E. ZANON

EZ Infrastructure for SC cavities production

Ambra Gresele

The Company

The Company was

founded in1919 and it is

located in the North-East of Italy (90Km far

from Venice). Around 180 person are

working at E. Zanon

The Company production is related to the

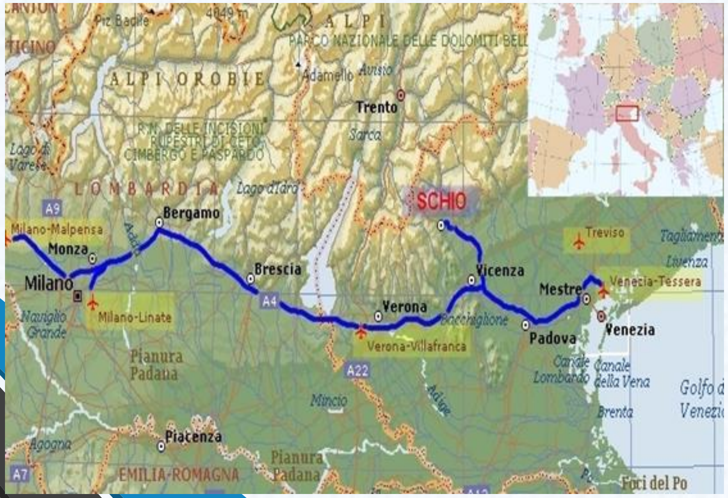
chemical industry but there is also a

tradition about the production of special

components for reaseach institutes (INFN)

and international laboratories (CERN,

DESY, FNAL, MSU, CEA)



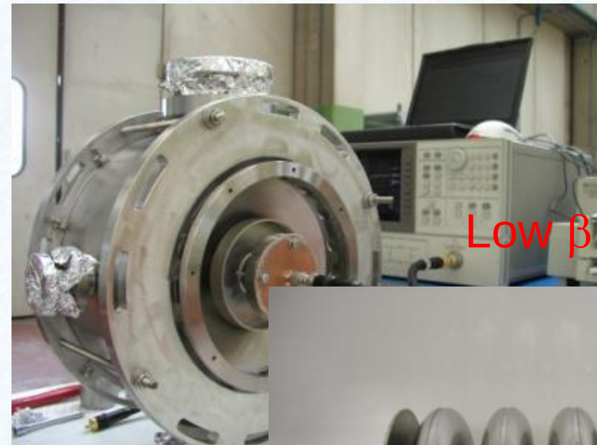
Ambra Gresele

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

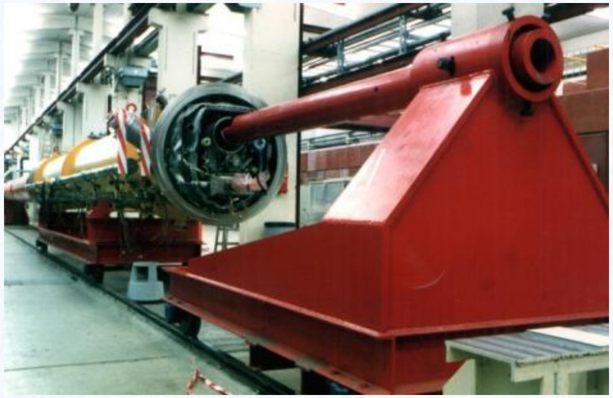
S.C. dipole magnets

LHC Project at CERN-Geneve

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

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 treatement 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 (Presssure Equipment Directive)
- Delivery production rate 4 units/week

