DETECTION UNIT LINE FIT ANALYSIS FOR KM3NeT

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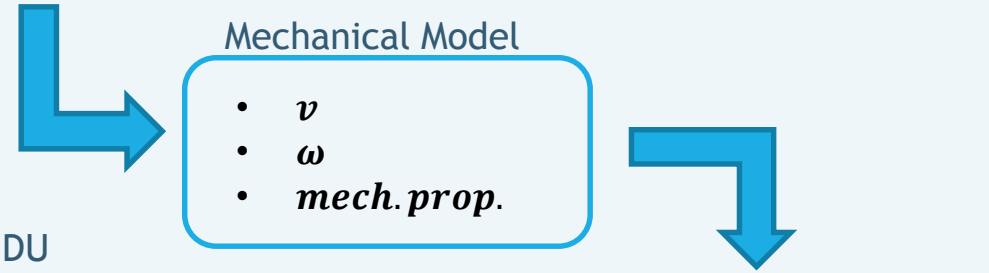
INTRODUCTION
Main Goal

INPUTS FOR DU LINE FIT

- APS data every 10' (average) → **LOCATION** of acoustic receivers $\{x, y, z\}$
- AHRS data every 10' (average) → **ORIENTATION** $\{YAW, PITCH, ROLL\}$

DU Line Fit necessary:
· If some sensor presents failures
· If some data is missing (fail detection)

DU Line Fit reconstructs the shape of the DU using a Mechanical Model using an effective value of sea current (v and ω) and the inputs APS and AHRS data and some mechanical properties of the items in the DU.

