A prototype tank for the SWGO detector

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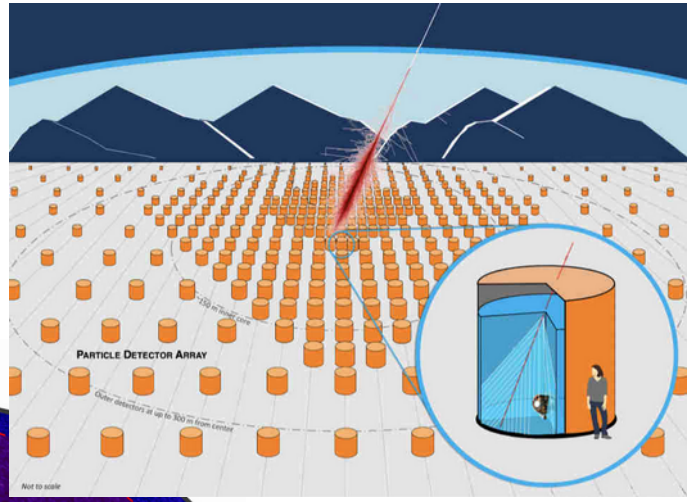
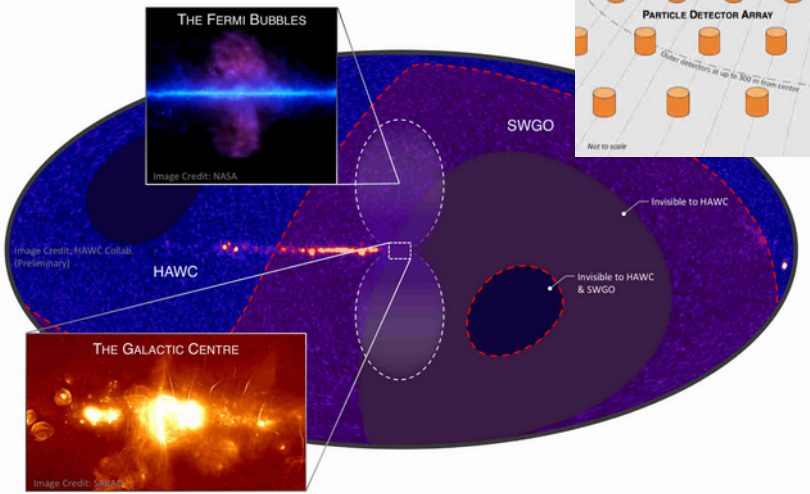
The Southern Wide-field Gamma ray Observatory

A new-generation observatory for very-high-energy gamma rays: SWGO

VHE gamma rays:
100 GeV – 100 TeV



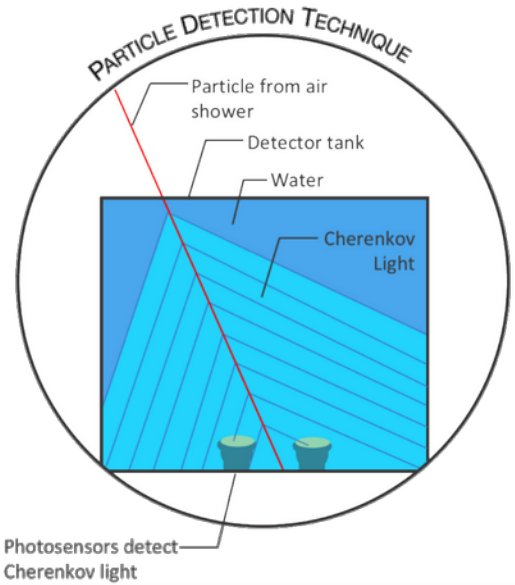


- Located in South America
- Latitude: -30° to -10°
- Altitude: 4.4 km or higher

Similar facilities:
- HAWC (Mexico)
- LHAASO (China)

First EAS detector in the Southern hemisphere: privileged view of galactic center region

