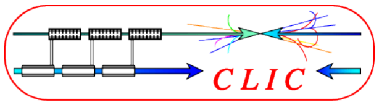


Experimental breakdown studies – breakdown diagnostics

Linking simulation and experiment

Jan W. Kovermann, CERN, RWTH Aachen

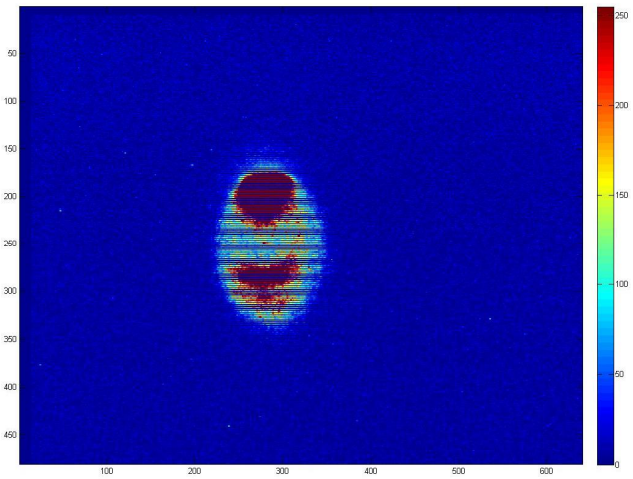
SLAC workshop 8 -10 July 2009

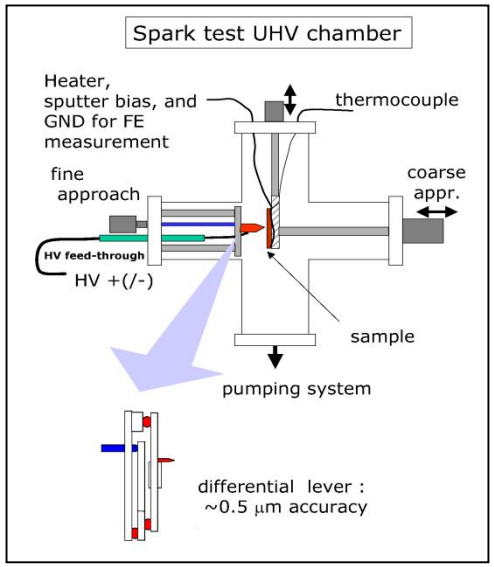
The connection between simulation and experiment

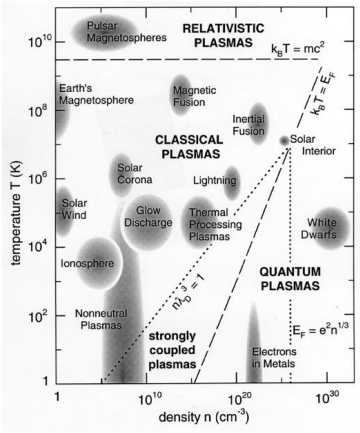
Emitted currents
-Dark current spectrum
-OTR
-X-rays
-Trigger mechanism
-Missing energy
-Breakdown rate
-Ion currents
-Fowler-Nordheim distribution

Plasma characteristics
-Time structure
-Physical dimension (imaging)
-Ion species (opt. spectroscopy)
-Ion currents
-Vacuum behavior

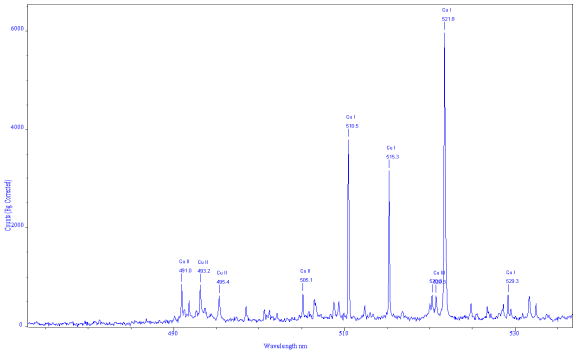
Surfaces
-Crater morphology
-Material diagnostics
-Fatigue process



