Status Report WP9, NCLinac

Grahame Blair/RHUL, Erk Jensen/CERN

16 April 2010

EuCARD 1st Annual Meeting

Preliminaries

To make this status report fit the allotted time, I could not do justice to all the work done.

I had to make omissions – please accept my excuses!

A more complete summary of all work done and results achieved will follow in the 2nd Semestrial Report.

Many thanks to all those who contributed to NCLinac and to this report!

NCLinac Tasks

9.1 Coordination and Communication

9.2 Normal Conduction High Gradient Cavities

9.3 Linac & FF Stabilisation

9.4 Beam Delivery System

9.5 Drive Beam Phase Control

NCLinac people matrix

	Coordination	High Gradient	Stabilisation	BDS	Phase control
CERN	Jensen	Riddone	Modena, Hauviller, Mainaud-Durand, Vorozhtsov		Andersson, [Needed]
CIEMAT		Toral, Carillo			
CNRS/LAPP			Jeremie		
INFN/LNF					Marcellini, Franzini
PSI					Dehler
RHUL	Blair			Blair, Boogert	
STFC/ASTEC				Angal-Kalinin	
UH		Österberg, Nordlund, Djurabekova, Pohjonen, Houpana			
UNIMAN		Jones, D’Elia, Khan		Appleby	
UOXF-DL			Burrows, Urner		
UU		Ziemann, Ruber, Palaia, Muranaka			

9.2 Normal Conduction High Gradient Cavities

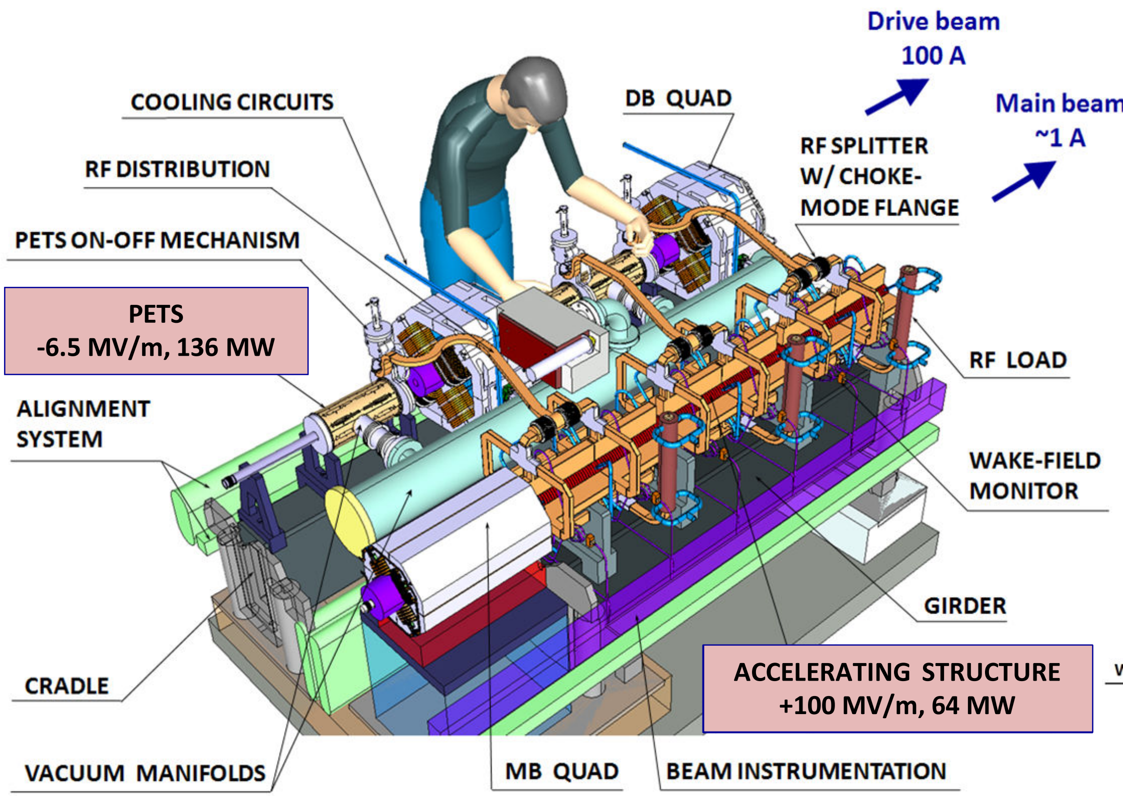
Sub-tasks (Co-ordination: CERN):

1. PETS (CIEMAT)
2. HOM Damping (UNIMAN)
3. Breakdown simulation (UH) *covered by Highlight Talk*
4. Instrumentation (UU)
5. Precise Assembly (UH)

This task is embedded in a major collaboration,

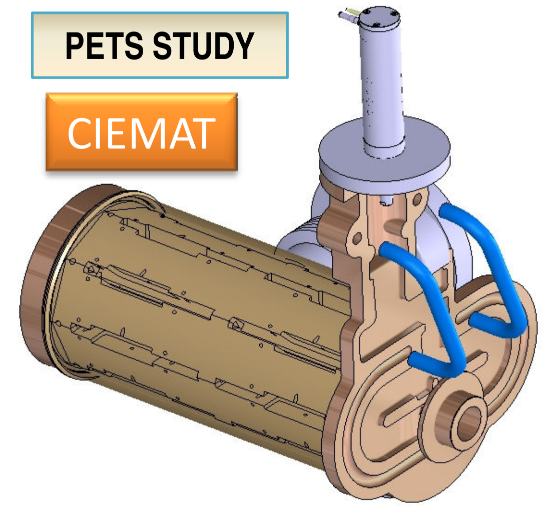
it is addressing (along with task 9.3) primarily the CLIC module **integration**)

CLIC MODULE

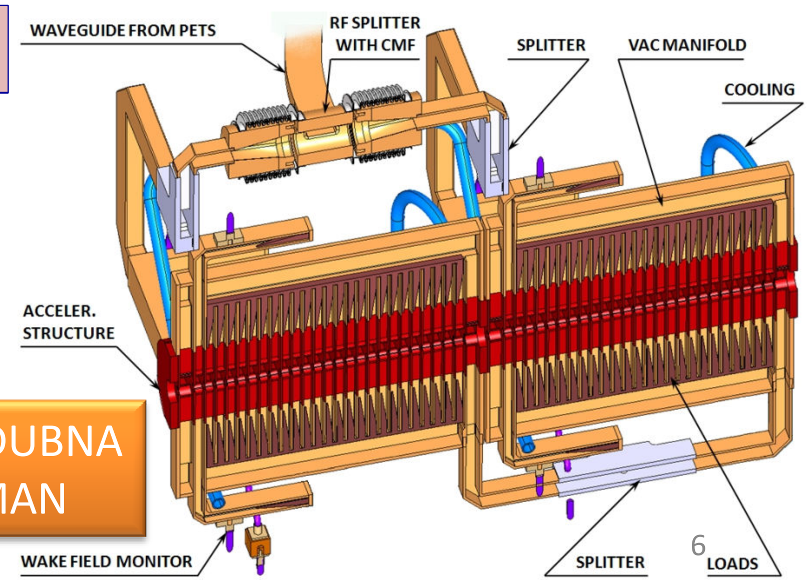


PETS STUDY

CIEMAT



ACCELERATING STRUCTURE STUDY



HIP, DUBNA
UNIMAN

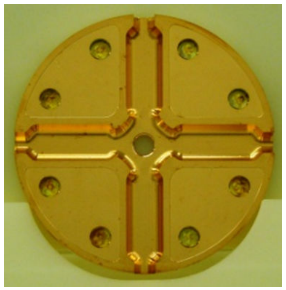
Approx. NUMBER of CLIC MODULES 21,000

- **ACCELERATING STRUCTURES – 143,000**
- **PETS – 71,500**
- **QUADRUPOLES:**
  Main Beam – 4,000
  Drive Beam – 42,000

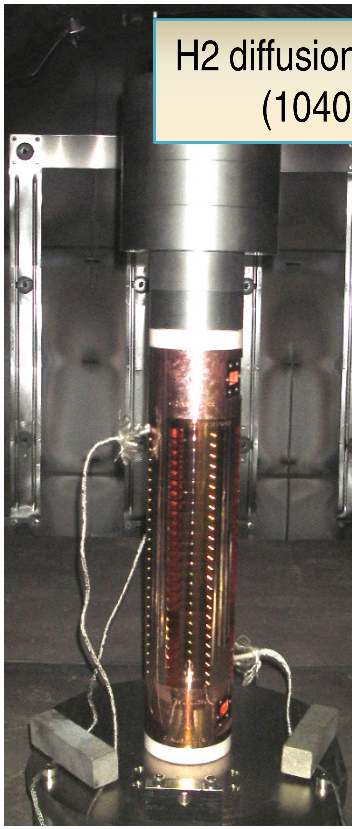
CERN
STRUCTURE PRODUCTION

HIP, DUBNA

NLC / JLC FABRICATION TECHNOLOGY VALIDATED TO 100 MV/m

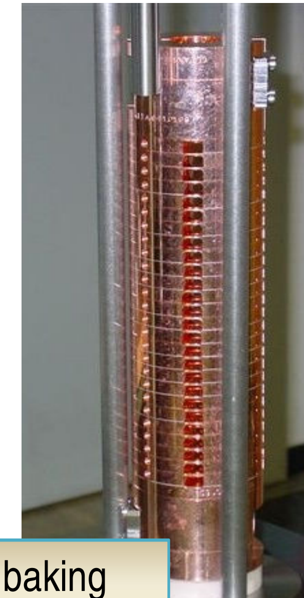


Damped disk after machining

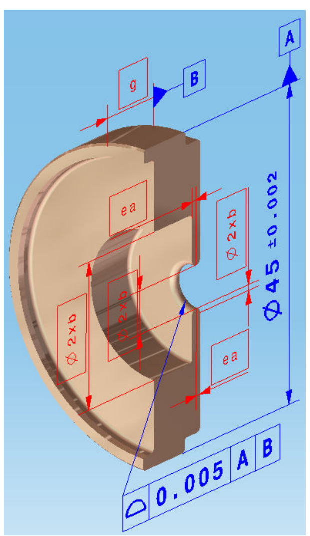


H2 diffusion bonding (1040 ˚C)

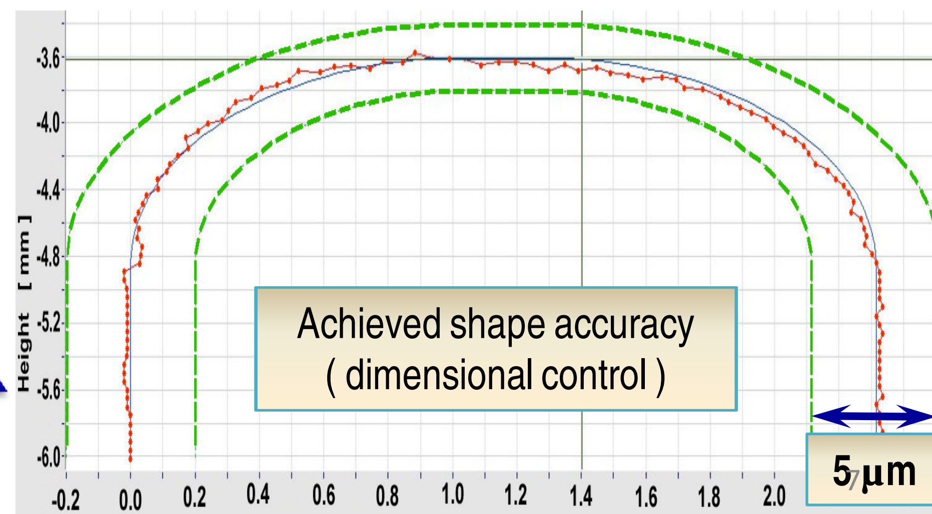
RF check in the clean room



Vacuum baking (650 ˚C)



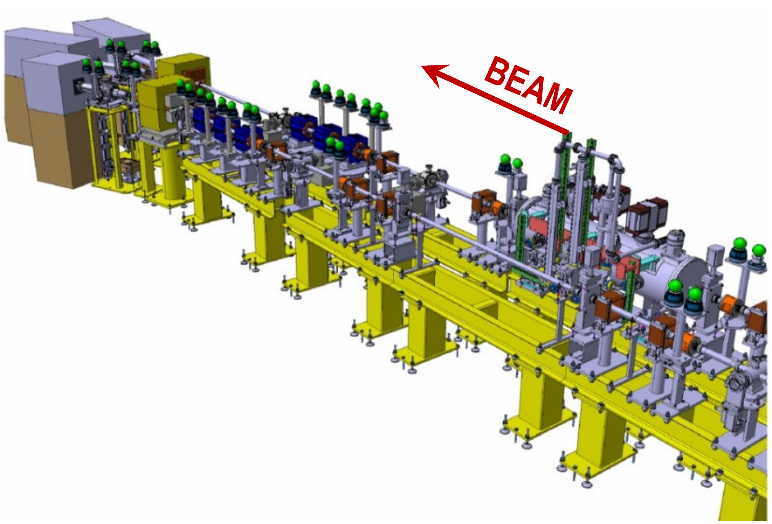
Mechanical design

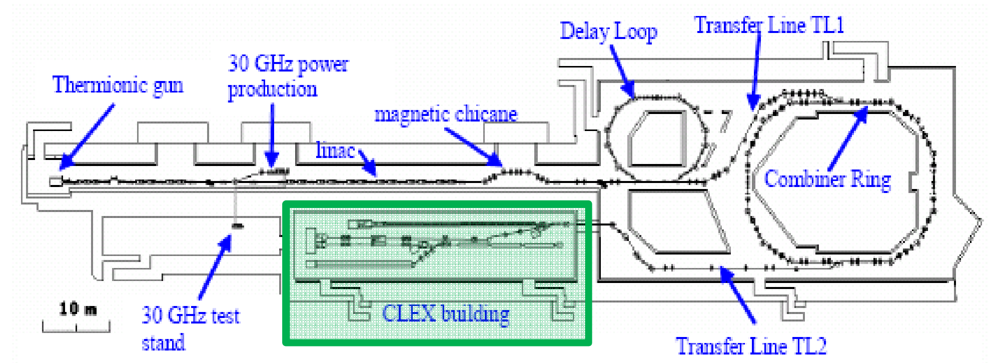


Achieved shape accuracy (dimensional control)

