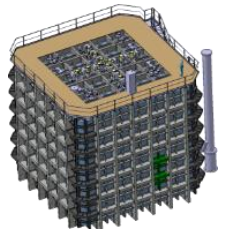
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich



WA105

Cryogenics cameras prototyping

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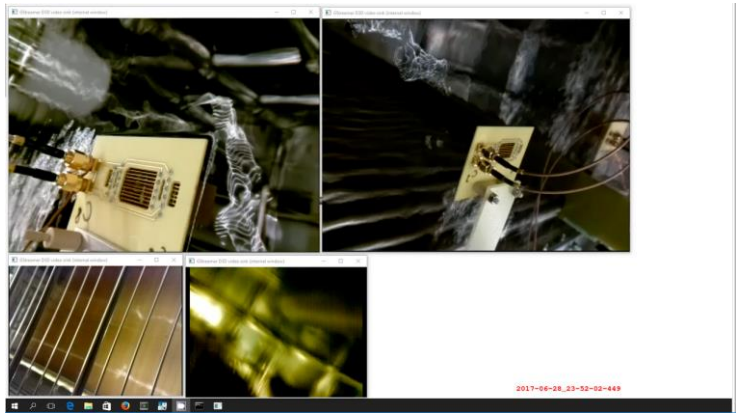
Thierry VIANT

ProtoDUNE-DP

Cameras : 3x1x1 experience

- 3x1x1 cameras inside cryostat are very important :
  - liquid argon level
  - bubbles
  - waving
  - etc …

