STATUS OF THE ILC R&Ds AT INFN PISA

International Linear Collider Workshop 2010

LCSW10 AND ILC10

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Carmine Elvezio Pagliarone

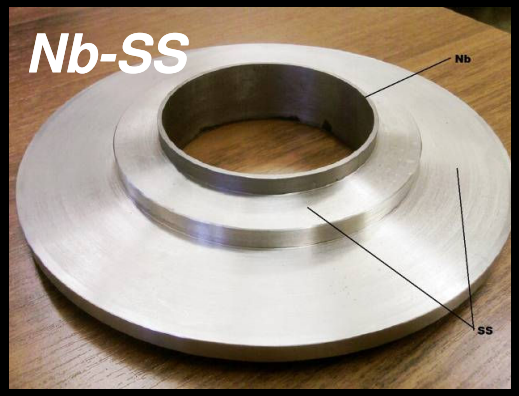
INFN & Università di Cassino - Italy

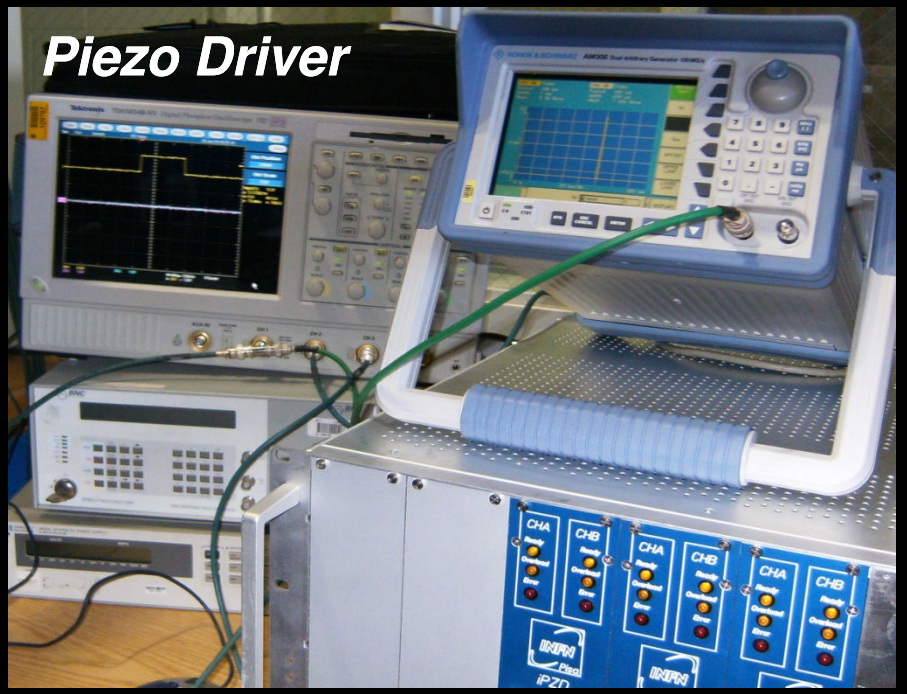
(on the behalf of the ILC Pisa Group)

Overview of ILC Pisa Activities

- **R&Ds:**
  - Cryomodule Mechanics
  - Control Electronics
  - Main Linac RF Klystron Modulators and related PSs
- **Collaborations:**
  - Fermilab
  - JINR (Dubna)
  - Universita' di Pisa & Scuola Superiore S. Anna
    - Department of Mechanic and Electronics
  - Universita' di Cassino
    - DAEIMI

    (MoU FNAL/Cassino Univ.)



