ROSETTA LANGMUIR PROBE PERFORMANCE

Simulation of Probe Sweep in SPIS-Science

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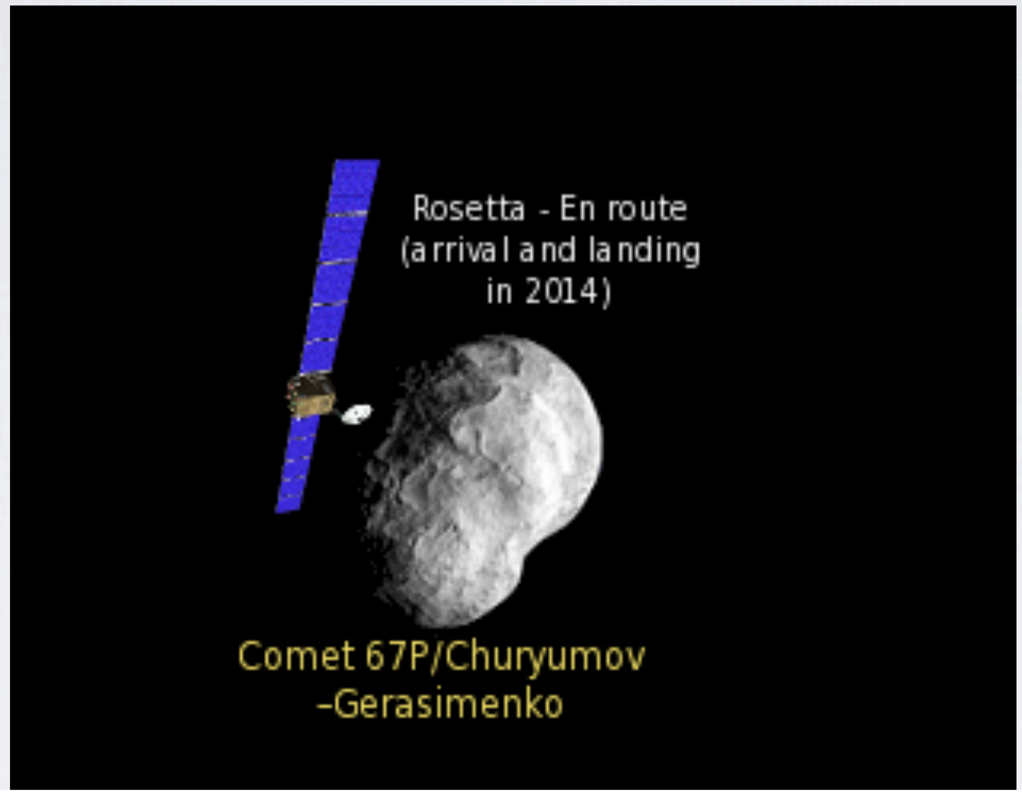
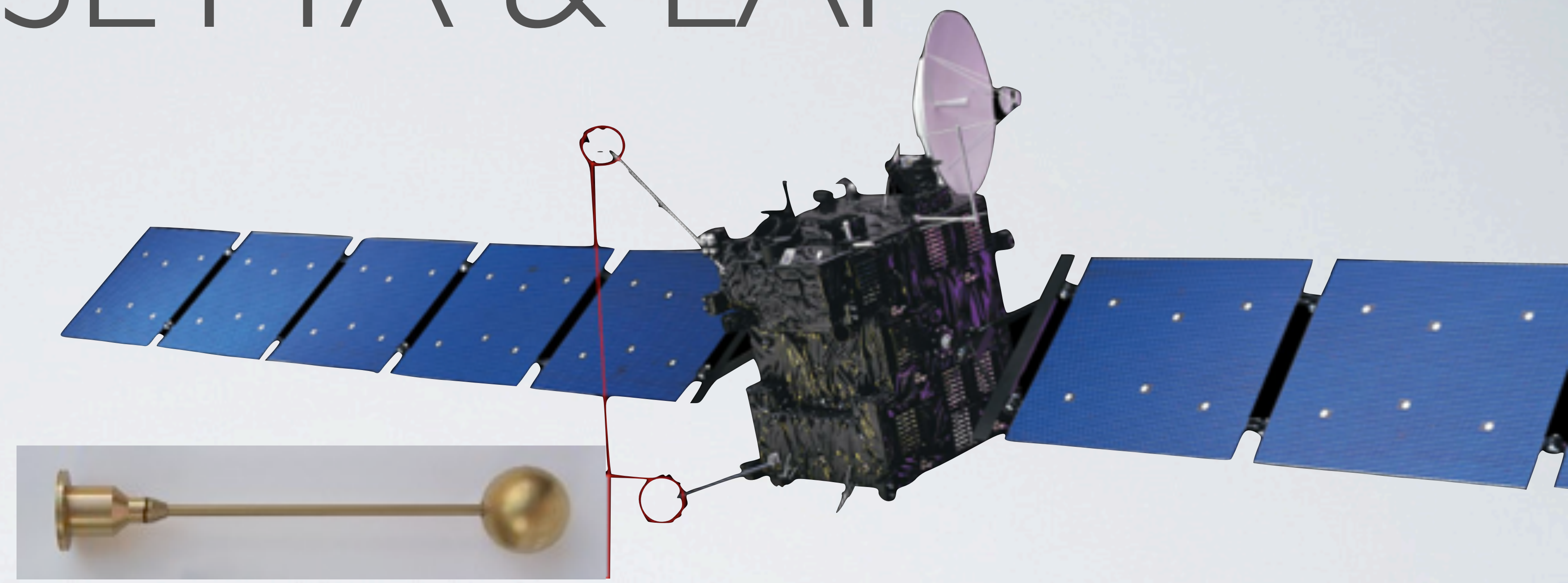
ROSETTA



http://www.planetary.org/multimedia/space-images/charts/whats-up-in-the-solar-system-frohn.html
http://www.chartgeek.com/wp-content/uploads/2013/01/solar-system-exploration.png

