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# Science with the ASTRI prototype

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On behalf of the INAF/ASTRI collaboration

# ASTRI: Astrofisica con Specchi a Tecnologia Replicante Italiana

## The italian proposal for the CTA's Small Size Telescope system

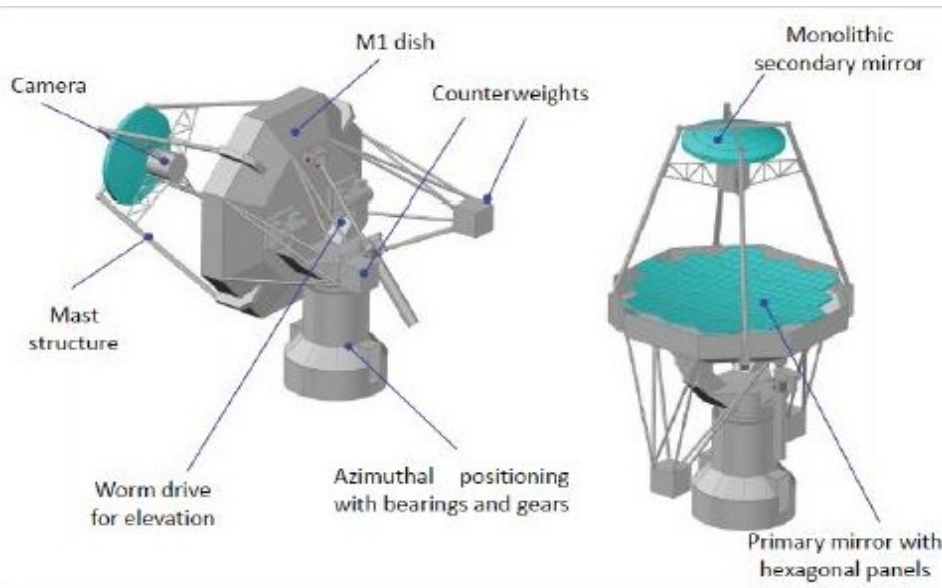
Credit: R. Canestrari

### Schwarzschild-Coud r design

Mirrors' main characteristics:

- ▶ **Primary Mirror diameter:** 4.3 m (tessellated)
- ▶ **Secondary Mirror diameter:** 1.8 m (monolithic)
- ▶ **F#:** 0.5
- ▶ **Equivalent focal length:** 2150 mm
- ▶ **FoV diameter:** 9.6 degrees

SiPM camera (some details on the posters of G. La Rosa and D. Impiombato)



## The proposed site for the SST-2M prototype

INAF - Catania Astrophysical Observatory  
 The "M. G. Fracastoro" Mountain Station  
 Serra La Nave (Mt. Etna)  
 Altitude: 1735 m a.s.l.  
 Longitude: +14° 58'.4; Latitude +37° 41'.5



