OLF Seminar Oslo, February 3rd 2012
Experience from subsea acute oil releases – from the Gulf of Mexico to Norwegian conditions

Studies of oil droplet formation from subsea releases, with and without use of dispersants

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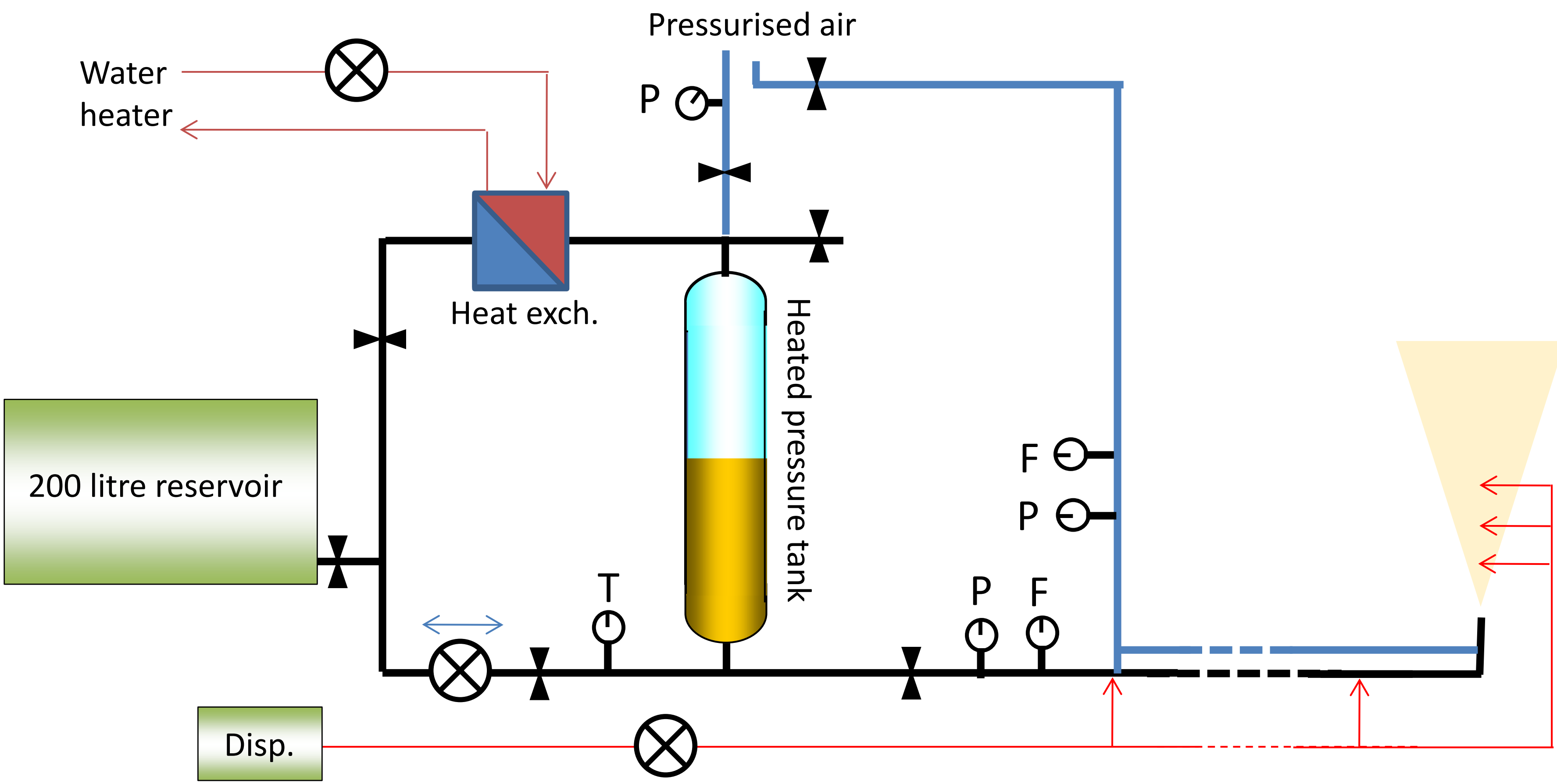
SINTEF Materials and Chemistry
Marine Environmental Technology department

SINTEF Tower basin – January 2011

- Diameter 3 m and 6 m high
- 40 m^3 of seawater
- Planned in 2000, constructed in 2005, mounted first time in Jan 2011

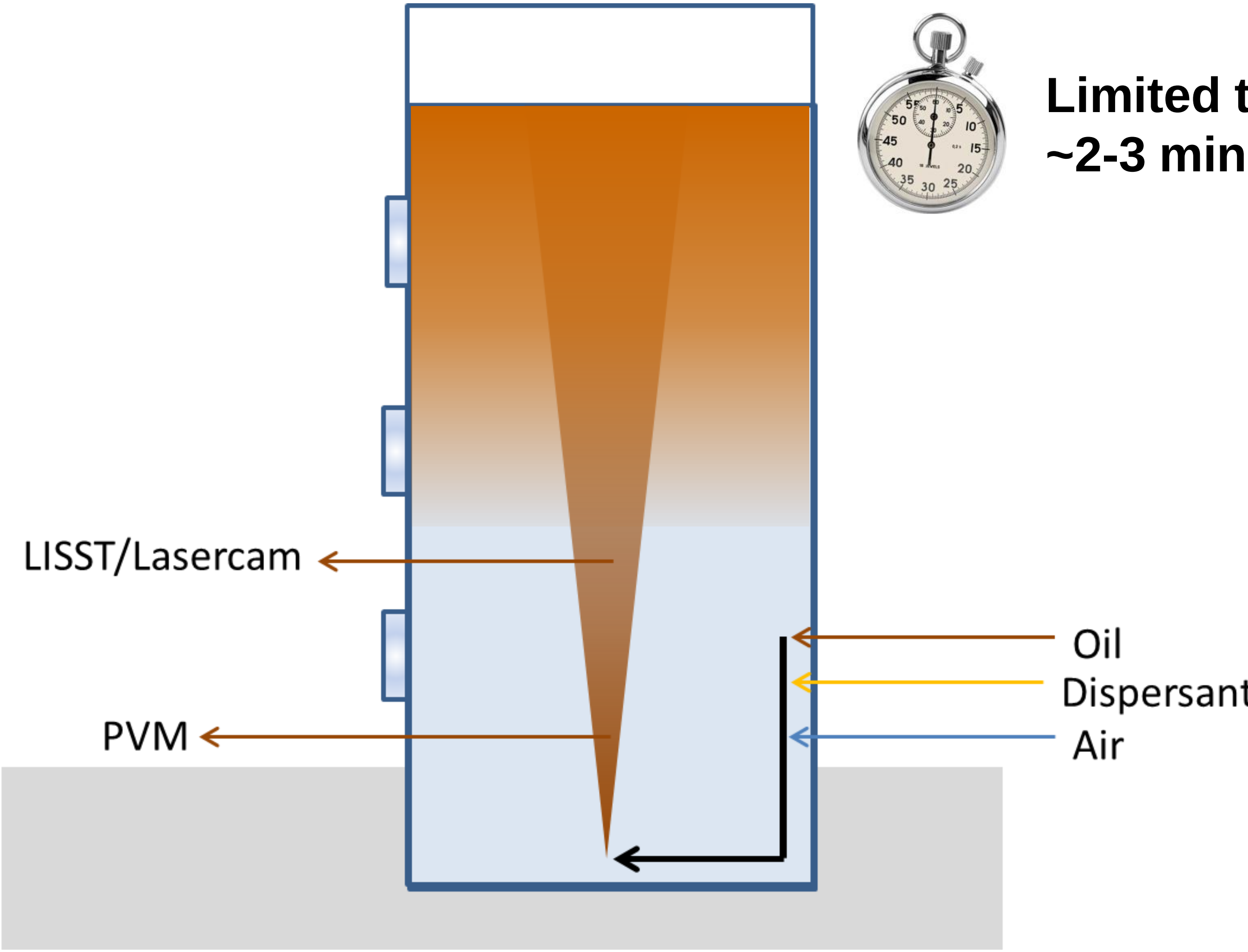
SINTEF Tower Basin – June 2011

Overview of experimental set-up



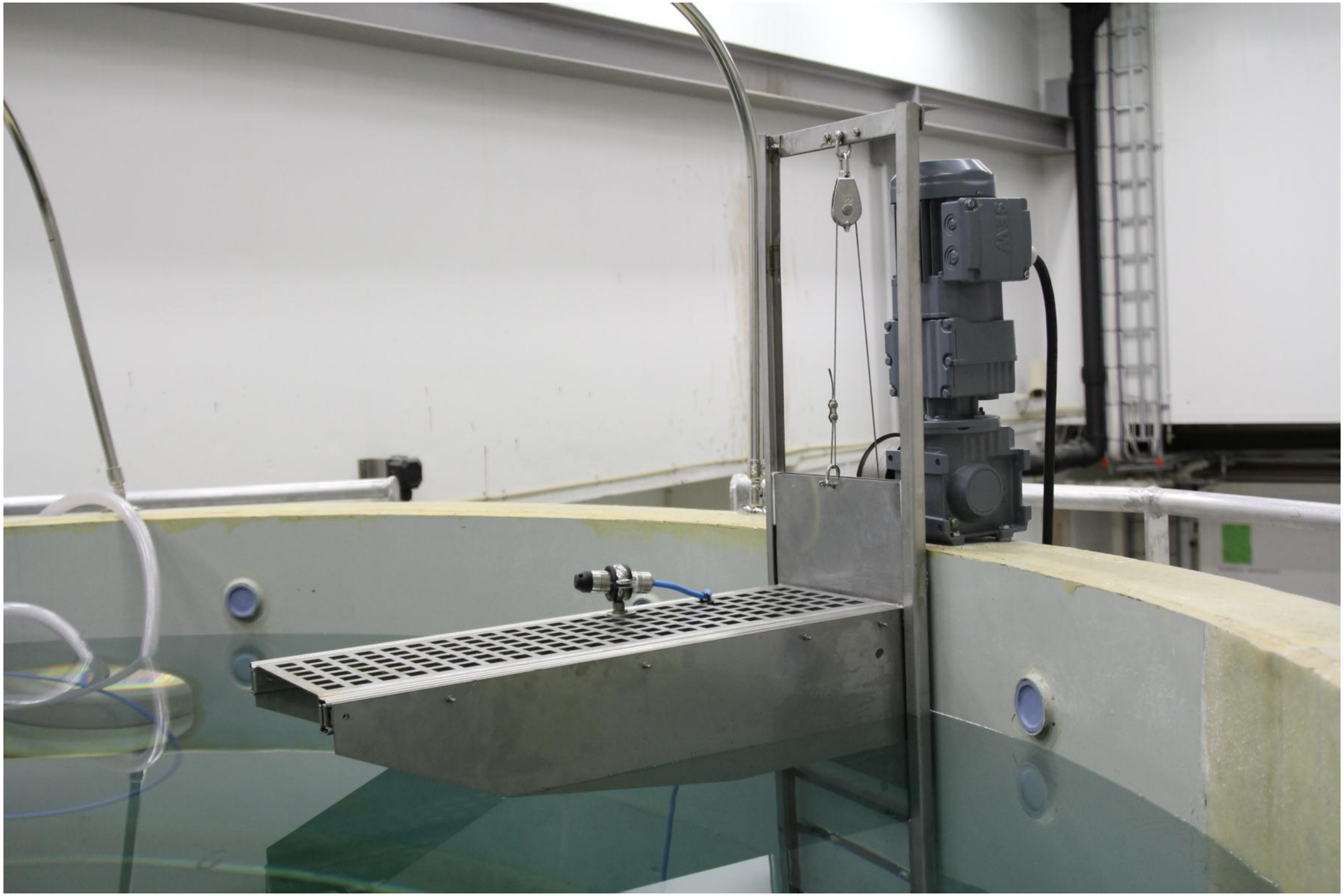
Principle overview of the set-up showing how oil, gas (air) and dispersant will be released during the experiments.

