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Correction of Galileos Energetic Particle Detector, EPD, data and the Effect on Sputtering at Europa

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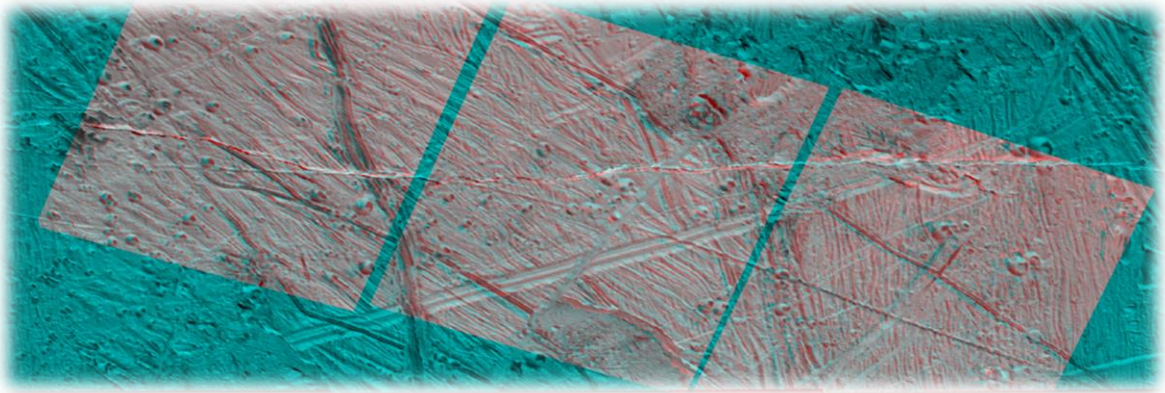
Solar System Physics
Ffiseg Cysawd yr Haul

Background Information:
Work completed and presented at EPSC16

Sputtering at Europa

Europa's surface and Future Work

A proof of concept in anticipation of JUICE data and Imaging



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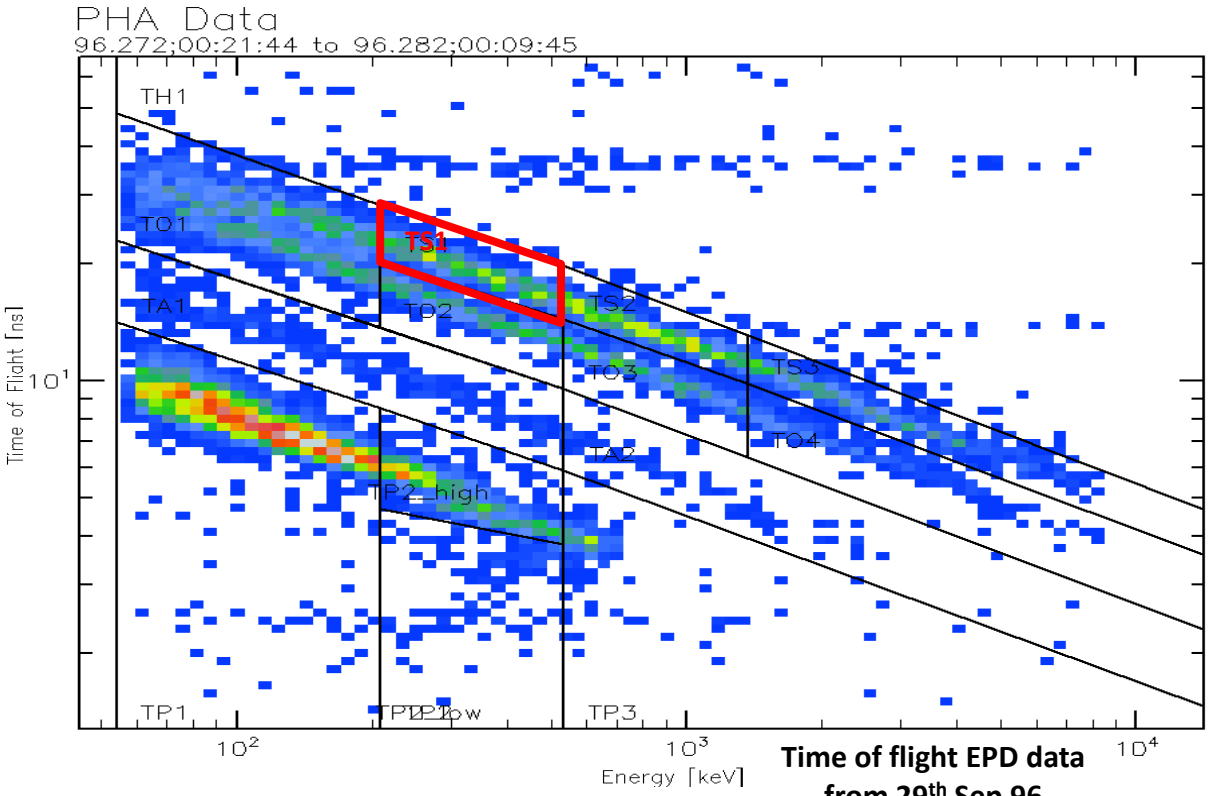
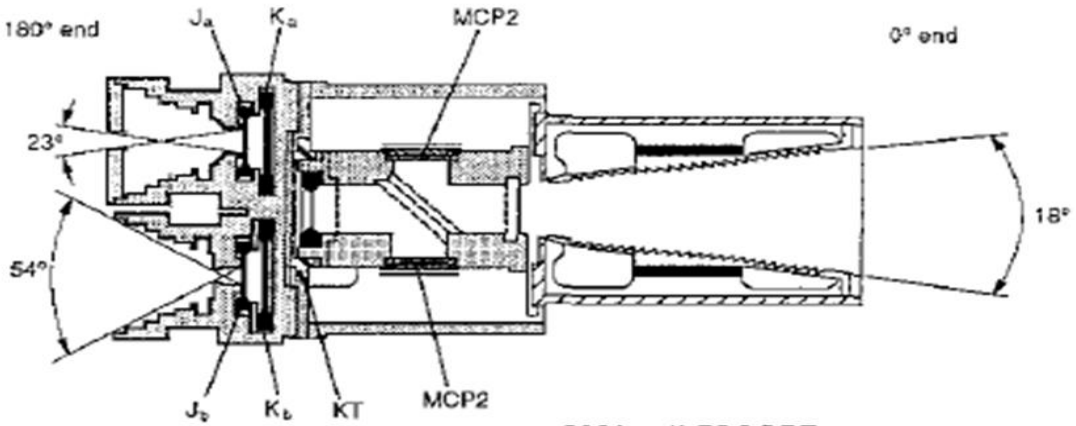
The Galileo Mission: Energetic Particle Detector

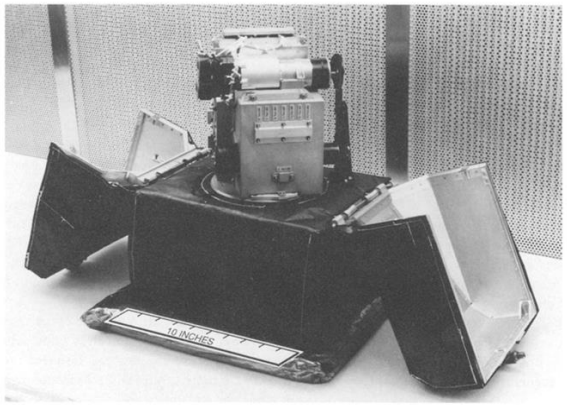


Time of flight EPD data from 29th Sep 96

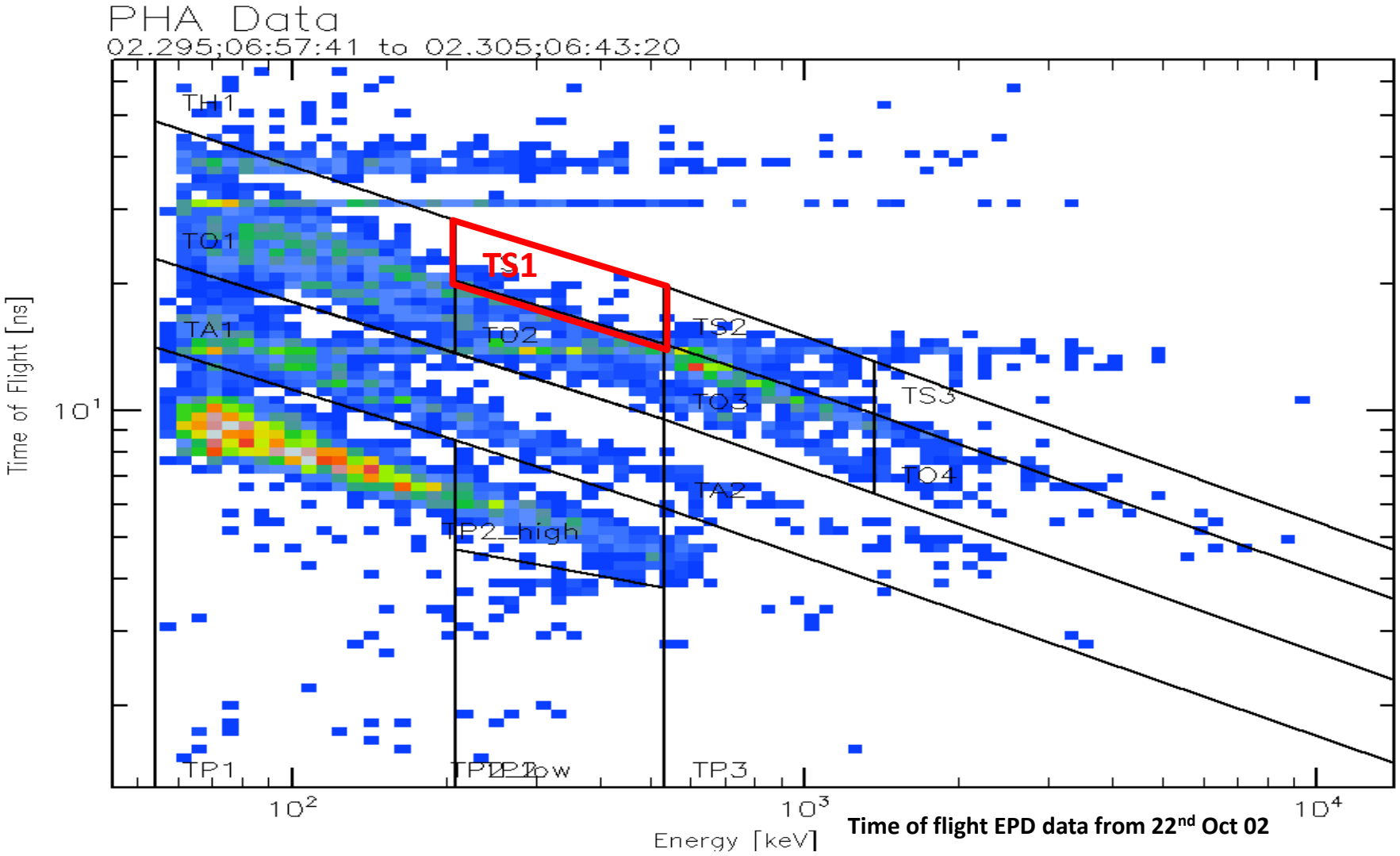
By measuring speed of a particle and it's Overall energy, the Composition Measurement System (CMS) data could be plotted to display the masses of the Jovian environment.