The Southern Wide-field Gamma ray Observatory

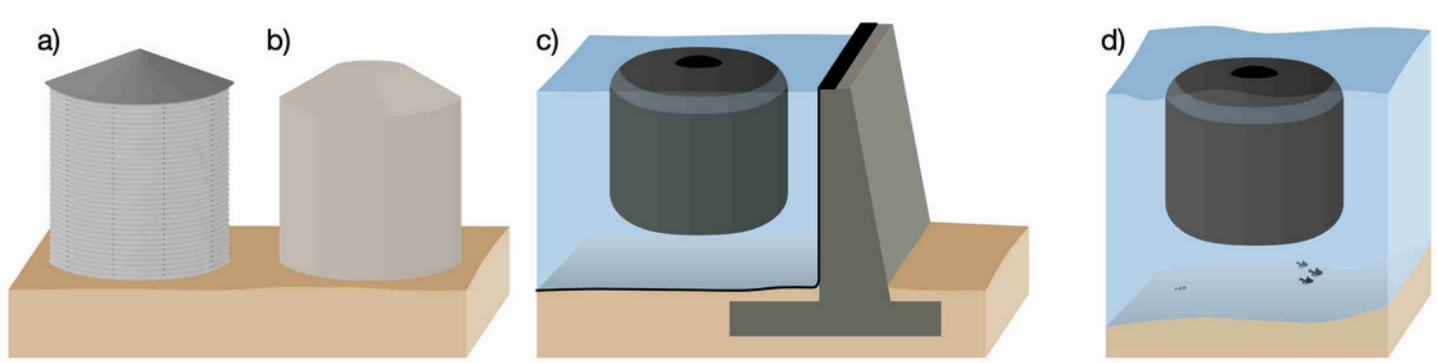


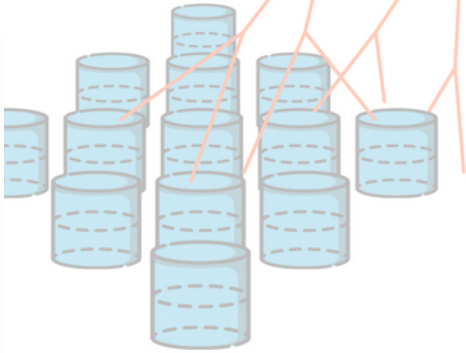
Based on <u>Water Cherenkov units</u>

Many variables to assess:

- Detector's geometry
- Type of sensors
- Sensors' configuration
- Materials

→ Necessity for test facilities





The prototype tank

Who?

INFN Istituto Nazionale di Fisica Nucleare

POLITECNICO MILANO 1863

UNIVERSITÀ DEGLI STUDI DI TORINO

UNIVERSITÀ DEGLI STUDI DI PADOVA

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

What?

A cylindrical tank:

- External structure: galvanized steel
- Intel coverage (liner): AQUATEX® PVC (can be changed)

Objectives

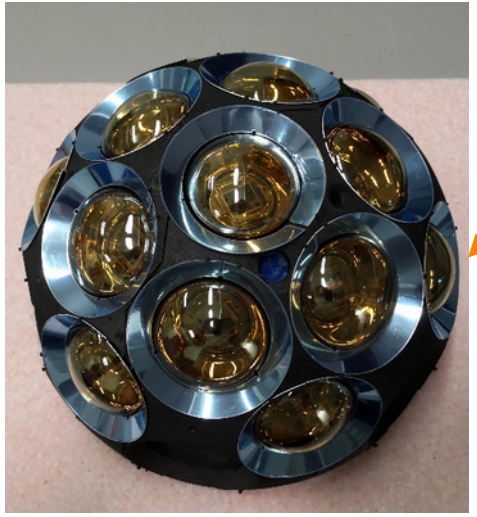
Test facility

- Types of sensors
- Sensors' configurations
- Types of liners
- Tank configuration
- Anything else useful to the collaboration

The prototype tank

Multi-PMT modules and light traps (in development at the universities of Napoli and Padova)

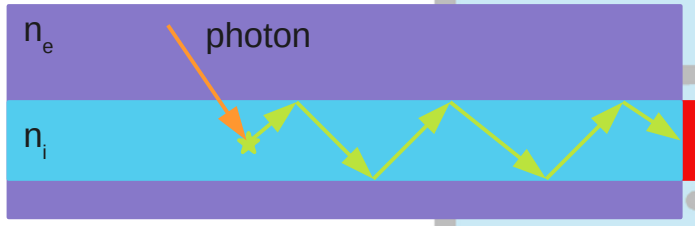
- Multi-PMT modules
  - Use modules of multiple 3'' PMTs as an alternative to large PMTs
  - Like KM3 and Hyper-Kamiokande

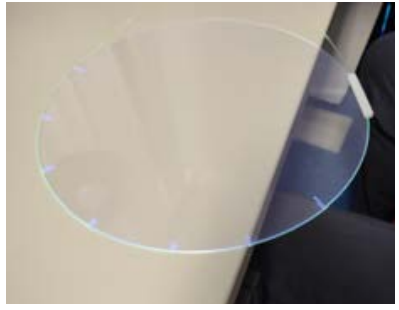


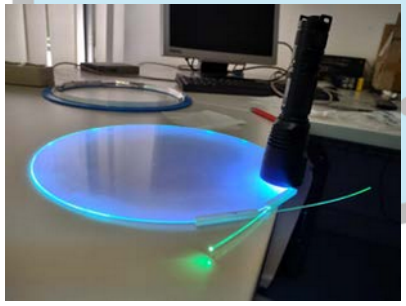
Hyper-K prototype considered as inspiration

MoU is being finalized

- WLS light traps: Wavelength Shifters light traps
  - WLS molecule absorbs light
  - it re-emits light at a lower energy in a different random direction
  - Light is trapped because of internal reflection
  - Use a small sensor but capture light on a large surface



