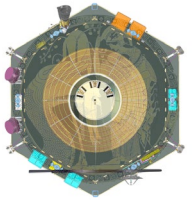


AEGIS

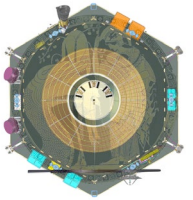
An Astrophysical Experiment for Grating & Imaging Spectroscopy

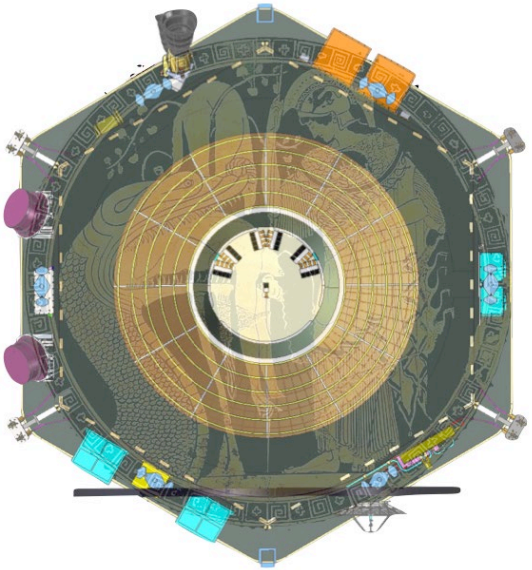
Mark Bautz

MIT Kavli Institute for Astrophysics & Space Research

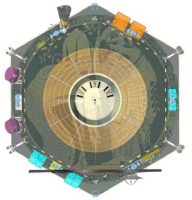
For the AEGIS Team

Aegis Collaborators





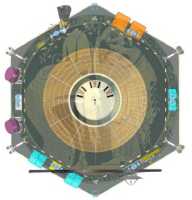
G. E. Allen	J. Bookbinder	D. Bower	J. Bregman	N. Brickhouse
D. N. Burrows	C. R. Canizares	S. Casement	D. Chakrabarty	K.-W. Chan
B. Costello	J. E. Davis	D. Dewey	J. J. Drake	M. S. Elvis
D. Evans	A. Falcone	K. Flanagan	R. K. Heilmann	J. C. Houck
D. P. Huenemoerder	S. Jordan	A. Klavins	J. C. Lee	J. Lempke
C. Lillie	M. Loewenstein	H. L. Marshall	S. Mathur	R. S. McClelland
J. M. Miller	R. Mushotzky	T. Nguyen	F. Nicastro	M. A. Nowak
S. L. O'Dell	F. Paerels	R. Petre	A. Ptak	T. T. Saha
M. L. Schattenburg	N. Schulz	R. K. Smith	D. Tenerelli	R. Vanbezooijen
G. Vasudevan	D. Wang	S. Wolk	W. W. Zhang	



Overview

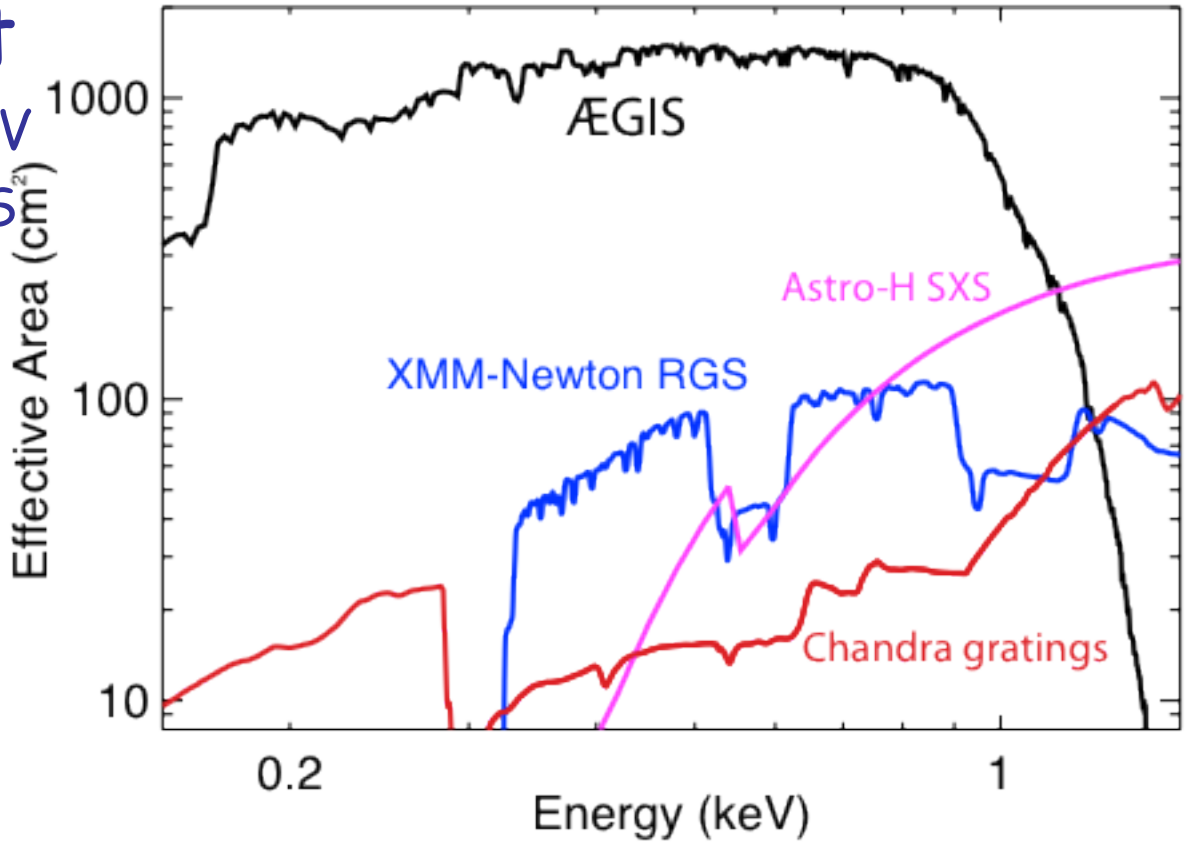
- AEGIS Overview
- RFI Questions Addressed by AEGIS
- Broader Aegis Science
- AEGIS Instruments
- AEGIS Mission

AEGIS Overview

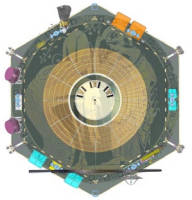


A dedicated soft X-ray grating spectroscopy mission with:

- High throughput
  - ★ A_{eff} ~1400 cm^2,0.5 keV
  - ★ ~100x Chandra HETGS
  - ★ ~2x Chandra ACIS !



