



EASISchool 2 on Cryogenics

30 September 2019 to 4 October 2019
CEA, France
Europe/Paris timezone

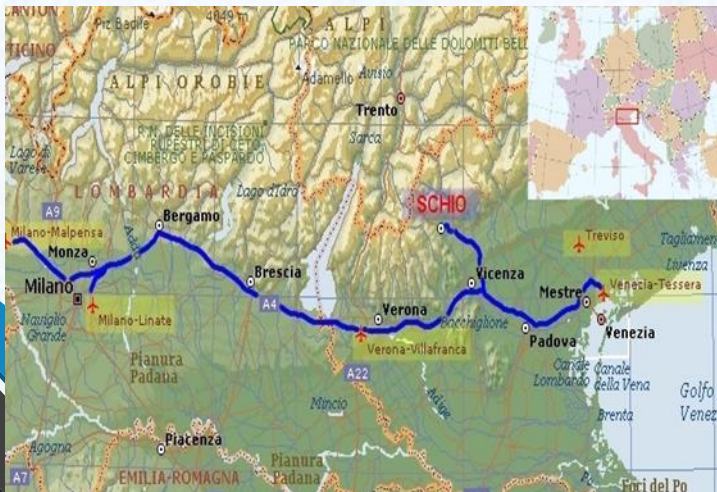
EZ Infrastructure for SC cavities production

The Company



The Company was founded in 1919 and it is located in the North-East of Italy (90Km far from Venice).

The Company production was related to the chemical industry; there is also a tradition about the production of special components for research institutes (INFN) and international laboratories (CERN, DESY, FNAL, MSU, CEA) which is now the main market of the company.

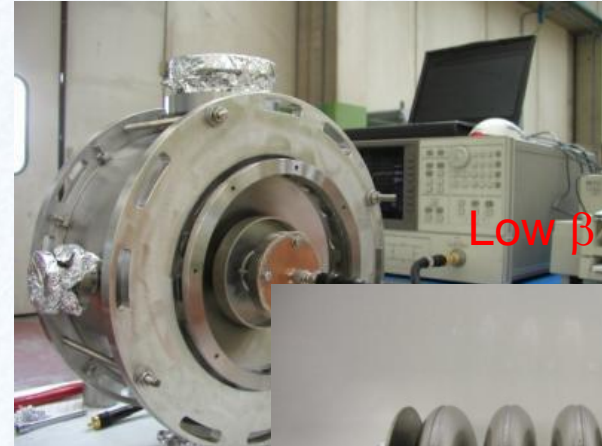


SC cavities production at E. Zanon

Ettore Zanon s.p.a has been working and manufacturing special components for superconducting applications since more than 20 years.

Experience with niobium superconducting cavities started in the early 90's and has continued without interruption since nowadays.

In a similar way , by using the available in house production facilities and processes , the production and test of cryomodules were successfully completed for many different scopes and projects.



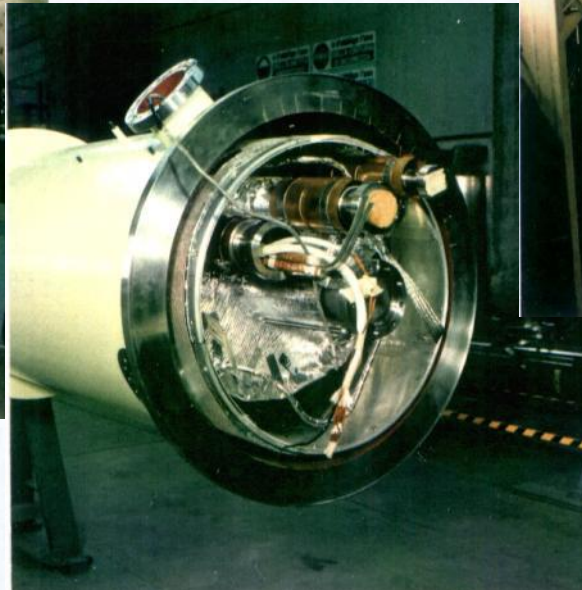
Production of cryostats for SC applications

HERA Project at DESY-Hamburg

Production and assembling of 242 cryostats for the
S.C. dipole magnets



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LHC Project at CERN-Geneve

Pre-series manufacturing and assembling of 10m. and 15m. long cryostats for the S.C. dipole magnets



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SPIRAL II Project – GANIL ,CEA
Series of cryomodule for SC cavities



TESLA Test Facility – XFEL Project at DESY



Past production of cryomodule for R&D phase



Production of 45 cryomodules for XFEL

Involvement to the EXFEL project

A) Manufacture and final treatment of 420 units of the 9 cells, 1,3GHz SC cavities

Scope of work has included :

- Manufacture of the 1,3GHz cavities / Manufacture of their Titanium Helium tanks
- Integration of the cavities into their tank / Treatments and Surface cleaning treatments
- Components manufacture and certification according to PED (Pressure Equipment Directive)
- Delivery production rate 4 units/week

B) Manufacture and final treatment of 20 units of the 9 cells, 3,9GHz SC cavities

Scope of work has included :

- Manufacture of the 1,3GHz cavities / Manufacture of their Titanium Helium tanks
- Integration of the cavities into their tank / Treatments and Surface cleaning treatments
- Components manufacture and certification according to PED (Pressure Equipment Directive)

C) Manufacture and testing of 45 units of XFEL Cryomodules

Scope of work has included

- Vacuum vessel and cold-mass prefabrication and testing
- Delivery to the assembly site (CEA-France)

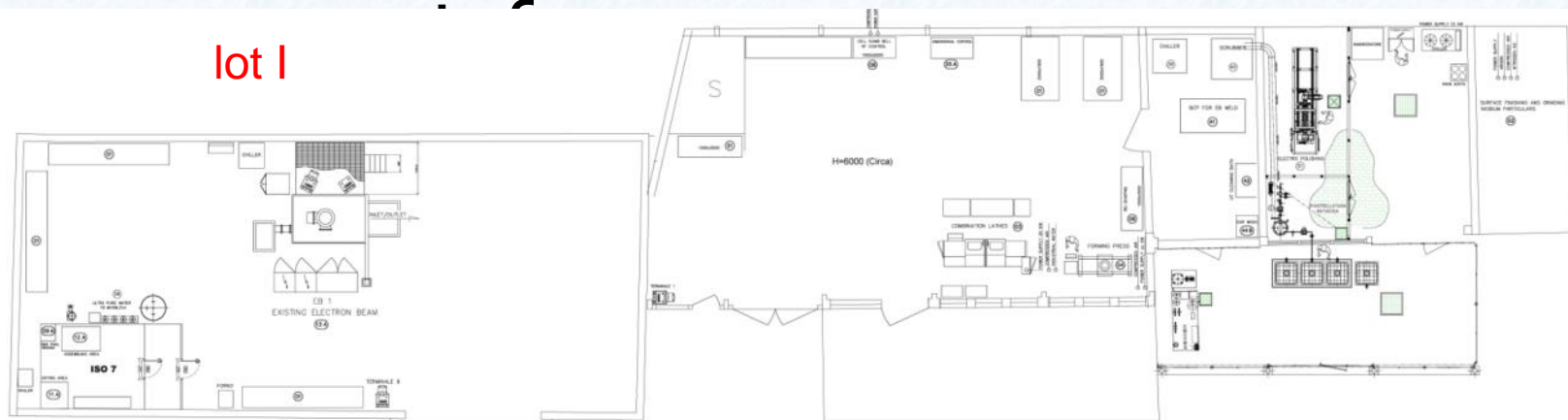
D) Manufacture and testing of 146 units of Titanium Helium tanks

