SRF Superconducting Radio Frequency

EucARD Annual Meeting

11 June 2013, CERN

WP10 - SRF

"SC RF technology for higher intensity proton accelerators & higher energy electron linacs"

WP10-SRF Task 'Patchwork'

WP 10 Organisation, version 01.04.12					
Task	Subtask	task / subtask leader	leading laboratory	participating laboratories	Task description
10,1		**O. Napoly, O. Brunner**	**CEA**	CEA, CERN	**SRF Coordination and Communication**
10,2		**F. Peauger**	**CEA**	CEA, CERN, CNRS,	**SPL Cavities**
	10.2.1	G. Orly	IPN-Orsay	CNRS	Design and fabrication of β = 0.65, 704 MHz elliptical cavity.
	10.2.2	F. Peauger	CEA	CEA	Design and fabrication of β = 1, 704 MHz elliptical cavity.
	10.2.3	V. Parma	CERN	CERN, CEA, CNRS	Study of interfaces between the cavity and the cryomodule.
10,3		**P. McIntosh**	**STFC**	STFC/Daresbury,UNIMAN,ULANC,CERN	**Crab cavities**
	10.3.1	F Zimmerman	CERN	CERN, ULANC	Design, build and test a single LHC crab cavity.
	10.3.2	R.M. Jones	UNIMAN	UNIMAN	Design, build and test a single CLIC crab cavity.
	10.3.3	A Dexter	ULANC	ULANC	Design, build and test a LLRF and synchronization systems.
10,4		**S. Calatroni**	**CERN**	CI, CEA, CERN, CNRS/IPNO, DESY, INFN-LNL, NCBJ	**Thin Films**
	10.4.1	S. Calatroni	CERN	INFN-LNL, CERN	Improve the Nb sputtering technology for low beta cavities.
	10.4.2	J. Sekutowicz	DESY	DESY, NCBJ	Perform arc sputtering of photo cathodes (Pb).
	10.4.3	R. Seviour	CI	CI, CEA, CERN, CNRS/IPNO, INFN-LNL	Research on new technologies for thin film depositing of superconductors for SC cavity applications.
10,5		**R.M. Jones**	**UNIMAN**	DESY, UNIMAN, UROS	**HOM Distribution**
	10.5.1	N. Baboi	DESY	DESY	Development of HOM based beam position monitors (HOMBPM).
	10.5.2	R.M.Jones	UNIMAN	UNIMAN	Development of HOM Cavity Diagnostics and ERLP (HOMCD).
	10.5.3	U. van Rienen	UROS	UROS	Measurement of HOM Distributions and Geometrical Dependences (HOMDG).
10,6		**M. Grecki**	**DESY**	DESY, TUL, IPJ, WUT, IFJ-PAN	**LLRF at FLASH**
	10.6.1	T. Jezynski	DESY	DESY, TUL, WUT	Development of ATCA carrier boards with FPGA and DSP
	10.6.2	D. Makowski	TUL	TUL, DESY, WUT	Development of AMC and RTM modules required IO functionality
	10.6.3	M. Grecki	DESY	DESY, TUL, IFJ-PAN	ATCA implementation of cavity resonance control
	10.6.4	J. Szewinski	NCBJ	NCBJ, DESY	Development of beam based longitudinal feedbacks for the ATCA based LLRF system
10,7		**J. Teichert**	**FZD**	FZD, HZB	**SCRF gun at ELBE**
	10.7.1	T. Kamps	HZB	HZB, FZD	Slice diagnostics system
	10.7.2	R. Xiang	FZD	FZD	Improvement of preparation chamber for GaAs photo-cathodes
	10.7.3	J. Teichert	FZD	FZD, HZB	SCRF gun experimental tests
10,8		**W. Kaabi**	**LAL-Orsay**	LAL	**Coupler Development at LAL**
	10.8.1	W. Kaabi	LAL-Orsay	LAL	Cleaning studies on samples
	10.8.2	M.Lacroix	LAL-Orsay	LAL	Automation of coupler washing

WP10-SRF Fifteen Institutes

Universität Rostock — Traditio et Innovatio

Lancaster University

CERN

CNRS IN2P3 — Les deux infinis

IPN — Institut de Physique Nucléaire Orsay

LAL — Laboratoire de l'Accélérateur Linéaire

Irfu cea saclay

Manchester 1824 — The University of Manchester

HZDR — Helmholtz Zentrum Dresden Rossendorf

HZB — Helmholtz Zentrum Berlin

DESY

DMCS

ise

Krakow

Swierk

INFN — Istituto Nazionale di Fisica Nucleare

Science & Technology Facilities Council

Pushing Accelerator Performance Barriers

R&D is needed to advance the Superconducting RF Technology for Accelerator applications

- High Gradient barrier (ILC, SPL, ESS, etc…) → Task 10.2, 10.4
- High Q0 barrier (efficiency, duty cycle) → Task 10.4
- High RF Power barrier (HPPAs) → Task 10.2, 10.8
- High Stability and Reliability barriers (ILC, XFEL, ADS) → Task 10.5, 10.6
- Low Beta barrier (e.g. Spiral2 β=0.07) → Task 10.4
- Industrialization and cost barrier (ILC) → Task 10.8
- New Applications barrier:
  - Crab cavities (LHC, ILC) → Task 10.3
  - SC-RF Gun (electrons) → Task 10.4, 10.7
  - Energy Recovery Linac (ALICE, BERLinPro) → Task 10.5, 10.7

WP10-SRF 1st Annual Review
7-9 April 2010, Cockcroft Institute, Daresbury

45 Participants = 47 Registrants – 2 Visa Problems (@ LAL and FZD)

14/15 Partner Institutes represented

https://espace.cern.ch/EuCARD/AnnualMeeting2010/default.aspx

WP10-SRF 2nd Annual Review
4-5 May 2011, IN2P3 – Inst. Phys. Nucl. Orsay

42 Participants, including the 2 Coordinators + 7 Task Leaders

14/15 Partner Institutes represented

http://indico.cern.ch/internalPage.py?pageId=7&confId=115634

WP10-SRF 3rd Annual Review
29-30 March 2012, HZB, Berlin

45 Participants, including the 2 Coordinators + 6 Task Leaders (1 excused)

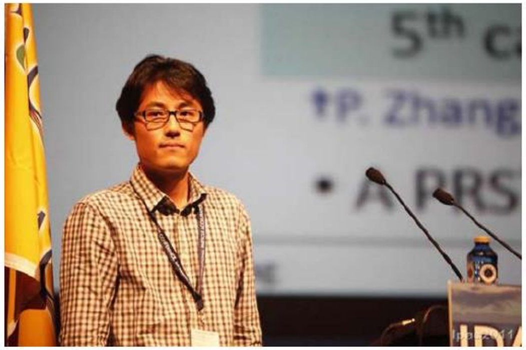
13/15 Partner Institutes represented

http://www.bessy.de/indico/conferenceDisplay.py?confId=380

WP10-SRF PhD Students

Ben Hall,	Lancaster University	T10.3
Ben Woolley,	Lancaster University	T10.3
Pei Zhang,	Manchester University, working at DESY	T10.5
Thomas Fligsen,	Rostock University	T10.5
Nawin Juntong,	Manchester University	T10.5
Chris Glasman,	Manchester University	T10.5
Jeniffa Rudolph,	HZ Berlin, working partly at Rossendorf	T10.7
André Arnold,	HZD Rossendorf	T10.7

EPS-AG Thesis Prize



- Pei Zhang, a Cockcroft Institute Ph. D. student at the University of Manchester and working at DESY, has been selected for Ph.D. thesis prize at the IPAC 2011 in San Sebastian, Spain.
- This prize is awarded to a student registered for a PhD or diploma in accelerator physics or engineering or to a trainee accelerator physicist or engineer in the educational phase of their professional career, for the quality of work and promise for the future.
- His contribution can be found in the SPMS session (THPPA00) in the conference (JACoW) website, cited as *"Study of Beam Diagnostics with Trapped Modes in Third Harmonic Superconducting Cavities at FLASH*

SRF Superconducting Radio Frequency

WP10.1: Coordination and Communication

➢ Deliverable:

Ref.	N°	Deliverable Name	Deliverable Type	Task	Delivered by Contractor (s)	Planned (in months)	Achieved (in months)
10.1.1	14	SRF web-site linked to the technical and administrative databases	Web-Site	Coordination	CEA, CERN	48	

Proposal to *link to TTC Infrastructure database under construction*

+ Database on SRF Accelerators in Europe, linked to the TTC server.

Name	Particles	# cavities		Type	Material	Gradient	Mode	T	Status	Location
HERA	electrons, positrons	16	500 MHz	β=1 elliptical 4-cell	Nb	4.0 MV/m	CW	4.2 K	de-commissioned	DESY
LEP200	electrons, positrons	16 272	352 MHz	β=1 elliptical 4-cell	Nb Nb/Cu	5 MV/m 7 MV/m	CW	4.5 K	de-commissioned	CERN
LISA	electrons	4	500 MHz	β=1 elliptical 4-cell	Nb	6 MV/m	pulsed	4.2 K	de-commissioned	LN Frascati
MACSE	electrons	5	1.5 GHz	β=1 elliptical 5-cell	Nb	10 MV/m	CW	1.8 K	de-commissioned	CEA-Saclay
Tandem PA	ions	16 34	81 MHz 135 MHz	β=0.085 helix λ/2 β=0.085 helix λ	Nb	2.2 MV/m	CW	4.2 K	de-commissioned	CEA-Saclay
Tandem PA	ions								de-commissioned	Daresbury
ALICE	electrons	2 2	1.3 GHz	β=1 elliptical 9-cell β=1 elliptical 9-cell	Nb	3-5 MV/m 13.5 MV/m	pulsed	2 K	operation	Daresbury
ALPI	ions	2 12 50 58	80 MHz 80 MHz 160 MHz 160 MHz	β=0.0255 RFQ β=0.055 QW β=0.13 QW β=0.13 QW	Nb Nb Pb/Cu Nb/Cu	2-3 MV/m 4 MV/m 2.7 MV/m 4.8 MV/m	CW	4.5 K	operation de-commissioned	LN Legnaro
DIAMOND	electrons	2	500 MHz	β=1 elliptical 1-cell	Nb	6.5 MV/m	CW	4.5 K	operation	Oxford
ELBE	electrons	1 4	1.3 GHz	β=1 elliptical 3½-cell β=1 elliptical 9-cell	Nb	8 MV/m 9 MV/m	CW	2 K	operation	HZDR
ELETTRA	electrons	1	1.5 GHz	β=1 elliptical 2-cell	Nb	5 MV/m	CW	4.5 K	operation	Trieste
FLASH	electrons	56 4	1.3 GHz 3.9 GHz	β=1 elliptical 9-cell	Nb	20-30 MV/m 14.5 MV/m	pulsed	2 K	operation	DESY
ISOLDE	ions	12 20	101 MHz	β=0.063 QW β=0.103 QW	Nb/Cu	6 MV/m	CW	4.5 K	operation	CERN
LHC	protons, ions	16	400 MHz	β=1 elliptical 1-cell	Nb/Cu	6 MV/m	CW	4.5 K	operation	CERN
S-DALINAC	electrons	1 1 10	3 GHz	β=0.85 elliptical 2-cell β=1 elliptical 5-cell β=1 elliptical 20-cell	Nb	5 MV/m 5 MV/m 5 MV/m	CW	2 K	operation	Darmstadt
SLS	electrons	1	1.5 GHz	β=1 elliptical 2-cell	Nb	5 MV/m	CW	4.5 K	operation	PSI
SOLEIL	electrons	4	352 MHz	β=1 elliptical 1-cell	Nb/Cu	6 MV/m	CW	4.2 K	operation	SOLEIL
*BER*LinPro	electrons	1 3 3	1.3 GHz	β=1 elliptical 1½-cell β=1 elliptical 2-cell β=1 elliptical 7-cell	Nb	20 MV/m 18 MV/m	CW	2 K	construction	HZB
E-XFEL	electrons	808 8	1.3 GHz 3.9 GHz	β=1 elliptical 9-cell	Nb	24 MV/m 15 MV/m	pulsed	2 K	construction	Hamburg
IFMIF-EVEDA	D+	8	175 MHz	β=0.094 HW	Nb	4.5 MV/m	CW	4.5 K	construction	Rokkasho
SPIRAL2	D+, ions A/Q = 3	12 14	88 MHz	β=0.07 QW β=0.12 QW	Nb	6.5 MV/m 6.5 MV/m	CW	4.2 K	construction	GANIL
ESS	protons	28 64 112	352 MHz 704 MHz 704 MHz	β=0.5 double spoke β=0.7 elliptical 5-cell β=0.9 elliptical 5-cell	Nb	8 MV/m 15.5 MV/m 18.2 MV/m	pulsed	4.5 K	design	Lund
EURISOL Driver	protons, deutons, H-, 3He2+	16 56 36 45 40 24	176 MHz 176 MHz 352 MHz 704 MHz 704 MHz 704 MHz	β=0.09 HW β=0.15 HW β=0.3 triple spoke β=0.47 elliptical 5-cell β=0.65 elliptical 5-cell β=0.76 elliptical 5-cell	Nb	4.7 MV/m 5.2 MV/m 5.8 MV/m 12 MV/m 15 MV/m 18 MV/m	CW	2 K	design	-
EURISOL PA	ions, A/Q from 2 to 8	15 27 80 154	88 MHz 88 MHz 176 MHz 264 MHz	β=0.065 QWR β=0.14 QWR β=0.27 HWR β=0.39 single-spoke	Nb	?	CW	4 K	design	-
ILC 500	electrons, positrons	16 900	1.3 GHz	β=1 elliptical 9-cell	Nb	35 MV/m	pulsed	2 K	design	-
LUNEX5	electrons	16	1.3 GHz	β=1 elliptical 9-cell	Nb	25 MV/m	pulsed	2 K	design	SOLEIL
LHeC ERL	electrons	944	721 MHz	β=1 elliptical 5-cell	Nb	20 MV/m	CW	2 K	design	CERN
MYRRHA	protons	8 48 34 60	176MHz 352 MHz 704 MHz 704 MHz	CH DTL β=0.35 single spoke β=0.47 elliptical 5-cell β=0.65 elliptical 5-cell	Nb	4 MV/m 6 MV/m 8 MV/m 11 MV/m	CW	2 K	design	SCK Mol
POLFEL	electrons	?	1.3 GHz	β=1 elliptical 9-cell	Nb	25 MV/m	pulsed	1.8 K	design	-
SPL	protons, H-	60 192	704 MHz	β=0.65 elliptical 5-cell β=1 elliptical 5-cell	Nb	19 MV/m 25 MV/m	pulsed	?	design	CERN
TRASCO	protons		704 MHz		Nb		pulsed		design	-

SRF Accelerators in Europe or involving EU labs:

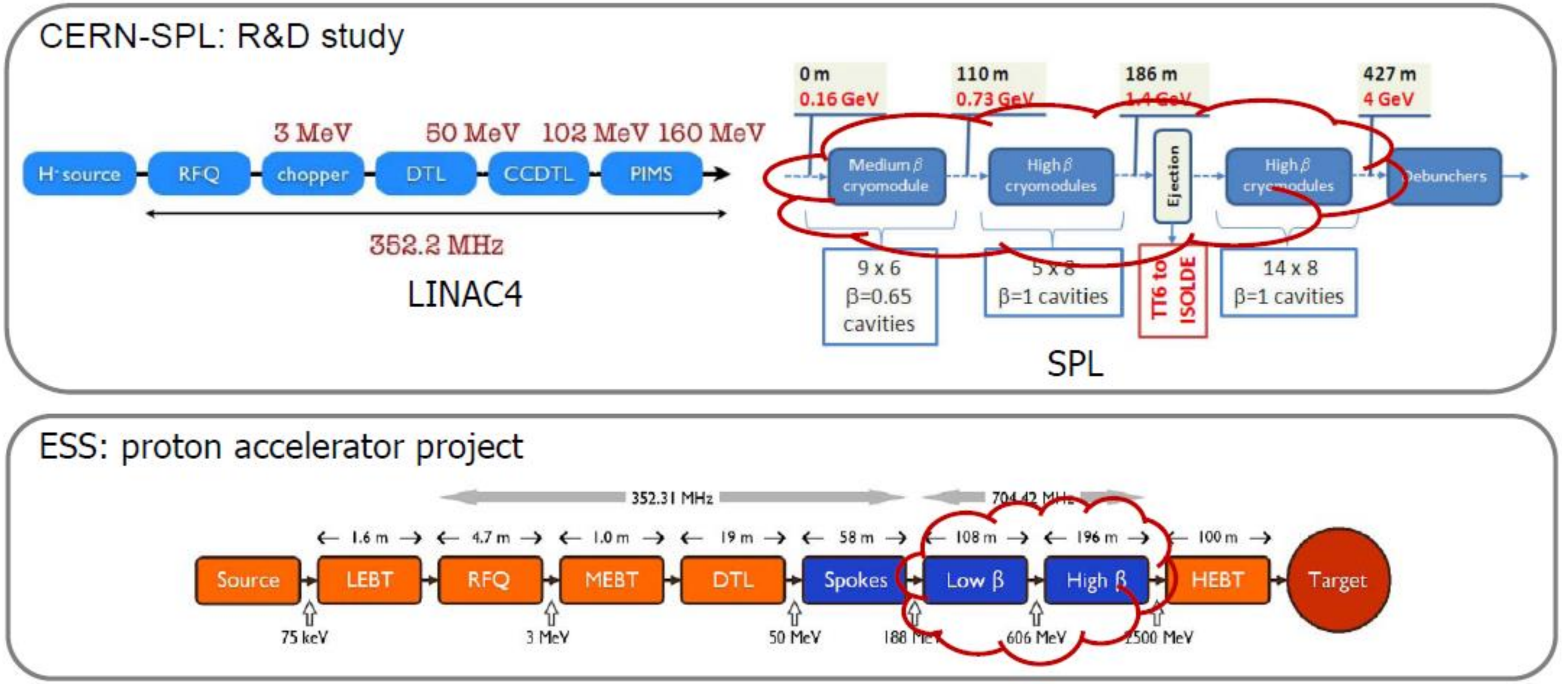
6 de-commissioned,
11 in operation,
4 in construction,
10 under design.

The TTC started this work for SRF Accelerators in America and Asia

WP10.2: SC Cavities for Proton Linac

Motivations

These developments are clearly essential for designing complete cryomodules for SPL and ESS whose machine parameters are very similar



704 MHz high gradient SC cavities to be built in large quantities

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WP10.2: SC Cavities for Proton Linac

Participants in the task: CEA/Saclay
CERN
IN2P3/IPN-Orsay

Target:
Eacc=19 and 25 MV/m for respectively β=0.65 and β=1 in vertical cryostat

Objective:
Demonstrate the feasibility of 704.4 MHz sc cavities at the specified performances (gradient)

- IPN/Orsay: Design and fabrication of β=**0.65** 704 MHz 5-cells elliptical cavity equipped with a Titanium helium reservoir.
Preparation and assembly in clean room and test in vertical cryostat.

- CEA-Saclay: Design and fabrication of β=**1** 704 MHz 5-cells elliptical cavity. Preparation of the cavity and assembly in clean room and test in vertical cryostat. Development of a vertical EP station and new HPR station. Upgrade of field-flatness set-up suited to the cavity size and weight

Milestones #2: Fabrication of cavities (P - M30)
Deliverable #1: Results of SC proton cavity tests (R - M33)

- CERN : Study of interfaces between the cavity and the cryomodule.

Milestones #1: Definition of cryomodule interface (R - M12)

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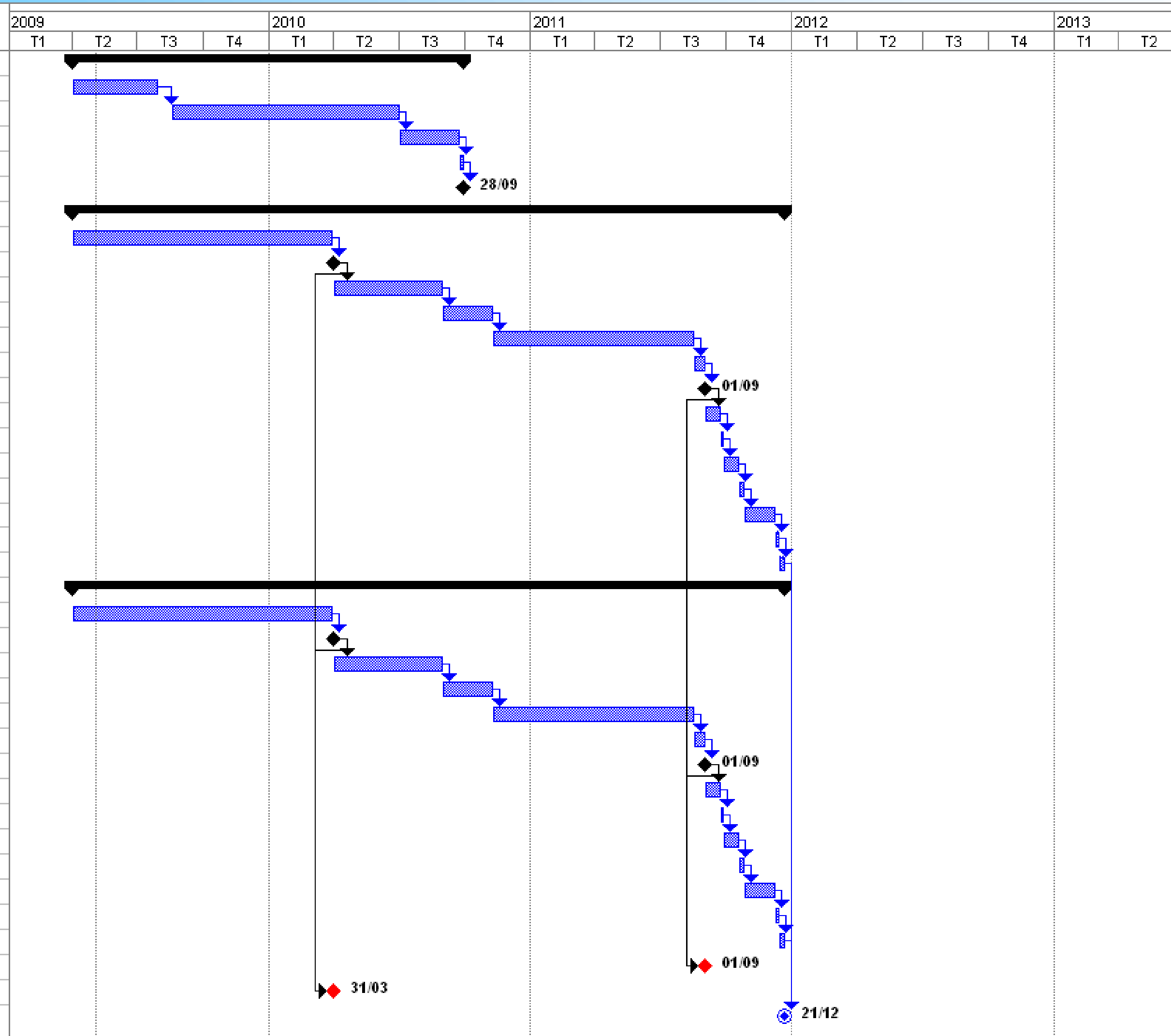
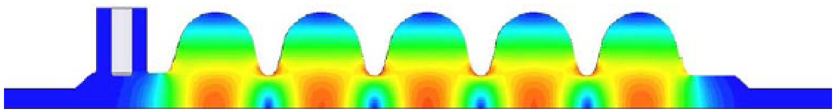
WP10.2: SC Cavities for Proton Linac

N°	Nom
1	**Vertical EP station**
2	Design, Study
3	Order, Fabrication
4	Firsts tests with water at Saclay
5	Qualification and Agreement from Safety group
6	Vertical EP operational
7	**Cavity Beta=0.65**
8	Design (RF & mechanical)
9	Cryostat Interfaces
10	Drawings & Specs
11	Call for offers & Order
12	Fabrication
13	Field flatness & Frequency tuning
14	Cavity fabrication completed
15	Dummy assembly before inner chemichal treatment
16	Chemical treatment or Vertical EP
17	UHV Annealing (650°C - 800°C)
18	Preparation of antennas for vert. Test
19	Last Chemical treatment (EP or BCP) + HPR + CR assembly
20	Assembly in vertical cryostat
21	Tests in Vertical Cryostat
22	**Cavity Beta=1.0**
23	Design (RF & mechanical)
24	Cryostat Interfaces
25	Drawings & Specs
26	Call for offers & Order
27	Fabrication
28	Field flatness & Frequency tuning
29	Cavity fabrication completed
30	Dummy assembly before inner chemichal treatment
31	Chemical treatment or Vertical EP
32	UHV Annealing (650°C - 800°C)
33	Preparation of antennas for vert. Test
34	Last Chemical treatment (EP or BCP) + HPR + CR assembly
35	Assembly in vertical cryostat
36	Tests in Vertical Cryostat
37	**Milestone 10.2.1: Cavity fabrication (proton linac)**
38	**Milestone 10.2.2: Definition of cryomodule interface**
39	**DELIVERABLE 10.2.1: Results of SC proton cavity tests (β=1 and β=0.65)**



WP10.2: SC Cavities for Proton Linac

RF design of β=1 cavity - reminder



704.4 MHz fundamental mode (π-mode)

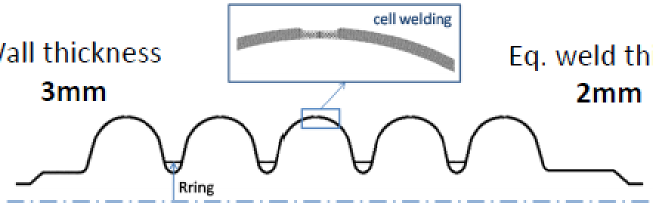
RF PARAMETERS OF THE CAVITY	
Number of gaps (Ngap)	5
Frequency [MHz]	704.4
Beta	1
Bpk/Eacc [mT/(MV/m)]	4.20
Epk/Eacc	1.99
G [Ohm]	270
Cell to cell coupling	1.92 %
r/Q [Ohms]	566
Beam diameter aperture [mm]	129.2
L_{acc} = Ngap.b.l/2 [m]	1.0647
Maximum energy gain @ Bpk = 100 mT	25 MeV
Operating Temperature (O.T.)	2 K
R_{BCS} @ O.T. (theoretical)	3.2 nW
Q_0 @ O.T. for R_{BCS}	$8.4*10^{10}$

Lorentz Force Detuning (critical in pulsed mode)

$|K_L| = \Delta F/E_{acc}^2 = 1\ Hz/(MV/m)^2$

Wall thickness **3mm**

Eq. weld thickn. **2mm**

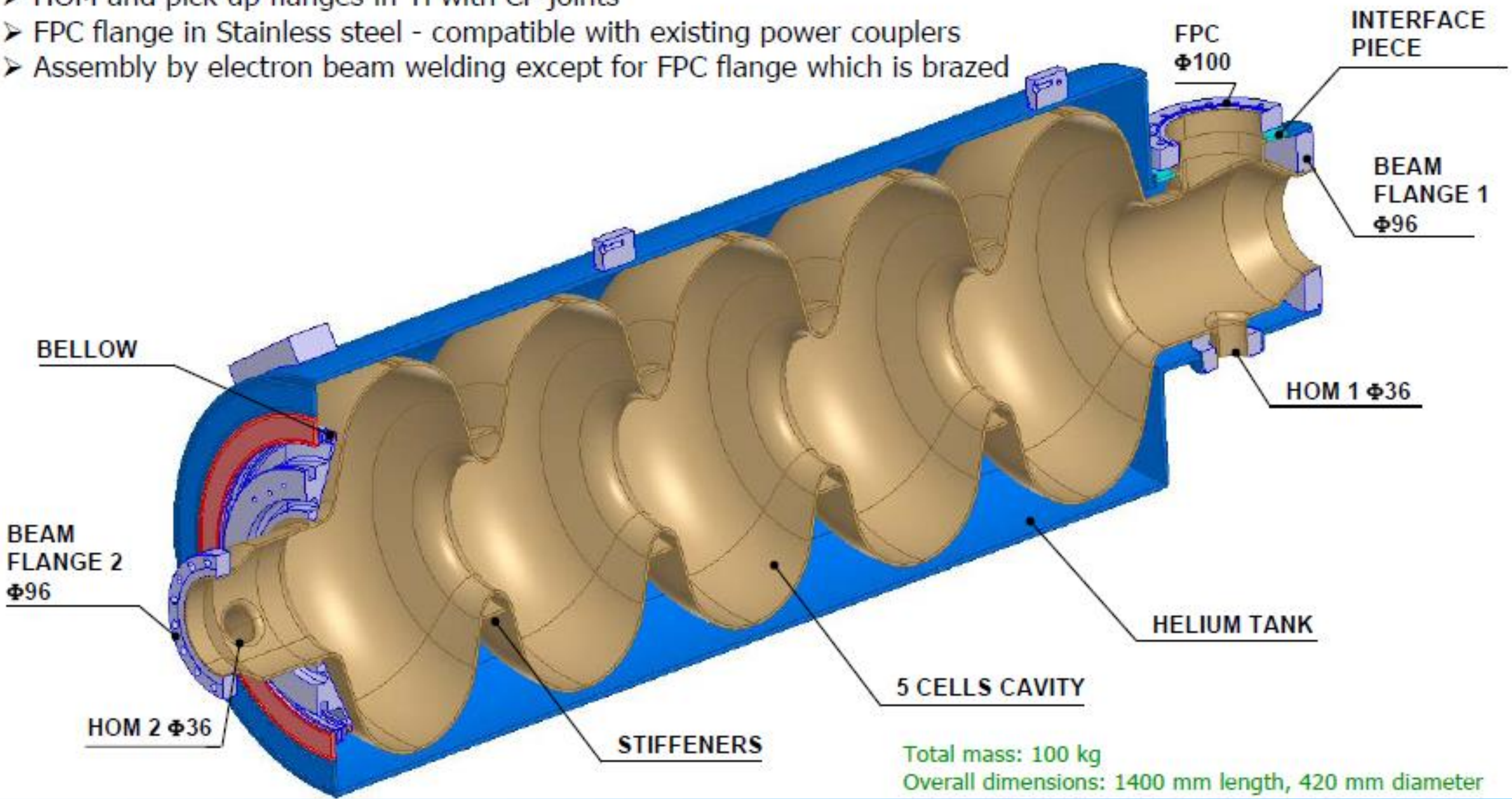


Stiffeners: Rring= 91 mm, thickn. = 3 mm

WP10.2: SC Cavities for Proton Linac

Engineering design of β=1 cavity and helium tank

- Half cells, beam pipes and ports in pure Niobium RRR > 300
- He tank in Titanium
- Beam flanges in NbTi with Helicoflex joints or hexagonal aluminium joints
- HOM and pick-up flanges in Ti with CF joints
- FPC flange in Stainless steel - compatible with existing power couplers
- Assembly by electron beam welding except for FPC flange which is brazed



Total mass: 100 kg
Overall dimensions: 1400 mm length, 420 mm diameter

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WP10.2: SC Cavities for Proton Linac

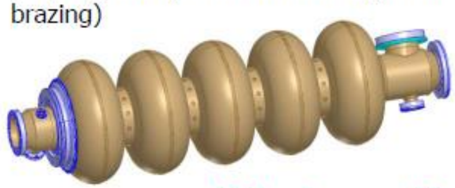
Fabrication and test procedure

Irfu — EuCARD

Step 1:
- fabrication, dimensionnal control and RF measurement of half Nb cells

at factory (phase 1)

