Drone calibration

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Basic information

Main Goal:

to obtain a **calibration constant** for every specific angle (0.25° precision after interpolation) for each FAST telescope – 4 PMTs per telescope.

In general, current FAST calibration follows three step procedure:

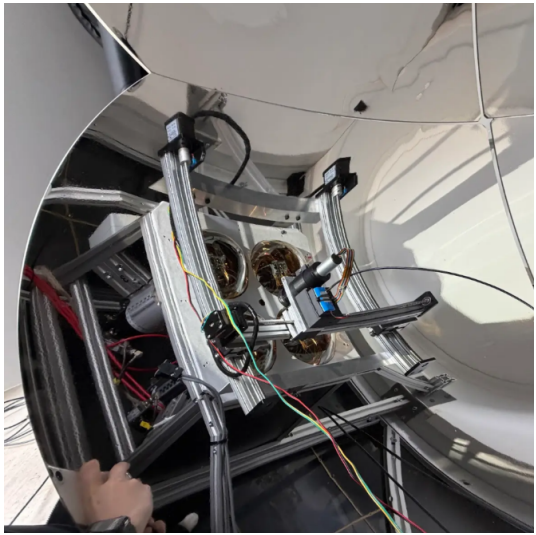
0. *Laboratory PMT calibration (out of the scope of this talk)*
1. **Relative PMT calibration:** using *PMT-Scanner*
2. **Relative FAST calibration:** using *Drone* giving the angular dependence of the detected signal (counts)
3. **Absolute radiometric calibration:** of the calibration light source assigning specific number of photons entering the FAST aperture

1) Relative PMT calibration

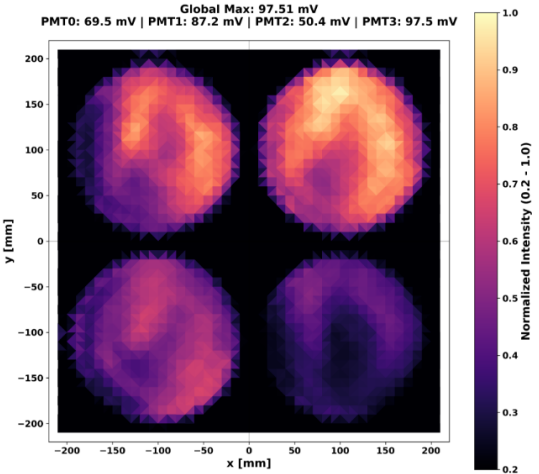
Goal:

to obtain the best rotation position of PMTs (with respect to the magnetic field at site) to get the most uniform pattern.

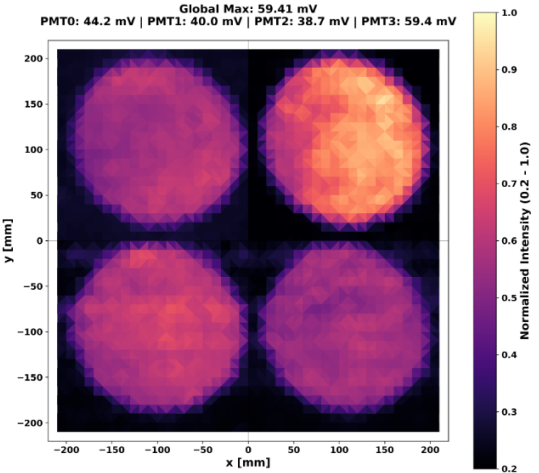
- PMT-Scanner is XY positioning stage,
- it is mounted directly on the camera,
- it carries optical collimator,
- which scans PMTs with light pulses
- that are recorded and evaluated.



1) PMT-Scanner results



FAST_3



FAST_4

2) Relative FAST calibration

Goal:

to obtain relative dependence of counts on incident angle.

- Drone follows scripted set of positions,
- where it stops for a period of time,
- emits light pulses of 100 Hz frequency
- that are detected by FAST camera.

