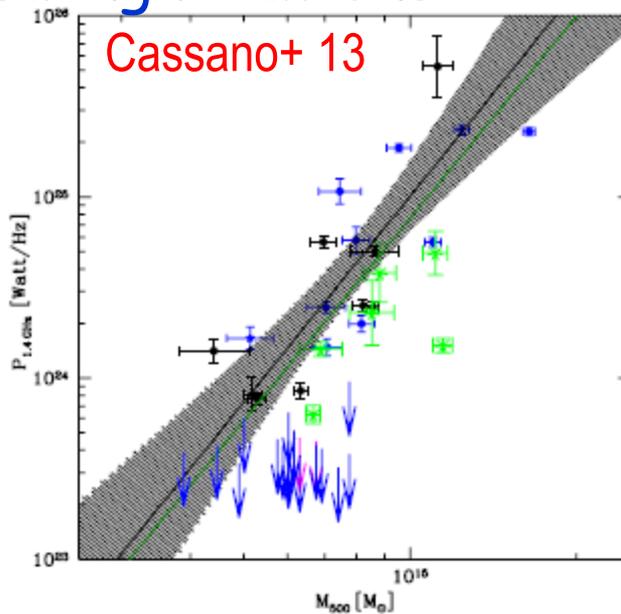
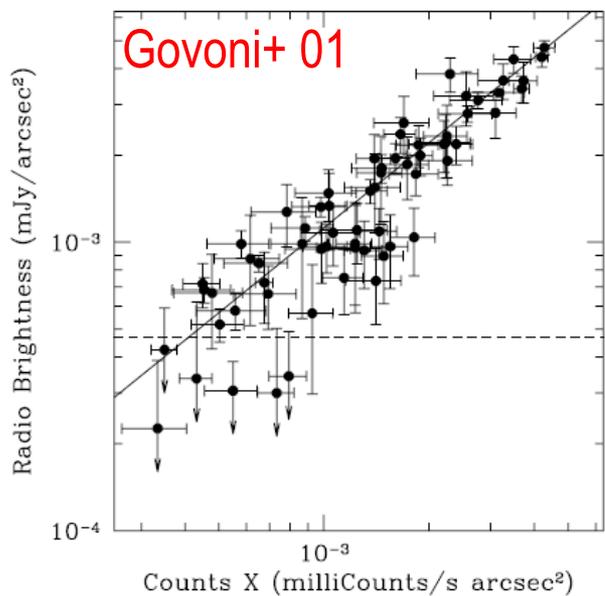
Kale + 2013

Kale + 2015

Connection with mergers

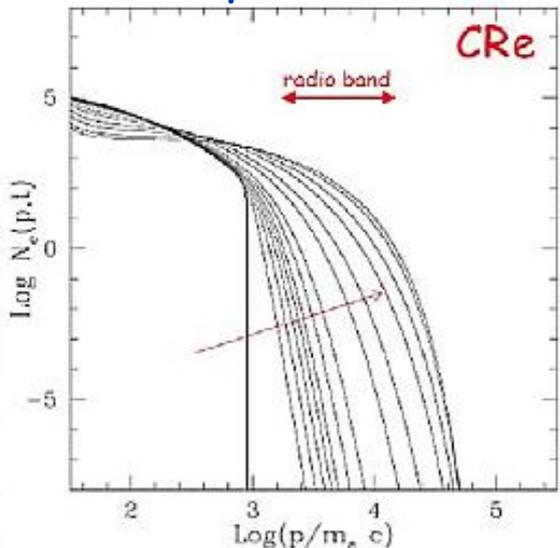
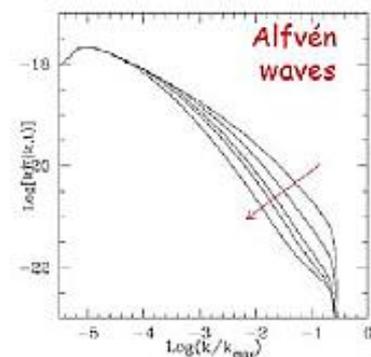
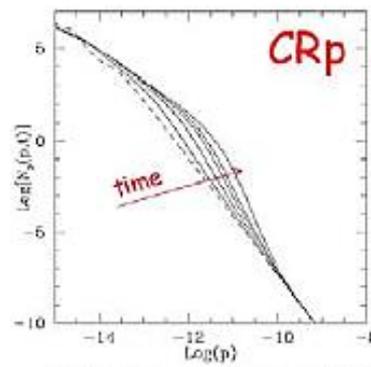


