Report on WP9 NCLinac

Erk Jensen/CERN
Grahame Blair/RHUL

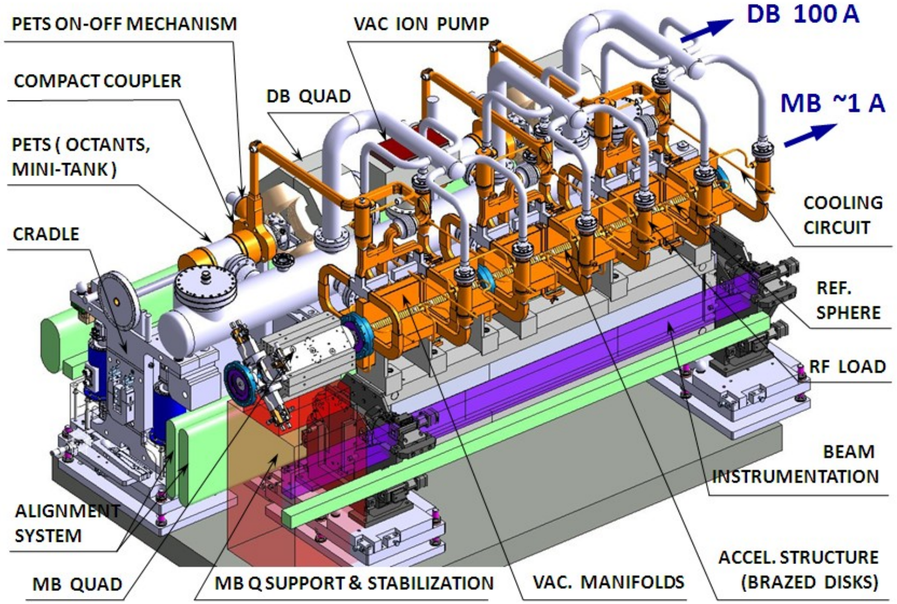
2nd EuCARD Annual Meeting
Paris, 13-May-2010

NCLinac: People (Task and Partner matrix)

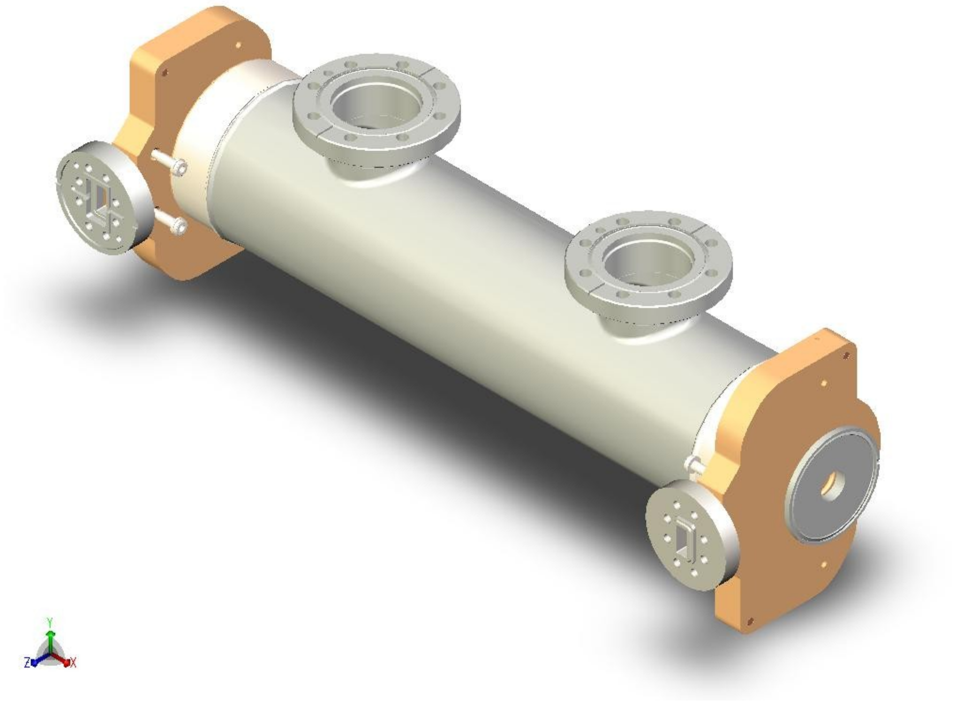
	Coordination	High Gradient	Stabilisation	BDS	Phase control
CERN	**Jensen**	**Riddone**	Modena, ~~Hauviller,~~ Mainaud-Durand, ~~Collette,~~ Artoos, Esposito, Fernandez Carmona		Andersson
CIEMAT		Toral, ~~Carillo,~~ ~~Rodríguez,~~ Sánchez			
CNRS/LAPP			**Jeremie**, Balik, Deleglise, Brunetti		
INFN/LNF					**Marcellini**, ~~Franzini~~
PSI					Dehler, Kaiser, Arsov
RHUL	**Blair**			**Blair**, Boogert, Lyapin	
STFC/ASTEC				Angal-Kalinin, J. Jones	
UH		Österberg, Nordlund, Timkó, Djurabekova, Raatikainen			
UNIMAN		R. Jones, D'Elia, Kahn		Appleby, Toader	
UOXF-DL			Burrows, ~~Urner~~		
UU		Ziemann, Ruber, Muranaka			

Task 9.2: Normal conducting high-gradient cavities

- Coordination: G. Riddone
- Sub-tasks:
  - 1. PETS (CIEMAT)
  - 2.HOM Damping (UNIMAN)
  - 3.Breakdown simulation (UH)
  - 4.Instrumentation (UU)
  - 5.Precise Assembly (UH)



9.2.1. Double length CLIC PETS

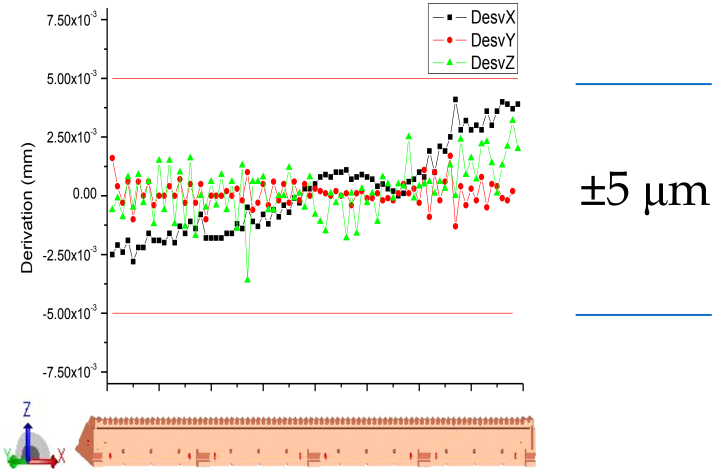


A. Lara, E Rodríguez, L. Sánchez and F. Toral
CIEMAT
03/05/2011

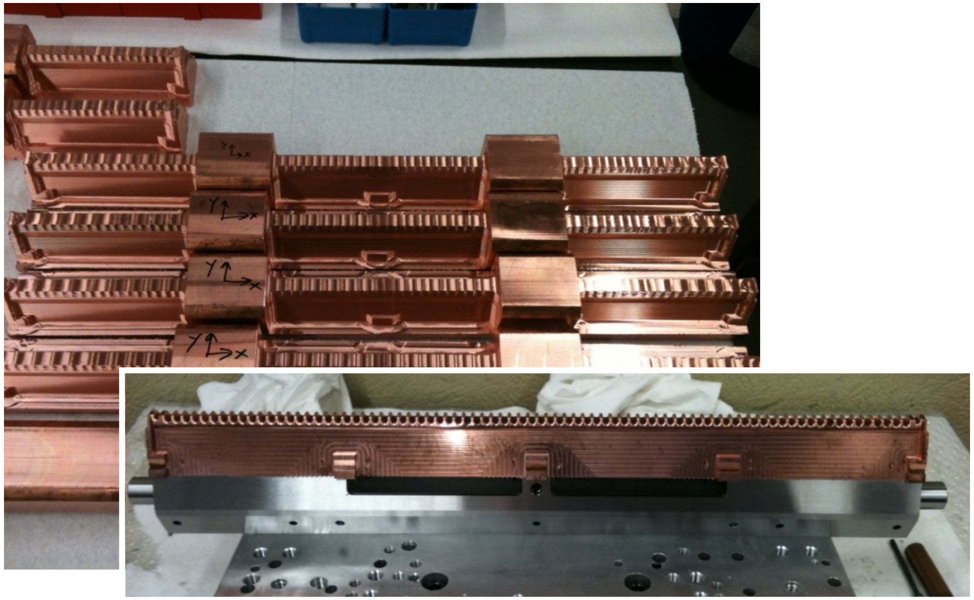
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

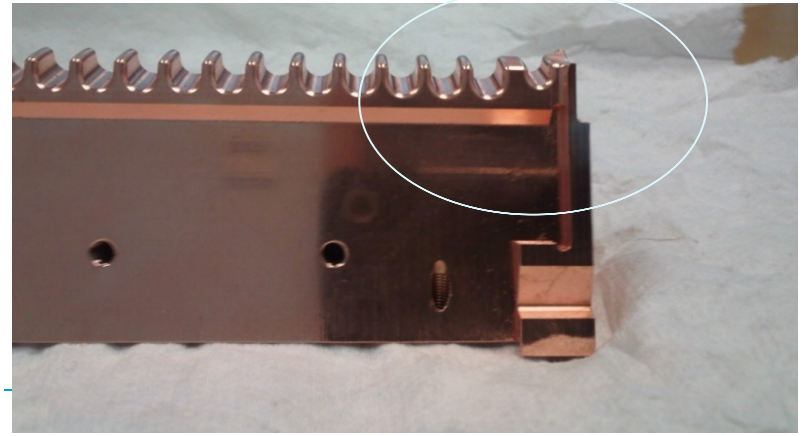
PETS fabrication: copper rods

- First copper rod is already at CIEMAT. Dimensional control OK.
- Seven copper rods are being machined.
- Expected to finish in week 21
- SiC firing: 1000ºC /10^{-5} mbar/ 2 h



Dimensional control of the first copper rod





First copper rod

PETS fabrication: couplers and tank

COUPLERS AND TANK DESIGN IS FINISHED

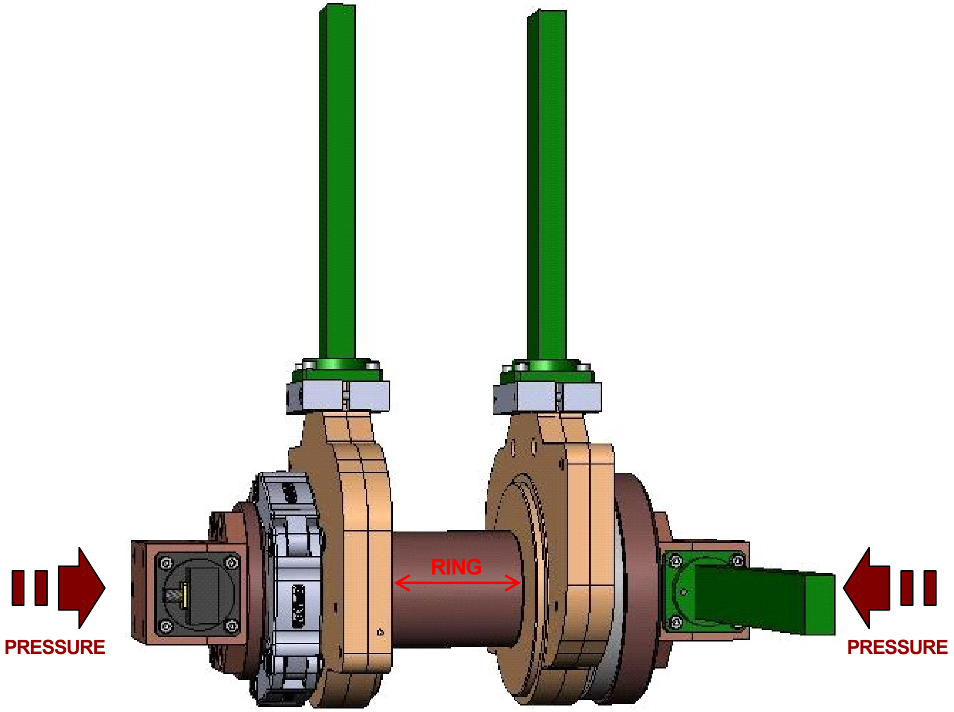
- Couplers are being machined at DMP, expected to finish in week 22. Brazing details are agreed with the brazing company (Ecor).
- Mini tank is ordered, expected to be finished on week 24.

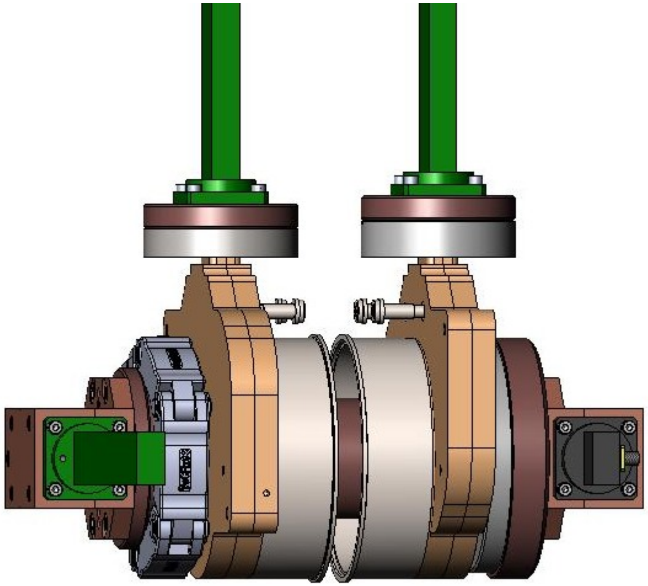
PETS testing: strategy for the RF measurements

COUPLERS MEASURING S11 AND S12

- Before brazing (optional).
- After brazing.

- Three different rings:
  - ☐ L_0 (70 mm)
  - ☐ $L_0 +\ 60^\circ$ (4.169mm)
  - ☐ $L_0 + 120^\circ$ (8.337mm)





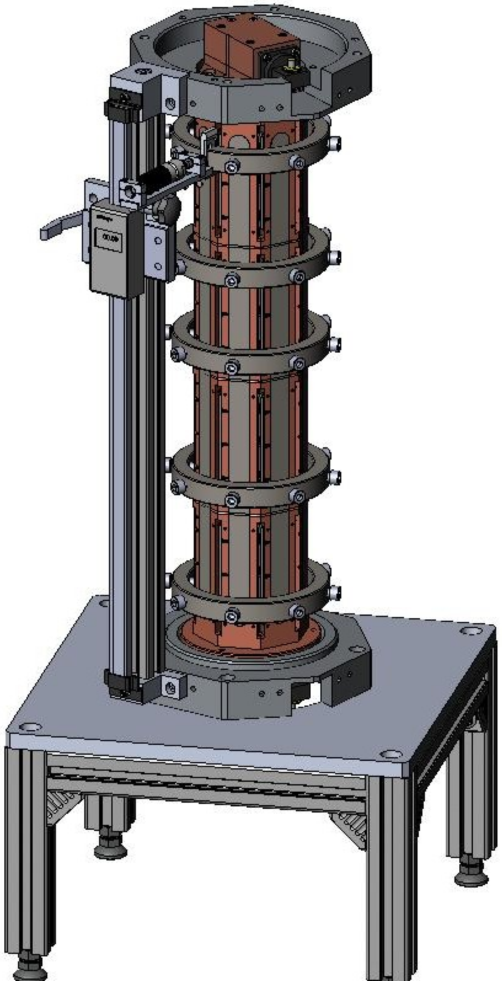
Before brazing

After brazing

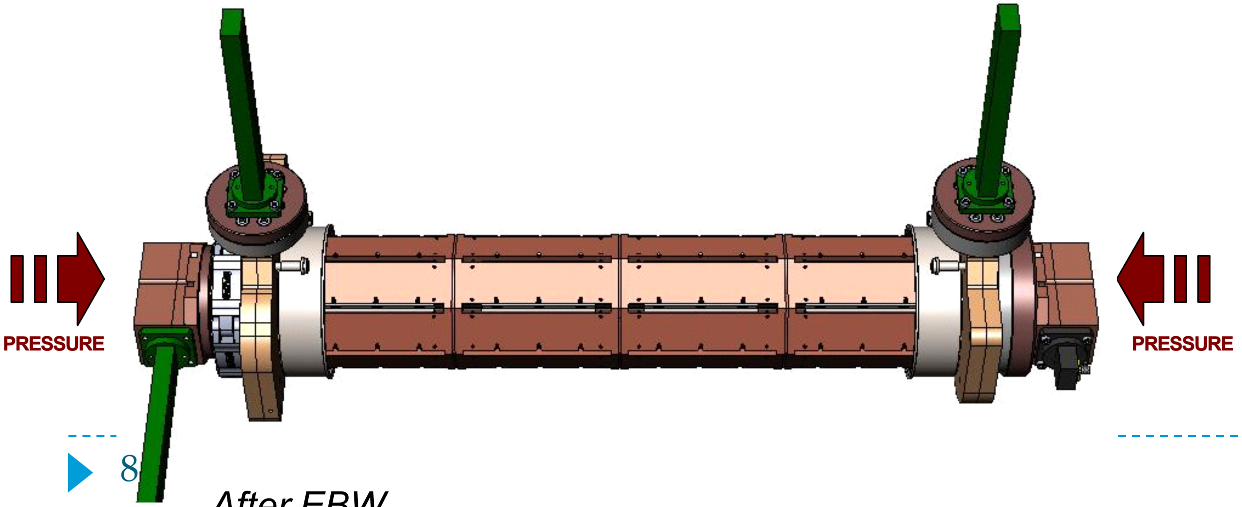
PETS testing: strategy for the RF measurements

EIGTH RODS WITH DAMPING MATERIAL

- Before EBW. Rods only.
  - Measurement of S_{11} and S_{12}.
  - Measurements of the phase shift with antenna held by a digital ruler (accuracy 0.01 mm) .
- After EBW. Rods + couplers.
  - Measurement of S_{11} and S_{12}.
  - Bead pull measurements (optional).



Before EBW

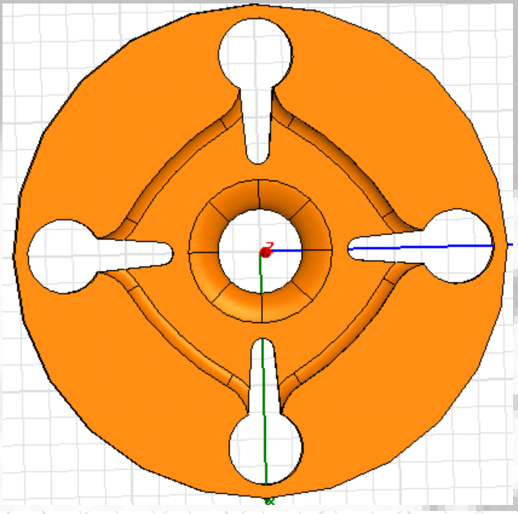


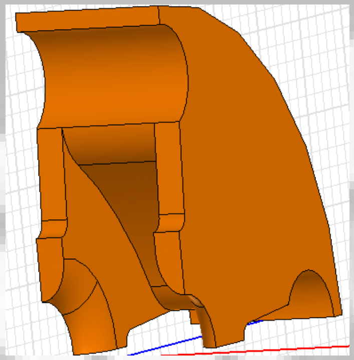
After EBW

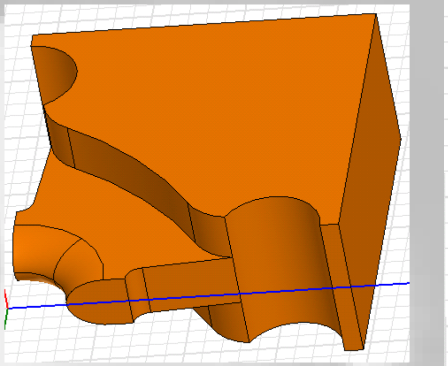
PETS: future steps

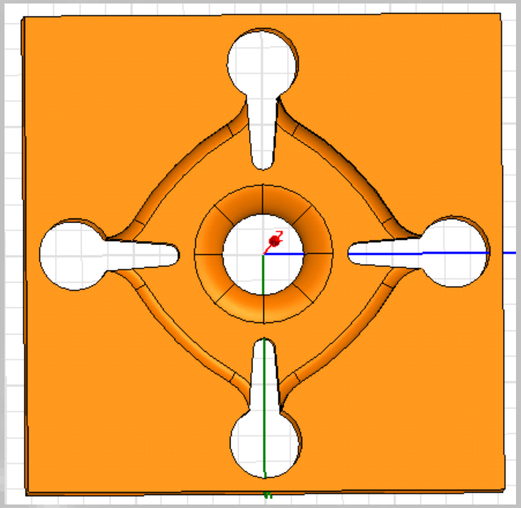
- Activities for the next months:
  - Finishing the bars, couplers and tank machining.
  - Brazing of one set of couplers at Ecor.
  - RF measurements of the copper rods before assembly.
  - Assembly of the rods by EBW at CERN.

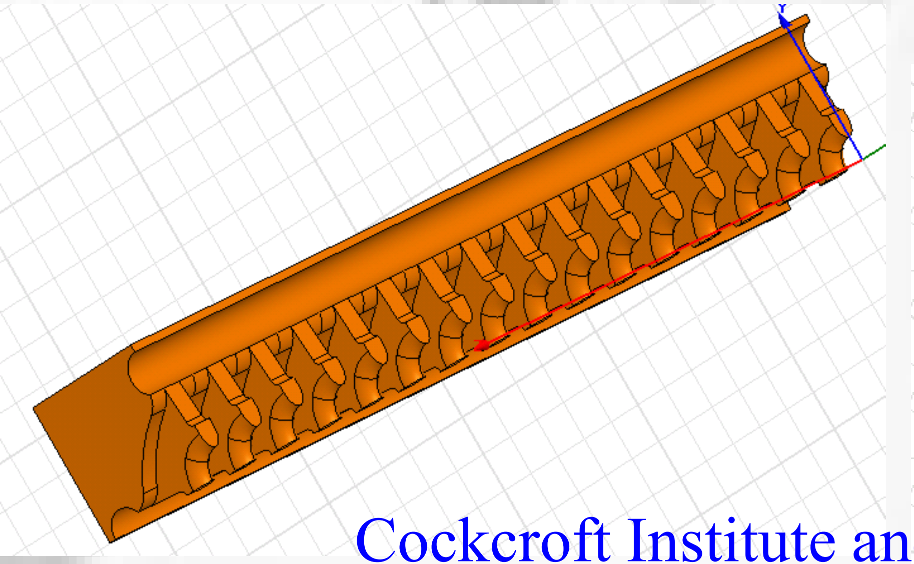
9.2.2: HOM Damping (UNIMAN)

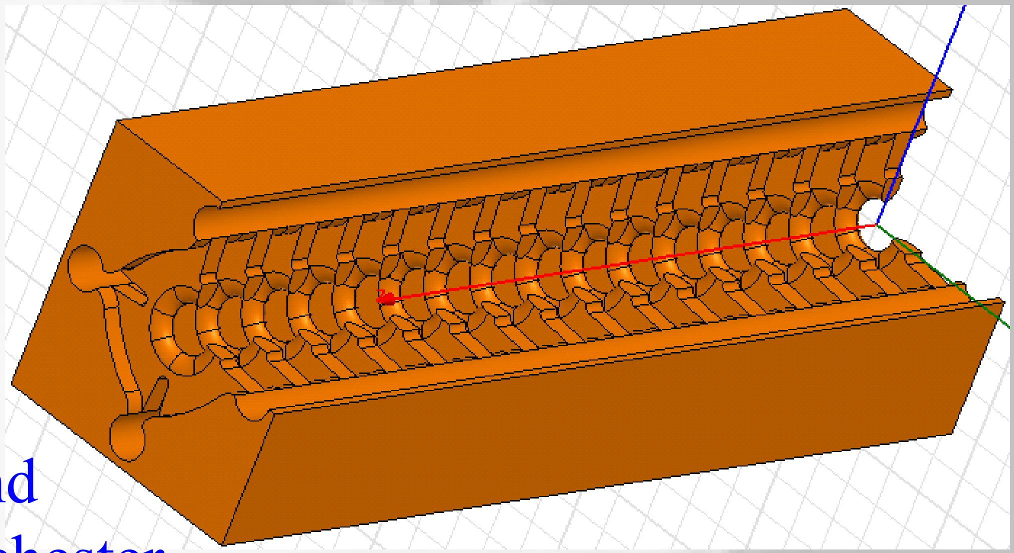












Cockcroft Institute and
The University of Manchester

Task 9.2.2: Wake Function Suppression for CLIC -Goals

- Provide an alternative to the baseline design for acceleration of beam and suppression of higher order mode wakefields.

- Baseline CLIC design uses heavy damping (*Q*~10) -alternative Task 9.2.2 design uses moderate damping (*Q*~1000) and strong detuning of a series of interleaved structures (8-fold interleaving of 24-cell structures).

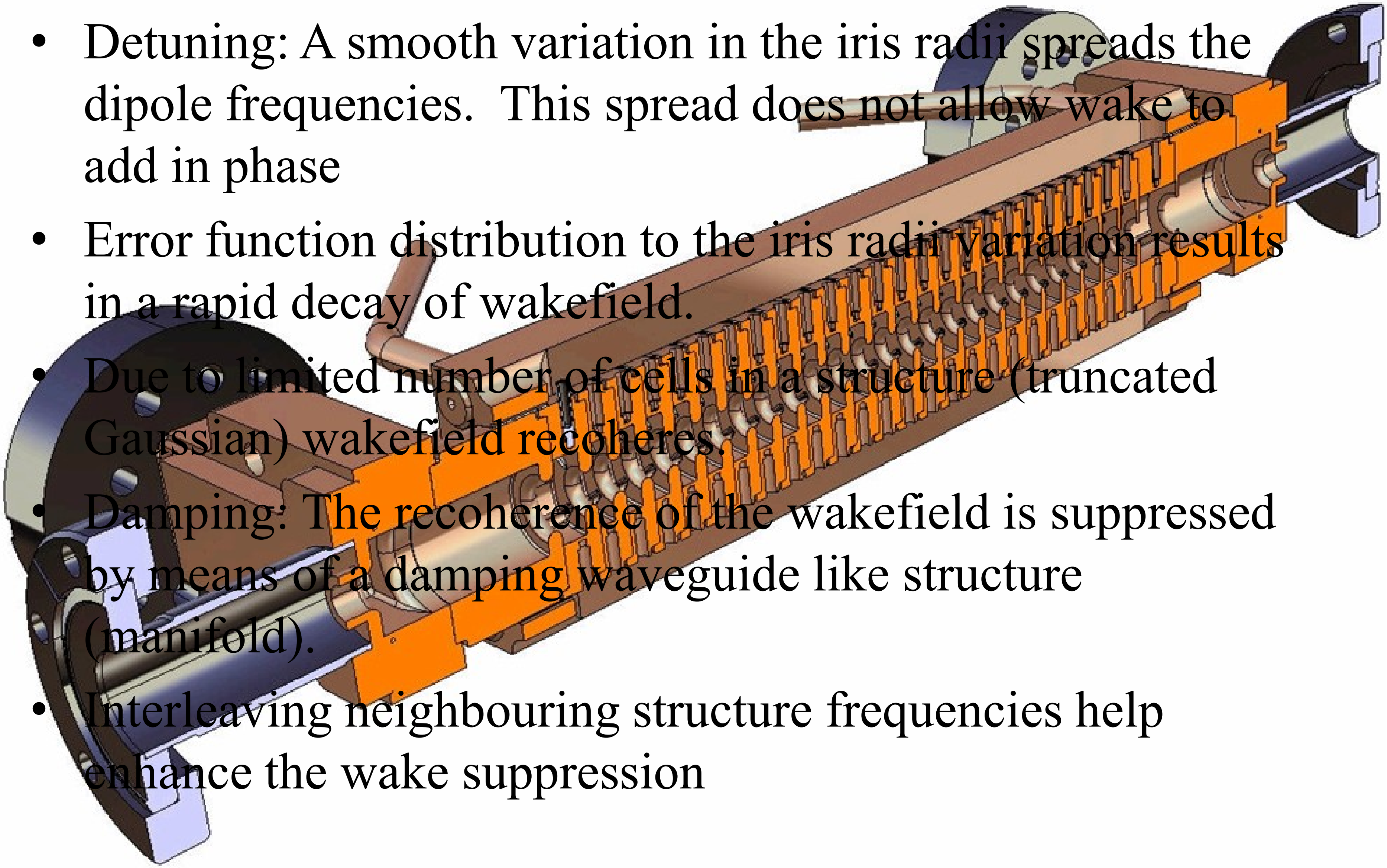
- Design finalised, with larger bunch spacing (6 to 8 RF cycles) which results in excellent wakefield suppression.