Tower Basin - Experiment specifications



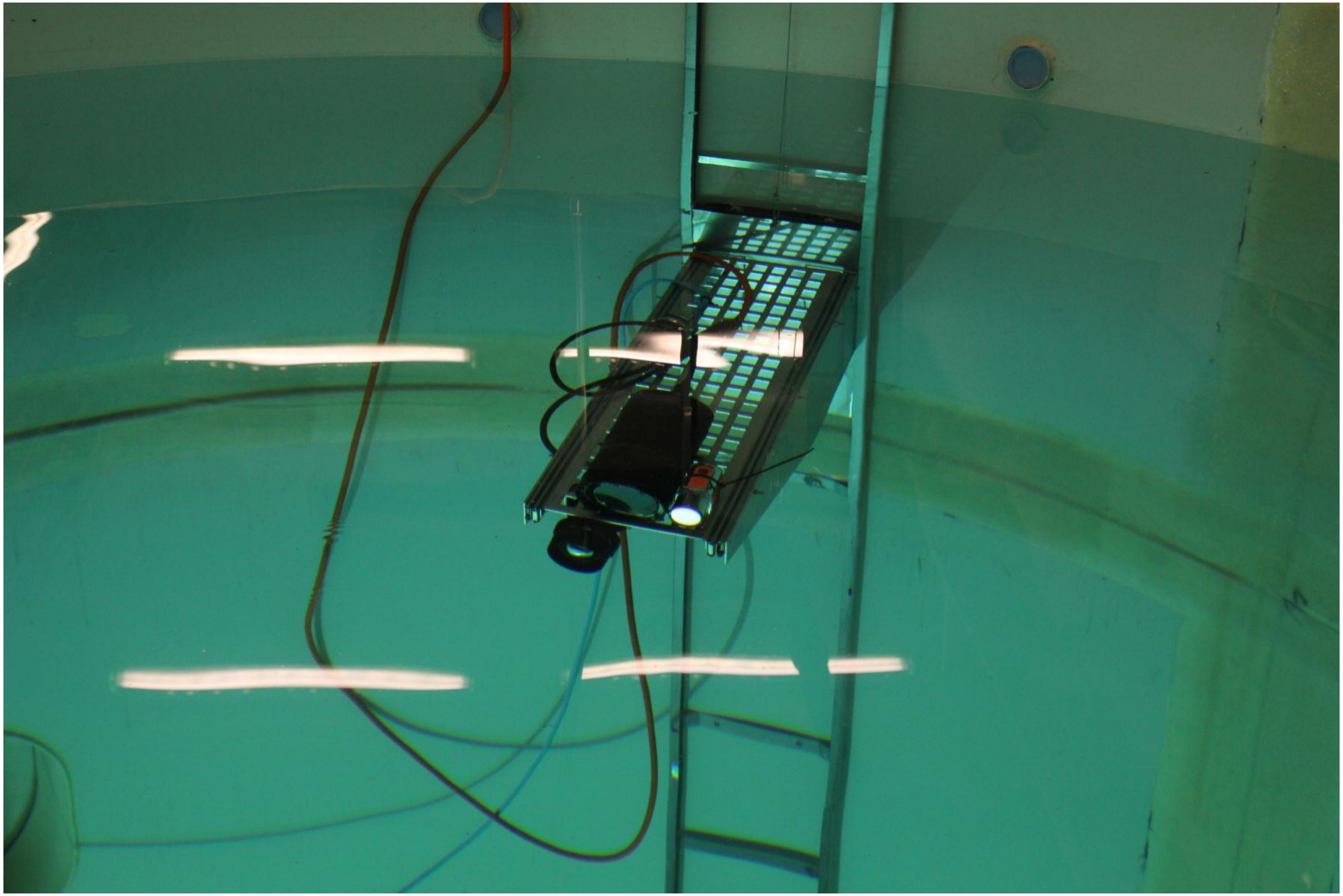
Limited test time
~2-3 minutes

Instrumentation Tower Basin



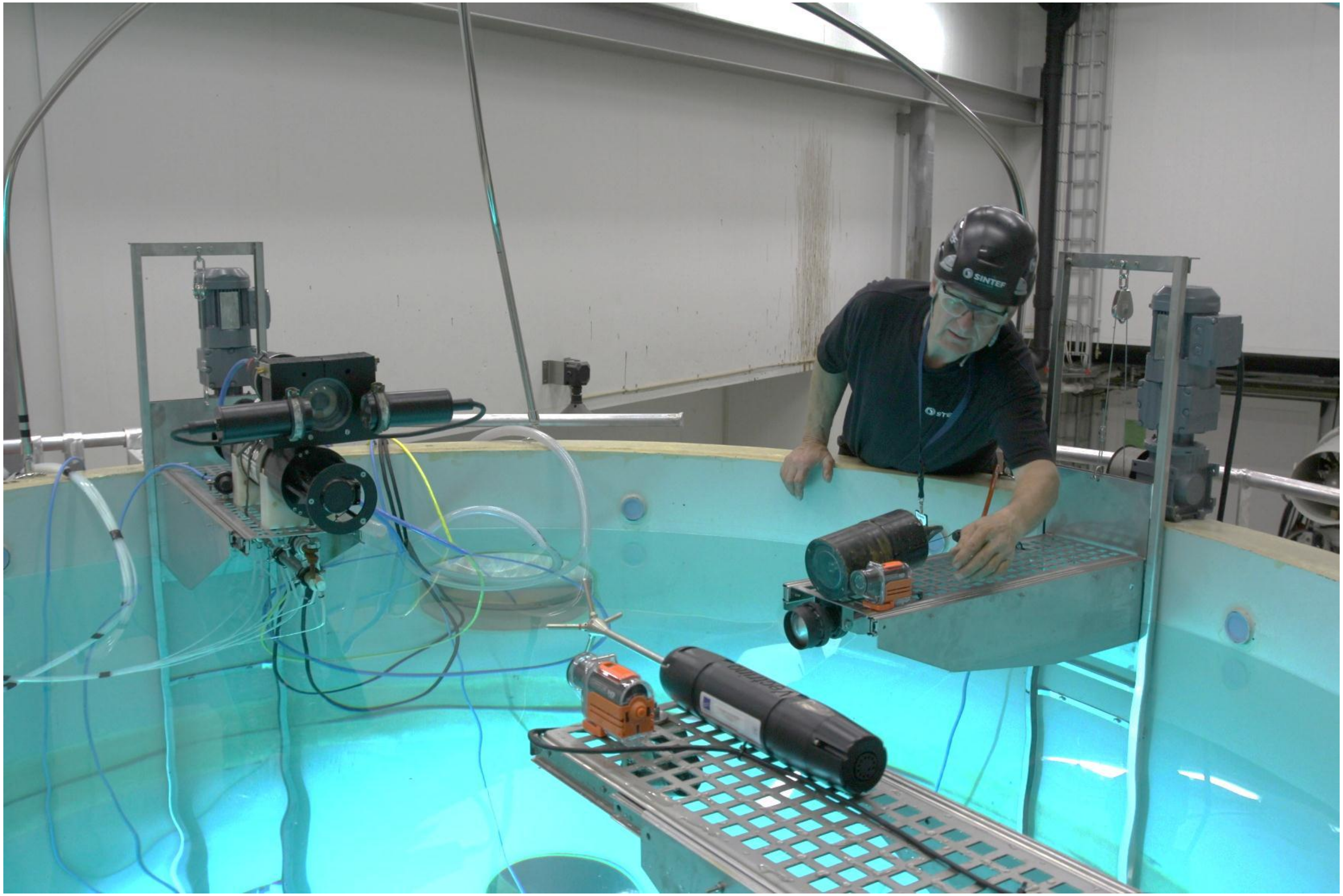
Remotely operated (vertical/axialy) instrument platform, with depth sensor (1-6 m)

