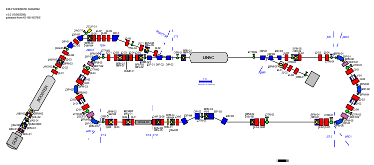

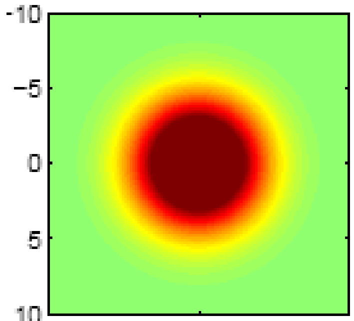

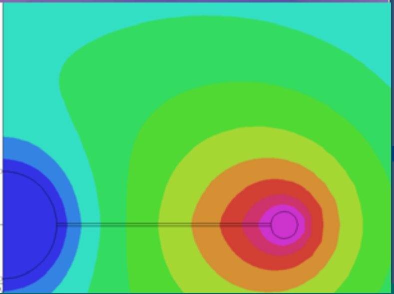

Science & Technology Facilities Council
Daresbury Laboratory

UNIVERSITY OF LIVERPOOL

Terahertz generation for ALICE microbunching experiments

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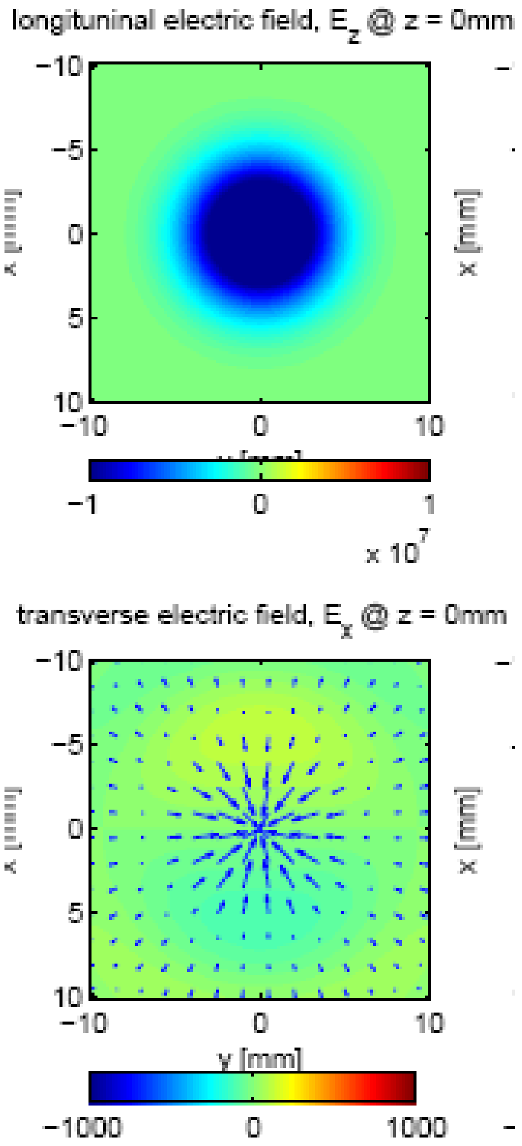
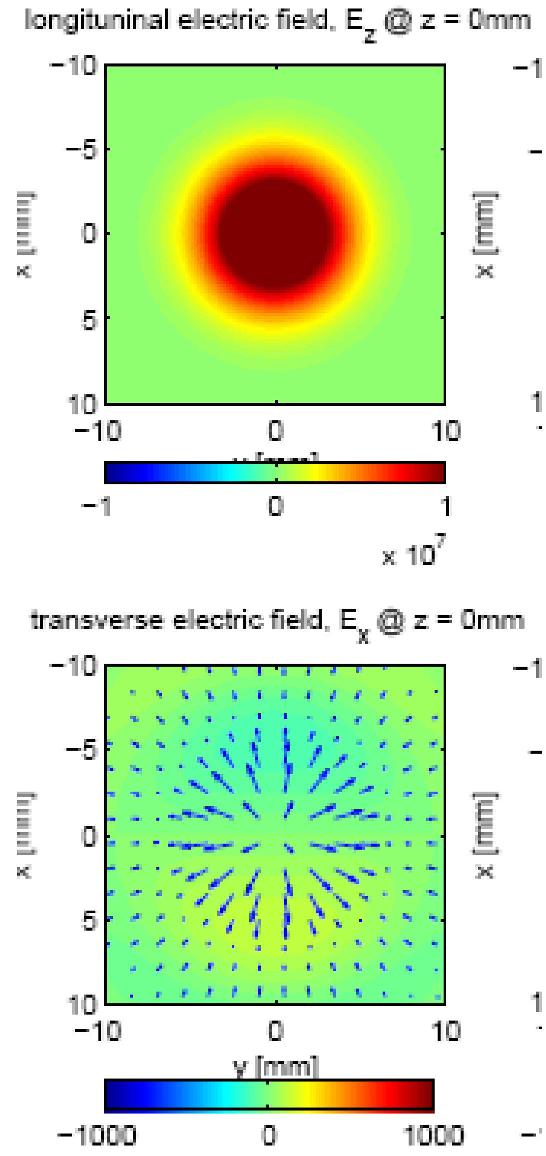
Project Outline