Scaling relations

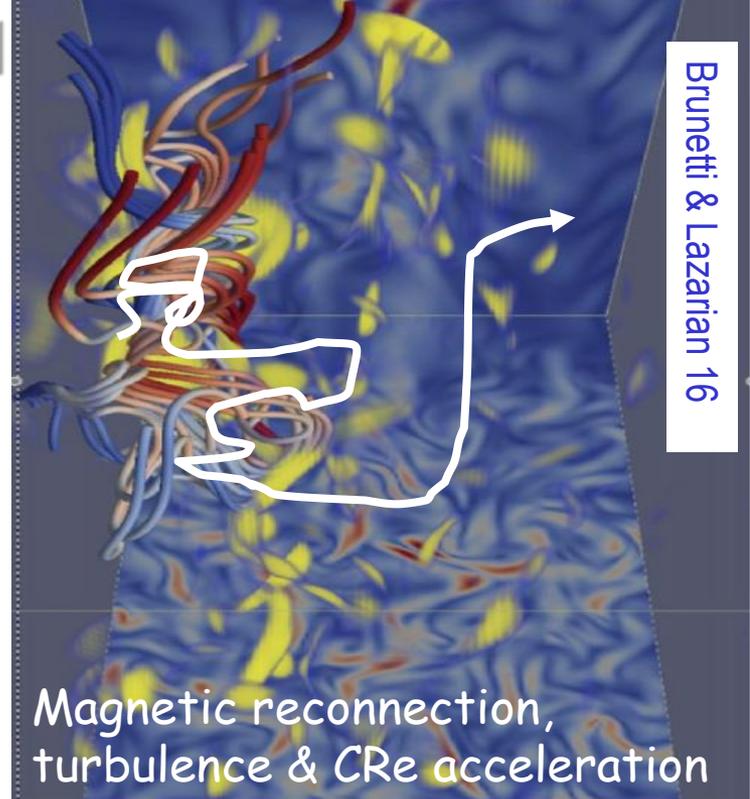


THEORY: STOCHASTIC ACCELERATION

Spectral evolution of CRe, CRp, turbulence



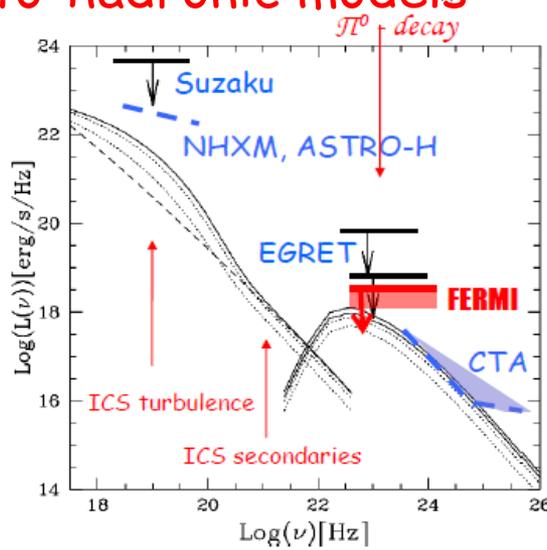
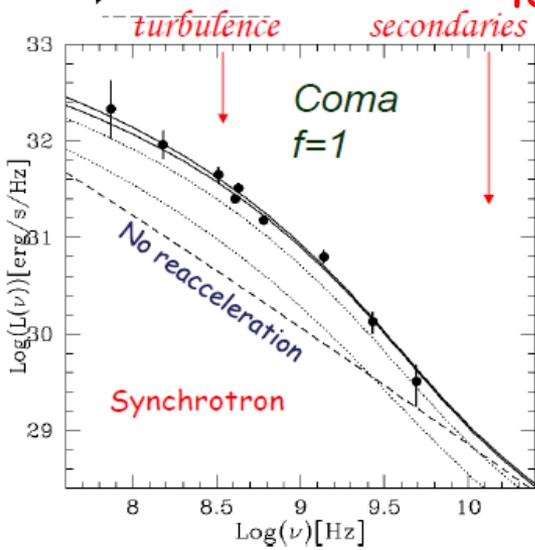
Brunetti, Blasi, Cassano, Gabicci (2004)