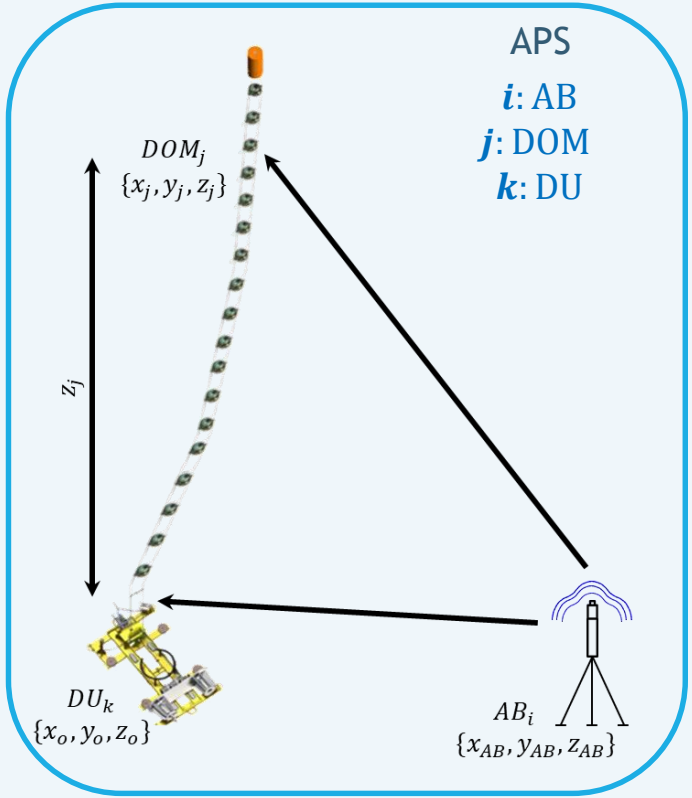


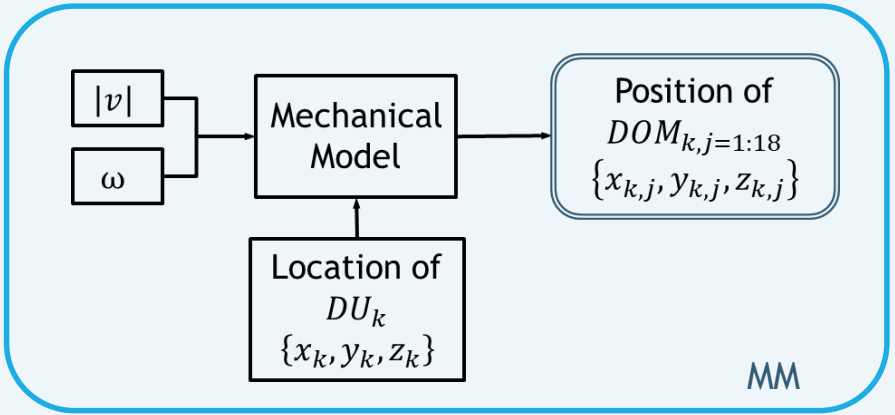
OUTPUTS FOR DU LINE FIT

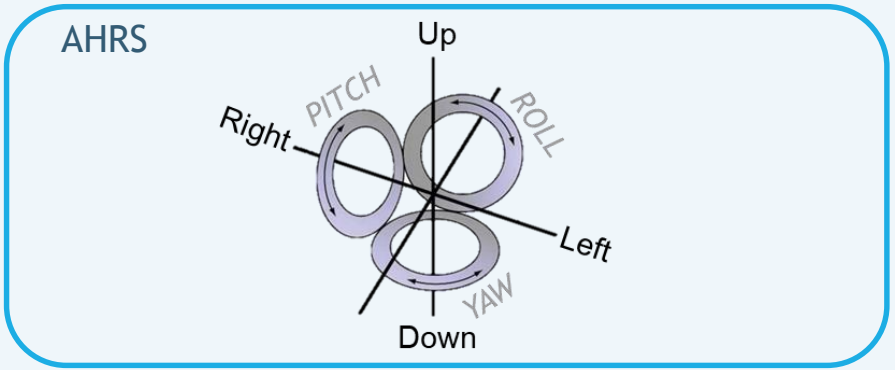
- **LOCATION** of DOMs $\{x, y, z\}$
- CORRECTED **ORIENTATION** $\{YAW, PITCH, ROLL\}$

INTRODUCTION

Parts of DU Line Fit

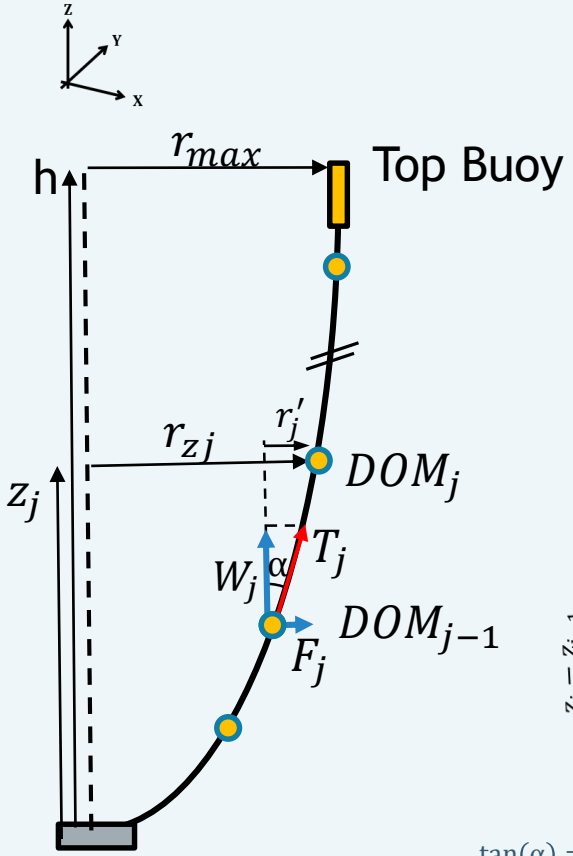


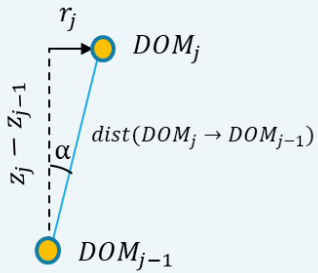




MECHANICAL MODEL

Mechanical equations





$$\tan(\alpha) = \frac{F(z)}{W(z)} = g(z)$$

$$F(z) = f(z)v^2 = \left\{\left[\sum_{i=1}^{18}\left(f_{DOM} + f_{cable_i}\right) + f_{long\ string}\right]\left(\frac{h-z}{z}\right) + f_{top\ buoy}\right\}v^2$$

$$W(z) = \left[\sum_{i=1}^{18}\left(W_{DOM} + W_{cable_i}\right) + W_{long\ string}\right]\left(\frac{h-z}{z}\right) + W_{top\ buoy}$$

$$r(z) = \int_0^z g(z)\ dz = \left[\frac{n}{q}z - \left(\frac{mq-nq}{q^2}\right)\ln\left(1-\frac{q}{p}z\right)\right]v^2$$

$$MM_{const}(z)$$

$$m = \left\{\left[\sum_{i=1}^{18}\left(f_{DOM} + f_{cable_i}\right)\right] + f_{long\ string}\right\} + f_{top\ buoy}$$

$$n = \left\{\left[\sum_{i=1}^{18}\left(\frac{1}{h}f_{DOM} + f_{cable_i}\right)\right] + \frac{1}{h}f_{long\ string}\right\} + \frac{1}{h}f_{top\ buoy}$$

$$p = \left\{\left[\sum_{i=1}^{18}\left(W_{DOM} + W_{cable_i}\right)\right] + W_{long\ string}\right\} + W_{top\ buoy}$$

$$q = \left\{\left[\sum_{i=1}^{18}\left(\frac{1}{h}W_{DOM} + W_{cable_i}\right)\right] + \frac{1}{h}W_{long\ string}\right\} + \frac{1}{h}W_{top\ buoy}$$

