University of Leicester

Department of Physics & Astronomy

SIRIUS: Stellar and ISM research via in-orbit (E)UV spectroscopy

M.A. Barstow
(on behalf of a consortium from the EU, NAOC, Peking and Hefei)

Introduction

- Mission opportunity gap
  - From ~€1M to ~€200M
- A scale-able high throughput spectrograph
- Observatory-class science goals from a small mission
- Readiness levels and collaboration opps.
- Conclusions

University of Leicester

Mission opportunity gap

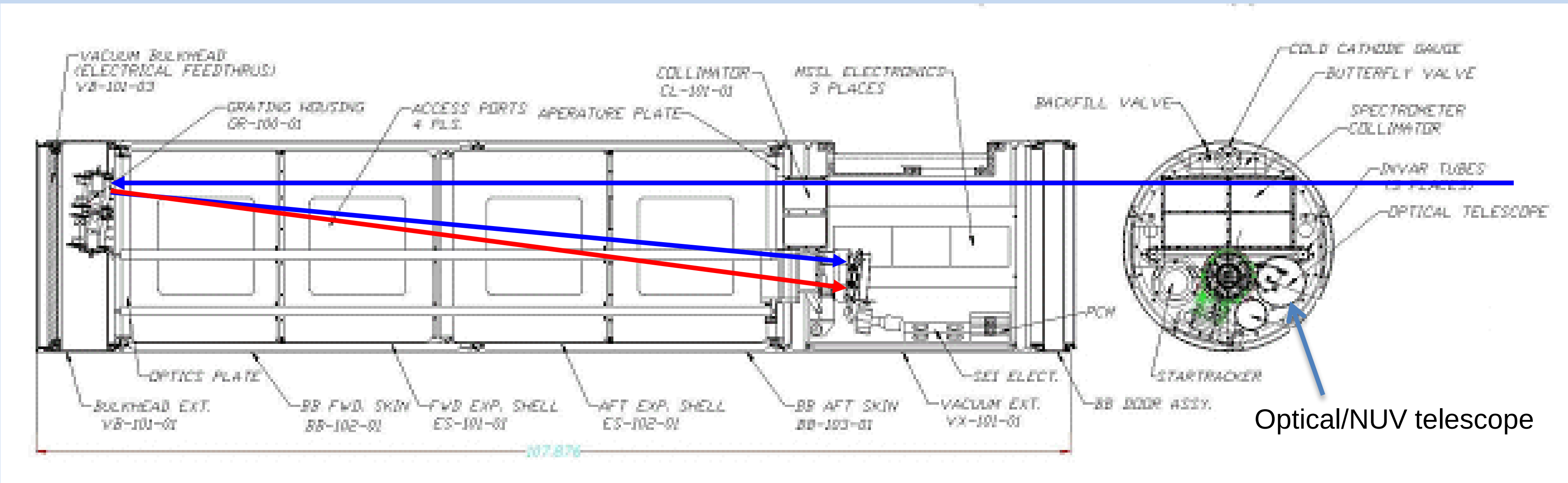
- Sounding rockets (WFSXC, J-PEX)
  - ~5 min… limited S/N, timing etc.
  - ~€2-3M (~€5k/sec; €2M/target)
  - Frequent flights
- Orbital (EXOSAT, ROSAT, EUVE, Hubble, FUSE)
  - 3 to 24 years
  - ~€200-2000M (~€2/sec; €50k/target)
  - Few opportunities
- Need something in between

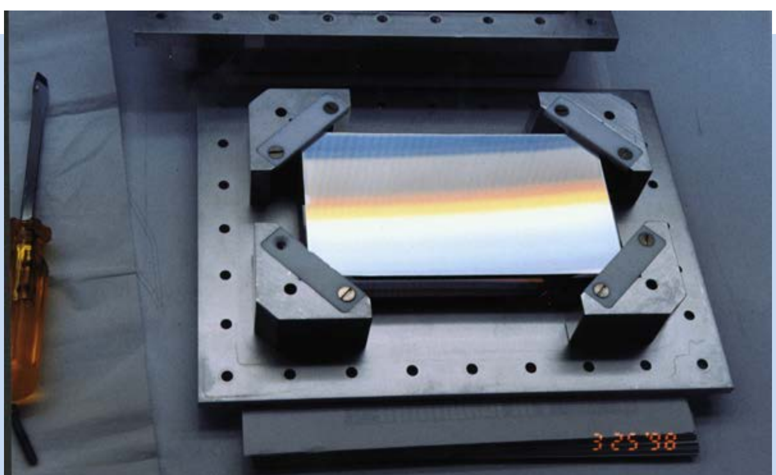
University of Leicester

Filling the gap – small missions

- Focused science goals – something new
- Control over requirement inflation
- Imaginative use of new technology
- But high TRL concepts
- Modular payloads, standard components & subsystems
- Innovative ground-station & mission operations concepts