Scope of work has included

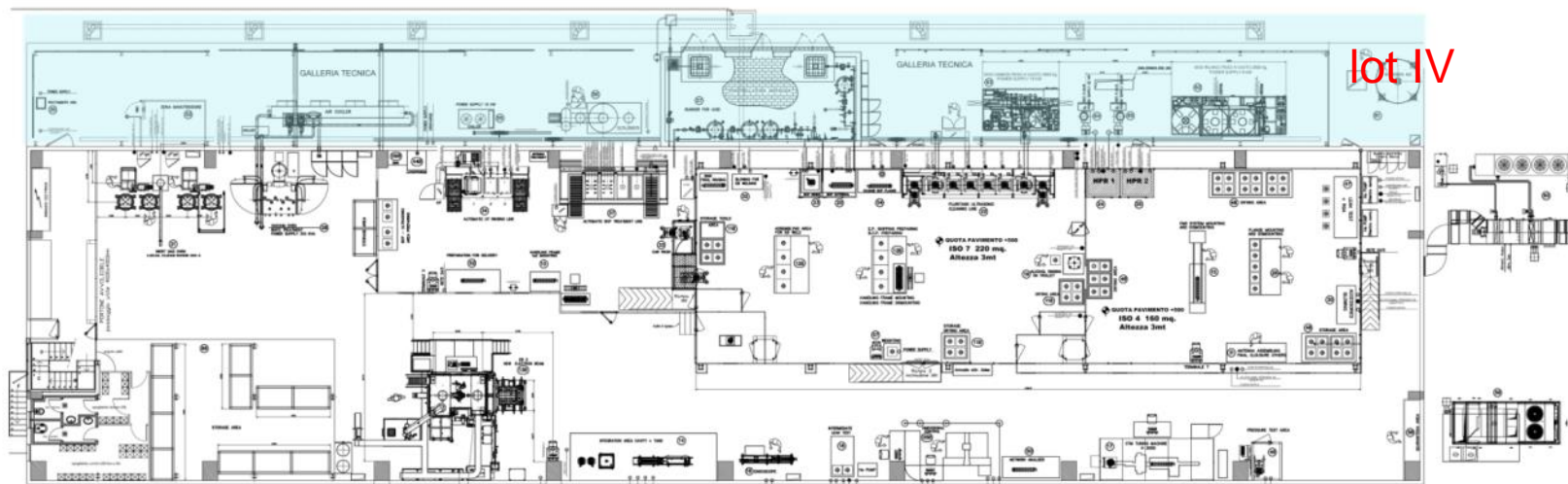
- Tank prefabrication and He leak check
- Delivery to DESY

Cavities serial production lay-out and

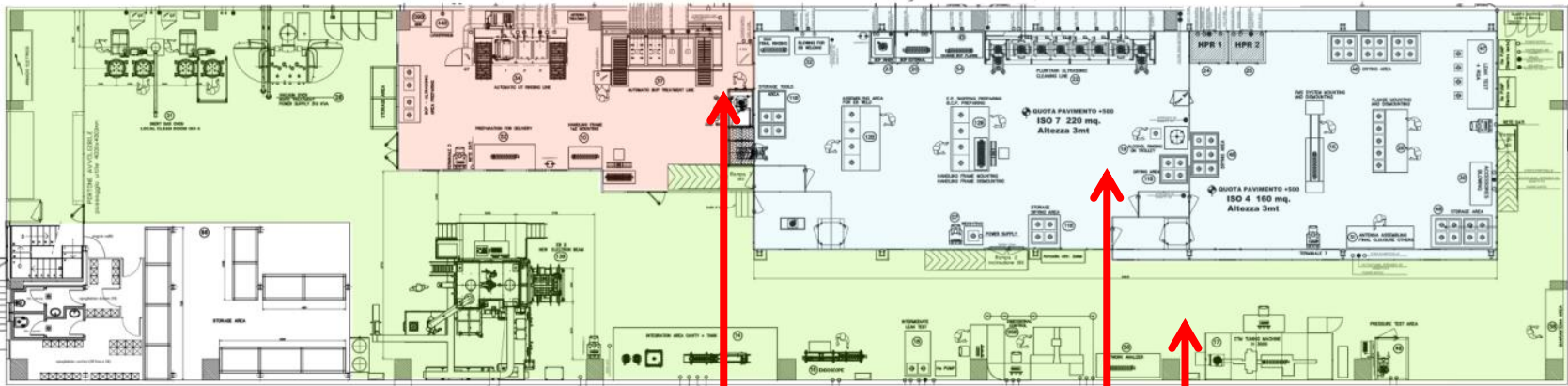
lot I



lot IV



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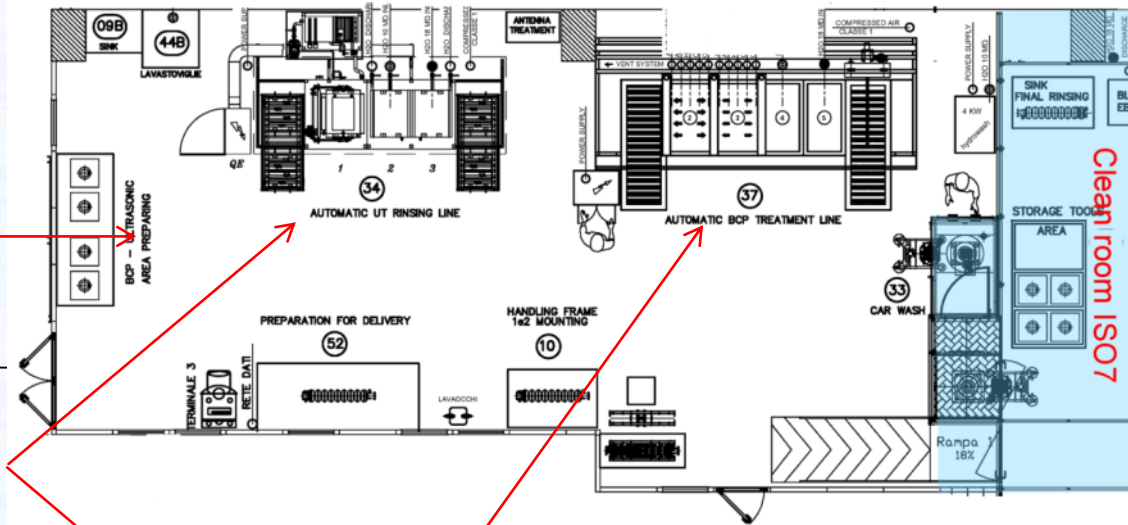
The building is organized
in three main areas

- A) Chemical treatment area
- B) Clean room ISO7/ISO4
- C) Controls , Integration ,
heat treatments and testing area

