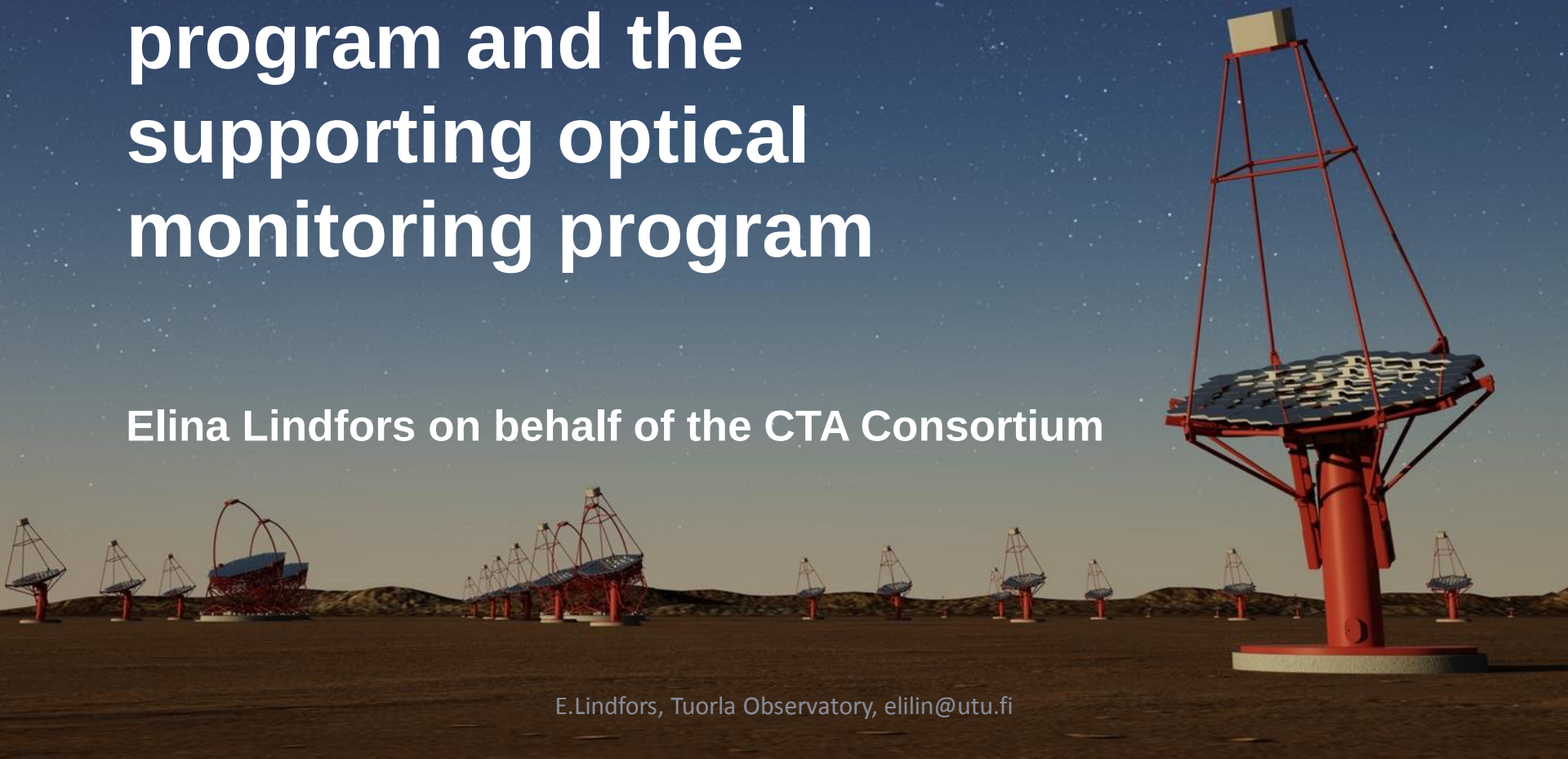
CTA blazar monitoring program and the supporting optical monitoring program

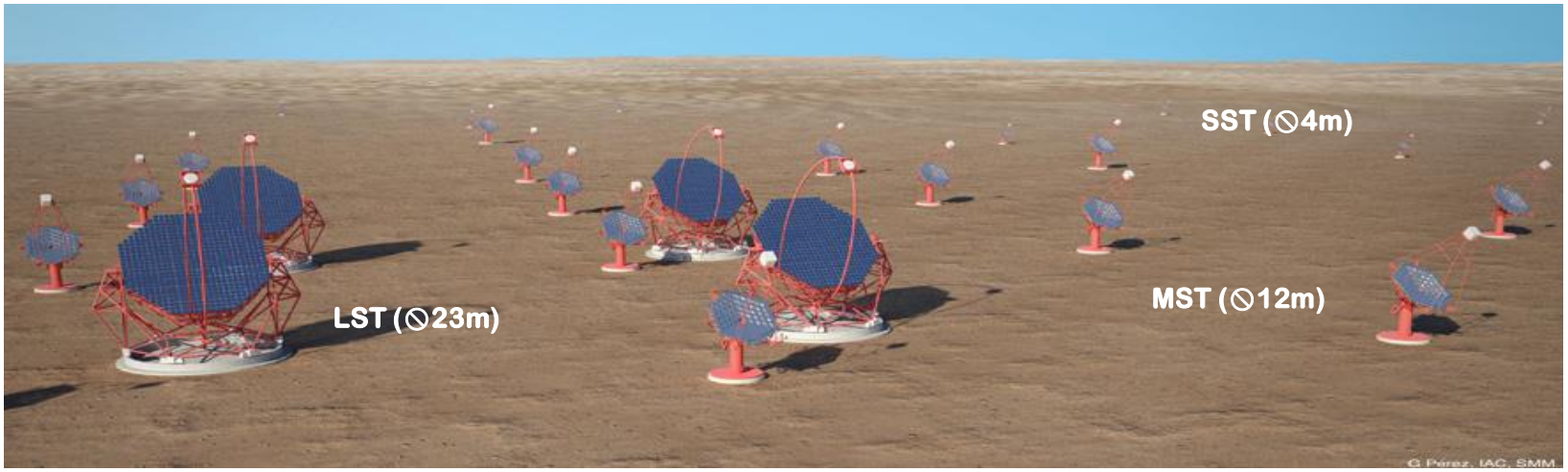
Elina Lindfors on behalf of the CTA Consortium



