

# Swarm Probes Simulation Results

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For  $V < 0$

$$\begin{aligned}
 I_{net} &= \pi a^2 q n \left( \frac{2kT_i}{\pi m_i} \right)^{1/2} \left[ e^{-x_{id}} + \left( 1 + 2x_{id} - \frac{2qV}{kT_i} \right) \frac{\sqrt{\pi}}{2} \frac{\text{erf}(x_{id})}{x_{id}} \right] \\
 &- \pi a^2 q n \left( \frac{2kT_e}{\pi m_e} \right)^{1/2} \left\{ \frac{x_{ed} + x_{em}}{2x_{ed}} e^{-(x_{ed}-x_{em})^2} + \frac{x_{ed} - x_{em}}{2x_{ed}} e^{-(x_{ed}+x_{em})^2} \right. \\
 &+ \left. \left[ \frac{1}{2} + x_{ed}^2 - \frac{qV}{kT_e} \right] \frac{\sqrt{\pi}}{2} \frac{\text{erf}(x_{ed} - x_{em}) + \text{erf}(x_{ed} + x_{em})}{x_{ed}} \right\}, \quad (1)
 \end{aligned}$$

and for  $V > 0$

$$\begin{aligned}
 I_{net} &= \pi a^2 q n \left( \frac{2kT_i}{\pi m_i} \right)^{1/2} \left\{ \frac{x_{id} + x_{im}}{2x_{id}} e^{-(x_{id}-x_{im})^2} + \frac{x_{id} - x_{im}}{2x_{id}} e^{-(x_{id}+x_{im})^2} \right. \\
 &+ \left. \left[ \frac{1}{2} + x_{id}^2 - \frac{qV}{kT_i} \right] \frac{\sqrt{\pi}}{2} \frac{\text{erf}(x_{id} - x_{im}) + \text{erf}(x_{id} + x_{im})}{x_{id}} \right\} \\
 &- \pi a^2 q n \left( \frac{2kT_e}{\pi m_e} \right)^{1/2} \left[ e^{-x_{ed}} + \left( 1 + 2x_{ed} - \frac{2qV}{kT_e} \right) \frac{\sqrt{\pi}}{2} \frac{\text{erf}(x_{ed})}{x_{ed}} \right], \quad (2)
 \end{aligned}$$

$$x_d = \frac{v_d}{\sqrt{2kT/m}}, \quad (3)$$

$$x_m = \sqrt{\frac{qV}{kT}}, \quad (4)$$

$$n = \frac{dI_{ion}}{dV} \left( \pi a^2 \frac{2q^2}{v_d} \sum_{j=1}^N \frac{n_j}{n_{tot}} \frac{1}{m_j} \text{erf} \left( \frac{v_d}{\sqrt{2kT_i/m_j}} \right) \right)^{-1}, \quad (5)$$

$$I_{ion} = \pi a^2 q n v_d \left( 1 - \frac{2qV}{16m_p v_d^2} \right), \quad (6)$$

$$n = \frac{dI_{ion}}{dV} \left( \pi a^2 \frac{2q^2}{16m_p v_d} \right)^{-1}. \quad (7)$$

$$T_e = \frac{I_{ret} - I_{ion} - d_{ion}(V_{ret} - V_{ion})}{d_{ret} - d_{ion}}, \quad (8)$$

$n$ $10^{10}m^{-3}$	$T_e$ $eV$	$T_i$ $eV$	$m_{eff}$ $amu$	$\lambda_D$ $mm$	$V_p$ $V$	$I_{sim}$ $nA$	$\delta I_{sim}$ $\%$	$\epsilon_{I_{OML}}$ $\%$	$\epsilon_{I_{OML16}}$ $\%$
3.16	0.070	0.070	7.4	11.1	-3.5	5.103	0.3	2.2	34.8
3.16	0.070	0.070	7.4	11.1	-4.5	5.988	0.4	2.2	37.8
3.16	0.070	0.070	7.4	11.1	-5.5	6.886	0.3	2.4	40.1
10.00	0.070	0.068	5.9	6.2	-3.5	18.608	0.3	1.9	43.4
10.00	0.070	0.068	5.9	6.2	-4.5	22.232	0.5	2.5	47.0
10.00	0.070	0.068	5.9	6.2	-5.5	25.703	0.3	2.3	49.2
31.6	0.070	0.070	4.1	3.5	-3.5	74.462	0.4	1.4	55.2
31.6	0.070	0.070	4.1	3.5	-4.5	90.428	0.6	1.8	58.8
31.6	0.070	0.070	4.1	3.5	-5.5	106.059	0.4	1.8	<b>61.1</b>
63.2	0.082	0.079	13.7	2.7	-3.5	73.020	0.7	2.0	8.8
63.2	0.082	0.079	13.7	2.7	-4.5	83.467	<b>1.1</b>	3.2	10.7
63.2	0.082	0.079	13.7	2.7	-5.5	92.387	0.7	2.5	10.7
1.00	0.156	0.116	8.3	29.4	-3.5	1.515	0.4	3.1	30.5
1.00	0.156	0.116	8.3	29.4	-4.5	1.770	0.4	3.5	33.4
1.00	0.156	0.116	8.3	29.4	-5.5	2.032	0.2	<b>4.2</b>	35.8
3.16	0.140	0.113	11.4	15.7	-3.5	3.999	0.3	2.3	16.8
3.16	0.140	0.113	11.4	15.7	-4.5	4.588	0.4	2.7	18.8
3.16	0.140	0.113	11.4	15.7	-5.5	5.175	0.3	3.1	20.3
10.0	0.140	0.112	13.0	8.8	-3.5	11.902	0.4	2.4	11.5
10.0	0.140	0.112	13.0	8.8	-4.5	13.520	0.5	2.6	12.8
10.0	0.140	0.112	13.0	8.8	-5.5	15.176	0.4	3.1	14.0
31.6	0.140	0.089	15.9	5.0	-3.5	34.381	0.5	2.3	3.2
31.6	0.140	0.089	15.9	5.0	-4.5	38.595	0.7	2.6	3.4
31.6	0.140	0.089	15.9	5.0	-5.5	42.745	0.5	2.7	3.5
3.16	0.210	0.120	12.6	19.2	-3.5	3.816	0.3	2.8	12.8
3.16	0.210	0.120	12.6	19.2	-4.5	4.356	0.5	3.4	14.5
3.16	0.210	0.120	12.6	19.2	-5.5	4.883	0.3	3.6	15.6
10.0	0.220	0.107	11.3	11.0	-3.5	12.761	0.3	2.5	17.4
10.0	0.220	0.107	11.3	11.0	-4.5	14.636	0.5	2.9	19.4
10.0	0.220	0.107	11.3	11.0	-5.5	16.521	0.3	3.3	21.0
10.0	0.280	0.121	16.0	12.4	-3.5	10.727	<b>1.1</b>	1.1	1.9
10.0	0.280	0.121	16.0	12.4	-4.5	12.093	1.0	1.7	2.5
10.0	0.280	0.121	16.0	12.4	-5.5	13.553	0.3	3.0	3.7

Table 1:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate an overestimation while negative signs an underestimation.

