The extra-CARE activity of the Superconductivity Laboratory

Enzo Palmieri

ISTITUTO NAZIONALE DI FISICA NUCLEARE
Legnaro National Laboratories
&
Padova University
Material Science Department

CARE, JRA1 Annual Meeting at LNL INFN October 2005

Legnaro National Laboratories

The Research activity at LNL

DEVELOPPMENT OF NEW TECHNOLOGIES
NEEDED FOR FUNDAMENTAL RESEARCH
AND THEN TRANSFERRABLE TO INDUSTRY

RESEARCH IN THE FIELD OF APPLIED PHYSICS:
MEDICAL PHYSICS, MATTER PHYSICS,
ATMOSPHERE PHYSICS, ...

RESEARCH IN THE FIELD OF FUNDAMENTAL PHYSICS,
BY USING THE 4 OPERATING ACCELERATORS

The ALPI LINAC for Heavy Ion Acceleration

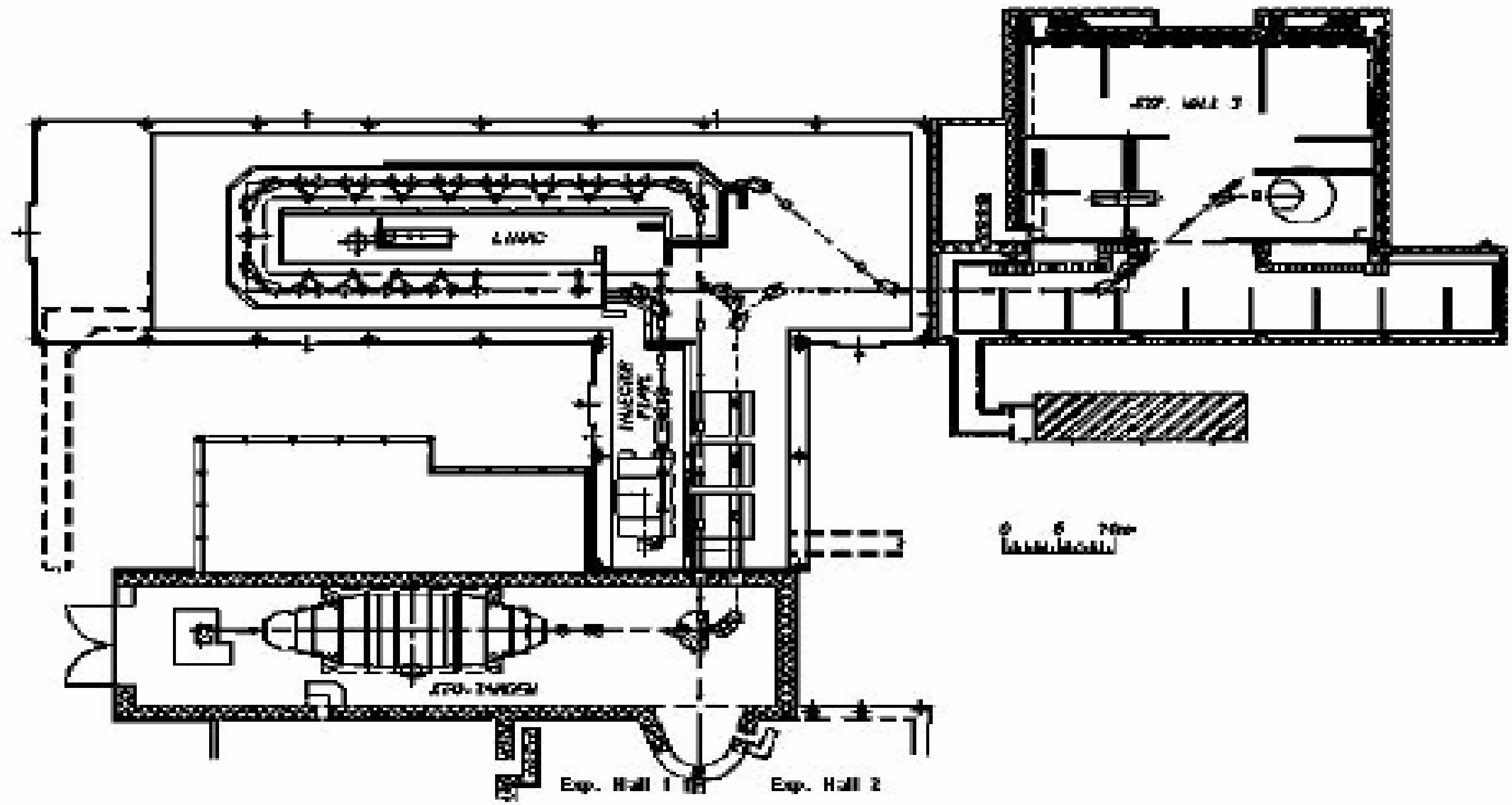


Fig. 1. Layout of the ALPI accelerator complex

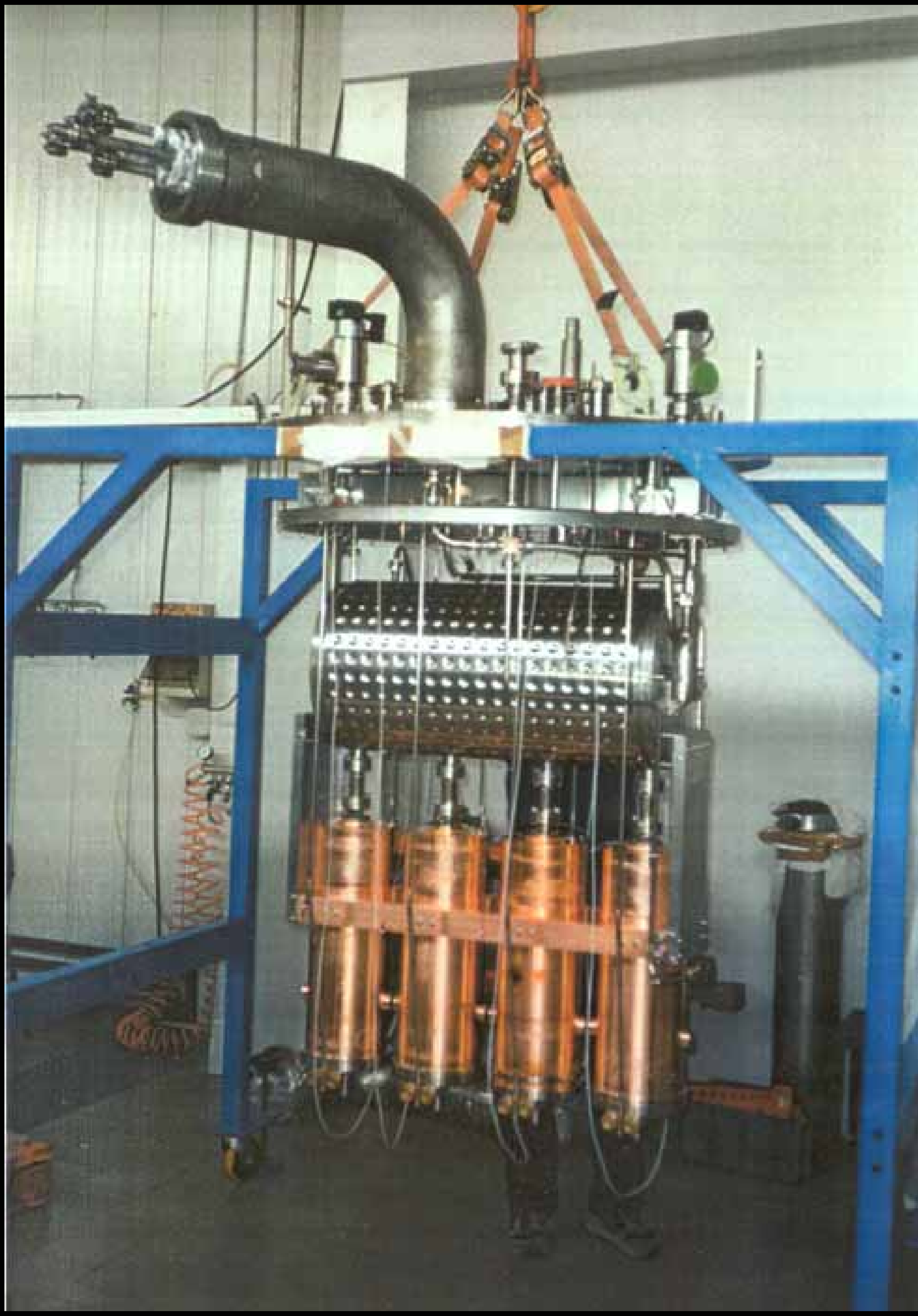
Nb Sputtered Cu QWRs

Over 44 resonators installed and operating into the ALPI LINAC

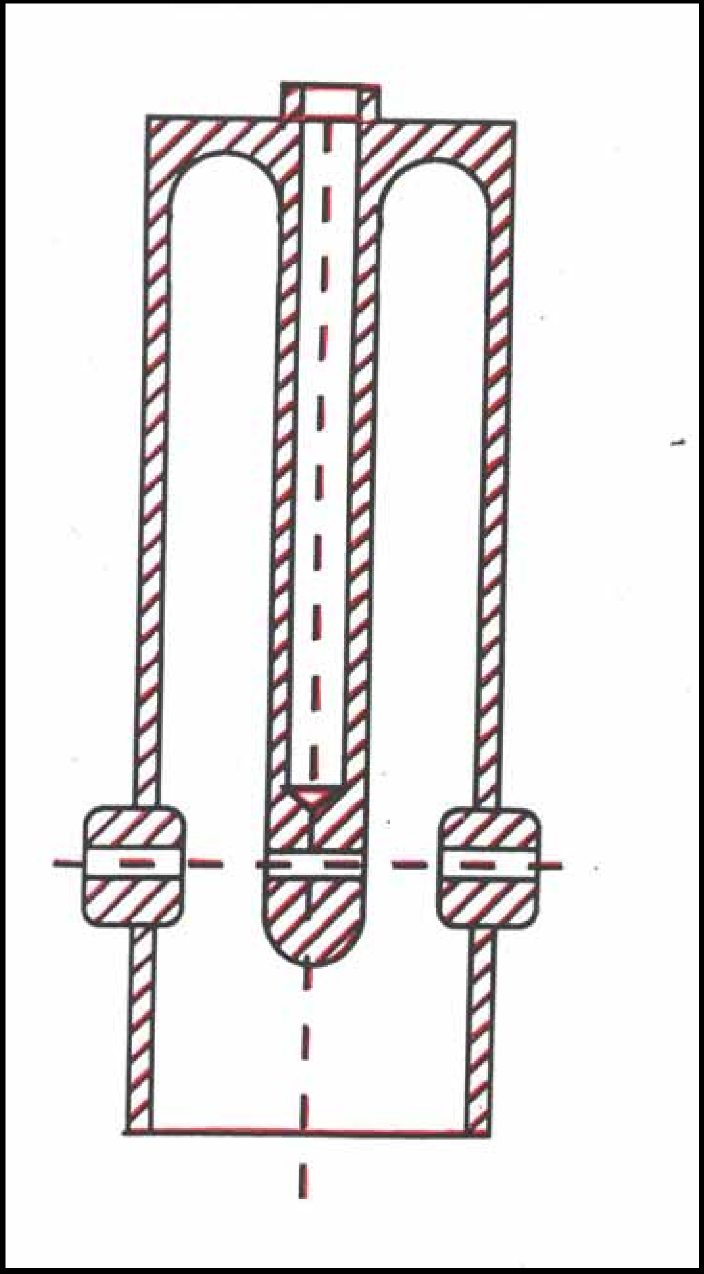
R&D Activity started by the Speaker in 1986;

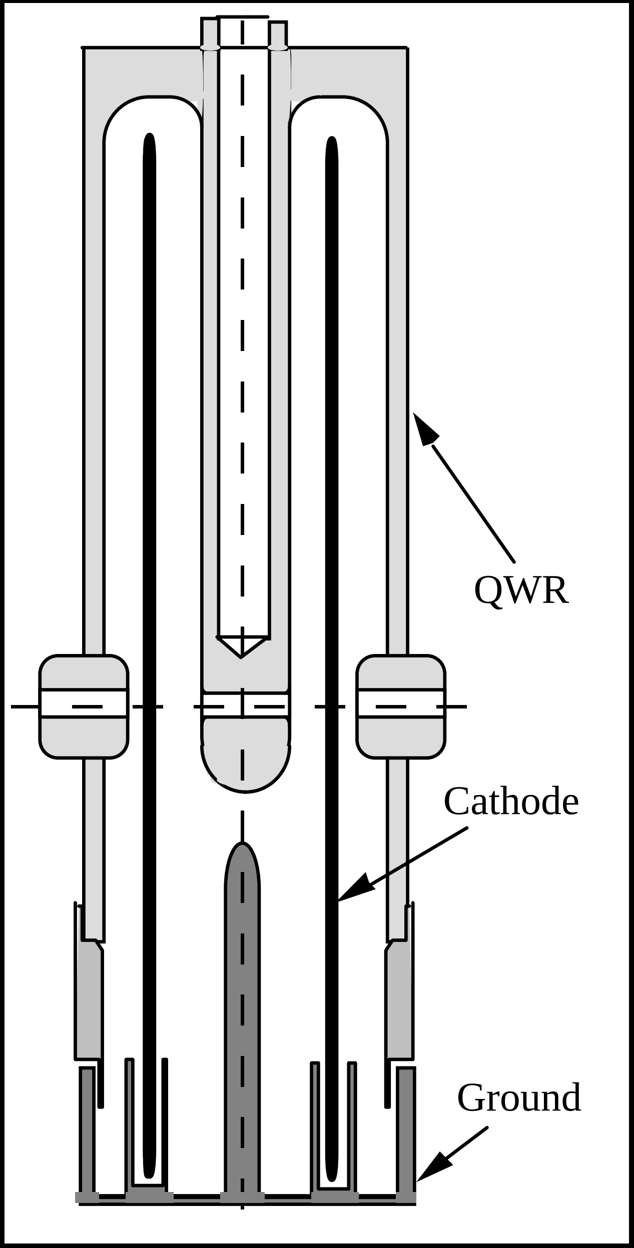
Production made by S.Yu. Stark;

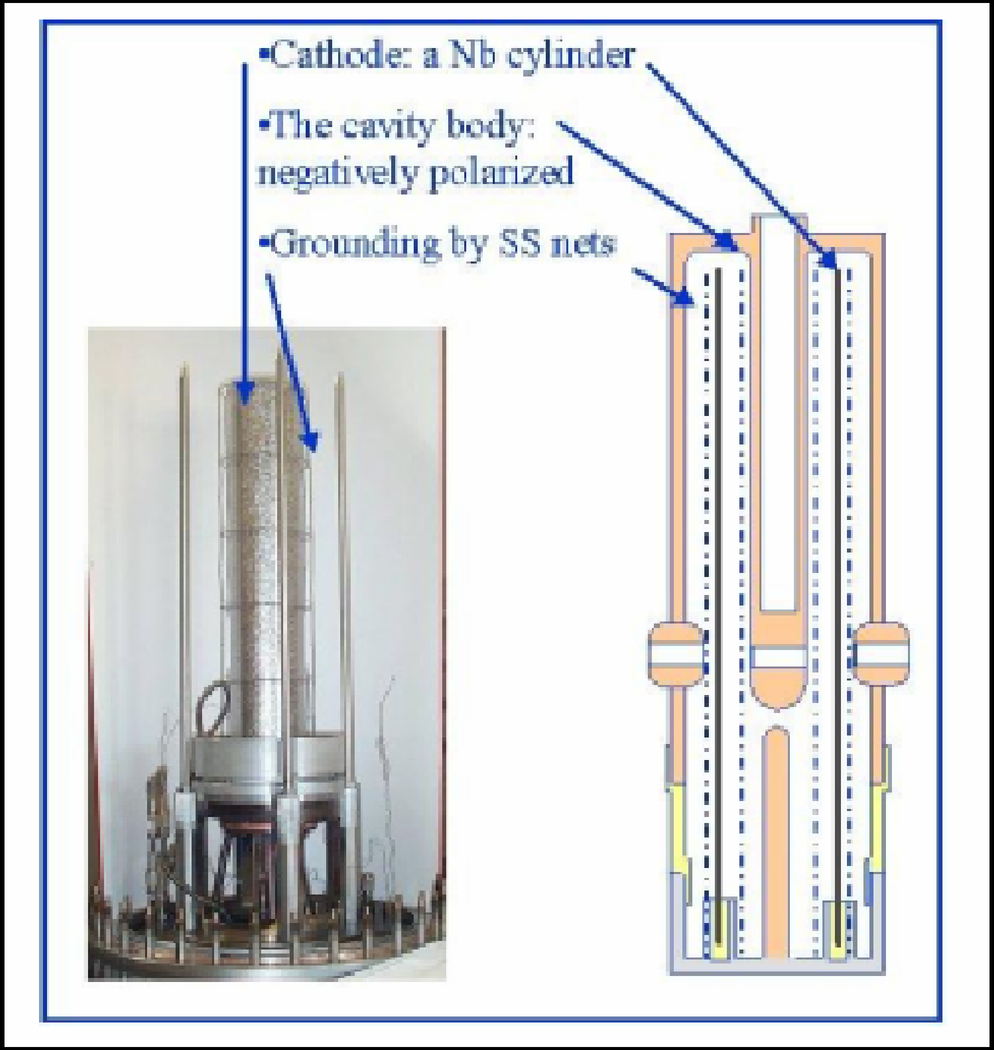
Installation done by A. Porcellato

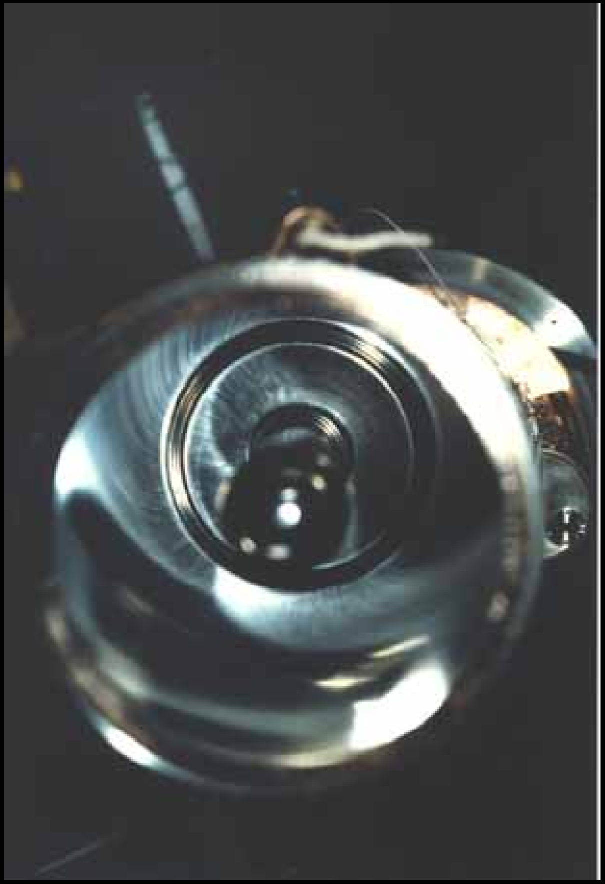


The sputtering configuration



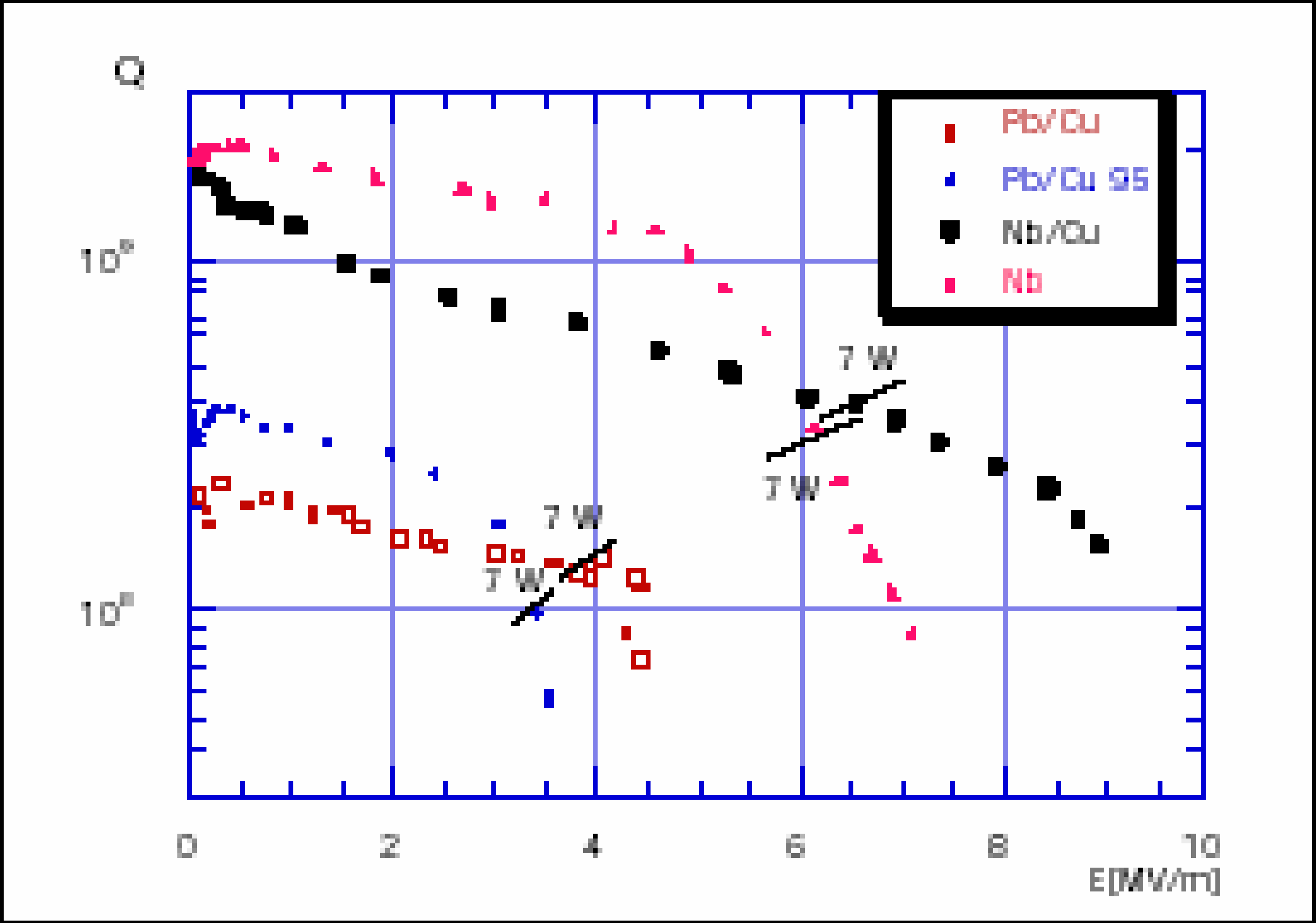






The bias technique is highly reliable

Comparison of the different technology choice used in ALPI Linear Accelerator



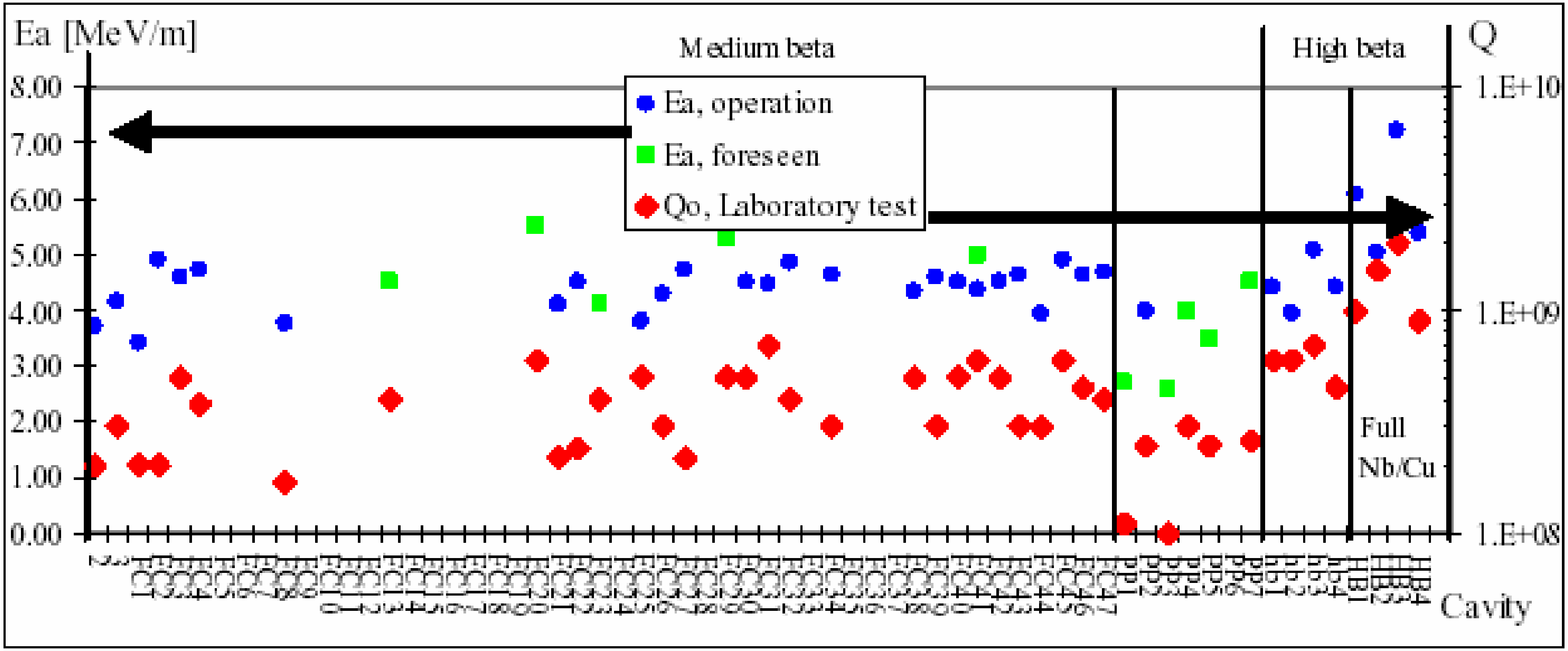


Fig.2 Performance of sputtered Nb resonators; the highest Q_o and accelerating field values, @ 7 W dissipated power have been obtained in properly built substrates. Average Ea in operation is 6 MV/m for high β cavities; 4.2 for medium β resonators.

