ARCA30 acoustic positioning: Positioning TDR method results

Preamble

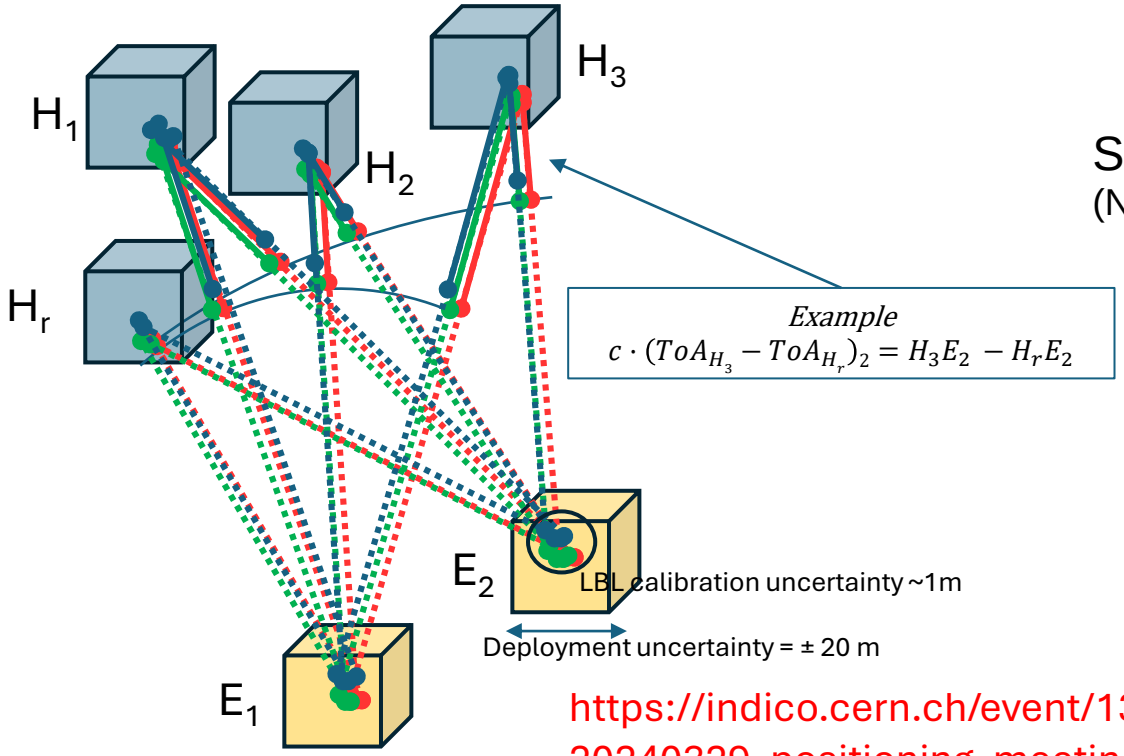
- Positioning method based on LBL calibration (see TDR positioning) can be applied to **any run**
- It doesn’t need “quite” runs
- The method can be independently applied to any single DOM

https://indico.cern.ch/event/1391057/contributions/5847579/attachments/2829089/4942927/20240329_positioning_meeting.pdf

Long BaseLine (LBL) calibration: Emitters + Hydrophones

- The accuracy on the relative positions of the fixed assets provided during deploymentsis too large to reach the accuracy on DOM relative positions requested by the project (~ 20 cm)

- LBL calibration goal: reduce errors on relative positions of the fixed LBL elements



System of N*(M-1) equations in (N+(M-1))*3 variables
(N=number of emitters ; M=number of hydrophones)

$$c \cdot (ToA_{H_i} - ToA_{H_r})_j = \overline{H_iE_j} - \overline{H_rE_j}$$

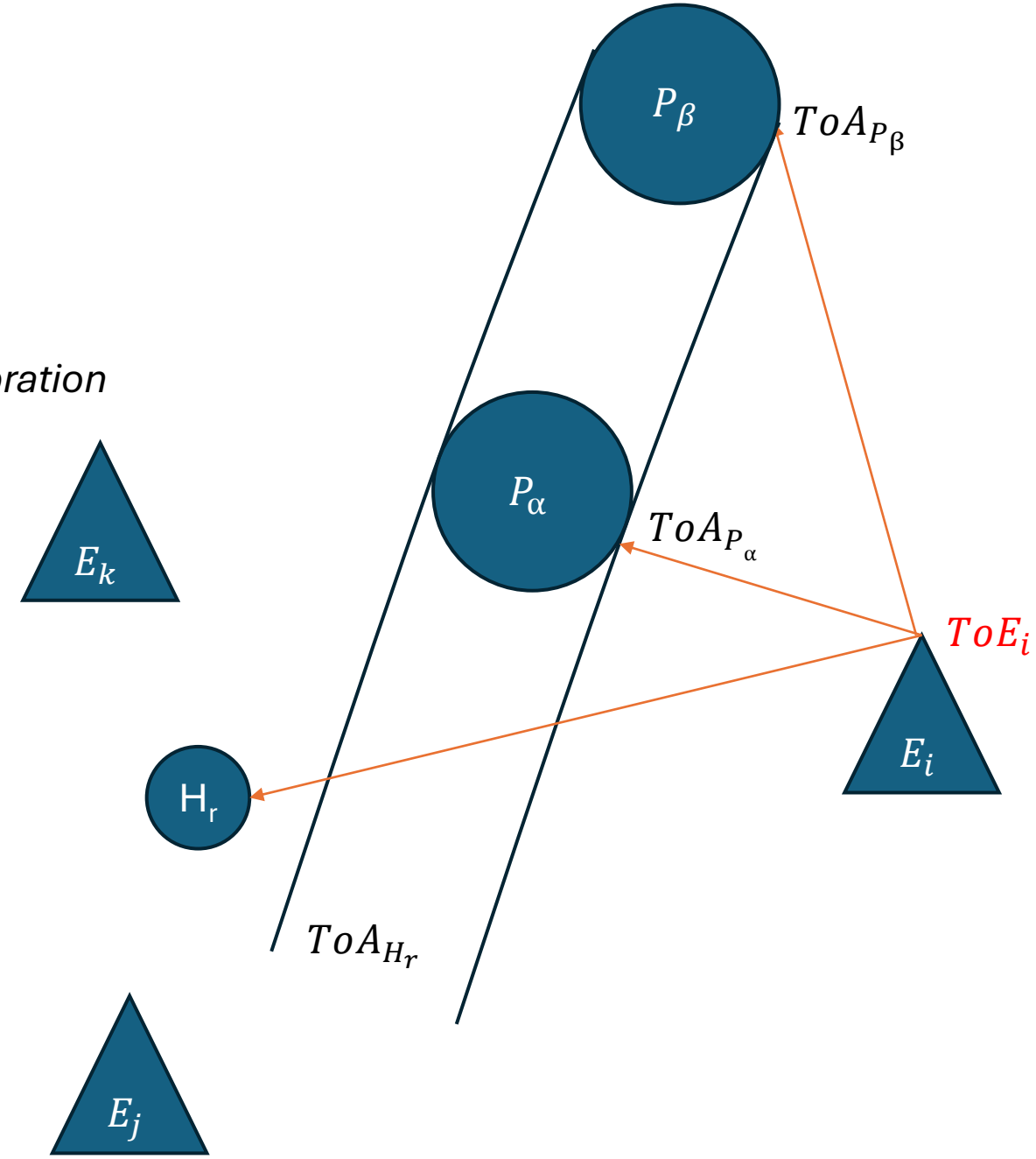
Sound velocity

https://indico.cern.ch/event/1391057/contributions/5847579/attachments/2829089/4942927/20240329_positioning_meeting.pdf

