Istituto Nazionale
di Fisica Nucleare
Sezione di Milano

OEC Integration Workshop in Frascati
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https://indico.cern.ch/event/1367997/

On detector piping loop assembly

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For the INFN Milano group

SUMMARY

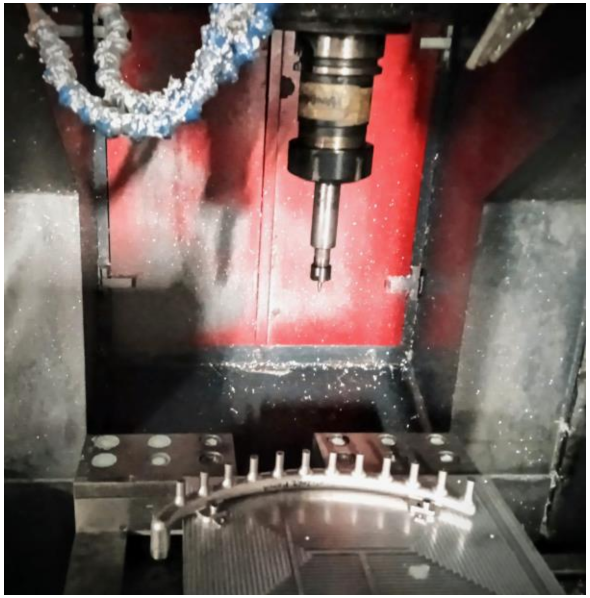
- **TYPE-1 PIPING AND MANIFOLDING**
- **INLET LINE FOR THE CO_2 COOLING DISTRIBUTION**
- **ORBITAL WELDING EXPERIENCE**
- **DE-MOUNTABLE FITTINGS ALTERNATIVE**

DETECTOR COOLING SYSTEM DISTRIBUTION CONSTRUCTION

Assembly of a complete Half-Shell piping system, work in progress

- For demonstration of the techniques and validation, pressure test
- To feed-back the design and relevant working drawings, that should include our production experience
- To test the Milano “INTEGRATION TOOL” design (and proposing a full integration test)
- Layer-2, Starting from the available Fred Gannaway model

MACHINING THE MANIFOLD



Preparation of interfaces:
- Cnc Machining
- reaming

Manifold/pipe (OD 4mm in layer 2)
- socket weld

ID 11 mm/ OD 12.7 mm/ th 0.85 mm
Remnant from the cooling test

Manifold to pipe OD 12,7mm
- butt welded extension
- 30 mm in the prototype
- used as connecton for the pressure test of the assembly after weldings
- For INTEGRATION purposes, PP1 design to be verified.

BENDING THE PIPES

The technology used to produce the piping system from the CAD model should be quality checked and approved (design feasibility feed-back).

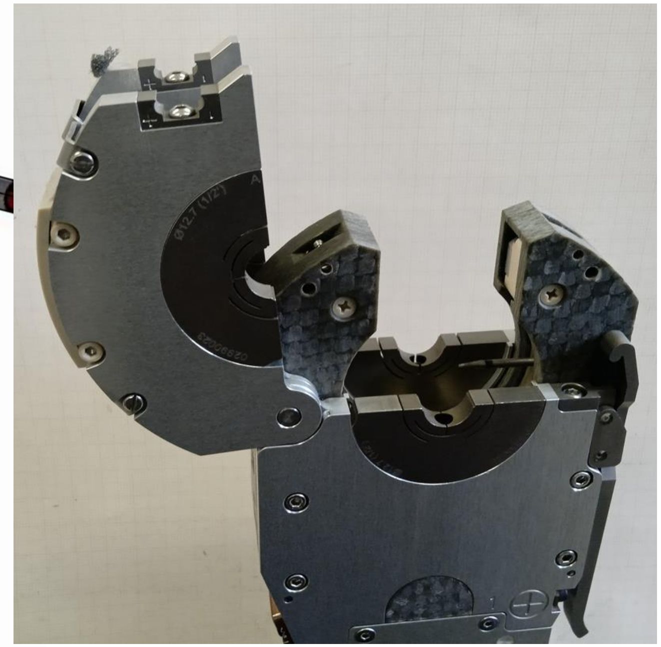
Quality Control to be done formally on the prototype (drawings with important quotes are needed)

Detail of the manifold connection at PP1

Image from the prototype construction.

To be pressure tested > 162 bar

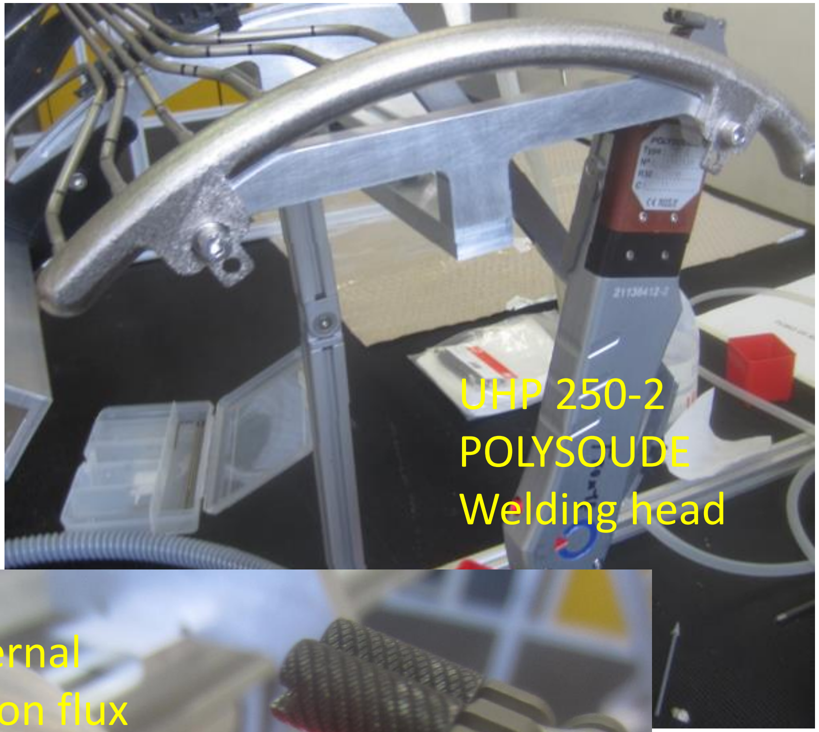
MW34 POLYSOUDE welding head
BUTT WELDING



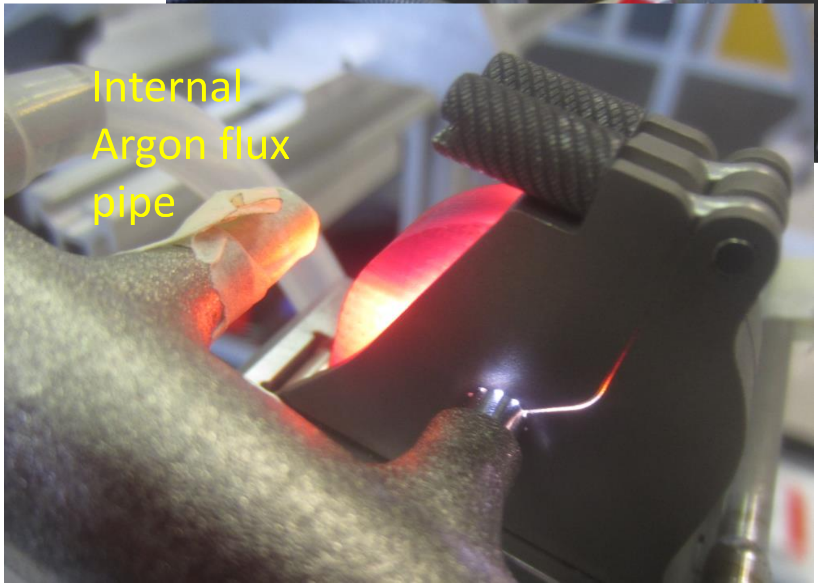
Notes:

- A minimum pipe length of 17 mm is needed on both sides to close it around the pipe during orbital welding.
  This has to be taken in account into the design, besides the accessibility of the head.
- A very pure Argon atmosphere is mandatory inside the tube.

TYPE-1 PIPING AND MANIFOLDING



Exhaust CO_2 type-1 return lines (11 + 1 bypass in Layer 2)

