ESA-CNES Space Environments and Radiation Effects on EEE components
Final presentations - *Status Update*

NUMERICAL SIMULATIONS OF SOLAR ORBITER AT ITS PERIHELION: SPACECRAFT CHARGING, EFFECTS ON RPW AND SWA-EAS INSTRUMENTS

Ref.: Assessment of Solar Orbiter surface charging impact on plasma instruments - ***ID:*** ESA RFP/NC/IPL-PSS/JK/jk/419-2015

STANISLAS GUILLEMANT[1,2], *M. MAKSIMOVIC[2], F. PANTELLINI[2], L. LAMY[2], A. HILGERS[3], F. CIPRIANI[3], C.-J. OWEN[4]*

1. *IRAP, 9, AVENUE DU COLONEL ROCHE, BP 44346, 31028 TOULOUSE, FRANCE*
2. *LESIA/CNRS, OBSERVATOIRE DE PARIS, 5 PLACE JULES JANSSEN, 92195 MEUDON, FRANCE*
3. *ESA HEADQUARTER, 8-10 RUE MARIO-NIKIS, 75015 PARIS, FRANCE*
4. *MSSL/UCL, DORKING, SURREY, UNITED KINGDOM*

Start and end dates:
14.10.2015 – 31.05.2017

CONTENTS

- Scientific context
- RPW study – Summary of previous results
  - Solar Orbiter and RPW modelling for SPIS simulations
  - E fields measurement principle
  - Estimations of antennas effective lengths
  - Effects of biasing currents
- SWA-EAS on-going study – Recent results
  - EAS modelling for SPIS
  - Simulations of EAS and electron measurements
    - Without EAS Baffle
    - Including EAS Baffle
- Conclusion and perspectives

SCIENTIFIC CONTEXT

Å **Solar Orbiter**

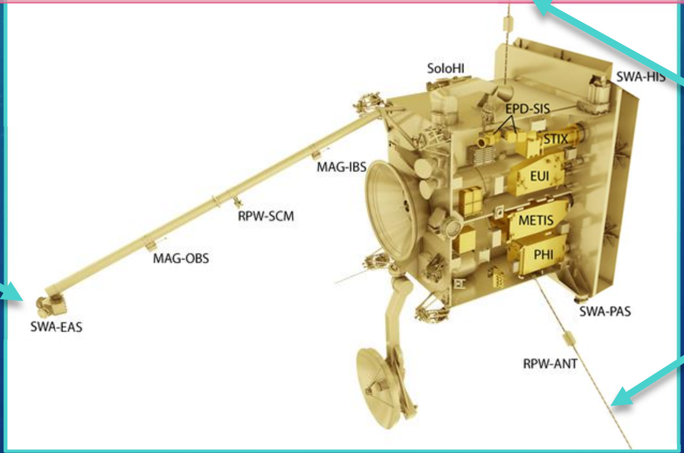
- ✓ **ESA** Mission + **NASA**, launch in 2019
- ✓ Study of the heliosphere, magnetic field, solar wind… in situ and remote sensing instrumentation
- ✓ Orbit varies between 0.9 and 0.28 AU
- ✓ Out of ecliptic observations (25° - 34° max)
- ✓ Moving parts (panels, HGA)
- ✓ Thermal environment: up to 10 Solar constants, antennas can reach up to 500-600° C.

Strong SC/plasma/EM fields interactions which will disturb environment analysis:

- ✓ **SC charging**
- ✓ **Env. reaction**
- ✓ **SC particle emission**
- ✓ **Fields**

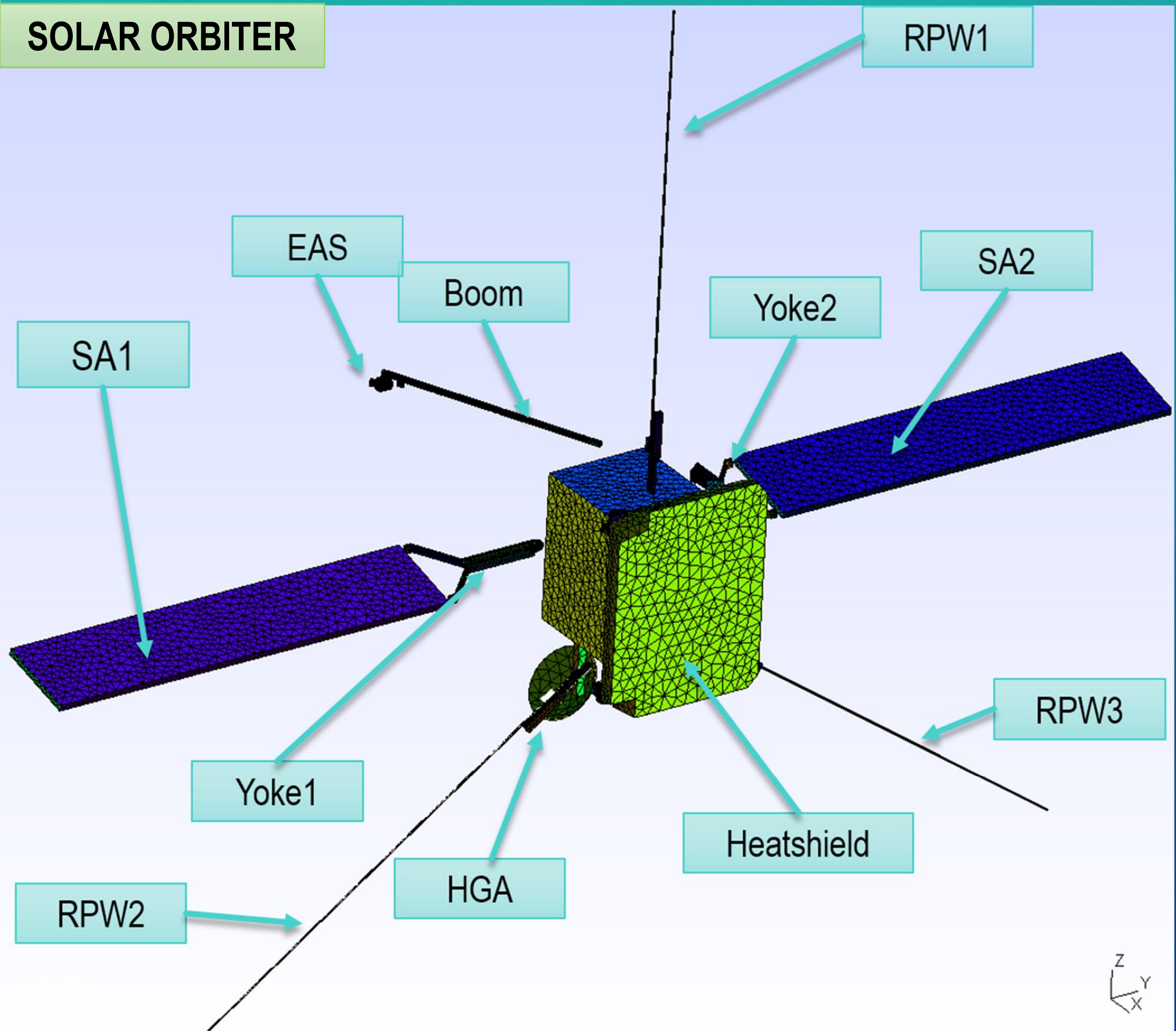
Objective of this study: *1) Evaluate the perturbations on the SC and 2 instrument measurements, through numerical simulations using the SPIS software (Spacecraft Plasma Interaction System: http://dev.spis.org/projects/spine/home/spis)*
2) Train and allow LESIA and MSSL tems to be autonomous for next studies

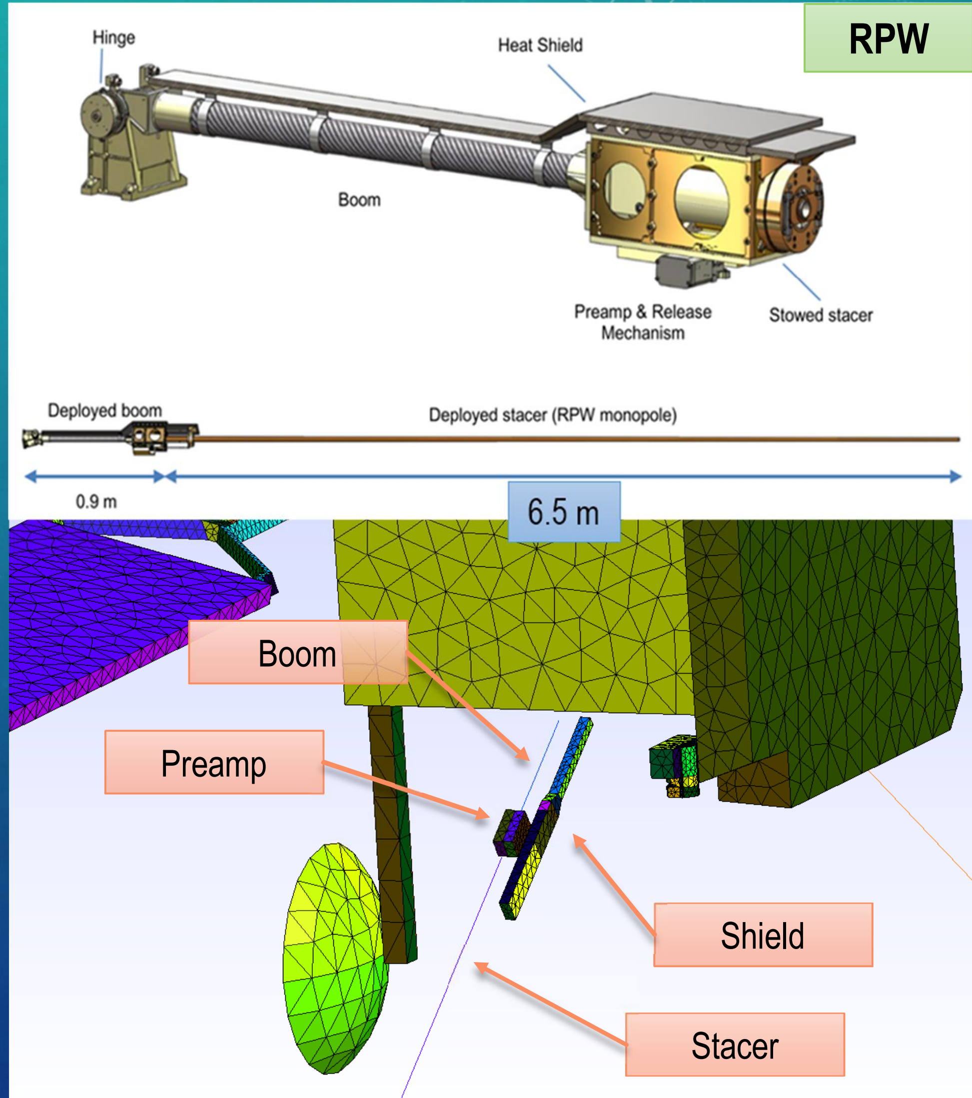
The Electron Analyzer System (**SWA-EAS**): measure electron bulk properties (N, V, and T) of the solar wind



The Radio and Plasma Waves (**RPW**) experiment: measure **B** and **E** fields at high time resolution and determine the characteristics of electromagnetic and electrostatic waves in the solar wind

RPW: SOLAR ORBITER AND RPW LATEST MODEL FOR SPIS

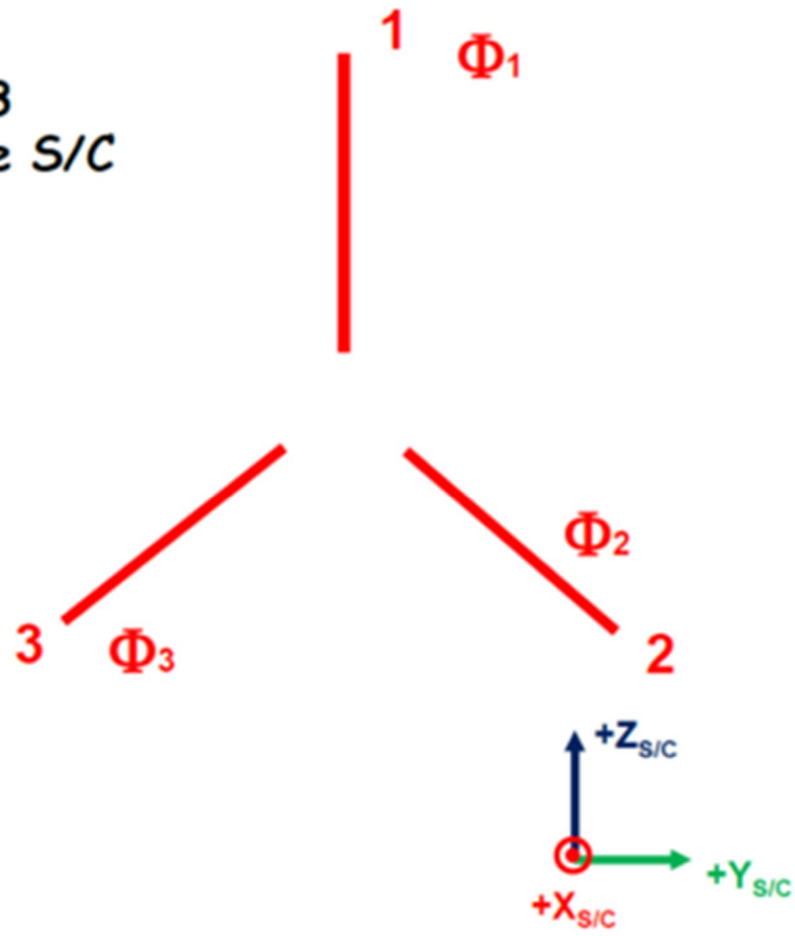




RPW: E FIELD MEASUREMENT PRINCIPLE

If we have :
- Equal illumination for 1, 2 & 3
- Symmetry with respect to the S/C
- Biasing on the probes

Then $\Phi_1 = \Phi_2 = \Phi_3$
and $\Phi_1 - \Phi_2 = 0$



RPW: E FIELD MEASUREMENT PRINCIPLE

If an external electric field $\vec{E}$ is applied then :

Then $\Phi_1^* \neq \Phi_2^*$
Actually $\Phi_1^* - \Phi_2^* = \delta\Phi_{12}$

With $\delta\Phi_{12} = \vec{E1_2} \cdot \vec{Leff_{12}}$
$\delta\Phi_{23} = \vec{E_{23}} \cdot \vec{Leff_{23}}$

$\vec{Leff}$ can only be precisely determined by simulation

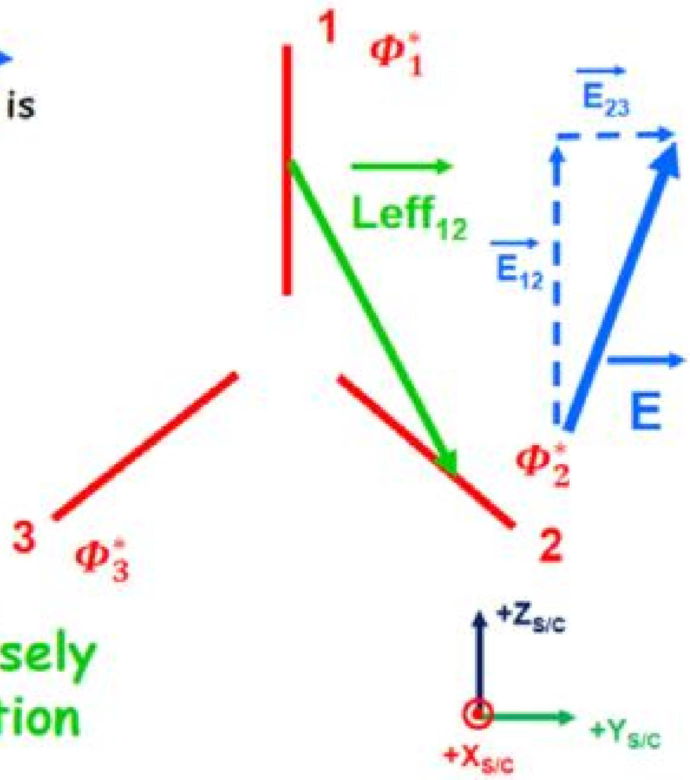
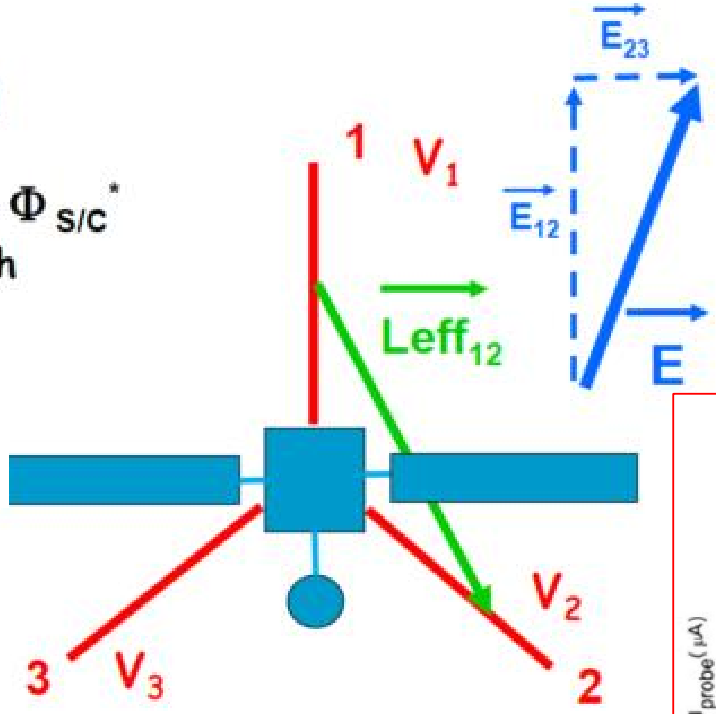


Figure 2

RPW: E FIELD MEASUREMENT PRINCIPLE

When a spacecraft if inserted between the RPW antennas then RPW measures $V_i = \Phi_i^* - \Phi_{S/C}^*$ where Φ_1^* and $\Phi_{S/C}^*$ are with respect to the plasma



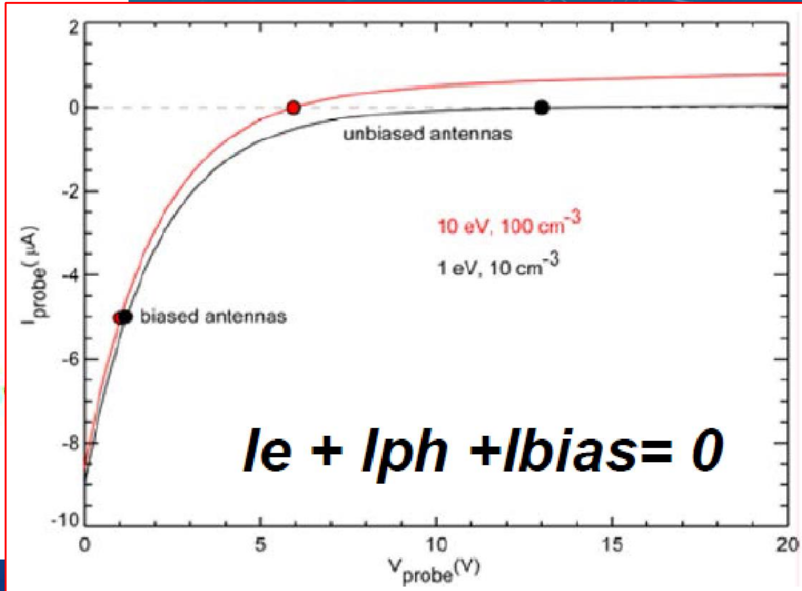
If Φ_{SC}^* is the same everywhere on the S/C surface then:

$$\delta V_{12} = V_2 - V_1 = \vec{E}_{12} \cdot \vec{Leff}_{12}$$

Effects of the S/C body on $\vec{Leffs}$ (1 2 & 3) ?

