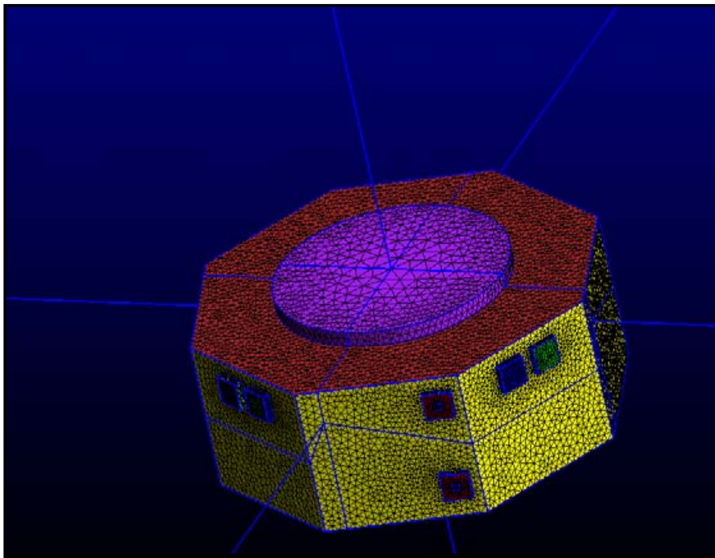

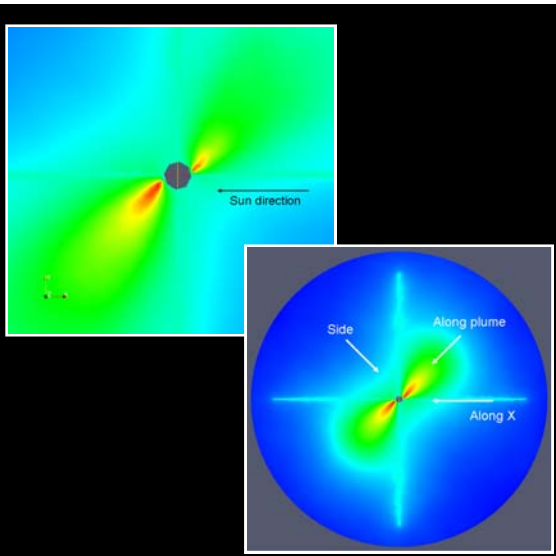

Magnetospheric Multiscale Mission (MMS): ASPOC Plume interactions

Simon Clucas / ESTEC
David Rodgers / ESTEC

SPINE Meeting
13-14 Nov 2008
ESTEC

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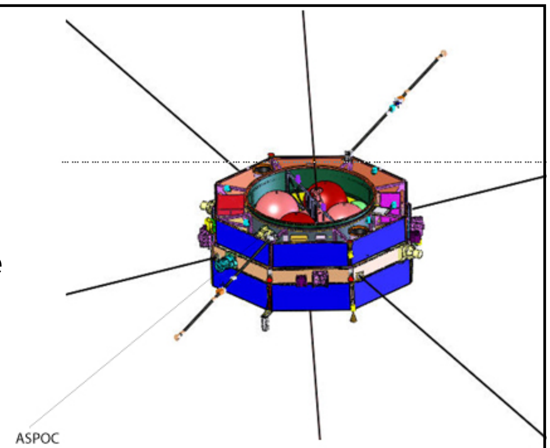
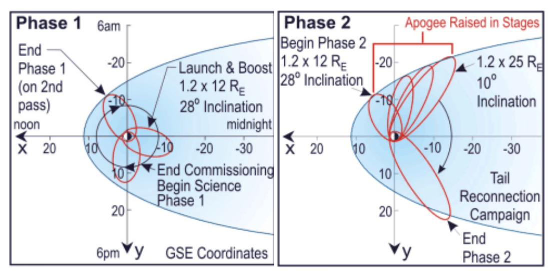
MMS SPACECRAFT / MISSION

- The Magnetospheric Multiscale (MMS) mission is a Solar-Terrestrial Probe mission comprising four identically instrumented spacecraft that will use Earth's magnetosphere as a laboratory to study the microphysics of **magnetic reconnection**



- MMS will be launched in October 2014 with a nominal mission duration of 2 years

- The instrumentation suite includes:
  - Fast Plasma Instrument
  - FIELDS
  - Active Spacecraft Potential Control (ASPOC)
  - Hot Plasma Composition Analyser
  - Energetic Particles



How does the ASPOCs effect the FIELDS and Fast Plasma instrumentation?

