



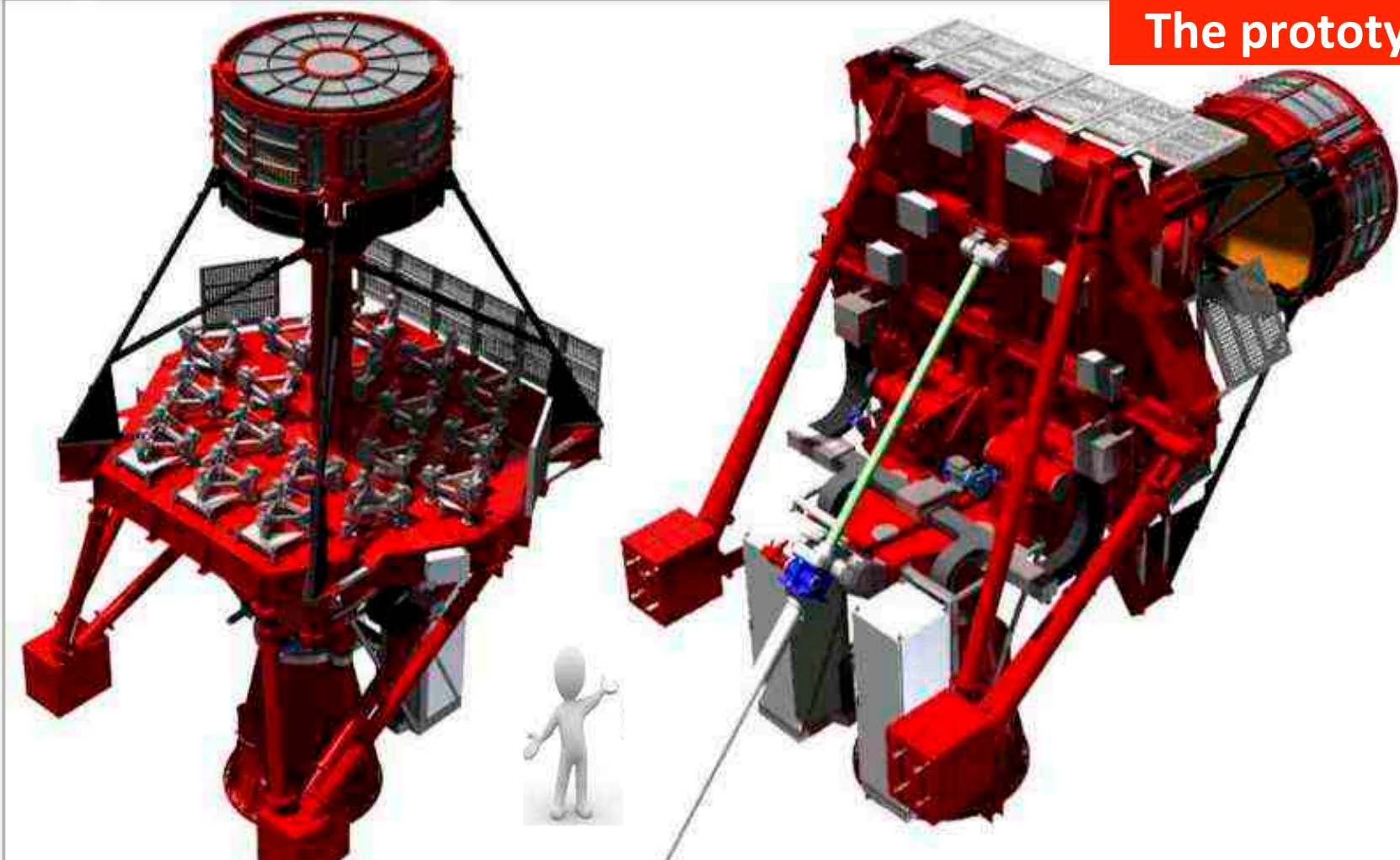
All Sky Camera, LIDAR, and Electric Field Meter for the ASTRI SST-2M prototype for CTA

*G. Leto, R. Zanmar Sanchez, G. Bellassai, P. Bruno,
M.C. Maccarone, E. Martinetti*

(for the ASTRI Collaboration and the CTA Consortium)



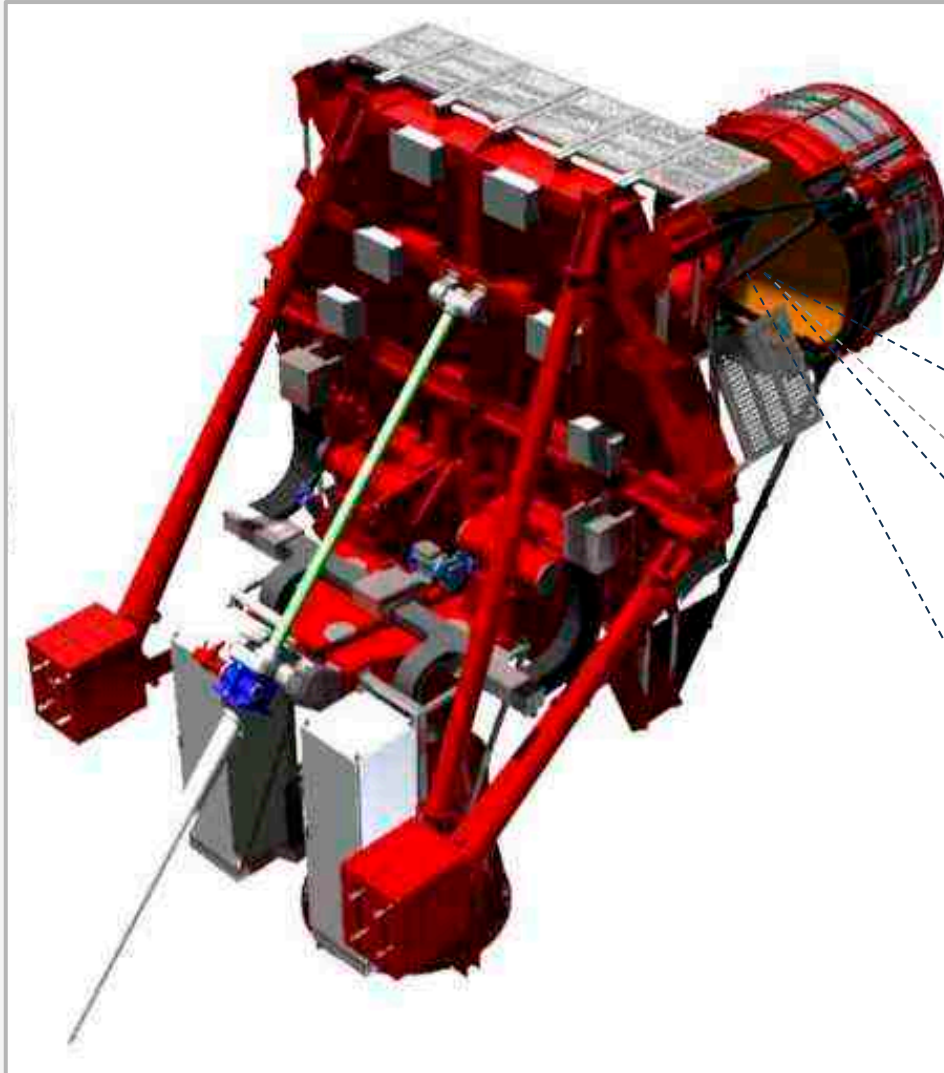
The prototype



... devoted to investigate the VHE region, 1-100 TeV, in a wide field of view, 9.6° full FoV, making use of innovative technological solutions:

- ✚ a dual-mirror optics Schwarzschild-Couder configuration,

The prototype



... and:

- ✚ a compact focal plane camera (50cm x 50cm x 50cm) based on Si-PMs sensors
- ✚ managed by a specifically designed front-end electronics.





Serra La Nave (SLN)

The **ASTRI SST-2M** telescope is an end-to-end prototype that will be tested on field.

The **ASTRI SST-2M prototype** will be placed, at the INAF "M.G. Fracastoro" observing station located in **Serra La Nave** on the Etna Mountain near Catania.

Latitude: 37° 41' 05" N

Longitude: 14° 58' 04" E

Altitude: 1735 m a.s.l

After the verification tests, devoted to probe the technological solutions adopted, the ASTRI SST-2M prototype will perform scientific observations on the Crab Nebula and on some of the brightest TeV sources ...





Monitoring the atmosphere at SLN – Auxiliary Instrumentation

Auxiliary Instruments	Level Guards (Alerts)	Data Calibration (Analysis)	Forecast and Statistics
Weather Station	Yes	Yes	Statistics
Dust Monitor, Pludix	Yes	Yes	Statistics
Sky Quality Meter, SQM	Yes	Yes	Statistics
...
Electric Field Meter, EFM	Yes	Yes	Yes
LIDAR	No	Yes	No
All Sky Camera, ASC	Yes	Yes	Statistics
...

The Electric Field Meter, EFM

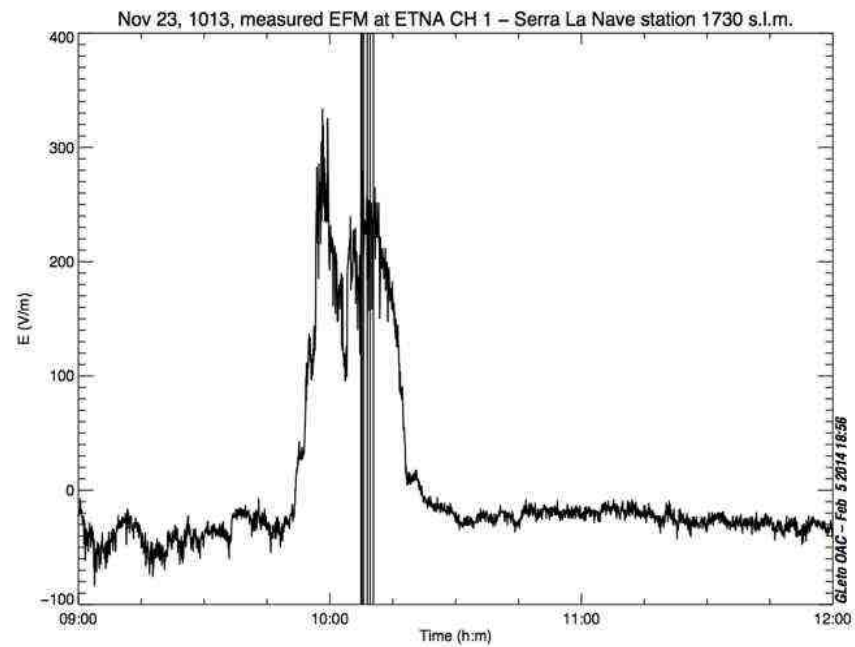


- Developed by the INAF Radio Astronomy Institute (IRA), contact Federico Perini
- Field-Mill sensor

EFM at work



Etna Eruption 23 November, 2013



Jan 5 2014 storm

EFM – SLN output alarms

First derivative

Signal
+
Alarm bits



Alarm bits issued from software are weighted to create an alert to ASTRI SST-2M

- Can issue alarms
- NO distance/direction (3 EFM needed!)
- Can detect lightning distance > 7 km!!