History of Nb Sputtered Cu QWR at LNL starting from scratch

1988 – **Choice of the Sputtering Configuration e design of the vacuum system**

1989 - Sputtering System mounted. Start of the research phasis of sputtering onto samples in a dummy cavity

1991 – Sputtering of the first prototype

1993 – Last three prototypes sputtered overcome 6 MV/m at 7 Watt

1994 – Design and test of resonator accessories (coupler, beamports, bottom plates)

1995 – Production and installation of four resonators in a ALPI Cryostat

1996 – Improved sputtering proceedure. New design of coupler, pick up and collars

1997 - **Fondation of the superconductivity laboratory.** Production of four middle beta resonators (Laboratory test 5,7 – 7.7 MV/m at 7 watt).

1999 – Start of Resonator production

2003 – **48 resonators are installed, accelerate the beam routinely and resonator performances increase with time. Cavities are much more stable than the double wall Bulk Nb cavities that instead suffer of microphonics.**

The Superconductivity Laboratory

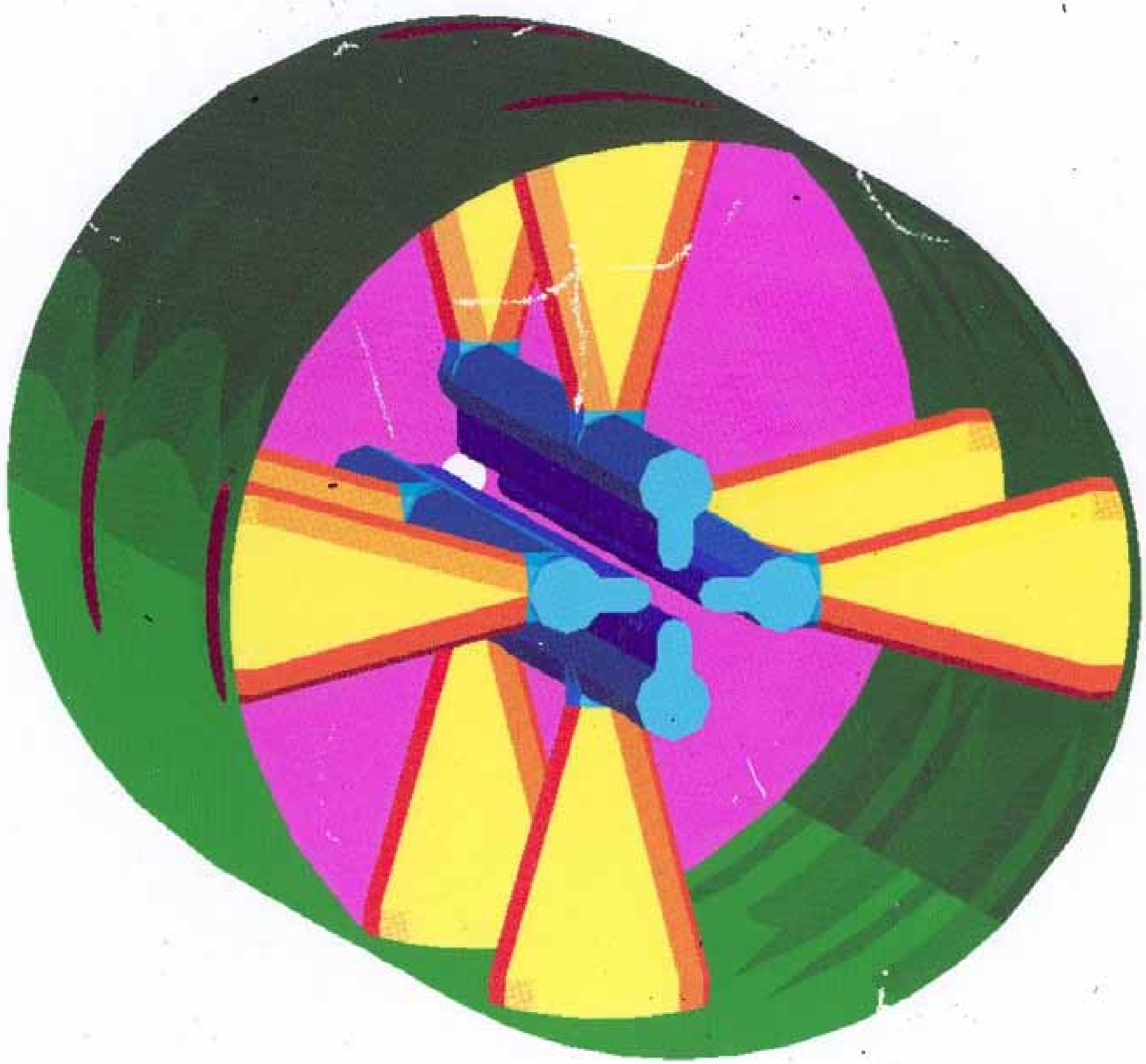
The Research lines besides CARE

- Nb sputtered films (in collaboration with Cornel University)
- A15 materials
- Cathodic arc deposition of Carbon films
- Ultracleaning of detector component for double beta decay experiments
- Technology Transfer
- Master on Surface Treatments for Industrial Applications

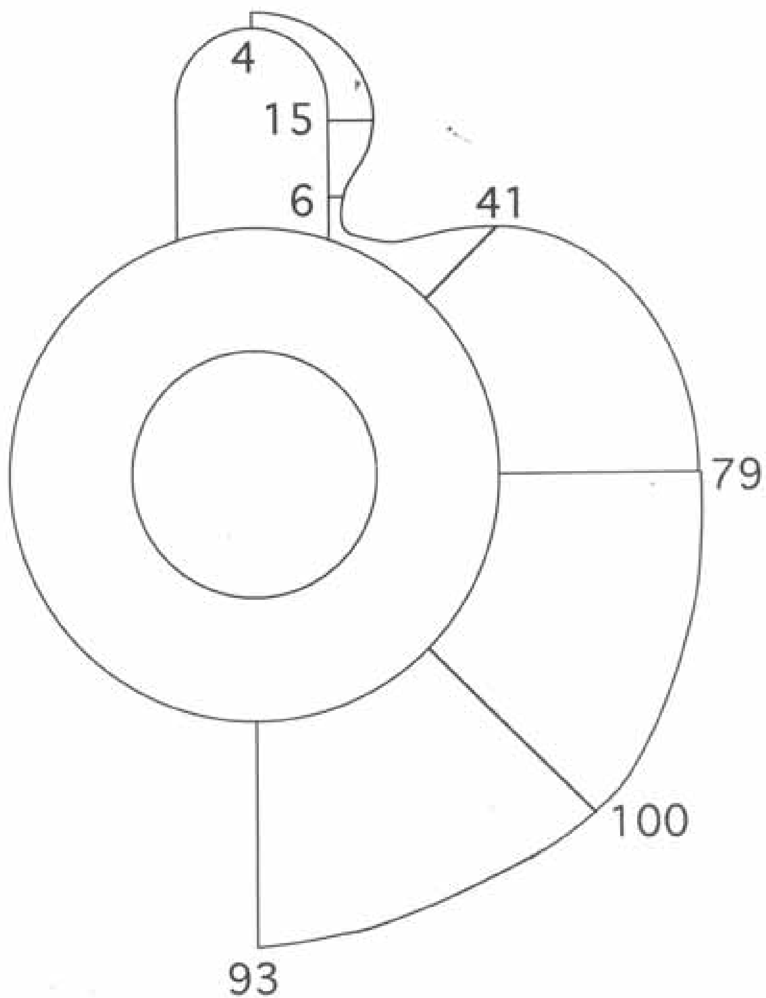
Composition of the Superconductivity Laboratory Group

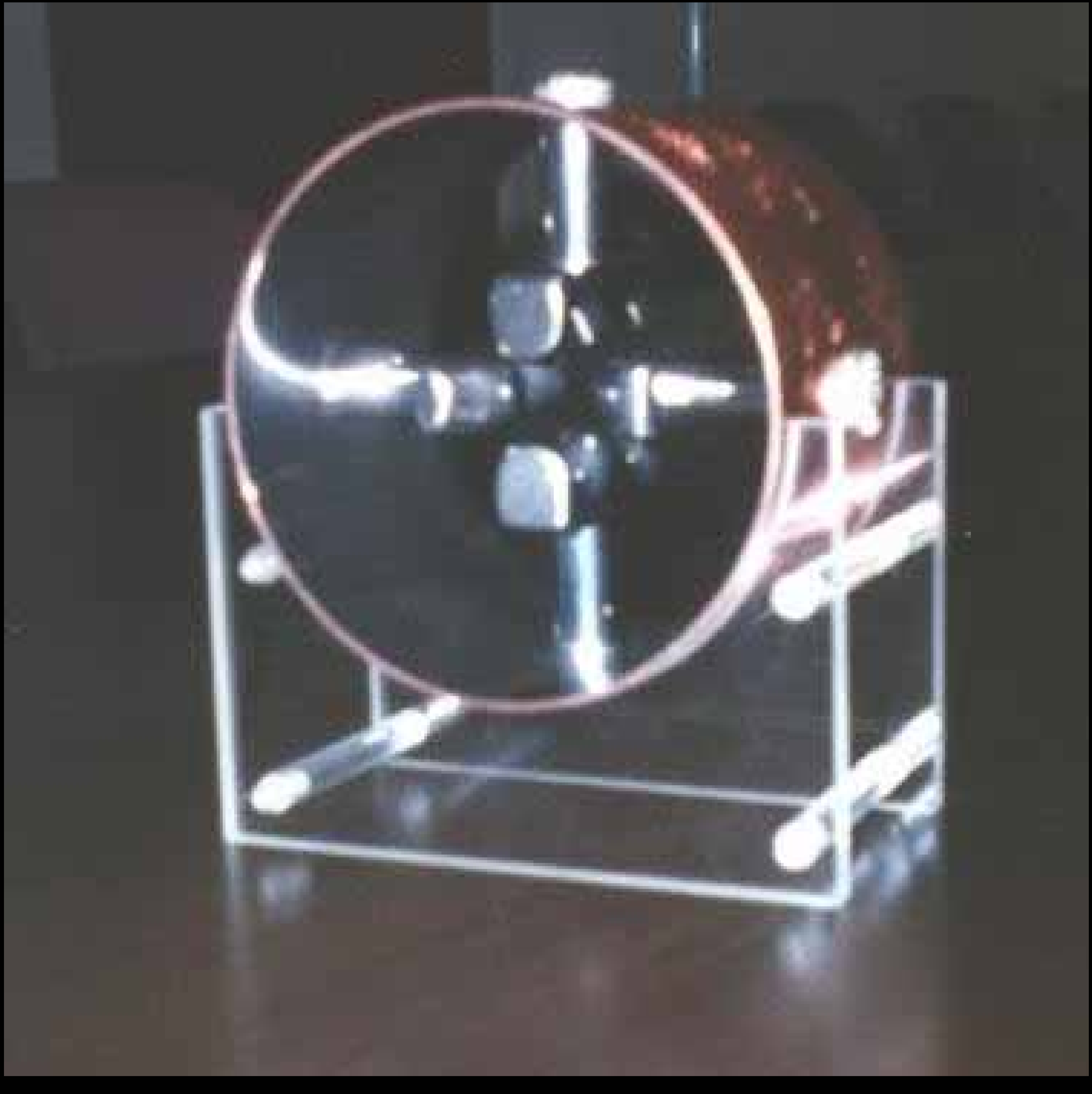
- Head: V. Palmieri
- Fellows: G. Keppel, S. Martin, A. Minarello, E. Morello, D.Tonini, V. Rampazzo,
- PhD.: G. Lanza, S. Deambrosis, C. Bonavolontà
- Master: E. Balsamo, A. Barbiero, J. Bermudez, N. Patron, D. Scagliusi, N. Schiccheri
- Students: A. Frigo, M. Guidolin, P. Menegatti, M.Pasetto, C. Pira, N. Pretto
- Technical Support: L.Badan, G. Galeazzi (part-time)
- Special Guest: R.G. Sharma (in average 3 month/year)

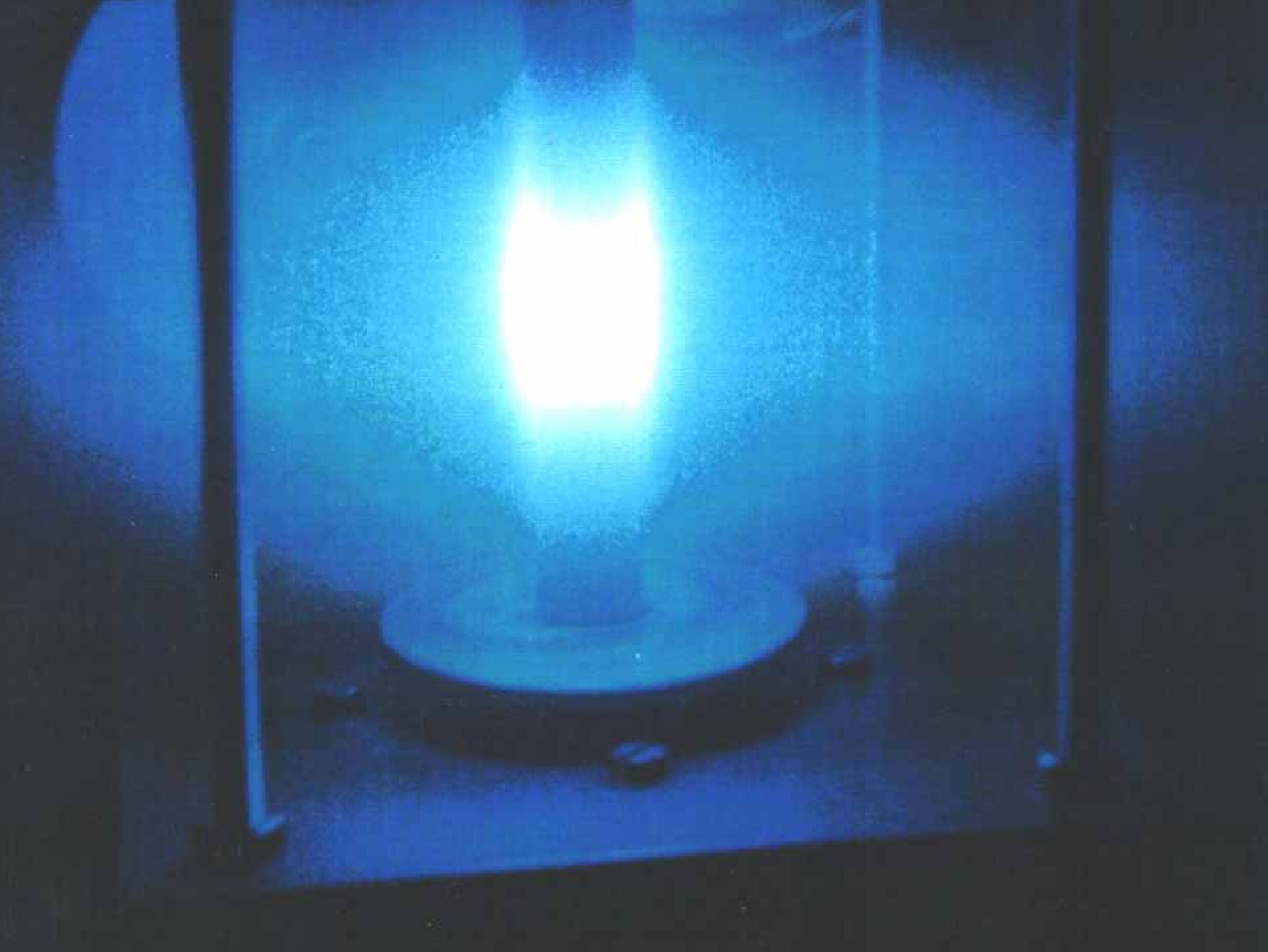
Nb Sputtered Feasibility proof

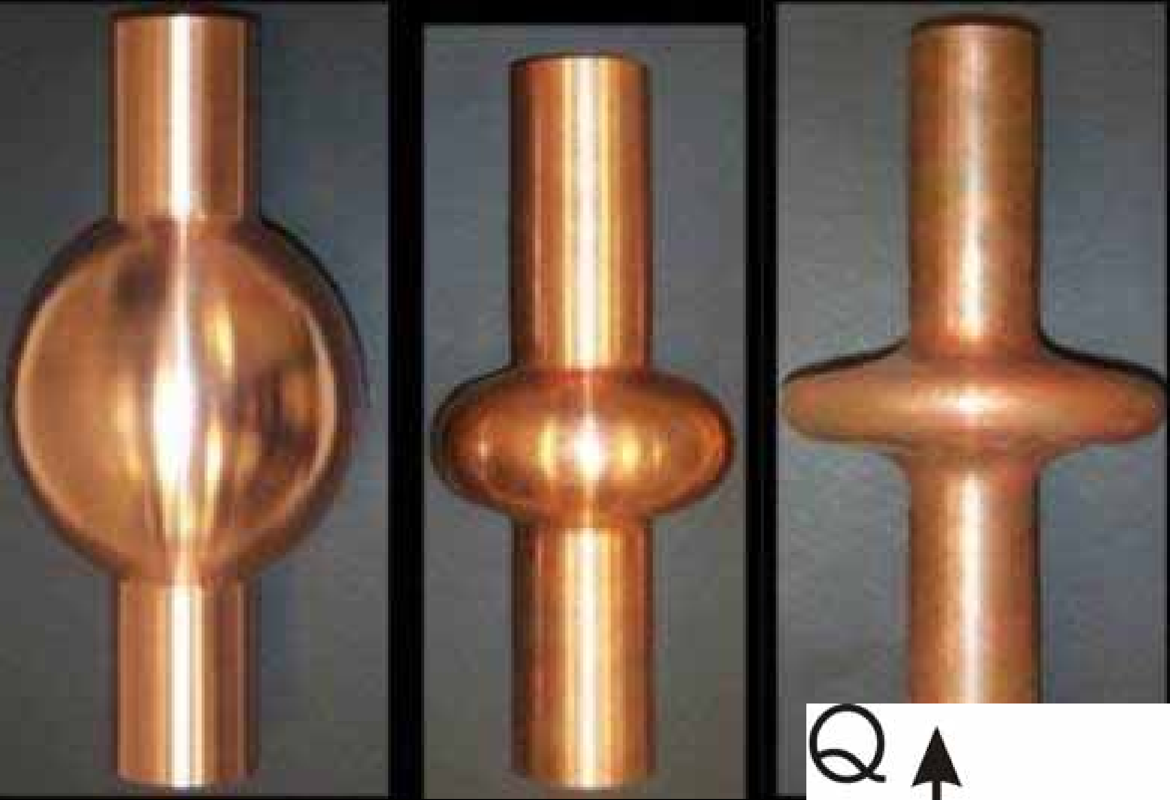


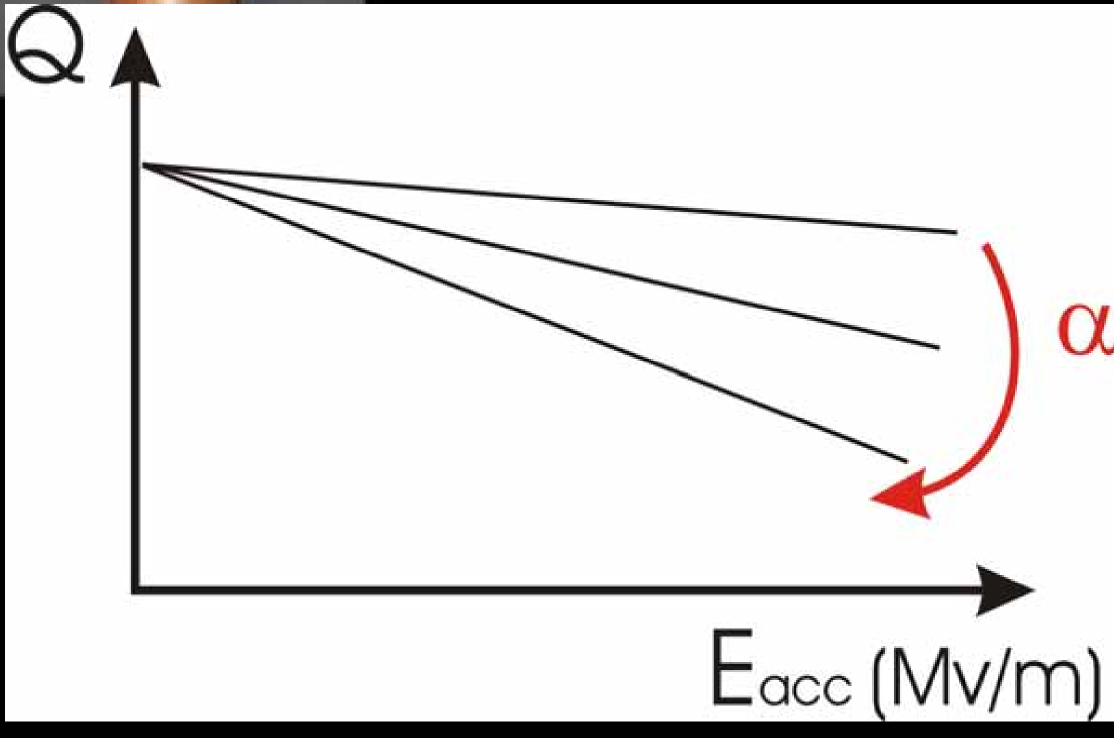
Film thickness distribution (%)