DOM positioning

Hyperbolic multilateration based on DToAs :
Emitters and hydrophones positions obtained by LBL calibration
Hydrophone as a reference

$$d_{E_i H_r} - d_{E_i P_\alpha} =$$
$$c \cdot \left(ToA_{H_r} - ToE_{E_i}\right) - c \cdot \left(ToA_{P_\alpha} - ToE_{E_i}\right) =$$
$$c \cdot \left(ToA_{P_\alpha} - ToA_{H_r}\right) =$$
$$c \cdot DToA_{P_\alpha H_r}$$



DOM positioning algorithm includes the dependency of the sound velocity on depth

As a first approximation at very deep sea:

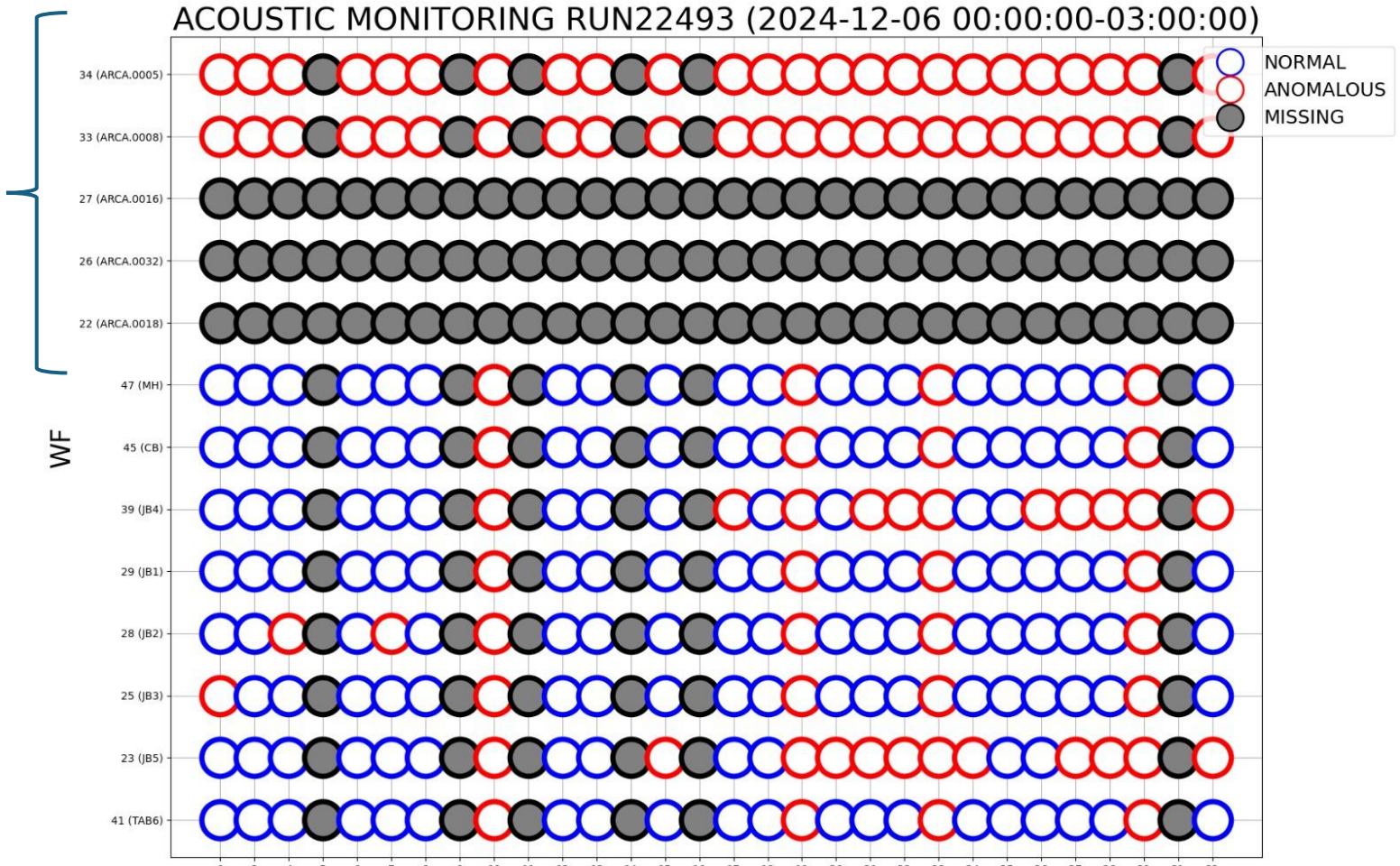
Effective sound velocity (beacon-receiver) =

$$c(z_{\text{Emitter}}, z_{\text{Receiver}}) = \frac{a * \Delta z}{\ln(c_{emitter} + a * \Delta z) - \ln c_{emitter}}$$

a=δc/δz ~ constant in deep sea

Run selection

- ARCA30 DOM positions have been recovered at the first run available (both hydros and emitters ON) (Run 22493: 2024-12-06)



LBL calibration procedure

Least squares minimization from initial guess

Initial guess= nominal positions + random offset on x,y,z(flat distribution -20m : +20m, 500 initial guesses)

Constraints:

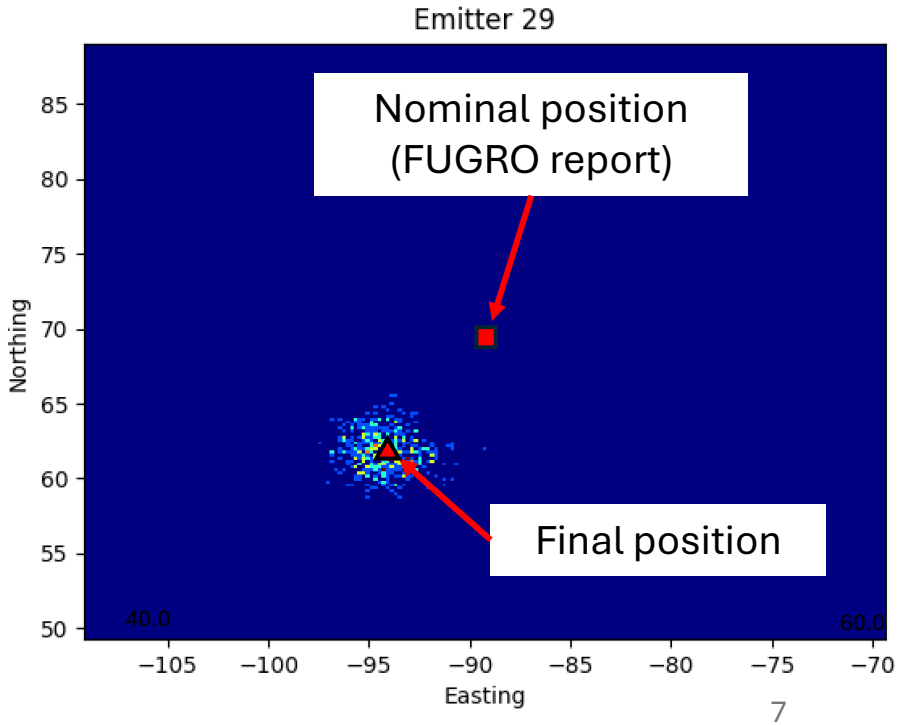
- distance final positions <35 m from nominal positions (pcal A05750828 for DUs and FUGRO reports for other beacons)
- Hydrophones on FUGRO multibeam bathymetry (2013) (https://drive.google.com/file/d/1n7E5o46X6G95tJ2-ynjFMAzjwCQIWTok/view?usp=drive_link)

Detector: D0ARCA030
Run:22493
Final position: geometrical median of the 500 solutions