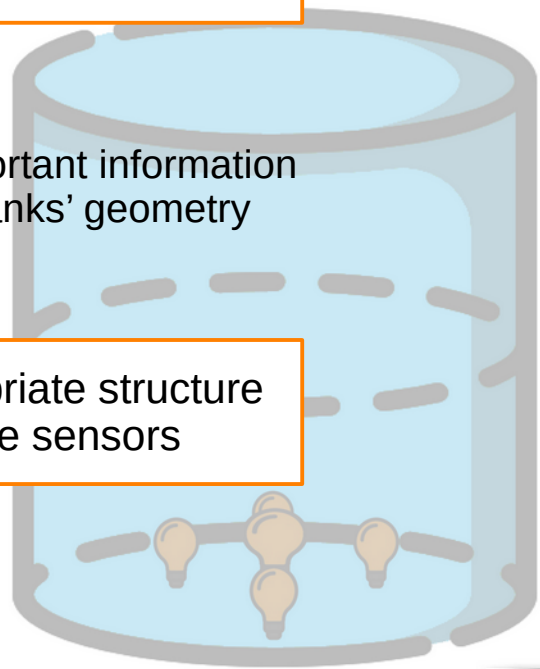




The prototype tank

Project main requirements

- Installation site:
  The floor must resist to the tank's pressure → Analysis on detection capabilities as a function of the water level → Could also give important information for the study on tanks' geometry
- Change sensors' configurations frequently → Design an appropriate structure for holding the sensors
- Maintain water purity → Limited choice of materials → Design an appropriate structure for holding the sensors



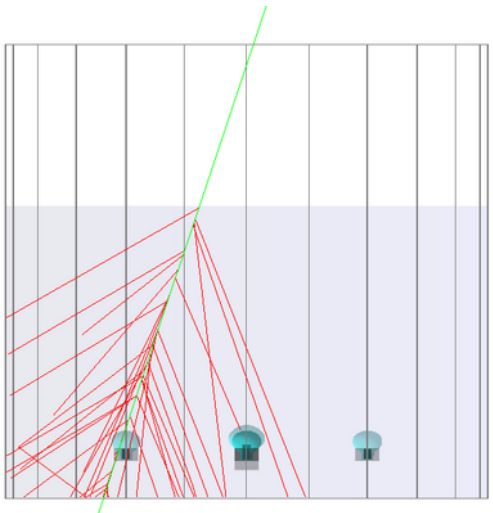
Study on particle detection as a function of the water level

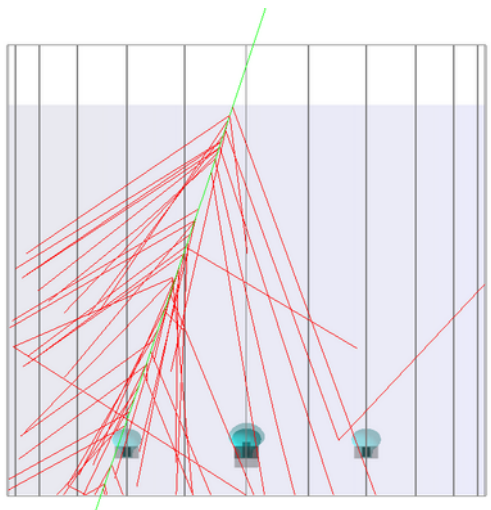
Methods

- Analyze muons' showers: 1 GeV and 10 GeV
  - → Only particles detectable at Milano's altitude

