Status of SCRF

Lutz Lilje
DESY

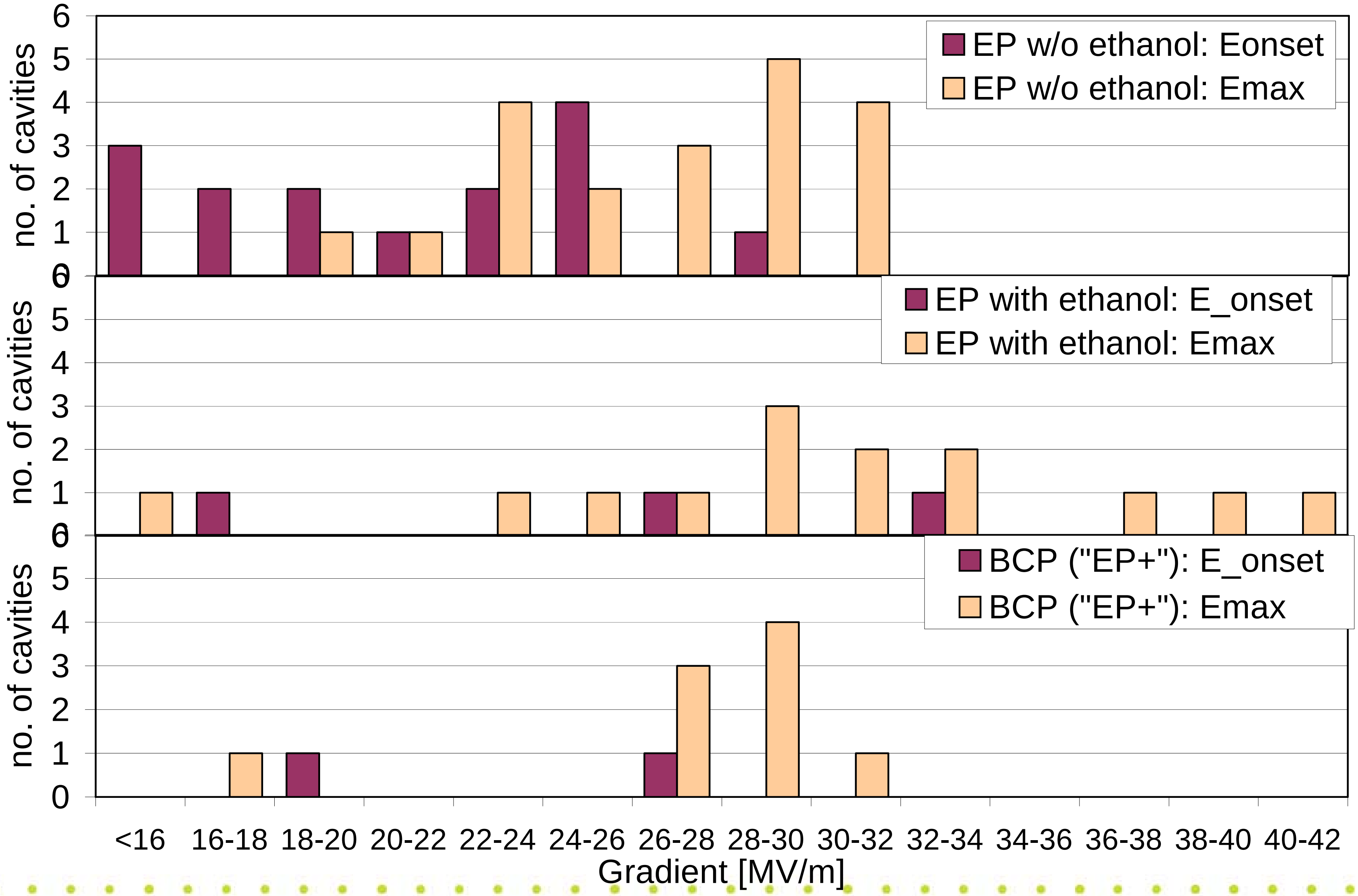
Overview

- S0S1
- Review of the information at Sendai
  - **(several slides from a talk by H. Hayano)**
  - **Japan**
  - **Americas**
  - **Europe**
- + some recent XFEL/DESY information
- Status of re-Planning

S0 Status: High Gradients

- Field emission has been reduced
  - **This is good news**
  - **Monitoring the three approaches (Ethanol, Ultrasound or Fresh EP) needed**
    - Is there a significant advantage of one over the other?
    - Data set for Fresh EP on multi-cells small
- Still rather large gradient differences are observed due to thermal breakdowns
  - **Needs improved understanding of the nature of these breakdowns**
    - E.g. some of the very low gradient breakdowns have been tracked to the equator region
    - At higher gradients this is not yet obvious
    - Need improved diagnostics
      - High-resolution temperature maps and high resolution optical inspection
  - **There is a broad consensus on this in the SCRF community**
    - See recent TTC Meeting at DESY

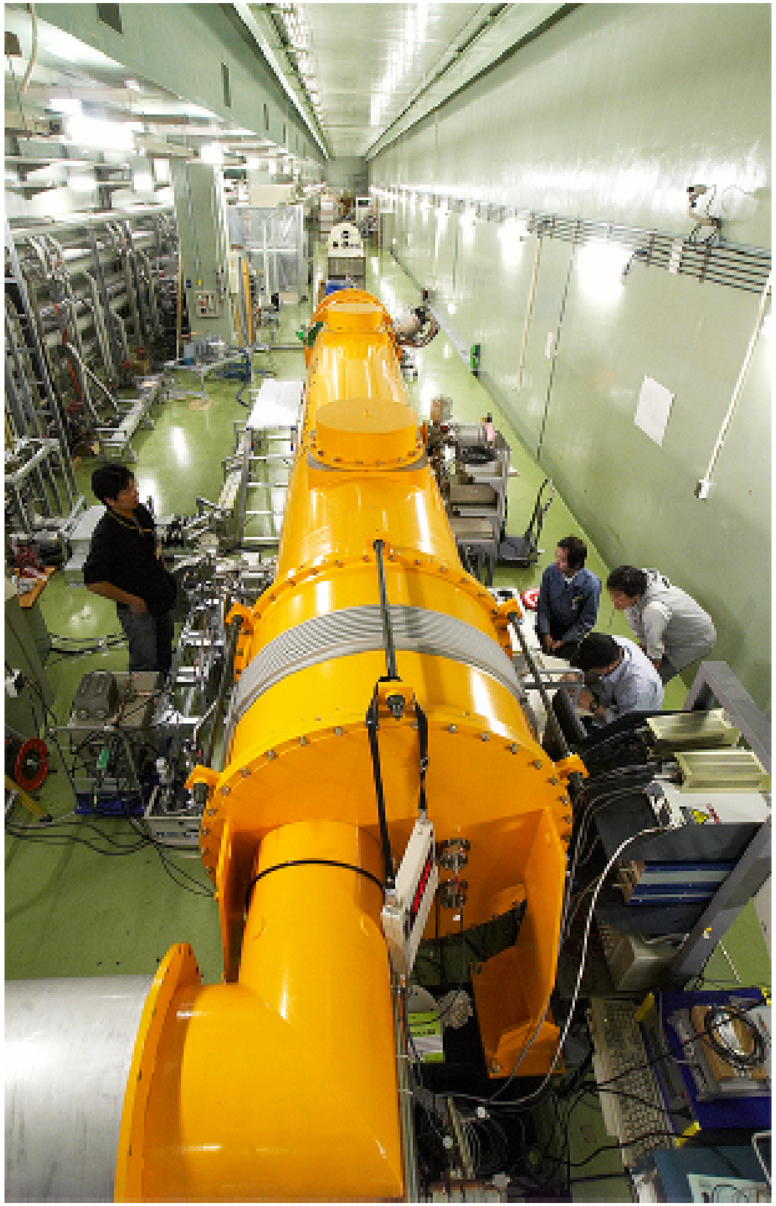
DESY 4th: Field Emission Analysis



Japan

- Module development
  - **First ILC-like module (with TESLA-type cavity) cooled down**
  - **4-cavity module assembled**
- EP
  - **Setup at KEK under commissioning**
    - In addition to industry setup
- Optical inspection
  - **High-resolution surface inspection developed**
- Vendor Qualification
  - **Two japanese companies**
- Alternatives
  - **Second module with one Low-Loss (Ichiro) type cavity under test now**

TESLA-shape cavity cool-down test



Program:

Oct. 03-12: cool down test,
suspended by SRF workshop

Oct. 22 -26: re-cool down

Oct.29 - Nov. 02 : 4K Test (1 week)

Nov.05 - Nov. 09 : 2K Test(1 week)

Nov.12 - Nov 22 : 2K with HLRF on (2 weeks)

Study Item:

Cool down control

Heat load measurements

Cavity fundamentals(Q,Eacc,f0..)

Lorentz detuning

Piezo compensation

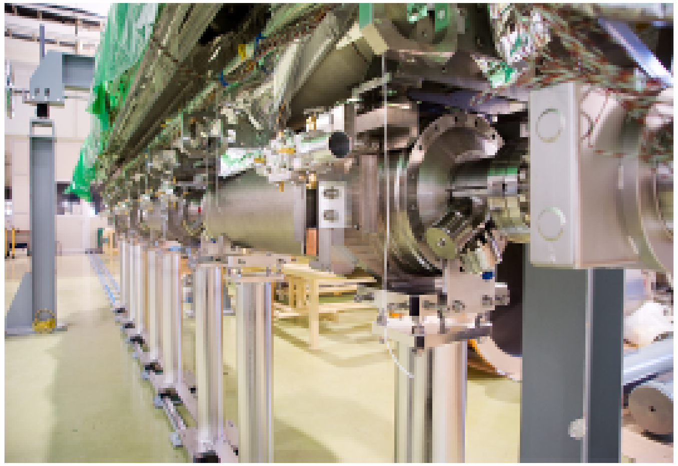
Mechanical vibration

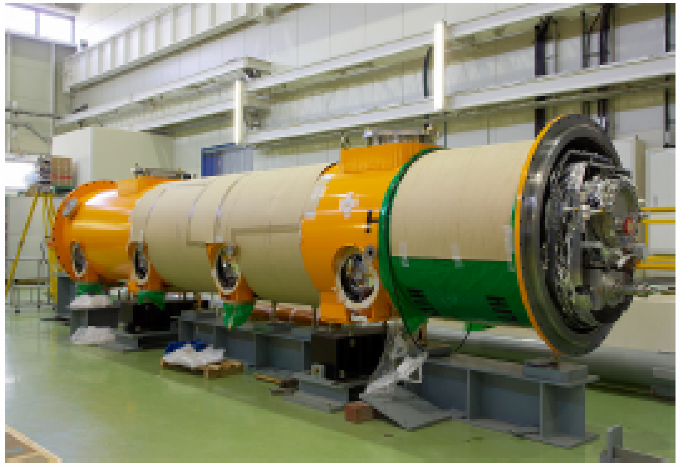
GRP distortion by WPM

etc.

4 TESLA cavities are ready for STF 1 experiment

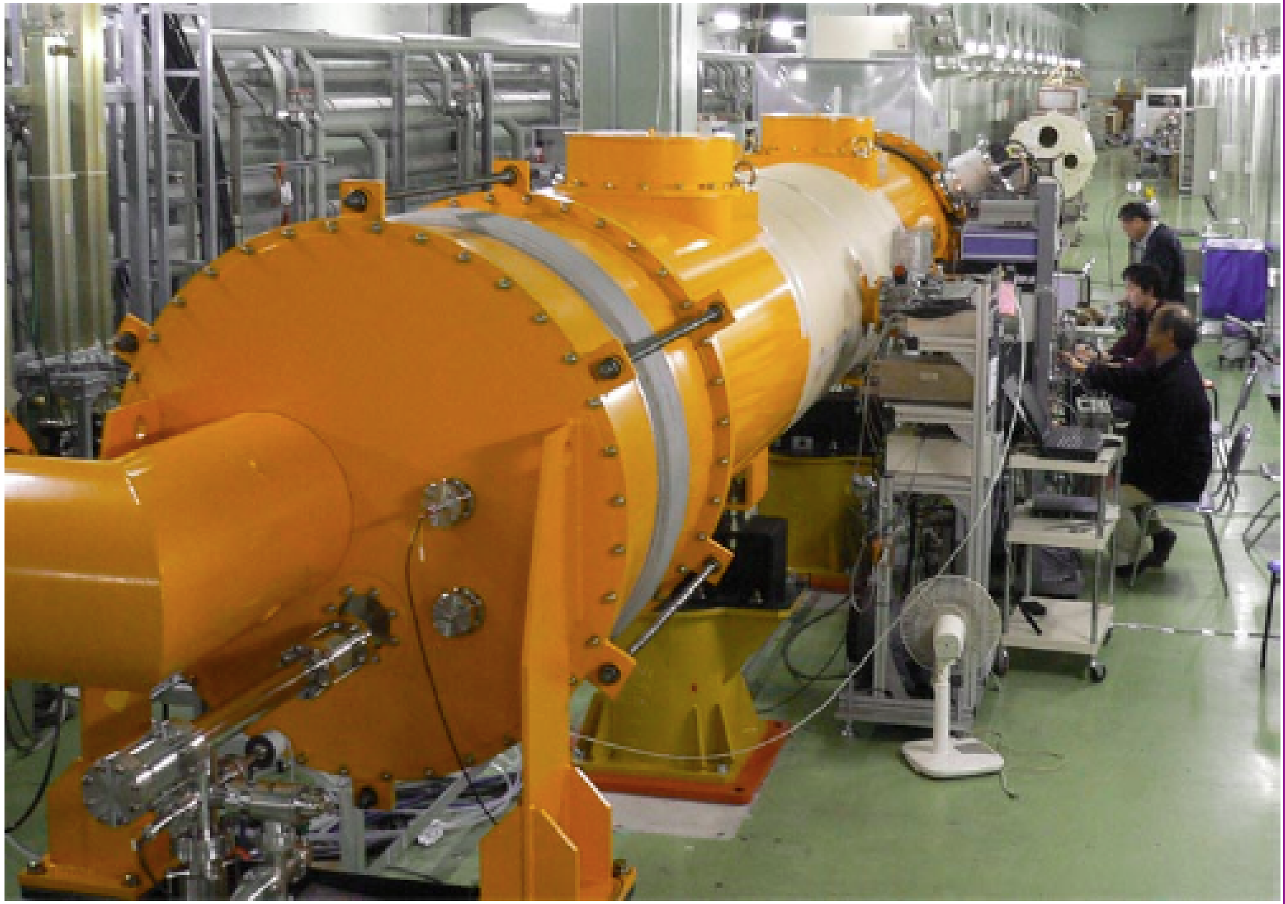
TESLA-style cavities were assembled in clean room, hung on the cold mass, and inserted into the vessel, on Feb. 29, 2008.





LL ICHIRO cavity in STF0.5 experiment

Ichiro #1 cool down test in cryomodule: Feb. 13 to Mar. 28, 2008

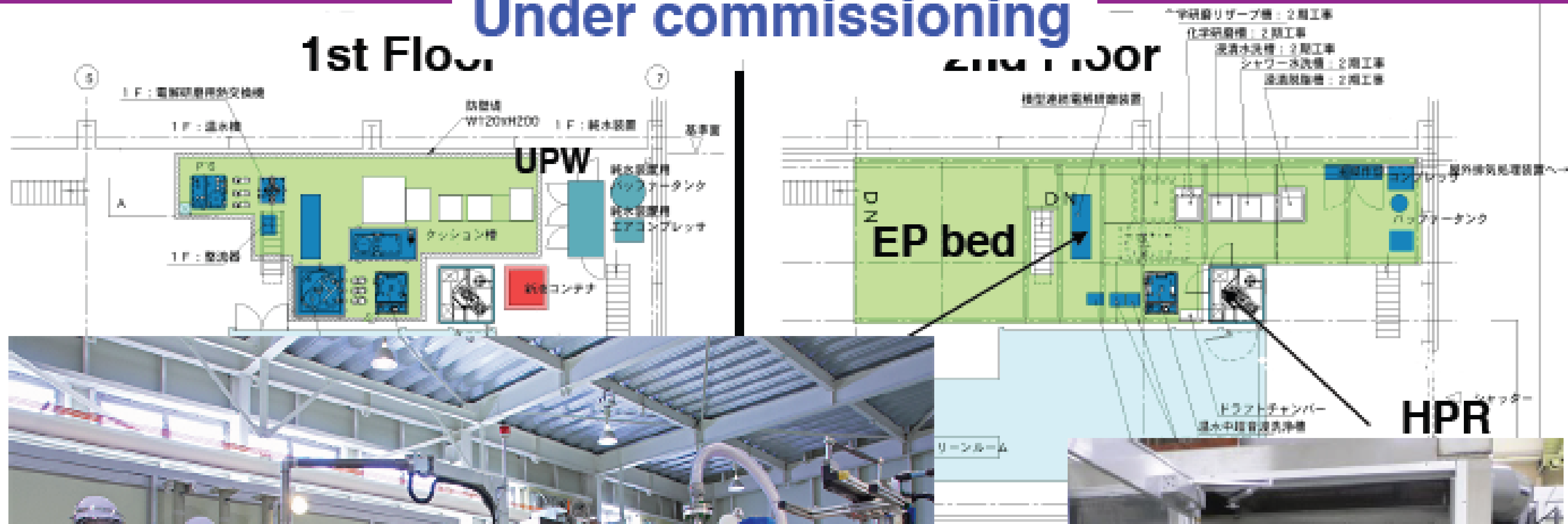


Now under test!

Heat load measurement,
Ball-screw tuner test,
coupler performance test,
cavity performance test (19.5MV/m in VT),
etc.

STF Cavity Surface Process Facility

Under commissioning

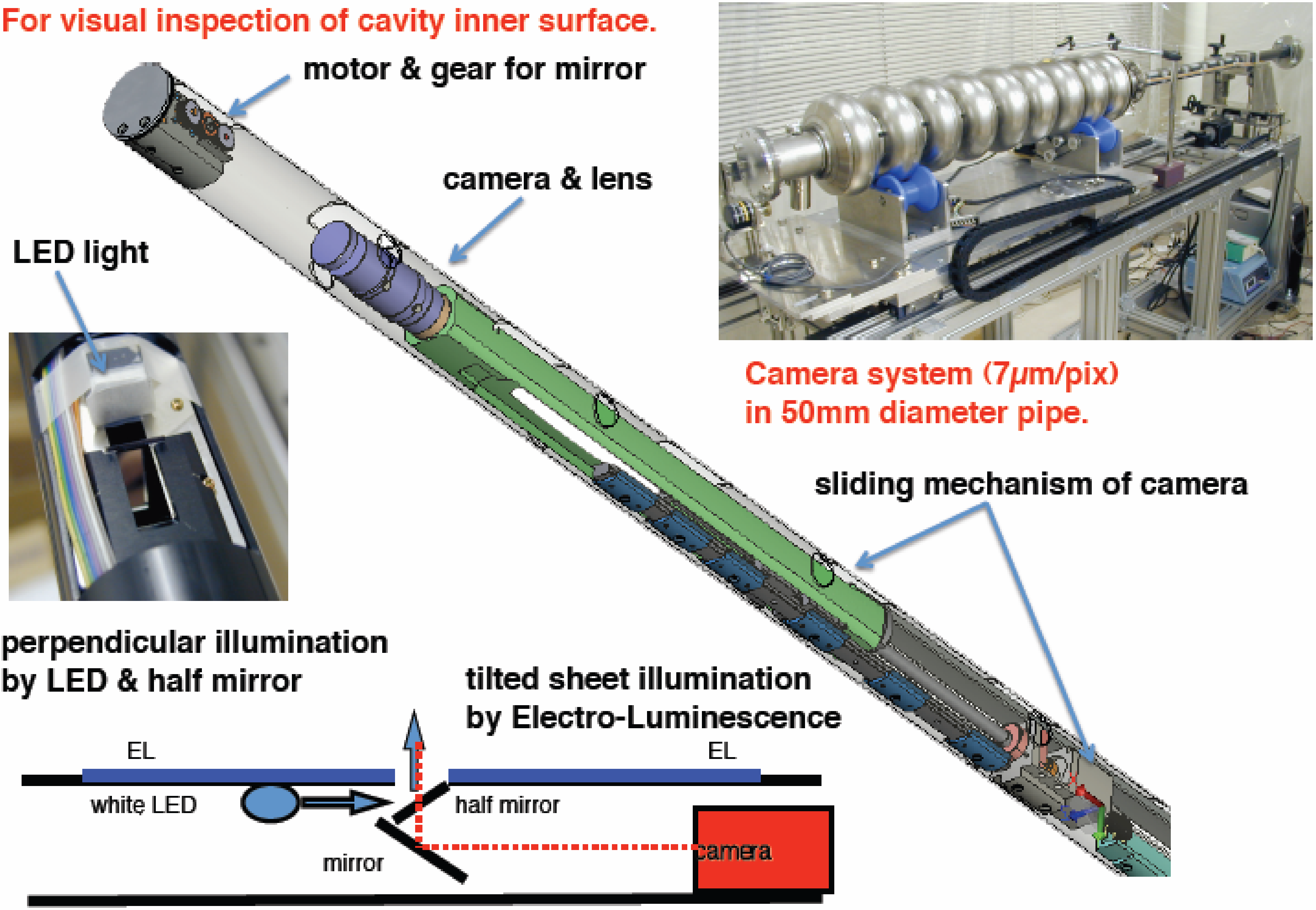


STF – EP system commissioning using old MHI cavity
Picture shows acid draining by holding cavity up.
3 times EP cycle (40+60+60μm removal) were done.

