The Fluorescence Detector - any% WR

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Outline

- Hardware
- Physics
- Access to data
- FD Shifts
- (Energy calibration)

Hardware

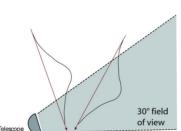
- 5 sites, 27 telescopes
 - 6 telescopes/bays per building (HEAT: 3)
 - Wide angle 30°x30° FOV per bay
 - Camera consists of 440 PMTs
 - 10 MHz sampling rate (HEAT: 20 MHz)

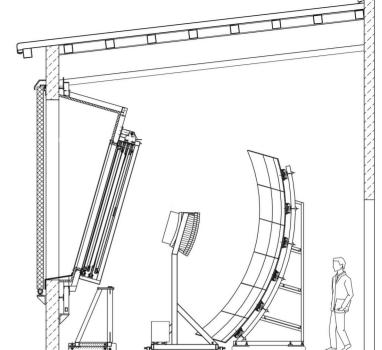
HEAT

- High-elevation extension of FD
- See higher showers / lower E

See also (e.g. for thesis)

- J. Abraham et al, NIMA-A 620 (2010) 227-251
- M. Kleifges et al, ICRC31 (2009) 10-13

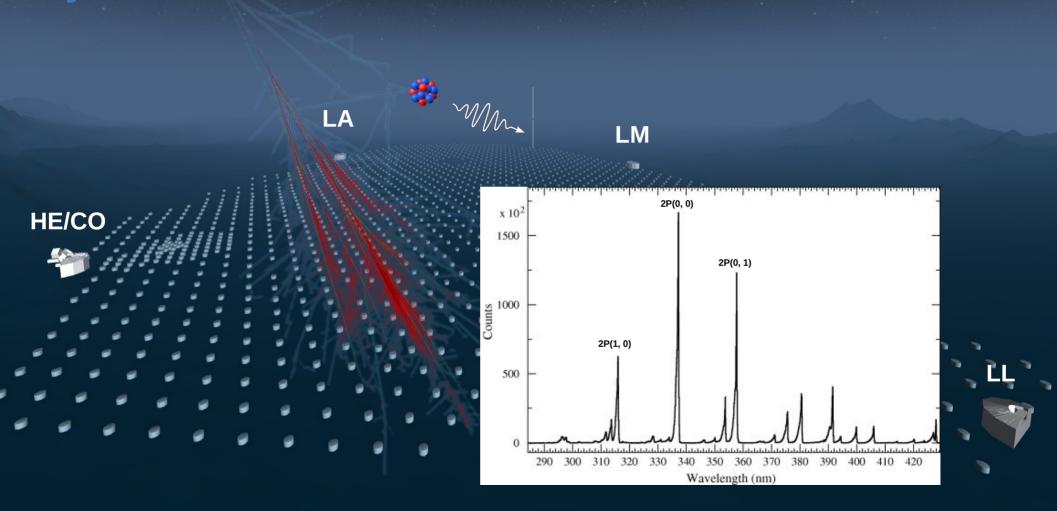




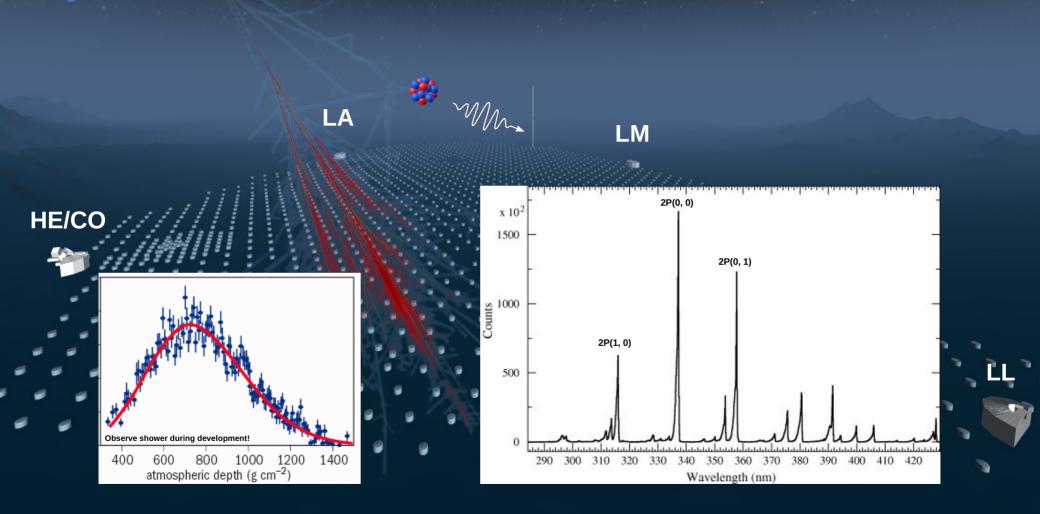


Physics LA LM HE/CO

Physics

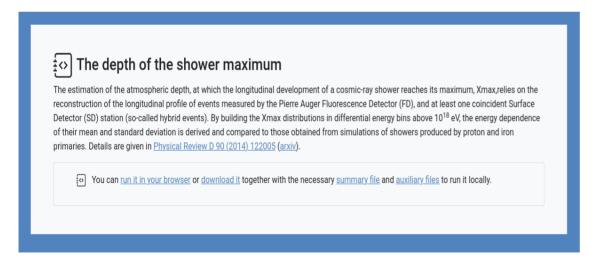


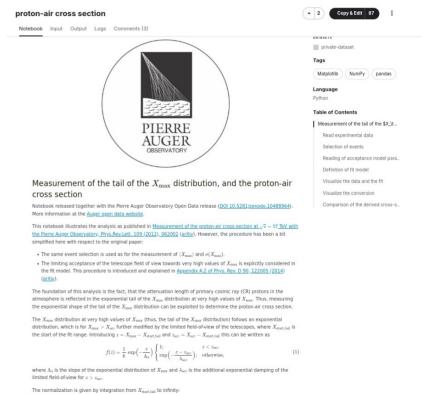
Physics



Access to data

- Auger Open Data (jupyter notebooks for various analysis)
 - The depth of the shower maximum
 - The energy calibration
 - The energy spectrum





 $z_{acc} = (z_{acc}) \left[\lambda_{acc} \right]$

Access to data

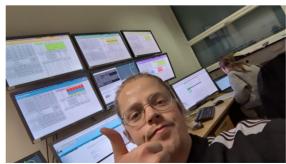
- iRODS @ Lyon (subject to change...)
 - All data Auger data (FD, SD, etc.) available
