Dark Current simulations and related experiments

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CONTENTS

- Dark Current simulations in High Gradient structures
- Radiation experiment at Xbox 2
- SEE and Multipactor
- TD24 dedicated experiment
- Conclusions

CONTENTS

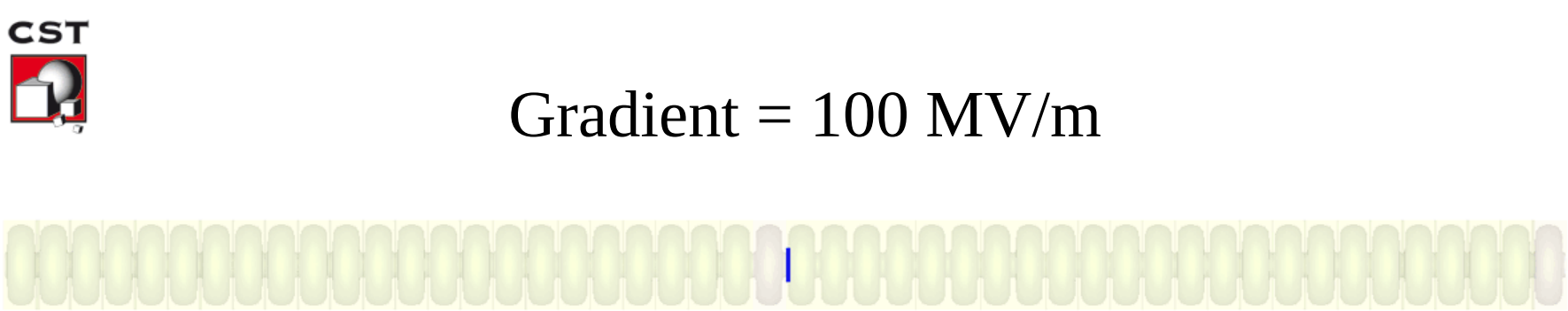
- Dark Current simulations in High Gradient structures
  - T24PSI
  - T24PSI double structure
  - Including tapering
- Radiation experiment at Xbox 2
- SEE and Multipactor
- TD24 dedicated experiment
- Conclusions

Dark Current simulations

T24PSI

- Is one of the best structures that we have tested in terms of stable High Gradient performance.
- T24PSI2 was installed in Xbox2 running stable when we made the radiation measurements.
- Especial mention to all the previous work of Thomas Lucas regarding to the CST Dark Current simulation.

