

ATMON'10: Welcome, Logistics, Agenda

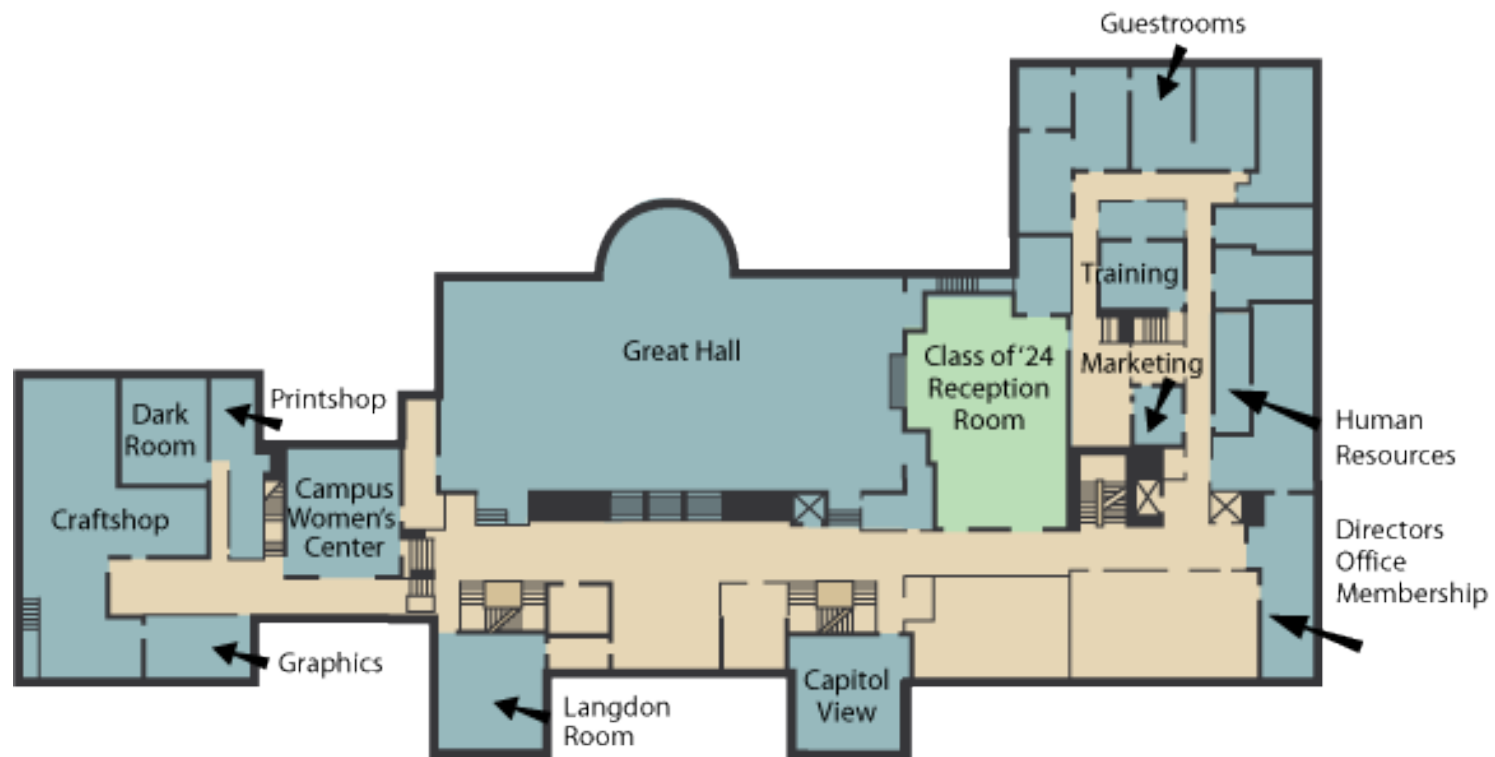
Segev BenZvi
University of Wisconsin – Madison

Logistics

- **Meeting Room:** different location tomorrow
- **Internet:** wireless access
- **Food:** options along State Street + group dinner
- **Transportation:** leaving Madison
- **Presentations**
- **Registration/Payment**

Meeting Room

- Today: “Old Madison Room”
- Tomorrow: “Class of '24” **Reception Room**



Internet

- **Wireless network keys** are available; get printouts with a name and key if you haven't already done so



Courtesy CERNLove

- Hold onto your printout: the keys are valid today and tomorrow
- Please try to **ignore** your computers until the breaks!

Food

- On your own:
 - Lunch today, tomorrow
 - Dinner tomorrow
- Cafeteria on first floor
- Food carts and restaurants on State Street: see handout
- Tonight: dinner at **Fresco**, rooftop of Overture Center near east end of State Street



Transportation

- Van Galder bus to Chicago-O'Hare: pick up directly outside Memorial Union, **\$27** one-way fare
- Taxis can be called for pick up to the airport
- Budget **15-20 minutes** for the taxi to arrive after you call (or arrange for a pickup time). Typical fare: **\$25**
- Budget **20-30 minutes** for travel to the airport, **15 minutes** for check-in/security
- Local cab companies:
 - **Union Cab**: (608) 242-2000
 - Madison Taxi: (608) 255-8294
 - Badger Cab: (608) 256-5566

Presentations

- Preferred: load your slides onto **this laptop** before your session begins
- Also acceptable: use your own laptop
- If using your own laptop, make sure **before the session** that it works with the projector
- Please also give the session convener a copy of the slides in a portable format

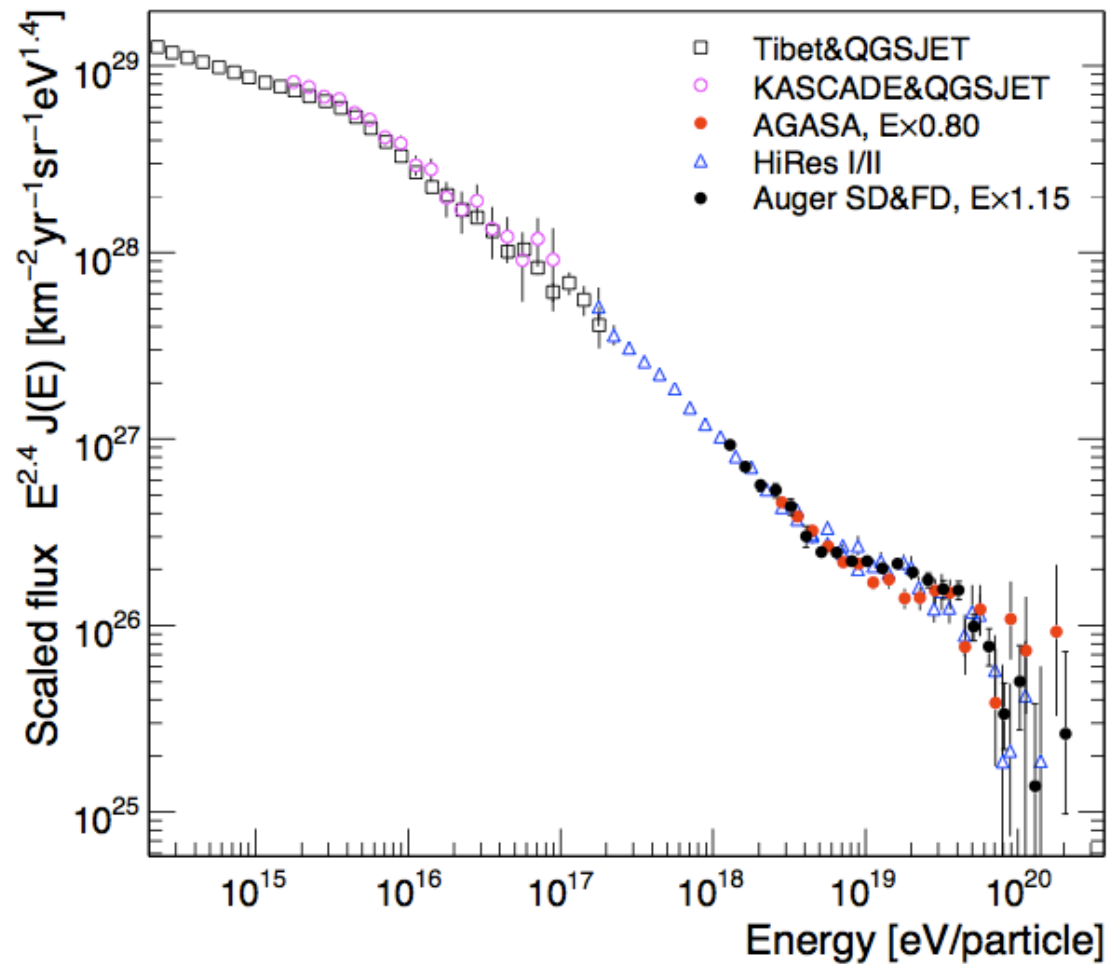
Registration and Payment

- Most of you have already registered and paid (thanks!)
- A few of you have not...
- Kim will be available **all day** to help you:
 - Credit card payment is preferred
 - We can provide receipts for cash payment
- Please complete the payment **today**. Thank you!

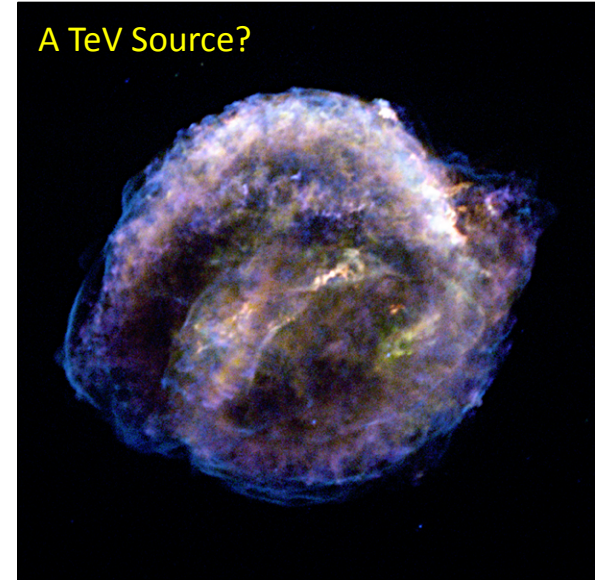
Introduction and Agenda

- Cosmic Rays and Air Shower Detectors
 - Air fluorescence detectors
 - Air Cherenkov detectors
- Monitoring techniques and atmospheric databases
 - Public satellite data
 - Raman and HSRL lidar
- Precision Ground-Based Astronomy
 - Example: light curve measurements
 - Monitoring needs
- Call for infrastructure funding: due Nov. 25, 2010

The Origins of Cosmic Rays



A TeV Source?



