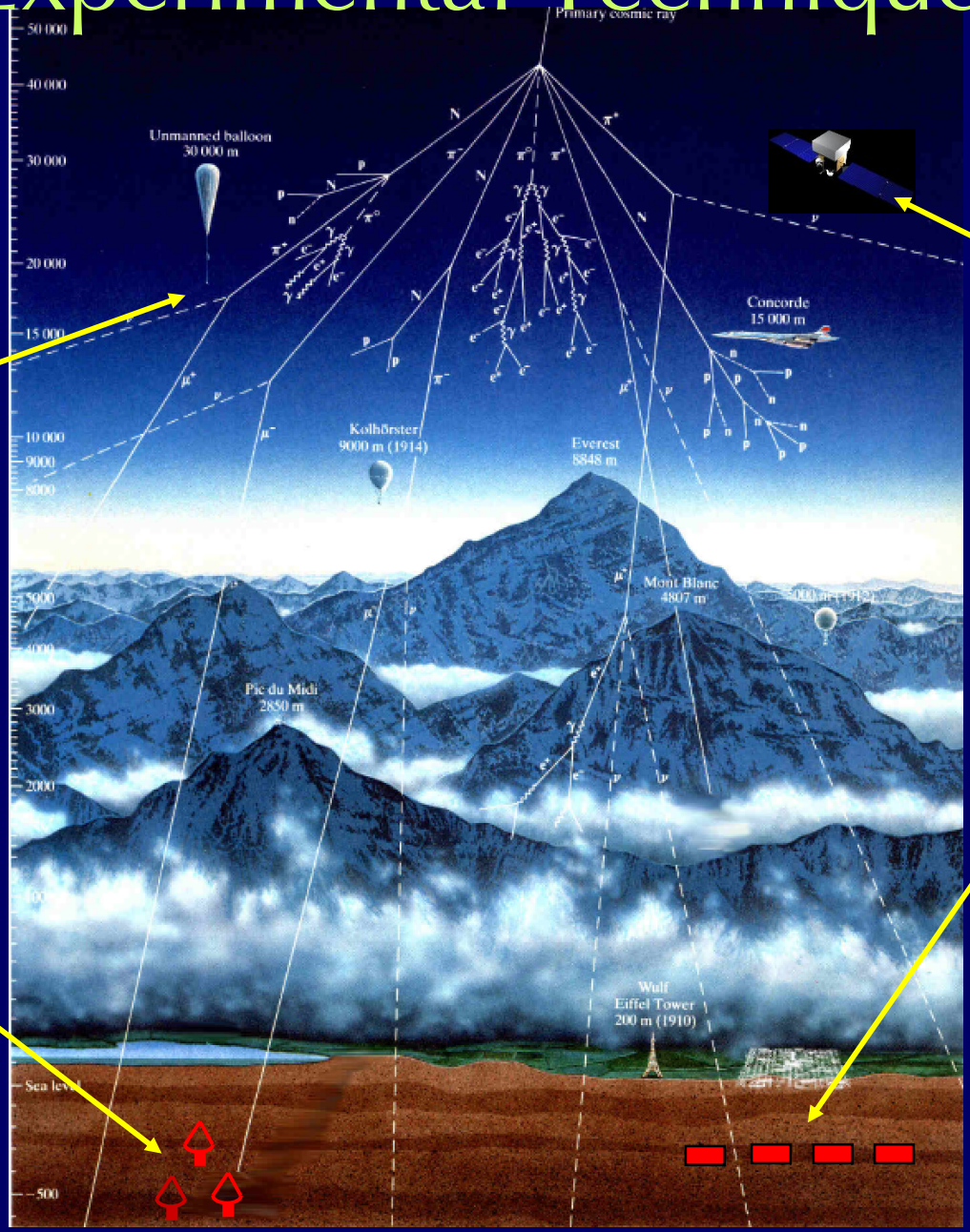
Experimental Techniques



Balloon

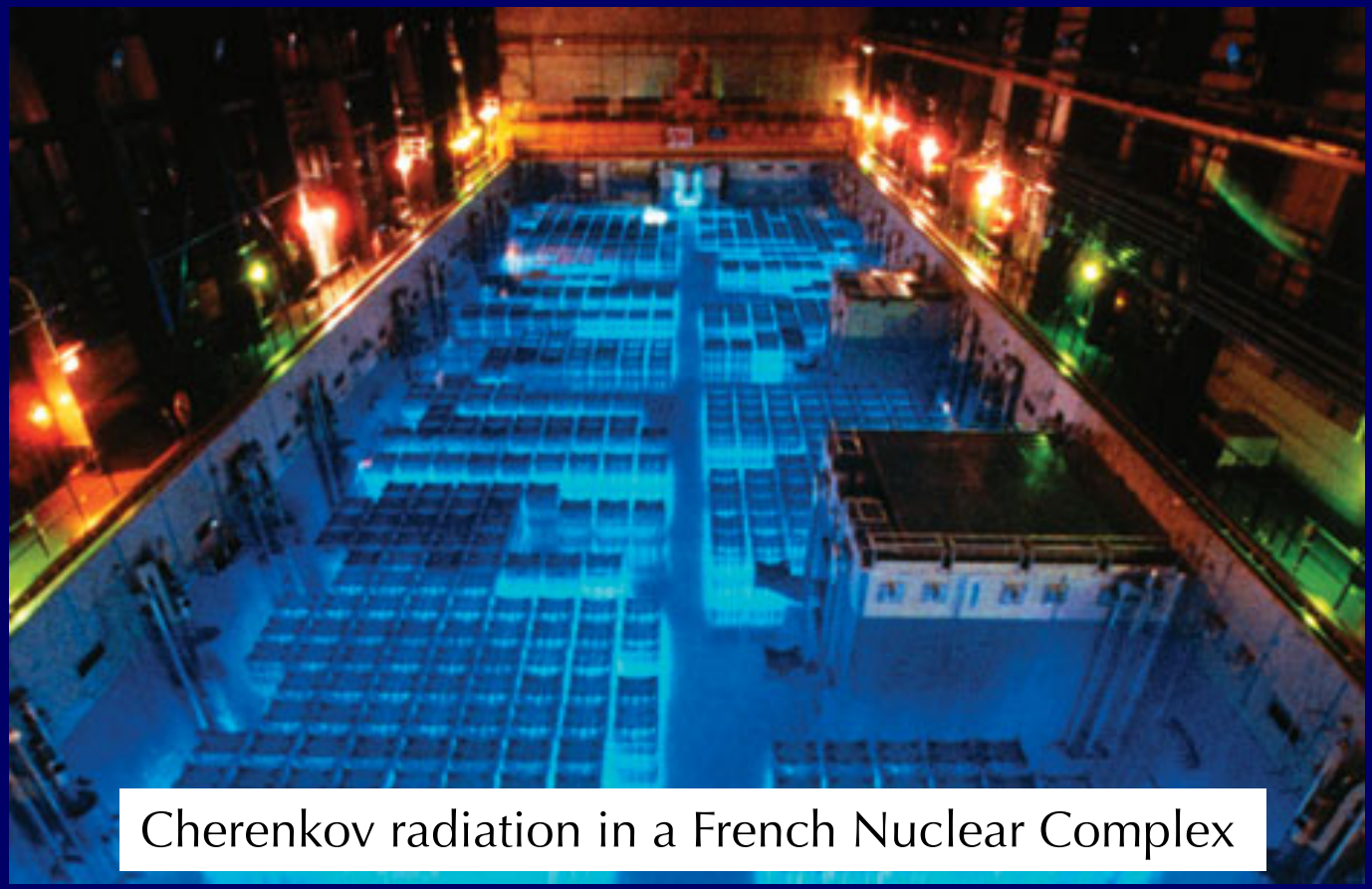
Satellite
(Fermi/GLAST)

Cherenkov
Telescopes
(VERITAS)

Air shower array
(Milagro)

Cherenkov Radiation

Čerenkov radiation is electromagnetic radiation emitted when a charged particle (such as an electron) passes through an insulator at a speed greater than the speed of light in that medium.