AEGIS Overview



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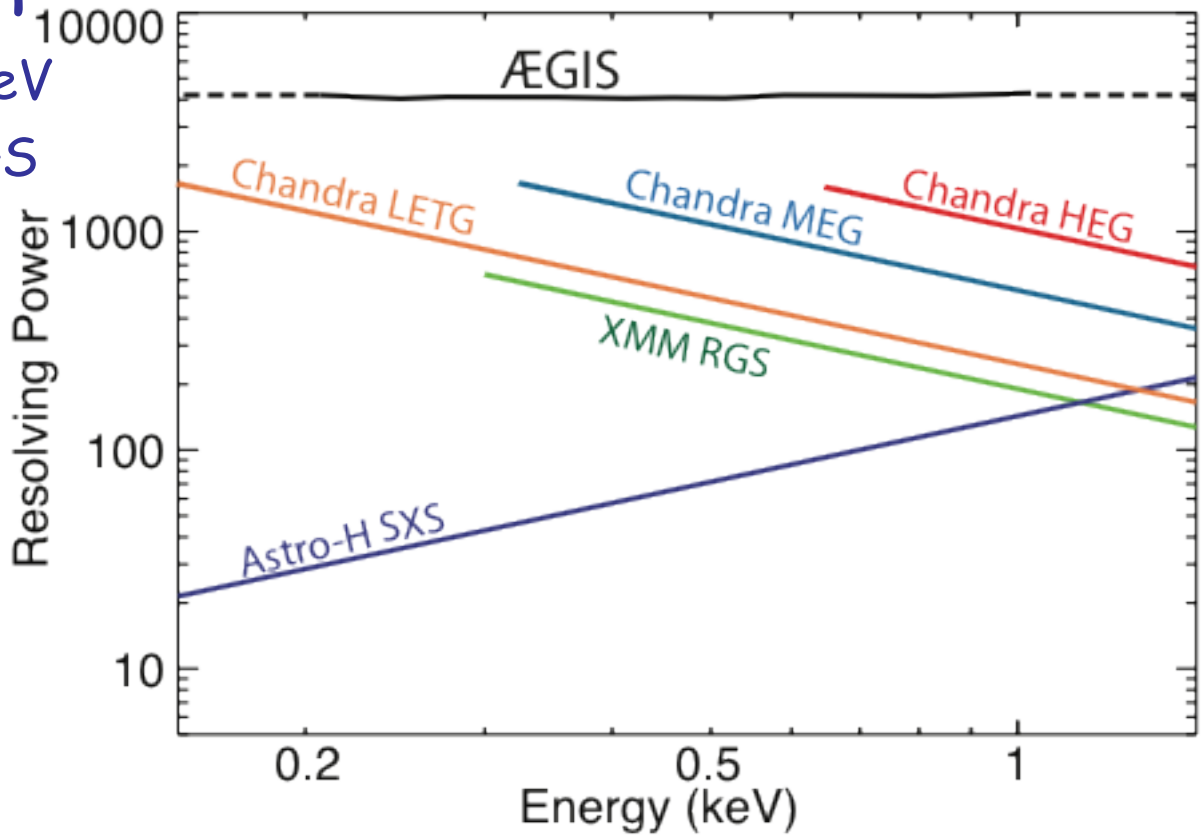
  - ★ R = $\lambda/\Delta\lambda$ > 3000
  - ★ >~30x calorimeter at 0.5 keV



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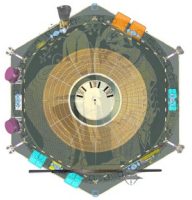

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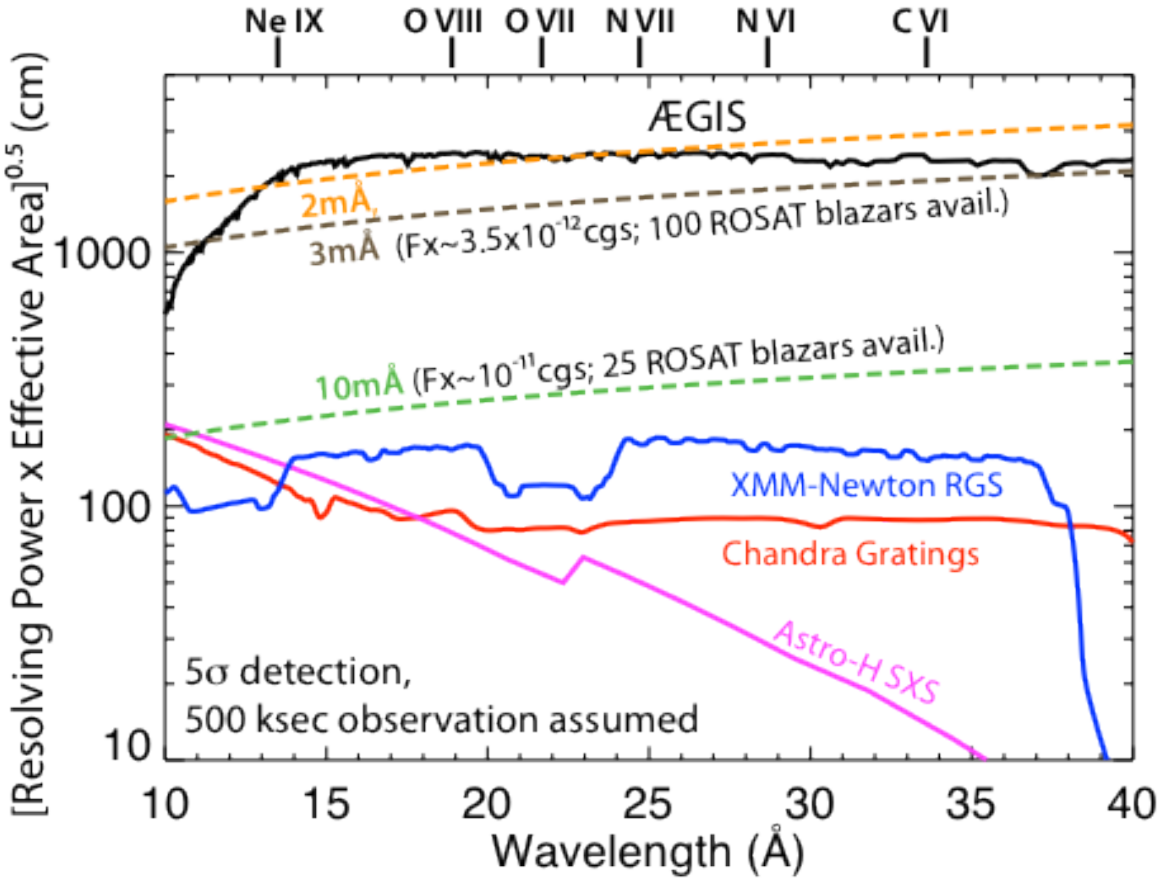
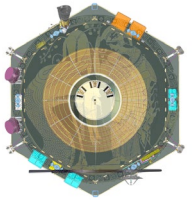
- **High resolution**
  - ★ R = λ/Δλ > 3000
  - ★ >~30x calorimeter at 0.5 keV
- **Moderate Cost**
  - ★ RFI Medium (~$760M)

