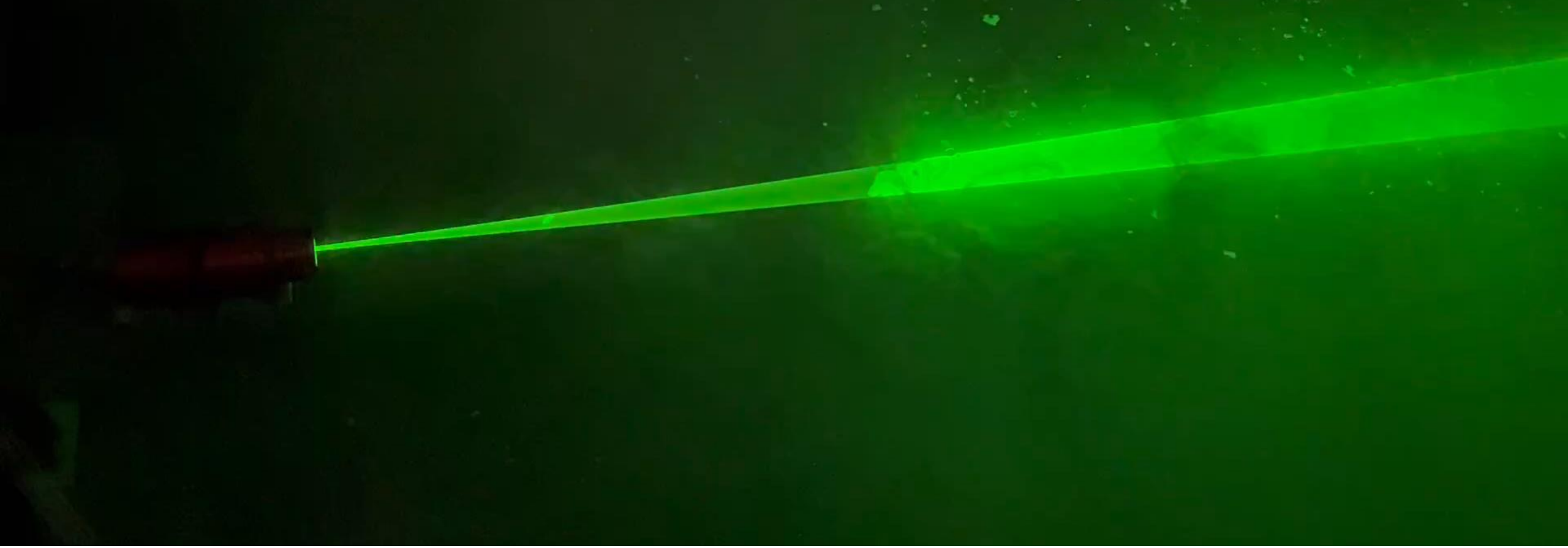

Laboratory-based accuracy evaluation of the Underwater Laser Scanner ULi

3D Underwater Mapping from Above and Below – 3rd International Workshop – Vienna 2025