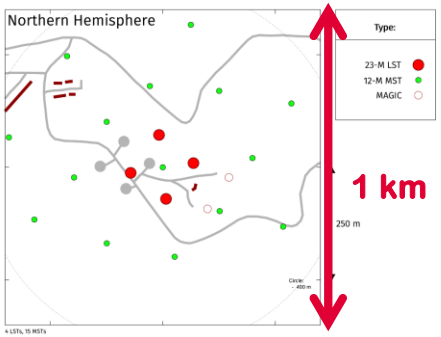
E.Lindfors, Tuorla Observatory, elilin@utu.fi

The CTA Observatory

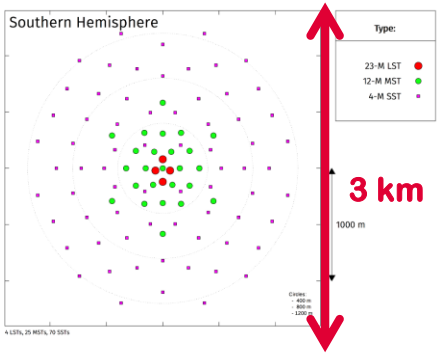
Cherenkov Telescope Array, CTA



North



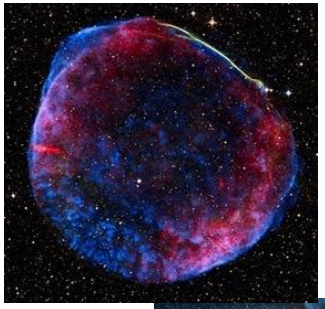
South



Characteristics

2 sites (north & south)
3 telescope size classes
About 120 telescopes in total

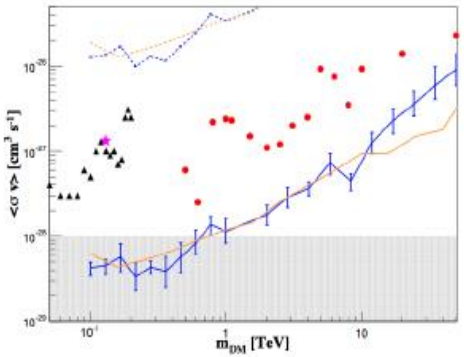
CTA Key Science

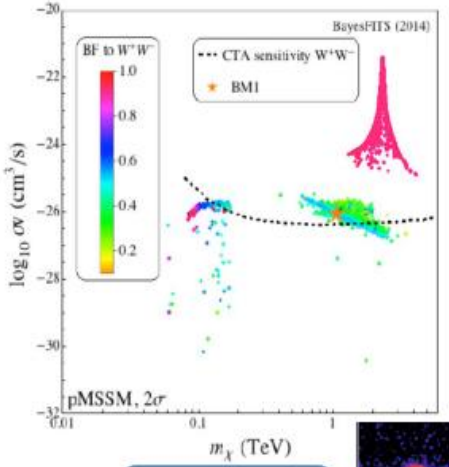


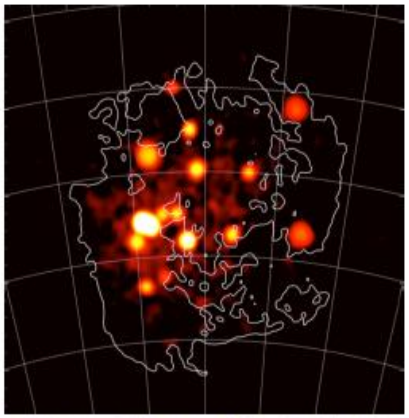
Cosmic Particle Acceleration
How and where are particles accelerated?
How do they propagate?
What is their impact on the environment?

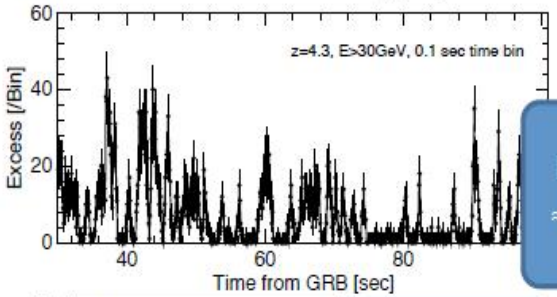
Probing Extreme Environments
Processes close to neutron stars and black holes?
Processes in relativistic jets, winds and explosions?
Exploring cosmic voids

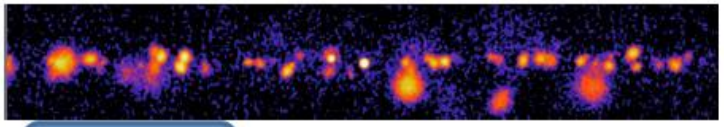
Physics frontiers – beyond the Standard Model
What is the nature of Dark Matter? How is it distributed?
Is the speed of light a constant for high-energy photons?
Do axion-like particles exist?