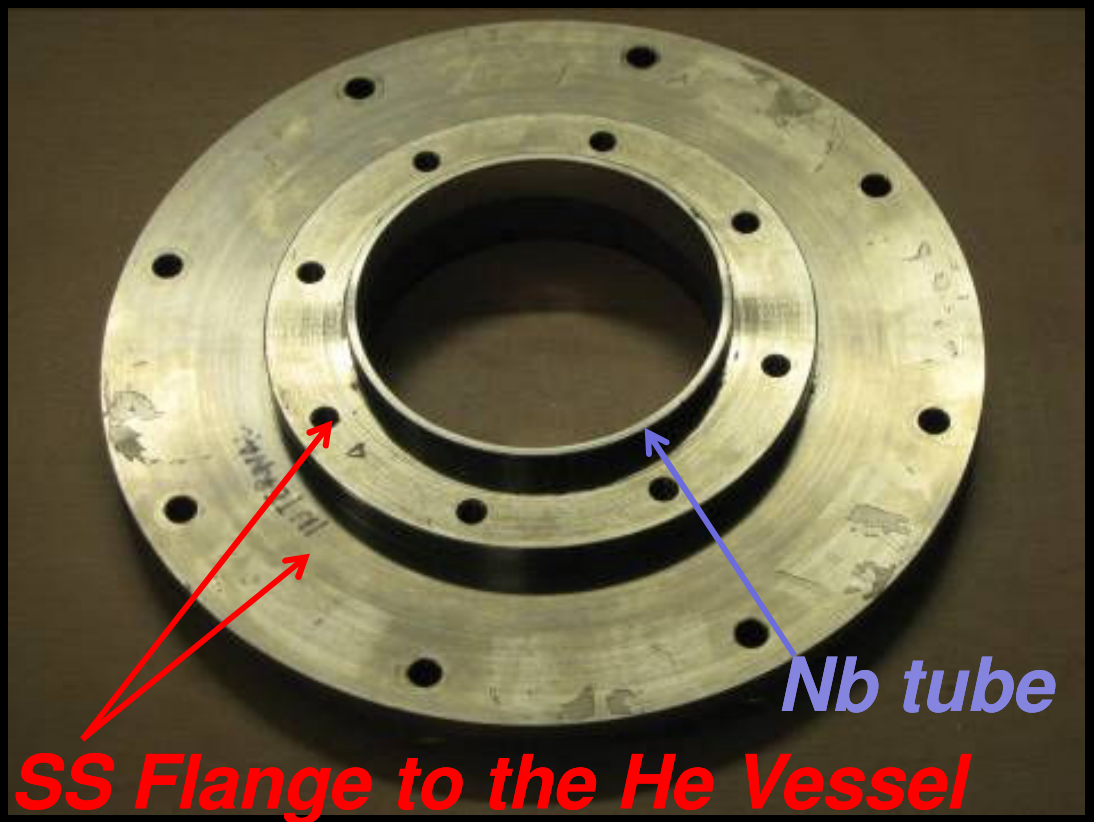


Cryomodule Mechanics

- **Bi-metallicTransitions by Explosion Welding (Production at JINR/Dubna, test in Pisa & FNAL):**
  - **Ti-SS Tubes:**
    - Produced and tested (leak tightness) in several amounts and proved to work;
  - **Nb-SS (tube to flange transitons)**
    - Recently produced;
    - The first tests in Pisa, at LN2 temperatures, are very encouraging;
- **Cavity-beam pipe connections**
  - Successful test (leak tightness/no particulate emission) of custom Helicoflex with quick chain clamp connection system.

The Nb-SS Transition Test at PISA

- The Nb-SS transitions have been tested after thermal cycles in LN2;
- No leaks were found over a background of $3 \cdot 10^{-10}$ mbar · l/s.



Low Cost Driver System for Piezoelectric Actuators for the ILC Superconductive Cavity Fast Tuners

Introduction

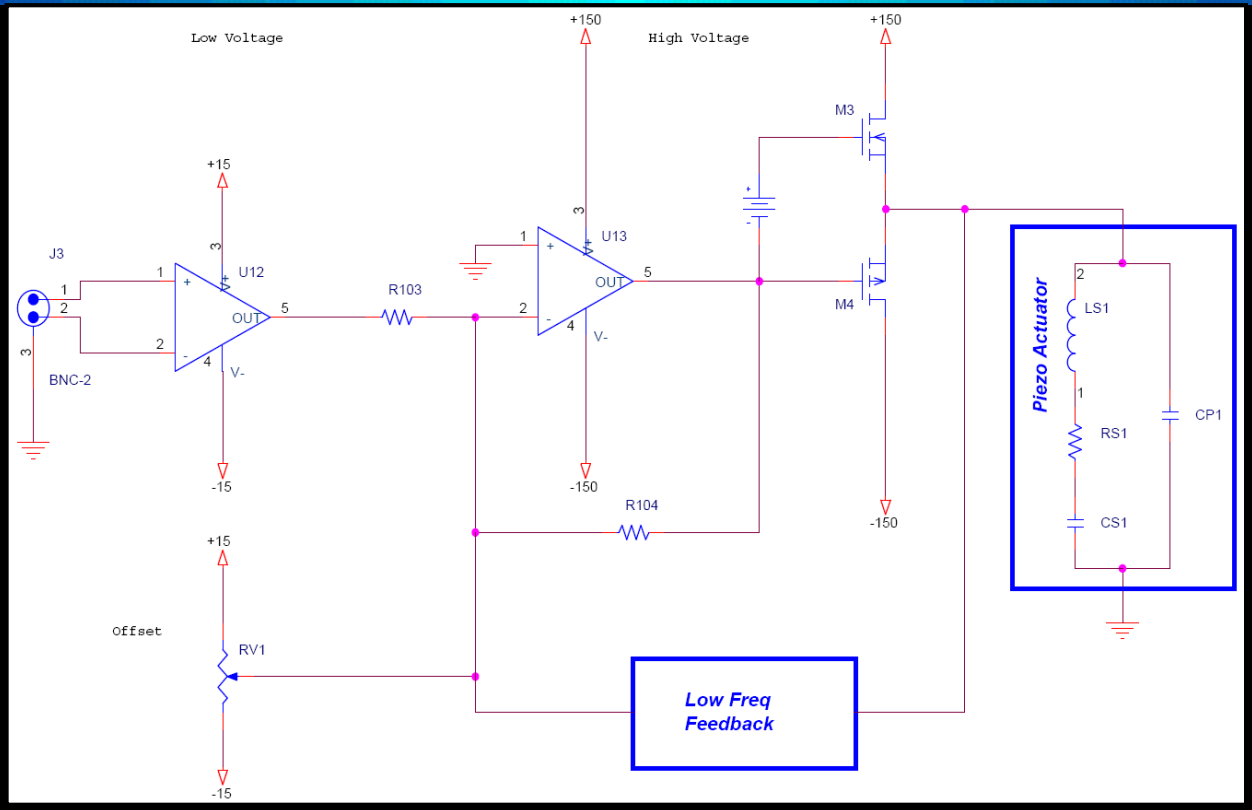
- Lorentz force detuning and micro-phonics requires cavity stabilization with fast tuners;
- Piezoelectric actuators are a common choice for active elements;
- Piezo Driver requirements are:
  - Capacitive Loads ranging from ~ 100 nF up to a few μF;
  - Bandwidth: ~ 100 Hz ÷ 1 kHz;
  - Output Voltage up to 200 V.
- Many units are needed (1 per each cavity);
- Commercially available Piezo Drivers are very expensive;
- We developed a Low Cost System with the required features.