ROSETTA & LAP



Langmuir Probe onboard Rosetta

image credit:
A. Eriksson, IRFU & ESA

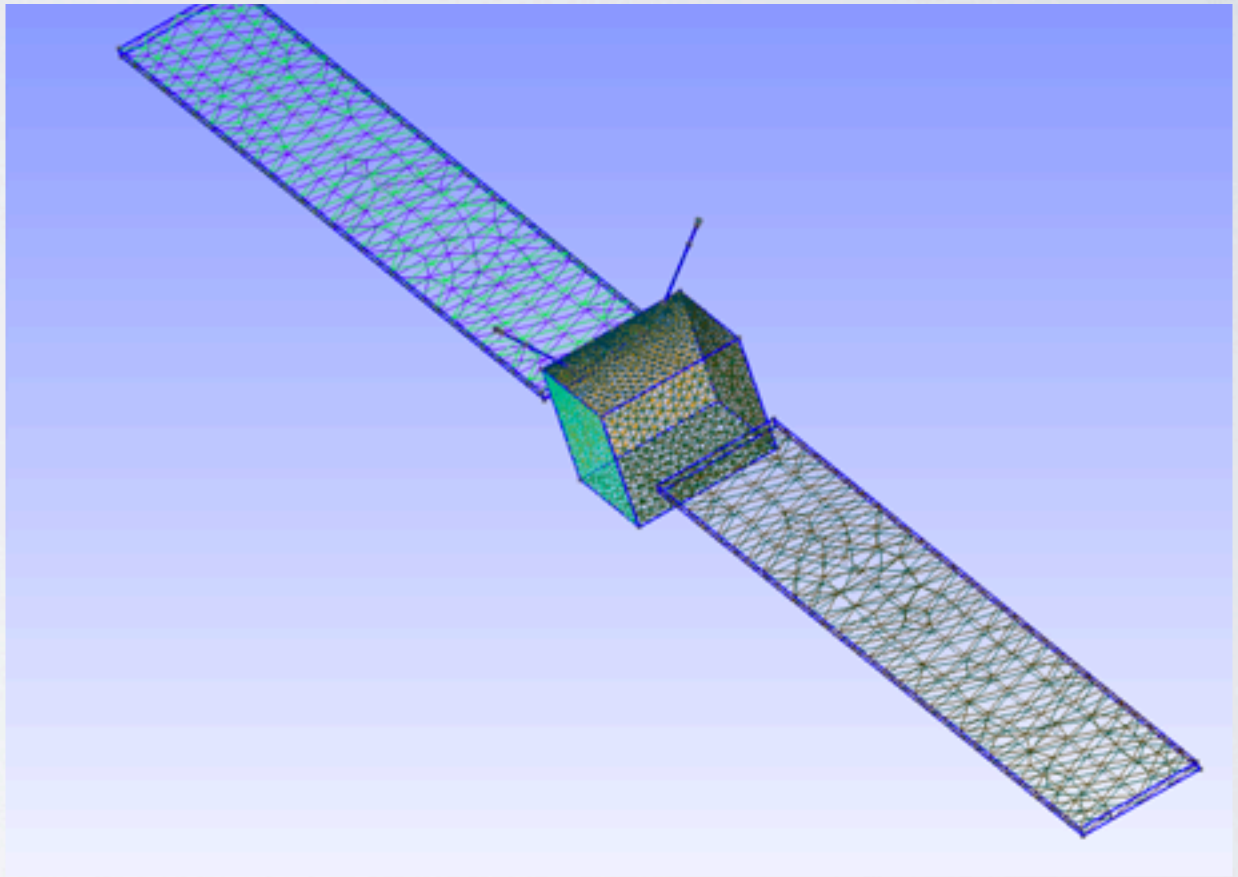
- Orbiter & Lander
- Langmuir Probes
    - Measures spacecraft potential and plasma parameters, such as plasma density, electron temperature, and plasma flow speed
    - Mounted on two booms of different length

OBJECTIVE

- Understand and interpret Langmuir probe sweep results on Rosetta by simulating probe sweep in SPIS-SCI.
- Validate results by comparison to previous work and real data.
- Model the solar angle dependence on probe sweep results

SPIS-SCIENCE

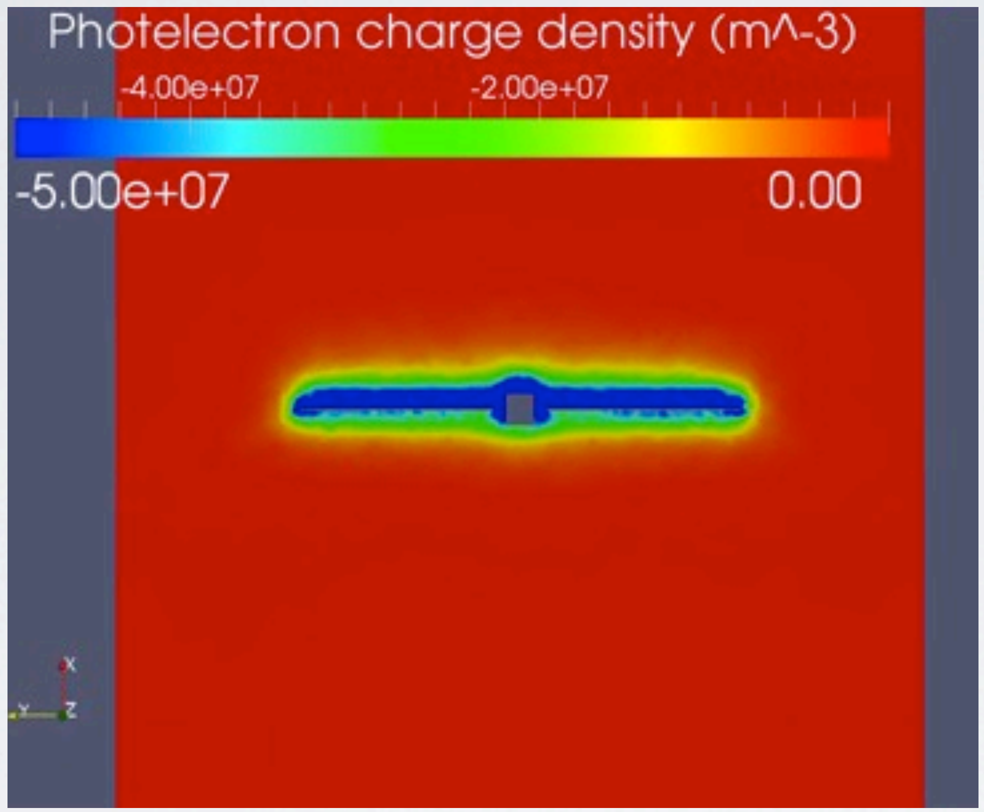
- Spacecraft charging
- S/C-Plasma induced environment
- For any material, shape, size & plasma
- New version allowing simulation of particle detectors and LPs
- Sponsored by ESA, IRF, CNRS2, and CNES3. developed by ONERA, Artenum