Instrumentation Tower Basin



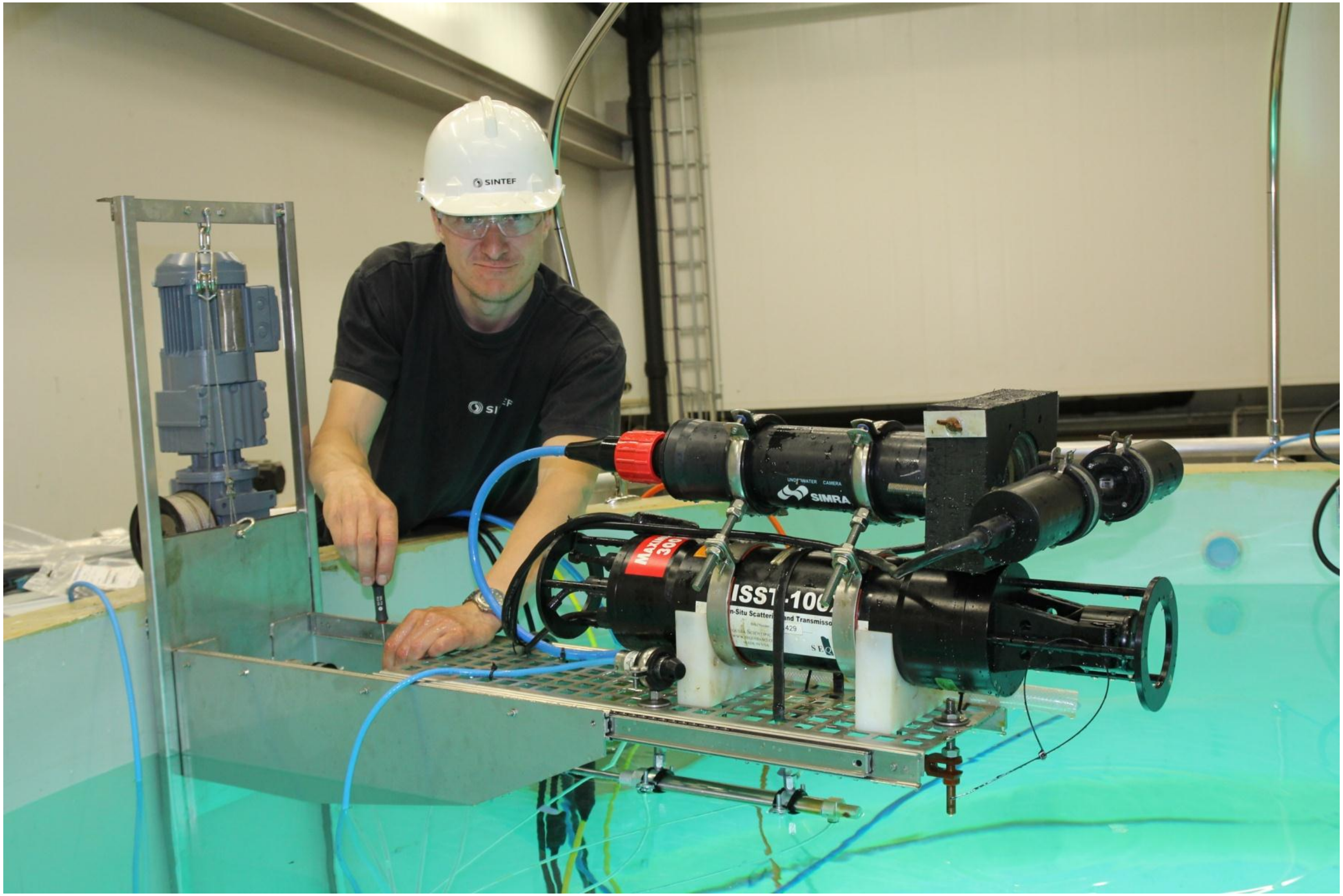
Cameras (zoom and fixed) and light mounted on instrument platform

Tower Basin - Initial experiments



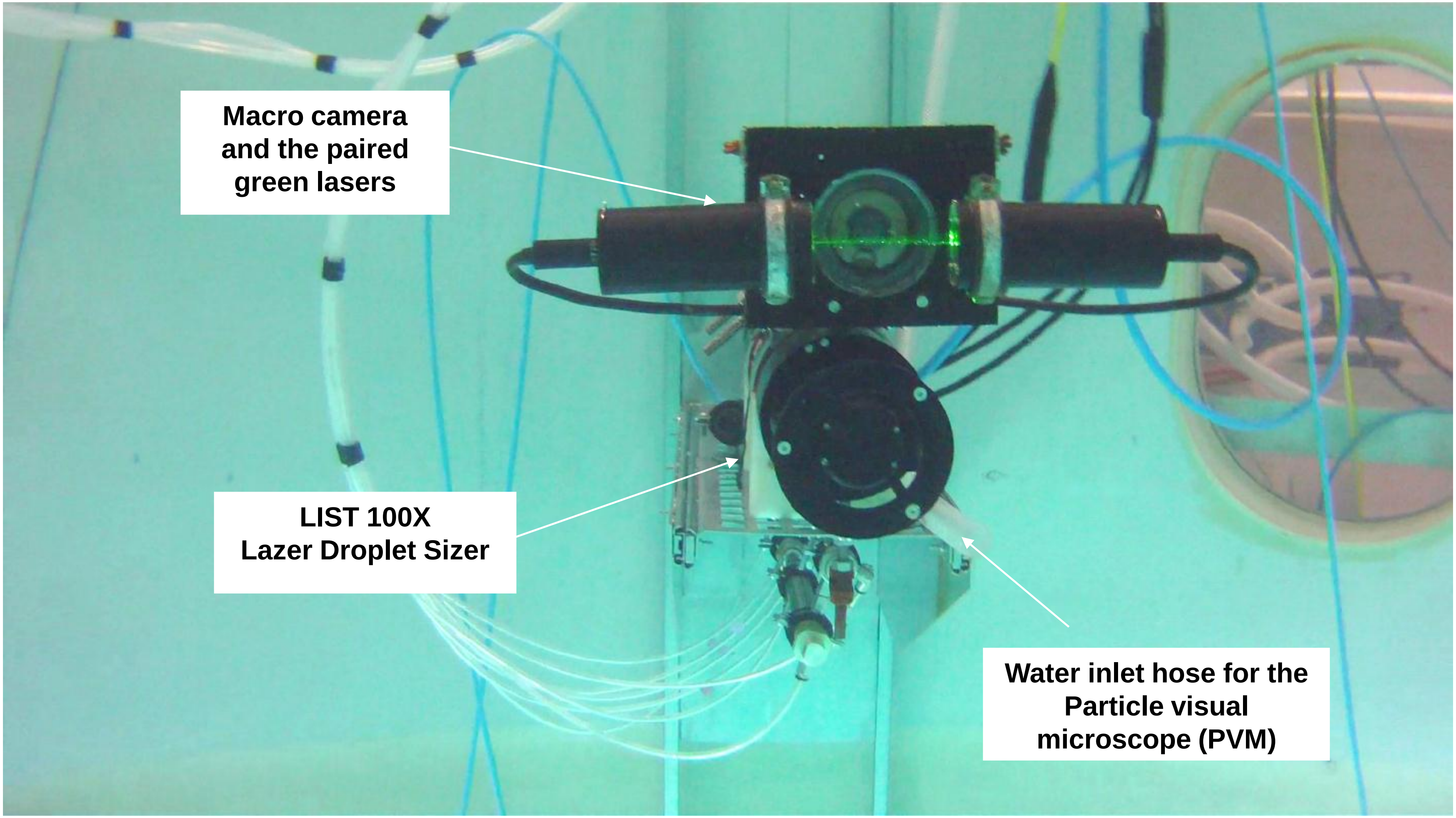
Adjusting cameras and sensors before the first experiment is initiated