Main Specifications

- Bipolar voltage rails (-175 V to +175);
- Full Power Bandwidth: 100 Hz;
- Small Signal Bandwidth: 10 kHz;
- 3 A max peak current;
- Noise on electrical output: < 10 mV_{RMS};

- The external control inputs are low voltage DC signals being the gain of the amplifier adjustable from 20x up to 400x;
- The driver is equipped with both output voltage and output current monitor;
- Additional features are one on board Digital Signal Controller for circuit supervision and protection, CANbus and RS-232 interfaces.

Conceptual Design and key features



- ***Complementary MOSFET output (source followers):***
  - ***Low output resistance (RDS On);***
  - ***Possibility to increase current driving using nultiple MOSFETs in parallel;***
  - ***AB class operation minimizing crossover distorsion;***
- ***Feedback: the iPZD operates in closed loop up to 30 Hz, thus allowing an optimal control of piezo DC bias without limiting the driver bandwidth.***

The Piezo Driver iPZD08 2

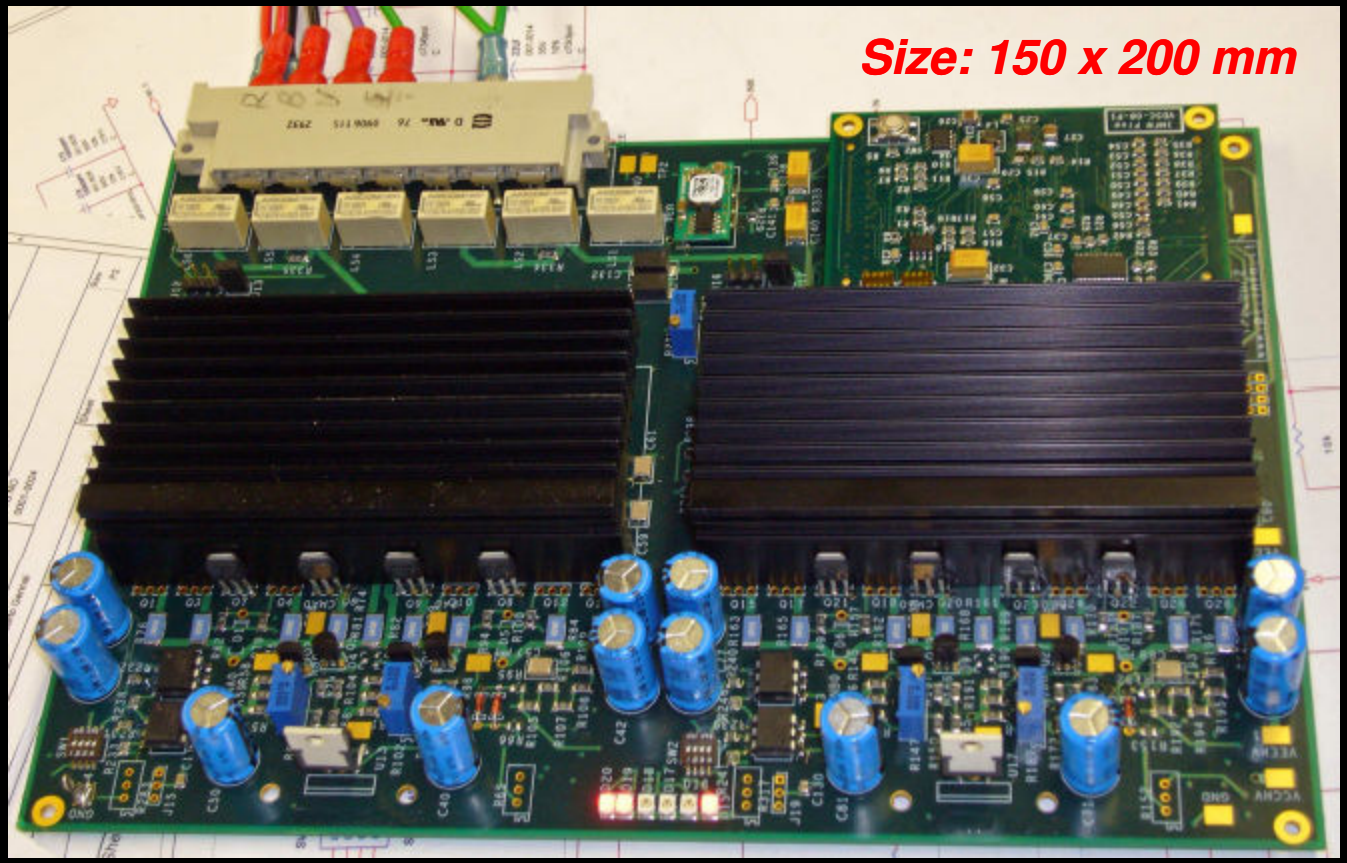
- The IpZD08 2 is a low cost driver design which is ideally suited for fast tuner applications, large system packaging and has an excellent flexibility in its implementation;

