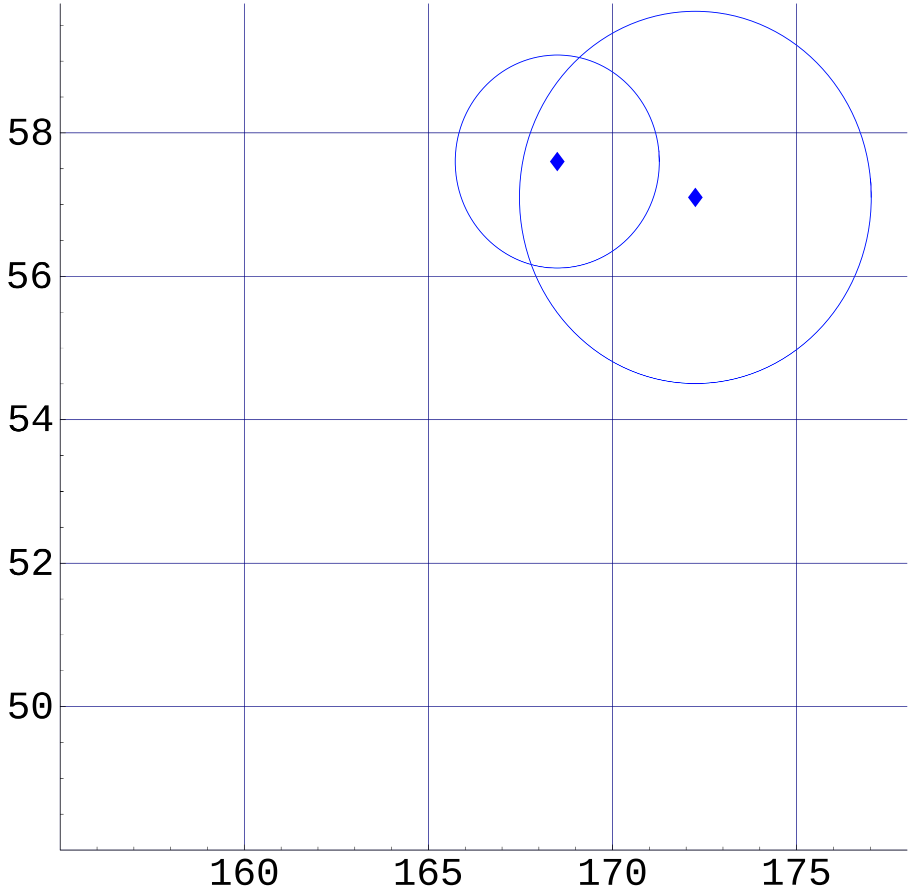
INR, Moscow,
April 15, 2005

A CLUSTER OF AGASA + YAKUTSK + HIRES COSMIC RAYS

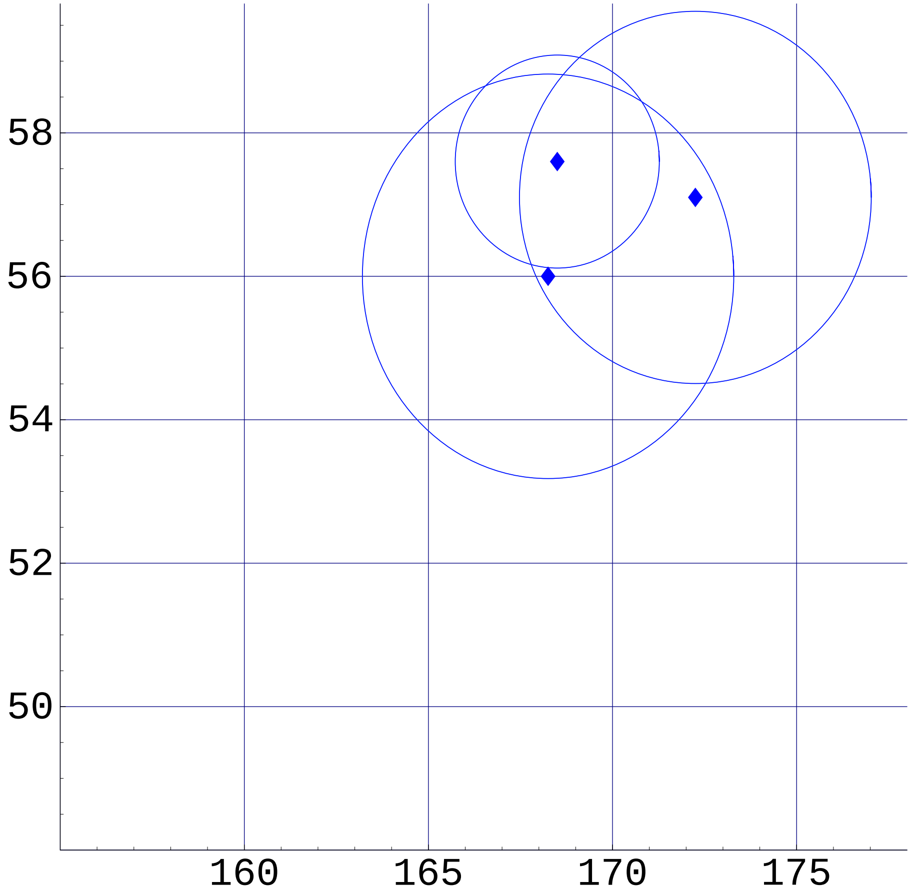
S. Troitsky

INR, Moscow

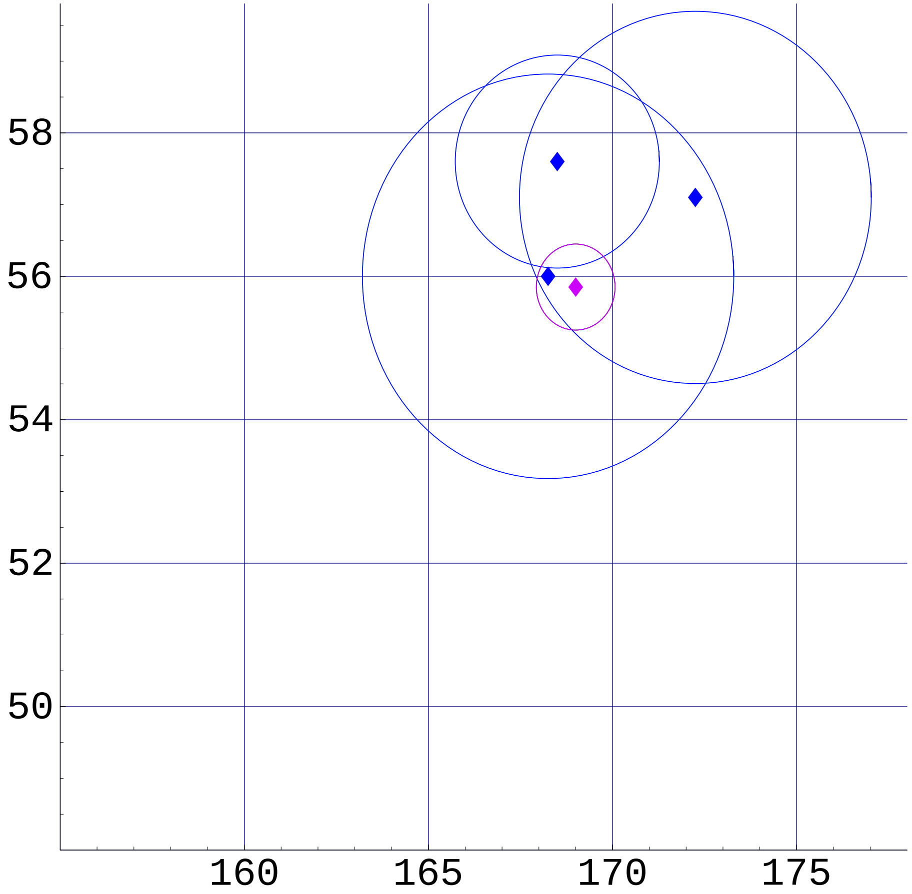
AGASA 1996: DOUBLET



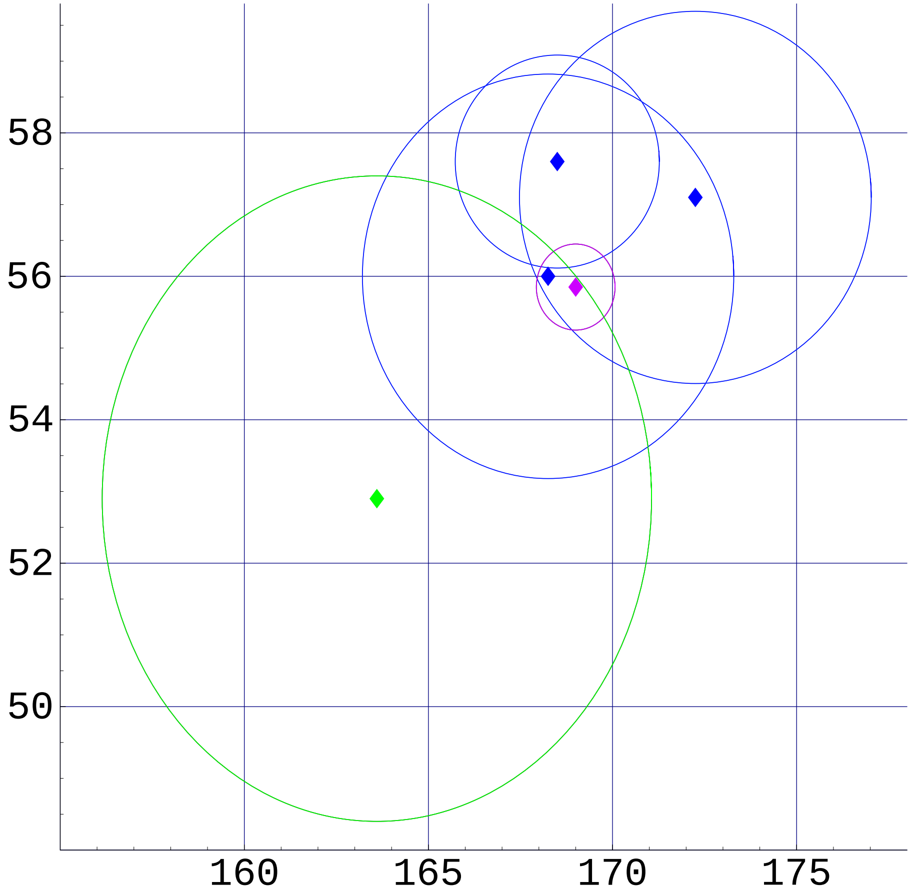
AGASA 1999: TRIPLET



HIRES 2004: QUADRUPLET



YAKUTSK 2005 REANALIZED: FIVEPLET



DETAILS ON THE FIVE EVENTS

Event	Experiment	Date	E, 10^{19} eV	$\Delta E/E$	α°	δ°	σ°
A1	AGASA	26/01/1995	7.76	0.18	168.5	57.6	1.0
A2	AGASA	01/08/1992	5.5	0.18	172.25	57.1	1.7
A3	AGASA	04/04/1998	5.35	0.18	168.25	56.0	1.9
H	HiRes	29/04/2003	3.76	0.20	169.0	55.85	0.4
Y	Yakutsk	17/03/1975	5.7	0.23	163.6	52.9	3.0

ENERGY RESCALING

TO FIT THE SPECTRUM AT 10^{19} eV:

$+25\%$ HiRes

-7% Yakutsk

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- EFFECT OF MAGNETIC FIELDS:
  - CAN THEY MAKE THE CLUSTER TIGHTER?
  - WHERE IS THE SOURCE?
- RANDOM DEFLECTIONS — *Farrar '05* without Yakutsk
- REGULAR DEFLECTIONS
  - GALACTIC MAGNETIC FIELD
  - EXTRAGALACTIC REGULAR COMPONENT?