5 different water levels:
1.65 m, 2.00 m, 2.35 m, 2.70 m, 3.05 m

Software: HAWCSim





- Additional study on electron showers (1 GeV) to verify the model

Study on particle detection as a function of the water level

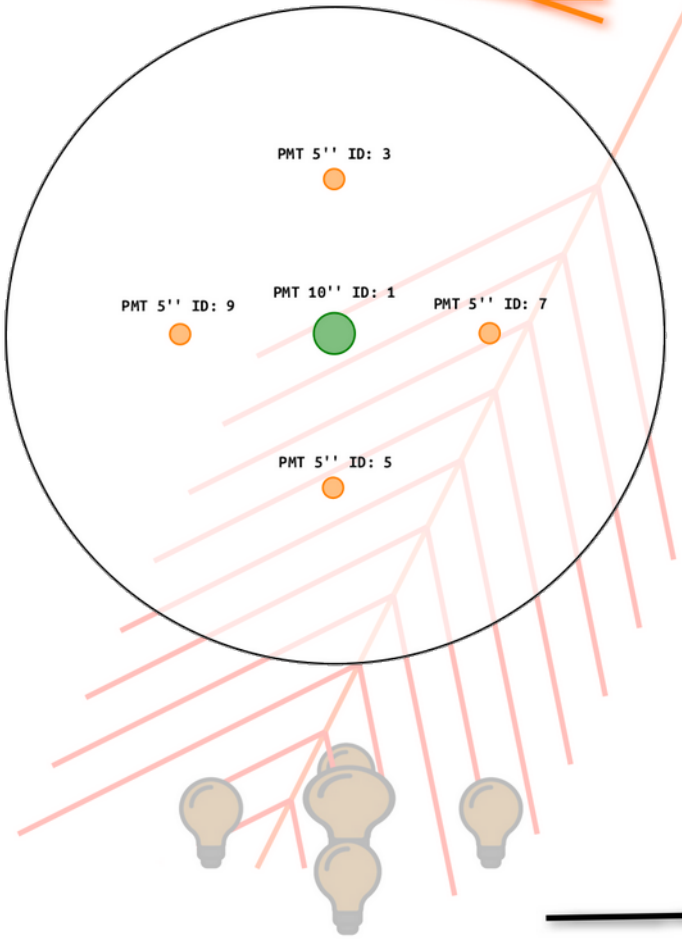
Methods

- Tank dimensions and materials
- Type and position of sensors

→ Reference configuration:
  - 1x 10’’ PMT
  - 4x 5’’ PMTs

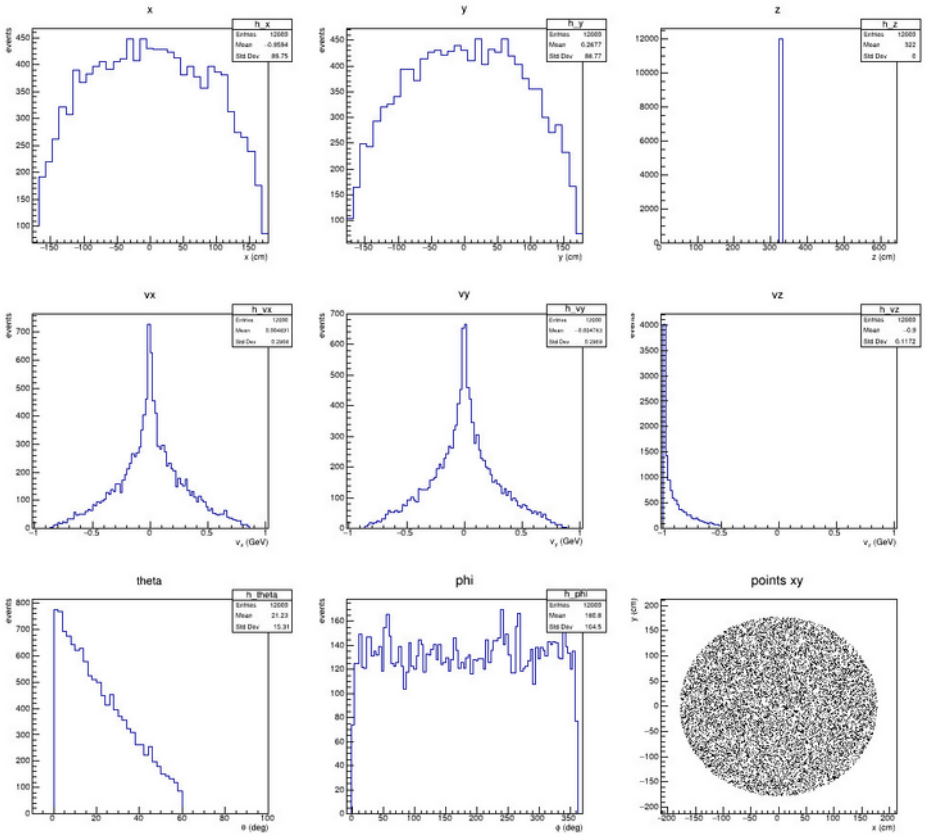
Problem:
5’’ PMTs are not implemented in HAWCSim

→ **Solution:**
Use 8’’ PMTs and scale to 5’’ during analysis phase



Study on particle detection as a function of the water level

Particles generation



Generate 12000 particles on a disk over the tank

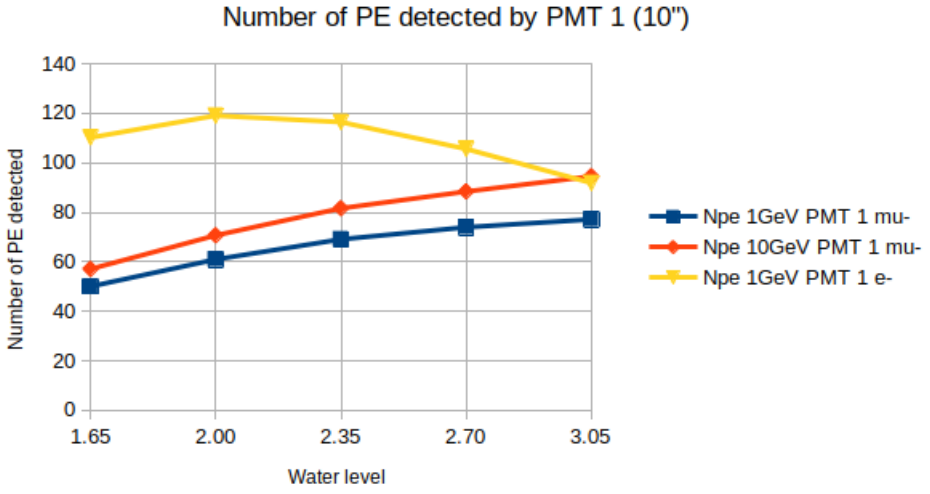
- Azimuth angle: 0-360°
- Zenith angle: 0-60°