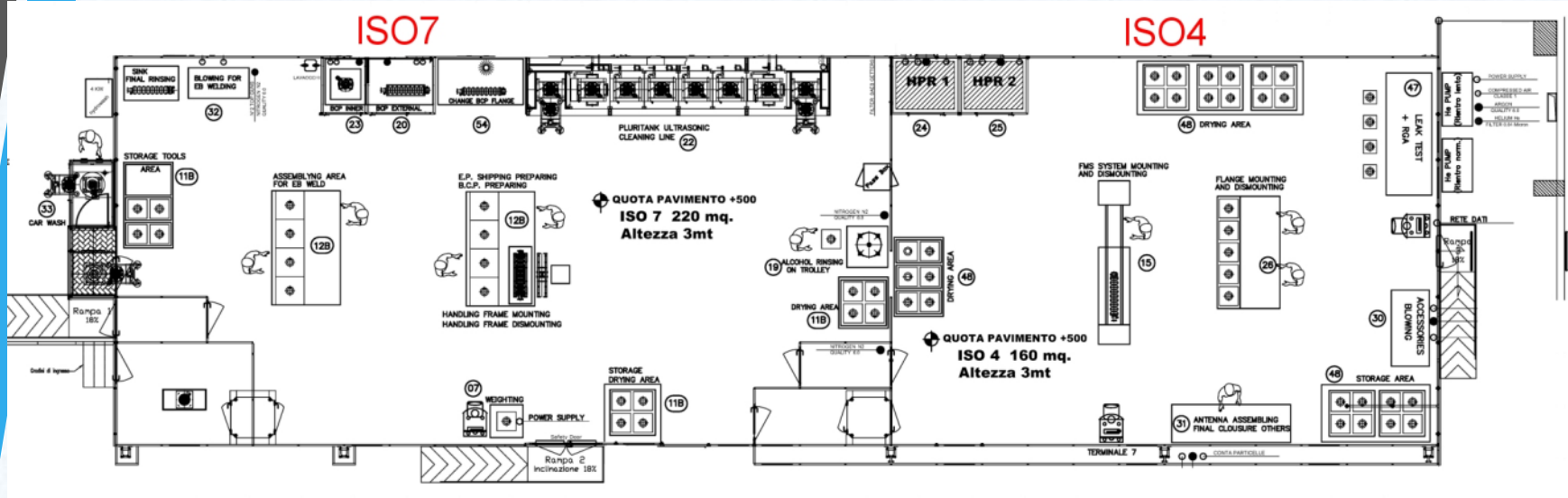
Preparation and drying areas

Automatic pluritank station for
US cleaning , rinsing
water 10 MΩcm and 18 MΩcm

Automatic BCP treatment line
2 cooled acid baths for Niobium
and Nb-55-Ti
1 bath first rinsing 1 bath final rinsing
water 10 MΩcm and 18 MΩcm
protection tunnel ,fumes extraction to the
scrubber



Building lot IV Clean room ISO7/ISO4



Dedicated to
clean assembling , final surface treatments , final assembling for the RFcold test

Total surface of about 450 m²

ISO7 area 220m² ISO4 area 200m²

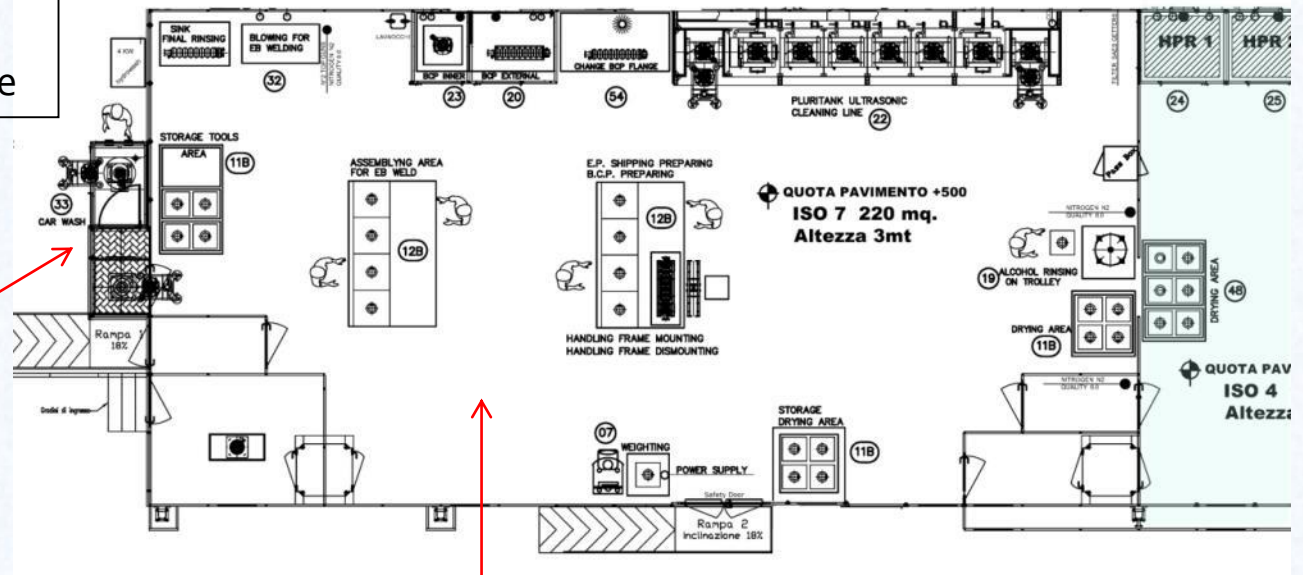
Operators dressing rooms , air showers

All metallic floating floor

Customized treatment stations

Building lot IV Clean room ISO7

100 bar UPW cleaning cabinet for ISO7 entrance



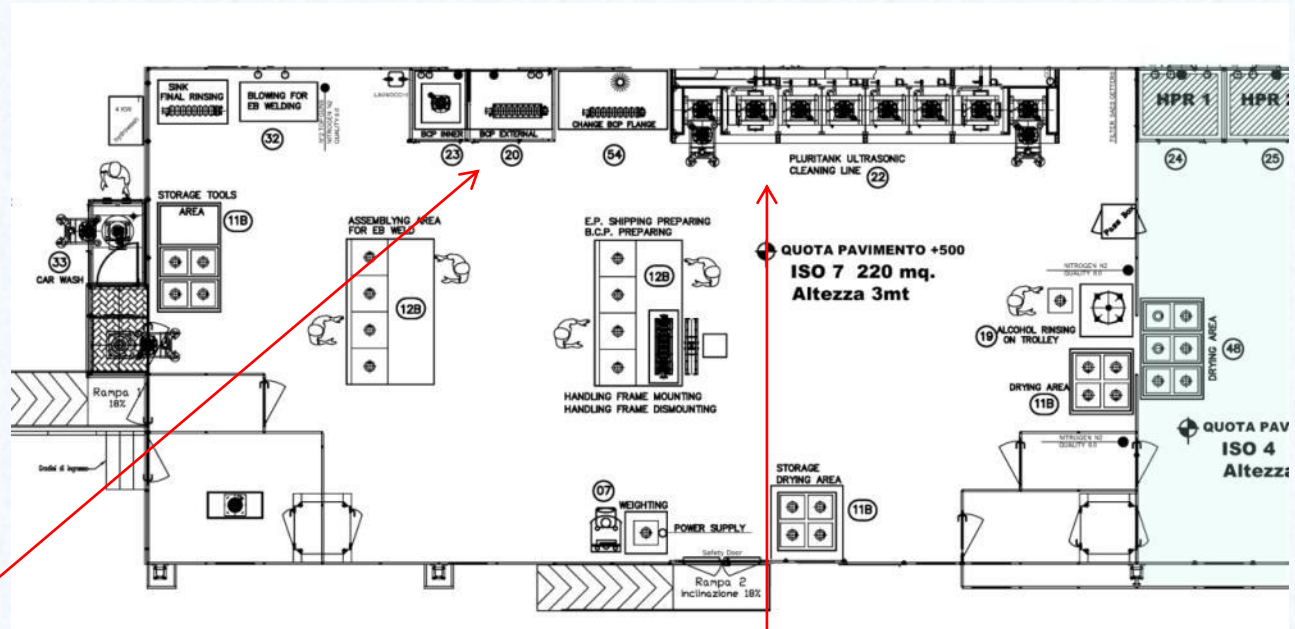
Pre-assembling stations for cavity EBW preparation



