



THE OBSERVATIONS OF THE VERY-HIGH-ENERGY GAMMA-RAY SKY BY

HAWC

**ADIV GONZÁLEZ MUÑOZ
FOR THE HAWC COLLABORATION
INSTITUTO DE FÍSICA, UNAM**

THE HAWC COLLABORATION



United States:

Pennsylvania State University
University of Maryland
Los Alamos National Laboratory
University of Wisconsin
University of Utah
Univ. of California, Irvine
University of New Hampshire

University of New Mexico
Michigan Technological University
NASA/Goddard Space Flight Center
Georgia Institute of Technology
Colorado State University
Michigan State University
University of Rochester
University of California Santa Cruz

Poland:

IFJ-PAN, Cracovia

Germany:

Max-Planck-Institut für Kernphysik, Heidelberg

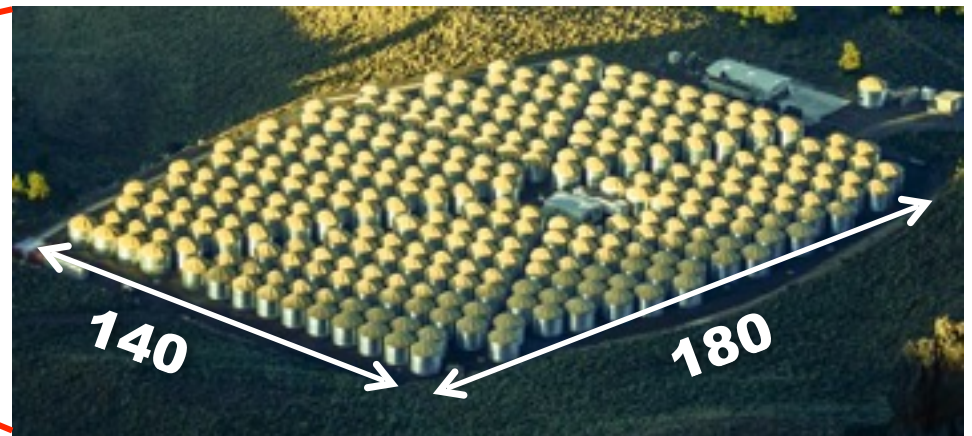
Mexico:

Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE)
Universidad Nacional Autónoma de México (UNAM)
Instituto de Física
Instituto de Astronomía
Instituto de Geofísica
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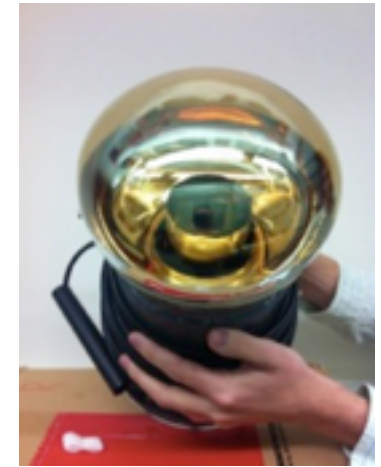
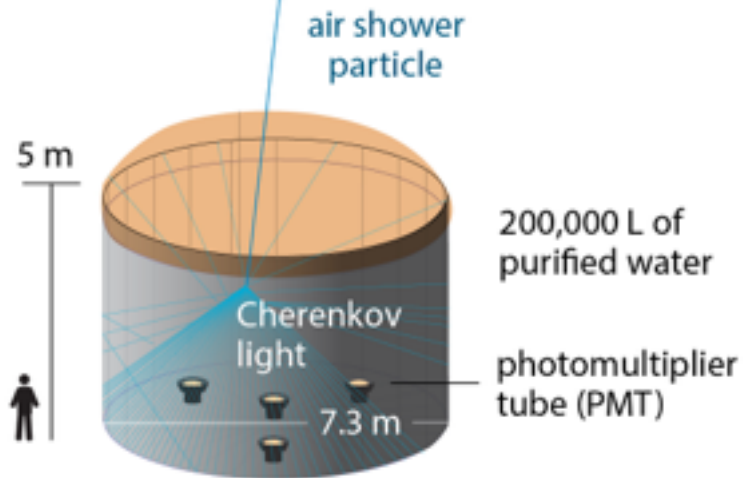
Universidad Michoacana de San Nicolás de Hidalgo
Centro de Investigación y de Estudios Avanzados
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Centro de Investigación en Computación- IPN



