SPIS 4.0
Multi physics modelling

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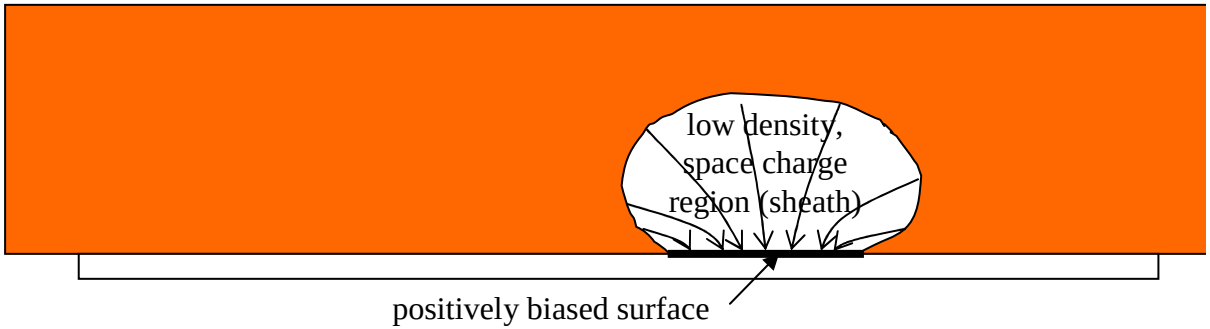
return on innovation

Outline

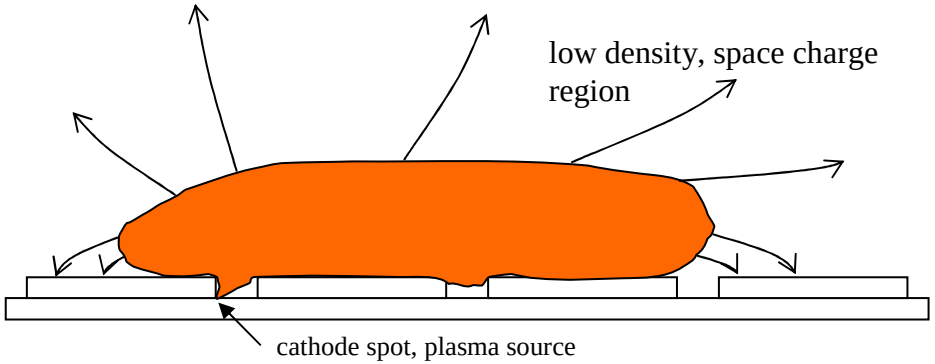
- Multiphysics modelling equirements
- Algorithm
- Test cases

Multi physics modelling requirement

- Typically simulate in a single simulation:
  - Dense quasi-neutral regions
  - Low density, space charge regions
- Examples:
  - Ambient plasma at rest / sheath:



  - Expanding plasma / fast electrons ahead of the plasma front (ESD):



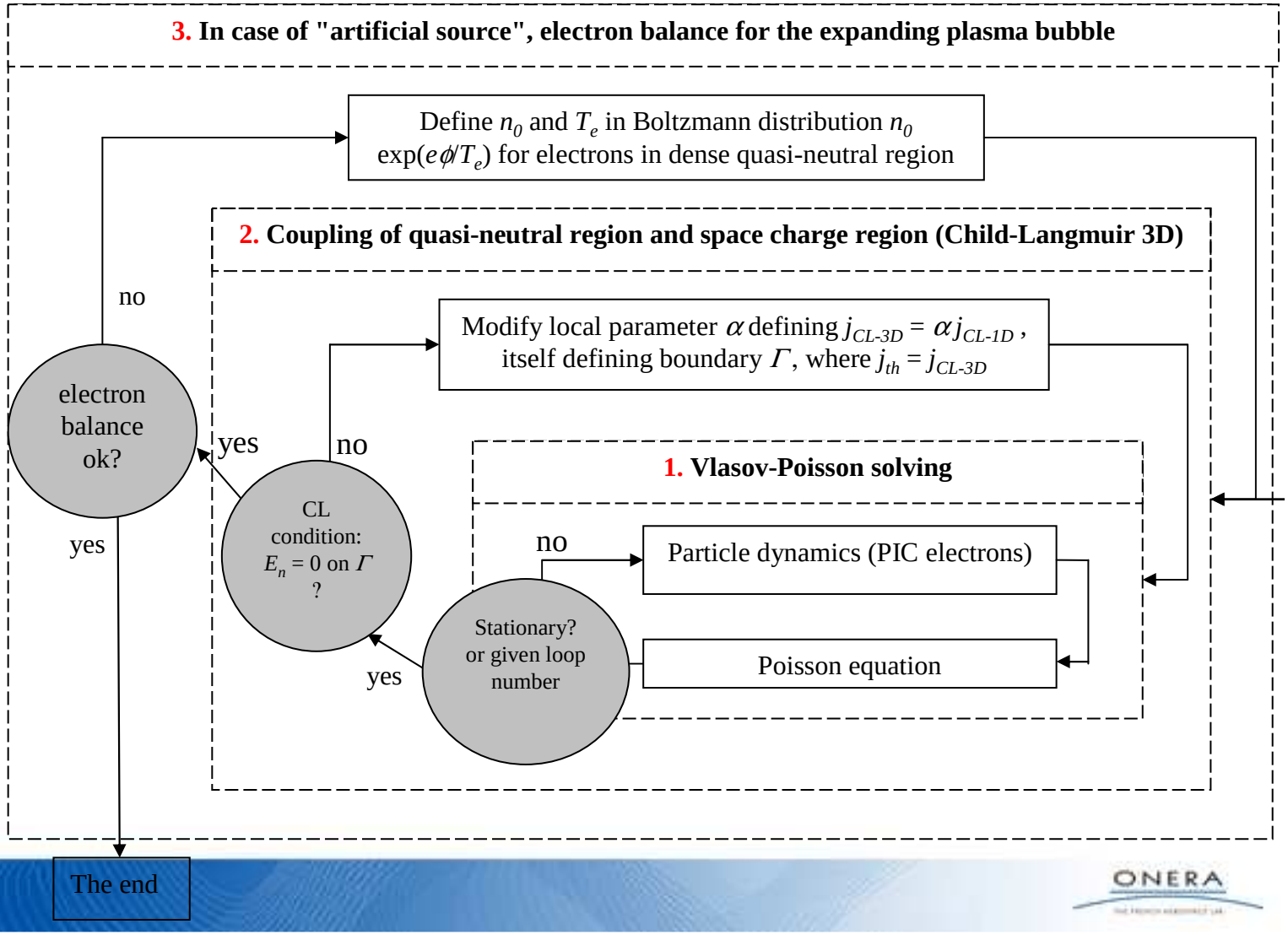
- Method:

multi-zone, interface handling

Algorithm

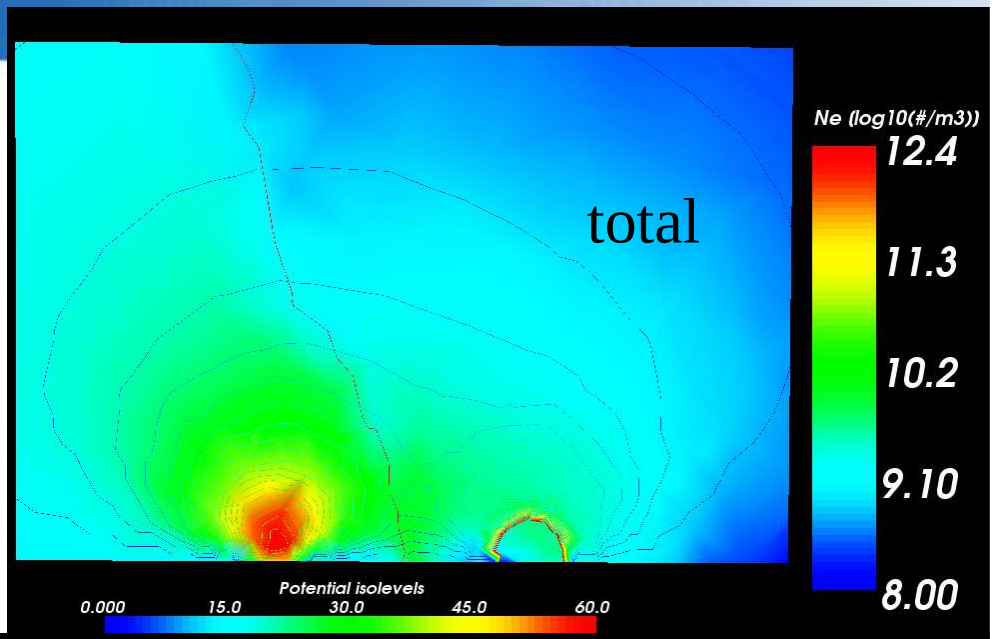
- Multi-physics solver design:

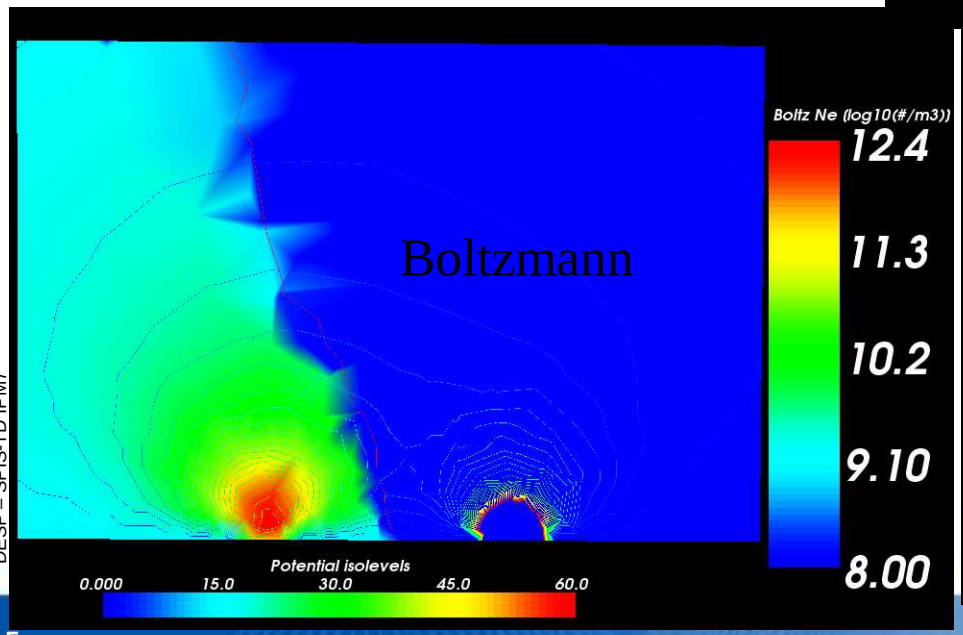
  - Loop 1 and 2 completed
  - Loop 3 implemented (including cathode spot), but still lacks stability