Raman Lidar - AMPLE

- Build for the VAMOS SEGURO project by CNISM, Napoli (contact Nicola Spinelli)

AMPLE main technical features:

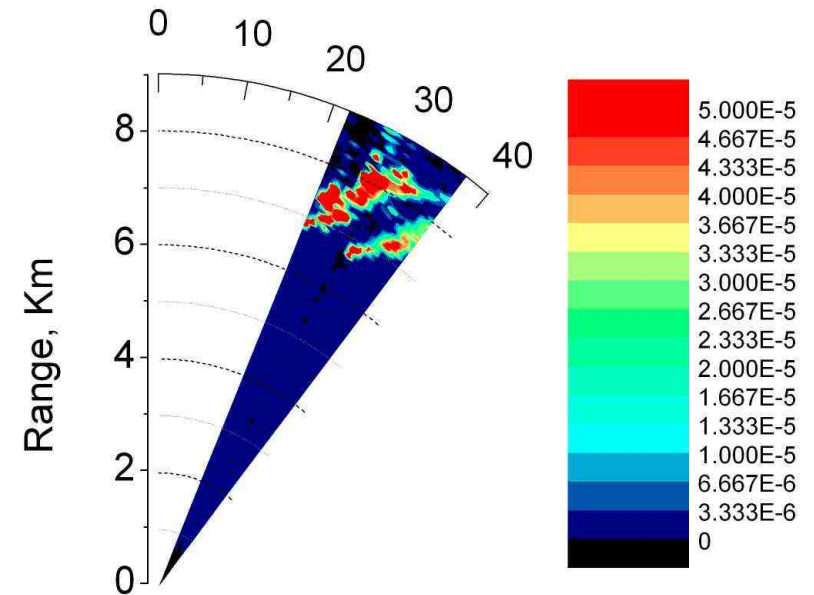
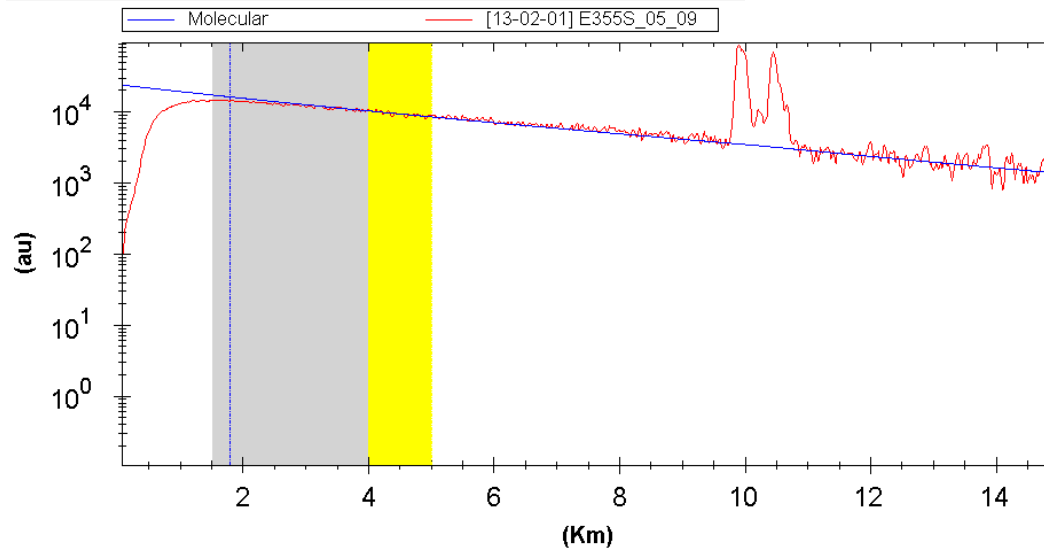
- Elastic channel at 355nm.
- Polarization measurements available.
- Raman channel at 386nm.
- Raw spatial resolution from 30cm to 30m
- Can be pointed from software



Raman Lidar - EARLINET

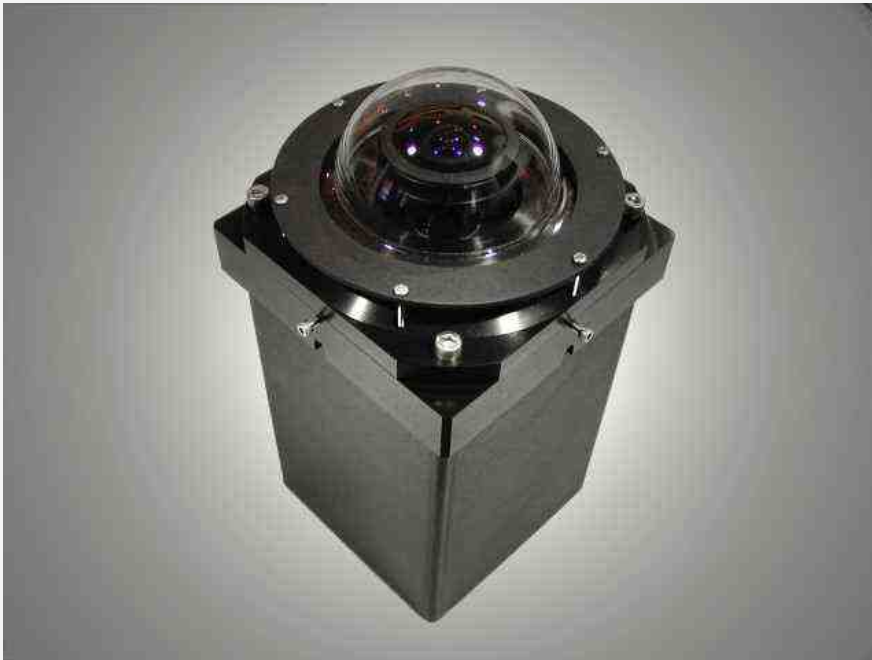


- Part of EARLINET since 2013: atmosphere monitoring routinely carried out.



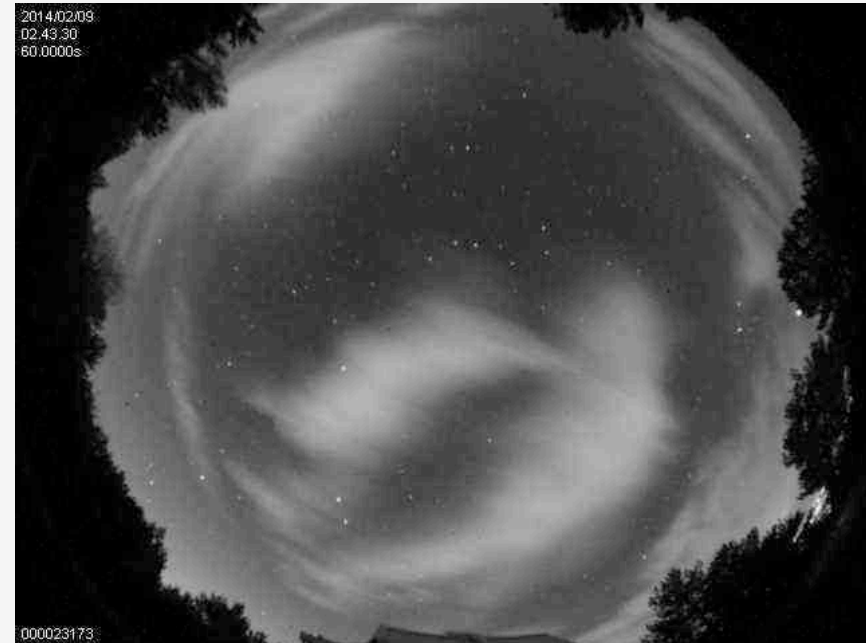
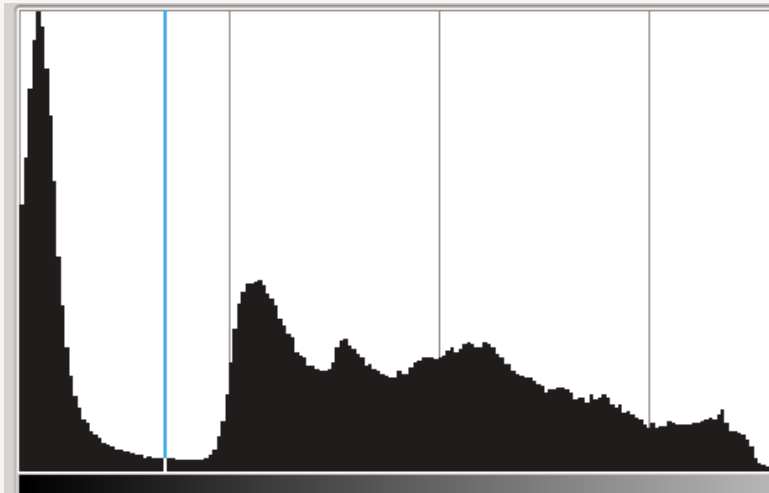
Particle backscatter, $\text{m}^{-1} \text{sr}^{-1}$
Elevation 14.4°

All-Sky Camera, ASC



- SBIG All-Sky Camera 340C
- Kodak KAI-340 CCD 640x480
- Exposure time 50 microseconds to 180 sec
- One image every five minutes

ASC- Thresholding



- Usually the 3 RGB channels are turned into one: R-B (Heinle et al 2010) or R/B (Long et al. 2006)
- RGB turned into HSL and Saturation is used (Souza-Echer et al 2006)
- Euclidean Geometric Distance (Sylvio et al 2010)

