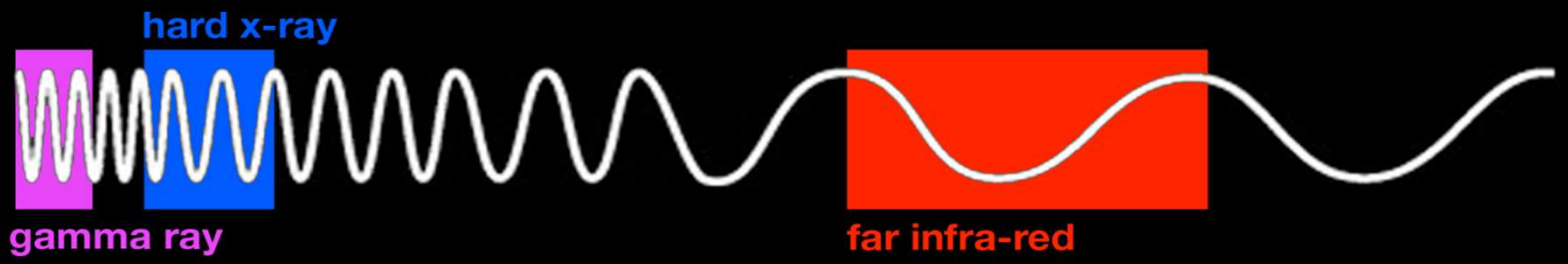
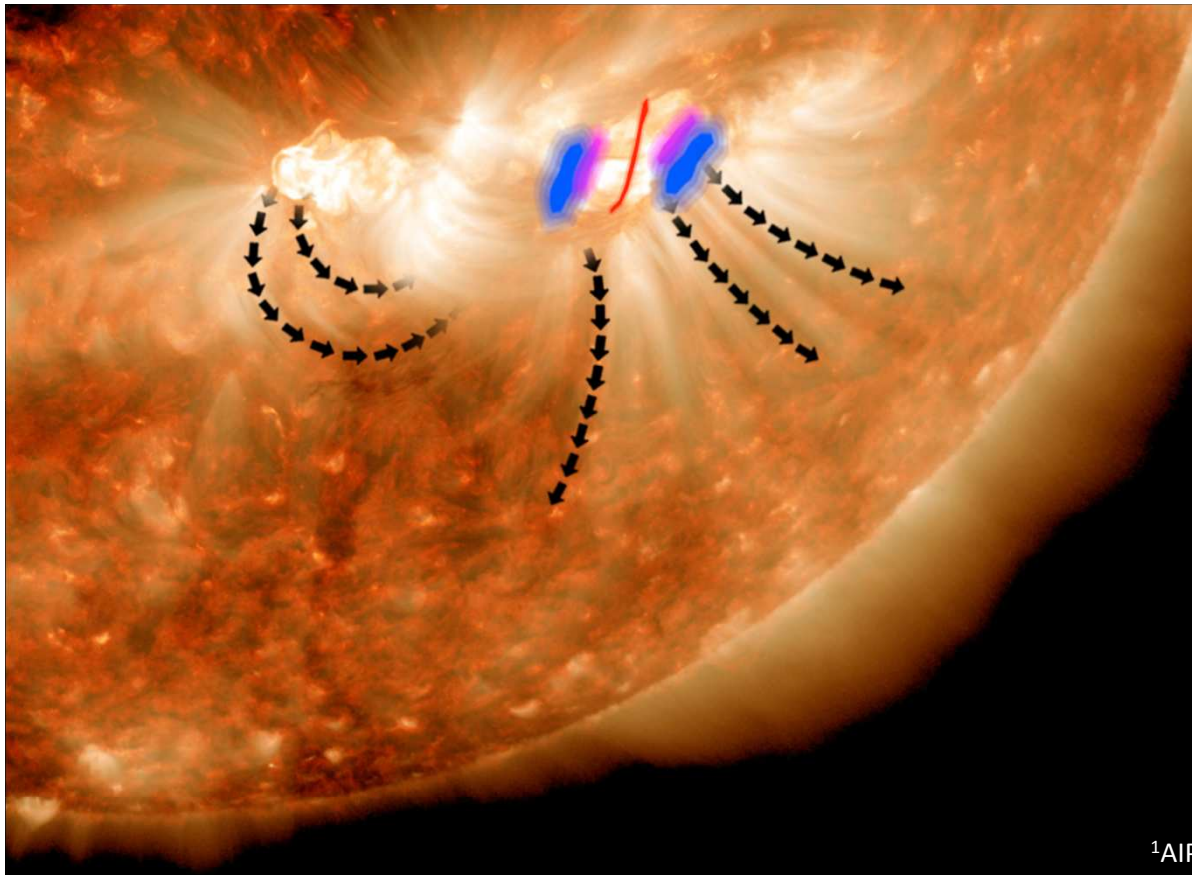
SPARK: Solar Particle Acceleration, Radiation and Kinetics