Tower Basin - Initial experiments

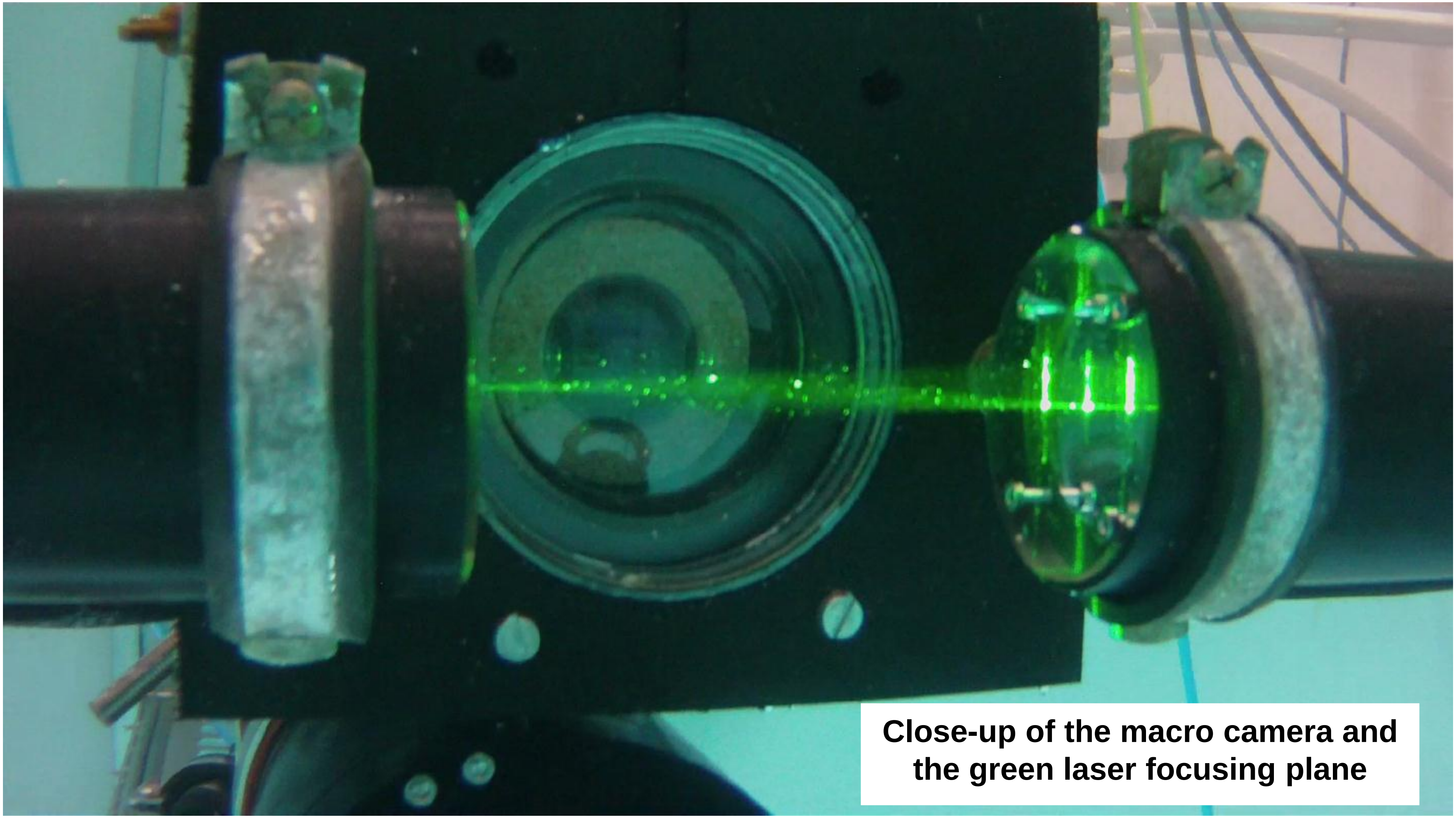


Adjusting camaras and sensors before the first experiment is initiated

Tower Basin - Droplet Size Monitoring

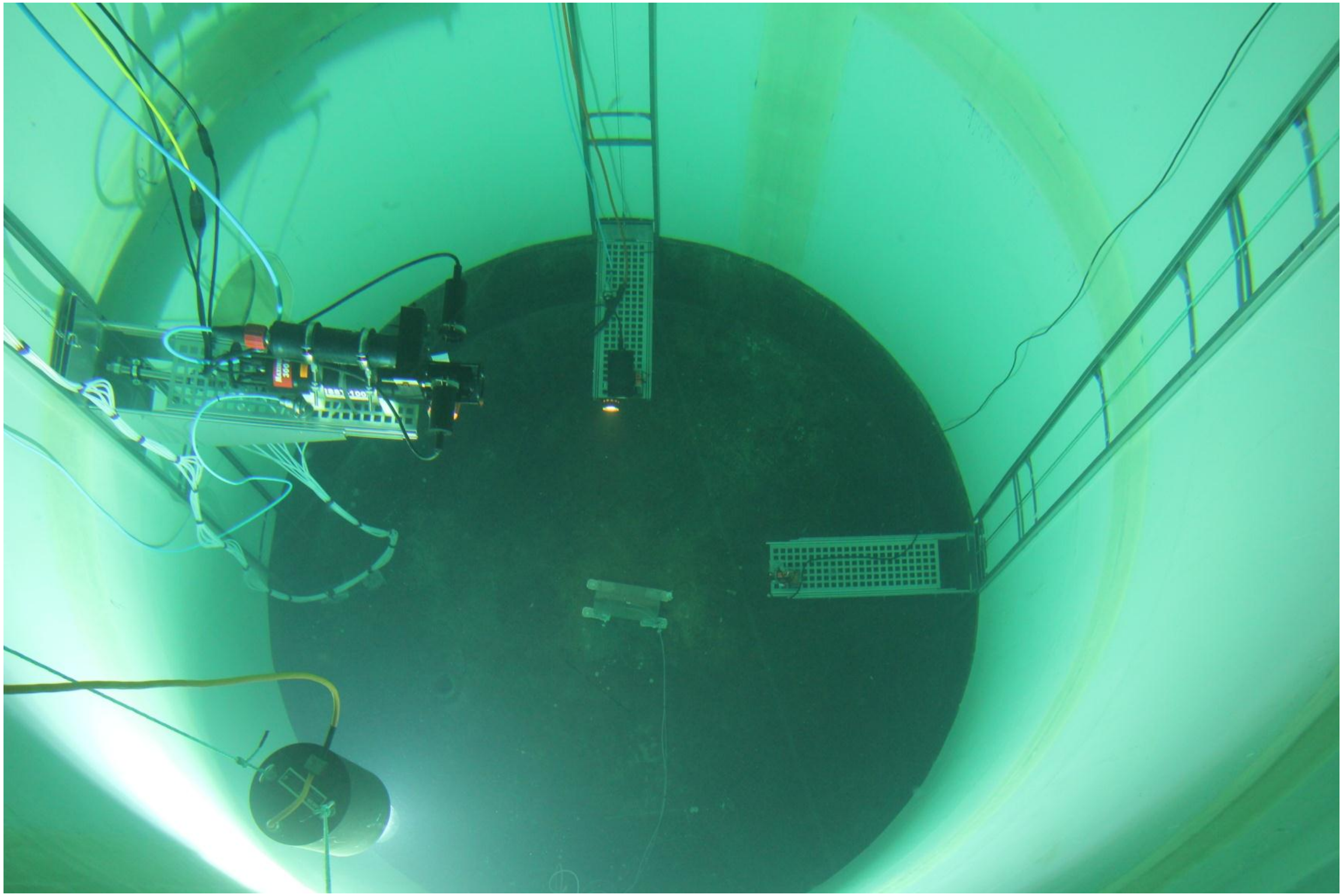


Tower Basin - Droplet Size Monitoring



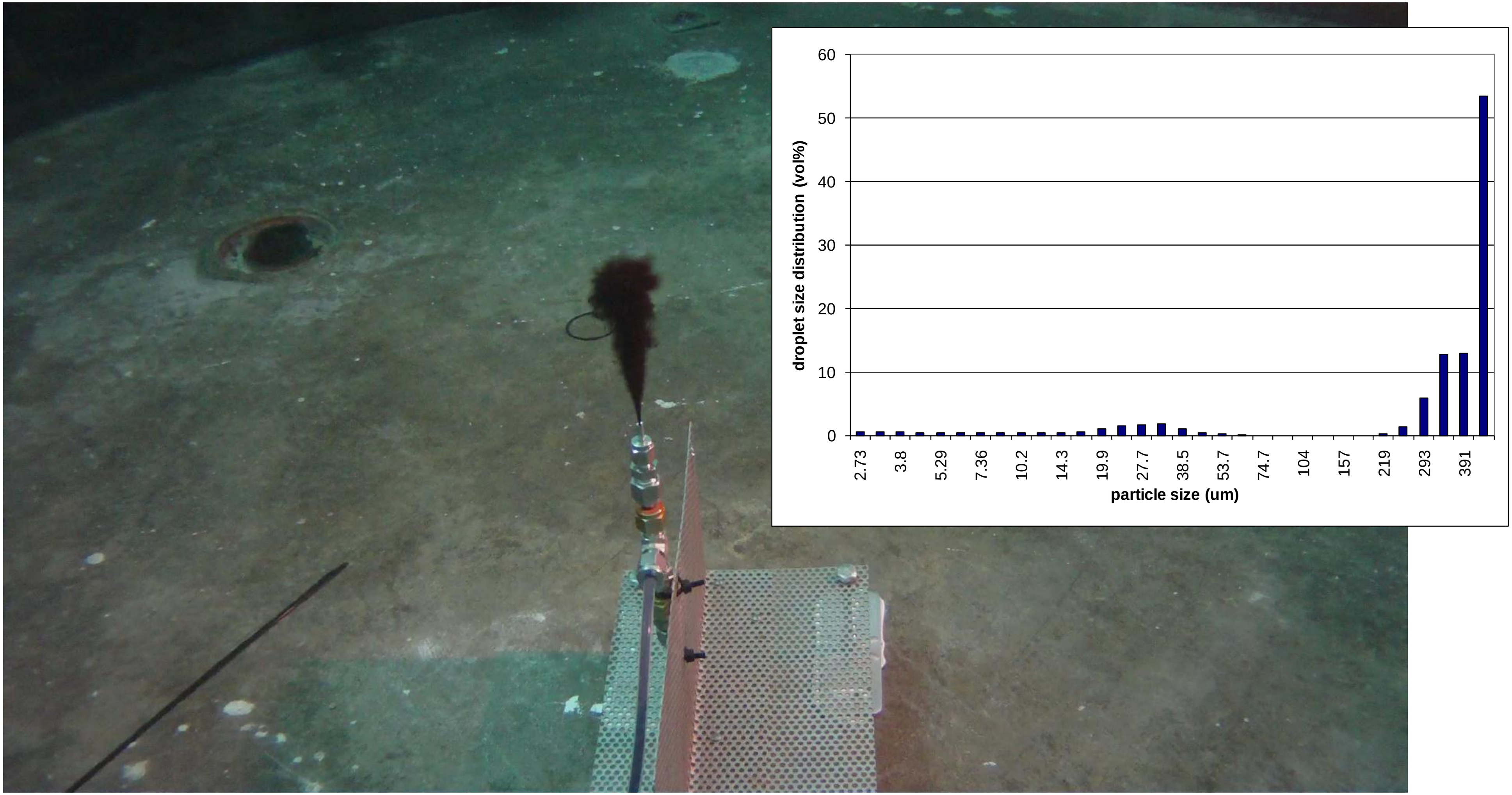
Close-up of the macro camera and the green laser focusing plane

Tower Basin – prior experiment initiation



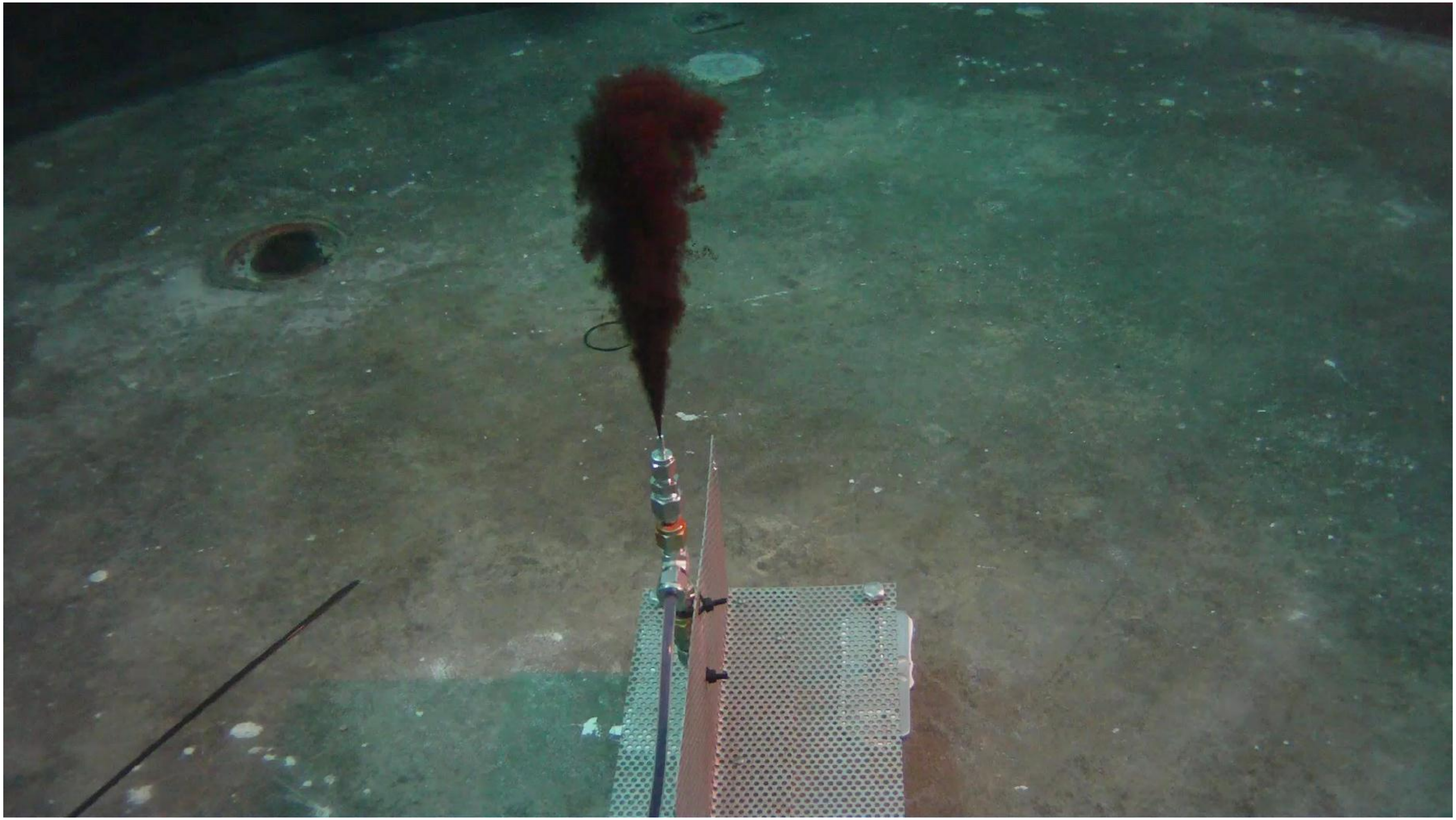
Droplet size monitoring equipment at 3 meters dept, cameras at bottom