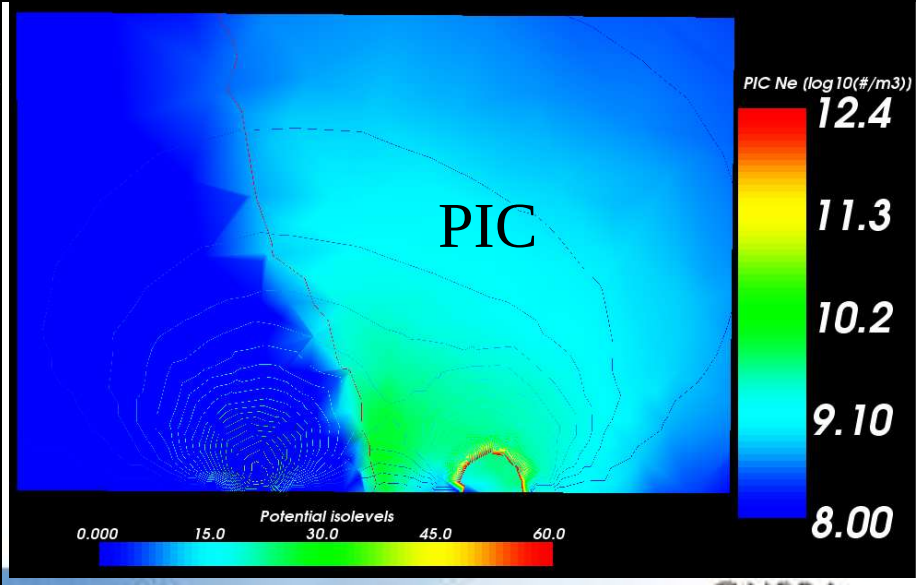


Test case 1 – bubble LD

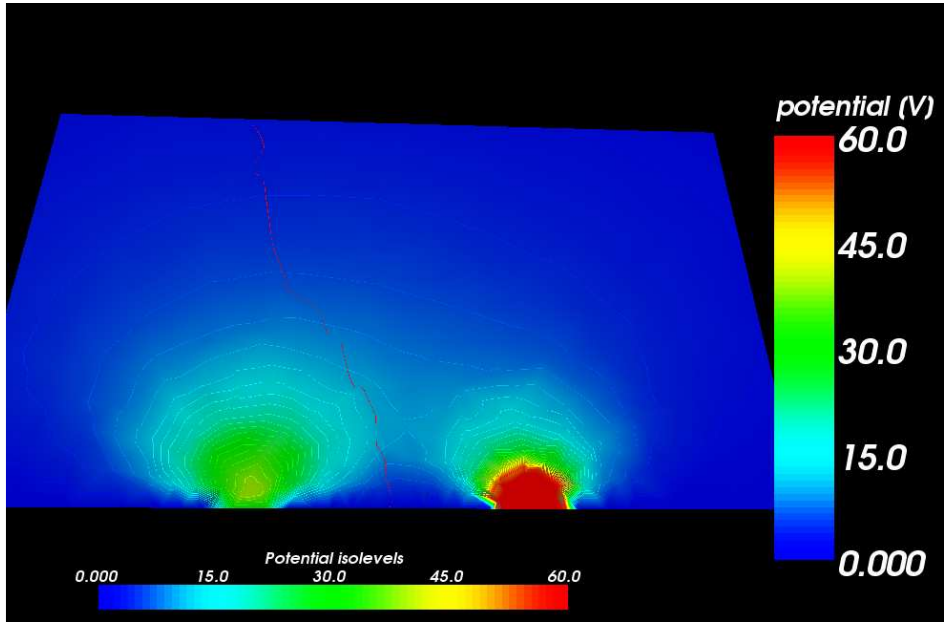
- Test case: plasma bubble expansion
- Electron density:
  - composed of Boltzmann electrons in dense ion zone (quasi neutral)
  - and PIC electrons in low density zone (non neutral)

