ILC International Linear Collider

INFN Istituto Nazionale di Fisica Nucleare

Ti/SS transitions

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Outline:

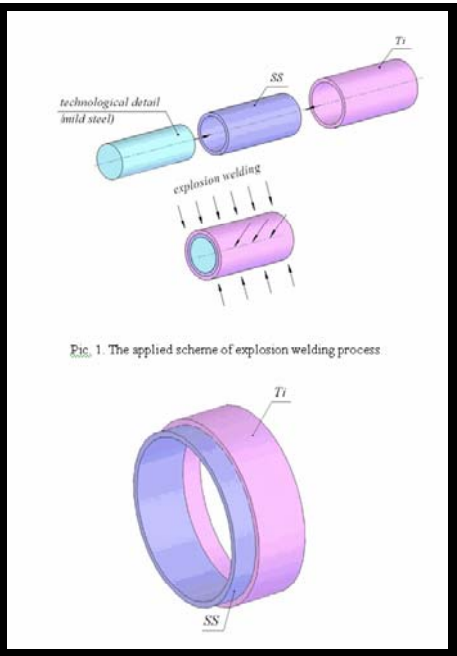
- Test results on two samples received from Dubna:
  - He Leak tests made in Pisa
    - Room temperature and 77 K
  - Welding tests
  - Next steps
- Discuss final specs for T4CM and/or Type 3+ He vessel to 2-phase line transition
- Discuss R&D on Stainless Steel He tank for T4CM
  - Significant R&D effort

Summary of R&D on Ti/SS transitions in Pisa

- Work done by technique:
  - Brazing:
    - Results **unsatisfactory** so far. Many other options to be explored.
  - Laser welding:
    - Costly and hard to find adequate equipment. Still looking for good industrial partner
  - Friction bonding:
    - Will test but worry about robustness
  - Explosion bonding (from Russian company):
    - Unique technique optimal to join tubes without additional machining
    - Fully tested Russian samples look very satisfactory
    - More samples will be available in fall for larger statistics tests
- Started collaboration with metallurgy department of Pisa University

First explosion welding sample from Dubna

- Full report from Russian company about this sample available
- He-leak tests re-made at Pisa at both 300K and 77K
- Will test at 4 K in the near future

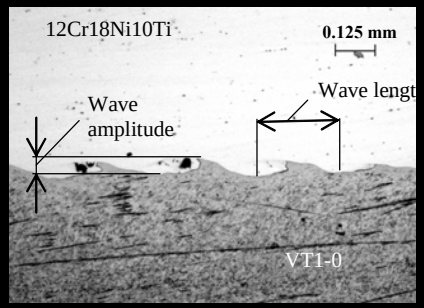


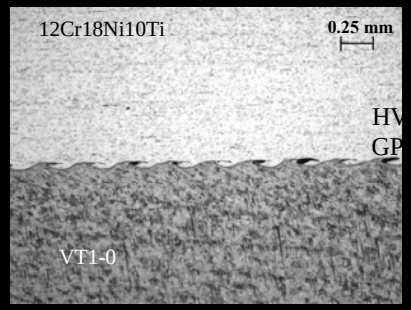
Pic. 1. The applied scheme of explosion welding process

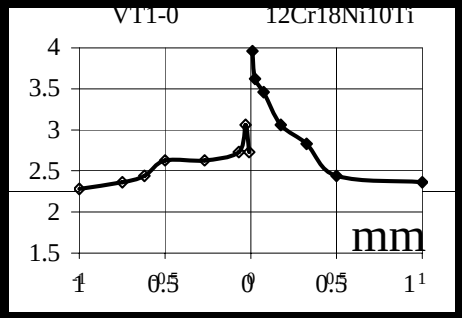
- RESULTS:
  - No He-leak in all test conditions (leak rate < 10^{-10} mbar *l /s with a vacuum of the order of 10^{-3} mbar)
  - The small sample dimensions doesn't allow to fully qualify the joint and they are not comparable with any cryomodule pipe dimensions too.

