



# Challenges in SRF Module Production for the European XFEL

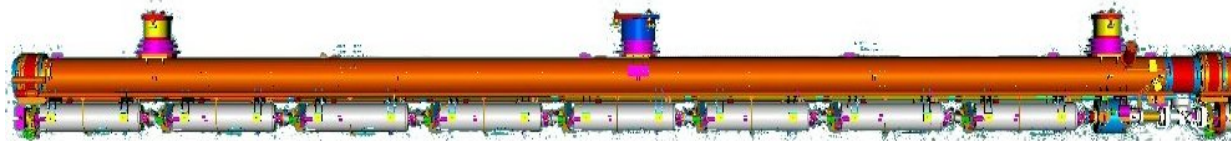
Detlef Reschke / DESY



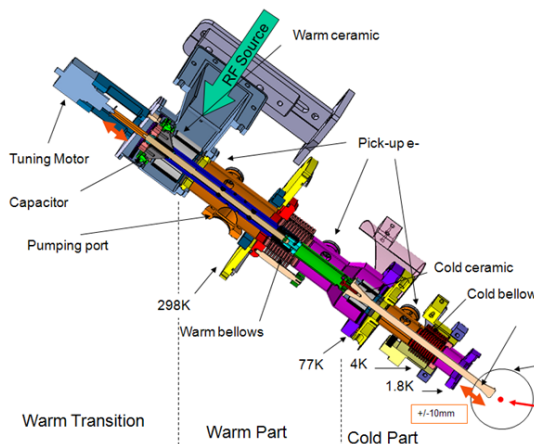
# DECIDED: Accelerator Complex 17.5 GeV Version

2

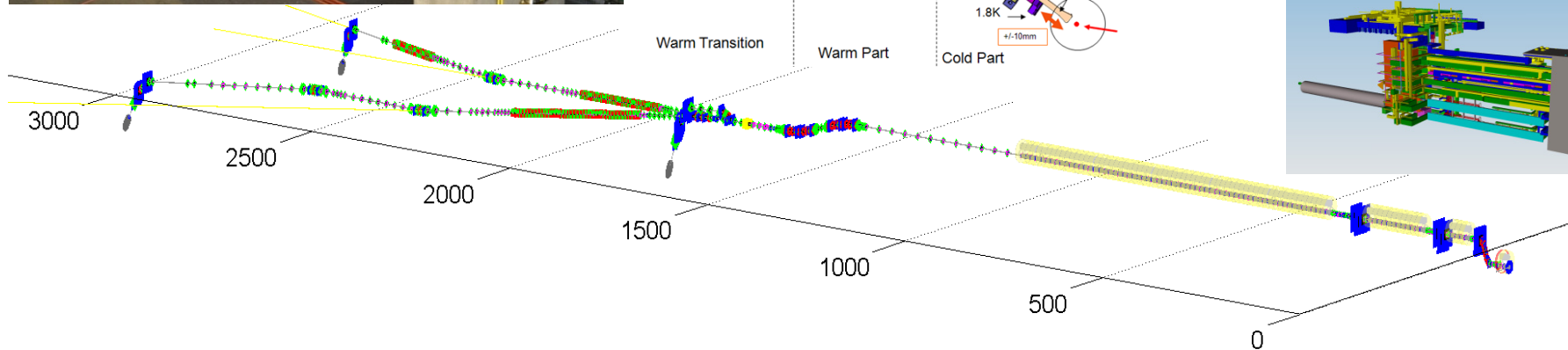
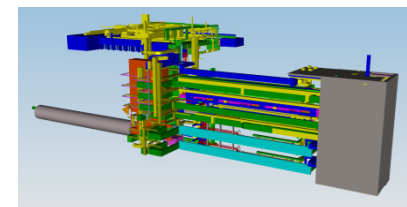
100 accelerator modules



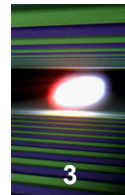
800 cavities + power couplers  
1.3 GHz / 23.6 MV/m