CMS TELESCOPE



A Hostile Environment

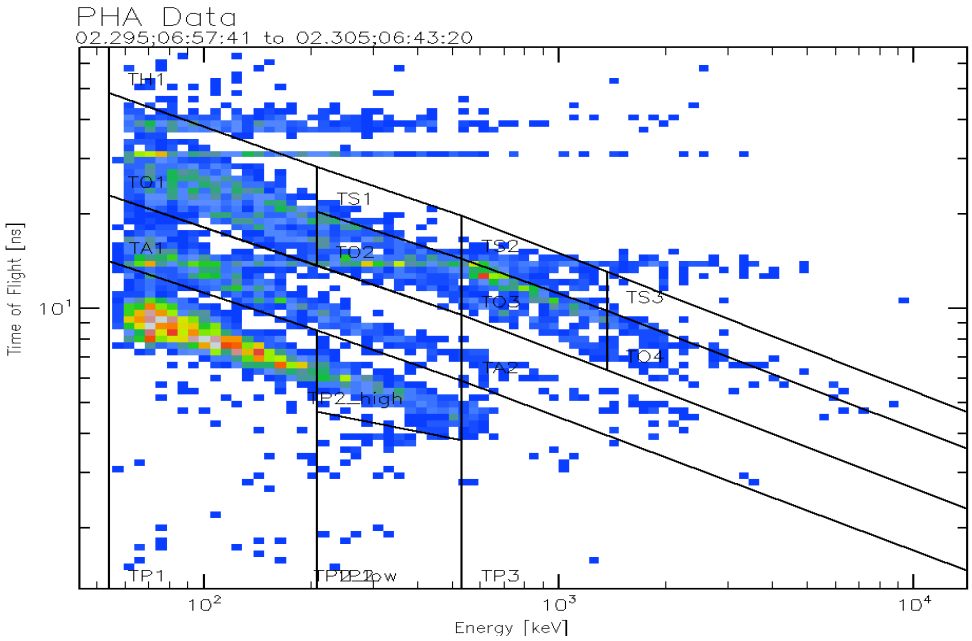


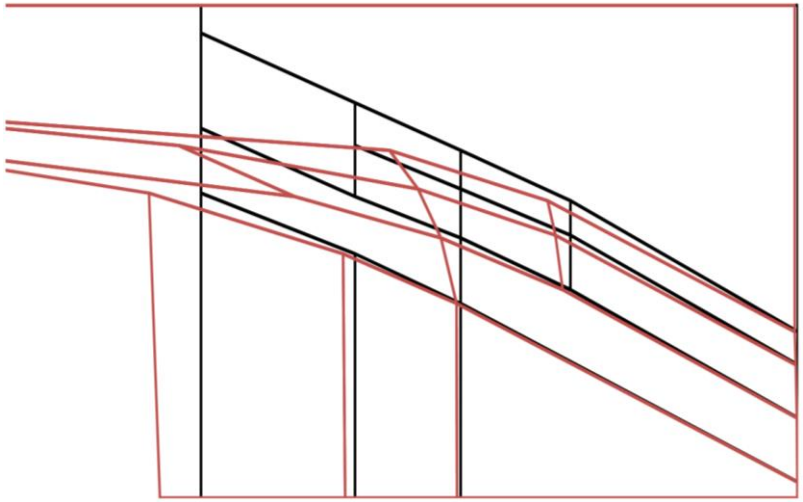
Time of flight EPD data from 22nd Oct 02

A build up of non-sensitive “dead layer” in the silicone detector is the reason behind the decreasing energy of the particles measured.

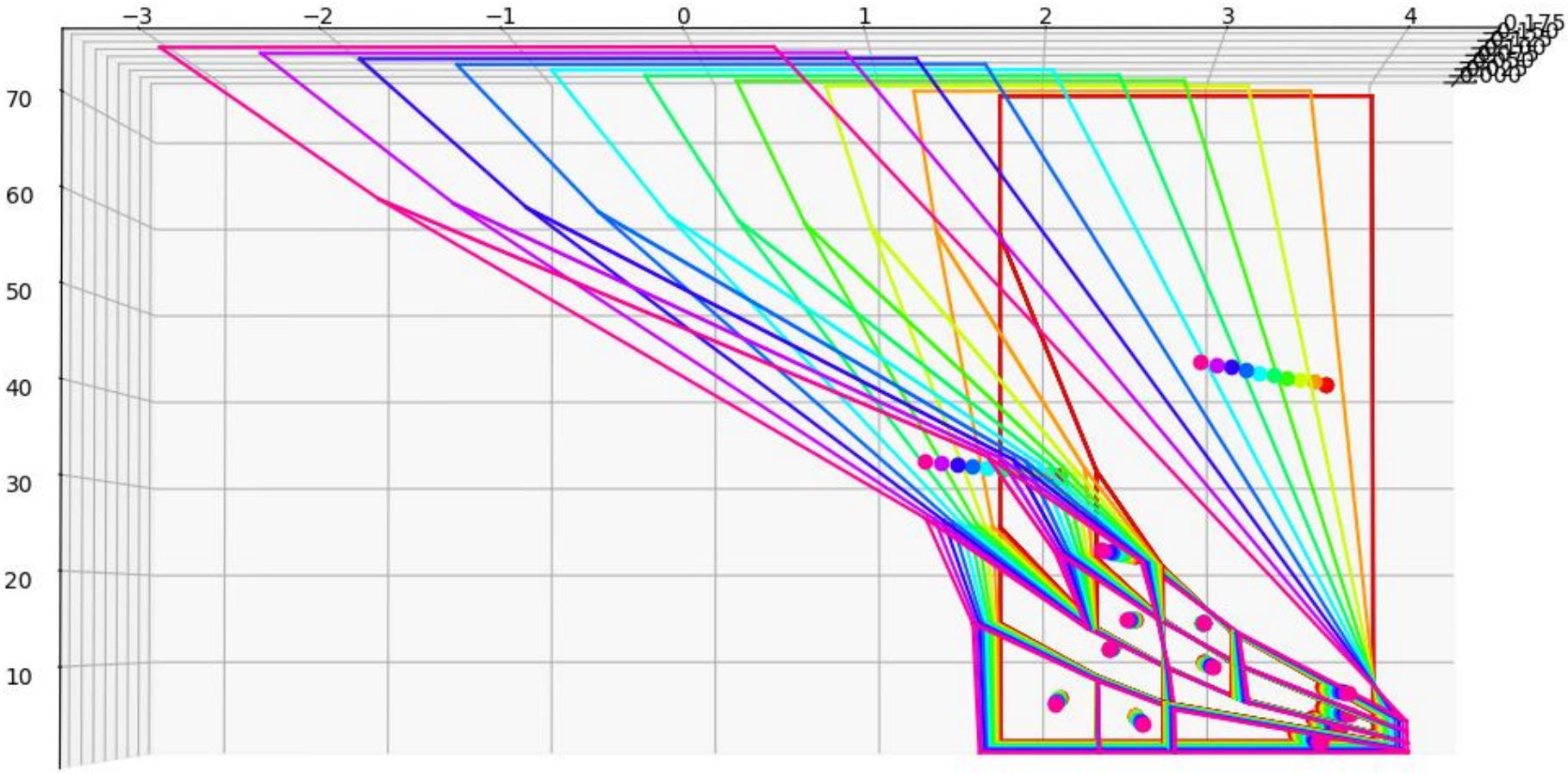
Modelling a Dead Layer

- The expended energy can be calculated using the SRIM software; and follows certain trends:
  - Higher energy loss with higher mass particles
  - Higher energy loss with thicker dead layer
- Applying these rules to the bounding boxes of the channels gives an enlightening visual as the state of the detector at the end of mission.