Building lot IV Clean room ISO7



Cabinets for BCP close circuit of the inner / outer cavity surfaces

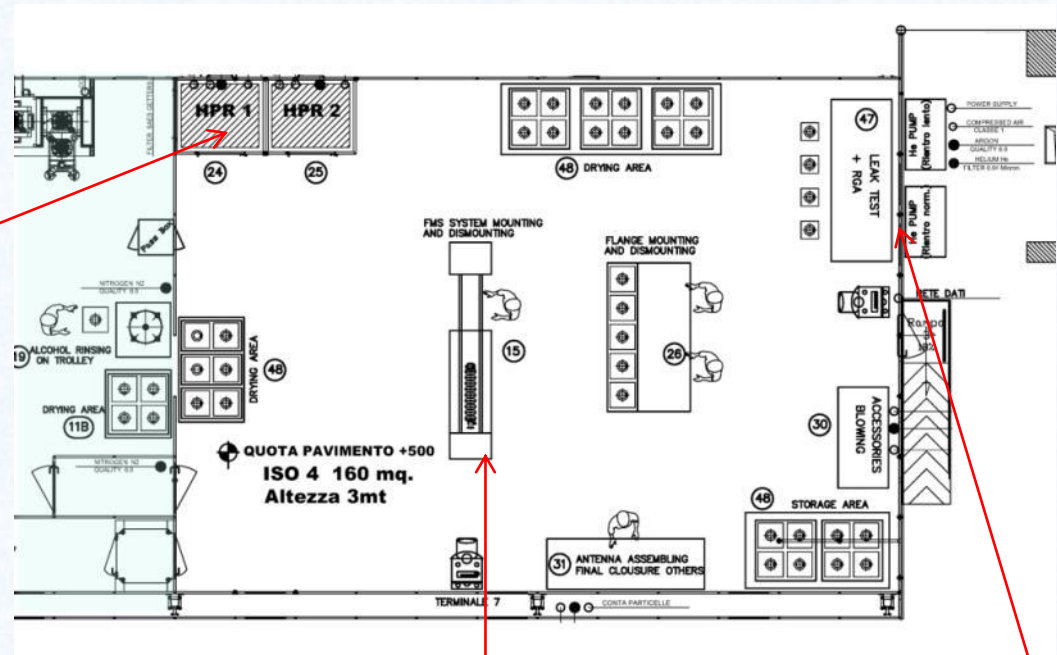


Automatic pluritank station for
UT cleaning and
rinsing baths
water 10 MΩcm
and 18 MΩcm

Alcol rinsing , Others

Building lot IV - Clean room ISO 4

N° 2 cabinet for final HPR
UPW 18 MΩcm water p>100bar ,
1.5m³/h
Cavity's rotation , vertical
translation Nitrogen overlay

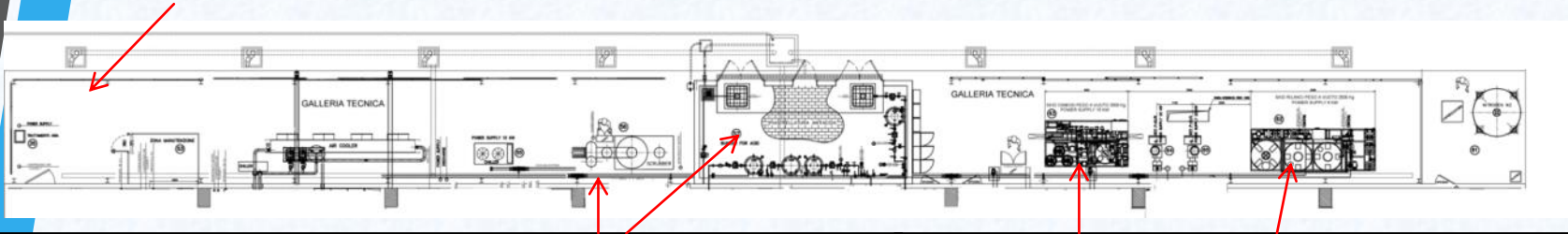


Station for final leak test
special equipments for
slow-controlled venting
of the cavity

Assembling stations for
FMS installation - RF antennas
assembly

Building lot IV - Service Area

Maintenance area



Chemistry service area : storage of BCP acid tanks-
cooling systems for BCP stations
Scrubber for acid gasses vent

Ultra pure Water (UPW) production
production up to $3\text{m}^3/\text{h}$ at $18\text{ M}\Omega\text{cm}$
 $5\text{m}^3/\text{h}$ at $>10\text{ M}\Omega\text{cm}$

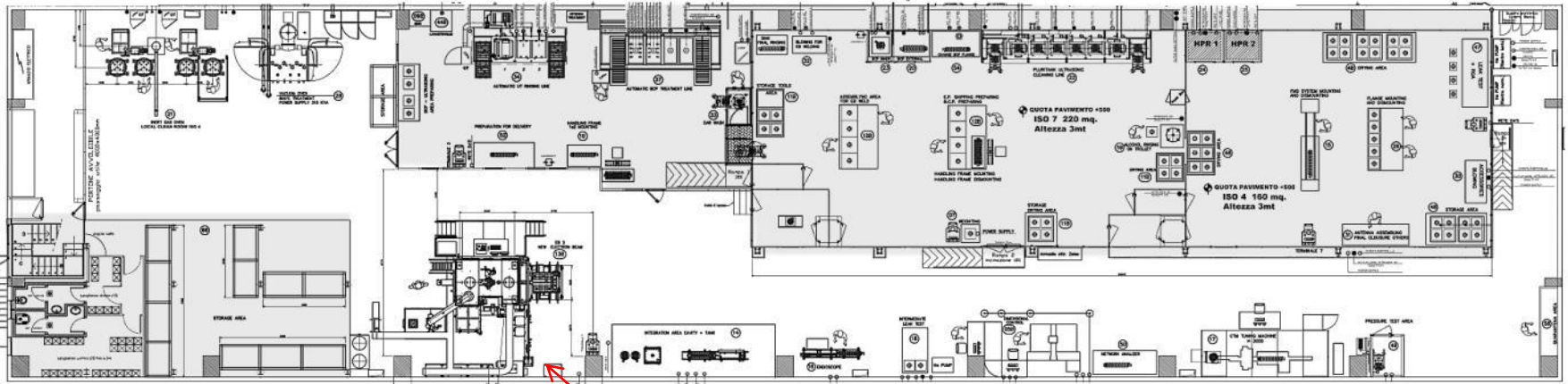


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Building lot IV Control , Integration , 800° C -120° C treatments and testing area

The area is organized to suit part of the production and control operations
(good clean environment , not classified)



New EB welding plant : S.S. Chamber ,
size 3,4x2x2 m , oil free pumping group with
cryogenic pump
(3×10^{-5} mbar 35 minutes)
nitrogen venting , RGA