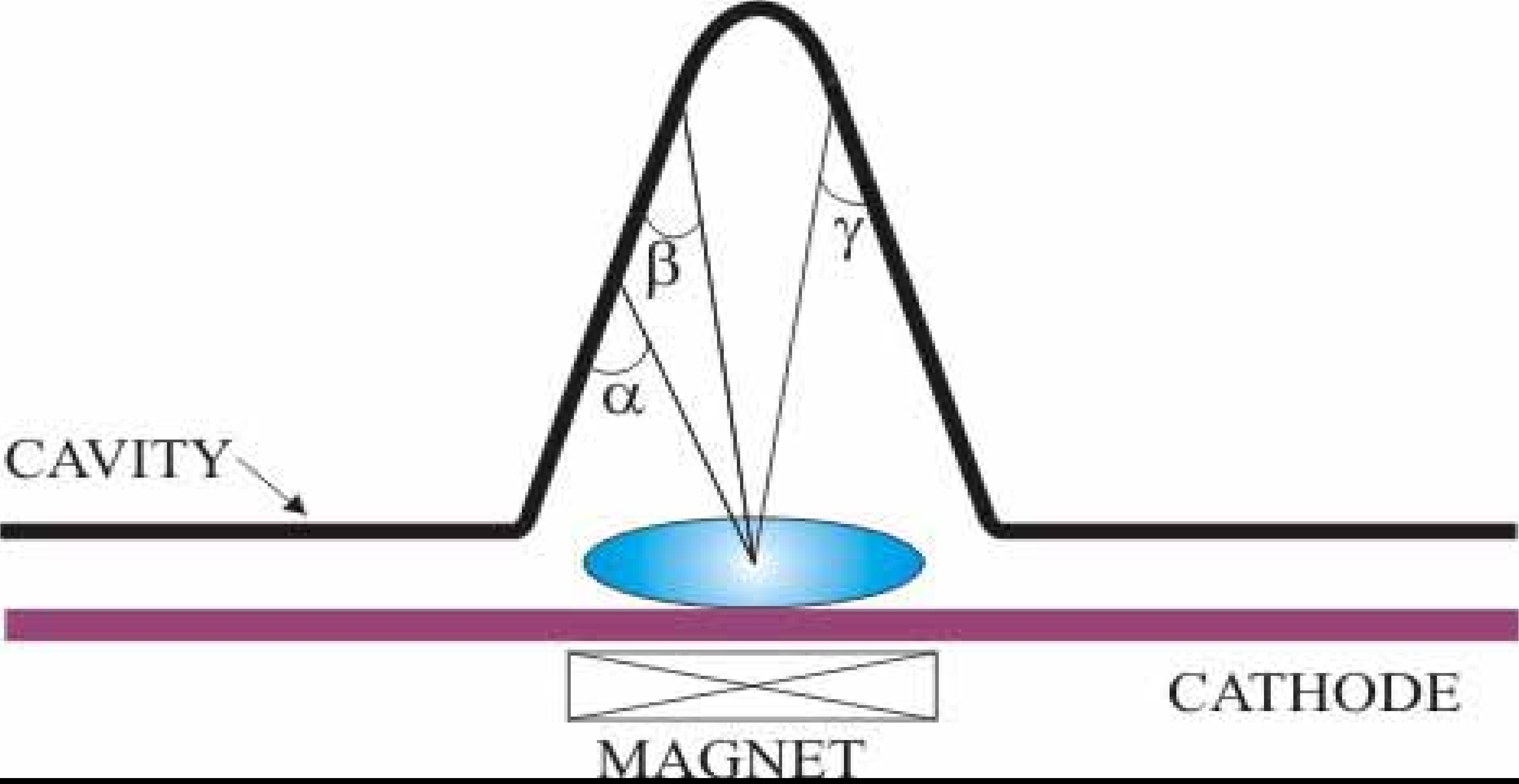




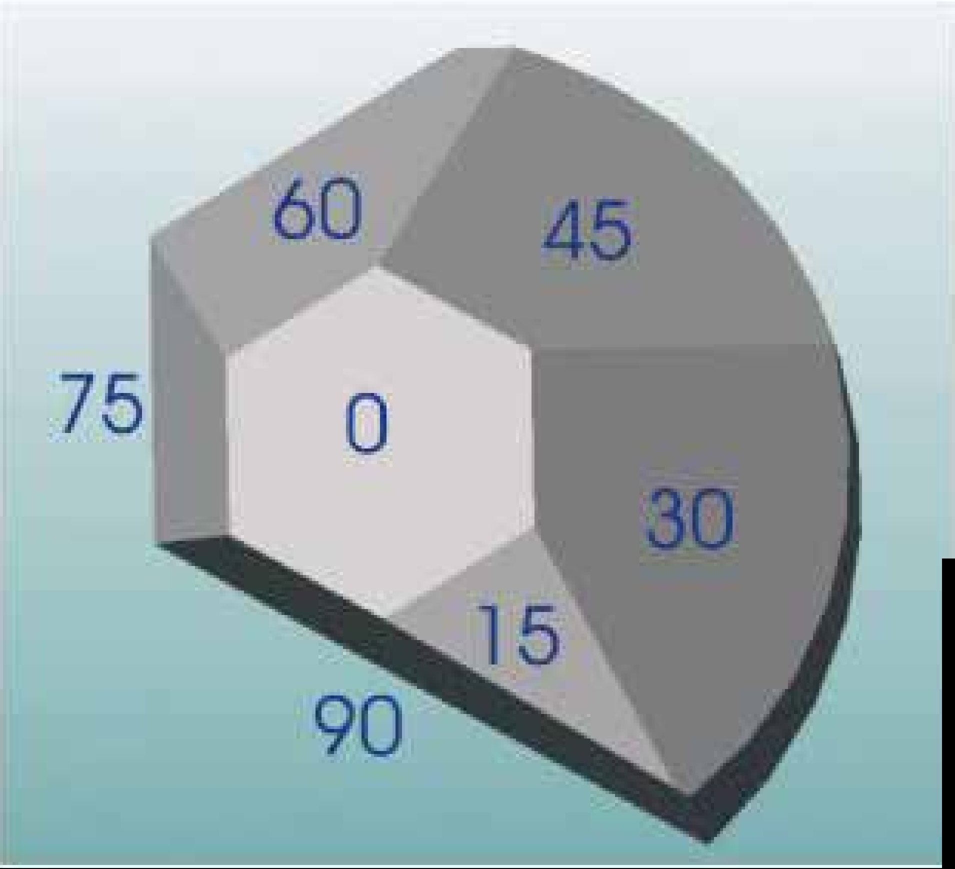




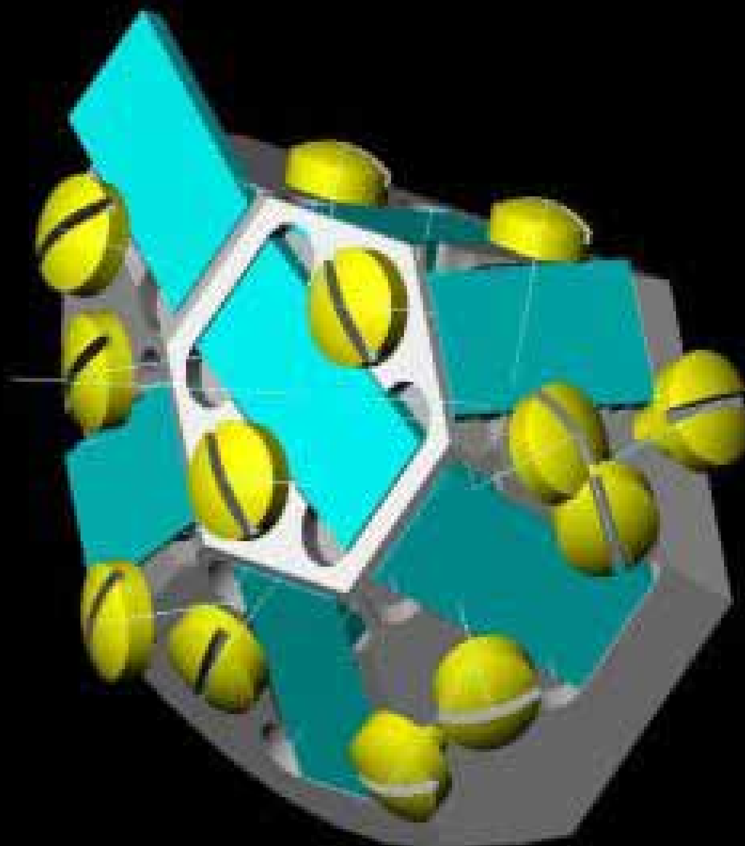

Q
α
Eacc (Mv/m)

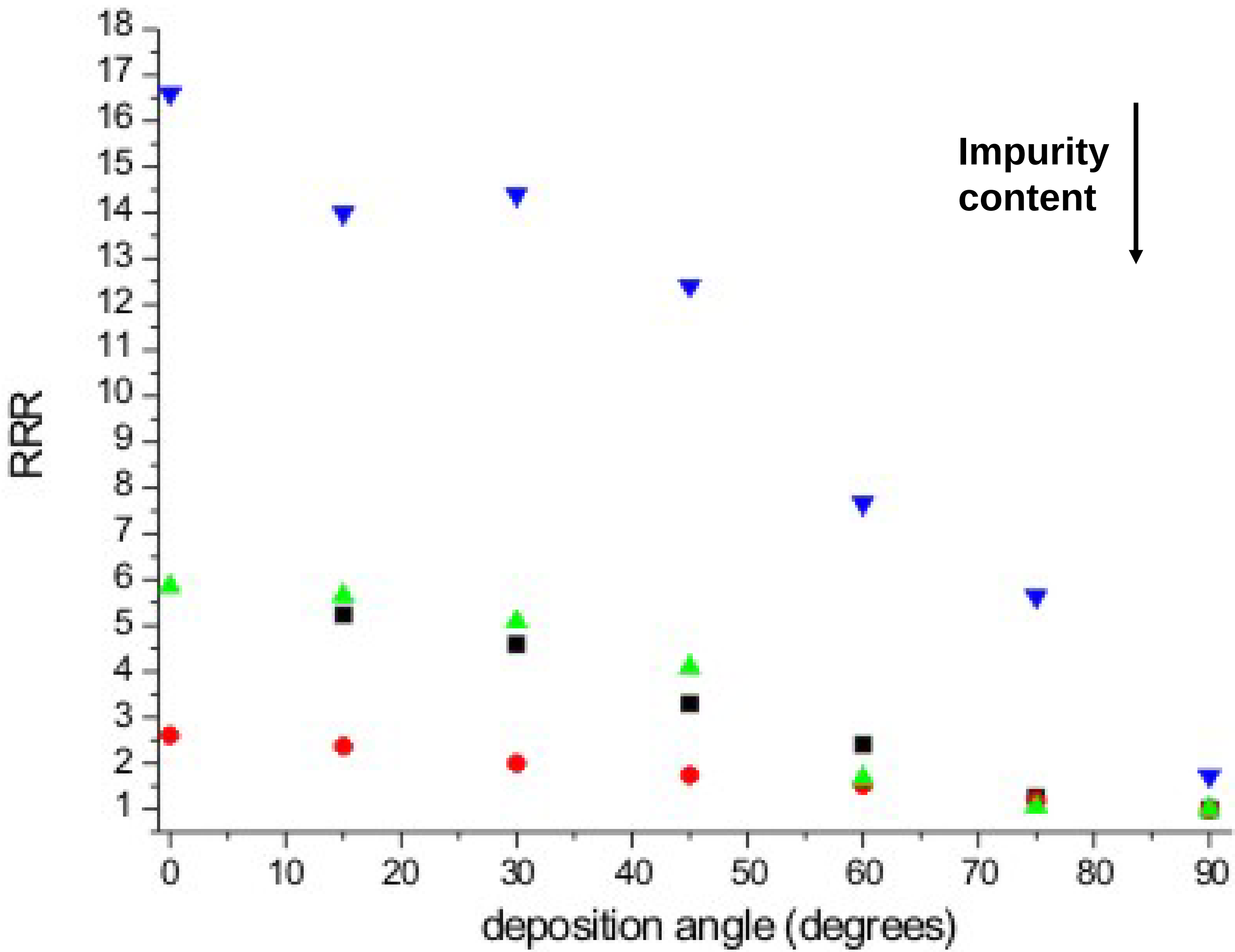


CAVITY
α
β
γ
CATHODE
MAGNET

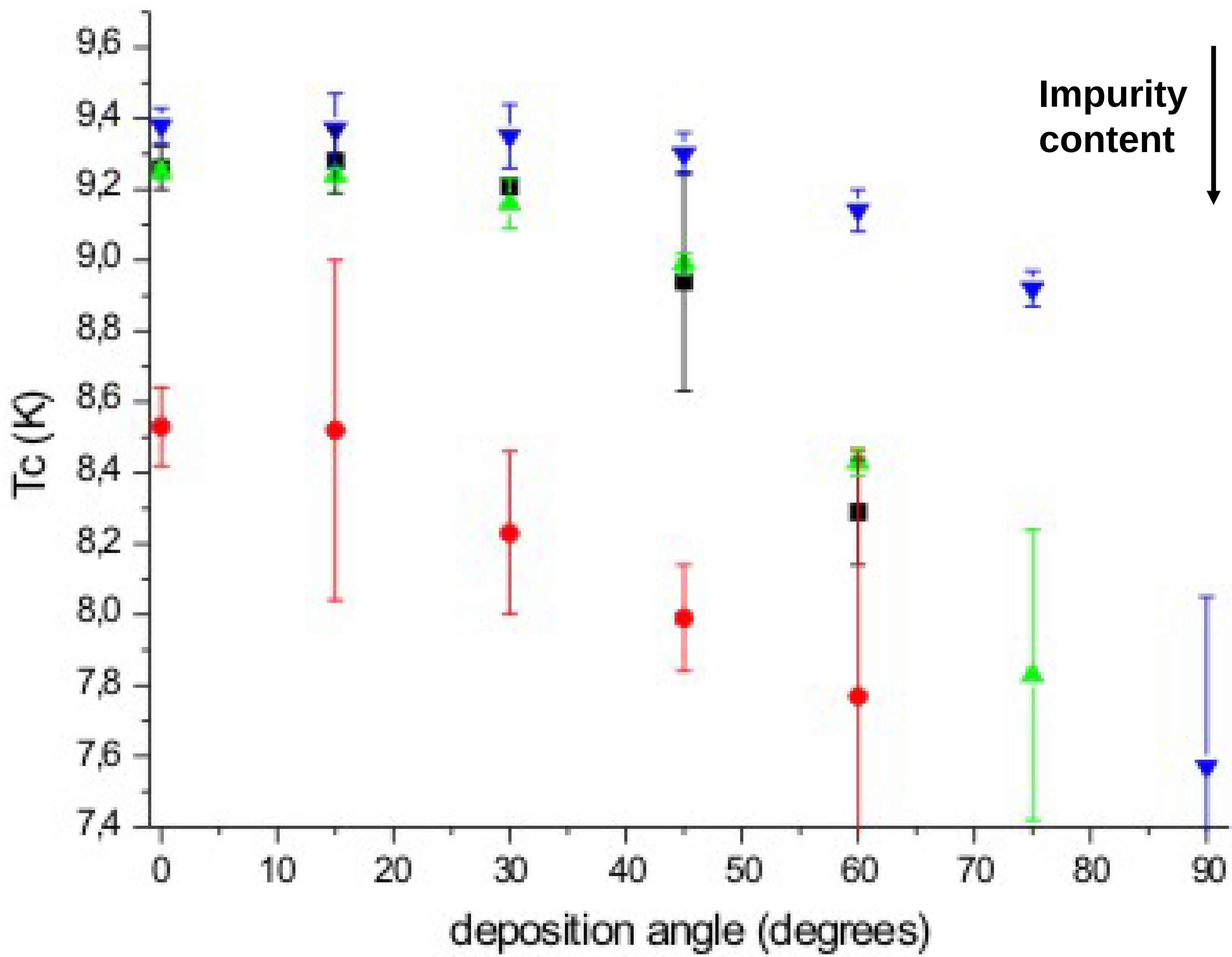


D. Tonini: Thesis
Material Science Department

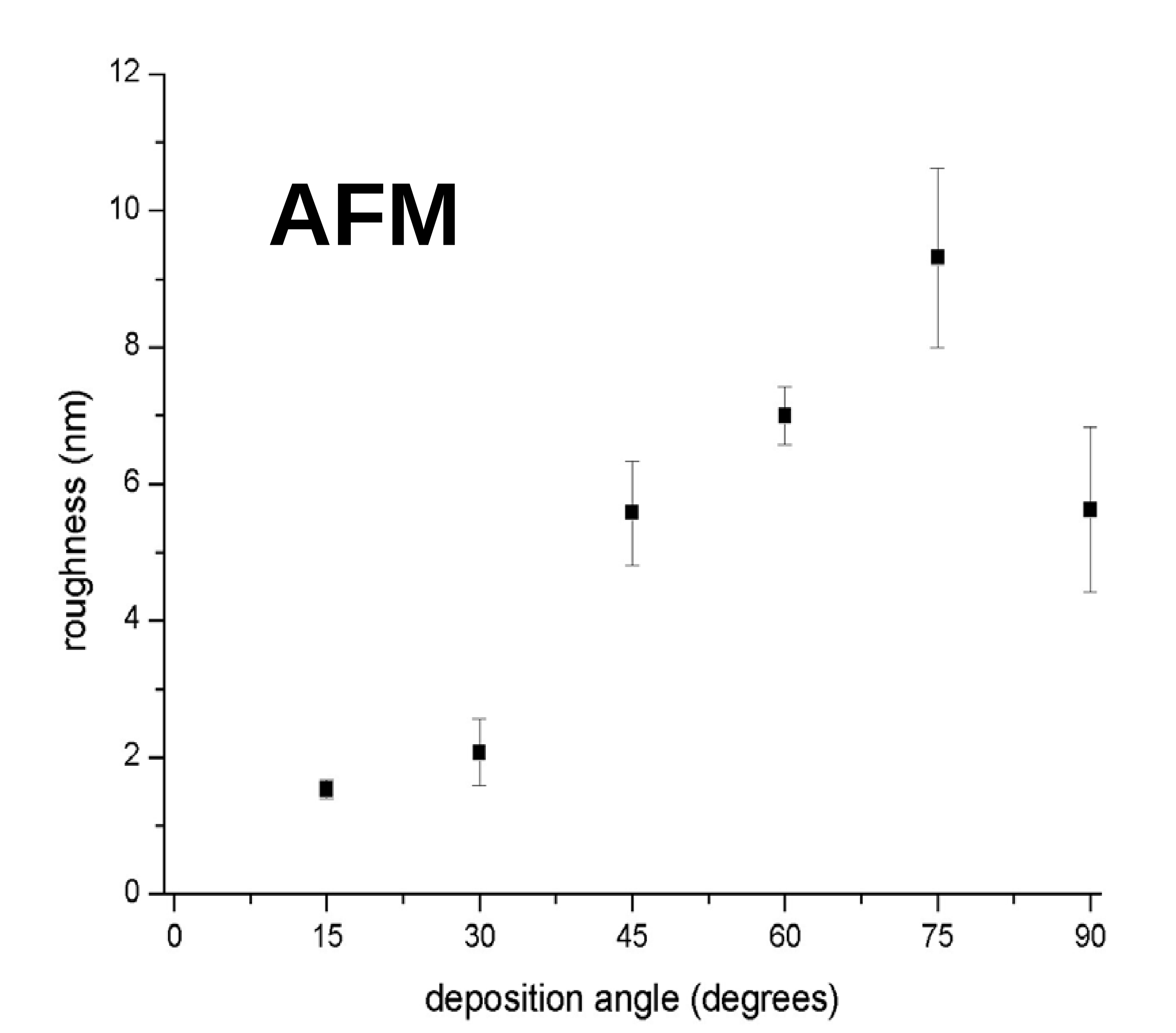


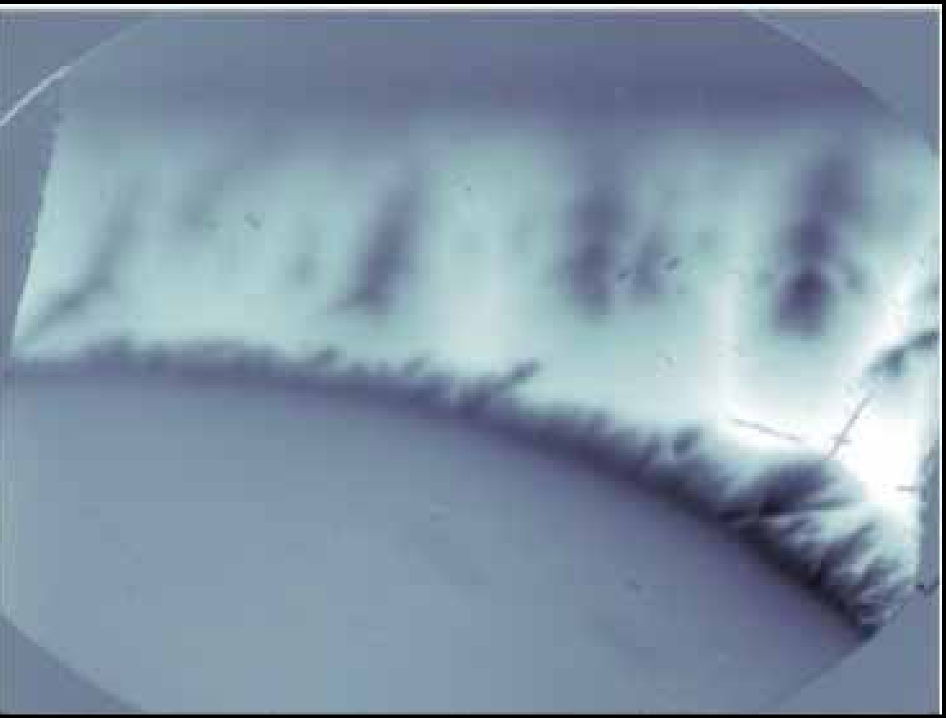


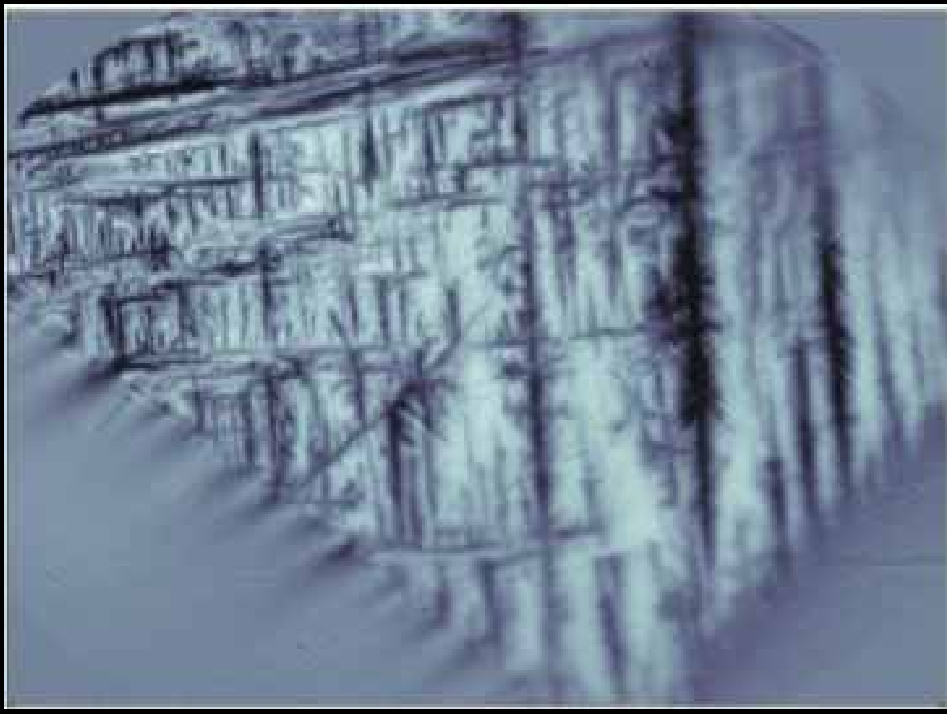
Impurity content
RRR
deposition angle (degrees)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
60
70
80
90