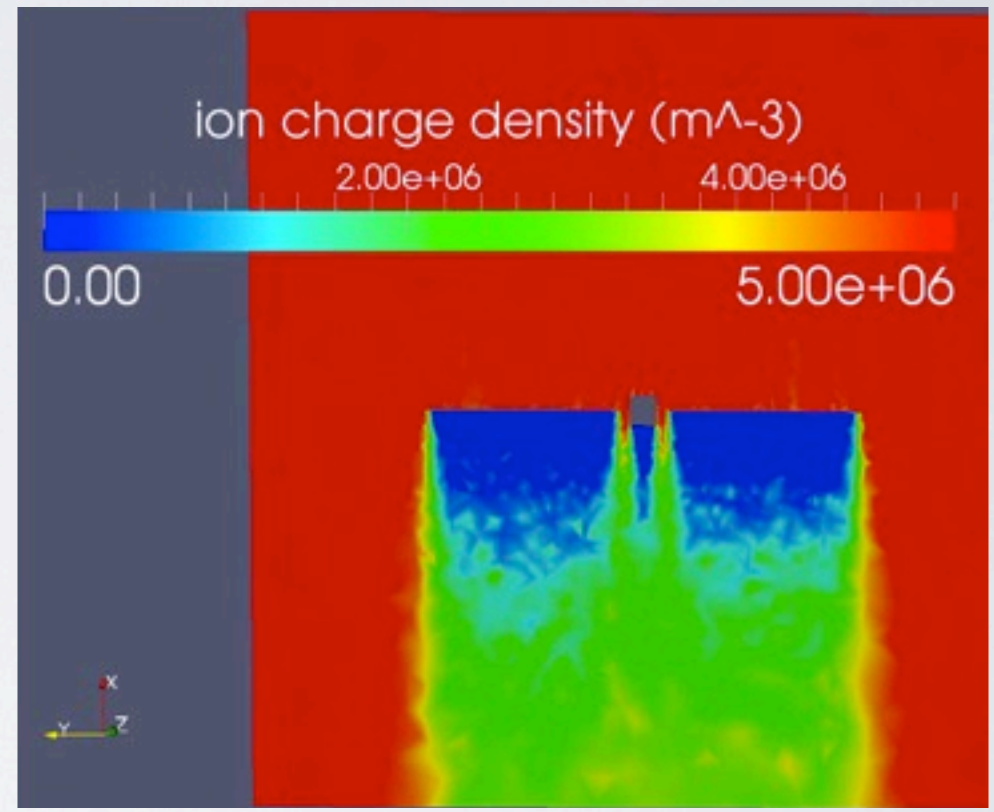


Model of Rosetta used in simulations in SPIS-Science

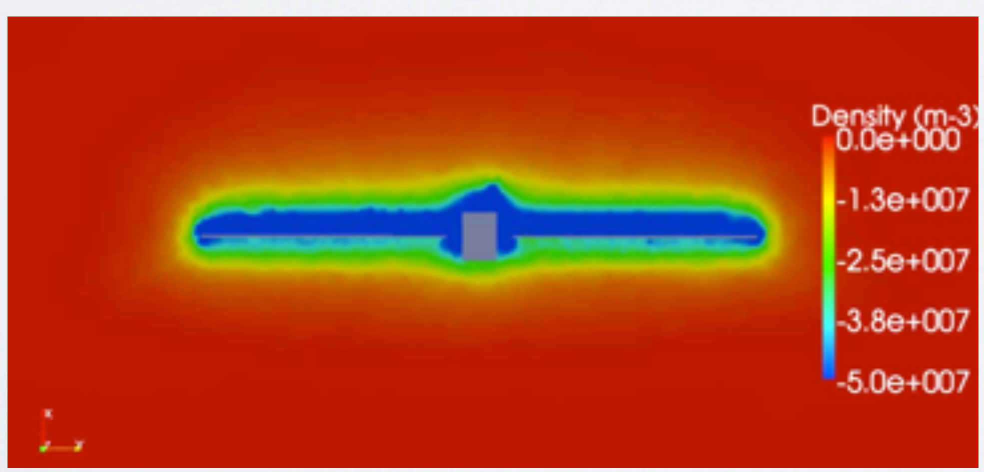
COMPARISON TO PREVIOUS WORK

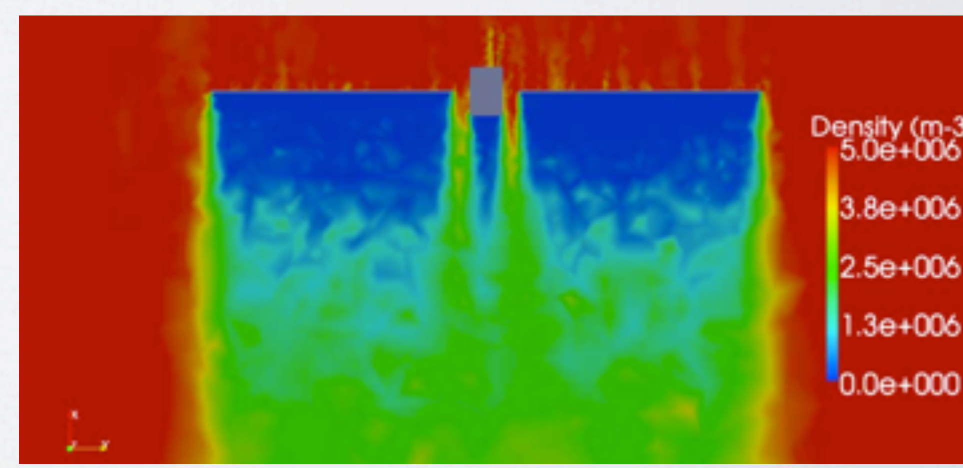
Identical parameter simulation of new model and SPIS version
Top:
SPIS-Sci simulation of current model