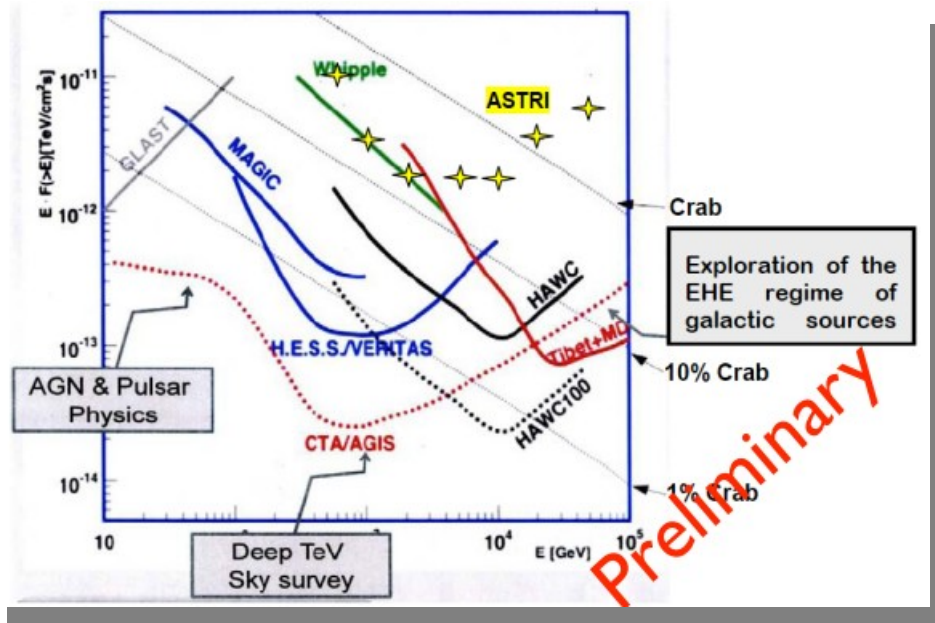
# Performance

Energy range: 0.5 – 100 TeV  
 Gamma-ray detection efficiency = 0.5  
 Hadron rejection efficiency = 0.9

From internal ASTRI document  
 ASTRI-MC-IFSITO-5000-001 by Vallania & Di Pierro

	WIPPLE	HESS	MAGIC	VERITAS	ASTRI SST-2M Sicily
Site	Arizona	Namibia	Canary Islands	Arizona	Sicily
Lat (°)	32	-25	29	32	38
Alt (km)	1.3	1.8	2.2	1.3	1.7
Tel. Ø (m)	10	12	17	12	4.3
N. Tel.	1	4	2	4	1
FoV Ø (°)	2.3	5	3	3.5	9.6
Thresh. (GeV)	300	100	50	100	>500(?)
Sensitivity (mCrab)	150	7	20	10	>200(?)

