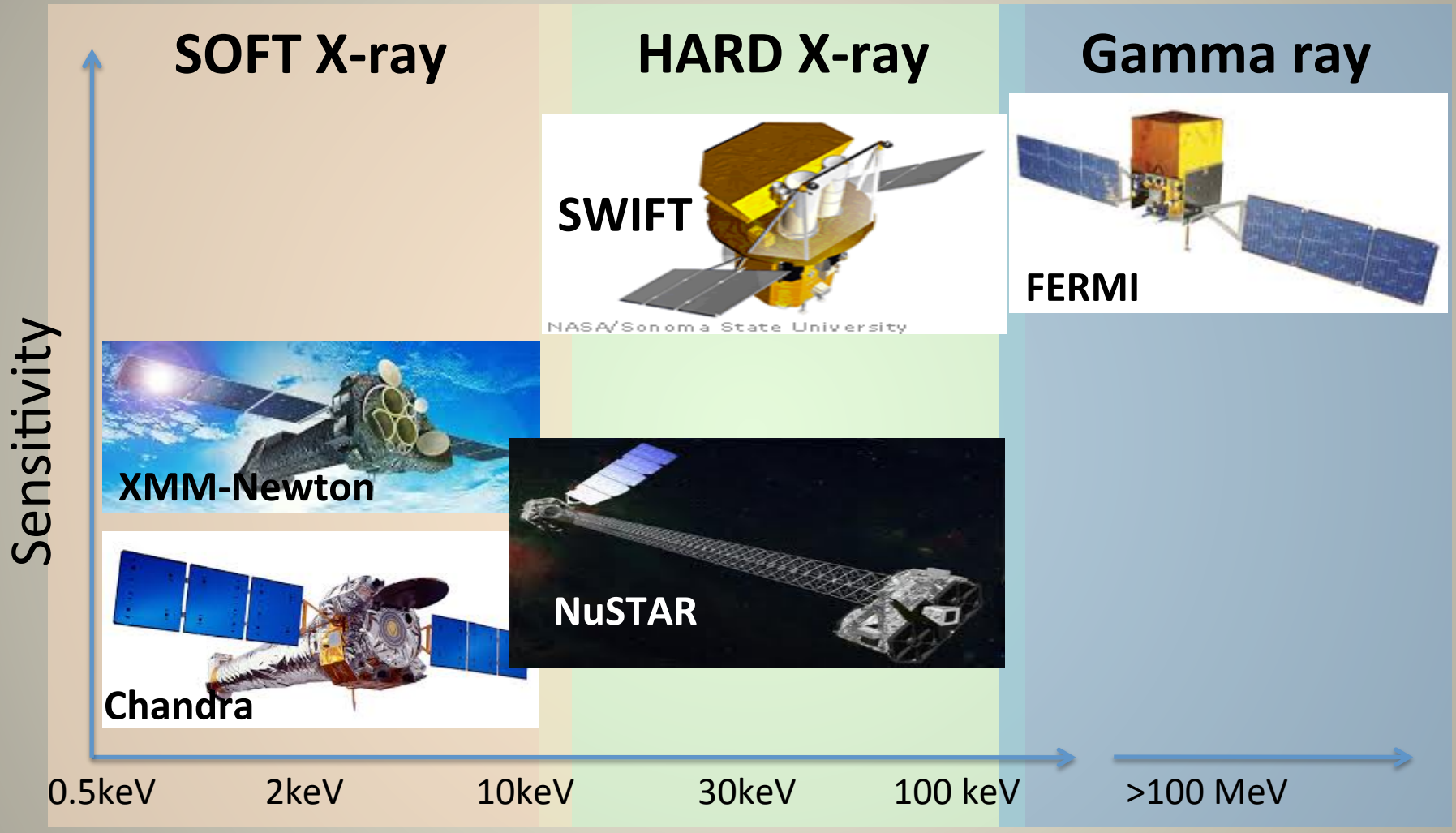
An overview of High-Energy Surveys for Active Galactic Nuclei