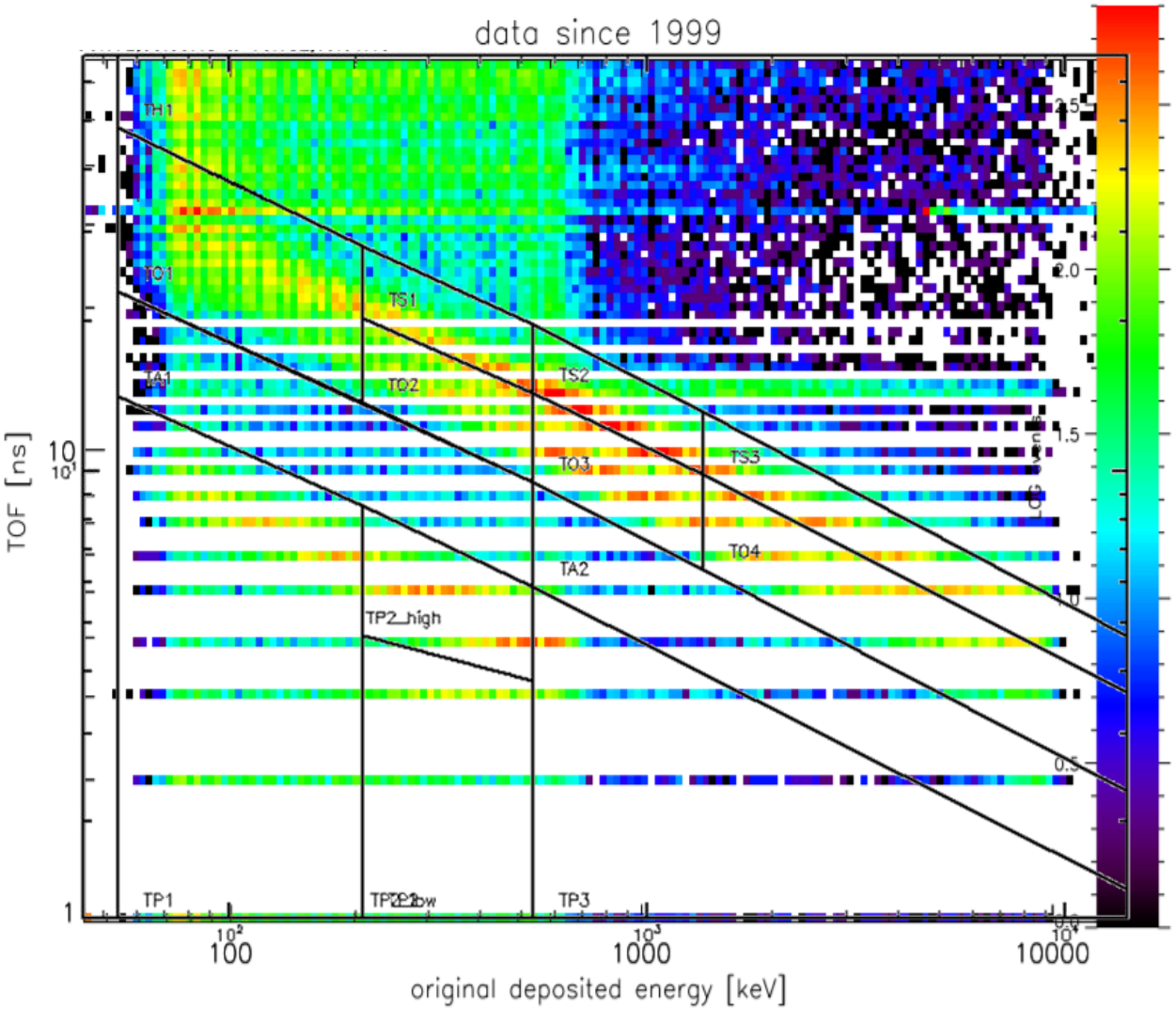




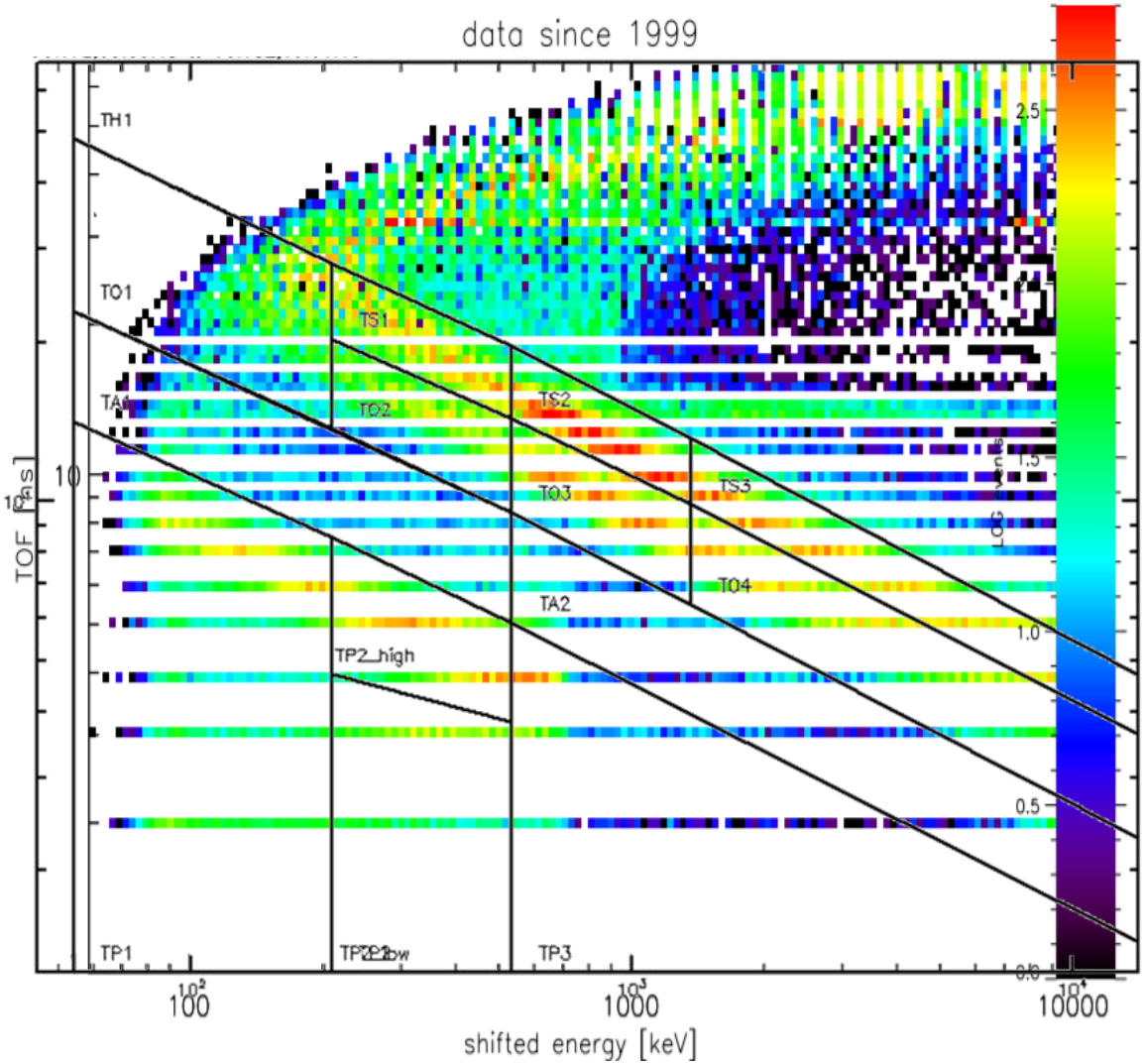
The Effect of a Dead Layer on the Channel Boundaries



Correcting for Energy Loss – Original Data

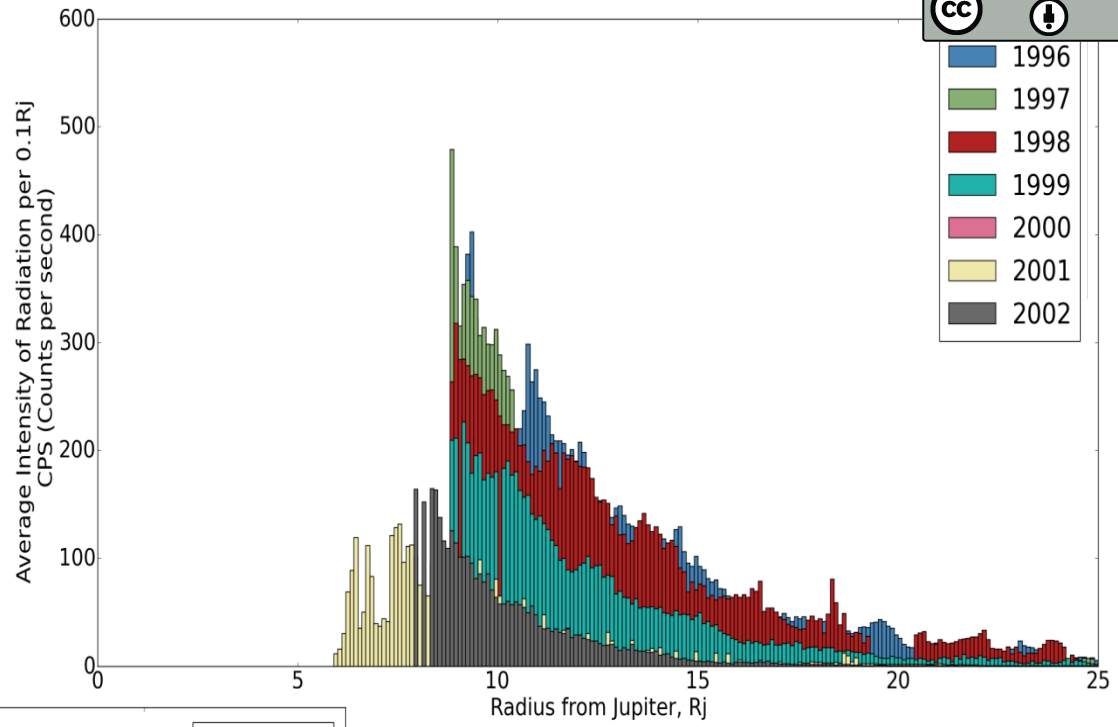


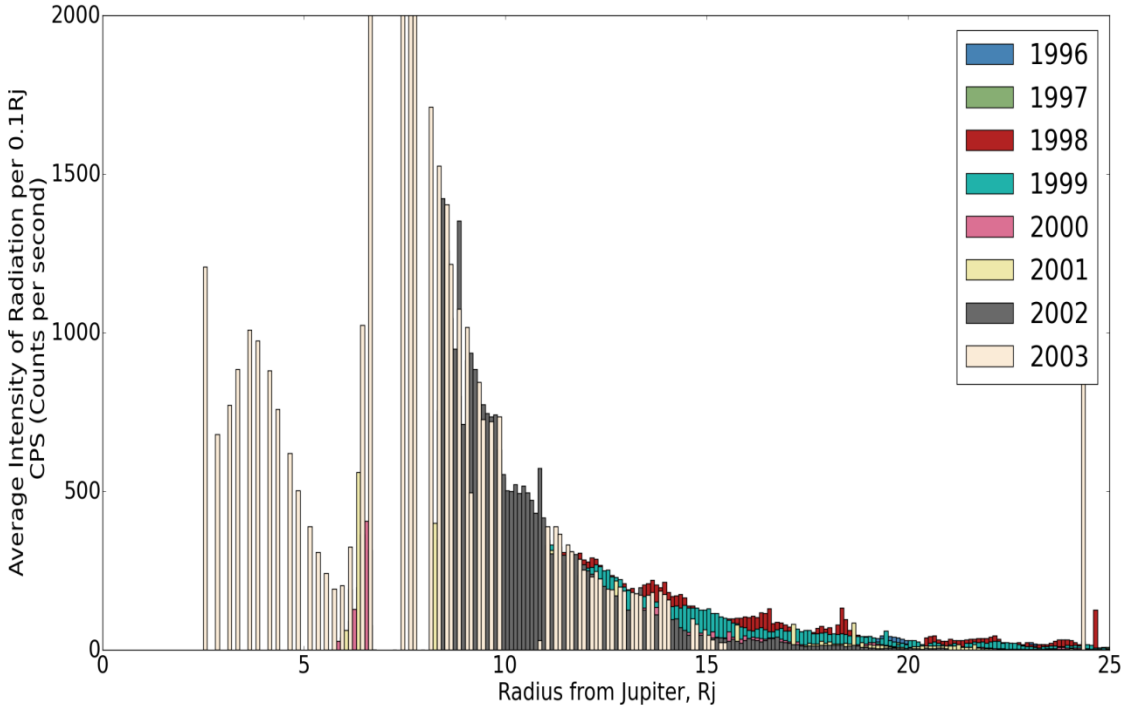
Correcting for Energy Loss – Corrected Data