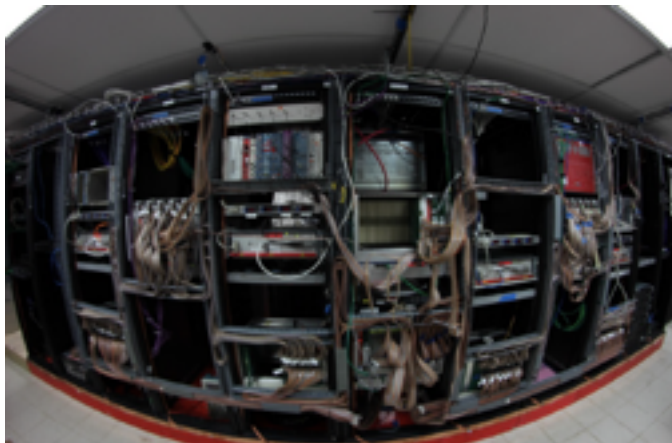
THE OBSERVATORY



THE OBSERVATORY

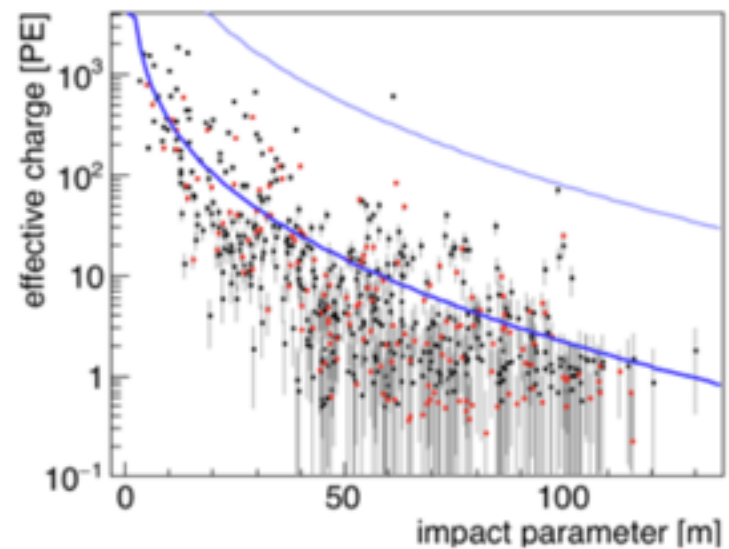
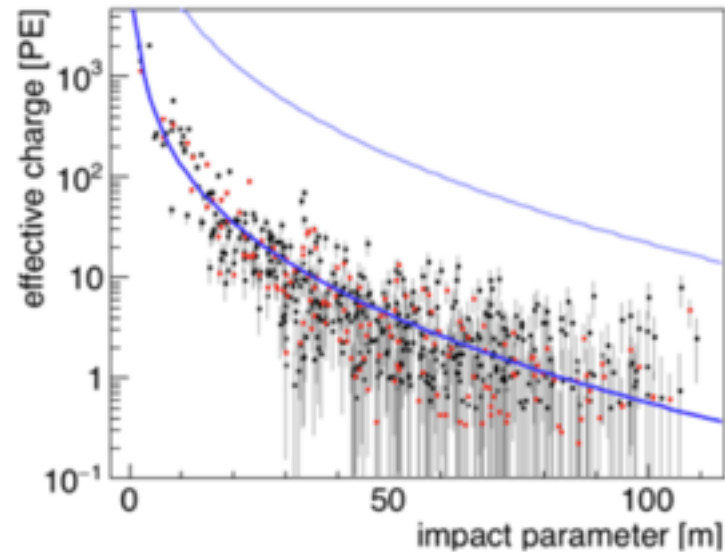
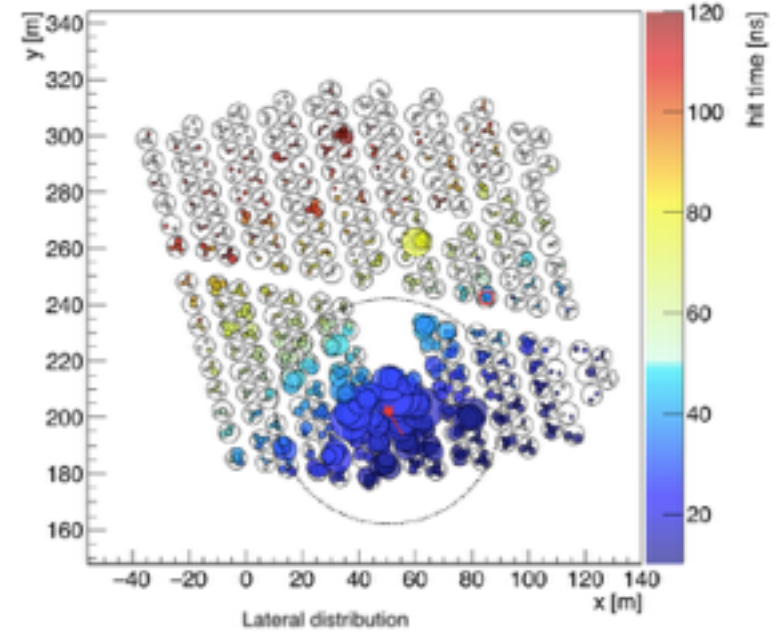
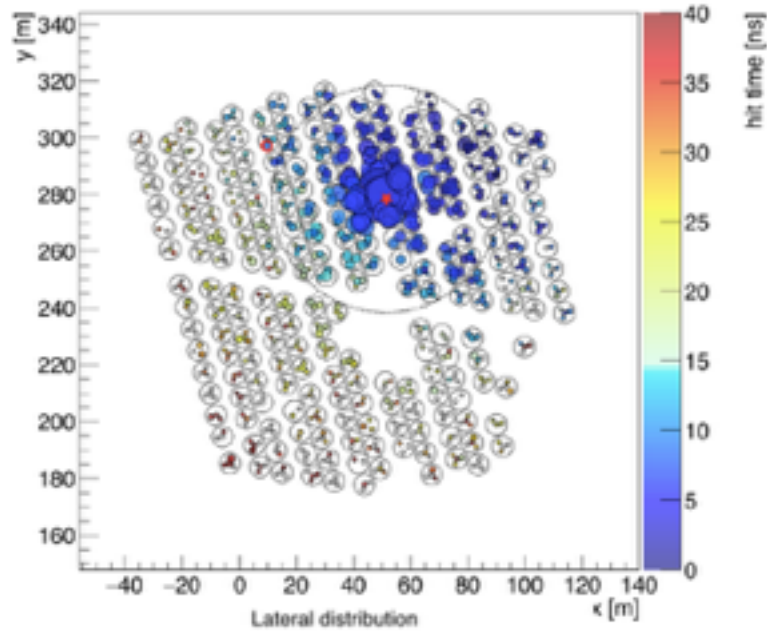


3 Hamamatsu R5912 (8")
1 Hamamatsu R7081 (10")



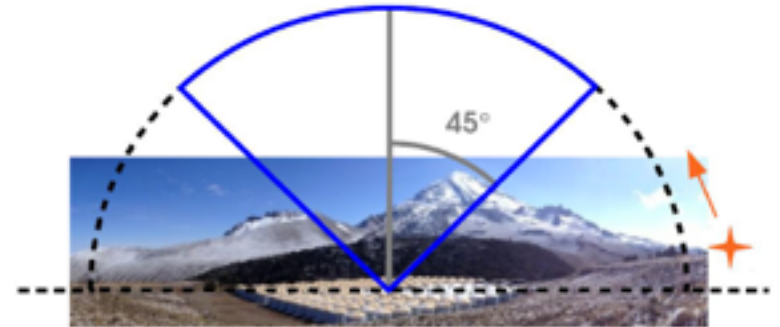
- 700 TB of data per year is produced and stored in 2 data centers: UNAM and University of Maryland.
- The data is reconstructed and analysed in real time using ~200 cores