J-PEX Normal Incidence Spectrometer

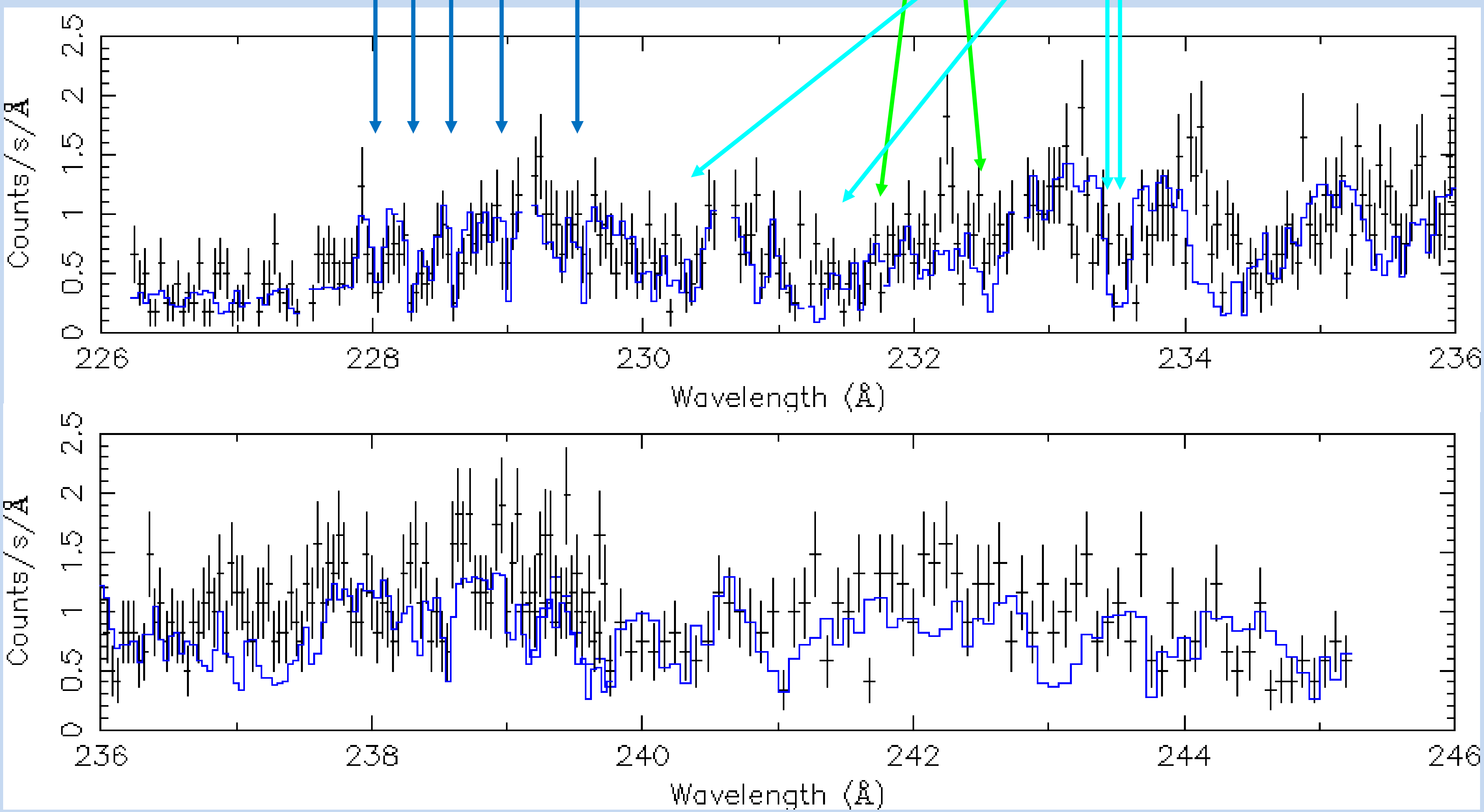




Ion etched, blazed grating.
MoSi multilayers for high reflection
Spherical figure, 2.2m focal length