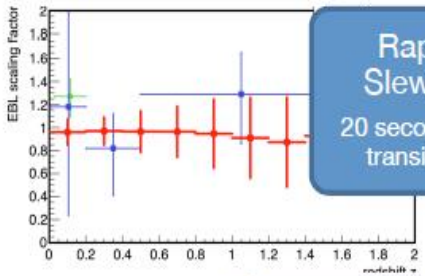




Energy Resolution
≈10% → lines, features

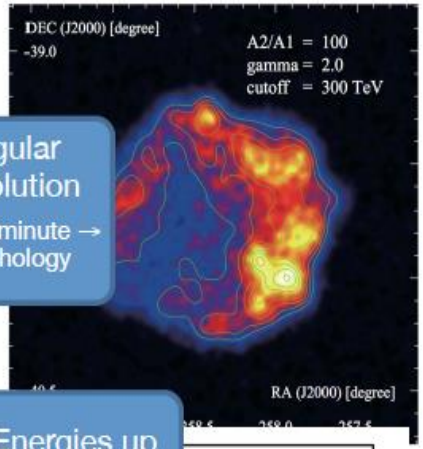
Sensitivity & Collection Area
×10 → all topics

Field of View
≈8° → surveys, extended objects



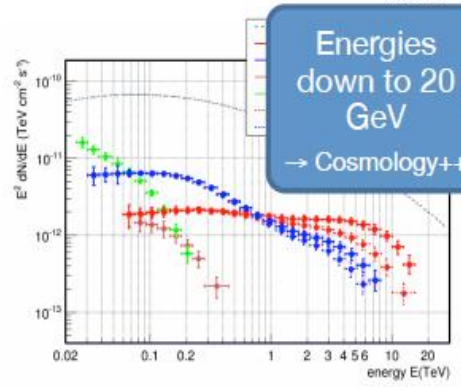
Rapid Slewing
20 seconds → transients

Angular Resolution
Few arcminute → morphology

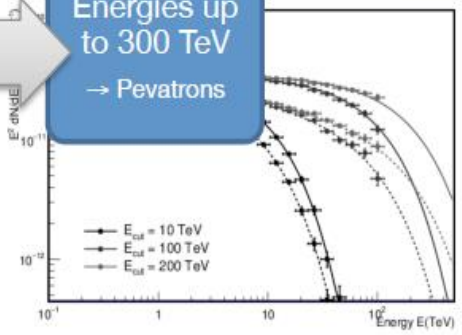


cta
cherenkov telescope array

Energies down to 20 GeV
→ Cosmology++



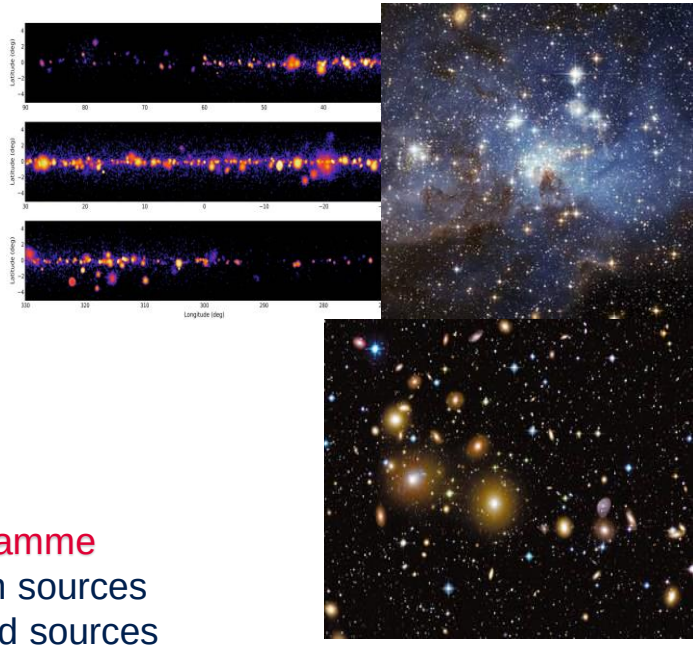
Energies up to 300 TeV
→ Pevatrons



CTA Science Projects

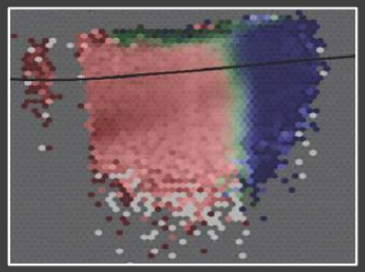
Key Science Projects (executed by consortium)
Ensure that important science questions for CTA are addressed in a coherent fashion and with a well-defined strategy
Conceived to provide legacy data sets for the entire community

Surveys: galactic center, galactic plane, extragalactic and LMC
Transients
Cosmic Ray PeVatrons
Starforming systems
Active Galactic Nuclei
Galaxy Clusters

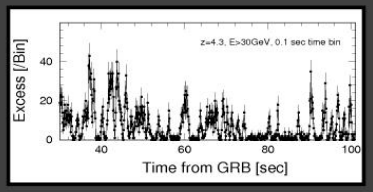


Proposal-driven User Programme
Deep investigation of known sources
Follow-up of KSP discovered sources
Multi-wavelength campaigns
Follow-up of ToOs from other wavebands or messengers
Search for new sources
…

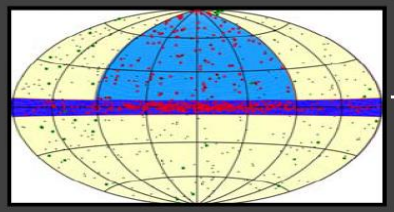
CTA KEY SCIENCE



Dark Matter Programme

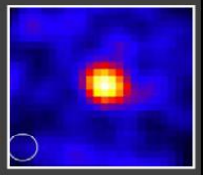


Transients



ExGal Survey

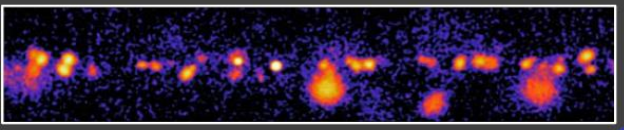
Galaxy Clusters



Extragalactic

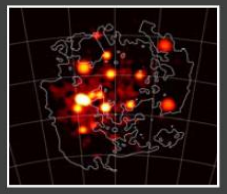
Star Forming Systems

AGN



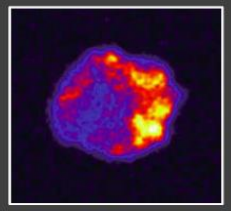
Galactic Plane Survey

LMC Survey

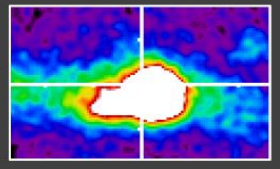


Galactic

PeVatrons



Galactic Centre



cta cherenkov telescope array

Active Galactic Nuclei

Key Science Project will address:

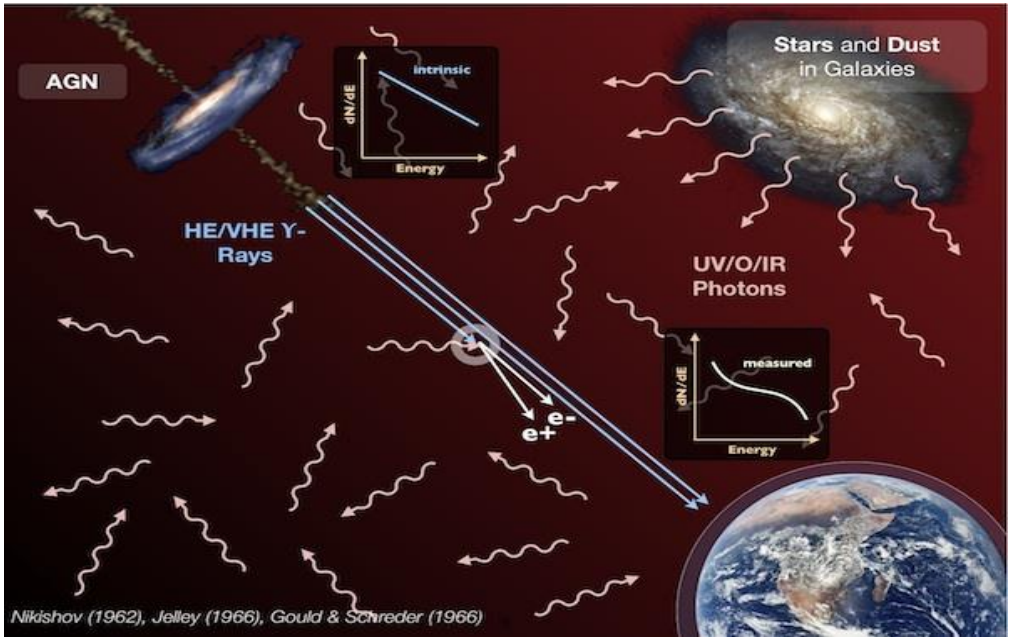
-AGN physics at Very High Energies

-gamma-ray cosmology

-ultra high energy cosmic rays and fundamental physics

Observational strategies:

1. Long-term monitoring
2. High-quality spectra
3. AGN flare programme



Credit: M.Raue

Long term monitoring with CTA

- Sample: known VHE emitters: UHBLs, HBLs, IBLs, LBLs, FSRQs, Radio Galaxies
- 30 minutes weekly exposures of known sources
- 12 hours per year at least for 5 years

1ES1218+304 and 1ES 1215+304 in same FoV

IC310 in same FoV

UHBLs	1ES 0229+200 (N) , 1ES 1426+426 (N) , 1ES 1101-232 (S)
HBLs	Mrk 421 (N) , Mrk 501 (N) , PKS 2155-304 (S)
IBLs	1ES 1011+496 (N) , 3C 66A (N) , W Comae (N)
LBLs	AP Librae (S) , BL Lacertae (N)
FSRQs	PKS 1510-089 (S) , PKS 1222+216 (N)
Radio Galaxies	M 87 (N) , NGC 1275 (N)

Table 12.1 – Example list of targets for long-term monitoring. The labels "(N)" and "(S)" indicate observations with the northern and southern array, respectively.

form of long-term light curves. If a source is found in a flaring state, more intensive coverage can be triggered as part of the "AGN flare programme" (see below).

The total exposure time for 15 fields of view would be <180 h per year. With the currently proposed list of targets, this would be split into 132 h of yearly observation time for the north and 48 h for the south. Observations would fall naturally into dark time (~50%) and moon time (~50%).

Long term monitoring now vs. CTA

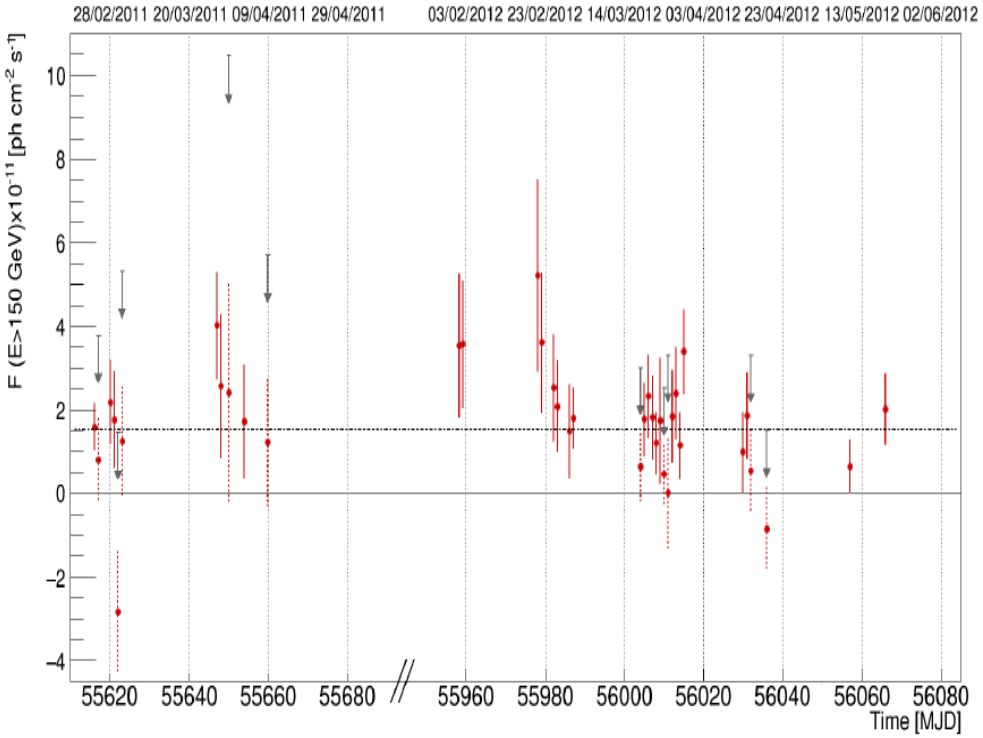
Now (see also talks this afternoon):