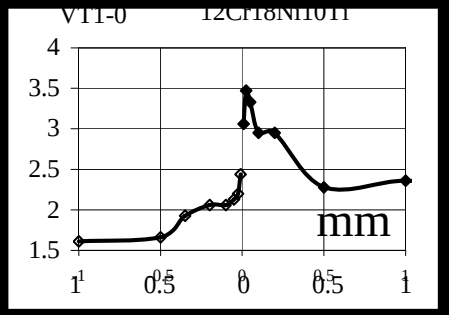
Pictures of first explosion welding sample







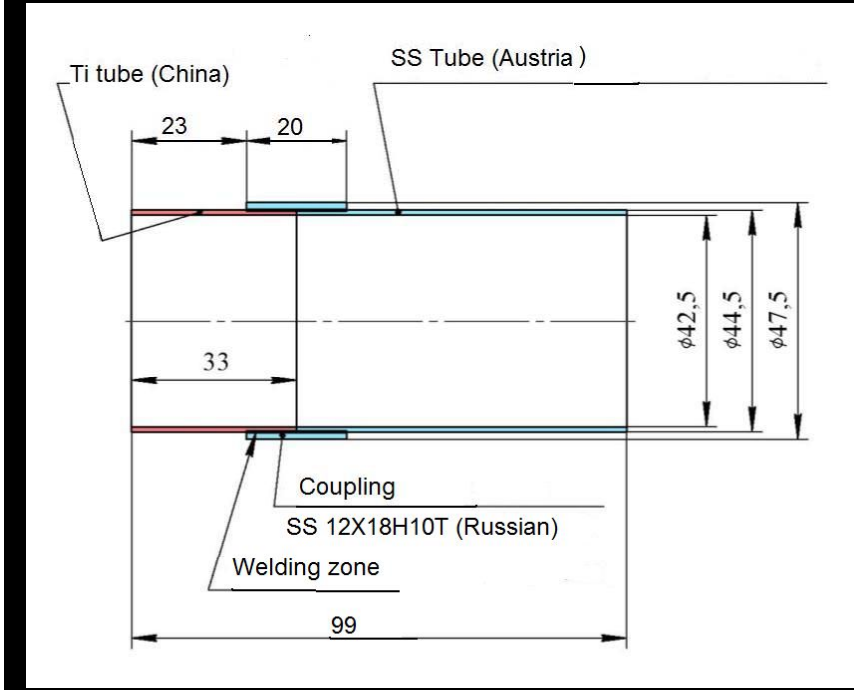


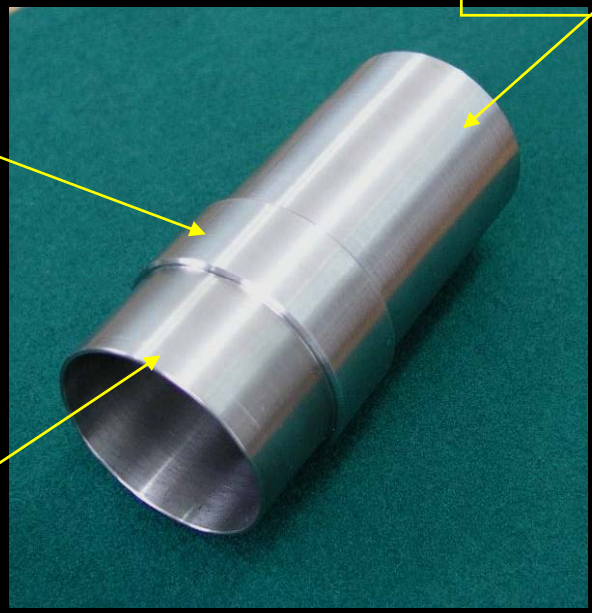


Figures taken from Russian company report

Second explosion welding sample from Dubna

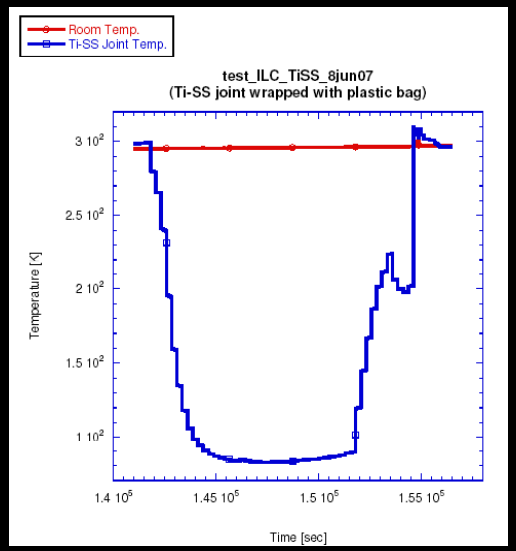
- External diameter comparable with diameter of transition pipe between He-vessel and 2-phase pipe in Fermilab 3th harmonic cryomodule
- Tests made :
  - He-leak tests at 300 K and 77 K





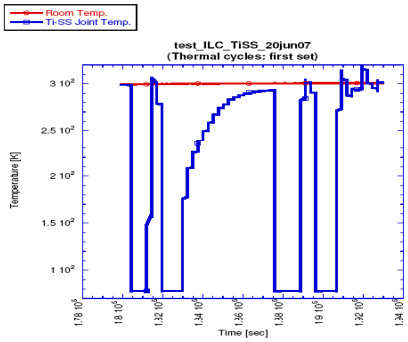
- Thermal cycles between 300 K and 77 K and He-leak checks
- He-leak test with pressure inside (6 bar)
- Welding tests

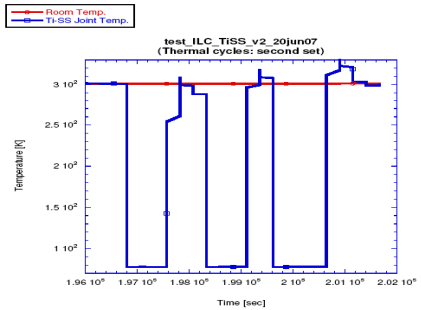
He-leak test at 300 K and 77K



- Enclose sample between two flanges with indium o-rings
- Place a plastic bag around the sample
- Temperature sensor on sample
- Fill He inside the bag after reaching test temperature
- Measure vacuum and He-leak rate
  - Vacuum ~10^{-3} mbar - never noticed any variation of He-leak rate