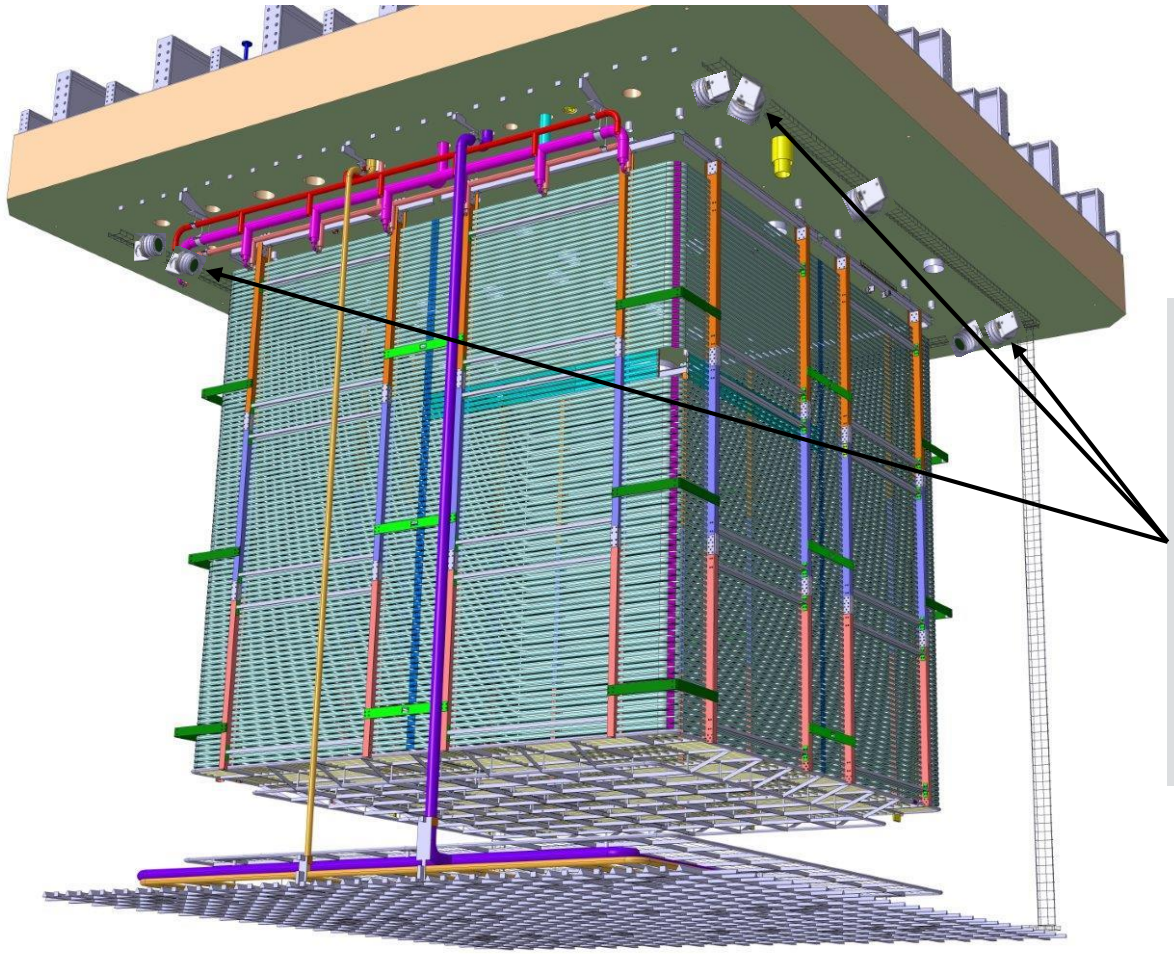


Wa105 website screenshot

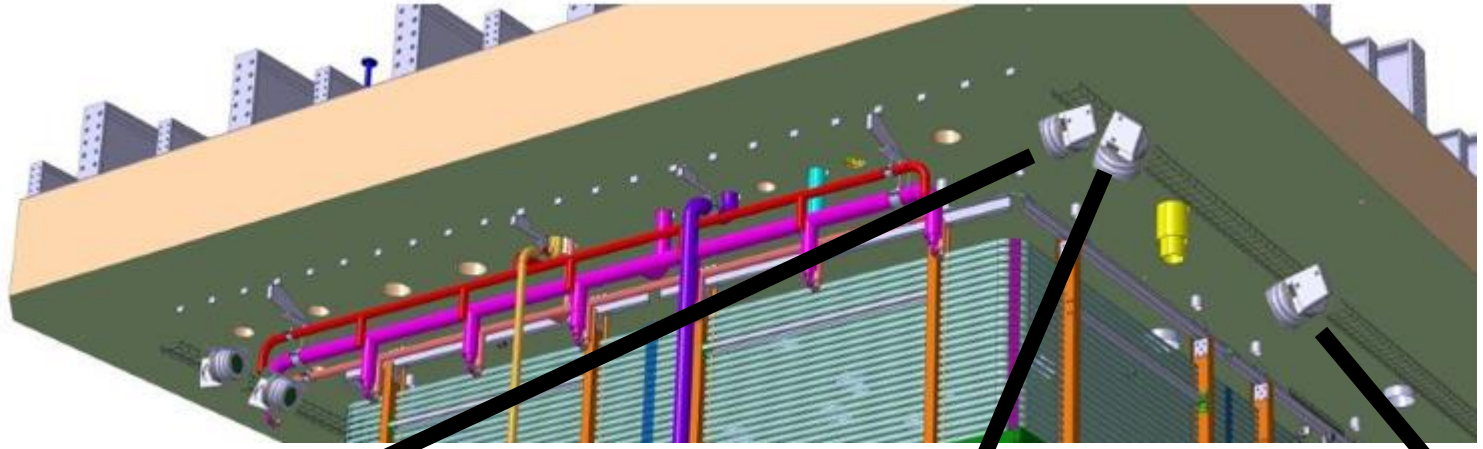
- Unfortunatelly , these cameras cannot be used :
  - Correct version camera module is discontinued
  - New camera models doen’st restart in liquid Argon
  - Cable length problem (6 meters max)
  - Noise

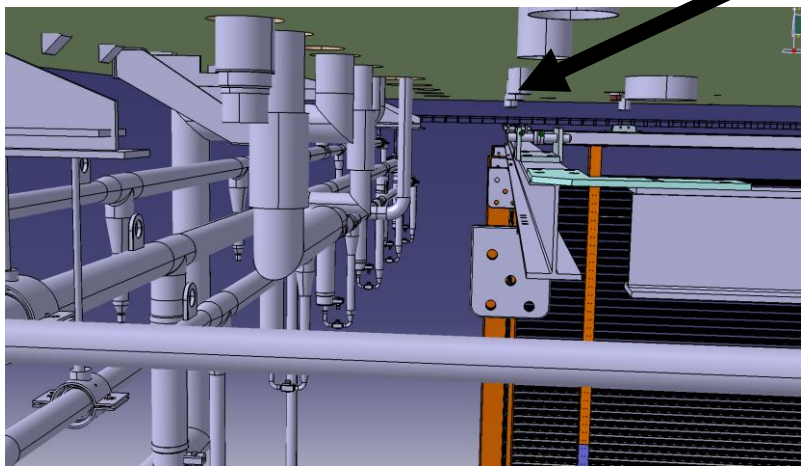
RaspBerry PI and his camera module

- We are studying the ethernet camera solution :
  - Length cable unlimited and shielded
  - POE cable and camera