University of Leicester

300s exposure of G191-B2B

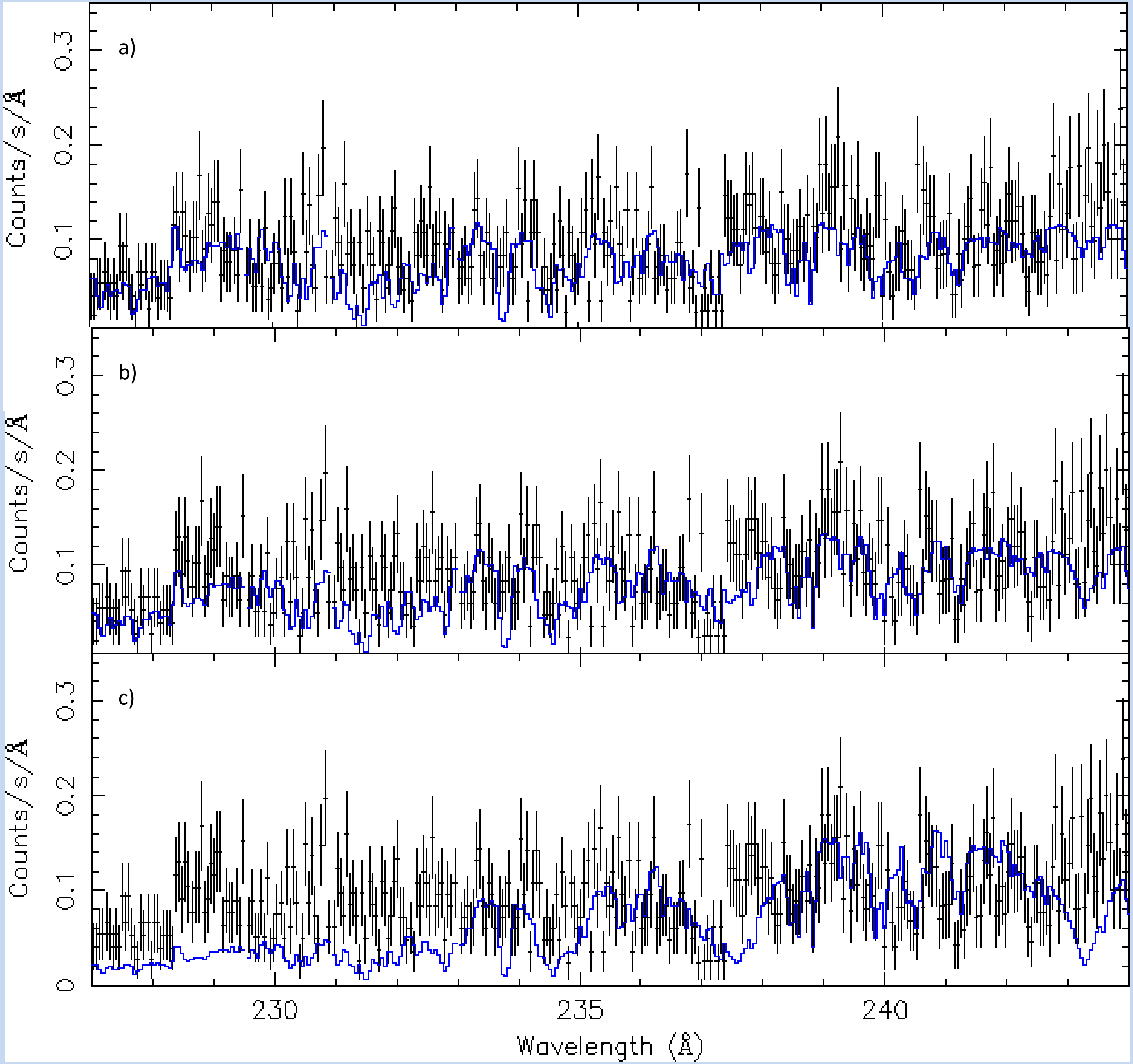


Feige 24; DA+dM

a) H-layer mass = $10^{-12.92}M_{\odot}$

b) H-layer mass = $10^{-13.5}M_{\odot}$

c) H-layer mass = $10^{-14}M_{\odot}$.