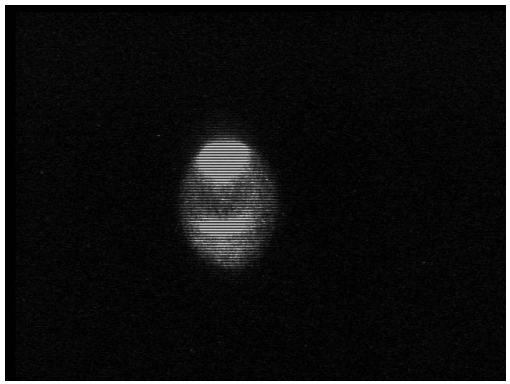




Plasma density ➔
simulation input



Plasma composition➔
simulation and mat.sci. input

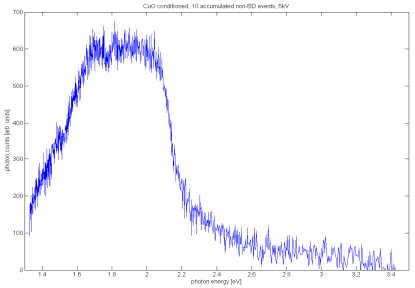


Plasma size/position ➔
simulation and design input

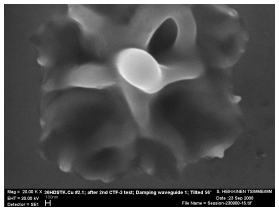
Spectroscopy

BREAKDOWN DIAGNOSTICS

RF measurements, FC, XRAY ➔
simulation and design input

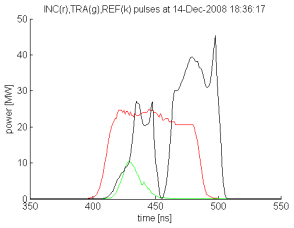


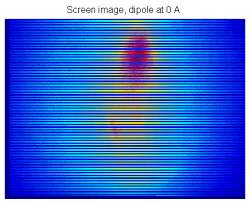
OTR in nominal pulses ➔
simulation and machine parameter input

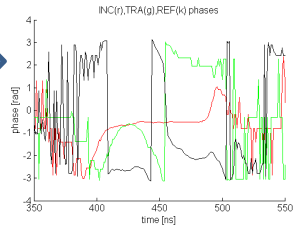


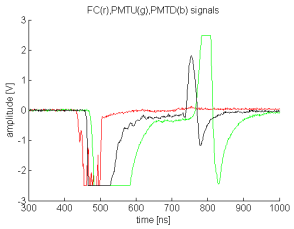
SEM ➔
simulation and design input

Missing energy ?