UHV oven

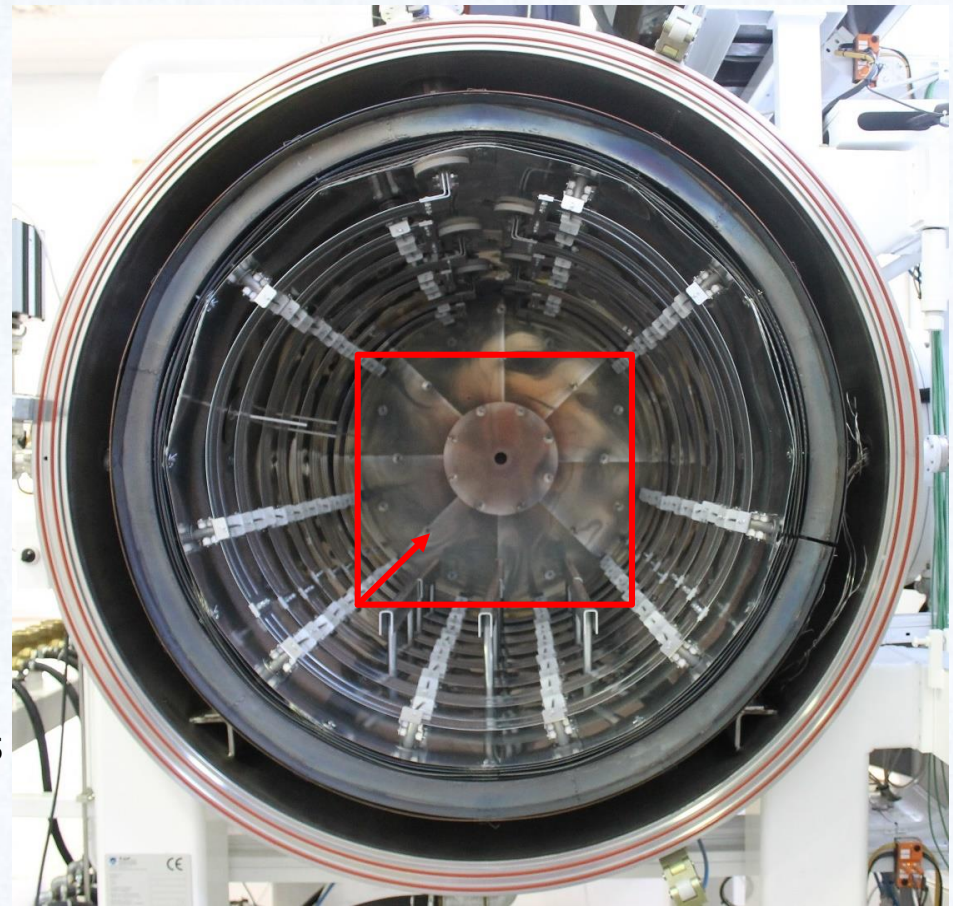
Built by TAV in 2011

Model 60/60/130

Data:

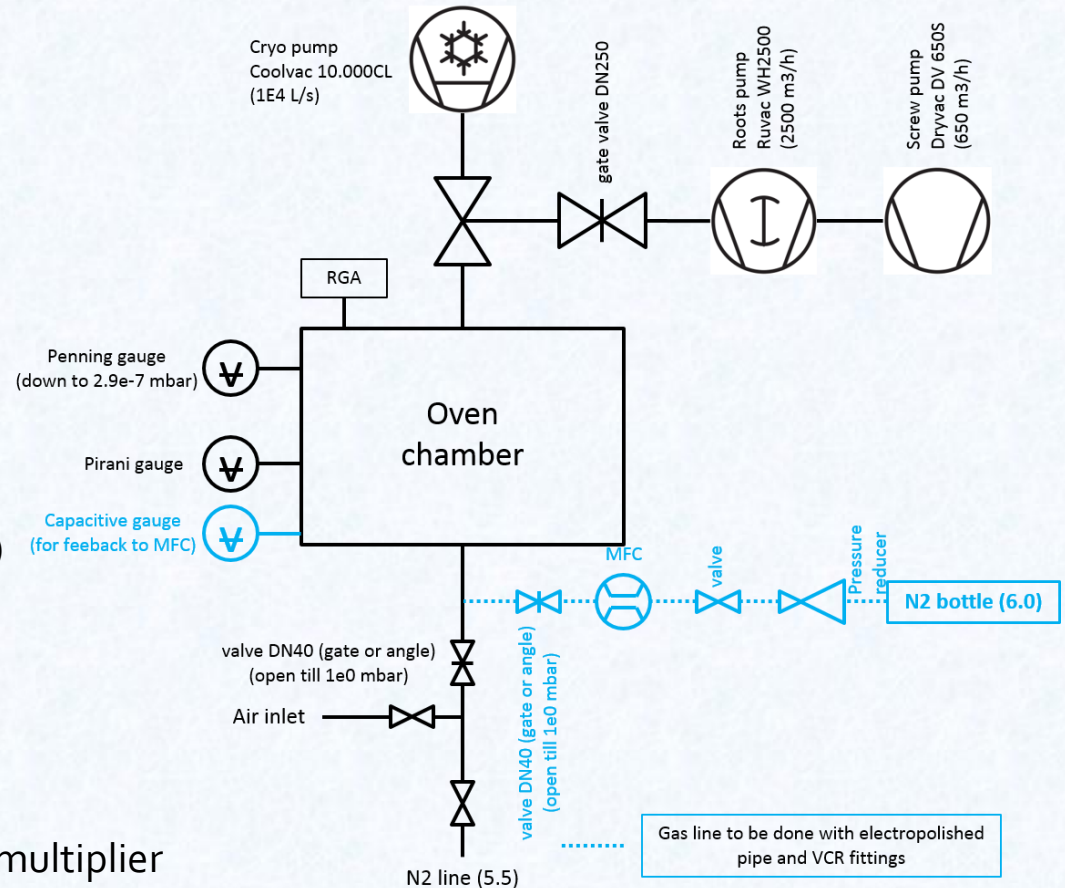
- Max working temp: 1250°C
- Temperature uniformity: $\pm 5^\circ\text{C}$
- Temperature control: over 3 zones
- Chamber: Stainless steel
- Chamber is actively water cooled
- 1st and 2nd thermal shield layer: Molybdenum
- Heaters: Molybdenum
- Load temp control: 10 K-type tc
- Chamber temp control: 4 S-type tc (3 + overtemp safety)

