The Pierre Auger Fluorescence Detector

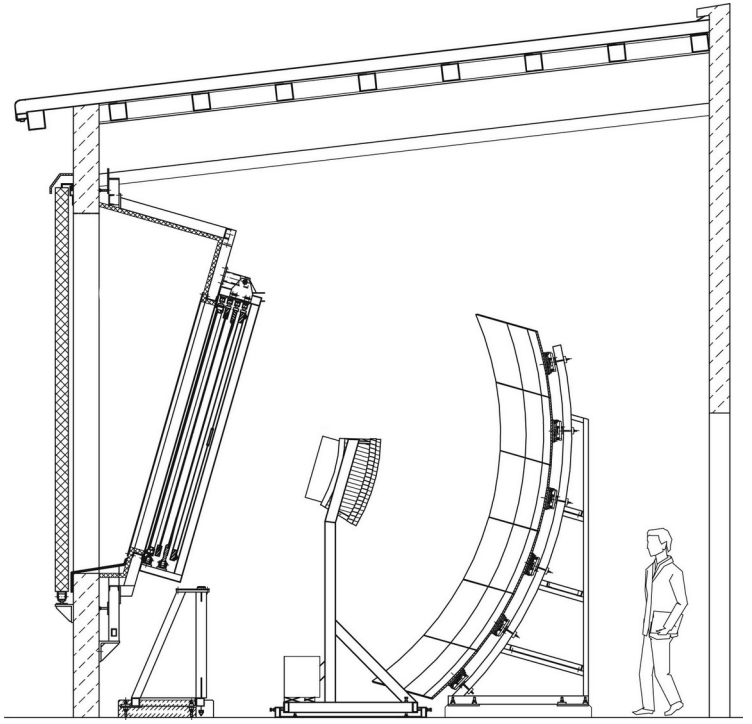
Paul Filip

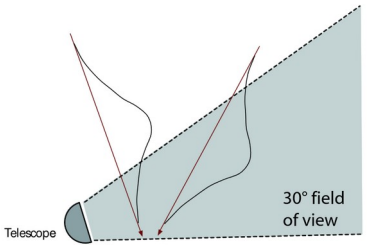
Outline

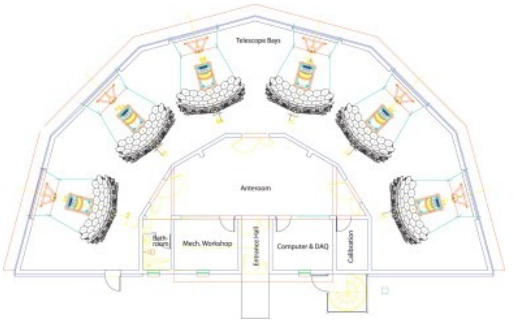
- Hardware
- Physics
- Energy calibration
- Access to data
- FD Shifts