Impurity
content
Tc (K)
9,6
9,4
9,2
9,0
8,8
8,6
8,4
8,2
8,0
7,8
7,6
7,4
0
10
20
30
40
50
60
70
80
90
deposition angle (degrees)

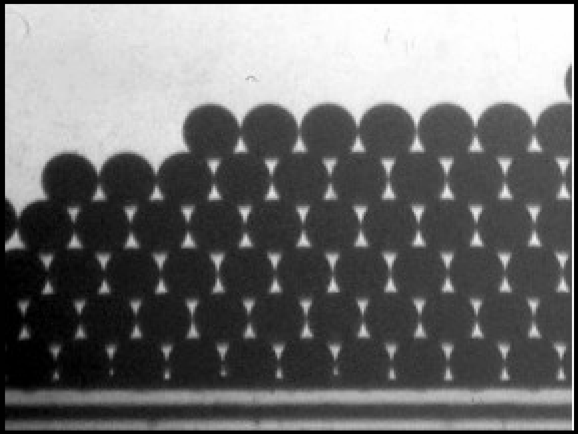

AFM
roughness (nm)
deposition angle (degrees)
0
2
4
6
8
10
12
0
15
30
45
60
75
90



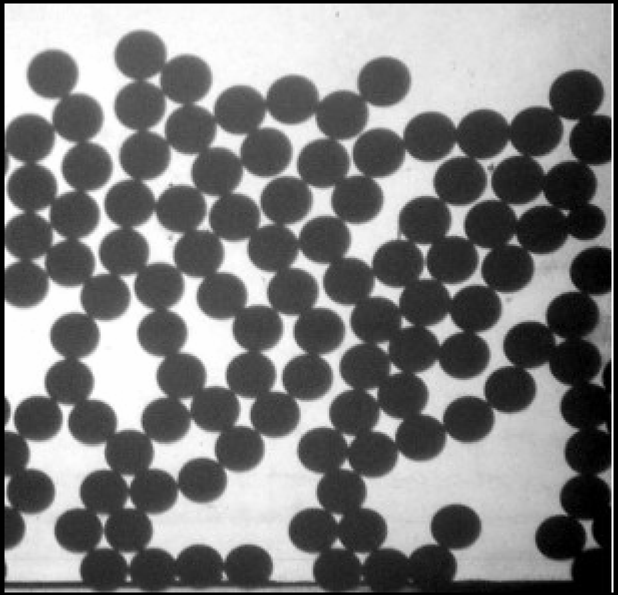


Magneto-optical images of film deposited at target - substrate angle of 0 (top) and 45 (bottom) degrees. depositions are performed onto copper substrate. External applied field is 176 mT at T = 5K

Simulation of the field growth



Target Parallel to the Substrate



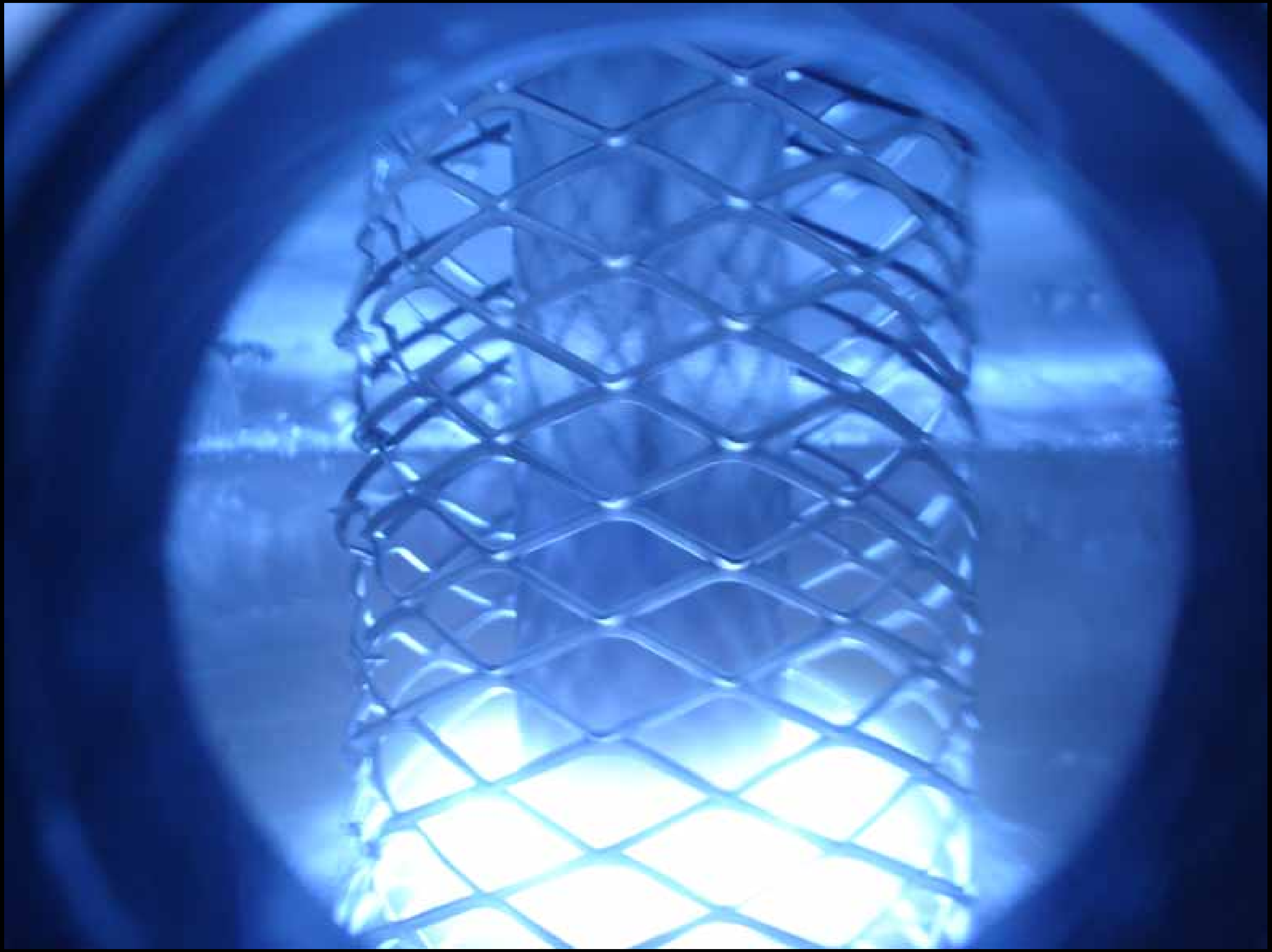
Angle of 45 degrees between target and substrate

Nb sputtered films
(in collaboration with Cornel University)

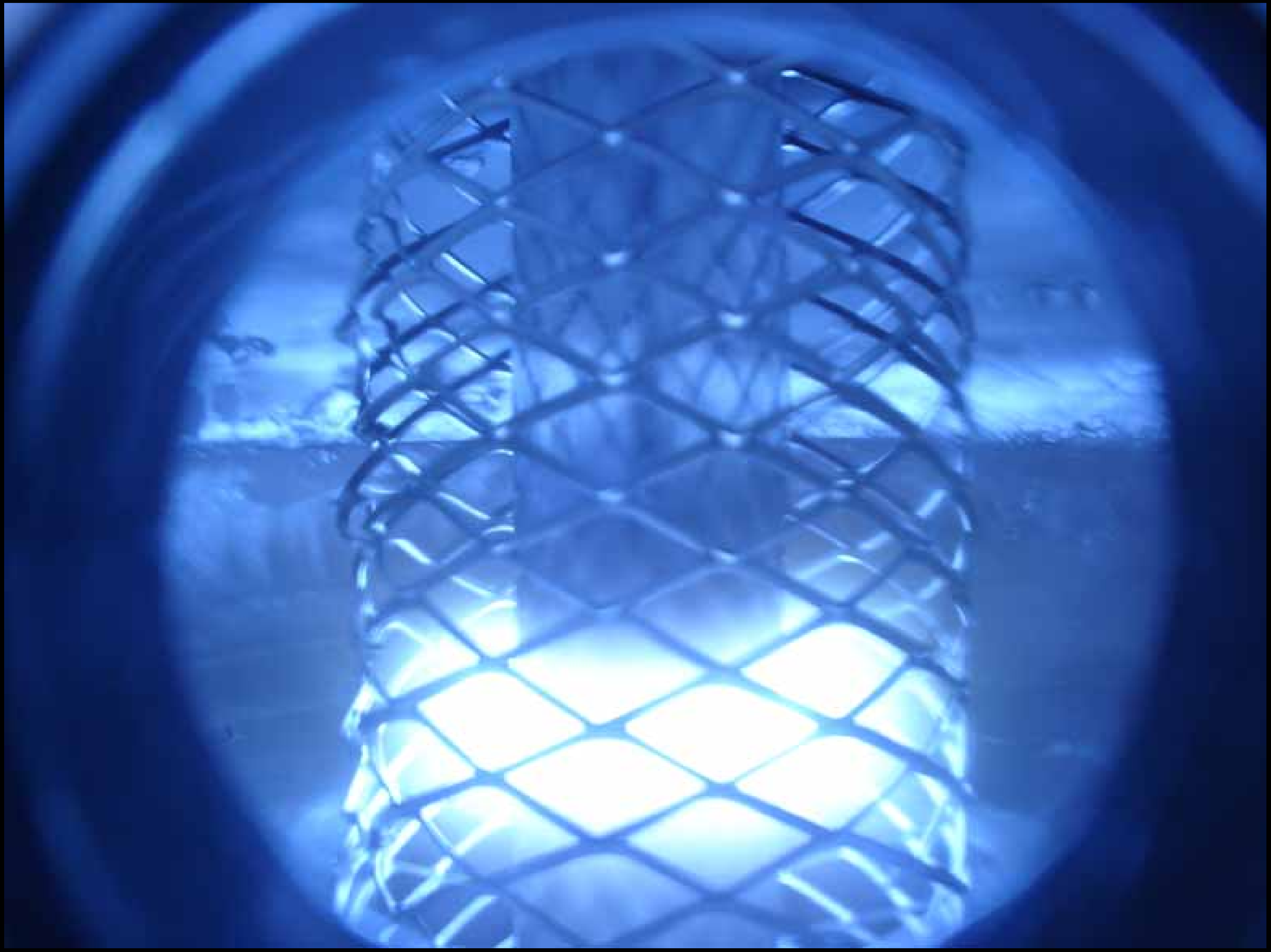
Biased Magnetron Sputtering (in collab. with Cornell University)

Biased grid (G. Lanza , A. Frigo)