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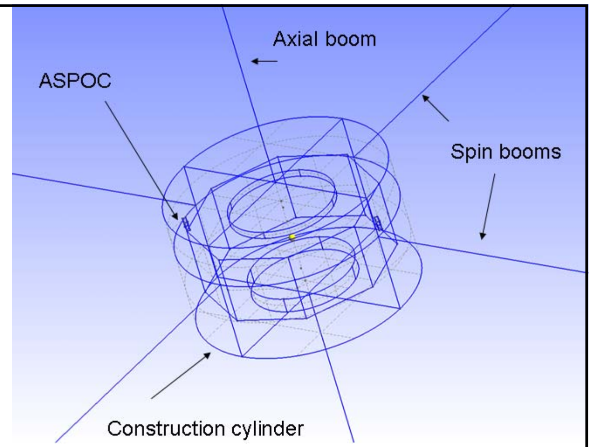
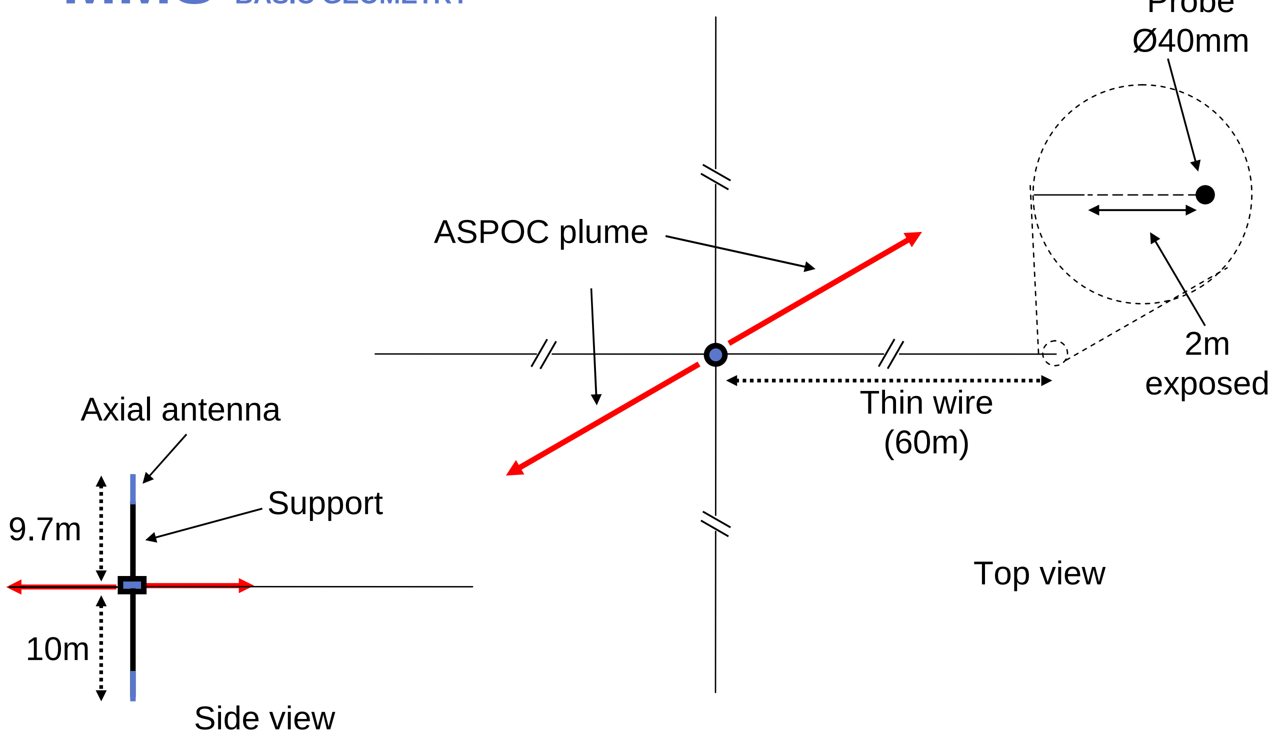
MMS BASIC GEOMETRY



- Main spacecraft geometrical considerations are
  - ASPOCs
  - Spin axis thin wire booms/ spherical probes (~60m)
  - Axial mounted antennas (~10m)
  - 4V S/C potential

- Issues include:
  - Very large simulation volume (~120m x 25m)
  - Use of thin wires
  - Small details such as spherical probes (4cm radius)

