SMILE

Solar wind Magnetosphere Ionosphere Link Explorer

Novel and global X-ray imaging of the Sun – Earth connection

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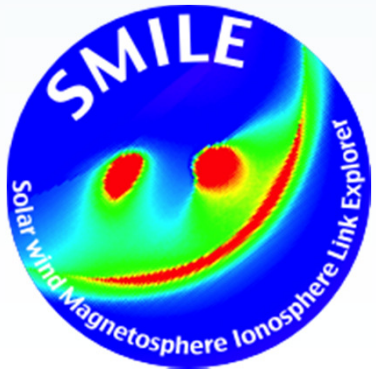
UCL – MSSL

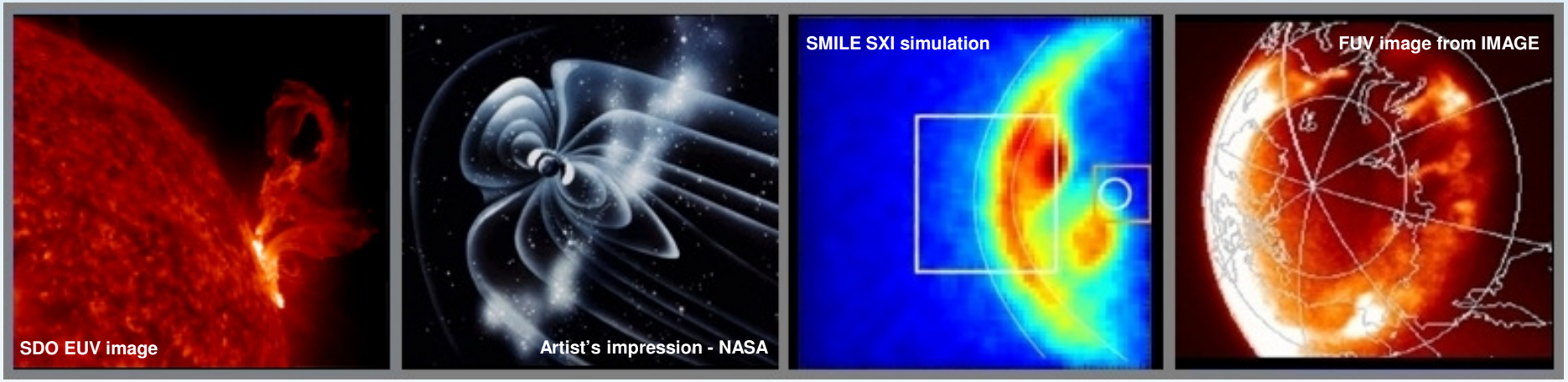
Chi Wang
CAS – NSSC

and the SMILE collaboration
(ESA, CAS and European, Canada, USA, China institutions)



The X-ray Universe 2017, Rome
6 – 9 June 2017

SMILE scientific objectives



- Investigate the dynamic response of the Earth's magnetosphere to the solar wind impact in a unique and global manner
- Combine Solar Wind Charge eXchange (SWCX) X-ray imaging of the dayside magnetosheath and the cusps with simultaneous UV imaging of the northern aurora, while monitoring the solar wind / magnetosheath conditions in situ, from a highly elliptical polar orbit
- → Full chain of events that drive Sun-Earth relationships: dayside reconnection / magnetospheric substorm cycle / CME-driven storms