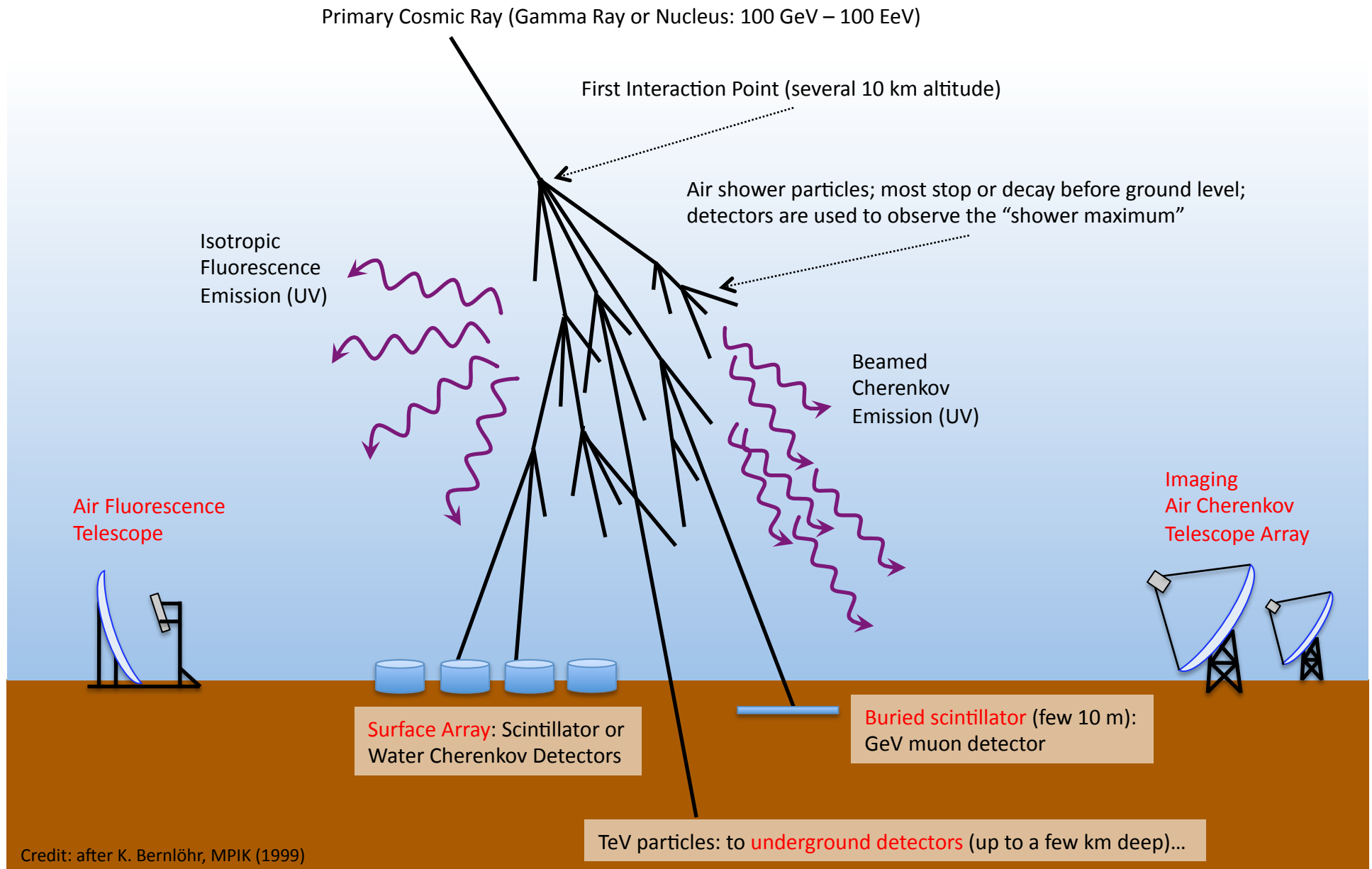
Kepler's Supernova – X-ray (CXC)

An EeV Source?

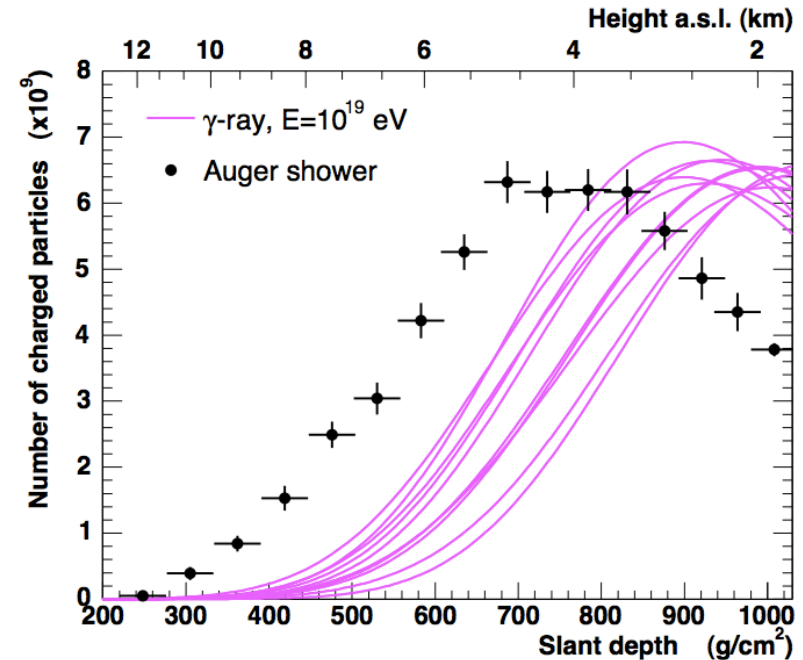
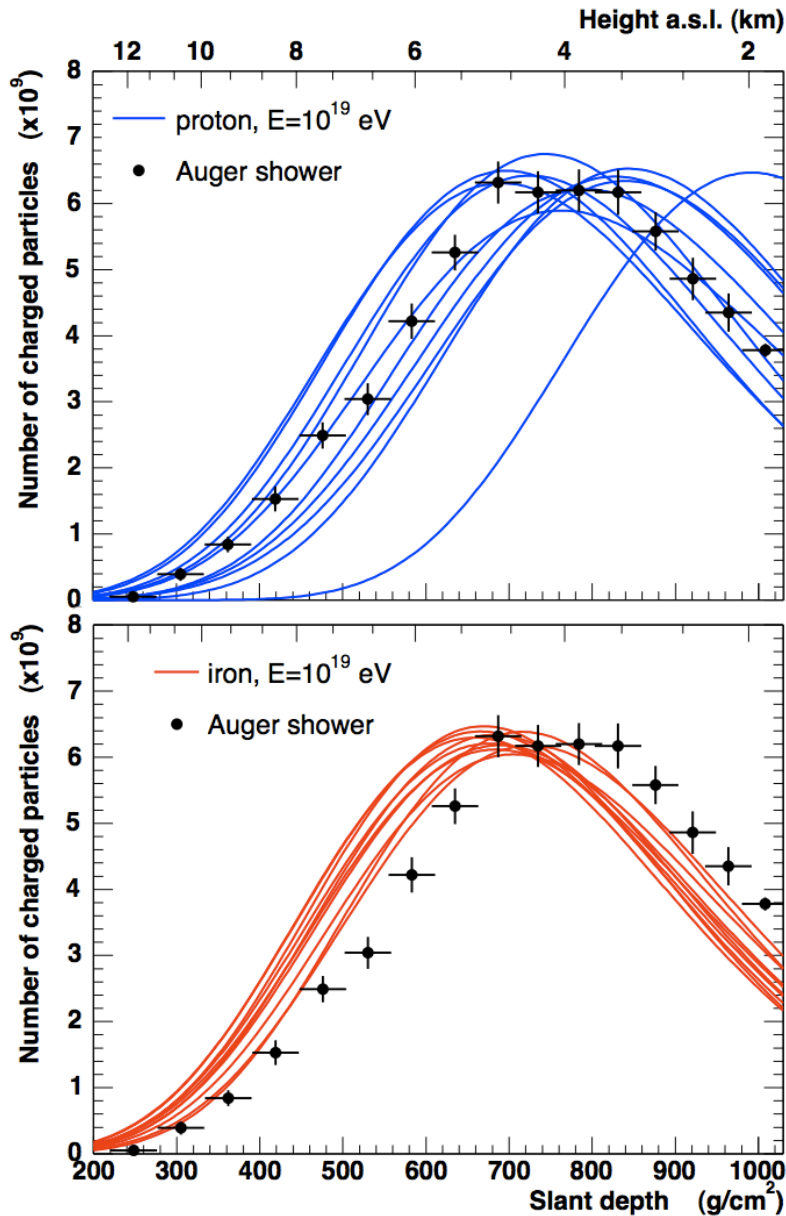


Cen A – Optical (ESO/WFI), Radio (VLA), X-ray (CXC)

Observing Cosmic Ray Air Showers



Shower Development



- Showers develop with a **characteristic shape**; lots of random fluctuation
- Depth/height of **maximum of shower** (X_{max} , D_{max} , h_{max}) depends on type of primary particle

The Atmosphere is a Calorimeter

- Number of charged particles as a function of atmospheric depth is proportional to energy deposit:

$$dE/dX = \alpha \times N(X)$$

- Number of **Cherenkov** photons is proportional to number of charged particles:

$$N_C(X) \sim N(X)$$

- Number of **fluorescence** photons is proportional to dE/dX :

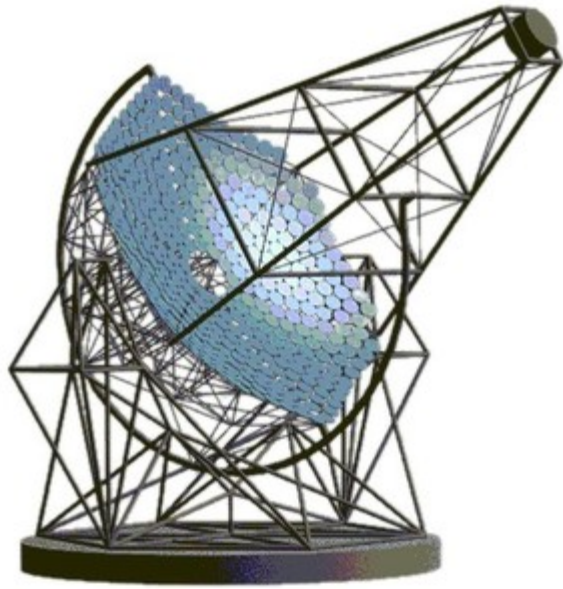
$$N_F(X) = Y(p, T, u) \times dE/dX$$

- Fluorescence production depends on weather-dependent light **yield** $Y(p, T, u)$; **talk by Maria Monasor tomorrow**

The Atmosphere: A Love/Hate Relationship

- The atmosphere is great!
 - For CR/ γ -ray experiments, the troposphere is our calorimeter
 - It is relatively transparent
 - Multiple scattering is a higher-order effect
 - In troposphere at near UV, we can basically ignore molecular absorption
- The atmosphere is awful!
 - It is constantly changing
 - Time scales of aerosol, cloud, state variations differ greatly
 - Conditions affect light transmission *and* light production
 - Aerosols are important: showers viewed at low elevation angles, across long distances, through particle boundary layer

