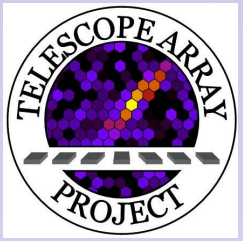
TA ANISOTROPY SUMMARY

P. Tinyakov
for the Telescope Array Collaboration.



TELESCOPE ARRAY COLLABORATION

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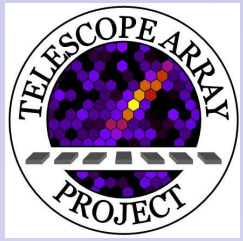

TA ANISOTROPY SUMMARY

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TA detector and data

Global distributions

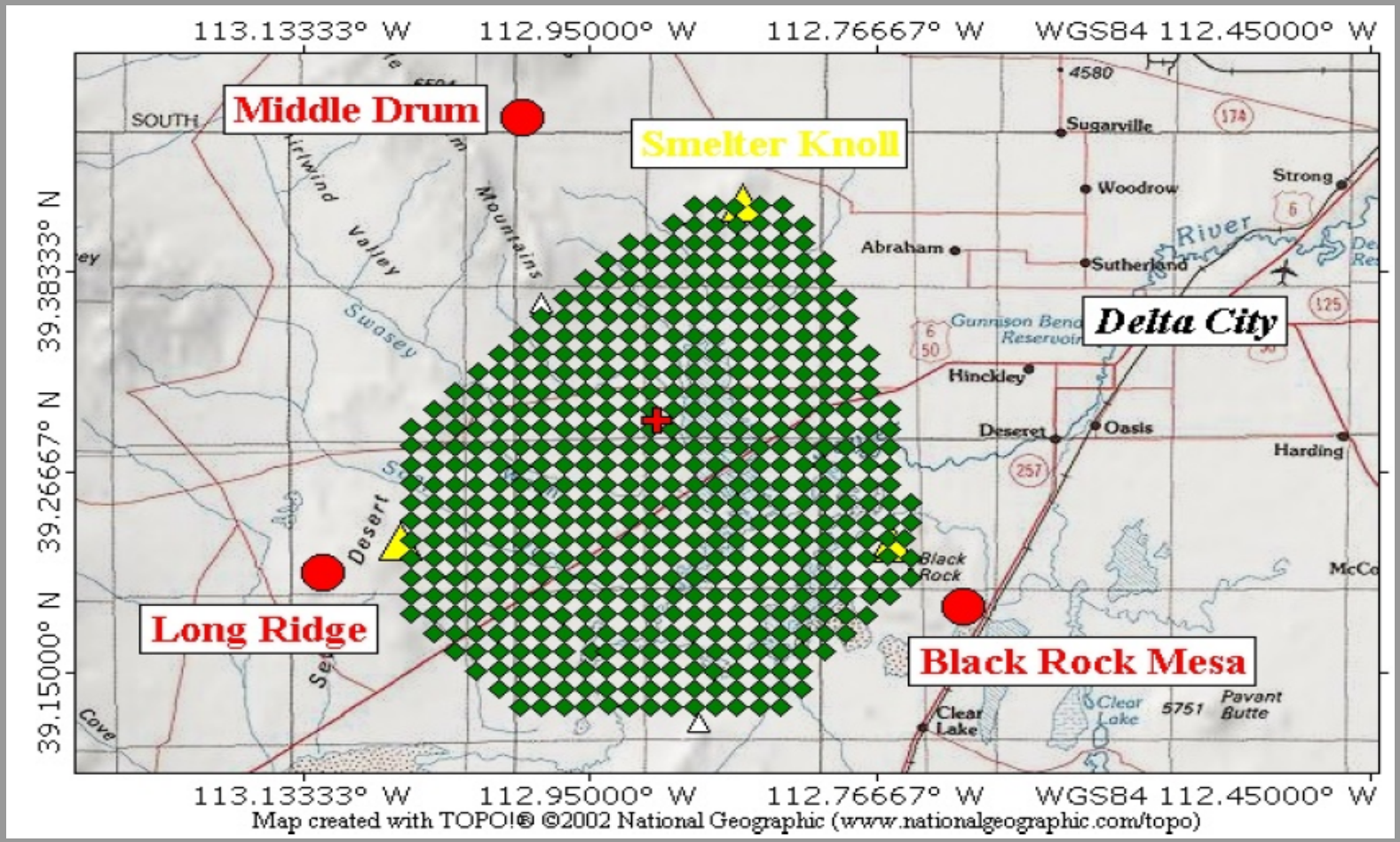
Point sources

Hot spot

Other searches

Conclusions

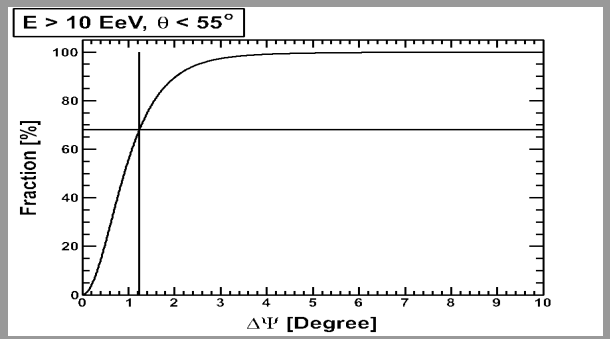
TA HYBRID DETECTOR

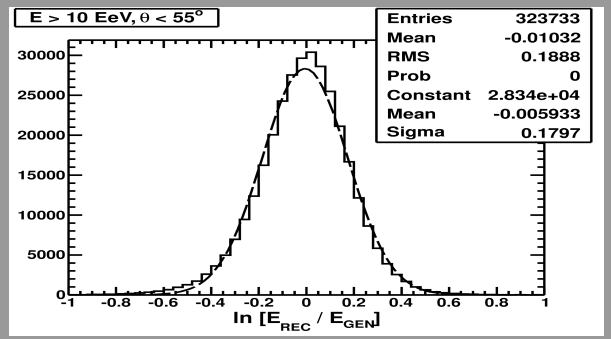


- 507 scintillator detectors covering 680 km^2
- 3 fluorescence sites, 38 telescopes
- SD fully operational from March 2008
- SD relative size: TA $\sim 9 \times$ AGASA $\sim$ PAO/4