- A single structure will be fabricated with reduced HOM features in order to rapidly assess its ability to sustain and high em fields and powers: **CLIC_DDS_A**

- Main structure cells, complete with manifolds, and end cells finalised.

- 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_DDS_A.

Damped and detuned design



- Detuning: A smooth variation in the iris radii spreads the dipole frequencies. This spread does not allow wake to add in phase
- Error function distribution to the iris radii variation results in a rapid decay of wakefield.
- Due to limited number of cells in a structure (truncated Gaussian) wakefield recoheres.
- Damping: The recoherence of the wakefield is suppressed by means of a damping waveguide like structure (manifold).
- Interleaving neighbouring structure frequencies help enhance the wake suppression

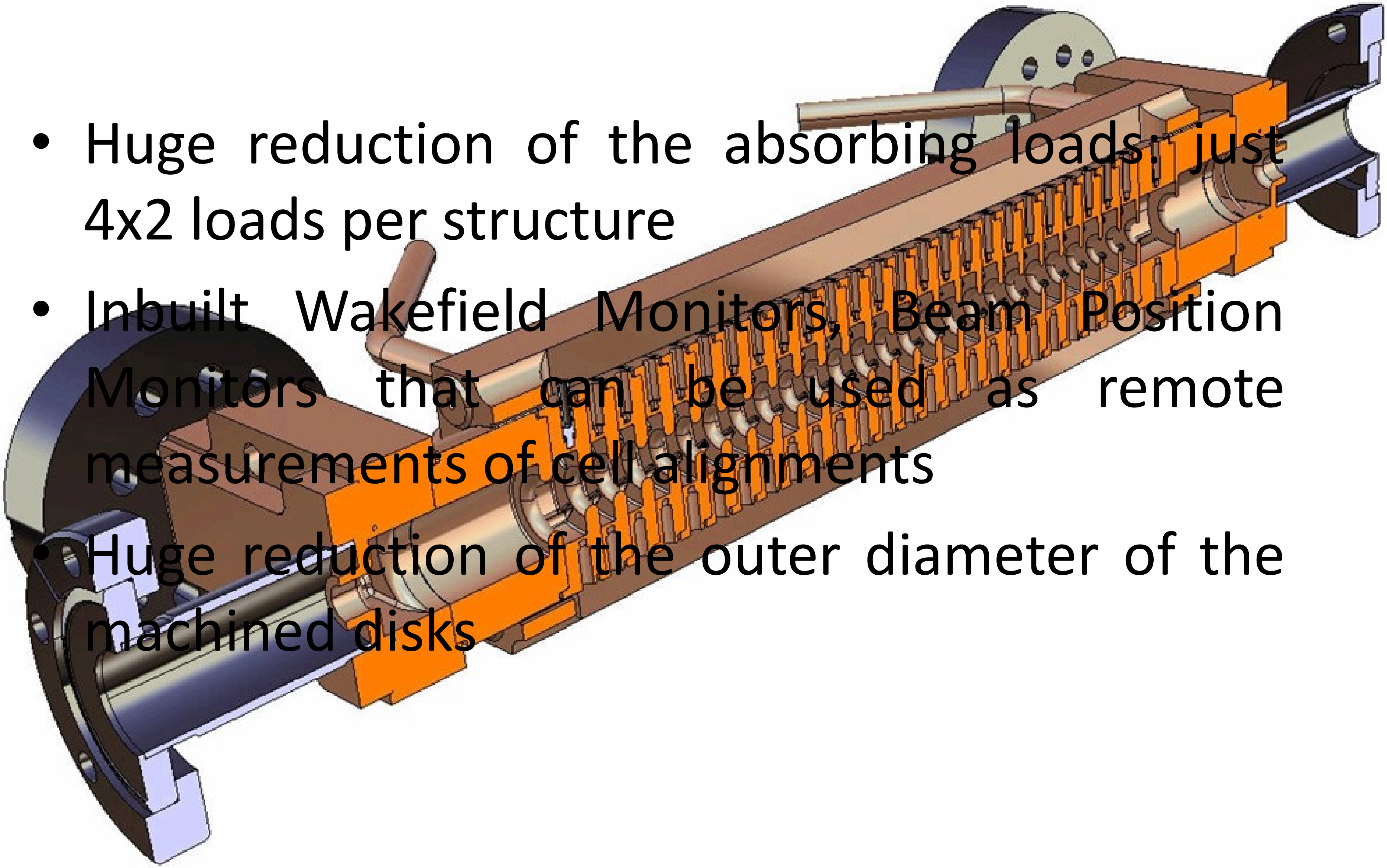
9.2.2: Wake Suppression for CLIC
Uni Manchester collaborators

- Roger M. Jones (Univ. of Manchester faculty)
- Alessandro D’Elia (Dec 2008, UNIMAN PDRA based at CERN)
- Vasim Khan (PhD April 2011, now CERN Fellow)
- Nick Chapman (UNIMAN PhD Student, based at CERN)

V. Khan, CI/UNIMAN PhD student, now CERN Fellow (pictured at EPAC 08)

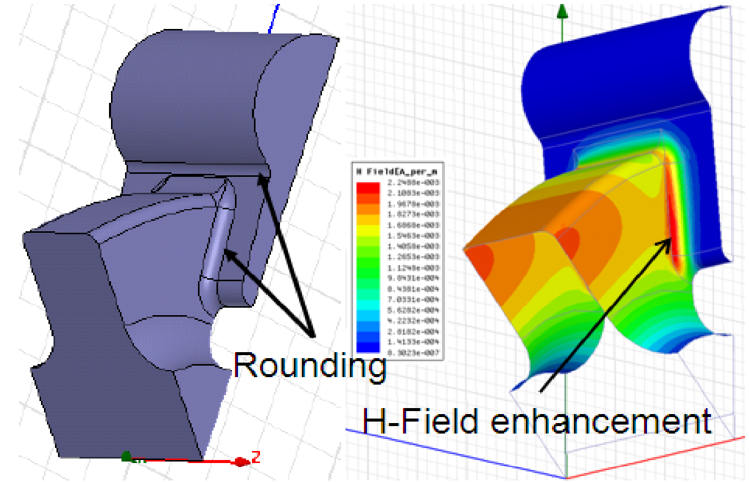
A. D’Elia, CI/Univ. of Manchester PDRA based at CERN (former CERN Fellow).

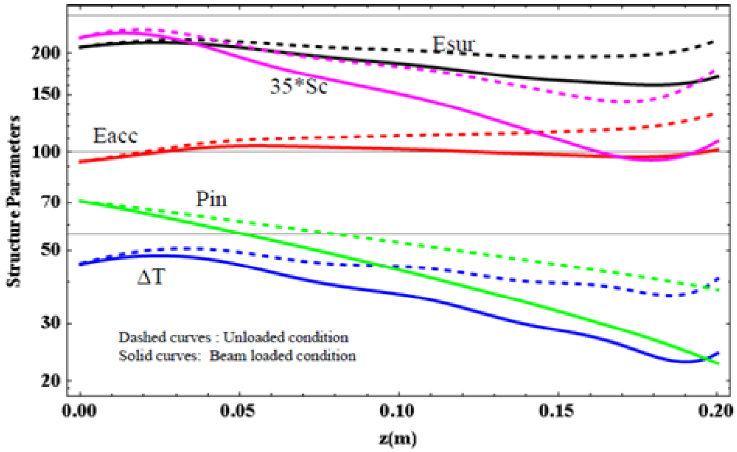
Why a Detuning Damping Structure (DDS) for CLIC

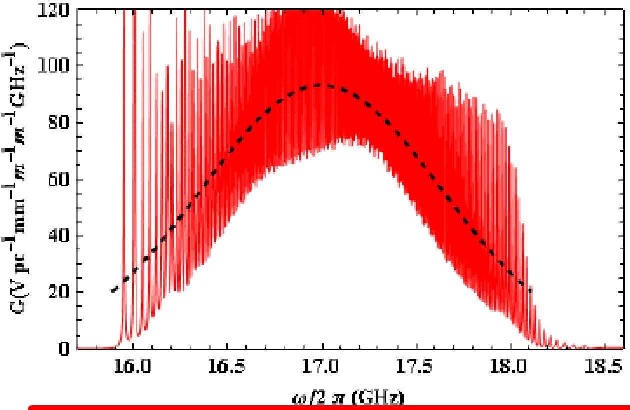


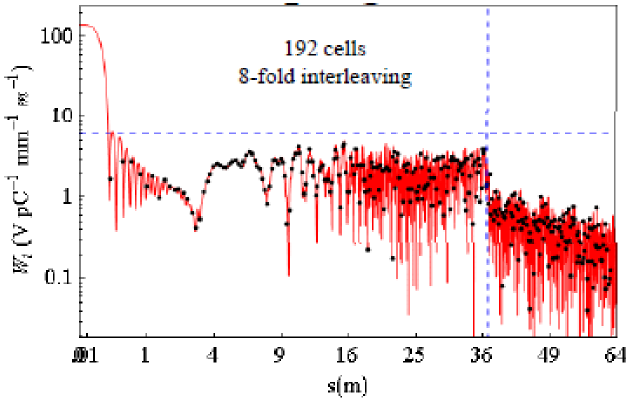
- Huge reduction of the absorbing loads: just 4x2 loads per structure
- Inbuilt Wakefield Monitors, Beam Position Monitors that can be used as remote measurements of cell alignments
- Huge reduction of the outer diameter of the machined disks

Final CLIC_DDS_A Design







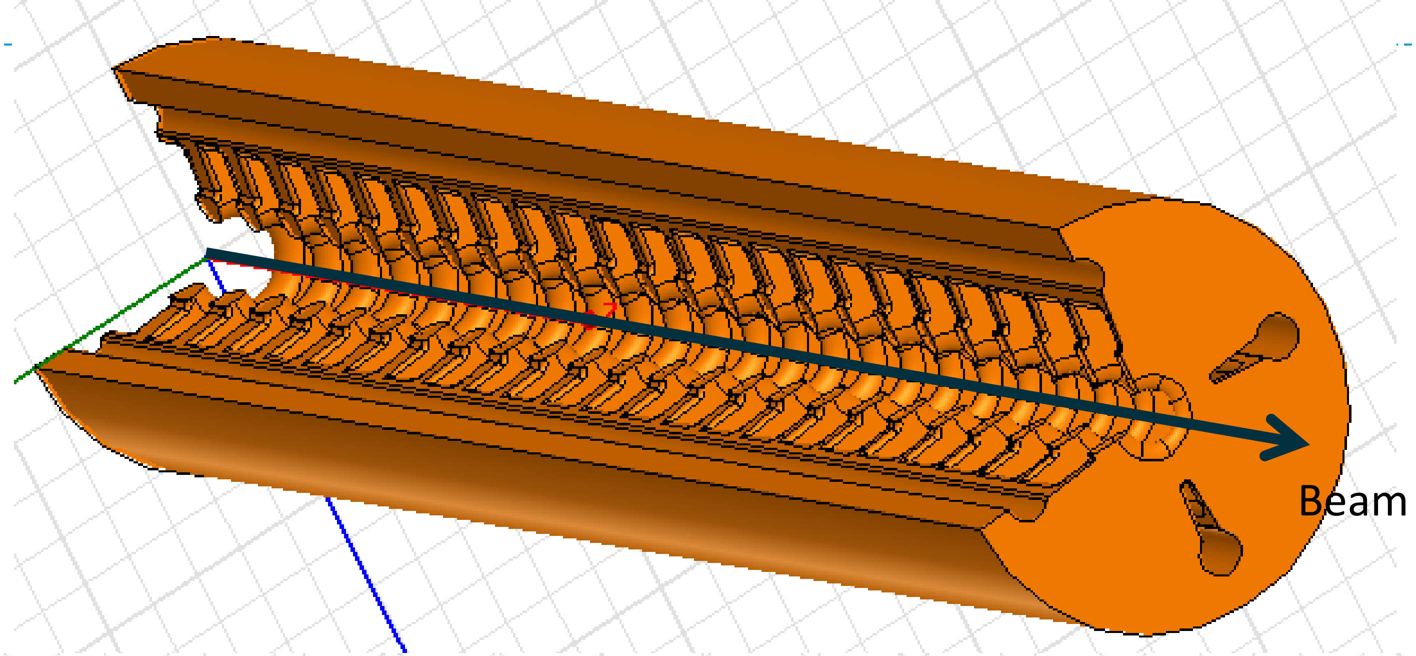


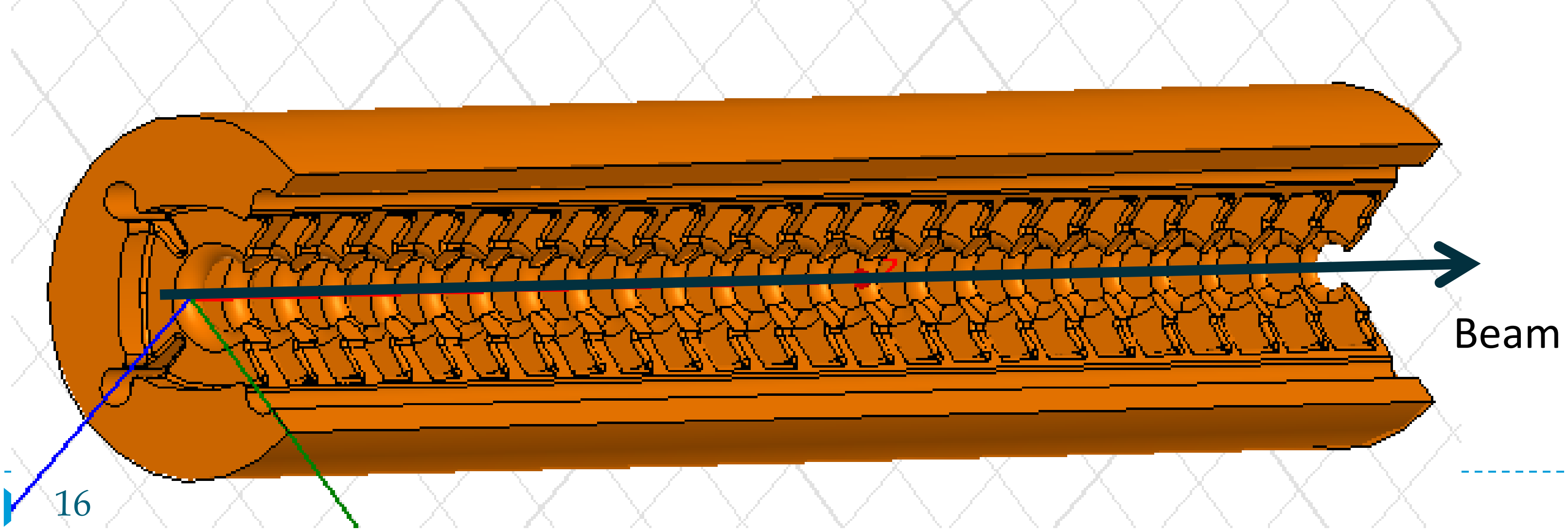
- ➢Rounding the slots enhances the magnetic field however a reduction of the slot size mitigates this enhancement and RF parameters are now back within required limits.
- ➢Wake suppression is well within the prescribed margins.

Major changes in DDS2 built for power tests (CLIC_DDS_A)

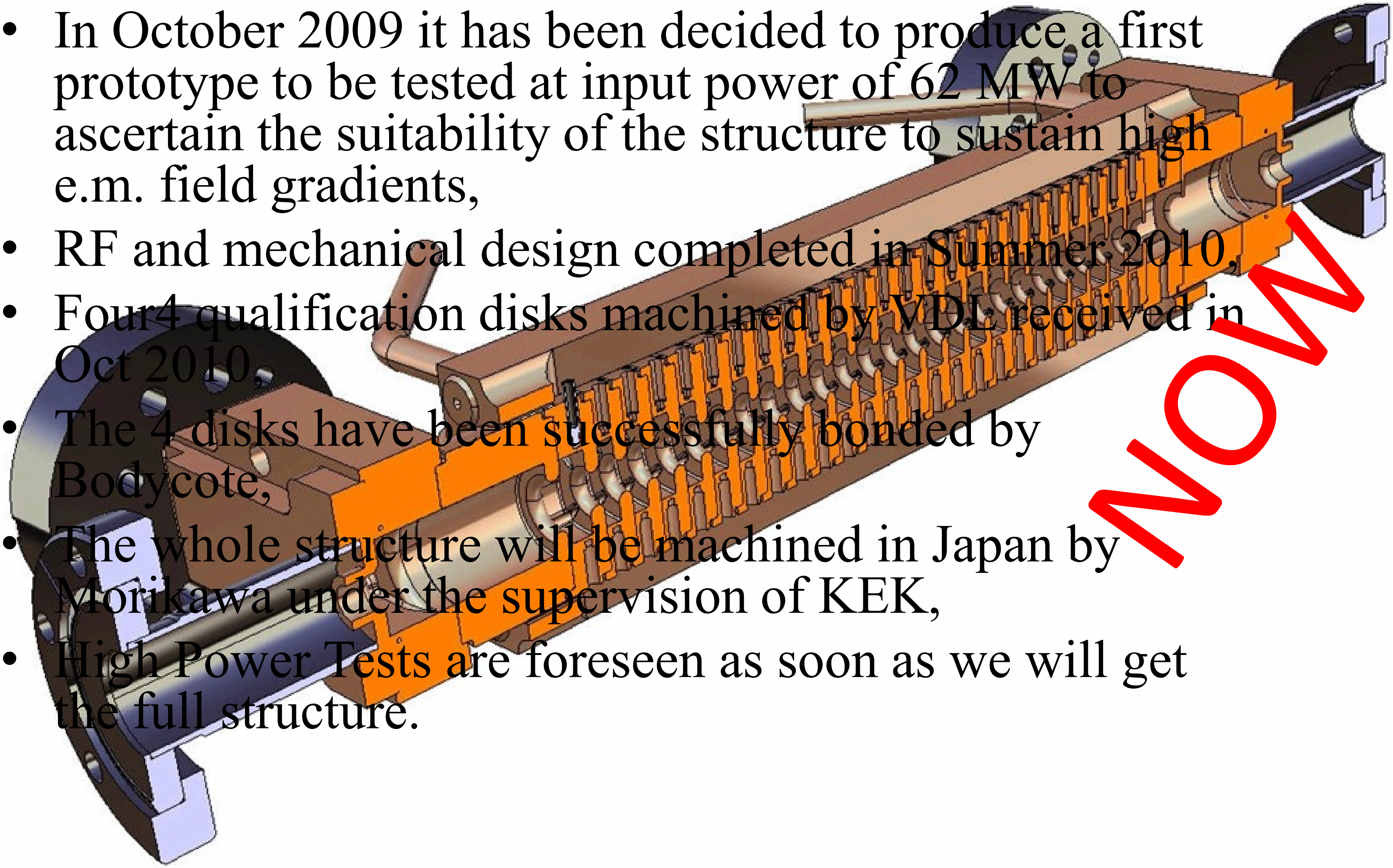
- ➢ **To ease mechanical fabrication, manifold dimensions are now uniform throughout the structure.**
- ➢ **The manifold radius is parameterised to ensure the lowest manifold mode is >12 GHz.**
- ➢ **Coupling is reduced for half of structure, leading to non-optimal suppression, but wakefield is acceptable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

CLIC_DDS_A





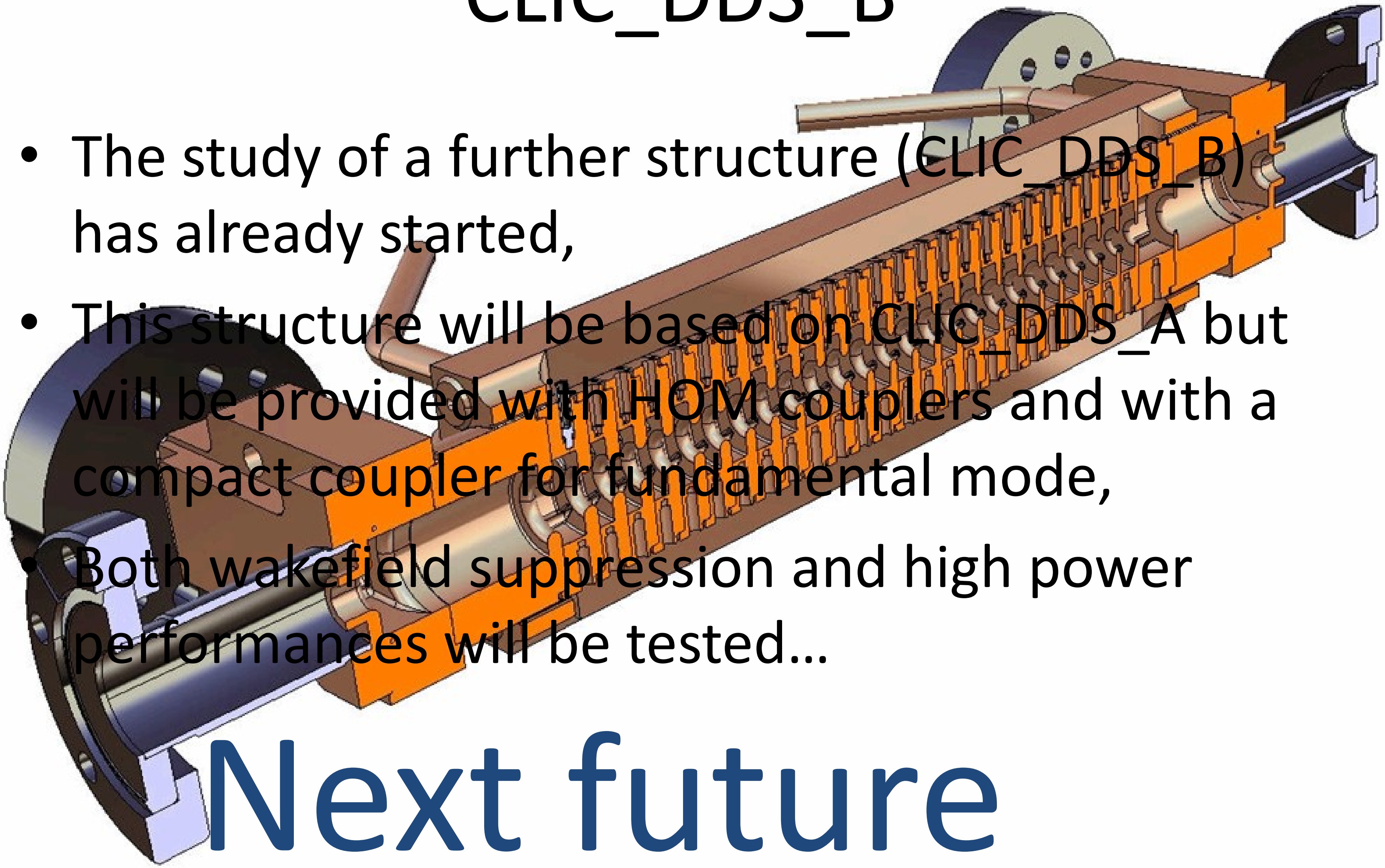
CLIC_DDS_A



- In October 2009 it has been decided to produce a first prototype to be tested at input power of 62 MW to ascertain the suitability of the structure to sustain high e.m. field gradients,
- RF and mechanical design completed in Summer 2010,
- Four4 qualification disks machined by VDL received in Oct 2010,
- The 4 disks have been successfully bonded by Bodycote,
- The whole structure will be machined in Japan by Morikawa under the supervision of KEK,
- High Power Tests are foreseen as soon as we will get the full structure.