Francesca Civano

Yale University (YCAA)– SAO

Definition of high energy



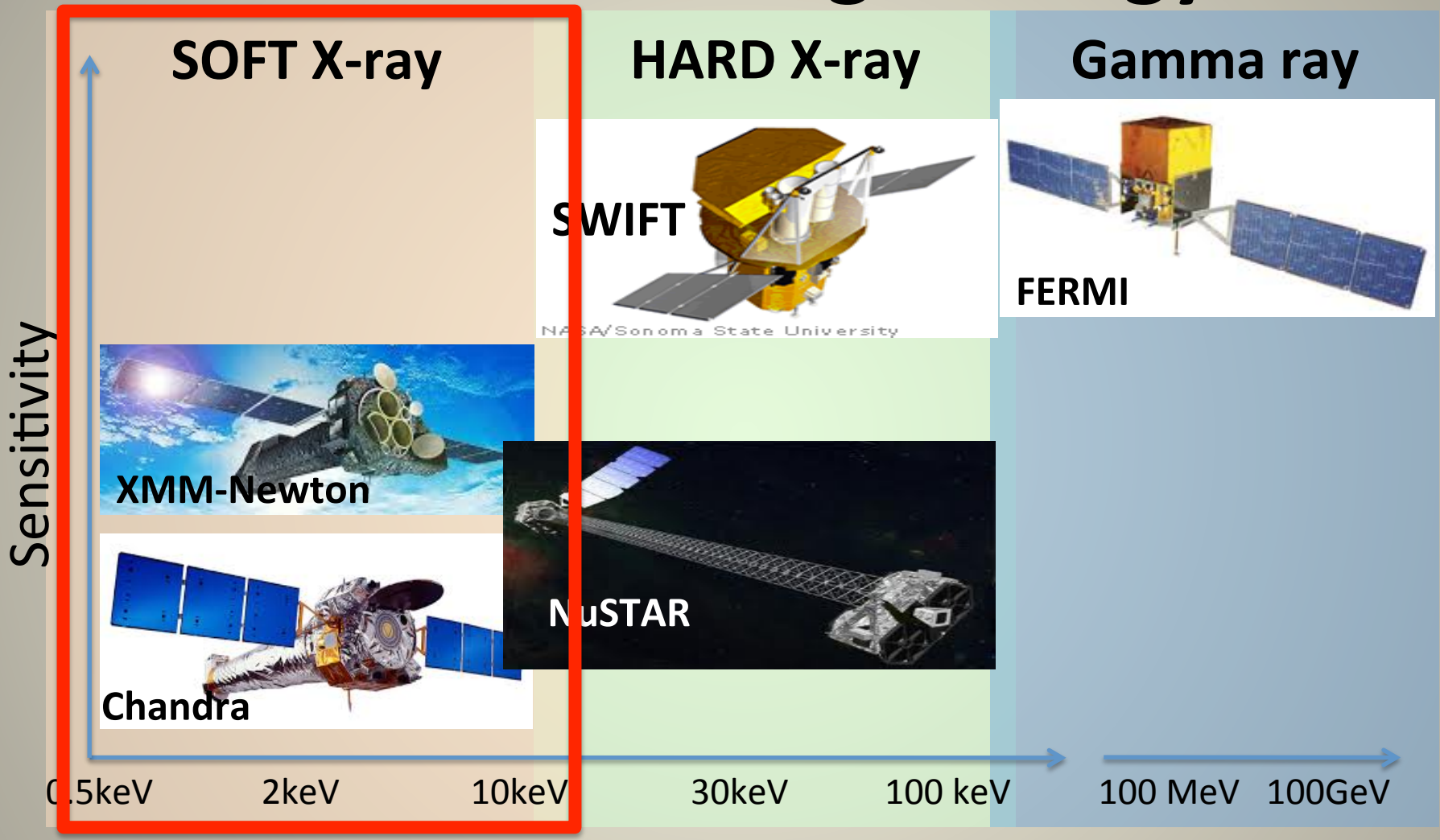
Francesca Civano, VLA workshop

Why AGN High Energy Surveys?

1. Successful tools in unraveling the formation and evolution of cosmic building blocks - Supermassive Black Holes (SMBHs)
2. Most complete **census of active SMBHs** as
   - **Insensitive to obscuration** finds sources missed by optical and IR surveys.
   - Particularly **effective "time machines"** since fainter objects generally lie at greater distances and therefore earlier epochs.
3. **Large area** surveys provide **rare sources** (e.g., high-z, obscured, blazar).
4. **Deep** surveys are able to probe intrinsically less luminous and more typical objects.
5. The fluxes of all detected objects, can be summed and compared with the extragalactic background light, which provides an **integral census** of SMBH emission in the corresponding wavelength range.

Francesca Civano, VLA workshop

Definition of high energy



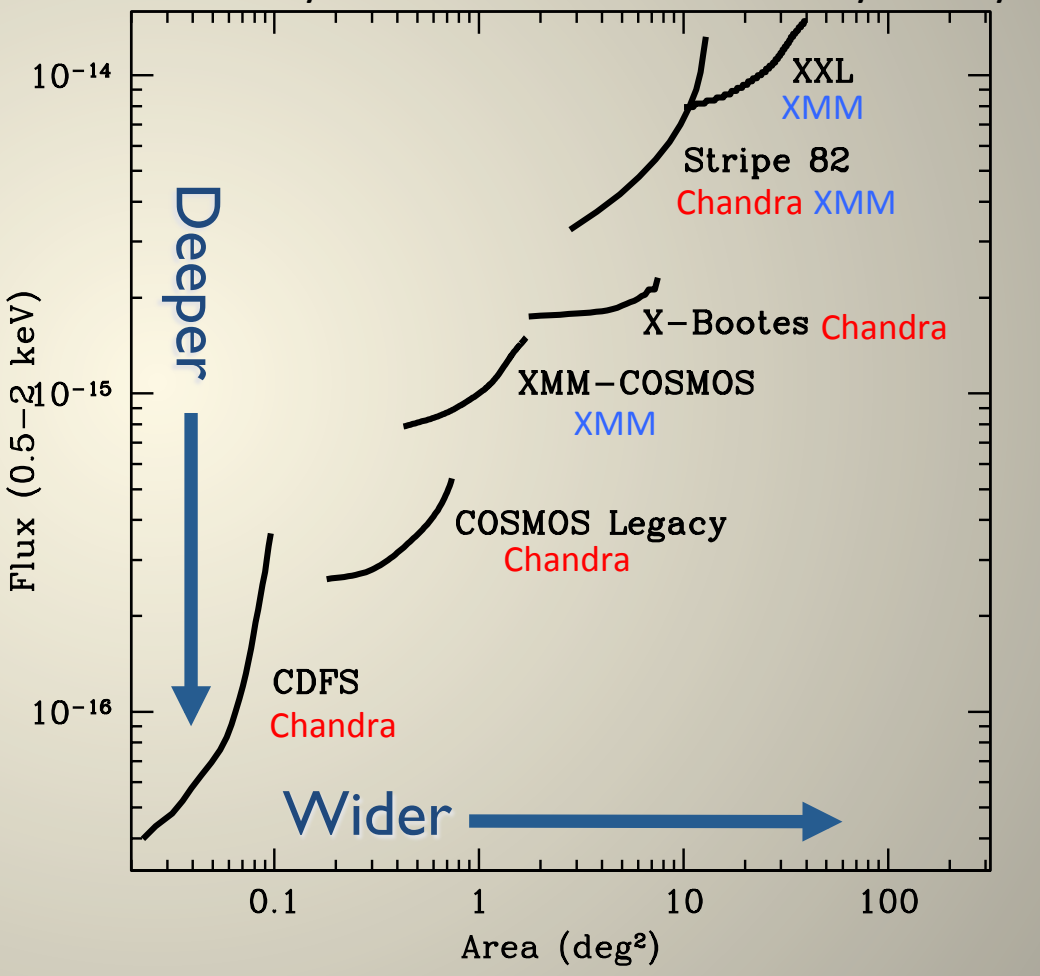
Francesca Civano, VLA workshop

Current status of (soft) X-ray surveys

The Chandra + XMM-Newton "Wedding Cake"