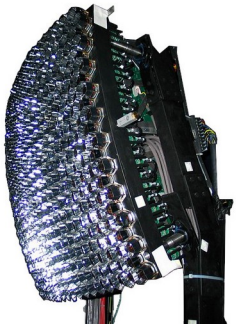
Hardware

- **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

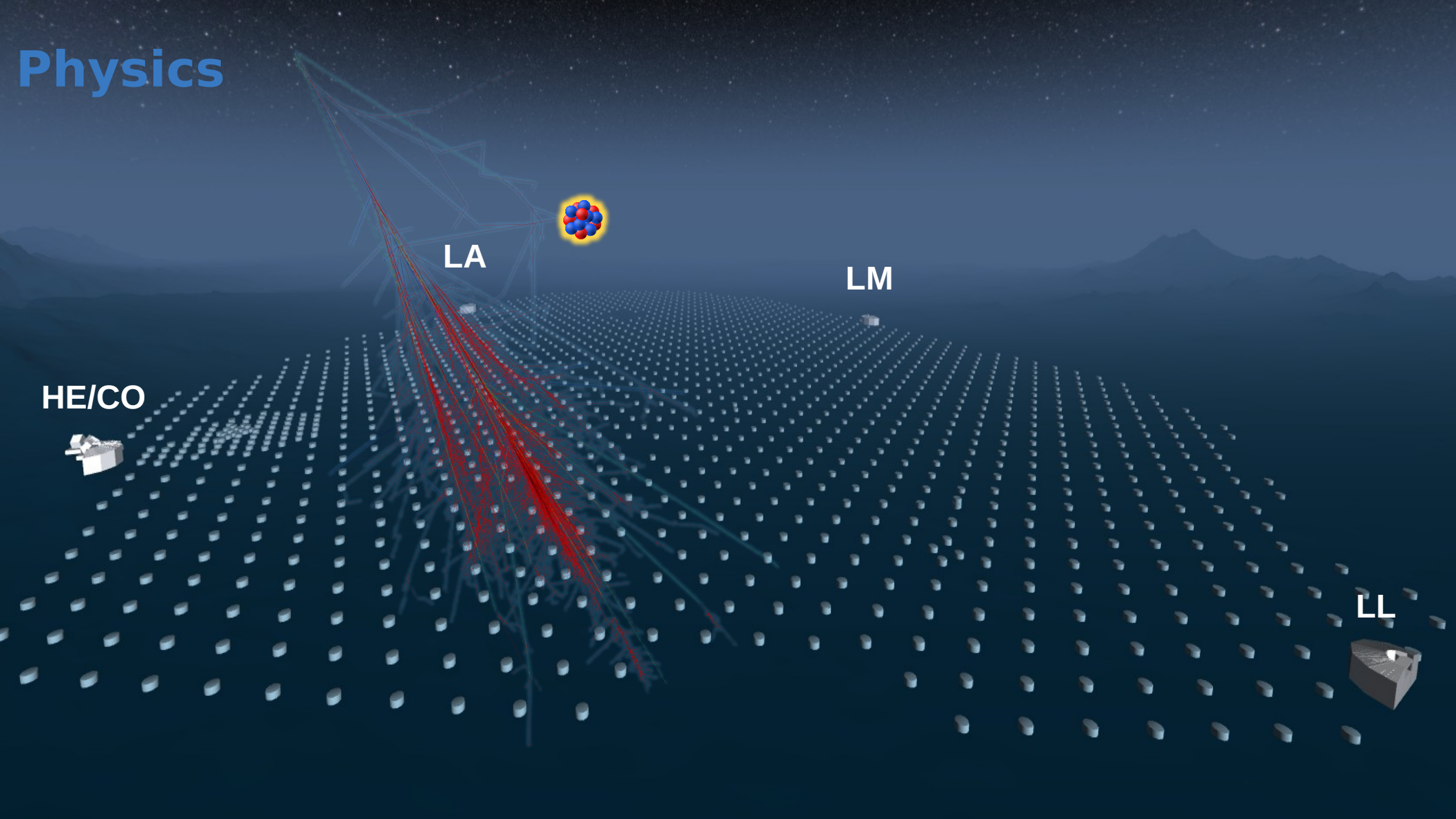




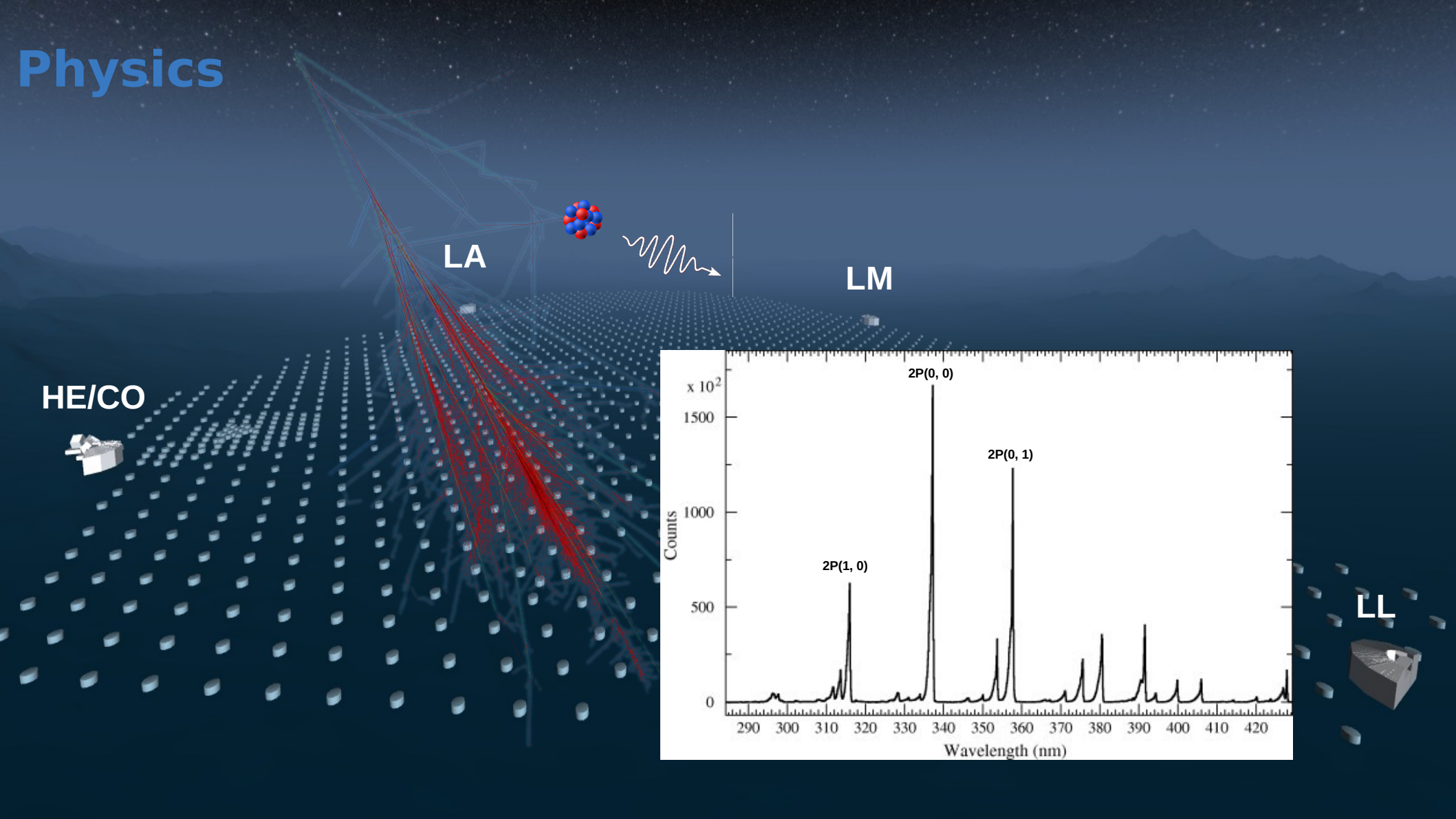




Physics



Physics


LA
LM
HE/CO
LL
2P(0, 0)
2P(0, 1)
2P(1, 0)
x 10^2
1500
1000
500
0
Counts
290 300 310 320 330 340 350 360 370 380 390 400 410 420
Wavelength (nm)