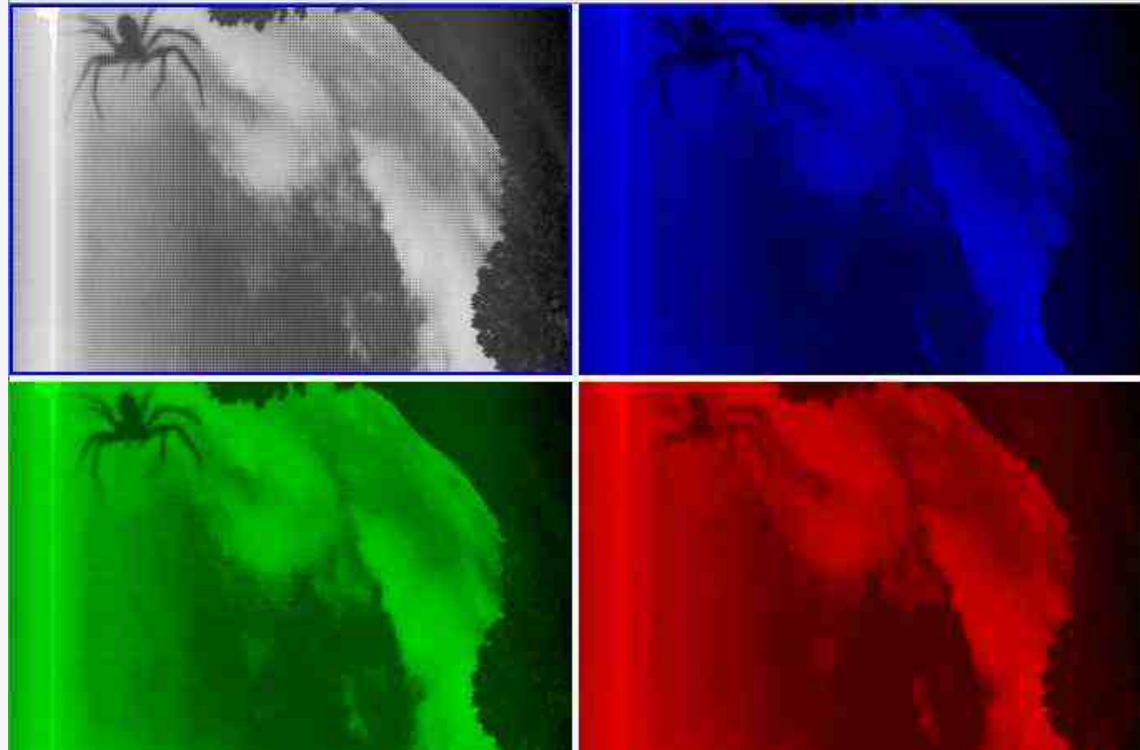
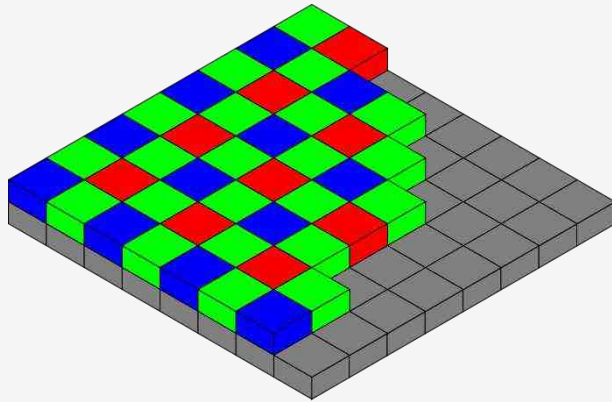
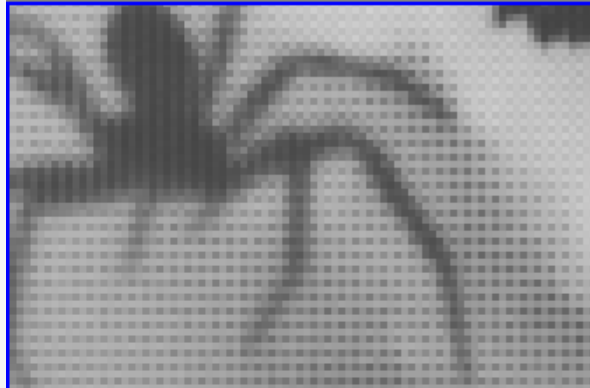


ASC: Cloud Detection

- What colors do we use for the night sky?
- Is it right to ignore the G channel.

