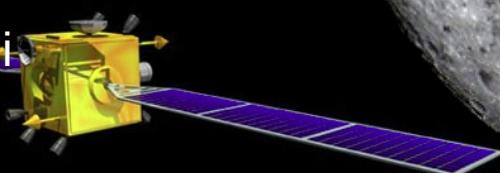


# Properties of the solar wind measured by moon satellite Chang'E-1

106° Congresso Nazionale Società Italiana di Fisica



Pietro Richelli  
Francesco Nozzoli  
INFN-TIFPA





# Space Science Data Center



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## Solar System Exploration @ SSDC

SSDC Solar System Home Moon Mapping Workshop

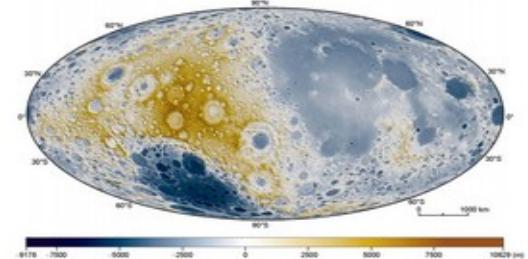
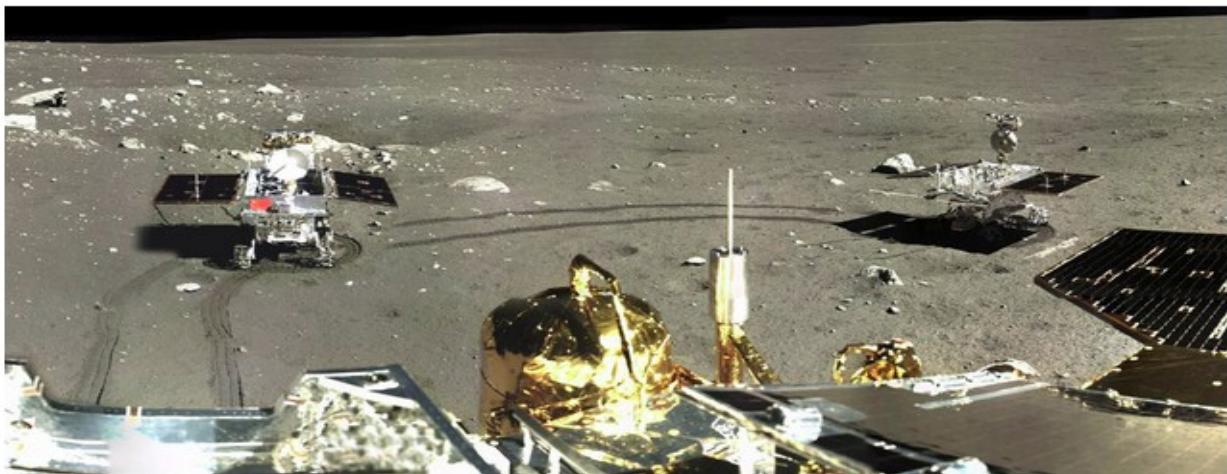
<https://solarsystem.ssdc.asi.it/change/>

MOON MAPPING PROJECT

CHANGE PROGRAM

DATA HUB

### MOON MAPPING PROJECT



#### Latest Solar System News

- (Jun 11, 2018) MATISSE v1.5 online with a better 3D online visualization method

Center of Space  
Exploration (COSE)  
Agenzia Spaziale  
Italiana (ASI)



5 topics on Moon Mapping  
with Chang'e satellite data



# Solar System Exploration @ SSDC

SSDC Solar System Home Moon Mapping Workshop

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MOON MAPPING PROJECT

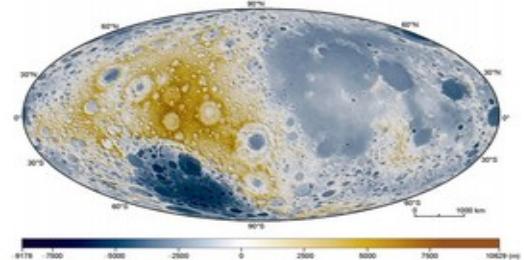
CHANGE PROGRAM

DATA HUB

SSDC stores and provides access to a large part of Chang'e 1 dataset, and to some data acquired by Chang'e 2.