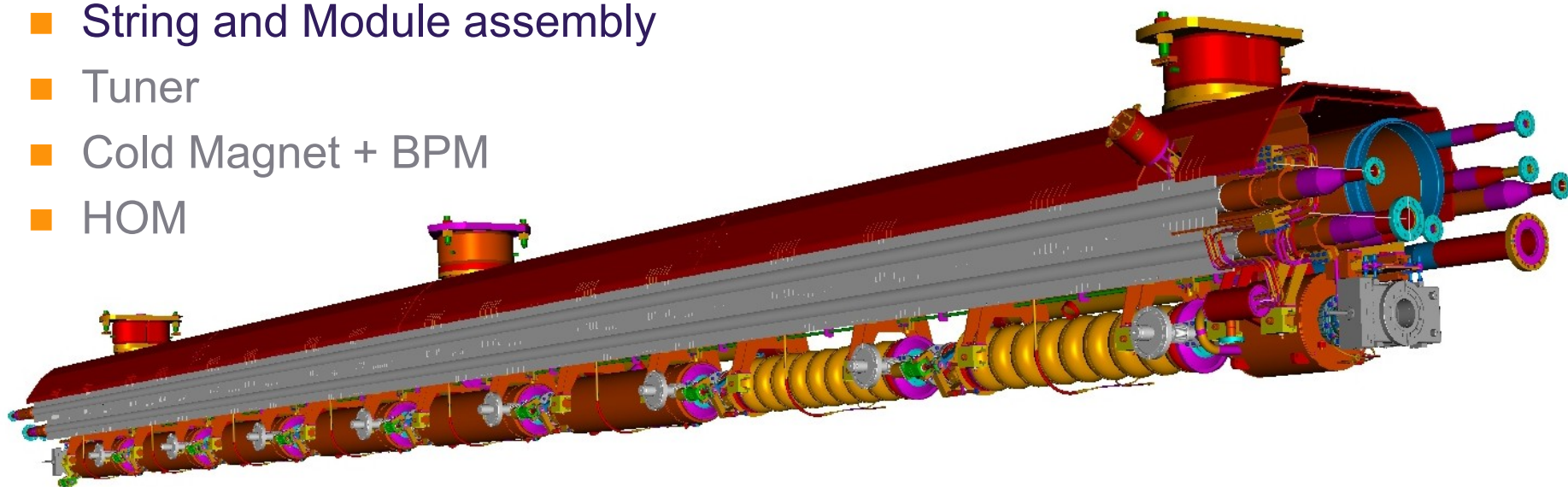
25 RF stations  
5.2 MW each

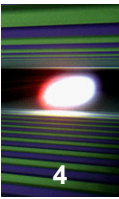


# Introduction - Module



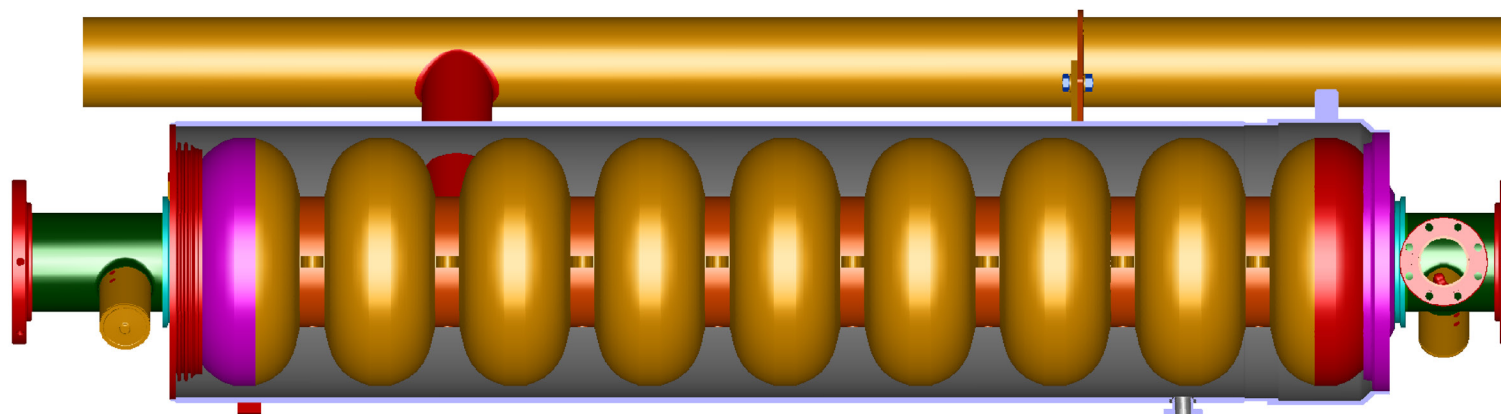
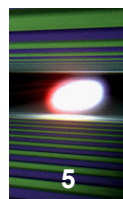
- Cavities incl. He-tank:
  - material, fabrication, preparation, acceptance test
- Cold Mass and Vacuum Vessel
  - fabrication
- Coupler
  - fabrication, conditioning
- String and Module assembly
- Tuner
- Cold Magnet + BPM
- HOM



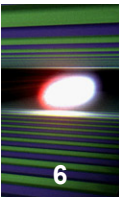


- **Knowledge transfer** to industry (especially new vendors) and collaboration partners !
- Experiences with:
  - Infrastructure
  - Procedures (incl. cleaning)
  - Handling
  - Tools
- Establish **procedures adapted to series production**
- Additional tasks taken over by DESY
  
- No discussion of budget + schedule aspects

# Cavities



# Cavities – First CFT to Contracts



- Original, first CFT included:
  - **Full material procurement** + quality assurance by **contractor**
  - Vendors responsible for performance (“**performance guarantee**”)  
“...Therefore cavities with a measured accelerating gradient value of  $<18$  MV/m or Q value  $Q < 1 \times 10^{10}$  at  $E_{\text{acc}} < 18$  MV/m will be rejected, this already taking into account a measurement accuracy of  $\pm 10\%$ .”
  - Three stages of pre-series cavities (4 + 4 + 4) by each vendor
- After first offer and negotiations with vendors:

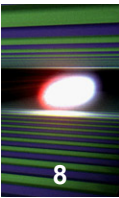
*Details about cavity procurement in talk WE0B04*



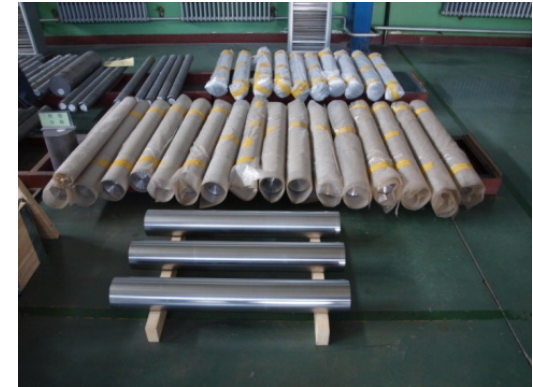
# Cavities – The Contracts

- **Research Instruments and E. Zanon** were contracted to produce each
  - **4+4 pre-series cavities** => 4 next pre-series cavities included in series cavities
  - **280 XFEL type series cavities**
  - **12 HiGrade cavities**, first used for quality assurance, later available for further investigations & treatments (high gradient R&D towards ILC)
  - **Additional 80 cavities** as an option to be placed after the evaluation of the successful start of the series production
  - **First series cavities beginning of 2012**; all cavities to be delivered within two years; He-vessels for RI cavities to be supplied by DESY
  - Final treatment after bulk electro-polishing (EP): EP for RI / “BCP Flash” for EZ
- **Nb / NbTi to be supplied by DESY**
- Production precisely following the specifications which also include the exact definition of infrastructure to be used (“**build-to-spec**”)
- **No performance guarantee by the vendors**, i.e. the risk of unexpected low gradient or field emission is with DESY (responsibility for re-treatment); goal: average usable XFEL gradient 23.6 MV/m

