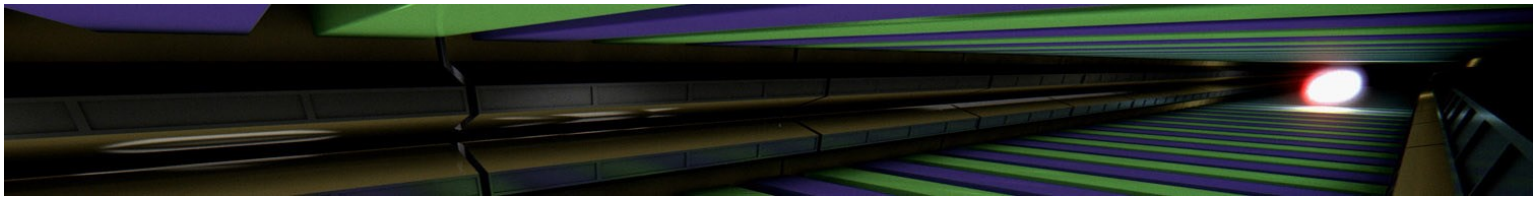
European XFEL



SRF2013 PARIS

Infrastructure, Methods and Test Results for the Testing of 800 Series Cavities for the European XFEL

Detlef Reschke / DESY

for all colleagues working on European XFEL series cavities

DESY HELMHOLTZ ASSOCIATION INFN Istituto Nazionale di Fisica Nucleare CRISP The Cluster of Research Infrastructures for Synergies in Physics

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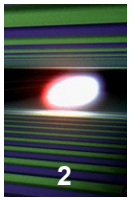
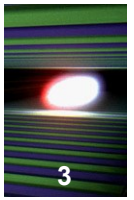
Outline



- Introduction
- Infrastructure for Vertical Acceptance Tests
- Cavities
- Procedures
- Vertical Test Results
  - “As received”
  - After re-treatment
  - Q-Values
- Summary + Outlook

Introduction



- Vertical acceptance tests of European XFEL
  - Pre-Series + Series Cavities
  - “HiGrade”-Cavities

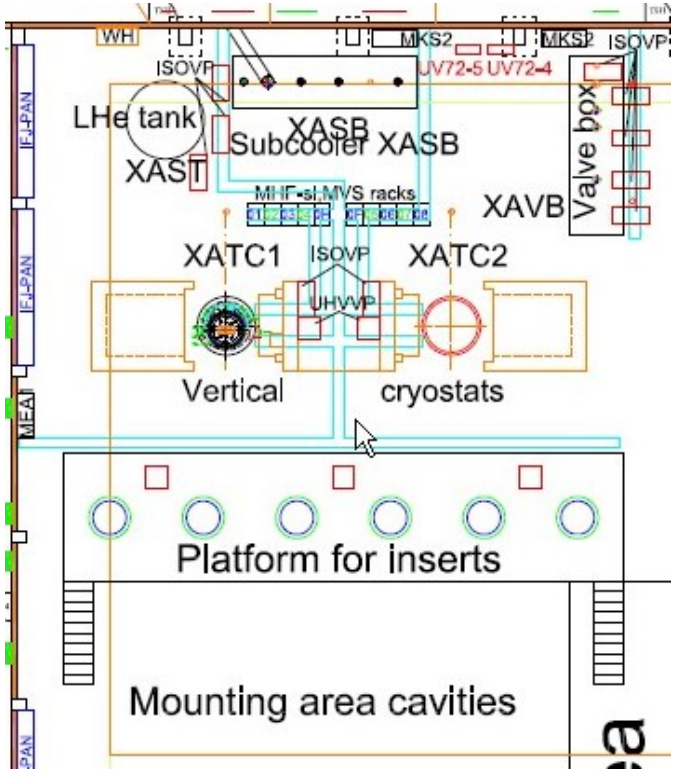
- 800 pre-series + series cavities
- ≥ 8 cavities per week (=> 1 module per week)