Step 2:
- EB welding of cells, beam tubes and coupler ports (+ some machining and brazing)



Milestones #2

at factory (phase 1)

Step 3:
- Controls, chemical and heat treatment
- Field flatness and freq. tuning
- EP and HPR
- Cold tests in vertical cryostat

Deliverable #1

at CEA

Step 4:
- Helium tank fabrication and welding with cavity

at factory (phase 2)

Step 5:
- Assembly of coupler and tuning system and preparation
- Cold tests in horizontal cryostat

at CEA

WP10.2: SC Cavities for Proton Linac

FABRICATION SCHEDULES

Cavity β = 0.65 (IPN) :

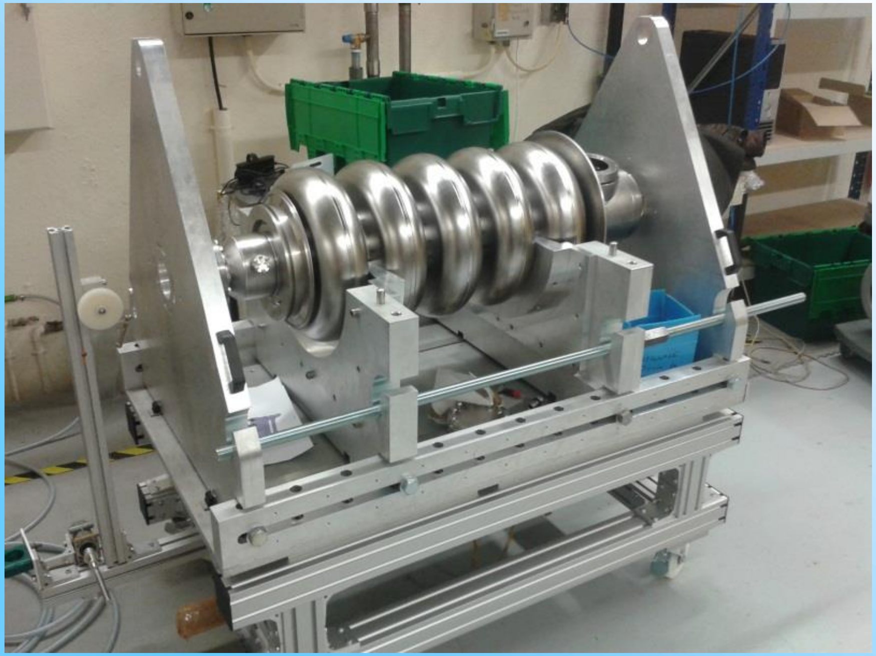
Week 13 : reception of the cavity without He tank
Week 14-15: resonant frequency measurements, vacuum tests, chemical etching and field flatness tuning at IPN
Week 16: cavity shipped back to RI for He tank welding
Week 23-26: reception of the cavity with He tank
September 2013: Test in vertical cryostat

Cavity β = 1 (CEA) :

Week 12 : resonant frequency measurements of dumbbells at ZANON before final welding
Week 22: reception of the cavity without He tank
Week 23 to 29: controls, resonant frequency measurements, vacuum tests, electropolishing, and field flatness tuning at CEA
Week 30-31: Clean room assembly, HPR
End of August 2013: Test in vertical cryostat
September 2013: cavity shipped back to ZANON for He tank welding

WP10.2: SC Cavities for Proton Linac

β=0.65 cavity ready for field flatness tuning at IPN Orsay



β=1 cavity after final welding at equators @ EZ in May 2013

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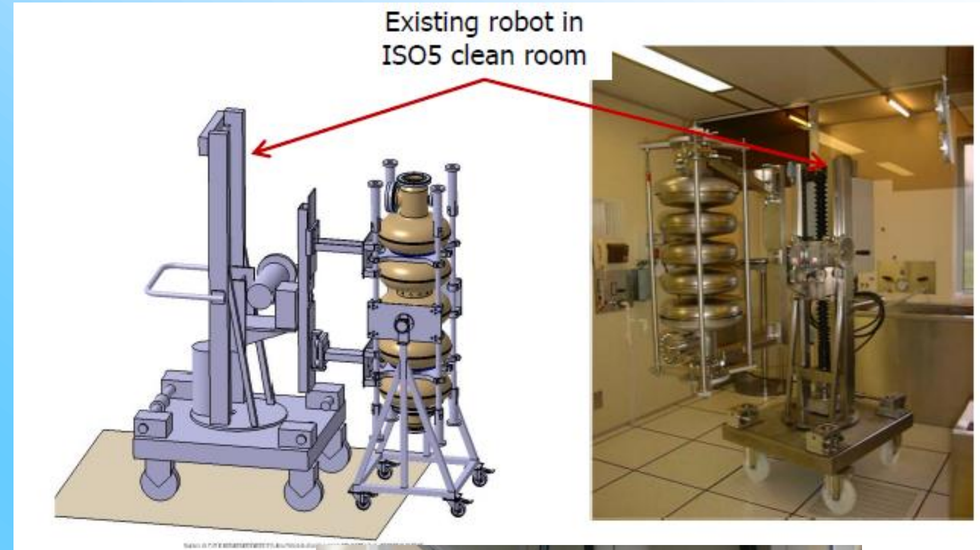
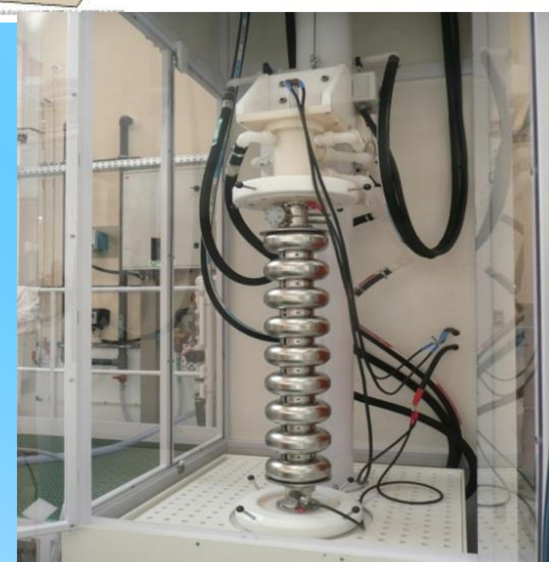
WP10.2: SC Cavities for Proton Linac

Clean room preparation
(with CARE β = 0.5 cavity)



Vertical EP cabinet
with ILC cavity from FNAL
(courtesy C. Ginsburg))



Irfu

HORIZONTAL VS VERTICAL ELECTROPOLISHING

Pros:

- Good evacuation of gases (cavity half filled)
- Demonstrated efficiency
- Large range of parameters

Cons:

- Complicated process
- Rotary seals
- Switching of the cavity
- Low removal rate

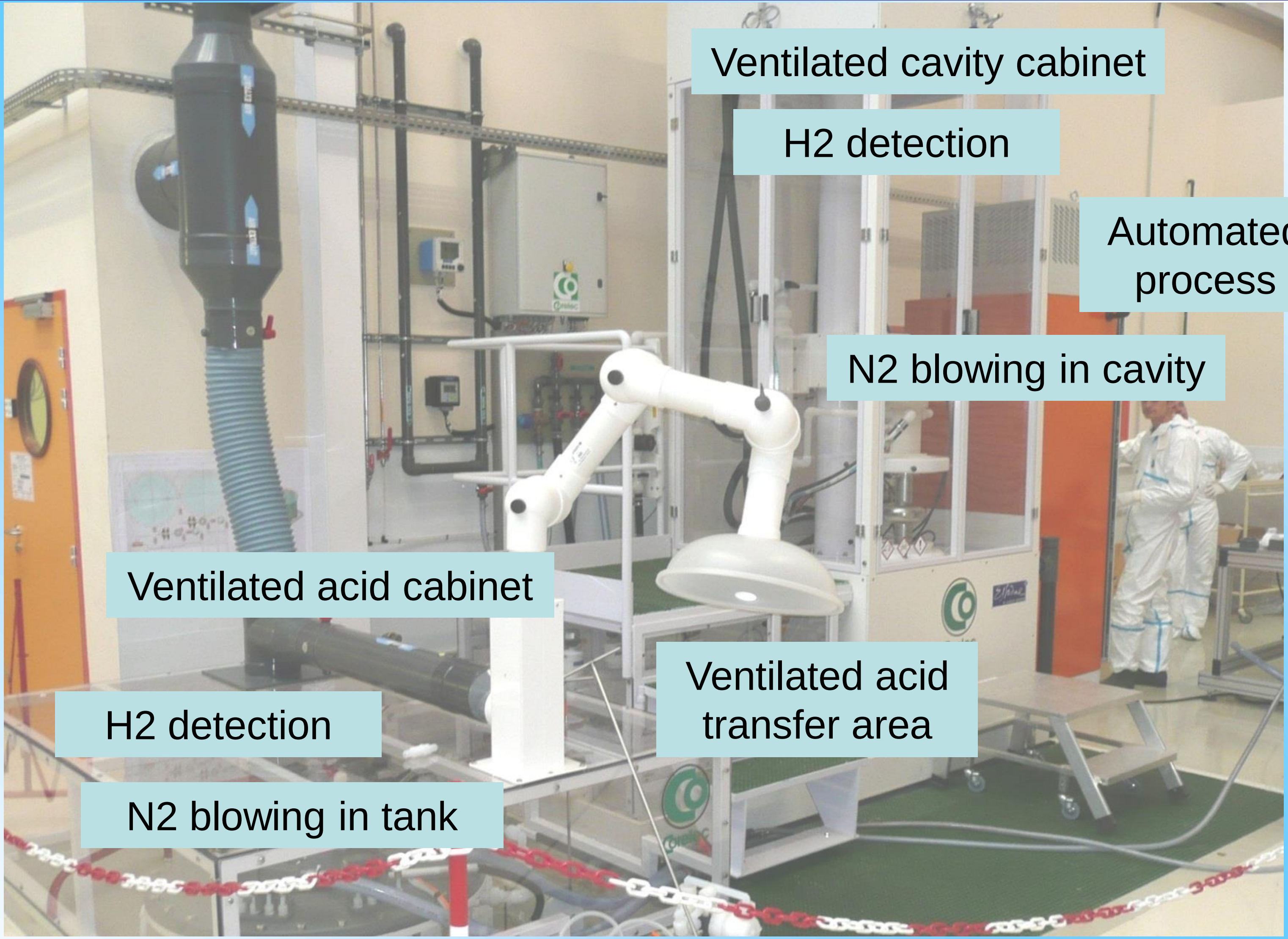
Pros:

- Simple process
- Low floor surface
- Improved safety
- Higher removal rate

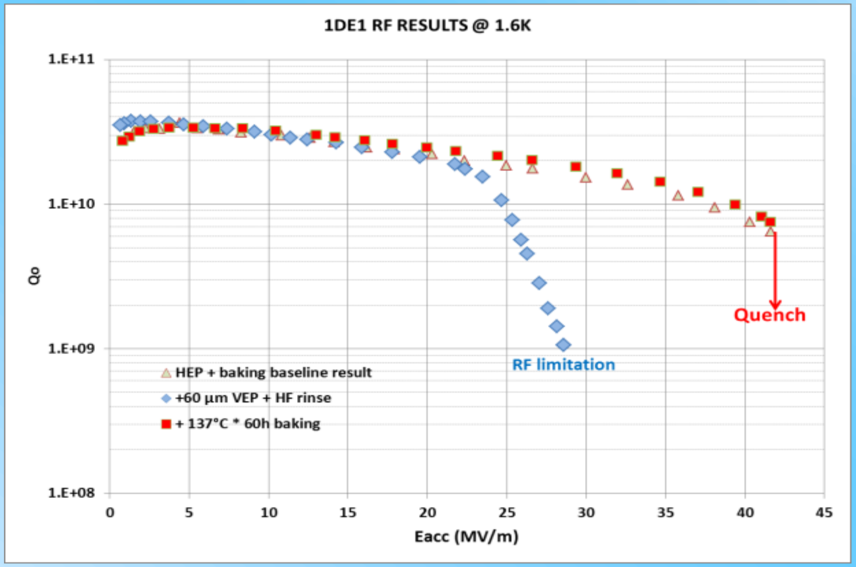
Cons:

- Sensitive to fluid dynamics
- Proper parameters to be determined

WP10.2: SC Cavities for Proton Linac

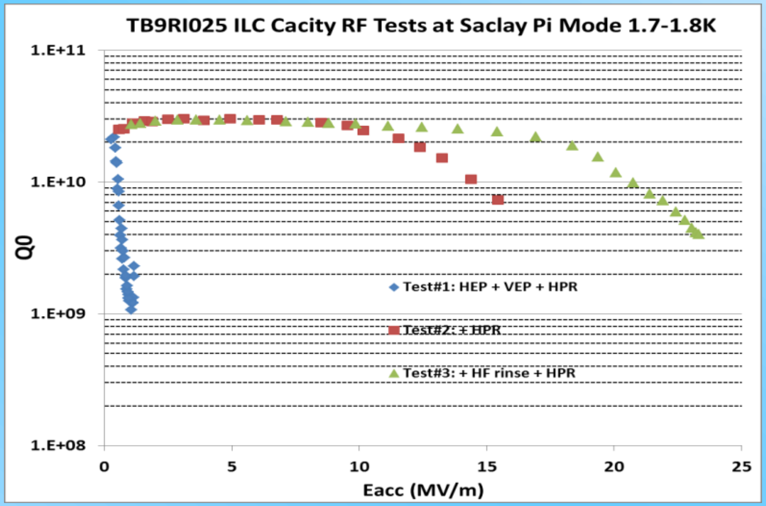


WP10.2: SC Cavities for Proton Linac



Top: RF vertical test on a single cell cavity
→ Eacc = 42 MV/m limited by quench

Bottom: RF vertical test on a 9-cell cavity
→ Eacc = 23 MV/m limited by field emission
→ new EP and RF test will be done.



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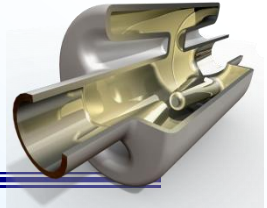
WP10.3: LHC and CLIC Crab Cavities



Goals:

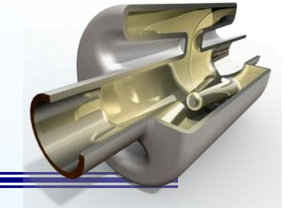
- Design, build and test a single LHC and CLIC crab cavity structure, including input coupler, mode couplers and tuners.
- Design, build and test a LLRF and synchronization system that meets the crab cavity phase and amplitude control specifications for LHC and CLIC.

➢ Deliverables:

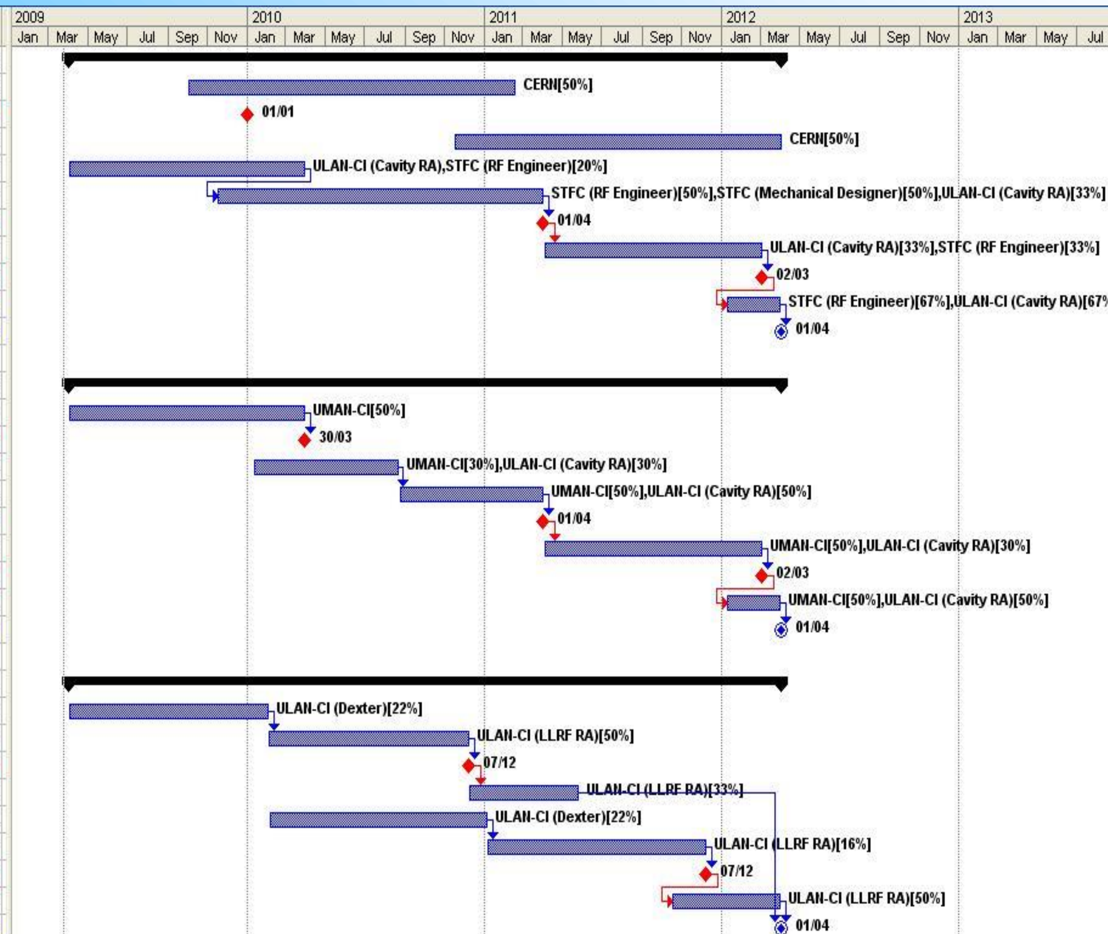
Ref.	N°	Deliverable Name	Deliverable Type	Task	Delivered by Contractor (s)	Planned (in months)	Achieved (in months)
10.3.1	7	LHC crab cavity final report	Report	Crab cavities	CERN	36	47
10.3.2	8	CLIC crab cavity final report	Report	Crab cavities	UNIMAN	36	47
10.3.3	9	LHC and CLIC LLRF final reports	Report	Crab cavities	ULANC	36	48

All deliverables are completed.

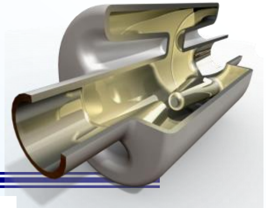
WP10.3: LHC and CLIC Crab Cavities



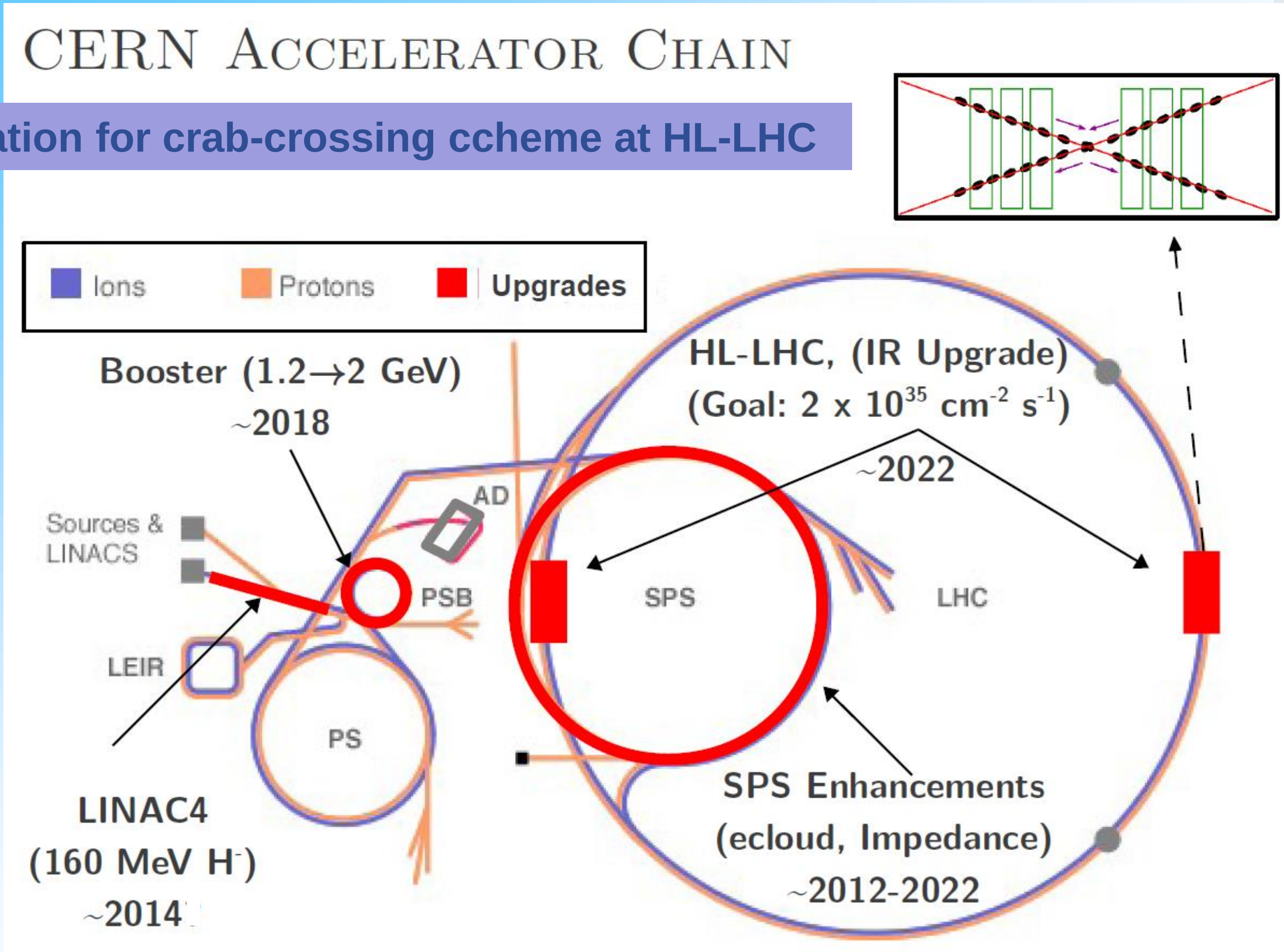
Task Name	Duration	Start	Finish
WP 10.3.1 LHC-CC Development	**783 days**	**Wed 01/04/09**	**Sun 01/04/12**
LHC-CC Coordination: Links, steering, info exchange	18 mons	Thu 01/10/09	Wed 16/02/11
M1: LHC-CC Specifications Completed	**0 days**	**Fri 01/01/10**	**Fri 01/01/10**
LHC-CC Integration: Location, cryostat, test stand etc	18 mons	Mon 15/11/10	Sun 01/04/12
Establish LHC-CC Design	13 mons	Wed 01/04/09	Tue 30/03/10
Manufactute/testing of LHC-CC Prototype	18 mons	Mon 16/11/09	Fri 01/04/11
M2: LHC-CC Prototype Model Tested	**0 days**	**Fri 01/04/11**	**Fri 01/04/11**
LHC-CC Coupler Designs	12 mons	Mon 04/04/11	Fri 02/03/12
M3: LHC-CC Coupler Development Completed	**0 days**	**Fri 02/03/12**	**Fri 02/03/12**
Complete LHC-CC Design Report	3 mons	Mon 09/01/12	Fri 30/03/12
Deliverable 1: LHC-CC Design, Prototyping and Validation	**0 days**	**Sun 01/04/12**	**Sun 01/04/12**
WP 10.3.2 CLIC-CC Development	**783 days**	**Wed 01/04/09**	**Sun 01/04/12**
Study CC effects on CLIC beam dynamics	13 mons	Wed 01/04/09	Tue 30/03/10
M4: CLIC-CC Specifications Completed	**0 days**	**Tue 30/03/10**	**Tue 30/03/10**
Establish CLIC-CC Design	8 mons	Mon 11/01/10	Fri 20/08/10
CLIC-CC Coupler Designs	8 mons	Mon 23/08/10	Fri 01/04/11
M5: CLIC-CC Coupler Development Completed	**0 days**	**Fri 01/04/11**	**Fri 01/04/11**
Manufacture/testing of CLIC-CC NC Prototype	12 mons	Mon 04/04/11	Fri 02/03/12
M6: CLIC-CC Prototype Tested	**0 days**	**Fri 02/03/12**	**Fri 02/03/12**
Complete CLIC-CC Design Report	3 mons	Mon 09/01/12	Fri 30/03/12
Deliverable 2: CLIC-CC Design, Prototyping and Validation	**0 days**	**Sun 01/04/12**	**Sun 01/04/12**
WP 10.3.3 LHC-CC and CLIC-CC LLRF Development	**783 days**	**Wed 01/04/09**	**Sun 01/04/12**
Establish LHC-CC phase control model and validate	11 mons	Wed 01/04/09	Tue 02/02/10
Develop LHC-CC LLRF system design and validate	11 mons	Wed 03/02/10	Tue 07/12/10
M7: Development of LHC-CC LLRF Completed	**0 days**	**Tue 07/12/10**	**Tue 07/12/10**
Complete LHC-CC LLRF Design Report	6 mons	Wed 08/12/10	Tue 24/05/11
Establish CLIC-CC phase control model and validate	12 mons	Thu 04/02/10	Wed 05/01/11
Develop CLIC-CC LLRF system design and validate	12 mons	Thu 06/01/11	Wed 07/12/11
M8: Development of CLIC-CC LLRF Completed	**0 days**	**Wed 07/12/11**	**Wed 07/12/11**
Complete CLIC-CC LLRF Design Report	6 mons	Mon 17/10/11	Fri 30/03/12
Deliverable 3: LHC-CC & CLIC-CC LLRF Design and Validation	**0 days**	**Sun 01/04/12**	**Sun 01/04/12**



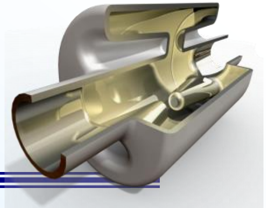
WP10.3: LHC and CLIC Crab Cavities

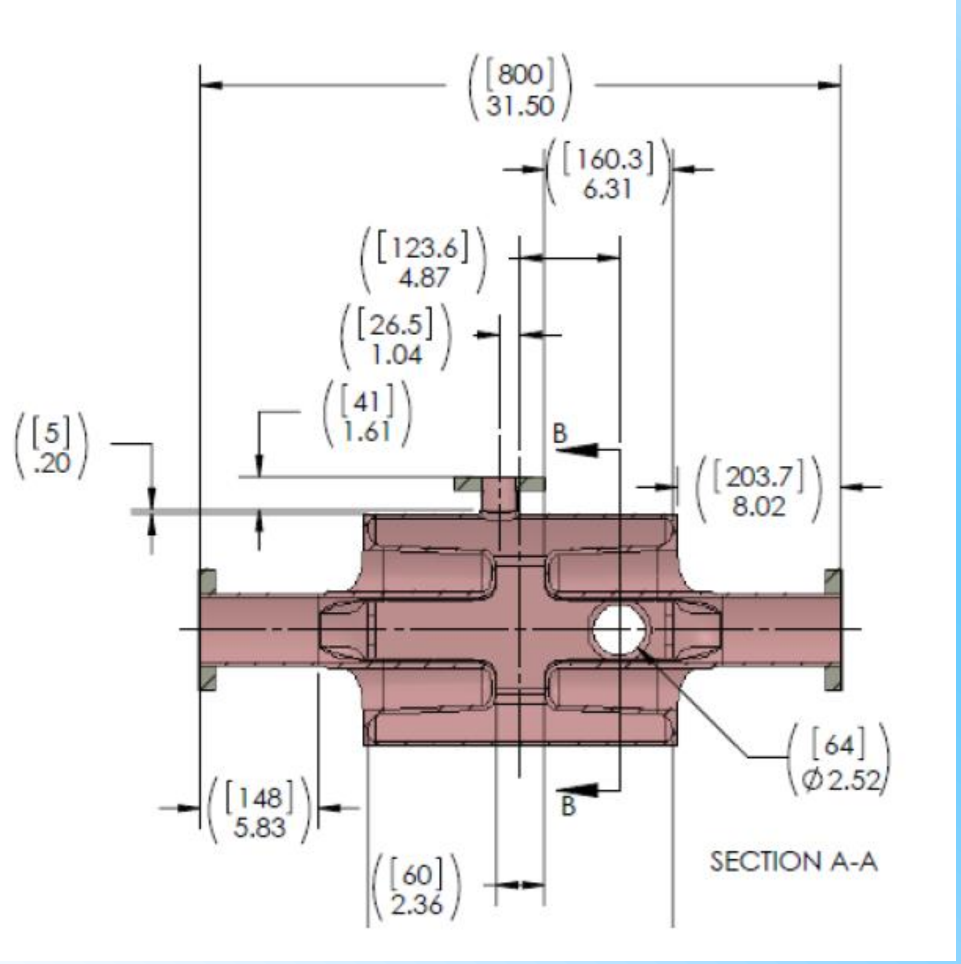


Motivation for crab-crossing ccheme at HL-LHC



WP10.3: LHC and CLIC Crab Cavities

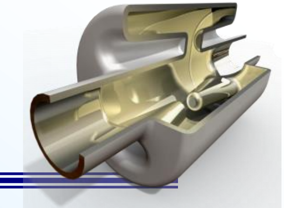




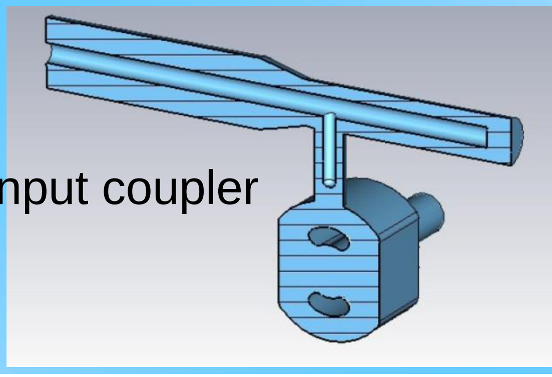
The LHC cavity is a four rod structure which makes it ultra-compact and appropriately applicable for local crab crossing on LHC, which has been optimised for low surface fields and a very high shunt impedance. The rod shape has been specially configured to minimise the sextupole component of the deflecting voltage to provide a uniform deflecting field as a function of transverse beam offset.