NOW

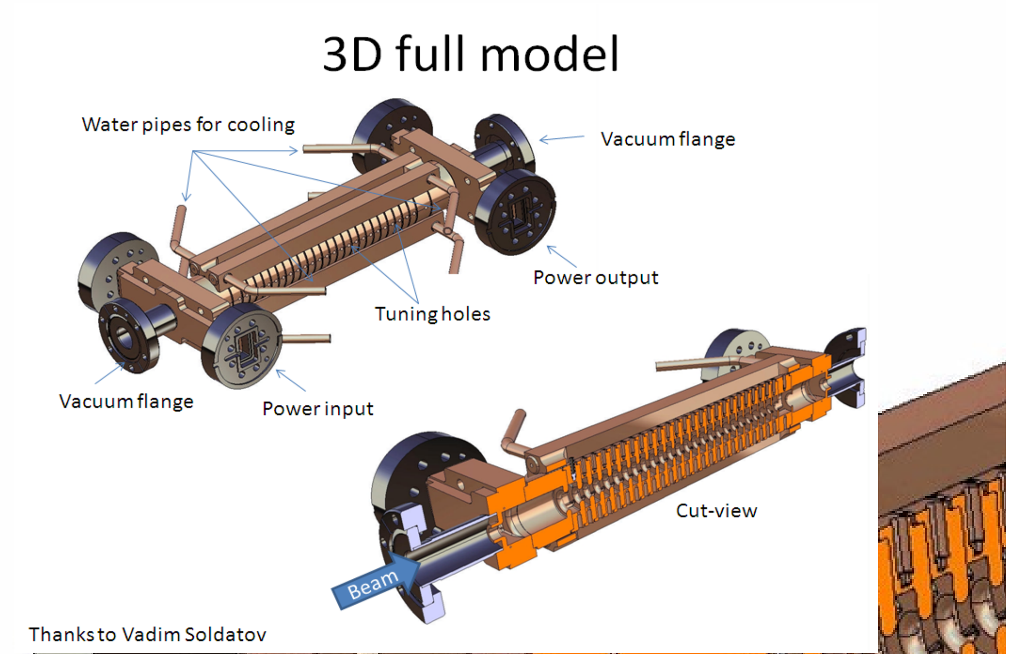
CLIC_DDS_B



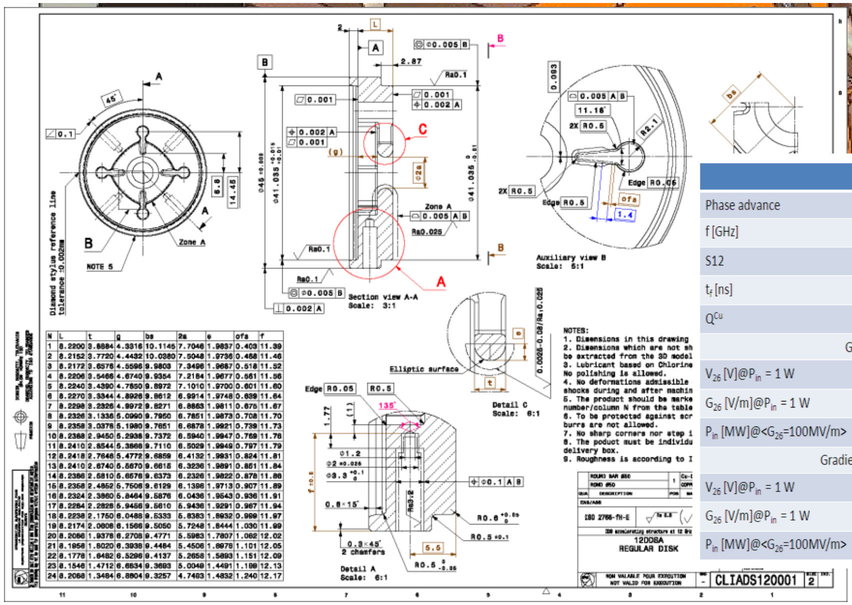
- The study of a further structure (CLIC_DDS_B) has already started,
- This structure will be based on CLIC_DDS_A but will be provided with HOM couplers and with a compact coupler for fundamental mode,
- Both wakefield suppression and high power performances will be tested…

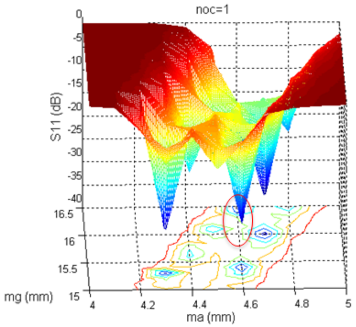
Next future

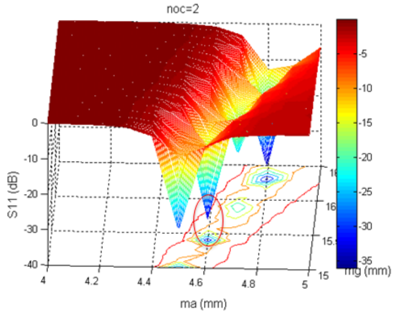
CLIC_DDS_A full structure

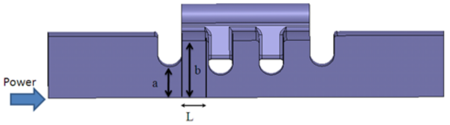


Thanks to Vadim Soldatov

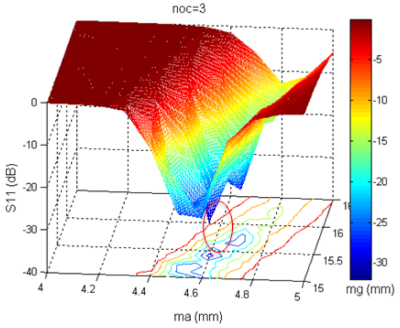


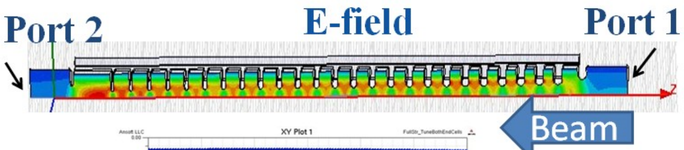


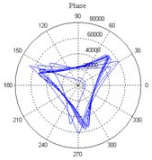




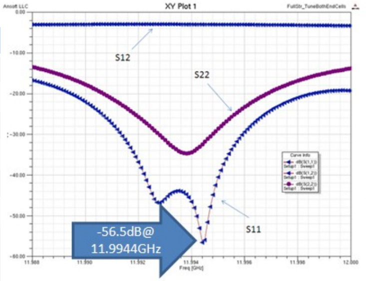
Two options
- Vary “a” and “b” : due to the manifold, very small room to vary “b”
- ✓ vary “a” and “L”

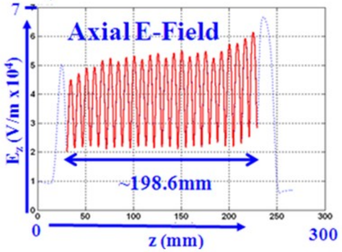




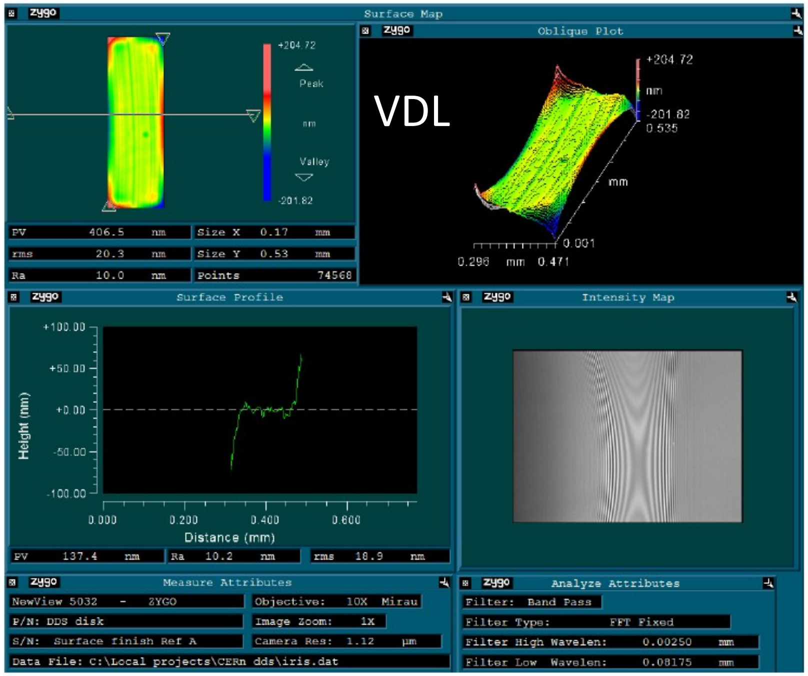


		comments
Phase advance	~120°/cell	min=114° 1st cell; max=125° cell#22
f [GHz]	11.9944	
S12	0.705	
t_f [ns]	57.15	
Q^{Cu}	6165	
Gradient averaged over all cells		
V_{26} [V]@P_{in} = 1 W	2894	2 matching +24 regular cells L_{acc} = 227.46 mm,
G_{26} [V/m]@P_{in} = 1 W	12724	
P_{in} [MW]@<G_{26}=100MV/m>	61.77	
Gradient averaged over regular cells only		
V_{26} [V]@P_{in} = 1 W	2678	24 regular cells only L_{acc} = 198.6326 mm,
G_{26} [V/m]@P_{in} = 1 W	13481	
P_{in} [MW]@<G_{26}=100MV/m>	55.03	





CLIC_DDS_A some further detail

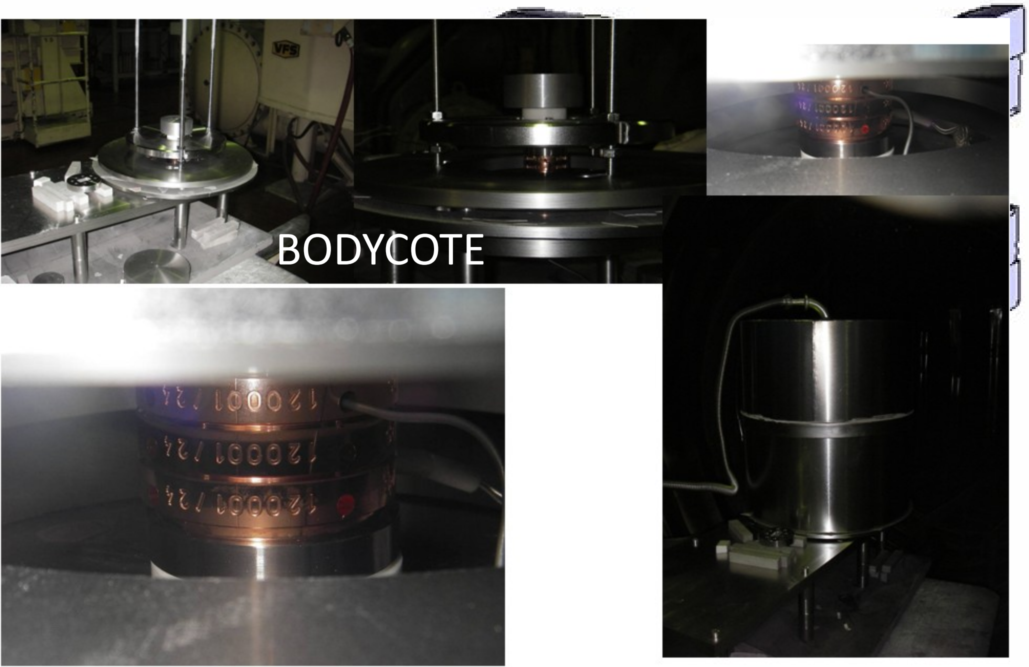


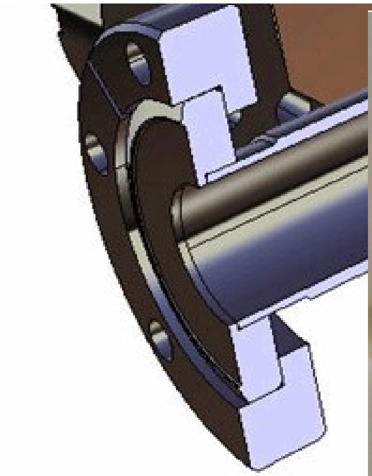
PV 406.5 nm
rms 20.3 nm
Ra 10.0 nm
Size X 0.17 mm
Size Y 0.53 mm
Points 74568

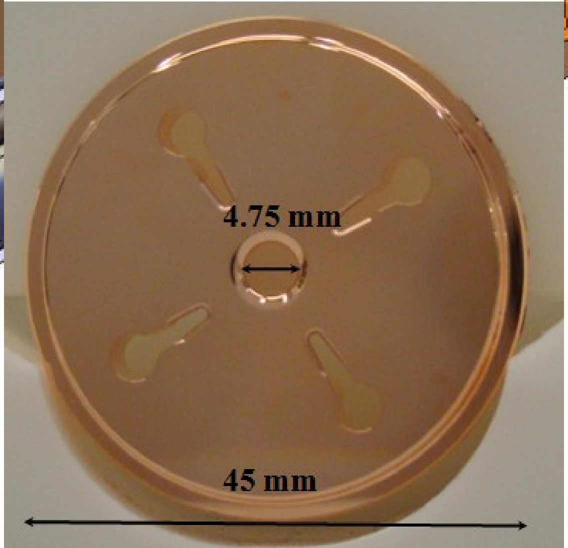
PV 137.4 nm
Ra 10.2 nm
rms 18.9 nm

NewView 5032 - ZYGO
P/N: DDS disk
S/N: Surface finish Ref A
Data File: C:\Local projects\CERn dds\iris.dat
Objective: 10X Mirau
Image Zoom: 1X
Camera Res: 1.12 µm

Filter: Band Pass
Filter Type: FFT Fixed
Filter High Wavelen: 0.00250 mm
Filter Low Wavelen: 0.08175 mm



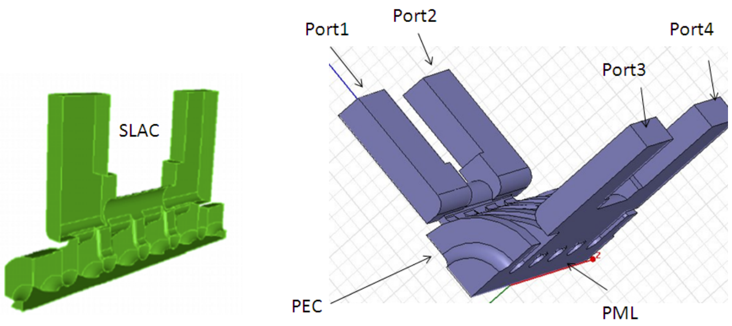




Preliminary HOM coupler thoughts

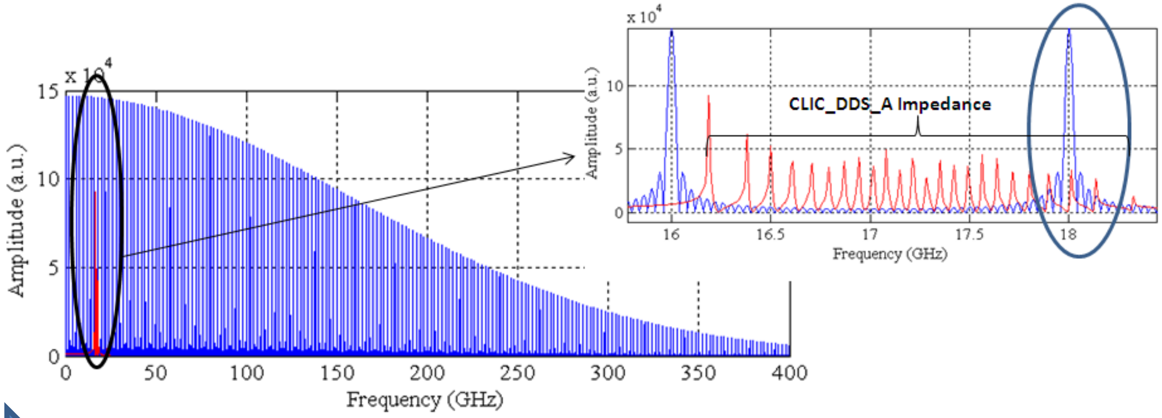
A possible structure

J. W. Wang and al. "Progress toward NLC/JLC prototype accelerator structure", LINAC04

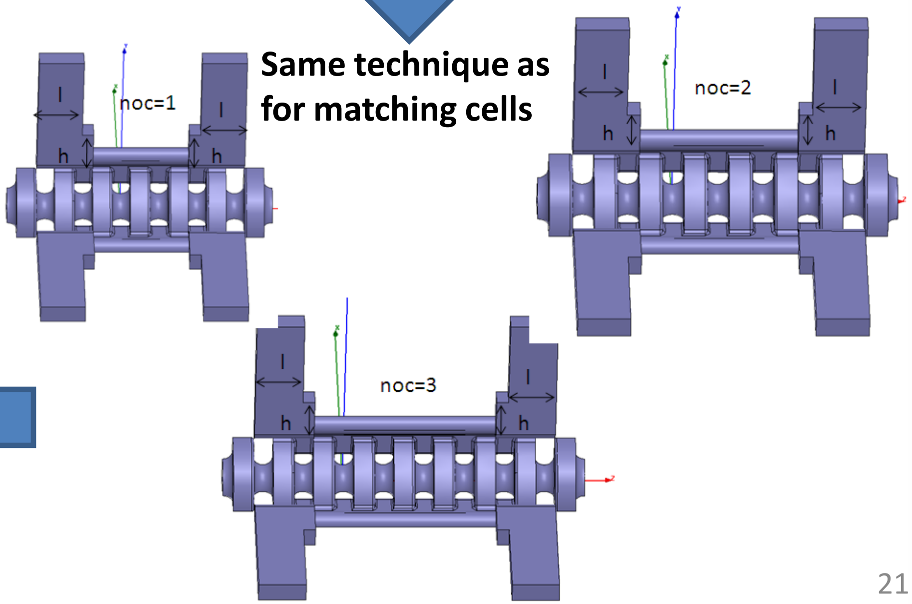


As a first approach we decided to reproduce the same as done at for NLC/JLC:

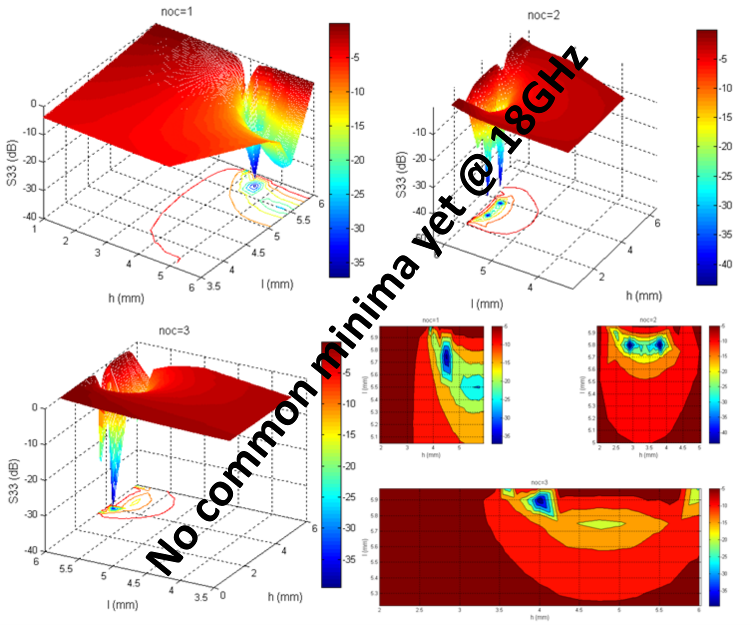
1) HOM coupler attached at the first regular cell
2) Only Matching cells uncoupled
3) HOM Coupler goes to WR62 load (Ku band=14-18GHz)
4) How much is the bandwidth?



Who is chatting with the beam? Only frequencies around 18GHz!!!



Same technique as for matching cells



No common minima yet @ 18GHz

9.2.3: Breakdown simulation

K. Österberg,
Department of Physics, University of Helsinki & Helsinki Institute of Physics

Outline:

- WP9.2 Sub-task 3: RF breakdown modeling
- WP9.2 Sub-task 5: Precise ACS & PETS assembly

Contributors: Helsinki Institute of Physics and Department of Physics, University of Helsinki

Contribution: 112 person-months

Task 9.2.3: RF breakdown modeling

Text in EuCARD DoW:

- “Breakdown simulation: Develop and use atomistic simulations of atom migration enhanced by the electric field or by bombarding particles, understand what kind of roughening mechanisms lead to the onset of RF breakdown in high gradient accelerating structures.”

Prof. Kai Nordlund (at ~ 10 %)
PhD Flyura Djurabekova
MSc Aarne Pohjonen

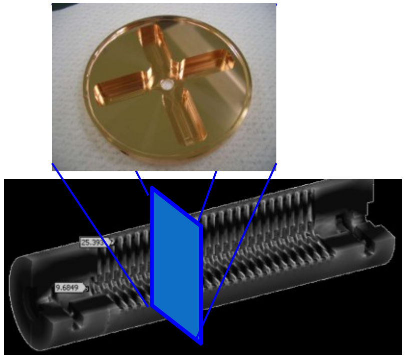
} **part of** EuCARD

MSc Helga Timko (doctoral student @ CERN)
MSc Stefan Parviainen
MSc Avaz Ruzibaev

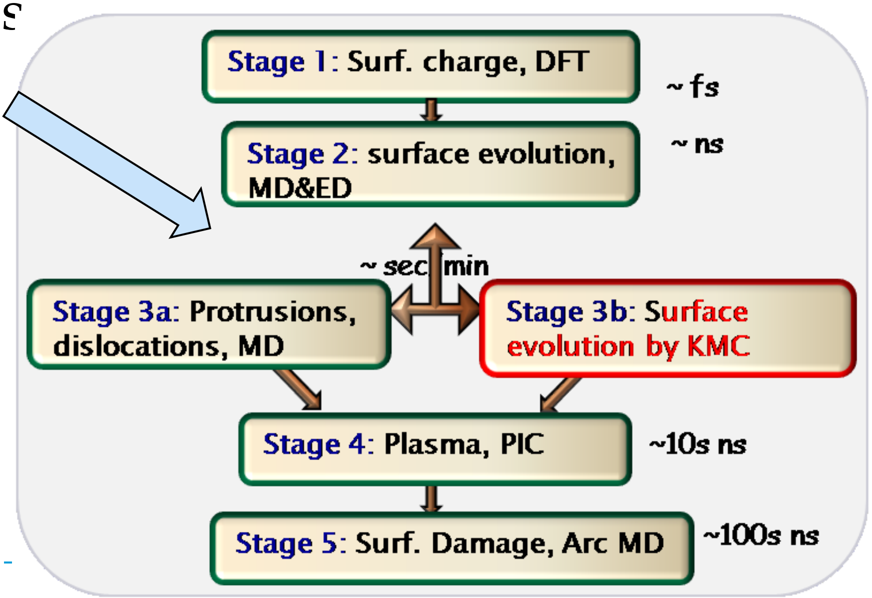
in collaboration with CERN *(S. Calatroni and W. Wuensch)*
and MPI Greifswald *(R. Schneider and K. Matyash)*

Multiscale modeling of break-down in CLIC RF structures

F. Djurabekova, H. Timko, A. Pohjonen, S. Parviainen, A. Ruzibaev, K. Nordlund, HIP; in close collaboration with W. Wuensch and S. Calatroni (CERN)



- CLIC RF structures: one of major challenges electrical breakdowns near structure surface under very high electric fields.
  - developing a **multiscale model** to understand the mechanisms in or close to the surface of the materials due to the effect of static electric field.
- Currently pursuing parallel activities in all steps of the *multiscale* model:
  - simulating plastic deformations of metal surfaces due to tensile stresses to tips on the surface
  - combining electrodynamic effects atomistic simulations to predict behavior of surface atoms;
  - simulation of created plasma and subsequent surface damage.



Stage 1: Surf. charge, DFT ~ fs

Stage 2: surface evolution, MD&ED ~ ns

~ sec min

Stage 3a: Protrusions, dislocations, MD

Stage 3b: Surface evolution by KMC

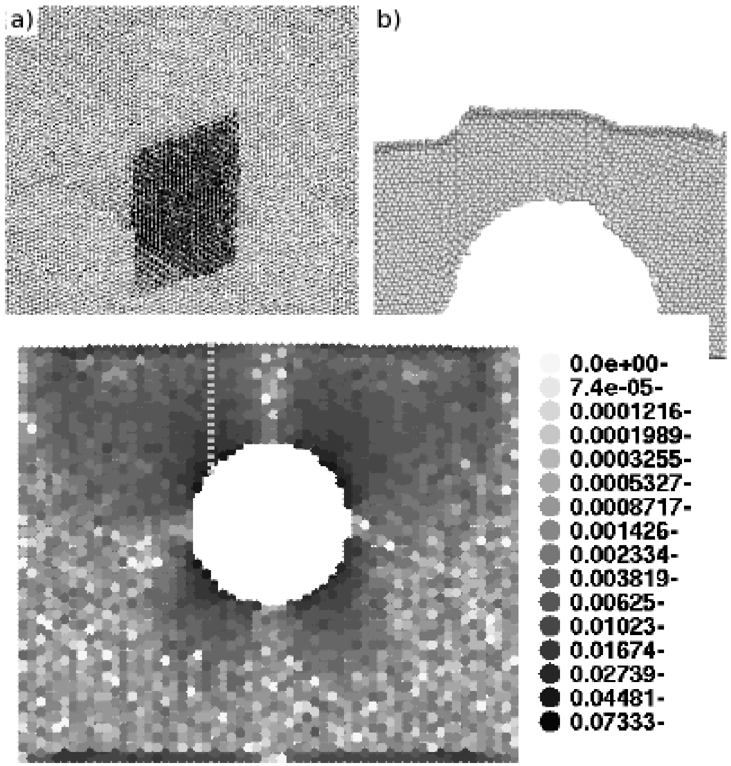
Stage 4: Plasma, PIC ~10s ns

Stage 5: Surf. Damage, Arc MD ~100s ns

Plastic deformations: near-to-surface voids can trigger tips

- We have applied different tensile stresses to investigate the effect of electric field on the plastic deformations in the crystals. The tensile stress $\vec{T}$ is varied from 2.4 to 4.58 GPa (or $E_0 \approx$ 16 GV/m to 22.7 GV/m).

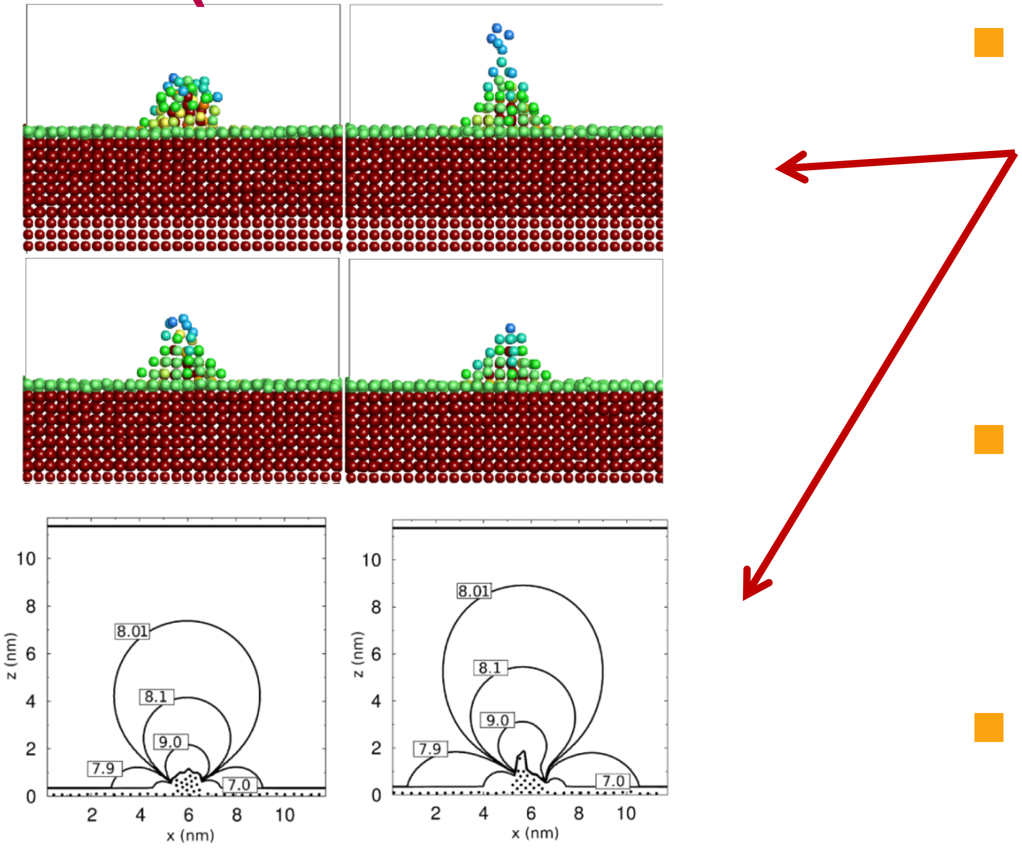
- The field has been exerted perpendicular to the surface, and the voids of different diameters were placed below the surface on the different depths.
- We found a linear dependence between the depth and the void diameter for different applied stresses.
- The theoretical consideration based on the isotropic elastic properties of crystals give good agreement with the simulation results, confirming that the prime importance for the formation of a protrusion is slip formation along 111 plane.



