Signals of dust impacts detected by the Time Domain Sampler

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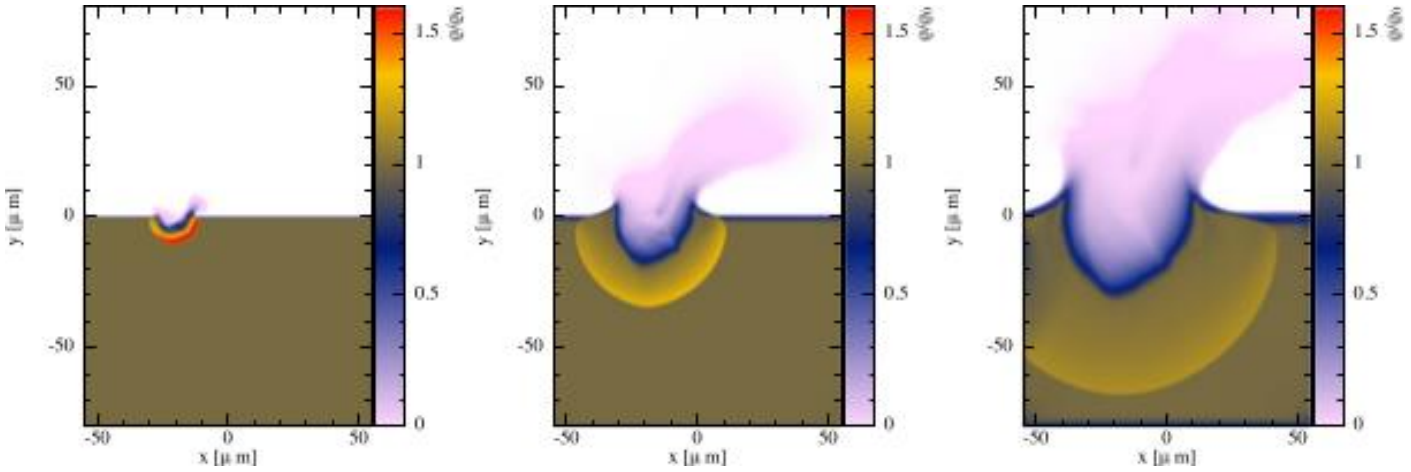
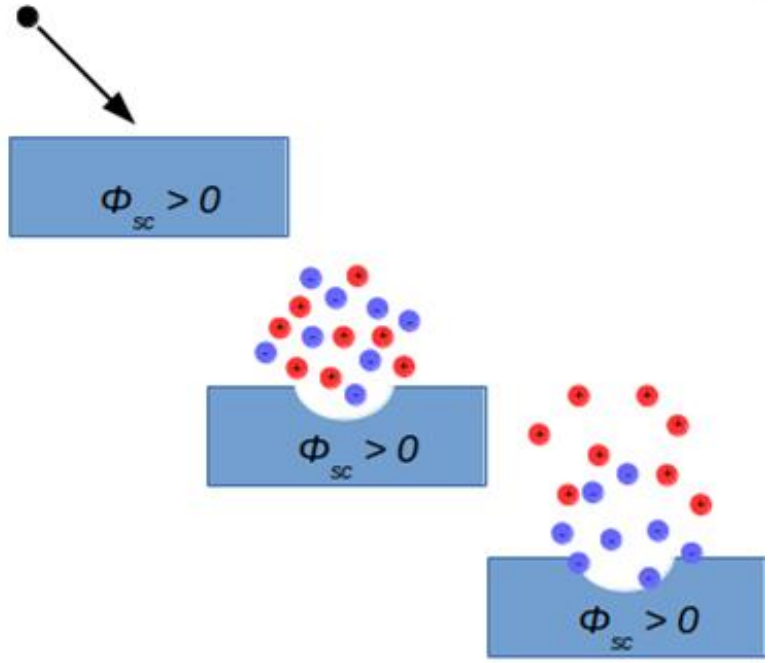
Dust impacts

Dust grains impacting with high velocities the spacecraft body can be partly or totally evaporated and create a cloud of charged particles.

Presence of electrons and ions generated by such hypervelocity impacts can consequently influence the spacecraft potential and/or measurements of **on-board scientific instruments.**



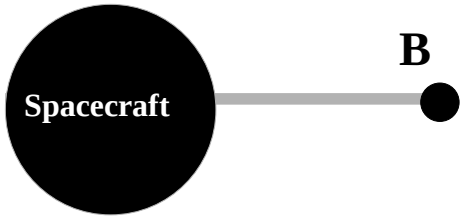
[Fletcher et al., 2015]



Electric field instruments

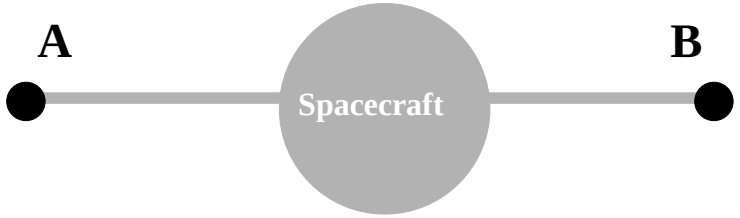
Electric field instruments are able to register signals generated by dust impacts as short pulses in the measured electric field.

The **monopole** configuration (probe-to-spacecraft potential measurement)



$$E = U/d = (\varphi_B - \varphi_{SC})/d$$

The **dipole** configuration (probe-to-probe potential measurement)

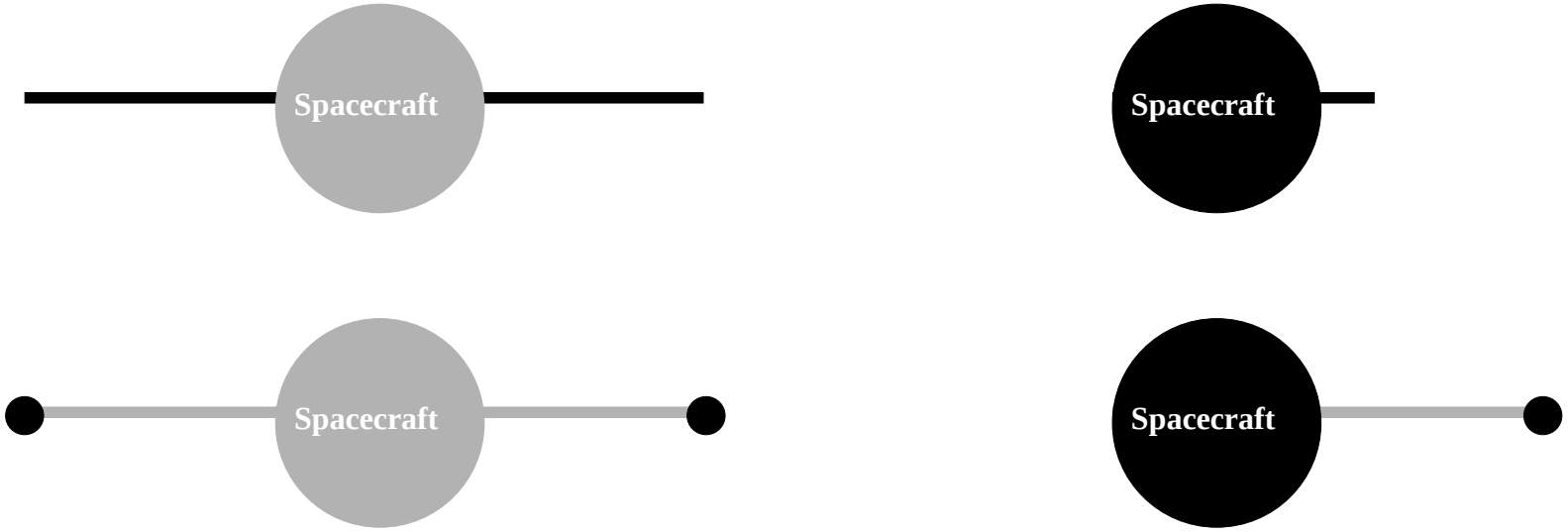


$$E = U/d = (\varphi_B - \varphi_A)/d$$

** black parts are sensitive*

Electric field instruments

Various configurations of the electric field instruments



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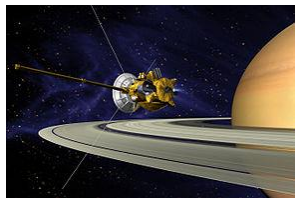
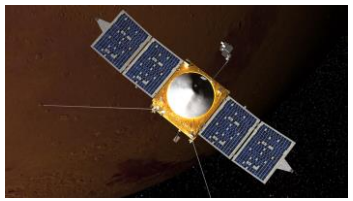
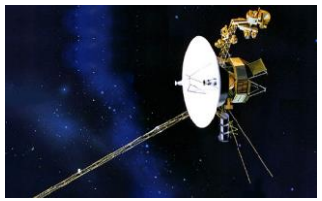
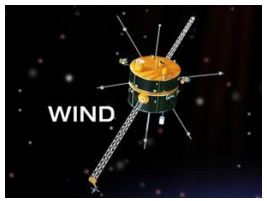
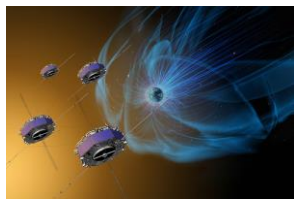
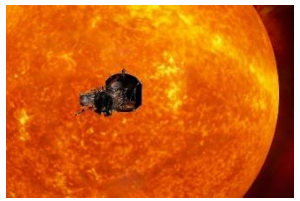







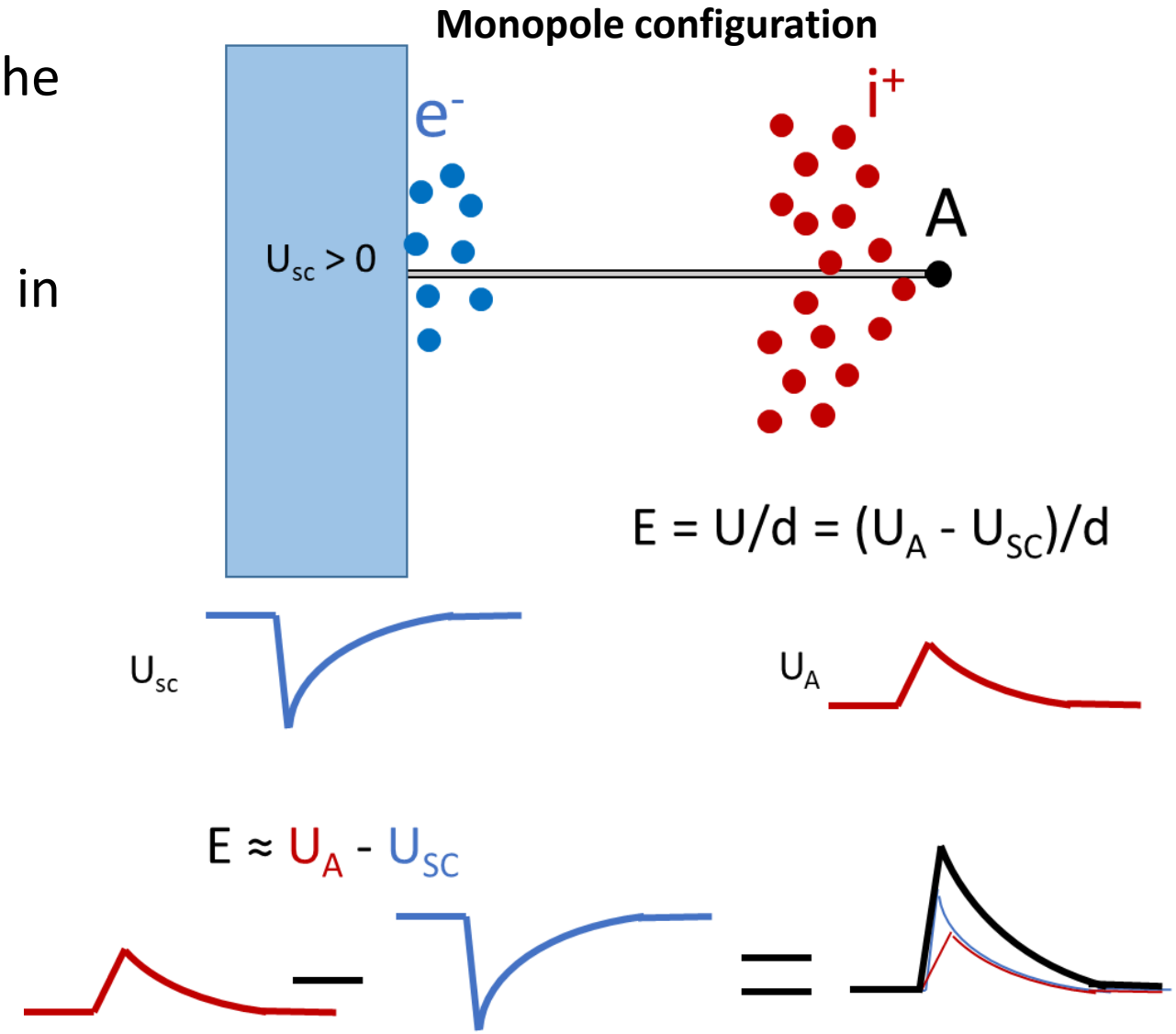
Dust impacts detection by electric field instruments

Electric field instruments are sensitive to the impact cloud generated by dust impacts.

This event can be detected as short pulses in the measured electric field.

Noise in electric field measurements.

This noise can be used for dust detection.



