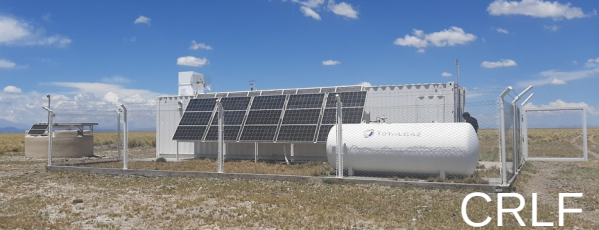


Summary of the Atmospheric Monitoring Task activities & ICRC 2025 contribution + CLRF upgrade

L. Valore, M. Tambone
INFN Napoli & University of Napoli



CRLF

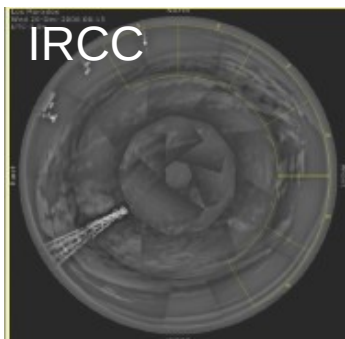


XLF

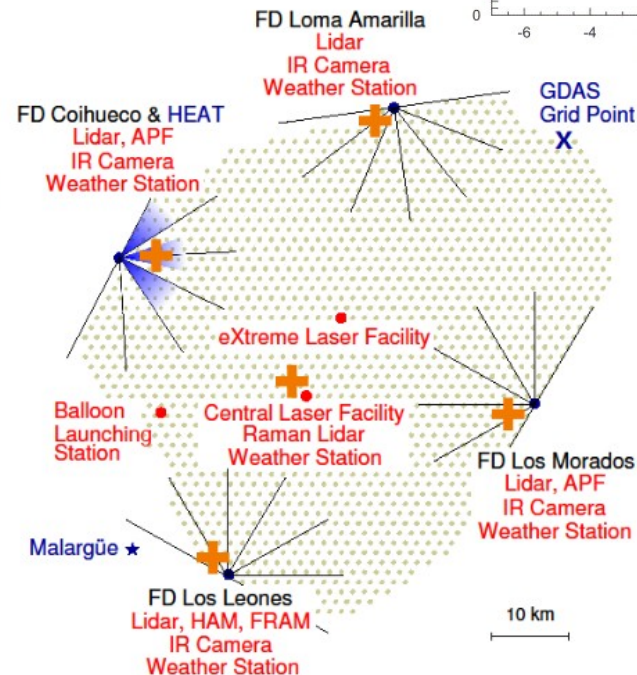
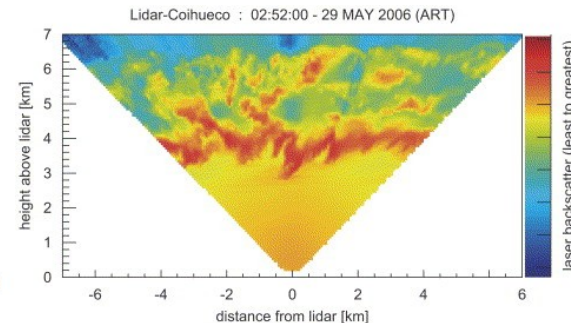
Atmospheric monitoring at the Auger Observatory

Status of instruments

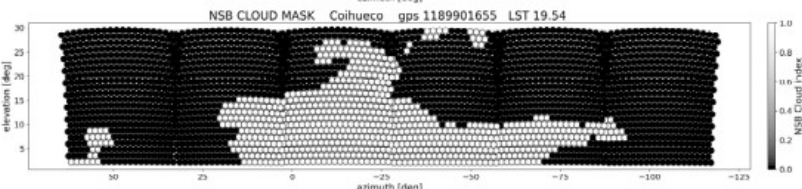
- Aerosols
 - CLF → being upgraded / XLF → running
 - Elastic lidars → operated at CO+LA
 - Raman lidar → being upgraded
- Clouds
 - IR Cameras → to be phased out
 - Elastic lidars
 - CLF / XLF
- Electric Field
 - E-Field Mills (+ in map) → running



IRCC



LIDAR



Atmospheric Databases Status

Molecular database

updated to Jan 22nd, 2025

Aerosol & Quality databases

updated to Dec 2023
(Software Version : ADE_NAP_v3.0)

*It includes the reference night correction for all years from 2004 to 2023.
Released on Dec 23rd 2024.*

Clouds databases

- **Atm_Cloud_1_A** **IRCC up to 2021 + NSB 2022/23** - Released on Jan 19th
 - **Atm_GOES_0_A** **updated to Dec 2023** - Released on Dec 23rd
 - **Atm_LIDAR_1_A** **ends in Mar 2014, test db available up to Dec 2022**
→ **sync to official in phase 2**
-

Offline Database Monitor

This page shows the date and time of the last update of the Offline Master and Mirror databases.

Database.Table	BUW Master db-master.auger.uni-wuppertal.de	BUW Mirror db.auger.uni-wuppertal.de	KIT Mirror offline1.auger.org	UNAM Mirror db.auger.unam.mx
AERA_4_A.RHardWareAssociation	2019-01-04 12:02:18 (id: 914)	2019-01-04 12:02:18 (id: 914)	2019-01-04 13:02:18 (id: 914)	2019-01-04 13:02:18 (id: 914)
Atm_Aerosol_1_A.aerosol	2024-12-17 11:17:40 (id: 120762)	2024-12-17 11:17:40 (id: 120762)	2024-12-17 12:17:40 (id: 120762)	2024-12-17 12:17:40 (id: 120762)
Atm_Molecular_1_A.molecular	2025-01-22 03:04:07 (id: 8769106)	2025-01-22 03:04:07 (id: 8769106)	2025-02-03 03:04:07 (id: 8782532)	2025-01-22 03:04:07 (id: 8769106)
Atm_Quality_0_A.overall_quality	2024-12-17 11:42:49 (id: 170256)	2024-12-17 11:42:49 (id: 170256)	2024-12-17 12:42:49 (id: 170256)	2024-12-17 12:42:49 (id: 170256)
Atm_Cloud_1_A.cloud_pixel	2025-01-19 17:29:30 (id: 279955878)	2025-01-19 17:29:30 (id: 279955878)	2025-01-12 10:20:46 (id: 275883122)	2025-01-19 17:29:30 (id: 279955878)
Atm_Lidar_1_A.lidar	2014-06-05 01:16:08 (id: 19966)	2014-06-05 01:16:08 (id: 19966)	2014-06-05 03:16:08 (id: 19966)	2014-06-05 03:16:08 (id: 19966)
Atm_GOES_0_A.cloud_pixel	2024-12-20 17:31:03 (id: 59771399)	2024-12-20 17:31:03 (id: 59771399)	2024-12-20 18:31:03 (id: 59771399)	2024-12-20 18:31:03 (id: 59771399)
FD_Calib_2_A.working_calib	2024-07-05 11:00:00 (id: 159867)	2024-07-05 11:00:00 (id: 159867)	2024-07-05 13:00:00 (id: 159867)	2024-07-05 13:00:00 (id: 159867)
FD_TelRelCalib_0_A.constants	2021-02-24 13:35:58 (id: 5173)	2021-02-24 13:35:58 (id: 5173)	2021-02-24 14:35:58 (id: 5173)	2021-02-24 14:35:58 (id: 5173)
BadPeriod_0_A.BadPeriod	2016-04-19 (id: 150)	2016-04-19 (id: 150)	2016-04-19 (id: 150)	2016-04-19 (id: 150)
BadPeriod_1_A.BadPeriod	2024-07-10 22:00:00 (id: 77079)	2024-07-10 22:00:00 (id: 77079)	2024-07-10 22:00:00 (id: 77079)	2024-07-11 00:00:00 (id: 77079)

- Color Coding:
- green: in sync with master
 - yellow: mirror currently out of sync with master, but mirror update is pending
 - red: mirror out of sync with master, and no update of mirror has happend in over 24 hours

Note 1 : You cannot connect directly to the master database. Use one of the mirrors instead.
Note 2 : If a field is empty, then the corresponding database could not be contacted. It could be that the server is offline, or that there are too many connections to the given database. In any case, if the field for one mirror is empty, try another mirror.