A. S. Pohjonen, F. Djurabekova, A. Kuronen, K. Nordlund: and S. Fitzgerald "*Dislocation nucleation from near surface void under static tensile stress in Cu*", Jour. Appl. Phys, submitted.(2010)

Evolution of a tip placed on the surface

(Published also as CLIC note)

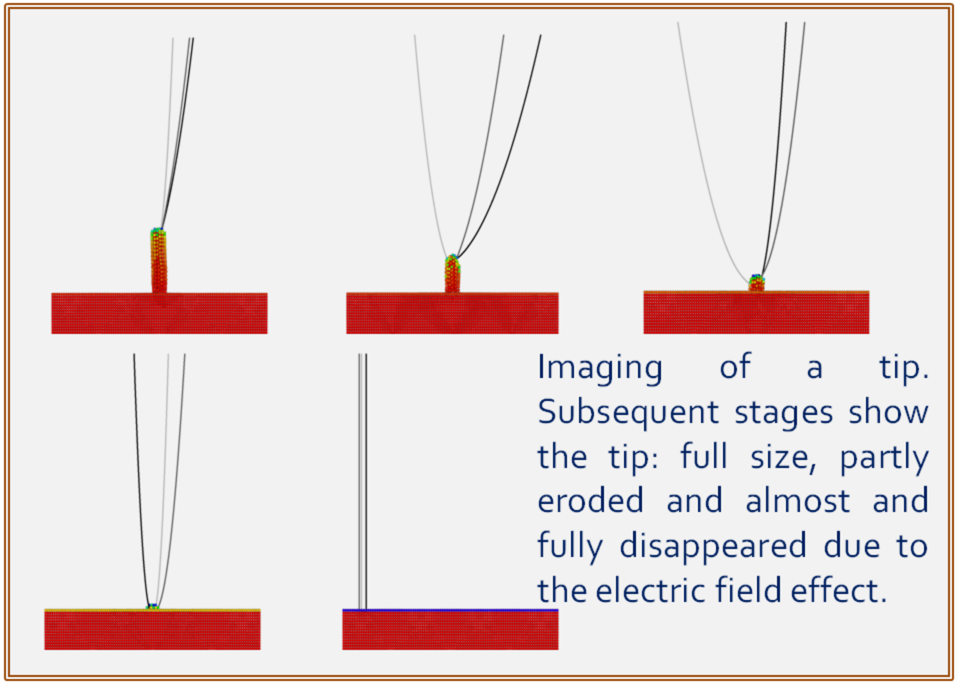


- We calculate the effect of high electric fields on the metal surface and consistently introducing this information into Molecular Dynamics simulations of the surface evolution.
- If temperature of the surface is sufficient, atom evaporation enhanced by the field can supply neutrals to build up the plasma densities above surface.
- We have also initiated the simulation of image reconstruction for Atom Probe tomography to include a KMC step (Initiation of Kinetic Monte Carlo studies)

F. Djurabekova, S. Parviainen, A. Pohjonen and K. Nordlund: “*Atomistic modelling of metal surfaces under electric fields: direct coupling of electric fields to a molecular dynamics algorithm*”, **PRE 83**, 026704 (2011)

KMC model of surface evolution

- We have initiated the modeling of surface evolution based on the Monte Carlo realization of probable events. To test this idea we simulate the image reconstruction in Atom probe tomography.

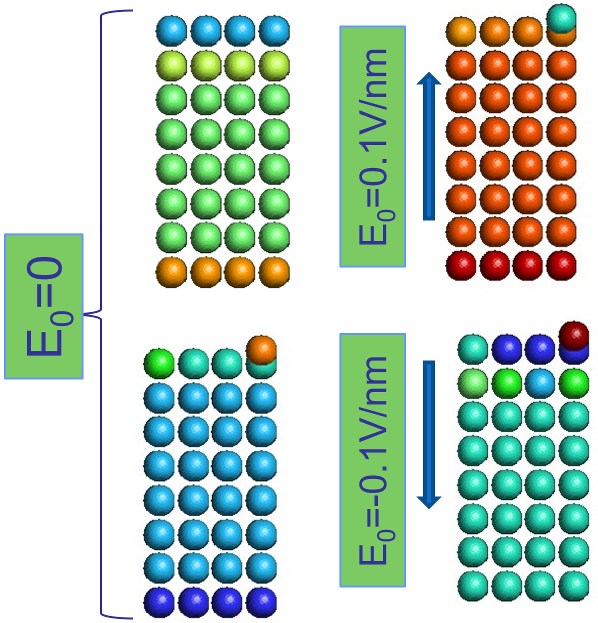


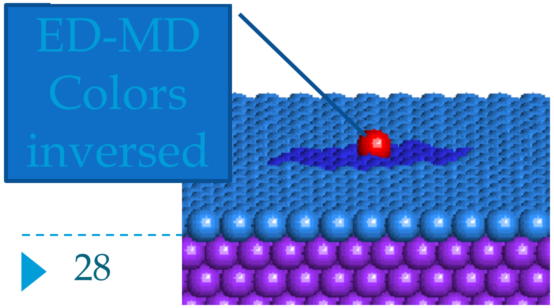
Imaging of a tip. Subsequent stages show the tip: full size, partly eroded and almost and fully disappeared due to the electric field effect.

- Combining two techniques, ED-MD and Monte Carlo to speed up the simulation process increasing the simulated timespan, we can reconstruct the image of a tip with higher accuracy than any of the contemporary techniques.
- This model takes into account inhomogeneity of the surface content. (inclusions, surface roughening)

Density functional theory calculations of the potential on the Cu (100) surface with and without an adatom

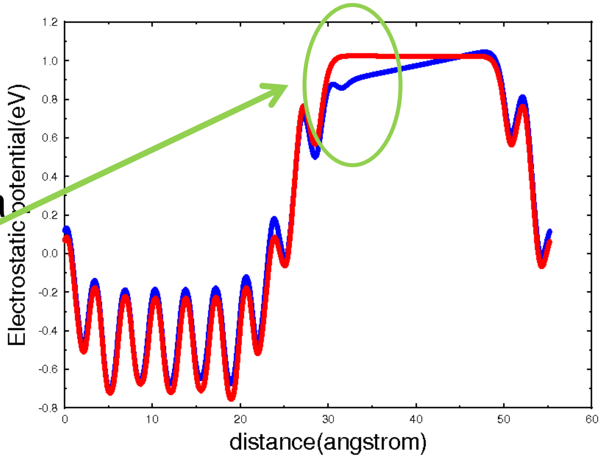
Calculations of the charges are consistent!

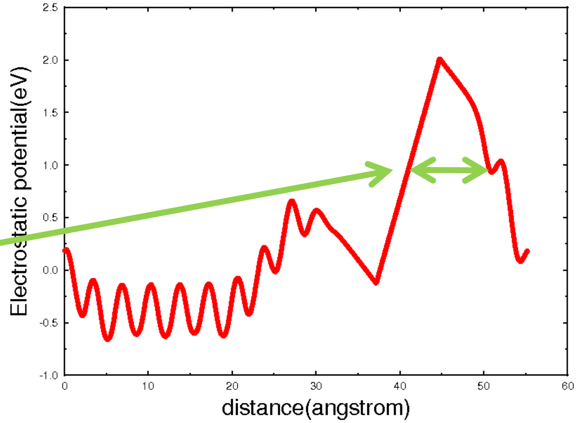




The vacuum level is reduced if the adatom is present. This gives a drop in work function. Presently we are estimating quantitatively the drop in work function due to the presence of 1,2 and 3 adatoms.

The width of the potential barrier in the presence of an electric field can give an accurate estimation for the field emission current.



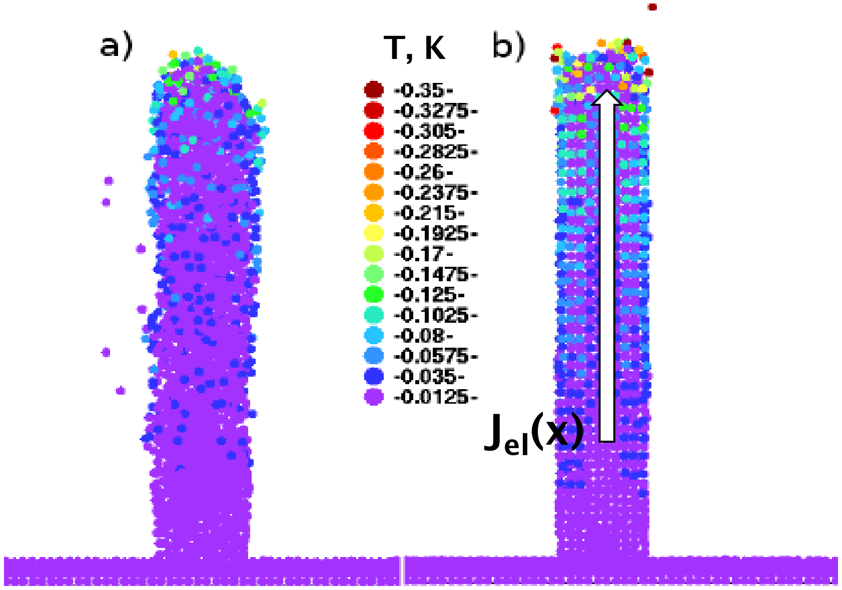


Field emission current induces a temperature gradient in surface tips

Published as a CLIC note

- The heat conduction from the tip has been implemented into PARCAS by solving the heat conduction equation to include only an electronic conductivity

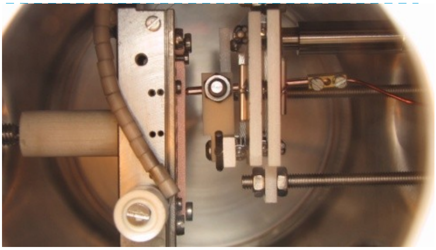
- This model is used to simulate the field supported thermal evaporation of the atoms from the tip.
- In the simulation, although the surface temperature is 300 K, at the tip apex it can raise to the melting point, increasing the evaporating of neutral atoms.

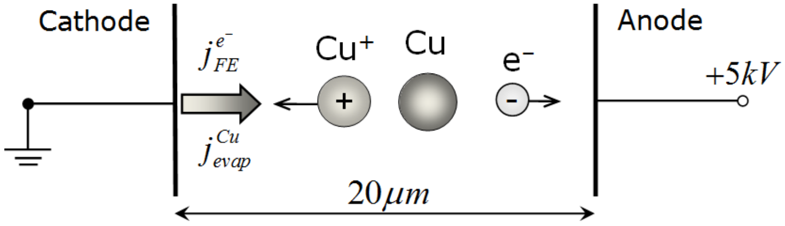


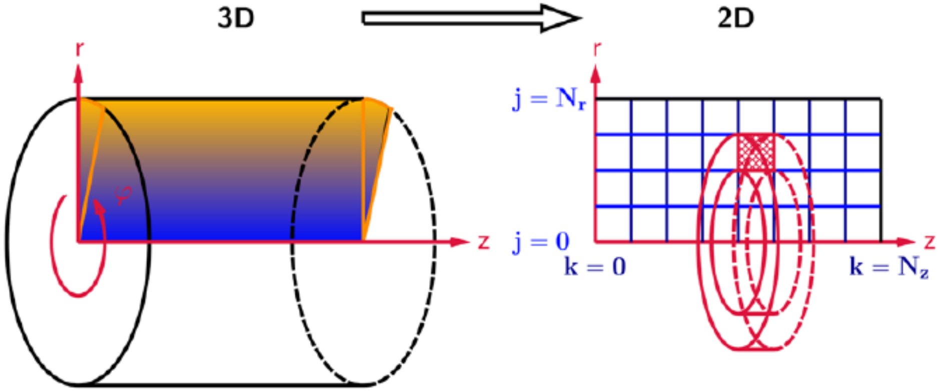
1. S. Parviainen, F. Djurabekova, H. Timko and K. Nordlund: "*Implementation of electronic processes into MD simulations of nanoscale metal tips under electric fields* ", **Comput. Mater. Sci.,** accepted 2010
2. S. Parviainen, F. Djurabekova, A. Pohjonen and K. Nordlund "Molecular Dynamics simulations of nano-scale metal tips under electric fields", NIMB, accepted 2010

Arc plasma formation & evolution

- To develop plasma model collaborate with Max Planck IPP (prof. R.Schneider, Dr. K. Matyash)
- For a direct comparison with **experiments**, adjust **simulation parameters** to DC setup at CERN







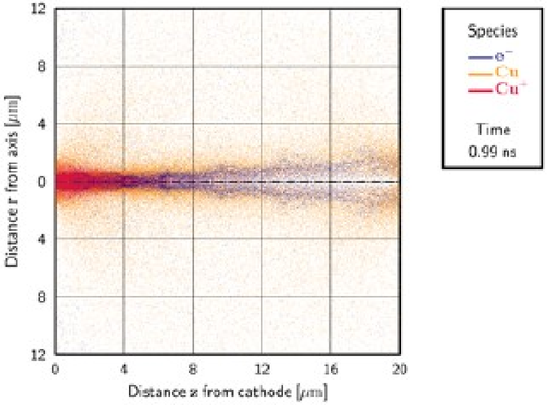
- The developed **2d 3v electrostatic ARC-PIC (MCC)** code is compared in details to another plasma simulation code developed at Sandia National Laboratory. The comparison is organized as scientific publication, prepared for submission.

  The code has following features:

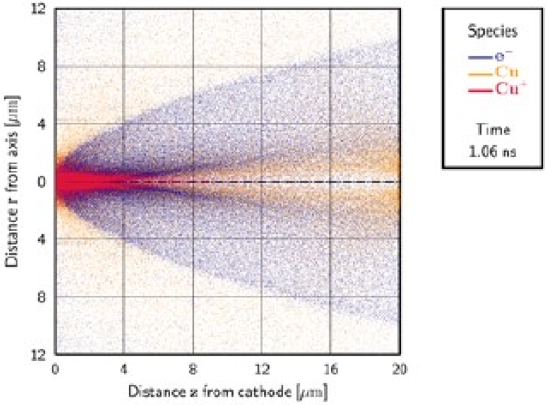
  - Resolving the main stream of plasma in 2D space (along the axis between cathode and anode and radially from the center of the cathode containing the emitting tip);

Plasma simulation results

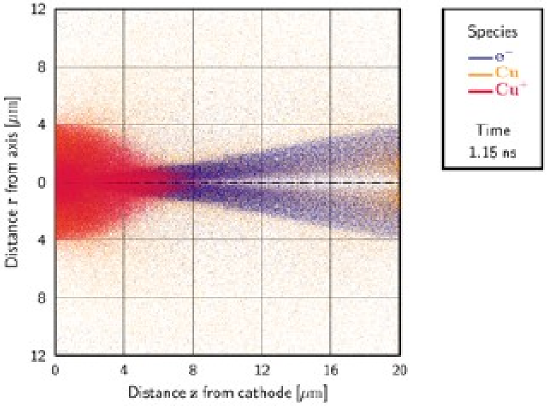
- Modeling of cathode plasma initiation in copper vacuum arc discharges via PIC simulations, *H. Timko, K.Matyash, R. Schneider, F. Djurabekova, K. Nordlund, S.Calatroni, W.Wuensch* ***Contr. Plasma Phys.**, 2011* (in progress)



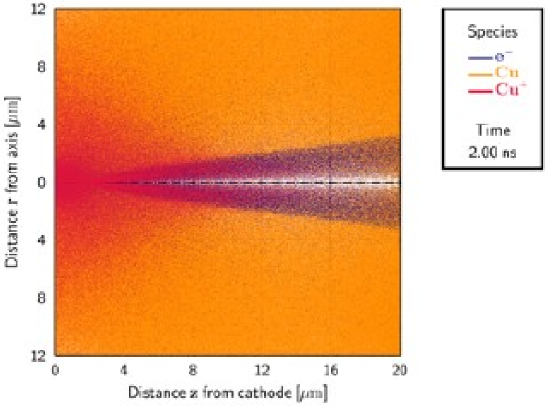
(a) Simulation system at 0.99 ns



(b) Simulation system at 1.06 ns

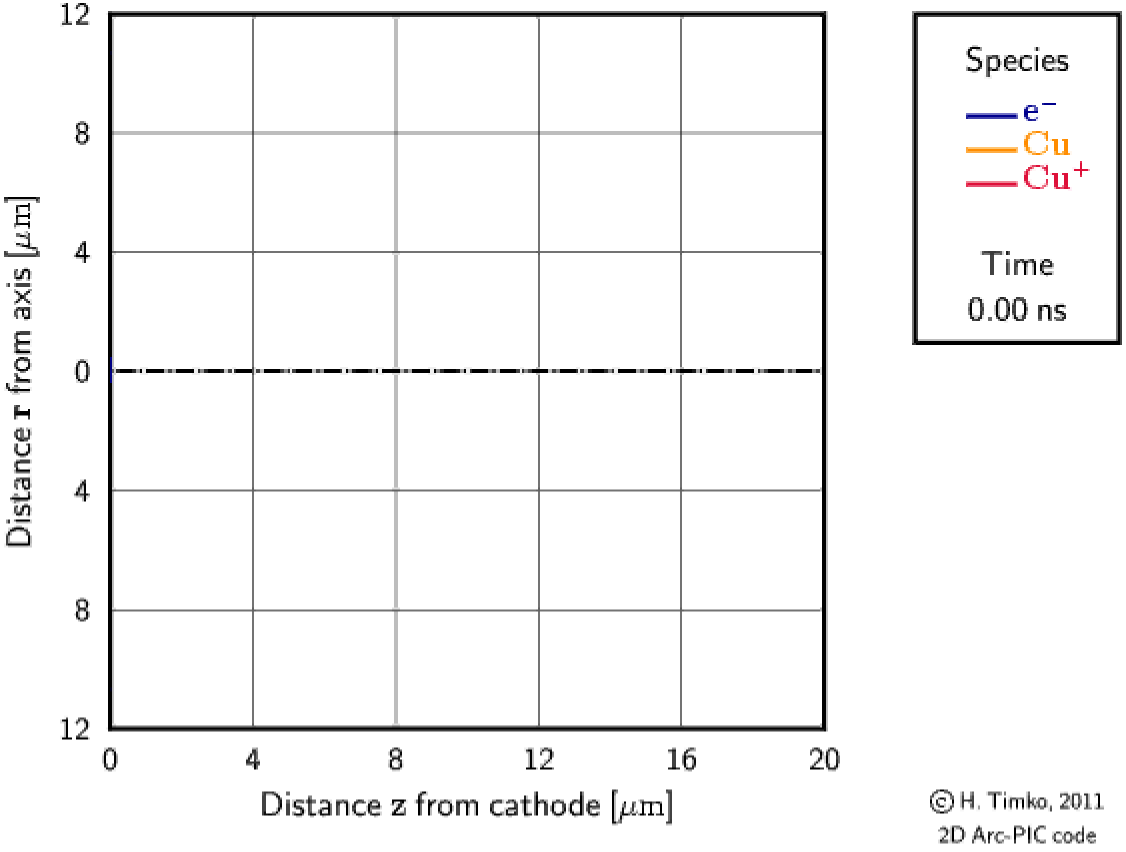


(c) Simulation system at 1.15 ns



(d) Simulation system at 2.00 ns

Vacuum arc formation (2D-PIC results)



Future activities

- **Dislocation activities:** Finalize the publications on theoretical prediction of dislocation activities leading to the formation of surface protrusions in the presence of electric fields.
- **Comparison of Electron densities from quantum and classical model:** Calculation of *work function* by first principles techniques (Density Functional Theory, DFT) in presence of surface defects. Calibration of the DFT results with the classical hybrid ED&MD model continues.
- **Evolution of surface defects in high electric fields:** Continue the design and development of Kinetic Monte Carlo model to follow the surface evolution of defects in presence of sufficiently high electric fields. Integrate the image reconstruction for the Atom probe tomography with the experimental measurements form Culham Centre for Fusion Energy.
- **2D plasma simulation:** Finalize plasma simulation using 2D model to estimate realistic densities required to support plasma during experimentally observed time lengths.

Sub-task 9.2.4: Instrumentation

T. Muranaka

- New sample holder
- IV measurements and surface damage observations
- 5 µm W tip – Cu mirror surface
- 5 µm W tip – Cu etched surface

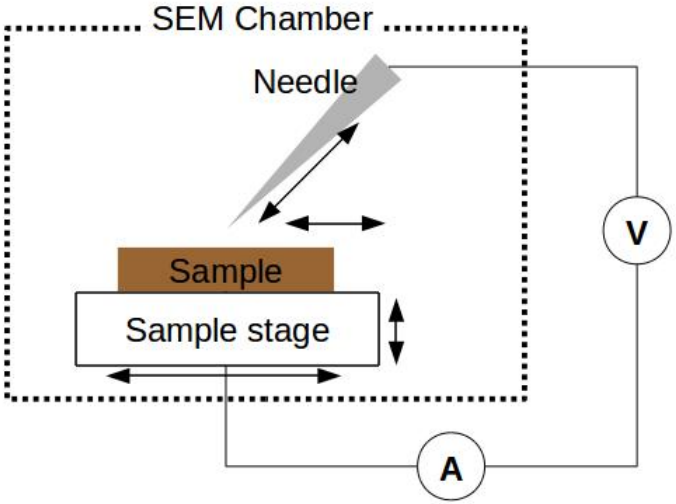
- NIMA XB10 proceeding was accepted

New setup

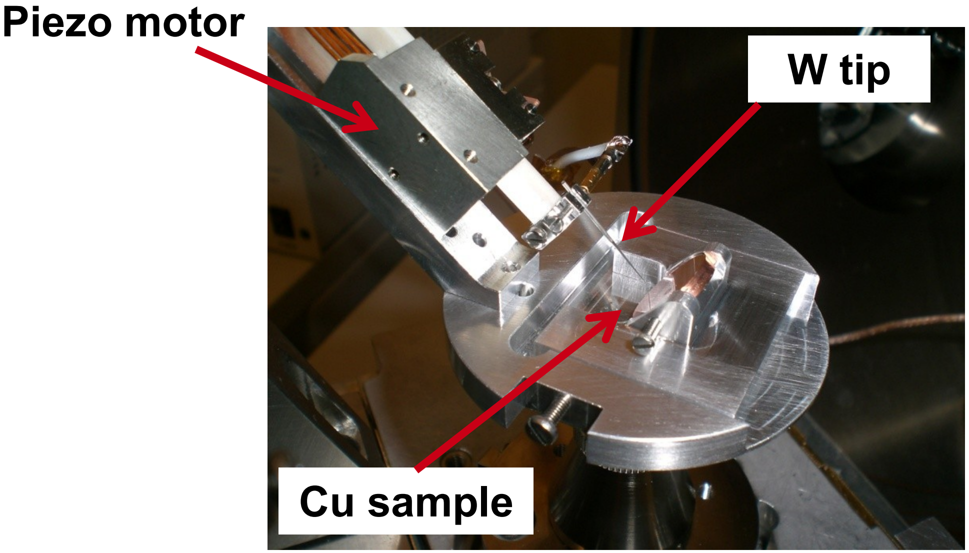
- **Basic Idea:** Reproduce high gradient electric field conditions in micro meter range: **1 GV/m = 1 kV/µm**

New! · An inclined sample holder has been installed

The piezo motor is on the ramp to avoid hitting the electron column. The new sample holder sets the sample surface perpendicular to the tip.