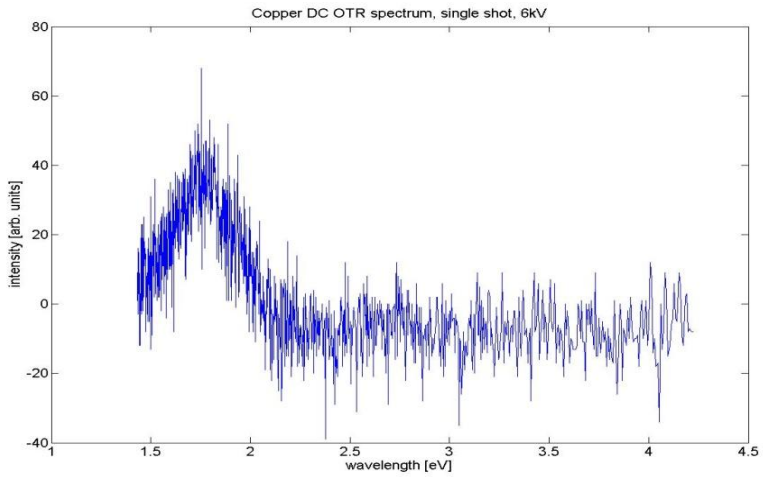


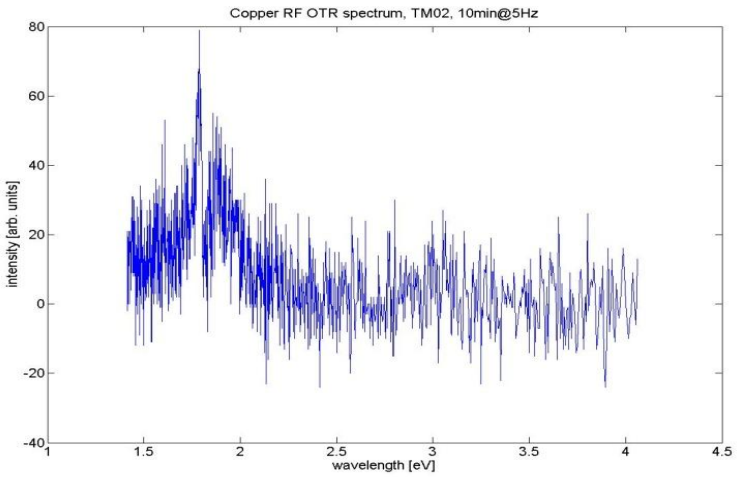
Breakdown diagnostics: some results

DC

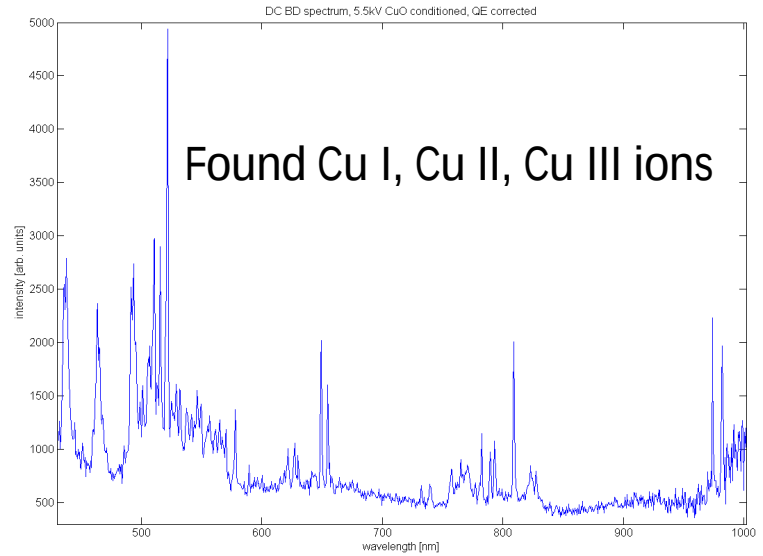
RF

OTR (Copper)





