

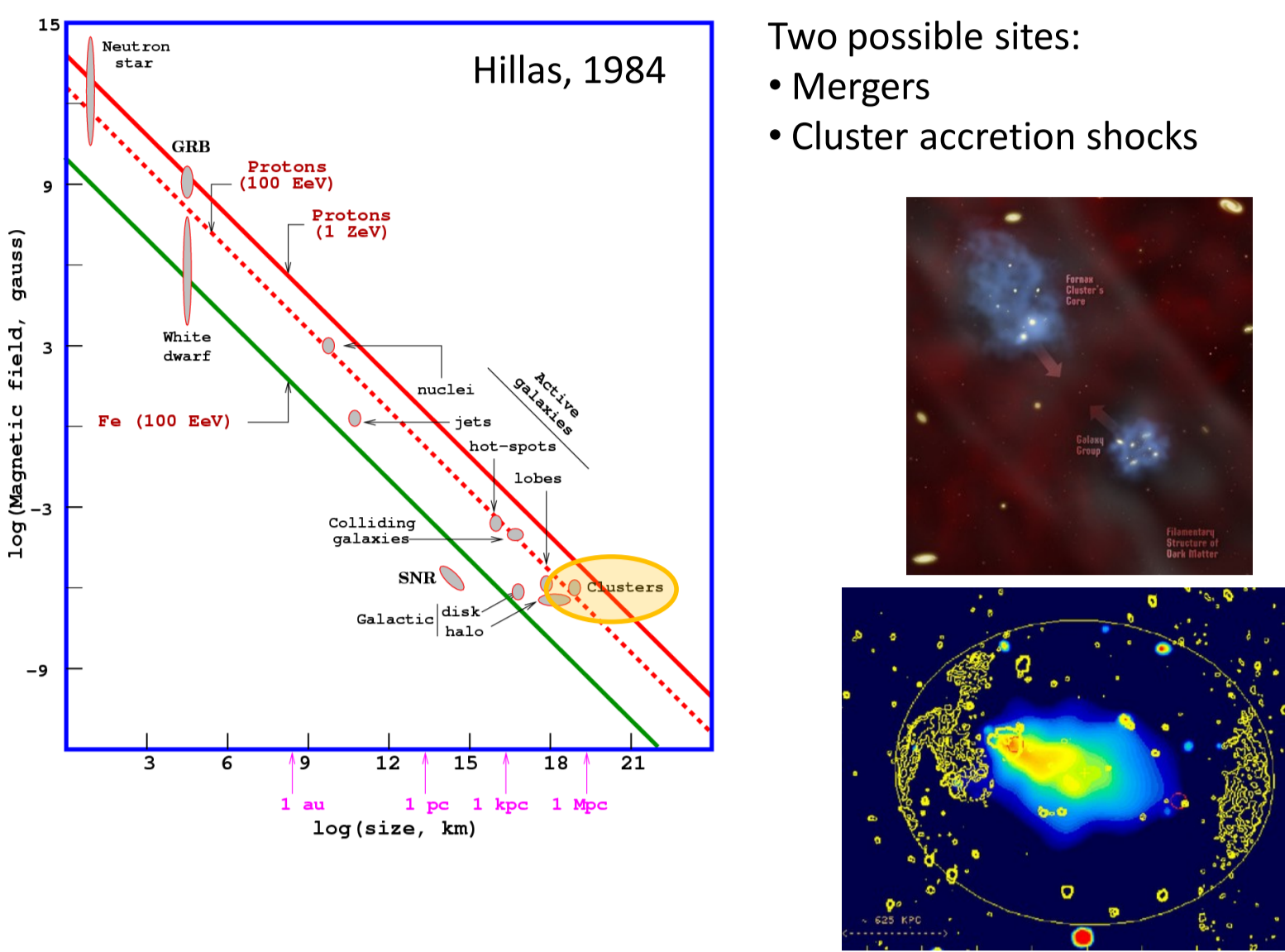
Search for GeV gamma-ray emission from clusters of galaxies studied by TeV telescopes

Masaki Mori *

Department of Physics, College of Science and Engineering, Ritsumeikan University, Kusatsu, 525-8577 Shiga, Japan