Anisotropy data set (SD)

- covers the period 12.05.2008 — 11.05.2014 (full 6 years)
- zenith angle up to 55°, loose border cut
- geometrical acceptance; exposure $\sim$ 7400 km^2 yr sr
- 2560 above 10 EeV
- 164 above 40 EeV
- 66 above 57 EeV
- angular resolution: better than 1.5°
- energy resolution: $\sim$ 20%





GLOBAL DISTRIBUTIONS

Comparison with isotropic distribution by KS test

KS p-values:

- 2560 events with $E > 10$ EeV

Coords	right ascension	declination
Equatorial:	0.38	0.92
Supergalactic:	0.60	0.35

- 164 events with $E > 40$ EeV

Coords	right ascension	declination
Equatorial:	0.075	0.39
Supergalactic:	0.10	0.21

- 66 events with $E > 57$ EeV

Coords	right ascension	declination
Equatorial:	0.022	0.16
Supergalactic:	0.10	0.005

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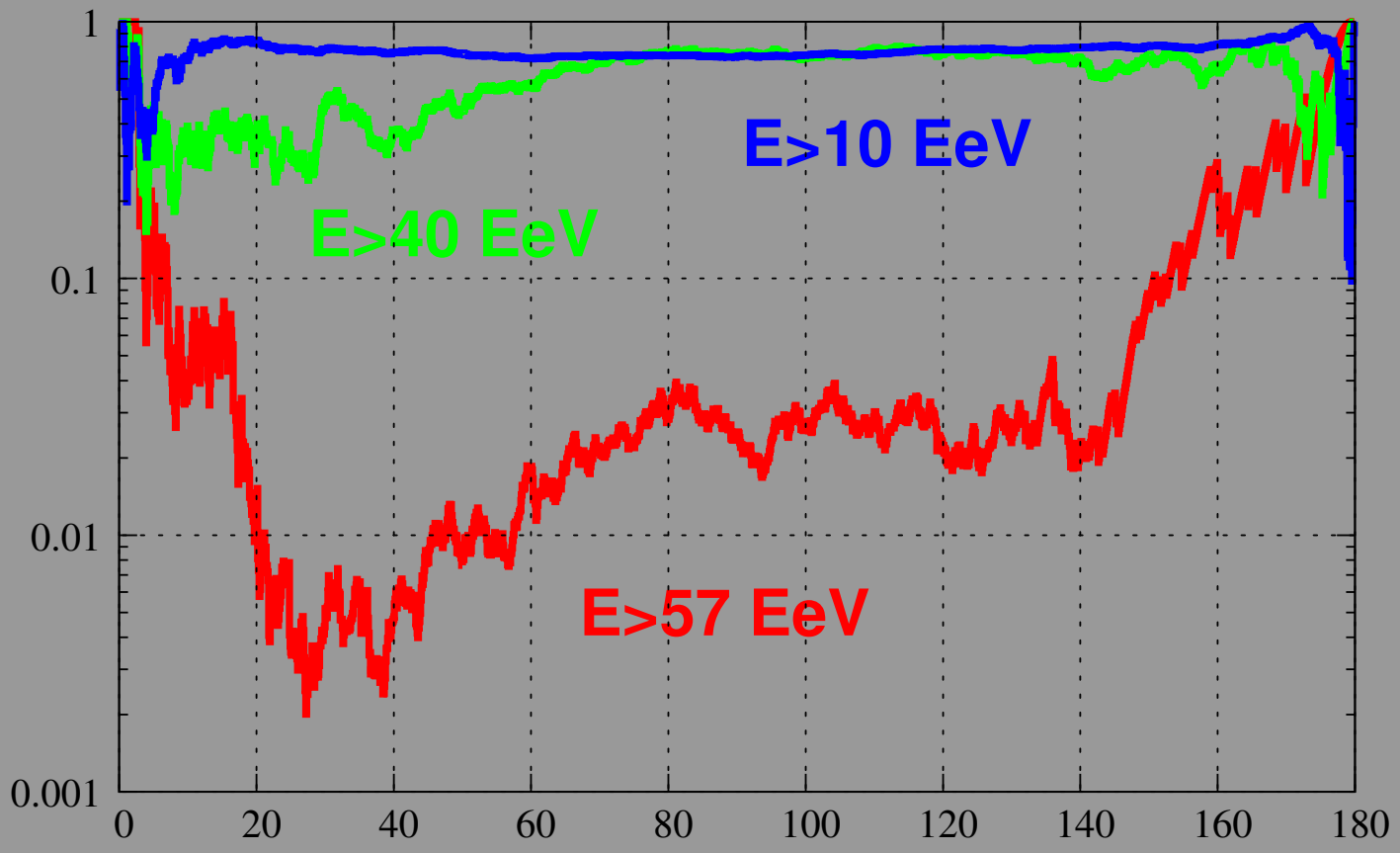
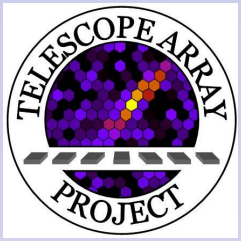
AUTOCORRELATION FUNCTION



$\Longrightarrow$ compatible with isotropy at $E > 10$ EeV and $E > 40$ EeV, tension at $E > 57$ EeV