A mission to understand the nature of particle acceleration

A proposal submitted in response to ESA's call for an M-class opportunity 2010





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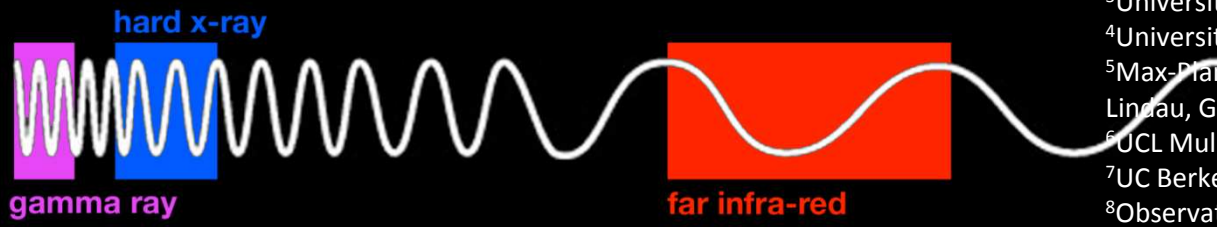

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Key Science Questions

- A) What is the role of the magnetic field in determining the onset and evolution of particle acceleration?
- B) What are the lower energy extremes of solar particle acceleration?
- C) What are the energy transport mechanisms associated with particle acceleration?
- D) How do energy budgets of particle populations compare and where are these populations accelerated?
- E) How and where are the most energetic particles accelerated on the Sun?
- SPARK will in particular target the extremes of the particle acceleration process.

Key measurements

- High temporal (tens of seconds) and spatial resolution (sub-arcsec) vector magnetic field chromosphere and photosphere
- HXR imaging with enough sensitivity and dynamic range to image faint coronal sources and bright chromospheric sources (spatial resolution >10’’) in the 4-60 keV range, FOV > AR.
- -HXR spectral measurements, 1 keV spectral resolution from 4 to 60 keV and 15 keV at 200 keV.
- -γ-ray spectral measurements with 40x RHESSI sensitivity (5 counts/cm^2) and 1.5% dE/E at 6.1 MeV and a range of 150 keV – 150 MeV.
- -γ-ray imaging with 40x RHESSI's sensitivity (50 counts/$cm^{2)}$ in the 2.2 MeV neutron-capture line.
- - FIR spectral imaging in a minimum of 2 wavelength bands (25 – 45 µm and 80 – 130 µm)
- - SXR imaging of Full Sun, minimum spatial resolution of 3’’, cadence of 10s in two bandpasses: 1 – 2.5 and 2.5 – 3.5 keV

Firsts…

- First measurements from space of the FIR component of solar flares
- First time series of images in γ-ray lines
- Most sensitive measurements to date over 4 keV – 150 MeV