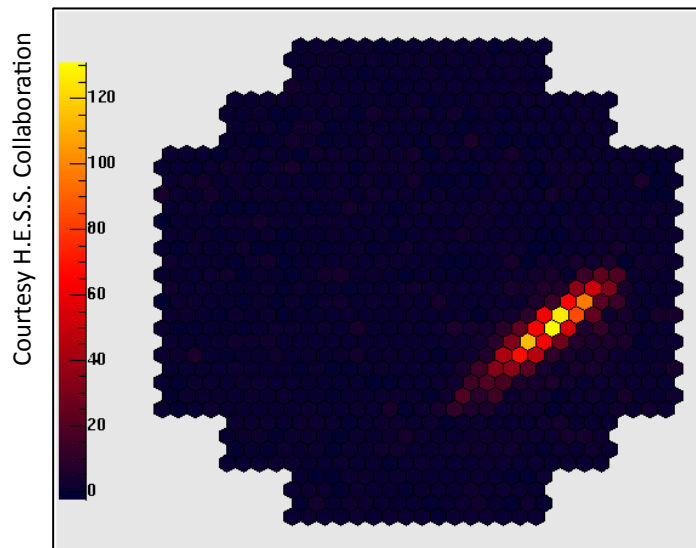
Imaging Air Cherenkov Technique (IACT)



- Cherenkov light from air showers can be recorded with UV telescopes (~ 10 m reflectors)

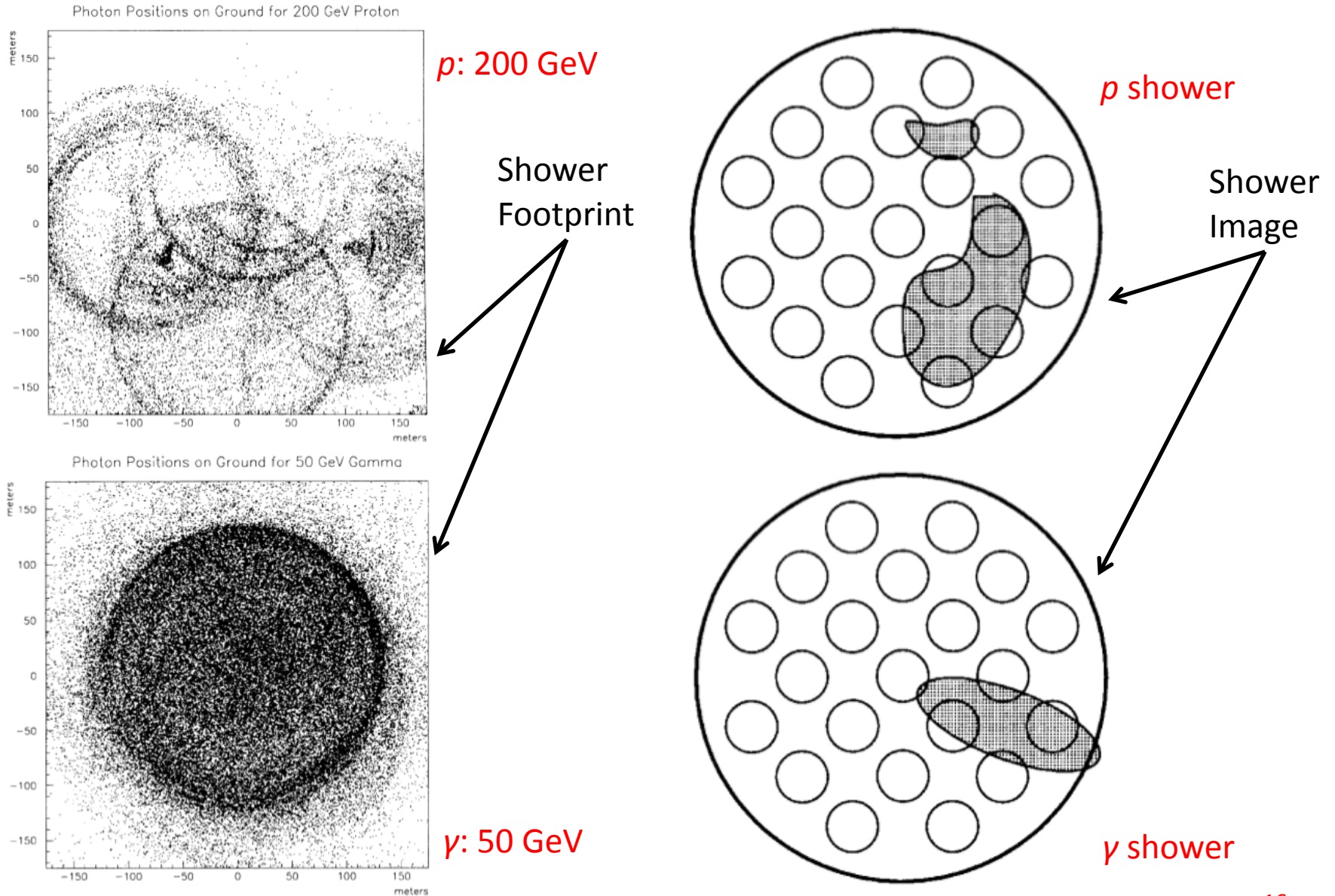
- **Advantages:**

- Excellent angular resolution (0.1°)
- Excellent gamma/hadron separation
- High sensitivity to point sources

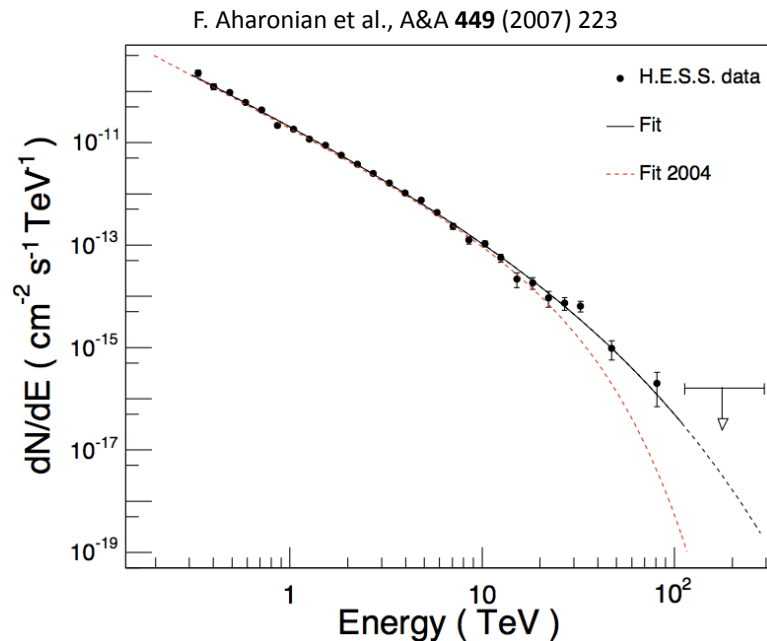


- But, energy reconstruction depends on correct estimates of:
 - Shower size
 - Shower max height (D_{\max}, h_{\max})
- Both can be **distorted** by clouds and aerosol layers

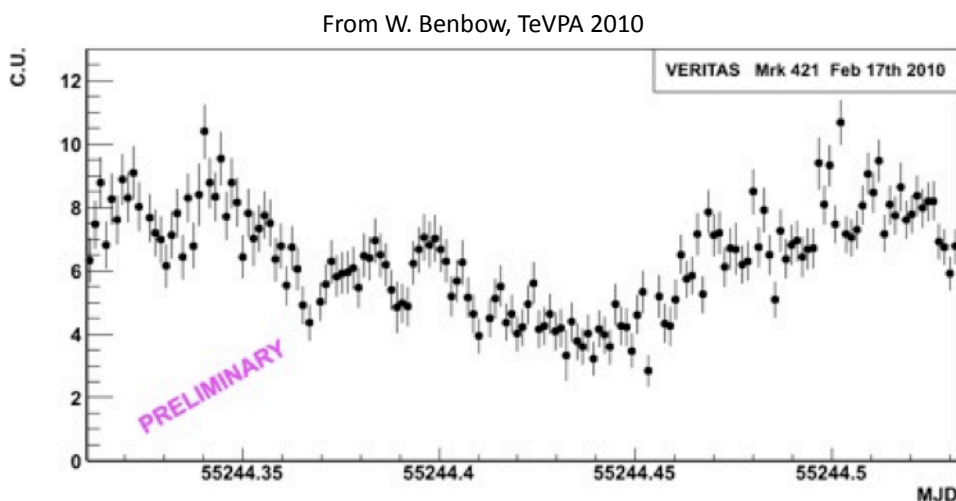
Air Cherenkov Detector Operation



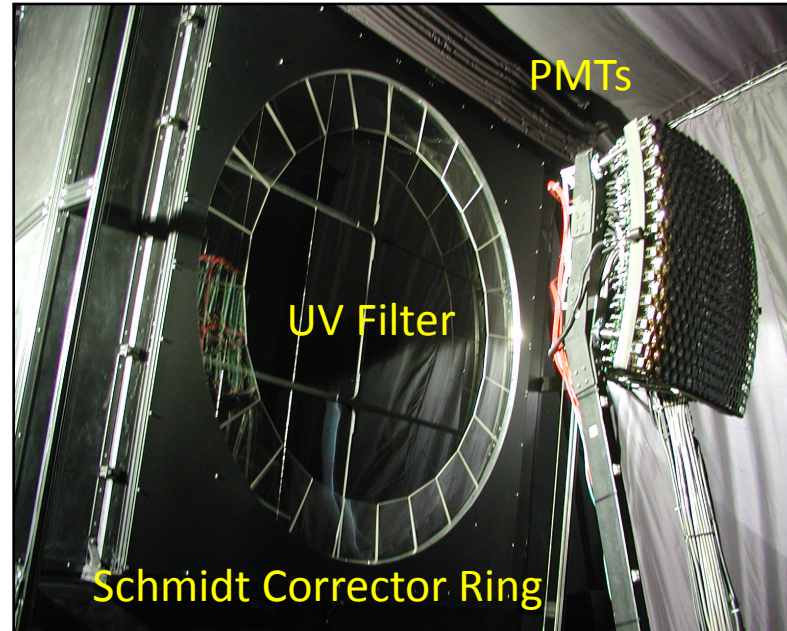
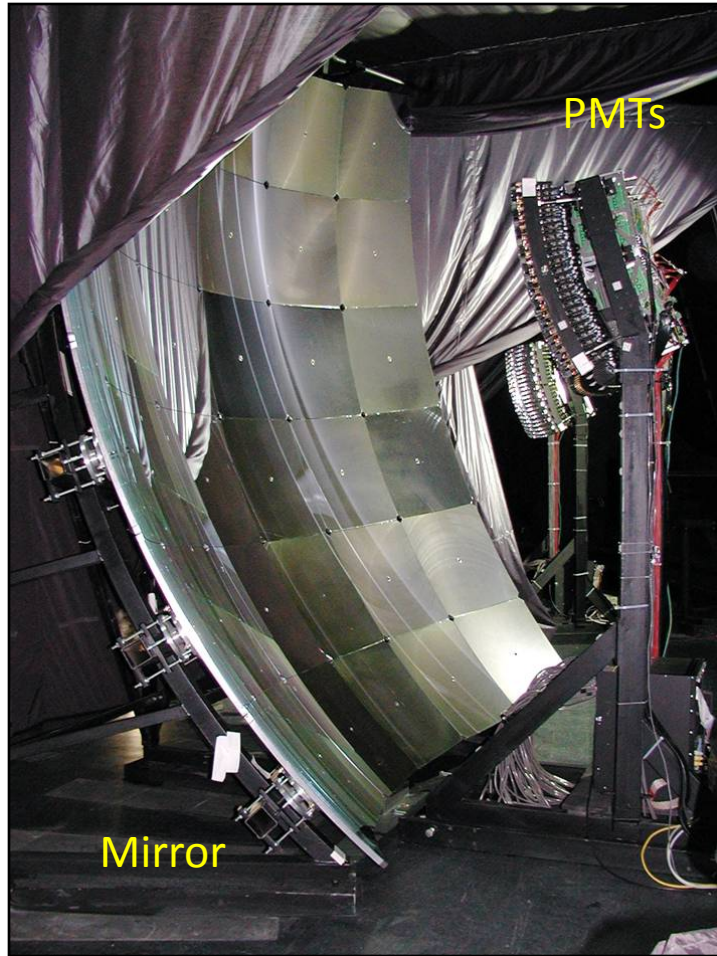
Motivation for Atmospheric Monitoring