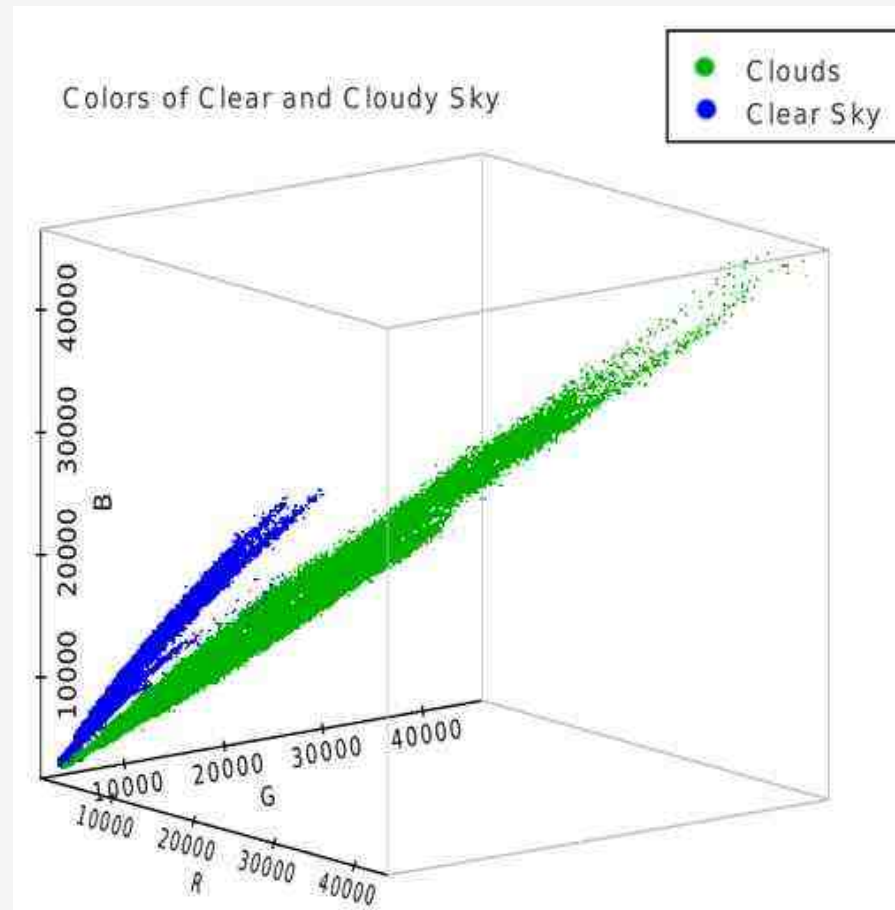


ASC: Color = Bayer Filter



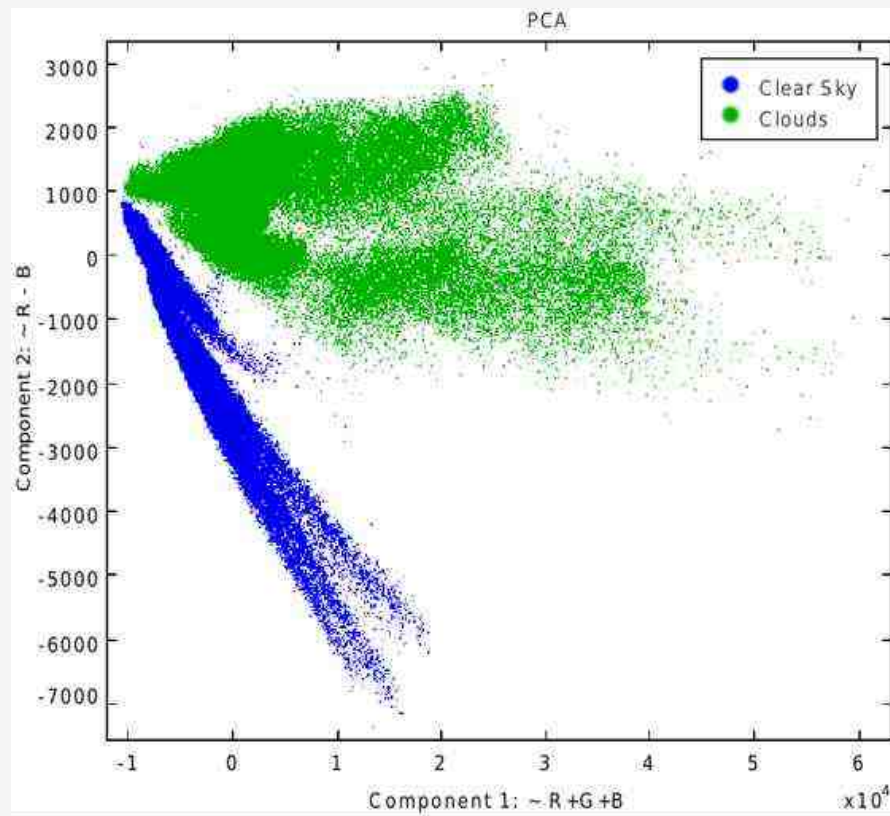
ASC - Thresholding

Principal Component Analysis



ASC - Thresholding

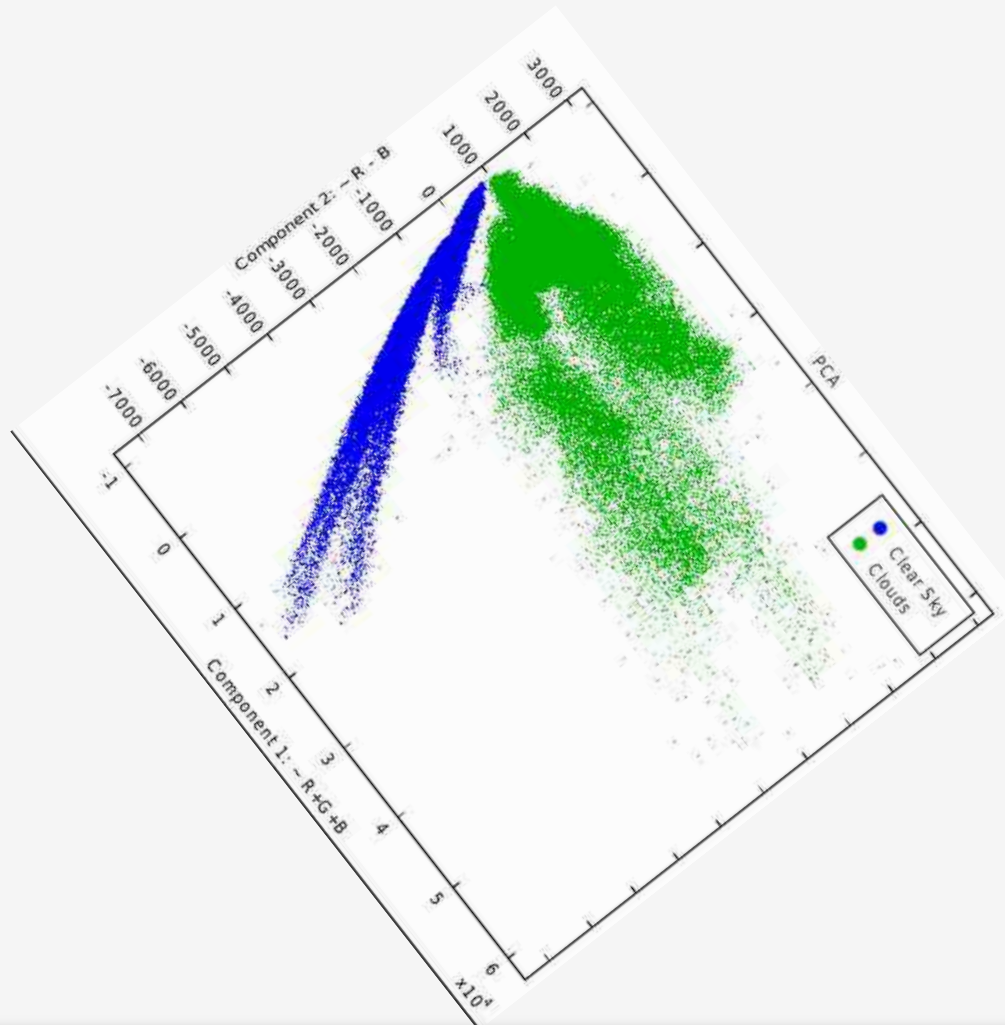
Principal Component Analysis



	Eigenvector		
Eigenvalue	R	G	B
9.2e7	0.5	0.6	0.6
1.6e6	0.7	0.1	-0.7
2.9e4	-0.5	0.8	-0.4

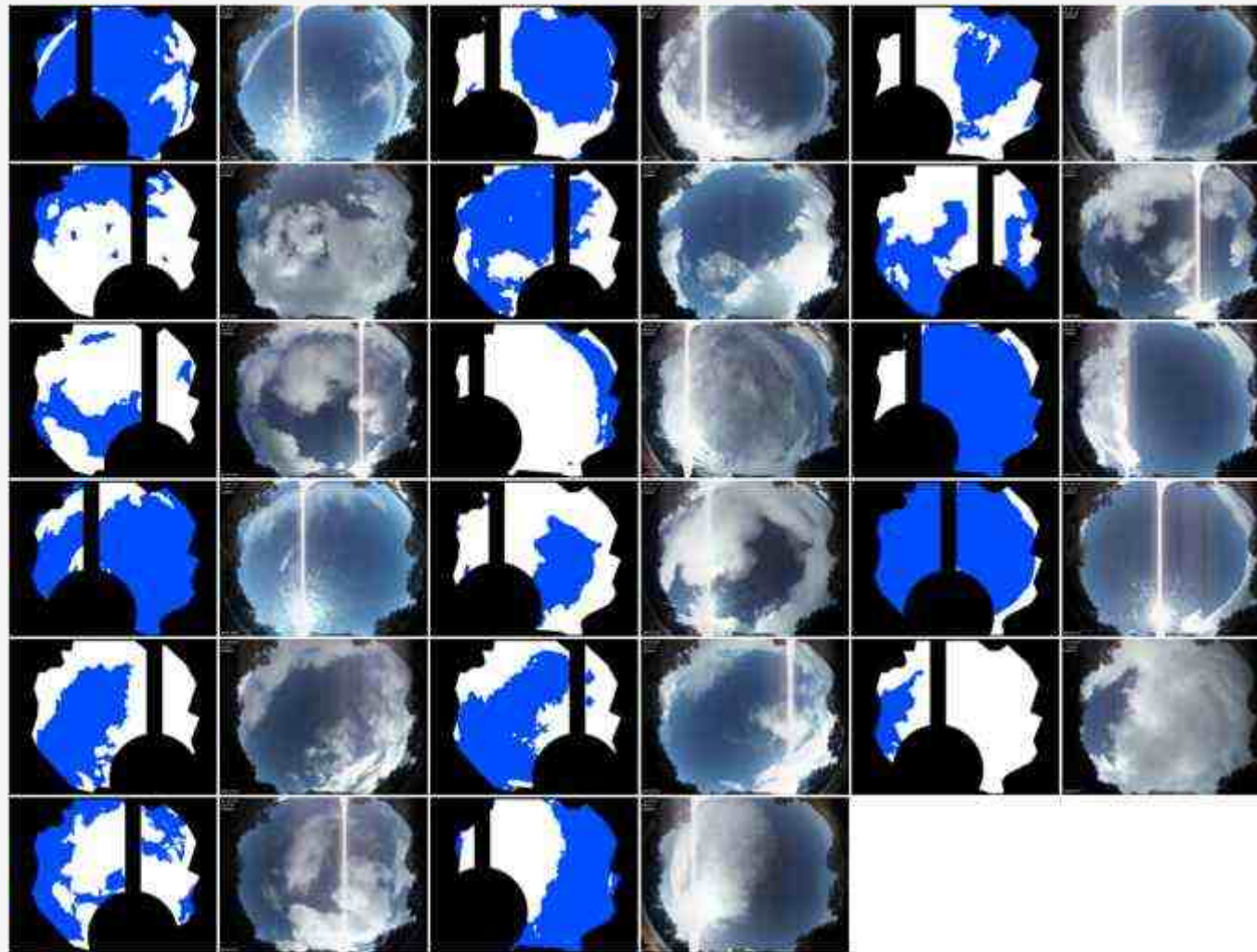
ASC - Thresholding

Principal Component Analysis



ASC - Thresholding

Ground Truth



ASC - Thresholding

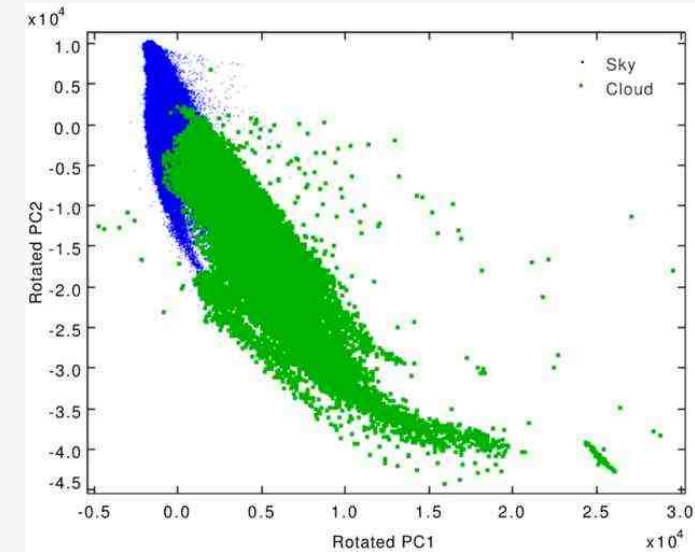
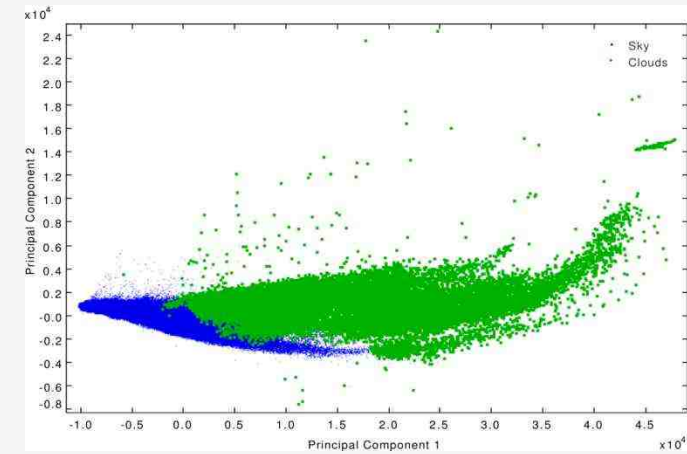
Confusion Matrix of Cloud Detection