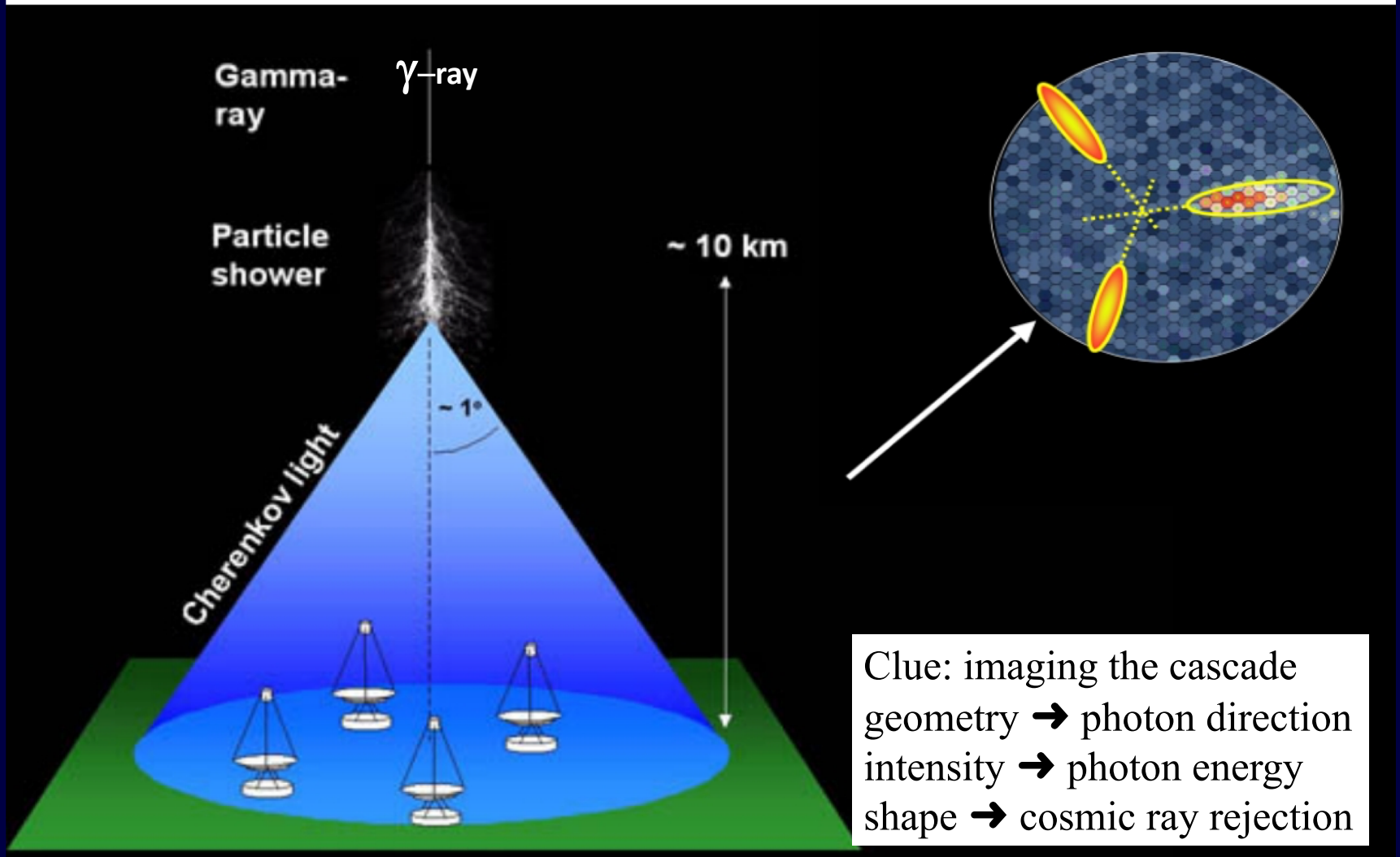


Cherenkov radiation in a French Nuclear Complex

Shock Wave

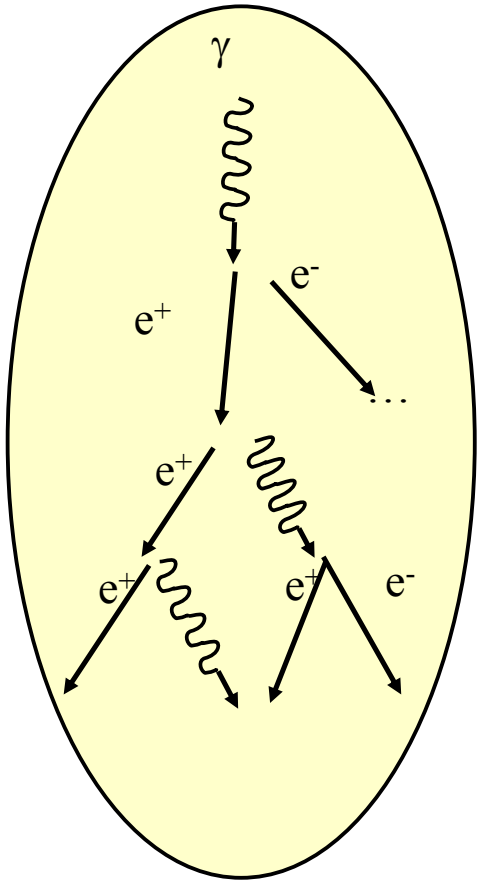
Credit: Science 2.0

The Atmospheric Cherenkov Technique

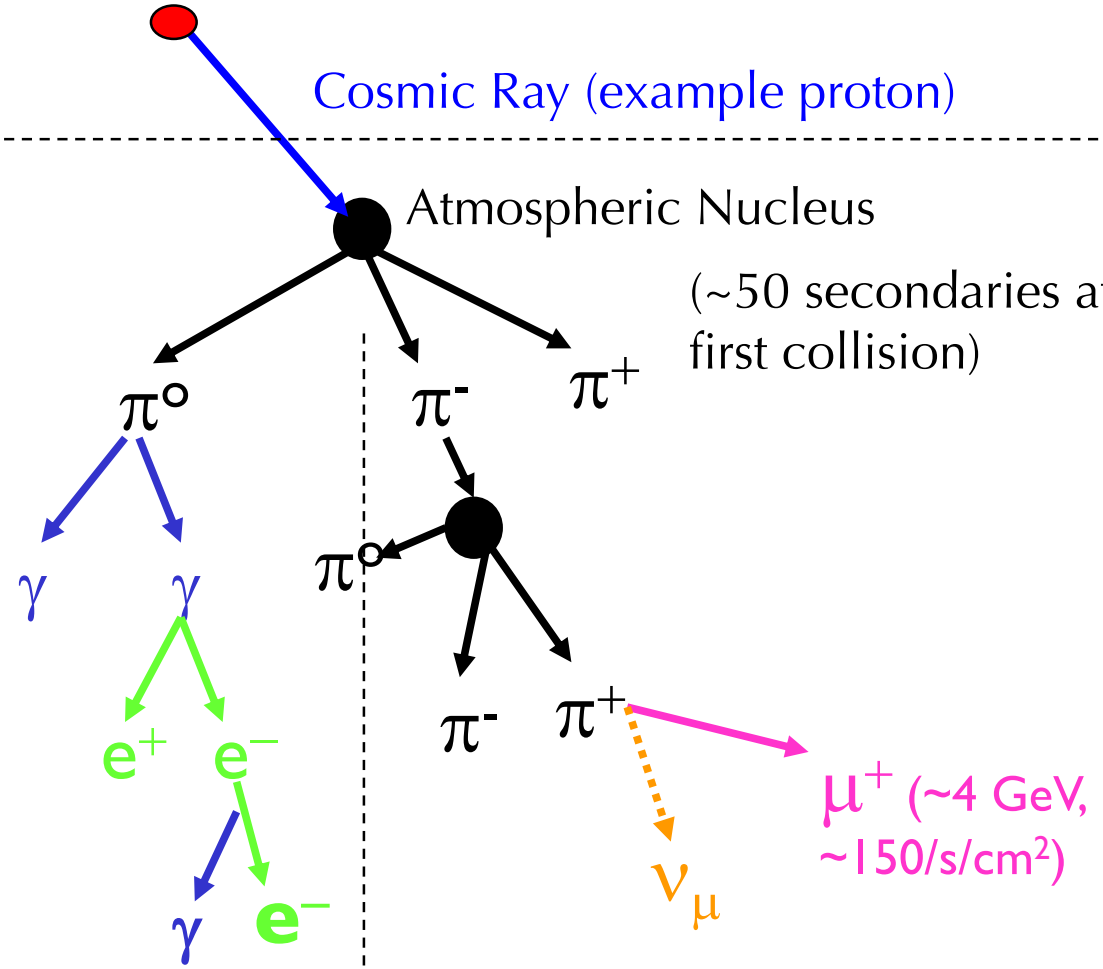


Clue: imaging the cascade
geometry ➜ photon direction
intensity ➜ photon energy
shape ➜ cosmic ray rejection

Physics of Extensive Air Showers



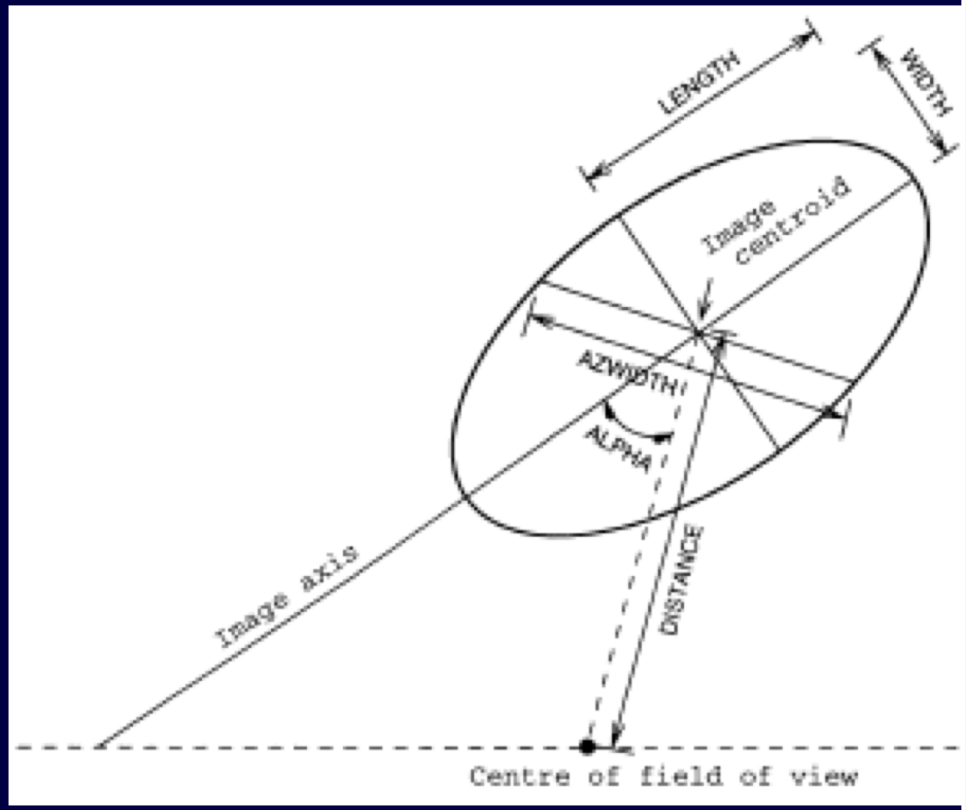
Gamma-ray shower



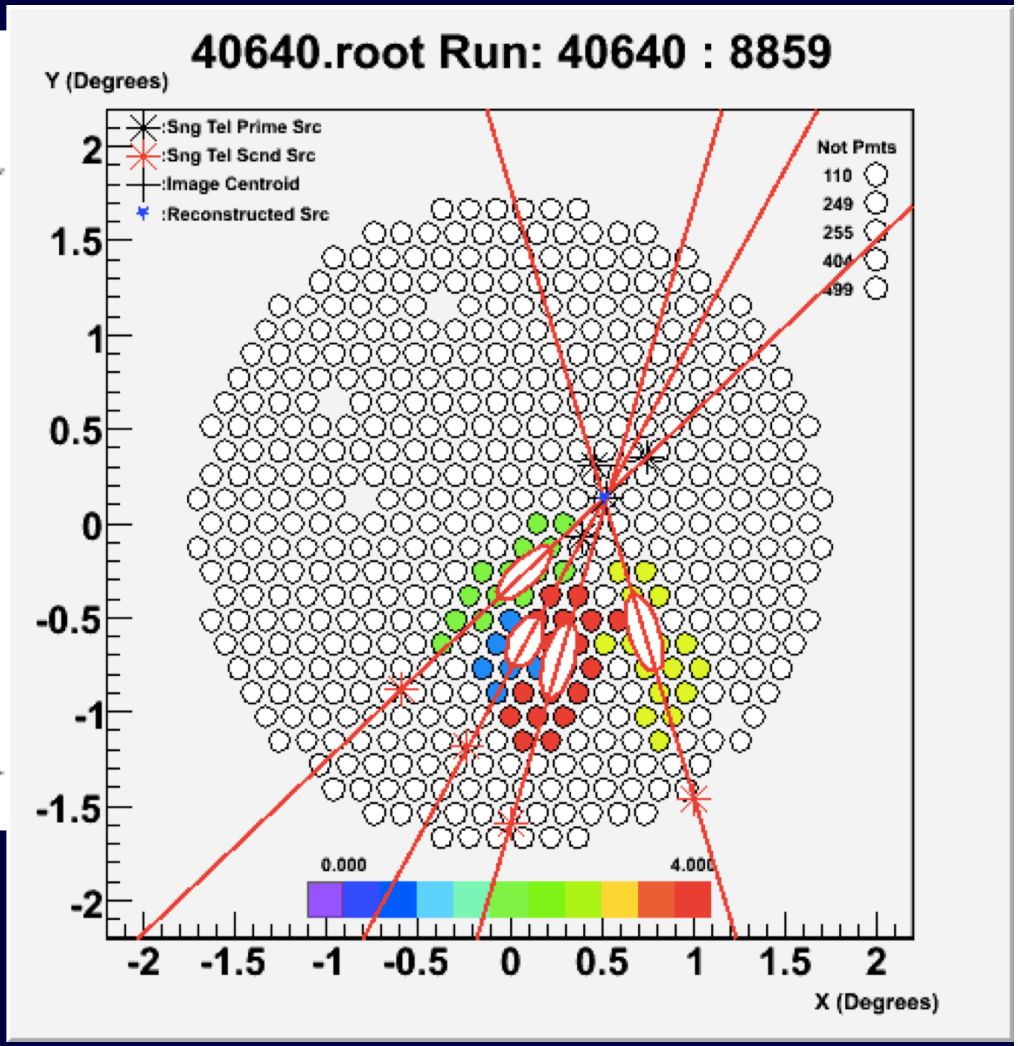
Electromagnetic Shower
(mainly γ-rays)

Hadronic Shower
(on earth mainly muons and neutrinos)