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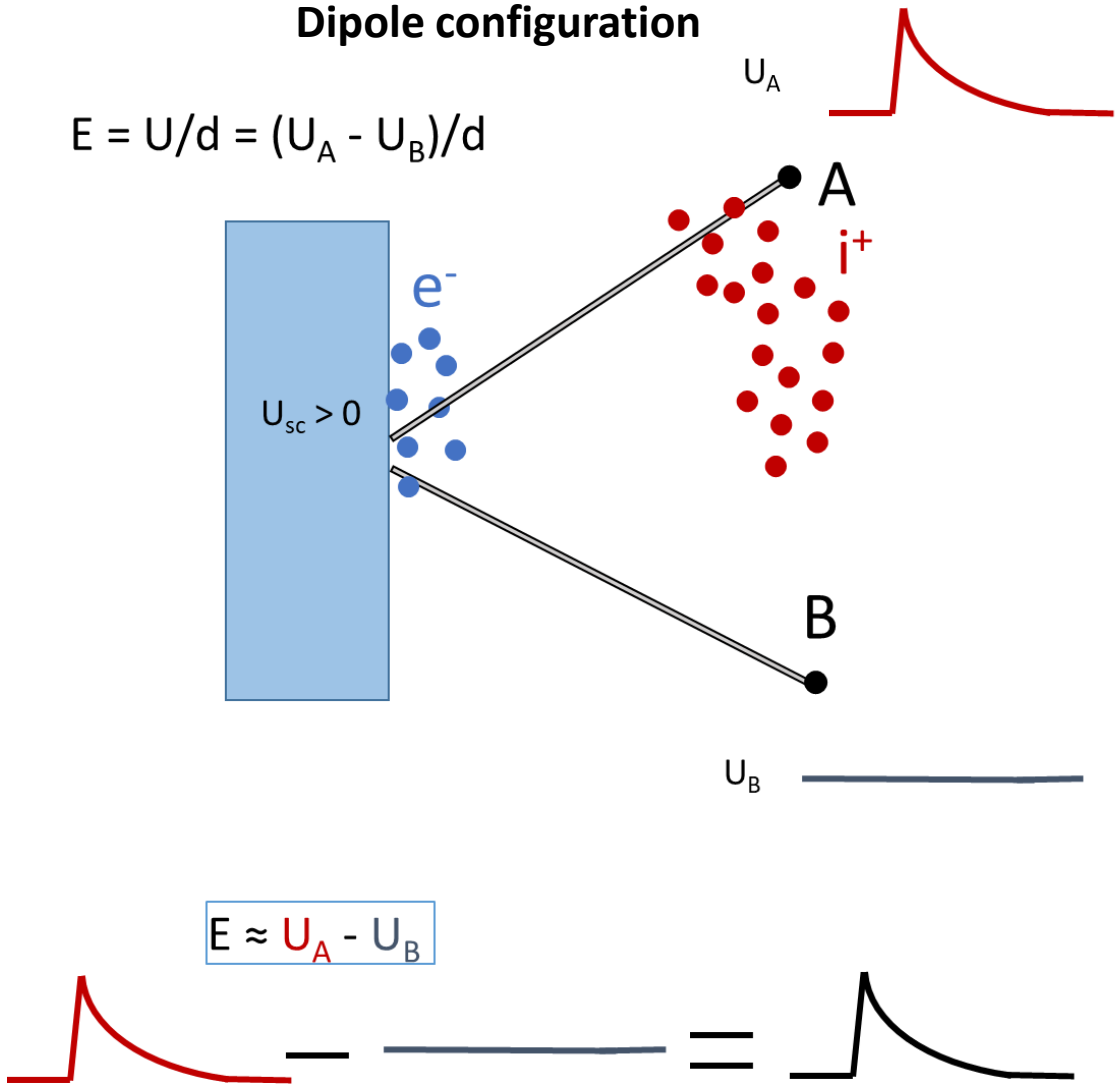
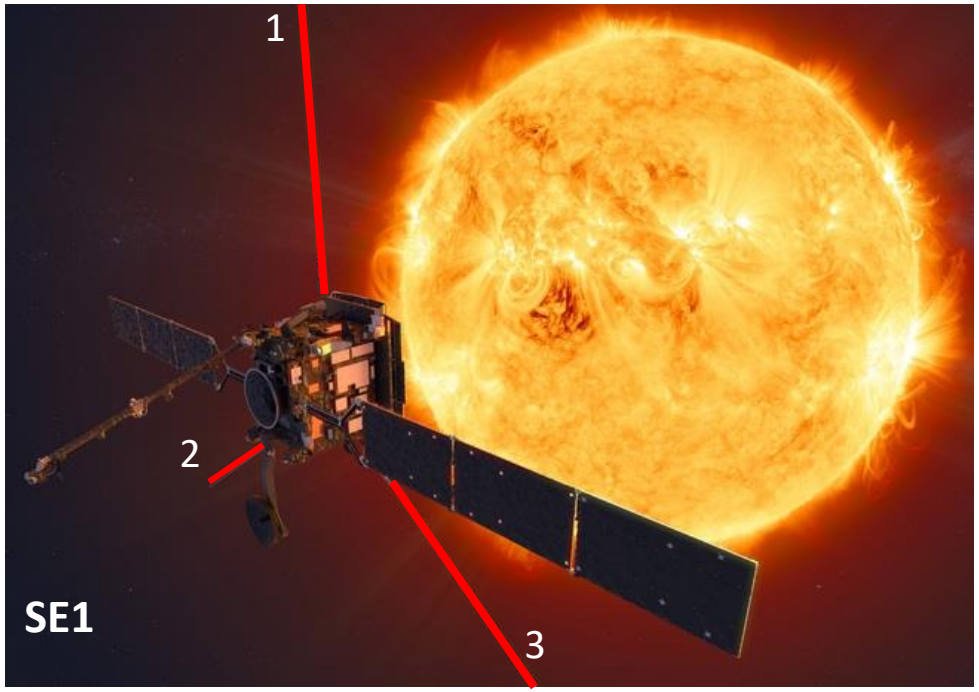
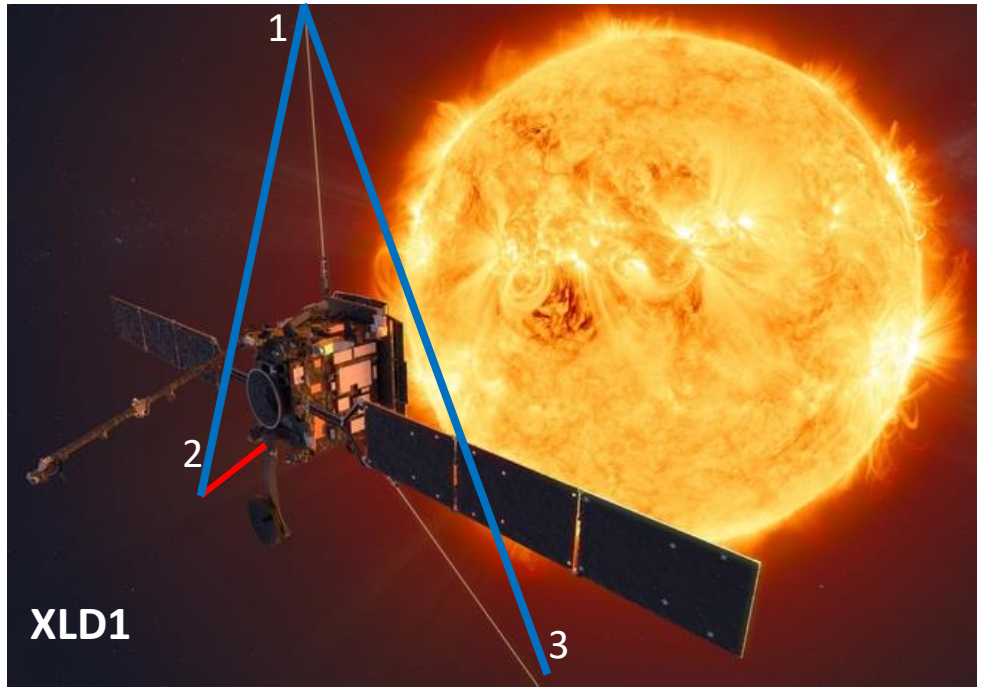


Solar Orbiter – TDS – SE1/XLD1

Main operation modes:

SE1	V1	V2	V3
XLD1	V1-V3	V2-V1	V2





Solar Orbiter – ZOO

Nice clear pulses
1439 in XLD1 mode
(6/2020 - 12/2021)

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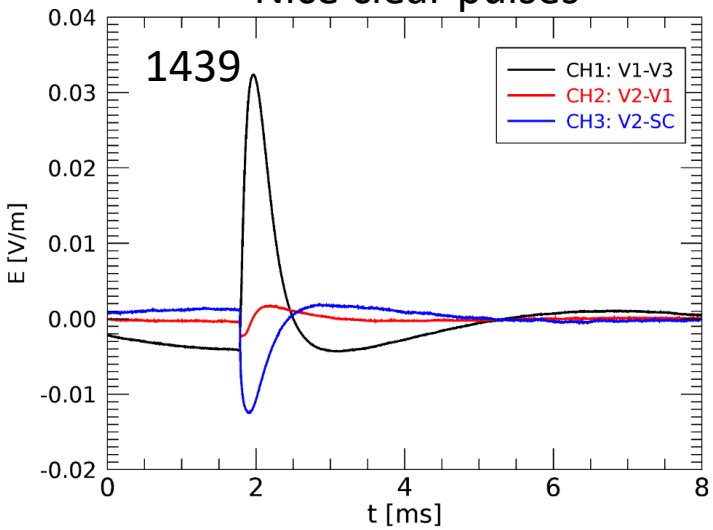
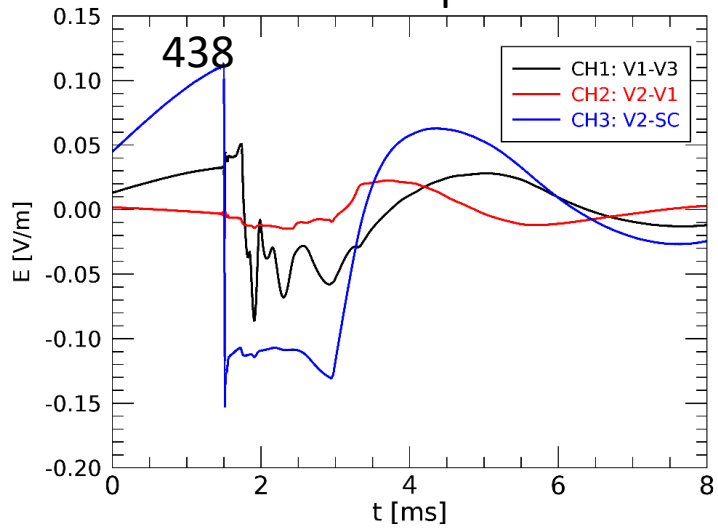
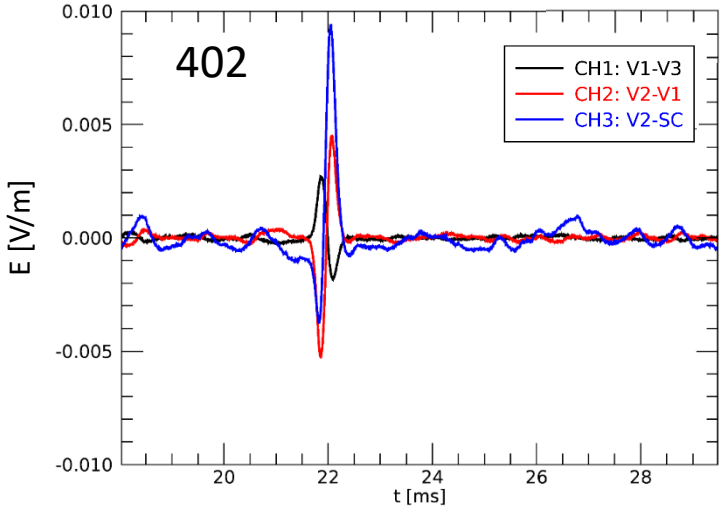


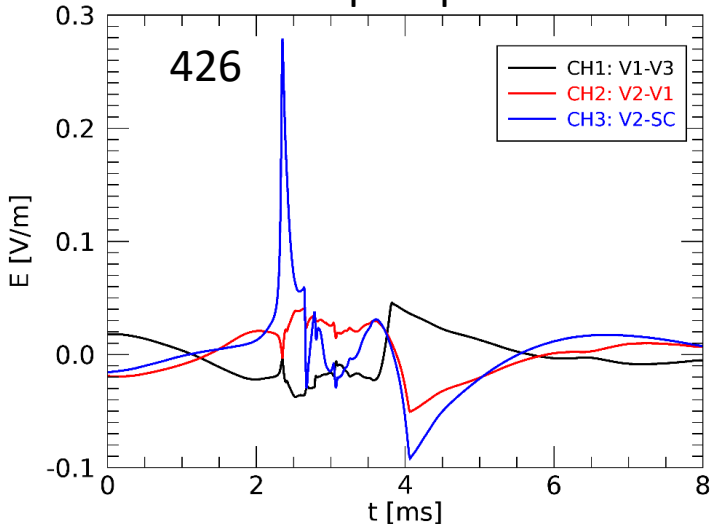
Saturated pulses



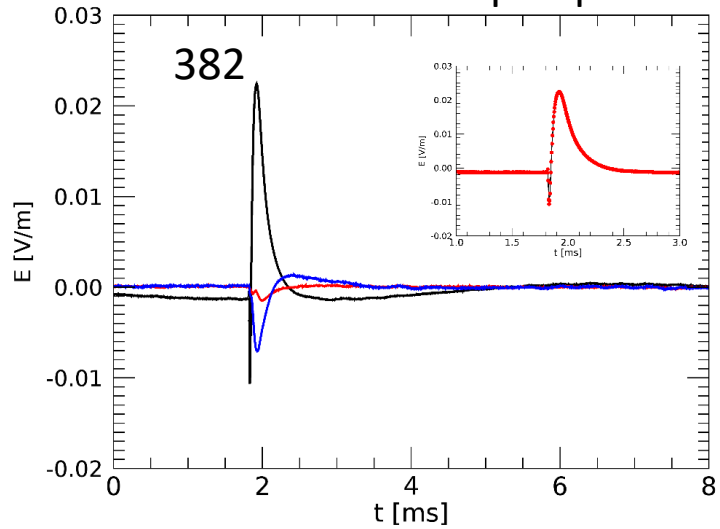
Solitary waves



Complex pulses



Pulses with “prespikes”