Gradient = 100 MV/m



Full Structure Upstream

Emitting Iris, FE

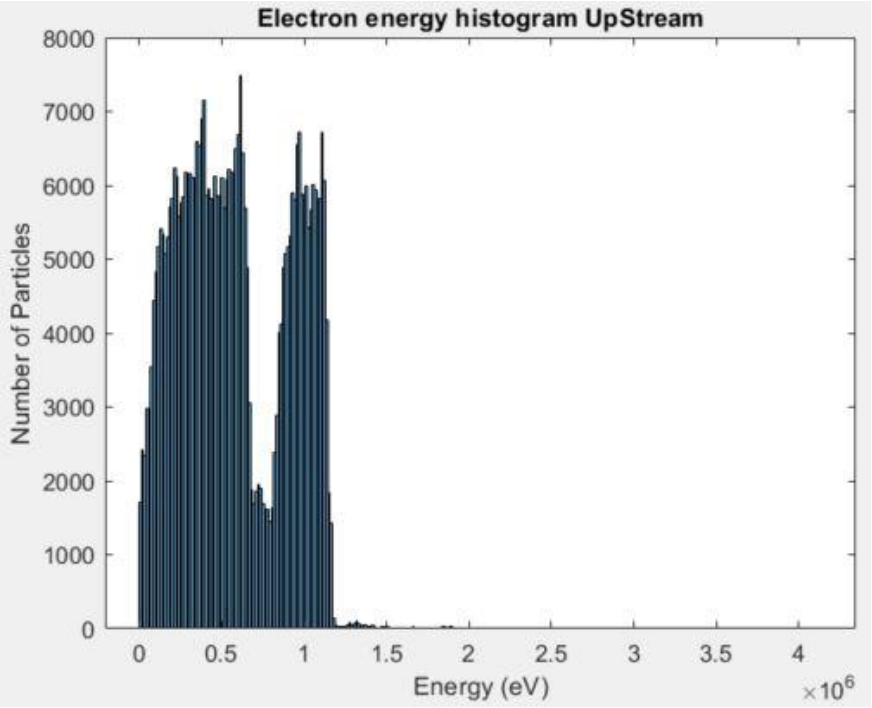
Full Structure Downstream

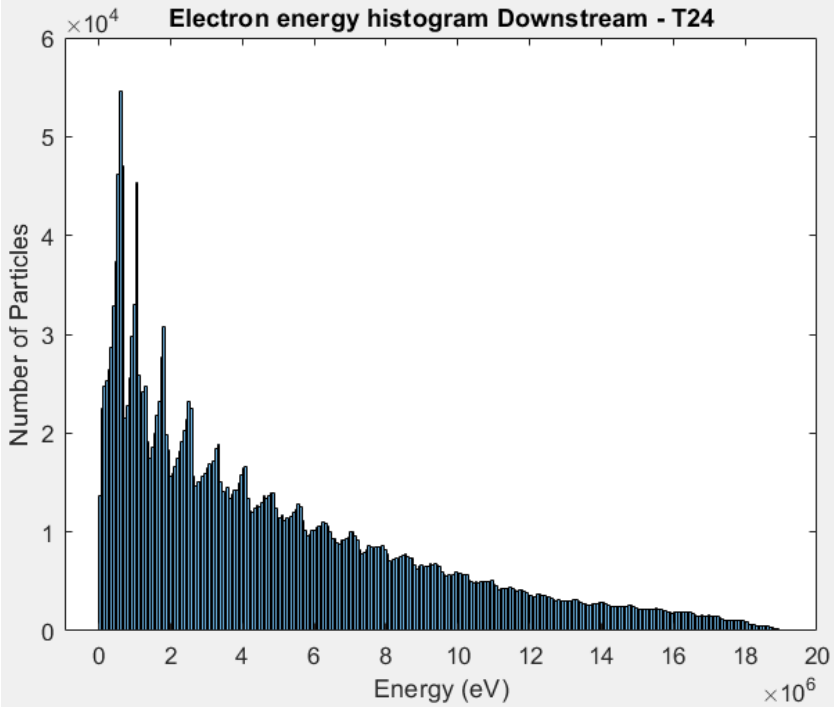
position monitor 1

Type	Energy
Sample	1/300
Time	0.00678889 ns
Particles	132
Maximum	2.91445 eV

Dark Current simulations

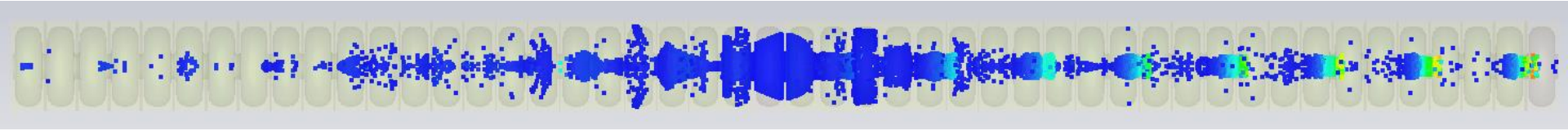
T24PSI Energy spectrum 2D monitors





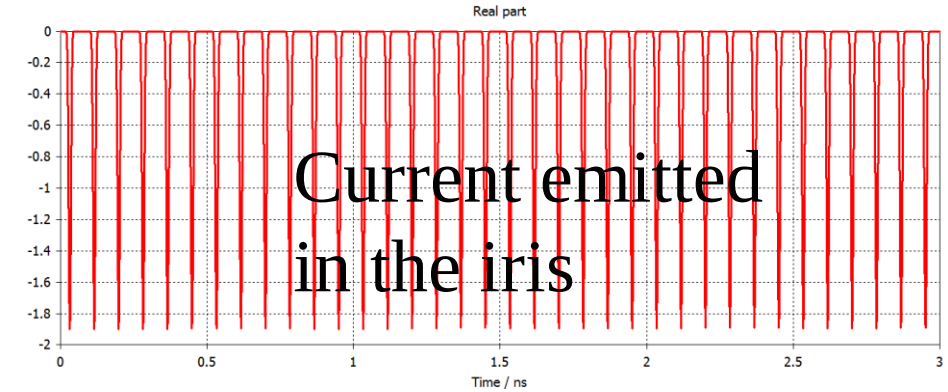
Upstream

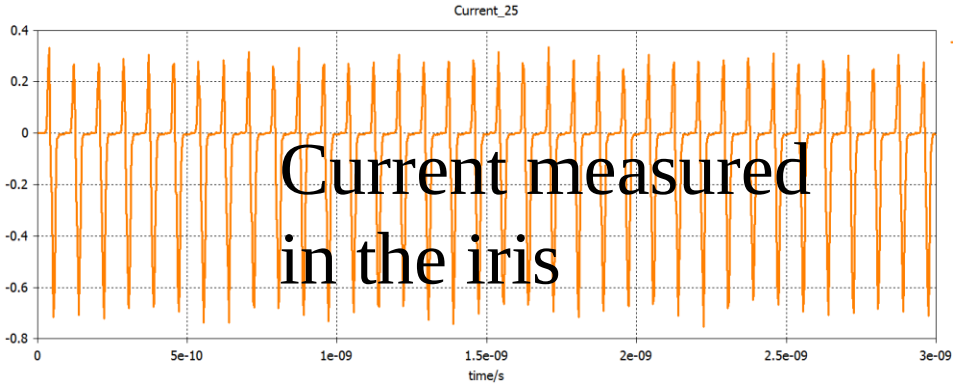
Downstream

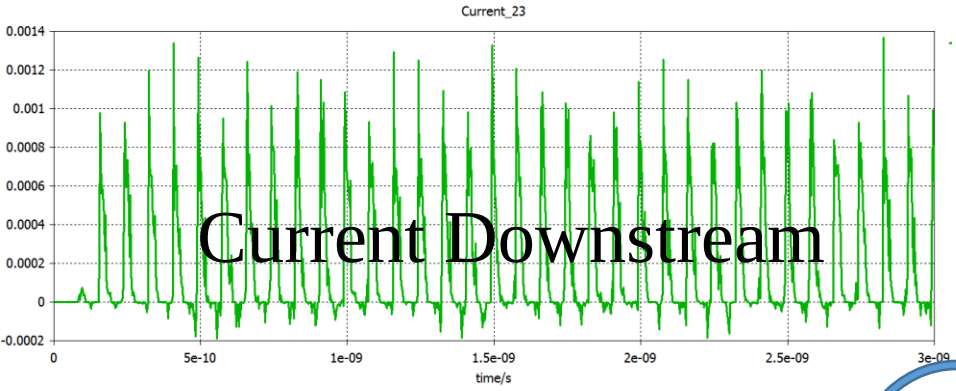


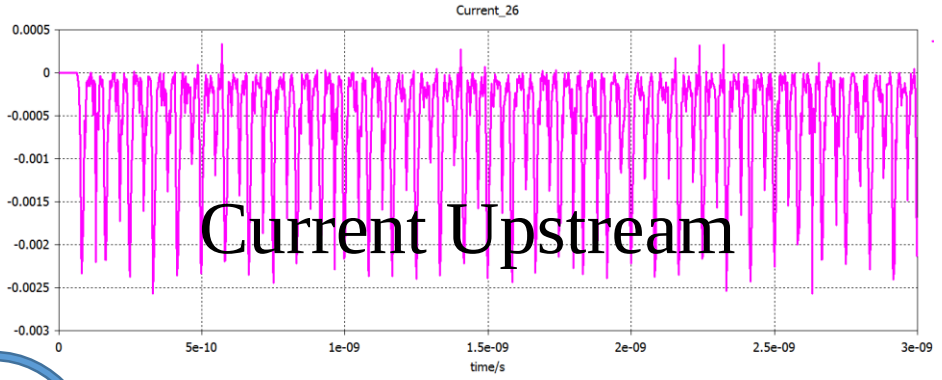
Dark Current simulations

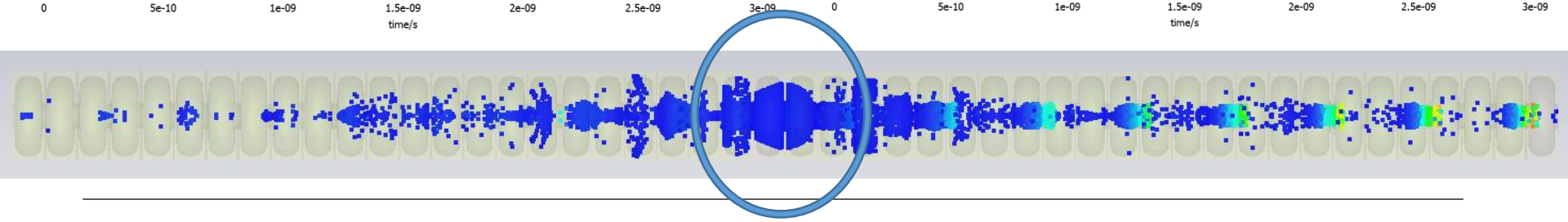
T24PSI Dark Current analysis





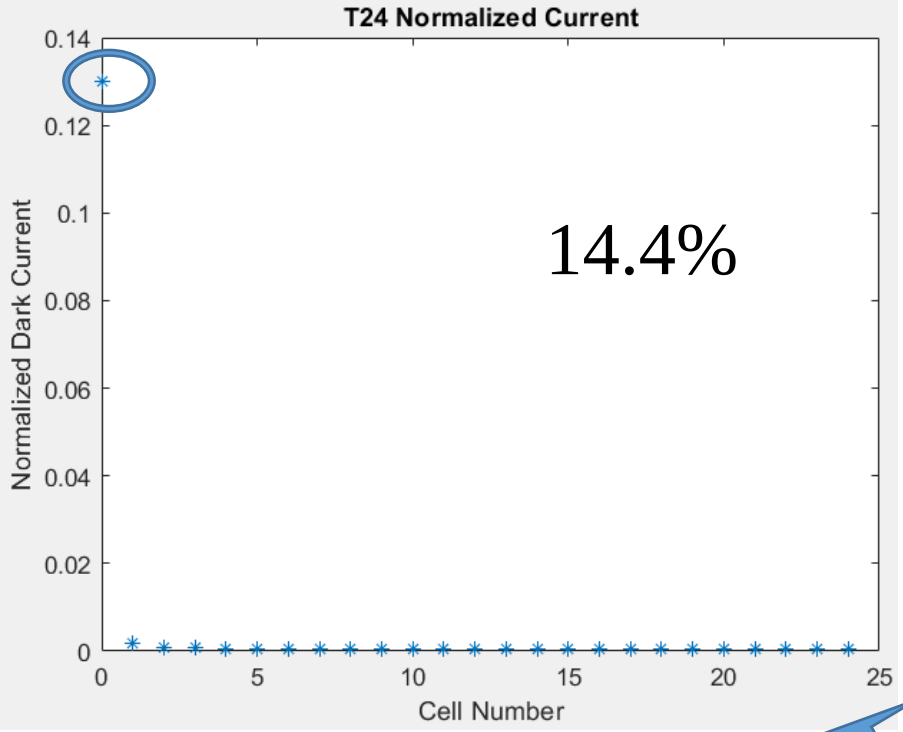


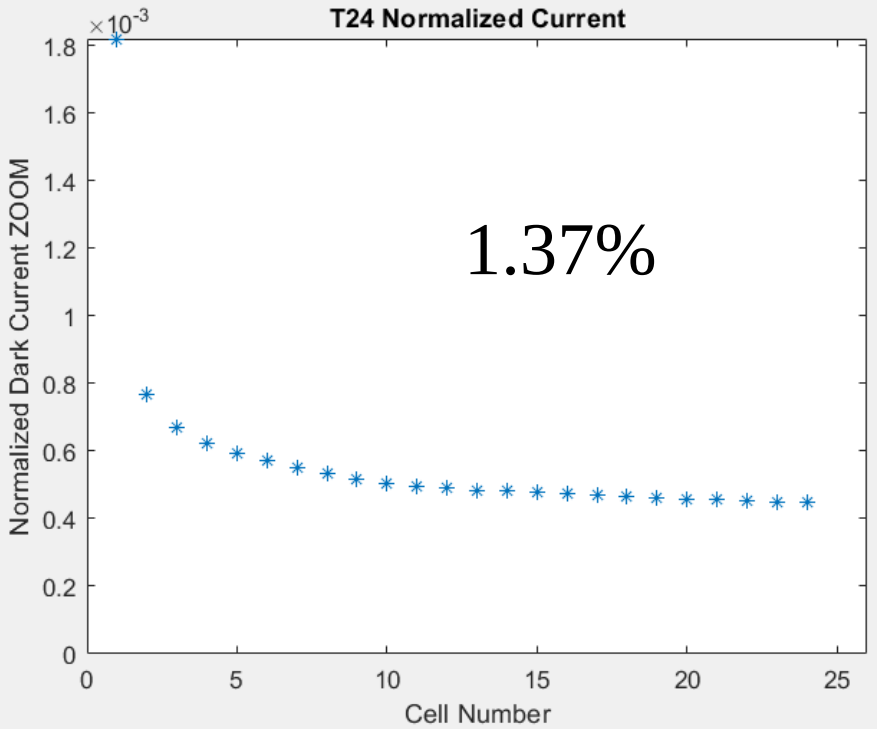