Opt. spectroscopy



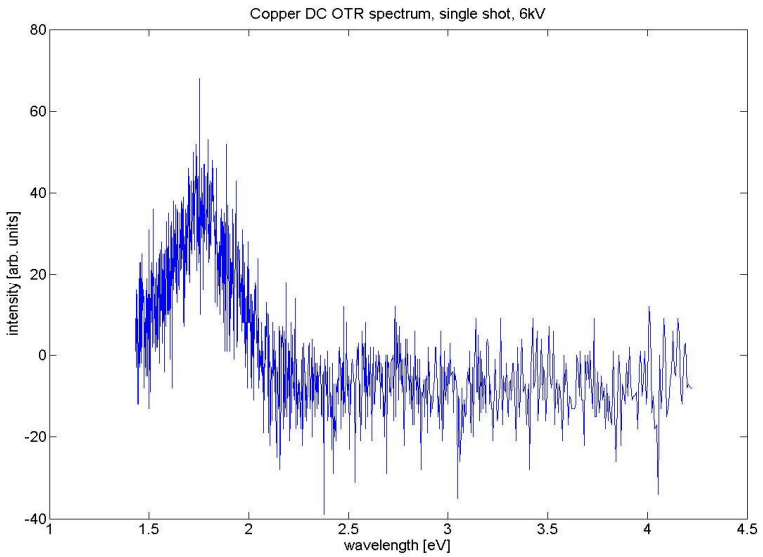
Found Cu I, Cu II, Cu III ions

Will be measured soon at

SLAC NATIONAL ACCELERATOR LABORATORY

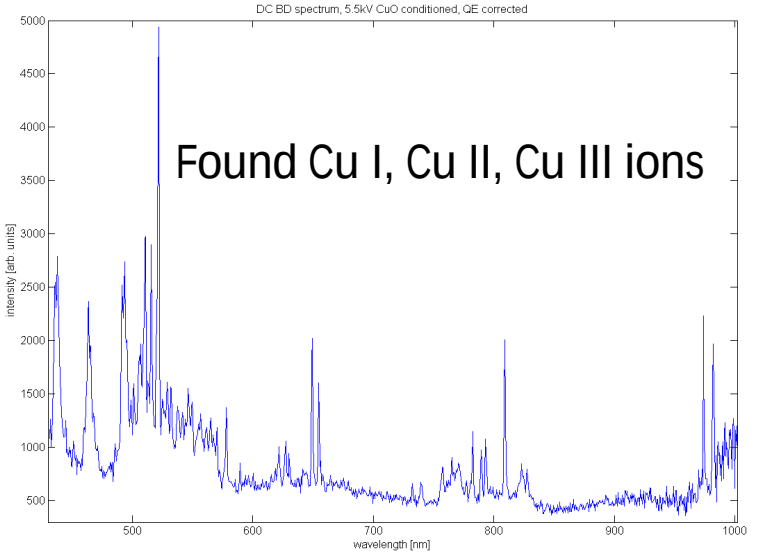
Breakdown diagnostics: some results

OTR (Copper)



➔ Spectrum typical for OTR in Cu (interband transition @ 2.1eV)
➔Beta measurements possible close to the breakdown limit (~105)
➔ OTR sometimes seems to rise before a breakdown
➔ Oxide layers suppress OTR
➔ An estimation of the energy absorbed by electrons in 30GHz structures: 0.1MW @ 14MW RF input power

Opt. spectroscopy



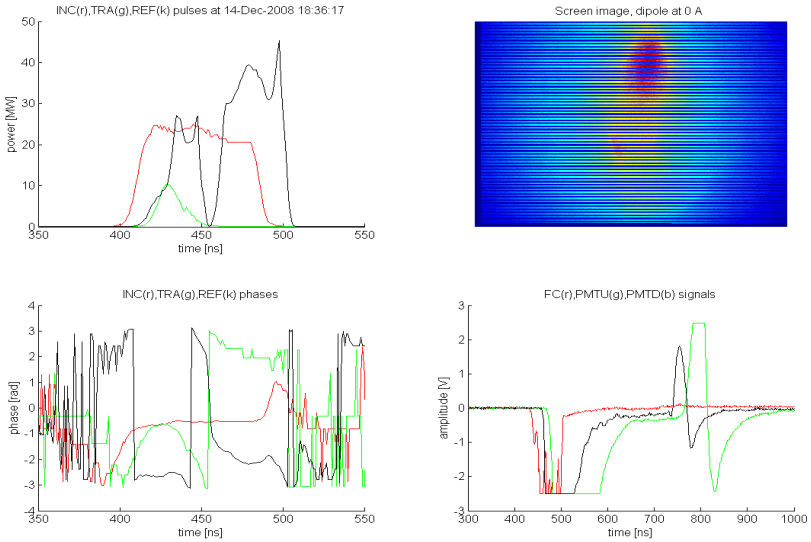
➔ found very little traces of O,H, probably no contribution to the breakdown physics
➔ Estimated temperature from two-line-method: 1-5eV, but Cu III (T>35eV) seen, plasma is a non-LTE plasma!
➔ Intensity waveform for different lines highly non-reproducible (clusters? Different plasma?
➔ density measurement under planning