Mission Profile

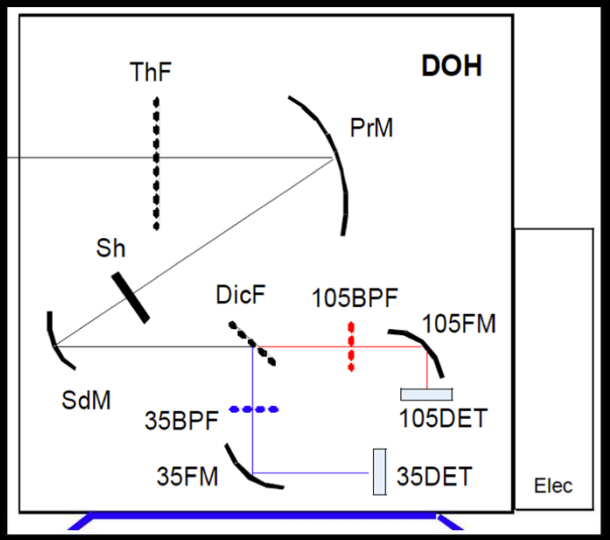
- LEO 600 km altitude, 10-15° inclination
- 3-axis stabilized spacecraft
- Absolute pointing: 60”
- Pointing stability: 2.0”/0.1s
- ≥ 3 year mission lifetime, range of solar activity

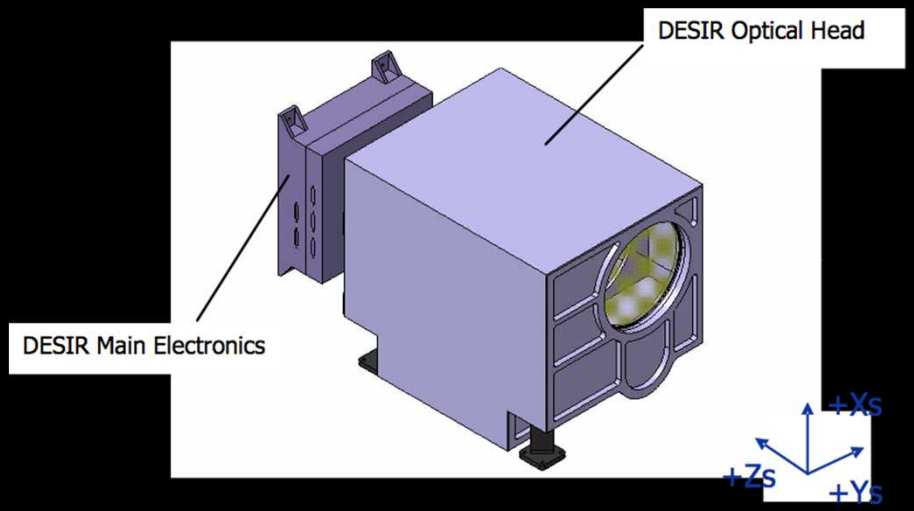
Strawman Payload

- Focussing HXR spectrographic imager: Super-FOXSI
- Hard X-ray and γ- ray imaging spectrometer (indirect imaging): LISSAN (Large Imaging Spectrometer for Solar Accelerated Nuclei)
- FIR radiometer : DESIR (Detection of Eruptive Solar Infrared Radiation)
- Chromospheric and photospheric magnetograph (ChroME)
- SXR Imager: DuPLEX (Dual Passband Low Energy X-ray telescope)