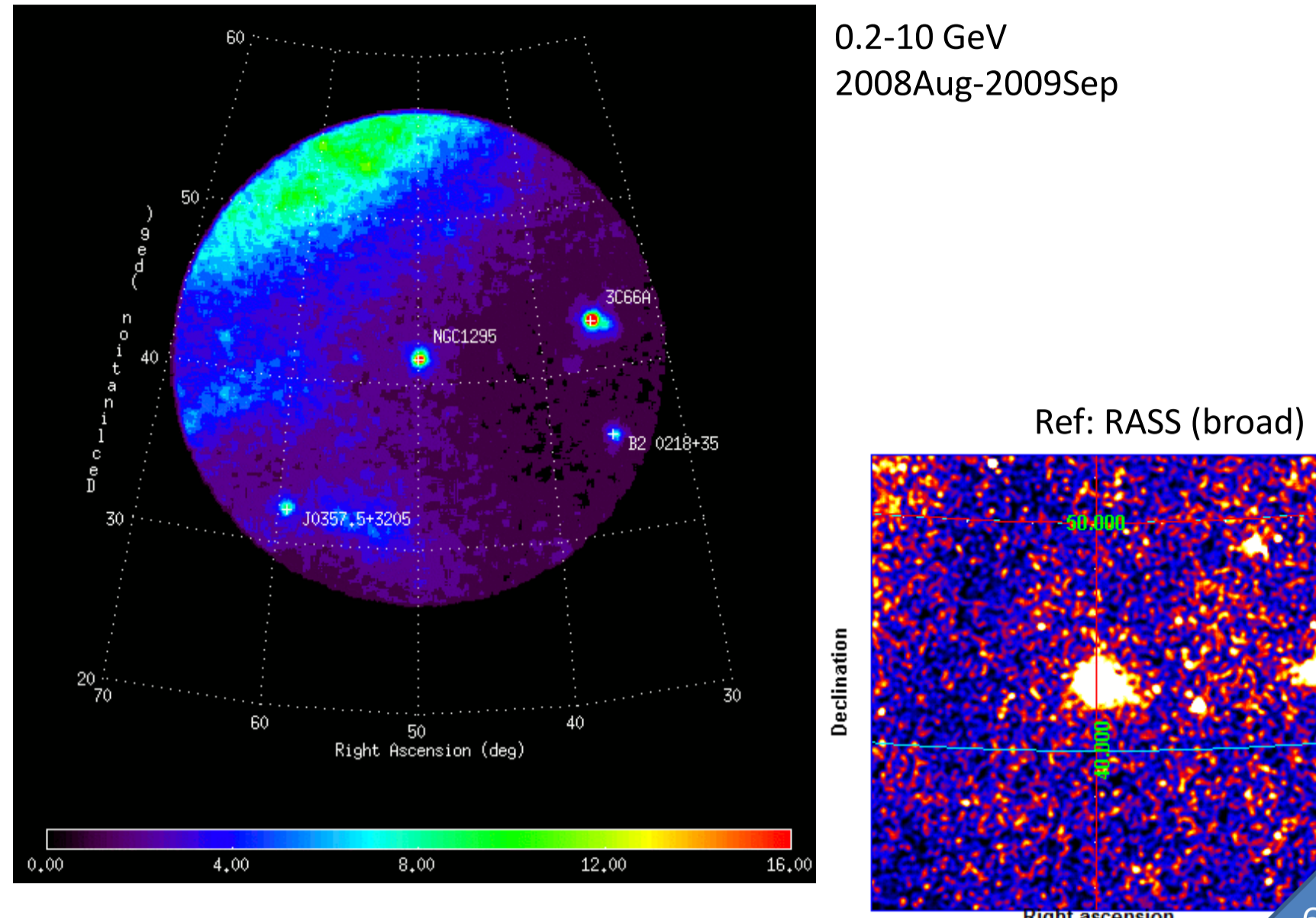
Results on study of GeV gamma-ray emission from clusters of galaxies which have been given upper limits by Cherenkov telescopes using Fermi archival data are presented.

Clusters as UHE cosmic-ray accelerator

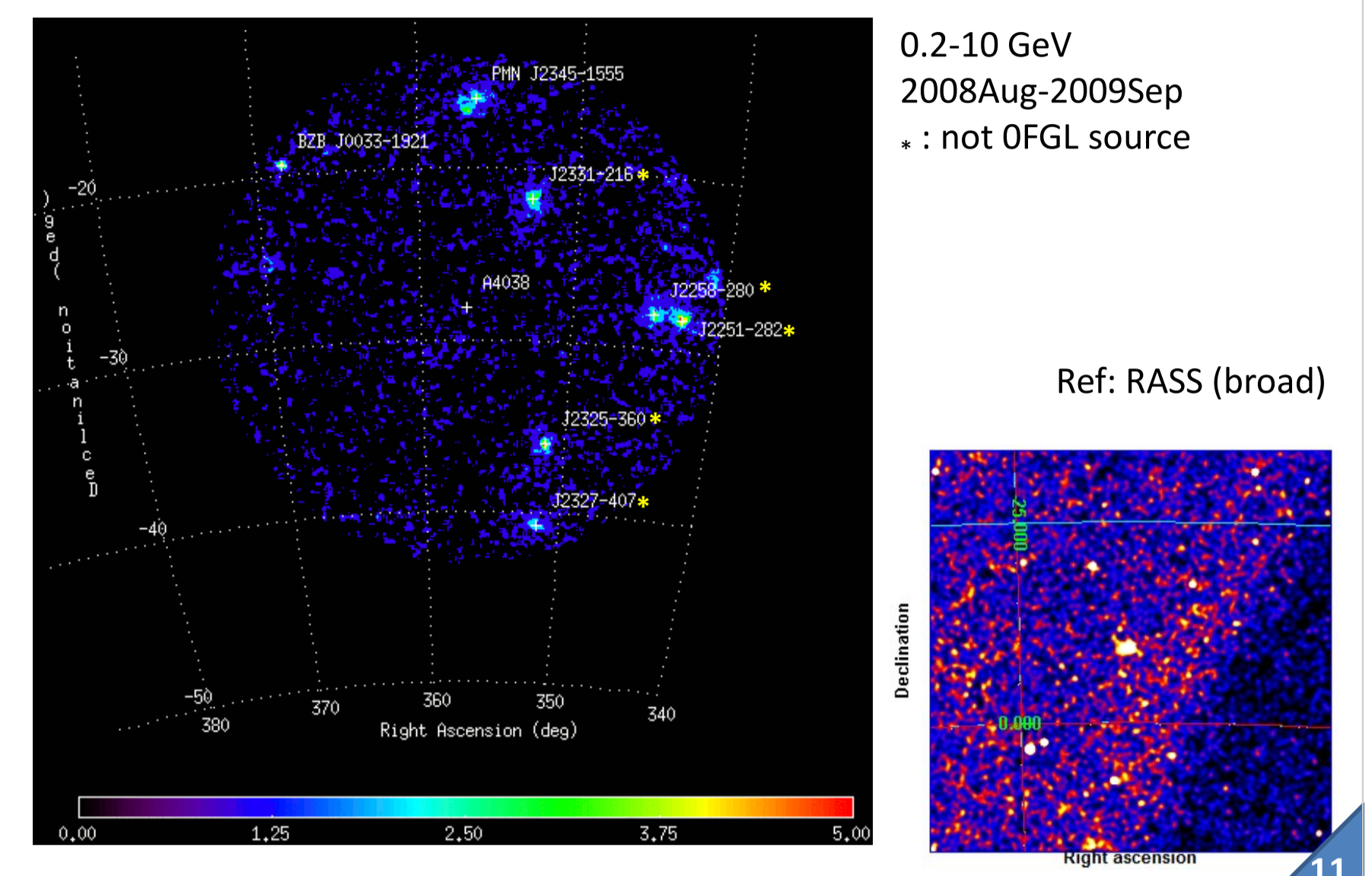


Model 1. Völk & Atoyan, ApJ 541,88 (2000)