Depth

Sensitivity versus area of current X-ray surveys



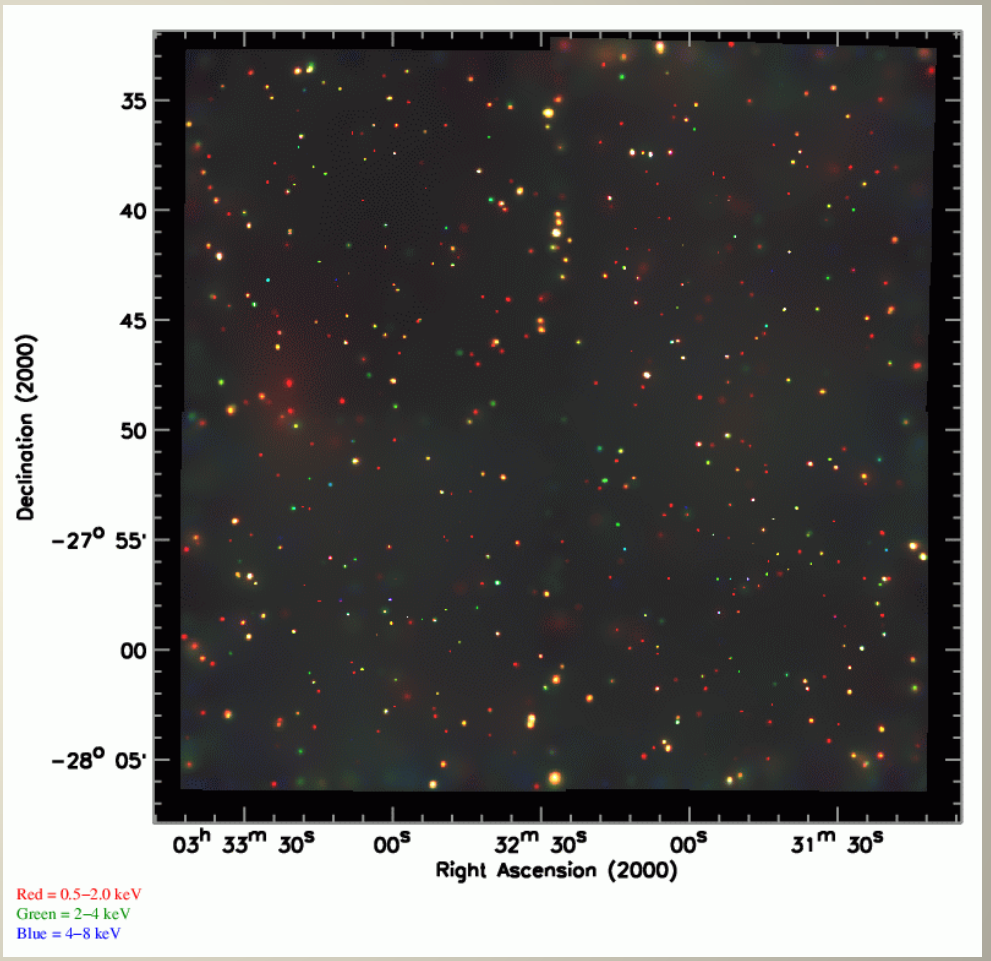
Francesca Civano, VLA workshop

Chandra Deep Field South

•4 Ms exposure (Xue et al. 2012) (adding another 6 Ms in 2014)
• Limiting flux ~$5x10^{-18}$ cgs
• Unlikely to get another one

• **PRO**: Deepest X-ray survey ever
→Reaching faint fluxes to detect normal galaxies (non AGN) at high redshifts
→Potentially detecting very high redshift AGNs

•**CON**: Very small area 0.1deg^2
→biased for the detection of rare sources
→Optical counterparts of X-ray sources are too faint for optical spectroscopy