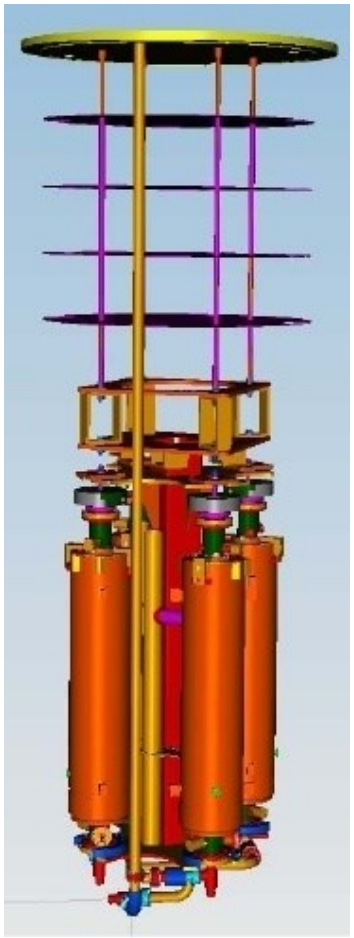
- Cavities are produced and surface treated at industry
  => ***Talk by W. Singer MOIOA03***

- Status of vertical tests: **September 10** !

Infrastructure: AMTF

- **A**ccelerator **M**odule **T**est **F**acility
- New Infrastructure for vertical acceptance test (+ module tests)
  - **Two** independent vertical cryostats
  - **Six** inserts for **four** cavities each
  - **Two** independent rf test stands





Infrastructure: AMTF II

- Vertical tests started in Feb 2013 (IFJ-Pan & DESY)
- Parallel commissioning of inserts + vertical tests on series cavities
  (last insert to be qualified end of Sep)
- New software for vertical tests
- no Second Sound; no T-Mapping
  => if necessary at hall3

Cavities

- Cavities arrive at DESY in a transport box
  - Fully equipped with HOM-antennas, Pick-up antenna + fix High Q antenna
  - Under vacuum
  - **Ready for testing**

- A) Pre-Series + Series Cavities **with He-tank**

- B) “HiGrade” Cavities **without He-tank**
  - 12 cavities by each vendor
  - Use as quality control with the option of Second Sound and/or T-Mapping
  - (later: use for high gradient ILC research)

Poster MOP043

Poster MOP053

Procedures: Incoming Inspection

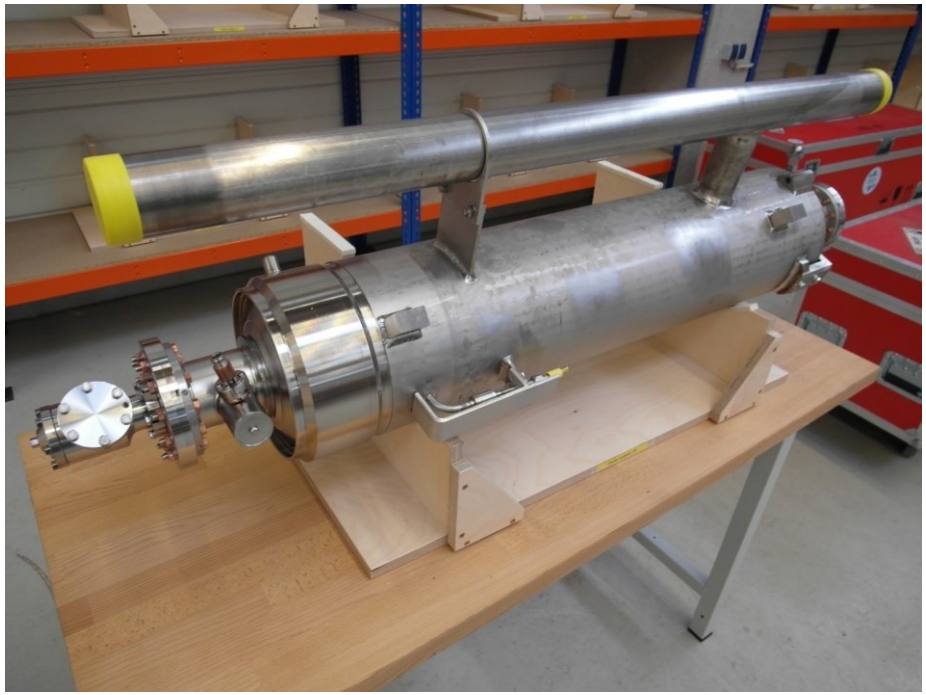
- Incoming inspection checks

  Poster MOP037

  - Mechanical: damages during transport, obvious assembly errors
    => feedback to companies!
  - Electrical: pi-mode frequency + fundamental mode spectrum, shorts at antennas