MMS BASIC GEOMETRY



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MMS SPIS MODELLING

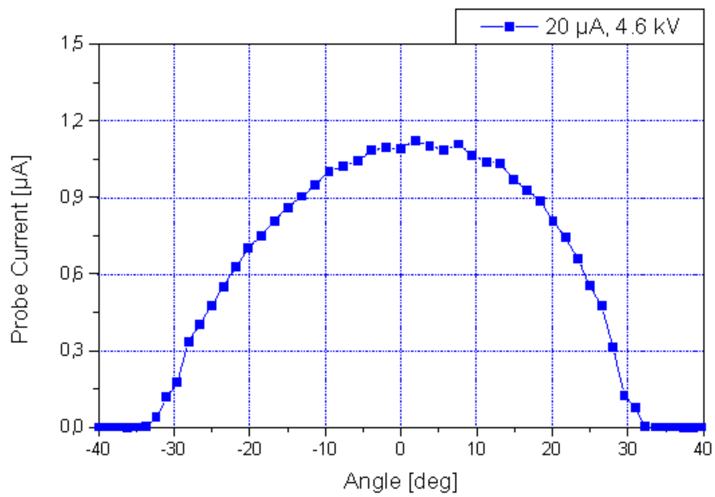
- Very challenging mesh (large memory requirements)
  - Very large simulation volume (~120m x 25m)
  - Use of SPIS thin wires
  - Very small details such as spherical probes with 4cm radius

- Simulations were attempted with and without the presence of the spin probes.

- Meshing issues and low current collection statistics have meant that no results are presented for simulations with the probes present
  - Not enough super-particles
  - Reverse tracking techniques may help

MMS ASPOC Modelling

- Two Caesium FEEPs mounted to operate in between the two spin boom wires, in the spin plane.
- Beam profiles provided
- Modelled using the Axis-symmetric source



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MMS PLASMA ENVIRONMENT

- Two plasma environments used to bound problem:
- Outer magnetosphere type – Debye~700m
  - $N \sim 10^6 \ m^{-3}$
  - T~10keV
- Interplanetary type – Debye~7m
  - $N \sim 10^6 \ m^{-3}$
  - T~1eV

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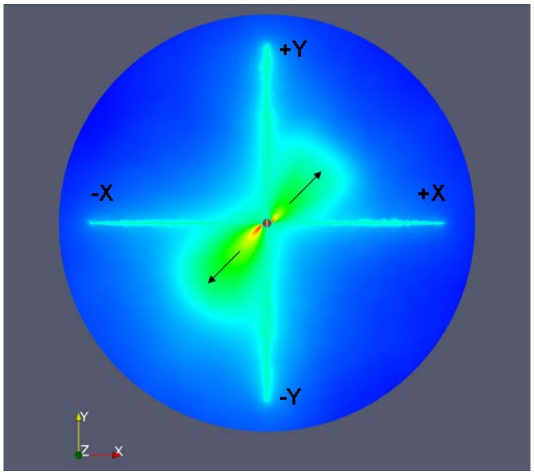
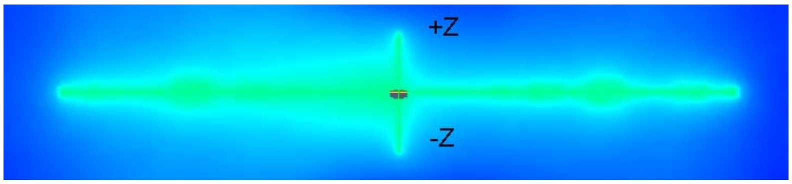
MMS PROBE LOCATIONS



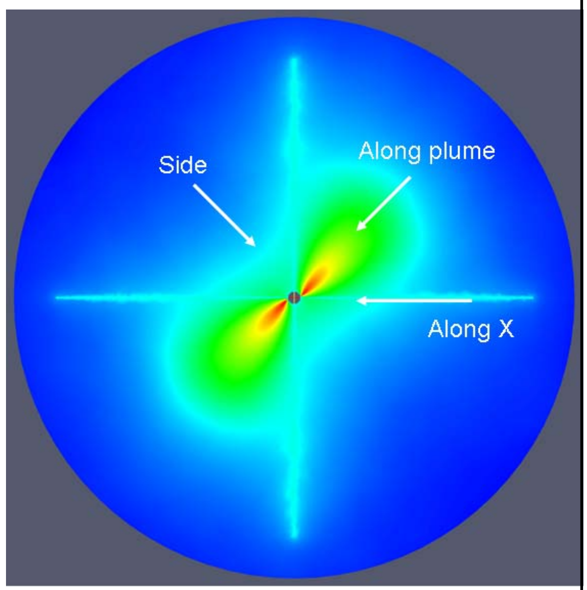
Probe locations as referred to in results table