All available data can be accessed by external users using the web-tool **MATISSE** after registration and only for user part of the Moon Mapping project are:

- 188 Digital Elevation Models (DEMs) computed on the basis of Chang'e 1 observations (250 m per pixel)
- 188 Orthophoto computed on the basis of Chang'e 1 observations (150 m per pixel)
- K, Th, U Elemental Abundance Maps (at 5° resolution) from Chang'e 1
- 187 Orthophoto from Chang'e 2 (50 m per pixel)
- 3244 Chang'e 1 CCD observations (Nadir, Backward, Frontward)
- 425 Chang'e 1 IIM imaging spectrometer observations



## Latest Solar System News

- (Jun 11, 2018) MATISSE v1.5 online with a better 3D online visualization method

**@ ASI - SSDC stored data of Chinese lunar orbiters:  
Chang'e-1 (2007)  
Chang'e-2 (2010)**



# Solar System Exploration @ SSDC

SSDC Solar System Home Moon Mapping Workshop

<https://solarsystem.ssdc.asi.it/change/>

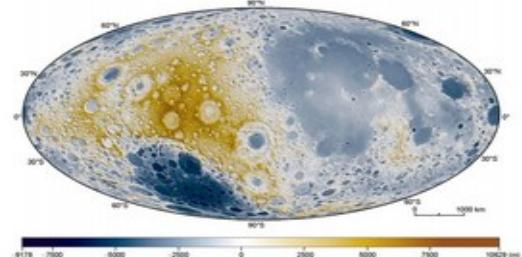
MOON MAPPING PROJECT

CHANG'E PROGRAM

DATA HUB

## CHANG'E-1

- Chang'E-1 was launched on 24 October 2007 with a Long March 3A carrier rocket from the Xichang Satellite Launch Center in Soutwest China, traveling 13 days to arrive at the Moon's orbit.
- Its nominal mission was 1 year, but it correctly worked for 1 year and 4 months, when, On Mar. 1st 2009 it was controlled to crash on the Mare Fecunditatis after 494 days of orbital operation.
- Chang'E-1 was equipped with eight scientific instruments, namely: a CCD stereo camera, a Sagnac-based Interferometer Spectrometer, a Laser Altimeter, a Microwave Radiometer, a Gamma-Ray Spectrometer, a High-Energy Particle Detector and a **Solar Wind Ion Detector**.
- It obtained a 120m-resolution global lunar map, an elevation map, abundance and distribution maps of various chemical elements.



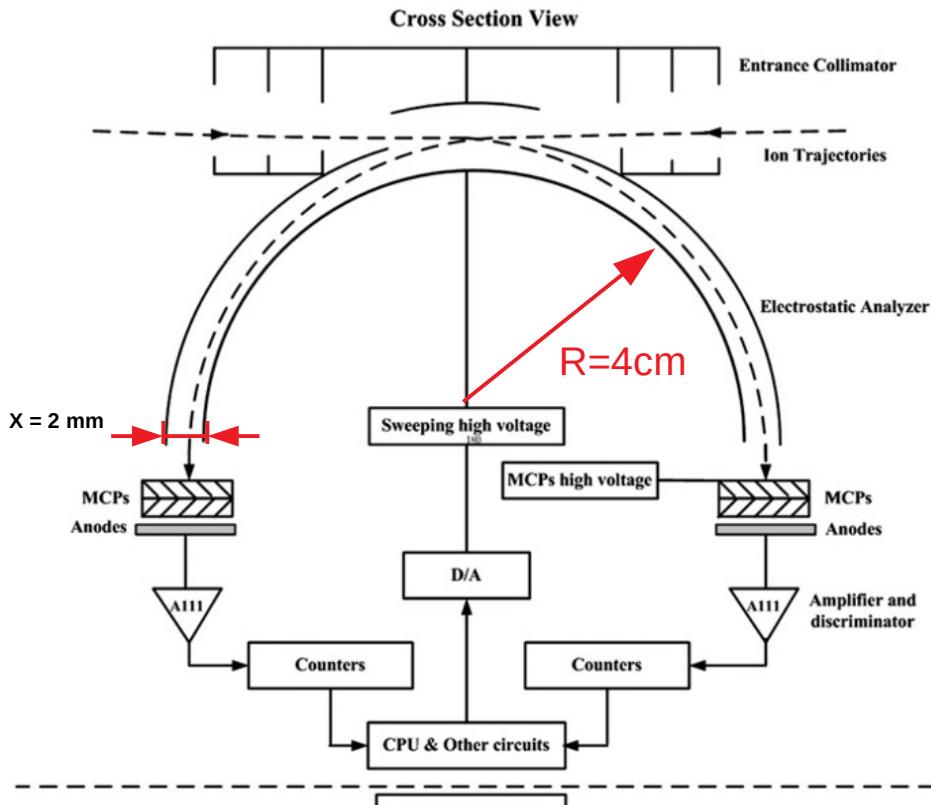
### Latest Solar System News

- (Jun 11, 2018) MATISSE v1.5 online with a better 3D online visualization method