AIR SHOWER DETECTION



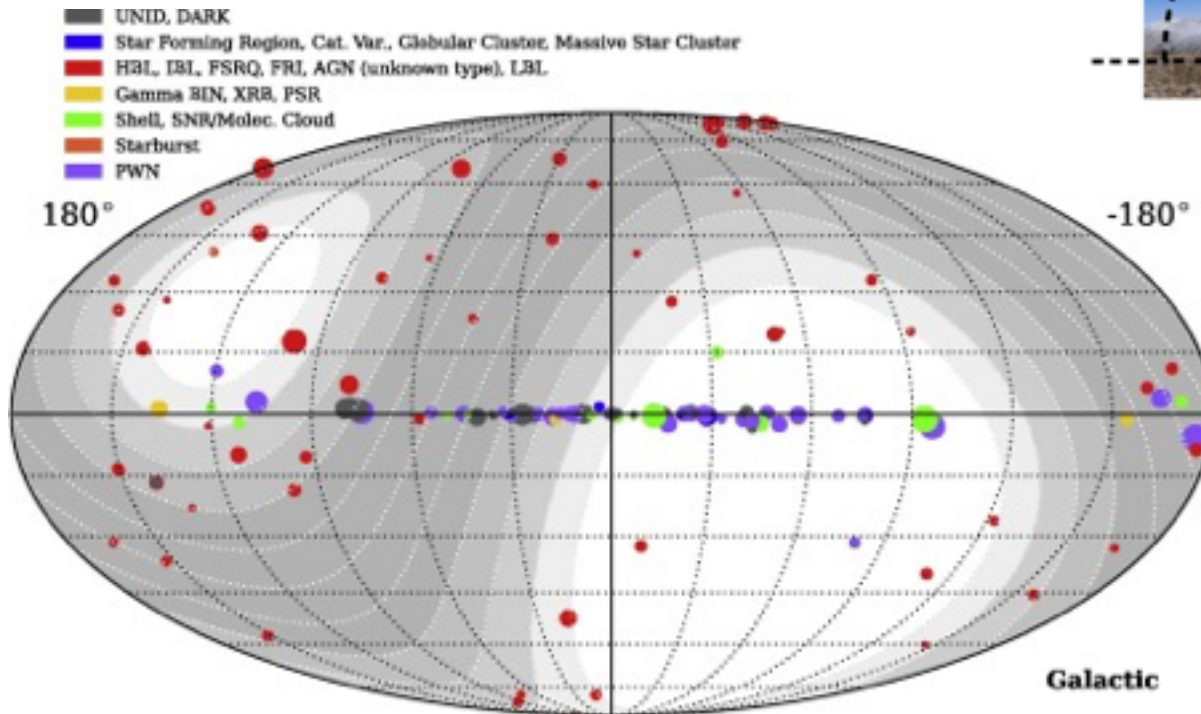
HAWC WIDE FIELD OF VIEW

FoV of 2 sr, we scan 2/3 of the sky per day



The Crab Nebula transits overhead of HAWC

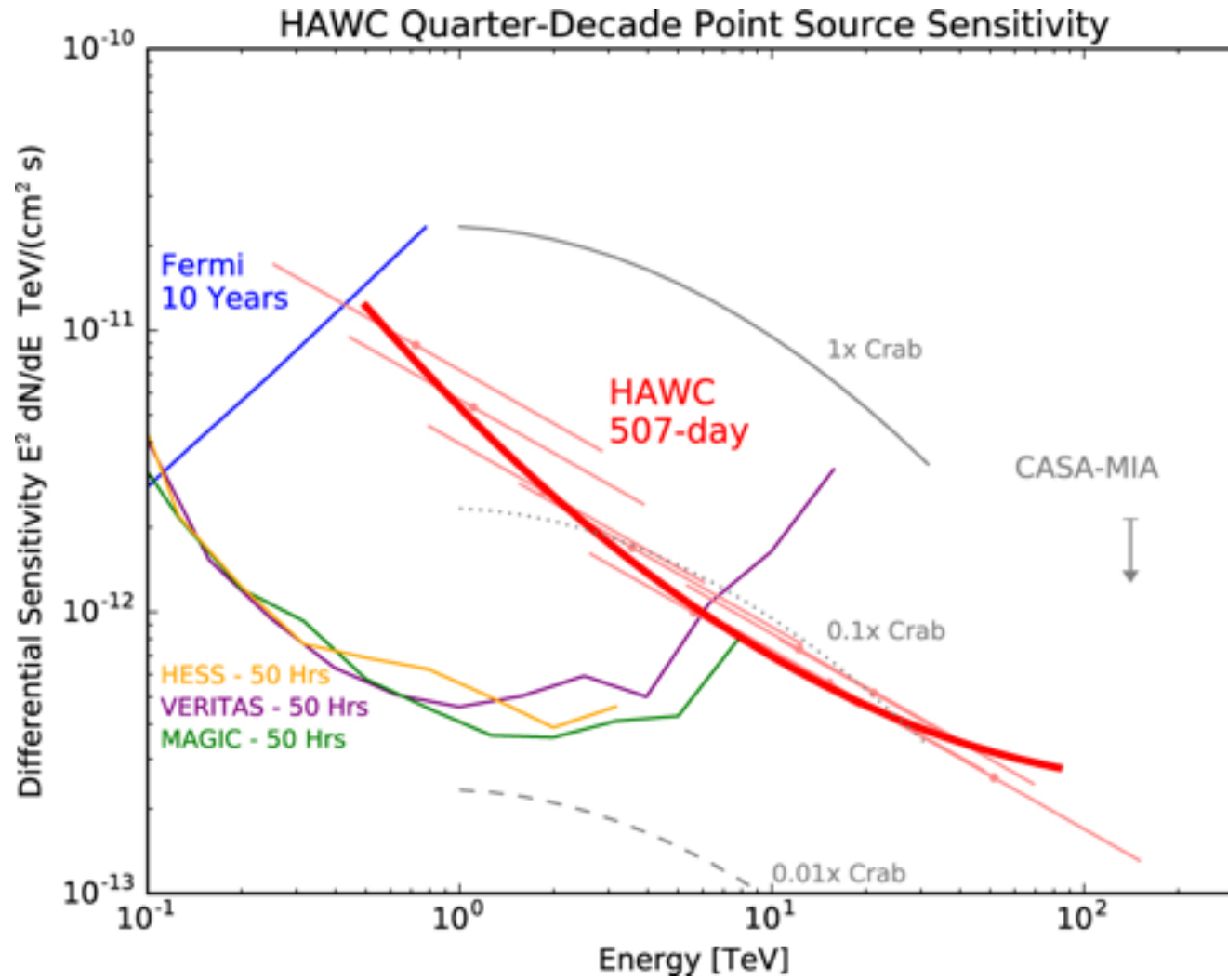
The galactic center is at the boundary of the field of view



10^{-12.5} 10⁻¹² 10^{-11.5}
 HAWC-300 1-year sensitivity $F(>2 \text{ TeV}) [\text{cm}^{-2} \text{ s}^{-1}]$

