

## SPIS4 Sphere validation

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**ESTEC**

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# Introduction

- New features of SPIS must be shown to be validated
- A simple sphere case was performed before:
  - ‘Modelling of Plasma Probe Interactions With a PIC Code Using an Unstructured Mesh’, A. Hilgers, S. Clucas, B. Thiébault, J.-F. Roussel, J.-C. Matéo-Vélez, J. Forest, and D. Rodgers
- We revisited this case for SPISv4
  - 64-bit java virtual machine
  - BacktrackingPICCompositeVoIDistrib



# PARAMETERS FOR THE TEST

| Quantity                  | Symbol    | Value                 |
|---------------------------|-----------|-----------------------|
| Temperature               | T         | 1.0 eV                |
| Electron density          | n         | $10^7 \text{ m}^{-3}$ |
| Debye length              | $\lambda$ | 2.35 m                |
| Potential                 | $\varphi$ | [0,12]V               |
| Sphere radius             | r         | 0.25 m                |
| Number of tetrahedrons    |           | 24000                 |
| Simulation box diameter   |           | 20 m                  |
| Number of macro-particles |           | ~100,000              |

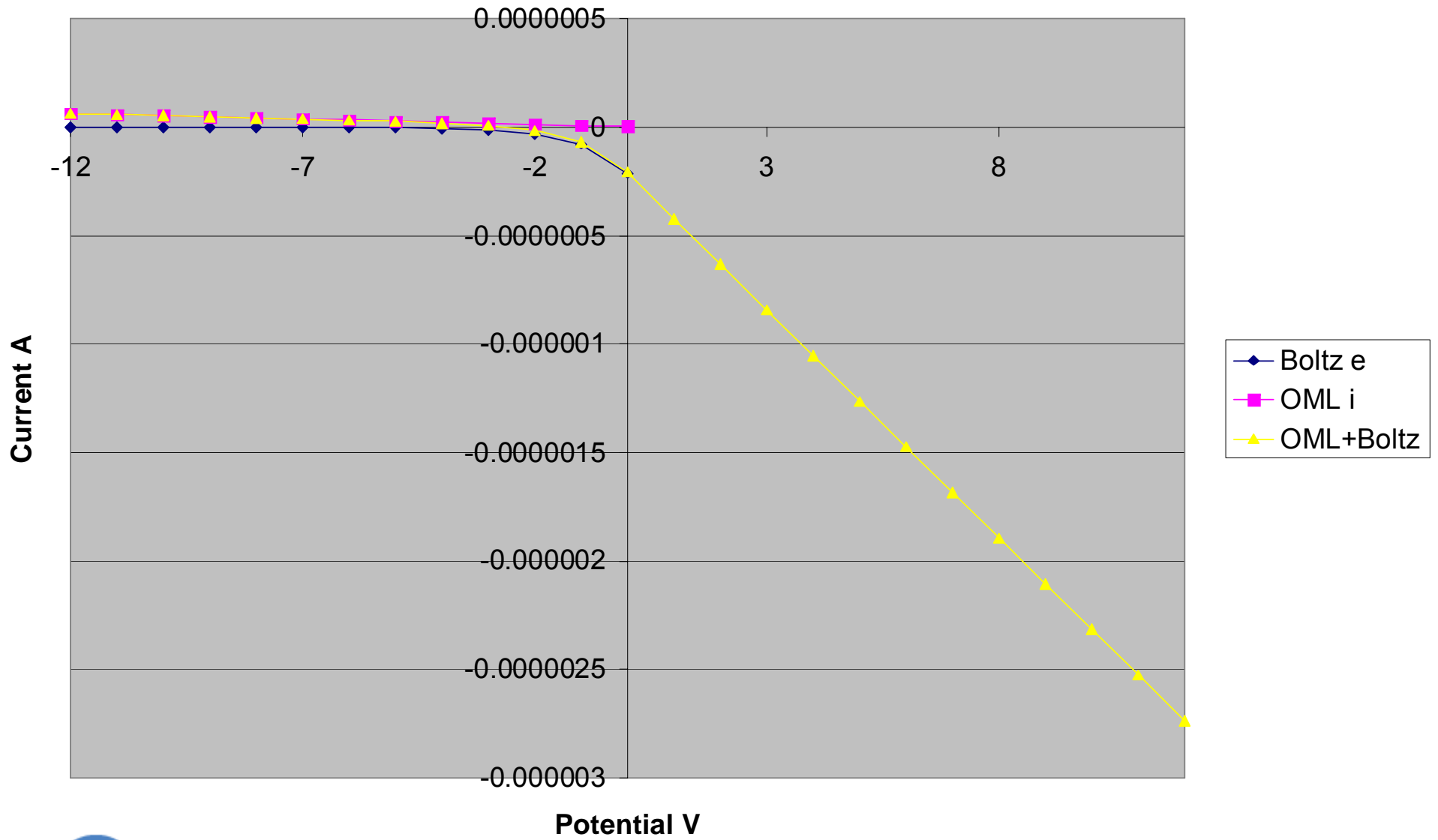
# Langmuir probe equations

OML – current of attracted species  
(valid for thick sheaths)

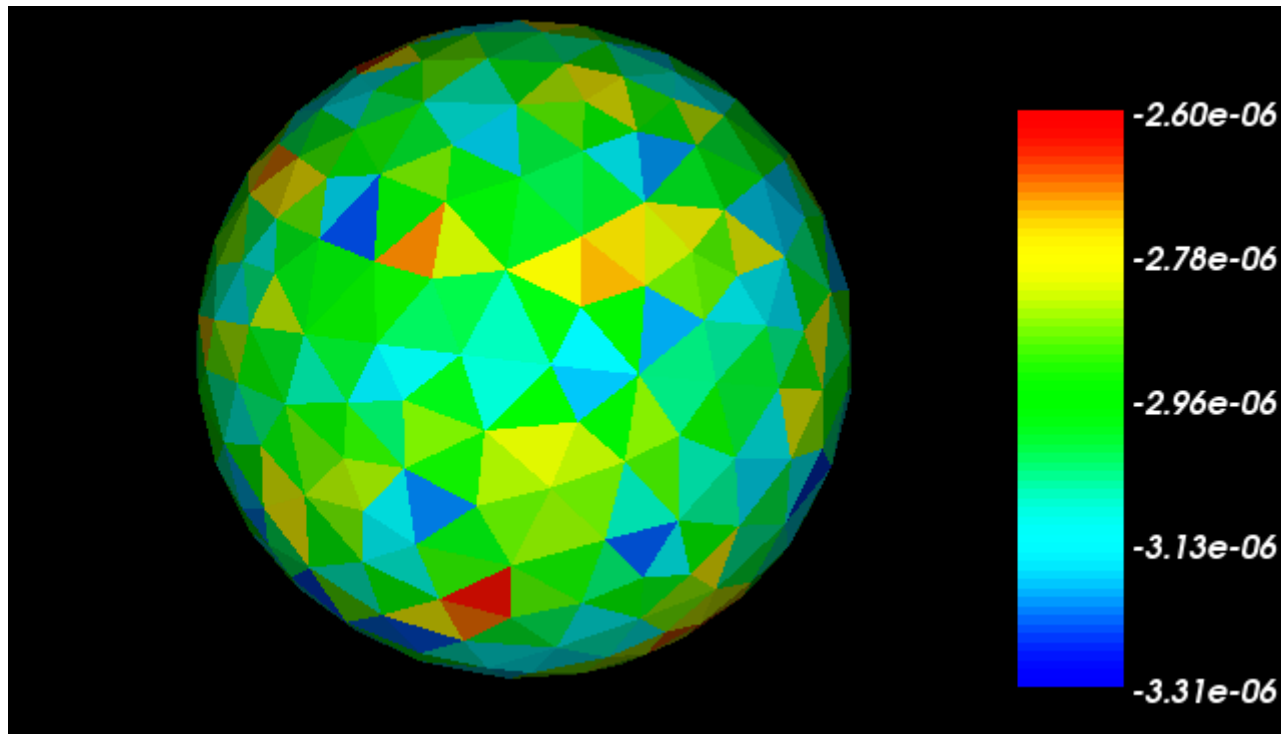
$$I = 4\pi qn \sqrt{\frac{kT}{2\pi m}} \left(1 + \frac{q\phi}{kT}\right) r^2$$