The EPD also produced low resolution count rate data over the majority of the mission. Theses count rates suffered with the same drops.

The Sulphur and Oxygen channels most highly effected.





Above: Original Sulphur Data from TS1 channel

Left: Corrected Sulphur Data from the same channel.

Effects of this on Sputtering Estimates

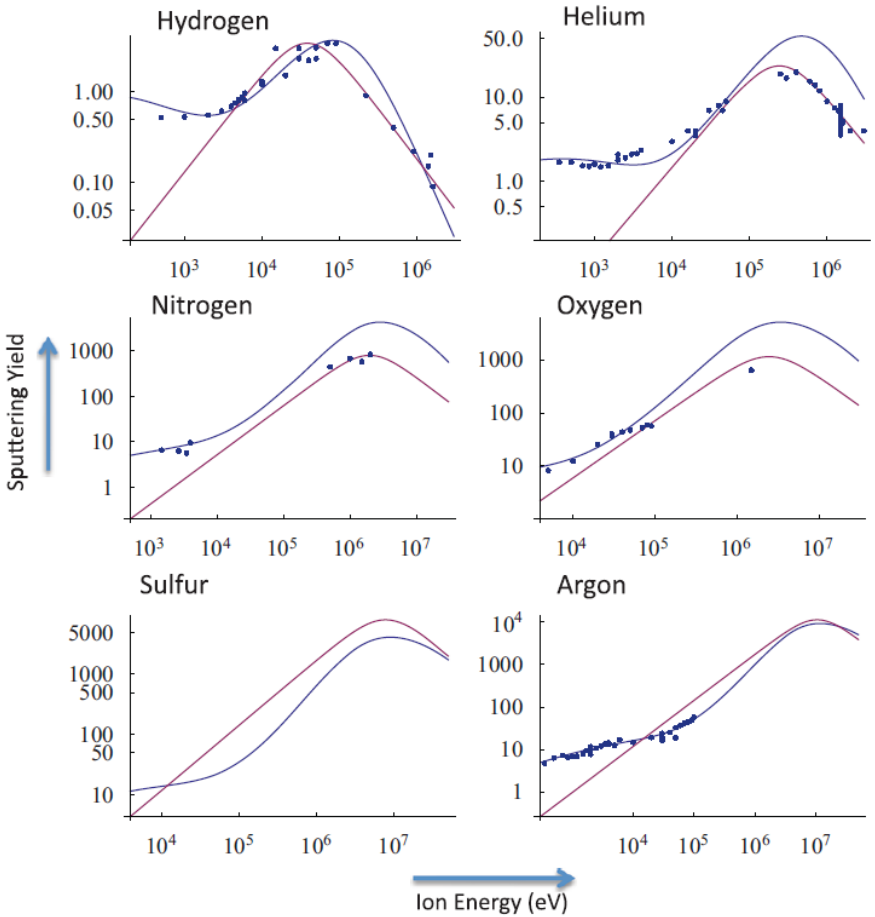


Fig. 3. Compilation of sputtering yield data and theory. Experimental data points best match the Fama et al. curve (blue) below ~100 keV and match the Johnson curve (red) above 100 keV. There are no available experimental results for sulfur ion sputtering, but the calculated sputtering yield is shown here because sulfur is the most important sputtering agent at Europa. The data were compiled from various experimental sputtering papers by R. E. Johnson and M. Liu at http://people.virginia.edu/~rej/h2o.html. Note that the cold ions hit Europa at ~ 500 eV (oxygen) or ~ 1000 eV (sulfur) while the hot ions have a wide range of energies (100s of keV to MeV). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Magnetospheric Ion Sputtering and Water Ice Grain Size at Europa: *Cassidy et al*

Count Rates to Sputtering Yields

1. Conversion from Counts to Intensity:

   This is done using the Geometric factor. This is a measure of the energy of the channel over the surface area, by the steradian visibility of the detector.

2. Evaluate the distribution from the Time of Flight vs. Energy Plots at the appropriate flyby:

   By fitting profiles over all channels of a single element

3. Map the channels count rates to this distribution:

   Each element has 2 to 4 channels worth of counts, so the each channel can be sectioned to match with the overall distribution.

4. Evaluate the total amount of sputtered particles at appropriate Energy intervals.

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Past and New Estimates of Surface Erosion

Depth in Gyrs	Estimation	Author/Paper	Specifics
6m – 100m	-	*Johnson et al, 1981* *Eviatar et al, 1981*	Pre-Galileo data
200m	-	*Ip et al., 1998*	Net erosion rate, Early Galileo EPD data
14m	-	*Tiscareno et al., 2002*	Estimated 42% - 86% redeposit on the surface.
16m	-	*Cooper et al., 2001*	Globally Averaged
70m	$\sim 7 \times 10^9\ cm^{-2}\ s^{-1}$	*Cassidy et al., 2012*	Globally Averaged

Depth in Gyrs	Estimation	Flyby
~70m	$\sim 7 \times 10^9\ cm^{-2}\ s^{-1}$	E4
~100m	$\sim 10 \times 10^9\ cm^{-2}\ s^{-1}$	E15
~80m	$\sim 8 \times 10^9\ cm^{-2}\ s^{-1}$	E26