MECHANICAL MODEL

Mechanical constants

$$f_j = \frac{1}{2} C_{w,j} A_j \rho \ [Ns^2/m^2]$$

- ρ: $Density\ of\ the\ water\ [kg/m^3]$
- A: $Cross\ section\ [m^2]$
- C_w: $drag\ coeficient$

$$W_j = WIW_j \cdot g \ [N]$$

- $Gravitacional\ acceleration\ [m/s^2]$
- $Weight\ In\ Water\ [kg]$
- $buoyancy$

Detector	Property	Elements		
		DOM	Long string	Top Buoy
ARCA	$f\ [Ns^2/m^2]$	52.86	659.10	482.66
	$W\ [N]$	125.57	0	1030.05
ORCA	$f\ [Ns^2/m^2]$	52.86	283.92	482.66
	$W\ [N]$	125.57	0	1226.25

MECHANICAL MODEL

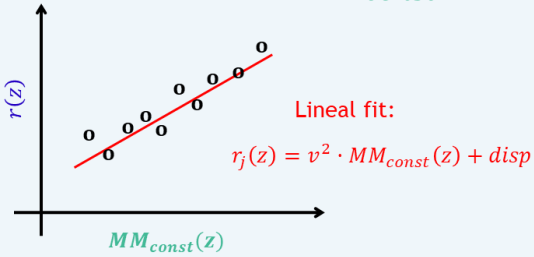
Mechanical Model for APS data

$$r(z) = \int_0^z g(z)\, dz = \left[\frac{n}{q} z - \left(\frac{mq - nq}{q^2}\right) \ln\left(1 - \frac{q}{p} z\right)\right] v^2$$

$$MM_{const}(z)$$

- **What do we expect?**

  Improve the position in reconstruction of DUs taking into account the uncertainty and inconsistencies of measures and analysis.

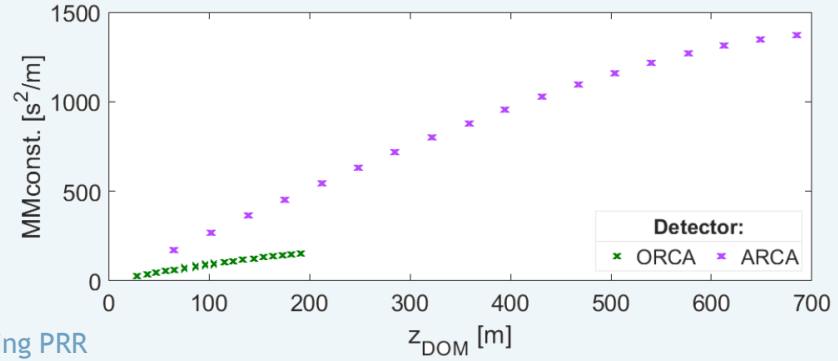


- **How to obtain v and ω from the acoustic data?**

$$r(z) = MM_{const}(z) \cdot v^2 \rightarrow \boldsymbol{v} = \sqrt{\frac{r_j(z)}{MM_{const}(z)}}$$

$$\boldsymbol{\omega} = atan2(diff_y, diff_x)$$

$diff$: Difference from pos. reference

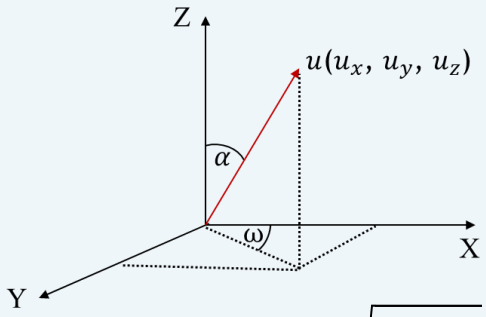


MECHANICAL MODEL + AHRS

$$\begin{pmatrix} u_x \\ u_y \\ u_z \end{pmatrix} = \begin{pmatrix} cos(P)cos(Y) & -sin(R)sin(P)cos(Y) - cos(R)sin(Y) & cos(R)sin(P)sin(Y) + sin(R)sin(Y) \\ cos(P)sin(Y) & sin(R)sin(P)sin(Y) + cos(R)cos(Y) & cos(R)sin(P)sin(Y) - sin(R)cos(Y) \\ -sin(P) & sin(R)cos(P) & cos(R)cos(P) \end{pmatrix} \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