[Notice: The status file for the page hasn't been updated for over 24 hours, some dates may be displayed with wrong colors.]

Hourly aerosol profiles with CRLF and XLF

laser tracks seen in the FD

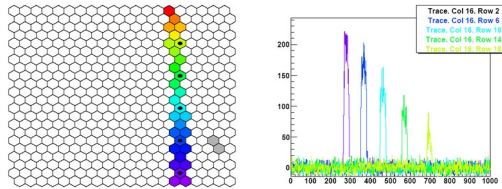


Figura 1: Eye1: Distance CLF - Eye1 26km

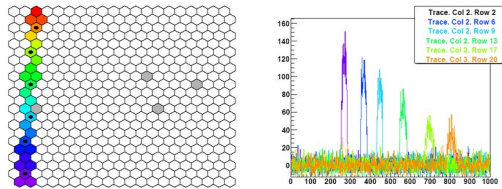
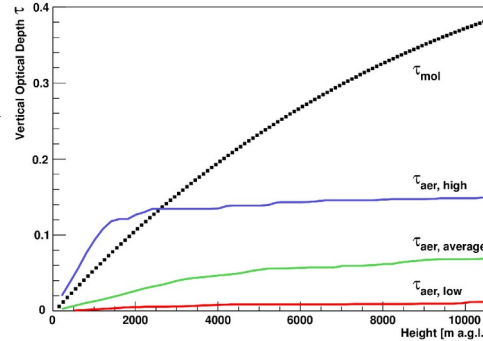
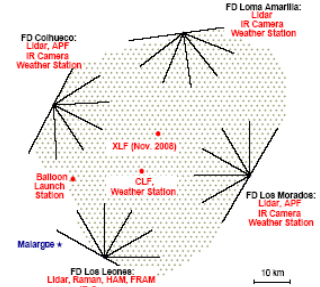
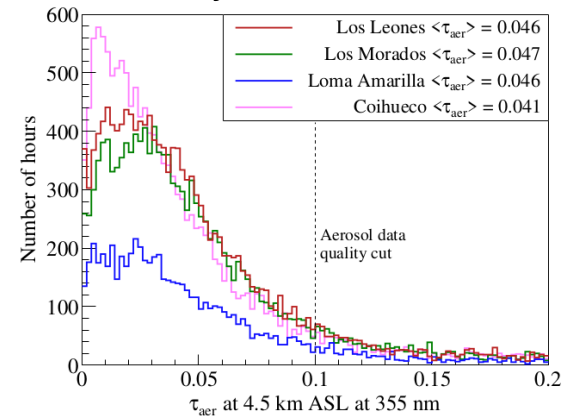


Figura 2: Eye2: Distance CLF - Eye2 30km

Aerosol optical depth profiles measured with DN analysis



Average VAOD @ 4.5 km asl V. Harvey ICRC2019



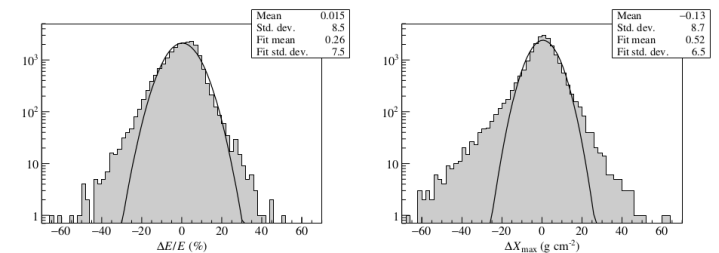
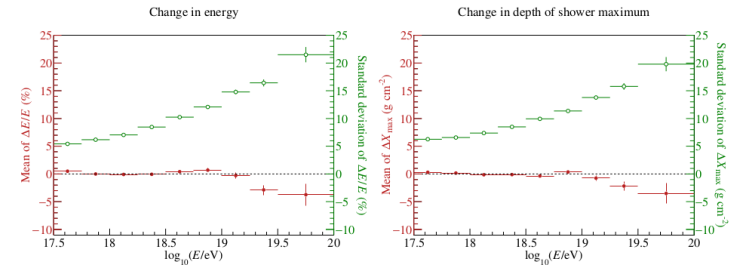
V. Harvey - ICRC2019

Changes in reconstructed E and Xmax and their energy-dependence when using average and hourly aerosol profiles

These distributions exhibit large non-Gaussian tails, and an increasing standard deviation with increasing shower energy.

This is a consequence of the average shower distance increasing with energy, and the hourly aerosol measurements being increasingly important.

The use of an average profile would significantly worsen the E and Xmax resolutions at high energies.



Hourly aerosol profiles with CRLF and XLF

laser tracks seen in the FD

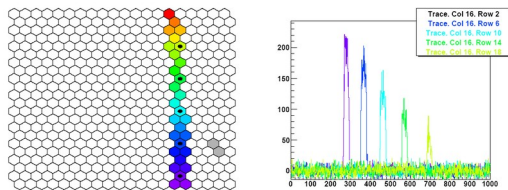


Figura 1: EYE1 : Distance CLF - EYE1 26km

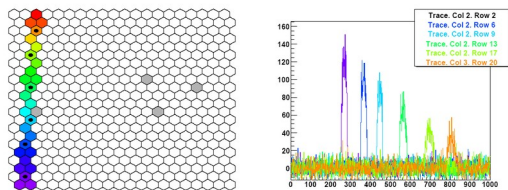
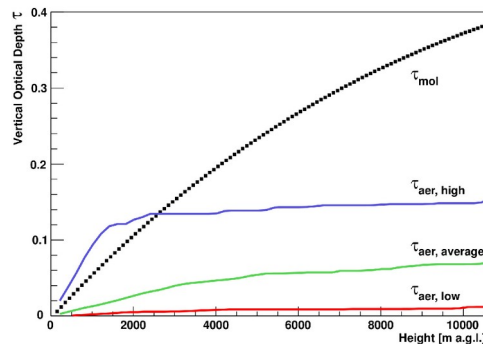
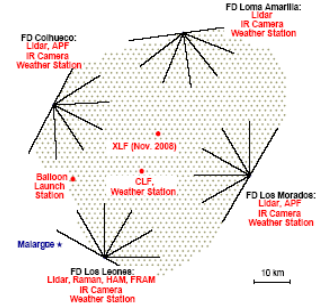
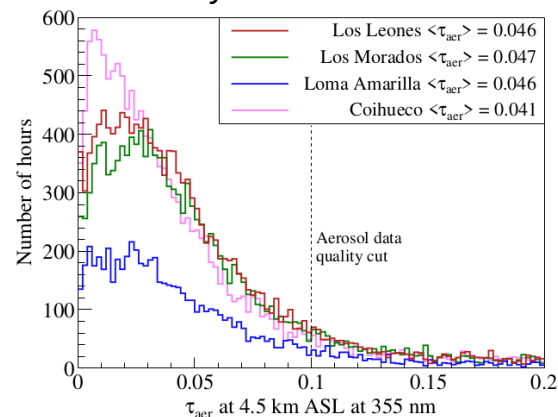


Figura 2: EYE2 : Distance CLF - EYE2 30km

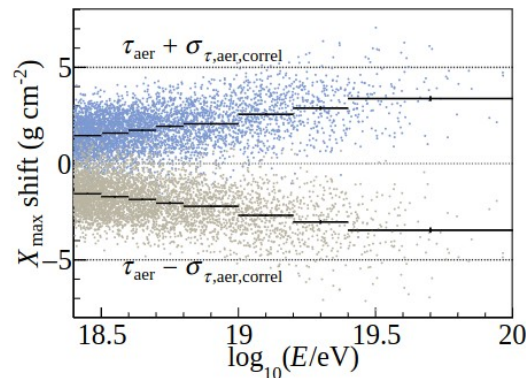
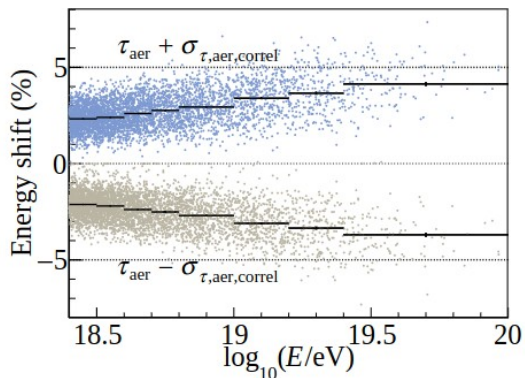
Aerosol optical depth profiles measured with DN analysis