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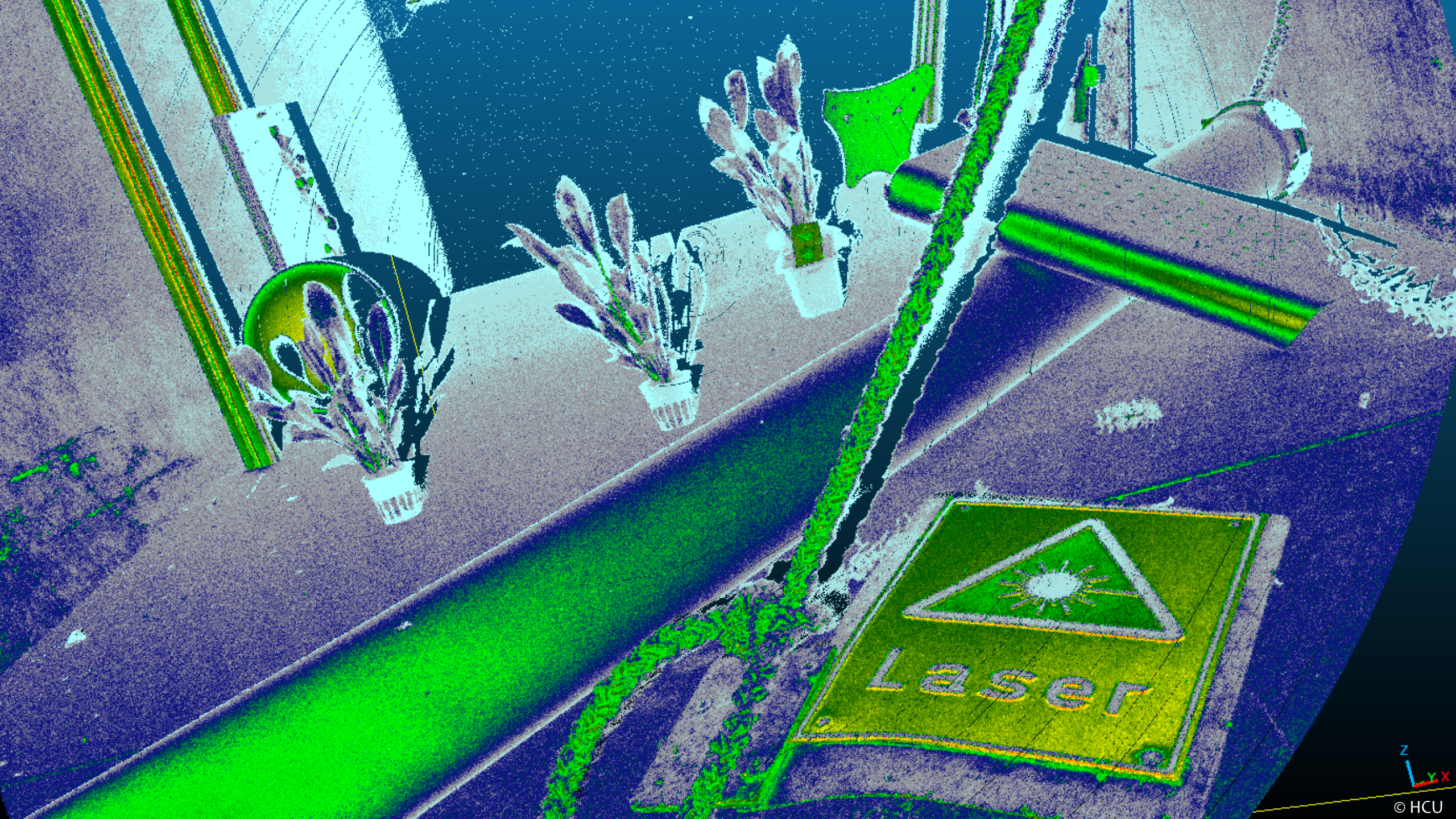

Laser
Z
Y
X
© HCU

Motivation

- Higher accuracy and resolution in comparison to acoustic instruments
  - Precision in the range of millimeters
  - Sensor outperforms conventional sonar systems by a factor of 10
  - More accurate and detailed capture of objects
- Usage of ToF
  - Range in turbid waters is three times larger compared to other optical systems
- Delivers a full waveform
  - Derivation of more information compared to a single pulse return

Research questions

(1) What is the maximum measurement range of ULi under varying water turbidity?

(2) Which range precision and relative accuracy can ULi achieve?

(3) How clearly can ULi capture structures for object recognition?

Underwater LiDAR System ULi

Methods: Instrumentation

532 nm wavelength (green)

100 000 Points per Second

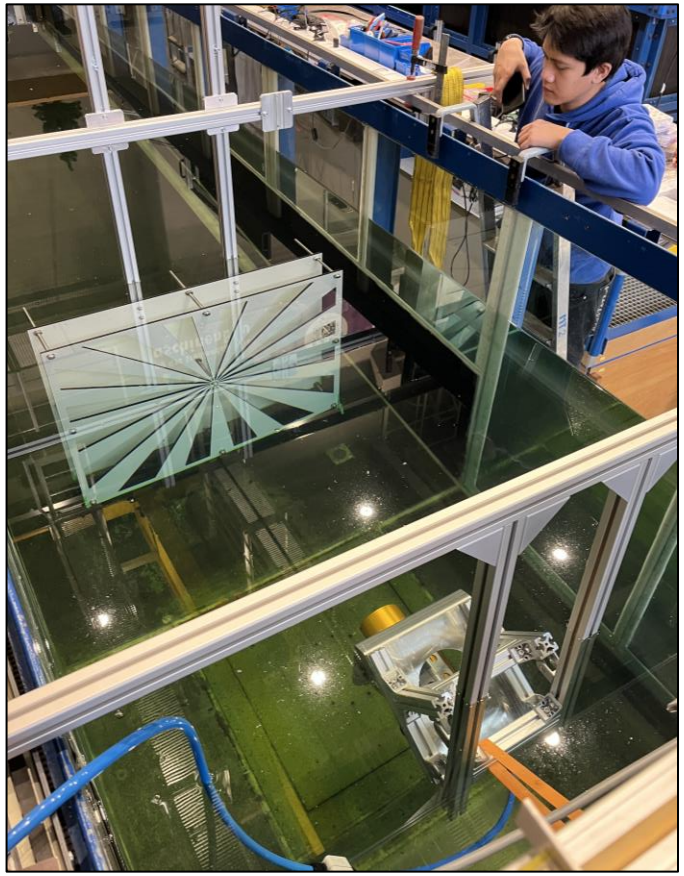
44 ° field-of-view

Adjustable scan pattern

two laser modes (2M and 3B laser class)