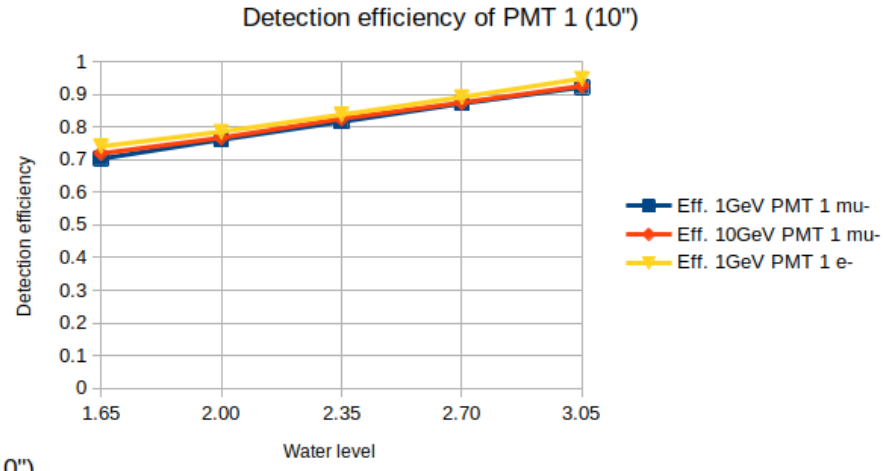
→ The first 10000 to enter the water will be analyzed

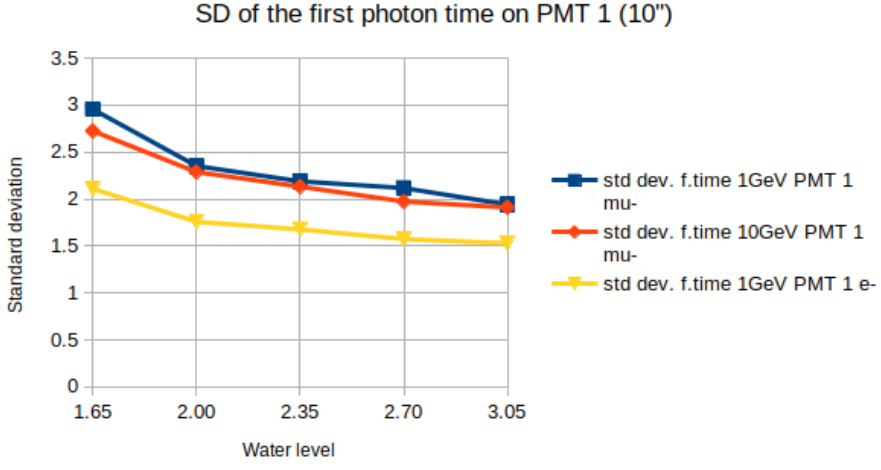
Analyzed parameters

- Detection efficiency: number of particles detected by a PMT configuration with respect to the total number entering the water
- Number of photoelectrons (PE) detected
- Standard deviation (SD) of the detection time of the first photon: how the detection precision varies with the water level

Study on particle detection as a function of the water level



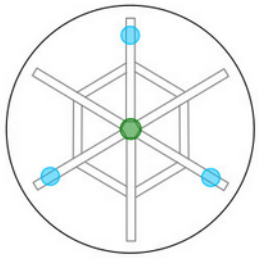




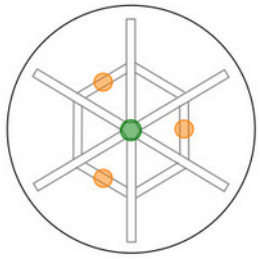
Design of the PMT holder

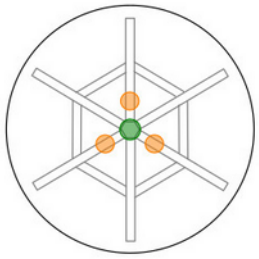
Material → Stainless steel AISI 304

Hold as many configurations as possible

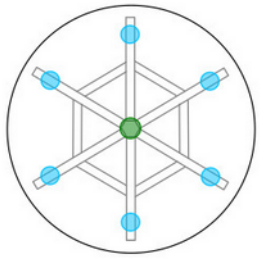


I - 4 sensors (1 + 3)