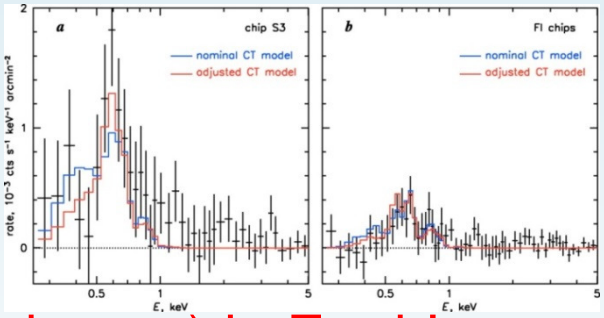
From unwanted variable soft X-ray bkg …

- LTE of the *ROSAT* All Sky Survey ¼ keV background ***Snowden et al. 1995***

- Time variable O emission lines on the dark side of the Moon

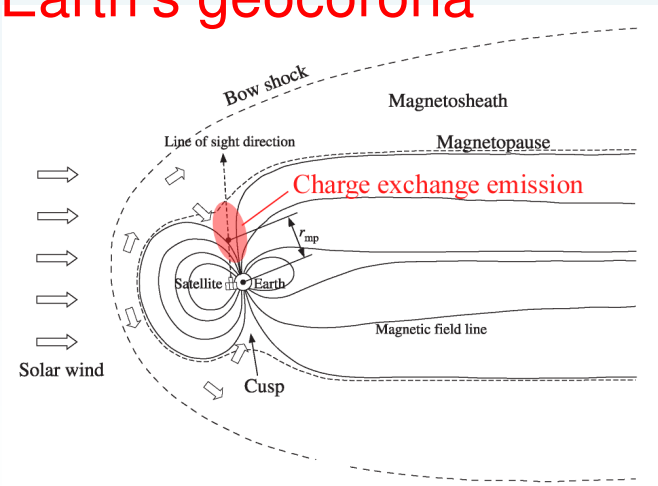
  Correlation with solar wind flux

  → SWCX (Solar Wind Charge eXchange) in Earth's geocorona



***Chandra* ACIS**
Wargelin et al. 2004

- *Suzaku* observations of the NEP:
  Increase in soft X-ray lines correlated with solar wind proton flux ***Fujimoto et al. 2007***

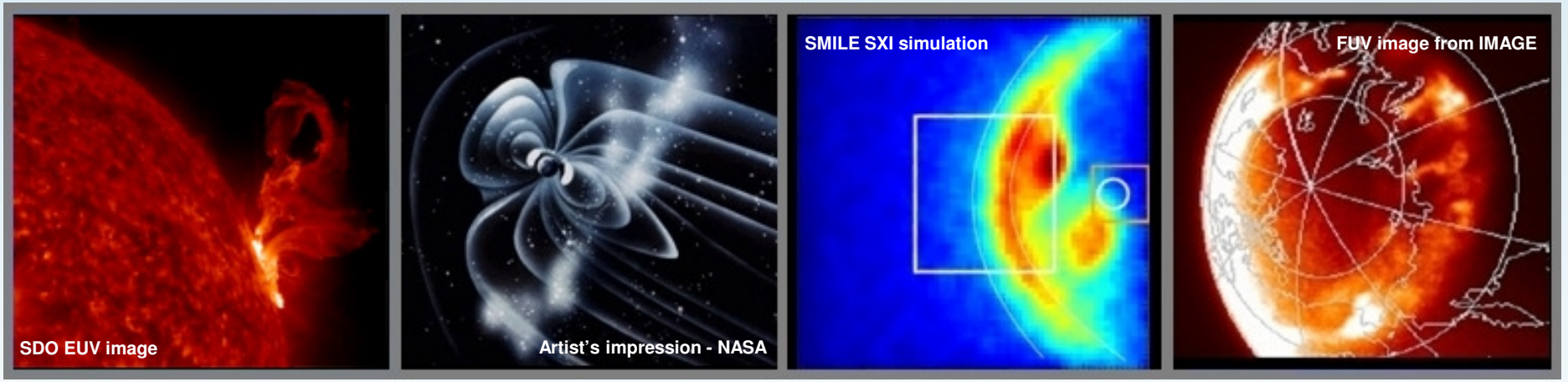


- Systematic study with *XMM-Newton*

  Carter et al. 2008, 2010 (CME), 2011

… and then we got to ***SMILE***

SMILE precursors



- X-rays from the magnetosphere: from 'noise' to diagnostic tool
- Early concept missions: MagEX (*Sembay et al. 2008; Collier et al. 2009)* and STORM *(Kuntz et al. 2008; Sibeck et al. 2011; Collier et al. 2015)* proposed to NASA; AXIOM and AXIOM-C (*B-R et al. 2010, 2012*) to ESA
- Lobster eye optic: DXL/STORM flights *(Thomas et al. 2013, Collier et al. 2015)*
- Concept has matured substantially → SMILE selected in June 2015 for joint ESA - CAS mission with launch expected at end 2021
- Phase A: Detailed mission configuration and instruments design ongoing