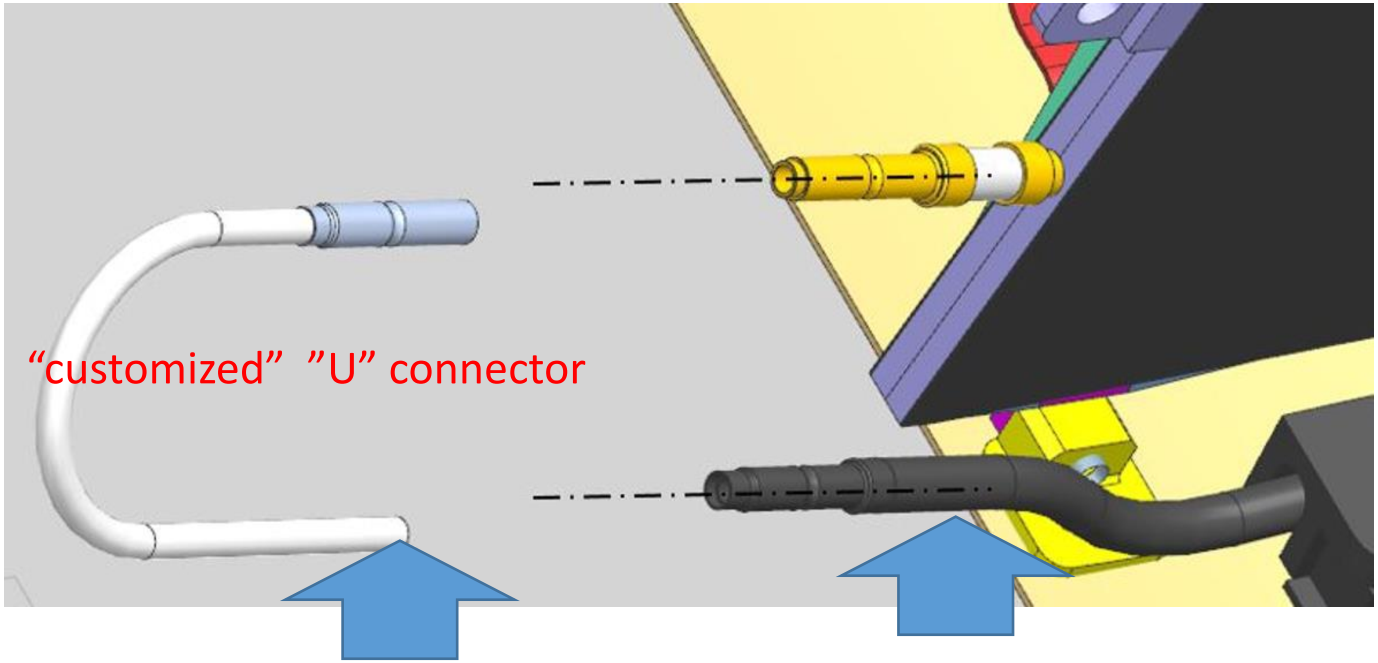


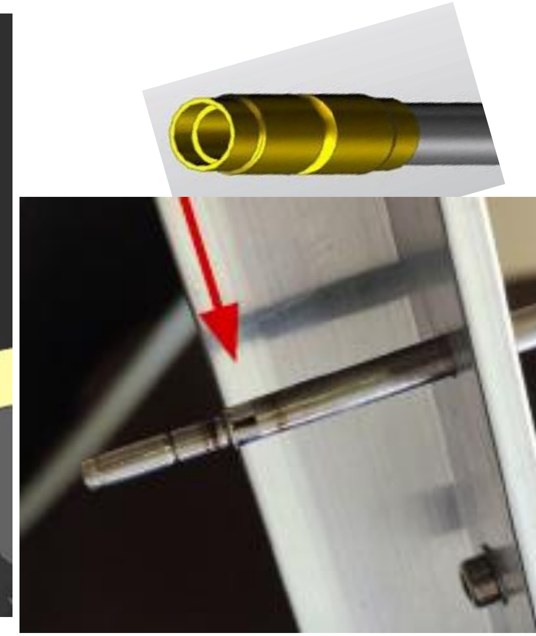
Pipes are collected into the 3D printed Manifold.

- Manifold is from SLM Additive Manufacturing
- Heat treated , cleaned
- Hirtization process

OUTLET HALF-RING COOLING CONNECTION

A very critical step in the integration of the Hal Ring cooling system.

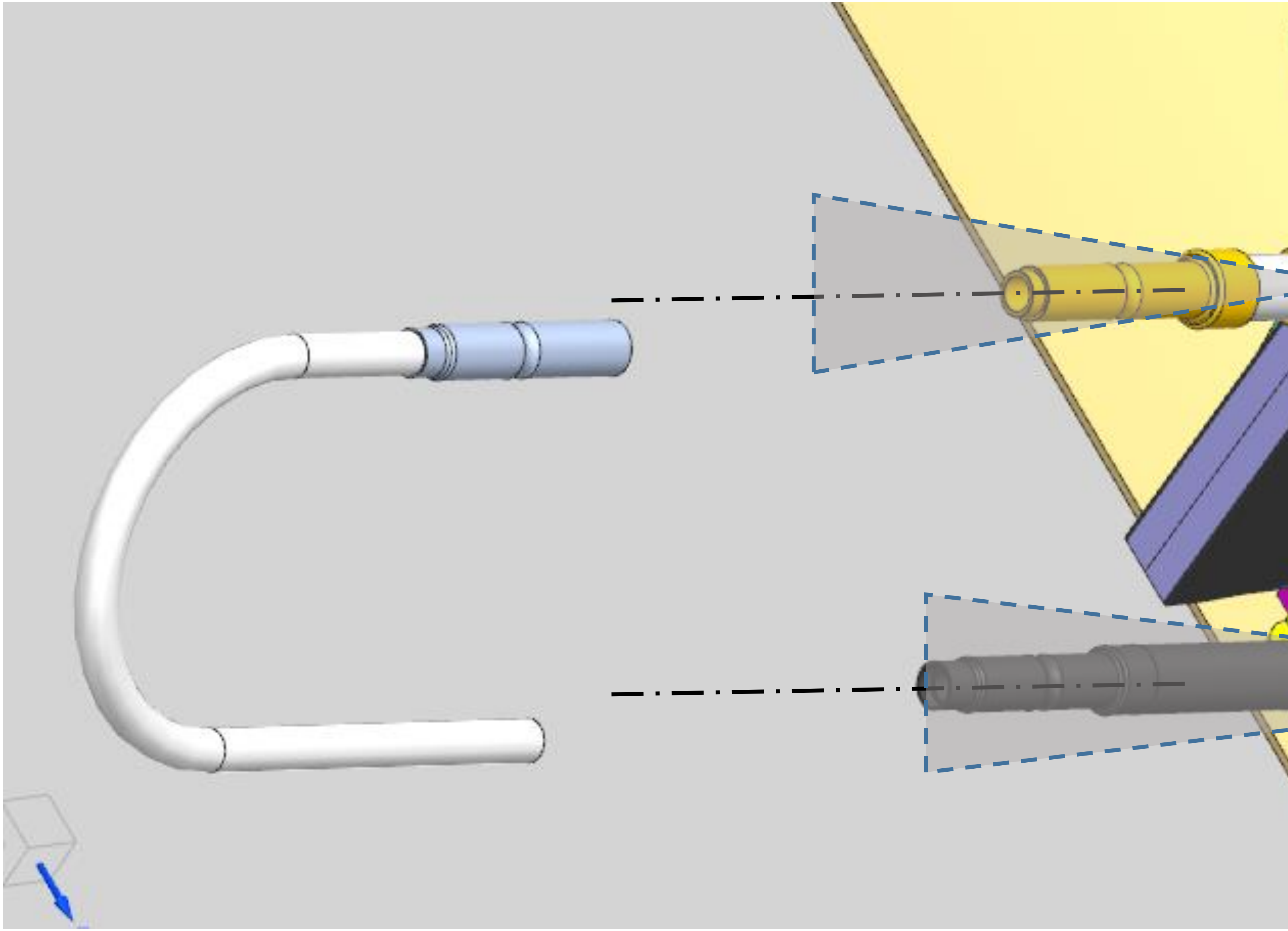




to be welded in opera
without a fitting sleeve?!

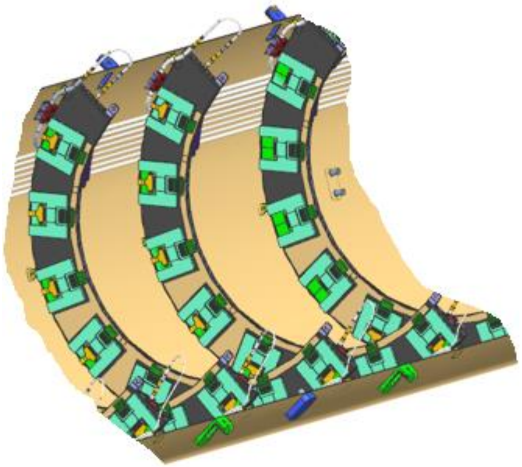
FITTING 4-2,5 (5-2,5 for layer-4), needed from beginning in the assembly

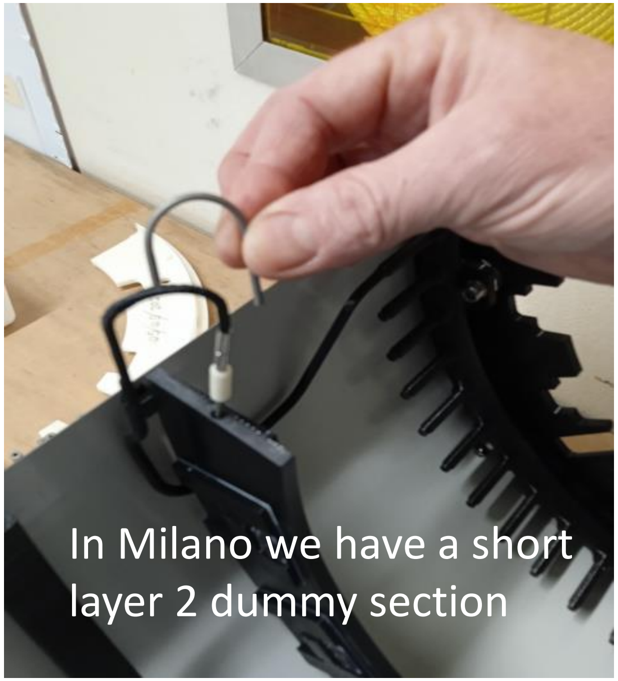
- For the prototype we’ve produced these fitting in house.
- For the production these fitting have to be produced by a “precision company” based on detaile working drawings.
- As always I think that **to approve a design it is mandatory to have done prototypes and qualification of components (P test etc). To be planned.**