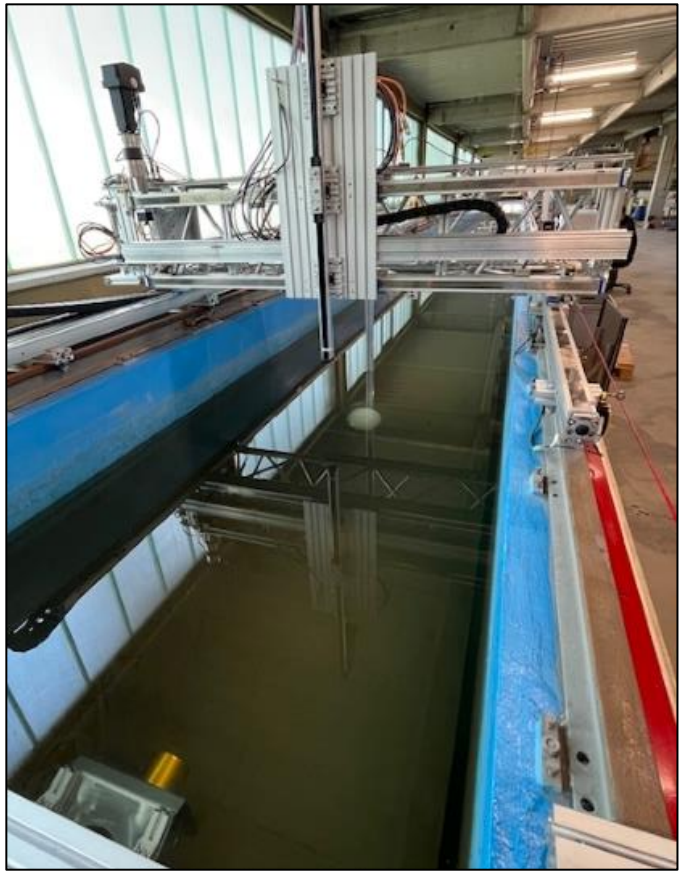
Tank measurements

Methods: Setups & targets



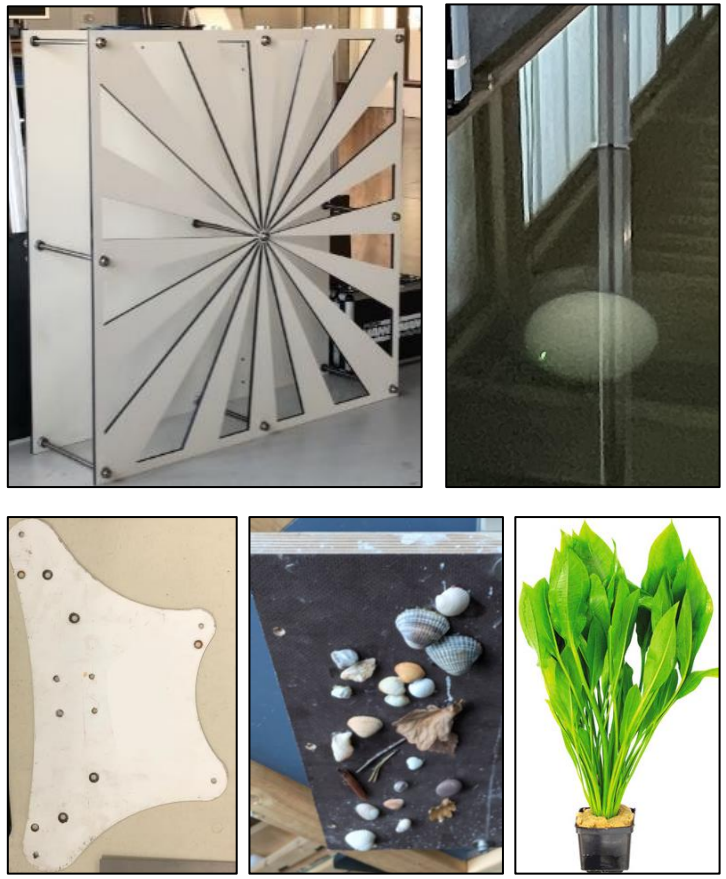
Freshwater tank (0 NTU)

at MUM (TUHH)



Recirculating flume (0.9 - 4.6 NTU)

at BAW (Hamburg)