- Use of longitudinally polarised terahertz beam to produce energy modulation in ALICE electron beam;
- Terahertz radiation generated by converting the mid-IR Coherent ***terawatt*** laser into ***terahertz*** radiation using a semiconductor wafer;
- Observe effect of the radiation-electron bunch interaction by its effect on the transverse beam properties (phase 1);
- Longitudinal diagnostics (e.g. transverse deflecting cavity) proposed as a future upgrade.

Longitudinally Polarised Radiation



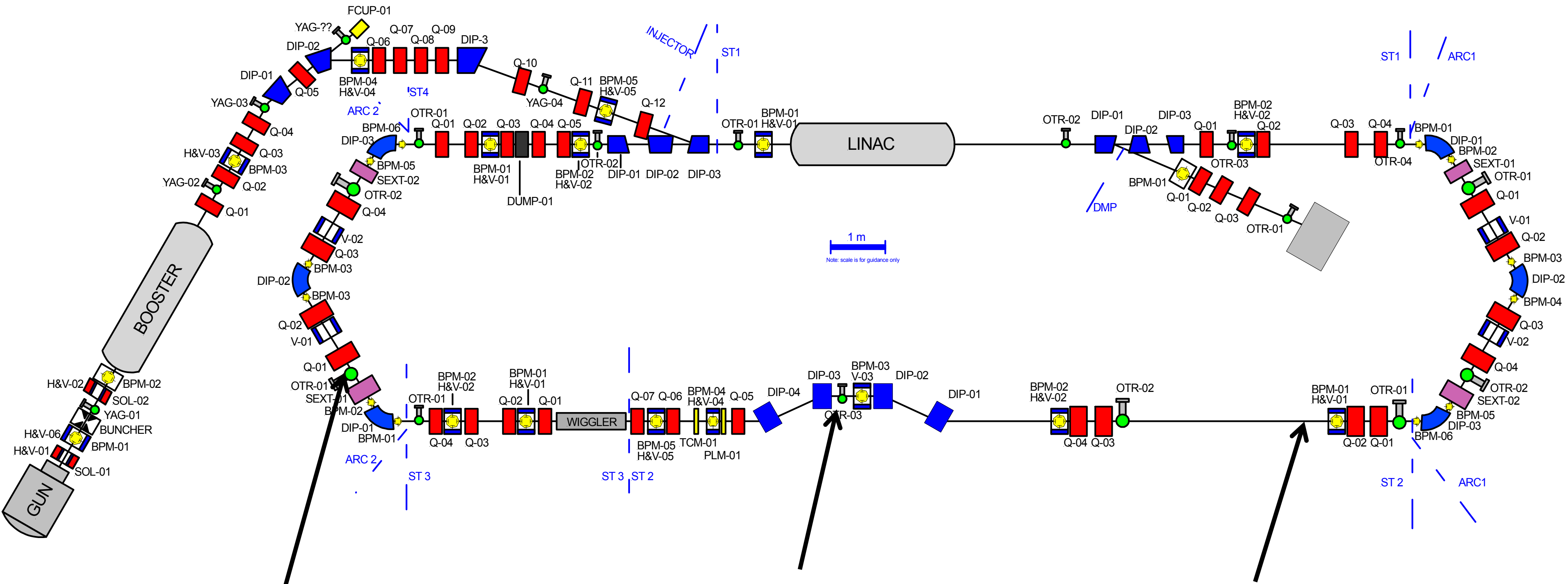
π phase later →



Proposed ALICE Microbunching Experiment

ERLP SCHEMATIC DIAGRAM

v.0.2 (15/06/2006)
extracted from AO-180/10078/E

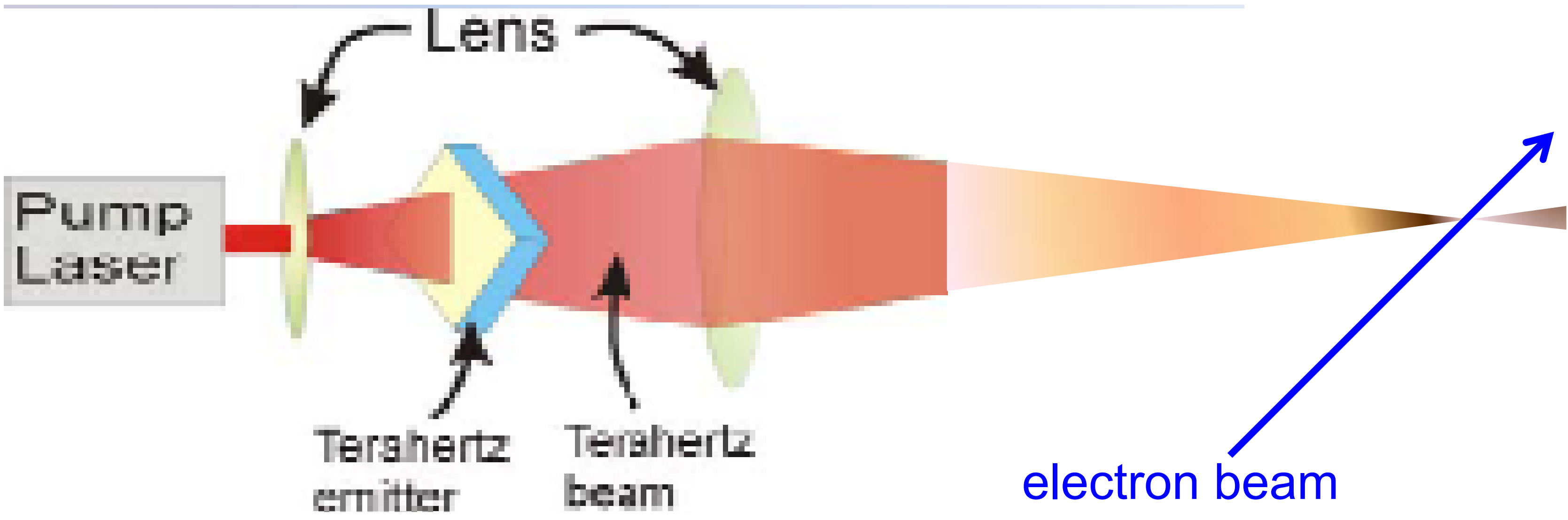


Observe transverse effect (phase 1) of interaction here or here

Terahertz radiation – electron beam interaction point

Generation of Terahertz Radiation

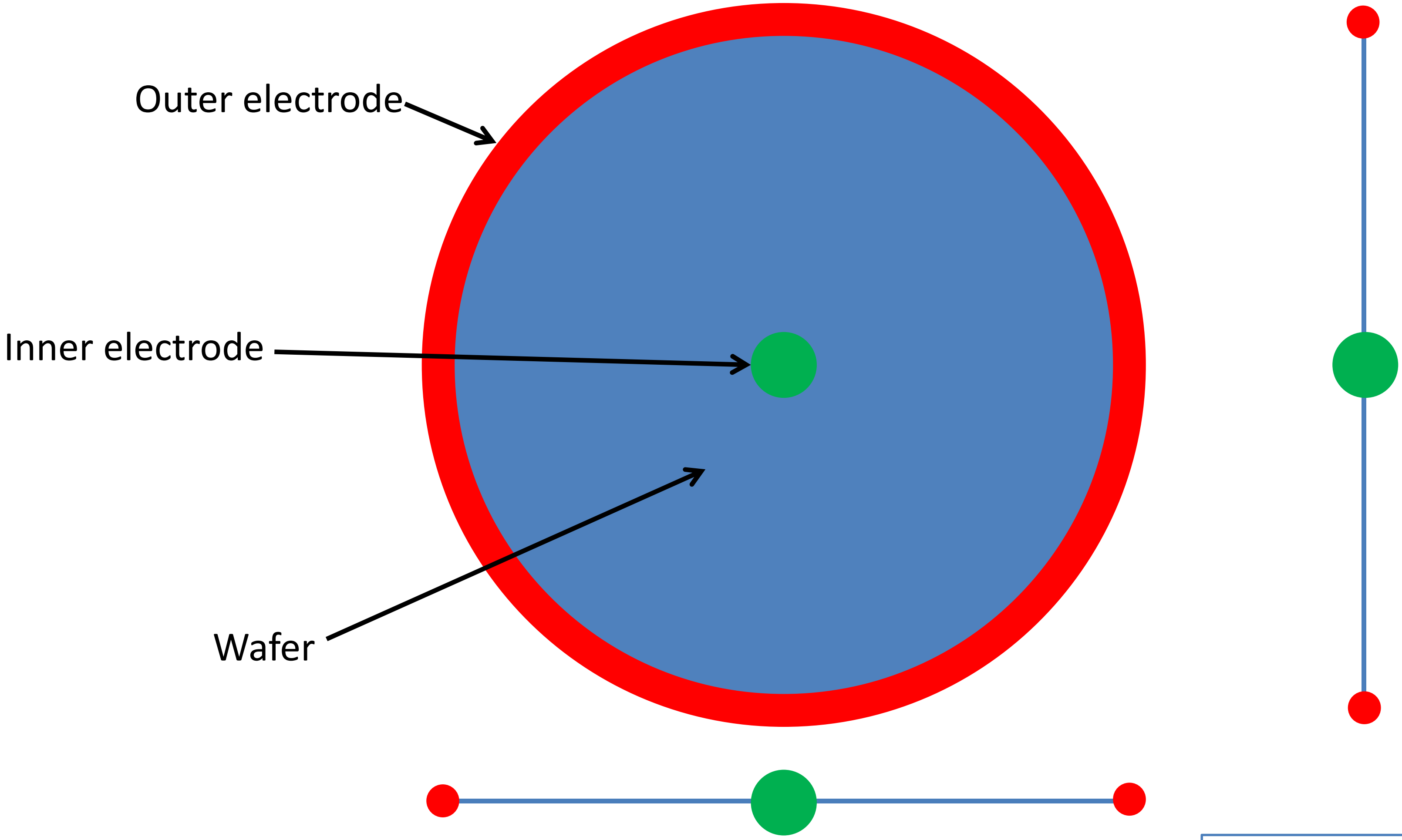
- Semiconductor wafer with one earth and one high-voltage (e.g. several 10s of kV, DC or pulsed) electrode;
- Short-pulse IR laser used to make wafer break down briefly (electrons promoted to the conduction band from valence band);
- During extremely fast rise in current radiation is emitted:



Wafer Properties

- Gallium arsenide (GaAs);
- 100 mm diameter;
- 300 to 500 μm thick;
- Dielectric constant ~ 13;
- Intrinsic (i.e. with no doping) resistivity 10^6 Ωm;