5 µm

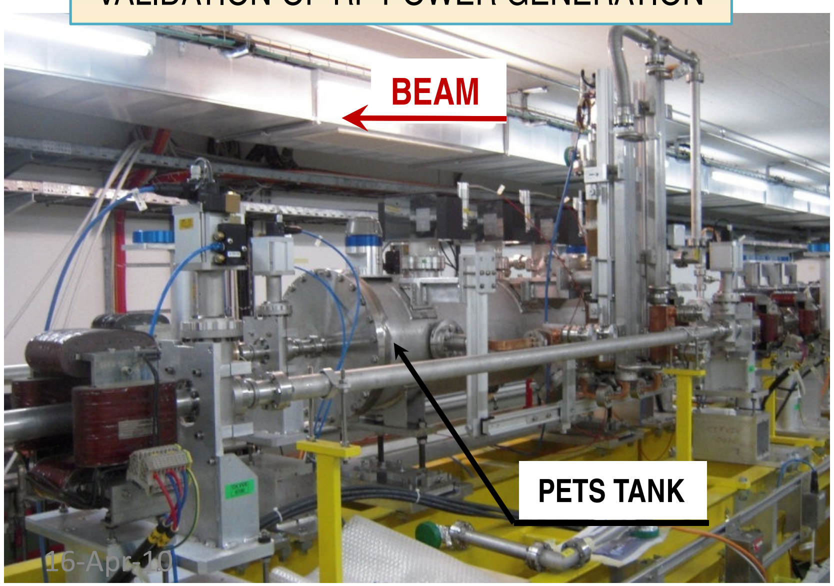
TWO-BEAM TEST STAND IN CLEX

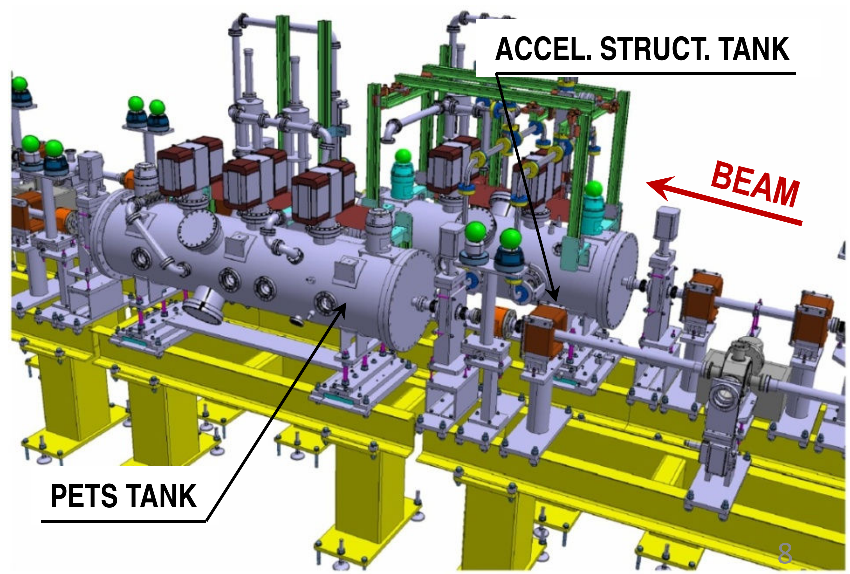




PHASE 1: PETS ONLY (2008-2009)
VALIDATION OF RF POWER GENERATION

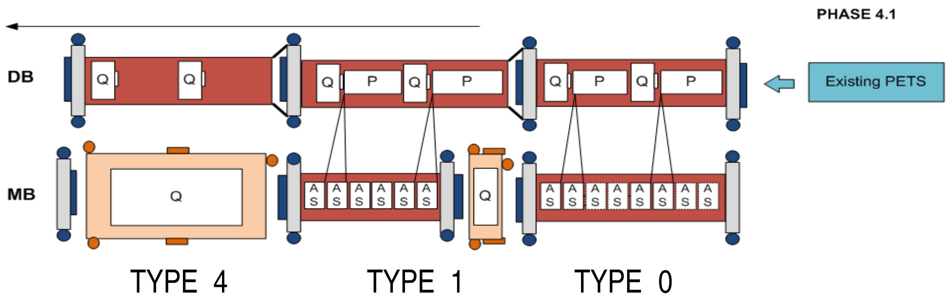
PHASE 2: PETS AND AC. STRUCTURES (2009-2010)
VALIDATION OF CLIC ACCELERATION SCHEME





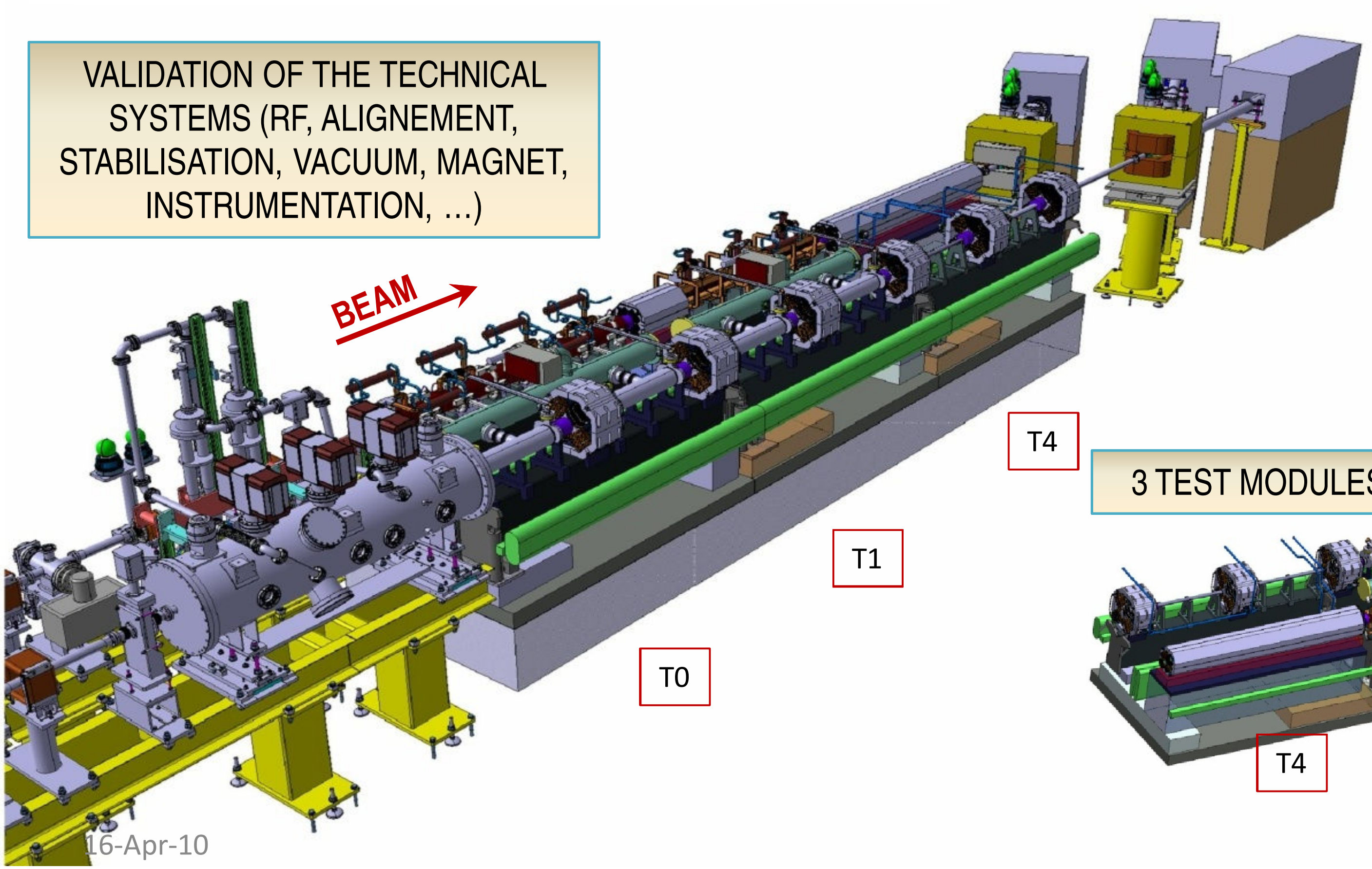
TEST MODULES IN CLEX

EuCARD

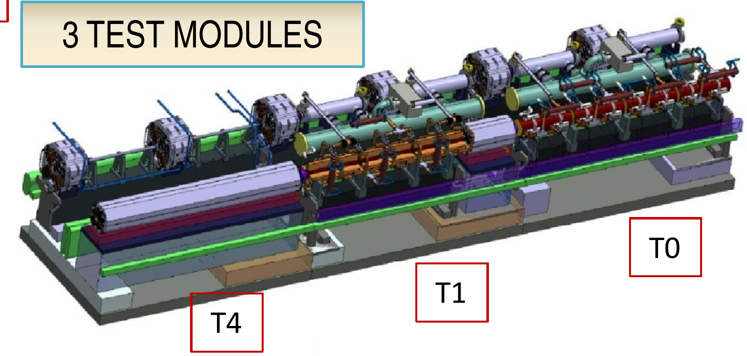


3 TEST MODULES (2011-2012)

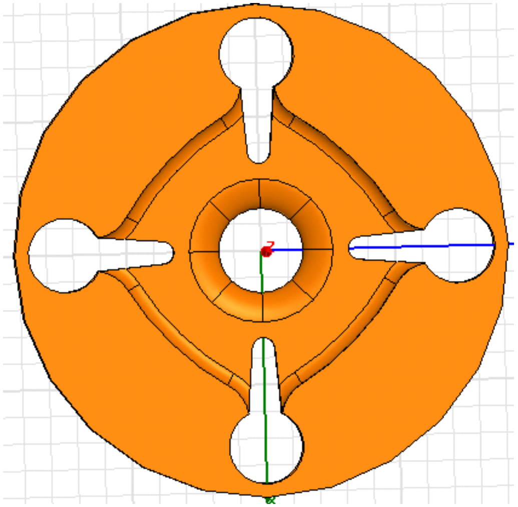
VALIDATION OF THE TECHNICAL SYSTEMS (RF, ALIGNEMENT, STABILISATION, VACUUM, MAGNET, INSTRUMENTATION, ...)

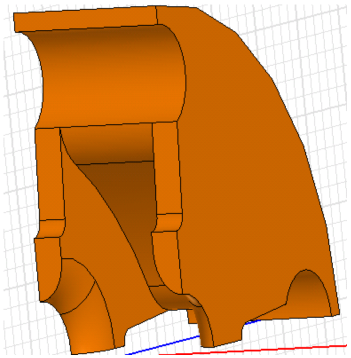


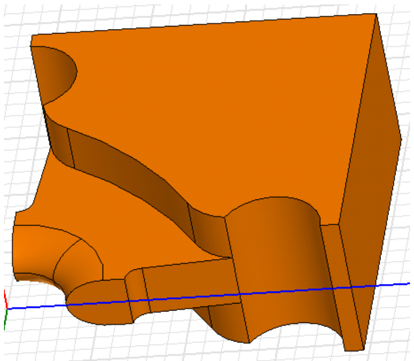
3 TEST MODULES

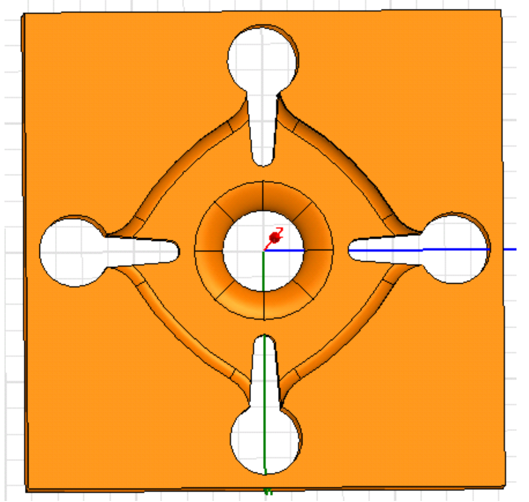


9.2.2: HOM Damping





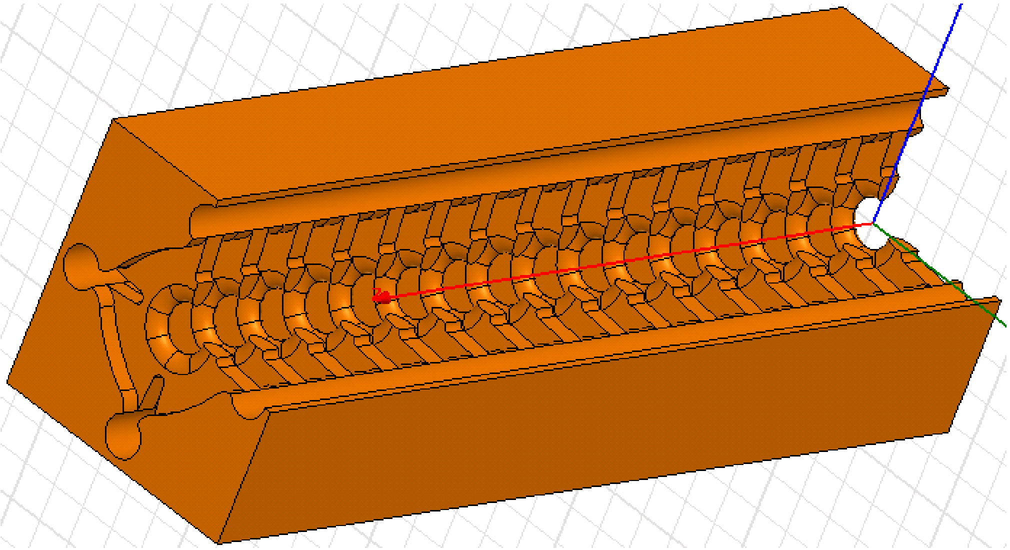




Main players:

Roger M. Jones
Vasim Khan,
Alessandro D'Elia

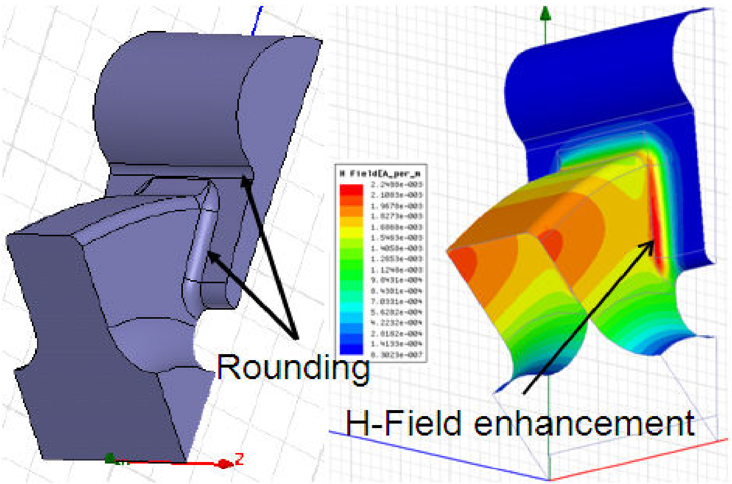
University of Manchester

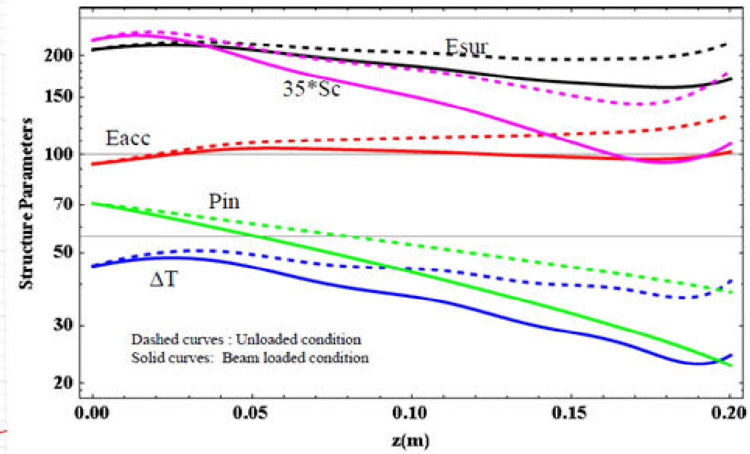


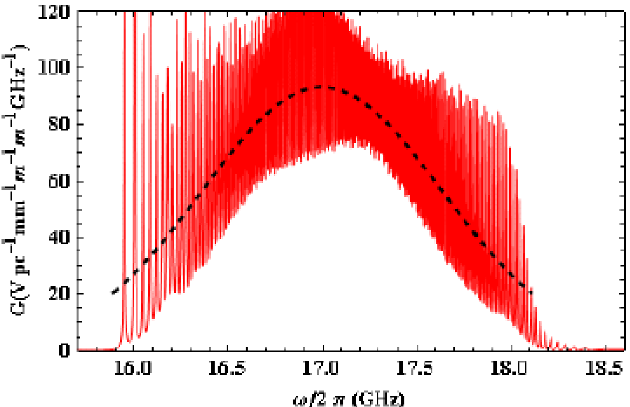
9.2.2

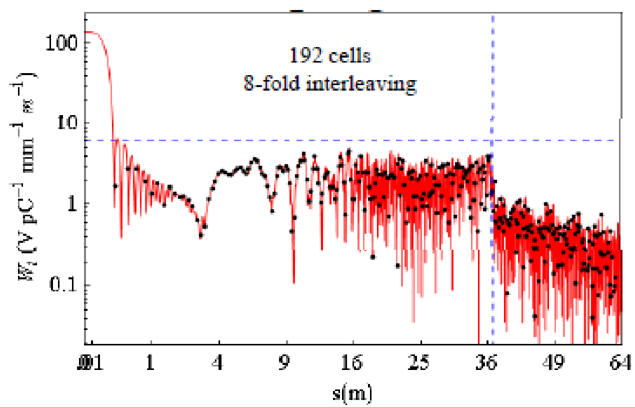
- Alternative design using moderate damping (Q~1000) and strong detuning of a series of interleaved structures (8-fold interleaving of 24-cell structures).
- Design is finalised, with relaxed bunch spacing (6 to 8 RF cycles) which results in excellent wakefield suppression.
- A single structure will be fabricated with reduced HOM features in order to rapidly assess its ability to sustain and high fields and powers: **CLIC_DT_A**
- Main structure cells, complete with manifolds, finalised. Matching end cells are being designed – expect complete RF design by April 2010.
- CERN will complete mechanical engineering design (including fabrication of a single prototype).
- Structure involving HOM coupler **CLIC_DDS_B** will be designed and fabricated in 2011. Main cells already design but modified end cells are anticipated. RF design is being undertaken in parallel with CLIC_DT_A.

9.2.2: "*CLIC_DT_A*" Design







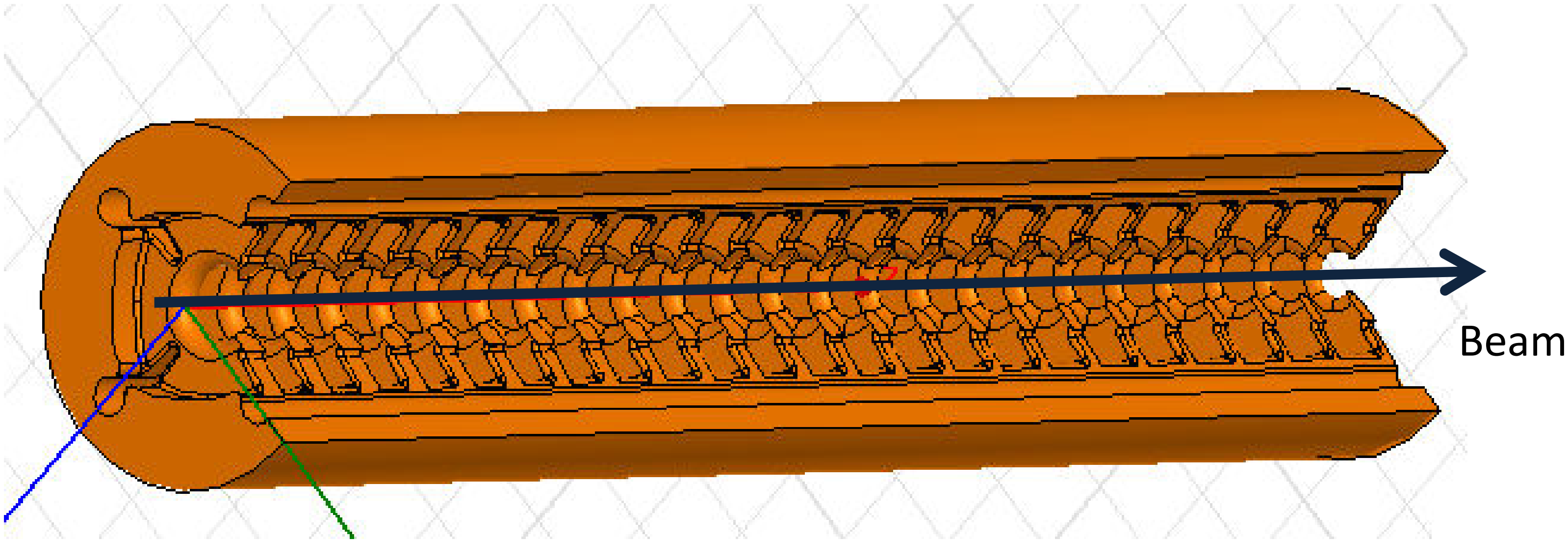


- ➢Rounding the slots enhances the magnetic field however a reduction of the slot size mitigates this enhancement and RF parameters are now back within required limits.
- ➢Wake suppression is well within the prescribed margins.

Major changes in DDS2 built for power tests (CLIC_DT_A)

- ➢ **To ease mechanical fabrication, manifold dimensions are now uniform throughout the structure.**
- ➢ **The manifold radius is parameterised to ensure the lowest manifold mode is >12 GHz.**
- ➢ **Coupling is reduced for half of structure, leading to non-optimal suppression, but wakefield is acceptable nonetheless!**
- ➢ **Last cell is partially over-coupled (not a cause for concern).**

9.2.2: "*CLIC_DT_A*"



9.2.3: Breakdown simulations

Thanks, Flyura and Kai, for your Highlight talk!

Main players:
Flyura Djurabekova, Kai Nordlund,
Helga Timkó, AarnePohjonen,
Stefan Parviainen, JuhaSamela,
AvazRuzibaev

HIP (University Helsinki)

Summary:

- Modeling gives clear insight to the ongoing processes,
- Finite Element Modeling reveals the temperature and deformation distribution along an accelerating structure,
- Modeling of DC electrical breakdown can shed the light on the metal surface response to the electrical field effect also in case of RF electrical breakdown,
- Simulation of craters created by formed plasma reveals the dependence between energy deposition and crater shape.

9.2.4: Instrumentation

Goals:

- Upgrade of Two-beam-test-stand (TBTS) with diagnostics (Flashbox)
- Breakdown experiments in electron-microscope
- Breakdown understanding (analytical model of gas-burst dynamics)

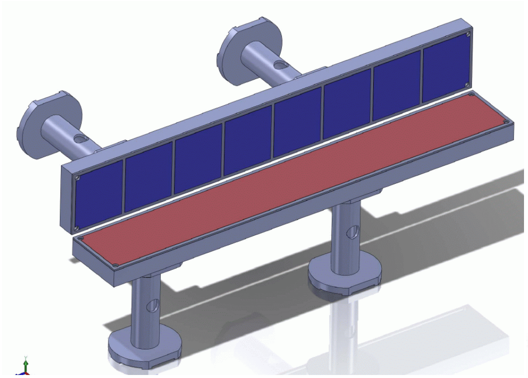
Main players:
Roger Ruber, Volker Ziemann,
Tord Ekelöf, A. Palaia, T. Muranaka (from May 1st)