DESIR

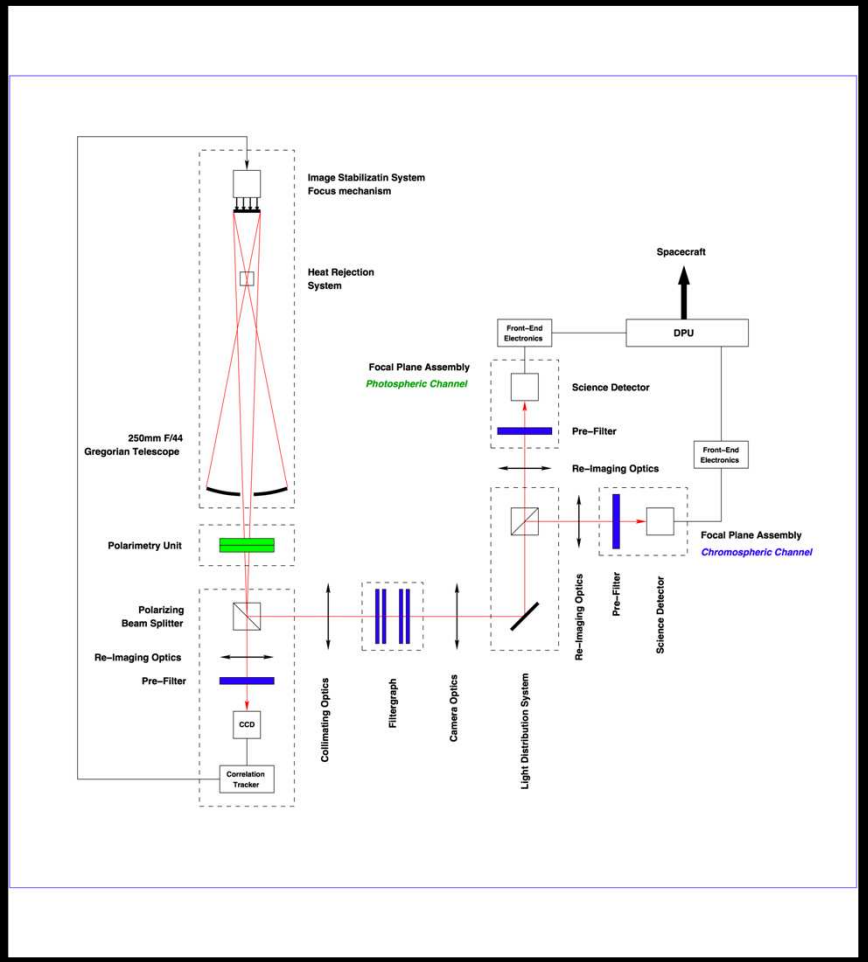
- Full disk observations
- 2 bandwidths: 25 – 45 µm and 80 -130 µm
- Detection goal: 10^{-18} $Wm^{-2}Hz^{-1}$ (10^4 SFU)
- SNR=80 @ 35 µm and 2.5 @ 105 µm
- Builds on SMESE heritage





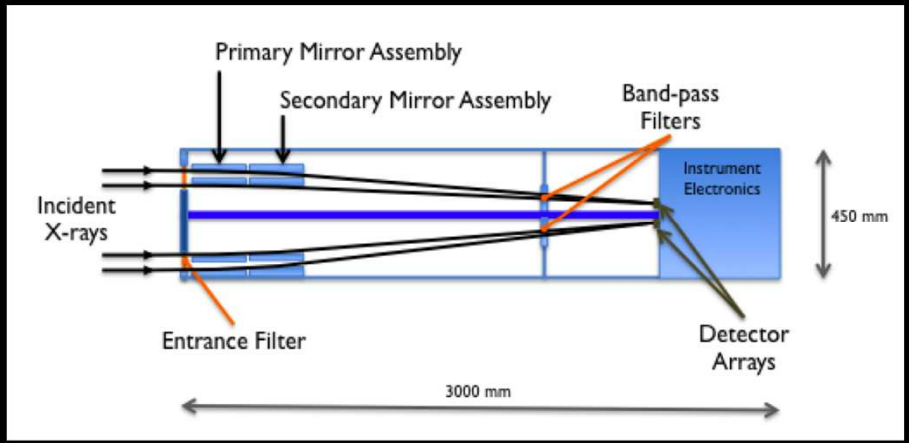
ChroME

- Maps of the chromospheric (0.28”) and photospheric (0.56”) magnetic field
- 300 x 300” FOV
- 30s cadence for 15 λ positions
- WL imaging capability



