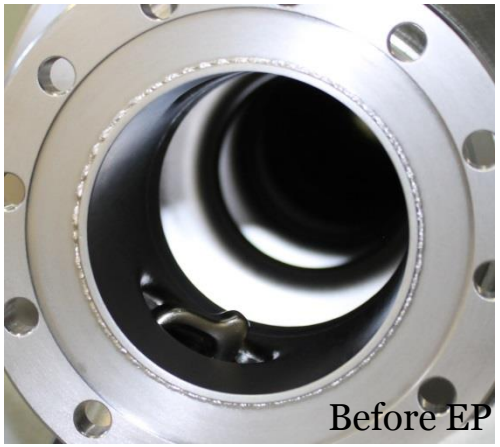
TTC Meeting DESY – Hamburg
24 - 27 March 2014

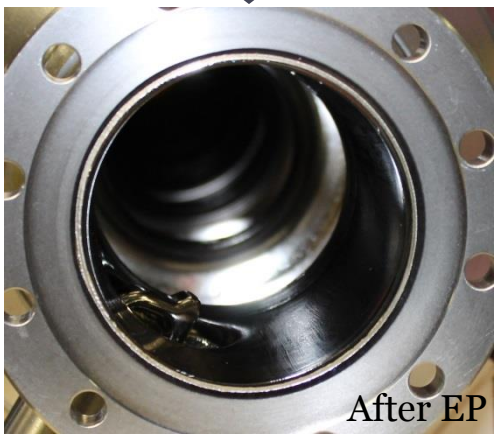
Experiences on Electropolishing set up at Ettore Zanon SpA

New EP facility developed for the treatment of EXFEL 1.3GHz cavities.

The new electropolishing facility at Ettore Zanon SpA

- Horizontal EP facility for 1.3 GHz – 9 cell cavities
- Developed by the technical department of Ettore Zanon SpA
  - specifications and hints given by experts from DESY.
- More than 100 cavities treated from July 2013.
- Now working at a rate of 5 cavities/week.
- Treatment data:
  - 140 µm bulk EP as first main polishing
    - Final surface treatment is done with 10 µm BCP
  - Constant 17 V applied on cavity for 6 hours
  - Mean current value: 270 A
  - Mean temperature value: 31°C.





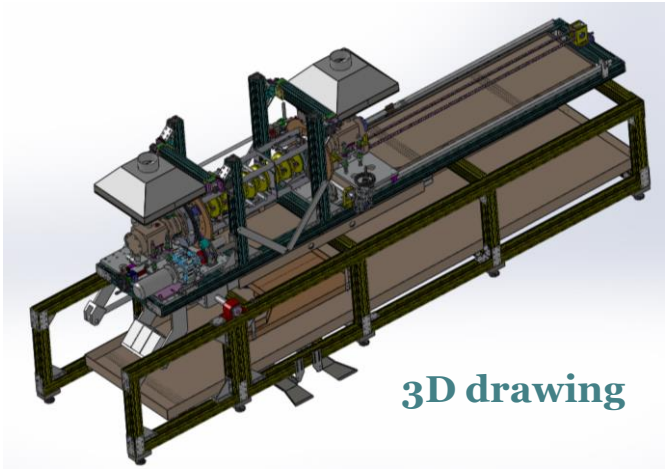
Steps for qualification

- Project with 3D drawing of the bench
- Mechanical and hydraulic installation by Zanon's staff
- First tests with dummy cavities (DCVs) for parameters setting
- **Qualification procedure:**
  - First EP test on reference cavity (RCVn°1):
    - 40 µm EP →vertical test failed
  - Modification of cathode shielding made with teflon tape
  - Second EP test on reference cavity (RCVn°2)
    - 40 µm EP → vertical test OK
  - Test with two series cavities
    - 140 µm EP, CAV599 →vertical test OK
    - 140 µm EP, CAV600 →vertical test OK

