UV/Optical Astronomy

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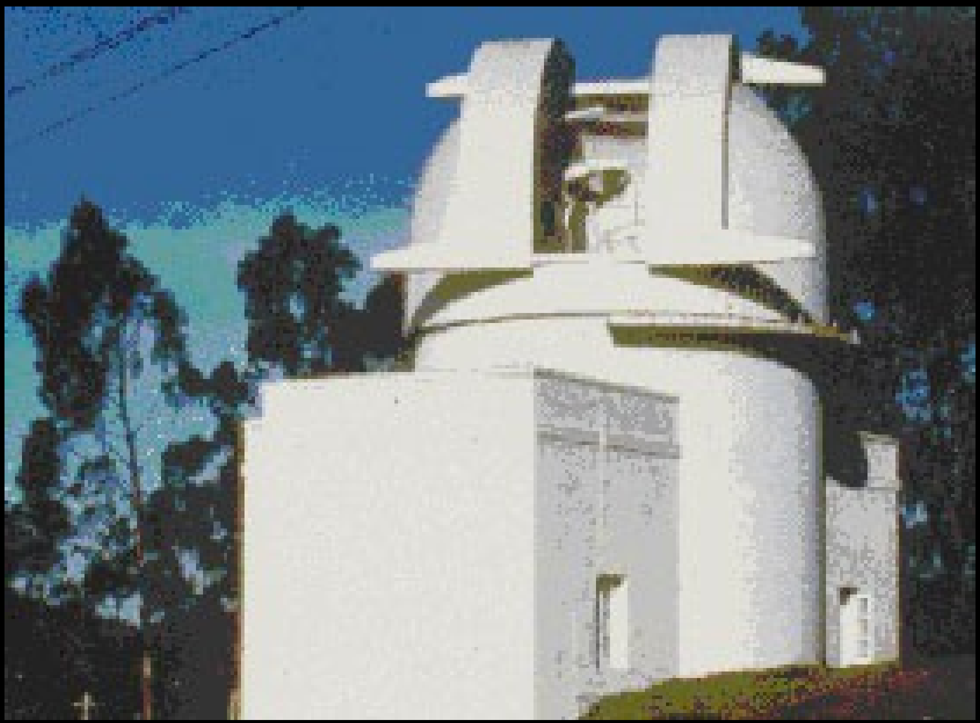
Solar Astronomy



Kodaikanal

Gauribidanur

Optical Telescopes

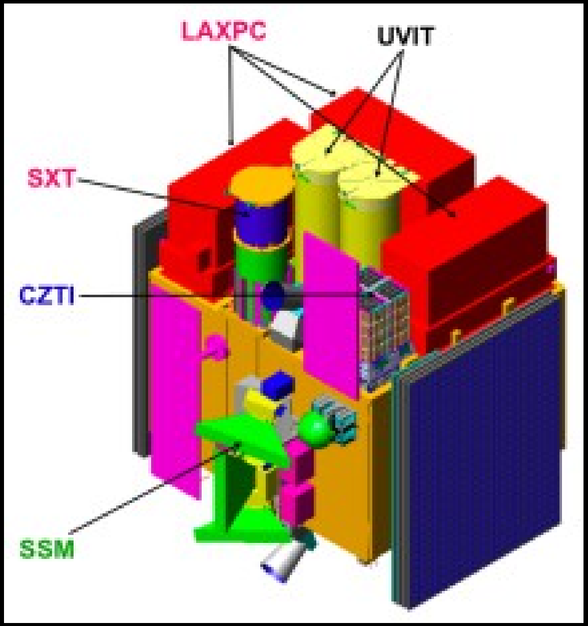
VBO, Kavalur

IAO, Hanle

Space Astronomy

TAUVEX

ASTROSAT



What is UV/Optical Astronomy?

- EUV: < 91 nm.
- FUV: 91 – 120 nm (FUSE)
- NUV: 120 – 300 nm (GALEX)
- Visible: 300 – 1000 nm
- Problems defined by technology.