POINT SOURCES



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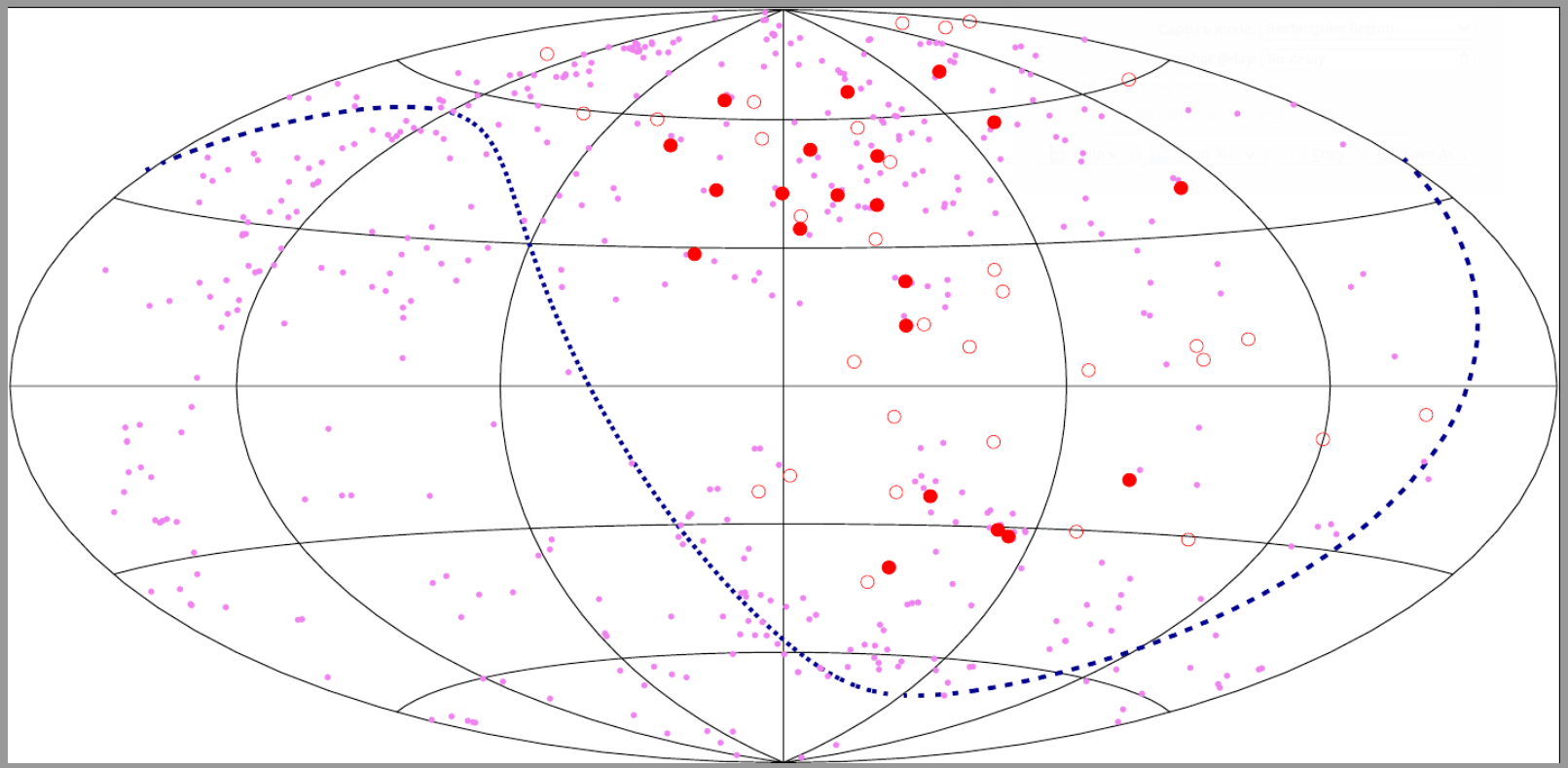
CORRELATION WITH NEARBY AGN

- DATA: strict cuts, $\theta_z < 45°$, $E > 57$ *EeV*, 6 years: 53 events



dots: AGN from VCV catalog

filled circles: TA events correlating within 3.1°

empty circles: non-correlating events

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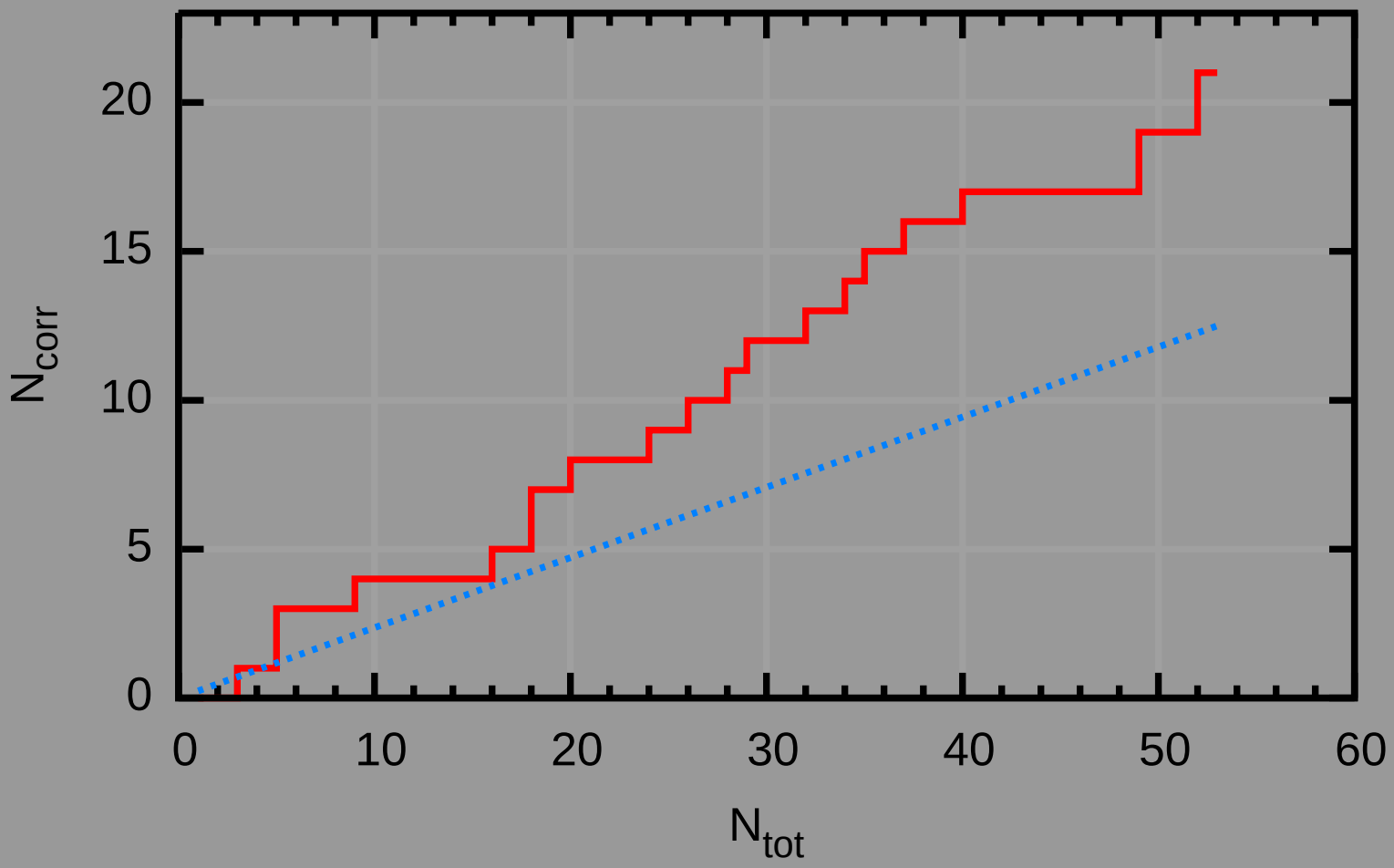
Correlation with AGN from VCV catalog