Go on with treatment of series cavities

EP facility: some details

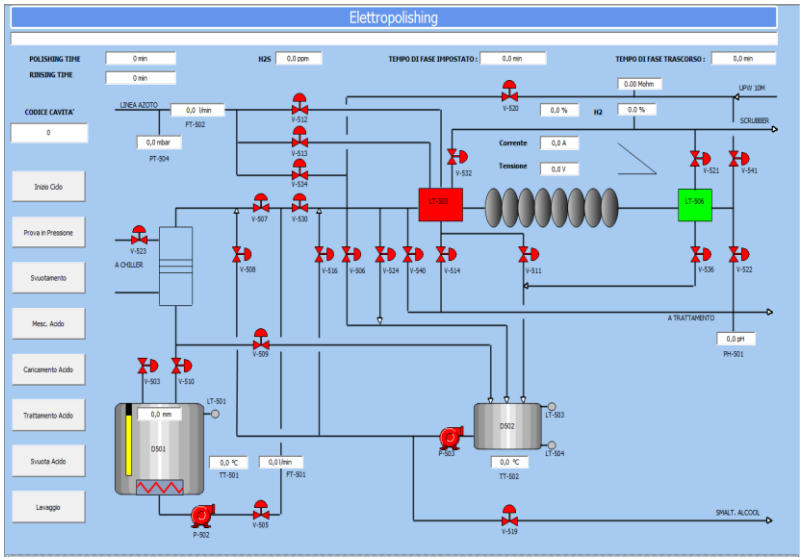
- Aluminium cathode 99.5% purity:
  - 5 mm holes for acid distribution,
  - Teflon tape to shield cathode at irises.
- Fluorinated polymers PTFE, PVD, PFA
  - For parts in contact with acid
- Ultrapure water 18MΩ*cm
- 99.999% pure nitrogen
- Acid mixture: H2SO4+HF (9:1 ratio)
- Usage up to 10 g/l Niobium dissolved

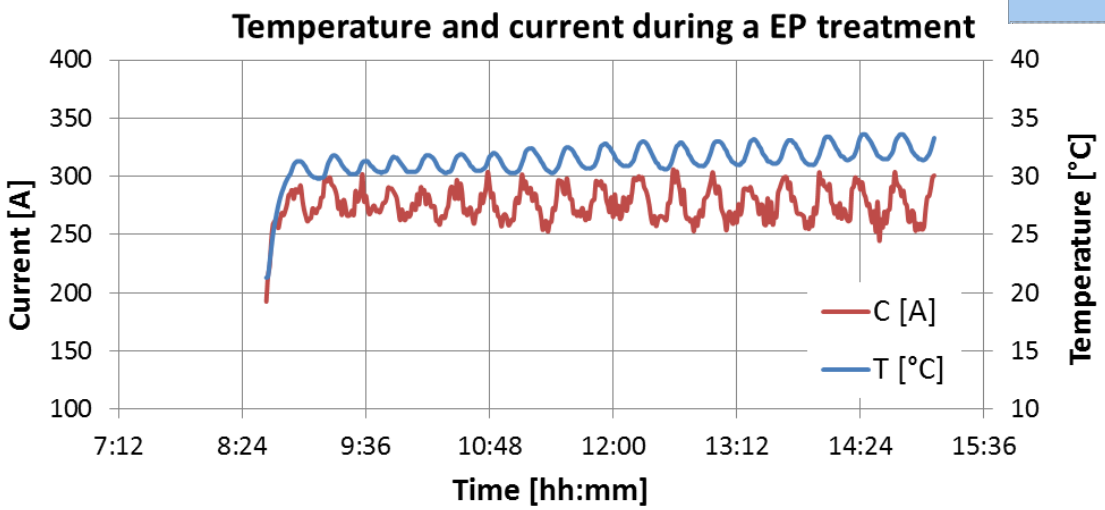


EP facility: automation of the process

Process sequence handled by a PLC

- Sensors for: temperature, pressure, flowrate, acid level
- H_2 and HF sensors for personnel and explosion safety.
- Movements and rotation controlled by position sensors.





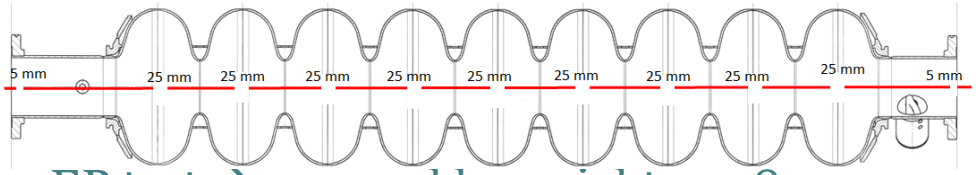
Automatic control of current and temperature:

- ON/OFF controller on cooling line
- Reaction rate control

Thank you for your attention!