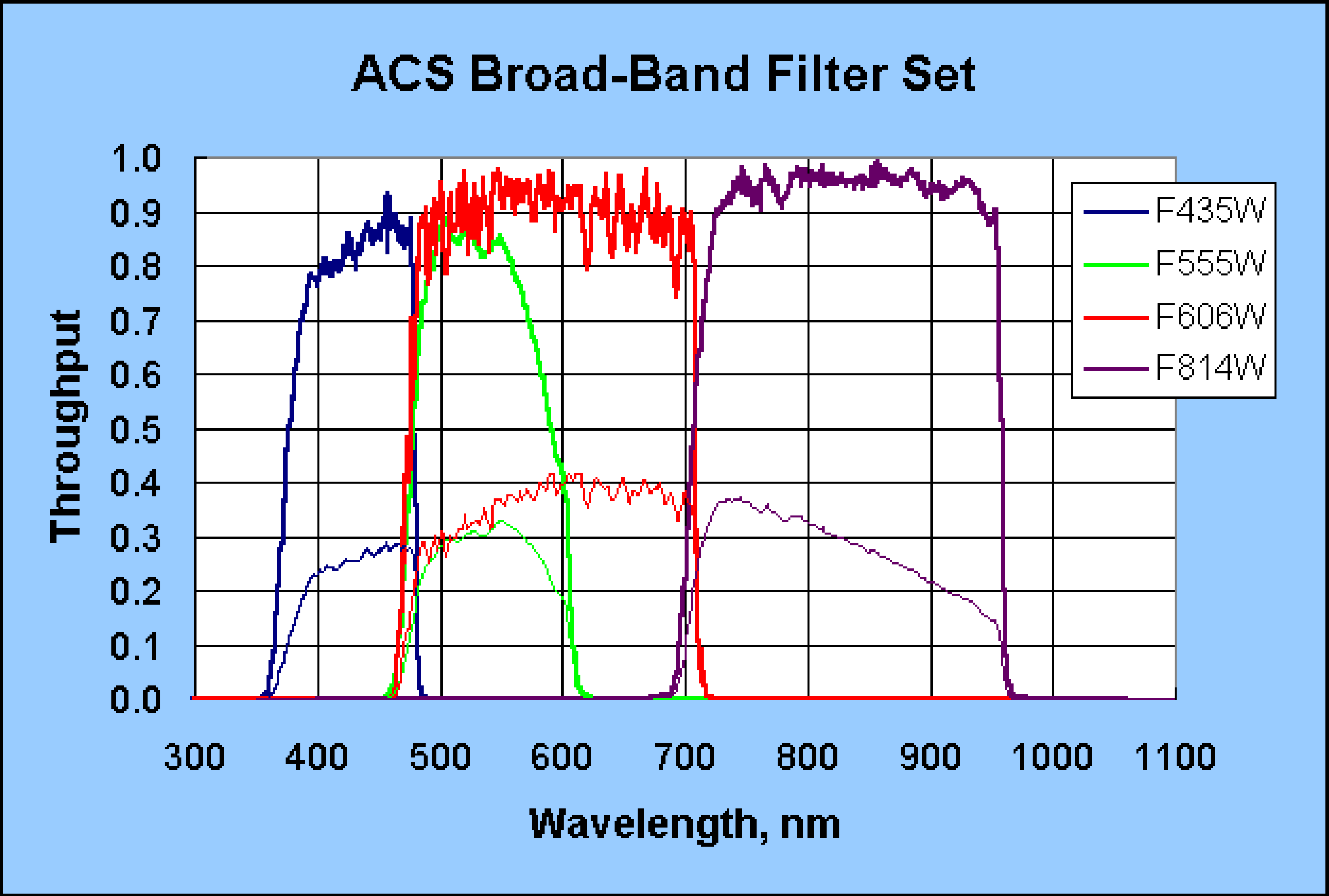
Technology

- Normal incidence optics.
  - Reflection and transmission optics.
- Detectors are generally CCDs or photon counting devices.
- Materials are different in different bandpasses.

Optics

- Wavelengths > 320 nm.
  - Use reflecting or transmission optics.
  - Mirrors made of glass with aluminium coating.
    - possibly with a MgF_2 overcoating.
  - Range of transmission filters.
  - Handling less critical.