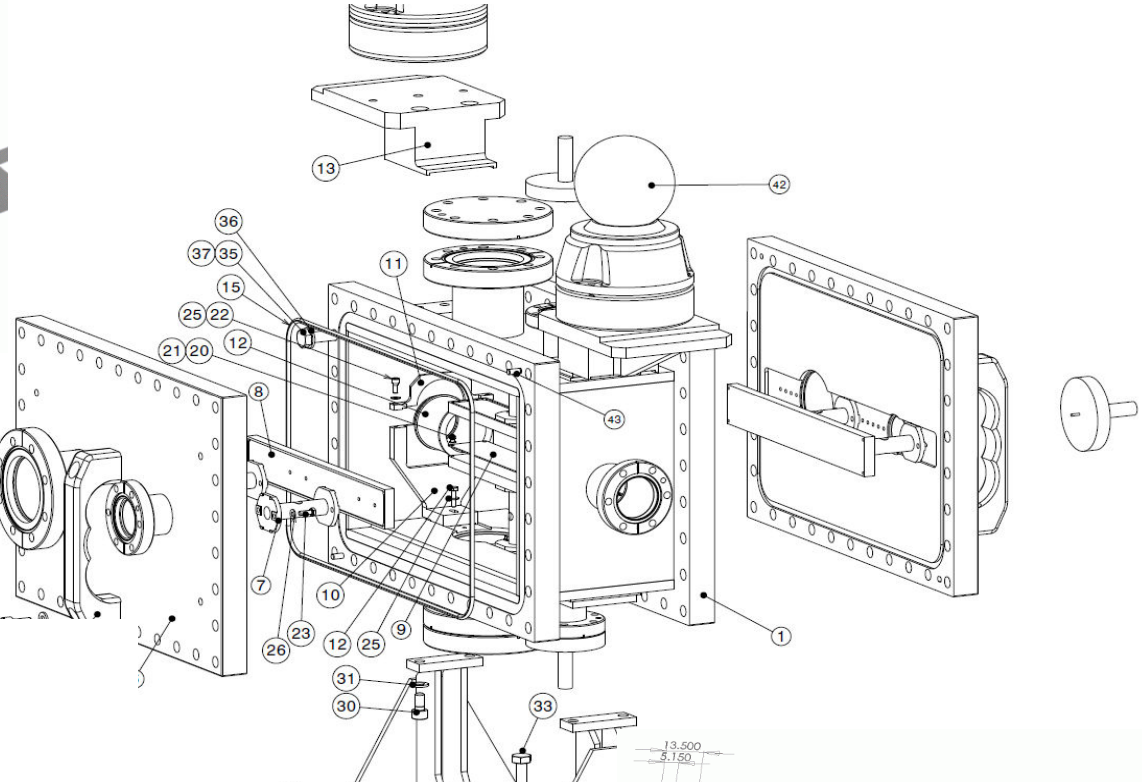
Uppsala University

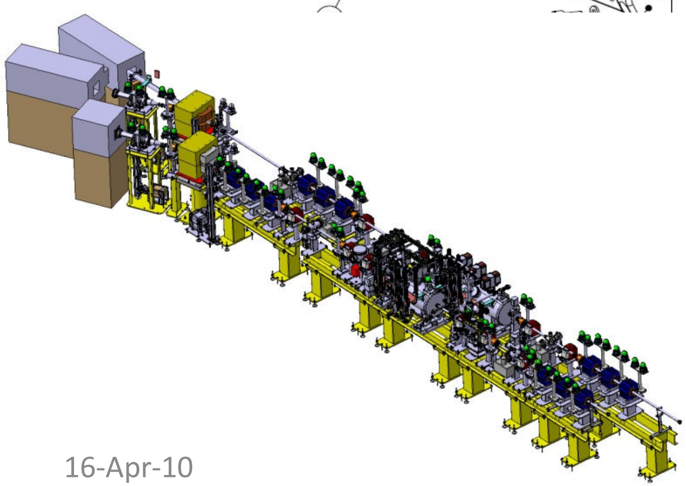
UPPSALA UNIVERSITET

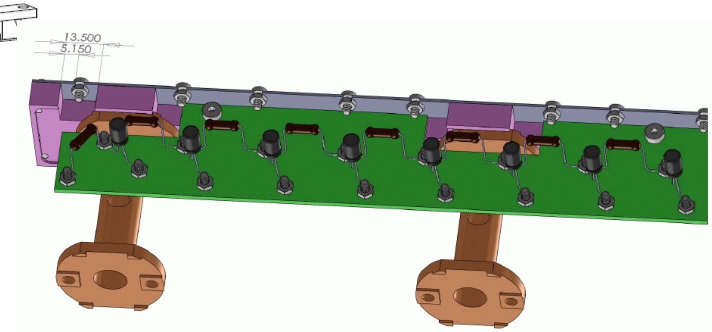
EuCARD

9.2.4: Flashbox for detection of electrons and ions ejected in RF structures in TBTS









9.2.4: Positioning Tests in Electron Microscope

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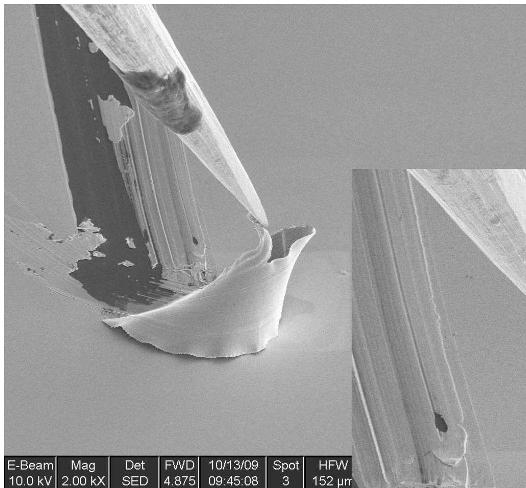
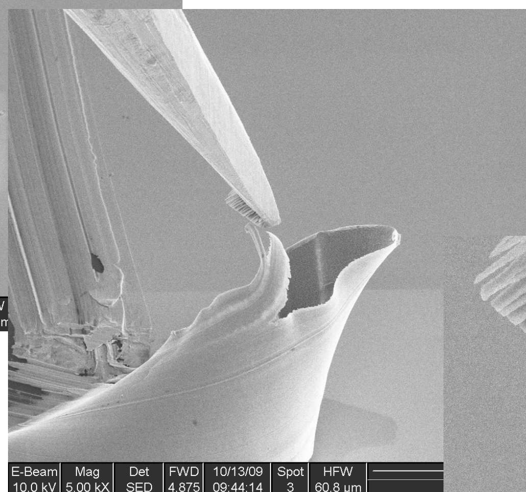
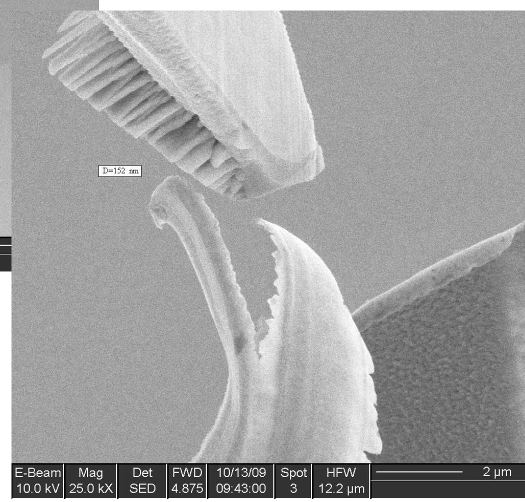
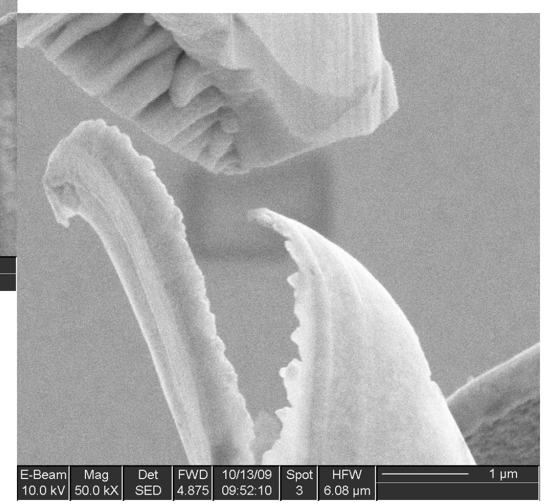
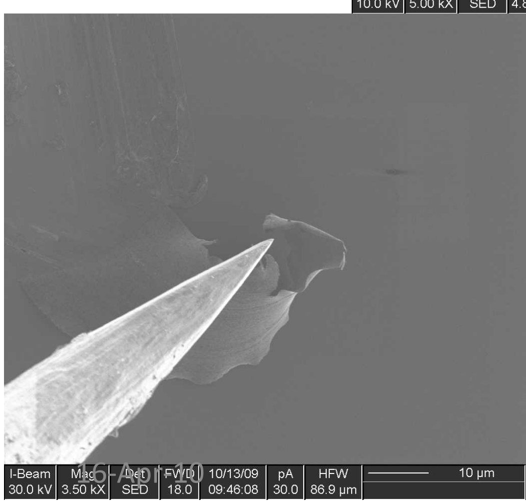








- FEI Strata DB235
- FIB & SEM
- 150 nm, tip sharpening



Ion image

9.2.4: Gas burst dynamics

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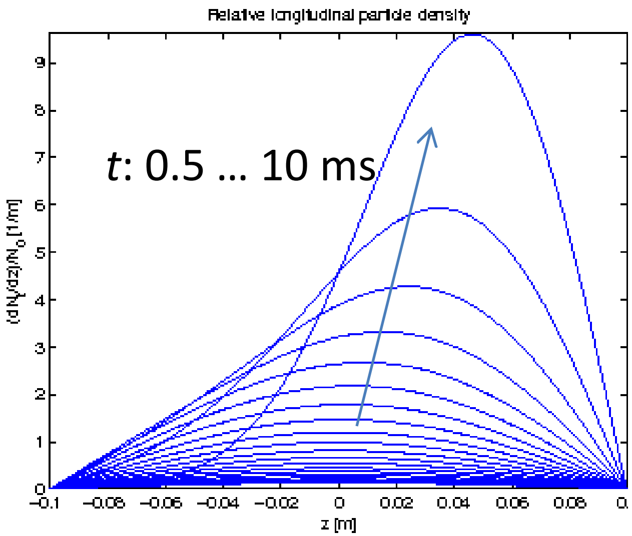
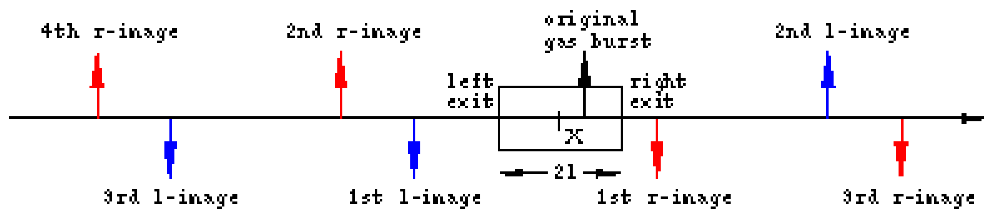
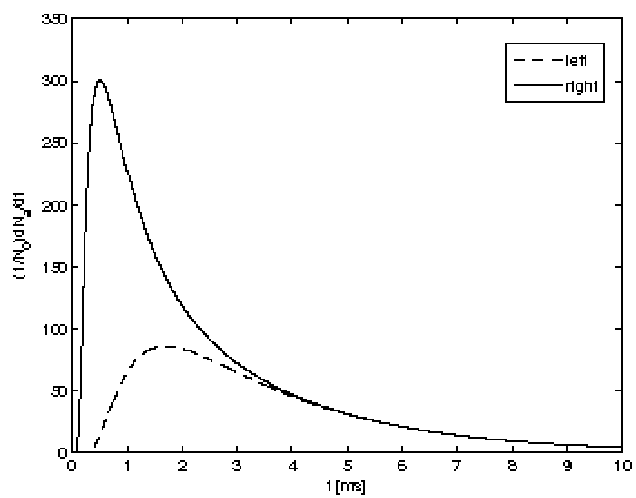
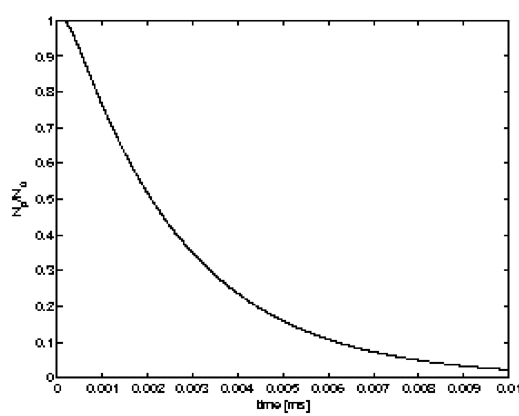
$$v\frac{\partial}{\partial t}P = \frac{\partial}{\partial z}c\frac{\partial}{\partial z}P - sP + q$$

$$\frac{dN}{dz}(z,t) = \frac{N_0}{\sqrt{4\pi Dt}}\exp\left[-\frac{(z-z_0)^2}{4Dt}\right]$$









- entirely analytical analysis
- recently added distributed pumps

9.2.5: Precise assembly

- Goal: Develop a strategy of assembly for the CLIC accelerating and power extractions structures satisfying the few to 10 μm precision requirement of positioning both radial and longitudinal taking account the dynamical effects during accelerator operation"

- Current status
  - Assembly test of high precision alignment method elastic averaging (for ACS quadrants, interesting also for octant PETS) – EuCARD publication
  - Design & simulation of the support for ACS & PETS in the CLIC module (in view of CLIC CDR) – finite element simulation of different configurations performed & technical sketch created.
  - Design of ACS made from interlocking disks with symmetrical assembly (CLIC-G) – manufacturing documentation to be made
  - Finite element simulation of residual stress & deformation during machining & brazing/bonding – for different structure configuration in disks & now also in halves – in progress

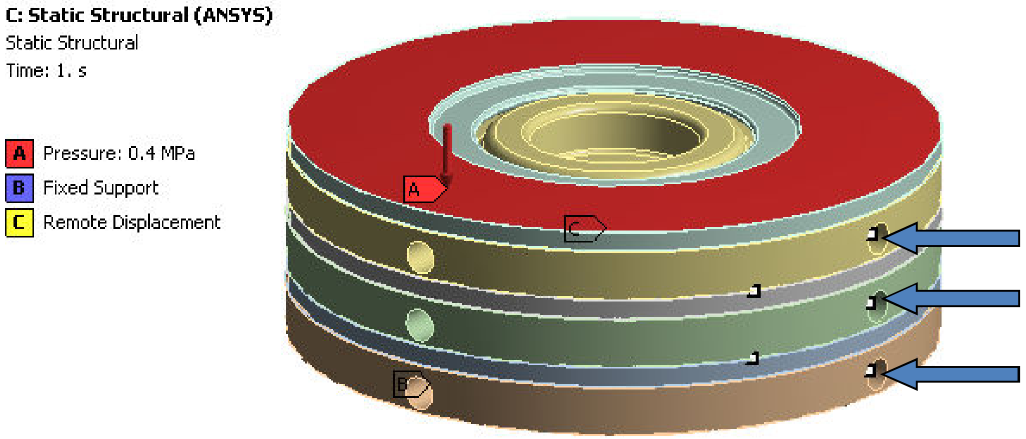
Main players:

Jouni Houpana, Kenneth Österberg

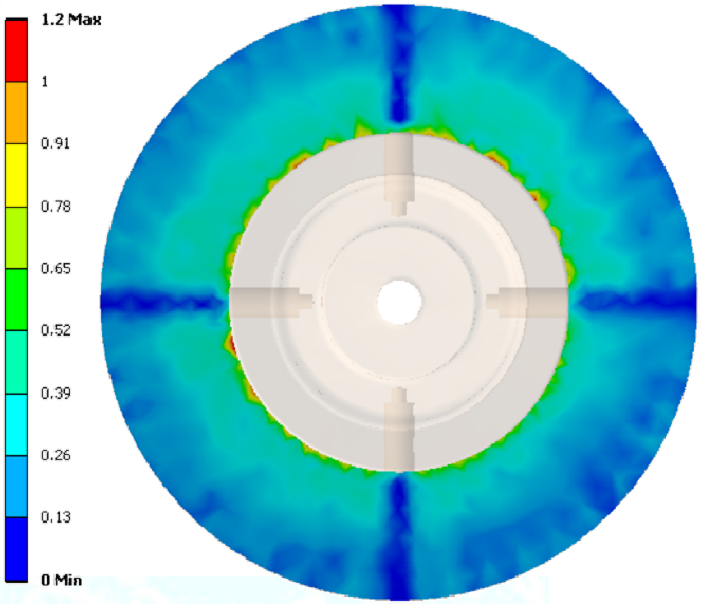
HIP, Helsinki University

HELSINKI INSTITUTE OF PHYSICS

9.2.5: Results on the effects of geometrical features



- Here a choke configuration was simulated with tuning holes.



- Average pressure is close to 0.59 MPa.
  - it can be seen that in the vicinity of the tuning holes the pressure is lower due to elastic deformation. (no gaps)

9.2.5 Conclusions

- Contact simulations show that pressure distribution is uneven on the contact areas
- Simulations give a comparative view between different ways to apply the pressure and provide information how the geometrical changes contribute to the contact.

Future work

- Continuing to provide information to the mechanical design/analysis of assembly with different configurations
- Participating to mass production study
- More in-depth bonding simulations – goal to see deformations during/after heat treatments & effects of applied pressure

9.3 Linac & FF Stabilisation

Sub-tasks (Co-ordination LAPP)

1. CLIC Main Linac quadrupole (CERN, LAPP)
   Thanks, Andrea, for the Highlight talk

2. Final Focus Stabilisation & Test stand
   - Interferometry at ATF2 (UOXF-DL)
   - Final Focus Quadrupole (CERN)
   - Stabilisation (LAPP)
   - Intra-train Feedback (UOXF-DL)

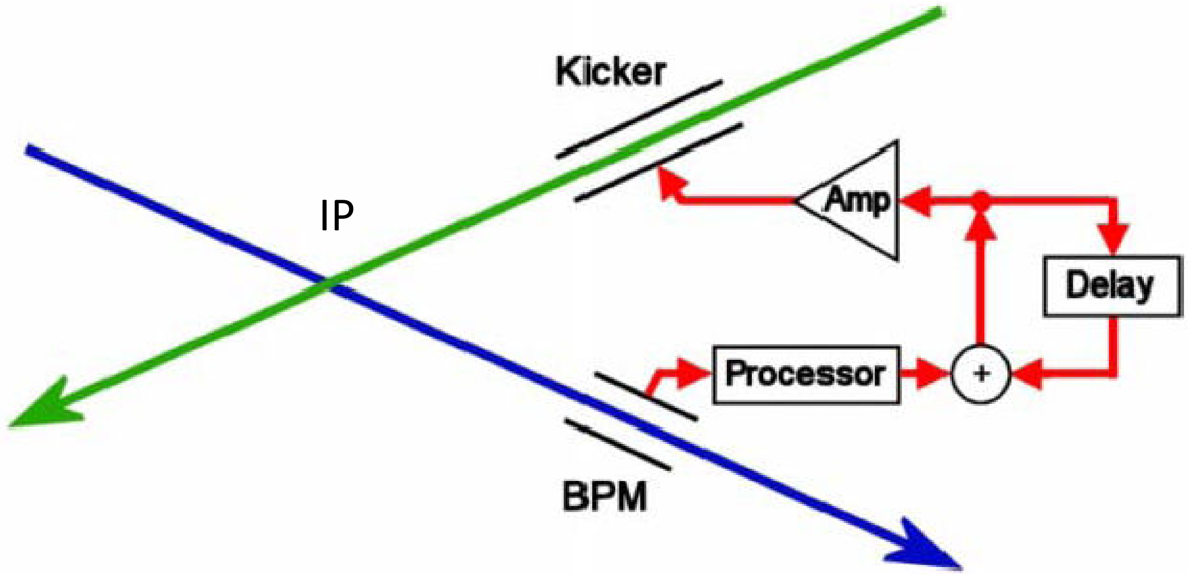
Main players:

A. Jeremie	LAPP
D. Urner, P. Burrows	JAI
C. Hauviller, K. Artoos, H. Mainaud-Durand, M. Modena	CERN

9.3.2: IP intra-train feedback system

Concept:

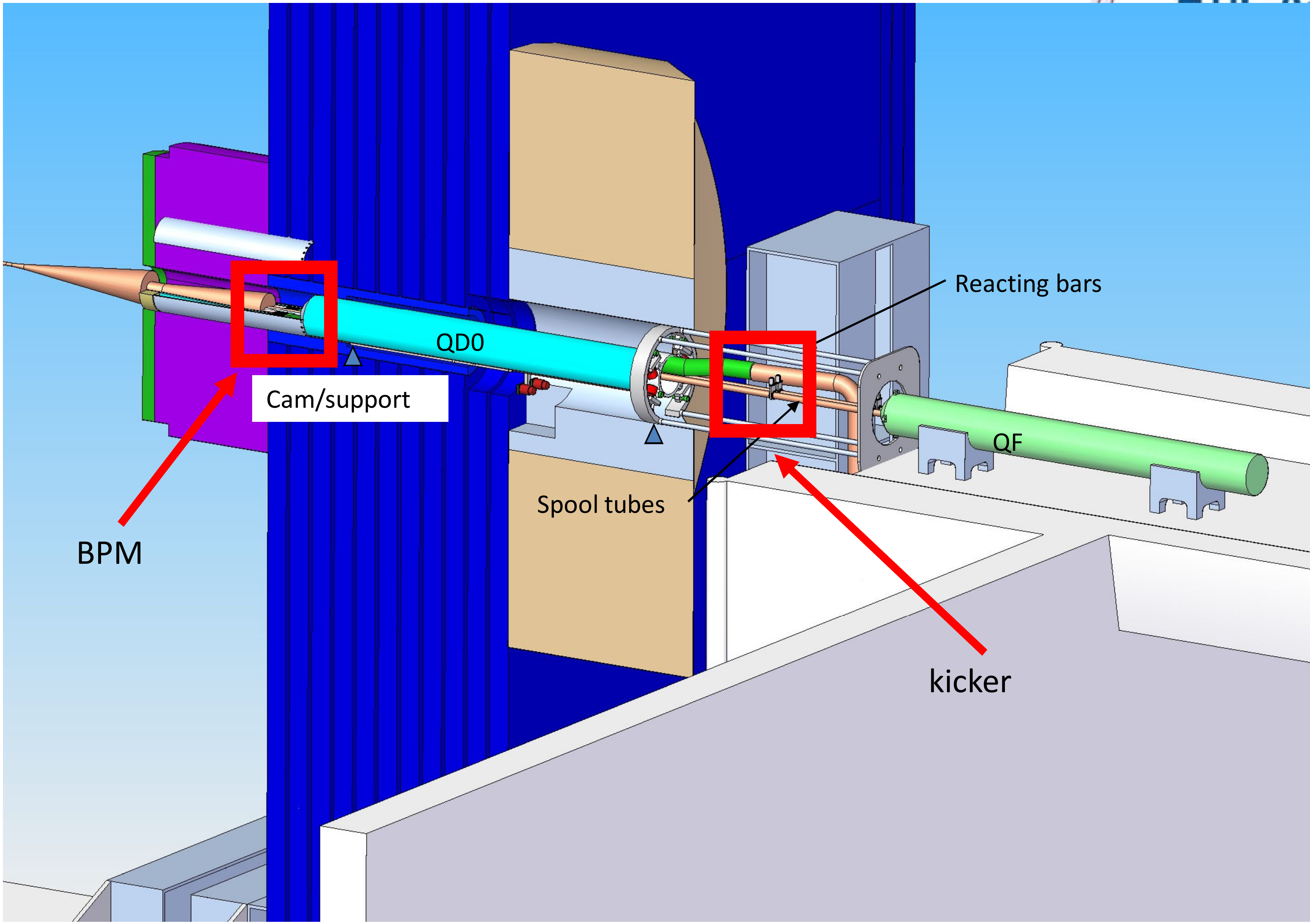
- Last line of defence against relative beam misalignment
- Measure vertical position of outgoing beam and hence beam-beam kick angle
- Use fast amplifier and kicker to correct vertical position of beam incoming to IR
- Prototype installed at ATF2
  (see Andrea's Highlight talk)



FONT – Feedback On Nanosecond Timescales

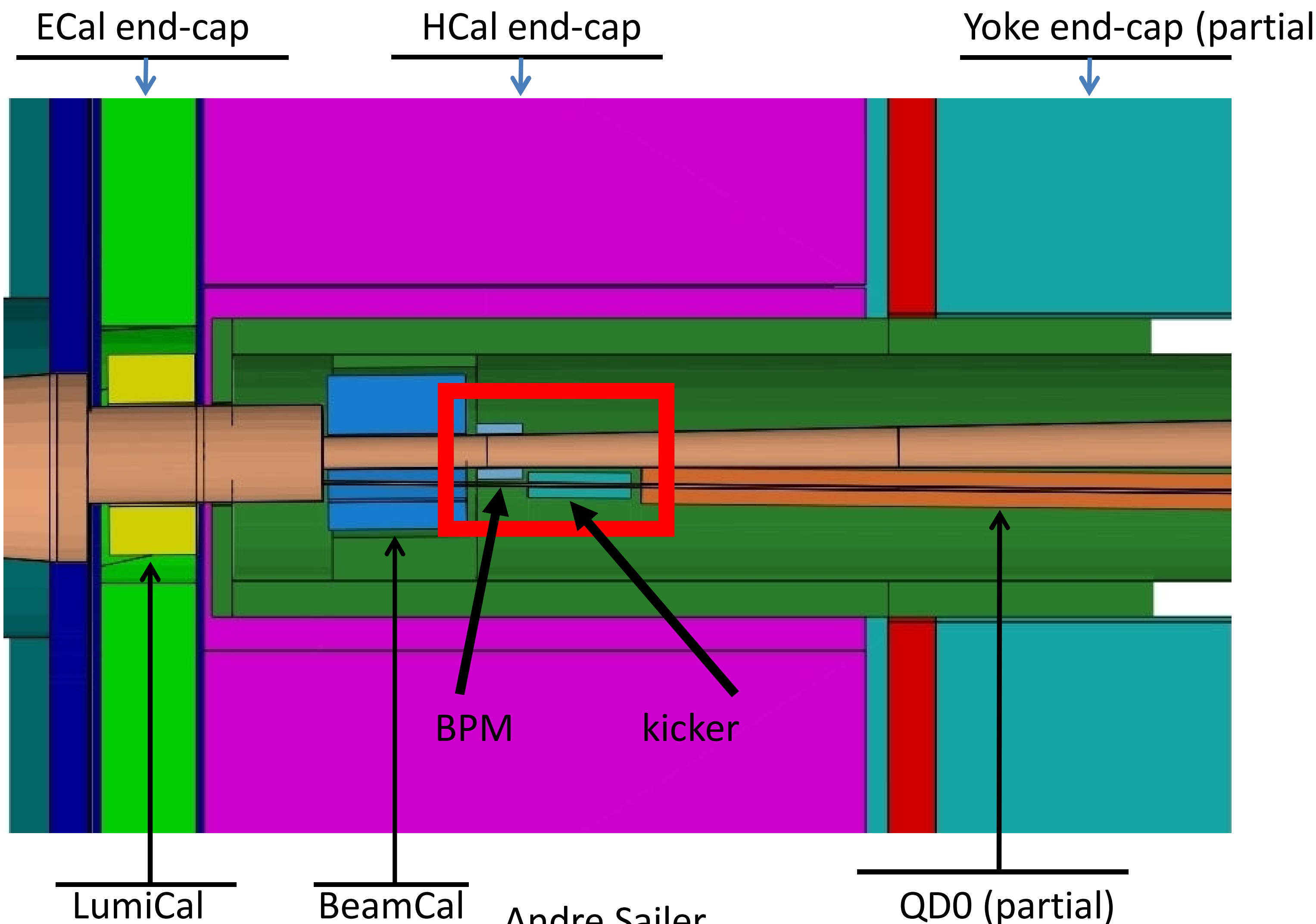
(Oxford, Valencia, CERN, DESY, KEK, SLAC)