# Cavities – Niobium / NbTi

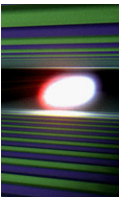


- DESY ordered Nb / NbTi material + supplies to companies
- DESY is responsible for:
  - **infrastructure incl. man power** for quality assurance and **logistics**
  - incoming visual inspection
  - dimension checks
  - Eddy-current scanning
  - documentation using the DESY EDMS (guarantee of **traceability for pressure bearing parts**)
  - definition of numbering system and marking
  - delivery to companies (including **risk of delays**)
- EZ: Titanium parts for He-tank and He-tank fabrication included
- RI: Titanium parts will be supplied by DESY





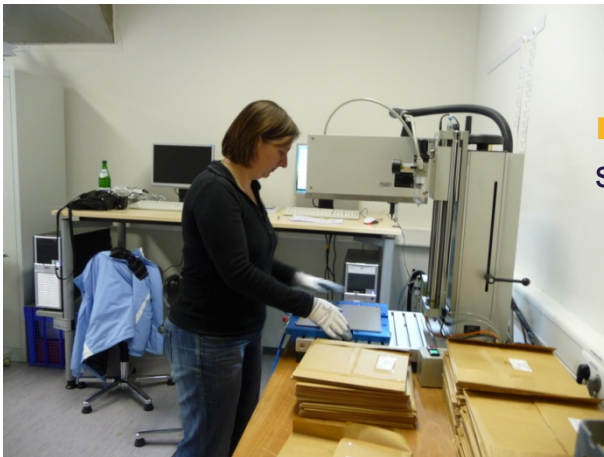
# Cavities – Niobium / NbTi II



■ Eddy current scanning of XFEL niobium sheets at DESY



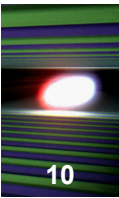
■ Equipment for tactile 3D dimension measurement



■ Equipment for sheets marking

- First sheets, tubes and other parts arrived at DESY (ca. 3.500 of 19.500 pcs)
- Entrance checks started
- First delivery to EZ + RI in-time end of July
- *Poster THPO053*

# Cavities – Fabrication according to PED



- Cavity fabrication according to **Pressure Equipment Directive** (PED 97/23/EC)
- “**Transfer of Identification**” from **material to final cavity**
- **PED process with Notified Body** (“TÜV Nord”):
  - Identification: classification of pressure equipment
  - **conformity assessment procedure** => choice of adequate procedure  
=> modules B + F of PED to be applied
  - “module B”: EC “**type examination**” of all relevant documents, companies, procedures, includes **test piece for weld qualification**
  - “module F”: “**product verification**” for series;  
based on results of module B  
e.g. pressure test of individual cavities required  
(not contracted yet)

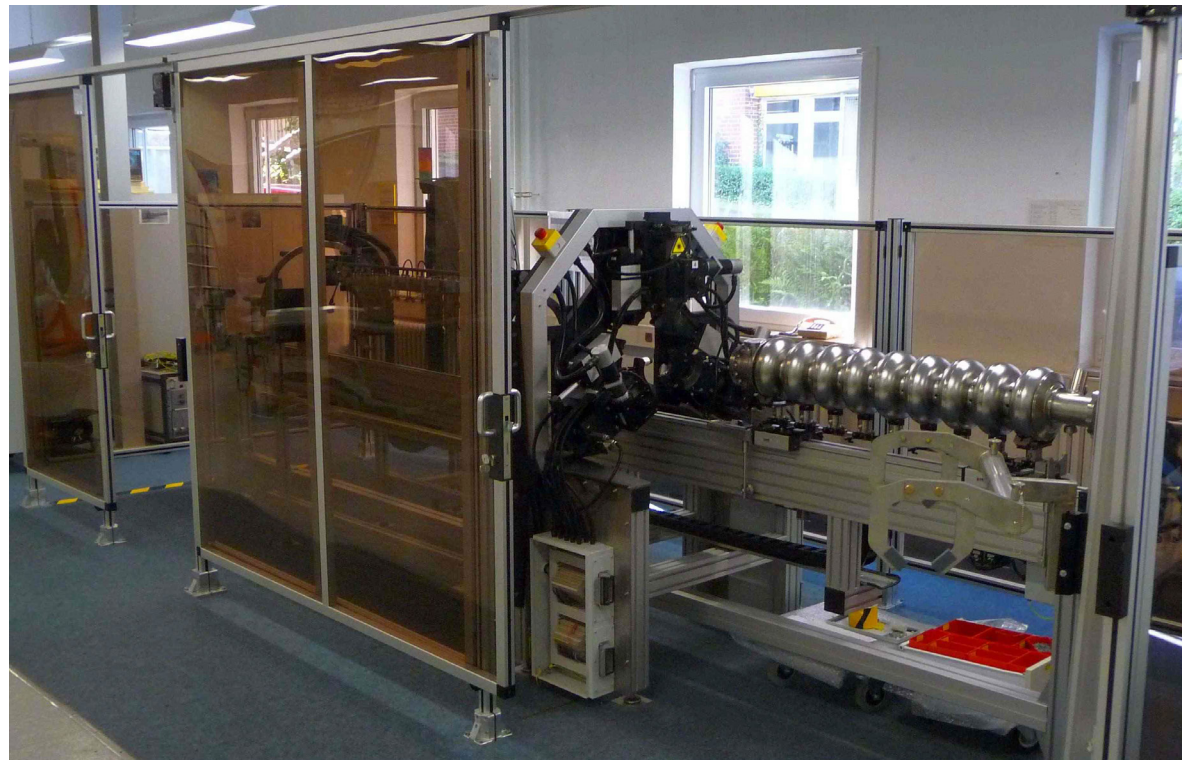
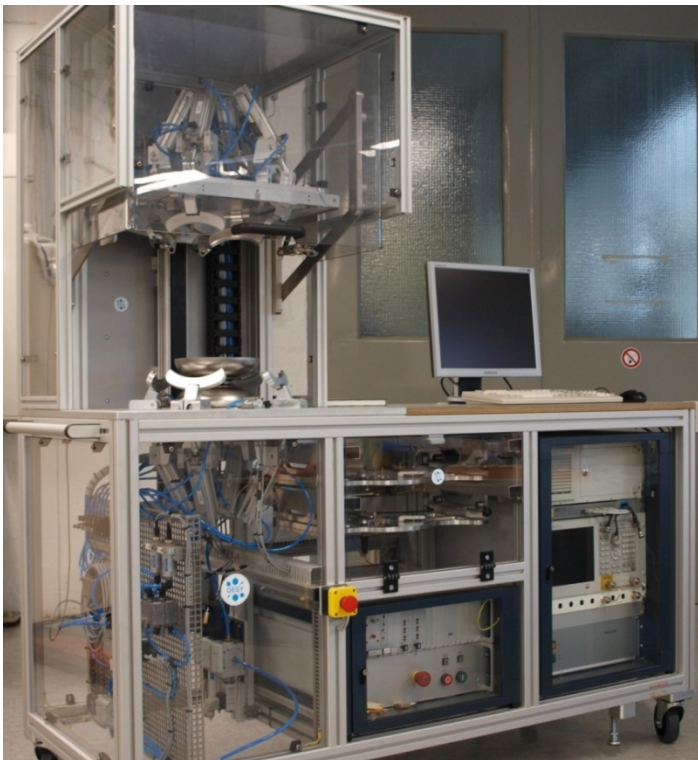
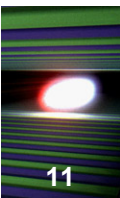