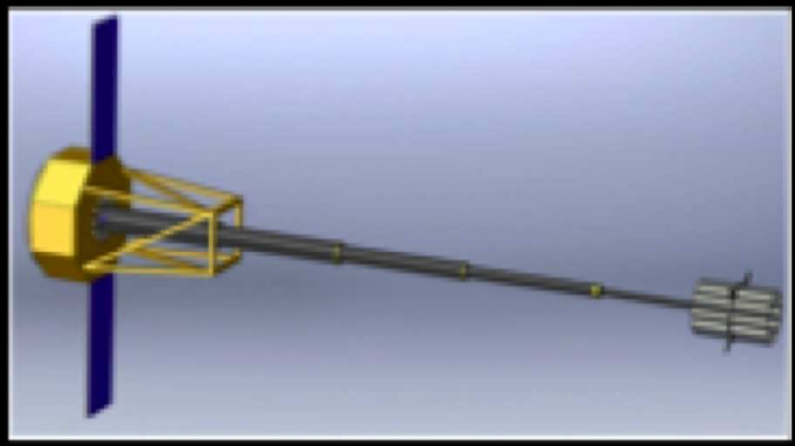
DuPLEX

- Grazing incidence X-ray telescope
- Two wavelength bands: 1 - 3.5 keV and 2.5 -3.5 keV
- On axis resolution 2.5 – 3.0”
- 1s cadence
- Full Sun FOV



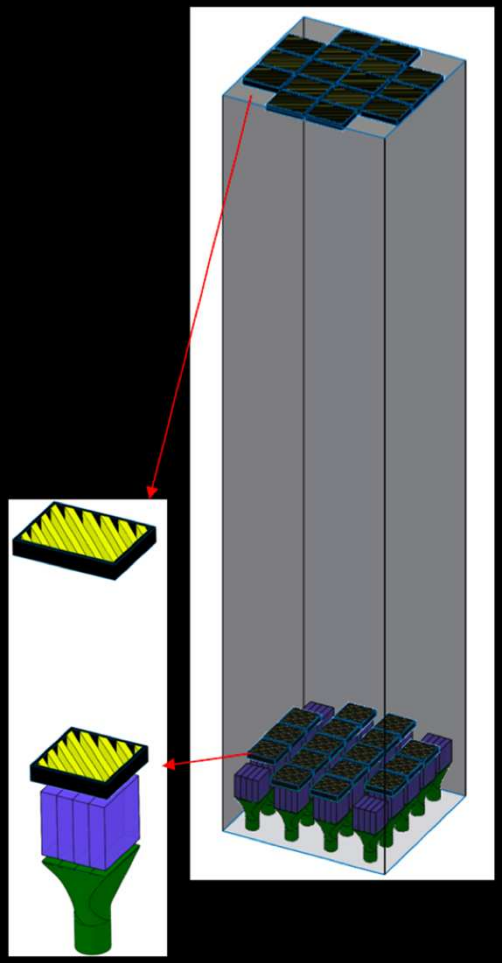
Super-FOXSI

- HXR focussing optics image directly 4 – 60 keV
- ~8” spatial resolution
- 12’ FOV
- 50 – 100 x RHESSI sensitivity @ 40 keV
- See Steven’s talk for more details



LISSAN

- HXR spectroscopy ~5 – 200 keV based on STIX (Gordon's talk)
- γ-ray spectroscopy 150 keV – 150 MeV
- Imaging in 2.2 MeV line for flares ~M3
- Few dozen frames for X-class events.
- 8" FWHM



In summary

- The SPARK concept combines novel technologies to target the extremes of particle acceleration.
- Would be the first space-borne investigation of the FIR in solar flares – discovery potential
- Alas didn’t manage to convince ESA this time round, but…
- Highly complementary to the other ideas just presented, especially SEE 2020 – can we find a way to combine?