

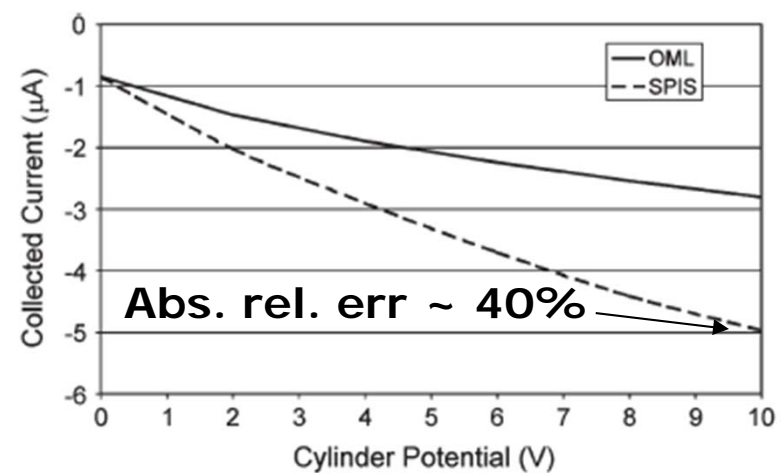
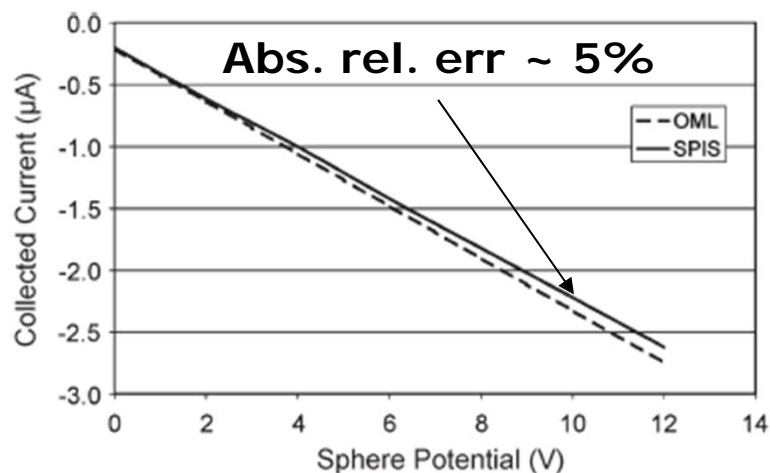
# Probe Current Collection Simulations for SPI S Validation

Christian Hanberg  
Young Graduate Trainee - ESTEC  
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# Background



- Validation of SPIS against analytical theories (OML)
  - Previous work carried out by Hilgers et al. (2008)



- Symmetry plane feature in SPIS 4.3.1
  - Possibility to mimic infinite cylinder
  - Reduced simulation time

# Plasma and simulation parameters



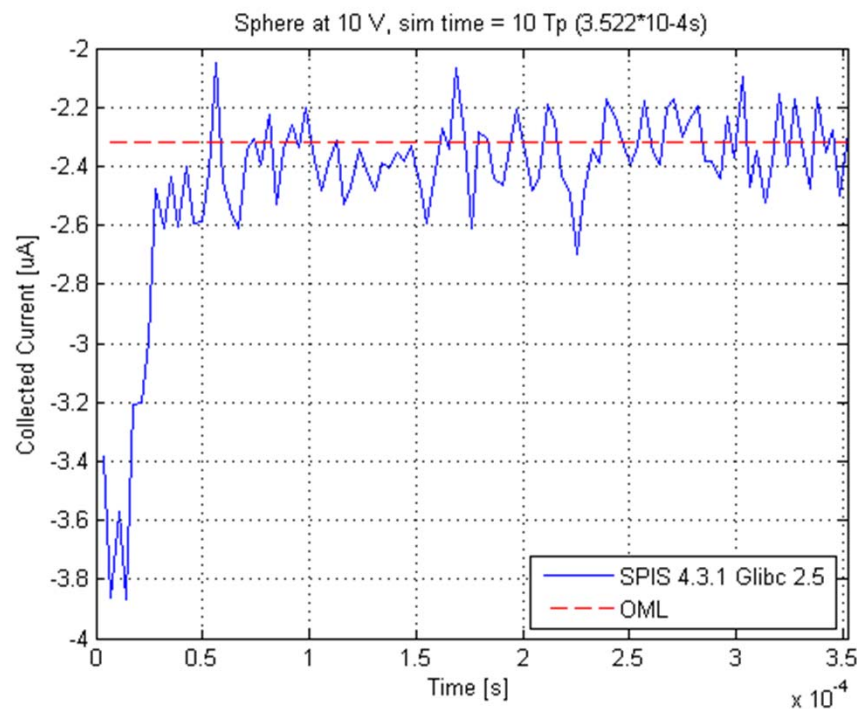
Quantity	Value	Unit
Temperature	1.0	eV
Electron & Ion density	$10^7$	$\text{m}^{-3}$
Debye length	$\sim 2.35$	m
Potential	10.0	V
Sphere radius	0.25	m
Cylinder radius	0.26	m
Cylinder length	2	m
Simulation box radius	20.0	m
Particles per cell	10	
Mesh size on probes	0.025	m