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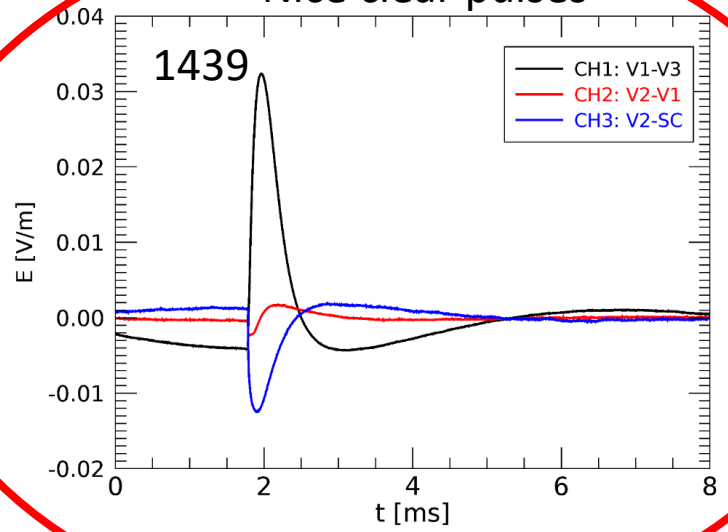

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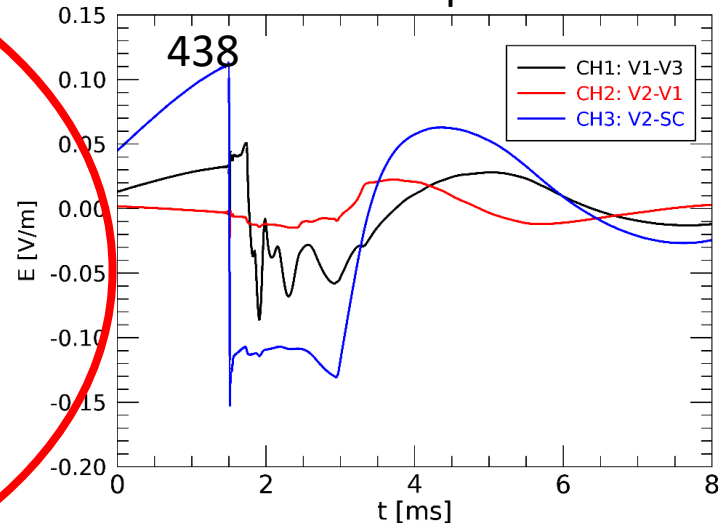

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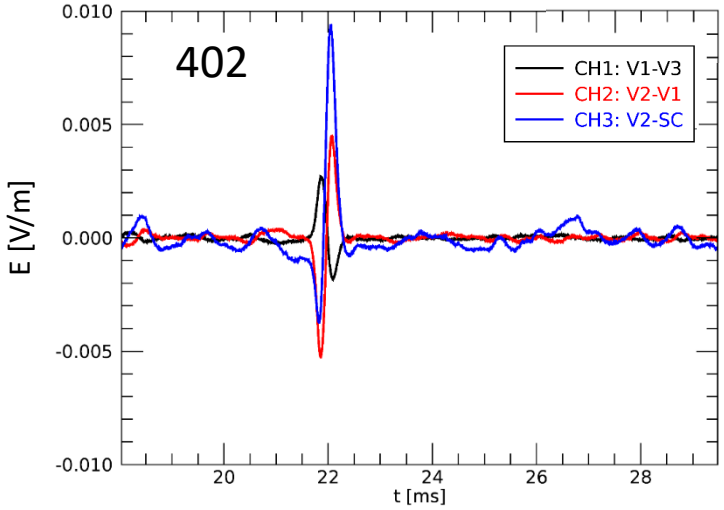

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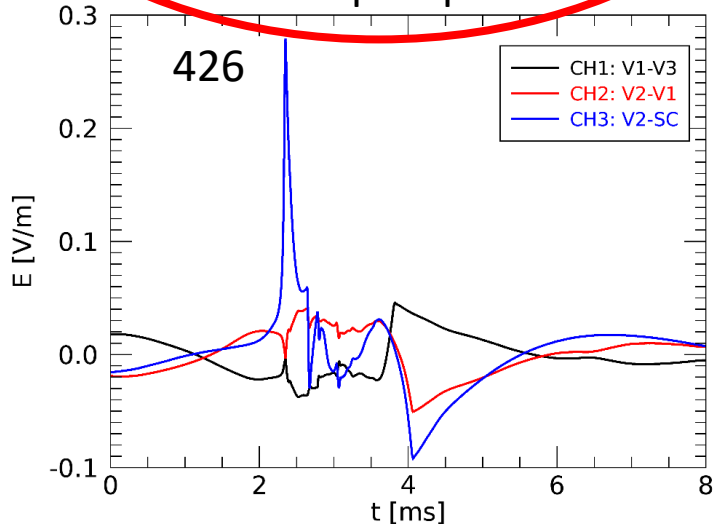

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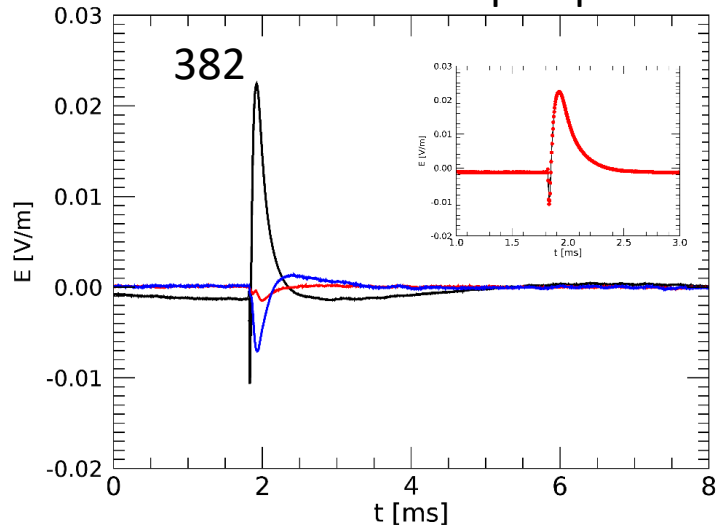
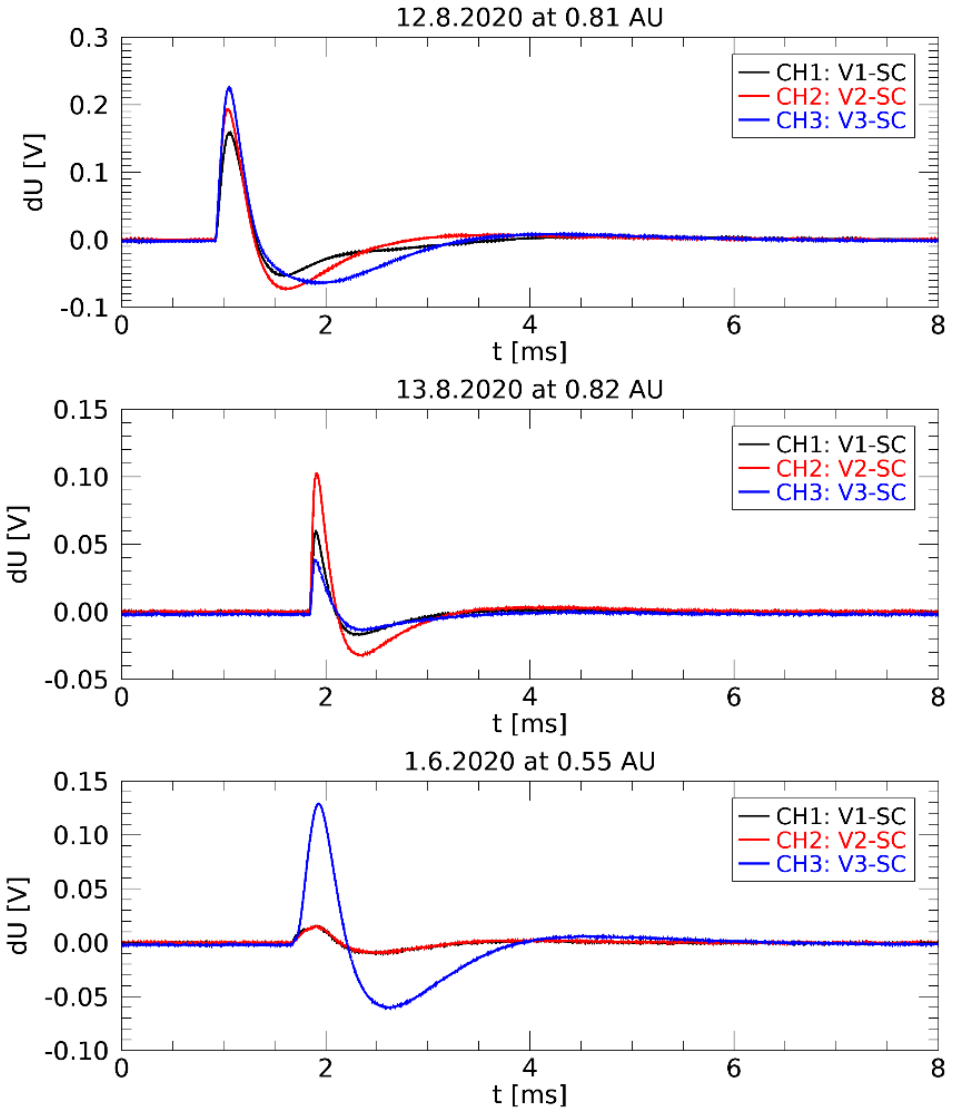
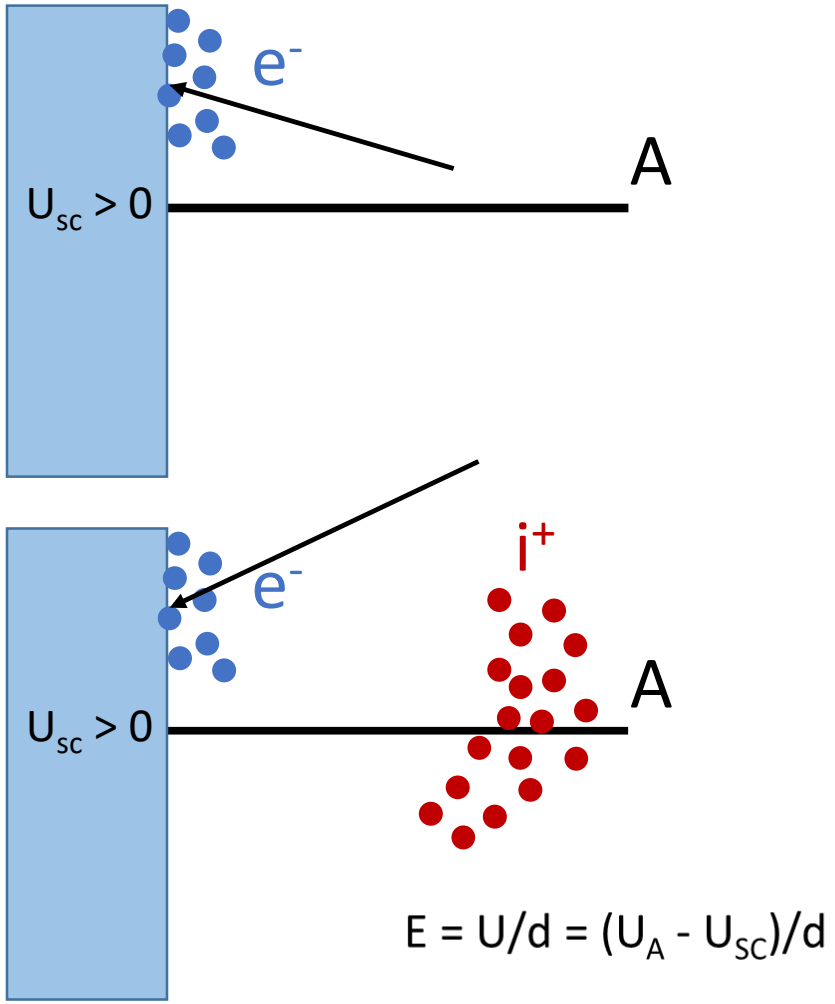