B) Manufacture and testing of 45 units of XFEL Cryomodules

Scope of work has included

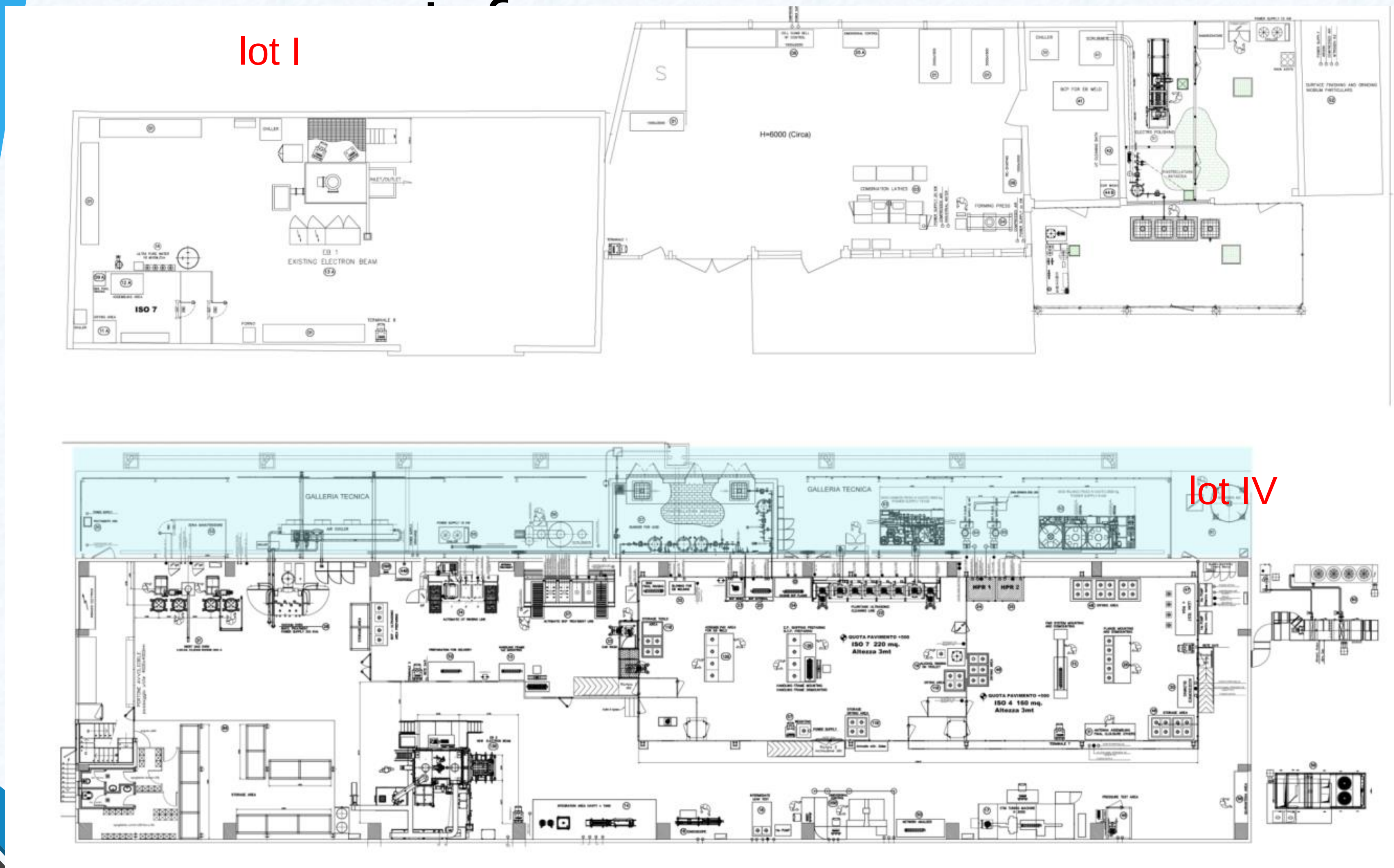
- Vacuum vessel and cold-mass prefabrication and testing
- Delivery to the assembly site (CEA-France)

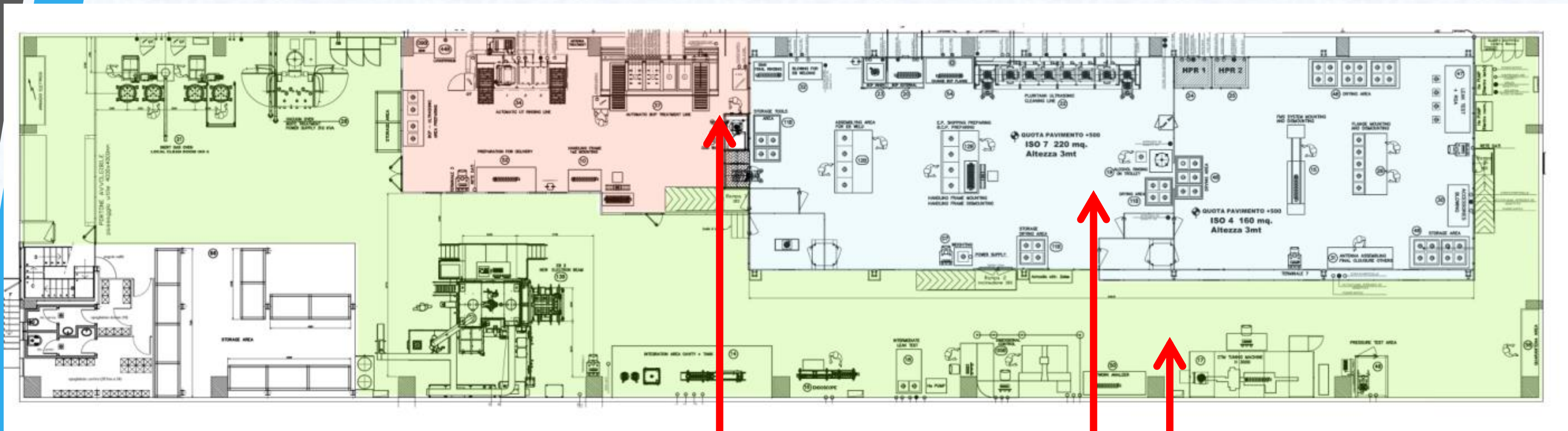
C) Manufacture and testing of 146 units of Titanium Helium tanks