Fermi/LAT count map: Perseus

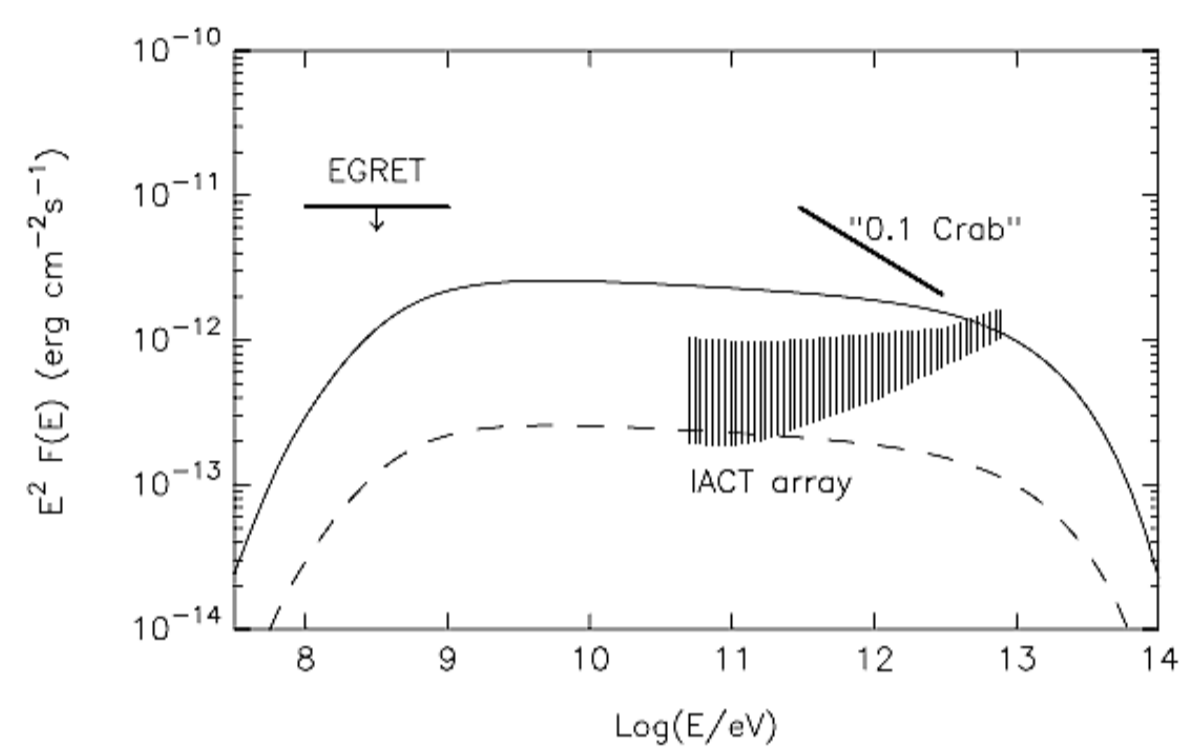


Fermi/LAT count map: Abell 4038



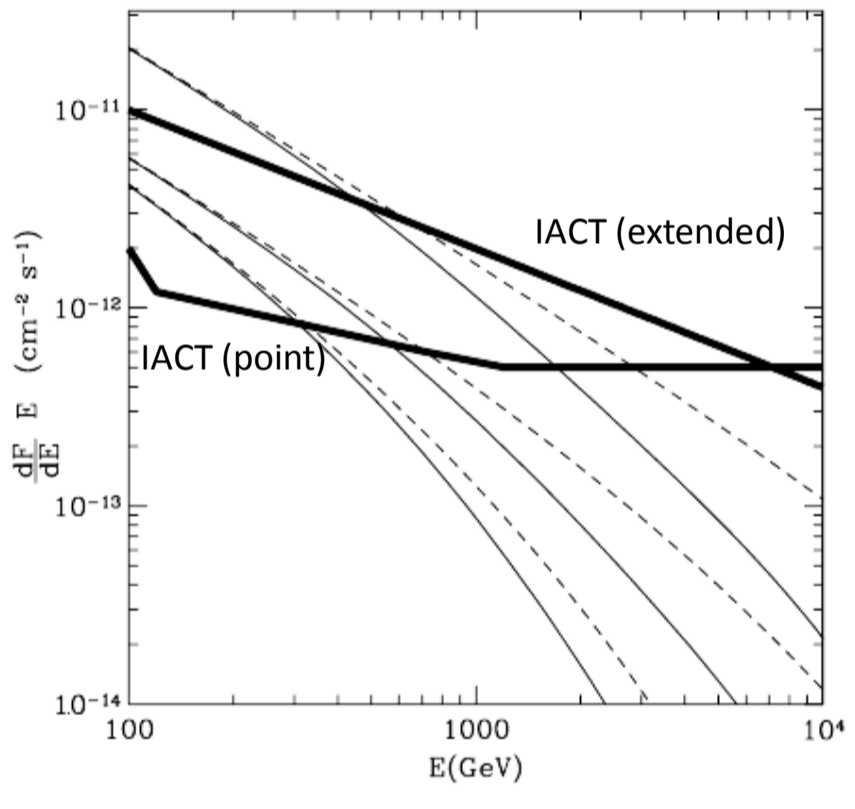
Preliminary

Hadronic gamma-ray emission



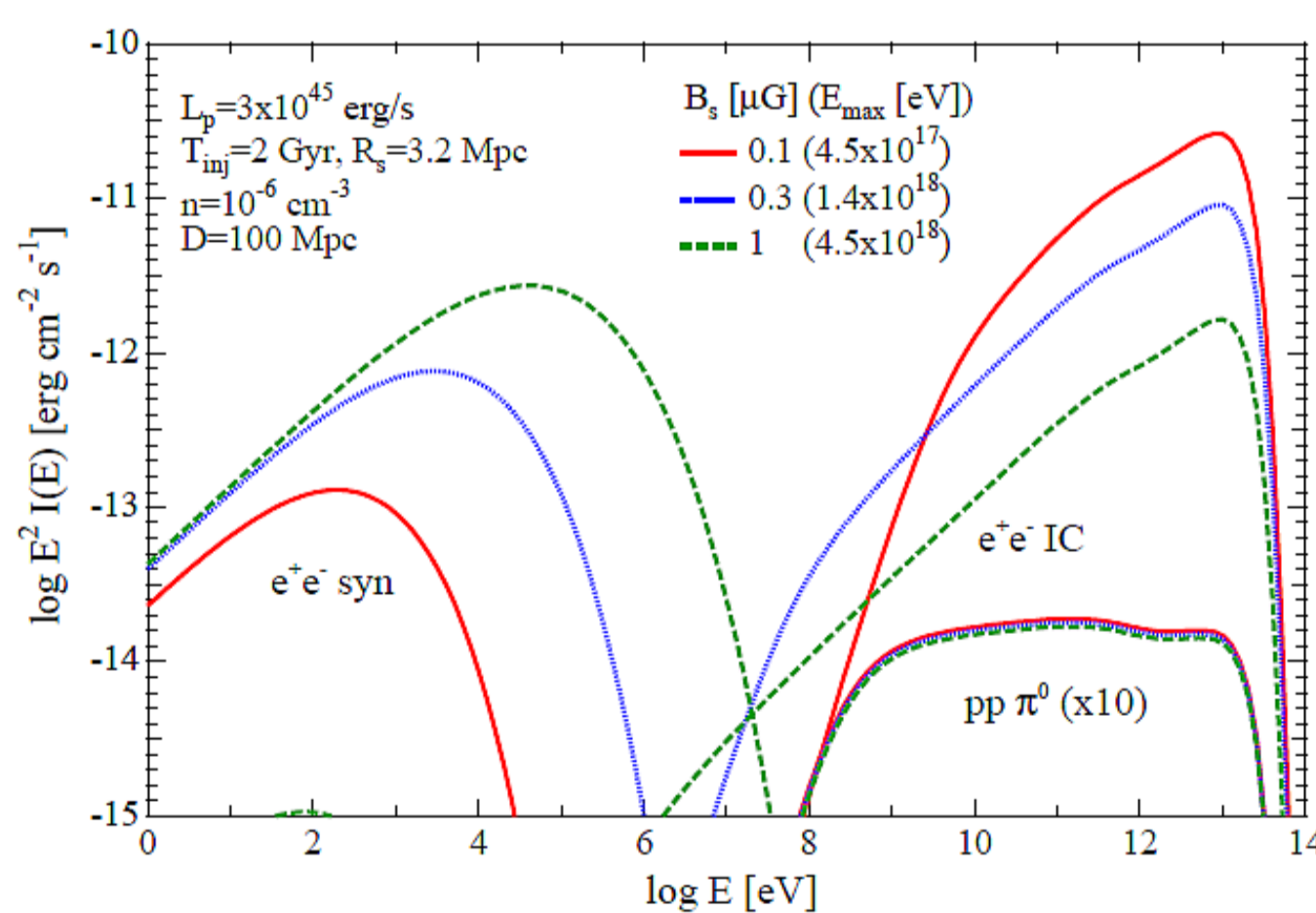
Model 2. Gabici & Blasi, Astropart. Phys. 20, 579 (2004)