Credit: P. Vallania

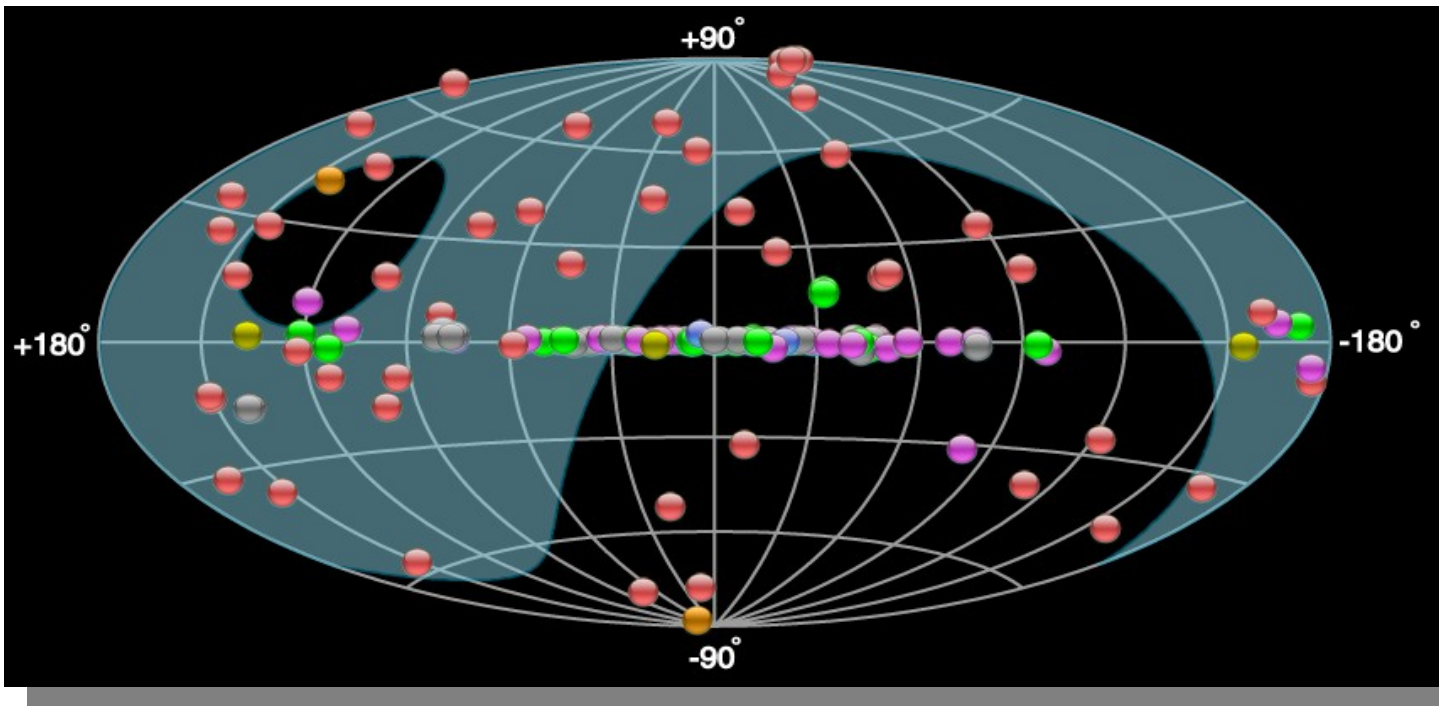


## The test cases

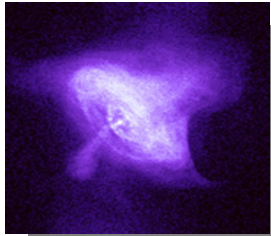
**Suitable sources of the northern sky form the online TeV catalogue**  
(<http://tevcat.uchicago.edu/#>)

### Source Types

- PWN
- XRB PSR Gamma BIN
- HBL IBL FRI FSRQ LBL  
AGN (unknown type)
- Shell SNR/Molec. Cloud
- Starburst
- DARK UNID Other
- uQuasar Star Forming  
Region Globular Cluster  
Cat. Var. Massive Star  
Cluster BIN WR



## Crab Nebula



PWN. Brightest galactic source, showing point-like, steady emission @ TeV energies

Log-parabolic spectrum  
(Aleksic et al. 2012)

Rate of excess photons is 157/hr

Detection of significant excess ( $5\sigma$ )  
Is expected after 2hrs

After 50 hrs, the expected significance  
of the excess is  $26\sigma$

The ideal (and only) choice for calibration  
observations of the ASTRI prototype

Energy Bin [TeV]	Significance ( $\sigma$ )	Sensitivity (Crab)
0.5 - 1	15	0.34
1 - 2	15	0.34
2 - 5	13	0.39
5 - 10	9.5	0.52
10 - 20	6	0.83
20 - 50	3	1.64
50 - 100	1.5	3.37

## LS I +61 303'

High mass X-ray binary, Be star + (unknown) compact object, orbital period of 26.5 days, high eccentricity ( $e=0.72$ ). Rich MWL phenomenology, with radio and X-ray bursts

TeV emission reported as periodic by MAGIC and VERITAS (Albert et al. 2008, Acciari et al. 2008), flux varies between cycles, maximum at orbital phase 0.6

WHIPPLE reported an upper limit of 0.184 mCrab with 5 hrs of data (Smith et al. 2006)

Rate of excess photons is 15/hr (10% of Crab photon rate)