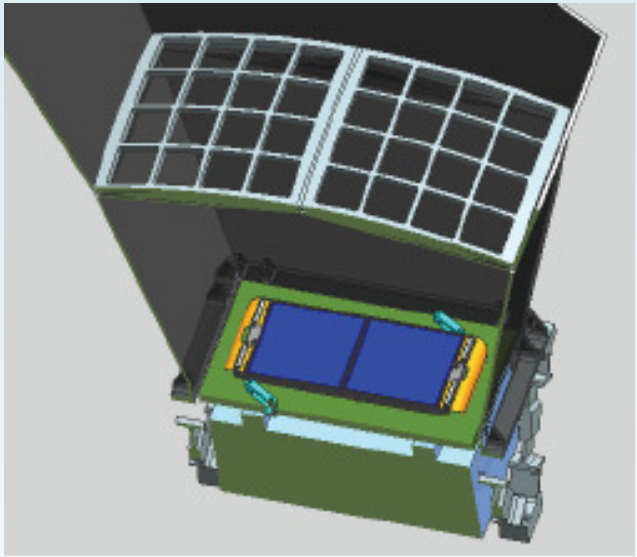
SMILE Soft X-ray Imager (SXI)

CCD Detector Plane

Photon counting: Event lists with 1 to 2 s time resolution

High QE in soft X-rays
~80% at 250 eV

Medium energy resolution
~50 eV FWHM at 500 eV



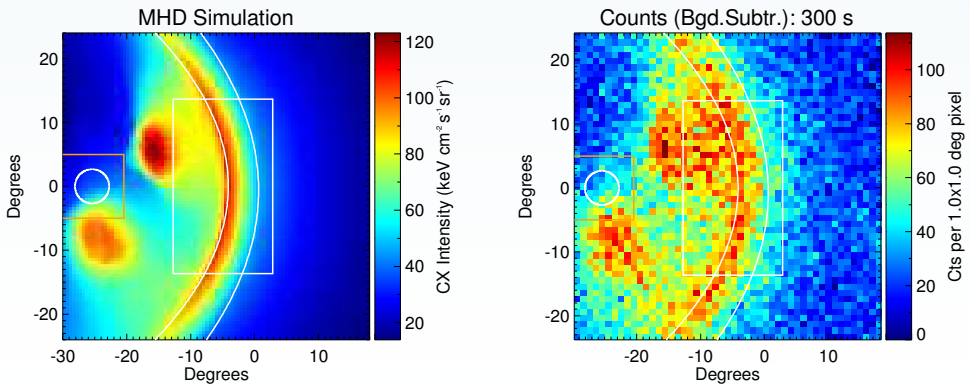
Lobster-eye Micropore Optic

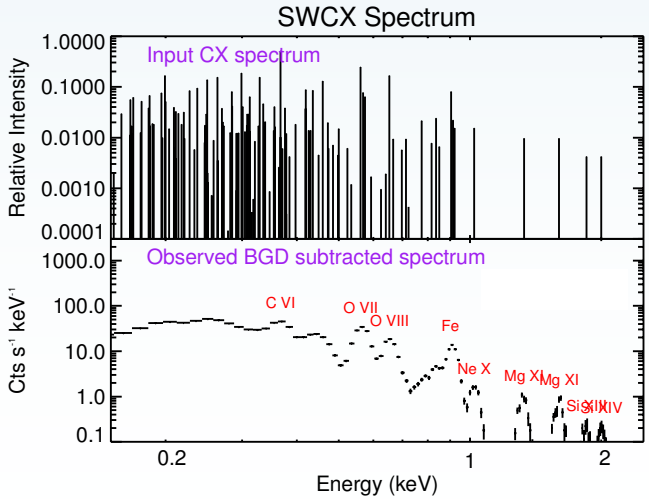
Ultra-wide field of view
~16° x 27°

Focal length 30 cm

Optic Mass < 1kg