Parameter	Value
Emax @ 3 MV	37.2 MV/m
Bmax @ 3 MV	60.5 mT
R_T/Q	912.67 Ohms
Geometry factor	62.8 Ohms

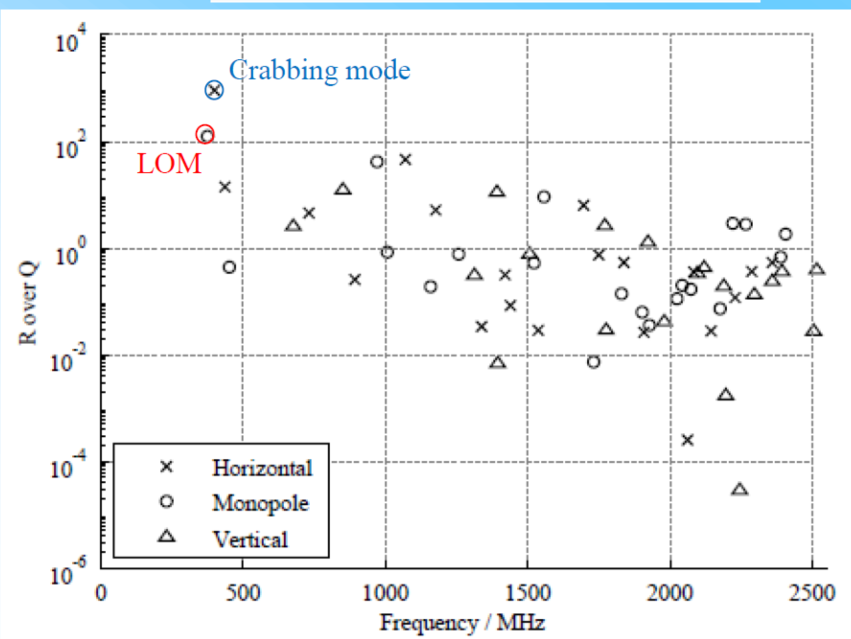
Four-Rod Crab Cavity (4RCC) geometric and RF parameters



WP10.3: LHC and CLIC Crab Cavities



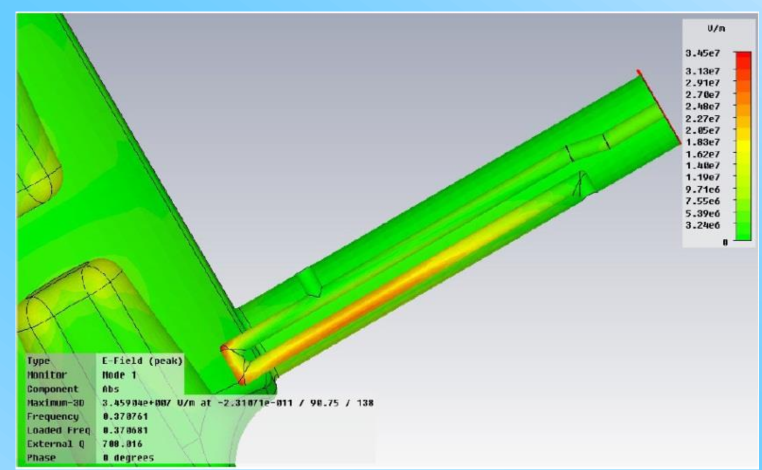
Input coupler



R/Q spectrum of LHC-4RCC

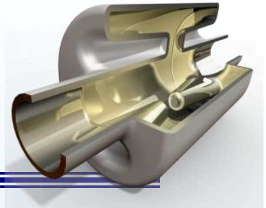
The input power coupler is a coaxial type coupler with a T-section which interfaces to a cavity coupler design which is identical to that of the existing LHC accelerating mode 400 MHz SRF cavities.

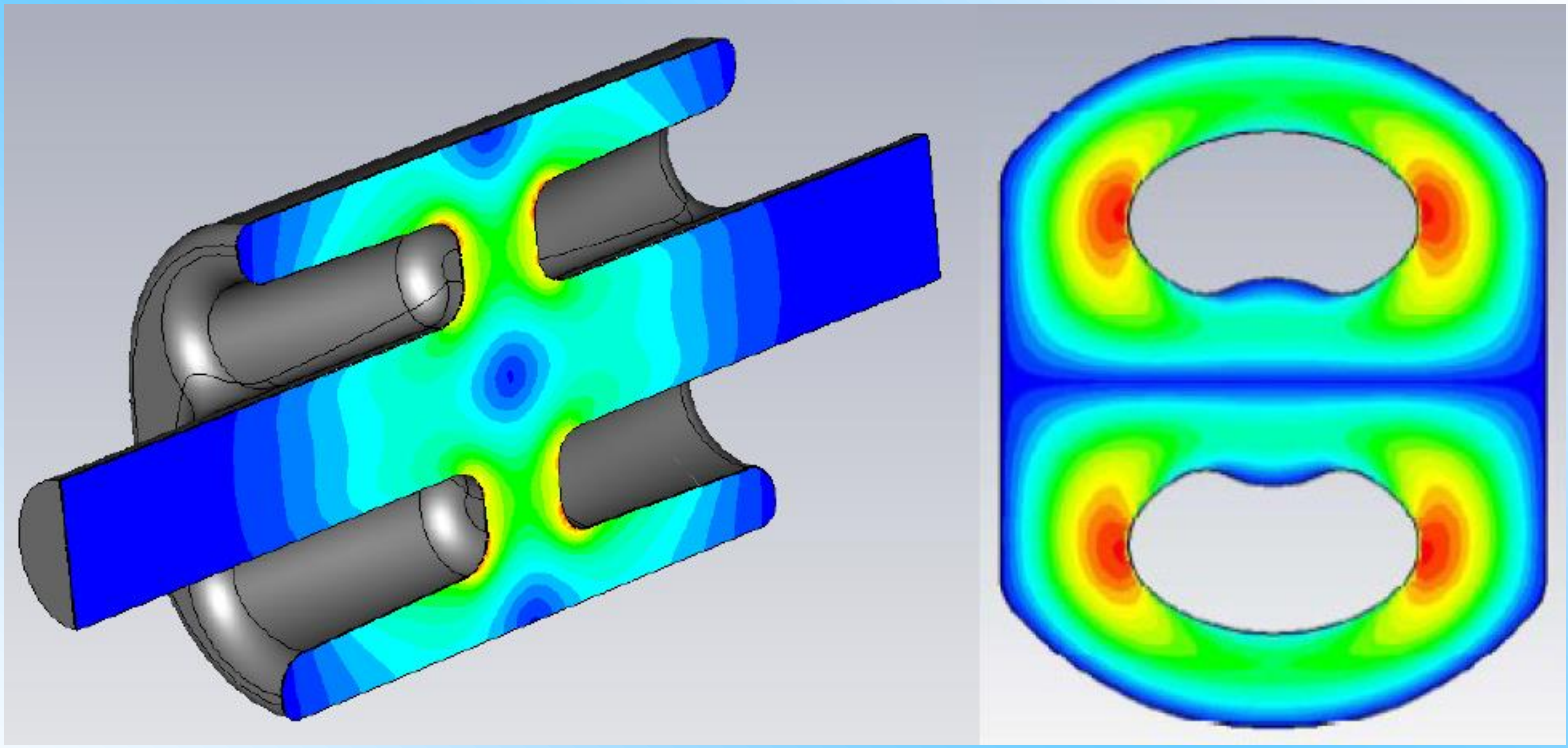
A special loop type coupler has been developed for damping the LOM and HOM impedances, with optimisation still being performed for the HOM coupler solutions.



LOM coupler

WP10.3: LHC and CLIC Crab Cavities



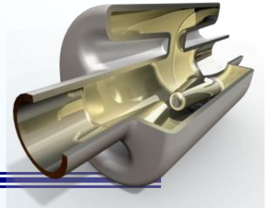


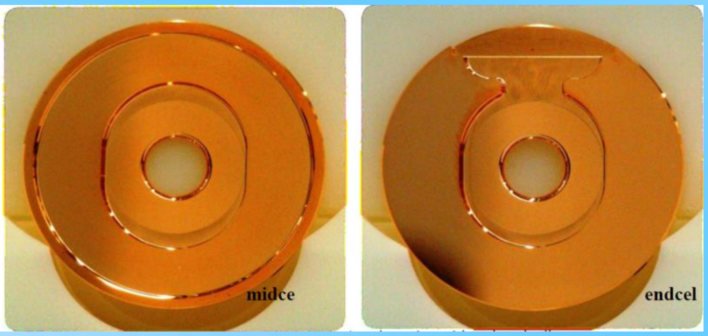
Geometry of the LHC 4RCC and magnitude of the electric field

WP10.3: LHC and CLIC Crab Cavities

Assembled prototype Niobium cavity, fabricated at Niowave Inc.

WP10.3: LHC and CLIC Crab Cavities

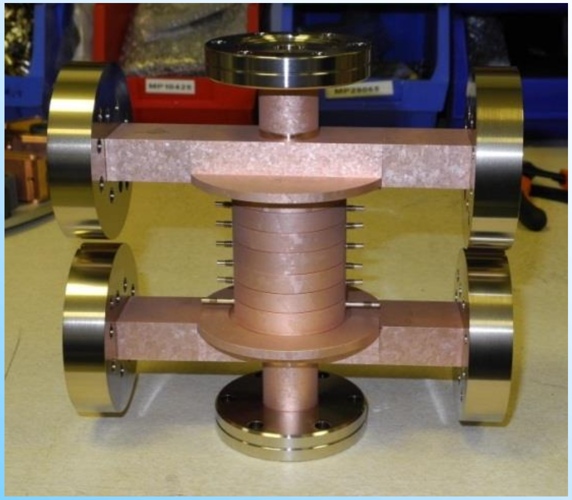




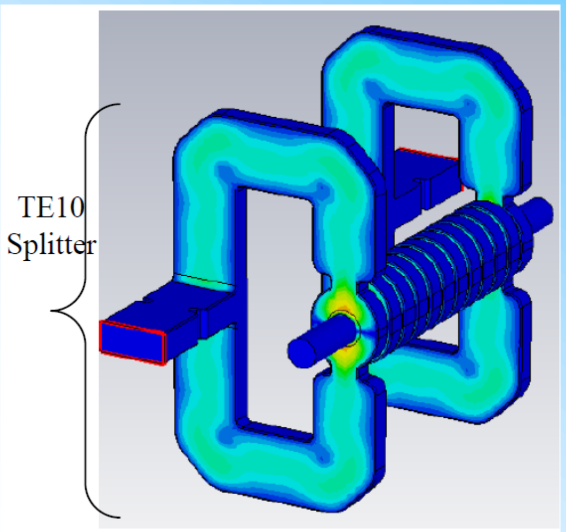
CERN end and mid cells

A prototype cavity has been manufactured in UK, which achieved machining tolerances of 1-2 µm. This is the first demonstrated X-band structure in the UK.

A 2nd structure is manu-factured by CERN for breakdown testing using the same manufacturing process as for the main linac.

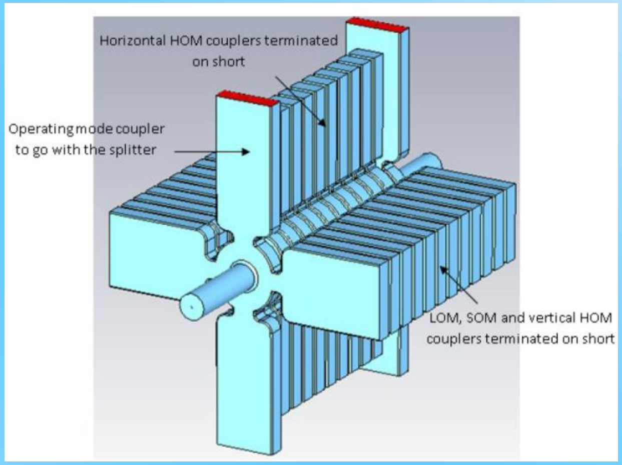


UK built CLIC crab cavity

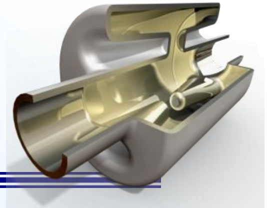


Dual feed coupler design

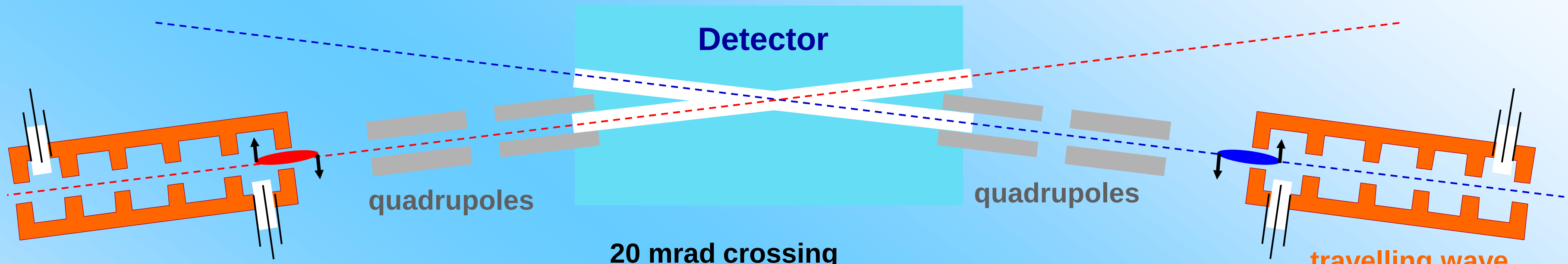
Horizontal and vertical waveguide damped cell with integrated SiC dielectric loads



WP10.3: LHC and CLIC Crab Cavities



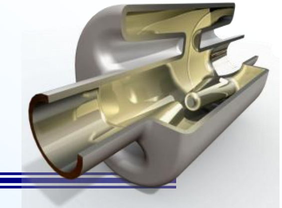
Crab cavity to cavity synchronisation requirement ~5 fs.
Crab cavity to beam synchronisation requirement ~ 100 fs.

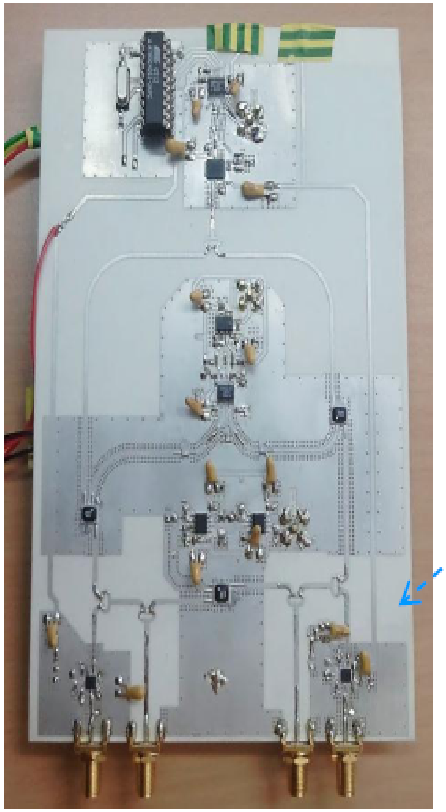


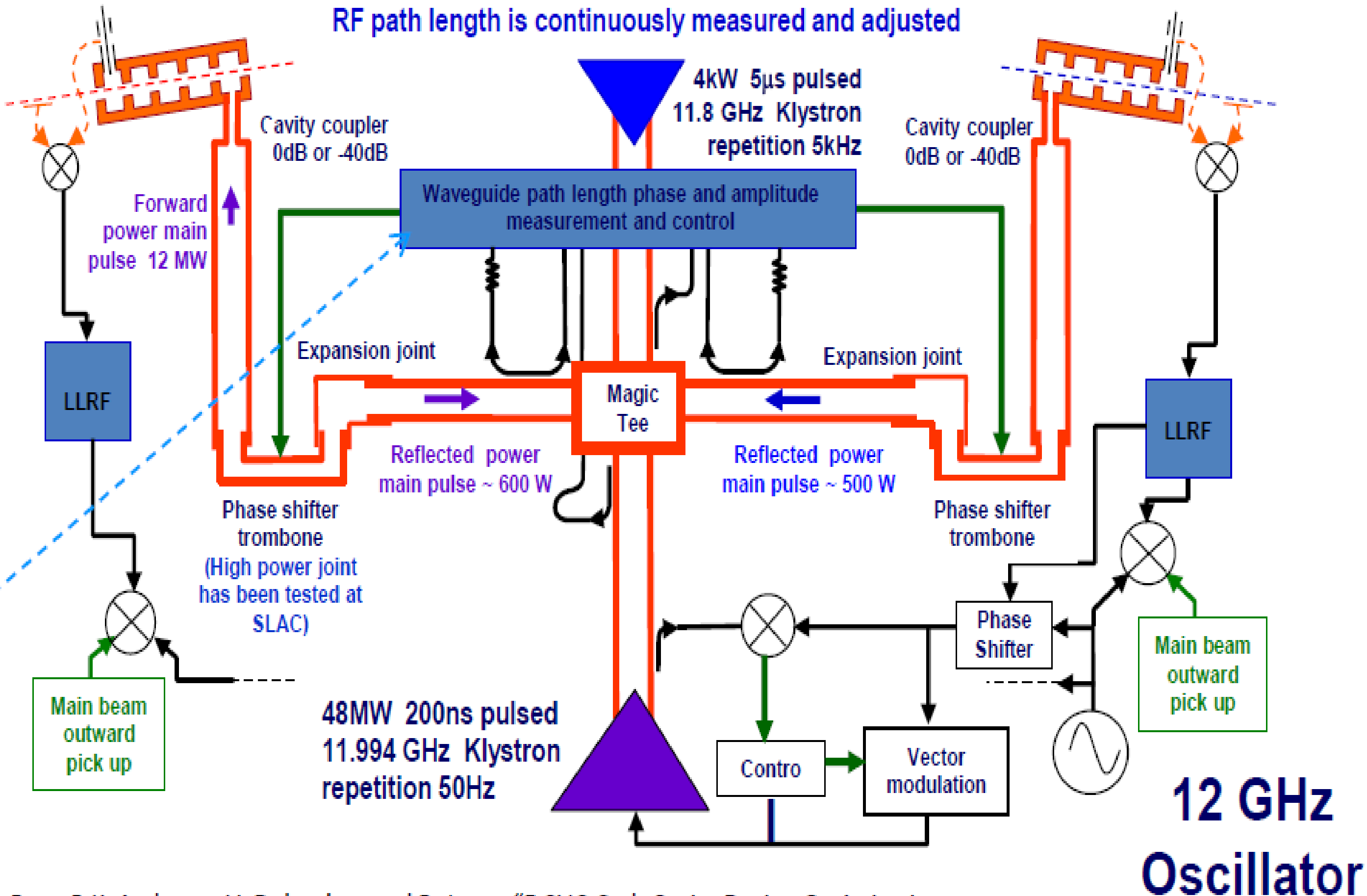
Target luminosity loss fraction	f (GHz)	σ_x (nm)	θ_c (rad)	ϕ_{rms} (deg)	Δt (fs)	Pulse Length (μs)
0.98	12.0	45	0.020	0.0188	4.4	0.156

RF path lengths need to be equal to better than $c\Delta t$ = 1.3 µm

WP10.3: LHC and CLIC Crab Cavities

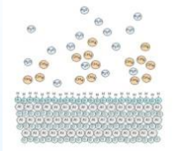


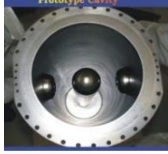




[1] **A.C. Dexter**, G. Burt, P.K. Ambattu, V. Dolgashev and R. Jones "F CLIC Crab Cavity Design Optimisation for Maximum Luminosity", Nuclear Instrumentation and Methods in Physics Research A, Volume 657, Issue 1, 21 November 2011 pp45-51

WP10.4: Thin Films





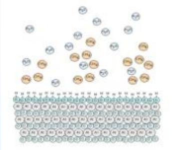
- **Goals:**

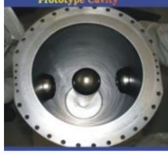
1. **Development of magnetron sputtering for the HIE-ISOLDE QW cavities**
2. **Build and test Pb coated phtocathodes on 1 ½ cell SRF gun**
3. **Facilitate communication about new thin film tehcniques**

- **Deliverables:**

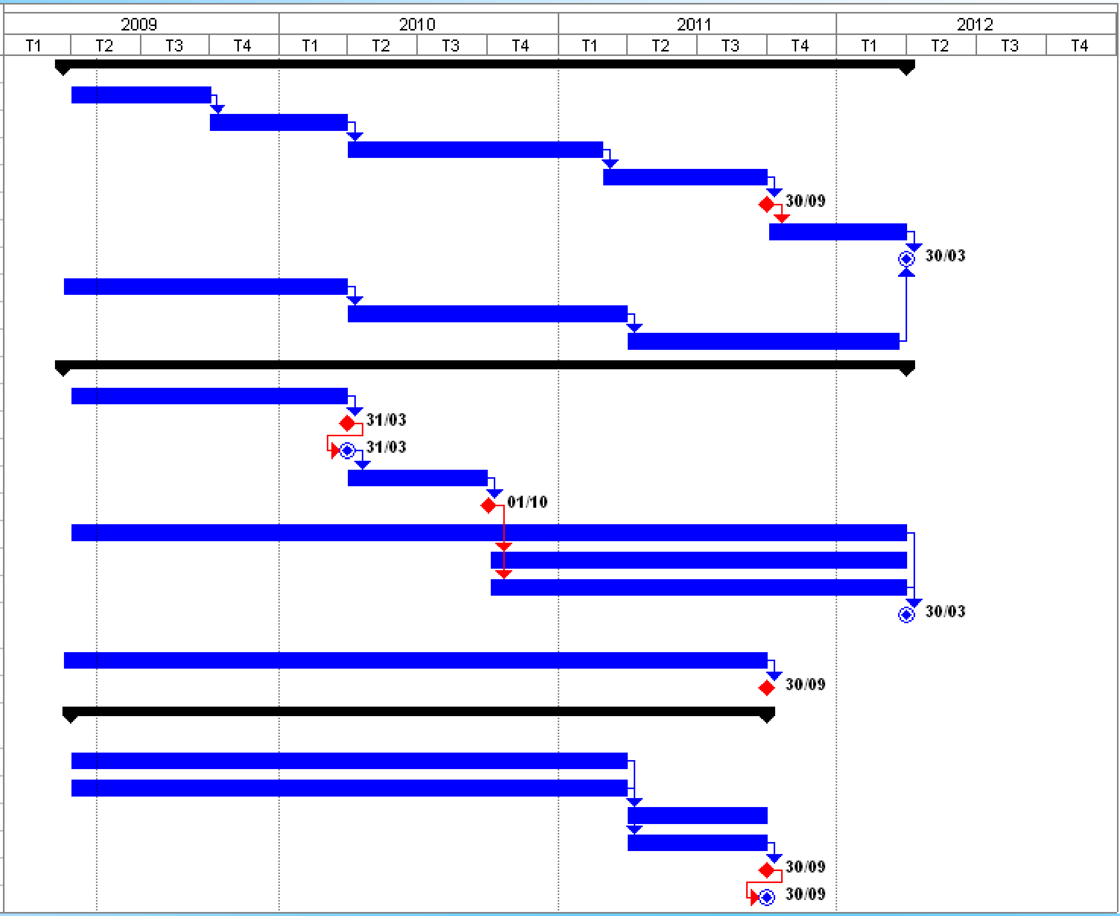
Ref.	N°	Deliverable Name	Deliverable Type	Task	Delivered by Contractor (s)	Planned (in months)	Achieved (in months)
10.4.1	1	QE data for Pb/Nb deposited photo cathode samples	Report	Thin Films	DESY, NCBJ	12	14
10.4.4	4	New thin film techniques for SC cavities and photocathodes	Report	Thin Films	ULANC	30	48
10.4.2	10	RF measurements on thin film deposited QWR prototype	Report	Thin Films	CERN	36	48
10.4.3	11	Cold test results for the test cavities w/out the deposited lead photo cathode	Report	Thin Films	DESY	36	43

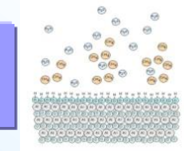
WP10.4: Thin Films



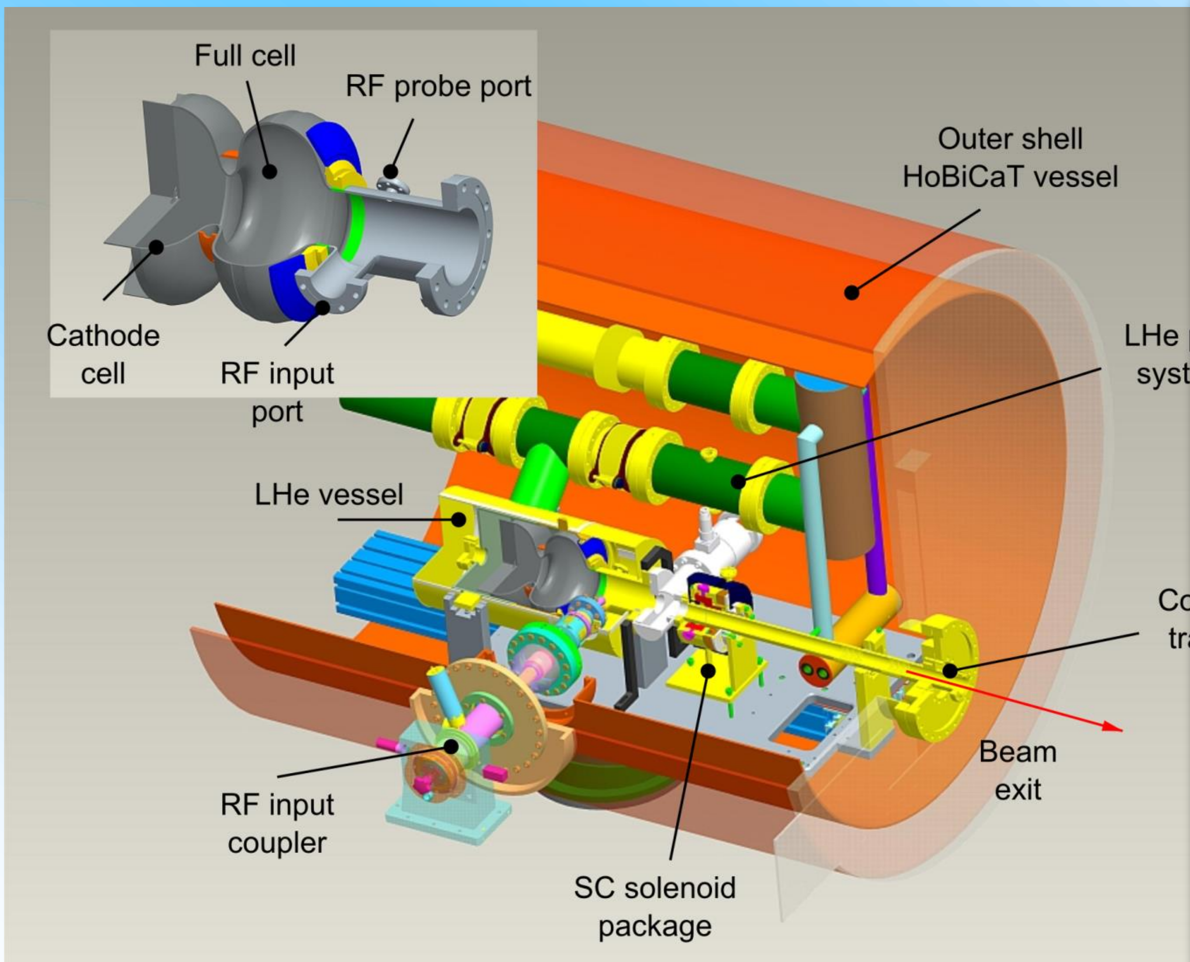


N°	Task Name
1	**Sub-Task 4.1: Improve the Nb sputtering technology for low beta cavities**
2	Study of magnetron assembly for prototype QWR of small size
3	Mechanical design of magnetron assembly, for small QWR
4	Construction of magnetron assembly
5	Study of sputtering parameters
6	**Milestone 10.4.3: QWR sputtering with Nb using the magnetron technique**
7	Optimisation of deposition inside small QWR
8	**DELIVERABLE 10.4.2: RF measurements on thin film deposited QWR prototype**
9	Purchase of HiPIMS (pulsed sputtering) power supply
10	Sputter parametr optimisation on samples
11	Test coatings on HIE-ISOLDE QWR cavity
12	**Sub-Task 4.2: Perform arc sputtering of photo-cathodes (Pb).**
13	Construction of planar pulsed arc biased deposition system
14	**Milestone 10.4.1: Lead deposition on samples for photocathode development**
15	**DELIVERABLE 10.4.1: QE data for Pb/Nb deposited photo cathode samples**
16	Adaptation of deposition system for half cell and 1.5 cell cavities
17	**Milestone 10.4.3: Lead deposition of half cells and 1.5 cell cavities**
18	Cold test of SRF cavities before Pb deposition
19	Optimisation of Pb deposition in SRF cavities
20	Cold Test of SRF cavities after Pb deposition
21	**DELIVERABLE 10.4.3: Cold test results for the cavities with and without the deposited Pb cathode**
22	Optimisation of RF design of the 1.5 cell injector cavity
23	**Milestone 10.4.5: Improved RF design of 1.5 cell**
24	**Sub-Task 4.3: Research on new technologies for thin film depositing of superconductors for SC cavity applications**
25	Development of ALD samples by CEA
26	Study of proximity effect on HTS by Cu coatings
27	RF characterisation using INPNO RF thermometric measurements
28	RF characterisation using CERN quadrupole resonator
29	**Milestone 10.4.5: Report on new thin film coating techniques for SC cavities**
30	**DELIVERABLE 10.4.4: New thin film techniques for SC cavities and photocathodes**

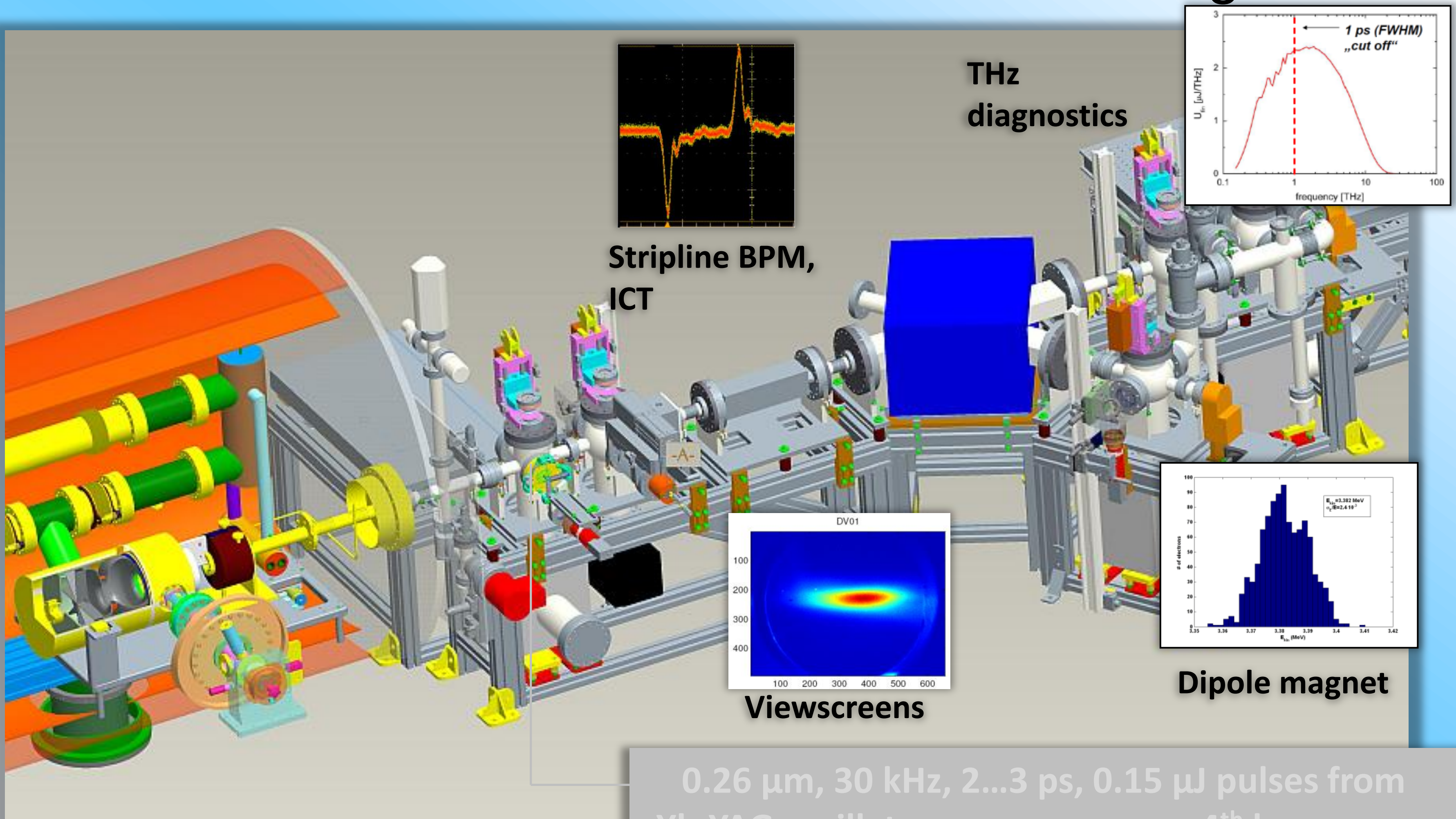




Completed cold mass inside cryomodule of HoBiCaT HZB).