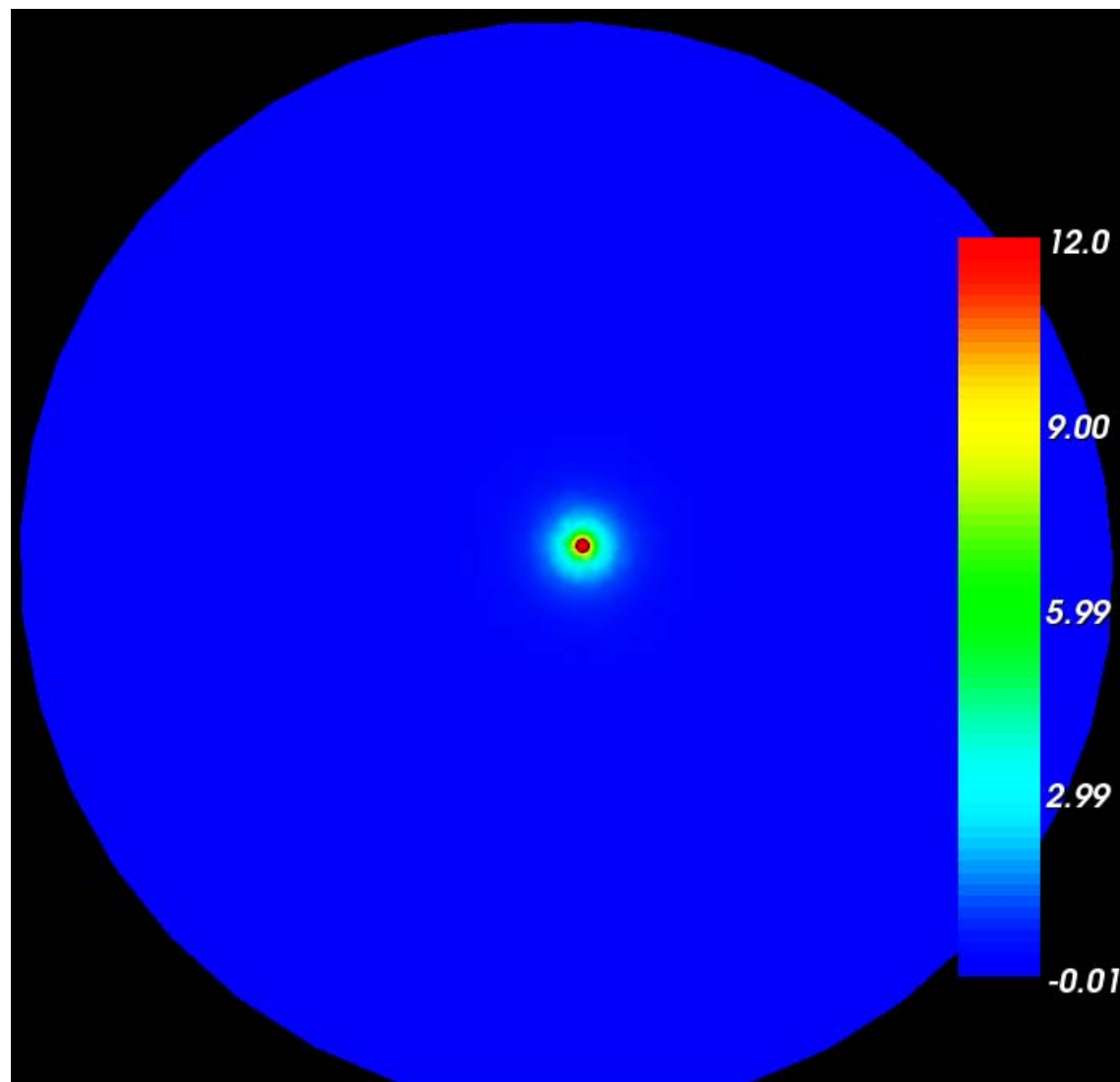
Boltzmann – current of repelled species

$$I = 4\pi qn \sqrt{\frac{kT}{2\pi m}} \exp\left(\frac{-q\phi}{kT}\right) r^2$$

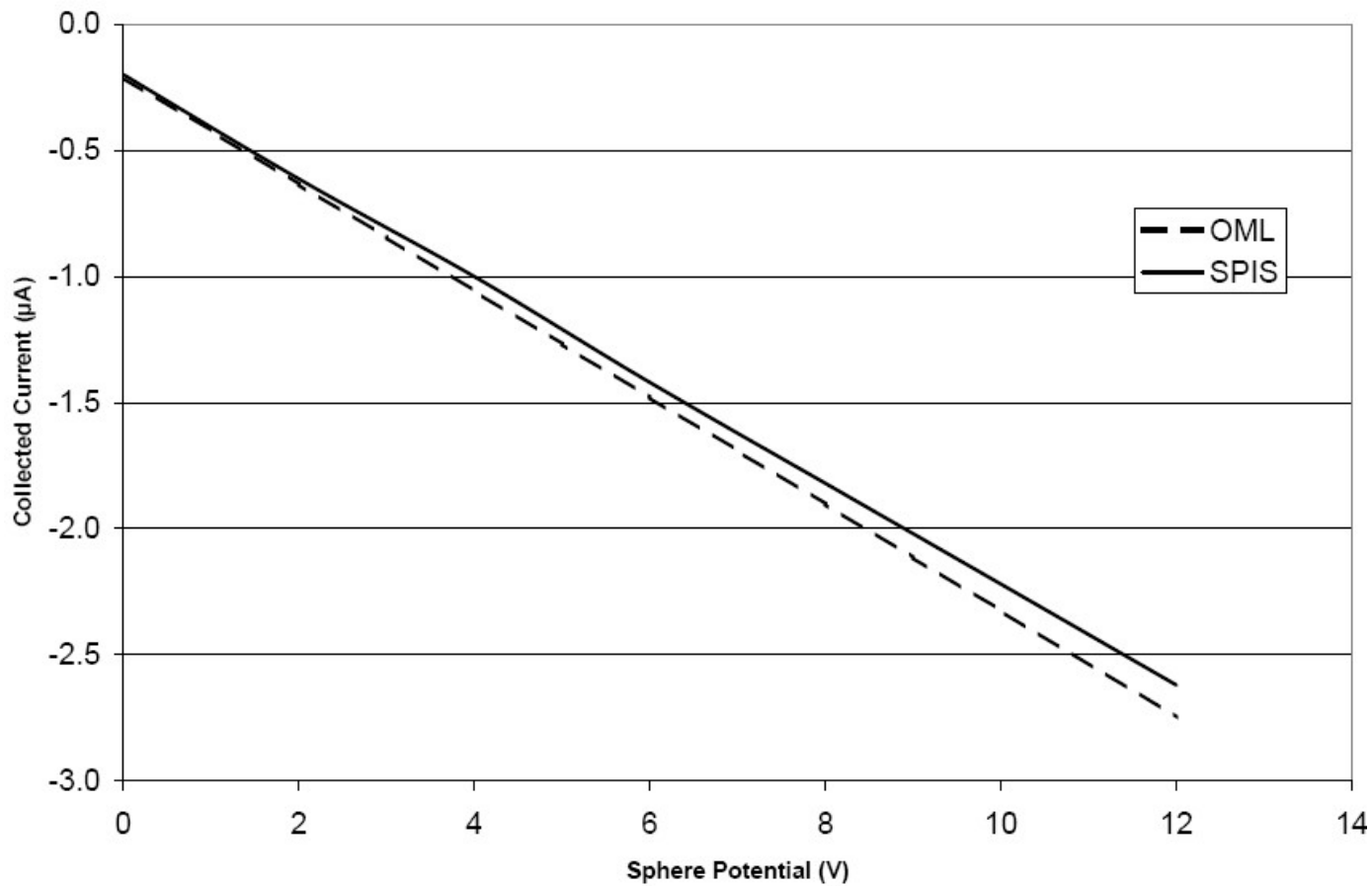