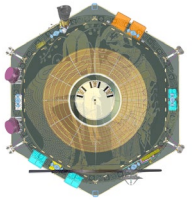




Aegis Science Overview

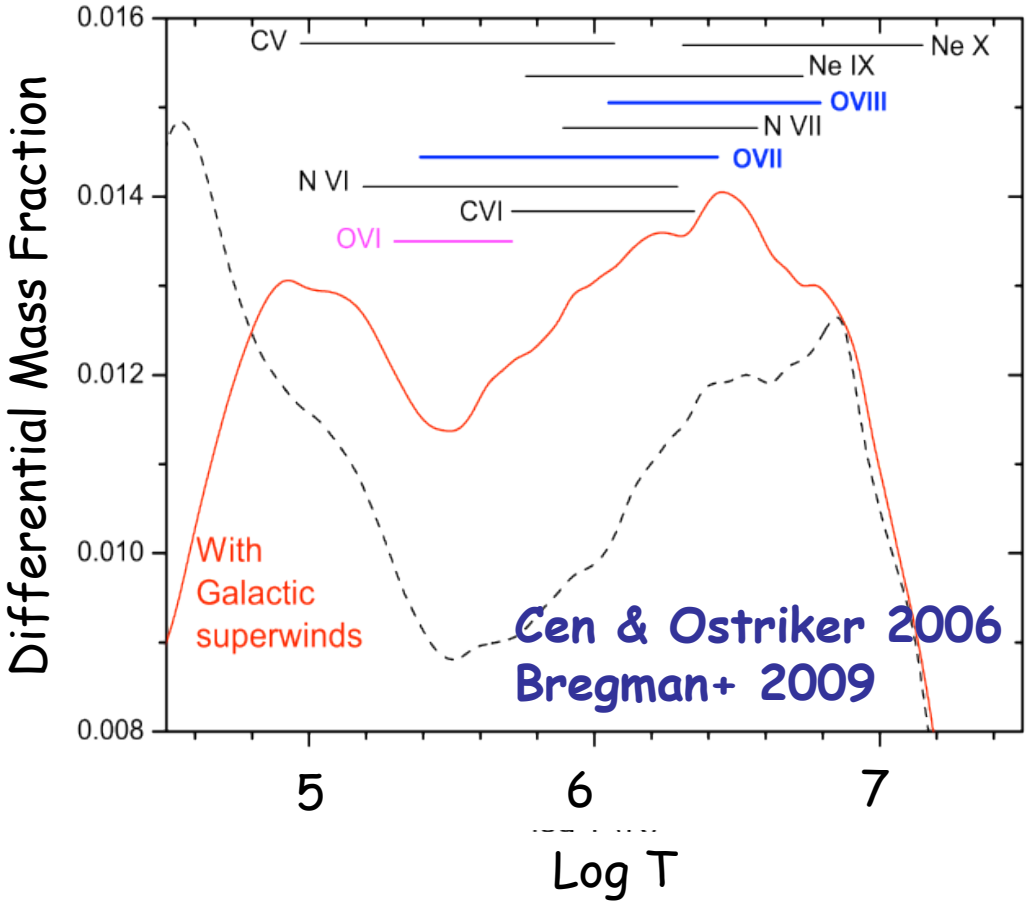
- Aegis outperforms the IXO grating (XGS)
- Aegis addresses 3 RFI questions:
  * How does large scale structure evolve?
  * What is the connection between SMBH formation and evolution of LSS (cosmic feedback)?
  * How does matter behave at very high density?
- Aegis addresses a broad range of other science highly-ranked by Astro2010

How does large-scale structure evolve?



Aegis approach:

- Detect & characterize the warm-hot IGM (WHIM) via absorption spectroscopy



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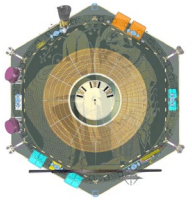
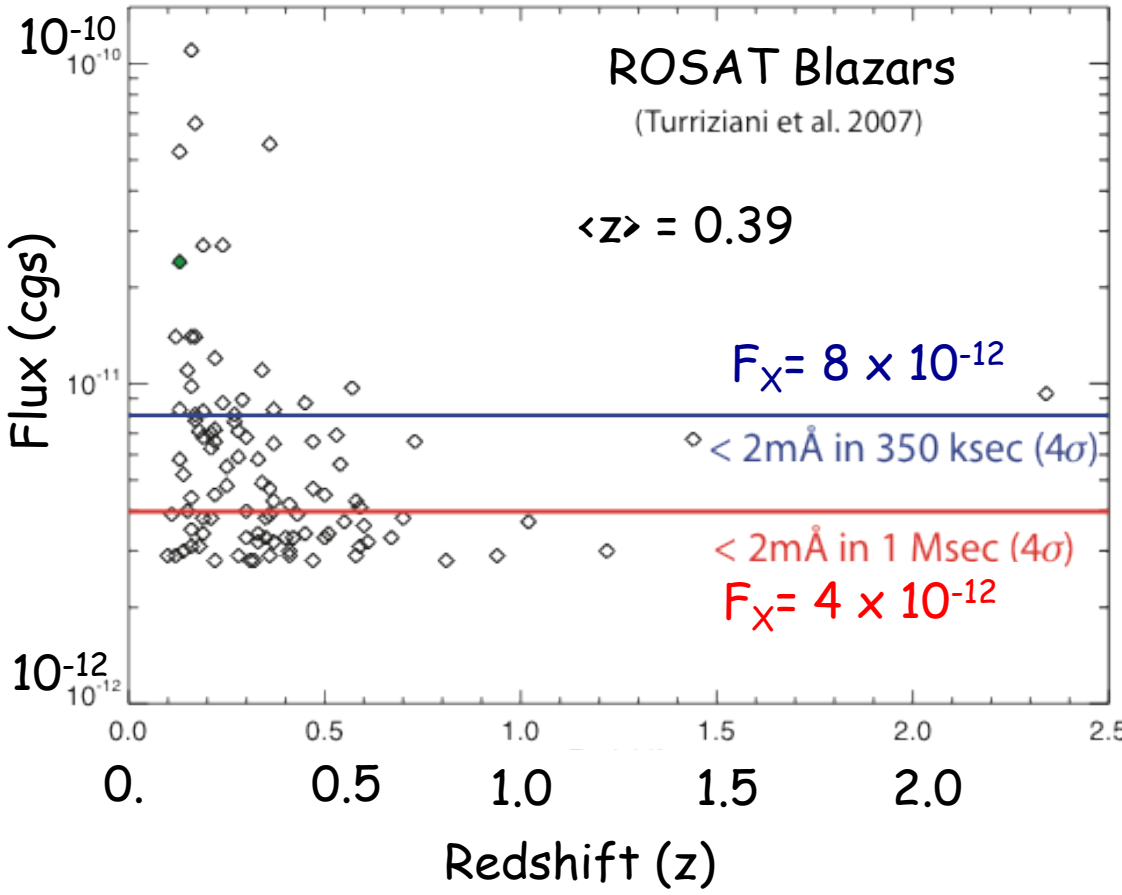