- Full Particles-In-Cell (PIC) mode
- Radius of sphere and cylinder  $\ll \lambda_D \Rightarrow$  OML regime
- Maxwellian plasma corresponding to plasma regime in the outermost layers of Earth's plasma sphere

# Simulation times in SPIS – Full sphere

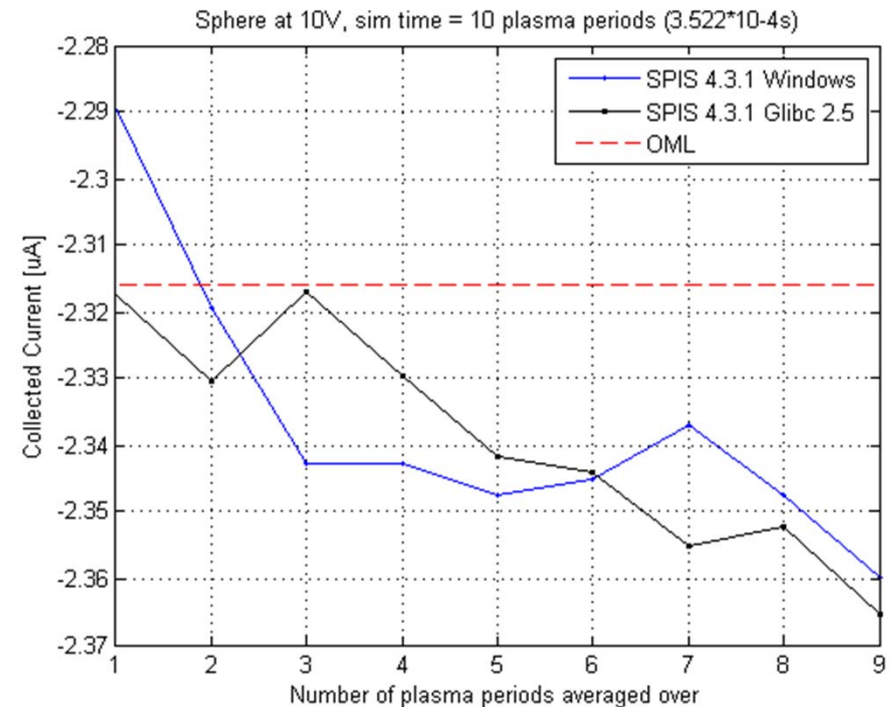


- Simulation time set to 10  $T_p$  (0.3522 ms)