Tower Basin – Oil release from Nozzle



Release of Oseberg oil: Diameter 1.5 mm, rate: 1 L/min (3 x 90 sec)

Tower Basin – Oil release from Nozzle



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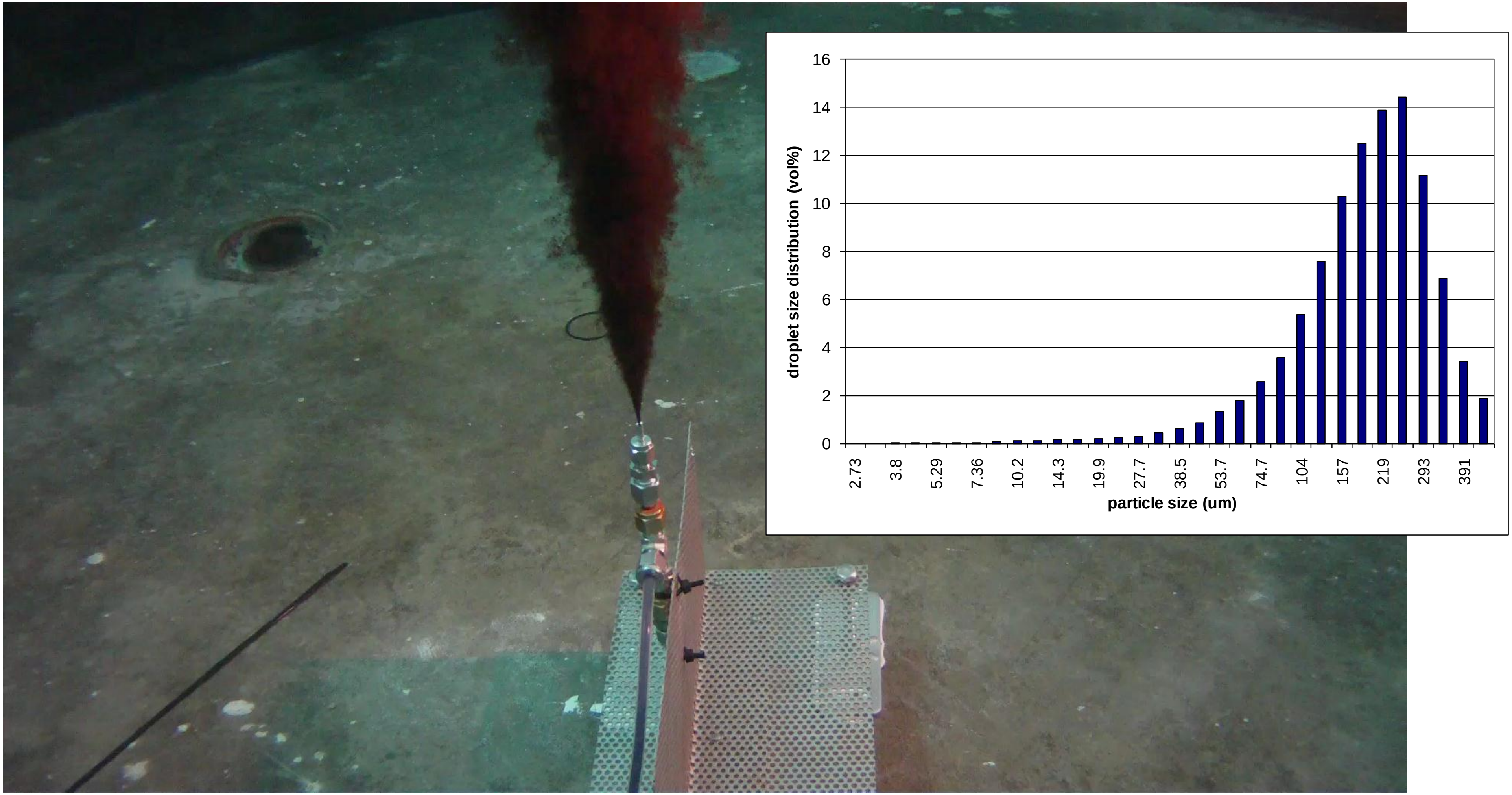
Tower Basin – Oil release from Nozzle

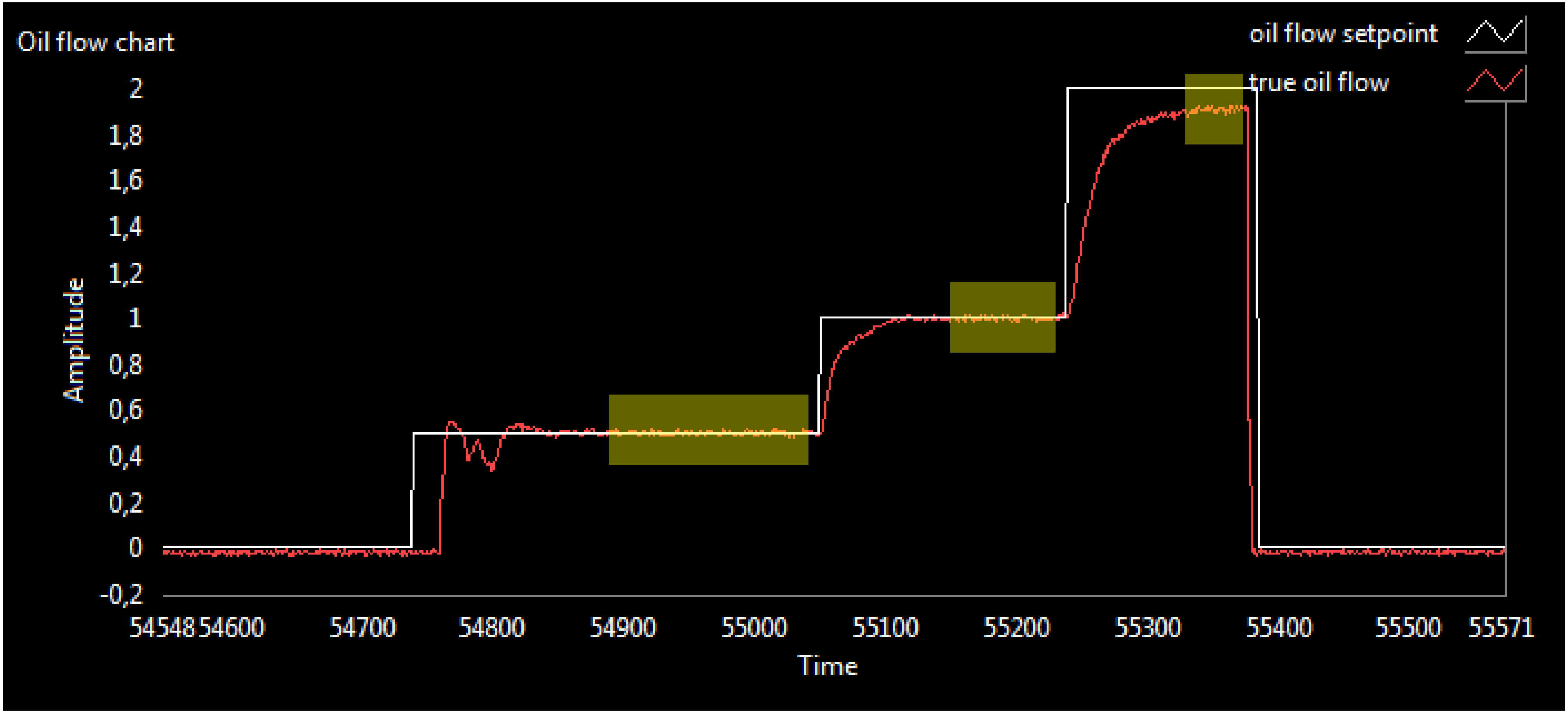


Release of Oseberg oil: Diameter 1.5 mm, rate: 1 L/min (3 x 90 sec)