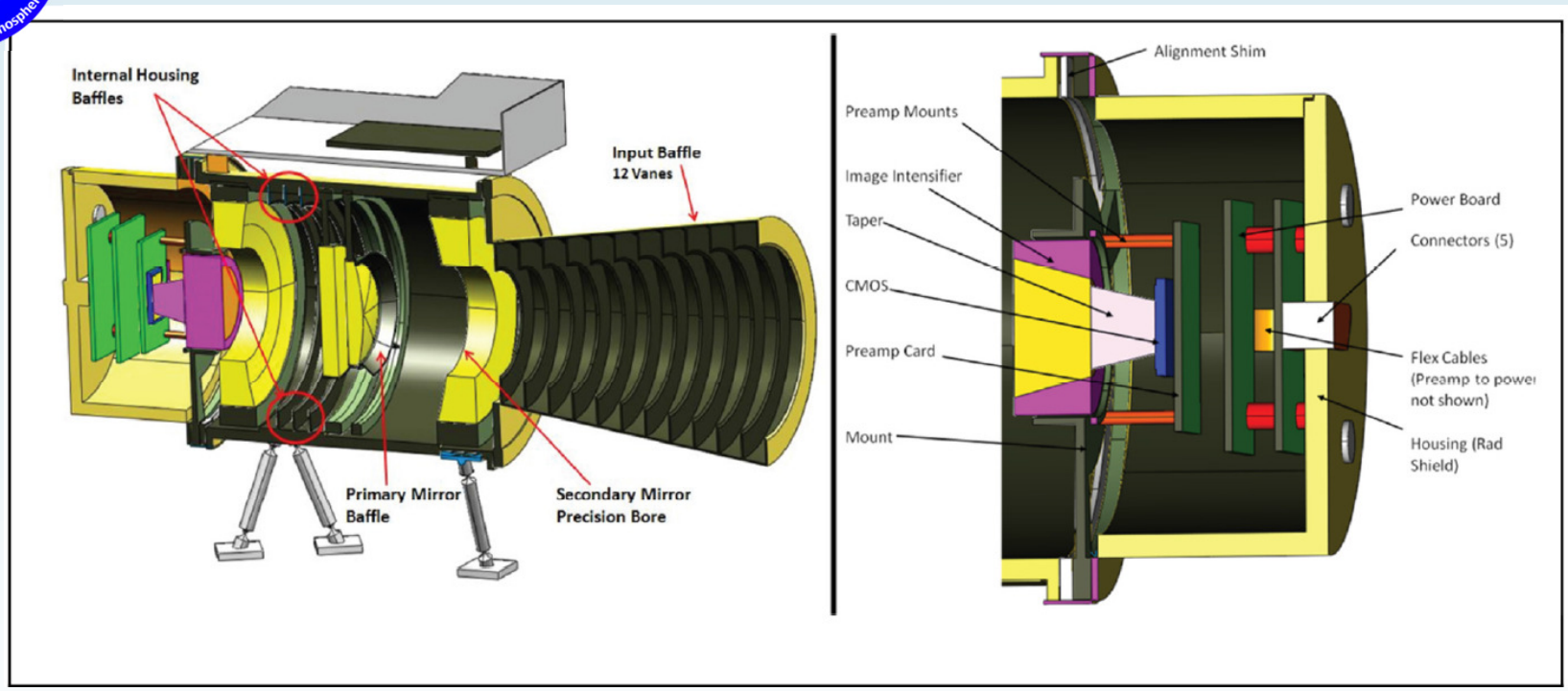
Instrument ~ 26 kg





PI S. Sembay, Univ. of Leicester, UK

SMILE UltraViolet Imager (UVI)

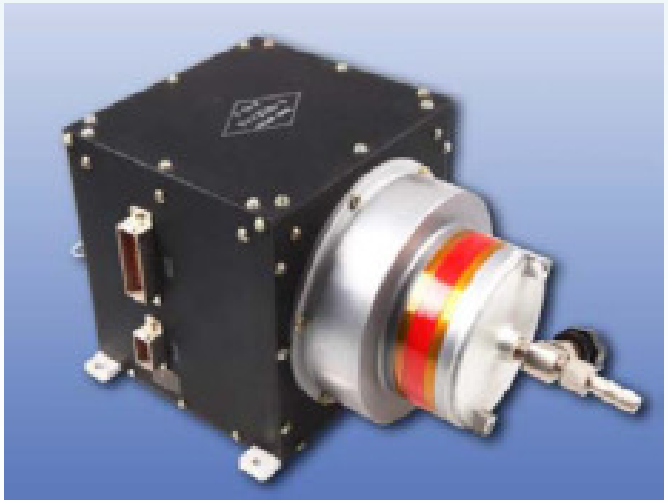


- Four mirror reflective UV imager of whole northern aurora at high spatial and temporal resolution
- UV bandpass (160-190 nm) achieved coating optical & detector surfaces
- Image intensifier detector (photocathode → MCP → phosphor (554 nm) → CMOS sensor)