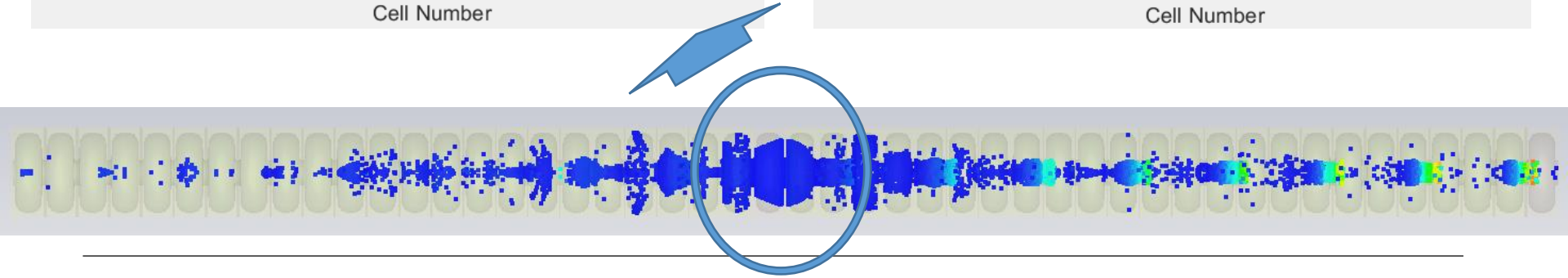


Dark Current simulations

T24PSI Current vs cell number, Downstream

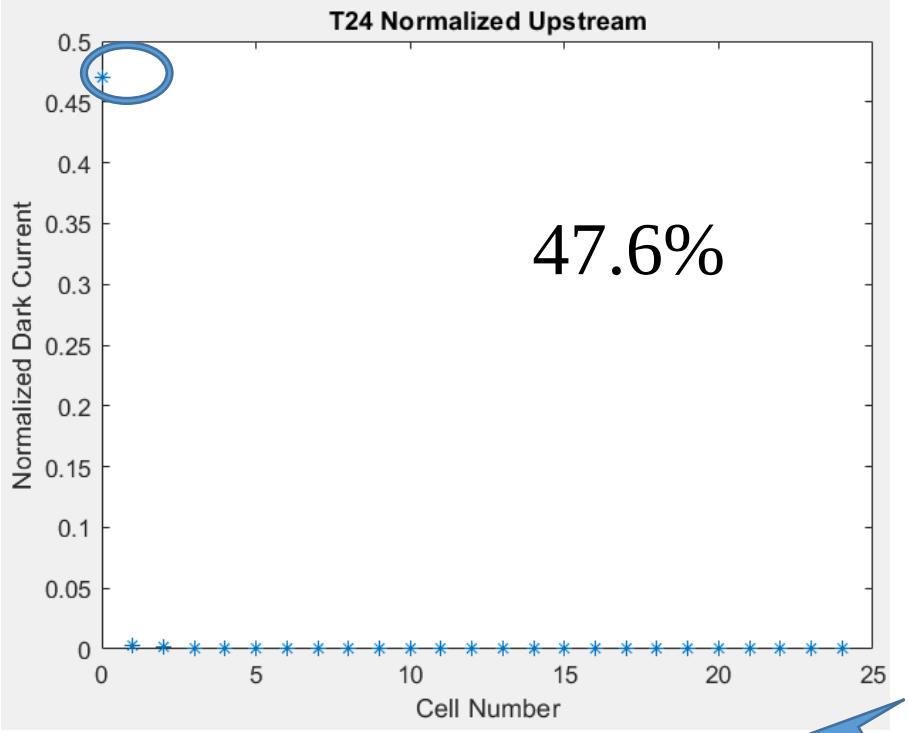


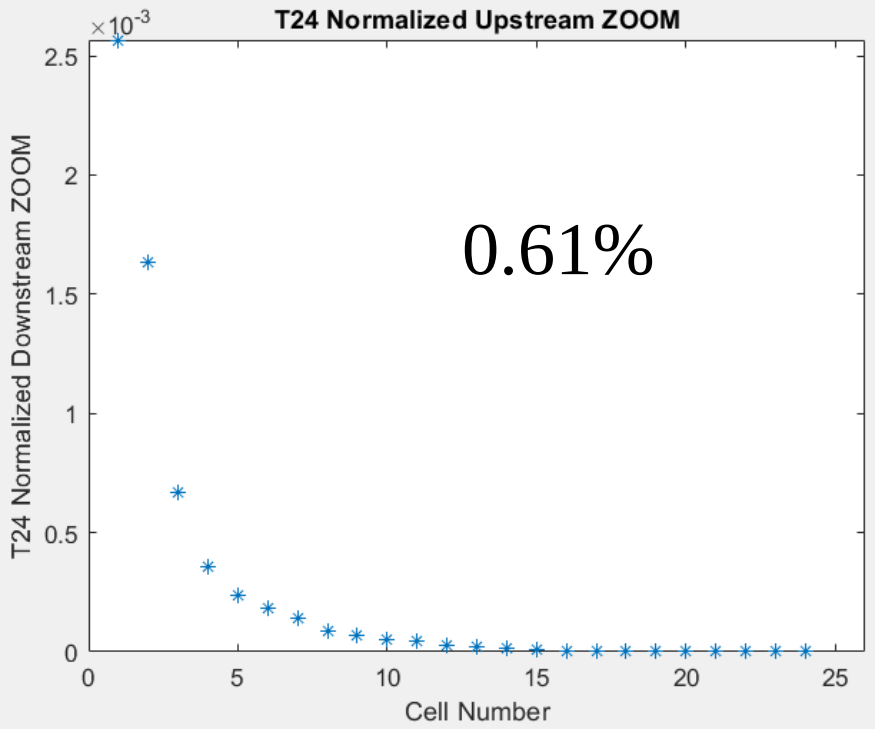


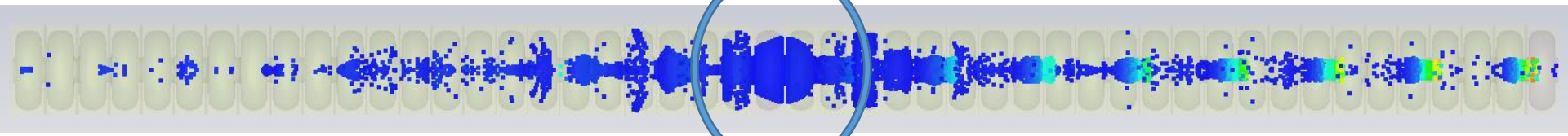


Dark Current simulations

T24PSI Current vs cell number, Upstream

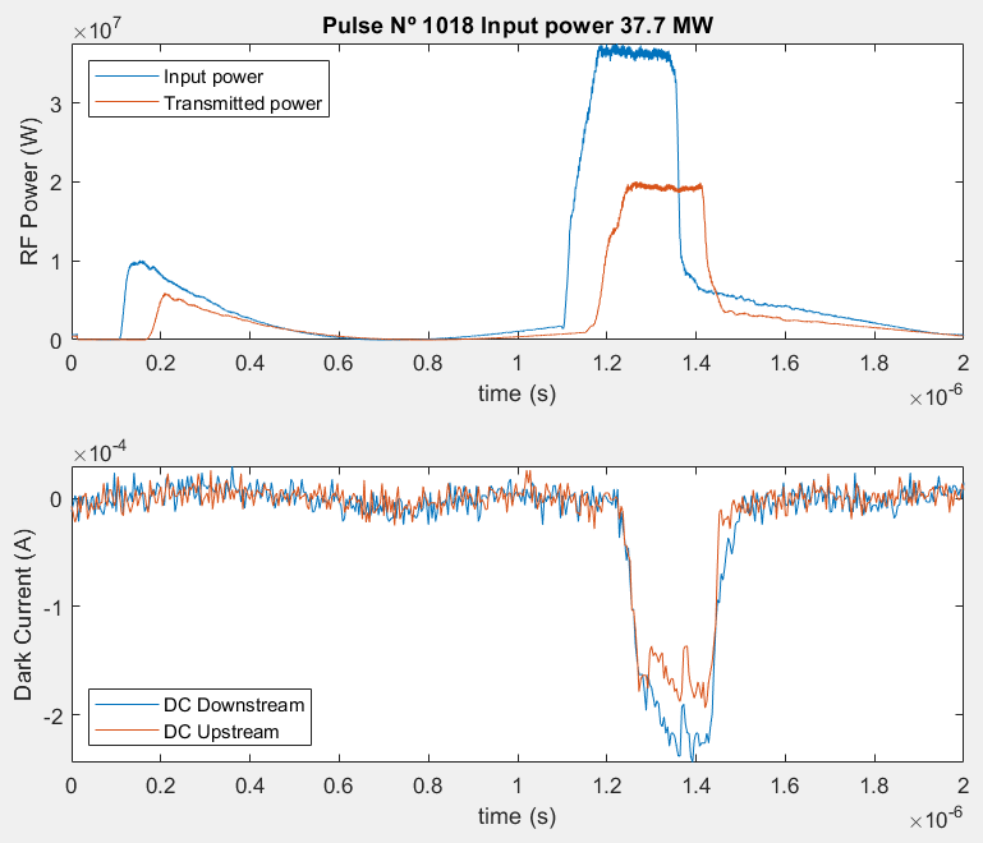


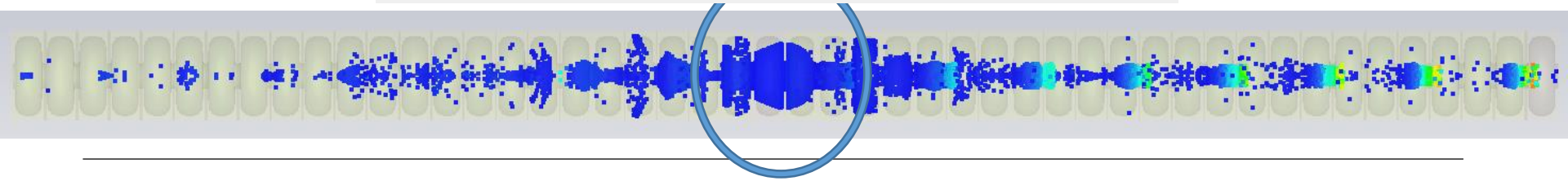




Dark Current simulations

T24PSI Normal measurement at 100 MV/m (37.7 MW)





Dark Current simulations

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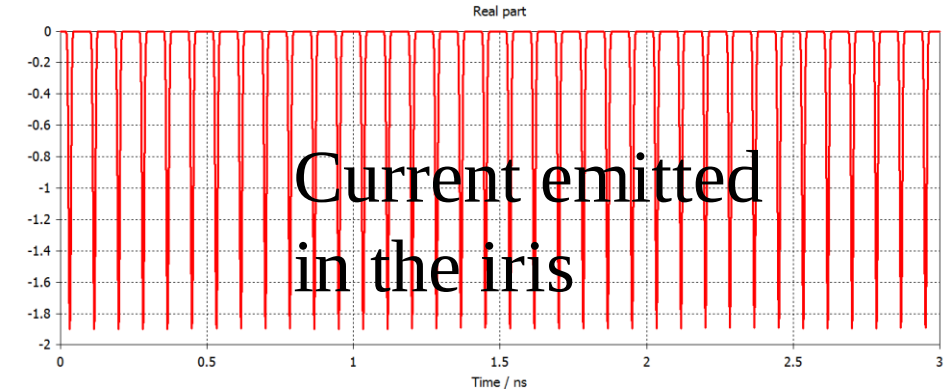
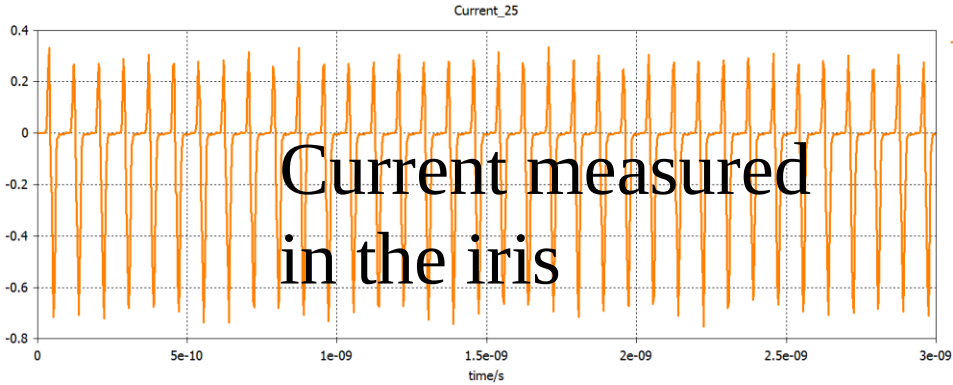
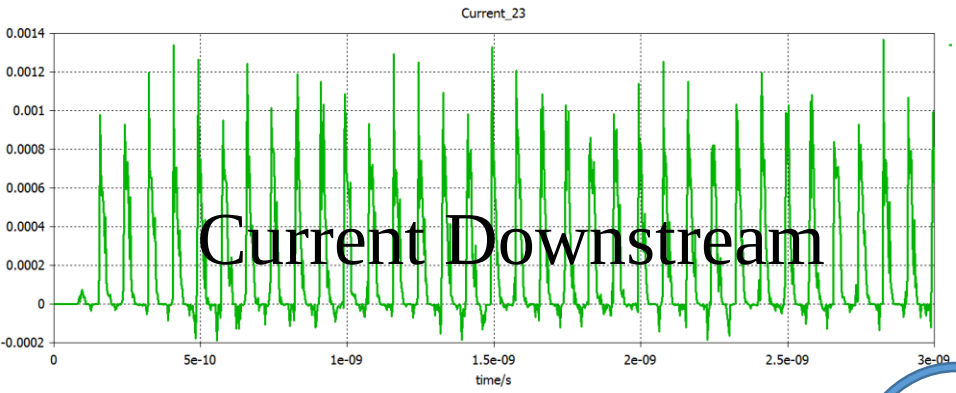
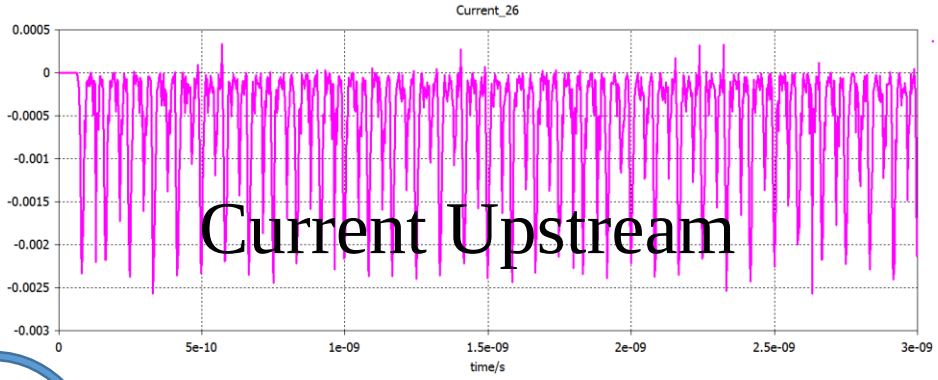
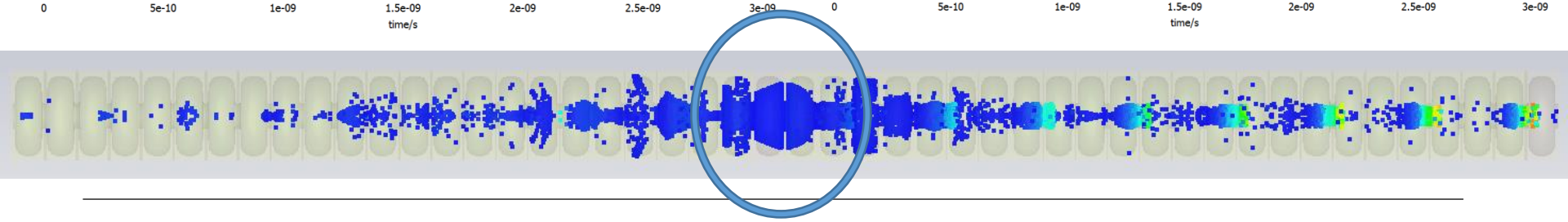