ACS Filters



ACS Broad-Band Filter Set
Throughput
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
300
400
500
600
700
800
900
1000
1100
Wavelength, nm
F435W
F555W
F606W
F814W

Optical Optics

- Wavelengths > 320 nm.
  - Use reflecting or transmission optics.
  - Mirrors made of glass with aluminium coating.
    - possibly with a MgF_2 overcoating.
  - Range of transmission filters.
  - Handling less critical. Can be done in air.

NUV/FUV Optics

- 120 – 320 nm.
  - Aluminium oxidizes so require MgF_2 overcoating.
  - Materials become opaque.
  - Minimize transmission optics.
  - Cleanliness important.
  - Hydrocarbons polymerize under UV light.
- <120 nm
  - No transmitting optics.

Detectors

- Photon counting detectors in the UV.
  - Detect and record every photon.
  - Photons are high energy and arrive in small numbers.
  - Statistics are Poissonian ($\sigma = \sqrt{N}$).
  - S/N increases with $\sqrt{t}$.
  - http://www.physics.rutgers.edu/~cjoseph/spierev.pdf
- Integrating detectors in the visible.
  - Charge-coupled devices (CCDs).
  - Statistics depend on instrumental background.

Photon Counting Detectors

http://tinyurl.com/4c9hsz

Microchannel Plate Detectors (current)

Our current workhorse is the cross delay line readout MCP detector

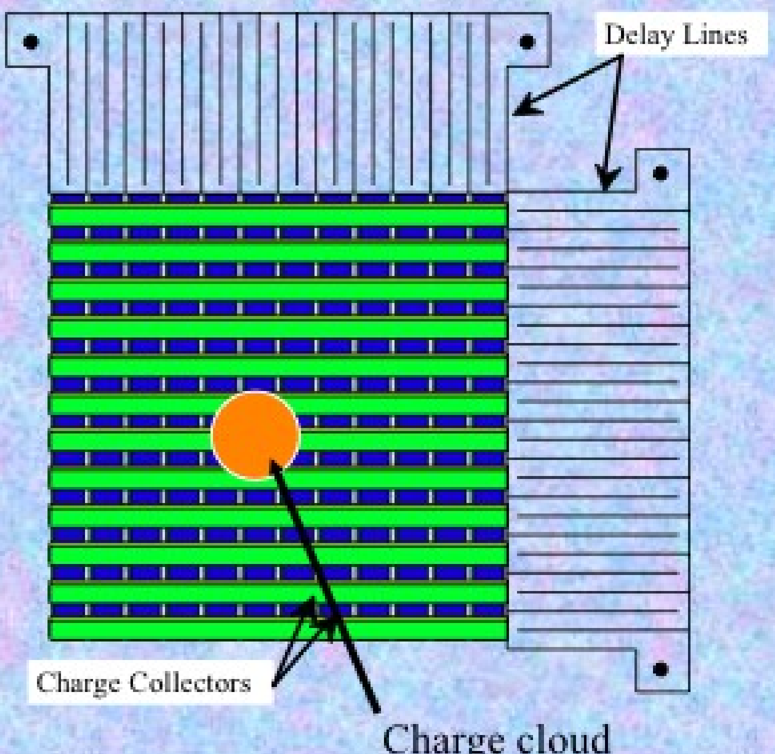
Typical characteristics

Use alkali halides for XUV QE (~50%),
Glass MCPs. Gain ~10^7
Photon, ion, electron, neutron sensing
Size formats to 100mm, Resolution ~30 m
Event rates to >1 MHz, (kHz/pixel rates)
Timing <100ps (~20ps limit)

Issues,

High gain/lifetime/local-global rate limits
Single event sequential processing

Cross delay line anode is a multi-layer crossed conductor layout. Period is ~0.5mm on ceramic. MCP charge divides between upper and lower charge collectors, Event centroids are linearly proportional to signal arrival time difference at ends of delay lines. Fast event propagation (50 ns). Compact and robust (900°C).