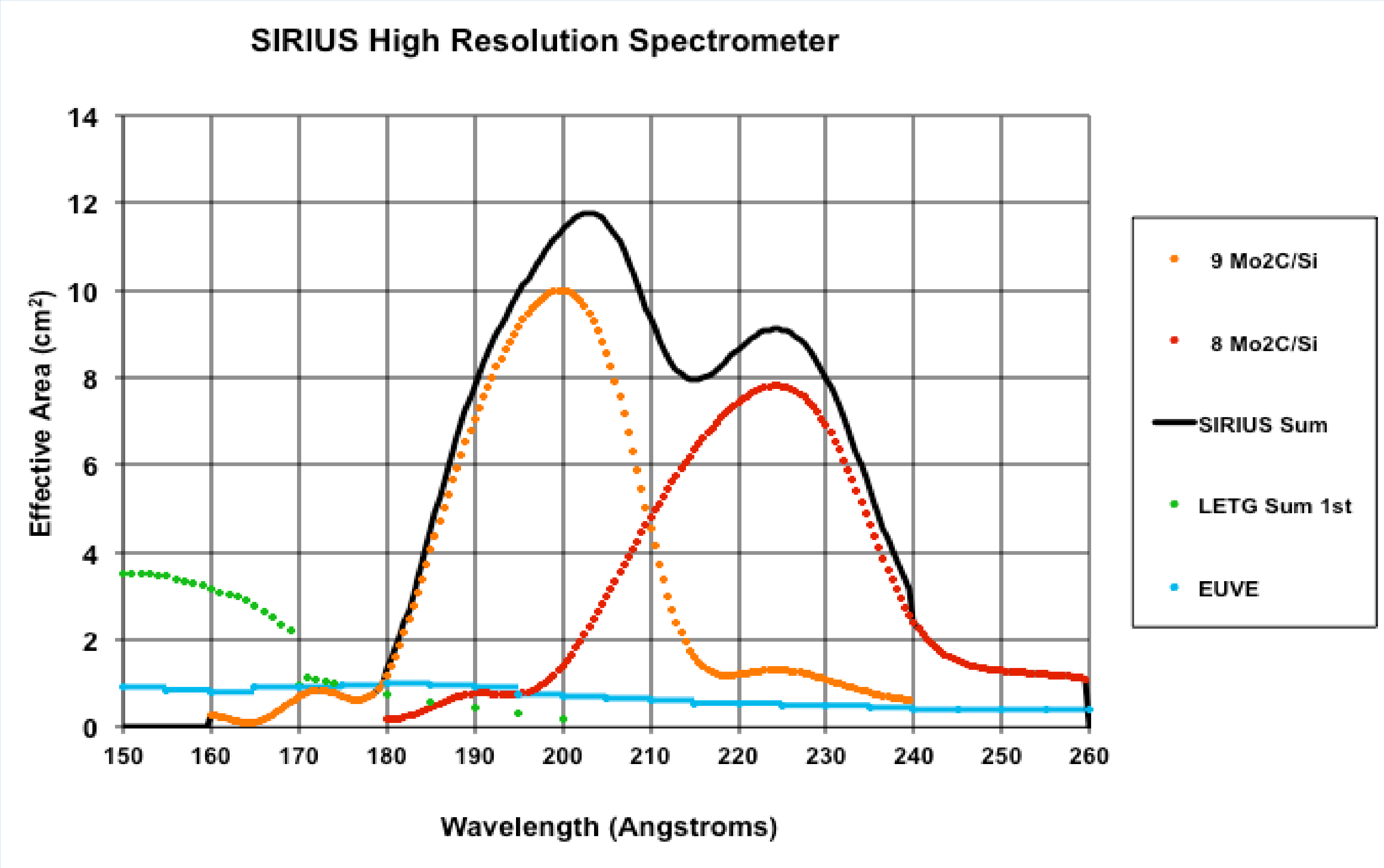


University of Leicester

Evolution into an orbital instrument

- The J-PEX design is scale-able
- Multiple units can be constructed
  - Tuned to different wavebands by multilayer thickness
- Gratings in a single unit can be divided for broader wavelength coverage
  - Recent, shortlisted, ESA S-mission proposal