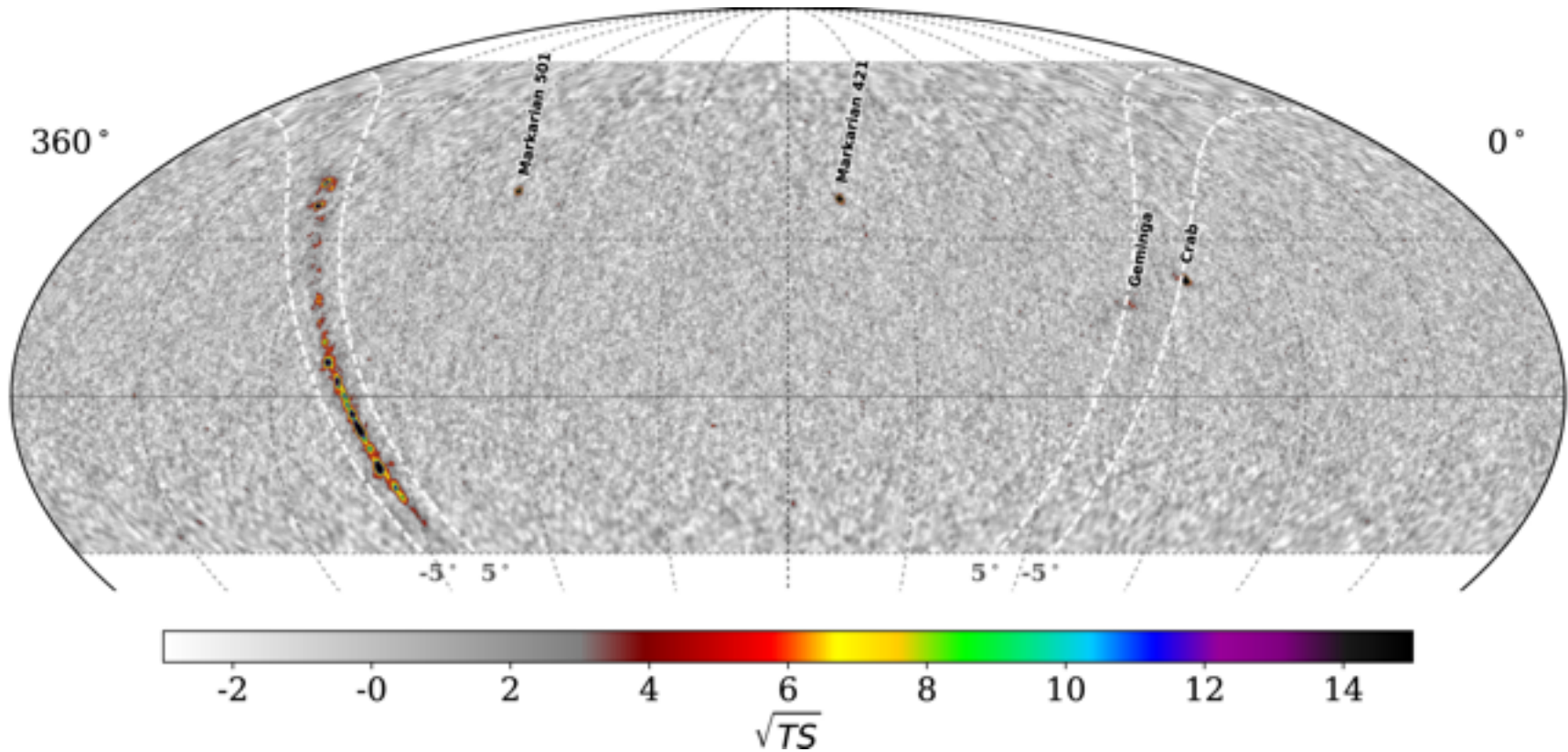
A.U. Abeysekara et al., APh, 50, 26A, 2013

HAWC SENSITIVITY



A. U. Abeysekara et al., ApJ, 843:39, 2017

EQUATORIAL FULL-SKY TS MAP FOR POINT SOURCE ANALYSIS

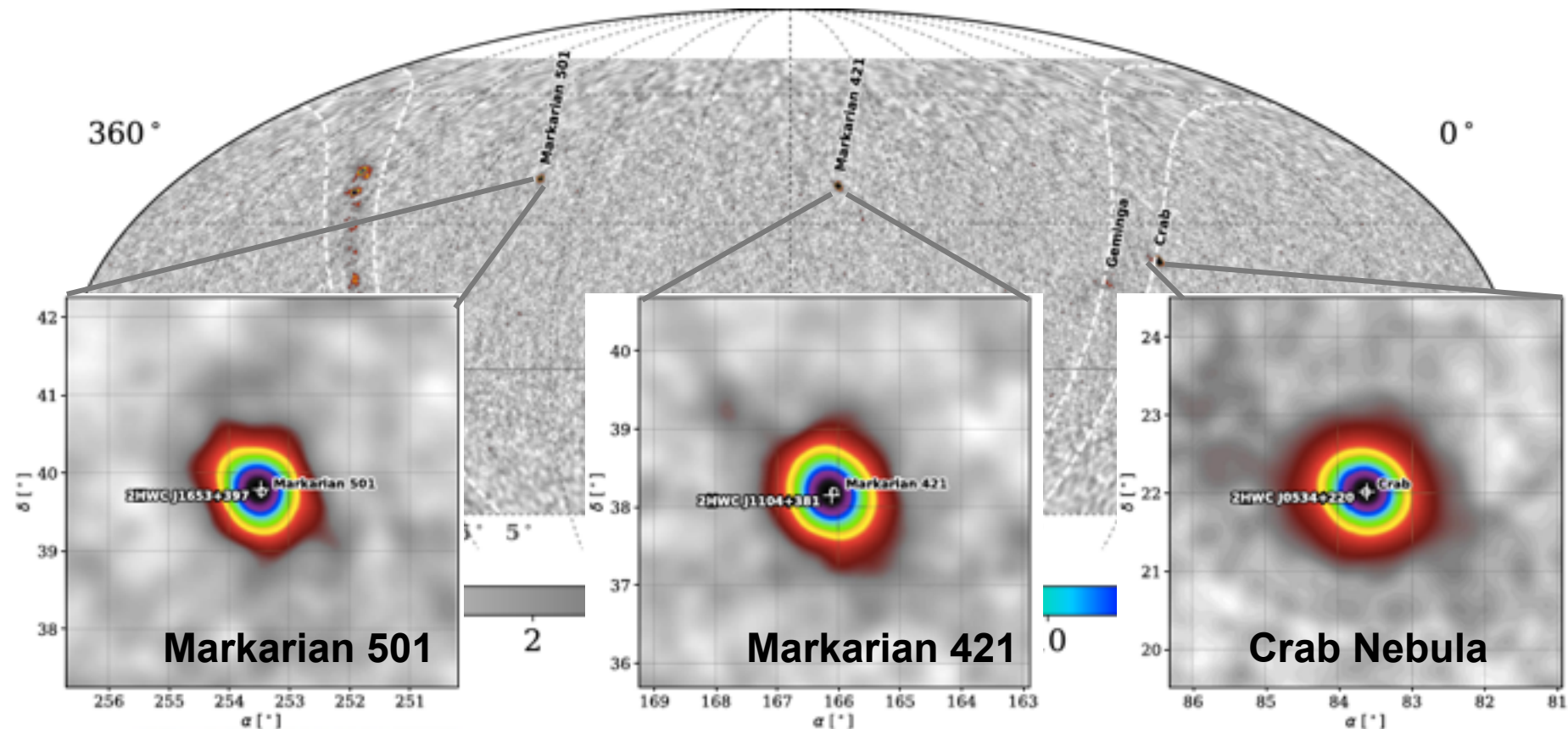


Source model: power-law with index -2.7

$$TS = 2 \ln \frac{\mathcal{L}^{\max}(\text{Source Model})}{\mathcal{L}(\text{Null Model})}$$