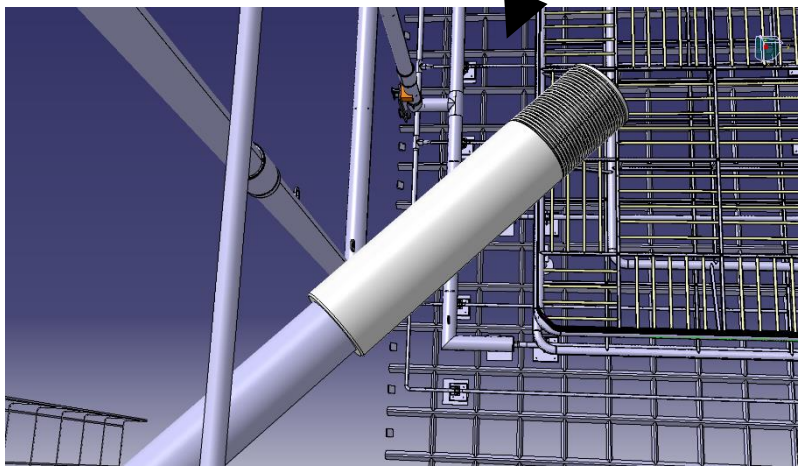


- 12 cameras fixed on the top cable trays:
  - 2 x VHV feedthroughts
  - 2 x cooling down nozzles
  - 1 x beam plug
  - 7 x liquid argon level + CRP
- No cameras in the liquid
- Safe distance from HV

