



MULTIBAND ASTRONOMY AND
THE ORIGIN OF COSMIC RAYS :
THE FUTURE

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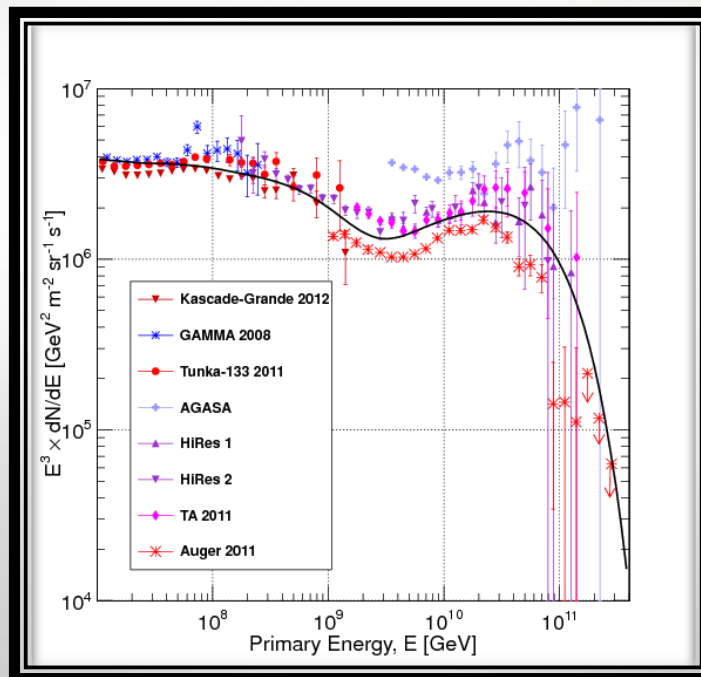
University of Crete & FORTH



PROGRAMME

- ❖ Inspiration ❖
- ❖ Hindrances ❖
- ❖ Wish list ❖
- ❖ Recent entertainment ❖
- ❖ Reprise & Finale ❖

YES, WE CAN



Gaisser et al. 2013,
arXiv: 1303.3565

SOME THINGS WE CAN'T

❖ Obstacle: losses



$$S_{\text{products}} = L_{\text{UHECR}}$$

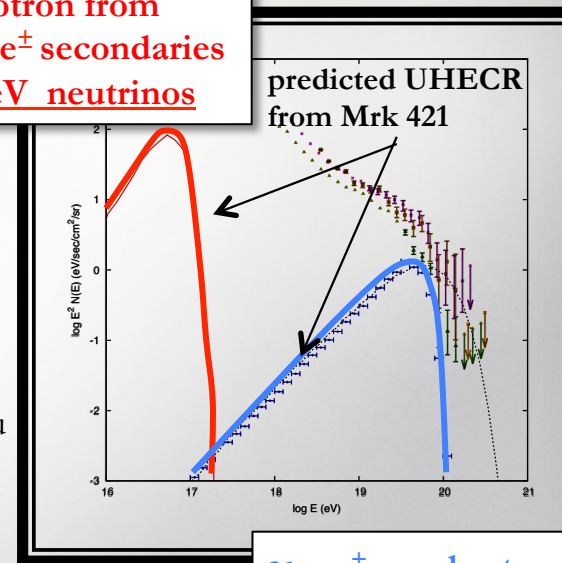
✗ Enough ν to detect likely means too few UHECR to be source candidate



Dimitrakoudis, Petropoulou
& Mastichiadis 2013

Cannot rely on ν detectors to identify UHECR sources

γ = synchrotron from
photopion e^\pm secondaries
tons 100 TeV neutrinos



γ = p^+ synchrotron
few EeV neutrinos

SOME THINGS WE CAN'T

❖ Obstacle: delays



$$\tau = 2.5 \left(\frac{D}{100 \text{ Mpc}} \right)^2 \left(\frac{E}{10^{20} \text{ eV}} \right)^{-2} \left(\frac{B}{10^{-11} \text{ G}} \right)^2 \left(\frac{l_c}{1 \text{ Mpc}} \right) \text{ yr}$$