Tests with different cathode shielding made with teflon tape

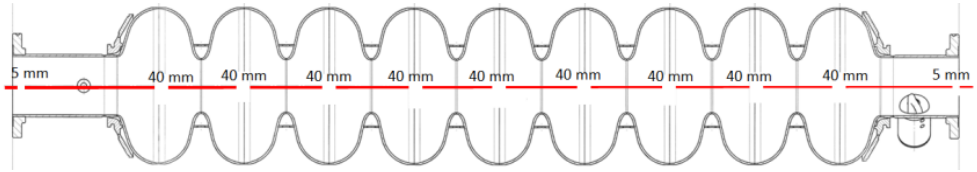
1. First configuration:



Constant V = 17V
Mean I = 230A
Mean T = 31°C

- 40 µm EP test → removal by weight: 42.8 µm
- vertical test failed!
- Hypothesis:
  - polishing at equators not sufficient?
  - Surface not perfectly smooth?

2. Second configuration:



Constant V = 17V
Mean I = 267A
Mean T = 30°C

- 40 µm EP test → removal by weight: 50 µm
- vertical test OK!

EP parameters

- 140 µm bulk EP as first main polishing
  - Usually more than 140 µm are removed to be on the safe side
- Constant 17 V applied on cavity for ~6 hours
- Mean current value: 270 A
- Mean temperature value: 31°C.
- Mean removal rate: 0.42 µm/min
- Average acid flowrate: 10 l/min
- Holes diameter: 5 mm
- Acid velocity at single hole: 0.94 m/s
- Average nitrogen overlay flowrate: 50 l/min
- Cavity rotation: 1 rpm/min

Main EP sequence

Ettore Zanon SpA follows the BCP flash production scheme:

- 140 μm EP as first cleaning,
- 10 μm BCP after helium tank integration.

MAIN STEPS:

1. US cleaning in clean room of ISO7 standard
2. Installation of cavity in EP bench CAVITY is HORIZONTAL
3. **Pressure test with ultrapure water** CAVITY is VERTICAL
4. Draining with nitrogen CAVITY is VERTICAL
5. Filling with acid CAVITY is HORIZONTAL
6. **17 V applied on cavity for approx. 6 hours** CAVITY is HORIZONTAL
7. Draining with nitrogen CAVITY is VERTICAL
8. Rinsing with ultrapure water to safe pH CAVITY is VERTICAL
9. Removal from EP bench CAVITY is HORIZONTAL
10. Transportation to clean room ISO7 and rinsing to 12 MΩ*cm
11. 30 minutes 100bar high pressure rinsing (HPR) in ISO4 cleanroom

140 µm removal: how is it calculated?