- Transitory regime effects

- Averaging over the last  $T_p$  to the last 9  $T_p$

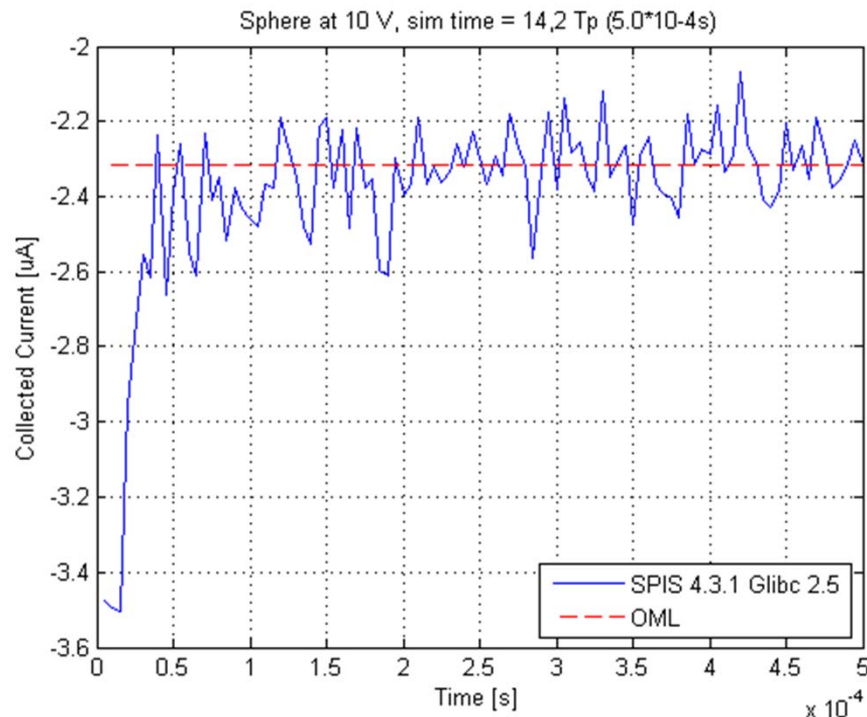


- $|CC_{OML}| < |CC_{SPIS}|$
- Opposite expected

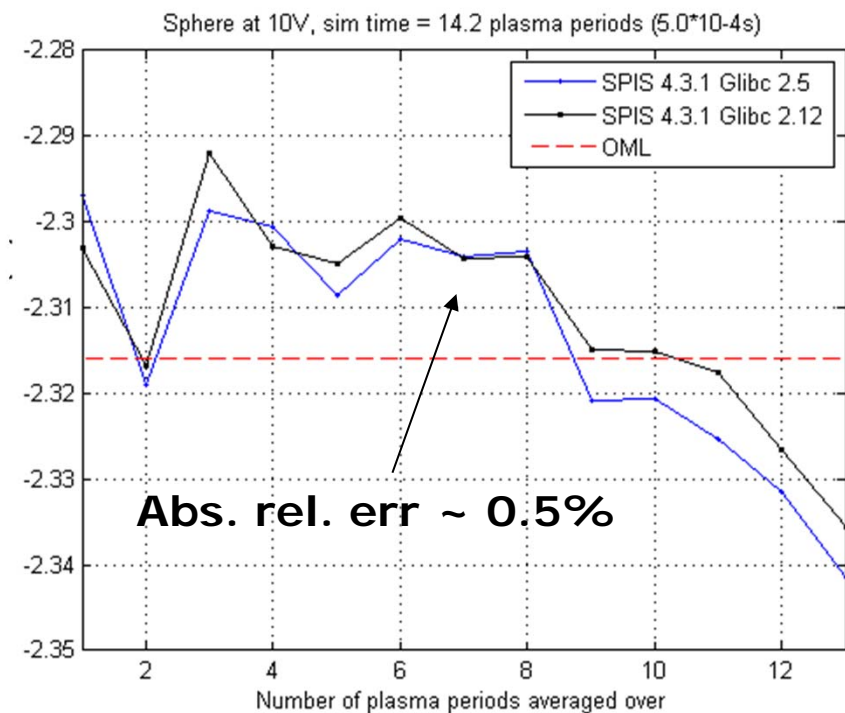
# Simulation times in SPIS – Full sphere



- Simulation time set to  $\sim 14.2$   $T_p$  (0.5 ms)



- Averaging over the last  $T_p$  to the last 13  $T_p$

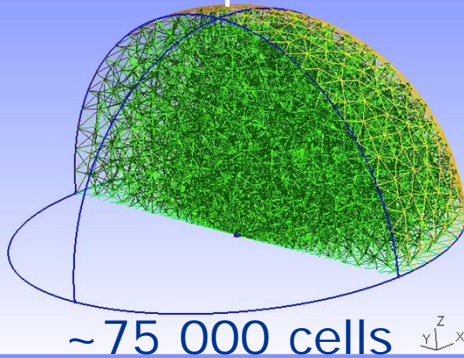


- OML theory assumptions  $\Rightarrow |CC_{OML}| > |CC_{SPIS}|$
- 14.2  $T_p$  results better than Hilgers et al. (2008) – 5 % abs. rel. err.