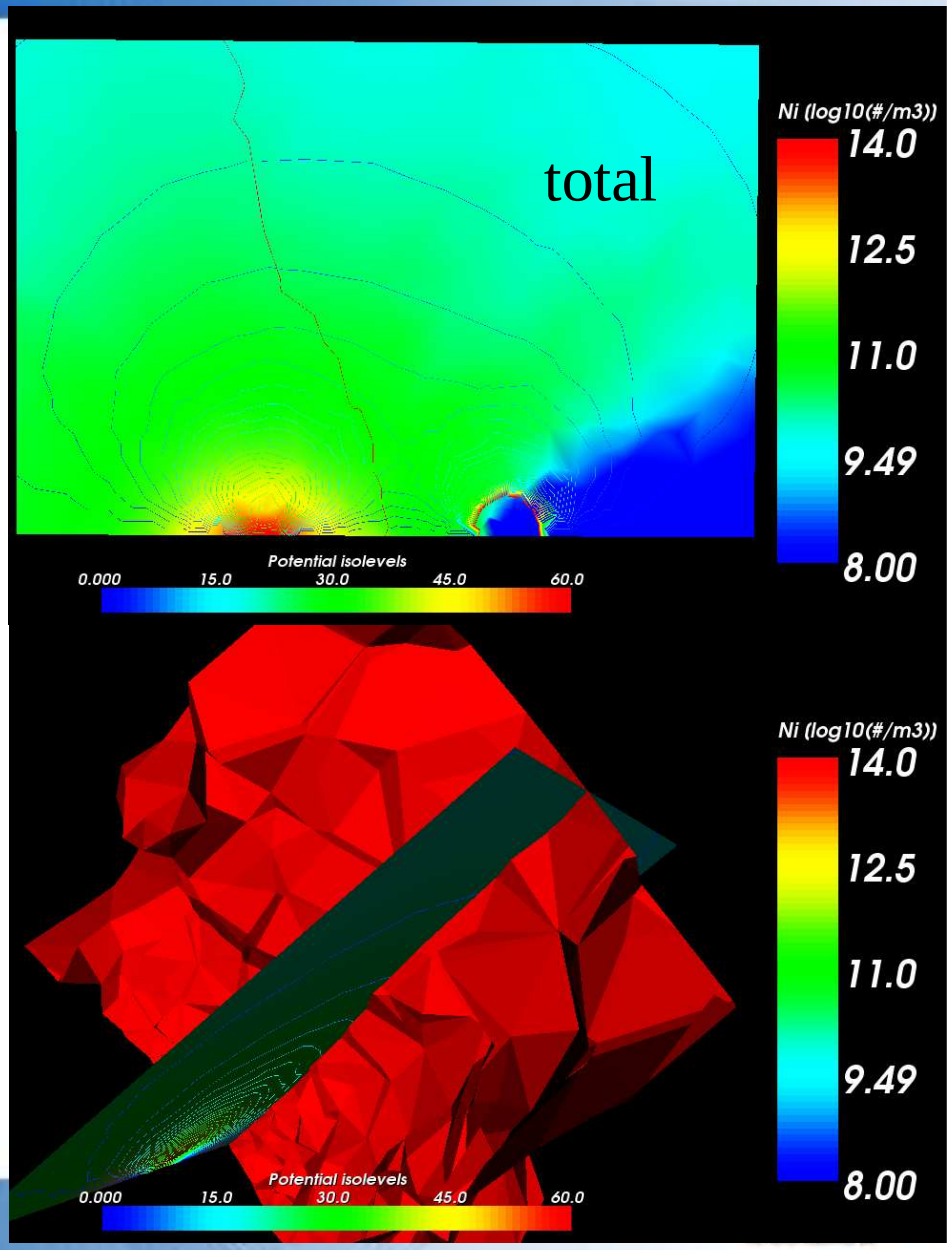






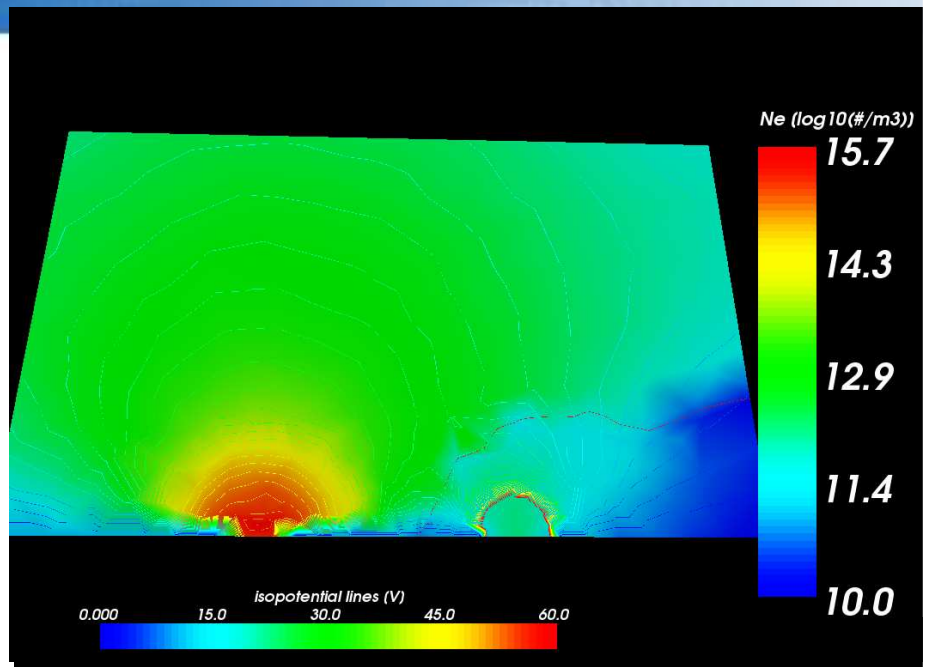
Test case 1 – bubble LD

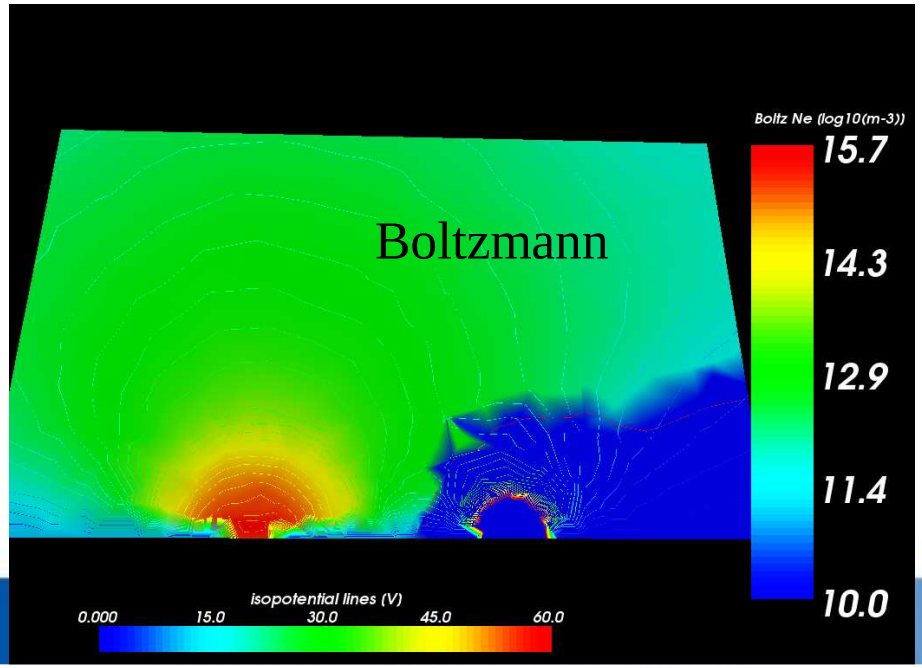