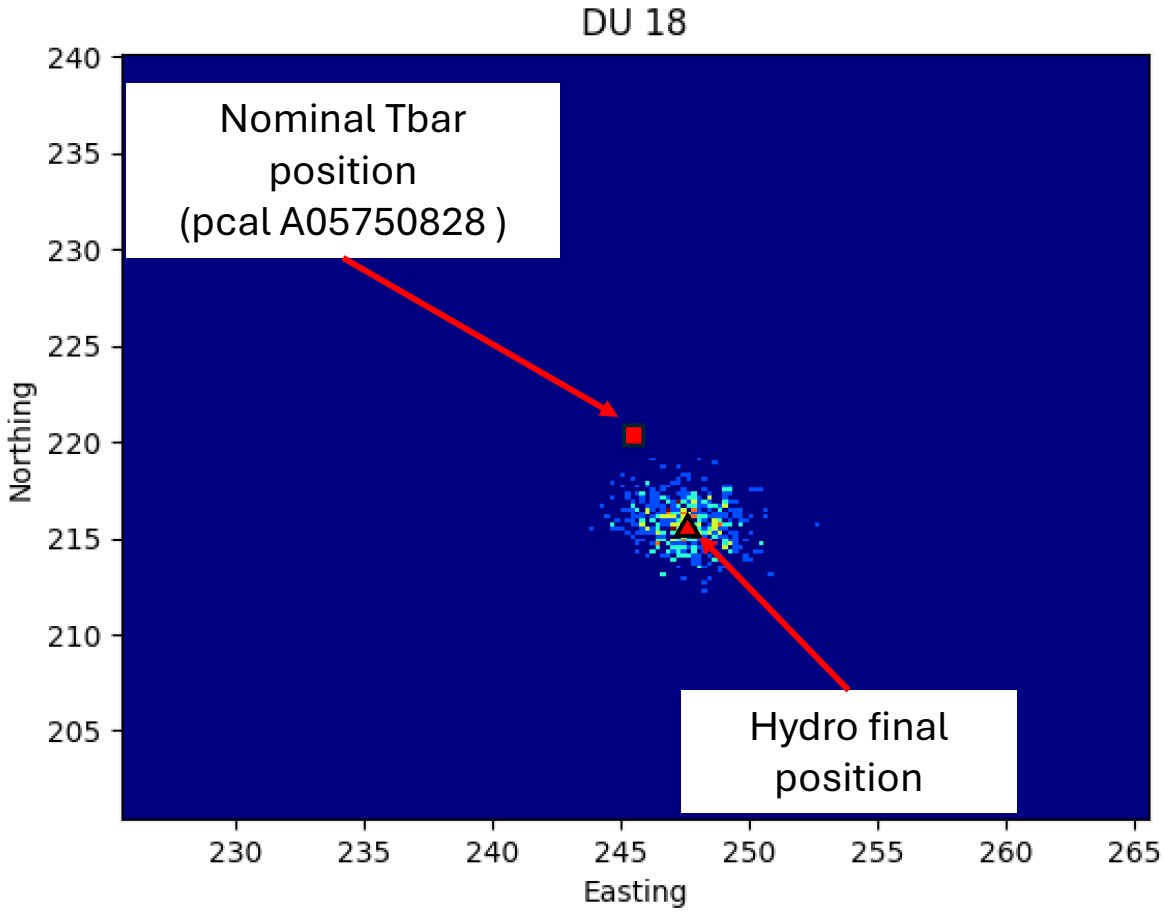
LBL calibration procedure

Detector: D0ARCA030
Run:22493
Final position: geometrical median of the 500 solutions

Final position distribution
Emitter JB1



Final position distribution
DU18

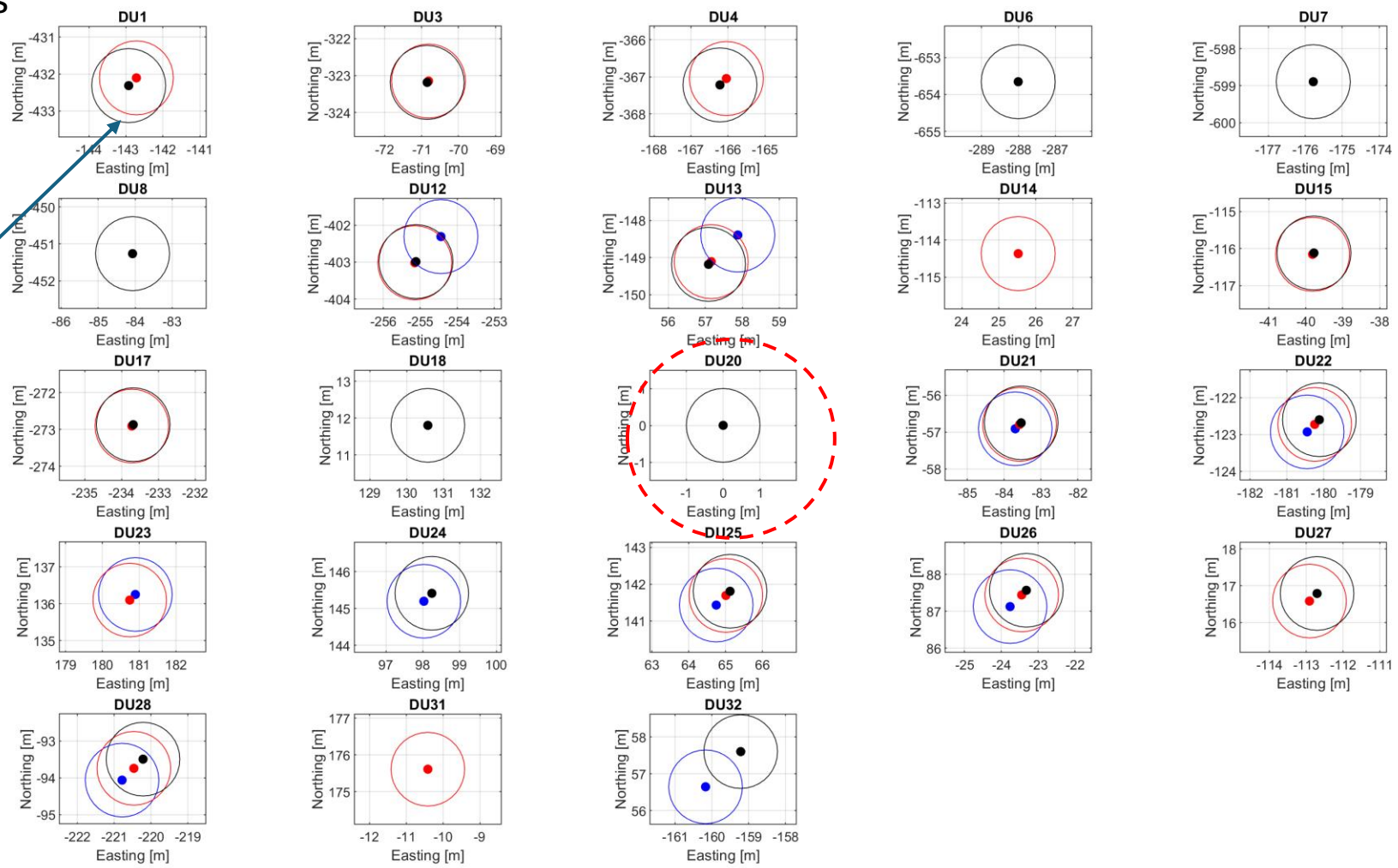


Hydrophones' position

DU hydrophones' position has been calculated with respect to the DU20 hydrophone's position.