- The Piezo Control Unit (PCU) is constituted by a single standard sub rack/19”-chassis (Height 6U, Width 84HP, Depth 415mm);
- The PCU can host up to 5 dual channel piezo driver modules;

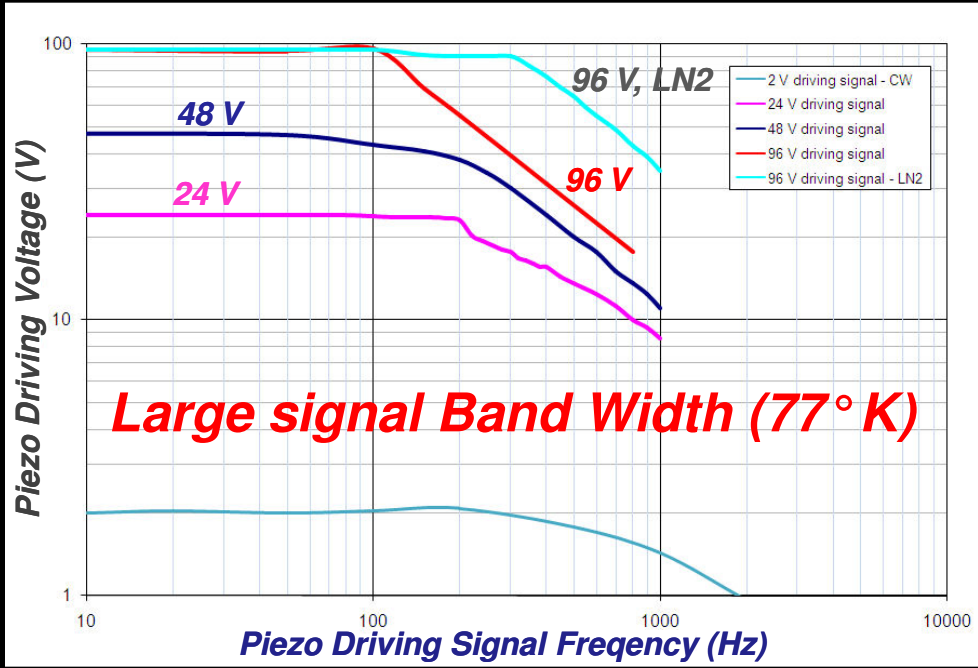
- Both Low Voltage and High Voltage power supplies are hosted in the case.

- The final cost is below 500 $/channel (cost is dominated by packaging options).