Courtesy of RI

15/6/2011



# Cavities - RF Measurement and Field Flatness Tuning using DESY-provided Tools



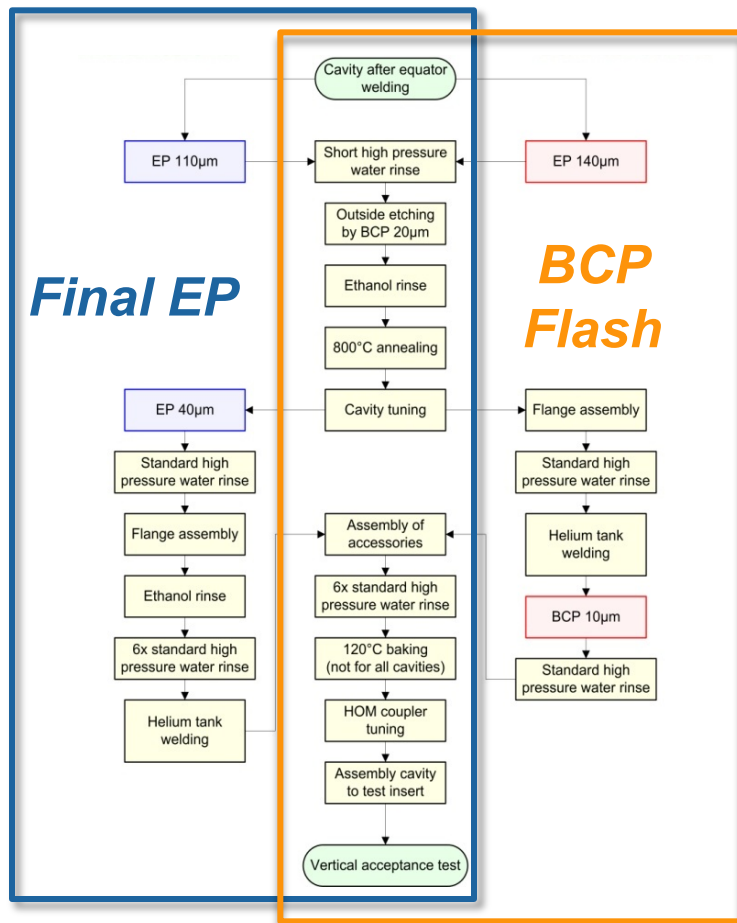
- Both machines in commissioning to be used at the companies (CE certified).
- Machines can be operated basically by Non-RF-Experts.
- **Considerably shorter measurement / tuning time.**
- Automation and documentation guaranteed.
- DESY has to **ensure maintenance.**

*Poster TUPO048*

# Cavities - Preparation

Two schemes for the final surface treatment:

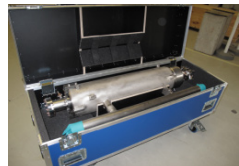
- EZ: BCP Flash
- RI: Final EP



- 4 dedicated Cv's for set-up of infrastructure at companies each
- 4 dedicated Cv's for commissioning of infrastructure each
- Close supervision of infrastructure, processes, procedures and handling by DESY + INFN Milano required
- No performance guarantee results in:
  - the risk of unexpected low gradient or field emission is with DESY
  - responsibility for re-treatment at DESY

# Cavities: Transport Solution

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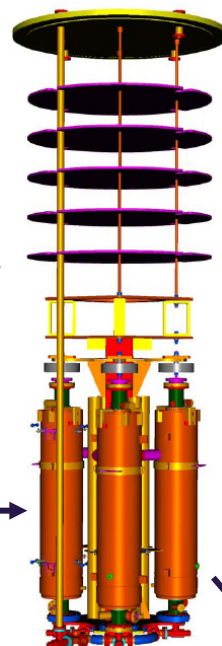
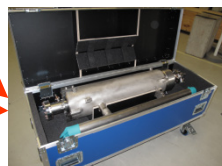
RI Germany