MAGNETIC FIELD POORLY KNOWN! KEEP IT $\pm$ FREE

A TWO-PARAMETRIC FIT:

- DIRECTION
- AMOUNT PER UNIT ENERGY

COMMON FOR ALL FIVE EVENTS (APPROXIMATION)

MODEL-INDEPENDENT

ASSUME A SINGLE SOURCE

LARGE ERRORS IN ENERGY DETERMINATION

$\Downarrow$

LARGE UNCERTAINTY IN DEFLECTION

CIRCULAR $\longmapsto$ ELLIPTICAL ERROR REGIONS

DIRECTION:

$$0^\circ \leq \phi \leq 360^\circ$$

SHIFT:

$$\rho = q\epsilon \frac{10^{19}\ \mathrm{eV}}{E}$$

q: CHARGE

E: ENERGY

ϵ, ϕ: MAGNETIC FIELD PARAMETERS

$$\chi^2 = \sum_i \chi_i^2$$

$$\chi_i^2 = \frac{\Delta_{i,||}^2}{\sigma_i^2 + \sigma_i^{(\pm)2}} + \frac{\Delta_{i,\perp}^2}{\sigma_i^2},$$

$$\sigma_i^{(\pm)} = \frac{q\epsilon}{E_{19\,i}} \frac{\Delta E_i}{E_i \pm \Delta E_i}$$

$$\rho(E_i \mp \Delta E_i) = \rho(E_i) \pm \sigma_i^{(\pm)}.$$

FOR EACH DIRECTION (α, δ),

VARY (ϵ, ϕ)

10 COORDINATES $-$ 4 PARAMETERS $=$ 6 D.O.F.

(no deflections $\Rightarrow$ 8 D.O.F.)

(given source direction $\Rightarrow$ 8 D.O.F.)

CHARGE ASSIGNMENTS:

- PROTONS
- NEUTRALS
- Z-BURST $(0, \pm 1)$
- NUCLEI $(0,\ +1,\ +2)$

Fit (1)	charges (2)					α (3)	δ (4)	χ^2/d.o.f. (5)	P (6)	ϵ (7)	ϕ (8)
	A1	A2	A3	H	Y						
All five events:											
0.5	0	0	0	0	0	169.0	56.1	6.44/8	0.40	-	-
1.5	1	1	1	1	1	167.6	62.7	2.83/6	0.17	35	265
Z.5	0	1	0	0	-1	168.8	56.0	3.30/6	0.23	15	144
N1.5	1	2	1	1	0	164.4	56.2	4.62/6	0.41	13	185
N2.5	1	0	1	1	2	171.6	58.3	2.16/6	0.10	14	301

PARTICULAR GMF MODELS
(EXPECTED TO WORK POORLY AT $b \approx 56^\circ$)

parameter		data	value used
		disk field:	
spiral structure		ASS or BSS	ASS or BSS
North-South reversal		D or Q	irrelevant
local strength of the *regular* field, B_0		(1.4 ± 0.2) mkG *Beck '03* (4 ± 1) mkG *Prouza, Smida*	free parameter B_0
pitch angle, p		$-8^\circ \pm 1^\circ$ *Beck '03*	-8°
distance to the nearest field reversal, d		$-0.2 \ldots -0.6$ kpc *Tinyakov, Tkachev*	-0.5 kpc
		field outside the disk:	
fall-off of the disk field		1 or 2 exponents	1 or 2 exponents
one-exponent height, h		1.5 kpc *Beck '03*	1.5 kpc
two-exponent heights	first, h_1	1 kpc *Stanev*	1 kpc
	second, h_2	4 kpc *Stanev*	4 kpc
	gluing, h_0	0.5 kpc *Stanev*	0.5 kpc
proper halo field		toroidal, poloidal?	no or toroidal+poloidal
maximal strength of the toroidal field		1 mkG *Prouza, Smida*	$B_0/1.5$
local vertical component of the field		0.2 mkG *Han*	$0.2{\cdot}B_0/1.5$
maximal extent of the field, $R_{\max}$			20 kpc

Charge assignment	without halo field			with halo field		
	χ^2/d.o.f.	P	B_0	χ^2/d.o.f.	P	B_0
(1)	(2.1)	(2.2)	(2.3)	(3.1)	(3.2)	(3.3)
0.5	6.44/8	0.40	-	6.44/8	0.40	-
1.5	5.49/7	0.40	-0.98	6.32/7	0.50	-0.15
Z.5	6.05/7	0.47	-0.38	5.11/7	0.35	-0.53
N1.5	5.01/7	0.34	-0.60	5.45/7	0.39	-0.23
N2.5	6.44/7	0.51	0.	6.44/7	0.51	0.