- HBLs Mrk421, Mrk501, PKS2155-304; monitoring data already extends >10 years with good sensitivity, high, low, intermediate flux states have been covered. For past ~8 years, also MWL.
- UHBLs seem rather stable, detections need >10 hours of data
- Rest: mostly during flares (low states require ~10 hours of exposure or more or is beyond the reach)

With CTA:

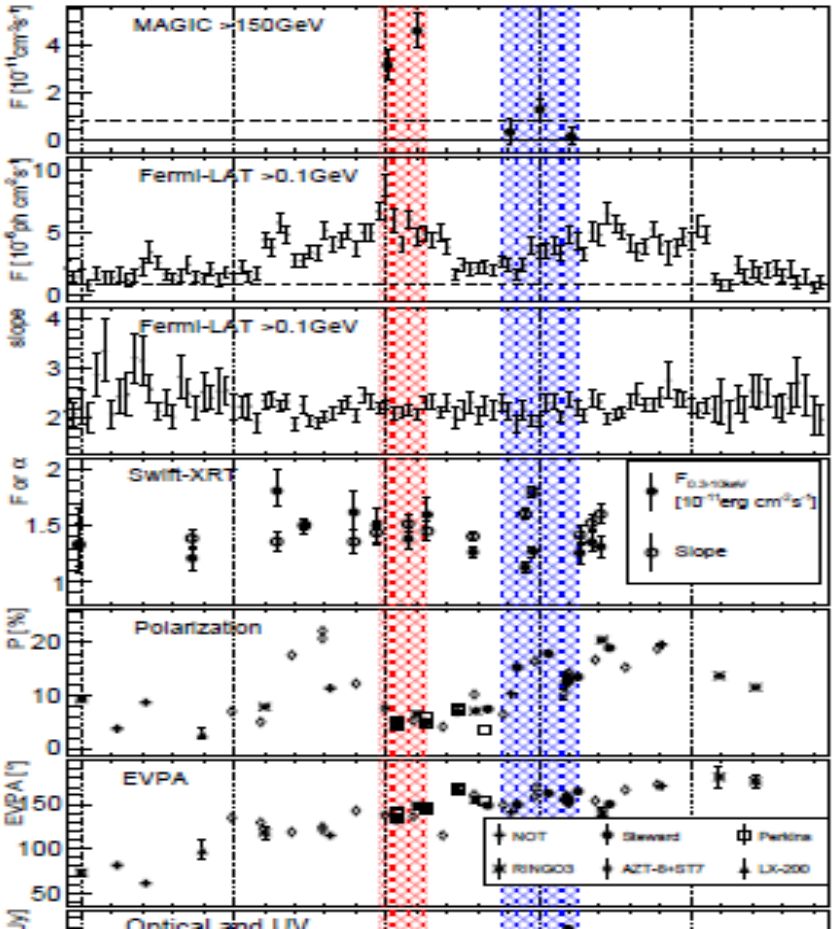
- For strongest sources in the sample 30 minutes will allow very significant detection even if in low state, can scope intra-night variability in low state
- For the weakest sources in the sample in low state 12 hours will allow significant detection

Long term monitoring now



1ES1011+496, MAGIC Collaboration

PKS1510-089, MAGIC Collaboration



Monitoring of Active Galactic Nuclei with CTA

Variability from longest timescales:

-Duty Cycle

-(quasi) periodicities

-breaks in the power spectra

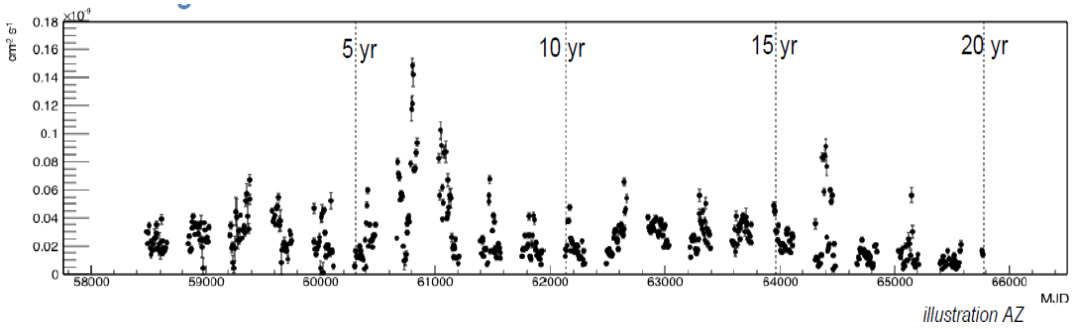
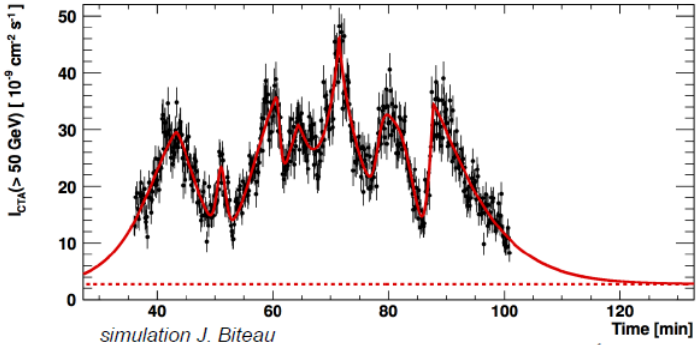


illustration AZ

to shortest:

-size (location, nature) of the emission reg

-acceleration and cooling mechanisms



simulation J. Biteau
(H. Sol, AZ, C. Boisson et al. 2013)

4

Multiwavelength in CTA era

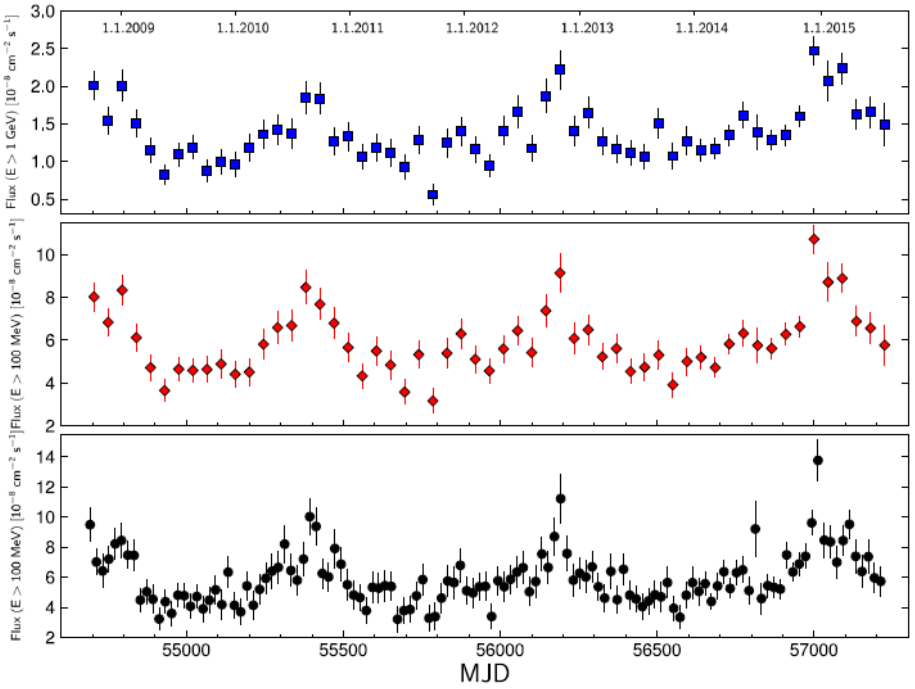
- Long term monitoring program: Well sampled, simultaneous light curves at different wavelengths (X-ray, optical, radio) are necessary to allow us to search for correlations and time-lags between different bands. *Optical photometry and polarimetry from dedicated telescope.*
- AGN flares: MWL coverage necessary, optical photometry and polarimetry from dedicated telescope. *The dedicated optical telescopes will provide source of alerts triggered by high flux states and changes in polarization.*
- High quality spectra: *dedicated optical data will be very useful to e.g. Compare the state of source vs. Archival data.*

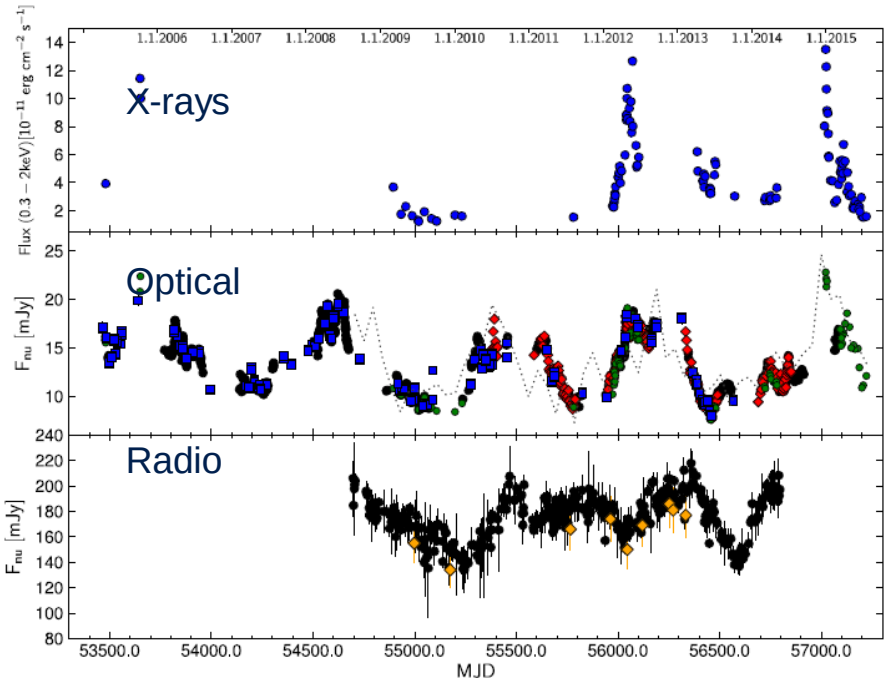
Optical monitoring

- MAGIC and HESS have dedicated optical support telescopes: KVA and ATOM
- Has been particularly useful for blazar observations
- Photometric long-term monitoring: to study the long term behavior, to define the flare conditions
- Before the Fermi era, the optical telescope was the main source of alerts for flaring AGN: e.g. with MAGIC >50% of blazar discoveries result of optical trigger

Optical monitoring for periodicity

PG 1553+113: Fermi-LAT quasi-periodicity quasi-periodicity in other bands?