  - background (~10^{-9} mbar *l /s).

He-leak test after cycles between 300 K and 77 K





- Performed seven cycles between 300 K and 77 K with the same sample configuration (no bag)
- Used hot gun for fast heating
- After thermal cycles we put the sample in a bag and we filled He
- Vacuum ~10^{-3} mbar
- Didn't notice any variation of He-leak rate
  - background (~10^{-9} mbar *l/s)

Leak test with pressurized He inside

- Connect sample to the He bottle
- We pressurized to 6 bar
- Check for leaks outside with an external sniffer connected to the He-leak detector
- No leaks found up to 10^{-7} mbar *l /s
  - best instrument sensitivity

Welding test preparation (company qualification)

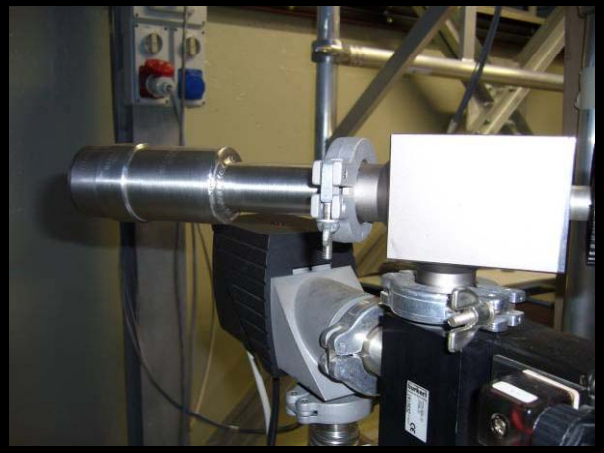
- Prepared closed box with Argon flow to make the Ti welds (small company close to Pisa)
- Test setup welding two plates and a standard vacuum connector to a 3” pipe
- Fully tested this sample at 300 K and 77 K without finding defects, leaks or cracks in the welds.