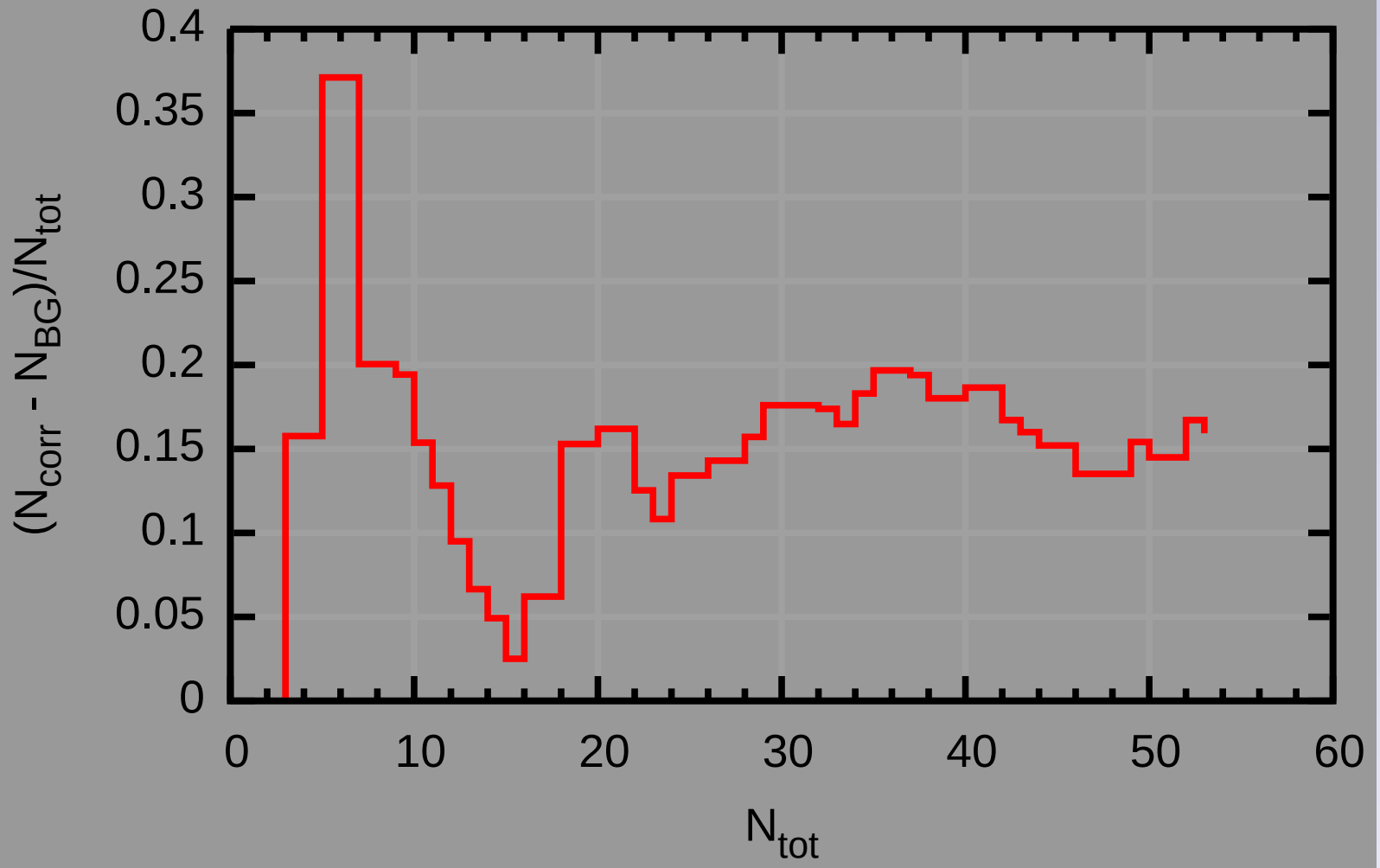


Correlating events (red solid) vs. background (blue dotted). Today's values:

$$N_{tot} = 53, \quad N_{cor} = 21, \quad N_{bg} = 12.5$$

P-value $= 0.007$ (2.7σ)

Correlation with AGN from VCV catalog



The fractional excess of correlating events $(N_{\mathrm{corr}} - N_{\mathrm{bg}})/N_{\mathrm{tot}}$.

TA ANISOTROPY SUMMARY

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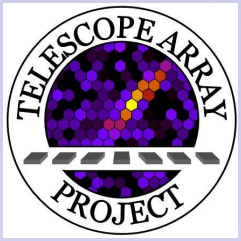
HOT SPOT UPDATE