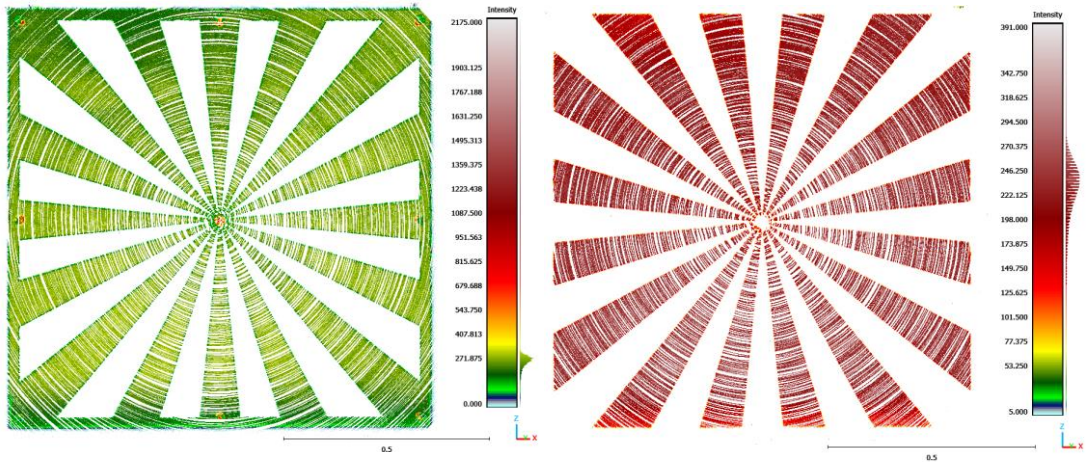


Targets: Böhler-Star, sphere, metal plate, wooden plate with shells, water plants

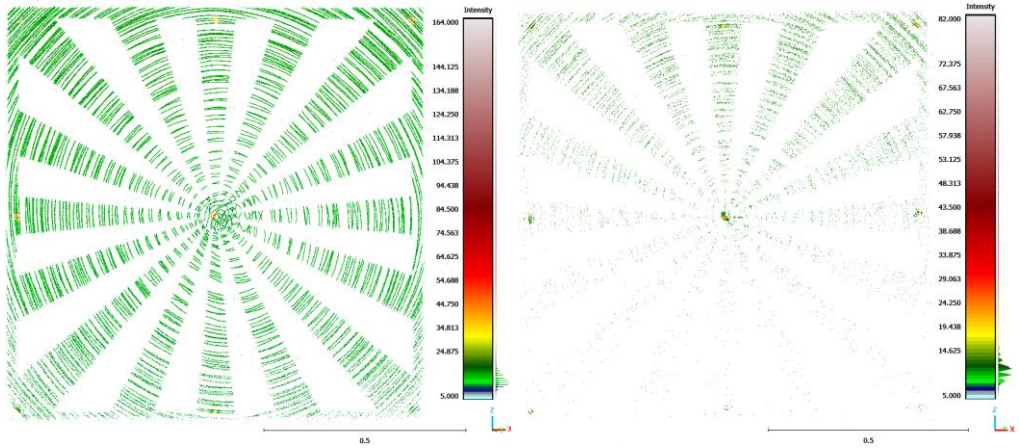
Böhler-Star scans

Results in different turbid waters

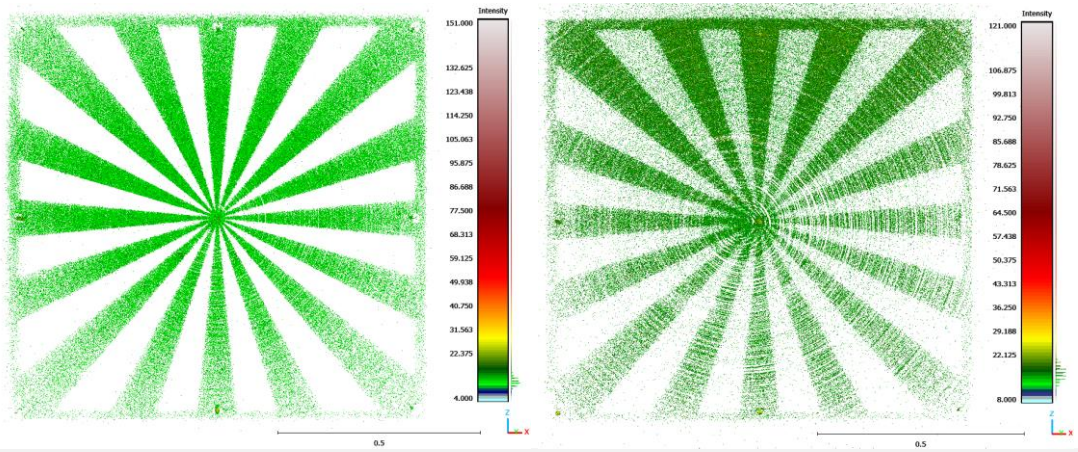
freshwater (0 NTU), scan distance 8 m, front / rear panel