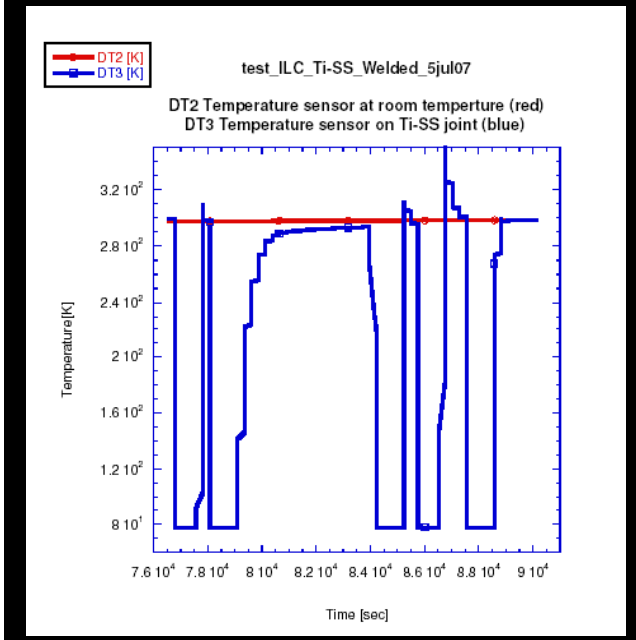
Welding of transition joint

- Inside the welding box we put a container with ice and water in which we soak the sample during welding.
- The fluid level was close to the welding area.
- We welded a 3 mm Ti cover on top of the transition joint.
- We monitor the temperature of transition joint with a probe in contact with external sleeve surface.
- The welding procedure was very fast (about 5 min) and the temperature detected was always 3-4 degree.
- On the other side of sample we welded a SS cover with a standard vacuum flange holding the piece in the same bath.

Sample after welding

He leak-test after the welding





- We repeated all leak-tests make before :
  - leak check at room temperature with bag filled with He;
  - thermal cycles between 300 and 77 K and after new leak checks at room temperature.
  - Leak test with pressure inside (6 bars of He).

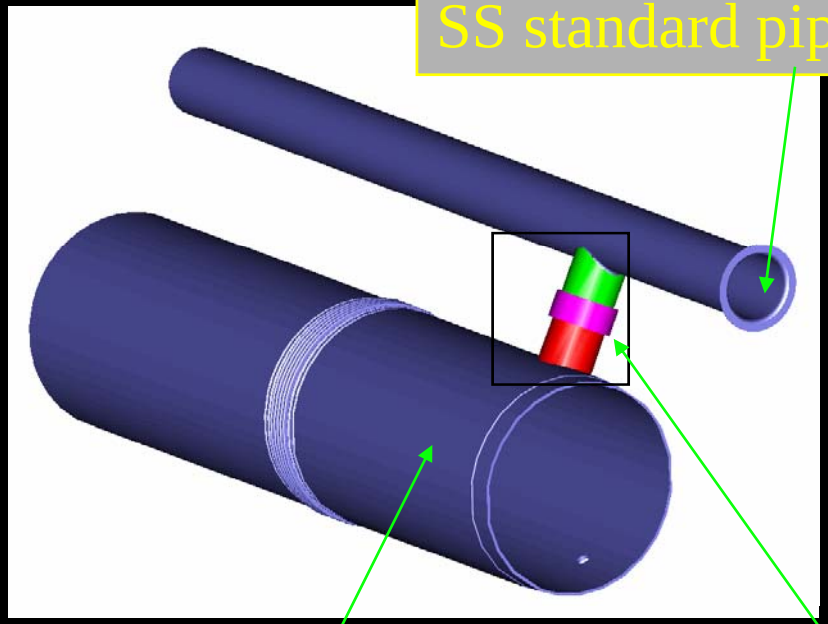
- At the end after the thermal cycles we found only a small leak in the weld between the SS tube and its cover (5 x 10^{-9} mbar *l /s).