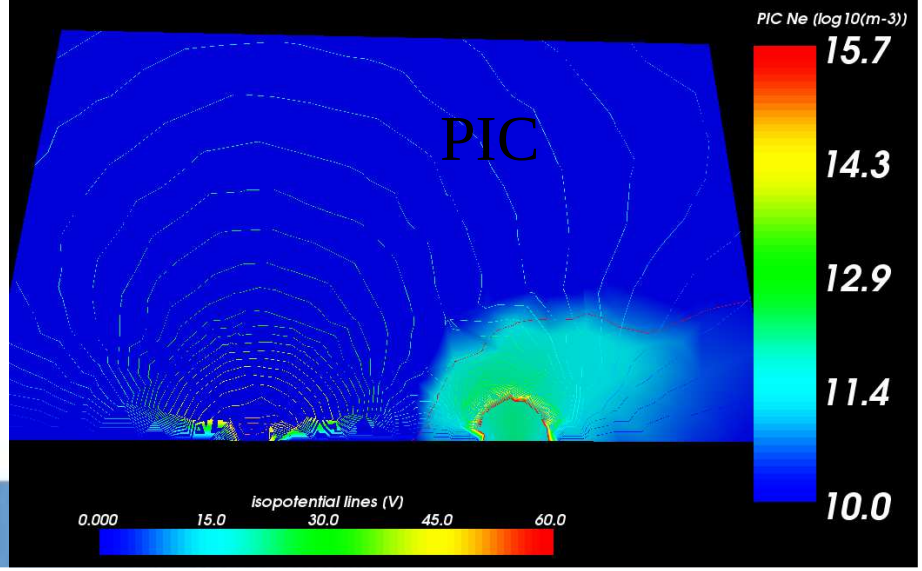


Test case 2 – bubble HD

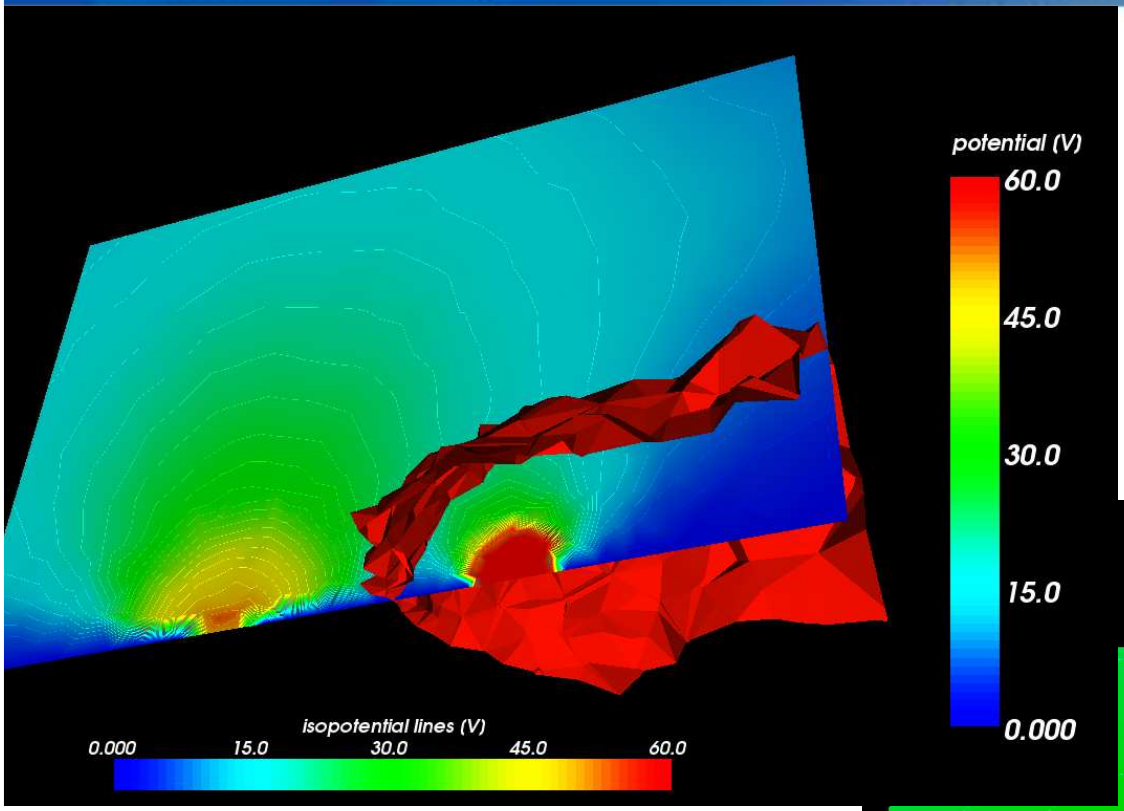
- Test case2: plasma bubble expansion
- Higher electron density (x 100)