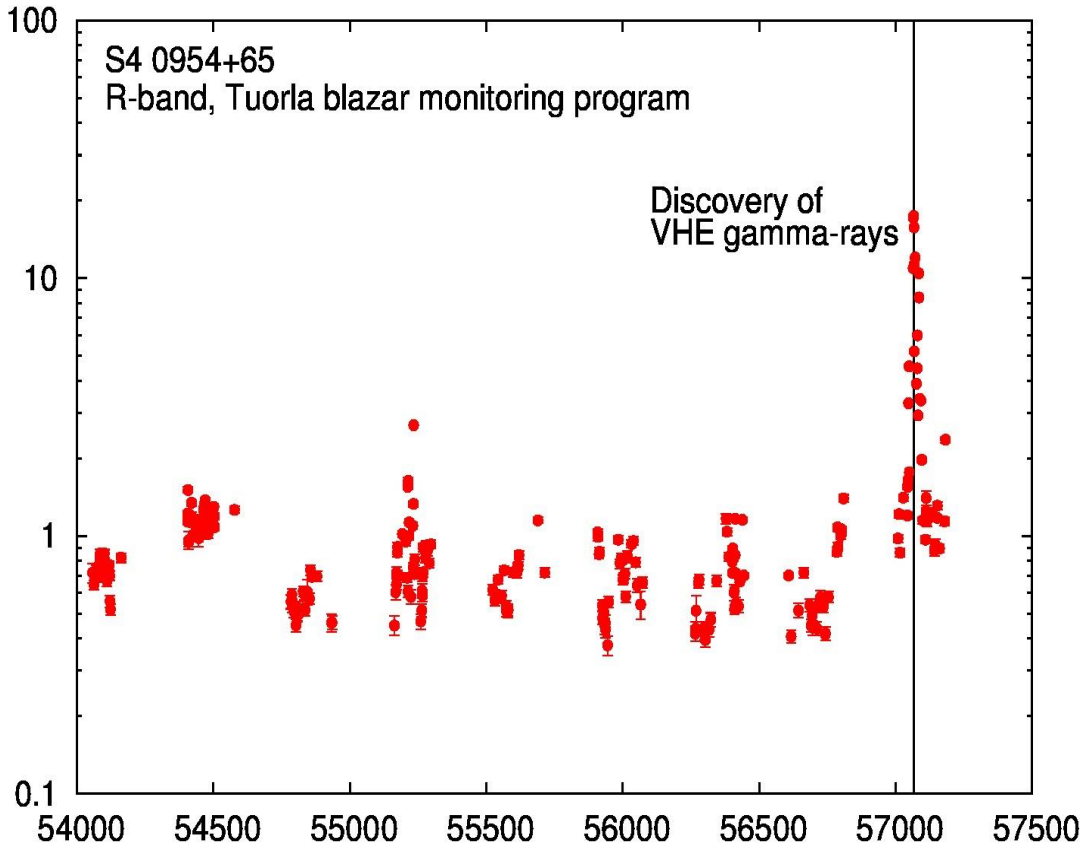




Ackermann et al. 2015, ApJ, 813, 41

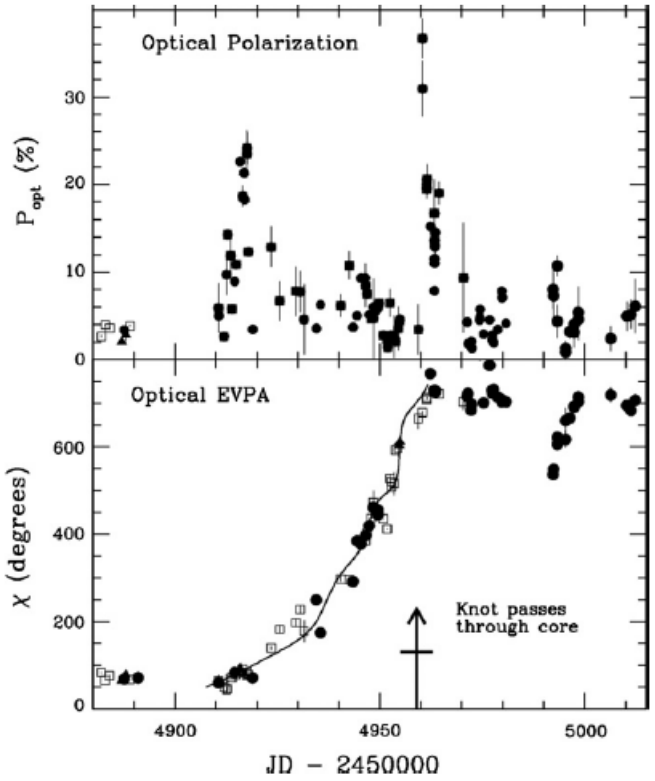
Optical monitoring for triggering

- MAGIC has been triggering from optical observations since 2005
- Many discoveries (Mrk180, 1ES1011+496, S50716+714, B32247+381, ON325, H1722+119, S40954+65)

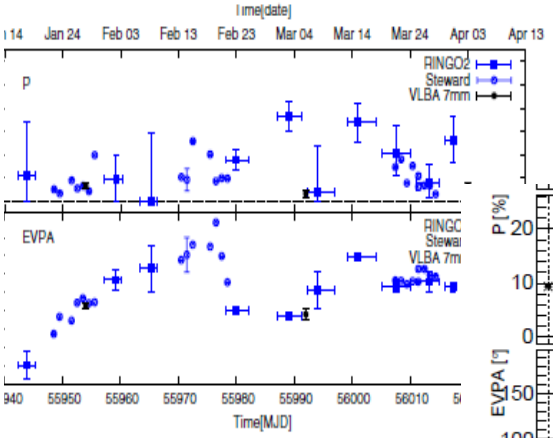


Optical monitoring for physics interpretation

- PKS 1510-089: repeating optical polarization swings during VHE emission: 2009, 2012, 2015