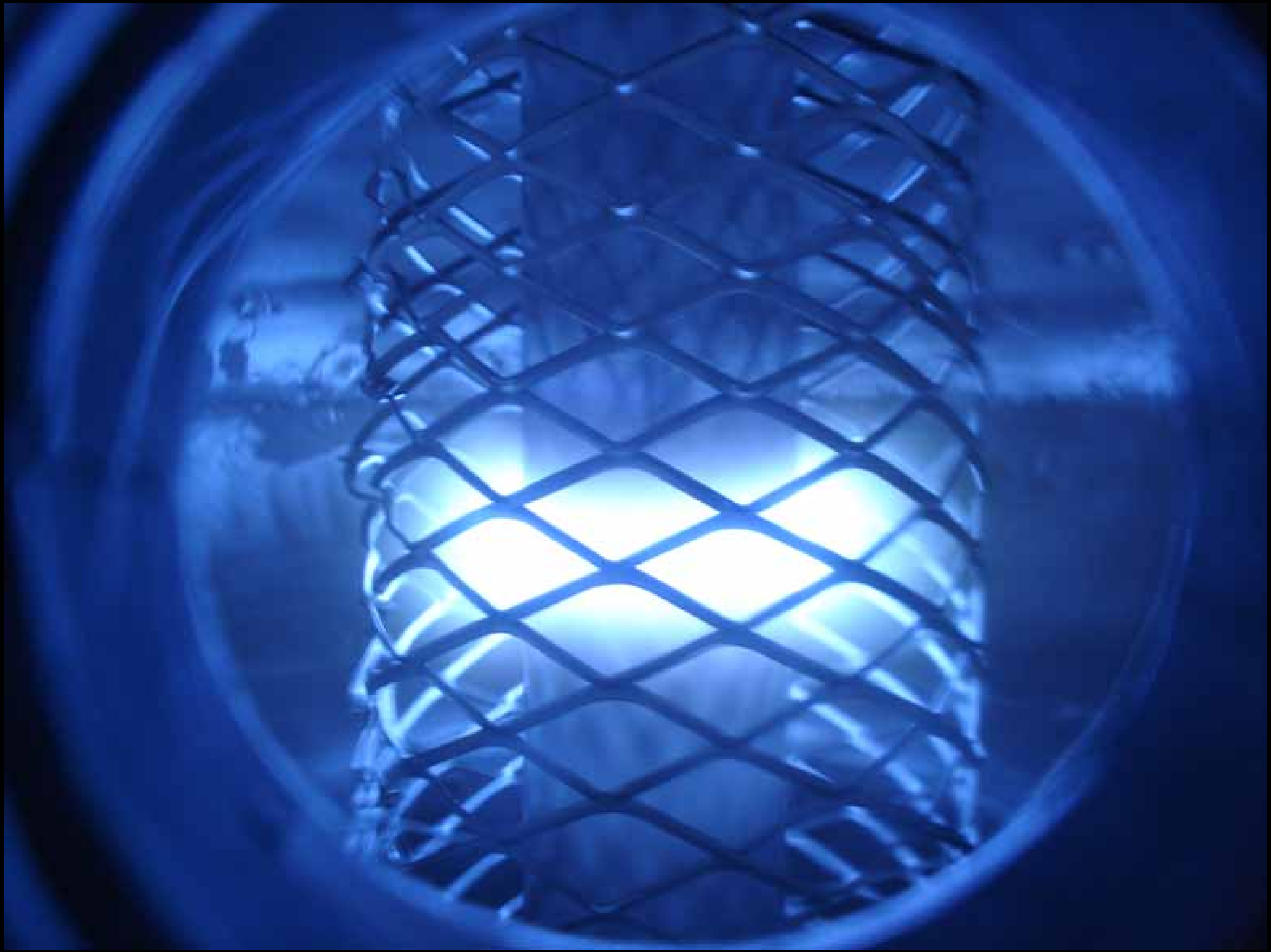
Biased Magnetron Sputtering



Biased Magnetron Sputtering

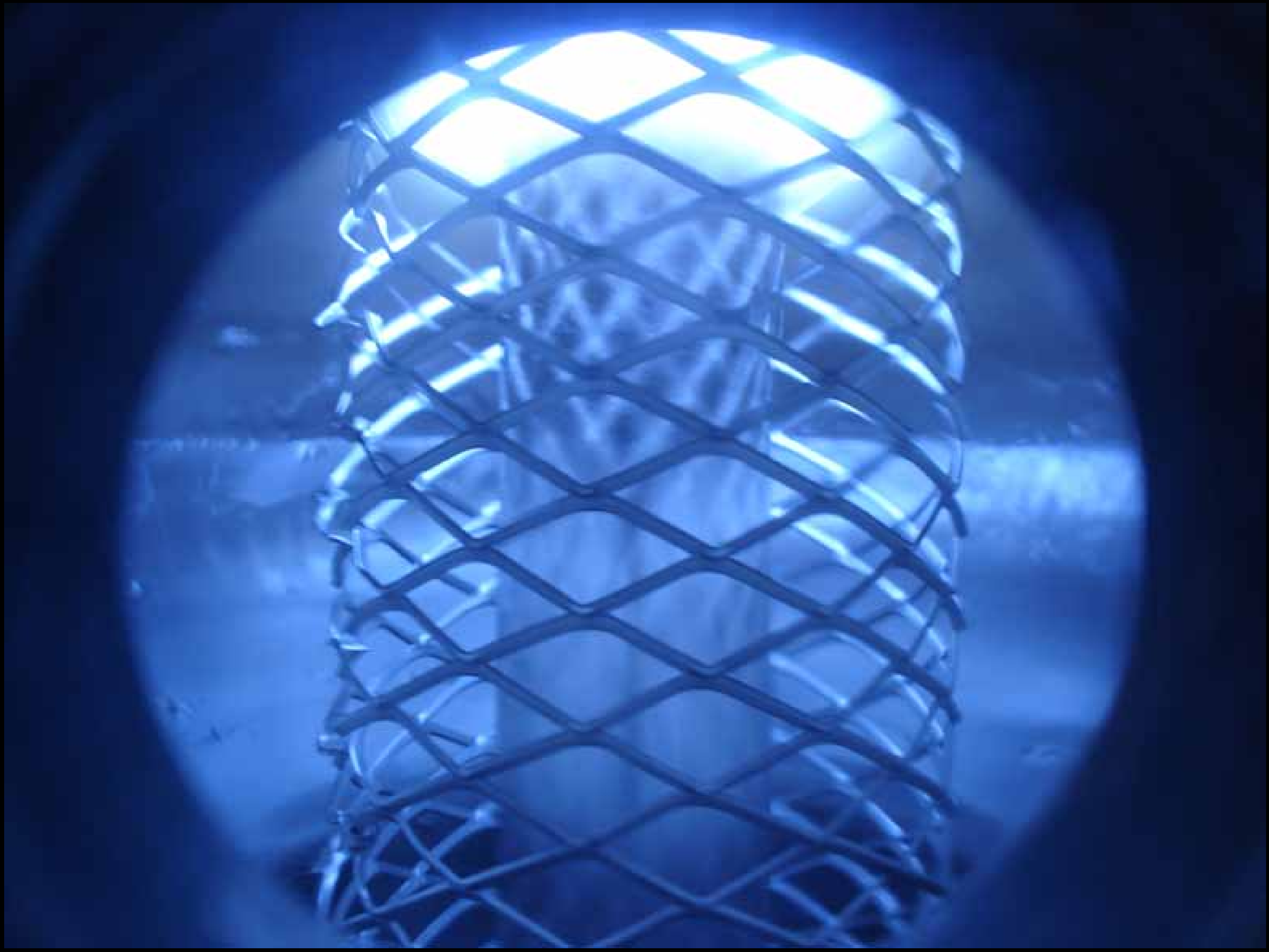


Biased Magnetron Sputtering

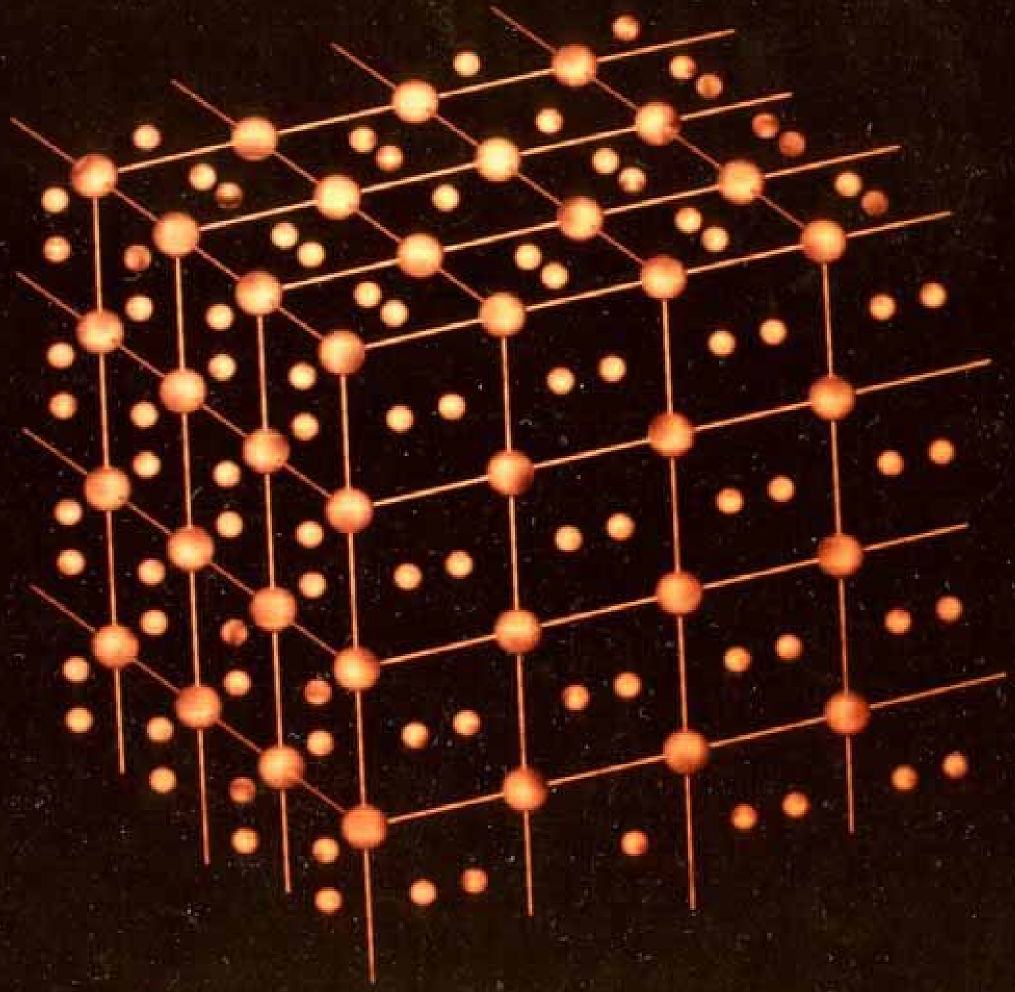


Biased Magnetron Sputtering

Biased Magnetron Sputtering

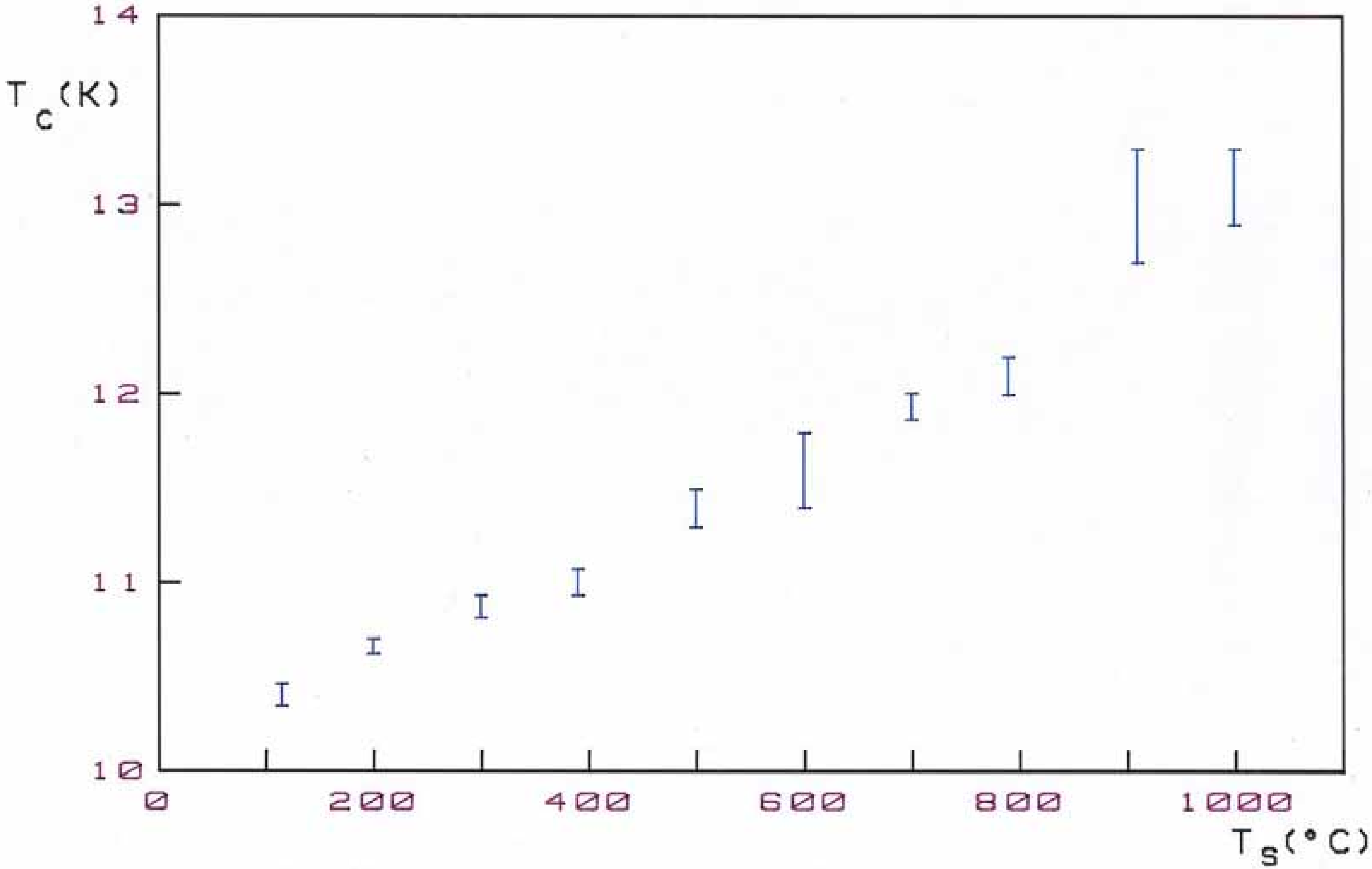


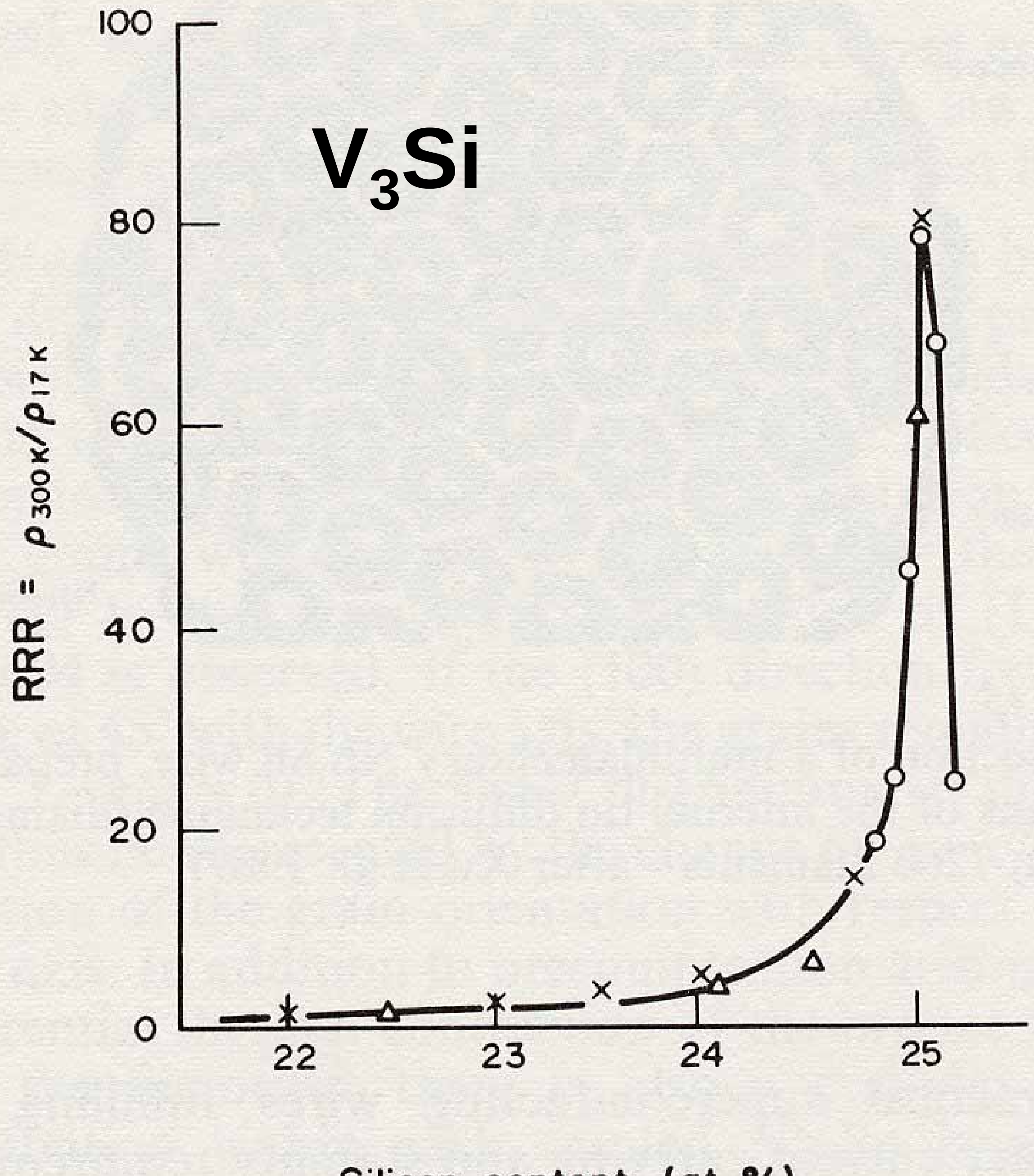
The A15 structure



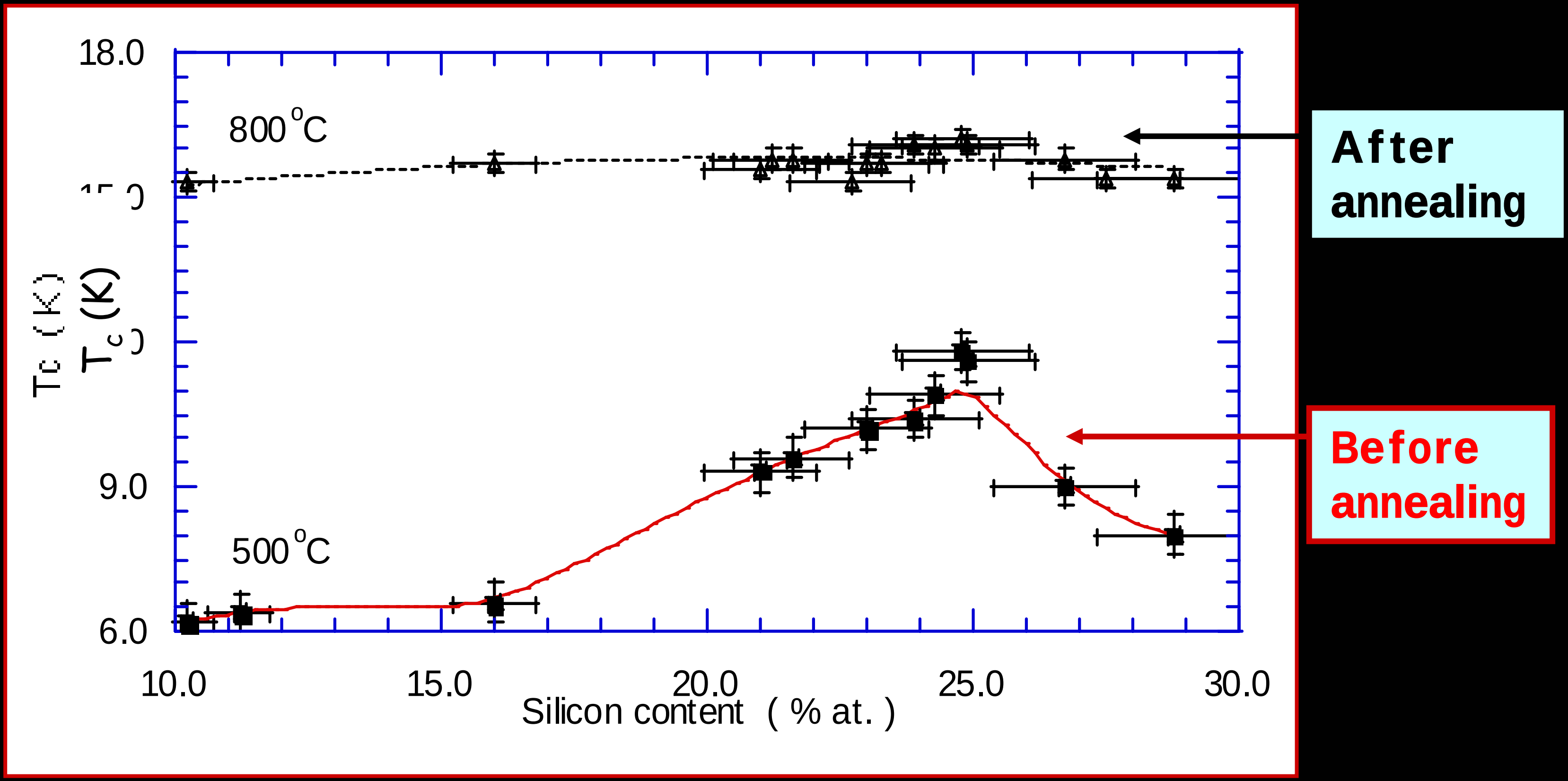
S. Deambrosis, M. Pasetto, N. Pretto

Mo60-Re40

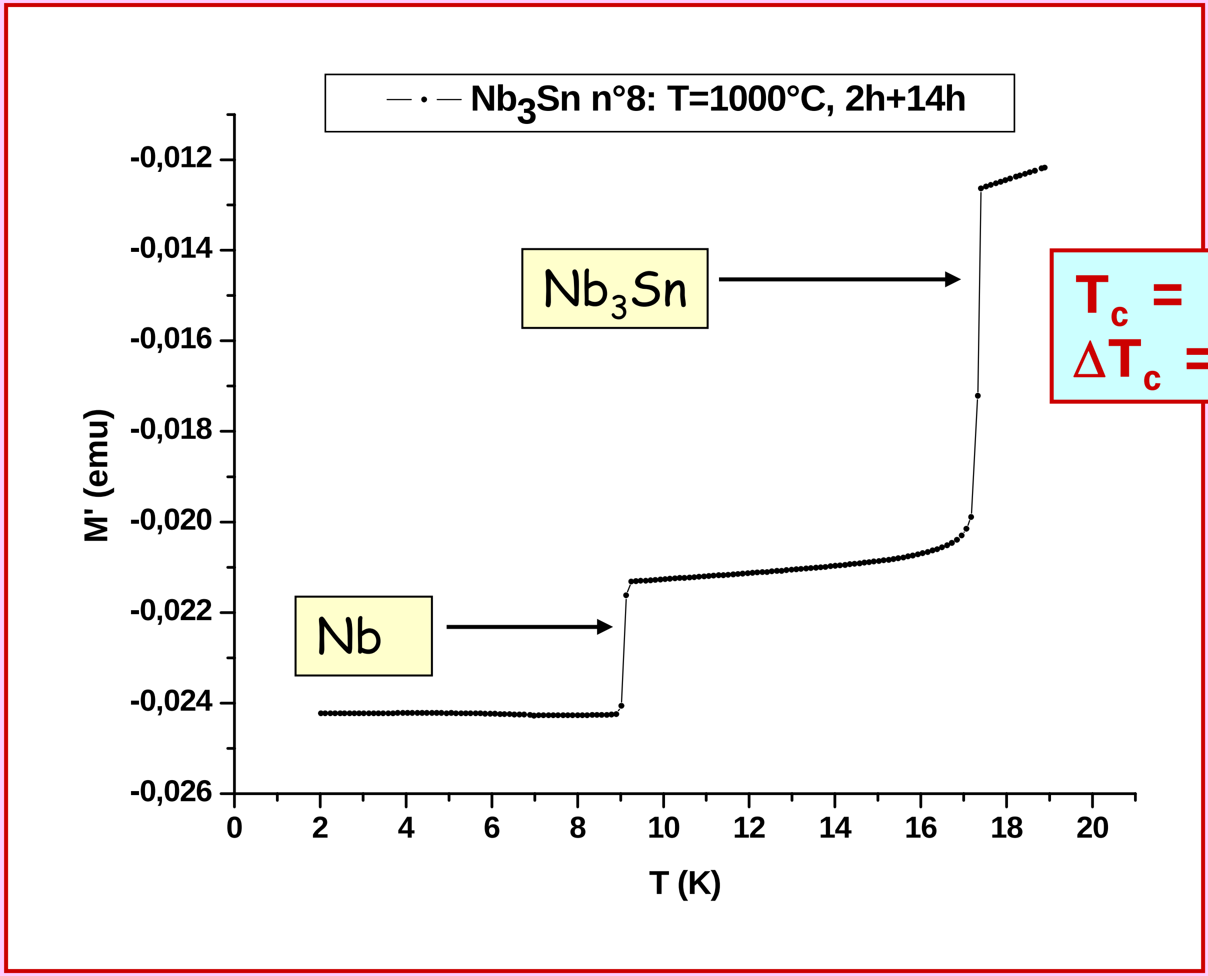



V3Si
100
80
60
40
20
0
RRR = ρ300K/ρ17K
22
23
24
25
Silicon content (at. %)

Silane atmosphere Thermal Diffusion into Vanadium



Nb_3Sn: A Superconductive Transition Curve



T_c = 17.3 K

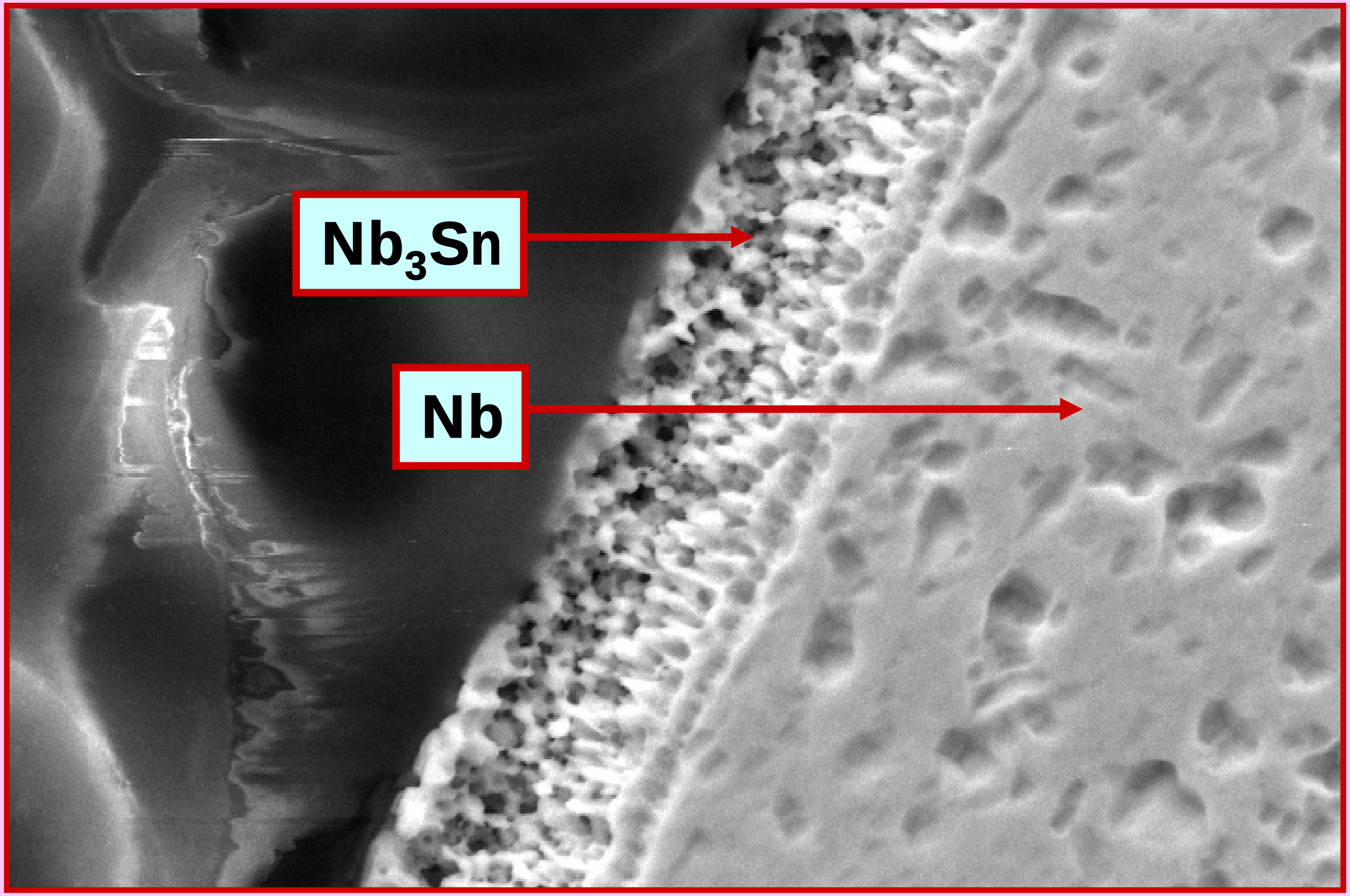
ΔT_c = 0.1 K

Nb_3Sn: Process Parameters and Some Results

Sample n°	Dipping Tempearture	Dipping time	Annealing time	Thickness	T_c	ΔT_c
4	970°C	30 min	6 h	12.8 μm		
5	970°C	2 h	14.5 h	34.3 μm	16.4 K	0.74 K
7	1025°C	2 h	14 h	31.3 μm	17.2 K	0.16 K
8	985°C	2 h	14 h	28.1 μm	17.3 K	0.11 K
9	970°C	1 h	14 h	16.6 μm	17.2 K	0.20 K
10	970°C	30 min	14 h		17.2 K	0.15 K
11	970°C	30 min	3 h		16.8 K	0.45 K
23	985°C	15 min	14 h			
24	985°C	15 min	20 h			
25	985°C	15 min	6 h			
26	990°C	10 min	14 h			
27	990°C	5 min	14 h			
28	986°C	2 min	14 h			