**Chang'e-1**  
**measure Solar Wind Ions**  
**@moon orbit ("outside"**  
**Earth geomagnetic field)**  
**Data taken in the periods:**  
**26/11/2007 - 06/02/2008**  
**15/05/2008 - 07/07/2008**  
**(minimum of Sun activity)**

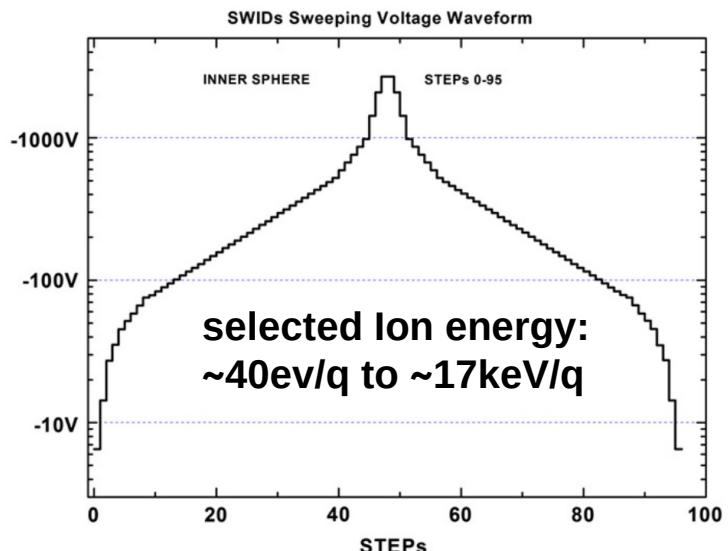
# Solar Wind Ion Detector

## Half-sphere electrostatic spectrometer



MCPs anode segmented in 12 channels  
(within  $180^\circ \times 6^\circ$  FoV of entrance collimator)

48 voltage logarithmic-step from 6.5V to 2690V  
sweep duration: 2.9 seconds, 61ms/step

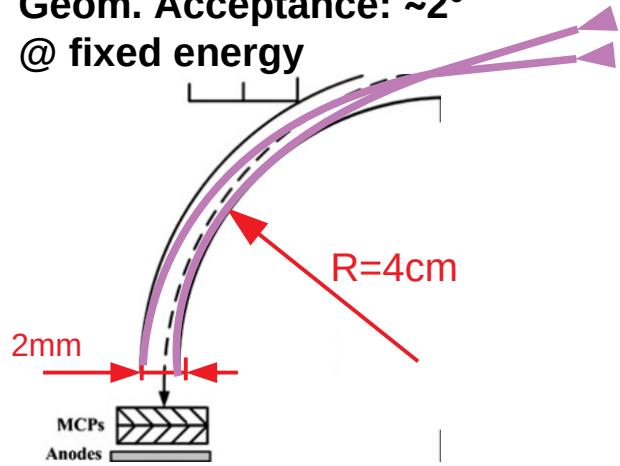


$$E_k = 1/2mv^2, mv^2/R = Vq/x$$

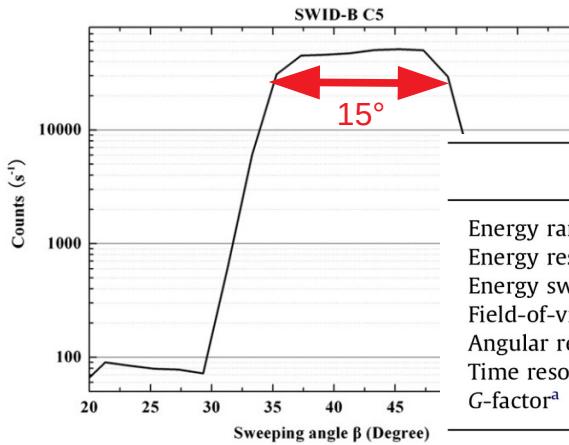
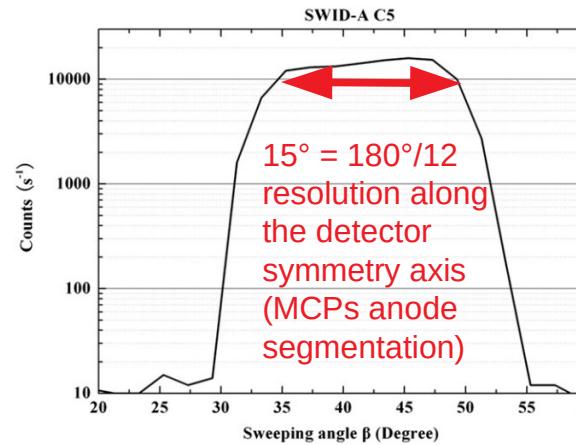
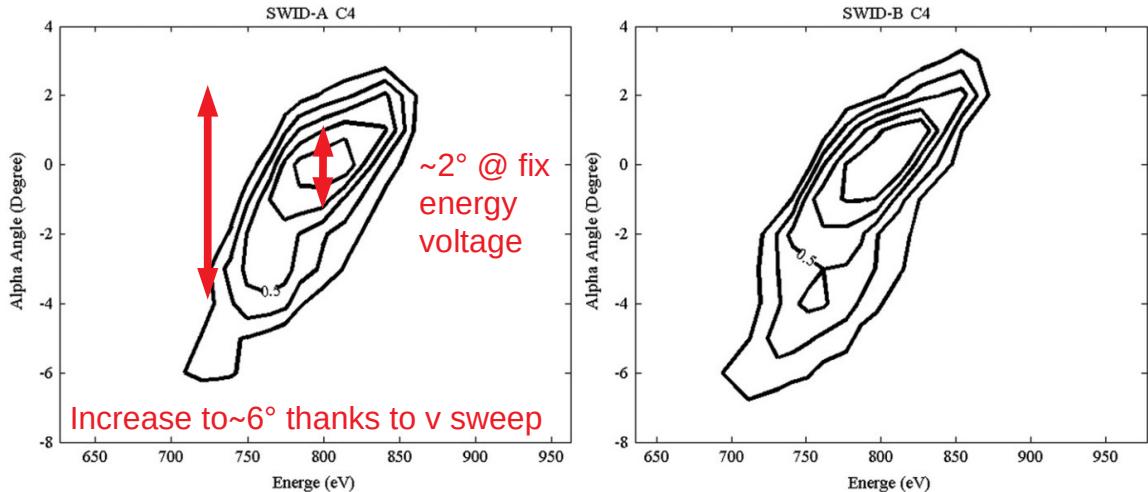
$$E_k/q = V \cdot R / (2x) = 10.375 \cdot V$$