Cross delay line readout scheme

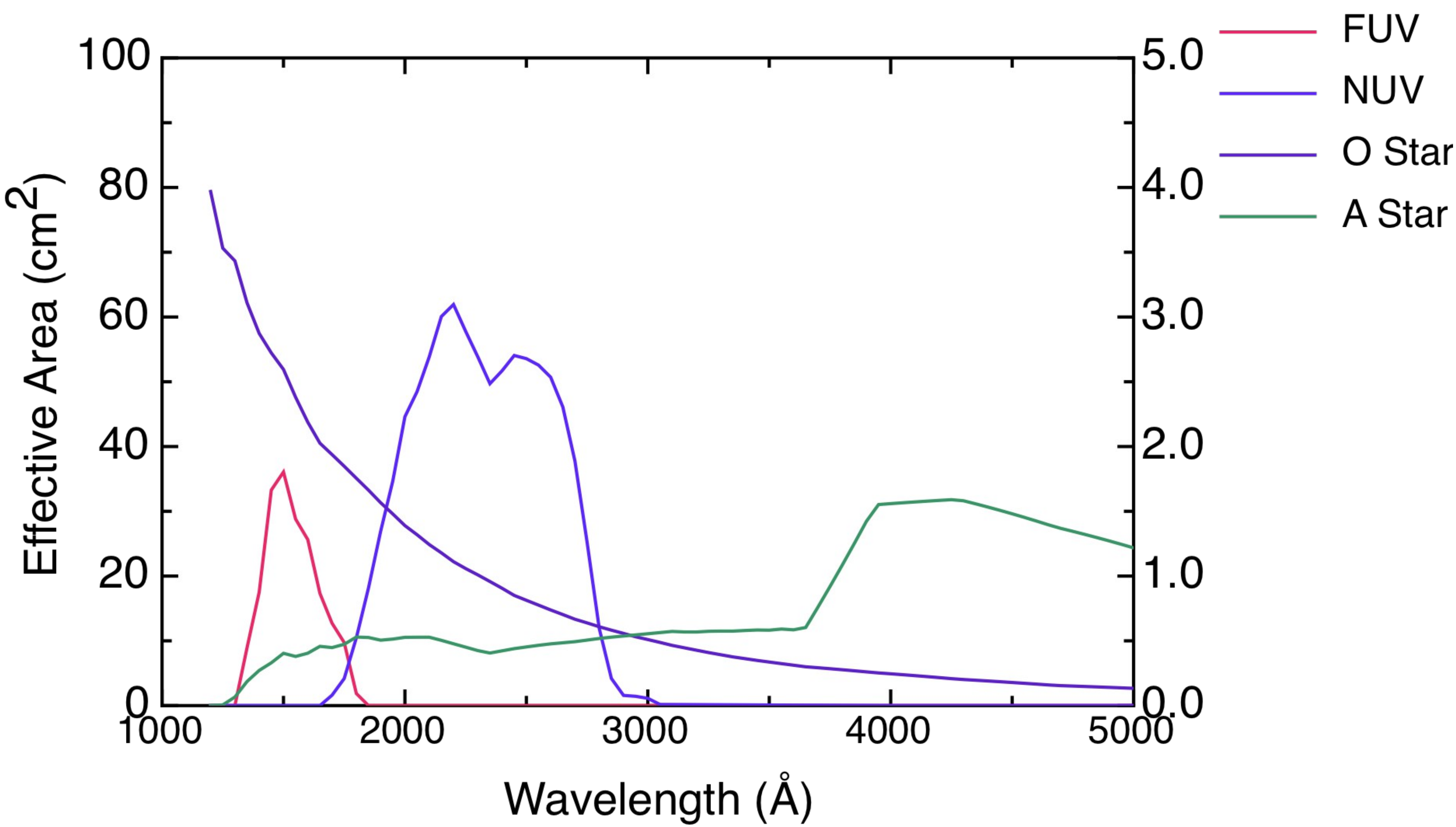
Events

- Measure X, Y, PH.
- Set the discriminator to exclude background events.
- Note that it is not possible to distinguish multiple events.