✗ no variability information

✗ no “timing” clues



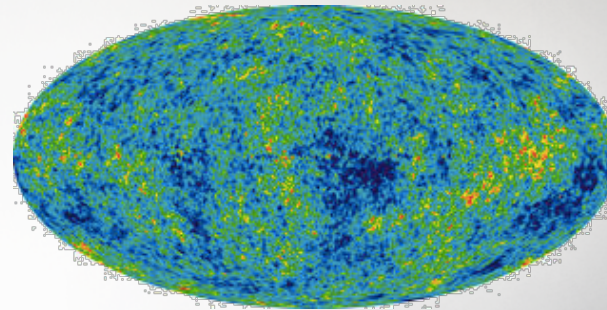
No direct application for time-domain experiments

can only use them to study properties of source classes



SOME THINGS WE CAN'T

- ❖ Obstacle: low statistics



$$SNR = \frac{F_{source}}{\sqrt{I_{BG}}} \frac{\sqrt{\Delta t A}}{\Delta \theta}$$

- ✗ Poor localization bad
- ✗ Low statistics bad

but neither exclusive to UHECR astronomy!

- ✗ Very poor localization + very few events = *UHECR astronomy curse*

well-tested astro techniques for anisotropy
or cross-correlation with multi- λ sky pushed to their limits.



WISH LIST

1. Assume that sources are something we already know exists
2. Model all candidates to the best of our current abilities
For what parameters are interesting UHECR quantities produced?
3. Predict what else these sources do for said parameters
4. Go out and look for predicted signs of UHECR activity
5. Reject as many candidates as possible
6. Cross-correlation studies using:
 - a) complete samples of candidates
 - b) more UHECR events
7. Remember: more than one source classes may be important!

ALREADY AT IT

- ❖ **Polarization** (optical, radio, X/ γ -ray) as a diagnostic of B-fields and emission processes

(Pavlidou et al. 2013;
Blinov et al. in prep; Chakraborty et al. in prep; Myserlis et a. in prep)

- ❖ **Population properties** of high-energy source classes (variability at different wavelengths, flare shapes as diagnostic of loss rates)

(Hovatta et al. 2013; Richards et al. 2013; Max-Moerbeck et al. 2013)

- ❖ **Hadronic modeling** emission, propagation, by-products of high-energy source classes

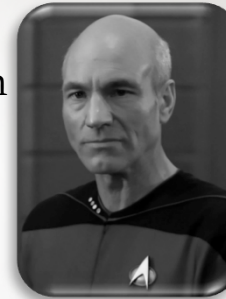
(Fang, Venters et al. in prep)



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❖ Optopolarimetric monitoring: The Next Generation

- for high-E sources: optical wavelengths
= optically thin lepton synchrotron
- polarization directly probes structure of B-field