# Solar Wind Ion Detector resolution

Geom. Acceptance:  $\sim 2^\circ$   
@ fixed energy

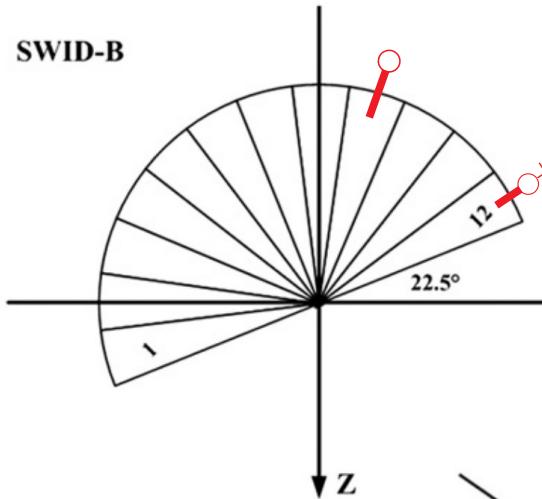
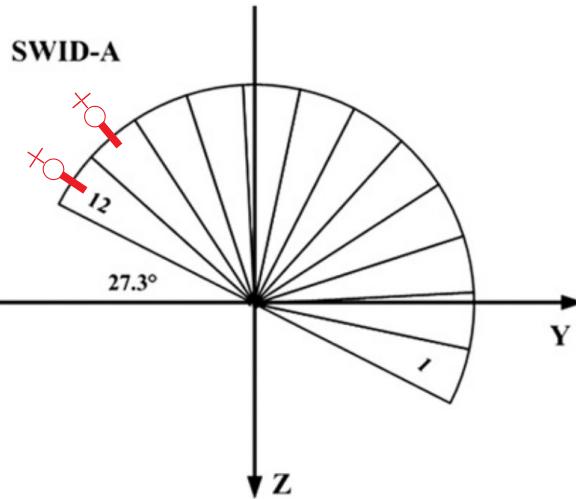