Figure 3

Biasing currents



RPW: PREVIOUS RESULTS WITH OLDER CONFIGURATION

- Older SC & RPW models
- Simulation @ 0.28 AU
- PIC populations
- Simulating a physical case using B fixes the reference basis of the simulation where Vplasma = 0. In this basis we have to set the spacecraft velocity in the reference of the plasma V, combining both plasma bulk velocity (related to the solar wind velocity) and the satellite motion over its orbit
- **Finally a VxB induced electric field is obtained**, *in those cases aligned with RPW1*

Environment parameters	Values at 0.28 AU from the Sun
Sun flux (# 1 AU)	12.76
Electron and Proton density (m^{-3})	1.04×10^8
Electron temperature (eV)	21
Proton temperature (eV)	27
Spacecraft velocity in X direction (m/s)	400000
Spacecraft velocity in Y direction (m/s)	-60000
Magnetic field (T)	Varying
Debye length (m)	3.4

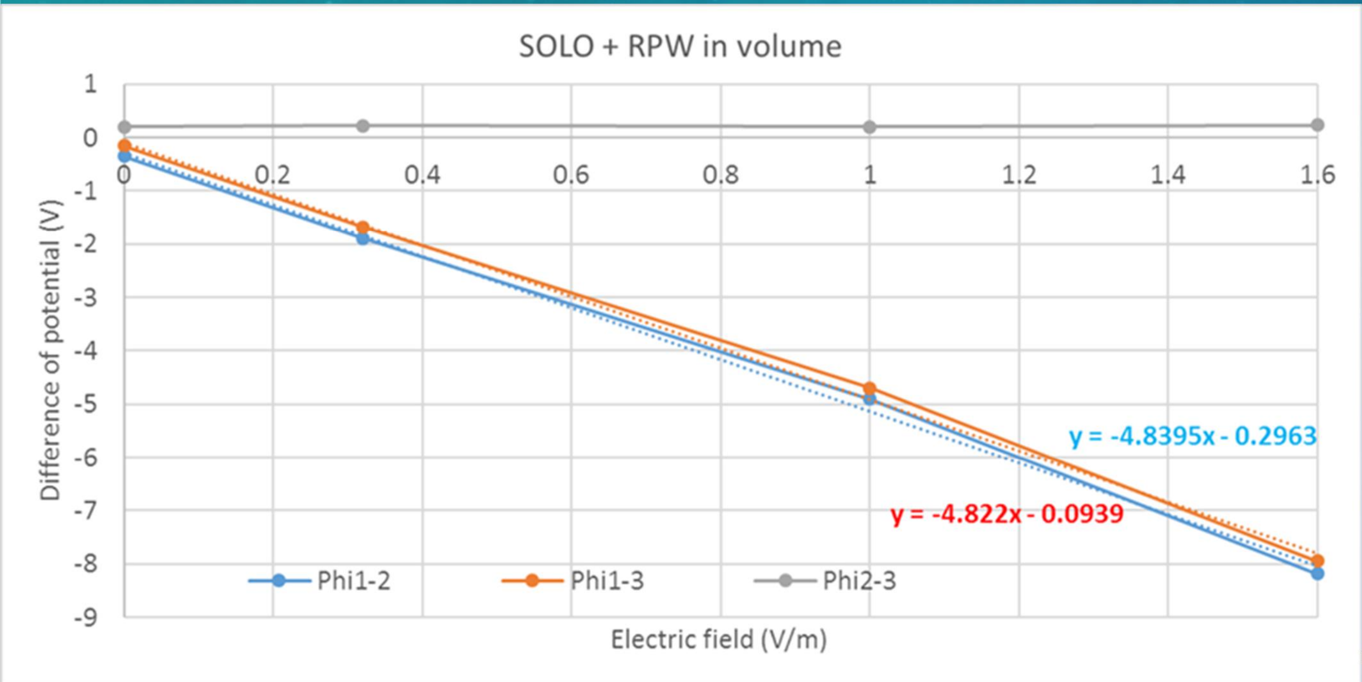
- Ions: *H+*, PIC with Maxwellian distribution and drift,
- Electrons: PIC with Maxwellian velocity distribution function,
- Photoelectrons: PIC with Maxwellian velocity distribution function and with a characteristic temperature $k_B T_{ph}$ = 3 eV,
- Secondary Electrons under Electron/Proton impact (SEE/SEP): PIC with Maxwellian velocity distribution function and with a characteristic temperature $k_B T_{SEE}$ = 2 eV, backscattered electrons with 2/3 of their initial energy,
- External boundary conditions: Fourier, $1/R^2$ decrease of potential
- No injected biasing current in the antennas

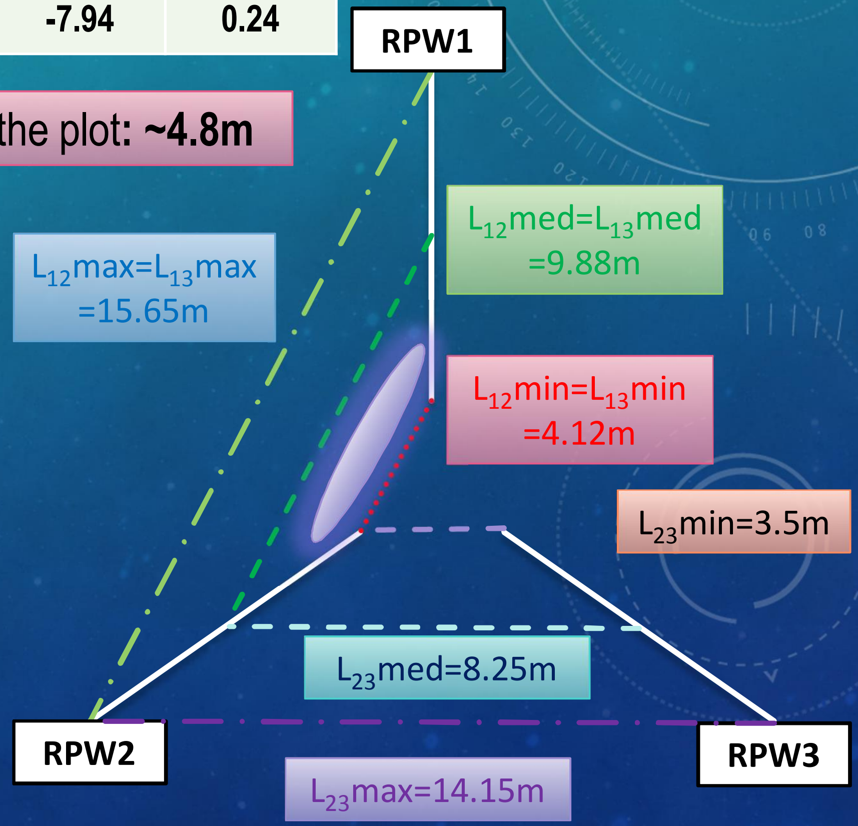
RPW: FIRST ESTIMATIONS OF EFFECTIVE LENGTHS

Case	*B (T)*	*E (V/m)*	*Ground (V)*	*RPW1 (V)*	*RPW2 (V)*	*RPW3 (V)*	*Phi1-2 (V)*	*Phi1-3 (V)*	*Phi2-3 (V)*
Case A	0	0	4.48	10.39	10.74	10.54	-0.35	-0.15	0.2
Case B	8.00E-07	0.32	9.38	15.39	17.28	17.06	-1.89	-1.67	0.22
Case D	2.50E-06	1	17.79	23.39	28.29	28.09	-4.90	-4.70	0.20
Case C	4.00E-06	1.6	25.15	30.73	38.91	38.67	-8.18	-7.94	0.24

Without SC body and considering only the 3 RPW elements: **Leff ~ 6 m**

Starting from E = - $\Delta\varphi$ / L_{eff} : it gives $\Delta\varphi$ = - L_{eff}.E, with L_{eff} being the slope of the plot: **~4.8m**



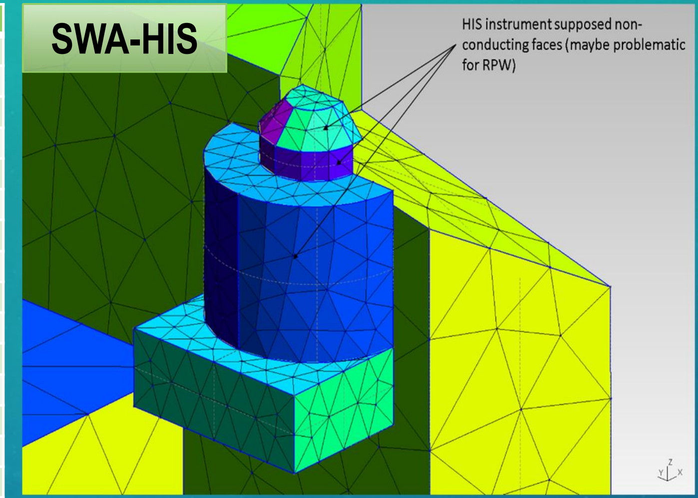


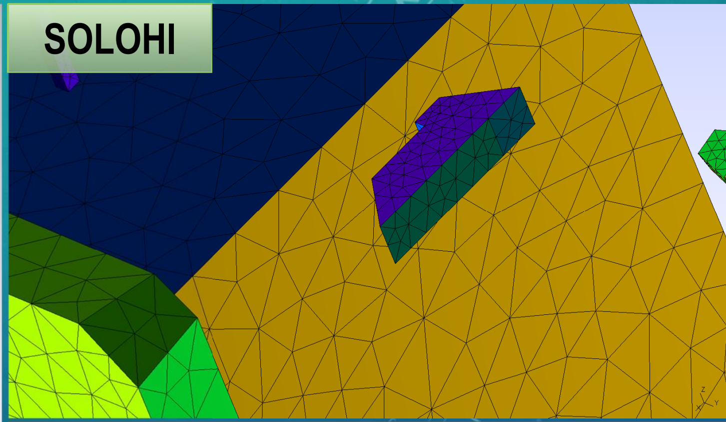
RPW: RECENT SIMULATIONS INCLUDING BIASING CURRENTS

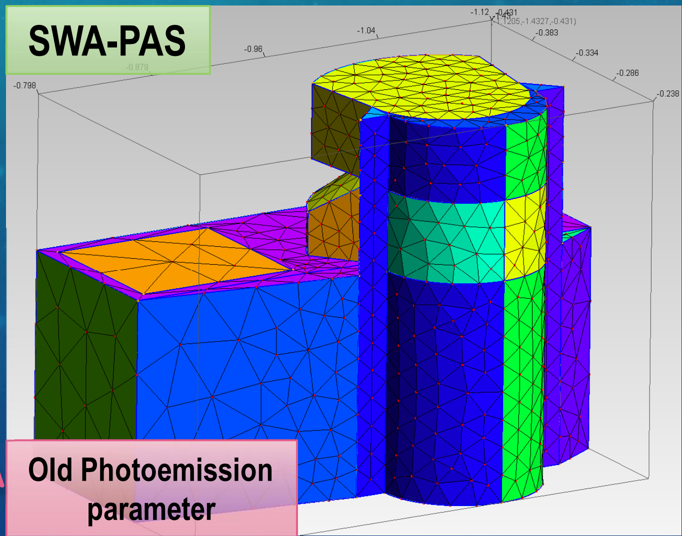
ElecNode	Name	ID	Localization	Material
0	SC BODY	117	"Center"	BK2K
0	SA1 rear	120	"-Y"	CFRP
0	SA2 rear	122	"+Y"	CFRP
0	SA1 side	124	"-Y"	CFRP
0	SA2 side	125	"+Y"	CFRP
0	HGA mast	197	"-Z"	BK2K
0	HGA	198	"-Z"	BK2K
0	BOOM	199	"-X"	CFRP
0	YOKE2 cond	1201	"+Y"	BK2K
0	YOKE1 cond	1203	"-Y"	BK2K
0	RPW1 shield	1702	"+Z"	NIOB
0	RPW2 shield	1706	"-Y"	NIOB
0	RPW3 shield	1710	"+Y"	NIOB
0	SC Shield	14156	"+X"	STEE
0	HIS cond	17072	"+Z"	BK2K
0	SOLOHI cond	18041	"+Y"	BK2K
0	PAS cond	19301	"-Z"	BK2K
0	RPW1 boom	1704	"+Z"	CFRP
0	RPW2 boom	1708	"-Y"	CFRP
0	RPW3 boom	1712	"+Y"	CFRP
1	RPW1	1703	"+Z"	**ELGI**
2	RPW2	1707	"-Y"	**ELGI**
3	RPW3	1711	"+Y"	**ELGI**
4	RPW1 preamp	1701	"+Z"	CFRP
5	RPW2 preamp	1705	"-Y"	CFRP
6	RPW3 preamp	1709	"+Y"	CFRP
7	SA1 front	119	"-Y"	CERS
8	SA2 front	121	"+Y"	CERS
9	YOKE1 diel	1202	"-Y"	OSR2K
10	YOKE2 diel	1200	"+Y"	OSR2K
11	HIS diel	17073	"+Z"	NP2K/BK2K
12	SOLOHI diel	18040	"+Y"	NP2K/BK2K
13	PAS diel	19300	"-Z"	NP2K/BK2K
14	YOKE2 diel in shadow	1204	"+Y"	KAPT/BK2K
15	YOKE1 diel in shadow	1205	"-Y"	KAPT/BK2K

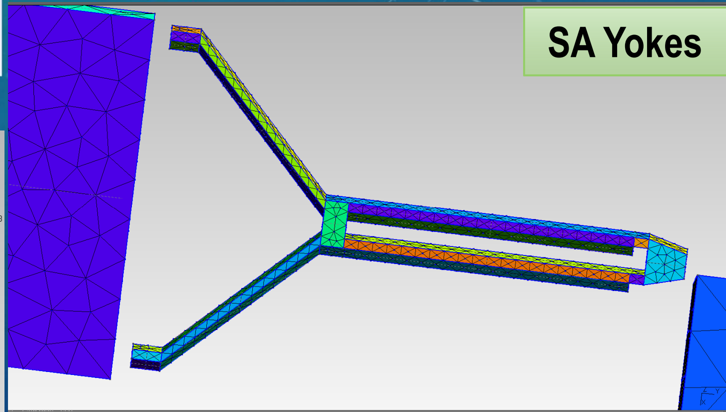
SC materials

Old Photoemission parameter



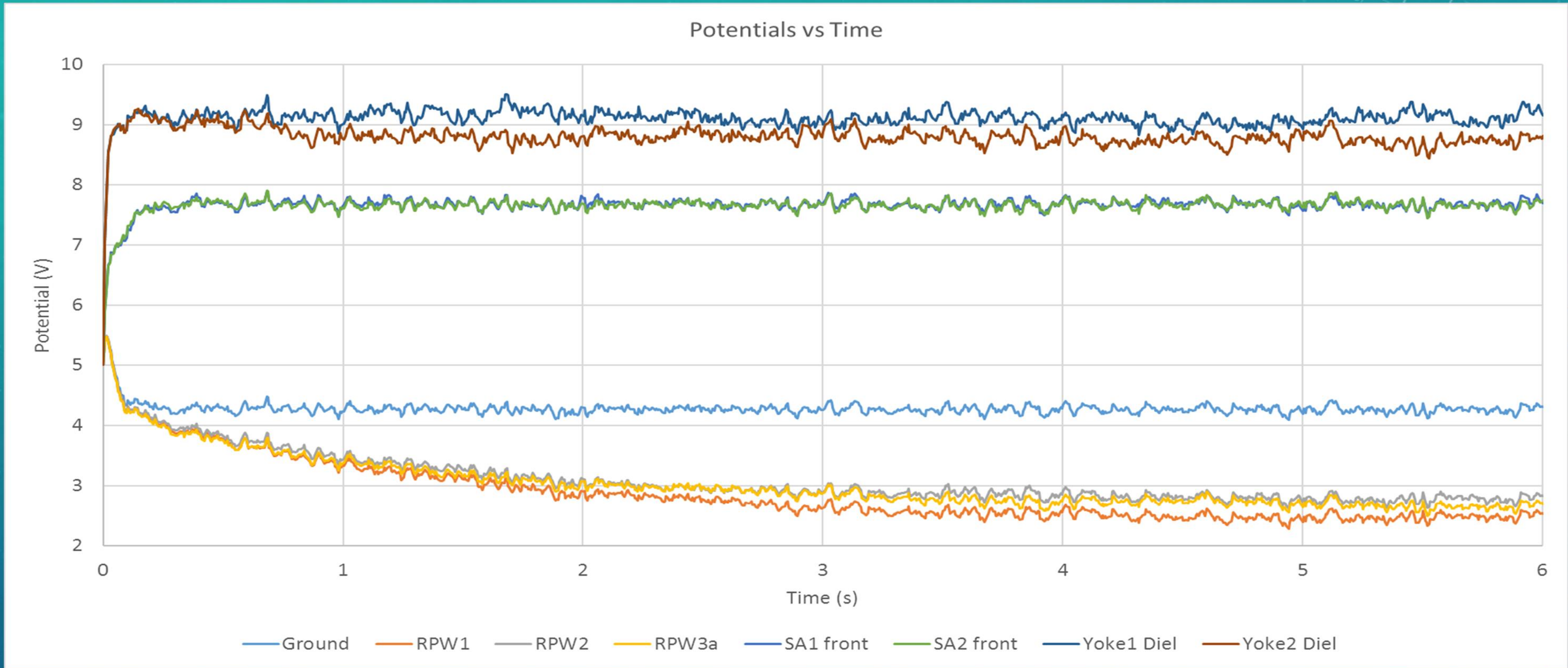






Other simulations with non-conducting parts of instruments and rear SA faces were performed and are detailed in report document