Cavity on the turntable,
moveable into rinse position.

Kyoto/KEK High Resolution Camera

For visual inspection of cavity inner surface.



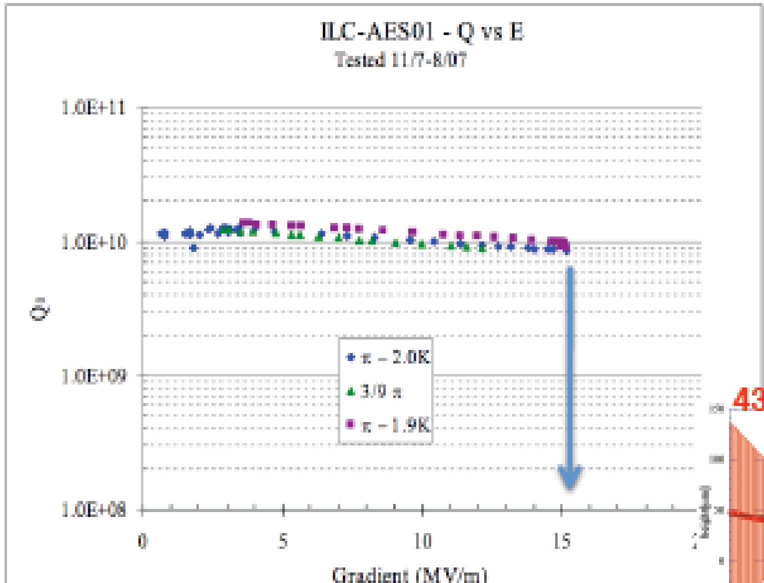
Camera system (7μm/pix)
in 50mm diameter pipe.

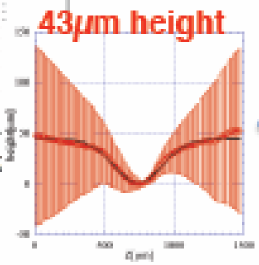
perpendicular illumination
by LED & half mirror

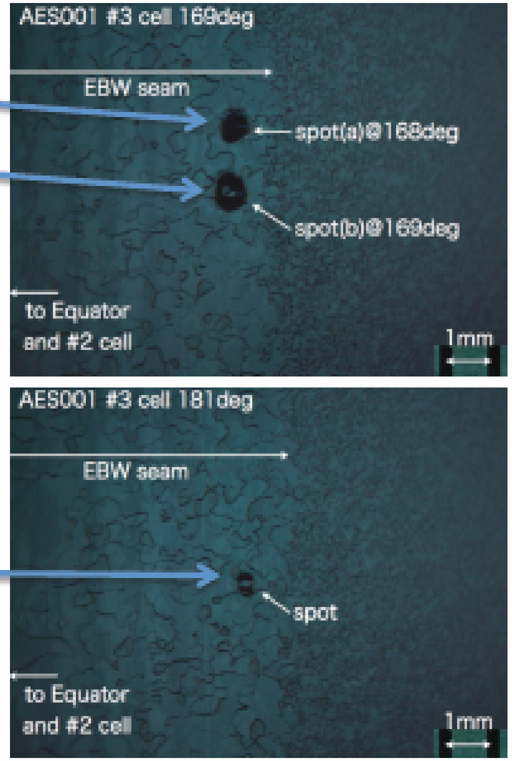
tilted sheet illumination
by Electro-Luminescence

Results of AES01 (FNAL)

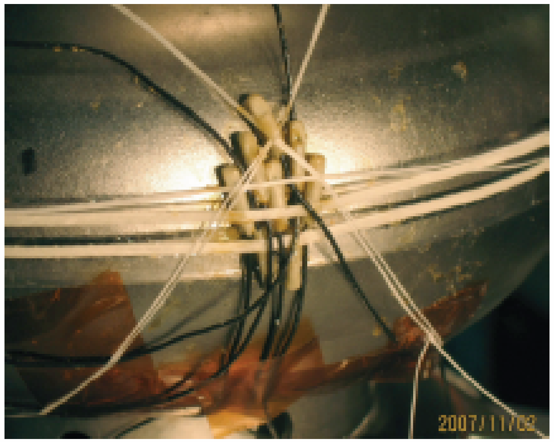
3rd Test Results

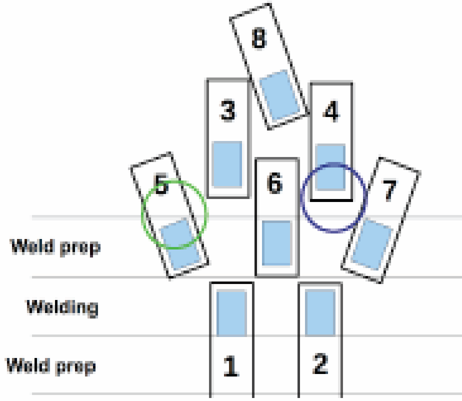


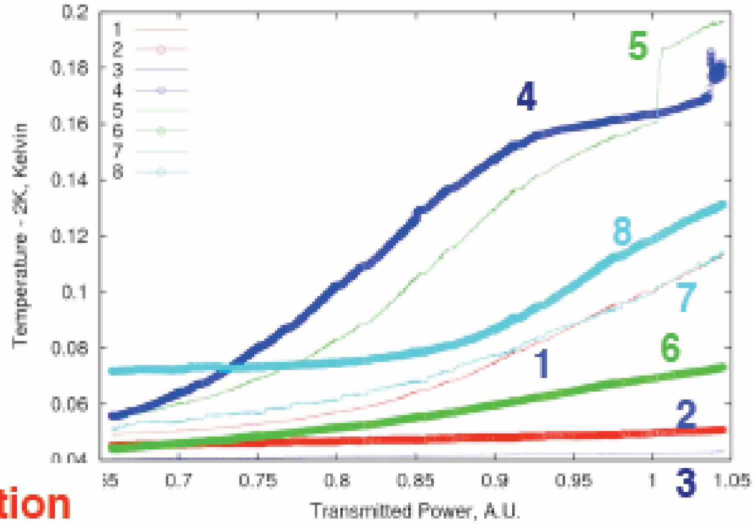




AES01 has hard quench at 15MV/m, its location was identified by Cernox at FNAL.





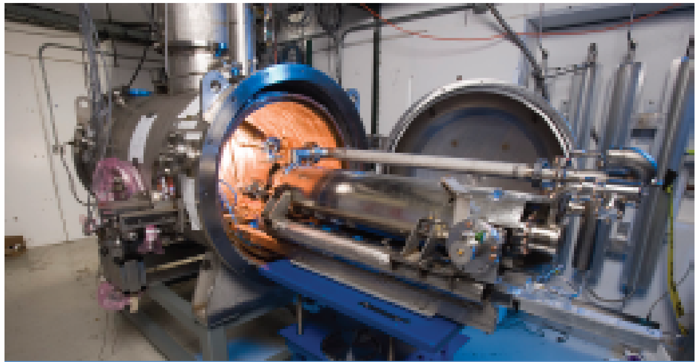


Kyoto-camera found 3 spots in their exact location

US

- Module
  - **First module assembled**
    - Together with several DESY experts
- Cavity
  - **Cavity order from last year**
    - Process as many as possible (< 10 cavities)
  - **Vendor Qualification for a US vendor**
  - **New EP installation at Argonne**
  - **Development of diagnostics**
    - Temperature mapping
  - **Alternatives**
    - Large-grain niobium material

FNAL CM Assembly



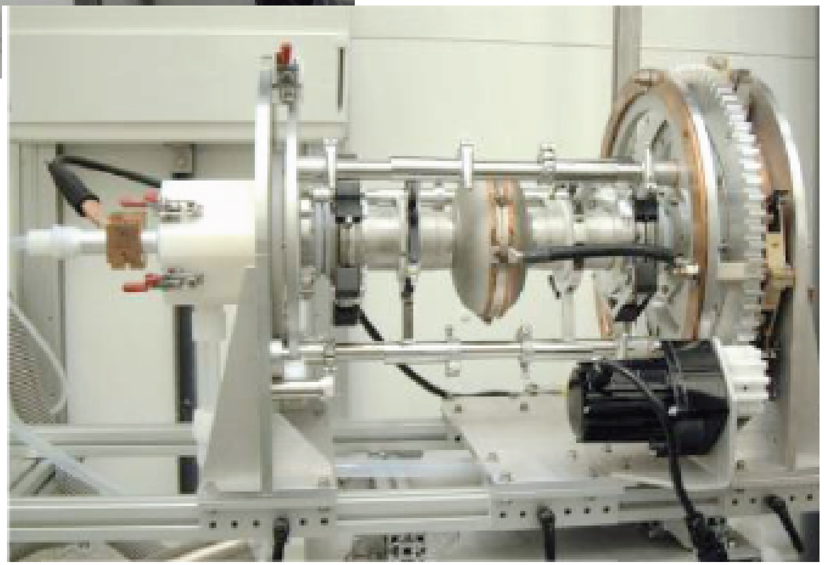
Horizontal Test
Cryomodule, C22 tested

String Assembly with DESY Cavities

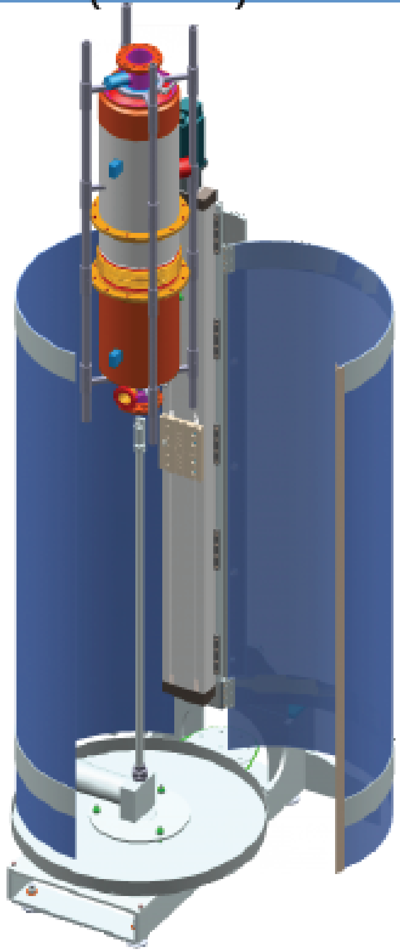
Cryomodule Assembly with DESY Assistance

First CM Ready for Test Facility

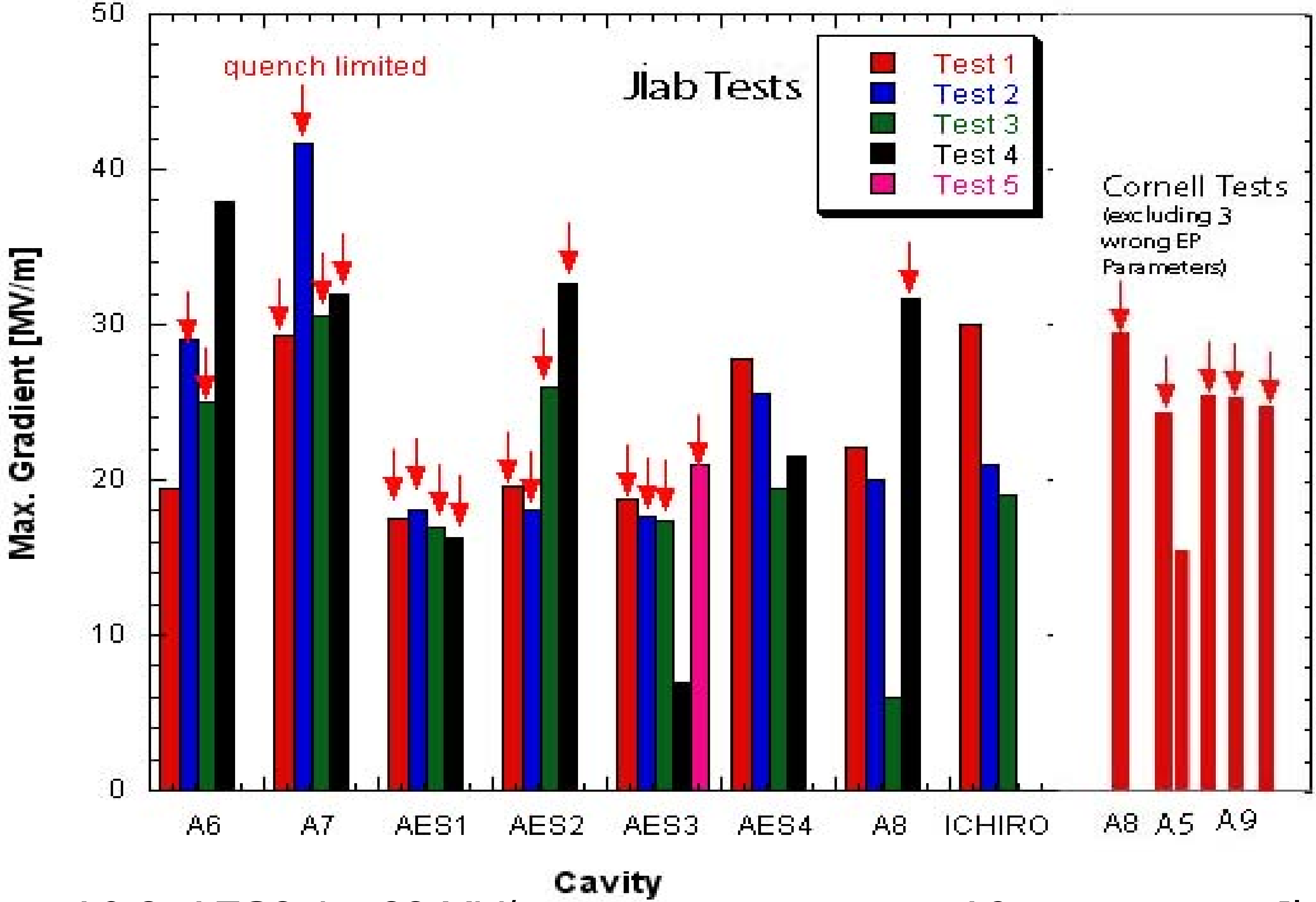
Argonne EP Commissioned with One-Cell



Cornell HPR System Designed and Under Construction (FNAL)