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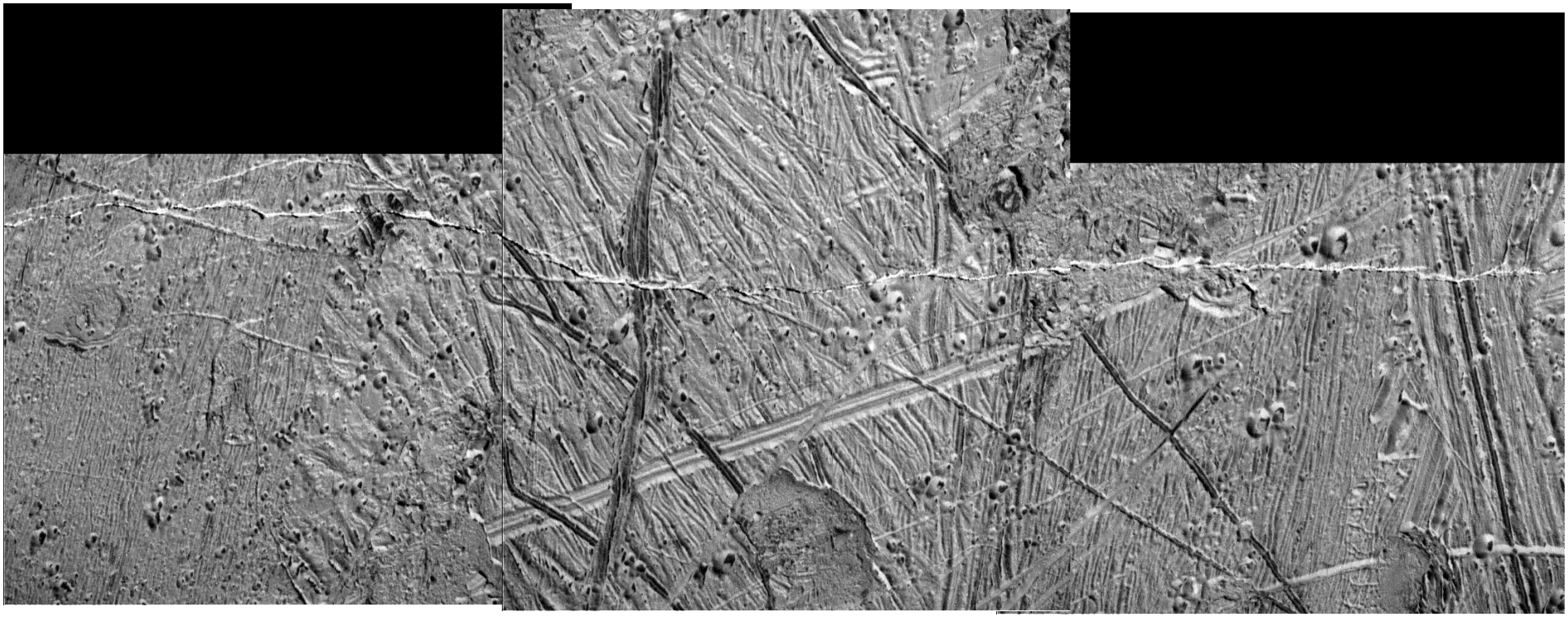
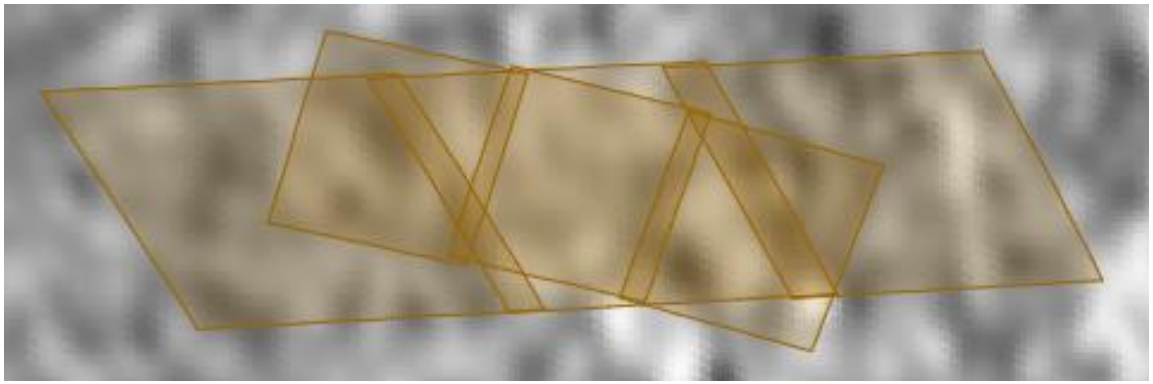
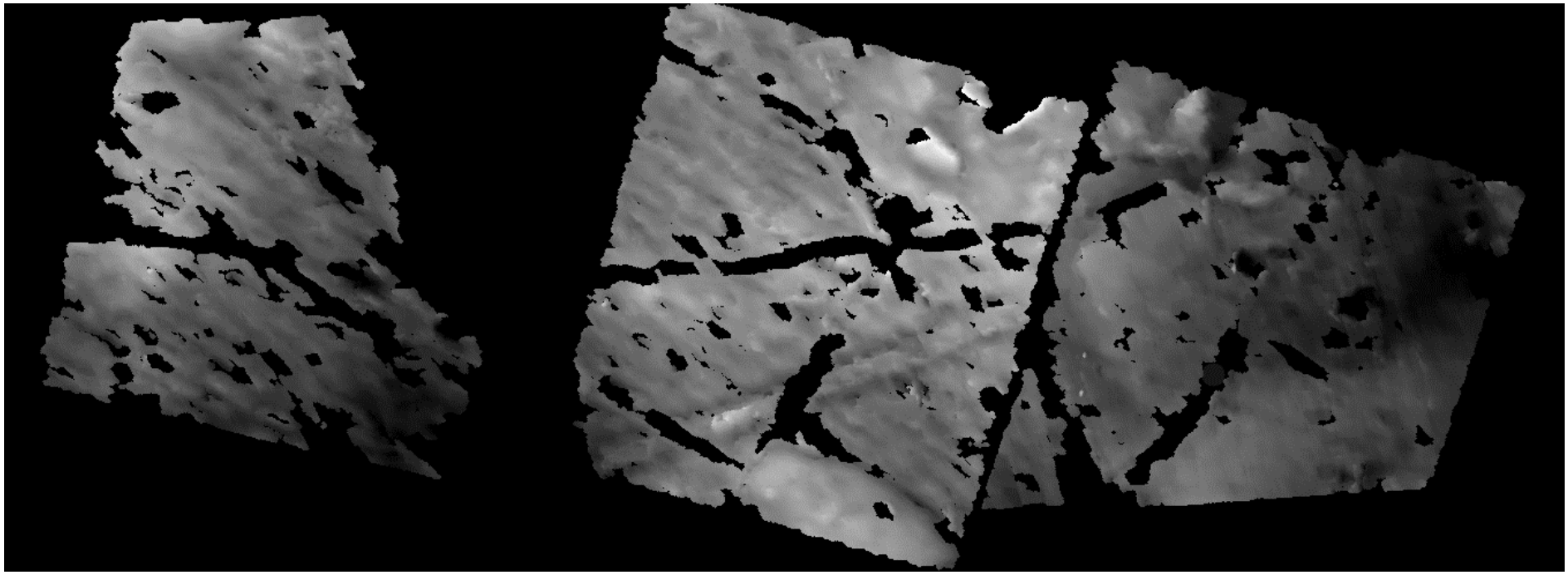
Surface Erosion from Sputtering:

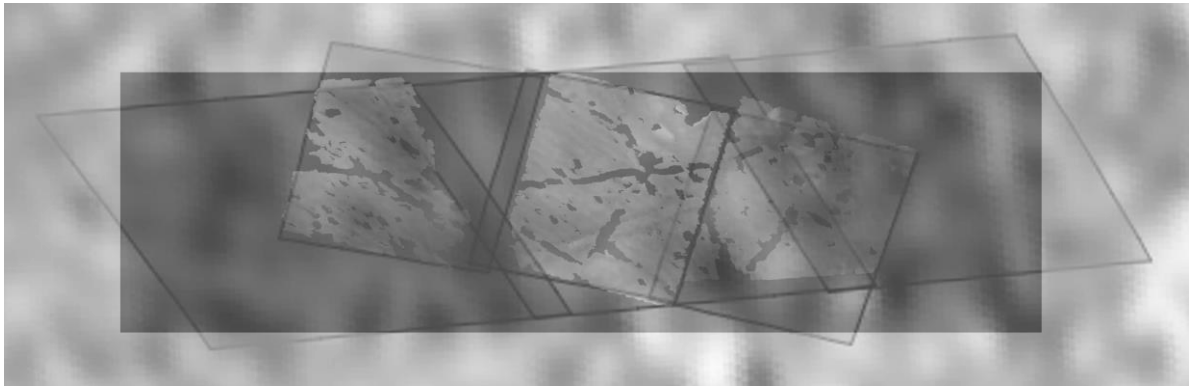




Digital Elevation Model, DEM



Produced by Tony Cook during his time at the Centre for Earth and Planetary Studies, at the Smithsonian's National Air and Space Museum, in 2002.
These were produced using University College London's Gotcha software written by Tim Day.



Generated from stereo images by applying consecutively smaller sample areas to build up the height profile image.