Tower Basin – operational control

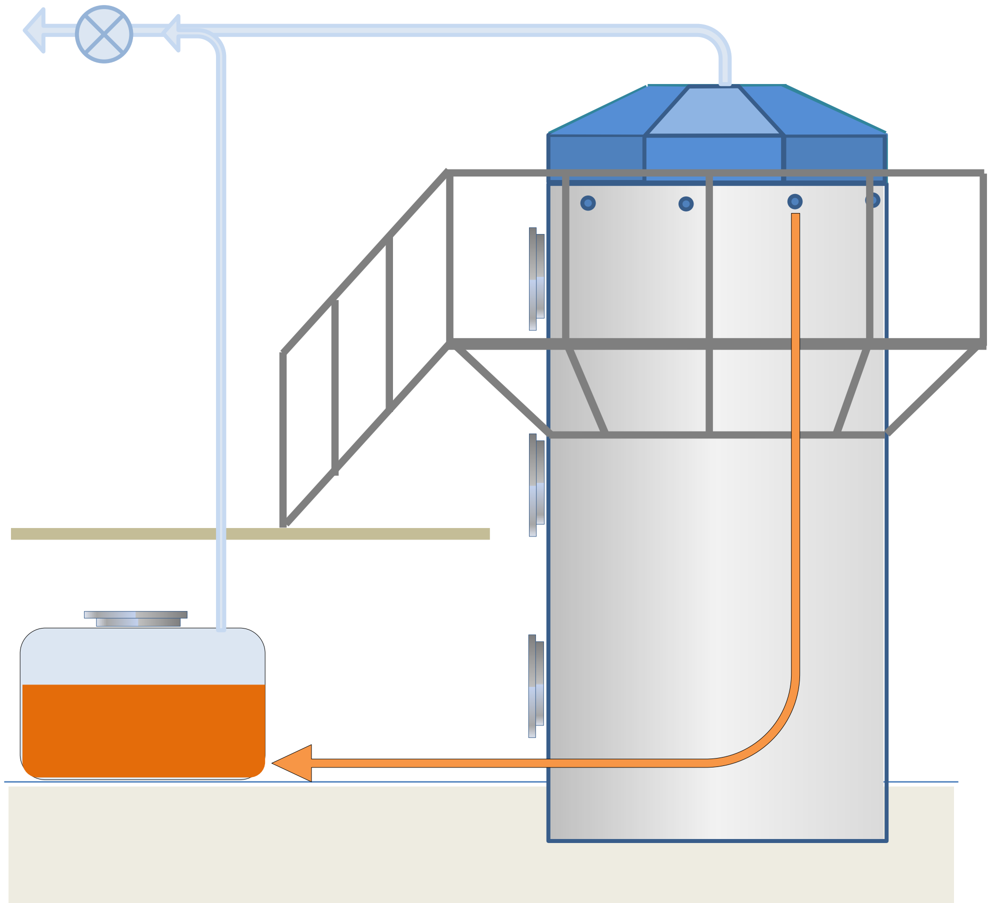
Monitoring and controll station

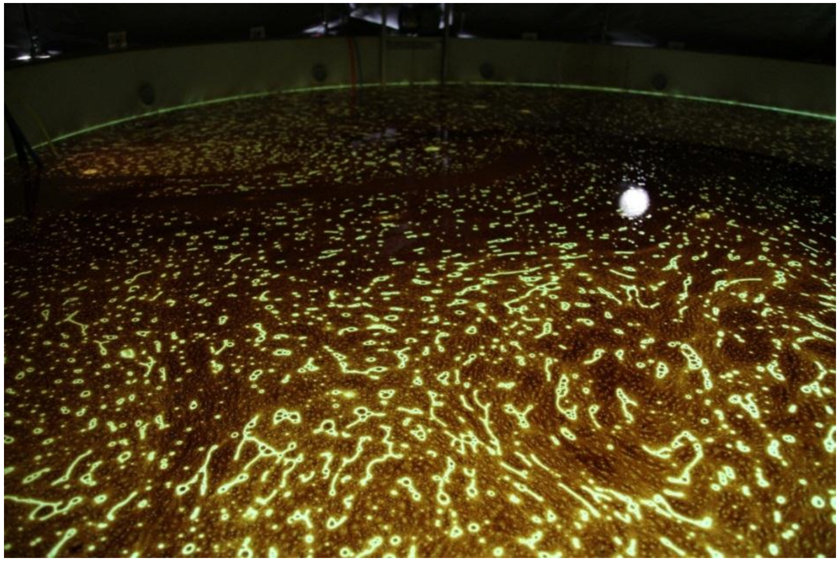
Operational control – Flowrates versus time



Controll and monitoring of oil flowrates for a typical experiment (one nozzle three flow rates)

HSE consideration: Evaporation and Waste management





Surfacing fresh oil on top of the Tower basin. Light components are taken care of by the ventilating hood.

Surface oil is drained off and stored for later treatment.
Oily water treated by an oil-water separator (lower than 50 ppm) and disposed.

Types of data - Tower basin experiments

1. Droplet size data
   a) LISST
   b) PVM
   c) In-situ macro camera
2. Video data (operational cams and HD video array)
3. Oil concentrations
   a) UVF sensor
   b) Water samples
4. Interfacial tension by spinning/pendant drop method
5. Monitoring of actual flow (gas/oil or water)

Video data – Operational cams

OpCam 1

OpCam 3

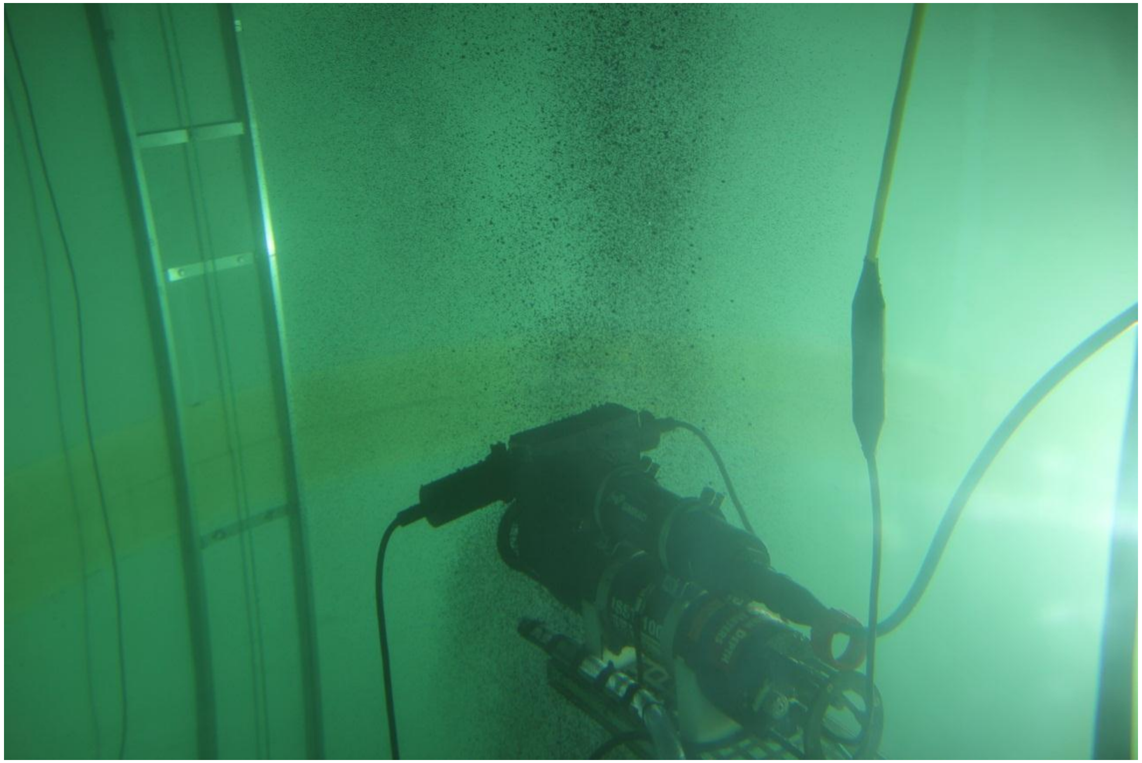
Important tool for operator to visualy follow/control Basin Tower operations