The Atmospheric Cherenkov Technique

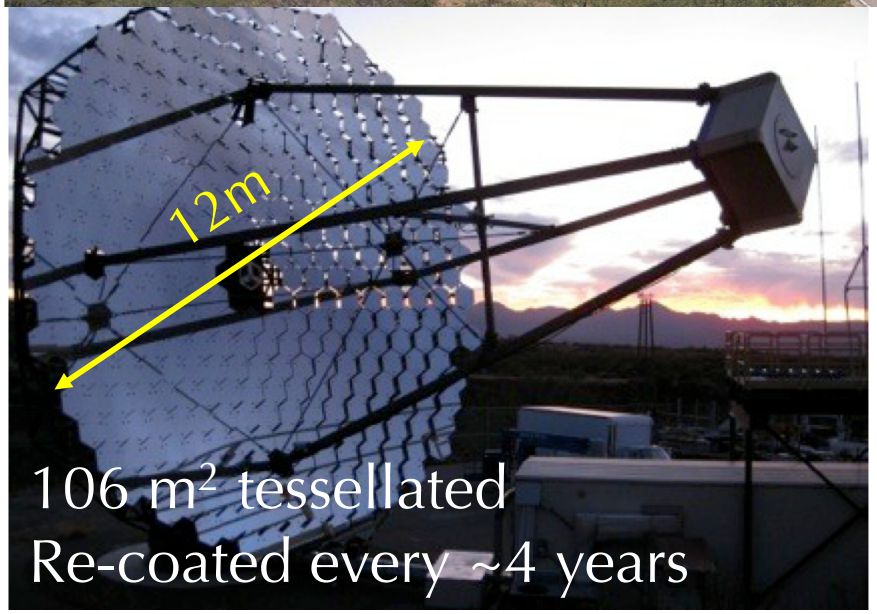


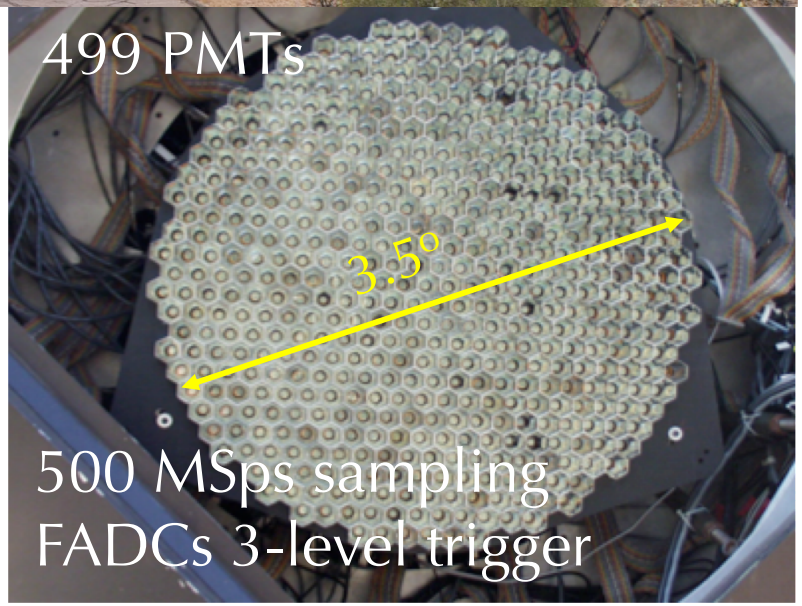
Whipple Observatory



VERITAS Cherenkov Telescope

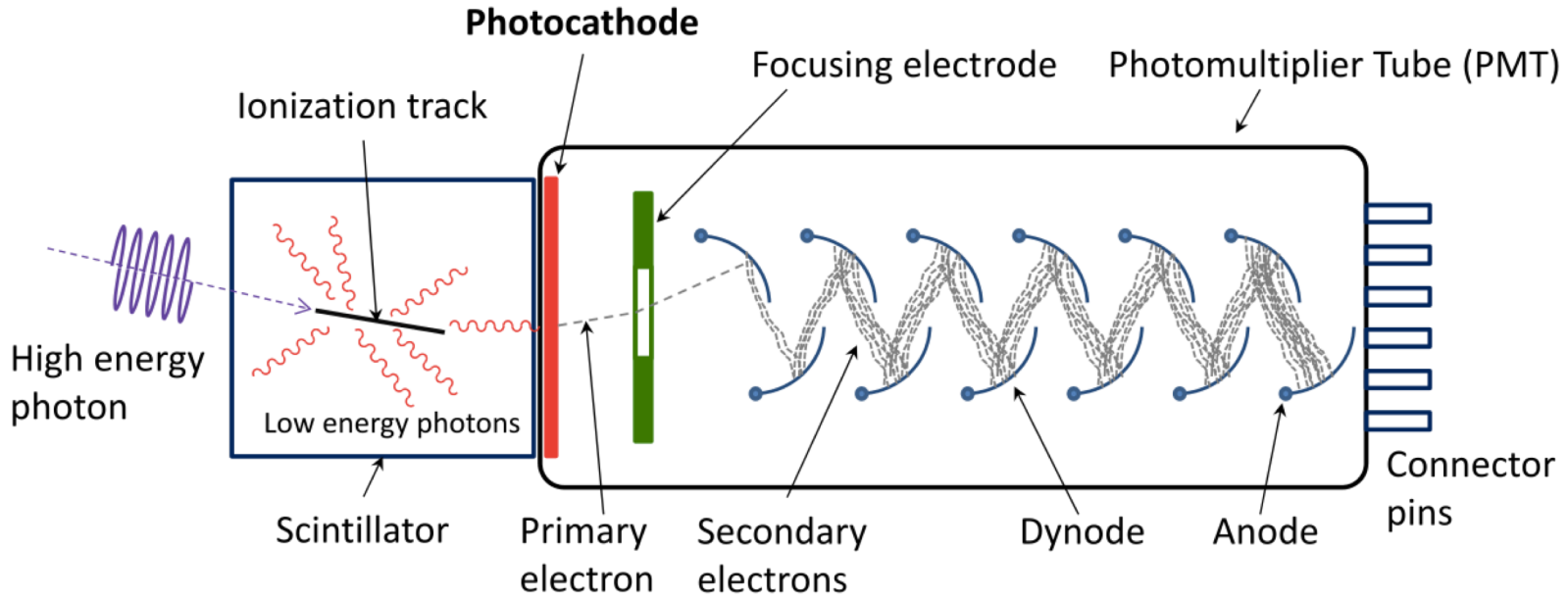
- Sensitivity: 1% Crab in ~25 hr
- Energy range: 100 GeV to 30 TeV





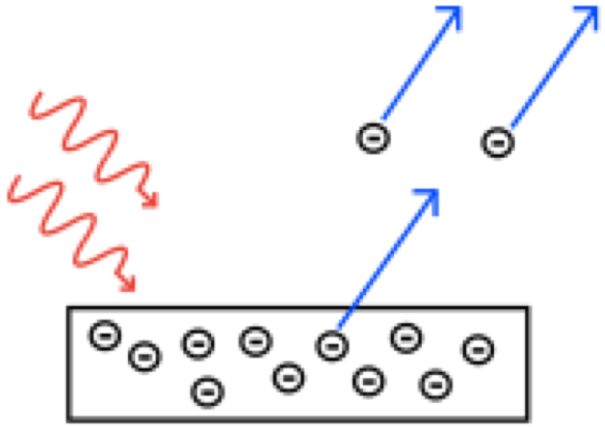
VERITAS

Quantum Physics in Action



Photomultiplier tubes (PMTs) from Hamamatsu Photonics

Photoelectric Effect: Light Matter Interaction



VHE Telescopes (2019)