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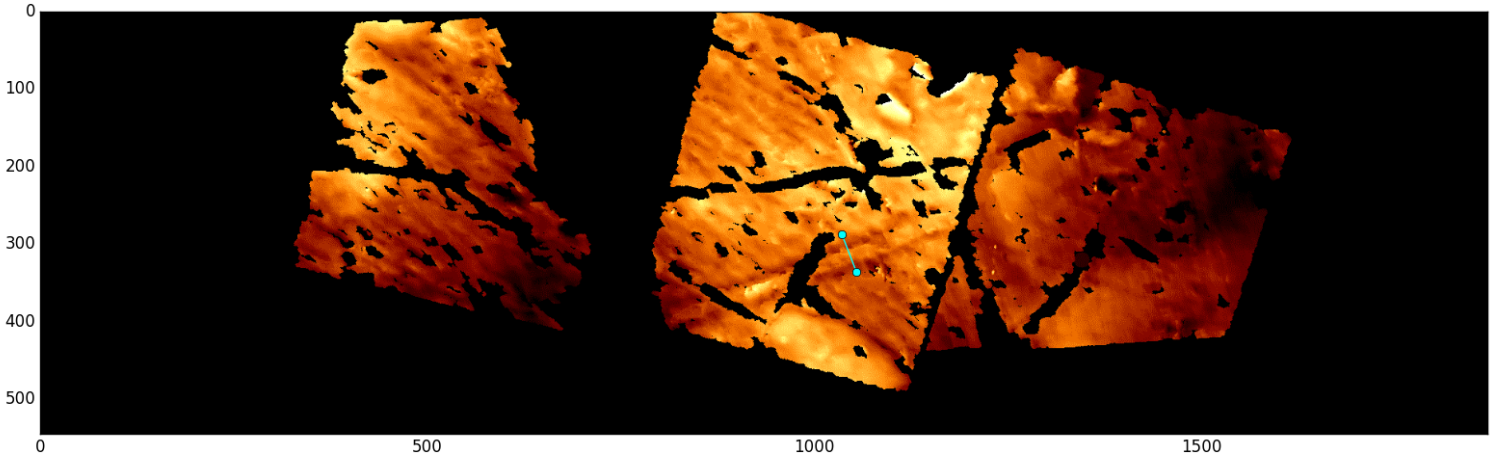
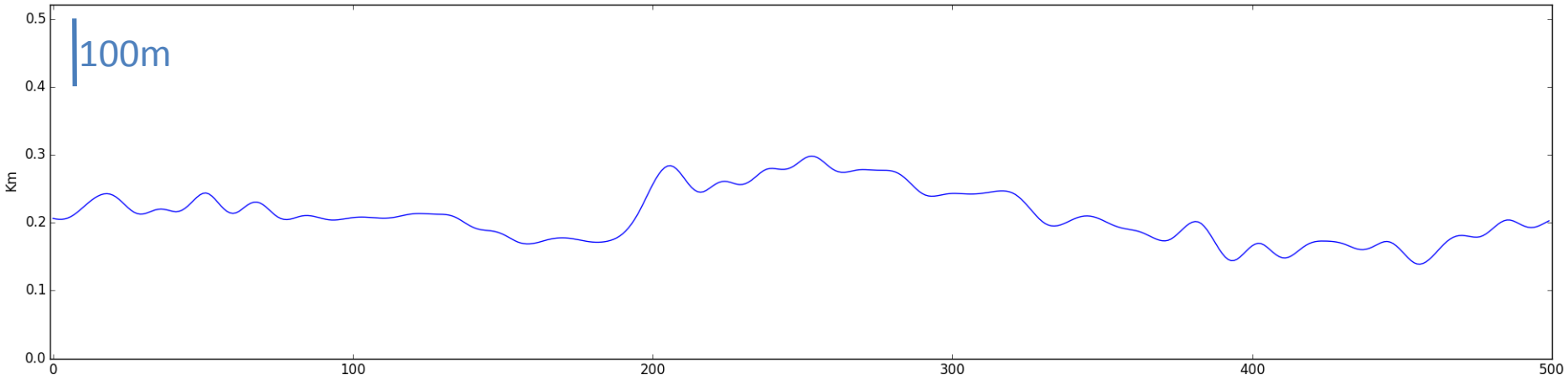
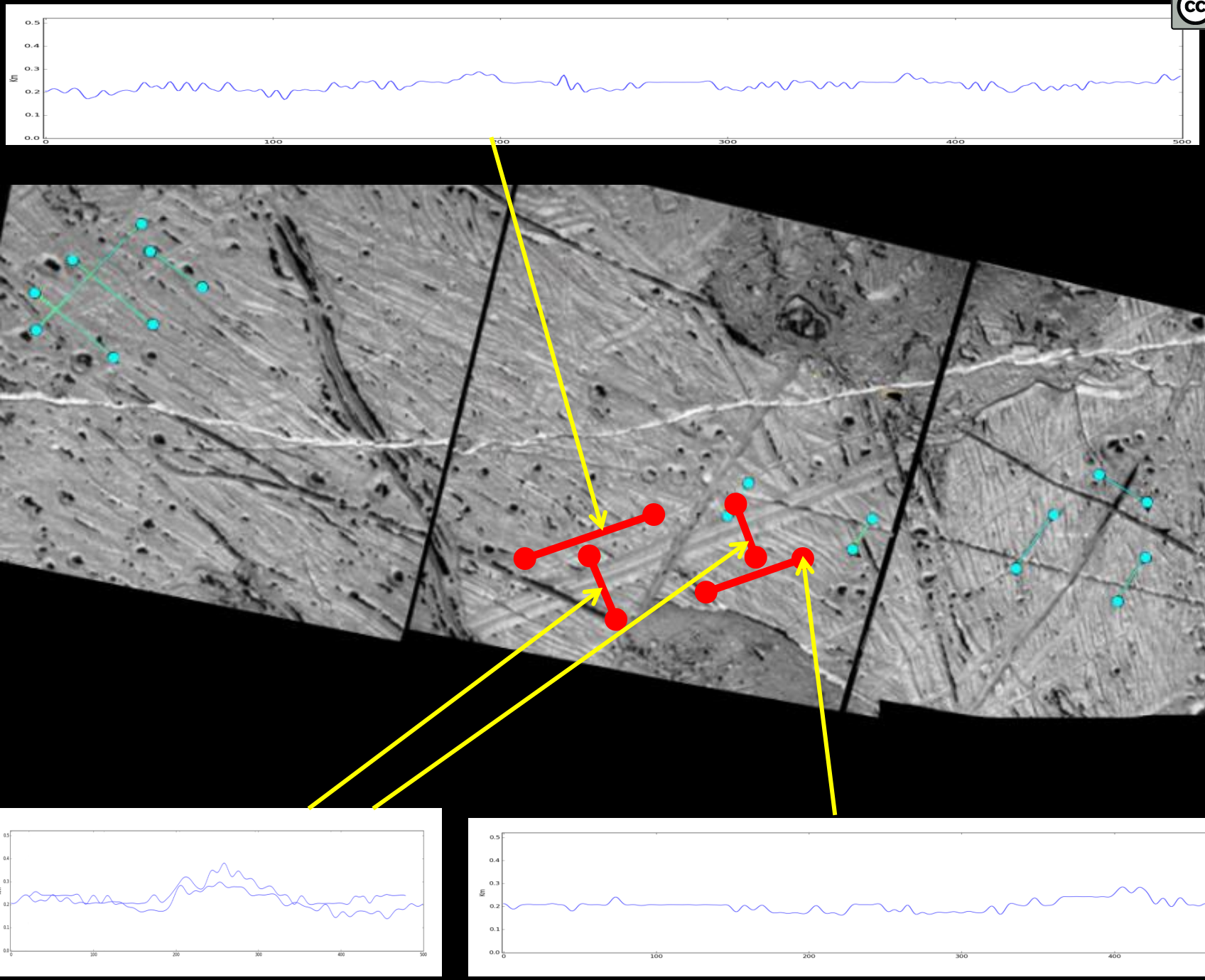
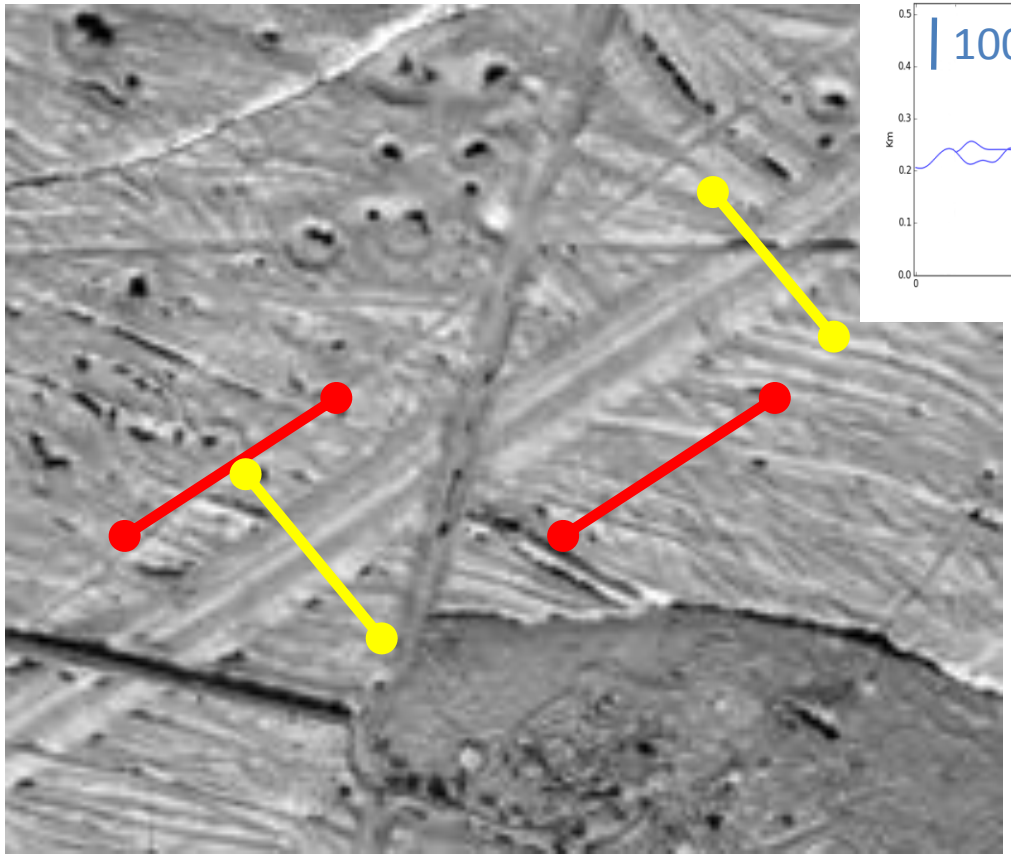
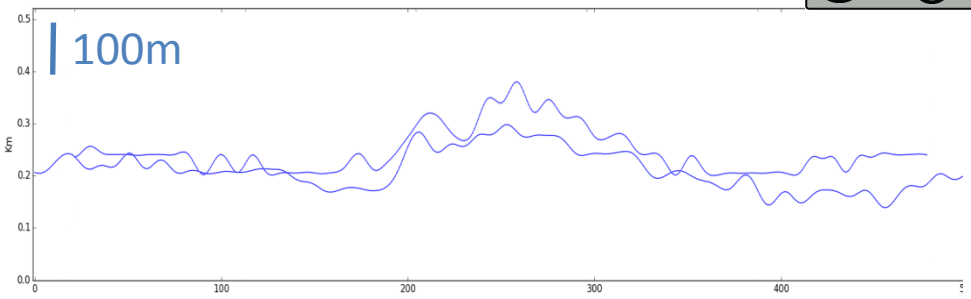
DEM, Selecting Areas of Interest





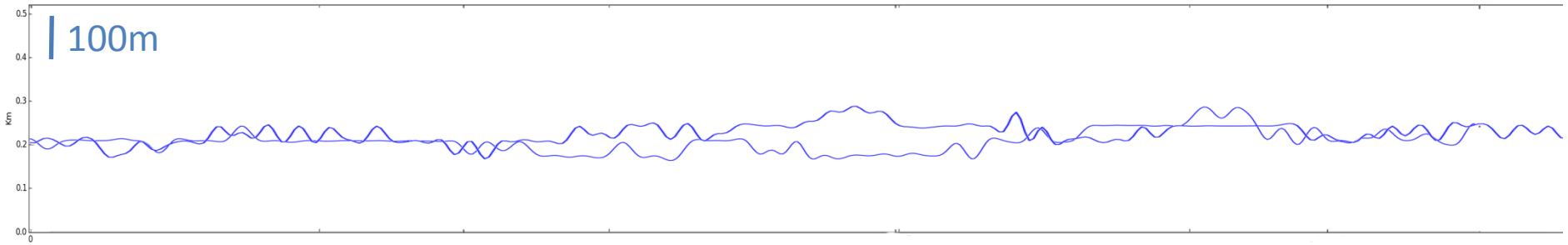

Km
0.0
0.1
0.2
0.3
0.4
0.5
0
100
200
300
400
500





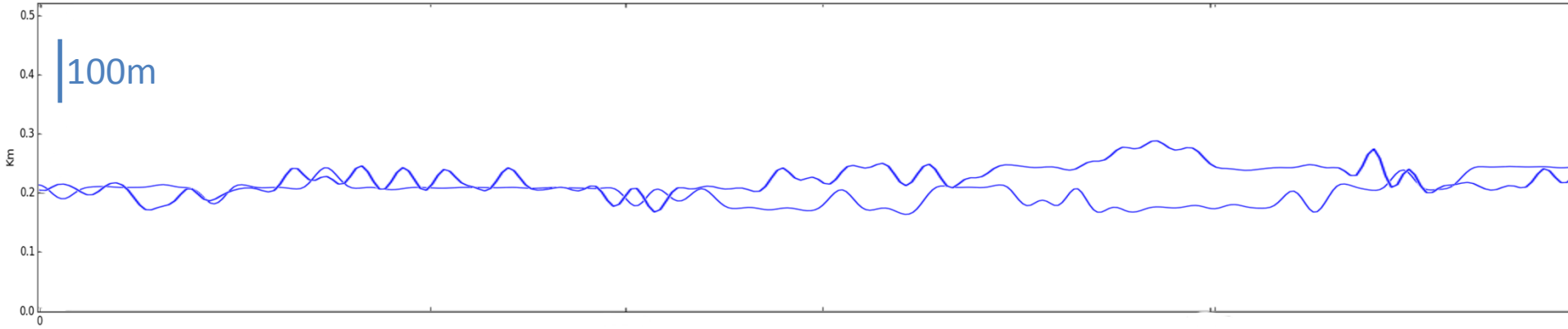
Above (Yellow): Over the main ridge there is an average height change of around 65m