		Truth	
		Cloud	Sky
Detected	Cloud	TP	FP
	Sky	FN	TN

$$\text{Accuracy} = (TP+TN)/(TP+FP+TN+FN)$$

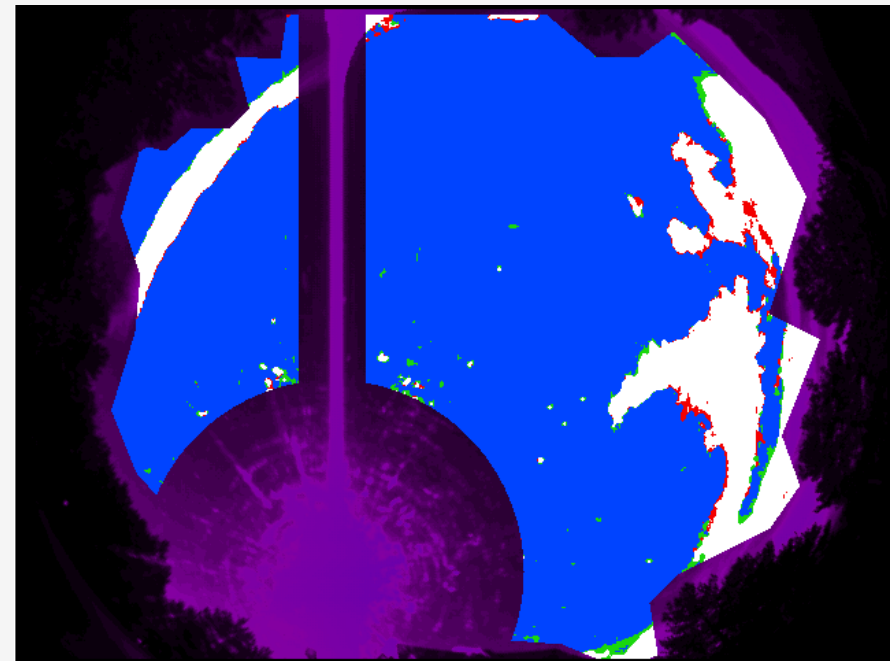
ASC - Thresholding

Principal Component Analysis



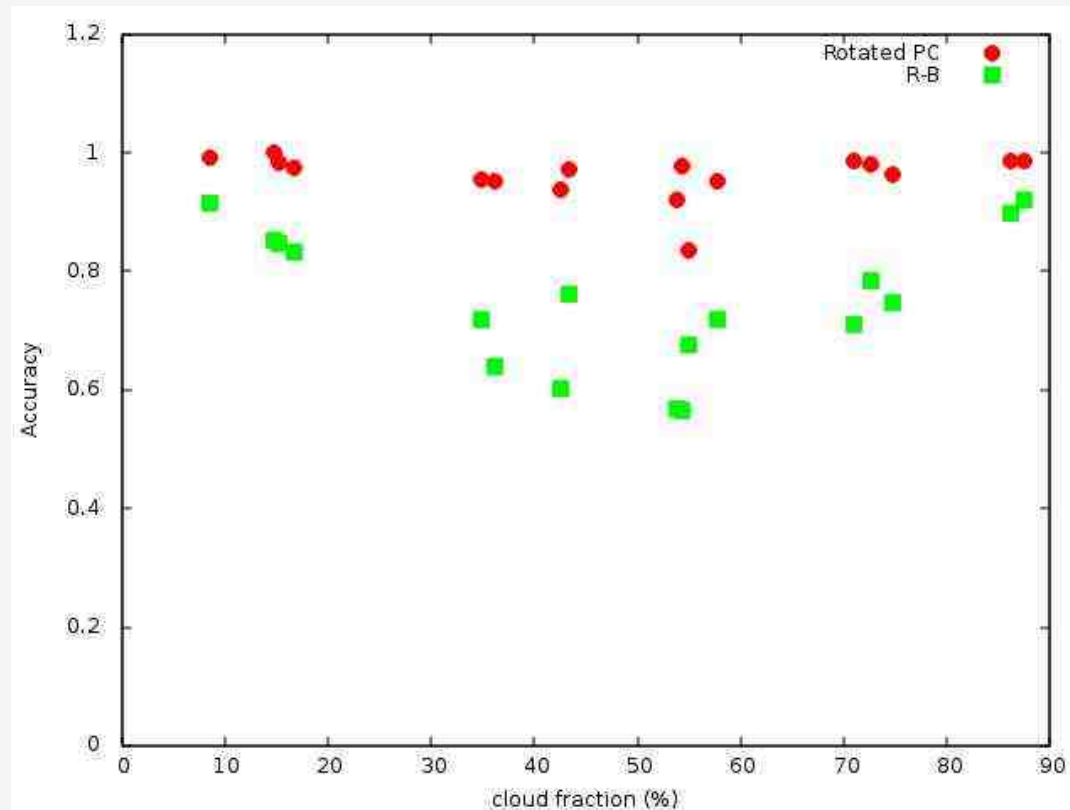
ASC - Thresholding

Principal Component Analysis



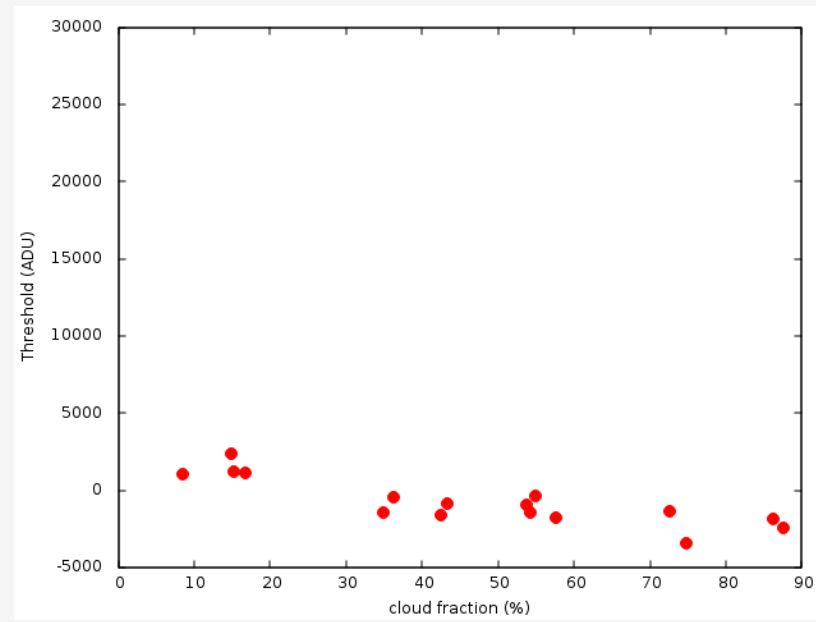
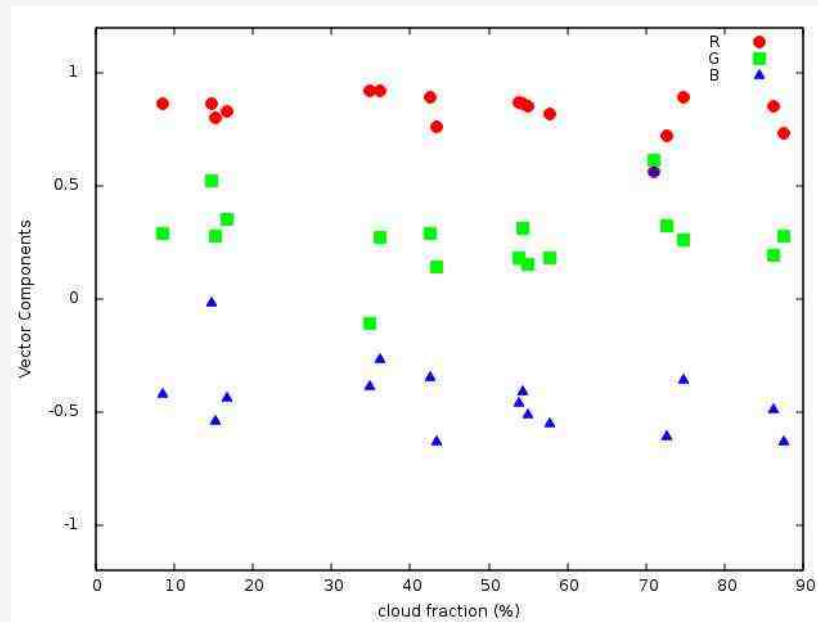
ASC - Thresholding