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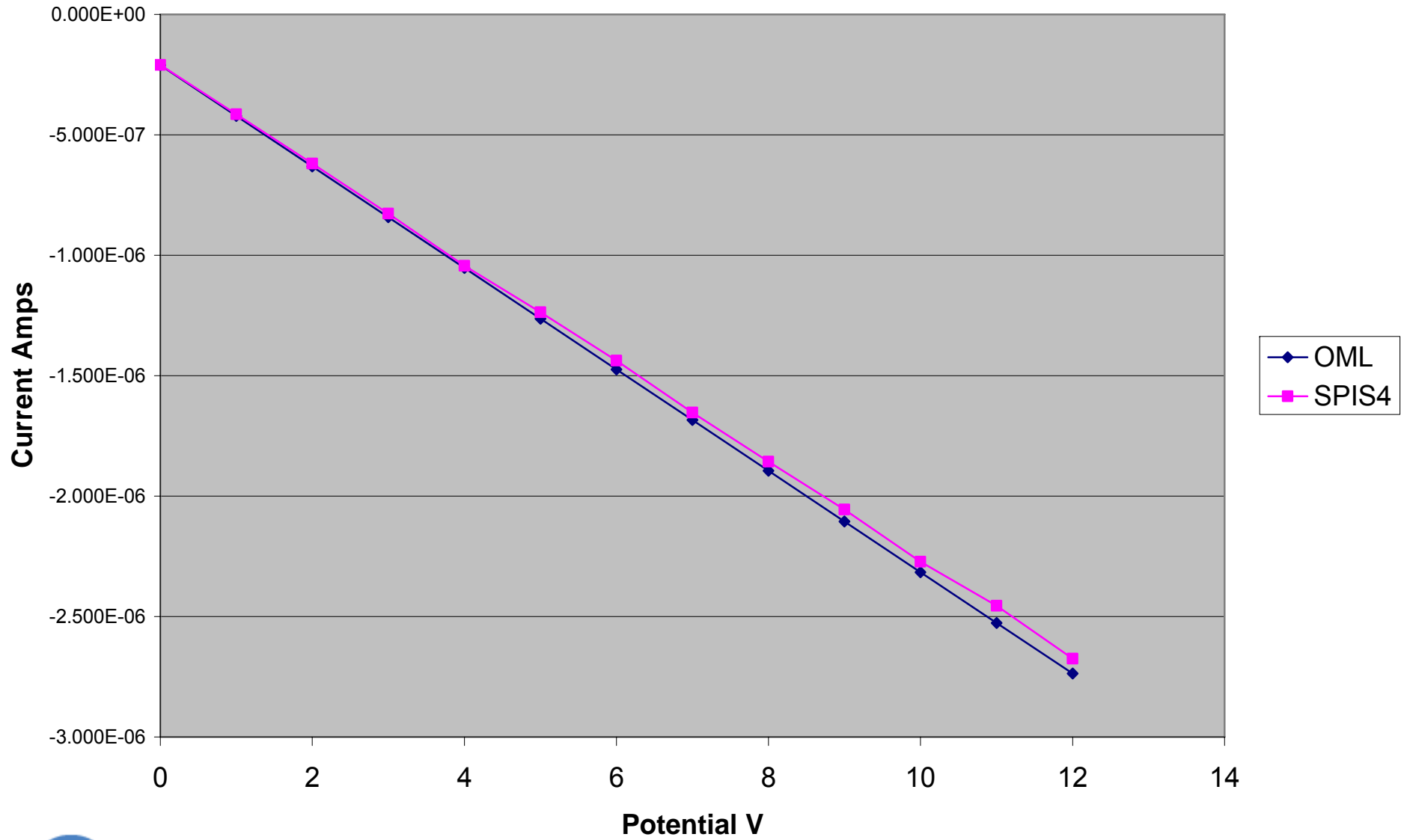