Photocathodes

Quantum Throughput

- How many counts will come from the sky?
- System efficiency as a function of wavelength.
  - Mirror reflectivity.
  - Filter transmission.
  - Photocathode efficiency.
  - $q.t.(\lambda) = M(\lambda) * f(\lambda) * D(\lambda)$
    - $M = 0.8$; $f = 0.8$; $D = 0.1$
    - $q.t. = 0.8 * 0.8 * 0.8 * 0.1 = 0.05 = 5\%$.
  - counts per second $= \int d\lambda F(\lambda)\ A\ q(\lambda)$



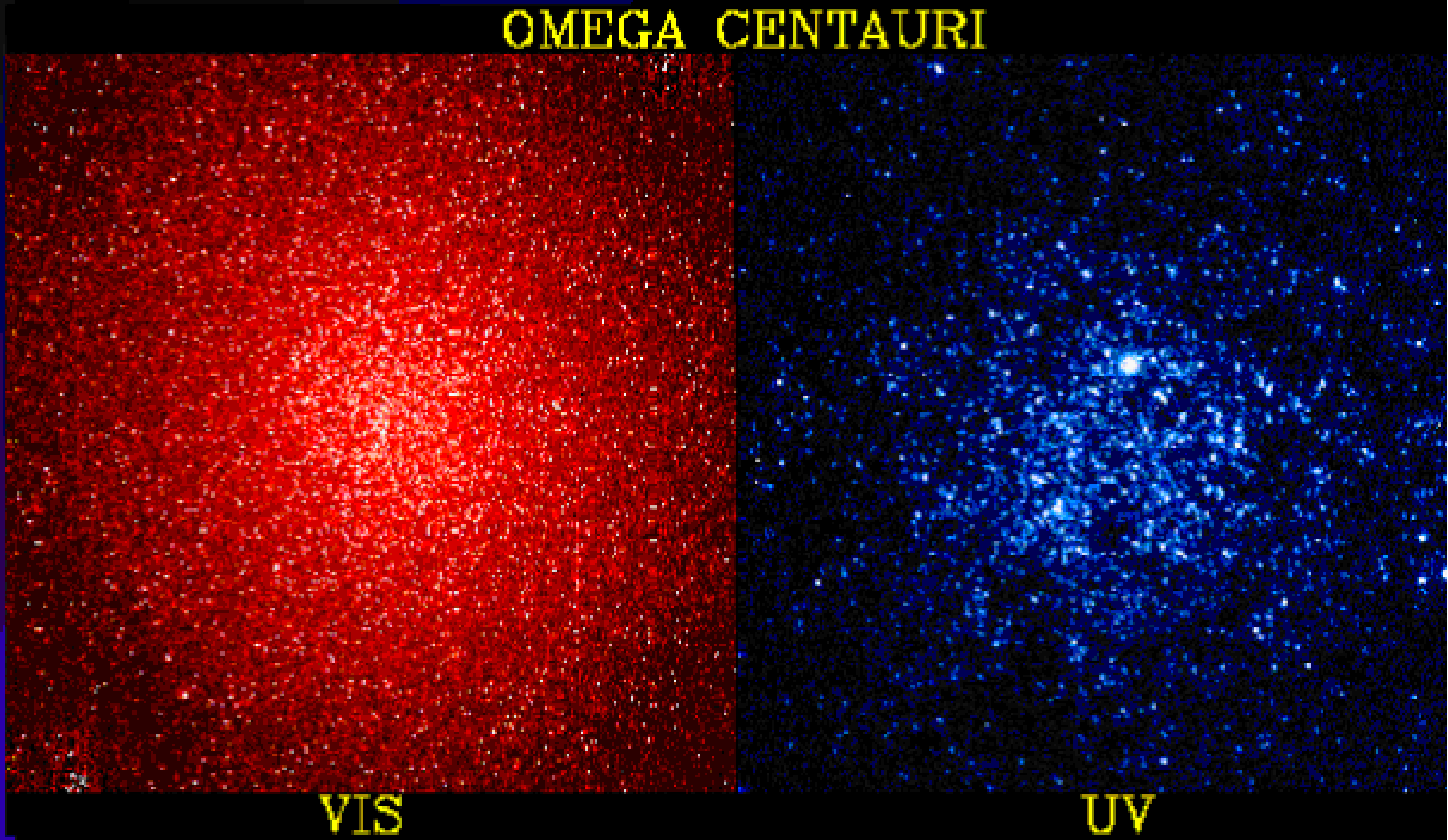
FUV
NUV
O Star
A Star
100
80
60
40
20
0
5.0
4.0
3.0
2.0
1.0
0.0
1000
2000
3000
4000
5000
Effective Area (cm^2)
Wavelength (Å)