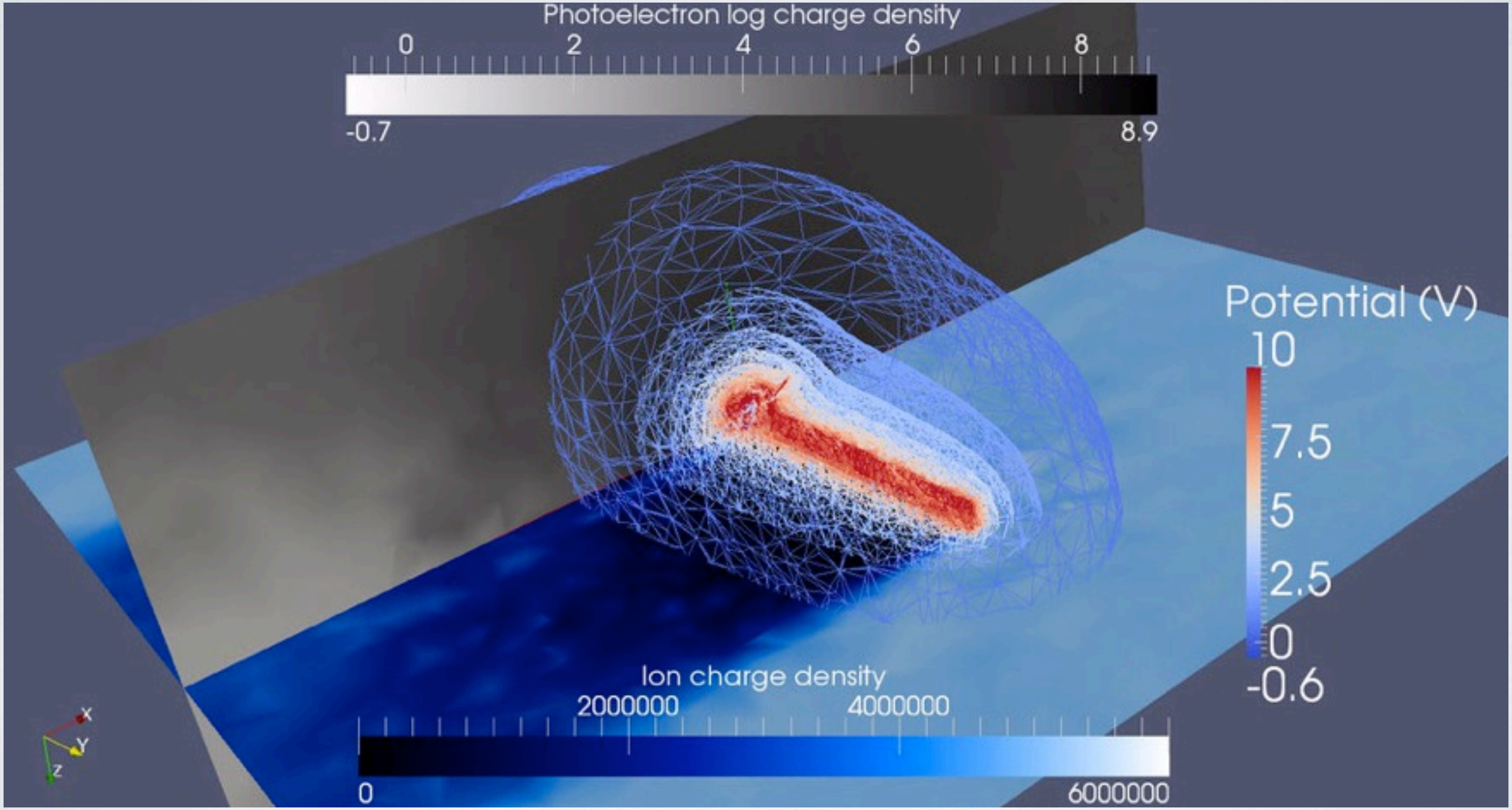


Below:
corresponding A.Sjögren SPIS 3.7. simulation





POTENTIAL, DENSITIES



PROBE THEORY

- Ion and electron absorption
- Photoelectron emission and absorption
- Model 1 (5.1)
- Model 2 (3.9)
- I_{tot} is sum of all parts

$$I_e = \begin{cases} I_{e0}\left(1 + \frac{V_p}{T_e}\right), & V_p > 0 \\ I_{e0} e^{\frac{V_p}{T_e}}, & V_p < 0 \end{cases} \tag{3.6}$$

$$I_i = \begin{cases} -I_{i0} e^{-\frac{V_p}{T_i}}, & V_p > 0 \\ -I_{i0}\left(1 - \frac{V_p}{T_i}\right), & V_p < 0 \end{cases} \tag{3.7}$$