<u>NO ROTATION HAS BEEN APPLYIED</u>

Radius = 1m



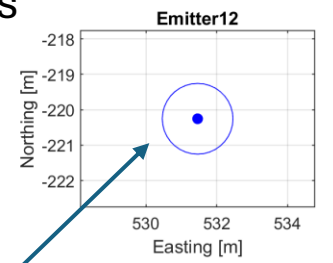
- **D0ARCA030**
- **D0ARCA028**
- **D0ARCA021**

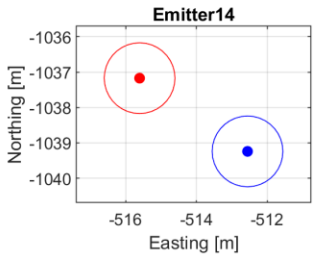
Emitters' position

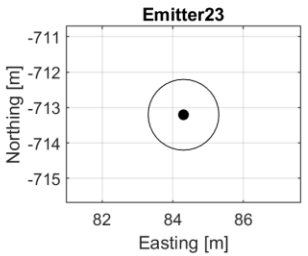
DU hydrophones' position has been calculated with respect to the DU20 hydrophone's position.

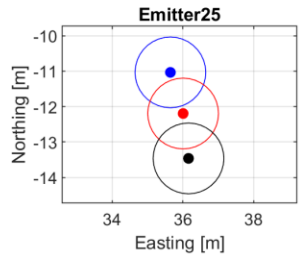
<u>NO ROTATION HAS BEEN APPLYIED</u>

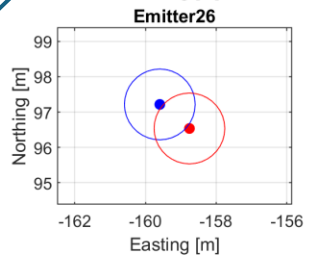
Radius = 1m

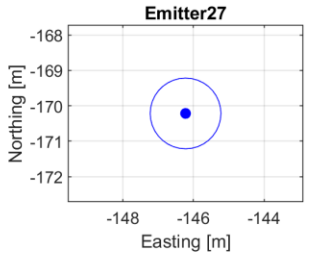


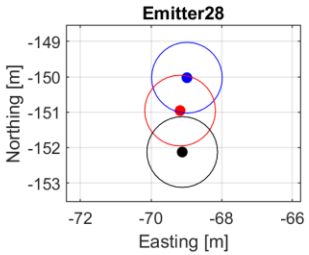


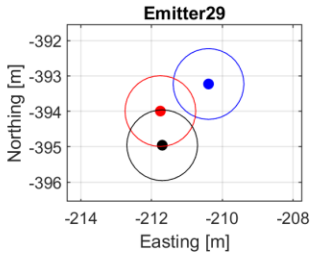


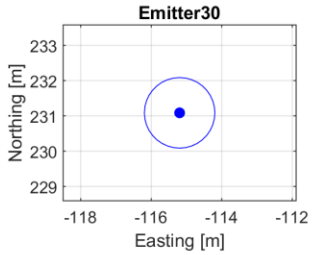


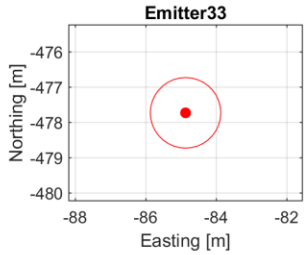


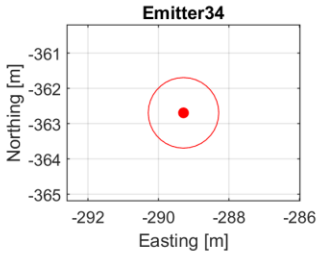


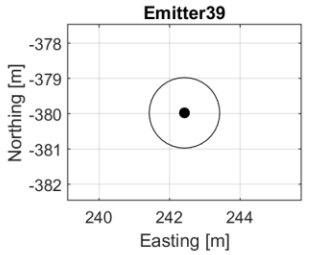


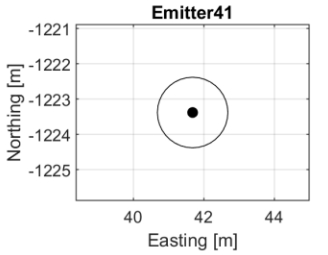


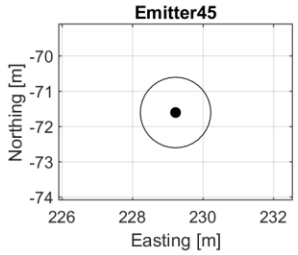


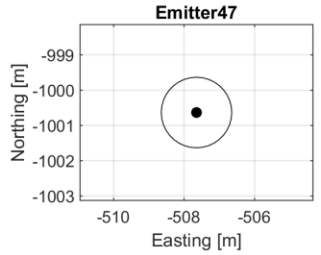






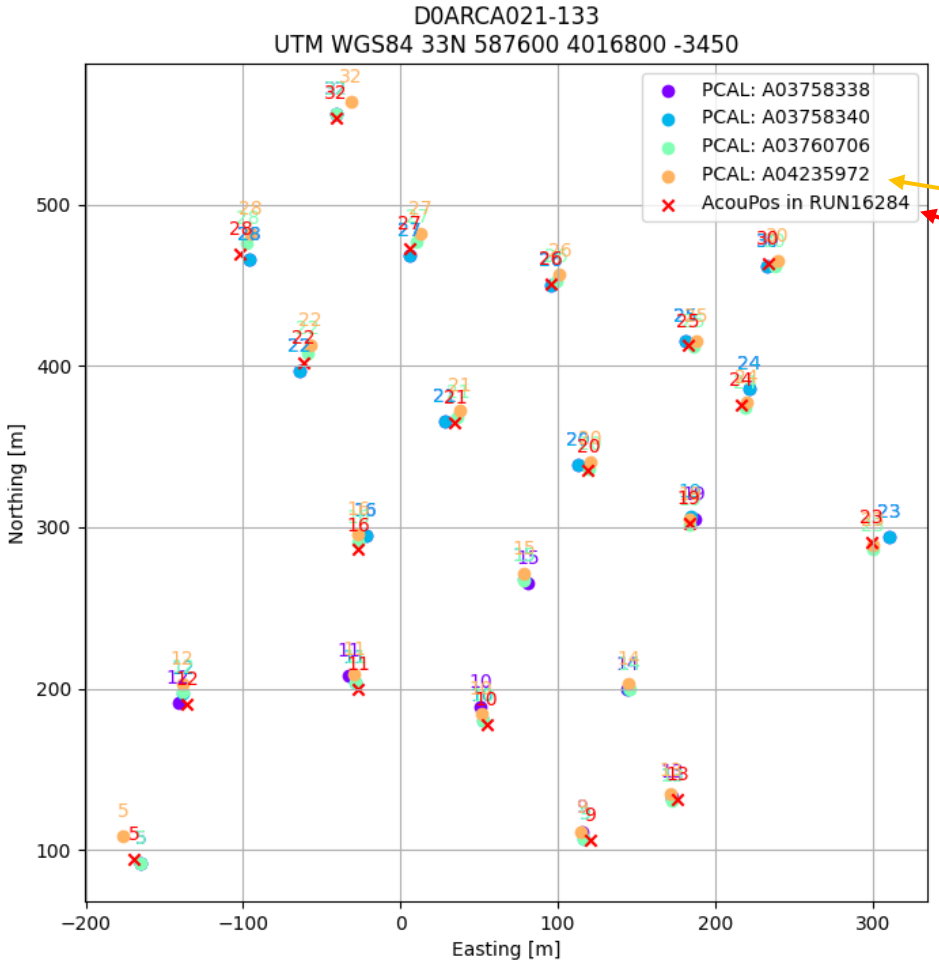






- **D0ARCA030**
- **D0ARCA028**
- **D0ARCA021**

DU Tbar absolute positions



In order to compare our results with the JPP positioning results the Tbar position (x) has been extrapolated for each DU by applying a fit based on a mechanical model of the DU (Didac's model)