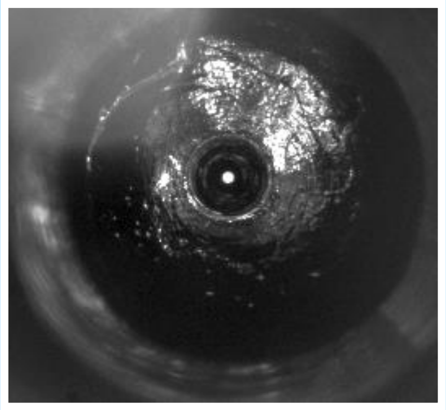
Beam test: drive laser and electron beam diagnostics

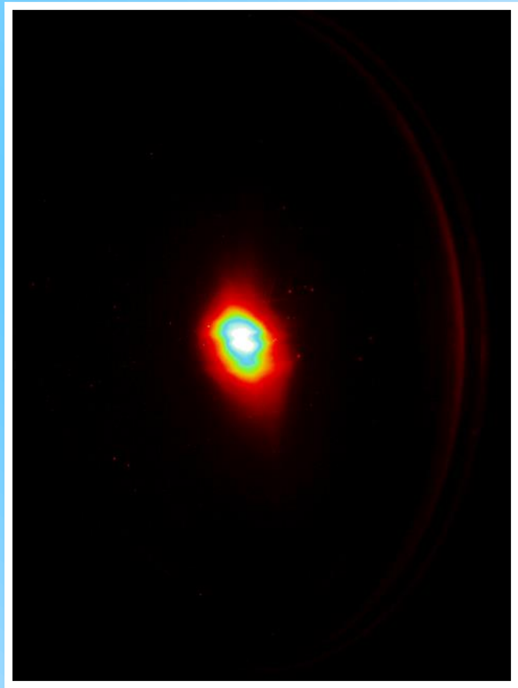


0.26 µm, 30 kHz, 2...3 ps, 0.15 µJ pulses from Yb:YAG oscillator + regen. amp. + 4^{th} harm conv.

T10.4 + T10.7 : Pb/Nb SC-RF Gun Operation

First beam of photoelectrons from Pb cathode generated and accelerated at 21st April 2011, < 2 years after project approval





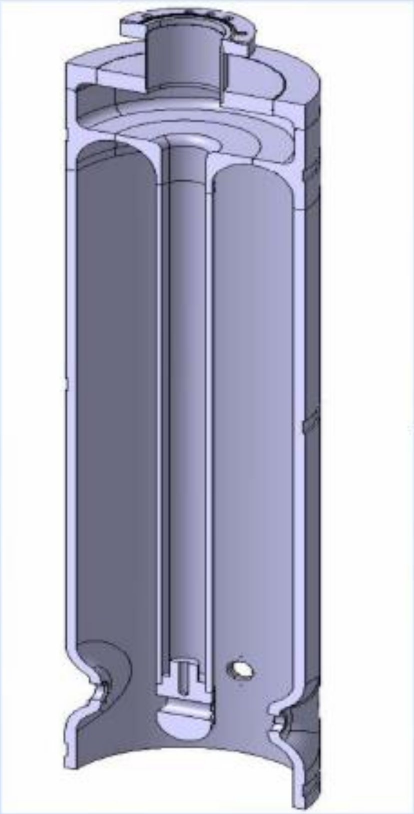
Lead coated photocathodes in 1 ½ SRF gun achieving QE of 3.3×10^{-3} (NCBJ, DESY, Jlab)

WP10.4: QWR for HIE Isolde

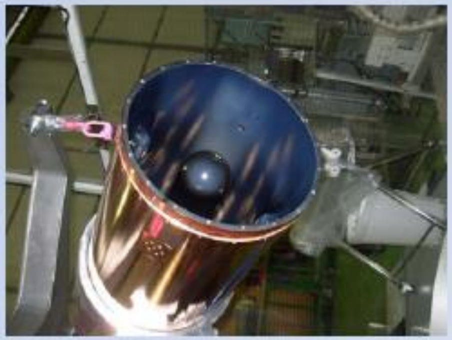
Quarter Wave Resonators (QWRs)

Nb\Cu technology

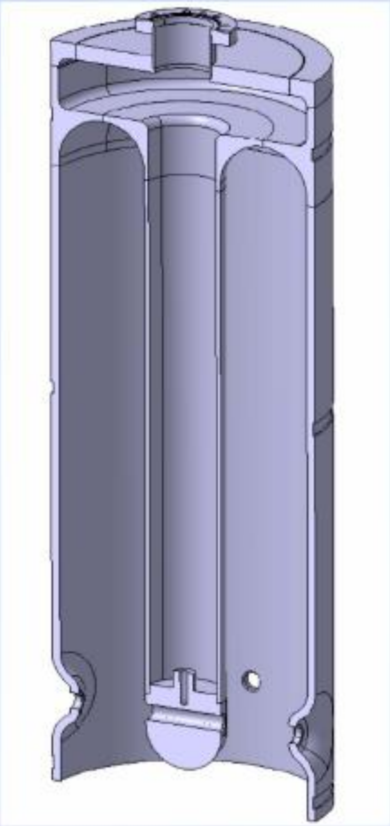
12 Low-β cavity



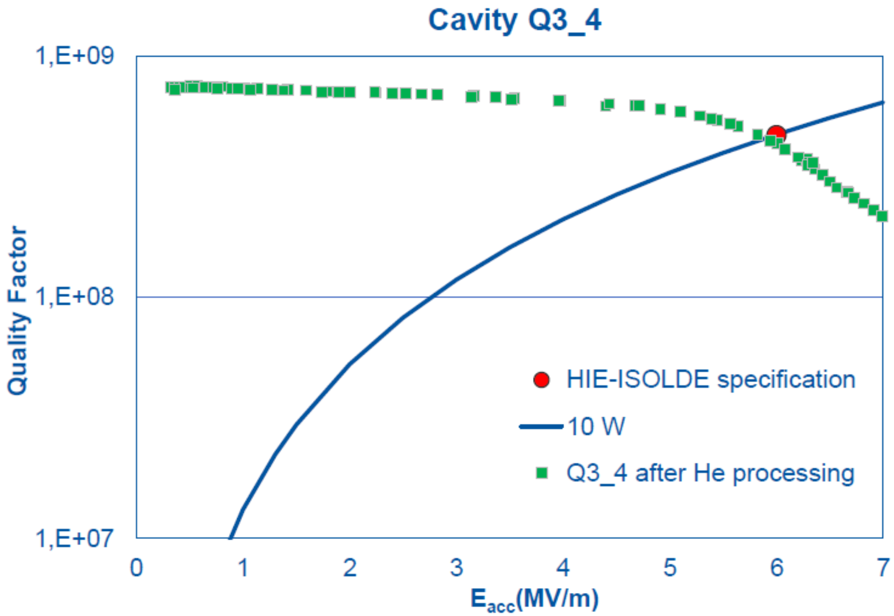
101.28	f (MHz)	101.28
50	Inner Cond. Diam (mm)	90
195	Outer Cond Diam (mm)	300
6	Designed Gradient (MV/m)	6
3.2×10^{8}	Q_0 for 6MV/m at 7W	5×10^{8}
5.4	Epk/Eacc	5.6
80	Hpk/Eacc (Oe/MV/m)	96



20 High-β cavity



HIE-ISOLDE

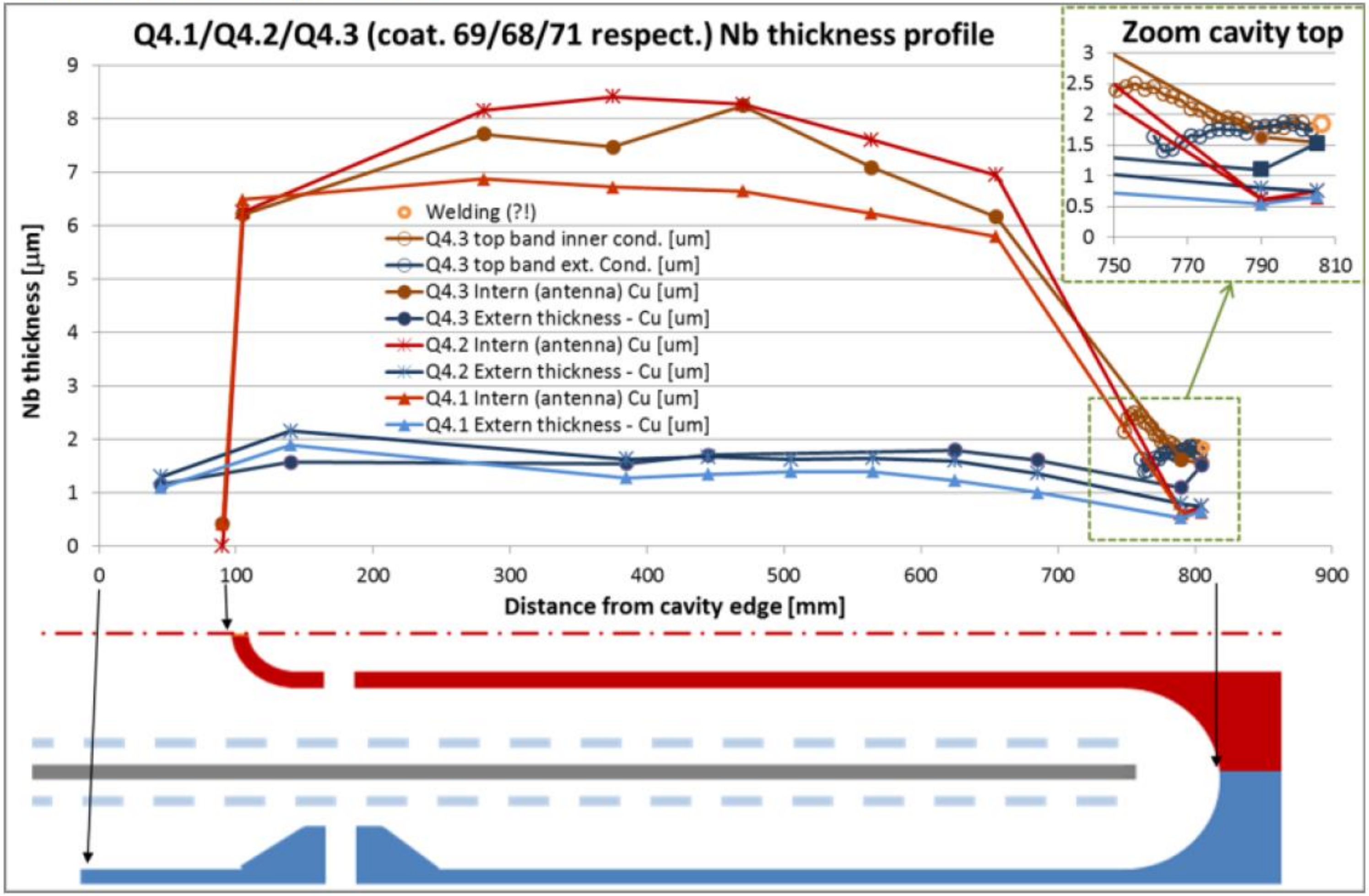


- Diode coating at nominal performance:
  - Improved coating thickness and rate (thanks to measurements on samples) at cavity top, high temperature deposition and pre-heating
- Ready for series production:
  - First copper cavities to be received in Fall 2013

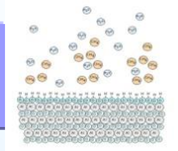
Vacuum, Surfaces & Coatings Group
Technology Department

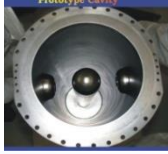
WP10.4: Thin Films

Thickness profile



WP10.4: Thin Films





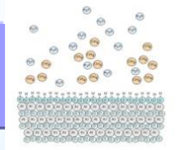
Magnetron sputtering facility at INFN/Legnaro

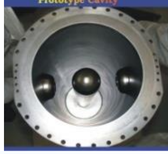
The RRR of our Nb sputtered samples was increasing when increasing the power of sputtering. We got progressive improvements. The film is uniform all over within the cavity. We can sputter over 1 micron in about 15 minutes.

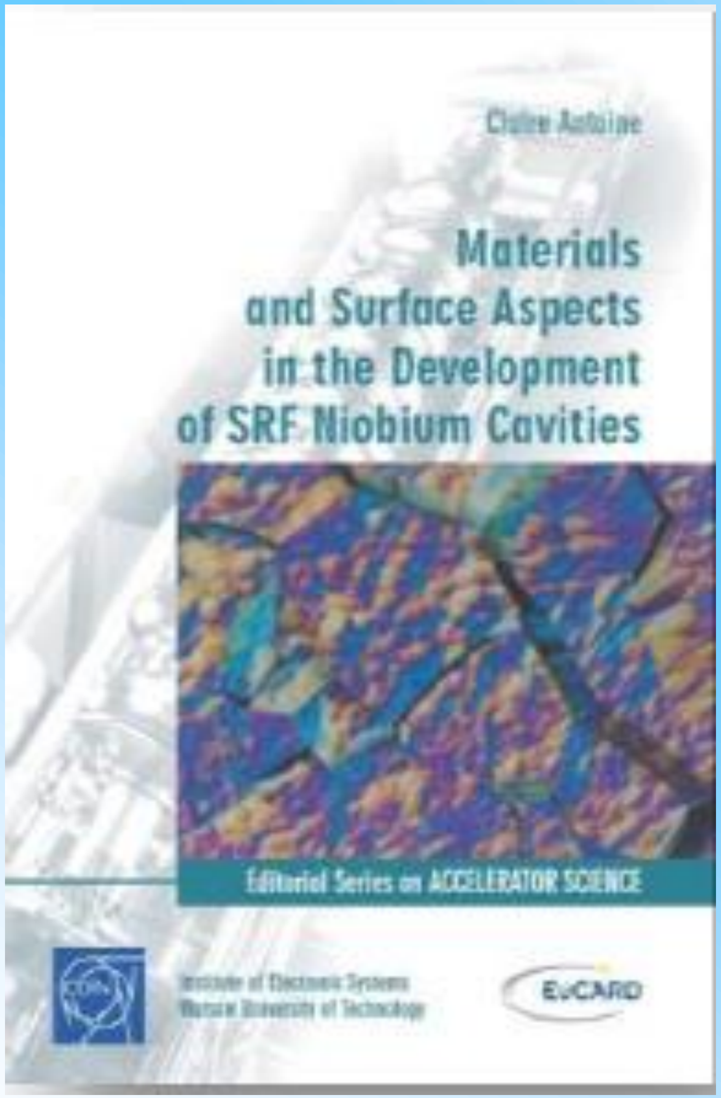
Today we got RRR values of 22, that means we are ready for sputtering the cavity.
In this situation, we could try the miracle to sputter and test it for the beginning of June, but we need the cavity, and the ancillary equipment (coupler, pickup, bottom plate and closing system).

Communication from E. Palmieri (15/05/2013)

WP10.4: Thin Films



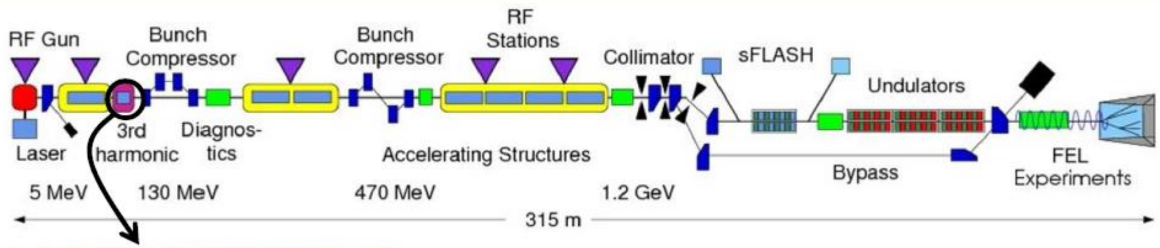


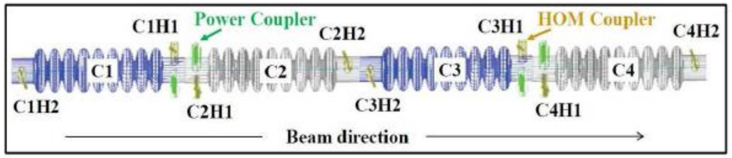


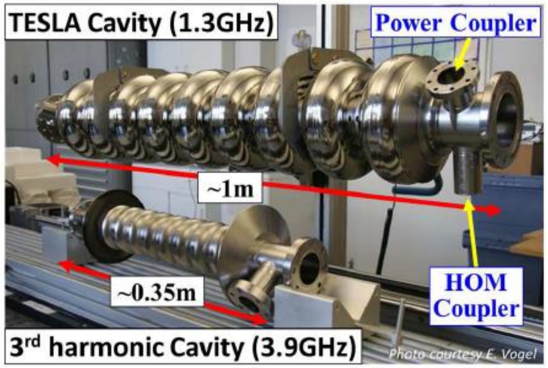
Monograph touching upon New Thin Film Techniques by C. Antoine (cf. EuCARD2 KoM)

WP10.5: HOM Distribution

Motivation







- Considerably larger wakefields (compare to 1.3GHz TESLA cavity)
- Reduction of the wakefields is important

↓

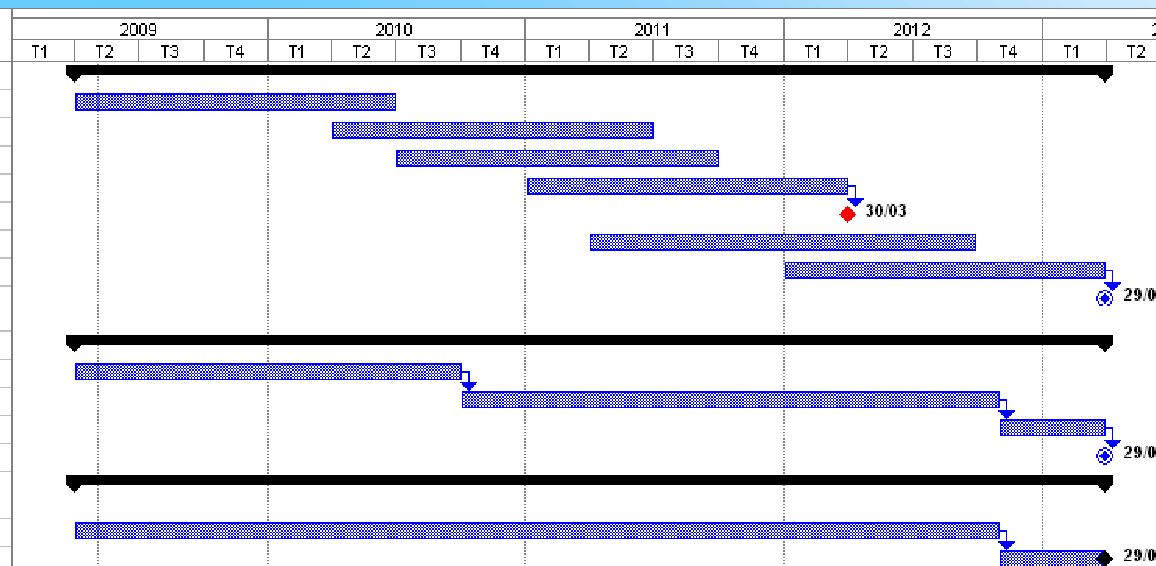
- Align the beam on the electrical axis
- Beam position diagnostics inside the module

WP10.5: HOM Distribution

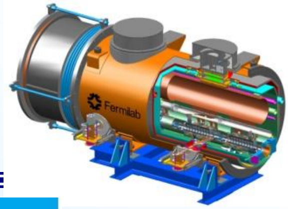
➢ Deliverables:

Ref.	N°	Deliverable Name	Deliverable Type	Task	Delivered by Contractor (s)	Planned (in months)	Achieved (in months)
10.5.1	15	HOM electronics and code to probe beam centring on 3.9 GHz cavities	Report	HOM distribution	DESY	48	50
10.5.2	12	Report on HOM experimental methods and code	Report	HOM distribution	UNIMAN	48	June'13

N°	Task Name
1	**Subtask 5.1: Development of HOM based beam position monitors (HOMBPM)**
2	Define requirements for HOMBPMs for 3.9 GHz
3	Study HOMs in the 3.9 GHz cavities at FLASH
4	Design and build electronics and LO
5	Test electronics
6	**Milestone 10.5.1: HOM alignment for 3.9 GHz cavity electronics verification**
7	Measure cavity alignment in 3.9 GHz cryomodule
8	HOMBPM calibration
9	**DELIVERABLE 10.5.1: HOM electronics and code to probe beam centering on 3.9 GHz cavities**
10	**Subtask 5.2: Development of HOM Cavity Diagnostics and ERLP (HOMCD)**
11	Develop HOM sub-structure alignment algorithm
12	Perform detailed sub-structure and cavity alignment via HOMs
13	Report on HOM experimental method and code
14	**DELIVERABLE 10.5.2: Report on HOM experimental method and code**
15	**Subtask 5.3: Measurement of HOM Distributions and Geometrical Dependences (HOMDG)**
16	Analyse mode distorsion and fabrication imperfections CSC
17	Report on influence of cavity fabrication tolerances on modes



WP10.5: HOM Distribution



Principle

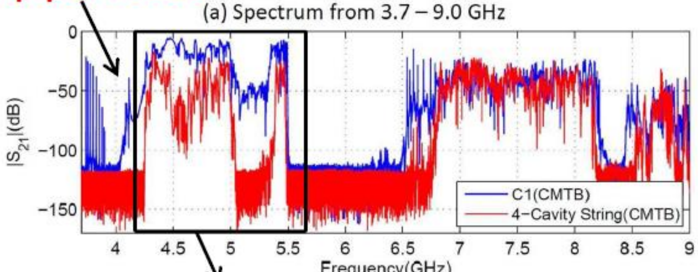
- Dipole modes **dominate** the transverse wakefield
- Dipole modes have **linear relation** to the transverse beam offset of the excitation bunch

$$\mathbf{W}_{\perp} \simeq rc\left(\hat{r}cos\theta - \hat{\theta}sin\theta\right)\sum_{n}^{\infty}\left(\frac{R}{Q}\right)_{1n} sin\frac{\omega_{1n}s}{c}, \quad s > 0$$

Dipole modes → Beam position

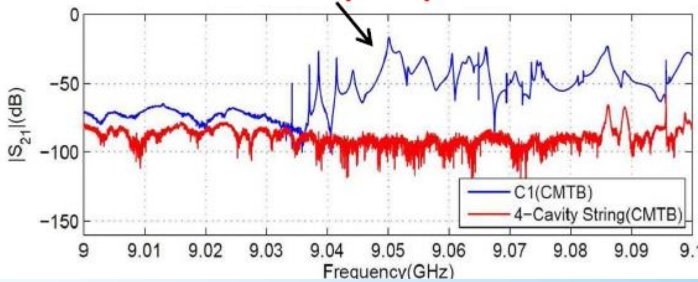
3.9GHz cavity

Beampipe modes

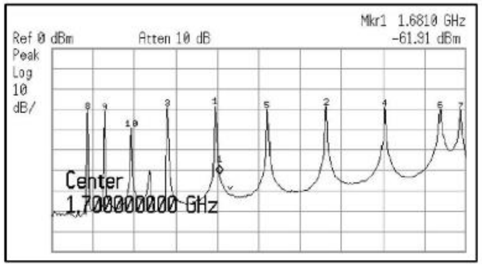


The first two dipole passbands

The 5th dipole passbands



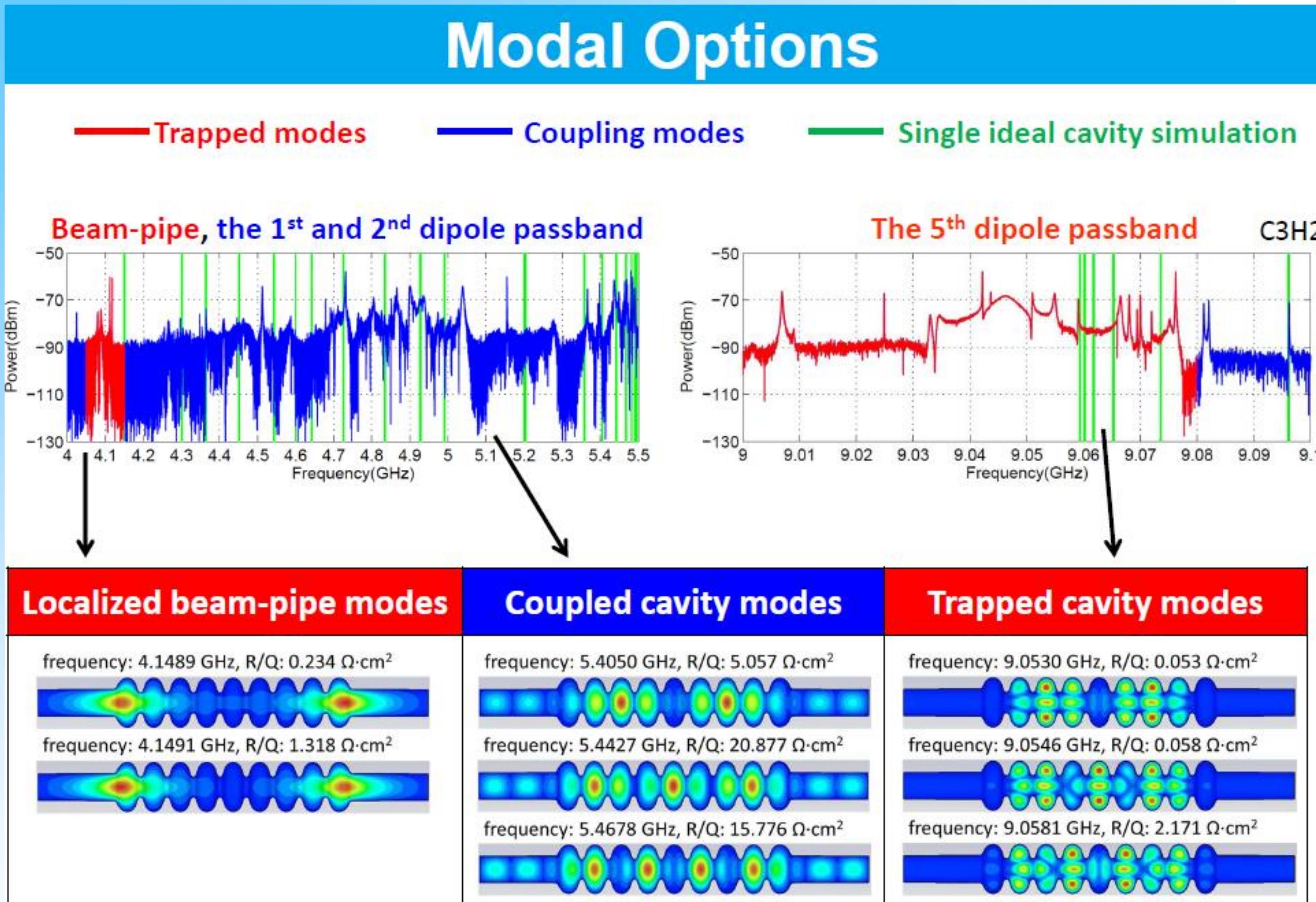
The 1st dipole passband of the TESLA 1.3GHz cavity



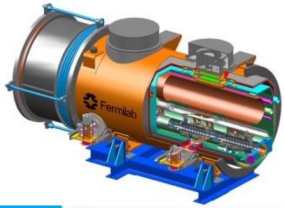
Principle proved in 1.3GHz TESLA cavity

[1] G. Devanz *et al.*, EPAC2002, WEAGB003
[2] N. Baboi *et al.*, LINAC2004, MOP36
[3] S. Molloy *et al.*, Phys. Rev. ST-AB 9, 112802 (2006)

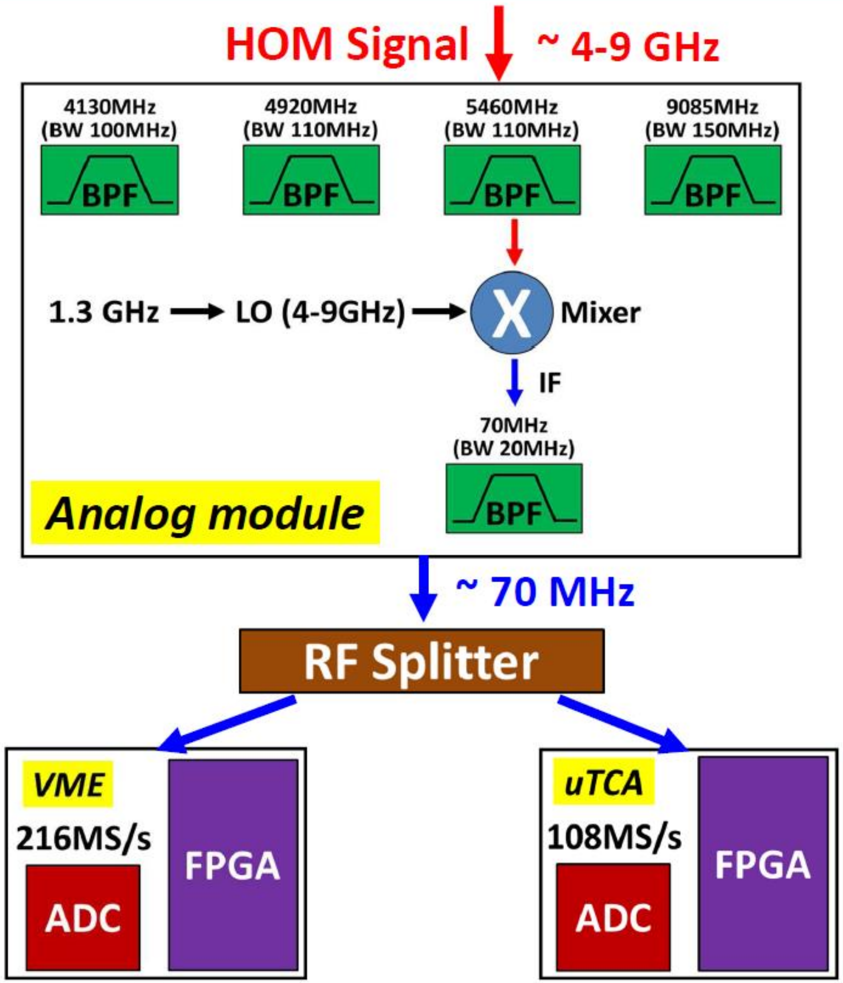
WP10.5: HOM Distribution

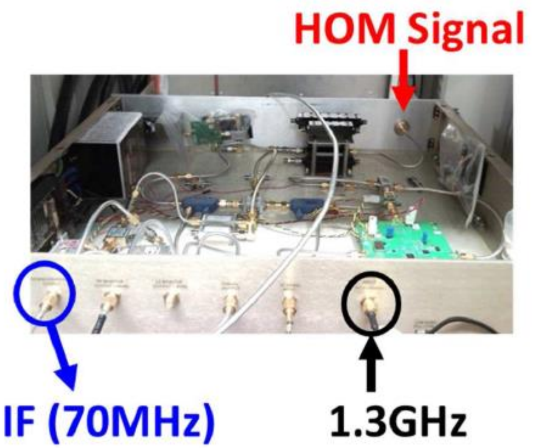


WP10.5: HOM Distribution



Electronics Prototype

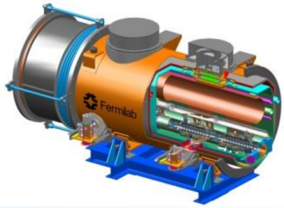




uTCA Digitizer (125MS/s)