$n$ $10^{10}m^{-3}$	$T_e$ $eV$	$T_i$ $eV$	$m_{eff}$ $amu$	$\lambda_D$ $mm$	$\epsilon_{n_I}$ %	$\delta n_I$ %	$\epsilon_n$ %	$\epsilon_{n_{16}}$ %	$\delta_{n-n_{16}}$ %
3.16	0.070	0.070	7.4	11.1	2.2	0.4	3.1	55.4	1.4
10.00	0.070	0.068	5.9	6.2	2.5	0.5	3.3	64.6	1.5
31.6	0.070	0.070	4.1	3.5	1.8	0.6	2.6	<b>74.9</b>	1.7
63.2	0.082	0.079	13.7	2.7	3.2	<b>1.1</b>	4.3	18.0	4.3
1.00	0.156	0.116	8.3	29.4	3.5	0.4	7.2	51.4	1.5
3.16	0.140	0.113	11.4	15.7	2.7	0.5	5.8	32.4	1.6
10.0	0.140	0.112	13.0	8.8	2.6	0.7	5.8	23.2	2.2
31.6	0.140	0.089	15.9	5.0	2.6	0.5	4.3	5.0	3.2
3.16	0.210	0.120	12.6	19.0	<b>3.4</b>	0.5	6.6	25.6	1.8
10.0	0.220	0.107	11.3	11.0	2.9	0.5	5.7	33.1	1.8
10.0	0.280	0.121	16.0	12.4	1.7	1.0	<b>10.3</b>	10.6	<b>4.4</b>

Table 2: Relative errors in the inferred density calculated from probe simulations results.  $\epsilon_{I_{pic}}$  are the relative errors when Eq. 1 is used to infer density.  $\epsilon_n$  and  $\epsilon_{n_{16}}$  correspond to relative errors in inferred density when Eq. 5 and 7 are used respectively.  $\delta_{n_I}$  and  $\delta_n$  represent the relative uncertainties in their respective inferred densities. Positive errors indicate that the calculated density is overestimated while negative signs refer to an underestimation. In all cases, the ram velocity is 7673 m/s.

SWARM LP ION SATURATION CURRENT C01

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$3.16 \times 10^{10} m^{-3}$	$0.070 \text{ eV}$	$0.070 \text{ eV}$	$7.7 \text{ amu}$	$11.1 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-0.201	-2.701	$LP_1$	4.311	3.1	32.1	1.3
-0.201	-2.701	$LP_2$	4.375	4.5	33.1	1.2
-0.201	-2.701	$LP_A$	4.343	3.8	32.6	0.9
-0.201	-3.701	$LP_1$	5.229	4.1	36.7	1.0
-0.201	-3.701	$LP_2$	5.333	5.9	37.9	1.0
-0.201	-3.701	$LP_A$	5.282	5.0	37.3	0.7
-1.0	-3.5	$LP_1$	4.468	-8.5	27.6	1.6
-1.0	-3.5	$LP_2$	4.589	-5.6	29.5	1.6
-1.0	-3.5	$LP_A$	4.529	-7.0	28.6	1.1
-1.0	-4.5	$LP_1$	5.324	-6.8	32.0	1.2
-1.0	-4.5	$LP_2$	5.412	-5.1	32.1	1.2
-1.0	-4.5	$LP_A$	5.368	-5.9	32.6	0.9
-2.0	-4.5	$LP_1$	4.453	-27.7	18.7	1.2
-2.0	-4.5	$LP_2$	4.507	-26.2	19.7	1.2
-2.0	-4.5	$LP_A$	4.480	-26.9	19.2	0.9
-2.0	-5.5	$LP_1$	5.134	-27.1	22.0	1.0
-2.0	-5.5	$LP_2$	5.230	-24.8	23.4	1.0
-2.0	-5.5	$LP_A$	5.182	-25.9	22.7	0.7

Table 3:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.6\%$

## SWARM LP ION SATURATION CURRENT C02

$n$ $10.0 \times 10^{10} m^{-3}$	$Te$ $0.070 \text{ eV}$	$Ti$ $0.068 \text{ eV}$	$m_{eff}$ $5.9 \text{ amu}$	$\lambda_D$ $6.2 \text{ mm}$	$v_d$ $7673 \text{ m/s}$	
$V_f$ $V$	$V_p$ $V$	$LP_x$	$I_{sim}$ $nA$	$\epsilon_{I_{OML}}$ $\%$	$\epsilon_{I_{OML16}}$ $\%$	$\delta I_{sim}$ $\%$
-0.195	-2.695	$LP_1$	15.658	3.9	40.9	1.6
-0.195	-2.695	$LP_2$	15.770	4.6	41.4	1.6
-0.195	-2.695	$LP_A$	15.714	4.3	41.1	1.1
-0.195	-3.695	$LP_1$	19.038	3.5	45.0	1.3
-0.195	-3.695	$LP_2$	19.439	5.5	46.1	1.3
-0.195	-3.695	$LP_A$	19.238	4.5	45.6	0.9
-1.0	-3.5	$LP_1$	17.217	-3.0	40.6	1.9
-1.0	-3.5	$LP_2$	17.218	-3.0	40.6	2.0
-1.0	-3.5	$LP_A$	17.218	-3.0	40.6	1.4
-1.0	-4.5	$LP_1$	20.458	-2.9	44.0	1.5
-1.0	-4.5	$LP_2$	20.806	-1.2	45.0	1.5
-1.0	-4.5	$LP_A$	20.632	-2.1	44.5	1.1
-2.0	-4.5	$LP_1$	18.648	-12.9	38.6	2.5
-2.0	-4.5	$LP_2$	18.676	-12.9	38.7	2.6
-2.0	-4.5	$LP_A$	18.665	-12.8	38.6	1.1
-2.0	-5.5	$LP_1$	21.981	-11.0	42.3	1.6
-2.0	-5.5	$LP_2$	22.173	-10.0	42.8	1.5
-2.0	-5.5	$LP_A$	22.077	-10.5	42.6	1.1

Table 4:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.5\%$

## SWARM LP ION SATURATION CURRENT C03

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$31.6 \times 10^{10} m^{-3}$	$0.070 \text{ eV}$	$0.070 \text{ eV}$	$4.1 \text{ amu}$	$3.5 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-0.195	-2.695	$LP_1$	60.311	1.0	51.2	1.4
-0.195	-2.695	$LP_2$	60.605	1.4	51.4	1.3
-0.195	-2.695	$LP_A$	60.458	1.2	51.3	1.0
-1.0	-3.5	$LP_1$	69.054	-4.1	52.8	2.0
-1.0	-3.5	$LP_2$	67.559	-6.4	51.8	2.0
-1.0	-3.5	$LP_A$	68.306	-5.2	52.3	1.4
-1.0	-4.5	$LP_1$	82.966	-4.8	56.0	1.1
-1.0	-4.5	$LP_2$	83.901	-3.6	56.5	1.0
-1.0	-4.5	$LP_A$	83.434	-4.2	56.3	0.7
-2.0	-4.5	$LP_1$	76.356	-13.9	52.2	1.4
-2.0	-4.5	$LP_2$	77.879	-11.6	53.2	1.4
-2.0	-4.5	$LP_A$	77.118	-12.7	52.7	1.0
-2.0	-5.5	$LP_1$	90.890	-12.2	55.6	1.1
-2.0	-5.5	$LP_2$	92.448	-10.3	56.3	1.1
-2.0	-5.5	$LP_A$	91.669	-11.3	56.0	0.8

Table 5:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.1\%$

## SWARM LP ION SATURATION CURRENT C04

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$63.2 \times 10^{10} m^{-3}$	$0.082 \text{ eV}$	$0.079 \text{ eV}$	$13.7 \text{ amu}$	$2.7 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-0.223	-2.723	$LP_1$	64.079	1.6	7.7	1.9
-0.223	-2.723	$LP_2$	66.806	5.7	11.5	1.9
-0.223	-2.723	$LP_A$	65.443	3.7	9.6	1.3
-1.0	-3.5	$LP_1$	69.716	-0.5	6.5	2.1
-1.0	-3.5	$LP_2$	71.276	1.7	8.5	2.1
-1.0	-3.5	$LP_A$	70.496	0.6	7.5	1.5
-1.0	-4.5	$LP_1$	82.321	3.9	11.4	1.8
-1.0	-4.5	$LP_2$	80.172	1.3	9.0	1.8
-1.0	-4.5	$LP_A$	81.246	2.6	10.2	1.3
-2.0	-4.5	$LP_1$	76.197	-3.9	4.2	2.3
-2.0	-4.5	$LP_2$	79.652	0.6	8.4	2.2
-2.0	-4.5	$LP_A$	77.925	-1.6	6.4	1.6
-2.0	-5.5	$LP_1$	88.760	0.6	9.0	1.9
-2.0	-5.5	$LP_2$	87.962	-1.4	7.1	1.9
-2.0	-5.5	$LP_A$	87.861	-0.4	8.1	1.3