Average VAOD @ 4.5 km asl V. Harvey ICRC2019



Systematic uncertainties in air shower energy (left) and $X_{\max}$ (right). The new systematic uncertainty on energy is 2 % to 4 %, which is smaller than the previous 3 % to 6 %
V. Harvey – ICRC 2023 - <https://pos.sissa.it/444/300/pdf>



Procedure for aerosol profiles production

I. **FD_Calib_2_A** including 2023 data → provided by Gaetano

II. **Laser Calibrations 2022/23** → needed to convert the shot-by-shot probe reading in energy

- Old procedure → raw data and c++ code partially provided by CSM
- New procedure (Matteo Tambone) → python code that reads directly from autolog files produced every night. *Some refinement in progress.*

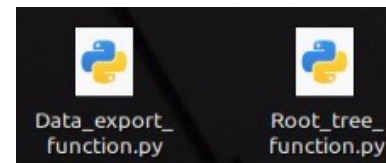
```
import shutil
import os
import argparse

> def create_folder(path):...
> def create_month_folders(path):...
> def autolog_to_txt(autolog_folder_path, txt_folder_path):...
> def output_files(folder_file_name, measurement_file_name, calibration_file_name):...

if __name__ == "__main__":
    parser = argparse.ArgumentParser("-s", "--source", type= str, help = "Complete path of the .autolog files folder", required = True)
    parser = argparse.ArgumentParser("-t", "--txt", type= str, help = "Complete path of the .txt files folder", required = True)
    parser = argparse.ArgumentParser("-c", "--calibration", type= str, help = "Complete path of the calibration file", required = True)
    parser = argparse.ArgumentParser("-m", "--measurement", type= str, help = "Complete path of the measurement file", required = True)

    source = parser.source
    txt = parser.txt
    calib_file = parser.calibration
    measur_file = parser.measurement

    create_folder(txt)
    create_month_folders(txt)
    autolog_to_txt(source, txt)
    source_path = os.path.dirname(source)
    meascal_path = f'{source_path}/Calibration@Measurement'
    create_folder(meascal_path)
    output_files(txt, measur_file, calib_file)
```



```
import uproot3
import numpy as np
import pandas as pd
import os
import shutil
import argparse

> def root_tree(file_path, shots):...

if __name__ == "__main__":
    parser = argparse.ArgumentParser("-i", "--input", type= str, help = "Complete path of the .autolog file", required = True)

    input = parser.input

    root_tree(input)
```

Procedure for aerosol profiles production

- I. **FD_Calib_2_A** including 2023 data → provided by Gaetano
- II. **Laser Calibrations 2022/23** → needed to convert the shot-by-shot probe reading in energy
 - Old procedure → raw data and c++ code partially provided by CSM
 - New procedure (Matteo Tambone) → python code that reads directly from autolog files produced every night. *Some refinement in progress.*
- III. **Reference Nights** → Raman Lidar VAOD and Beta profiles (V. Rizi) to identify the cleanest nights, cross-checked with reconstructed laser profiles (Violet Harvey)
- IV. **Hourly aerosol profiles** → produced by Data Normalized Analysis (Violet Harvey) & quality checks performed
- V. **Databases Atm_Aerosol_1_A and Atm_Quality_0_A** updated with new data (L. Valore)

Adelaide continue to support VAOD production in 2024. Violet will make the code available in the near future.

Lidar Cloud Coverage and Cloud Base Height

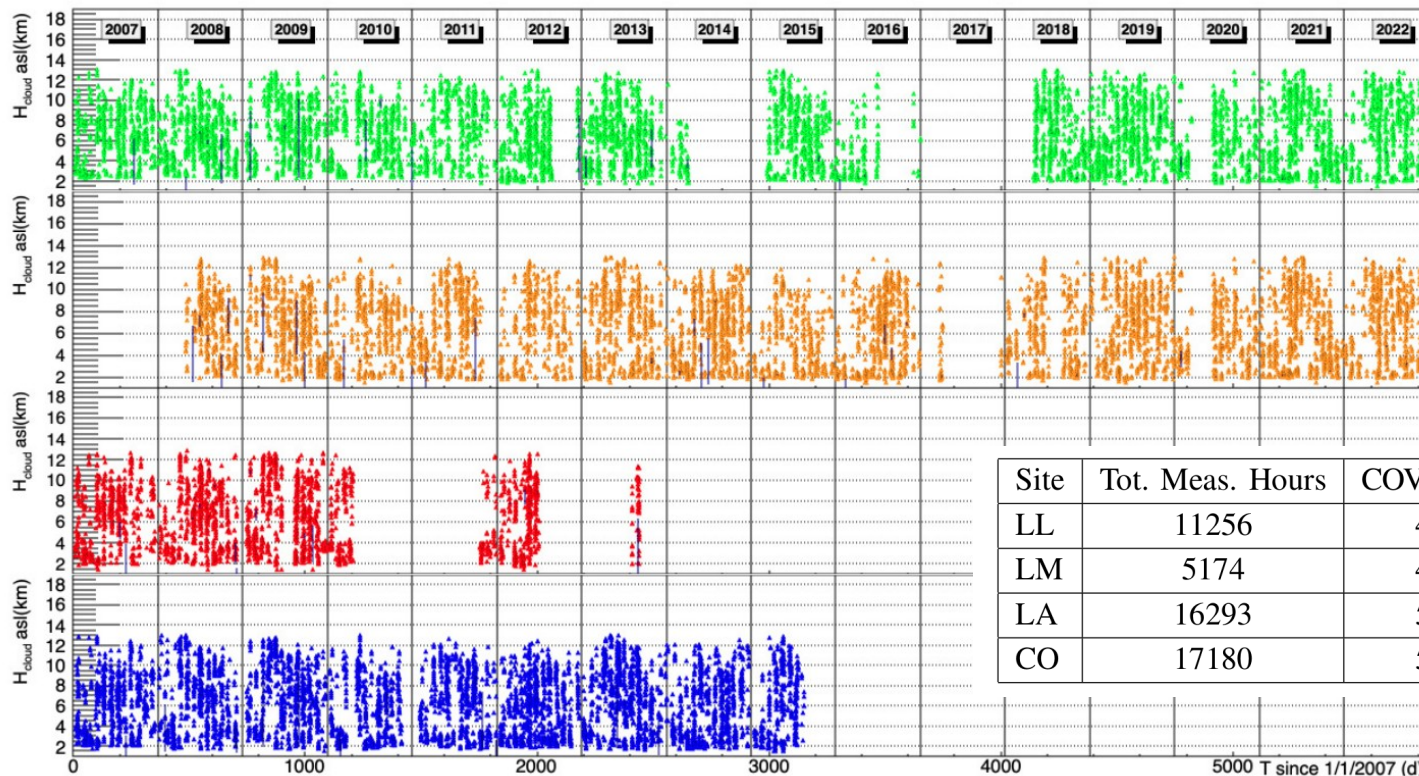
R. Mussa / J. Pallotta

ADST files 2007-2018 produced by Lorenzo P. for checks

New analysis much more robust.

Lidar db 2007-2022 exist only in test mode.
Waiting for 2023 data to be added

More details on results of the use of the new DB in talk by Roberto Mussa (both new vs old DB before 2014, and new vs NO db after 2014).