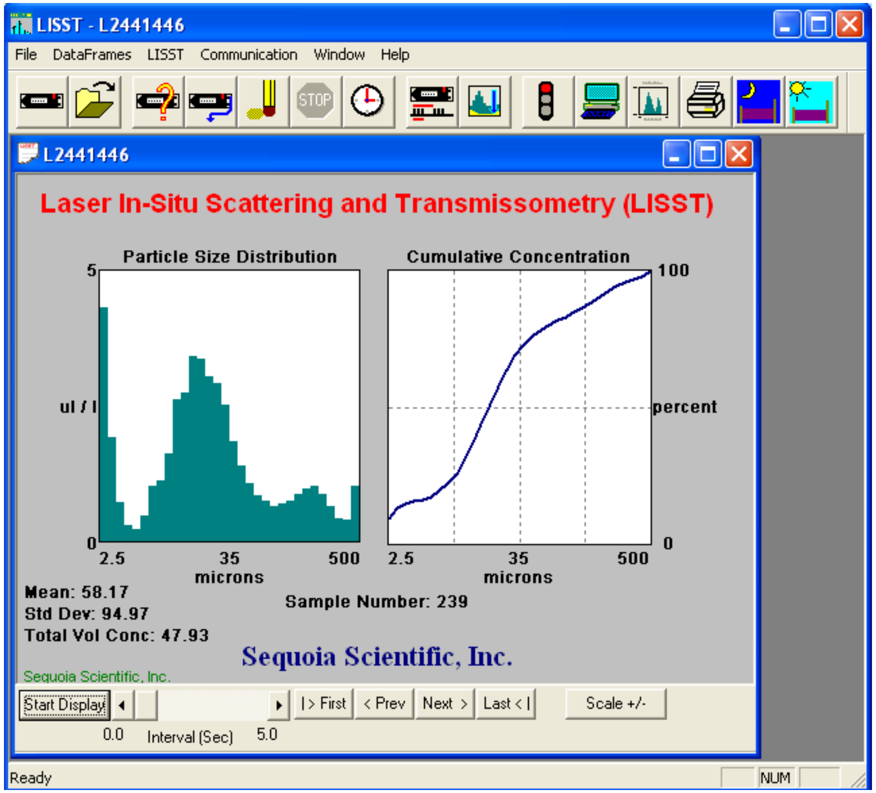
Video data – HD video array

Used to document the droplet formation and plume behaviour in the Tower basin

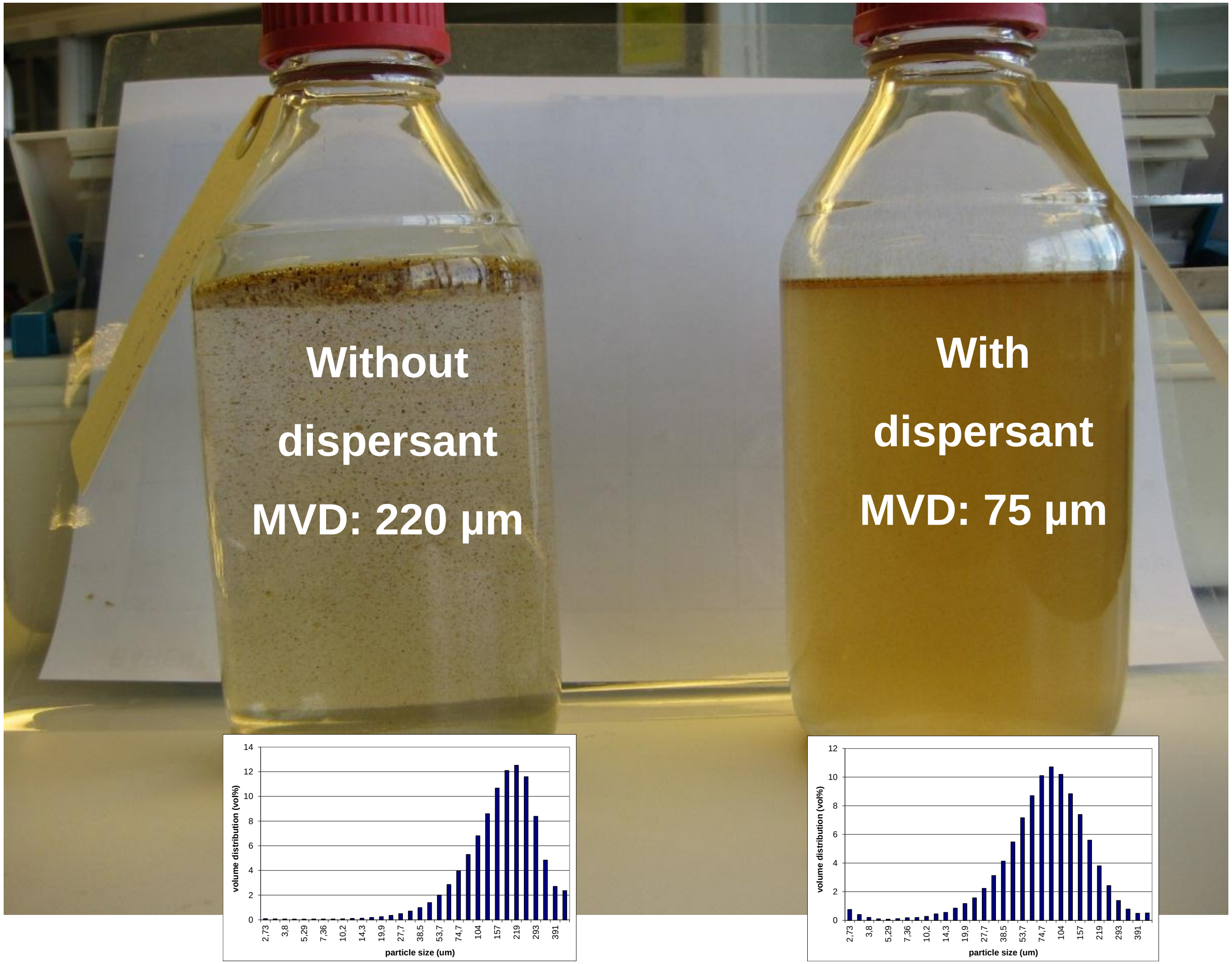
Droplet size data

1. Droplet size data
   a) LISST



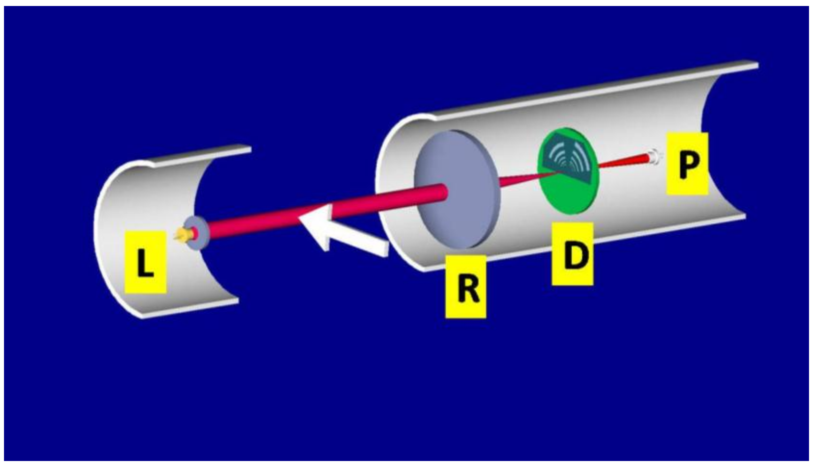


Droplet size data



Water samples from Oseberg experiments **with** and **without** dispersant injection

Laser scatter difraction - LISST 100X



Detecting particle size distribution by laser diffraction technique.

Laser beam passing through the sample area

Scattering of the laser depend on the size of the droplets in the laser path (small particles → high scattering)

32 ring sensors detect the degree of scattering.

PVM (Particle vision microscope)

Microscope probe illuminated by 8 lasers

Lasers can be individually controlled

2 lasers provide optional backlighting of droplets

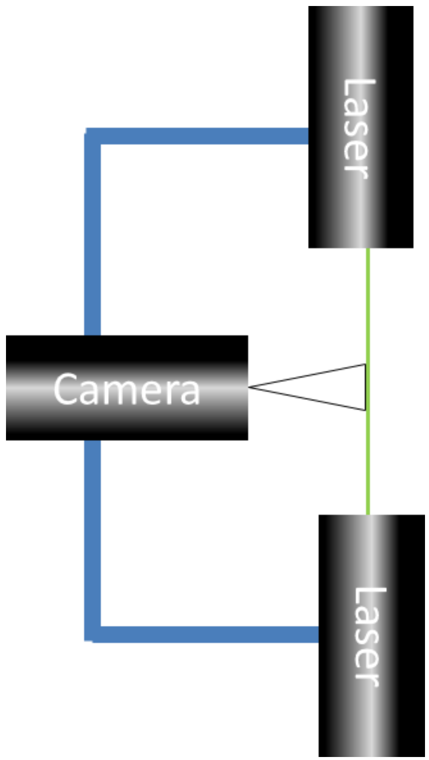
Image frame is 1.1 mm

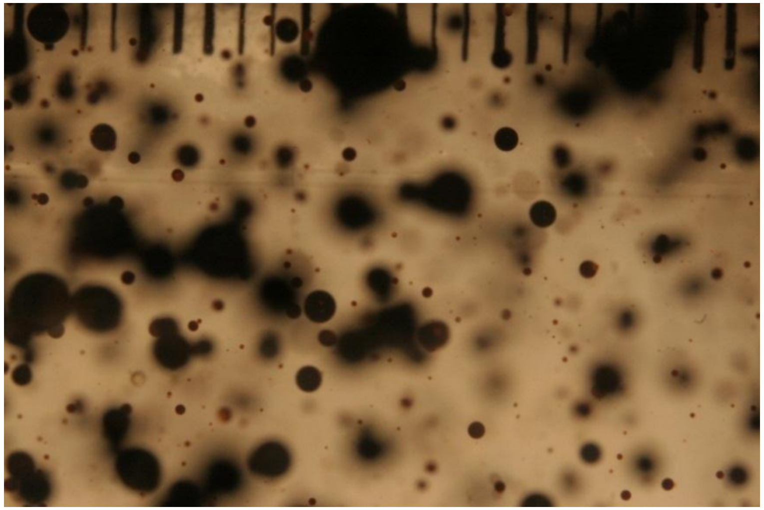
1.4 Mp images at max 10 images /second

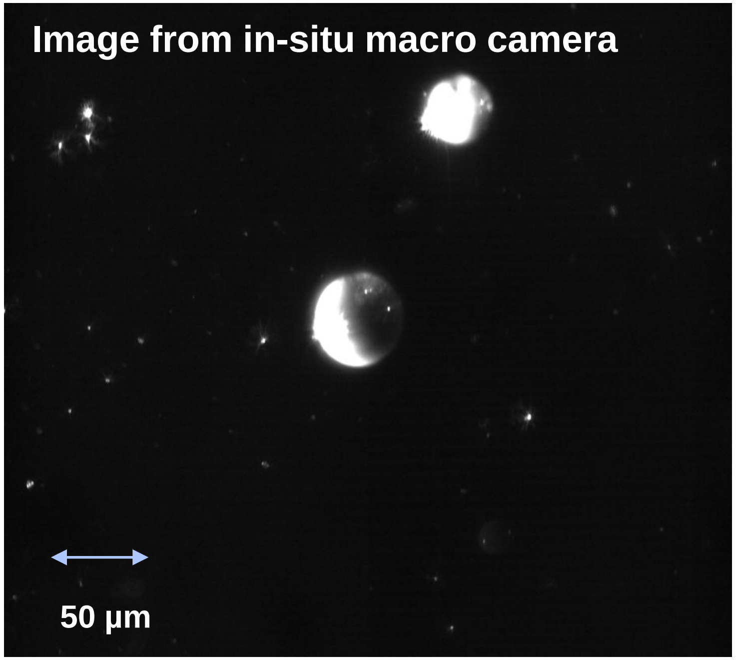
GigEthernet machine vision Camera (5Mp)