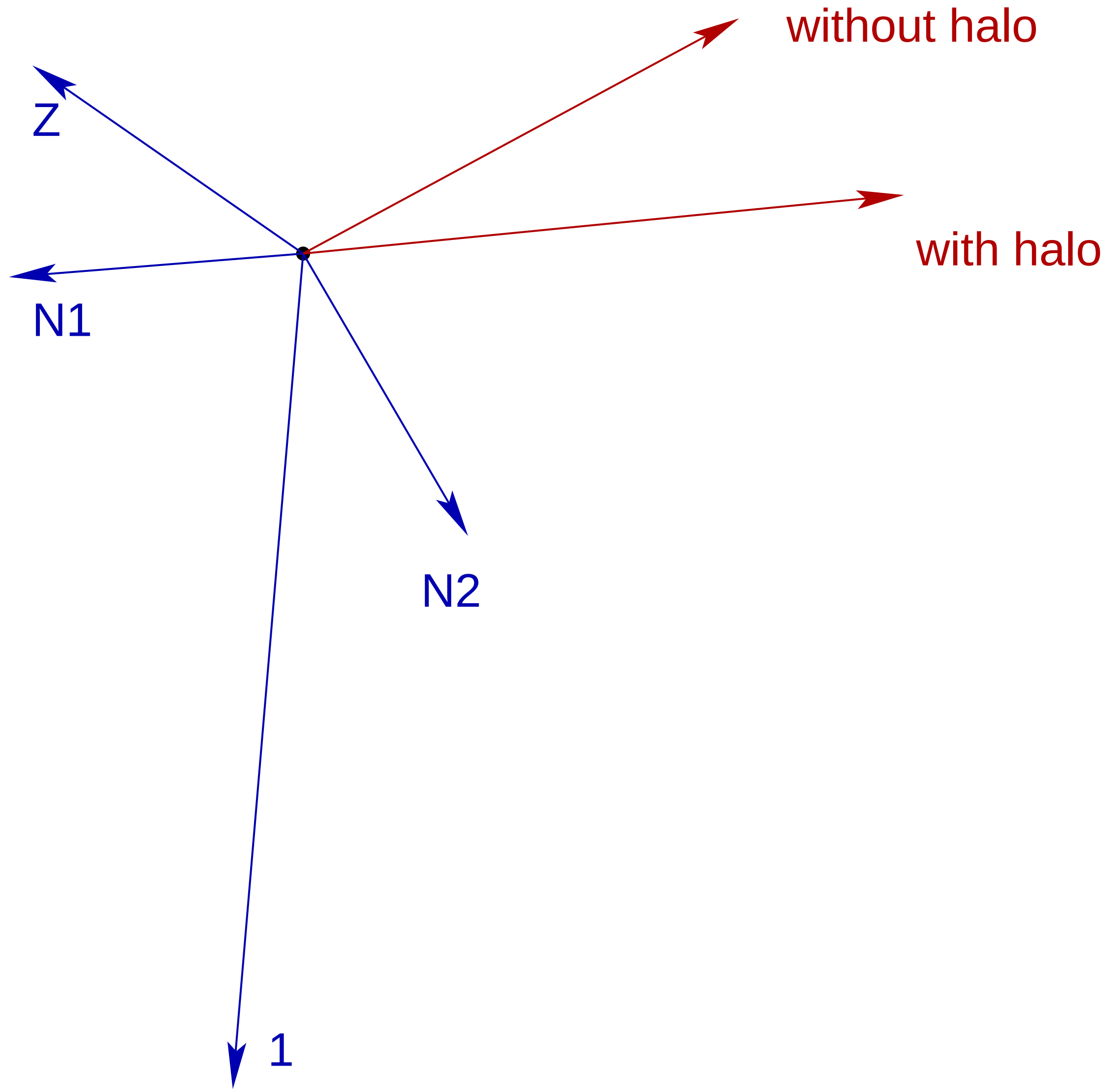
- THESE MODELS DO NOT MAKE THE FIT BETTER.
- BUT SOME MAGNETIC FIELDS DO

$$\Downarrow$$

AN UNKNOWN COMPONENT

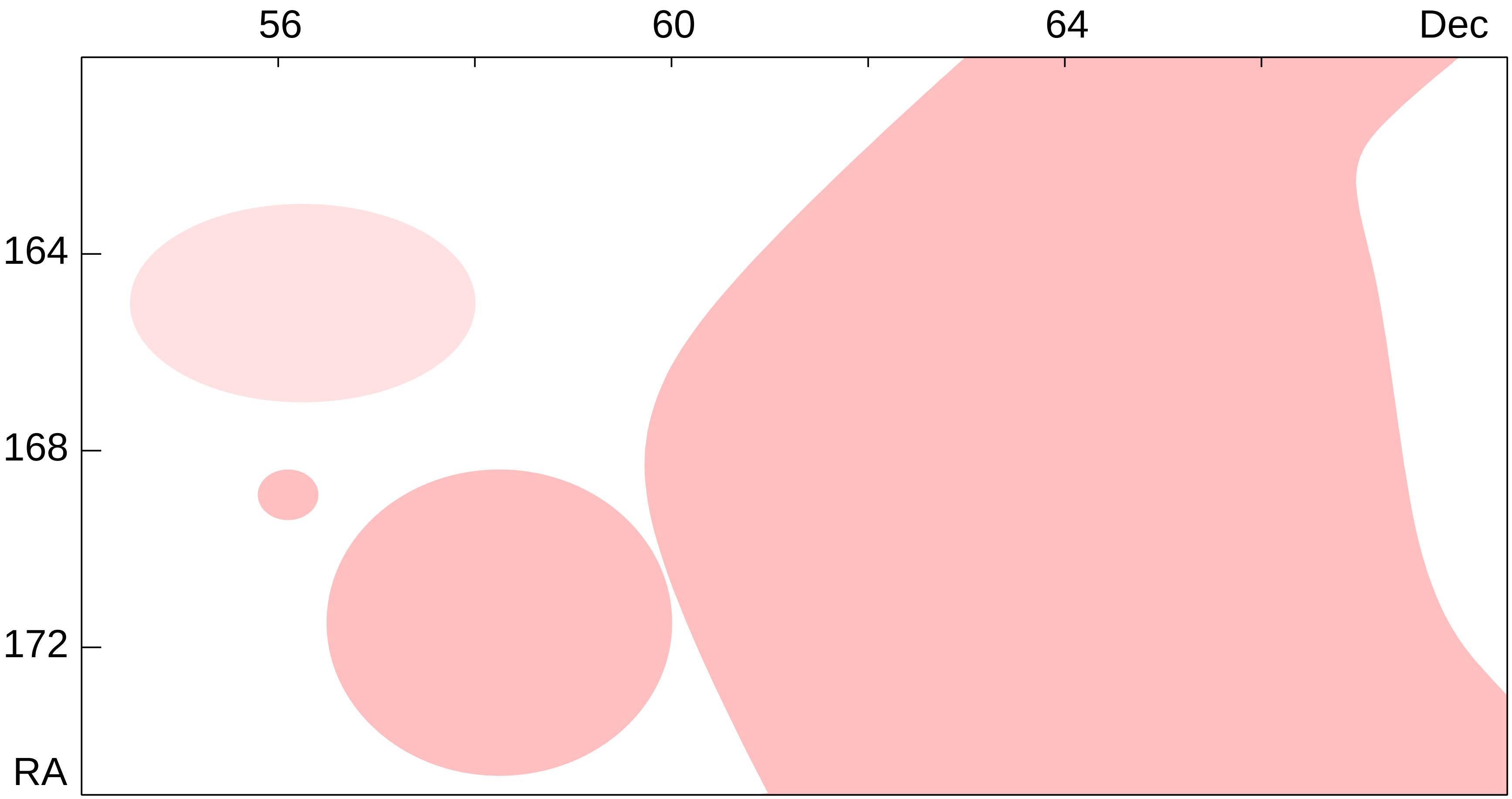