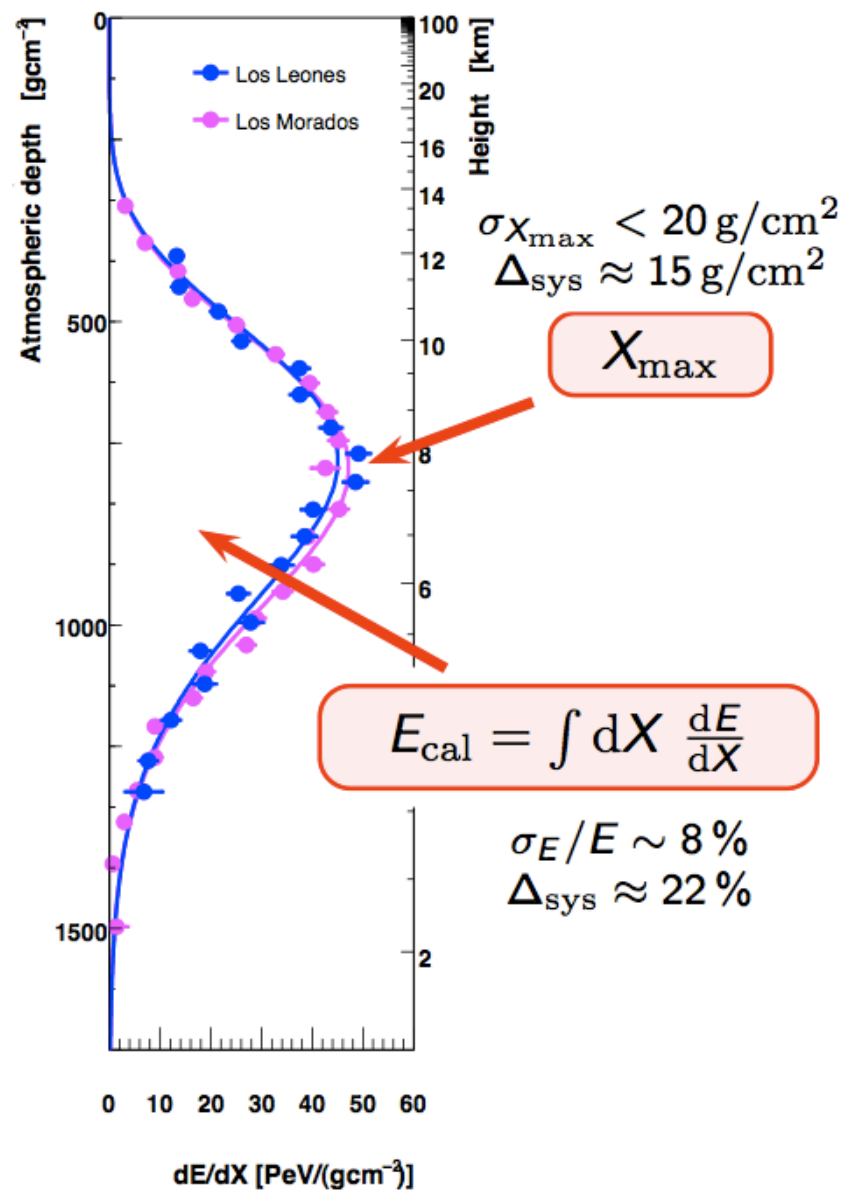
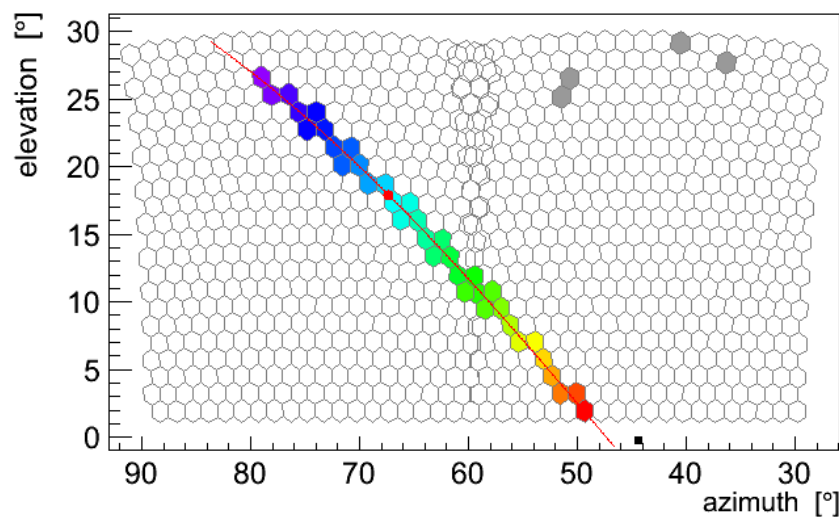
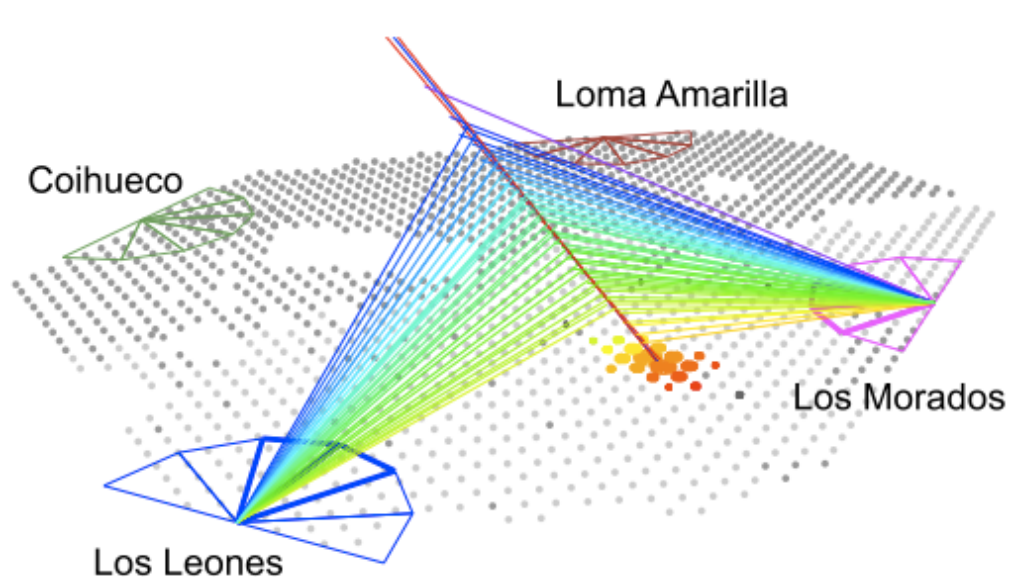
- Atmospheric variations affect measurements of:
 - Absolute fluxes
 - Energy scale
 - Shower maximum position
- Spectra hint at hadronic or leptonic **origins** of gamma rays (esp. cutoffs)
- Also: sources are known to exhibit **flaring/intrinsic variability**



Air Fluorescence Telescopes



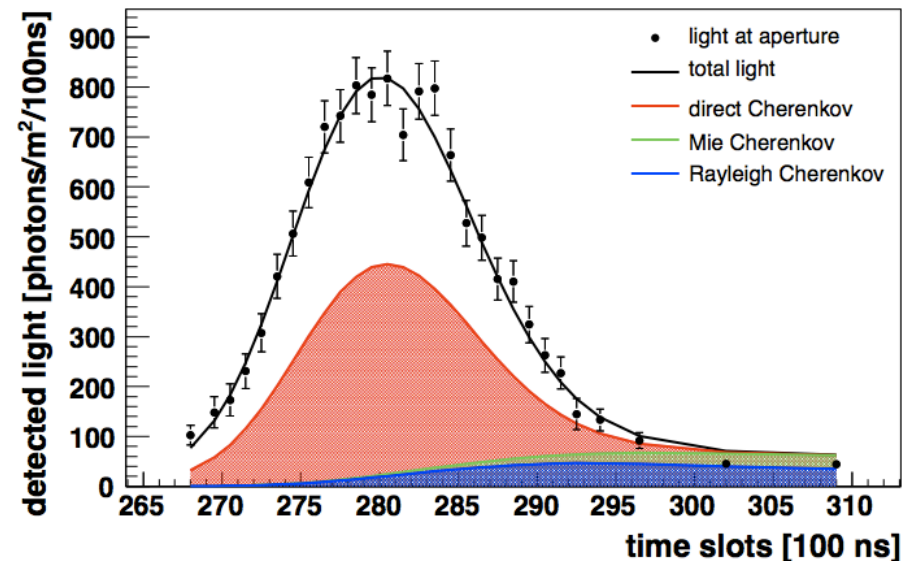
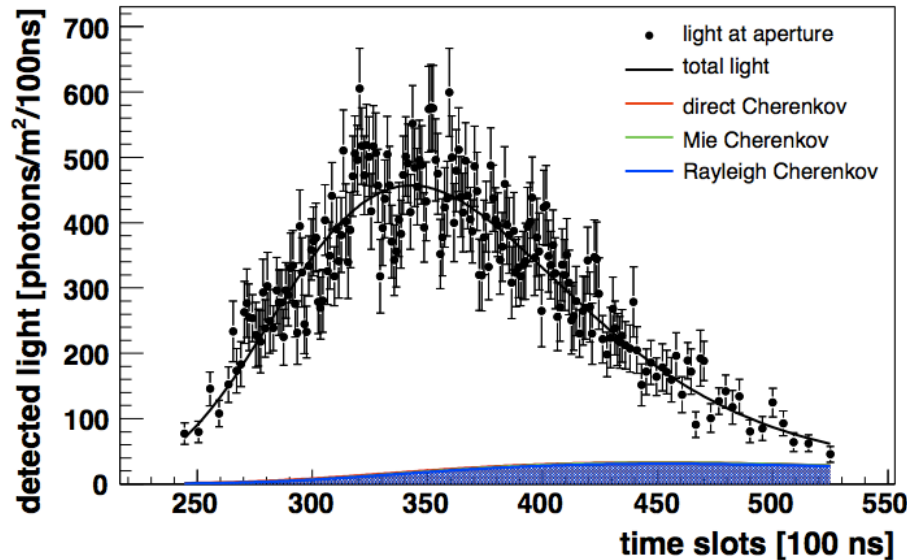
Fluorescence Detector Operation