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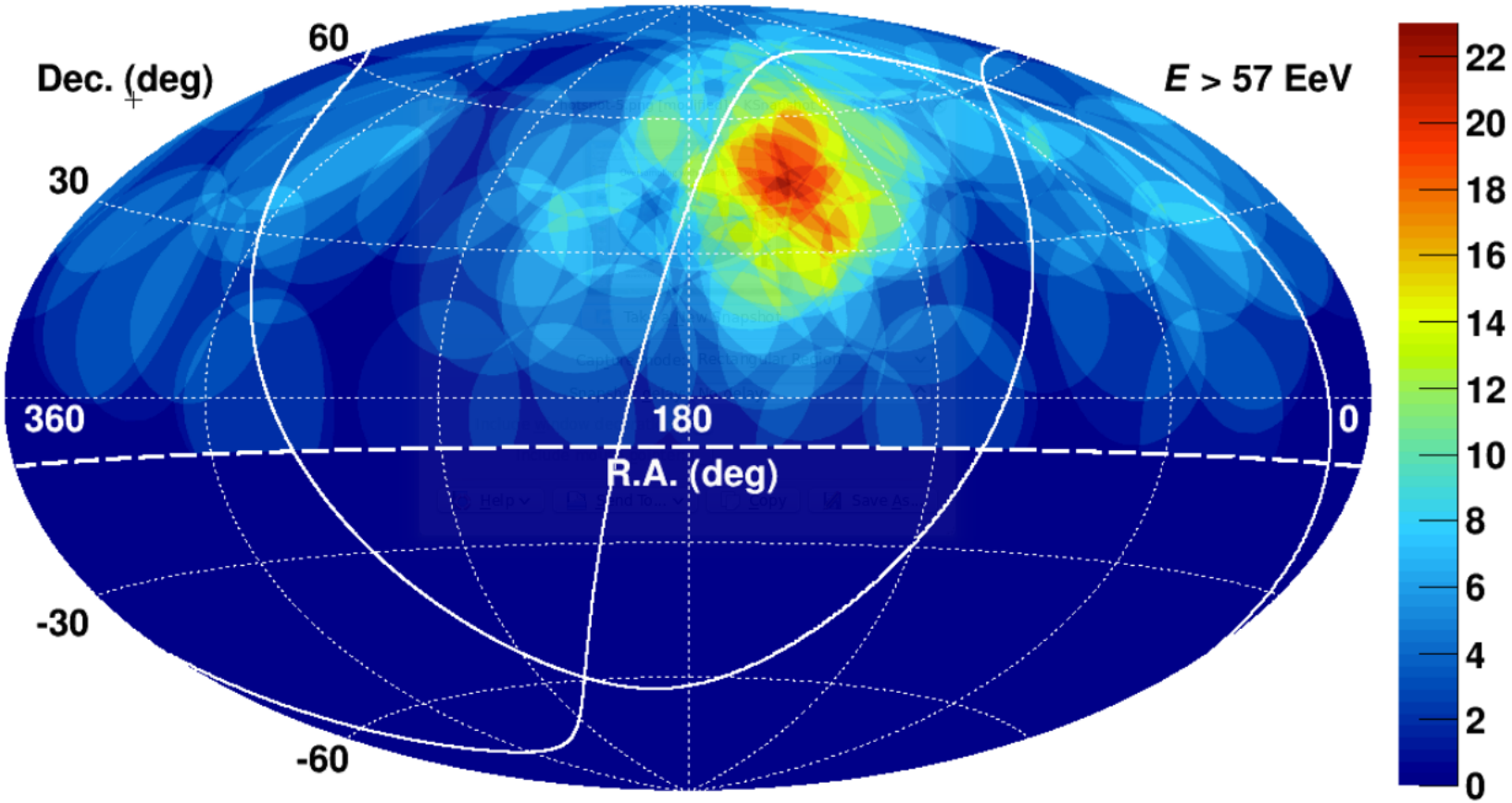
HOT SPOT: 6 yr update

- Reconstruction with loose cuts optimized for statistics (72 events above 57 EeV in 5 yr).
- "Hot spot" within the circle of radius 20° centered at $\mathrm{RA} = 146°$, $\mathrm{Dec.} = 43°$ [ApJ 790:L21 (2014)]. Significance of excess 5.1σ (pre-trial).
- After accounting for arbitrary position and opening angles 15°, 20°, 25°, 30°, 35° the significance 3.4σ (post-trial).