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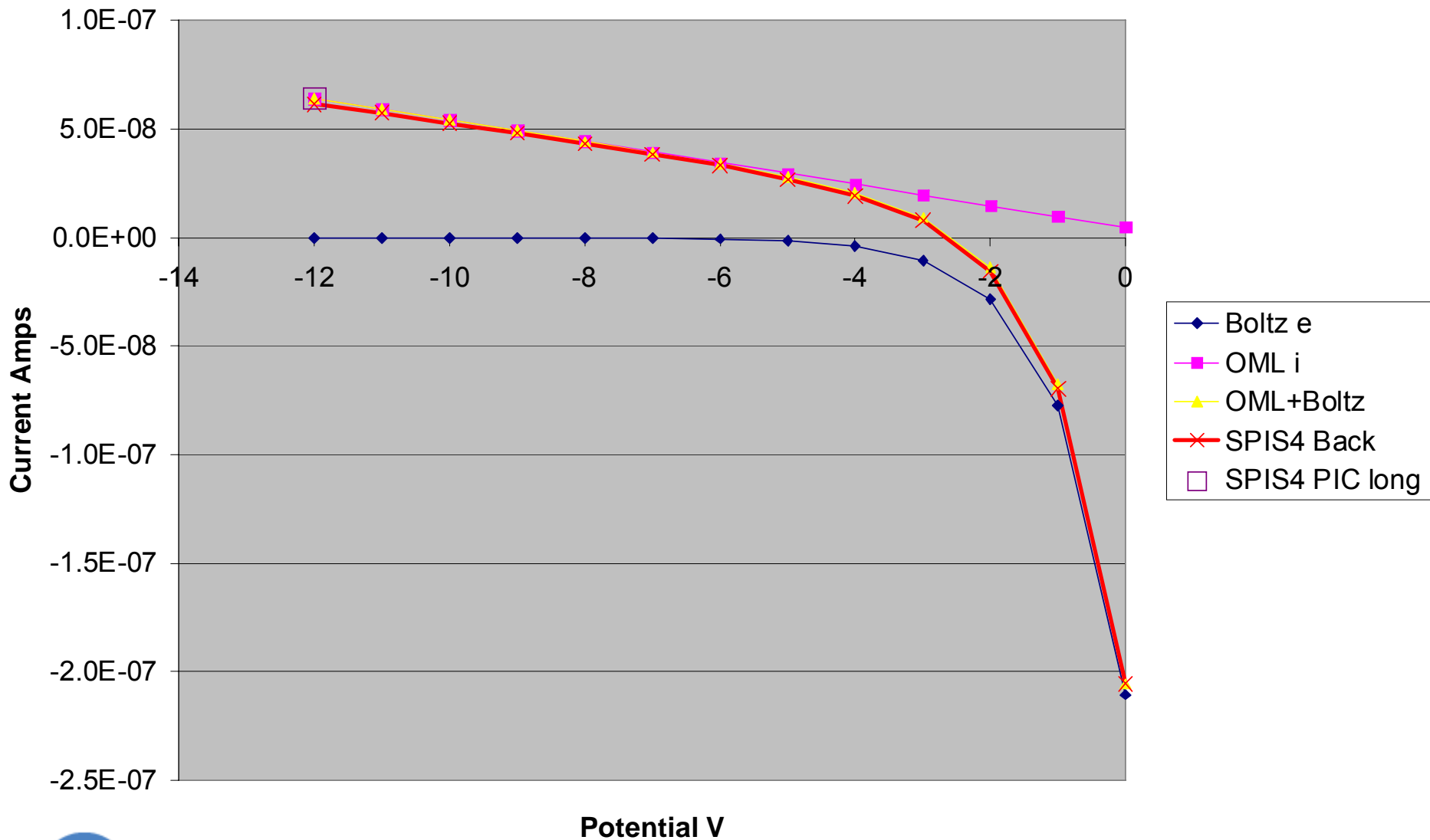