OF GALACTIC OR EXTRAGALACTIC MAGNETIC FIELD

MAY EXIST

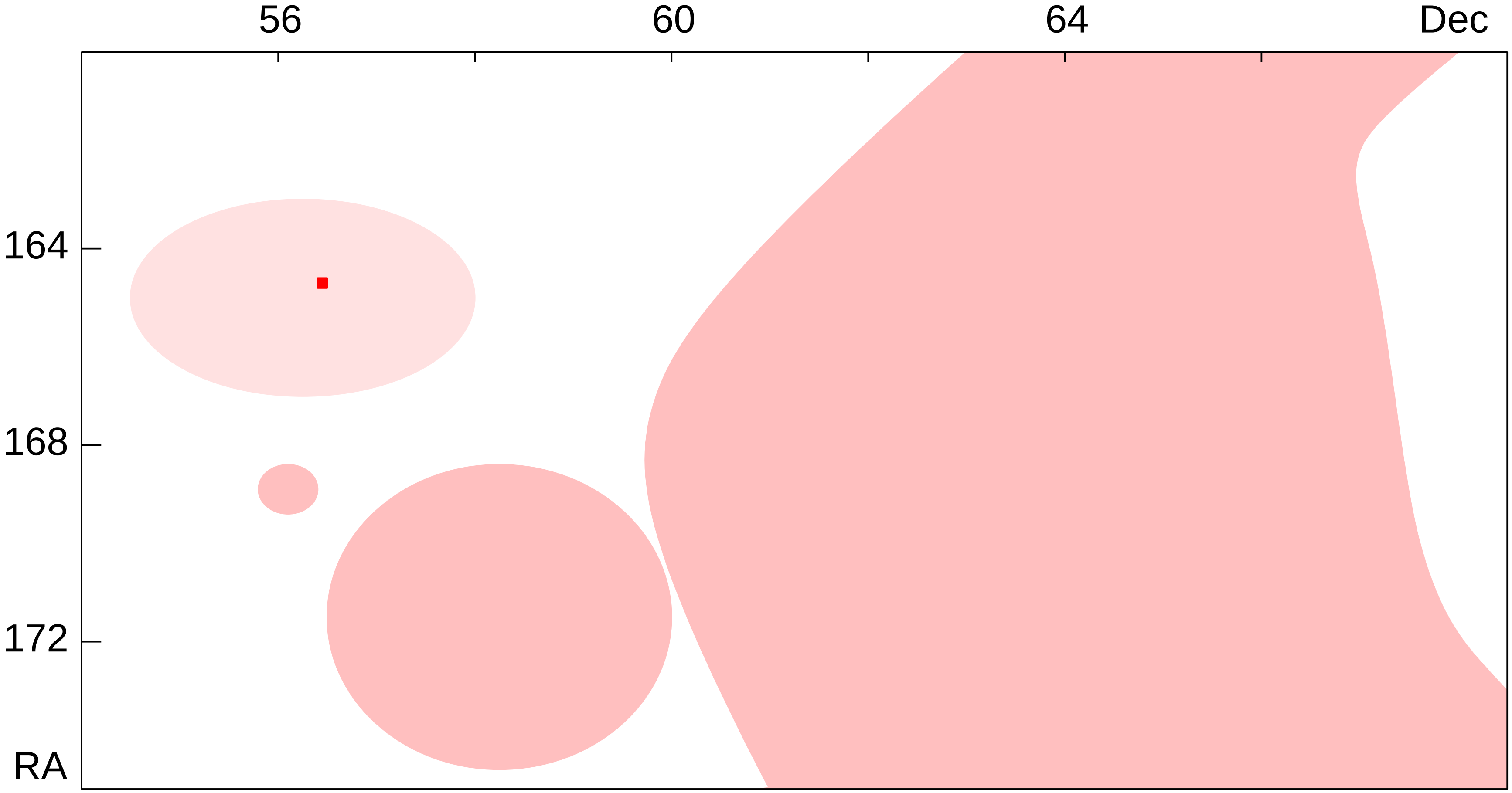

without halo
Z
with halo
N1
N2
1

SKYMAP AND POTENTIAL SOURCES

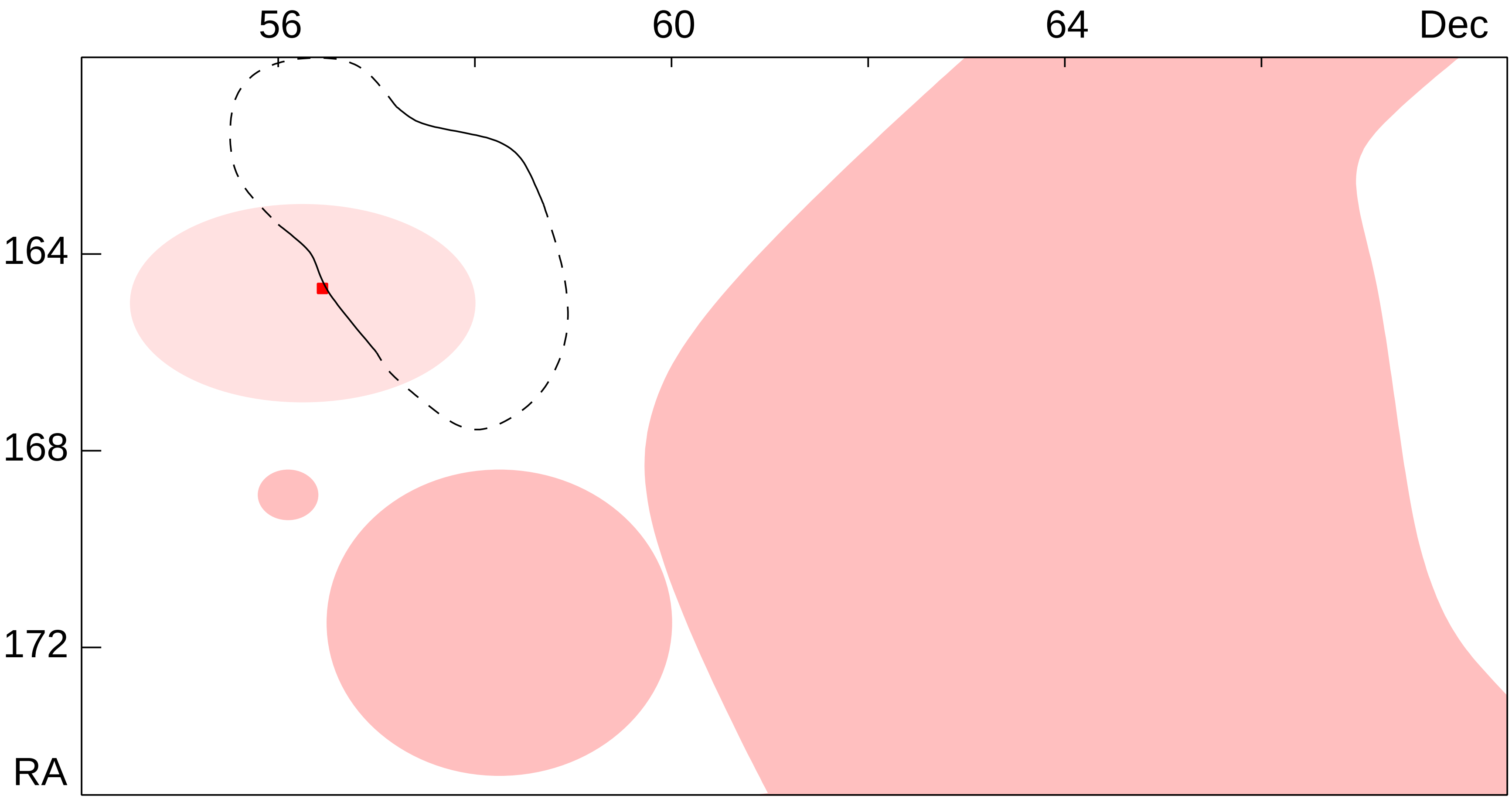