- JPP

X Positioning TDR

~2° anti-clockwise rotation wrt the Jpp positioning results was found for D0ARCA021

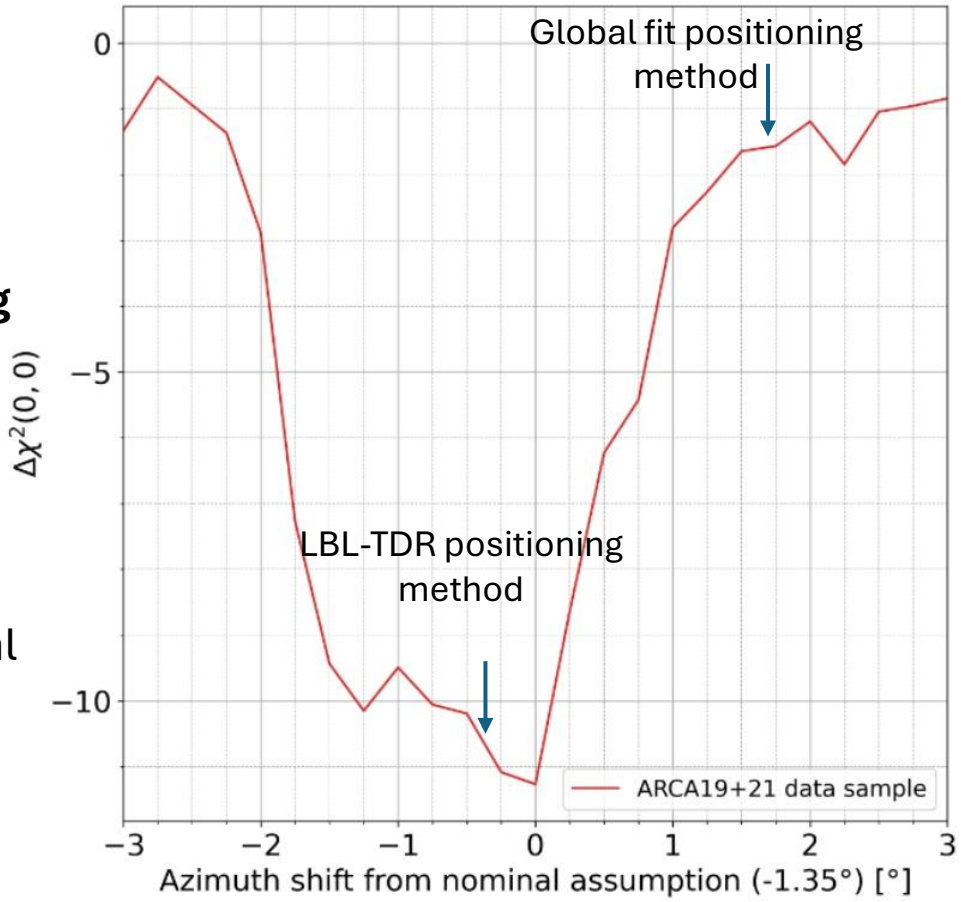
→ same rotation expected in D0ARCA030

Comparison with the moon shadow analysis

See Francesco Benfenati's presentation at WP7 meeting

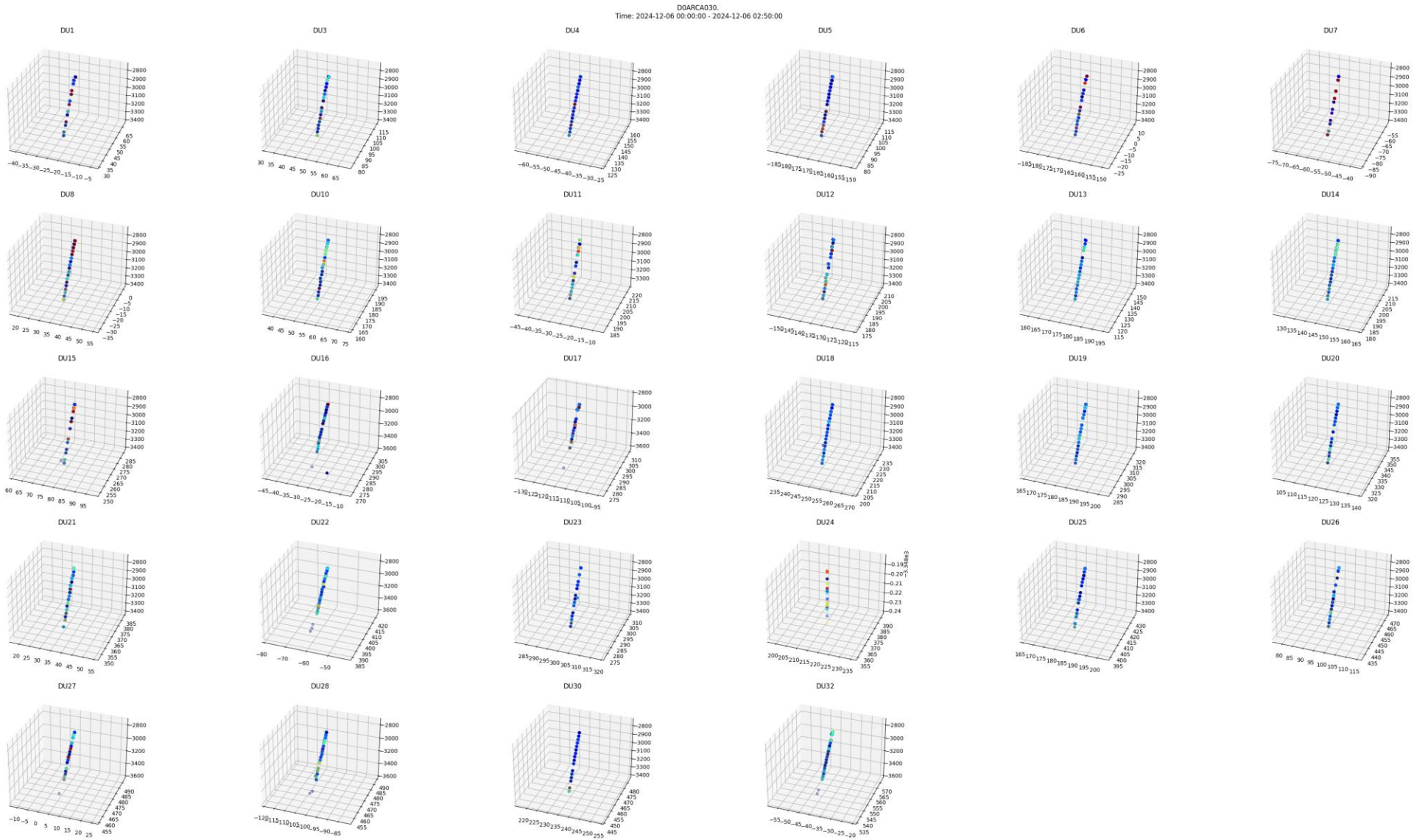
https://agenda.infn.it/event/35878/contributions/249176/

The Δ χ^2 minimum of the moon-shadow was found by applying a 2D anti-clockwise rotation of 1.35° to the official D0ARCA21 detector positions.