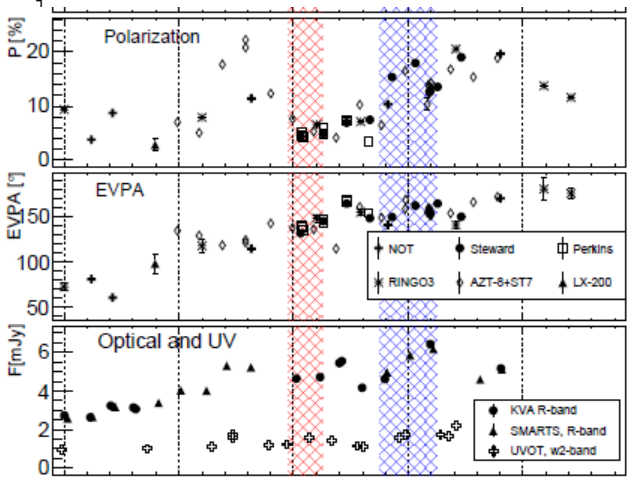


Marscher et al. 2010



Radio and optical polarisation behaviour of PKS 15
ebruary–April.

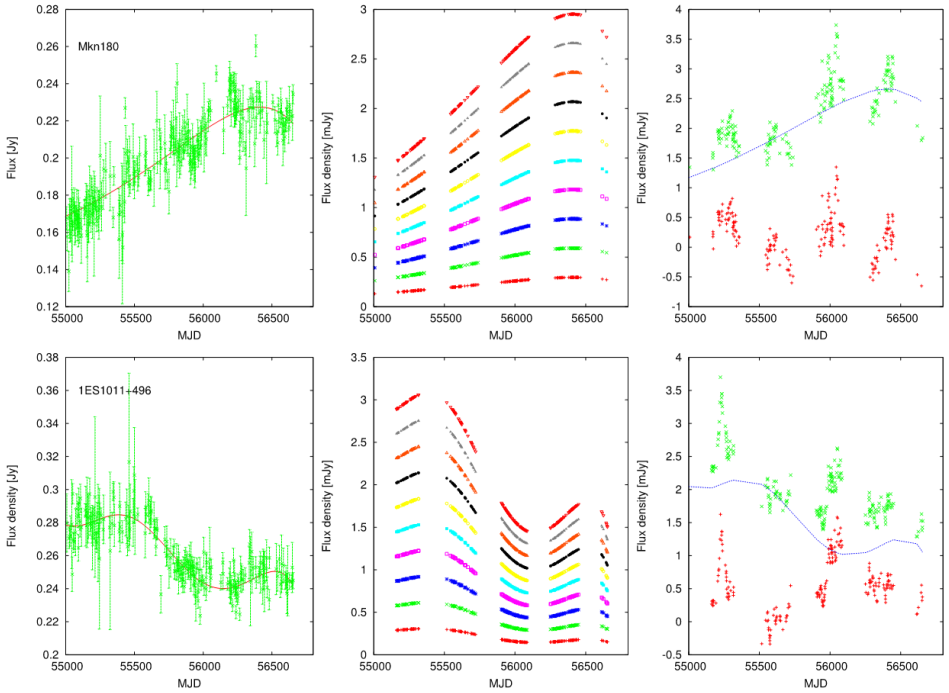
Aleksic et al. 2014



Aleksic et al. 2016, submitted

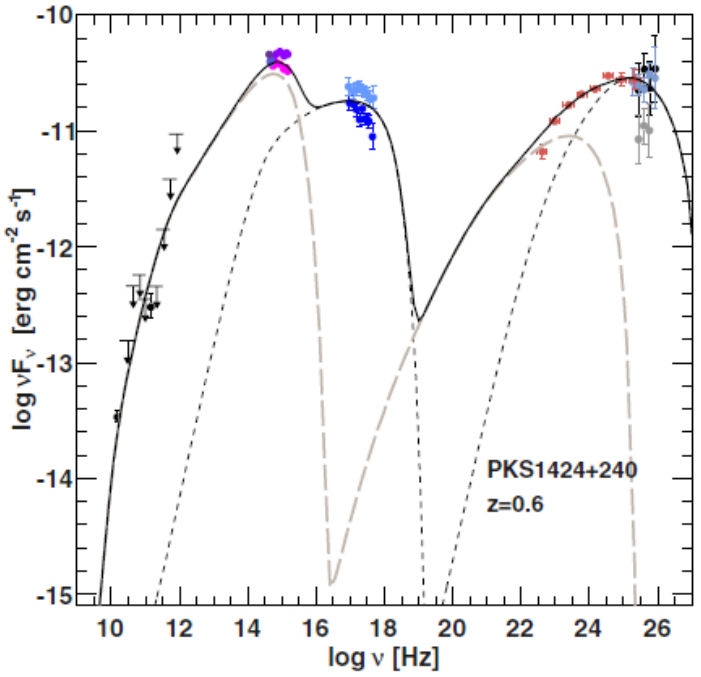
Optical monitoring for physics interpretation

Common optical-radio variability



Lindfors, Hovatta et al. 2016, A&A, 593, 98

To constrain two-zone models



Aleksic et al. 2014, A&A, 567, 135

Summary

- CTA Key science projects combine guaranteed scientific return with large discovery potential
- As part of the Active Galactic Nuclei Key Science Project Long Term Monitoring of a representative sample of AGN will be performed
- CTA will generate several legacy datasets for the use of wider astrophysics/astroparticle physics community: long-term monitoring will be one of them
- Optical monitoring to support VHE blazar observations has proven to be very successful for triggering and for physics interpretation
- To maximize the scientific return of long term monitoring program of CTA an extensive MWL monitoring is needed