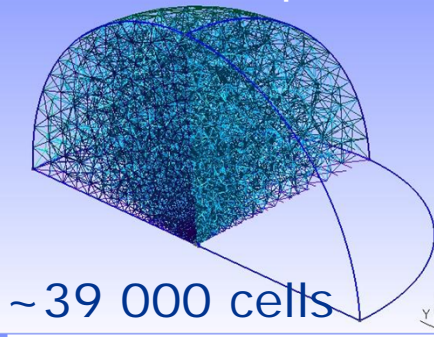
# Symmetry plane geometries



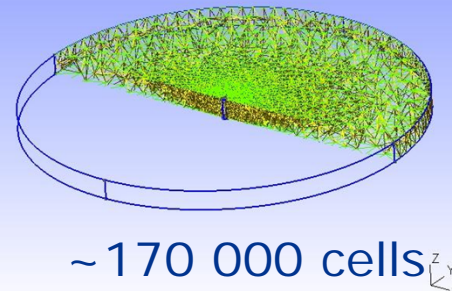
Hemisphere



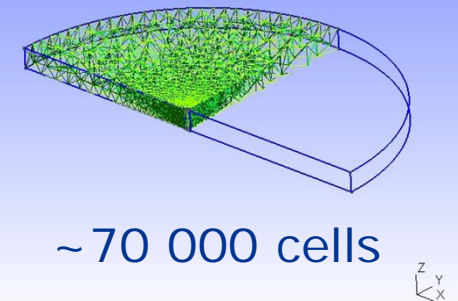
Half Hemisphere



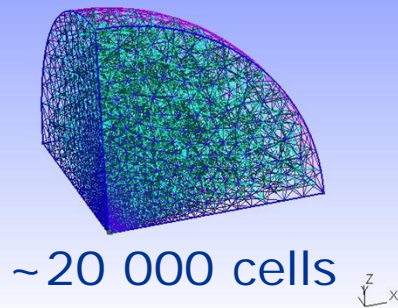
Full Cylinder



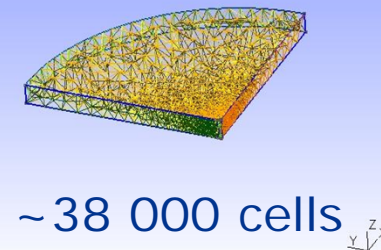
Half Cylinder



Quarter Hemisphere

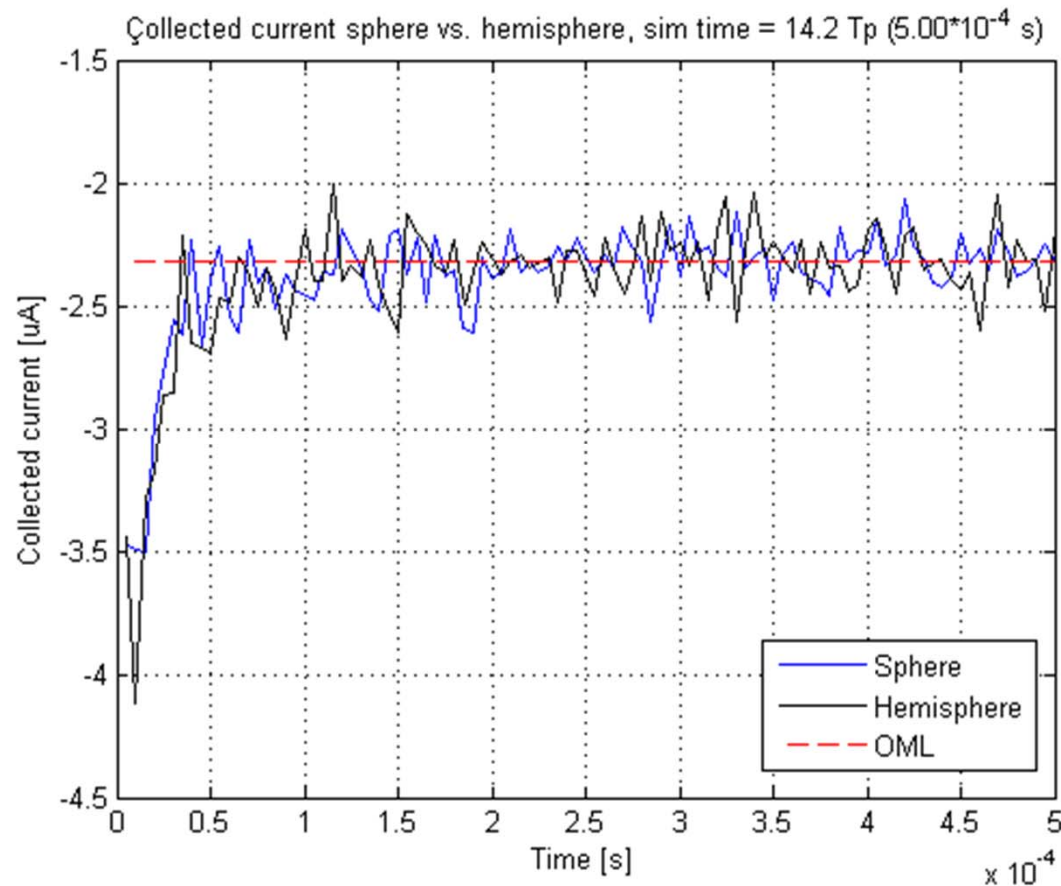


Quarter Cylinder



- Full sphere has ~100 000 cells (not visible)

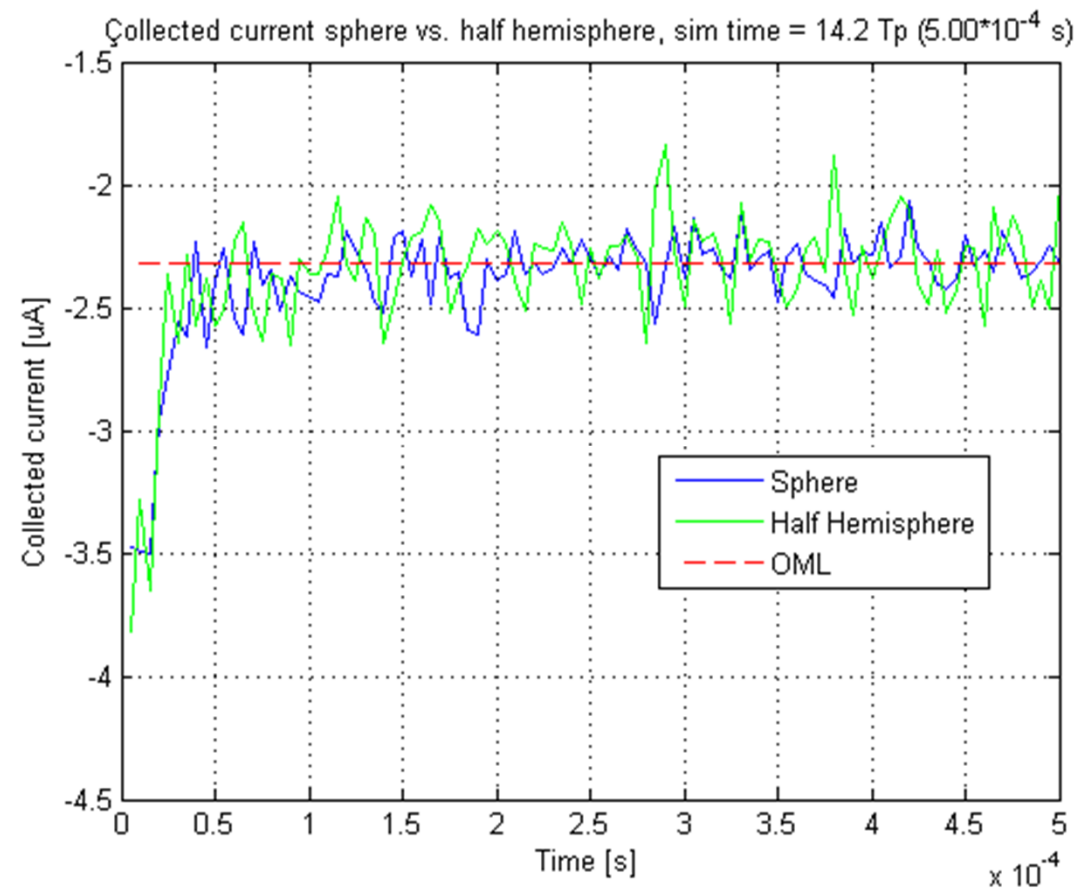
# Collected current – sphere vs. hemisphere