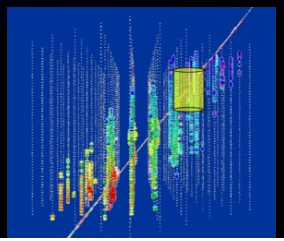
VERITAS

MAGIC

ARGO / YBJ

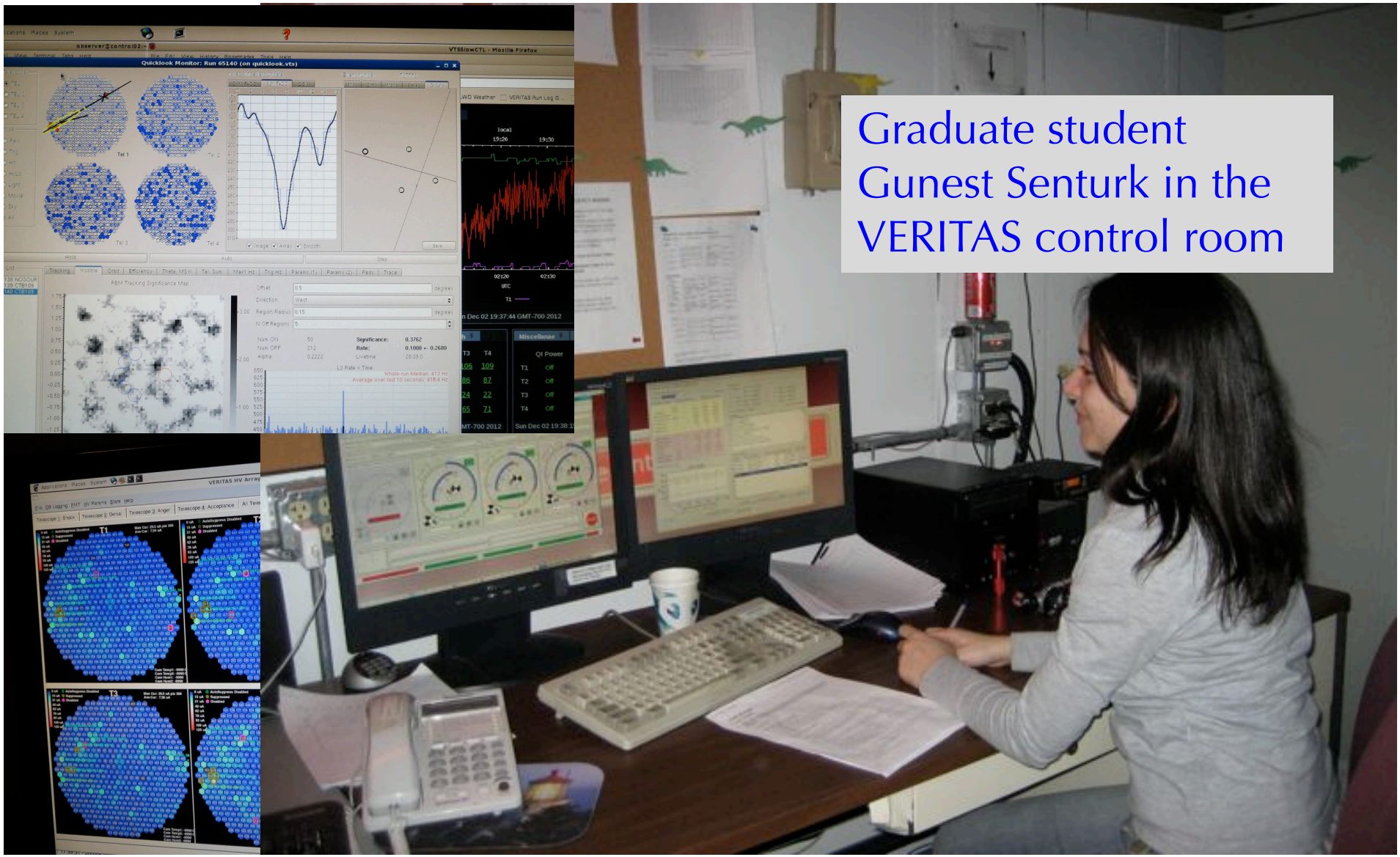
HAWC

HESS



IceCube

A VERITAS Shift

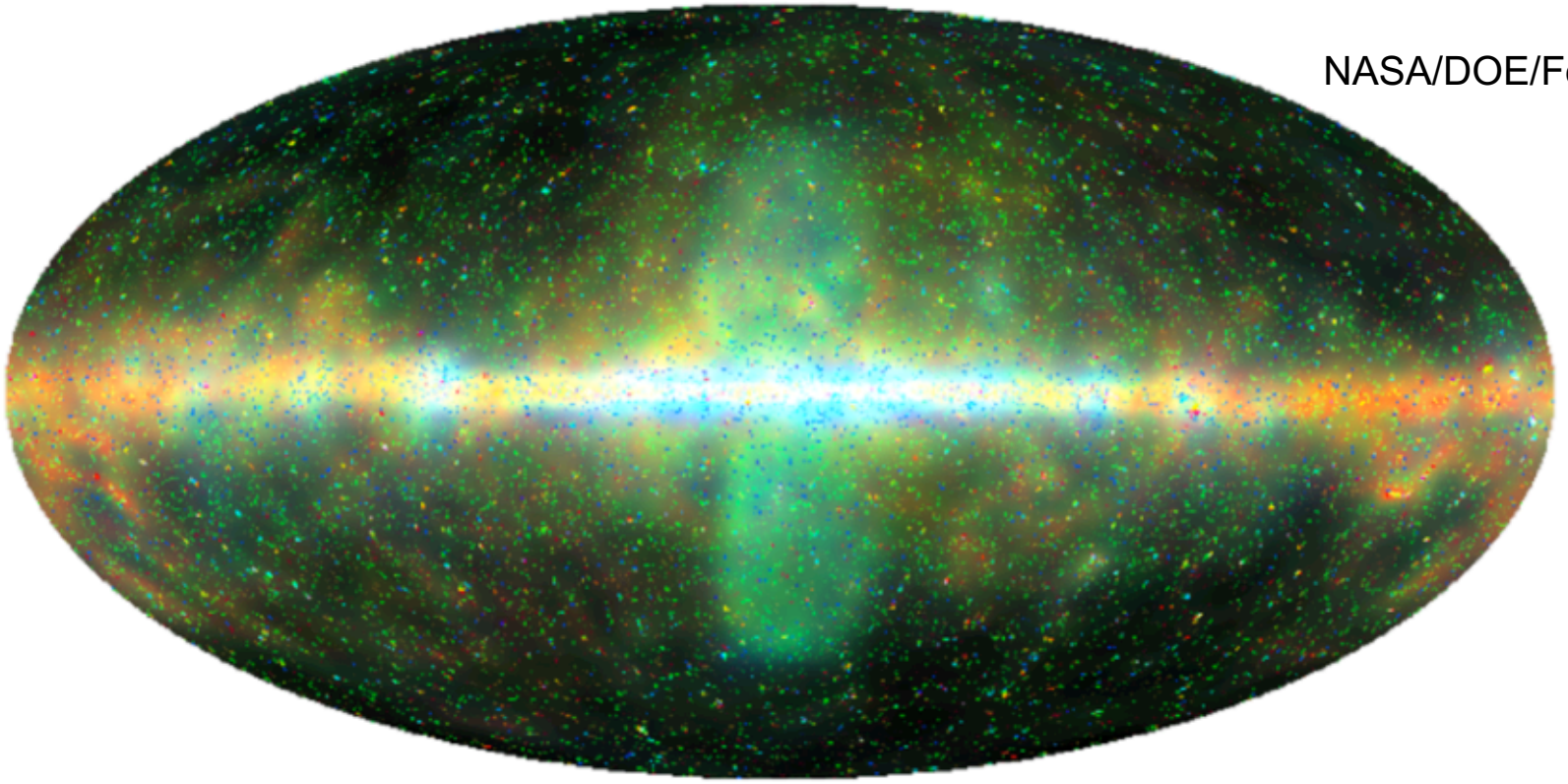


The Universe through γ rays

- Gamma-ray sky surveys and catalogues
- Pevatrons & Tevatrons in the outer Galaxy
- Relativistic Jets

Fermi-LAT γ-ray sky

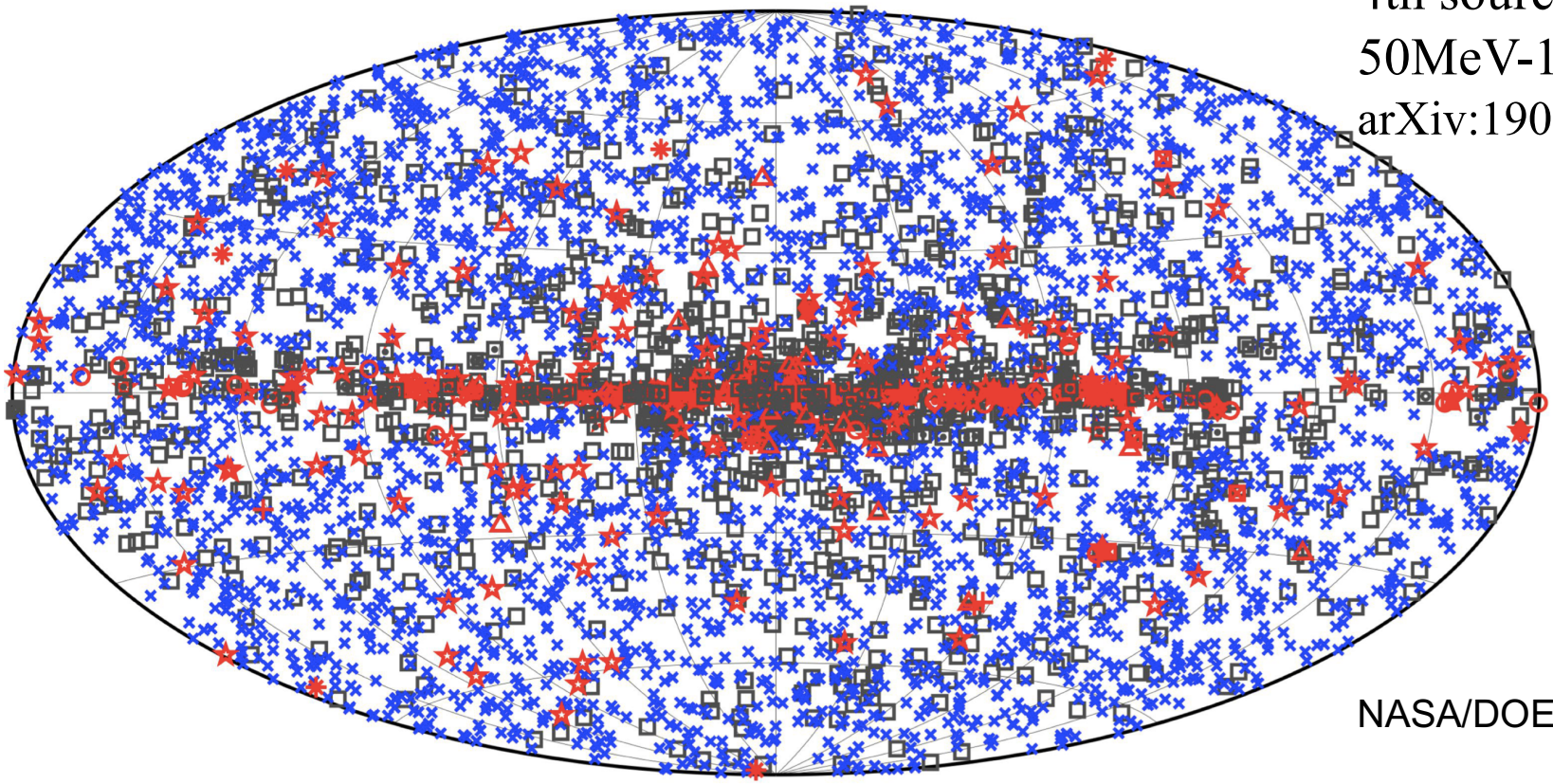
Gamma ray sky above 600 MeV in Galactic coordinates



- Log flux (red ~ 1 GeV. Blue ~ 300 GeV).
- Galactic diffuse emission dominates (~80% in the GeV range) ,below TeV energies.
- γ-rays from CRs interacting with the Galactic interstellar gas, via neutral pion decay.
- Diffuse emission also seen at TeV energies by H.E.S.S. (inner Galaxy) and by HAWC (Galactic Plane).

Fermi-LAT γ-ray sky

4th source catalog
50MeV-1TeV (8 yrs)
arXiv:1902.10045_v3

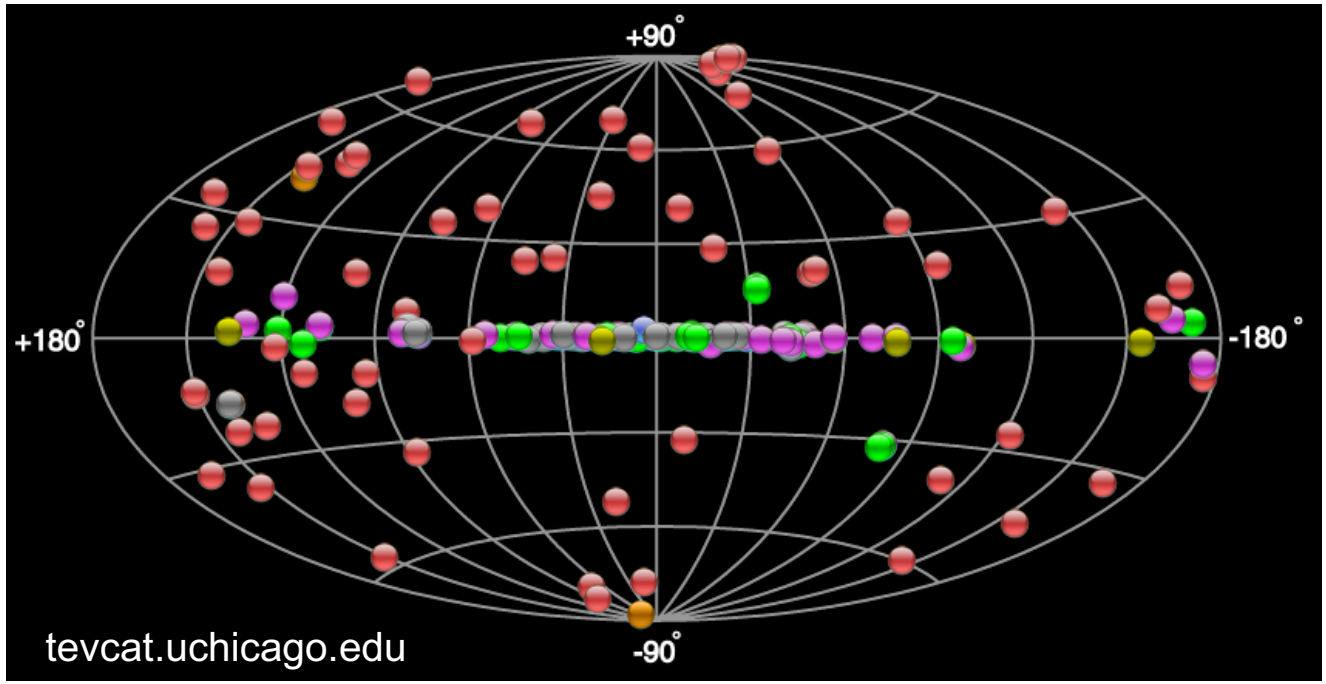


NASA/DOE/Fermi-LAT

- > 5000 sources > 100 MeV
- > 1550 sources above 10 GeV (3FHL) Fermi-LAT Collab., ApJS, 232 (2017)