Brunetti & Lazarian 16

Magnetic reconnection, turbulence & CRe acceleration

Radio to gamma-ray SED leptohadronic models



Brunetti & Lazarian 11

INAF proposed the most popular models in the field

- Blasi & Colafrancesco 99
- Brunetti + 01
- Gitti + 02
- ...
- Brunetti+ 04, Brunetti & Blasi 05
- Cassano + 06
- Brunetti & Lazarian 07
- ...
- Brunetti & Lazarian 11,16

Future 1: INAF inspired the LOFAR science case

nature

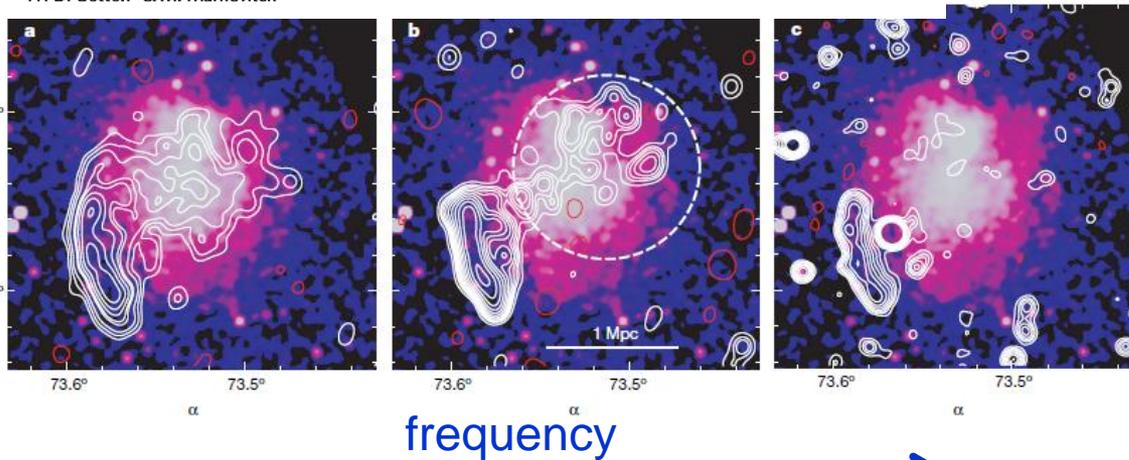
Vol 455|16 October 2008 |doi:10.1038/nature07379

LETTERS

A low-frequency radio halo associated with a cluster of galaxies

G. Brunetti¹, S. Giacintucci^{1,2}, R. Cassano¹, W. Lane³, D. Dallacasa⁴, T. Venturi¹, N. E. Kassim³, G. Setti^{1,4}, W. D. Cotton³ & M. Markevitch²

Brunetti + 08



240 MHz

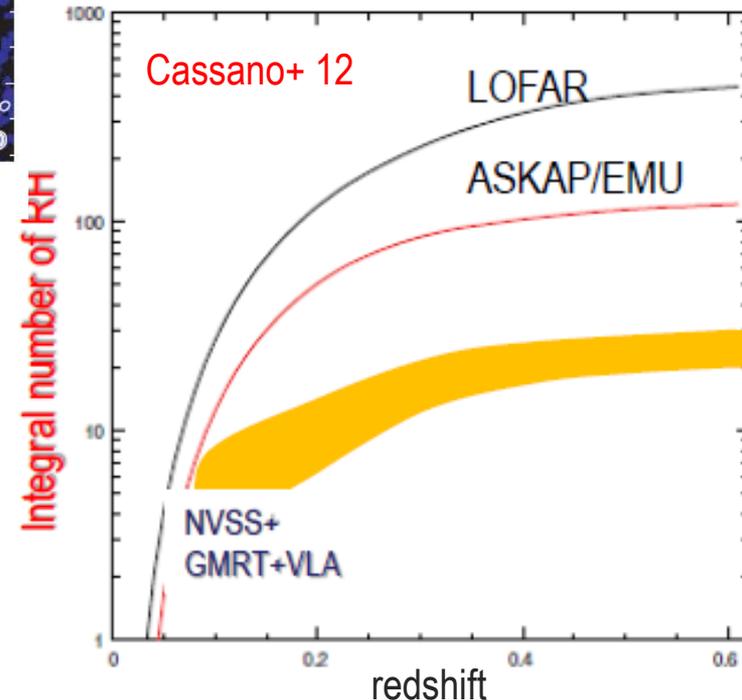
1400 MHz

INAF people involved in Science Programs with SKA precursors/pathfinders :
LOFAR, ASKAP, MeerKAT, MWA