    Poster MOP052
  - Vacuum: next slide

    Poster THP093



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Procedures: Preparation for Vertical Test

- RF preparation:
  - Time-Domain reflectometer measurement
  - Tuning of Fundamental Mode Rejection Filters of both HOM couplers
- Vacuum:
  - Leak check (< 1 x 10^{-10} mbar·l/s)
  - Residual Gas Analysis => check for hydro carbon contamination

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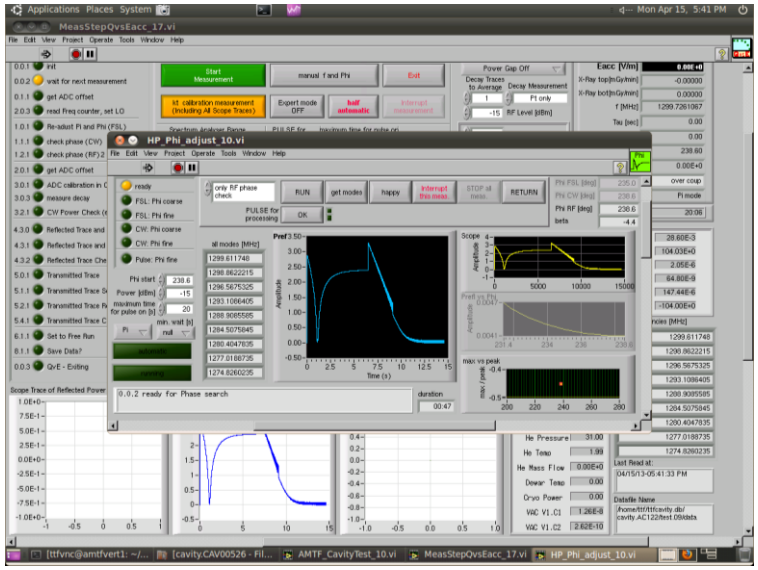
Procedures III: Vertical Acceptance Test at 2K

- "Standard" cavity test at **2K**
  - Measurement of **$Q_0(E_{acc})$ in π-mode**
  - Measurement of **fundamental mode frequencies**
  - **X-ray** measurement on top and below each cryostat
  - Remark: no $Q_0(T)$,
    no $Q_0(E_{acc})$ in fundamental modes,
    no $Q_0(E_{acc})$ at various bath temperatures
  - Remark II: RF measurement one by one



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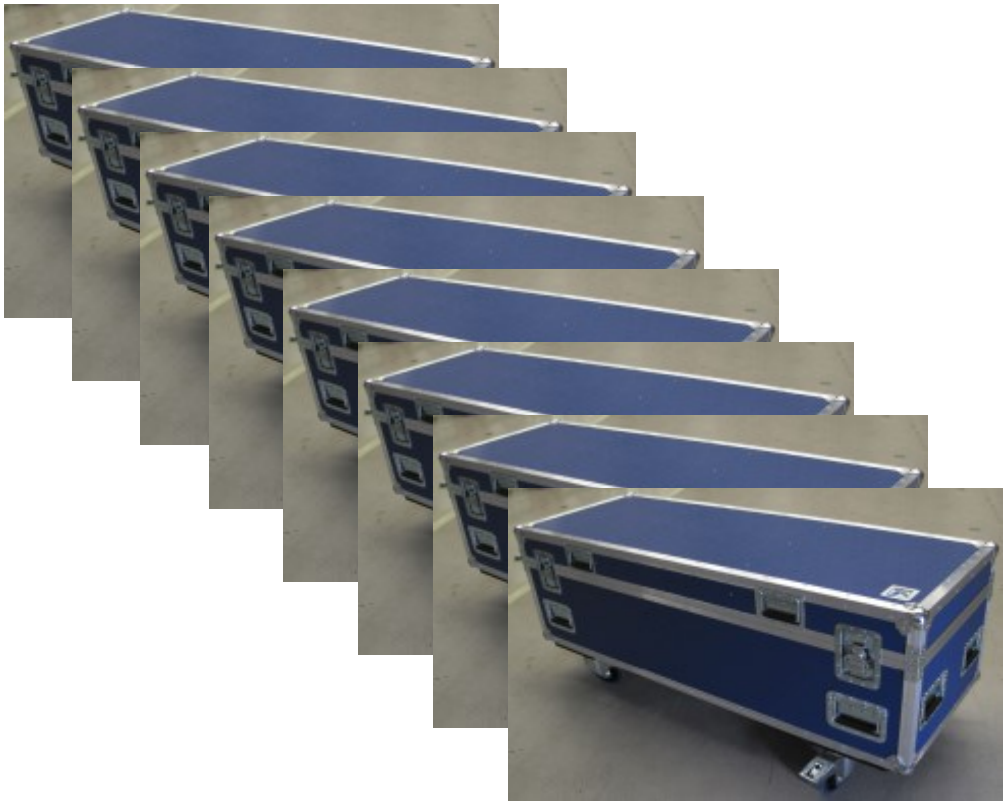
Procedures: Outgoing inspection + transport