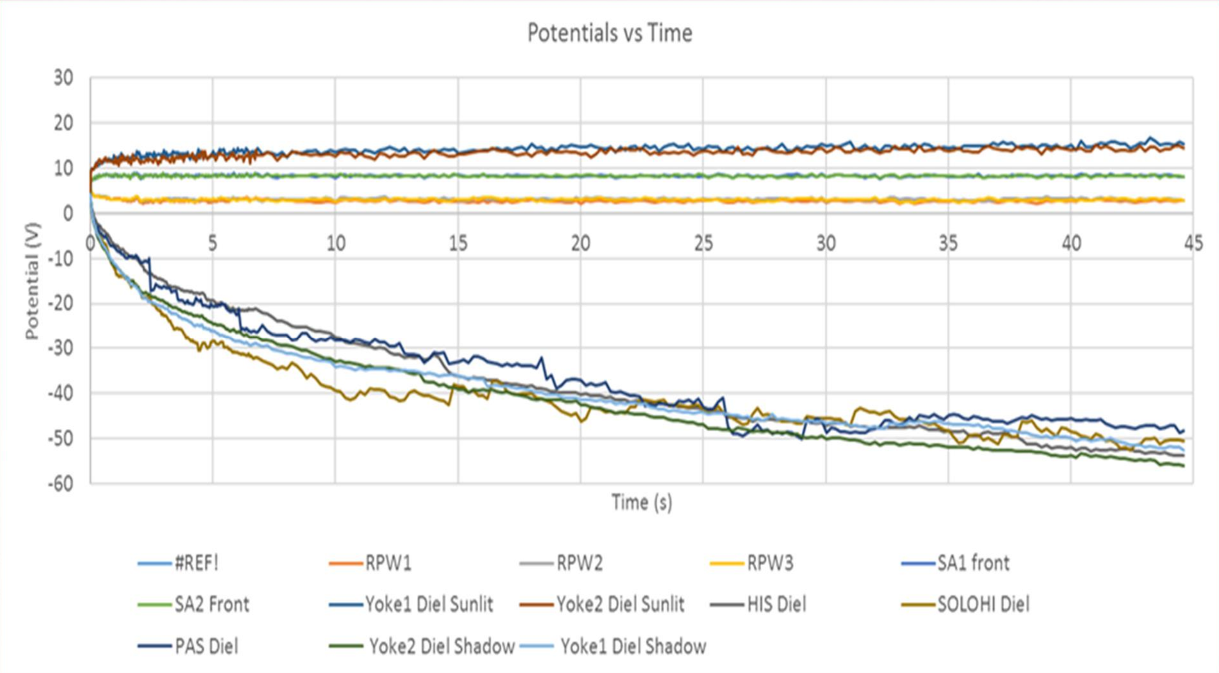
RPW: REF CASE: NO B, NO I_BIAS, NO DIELECTRICS IN SHADOW



	Ground	RPW1	RPW2	RPW3	SA1 front	SA2 front	Yoke1 Diel	Yoke2 Diel
Φ (V)	4.264	2.492	2.812	2.712	7.678	7.667	9.094	8.748
σ (V)	0.060	0.069	0.072	0.074	0.067	0.071	0.104	0.099
ΔΦ (V)	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002

RPW: WORST CASE: NO B, NO IBIAS, BUT WITH DIELECTRICS IN SHADOW

ElecNode	Name	ID	Localization	Material
7	SA1 front	119	"-Y"	CERS
8	SA2 front	121	"+Y"	CERS
9	YOKE1 diel	1202	"-Y"	OSR2K
10	YOKE2 diel	1200	"+Y"	OSR2K
11	HIS diel	17073	"+Z"	NP2K/BK2K
12	SOLOHI diel	18040	"+Y"	NP2K/BK2K
13	PAS diel	19300	"-Z"	NP2K/BK2K
14	YOKE2 diel in shadow	1204	"+Y"	KAPT/BK2K
15	YOKE1 diel in shadow	1205	"-Y"	KAPT/BK2K

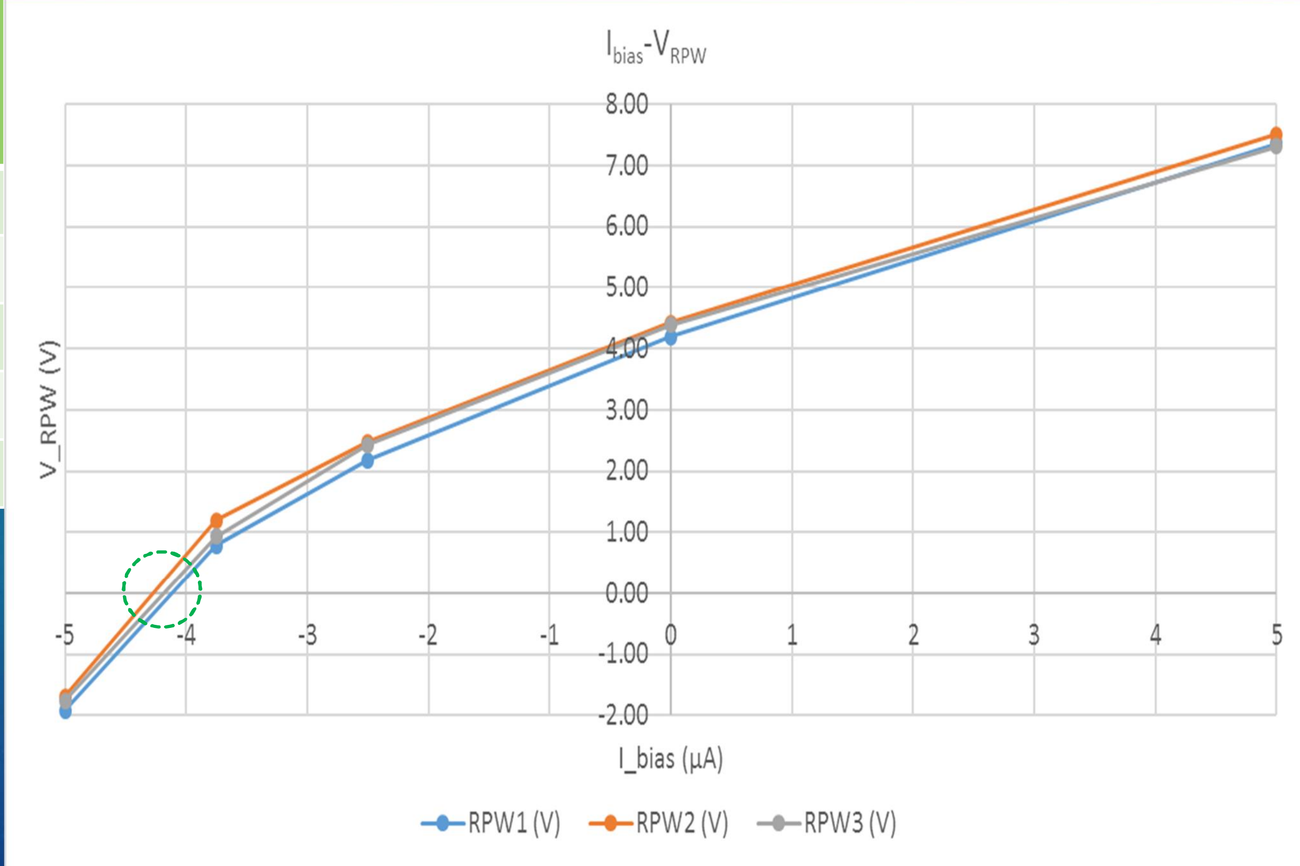


SC Element \ Value	REF Φ (V)	σ (V)	ΔΦ (V)	Worst Φ (V)	σ (V)	ΔΦ (V)	Diff Worst#REF (%)
Ground	4.26	0.060	0.001	4.18	0.131	0.009	2.1
RPW1	2.49	0.069	0.002	2.72	0.222	0.015	9.3
RPW2	2.81	0.072	0.002	3.13	0.244	0.016	11.6
RPW3	2.71	0.074	0.002	2.98	0.209	0.014	10.2
SA1 front	7.67	0.067	0.002	8.30	0.204	0.014	8.1
SA2 front	7.66	0.071	0.002	8.22	0.180	0.012	7.3
Yoke1 Diel Sun	9.09	0.104	0.002	15.1	0.512	0.034	66.4
Yoke2 Diel Sun	8.74	0.099	0.002	14.20	0.435	0.029	62.3
HIS Cond/Diel	4.26	0.060	0.001	-51.32	1.779	0.120	1303.7
SOLOHI Cond/Diel	4.26	0.060	0.001	-49.61	1.448	0.098	1263.5
PAS Cond/Diel	4.26	0.060	0.001	-46.25	0.991	0.067	1184.9
Yoke2 Cond/Diel Shadow	4.26	0.060	0.001	-53.59	1.201	0.081	1357.0
Yoke1 Cond/Diel Shadow	4.26	0.060	0.001	-49.60	1.759	0.118	1263.3

RPW: OTHER CASES: B, NO DIELEC IN SHADOW, MAKING I_BIAIS VARY

Constant magnetic field B of 124.4 nT in the X-Y plane with By= 36.3×10^{-9} T and Bx = -119.7×10^{-9} T (angle of ~17° with the -X direction). This B field generates the expected electric field E: Ez = +7.38 mV/m, fully vertical.

I_biais (µA) *Std Dev (V)*	RPW1 (V)	RPW2 (V)	RPW3 (V)	Ground (V)	SA1 front (V)	SA2 front (V)	Yoke1 Diel (V)	Yoke2 Diel (V)
-5.00 (0.6)	-1.92	-1.68	-1.75	6.85	10.24	10.21	12.31	12.03
-3.75 (0.3)	0.78	1.19	0.93	5.73	9.15	9.14	10.59	10.27
-2.50 (0.3)	2.18	2.47	2.43	5.81	9.22	9.20	10.64	10.31
0.00 (0.4)	4.20	4.42	4.39	5.91	9.32	9.28	10.78	10.46
5.00 (0.3)	7.36	7.51	7.32	6.15	9.25	9.22	10.78	10.37

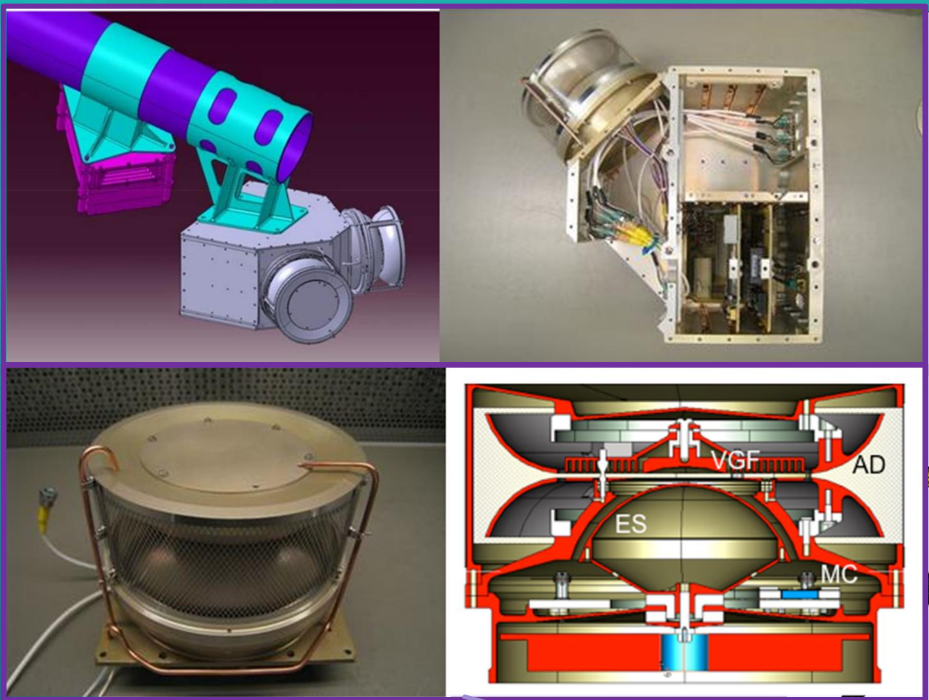


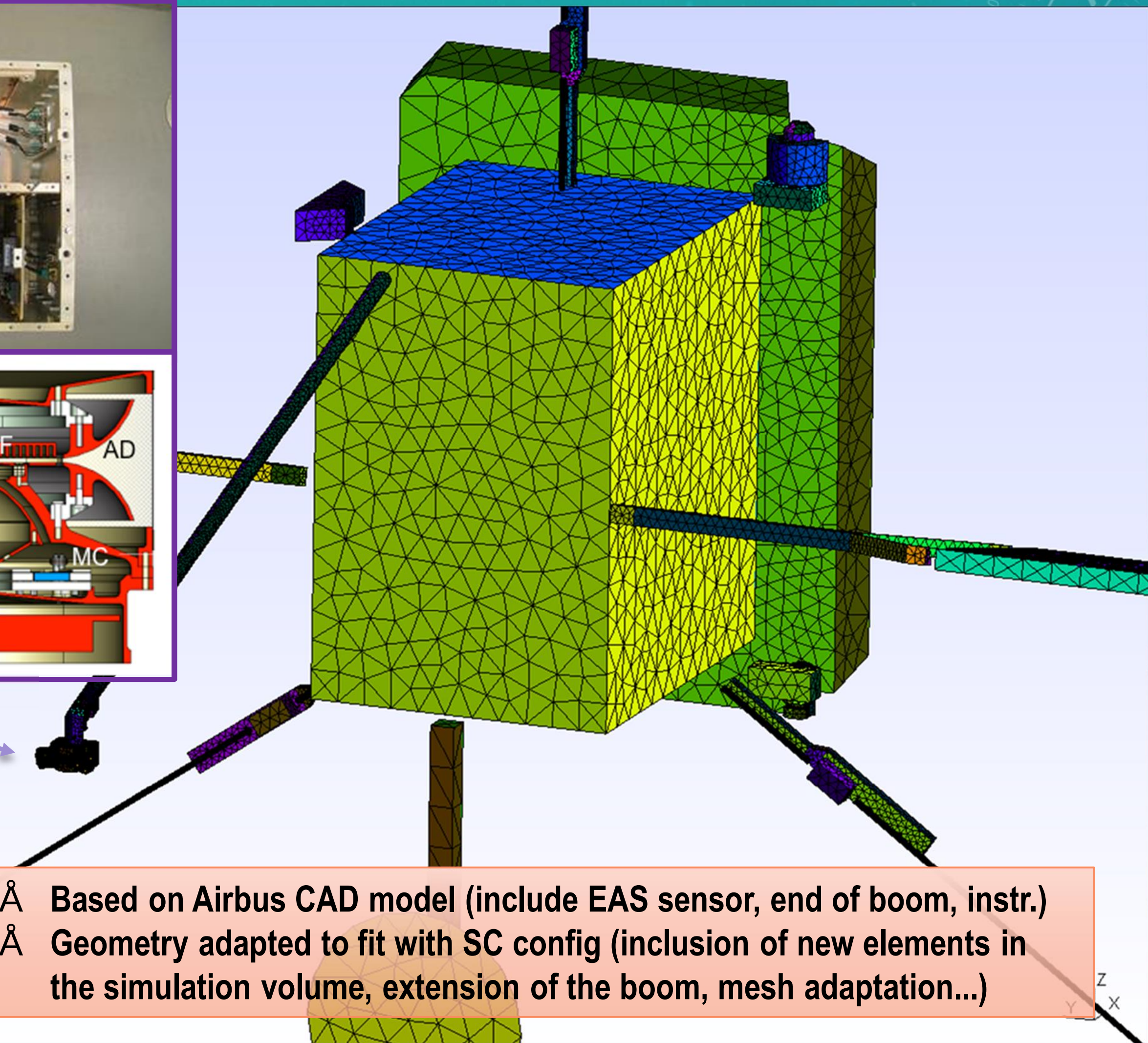
Plot of the RPW stacer potential evolution as a function of I_bias injected. RPW potential should be null for I_biais ~ -4.25 µA: for this photoemission parameter of ELGILOY (properties changed since…)

RPW: CONCLUSION

- This study provided answers to many questions raised from the RPW experiment
- Adequate Solar Orbiter model including the desired RPW system and other modular elements (HGA, solar arrays, yokes, HIS, PAS, SOLOHI instruments) was conceived and updated all along the project
- This model is fully parametrized and easily modifiable, even though it is for now updated with latest information available concerning materials and dimensions of the satellite
- New materials have been generated for SPIS to simulate the Elgiloy and Niobium surfaces. Note that Elgiloy requires updated data on its photoemission properties (ONERA) but they were not available by the end of this project phase (now are available)
- Effective lengths estimation studies were performed, but without spacecraft elements such as solar array yokes or SWA and SoloHI instruments and out-dated ELGILOY prorperties. The latest spacecraft model however provided the I-V curves for antennas in a typical perihelion environment at 0.28 AU from the Sun
- As requested: all required and necessary models and datasets were provided to LESIA in order to continue this analysis throughout the pre- and post-launch period. LESIA team is now autonomous and trained on this subject
  - New simulations for L_{eff} estimations will be performed at LESIA including new material parameters and latest models of instruments
  - I-V curves will also be redrawn considering new ELGILOY properties