detector response calibrated @ 5eV-800eV ion beam

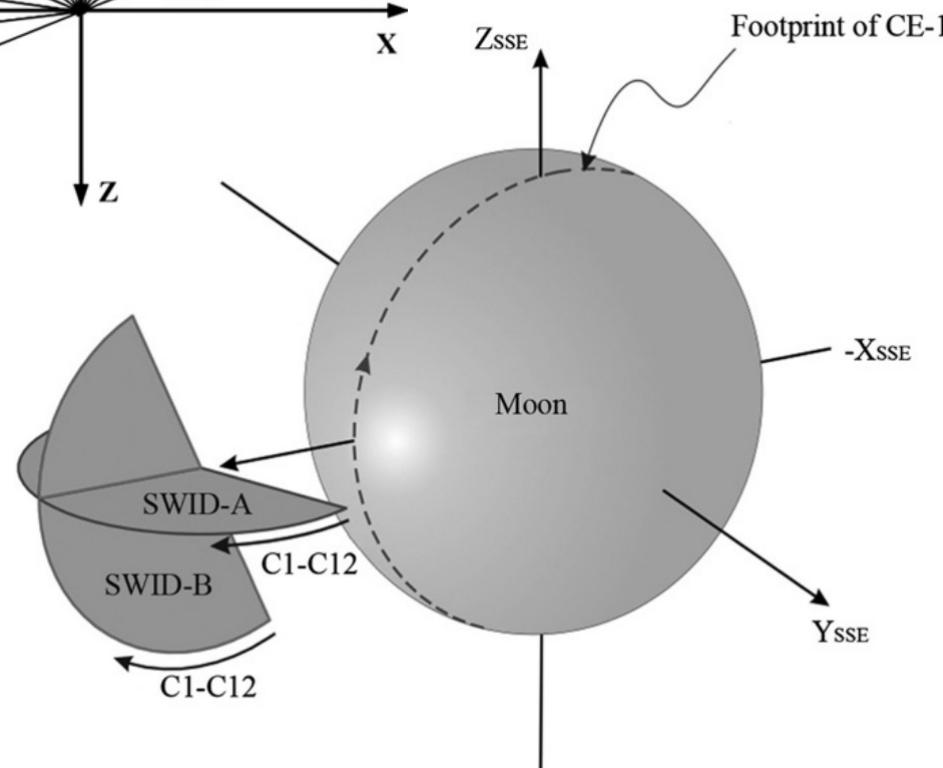


	SWID-A	SWID-B
Energy range	40 eV/q-16.48 keV/q	44 eV/q-17.98 keV/q
Energy resolution	8.1% (FWHM)	8.3% (FWHM)
Energy sweep steps	48	48
Field-of-view	$180^\circ \times 5.7^\circ$ (FWHM)	$180^\circ \times 6.6^\circ$ (FWHM)
Angular resolution	$15^\circ \times 5.7^\circ$ (FWHM)	$15^\circ \times 6.6^\circ$ (FWHM)
Time resolution	2.9 s	2.9 s
G-factor <sup>a</sup>	$4.6 \times 10^{-4} \text{ cm}^2 \text{ sr eV/eV}$	$5.7 \times 10^{-4} \text{ cm}^2 \text{ sr eV/eV}$

# Solar Wind Ion Detector FoV



For each Chang'e-1 orbit (2h):  
SWID-A scan most of the sky  
and all SWID-B channels scan the “same” 6° slice but with 15°  
& 5 minute redundancy/delay  
(+Moon is moving wrt the Sun)



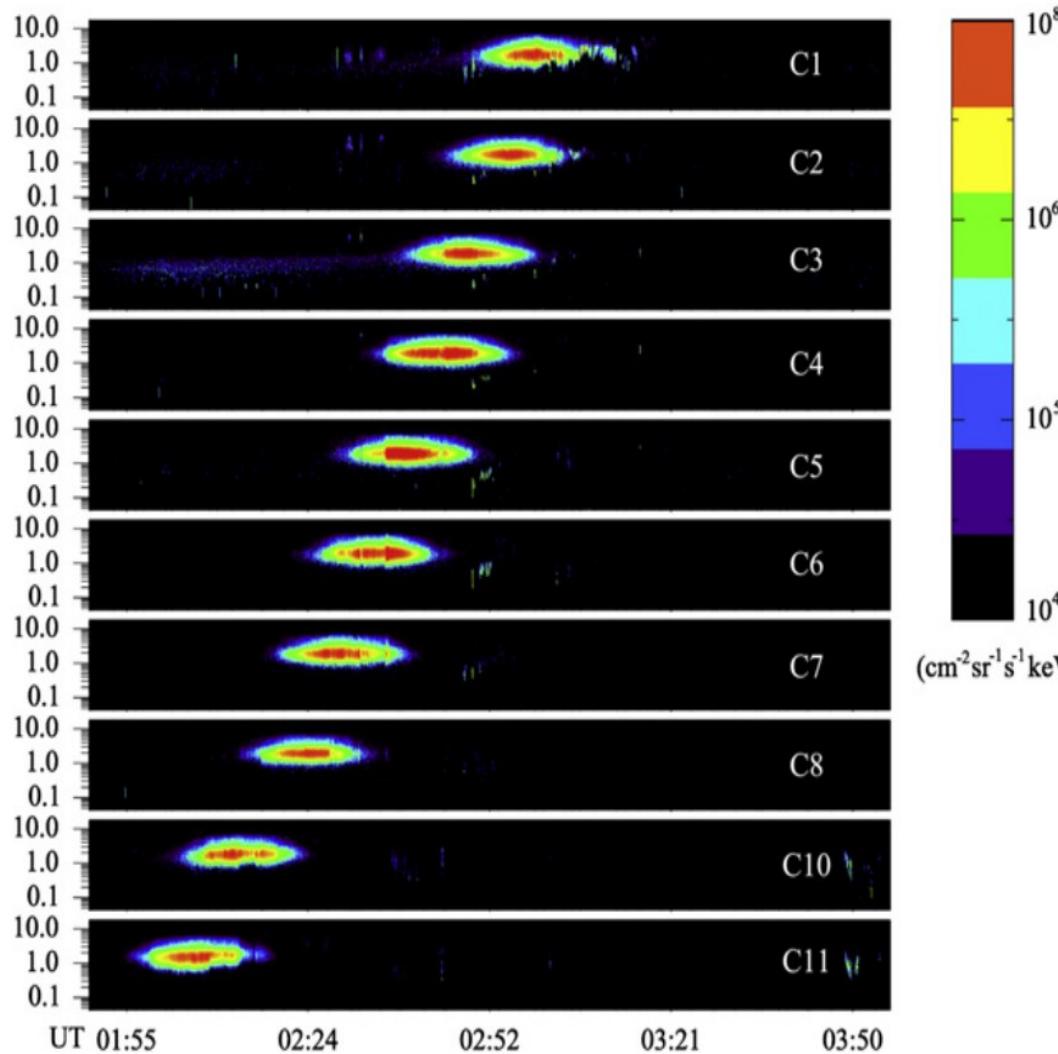
## KNOWN PROBLEMS:

- SWIDA-11
- SWIDA-12
- SWIDB-12

Channels are blocked  
by the satellite body

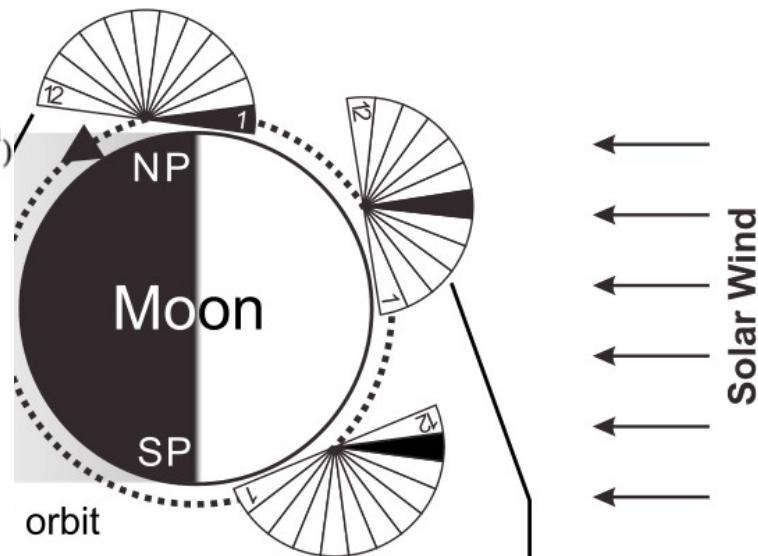
SWIDB-9 amplifier is  
broken (gain 1/10)