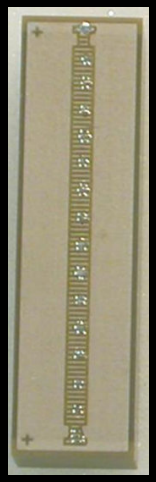
The two channels Piezo Driver board



Test Results

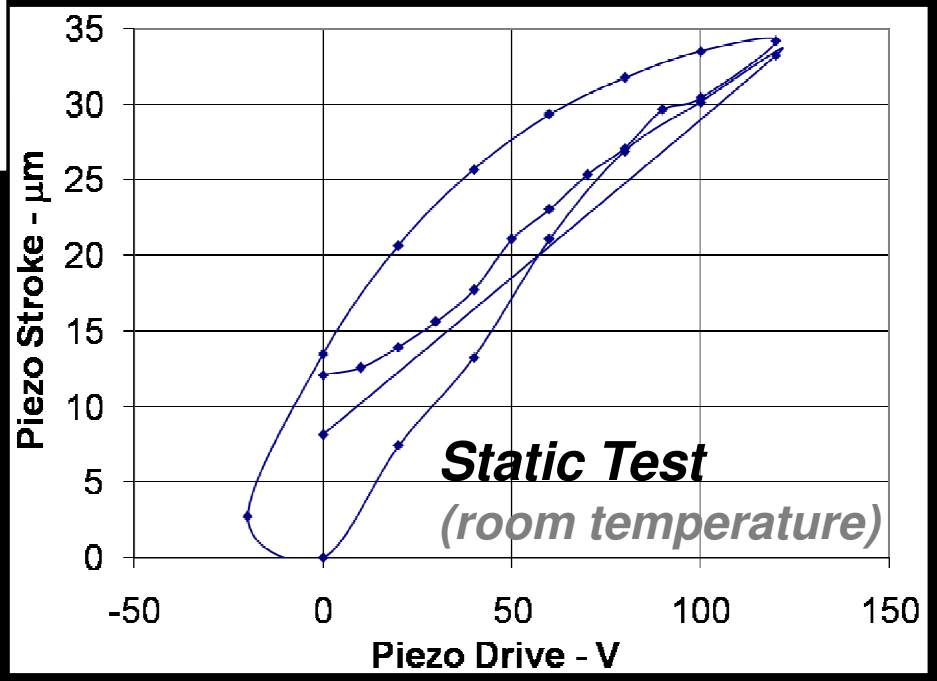


Temp K	Load µF	Driving Signal Vpp	BW Hz
300	14	2	1000
300	14	24	320
300	14	48	250
300	14	95	150
77	6.2	95	450



P-888 Physik Instrumente

- -20 to 120 V driving range
- stroke up to 35 mm
- static capacity at RT of 14 µF
- 10 x 10 x 36 mm size



The iPZD08 2 at Fermilab ILCTA

- 3 Modules x 2 Channels + Crate under test at Fermilab;
- Still tuning protection control firmware;
- The crate can host 5 modules (10 channels in total).

What next ?

- *A new version of the iPZ08, able to give x6 more current, is under development*
  - *Higher reliability;*
  - *Higher bandwidth;*
  - *No significant increase in the cost.*

- *We are developing an optional mezzanine board which adds functionality to the unit at a small additional cost:*
  - *400 MHz CPU;*
  - *Ethernet connection;*
  - *1 ADC + 1 DAC.*

- *This should be sufficient to drive local control loops on a single cavity.*

Conclusion

- *Excellent progress on developing a very cost effective Piezo Driver System;*
  - *new version available by summer 2010;*
  - *new version engineered for series production, by local firms.*

- *Successful progresses in Mechanical R&Ds;*

  - no time for details

- *Klystron Modulator and related PS Development .*

  - no time for the subject

ILC INFN Pisa Group

F. Bedeschi, G. Bellettini, A. Menzione,

C. Pagliarone, D. Passuello, G.M. Piacentino

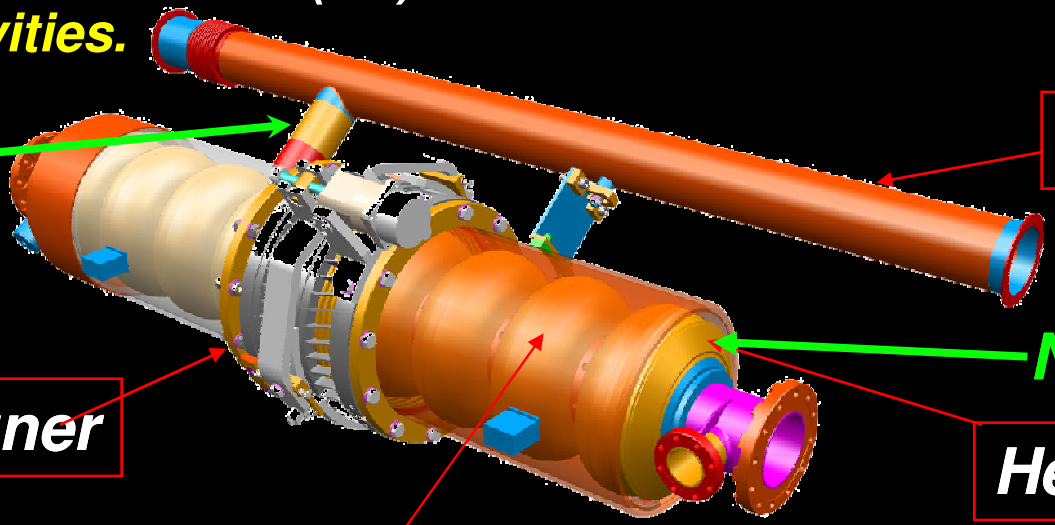
A. Basti , G. Busatto, G. De Carolis, F. Frasconi, F. Iannuzzo, F. Raffaelli ,

S. Galeotti, A. Gennai, F. Spinella , F. Velardi

Thank you !