Table 6:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 3.0\%$

## SWARM LP ION SATURATION CURRENT C05

$n$ $10^{10} m^{-3}$	$Te$ $0.156 eV$	$Ti$ $0.116 eV$	$m_{eff}$ $8.3 amu$	$\lambda_D$ $29.4 mm$	$v_d$ $7673 m/s$	
$V_f$ $V$	$V_p$ $V$	$LP_x$	$I_{sim}$ $nA$	$\epsilon_{I_{OML}}$ $\%$	$\epsilon_{I_{OML16}}$ $\%$	$\delta I_{sim}$ $\%$
-0.513	-3.013	$LP_1$	1.217	-7.8	20.8	1.3
-0.513	-3.013	$LP_2$	1.222	-7.4	21.1	1.3
-0.513	-3.013	$LP_A$	1.220	-7.6	21.0	0.9
-0.513	-4.013	$LP_1$	1.448	-6.7	25.0	1.1
-0.513	-4.013	$LP_2$	1.443	-7.1	24.8	1.1
-0.513	-4.013	$LP_A$	1.446	-6.9	24.9	0.7
-1.0	-3.5	$LP_1$	1.191	-19.6	14.1	1.4
-1.0	-3.5	$LP_2$	1.211	-17.7	15.5	1.4
-1.0	-3.5	$LP_A$	1.201	-18.7	14.8	1.0
-1.0	-4.5	$LP_1$	1.392	-19.2	17.7	1.1
-1.0	-4.5	$LP_2$	1.399	-18.5	18.2	1.0
-1.0	-4.5	$LP_A$	1.396	-18.8	17.9	0.7
-2.0	-4.5	$LP_1$	1.136	-46.0	-0.8	1.7
-2.0	-4.5	$LP_2$	1.153	-43.9	0.6	1.7
-2.0	-4.5	$LP_A$	1.145	-44.9	0.0	1.2
-2.0	-5.5	$LP_1$	1.300	-45.5	2.5	1.1
-2.0	-5.5	$LP_2$	1.328	-42.4	4.6	1.1
-2.0	-5.5	$LP_A$	1.314	-44.0	3.6	0.8

Table 7:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 0.7\%$



## SWARM LP ION SATURATION CURRENT C06

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$3.16 \times 10^{10} m^{-3}$	$0.140 \text{ eV}$	$0.113 \text{ eV}$	$11.4 \text{ amu}$	$15.7 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	%	%	%
-0.454	-2.954	$LP_1$	3.497	-0.2	13.6	1.5
-0.454	-2.954	$LP_2$	3.545	1.2	14.7	1.5
-0.454	-2.954	$LP_A$	3.521	0.5	14.2	1.1
-1.0	-3.5	$LP_1$	3.647	-4.1	11.3	1.5
-1.0	-3.5	$LP_2$	3.680	-3.2	12.1	1.5
-1.0	-3.5	$LP_A$	3.663	-3.6	11.7	1.1
-1.0	-4.5	$LP_1$	4.187	-3.5	13.6	1.2
-1.0	-4.5	$LP_2$	4.256	-1.8	15.0	1.1
-1.0	-4.5	$LP_A$	4.222	-2.7	14.3	0.8
-2.0	-4.5	$LP_1$	3.771	-15.0	4.0	1.9
-2.0	-4.5	$LP_2$	3.809	-13.8	5.0	1.9
-2.0	-4.5	$LP_A$	3.790	-14.4	4.5	1.36
-2.0	-5.5	$LP_1$	4.245	-14.8	5.6	1.2
-2.0	-5.5	$LP_2$	4.304	-13.2	7.0	1.2
-2.0	-5.5	$LP_A$	4.275	-14.0	6.3	0.8

Table 8:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.3\%$

## SWARM LP ION SATURATION CURRENT C07

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$10.0 \times 10^{10} m^{-3}$	$0.140 \text{ eV}$	$0.112 \text{ eV}$	$13.0 \text{ amu}$	$8.8 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-0.443	-2.943	$LP_1$	10.730	2.6	11.0	1.3
-0.443	-2.943	$LP_2$	10.902	4.2	12.4	1.3
-0.443	-2.943	$LP_A$	10.816	3.4	11.7	0.9
-1.0	-3.5	$LP_1$	11.106	-1.6	7.9	2.0
-1.0	-3.5	$LP_2$	11.518	2.0	11.2	2.0
-1.0	-3.5	$LP_A$	11.312	0.2	9.5	1.4
-1.0	-4.5	$LP_1$	12.949	1.3	11.6	1.5
-1.0	-4.5	$LP_2$	13.3	3.8	13.8	1.4
-1.0	-4.5	$LP_A$	13.116	2.5	12.7	1.0
-2.0	-4.5	$LP_1$	12.383	-3.2	7.5	2.2
-2.0	-4.5	$LP_2$	12.365	-3.4	7.4	2.2
-2.0	-4.5	$LP_A$	12.374	-3.3	7.4	1.5
-2.0	-5.5	$LP_1$	13.972	-2.2	9.3	1.4
-2.0	-5.5	$LP_2$	14.120	-1.1	10.2	1.3
-2.0	-5.5	$LP_A$	14.046	-1.7	9.8	1.0

Table 9:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 2.2\%$

## SWARM LP ION SATURATION CURRENT C08

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$31.6 \times 10^{10} m^{-3}$	$0.140 \text{ eV}$	$0.089 \text{ eV}$	$15.9 \text{ amu}$	$5.0 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-0.437	-2.937	$LP_1$	31.629	3.0	3.9	1.5
-0.437	-2.937	$LP_2$	31.534	2.7	3.6	1.6
-0.437	-2.937	$LP_A$	31.581	2.9	3.7	1.1
-1.0	-3.5	$LP_1$	33.473	1.8	2.6	1.7
-1.0	-3.5	$LP_2$	33.097	0.7	1.5	1.6
-1.0	-3.5	$LP_A$	33.285	1.2	2.1	1.2
-1.0	-4.5	$LP_1$	37.917	3.0	3.8	1.7
-1.0	-4.5	$LP_2$	37.744	2.5	3.3	1.7
-1.0	-4.5	$LP_A$	37.830	2.7	3.5	1.2
-2.0	-4.5	$LP_1$	36.316	-1.3	-0.5	1.8
-2.0	-4.5	$LP_2$	36.057	-2.0	-1.2	1.8
-2.0	-4.5	$LP_A$	36.187	-1.7	-0.8	1.3
-2.0	-5.5	$LP_1$	41.0442	0.8	1.6	1.4
-2.0	-5.5	$LP_2$	40.900	0.5	1.3	1.4
-2.0	-5.5	$LP_A$	40.972	0.6	1.5	1.0