PI E. Donovan, Univ. of Calgary, Canada

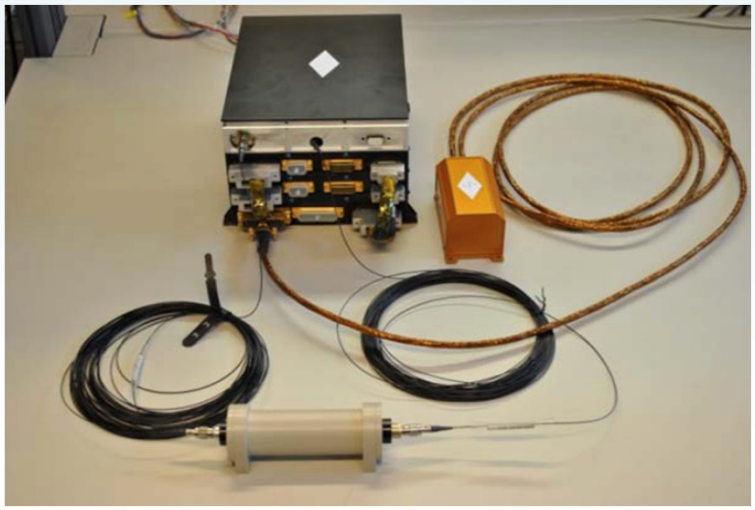
SMILE Light Ion Analyser (LIA) & MAGnetometer (MAG)

- Top-hat analyser for p and α density, velocity and temperature
- Energy range: 50 eV - 20 keV
- FOV : 360º and up to +/-45º with deflector plates