Scope of work has included

- Tank prefabrication and He leak check
- Delivery to DESY

Cavities serial production lay-out and





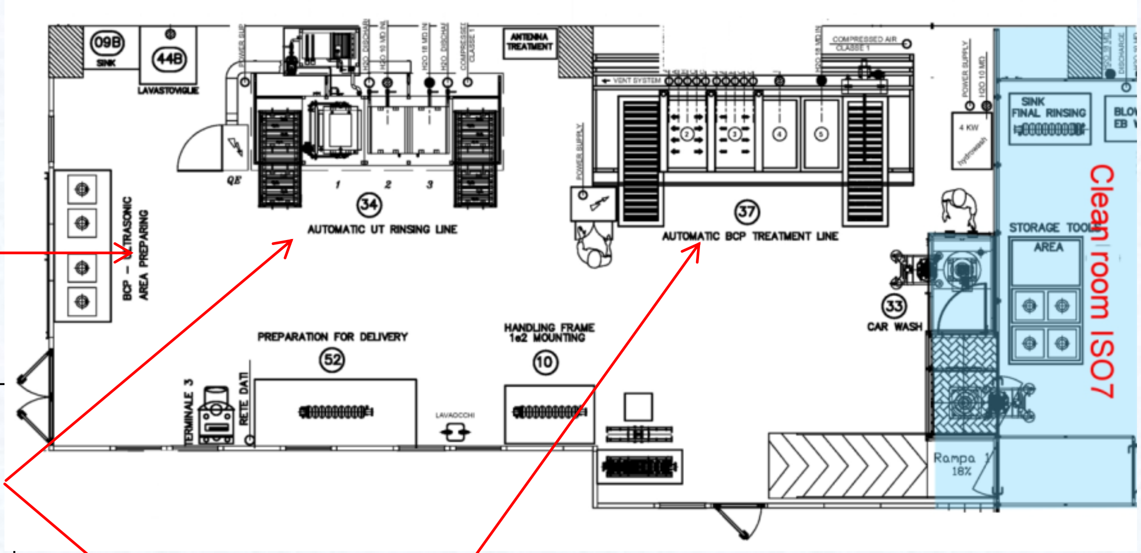
The buidling is organized
in three main areas