SKYMAP AND POTENTIAL SOURCES



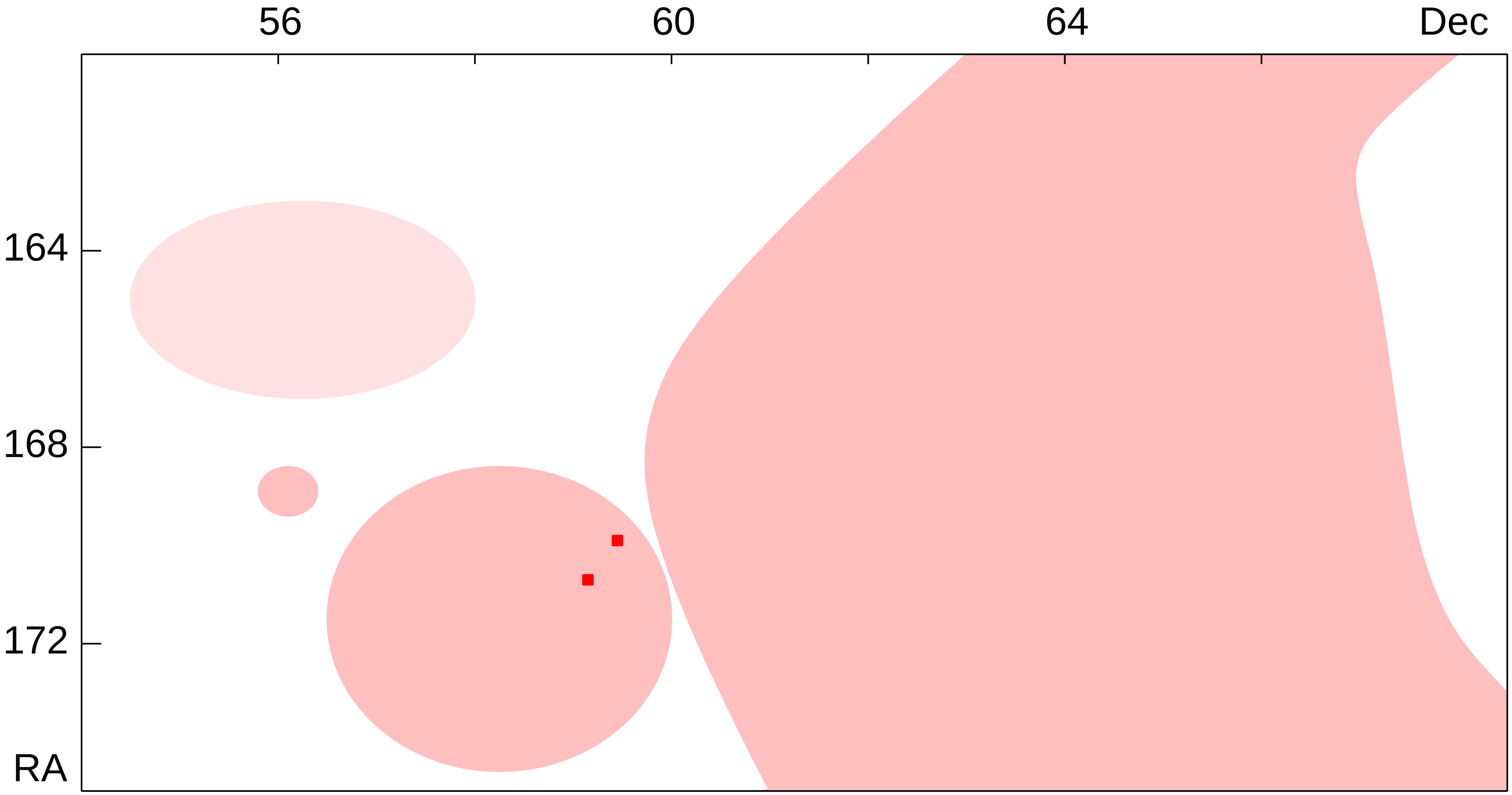
- TXS 1055+567
  - a BL LAC type object, $15^m.8$, optical dominance, possible EGRET association