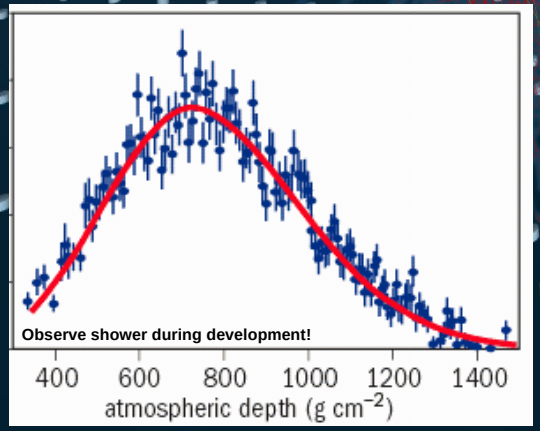
Physics

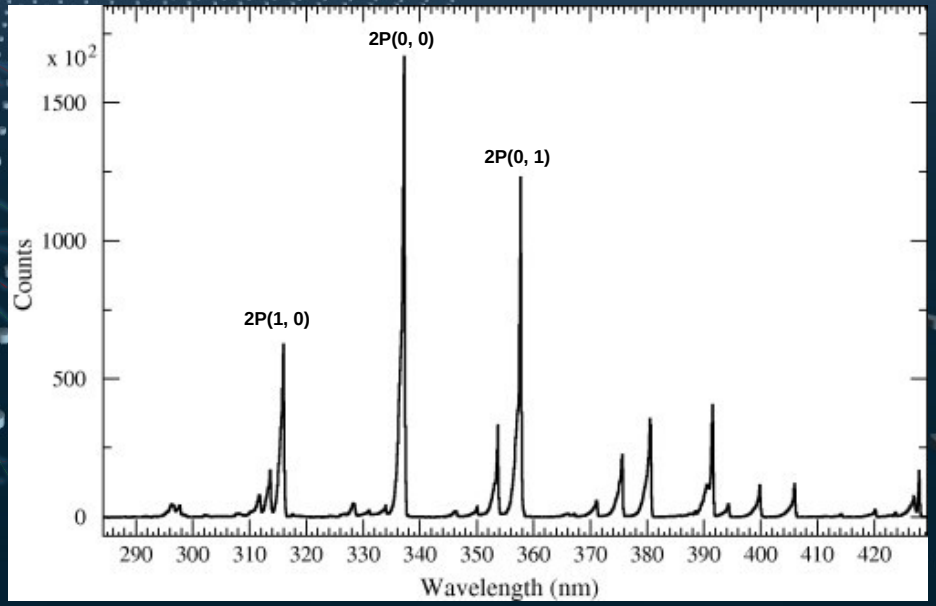
LA

LM

HE/CO

LL

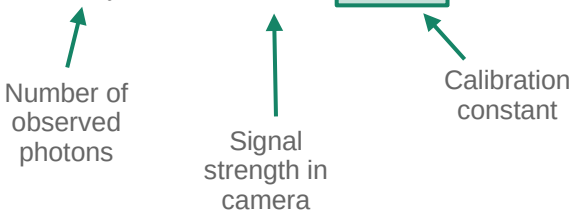




(Energy) calibration

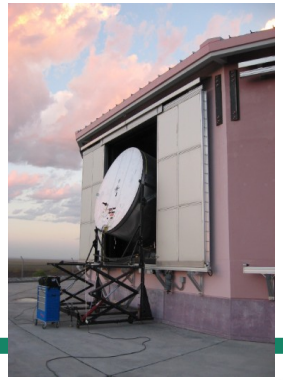
$$E \leftarrow N_\gamma \sim S_{\mathrm{FD}} \, C_{\mathrm{FD}} \rightarrow$$

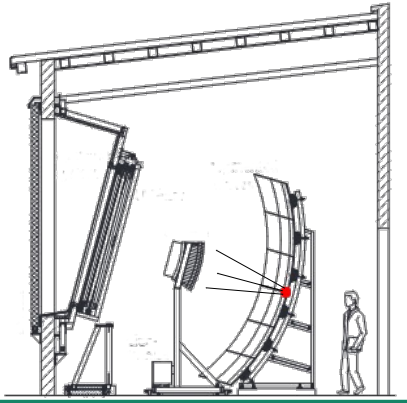
require dedicated calibration measurements!