VME Digitizer (250MS/s)

WP10.5: HOM Distribution



- **Electronics prototype tested with FLASH beam**

Resolution	Beampipe	D1	D2	D5
x (µm)	50 – 100	20 – 30	10 – 25	40 – 50
y (µm)	100 – 150	40 – 60	30 – 40	40 – 80

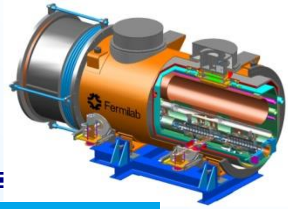
①BPM resolution: 20 µm. ②Resolution varies among couplers

- **Decision made for the final HOM electronics**

Band	Center frequency	Bandwidth	# of channels
D2	5460 MHz	100 MHz	2
D5	9058 MHz	40MHz	6

- **Final electronics is being built**
  - Analog module: Fermilab Digital module: DESY
  - Expected by the end of 2012
- **Next step**
  - HOMBPM performance study and calibration stability

WP10.5: HOM Distribution

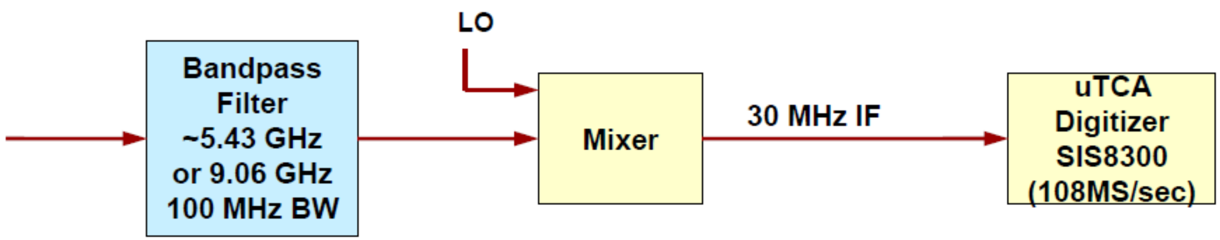


Specs for Final Electronics for FLASH defined

> Based on EuCARD work, specs defined for HOMBPM electronics for

- FLASH

Position type	Resolution	# of channels
Local position in the cavity	~ 50-100 µm	6 HOM couplers
Global position over the module	~ 20-30 µm	2 HOM couplers



Brian Fellenz,
Nathan Eddy,
Fermilab

- The European XFEL

More research necessary, since there will be 8 cavities in 3.9 GHz module (EuCARD2, incl. 1.3 GHz cavities)

WP10.5: HOM Distribution

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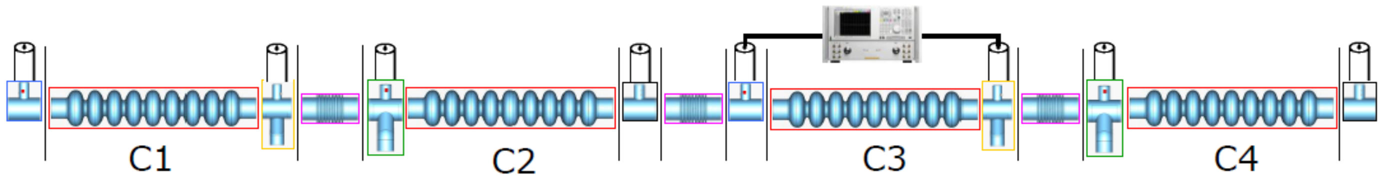
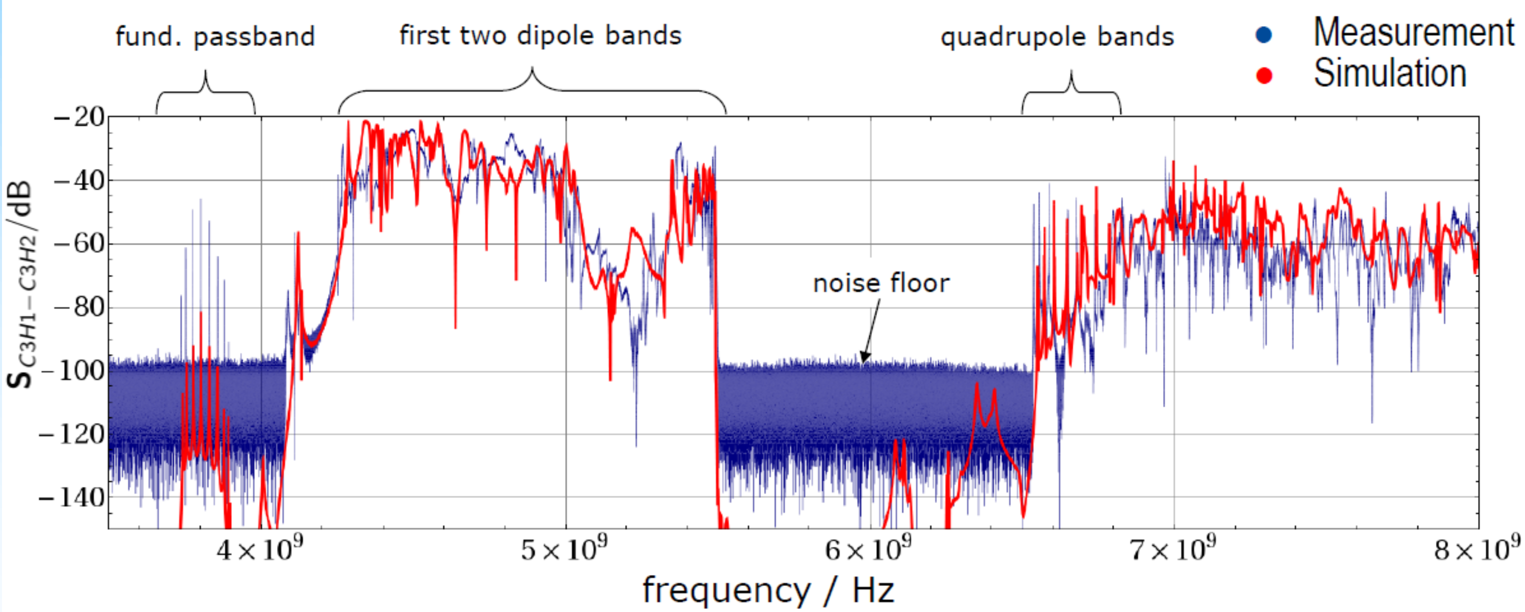
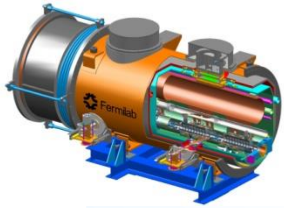
Example I: Transmission via Cavity 3





WP10.5: HOM Distribution



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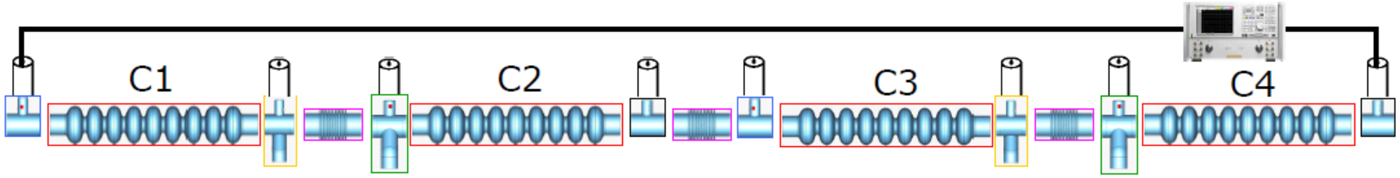
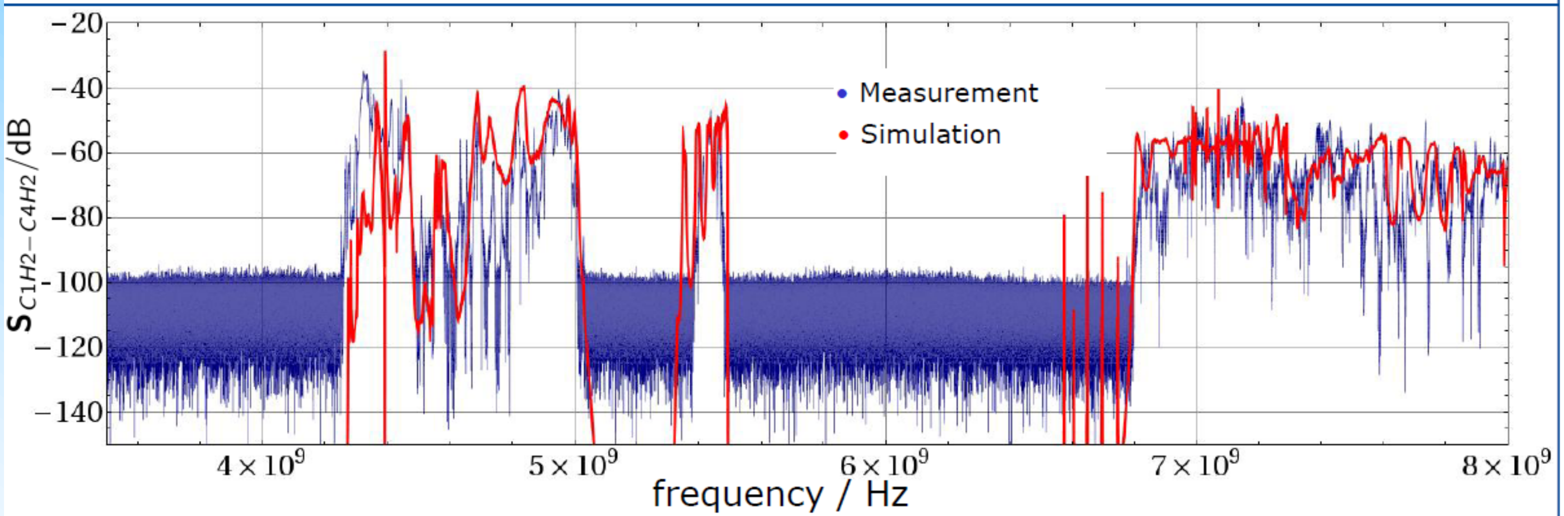
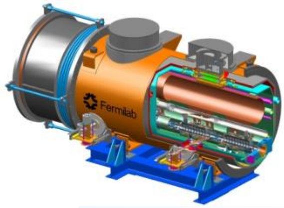
Example IV: Transmission via entire String





Need to consider the whole string instead of individual cavities since HOMs can propagate through entire string

WP10.5: HOM Distribution



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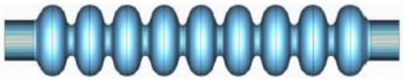
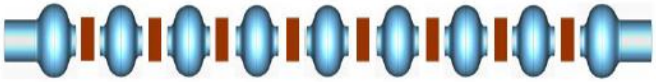
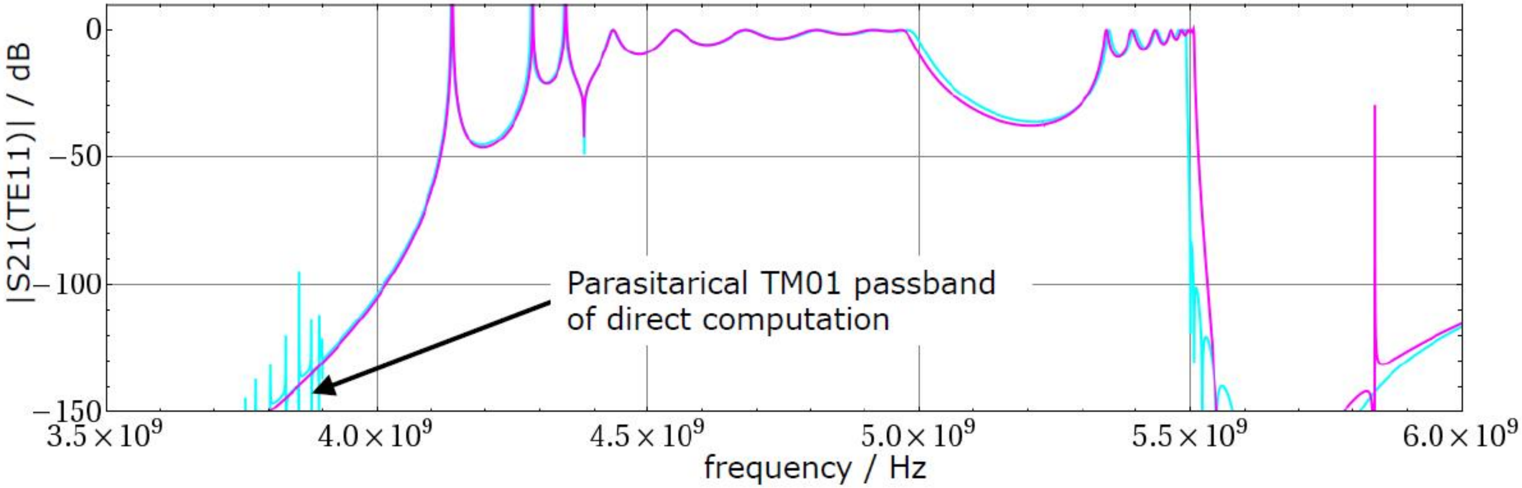
Comparison: Direct vs. Coupling

Direct computation with N=8,12 Mio hexahedral mesh cells, computing time FR solver: T=11h



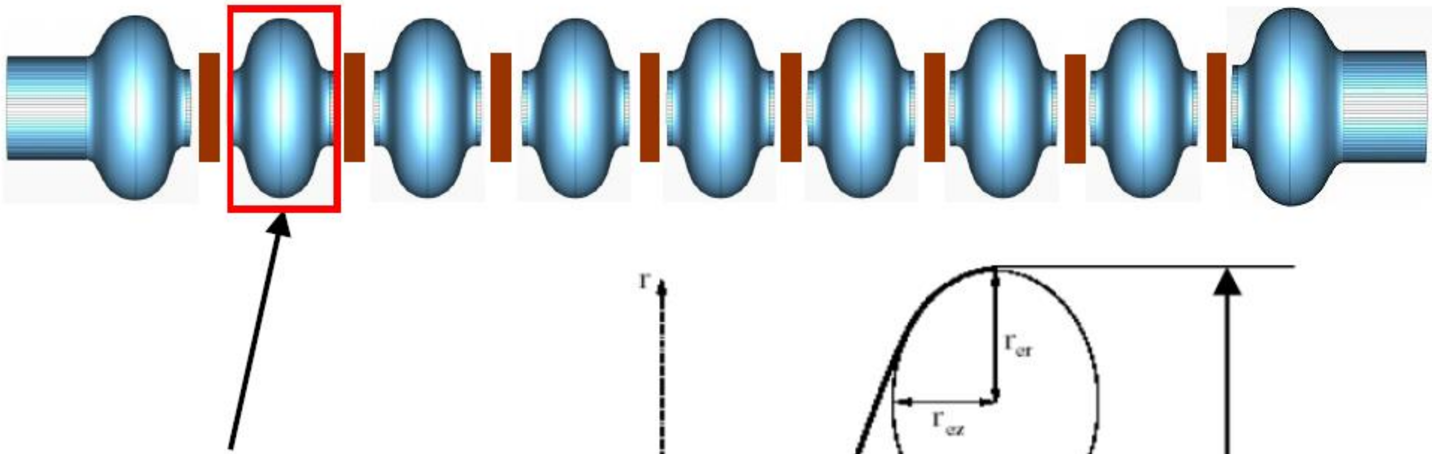
CSC coupling of mid- and end cell elements (only TE11 mode is considered), computing time CSC: couple of seconds



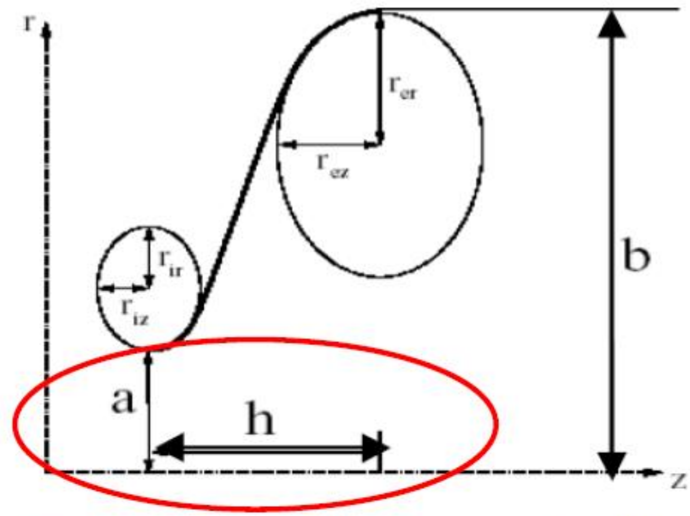


WP10.5: HOM Distribution

Perturbation of a Single Cell in the Resonator

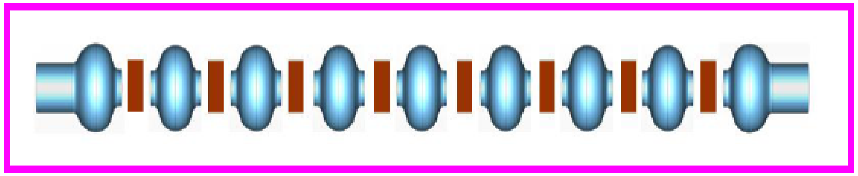
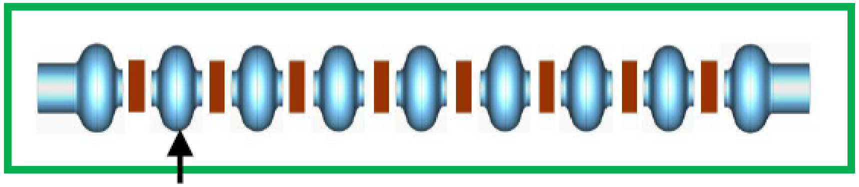


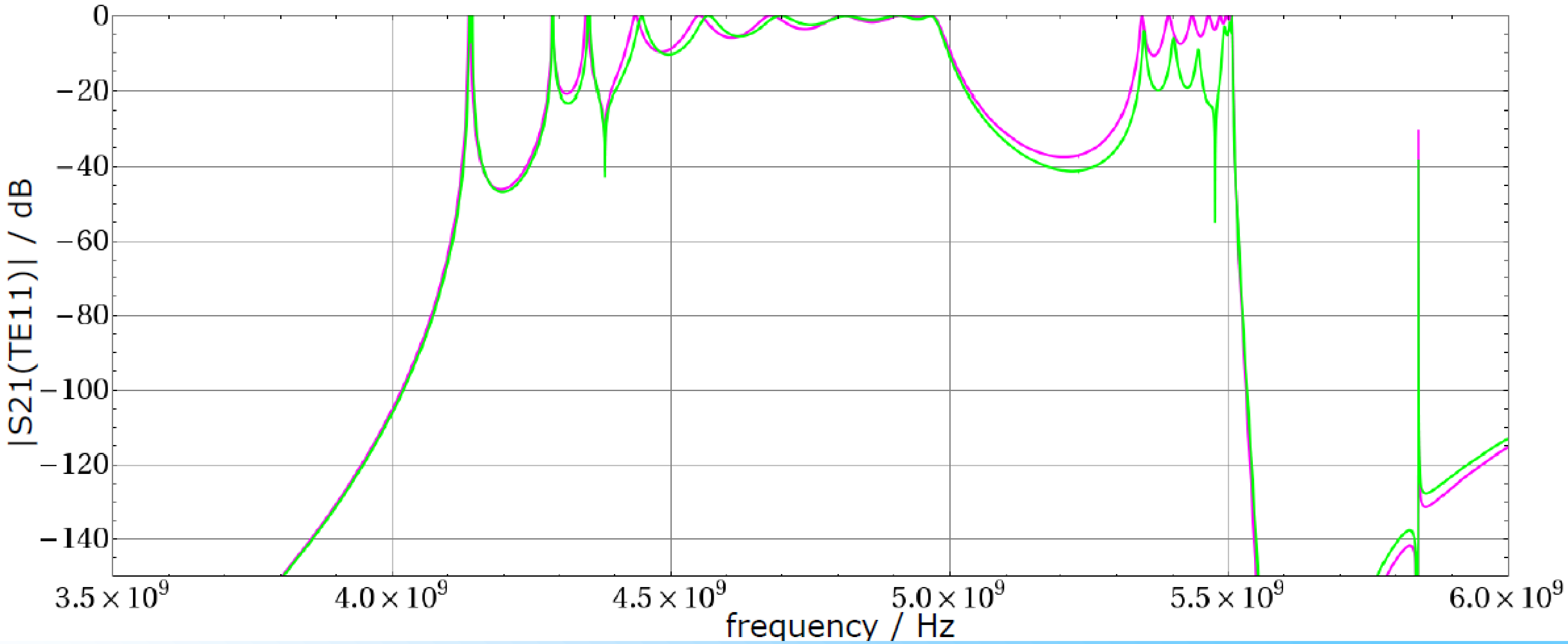
Length of mid cup is 18.2167 mm
instead of 19.2167 mm!



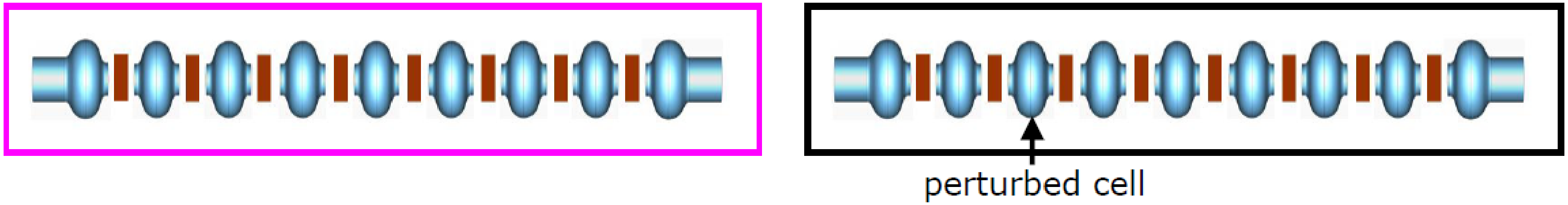
Source: T. Khabibouline et al.: Higher Order Modes of a 3rd Harmonic Cavity with an Increased End-cup Iris. TESLA-FEL 2003-01, May 2003

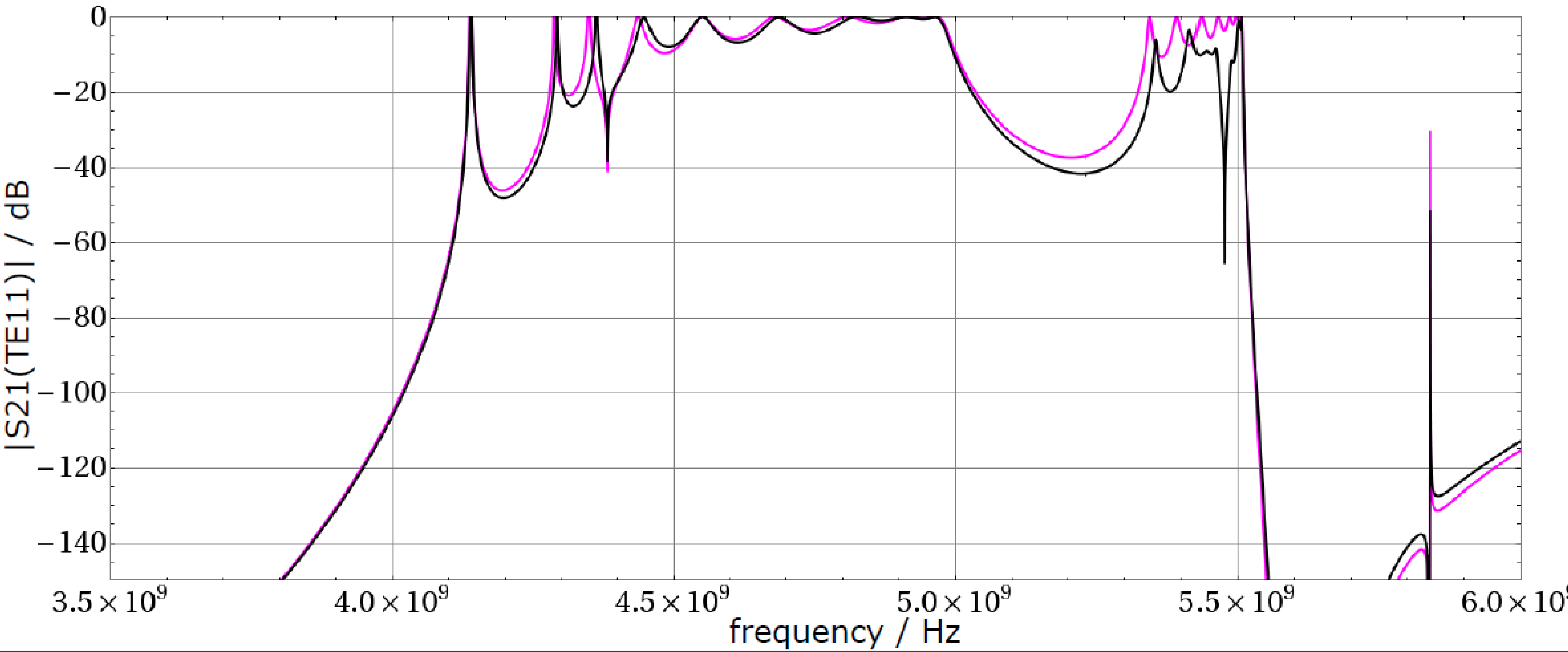
Influence of Pertubed Cell Position on HOM (1/4)

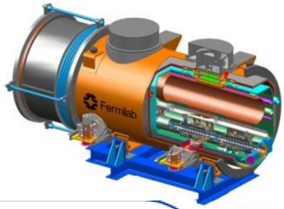


Influence of Pertubed Cell Position on HOM (2/4)

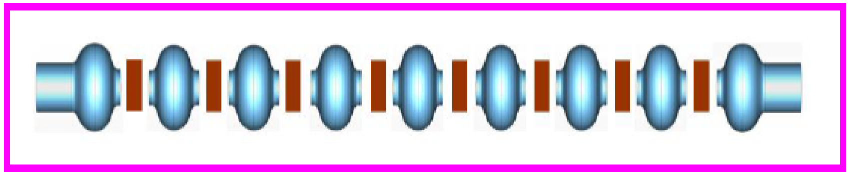


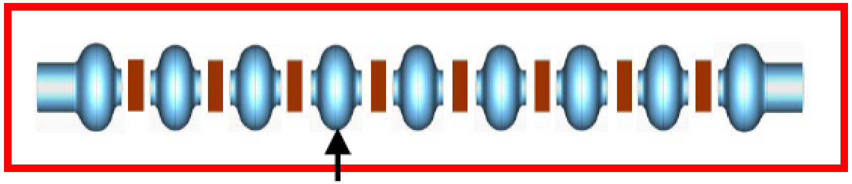


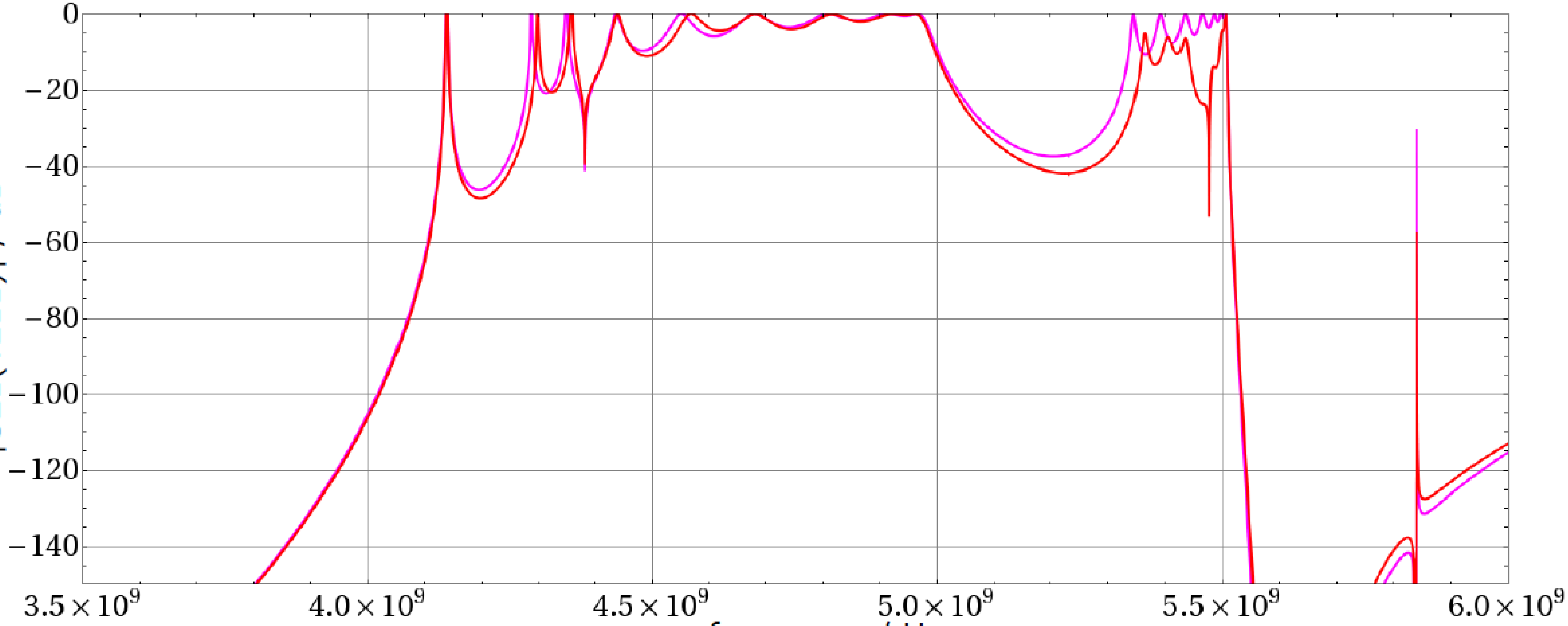
WP10.5: HOM Distribution



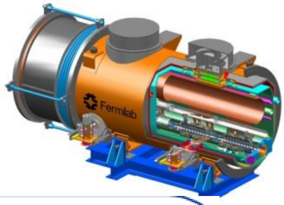
Influence of Pertubed Cell Position on HOM (3/4)