Site	Tot. Meas. Hours	$COV \leq 0.1$ ($COV=0$)	$0.1 < COV < 0.9$	$COV \geq 0.9$
LL	11256	43 % (42 %)	14 %	43 %
LM	5174	48 % (46 %)	15 %	37 %
LA	16293	53 % (51 %)	18 %	29 %
CO	17180	52 % (51 %)	17 %	31 %

ICRC2019
Madison, WI, USA
V. Harvey

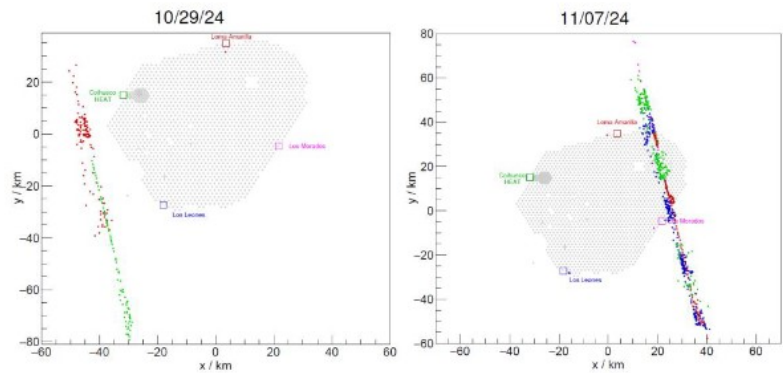
1. Cloud camera
2. FD Lidar of the site (cloud fraction, CBH)
3. GOES (cloud probability)
4. CLF/XLF (CBH above laser facility)

Michael Unger & Bianca Keilhauer looked deeply into the code and the conclusion is that the procedure works as intended.



EarthCARE satellite cross-overs

- New satellite in orbit since May 2024
- New orbit allows cross-overs more frequently at the Auger Observatory and at TA
- Studies to use this satellite also for gamma-ray telescopes (VERITAS, CTAO, H.E.S.S.) will start soon
- First laser tracks observed at Auger and TA since Sep 24

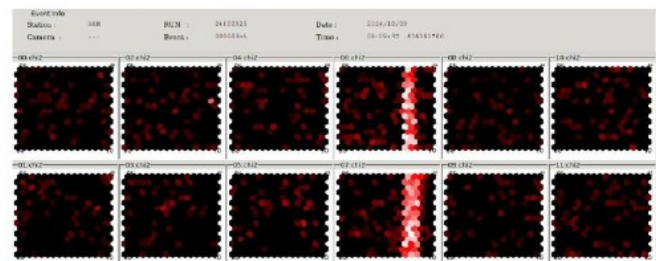
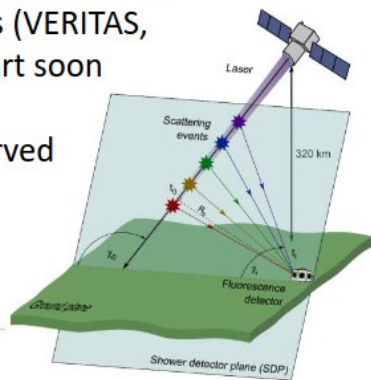


Passes above Auger and TA

Laser energy known at 1-2%

Level 2 products to be released in March/April

- Aerosol properties
- Clouds



Online event display at TA
10/09/24

EarthCARE



First call EarthCARE @ Auger scheduled on Feb 14th

Joint Auger - AEOLUS
Publication 2024

Research Article

Vol. 11, No. 2 / February 2024 / Optica 263

OPTICA

Ground observations of a space laser for the assessment of its in-orbit performance

THE PIERRE AUGER COLLABORATION,^{1,6,1} OLIVER LUX,^{2,*} ISABELL KRISCH,² OLIVER REITEBUCH,² DORIT HUBER,² DENNY WERNHAM,⁴ AND TOMMASO PARRINELLO⁵



ATM1 poster



Cloud Detection at the Pierre Auger Observatory using Night-sky Background Light

proposed ATM1 ICRC2025 contribution

Fedor Tairli, University of Adelaide

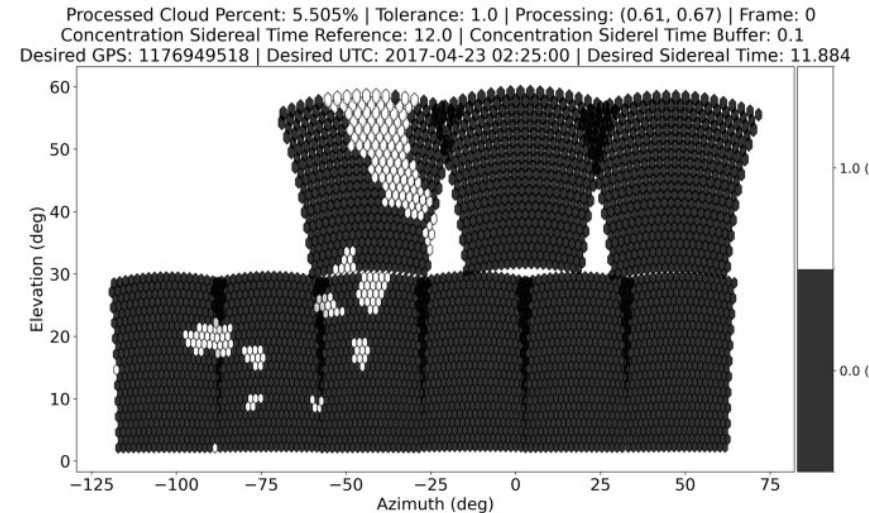
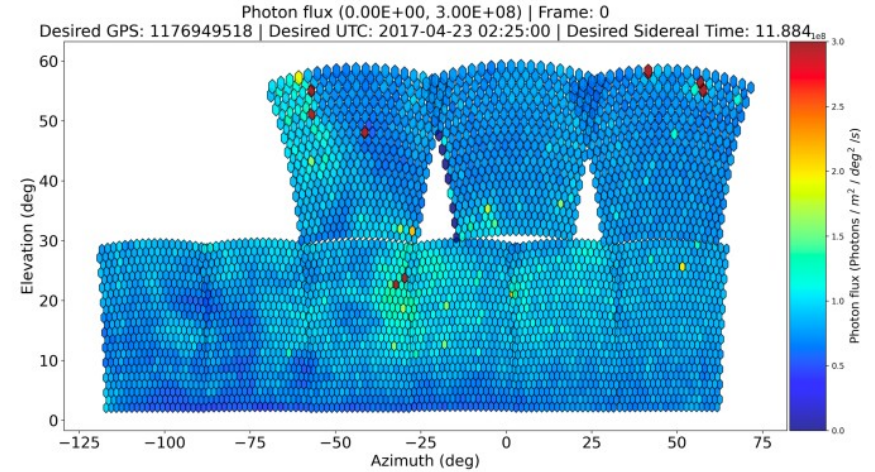
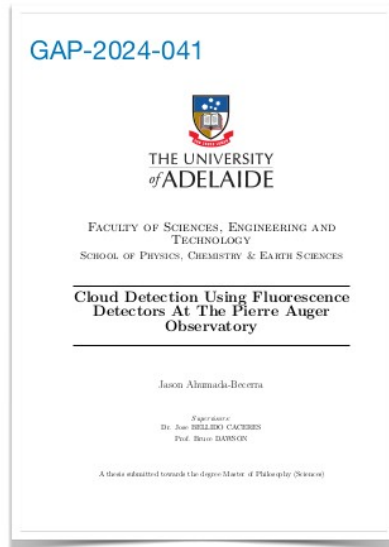


Steven Safi

with Jason Ahumada-Becerra, Jose Bellido, Bruce Dawson & Darko Veberic

Background to the contribution

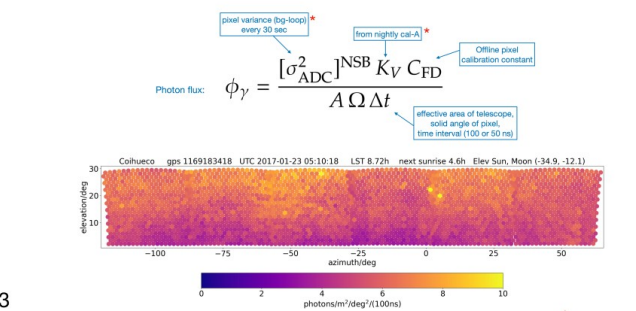
- Replacement of infra-red cloud cameras
- exploitation of continuous measurements of NSB by the FD over the life of the observatory
- original analysis by Jason Ahumada (Masters, 2024)
- NSB cloud masks now available in Offline database Atm_Cloud_1_A for 2022 & 2023 for all sites over all FD operation times.