Table 10:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.1\%$

## SWARM LP ION SATURATION CURRENT C09

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$3.16 \times 10^{10} m^{-3}$	$0.210 \text{ eV}$	$0.120 \text{ eV}$	$12.6 \text{ amu}$	$19.2 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	%	%	%
-0.719	-3.219	$LP_1$	3.481	0.4	10.2	1.5
-0.719	-3.219	$LP_2$	3.466	0.0	9.8	1.5
-0.719	-3.219	$LP_A$	3.474	0.2	10.0	1.0
-1.0	-3.5	$LP_1$	3.514	-2.5	8.0	1.5
-1.0	-3.5	$LP_2$	3.522	-2.3	8.2	1.5
-1.0	-3.5	$LP_A$	3.518	-2.4	8.1	1.0
-1.0	-4.5	$LP_1$	4.059	-0.7	10.8	1.1
-1.0	-4.5	$LP_2$	4.002	-2.2	9.6	1.2
-1.0	-4.5	$LP_A$	4.031	-1.4	10.2	0.8
-2.0	-4.5	$LP_1$	3.621	-12.8	0.1	1.8
-2.0	-4.5	$LP_2$	3.624	-12.8	0.1	1.8
-2.0	-4.5	$LP_A$	3.623	-12.8	0.1	1.2
-2.0	-5.5	$LP_1$	4.067	-12.4	1.5	1.2
-2.0	-5.5	$LP_2$	4.100	-11.5	2.3	1.2
-2.0	-5.5	$LP_A$	4.084	-11.9	1.9	0.9

Table 11:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.2\%$

## SWARM LP ION SATURATION CURRENT C10

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$10.0 \times 10^{10} m^{-3}$	$0.220 \text{ eV}$	$0.107 \text{ eV}$	$11.3 \text{ amu}$	$11.0 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	%	%	%
-0.752	-3.252	$LP_1$	11.689	0.3	15.1	1.1
-0.752	-3.252	$LP_2$	11.884	2.0	16.5	1.1
-0.752	-3.252	$LP_A$	11.787	1.1	15.8	0.8
-1.0	-3.5	$LP_1$	12.012	-0.6	14.8	1.7
-1.0	-3.5	$LP_2$	11.977	-0.8	14.6	1.7
-1.0	-3.5	$LP_A$	11.995	-0.7	14.7	1.2
-1.0	-4.5	$LP_1$	13.768	-0.2	16.8	1.2
-1.0	-4.5	$LP_2$	13.754	-0.3	16.7	1.2
-1.0	-4.5	$LP_A$	13.761	-0.3	16.8	0.8
-2.0	-4.5	$LP_1$	13.043	-5.8	12.2	2.1
-2.0	-4.5	$LP_2$	13.125	-5.2	12.7	2.1
-2.0	-4.5	$LP_A$	13.084	-5.5	12.5	1.5
-2.0	-5.5	$LP_1$	14.753	-5.2	14.1	1.4
-2.0	-5.5	$LP_2$	14.761	-5.2	14.1	1.4
-2.0	-5.5	$LP_A$	14.757	-5.2	14.1	1.0

Table 12:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.0\%$

## SWARM LP ION SATURATION CURRENT C11

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$10.0 \times 10^{10} m^{-3}$	$0.280 \text{ eV}$	$0.121 \text{ eV}$	$16.0 \text{ amu}$	$12.4 \text{ mm}$	$7673 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-0.990	-3.490	$LP_1$	10.583	2.5	3.4	1.3
-0.990	-3.490	$LP_2$	10.607	2.7	3.7	1.3
-0.990	-3.490	$LP_A$	10.595	2.6	3.5	0.9
-1.0	-3.5	$LP_1$	10.616	2.7	3.6	1.8
-1.0	-3.5	$LP_2$	10.402	0.7	1.6	1.8
-1.0	-3.5	$LP_A$	10.509	1.7	2.6	1.3
-1.0	-4.5	$LP_1$	11.948	3.2	4.1	1.3
-1.0	-4.5	$LP_2$	12.001	3.7	4.6	1.3
-1.0	-4.5	$LP_A$	11.974	3.4	4.4	0.9
-2.0	-4.5	$LP_1$	11.482	-0.7	0.3	2.2
-2.0	-4.5	$LP_2$	11.723	1.4	2.3	2.2
-2.0	-4.5	$LP_A$	11.603	0.4	1.3	1.6
-2.0	-5.5	$LP_1$	12.723	-0.5	0.4	1.6
-2.0	-5.5	$LP_2$	12.787	0.0	0.9	1.6
-2.0	-5.5	$LP_A$	12.755	-0.3	0.6	1.1

Table 13:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 2.0\%$

## SWARM LP ION SATURATION CURRENT C12

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$3.16 \times 10^{10} m^{-3}$	$0.070 \text{ eV}$	$0.070 \text{ eV}$	$7.4.0 \text{ amu}$	$11.1 \text{ mm}$	$8173 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-1.0	-4.5	$LP_1$	5.182	-7.7	29.8	2.2
-1.0	-4.5	$LP_2$	5.424	-2.9	33.0	2.1
-1.0	-4.5	$LP_A$	5.303	-5.2	31.4	1.5
-2.0	-5.5	$LP_1$	5.105	-24.7	21.7	2.1
-2.0	-5.5	$LP_2$	5.278	-20.6	24.3	2.2
-2.0	-5.5	$LP_A$	5.192	-22.7	23.0	1.5

Table 14:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 3.9\%$

## SWARM LP ION SATURATION CURRENT C13

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$10.0 \times 10^{10} m^{-3}$	$0.070 \text{ eV}$	$0.068 \text{ eV}$	$5.9 \text{ amu}$	$6.2 \text{ mm}$	$8173 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-1.0	-4.5	$LP_1$	20.403	-0.7	43.6	2.6
-1.0	-4.5	$LP_2$	20.457	-0.4	43.8	2.6
-1.0	-4.5	$LP_A$	20.430	-0.5	43.7	1.9
-1.0	-5.5	$LP_1$	21.680	-9.2	41.6	2.6
-1.0	-5.5	$LP_2$	21.985	-7.6	42.5	2.6
-1.0	-5.5	$LP_A$	21.832	-8.4	42.1	1.8

Table 15:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 0.8\%$

## SWARM LP ION SATURATION CURRENT C14

$n$ $10^{10} m^{-3}$	$Te$ $0.156 \text{ eV}$	$Ti$ $0.116 \text{ eV}$	$m_{eff}$ $8.3 \text{ amu}$	$\lambda_D$ $29.4 \text{ mm}$	$v_d$ $8173 \text{ m/s}$	
$V_f$ $V$	$V_p$ $V$	$LP_x$	$I_{sim}$ $nA$	$\epsilon_{I_{OML}}$ $\%$	$\epsilon_{I_{OML16}}$ $\%$	$\delta I_{sim}$ $\%$
-1.0	-4.5	$LP_1$	1.389	-17.8	17.2	1.7
-1.0	-4.5	$LP_2$	1.399	-18.0	17.8	1.8
-1.0	-4.5	$LP_A$	1.394	-17.4	17.5	1.2
-2.0	-5.5	$LP_1$	1.318	-40.8	4.0	2.9
-2.0	-5.5	$LP_2$	1.309	-41.7	3.4	3.0
-2.0	-5.5	$LP_A$	1.314	-41.3	3.7	2.1

Table 16:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.0\%$

## SWARM LP ION SATURATION CURRENT C15

$n$ $10.0 \times 10^{10} m^{-3}$	$Te$ $0.280 \text{ eV}$	$Ti$ $0.121 \text{ eV}$	$m_{eff}$ $16.0 \text{ amu}$	$\lambda_D$ $12.4 \text{ mm}$	$v_d$ $8173 \text{ m/s}$	
$V_f$ $V$	$V_p$ $V$	$LP_x$	$I_{sim}$ $nA$	$\epsilon_{I_{OML}}$ $\%$	$\epsilon_{I_{OML16}}$ $\%$	$\delta I_{sim}$ $\%$
-1.0	-4.5	$LP_1$	12.167	4.8	5.4	3.2
-1.0	-4.5	$LP_2$	11.810	1.9	2.6	3.2
-1.0	-4.5	$LP_A$	11.989	3.3	4.0	2.3
-2.0	-5.5	$LP_1$	12.725	-0.1	0.6	2.1
-2.0	-5.5	$LP_2$	12.794	0.4	1.1	2.1
-2.0	-5.5	$LP_A$	12.759	0.2	0.8	1.5