MMS MODELLING PLAN

- Nine simulation cases were performed, covering:
  - Long (~700m) and shorter (~7m) Debye length
  - 3 sun angles (all with 4º +Z in addition)
    - Along +X direction
    - Along +X plume
    - Perpendicular to plumes
  - Eclipse
  - Both ASPOCs operating (20mA)
  - 1 ASPOC (-X) operating
    - Nominal beam current, 20mA
    - Double beam current, 40mA

- All results are fixed s/c potential (4v), self-consistent simulations could not be presented due to low statistics on the current collection

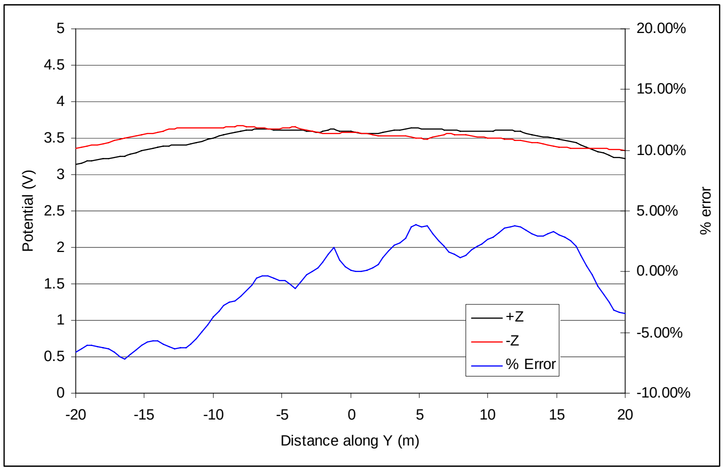


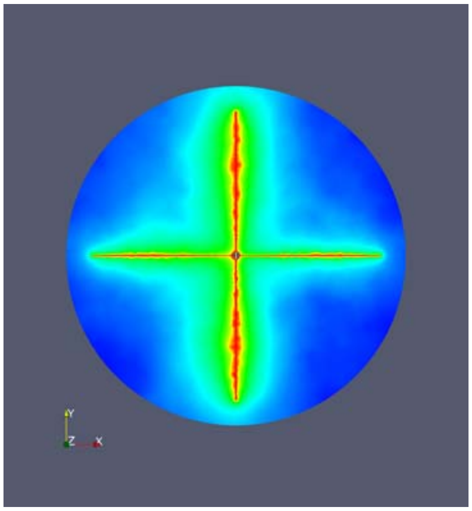
MMS MODELLING PLAN

	ASPOCS	Plasma	Sunlight	S/C Pot.
Case 1	None	Max Debye	Along X	4
Case 2	Both	Max Debye	Eclipse	4
Case 3	Both, 20mA	Max Debye	Along X	4
Case 4	Both, 20mA	Max Debye	Along plume	4
Case 5	Both, 20mA	Max Debye	Side	4
Case 6	One, -X dir. 20mA	Max Debye	Along X	4
Case 7	One, -X dir. 40mA	Max Debye	Along X	4
Case 8	None	Short Debye	Along X	4
Case 9	Both, 20mA	Short Debye	Along X	4

- Case 1 taken as a baseline
- Cases 2 to 7 will be considered as potential deltas from case 1
- Cases 8 and 9 will be considered separately

MMS MESH INDUCED ASSYMETRY





Case 2 shows the potentials with both ASPOCs in eclipse. The mesh induced asymmetry for this case is quite low at the probe/antenna positions (about 1%-1.5%).

However this error increases to 5-6% as you move away, possibly due to the mesh getting progressively courser.