200 hrs of data(!) are needed for a  $5\sigma$  detection in the high flux level

Credit: Acciari et al. 2008

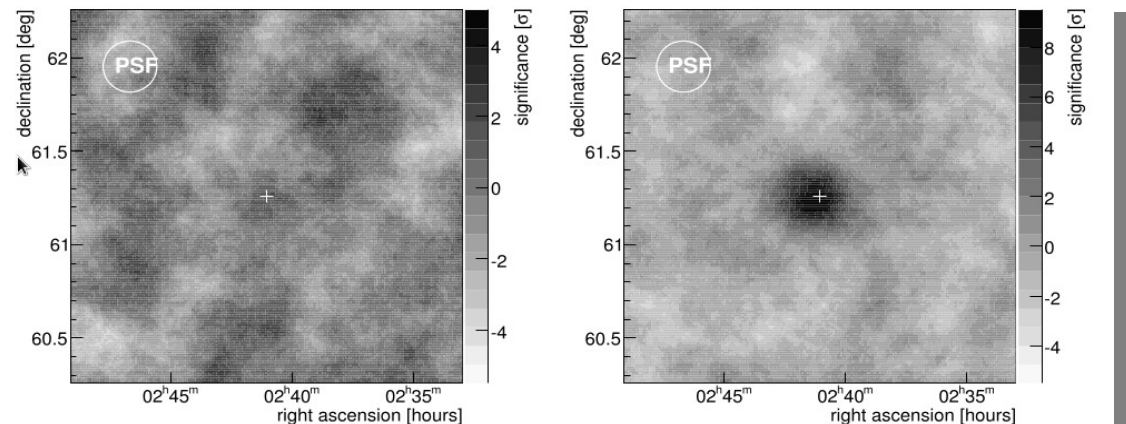


FIG. 1.—Significance map of the region around LS I +61 303 in equatorial J2000.0 coordinates. *Left*: Observations during orbital phases 0.8–0.5 (18.5 hr of data). *Right*: Observations during orbital phases 0.5–0.8 (around apastron, 25 hr of data). Significances are not corrected for number of trials. The position of the optical source (Perryman et al. 1997) is indicated by a white plus sign. The background is estimated using the ring-background model. Neighboring bins are correlated. Significances are calculated using the method of eq. (17) from Li & Ma (1983).

Not on the top of the list...

## MGRO J2019+37

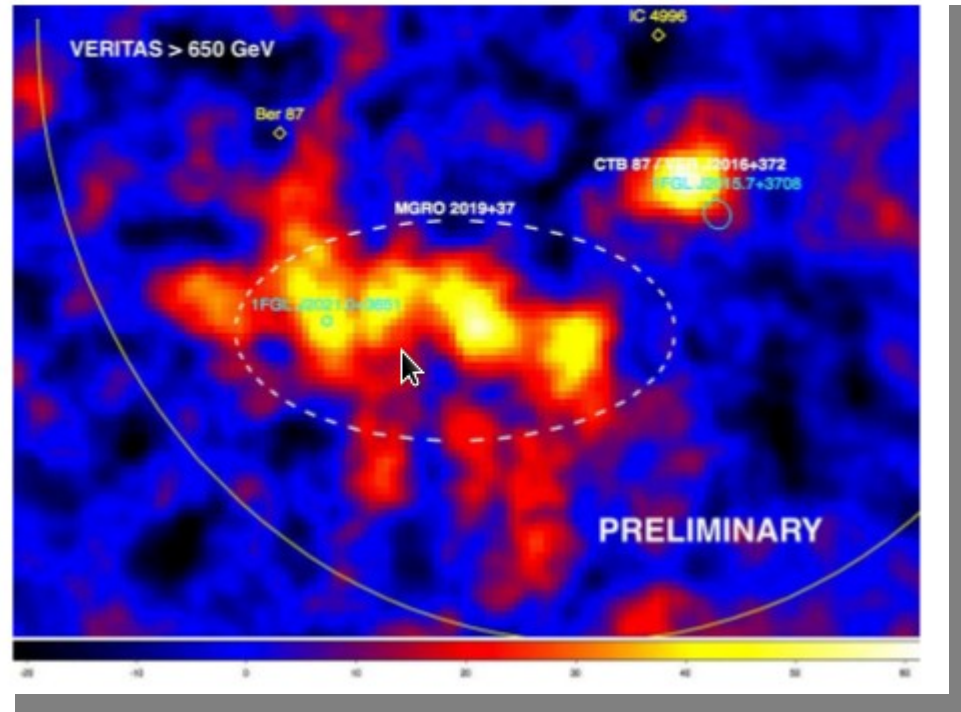
A portion of the Cygnus region which overlaps with the Cyg OB1 association. Many types of possible TeV emitters, like PWNs, WR stars and SNRs. TeV emission is likely due to a superposition of unresolved sources

Size of the VERITAS best-fit ellipse is  $0^\circ.6 \times 1^\circ.0$ , **well within expected FOV**

PL spectrum (Aliu 2011)  
Rate of excess photons is 114/hr  
**(70% of Crab photon rate)**

Problem: not a point source, needs dedicated signal extraction/ background rejection procedures

Credit: VERITAS coll.