Solar Orbiter – TDS – SE1 mode





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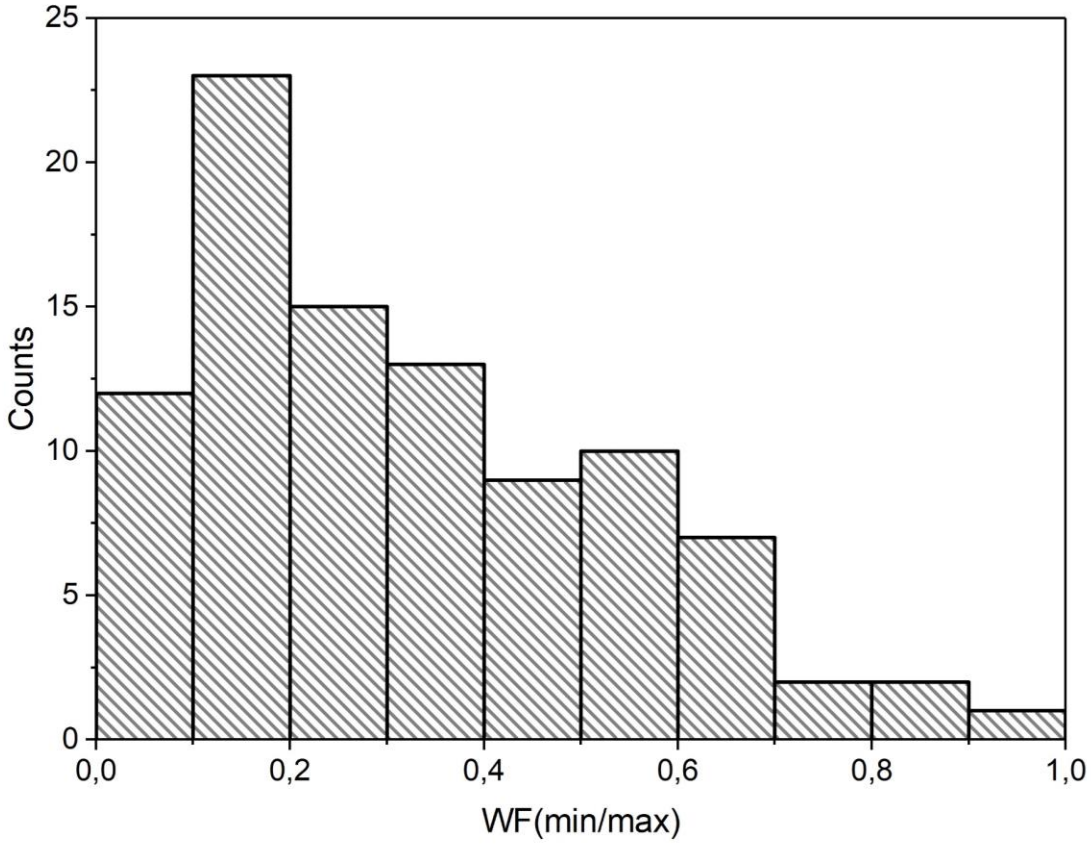

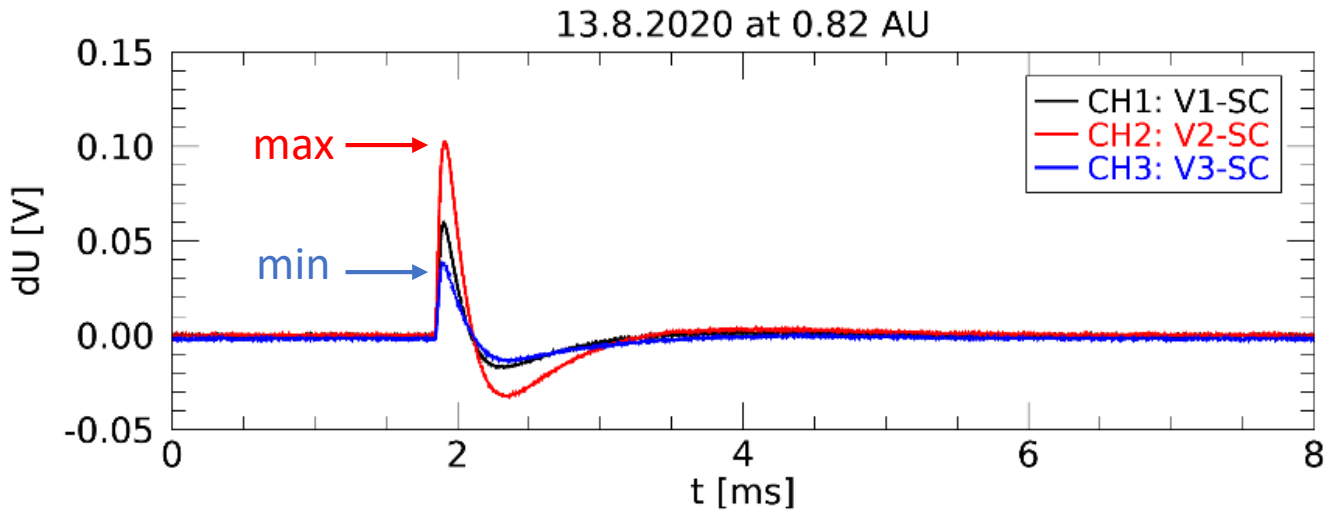

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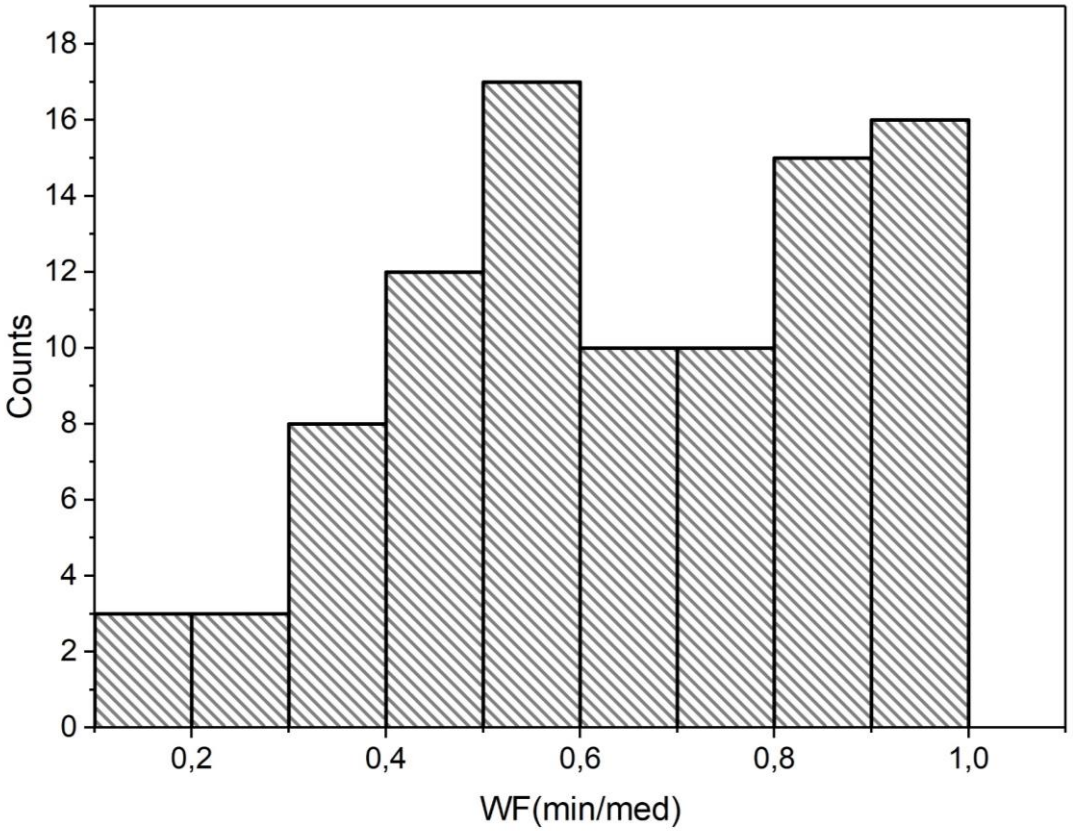