Aegis approach:

- Detect & characterize the warm-hot IGM (WHIM) via absorption spectroscopy
- Select from ~100 blazars with $F_x > 4 \times 10^{-12}$ erg s^{-1} cm^2 & $z > 0.1$ for backlights



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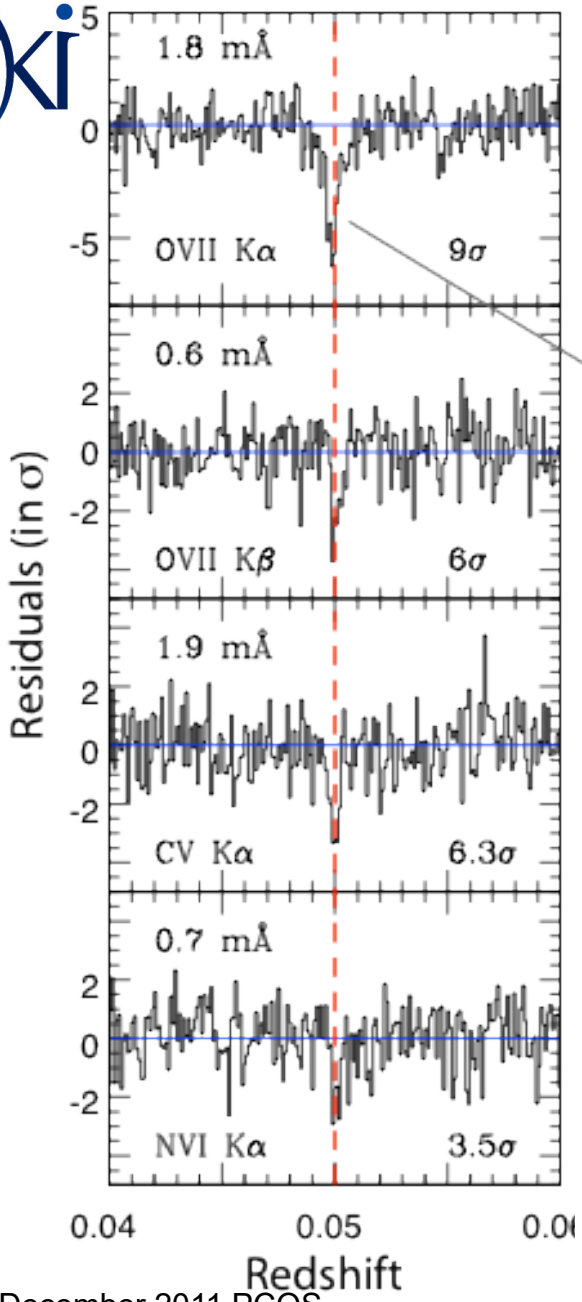
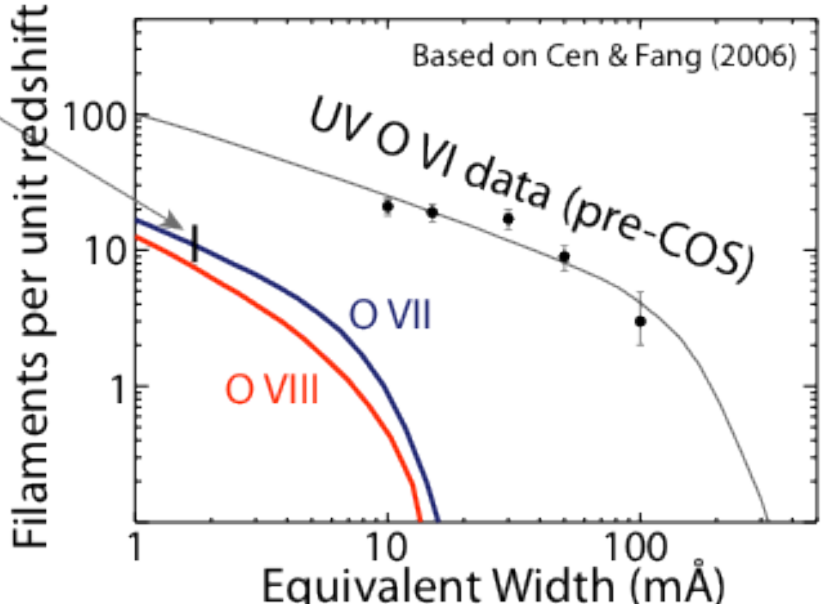




Key Goals:

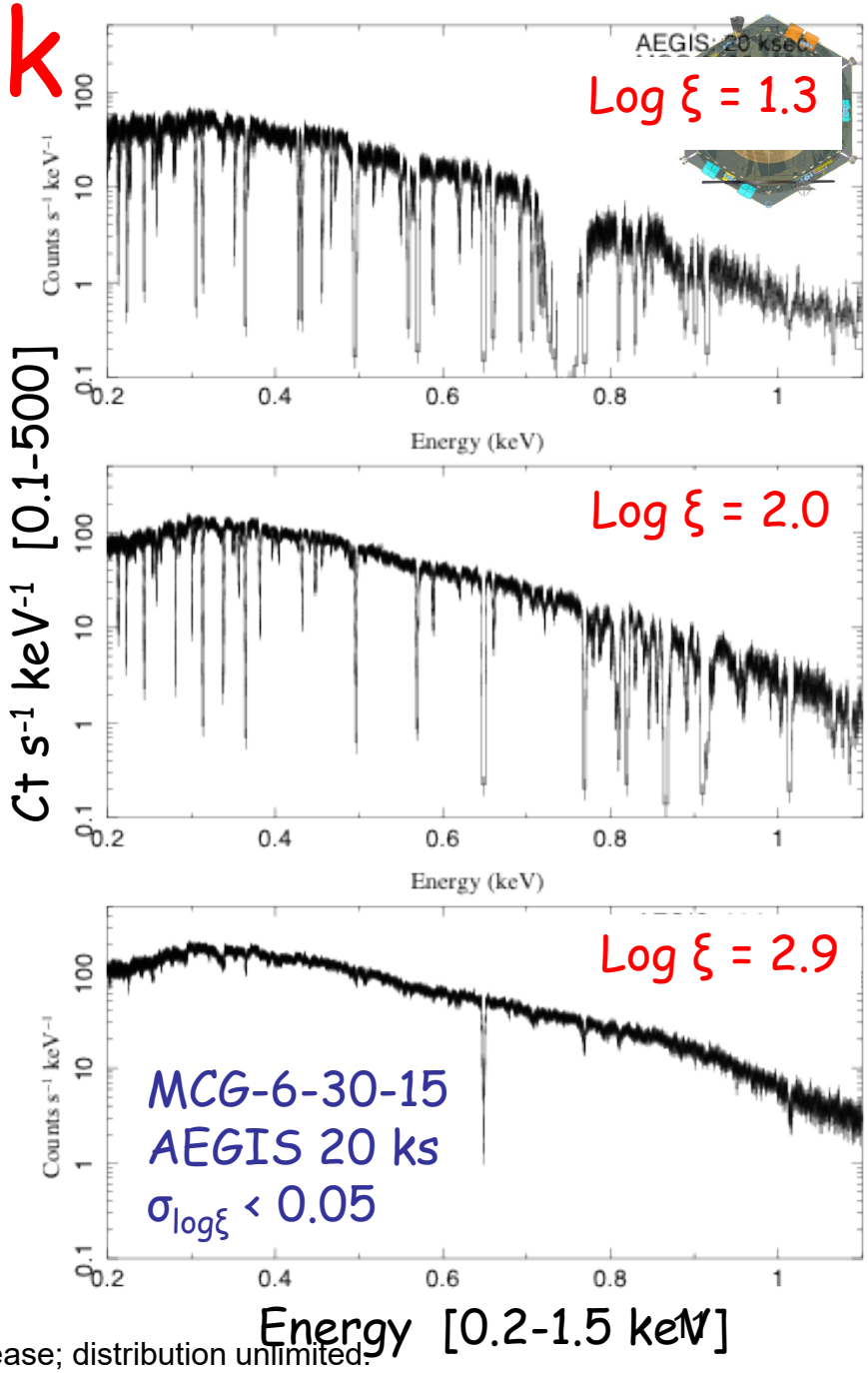
- Test structure formation via census; expect ~100 systems in 20 Ms program
- Look for signs of superwind feedback
- Constrain turbulence in filaments
- Compare to OVI, probe ion. mechanism

Cosmic Feedback

What is the connection between SMBH formation & evolution of large-scale structure?

Aegis approach 1:

- Measure outflows of mass & energy from AGN→ constrain impact on galaxies & environs
- Infer AGN wind density & velocity from ionization changes on short (~5 ks) timescales (t_{eq}→ n)
- Large A_{eff} probes shorter timescales→closer to SMBH

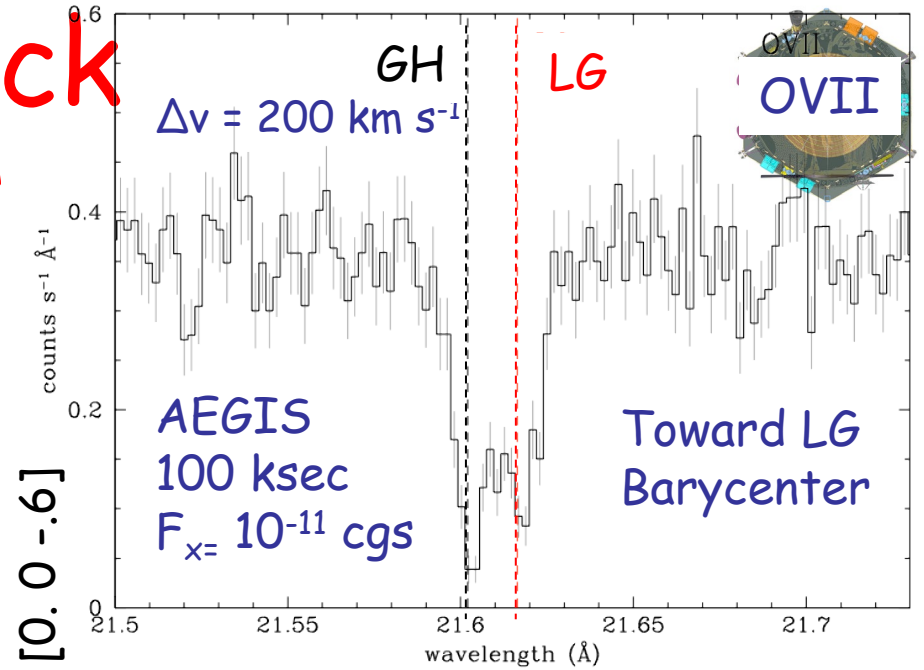


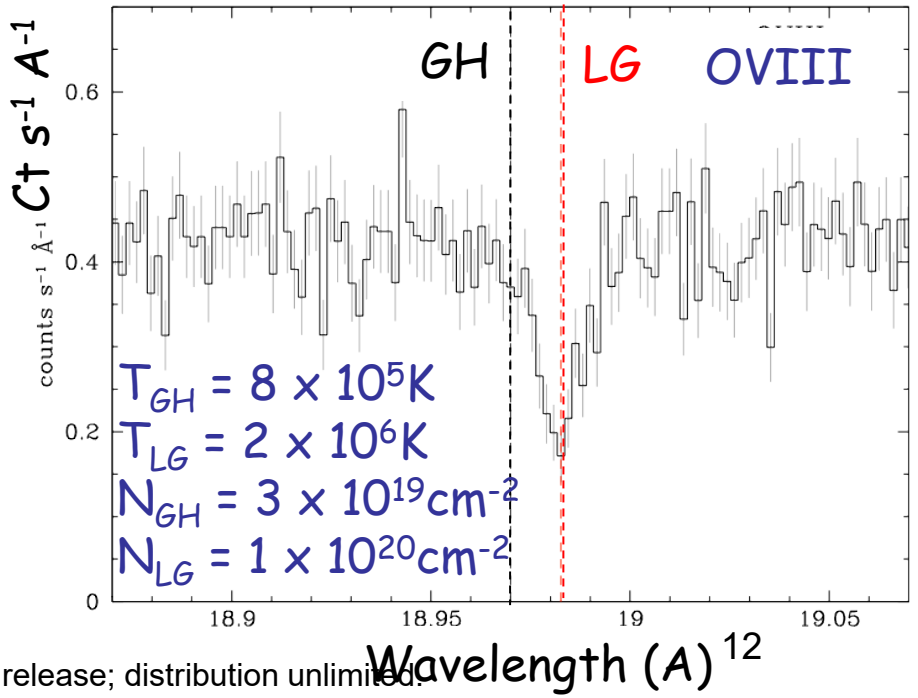
Cosmic Feedback

What is the connection between SMBH formation & evolution of large-scale structure?