COOLING SYSTEM - INTEGRATION PROPOSAL

We propose TO DO **a complete cooling circuit connection**

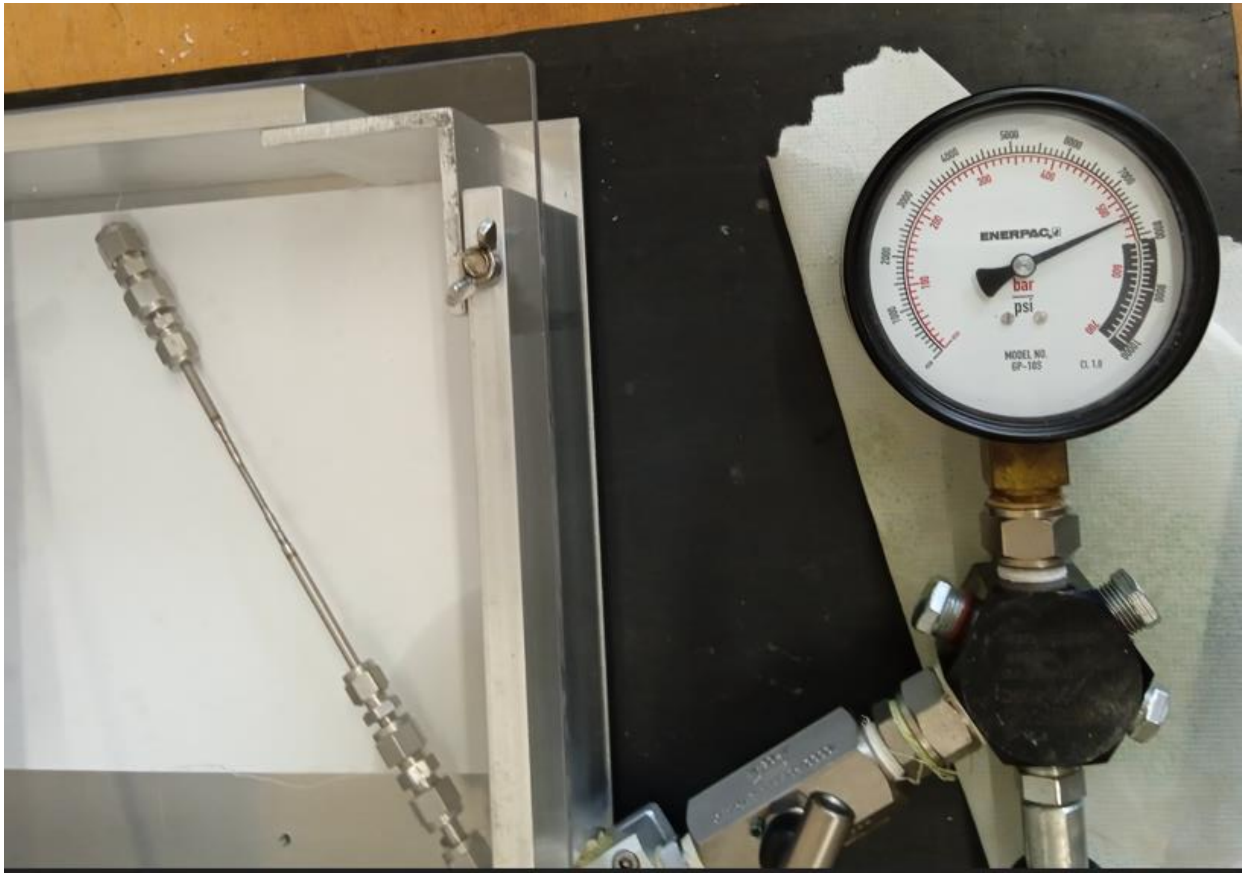




- **Are needed 'some' Layer-2 Half-ring cooling pipes**, to be connected on the distribution system prototype, INLET and OUTLET sides
- HR dummies, with real pipe **INTERFACES: REAL FITTINGS**
- At the INLET side: **Brazed Capillaries (Length to be verified) to be accommodated** in the Half- shell dummy => geometry check for the design
- **Pressure test >162 bar** (multiple times?), He leak rate to be performed
- for validation