2 images/second

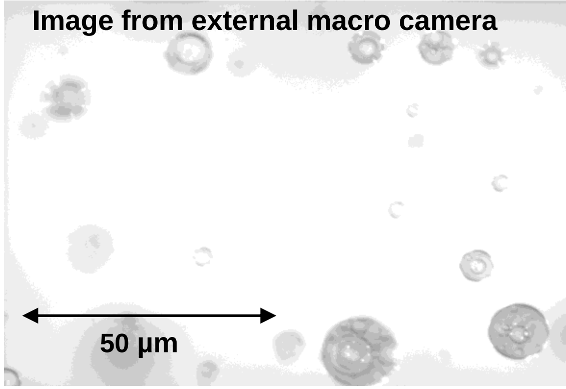
2 x 150mW green lasers

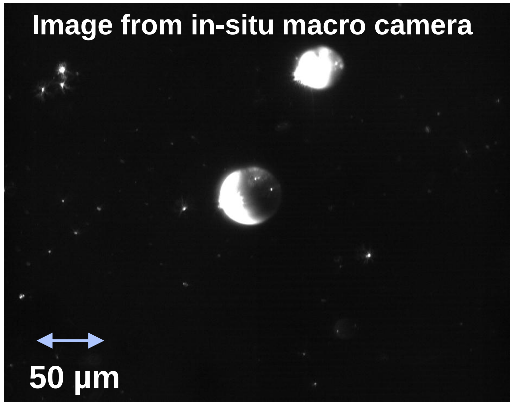


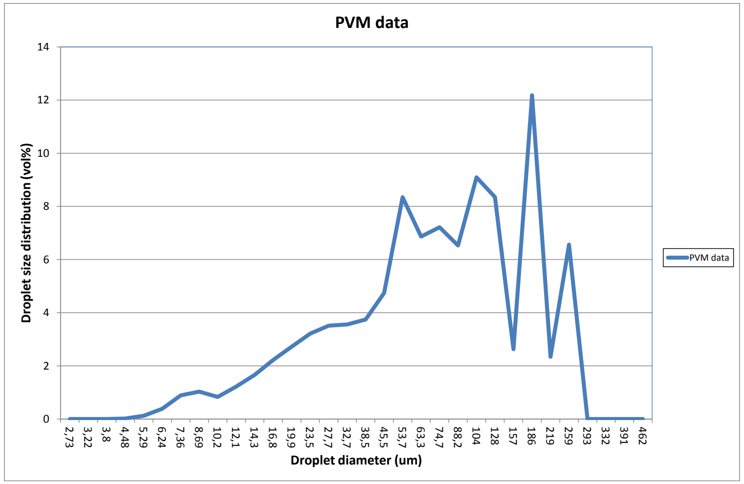




From images to droplet size distribution



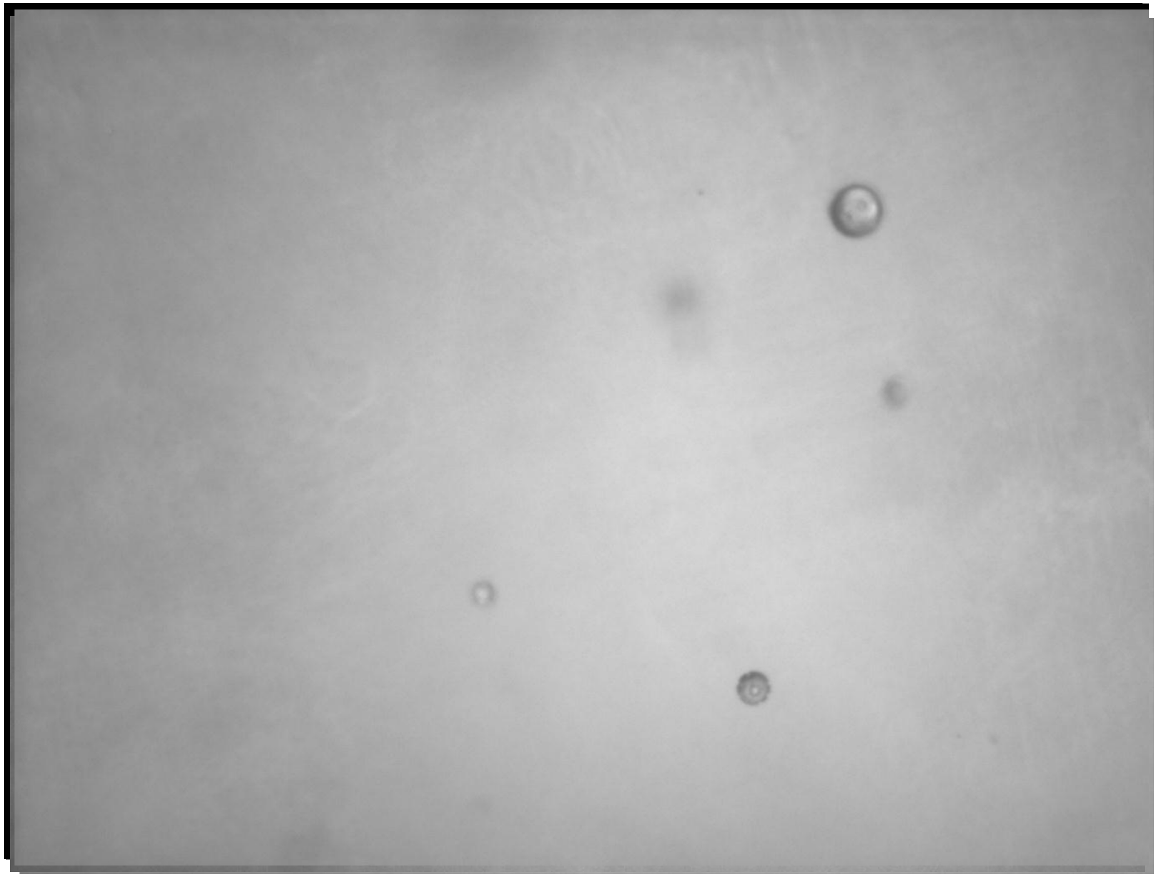




- Contrast adjustment
- Image enhancement
- Growing/Filling/erosion
- Particle identification
- Diameter estimation
- ➔Distribution

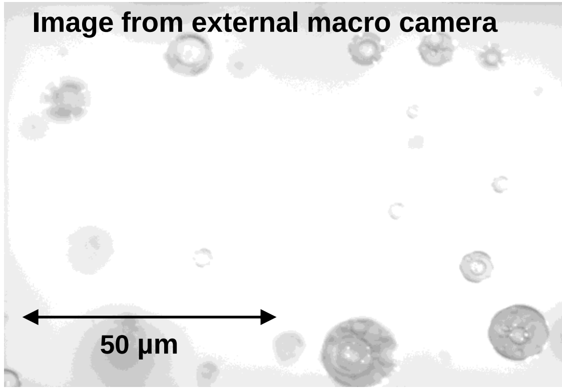
875 images or 51250 particles

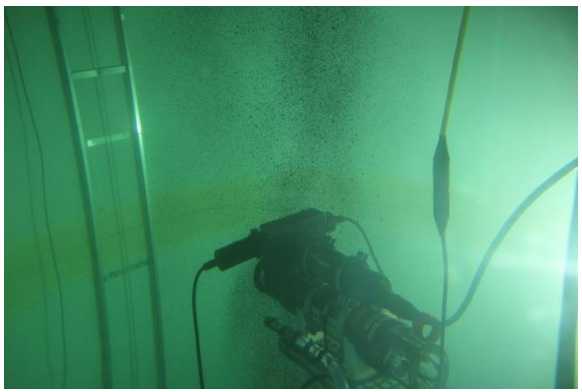
From images to droplet size distribution

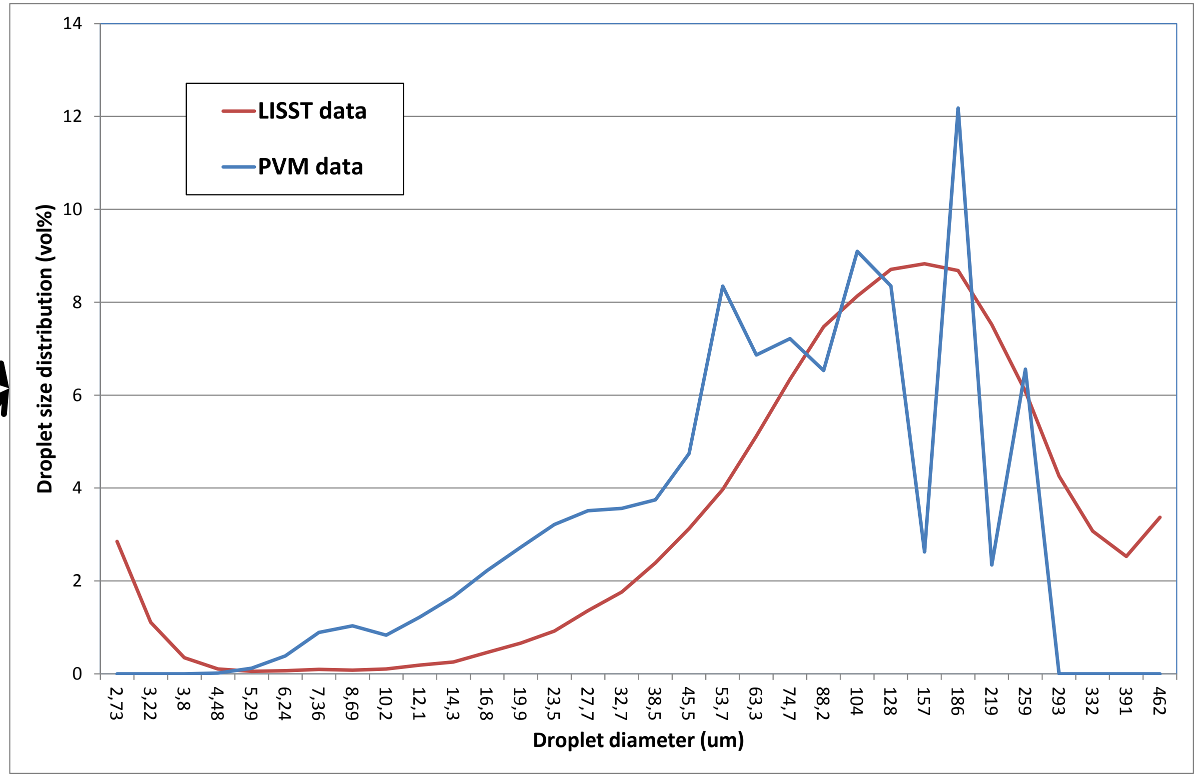


A stream of raw mages (400 – 4500) from each Tower Basin experiment is processed by an automatic droplet analysis system

From images to droplet size distribution PVM vs. LISST







TB experiment 1th Nov 2011, Nozzle: 0.5 mm, 0.1 L/Min

Estimation of droplet sizes based on release parameters, oil chemistry and use of dispersants

Current approach: Weber number estimation (Hinze 1955):

$$d_{50}/D = F\,We^{-3/5} = F\,(\rho\,U^2\,D/\sigma)^{-3/5}$$

- d_{50} - parameter describing distribution
- *D - outlet diameter*
- *F - factor of proportionality*
- *ρ - density of the continuous phase (water)*
- *U - exit velocity*
- *σ - interfacial tension (oil-water)*

Based on our calibration dataset, we will present a modified "Weber equation" ➔ better predictions of droplet sizes!

Conclusions – Final remarks

- **Improved predictions of droplet sizes from subsurface release are important:**
  - ➢ **Fate of oil; Surface or entrained in the water?**
  - ➢ **Where will the oil surface, thickness and lifetime of surface slick?**
  - ➢ **Could we reduce personnel VOC exposure at the surface?**
  - ➢ **Rate of biodegradation and possible environmental effects (NEBA)**

- **What is the effect of injecting dispersants:**
  - ➢ **How much smaller will the droplets be?**
  - ➢ **How should the dispersant be injected?**
  - ➢ **How large quantities of dispersants do we need?**

- **These and other important questions can be answered by the on-going experimental studies (for example SINTEF API D3 project).**

Thanks for your attention!

For further information contact:

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