Table 17:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.3\%$



## SWARM LP ION SATURATION CURRENT C16

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$3.16 \times 10^{10} m^{-3}$	$0.070 \text{ eV}$	$0.070 \text{ eV}$	$7.4 \text{ amu}$	$11.1 \text{ mm}$	$7173 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-1.0	-4.5	$LP_1$	5.366	-8.5	32.6	1.8
-1.0	-4.5	$LP_2$	5.360	-8.6	32.5	1.8
-1.0	-4.5	$LP_A$	5.363	-8.6	32.5	1.3
-2.0	-5.5	$LP_1$	5.193	-29.4	22.4	2.2
-2.0	-5.5	$LP_2$	5.167	-30.8	22.0	2.2
-2.0	-5.5	$LP_A$	5.180	-29.7	22.2	1.6

Table 18:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 0.3\%$

## SWARM LP ION SATURATION CURRENT C17

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$10.0 \times 10^{10} m^{-3}$	$0.070 \text{ eV}$	$0.068 \text{ eV}$	$5.9 \text{ amu}$	$6.2 \text{ mm}$	$7173 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	$\%$	$\%$	$\%$
-1.0	-4.5	$LP_1$	21.069	-3.0	45.7	2.6
-1.0	-4.5	$LP_2$	21.591	-0.5	47.0	2.6
-1.0	-4.5	$LP_A$	21.330	-1.7	46.3	1.8
-2.0	-5.5	$LP_1$	22.216	-13.7	42.6	2.4
-2.0	-5.5	$LP_2$	22.428	-12.6	43.1	2.4
-2.0	-5.5	$LP_A$	22.322	-13.1	42.9	1.7

Table 19:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.7\%$

## SWARM LP ION SATURATION CURRENT C18

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$10^{10} m^{-3}$	$0.156 \text{ eV}$	$0.116 \text{ eV}$	$8.3 \text{ amu}$	$29.4 \text{ mm}$	$7173 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	%	%	%
-1.0	-4.5	$LP_1$	1.401	-20.5	18.3	1.6
-1.0	-4.5	$LP_2$	1.410	-19.7	18.8	1.6
-1.0	-4.5	$LP_A$	1.405	-20.1	18.5	1.1
-2.0	-5.5	$LP_1$	1.303	-48.6	2.1	2.0
-2.0	-5.5	$LP_2$	1.322	-46.4	3.5	2.0
-2.0	-5.5	$LP_A$	1.313	-48.5	2.9	1.4

Table 20:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 1.1\%$

## SWARM LP ION SATURATION CURRENT C19

$n$	$Te$	$Ti$	$m_{eff}$	$\lambda_D$	$v_d$	
$10.0 \times 10^{10} m^{-3}$	$0.280 \text{ eV}$	$0.121 \text{ eV}$	$16.0 \text{ amu}$	$12.4 \text{ mm}$	$7173 \text{ m/s}$	
$V_f$	$V_p$	$LP_x$	$I_{sim}$	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	$\delta I_{sim}$
$V$	$V$		$nA$	%	%	%
-1.0	-4.5	$LP_1$	11.850	2.6	3.4	2.4
-1.0	-4.5	$LP_2$	12.114	4.7	5.5	2.5
-1.0	-4.5	$LP_A$	11.982	3.7	4.5	1.7
-2.0	-5.5	$LP_1$	12.573	-2.2	-1.4	2.5
-2.0	-5.5	$LP_1$	12.907	0.4	1.2	2.5
-2.0	-5.5	$LP_1$	12.740	-0.9	-0.1	1.7

Table 21:  $I_{sim}$  are the ion currents calculated from simulations.  $\epsilon_{I_{OML}}$  and  $\epsilon_{I_{OML16}}$  are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively.  $\delta I_{sim}$  is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation.  $\delta_{mesh} = 2.4\%$

## INFERRED PLASMA DENSITY FROM SWARM LP

$n$ $10^{10} m^{-3}$	$Te$ $eV$	$Ti$ $eV$	$m_{eff}$ $amu$	$\lambda_D$ $mm$	$V_f$ $V$	$LP_x$	$\epsilon_{n_I}$ %	$\delta_{n_I}$ %	$\epsilon_n$ %	$\epsilon_{n_{16}}$ %	$\delta_n$ %
3.16	0.070	0.070	7.4	11.1	-0.201	$LP_1$	3.1	1.8	8.7	58.0	8.3
					-0.201	$LP_2$	4.5	1.8	12.5	59.7	8.0
					-0.201	$LP_A$	3.8	1.2	10.6	58.9	5.7
					-1.0	$LP_1$	-8.5	2.2	2.0	54.9	11.4
					-1.0	$LP_2$	-5.6	2.1	-2.0	53.1	12.0
					-1.0	$LP_A$	-7.0	1.5	0.0	54.0	8.3
					-2.0	$LP_1$	-27.7	1.6	-23.0	43.4	10.7
					-2.0	$LP_2$	-26.2	1.6	-16.0	46.6	10.2
					-2.0	$LP_A$	-26.9	1.2	-19.4	45.1	7.4
10.00	0.070	0.068	5.9	6.2	-0.195	$LP_1$	3.9	2.2	1.5	63.9	10.3
					-0.195	$LP_2$	4.6	2.2	9.2	66.7	9.7
					-0.195	$LP_A$	4.2	1.6	5.5	65.4	7.0
					-1.0	$LP_1$	-3.0	2.7	-2.8	62.3	14.2
					-1.0	$LP_2$	-3.0	2.7	7.2	66.0	12.9
					-1.0	$LP_A$	-3.0	1.9	2.5	64.2	9.6
					-2.0	$LP_1$	-12.9	3.1	0.1	63.4	17.6
					-2.0	$LP_2$	-12.8	3.1	4.8	65.1	16.8
					-2.0	$LP_A$	-12.8	2.2	2.5	64.2	12.2
31.6	0.070	0.070	4.1	3.5	-1.0	$LP_1$	-4.1	2.4	-8.3	72.0	11.9
					-1.0	$LP_2$	-6.4	2.4	7.8	76.2	9.9
					-1.0	$LP_A$	-5.2	1.7	-0.4	74.3	7.6
					-2.0	$LP_1$	-13.9	1.9	-3.6	73.2	10.1
					-2.0	$LP_2$	-11.6	1.9	-3.4	73.3	10.3
					-2.0	$LP_A$	-12.7	1.4	-3.5	73.3	7.2
63.2	0.082	0.079	13.7	2.7	-1.0	$LP_1$	-0.5	3.0	28.0	38.3	16.5
					-1.0	$LP_2$	1.7	2.9	-2.0	12.6	23.3
					-1.0	$LP_A$	0.6	2.1	15.6	27.6	13.6
					-2.0	$LP_1$	-3.8	3.1	27.8	38.1	19.0
					-2.0	$LP_2$	0.6	3.0	-24.1	-6.4	32.4
					-2.0	$LP_A$	-1.5	2.2	8.7	21.7	16.9