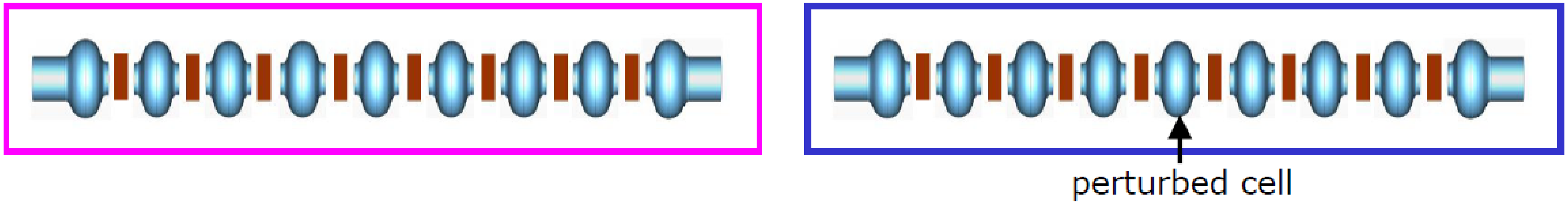


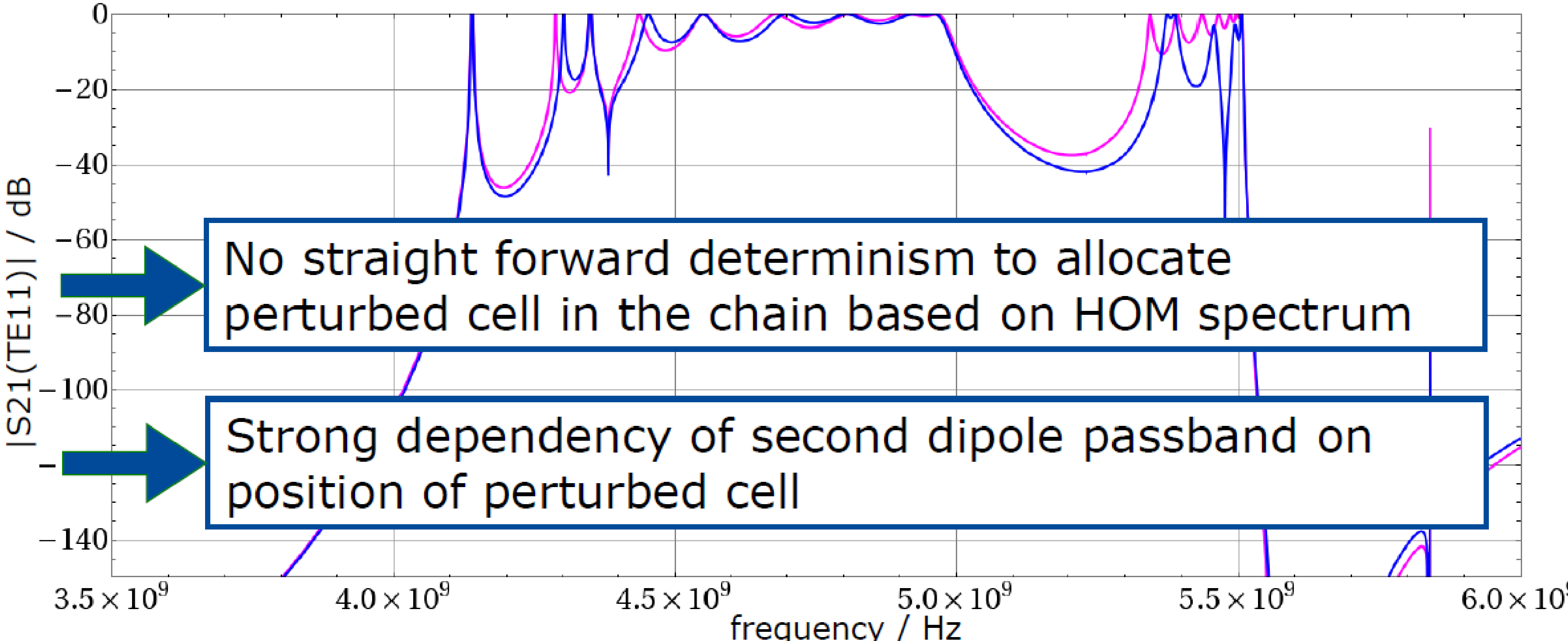


WP10.5: HOM Distribution



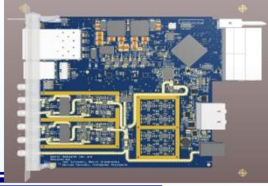
Influence of Pertubed Cell Position on HOM (4/4)





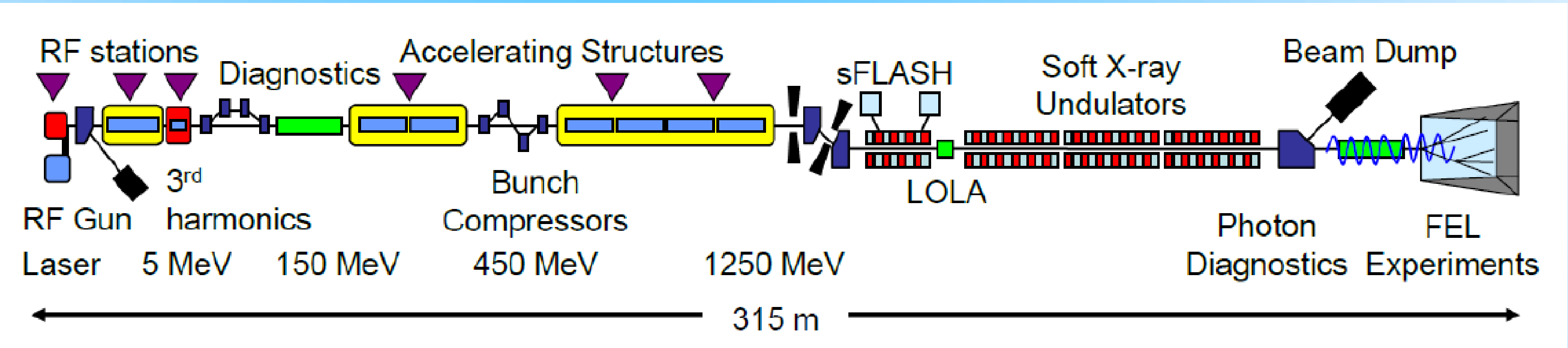
- No straight forward determinism to allocate perturbed cell in the chain based on HOM spectrum
- Strong dependency of second dipole passband on position of perturbed cell

WP10.6: LLRF at FLASH



➢ Goals:

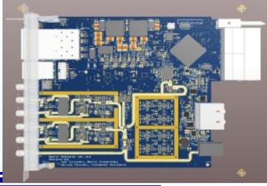
- Develop components of LLRF system using µTCA technology.
- Improve the reliability and functionality of the LLRF at FLASH
- Improve the energy stability of the beam in FLASH



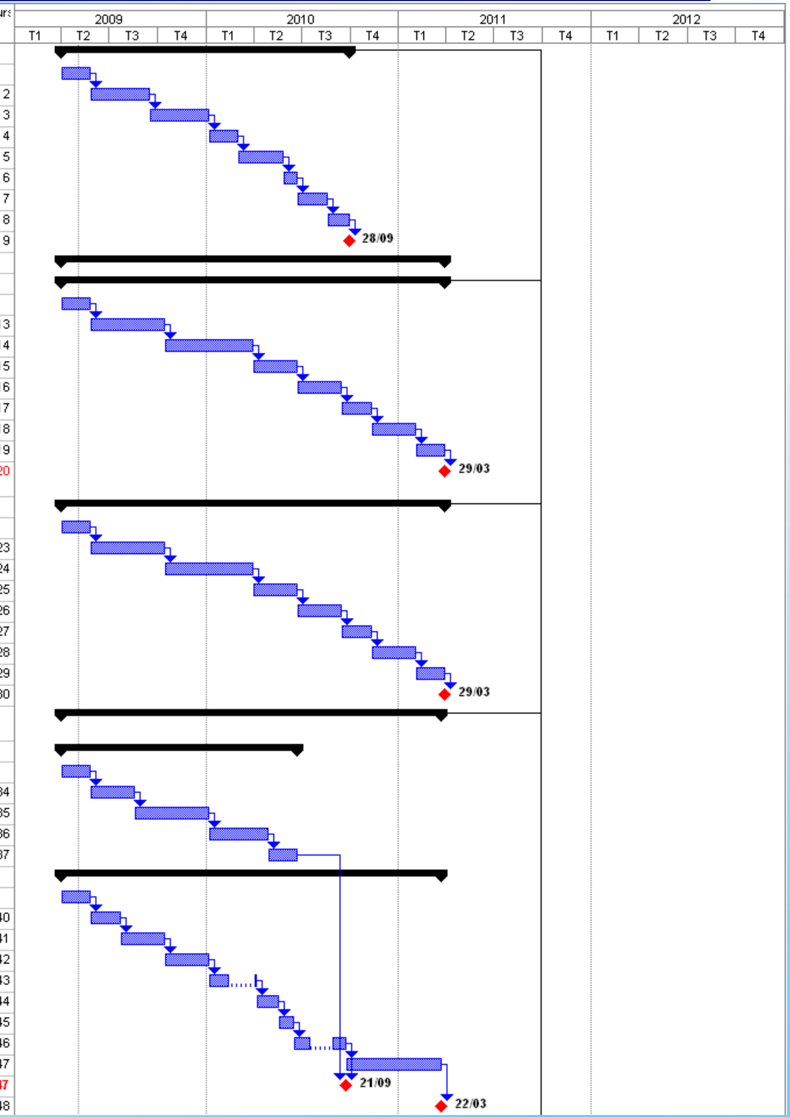
➢ Deliverables:

Ref.	N°	Deliverable Name	Deliverable Type	Task	Delivered by Contractor (s)	Planned (in months)	Achieved (in months)
10.6.1	13	Report on system test and performance	Report	LLRF at FLASH	DESY	42	51

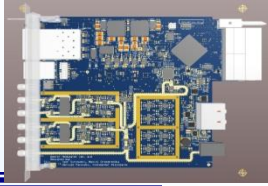
WP10.6: LLRF at FLASH



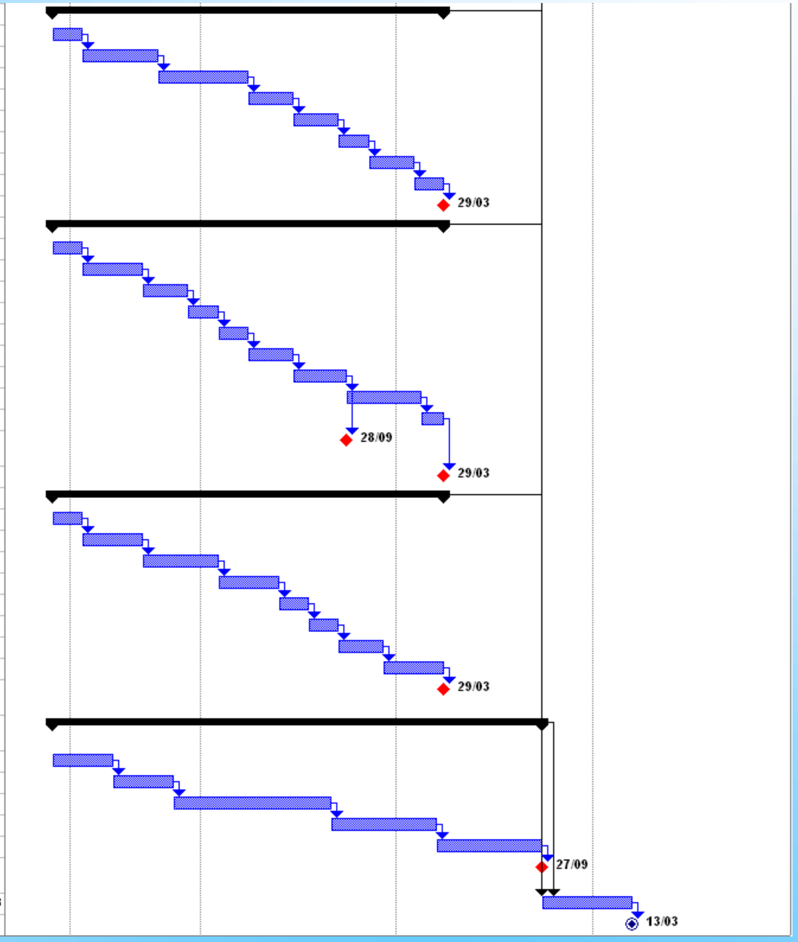
N°	Task Name	Durée	Début	Fin	% achevé	Prédécesseurs
1	**Subtask 6.1: Development of ATCA carrier boards with FPGA and DSP**	**390 jours**	**Mer 01/04/09**	**Mar 28/09/10**	**0%**	
2	Requirements analysis and capture	2 mois	Mer 01/04/09	Mar 26/05/09	0%	
3	Schematic desig	4 mois	Mer 27/05/09	Mar 15/09/09	0%	2
4	PCB design	4 mois	Mer 16/09/09	Mar 05/01/10	0%	3
5	Prototype fabrication	2 mois	Mer 06/01/10	Mar 02/03/10	0%	4
6	Debugging	3 mois	Mer 03/03/10	Mar 25/05/10	0%	5
7	Schematic and PCB modifications	1 mois	Mer 26/05/10	Mar 22/06/10	0%	6
8	Fabrication of final boards	2 mois	Mer 23/06/10	Mar 17/08/10	0%	7
9	Tests	1,5 mois	Mer 18/08/10	Mar 28/09/10	0%	8
10	**Milestone 10.6.1 : Design and manufacturing of the carrier board prototypes**	0 jour	Mar 28/09/10	Mar 28/09/10	0%	9
11	**Subtask 6.2: Development of AMC and RTM modules required IO functionality**	**520 jours?**	**Mer 01/04/09**	**Mar 29/03/11**	**0%**	
12	**Development of AMC modules with fast analog IO and digital IO**	**520 jours**	**Mer 01/04/09**	**Mar 29/03/11**	**0%**	
13	Requirements analysis and capture	2 mois	Mer 01/04/09	Mar 26/05/09	0%	
14	Schematic desig	5 mois	Mer 27/05/09	Mar 13/10/09	0%	13
15	PCB design	6 mois	Mer 14/10/09	Mar 30/03/10	0%	14
16	Prototype fabrication	3 mois	Mer 31/03/10	Mar 22/06/10	0%	15
17	Debugging	3 mois	Mer 23/06/10	Mar 14/09/10	0%	16
18	Schematic and PCB modifications	2 mois	Mer 15/09/10	Mar 09/11/10	0%	17
19	Fabrication of final boards	3 mois	Mer 10/11/10	Mar 01/02/11	0%	18
20	Tests	2 mois	Mer 02/02/11	Mar 29/03/11	0%	19
21	**Milestone 10.6.2 : Design and manufacturing of the AMC modules with fast analogue and digital IO (at least 100 Ms/s, 14 b)**	0 jour	Mar 29/03/11	Mar 29/03/11	0%	20
22	**Design and manufacturing of the AMC board with ultra fast ADC (at least 2 Gs/s, 10 b)**	**520 jours?**	**Mer 01/04/09**	**Mar 29/03/11**	**0%**	
23	Requirements capture	2 mois	Mer 01/04/09	Mar 26/05/09	0%	
24	Schematic desig	5 mois	Mer 27/05/09	Mar 13/10/09	0%	23
25	PCB design	6 mois	Mer 14/10/09	Mar 30/03/10	0%	24
26	Prototype fabrication	3 mois	Mer 31/03/10	Mar 22/06/10	0%	25
27	Debugging	3 mois	Mer 23/06/10	Mar 14/09/10	0%	26
28	Schematic and PCB modifications	2 mois	Mer 15/09/10	Mar 09/11/10	0%	27
29	Fabrication of final boards	3 mois	Mer 10/11/10	Mar 01/02/11	0%	28
30	Tests	2 mois?	Mer 02/02/11	Mar 29/03/11	0%	29
31	**Milestone 10.6.3 : Development of ultra fast analog IO (2 Gs, 10 bit)**	0 mois	Mar 29/03/11	Mar 29/03/11	0%	30
32	**Development of AMC module with radiation sensors (gamma and neutron detector with customized ASICs)**	**515 jours?**	**Mer 01/04/09**	**Mar 22/03/11**	**0%**	
33	**Gamma detector board**	**320 jours**	**Mer 01/04/09**	**Mar 22/06/10**	**0%**	
34	Study and comparison of available gamma dosimeters	2 mois	Mer 01/04/09	Mar 26/05/09	0%	
35	Design and fabrication of prototype board for initial tests of dosimeters	3 mois	Mer 27/05/09	Mar 18/08/09	0%	34
36	Radiation sensitivity tests of selected gamma dosimeters	5 mois	Mer 19/08/09	Mar 05/01/10	0%	35
37	Design of detector board	4 mois	Mer 06/01/10	Mar 27/04/10	0%	36
38	Fabrication of detector board	2 mois	Mer 28/04/10	Mar 22/06/10	0%	37
39	**Neutron detector board**	**515 jours**	**Mer 01/04/09**	**Mar 22/03/11**	**0%**	
40	Study, comparison and simulation of various radiation sensitive SRAM cells	2 mois	Mer 01/04/09	Mar 26/05/09	0%	
41	Selection of optimum radiation-sensitive cells for the neutron dosimeter array	2 mois	Mer 27/05/09	Mar 21/07/09	0%	40
42	Design of a test integrated circuit ASIC 1	3 mois	Mer 22/07/09	Mar 13/10/09	0%	41
43	Design and fabrication of a prototype board for initial tests of dosimeters	3 mois	Mer 14/10/09	Mar 05/01/10	0%	42
44	Fabrication of the test integrated circuit ASIC 1 in the silicon foundry	1,5 mois	Mer 06/01/10	Mar 06/04/10	0%	43
45	Tests in the radiation environment and selection of final cells and the detector structure	1,5 mois	Mer 07/04/10	Mar 18/05/10	0%	44
46	Design of the final integrated circuit ASIC 2 of the neutron fluence dosimeter	1 mois	Mer 19/05/10	Mar 15/06/10	0%	45
47	Fabrication of the final integrated circuit ASIC 2 in silicon foundry	2 mois	Mer 16/06/10	Mar 21/09/10	0%	46
48	Tests and calibration of the radiation dosimeter	6,5 mois	Mer 22/09/10	Mar 22/03/11	0%	47
49	**Milestone 10.6.4 : Design and manufacturing of AMC radiation dosimeter**	**0 jour**	**Mar 21/09/10**	**Mar 21/09/10**	**0%**	**38;47**
50	**Milestone 10.6.5 : Report on tests and calibration of the radiation dosimeter**	**0 jour?**	Mar 22/03/11	Mar 22/03/11	0%	48



WP10.6: LLRF at FLASH



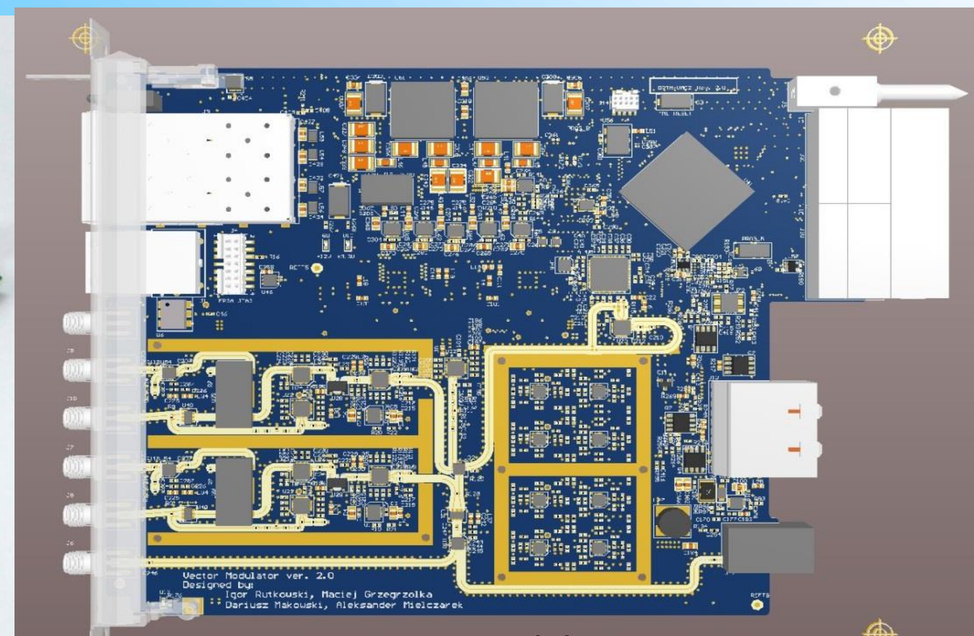
51	**Development of reference, clock and timing distribution for ATCA**	**520 jours**	**Mer 01/04/09**	**Mar 29/03/11**	**0%**	
52	Requirements analysis and capture	2 mois	Mer 01/04/09	Mar 26/05/09	0%	
53	Schematic desig	5 mois	Mer 27/05/09	Mar 13/10/09	0%	52
54	PCB design	6 mois	Mer 14/10/09	Mar 30/03/10	0%	53
55	Prototype fabrication	3 mois	Mer 31/03/10	Mar 22/06/10	0%	54
56	Debugging	3 mois	Mer 23/06/10	Mar 14/09/10	0%	55
57	Schematic and PCB modifications	2 mois	Mer 15/09/10	Mar 09/11/10	0%	56
58	Fabrication of final boards	3 mois	Mer 10/11/10	Mar 01/02/11	0%	57
59	Tests	2 mois	Mer 02/02/11	Mar 29/03/11	0%	58
60	**Milestone 10.6.6 : Designed and manufactured Frequency Synthesizer Board (AMC)**	0 jour	Mar 29/03/11	Mar 29/03/11	0%	59
61	**Development of AMC/RTM module for downconverters and upconverters**	**520 jours**	**Mer 01/04/09**	**Mar 29/03/11**	**0%**	
62	Requirements analysis and capture	2 mois	Mer 01/04/09	Mar 26/05/09	0%	
63	Prototype design	4 mois	Mer 27/05/09	Mar 15/09/09	0%	62
64	Fabrication of prototype	3 mois	Mer 16/09/09	Mar 08/12/09	0%	63
65	Tests and debugging	2 mois	Mer 09/12/09	Mar 02/02/10	0%	64
66	Design modification	2 mois	Mer 03/02/10	Mar 30/03/10	0%	65
67	Fabrication of final design	3 mois	Mer 31/03/10	Mar 22/06/10	0%	66
68	Tests of final design	3,5 mois	Mer 23/06/10	Mar 28/09/10	0%	67
69	Design of AMC/RTM module	5 mois	Mer 29/09/10	Mar 15/02/11	0%	68
70	Tests	1,5 mois	Mer 16/02/11	Mar 29/03/11	0%	69
71	**Milestone 10.6.7 : Design and manufacturing of high linearity multichannel downconverter**	0 jour	Mar 28/09/10	Mar 28/09/10	0%	68
72	**Milestone 10.6.8 : Integration of downconverters and upconverters in RTM (ATCA)**	0 jour	Mar 29/03/11	Mar 29/03/11	0%	70
73	**Subtask 6.3: ATCA implementation of piezo & waveguide control**	**520 jours**	**Mer 01/04/09**	**Mar 29/03/11**	**0%**	
74	Requirements analysis and capture	2 mois	Mer 01/04/09	Mar 26/05/09	0%	
75	Schematic desig	4 mois	Mer 27/05/09	Mar 15/09/09	0%	74
76	PCB design	5 mois	Mer 16/09/09	Mar 02/02/10	0%	75
77	Prototype fabrication	4 mois	Mer 03/02/10	Mar 25/05/10	0%	76
78	Debugging	2 mois	Mer 26/05/10	Mar 20/07/10	0%	77
79	Schematic and PCB modifications	2 mois	Mer 21/07/10	Mar 14/09/10	0%	78
80	Fabrication of final boards	3 mois	Mer 15/09/10	Mar 07/12/10	0%	79
81	Tests	4 mois	Mer 08/12/10	Mar 29/03/11	0%	80
82	**Milestone 10.6.9 : Design and fabrication of AMC modules for controling step motors, piezo and waveguide tuners**	0 jour	Mar 29/03/11	Mar 29/03/11	0%	81
83	**Subtask 6.4: Development of beam based longitudinal feedbacks for the ATCA based LLRF system**	**650 jours**	**Mer 01/04/09**	**Mar 27/09/11**	**0%**	
84	Requirements analysis and capture	4 mois	Mer 01/04/09	Mar 21/07/09	0%	
85	Design of required interfaces to LLRF controller	4 mois	Mer 22/07/09	Mar 10/11/09	0%	84
86	Software development	10,5 mois	Mer 11/11/09	Mar 31/08/10	0%	85
87	Installation and debugging	7 mois	Mer 01/09/10	Mar 15/03/11	0%	86
88	Performance tests	7 mois	Mer 16/03/11	Mar 27/09/11	0%	87
89	**Milestone 10.6.10 : Report on longitudinal beam parameter studies and their controllability by fast feedback systems in conjunction with the LLRF system**	0 jour	Mar 27/09/11	Mar 27/09/11	0%	88
90	System tests	6 mois	Mer 28/09/11	Mar 13/03/12	0%	2;32;51;61;73
91	**DELIVERABLE 10.6.1 : Report on system test and and performance**	0 jour	Mar 13/03/12	Mar 13/03/12	0%	90



WP10.6: LLRF at FLASH

- Downconverter optimization
- Vector modulator improvements

Downconverter



Vector modulator

It has been optimized for an input frequency of 1.3 GHz, a heterodyne of 1.354 GHz and an intermediate frequency of 54 MHz.

After extensive tests and requests for new features a second revision of the board with two output channels has been developed. The second channel will be used in the future to perform system calibration.

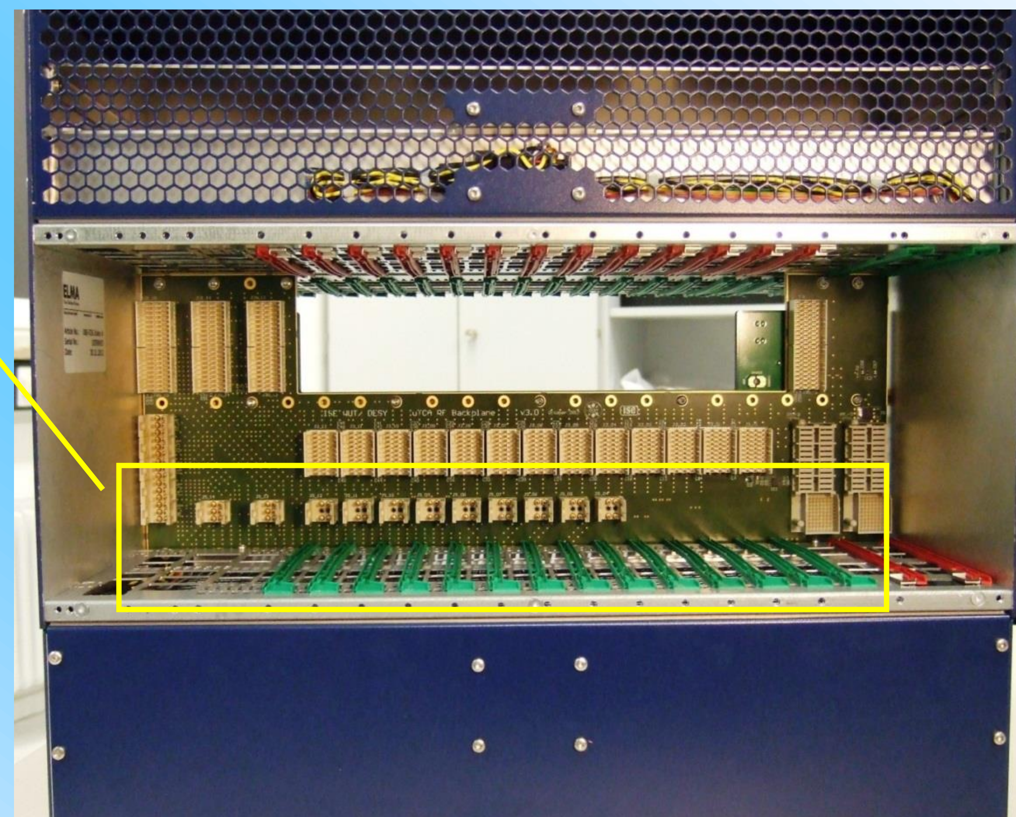
WP10.6: LLRF at FLASH

- Synthesis and distribution of clock and reference signals in xTCA system (RF Backplane)

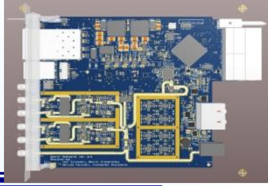
RF backplane for the MTCA crate increases reliability and maintainability and reduces the limitations external RF cabling. It generates and distributes high-quality synchronization and reference signals as well as low-jitter clock signals.

There is a patent application for RF Backplane requested and beeing processed.

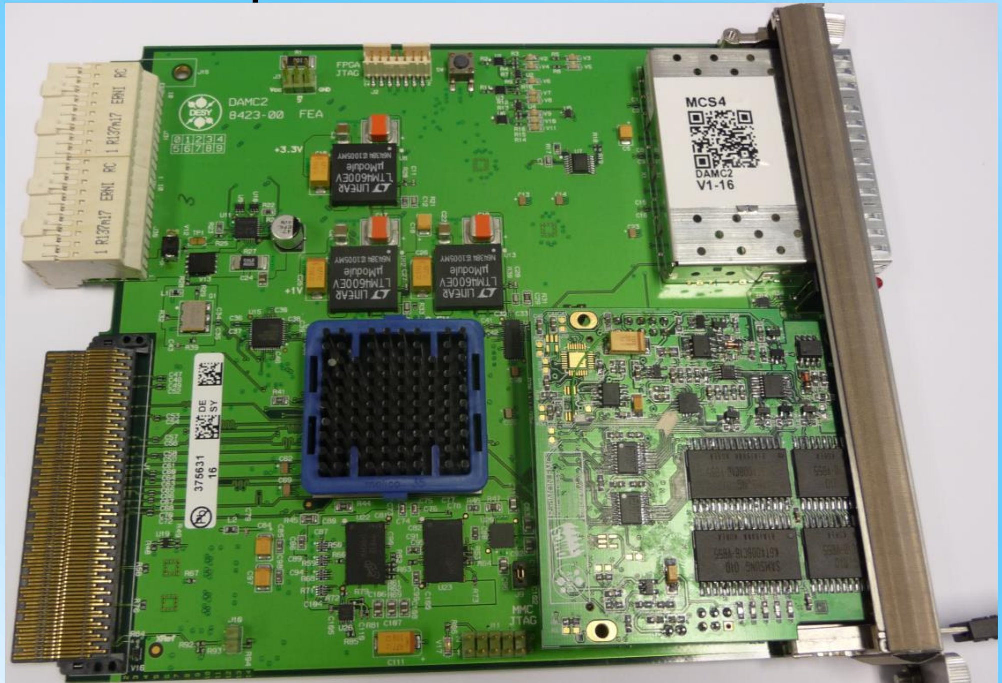
The patent requiest for RF Backplane was filled in (June 2012).