# Typical SWID-B flux measurement in one orbit

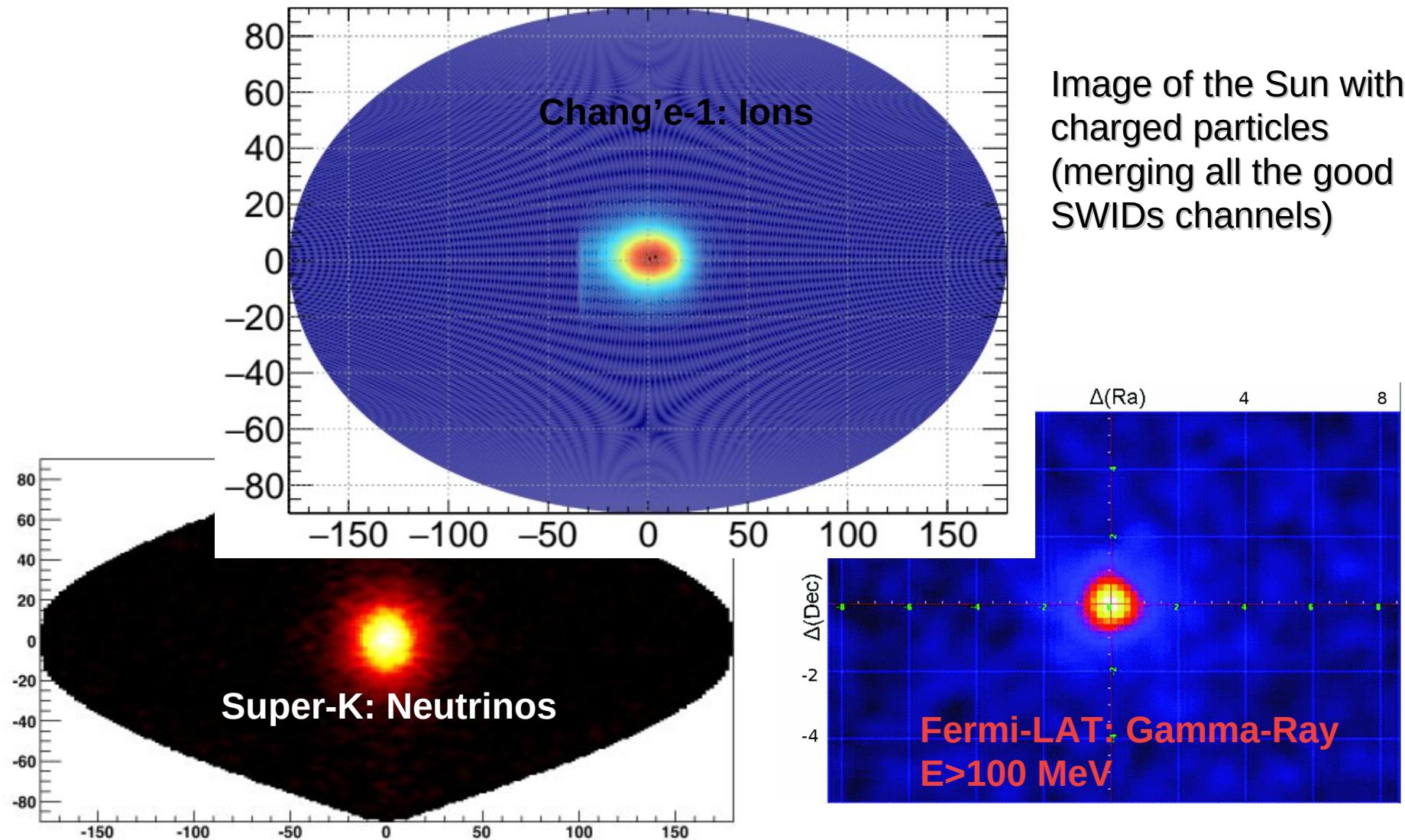


When the SUN (i.e. the solar wind) enter in the acceptance of a given channel, a large flux is measured.