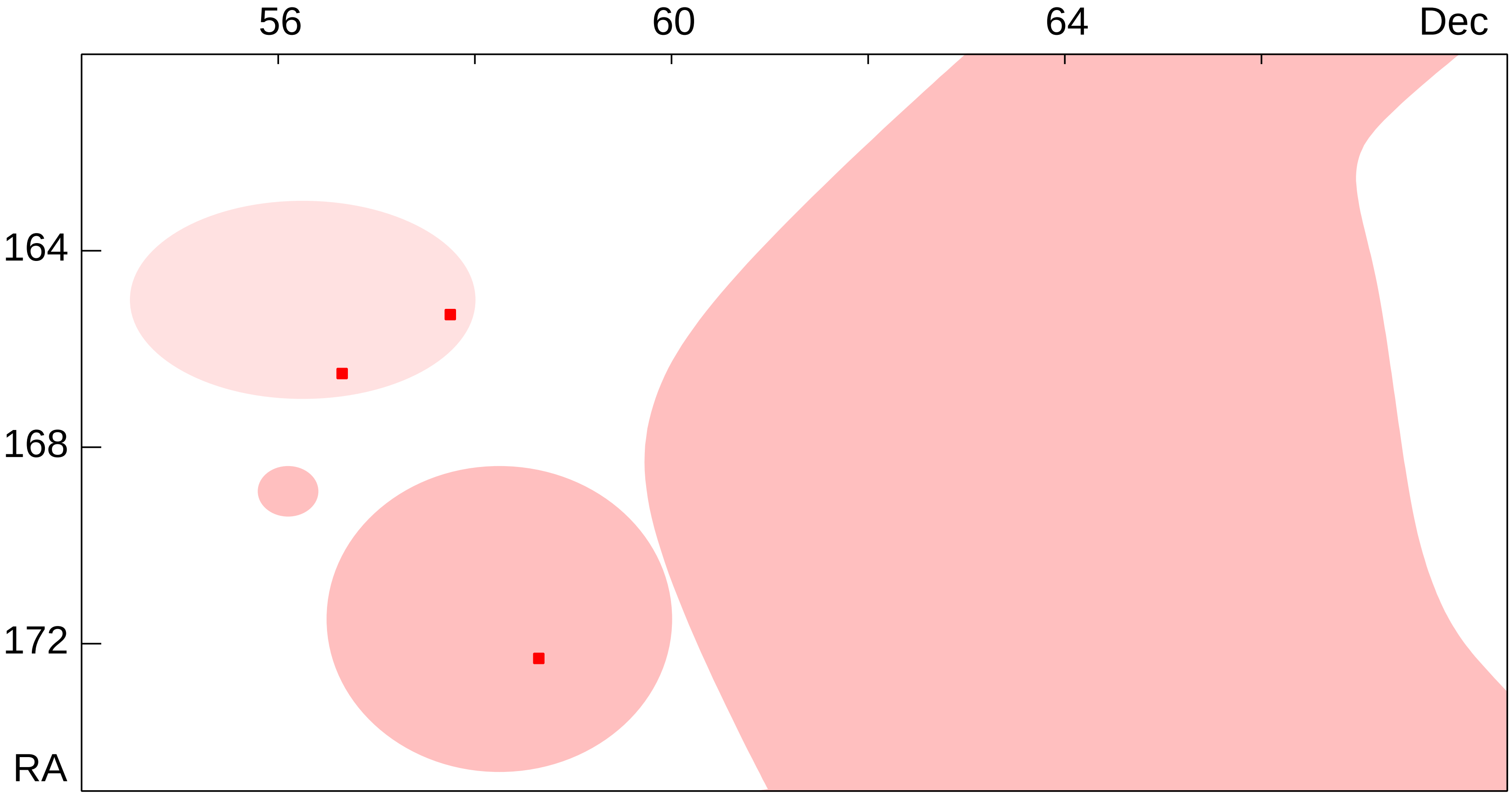
- TXS 1055+567 – a BL LAC type object
- 3EG J1052+5718 – a EGRET source possibly associated with TXS 1055+567
  - weak, variable, extended/inaccurate



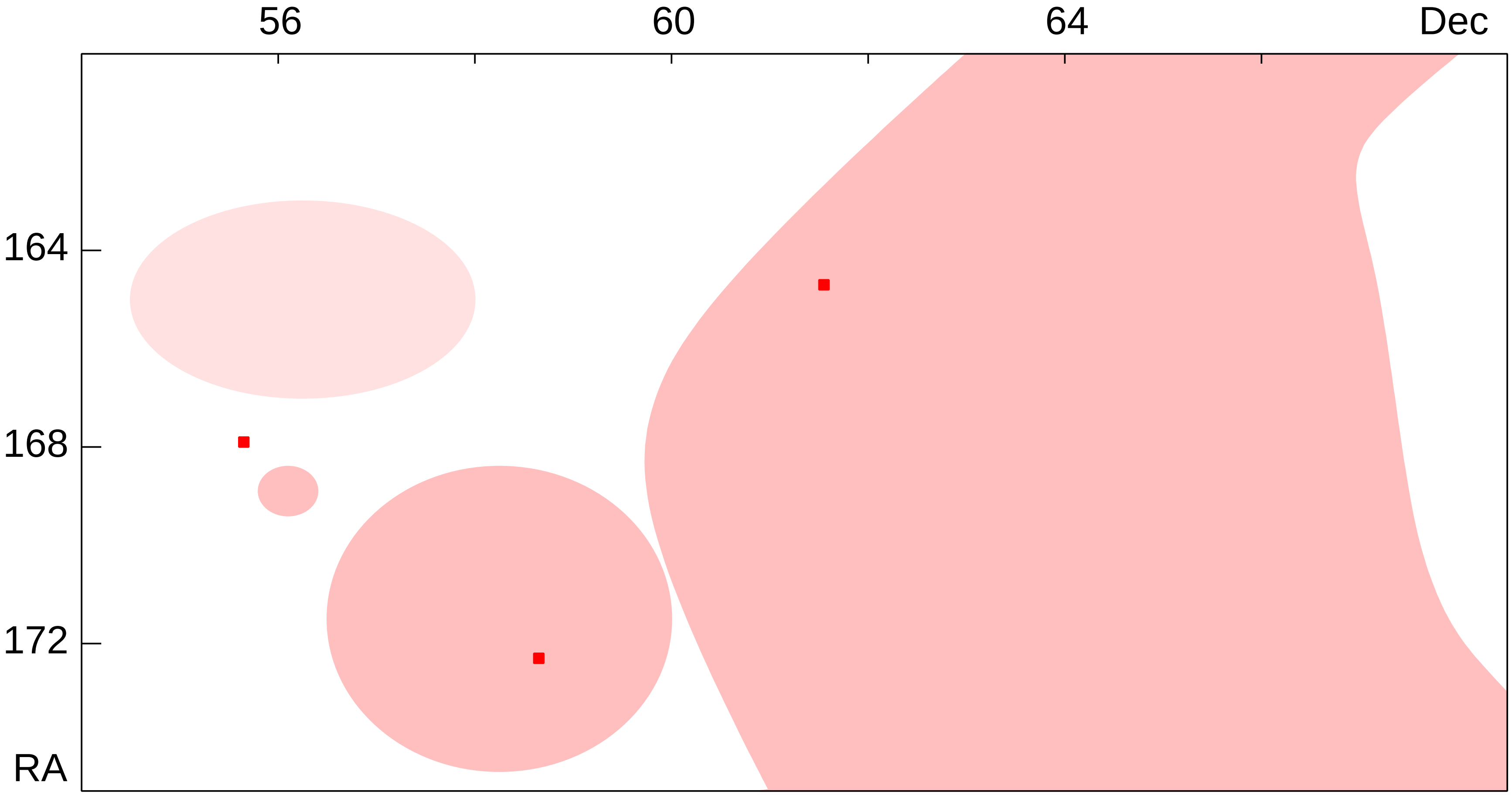
• NGC 3642 and MCG +10-16-111: nearby Seyfert galaxies