9-cell Test Results



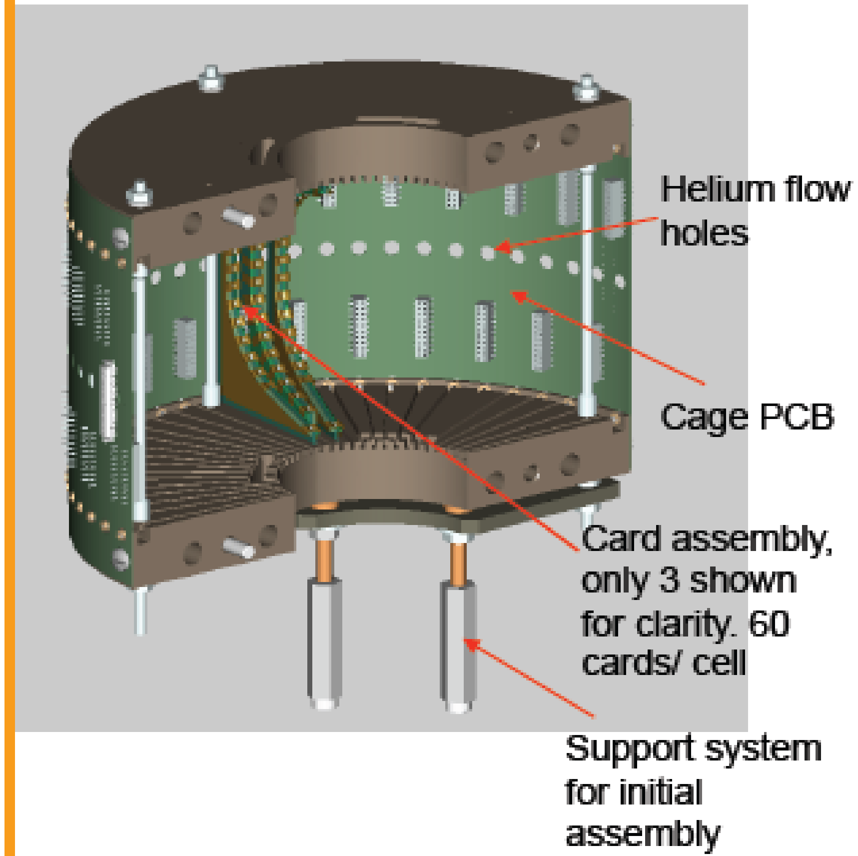
Average A6-8, AES2,4 = 32 MV/m

A9 reprocess at Jlab

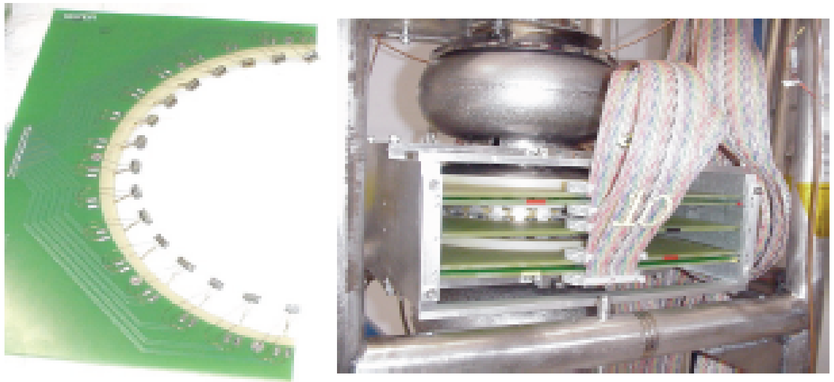
T-map development

FNAL

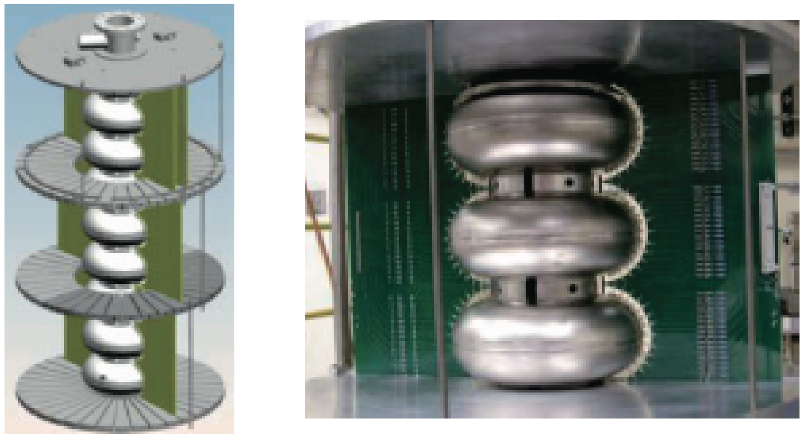
Model of half cage assembly



1-cell prototype was made and the fixture was cold tested (shock) successfully



Jlab One Cell Thermometry Assembly

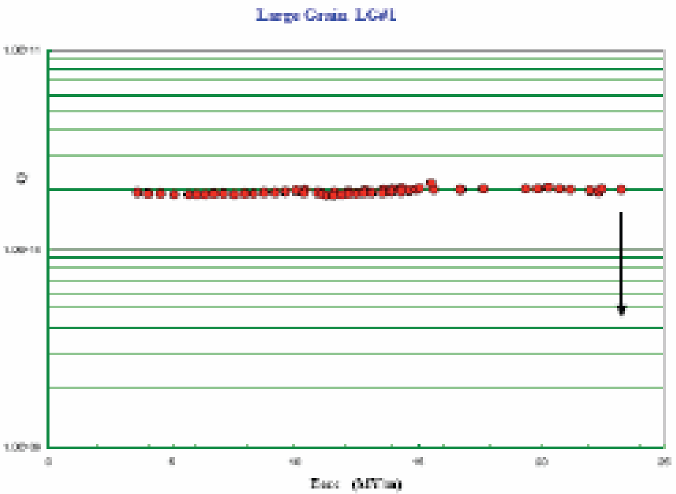


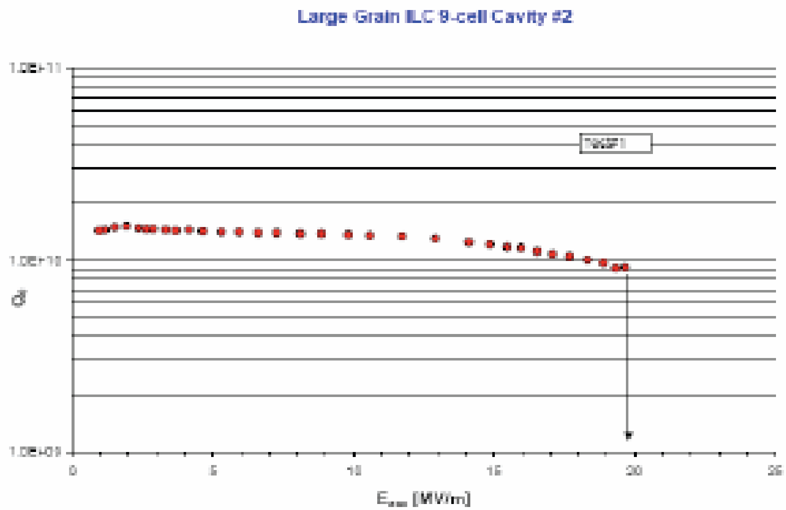
LANL 9-cell T-map development

9-cell Cavity performance(Jlab)

Large Grain

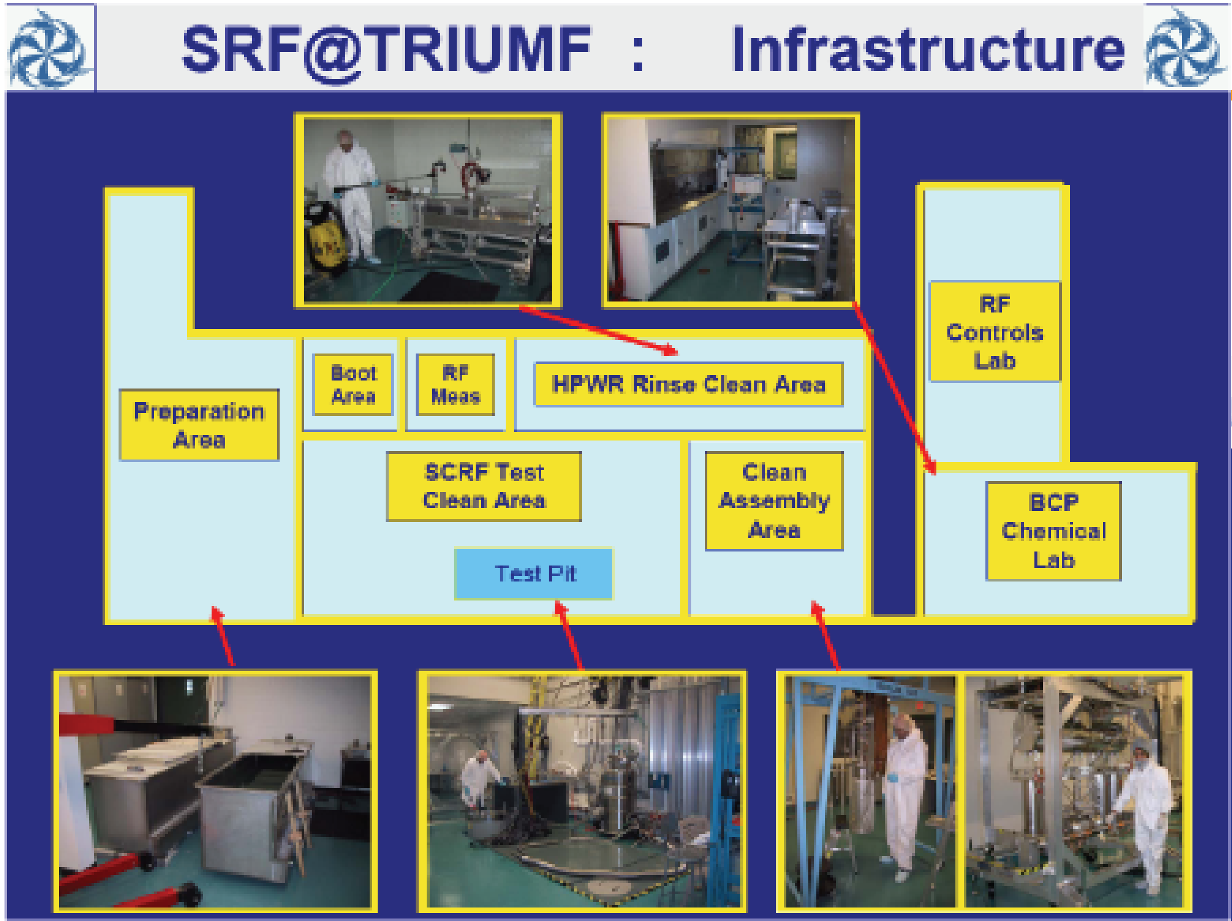
- Two 9-cell cavities (LG#1,LG#2) were fabricated at Jlab from large grain CBMM niobium (ingot"D"); several holes during EBW in both cavities
- Standard processing:pre-tuning, 100 micron bcp,hydrogen degassing at 600C for 10 hrs,final tuning, final bcp
- LG #1 received only ~ 40 micron, LG#2 ~ 57 micron bcp in final bcp
- LG#1: quench at Eacc = 23 MV/m,
- LG#2: quench at Eacc = 20 MV/m





October 15-19, 2007 SRF 2007 40

TRIUMF



PAVAC

Europe

- XFEL
  - **Setting up a cold linac collaboration**
    - Distribution of workload, knowledge, money… amongst several partners
  - **Module 'Crash' Tests**
    - Demonstrate compliance with high pressure vessel codes etc.
    - Understand recovery options
- Cavity
  - **Further tests with Ethanol rinse**
  - **Large-grain with EP**
  - **Fast Argon-bake**

XFEL Components (Some…)

XFEL needs

808 cavities for
101 accelerator modules, i.e.
808 frequency tuners,
808 RF main input couplers,
1616 HOM pick-ups,
101 HOM absorbers
etc.

Due to the long leadtime all **components need to be specified in 2008**,

the call for tender process to be started before end of 2008,
orders be placed not later than beginning of 2009.

Reminder: Proposal Made to the In-kind Review Committee

Common in-kind proposal for the superconducting linac of the XFEL WP3 – WP9 and WP11

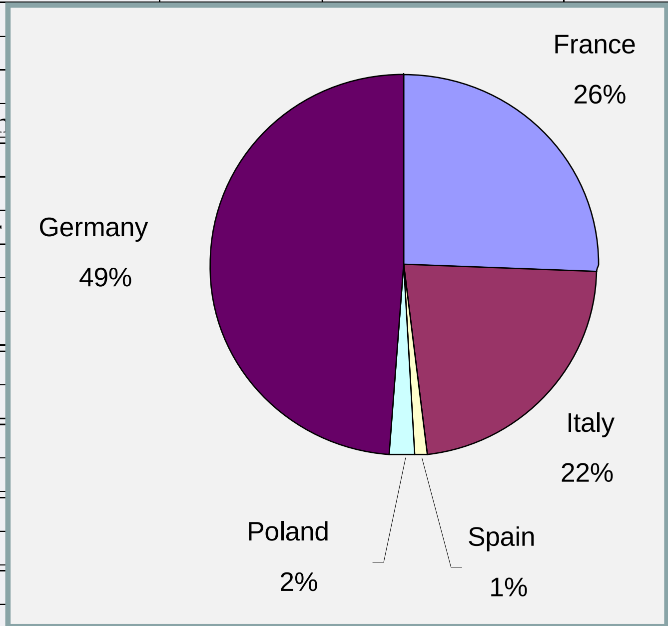
presented to the IKRC by Hans Weise / DESY

for

CEA Saclay
CIEMAT
DESY
INFN
IPJ Swierk
LAL Orsay

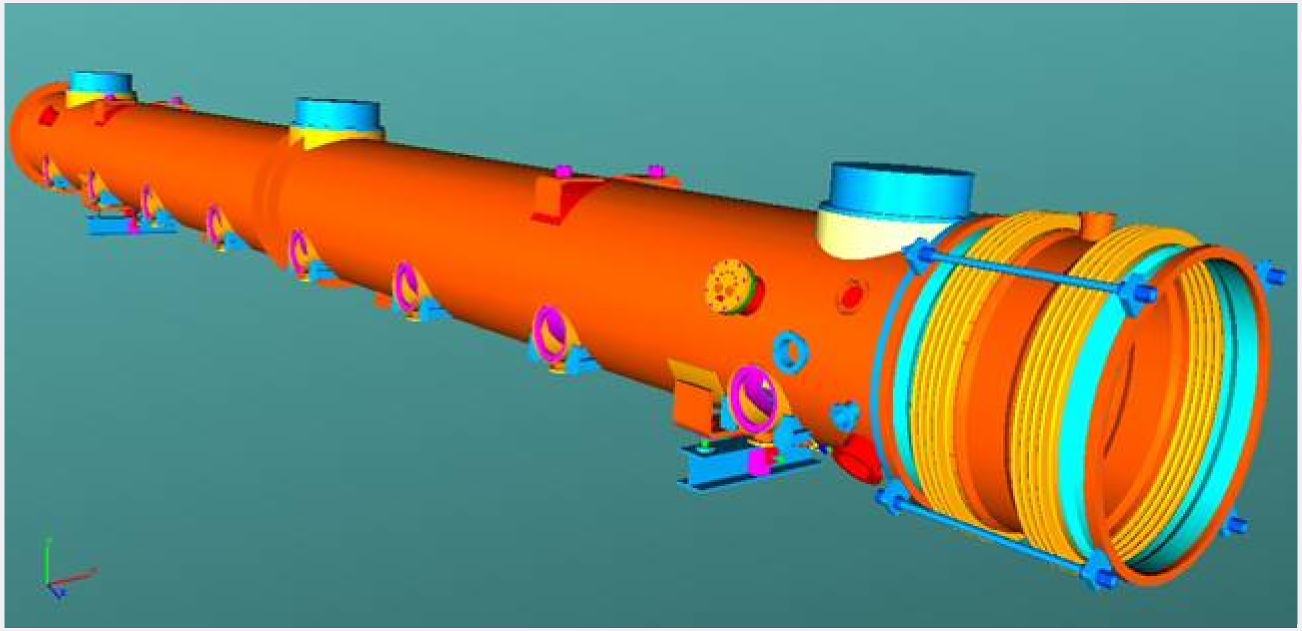
Summary

		Laboratory	Country	Invest / M€	FTE	FTE / M€
Accelerator Modules	**WP – 3**	CEA Saclay	France	60%		43%
		INFN	Italy	19%		29%
		DESY	Germany	21%		29%
	sum			***100%***		***100%***
Superconducting Cavities	**WP – 4**	INFN				34%
		DESY				66%
	sum					***100%***
		Received from				
Power Couplers	**WP – 5**	LAL Orsay				52%
		DESY				48%
		or				
		LAL Orsay				100%
		DESY				0%
	sum					***100%***
HOM Coupler / Pick-up	**WP – 6**	IPJ Swierk				100%
	sum					***100%***
Frequency Tuners	**WP – 7**	DESY				100%
	sum					***100%***
Cold Vacuum	**WP – 8**	DESY				100%
	sum					***100%***
Cavity String Assembly / Clean Room Quality Assurance	**WP – 9**	CEA Saclay				51%
		DESY	Germany			49%
		Transferred to WP -4				
	sum			***100%***		***100%***
Cold magnets	**WP - 11**	CIEMAT	Spain	56%		10%
		DESY	Germany	44%		90%
	sum			***100%***		***100%***



WP – 3 Accelerator Modules

Invest	FTE
60% CEA 19% INFN 21% DESY	43% CEA 29% INFN 29% DESY

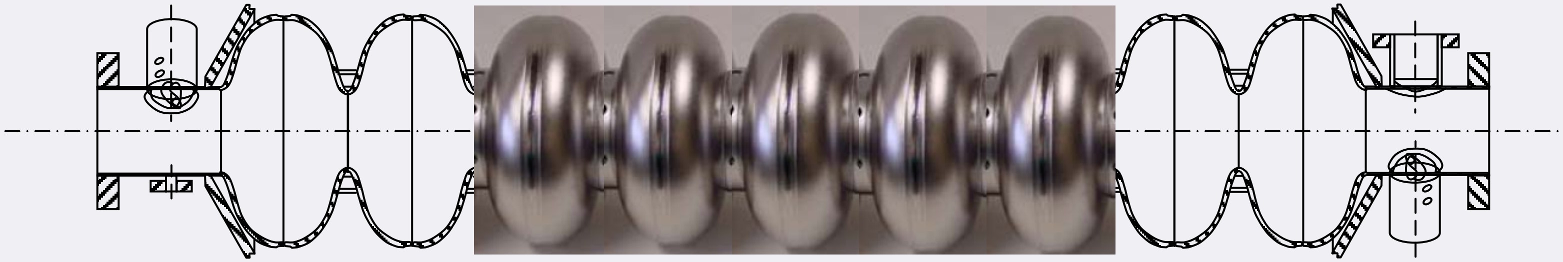


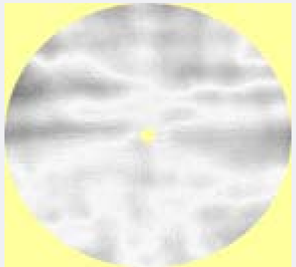
- Fabrication of cold masses (incl. outer vessel)
- module assembly w/o frequency tuner & power coupler; start with assembled string and finish with module installation
- weld connections
- alignment inside modules
- transportation of assembled accelerator modules

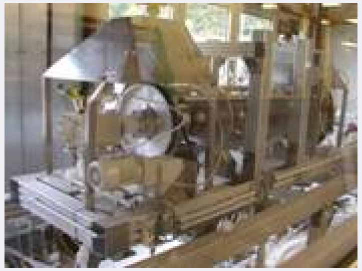
- material specifications, safety issues
- define processes for integration / assembly
- magnetic shielding / demagnetization
- sensors inside the accelerator modules
- pre-alignment of cavities and coupler position

WP – 4 Supercond. Cavities

Invest	FTE
50% INFN 50% DESY	34% INFN 66% DESY





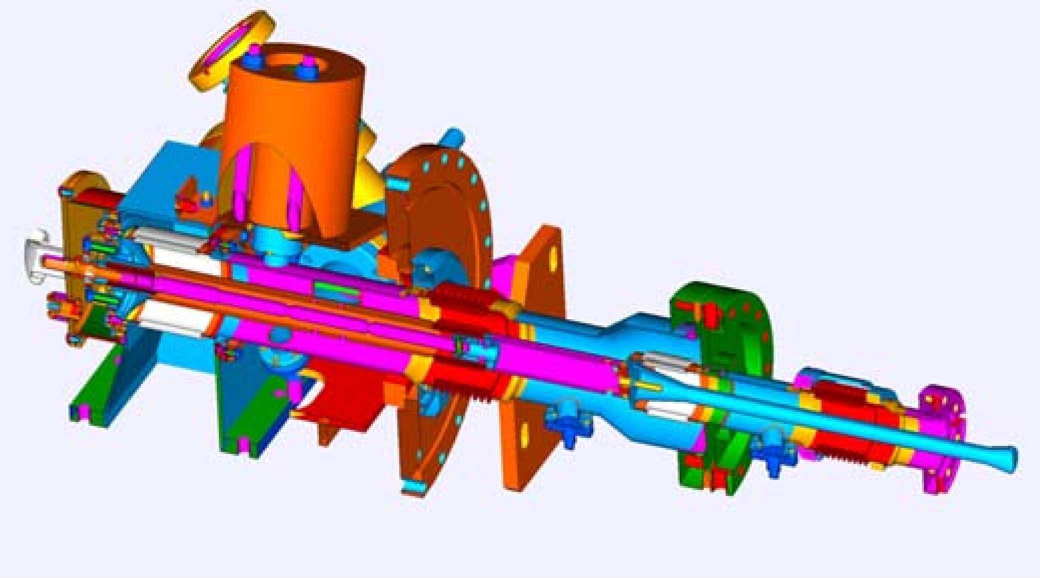


- Procurement of all niobium
- Scanning of NB sheets
- Complete mechanical fabrication of all cavities
- Surface treatment
- Consultant at start up of infrastructure and at full running production

- Data base setup and database running
- EDMS
- Helium vessel incl. Titanium parts (taken over from WP-9)

WP – 5 Power Coupler

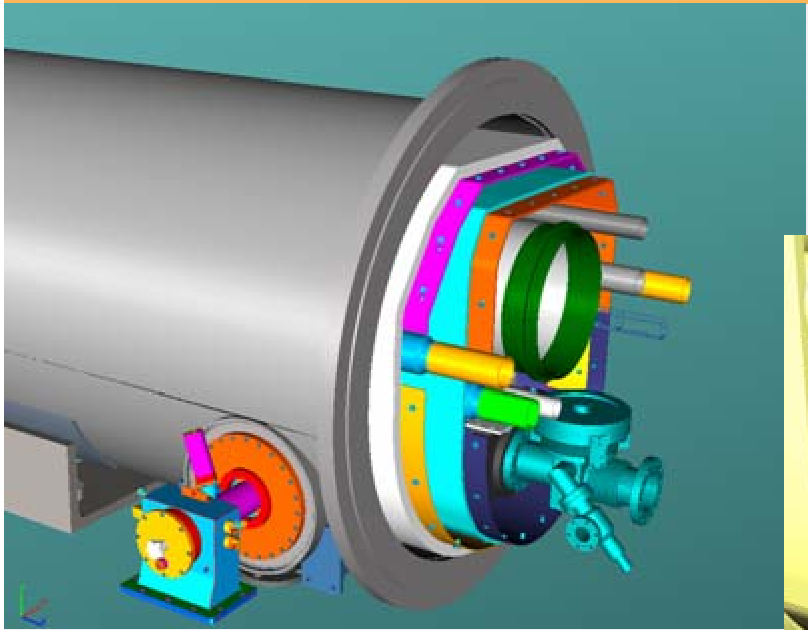
73% LAL 27% DESY	Invest	FTE	52% LAL 48% DESY