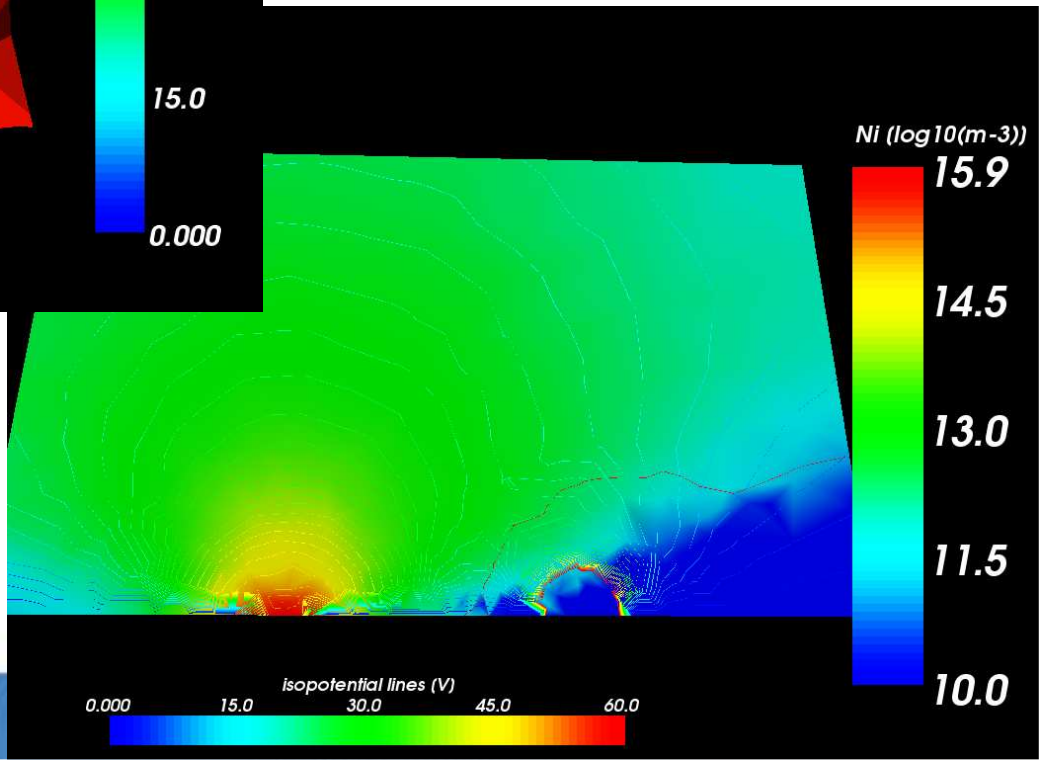




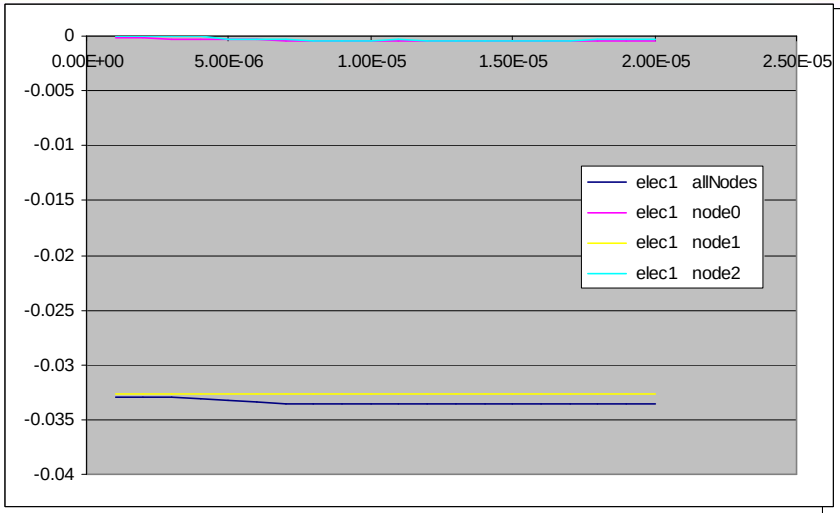


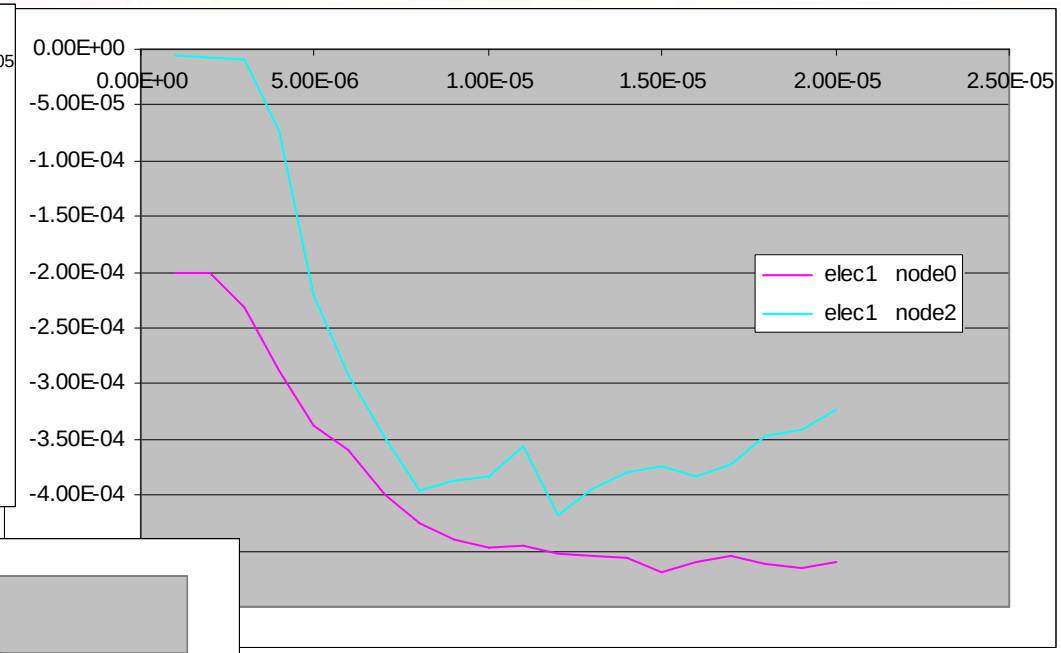
Test case 2 – bubble HD

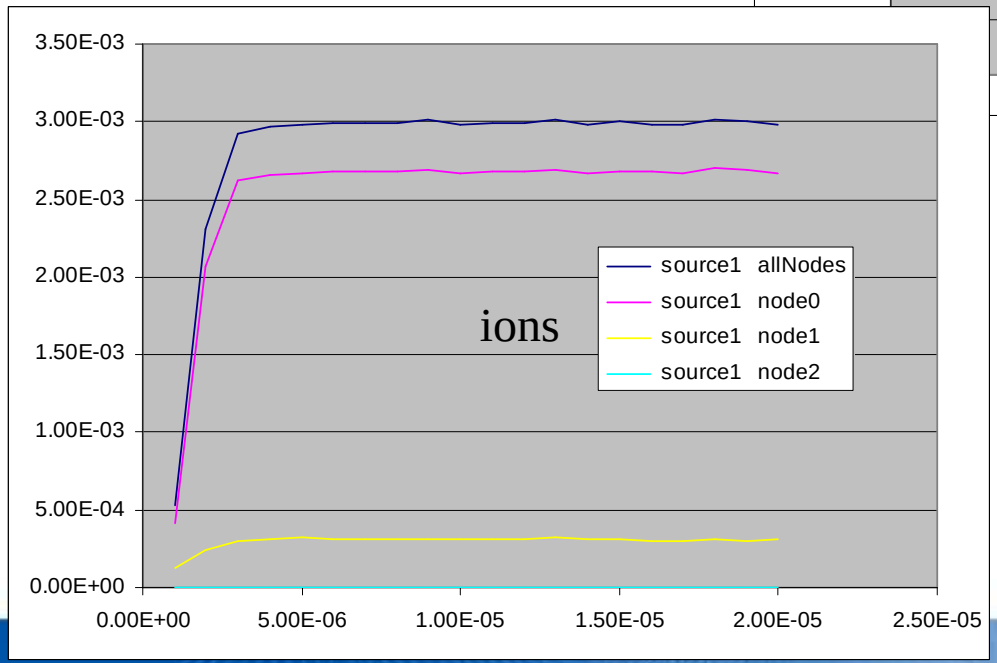




Test case 2 – bubble HD, collected currents

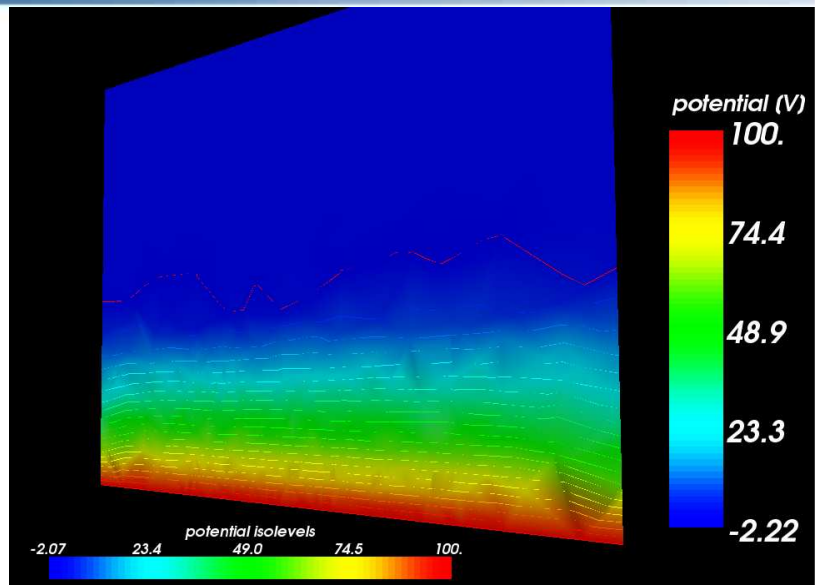