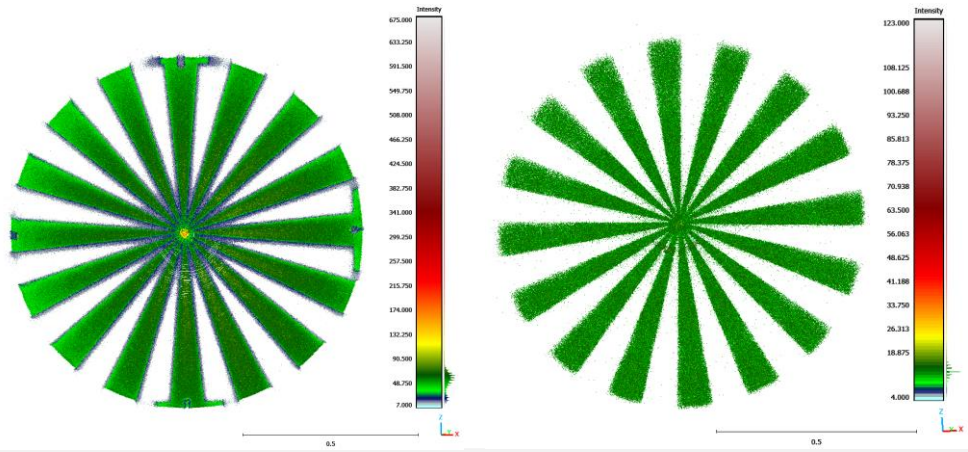
low turbid water (0.9 NTU), scan distance 17 m / 18 m