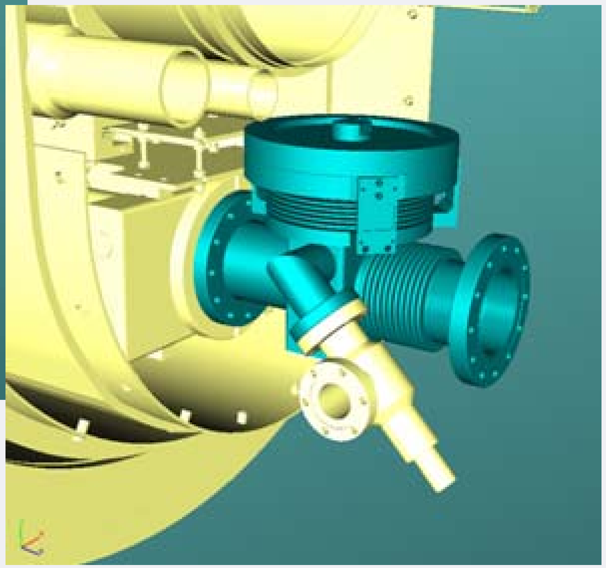


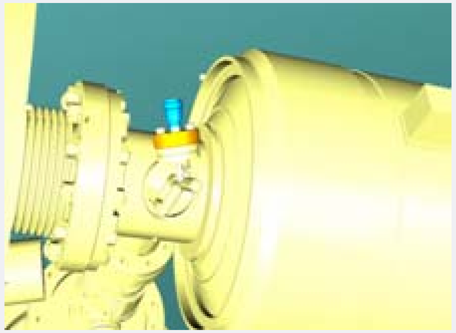
- Coupler production incl. project and industries follow-up
- Coupler conditioning
- Infrastructure required for coupler assembly and conditioning, i.e. clean room and modulator / klystron
- Technical interlock
- Tunnel installation / cabling of technical interlock
- Motor electronics

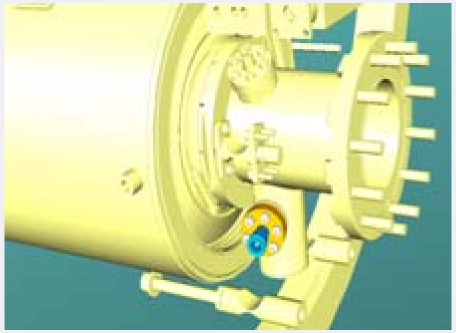
WP – 6 HOM Coupler / Pick-up

Invest	FTE
100% Swierk	100% Swierk





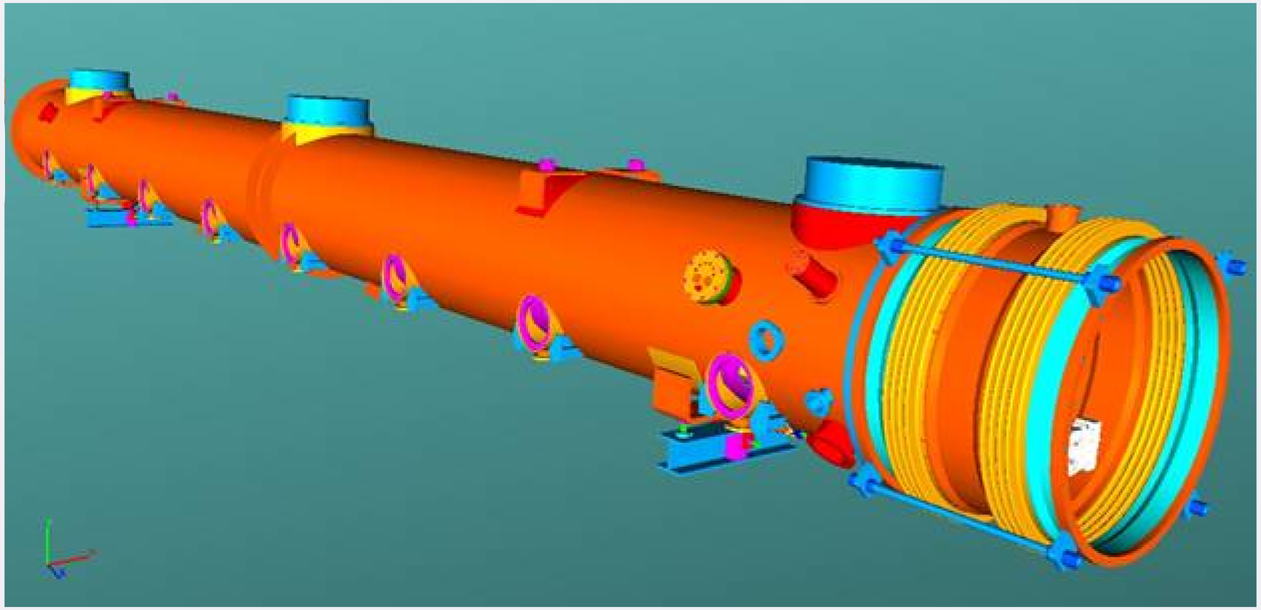




- Fabrication of HOM beam pipe absorbers
- HOM Pick-ups and cables

WP – 9 Cavity String Assembly / Clean Room Quality Assurance

90% CEA 10% DESY	Invest	FTE	51% CEA 49% DESY

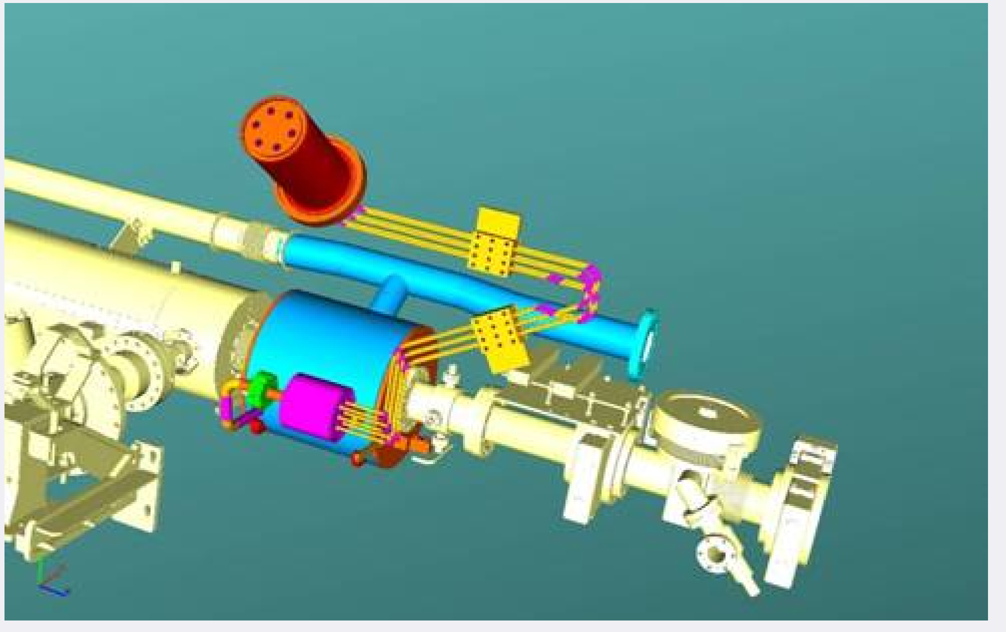


Module assembly see WP-3

- Helium vessel fabrication
- Titanium Tube and 2-phase line
- String assembly
- Knowledge transfer / consultant / training
- Database set-up and running / Quality control of infrastructure
- EDMS

WP – 11 Cold Magnets

Invest	FTE
56% CIEMAT 44% DESY	10% CIEMAT 90% DESY



- fabrication of 2K quadrupole package
- test of quadrupole package

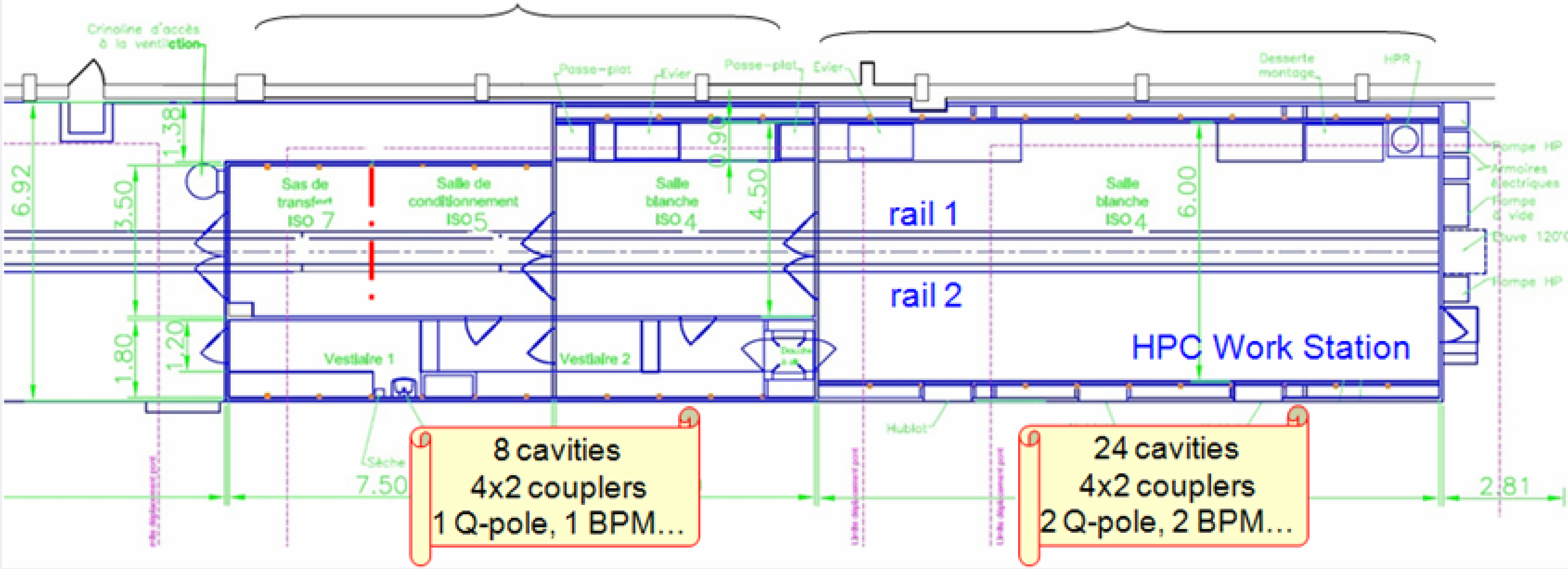
String Assembly Plans at Saclay

Description of expanded clean room

Class 10 (ISO4) : 73.5 m² + 21 m² (dividing curtain - door open)
Class 100/10 000 : 13 m² / 13 m² (fitting wall)

Components
for String N+3
cleaning - storage

String N assembly on rail 1
String N+1 (or spare) equipped with HPC
ready on carrousel to be assembled on rail 2
HPC Work Station : cold part on 8 cavities
for String N+2 → on carrousel



DAPNIA (Saclay) Expertise on SCRF Technology

Soleil: From the prototype to CM1 and CM2

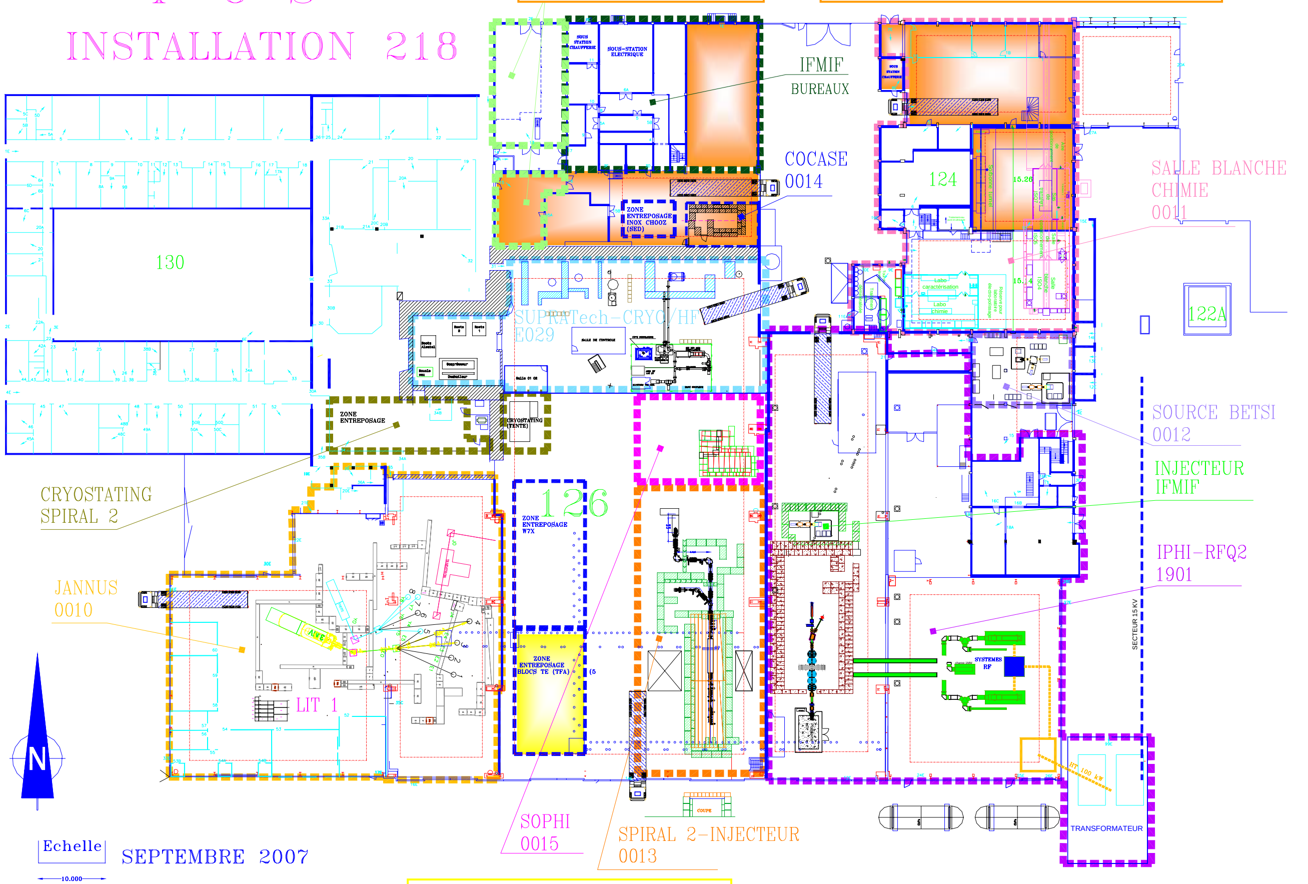
Saclay Plans for Module Assembly

Bâtiment 126 Nord

200 m² + 300 m²

Bâtiment 124 Zone Salle Blanche

200 m² + 200 m²



Bâtiment 126 Sud Stockage

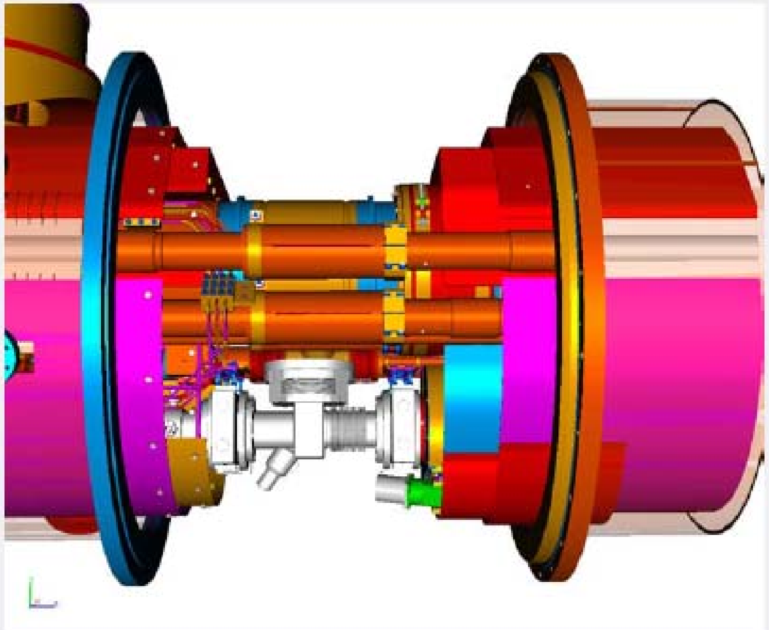
250 m²

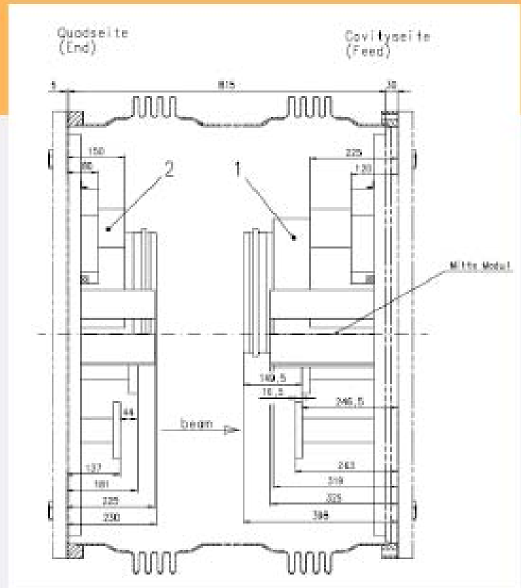
Mock-up Tunnel

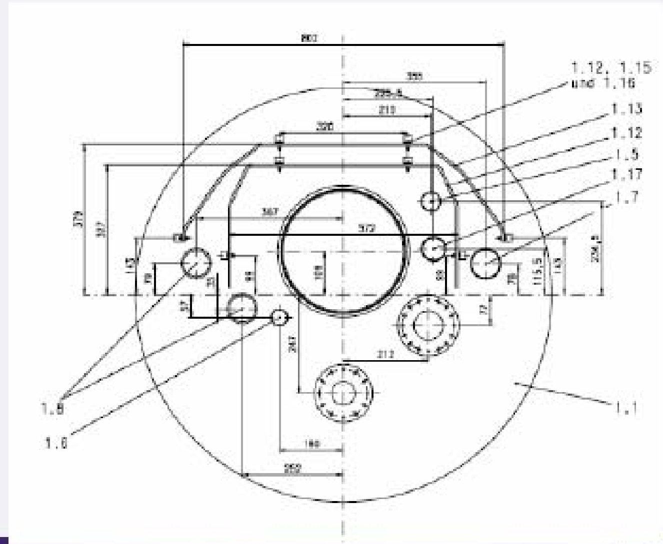
-The two Vacuum Vessel in the Mock-up tunnel