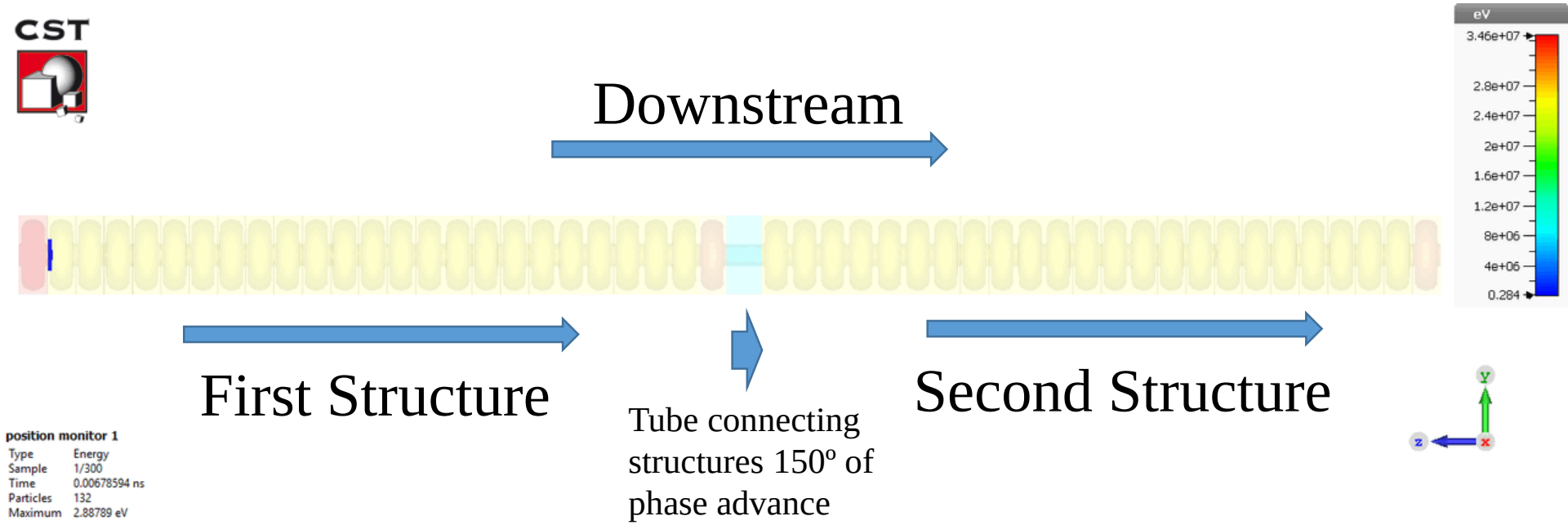




Dark Current simulations

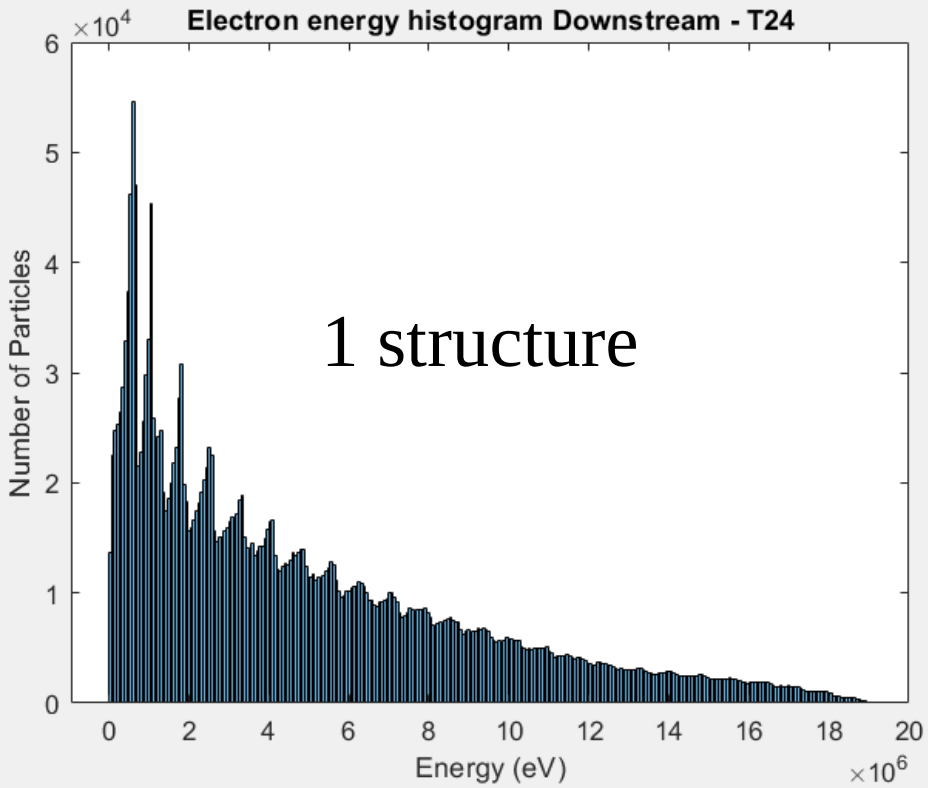
T24PSI double structure

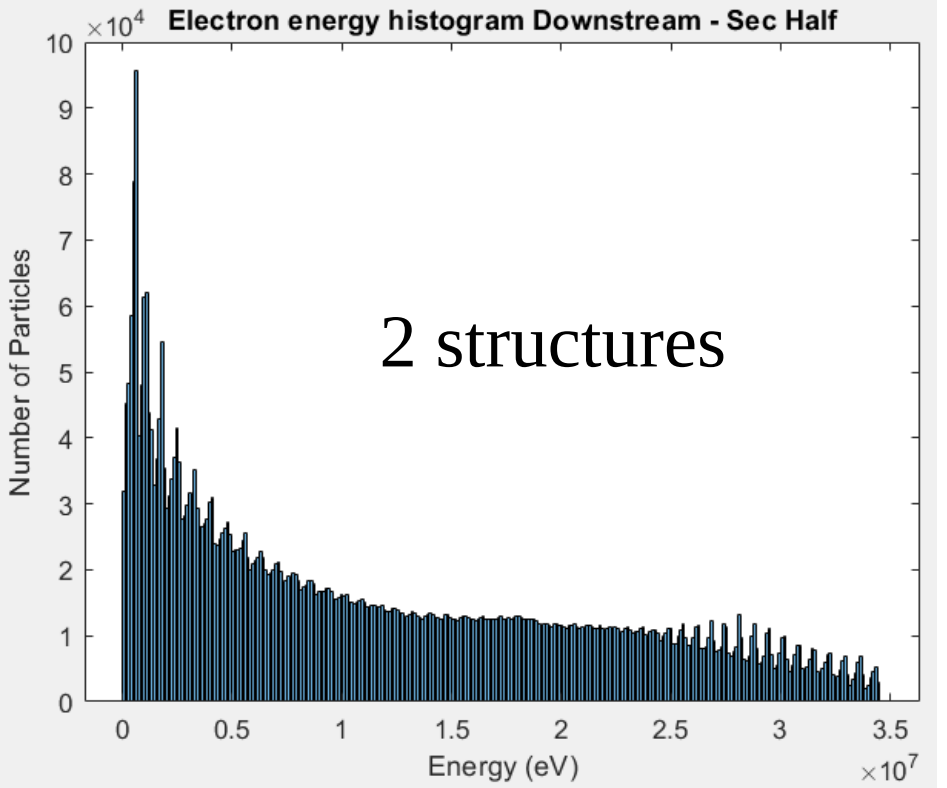
- First approach to the simulation of the DC in a CLIC superstructure.
- Undumped structure reduces considerably the calculation time.
- RP Group at CERN need this information for estimating the radiation generated during the conditioning of a CLIC module.
- Xbox 2 is currently being adapted for testing the first superstructure.