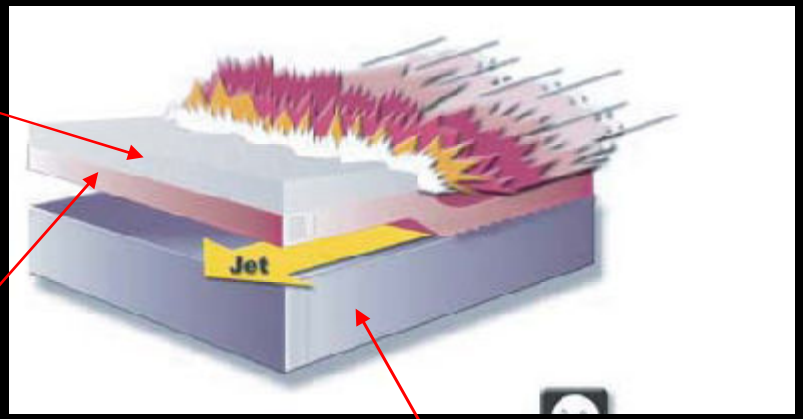
Backup Slides

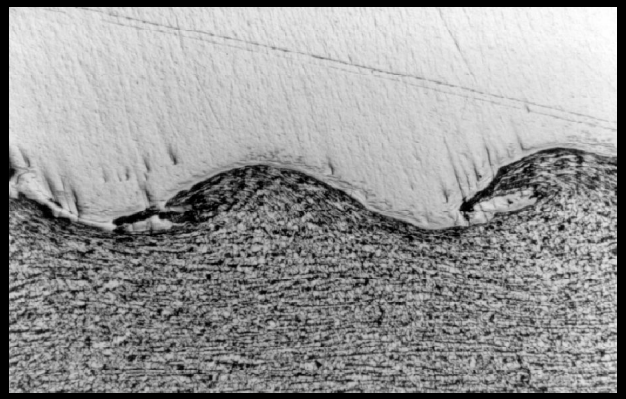
- The He-Vessel is a container that hold the supercritical helium that surrounds and cools the cavity to the operating temperature.
- In the Tesla-like SRF cavities the vessel around the cavity is made in Titanium.
- Several studies show that the cost of this component is one of the most dominant cost element (together with the niobium material and cavity fabrication).
- The principal goal of this R&D is to find a good transition between the Nb and Stainless Steel (SS) to be able to built a He-Vessel in SS for ILC SRF cavities.



The explosion bonding process

- With this technology we are able to join metallic materials that cannot be welded with standard techniques.
- Extensively used to join Al and SS. Commercial SS-Al explosion bonding transitions are available on the market.
- Bimetallic plates (Al-SS and Ti-SS) with this technique are easy to find.
- It's not easy to find transitions made using tube elements and between the Nb and other material (Nb no widely used in the industry)

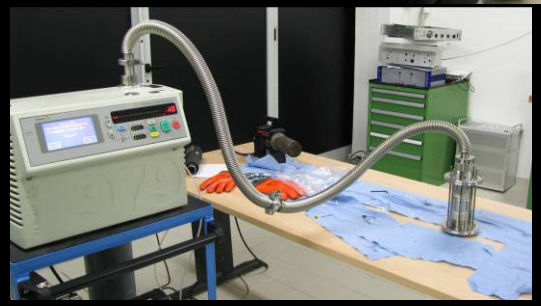




Explosion bond interface

The Ti/SS explosion bonding transition

- The Sarov company produced several samples starting from small diameter until to reach the maximum of 2" inches.
- The final samples were made using standard 2" tubes (one in Ti and the other in SS with the same diameter) with a SS collar explosion bonded from outside to join them.
- All samples produced were successfully tested in Pisa at room and nitrogen temperatures and after thermal cycles between these two values.
- Finally they was tested at He liquid temperature at FNAL.