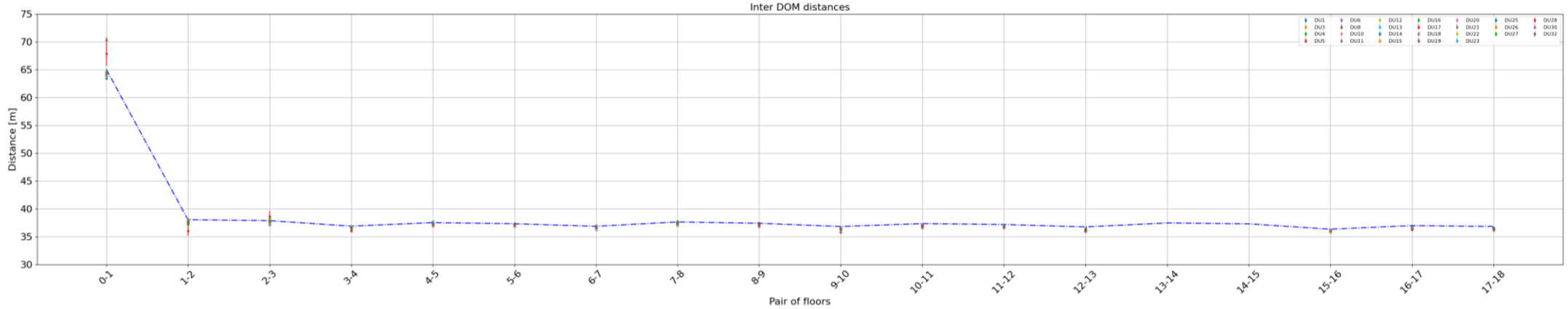


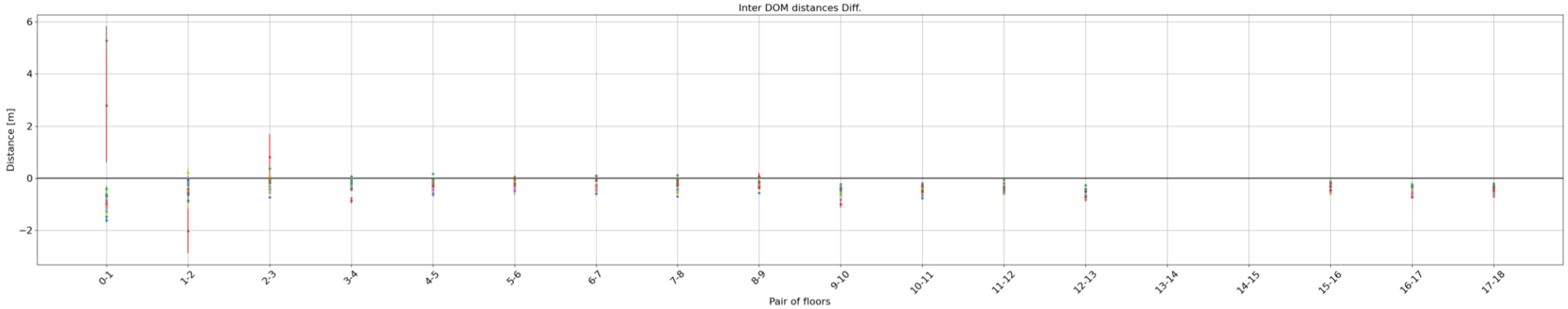
ARCA30 results

D0ARCA030 Run:22493



Sanity check: Inter-DOM distances

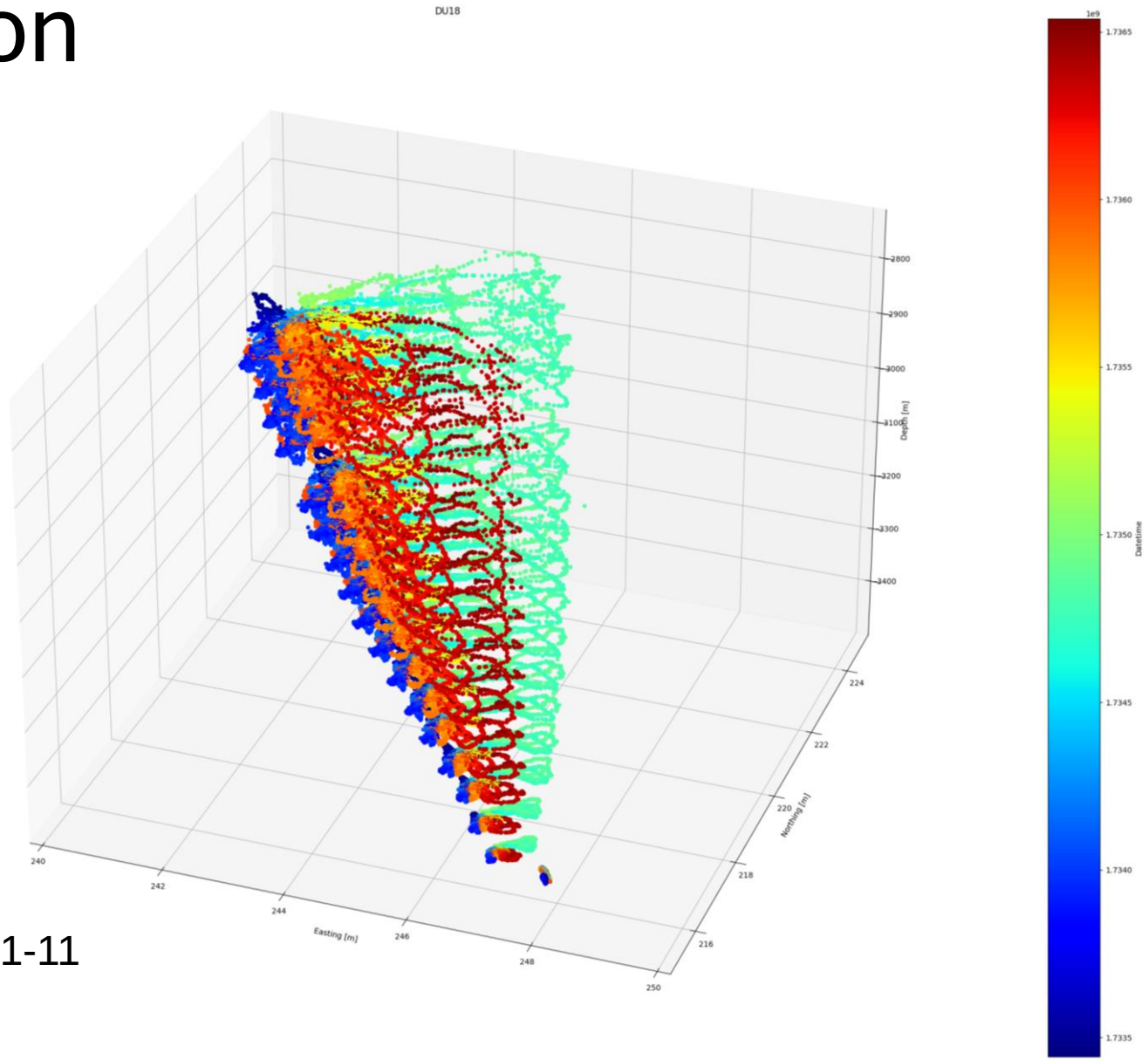




DU18 DOMs position

RAW DOMs and hydrophone positions

- Time resolution: 10 minutes
- NO FIT
- NO MECHANICAL MODEL
- EACH DOM POSITION COMPUTED INDIPENDENTLY