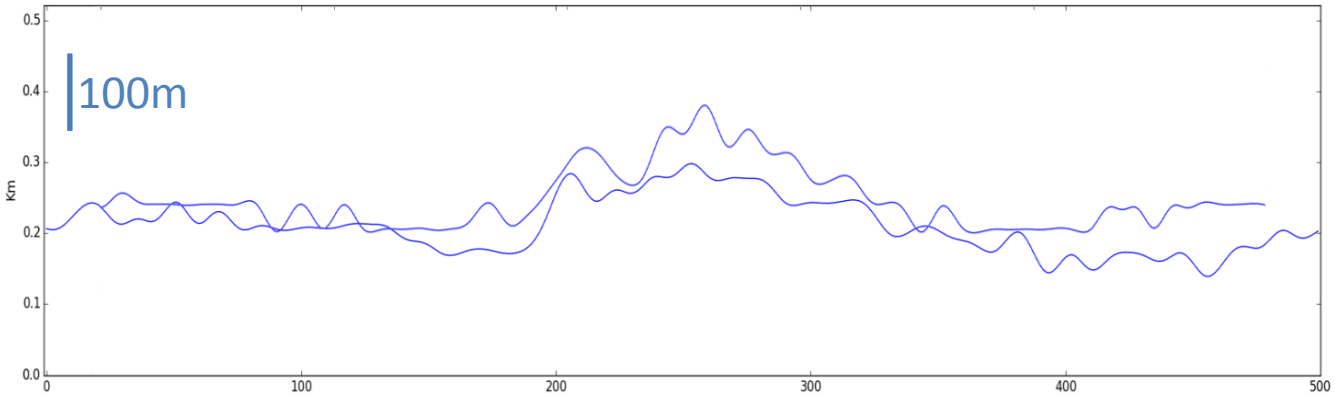
Below (Red): The older Surrounding ridges have an average height change of around 35m



With some assumptions of the redistribution of mass, an estimation of relative age can be made.

Geographic Ages





The difference in one surface to another, is approximately 30m, either being removed from the highest points or being re-deposited in the lowest.

In Sputtering time this is 300Myrs.

This makes huge assumptions on the redistribution of particles, the asymmetries of sputtering over the surface, and the age progression of features.

However, with greater quality and quantity of images, and a higher number of examples of crosscutting; I believe this is a viable method for dating the surface.

Thanks for Listening

Any Questions?

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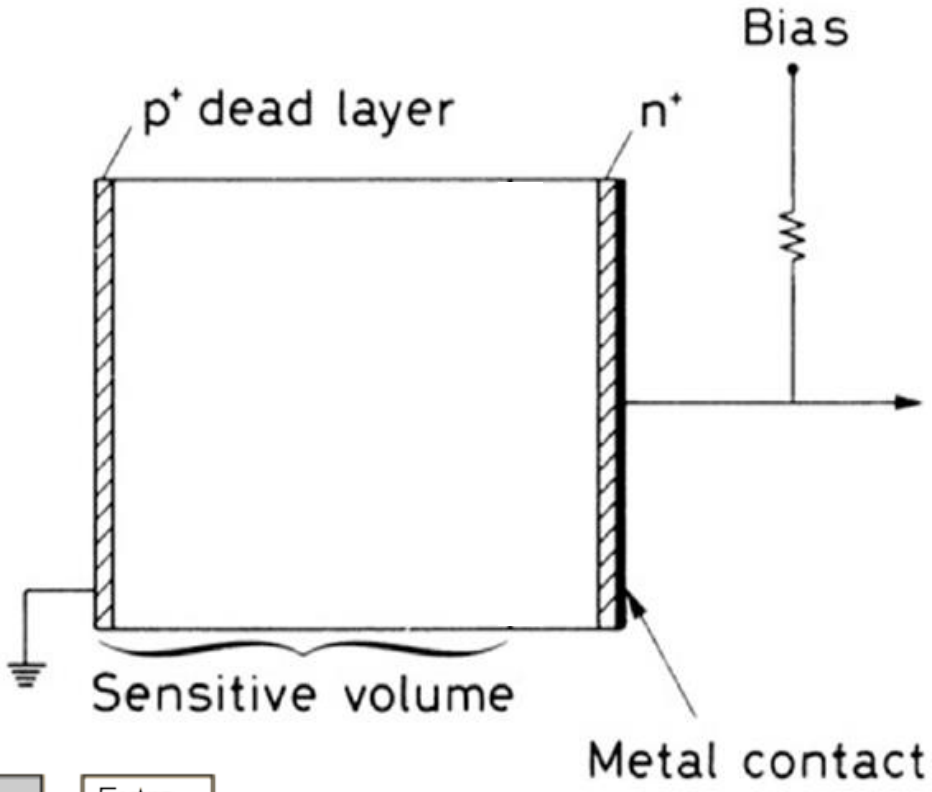
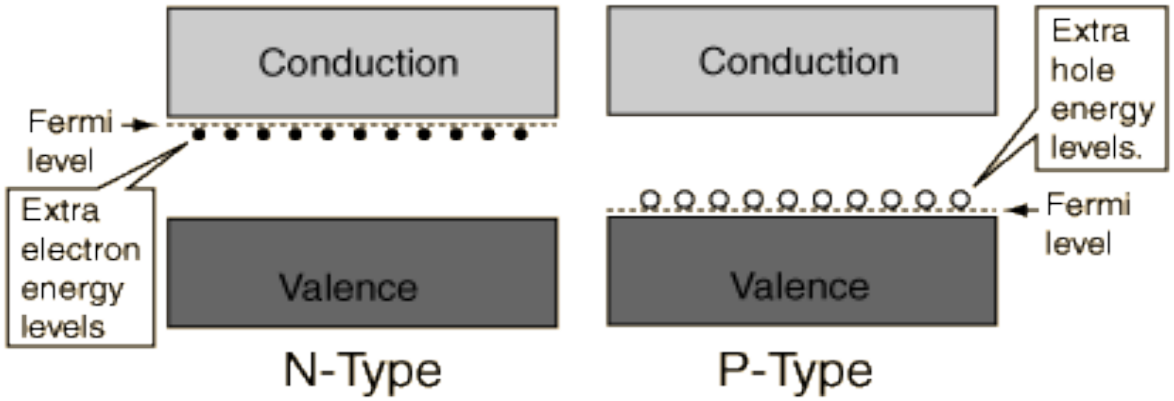
Extra Slide 1: Semiconductor Detector Decay

By adding impurities into the Silicon there have been extra levels added in the energy gaps. The whole detector has a current over it that determines the measurements made.

In p-type material, extra holes in the band gap allow excitation of valence band electrons, leaving mobile holes in the valence band These energy holes use up the energy of the impacting particles making measurement made in the sensitive volume lower.



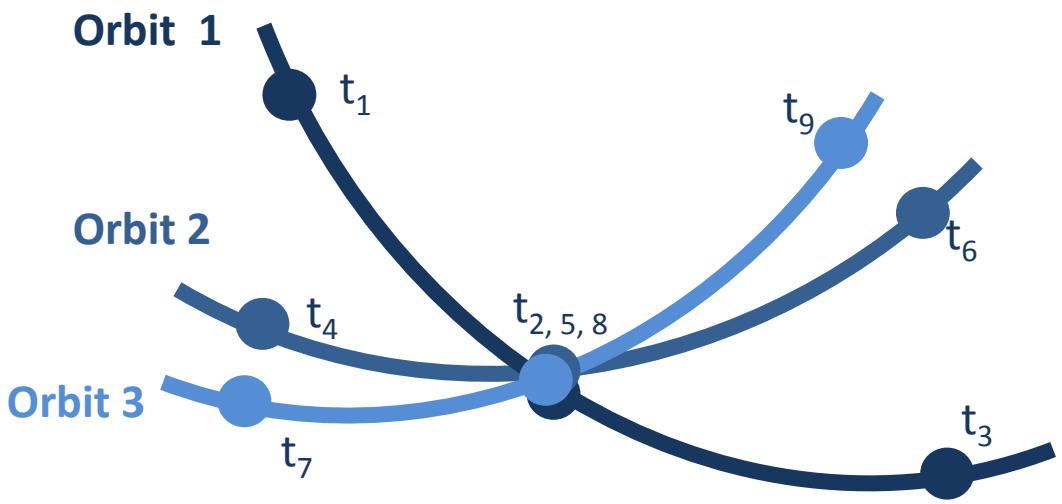


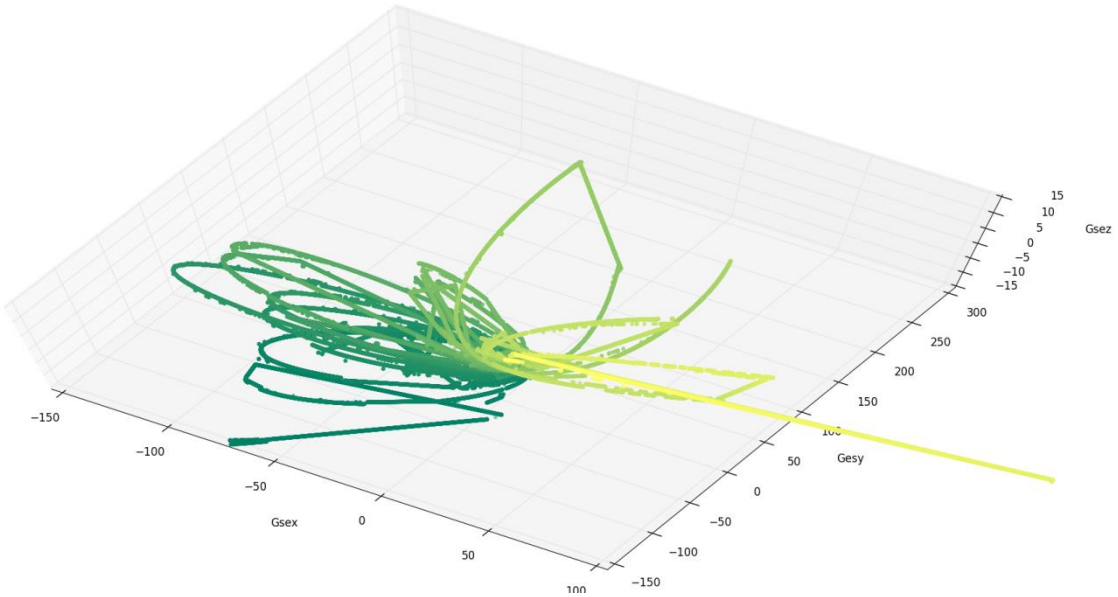
Extra Slide 2: Correcting for the Count Drop

By comparing the orbit paths and calculating where they cross approximately, an average can be computed containing:

- Overall drop
- The time gap (in increments)
- Overall number of impacts on the detector

All between the two coinciding points.