Accuracy Rotated PC Vs. R-B



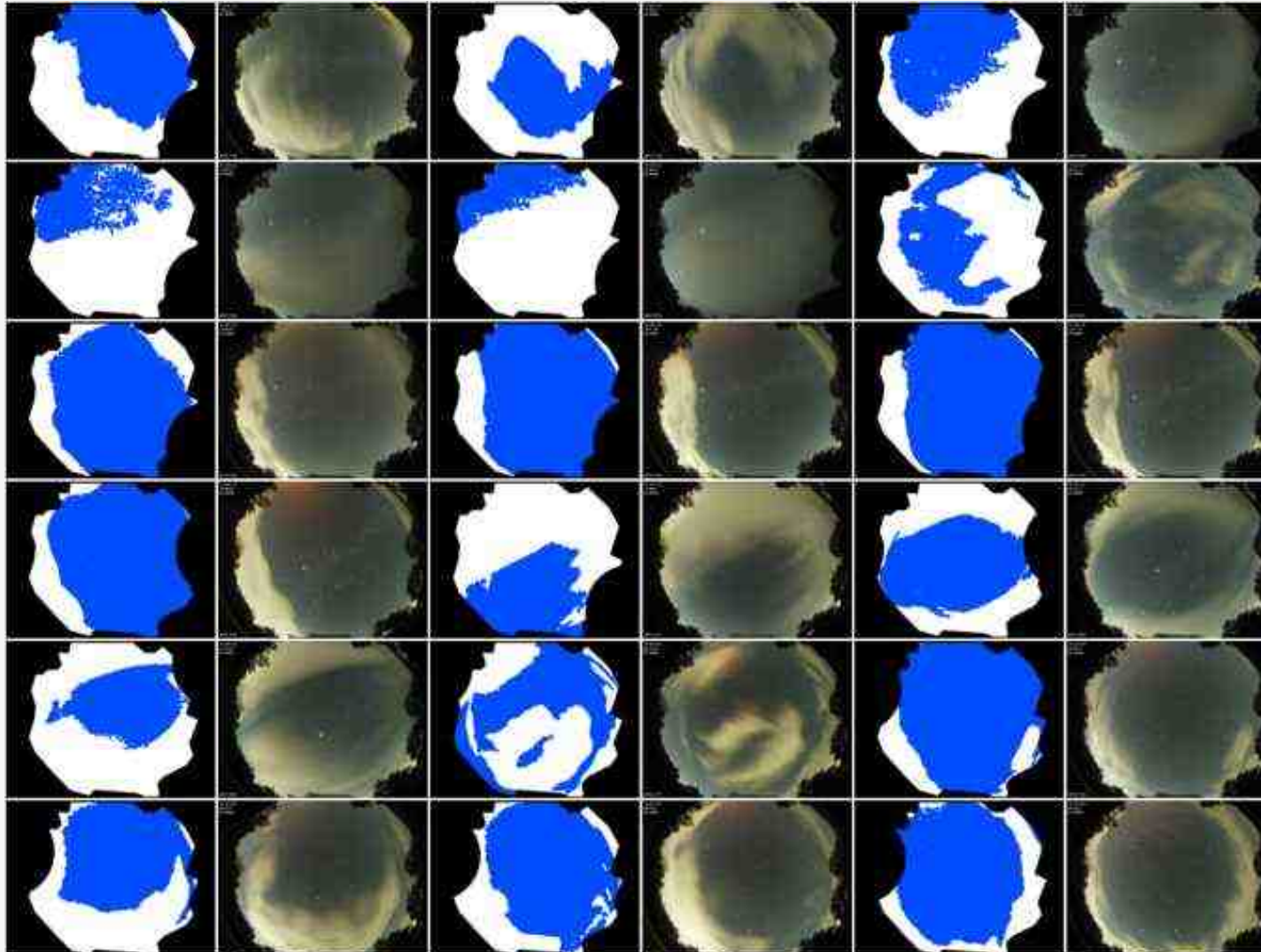
ASC - Thresholding

Final Mix of Colors And Threshold



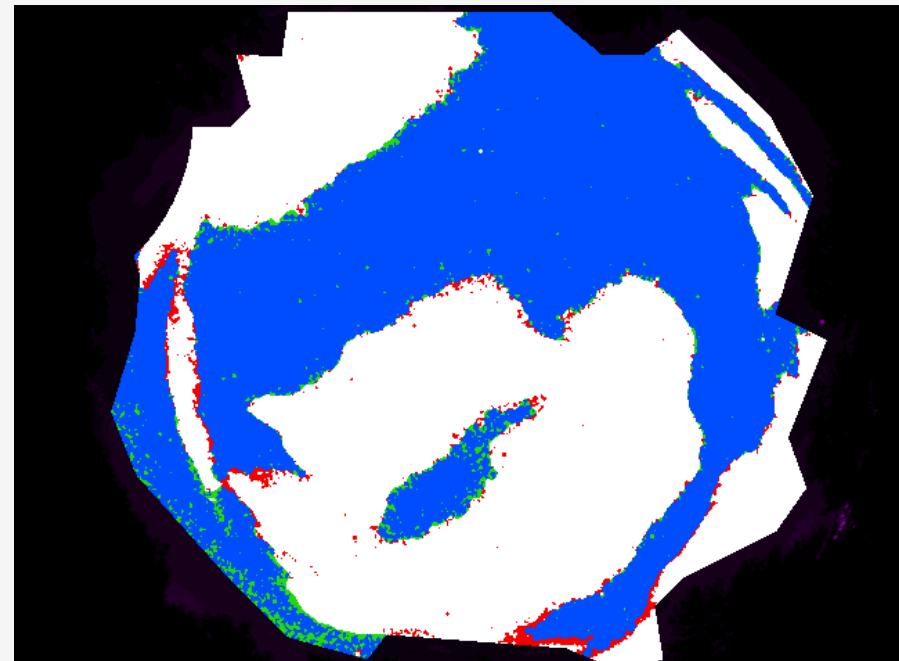
ASC - Thresholding

Ground Truth

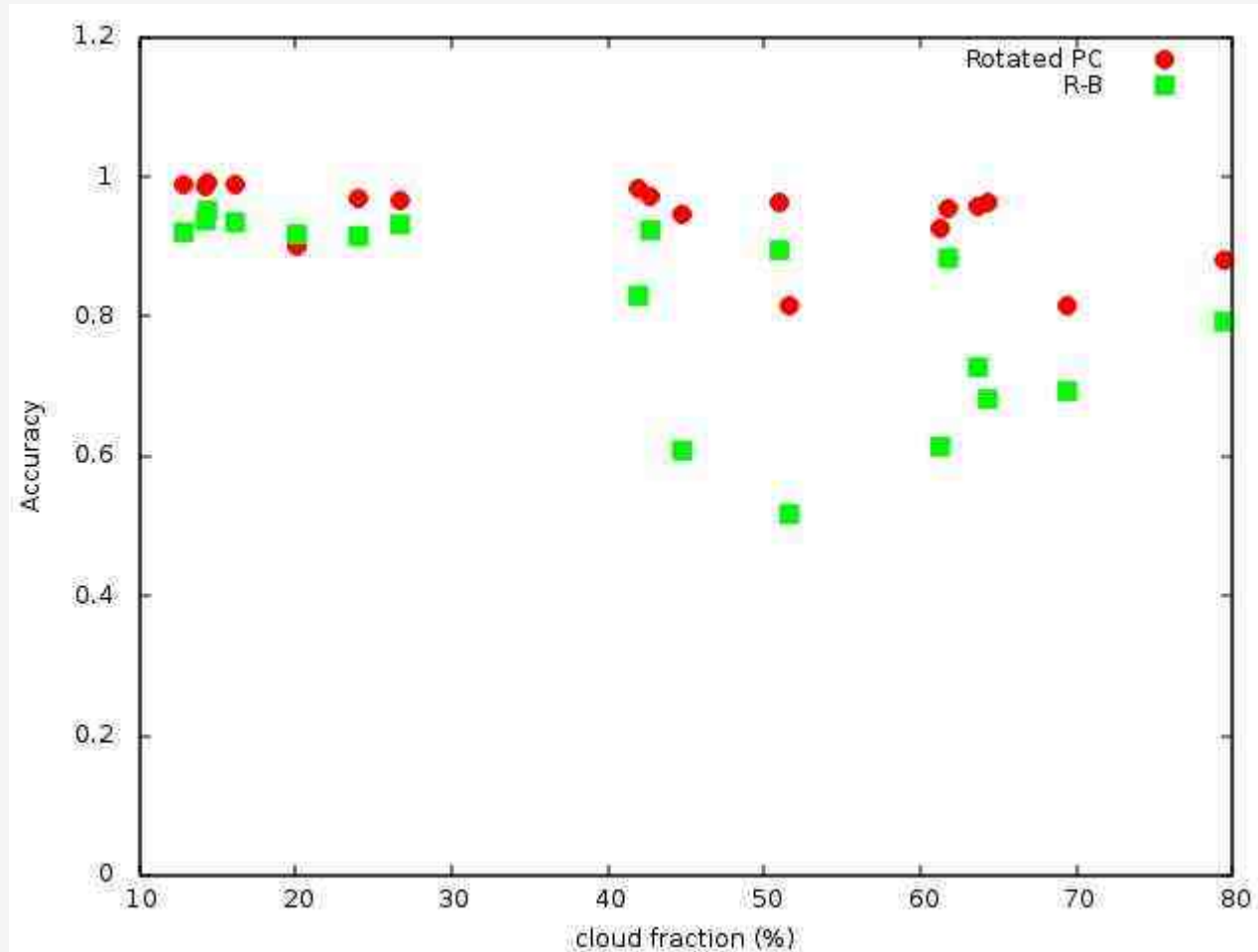


ASC - Thresholding

Principal Component Analysis

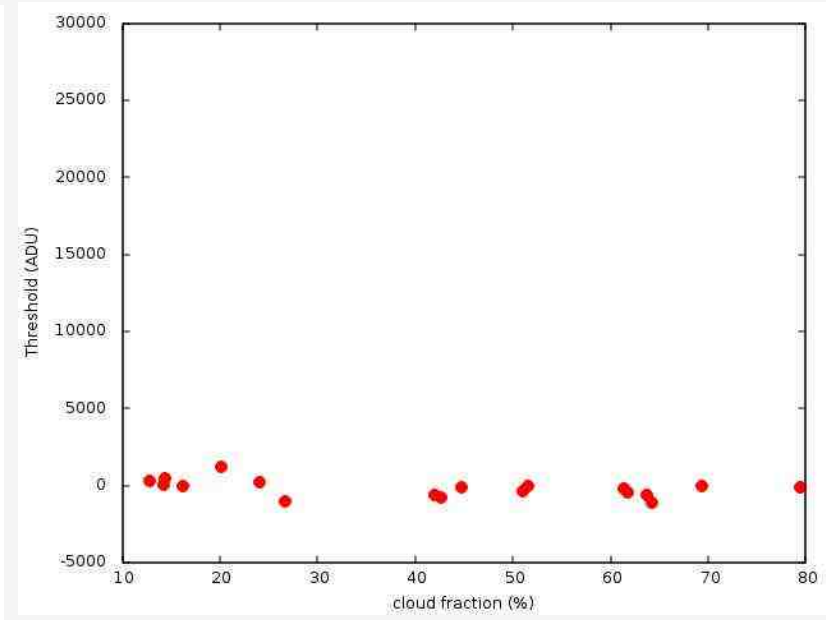
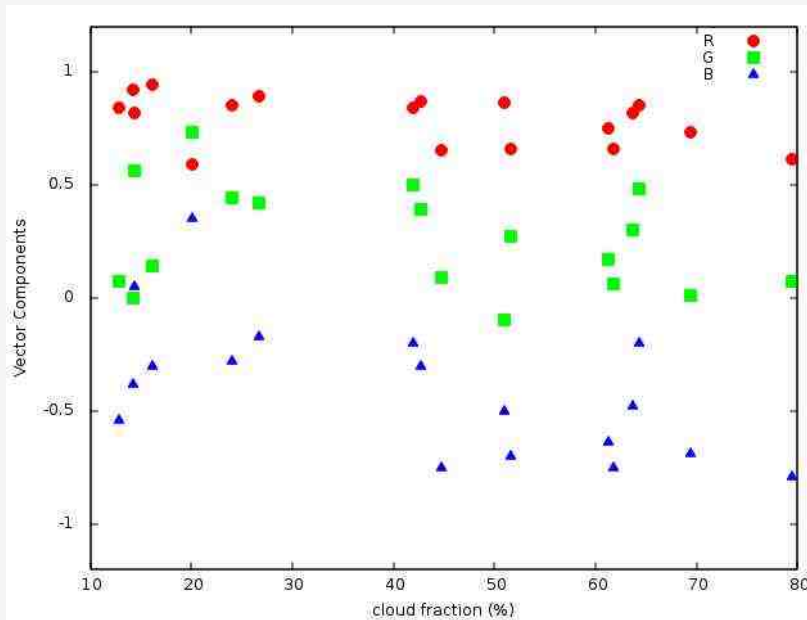