From R. Ulrich, APS 2010

dE/dX Dependence on Atmosphere

From F. Schüssler, ATMON'08

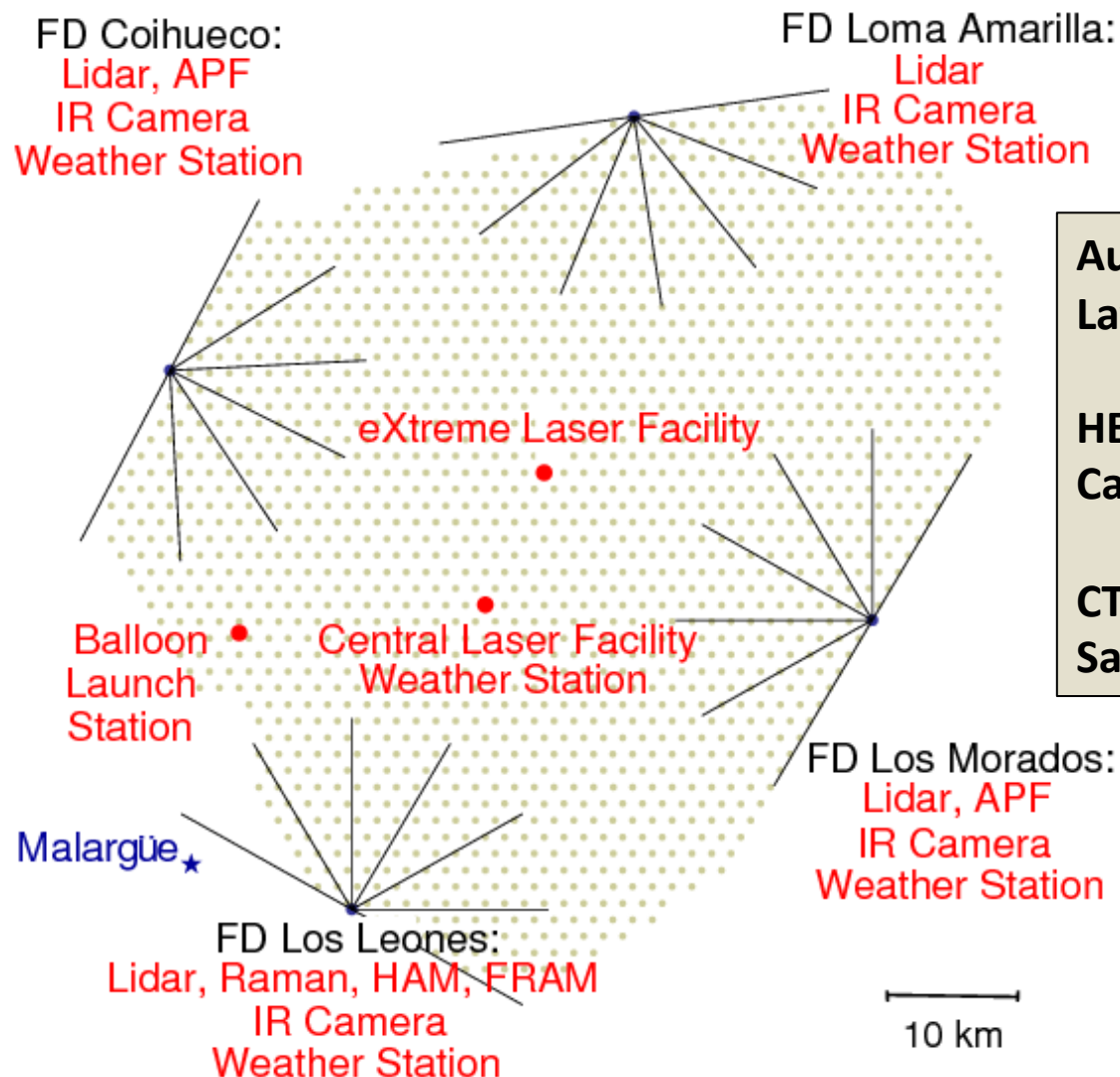


- Shower profile estimate: **simultaneous fit** to fluorescence and Cherenkov components
- Direct and scattered Cherenkov contribution depends on shower-detector geometry and atmospheric transmission
- Fit requires **molecular + aerosol scattering measurements** as input

Atmospheric Monitoring Techniques used in the Field

Example: Pierre Auger Observatory

Pierre Auger Observatory Atmospheric Monitoring Program

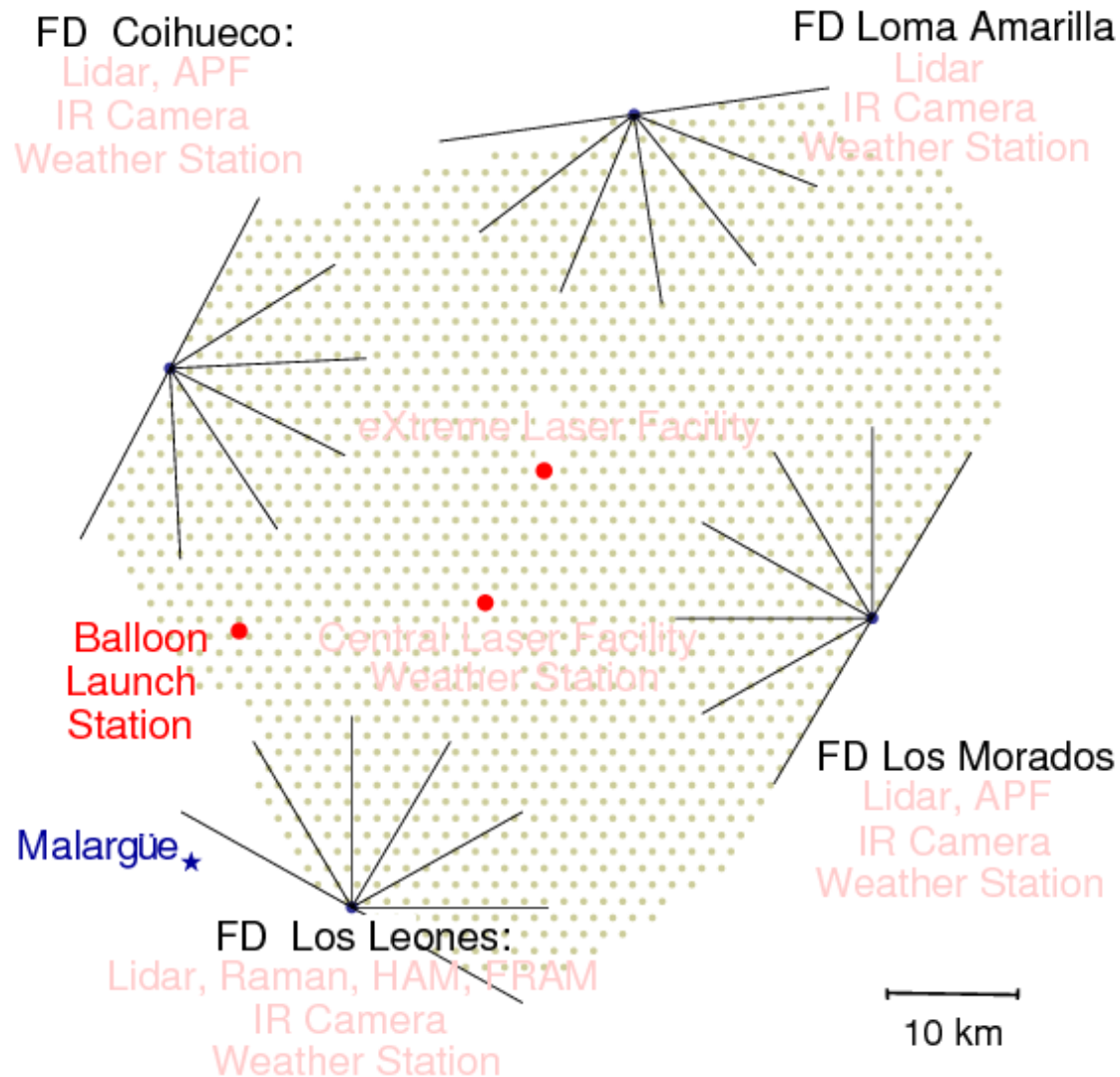


**Auger overview by
Lawrence Wiencke**

**HESS overview by
Cameron Rulten**

**CTA overview by
Sam Nolan**

Atmospheric Profile Measurements



Atmospheric Profile Measurements



Lidar, Raman, HAM, T-RAM
IR Camera
Weather Station

FD Loma Amarilla

Semi-weekly radiosonde flights

Recover profiles of:

- temperature
- pressure
- vapor pressure

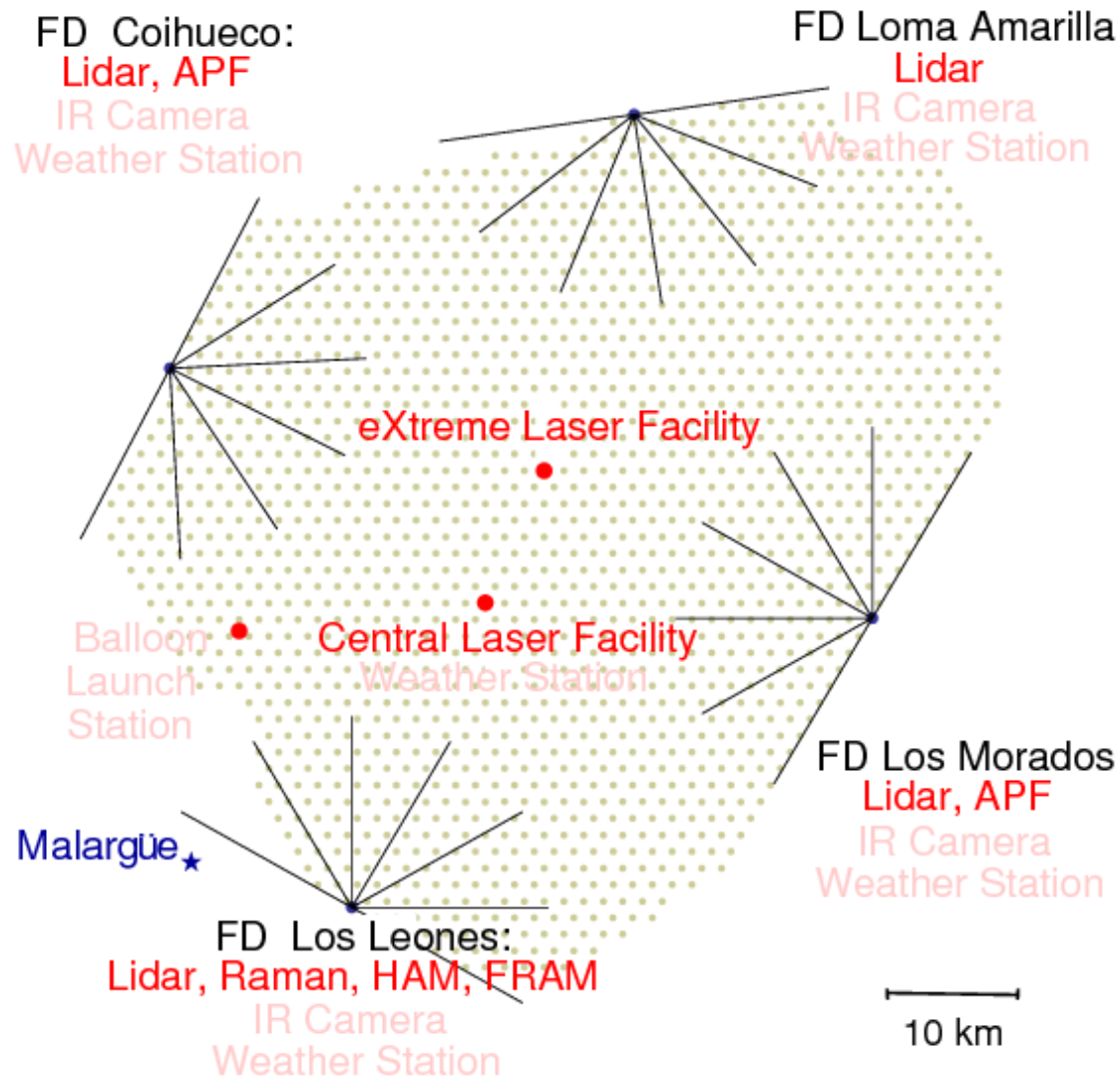
Data incorporated into *monthly* site models