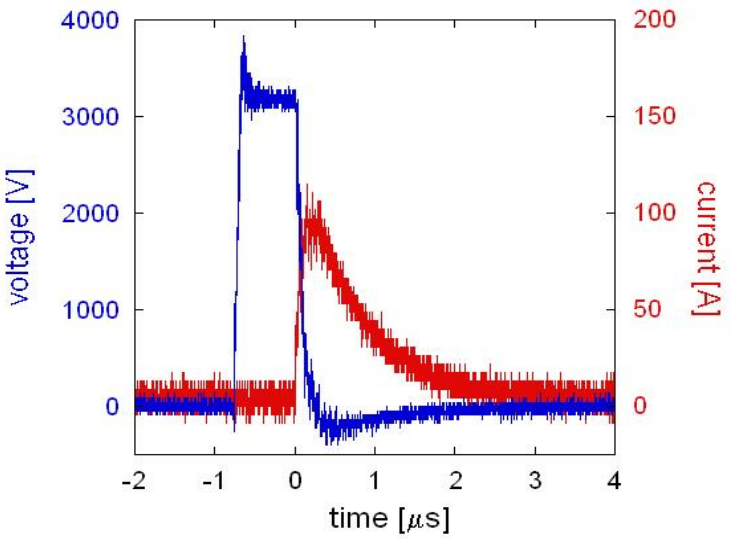
Breakdown diagnostics: further measurements