SOLAR WIND ANALYZER – ELECTRON ANALYZER SYSTEM: SWA-EAS



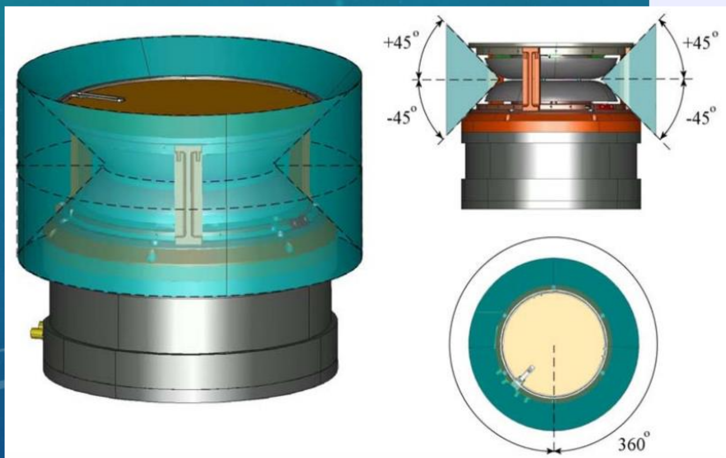


SWA-EAS located at the end of Solar Orbiter rear boom

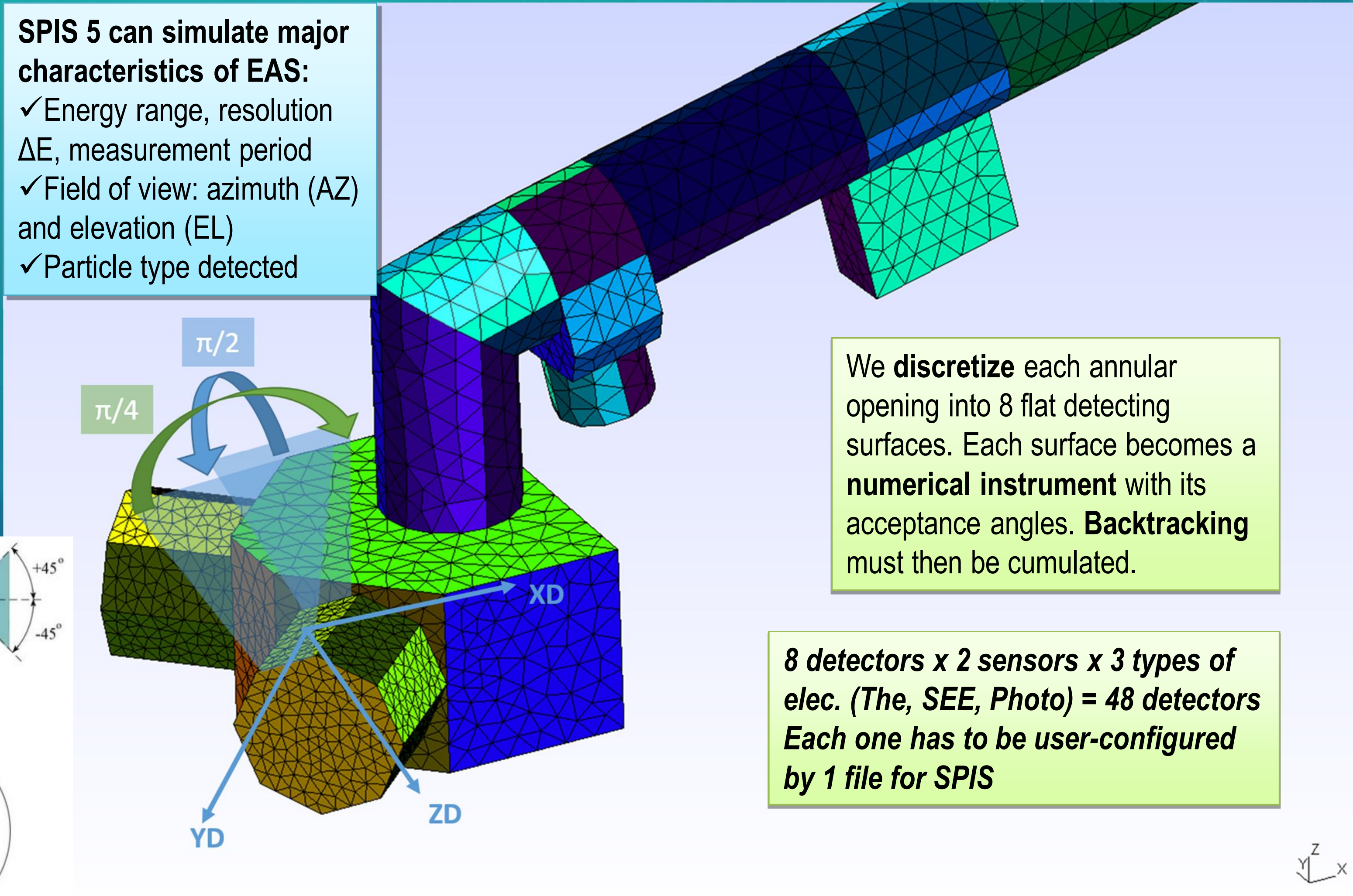
- **Based on Airbus CAD model (include EAS sensor, end of boom, instr.)**
- **Geometry adapted to fit with SC config (inclusion of new elements in the simulation volume, extension of the boom, mesh adaptation...)**

SWA-EAS: REAL AND NUMERICAL CONFIGURATION

Parameter	Range/resolution	EAS
Sensors		2 x EA
Mass	Species	Electrons
	Resolution ($m/\Delta m$)	-
Energy	Range	1 eV – 5 keV
	Resolution ($\Delta E/E$)	12%
	Analyzer constant (eV/V)	7
Angle	Range (AZ)	360°
	Range (EL)	±45°
	Range scan (EL)	16 steps
	Angular Resolution (AZ × EL)	11.25º x 3º - 8º
	Pixel Field of view	11.25º x 3º - 8º
Temporal	Resolution – Normal mode	3s / 10 s
	Burst mode	0.125 s
Sensitivity	Per pixel (cm^2 sr eV/eV)	Variable, < 2.6×10^{-4}



SPIS 5 can simulate major characteristics of EAS:
✓Energy range, resolution ΔE, measurement period
✓Field of view: azimuth (AZ) and elevation (EL)
✓Particle type detected



We **discretize** each annular opening into 8 flat detecting surfaces. Each surface becomes a **numerical instrument** with its acceptance angles. **Backtracking** must then be cumulated.

8 detectors x 2 sensors x 3 types of elec. (The, SEE, Photo) = 48 detectors
Each one has to be user-configured by 1 file for SPIS

SWA-EAS: SIMULATION CONFIGURATION

Å Main goal of this work:

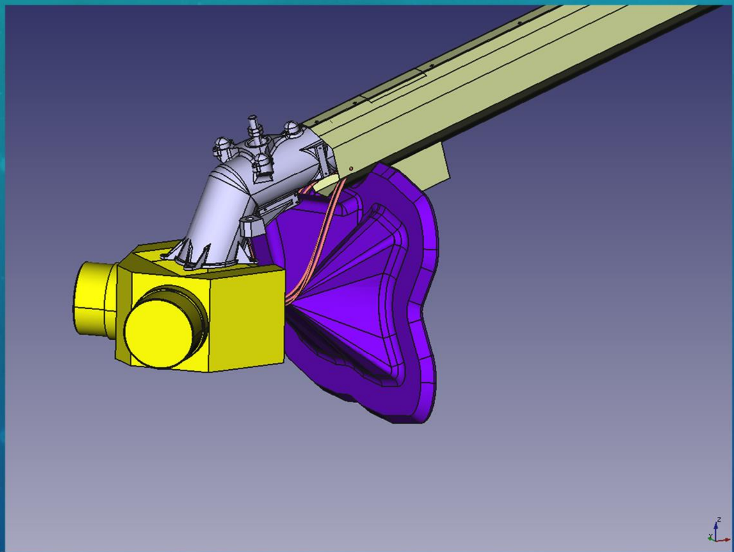
  Å Provide detailed and adaptable model of SC + EAS system

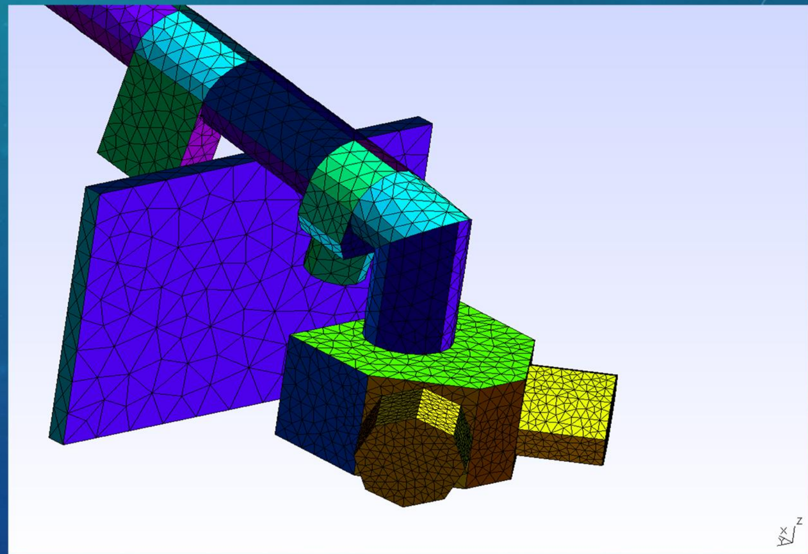
  Å Use realistic env. parameters so that major perturbations to the env. & their effects on EAS measurements can be identified/quantified

  Å Provide ready-to-run sets of models for pre- and post-launch period

Å In the meanwhile: possibility of a Baffle in front of EAS to protect it from spatters emitted by SC thrusters

  Å What is the impact on EAS measurements ?





Å 2 simulations at Solar Orbiter perihelion (0.28 AU): W/W-O EAS Baffle

SWA-EAS: REF CASE NO BAFFLE - SIMULATION CONFIGURATION

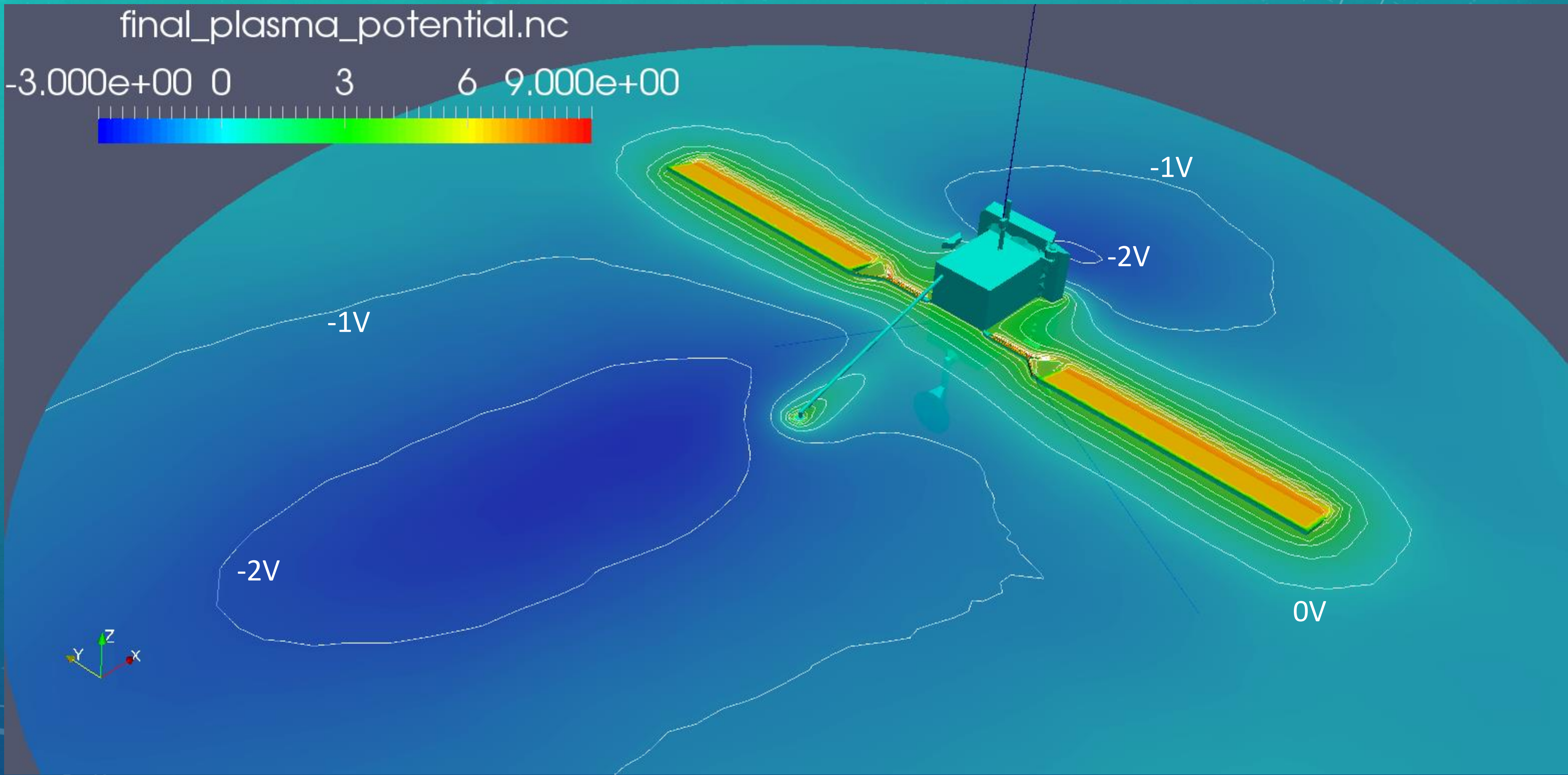
- Simulation without Baffle @ 0.28 AU
- PIC populations
- No B, no E
- SC potentials kept constant based on former RPW simulations (no circuit solver -> gain of CPU time)

Environment parameters	Values at 0.28 AU from the Sun
Sun flux (# 1 AU)	12.76
Electron and Proton density (m^{-3})	1.04×10^8
Electron temperature (eV)	21
Proton temperature (eV)	27
Spacecraft velocity in X direction (m/s)	400000
Spacecraft velocity in Y direction (m/s)	-60000
Magnetic field (T)	0
Debye length (m)	3.4

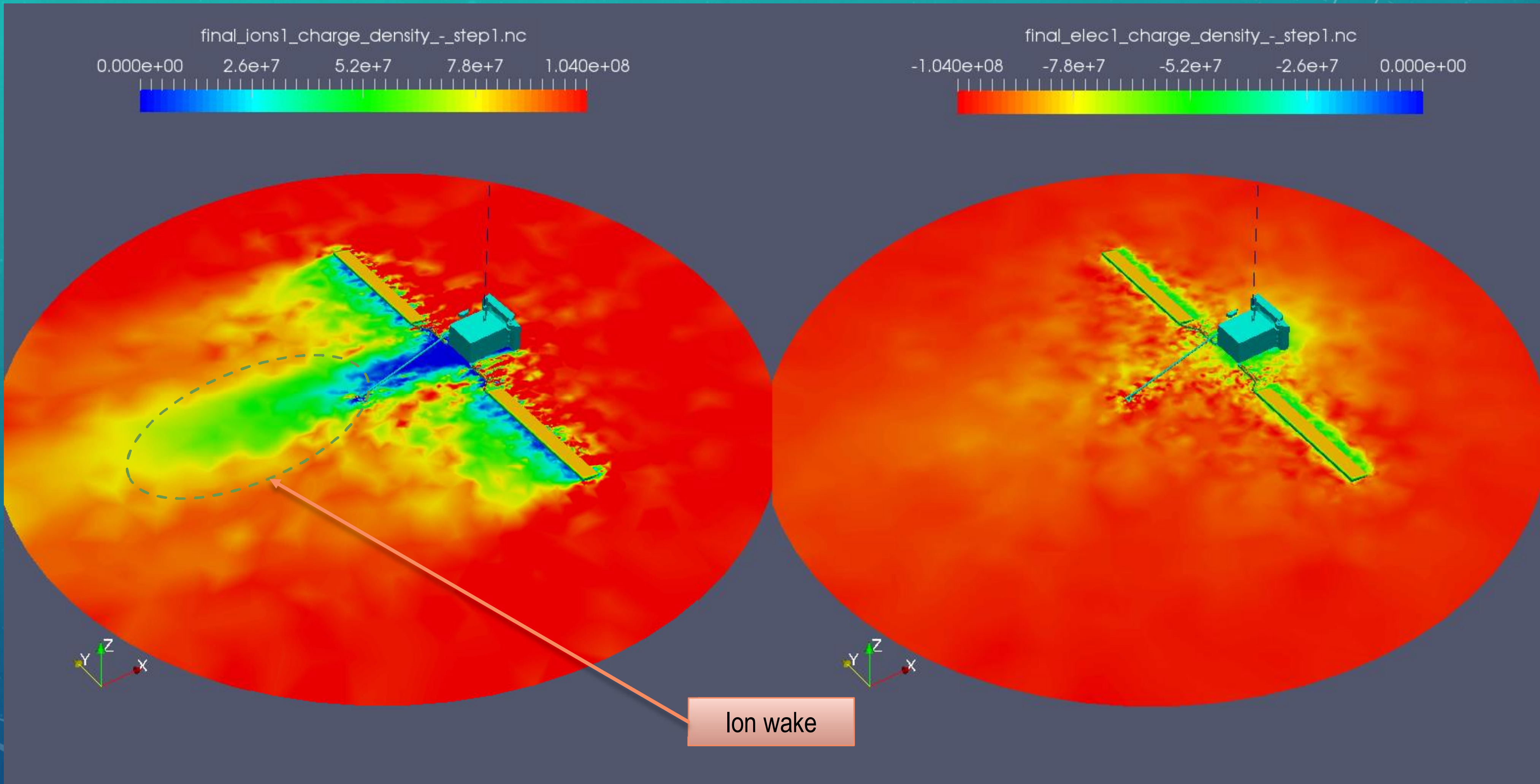
SC element	Potential (V)
Ground	**4.2**
RPW1	**2.5**
RPW2 and RPW3	**2.8**
SA1 and SA2 sunlit	**7.7**
Yoke1 and Yoke2 sunlit	**9**
EAS box	**4.2**
EAS sensors	**4.2**

- Ions: *H+*, PIC with Maxwellian distribution and drift,
- Electrons: PIC with Maxwellian velocity distribution function,
- Photoelectrons: PIC with Maxwellian velocity distribution function and with a characteristic temperature $k_B T_{ph}$ = 3 eV,
- Secondary Electrons under Electron/Proton impact (SEE/SEP): PIC with Maxwellian velocity distribution function and with a characteristic temperature $k_B T_{SEE}$ = 2 eV, backscattered electrons with 2/3 of their initial energy,
- External boundary conditions: Fourier, $1/R^2$ decrease of potential
- No injected biasing current in the antennas