HOT SPOT: 6 yr update

Oversampling with 20°-radius circle

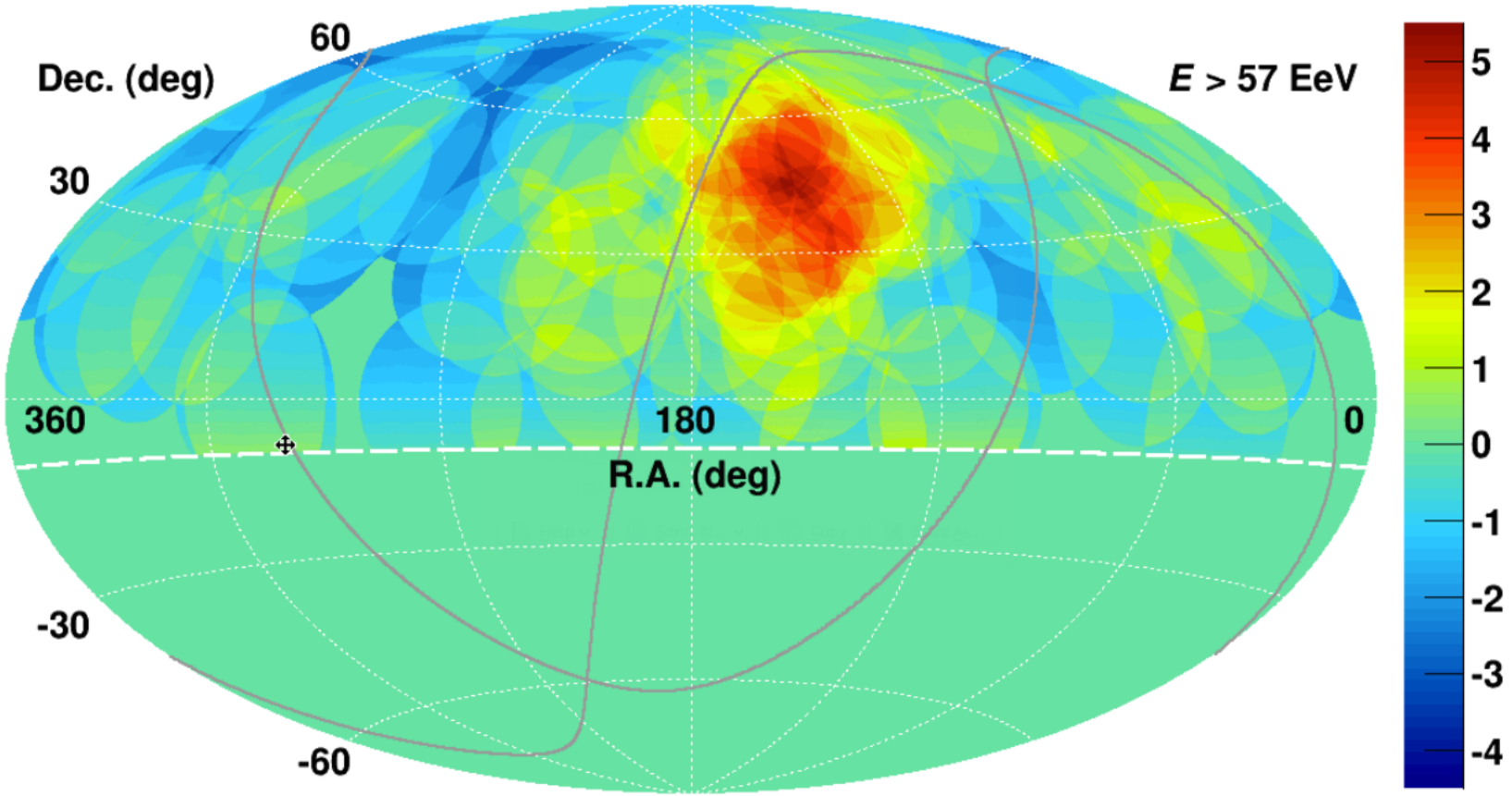


Maximum excess
19 events → 23 events

HOT SPOT: 6 yr update

Significance Map (Li-Ma) 6 years

Oversampling with 20°-radius circle

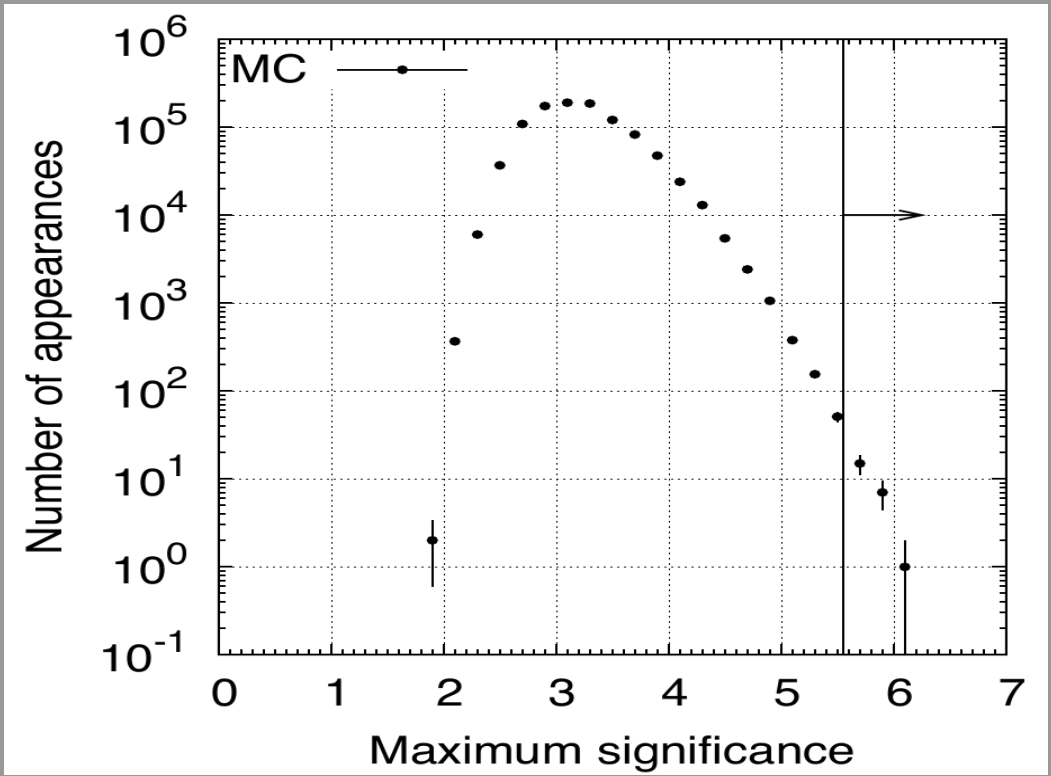


Max significance **5.55σ** (N_{on} = 23, N_{bg}=5.49) for 6 years (5.07σ for 5 years)
Centered at R.A=148.4°, Dec.=44.5° (shifted from SGP by 17°)