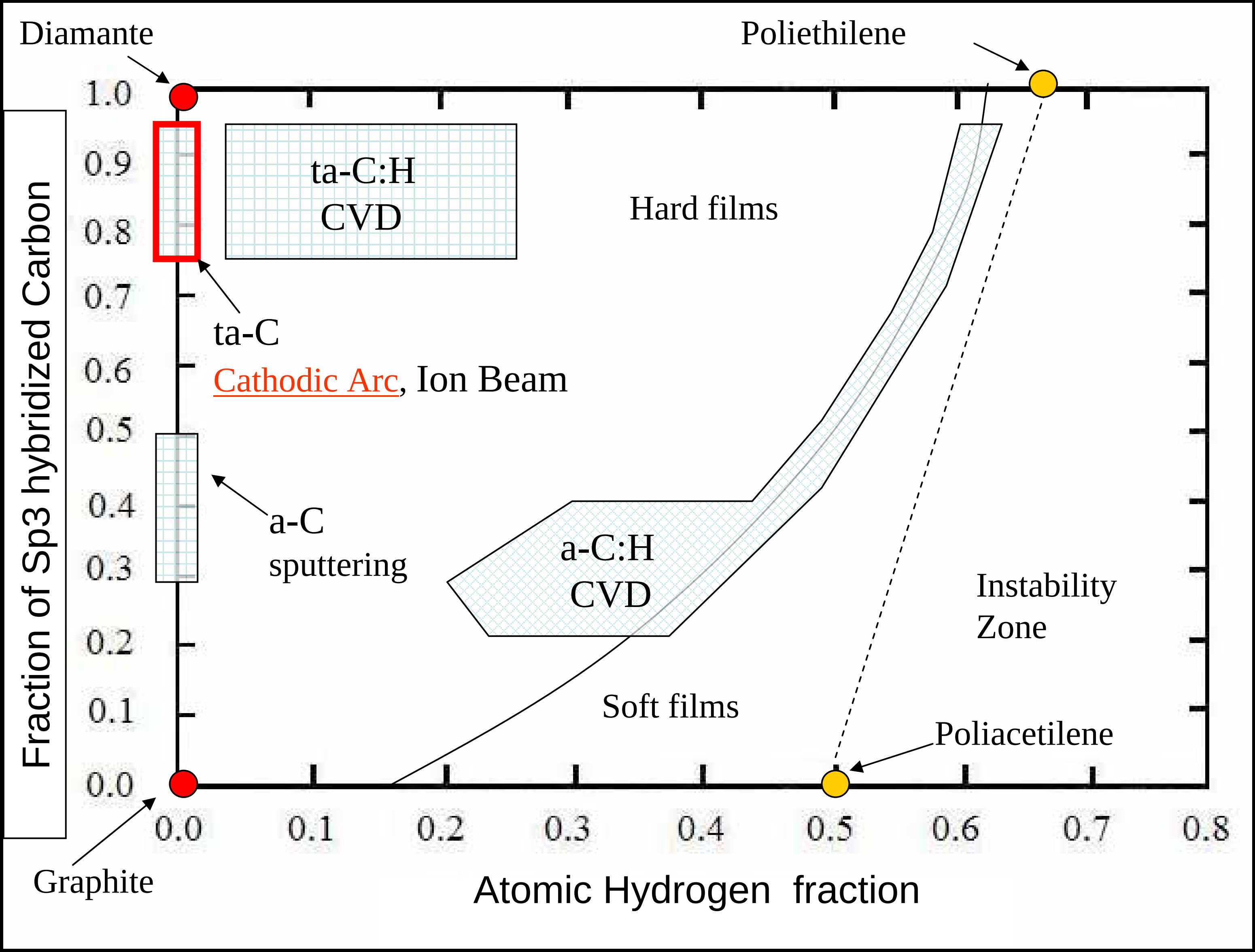
Nb_3Sn: SEM Image

DIPPING TIME = 30 min   ANNEALING TIME = 6 h

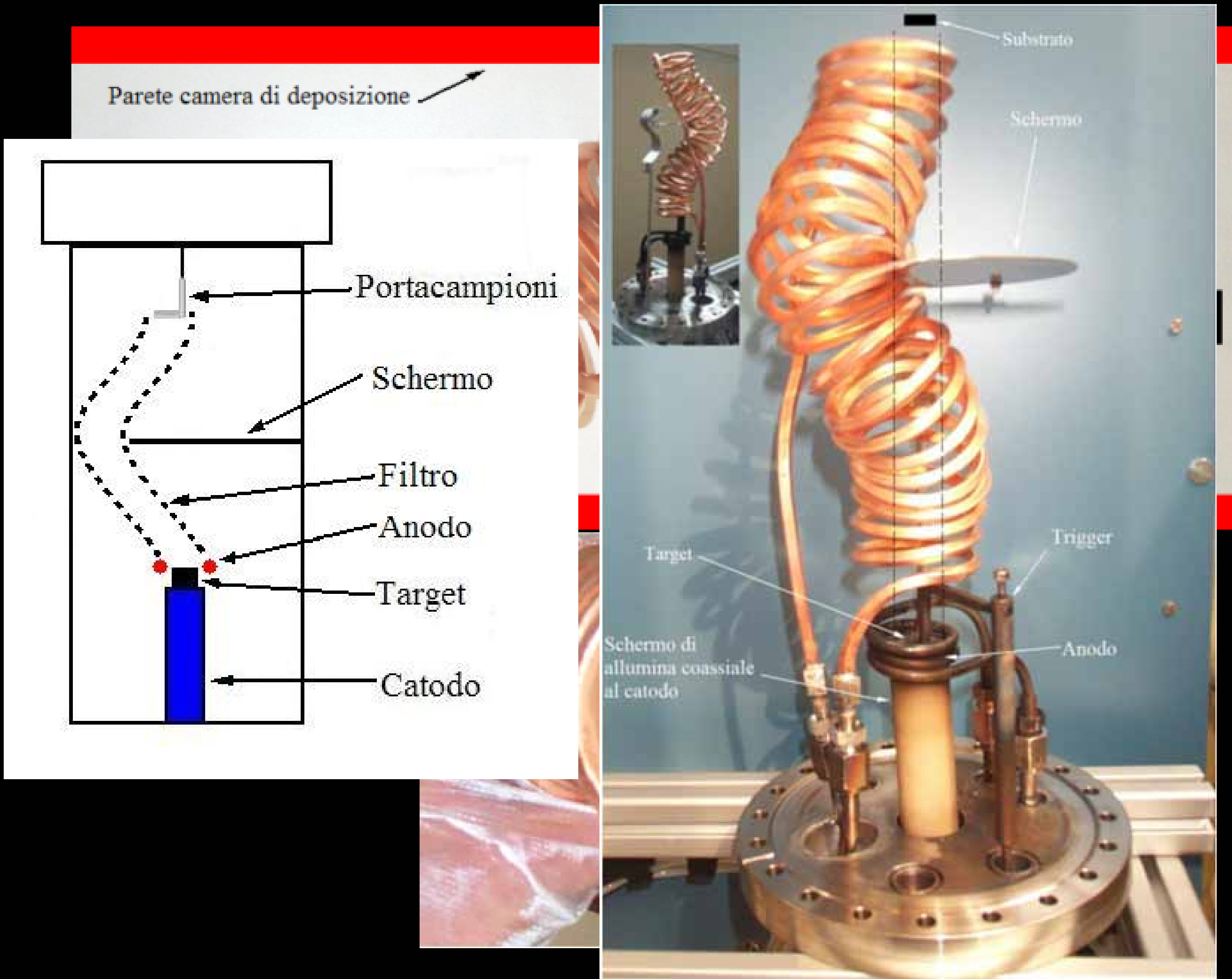


20 µm

DLC Composition



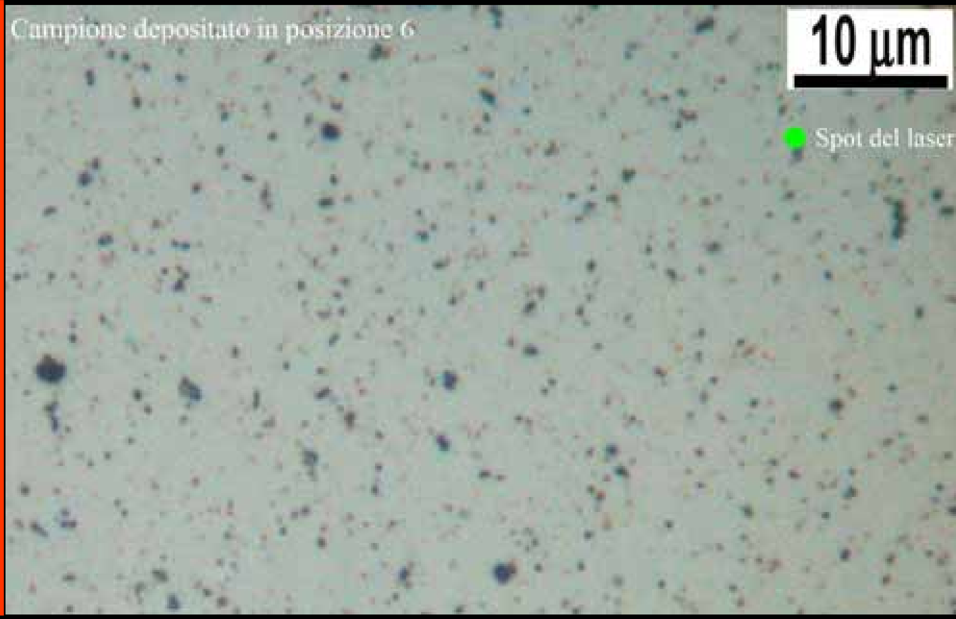
FILTRO PER MACROPARTICELLE



Optical Images of DLC

FILTERED

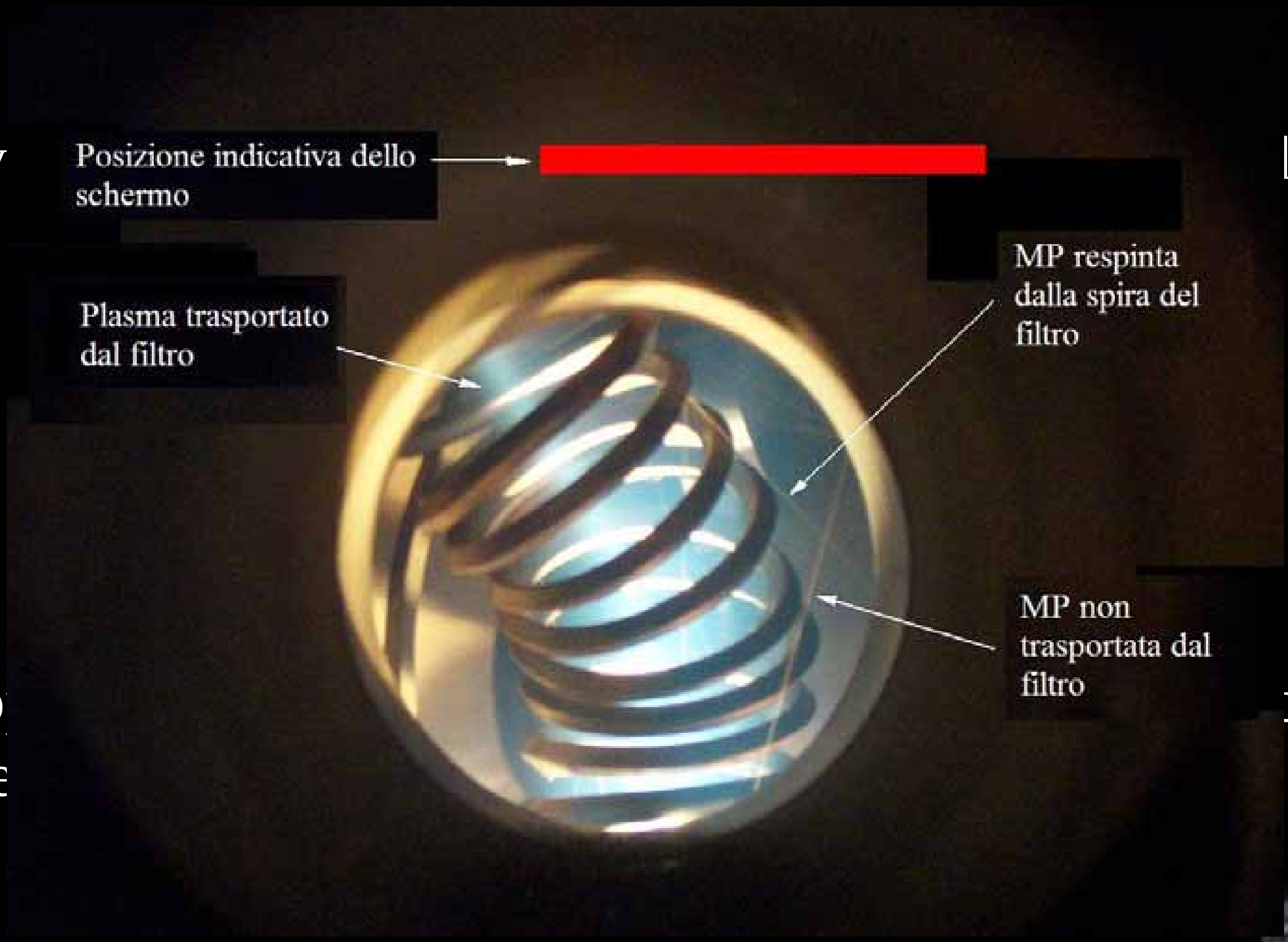
NON Filtered



Deposition time: 6 minutes

Deposition time: 90 s

•Gli ioni v … filtro.



•Le macro … ettate
dallo sche

Ultra cleaning from radiactive contamination of NEUTRINO DETECTOR

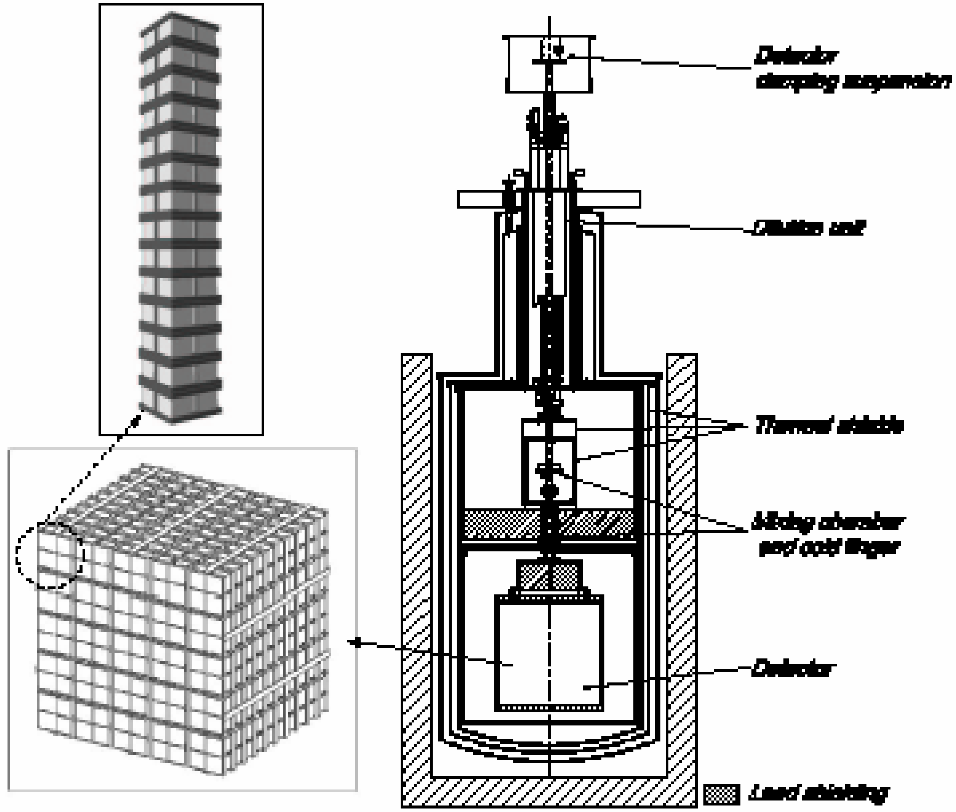


Figure 1: The 1000 crystals CUORE array (bottom left), the single tower of CUORE (top left) and the experimental set-up (right)

We wish to lower the U and Th contamination on the copper frames under the detectable level

THE POLISHING SYSTEM

1. ABRASIVE CLEANING, GRINDING and MECHANICAL POLISHING
2. SOLVENT CLEANING: Chlorofluorocarbons and Liquid CO2
3. SEMI-AQUEOUS CLEANERS: Terpenes; Alcohols; Ketones; Esters; Amines
4. ULTRASONIC CLEANING
5. MEGASONIC CLEANING
6. SAPONIFIERS, SOAPS, AND DETERGENTS
7. WIPE-CLEAN
8. SUPERCRITICAL FLUIDS
9. CHEMICAL ETCHING
10. ELECTROCHEMICAL POLISHING
11. ELECTROLESS ELECTROLYTIC CLEANING
12. DEBURRING: laser vaporization, thermal pulse flash deburring
13. STRIPPABLE COATINGS
14. OUTGASSING
15. REACTIVE CLEANING: Anodic Oxidation and subsequent removal of the oxide
16. OZONE CLEANING
17. HYDROGEN CLEANING
18. REACTIVE PLASMA CLEANING AND ETCHING
19. PLASMA CLEANING
20. SPUTTER CLEANING
21. ION BEAM CLEANING

Surface Cleaning of CUORE Components

Copper Frames

- Tumbling
- US degreasing
- Electropolishing
- US Rinsing
- Chemical Polishing
- Passivation
- US Rinsing
- Plasma Cleaning
- Ion Gun Cleaning

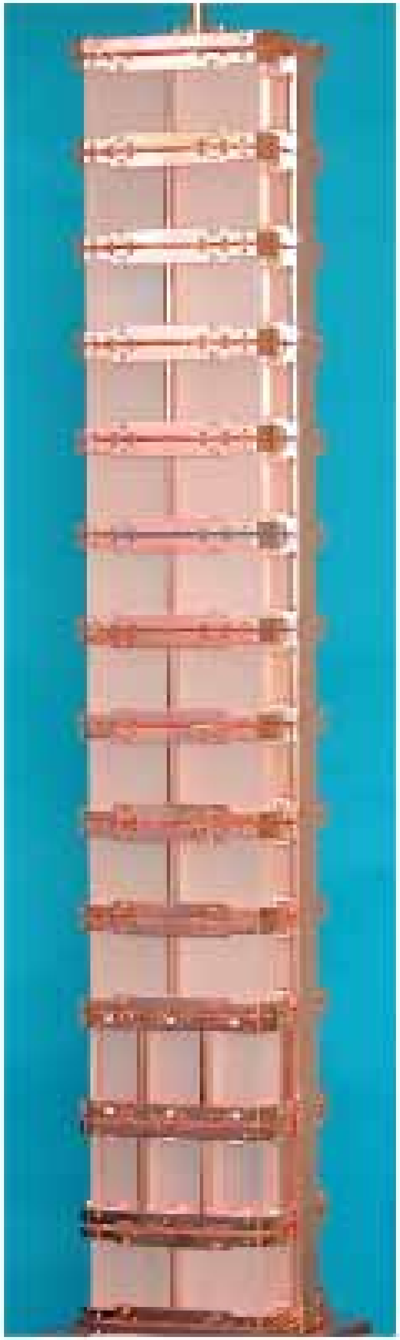
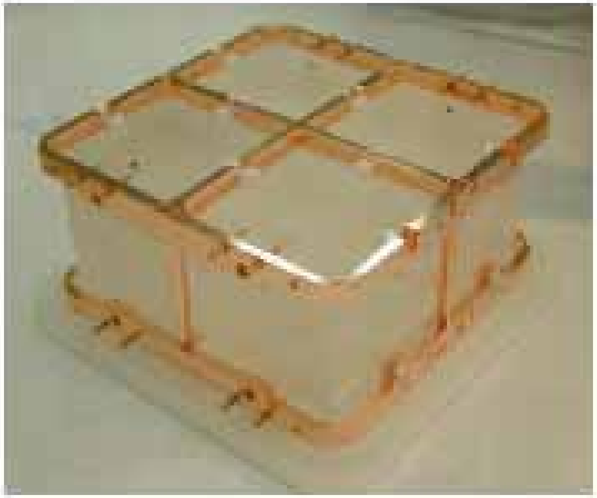
TeO_2 Crystals