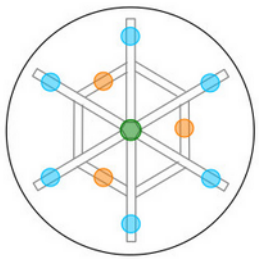




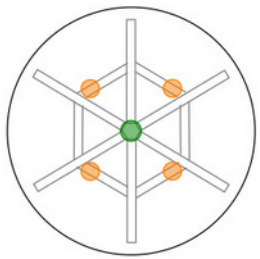
IIa and IIb - 4 sensors compact (1 + 3)



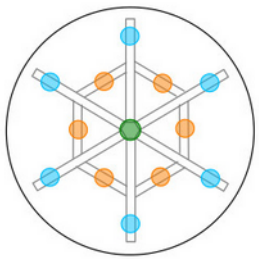
III - 7 sensors (1 + 6)



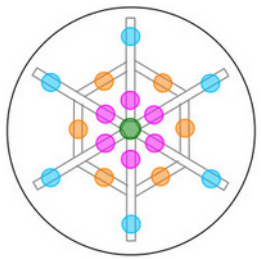
IV - 10 sensors (1 + 3 + 6)



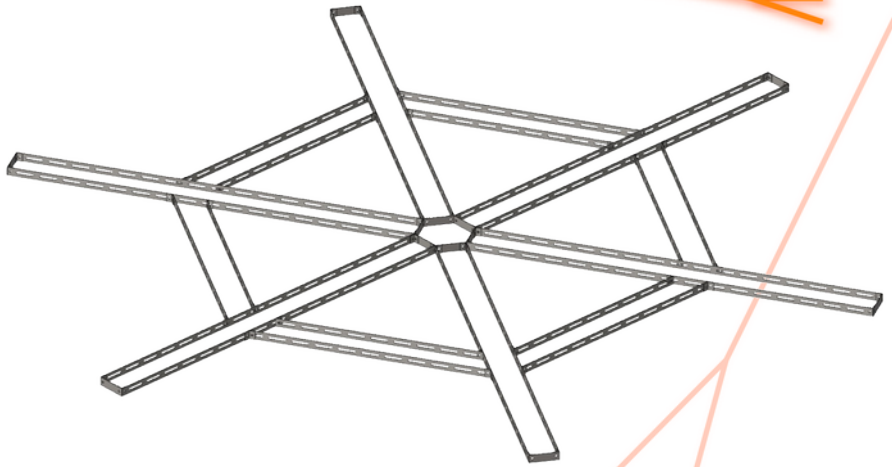
V - 5 sensors (1 + 4)



VI - 13 sensors (1 + 6 + 6)



VII - 19 sensors (1 + 6 + 6 + 6)



Good compromise between weight, robustness and number of configurations that could be handled

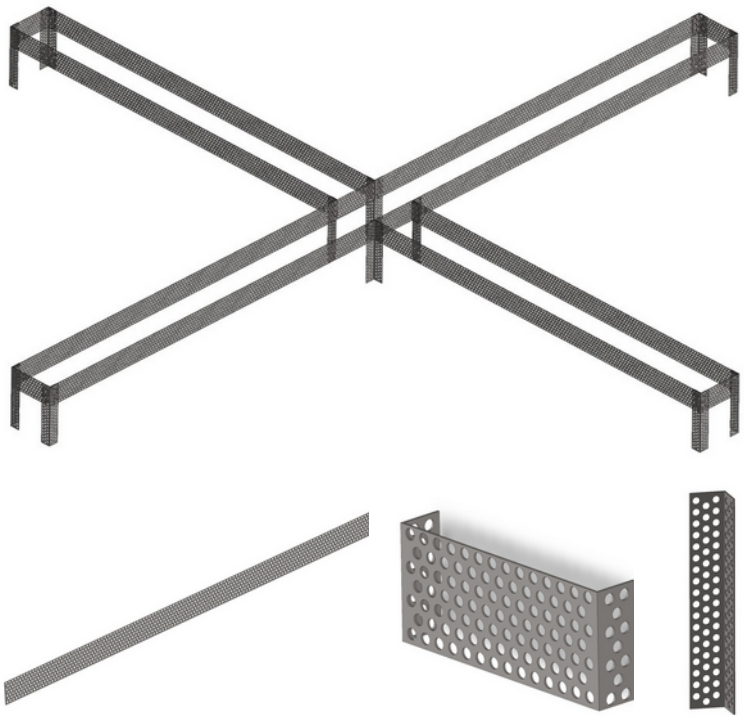
but

- Had to be adapted to parts available on the market
- Reference configuration PMT were nearly ready for testing