Usable working space: 600 x 600 x 1300 mm



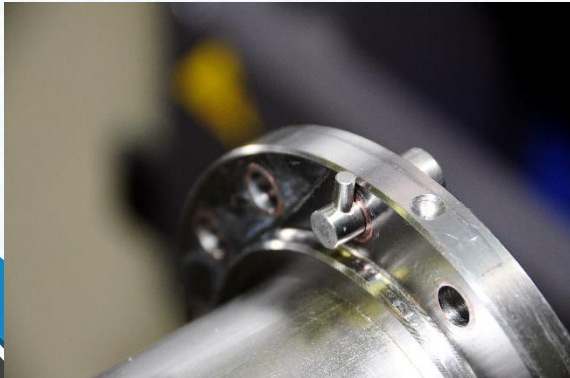
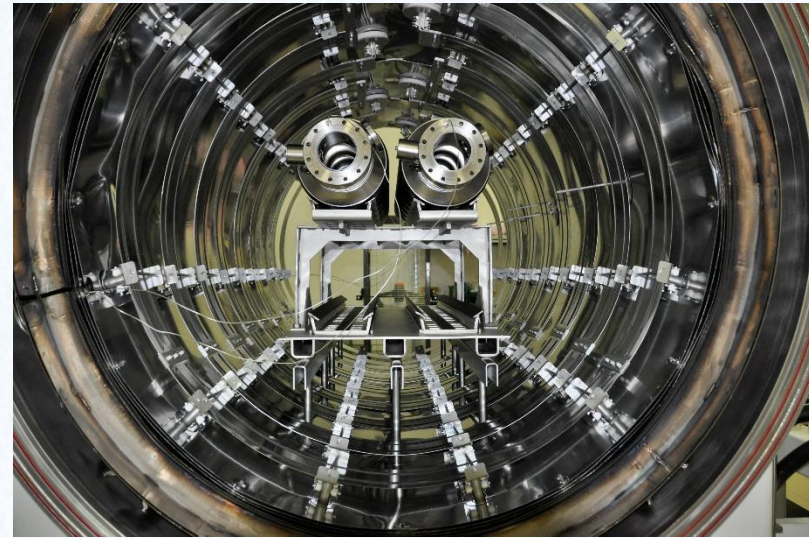
UHV oven #2

- Oil free pumping system
 - Screw 650 m³/h
 - Roots 2500 m³/h
 - Cryo 10000 L/s
- Pressure gauges
 - Pirani
 - Inverted magnetron
 - Capacitive (doping only)
 - Ultimate $p \leq 3 \times 10^{-7}$ mbar
- RGA
 - Inficon Transpector 2
 - Faraday cup & electron multiplier
 - RGA continuously recorded
- Maintenance
 - 2h hold @ 1100°C (weekly/biweekly)
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 - Cryo pump regen after each outgas cycle



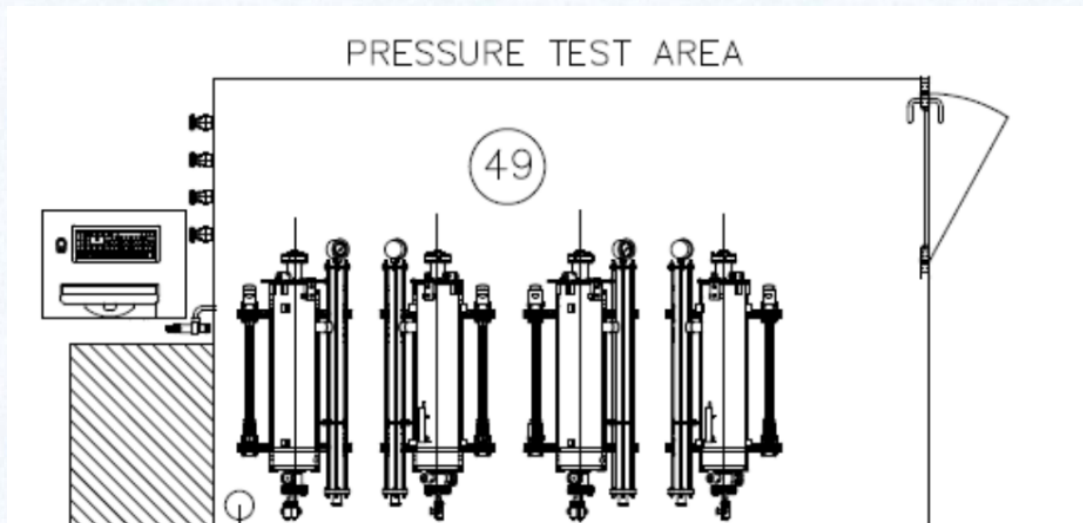
Setup for EXFEL

- Dedicated equipment for loading/unloading operations
- Niobium caps to preserve cavities' inner surface
- Up to 4 CAVs per batch
 - Stainless steel double floor frame
 - Cavity on metallic supports
 - Contact points w/ceramics
- Temperature control on each cavity
 - Pins placed on end flanges
 - Last ramp up linked to load temp check
 - During hold ΔT on each cavity ≤ 1 °C



Pressure test area

- Realized with 10 mm thick steel walls
- Pressure monitored via webcam in real time
- Capable of testing up to four units at once
- Test pressure up to 8 bar g
- Gauges calibrated every three months



120°C baking stand

EZ built in house two stands for EXFEL, adaptable to other cavities:

- Pumping system with LD for efficient and clean leak detection
- Pumping system supported by UPS to avoid power failures
- Connection/disconnection in ISO5 local clean room
- Operations monitored w/particle counter
- Capable of treating two cavities at once
- Heating in inert atmosphere (N_2)

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The Electropolishing facility

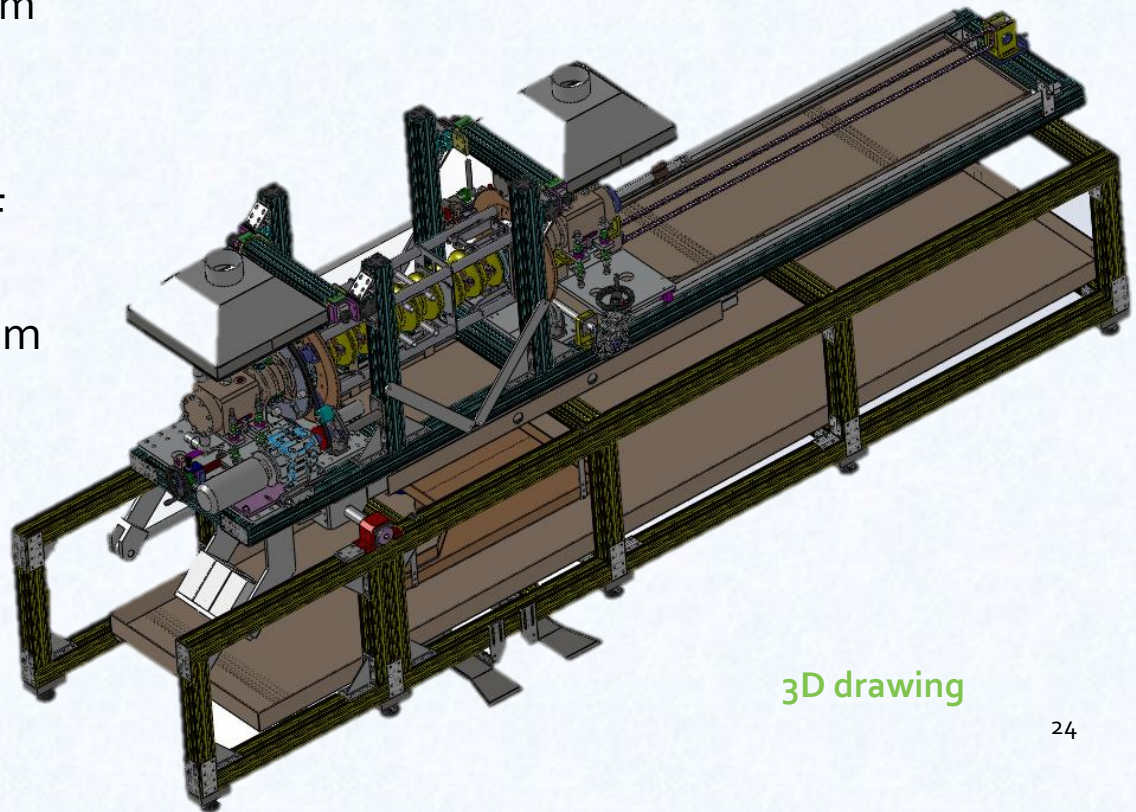
EXFEL Treatment data:

- Horizontal EP, with cavity rotating
- 140 μm EP as first main polishing
 - Usually more than 140 μm are removed to
- Constant 17 V applied on cavity for 6 hours
- Mean current value: 270 A
- Mean temperature value: 31°C.