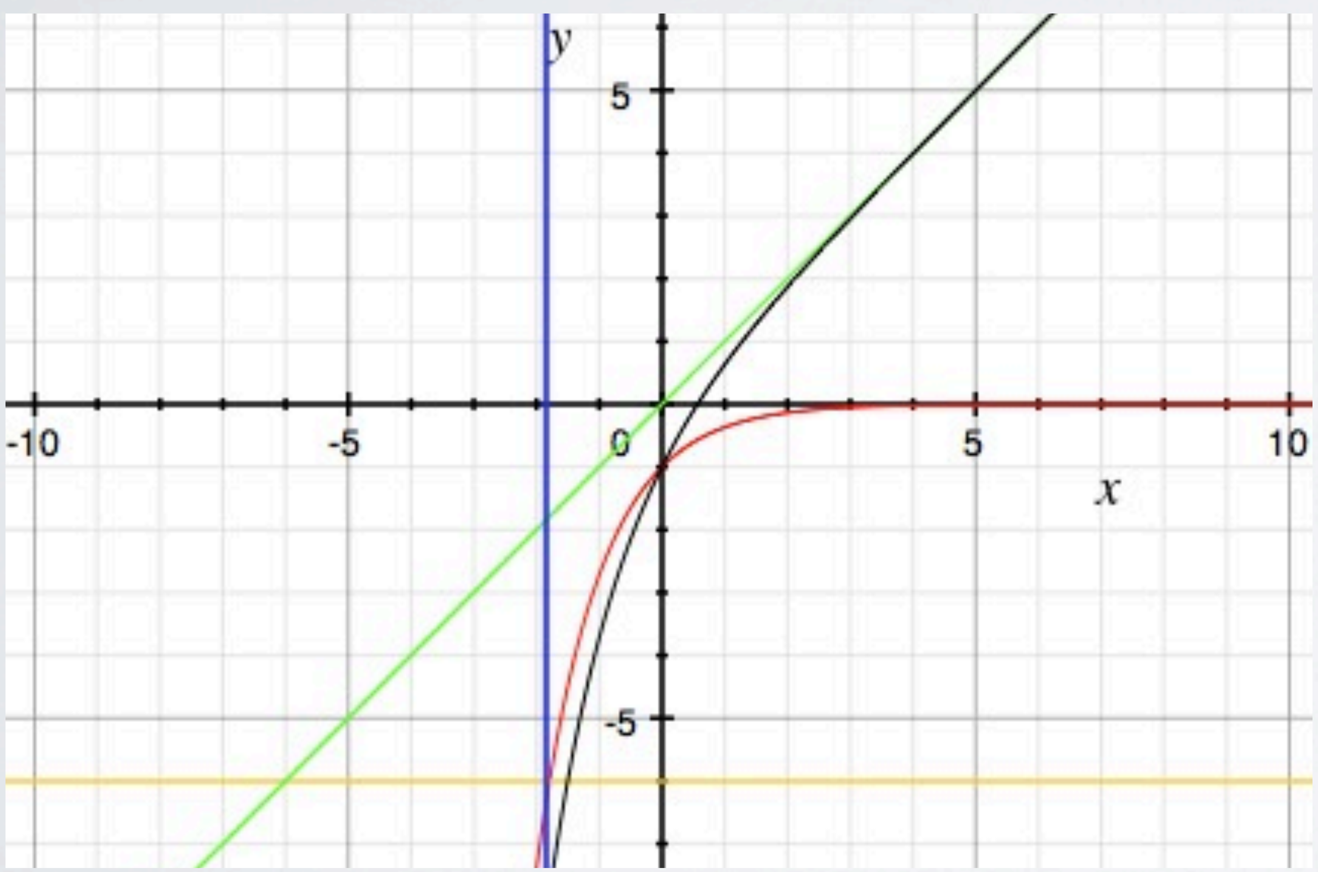
$$I_{sc} = \begin{cases} I_{s0}(1 + \frac{V_b}{T_s}), & V_b > 0 \\ I_{s0} e^{\frac{V_b}{T_s}}, & V_b < 0 \end{cases} \tag{3.10}$$

$$I_{ph} = \begin{cases} -I_{ph,0}\left(1 + \frac{V_p}{T_{ph}}\right) e^{-\frac{V_p}{T_{ph}}}, & V_p > 0 \\ -I_{ph,0}, & V_p < 0 \end{cases} \tag{3.9}$$

$$I_{ph} = \begin{cases} -I_{ph,0} e^{-\frac{V_p}{T_{ph}}}, & V_p > 0 \\ -I_{ph,0}, & V_p < 0\ . \end{cases} \tag{5.1}$$

LP Sweep Model asymptotes for demonstrational purposes

I vs V_b



$$I_e = \begin{cases} I_{e0}\left(1+\frac{V_p}{T_e}\right), & V_p > 0 \\ I_{e0}e^{\frac{V_p}{T_e}}, & V_p < 0 \end{cases} \tag{3.6}$$