- Outgoing inspection: backwards incoming inspection
- Transport to CEA Saclay for string + module assembly



Procedures: Result + Decision

- Vertical test results stored as **raw data** and in **XFEL Cavity data base**

  Poster MOP041

- **Acceptance Criteria**:
  "…maximum gradient > 26 MV/m with an unloaded Q_0 of ≥ $1x10^{10}$ and a X-ray level lower than $1x10^{-2}$ mGy/min."
  (with 26 MV/m to give 10% margin compared to 23.6 MV/m design gradient)

- If acceptance criteria **passed**
  => preparation for transport + string assembly
- If acceptance criteria is **not passed**
  => **re-treatment at DESY**
  (Reminder: **No performance guarantee by the vendors**, i.e. the risk of unexpected low gradient or field emission is with DESY)

- **"Usable Gradient":** i) Quench
  ii) $Q_0 < 1x10^{10}$
  iii) radiation > $1x10^{-2}$ mGy/min

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Vertical test results: As received / 1. Pass

- 79 cavities tested **as received** (1. pass) with
  - 23 from Research Instruments (RI)
  - 56 from E. Zanon (EZ)

- As received: **50 cavities passed**
  - 15 from RI
  - 35 from EZ

- Strict application of acceptance criteria
  (Comment: Some cavities retreated though acceptance criteria formally met)
- No selection, no cut

- 29 cavities in re-treatment loop => later

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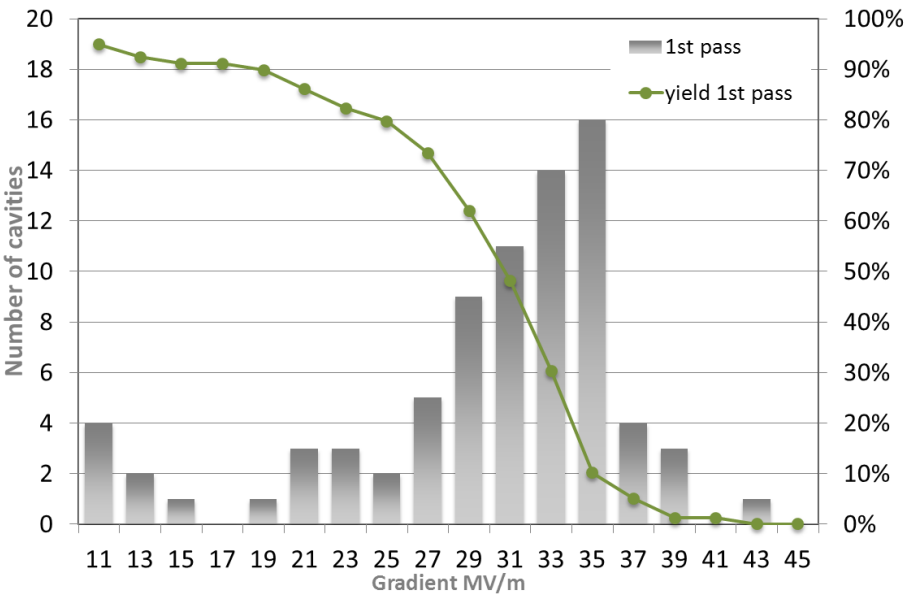
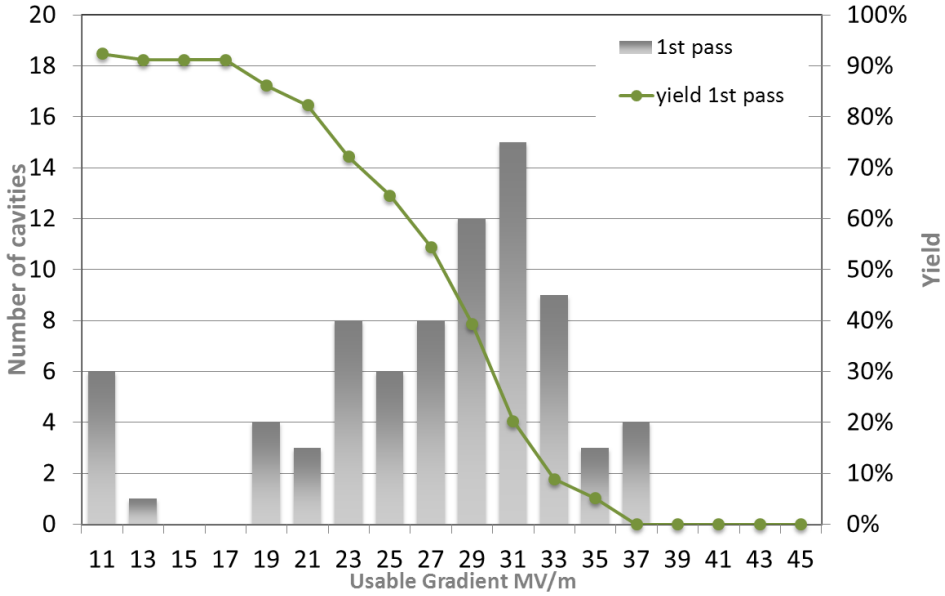
Yield of gradients: As received / 1. Pass