Plan for ICRC contribution (first draft)

1. Introduction

- importance of cloud detection, Auger's instruments, past and present.
- components of the Night sky background in the near-UV
- measuring the NSB continuously via the FD bg-loop process
- data available for every pixel every 30 sec over the full FD lifetime
- converting base-line variance to photon flux (Segretto 2011)

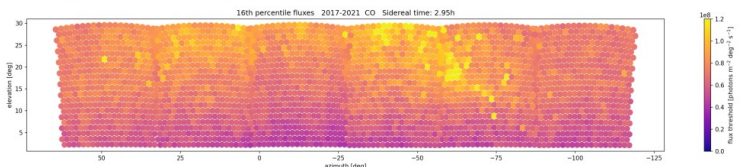


3

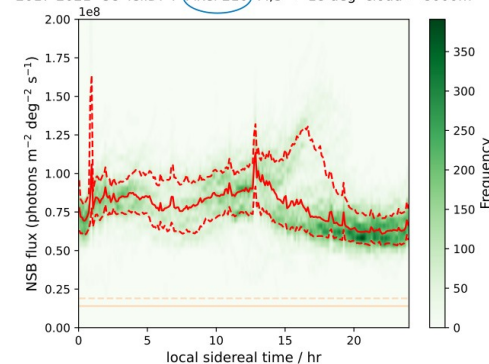
2. Determining the threshold for cloud detection

- Goal: threshold for every one of >11,000 pixels as a function of local sidereal time (LST).
- cuts on sun and moon elevation, and a minimum cloudbase height > 8000m from XLF/CLF (Quality DB)
- 2D histogram (right) shows the 16th percentile of the NSB flux as a function of LST for one pixel - used as the cloud threshold

Example: cloud thresholds (photon flux) for Coihueco, LST = 2.95 hr.



2017-2021 CO TelID: 4 (Pixel 210) M,S < -18 deg cloud > 8000m



Cuts: moon and sun elevation < -18°
cloud base height > 8000 m (from CLF/XLF)

red lines: median flux, and 16th and 84th percentile fluxes

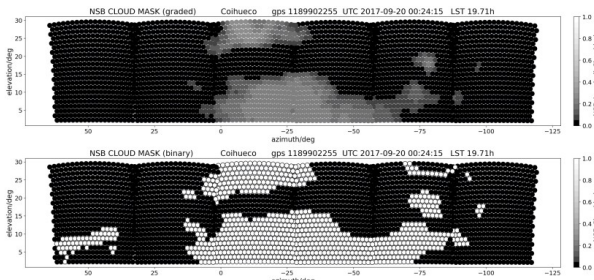
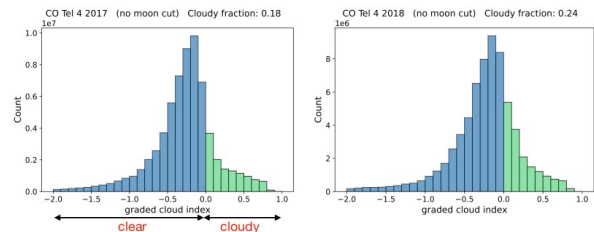
3. Defining “graded” and “binary” cloud indices

- For a given pixel at some time, the **graded cloud index**:

$$C_{\text{graded}} = \begin{cases} 0 & \text{if flux } F \geq F_{16} \\ (F_{16} - F) / (F_{16} - F_{\text{shutter}}) & \text{otherwise} \end{cases} \quad (5)$$

given a pixel flux F , a cloud-threshold F_{16} and the closed-shutter flux F_{shutter} . We also define a **binary cloud-index** C_{binary} which replaces all values of $C_{\text{graded}} > 0$ with unity.

- typically has a value between -2 and 1. From this define the **binary cloud index**.
- some filtering is done to remove isolated cloudy or clear pixels.
- (NB: For the current Offline database, we first find the cloudiest state of a pixel in a given 5 minute period, then filter isolated cloudy/clear pixels)



[link](#) to the the animations

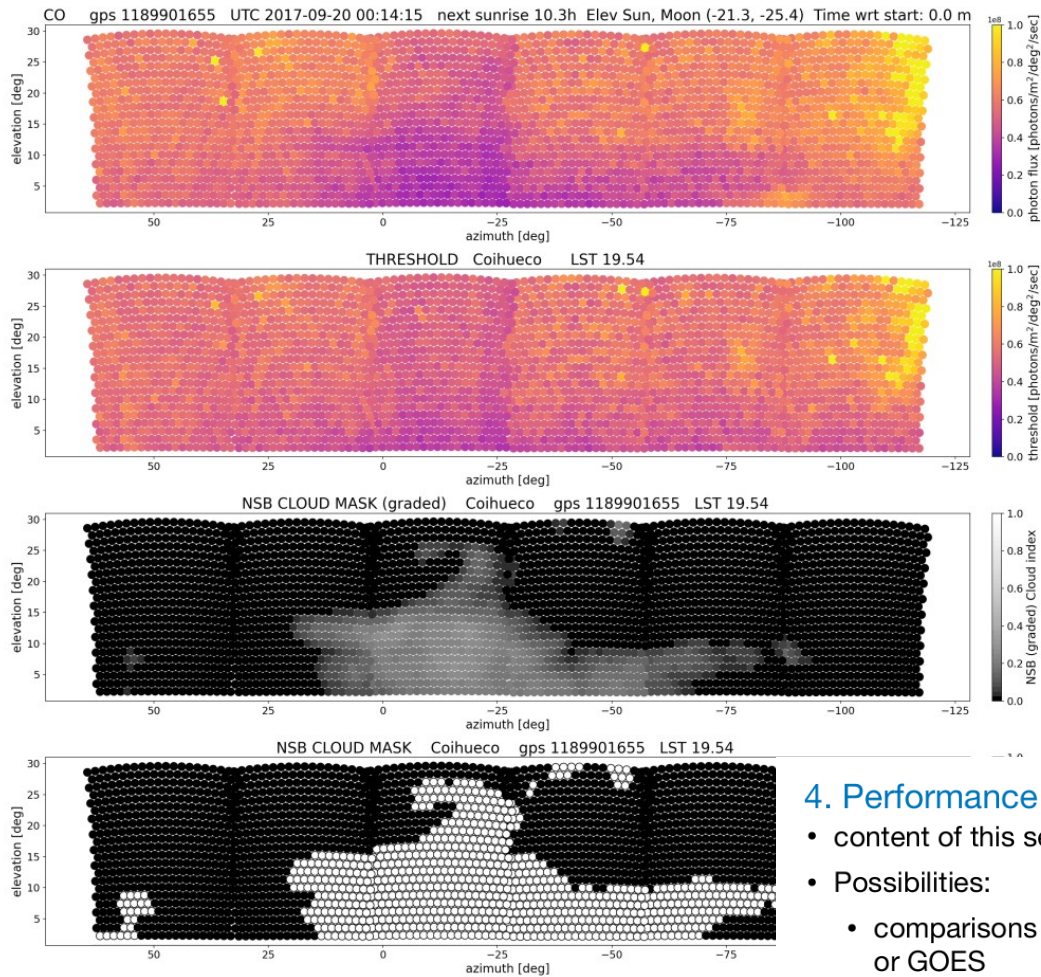
the NSB at some time
(glitch every 30m due to
DAQ overload - calA in 2017)

threshold changes
every 6 minutes

For the ICRC paper/
poster, we will have a url
or a QR code for an
animation. Probably use
a more recent example!