RF

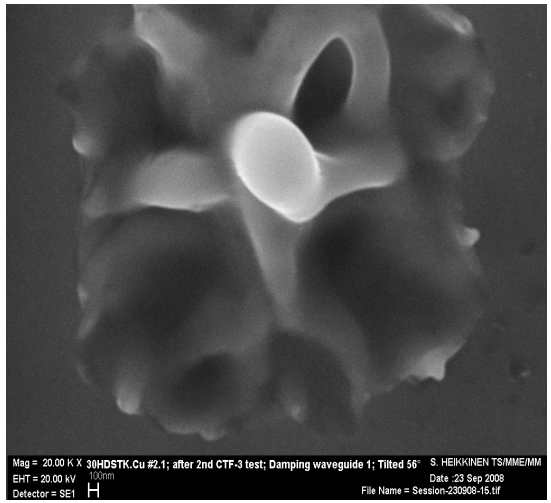
DC

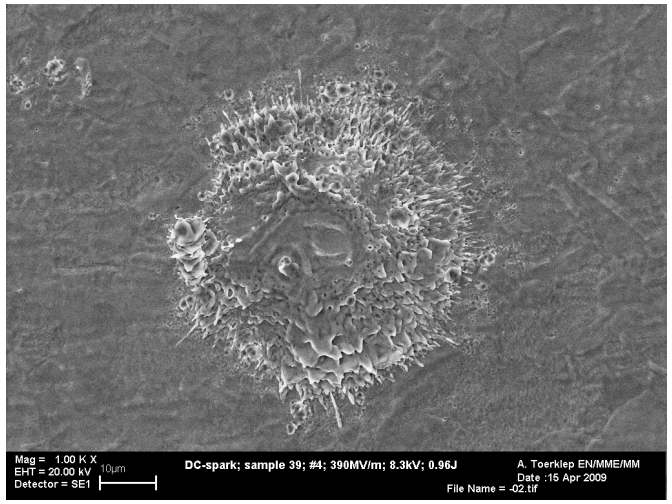
RF (I,Q), Xray, FC @30GHz





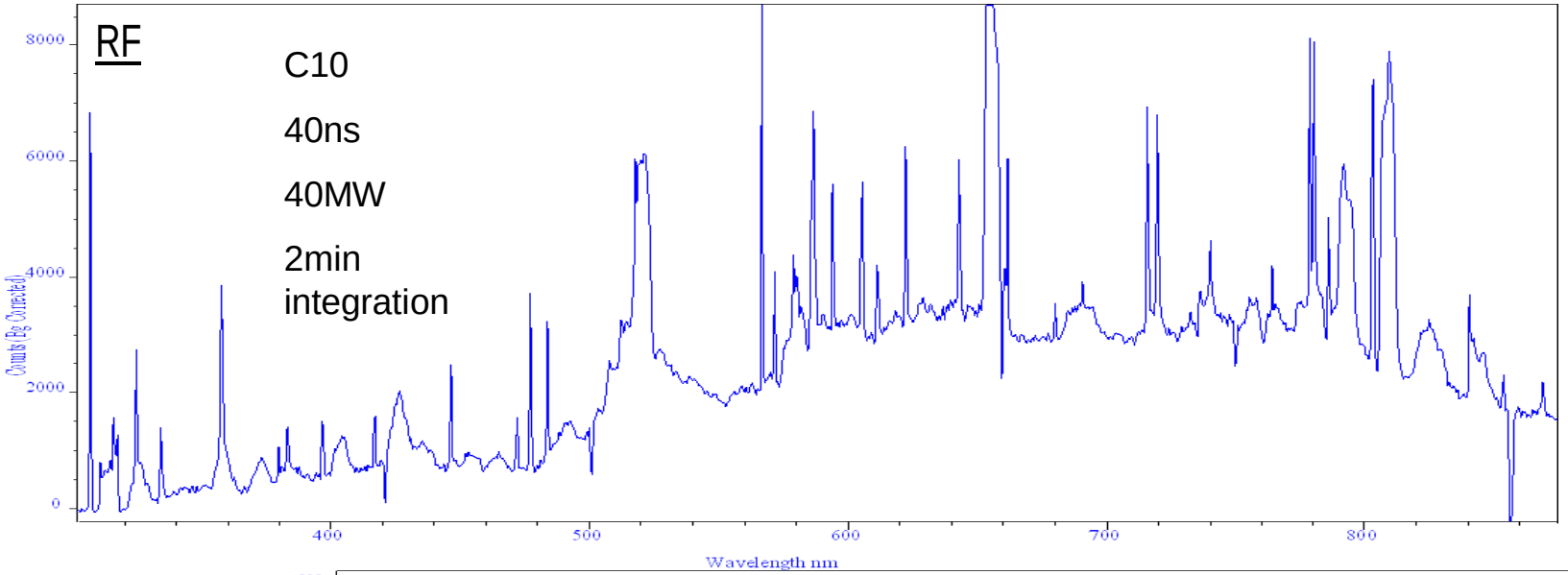
Current, voltage and delay