Exp. setup

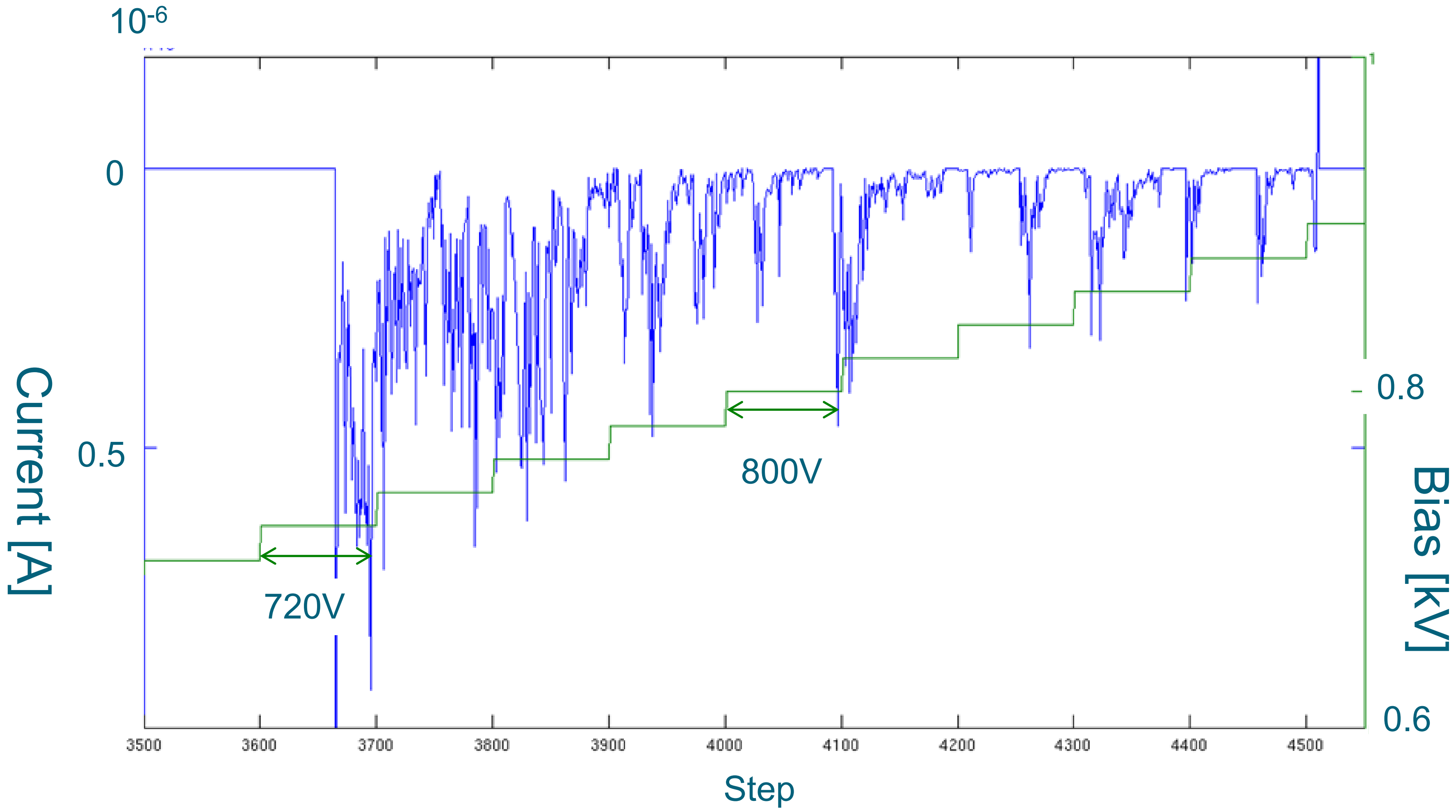


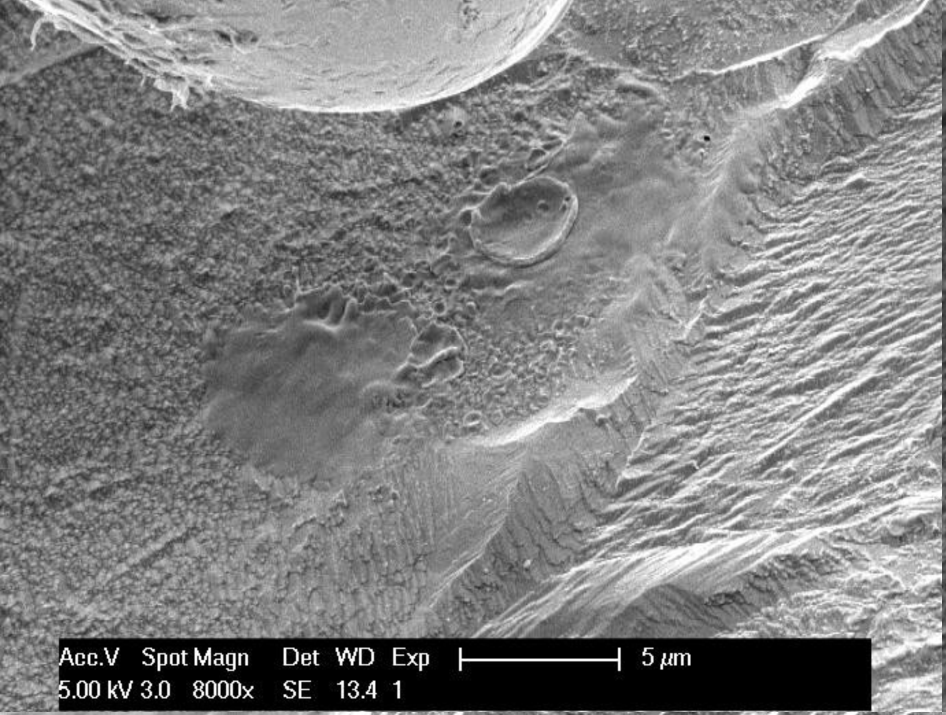
New measurements

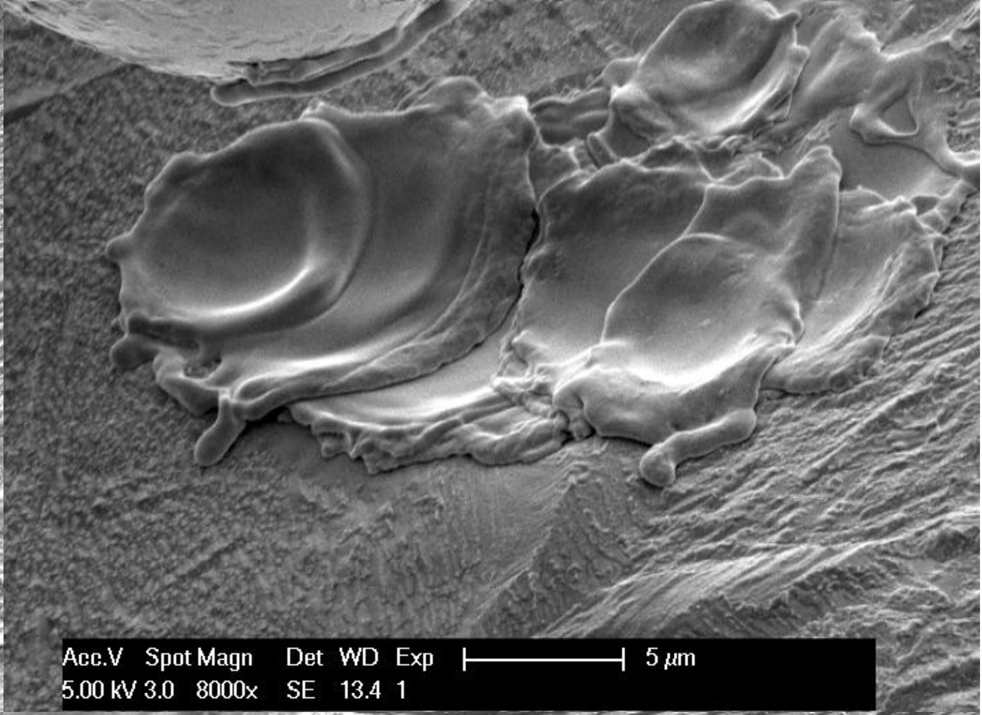
Condition 1 (17-18 Feb, 23-24 Feb)
Cathode: Cu etched surface (17 Feb morning)
Anode: 5 µm W tip
Gap: 1.5 µm
Bias: 0 – 2 kV

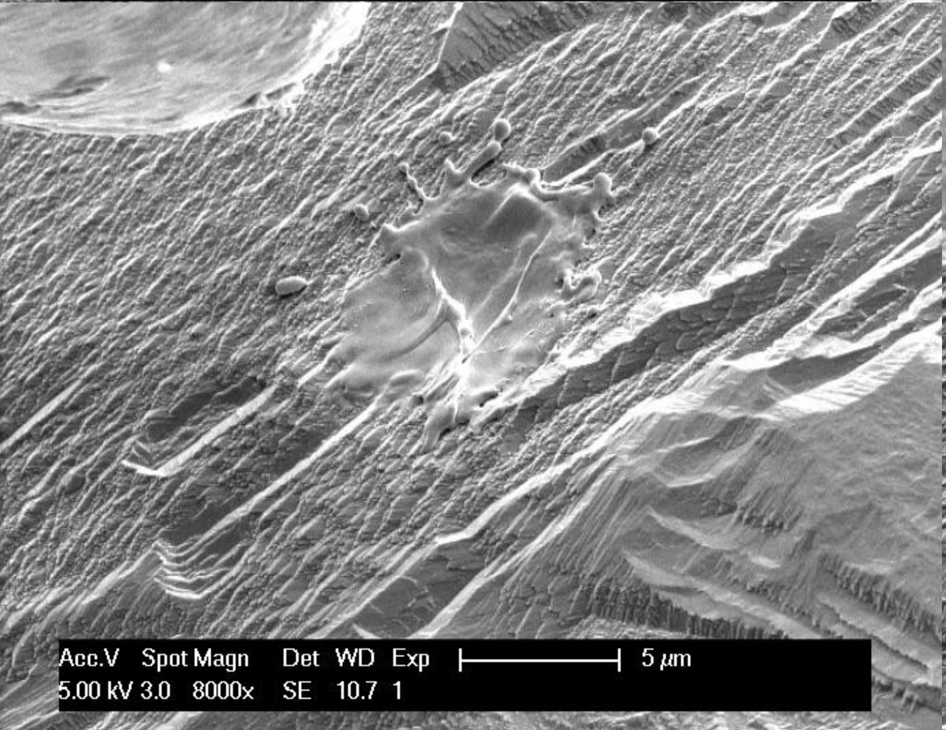
Distinct variations in the size of damaged area were observed among several measurements with same condition, although measured currents were almost the same (i.e. deposited energy on the surface were same) (see the next slide).
The positive bias was put on the W tip (of 5 µm radius instead 0.5 µm in the last report) keeping the gap of 1 µm from the sample surface.

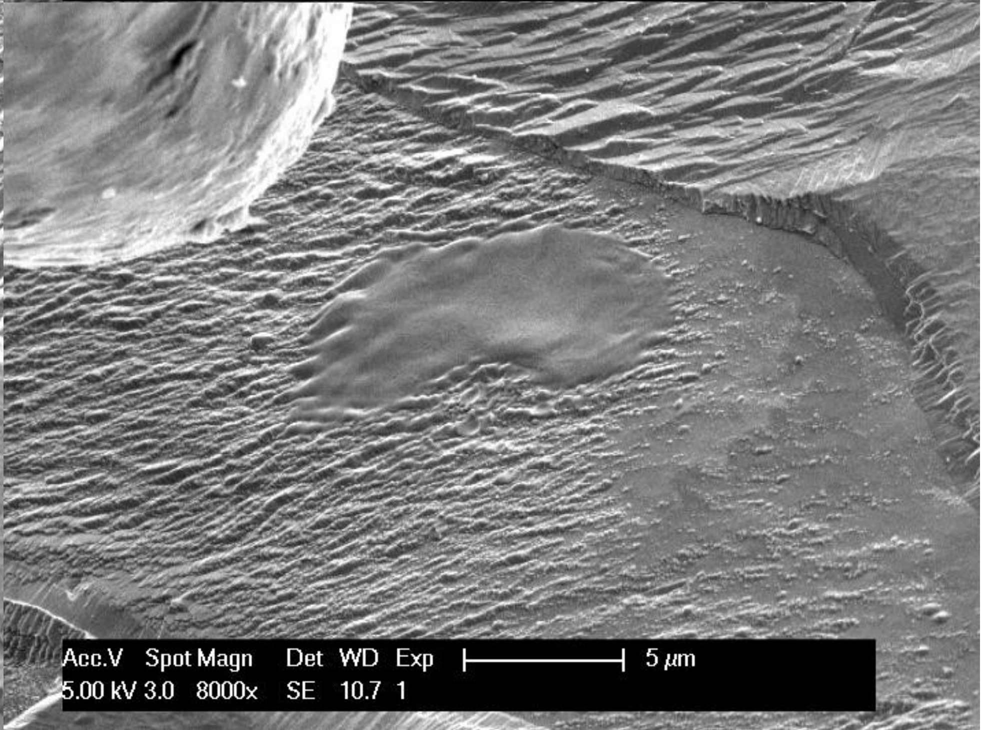
Current vs time (bias step: 20V)




Acc.V Spot Magn Det WD Exp
5 µm
5.00 kV 3.0 8000x SE 13.4 1


Acc.V Spot Magn Det WD Exp
5 µm
5.00 kV 3.0 8000x SE 13.4 1


Acc.V Spot Magn Det WD Exp
5 µm
5.00 kV 3.0 8000x SE 10.7 1

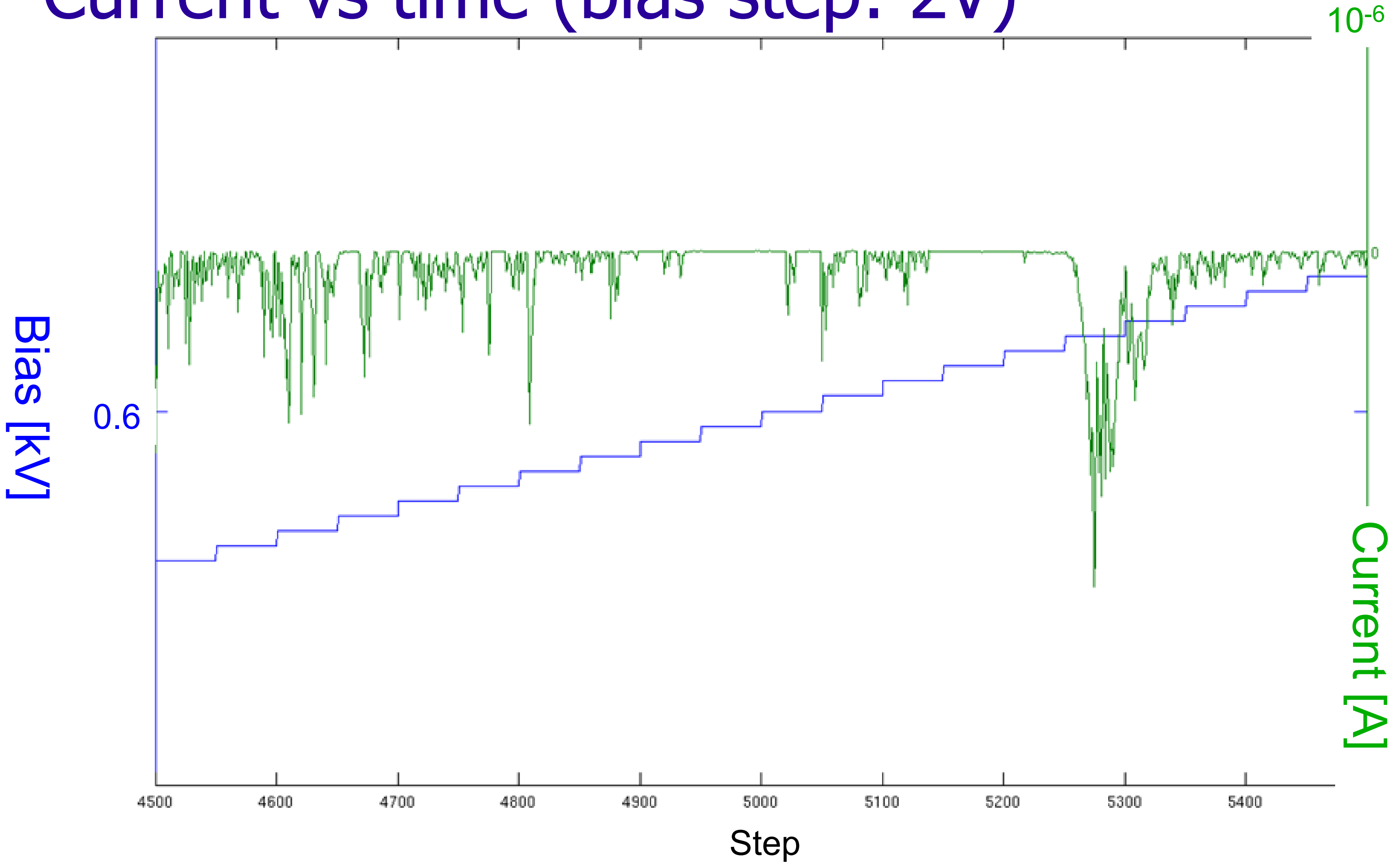

Acc.V Spot Magn Det WD Exp
5 µm
5.00 kV 3.0 8000x SE 10.7 1

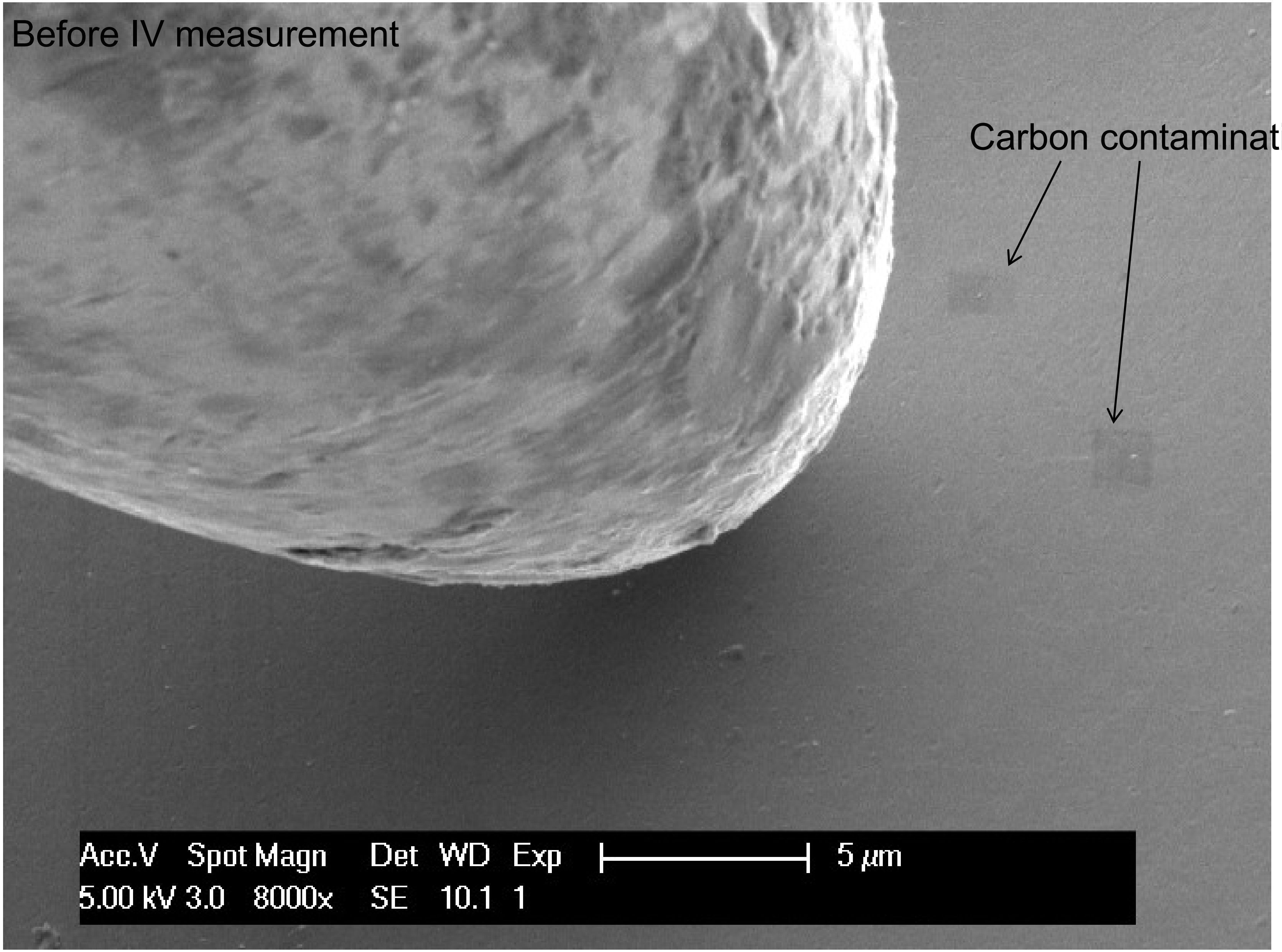
New measurements

Condition 2
Cathode: Cu mirror surface
Anode: 5 µm W tip
Gap: 1 µm
Bias: 0 – 1 kV

Measured currents were similar to that of the condition 1 (with etched surface) but surface melting was not observed.
Carbon contaminations were used as markers but dispersed after IV measurements.
Whitish contaminations were observed several times.

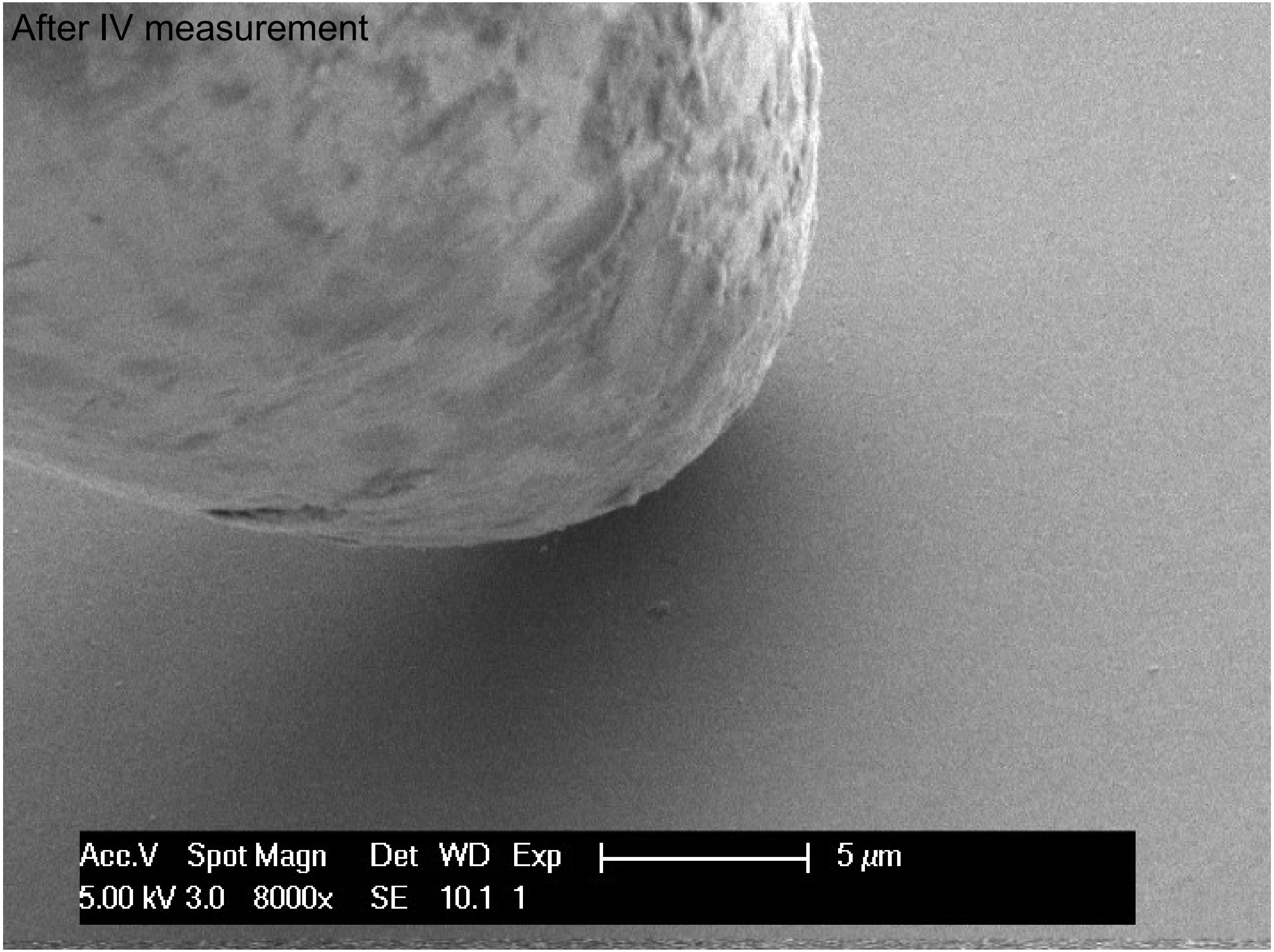
Current vs time (bias step: 2V)