Talk by Bonafede

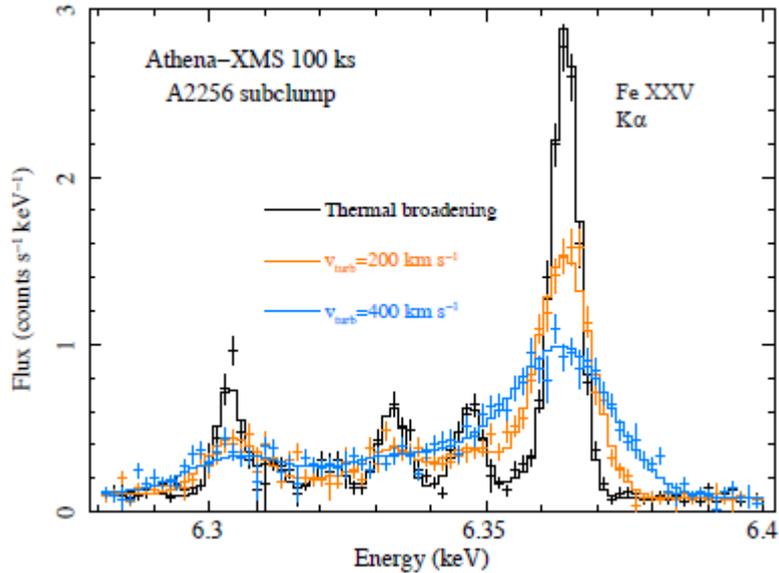
Models predict that the majority of cluster-scale radio emission should glow-up at low frequencies !

LOFAR will enter into an unexplored parameter-space



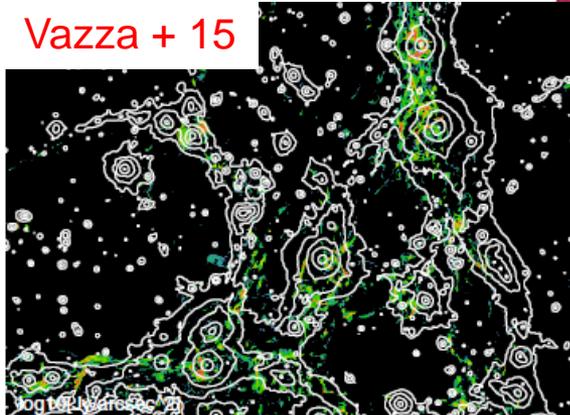
Future 2: long term... SKA & Athena

- # energy transport (plasma-ICM)
- # turbulence
- # connection with CRs acceleration