WELDED SAMPLES

pipes to be used for the “U connectors”
OD=2,5mm



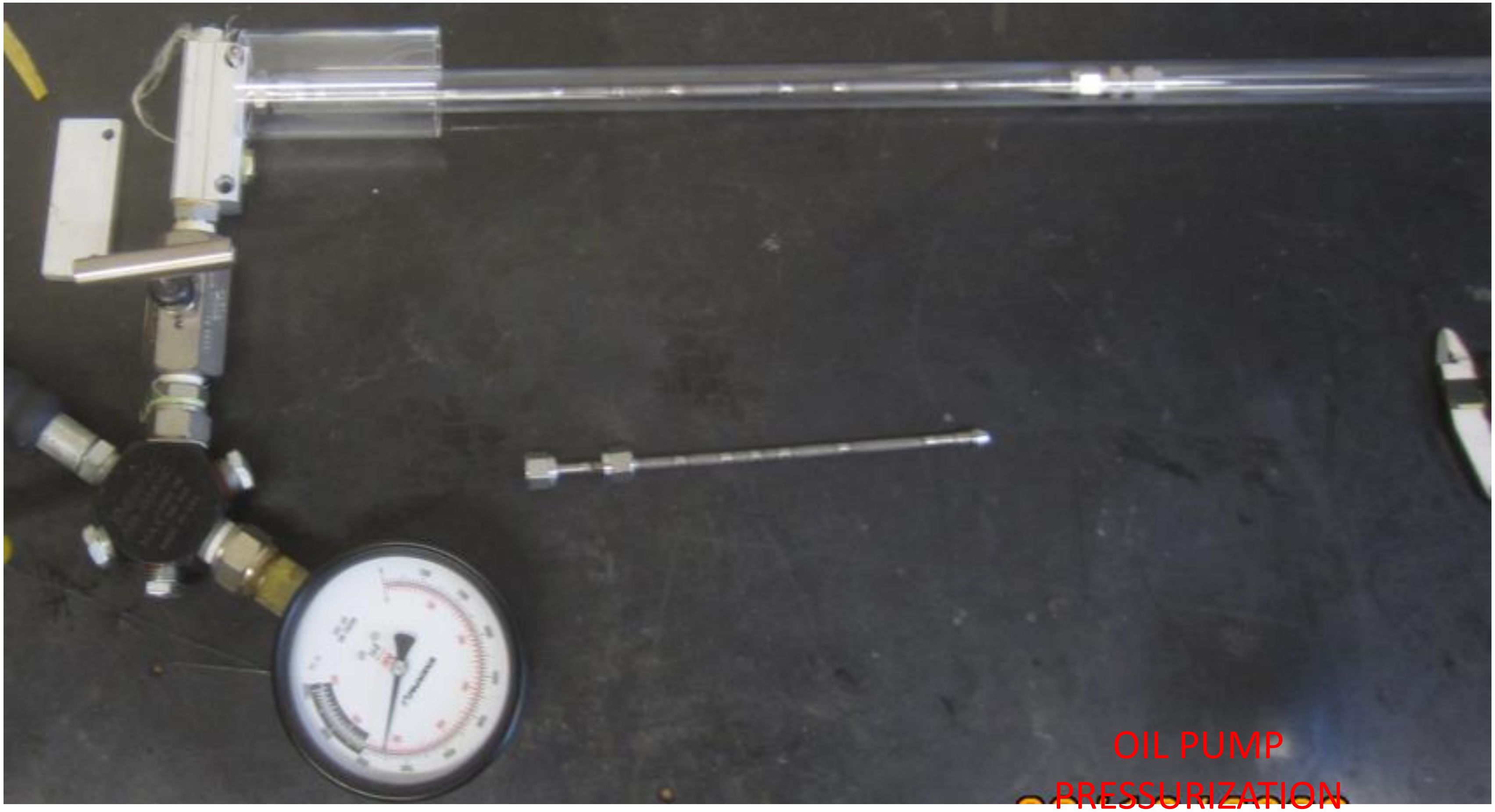
OIL PUMP
PRESSURIZATION

RESISTING UP TO 520 bar

WELDED SAMPLES

pipes butt and socket welded

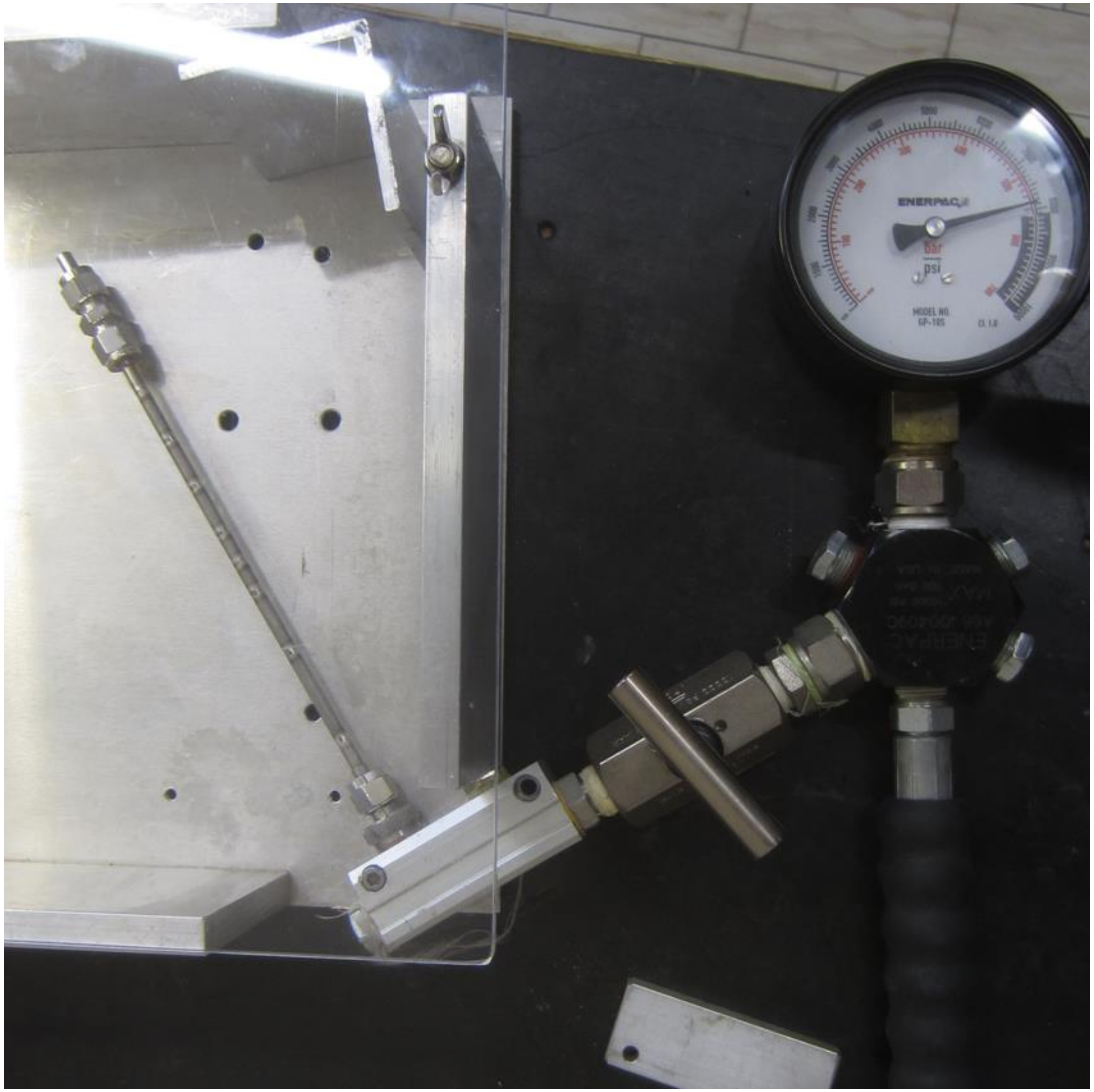
OD=4mm



OIL PUMP PRESSURIZATION

RESISTING UP TO 520 bar

WELDED SAMPLES



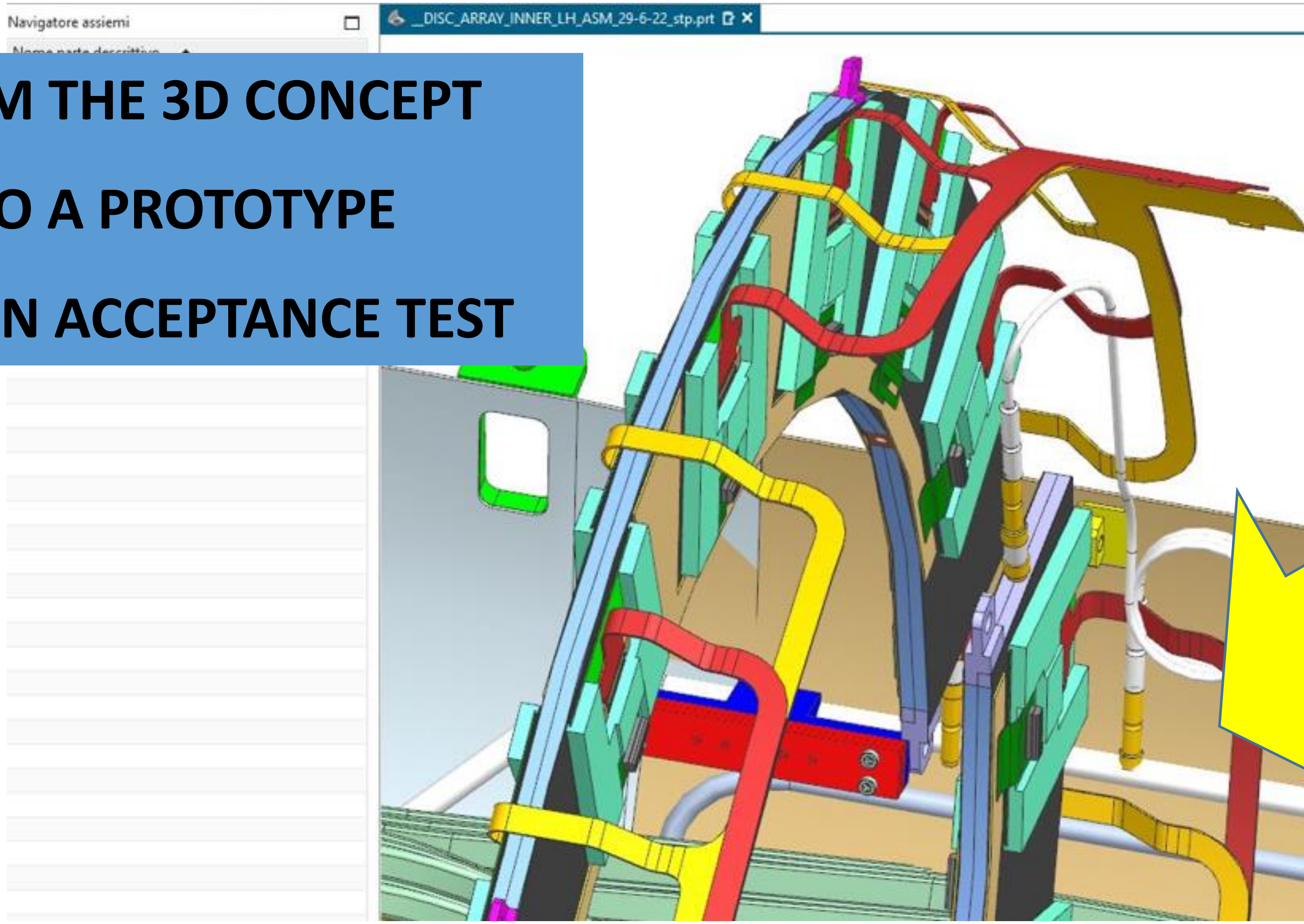
pipes butt and socket welded

OD=5mm

OIL PUMP PRESSURIZATION

RESISTING UP TO 520 bar

INLET LINE FOR THE CO2 COOLING DISTRIBUTION



FROM THE 3D CONCEPT

TO A PROTOTYPE

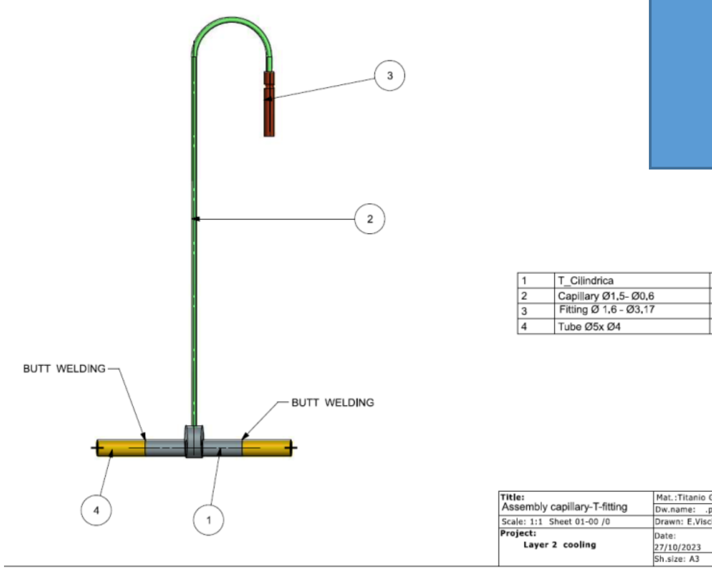
FOR AN ACCEPTANCE TEST

last concept model for a half shell LAYER 2

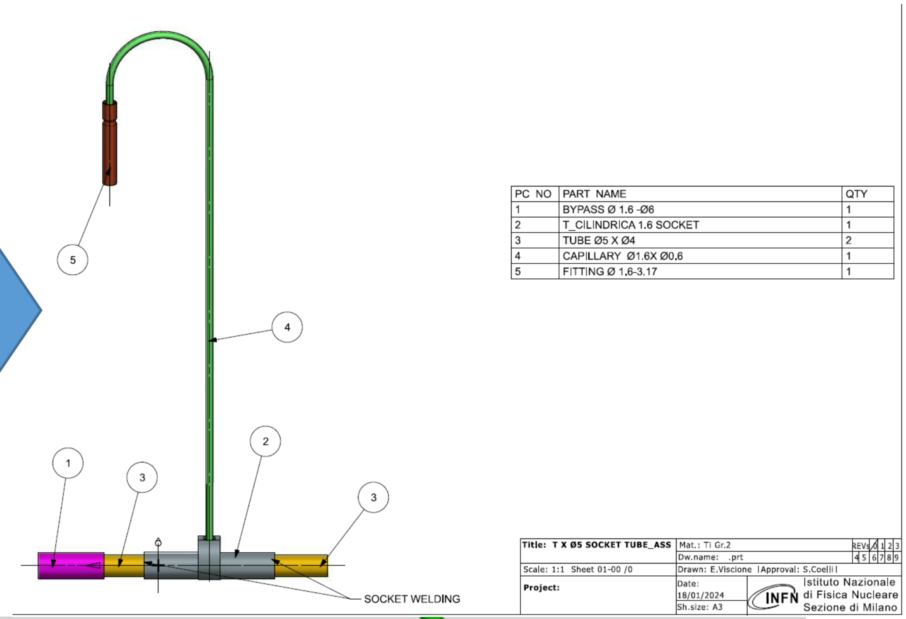
by Fred Gannaway June 2022
https://edms.cern.ch/document/2858201/1

INLET LINE ASSEMBLY

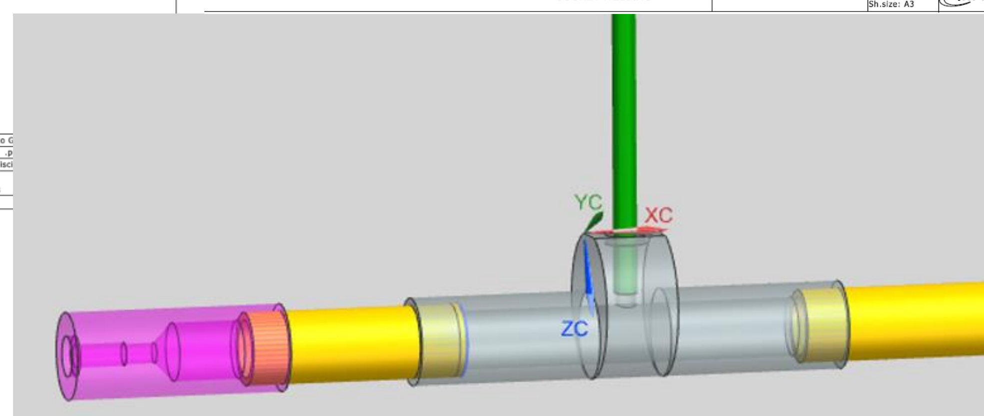
- ORBITAL WELDING ON BOTH SIDES OF THE «T» COMPONENT
- AFTER WELDING TEST, NOT SATISFACTORY WITH BUTT WELDING
- NEW DESIGN IMPLEMENTING **SOCKET WELDING**
- TITANIUM GR.2 OD 5mm/ID 4mm



1	T_Cilindrica	Titanio Gr 2
2	Capillary Ø1,5- Ø0,6	Titanio Gr 2
3	Fitting Ø 1,6 - Ø3,17	Titanio Gr 2
4	Tube Ø5x Ø4	Titanio Gr 2