9.3.2: ILC Intra-train Feedback Engineering Design (SiD detector)



Opening 2 m on the beam

9.3.2: Concept adapted for CLIC IR



Andre Sailer

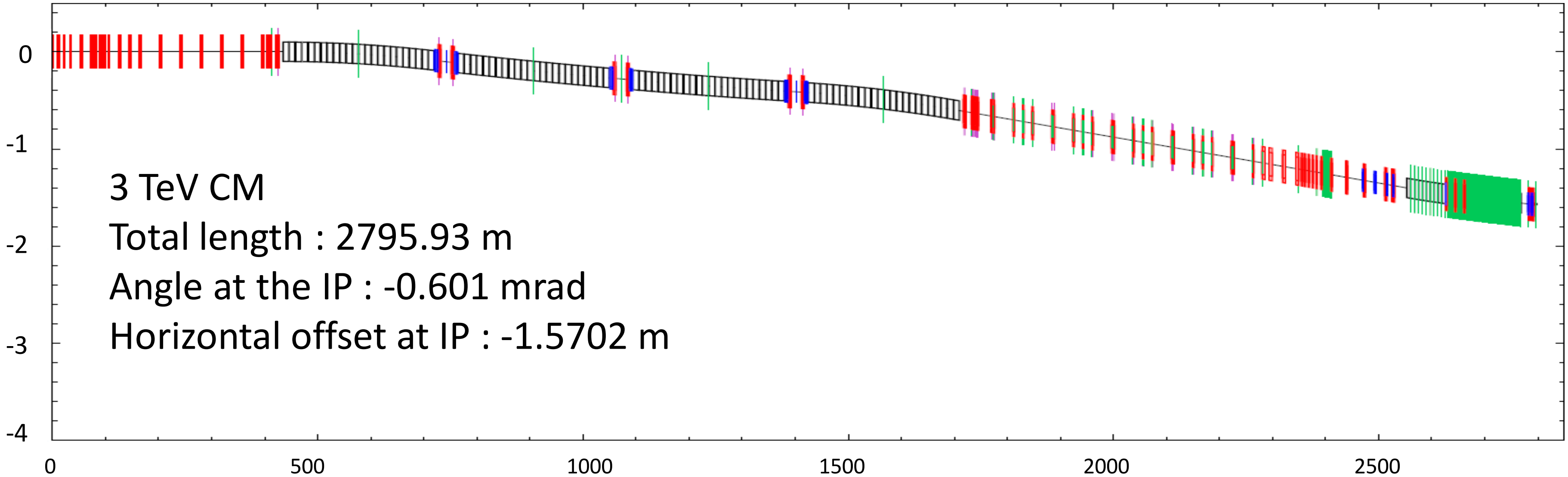
9.4 Beam Delivery System

Sub-tasks (Co-ordination RHUL)

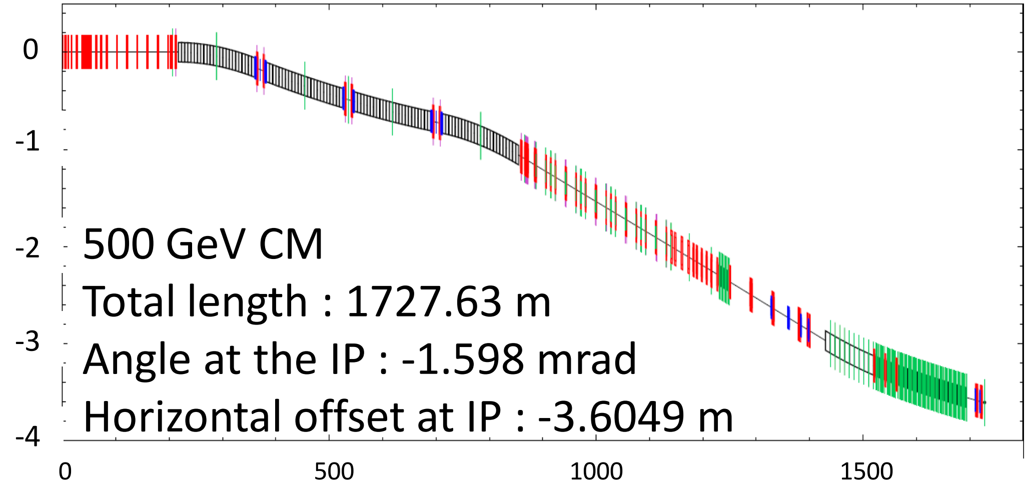
1. ATF2 Tuning – and its application to ILC and CLIC FF/IR region (STFC & UNIMAN)
2. Laser-wire (RHUL)
3. BPM (RHUL)

Main players:
G. Blair, S. Boogert (RHUL)
D. Angal-Kalinin (ASTEC/STFC)
R. Appleby (UNIMAN)

9.4.1: CLIC BDS, 0.5 … 3 TeV c.m.

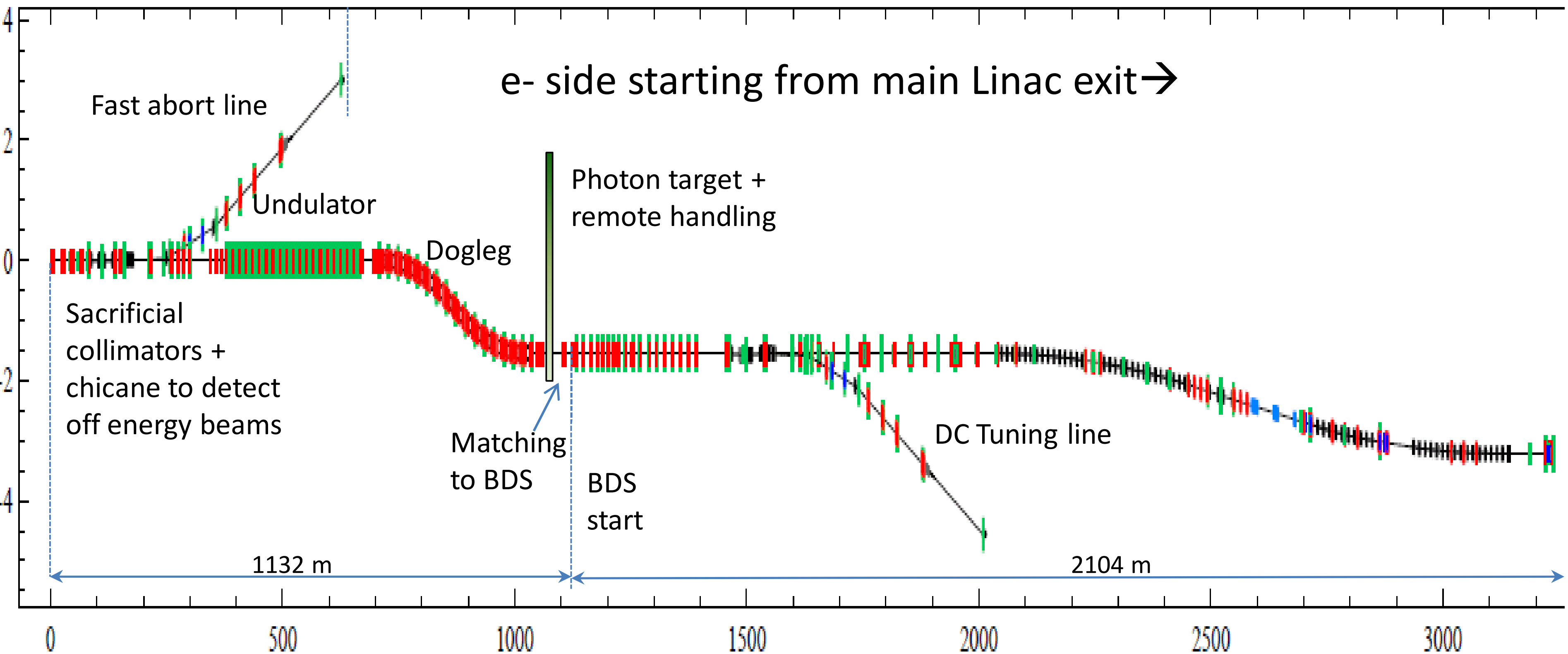


Followed up by the CLIC team to accommodate the layout changes in the same tunnel.



D. Angal-Kalinin

9.4.1: ILC BDS, including undulator



Needs dogleg design to accommodate photon target for e+ with satisfying the layout constraints and without much degradation of emittance at 1 TeV CM due to synchrotron radiation in dipoles of dogleg.

J. Jones, D.Angal-Kalinin

9.4.2: Laser-Wire, ATF2 Infrastructure installation

EuCARD

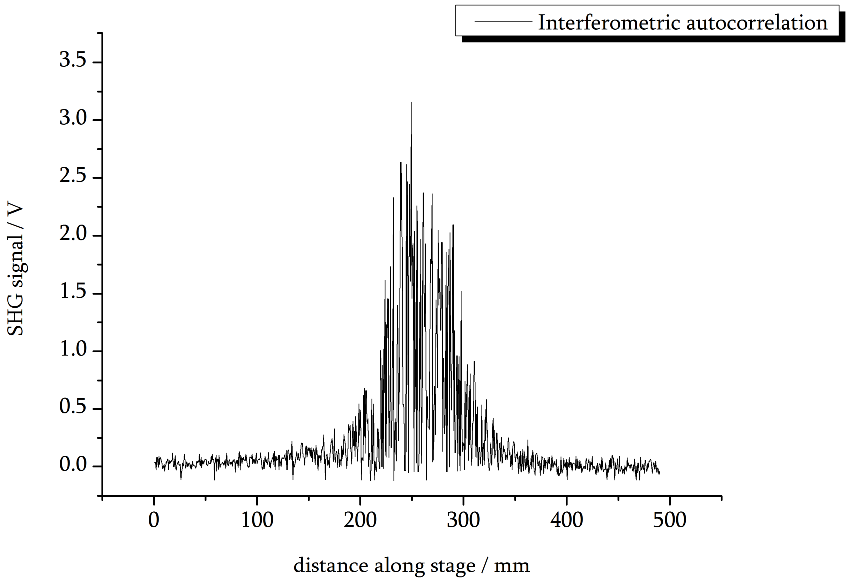
- Large laser room on ATF2 shield blocks
  - Facility for future users
  - 6 m optical table
  - Temperature stabilised
  - Seismic safe

9.4.2: ATF2 Laser Tests

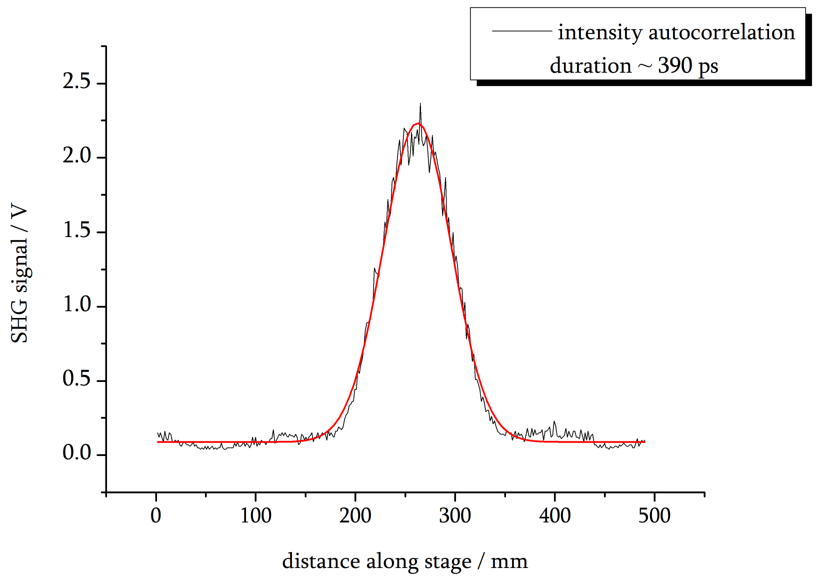
Tasks completed:

1. Check laser working (sorted out cooling) – very good
2. Started work on software for DAQ and experiment control
3. Set up temperature logging around laser hut
4. Aligned cw laser into tunnel and through laser-wire IP
5. Completed laser pulse duration measurements
6. Started laser spatial quality measurements

Laura Corner
Laurie Nevay
Stewart Boogert
Alex Aryshev (KEK)



Interferometric autocorrelation



Intensity autocorrelation

9.4.3: BPM

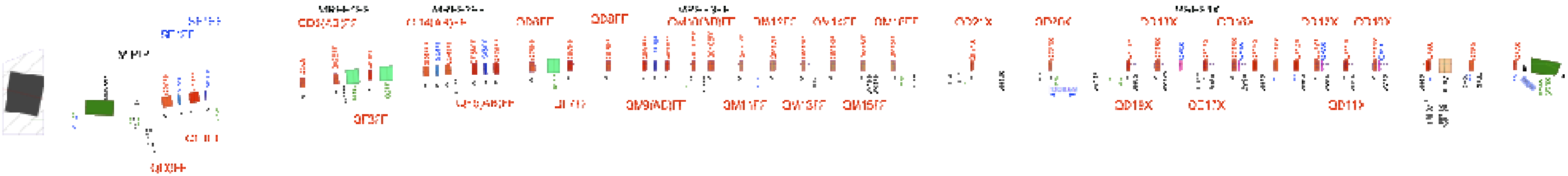
Highlights for last 6 months (RHUL):