Used to calculate Rayleigh scattering

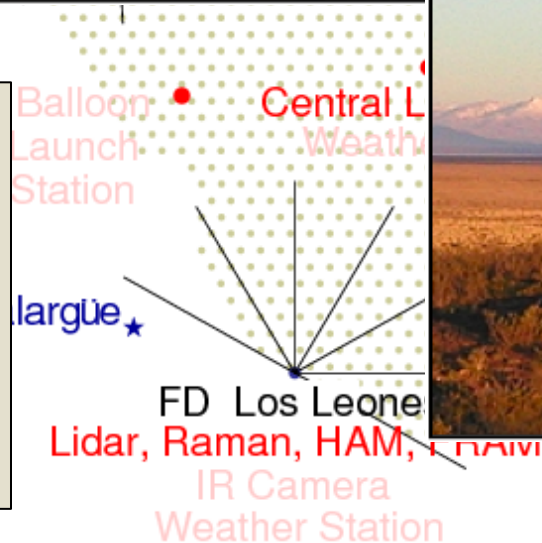
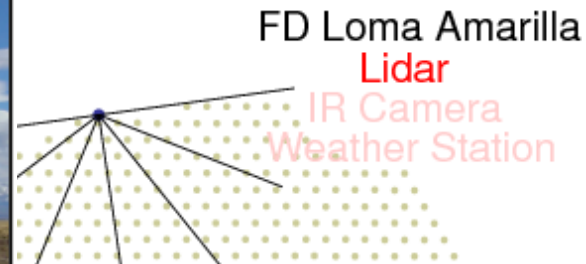
**Talk by Bianca Keilhauer
after lunch**

10 km

Aerosol Measurements



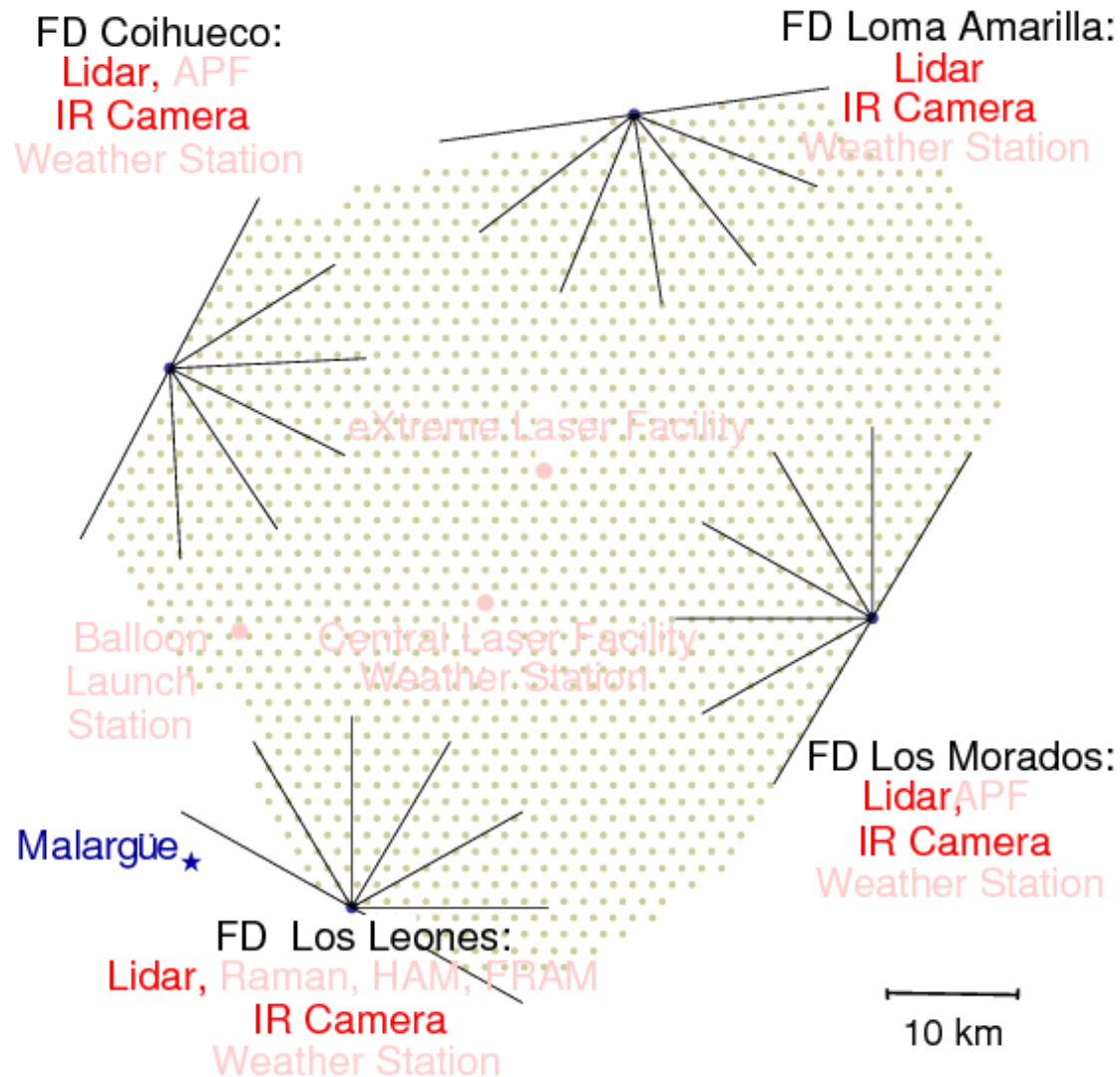
Aerosol Measurements



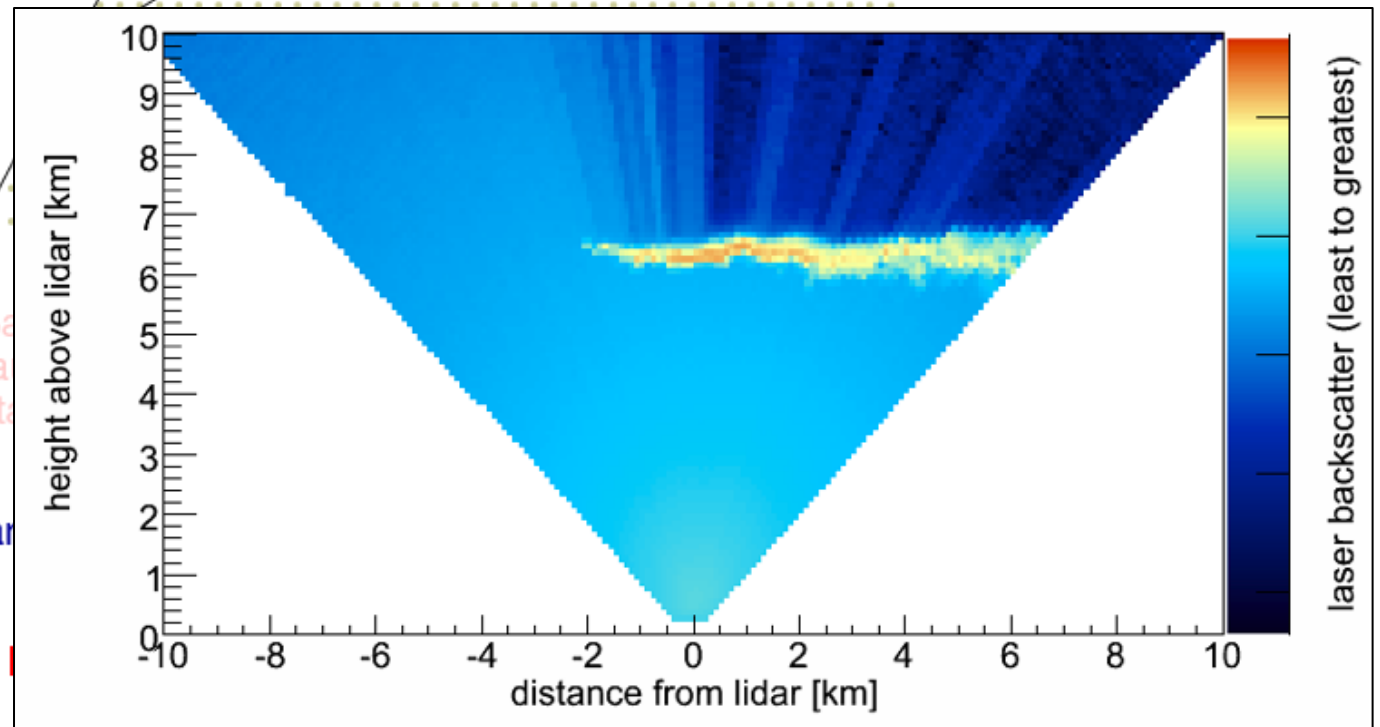
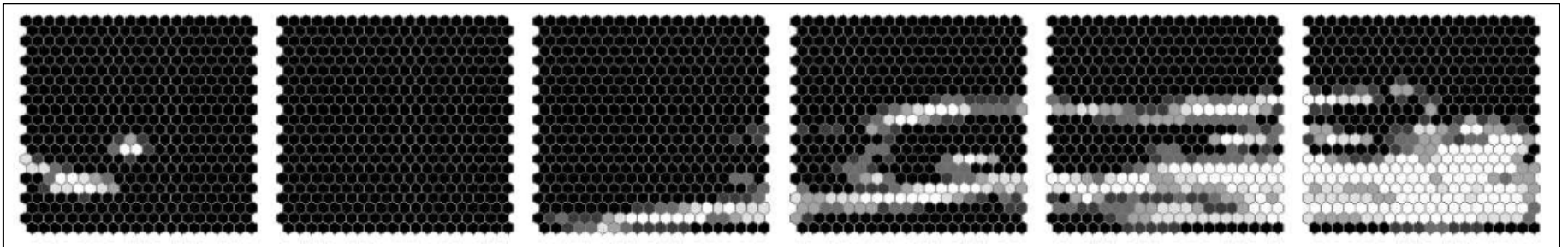
Hourly aerosol
corrections

Talks by
Karim Louedec,
David Starbuck
tomorrow

Cloud Measurements



Cloud Measurements



Tomorrow:

**Auger talk by
Johana Chirinos**

**LSST talk by
Jacques Sebag**

Weather Station

Lessons Learned in Malargüe, Part 1:

Lasers are Bright

LIDAR WARS

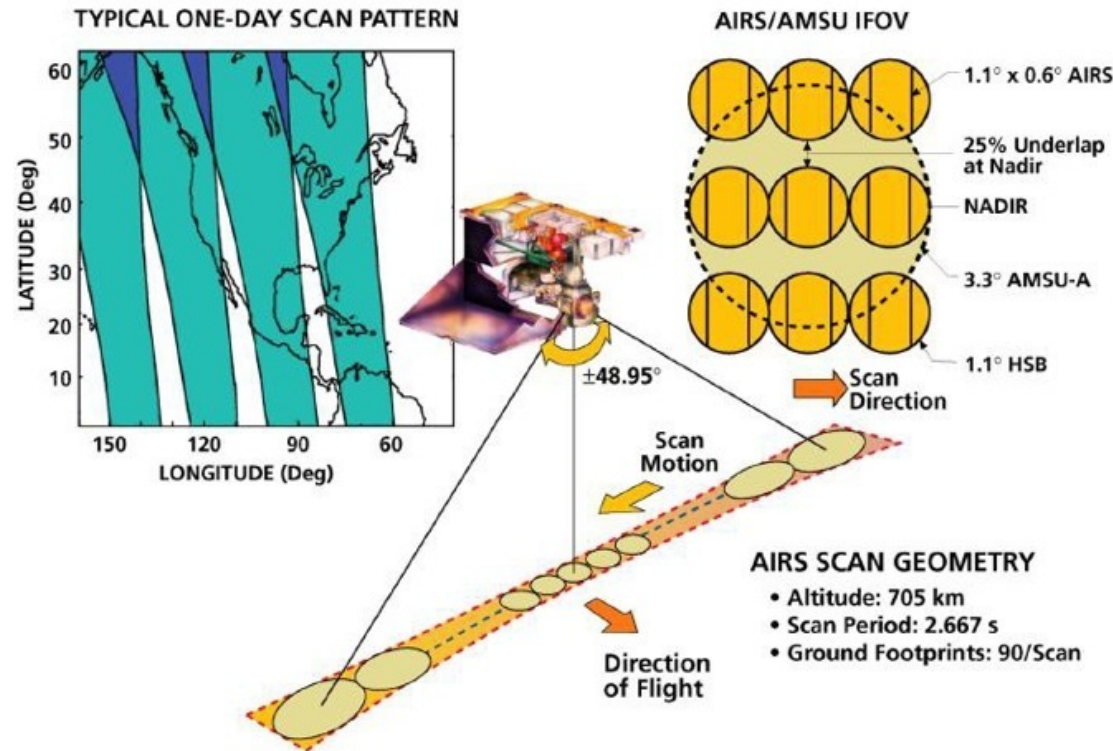


From R. Mussa, Auger Collaboration Meeting, Sep. 2006

- Lidars can **interfere** with photon-counting telescopes
- “**Crossfire**” effect on FD DAQ was not fully appreciated before lidar installation
- This was a source of tension in the collaboration...
- Solution: full DAQ veto + **event-based trigger**: **talk by Martin Will tomorrow**

Lessons Learned, Part 2:

Useful Public Data are Available

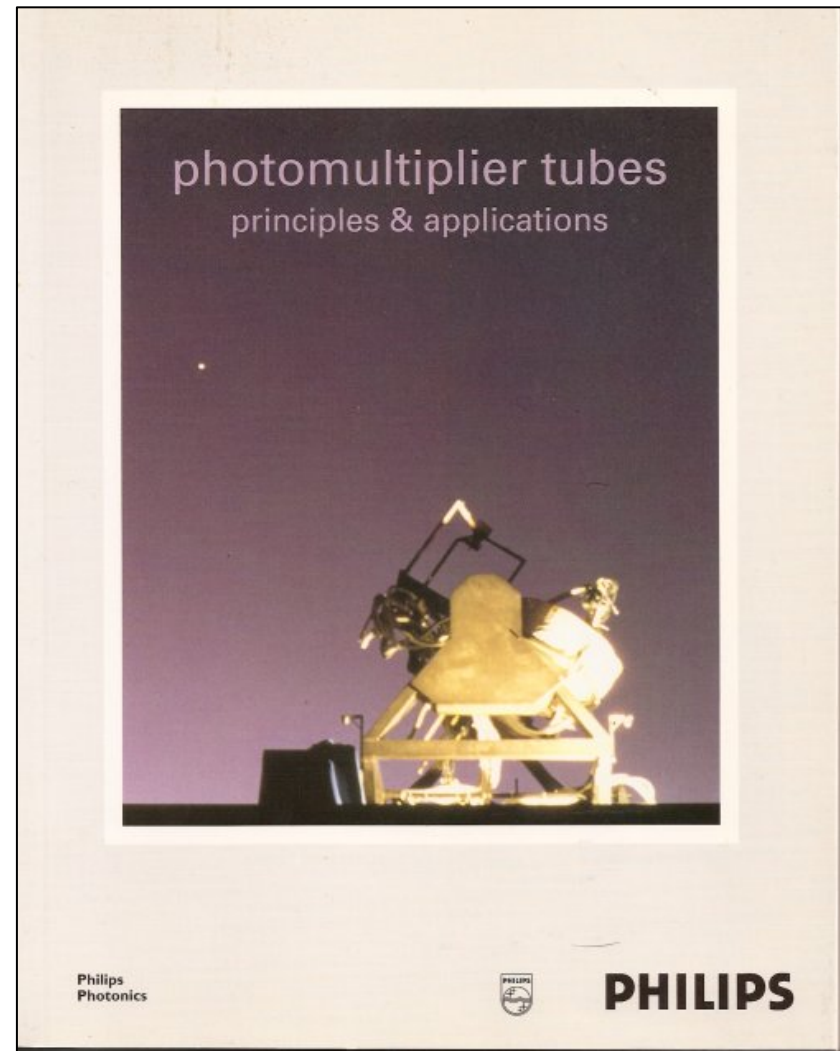


- **Public weather databases** have been built with satellite sounding + modeling. The data are freely available, if you know where to look
- Talks by **Ralf Bennartz** and **Bianca Keilhauer** after lunch today

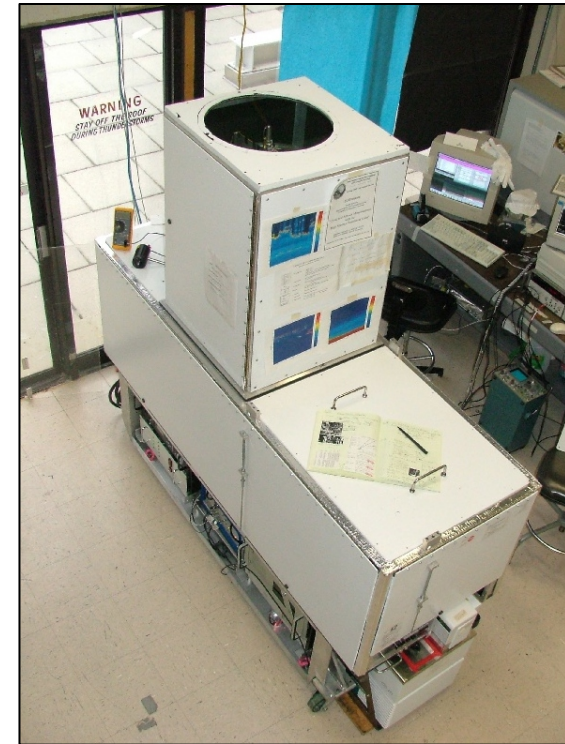
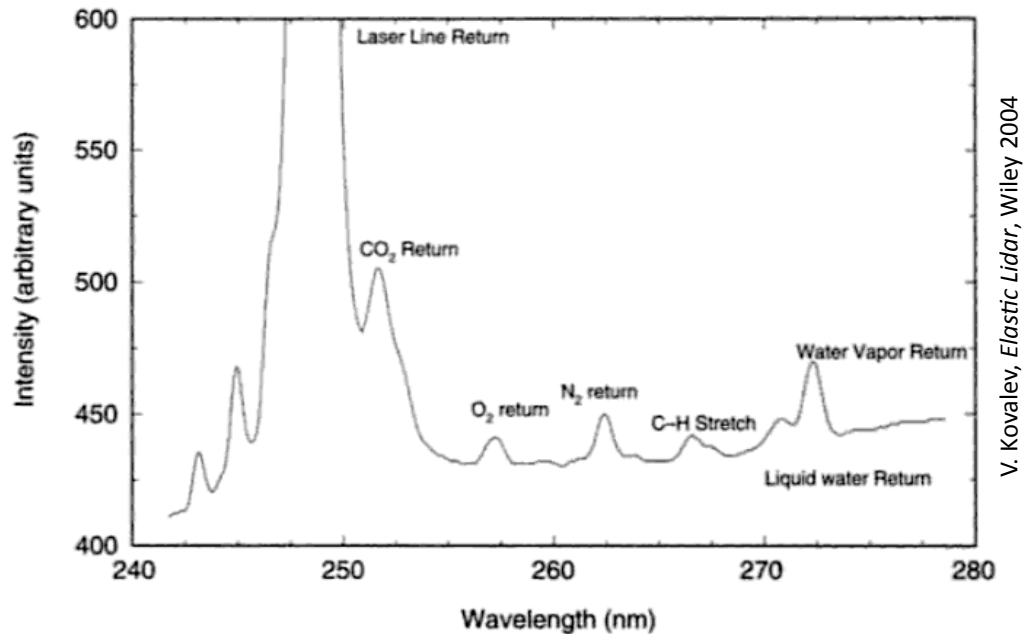
Lessons Learned, Part 3:

You Get What You Pay For

- Lasers are expensive; optics are tough to custom-build on a low budget
- Monitoring instruments may be **repurposed** from other experiments: see **talk by Alicia López Oramas on Tuesday**
- These may **not be optimized** for lidar measurements:
 - Fast optics
 - Wide FOV
 - Large, heavy telescopes



Alternatives to Elastic Lidar: Raman and HSRL



UW Madison Arctic HSRL – lidar.ssec.wisc.edu

- Advantages: access to molecular concentration
- Disadvantage of Raman: **high power** (see *Lidar Wars*)
- Talks by **Ed Eloranta**, **Gary Swenson**, **Emmanuel Fokitis**, and **George Vasileiadis** this afternoon