moderate turbid water (2.4 NTU), scan distance 2.5 m / 5 m

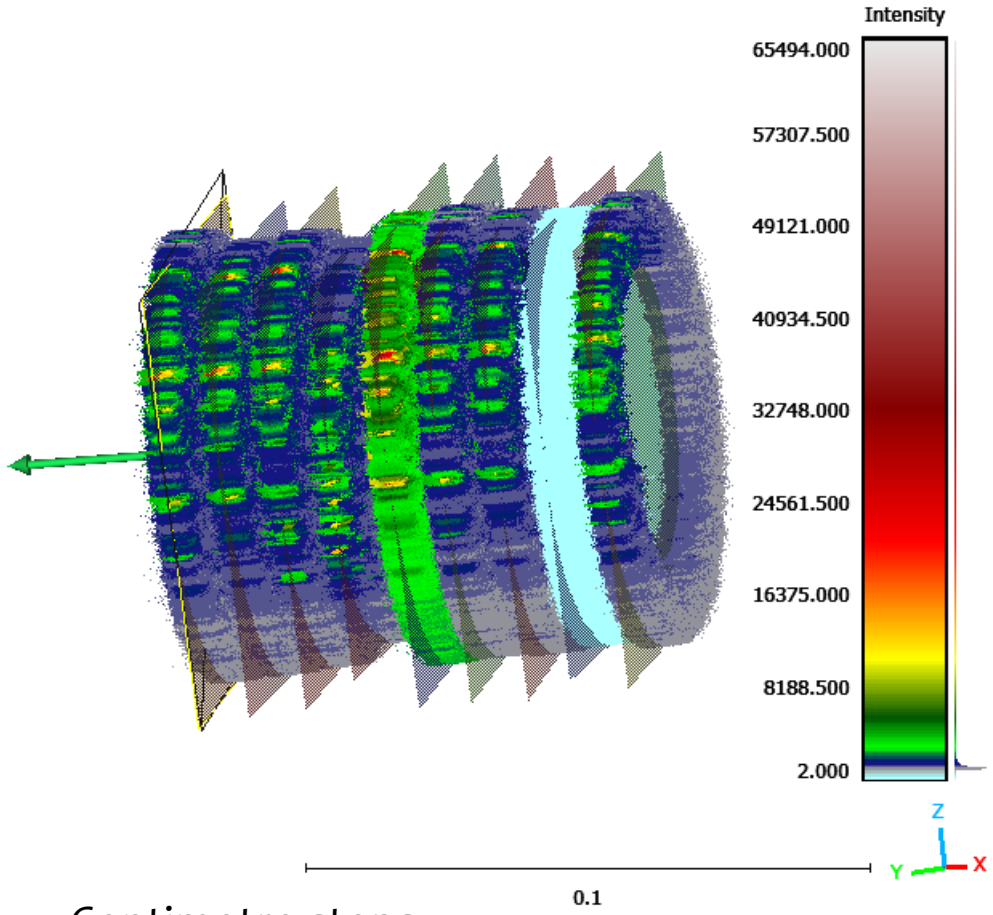


turbid water (4.6 NTU), scan distance 1 m / 1.4 m



Range precision and relative accuracy

Results from repetitive range measurements on a white metal plate



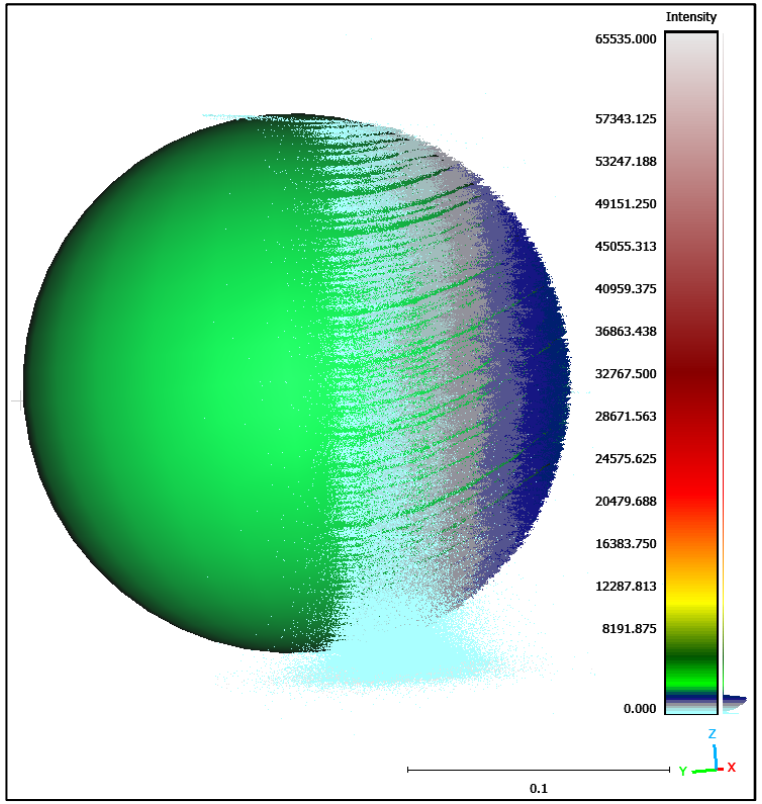
Centimetre steps

Mean range precision (RMS plane)	
Centimetre steps	2.12 mm

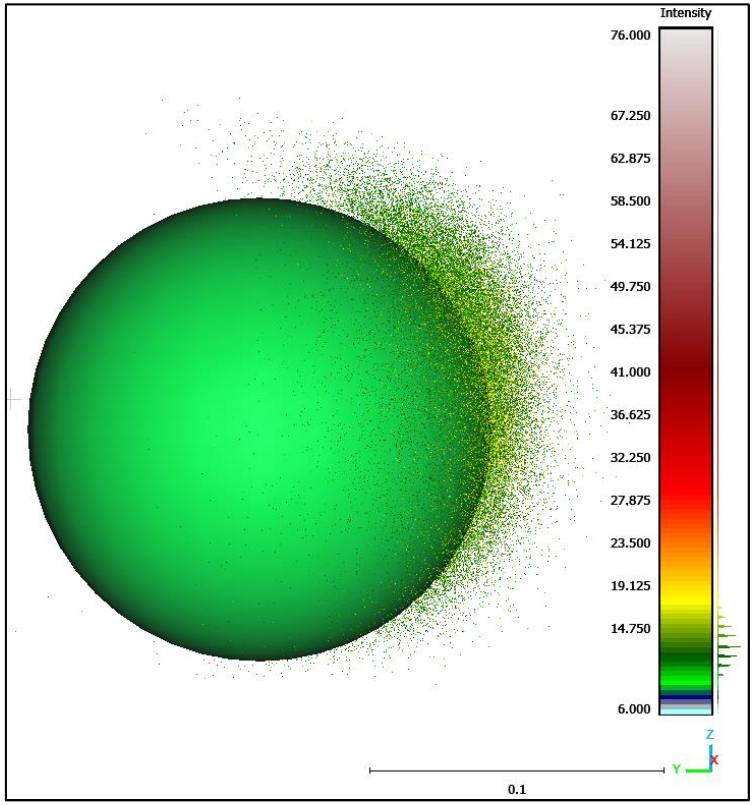
Moving direction of plate from scanner	Calculated mean distance	Mean bias from true distance
Forward [cm steps]	1.133 cm	0.133 cm
Backward [cm steps]	- 1.694 cm	- 0.694 cm
Combined	1.414 cm	0.414 cm