ASC - Thresholding



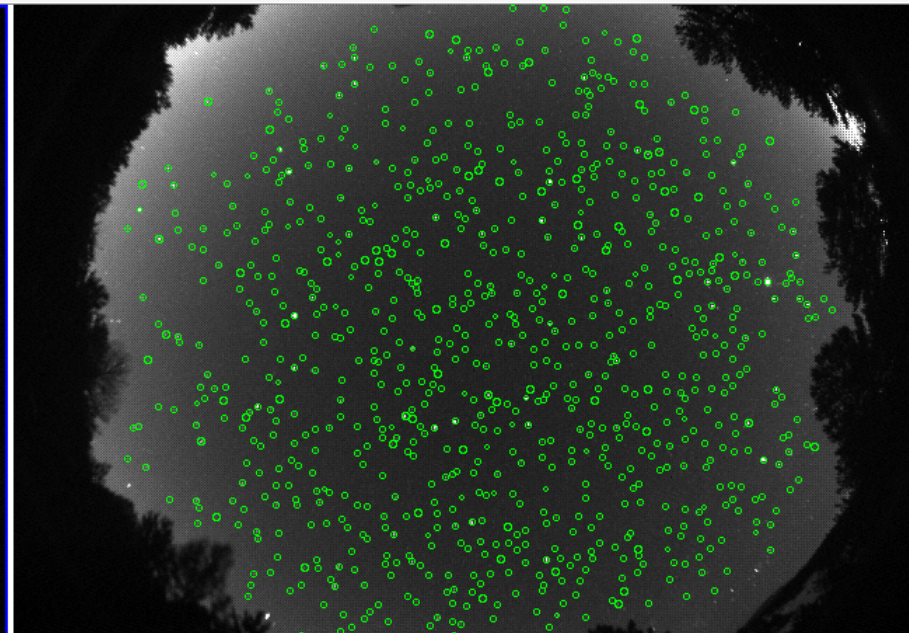
ASC - Thresholding

Final Mix of Colors And Threshold



ASC - Star Counting

Find stars



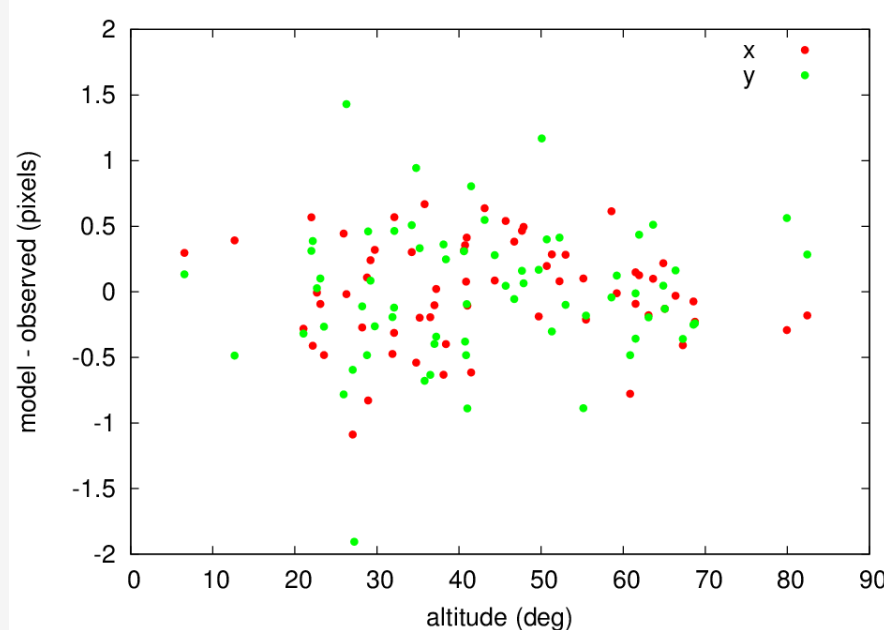
ASC - Star Counting

Confront with a catalog

We need an accurate transformation between pixel and celestial coordinates

Zenithal Equal Area (ZEA) projection

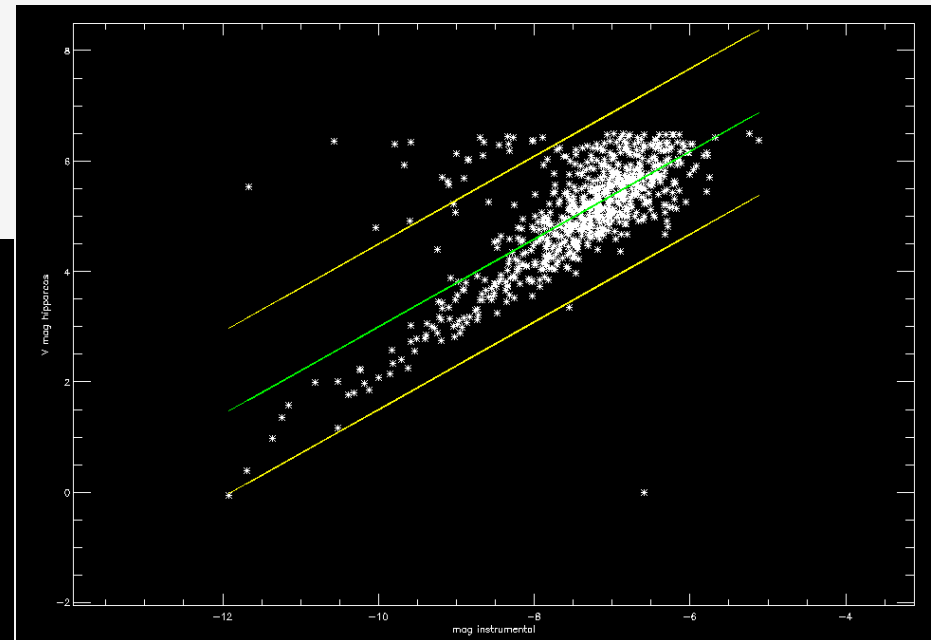
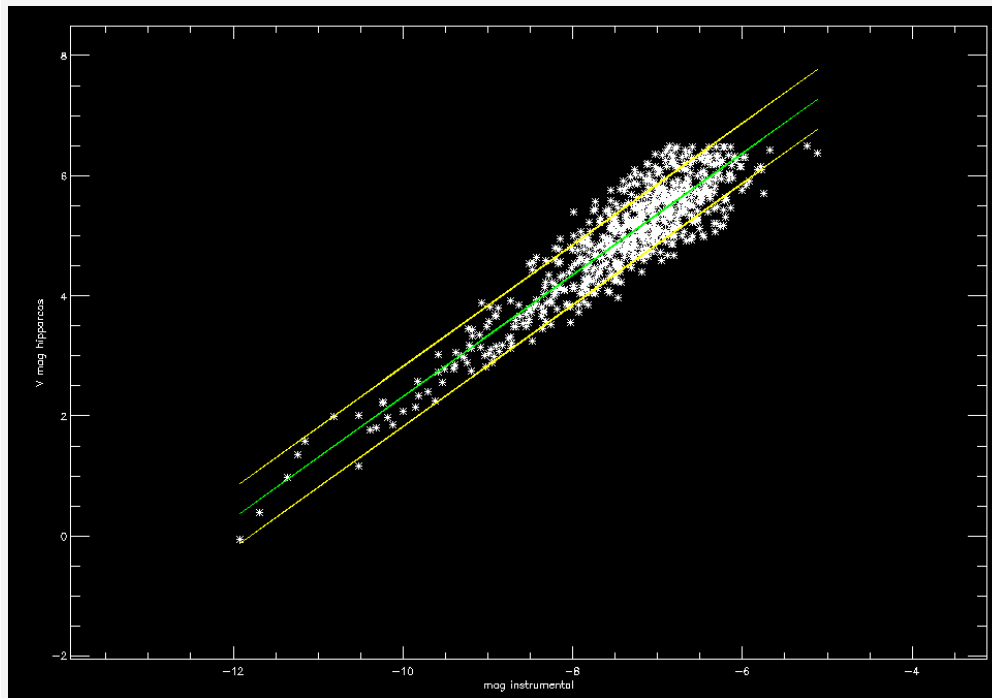
Distortions modeled with 6 order polynomial series



ASC - Star Counting

Discard Outliers

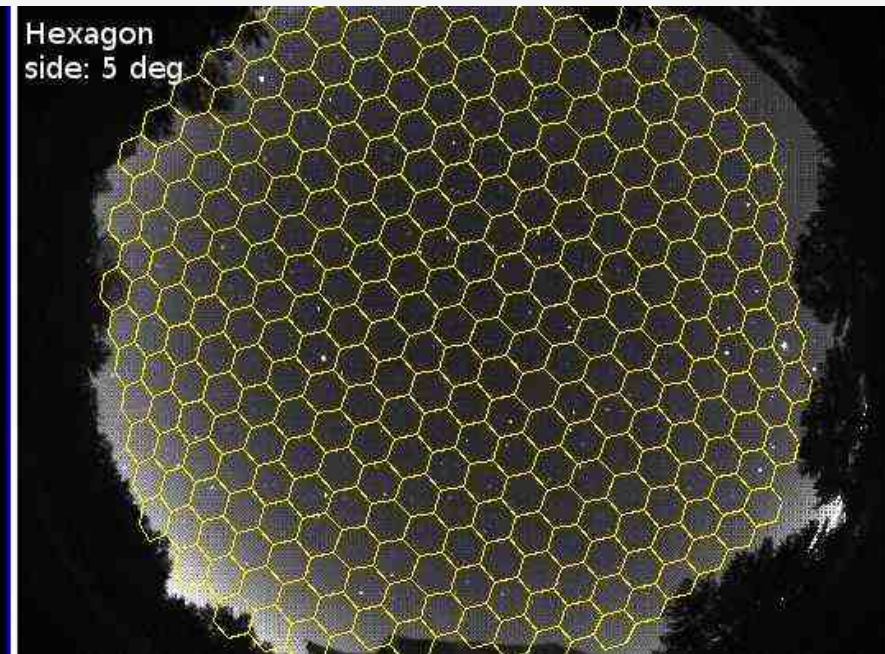
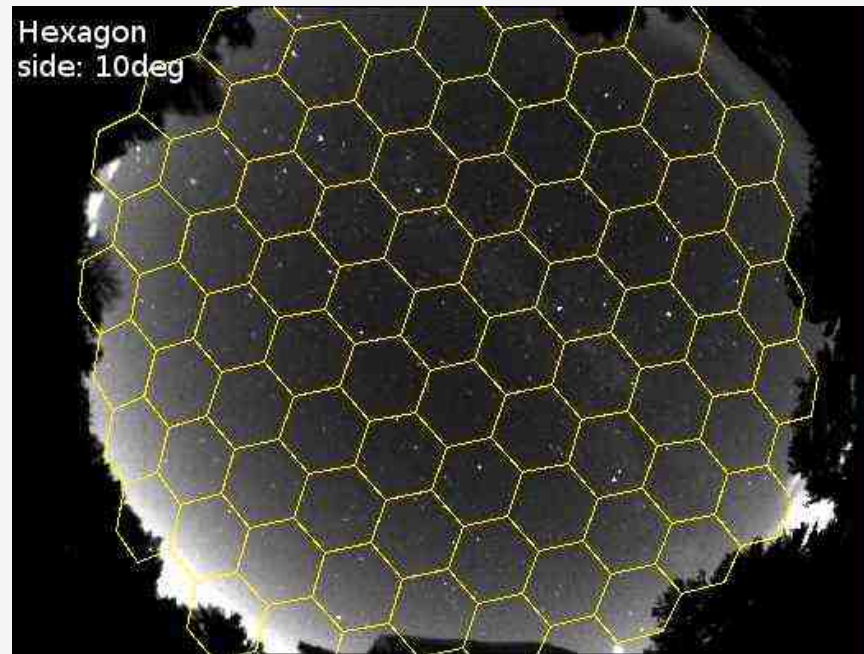
Fit for the magnitude transformation