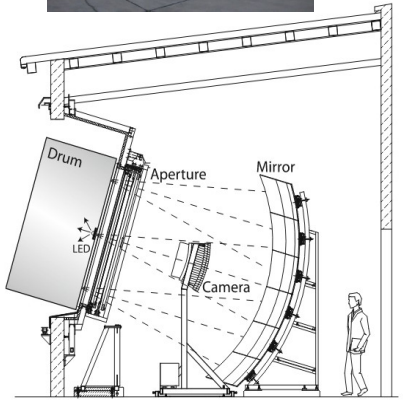
(Energy) calibration

$E \leftarrow N_\gamma \sim S_{\mathrm{FD}}\, C_{\mathrm{FD}}$ → **require dedicated calibration measurements!**



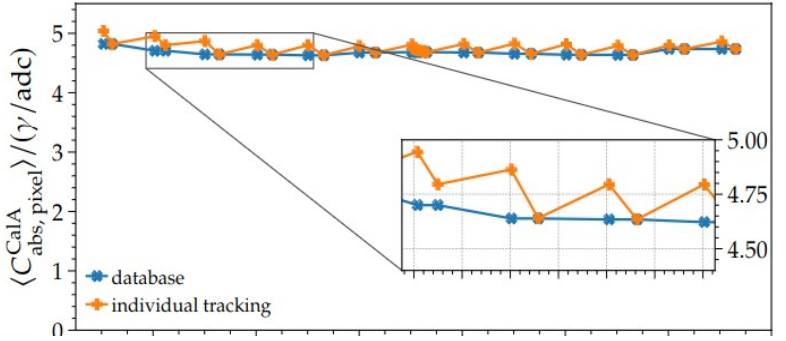


- Track relative drift by exposing **camera** to known light source
- **Blind to changes in mirror/filter!**
- Combined calibration error of **~9%**
- Biggest contribution to *E* error



Expose **telescope** to lightsource and measure response from known signal

2013



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

(Energy) calibration

$E \leftarrow N_\gamma \sim S_{\mathrm{FD}} \boxed{C_{\mathrm{FD}}}$ → **require dedicated calibration measurements!**

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

N. Barenthien, K. Daumiller, J. Debatin, R. Engel, M. Kleifges, H.-J. Mathes, A. Menshikov, M. Roth, R. Šmída, 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)

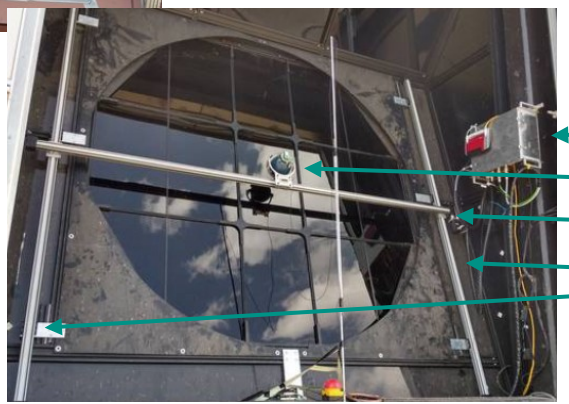
First idea discussed at collaboration meeting in 2017