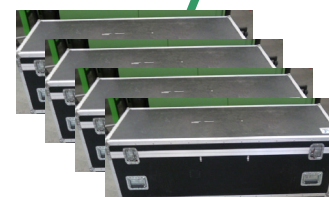
EZ Italy



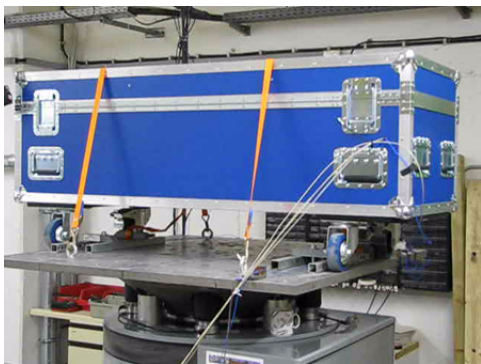
DESY Germany



IRFU /CEA France



## ■ Transport tests done

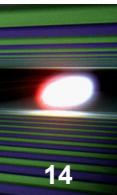


*Poster TUPO050*

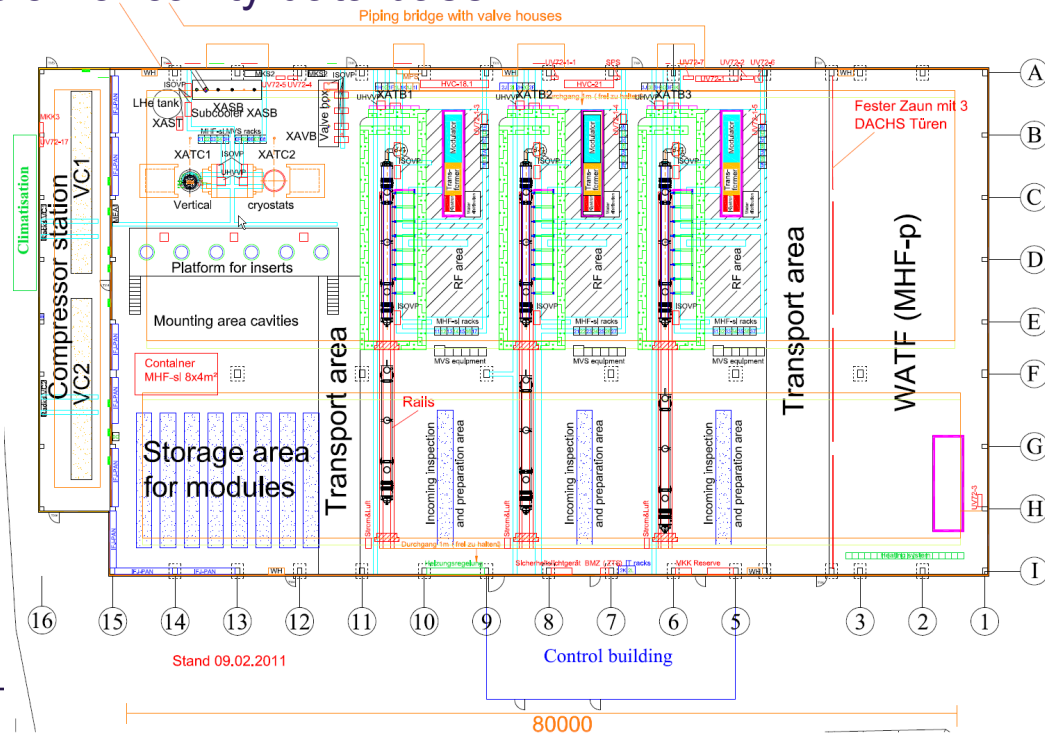
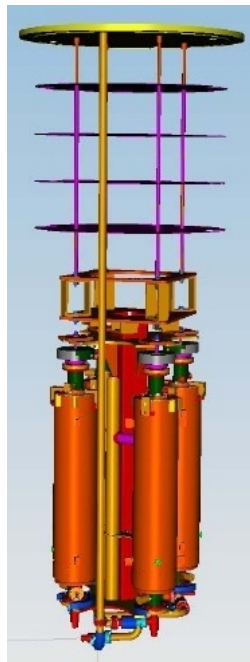
- DESY takes care of installation / dismounting of cavities into / from test insert
- Transport to CEA in transport boxes as well

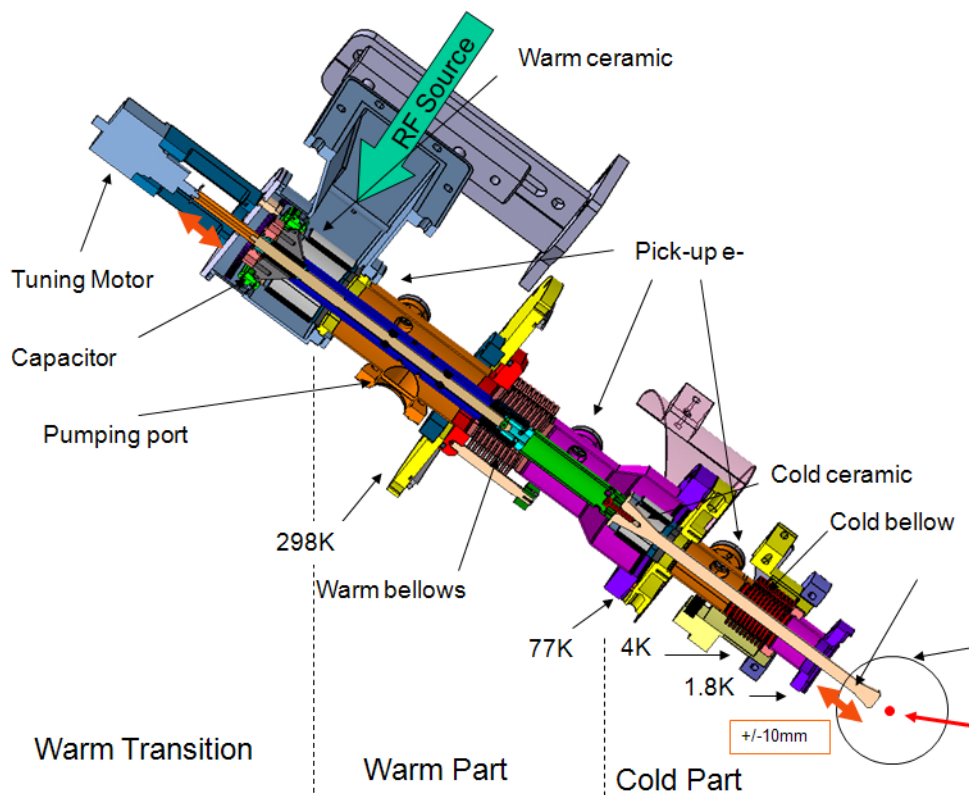


# Cavities – Acceptance + Module Test



- Accelerator Module Test Facility
- New Infrastructure for vertical acceptance test and module test
  - two cryostats for test of 4 cavities in parallel + 3 module test stands
  - WATF: assembly + test of customized waveguide distribution
  - new software development for vertical and horizontal test
  - training of new team
  - modification + extension of cavity data base





■ Contract for the **production of 640 couplers** placed at a consortium of **THALES & Research Instruments**.