Aegis approach 2:

- Search Milky Way halo & local group (LG) to trace 'missing' Galactic baryons
- Use absorption lines from halo, LG in spectra of background AGN
- Velocities distinguish halo and LG components
- >200 sightlines observable in 10 Ms (many 'for free')





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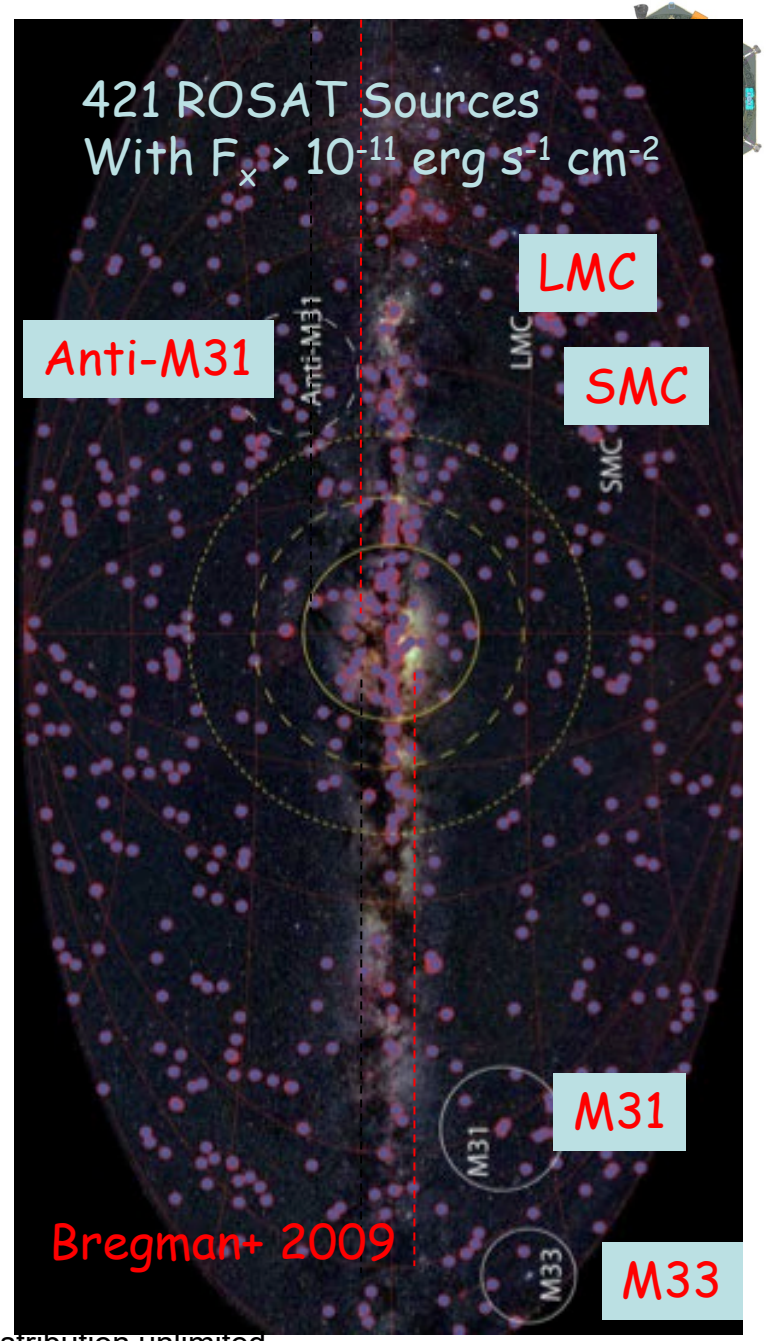
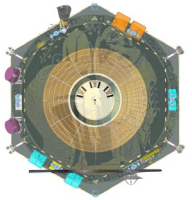


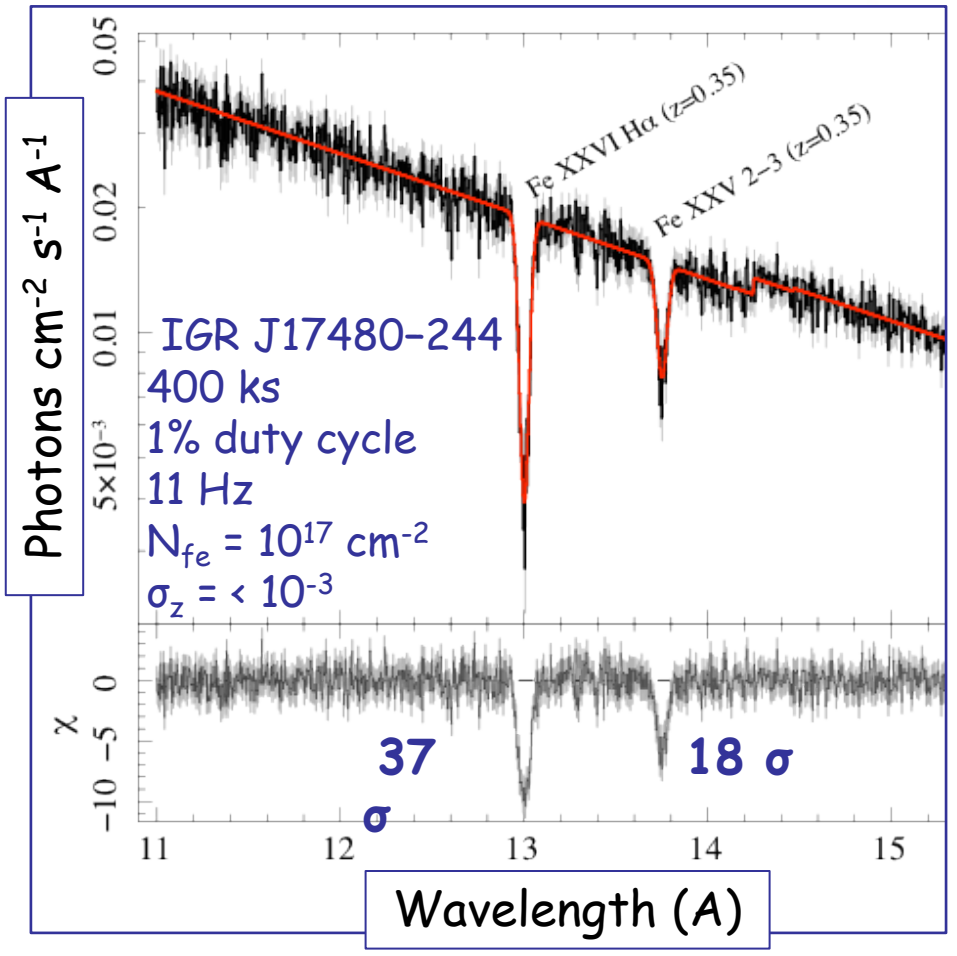
Matter at High Density



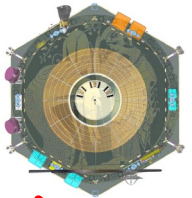
How does matter behave at very high density?