$n$ $10^{10}m^{-3}$	$Te$ $eV$	$Ti$ $eV$	$m_{eff}$ $amu$	$\lambda_D$ $mm$	$V_f$ $V$	$LP_x$	$\epsilon_{n_I}$ %	$\delta_{n_I}$ %	$\epsilon_n$ %	$\epsilon_{n16}$ %	$\delta_n$ %
1.00	0.156	0.116	8.3	29.4	-0.513	$LP_1$	-7.8	1.8	-1.1	47.1	9.7
					-0.513	$LP_2$	-7.4	1.8	-5.3	44.9	10.0
					-0.513	$LP_A$	-7.6	1.3	-3.1	46.0	7.0
					-1.0	$LP_1$	-19.6	1.9	-16.4	39.0	11.1
					-1.0	$LP_2$	-17.7	1.8	-23.3	35.4	11.8
					-1.0	$LP_A$	-17.7	1.3	-19.8	37.3	8.1
					-2.0	$LP_1$	-46.0	2.1	-42.5	25.4	14.8
					-2.0	$LP_2$	-43.9	2.1	-32.7	30.5	14.0
					-2.0	$LP_A$	-44.9	1.5	-37.5	28.0	10.2
3.16	0.140	0.113	11.4	15.7	-1.0	$LP_1$	-4.1	2.0	0.5	28.7	13.6
					-1.0	$LP_2$	-3.2	2.0	6.7	33.1	12.8
					-1.0	$LP_A$	-3.6	1.4	3.7	30.9	9.3
					-2.0	$LP_1$	-15.0	2.3	-13.5	18.6	18.6
					-2.0	$LP_2$	-13.8	2.4	-8.7	22.1	18.1
					-2.0	$LP_A$	-14.4	1.7	-11.1	20.4	13.0
10.0	0.140	0.112	13.0	8.8	-1.0	$LP_1$	-1.6	2.6	18.7	33.8	15.8
					-1.0	$LP_2$	2.0	2.6	15.2	30.9	16.8
					-1.0	$LP_A$	0.2	1.8	17.0	32.4	11.5
					-2.0	$LP_1$	-3.2	2.7	5.7	23.2	20.7
					-2.0	$LP_2$	-3.4	2.7	14.7	30.4	18.7
					-2.0	$LP_A$	-3.3	1.9	10.4	27.0	13.9

$n$ $10^{10} m^{-3}$	$Te$ $eV$	$Ti$ $eV$	$m_{eff}$ $amu$	$\lambda_D$ $mm$	$V_f$ $V$	$LP_x$	$\epsilon_{n_I}$ %	$\delta_{n_I}$ %	$\epsilon_n$ %	$\epsilon_{n16}$ %	$\delta_n$ %
31.6	0.140	0.089	15.9	5.0	-1.0	$LP_1$	1.8	2.6	11.8	12.5	19.2
					-1.0	$LP_2$	0.7	2.6	15.7	16.3	18.3
					-1.0	$LP_A$	1.2	1.8	13.8	14.4	13.2
					-2.0	$LP_1$	-1.3	2.4	17.1	17.8	18.8
					-2.0	$LP_2$	-2.0	2.4	19.1	19.7	18.1
					-2.0	$LP_A$	-1.7	1.7	18.1	18.7	13.0
3.16	0.210	0.120	12.6	19.2	-1.0	$LP_1$	-2.5	2.0	11.2	29.2	12.6
					-1.0	$LP_2$	-2.3	2.0	-1.0	19.6	14.4
					-1.0	$LP_A$	-2.4	1.4	5.5	24.7	9.5
					-2.0	$LP_1$	-12.8	2.2	-8.6	13.5	18.2
					-2.0	$LP_2$	-12.8	2.2	-1.6	19.1	16.9
					-2.0	$LP_A$	-12.8	1.6	-5.0	16.4	12.4
10.0	0.220	0.107	11.3	11.0	-1.0	$LP_1$	-0.6	2.2	1.9	30.5	15.0
					-1.0	$LP_2$	-0.8	2.2	3.0	31.3	14.8
					-1.0	$LP_A$	-0.7	1.6	2.5	30.9	10.5
					-2.0	$LP_1$	-5.8	2.7	-0.7	28.6	20.2
					-2.0	$LP_2$	-5.2	2.6	-5.3	25.4	21.3
					-2.0	$LP_A$	-5.5	1.9	-2.9	27.0	14.7
10.0	0.280	0.121	16.0	12.4	-1.0	$LP_1$	2.8	2.3	8.0	8.3	18.5
					-1.0	$LP_2$	0.8	2.4	23.4	23.6	15.4
					-1.0	$LP_A$	1.8	1.7	16.4	16.7	11.9
					-2.0	$LP_1$	-0.5	2.8	1.4	1.6	25.7
					-2.0	$LP_2$	1.5	2.8	-15.0	-14.7	30.9
					-2.0	$LP_A$	0.5	2.0	-6.2	-5.9	19.9

Table 22: Relative errors in the inferred density calculated from probe simulations results.  $\epsilon_{I_{pic}}$  is the relative error when Eq. 1 is used to infer density.  $\epsilon_n$  and  $\epsilon_{n_I}$ , correspond to relative error in inferred density when Eq. 5 and 7 are used respectively.  $\delta_{n_I}$  and  $\delta_n$  represents the relative uncertainties in their respective inferred densities. Positive errors indicate that calculated density is overestimated while negative signs refer to an underestimation. In all cases, ram velocity is 7673 m/s.

## ELECTRON LINEAR AND RETARDATION CURRENTS C05

$n$ $10^{10} m^{-3}$	$Te$ $0.156 \text{ eV}$	$T_i$ $0.116 \text{ eV}$	$m_{eff}$ $8.3$	$\lambda_D$ $29.4 \text{ mm}$	$v_d$ $7673 \text{ m/s}$	
$LP_x$	Swarm Bus Included	$ \vec{B} $ $\mu T$	$V_p$ $V$	$I_{sim}$ $nA$	$\epsilon_{I_{OML}}$ $\%$	$\delta_{I_{sim}}$ $\%$
LP1	No	0	0.196	-45.267	1.2	0.1
LP1	No	0	0.496	-86.456	1.4	0.1
LP1	No	0	-0.168	-6.044	4.3	0.3
LP1	No	0	-0.138	-7.498	4.5	0.3
LP1	No	0	-0.109	-9.214	4.9	0.2
LP1	No	37.6	0.197	-40.871	-9.4	0.1
LP1	No	37.6	0.497	-71.750	-18.9	0.1
LP1	No	37.6	-0.236	-3.615	4.2	0.4
LP1	No	37.6	-0.207	-4.508	4.2	0.3
LP1	No	37.6	-0.178	-5.597	4.5	0.3
LP1	Yes	0	0.186	-36.179	-20.4	0.4
LP2	Yes	0	0.186	-35.535	-22.6	0.4
LPA	Yes	0	0.186	-35.857	-21.5	0.4
LP1	Yes	0	0.485	-72.408	-14.5	0.3
LP2	Yes	0	0.485	-73.237	-13.2	0.3
LPA	Yes	0	0.485	-72.822	-13.9	0.3
LP1	Yes	0	-0.136	-6.872	-10.4	0.8
LP2	Yes	0	-0.136	-6.965	-9.0	0.8
LPA	Yes	0	-0.136	-6.918	-9.7	0.8
LP1	Yes	0	-0.107	-8.577	-8.2	0.7
LP2	Yes	0	-0.107	-8.498	-9.2	0.7
LPA	Yes	0	-0.107	-8.537	-8.7	0.7
LP1	Yes	0	-0.078	-10.332	-9.4	0.6
LP2	Yes	0	-0.078	-10.379	-8.9	0.6
LPA	Yes	0	-0.078	-10.355	-9.2	0.6

Satellite floating potential  $V_f = -1$  V.