2) Relative FAST calibration

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- Drone follows scripted set of positions,
- where it stops for a period of time,
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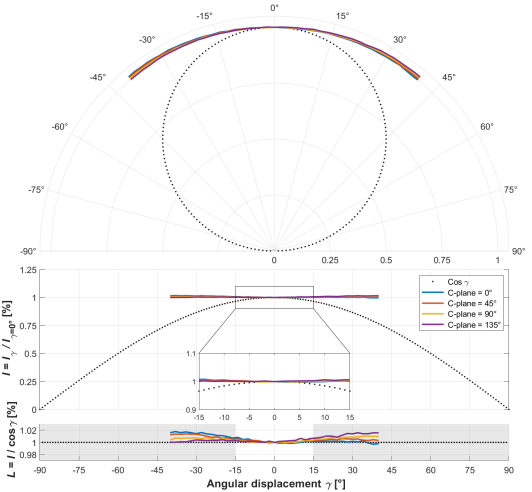
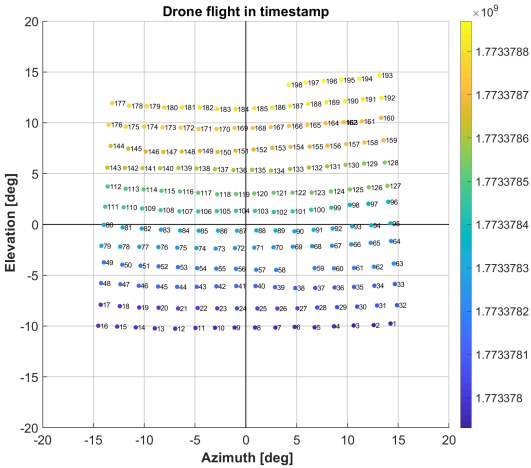
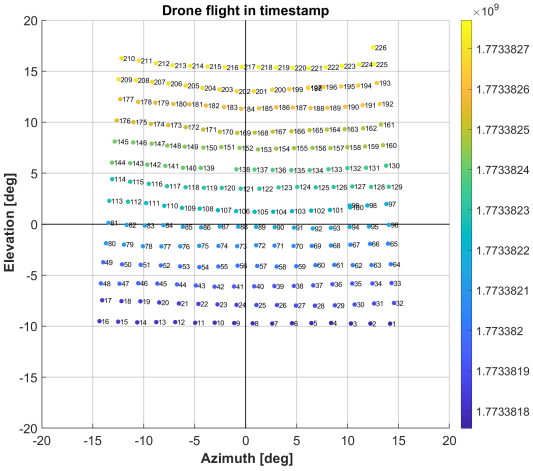