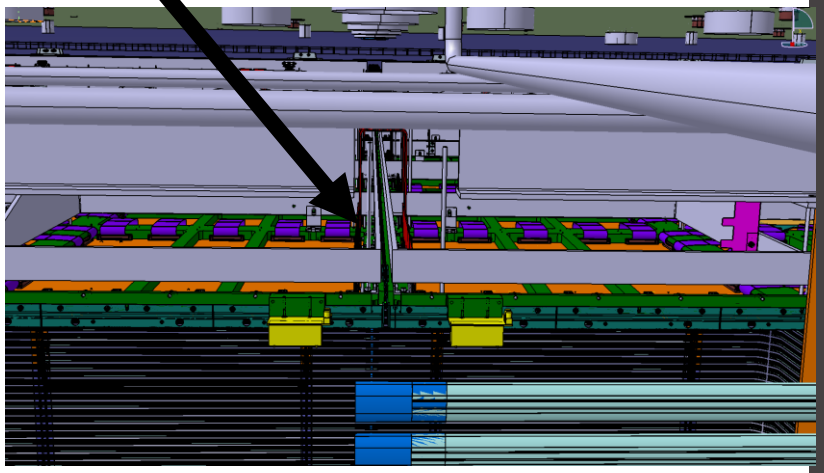




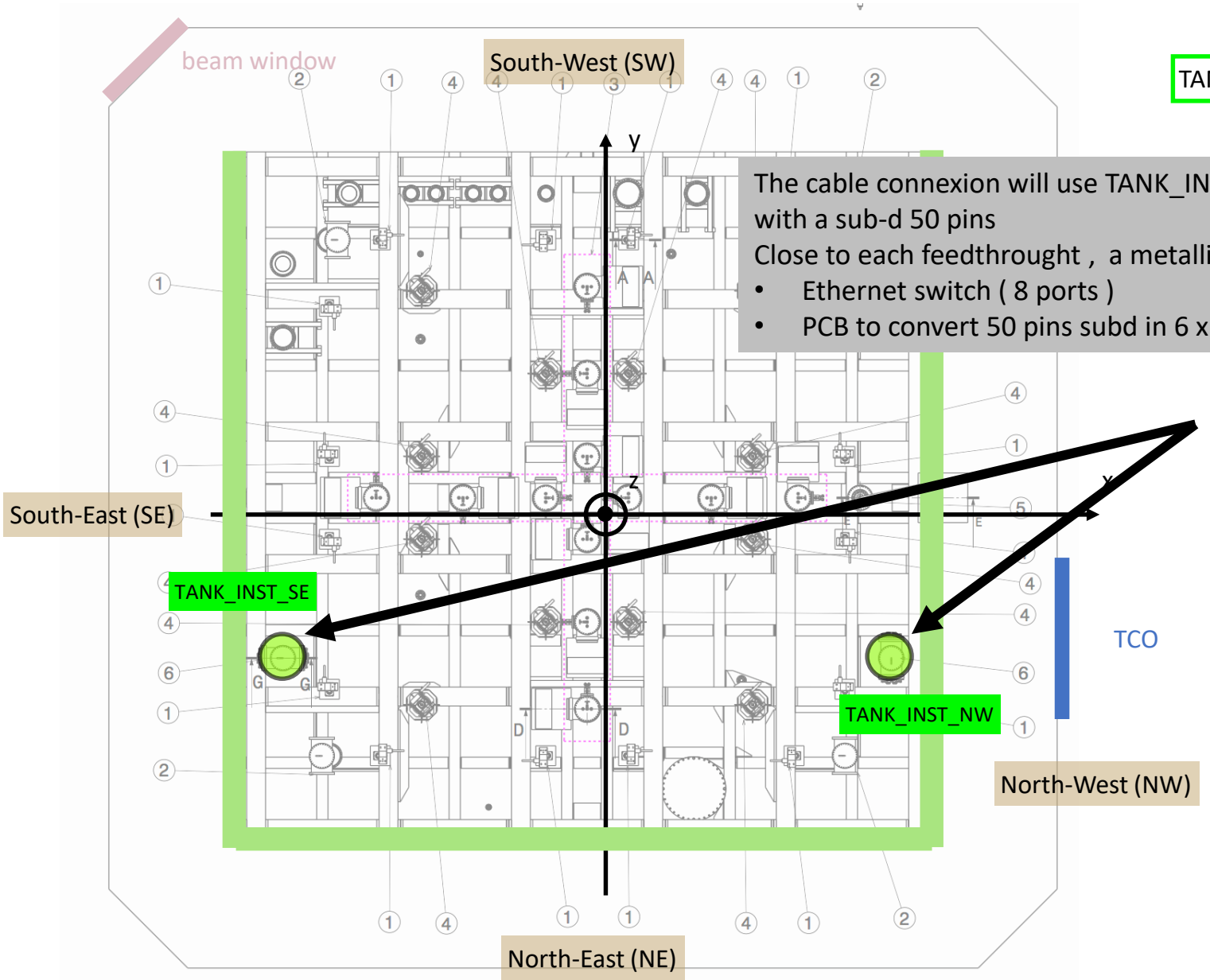
Cooling down nozzles



Beam plug



Levelmeters

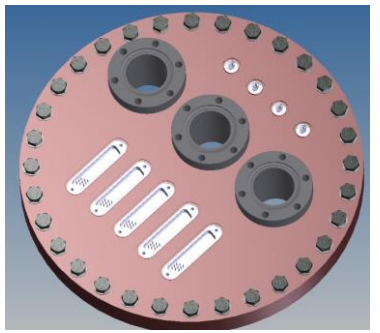


TANK_INST_*SE,NW*

The cable connexion will use TANK_INST_SE and TANK_INST_NW feedthroughs with a sub-d 50 pins

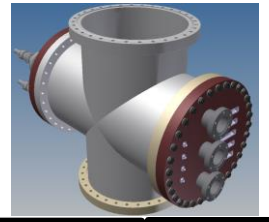
Close to each feedthrought , a metallic box will contain:

- Ethernet switch (8 ports)
- PCB to convert 50 pins subd in 6 x RJ45 ethernet connexion



Feedthroughts with subd 50 pins

Electrical camera design



Inside the cryostat

On the roof

SE and SW cameras connected to the TANK_INST_SE feedthroughs

12 x cameras

NE and NW cameras connected to the TANK_INST_NW feedthroughs

Ethernet Camera

6 x cameras

Ethernet Camera

3 to 10 meters length

Ethernet Camera

6 x cameras

Ethernet Camera

- Ethernet cable
- PTs cable : temperature check

sub-d 50 pins TANK_INST_SE feedthroughs

sub-d 50 pins TANK_INST_NW feedthroughs

Ethernet switch

To the network

Camera temp controlled by PVSS (option)