SIRIUS

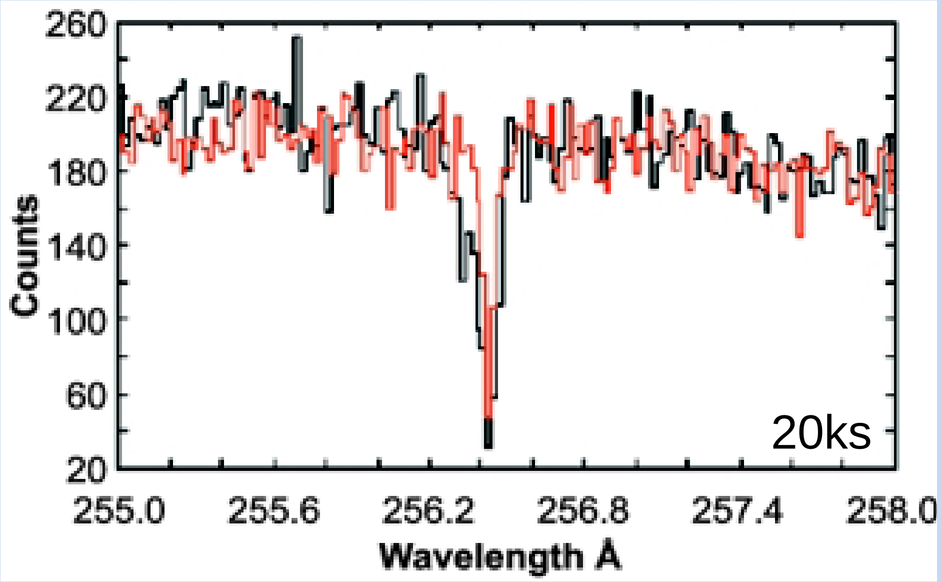


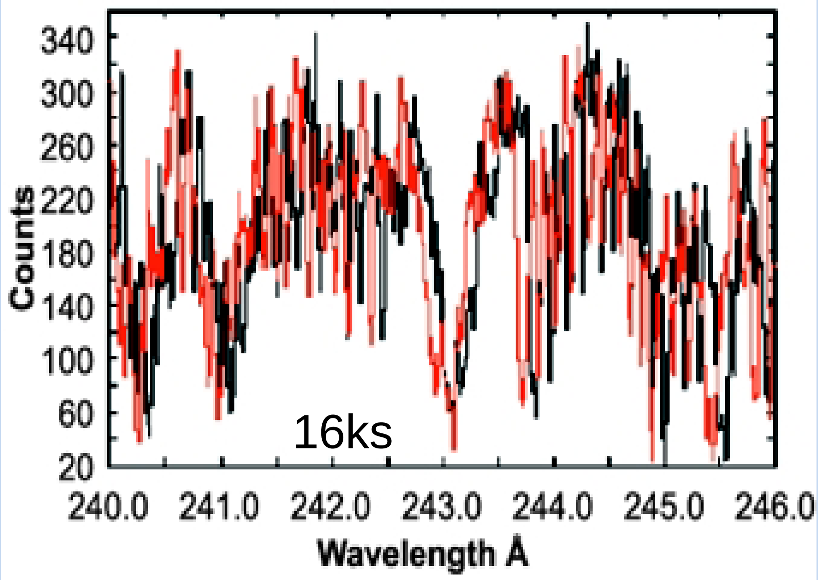
SIRIUS High Resolution Spectrometer
Effective Area (cm²)
14
12
10
8
6
4
2
0
150
160
170
180
190
200
210
220
230
240
250
260
Wavelength (Angstroms)
9 Mo2C/Si
8 Mo2C/Si
SIRIUS Sum
LETG Sum 1st
EUVE

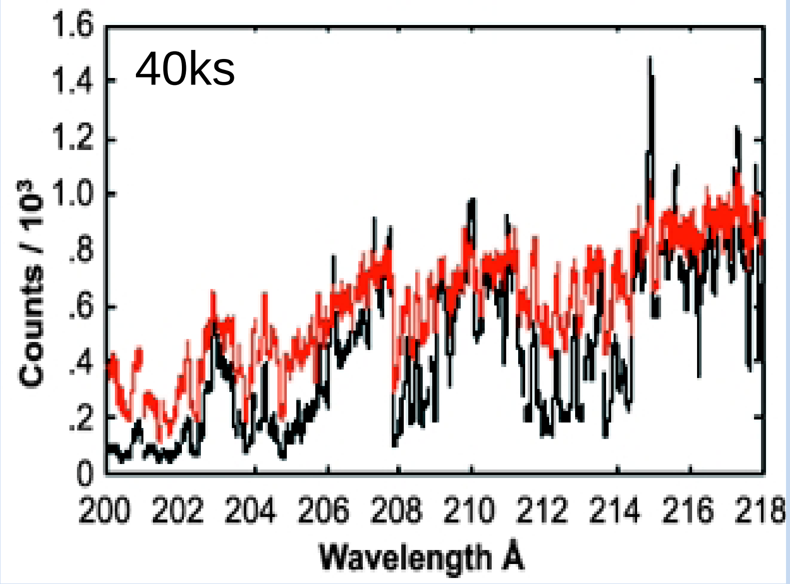
Science – The Galactic Environment

- Structure & Dynamics of Stellar Coronae
  - Coronal Activity – Solar quality data for nearby stars
  - Exoplanet Environments
- Evolution of White Dwarfs
  - Atmospheric composition & structure
  - Extrasolar planetary debris (arXiv – 1402.2164)
- Structure & Ionization of the Local Interstellar Gas
  - Can only be directly measured in the EUV