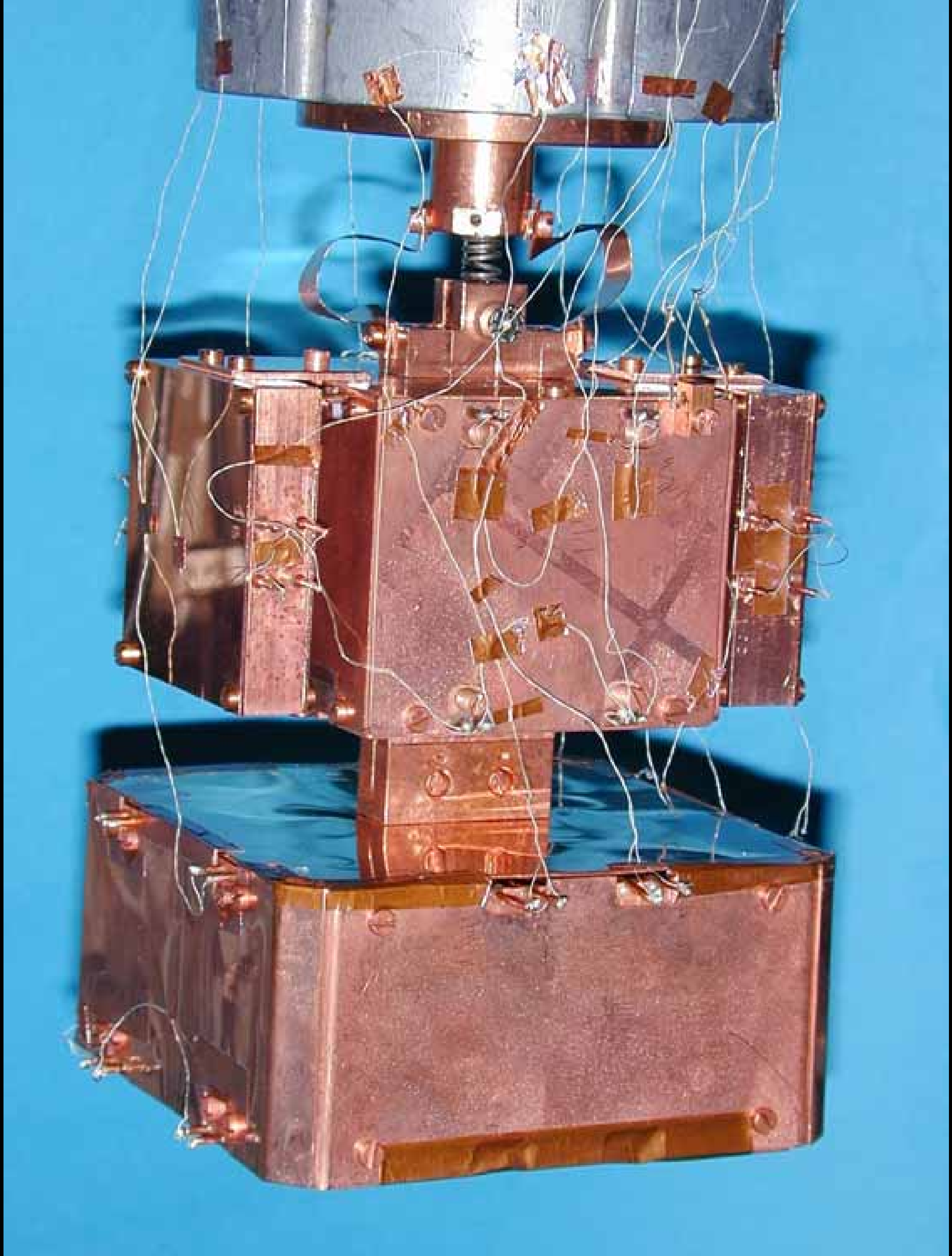
- Plasma Cleaning
- Ion Gun Cleaning

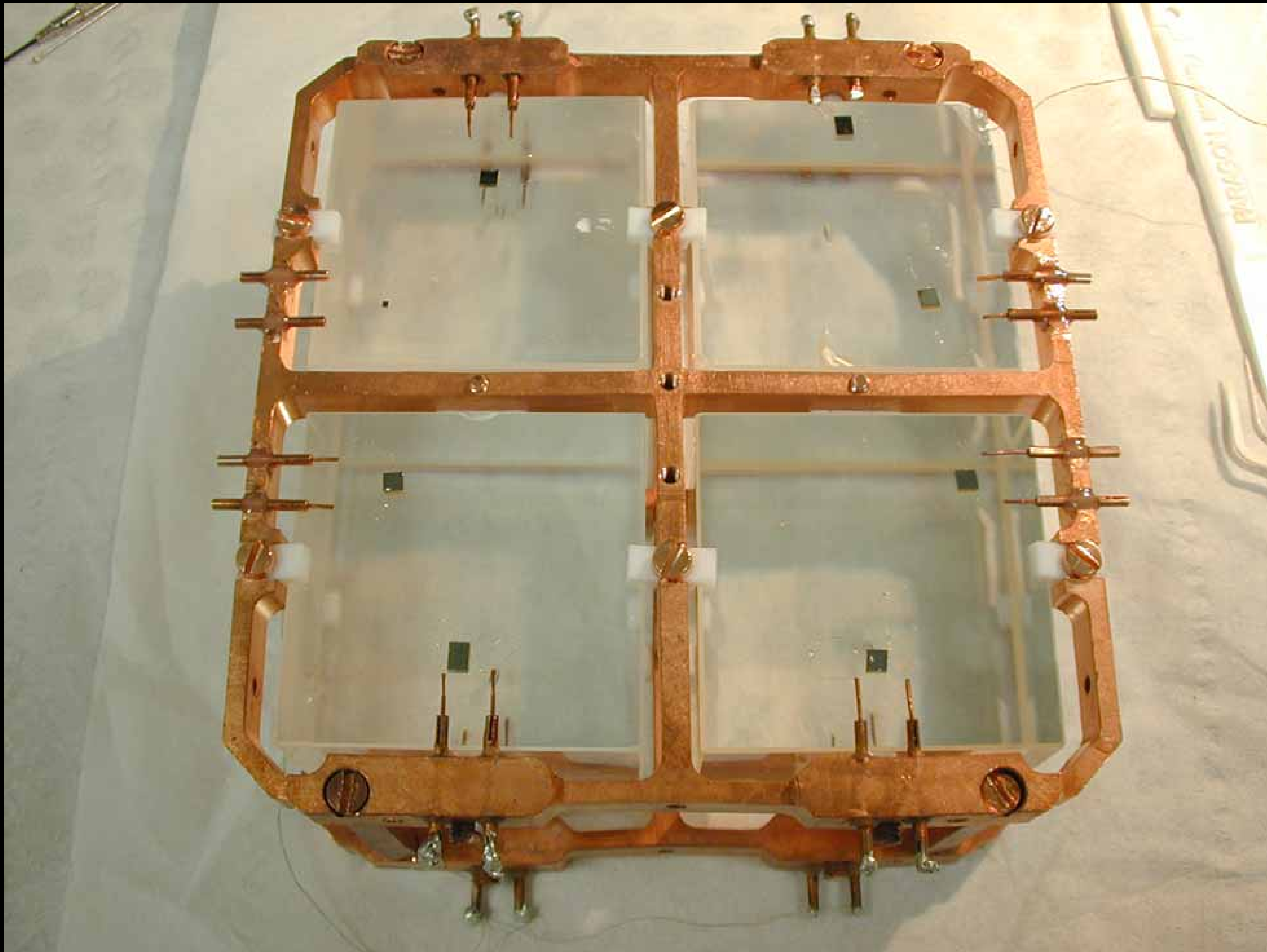
G. Keppel,

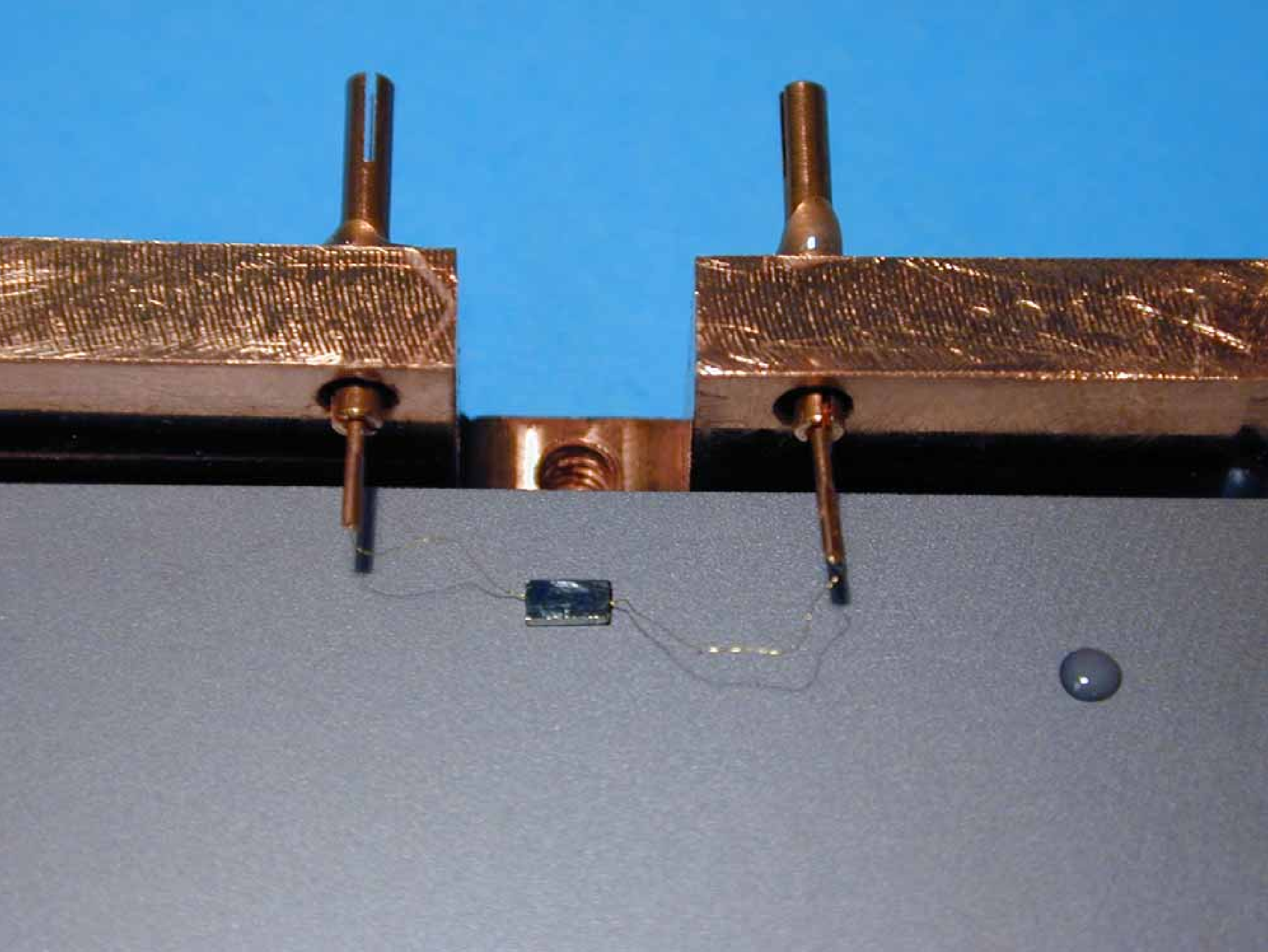
P. Menegatti,

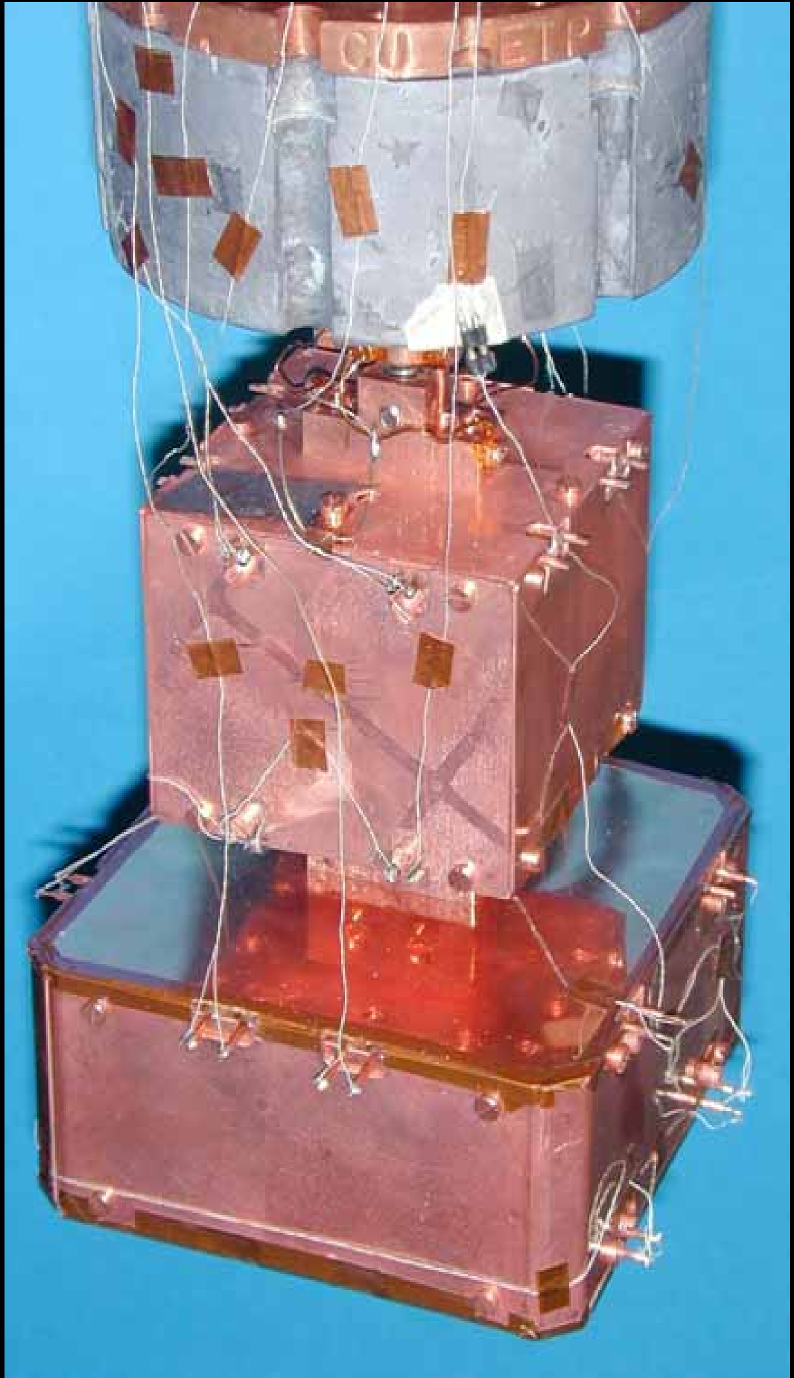
V. Rampazzo

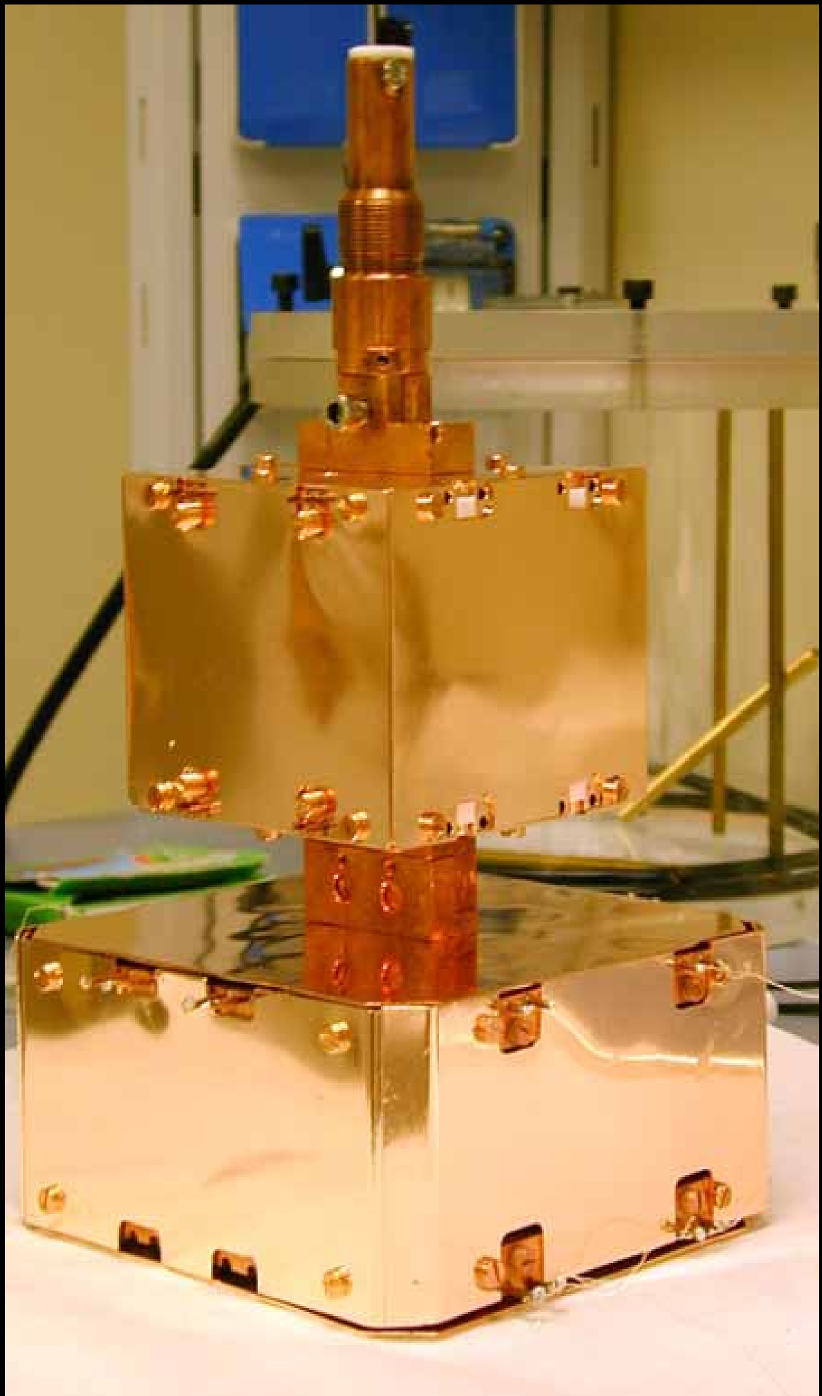



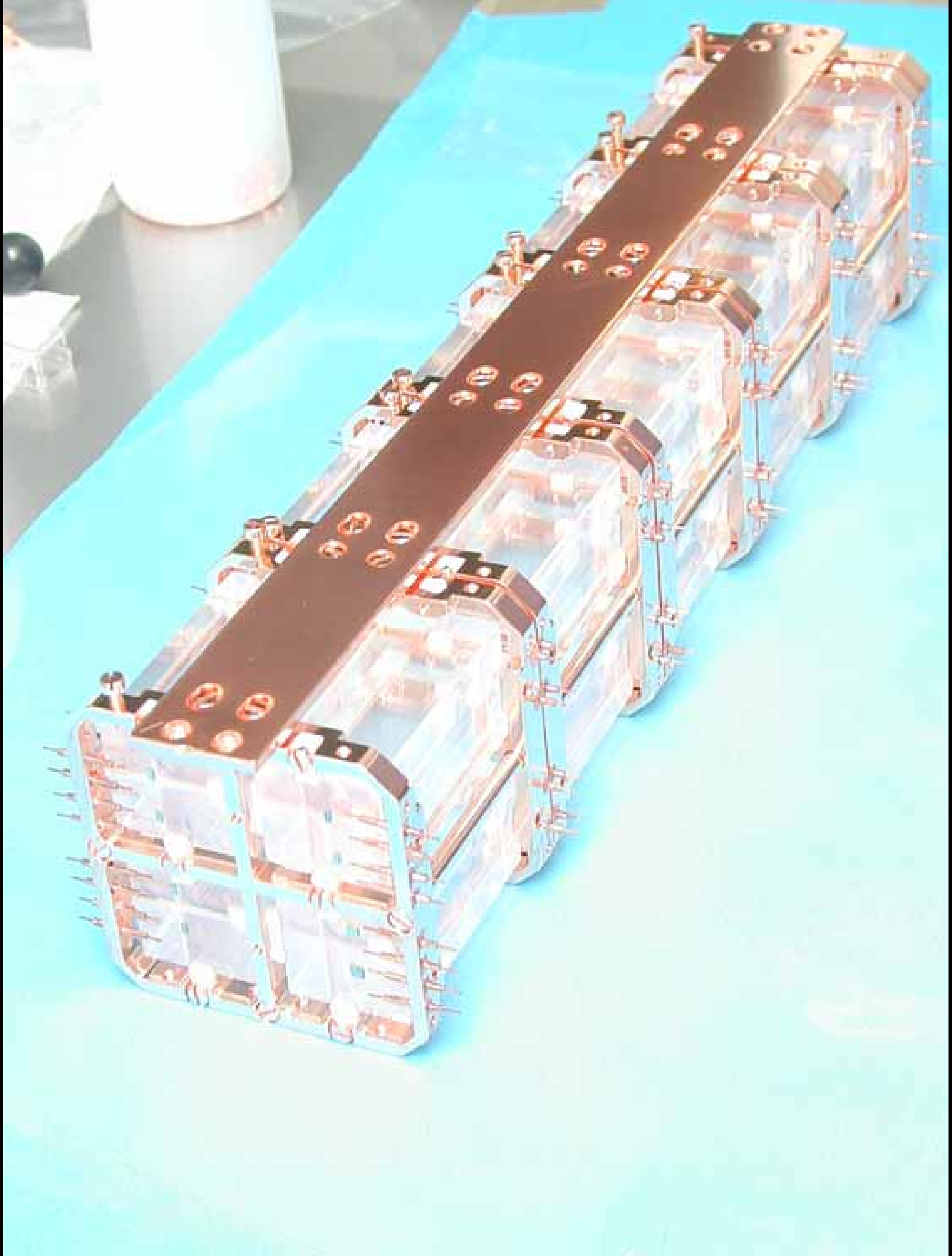



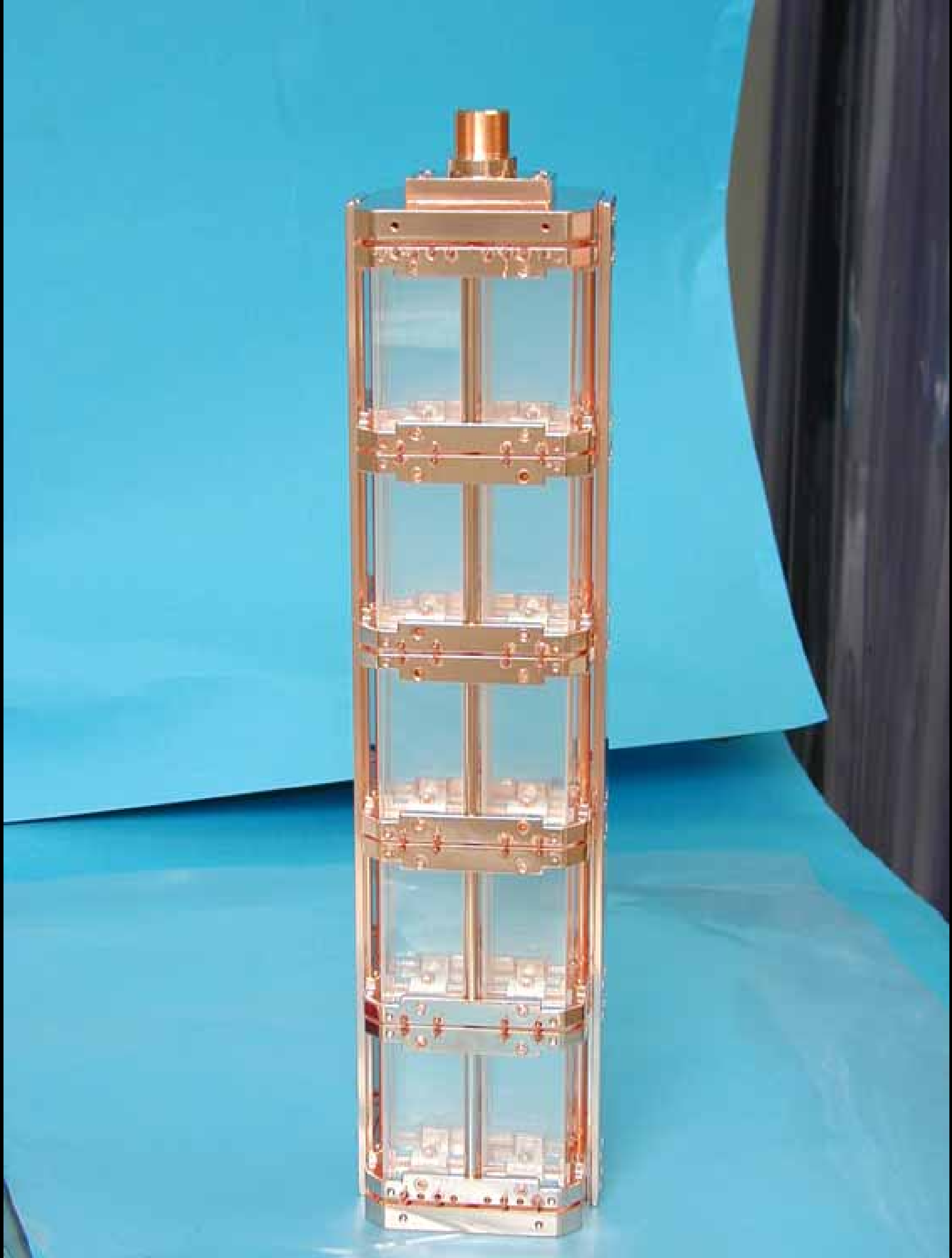


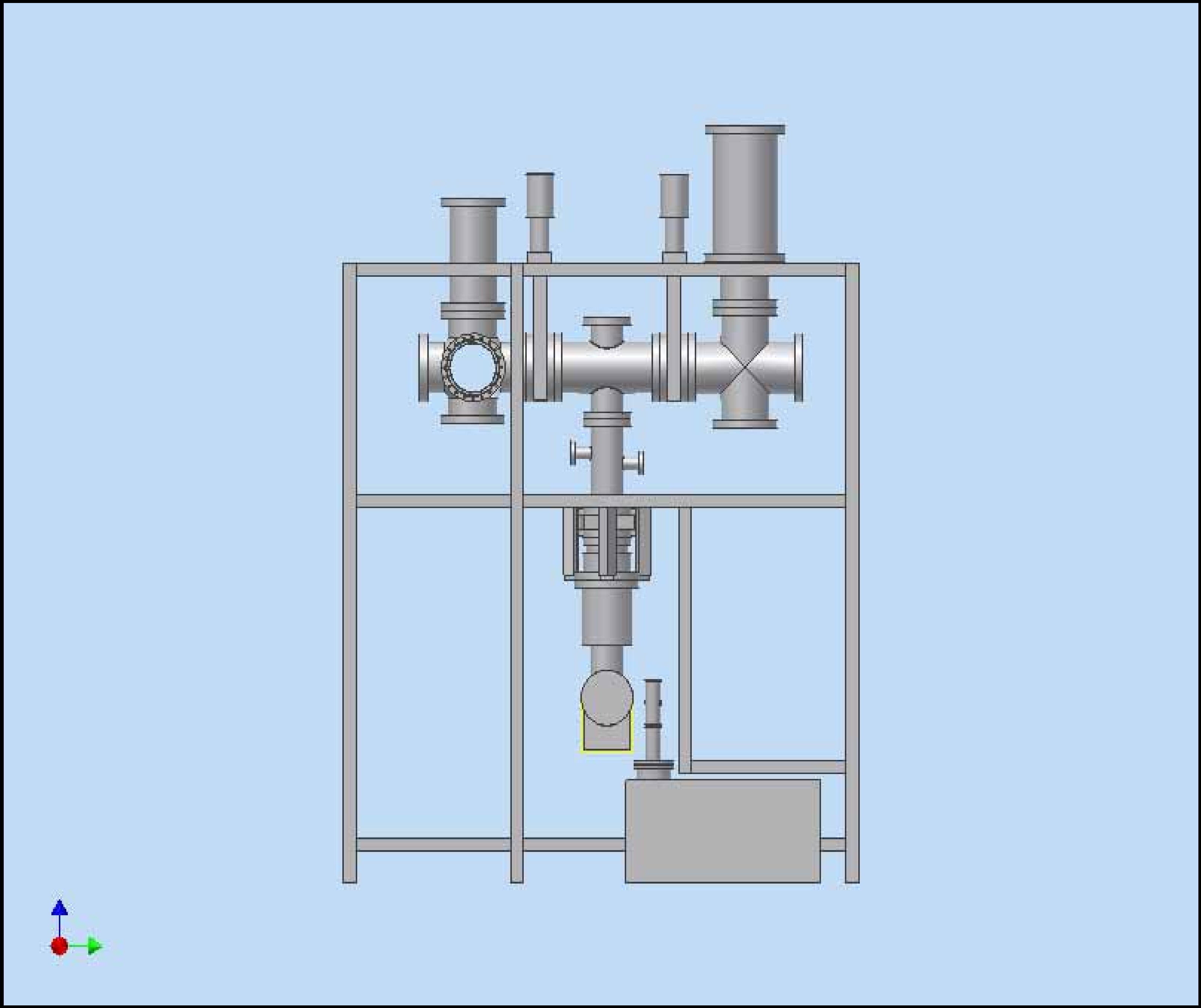




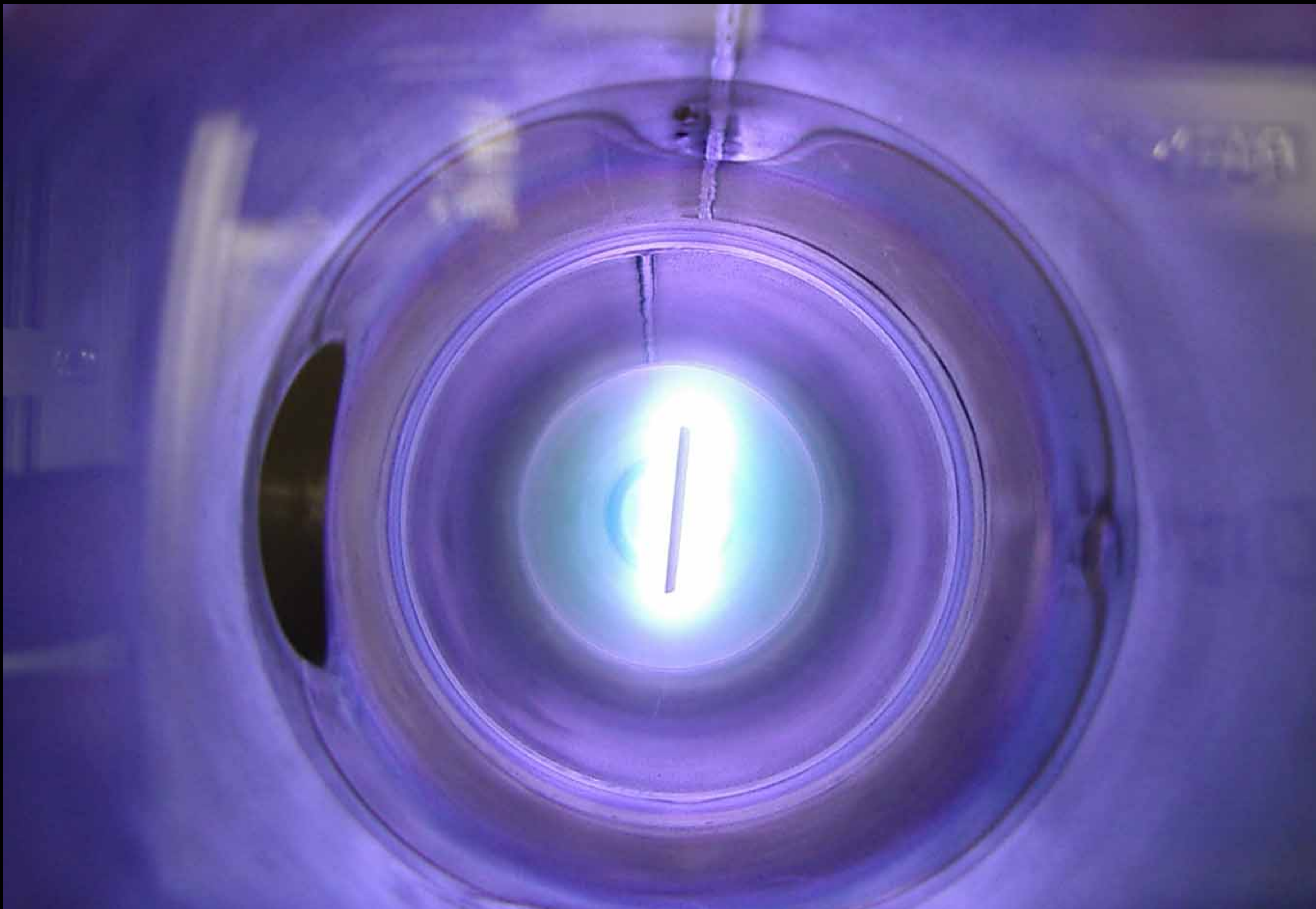









PLASMA Cleaning



Identification of the samples

- T = Tumbling
- E = Electro polishing
- C = Chemical Etching
- M = Magnetron Plasma Cleaning