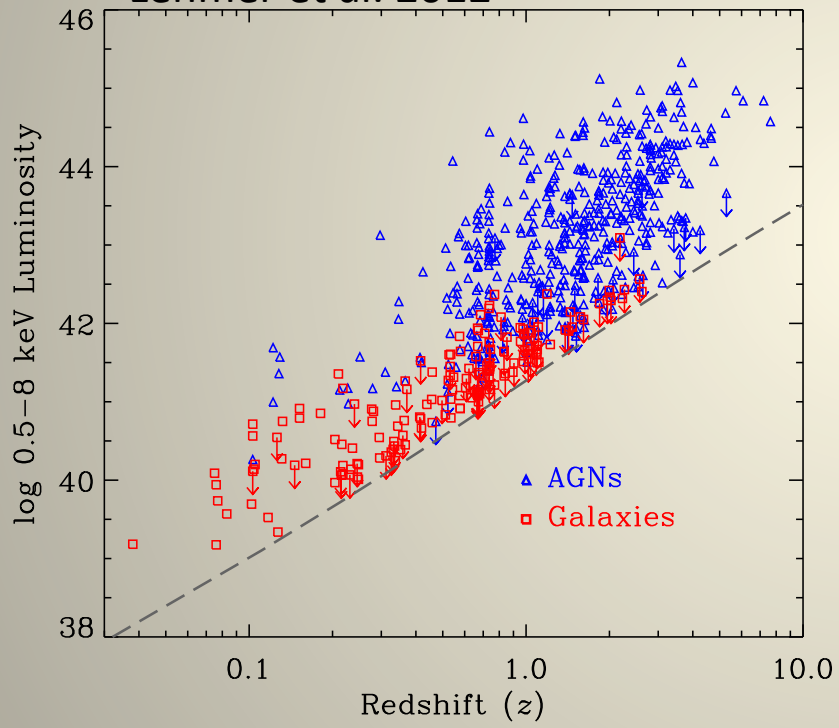


Francesca Civano, VLA workshop

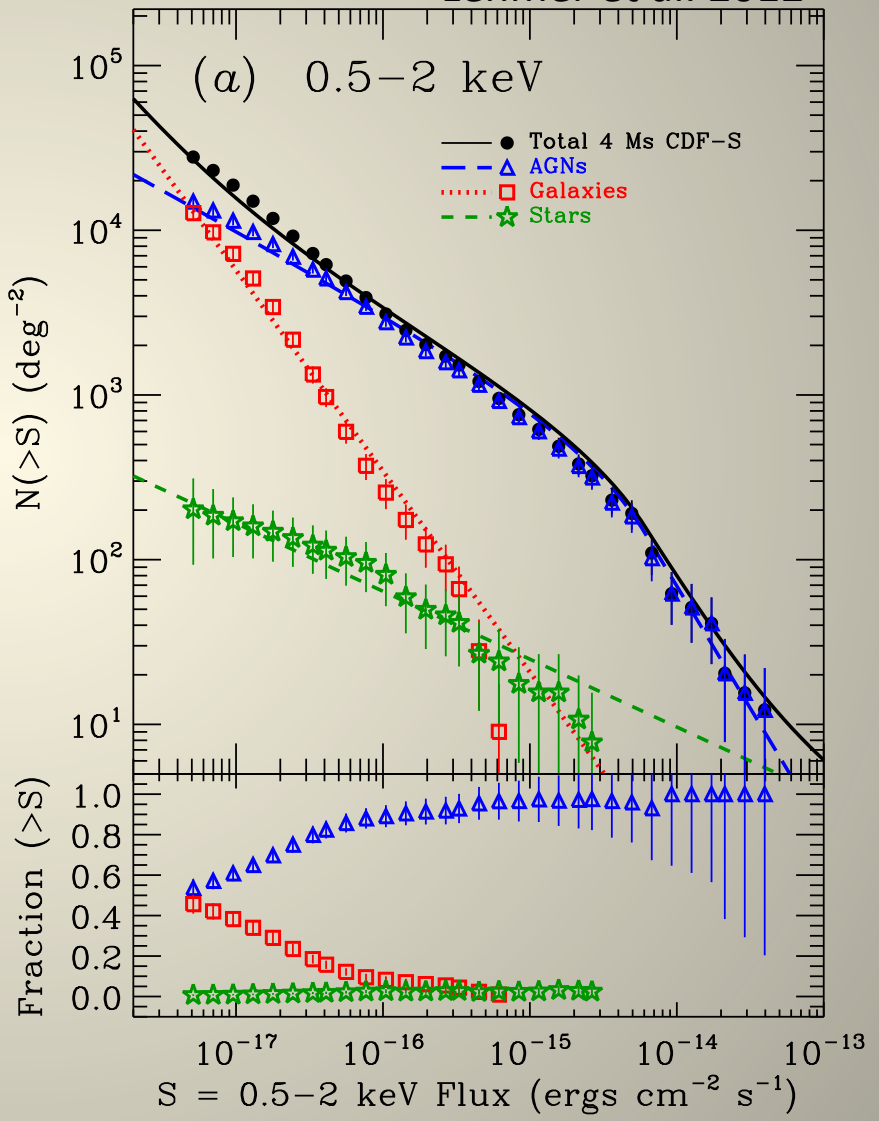
CDFS: detection of Galaxies at high-z

Detects normal galaxies (non-AGN) at 1<z<~3

Lehmer et al. 2012



Lehmer et al. 2012



Francesca Civano, VLA workshop

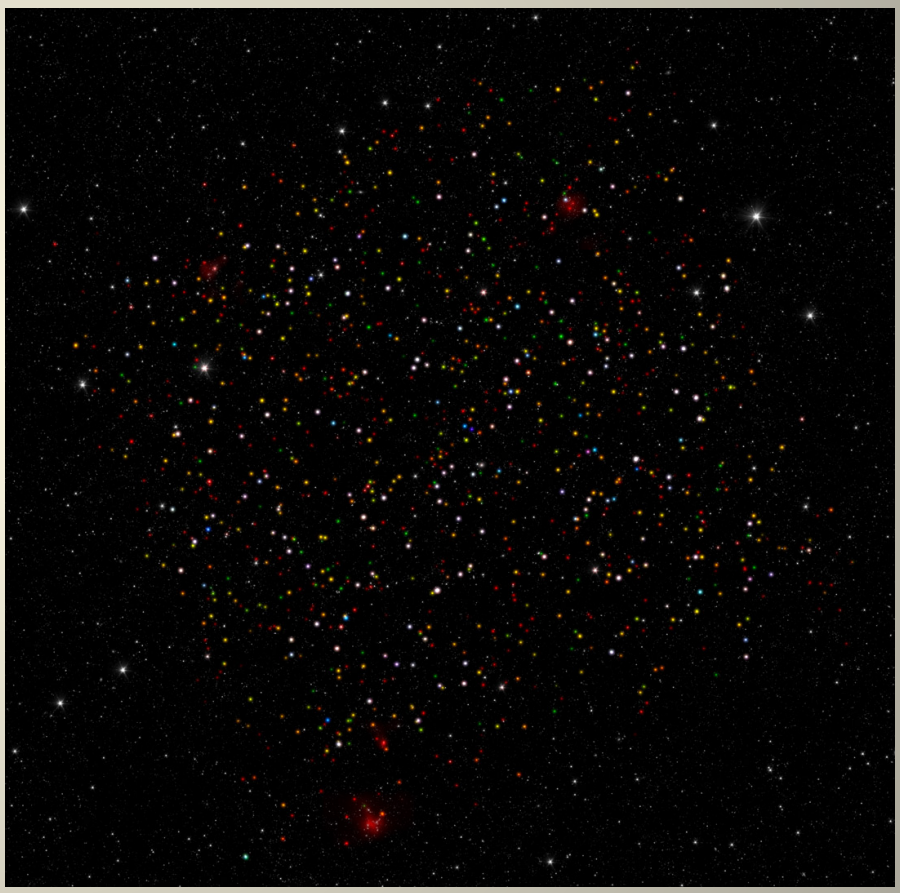
C-COSMOS survey

- 200 ks exposure over 1 deg^2 (Elvis et al. 2009)
  - Limiting flux ~$3x10^{-16}$ cgs
  - 1700 sources
- Extending to 2 deg^2 (2.8 Ms XVP, PI: F. Civano)

See Poster 254.46 on Tuesday

- **PROs**: large area at medium depth→
  - Largest X-ray sample to date
  - good for statistical studies
  - able to find rare sources
  - High optical/IR counterpart rate
- **CON**: reaches only medium fluxes = high L_X

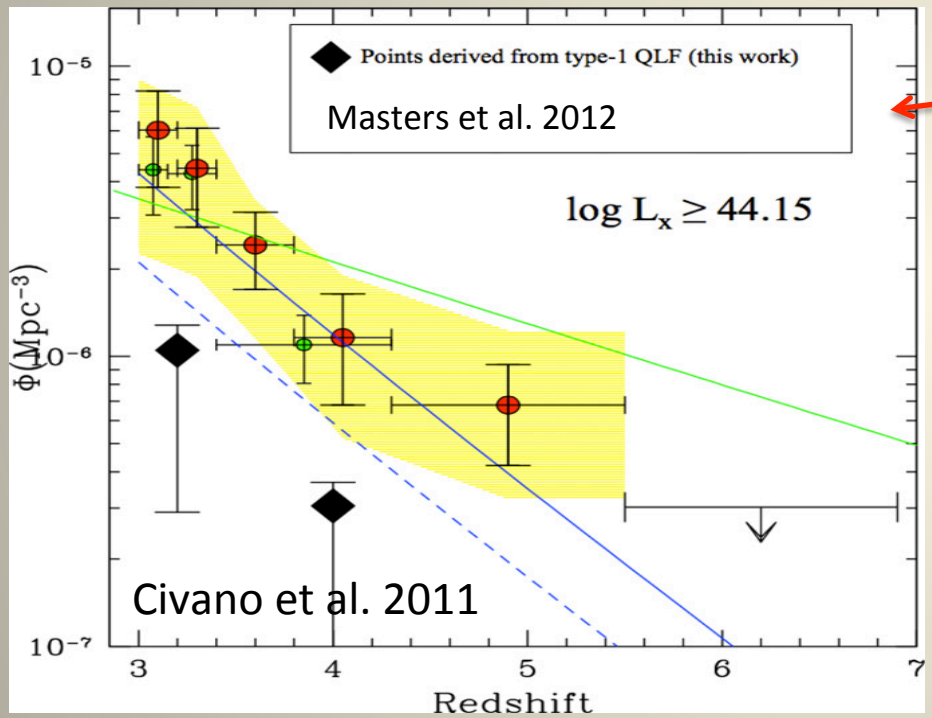
- VLA survey covers the full field→20% of matches between X-ray and radio sources
- NEW JVLA survey (PI: Smolcic) just covered the full field→ increase matches to 50%