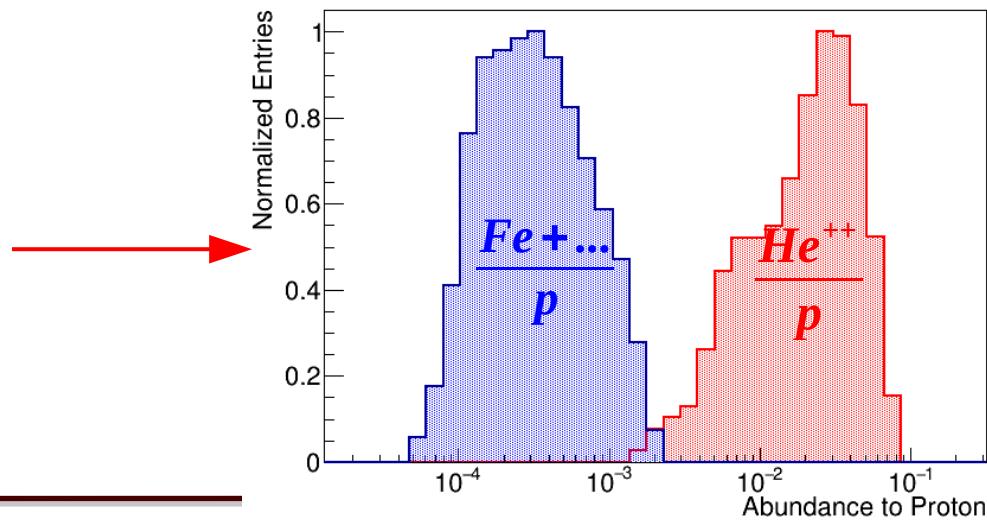
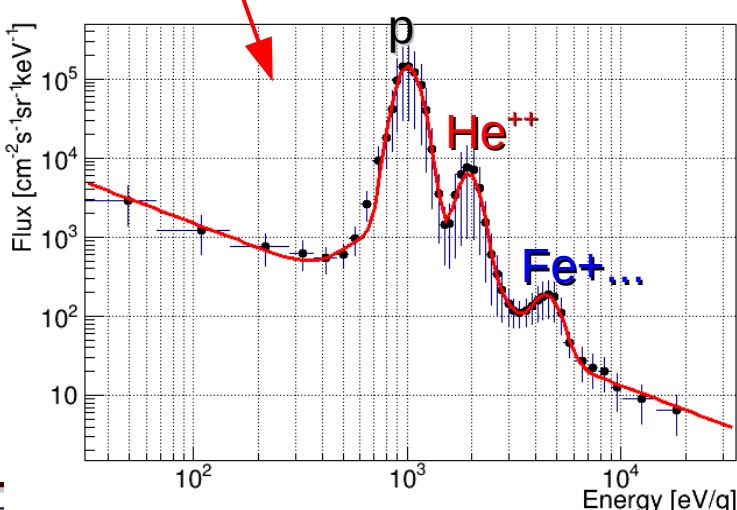
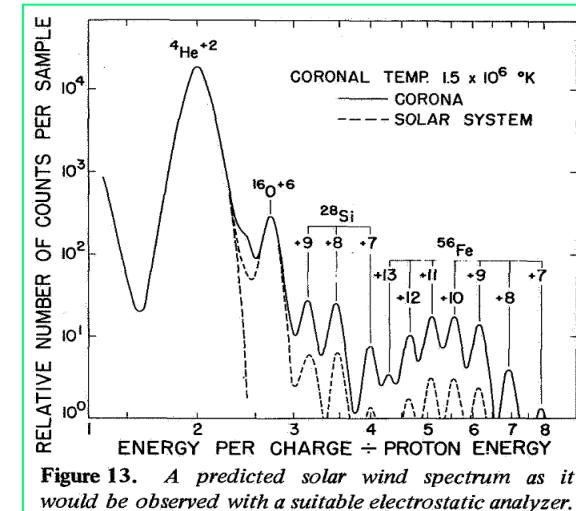
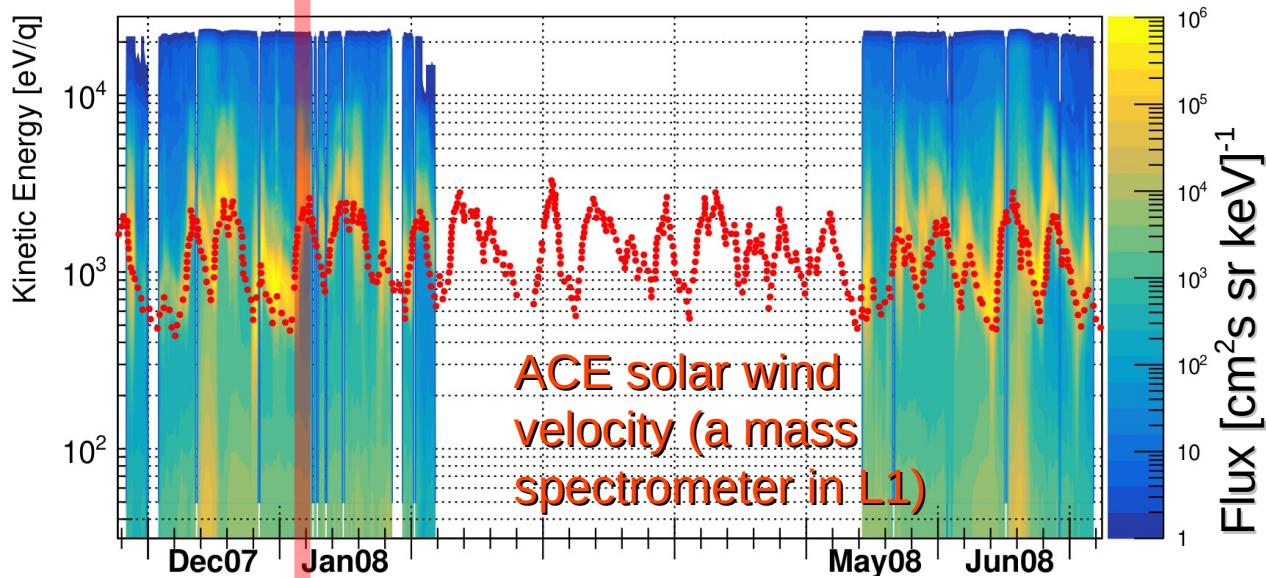
“SUN Imaging” with ions  
(thanks to the small magnetic field)  
This would be not possible within  
Earth Magnetosphere.



# multi-messenger view of the Sun



# Flux vs time (Sun activity & solar wind composition)



## summary

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Chang'e-1 Solar Wind Ion Detectors:

- multi-messenger view of the Sun
- complementary information of solar activity/space weather @ 1AU
- study of exotic plasma effects on Moon surface

DATA HUB from Moon-Mapping project:

<https://solarsystem.sscdc.asi.it>