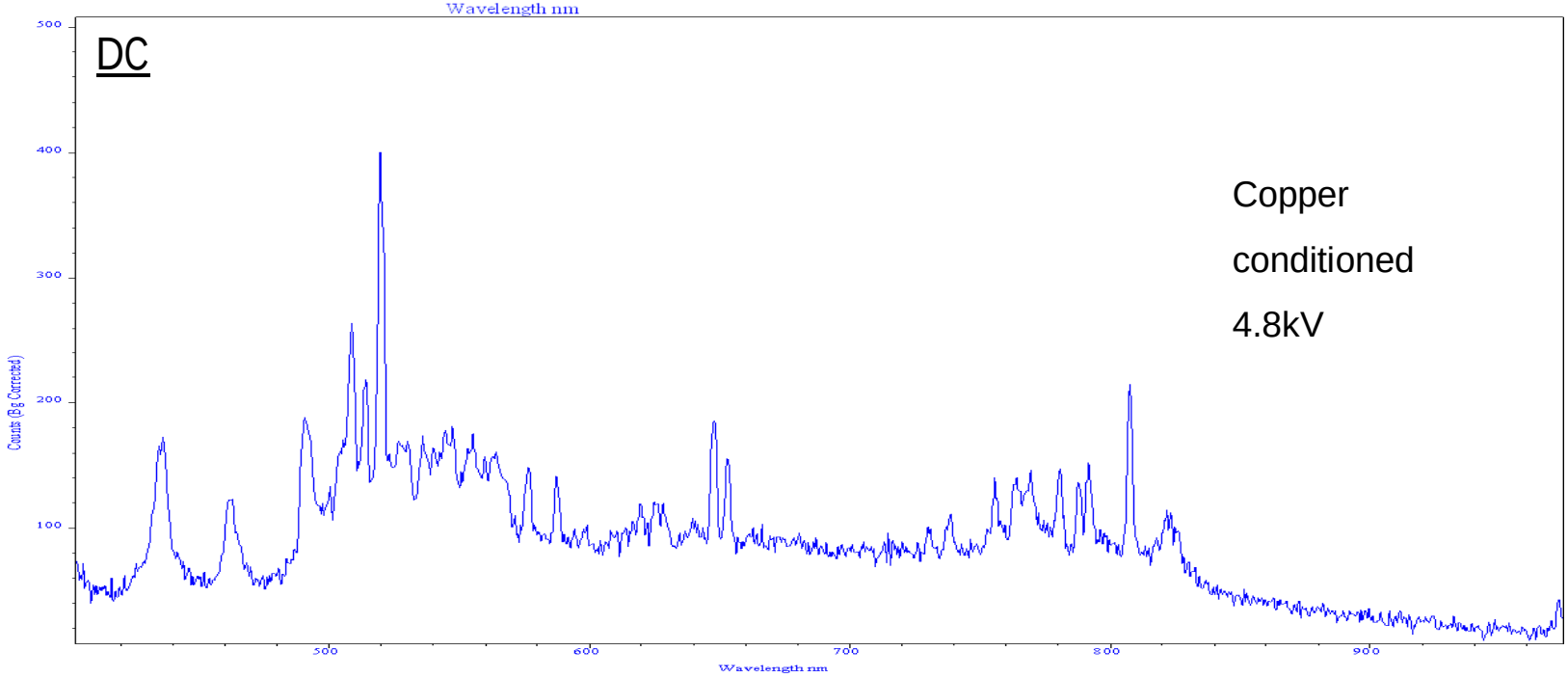




SEM of single breakdowns

New measurements Raw data from today!





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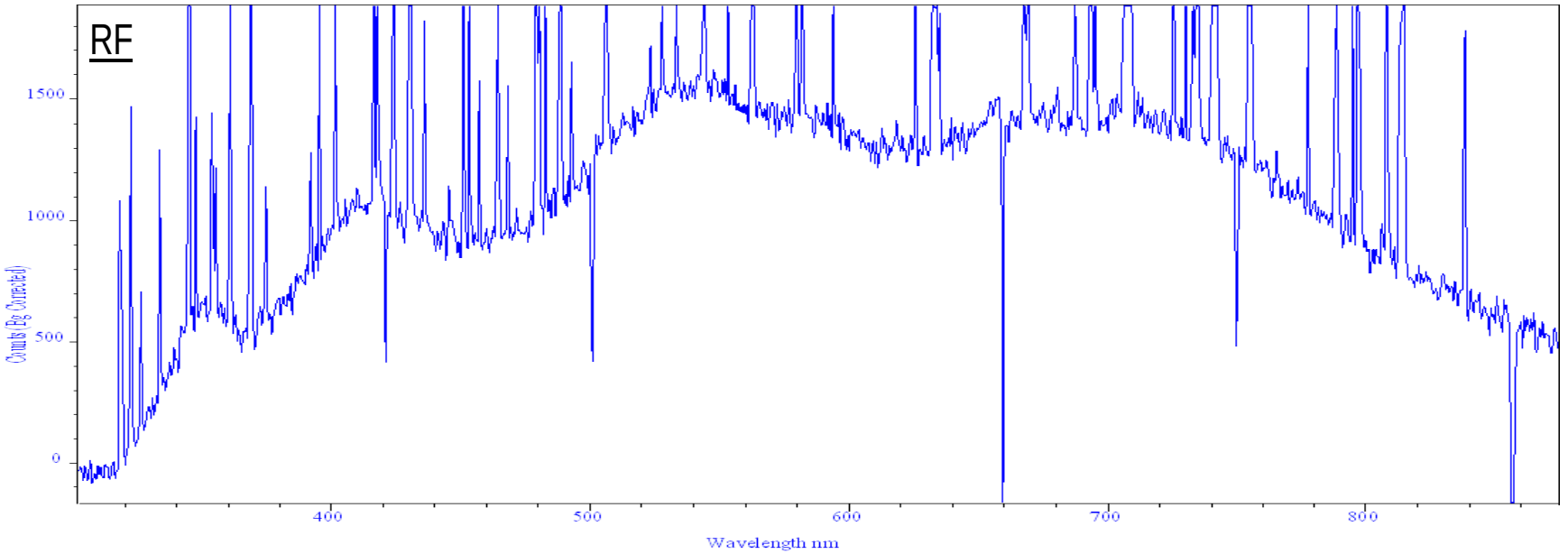