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

Building lot IV Chemical treatment area

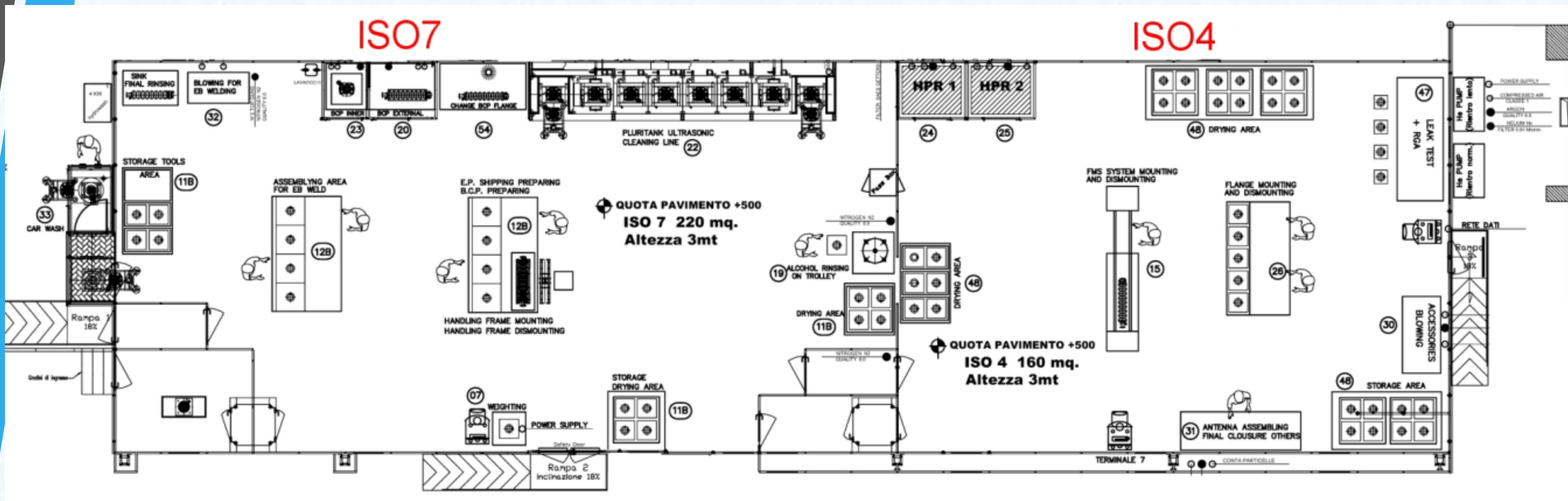
Preparation and drying areas

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

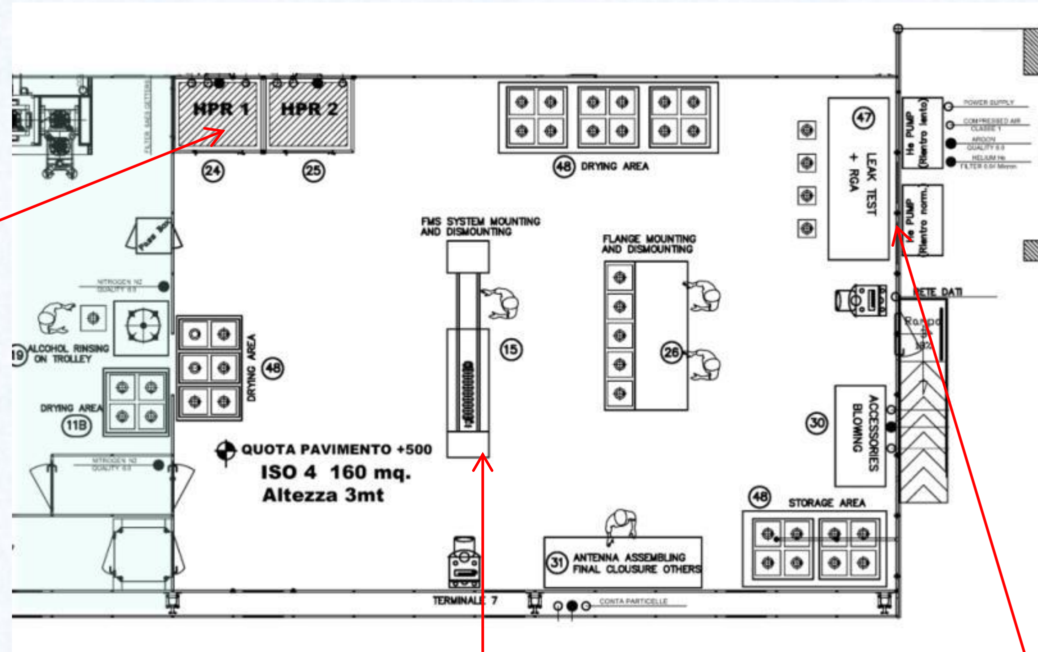
Operators dressing rooms , air showers

All metallic floating floor

Customized treatment stations

Building lot IV - Clean room ISO 4

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



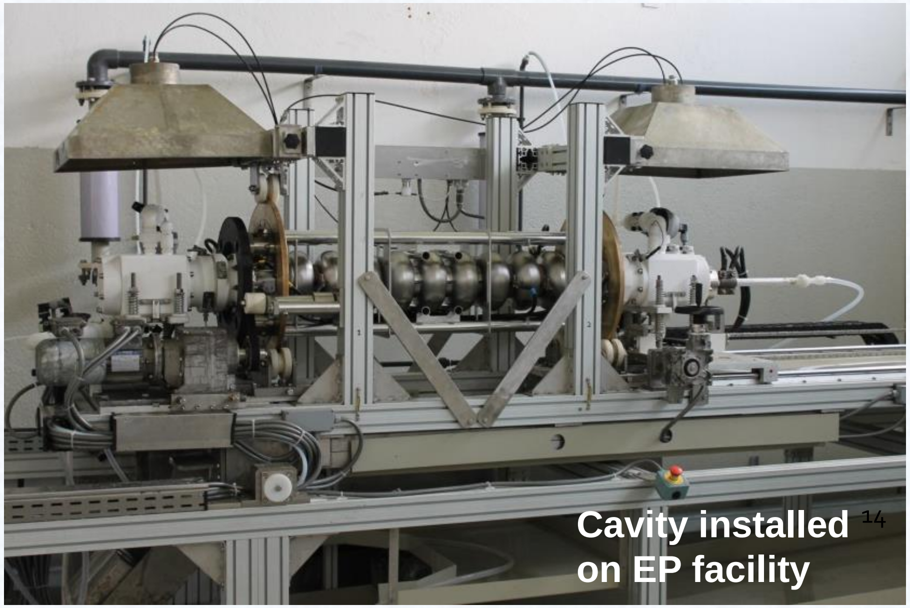
Station for final leak test special equiments for slow-controlled venting of the cavity

Assembling stations for FMS installation - RF antennas assembly

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 t
  - Constant 17 V applied on cavity for 6 hou
  - Mean current value: 270 A
  - Mean temperature value: 31°C.