■ **LAL Orsay** has taken over the responsibility for the XFEL RF power coupler production.

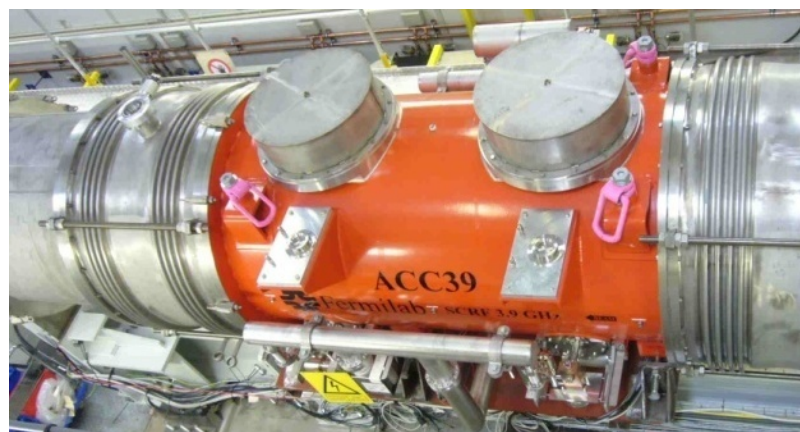
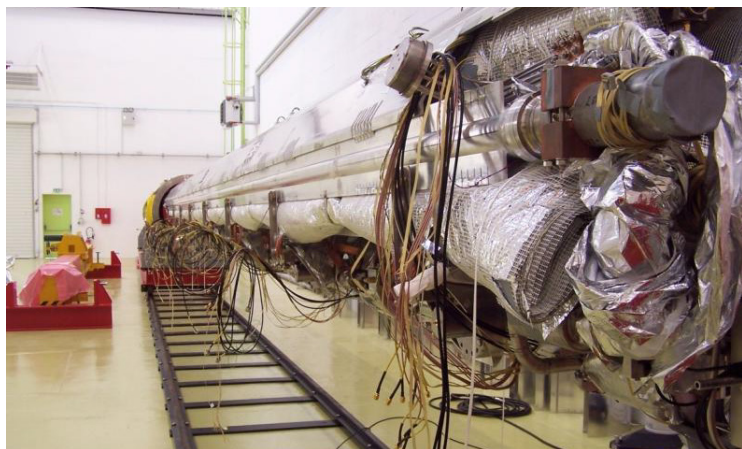
■ **Conditioning** of the couplers will take place at LAL Orsay in **new cleanroom infrastructure**.

■ Direct delivery to assembly site at CE Saclay

■ **Coupler interlock system** developed and **contributed by DESY**.