Dark Current simulations

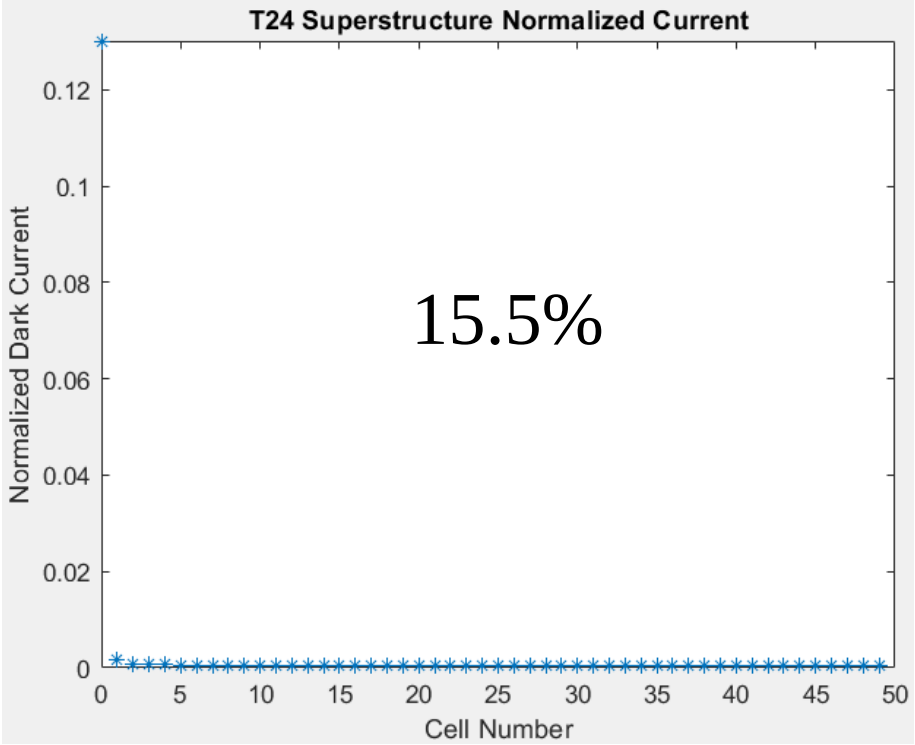
T24PSI double structure

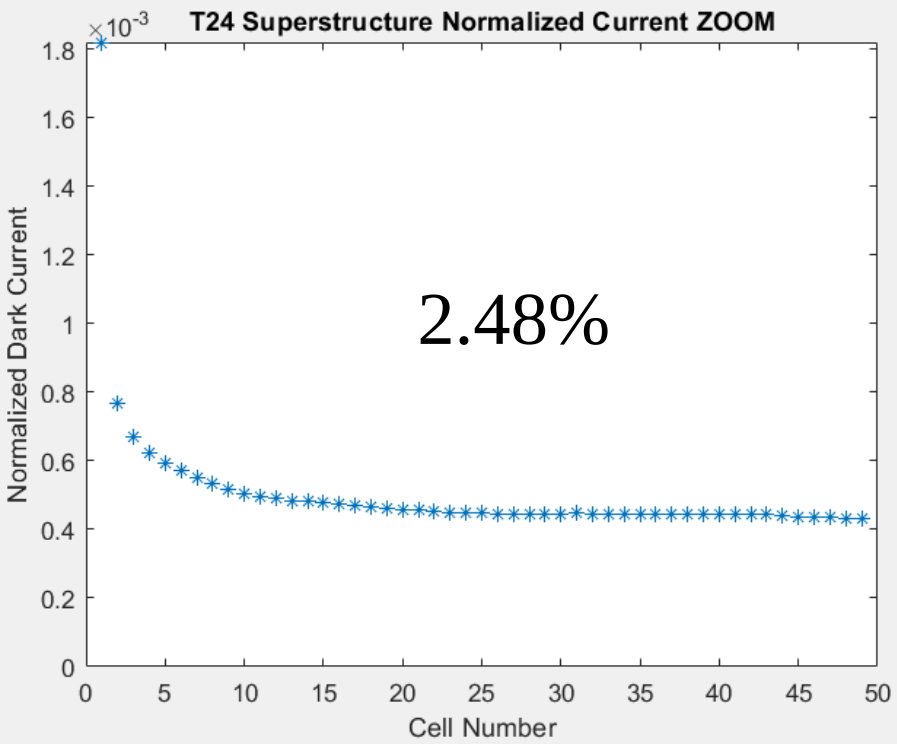




Dark Current simulations

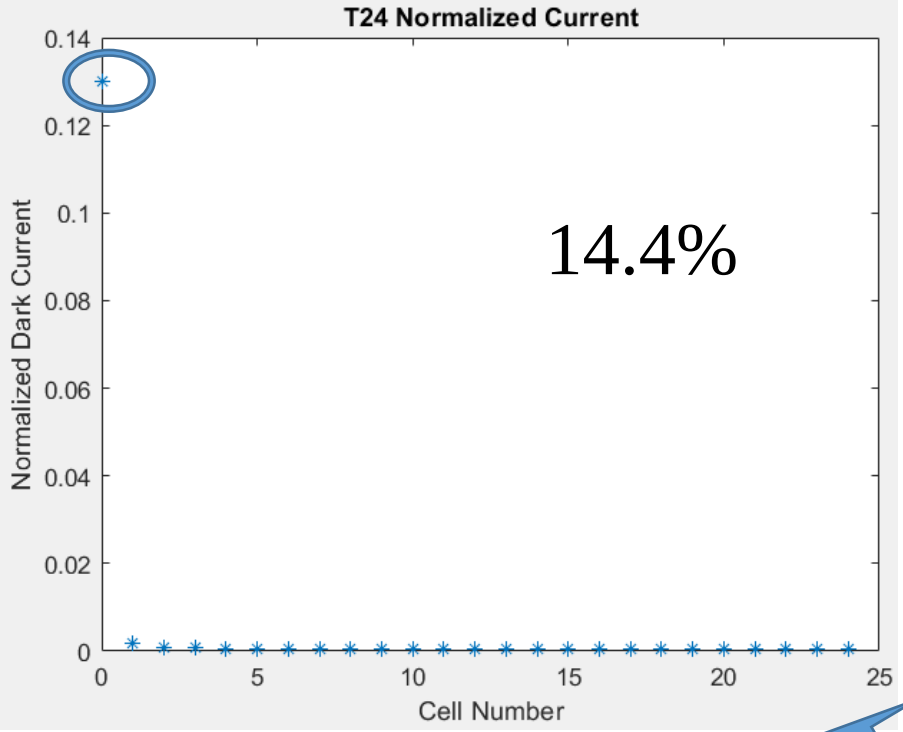
T24PSI double structure

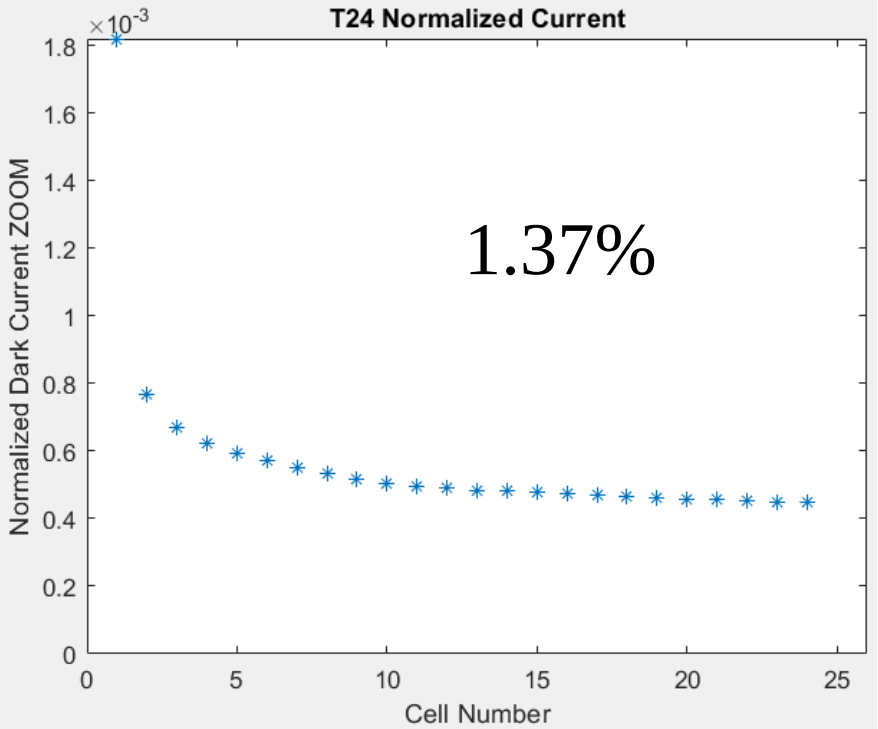


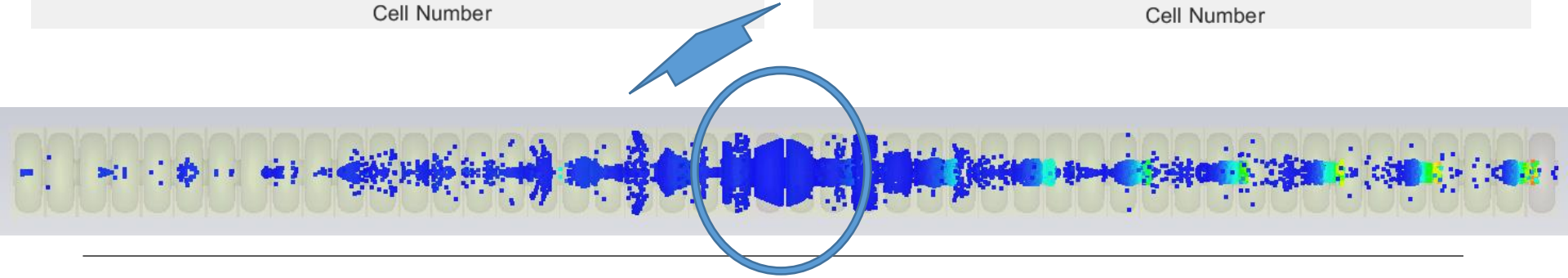


Dark Current simulations

T24PSI Current vs cell number, Downstream







Dark Current simulations

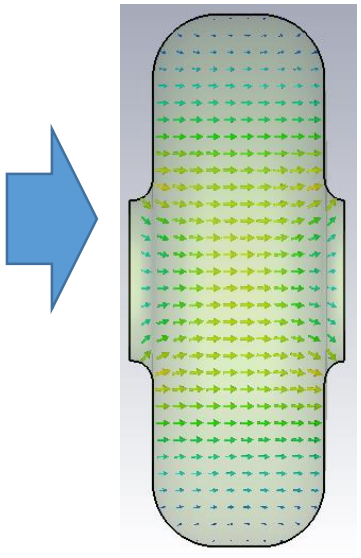
T24PSI Double structure conclusions

- As the Dark Current measured Downstream and Upstream is almost the same, the cells closer to the FC give almost all the electrons.
- That is visible in the simulation when we include or not the current monitor in the emitting iris.
- However, a good capture in the Downstream side doubles the energy of the electrons.
- With this we can expect that the Dark Current measurement of a double structure does not differ too much of a single structure, whereas the energy of the electrons does scale with its important impact in the radiation generated.

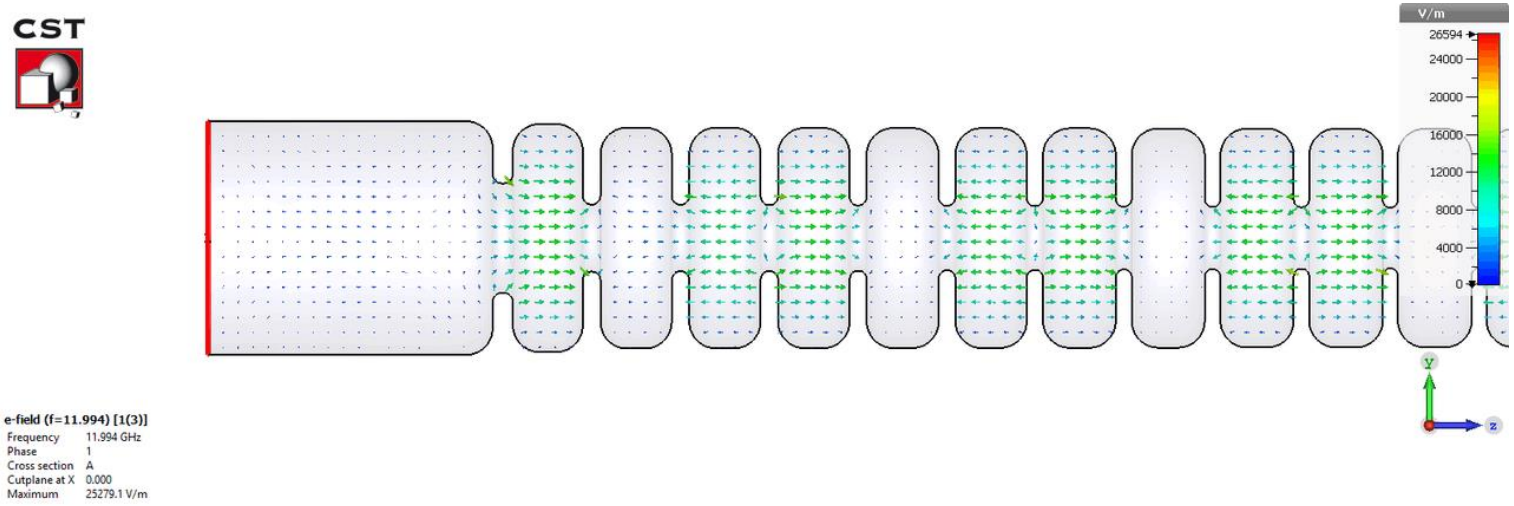
Dark Current simulations

Introducing tapering in the simulation

Normally we use the Eigenmode of a single cell with periodic conditions and 120º of phase advance



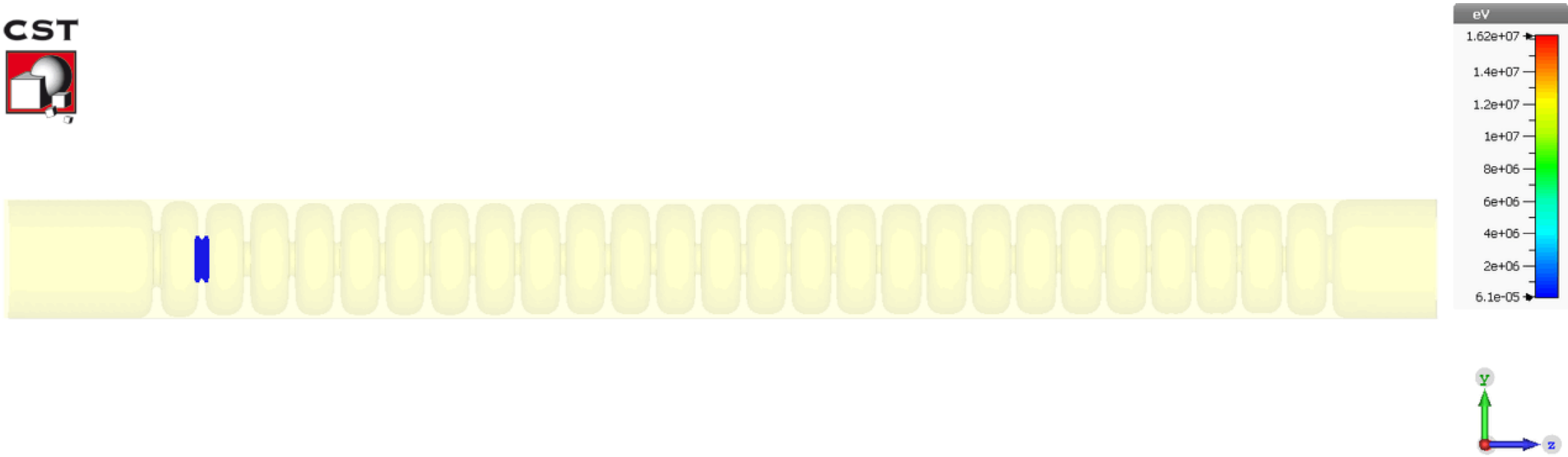
Now we put the full structure with a circular WG port with the TM01 mode.



Dark Current simulations

Introducing tapering in the simulation

We still need to find an efficient way of processing all the data: current and energy spectrum. Now every iris is different so in principle we need to run 24 different simulations…



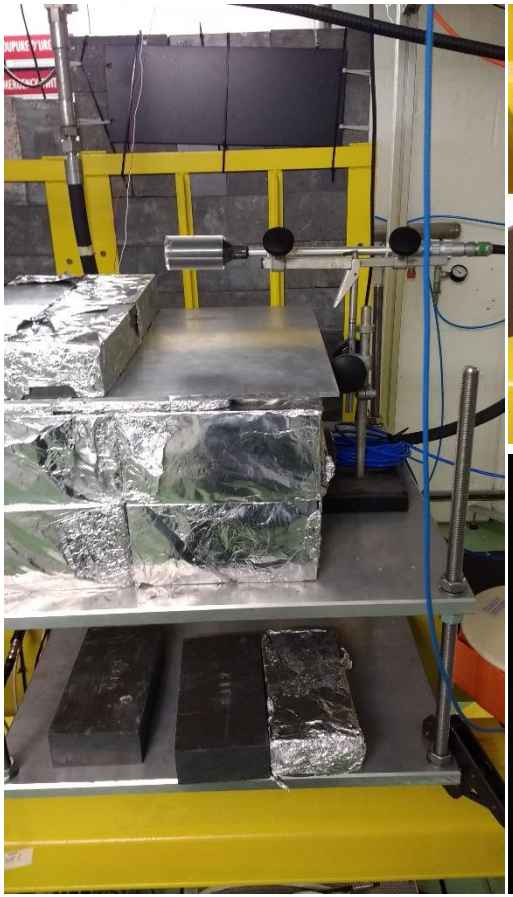
CONTENTS

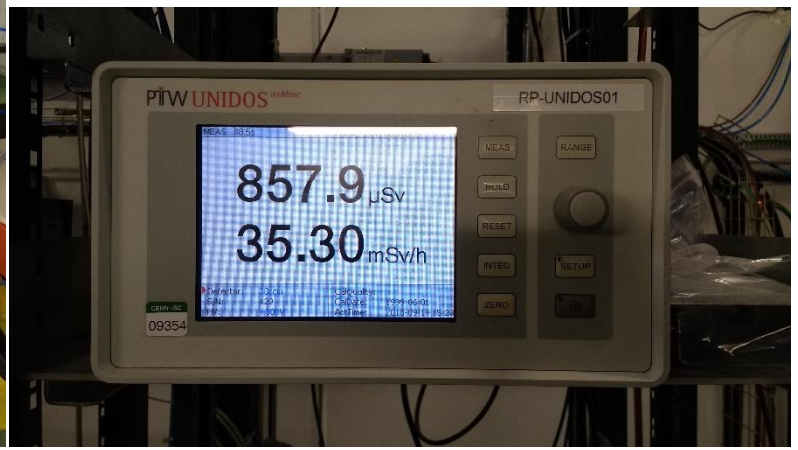
- Introduction
- Dark Current simulations in High Gradient structures
- Radiation experiment
  - T24PSI2 at Xbox 2
  - Radiation monitor at the top/front of the FC
  - Next steps
- SEE and Multipactor
- TD24 dedicated experiment
- Conclusions

Radiation experiment

T24PSI2 at Xbox 2

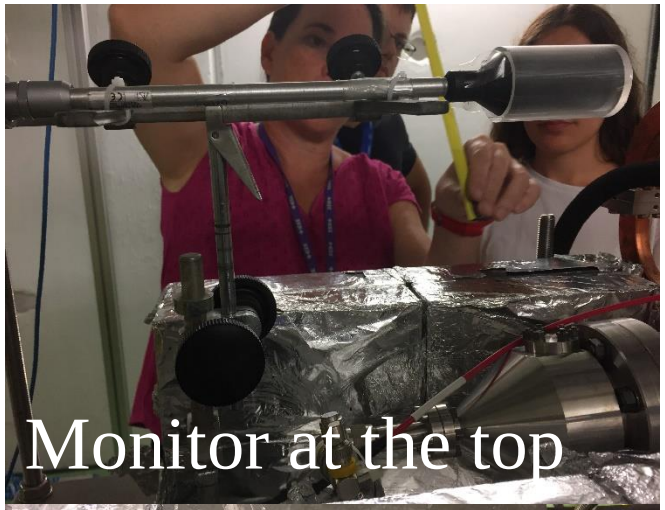
- For more details of the test stand and the conditioning process of this structure at Xbox 2 please refer to Jan and Lee presentations.