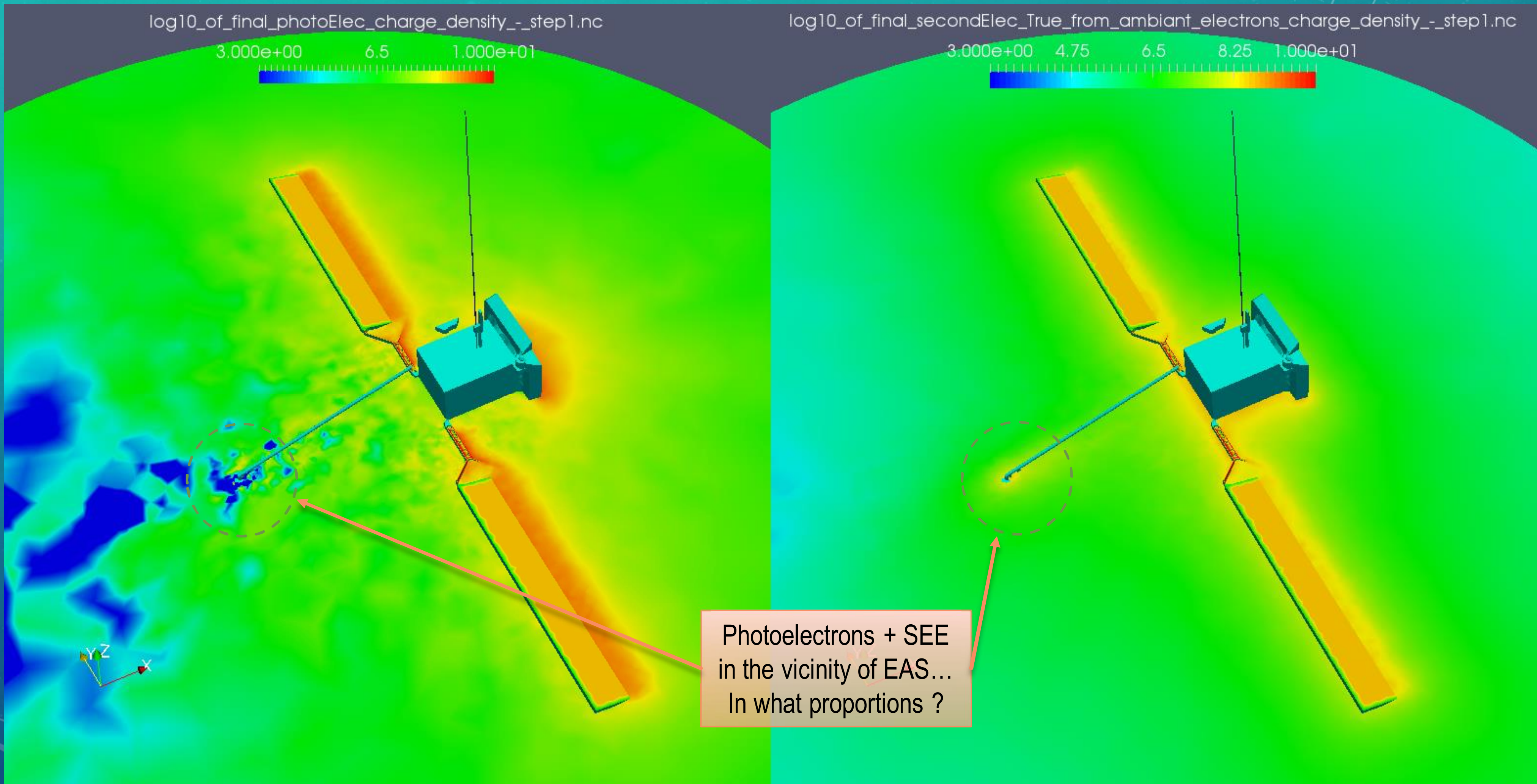
SWA-EAS: REF CASE NO BAFFLE – PLASMA POTENTIAL



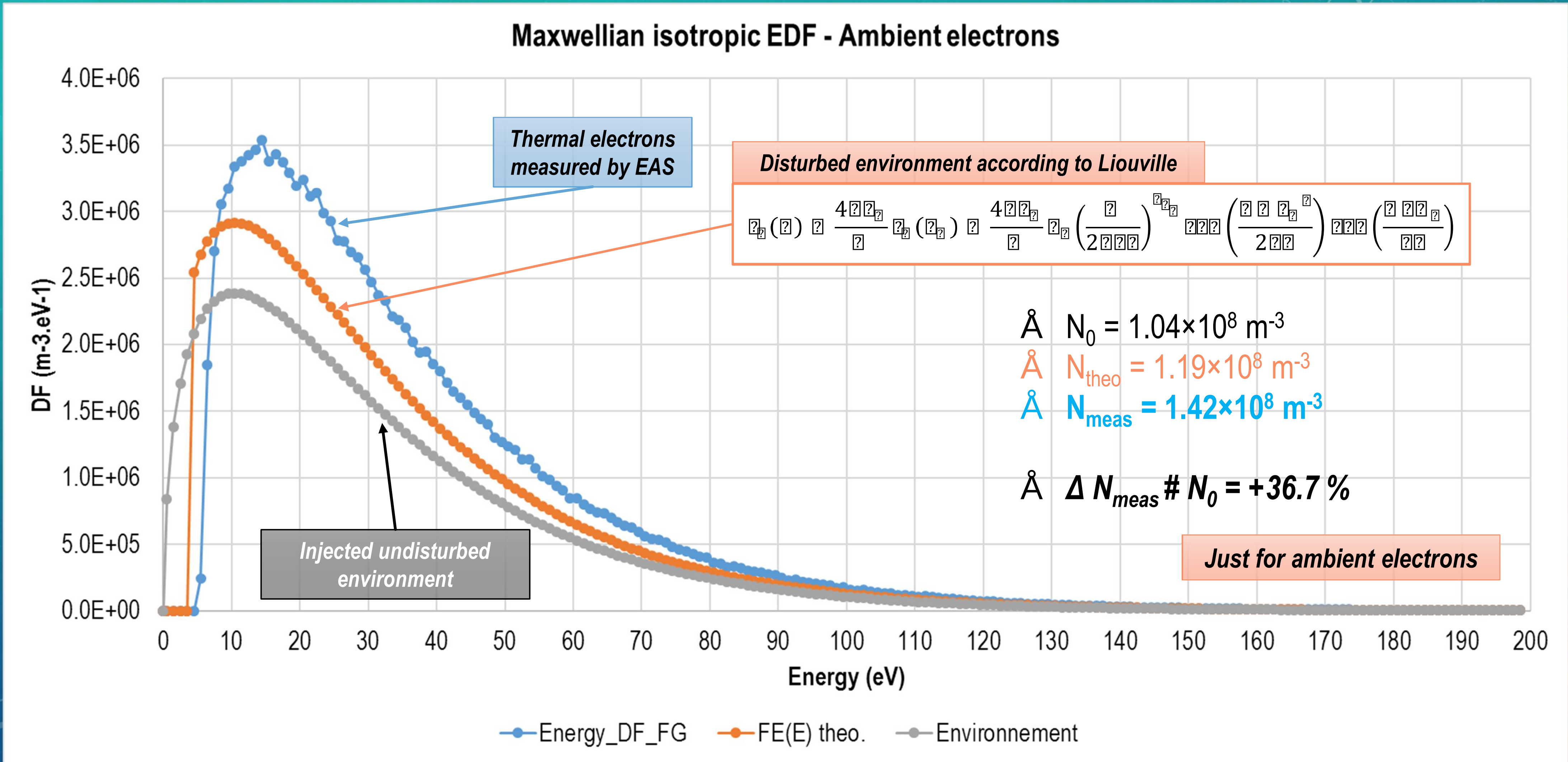
SWA-EAS: REF CASE NO BAFFLE – PLASMA DENSITIES



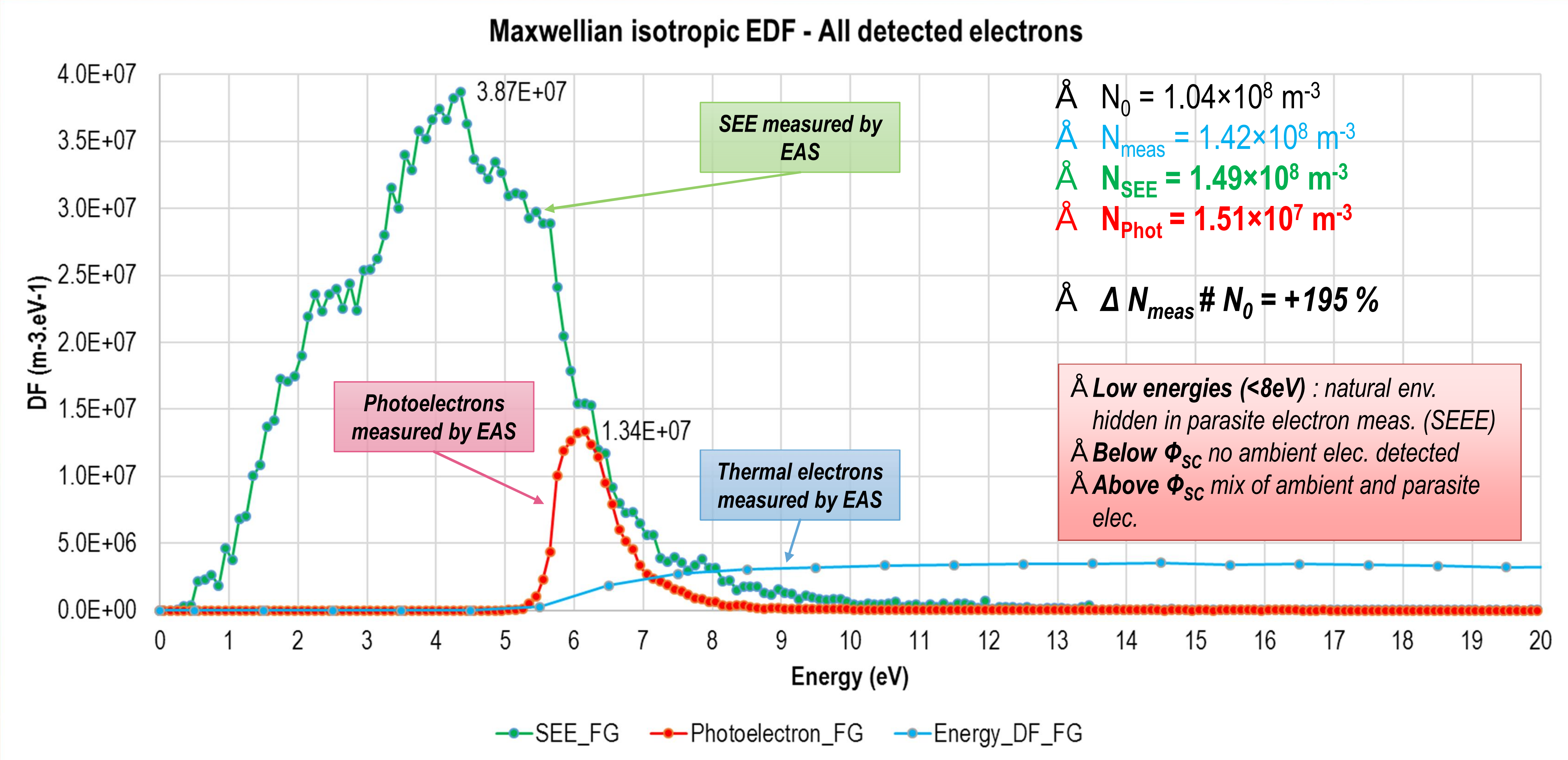
SWA-EAS: REF CASE NO BAFFLE – PLASMA DENSITIES



SWA-EAS: REF CASE NO BAFFLE – EAS MEASUREMENTS



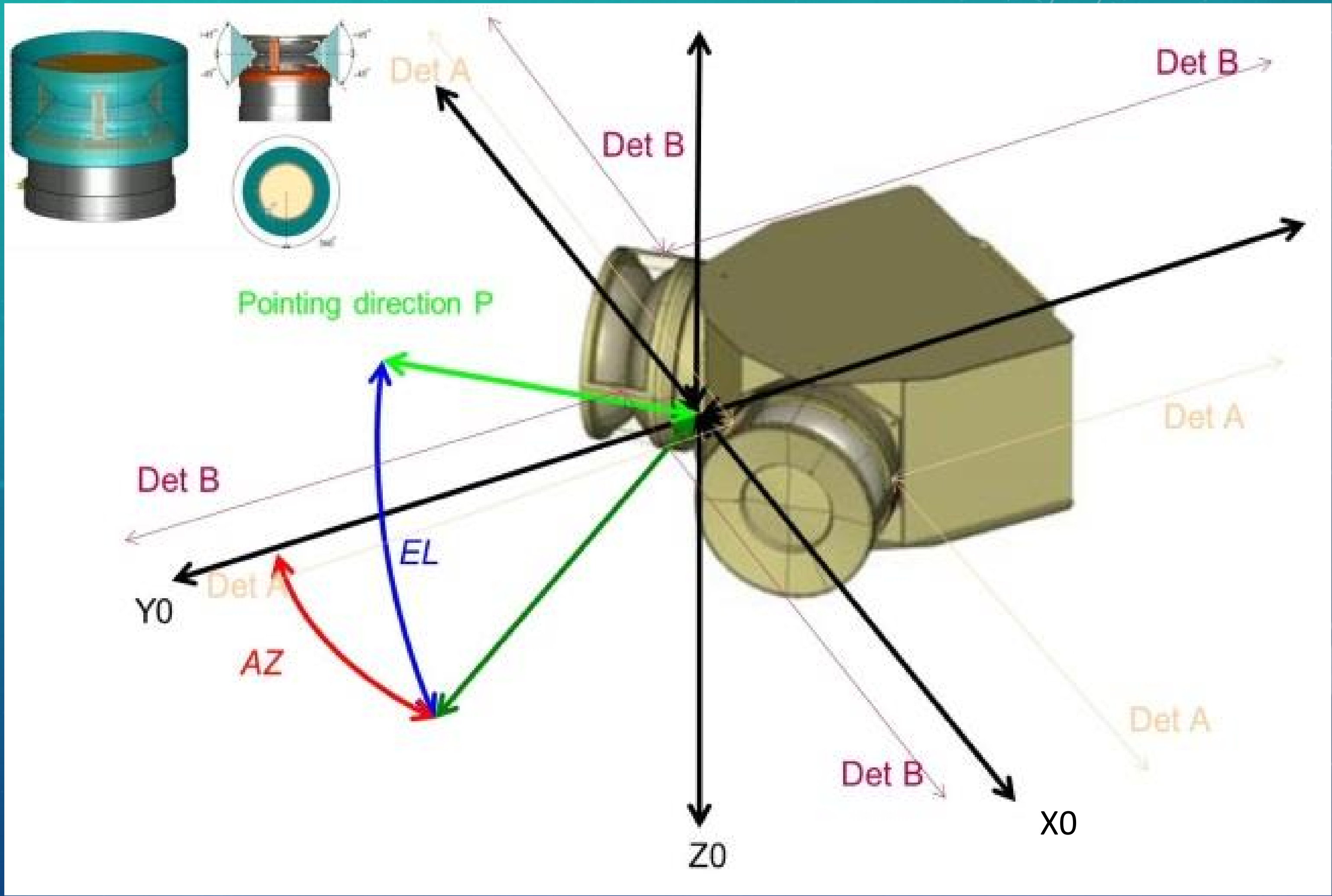
SWA-EAS: REF CASE NO BAFFLE – EAS MEASUREMENTS



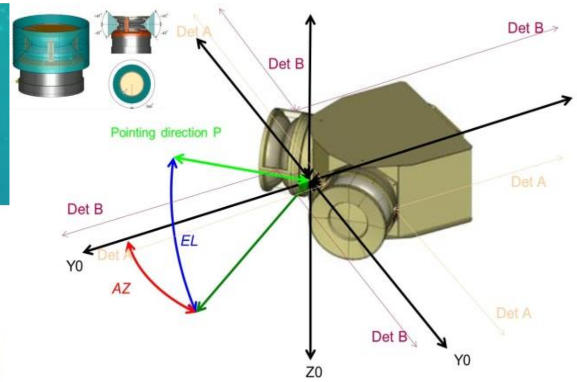
SWA-EAS: REF CASE NO BAFFLE – EAS FIELD OF VIEW

- *SPIS provides results for each particle detector separately -> we have to cumulate/filter output files for better interpretation and analysis*
- *Development of Scilab routines for advanced post-processing methods*

- *Here, representation of EAS Field Of View (FOV) with 2 angles: AZ (0->360°) and EL (-90->+90°) to illustrate particle fluxes asa function of the instrument pointing direction*
  - *EL = AZ = 0: Wake*
  - *EL = 0, AZ = 180: rear SC*
  - *EL = +90: +Z direction*
  - *EL = -90: -Z direction*
  - *…*

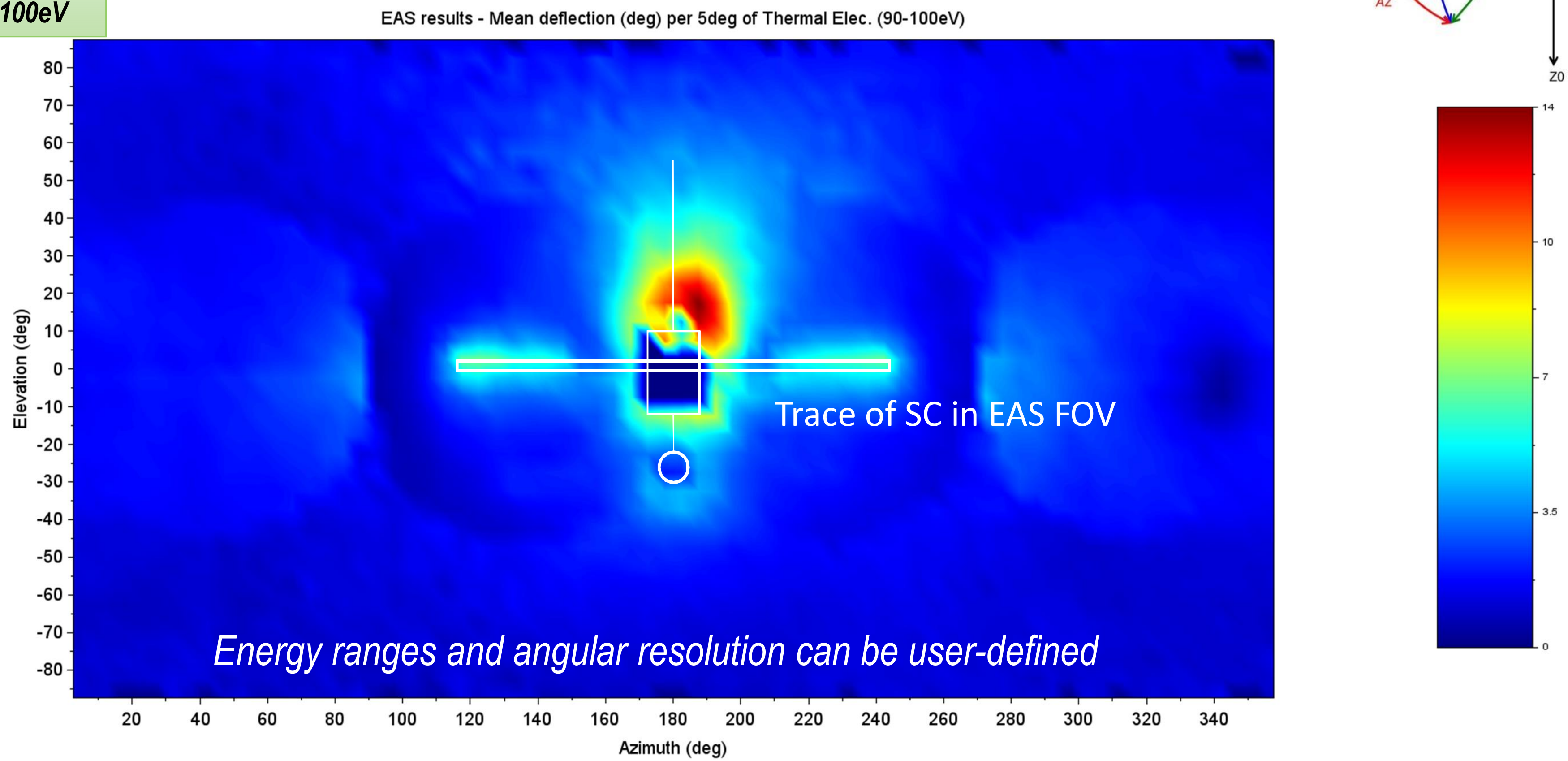


SWA-EAS: REF CASE NO BAFFLE – EAS FIELD OF VIEW



Deflection = angle between V_∞ and V_D : at **higher energies**, it is weak and electrons have ~ straight traj.