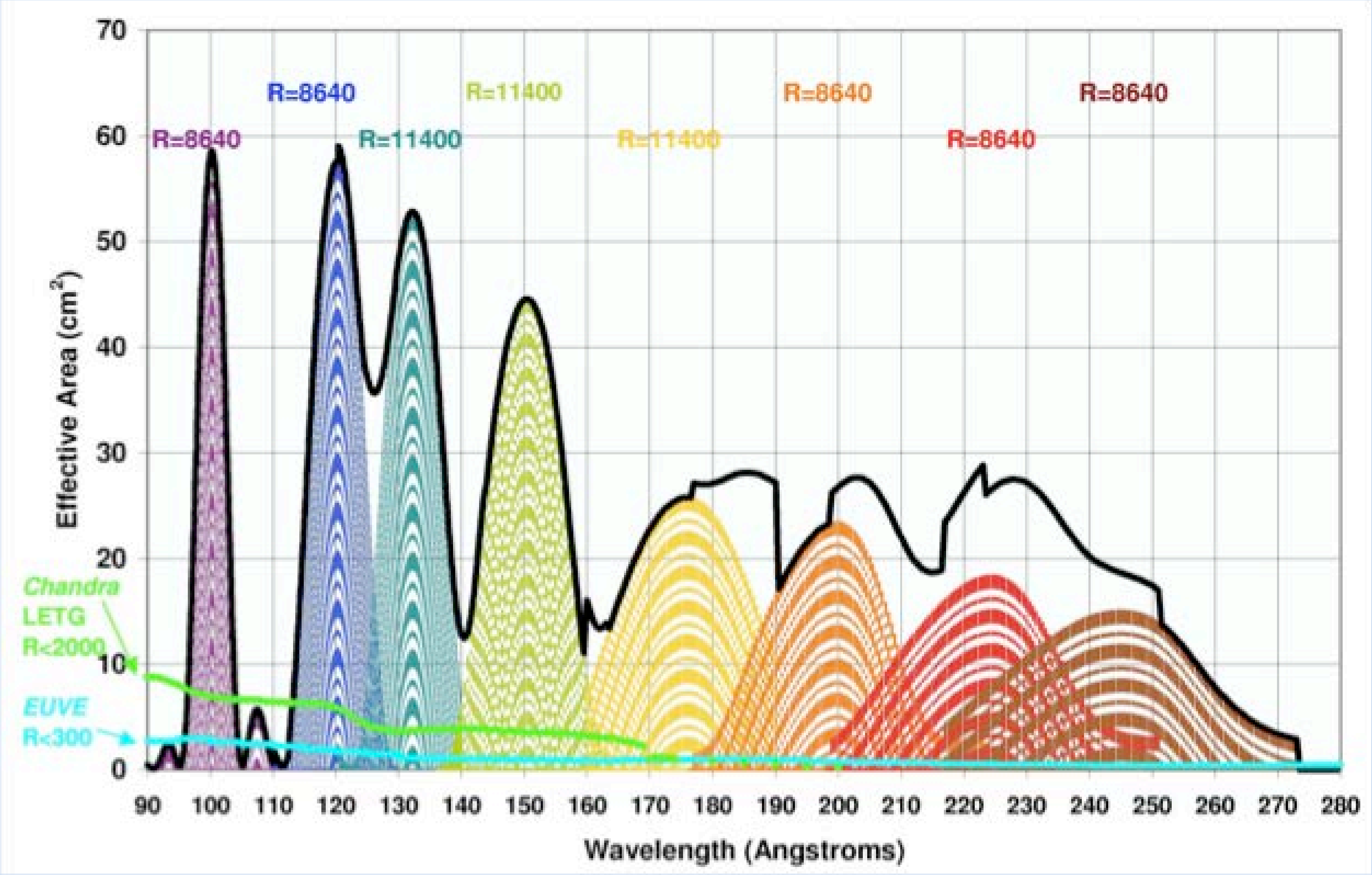
Capability


260
220
180
140
100
60
20
Counts
20ks
255.0
255.6
256.2
256.8
257.4
258.0
Wavelength Å


340
300
260
220
180
140
100
60
20
Counts
16ks
240.0
241.0
242.0
243.0
244.0
245.0
246.0
Wavelength Å

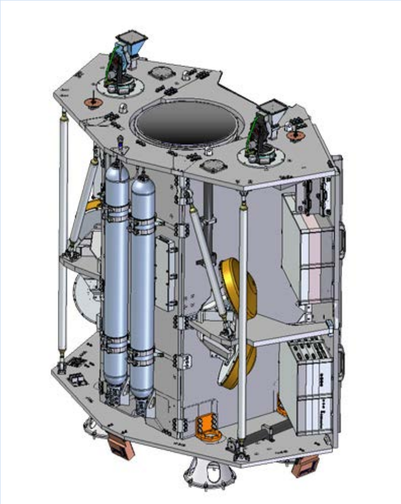

1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
Counts / 10³
40ks
200
202
204
206
208
210
212
214
216
218
Wavelength Å