a “graded” cloud index
0 if flux <= threshold,
1 if flux = closed shutter flux

binary cloud index
for the database

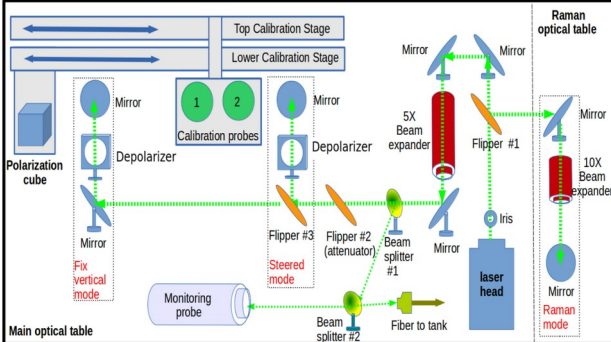


WORK IN PROGRESS

4. Performance

- content of this section TBD.
- Possibilities:
 - comparisons with IR CloudCam ([this slide](#)), and/or GOES
 - NSB cloud fractions at different FD sites in a year ([next slide](#))
 - average cloudiness across a site, and average index validity time ([the slide after next](#))

CLRF & XLF status



CLRF : some parts of the system are obsolete (15 years or more!)



High instability of CLRF since a few years, and it didn't work at all between April 24th and Nov 21st 2024



XLF has been running quite normally since after the laser replacement in March 2023 ($E = 5.5$ mJ)

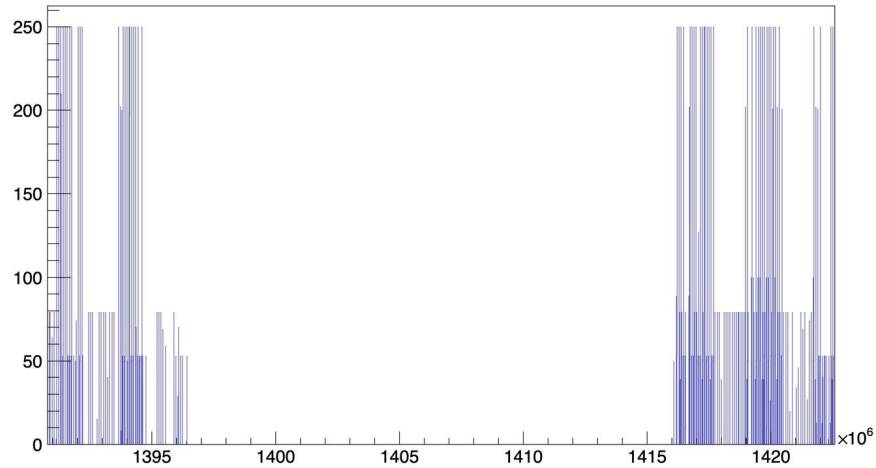
Work on site of many people! Small technical issues solved and CLF restarted for end-Nov shift.
[...] this means, that the CLF is back, but still in its unreliable status because of the old SBC and laser. However now, with the gained experience of the last days, we can concentrate now on the upgrade of the system which can probably be installed or at least tested already in March 2025.

- Main instability of the system : the GPS module fails and this prevents the laser from firing
- New design of the Single Board Computer + GPS board (finalized)

To have a stable system for the next 10 years, the upgrade is mandatory (also at XLF!)

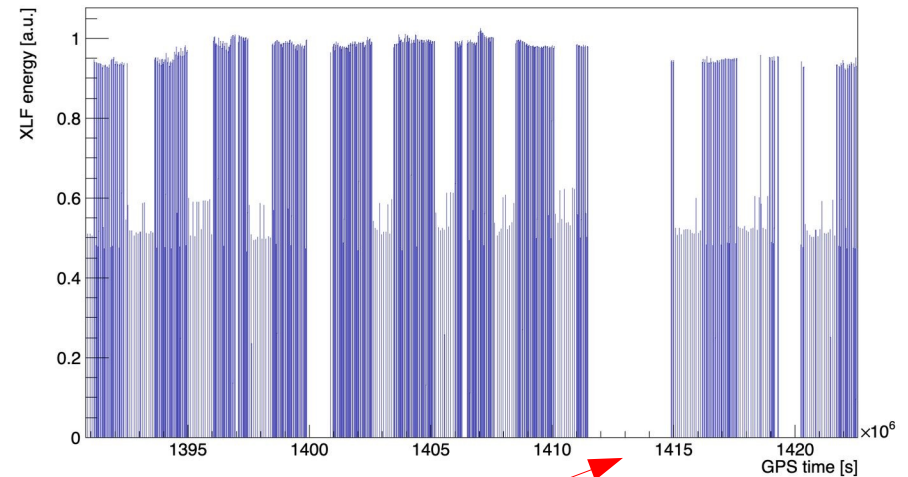


CLF shots rate feb 2024 – feb 2025



Known problems of instability

XLF shots rate feb 2024 – feb 2025

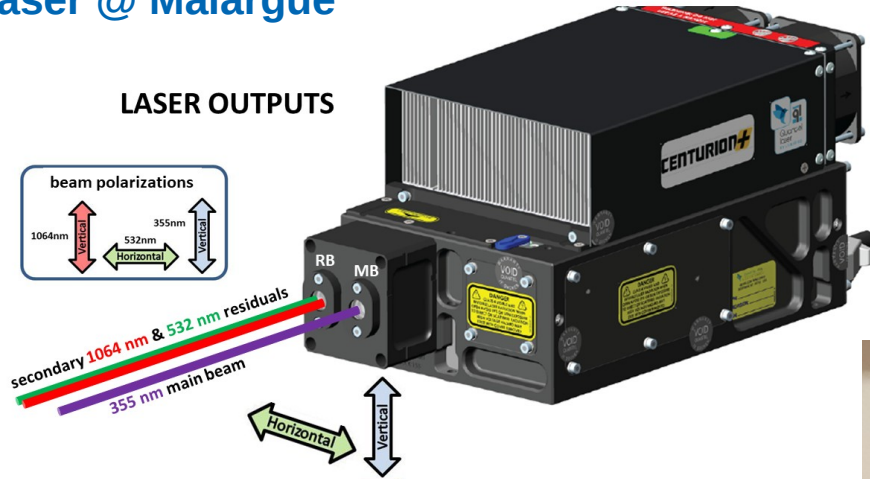


storage disk full

New Centurion+ laser for CRLF

laser @ Malargue

LASER OUTPUTS



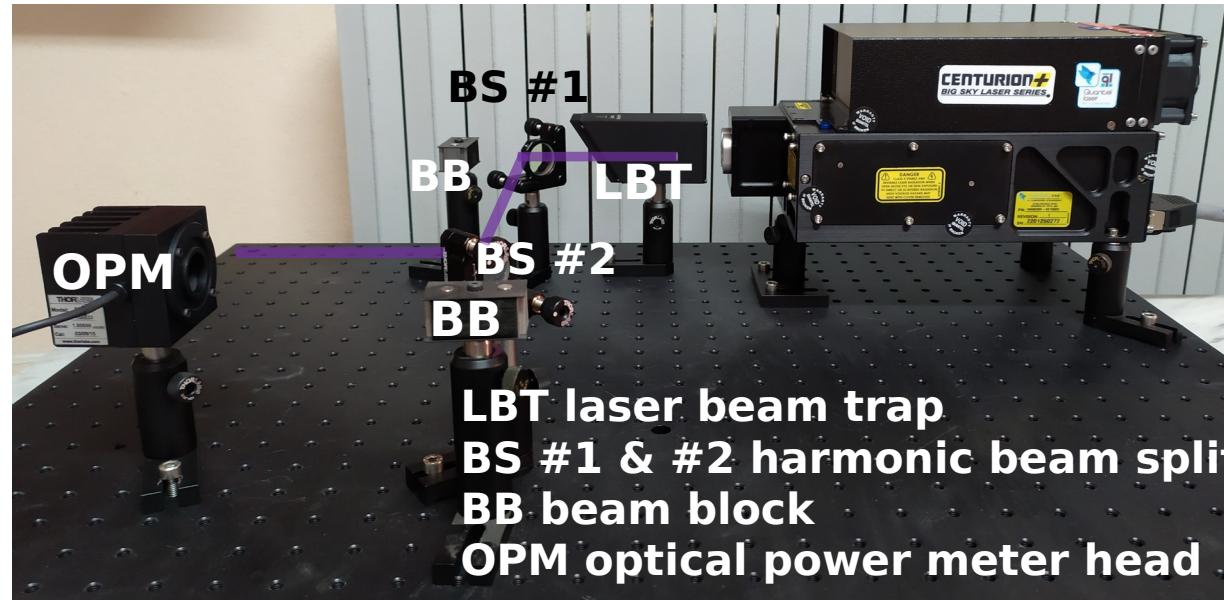
Tested in L'Aquila (V. Rizi)