Wafer Geometry



Third-angle projection

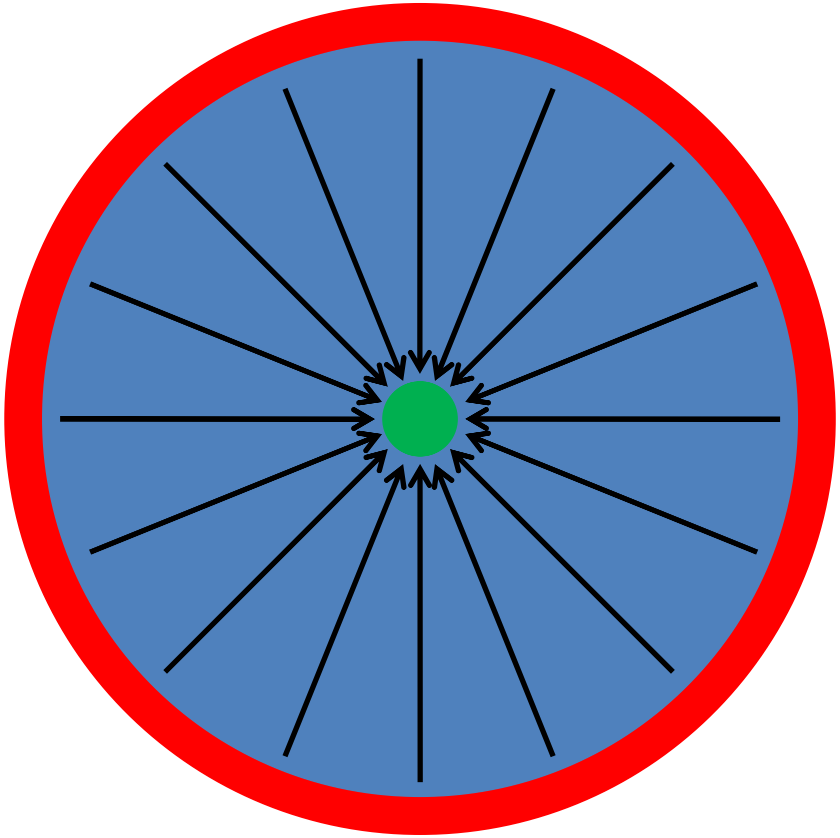
Current Flow

Laser beam with idealised top-hat transverse profile fills wafer aperture.

Sudden promotion of electrons from valence band to conduction band.

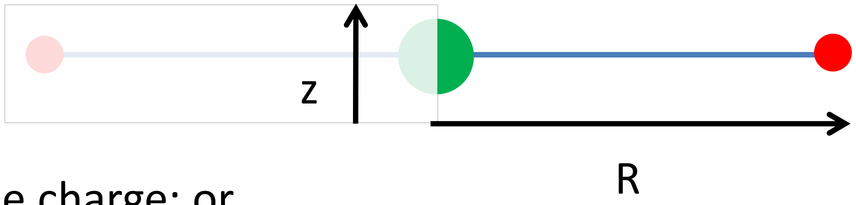
Large voltage across wafer causes large current surge.

Radiation emitted in both forward ***and reverse*** directions as current rises.



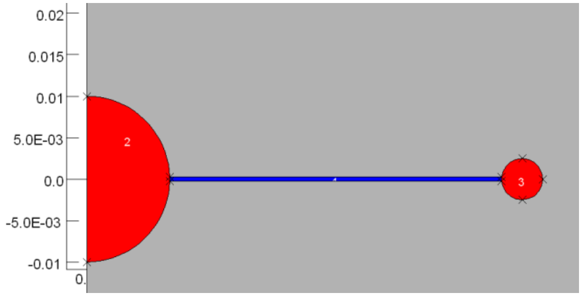
Opera 2D Electrostatic Modelling

Axi-symmetric model (R, z) used with the following variables:



1. Relative size of inner and outer electrodes.
2. Inner electrode grounded and outer electrode charge; or vice versa;

Nominal 30 kV chosen as operating voltage.
Electrodes metal, wafer characteristics as published data.