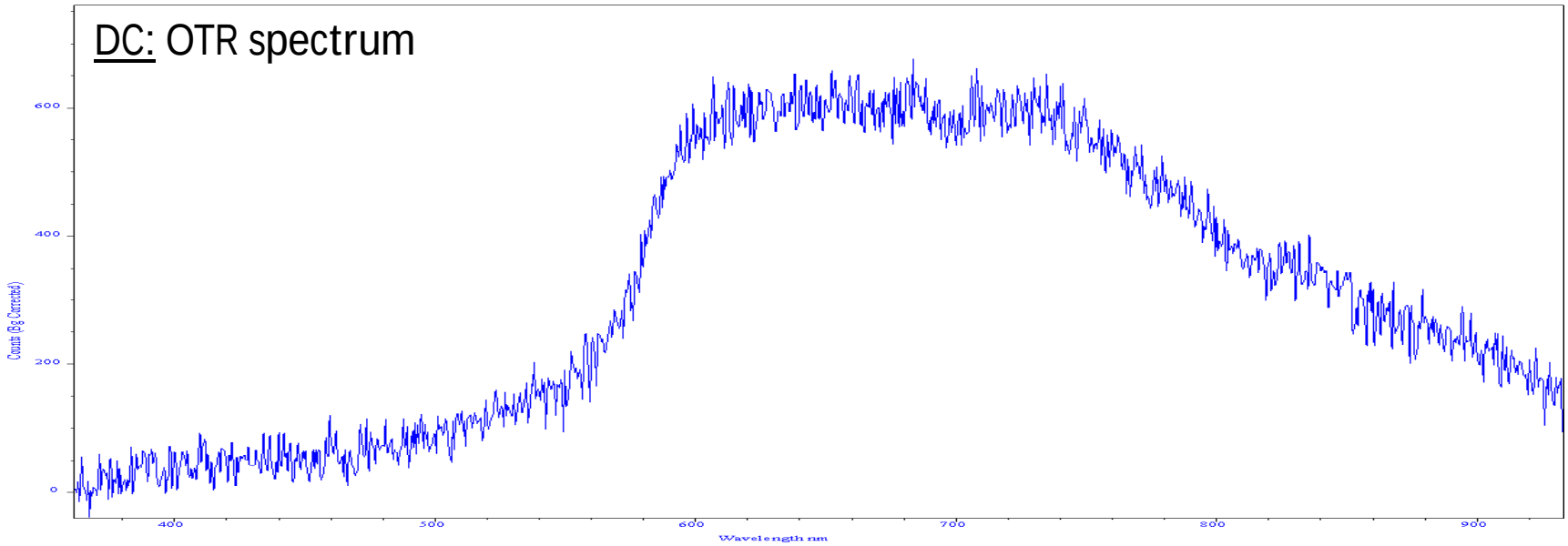

Conclusion

➔ High resolution optical spectroscopy in DC and RF almost done

➔ Time resolved measurements will follow

➔ There are differences in the continuum background for DC and RF

➔ C10 does not show OTR like expected, have to check 30GHz TM02 again

➔ Traces of oxygen and hydrogen have been seen during multipaktor events

➔ Breakdowns seem to emit less line-like radiation and more continuum background than multipaktor

➔ Interpretation of the data is ongoing…

THANK YOU!