A. U. Abeysekara et al., ApJ, 843:40, 2017

EQUATORIAL FULL-SKY TS MAP FOR POINT SOURCE ANALYSIS

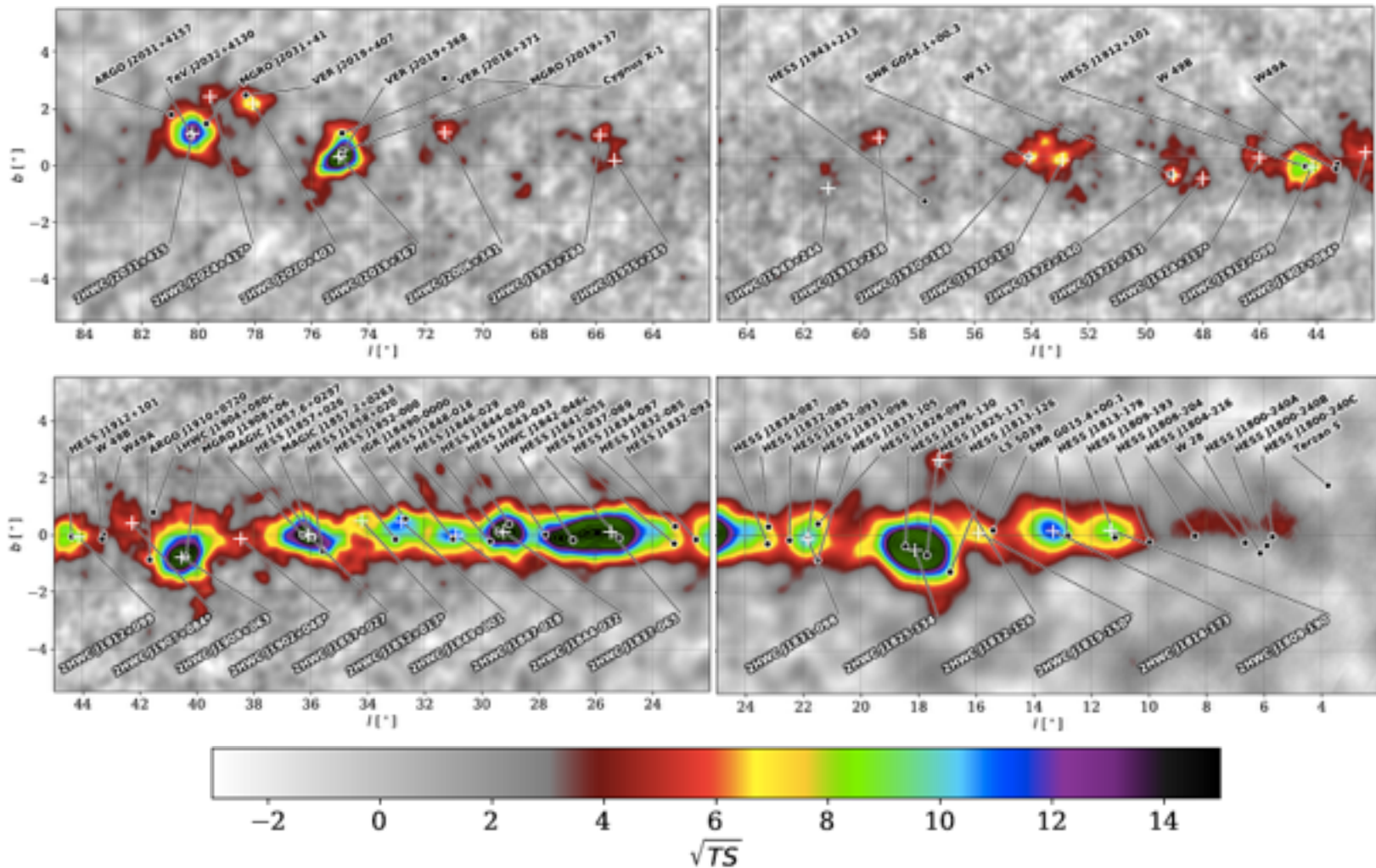


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A. U. Abeysekara et al., ApJ, 843:40, 2017