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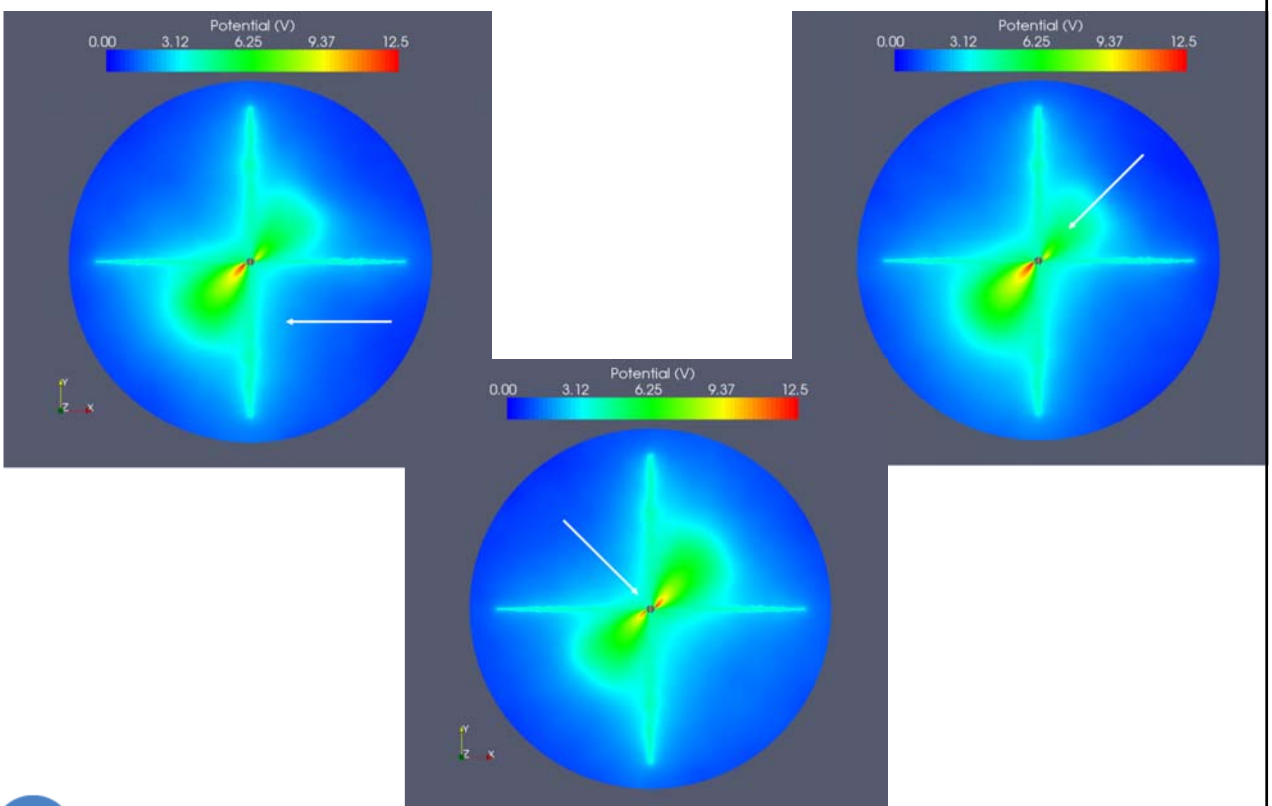
MMS SUN ANGLE EFFECT ON PLUMES



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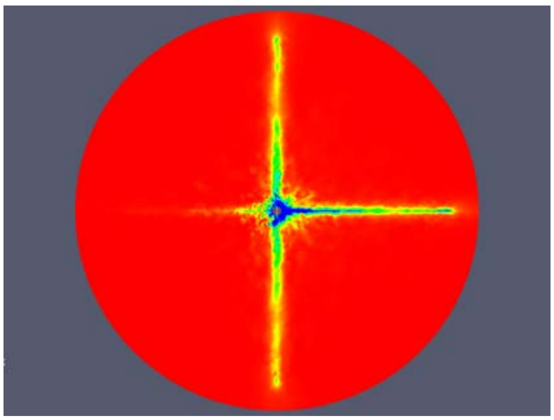
MMS RESULTS

	Baseline potential (V)	Potential deltas (V)						
	Case 1	**2-1**	**3-1**	**4-1**	**5-1**	**6-1**	**7-1**	**9-8**
-X	1.03	+0.69	+0.44	+0.56	+0.36	+0.38	+0.90	+0.24
+X	0.93	+0.75	+0.59	+0.44	+0.81	+0.08	+0.15	+0.07
-Y	1.64	+0.52	+0.54	+0.57	+0.47	+0.57	+0.92	+0.15
+Y	1.79	+0.39	+0.15	+0.02	+0.07	+0.04	+0.14	+0.08
-Z	1.96	+1.61	+1.09	+1.12	+1.19	+0.72	+1.54	+0.82
+Z	1.76	+1.82	+1.24	+1.36	+1.35	+0.95	+1.91	+0.82