- Symmetry plane case oscillates slightly more



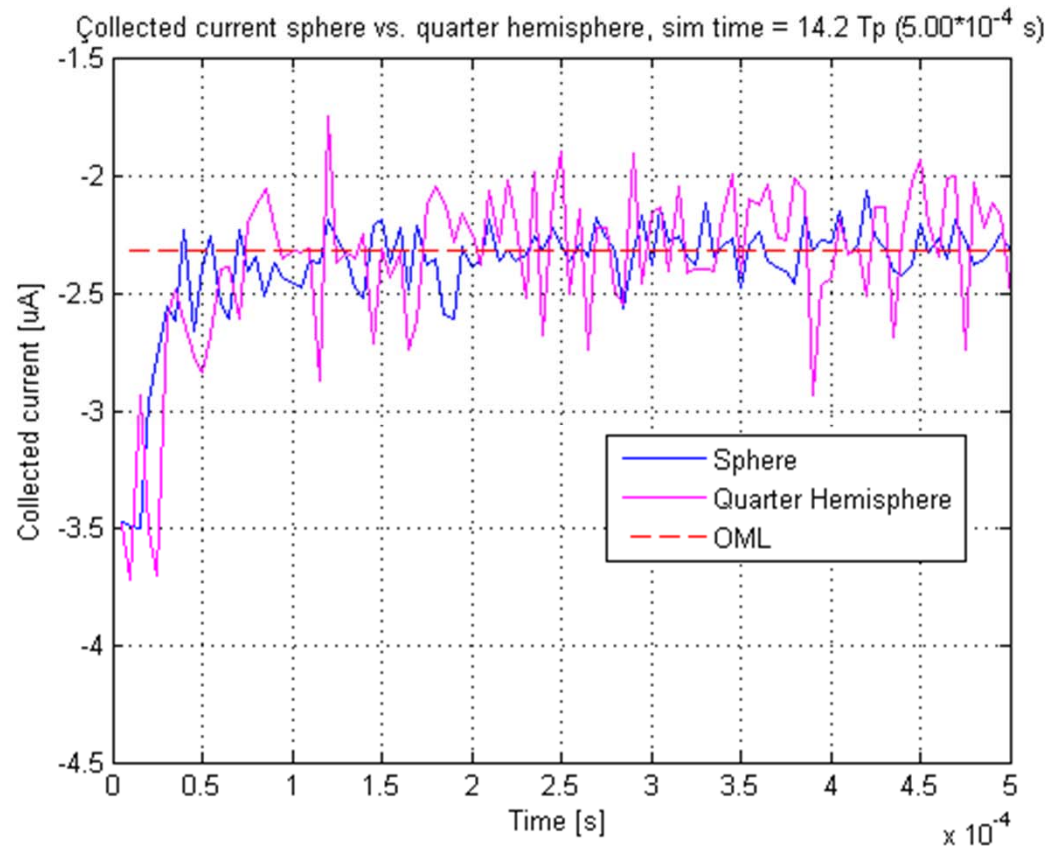
# Collected current – sphere vs. half hemisphere