Cavity ready for installation on EP bench



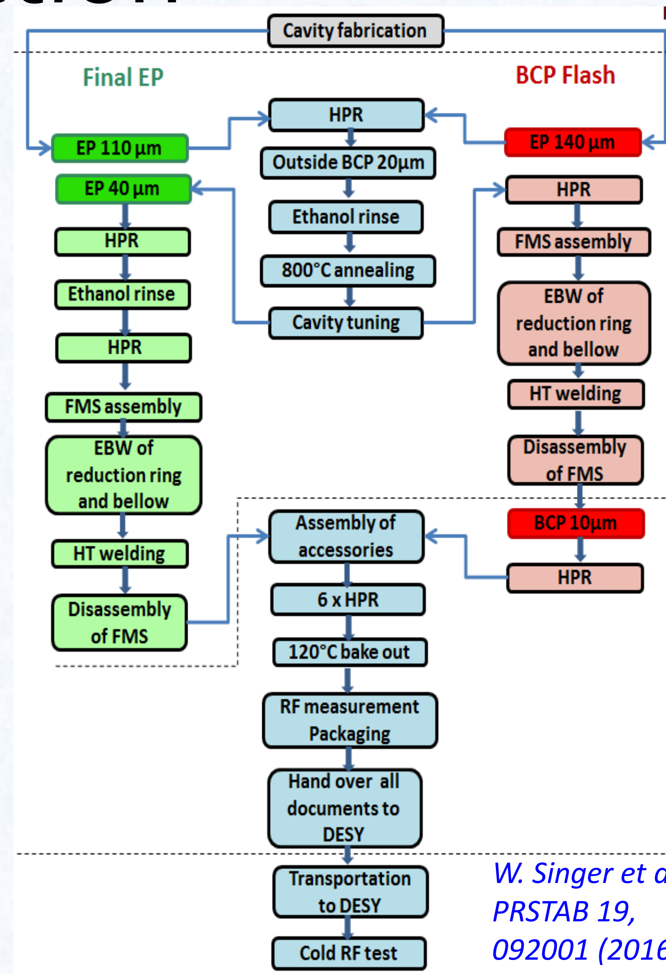
Cavity installed on EP facility

E-XFEL Cavity Production

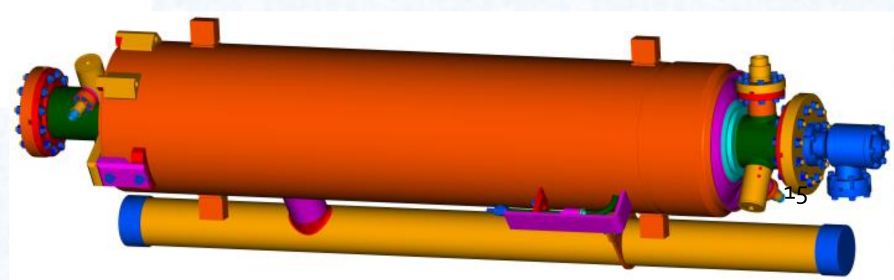
- Two recipes (choice left to the Companies): **Flash BCP** & **Final EP**
  - **EZ applied the Flash BCP**
- **Strategy: Built to Print** (**no performance guaranteed!**) for the first time applied on a large scale cavity production