 - Account @ CCIN2P3, or local iRODS installation

```
cca011:/pbs/home/p/pafilip(0)>module load irods
cca011:/pbs/home/p/pafilip(0)>iinit
Enter your current iRODS password:
cca011:/pbs/home/p/pafilip(0)>ils /pauger/Malarque/Raid/data/Fd/
/pauger/Malarque/Raid/data/Fd:
 FD-minbias.log
  FD-minbias.sum
  ListToDelete 20150325 135210.txt
  C- /pauger/Malarque/Raid/data/Fd/FD-Coihueco
  C- /pauger/Malarque/Raid/data/Fd/FD-Heat
  C- /pauger/Malarque/Raid/data/Fd/FD-LomaAmarilla
  C- /pauger/Malarque/Raid/data/Fd/FD-LosLeones
  C- /pauger/Malarque/Raid/data/Fd/FD-LosMorados
  C- /pauger/Malargue/Raid/data/Fd/RAuger
cca011:/pbs/home/p/pafilip(0)>
```

Hands on session

- Go to https://www.auger.org.ar/FD/shift_form/Form.php
 - Manual data taking during night operation
 - Enlist for FD shift, help Auger run the FD
 - 2 open spots for Dec 22nd Jan 08th
 - (typically) 7 nights of intermittent work
 - Can use the rest of the time to work

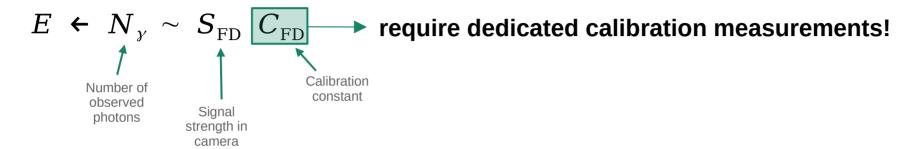
CU in the control room!;)





Backup

(Energy) calibration



(Energy) calibration

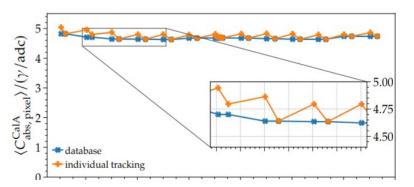
 $E \leftarrow N_{\gamma} \sim S_{\rm FD} / C_{\rm FD} \rightarrow$ require dedicated calibration measurements!