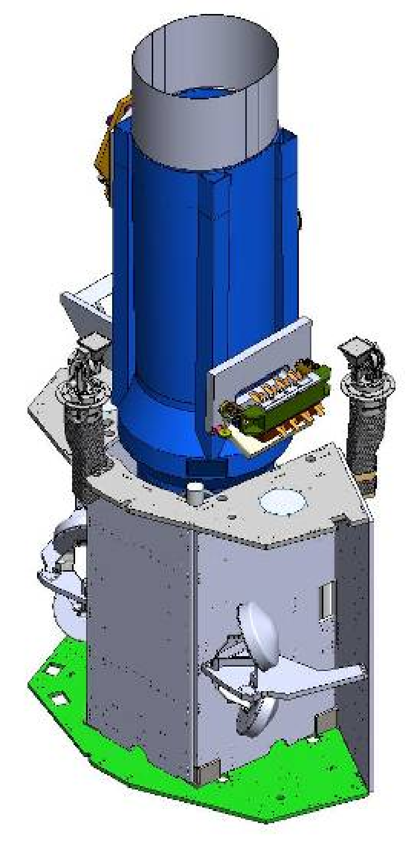
University of Leicester

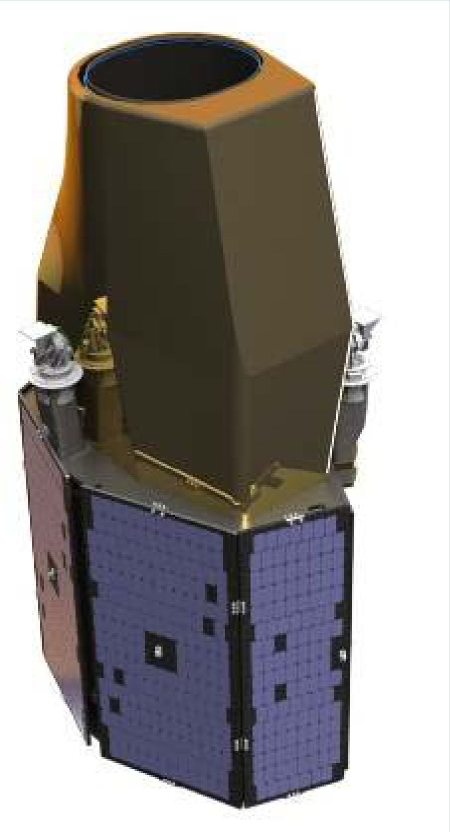


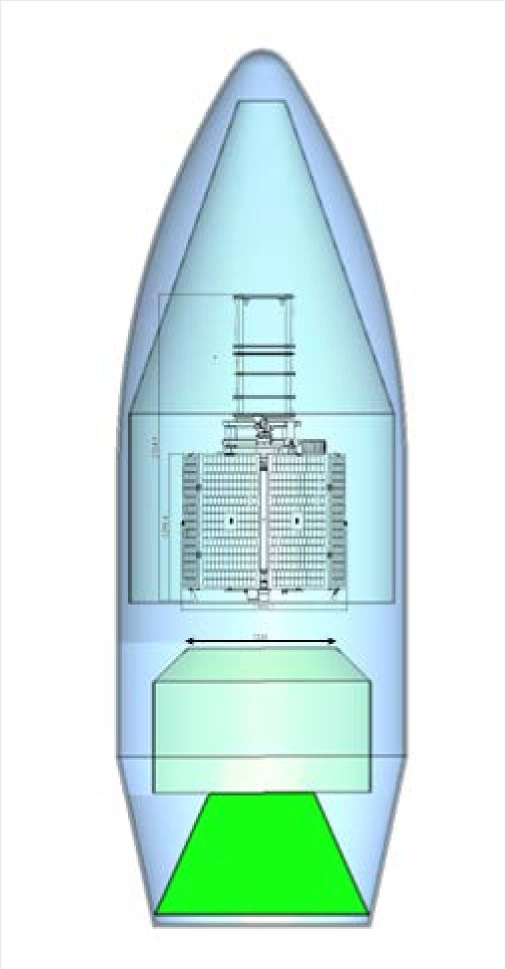
Assembled Satellite

SSTL 300









Vega Launch

University of Leicester

Mission Summary

Category	Requirements
Launch Vehicle	Shared launch on Vega or Long March 2C/2D
Trajectory Design	Science Orbit: LEO, above 300km
Flight System	Design Lifetime: 5 years, nominal mission 3 years Consumables: 5 years Payload: EUV spectrograph + opt/UV monitor Mass:55 kg, Power:13.5 W Observing Mode: 3-axis Platform Pointing Accuracy: 1 arcmin Pointing Stability: 1 arcsec/s Average Science Data Acquisition Rate: 20kb/s
Spacecraft Bus	SSTL-300 or Chinese
Data Return Strategy	Downlink Volume <1.2Gb per day, X-band
Telecommunications	ESA, China or UKSA
Ground Systems	2 contacts per day
Solar Array	1.66 m^2 Emcore BTJM triple junction GaAs cells
Propulsion (for attitude control)	24kg Xe, 32m/s delta-v at an Isp of 48s