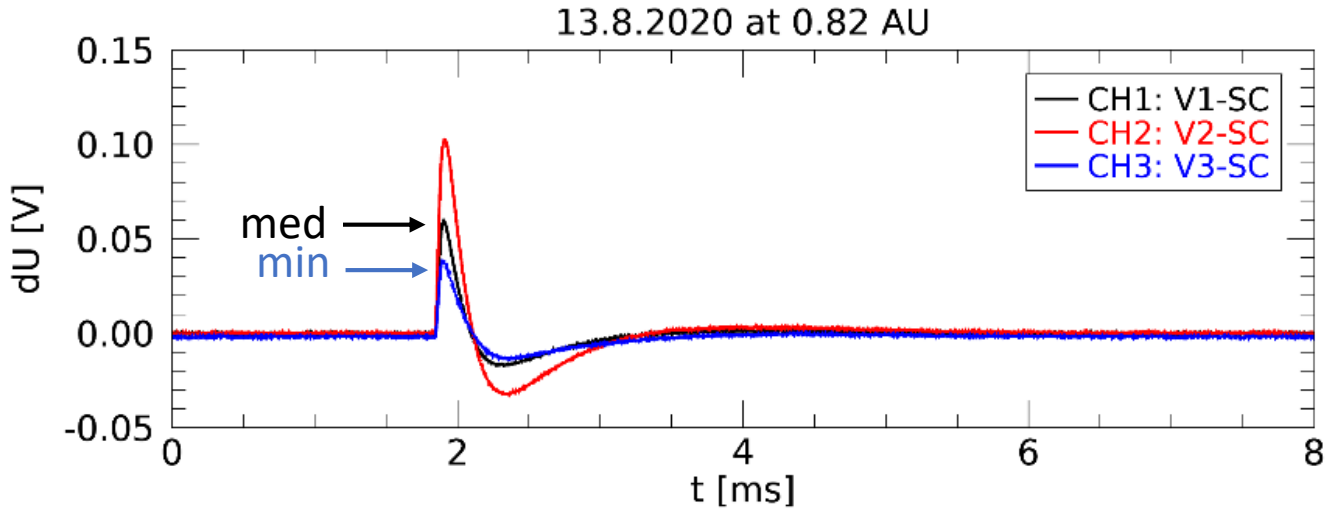

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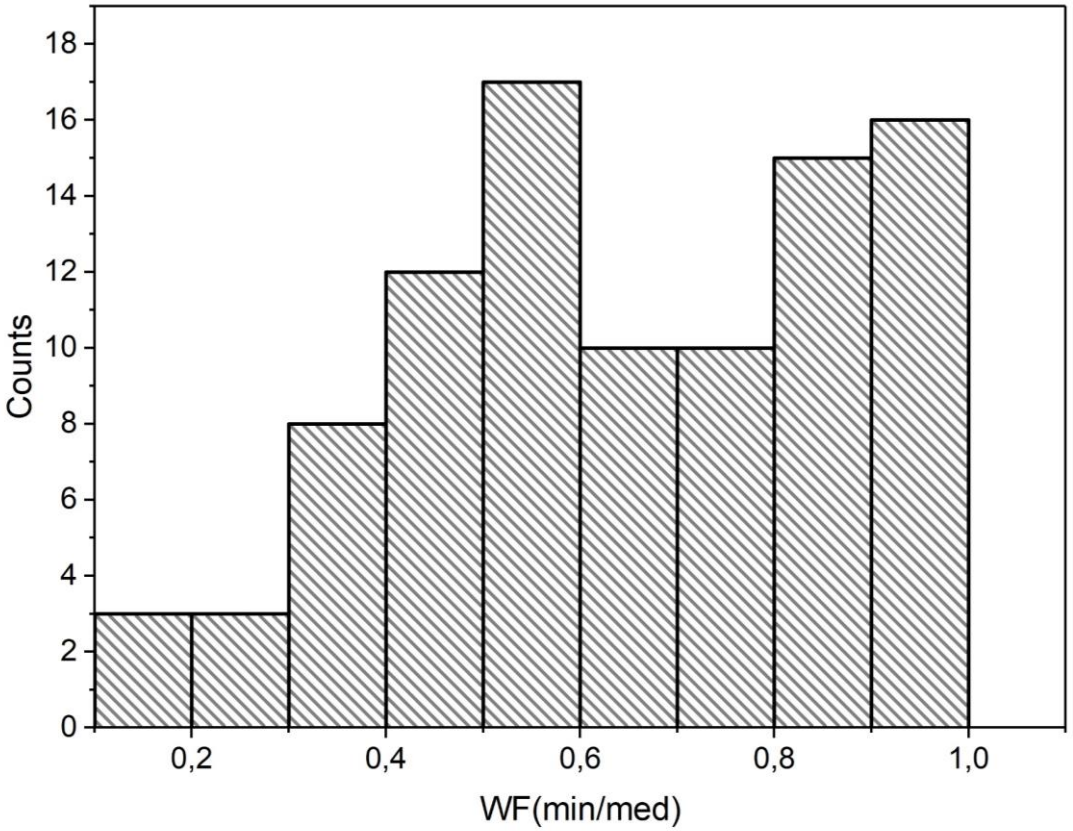
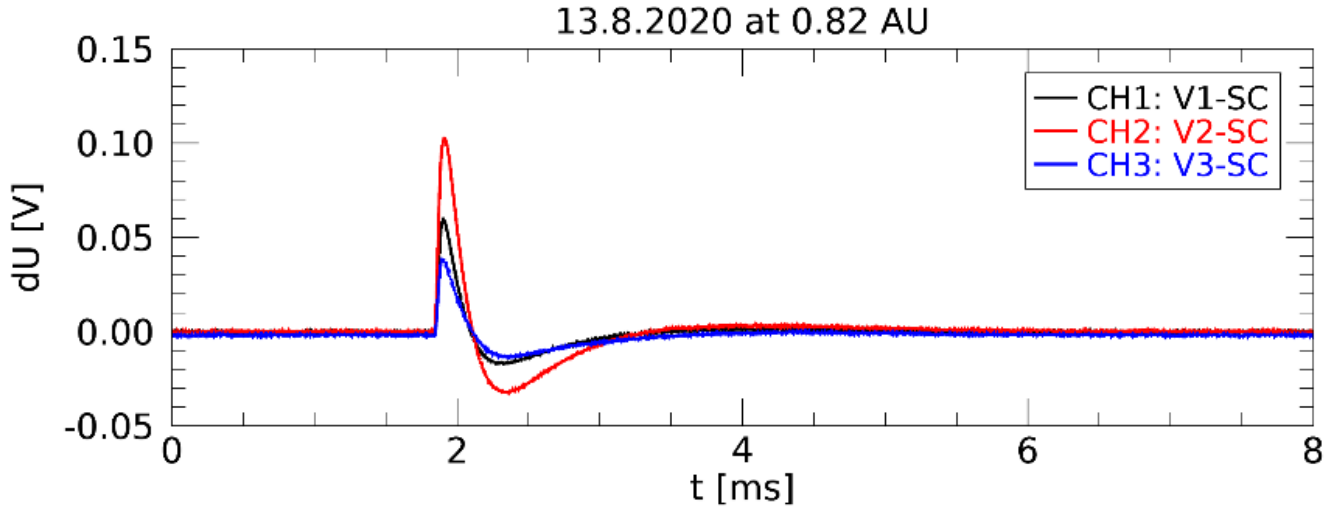
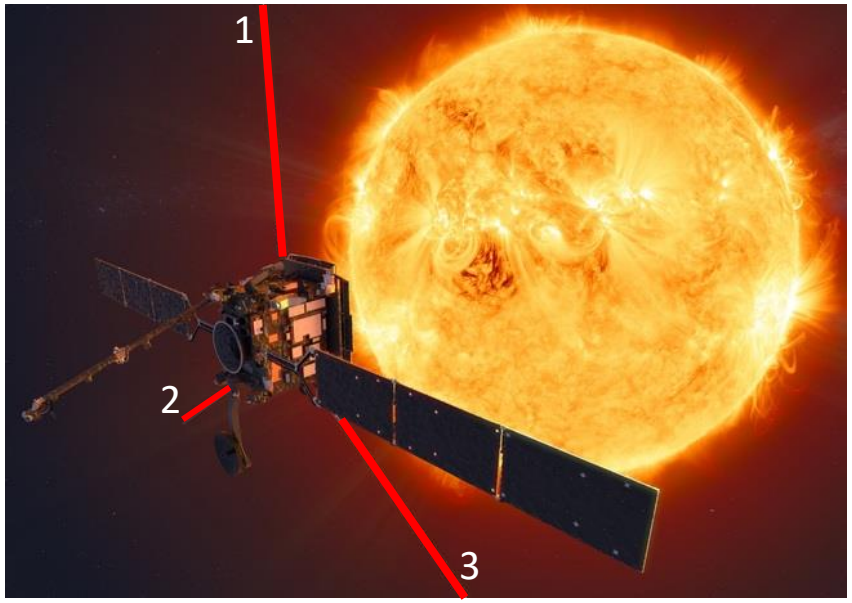
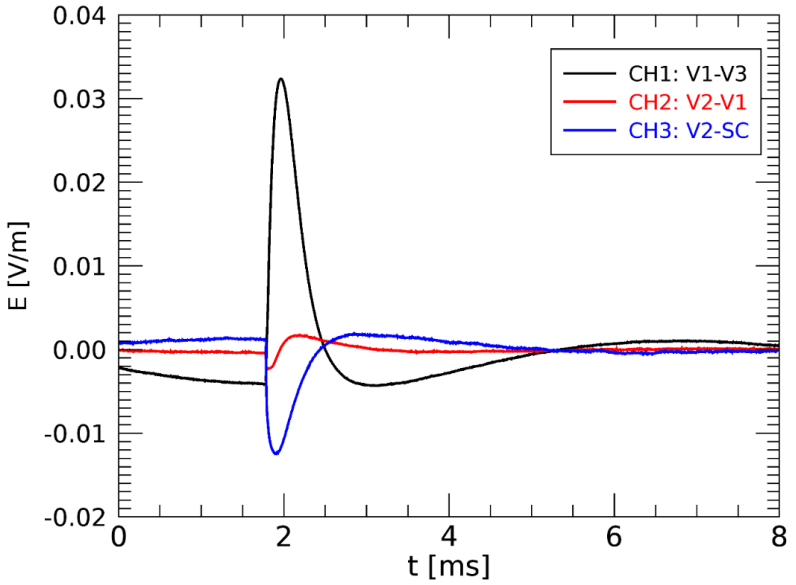
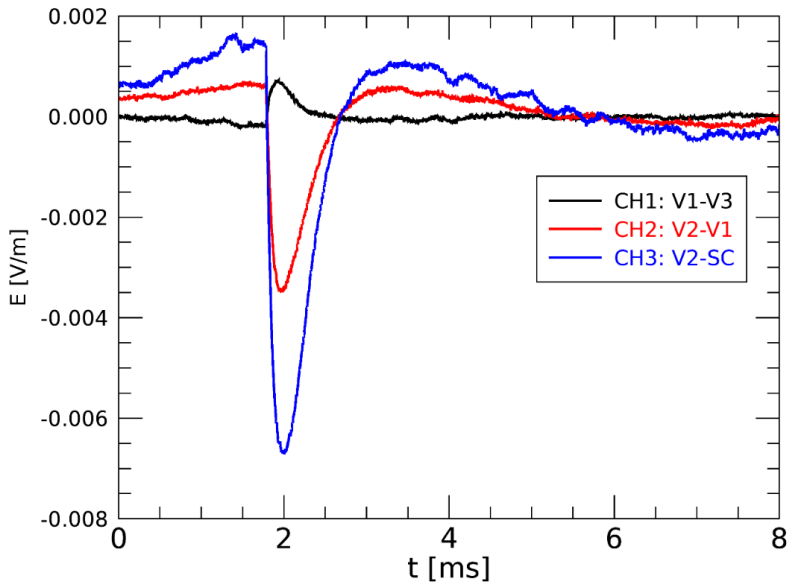