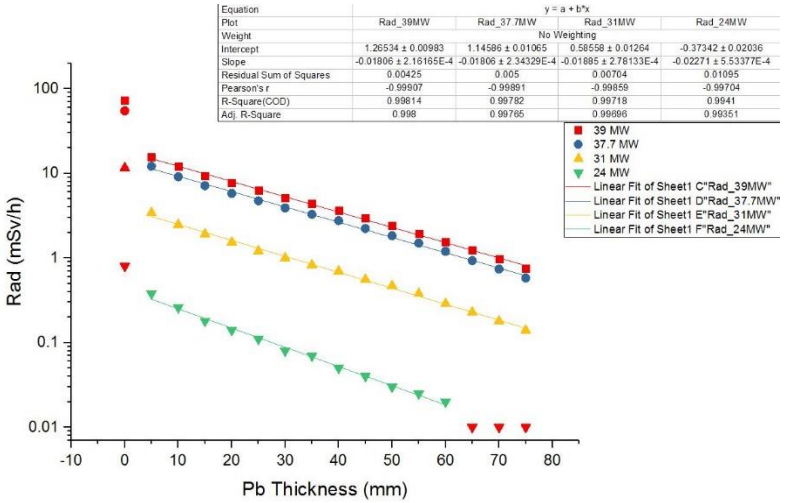


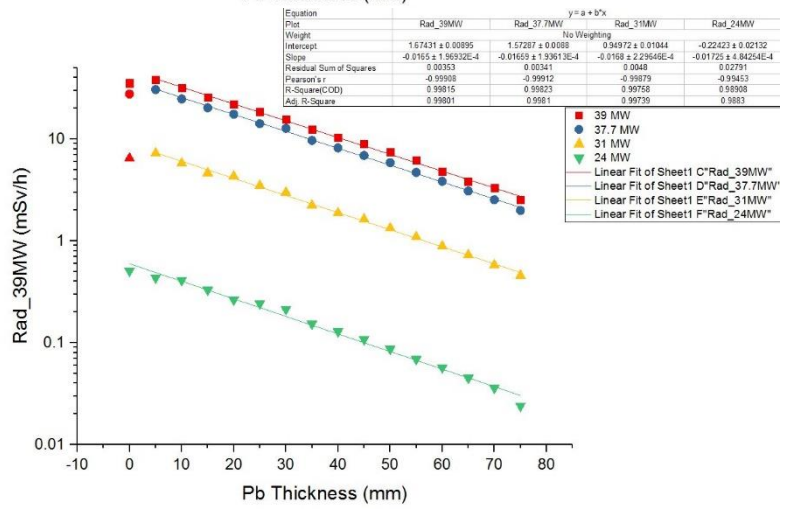


Radiation experiment

Radiation monitor at the top/front of the FC



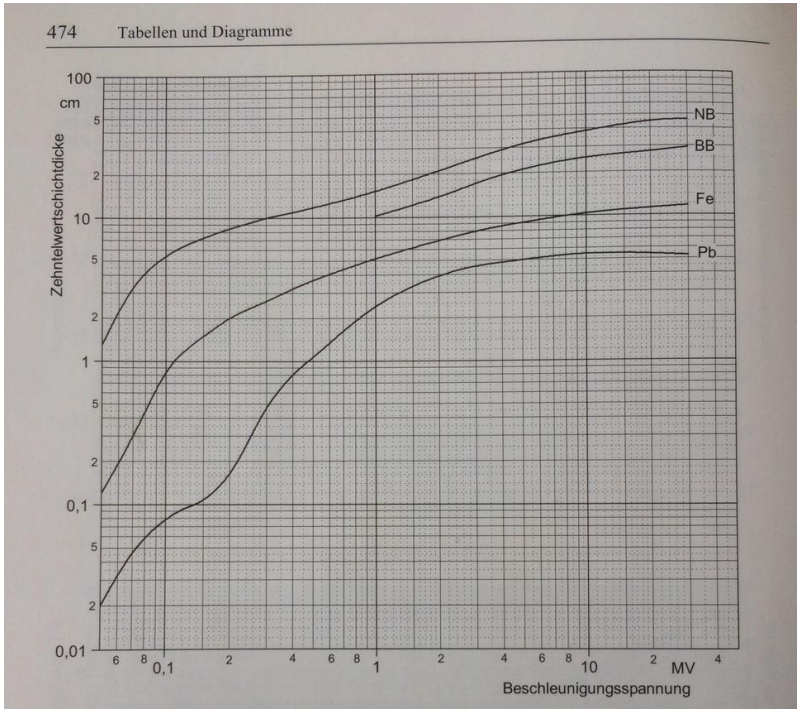


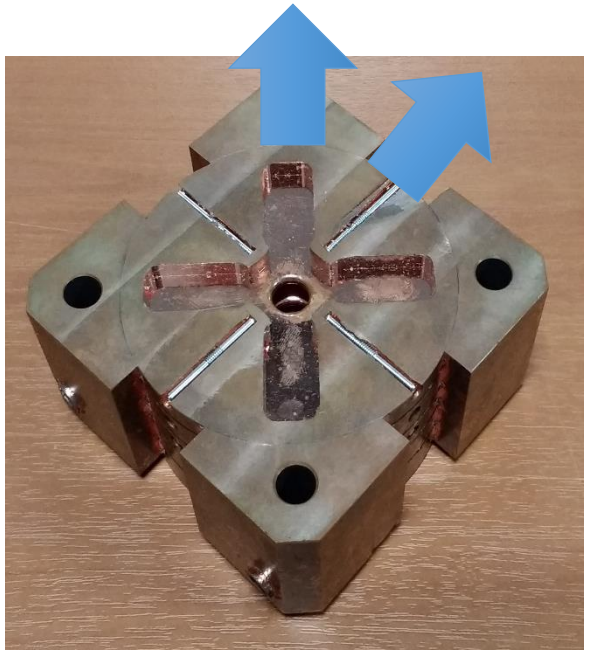


Radiation experiment

Conclusions and next steps

Downstream Lateral
39MW 62.52421 53.86634
37.7MW 61.77425 52.95544
32MW 61.79592 49.09272
24MW 64.22992 37.78744





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  - Basics on secondary emission and Multipactor
  - First experimental results
- TD24 dedicated experiment
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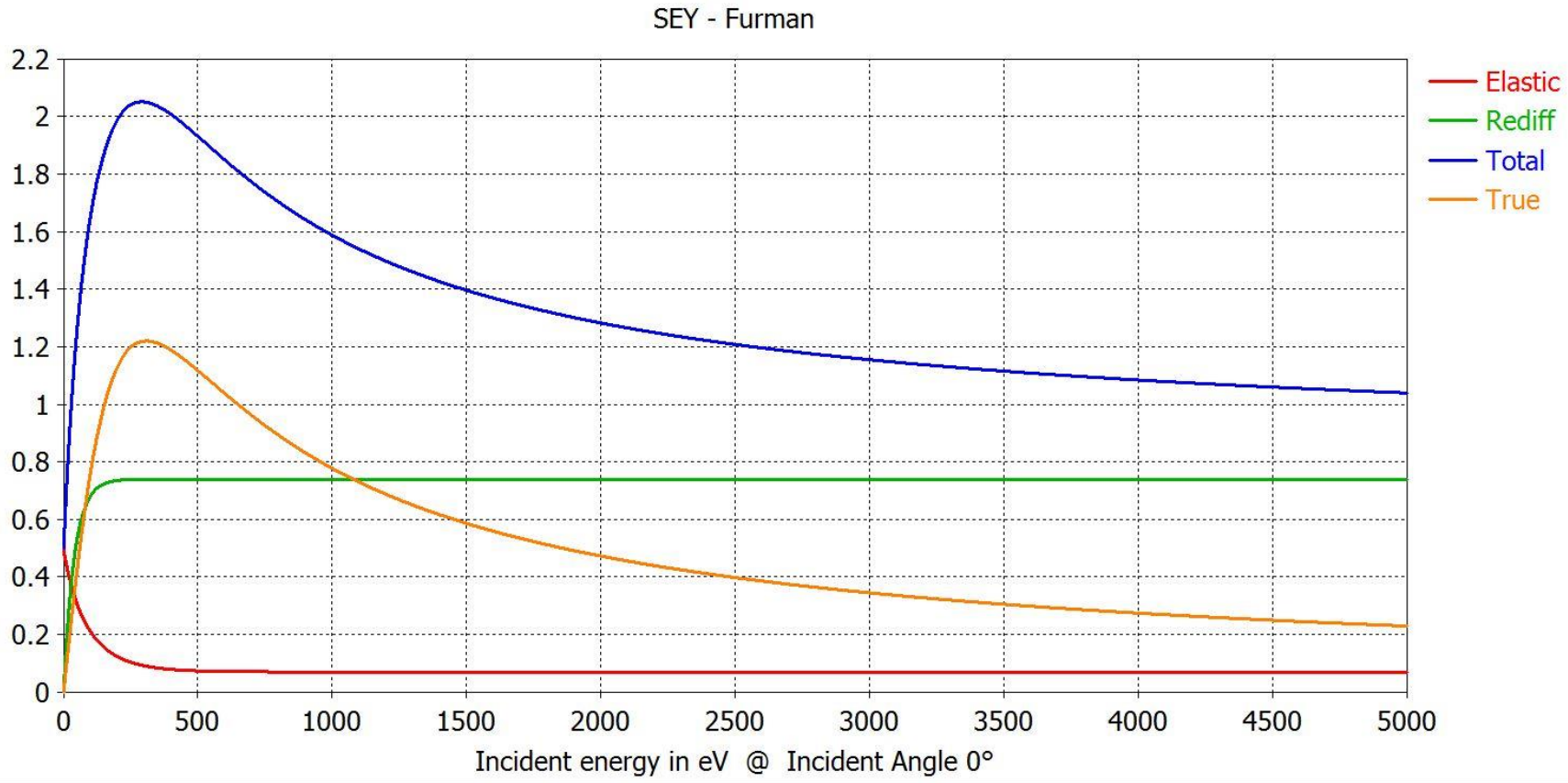
SEE and Multipactor

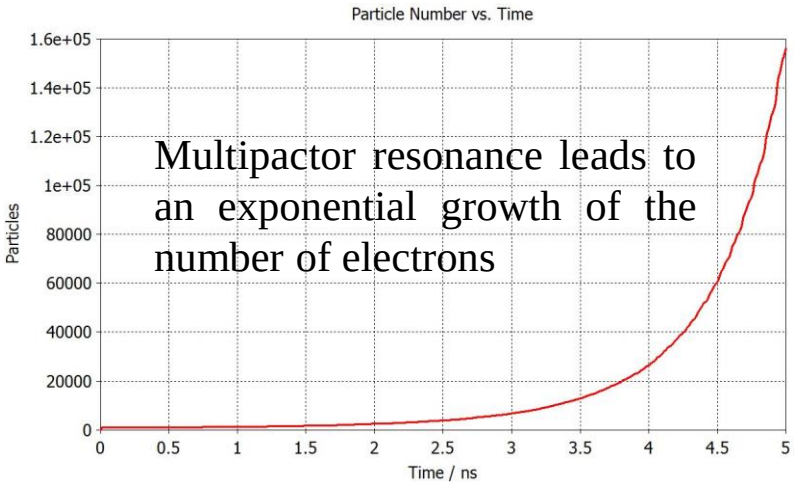
Basics on secondary emission and Multipactor



[1] M. A. Furman and M. T. F. Pivi. Probabilistic model for the simulation of secondary electron emission. Physical Review Special Topics – Accelerators and Beams, Vol 5, 124404. 2002.