- Symmetry plane case oscillate more

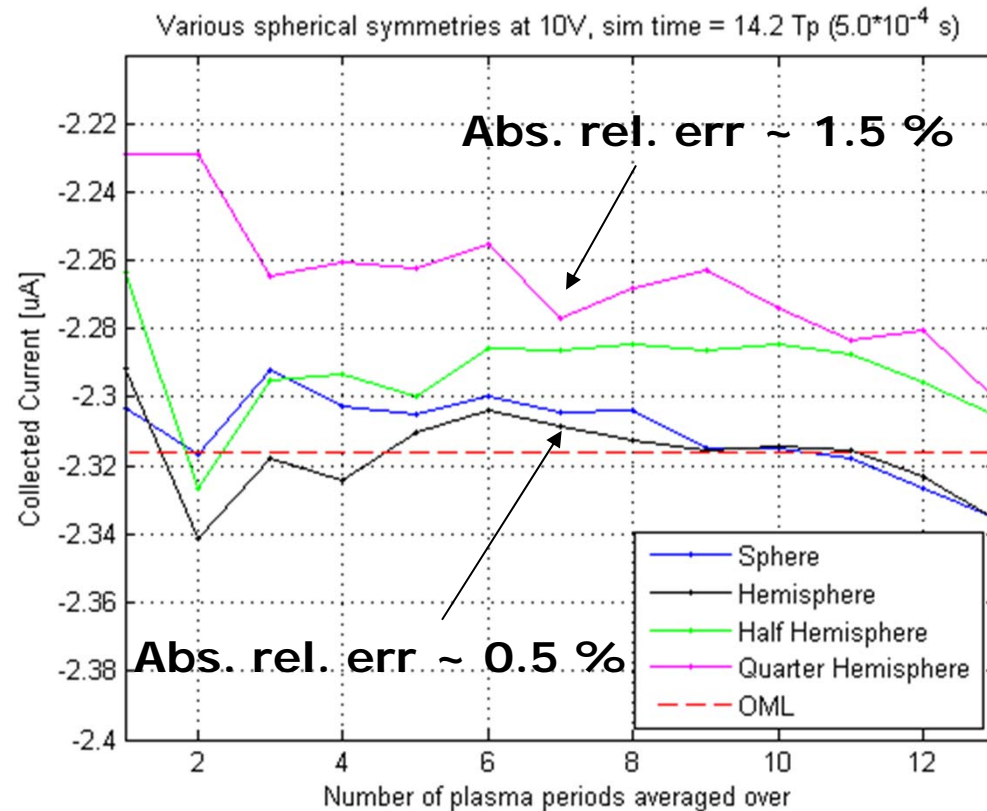


# Collected current – sphere vs. quarter hemisphere



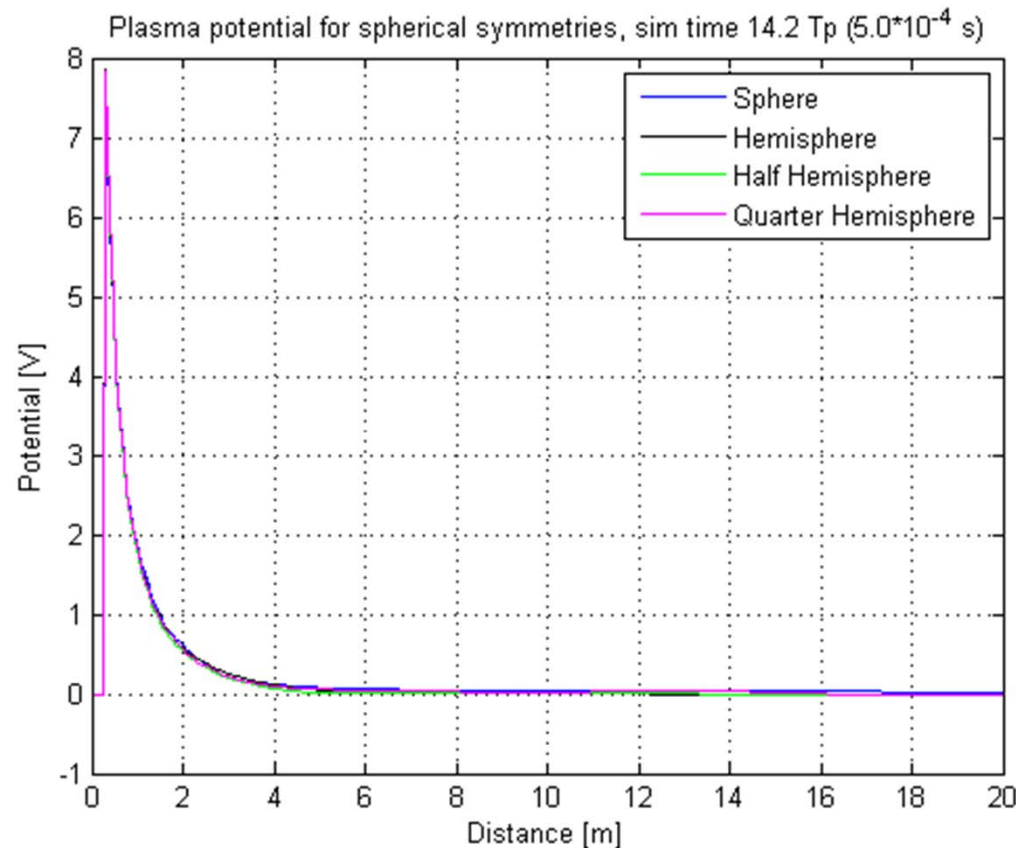
- Symmetry plane case oscillate more

# Average collected current Spheres with symmetry planes



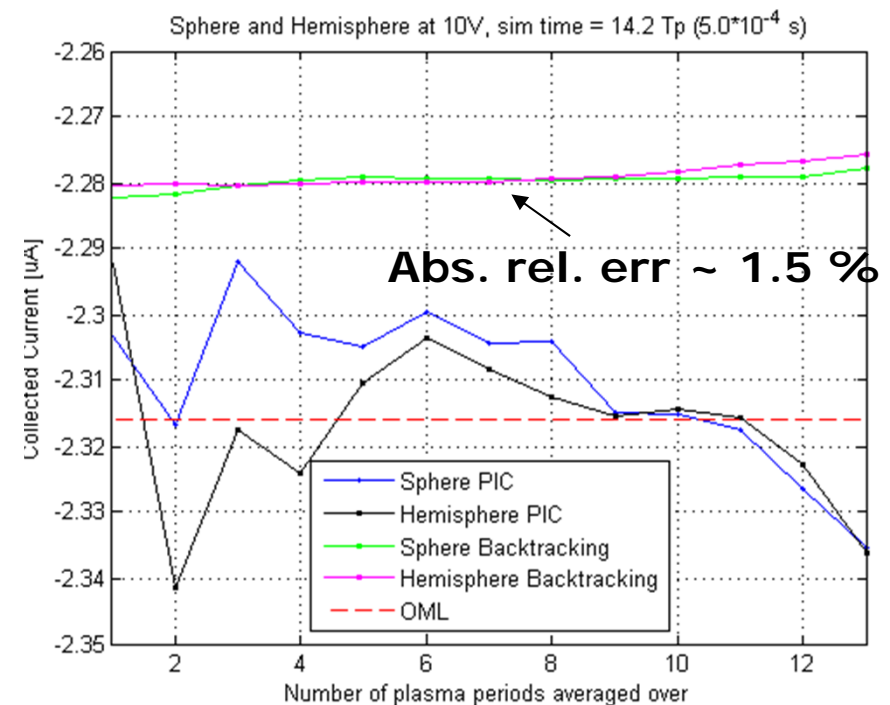