- **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**



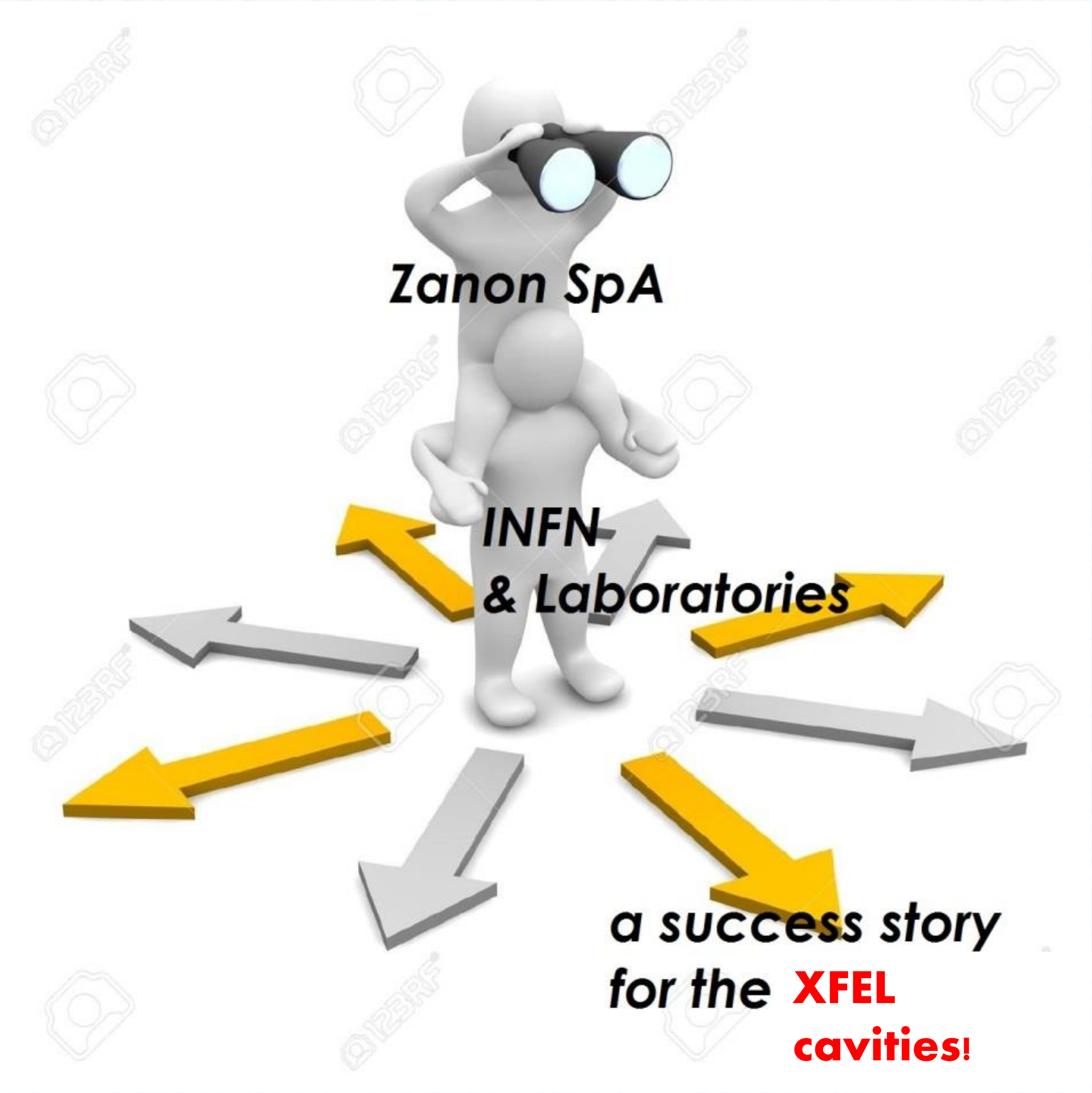
W. Singer et al., PRSTAB 19, 092001 (2016)



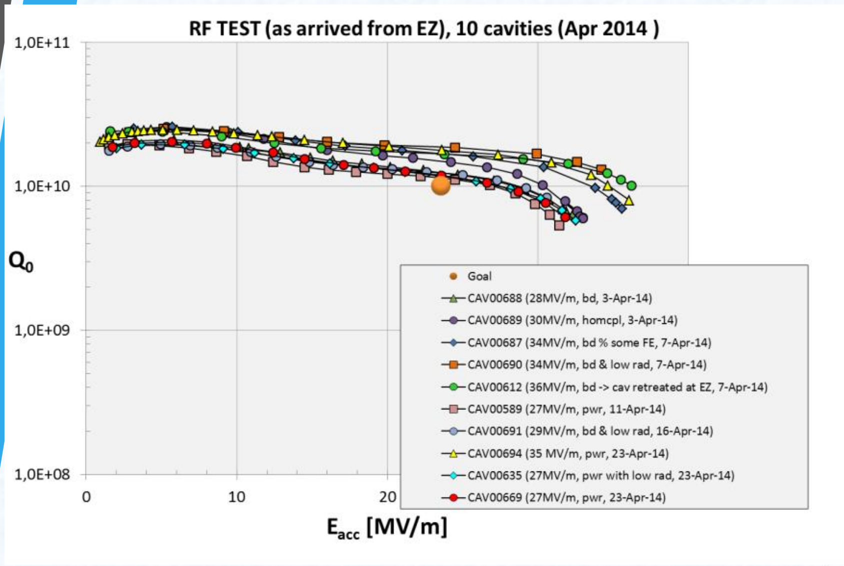
- **Material** and vendor qualification for Nb
- Cavity **design qualification**
- **Surface treatment** qualification
- Cavity producer **qualification**: mechanical fabrication
- Procurement of Nb and semi- finished parts
- **Definition** of the "external" QA/QC for the company
- **PED issue analysis** (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