SEE and Multipactor

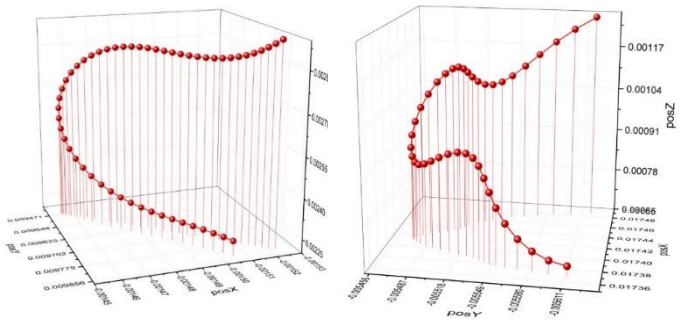
Basics on secondary emission and Multipactor

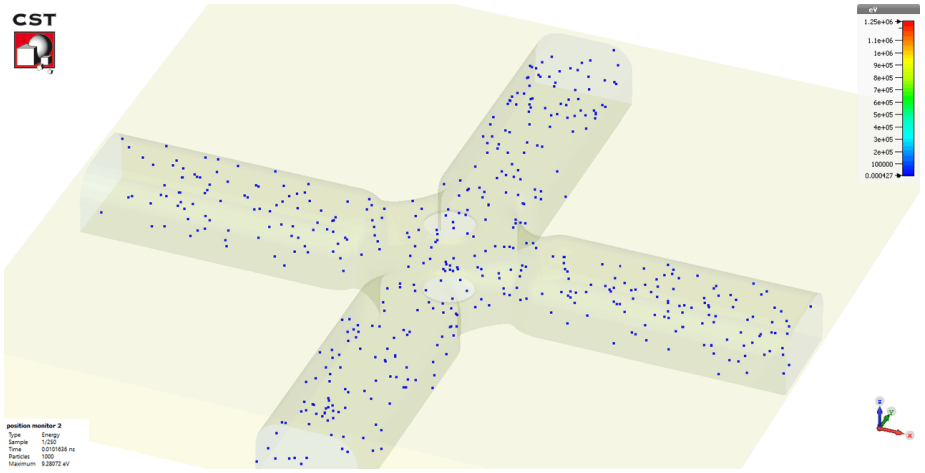


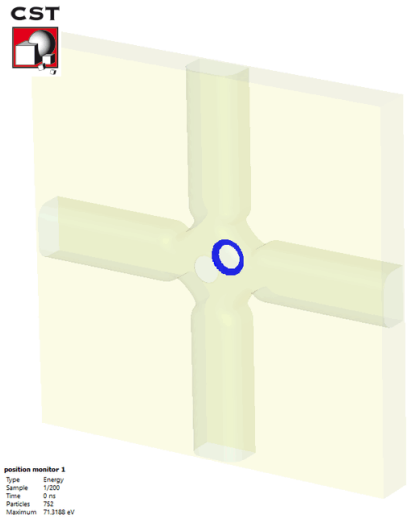
Multipactor resonance leads to an exponential growth of the number of electrons

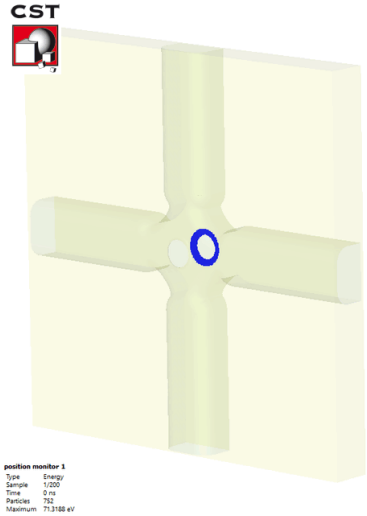
For 100 MV/m of average gradient

Example of the resonant trajectories that lead to the **Multipactor avalanche**



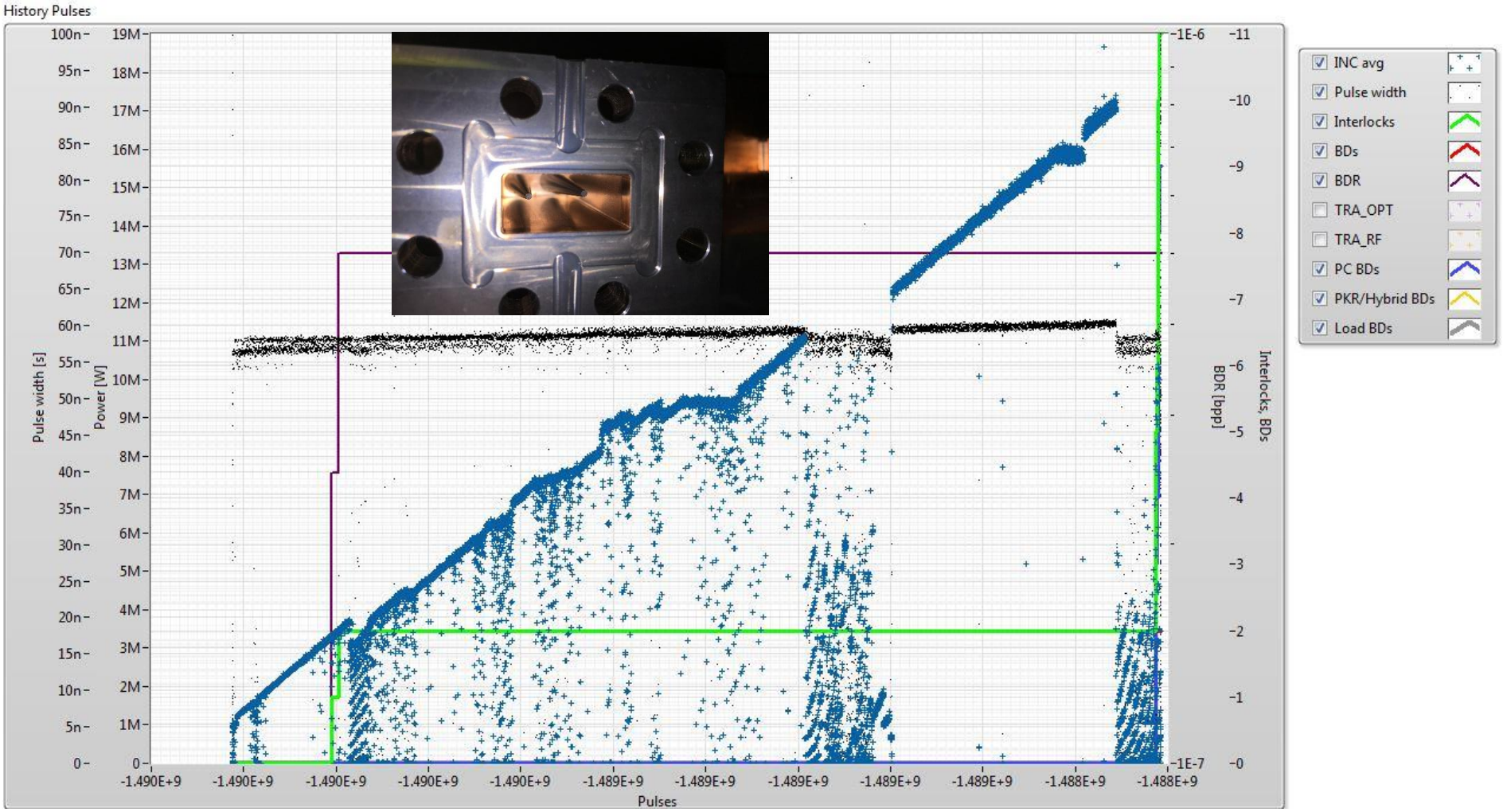






SEE and Multipactor

First experimental results - RF terminators tested at Xbox 3



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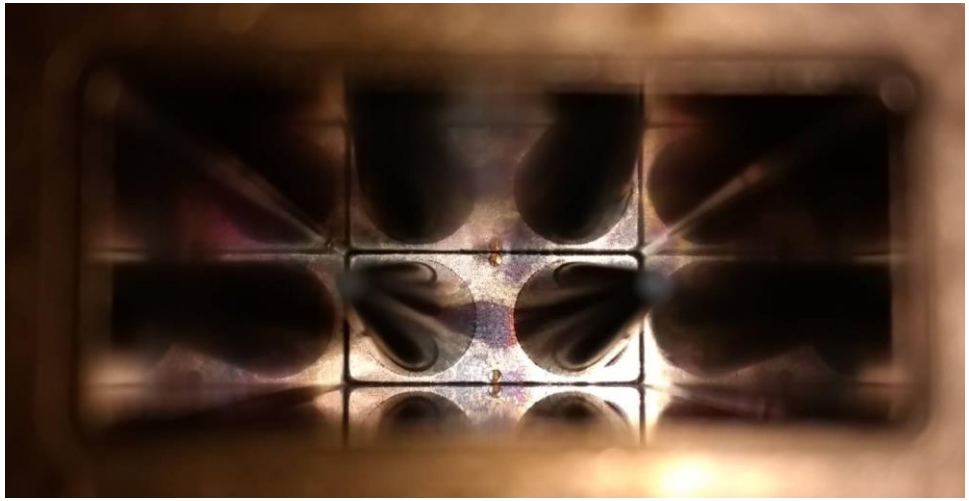

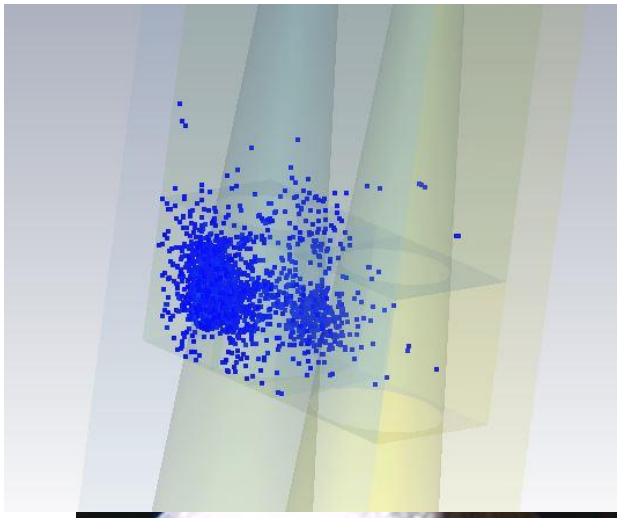

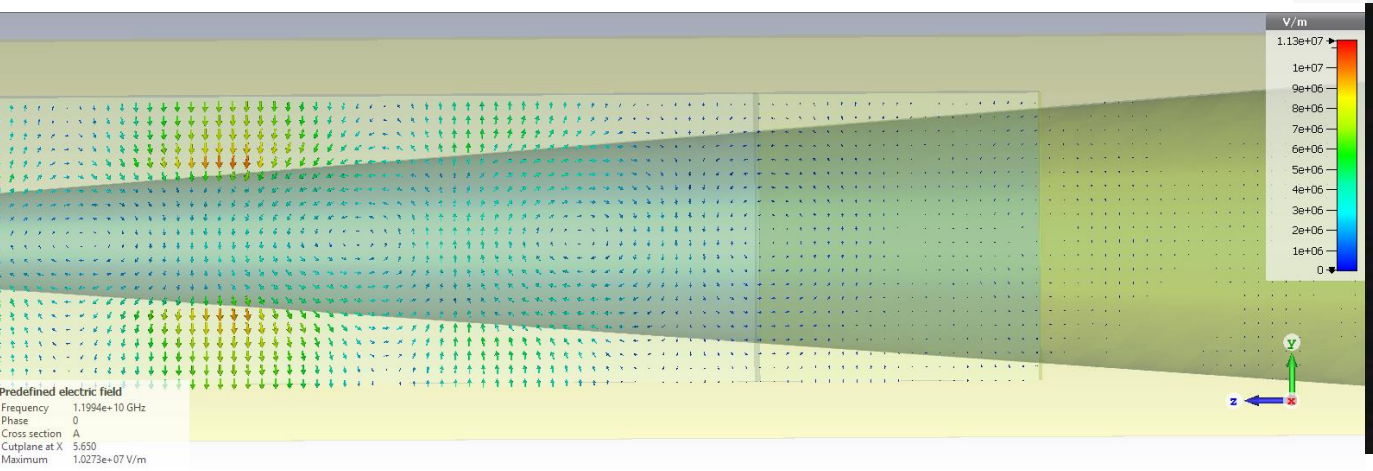

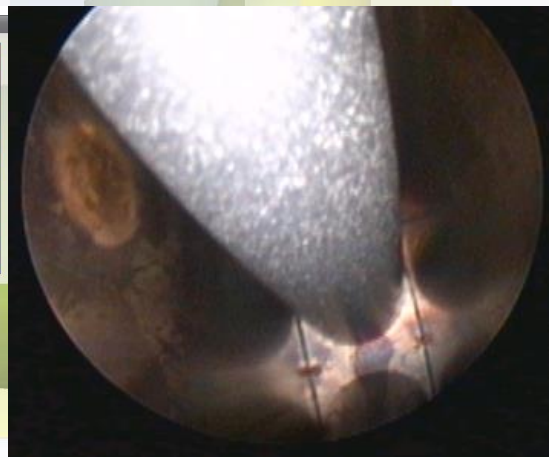

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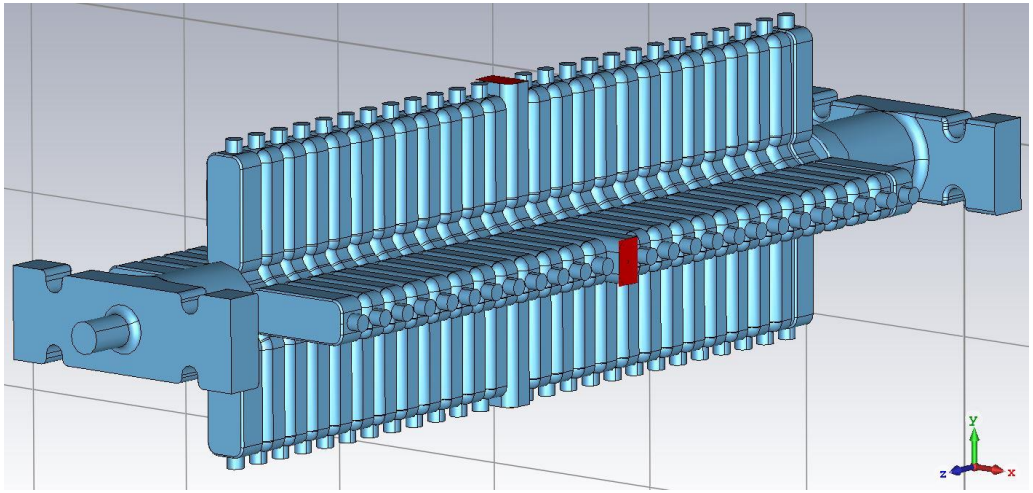
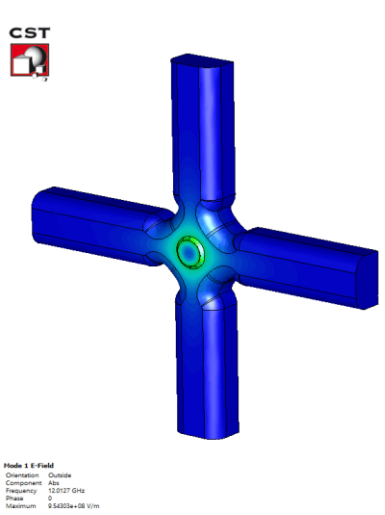
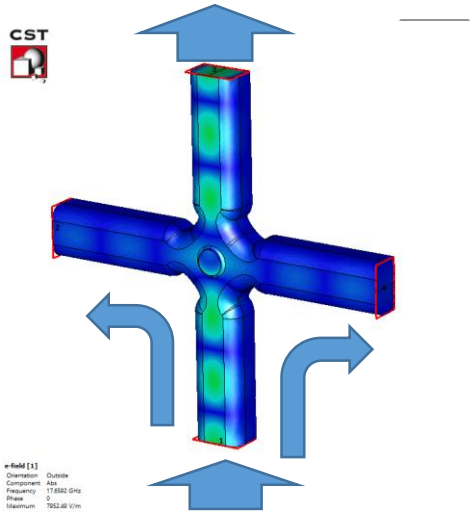
  - Summary of the previous work
  - New progress done
- Conclusions