IC emission from high-energy electron interactions with the CMB



Model 3. Inoue, Aharonian & Sugiyama, ApJ 628, L9 (2005)

Synchrotron and IC emission from secondary electron/positron pairs produced in $p-\gamma$ interactions with the CMB



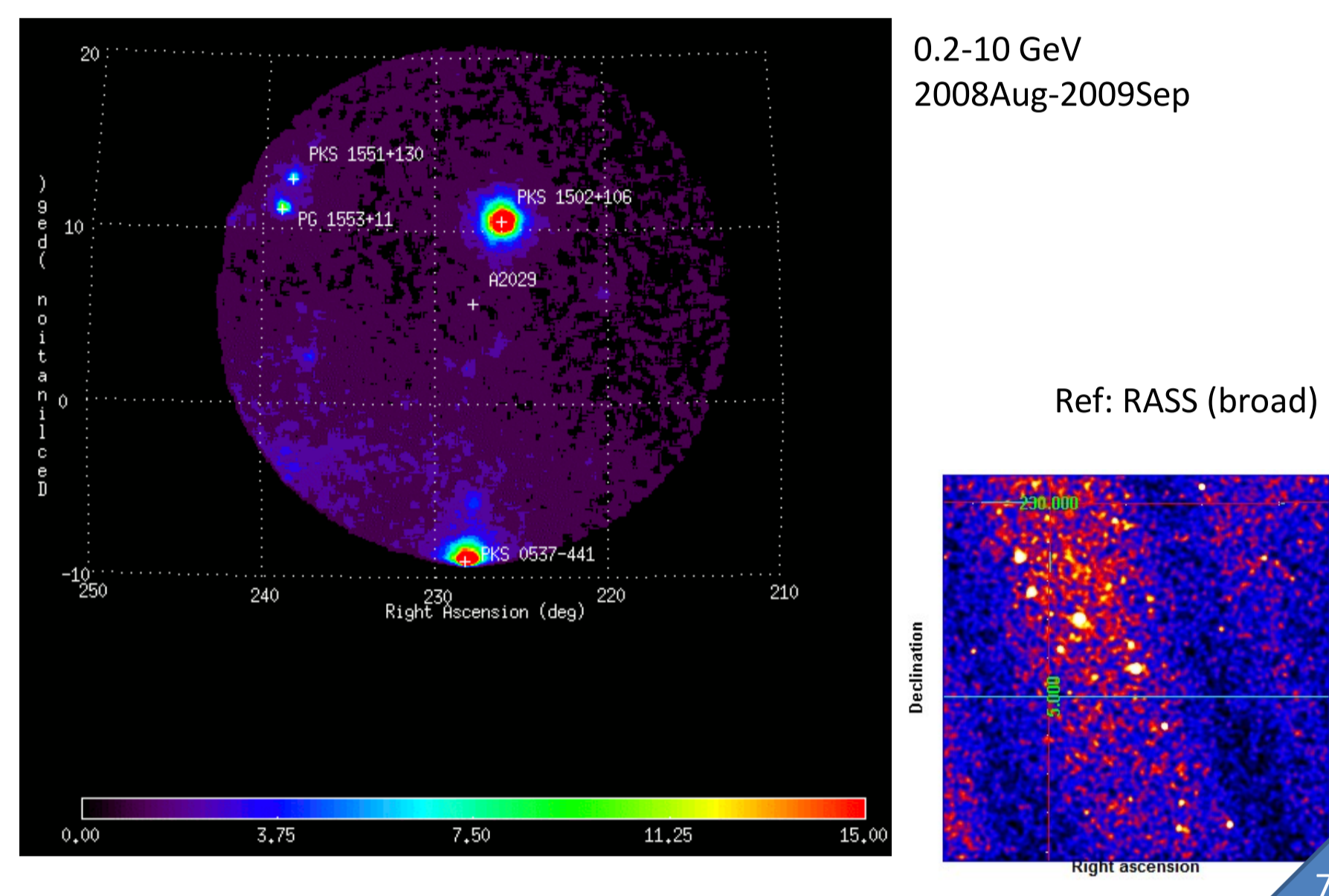
Model 3. Inoue, Aharonian & Sugiyama, ApJ 628, L9 (2005)