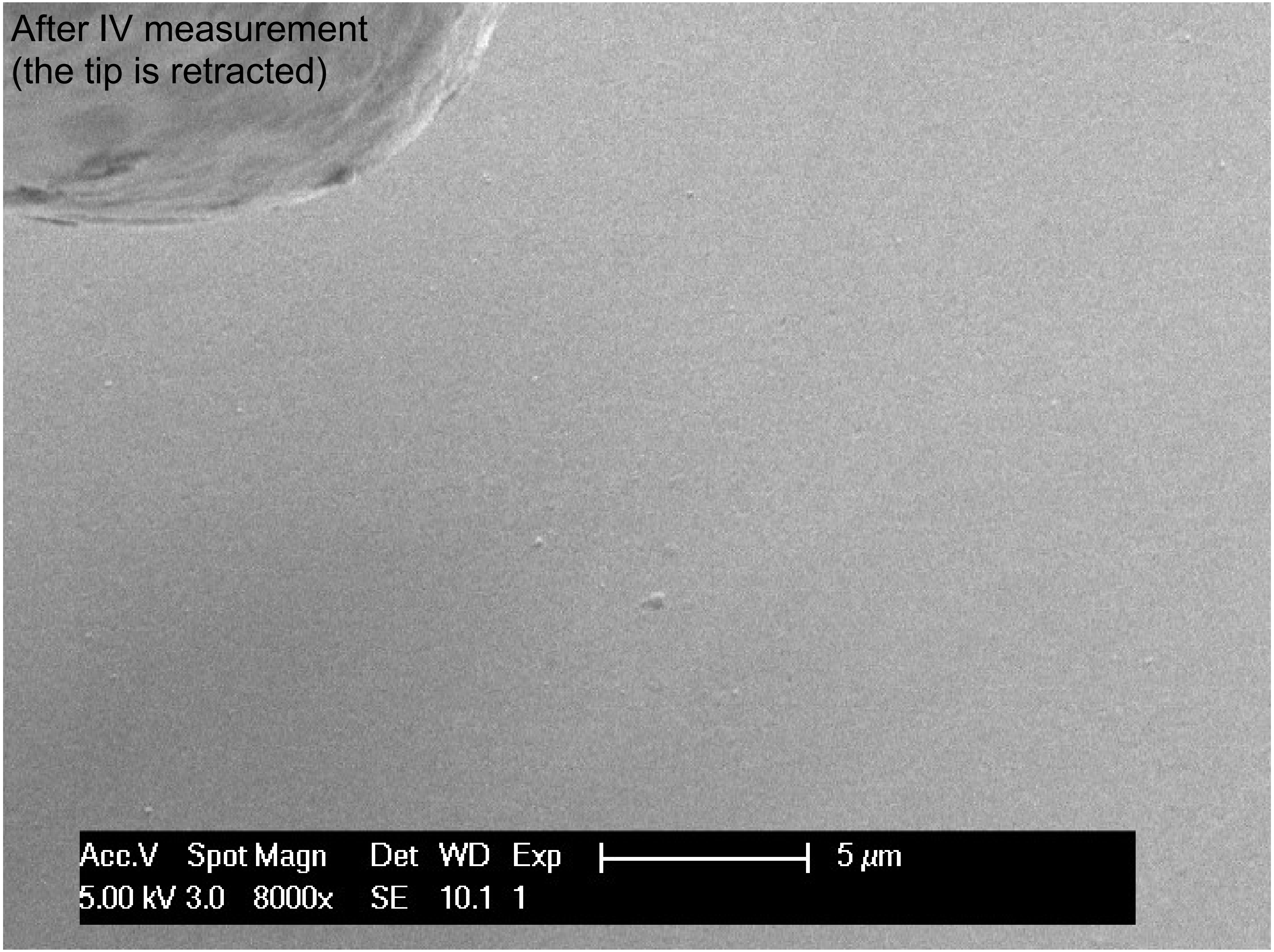




Before IV measurement

Carbon contamination

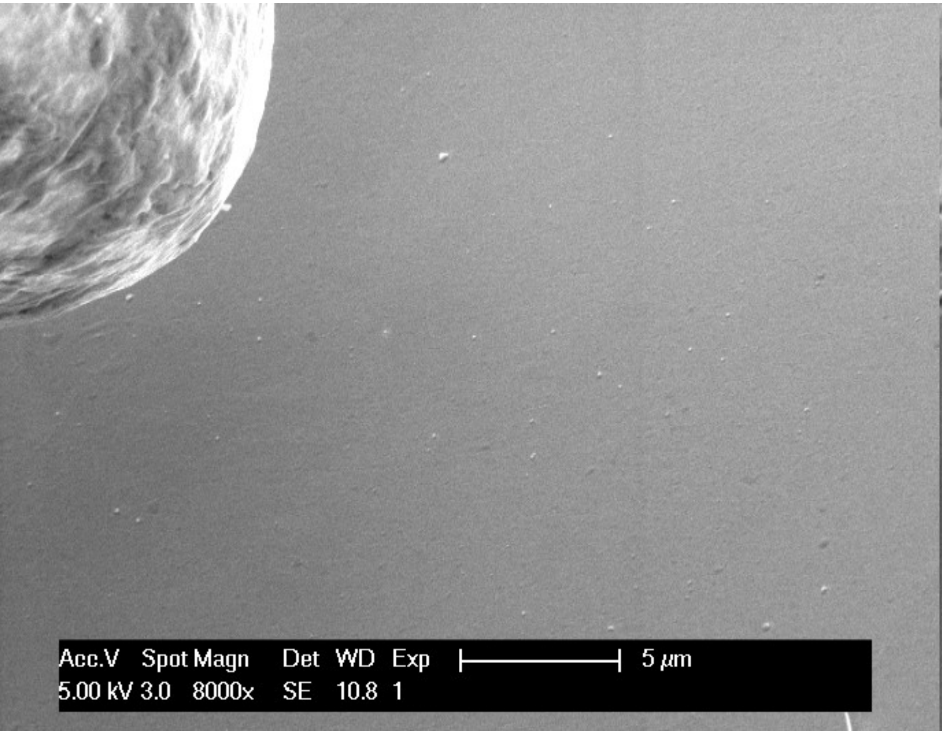

After IV measurement
Acc.V Spot Magn Det WD Exp
5.00 kV 3.0 8000x SE 10.1 1
5 µm



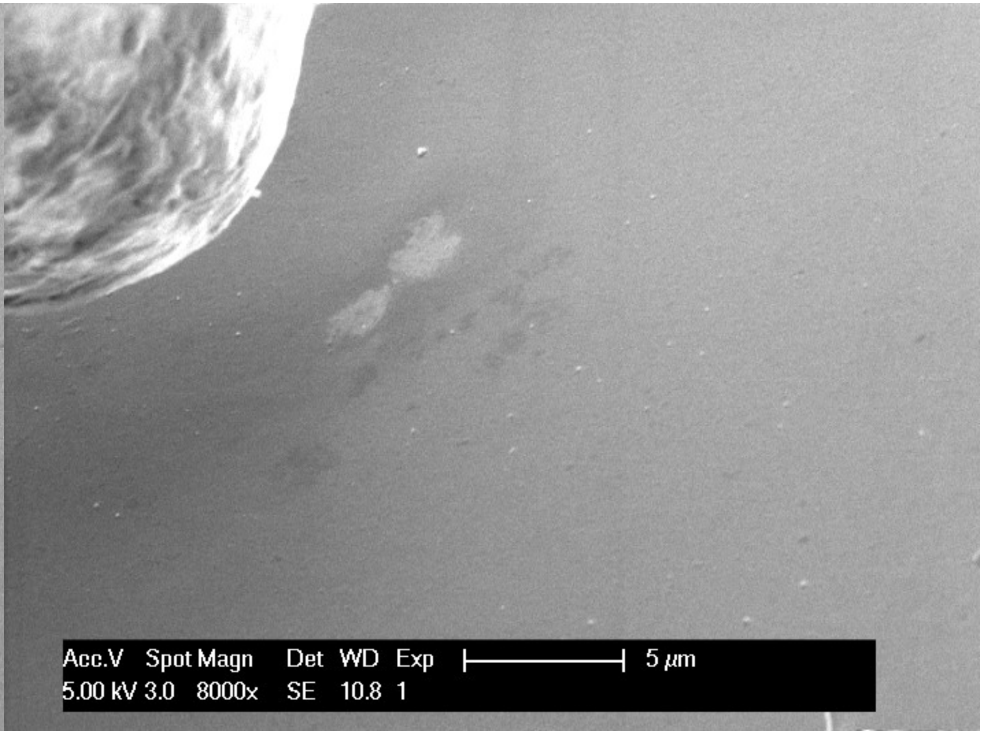
After IV measurement
(the tip is retracted)

New measurements

Before measurement



After measurement



Summary 9.2.4

Questions:

- Why the current is unstable? (even after 3 h of run)
- Why higher gradient?
- Is cleaning needed?
- Is conditioning needed?
- Is there any correlation between emission current (or emission process?) and surface damage/contamination?

Plan:

- Cleaning & conditioning process on the mirror surface

Task 9.2.5: precise ACS & PETS assembly

Helsinki Institute of Physics (HIP) & University of Helsinki (UH)

Text in EuCARD DoW:
"Precise assembly: Develop a strategy of assembly for the CLIC accelerating and power extraction structures satisfying the few to 10 micrometer precision requirement of positioning both radial and longitudinal taking into account dynamical effects present during accelerator operation."

Lecturer Kenneth Österberg (at ~ 10 %)

MSc (eng.) Jouni Huopana (→ 31.12.2010)

BSc (eng.) Riku Raatikainen (1.3.2011 →)

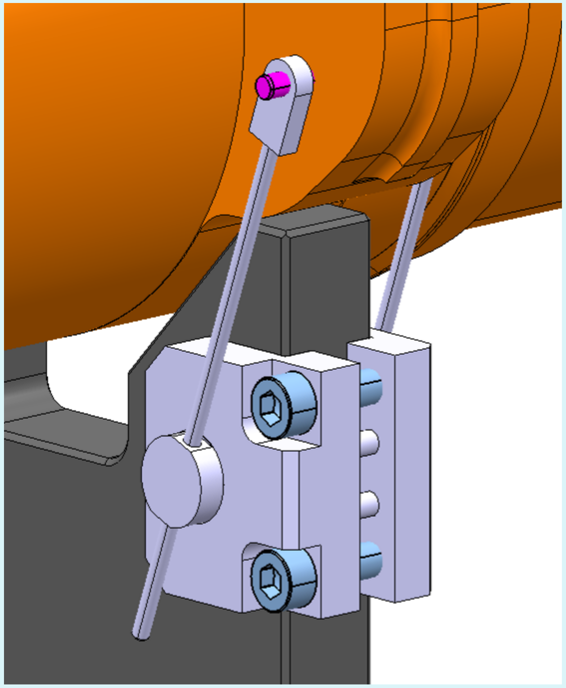
in close collaboration with CLIC module working group *(G. Riddone et al)* & VTT Technical Research Centre of Finland *(J. Paro et al, K. Mäkelä et al)*

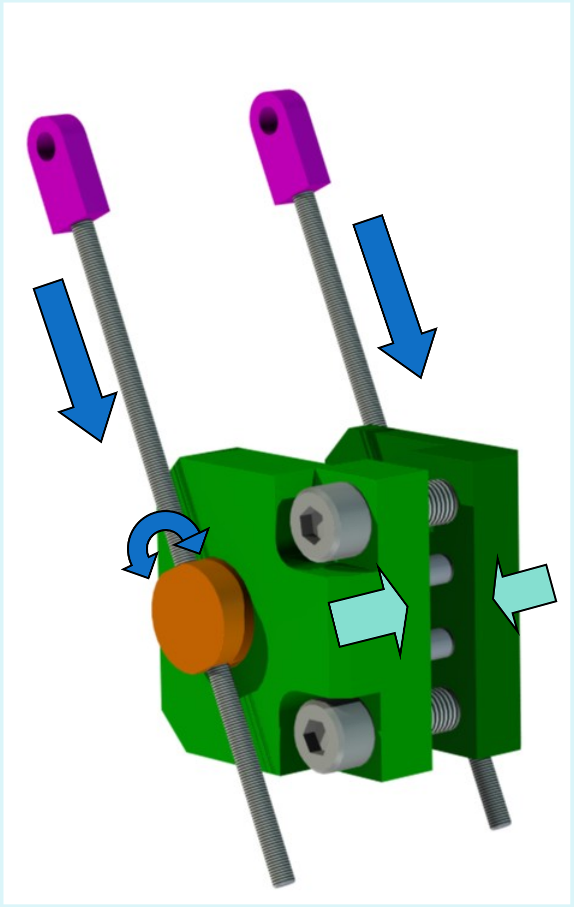
Precision assembly status

- Design & simulation of V-support for CLIC accelerating structures & PETS in CLIC module – finalized.
- Design of girder for CLIC module from mineral cast material – finalized.
- Design of interlocking accelerating structures disks with symmetrical assembly (CLIC-G) – finalized
- Finite Element Analysis FEA for CLIC accelerating structures: simulation of residual stress & deformation during machining & brazing/bonding – simulations for CLIC-G done
- Structural analysis for PETS tooling – finalized
- PhD on precision manufacturing & assembly – in progress
- Thermo-mechanical modelling of CLIC two-beam module: laboratory test module simulation & CLIC module simulation with updated configuration – in progress

Design of a clamping device to keep the RF-structures in place

J.Huopana

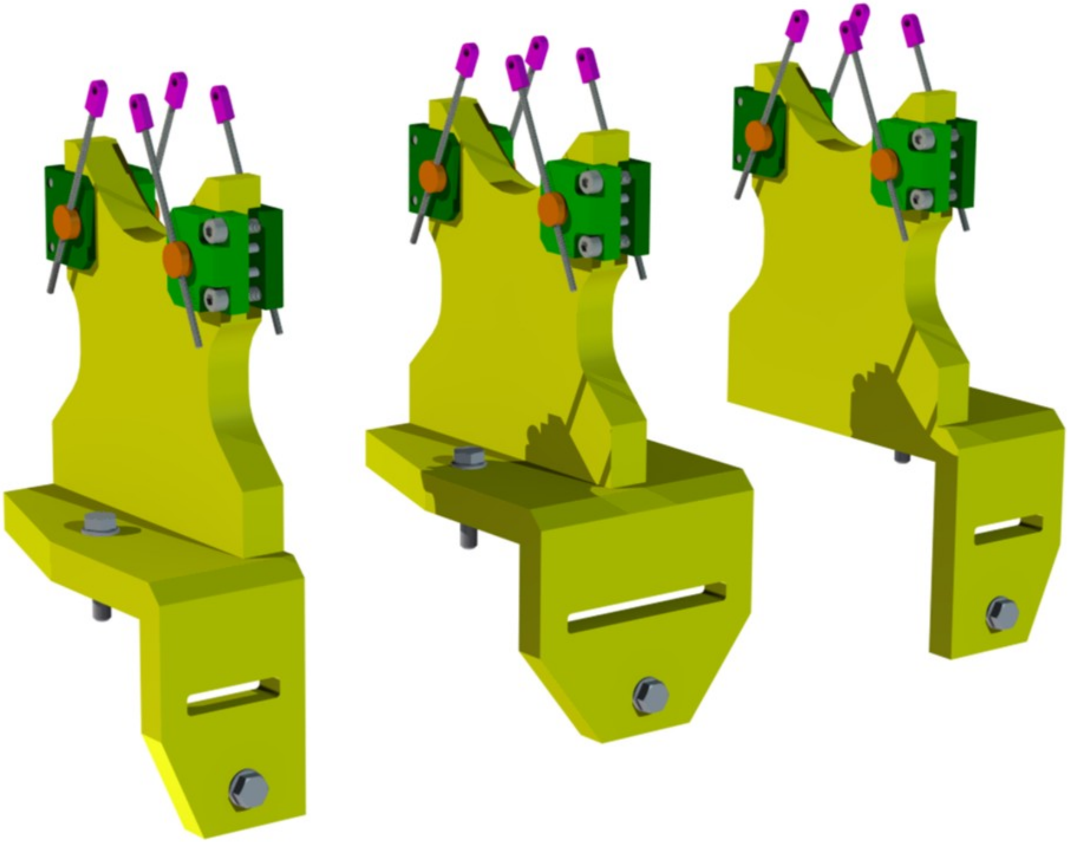




- Clamp (green) fixed to V-support
- Threaded bars used to “pull down” pin which works as coupler
- Bars can be rotate “freely” (orange)

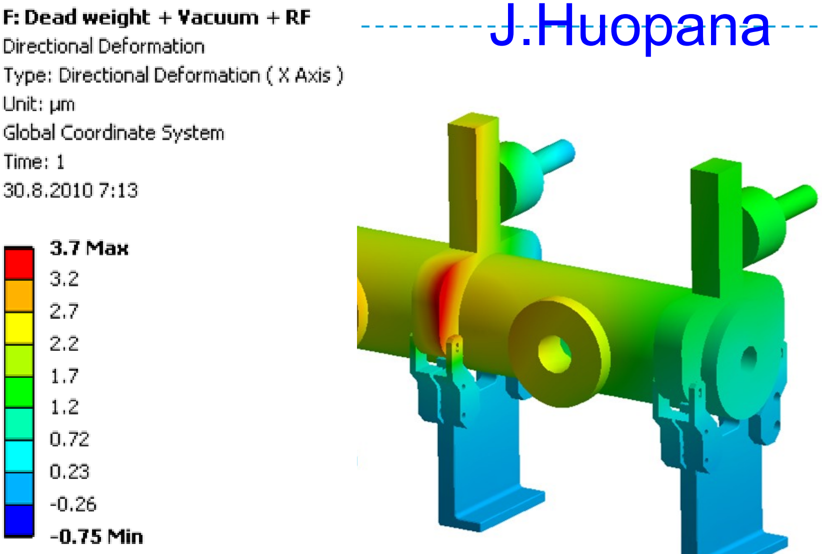
Designed V-supports and clamping mechanics illustration

J.Huopana

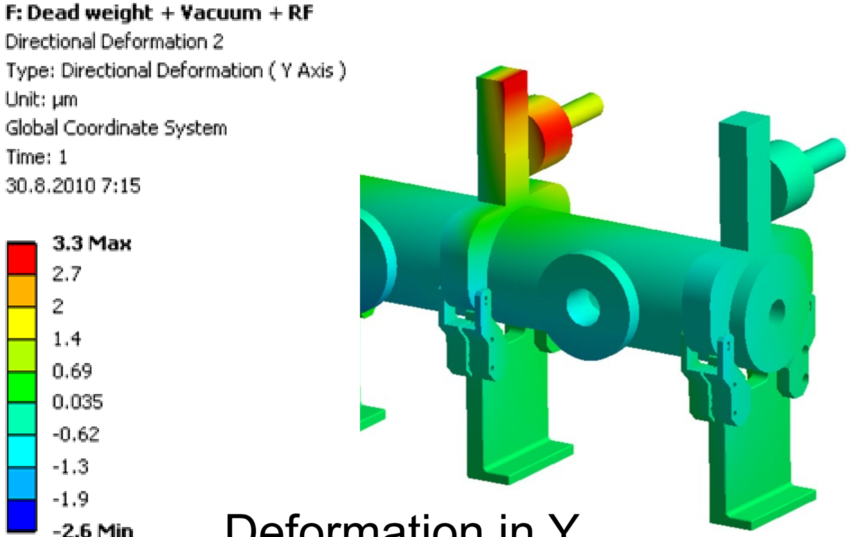


Simulation of weight + vacuum + RF on the PETS and support

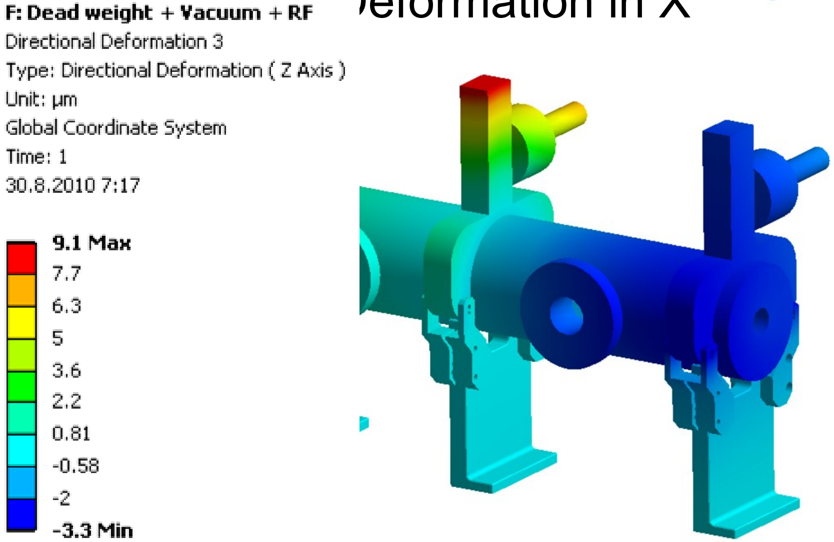
J.Huopana


F: Dead weight + Vacuum + RF
Directional Deformation
Type: Directional Deformation (X Axis)
Unit: µm
Global Coordinate System
Time: 1
30.8.2010 7:13

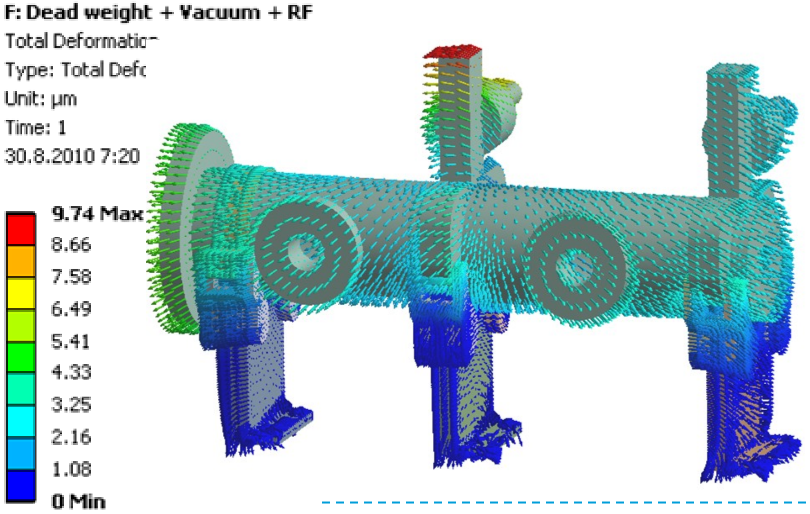
Deformation in X


F: Dead weight + Vacuum + RF
Directional Deformation 2
Type: Directional Deformation (Y Axis)
Unit: µm
Global Coordinate System
Time: 1
30.8.2010 7:15

Deformation in Y


F: Dead weight + Vacuum + RF
Directional Deformation 3
Type: Directional Deformation (Z Axis)
Unit: µm
Global Coordinate System
Time: 1
30.8.2010 7:17

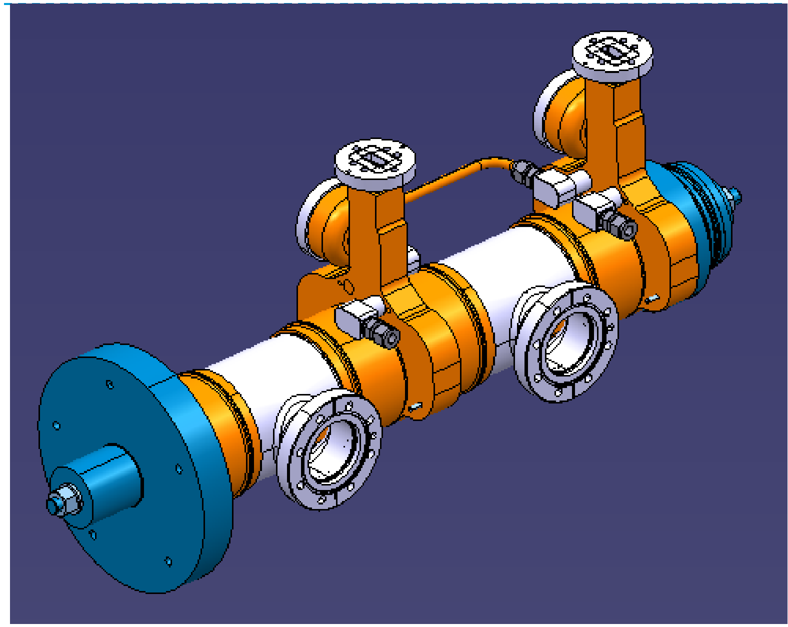
Deformation in Z


F: Dead weight + Vacuum + RF
Total Deformatio
Type: Total Defo
Unit: µm
Time: 1
30.8.2010 7:20

Deformation in total

Structural analysis for PETS tooling

R. Raatikainen



Power Extraction and Transport Structure (PETS) used in the CLIC lab test module

To ensure reliable welding structural analysis was implemented to point out the deformation under axial loading

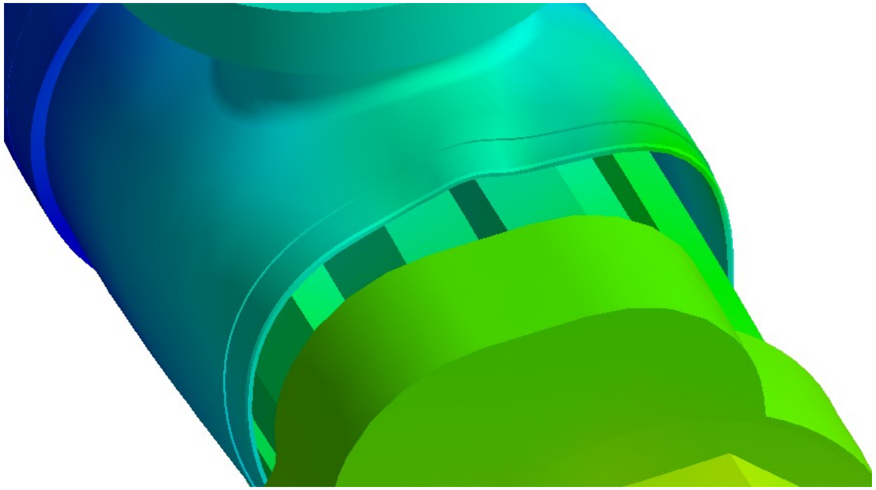
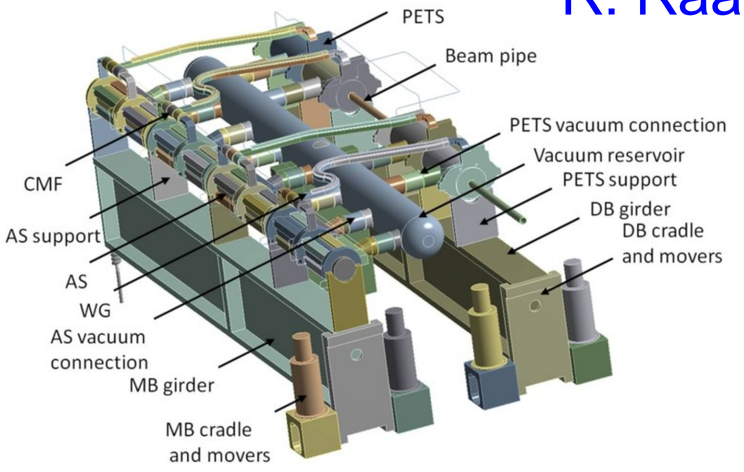


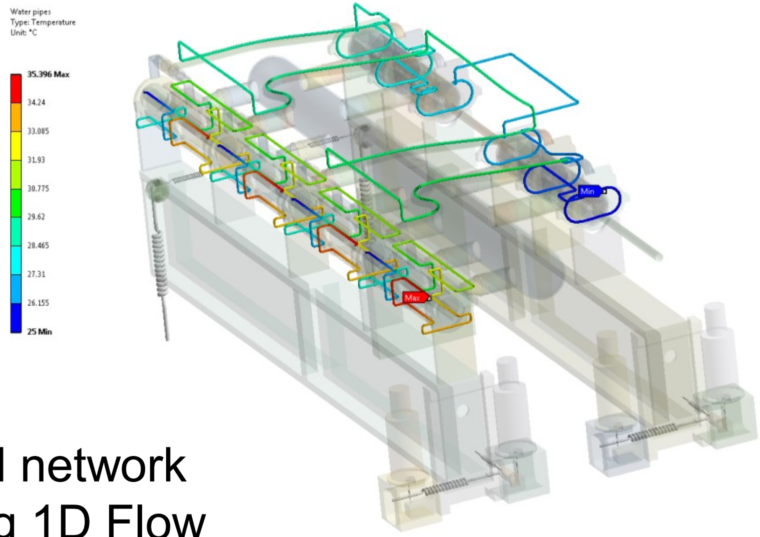
Illustration of too large axial loading => Steel shell losing its stability

Thermo-mechanical modeling of CLIC two-beam module

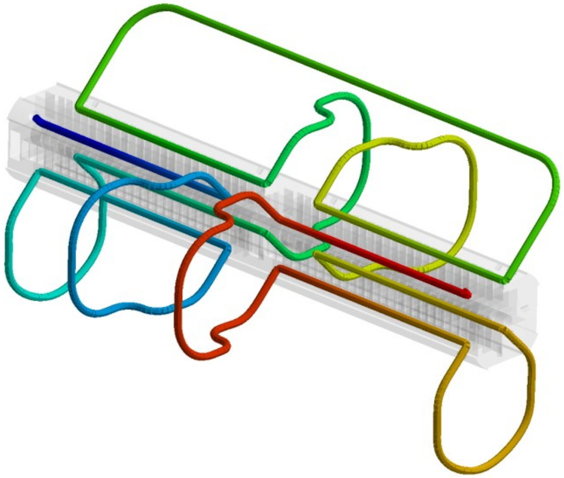
R. Raatikainen



CLIC module to be upgraded



Fluid network using 1D Flow



Two Accelerating Structures and Fluid Network for CLIC lab test Module

Future activities

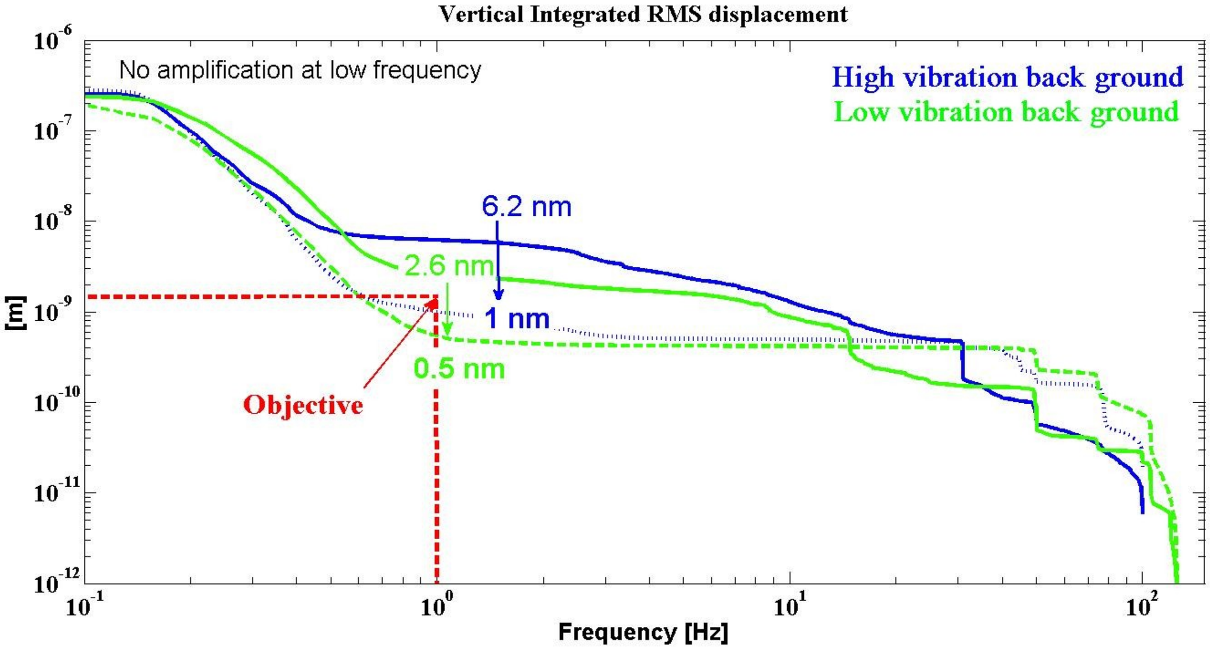
- More in-depth Finite Element Analysis FEA for CLIC accelerating structures
- Thermo-mechanical modelling of CLIC two-beam module: laboratory test module simulation & CLIC module simulation with updated configuration