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# Errors

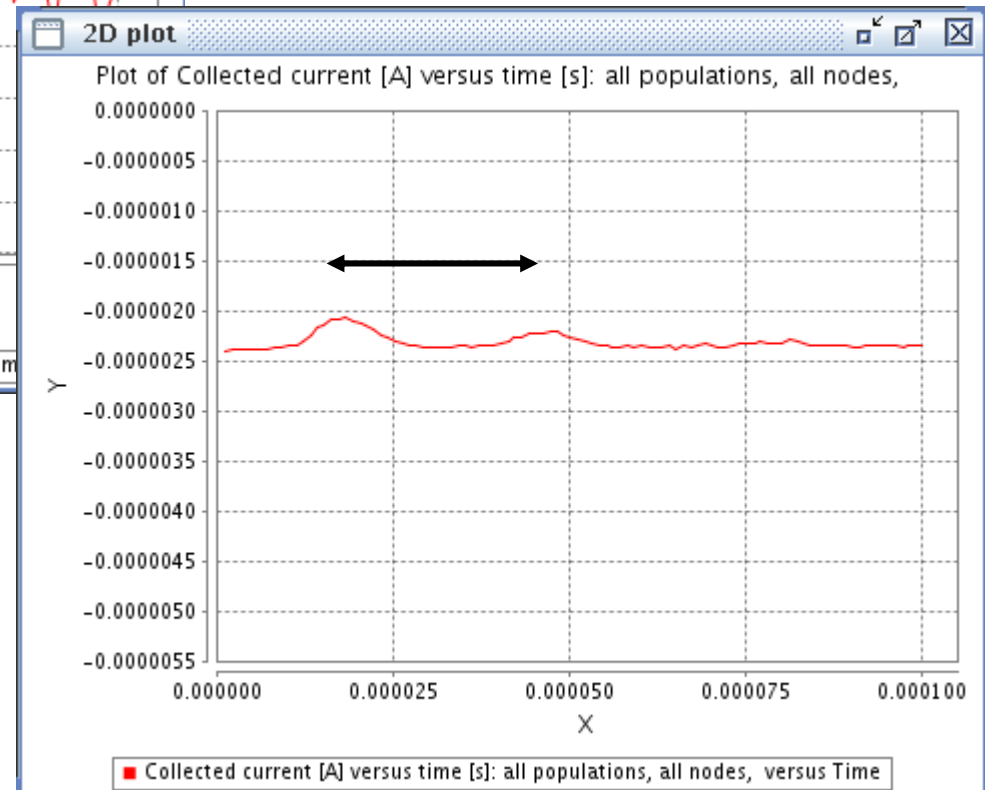
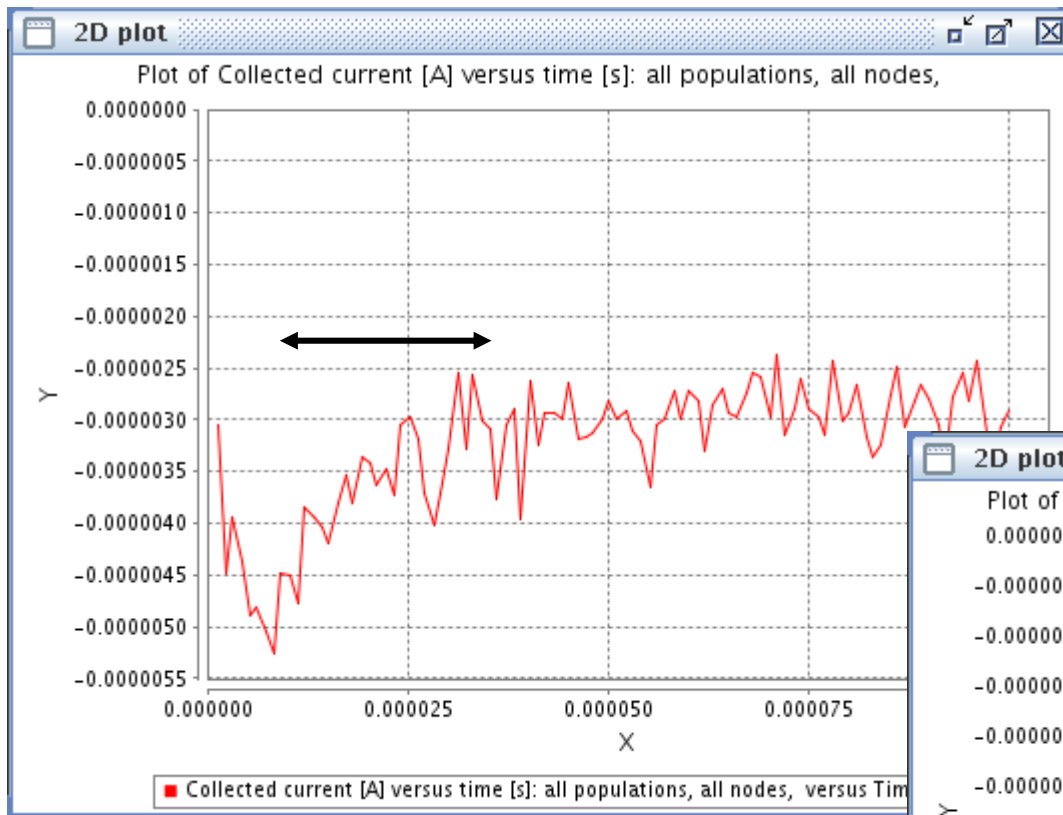
| V  | SPIS3% | SPIS4 Backtracking% |
|----|--------|---------------------|
| 0  | -3.49  | -0.31               |
| 2  | -3.33  | -1.88               |
| 4  | -5.38  | -0.83               |
| 6  | -4.03  | -2.50               |
| 8  | -4.33  | -2.00               |
| 10 | -4.52  | -1.89               |
| 12 | -4.65  | -2.28               |



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# Errors

| V   | SPIS4 Backtracking% |
|-----|---------------------|
| 0   | 0.31                |
| -1  | 3.02                |
| -2  | 13.7                |
| -3  | 13.0                |
| -4  | 7.49                |
| -5  | 4.57                |
| -6  | 2.43                |
| -8  | 1.93                |
| -10 | 3.60                |
| -12 | 4.19                |



# Conclusion

- Backtracking electron currents show good agreement with OML
- Results are improvement on PIC method
- Both electron and ions currents have been validated
- Results are quasi-steady state solutions, even when the simulation has not converged
  - Good if seeking steady state solution
  - Caution required if seeking dynamic behaviour



THE END



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