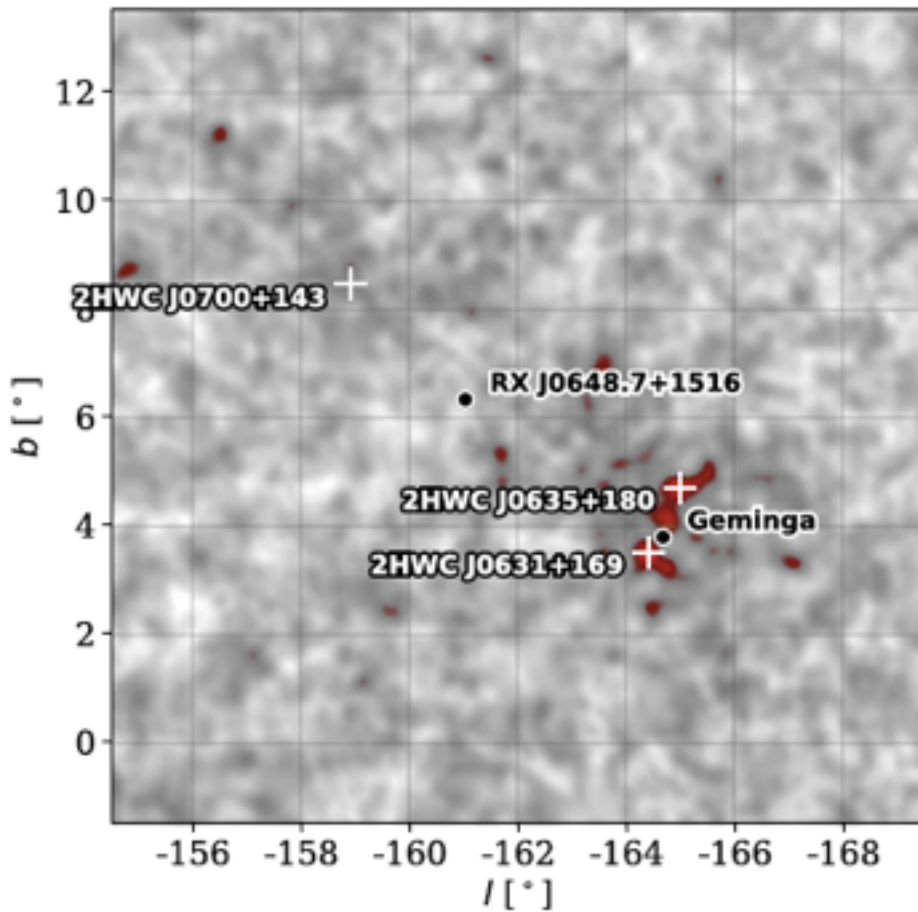
GALACTIC PLANE



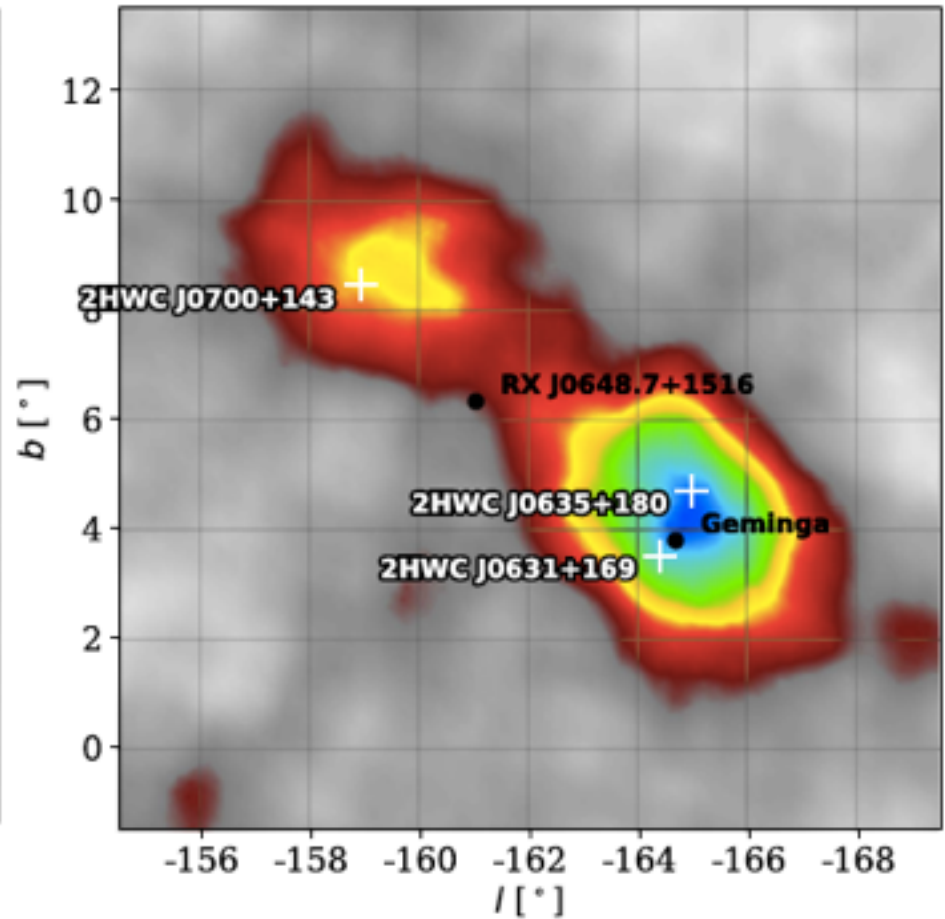
39 sources were detected, with 19 not associated with previously known TeV sources (association criteria $<0.5^\circ$ away)