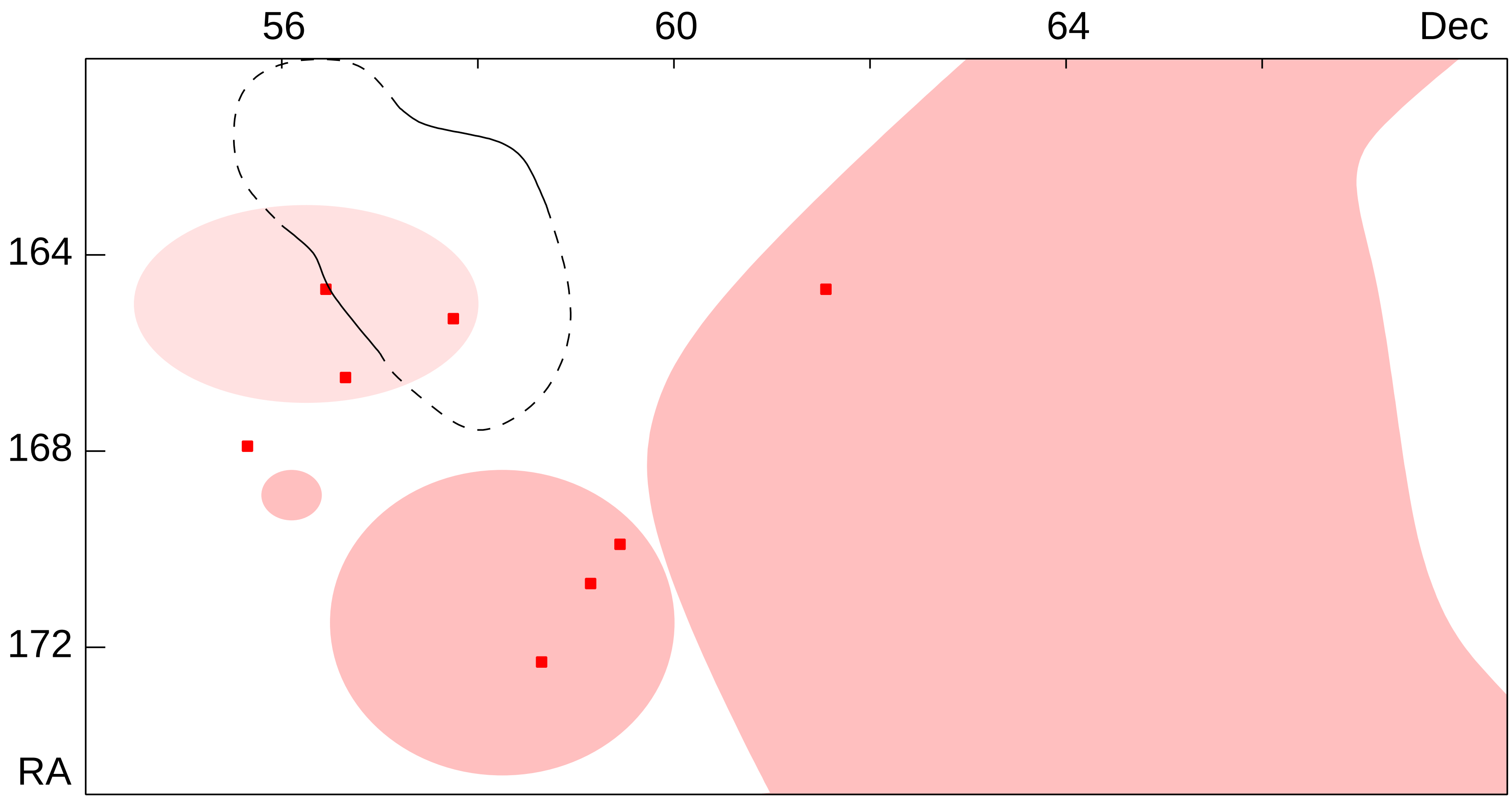


- NGC 3488, NGC 3517, IC 694: colliding galaxies



- NGC 3556, NGC 3471: luminous IR galaxies
- IC 694: luminous IR + colliding




56
60
64
Dec
164
168
172
RA

CONCLUSIONS

- A FIVE-PLET AT $E \gtrsim 4 \cdot 10^{19}$ eV
- WITH THE ORIGINAL AGASA CLAIM DROPPED, STILL A TRIPLET
- FITS WITH DEFLECTION BETTER THAN WITHOUT
- BUT NOT WITHIN AVAILABLE GMF MODELS
- CANDIDATE SOURCES?

FURTHER STUDIES

- ASTROPHYSICAL STUDIES OF MAGNETIC FIELDS
- STUDIES OF OTHER CLUSTERS
- HIGH-PRECISION POINTING (HIRES, TA)
- HINTS ABOUT PRIMARIES OF THESE PARTICULAR EVENTS