Sphere fitting

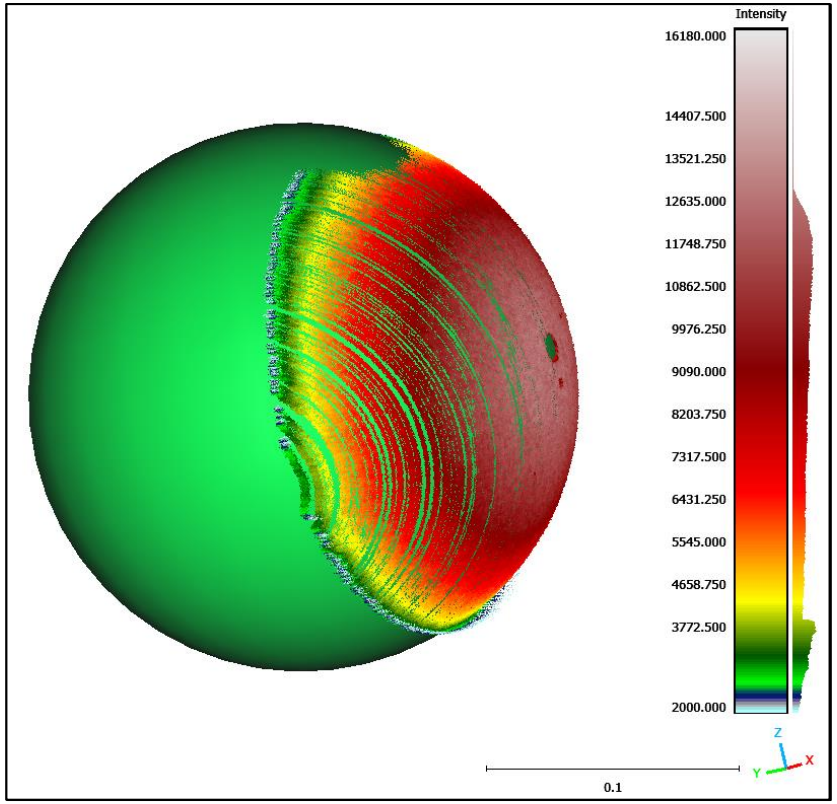
Results from sphere scans in freshwater and low turbid water



0 NTU, 3 m distance, 2M laser
Fitted radius: 10.26 cm
Standard deviation: 0.11 cm



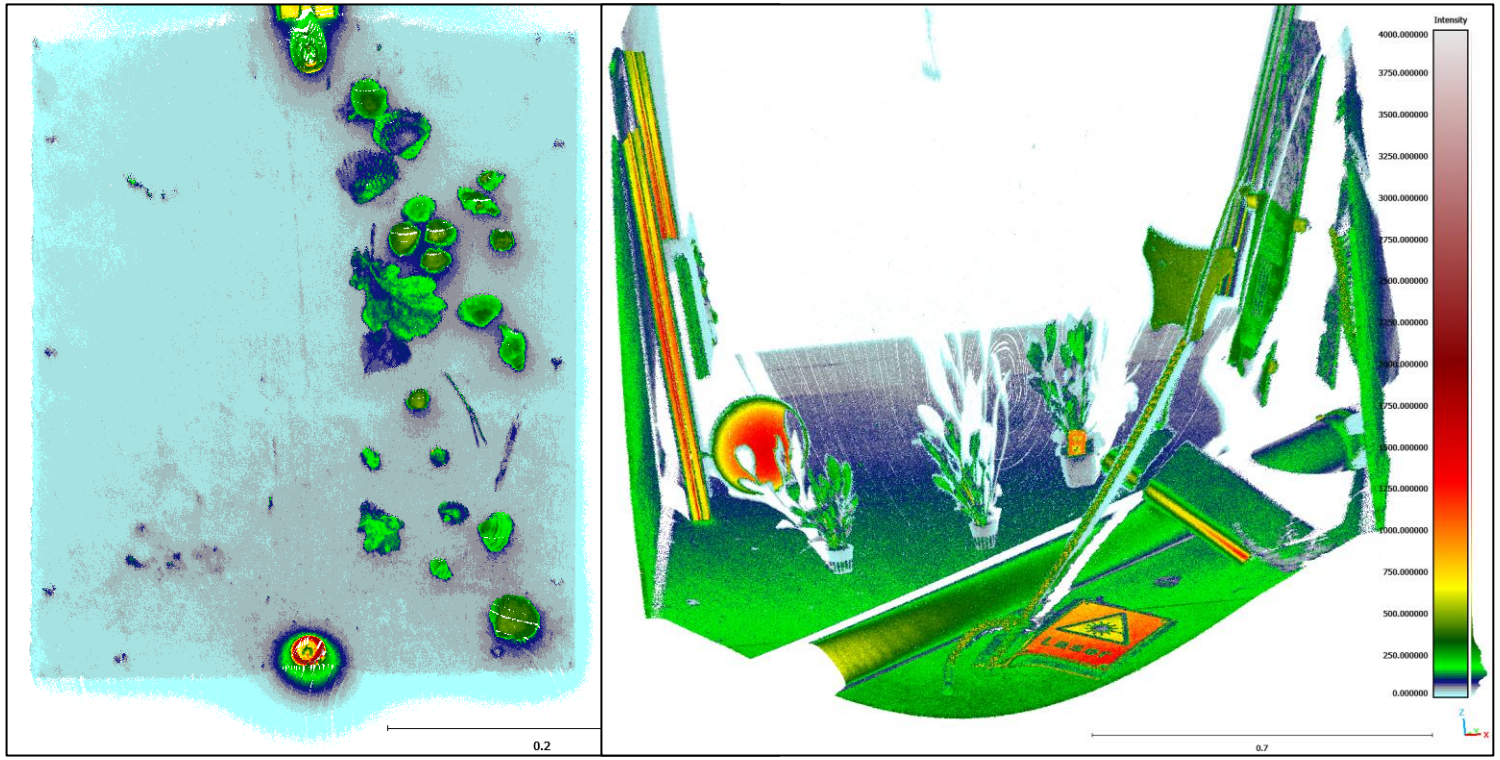
1.6 NTU, 2.5 m distance, 2M laser
Fitted radius: 6.21 cm
Standard deviation: 1.26 cm