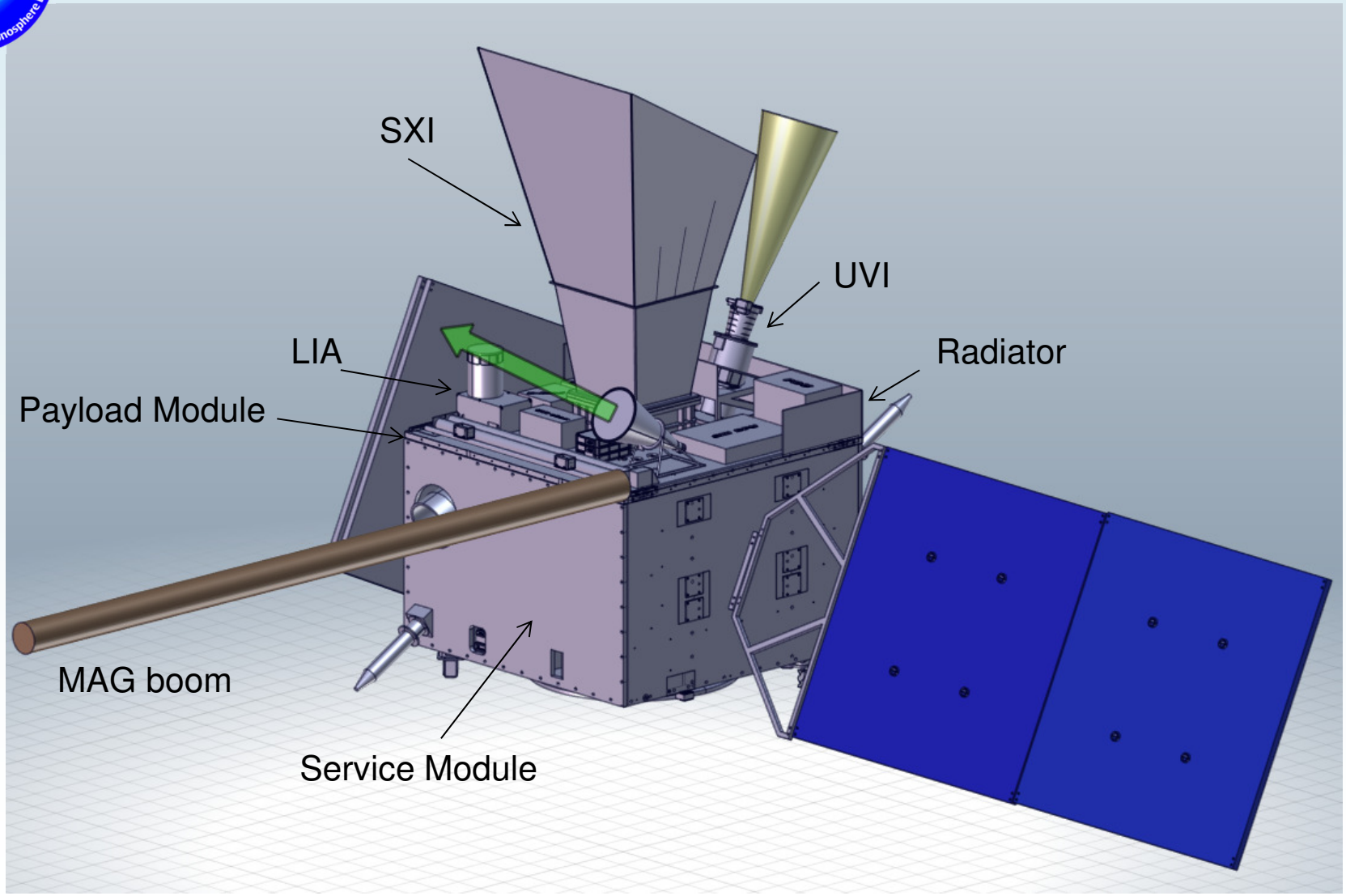
PI L. Dai, NSSC, CAS, China

- Fluxgate magnetometer for magnetic field strength and direction
- 2.5 m boom, sensors separated by 0.8-1 m



PI L. Li, NSSC, CAS, China

SMILE spacecraft



From ESA-CAS CDF

SMILE shares of responsibilities

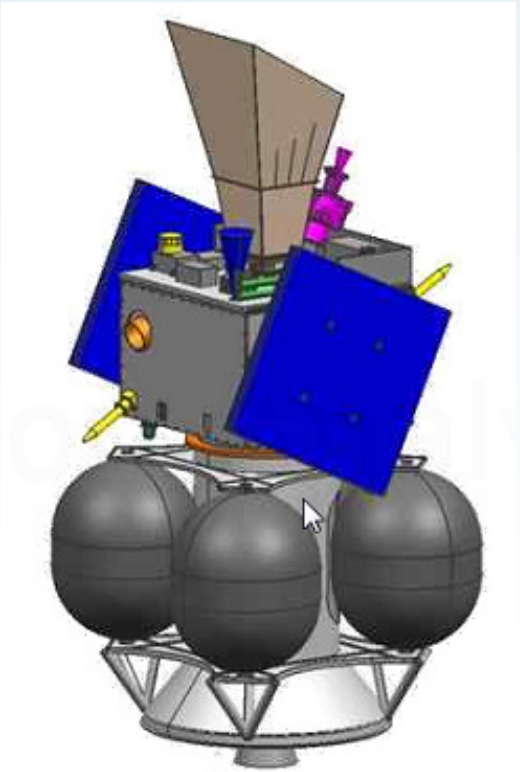
- **CAS** provides the Propulsion Module, Service Module, Spacecraft Prime, Mission Operations (with ESA contribution), Chinese instruments
- **ESA** provides the Payload Module, launcher, AIT facilities for spacecraft integration and testing; ESA member states/Canada provide instruments

SMILE orbit

Baseline: ~ 5000 km x 120,000 km HEO, ~ 41h science operations (SXI & UVI)