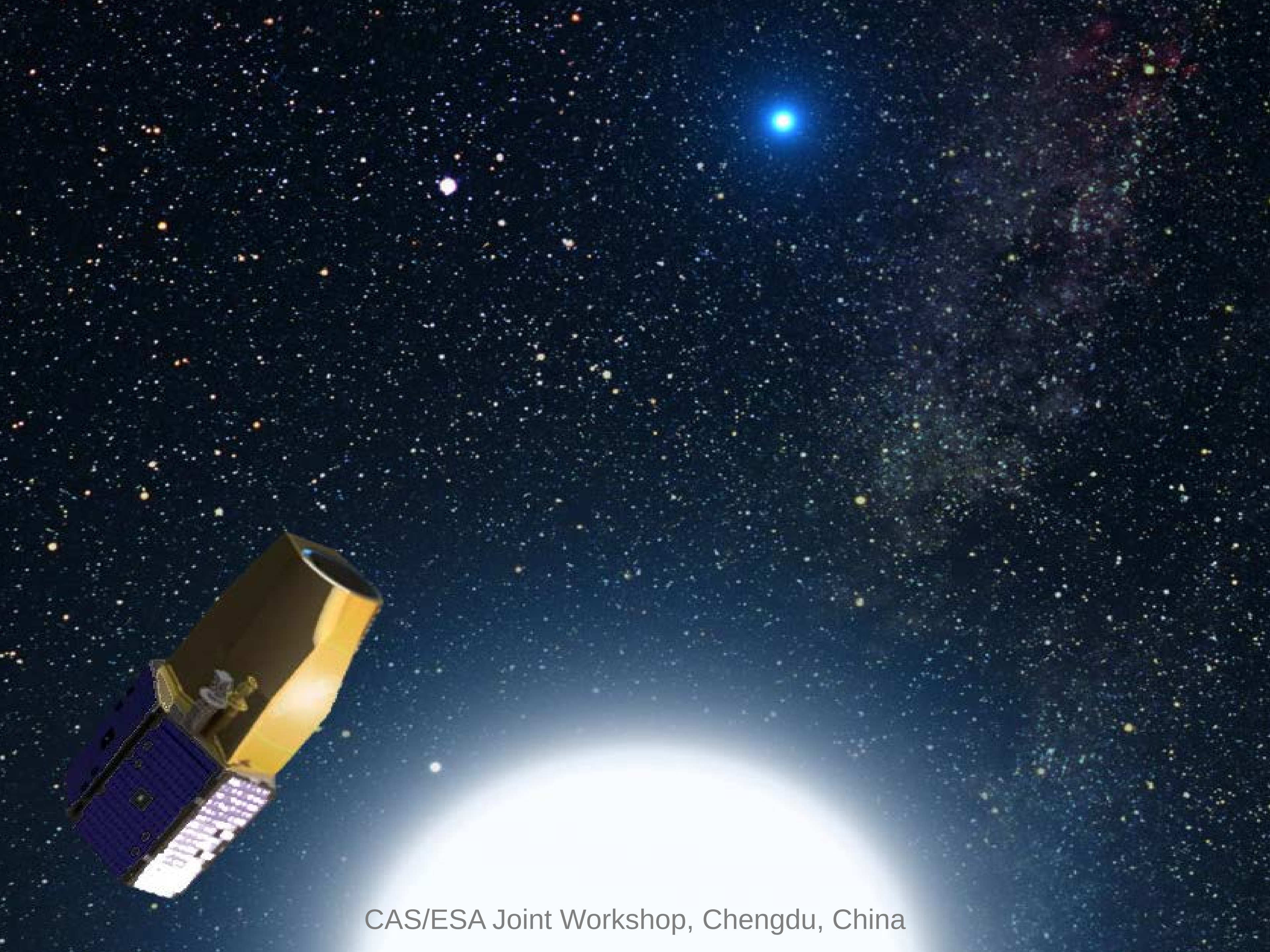
Technology opportunities & readiness

- Opportunities for the EU
  - Gratings (TRL≥7) – Carl Zeiss, Horiba
  - Detectors (TRL≥7) – EU institutes, e2v, Photonis
  - Spacecraft – SSTL, Astrium
  - Launch, ground segment & operations
- Opportunities for China
  - Optical/NUV telescope
  - Structure, collimator, processing electronics
  - Spacecraft – TBD
  - Launch, ground segment & operations

University of Leicester

Conclusion

- New technology & innovative design yield high sensitivity instrumentation
- New, unique science from a unique instrument
- Observatory-class science at low cost
- Study indicates our proposed SIRIUS EUV spectrograph feasible (within the defined parameters) for this joint opportunity
- Happy to discuss potential ways forward with ESA/CAS colleagues


CAS/ESA Joint Workshop, Chengdu, China