GEMINGA

Point source hypothesis
with spectral index -2.7

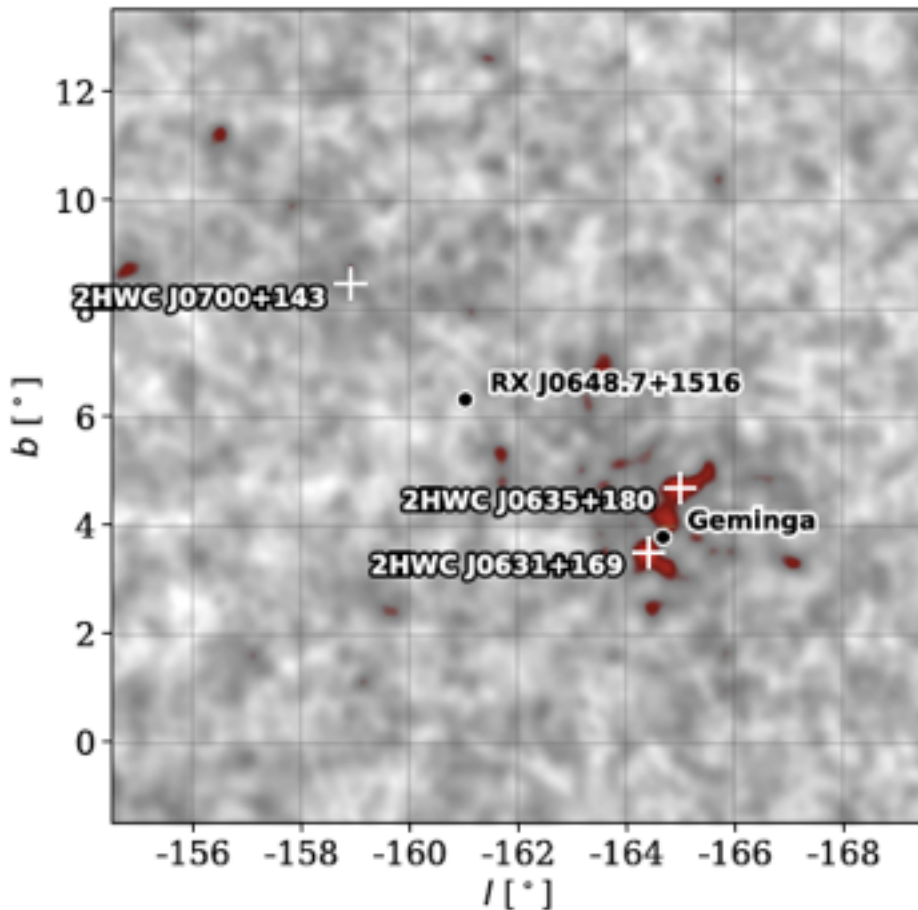


Extended source hypothesis
disc of radius 2° and spectral index -2.7

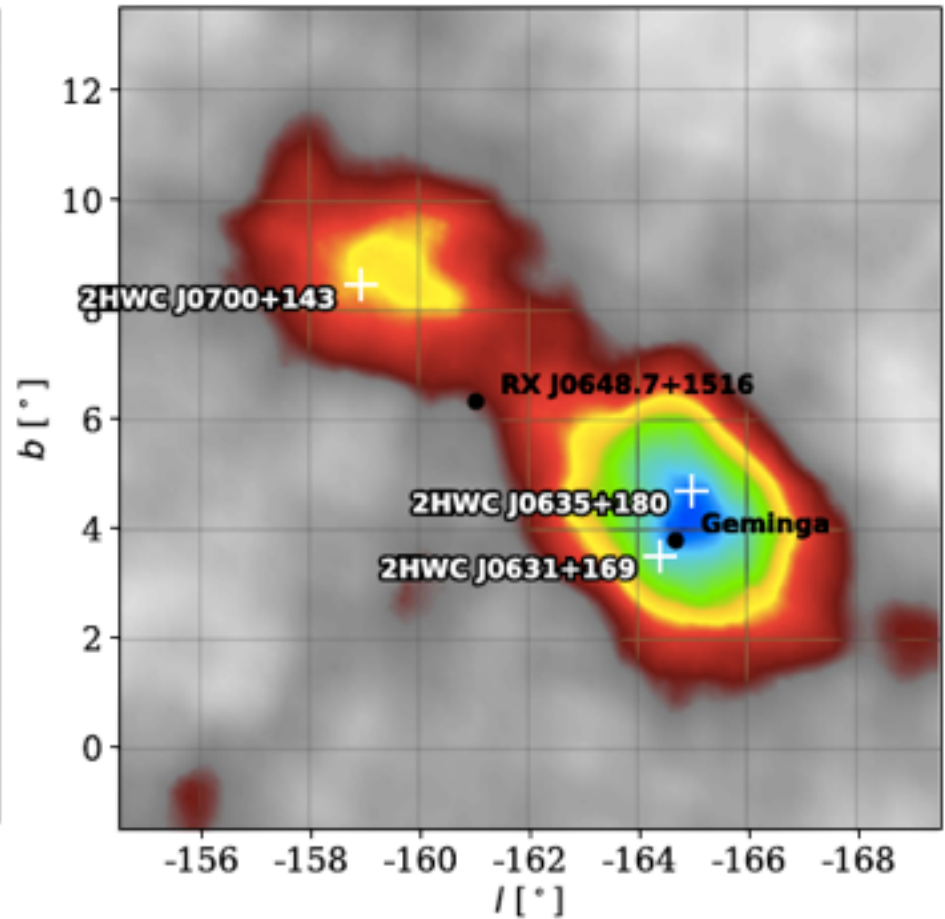


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Point source hypothesis
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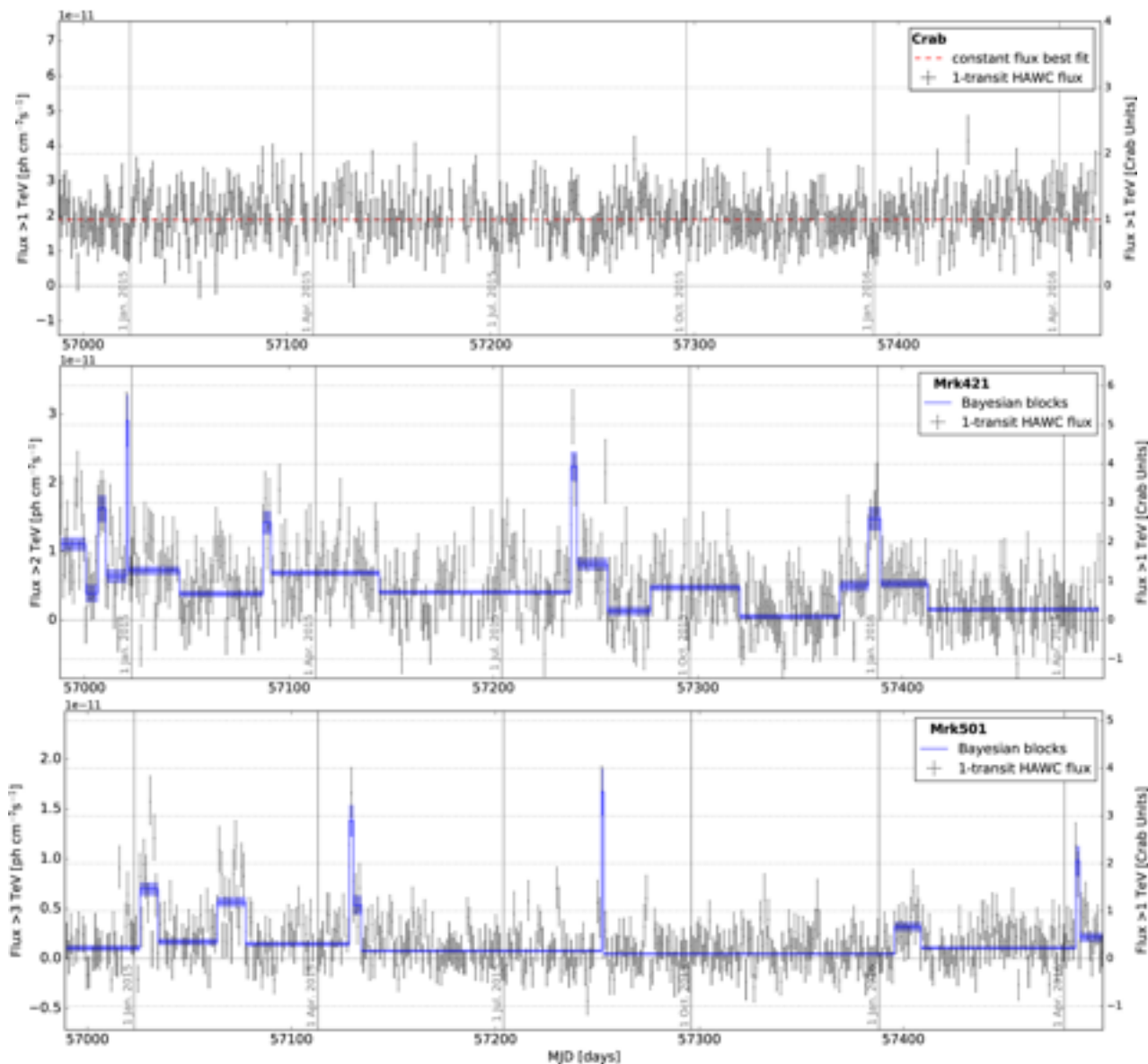
More about this source and dark matter related searches with HAWC in J. Linnemann's talk (Thu. 16:00, C112)

A. U. Abeysekara et al., ApJ, 843:40, 2017

LIGHTCURVES

Data from
November 26, 2014
to April 20, 2016.

Blue lines mark
distinct flux states
identified via
Bayesian block
analysis



TRANSIENTS EVENTS SEARCHES

- **GRB searches:**

- **Follow-up observations on alerts from satellites: Fermi-LAT, GBM and Swift**
- **64 GRBs has been analysed. No significant detection has been found but upper limits has been stablished**