-Endplates for Vacuum vessel under preparation

-Dress the Mock-up vessel with all outer flanges and supports



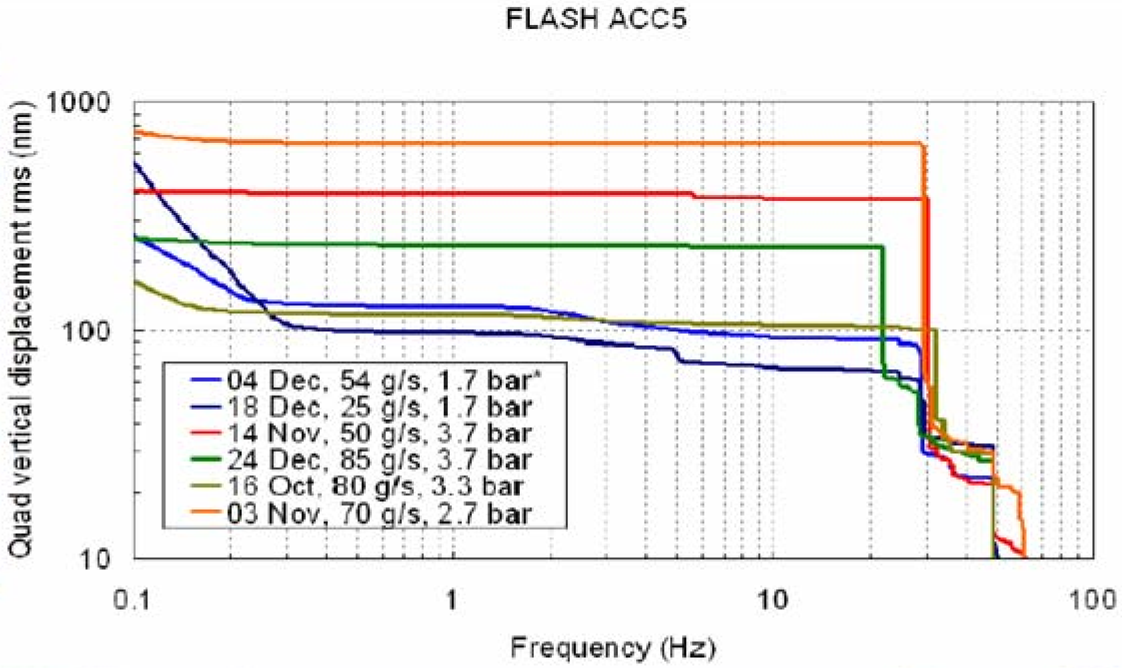




Tunnel Mock-up Status

– Preparation of dummy modules for installation tests

Effects of the cryogenics on the mechanical stability of CM in FLASH - **Spectral analysis-**



General comments

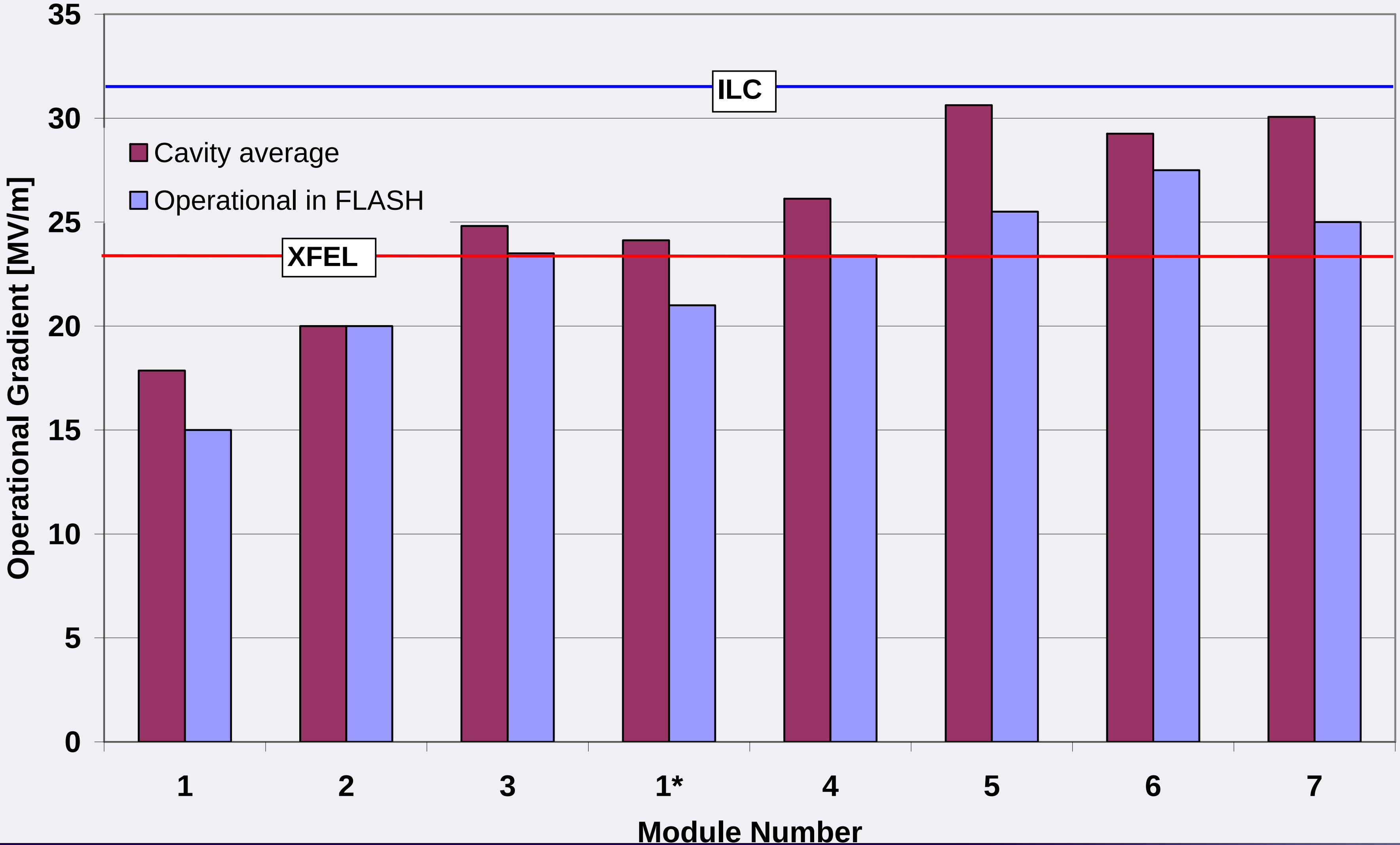
Three typical behaviour observed as a function of the pressure:
- Low pressure (1.5-1.7 bar) -> low noise
- Intermediate pressure (2.7-3.3 bar) -> appearance of a strong line around 30 Hz
- High pressure (3.7 bar) -> ~30 Hz line plus a low frequency line around 6 Hz

No systematic dependence on the flow.

Disturbances have the same frequencies along the whole linac.

Ramila Amirikas, Alessandro Bertolini, Jürgen Eschke, Mark Lomperski

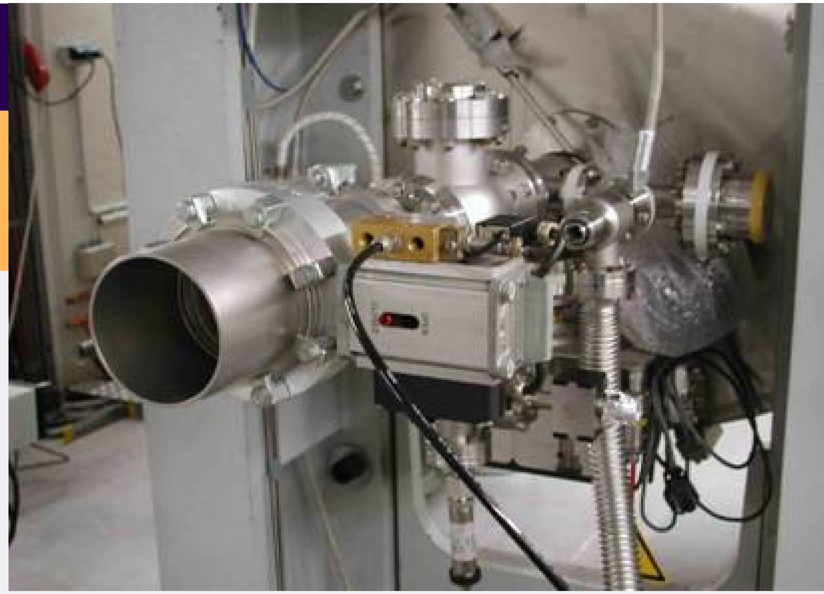
XFEL: Accelerator Module Performance



Sequence of Tests in Module Crash Test

Venting	Condition	Cavity	Coupler	Tuner	Cryo	BPM	Vacuum	Remark
Iso slow	2K, 30 mbar RF Off			Check Piezo	Measure losses		Measure	Helium Rate and Level tbd.
Coupler slow	2K, 30 mbar RF Off		Perfomance Reprocessing		Measure losses		Measure	Nitrogen Rate and Level tbd.
Cavity slow	2K, 30 mbar RF Off	Performance Detuning Reprocessing			Measure losses		Measure	Nitrogen Rate and Level tbd.
Iso fast I	2K, 30 mbar RF Off	Performance Detuning Reprocessing	Ceramic rupture	Tuner motors	Pressure increases, He Pipe rupture, MLI integrity	Ceramic rupture	Measure Leaks	Controlled, Rate tbd, Nitrogen
Iso fast II	2K, 30 mbar RF Off	Performance Detuning Reprocessing	Ceramic rupture	Tuner motors	Pressure increases He Pipe rupture MLI integrity	Ceramic rupture	Measure Leaks	Catastrophic, Air
Coupler fast	2K, 30 mbar RF Off	Performance Detuning Reprocessing	Ceramic rupture		Pressure increases He Pipe rupture		Measure Leaks	Controlled, Rate tbd, Nitrogen
Cavity fast I	2K, 30 mbar RF Off	Performance Detuning Reprocessing	Ceramic rupture		Pressure increases He Pipe rupture	Ceramic rupture	Measure Leaks	Controlled, Rate tbd, Nitrogen
Cavity fast II	2K, 30 mbar RF Off	Performance Detuning Reprocessing	Ceramic rupture		Pressure increases He Pipe rupture	Ceramic rupture	Measure Leaks	Catastrophic, Air
Cavity fast III	2K, 30 mbar RF On	Performance Detuning Reprocessing	Ceramic rupture		Pressure increases He Pipe rupture	Ceramic rupture	Measure Leaks	Controlled, Rate tbd, Nitrogen
Cavity fast IV	4.5K, 1.7 bar, RF Off	Performance Detuning Reprocessing	Ceramic rupture		Pressure increases He Pipe rupture	Ceramic rupture	Measure Leaks	Air, **Need to block 2 safety valves** (VD1R130 and VS1R90)

Venting systems for Coupler-, Cavity- and Iso-vacuum

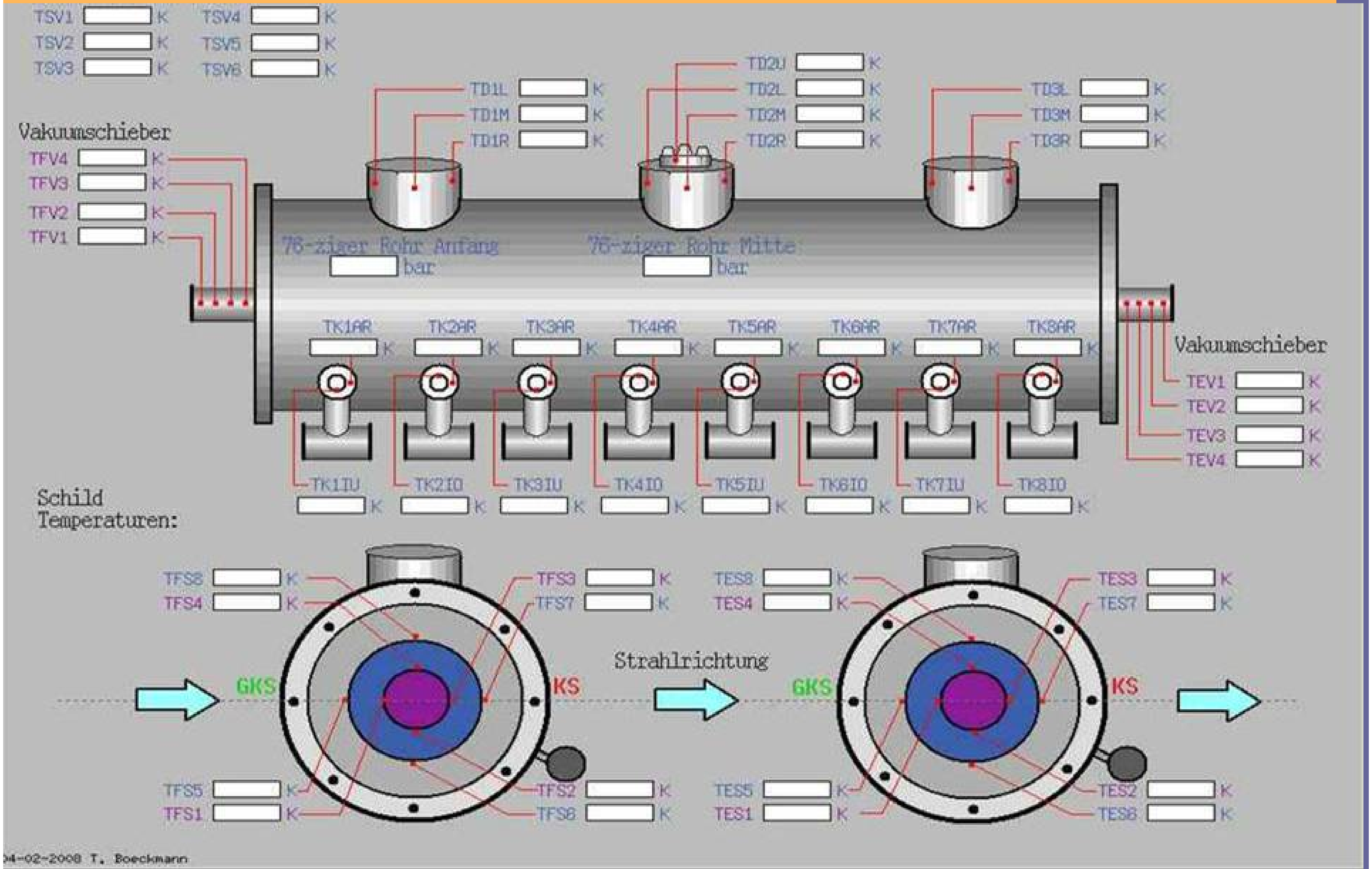


Venting system beam-pipe-vacuum DN 100

Venting system coupler-vacuum DN 100

Venting system isovacuum DN 100

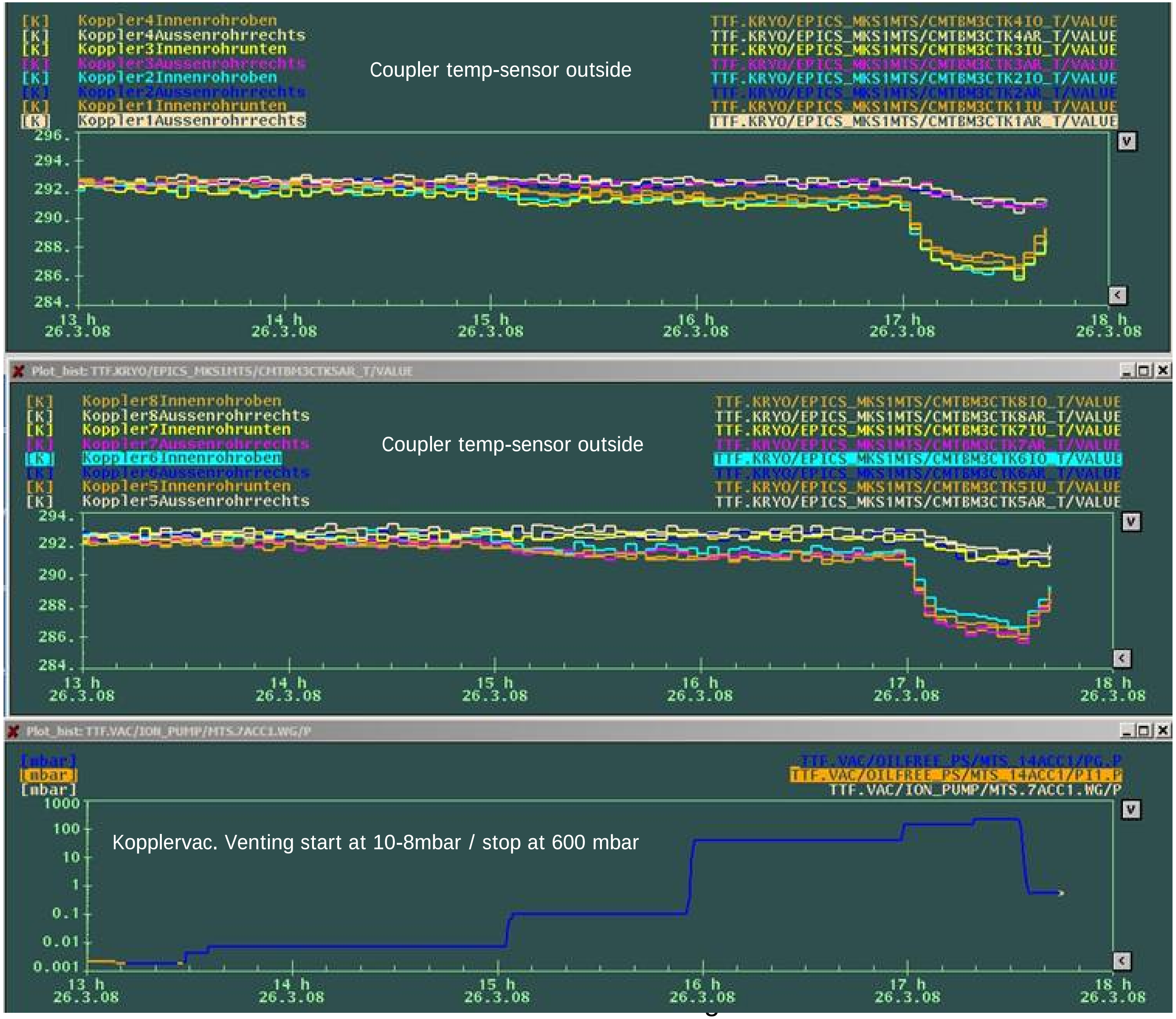
Additional Sensors for Crash Test



Slow Isolation Vacuum Venting with Helium

	TTF 2003 Iso 1*10-6	03.2008 Iso 3*10-5	03.2008 Iso 7*10-5	03.2008 Iso 2*10-4
4,3 K circuit	14 W	14,43 W	22,7 W	58 W
2 K circuit	< 3,5 W	3,3 W	3,84 W	12,47 W
40/80 K circuit	75 W	125,6 W (endcaps!)	112 W (endcaps!)	43,3 W

Koppler slow-venting with N2 at 2 K



Cryo-losses : **isolation-vac.: 6 – 7 * 10-5 mbar / coupler-vac. vented!**

	Design TDR	Couplervac. 10-8 mbar	Couplervac. 10-1 mbar
4,3 K circuit	**21 W**	**22,70 W**	**23,77 W**
2 K circuit	**4,2 W**	**3,84 W**	**4,07 W**
40/80 K circuit	**115 W**	**112 W !** Flow 12,20 g/sec	**108,66W!** Flow 11,56 g/sec