- Yield of usable and maximum gradient of **79 cavities as received**





Average **maximum** gradient:

(28.1 ± 7.8) MV/m

EZ: (27.6 ± 7.7) MV/m

RI: (29.2 ± 8.2) MV/m

Average **usable** gradient:

(25.0 ± 7.7) MV/m

EZ: (24.5 ± 7.6) MV/m

RI: (26.1 ± 7.8) MV/m

given errors are standard deviation

Vertical test results: Re-treatment / 2. Pass

- Re-treatment decided mainly because of field emission and/or low Q-value

- Two re-treatment options at DESY applied:
  - **High Pressure Rinsing (HPR)**
  - **10µm BCP + HPR + 120C bake**
- after HPR: 13 cavities with 11 passed
- after BCP: 1 cavities with 0 passed

- 15 cavities missing???
  => still in re-treatment loop !!!

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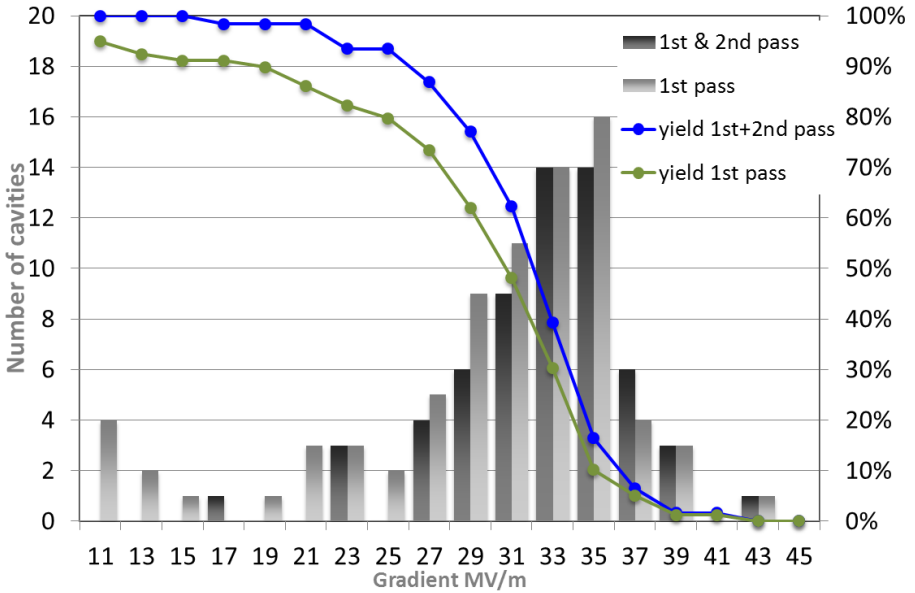
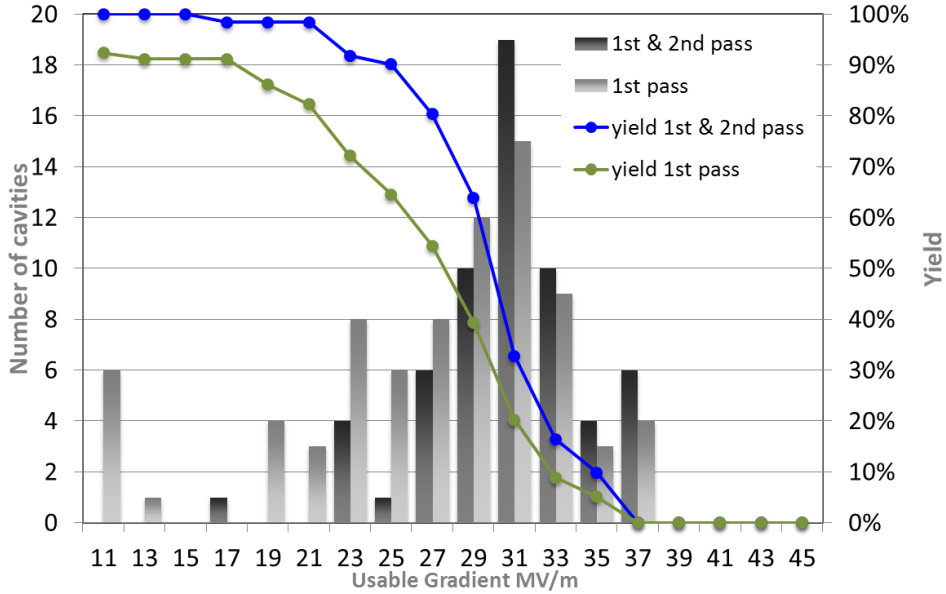
Yield of gradients: After re-treatment (2. pass)

- Yield of usable and maximum gradient of 64 cavities (2.pass): 50 cavities passed in 1.pass + 14 cavities after re-treatment
- **Average gradients increased + spread reduced** (standard deviation)





Average **maximum** gradient:

(30.9 ± 4.4) MV/m

EZ: (30.4 ± 4.5) MV/m

RI: (32.3 ± 4.1) MV/m

Average **usable** gradient:

(29.0 ± 3.9) MV/m

EZ: (28.4 ± 4.0) MV/m

RI: (30.6 ± 3.1) MV/m

Vertical test results: Q-Values

- Measurement with fix coupling
  => overcoupled at low and medium gradients
  => larger error than $\beta \approx 1$

- Low field Q_0-value:
- As received / 1.pass: $Q_{0,max} = (2.2 \pm 0.4) \cdot 10^{10}$
  (as before 79 cavities) (standard deviation)