Ethernet switch

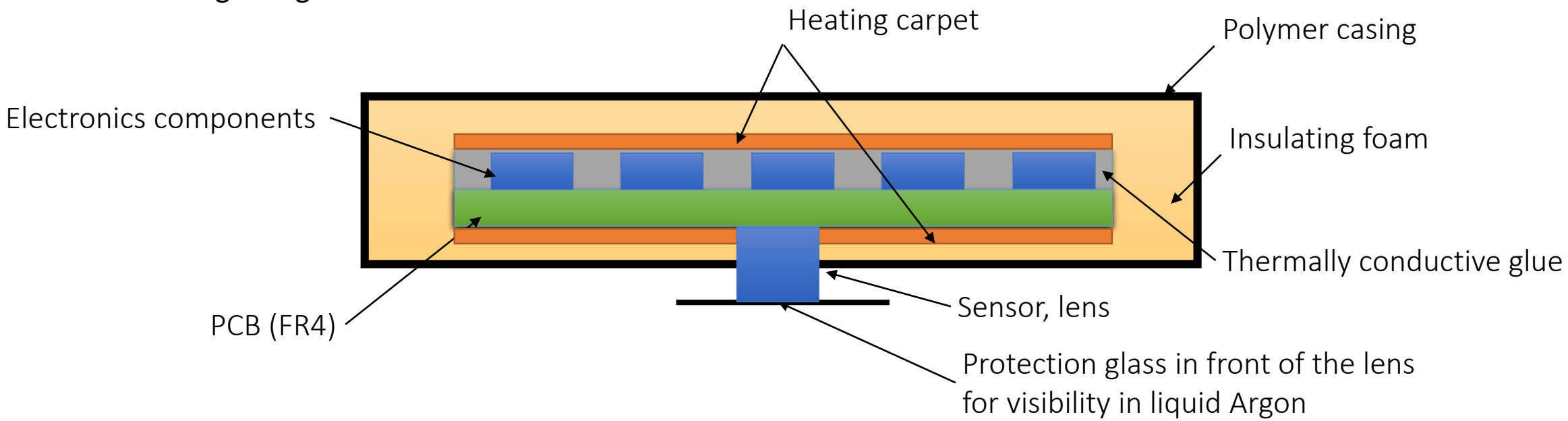
To the network

Camera temp controlled by PVSS (option)

Selection of thermal conductive glue
->optimise local heating efficiency on components. Need to find the appropriate heaters (size and power) and direct the right amount of power to the components, also minimising the dissipation to the liquid argon.

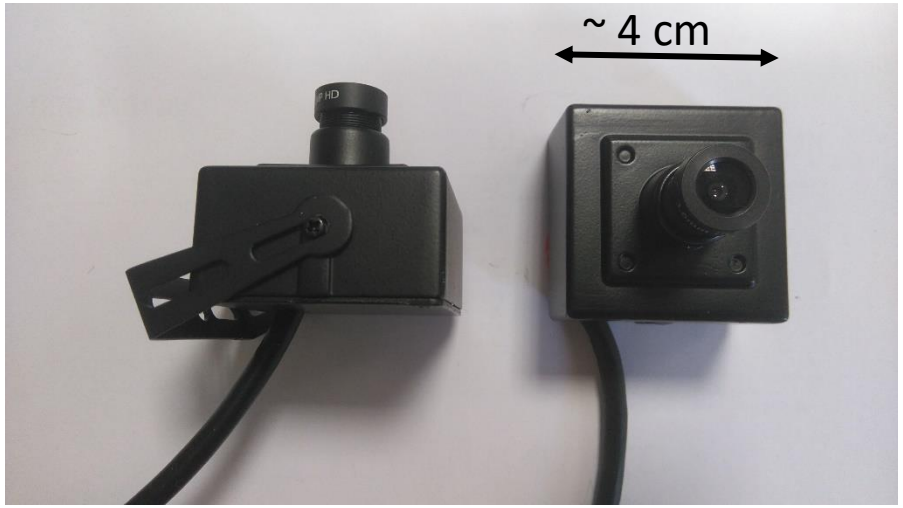
Needs appropriate conductive glue and surround insulation:
->investigation ongoing with CERN polymer lab to find appropriate polymer that are:

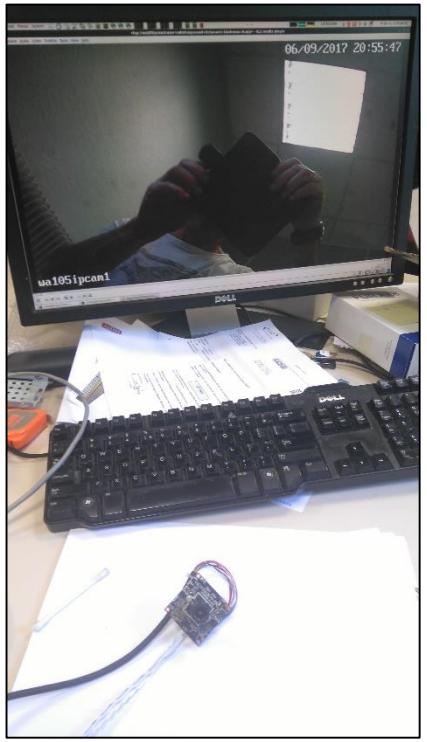
1. well suited for optimal thermal insulation
2. compatible with LAr temperature
3. have low outgassing