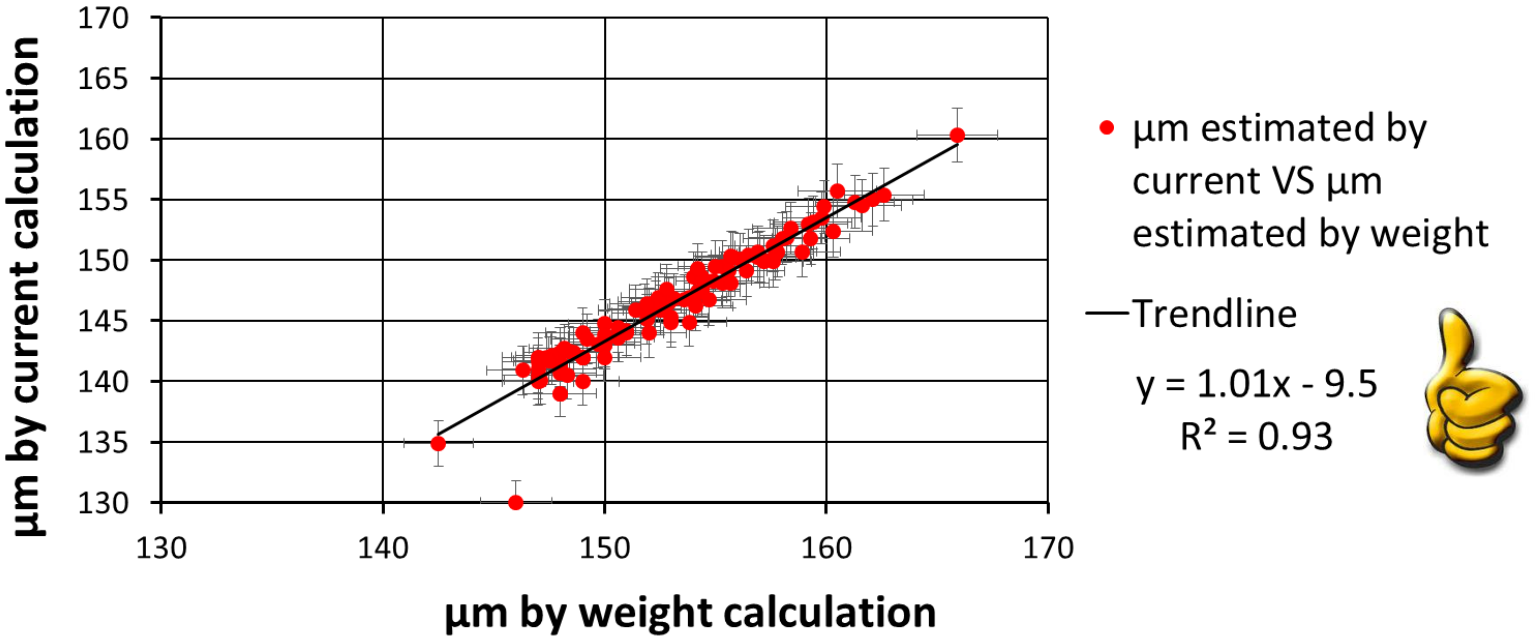
Two different ways to estimate mean thickness removal

1. **by cavity weight before and after EP** $\mu m = \frac{W_{before} - W_{after}}{7.6}$

2. **by the integral of current over time** $\mu m = \sum_{t=0}^{t=t_{EP}} (1.484 \cdot 10^{-3} \cdot I \cdot \Delta t)$

No infos about actual removal at irises and equators

- For this topic, see Ambra Gresele's presentation



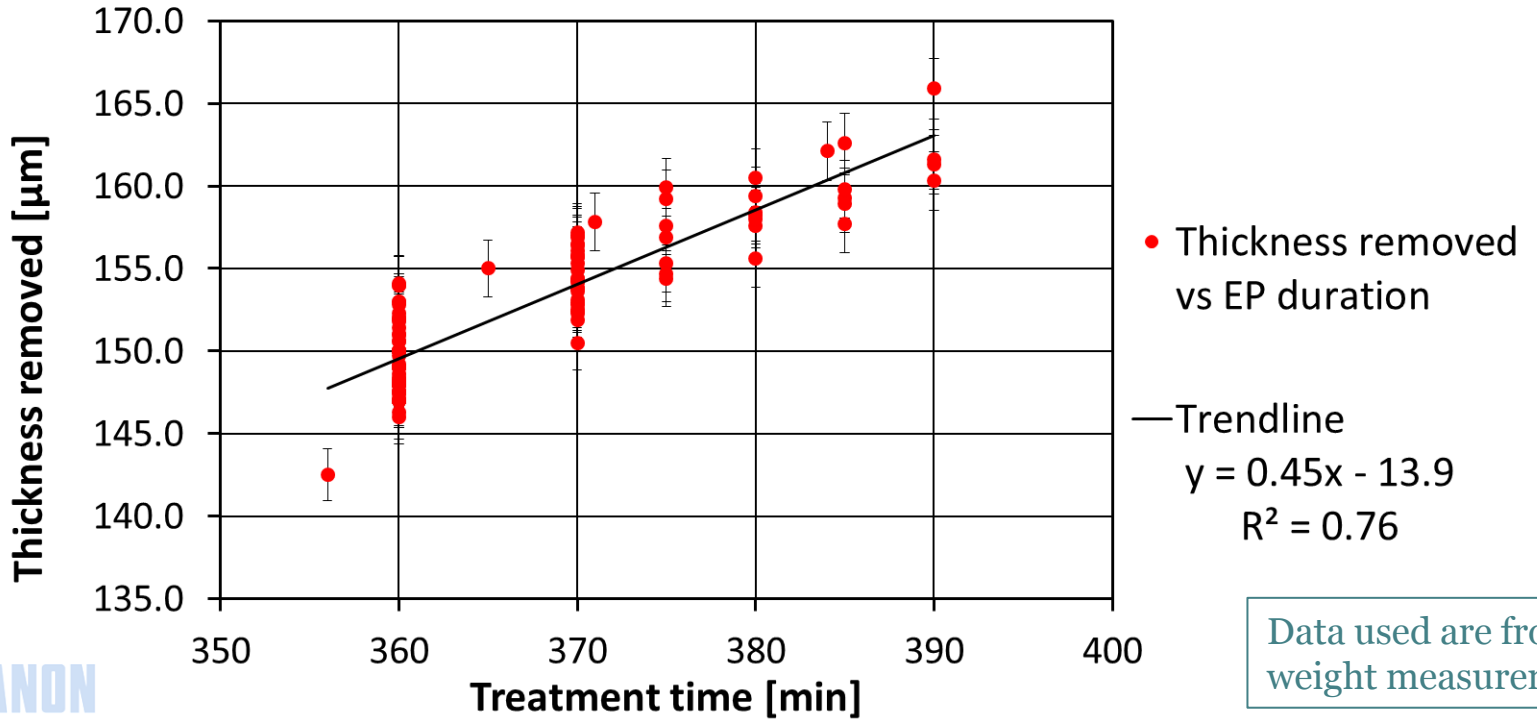
140 µm removal: how is it achieved?