A. U. Abeysekara et al. ApJ, 843:88, 2017

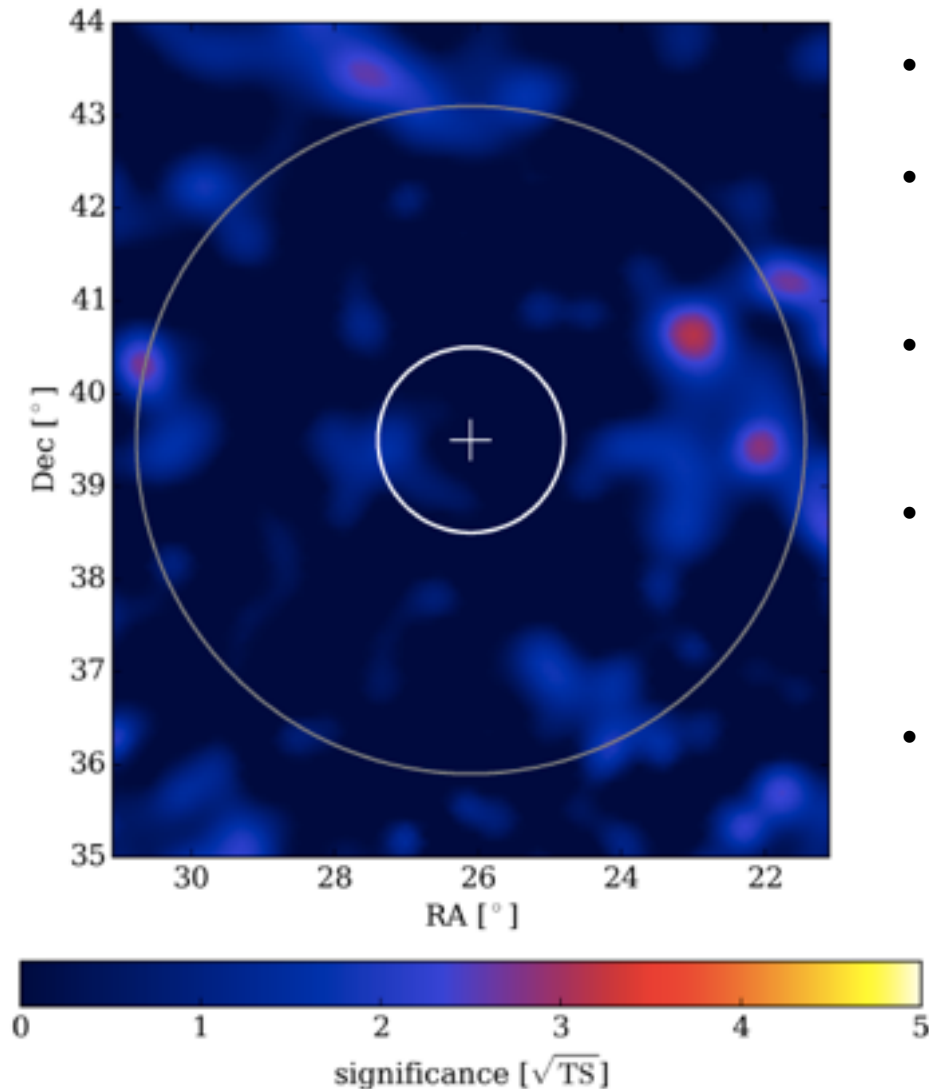
- **Online all-sky searches (~4 sec latency)**

- **Real-time flare monitor**

- **Fully operational since January 2017**
- **187 targets (blazars): 46 from TeVCat and 141 from 2FHL**
- **Detect events in time scales from 2 min to 10 hours**

A. U. Abeysekara et al. ApJ, 843:116, 2017

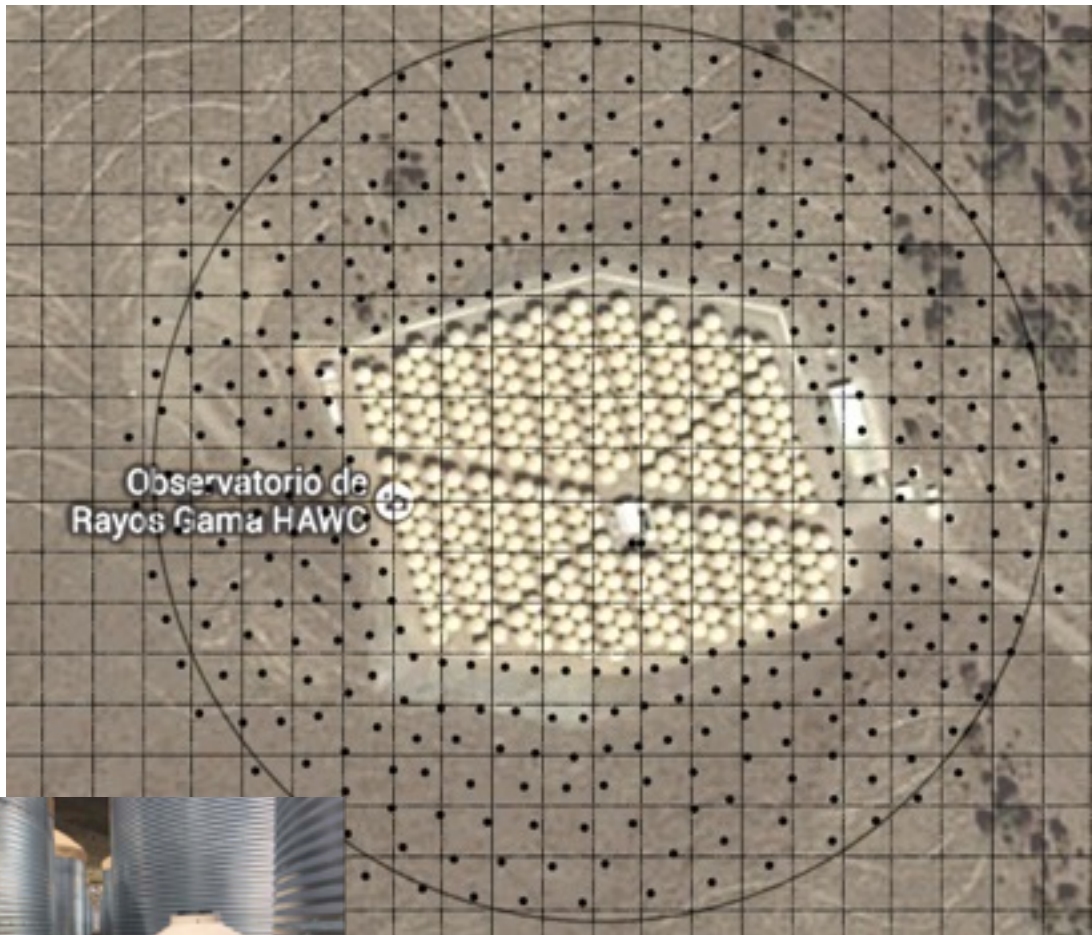
HAWC MULTI-MESSENGER: ICECUBE NEUTRINO TRIPLET



- On February 17 2016 IceCube detected three neutrino candidates within 100 s
- The position of the event entered HAWC's field of view right after it happened
- HAWC observed a full transit ~6 hours:
 - 19:18 UTC 2016-02-17
 - 01:31 UTC 2016-02-18
- Search was performed using likelihood analysis for point sources with photon index -2.7
- Sky map for $500 \text{ GeV} < E < 160 \text{ TeV}$

arXiv:1702.06131 [astro-ph.HE]

WHAT'S NEXT? OUTRIGGERS



- It will improve the determination of the core when it hits outside the main array
- Event reconstruction efficiency will improve by a factor 3-4 for $E > 10 \text{ TeV}$



- 350 tanks of 2500 L
- Tank deployment is ongoing

SUMMARY

- HAWC has been operating with its 300 tanks configuration for >2 years
- HAWC is scanning 2/3 of the sky every day with a duty cycle >90%
- A first catalog of TeV gamma-ray sources has been published with 19 new sources
- HAWC provides a quasi-continuous monitoring of the gamma-ray fluxes of the most intense TeV sources: Crab Nebula, Markarian 501 and Markarian 421
- HAWC has MoUs with different experiments providing follow-up observations and also sending alerts
- The outrigger array is being built and it will improve HAWC observations