GALEX Example

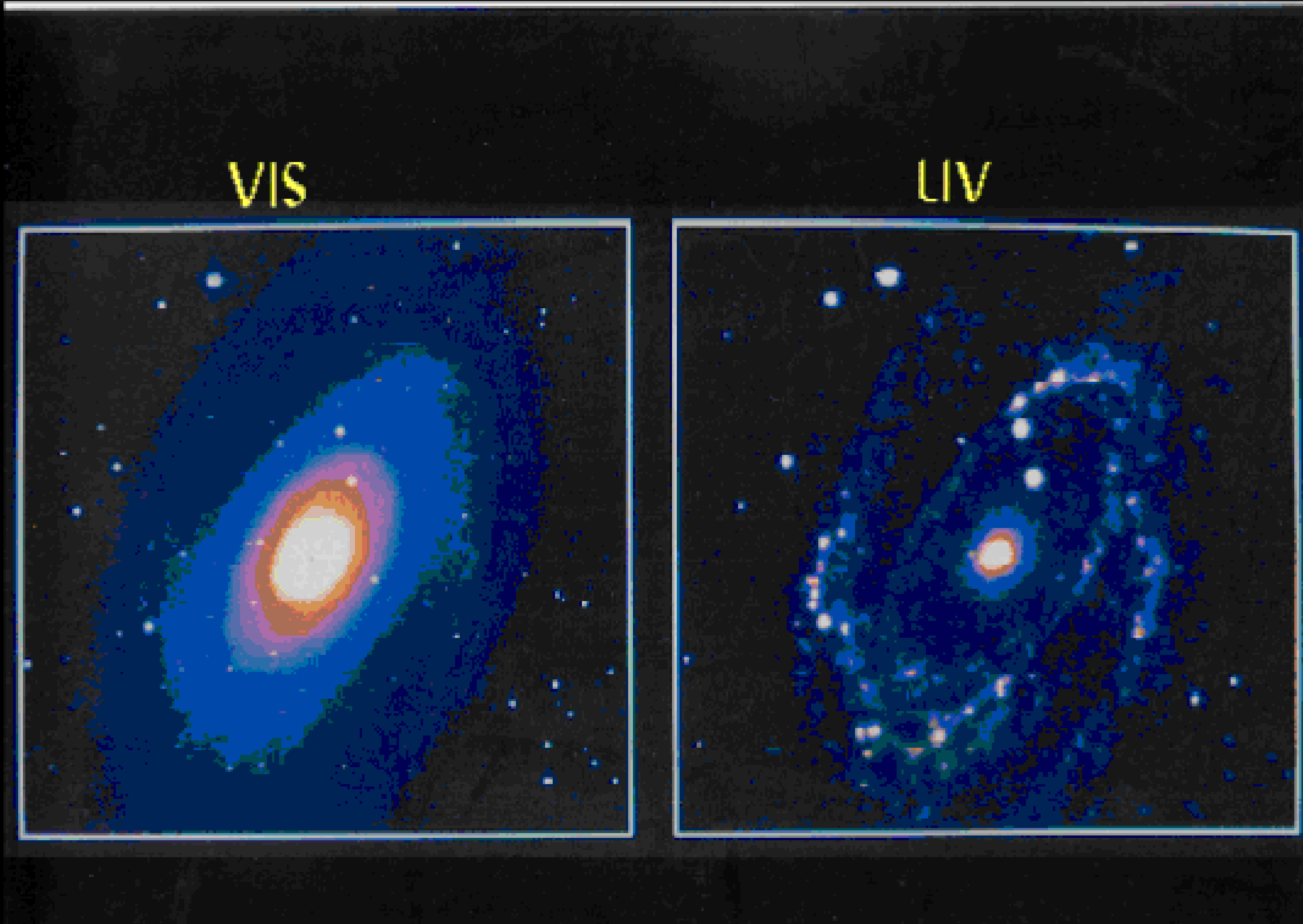
- GALEX calibration from http://tinyurl.com/5gzwef
-