Two main parameters: Time and Current

TIME

- With an error of ~10µm, duration of EP is the best way to control total removal.

+ 10 minutes → + 5 micron



Data used are from weight measurements

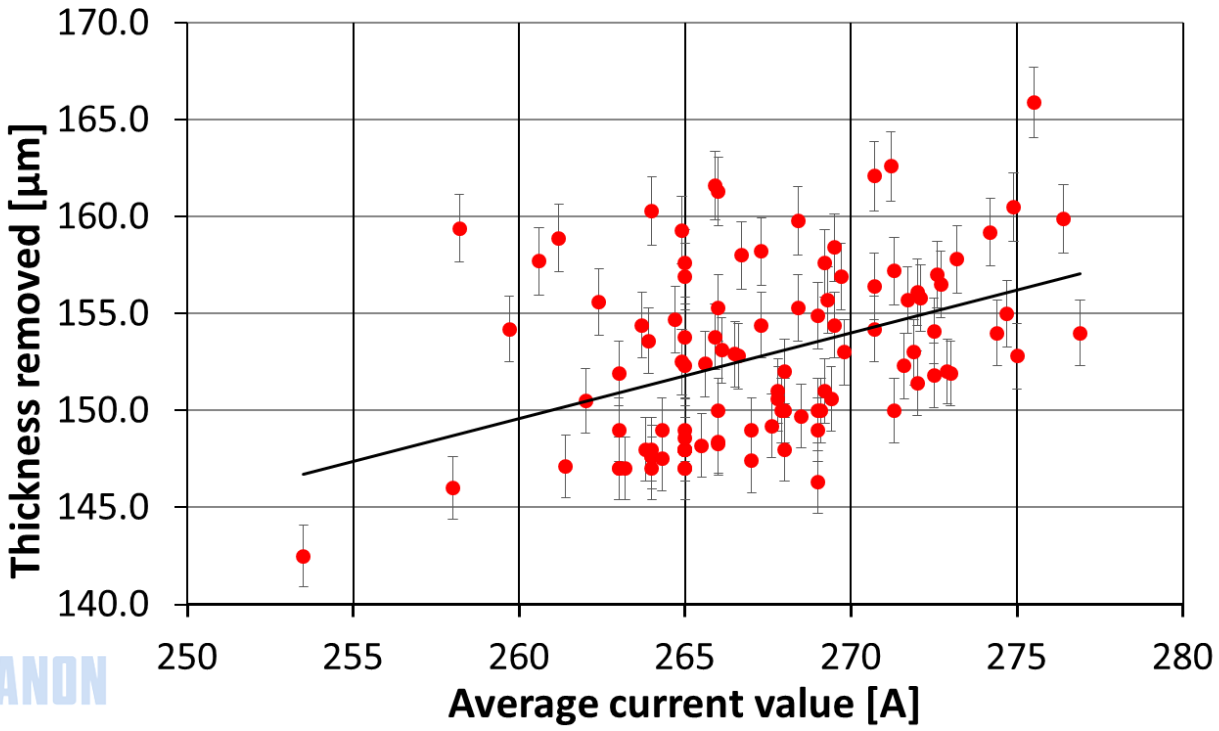
140 µm removal: how is it achieved?