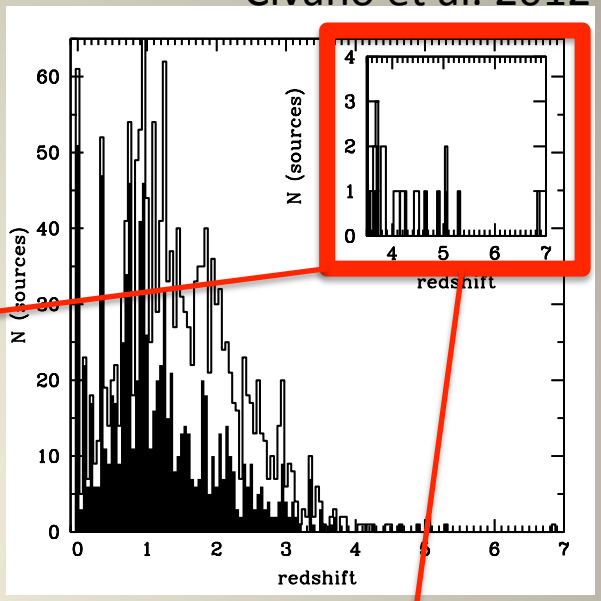
Francesca Civano, VLA workshop

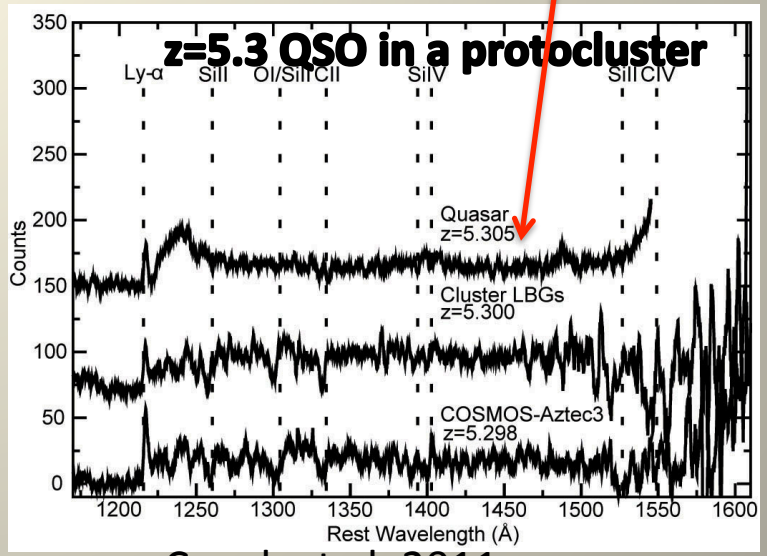
COSMOS: Catching Rare high-z AGN

Largest sample of high-z AGN (~100 sources) to compute the luminosity function at z>3