Need some optical adjustment to work at the CLF:

- Beam cleaning (too much green and IR)
- Different beam exit
- Different beam divergence and diameter

... also some commands to drive it are different

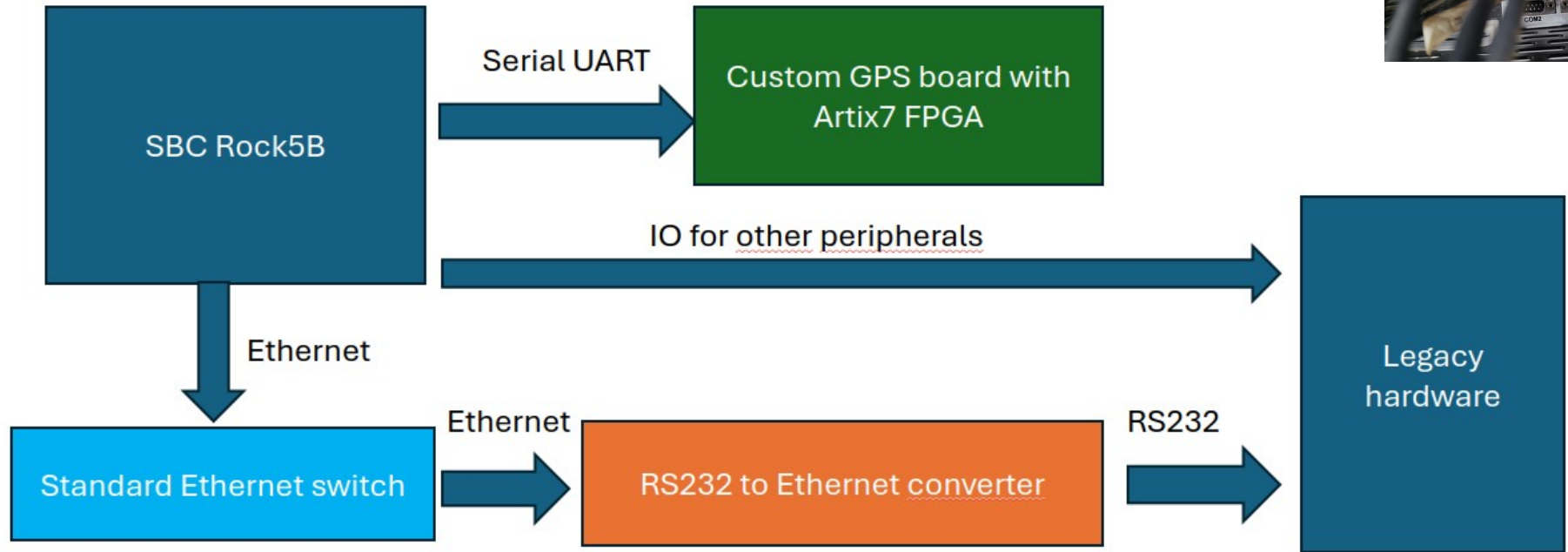
Plan to substitute it in the near future, but not in March (maybe November?)