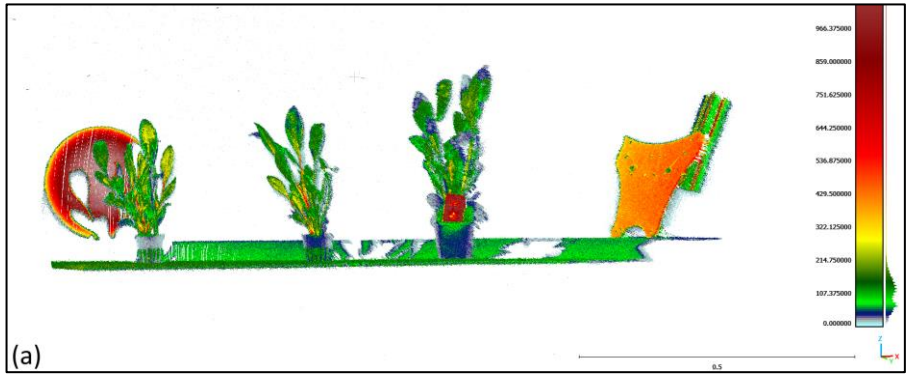
1.6 NTU, 2.5 m distance, 3B laser
Fitted radius: 10.80 cm
Standard deviation: 0.06 cm

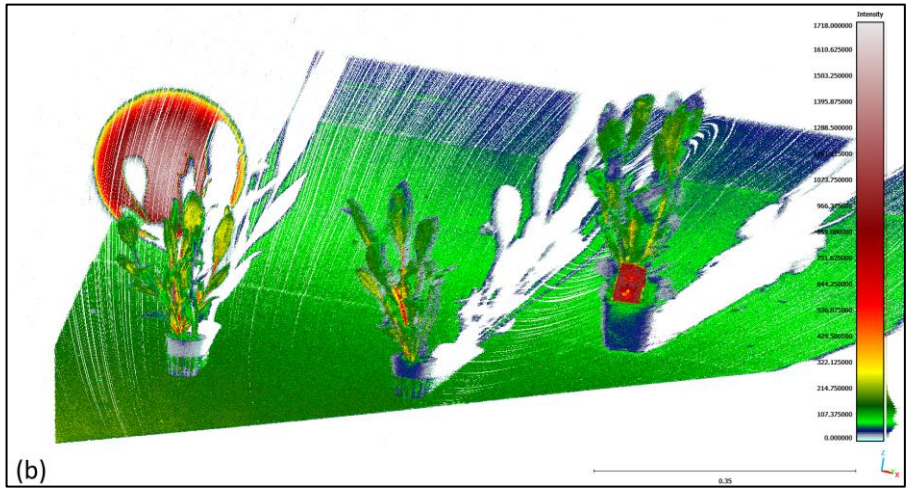
Plant detection and object recognition

Results from scanned sceneries in moderate and low turbid water



2.6 NTU
Shells and leaves
glued on a wooden plate





0.9 NTU
Scenery with several objects
and water plants

Key outcomes

Conclusion

(1) ULi fully resolves a Böhler-Star in low turbid water (0.9 NTU) at 18 m, in moderate turbid water (2.4 NTU) at 5 m and in turbid water (4.6 NTU) at 1.4 m maximum measurement range.

(2) ULi showed range precision of 2.12 mm and relative range accuracy of 4.14 mm throughout repetitive range measurements.

(3) A white sphere of 10 cm radius can be captured well in moderate turbid water at 2.5 m distance in 3B laser mode, where the fitted diameter results in 10.80 cm with a standard deviation of 0.06 cm.

(4) Objects like small shells and water plants can be clearly identified in moderate and low turbid water.

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Thank you

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