EP facility

- Aluminum cathode 99.5% purity:
 - 4 mm holes for acid distribution,
 - Teflon tape to shield cathode at irises.
- Fluorinated polymers PTFE, PVDF, PFA
 - For parts in contact with acid
- Ultrapure water $18\text{M}\Omega\cdot\text{cm}$
- 99.999% pure nitrogen
- Acid mixture: $\text{H}_2\text{SO}_4 + \text{HF}$ (9:1 ratio)
- Usage up to 10 g/l Niobium dissolved



3D drawing

E-XFEL Cavity Production

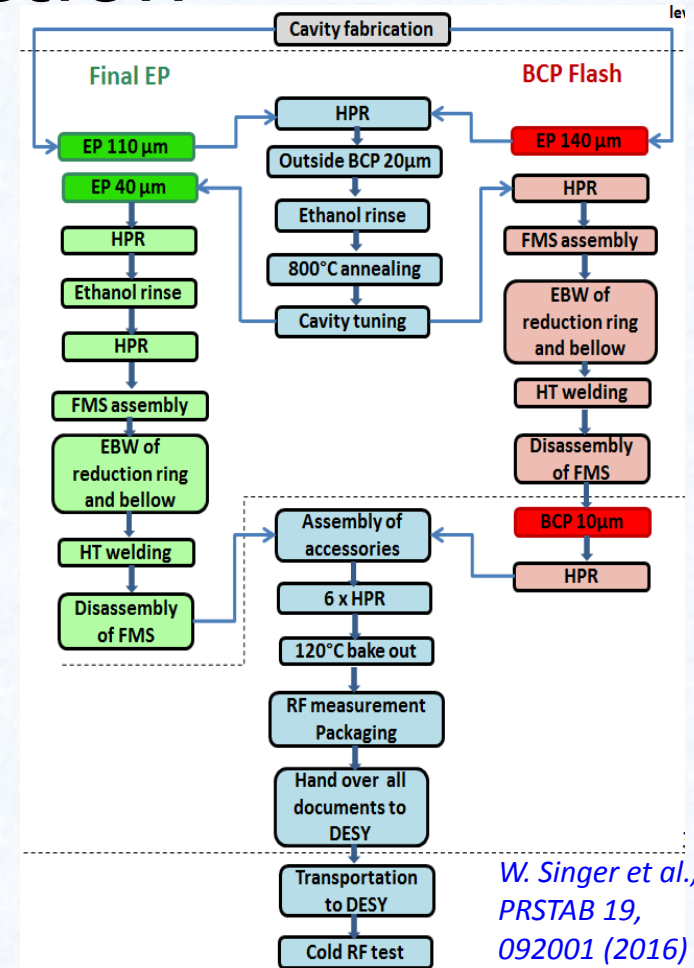
- Two recipes (choice left to the Companies):
Flash BCP & **Final EP**

- EZ applied the **Flash BCP**

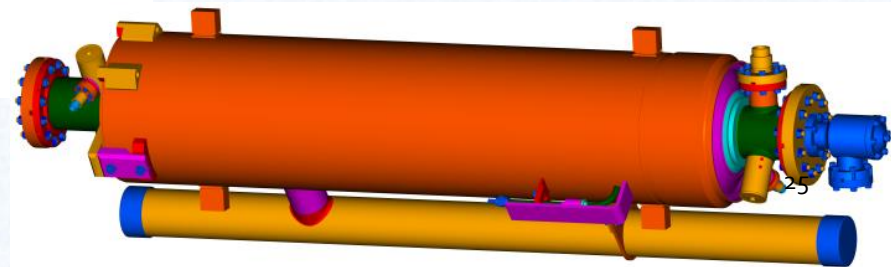
- Strategy: Built to Print** (no performance guaranteed!) for the first time applied on a large scale cavity production

- Full procedure** (from the raw material to the cavity ready to be tested) **done at the Industry** (mechanical, RF, surface treatments, vacuum, etc)

- Recovery of cavity** with poor performance -> responsibility of **DESY / INFN**



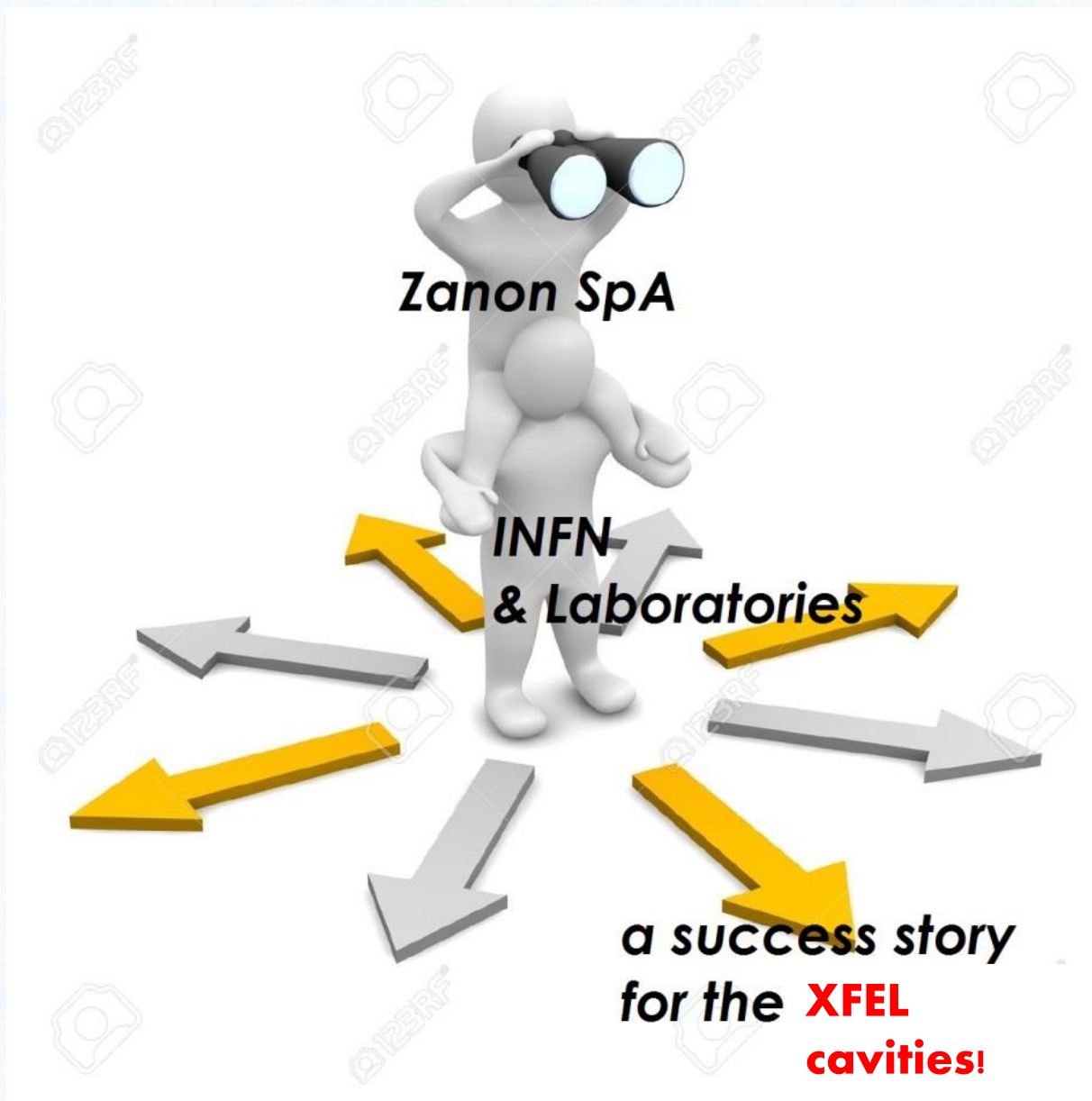
W. Singer et al.,
PRSTAB 19,
092001 (2016)