Civano et al. 2012



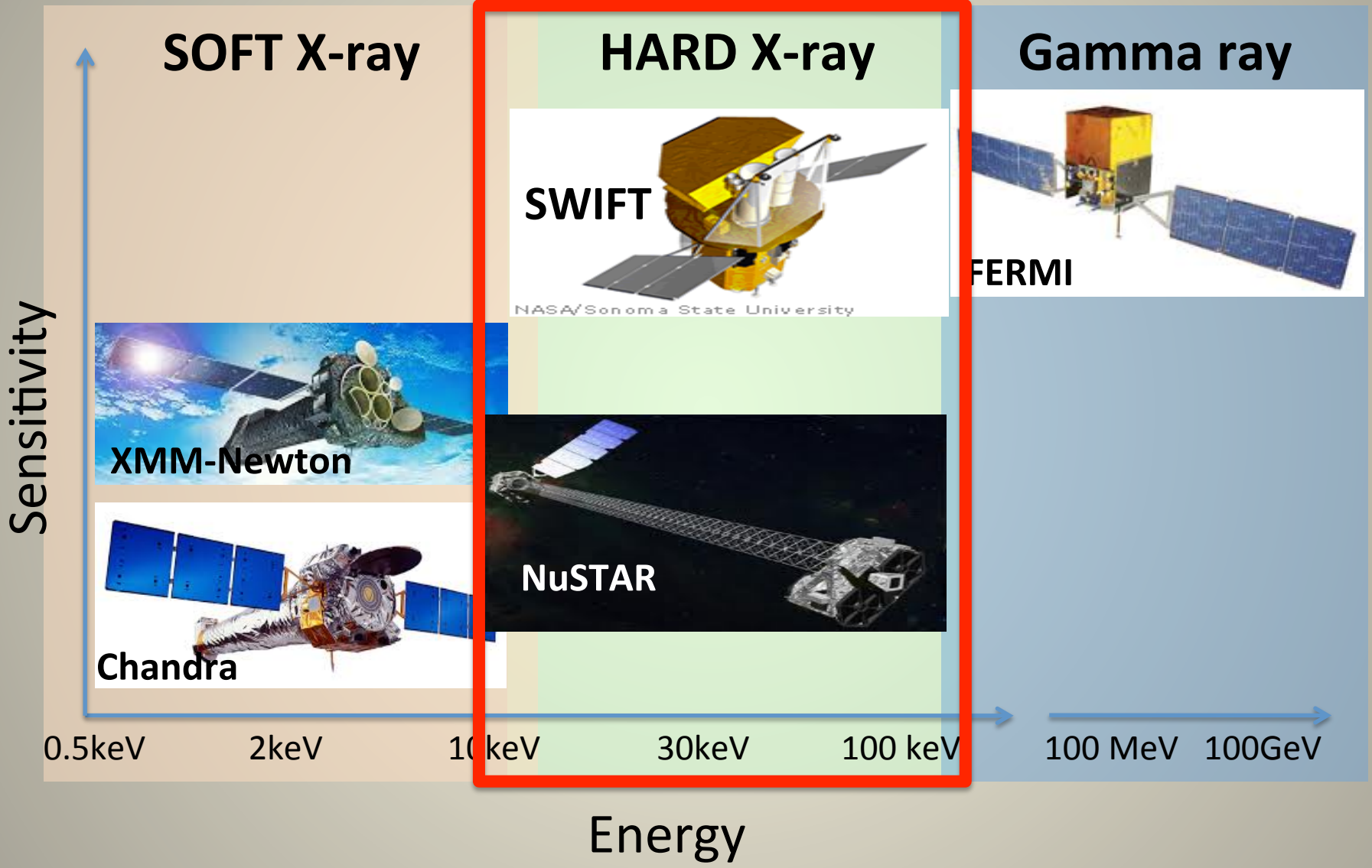


Capak et al. 2011

See Poster 150.05, 150.10 on Monday

Francesca Civano, VLA workshop

Definition of high energy



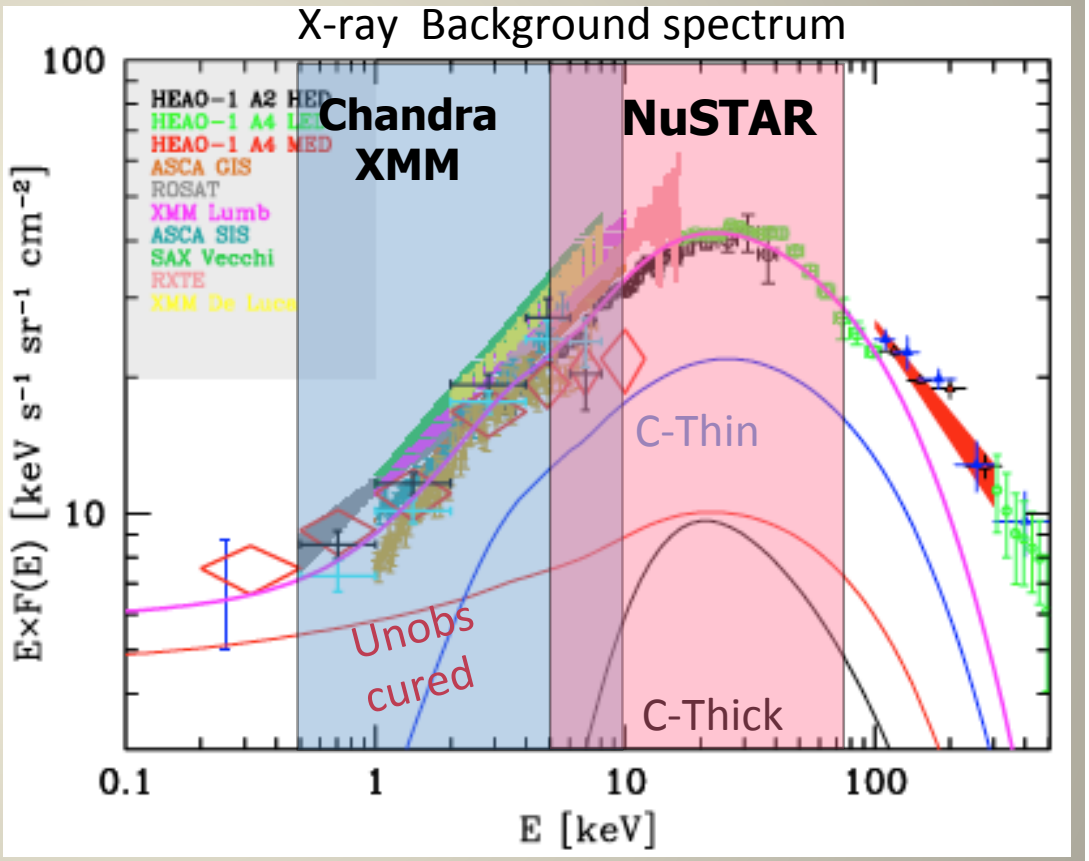
Francesca Civano, VLA workshop

A new window on the hard X-ray

NuSTAR Extragalactic surveys: a key project

1. NuSTAR AGN selection almost independent of obscuration
   - Evolution of obscuration
2. Direct observation of ~20-30 keV peak in X-ray background
3. Resolve >30-50% of the XRB
   - from direct detections
   - stacking Chandra/XMM sources

X-ray Background spectrum



Gilli, Comastri & Hasinger 2007

NuSTAR Extragalactic survey: a Hard*Wedding Cake

**** But tasty!***

Depth

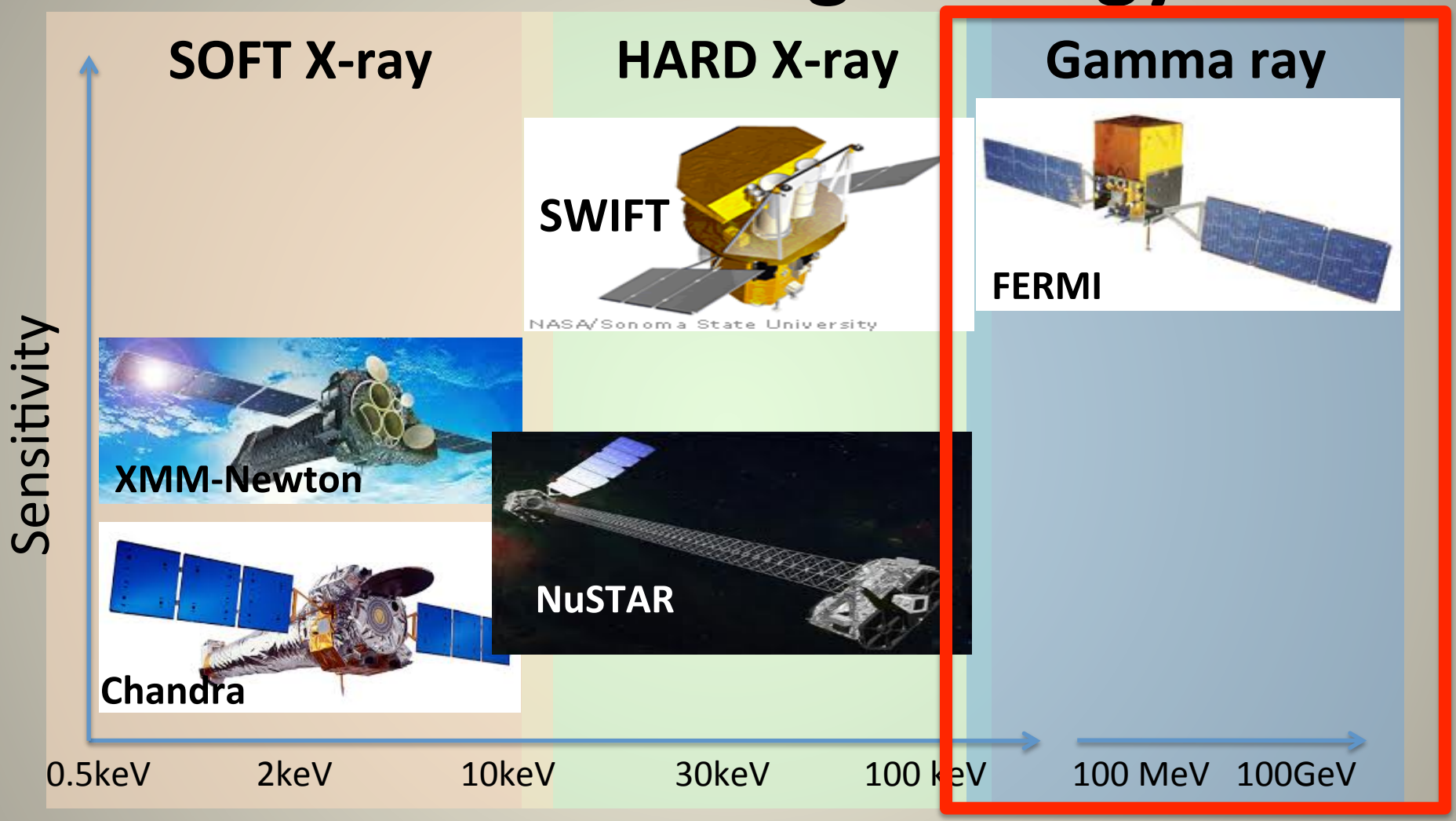
1. Deep: E-CDF-S (GOODS-S)
~200 ks/pointing over 0.3 deg^2