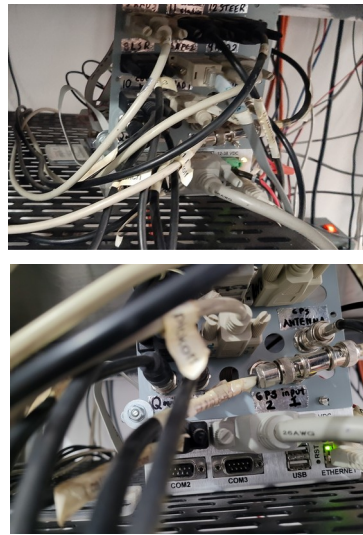
CLRF hardware upgrade

IDEA

New SBC, new GPS board, full switch to Ethernet from RS232



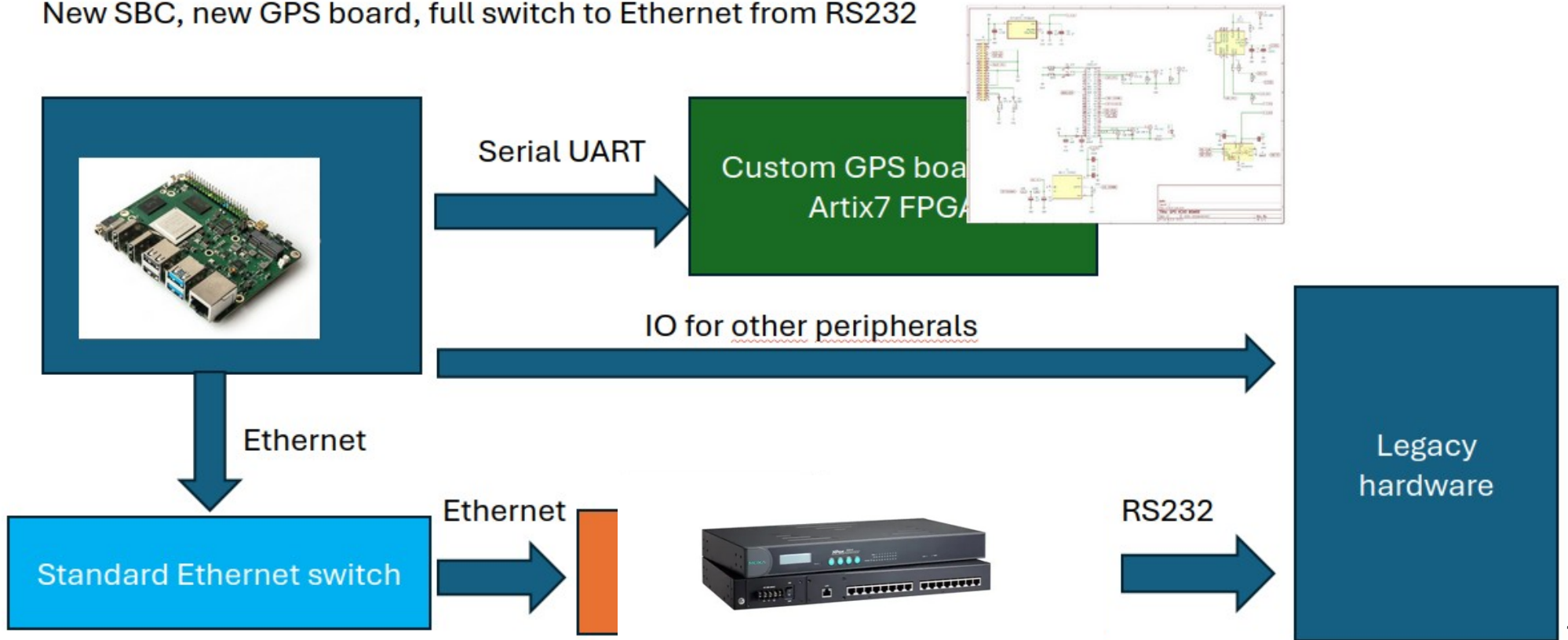
Present SBC



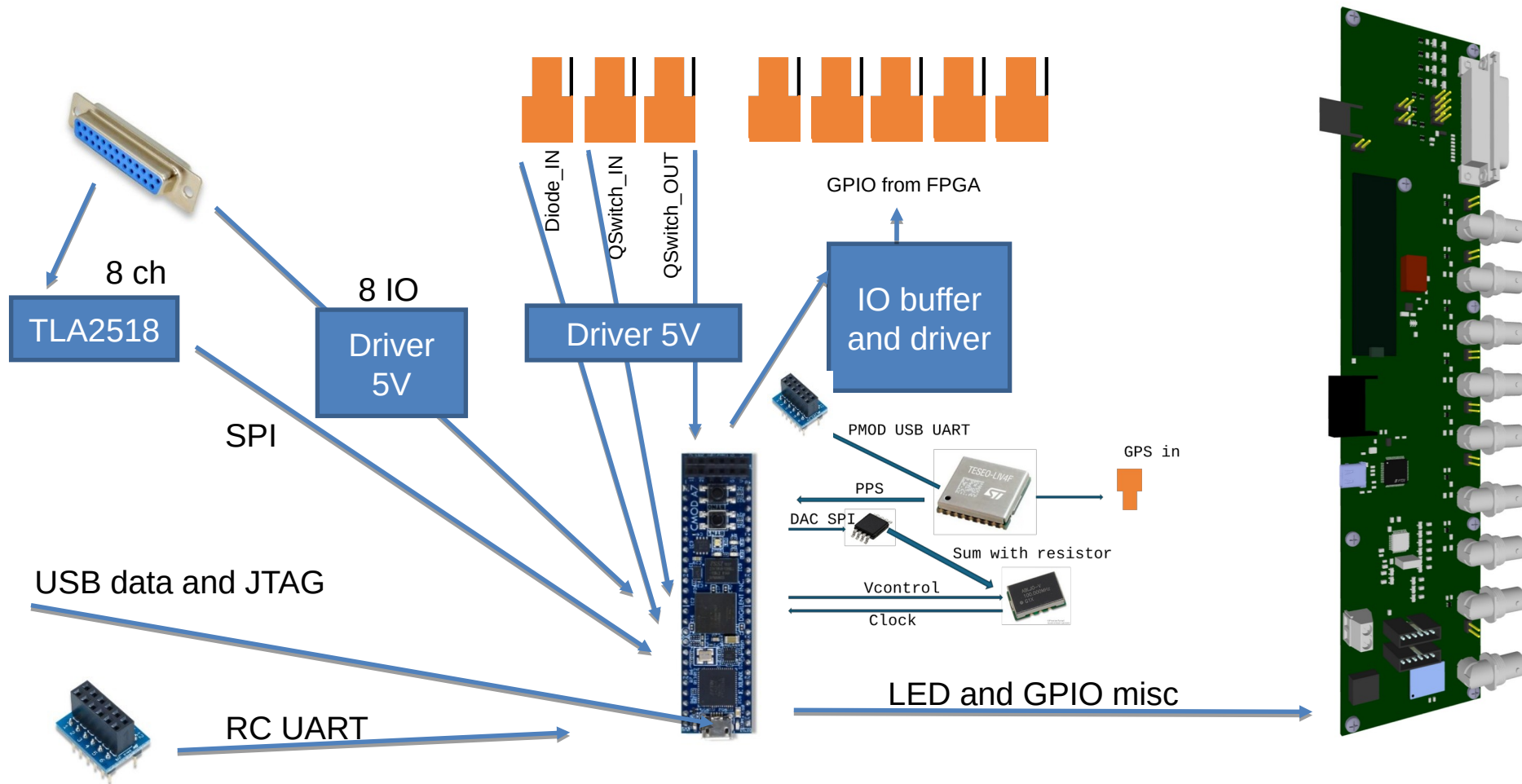
CLRF hardware upgrade

IDEA

New SBC, new GPS board, full switch to Ethernet from RS232

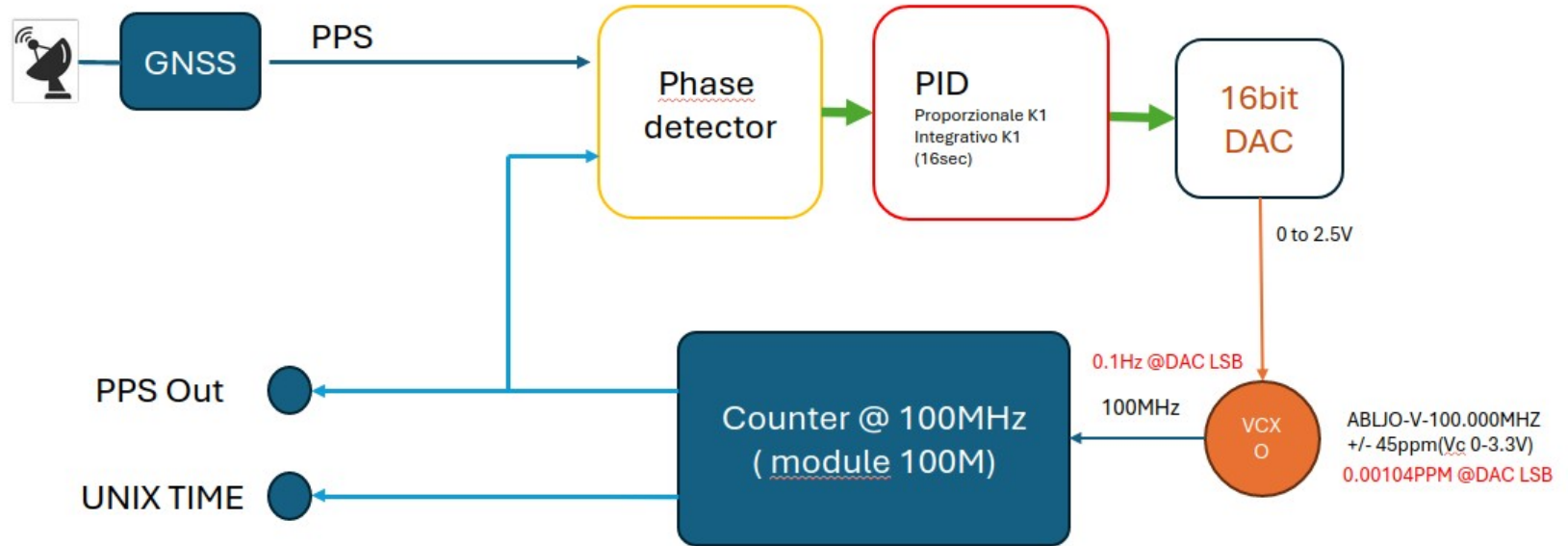


Schematic of the custom GPS board



GPS feedback loop

Behaviour (VCXO mode)



CLRF software upgrade

CLF source shared on gitlab

 CLF 

main

 /

clf

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Code

 header for weather station wind coding
Lawrence Wiencke authored 4 days ago

506f13d4



History

Name	Last commit	Last update
source	header for weather station wind coding	4 days ago
A0_README_lw_2025_01_29....	README about the different source and...	4 days ago
README.md	Initial commit	1 week ago
README_compile_crlf_code	Upload New File	4 days ago
crlf_code_2025_01_29.tgz	tarball of crlf code as currently in use (...)	4 days ago

 Uploaded by Lawrence Wiencke

Received a few days ago

Plan to rewrite / translate some parts
and drop others which are no more useful

Naples software expert (G. Tortone – INFN)
will help in this process

Plan for the upgrade

- Design of the PCB completed and sent to production. Delivery in two weeks for the first prototype. Mechanics under design and production in Naples Mechanical workshop
- Code update in progress
- Test in Napoli
- Installation in Malargue during the March meeting

Many people involved in this effort :

A. Boiano (SER – INFN_NA), L. Lavitola (INFN_NA), G. Tortone (INFN_NA)
+ Napoli and L'Aquila Auger groups + support from experts from CSM