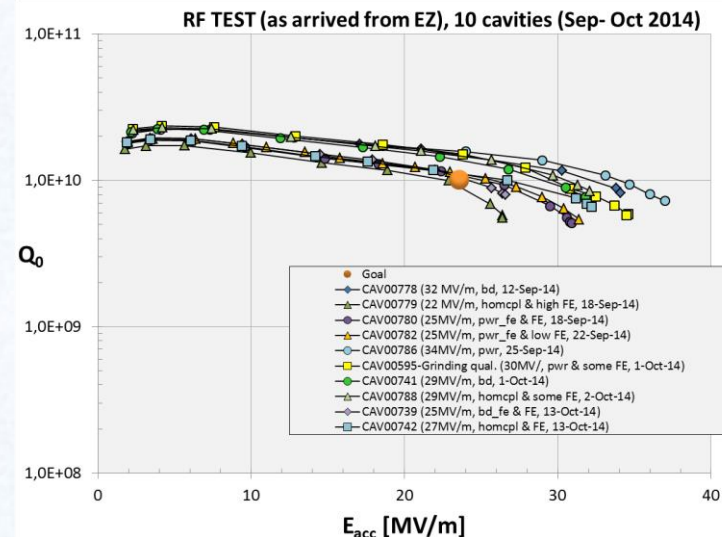
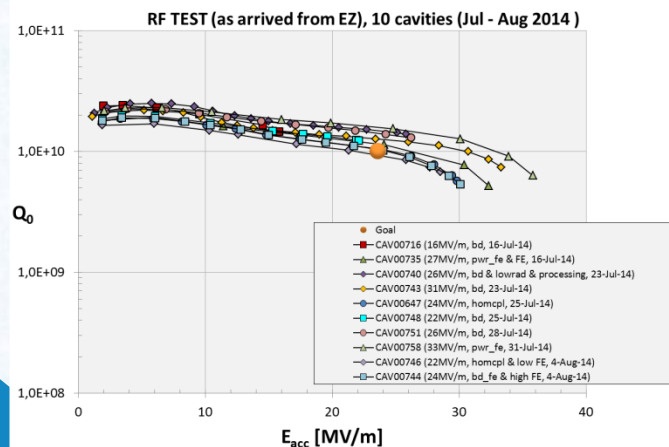
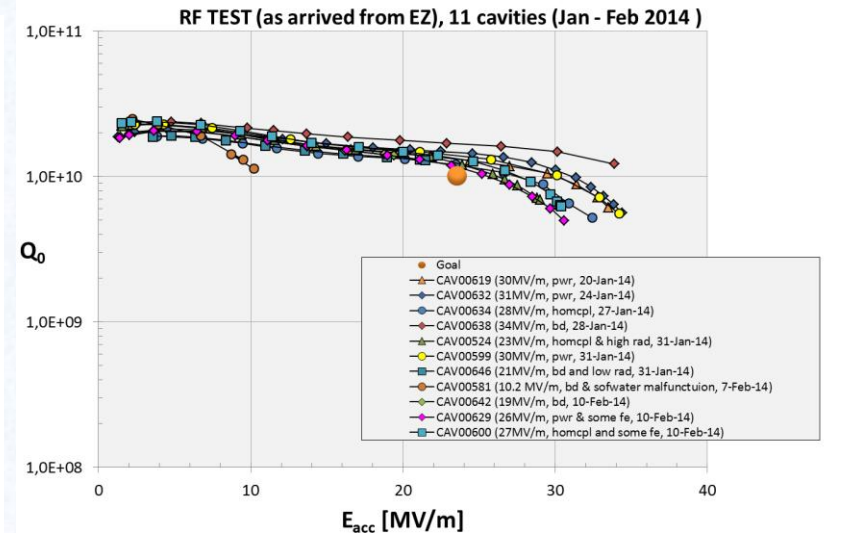
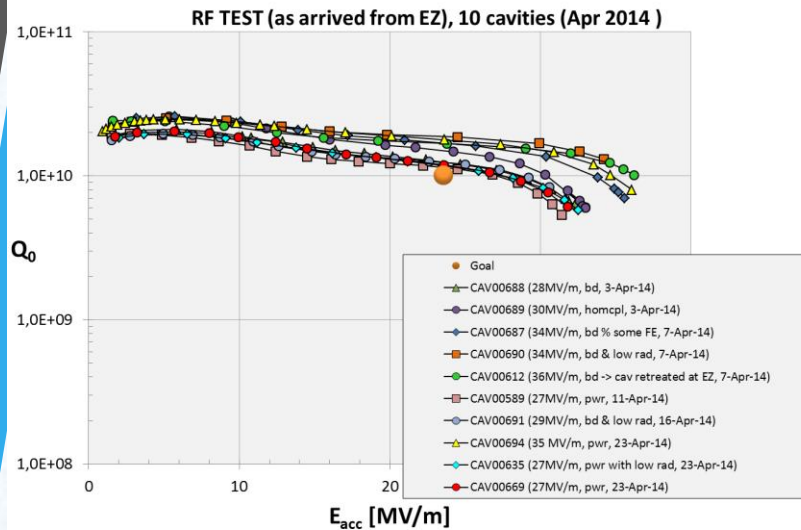
- **Material** and vendor qualification for Nb
- Cavity design qualification
- **Surface treatment** qualification
- Cavity producer **qualification**: mechanical fabrication
- Procurement of Nb and semi- finished parts
- **Definition** of the “external” QA/QC for the company
- **PED issue analysis** (E-XFEL is cat. IV!, modul B + F)
- **Technology Transfer to the companies for series cavities production**
- **Set up of infrastructures**
- **Qualification** of the transferred technology: 8 DCV e 8 RCV
- Set up of the **external QA/QC** system at the industry
- **Series cavities** production: continuous monitoring of key parameters

Preparatory phase
Laboratory level

Series production
Industry level



XFEL Cavities results



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Conclusions

- **After XFEL, Ettore Zanon SpA has qualified infrastructure and team** for large scale production
 - **Qualified personnel** at the companies **will be maintained in the future?**
- **QA / QC on process, infrastructure and plants** is a **key point** in the success of the industrialization process.
 - **Intermediate diagnostic tools** during production reduce risk of the defective cavities number
- **Proved recipe and design** is a must before starting industrialization
 - Cavity design should foresees repair action, as the He tank removal
- **FE** is one of limiting factor, and **HPR** usually **can cure it** (for XFEL > 80%)
- **Process choice** is depending on the cavity specification: BCP, EP, N₂ doping.
 - EP process ensure higher maximum accelerating gradients

Thank
You