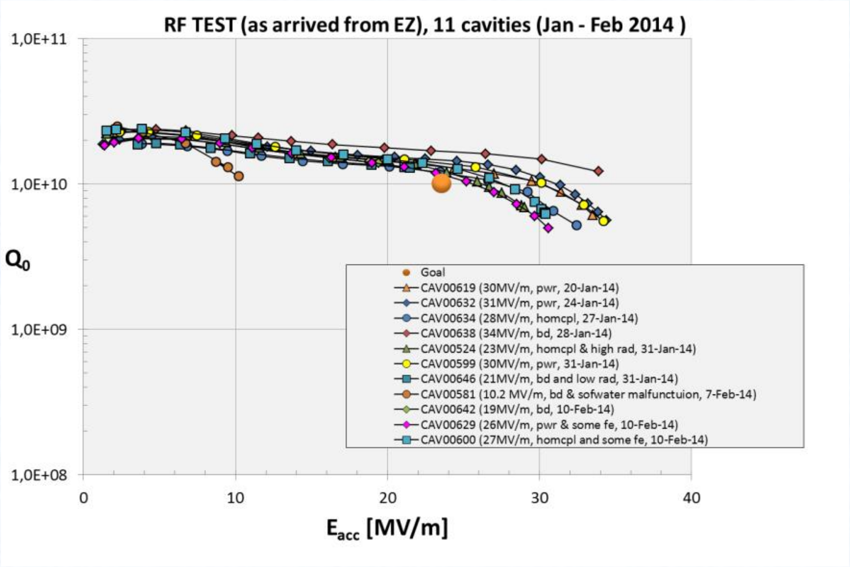
Preparatory phase
Laboratory level

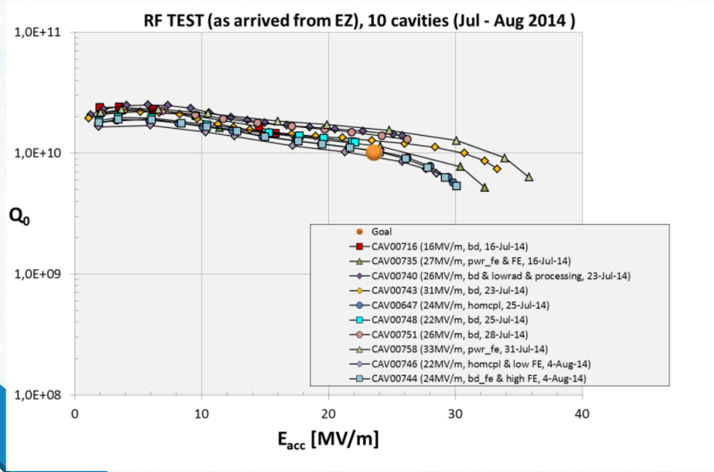
Series production
Industry level

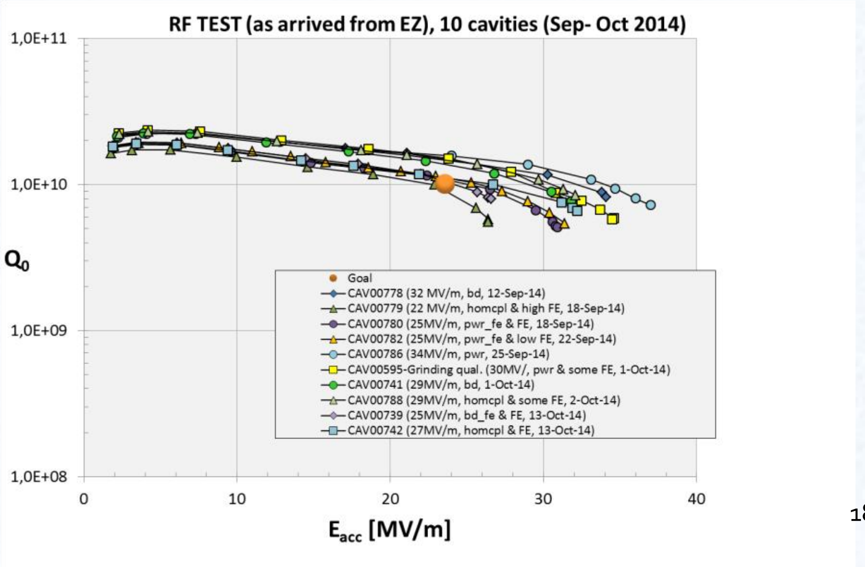

Zanon SpA
INFN
& Laboratories
a success story
for the XFEL
cavities!