2) Drone scanning positions

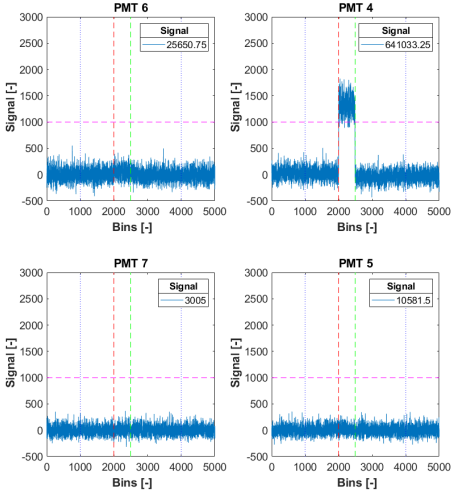


FAST_3

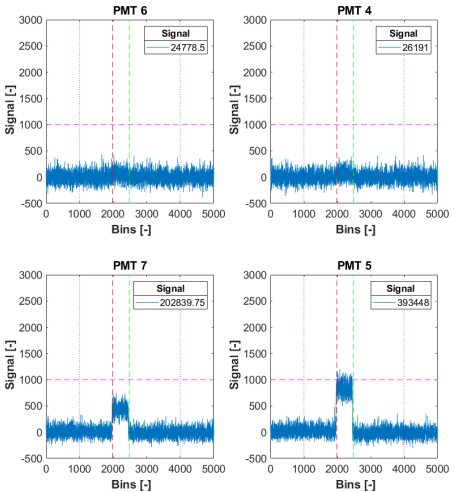


FAST_4

2) Typical recorded signals



TOP RIGHT

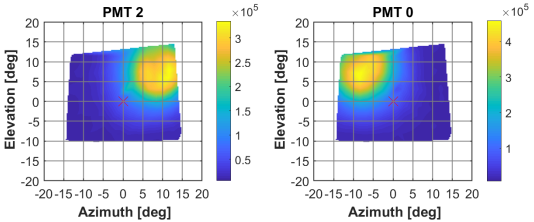


BOTTOM CENTER

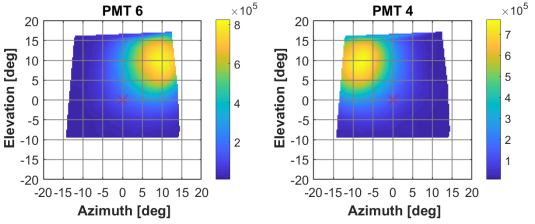
2) Analysis

1. Process the huge amount of data and convert it into a readable format,
   - *Work done solely by Petr, thank you!*
2. assign the azimuth and the elevation to each position,
   - *Image analysis by Dušan, thank you!*
3. find the closest event using the timestamp,
4. reliably find the pulse and calculate its signal in counts for each PMT,
   - *Thank you, Jakub, for your advices!*
5. expand the number of events around the selected one sufficiently,
   - *No final decision yet*
6. interpolate the signals along incident angles to achieve finer grid of results,
7. plot the efficiency map for each single PMT (in counts),
8. sum all 4 PMT together and acquire relative efficiency on incident angle.

2) Results single PMTs

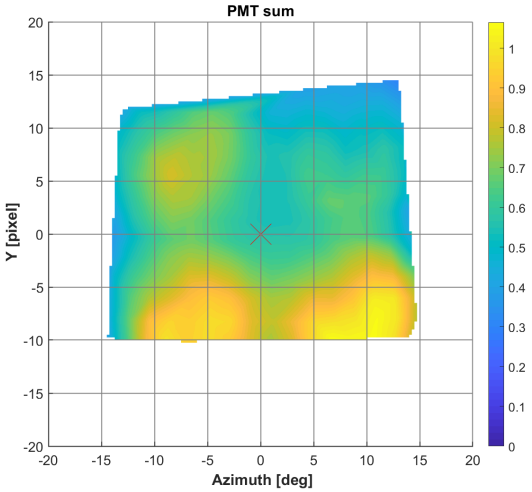


FAST_3

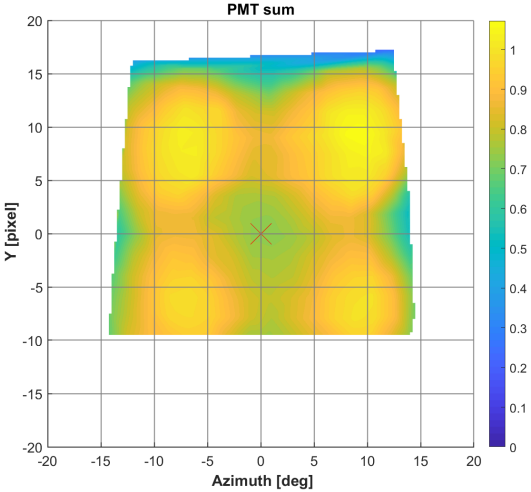


FAST_4

2) Results PMT sum



FAST_3

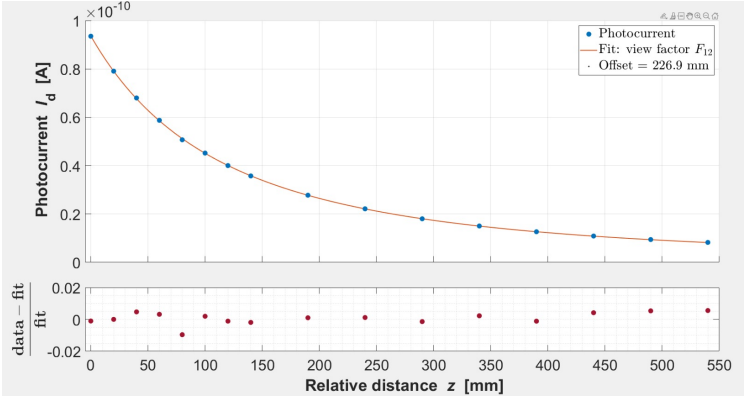


FAST_4

3) Absolute radiometric calibration

Goal:

to obtain the number of photons entering the FAST aperture to ultimately acquire the calibration constants for each incident angle. Work in progress.



Outlook

1. First set of Drone calibration scans performed in March 2026.
2. We know what to expect and how to evaluate data.
   - Yet the analysis is in progress and still improving.
3. There is a space for improvement in terms of execution.
   - We already know what has to be done better and how.
4. FAST training telescope is being assembled and will be used for tuning of various methods and measurements in the near future.
5. Even though it may not be obvious at first glance, we are making progress!