Design of the PMT holder

The CAD model

Simple structure: 3 types of parts



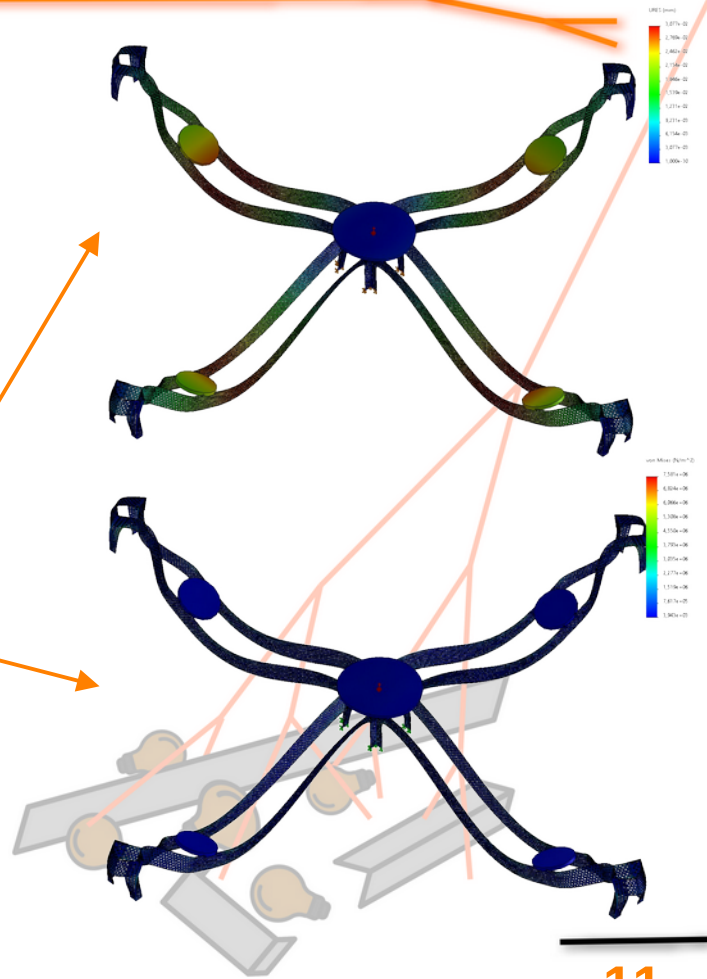
Loading analysis with reference configuration PMTs

Software: SolidWorks

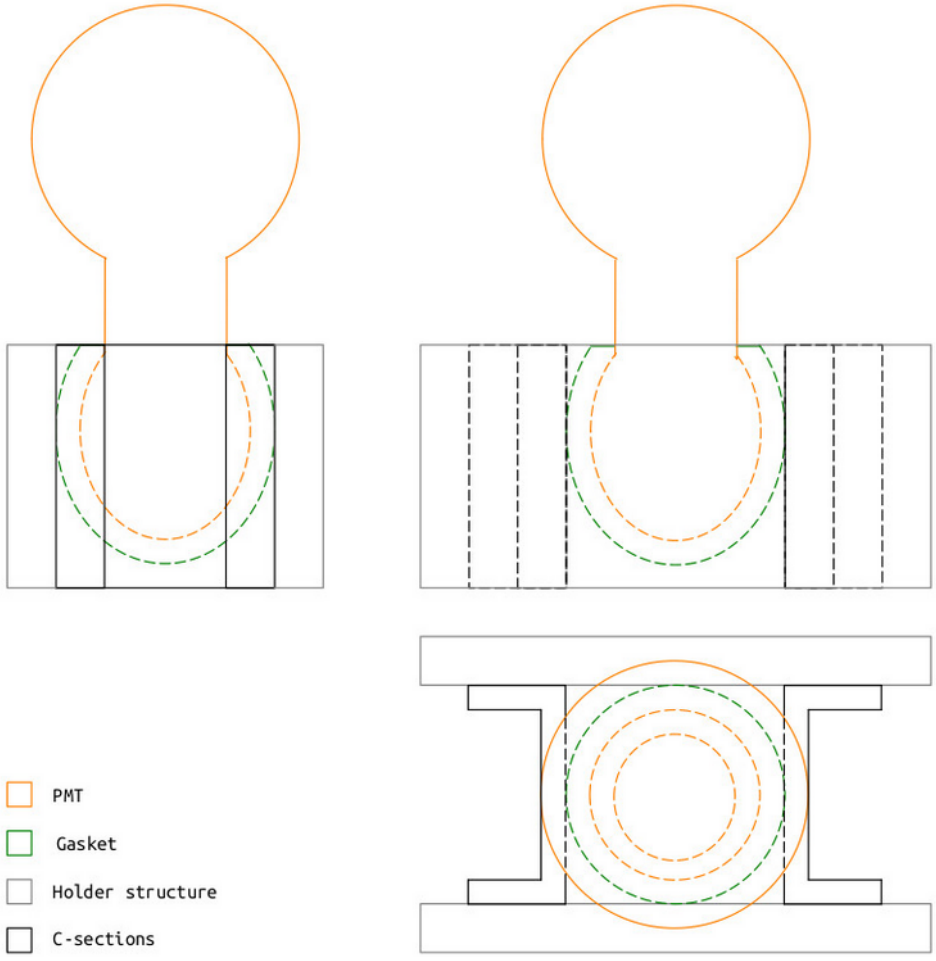
Displacements
Maximum value reached:
3.077×10^{-2} mm