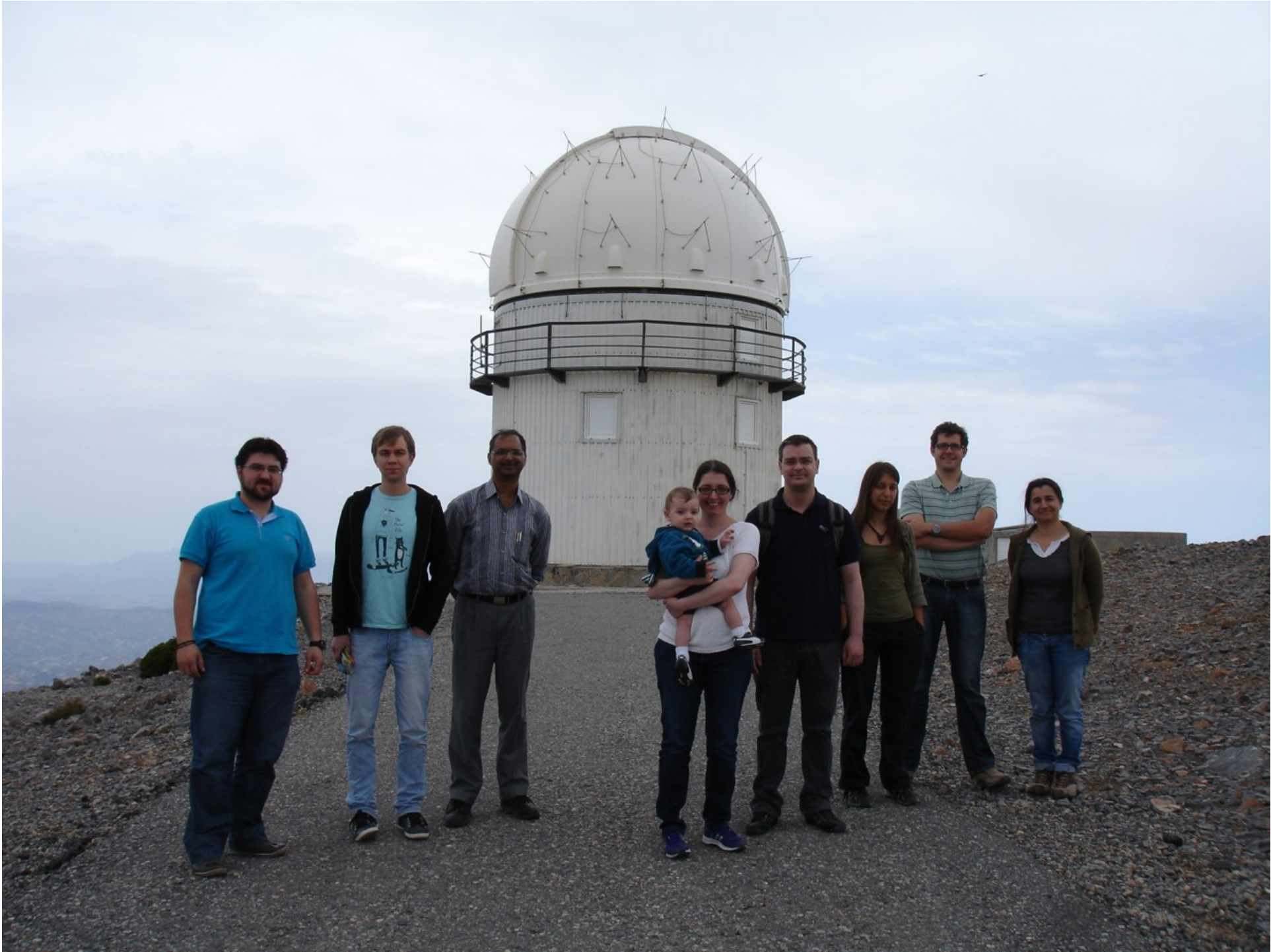


❖ Incredible instrument

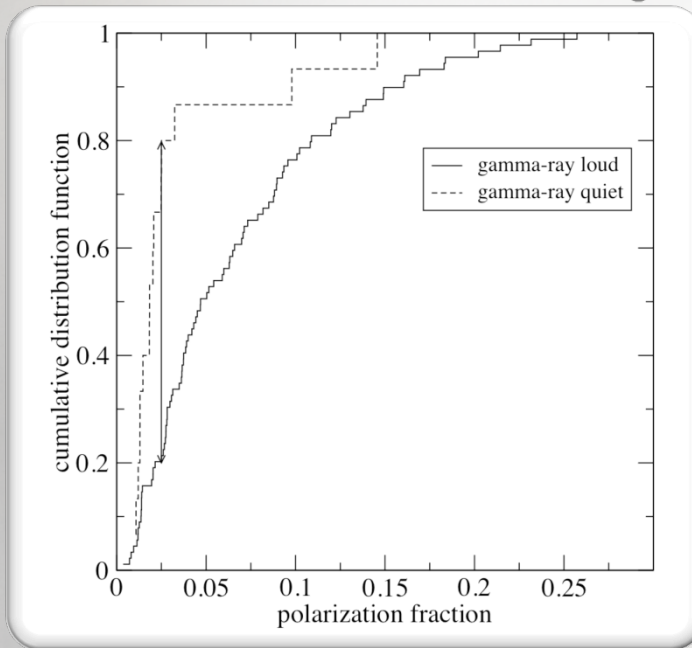
❖ Unebieveable amounts of telescope time

❖ Well-controlled blazar samples: polarization properties, rotations

+ TOOs, “interesting sources”







June 2013
optopolarimetric survey
of ~ 100 sources:

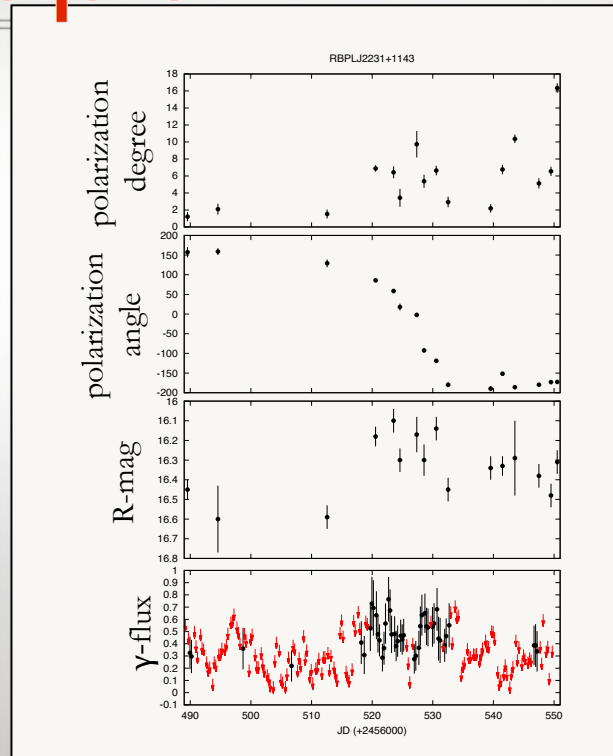
**γ -loud sources
more polarized**
(by factor of 2 on average)

Pavlidou et al. 2013
arXiv:1311.3304



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Preliminary



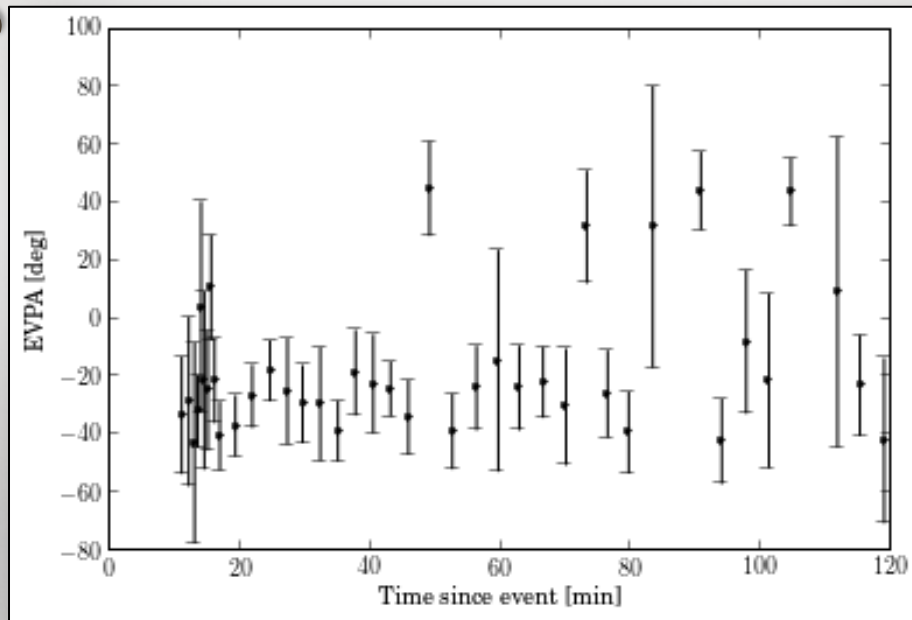
CTA 102 rotation

D. Blinov et al. 2013
in prep.



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Preliminary



GRB 131030A
~2% polarization
no indication of
time-dependence

D. Blinov et al. 2013
in prep.

WE ARE ALL LOBBYISTS

Come work with us in Crete

- ❖ UHECR experiments
- ❖ All hadronic modeling
- ❖ Surveys in all wavelengths /messangers/ of all properties
 - Wide field always best
 - For targeted surveys: well-controlled samples *are essential*

**We will need to understand the source astrophysics and do astronomy
at the same time**

THE END

Crete Work Fun Swim
Sun Food Work
Beautiful Crete Go Must