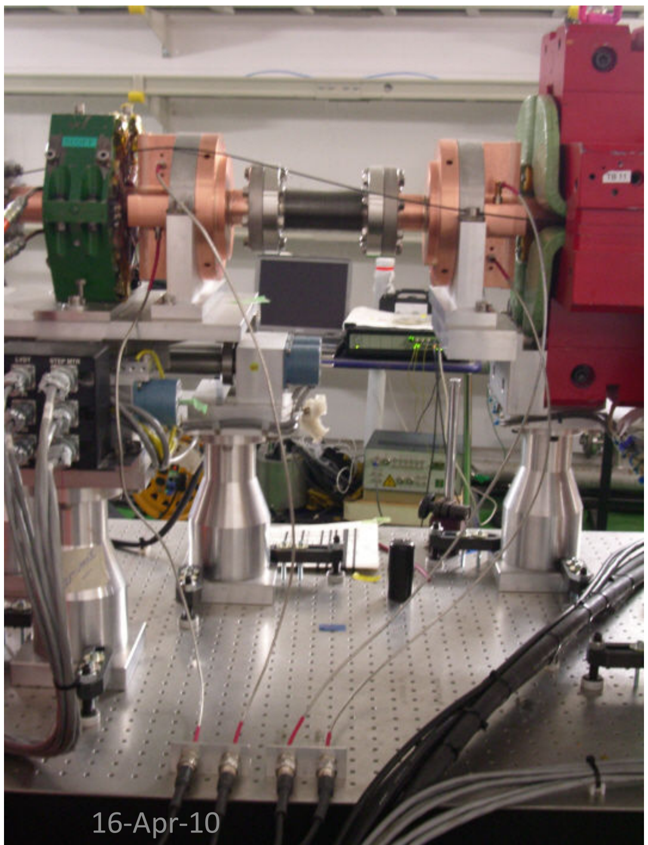
- Commissioning of the ATF2 BPMs
- 250 nm resolution
- Recruitment of RA nearly complete.

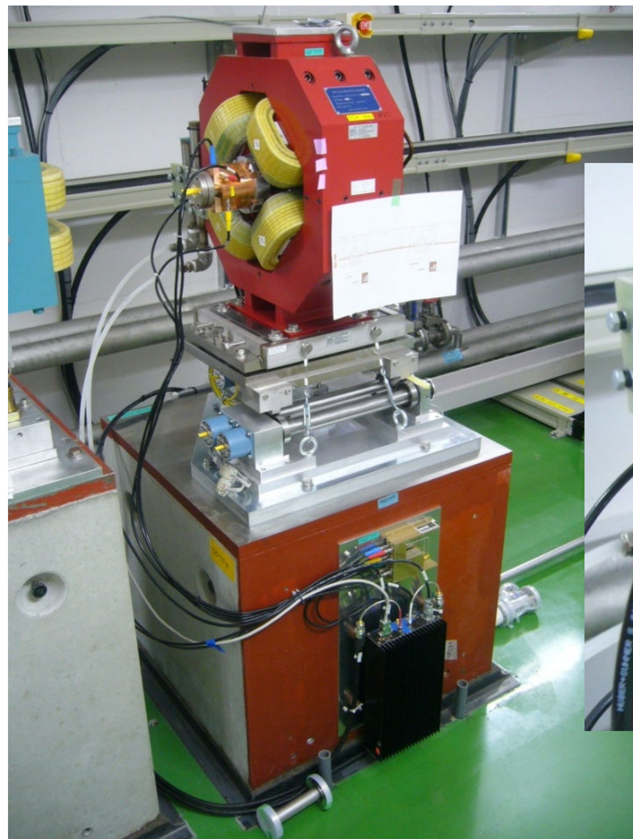
9.4.3: BPMs; ATF2 BPM layout

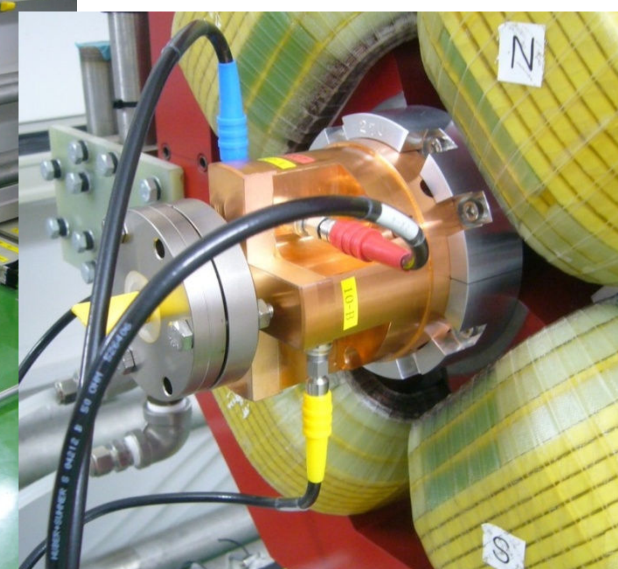
S-Band BPMs

C-Band BPMs



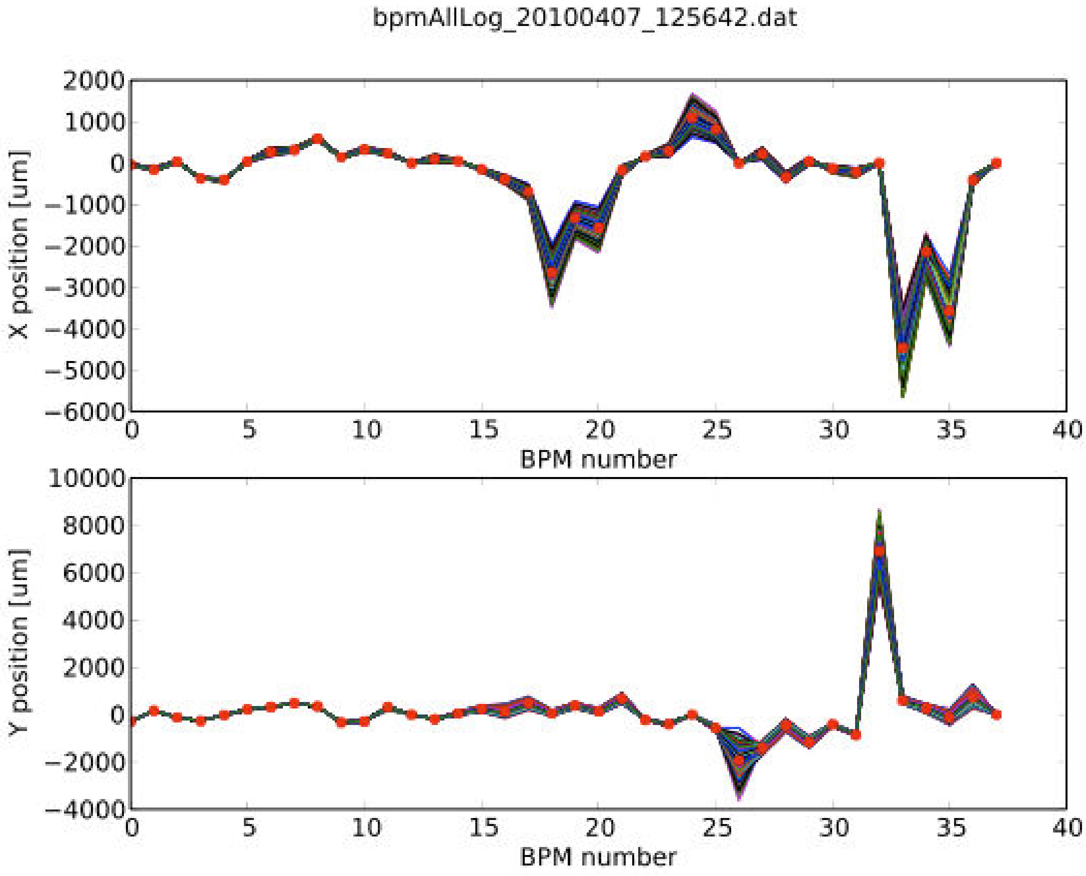






9.4.3: BPMs; orbit measurements

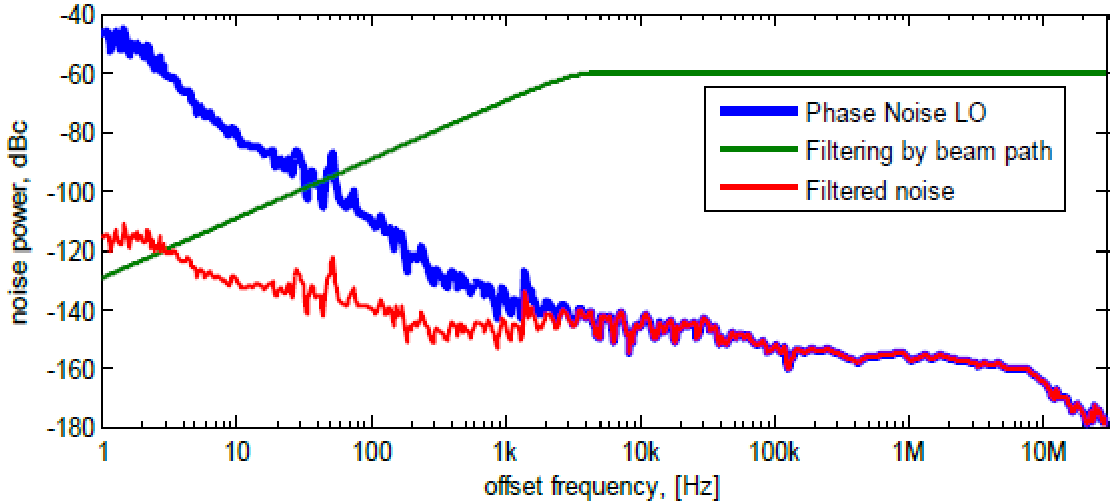
- ATF2 Orbit as measured by cavity BPM system
  - 1000 machine pulses
  - Complete calibration (by moving each BPM) takes 4 hours
  - Note large dynamic range, although cavity system
  - Routinely used for alignment, dispersion measurement, beam based alignment



9.5 Drive beam phase control

Sub-tasks (Co-ordination INFN)

1. RF Monitor (INFN/CERN)
2. Electro-Optical Monitor (PSI/CERN)



Main players:

F. Marcellini	INFN
M. Dehler	PSI
A. Andersson	CERN

9.5.1: RF Monitor

Phase monitor main requirements

- Resolution of the order of 20 fs (0.008 ° at 1 GHz)
- Very low coupling impedance due to the high beam current.
- Rejection, by means of proper designed filters, of RF noise and weak fields in the beam pipe that otherwise could affect the measurements.
- Detection is done at 12 GHz.
- $\tau_{f\ monitor} \approx$ 10ns = 2Q/ω → Q ≈ 380, BW ≈ 30 MHz.

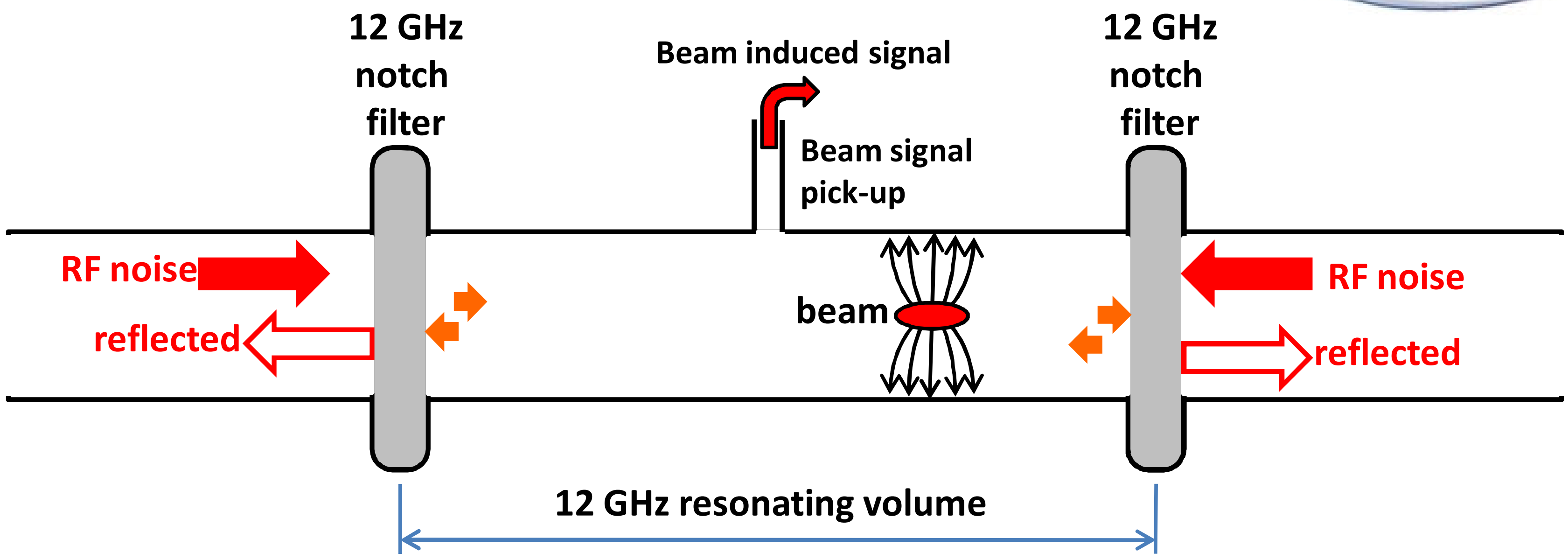
Pick-up design

- A prototype could be tested in CTF3 and installed in the chicane region, before the Delay Loop, where the vacuum pipe Ø is 40 mm.