VHE γ-ray Sky

- ~200 GeV and/or TeV emitters discovered
- representing 10+ source populations

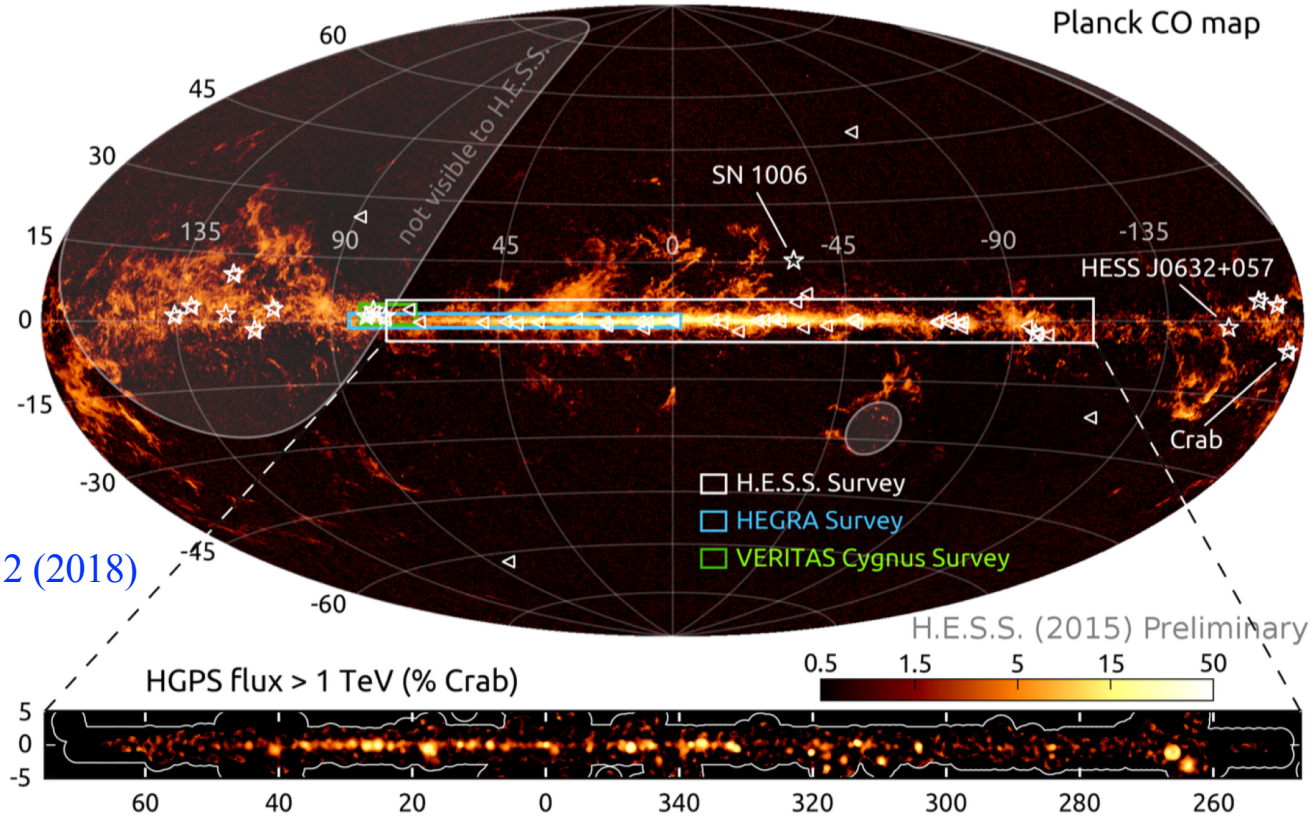


All gamma-ray sources are particle accelerators - factories of relativistic matter.

- Cosmic plasmas are easily heated up to keV temperatures (X-ray).
- Thus, particles (electrons and protons/nuclei) can be easily accelerated to TeV energies - almost everywhere!

Gamma-Ray Surveys: H.E.S.S. GPS

The deepest and most comprehensive, high resolution (~ 0.1°) and sensitive (<2% Crab Nebula) survey of the Milky Way in very-high-energy γ-rays.

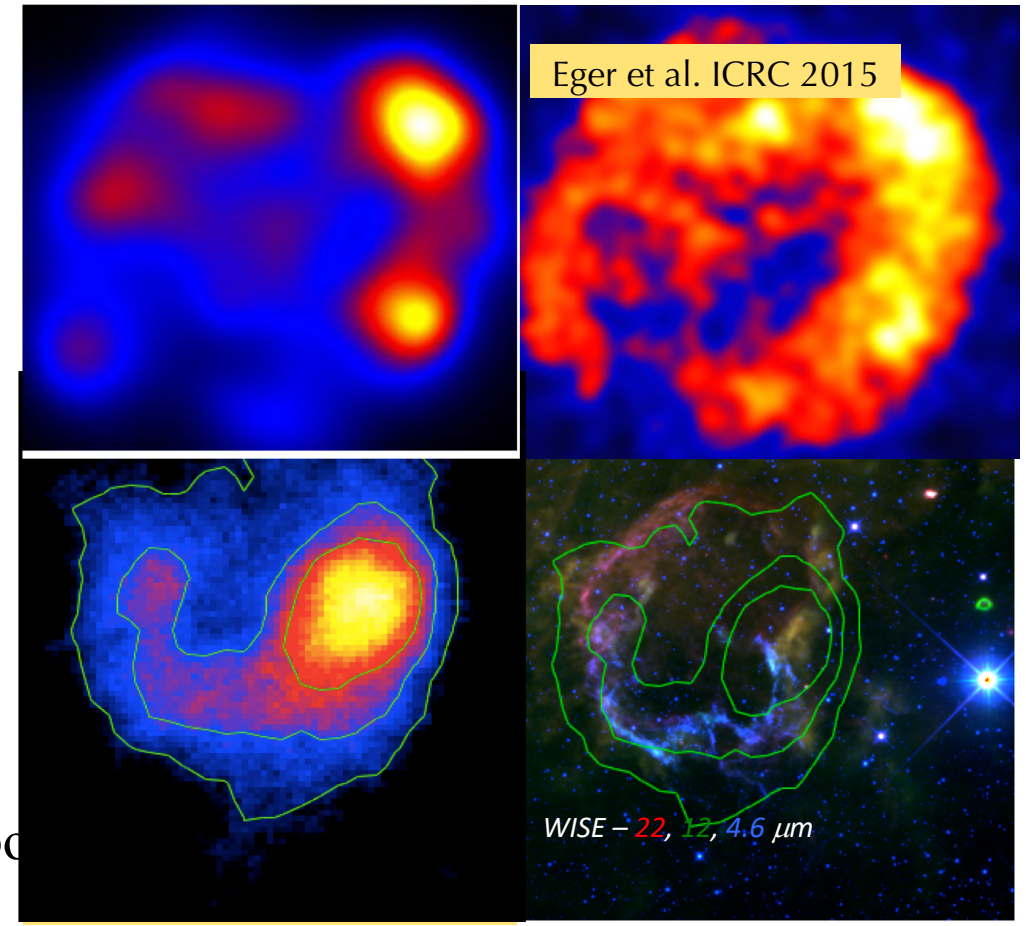


H.E.S.S. , A&A, 612 (2018)

- The Milky Way is aglow with TeV γ-ray emission!
- 78 sources, 36 unidentified. Different classes of Galactic sources.
- Population studies are now possible.

Supernova Remnants

- Detected at sub-TeV, TeV, sub-PeV
- Several young shell-type SNRs detected, but the main question "whether SNRs are main contributors to GCRs?" is not yet resolved.

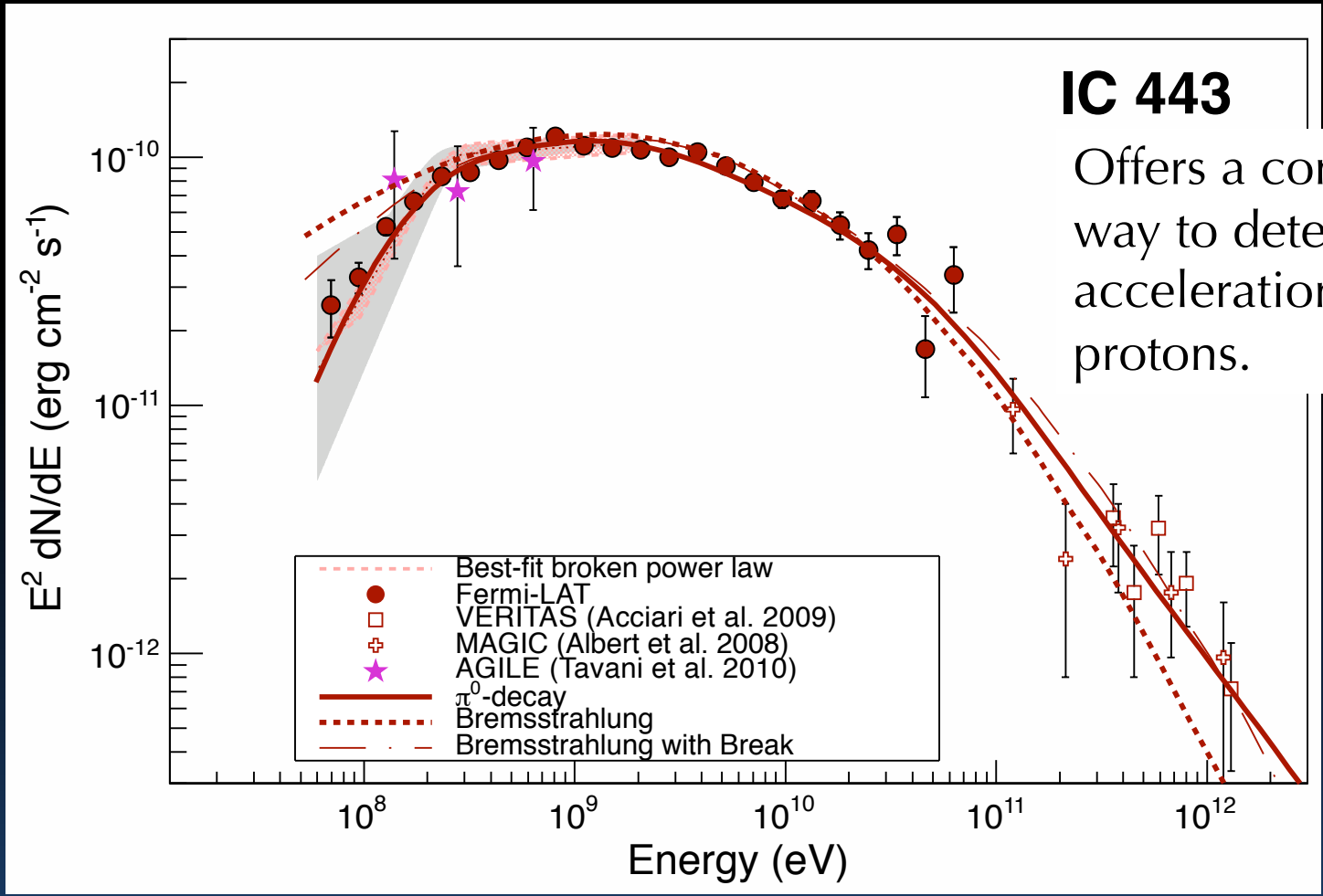


RX J1713.7–3946

IC 443
VERITAS Collabo

Cosmic rays?