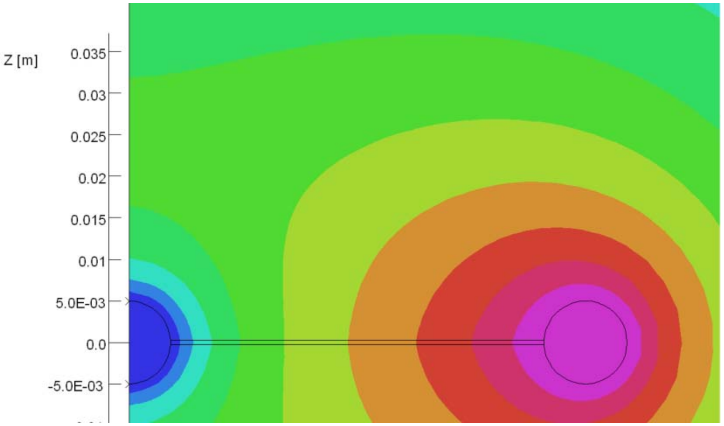


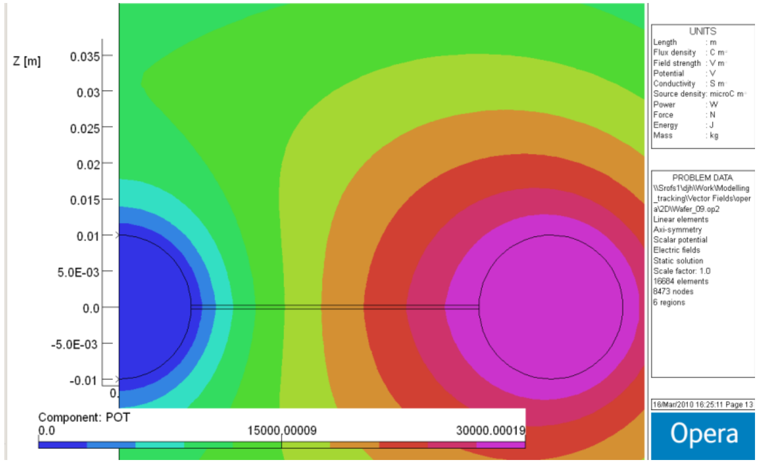
Optimisation Strategy

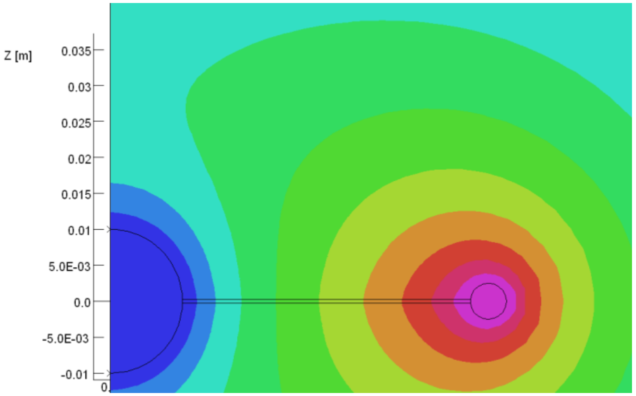
Assume electrical breakdown (i.e. before laser-induced current flows) limits the maximum voltage that can be applied between the electrodes.

Thus smooth electrodes chosen for centre and edge to minimise field emission triggering breakdown.

Aim to minimise the extremes of potential gradient (≡ field) to maximise voltage before breakdown.