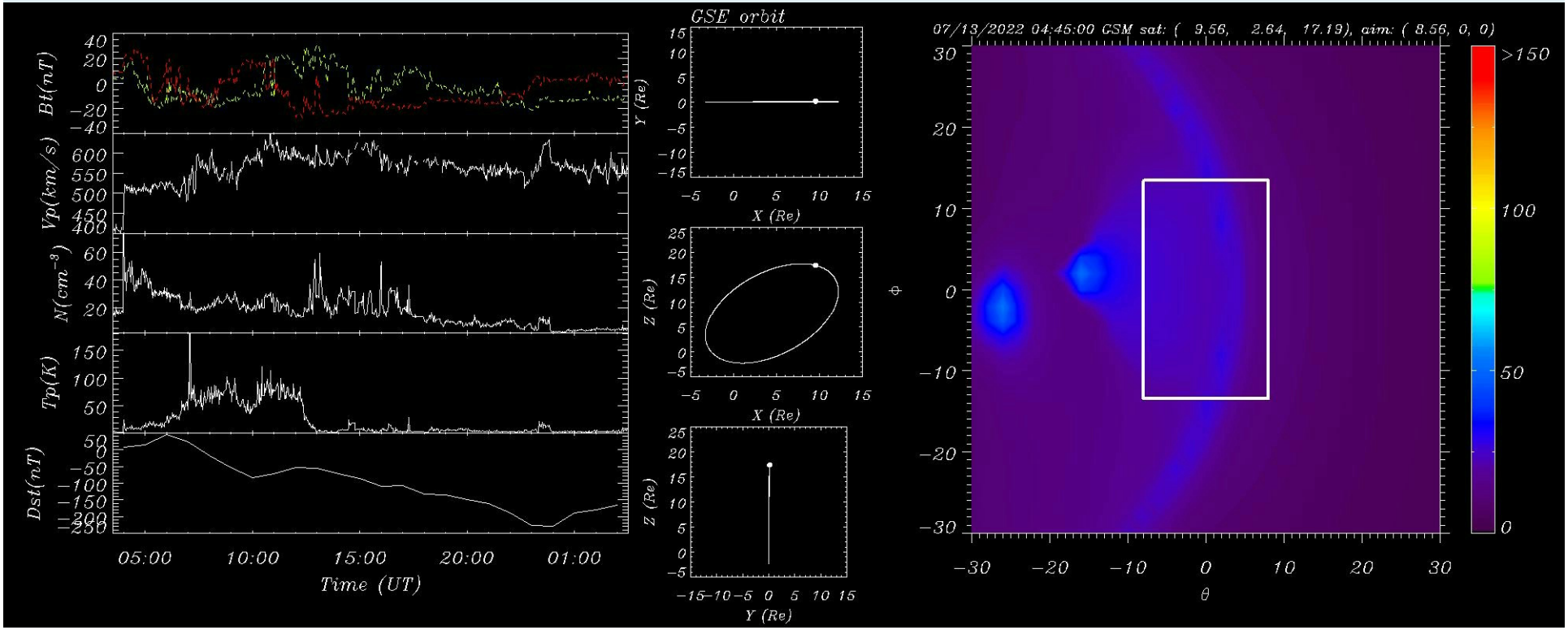
Ground stations: Troll (Antarctica), possibly Kourou (French Guyana) and Sanya (China)

Launch (2021): Soyuz or Ariane 6 (dual launch into SSO 700 km; 98^{o} incl.) or Vega-C (single passenger, ~70^{o} incl.), both from Kourou