PROBLEM:

The process analyzed for AHRS data is more sensitive to YAW, PITCH and ROLL values, so they needs a filter to take only the good AHRS data



$$tan(\alpha) = \frac{\sqrt{u_x^2 + u_y^2}}{u_z}$$

SOLUTION:

In principle, it's more easy discard wrong data in AHRS because the difference between DOMs are not big

$$tan(\alpha) = \frac{F_j}{W_j} = \frac{f_j \cdot v^2}{W_j} \rightarrow v = \sqrt{\frac{tan(\alpha) \cdot W_j}{f_j}}$$

$$cos(\omega) = \frac{u_x}{\sqrt{u_x^2 + u_y^2}} \rightarrow \omega$$

DU LINE FIT ANALYSIS

INPUTS FOR DU LINE FIT

- **LOCATION** of acoustic receivers $\{x, y, z\}$
- **ORIENTATION** $\{YAW, PITCH, ROLL\}$

ANALYSING APS data:
- r for every DOM
- v_{aps} for every DU
- ω_{aps} for every DOM

ANALYSING AHRS data:
- v_{ahrs} for every DOM
- ω_{ahrs} for every DOM

RECONSTRUCTION v0:
- *Bezier's curve for APS data*
- *Spline for AHRS data*

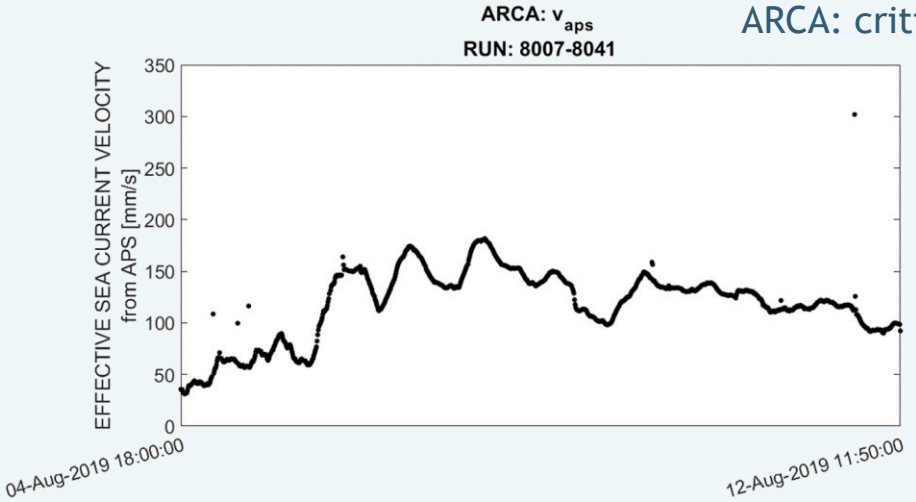
RECONSTRUCTION v1: Mechanical Model
- *MM for APS data* $\rightarrow$ *needs* v, ω *and* DU_{base} *location*
- *Spline for AHRS data*

OUTPUTS FOR DU LINE FIT

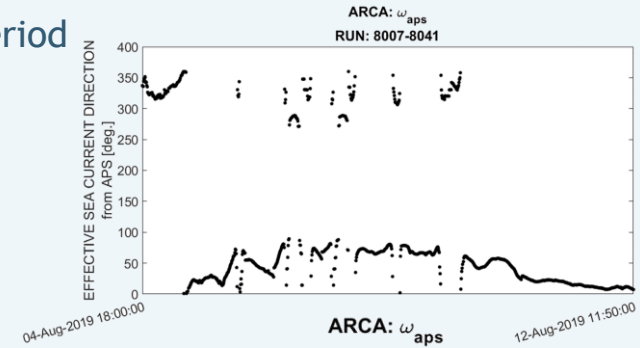
- **LOCATION** of DOMs $\{x, y, z\}$
- **CORRECTED ORIENTATION** $\{YAW, PITCH, ROLL\}$