Clusters observed by IACTs

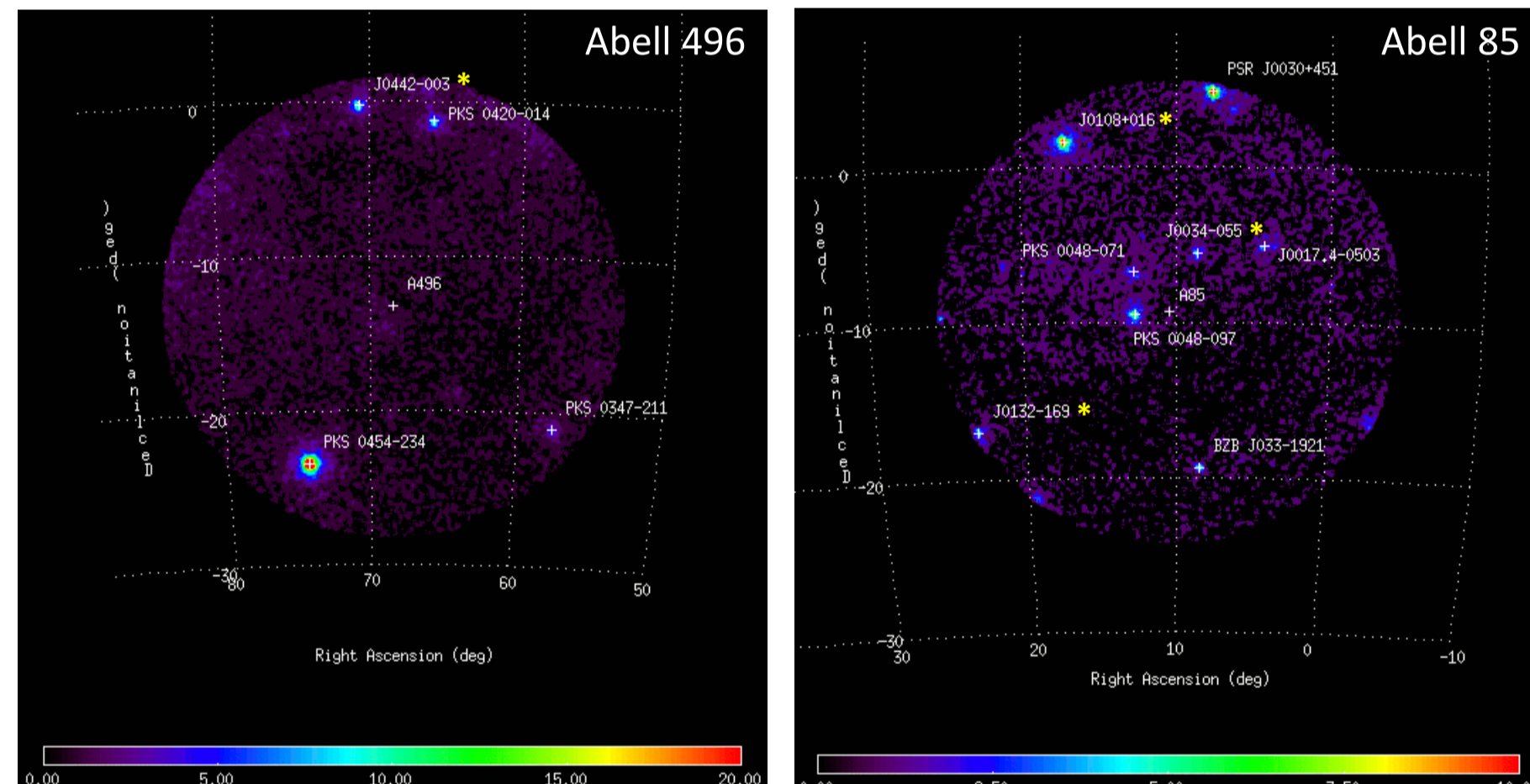
Name	Position	Redshift	Limit	Reference
Perseus	(03h19m, 41° 30')	0.018	<13% Crab (>400GeV, 0.3°)	Whipple (Perkins+ 2006)
↑			<1-2% Crab (>150GeV, point-like)	MAGIC (Aleksic+ 2009)
Abell 2029	(15h10m, 05° 45')	0.077	<14% Crab (>400GeV, 0.3°)	Whipple (Perkins+ 2006)
Abell 496	(04h34m, -13° 16')	0.033	<5% Crab (>0.57TeV, 0.6°)	H.E.S.S. (Aharonian+ 2008)
Abell 85	(00h42m, -09° 21')	0.055	<2% Crab (>0.46TeV, 0.49°)	H.E.S.S. (Aharonian+ 2008)
Coma	(12h59m, 27° 58')	0.023	<15% Crab (>1TeV, 0.4°)	H.E.S.S. (Aharonian+ 2009)
Abell 3667	(20h12m, -56° 50')	0.055	<29% Crab (>950GeV, 0.4°)	CANGAROO-III (Kiuchi+ 2009)
Abell 4038	(23h47m, -28° 12')	0.029	<12% Crab (>750GeV, 0.25°)	CANGAROO-III (Kiuchi+ 2009)