Th E: 90-100eV

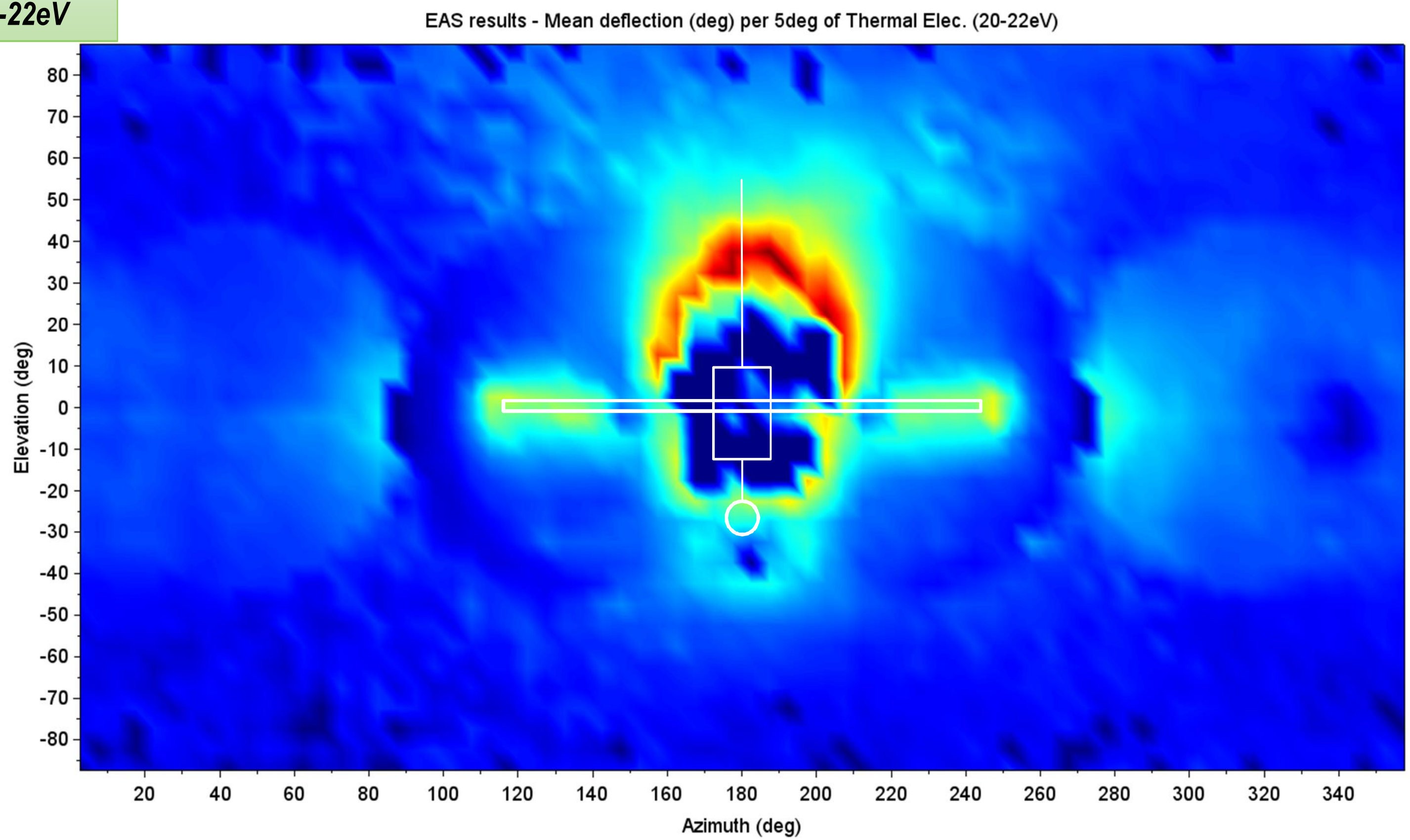


Max: 14°

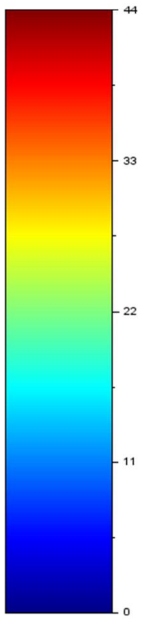
SWA-EAS: REF CASE NO BAFFLE – EAS FIELD OF VIEW

Deflection = angle between V_∞ and V_D : at **lower energies**, angle increases because of SC potential.

Th E: 20-22eV



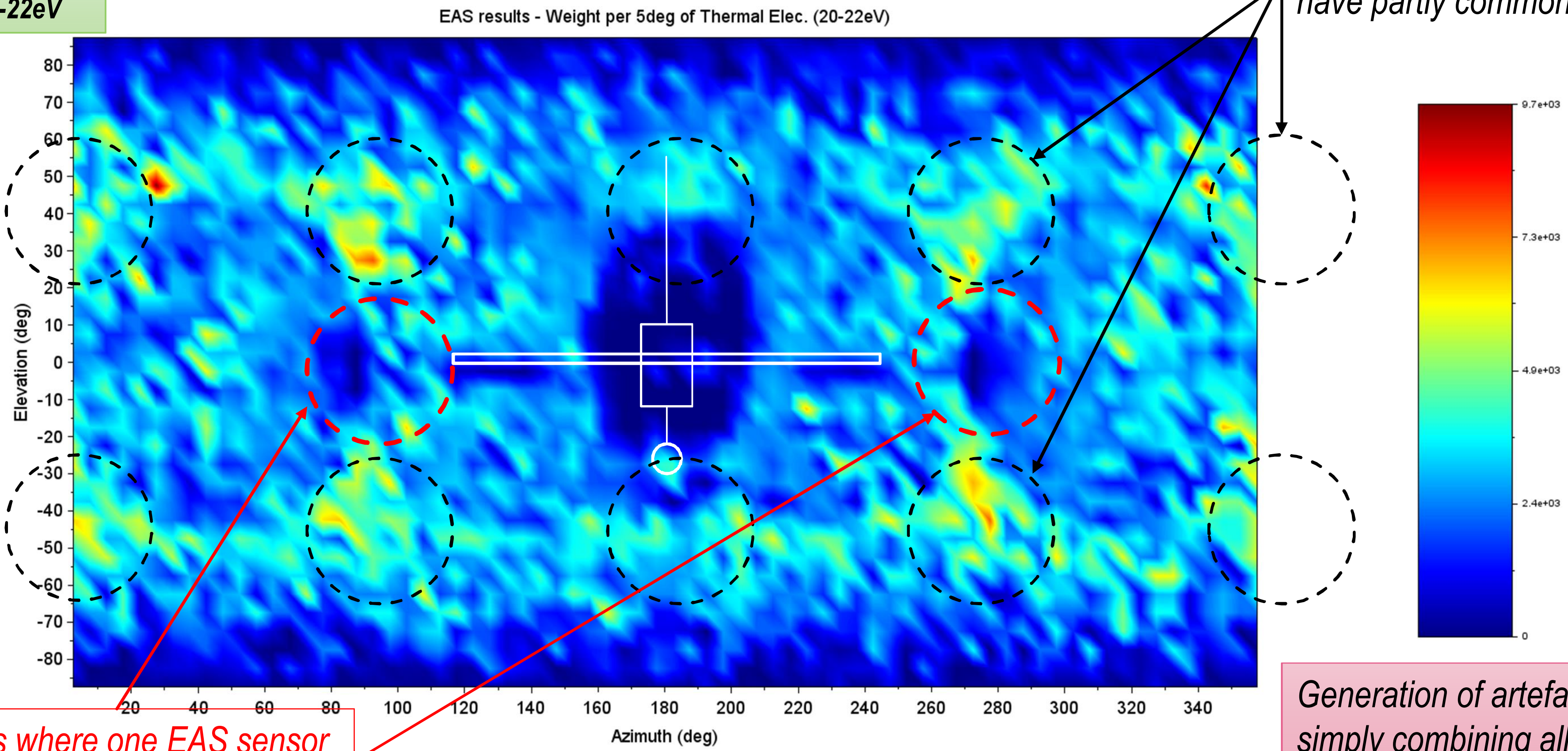
Max: 44°



SWA-EAS: REF CASE NO BAFFLE – EAS FIELD OF VIEW

Representing the sum of weight (here N) cumulated per solid angle

Th E: 20-22eV



Regions where 2 EAS detectors have partly common FOV

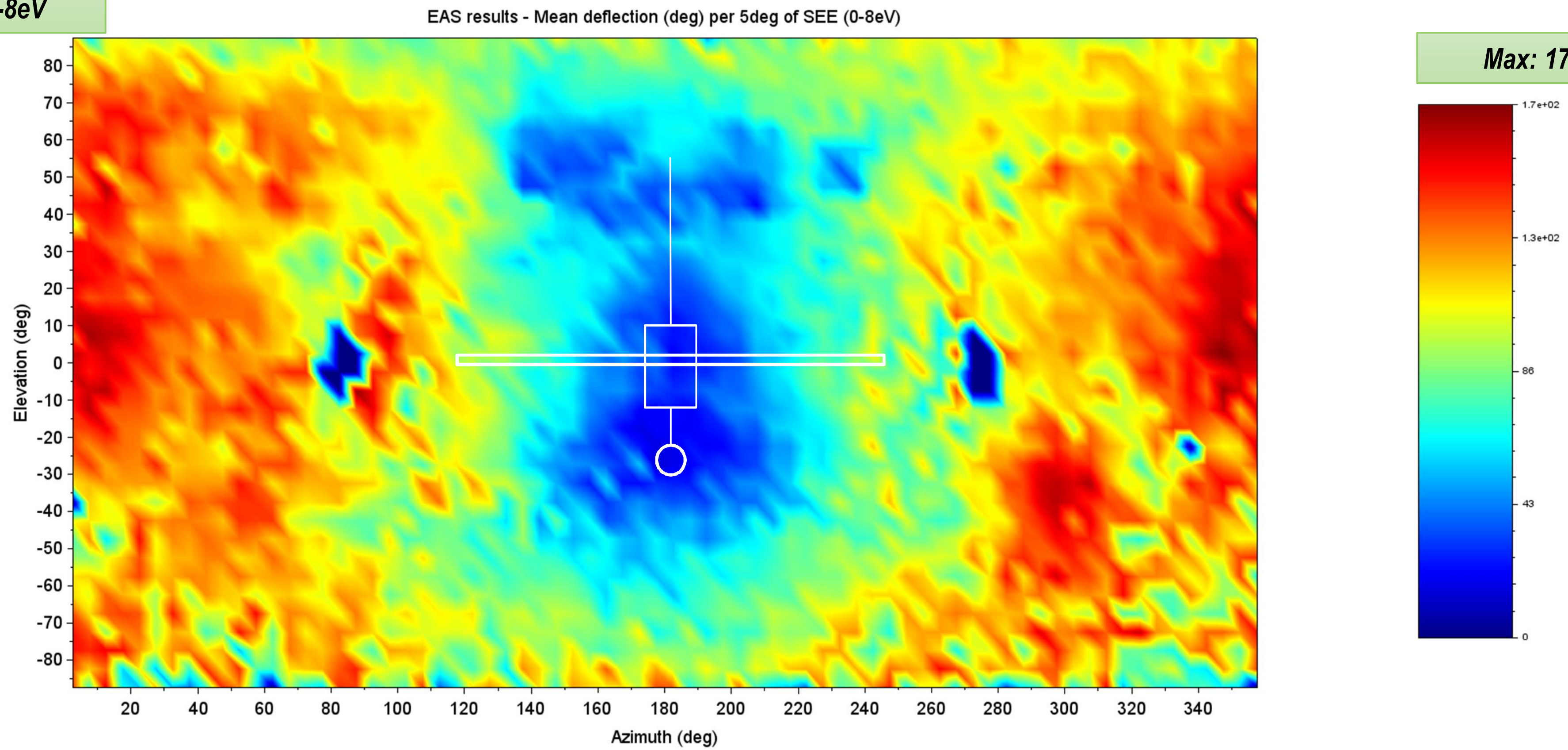
Regions where one EAS sensor points towards the other

Generation of artefacts when simply combining all detectors outputs

SWA-EAS: REF CASE NO BAFFLE – EAS FIELD OF VIEW

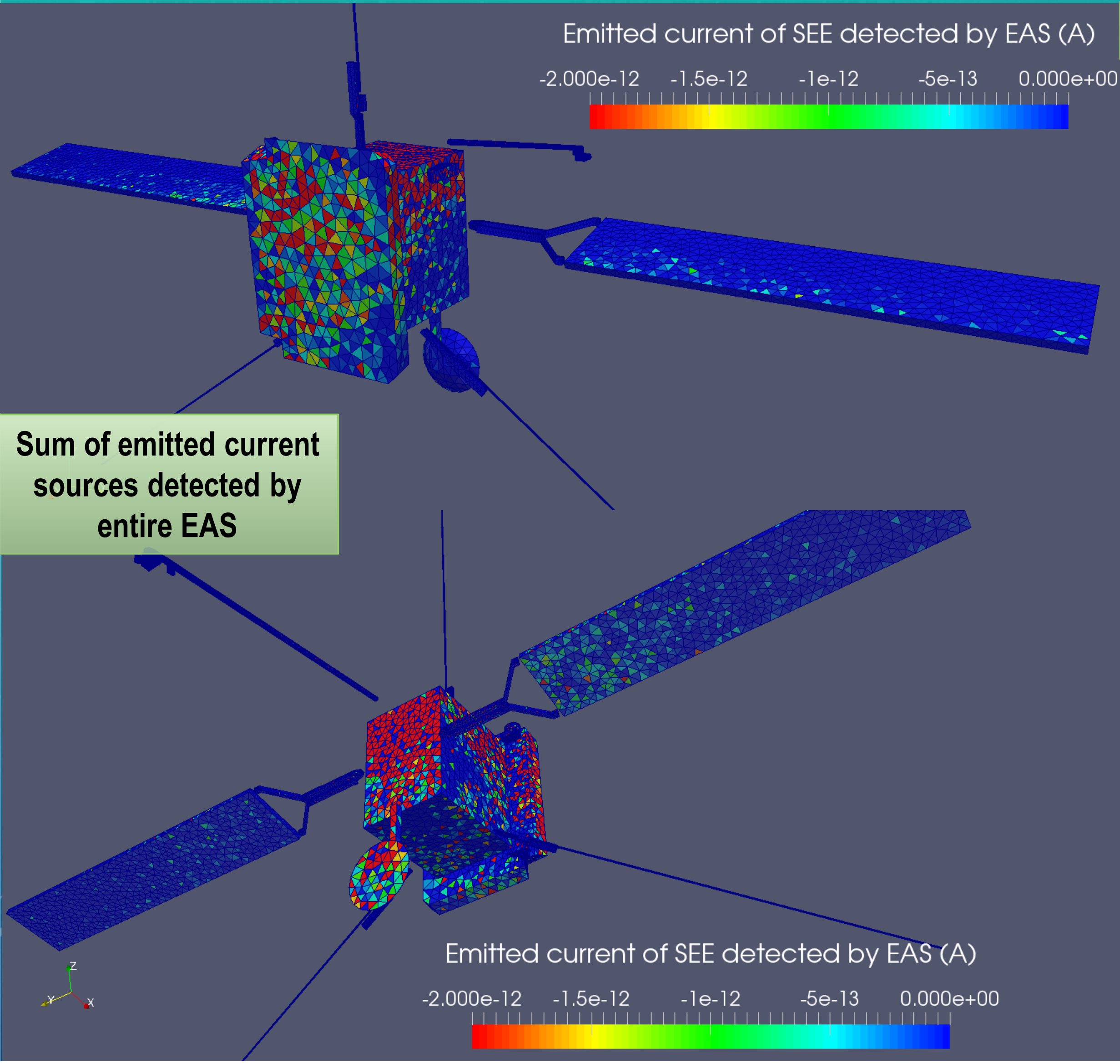
Deflection = angle between V_∞ and V_D : at **lower energies**, angle increases because of SC potential.