2. Medium: COSMOS
~25 ks/pointing over 2 deg^2
Civano et al. in preparation

3. Large/Shallow: Serendipitous
- 100 Swift-BAT AGN fields (~16 ks each)
- + all other NuSTAR targets
- Total: ~3-4 deg^2 of coverage

Francesca Civano, VLA workshop

Definition of high energy



Francesca Civano, VLA workshop

Gamma-Ray Surveys: Blazars dominate the Gamma-ray sky

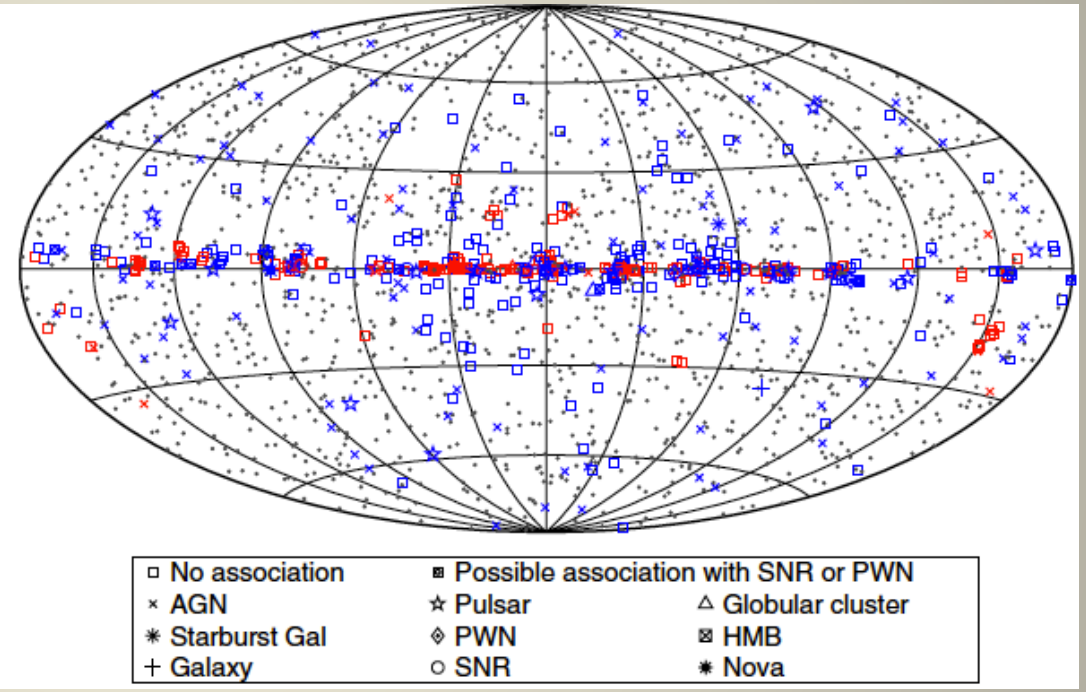
Fermi scans the sky every 3 hrs detecting transients and localizing gamma ray sources to ~1'

Second *Fermi LAT* Catalog (Nolan et al. 2012):

- 1800 detections (many more in the 4 year catalog)
- 84% of these are AGN, mostly BLAZARS

6 times more sources than previous Gamma ray catalog (EGRET) at >100 MeV

FERMI team is working to improve the response matrix: this will provide an even deeper all sky survey.