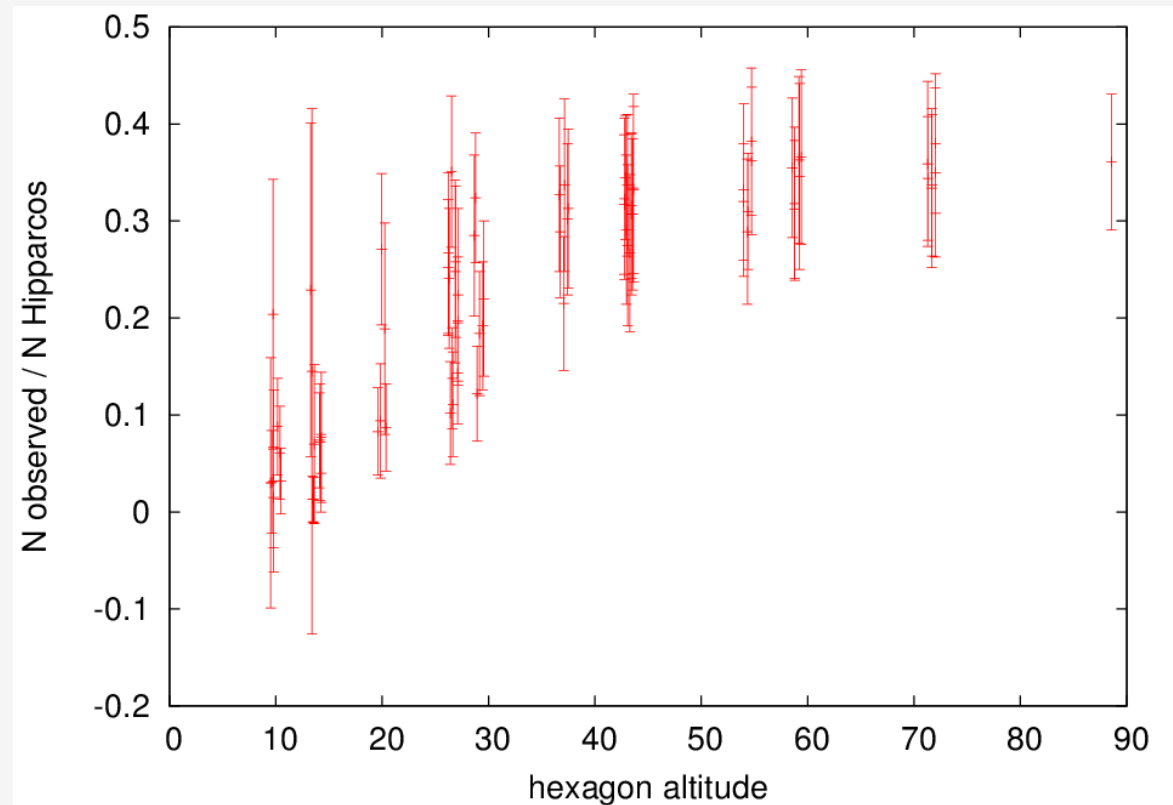
zeropoint	12.7+-0.2
slope	1.04+-0.02

ASC - Star Counting

Tiling

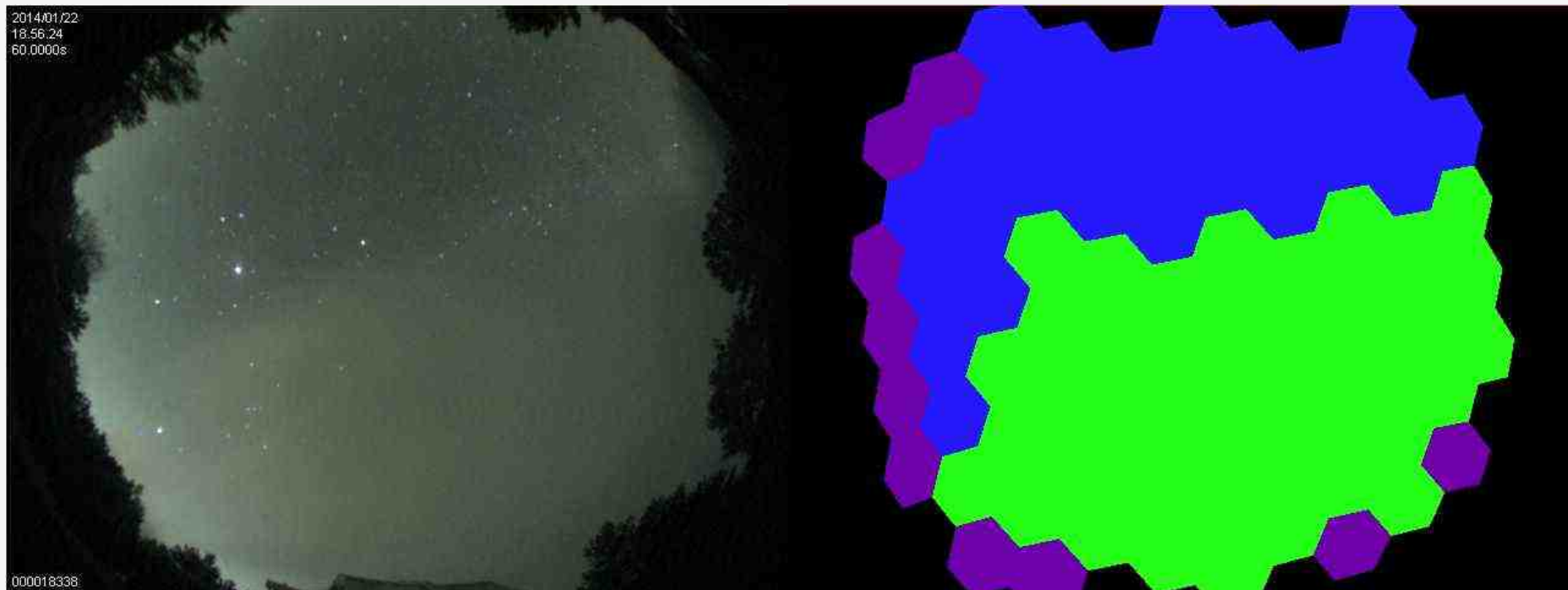


ASC - Star Counting



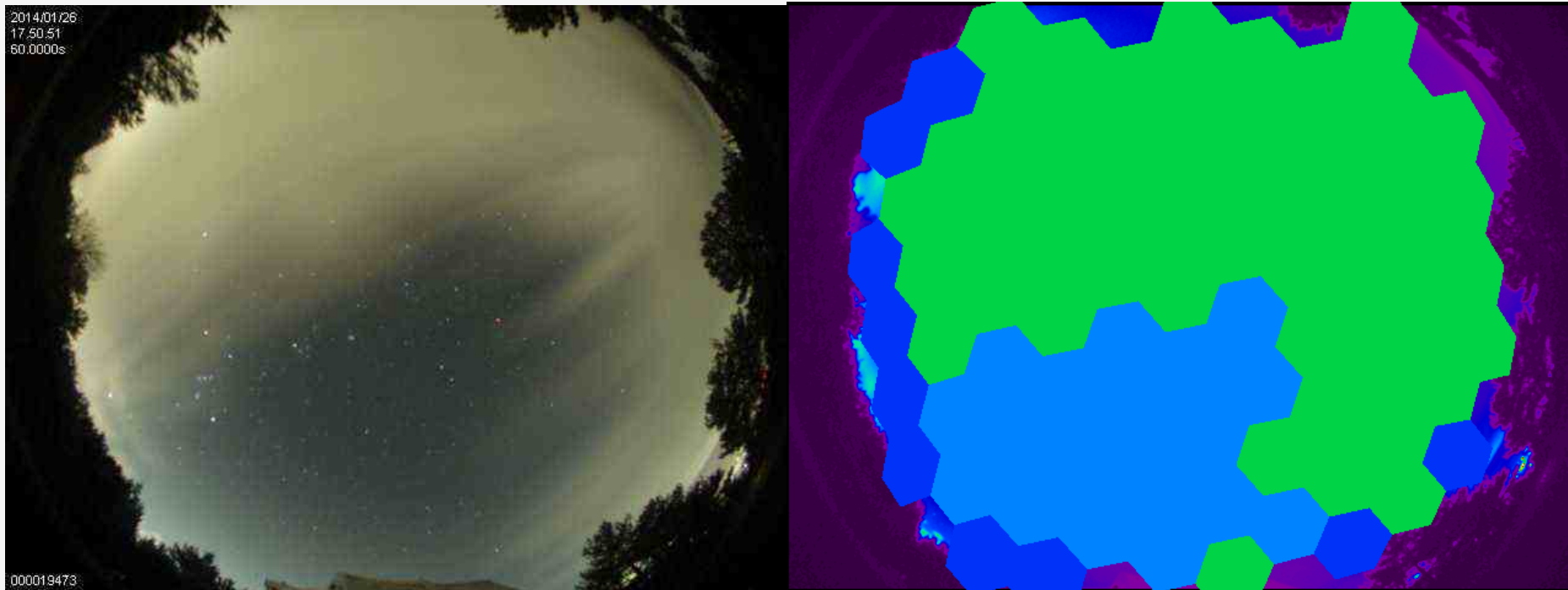


ASC - Star Counting





ASC - Star Counting





Conclusions and Future Work

All Sky Camera: Thresholding

- Increase statistics with more ground truth images
- Find a fixed threshold
- Work cases with the moon in the sky
- Sunset and sunrise

All Sky Camera: Star counting

- Build our own catalog

EFM:

- Deliver real alerts to ASTRI SST-2M software (dummy software already implemented)
- Calibrate it against a standard LINET instrument

Lidar:

- Data taken during ASTRI SST-2M observation will be available to define the real sky condition



The ASTRI Program




ASTRI **Astrofisica con Specchi a Tecnologia Replicante Italiana**

Home About Team Links Publications Outreach Contacts Copyright Login ASTRI Events

Welcome to ASTRI project Home Page

ASTRI (Astrofisica con Specchi a Tecnologia Replicante Italiana) is a flagship project of the Italian Ministry of Education, University and Research related to the next generation IACT (Imaging Atmospheric Cherenkov Telescope), within the framework of the **CTA** (Cherenkov Telescope Array) International Observatory. In this context, INAF (Italian National Institute of Astrophysics) is currently developing a scientific and technological breakthrough to allow the study of the uppermost end of the VHE domain (a few TeV - hundreds of TeV). The ASTRI project timeframe is of about 3 years, and foresees the full development, installation and calibration of a Small Size class Telescope prototype compliant with the requirements of the High Energy array of CTA. The ASTRI prototype will adopt an aplanatic, wide field, double reflection optical layout in a Schwarzschild-Couder configuration. Moreover, the focal plane instrument will explore small pixelated detector sensors such as multi-anode PMTs or Silicon PM. Among the number of technological challenges, this telescope will be the very first instrument implementing both the Schwarzschild-Couder optical configuration and the double reflection for air Cherenkov imaging.

For other information about INAF Institutes involved in the ASTRI Project click on [Team](#) in the menu above.

News

March 12, 2013

The Final Design Review (FDR) of the telescope structure and electro-mechanical components has been successfully completed in February 2013. The ASTRI project can now move into the manufacturing phase of the telescope, its on-site erection is foreseen to happen in Spring 2014.

Logos: INAF, ASI, IASF, INAF-OAR, CTA, etc.



<http://www.brera.inaf.it/astri/>