- Track relative drift by exposing camera to known light source
 - Blind to changes in mirror/filter!
- Combined calibration error of ~9%
- Biggest contribution to *E* error



Mean pixel calibration constant for 2-week period in november 2022, from Calibration A

2013

(Energy) calibration

 $E \leftarrow N_{\gamma} \sim S_{\text{FD}} | C_{\text{FD}} |$ require dedicated calibration measurements!

Towards a new end-to-end calibration of FD using a light source on a x-v scanner

N. Barenthien, K. Daumiller, J. Debatin, R. Engel, M. Kleifges. H.-J. Mathes, A. Menshikov, M. Roth, R. Šmida, R. Ulrich, M. Unger (Karlsruhe Institute of Technology, KIT)

> P. Horváth, S. Michal, M. Palatka, M. Pech, J. Šupík (Palacký University Olomouc)

K.-H. Becker, K.-H. Kampert, E. Mayotte, J. Rautenberg (Bergische Universität Wuppertal)

First idea discussed at collaboration meeting in 2017

2017

- Replace large drum with light source on XY stage
- Easy transport of light source (fits in carry-on luggage)
- Reduce workforce/time

- 8 Measurement campaigns to quantify short/long-term systematics (+1 this fall)
- 23/27 telescopes measured at least once, all telescopes in foreseeable future



Scanner control

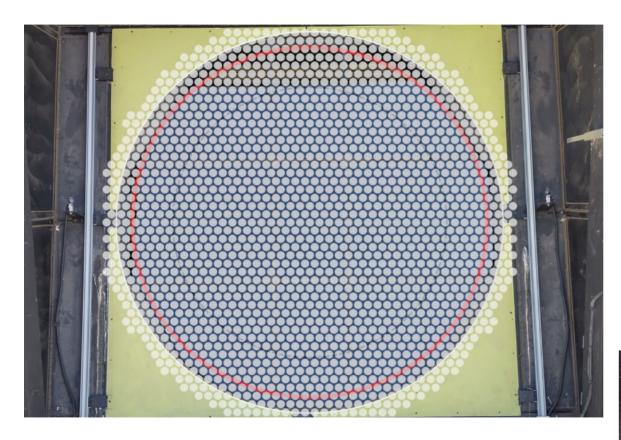
Light source

X stage

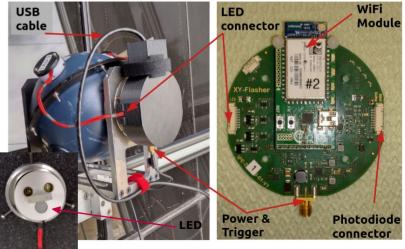
Y stage(s)

The XY Scanner – size matters





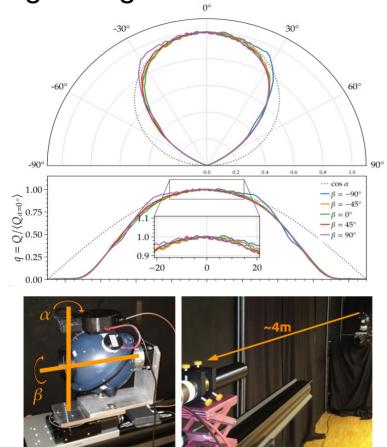
- Sum of many measurements at different positions mimic the drum
- Portable light source
- Absolute calibration is possible onand off-site

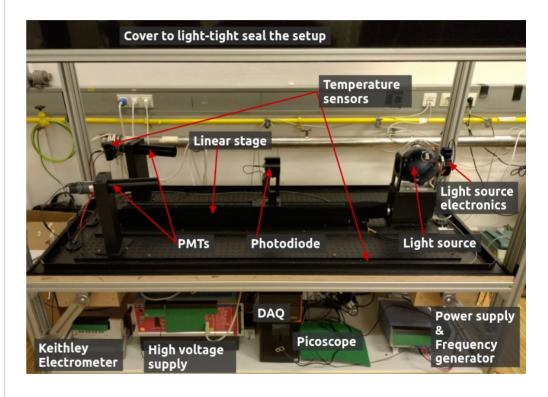


Probing the light source



Determine emission characteristics





Determine photon flux of photodiode