HOT SPOT: 6 yr update

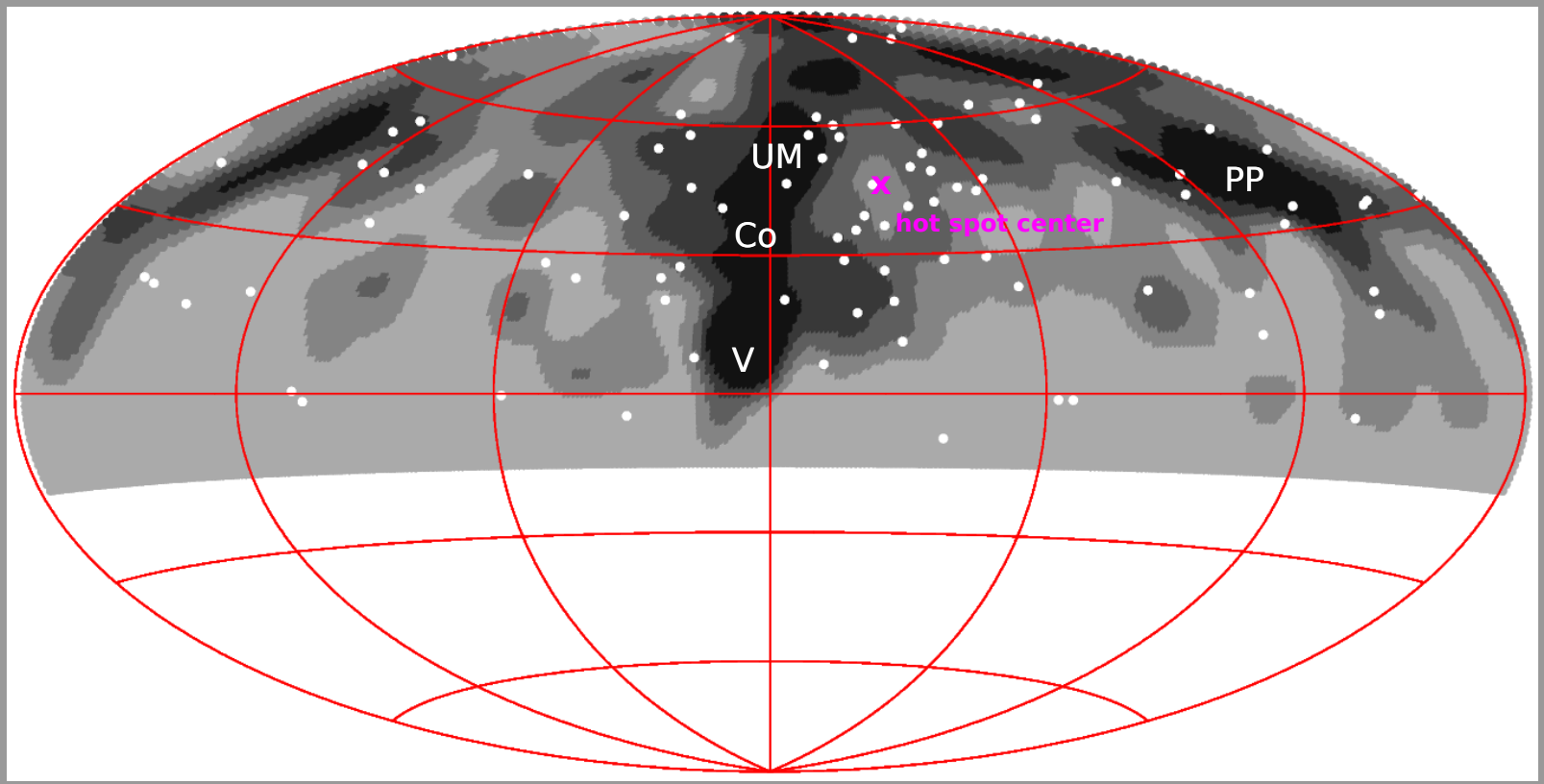
Significance (same procedure as ApJL 790 (2014) L21):

- oversampling at 15°, 20°, 25°, 30°, 35°, moving center



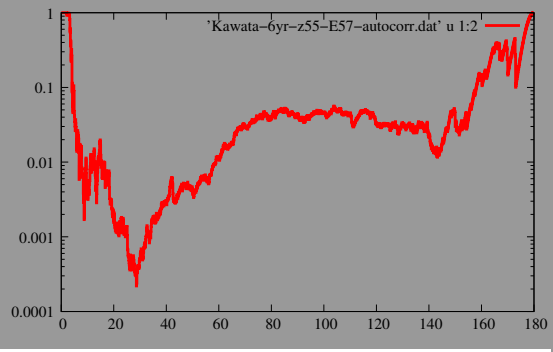
- Pre-trial: $P = 5.55\sigma$; Post-trial $P = 3.1 \times 10^{-5}$ (4σ)
- Blind search with 1yr data: expected 0.94, observed 3, $P = 0.07$

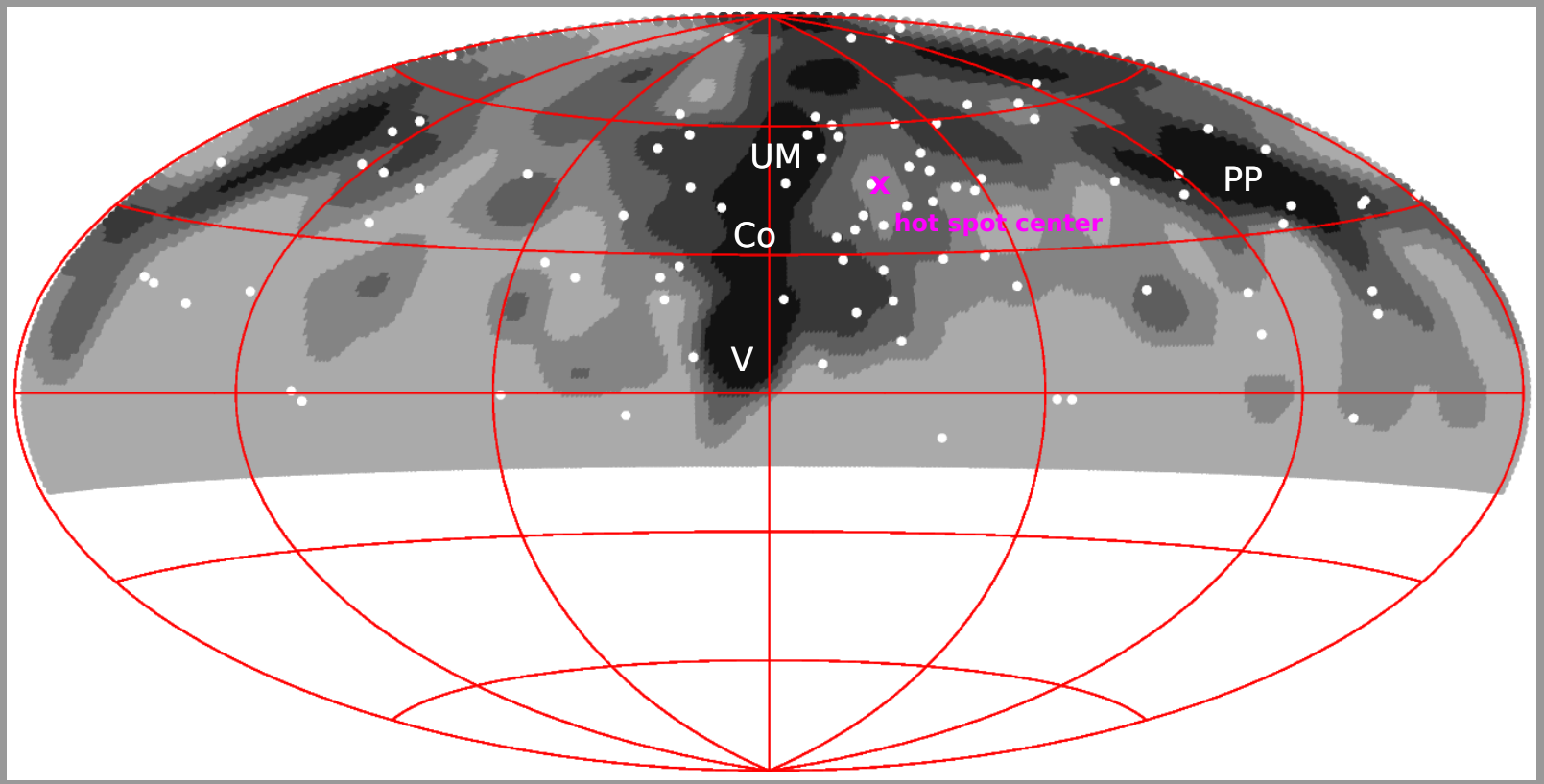
HOT SPOT: 6 yr update



Events vs. flux expectation from the LSS (equatorial coordinates). Darker color represents larger flux.