Aegis approach:

- Measure neutron star M/R, M/R^2 from burst spectra
- Photospheric Fexxv & Fexxvi Balmer features could yield gravitational z (M/R) if $N_{Fe} \sim 10^{17}$ cm^{-2}
- Stark-broadening, e.g. of OVIII, could yield M/R^2
- Sample of 10 observable in < 5% of Aegis mission time



- NB: Aegis's count-rate capability >~100x Chandra @ 24 A

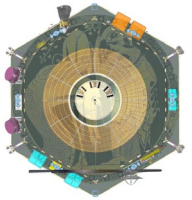


Broader Aegis Science Program

Aegis brings high-resolution X-ray spectroscopy to bear on many other astrophysical questions:

- Kinematics & composition of gas & dust in the ISM
- Accretion kinematics in young stars & proto-planetary disks
- Physics of stellar coronae
- Accretion, jets & winds in X-ray binary systems
- Nature & physics of neutron star atmospheres
- Distribution of metals in the Milky Way & other galaxies
- Flows of matter, energy around AGN from pc to kpc scales
- Cooling, heating & kinematics in galaxy cluster cores

Aegis Instruments

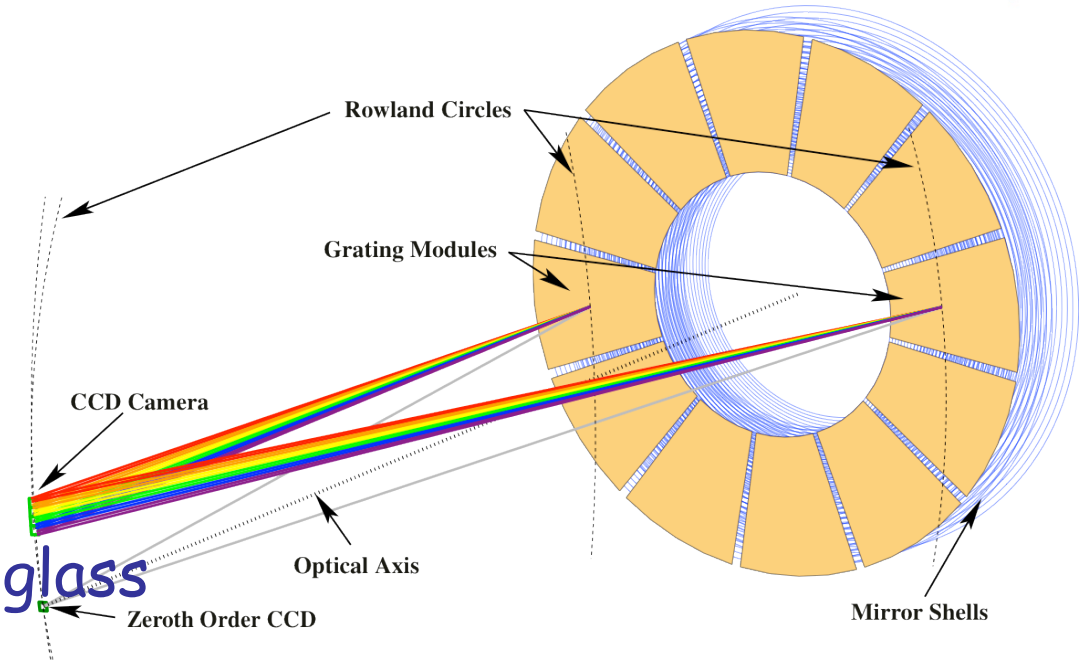


Six spectrometers

* Each uses 2 x 30 deg mirror sub-apertures

Lightweight mirror

* 10" HPD, F=4.4m
* Segmented, slumped glass



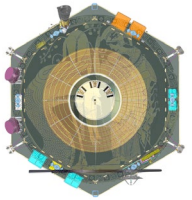
CAT Gratings

* Blazed transmission gratings
* Low-mass, relaxed alignment tolerances

CCD Focal plane

* High QE, fast readout
* Six readout arrays

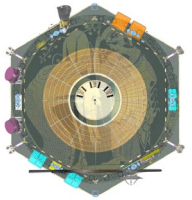
Aegis Technology



- Aegis technology development supported by NASA ARA, SAT
- Expect readiness for Aegis new start by mid-decade

Component	Current TRL	Development Status & Plans
Mirror	4	*Single mirror-pairs meets LSF requirement *Expect TRL 5 by end of CY2012 *See Zhang talk, this workshop
CAT Grating	3	*Period, aspect ratio meet requirements *High-efficiency supports now in development *Expect TRL 4 end of CY2012 *See Heilmann talk, this workshop
Detectors	5	*BI Suzaku CCDs meet all req'ts but readout speed *Non-Xray CCDs show required speed *Integral OBF now in development *High-performance APS a promising future option