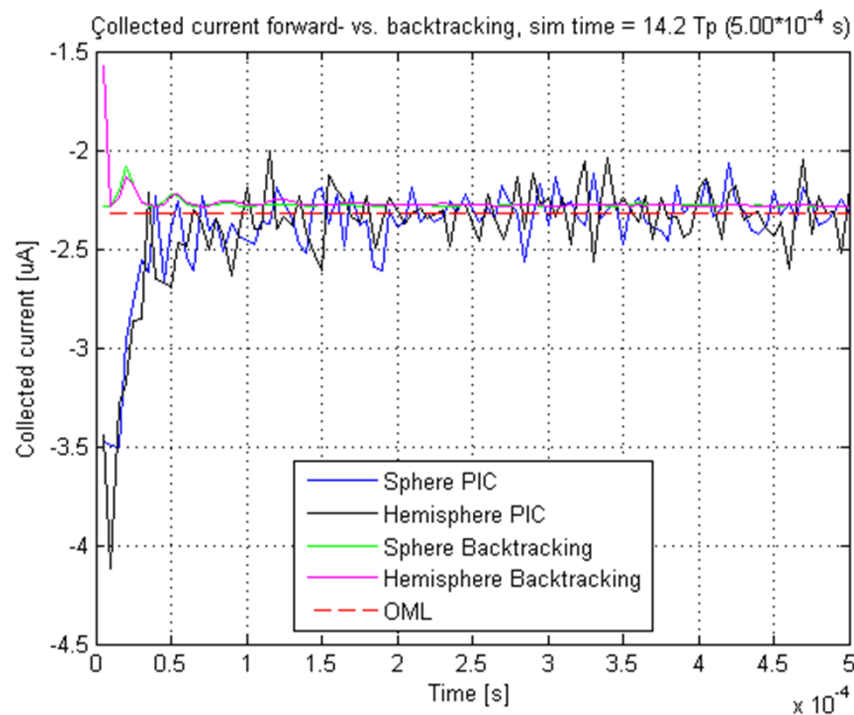
- Good results wrt OML for hemisphere, half hemisphere and quarter hemisphere

# Potential profiles - Spheres



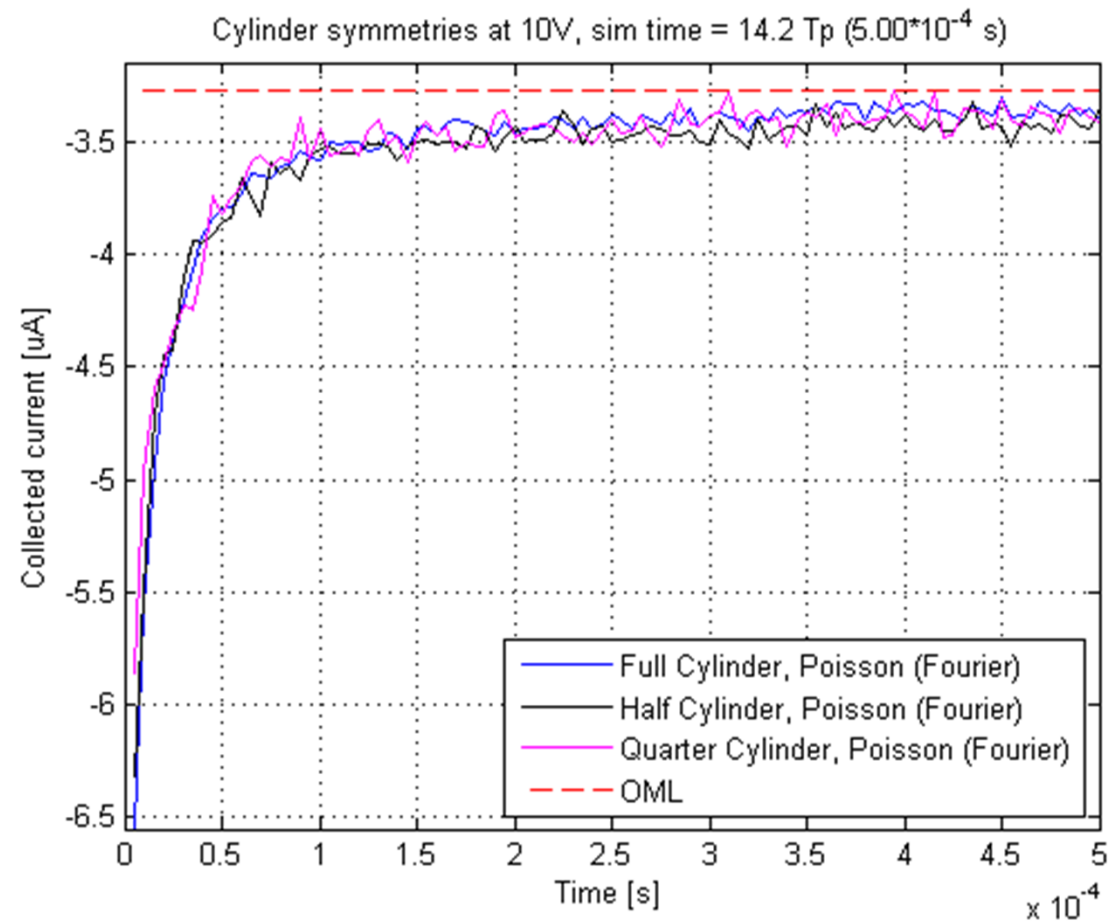
- Full sphere verified against Laframboise (1966) in Hilgers et al. (2008)