Final considerations:

- The Ti/SS transition from Dubna has shown very good results in each test performed.
  - We need more statistic to fully certify this joint.
  - No He-leaks were detected in any conditions
- The procedure developed to weld the Ti and SS cannot be used in the real conditions but shows that if we cool the transition we are able to weld close to it (2 cm Ti side – 6 cm SS side) without damaging the weld
- Waiting for results of metallographic analysis on a separate sample
- ~10 new samples we will be available in early fall
  - Improve statistics
  - Make also destructive tests: traction, hardness, etc.
- Will push tests to 4 K as small cryostat becomes operational in next few months

Ti/SS transition in TCM4 design:

- Ti/SS transitions between the He vessel and the 2-phase pipe can be easily introduced in the TCM4/Type 3+ design
- This solution was already been adopted in KEK cryomodules.
- A design of that is ready and approved from Russian colleagues.

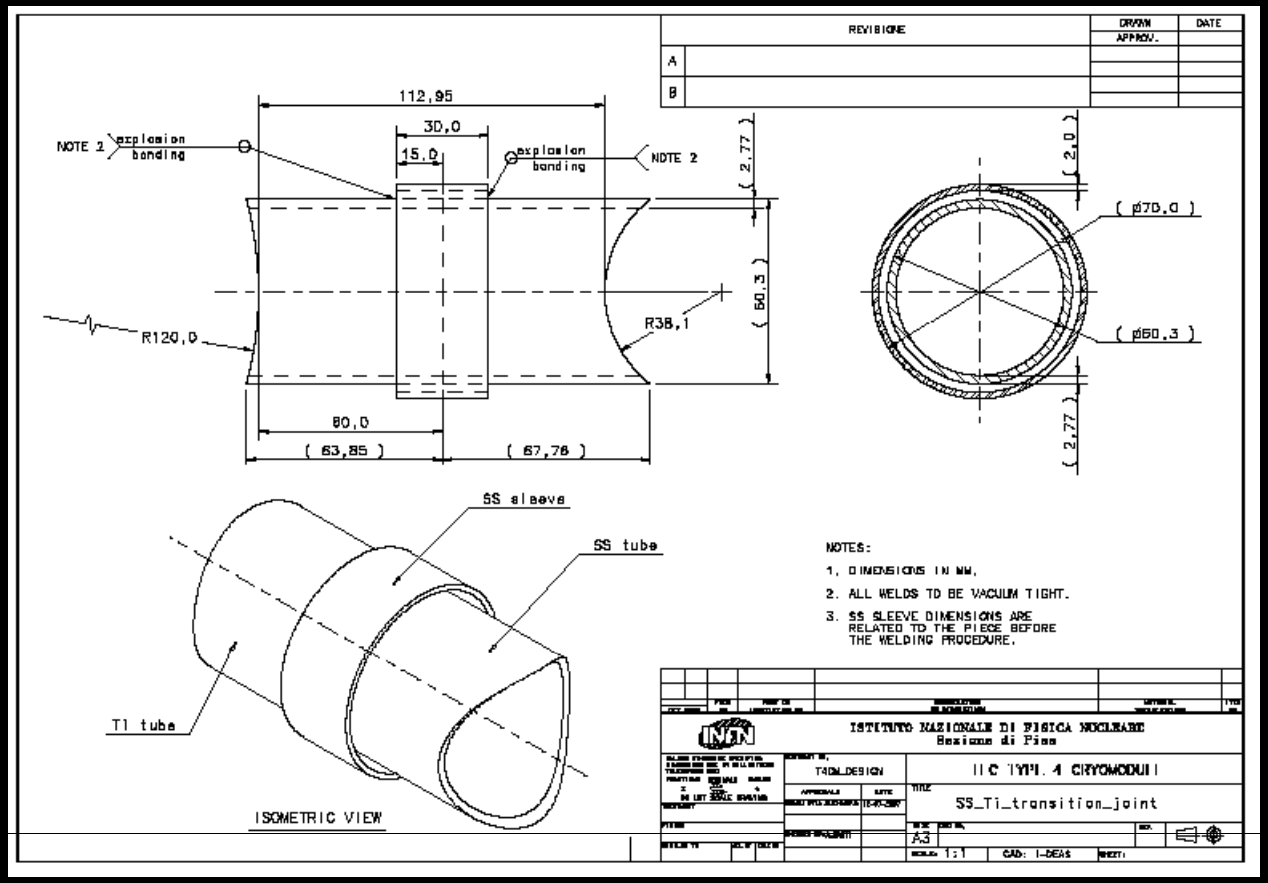


- The Russian colleagues are ready to produce samples with this dimensions (2" pipes).
- In Pisa we are ready to fully validate these transitions and develop a faster procedure to test them.