Ethernet camera : Revotech i706

- Resolution : 1920x1080
- Only one PCB (40mmx40mm)
- Web server
- H264 protocol → reachable by VLC or other streaming video reader
- Ethernet POE (Power Over Ethernet)

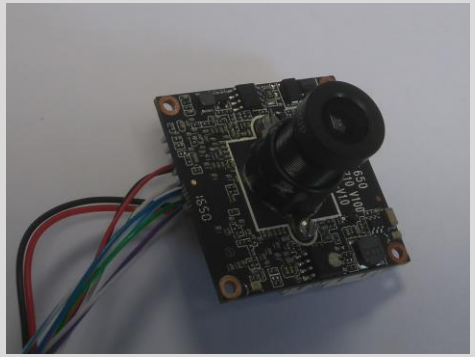




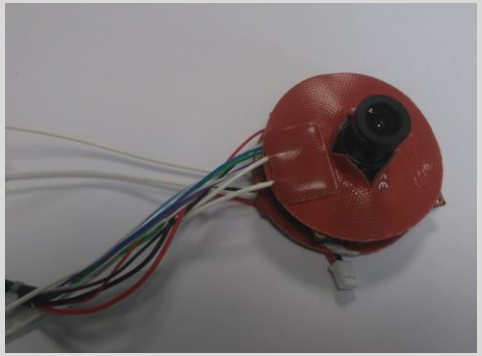
Camera and the stream on the screen in using VLC

Construction protocol :

- remove casing
- fix 2 heating carpets (one / side) with the thermal glue
- glue a window on the lens
- cast the entire camera by component in insulating foam
- adapt thread system for fixation to the cable tray
- cast the entire system in a low outgassing polymer
  (under test at CERN Polymer lab)

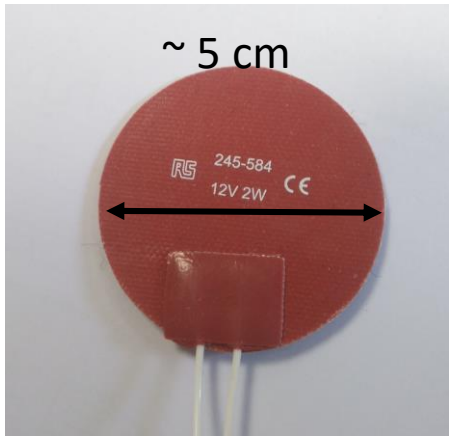


Camera without casing



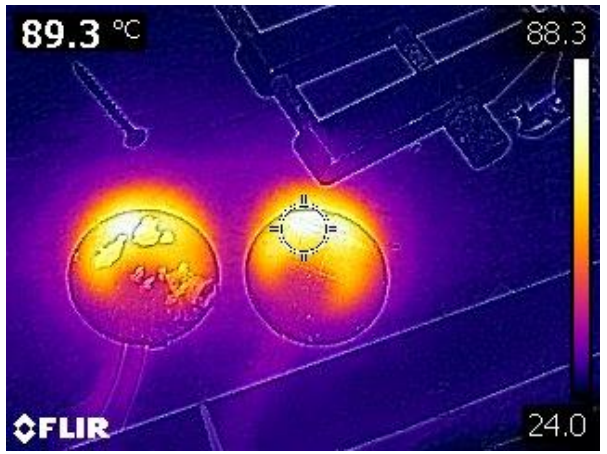
Camera with heater fixed with thermal glu