# Collected current Spheres - Backtracking



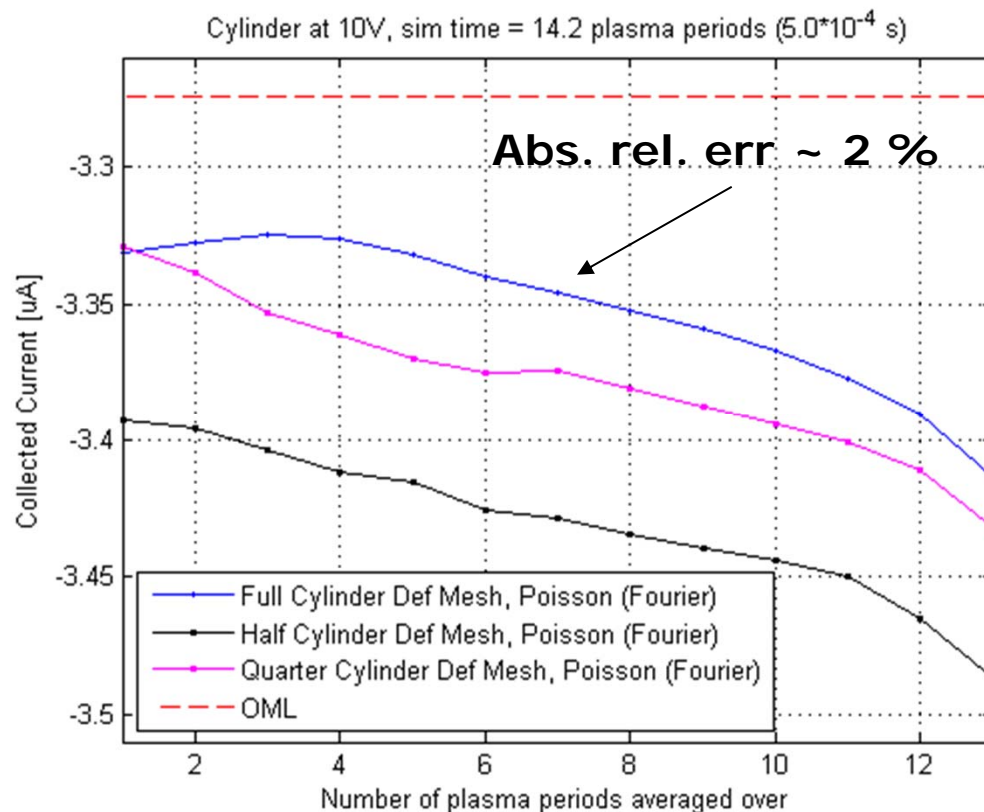
- Collected current computed through backtracking corresponds well with forward tracking results

# Collected current - Cylinders



- Similar oscillation amplitudes

# Average collected current Cylinders with symmetry planes



Infinite cylinder mimicked  
with parallel symmetry  
planes

Hilgers et. al (2008) used  
2m section in the middle of  
a finite 16m cylinder

— Abs. rel. err. ~ 40%

$$|CC_{\text{OML}}| < |CC_{\text{SPIS}}|$$

— Opposite expected

- PIC accuracy for sphere now much better than reported in Hilgers et al. (2008)
  - Abs. rel. error down from ~5% to ~0.5% wrt to OML
- Transitory regime effects important to consider
  - Optimise simulation duration
- Symmetry plane function successfully verified against OML for hemisphere, half hemisphere and quarter hemisphere
  - Both for back tracking and forward tracking
- Symmetry plane function used successfully to mimic infinite cylinder, half cylinder and quarter cylinder in forward tracking wrt OML
  - Improvements on these results are expected



# Questions?



## The end