Slow venting beampipe-vac.at 2 K operation

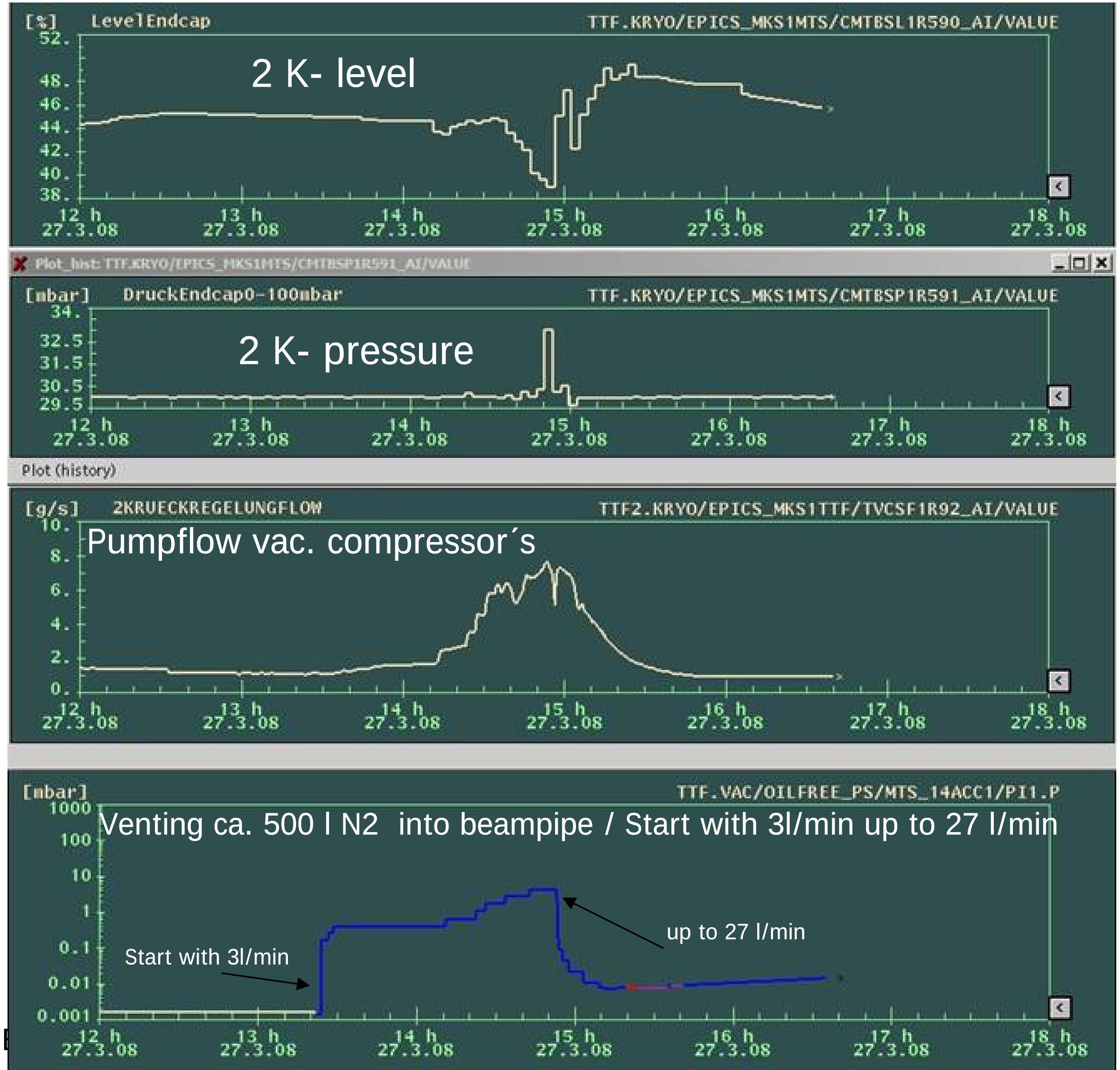
- First step venting ca. 500 l with N2 (27.03)
- Overnight-break: measure kryo-losses
- Second step venting ca. 1600 l with N2 (28.03)

- Warm up complete modul
- Check of safety valves beampipe

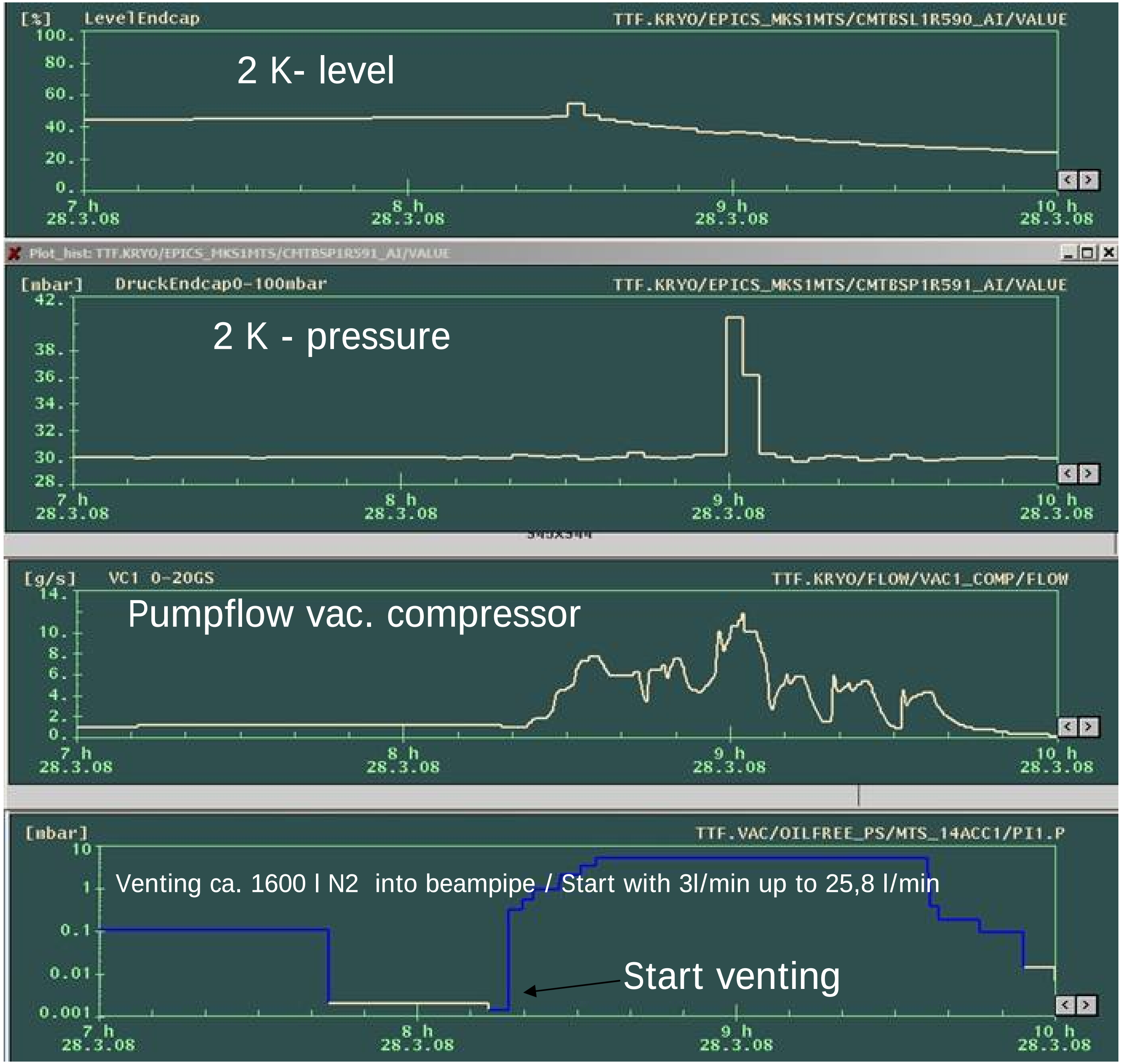
Slow venting beampipevac. with N2

Steps	Pressure Beampipe Feedcap	He-Flow Vacuum-compressor	2K pressurse
Venting beampipe with ca. 500 l N2	**5,5*10-7 mbar**	**Exept to 8 g/sec**	**max. 32,5mbar**
Over night - braek	**5,5*10-7 mbar**	**Normal 1,15-1,2g/sec**	**30 mbar**
Venting beampipe with ca. 1600 l N2	**5,5*10-7 mbar**	**Exept to 12/sec**	**max. 40 mbar**

First slow venting beampipe 27.03.2008



Second slow venting beampipe 28.03.2008



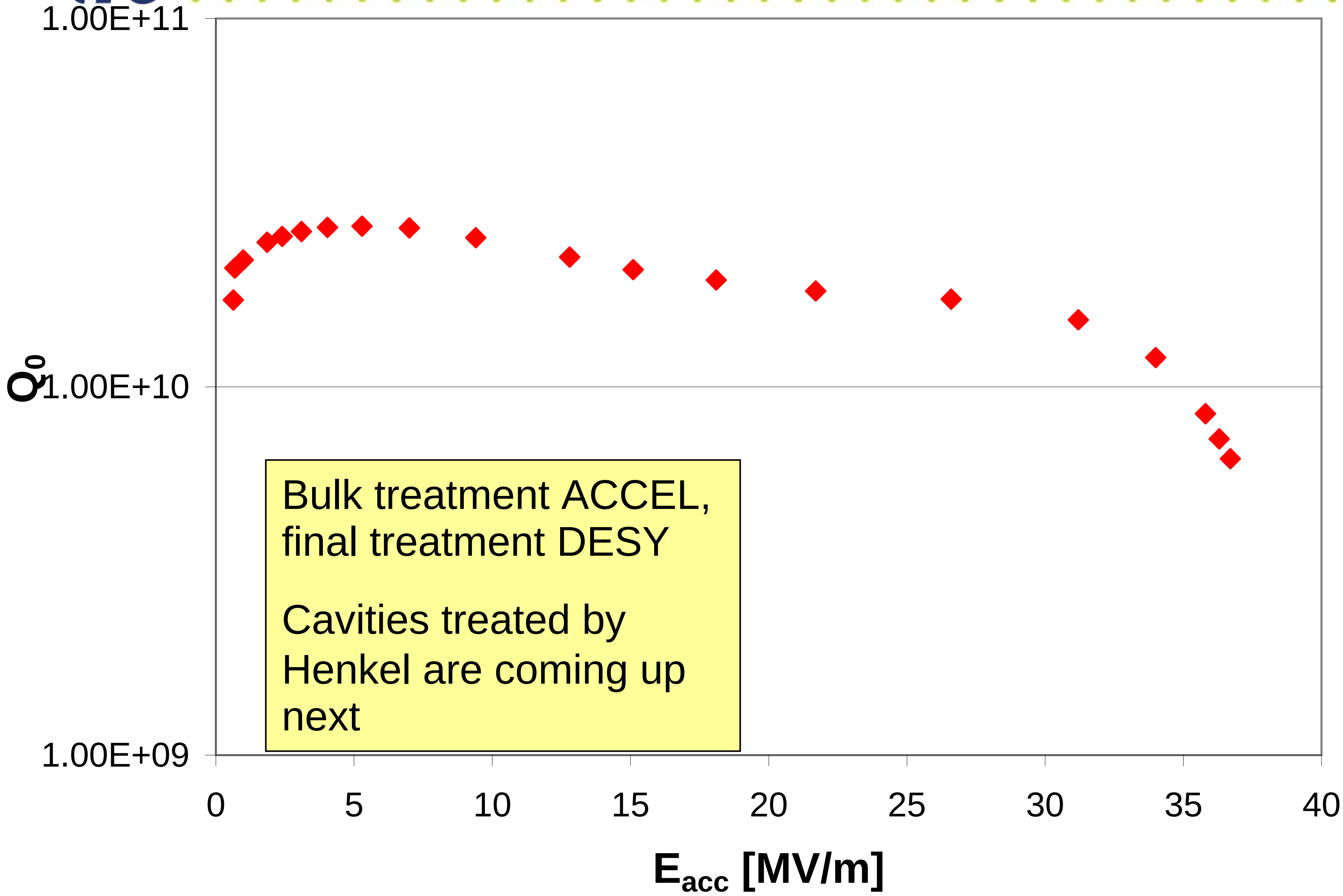
Venting Tests: Summary + Outlook

- Under cold conditions all three vacuum systems of the accelerator module have been slowly vented
- Observations
  - **Cryolosses increase as expected**
  - **NO broken components so far!**
- Next steps
  - **Warm up**
  - **Performance check on cavities + couplers**
  - **Start crash vents:**
    - Isolation vacuum first

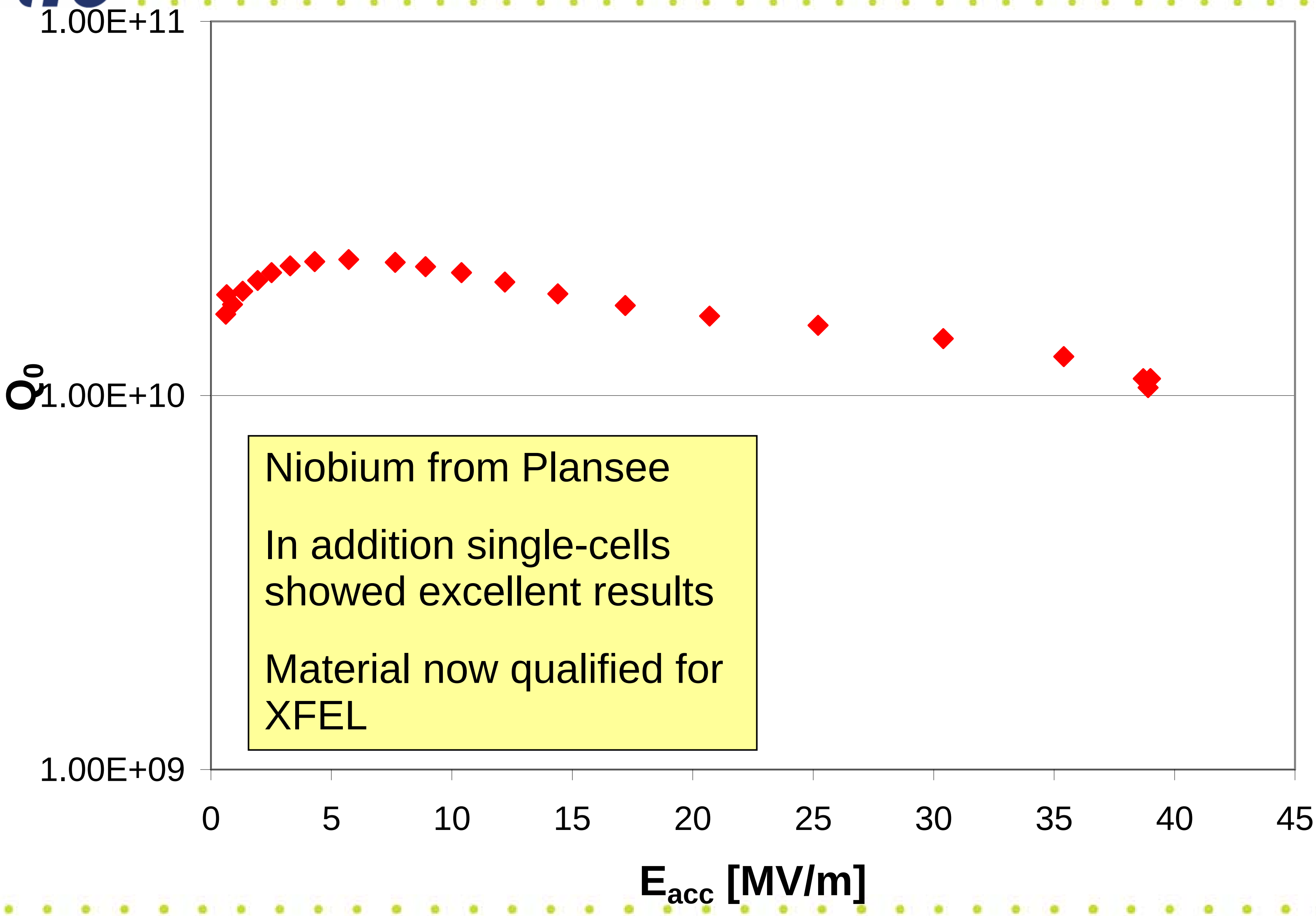
Europe: Cavity Tests

- First Industry EP multi-cell cavities
  - **Bulk EP at companies, final treatment at DESY**
- Qualification of niobium vendors
  - **Plansee qualified**
- Large grain multi-cell cavity with EP
- Fast Argon bake
  - **Saclay (Closed) and DESY (Open)**