Ackermann et al. 1302.3307

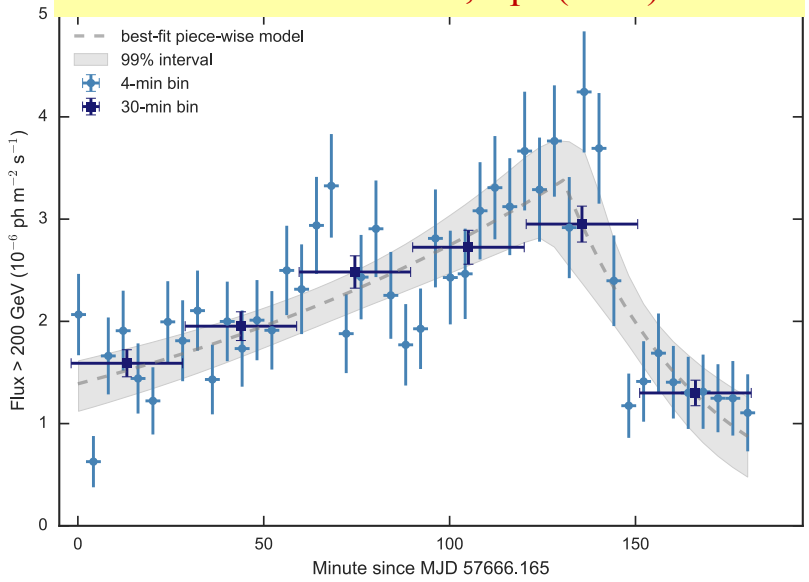


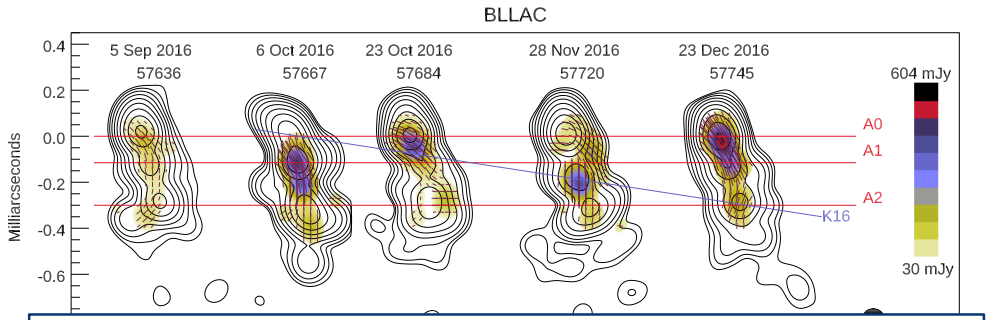
Offers a compelling way to detect the acceleration sites of protons.

- Fermi-LAT SED cutoff around 200 MeV, "pion bump," is direct indication of hadronic interactions.

Unique Capabilities: Short time scale variability

VERITAS Collaboration, ApJ (2018)



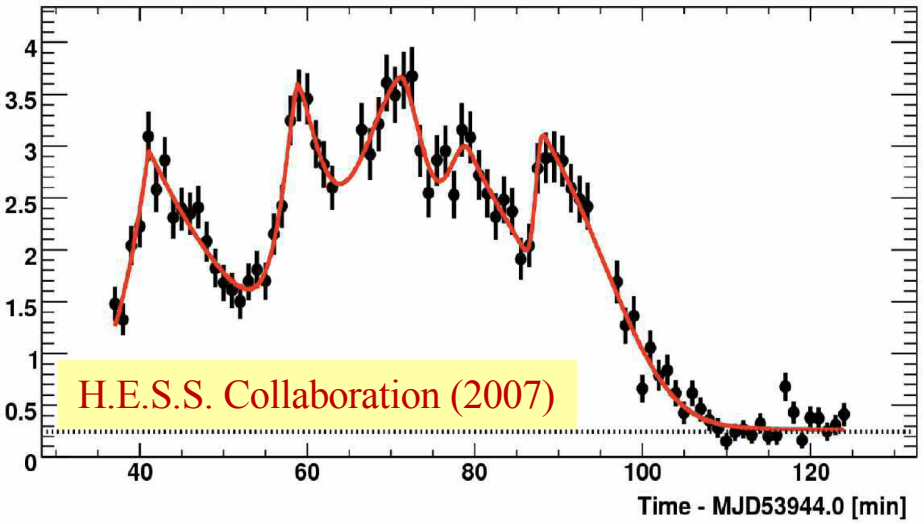


- BL Lac: Major flare in Oct 2016
- 150% Crab flux, $\tau \sim 36$ min.
- 43 GHz VLBA imaging, coincident knots
- $R < ct\delta/(1+z) < 12\ R_{Sch.}$

- Locating the emission region in the jet.
- Measuring minute-scale variability.

PKS 2155-304

- Peak flux ~15 x Crab
- Doubling times ~ 1-2 min
- $R_{BH}/c \sim 1...2 \times 10^4$

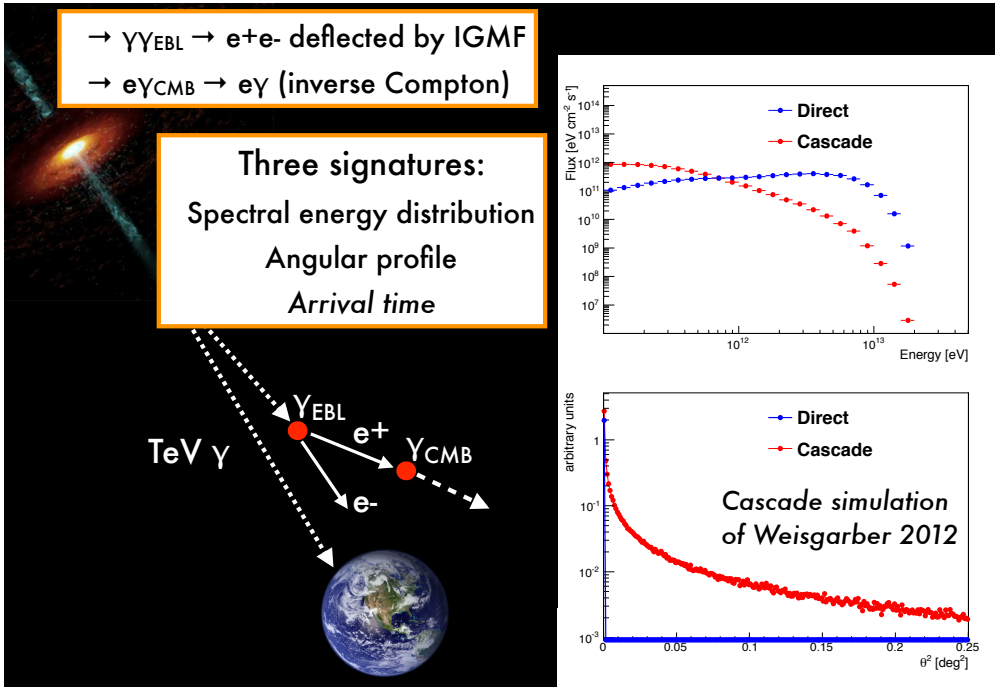


Classic flare from PKS 2155-304, still unbeatable!

Intergalactic Magnetic Field (IGMF)

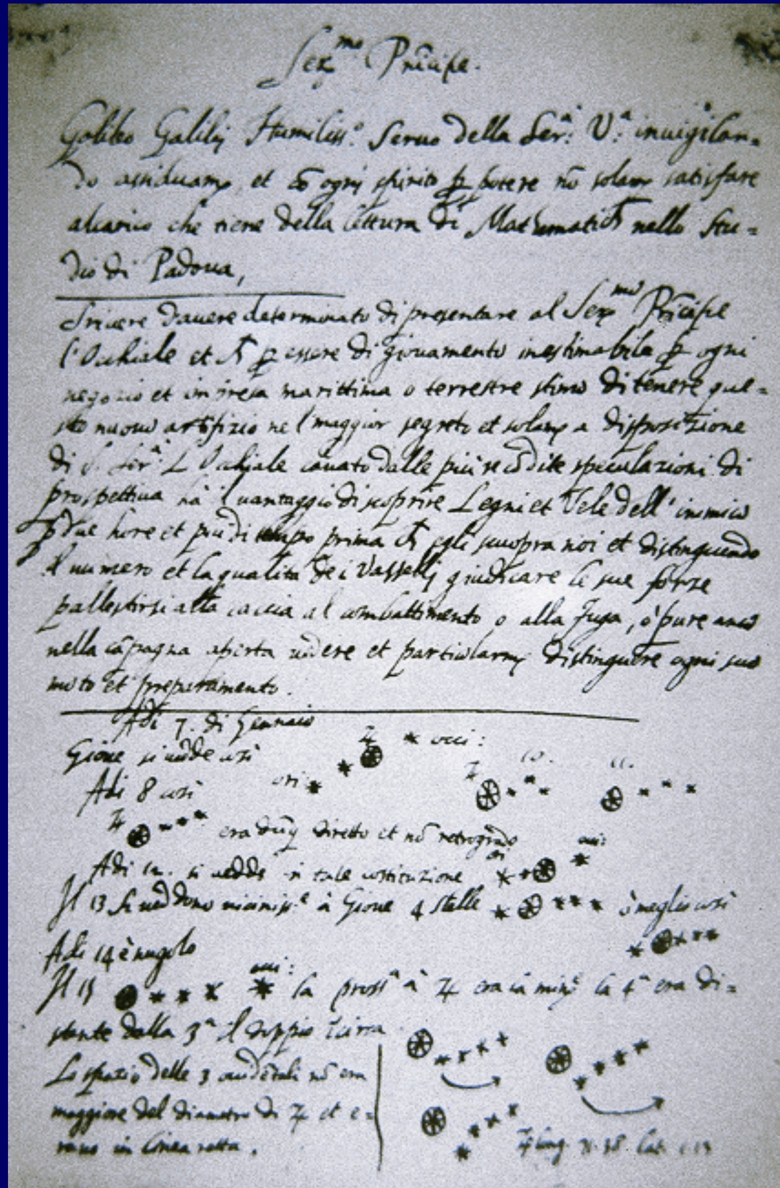
- How to produce strong B fields in galaxies/galaxy clusters?
→ IGMF as seed field?
- Produced in early universe
- Probe earlier era than CMB
- Search for IGMF-broadened cascade emission
- EBL produces e+e- pair, secondary particles bent by IGMF

- Search for angular extension in 7 BL Lacs
- → Exclude IGMF strengths (5-10)×10^{-15} G at 95% CL



Conclusion …

The New Astronomy (c1609)