See Bechtol+ (TeVPA2009) for 15 clusters top-ranked by Pfrommer (2008)

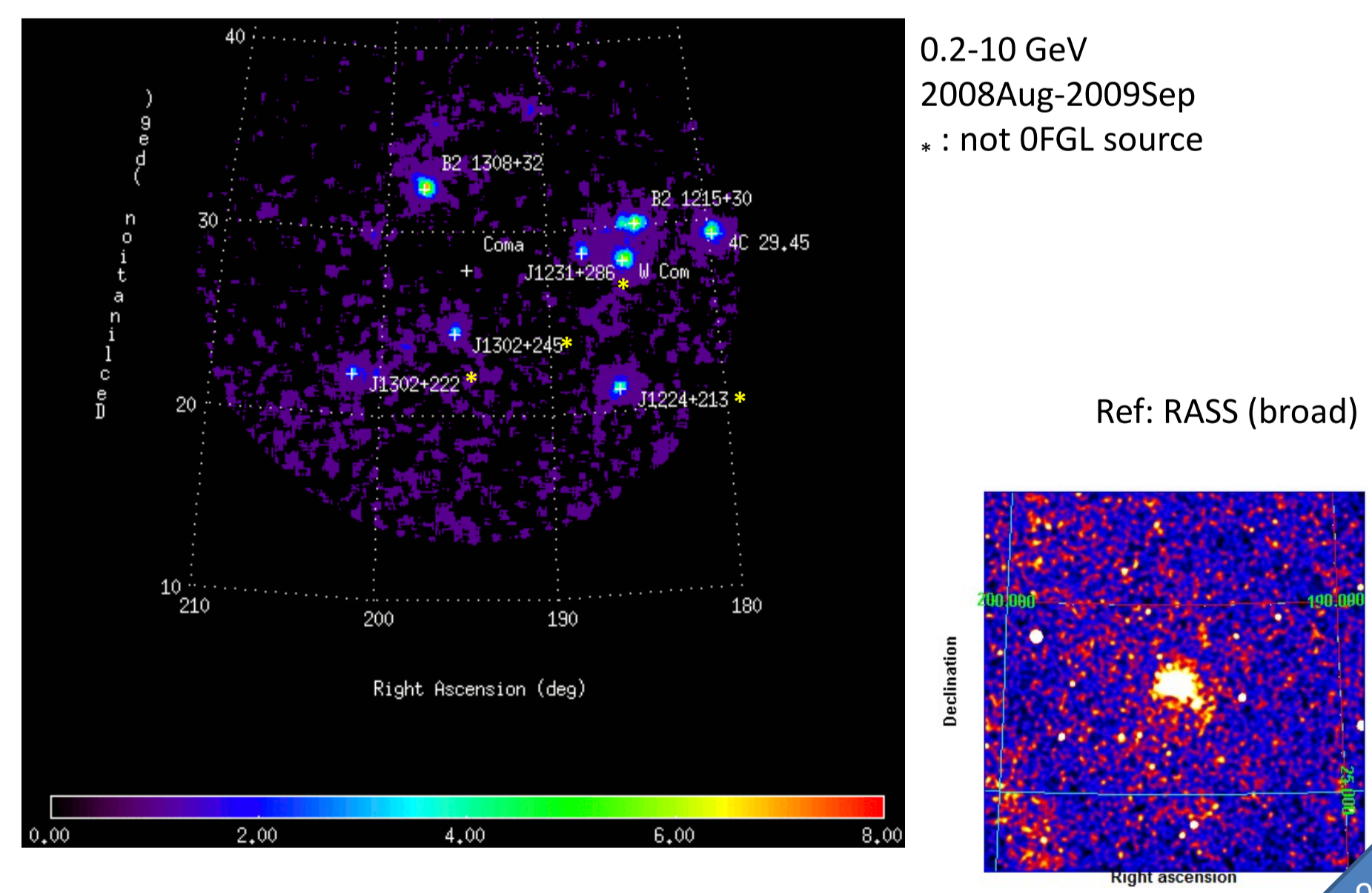
Fermi/LAT count map: Abell 2029



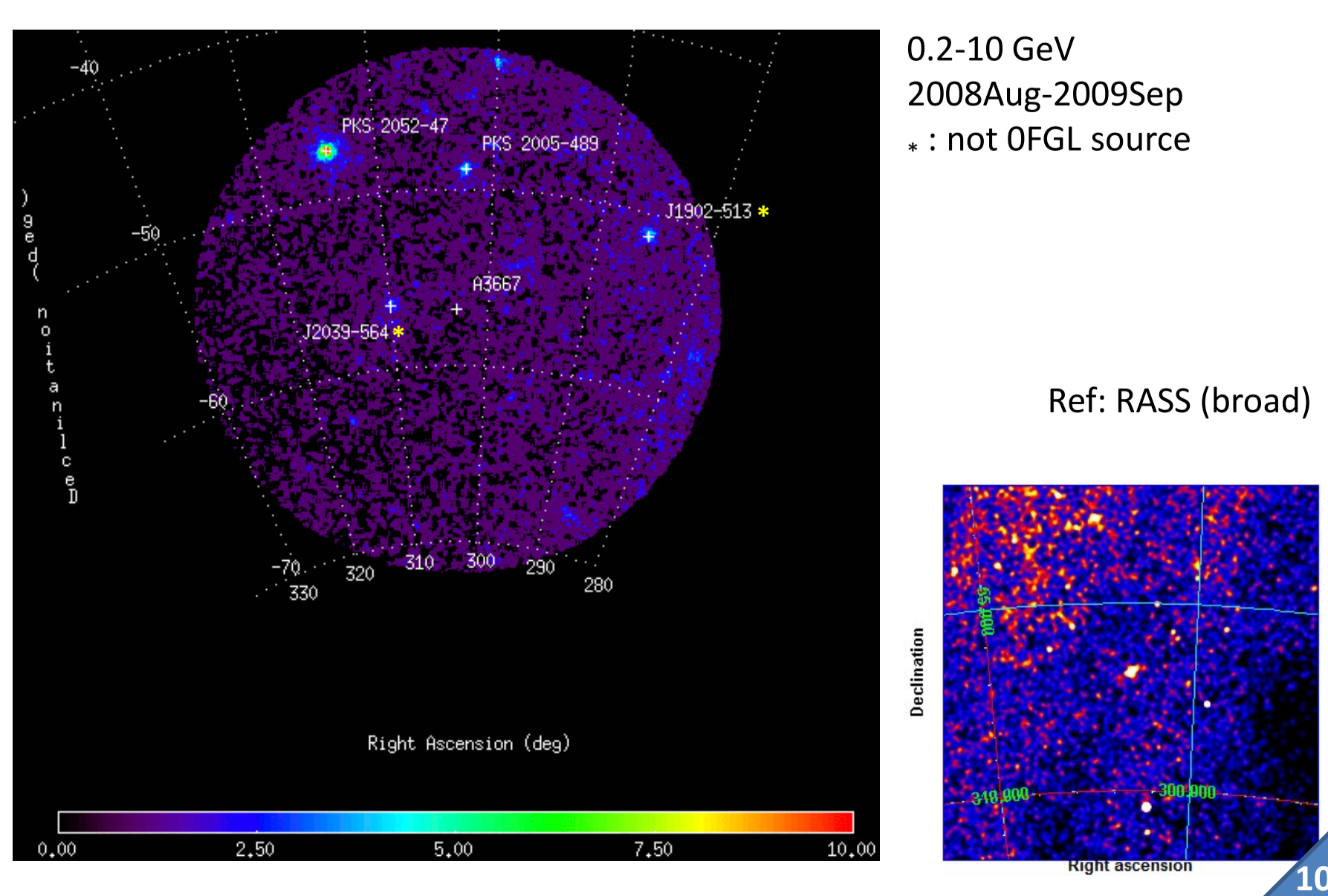