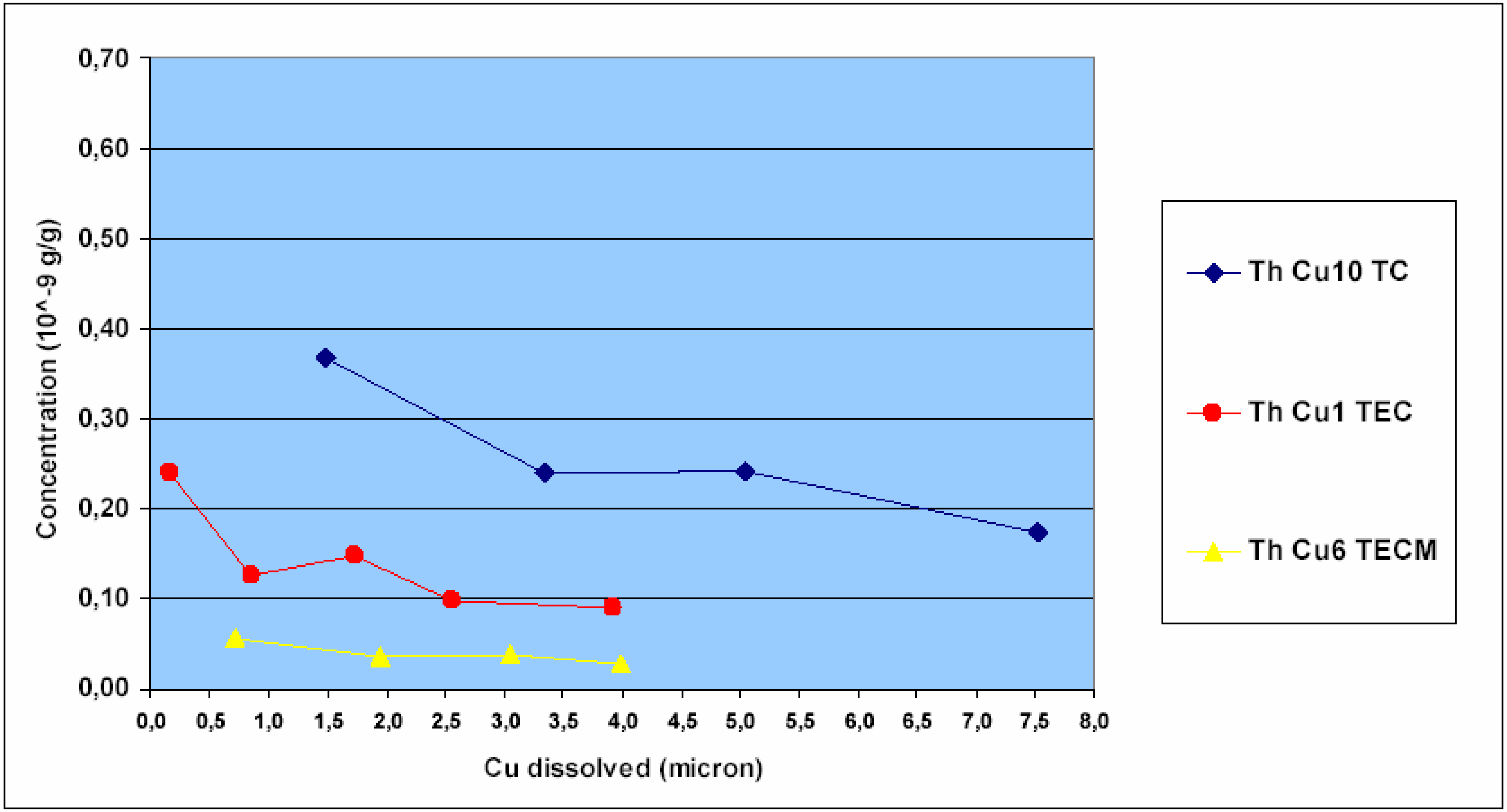
First batch
(Ispra January 2004)

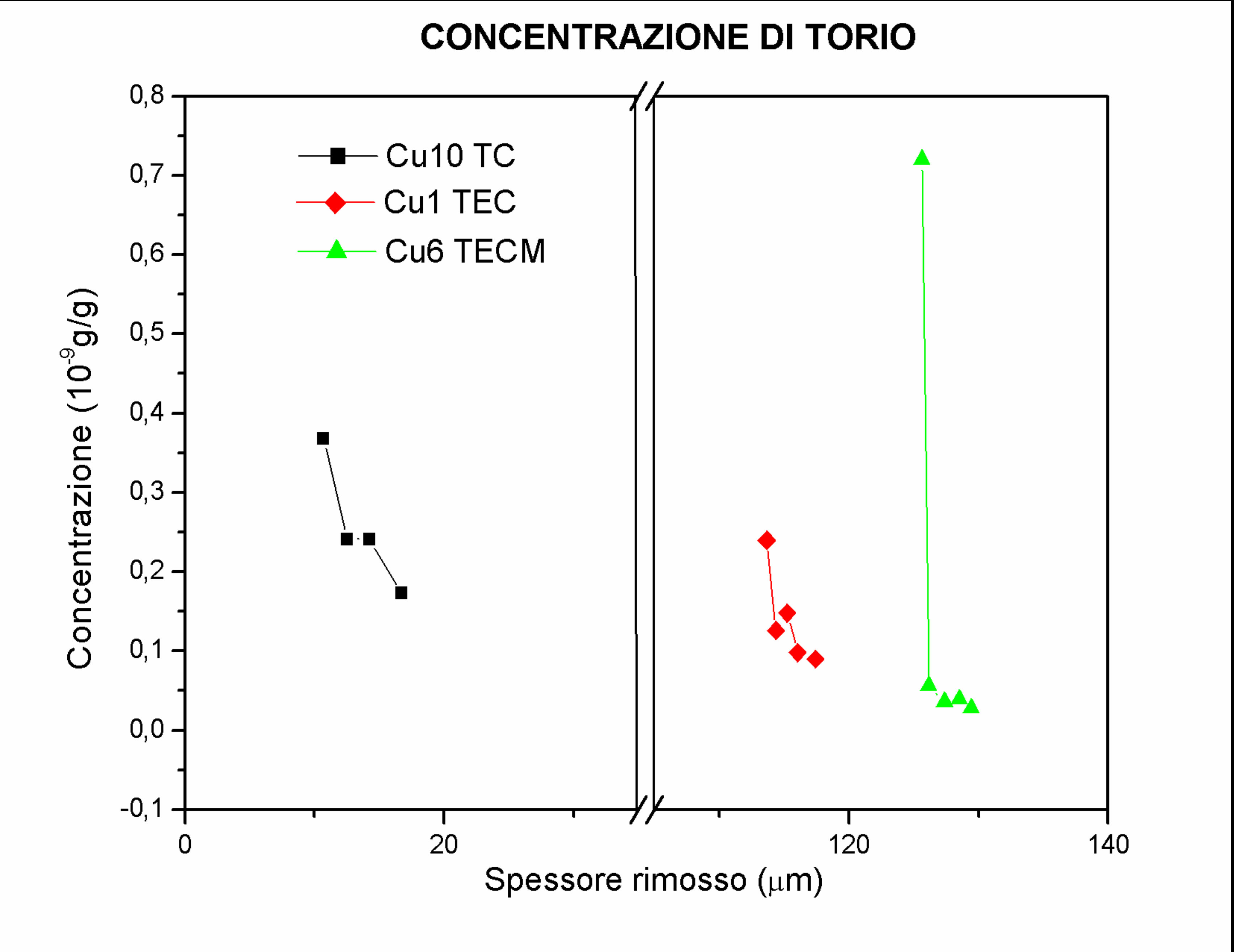
- Cu11 =no treatment
- Cu 2 = T
- Cu 4 = T C
- Cu10 = T C
- Cu 7 = T E
- Cu12 = T C
- Cu 5 = T C E

Second batch
(Ispra March 2004)

- Cu 3 = T C
- Cu 9 = T C
- Cu 1 = T E C
- Cu 6 = T E C M

Th concentration in the different thickness of Cu ("integral")




CONCENTRAZIONE DI TORIO
Cu10 TC
Cu1 TEC
Cu6 TECM
Concentrazione (10^-9 g/g)
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
-0,1
0
20
120
140
Spessore rimosso (μm)

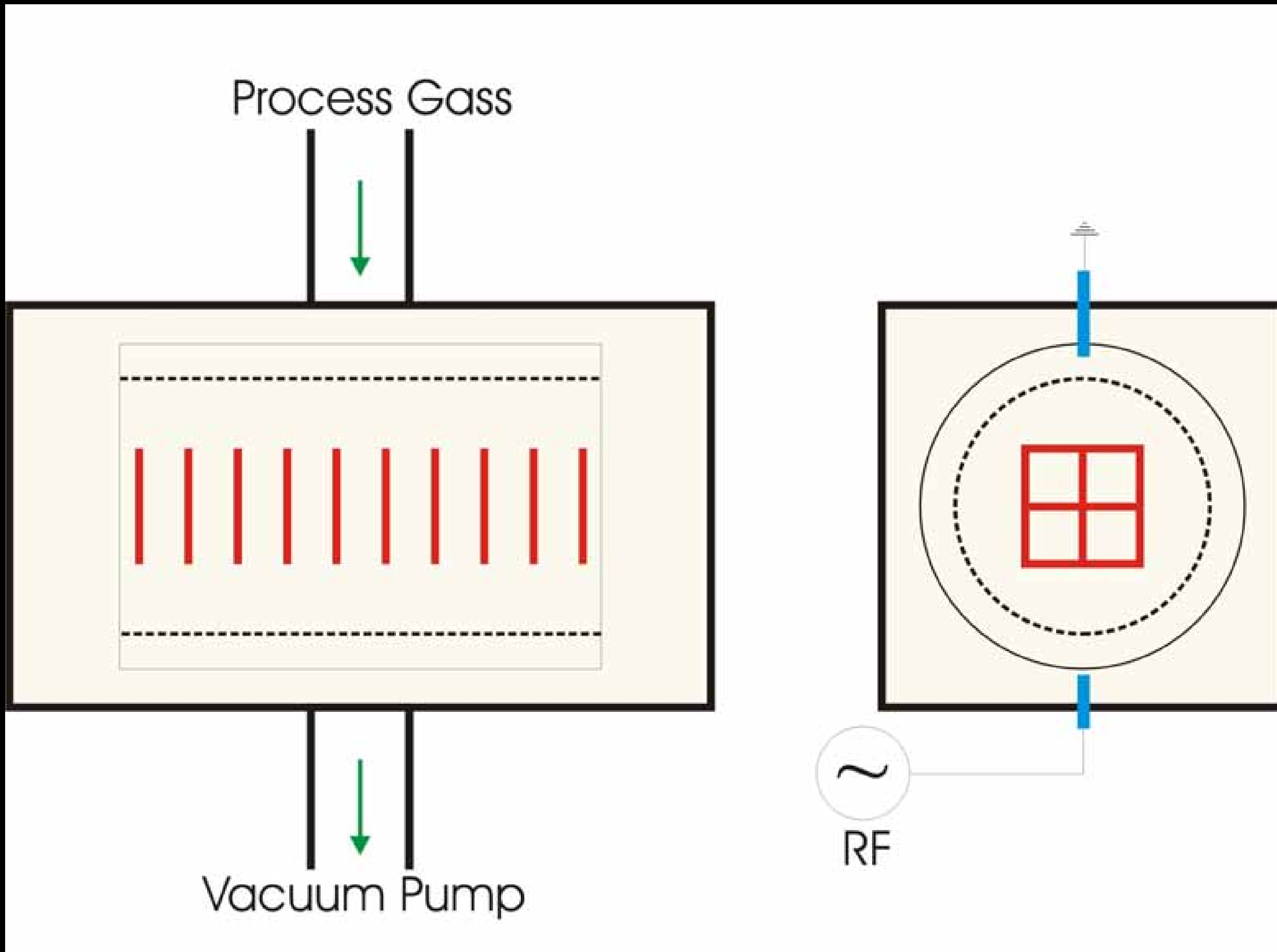
TeO_2 Crystals : 988 pieces

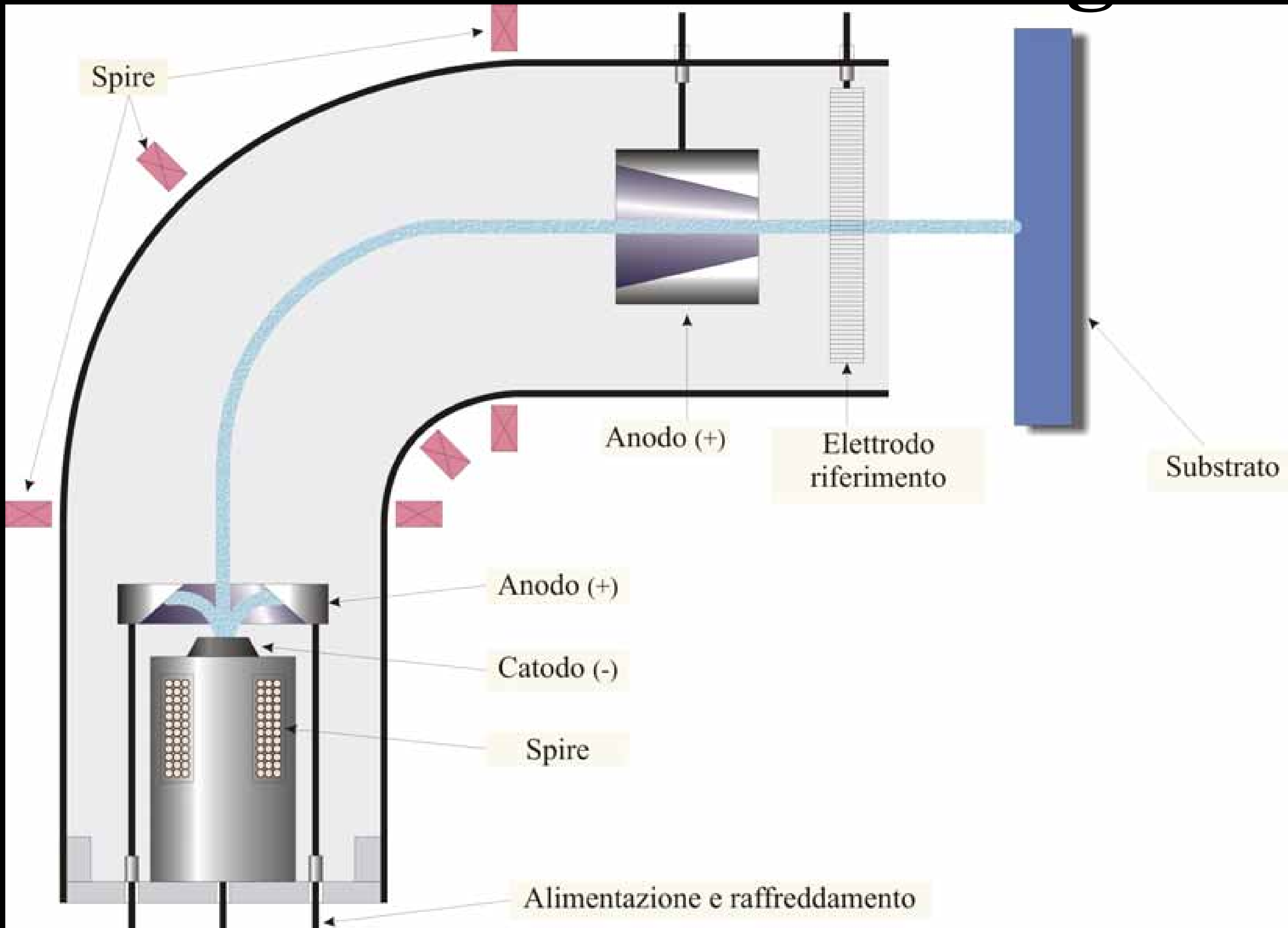
Copper parts:

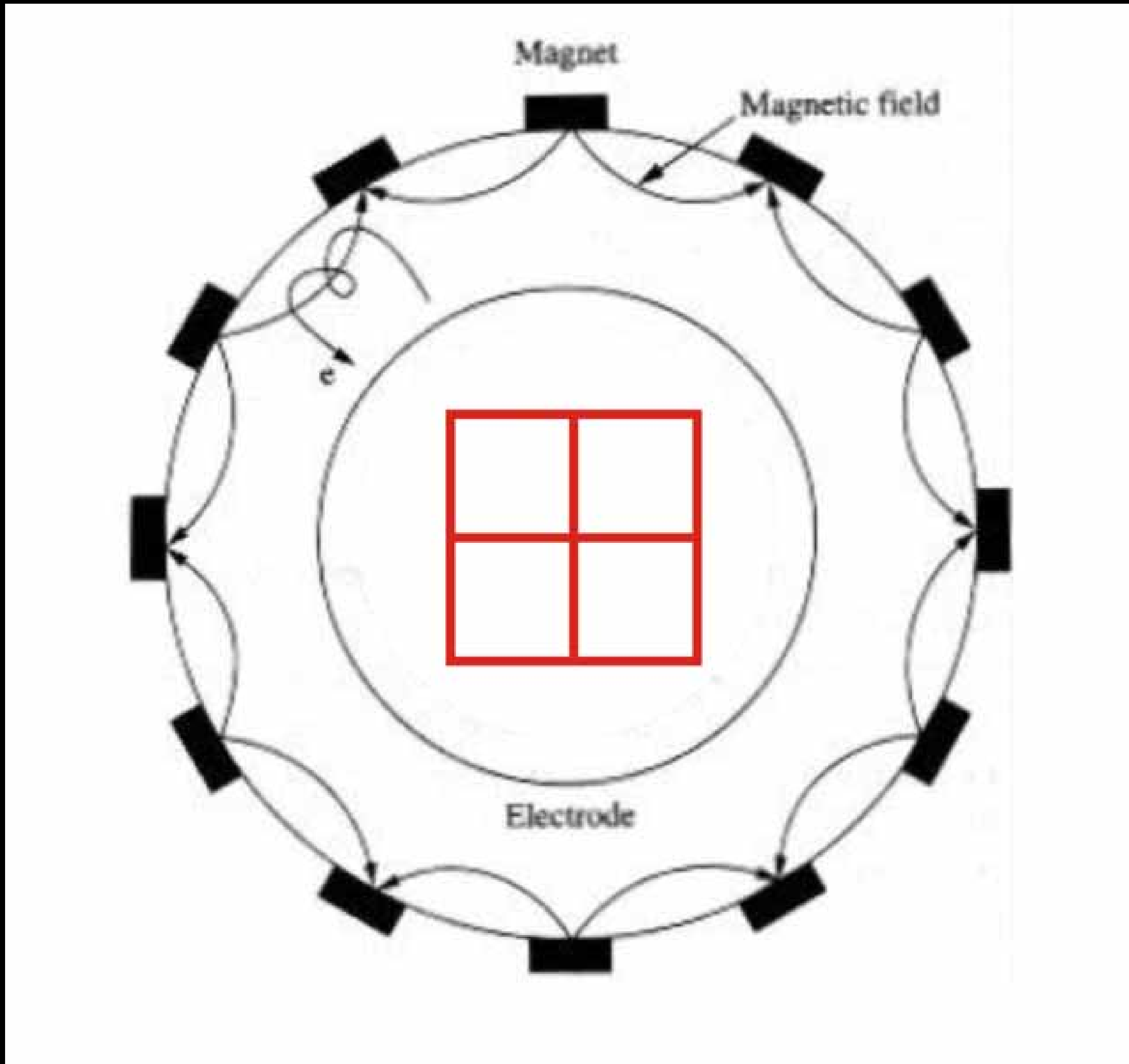
Frames:	**Columns:**	**Screws:**
Min 266 . Max 500 pieces	1235	Min 50 max 1500

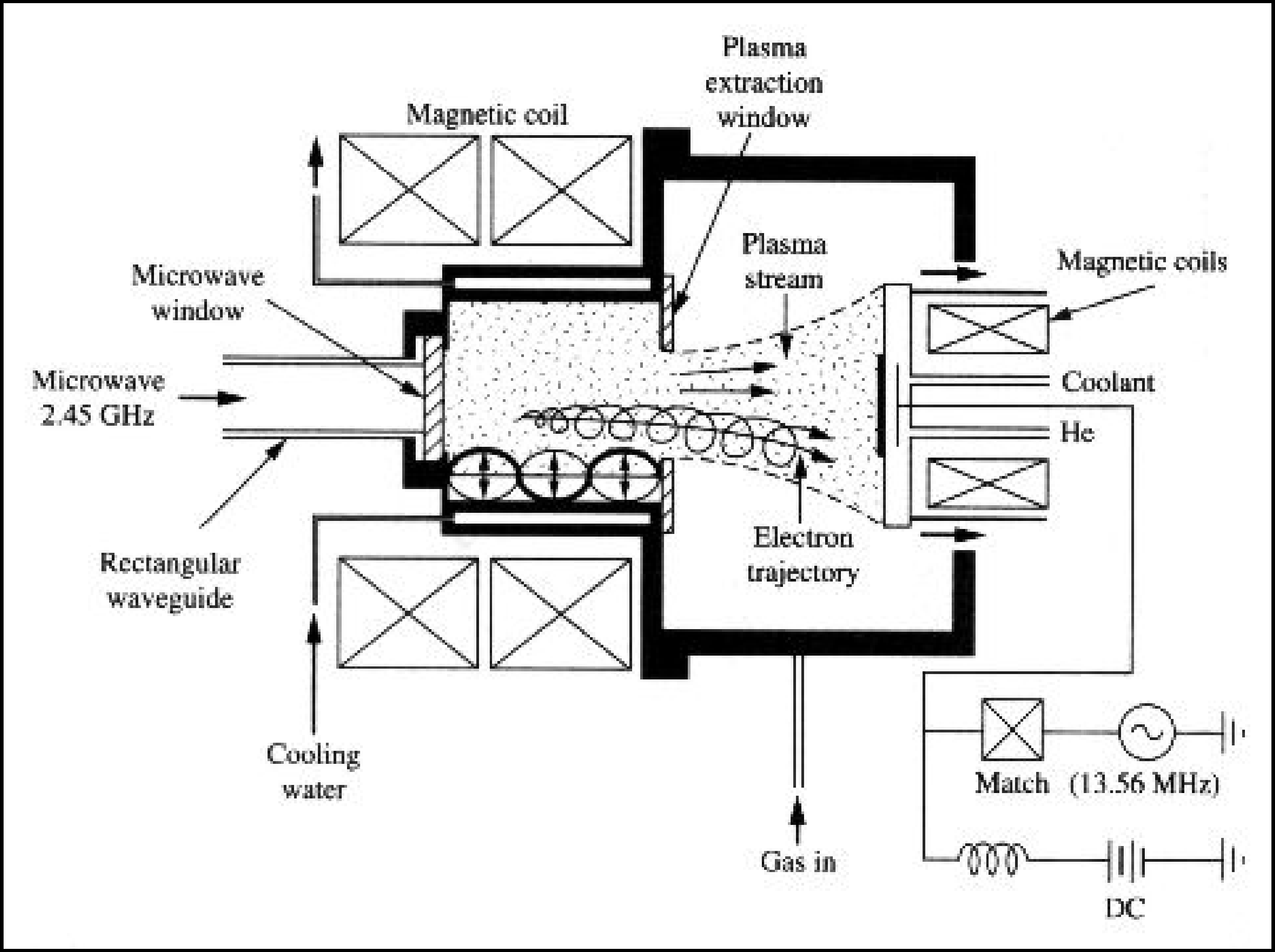
Prototype exp:

Quantity of pieces treated at LNL = 2 x Estimated


Process Gass
Vacuum Pump
RF


Spire
Anodo (+)
Elettrodo
riferimento
Substrato
Anodo (+)
Catodo (-)
Spire
Alimentazione e raffreddamento


Magnet
Magnetic field
e
Electrode


Plasma
extraction
window
Magnetic coil
Plasma
stream
Magnetic coils
Microwave
window
Coolant
Microwave
2.45 GHz
He
Rectangular
waveguide
Electron
trajectory
Cooling
water
Match
(13.56 MHz)
Gas in
DC