WP10.6: LLRF at FLASH



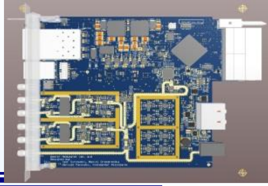
- Development of an AMC module with fast radiation sensors

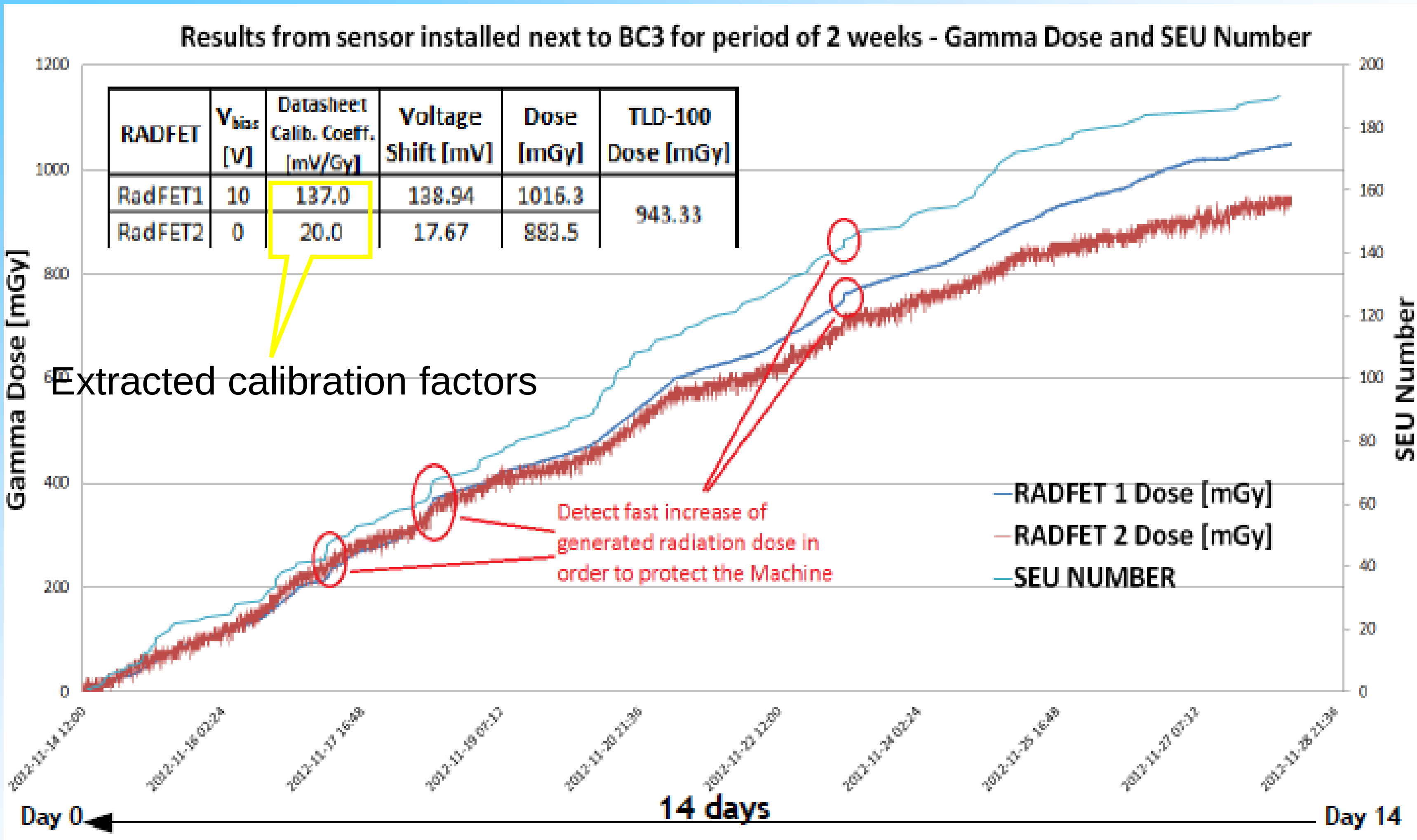


FMC board with RadMon mezzanine

The neutron radiation sensors developed with support of CARE project has been patented (EP 1 729 149 B1, Solid State Neutron Detection System, 09.01.2013) – this work was a base for current developments.

WP10.6: LLRF at FLASH

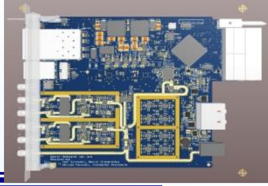




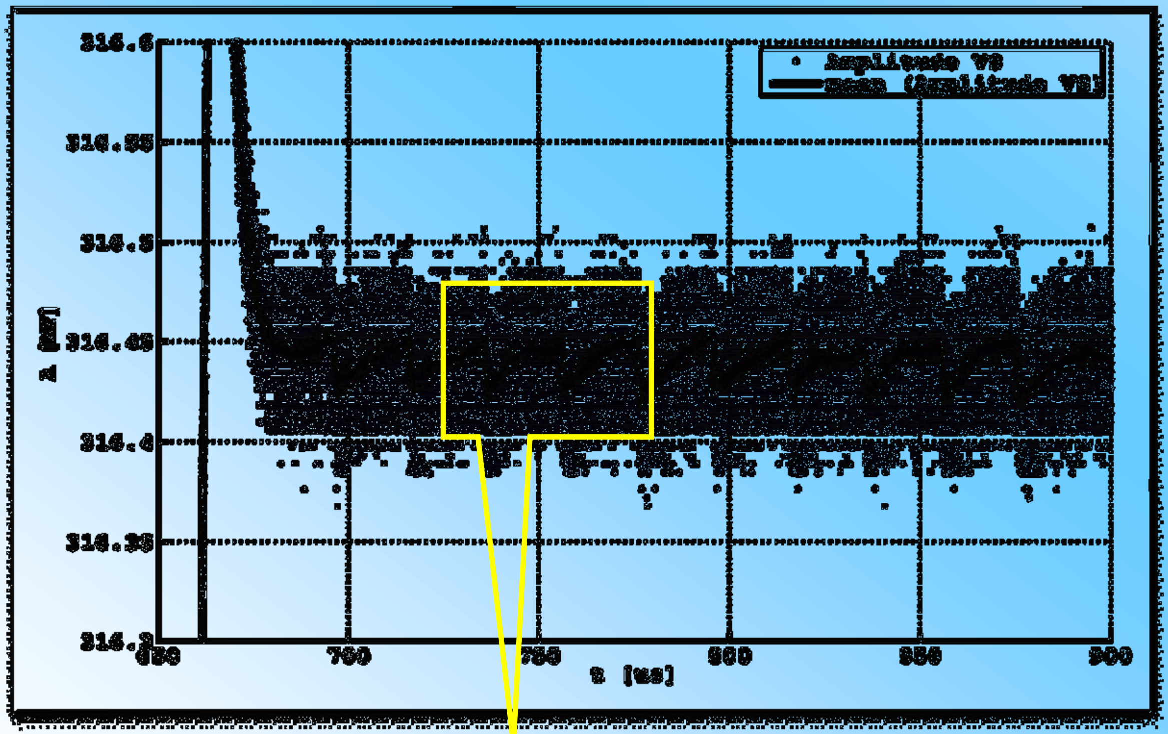
RADFET	V_{bias} [V]	Datasheet Calib. Coeff. [mV/Gy]	Voltage Shift [mV]	Dose [mGy]	TLD-100 Dose [mGy]
RadFET1	10	137.0	138.94	1016.3	943.33
RadFET2	0	20.0	17.67	883.5	

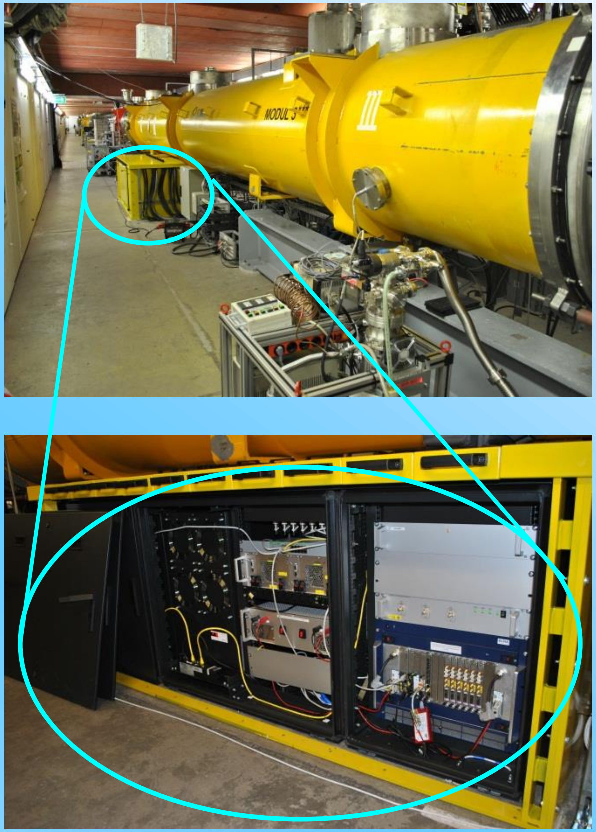
Calibration of the radiation sensors in FLASH

WP10.6: LLRF at FLASH



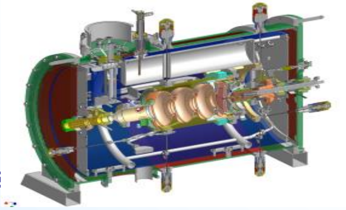
- The developed LLRF system has been installed in the FLASH accelerator and commissioned during maintenance periods. The system was tested with and without beam.





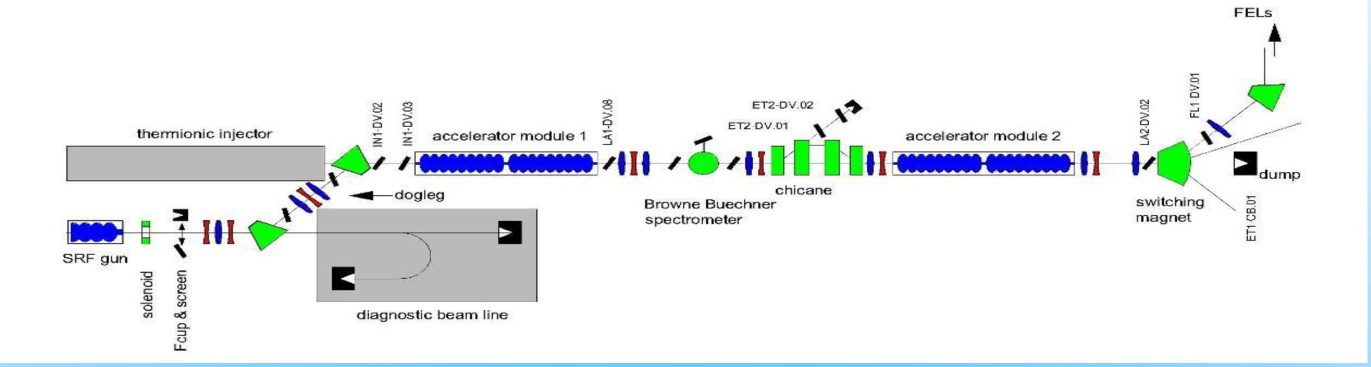
RF field stability (with beam) is of order of 10^{-4}

WP10.7: SC RF Gun at ELBE



- **Goals:**

1. **Slice emittance measurements on the SRF gun of ELBE**



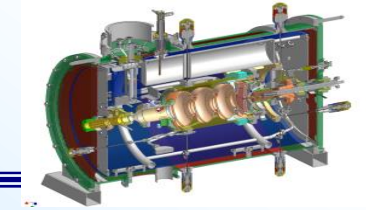
2. **Development of GaAs photocathodes in SRF gun**
3. **Evaluation of critical Issues of SRF guns**

- **Deliverables:**

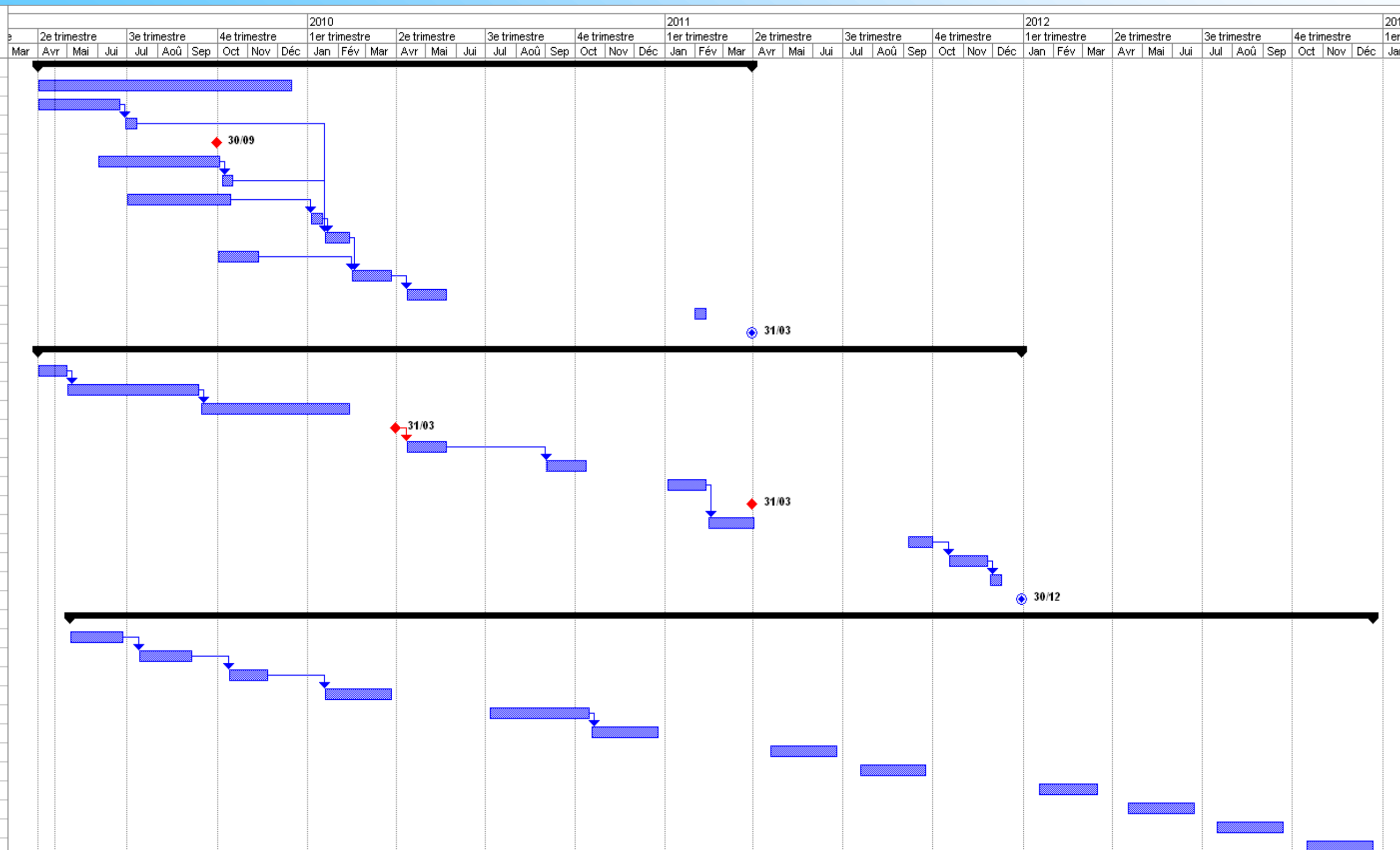
Ref.	N°	Deliverable Name	Deliverable Type	Task	Delivered by Contractor (s)	Planned (in months)	Achieved (in months)
10.7.1	2	Results of slice measurements	Report	SCRF Gun	FZD, HZB	24	26
10.7.2	6	Results for GaAs photocathodes	Report	SCRF Gun	FZD, HZB	33	50

Superconducting Radio Frequency

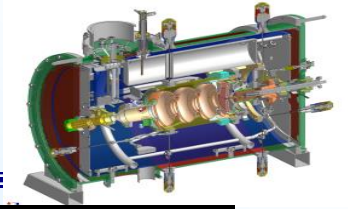
WP10.7: SC RF Gun at ELBE

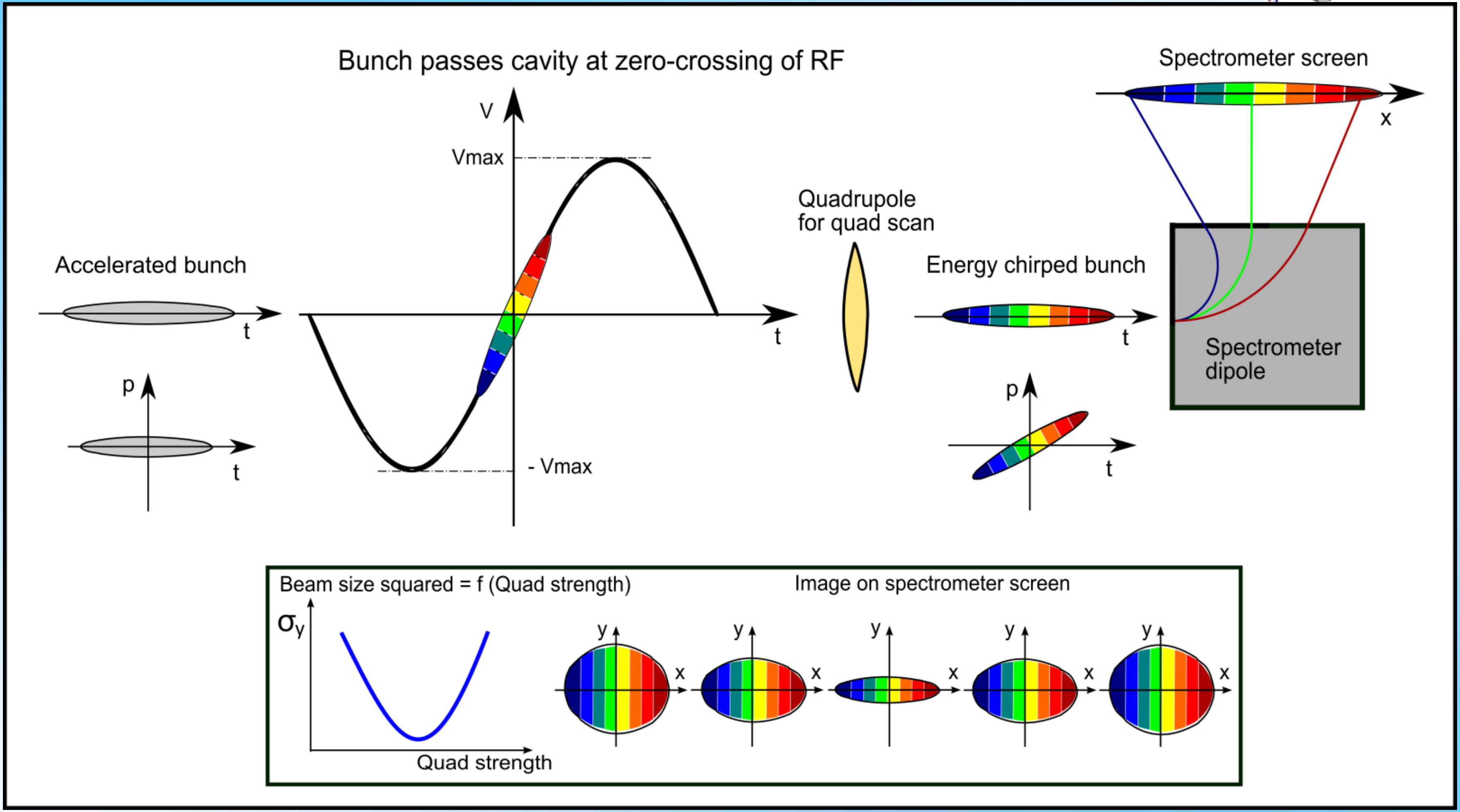


N°	Vorgangsname
1	**Subtask 7.1 Slice emittance**
2	simulation
3	fabrication spec magnet
4	installation spec magnet
5	**Milestone 10.7.2: Installation Spectrometer Dipole**
6	fabrication beamline to ELBE
7	installation beamline to ELBE
8	design &fabrication diagnostic
9	installation diagnostic
10	test slice emittance
11	software development
12	measurement period 1
13	measurement period 2
14	report
15	**DELIVERABLE 10.7.1: Results of Slice Measurements**
16	**Subtask 7.2 GaAs PC**
17	improvement transfer chambers
18	fabrication Cs2Te PC
19	modification prep system
20	**Milestone 10.7.1: Preparation system for GaAs ready**
21	preparation GaAs PC
22	preparation GaAs PC 2
23	prep GaAs PC for SRF gun
24	**Milestone 10.7.3 : GaAs photo cathodes produced**
25	test GaAs PC in gun
26	prep GaAs PC for SRF gun 2
27	test GaAs PC in gun 2
28	report
29	**DELIVERABLE 10.7.2: Results for GaAs Photo Cathodes**
30	**Subtask 7.3 Critical Issues**
31	high current operation with CsTe 1
32	high current operation with CsTe 2
33	first beamtime for ELBE
34	emittance comp methods 1
35	installation of new cavity
36	test new cavity
37	high gradient operation
38	emittance comp methods 2
39	CsTe PC at high gradient
40	emittance comp methods 3
41	alternative PC in gun
42	alternative PC in gun



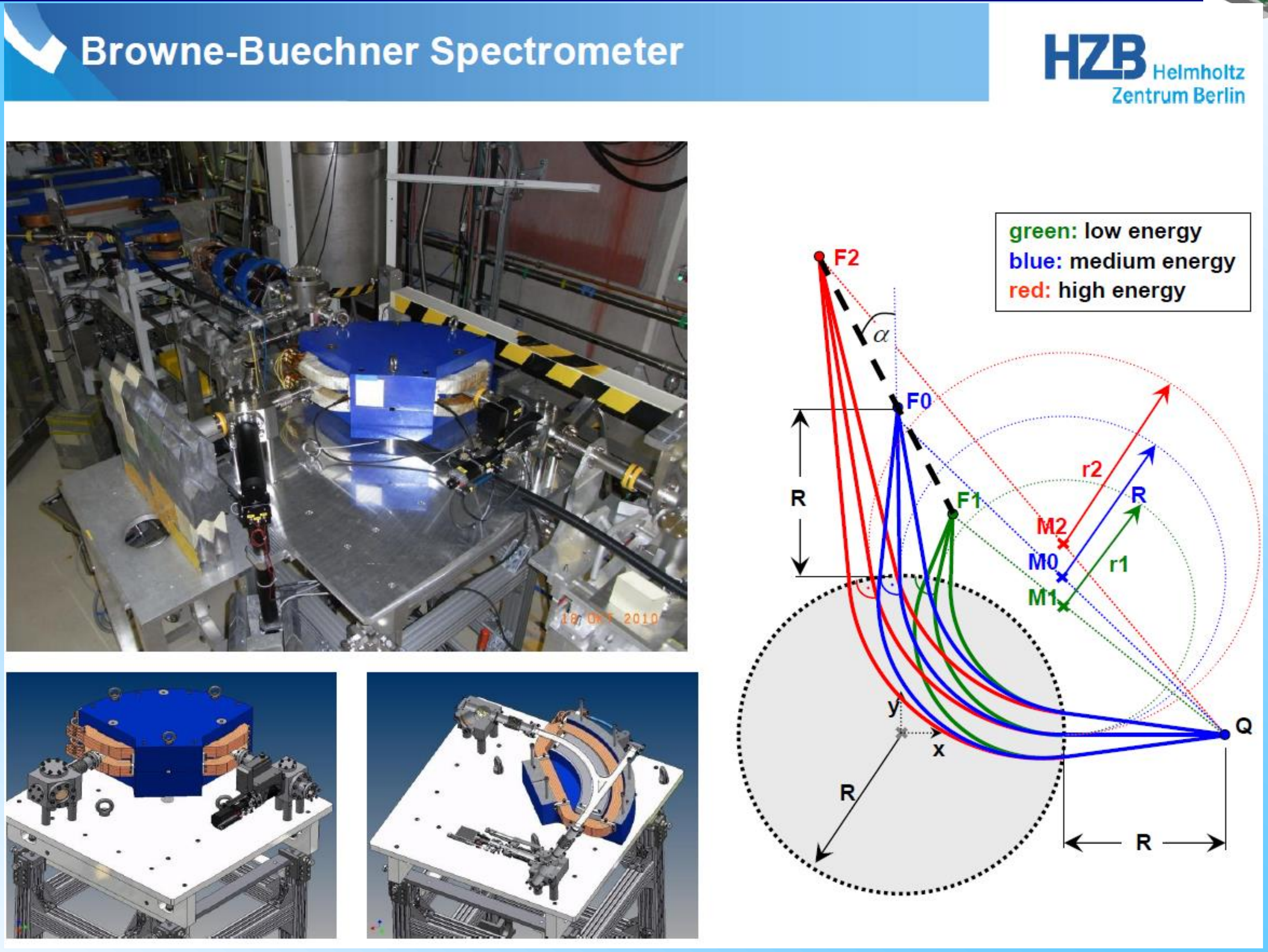
WP10.7: SC RF Gun at ELBE





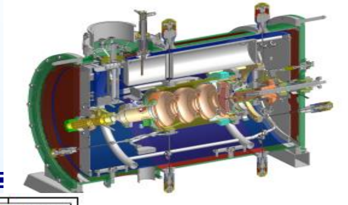
Zero Phasing Measurement Principle (PhD Thesis J. Rudolph)

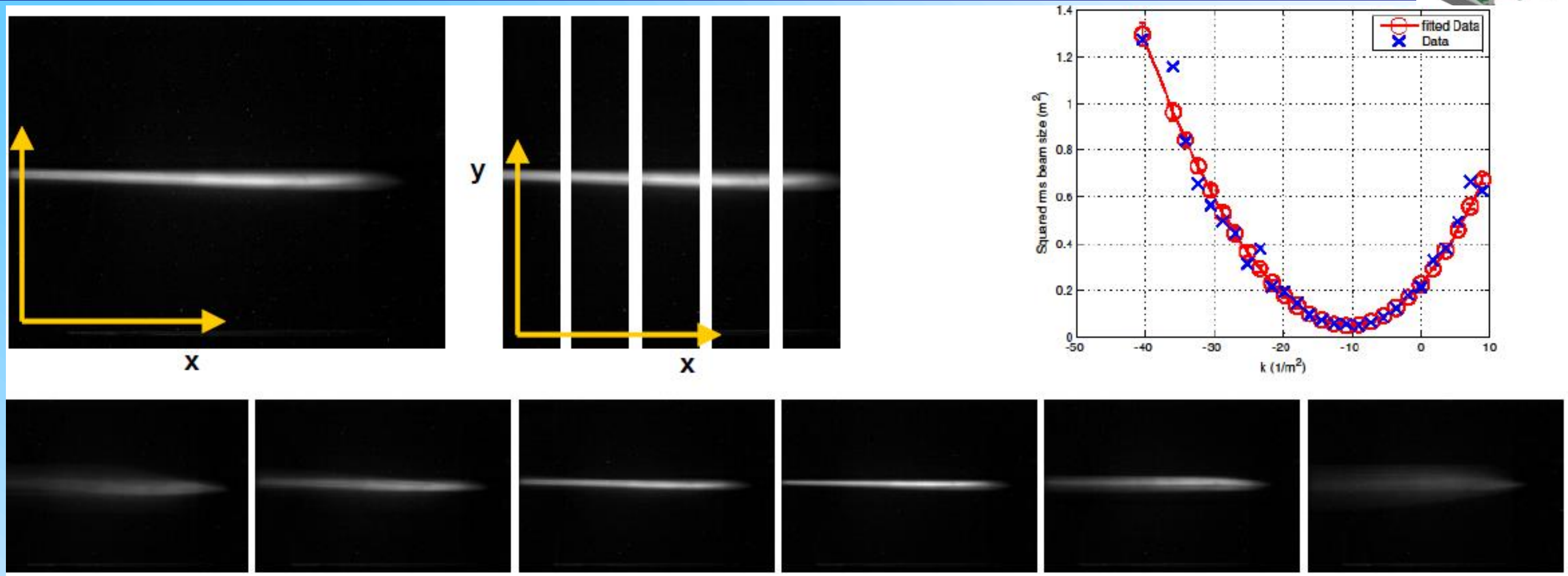
WP10.7: SC RF Gun at ELBE



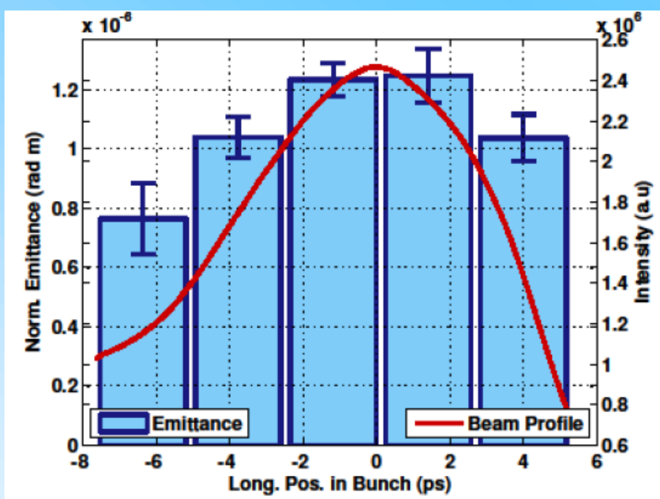
Browne-Büchner Spectrometer realizes point to point imaging

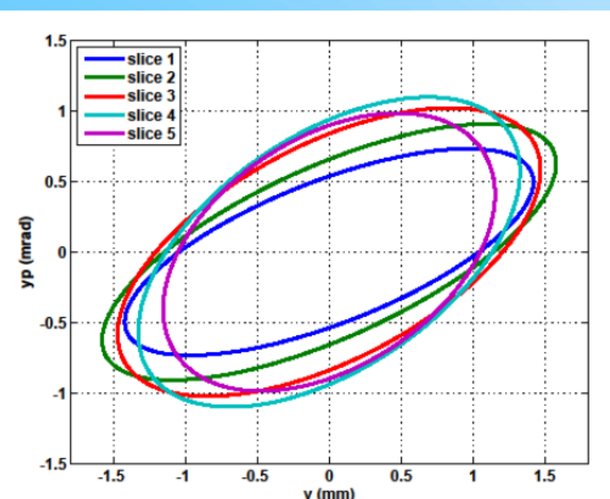
WP10.7: SC RF Gun at ELBE



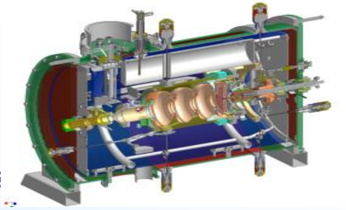


Quad scan method applied to slice profiles





WP10.7: SC RF Gun at ELBE



Report of the GaAs activity will be presented by J. Teichert this week.