9.3 Stabilisation (LAPP/CNRS, CERN, UOXF-DL)

- Coordination: A Jeremie, LAPP/CNRS
- Subtasks:
  - Design, build and test for stabilisation a CLIC quadrupole module in an accelerator environment,
  - Design, build and test for stabilisation a Final Focus test stand

Feasibility demonstration
2 d.o.f. with type 1 mass 100 kg

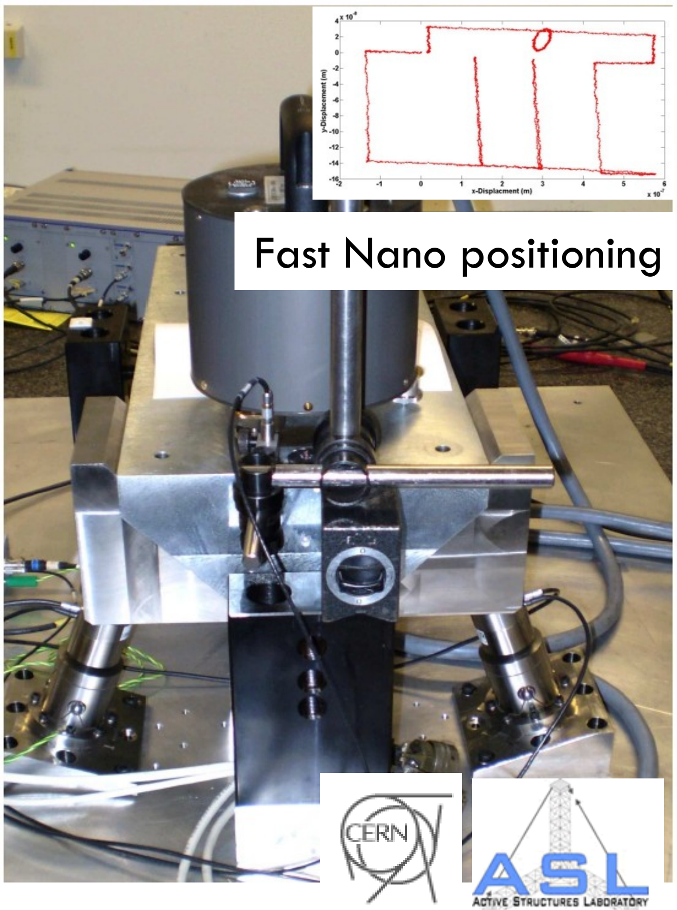
Simultaneous vertical and lateral stabilization



<u>Feasibility demonstrated on type 1 mass:</u>

0.5 nm is factor 3 better than objective

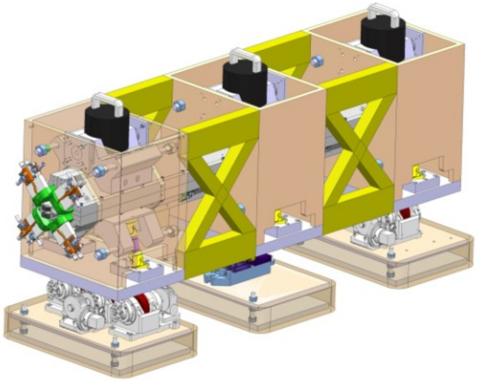
For high ground motion the R.M.S. ratio at 1 Hz > 6



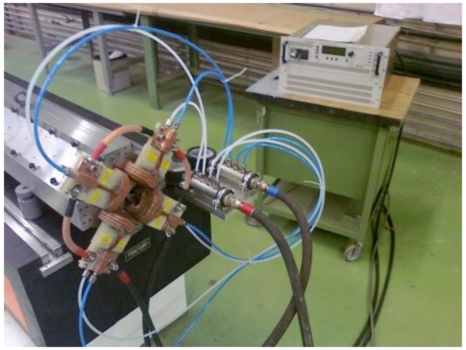
Fast Nano positioning

With low cost analogue controller

Ongoing work:
CLIC MBQ Stabilisation



- ☐ Mechanical design and construction Type1 and Type4 CLIC MBQ stabilization and nano-positioning system



- ☐ Modal analysis and water cooling induced vibration measurements of Type 4 MBQ prototype

- ☐ Development of an accelerator environment compatible vibration sensor
- ☐ Cost reduction and pre industrialization

K. Artoos, C. Collette, M. Esposito, P. Fernandez Carmona, M. Guinchard, C.Hauviller, S.Janssens, A. Kuzmin, R. Leuxe, R. Moron-Ballester

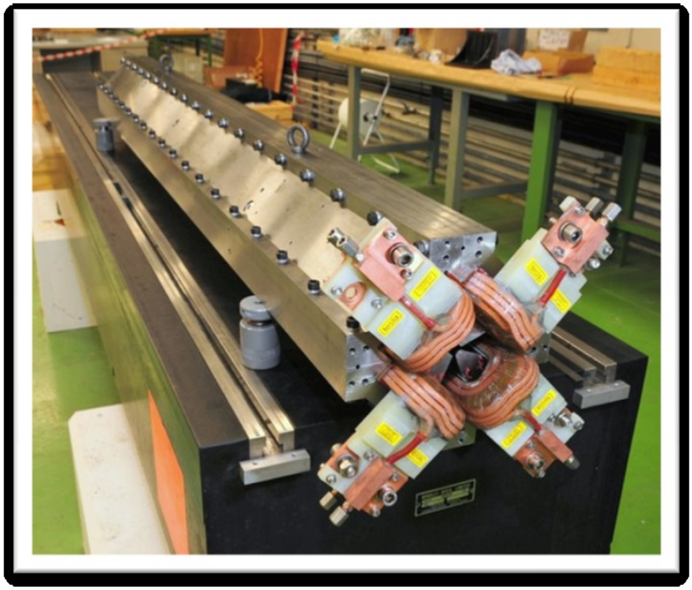
Support of MB Quad

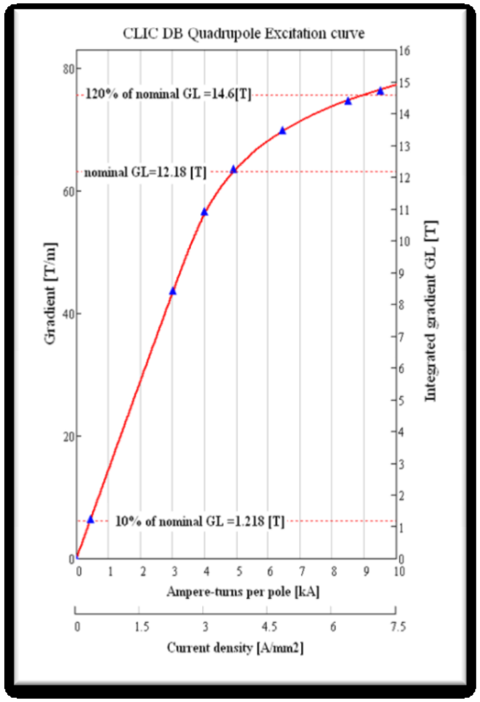
installed on cam movers in building 927 at CERN

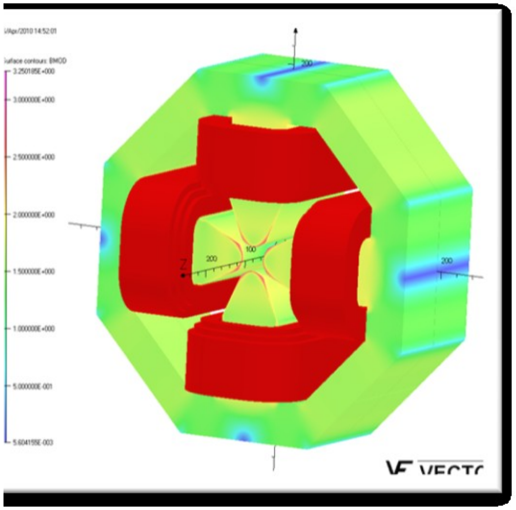
courtesy: Helène Mainaud-Durand

Quadrupoles prototypes for the CLIC "Two-Beams" Modules:

(right): **"Main Beam Quads"** (**MBQ**): 2 Prototypes (Type1 and Type4) for **LAB** and **CLEX Test Program**: components procured and magnet now assembled at CERN and ready for stabilization studies.
(Magnet Aperture: 10 mm; Nominal Gradient: 200 T/m; 4 different lengths)

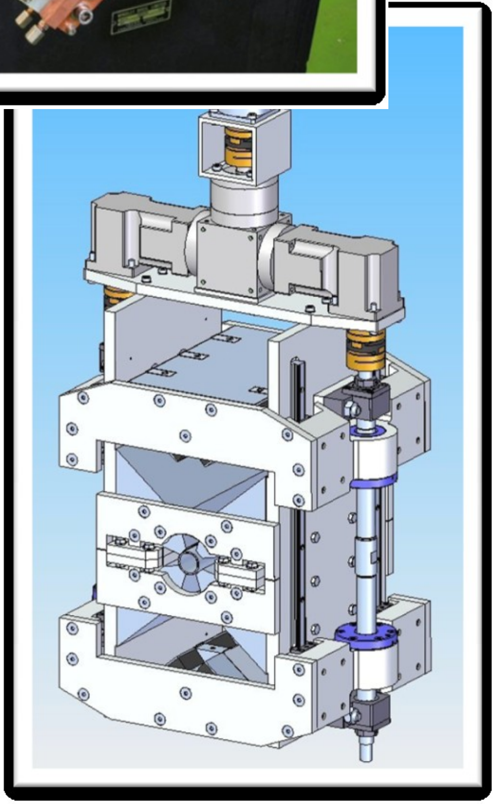






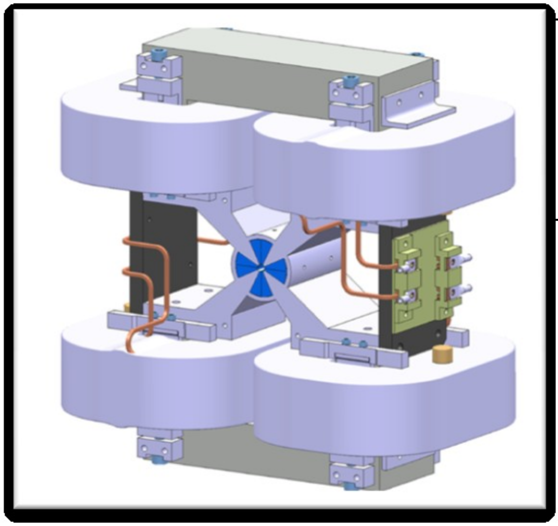
(above) ***"Drive Beam Quads" BASELINE EM version:*** *Design for a wide operation range completed at CERN. Procurement just launched for 6-8 units*

(right) ***"Drive Beam Quads" ALTERNATIVE TUNABLE PM design (by Cockcroft Institute):***
Design close to completion. Prototypes procurement will now follow.

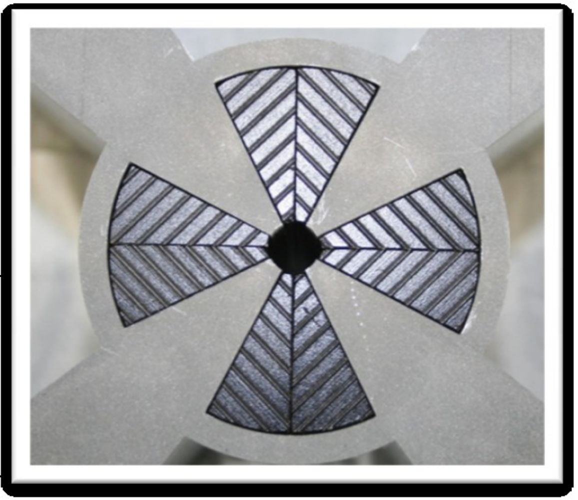


Quadrupole prototype for the Final Focus QDO :

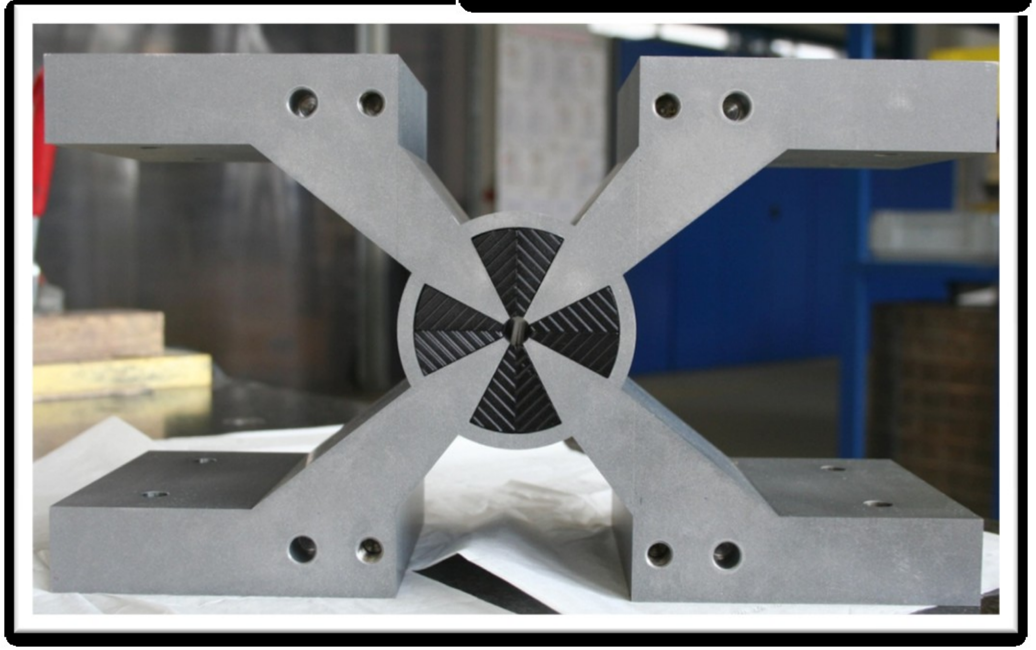
"Final Focus High Gradient Hybrid Quadrupole (QD0)" Short Prototype Status:
Main components procured (in Industry and at CERN); assembly started at CERN.



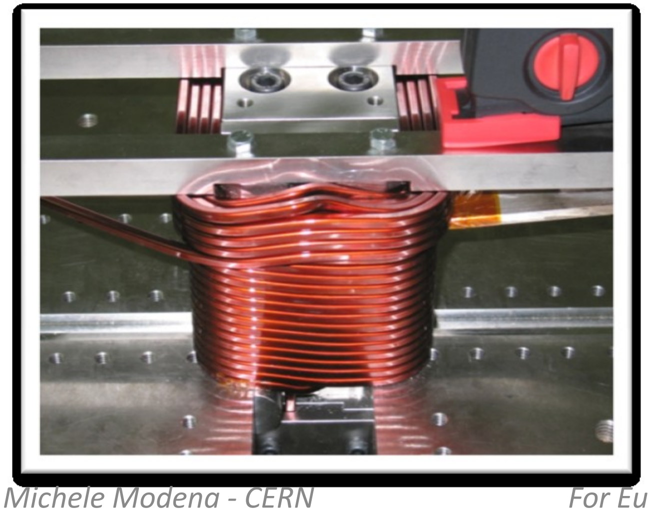
(left) : a view of the assembled prototype :
- *Magnet aperture: 8.25 mm*
- *Expected Gradient: ≥ 530 T/m*



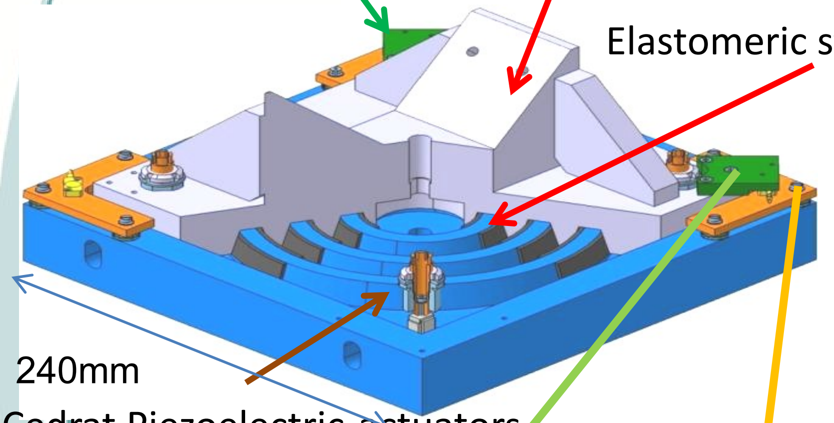
(right and below) Permendur core part with Permanent Magnet blocks



(below) winding of coils at CERN :
- N: 324 turns
- NI : 5000 A



CLIC QDO stabilisation tests in Annecy



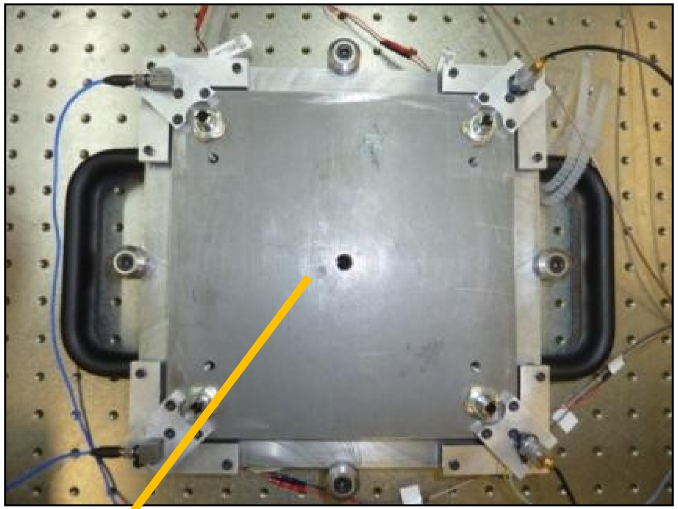
4 PI Capacitive sensors

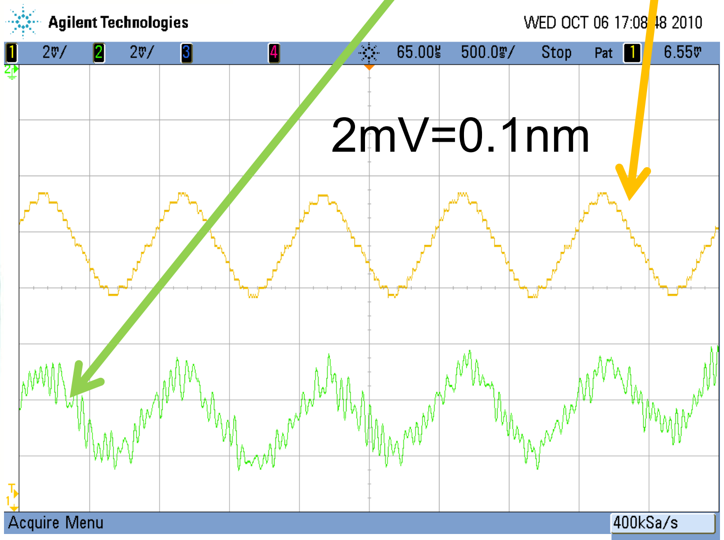
V-support for the magnet

Elastomeric strips for guidance

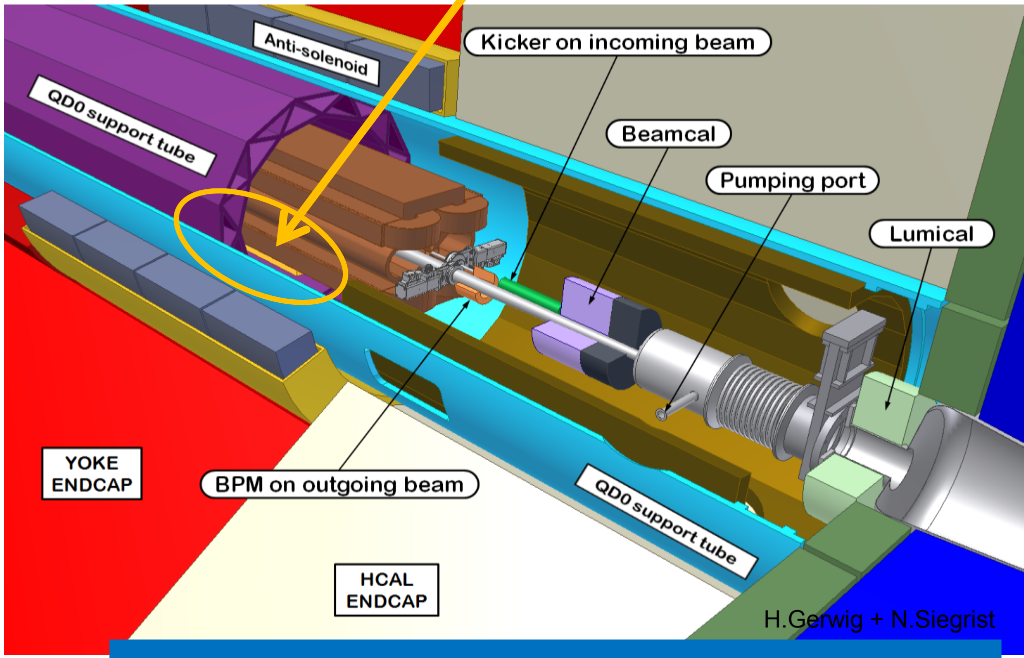
240mm

4 Cedrat Piezoelectric actuators





2mV=0.1nm



First tests without feedback
Ongoing tests with feedback

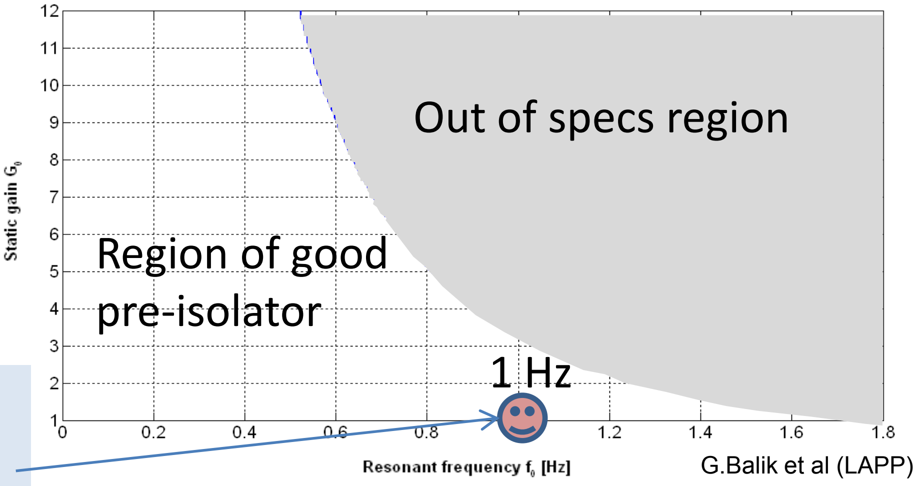
Integration in CLIC MDI (the yellow object under the brown QD0)

Passive isolation needed for a 0,1nm CLIC IP stabilisation

Second order low pass filter (spring-mass system)

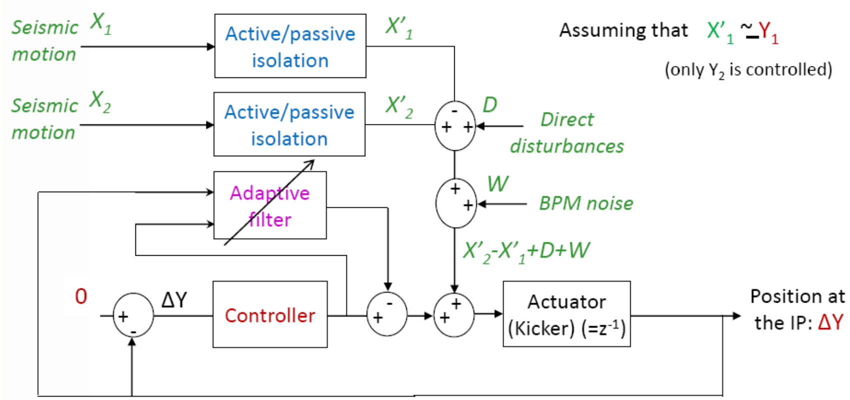
Independent of the damping ratio ξ

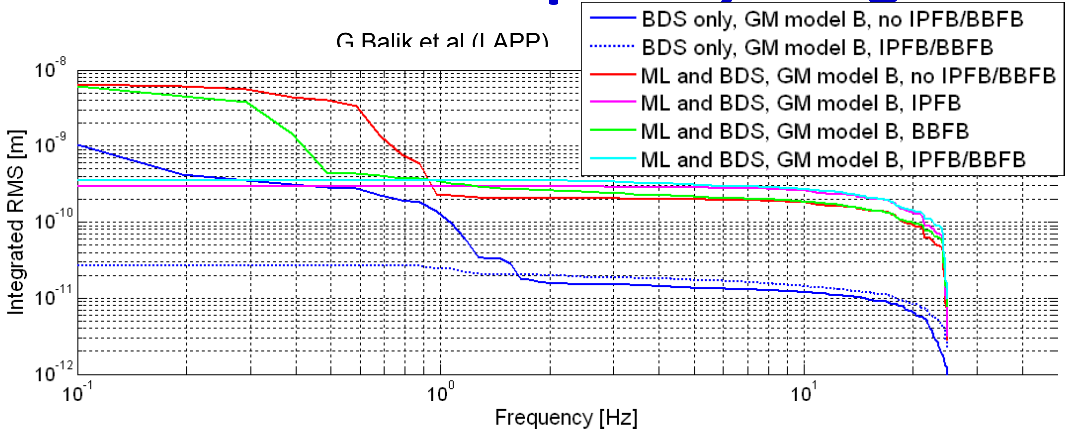
=> CERN is studying a pre-isolator with the right characteristics : prototype under measurement