- After re-treatment / 2.pass: $Q_{0,max} = (2.4 \pm 0.4) \cdot 10^{10}$
  (as before 64 cavities)

- Few cavities show Q-value < $2 \cdot 10^{10}$ at low gradient
  => feedback and quality control to companies

Poster MOP042

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Summary + Outlook

- Vertical test operation in AMTF started successfully
- Handling + inspection procedures for series cavity delivery developed and in application
- **Vertical acceptance test results are satisfactory for both vendors**
- Re-treatment by HPR at DESY very successful
- 44 cavities shipped to Saclay

- Ramp-up to > 8 cavities tested per week
- Follow-up of gradient and Q-value for quality control
- Goal: Improvement of “as received”-yield

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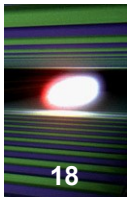
Acknowledgement



- Thanks to all colleagues of the different institutes and companies involved in cavity production, surface preparation and cavity testing

- Special thanks to Krzysztof Krzysik, Laura Monaco, Vladimir Gubarev and Nick Walker for their material for this talk

CRISP HELMHOLTZ ASSOCIATION

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Additional Slides

- text

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Infrastructure: Hall 3

- "Old" Infrastructure for vertical acceptance test
  - Two vertical cryostats
  - Four inserts for **one** cavity each
  - Two independent rf test stands
  - Analysis with Second Sound + Temperature Mapping available (only for cavities w/o He-tank!)