Fermi/LAT count map: Abell 496/85



Fermi/LAT count map: Coma



Fermi/LAT count map: Abell 3667



Upper limits

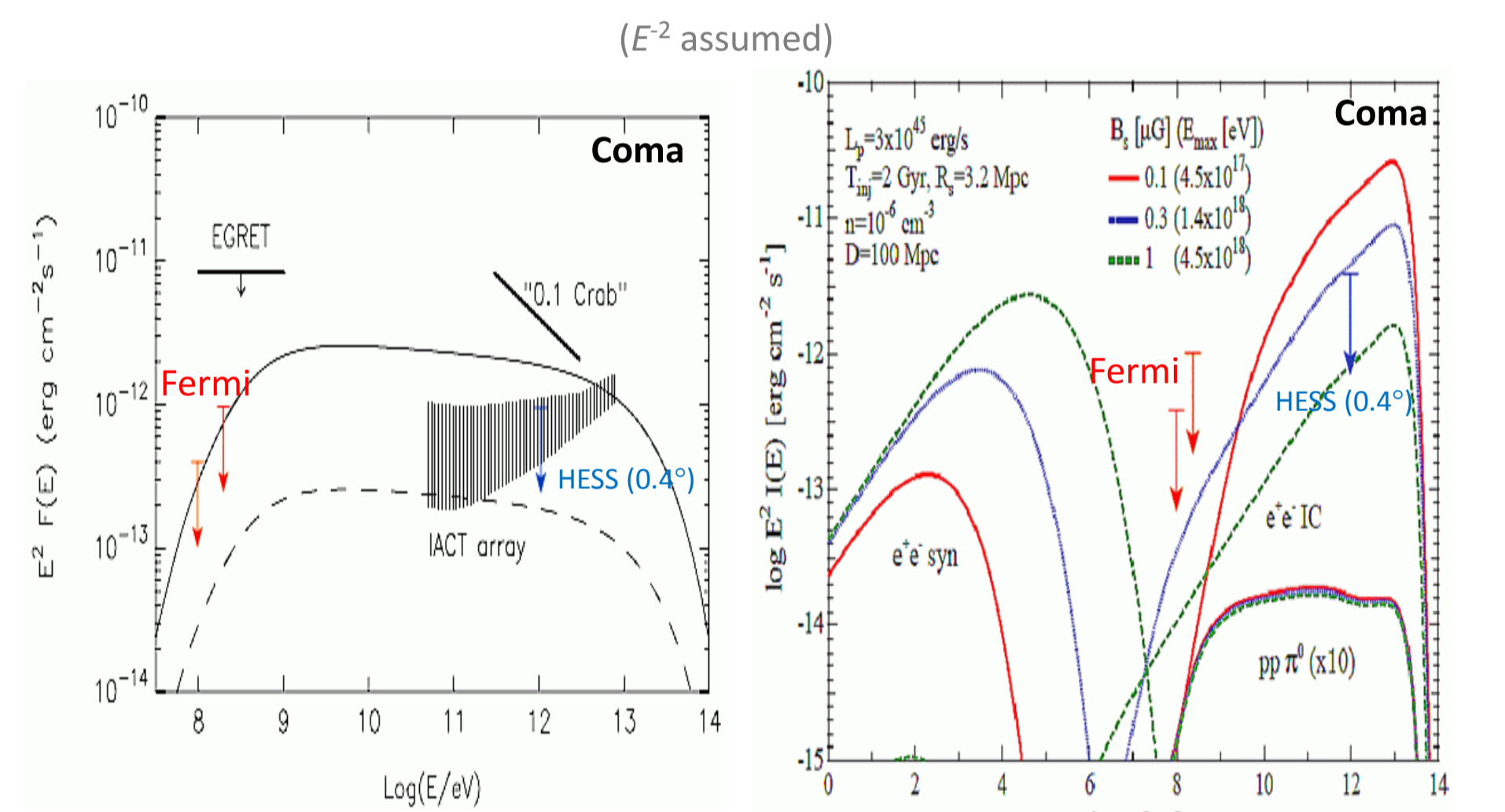
[Unit: $10^{-8} \text{cm}^{-2} \text{s}^{-1}$]