SEE: 0-8eV



Max: 170°

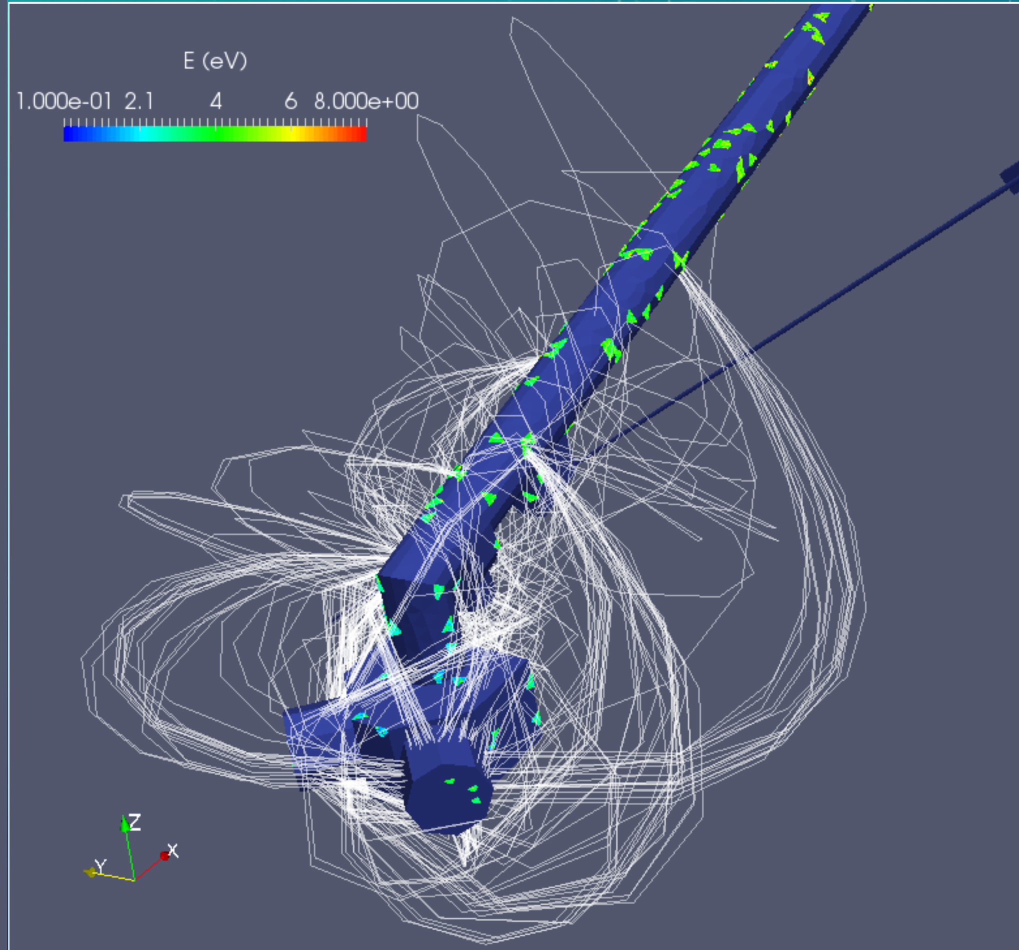
SWA-EAS: REF CASE NO BAFFLE – SEE SPIS OUTPUTS PROCESSED



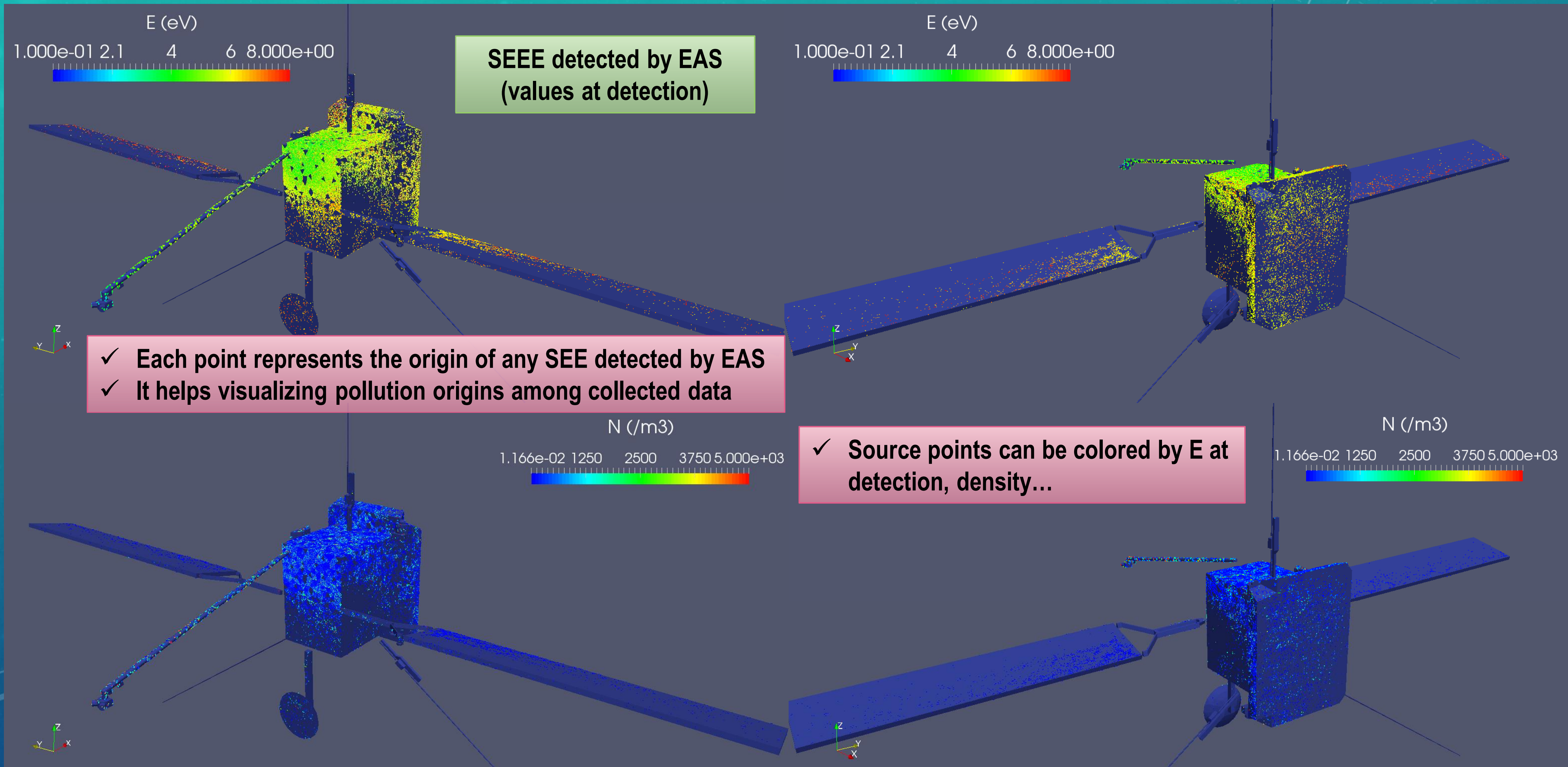
Sum of emitted current sources detected by entire EAS

SEEE detected by EAS

SPIS plots main trajectories, but others do exist



SWA-EAS: REF CASE NO BAFFLE – ADVANCED POST-PROCESSING

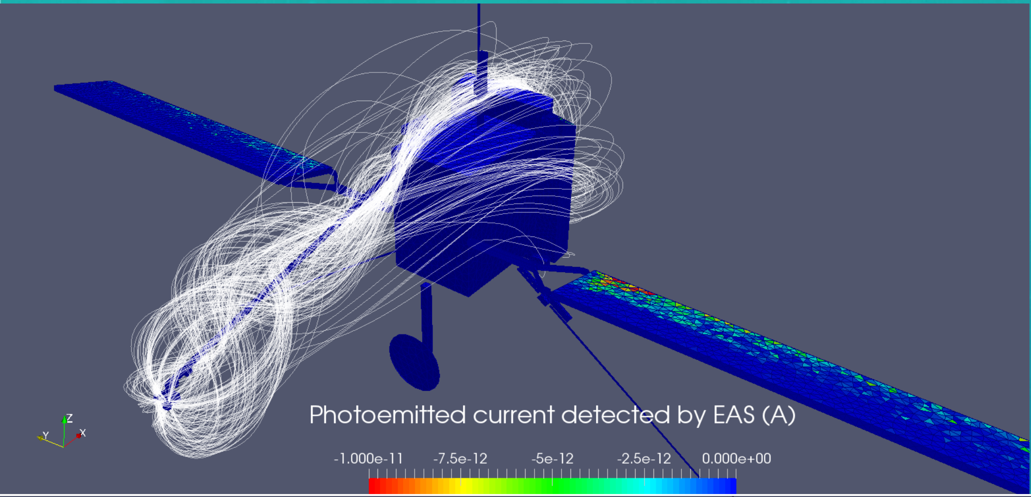


SEEE detected by EAS (values at detection)

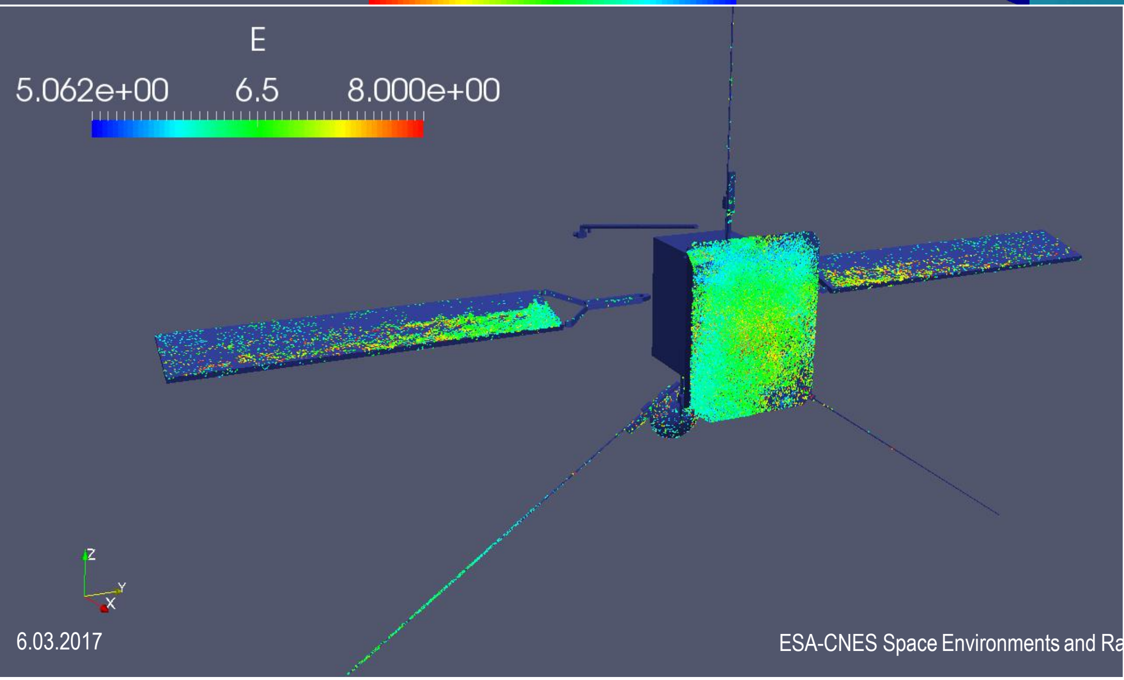
- ✓ **Each point represents the origin of any SEE detected by EAS**
- ✓ **It helps visualizing pollution origins among collected data**

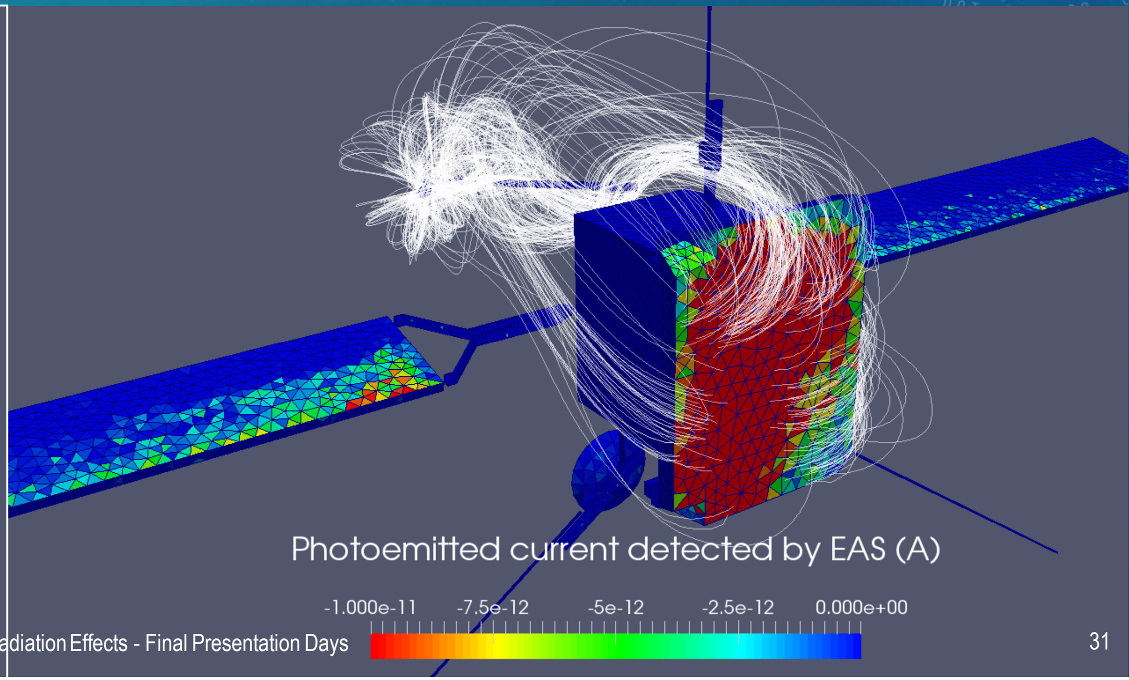
- ✓ **Source points can be colored by E at detection, density…**

SWA-EAS: REF CASE NO BAFFLE – PHOTO. SPIS OUTPUTS PROCESSED



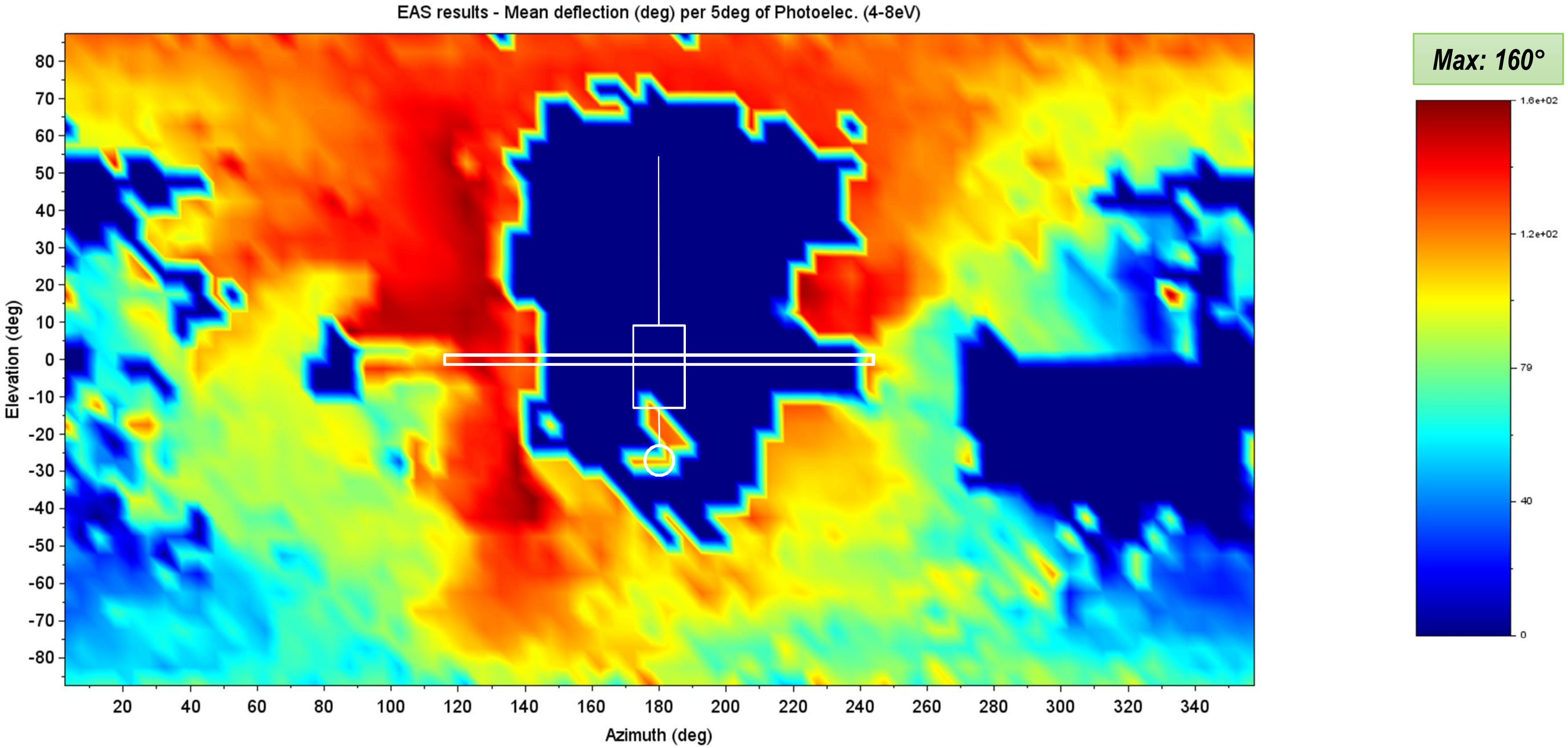
- Photoelectrons are emitted by all sunlit surfaces but not all of them can reach EAS
- Most positively charged faces recollect the majority of Photoelectrons
- RPW photoelectrons also reach EAS



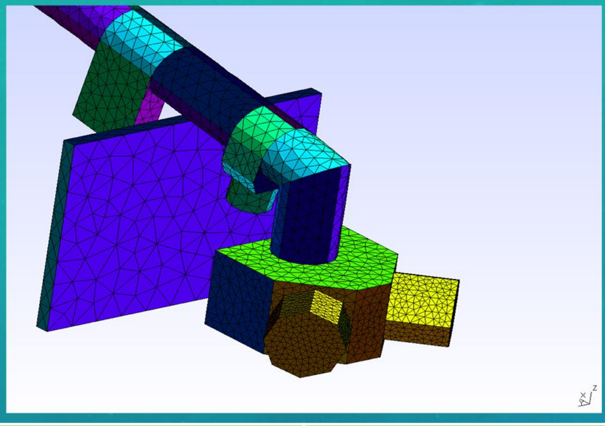


SWA-EAS: REF CASE NO BAFFLE – EAS FIELD OF VIEW

Photoelec. here made several loops around the boom



SWA-EAS: 2ND CASE WITH BAFFLE

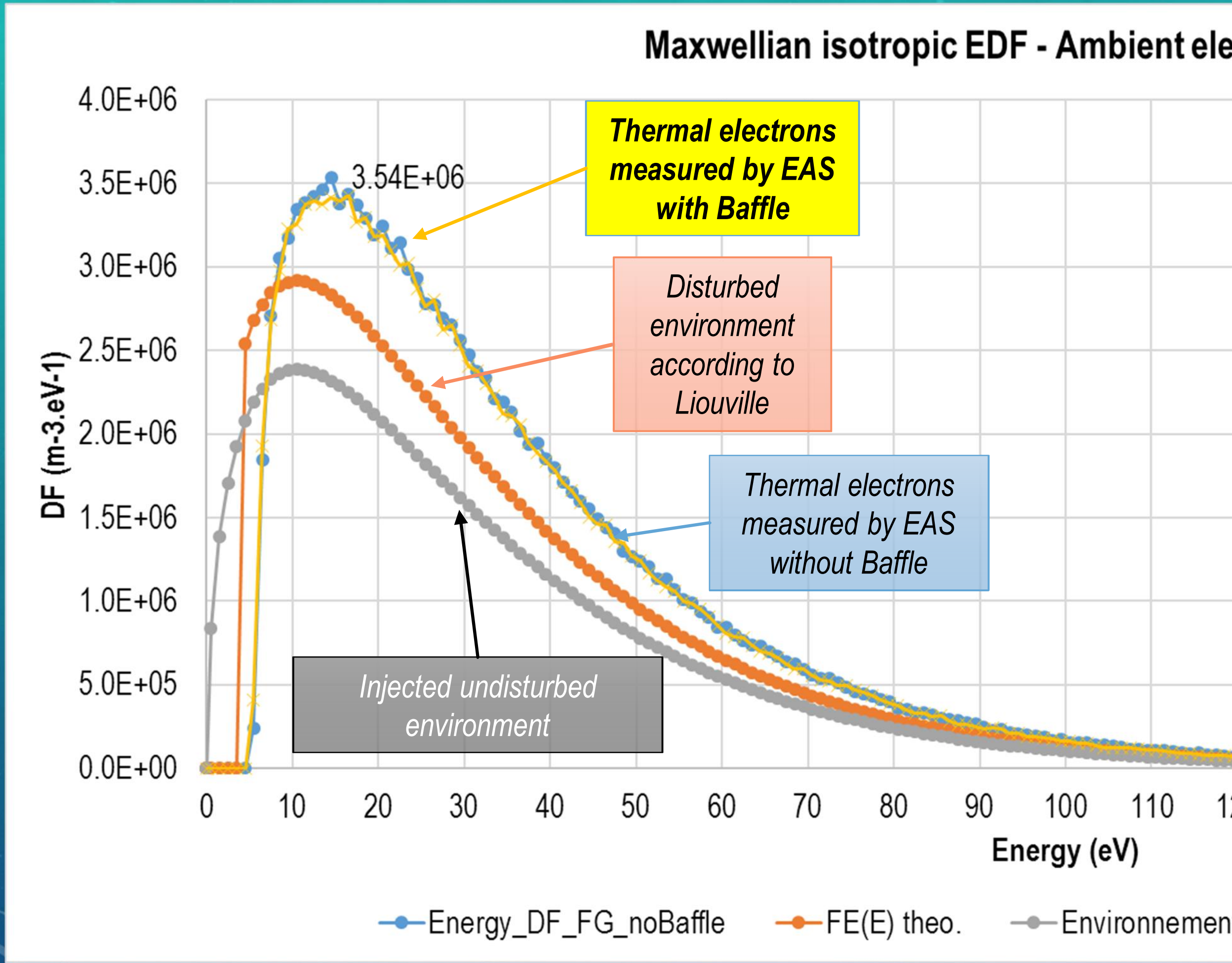


SC element	Potential (V)
Ground	4.2
RPW1	2.5
RPW2 and RPW3	2.8
SA1 and SA2 sunlit	7.7
Yoke1 and Yoke2 sunlit	9
EAS box	4.2
EAS sensors	4.2
Baffle	4.2