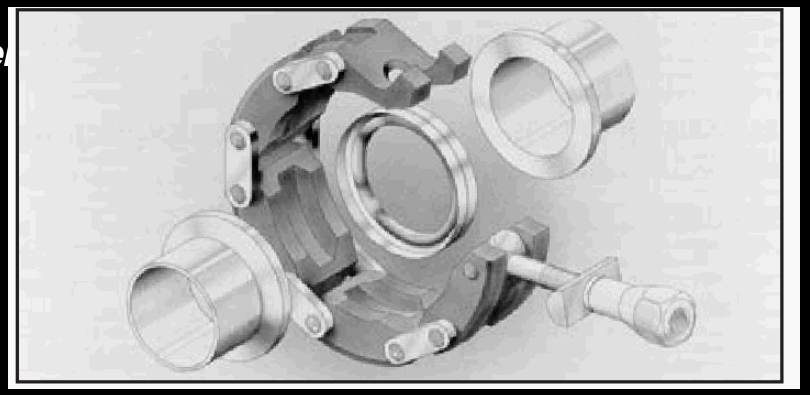
SS tube

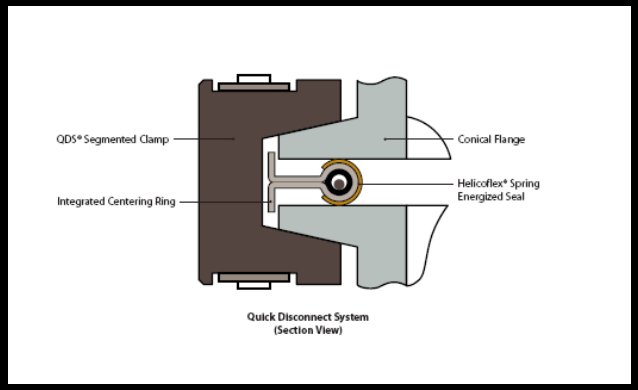
SS sleeve

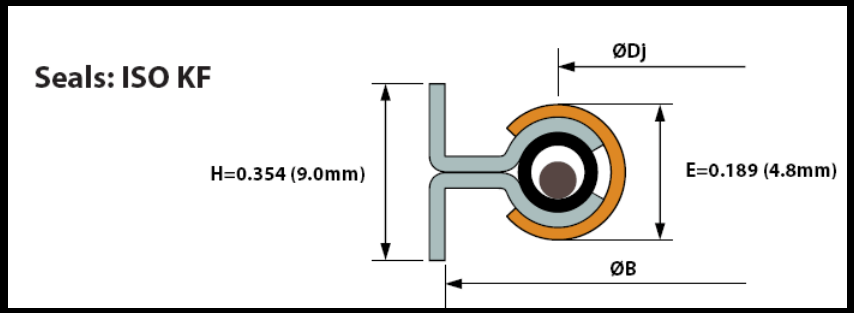
Ti tube

The Garlock Quick Disconnect System

- ***The Garlock Quick Disconnect System (QDS) use a conical flange design (conical profile 15 or 25 gr.), an external clamp with only one screw and Delta Helicoflex seal (with an external integrated centering guide) to performance a quick disconnect system with clear advantages:***
  - *Quick connection and disconnection*
  - *Compact size – Fast and easy installation and re*
  - *Easy application of tightening force*
  - *No twisting torque in the piping*
  - *High seal level*