RF noise and wakefields:

- At 12 GHz, 6 modes can propagate 40 mm pipe.
- A smaller pipe cross section would be useful to reduce the no. of modes.
- Reducing the pipe diameter at 30 mm, only 3 modes have a cut-off frequency lower than 12 GHz.

9.5.1: Filtering out RF noise



Beam induced field in the volume between the notch filters.

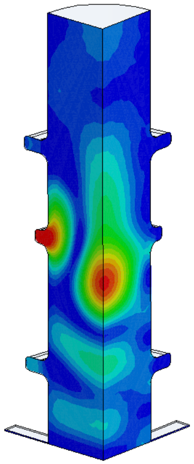
12 GHz component of beam generated field after the first filter could be reflected back by the second filter and detected again.

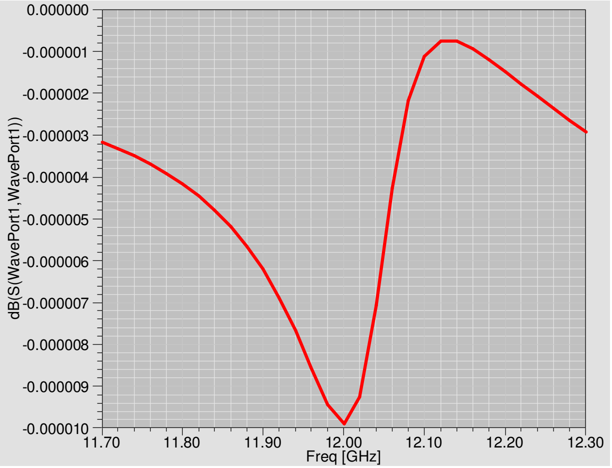
Multi-reflection process could start and affect measurement.

Unless the distance between the filters is chosen to define a volume resonating at 12 GHz. The pick-up is positioned in correspondence of zero crossing standing wave field.

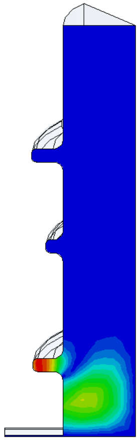
9.5.1: Multiple notch filters

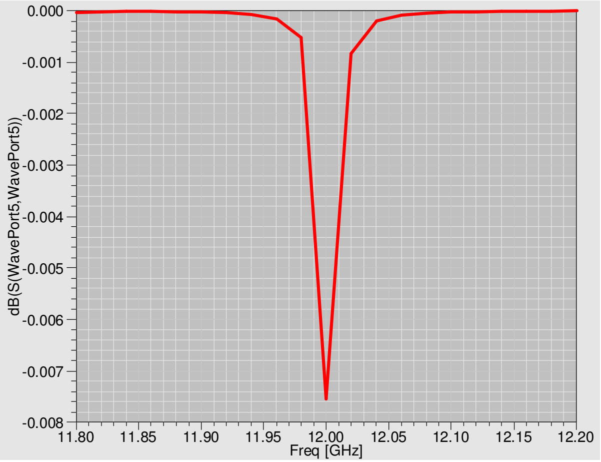
Notch for the TE11



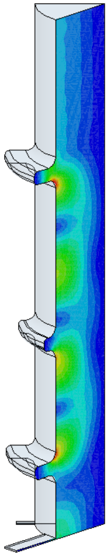


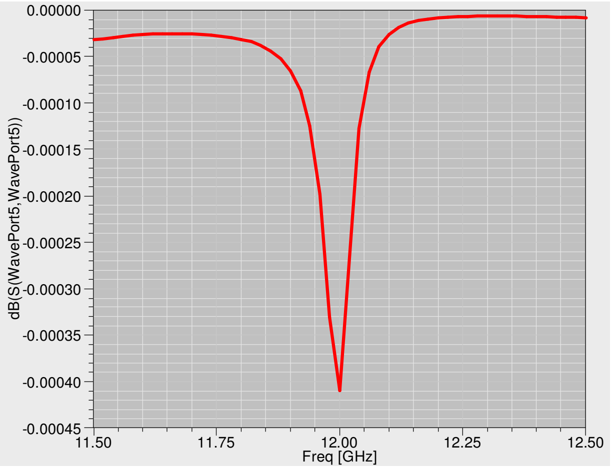
Notch for the TM01



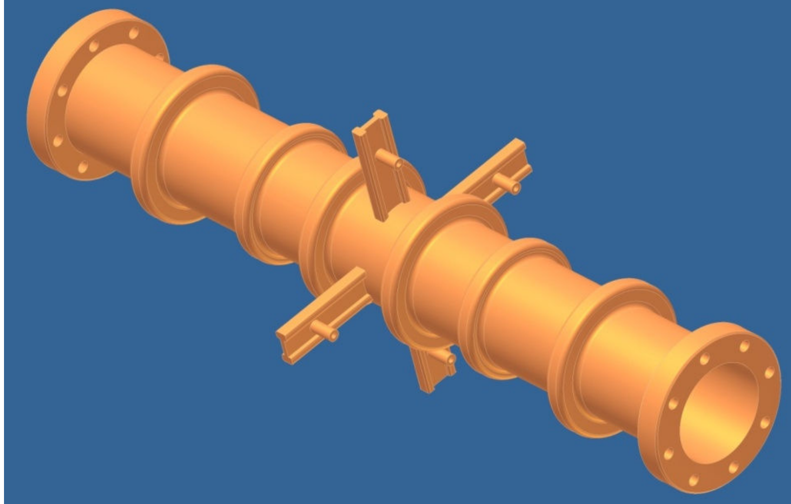


Notch for the TE21





Mechanical design has started



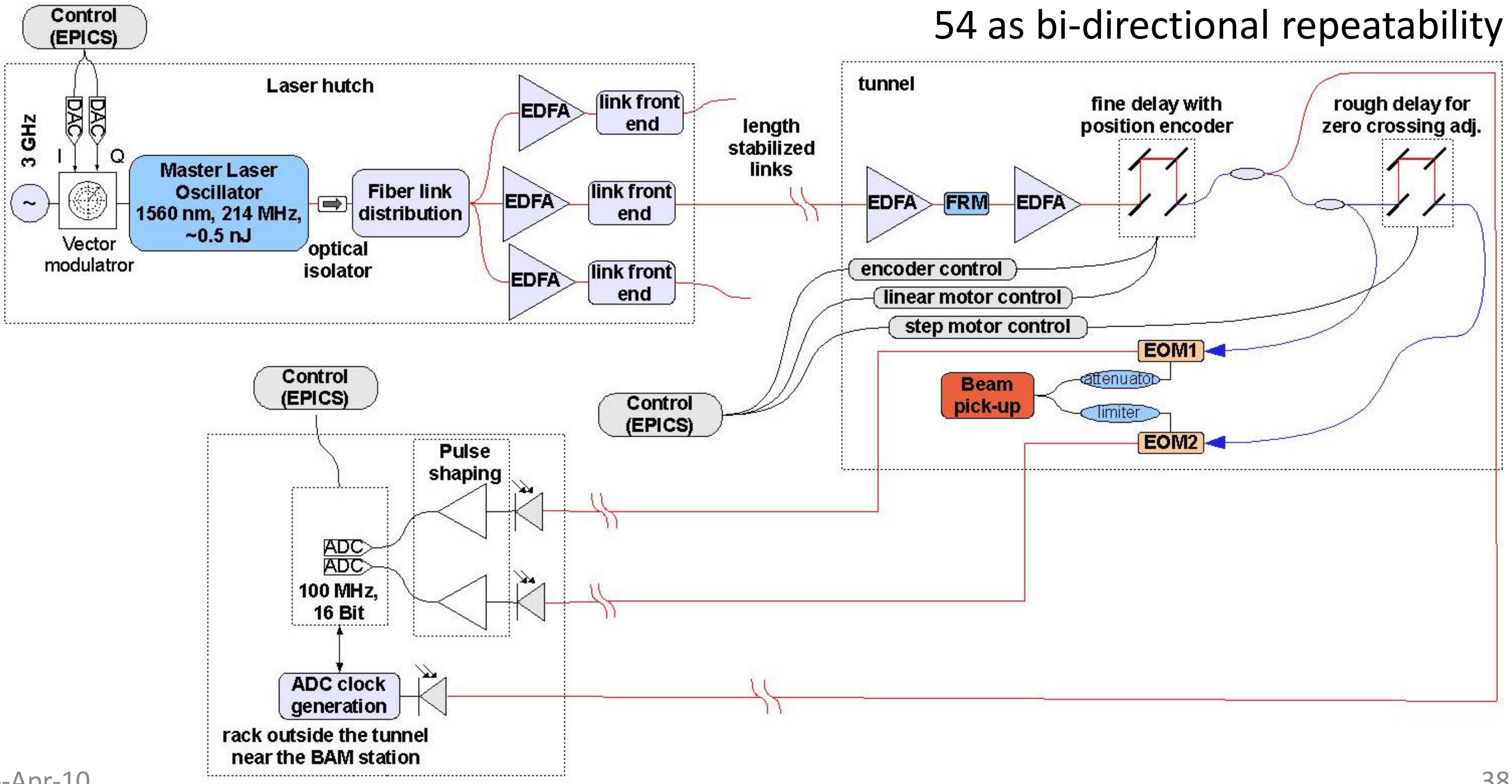
9.5.2: Electro-Optical Monitor

aka: BAM (bunch arrival monitor)

Position encoder (Parker MX80LT03):
was tested. It contributes:

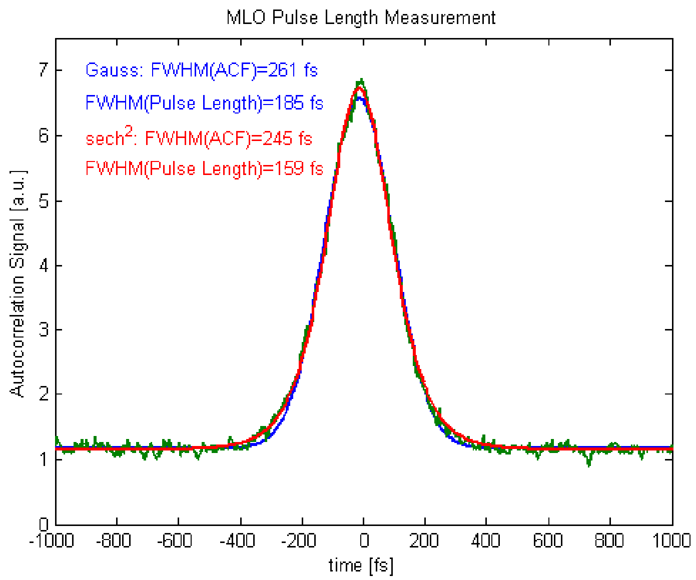
8 as jitter

54 as bi-directional repeatability



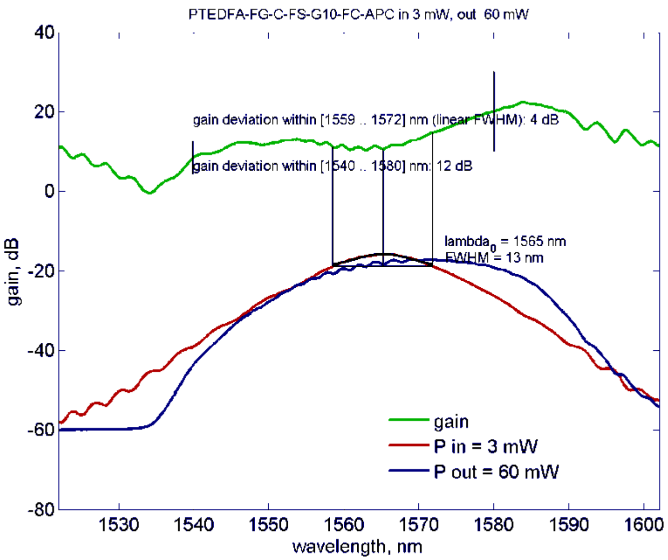
9.5.2: Master Laser Oscillator

- Commercial (OneFive) Er:Yb:glass soliton laser, operating at 1562 nm, bandwidth 13 nm.
- Thoroughly tested for continuous operation, results:
- Constant phase noise stability of 3.3 fs (rms) in the range 1 kHz – 10 MHz, repeatable over weeks.
- Phase locking to a rubidium reference demonstrated.
- Autocorrelation and FROG traces have been recorded.



9.5.2: Erbium Doped Fibre Amplifier

- EDFA is non-standard device → development requires iterations.
- Three companies to deliver prototypes (Menlo, Photop and Keopsys)
- Most critical characteristics:
  - stable bi-directional operation,
  - gain flatness,
  - possibility for re-compression of the chirped pulse,
  - possibility for remote control.
- First prototype (Photop) has arrived and been tested, it does not (yet) satisfy all specifications.



Conclusions

- NCLinac has made excellent progress during its first year.
- Technical challenges exist and are being addressed.
- Some tasks depend on external availability (ATF2) – these issues are being addressed.

Thank you very much!