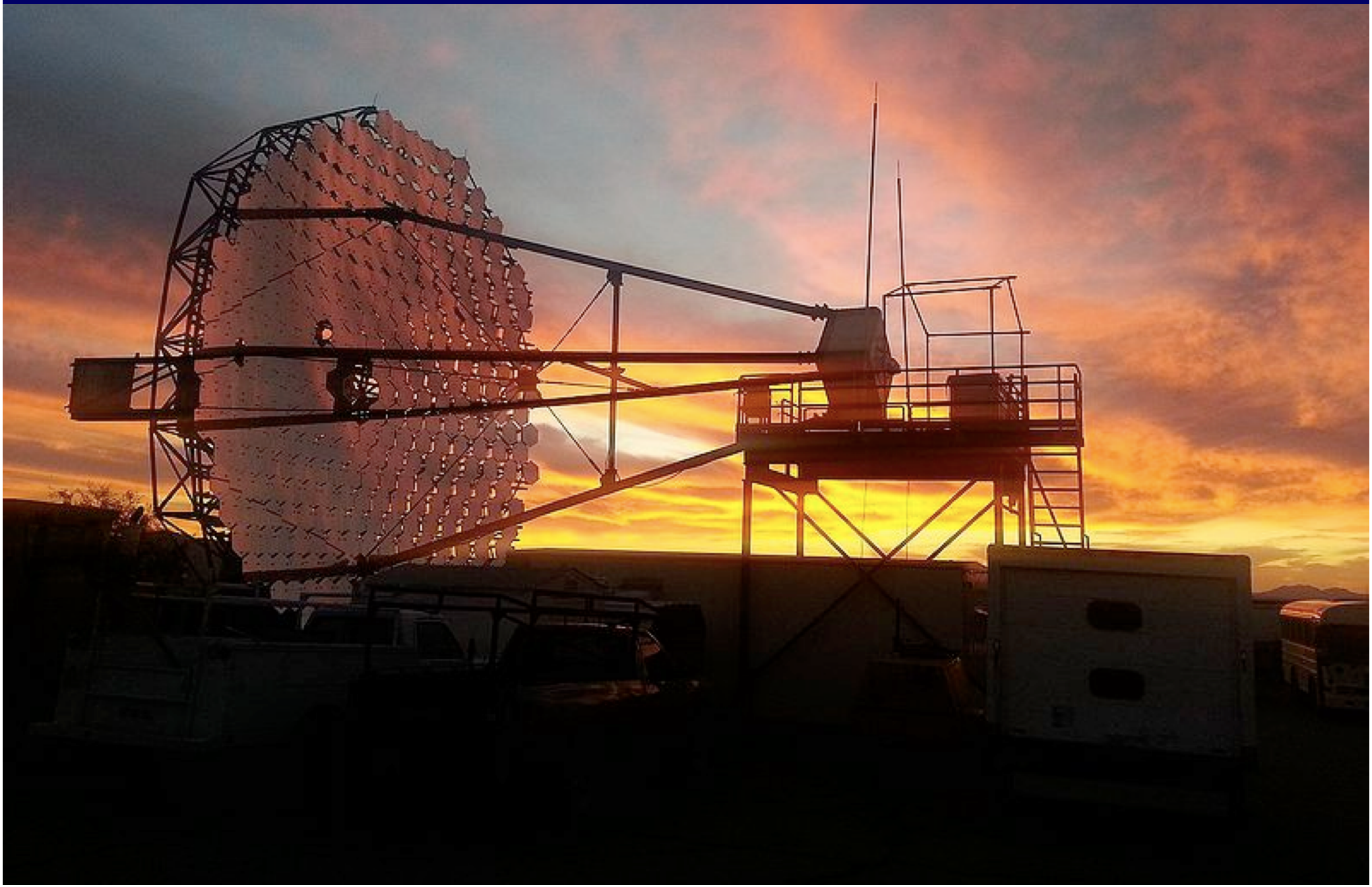
Ser.mo Principe.

Galileo Galilei Humiliss.o Servo della Ser.tà V.a invigilando assiduamente et con ogni spirito per potere non solamente satisfare al carico che tiene della lettura di Matematiche nello Studio di Padova,

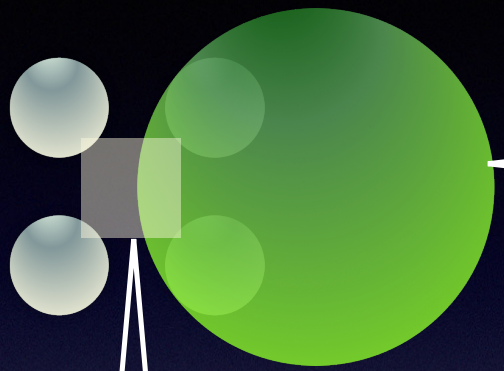
Havere determinato di presentare al Ser.mo Principe l'Occhiale et quello essere di giovamento inestimabile per ogni negozio et impresa marittima o terrestre stima di tenere questo nuovo artifizio nel maggior segreto et solamente a disposizione di V. Ser.tà L'Occhiale cavato dalle più recondite speculazioni di prospettiva ha il vantaggio di scoprire Legni et Vele dell'inimico due hore et più di tempo prima che egli scuopra noi et distinguendo il numero et la qualità de i Vasselli giudicare le sue forze pallestirsi alla caccia al combattimento o alla fuga, o pure ancora nella campagna aperta vedere et particolarmente distinguere ogni suo moto et preparamento.

Adì 7. di Gennaio
Giove si vedde così
Adì 8 così
era dunque diretto et non retrogrado
Adì 12. si vedde in tale costituzione
Il 13 si veddono vicinissime a Giove 4 stelle così
Adì 14 è nugolo
Il 15 così: la prossima a ♃ era la minore la 4a era distante dalla 3a il doppio in circa
Lo spatio delle 3 occidentali non era maggiore del diametro di ♃ et erano in linea retta.
♃ long. 71.38 Lat. 1.13

The New Astronomy (c2007)

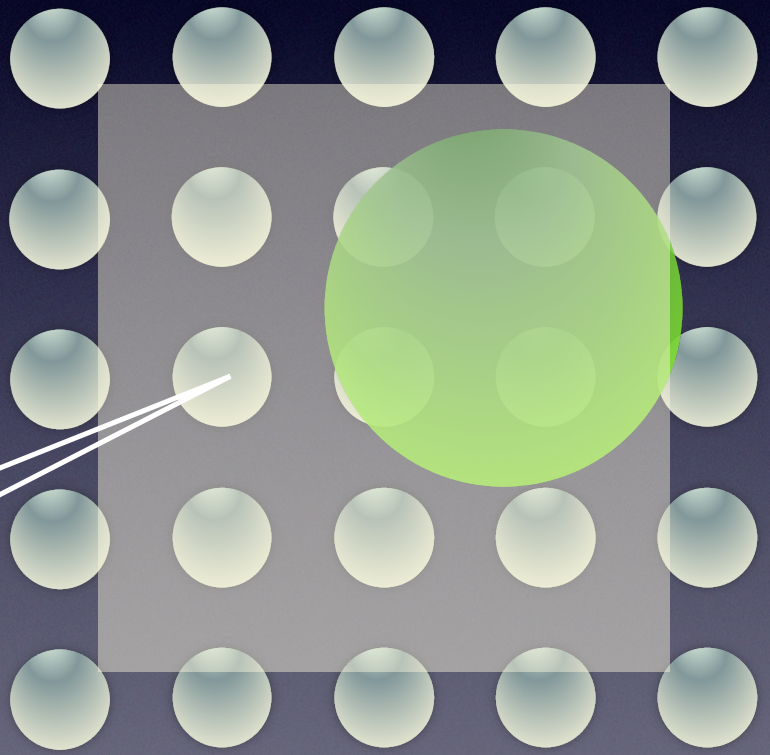


From Current Arrays to Future



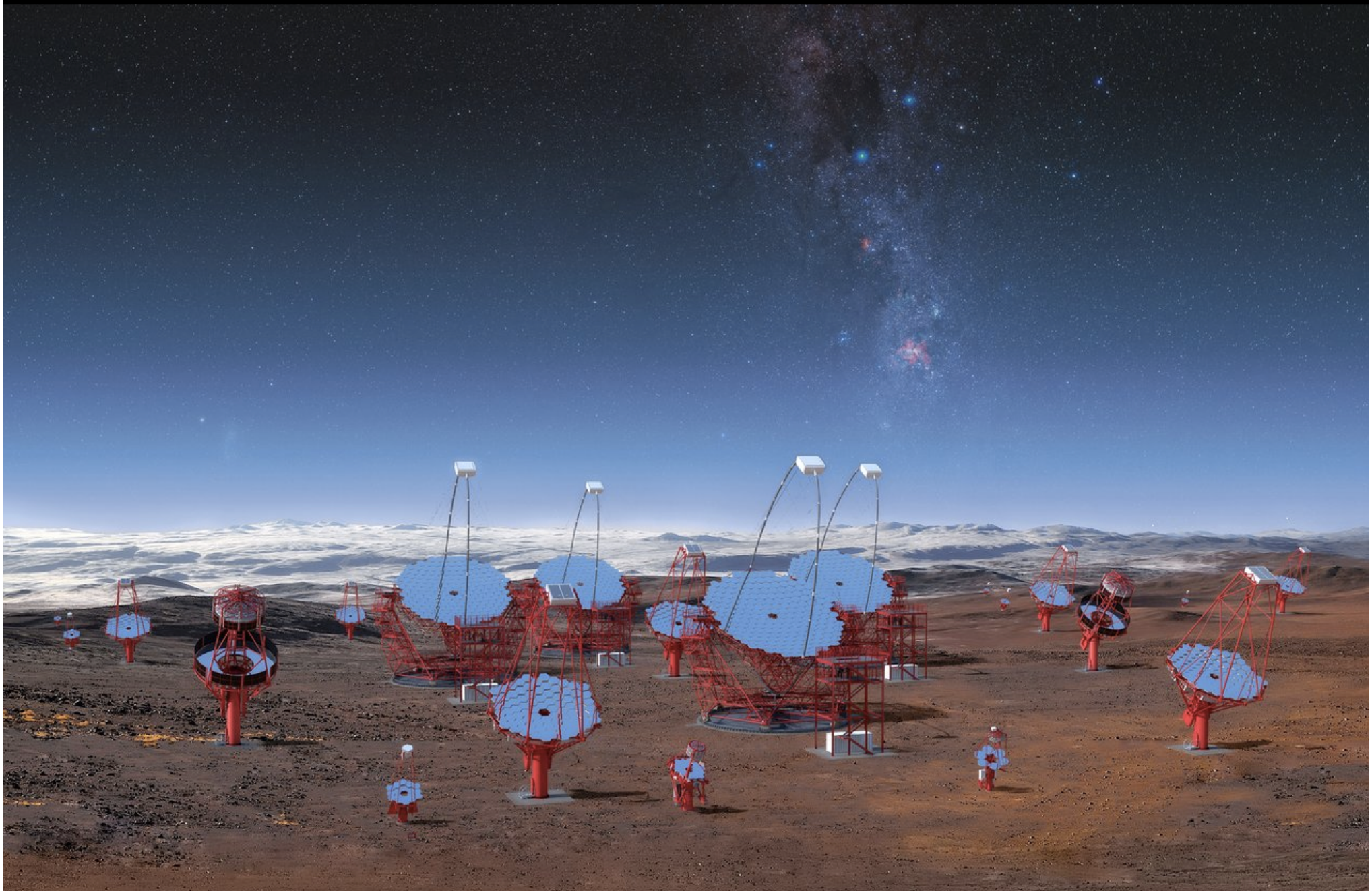
Light pool radius
R ≈ 100-150m
≈ typical telescope Spacing

- Sweet spot for best triggering & reconstruction…
- most showers miss it!