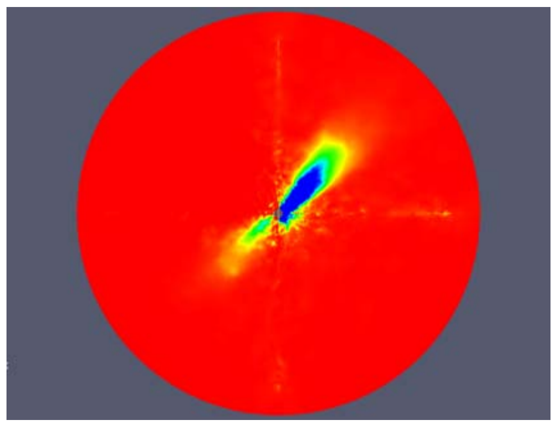
- The operation of the ASPOCs increases the potential at the spin probes (+/-X,Y) by ~0.5V and ~1.7V at the axial antennal locations (+/-Z) for long Debye
- Cases 3,4, and 5 have both ASPOCs operating with differing sun angles. In all cases the potentials at axial antennas is reduced
- For spin probes, some asymmetry is evident due to the differing location of the photoelectrons

MMS RESULTS – POPULATION OF PHOTOELECTRONS



No ASPOCs

Both ASPOCs



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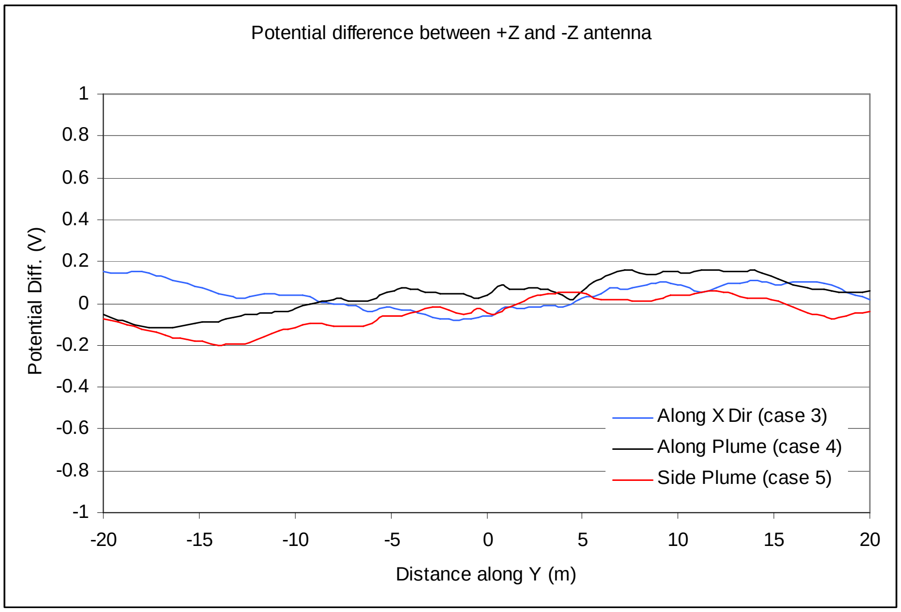
MMS RESULTS



Difference in potential between the +Z and –Z antenna for cases 3, 4, and 5

MMS RESULTS

	Baseline potential (V)	Potential deltas (V)						
	Case 1	2-1	3-1	4-1	5-1	6-1	7-1	9-8
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- Cases 6 & 7 show the 1 ASPOC case (20mA and 40mA respectively). The nominal case reduces the potentials at the +X and +Y spin probes, with the –X and –Y remaining largely unchanged.
- The potential at the axial antennas are reduced also.
- The single ASPOC case will show higher electric fields due to the asymmetry

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MMS RESULTS

	Baseline potential (V)	Potential deltas (V)						
	Case 1	2-1	3-1	4-1	5-1	6-1	7-1	9-8
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+Z	1.76	+1.82	+1.24	+1.36	+1.35	+0.95	+1.91	+0.82

- Cases 8 & 9 are identical to cases 1 & 3 except the ambient plasma conditions are chosen to give a small Debye length of about 7m.
- The potential increase at the spin probes and axial antennas are not as pronounced for the small Debye length cases (9-8) in comparison to (3-1)

THE END

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