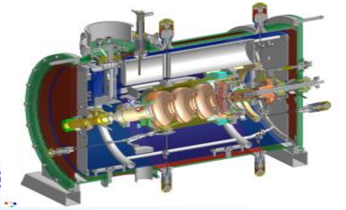
The conclusion of the project results is to develop a more advanced system which includes the experience of the previous work and state-of-the-art technique in this field:

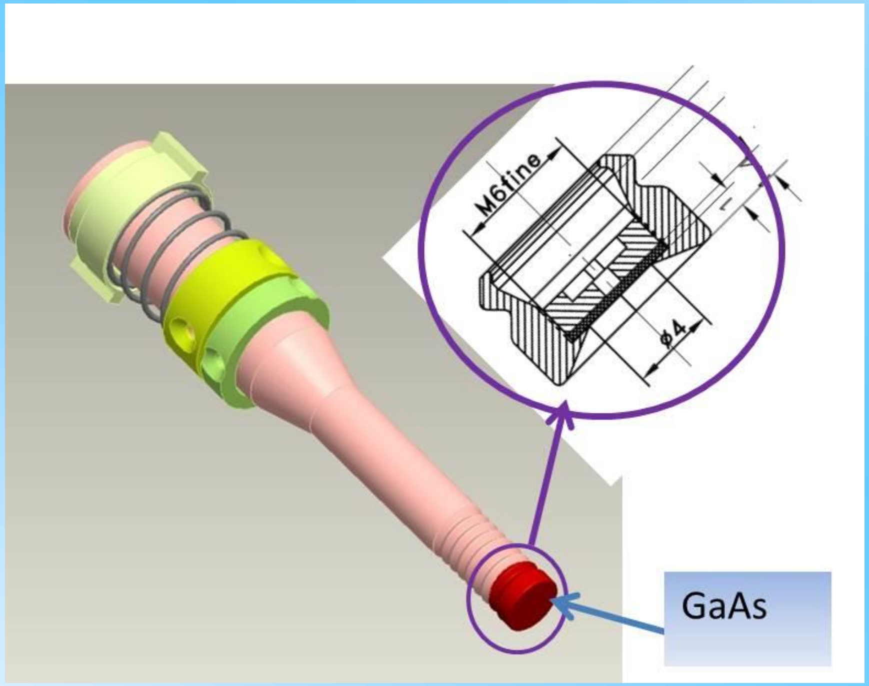
- **split of the cathode body and the new plug,**
- **only the plugs are treated in the preparation system,**
- **design of preparation system which can installed near the electron gun,**
- **using different chambers for cleaning, transfer and preparation.**

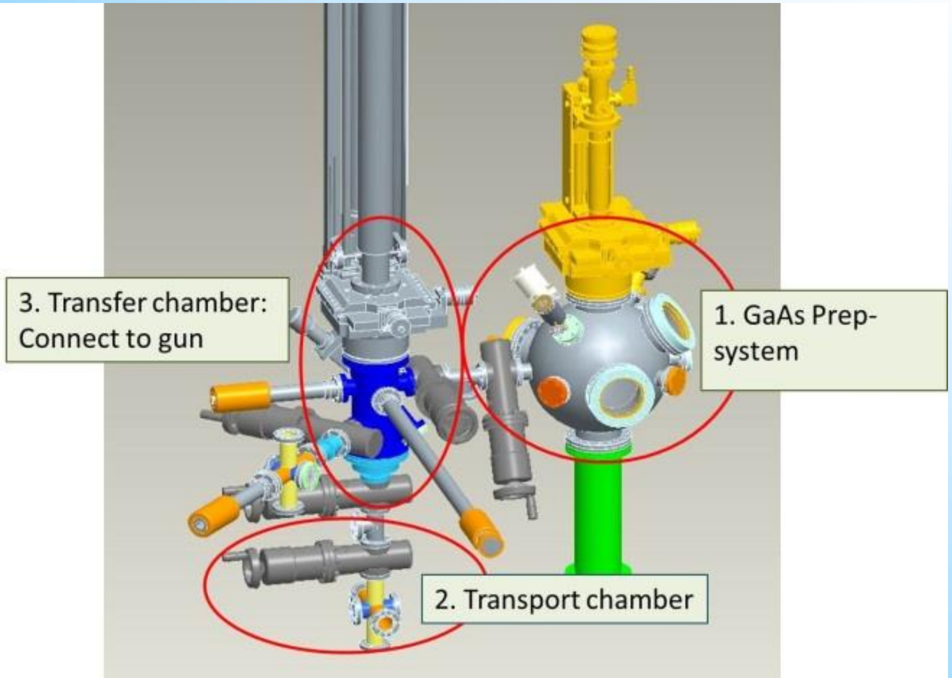
Furthermore a standard design of the photocathodes, plugs and storage chambers was fixed between the German institutes HZB, HZDR and University of Mainz. This required a further redesign but will allow the exchange of photocathodes for tests and characterization between these institues in the future.

HZDR gives additional funds for investment for this project in 2012 and 2013.

WP10.7: SC RF Gun at ELBE

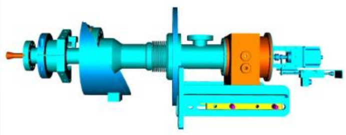






New design of the exchangeable cathode plug for GaAs (left) and the new preparation chamber with the interface to the gun and the transport chamber

WP10.8: RF Coupler Cleaning at LAL



- **Goals:**

Demonstrate new coupler cleaning procedures suitable for

a) mass production of 1.3 GHz couplers

b) short RF conditioning time.

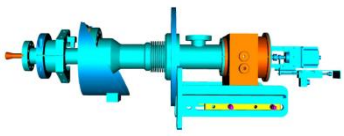
Three methods have been investigated:

1. **High Pressure Water rinsing**
2. **Argon plasma discharge**
3. **Automatic cleaning**

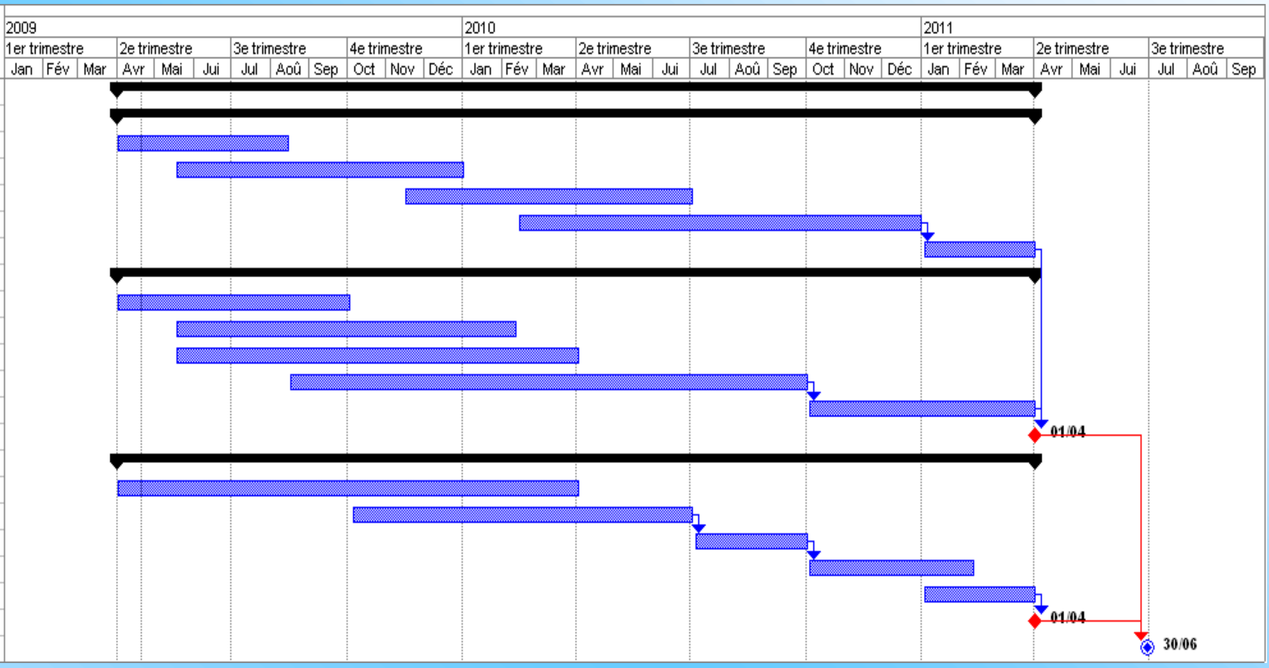
- **Deliverables:**

Ref.	N°	Deliverable Name	Deliverable Type	Task	Delivered by Contractor (s)	Planned (in months)	Achieved (in months)
10.8.1	3	Test and operation of the coupler preparation procedure	Report	Coupler Development	CNRS-LAL	24	50

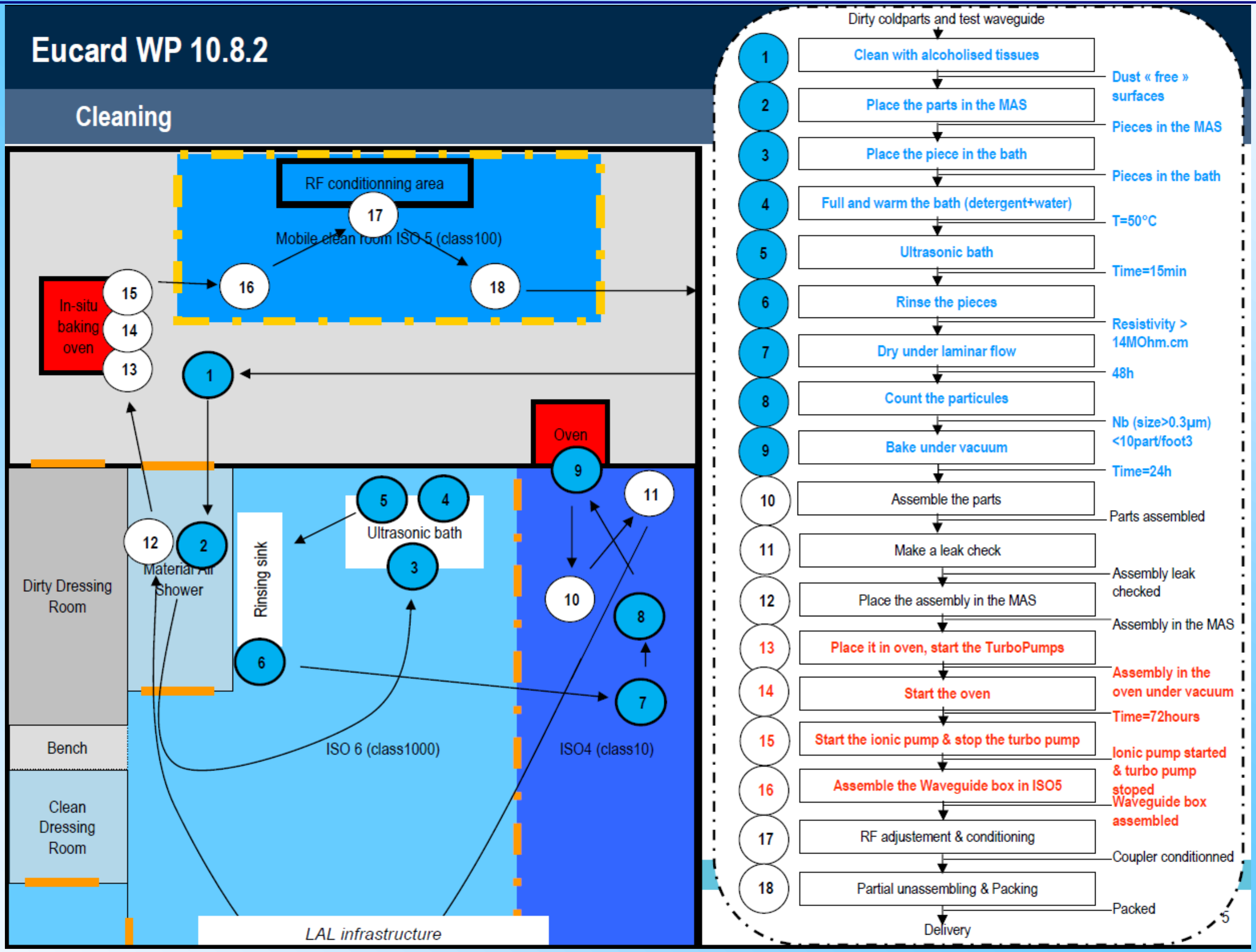
WP10.8: RF Coupler Cleaning at LAL



N°	Tâche
1	**Subtask 8.1: Cleaning studies**
2	**Argon discharge cleaning of couplers**
3	Experimental setup design
4	Hardware procurement
5	Argon discharge experiments
6	Coupler tests
7	Report
8	**High pressure rinsing on samples**
9	Samples procurement
10	Sample plating and coating
11	High pressure rinsing experiments
12	Sample analysis
13	Report
14	**Milestone 10.8.1: Argon discharge cleaning and HPR results and analysis**
15	**Subtask 8.2: Automatic coupler cleaning**
16	Rinsing station design
17	Hardware procurement
18	Coupler rinsing tests
19	Coupler conditioning
20	Report
21	**Milestone 10.8.2: Automatic cleaning procedure**
22	**DELIVERABLE 10.8.1: Test and operation of the coupler preparation procedure**

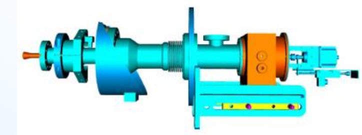


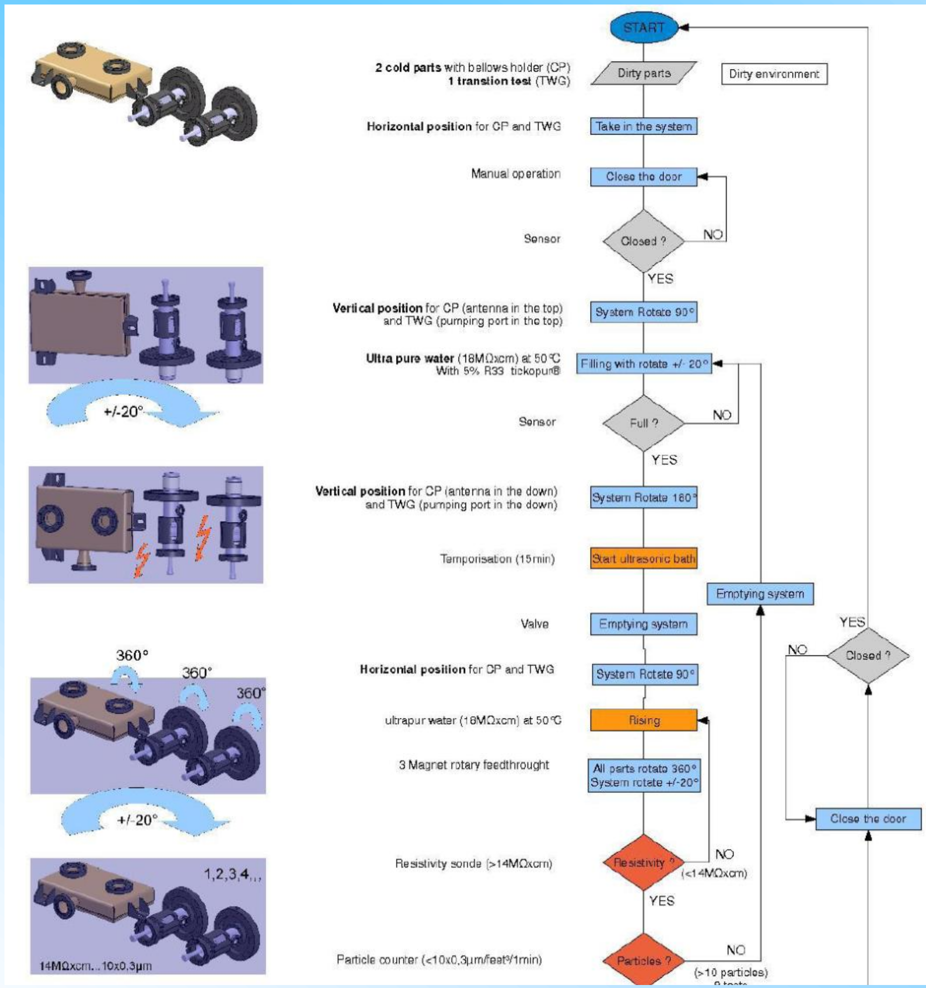
WP10.8: RF Coupler Cleaning at LAL

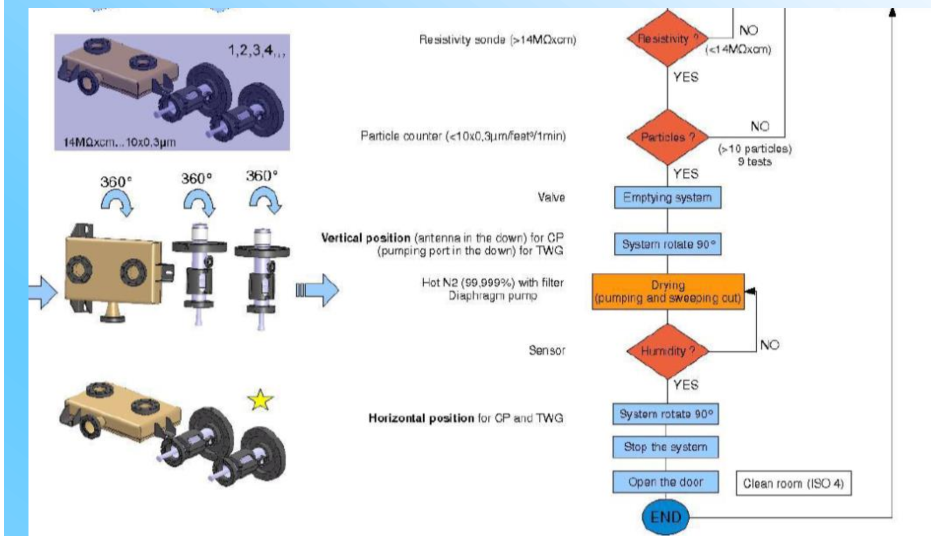


The man-made preparation procedure: E-XFEL case for 800 couplers

WP10.8: RF Coupler Cleaning at LAL

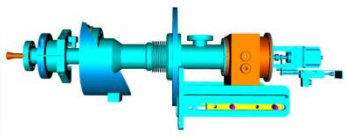






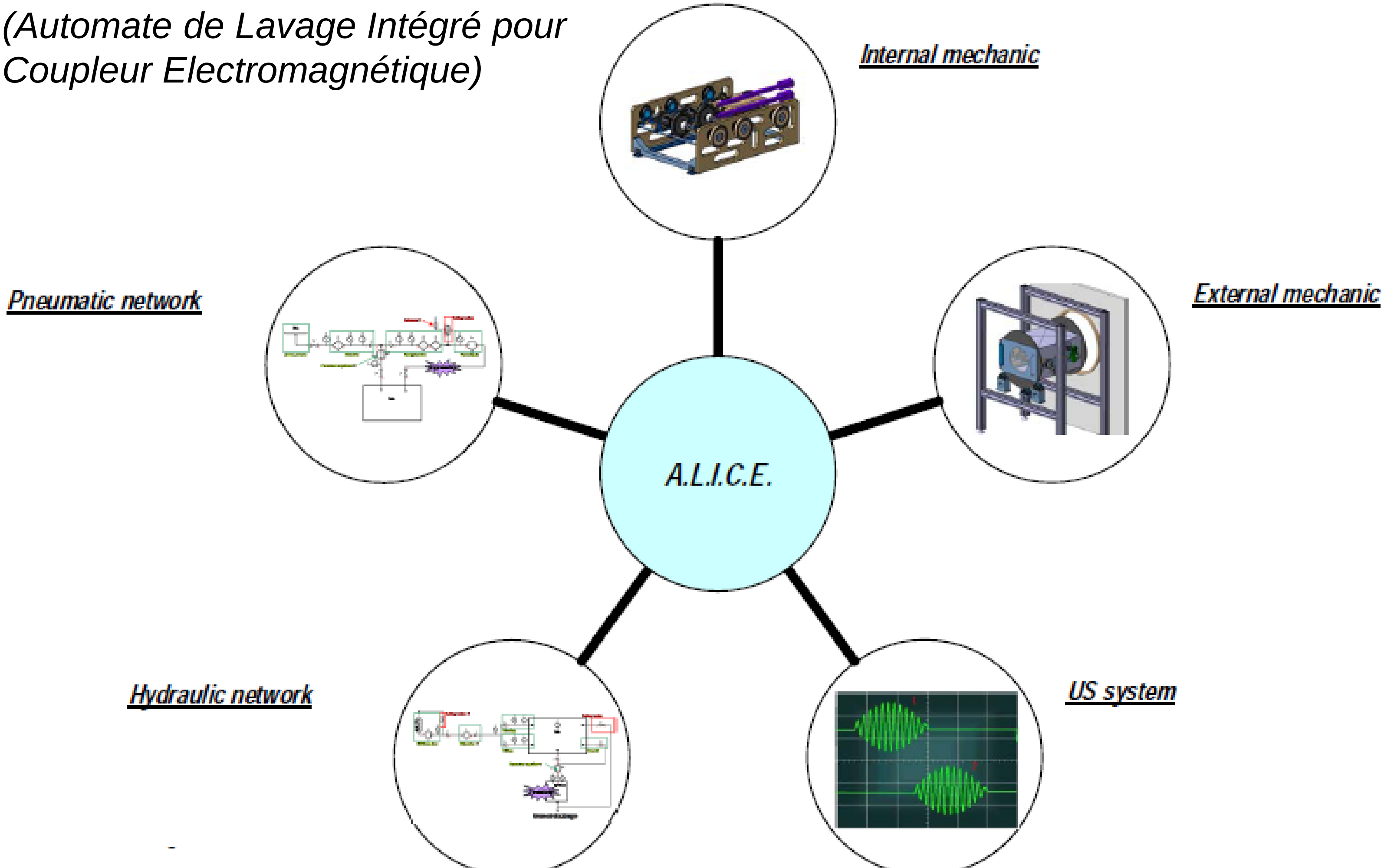
The EuCARD automated reparation procedure

WP10.8: RF Coupler Cleaning at LAL

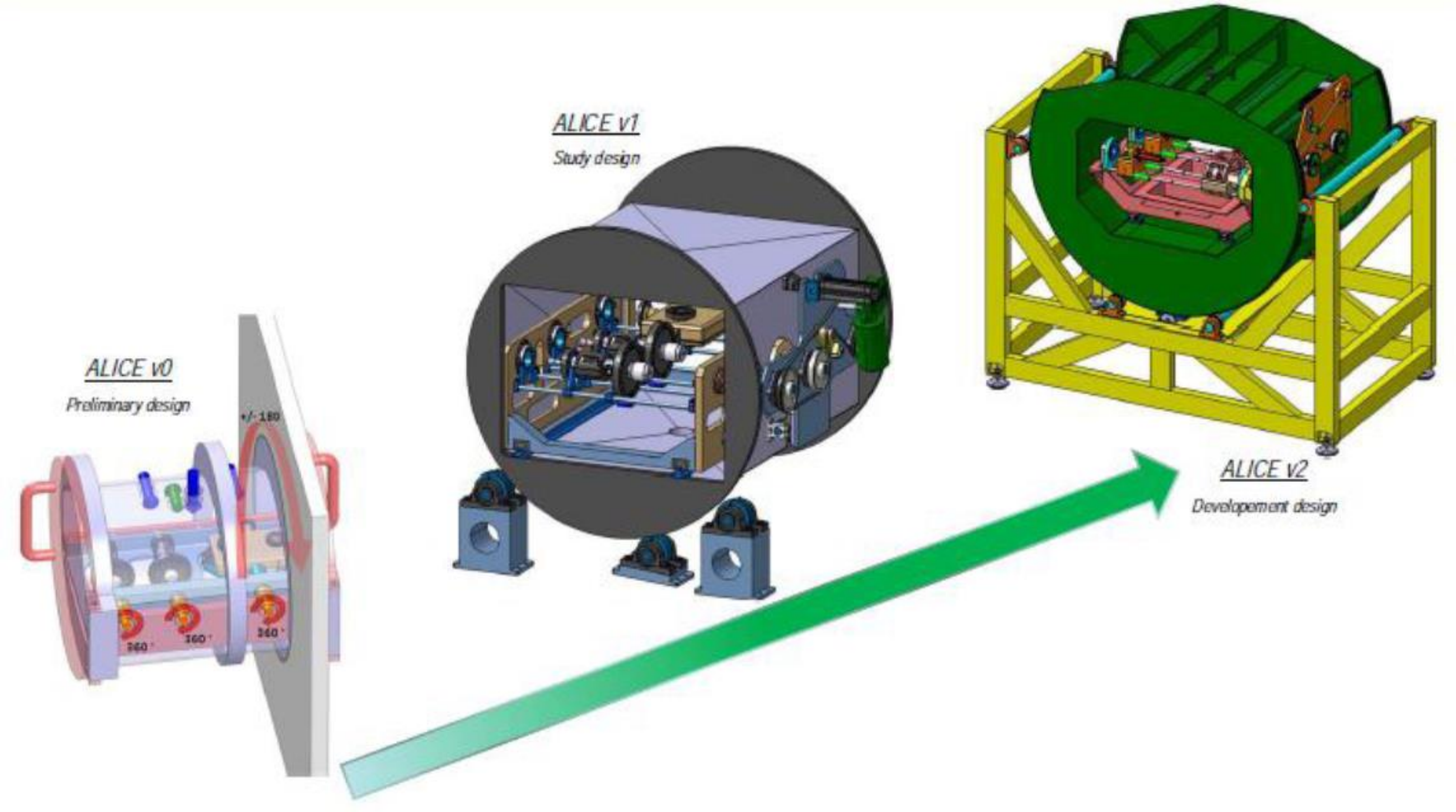


A.L.I.C.E. overview

(Automate de Lavage Intégré pour Coupleur Electromagnétique)

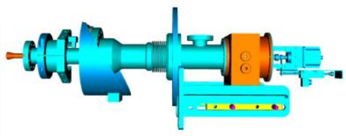


WP10.8: RF Coupler Cleaning at LAL



Evolution of the concept of automatic coupler washer, over the 4 past years

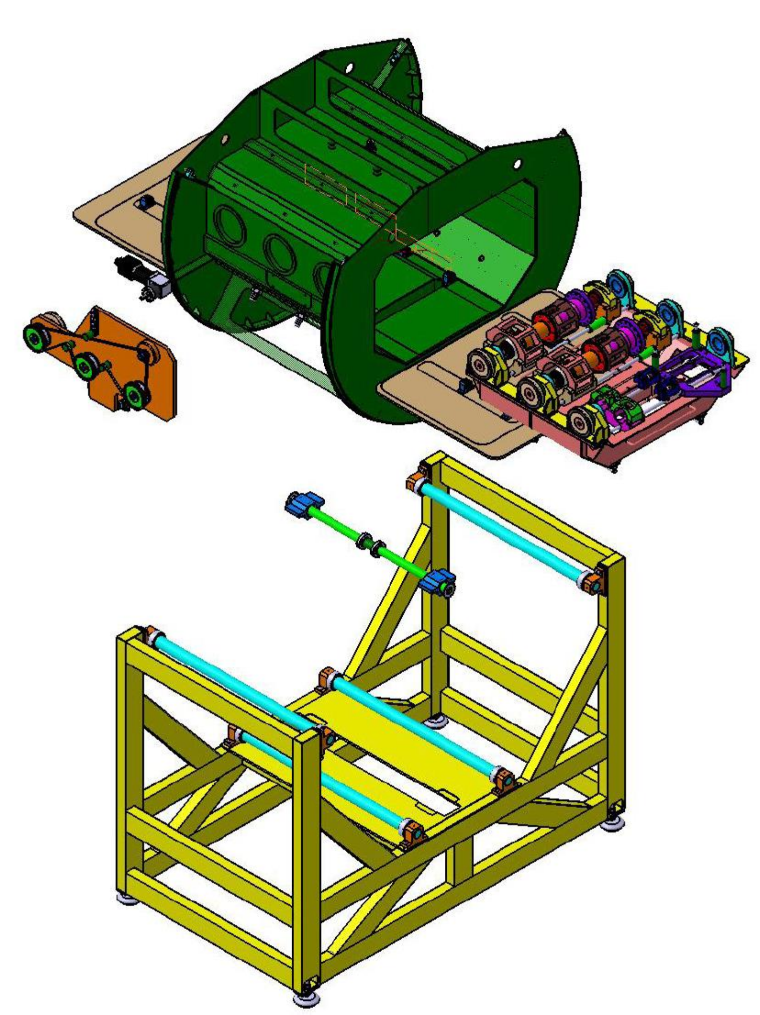
WP10.8: RF Coupler Cleaning at LAL



The studies of ALICE are complete enough to give us a complete overview and estimation of the feasibility, the process and the costs: the efficiency of the process, as far as the large mass production is concerned, is undisputed.

The cost of a such machine as ALICE is estimated at 150 k€.

All the technical functions can be respected to clean couplers automatically and correctly without any damage for them.



ALICE design v2

SRF Superconducting Radio Frequency

WP10-SRF: The fifteen deliverables

Ref.	N°	Deliverable Name	Deliverable Type	Task	Delivered by Contractor (s)	Planned (in months)	Achieved (in months)
10.4.1	1	QE data for Pb/Nb deposited photo cathode samples	Report	Thin Films	DESY, NCBJ	12	14
10.7.1	2	Results of slice measurements	Report	SCRF Gun	FZD, HZB	24	26
10.8.1	3	Test and operation of the coupler preparation procedure	Report	Coupler Development	CNRS-LAL	24	50
10.4.4	4	New thin film techniques for SC cavities and photocathodes	Report	Thin Films	ULANC	30	48
10.2.1	5	Results of SC proton cavity tests (β = 1 and β = 0.65)	Report	SPL cavities	CEA, CNRS-IPNO	33	Sept'13
10.7.2	6	Results for GaAs photocathodes	Report	SCRF Gun	FZD, HZB	33	50
10.3.1	7	LHC crab cavity final report	Report	Crab cavities	CERN	36	47
10.3.2	8	CLIC crab cavity final report	Report	Crab cavities	UNIMAN	36	47
10.3.3	9	LHC and CLIC LLRF final reports	Report	Crab cavities	ULANC	36	48
10.4.2	10	RF measurements on thin film deposited QWR prototype	Report	Thin Films	CERN	36	48
10.4.3	11	Cold test results for the test cavities w/out the deposited lead photo cathode	Report	Thin Films	DESY	36	43
10.5.1	15	HOM electronics and code to probe beam centring on 3.9 GHz cavities	Report	HOM distribution	DESY	48	50
10.5.2	12	Report on HOM experimental methods and code	Report	HOM distribution	UNIMAN	48	June'13
10.6.1	13	Report on system test and performance	Report	LLRF at FLASH	DESY	42	51
10.1.1	14	SRF web-site linked to the technical and administrative databases	Web-Site	Coordination	CEA, CERN	48	?

Thank You for Your Attention

Many thanks to:

Olivier Brunner
Stéphane Chel
Frank Peauger
Peter McIntosh
Sergio Calatroni
Roger Jones
Nicoleta Baboi
Mariusz Grecki
Jochen Teichert
Walid Kaabi