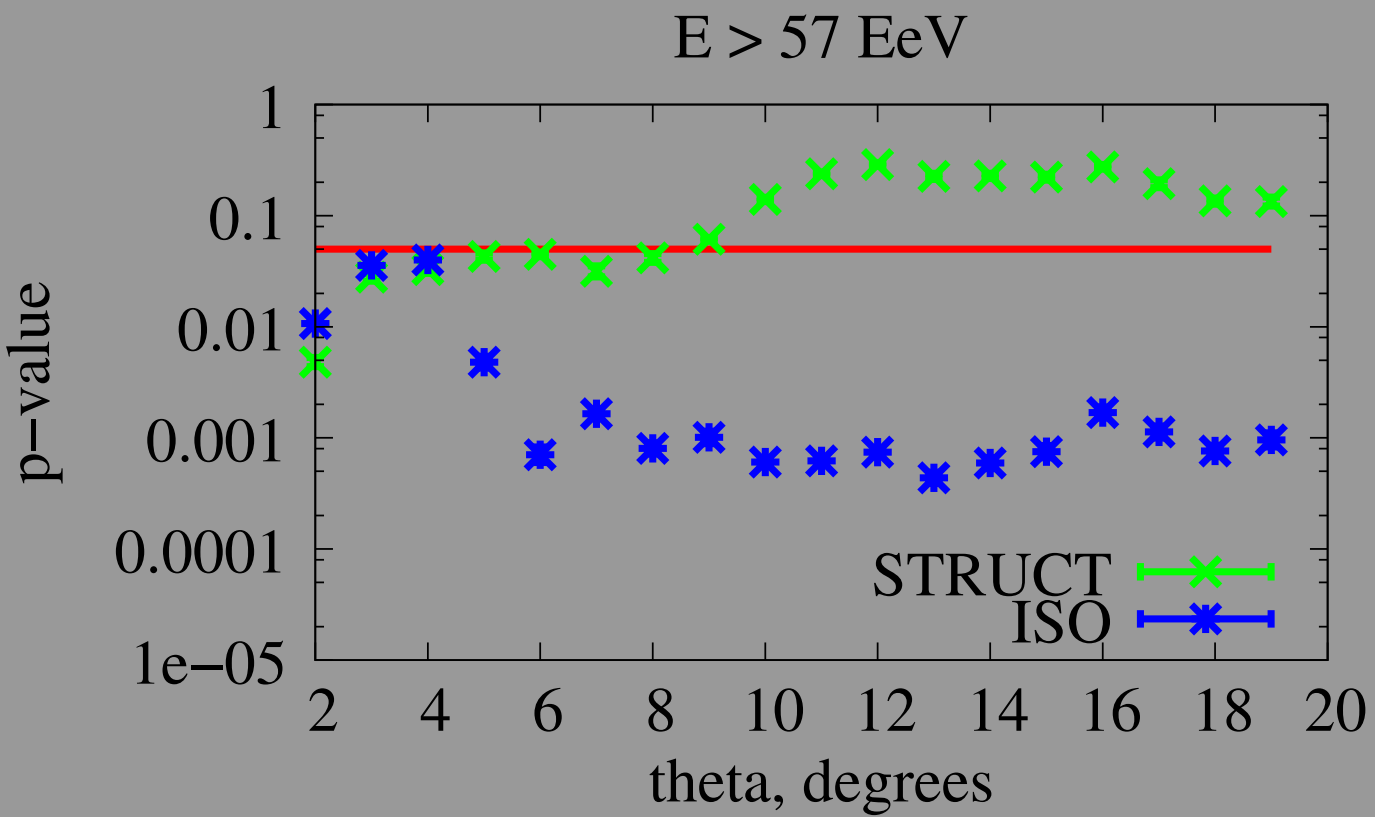
HOT SPOT: 6 yr update





Events vs. flux expectation from the LSS (equatorial coordinates). Darker color represents larger flux.

Statistical test for compatibility with LSS & isotropy



Compatibility as a function of smearing angle theta (low p-values = incompatibility).

OTHER SEARCHES

SEARCHES COMPATIBLE WITH ISOTROPY

- Search for correlations with catalogs of sources detected in different bands [ApJ, 777, 2013, 88]:
  - 13th VCV AGN catalog
  - the third Cambridge catalog of radio sources catalog (3CRR)
  - the 2MASS (the Two Micron All-Sky Survey) redshift survey catalog (2MRS)
  - Swift BAT 58-Month hard X-ray survey catalog
  - 2nd Fermi AGN catalog (2LAC)
- Low energy $\sim 10^{18}$ eV point-like source search [arXiv:1407.6145]
- Medium-scale anisotropy at low energy $\sim 10^{18}$ eV
- Correlations with LSS at 10 EeV and 40 EeV
- Harmonic analysis [arXiv:1409.3128]

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CONCLUSIONS

- Isotropy at low energies
- "Hot spot" of a medium angular scale at highest energies $E > 57$ EeV; current significance $\sim 4\sigma$ (post-trial). Shows up in various other tests as incompatibility with isotropy:
  - distribution in RA: $p \sim 0.02$
  - autocorrelation function: ~ 0.001 at $\delta \sim 20^\circ - 25^\circ$
  - correlation with AGN: $p \sim 0.01$
  - correlation with LSS: $p \sim 0.001$
- $\Longrightarrow$ Should be tested with a few times larger statistics