XFEL Cavities results









Involvement to the LCLS-II production

A) Manufacture and final treatement of 133 units of the 9 cells , 1,3GHz SC cavities

Scope of work includes :

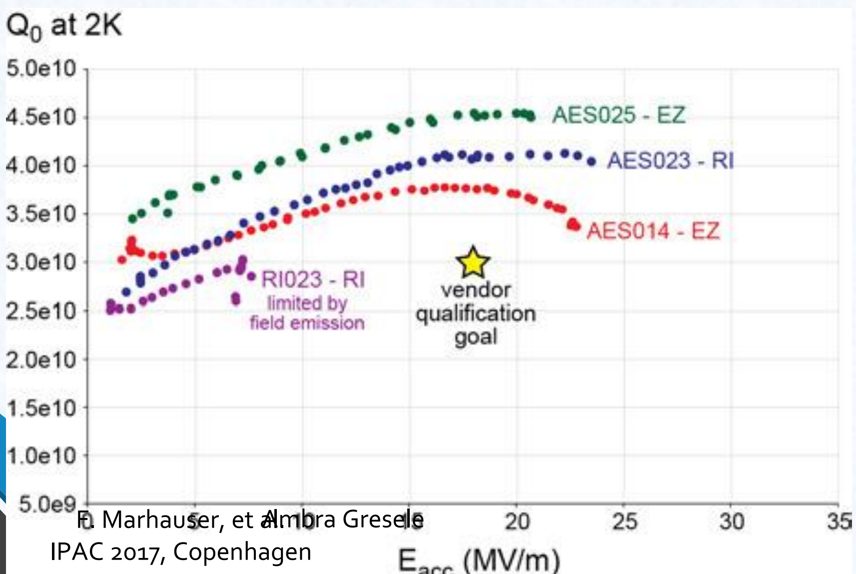
- Manufacture of the 1,3GHz cavities / Manufacture of their Titanium Helium tanks
- Integration of the cavities into their tank /Treatments and Surface cleaning treatments
- Delivery production rate 4 units/week

- **Very ambitious acceptance criteria**
  - **$Q_0 \geq 2.5\times10^{10}$ at E_{acc} = 16 MV/m (Equivalent to Q_0 of 2.7×10^{10} in CM)**
  - **Field emission onset at $E_{acc} \geq 17.5$ MV/m**
  - **Maximum $E_{acc} \geq 19$ MV/m**
- Production recipe: based on the **Nitrogen Doping** technique
- **Cavities tested "as received".**
- **QA / QC:** similar to the E-XFEL one. 3 acceptance levels.
  >100 documents /cavity
- **Two niobium vendors**: Tokyo Denkai (TD) and Ningxia OTIC (NX)

Preparatory phase, first production recipe

Technology transfer of the **doping** recipe

- Infrastructure set up:
  - UHV furnace
  - N_2 lines, flow controller, pressure gauges, plc, etc.
  - EP parameters
- Process verification using reference pre-processed cavities to validate the nitrogen doping and the light EP



F. Marhauser, et al. Ambra Gresele
IPAC 2017, Copenhagen

ORIGINAL RECIPE

- Cavity mechanical fabrication
- Bulk EP: 140 µm
- Heat treatments: 800°C, 3 h
- DOPING: 800 °C, 2 min, 20 – 30 mTorr, Nitrogen
- 800 °C, in vacuum, 6 minutes Cooling to room temperature
- Tuning
- Light EP: 5 – 7 µm
- Fine tuning with fms
- Tank integration
- Standard Clean Room process

The updated production recipe

E. ZANON

Thicker damaged layer at the surface

Updated recipes **needed to fix the effect of limited flux expulsion.**

- The bulk property of the Nb sheet, as grain size, used for cavity production significantly affects the flux expulsion efficiency during cooldown and consequently impacts on the residual resistance.
- NX material for LCLS production have small grain size and require **higher heat treatment temperature** to have better magnetic flux expulsion. 3 lots produced: A, B, C. (≥ ASTM6, in some case for lot C ≥ ASTM7).

900°C OK for Tokyo Denkai
950°C OK for NX (A + B)
975°C OK for NX (C)

These 3 recipes give $Q_0 > 2.5 \times 10^{10}$

UPDATED RECIPE

- Cavity mechanical fabrication
- Bulk EP: 200 μm
- Heat treatments: 900°C, 3 h
- DOPING: 800 °C, 2 min, 20 – 30 mTorr, Nitrogen
- 800 °C, in vacuum, 6 minutes Cooling to room temperature
- Tuning
- Light EP: 5 – 7 μm
- Fine tuning with fms
- Tank integration
- Standard Clean Room process

Dan Gonnella, SRF 2017,
Ari Palczewsky, SRF2017

Conclusions

- **After XFEL and with LCLSII, 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, N_2 doping.
  - EP process ensure higher maximum accelerating gradients
- **N_2 doping** process is more "**delicate**" w.r.t. standard EP recipe.

Back-up

Other productions

- FRIB: **94** Quarter Wave Resonator (QWR, β = 0.0085), only mechanical construction

- ESS:

❖ **38** elliptical cavities 704 MHz (β = 0.67) treated & integrated, ready for VT

❖ **26** double spoke cavities only mechanical construction