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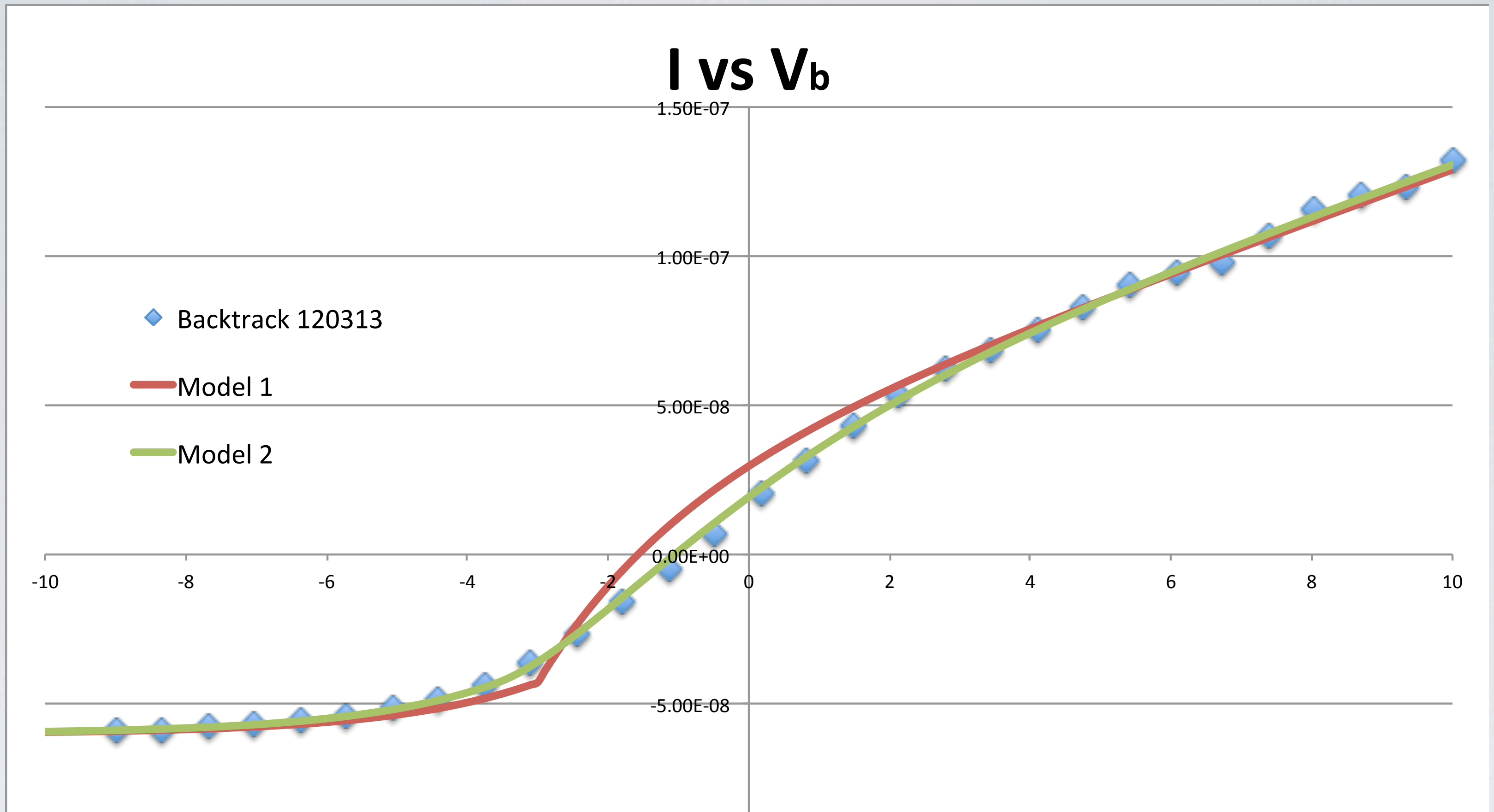
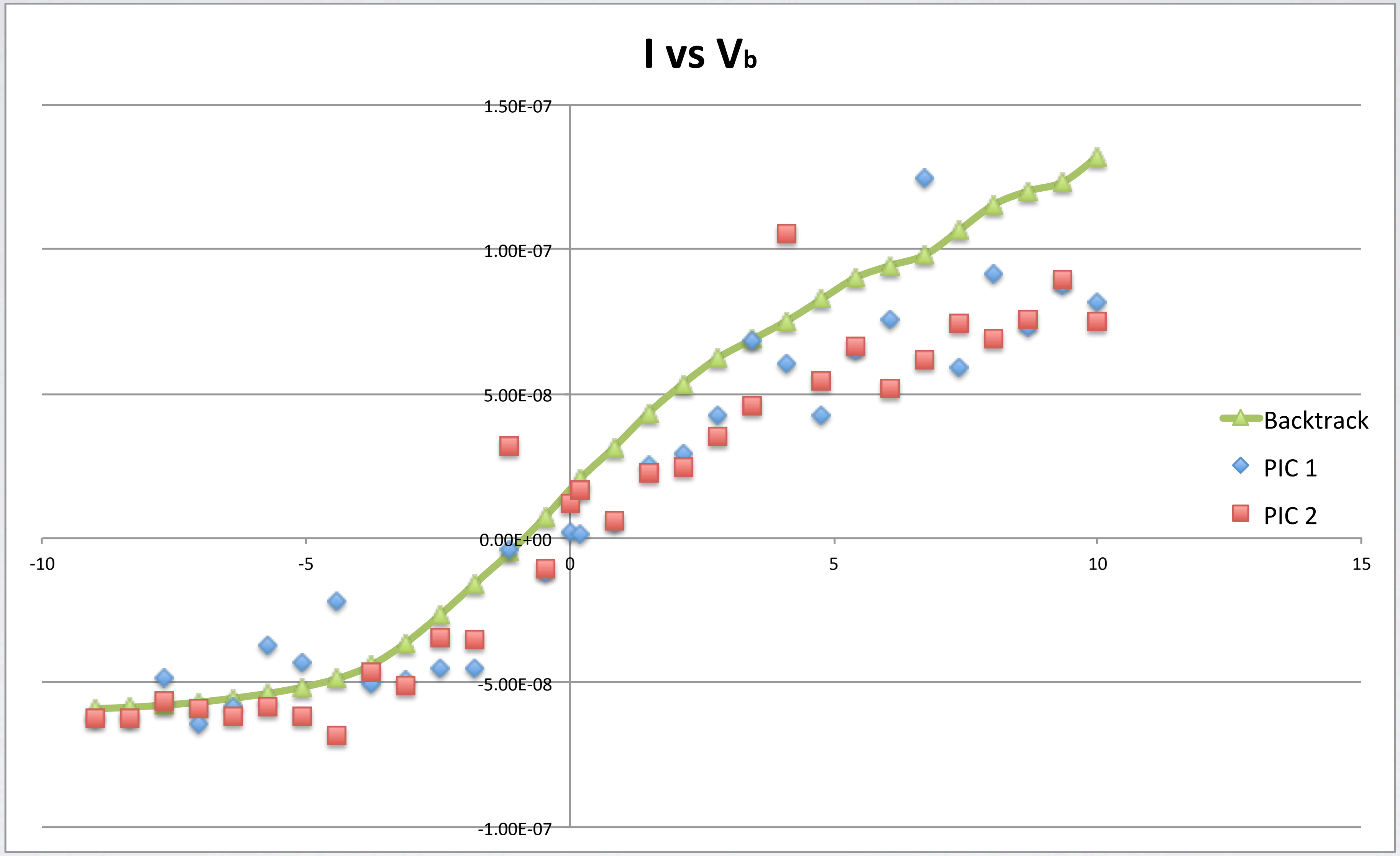
Blue line defines V_{float}, the plasma potential in the immediate vicinity of probe, depending on S/C and plasma conditions



Parameter		I_{s0}	V_{float}
Model 1	$-I_{ph,0}e^{-\frac{V_p}{T_{ph}}}, \quad V_p > 0$	1.72×10^{-8} A	7
Model 2	$-I_{ph,0}\left(1+\frac{V_p}{T_{ph}}\right)e^{-\frac{V_p}{T_{ph}}}, \quad V_p > 0$	1.68×10^{-8} A	6.4
Both	$\begin{cases} I_{s0}(1+\frac{V_b}{T_s}), & V_b > 0 \\ -I_{ph,0}, & V_p < 0\,. \end{cases}$	$V_{S/C}=10$ V, $T_{ph}=2$eV, $I_{ph,0}=6\times10^{-8}$ A	

Langmuir Probe Sweep, current vs V_b. SPIS 8.3 million particle simulation probe sweeps, Sunlit Langmuir probe, 180° SAA, 10 V charged spacecraft at 1 AU, in T_e=12eV, T_{ion}=5eV, T_{ph}= 2eV, $n_e = 5\text{cm}^{-3}$ solar wind at v = 400 km/s,