# String and Module



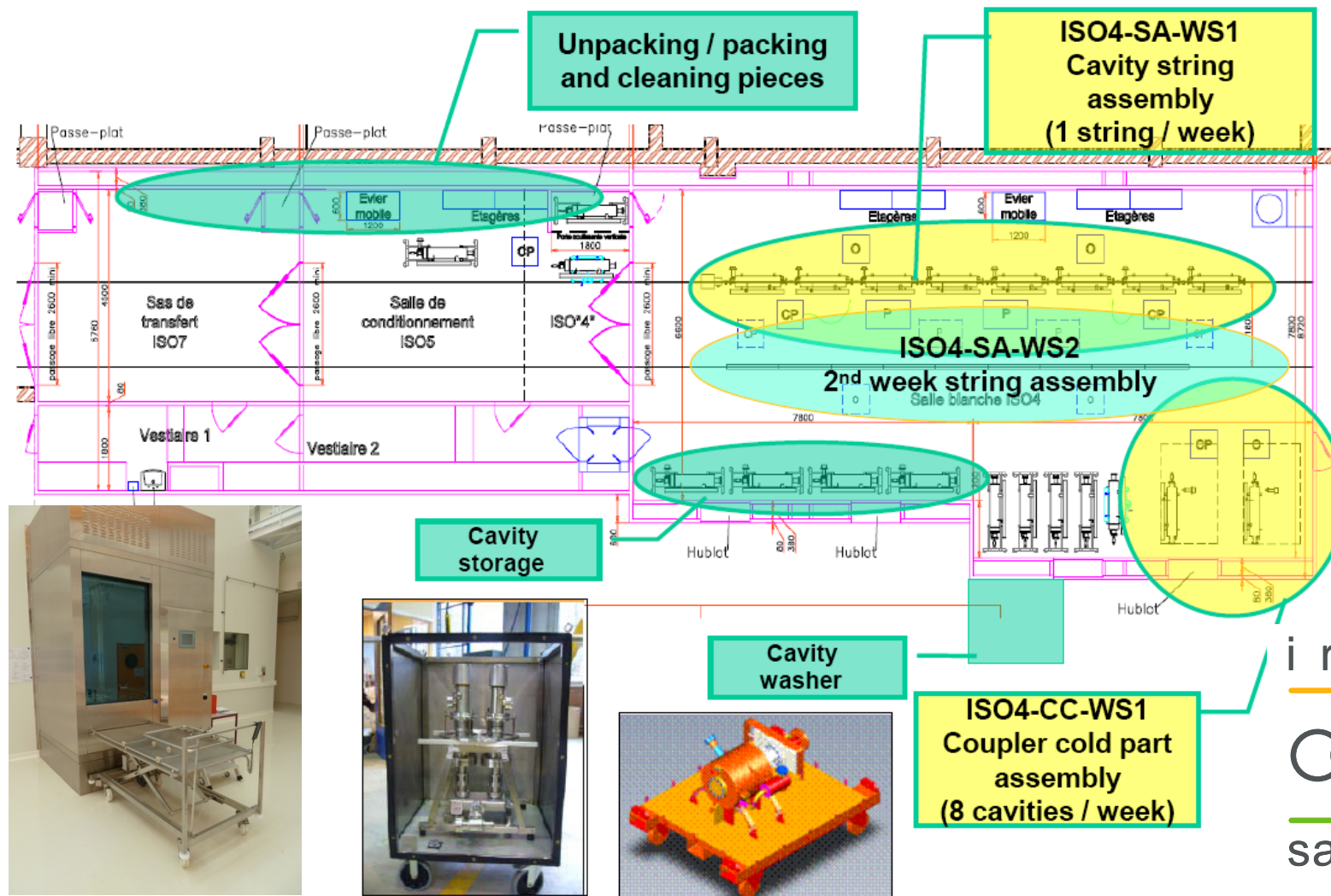
## Module: Cavity String Assembly

- String assembly is crucial for the cavity performance
- String + power coupler assembly for all modules will take place at **CEA Saclay site**
- **Commissioning of infrastructure** and **training of CEA** staff with prototype modules ongoing
- **Knowledge transfer to executing company** to be done after placing of order





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■ All cavities with He tank, the coupler cold parts and the quadrupole-BPM units will be cleaned and dried externally before entering ISO4 area

# Module: Cold Mass / Vacuum Vessel

- Three XFEL prototype modules built and tested  
=> in use for technology transfer
- Now four qualified vendors for cold mass / vac vessel

*Poster:*  
MOPO010  
TUPO041  
TUPO045



Institute of High Energy Physics  
Chinese Academy of Sciences

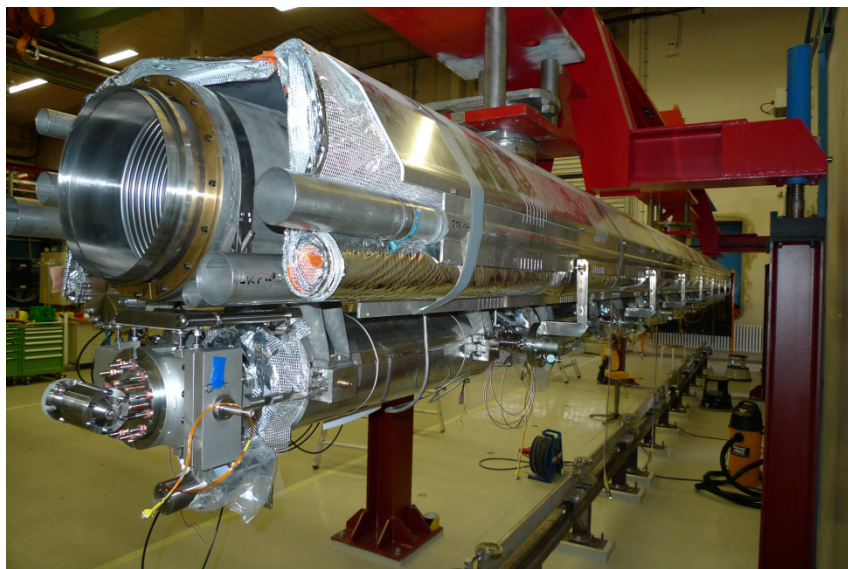
THALES

duro  
felguera, s.a.

- Assembly procedures improved during training with new teams
- Contracts for 83 modules placed (25 EZ, 58 IHEP with subcontractors)
- ACC39 by INFN Milano + assembly at DESY