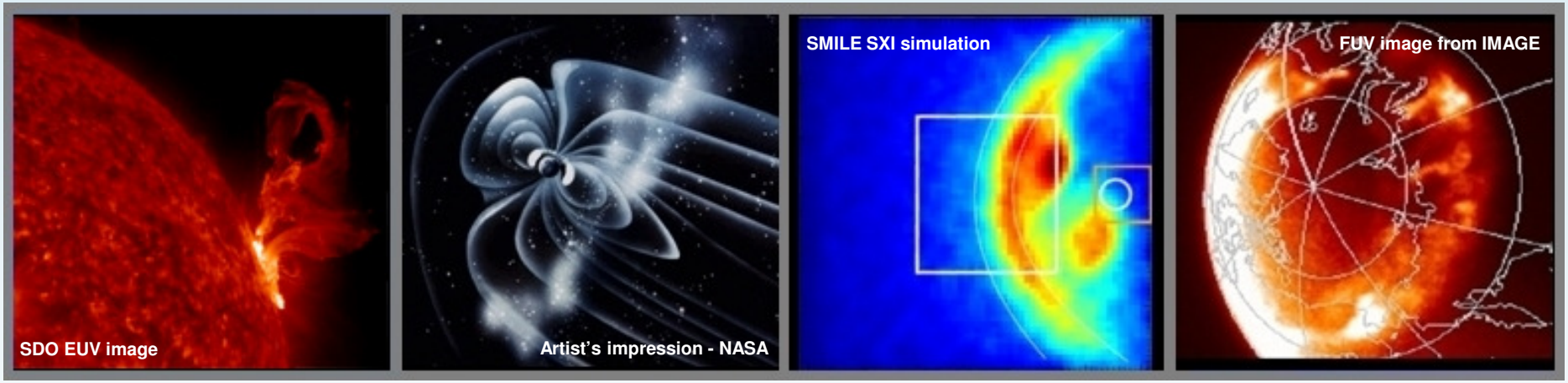
From ESA-CAS CDF

17th March 2015 storm event conditions



T. Sun, NSSC, CAS, China

In summary …



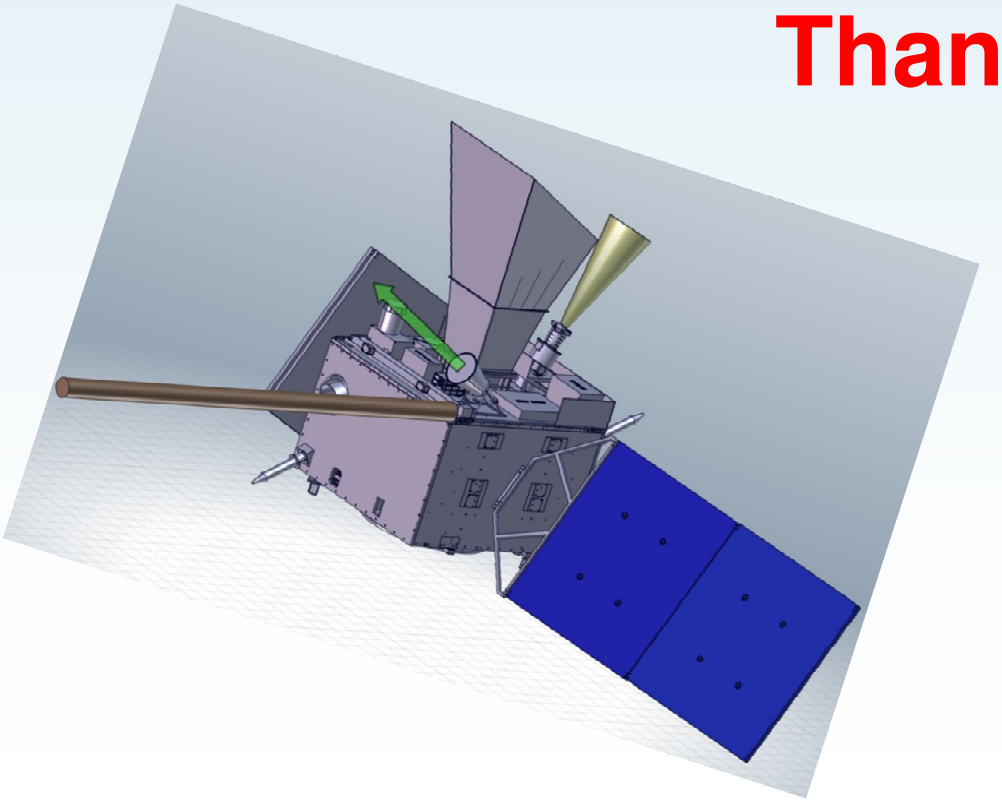
- X-rays from the magnetosphere: from 'unwanted background' for X-ray astrophysical observatories to diagnostic tool of Sun-Earth relationships
- SMILE will provide direct scientific input to the studies of space weather by providing the remote sensing measurements needed to validate global models of solar wind-magnetosphere interactions
- Outreach: Images and movies will captivate public to science (magnetic field) so far invisible
- Cooperation with China: SMILE is a showcase, building on Double Star

UCL

esa

CHINESE ACADEMY OF SCIENCES

Thank you



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