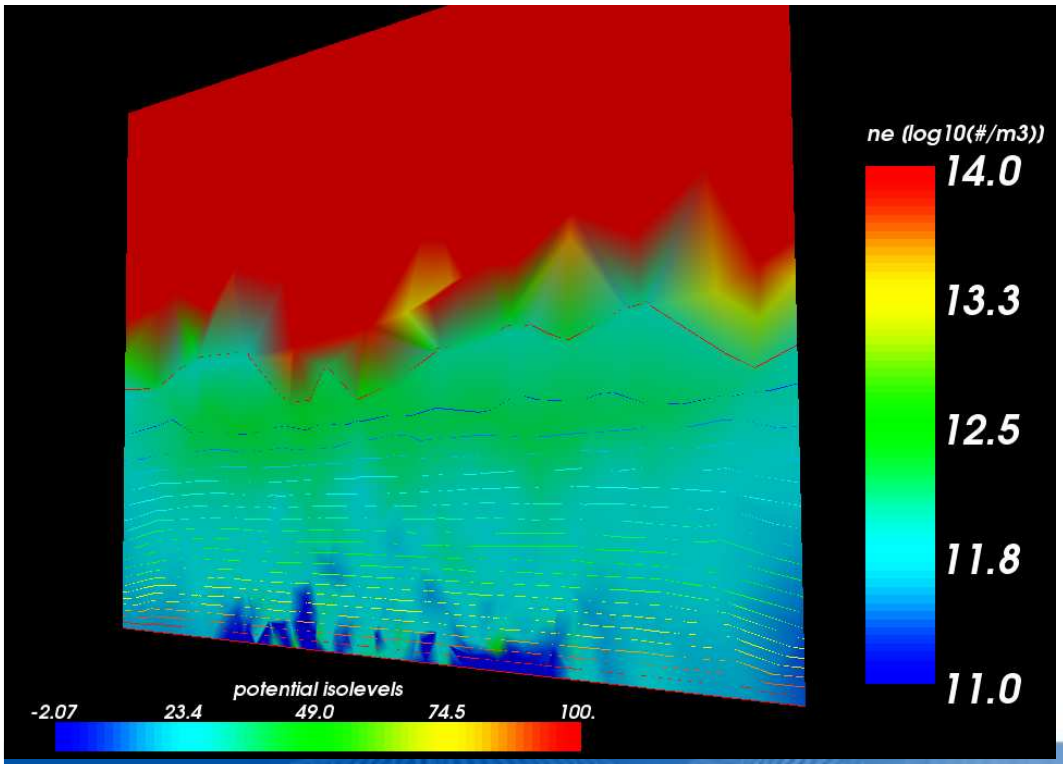


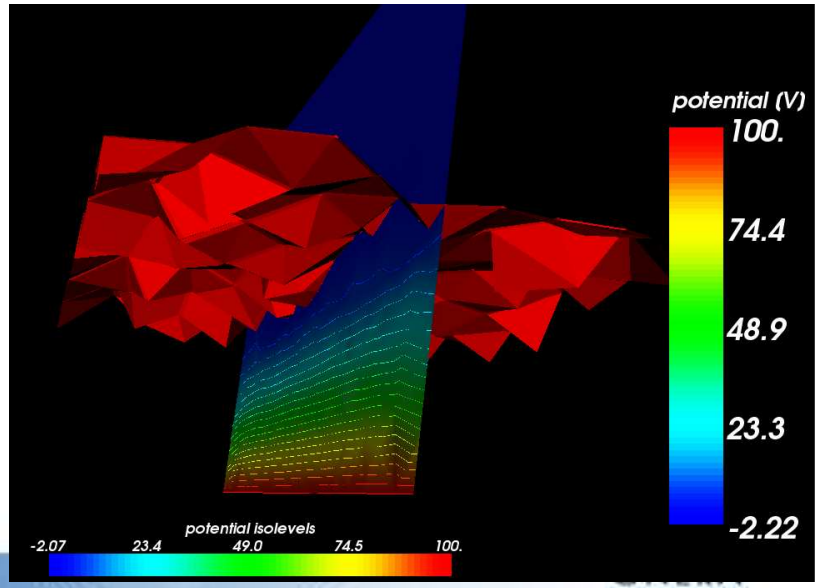


- Node 0 = large surface
- Node 1 = first electrode (plasma source)
- Node 2 = second electrode (+ 300V)

Test case 3 – Child-Langmuir test case







A few details of algorithm tuning

- Two examples of instabilities discovered and solved:
  - Sheath instability (Bohm-like) in case of positive space charge in the space charge zone: stability if $(l_i / d)\ (e\phi_s/kTe) < 1$
  - Bi-stable behaviour: either in the PIC zone with lower electron density hence lower emission at boundary (nearby influence) or in Boltzmann with higher density