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

2017

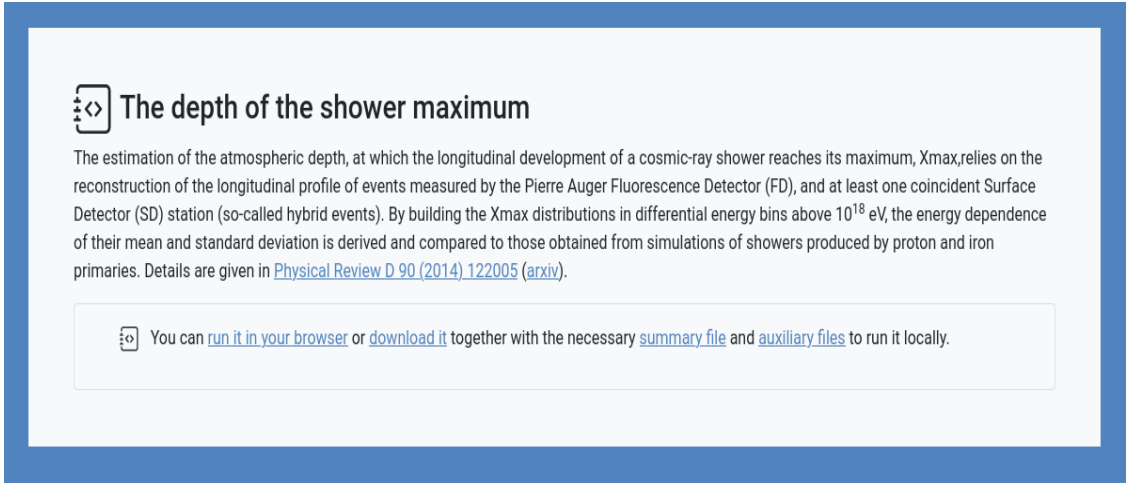
2024

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



Access to data

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



Access to data

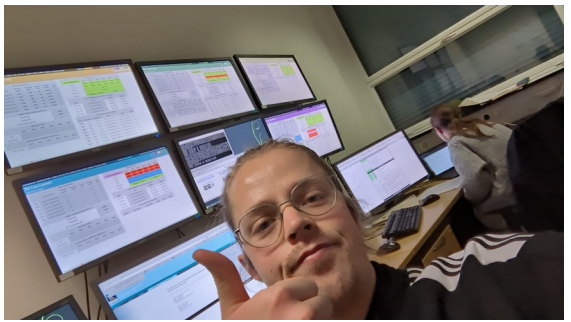
- iRODS @ Lyon (subject to change…)
  - All data Auger data (FD, SD, etc.) available
  - Account @ CCIN2P3, or local iRODS installation

```
################################################################################
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/Malargue/Raid/data/Fd/
/pauger/Malargue/Raid/data/Fd:
  FD-minbias.log
  FD-minbias.sum
  ListToDelete_20150325_135210.txt
  C- /pauger/Malargue/Raid/data/Fd/FD-Coihueco
  C- /pauger/Malargue/Raid/data/Fd/FD-Heat
  C- /pauger/Malargue/Raid/data/Fd/FD-LomaAmarilla
  C- /pauger/Malargue/Raid/data/Fd/FD-LosLeones
  C- /pauger/Malargue/Raid/data/Fd/FD-LosMorados
  C- /pauger/Malargue/Raid/data/Fd/RAuger
cca011:/pbs/home/p/pafilip(0)>
```