Environment parameters	Values at 0.28 AU from the Sun
Sun flux (# 1 AU)	12.76
Electron and Proton density (m^{-3})	1.04×10^8
Electron temperature (eV)	21
Proton temperature (eV)	27
Spacecraft velocity in X direction (m/s)	400000
Spacecraft velocity in Y direction (m/s)	-60000
Magnetic field (T)	0
Debye length (m)	3.4

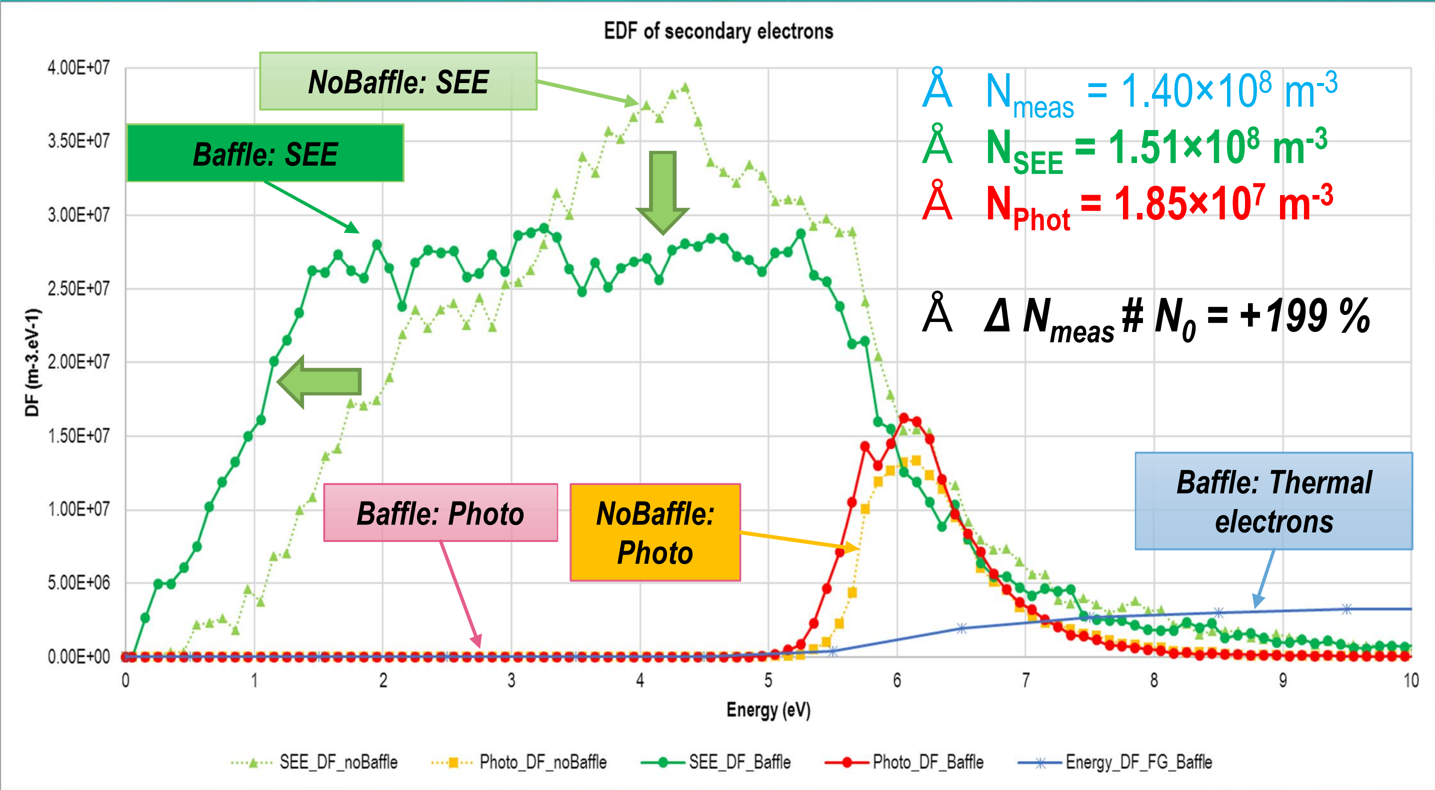
- Ions: *H+*, PIC with Maxwellian distribution and drift,
- Electrons: PIC with Maxwellian velocity distribution function,
- Photoelectrons: PIC with Maxwellian velocity distribution function and with a characteristic temperature $k_B T_{ph}$ = 3 eV,
- Secondary Electrons under Electron/Proton impact (SEE/SEP): PIC with Maxwellian velocity distribution function and with a characteristic temperature $k_B T_{SEE}$ = 2 eV, backscattered electrons with 2/3 of their initial energy,
- External boundary conditions: Fourier, $1/R^2$ decrease of potential
- No injected biasing current in the antennas

SWA-EAS: 2ND CASE WITH BAFFLE – EAS MEASUREMENTS



- $N_0 = 1.04 \times 10^8\ m^{-3}$
- $N_{theo} = 1.19 \times 10^8\ m^{-3}$
- **w/o baffle $N_{meas} = 1.4172 \times 10^8\ m^{-3}$**
- **w baffle $N_{meas} = 1.4048 \times 10^8\ m^{-3}$**
- ***$\Delta\ N_{meas\text{-}baffle}\ \#\ N_{meas} = -0.87\%$***
- *Fortunately the baffle does not seem to affect dramatically ambient electrons detection.*
- *What about SEE and Photoelec. ?*

SWA-EAS: 2ND CASE WITH BAFFLE – EAS MEASUREMENTS



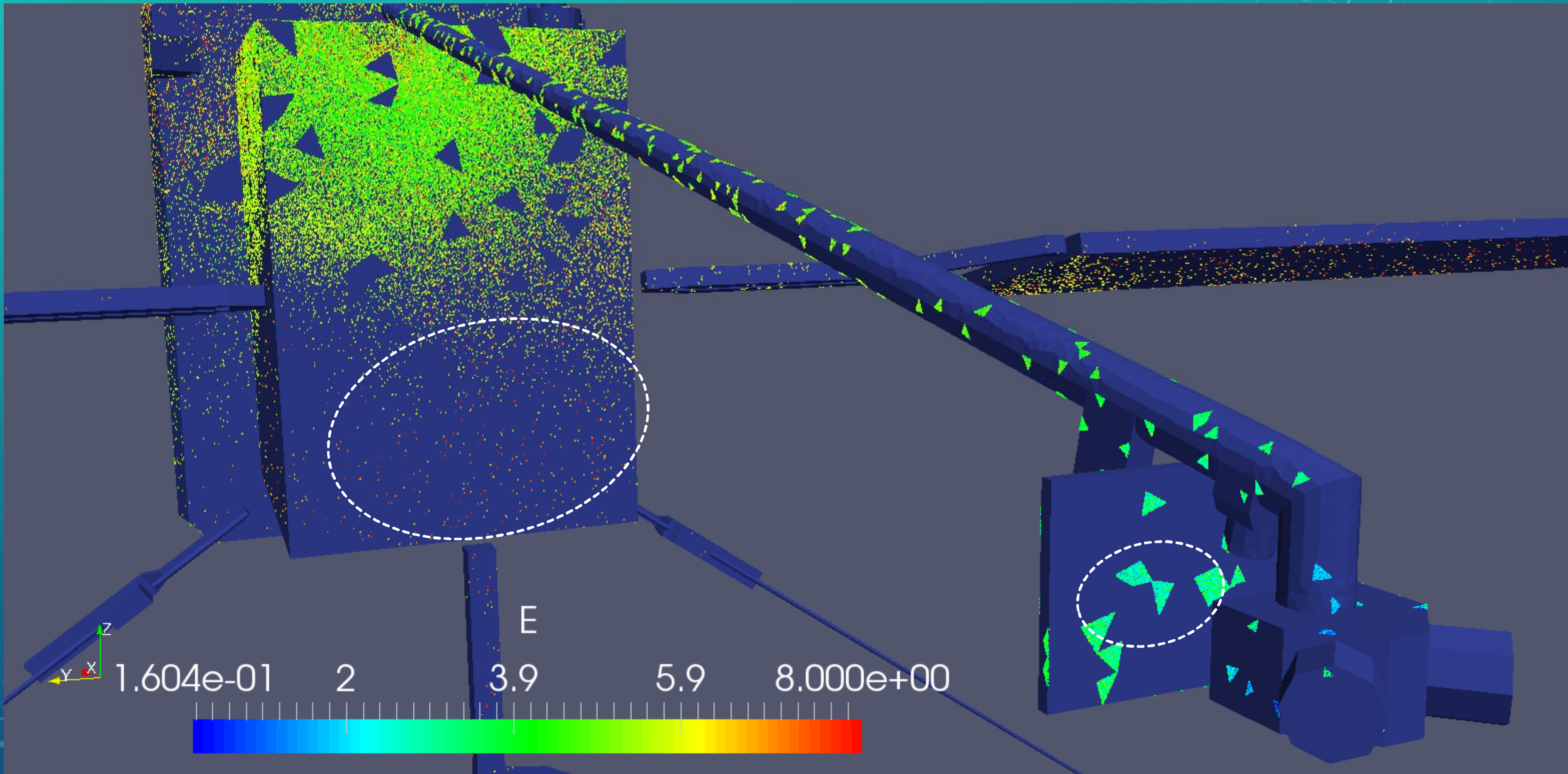
- $N_{meas} = 1.40\times10^{8}\ m^{-3}$
- $N_{SEE} = 1.51\times10^{8}\ m^{-3}$
- $N_{Phot} = 1.85\times10^{7}\ m^{-3}$

- ΔN_{meas} # N_0 = +199 %

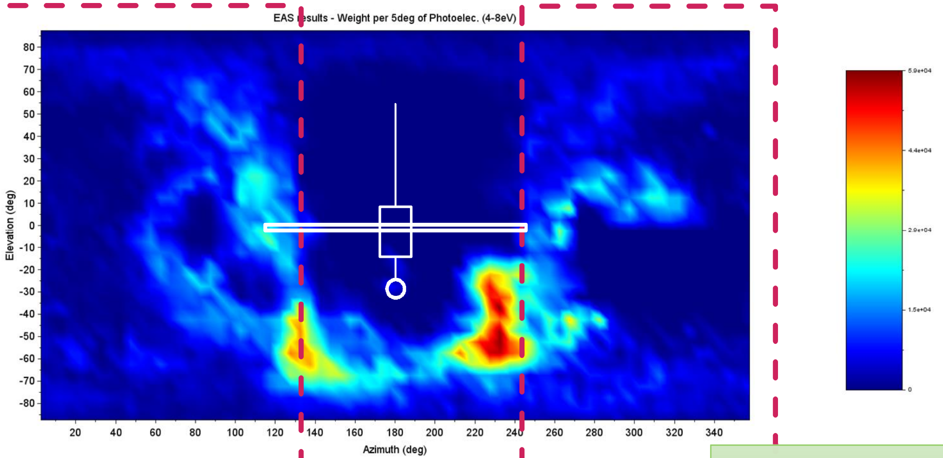
Value	With Baffle	Without Baffle	Diff Δ w#w/o
N_{meas}	$1.4048\times10^{8}\ m^{-3}$	$1.4172\times10^{8}\ m^{-3}$	-0.9%
N_{SEE}	$1.5114\times10^{8}\ m^{-3}$	$1.4895\times10^{8}\ m^{-3}$	+1.5%
N_{photo}	$1.8457\times10^{7}\ m^{-3}$	$1.5066\times10^{7}\ m^{-3}$	+22%
N_{total}	$3.1008\times10^{8}\ m^{-3}$	$3.0573\times10^{8}\ m^{-3}$	+1.4%

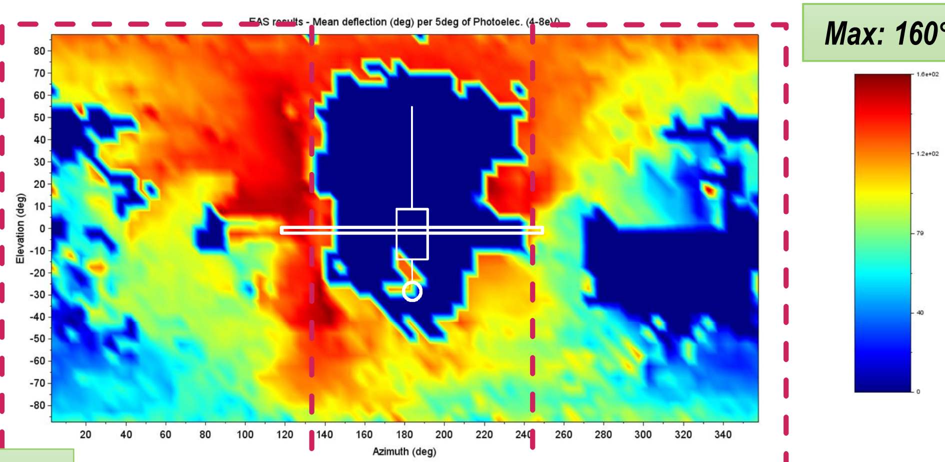
- The presence of EAS Baffle modifies the aspect of SEE EDF, without dramatically increasing the flux: **+1.5%**
- Surprisingly: Photoelectrons detected by EAS are the most increased population: **+22%**, even though their density remain weak # other electrons…

SWA-EAS: 2ND CASE WITH BAFFLE – SEE MEASUREMENTS



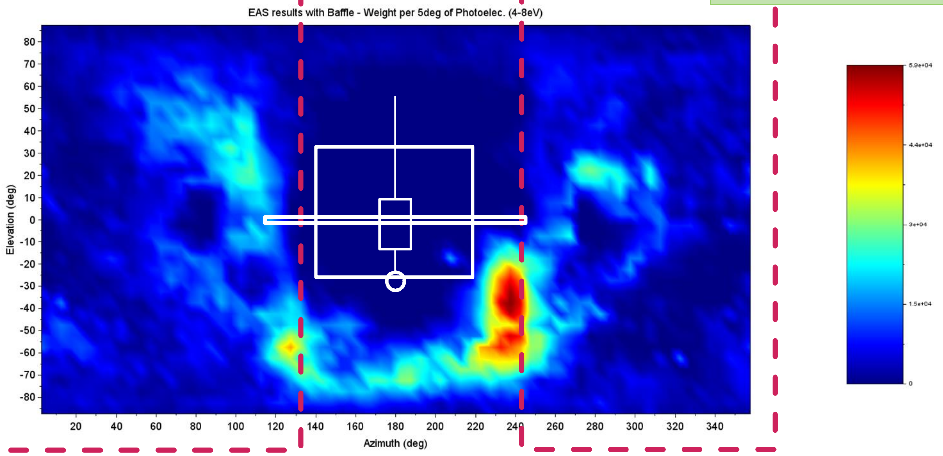
SWA-EAS: 2ND CASE WITH BAFFLE – EFFECT IN EAS FOV FOR PHOTO-E

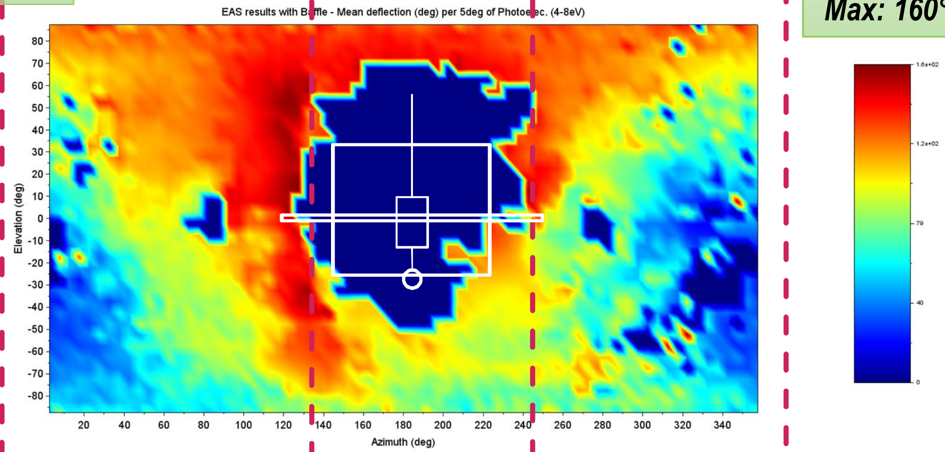




Max: 160°

More photoelectrons coming from vicinity of baffle: electrostatic lens





Max: 160°

SWA-EAS: CONCLUSION

Achievements:

Å Modelling of the instrument, now adapted to the most recent CAD model of Solar Orbiter, parametrized and easily adaptable to any new changes in SC config/material

Å Generation of several configured simulations and SPIS-independant routines which provide powerfull anlayzing tools for EAS measurement analysis

Å Development within those packages of the possibility to understand and quantify EAS data and included biases: distinguish ambient and SC generated electrons, determinate the sources, anticipate needed corrections

Å Share models and tools with other labs, train and allow teams to be autonomous for performing future simulations

Perspectives:

Å Update materials on SC (ELGILOY photoemission properties)

Å Update baffle geometry with more realistic shape

Å Include electromagnetic fields within simulation volume

Å Consider the biasing currents into RPW antennas to study the corresponding effects on EAS measurements