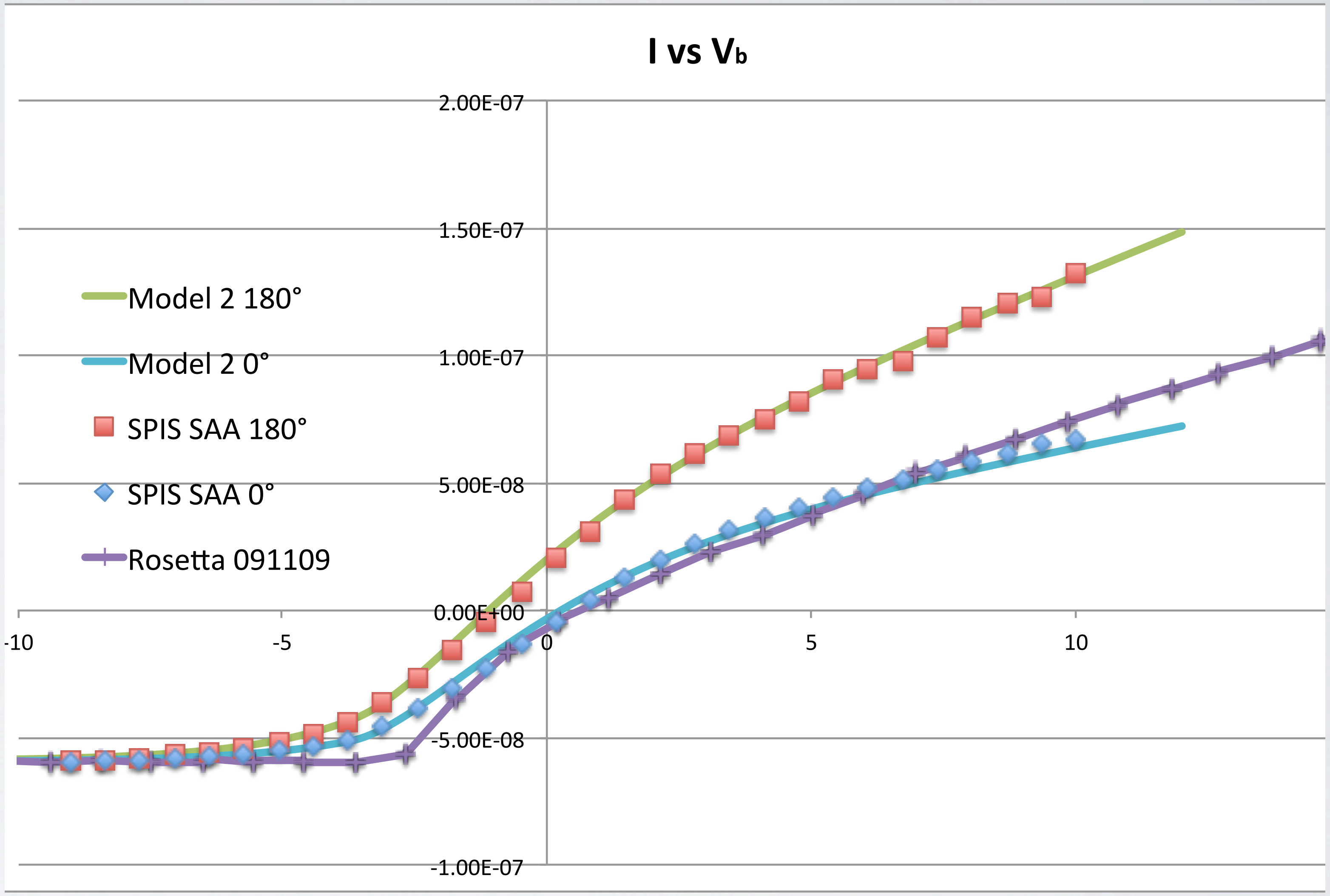
BACKTRACK VS PIC



Current vs V_b. SPIS 8.3 million particle simulation probe sweeps, Sunlit Langmuir probe, 180° SAA ,10V charged spacecraft at 1 AU, in T_e=12eV, T_{ion}=5eV, T_{ph}= 2eV, $n_e = 5cm^{-3}$ solar wind at v = 400 km/s,

SOLAR ASPECT ANGLE & ROSETTA

	Model 2 180°	Model 2 0°
$-I_{ph0}$ (A)	-5.90E-08	-5.93E-08
I_{S0} (A)	1.69E-08	8.20E-09
V_{float} (V)	6.4	6.3
n_{ph} (cm^{-3})	14.2	6.90