Two main parameters: Time and Current

CURRENT

Surface removal control by current is more difficult:

- Current is not constant during EP
- Not a free parameter: related to temperature

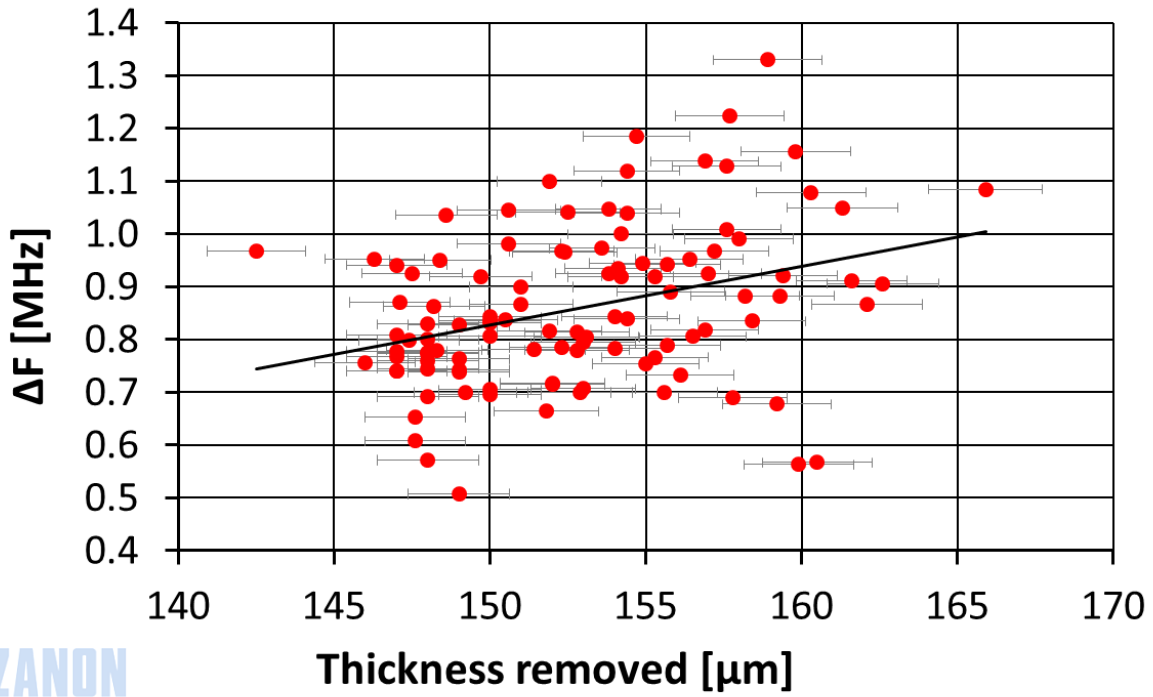


Data used are from weight measurements

Comparing surface removal and frequency variation

ΔF as a different method to estimate material removal

1. All methods presented can only estimate the **MEAN REMOVAL**
2. ΔF determines the cavity lenght after tuning
   - Is it possible to predict correctly ΔF → cavity final lenght from EP variables?
3. Correlation between ΔF and µm removed by weight
   - Data are scattered → no clear correlation



Data used are from weight measurements

About removal at irises and equators

- Surface thickness measured by means of a ultrasonic thickness gauge.
  - Krautkramer Branson CL3 Ultrasonic Thickness Gauge with sensor Alpha 20/125 016dry.
  - Data taken from four cavities.
- Removal at irises is higher than at the equators.
  - ✓ 100 µm guaranteed also at equators.

High measuring error

It makes sense only with long EP treatment (es. 140 µm)