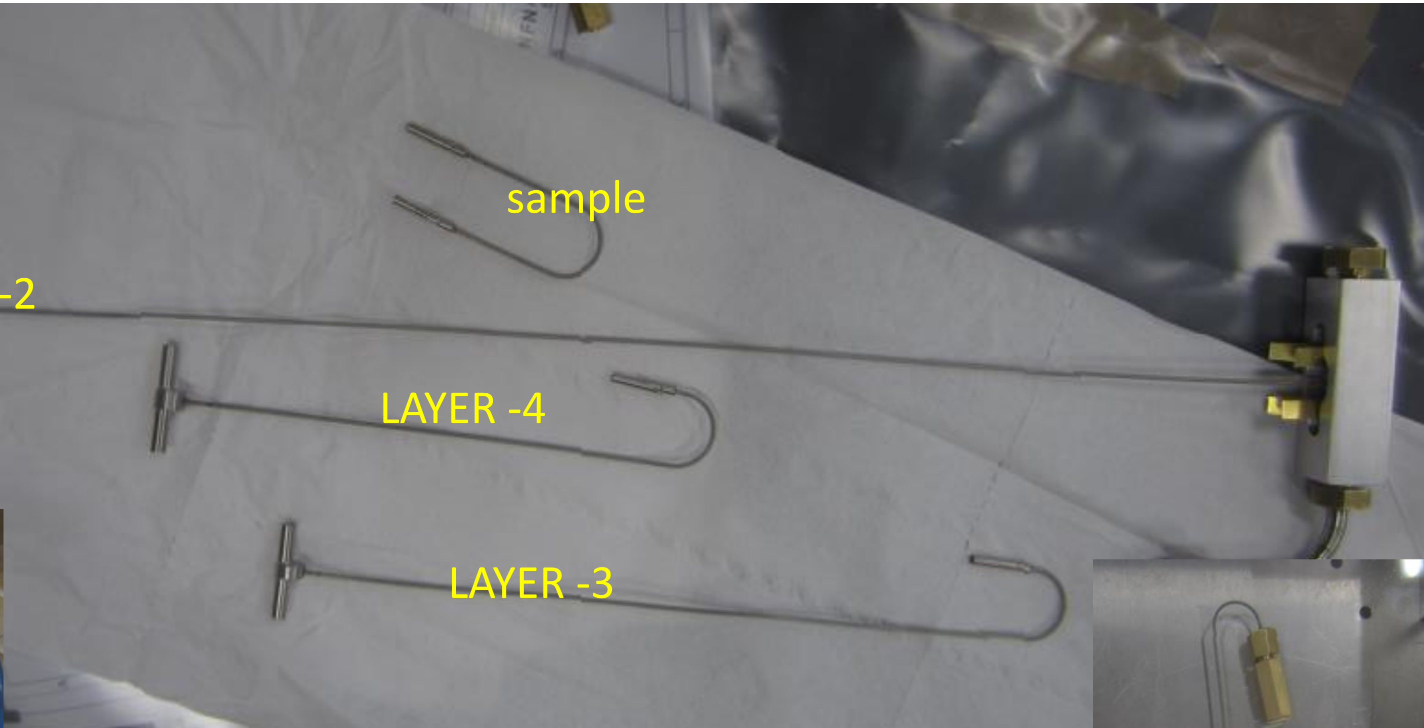


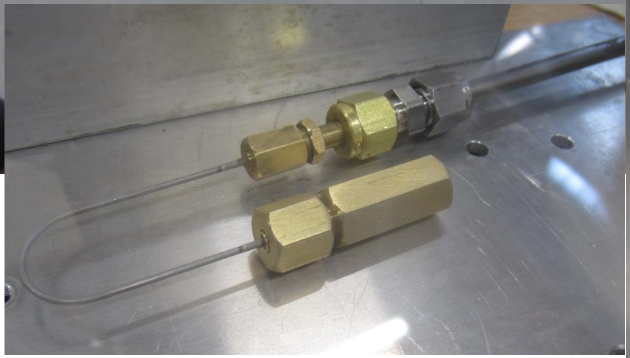
PC NO	PART NAME	QTY
1	BYPASS Ø 1.6 -Ø6	1
2	T_CILINDRICA 1.6 SOCKET	1
3	TUBE Ø5 X Ø4	2
4	CAPILLARY Ø1,6X Ø0,6	1
5	FITTING Ø 1,6-3,17	1

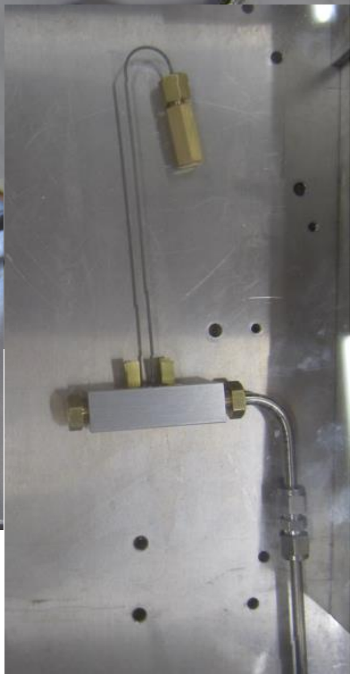


CAPILLARY HIGH VACUUM BRAZED PROTOTYPES

T + CAPILLARY + FITTING (Fred groove system for test)







PRESSURE TEST VERIFICATION: OK
WITH COMPRESSED AIR UP TO ~200bar

INLET LINE – BY-PASS LINE CAPILLARY CONNECTION

last concept model for a half shell LAYER 2

by Fred Gannaway June 2022

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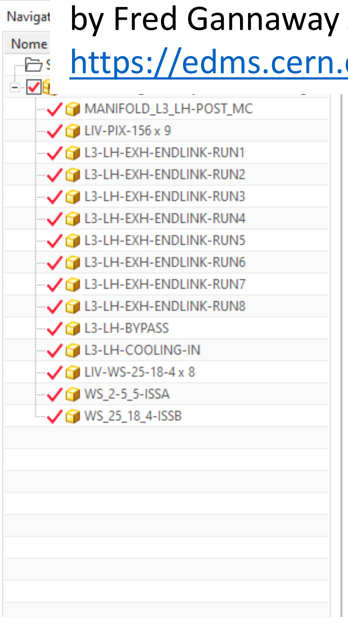
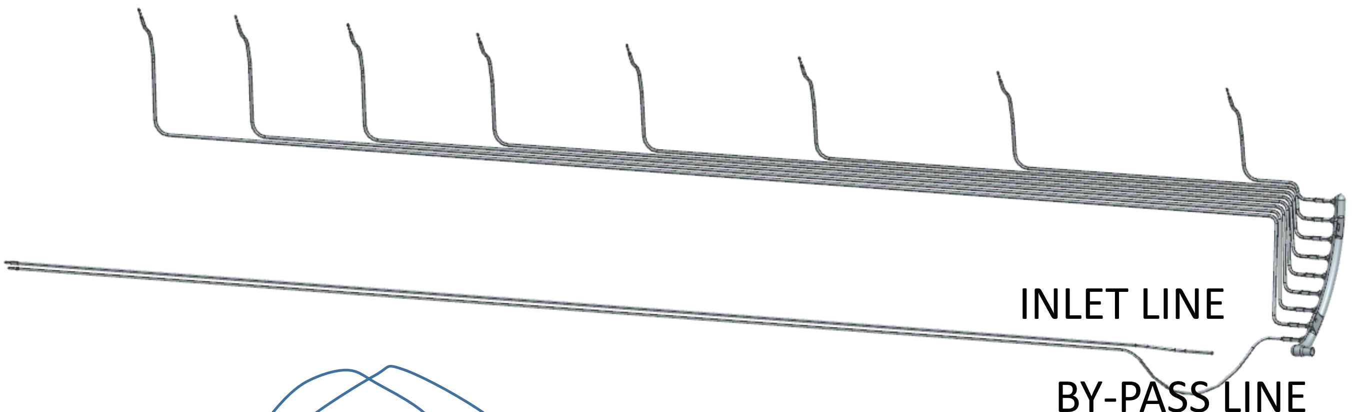
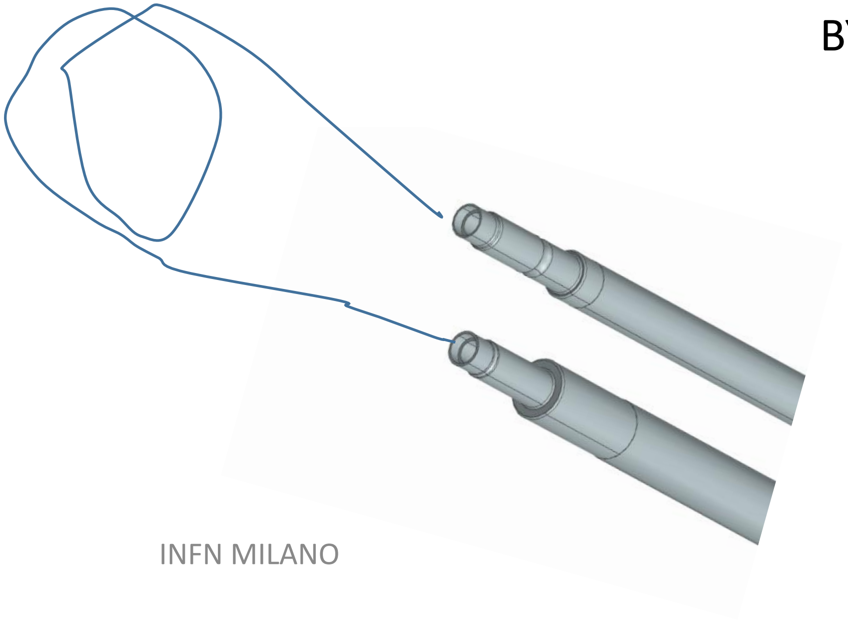
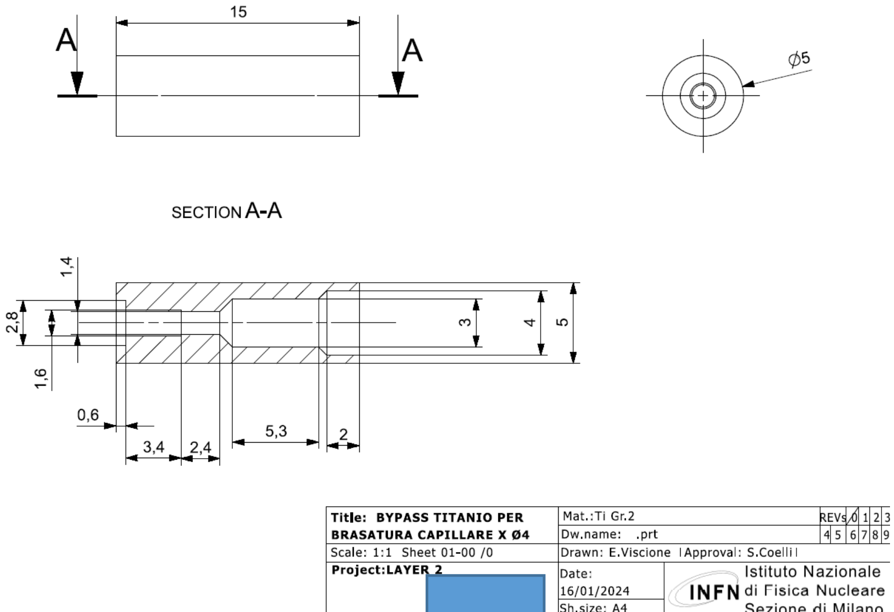