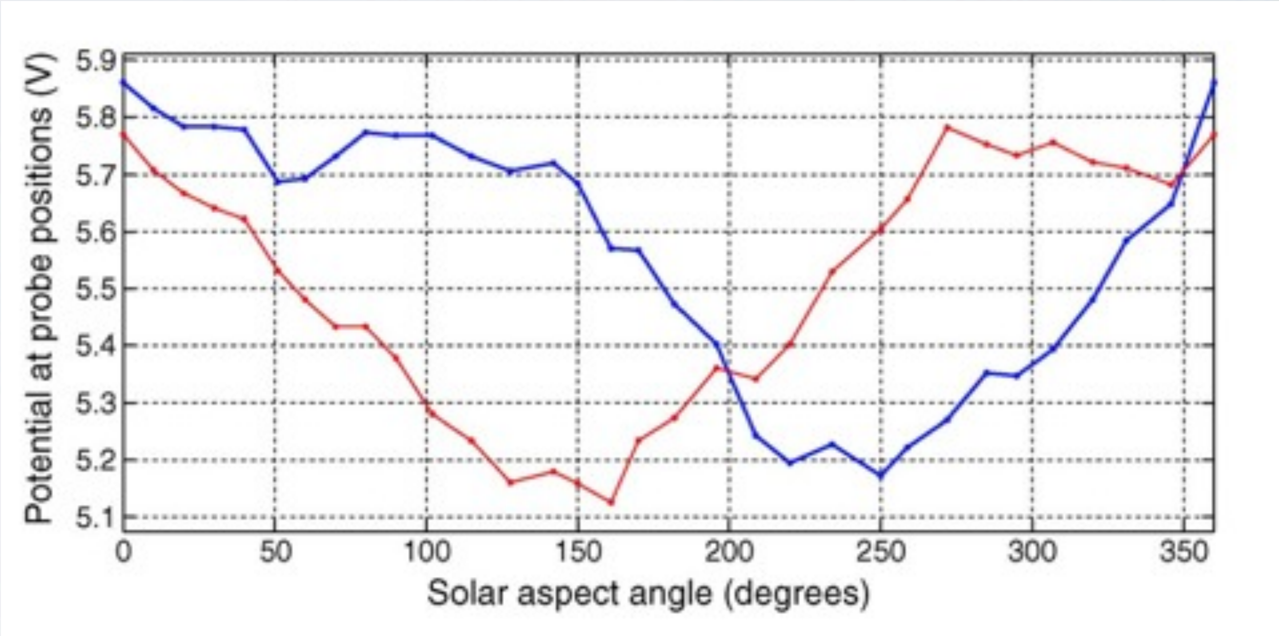


Langmuir probe sweeps, current against bias voltage. SPIS 8.3 million particle simulations (blue & red points) at different solar aspect angles, Sunlit Langmuir probe, for a10V charged spacecraft at 1 AU, in T_e=12eV, T_{ion}=5eV, T_{ph}= 2eV, n_e = 5cm^{-3} solar wind at v=400 km/s. Rosetta Langmuir probe sweep (purple) at 1 AU with unknown plasma parameters.

SPIS-SCI VS PREVIOUS WORK

	Model 2 180°	Model 2 0°
$-I_{ph0}$ (A)	-5.90E-08	-5.93E-08
I_{S0} (A)	1.69E-08	8.20E-09
V_{float} (V)	6.4	6.3
n_{ph} (cm^{-3})	14.2	6.90

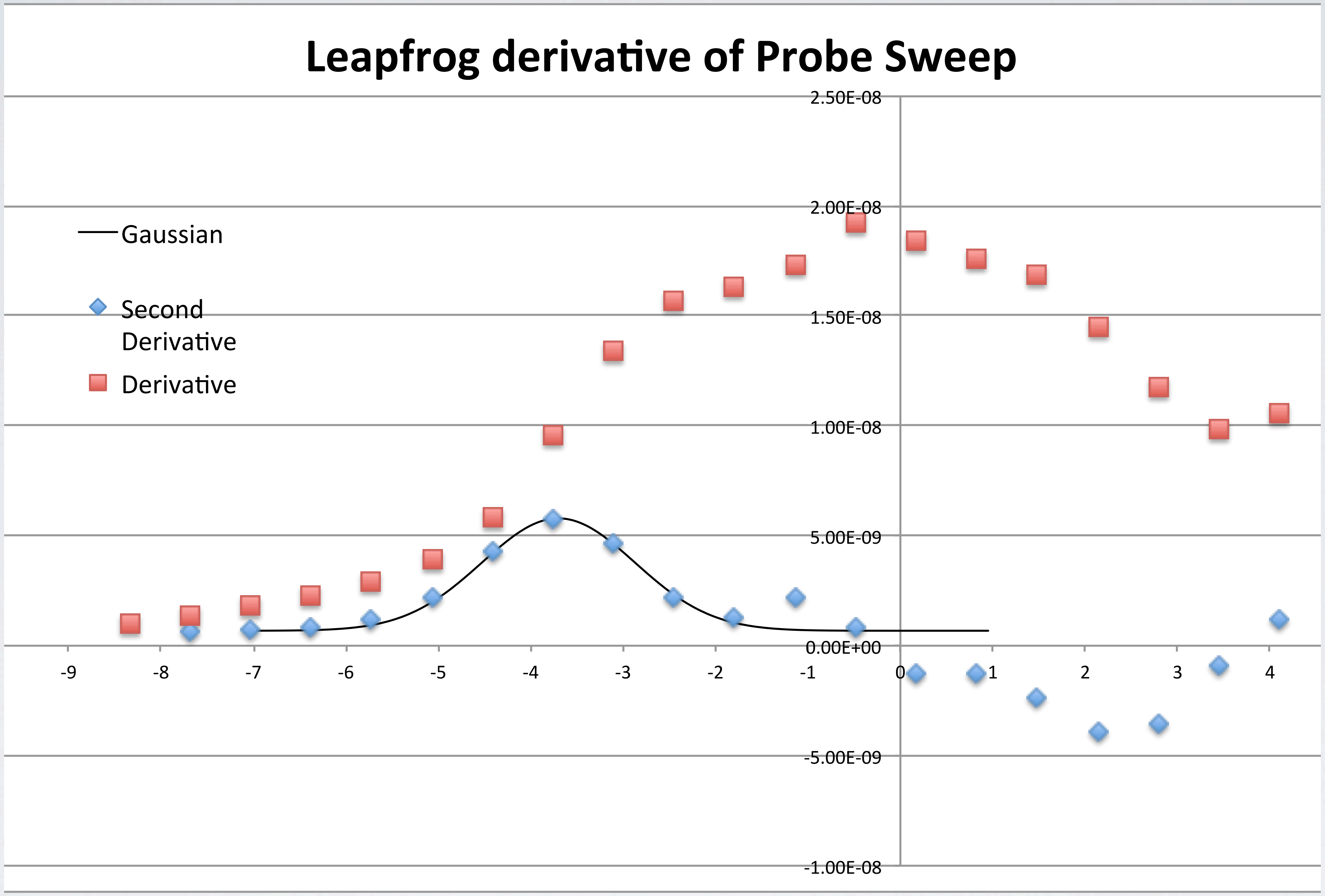
Spis-SCI results from Model fit



Spis 3.7 Simulated probe potentials for Probe 1 (blue) and Probe 2 (red) assuming a spacecraft potential of +10V [Sjogren et al., 2012].

$$V_{float(0°)} - V_{float(180°)} = 0.4$$

SPIS-SCI result more consistent with real data



180° SAA Probe sweep derivatives.
Gaussian centered at **μ**= -3.6V, **σ**= 0.9, corresponding to a plasma potential of 6.4V at probe position, as expected from model result

CONCLUSIONS

- SPIS Science can confidently simulate the Langmuir probe sweep of a real Spacecraft
- Plasma potential at probe position can be extrapolated from fit with theoretical model and second derivate of LP sweep.
- Floating potential SAA dependence in SPIS-SCI is consistent with real data
- Results consistent with theoretical model assuming photoemission from point

Future Work:

- Simulation with parameters identical to real data
- All solar aspect angles
- Other Plasma environments

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