- **What is needed to decide to use this technology in the next cryomodules?**

Ti/SS transition between He-vessel and 2-phase pipe:

- With these dimensions we have only two welds in the assembly.



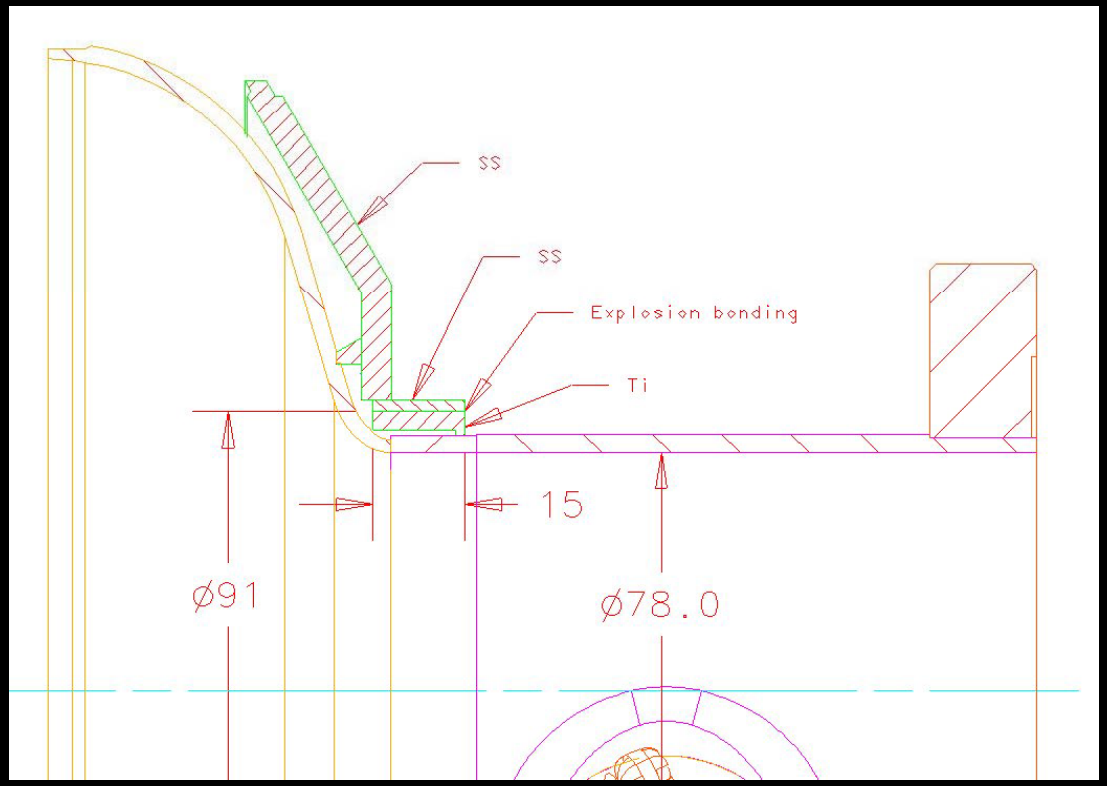
- The assembly procedure can be :
  - weld the transition joint to He vessel (Ti-Ti weld),
  - weld the 2-phase pipe to the transition joint (SS-SS weld).

Must agree on dimensions and shape!!!

- diameter
- thickness
- length

Ti/SS transition between cavity and He-vessel:

- More complicate:
  - Big diameter (internal cavity diameter 78 mm)
  - Less longitudinal space (about 15 mm)



- Issues:
  - Stress on cavity
  - Magnetic field
  - Welding directly on explosion bonded transition
  - Integration with cavity construction
  - Large radius option
    - Is explosion bonding feasible?