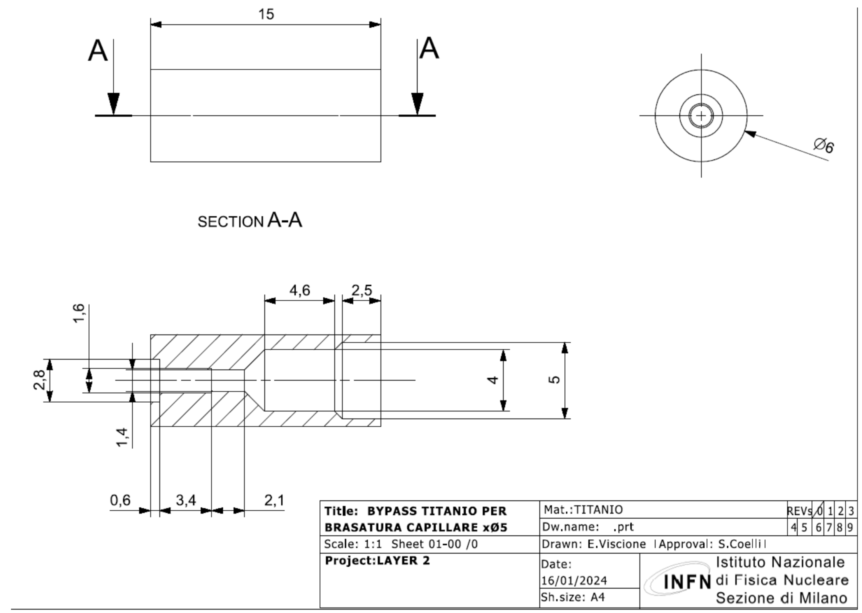


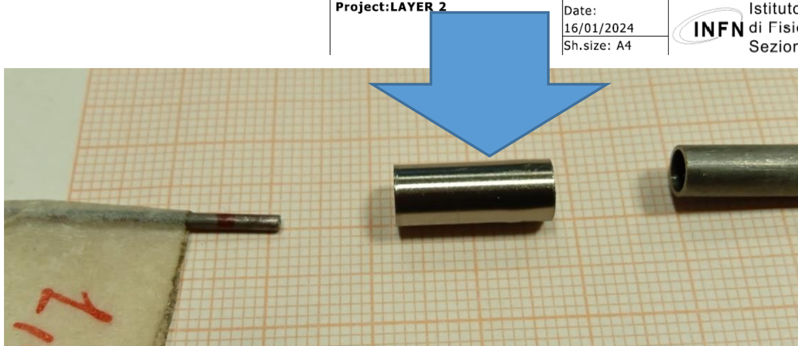


INLET LINE – BY-PASS LINE CAPILLARY CONNECTION

axial tube head proposal for capillary brazing







PROTOTYPES:

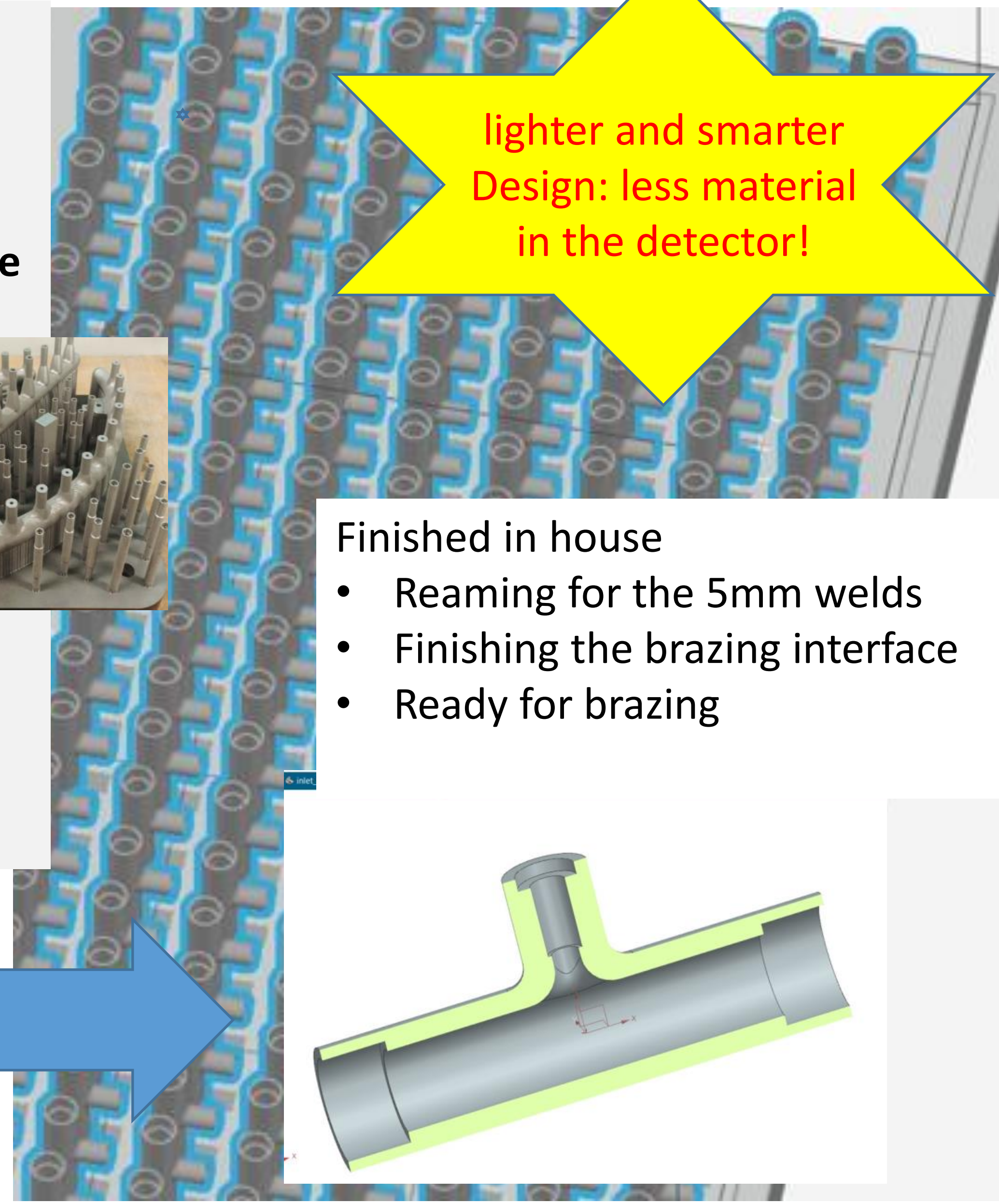
- OD 5mm FOR INLET LINE and bypass layer 4
- OD 4mm FOR bypass layer 2 and 3

INLET LINE COMPONENTS FROM ADDITIVE MANUFACTURING

A production solution has been investigated

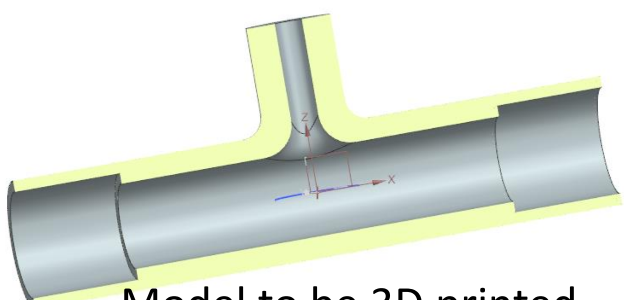
- Based on our previous, positive experience with components from the SLM printing process (from manifold to socket samples)

- We can print everything in one shot (both T pieces and including axial heads) with a budget of 2k€, then working them (finishing) in house



lighter and smarter Design: less material in the detector!

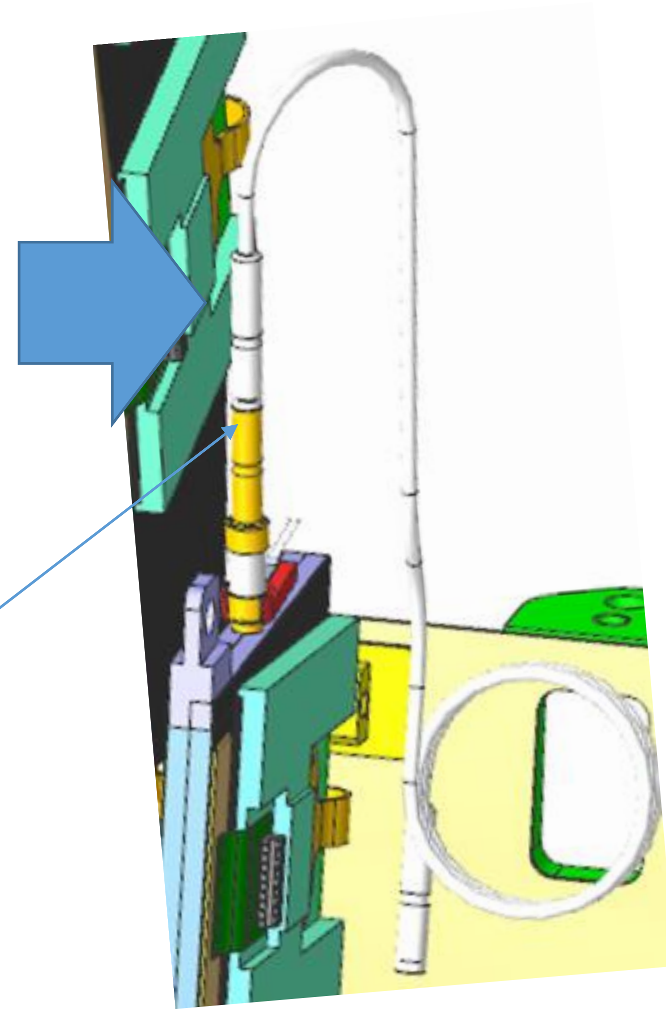
Finished in house
- Reaming for the 5mm welds
- Finishing the brazing interface
- Ready for brazing