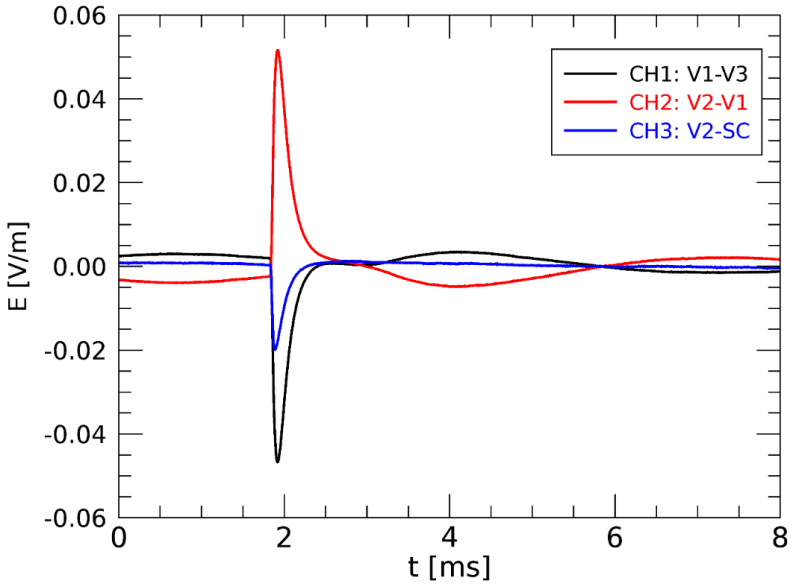


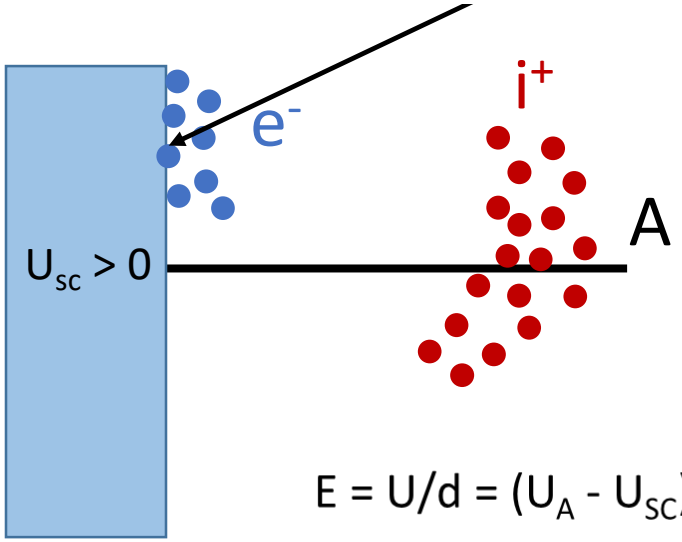


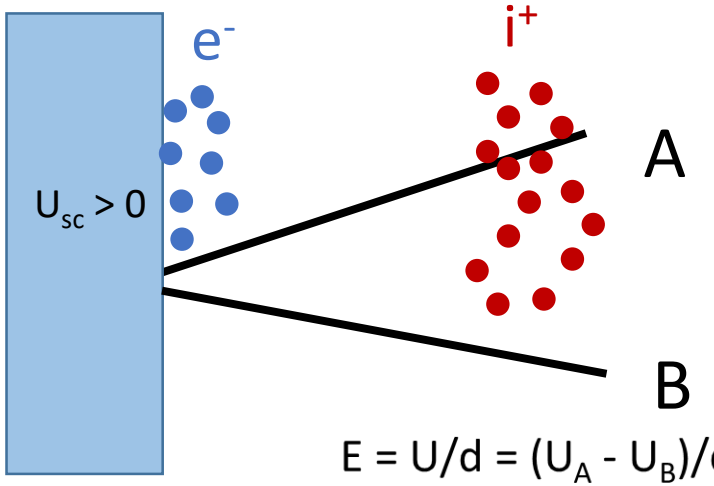
Solar Orbiter – TDS – XLD1 mode



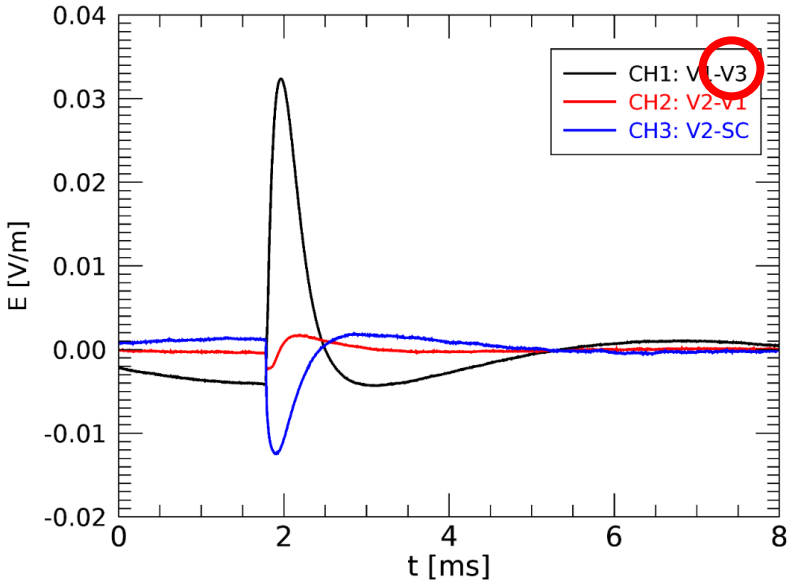


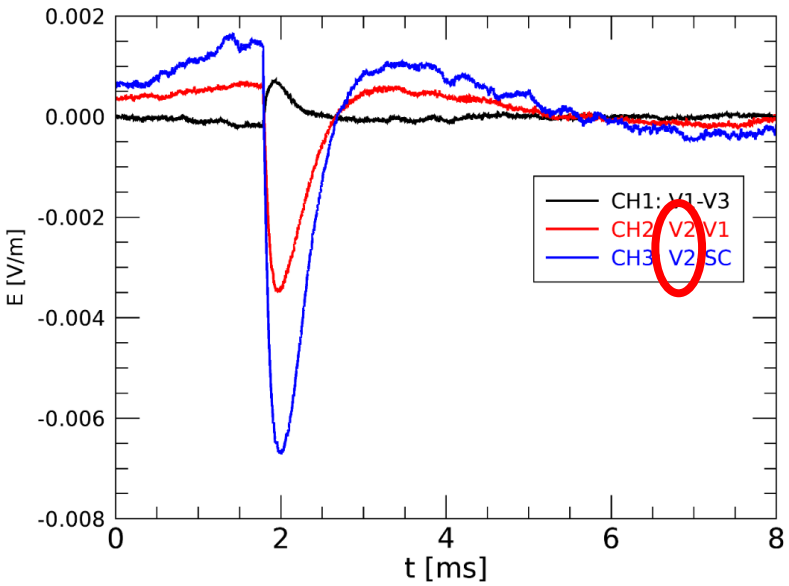


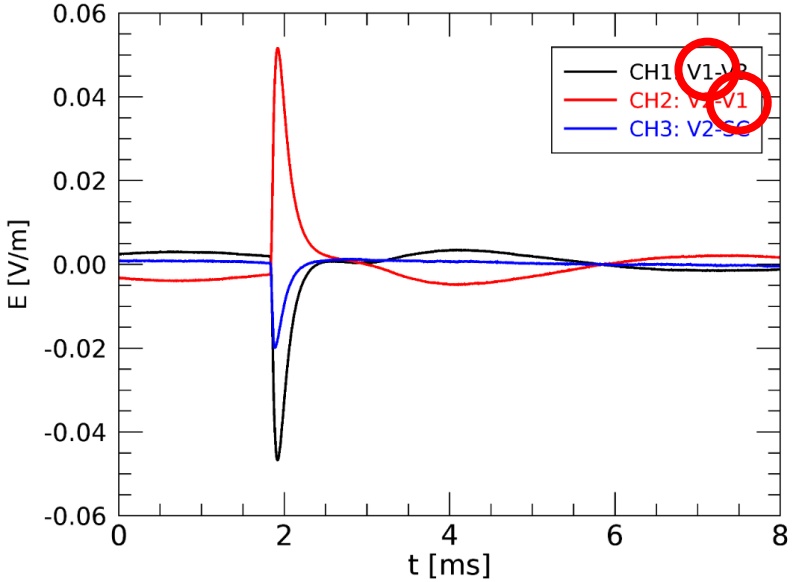


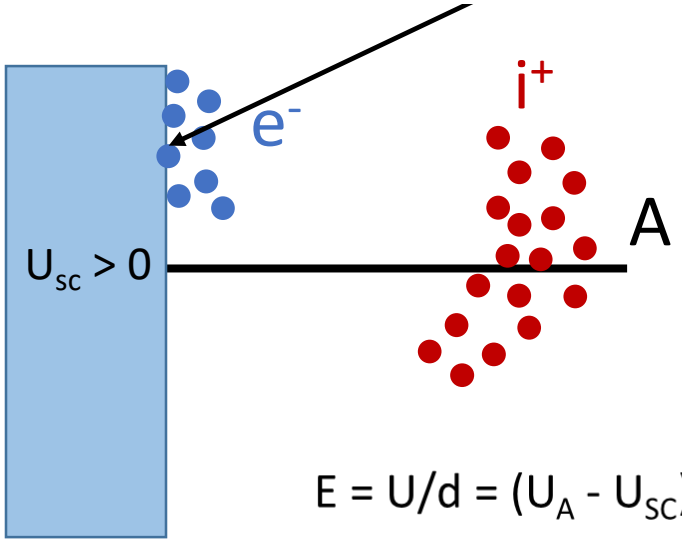


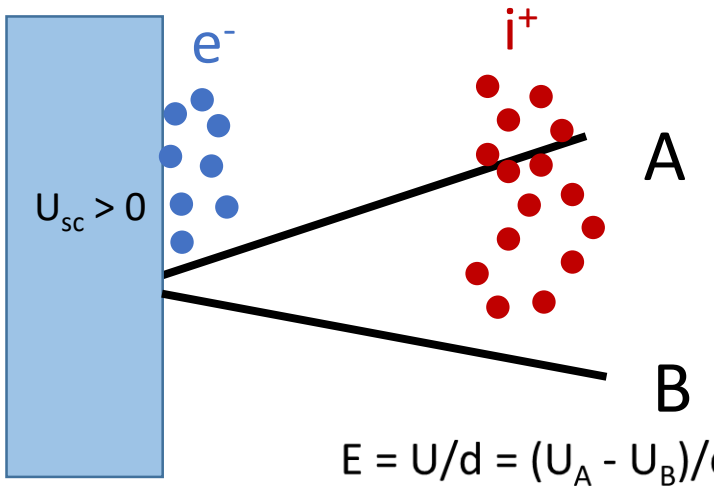
Solar Orbiter – TDS – XLD1 mode

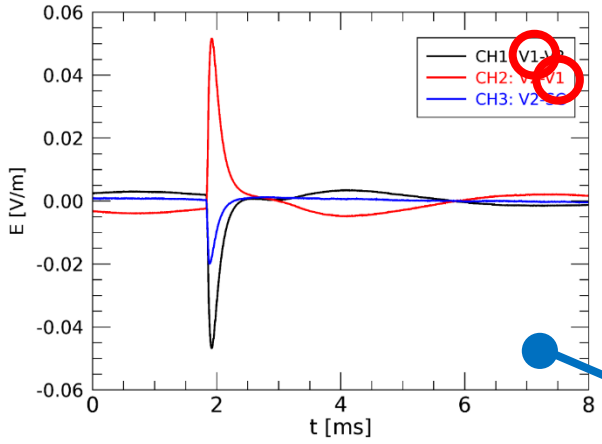


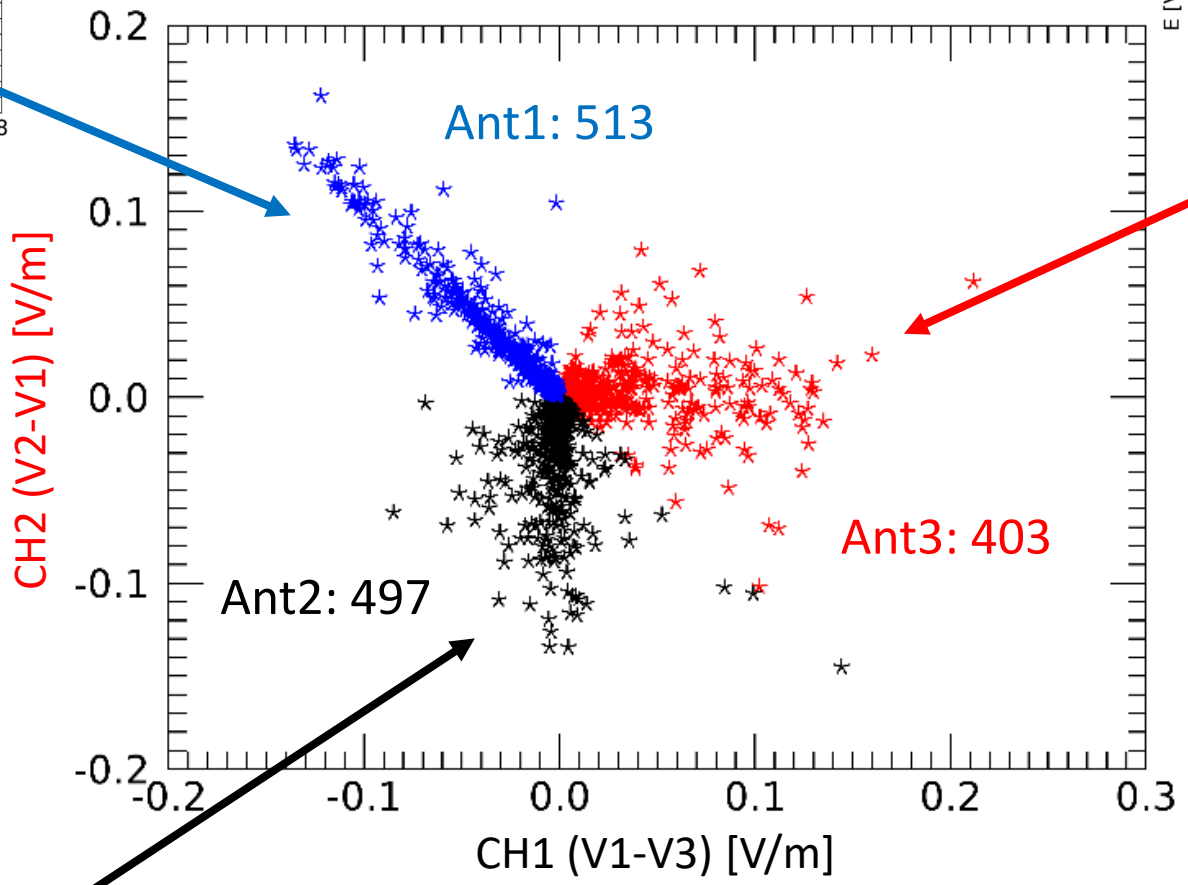


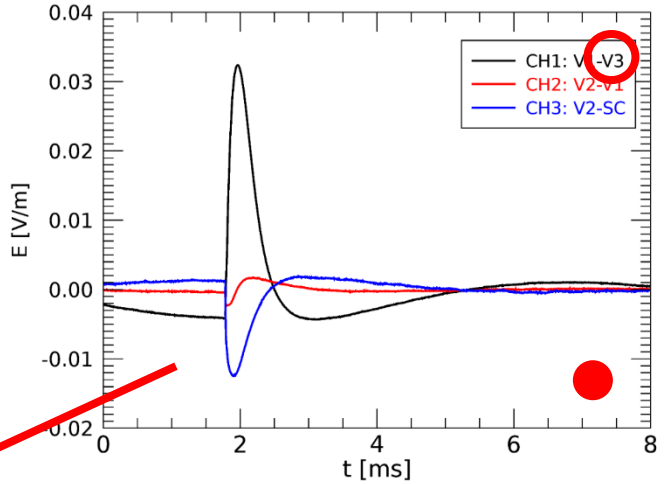







E [V/m]
t [ms]
CH1: V1-V3
CH2: V2-V1
CH3: V2-SC


Ant1: 513
Ant2: 497
Ant3: 403
CH2 (V2-V1) [V/m]
CH1 (V1-V3) [V/m]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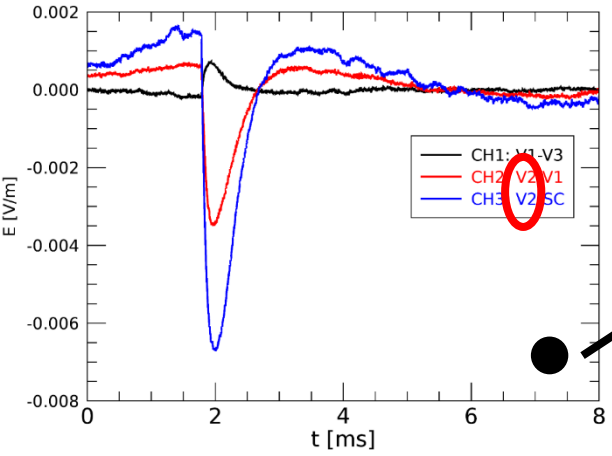
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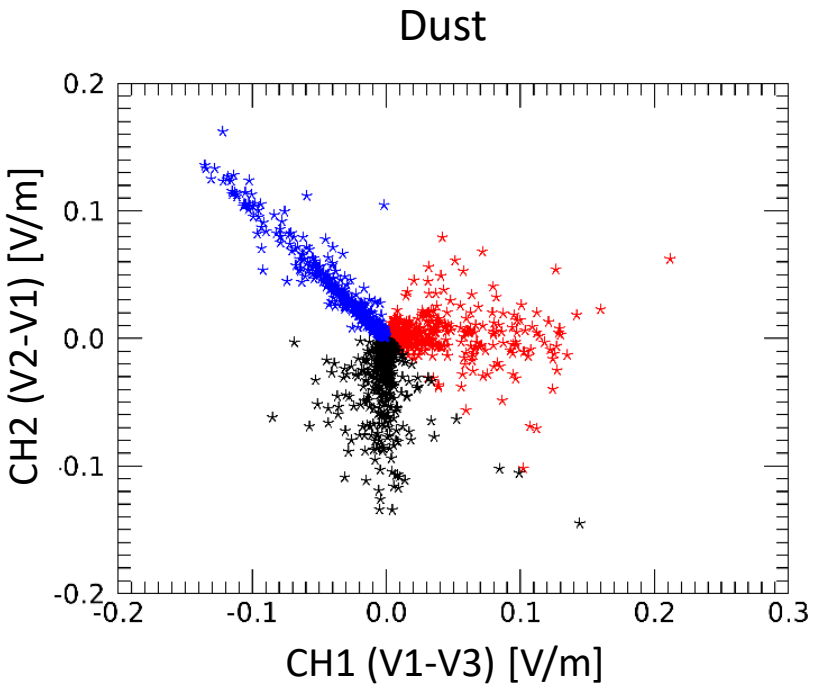
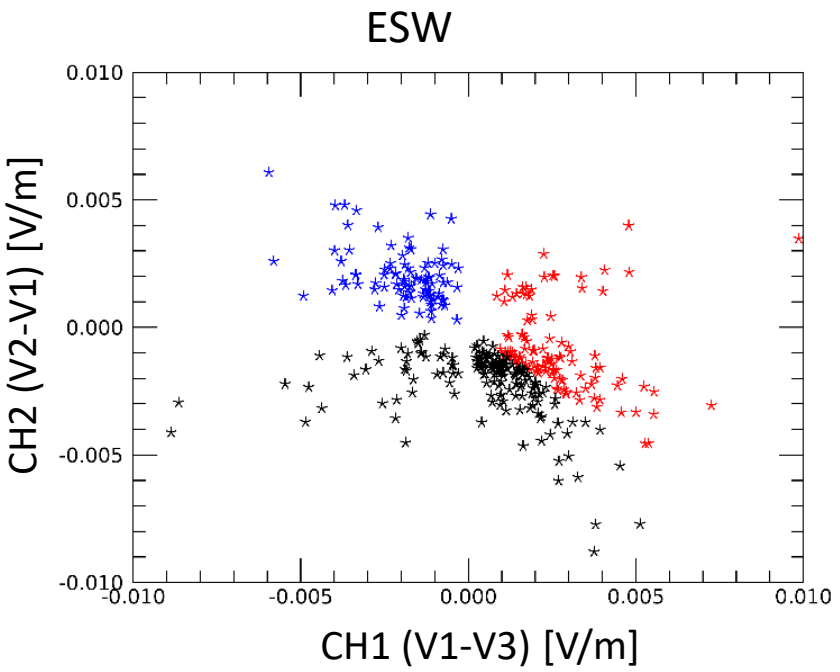
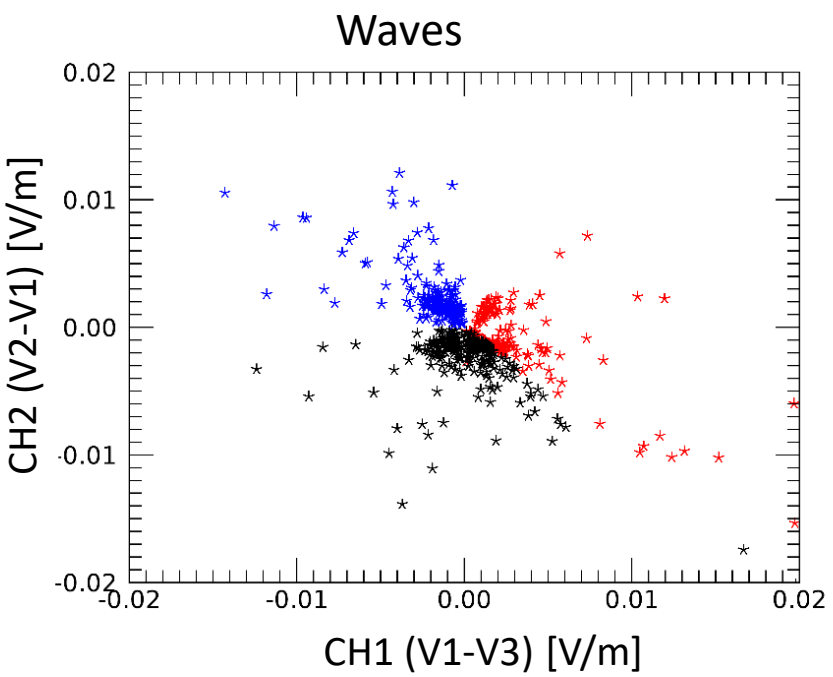
Solar Orbiter – TDS – non dust signal