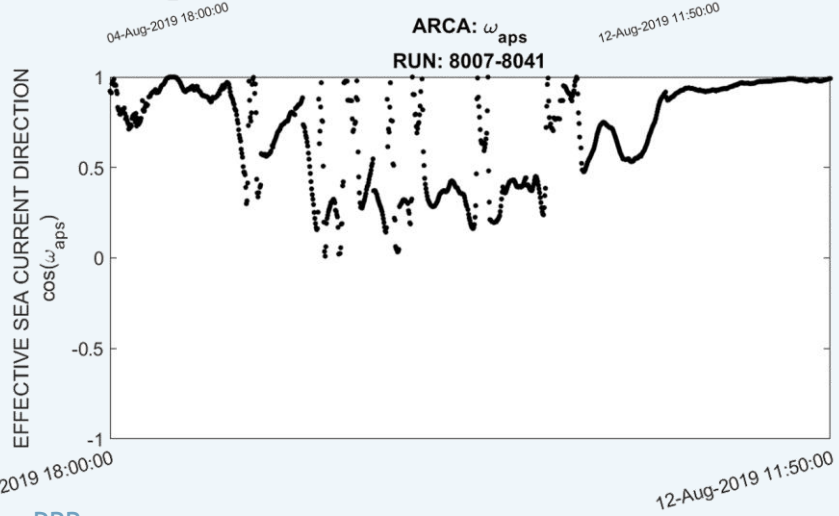
TESTING EXPERIMENTAL DATA

APS Analysis



ARCA: critical period

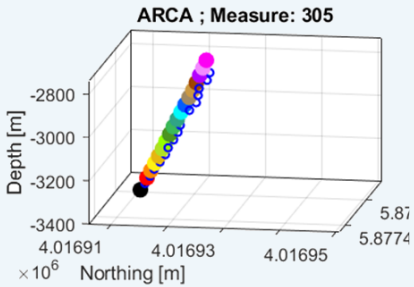


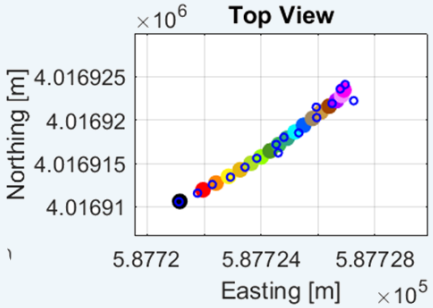


TESTING EXPERIMENTAL DATA

APS Analysis

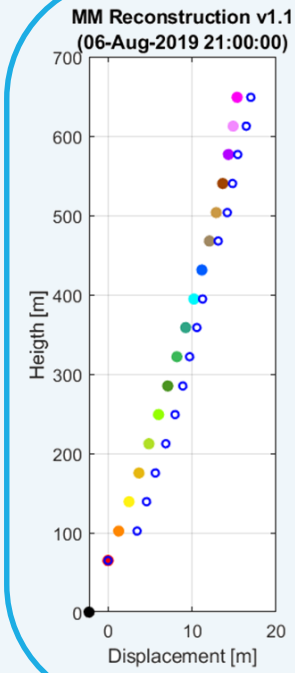
Reconstruction v0

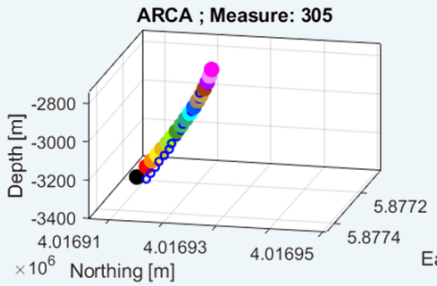


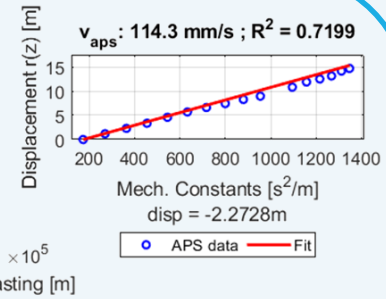


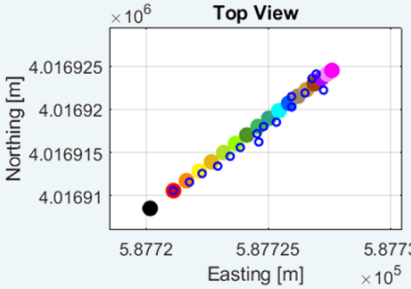
ARCA: critical period

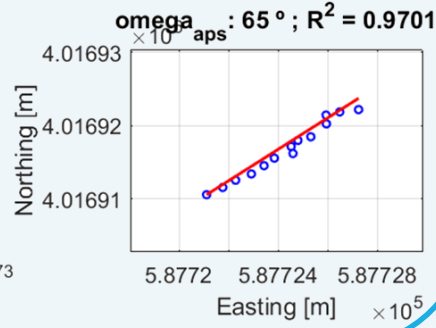
Reconstruction v1











THANKS FOR YOUR ATTENTION

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