Model to be 3D printed

INLET LINE COMPONENTS

The fittings on the capillaryHR side: have to be produced by a precision company



INTEGRATION SIDE: connection to the E-breacker

WELDING EXPERIENCE:

BUTT WELDING VS SOCKET WELDING

QUALIFICATION OF THE COOLING SYSTEM:

PRESSURE TEST

$\Rightarrow$ **DE-MOUNTABLE FITTINGS "NEW DESIGN"**

$\Rightarrow$ **OD 4mm, OD 5mm, OD 12.7mm pipes**

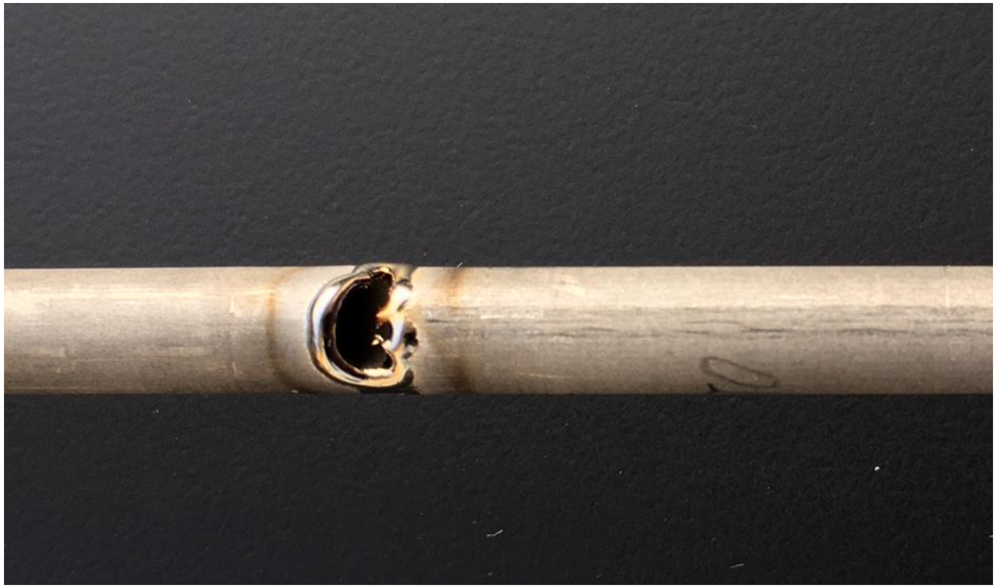
$\Rightarrow$ **PRODUCTION AND TEST**

Pocket welding is more reliable than butt welding

Welding head setup procedure (butt welding case):

-lock in the first pipe centering its top in front of the tungsten electrode
-push the second pipe against the first one (already locked)
-close the welding head locking the second pipe

When you close the welding head to clamp the second pipe you CANNOT see if it moves from the first one



Possible effects:
-Welding is ok
-welding is ok but the pipes are misaligned resulting in a narrower inner diameter
-welding has a burn through due to the non-perfect contact between pipes

In pocket welding one pipe is inserted in the other one for few millimeters.
Thanks to the overlapping, the welding is sturdy even in presence of small misalignements.

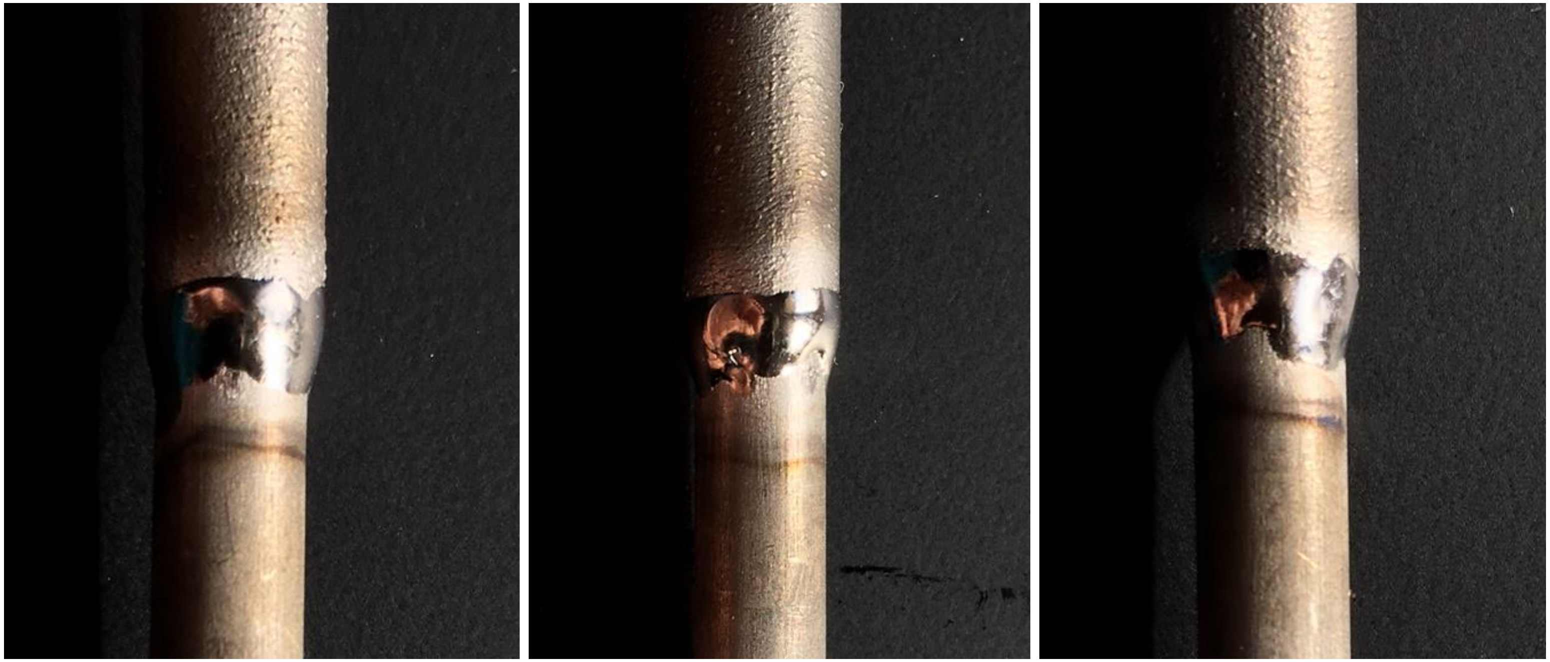
You never burn through.
You are less sensitive to protection gas pressure variations.

Possible defects are the uncomplete welding between pocket and inner pipe.

A bad welding is often caused by clearance between pipe and socket

In this case you can repeat the welding procedure possibly moving the head

Theese FAULTY and UGLY weldings are mechanically strong and leakproof: we vacuum tested them with helium and they have been pressured with dry air at 180Bar and oil at 500Bar:



We developed a clamping system to pressurize «face-machined» pipes without any additional fit.

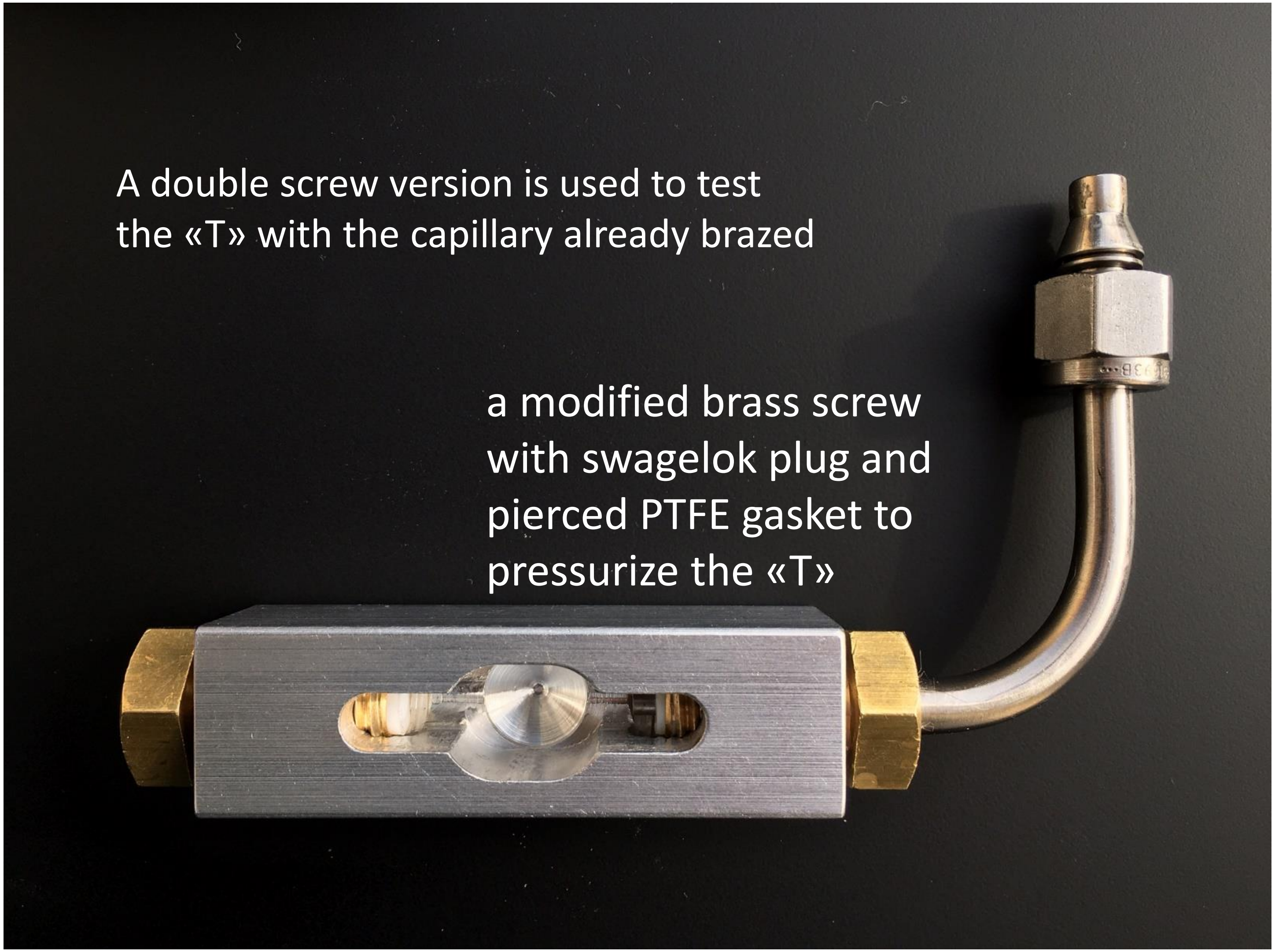
From right to left you find:
-clamp internally bored to the pipe’s nominal size
-central inspection&venting hole
-brass screw as stopper with PTFE gasket

Depending on the working pressure and pipe diameter it’s necessary to adjust the clamping force and the brass screw.