Runs 22493-22966: 2024-12-06 → 2025-01-11

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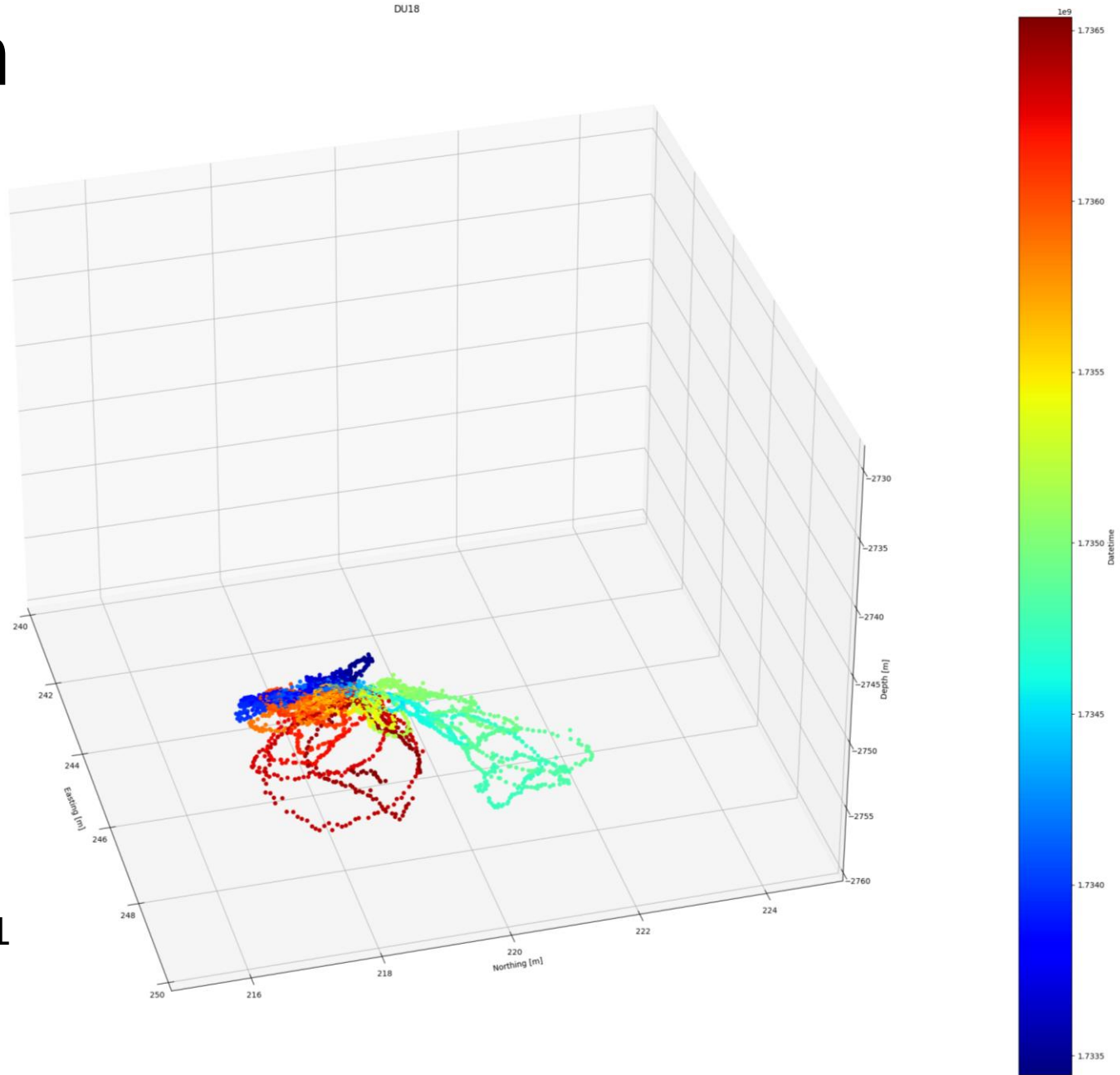
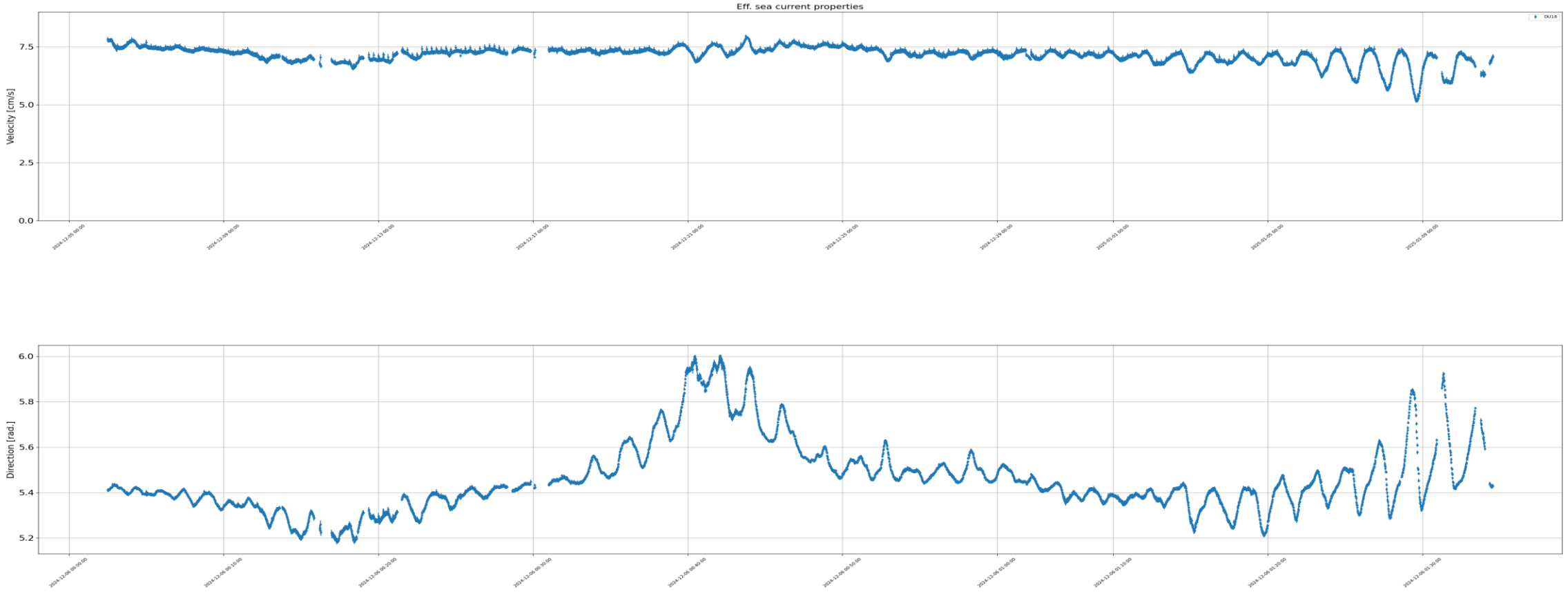