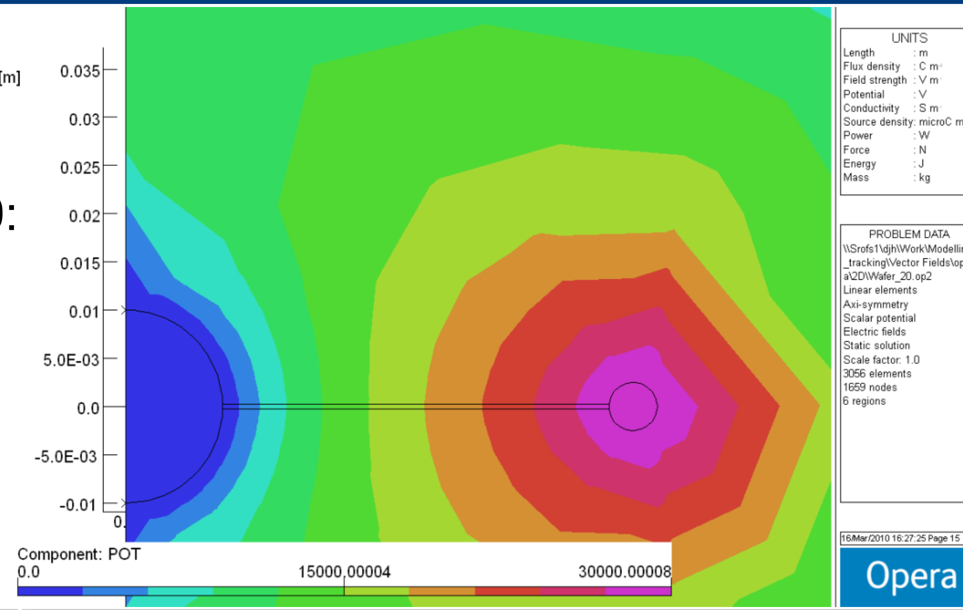


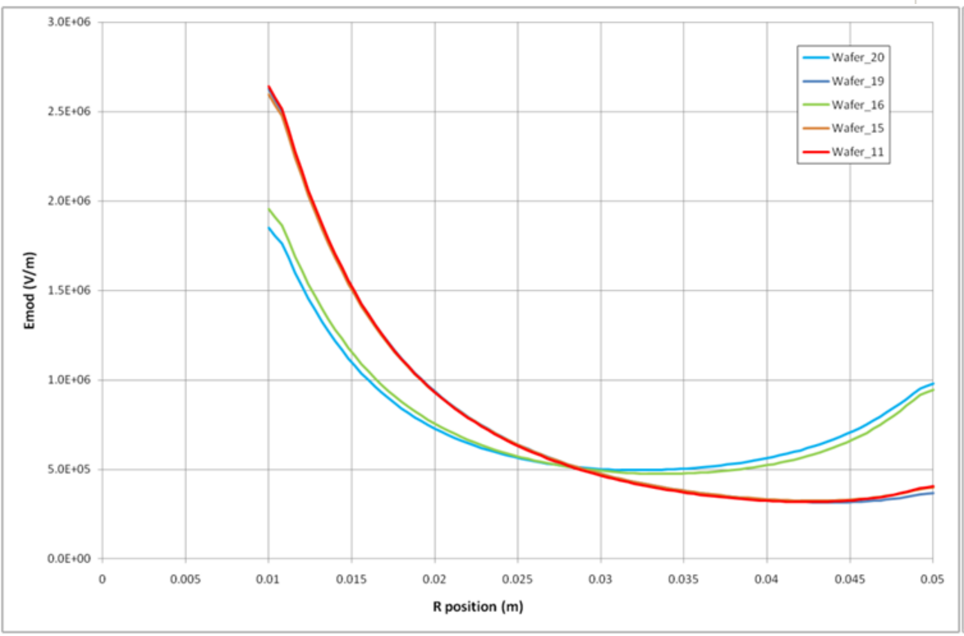


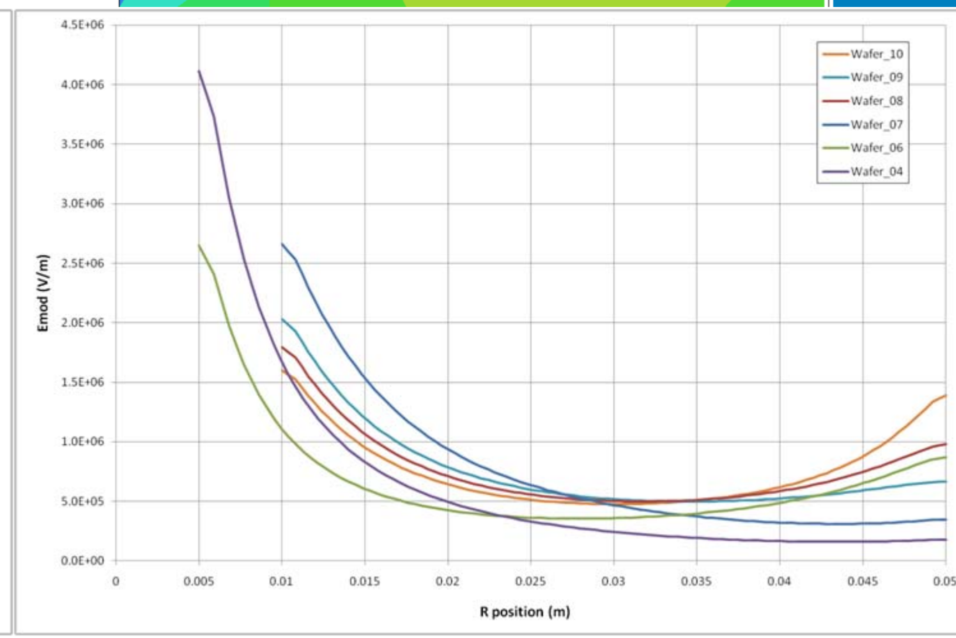
Results (E_{mod} vs. R)

Smallest E_{mod} (= $\sqrt{[E_R^2 + E_z^2]}$) with model #20:

- Centre electrode ∅ 20 mm, ground.
- Edge electrode ∅ 5 mm, high voltage.







Questions:

Is the optimisation strategy the right one?

Are the results valid?

Are the results useful?

Can this be manufactured?