Stress
Maximum value reached:
7.581×10^{6} N/m^2

AISI 304 Yield stress:
$8{,}07 \times 10^{8}$ N/m^2



Design of the PMT holder

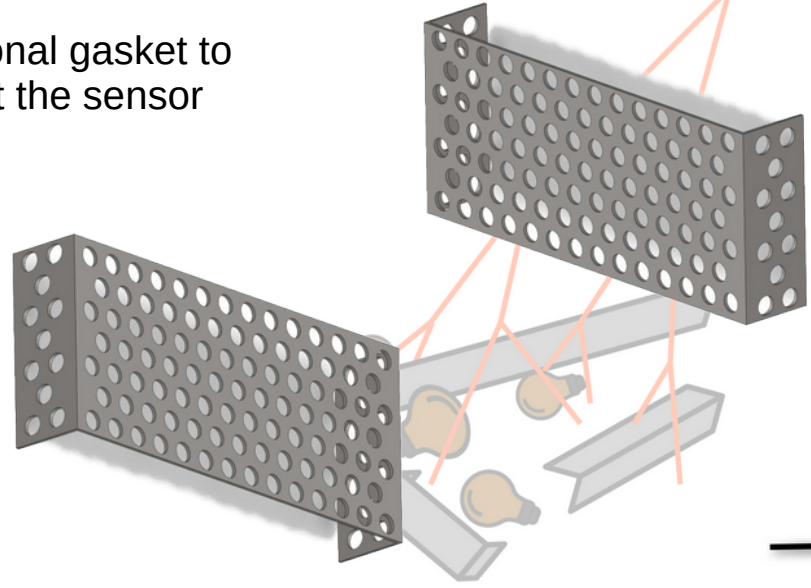


Holding the PMTs

Use C-profiles

- Materials already available
- Good stability

Additional gasket to protect the sensor

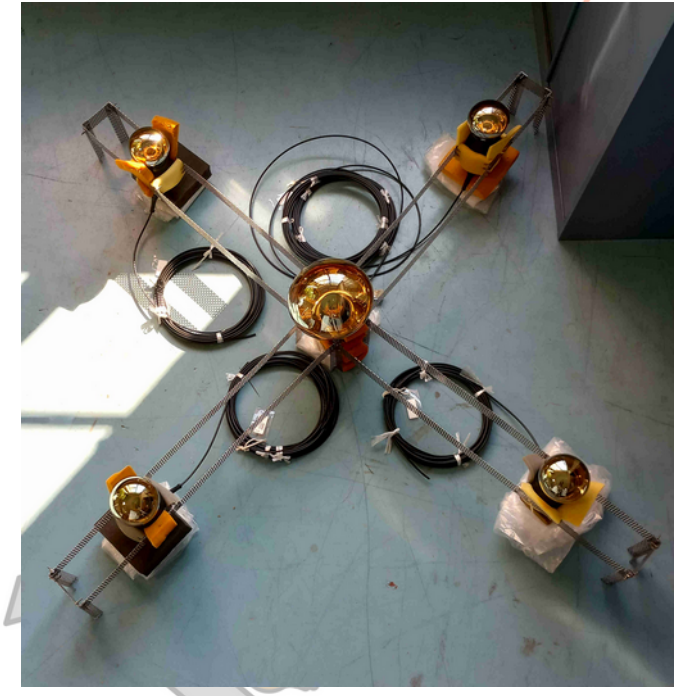


Design of the PMT holder

Manufacturing and testing

Parts manufactured in Politecnico's DAER workshop

Holding test: successful ✓

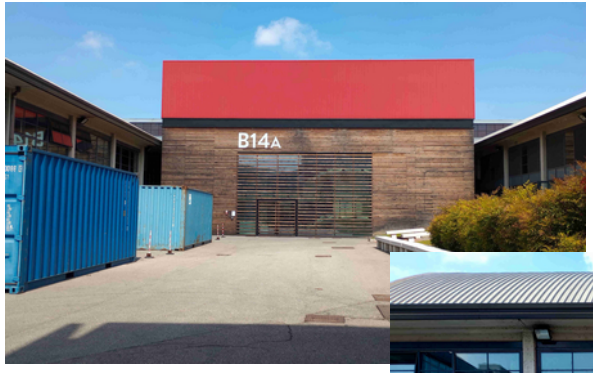


What now?

Study on particle detection as a function of the water level

↓

Tank location changed: new place outside



Schedule	Period	Status
Order reference configuration PMT	Q4 - 2021	✓
Reference configuration PMT delivery	Q1 - 2022	✓
Tank installation	Q3 - 2022	in progress
Fill the tank with water	Q3 - 2022	to do
Start tests with the reference configuration	Q4 - 2022	to do
Start tests with novel sensors designs (Naples and Padova)	Q1 - 2023	to do

+

Anything else that can be useful to the collaboration

Thank you for your attention