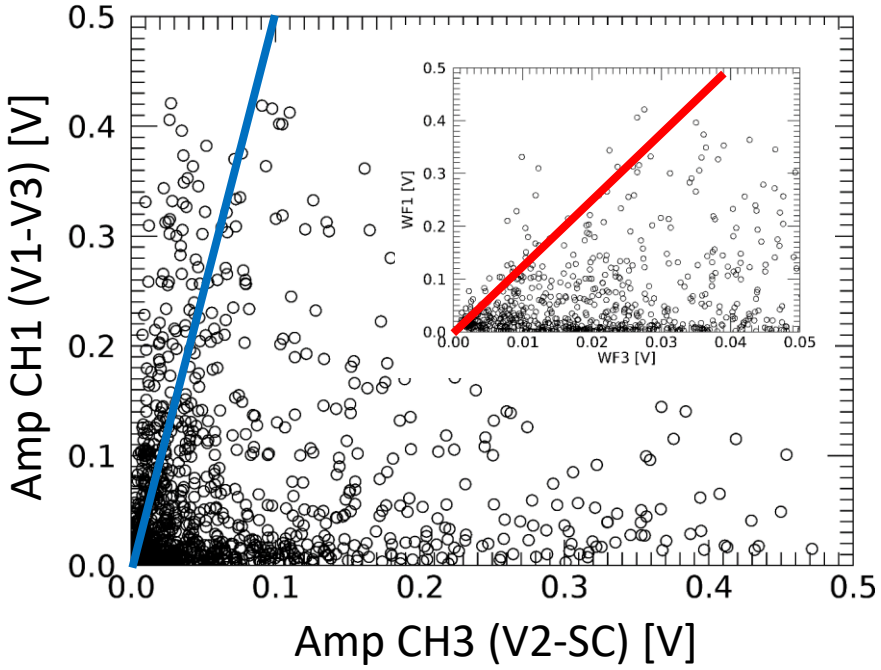


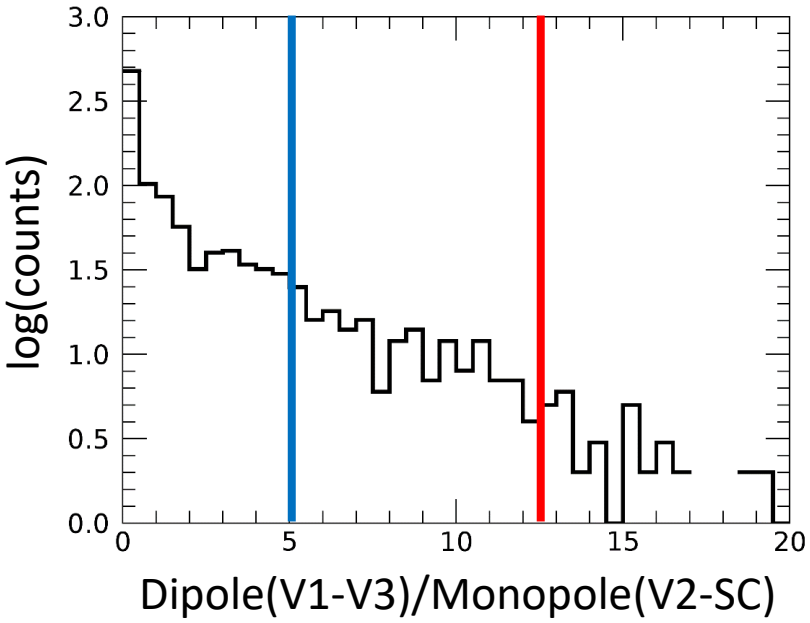


XLD1 – Amplitudes (Dipole vs. Monopole)

Signal on the dipole significantly stronger than on the monopole
(capacitance of the antenna is approximately five times smaller than the capacitance of the spacecraft).

- Not efficient collection of electrons by spacecraft
- Amplified antenna signal





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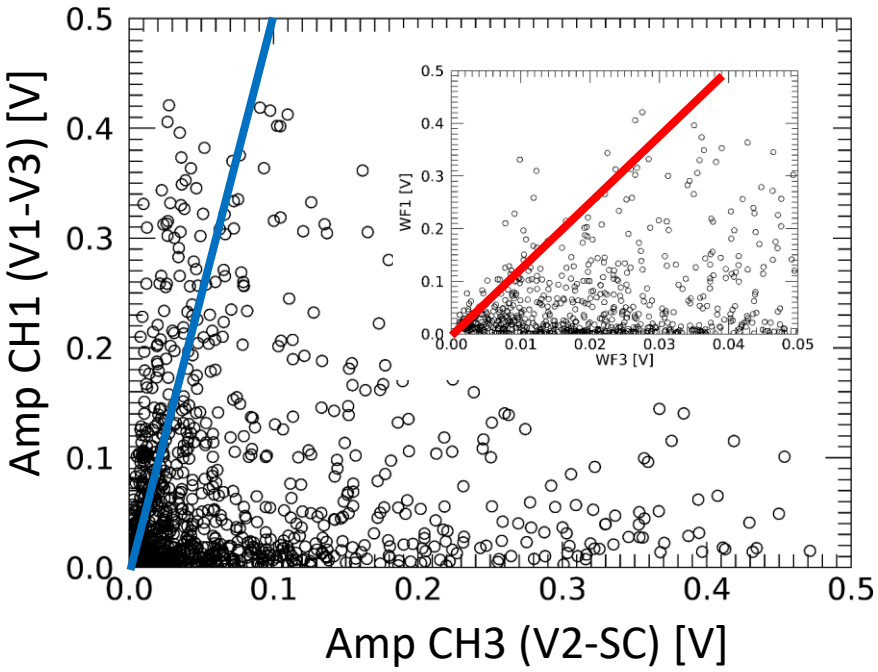
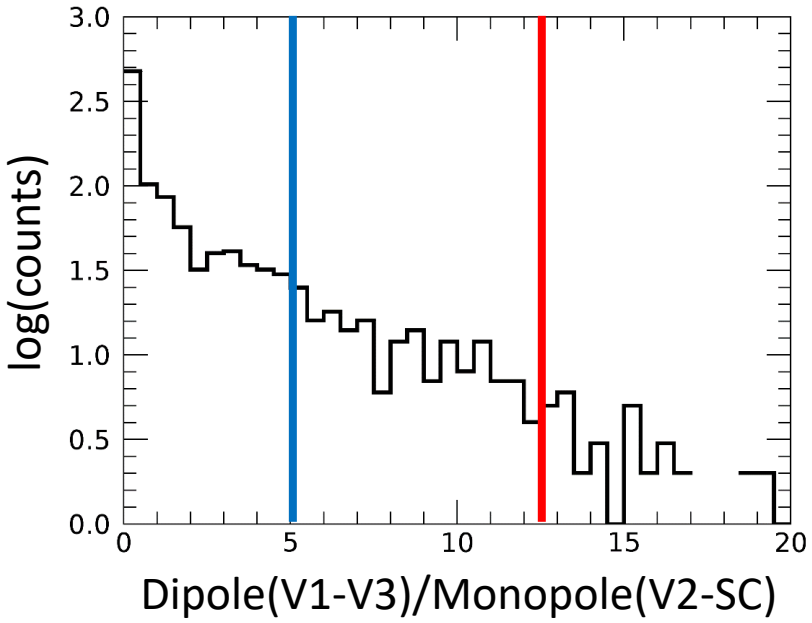
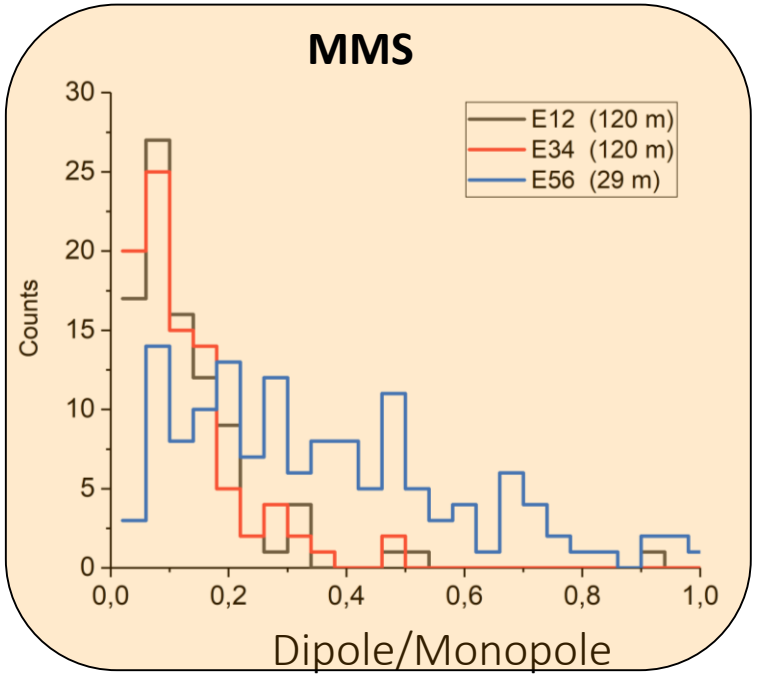
- Amplified antenna signal

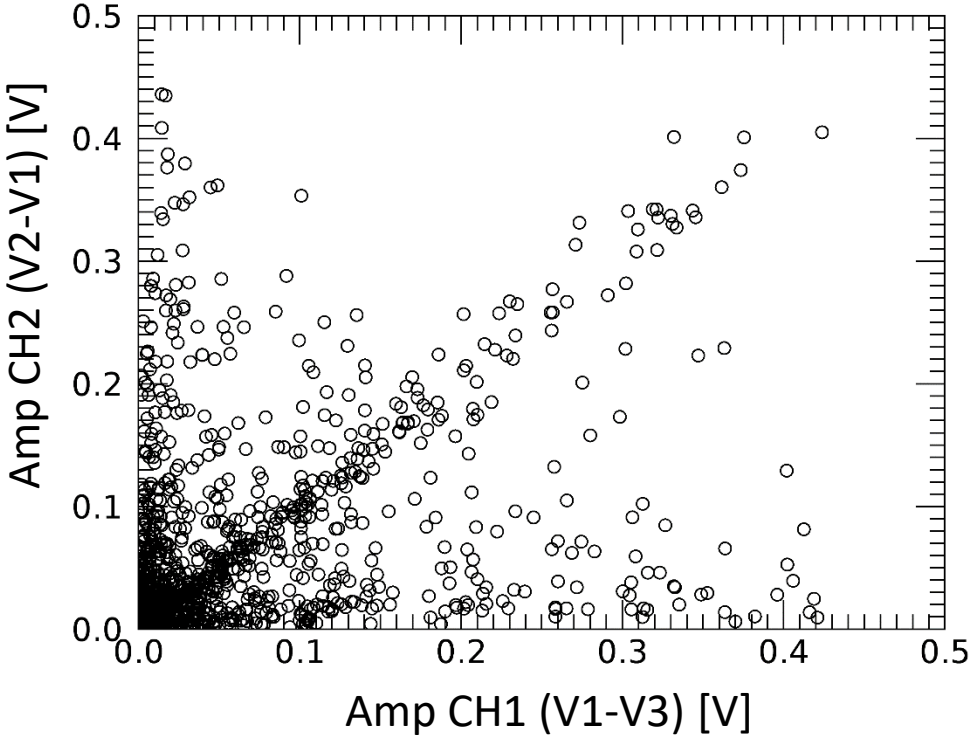


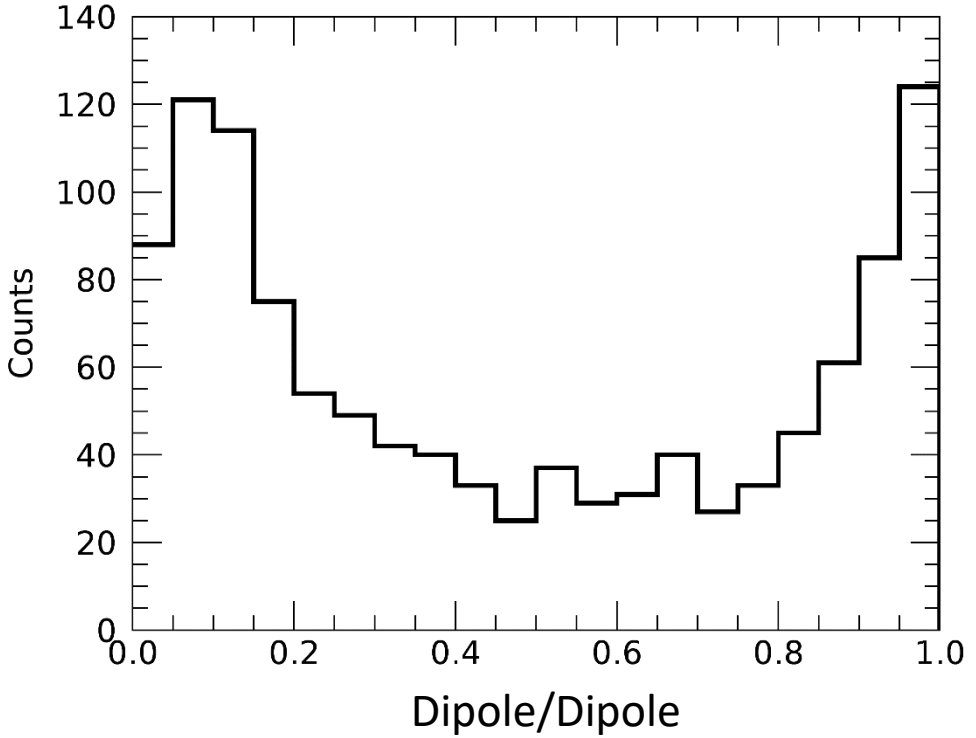




XLD1 – Amplitudes (Dipole vs. Dipole)