Hands on session

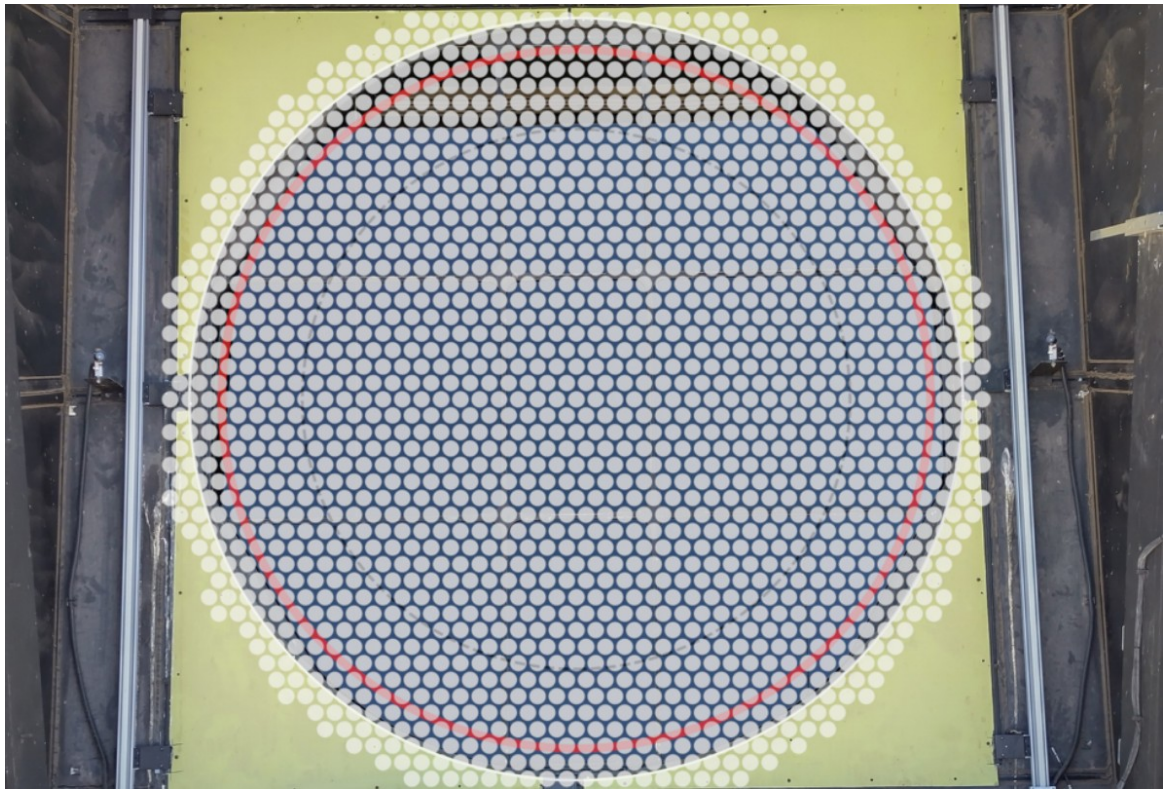
- Go to https://www.auger.org.ar/FD/shift_form/Form.php
  - Manual data taking during night operation
  - Enlist for FD shift, help Auger run the FD
  - 2 open spots for Dec 22nd - Jan 08th
  - (typically) 7 nights of intermittent work
  - Can use the rest of the time to work

- CU in the control room! ;)