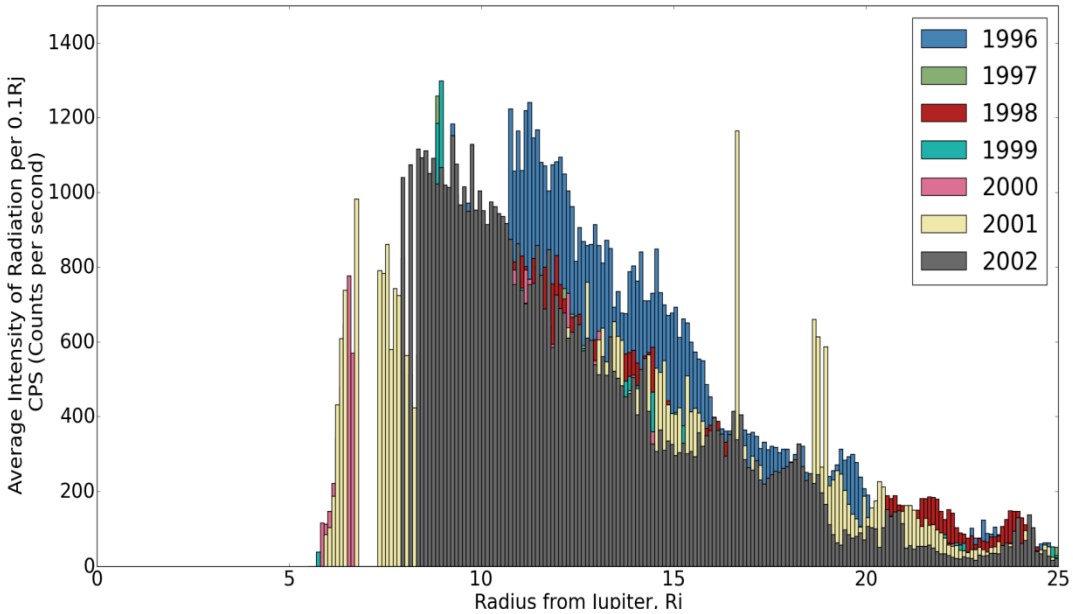


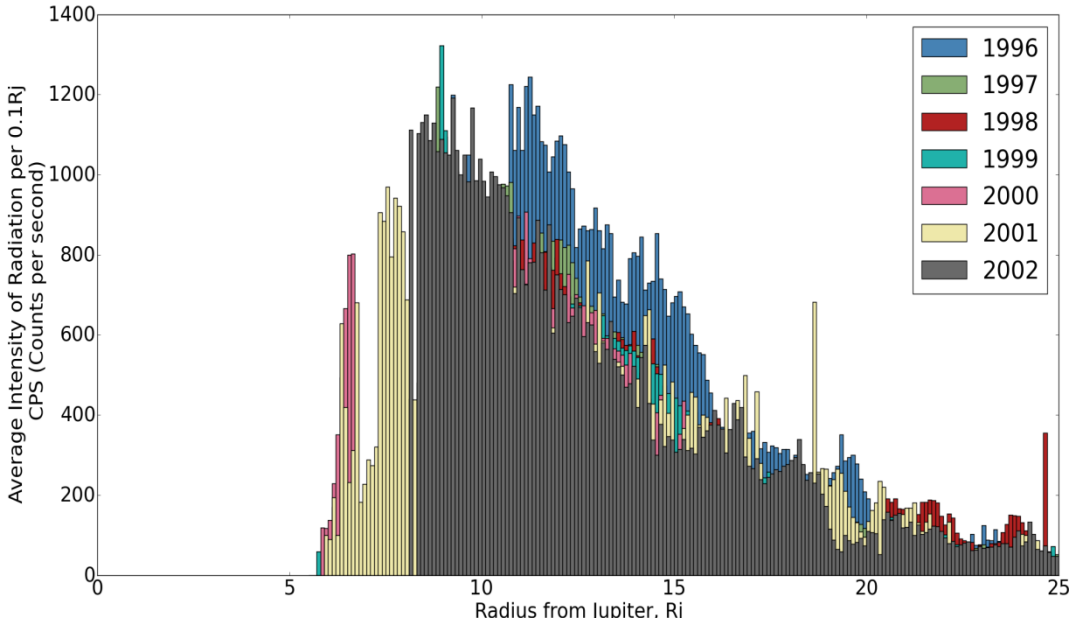
These can then be used to calculate:

- Average drop per increment
- Average number of impacts per increment

Extra Slide 3: Correction of Other Channels (Hydrogen)

TP1 channel. On of the proton channels shouldn't have been effected much by the decay and such the correction, which is show to be accurate.



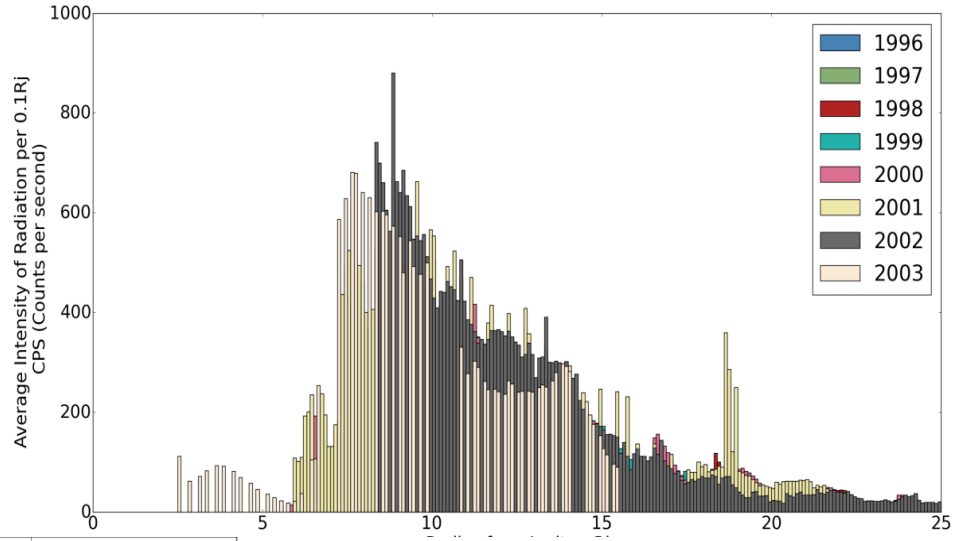


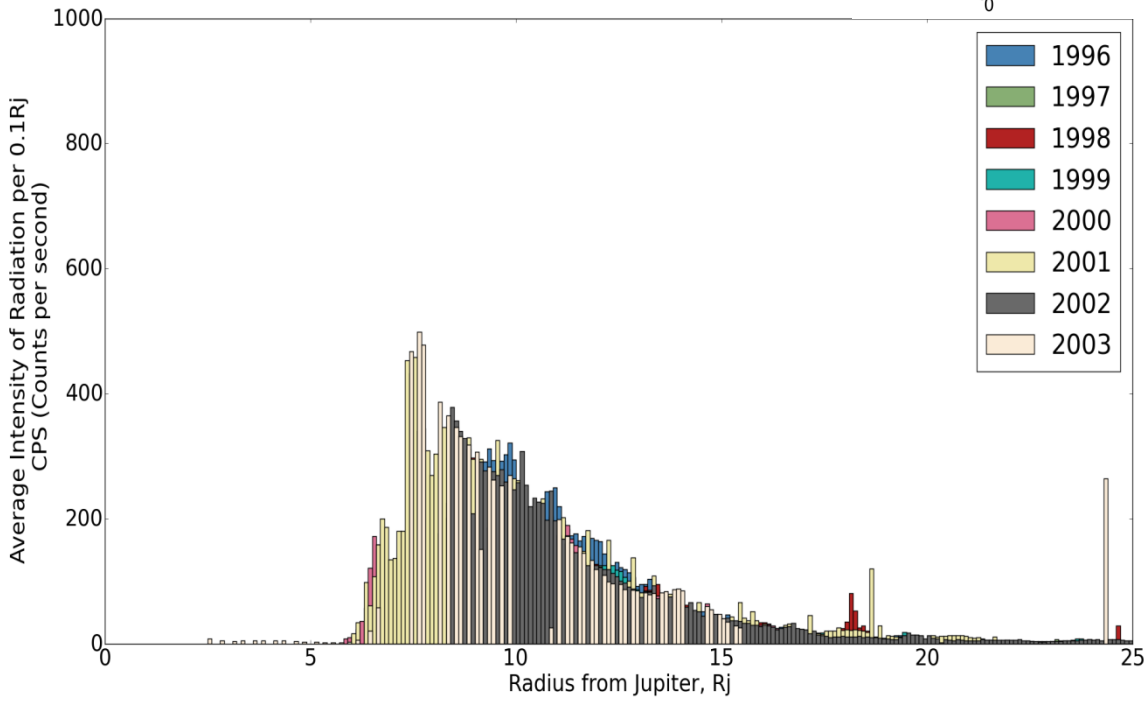
Above: Original data

Left: Corrected data.

Extra Slide 4: Correction of Other Channels (Oxygen)

The oxygen channels (TO4: right) had a differing problem to the sulphur channels. Many of the sulphur particles were being measured instead by the Oxygen channels. This lead to an apparent increase in efficiency.





The correction on its own did a good job of taking this into account, As shown earlier with the negative corrections values but more was needed.

Extra Slide 5: Testing Correction against Voyager Data