$n$ $10^{10} m^{-3}$	$Te$ $0.156$ eV	$T_i$ $0.116$ eV	$m_{eff}$ 8.3	$\lambda_D$ $29.4$ mm	$v_d$ $7673$ m/s	
$LP_x$	Swarm Bus Included	$ \vec{B} $ $\mu T$	$V_p$ V	$I_{sim}$ nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	0	0.186	-24.033	-81.2	1.8
LP2	Yes	0	0.186	-23.920	-82.1	1.8
LPA	Yes	0	0.186	-23.976	-81.6	1.8
LP1	Yes	0	0.485	-51.631	-60.6	1.3
LP2	Yes	0	0.485	-50.668	-63.7	1.3
LPA	Yes	0	0.485	-51.149	-62.1	1.3
LP1	Yes	0	-0.136	-6.018	-26.1	1.8
LP2	Yes	0	-0.136	-6.017	-26.1	1.6
LPA	Yes	0	-0.136	-6.018	-26.1	1.7
LP1	Yes	0	-0.107	-7.173	-29.3	1.6
LP2	Yes	0	-0.107	-7.287	-30.1	1.5
LPA	Yes	0	-0.107	-7.151	-29.7	1.6
LP1	Yes	0	-0.078	-8.404	-34.5	1.5
LP2	Yes	0	-0.078	-8.339	-35.6	1.5
LPA	Yes	0	-0.078	-8.372	-35.0	1.5

Satellite floating potential  $V_f = -2$  V.

$n$ $10^{10} m^{-3}$	$Te$ $0.156$ eV	$T_i$ $0.116$ eV	$m_{eff}$ 8.3	$\lambda_D$ $29.4$ mm	$v_d$ $7673$ m/s	
$LP_x$	Swarm Bus Included	$ \vec{B} $ $\mu T$	$V_p$ V	$I_{sim}$ nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	0	0.186	-7.398	-488.7	4.3
LP2	Yes	0	0.186	-7.287	-497.6	4.4
LPA	Yes	0	0.186	-7.342	-493.1	4.3
LP1	Yes	0	0.485	-15.289	-442.4	2.8
LP2	Yes	0	0.485	-14.887	-457.1	2.9
LPA	Yes	0	0.485	-15.088	-449.7	2.8
LP1	Yes	0	-0.136	-2.535	-199.3	3.6
LP2	Yes	0	-0.136	-2.462	-208.3	3.9
LPA	Yes	0	-0.136	-2.498	-203.7	3.7
LP1	Yes	0	-0.107	-2.866	-223.6	3.4
LP2	Yes	0	-0.107	-2.784	-233.2	3.8
LPA	Yes	0	-0.107	-2.825	-228.3	3.6
LP1	Yes	0	-0.078	-3.242	-248.8	3.4
LP2	Yes	0	-0.078	-3.125	-261.7	3.8
LPA	Yes	0	-0.078	-3.183	-255.1	3.6



$n$ $10^{10} m^{-3}$	$Te$ $0.156 \text{ eV}$	$T_i$ $0.116 \text{ eV}$	$m_{eff}$ $8.3$	$\lambda_D$ $29.4 \text{ mm}$	$v_d$ $7673 \text{ m/s}$	
$LP_x$	Swarm Bus Included	$ \vec{B} $ $\mu T$	$V_p$ $V$	$I_{sim}$ $nA$	$\epsilon_{IOML}$ $\%$	$\delta_{I_{sim}}$ $\%$
LP1	Yes	-37.6	0.235	-43.127	-1.3	1.0
LP2	Yes	-37.6	0.235	-40.534	-7.8	1.1
LPA	Yes	-37.6	0.235	-41.830	-4.4	1.0
LP1	Yes	-37.6	0.534	-76.634	-8.4	0.9
LP2	Yes	-37.6	0.534	-73.951	-12.3	0.9
LPA	Yes	-37.6	0.534	-75.293	-10.3	0.9
LP1	Yes	-37.6	-0.171	-5.644	26.0	1.9
LP2	Yes	-37.6	-0.171	-4.888	14.6	2.0
LPA	Yes	-37.6	-0.171	-5.266	20.7	1.9
LP1	Yes	-37.6	-0.142	-7.029	26.5	1.6
LP2	Yes	-37.6	-0.142	-6.031	14.3	1.8
LPA	Yes	-37.6	-0.142	-6.530	20.8	1.7
LP1	Yes	-37.6	-0.113	-8.597	26.0	1.5
LP2	Yes	-37.6	-0.113	-7.366	13.6	1.6
LPA	Yes	-37.6	-0.113	-7.982	20.3	1.6
LP1	Yes	+37.6	0.236	-40.708	-7.3	0.8
LP2	Yes	+37.6	0.236	-40.890	-6.8	0.8
LPA	Yes	+37.6	0.236	-40.799	-7.1	0.8
LP1	Yes	+37.6	0.535	-74.345	-11.7	0.6
LP2	Yes	+37.6	0.535	-75.426	-10.1	0.6
LPA	Yes	+37.6	0.535	-74.886	-10.9	0.6
LP1	Yes	+37.6	-0.154	-5.242	10.3	1.7
LP2	Yes	+37.6	-0.154	-5.912	20.5	1.6
LPA	Yes	+37.6	-0.154	-5.575	15.7	1.7
LP1	Yes	+37.6	-0.125	-6.518	11.0	1.5
LP2	Yes	+37.6	-0.125	-7.574	23.4	1.4
LPA	Yes	+37.6	-0.125	-7.046	17.7	1.4
LP1	Yes	+37.6	-0.096	-8.078	11.8	1.4
LP2	Yes	+37.6	-0.096	-9.342	23.7	1.3
LPA	Yes	+37.6	-0.096	-8.710	18.2	1.3

Satellite floating potential  $V_f = -2$  V.

$n$ $10^{10} m^{-3}$	$Te$ $0.156$ eV	$T_i$ $0.116$ eV	$m_{eff}$ 8.3	$\lambda_D$ $29.4$ mm	$v_d$ $7673$ m/s	
$LP_x$	Swarm Bus Included	$ \vec{B} $ $\mu T$	$V_p$ V	$I_{sim}$ nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	+37.6	-0.136	-2.379	-219.0	4.4
LP2	Yes	+37.6	-0.136	-2.734	-177.5	3.6
LPA	Yes	+37.6	-0.136	-2.556	-196.8	4.0
LP1	Yes	+37.6	-0.107	-2.713	-241.9	4.3
LP2	Yes	+37.6	-0.107	-3.090	-200.1	3.5
LPA	Yes	+37.6	-0.107	-2.902	-219.6	3.9
LP1	Yes	+37.6	-0.078	-2.982	-279.1	4.3
LP2	Yes	+37.6	-0.078	-3.422	-230.4	3.5
LPA	Yes	+37.6	-0.078	-3.202	-253.1	3.9

Table 23: Electron linear and retardation currents calculated from simulations for configuration cases considered.  $\epsilon_{I_p}$  is the relative error in the calculated current from simulations compared to predicted with OML theory Eq. 2, while  $\delta_{I_p}$  is the relative uncertainty. Positive errors indicate overestimation while negative signs refer to an underestimation.