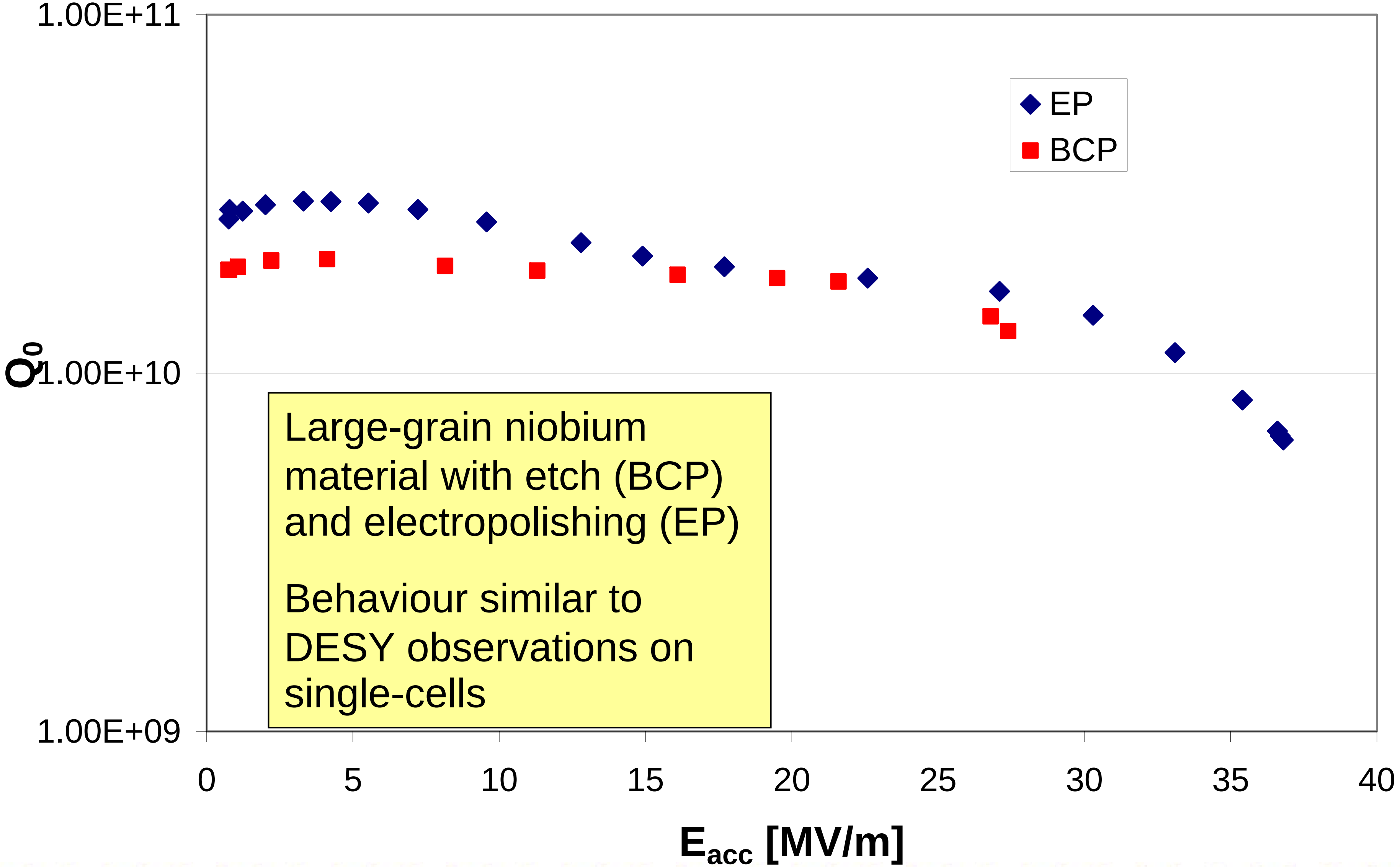
XFEL Industry EP on Multi-cells



XFEL Qualification of Niobium Vendors: Nine-cell of Plansee Material



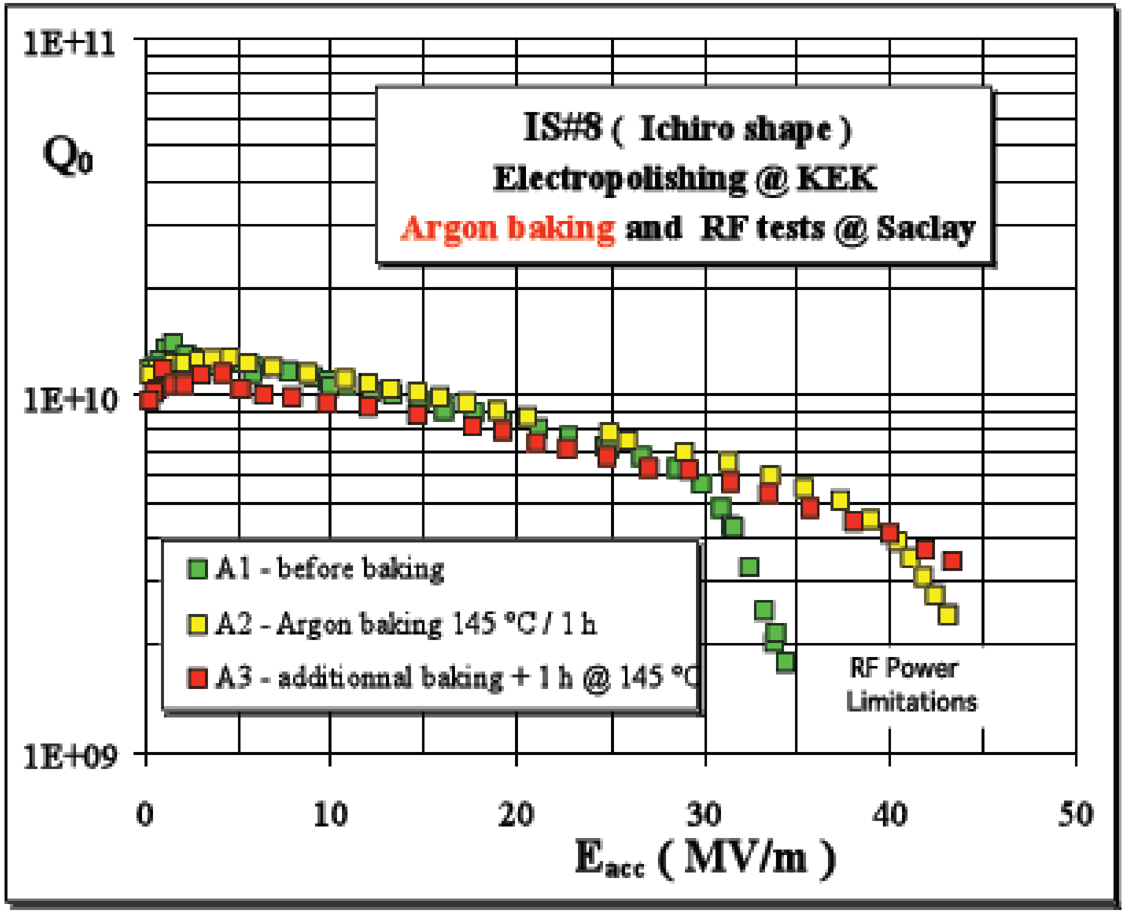
XFEL: Large Grain Multi-cell with EP

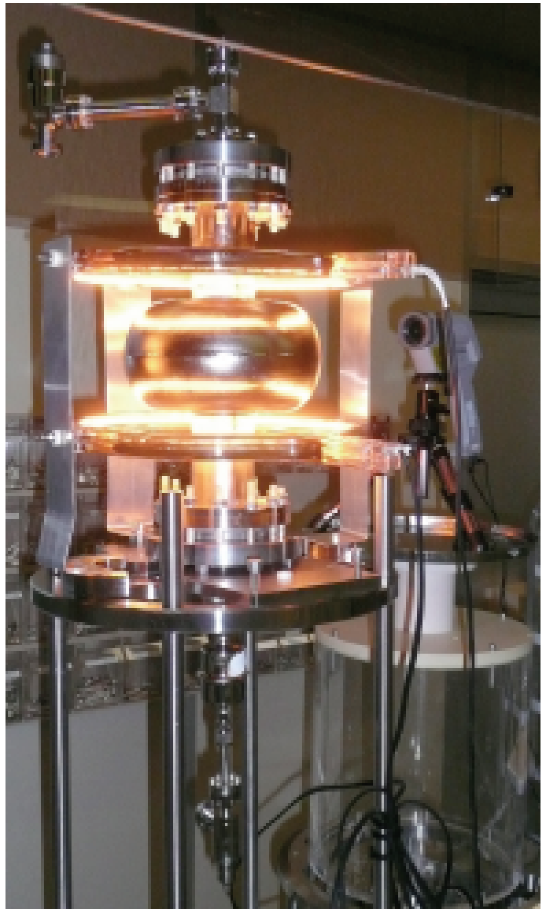


Argon Baking @ 145 °C vs. time

Electropolishing at KEK

Argon baking and RF tests at Saclay



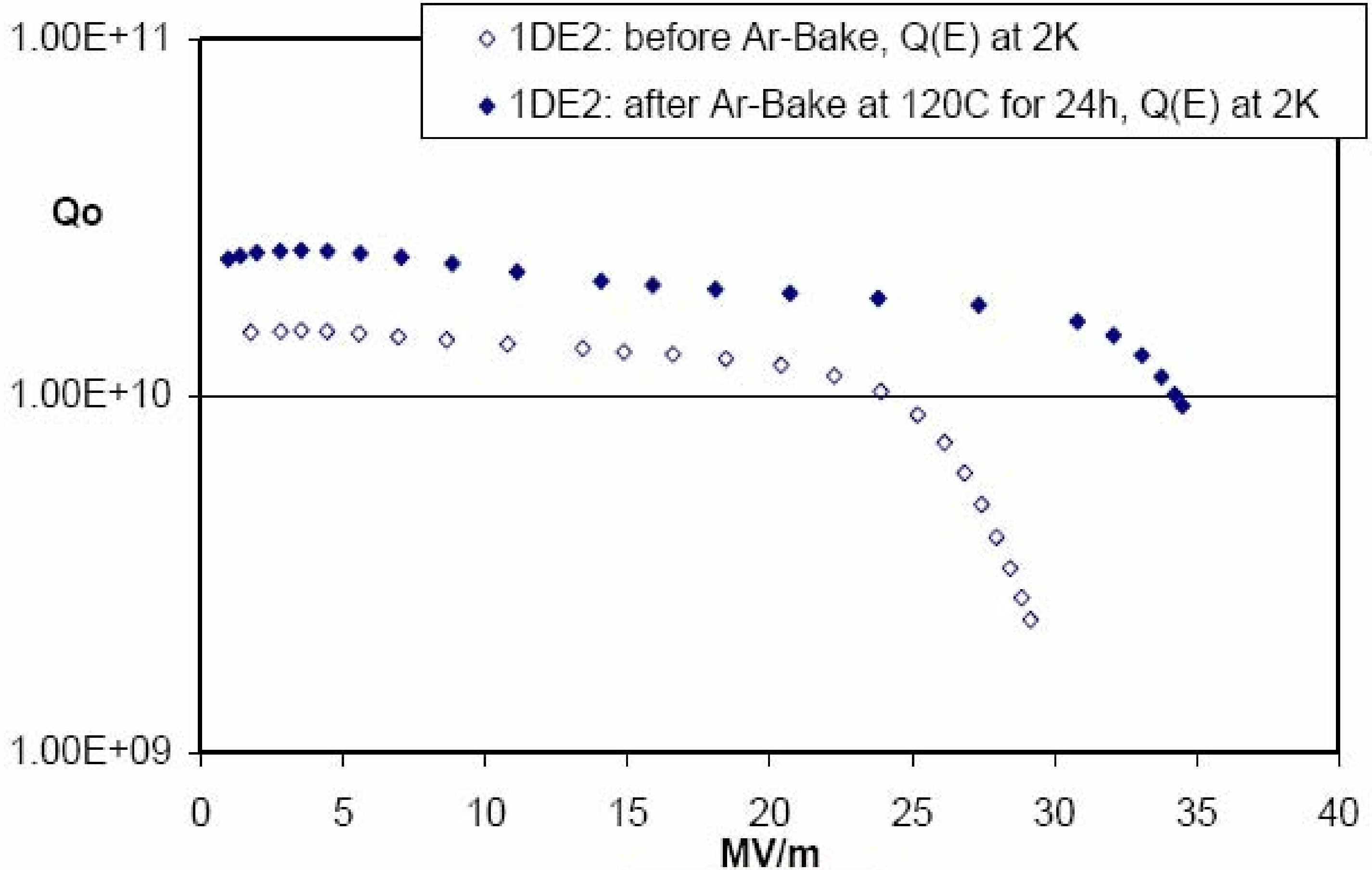


ICHIRO IS#8

Open Bake in Ar-atmosphere: set-up

1DE2: Open Bake in Ar-atmosphere

- Goal: Realize simple 120C-bake procedure for open cavity
  (cavity not assembled; no cavity vacuum necessary)



Status of Re-Planning

- Address variability in gradients with improving on diagnostics
  - **Add temperature mapping capacity to labs who have no capabilities yet**
  - **Add high-resolution inspection**
  - **Monitor on-going effort with best preparation methods**
- Less resources, stretch timeline to 2012
- International ‘proof-of-principle’ module
- Next:
  - **FNAL Meeting 21-25th of April**

Replan of ILC-SCRF R&D

updated, March 4, 2008

- **TDP1 by 2010:**
  - **S0:** achieve 35 MV/m with 9-cell cavities at the yield 50 % under well defined processing-base,
  - **S1-Global:** achieve <31.5 MV/m> with cryomodule-assembly
    - with global cooperation (for example, 4-AS, 2-US, 2-EU).
    - Note: the S1 achievable also, if 3 Tesla-type cavities added to the existing 5 cavities in CM2 at Fermilab.
  - **Cryomodule design:** establish "plug-compatible interface and design
- **TDP2-by 2012:**
  - **S0:** achieve 35 MV/m with 9-cell cavities at the yield 90 % under well defined processing-base.
  - **S1:** achieve <31.5 MV/m> with full cavity-assembly (similarly processed) in single cryomodule, CM3 or CM4 (at Fermilab, US)
  - **S2:** achieved <31.5 MV/m> with 3 cryomodule assembly to be powered by 1 RF unit, and with beam acceleration, in STF-2 at KEK.
  - **Industrialization:** Learn from XFEL, & Cooperation with Project-X

Global Plan proposed

		CY08		CY10		CY12
EDR	TDP1			TDP-II		
S0: Cavity Gradient (MV/m)	30					35 (>90%)
KEK-STF-0.5a: 1 Tesla-like						
KEK-STF-0.5b: 1 LL						
KEK-STF1: 4 cavities						
S1-Global (AS-US-EU) 1 CM (4+2+2 cavities)			CM ($4_{AS}+2_{US}+2_{EU}$) <31.5 MV/m>			
S2 & STF2: One RF unit & 3 CM with beam		design	Fabrication in industries	Assembled and test at STF		
S1-Fermilab/US ILC-CM-3 or -4		CM1	CM2	CM3(Type-IV)		CM4

Cryomodule Design
with plug-compatible components

	Cost fraction
CM with modular sub-assemblies	
– Cavity unit (cavity + helium vessel + tuner)	64%
– Coupler	12%
– Quad package (quad + corrector)	4%
– BPM	2%
– Cold-mass (cold-piping)	x/19%
– Vacuum vessel	y/19%

- **Plug-compatible, Interface specifications (IS)**
  - To be generally agreed at Fermilab meeting, in April, 2008

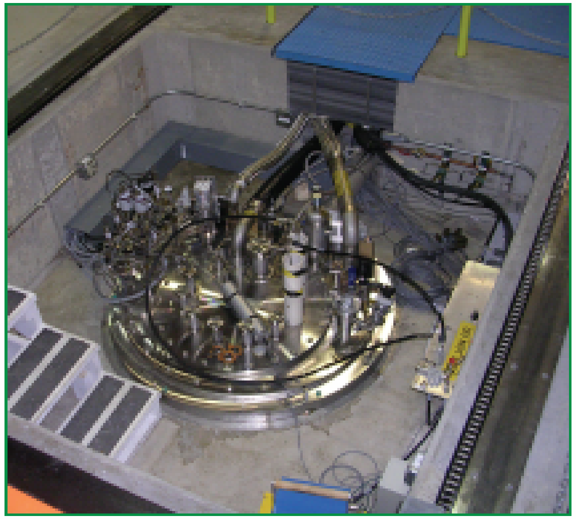
- **Plug-compatible IS** enables parallel development, afterwards, during the TDP phases,

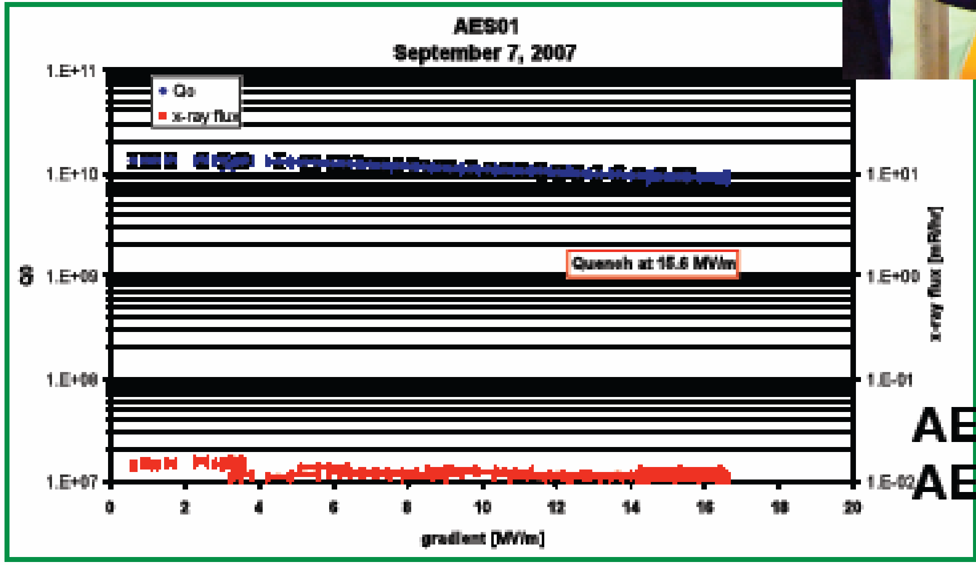
Summary

- Basis of ILC Technology is broadening
  - **Asia and America have built the first modules**
- Surface preparation improved
  - **Field emission reduced somewhat**
- Scatter of gradients due to thermal breakdowns
  - **Partially new vendor qualification**
  - **Potentially other reasons as well**
    - Need to improve diagnostics (optical and thermal)
- XFEL is a big asset for ILC
  - **Industrialisation**
  - **Internationalization of a project**
  - **Crash test**
  - **Operational experience with FLASH**
  - **Continuous production of cavities**
- Some Alternates very promising
  - **Fast Argon bake**
  - **Large grain niobium material**

Backup

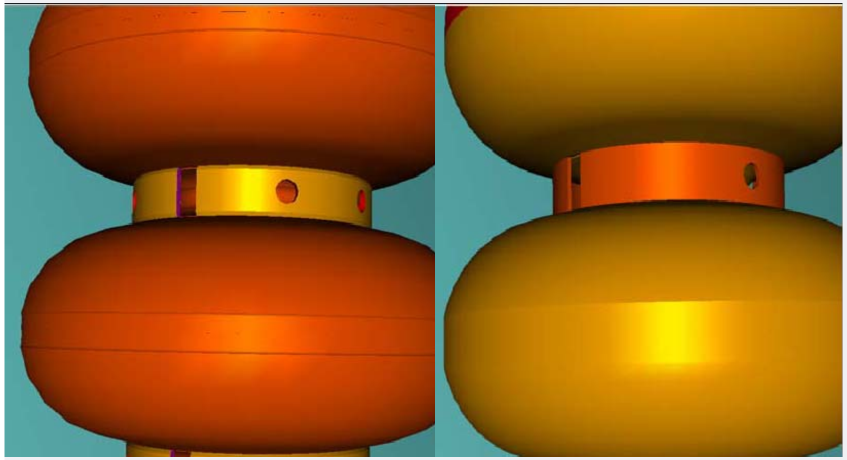
FNAL: Vertical Test Set Up Complete
AES 9-cell Cavities under Test

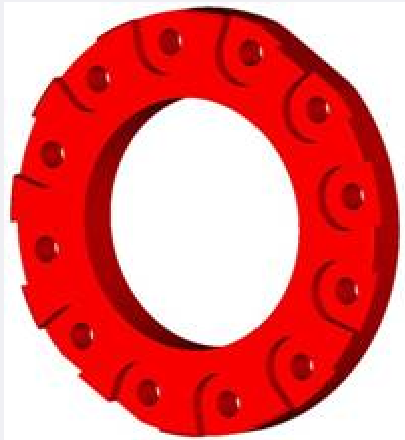




AES01 Tested,
AES03 under test

Small design changes to reduce cost and simplify fabrication

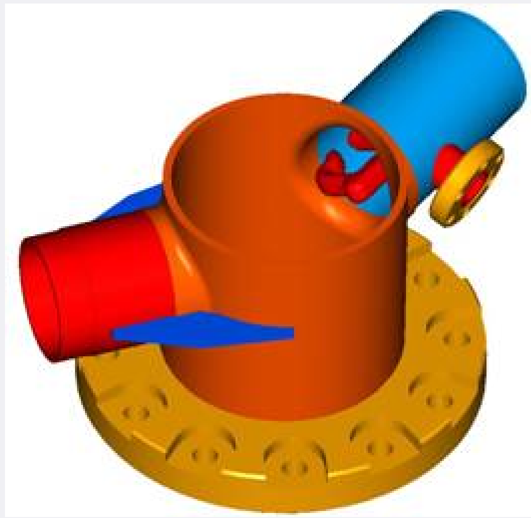




Long side

Short side (machined step under discussion)