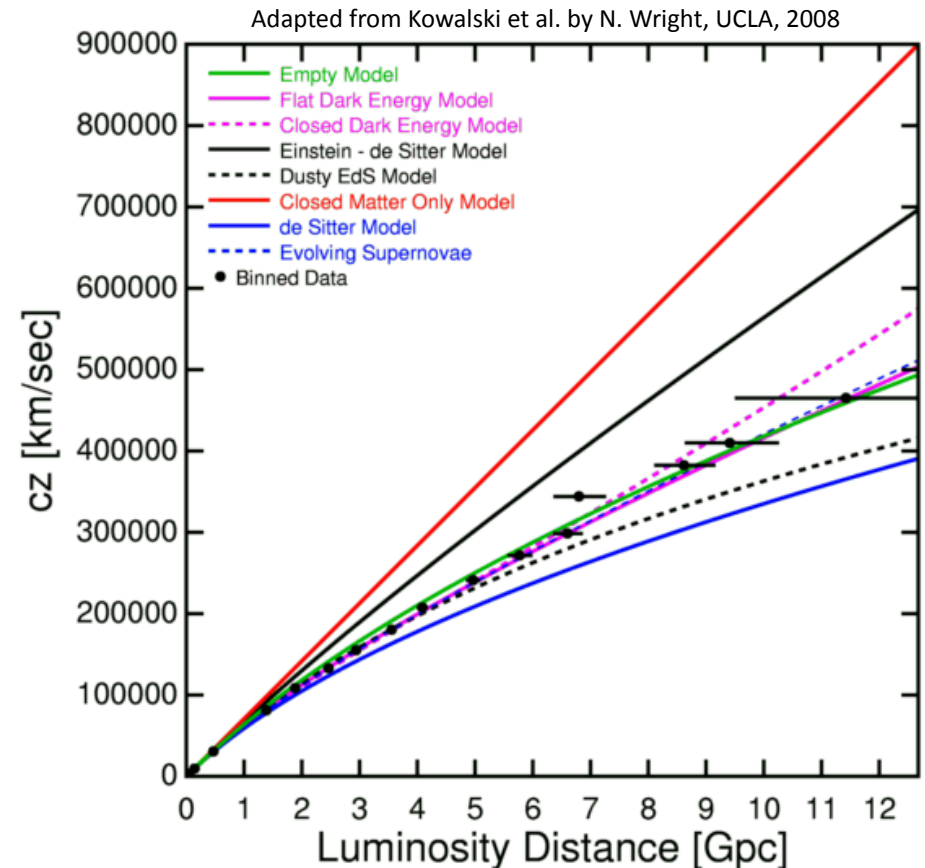
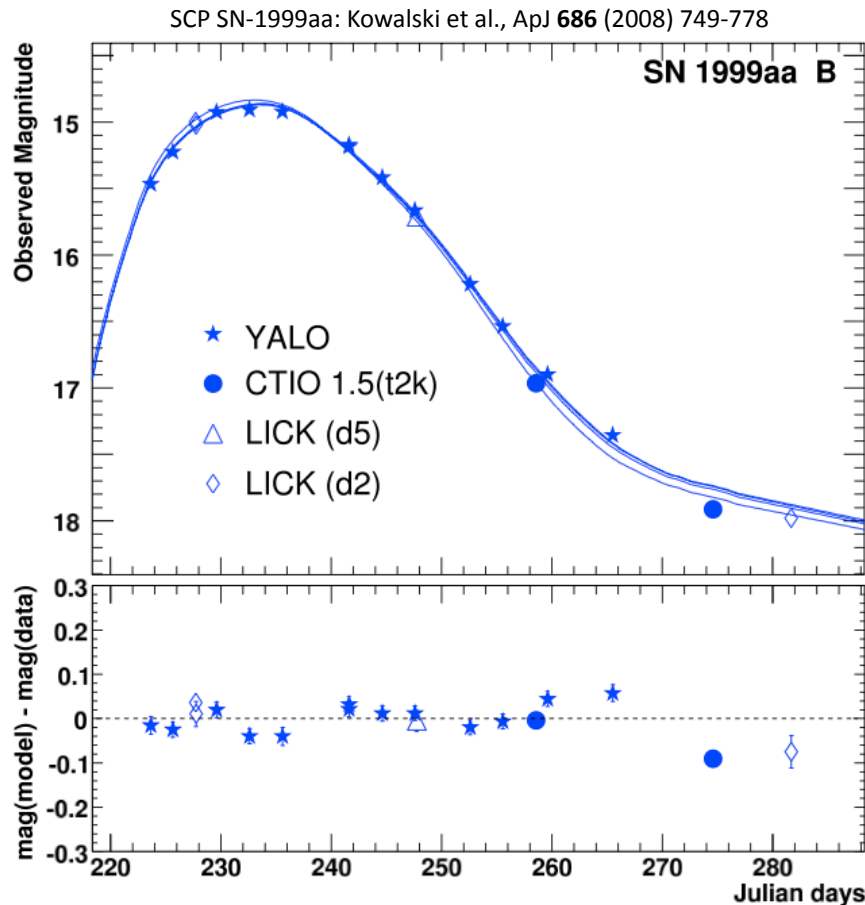
Optical Astronomy

Ground-Based Optical Telescopes



- Next-generation instruments: ground-based **absolute photometry**
- Large Synoptic Survey Telescope (LSST) – next talk by **Chris Stubbs**
- Physics goals:
 - Galactic + extragalactic surveys
 - Large-scale structure
 - Weak and strong lensing
 - Cosmology: Type Ia supernovae, large-scale structure, weak lensing, ...

Example: Supernova Cosmology



- Unlike air shower experiments, the atmosphere is **not useful**
- To reduce systematic uncertainties due to transmission to <1%, **cut most of the data**, or perform atmospheric monitoring

“Removing the Atmosphere”

- In current optical observatories: mean *nightly* extinction coefficients are used to correct data during post-processing
- Next generation: *real-time* incorporation of monitoring data with astronomical observations. This morning:
 - Stratospheric observations with lidar: **Peter Zimmer**
 - Calibrating and cataloging “standard” stars at NIST: **John Woodward**
- Monitoring efforts on Cerro Pachón, Chile:
 - Mesospheric lidar and airglow measurements: **Gary Swenson**
 - IR cloud measurements: **Jacques Sebag**

For Europeans Present: Call for Infrastructure Proposals

HEAPnet

HEAPnet Proposal: This Fall

- For European participants: major grant proposal **this fall**. There will be a targeted HEAPnet (High-Energy Particle Astrophysics Network) I3 call:

FP7 Capacities Work Programme: Infrastructures

FP7-INFRASTRUCTURES-2011-1

- **INFRA-2011-1.1.23. Research Infrastructures for astroparticle physics: High energy cosmic rays, multi-messenger approach.** A project under this topic must provide and facilitate access to the key research infrastructures in Europe for multi-messenger astronomy and astroparticle physics. It should aim to integrate these facilities and resources with a long term perspective. A project under this topic should also stimulate new scientific activities aimed at taking full advantage of new possibilities which will be offered by the future Cherenkov Telescope Array ("CTA"), High Energy Stereoscopic System ("HESS"), the Pierre Auger Observatory and the Kilometre Cube Neutrino Telescope ("KM3NeT").
- The expected total budget of each grant: **10 M€** for four years
- The indicative budget of the “Integrating Activities” chapter of the call is 103.95 M€. In this chapter, there are 23 targeted calls in total, and three other calls in Physics and Astronomy

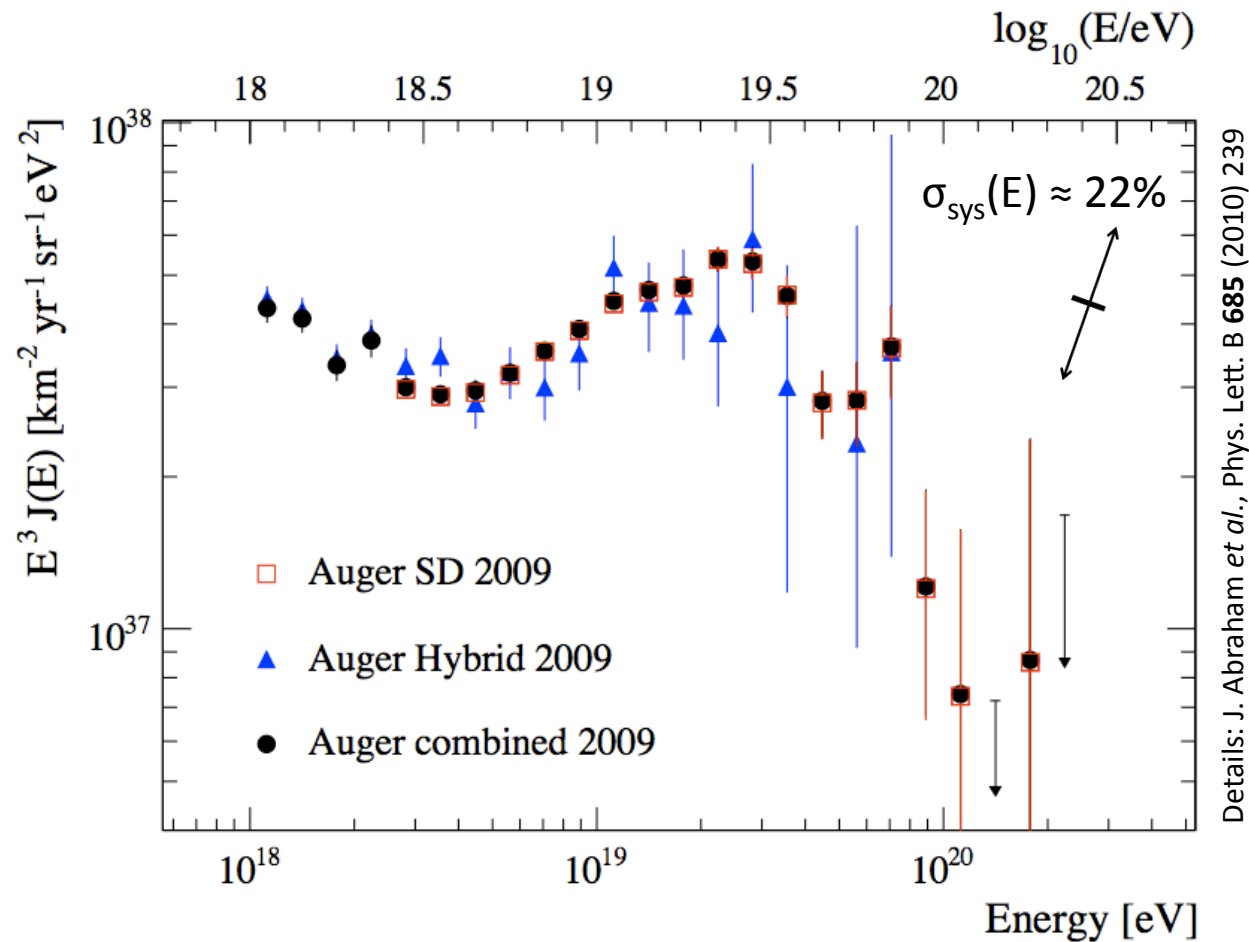
HEAPnet: Organization

- The call was published July 20. Submission deadline is Nov. 25, 2010. Full documentation is available at

<http://ipnweb.in2p3.fr/~heapnet/>

- One of the work packages of the prepared proposal will be dedicated to **atmospheric monitoring**:
 - JRA: Joint Research Activity
 - NA: Network Activity
- Plenary HEAPnet meeting and proposal creation: Oct. 4-5, 2010, “Institut Henri Poincaré,” Paris, FR. Interested participants welcome
- General questions about proposal:
Tiina Suomijarvi – tiina@ipno.in2p3.fr
- Questions/suggestions related to the atmospheric monitoring work package:
Michael Prouza – prouza@fzu.cz

Auger Energy Spectrum



Details: J. Abraham *et al.*, Phys. Lett. B 685 (2010) 239

- **Suppression/cutoff of flux** above 4×10^{19} eV: expected due to interaction of high-energy protons with CMB

GZK Effect and Source Distance