Name	2 σ U.L. (>100MeV)	2 σ U.L. (>200MeV)	Bechtol et al. (>100 MeV, TeVPA 2009)	Note
Perseus	—	—	20	NGC1275 (point source)
Abell 2029	0.78	1.7	—	
Abell 496	0.43	0.69	—	
Abell 85	0.020	0.0030	—	
Coma	0.24	0.32	0.6	
Abell 3667	0.13	0.024	—	
Abell 4038	0.035	0.34	—	

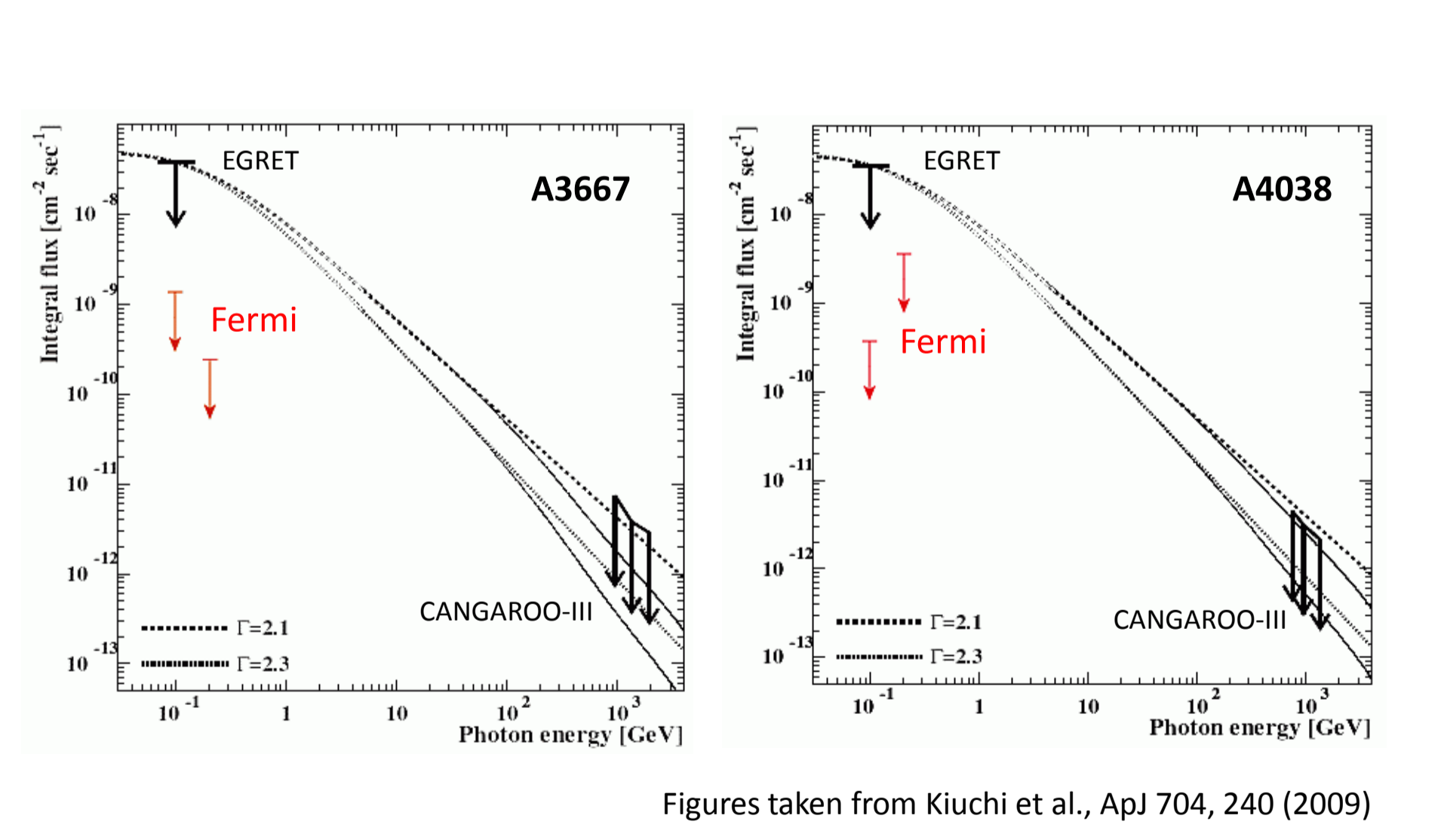
Fermi Science Tools v.9.15.2, *gtlike* (unbinned), point-like source, "PowerLaw2" model

Preliminary

Upper limits compared with model/TeV data (1)



Upper limits compared with model/TeV data (2)



Summary

- No significant gamma-ray emission was found among clusters observed by IACTs, except the Perseus cluster, which contains a point-like source (NGC1275) [as reported in Abdo et al. ApJ 699, 31, 2009].
- Upper limits, better than one order compared with those by EGRET, were given for six clusters (2σ , >100MeV, preliminary)
 - Perseus
 - A2029 $0.78 \times 10^{-8} \text{cm}^{-2} \text{s}^{-1}$
 - A496 0.43
 - A85 0.020
 - Coma 0.24
 - A3667 0.13
 - A4038 0.035
- Next step: broad-band SED analysis with various emission models.