Talk by
Gastaldello

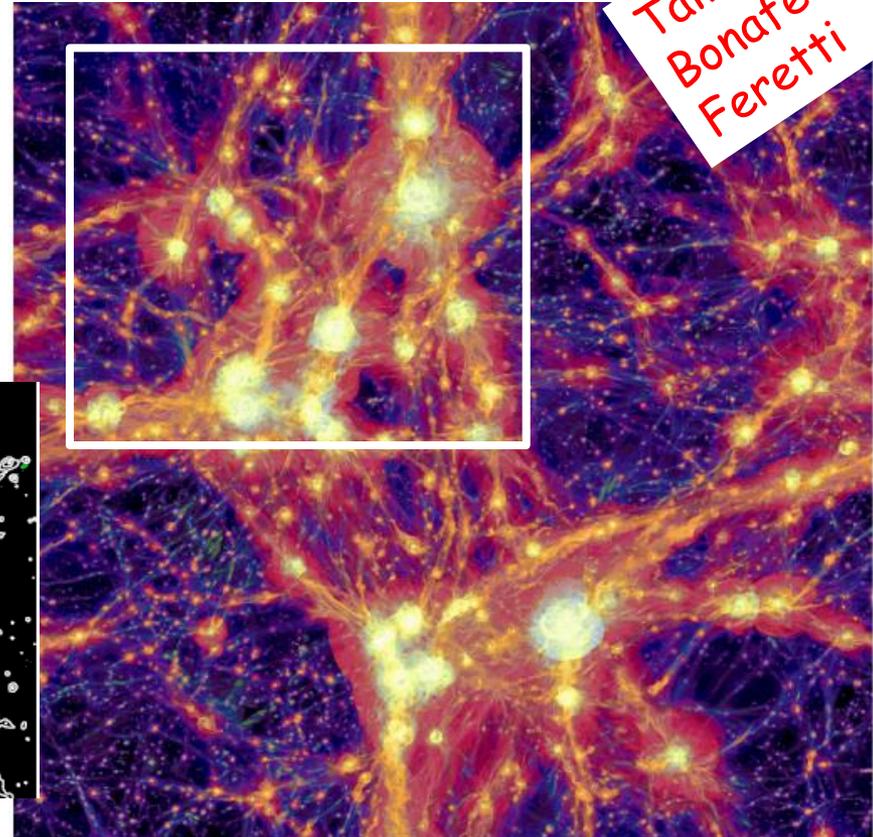
Vazza + 15



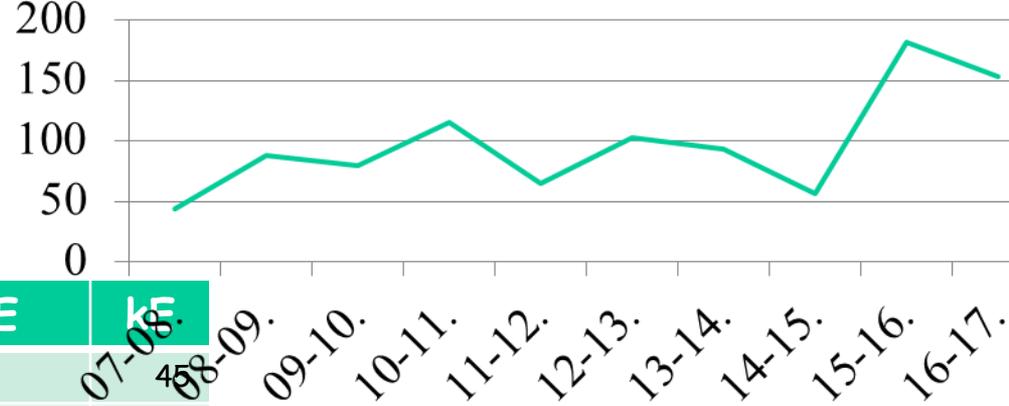
Beyond Cluster-scale

- # physics basically unknown
- # magnetic field amplification
- # CRs transport/acceleration

Talks by
Bonafede
Feretti



FUNDS (2007+)



YEAR	TYPE	ROLE	NAME	K€
2007-2009	PRIN-INAF	PI	G. Brunetti	45
2007-2008	ASI TH	PI	G. Brunetti	21
2008-2009	ASI TH	PI	G. Brunetti	28
2008-2009	ASI OB	PI	G. Giovannini	32
2009-2010	ASI OB	PI	G. Giovannini	8
2009-2010	ASI TH	PI	G. Brunetti	23
2009-2011	PRIN-INAF	PI	T. Venturi	98
2010-2012	PRIN-INAF	PI	L. Feretti	41
2010-2012	PRIN-INAF	RU	G. Brunetti	31
2010-2015	ERC FP7	RU	T. Venturi	30
2011-2012	ASI	PI	M. Murgia	10
2011-2012	ASI	PI	L. Feretti	8
2012-2014	ERC IF	PI	G. Brunetti	186
2014-2017	PhD-INAF	PI	G. Brunetti	64
2014-2015	ASI NARO	RU	F. Gastaldello	36
2015-2017	PRIN-INAF	PI	G. Brunetti	94
2015-2016	ASI NARO	PI	F. Gastaldello	33
2015-2018	ERC GF	PI	G. Brunetti	244
2016-2019	ASTRO-FIT2	Fellow	F. Vazza	157
				1189

Personnel (+FFO, Uni)

INAF-PhD (2)

ERC (2)

AstroFIT (1)

Feodor Lynen
Fellowship