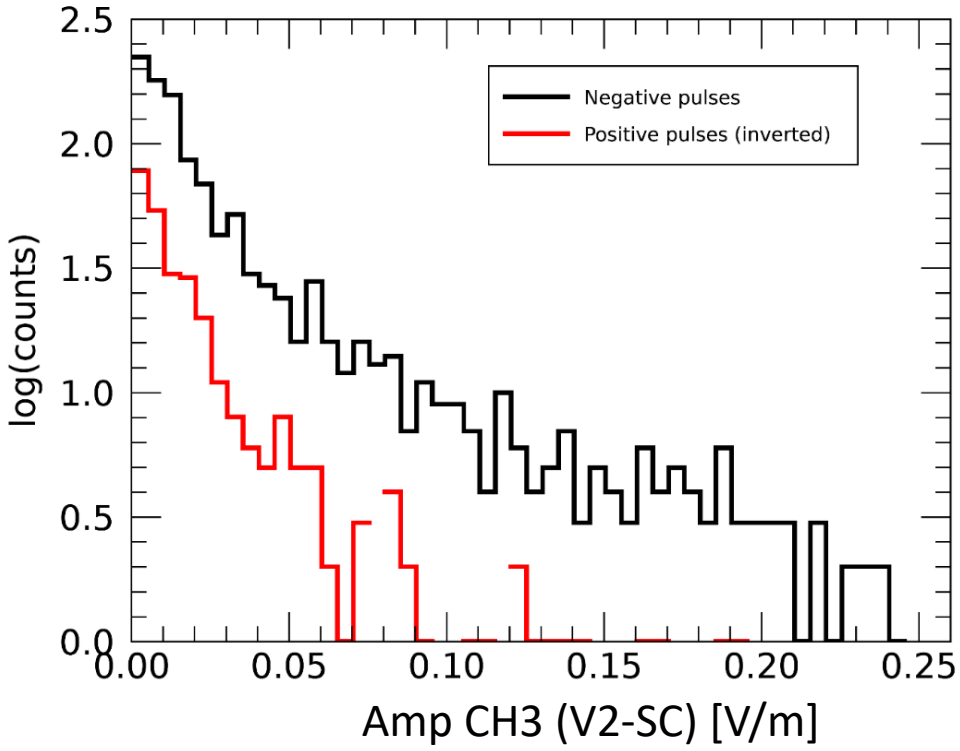
The pulse in one dipole could be significantly stronger than in second dipole (impacts very close to antenna V2 or V3)

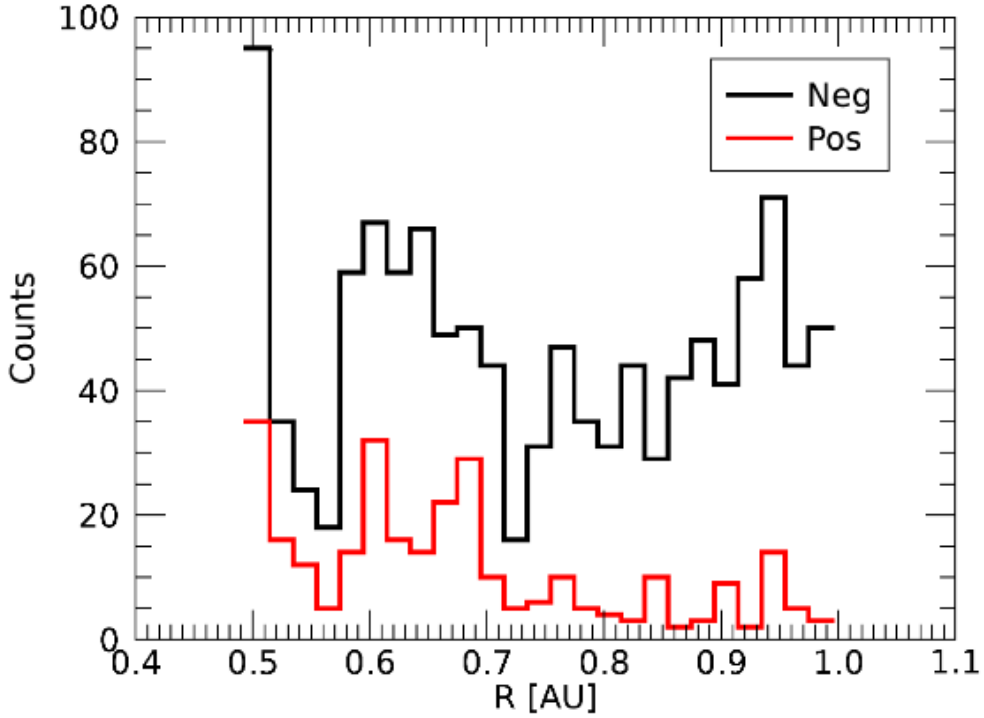




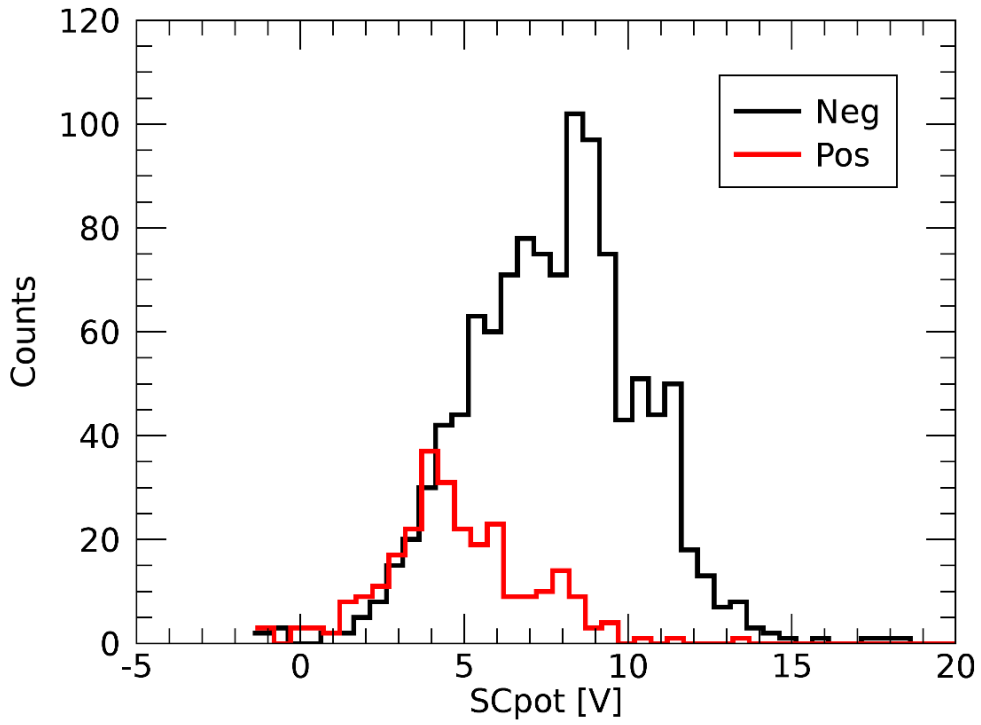
Inverted monopole signal

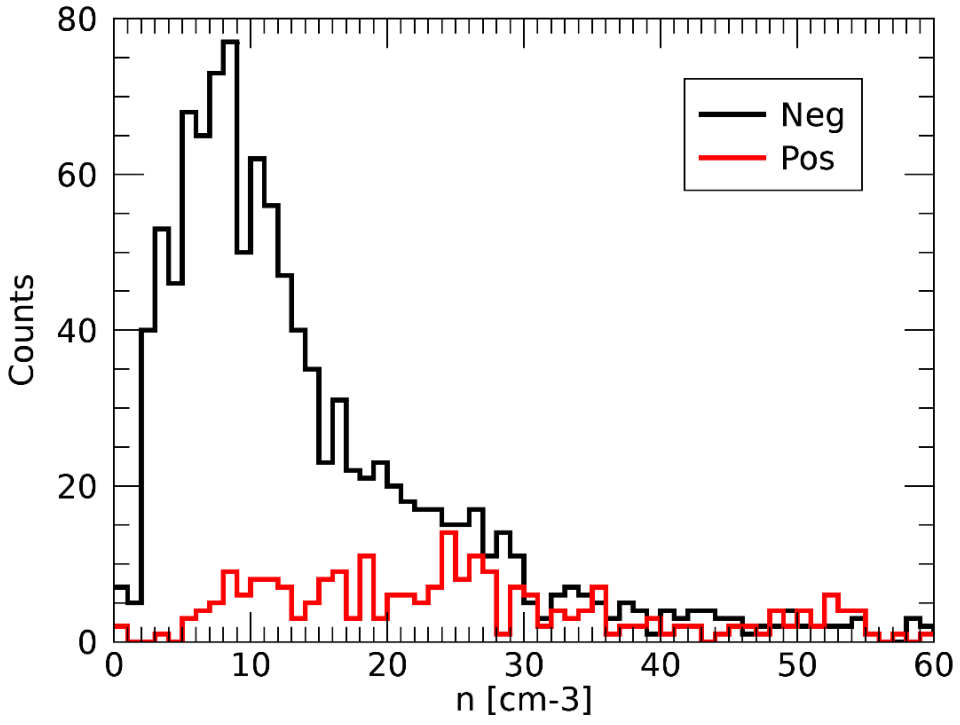
A surprising fact is that 286 out of 1439 monopole signals (V2-SC) have inverted polarity.
This is very challenging to explain. One of the possibilities could be negative spacecraft potential.





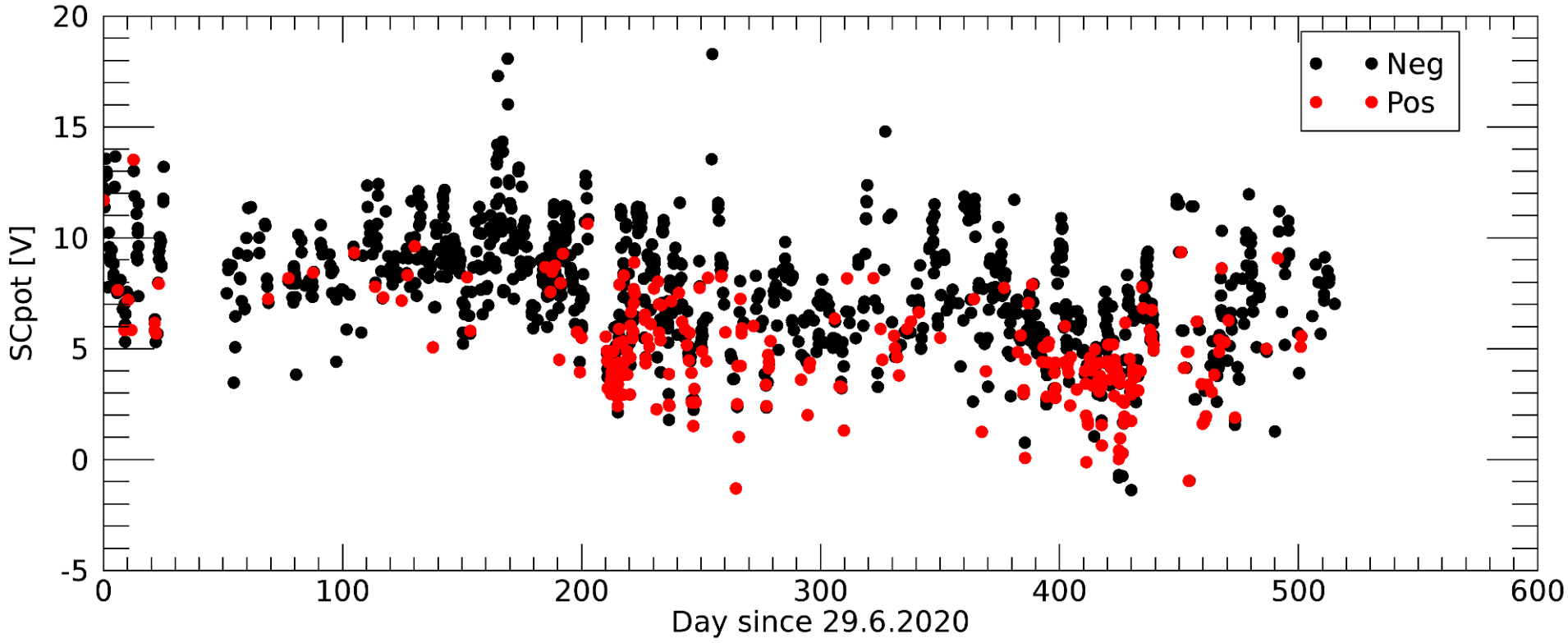
Inverted monopole signal





Inverted pulses: median plasma density, $n = 25\ cm^{-3}$ and median spacecraft potential, $Usc = 4.5\ V$.
Expected pulses: median plasma density, $n = 11\ cm^{-3}$ and median spacecraft potential, $Usc = 7.9\ V$.

Inverted monopole signal



Inverted monopole signal

Could inverted pulses be effect of the negative spacecraft potential?