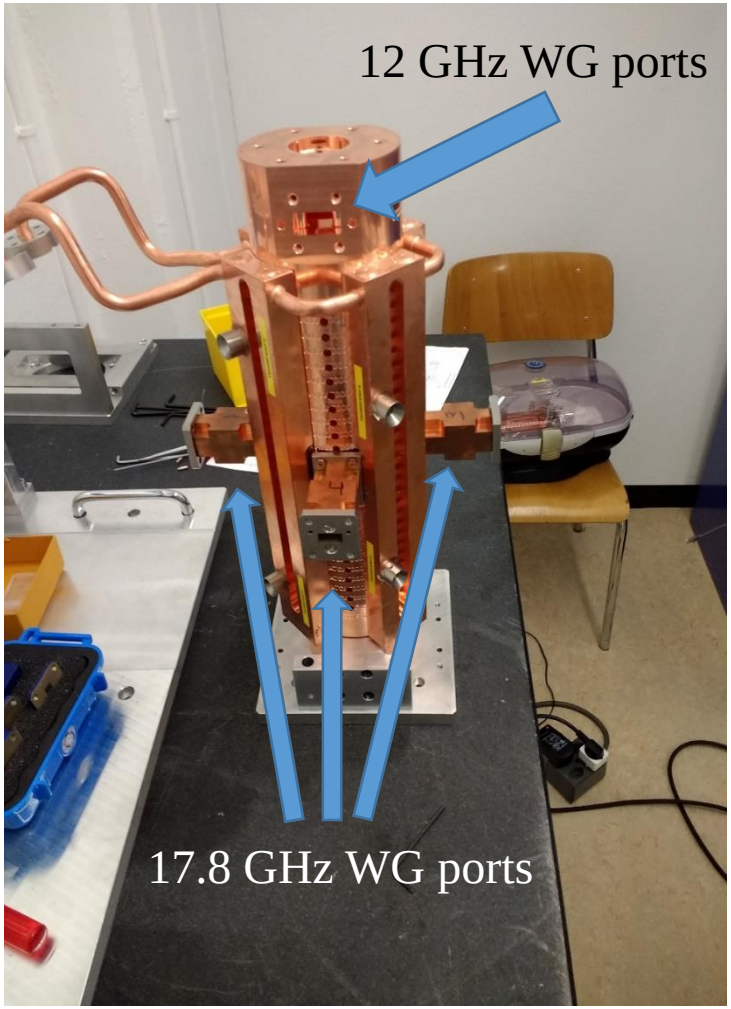
TD24 dedicated experiment

Summary of the previous work



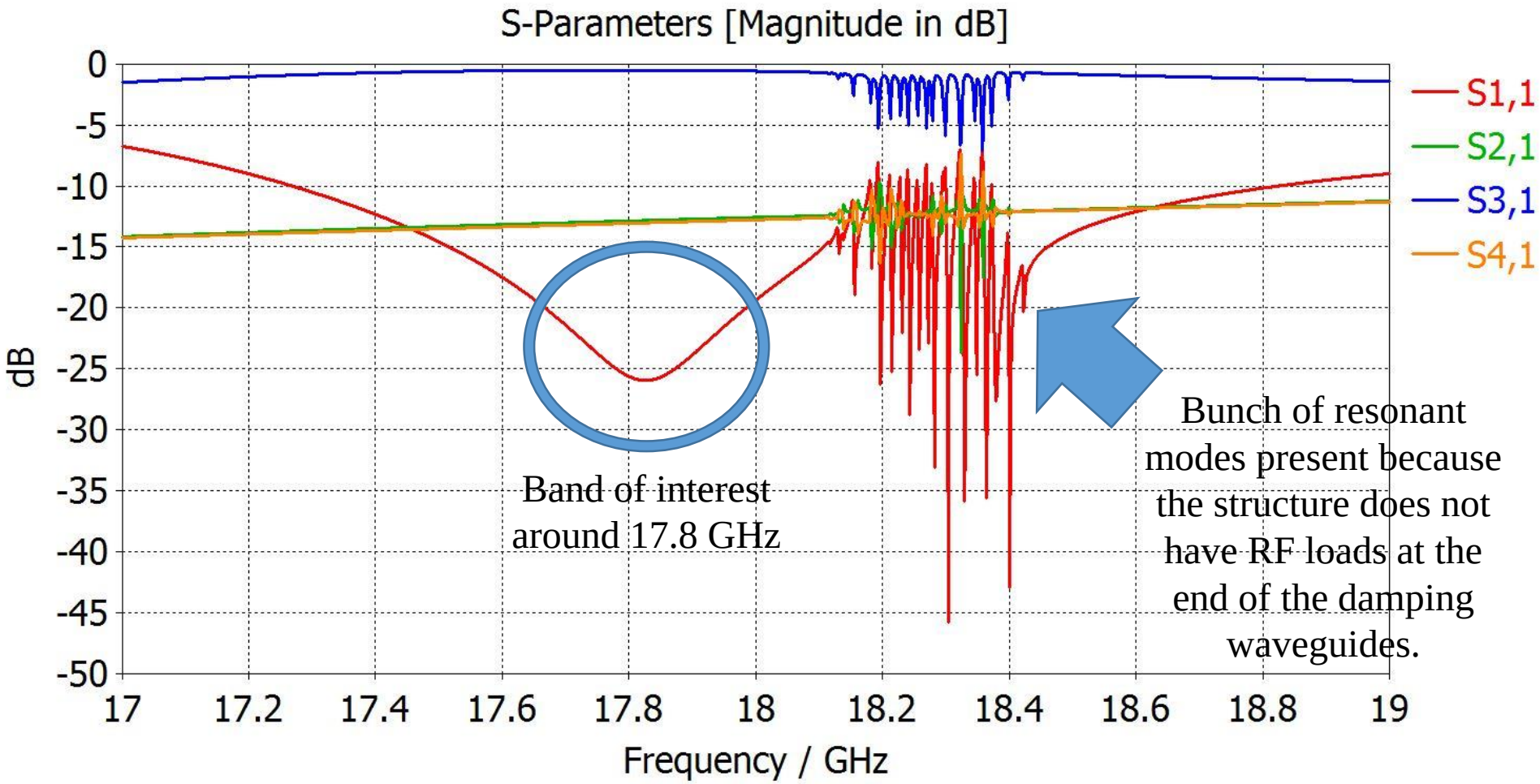




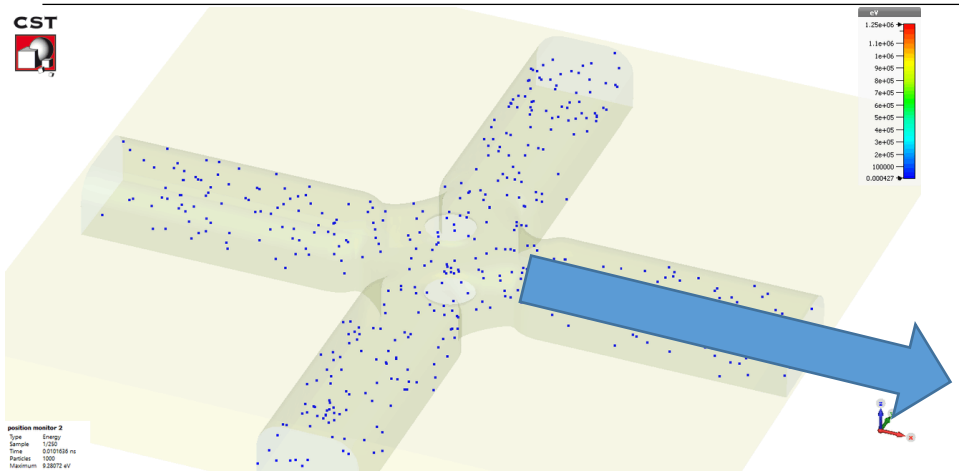


TD24 dedicated experiment

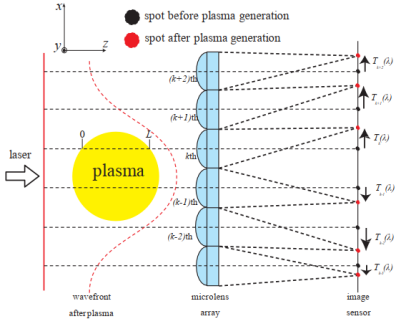
Summary of the previous work

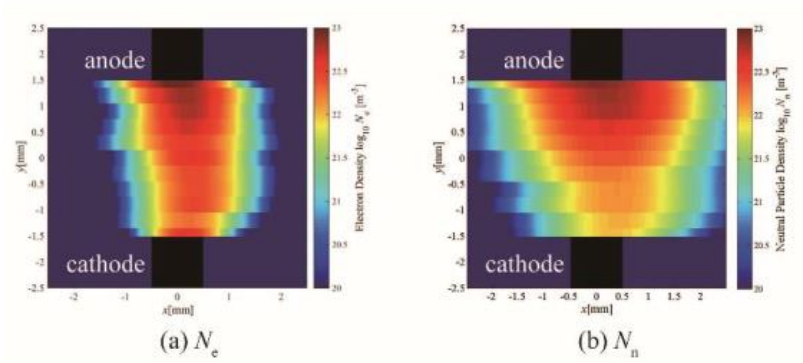


TD24 dedicated experiment



Putting a Faraday Cup we can measure the Dark Current sideways and search for harmonic contributions to see if there is a Multipactor contribution to the well known Field Emission Current.





Introducing a laser beam and a microlens array detector we could also analyse the shape of the plasma generated in an RF Breakdown

[2] Akiko Kumada. Laser Diagnostics for Elucidation of Vacuum Arc Behavior. Proceedings for the XXVIII ISDEIV 2018.

TD24 dedicated experiment

New progress done

- We are in the process of building a structure with one cell open but ready for working in vacuum, needed for the high power test.
- We have the machined disks of a TD24 ready for bonding.
- We are designing a taper transition for the RF and the cooling system that allows opening the structure.

- We need to design the data acquisition system. For the RF experiment and also for the DC measurements.
- We need to decide the new electronics that we need, and see how we can integrate the experiment in Xbox 3.

CONTENTS

- Dark Current simulations in High Gradient structures
- Radiation experiment at Xbox 2
- SEE and Multipactor
- TD24 dedicated experiment
- Conclusions

Conclusions

- DC simulations presented for a normal T24PSI structure and a double structure gives us some sense on what to expect in the conditioning of the CLIC superstructure: current should not change too much but the radiation will be bigger as the electrons double the energy.

- The radiation experiment looks promising but we still need to finish the theoretical part with the FLUKA simulations.

- In the conditioning of the RF terminator seems to be evidence of Multipactor effect. So this kind of vacuum discharge can also affect to the high power RF devices.

- In the open TD24 experiment we have many possible experiments to be implemented, but the first step is to fabricate and test the structure to see the feasibility of the experiment.


thank you very much
for your attention