First prototype : Camera with insulating foam and polymer protection

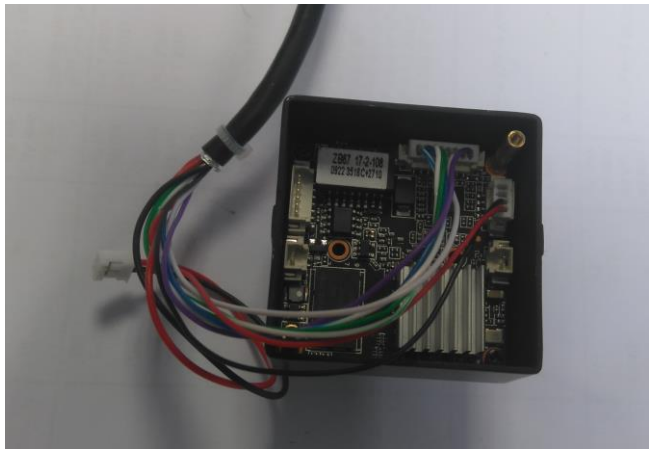


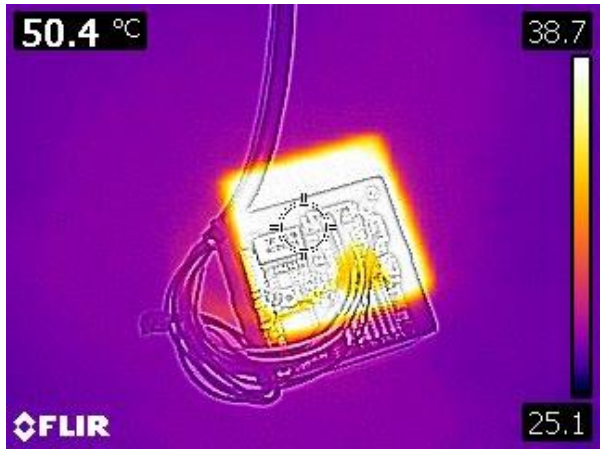
The heater 12V / 2W

Heating carpet



The heater 12V / 2W
T° stabilized around 90°C





Camera 12V / 0.2A 6W - T° stabilized around 50°C

Goal : test stability and restarting of the camera once immersed in liquid Argon

A temperature sensor (pt) connected on the camera PCB and record the temperature :

- Heater off and camera on
- Camera immersed liquid Argon
- Wait until the camera has reached liquid argon temperature
- Heater on and wait the camera is able to restart (~-85°C)

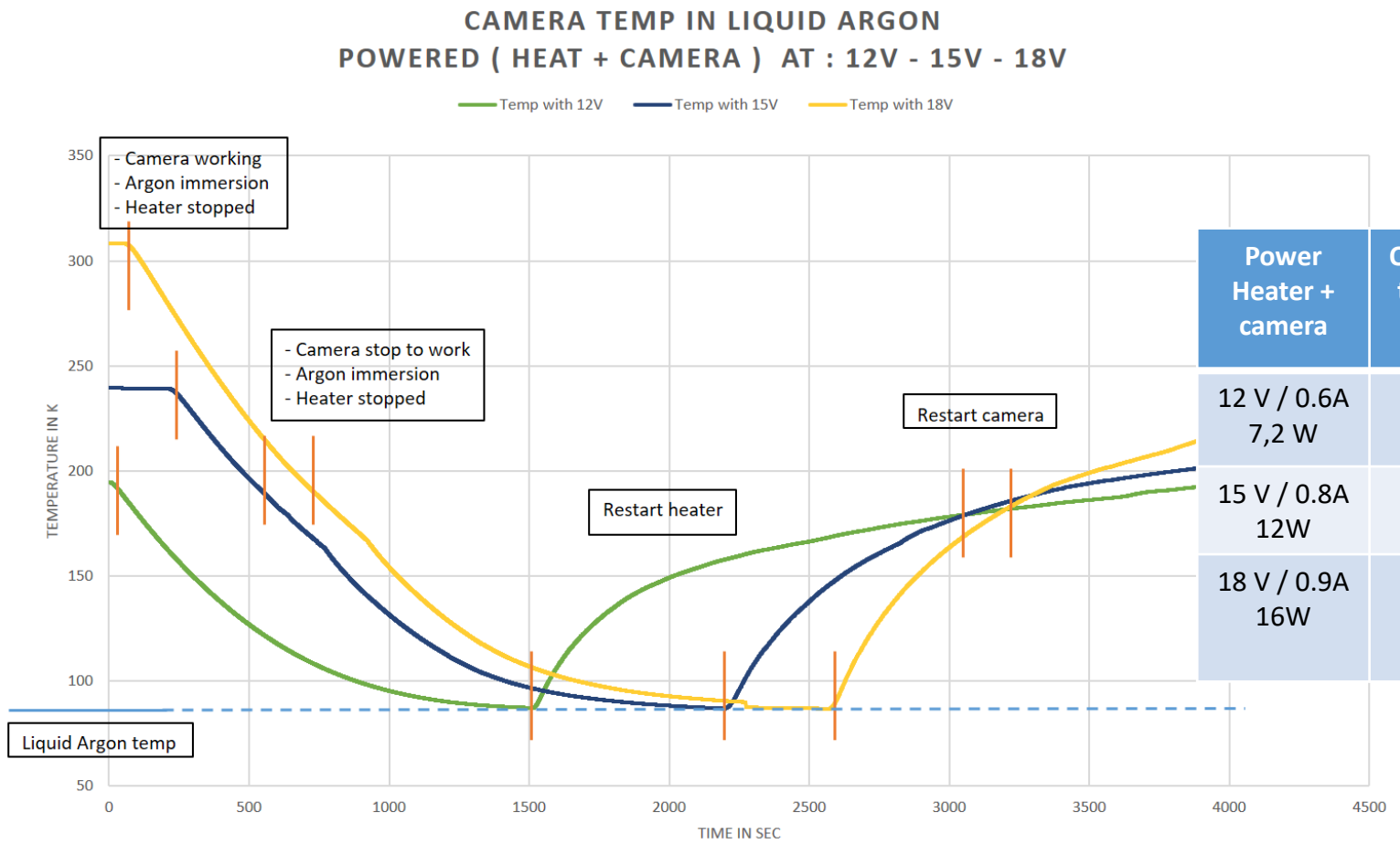
Remark :