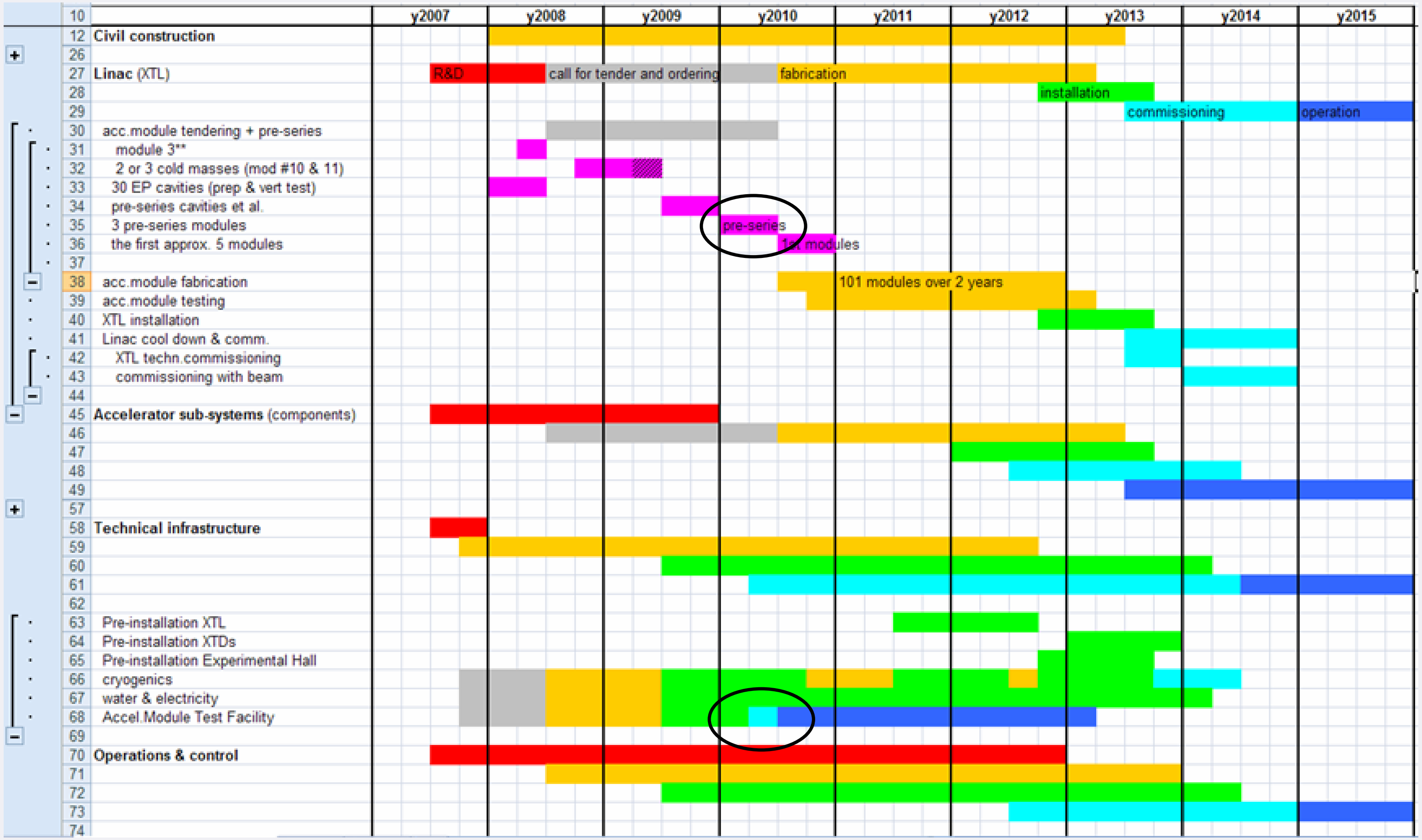
- **Removal of coupler port stiffener**
- **Reducing of flange machining short side**
- **Removal of outside recess (equator area)**
- **Less holes and thinner the stiffener ring**
- **Review tolerances**



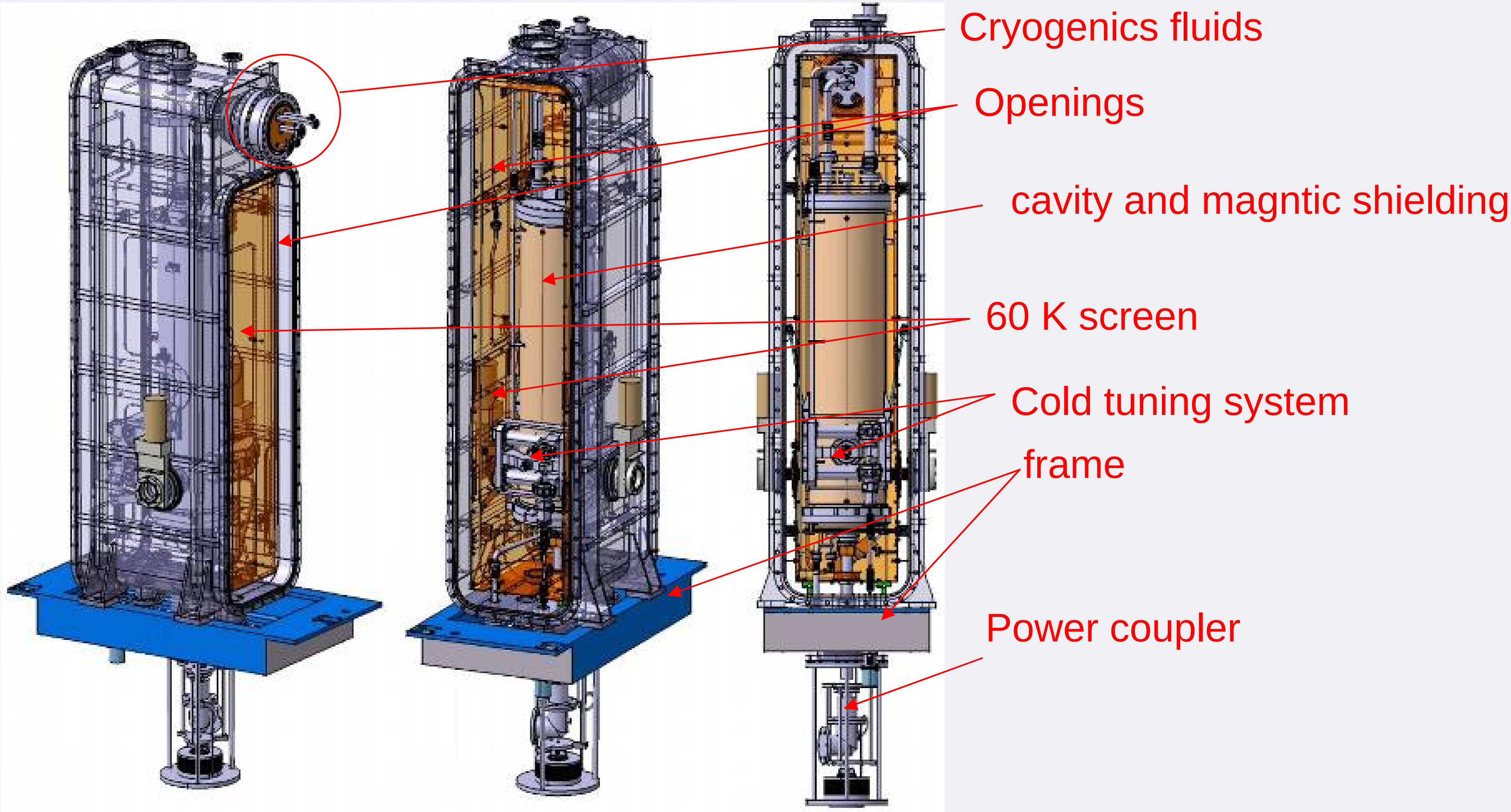
No rib

XFEL Overall Schedule as the Basis

XFEL Overall Schedule - First Details



Details of the Spiral 2 Cryomodule

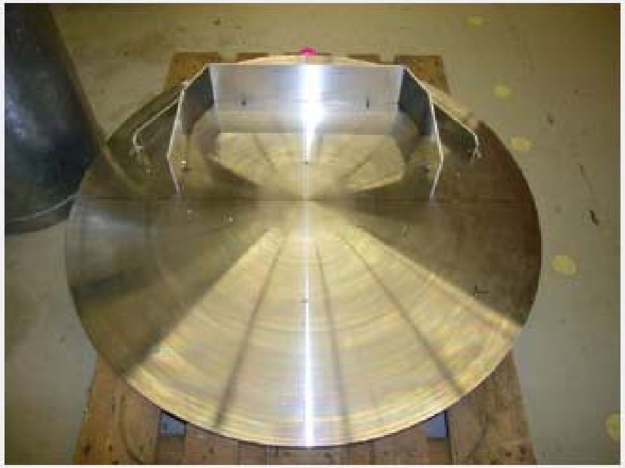


Mock-up Tunnel

HOM-Ab and Gate valves

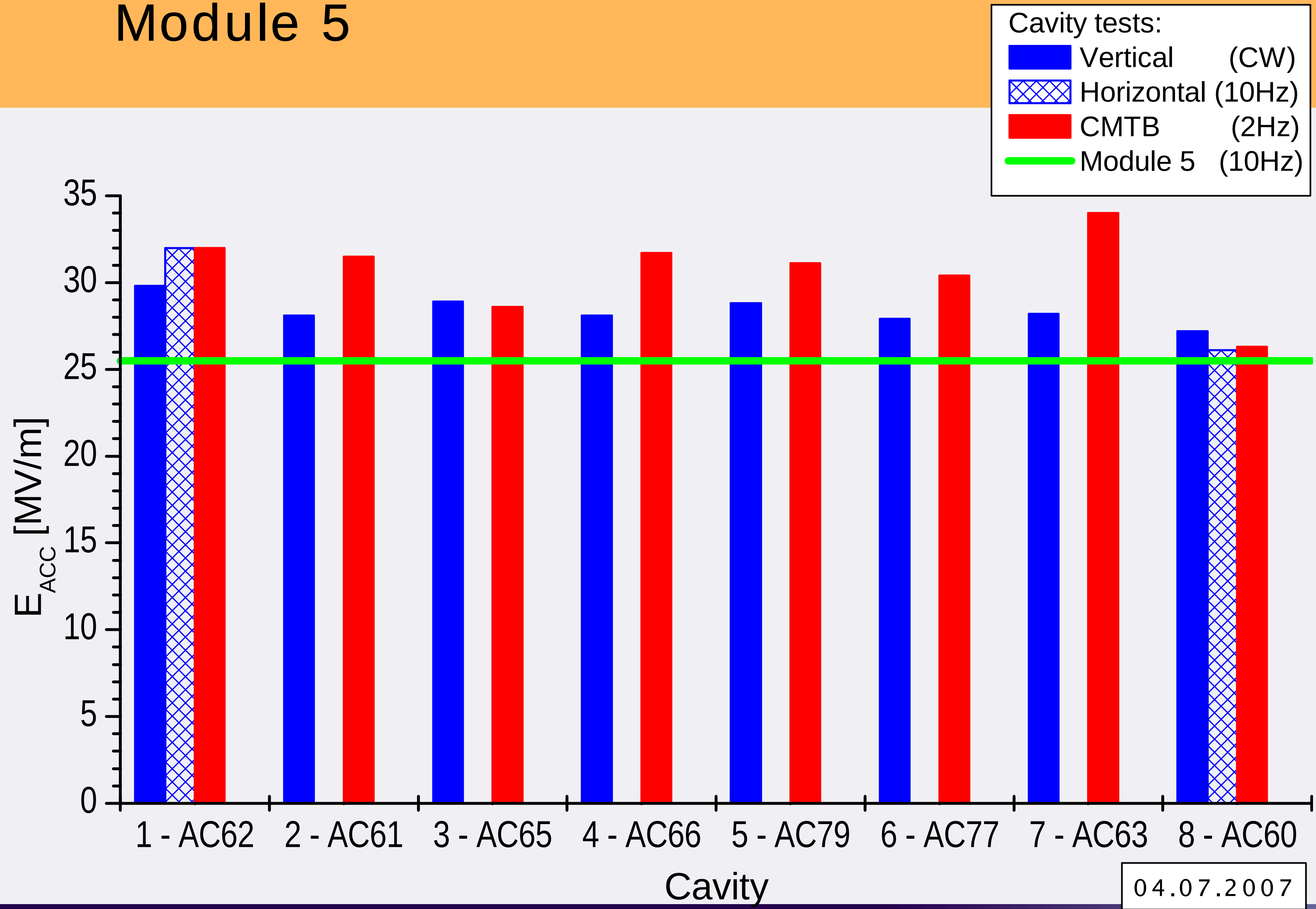
Module Connection on single dummy

Endplate (4) for Mock-up vessel

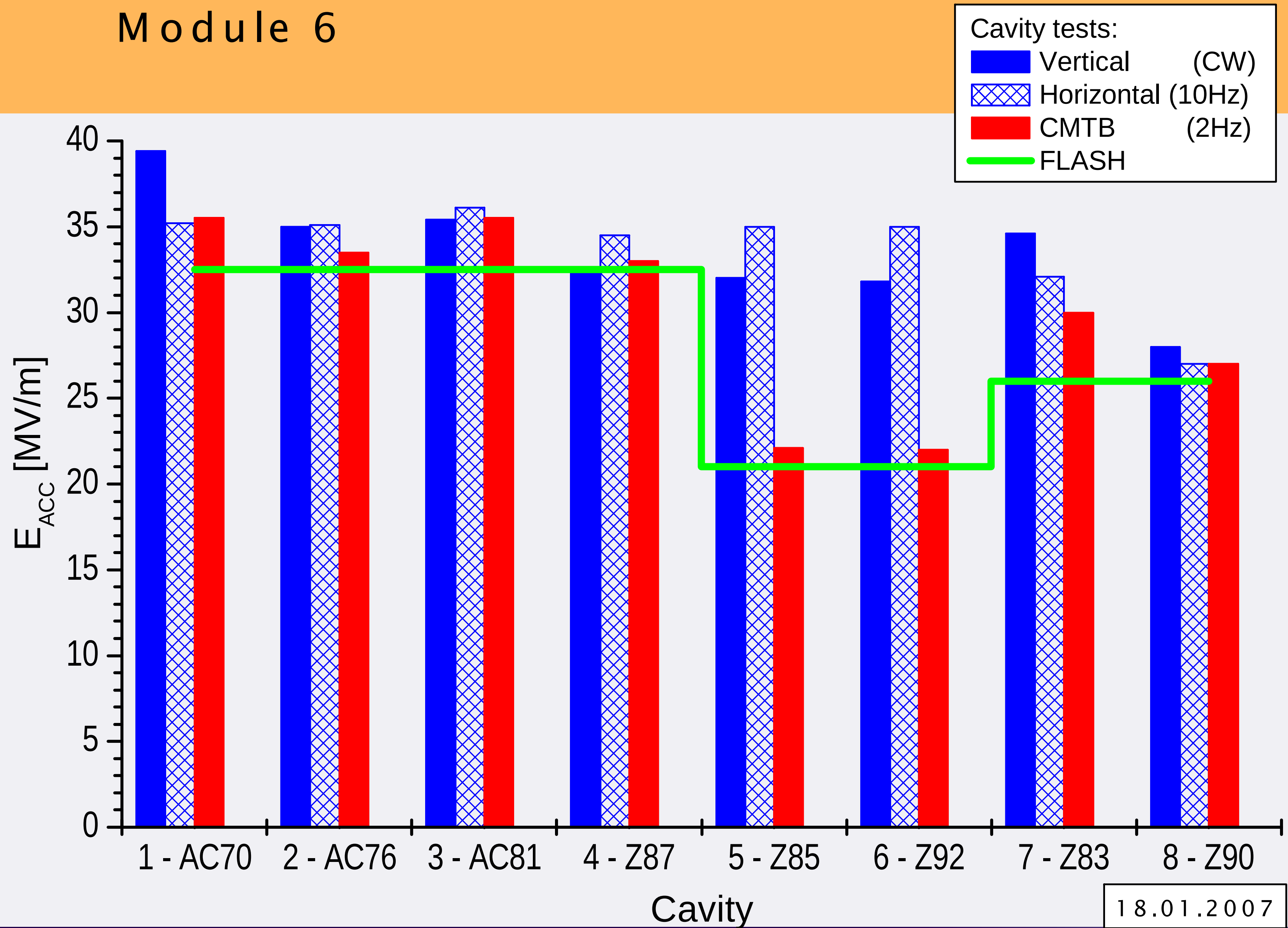


Weld tractor with
special weld head for
HeGRP connection,
developed at Desy

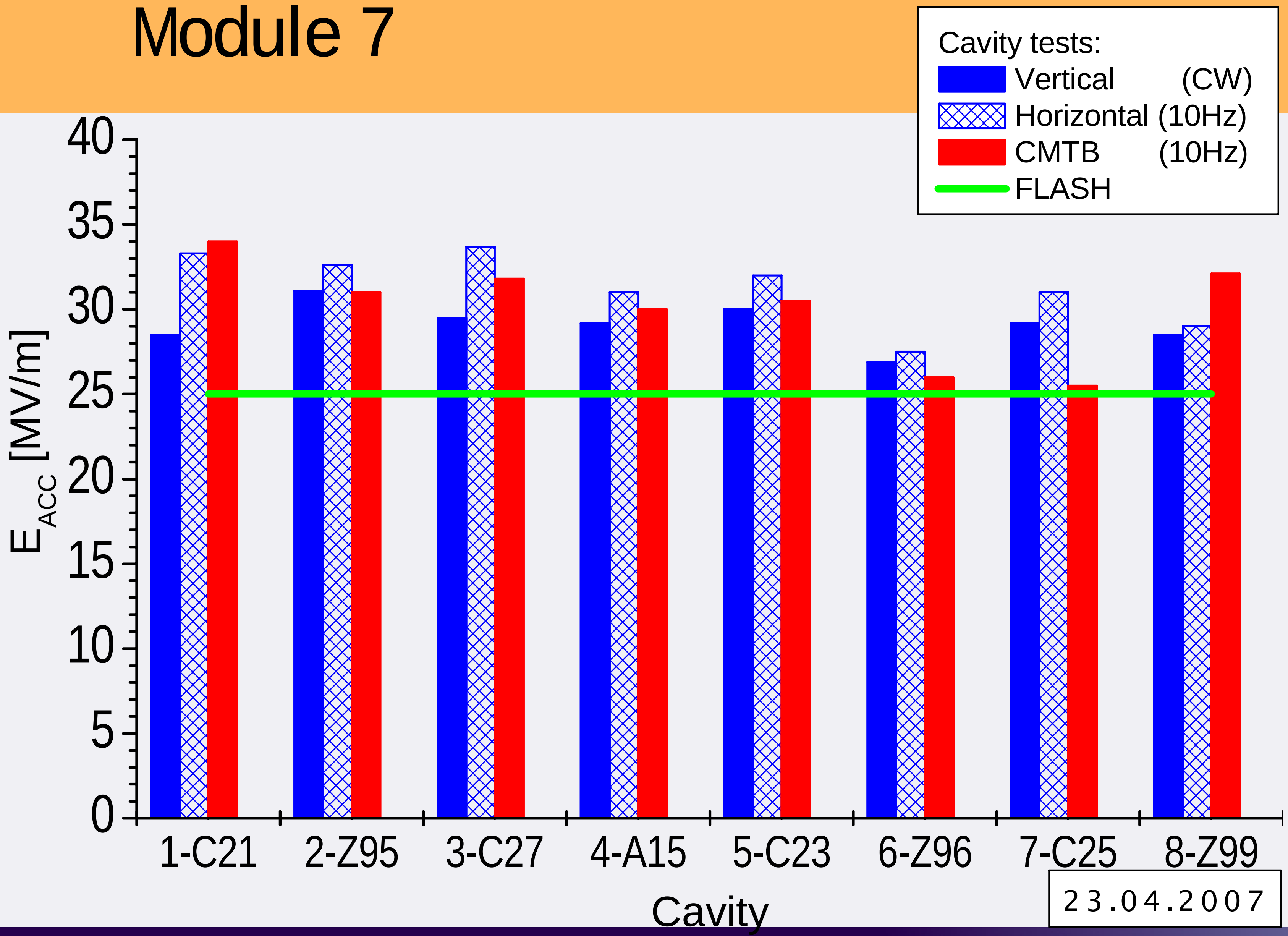
Module 5


Cavity tests:
Vertical (CW)
Horizontal (10Hz)
CMTB (2Hz)
Module 5 (10Hz)
35
30
25
20
15
10
5
0
E_{ACC} [MV/m]
1 - AC62
2 - AC61
3 - AC65
4 - AC66
5 - AC79
6 - AC77
7 - AC63
8 - AC60
Cavity
04.07.2007

Module 6


Cavity tests:
Vertical (CW)
Horizontal (10Hz)
CMTB (2Hz)
FLASH
E_{ACC} [MV/m]
0
5
10
15
20
25
30
35
40
1 - AC70
2 - AC76
3 - AC81
4 - Z87
5 - Z85
6 - Z92
7 - Z83
8 - Z90
Cavity
18.01.2007

Module 7


Cavity tests:
Vertical (CW)
Horizontal (10Hz)
CMTB (10Hz)
FLASH
40
35
30
25
20
15
10
5
0
E_ACC [MV/m]
1-C21
2-Z95
3-C27
4-A15
5-C23
6-Z96
7-C25
8-Z99
Cavity
23.04.2007