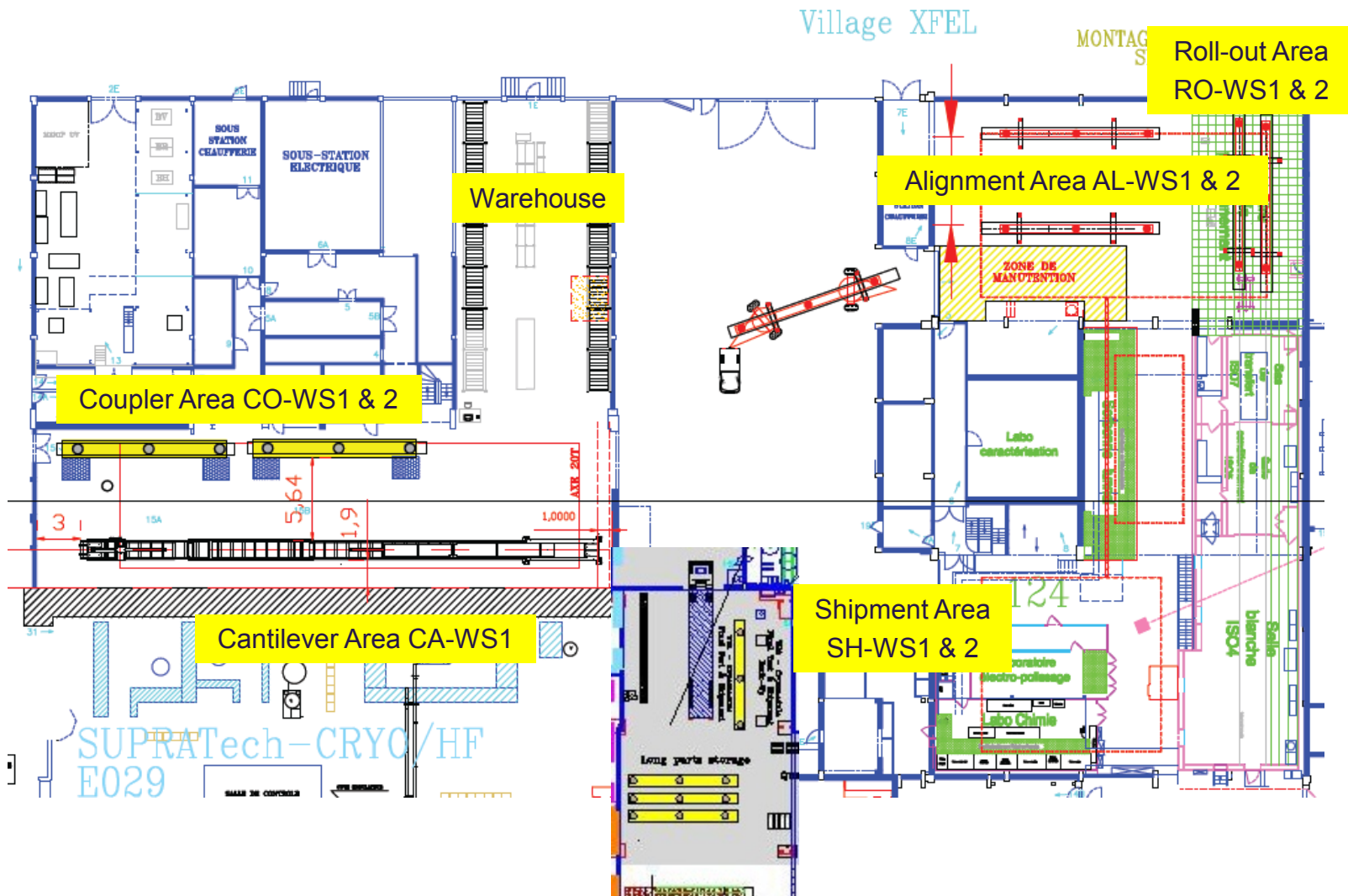


- Module assembly facility for all modules is set up at **CEA Saclay site**
- **Commissioning of infrastructure** and **training of CEA staff** with prototype modules ongoing
- Knowledge transfer to executing company to be done after placing of order
- **Several assemblies, transports and tests** of prototype modules ongoing



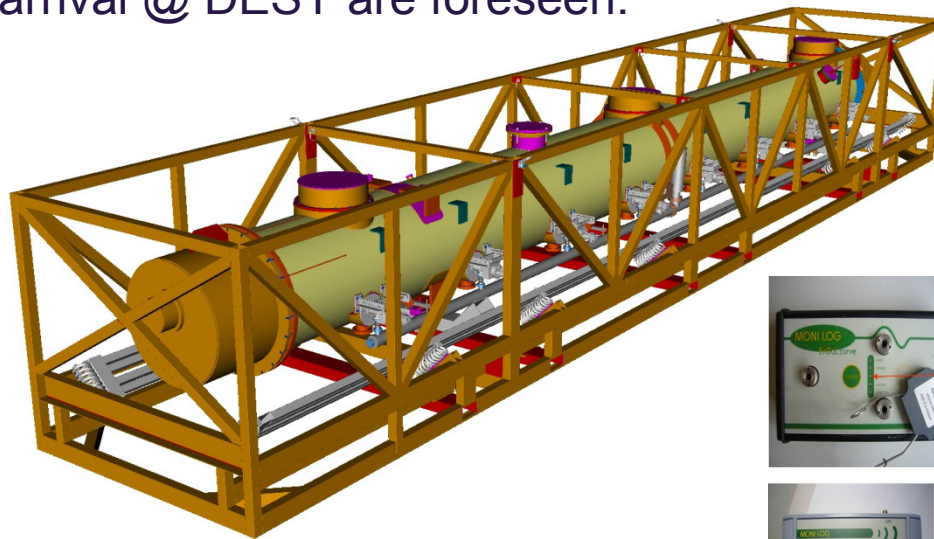


# Module: Assembly - Workstations



# Module: Transport

- All 83 (+20) assembled modules must be **transported** on road from **CEA Saclay to DESY** about a distance of approx. 1000km.
- Allowed max. impact to the modules during the transport 1.5g
- The **transport frame** is equipped with electronic shock loggers and GPS
- Until now 5 transports took place
- Before start of the series assembly ~4-5 further transport with additional alignment checks after arrival @ DESY are foreseen.



Parameter

Mass channels: ☒ GPS ☒ 1 ☐ 2 ☐ 3 ☐ 4

Events: ☐ 00 ☐ 01 ☐ 02 ☐ 03

Mass range:  1  2  3  4

Log threshold [1]:  10  20  30

Alarm threshold [2]:  20  30  40

Frequency range [Hz]:  100

Min. shock duration [ms]:  1

Curve duration [ms]:  2000

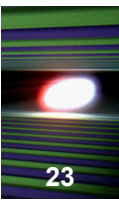
1/Hz (Hz) interval [min/sec]:  10/00

\*1  
\*2

GPS-Module

|           | Hamburg - Saclay |               | Saclay - Hamburg |               |
|-----------|------------------|---------------|------------------|---------------|
|           | inside frame     | outside frame | inside frame     | outside frame |
| *1 Record | 0.5 g            | 2.0 g         | 0.5 g            | 1.0 g         |
| *2 Alarm  | 1.0 g            | 2.0 g         | 1.0 g            | 1.5 g         |

# Refurbished DESY Clean Room



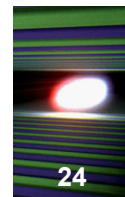
- **Assembly training**
- Prepared for **routinely assembly of Quad/BPM**
- **Future re-treatment of cavities**



- State-of-the-art air distribution + condition
- Increased ISO4 assembly area
- Chemistry and cleaning infrastructure now in ISO6/5 instead of ISO7/6
- New rotational clean room airlock

*See Poster TUPO018*





Thanks to  
K. Jensch, J. Iversen,  
C. Madec, A. Matheisen, W.-D. Möller,  
H. Weise, W. Singer  
and all other colleagues for their material  
and support

# The end