G.Balik et al (LAPP)

CLIC IP beam-beam feedback low frequency range





Beam-beam offset ΔY at the IP down to 0.1nm at 0.1Hz integrated RMS (degrades slightly at higher frequencies : “waterbed” effect)

⇒Strongly depends on the beam stability in the linac

⇒Simulation optimisation with PLACET ongoing

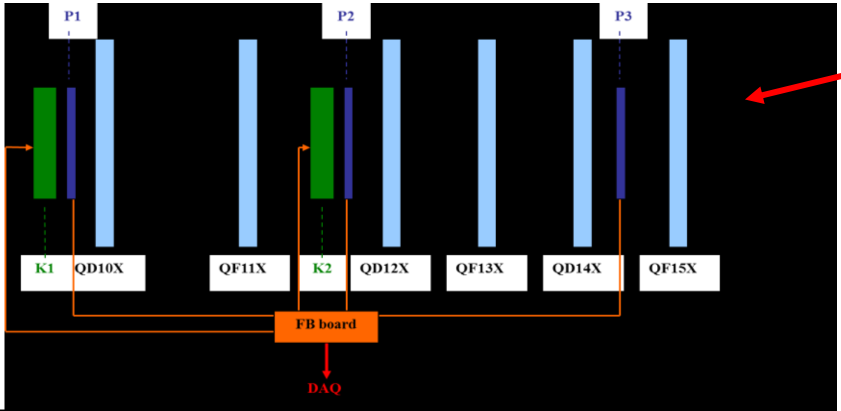
FONT fast feedback R&D (1)

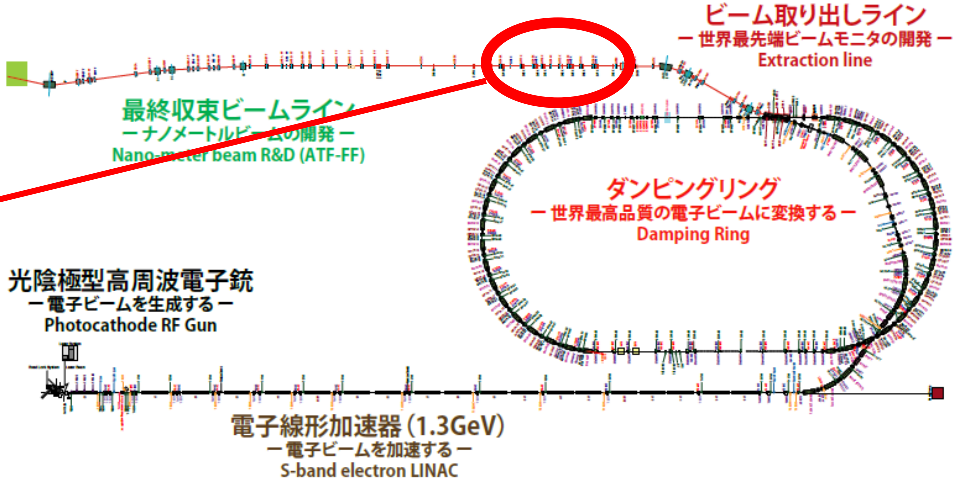
John Adams Institute, Oxford University:

Philip Burrows, Glenn Christian, Javier Resta Lopez, Colin Perry,

Ben Constance, Robert Apsimon, Douglas Bett, Alexander Gerbershagen, Michael Davis

Intra-train beam-steering feedback system prototype at ATF2:



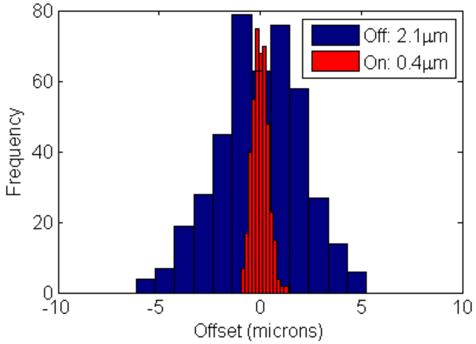


ILC goals met: latency, BPM resolution, kicker drive

Beam correction demonstrated to 400nm level →

y, y' coupled-loop FB (ATF goals 1,2) commissioning ongoing

Design of ATF2 interaction point FB ongoing



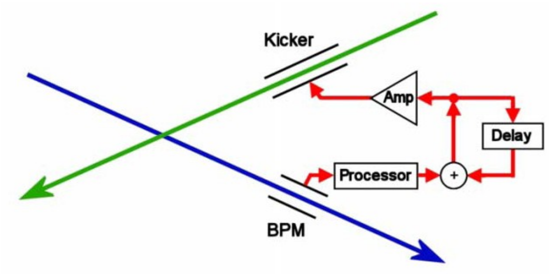
FONT fast feedback R&D (2)

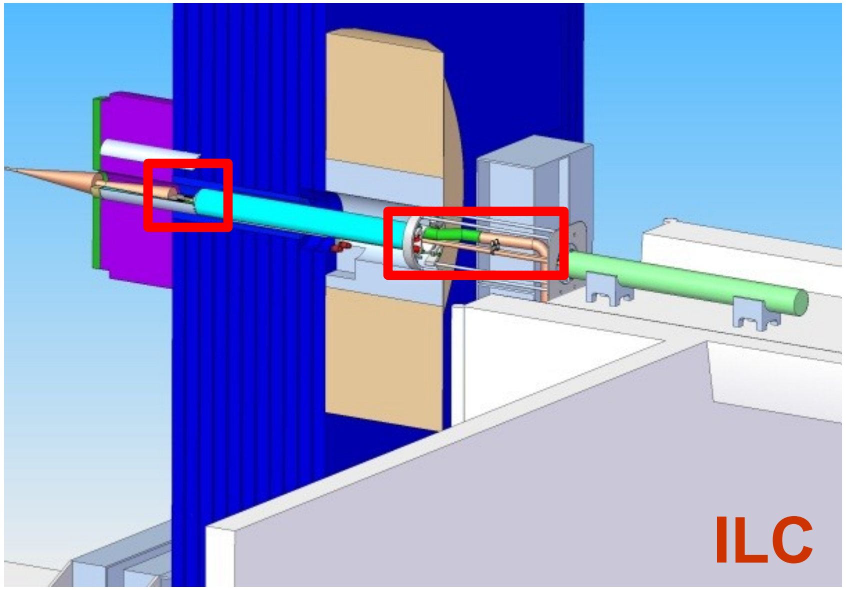
- **Integration of beam collision feedback system into Machine Detector Interface designs:**

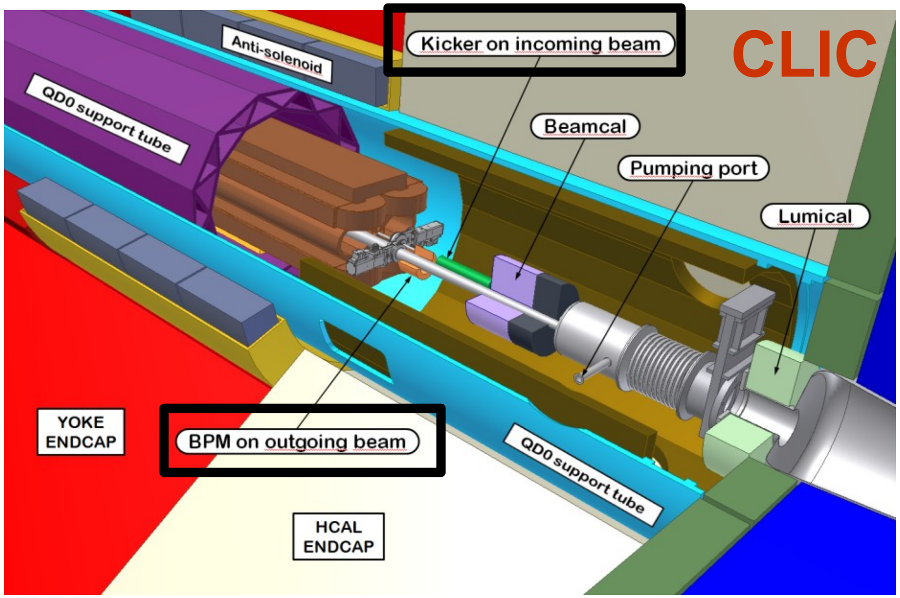
Conceptually engineered designs for both ILC + CLIC

Documented in CLIC CDR: design iterations ongoing

Luminosity performance simulations ongoing







9.4 BDS (UNIMAN, RHUL, STFC)

- Coordinator: Grahame Blair (RHUL)
- Subtasks:
  - Develop tuning strategies at ATF2, optimize the Linear Collider interaction region,
  - Develop High precision BPM's for ILC & CLIC,
  - Laser-wire systems for ILC & CLIC

Highlight talk by Stewart Boogert

CLIC Interaction studies

R. Appleby, UNIMAN/CI

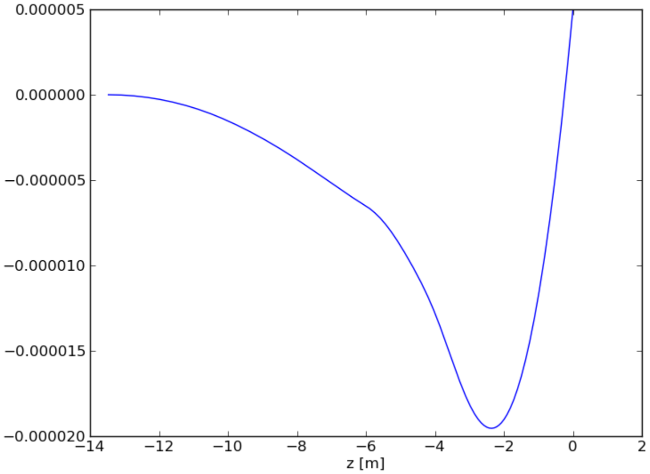
The CLIC detector solenoid in the interaction region causes vertical orbit distortion and beam cross-plane coupling

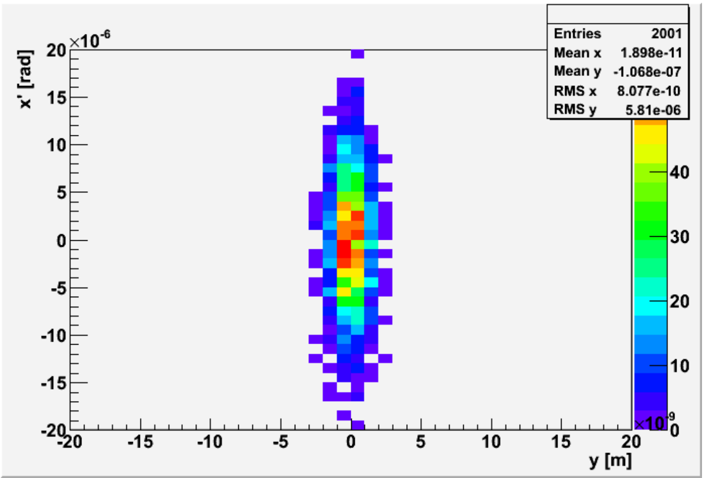
Solenoid is SiD 5 T model

Computed with new code IRSYN (particle integration from field map plus MC SR)

Solenoid compensation performed with anti-solenoid coils

Beam vertical orbit with solenoid

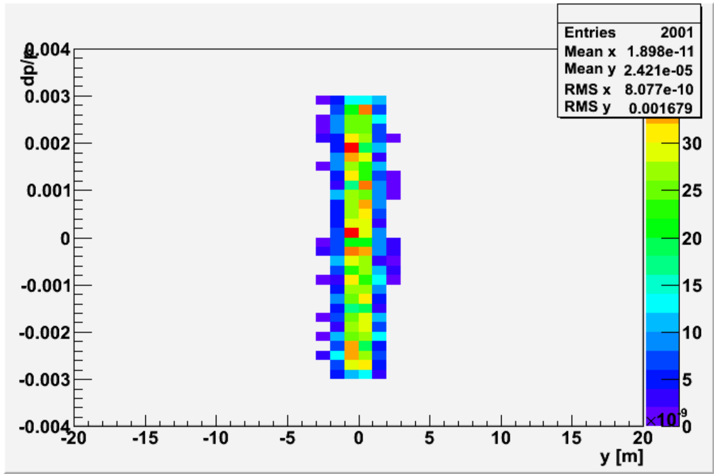




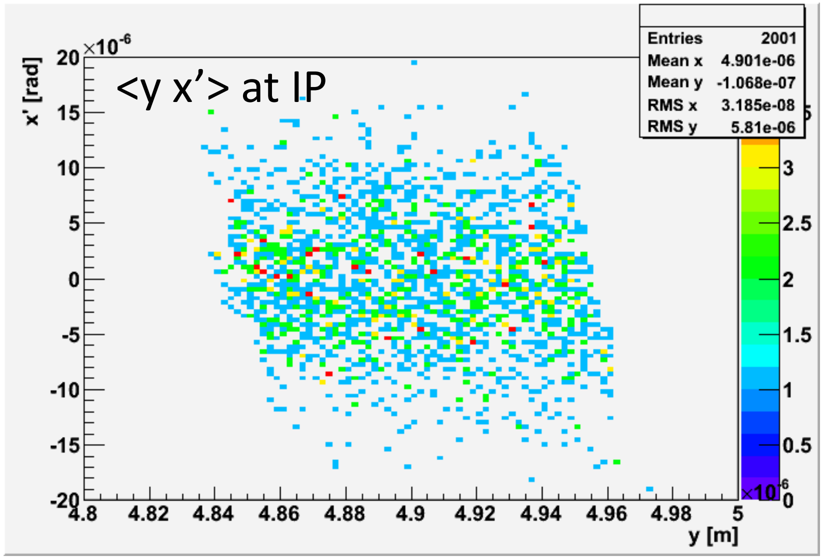
Interaction point phase space with SID solenoid and no compensation, showing coupling

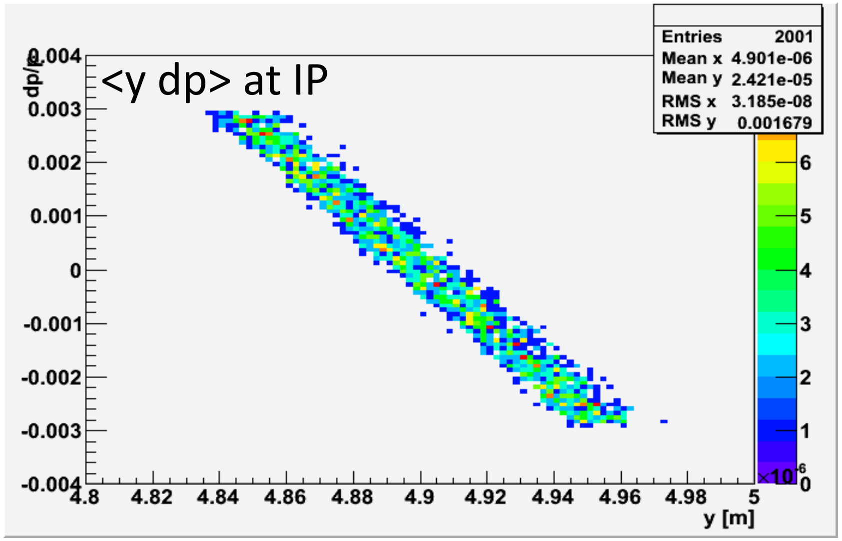
<y x'> at IP

<y dp> at IP

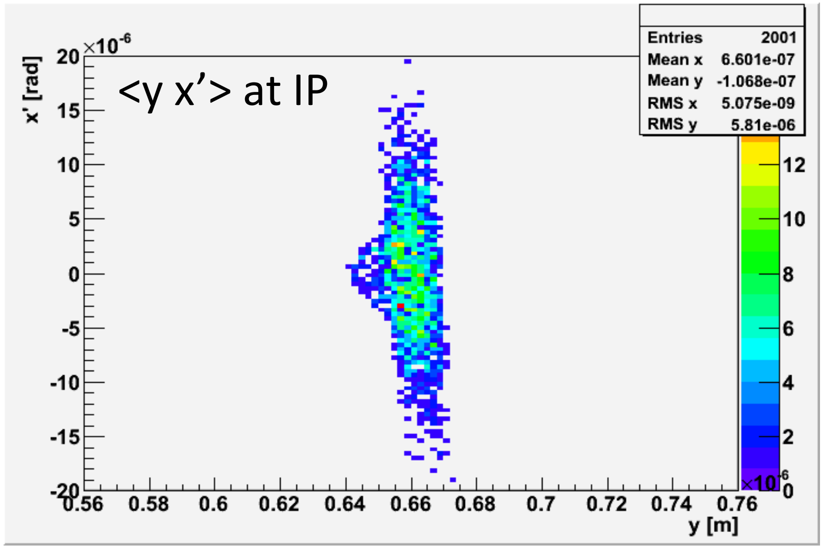


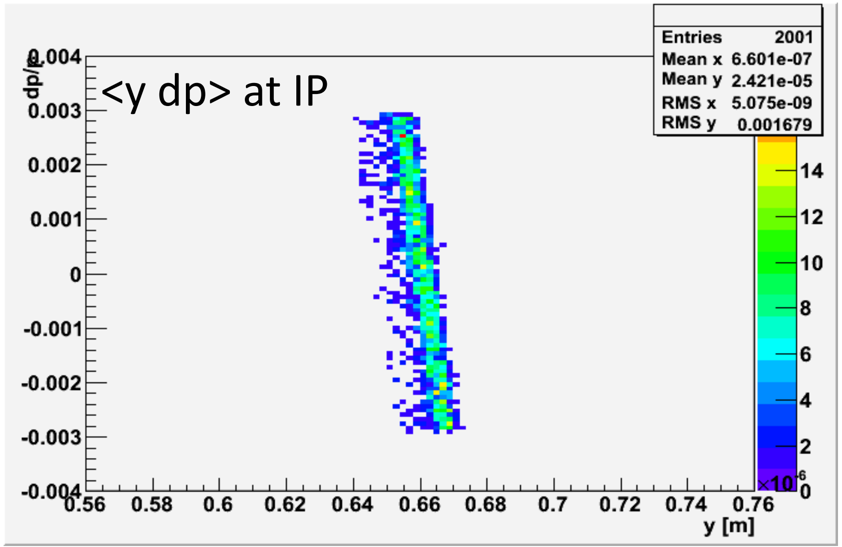
SiD 5T solenoid with no compensation



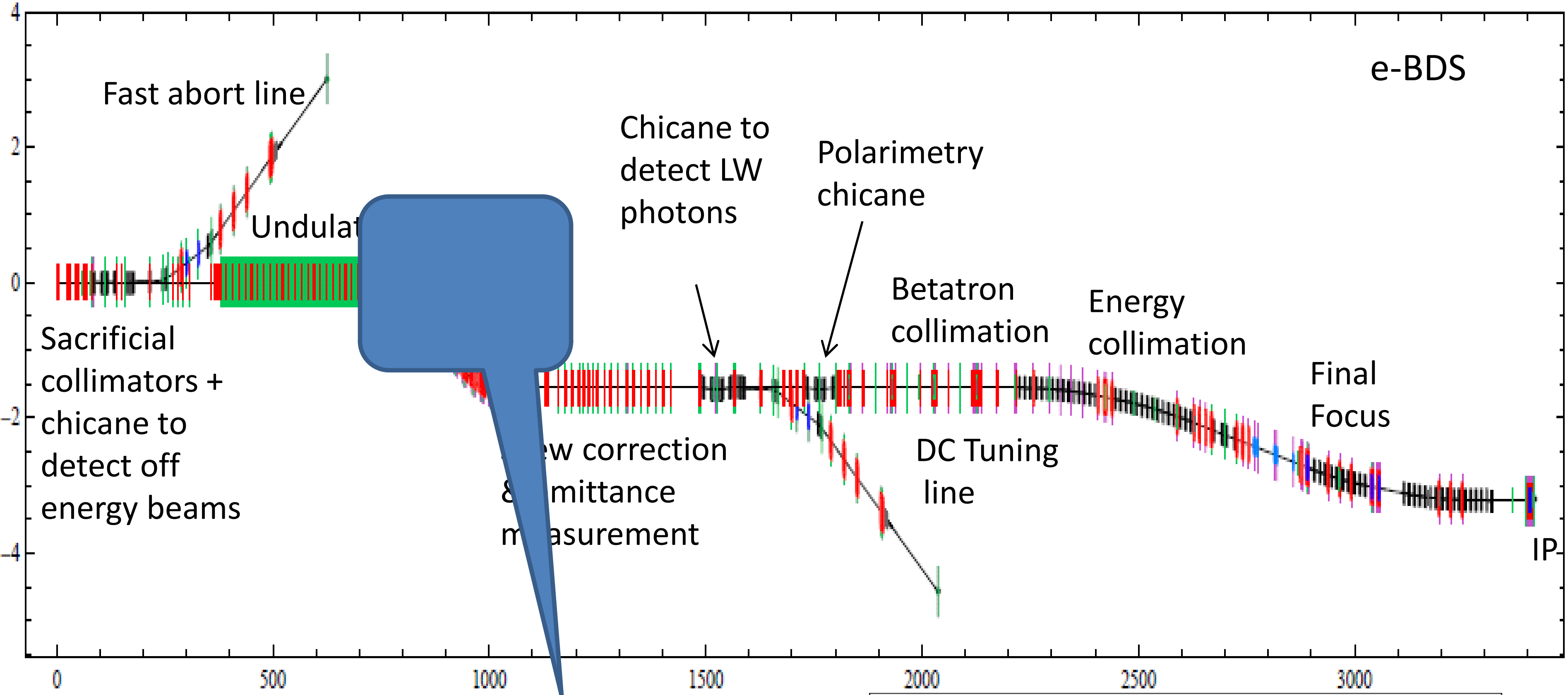


SiD 5T solenoid with compensation coils





ILC SB2009 e- BDS Design



e-BDS

Fast abort line

Undulat

Chicane to detect LW photons

Polarimetry chicane

Betatron collimation

Energy collimation

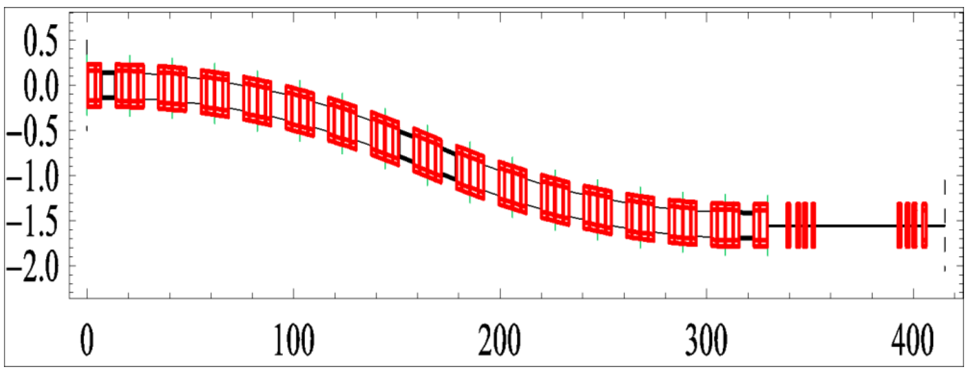
Final Focus

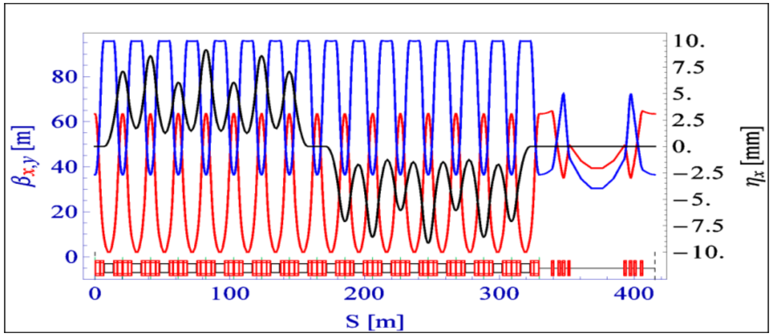
Sacrificial collimators + chicane to detect off energy beams

ew correction & mittance m asurement

DC Tuning line

IP





Lattice functions of dogleg

The Dogleg Tolerances

European Coordination for Accelerator Research and Development Newsletter

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EuCARD >> News >> Newsletters >> Issue 8 >> Article 3

ILC dogleg prepares electron beam for success

The International Linear Collider (ILC) is the proposed particle physics machine which will be the successor to the Large Hadron Collider (LHC). It will operate at energies of up to 1 TeV centre of mass and will be able to explore physics beyond the reach of the LHC. The ILC will collide beams of electrons and positrons together to achieve new results in particle physics.

The ILC is hoping to make new discoveries in particle physics including contributing to the search for the elusive Higgs Boson: *Image courtesy of DESY. Thumbnail image on main page courtesy of SLAC.*

- Due to the ***space constraints*** and ***strong focusing*** in the dogleg design, the tolerances are tight.

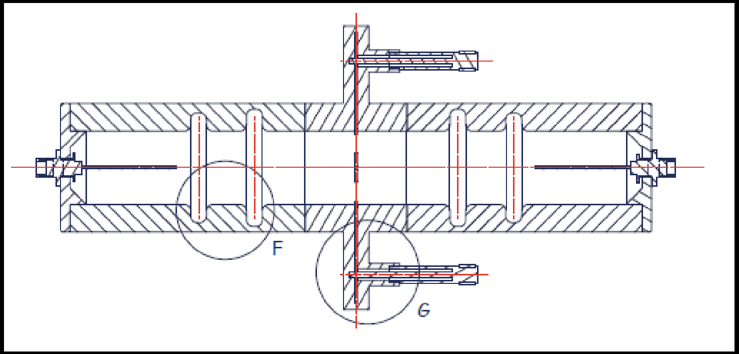
- The results of uncorrected mismatch entering the lattice, for a 10% emittance growth in the lattice at 1TeV CM (cf. 3.8% nominal).

Parameter	Tolerance	With Correction
Initial α_x	-1.7 – 1.71	N/A
Initial β_x *(m)*	10 →200	N/A
Initial η_x *(mm)*	-9.5 – 11	-21 – 27
Initial η_x' *(mrad)*	-0.13 – 0.2	-0.32 – 0.4
Initial x (mm) (centroid)	-0.13 – 0.21	-0.6 – 0.75
Initial x′ (μrad) (centroid)	-2 – 3.2	-11.5 – 12.9

WEPE031, IPAC10

N. Wyles

9.5 Phase stabilisation (LNF, CERN, PSI)



- Coordinator: Fabio Marcellini (INFN/LNF)
- Subtasks:
  - low-impedance RF beam phase monitor
  - electro-optical phase monitor
  - Ultra-low phase noise electronics

Highlight talk by Alexandra Andersson

WP 9, NCLinac: Summary

- Globally, progress is good – NCLinac is on track!
- 9.2 is ahead, 9.5 is slightly behind.
- Spending profile looks correct.
- 9.3 : MONALISA discontinued – milestone satisfied with different approach – resources redirected.

Thank you very much!