- The restarting test has been done many times (more than 10) wihout any problem
- Test has been done at 12V , 15V and 18 V

- Temperature monitoring with Labview
- Camera streaming

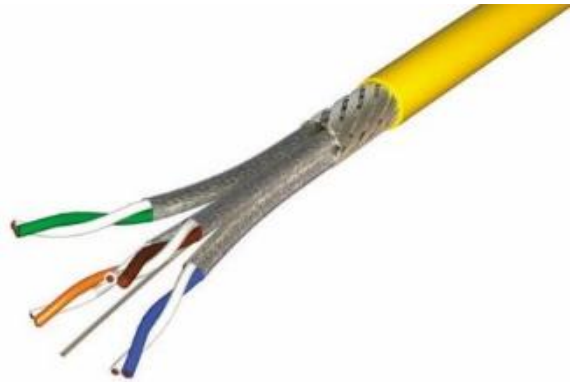
The camera immersed in the liquid Argon

Goal : test stability and restarting of the camera once immersed in liquid Argon



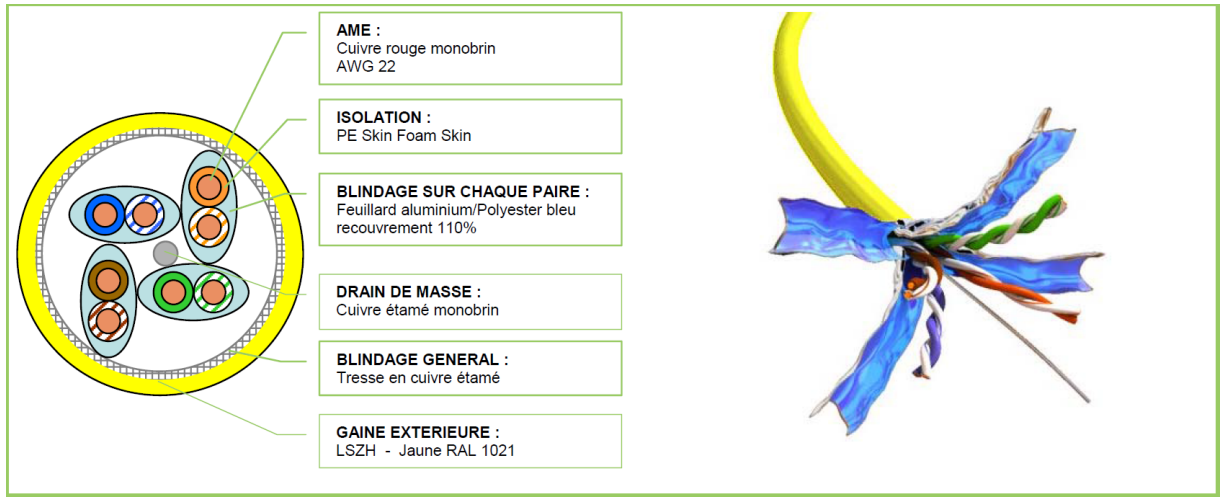
Power Heater + camera	Operation/stable temperature on camera (°C)	Duration form camera at Lar temperature until restart	Camera temperature restart
12 V / 0.6A 7,2 W	-78	30 min	-90 … -85
15 V / 0.8A 12W	-30	15 min	-90 … -85
18 V / 0.9A 16W	+35	10 min	-90 … -85

Ethernet cable



The ethernet cable connected to each camera in the cryostat will be :

- Cable 100 ohm S/FTP 4P1200MHz CAT7A SH
- Double shielded
- Categorie 7A
- Zero halogen
- Low outgassing
- 10 Gb
- POE



- Our first test with the system(ethernet camera + heater) was with good results.
- The camera can stop/restart correctly in the liquid Argon without any problem

- Still to test :
  - the camera/heaters (with/without automatic temperature regulation) in argon gas
  - during a long period (few weeks) in argon
  - the bubbling
  - Stress the camera by stop and start
  - Final design with outgassing polymer