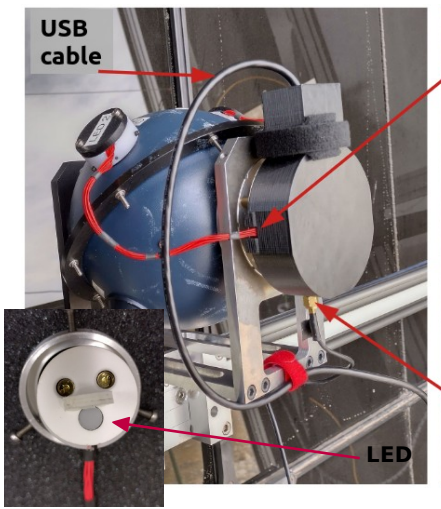


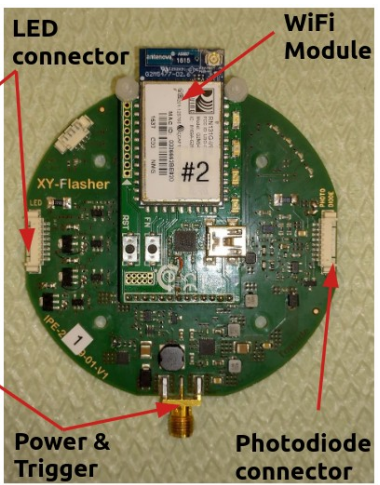
Backup

The XY Scanner – size matters



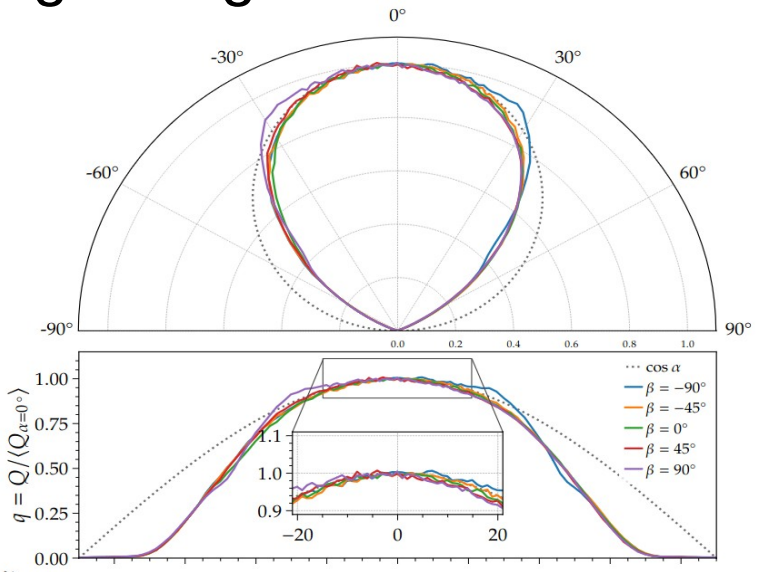
- Sum of many measurements at different positions mimic the drum
- Portable light source
- Absolute calibration is possible on- and off-site

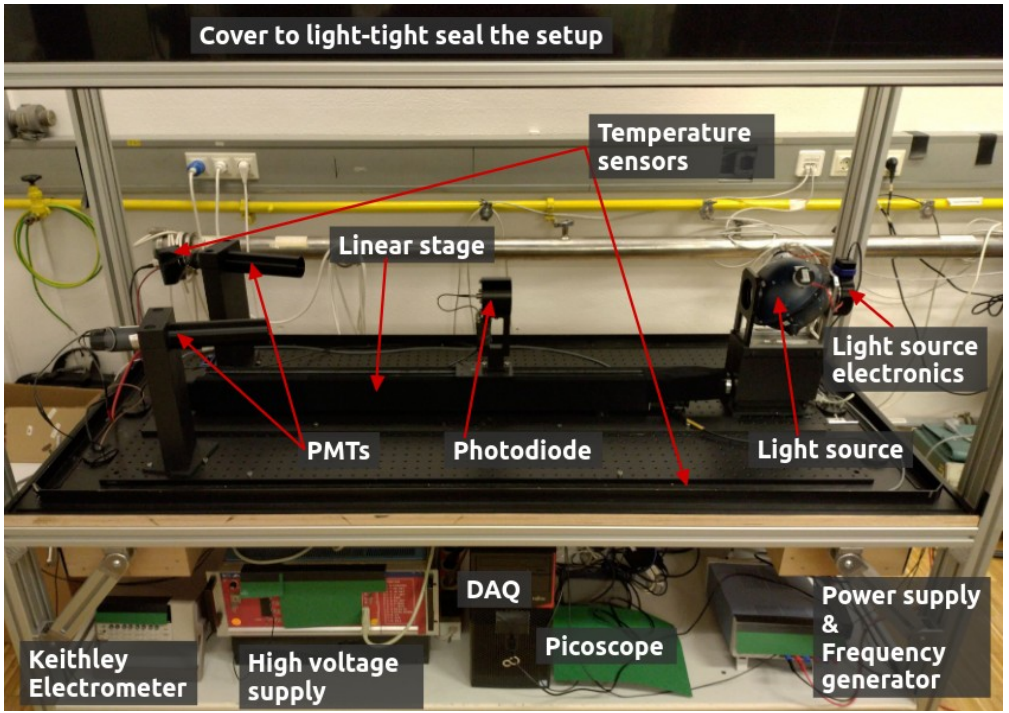




Probing the light source

- Determine emission characteristics





- Determine photon flux of photodiode