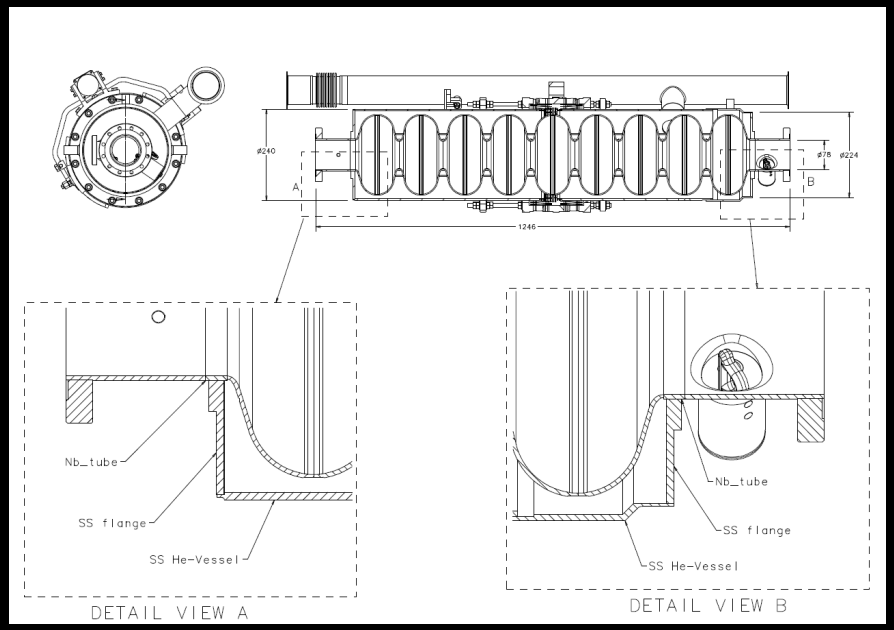


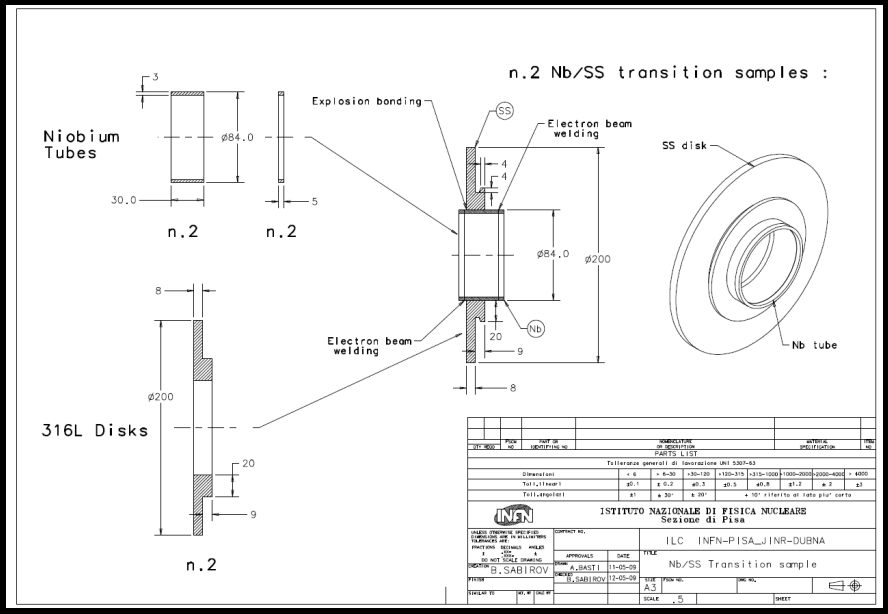




The Nb/SS transition design

- Starting from the standard 9 cell SRF cavity plus He-vessel design we defined a transition in wich a SS flat flange is joined by explosion bonding to a short Nb tube with the internal diameter of cilindrical part of cavity ends (78 mm).
- During the cavity fabbrication this transition will be connect by EB weld on both side on the rest of cavity.
- Two similar Nb/SS transitions like that need to be used in the cavity assembly.
- Finally the SS He-Vessel will be TIG weld to two SS flanges of these two Nb/SS transitions.

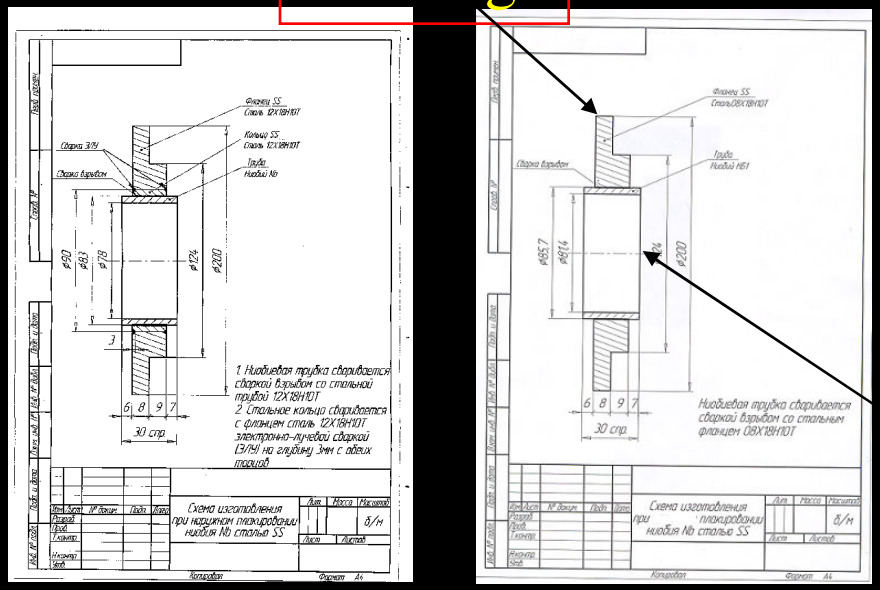


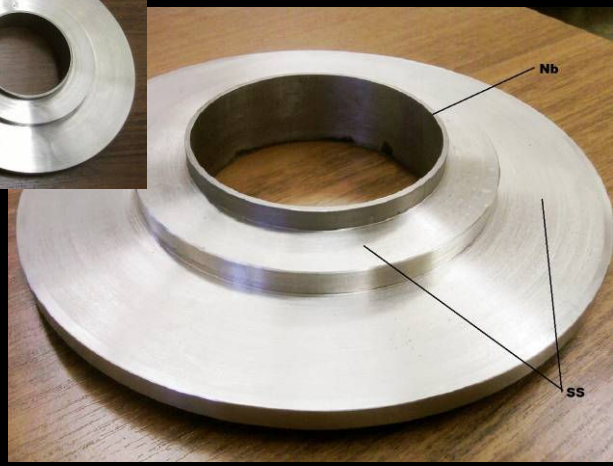


The Nb/SS transition samples

- The Sarov company produced four samples according this design.
- Two samples were produced with the explosion bonding from outside to inside ("external explosion bonding"), two with the explosion bonding from inside to outside ("internal explosion bonding")
- In the external explosion bonding samples a SS collar is joint by explosion to the Nb tube then the SS flange is EB weld to this collar.
- In the internal explosion bonding samples the Nb tube is direct connect to SS flange.

SS flange





Nb tube

- ***A list of piezoelectric actuators that could be used includes:***

EPCOS, 7x7x30 mm, 2.1 uF, 0-160 V, 40 um.
NOLIAC, 10x10x30 mm, 6 uF, 0-200 V, 42 um.
HYSIK INSTRUMENTE, 10x10x36 mm, 12 uF, -20-120 V, 35 um.
NOLIAC, 10x10x70 mm, 40 uF, 0-200 V, 100 um.
PIEZOMECHANIC, 14 uF, -30-150 V, 80 um.