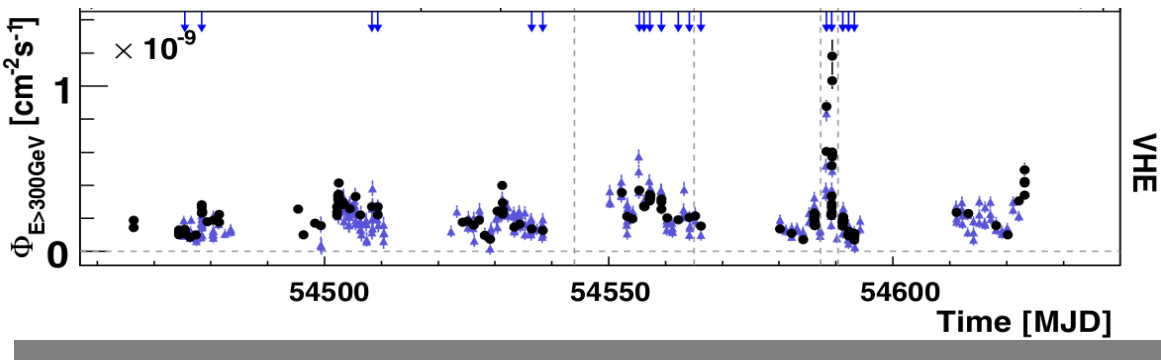


## Mrk 421

A very bright blazar at redshift  $z=0.031$ , showing flaring activity at  $>$ Crab fluxes

Spectrum model is PL with exponential cut off due to EBL effects (Acciari et al. 2011)

Credit: VERITAS coll.



Flux State	Rate [photons / hr]	Rate [Crab]	Time to $5\sigma$ [hr]
V.low	94	0.6	5
Low	216	1.3	1
Medium	348	2.2	0.5
High	426	2.7	0.3
V.High	1066	6.7	0.06

Nightly observations may reach good sensitivity also for the lowest flux state

A very good candidate for the ASTRI observation program

## Mrk 501

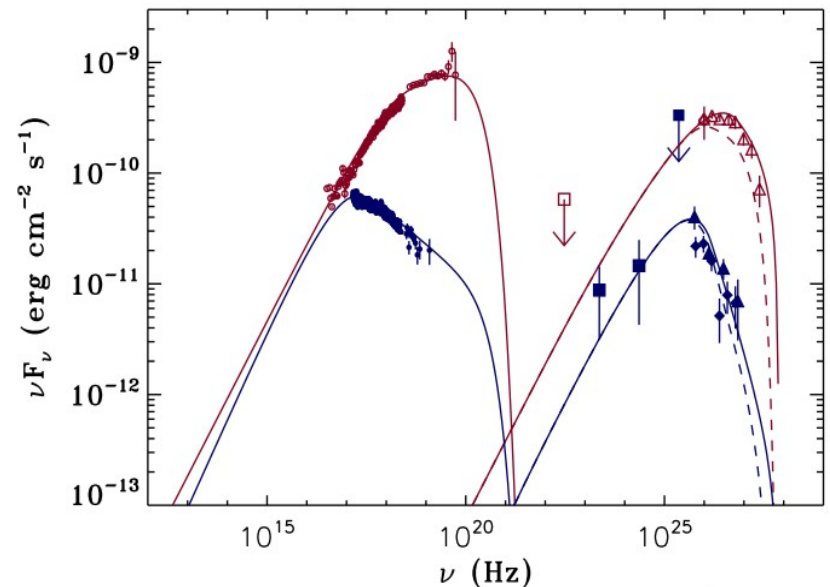
Another bright blazar at redshift  $z=0.033$ , showing flaring activity

Rate of excess photons is 60/hr (40% of Crab photon rate)  
In the low flux state measured by VERITAS

$5\sigma$  detection is reached in about 10 hrs  
but during flares WHIPPLE reported a flux  
1.6 Crab (Catanese et al. 1997) during  
a bright flare ( $5\sigma$  detection is 1 hr)

Another good candidate for the ASTRI  
observation program

Credit: VERITAS coll.



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## Summary

The model is simplistic, **results are very preliminary** – A second run of MC simulations is ongoing, the dedicated data reduction SW is being developed.

The ASTRI performance is worse than that of current IACTs, so it will be mainly a **probe for the SST technology solutions**. Still, it may act as a dedicated observatory for selected sources (no schedule issues)

Only the brightest point-like sources in the Northern sky are accessible (Crab, Mrk 421, Mrk 501). The ASTRI prototype could act as **dedicated facility for monitoring programs** on these sources

Wide FOV of 10 degrees. Test on an extended source: the Cygnus region

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**THANKS**