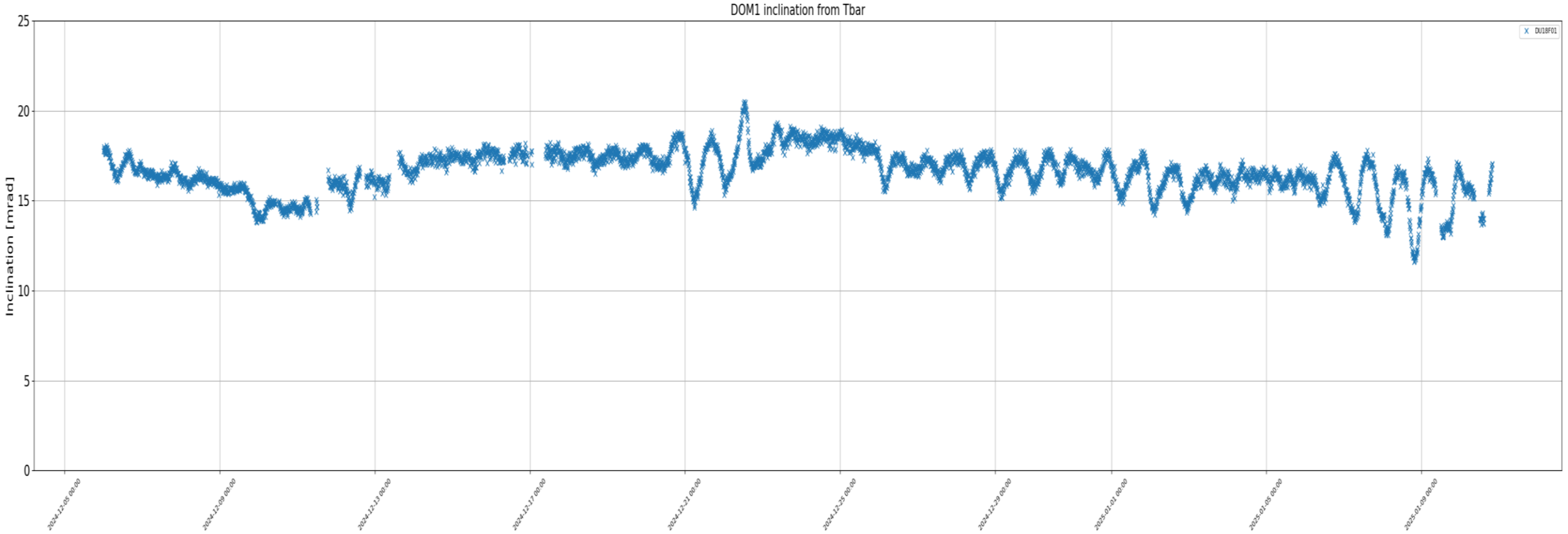
Runs 22493-22966: 2024-12-06 → 2025-01-11

DU directions: azimuth



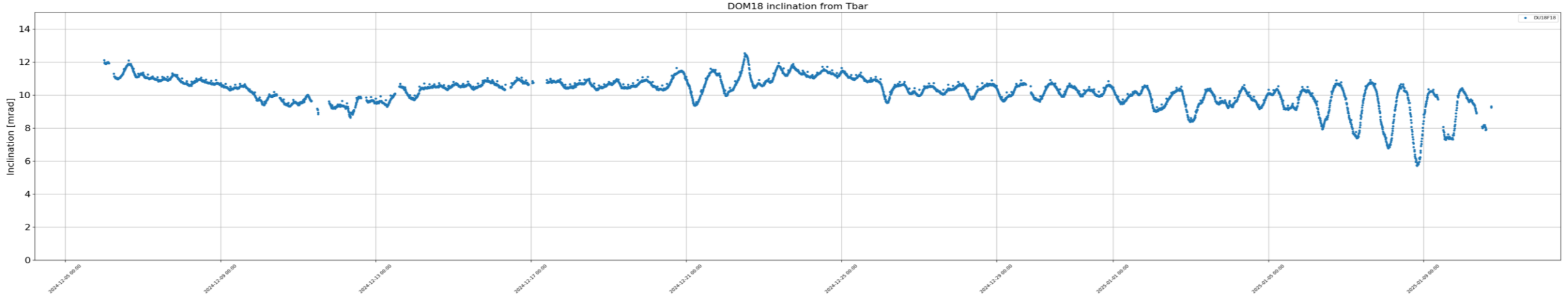
Runs 22493-22966: 2024-12-06 → 2025-01-11

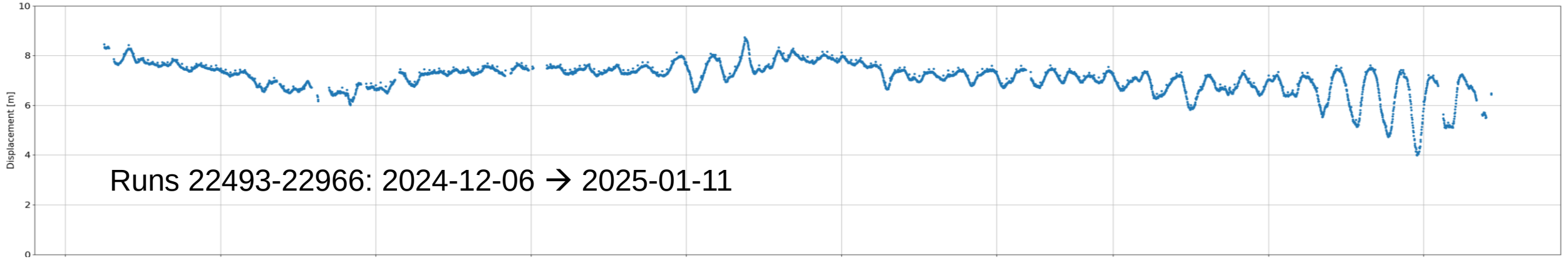
DOM1 inclination



Runs 22493-22966: 2024-12-06 → 2025-01-11

DOM18 inclination





Runs 22493-22966: 2024-12-06 → 2025-01-11

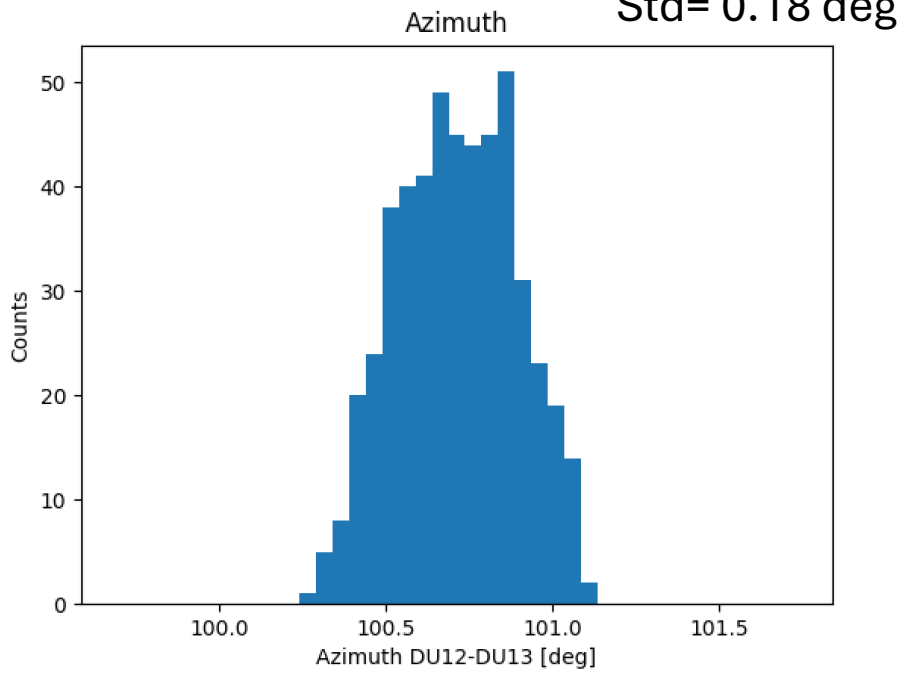
BACKUP

LBL calibration results

Least squares minimization from initial guess
Initial guess= nominal positions + random offset on x,y,z (flat distribution -20m : +20m, 500 initial guesses)
Constraints: maximum distance 35 m from nominal positions
Detector: D0ARCA030
Run:22493

DU12-DU13 Azimuth distribution

Std= 0.18 deg



LBL calibration procedure

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Constraints:

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- Hydrophones on FUGRO multibeam bathymetry (2013) (google drive)

Detector: D0ARCA030
Run:22493
Final position: geometrical median of the 500 solutions