## ELECTRON LINEAR AND RETARDATION CURRENTS C11

$n$ $10^{11} m^{-3}$	$Te$ $0.280 \text{ eV}$	$T_i$ $0.121 \text{ eV}$	$m_{eff}$ $16.0$	$\lambda_D$ $12.4 \text{ mm}$	$v_d$ $7673 \text{ m/s}$	
$LP_x$	Swarm Bus Included	$ \vec{B} $ $\mu T$	$V_p$ $V$	$I_{sim}$ $nA$	$\epsilon_{I_{OML}}$ $\%$	$\delta_{I_{sim}}$ $\%$
LP1	No	0	-0.290	-86.9	2.9	0.3
LP1	No	0	0.010	-274.3	12.2	0.2
LP1	No	0	-0.469	-41.7	1.2	0.4
LP1	No	0	-0.440	-47.1	1.5	0.3
LP1	No	0	-0.411	-53.2	1.7	0.3
LP1	No	37.6	-0.285	-88.4	2.7	0.3
LP1	No	37.6	0.015	-274.4	3.8	0.1
LP1	No	37.6	-0.467	-42.1	1.4	0.3
LP1	No	37.6	-0.438	-47.7	1.8	0.3
LP1	No	37.6	-0.409	-53.7	1.9	0.3
LP1	Yes	0	-0.291	-73.9	-10.7	1.1
LP2	Yes	0	-0.291	-75.1	-9.0	1.1
LPA	Yes	0	-0.291	-74.5	-9.8	1.1
LP1	Yes	0	0.008	-239.1	-4.8	0.6
LP2	Yes	0	0.008	-237.9	-5.3	0.6
LPA	Yes	0	0.008	-238.5	-5.1	0.6
LP1	Yes	0	-0.467	-35.1	-15.3	1.4
LP2	Yes	0	-0.467	-35.6	-13.7	1.4
LPA	Yes	0	-0.467	-35.3	-14.5	1.4
LP1	Yes	0	-0.438	-40.2	-13.6	1.3
LP2	Yes	0	-0.438	-40.2	-13.6	1.4
LPA	Yes	0	-0.438	-40.2	-13.6	1.3
LP1	Yes	0	-0.410	-44.6	-14.8	1.3
LP2	Yes	0	-0.410	-4.0	-11.2	1.3
LPA	Yes	0	-0.410	-45.3	-13.0	1.3

$n$	$T_e$	$T_i$	$m_{eff}$	$\lambda_D$	$v_d$	
$10^{11} m^{-3}$	0.280 eV	0.121 eV	16.0	12.4 mm	7673 m/s	
$LP_x$	Swarm Bus Included	$ \vec{B} $ $\mu T$	$V_p$ $V$	$I_{sim}$ $nA$	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	-37.6	-0.213	-104.607	21.5	1.7
LP2	Yes	-37.6	-0.213	-96.506	14.9	1.7
LPA	Yes	-37.6	-0.213	-100.557	18.3	1.7
LP1	Yes	-37.6	0.086	-313.017	19.6	0.9
LP2	Yes	-37.6	0.086	-294.718	14.6	0.9
LPA	Yes	-37.6	0.086	-303.868	17.2	0.9
LP1	Yes	-37.6	-0.395	-48.783	18.5	1.9
LP2	Yes	-37.6	-0.395	-44.561	10.7	1.9
LPA	Yes	-37.6	-0.395	-46.672	14.8	1.9
LP1	Yes	-37.6	-0.365	-55.635	19.3	1.8
LP2	Yes	-37.6	-0.365	-50.284	10.7	1.9
LPA	Yes	-37.6	-0.365	-52.960	15.3	1.8
LP1	Yes	-37.6	-0.336	-63.136	20.0	1.6
LP2	Yes	-37.6	-0.336	-57.028	11.4	1.7
LPA	Yes	-37.6	-0.336	-60.082	15.9	1.7
LP1	Yes	+37.6	-0.210	-94.592	12.8	1.4
LP2	Yes	+37.6	-0.210	-101.242	18.5	1.4
LPA	Yes	+37.6	-0.210	-97.917	15.8	1.4
LP1	Yes	+37.6	0.088	-292.430	14.0	0.9
LP2	Yes	+37.6	0.088	-304.611	17.4	0.8
LPA	Yes	+37.6	0.088	-298.520	15.7	0.8
LP1	Yes	+37.6	-0.388	-42.764	5.4	1.7
LP2	Yes	+37.6	-0.388	-46.757	13.5	1.6
LPA	Yes	+37.6	-0.388	-44.760	9.6	1.6
LP1	Yes	+37.6	-0.359	-48.622	6.2	1.6
LP2	Yes	+37.6	-0.359	-54.105	15.7	1.5
LPA	Yes	+37.6	-0.359	-51.363	11.2	1.5
LP1	Yes	+37.6	-0.330	-55.373	7.3	1.7
LP2	Yes	+37.6	-0.330	-60.972	15.8	1.6
LPA	Yes	+37.6	-0.330	-58.172	11.7	1.7

Table 24: Electron linear and retardation currents calculated from simulations for configuration cases considered.  $\epsilon_{I_p}$  is the relative error in the calculated current from simulations compared to predicted with OML theory Eq. 2, while  $\delta_{I_p}$  is the relative uncertainty. Positive errors indicate overestimation while negative signs refer to an underestimation.

## INFERRED ELECTRON TEMPERATURE

$n$ $10^{10} m^{-3}$	$T_e$ $eV$	$T_i$ $eV$	$m_{eff}$ $amu$	$\lambda_D$ $mm$	$V_f$ $mV$	$ \vec{B} $ $\mu T$	Swarm	$LP_x$	$\epsilon_{T_e}$ %	$\delta_{T_e}$ %
1.00	0.156	0.116	8.3	29.4	-504	0	No	LP1	-3.8	0.5
1.00	0.156	0.116	8.3	29.4	-503	37.6	No	LP1	-1.9	0.7
1.00	0.156	0.116	8.3	29.4	-514	0	Yes	LP1	-1.4	1.0
								LP2	-0.6	1.0
								LPA	-1.0	1.0
1.00	0.156	0.116	8.3	29.4	-1000	0	Yes	LP1	17.1	1.8
								LP2	19.4	1.7
								LPA	18.3	1.8
1.00	0.156	0.116	8.3	29.4	-2000	0	Yes	LP1	43.0	4.4
								LP2	44.6	4.5
								LPA	43.8	4.5
1.00	0.156	0.116	8.3	29.4	-466	-37.6	Yes	LP1	-4.1	1.8
								LP2	0.0	1.6
								LPA	-2.2	1.7
1.00	0.156	0.116	8.3	29.4	-465	+37.6	Yes	LP1	-7.2	1.7
								LP2	-12.4	1.9
								LPA	-10.0	1.8
1.00	0.156	0.116	8.3	29.4	-2000	+37.6	Yes	LP1	49.1	5.1
								LP2	47.6	5.0
								LPA	48.3	5.0
10.0	0.280	0.121	16.0	12.4	-990	0	No	LP1	-2.7	1.0
10.0	0.280	0.121	16.0	12.4	-985	37.6	No	LP1	-2.3	1.0
10.0	0.280	0.121	16.0	12.4	-990	0	Yes	LP1	3.2	2.0
								LP2	-8.9	2.3
								LPA	-2.8	2.2
10.0	0.280	0.121	16.0	12.4	-913	-37.6	Yes	LP1	-10.8	2.0
								LP2	-7.1	1.9
								LPA	-9.0	2.0
10.0	0.280	0.121	16.0	12.4	-911	+37.6	Yes	LP1	-9.7	2.0
								LP2	-14.4	2.1
								LPA	-12.1	2.1

Table 25: Relative errors in the inferred electron temperature from probe currents calculated from simulations. Two cases of plasma parameters are considered, whereas, the inclusion and orientation of a background magnetic field, as well as the presence of the Swarm satellite have been varied in both cases. The relative errors in the inferred electron temperature calculated from Eq. 8, are labeled as  $\epsilon_{T_e}$ , while  $\delta_{T_e}$  is the relative uncertainty in the estimated temperature. Positive errors indicate overestimation while negative signs refer to an underestimation. In all cases the drifting plasma speed is equal to the satellite ram velocity,  $v_{\perp} = 7673 \text{ m/s}$ .