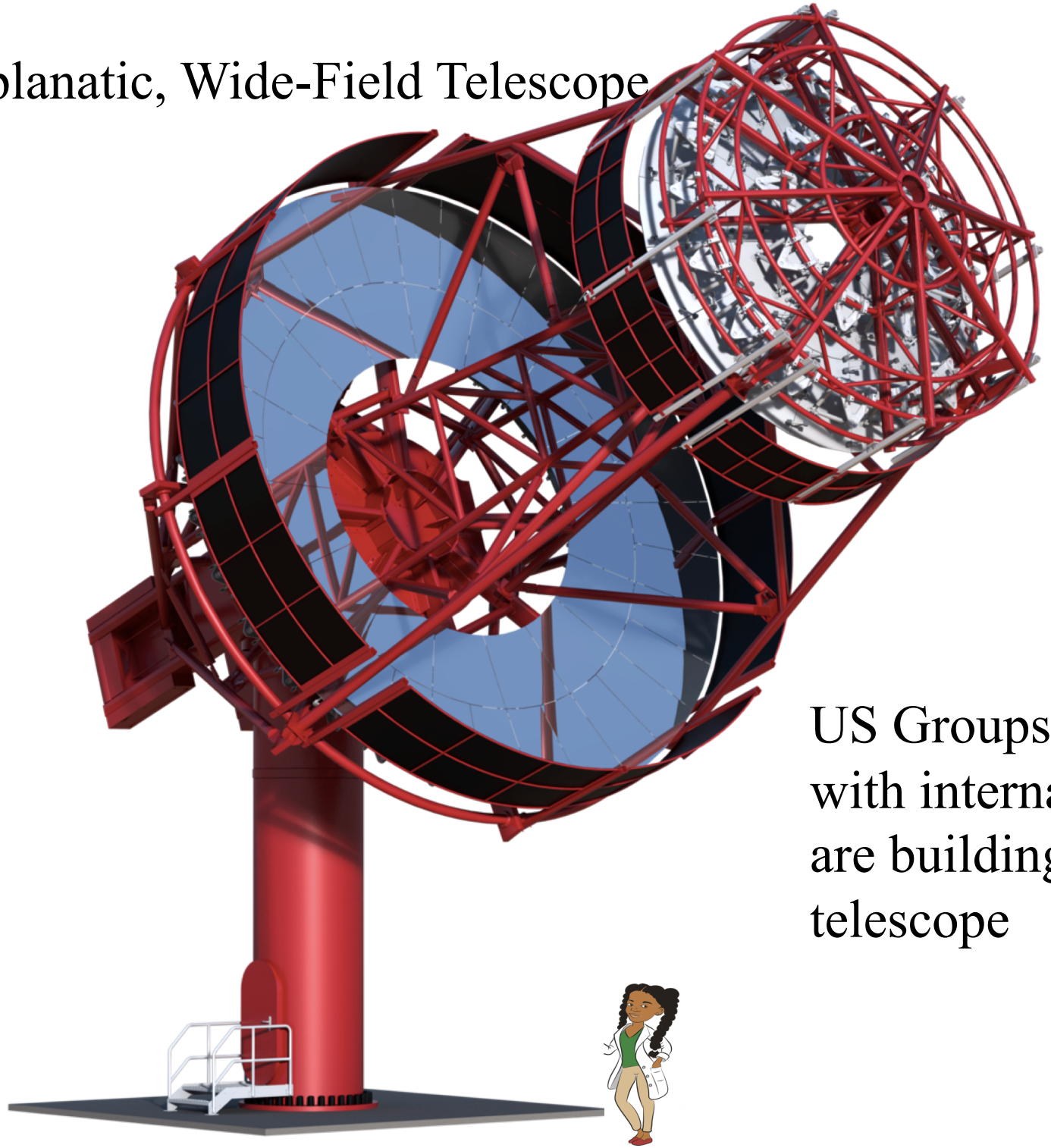


- Large detection Area
- More Images per shower
- Lower trigger threshold

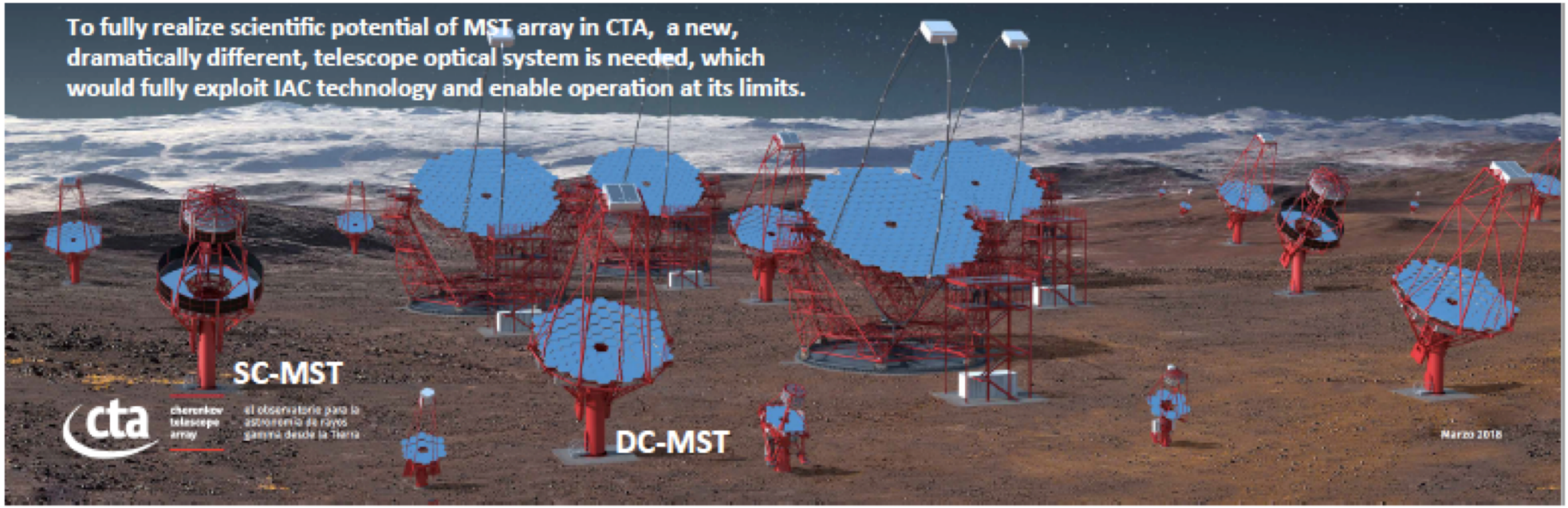
Cherenkov Telescope Array

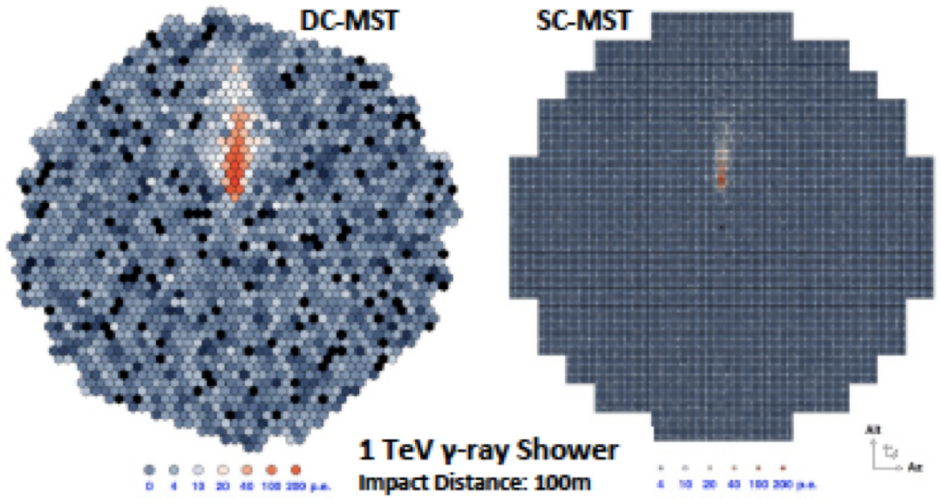


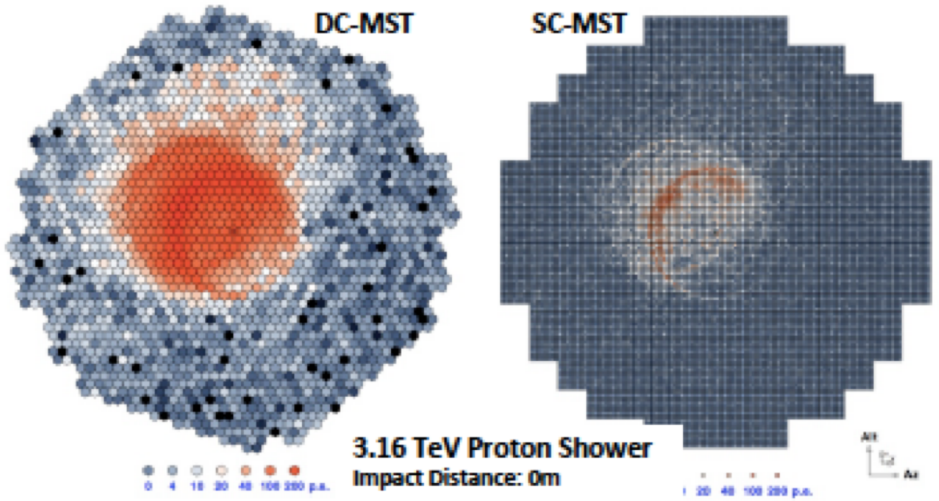
Aplanatic, Wide-Field Telescope



US Groups in collaboration with international partners are building an innovative telescope







DC-MST: 8 deg /0.18 deg / 1,570 pixels

SC-MST: 8 deg /0.067 deg /11,328 pixels

Some exciting news!

MEDIA INAF
Il notiziario online dell'Istituto nazionale di astrofisica

HOME CATEGORIE GALLERY MEDIAINAF TV INAF

IN ARIZONA, CON TECNOLOGIA MADE IN ITALY

Osservata con pSct la Nebulosa del Granchio

Il telescopio pSct – il più grande telescopio Schwarzschild-Couder, un prototipo dell'osservatorio di prossima generazione Cta – ha osservato la sua prima sorgente gamma, proveniente dalla Nebulosa del Granchio. Questo risultato, fondamentale per i futuri sviluppi di Cta, è stato possibile grazie a soluzioni tecnologiche innovative sviluppate in Italia dall'Inaf e dall'Infn

Ufficio Comunicazione Infn 02/06/2020 Tweet Share 374

Il telescopio pSct, un prototipo di telescopio di tipo Schwarzschild-Couder dell'osservatorio di prossima generazione Cherenkov Telescope Array (Cta), ha osservato la sua prima sorgente gamma, grazie a soluzioni tecnologiche innovative sviluppate in Italia dall'Istituto nazionale di astrofisica (Inaf), e dall'Istituto nazionale di fisica nucleare (Infn).

Inaugurato il 17 gennaio 2019 all'osservatorio Veritas (Very Energetic Radiation Imaging Telescope

About Research Education & Outreach Facilities

Scientists Detect Crab Nebula Using Innovative Gamma-Ra Proving Technology Viability

Release No.: 2020-11
For Release: Monday, June 1, 2020 - 3:00pm

Cambridge, MA - Scientists in the Cherenkov Telescope Array (CTA) consortium today ani meeting of the American Astronomical Society (AAS) that they have detected gamma rays from a prototype Schwarzschild-Couder Telescope (pSCT), proving the viability of the novel telesc gamma-ray astrophysics.

COLUMBIA NEWS

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Home News Archive Scientists Detect Crab Nebula Using Innovative Ga...

Scientists Detect Crab Nebula Using Innovative Gamma-Ray Telescope

First-of-its-kind telescope promises to shed new light on the physics of high-energy phenomena, from supernovae to dark matter.

By Carla Cantor
June 01, 2020

The Schwarzschild-Couder telescope, located at the Fred Lawrence Whipple Observatory in Amado, Arizona, detected gamma-ray showers from the Crab Nebula in early 2020, proving the viability of the technology design for gamma-ray astrophysics. Photo: Amy C. Oliver, Center for Astrophysics | Harvard & Smithsonian

Scientists have detected gamma rays from the Crab Nebula, the most famous of supernova remnants, using a next-generation telescope that

Prototype Schwarzschild-Couder Telescope Inaugurated at Fred Lawrence Whipple Observatory

Fred Lawrence Whipple Observatory, Amado, AZ
January 17-18, 2019

Amado, AZ - Expected to see first light in early 2019, a prototype Schwarzschild-Couder Telescope (pSCT) for gamma-ray astronomy will be unveiled in a special inauguration event on January 17, 2019 at the Center for Astrophysics | Harvard & Smithsonian, Fred Lawrence

Thanks to the VERITAS Collaboration

Please check out: http://veritas.sao.arizona.edu

Stay tuned for some exciting fireworks in the future!