4 and 5 mm pipes have 0.5mm wall and are easily deformed if clamped too much

12.7mm pipes are stronger and need a much higher force to seal them at the same pressure (higher surface area)

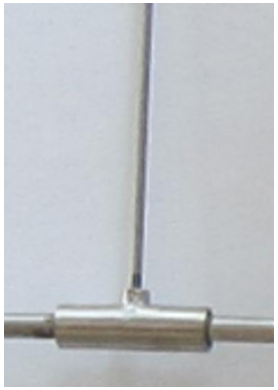
After some testing we choose to use 1Nm torque for 4mm and 5mm pipes (M4 screws) and 5Nm torque for 12.7mm pipe (M5 screws)


A double screw version is used to test
the «T» with the capillary already brazed
a modified brass screw
with swagelok plug and
pierced PTFE gasket to
pressurize the «T»

Back-up slides

simone.coelli@mi.infn.it

BRAZING FRASCATI LABORATORIES



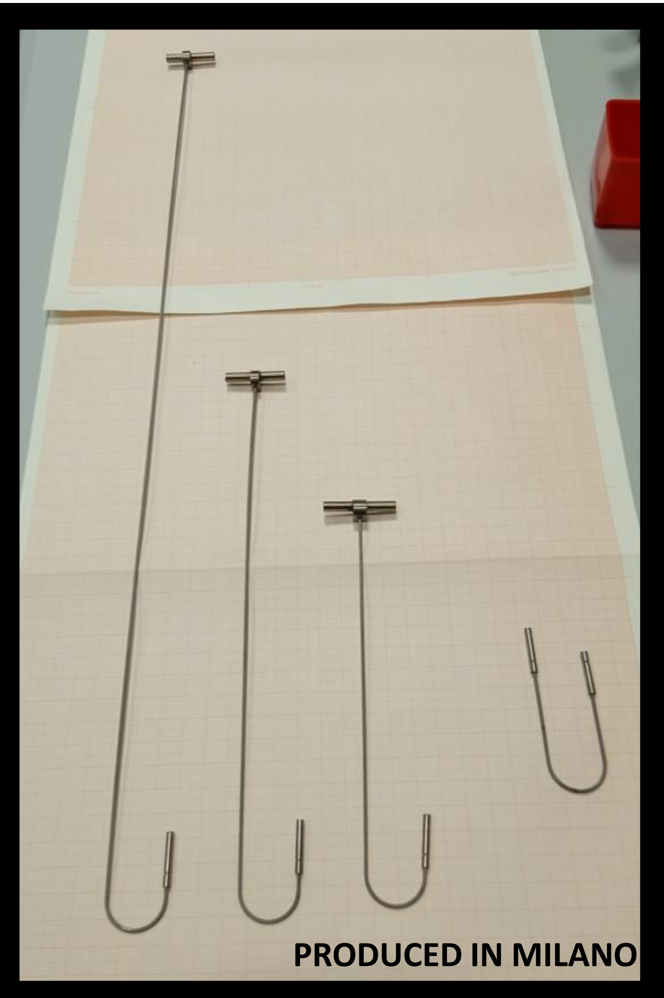
TEST ASSEMBLIES USED TO SET UP THE PROCESS

Roberto Di Raddo (LNF) inserting the BFM
The Brazing Filler Material = PALCOSIL Al-Ag-Pd
Temperatures UP TO 860°C

Leak thightness is tested

The brazing furnace process details and parts positioning
Have been tested
It was a «new» experience with PURE TITANIUM (gr2) in LNF

PROTYPES FOR THE NEXT BRAZING CYCLE

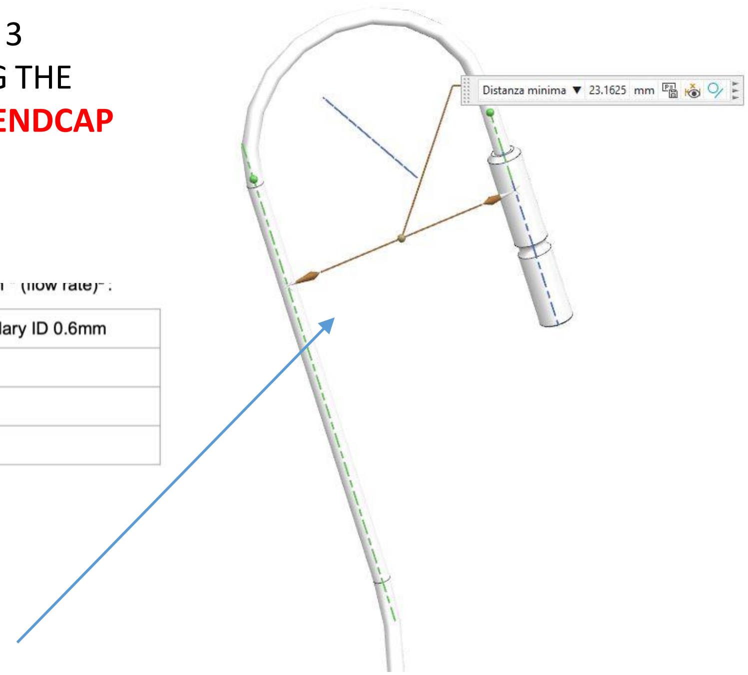


WE HAVE PREPARED THE 3 ASSEMBLIES SIMULATING THE **CAPILLARIES FOR THE 3 ENDCAP LAYERS**

ESTIMATED LENGTHS

Scaling capillary length for each layer $\Delta P \propto$ length · (flow rate)^2:

	CO2 flow / HR	Length Capillary ID 0.6mm
Layer 2	1.87 g/s	553 mm
Layer 3	2.57 g/s	293 mm
Layer 4	3.04 g/s	209 mm



U BENDING ACCORDING TO FRED PRELIMINARY CONCEPT DESIGN AND ACCORDING TO BRAZING EXPERIENCE => DURING THE BRAZING PROCESS THE PARTS ARE PLACED VERTICALLY SO THAT BRAZING FILLER CAN FILL IN THE GAP EASILY (GRAVITY HELPS)

PRODUCED IN MILANO AND NOW AT LNF FOR BRAZING

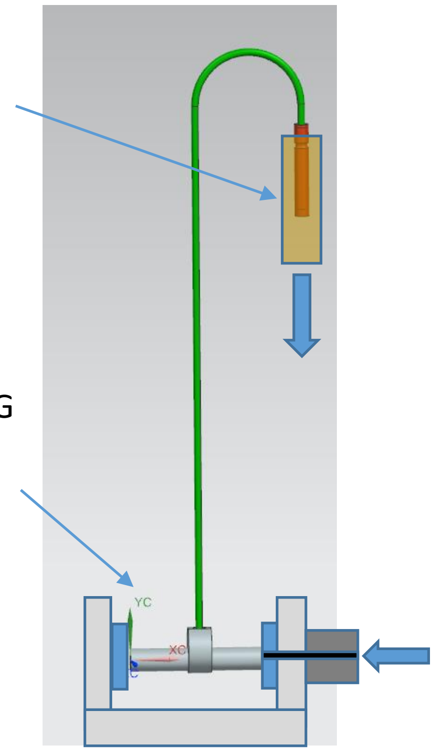
PRESSURE DROP TEST ON THE BRAZED ASSEMBLY

«T» + CAPILLARY + FITTING

- OUTLET FLOW USING
A REMOVABLE FITTING («FRED FITTING»)
(I.E. WITH A SWAGELOK FITTING ¼ INCH)

- INLET FLOW WITH A CUSTOM TOOL
- TO CLOSE THE «T» COMPONENT ONE SIDE.
- TO ALLOW A FLOW THROUGH THE CAPILLARY ON THE OTHER SIDE USING A CHANNEL IN A CAP (I.E. WITH A SWAGELOK FITTING ¼ INCH)

THIS IS A «CONCEPT»
TO BE DESIGNED,
AGREED WITH CERN FACILITY DESIGNERS AND USERS ,
THEN TO BE PRODUCED
AND TESTED!



PROPOSED TEST SEQUENCE:

- BRAZING PROCESS
- THIGTHNESS TEST (HELIUM LEAK RATE MEASUREMENT)
- PRESSURIZATION ACCEPTANCE TEST (>162 BAR)
- COILING, NEEDED AT LEAST FOR LAYER 2 AND LAYER 3 (TO TAKE IN ACCOUNT ACCIDENTAL SQUASHING IN THE COILING PROCESS)
- **PRESSURE DROP MEASUREMENT AT THE CERN FACILITY USING CO2 WITH THE CORRECT PHYSICAL CONDITIONS**

Then:

- ORBITAL WELDING OF THE PIPES ON BOTH SIDES
- THIGTHNESS TEST (HELIUM LEAK RATE MEASUREMENT)
- PRESSURIZATION ACCEPTANCE TEST (>162 BAR)
- GEOMETRY CONTROL