O	121.94	51.6
B	55.14	30.4
A	1.89	2.39
F	0.01	0.6
G	0	0.16

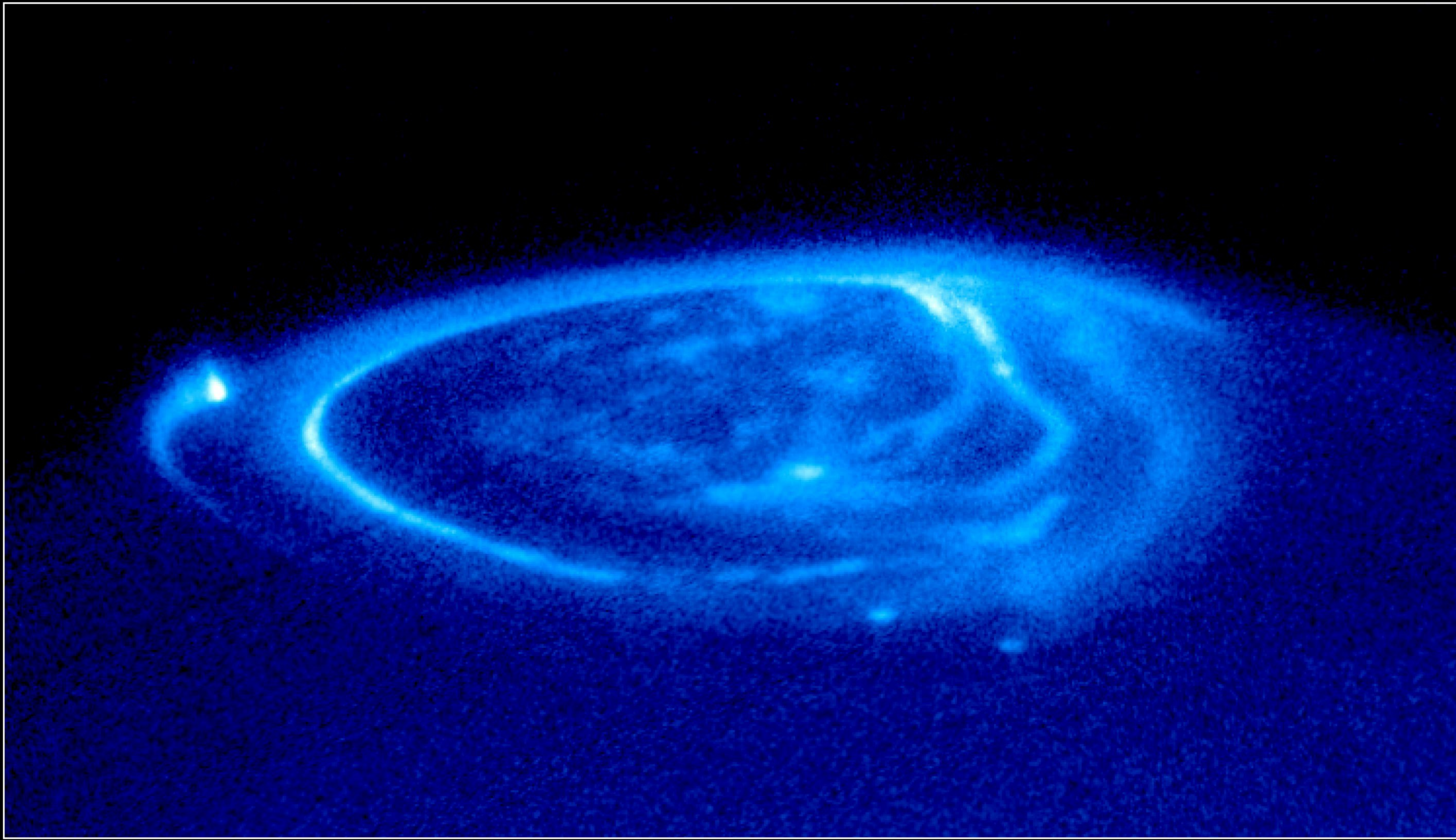
What do we see in the UV?



What do we see in the UV?



Vela SNR



Jupiter Aurora

Hubble Space Telescope • STIS

NASA and J. Clarke (University of Michigan) • STScI-PRC00-38

Virtual Observatory

- Data available from multiple spacecraft and bands.
- http://archive.stsci.edu
- http://www.ivoa.net
- http://www.virtualobservatory.org