Aegis Technology



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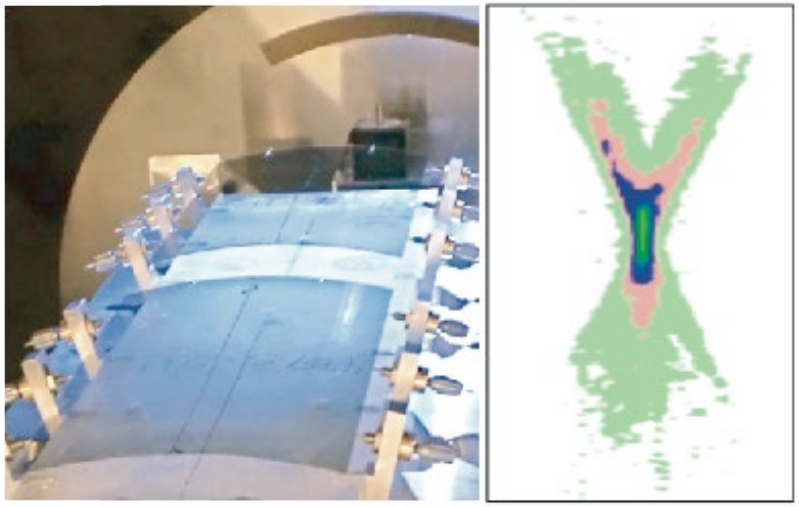
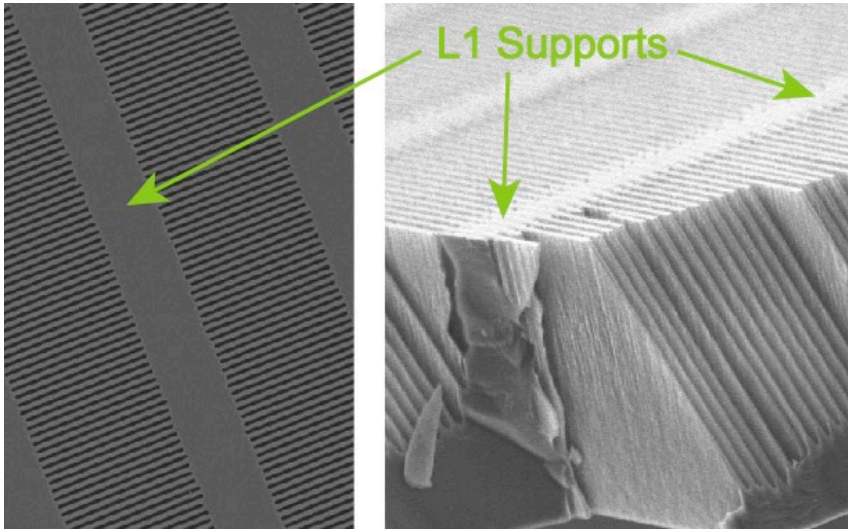
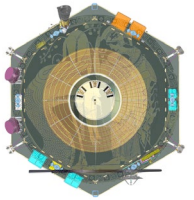


- Single mirror-pairs surpass 3" LSF



- CAT gratings have required period (200nm) and aspect ratio (150:1)
- High-throughput, hierarchical support structures demonstrated



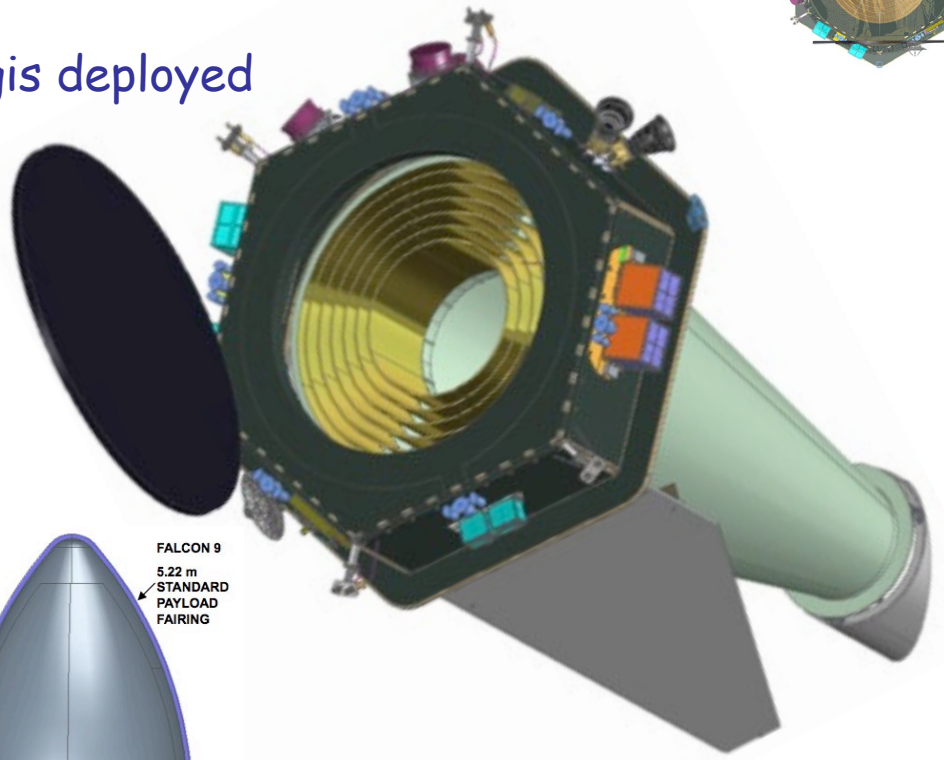
Aegis Mission

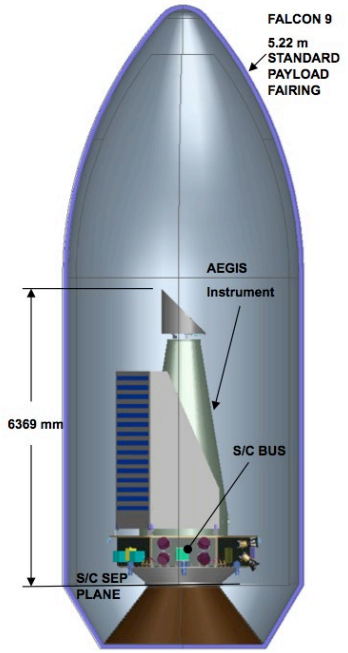
- Moderate size (1090 kg), conventional spacecraft, Falcon-9 launcher
- L2 orbit provides >70 (115) Msec of on-source observing time in 3 (5) year mission *(3.5x-6x IXO grating program)*
- Open competition for all observing time
- Costing assumes efficient Swift operations model, includes robust science and GO support

Aegis Mission Characteristics

Parameter	Value	Units	Remarks
Payload[1]			
Mass	325	kg	
Power	250	W	
Telemetry	128/1280	kbps	avg./peak
Spacecraft[1]			
Mass	385	kg	
Power	320	W	
Pointing control	30	arcsec	max. deviation (200 ks)
	1	arcsec s^{-1}	max. drift rate
Pointing knowledge	1.3	arcsec	3σ per axis
Observatory[2]			
Mass	1090	kg	at launch
Power			
Total	740	W	
Capability	1330	W	EOL
Margin	590	W	44% EOL
Telemetry	208	kpbs	average
Recorder	24	Gbyte	12.7 days
Mission			
Launcher			
Vehicle	Falcon-9		std. fairing
Capability	2010	kg	to L2
Margin	920	kg	46%
Orbit	L2		Sun-Earth
Duration			
Prime	3	yr	
Goal	5	yr	
Comm.	1	day^{-1}	DSN

Aegis deployed

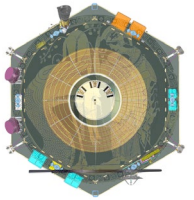




Aegis in Falcon-9 Standard Fairing

Ball Aerospace graphics

Summary



- High-resolution grating spectroscopy is indispensable in addressing NWNH science
- Aegis can provide, at moderate cost, high-resolution grating spectroscopy with:
  * 30-100x better performance than we have now
  * Higher performance than IXO XGS
  * 3x-6x more grating observing time cf IXO XGS
- A NASA mission with grating spectroscopy is essential:

No other space agency in the world will do it.