S. Cutini talk 115.08

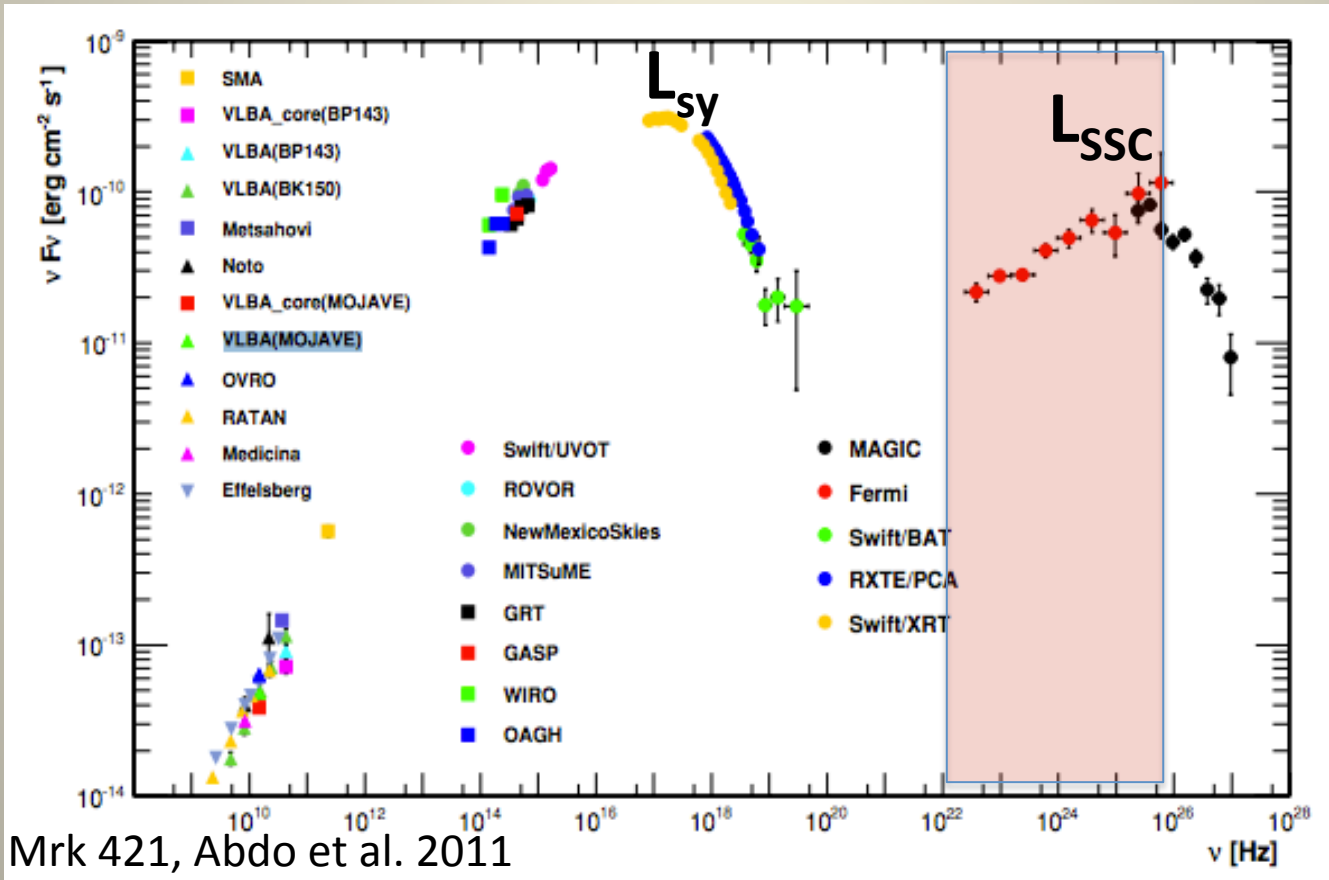
Francesca Civano, VLA workshop

Nonthermal Blazar Emission

Blazar SEDs dominated by two “bumps”:

1- Synchrotron bump: peaking between optical and soft X-rays

2- Compton bump: peaking at γ-ray energies. Seed photon sources: Radio Synchrotron photons (synchrotron self-Compton or SSC)



Mrk 421, Abdo et al. 2011

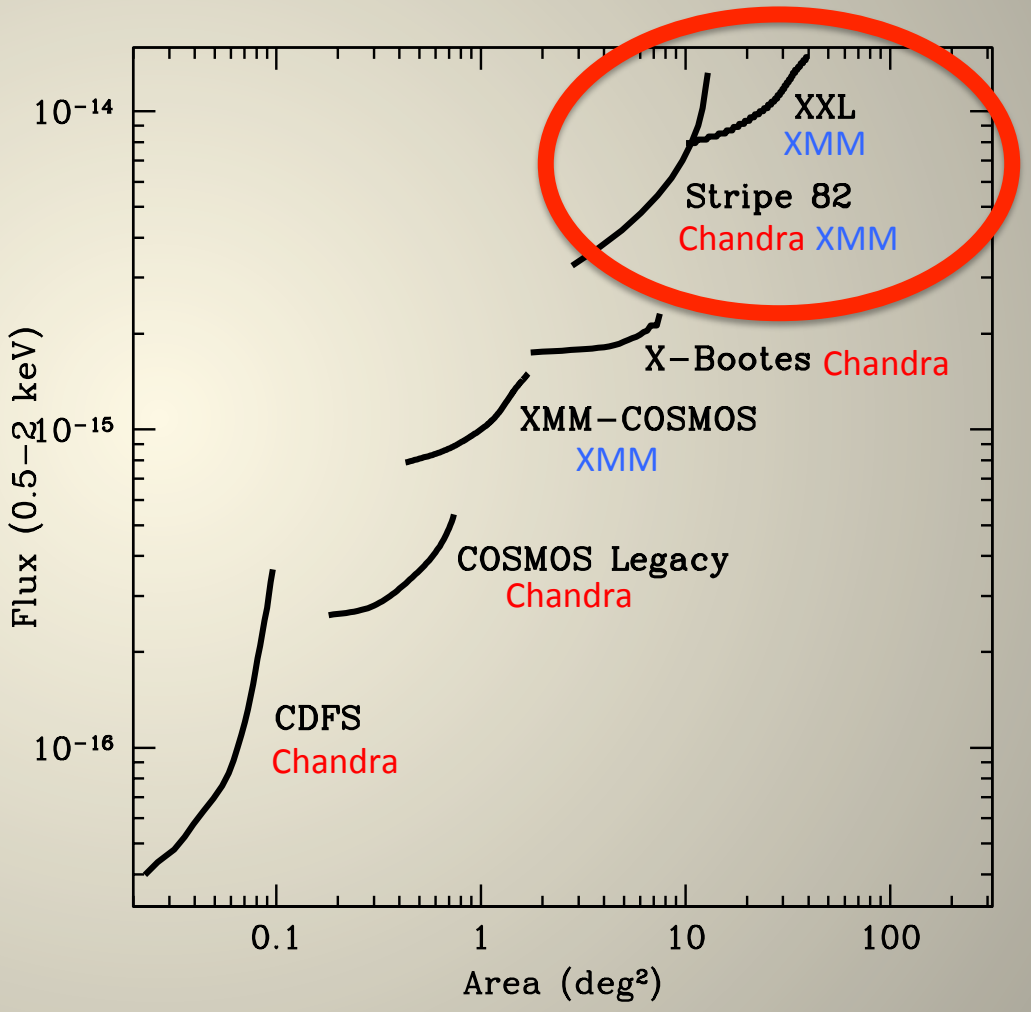
Looking at the Near Future: Current Missions

Long life to Chandra, XMM and NuSTAR!

- Chandra is still accepting for another year X-ray Visionary Projects (up to 6 Ms)→ room for a survey

- XMM-Newton Just approved an extension of Stripe 82 to 70 deg^2

- NuSTAR will (finger crossed) get an extension of the mission and can fly for up to 10 years in the same orbit → Will work simultaneously with Astro-H



Francesca Civano, VLA workshop

Looking at the Near Future

Long live to Chandra, XMM and NuSTAR!

2015: eROSITA

German + Russian soft X-ray satellite

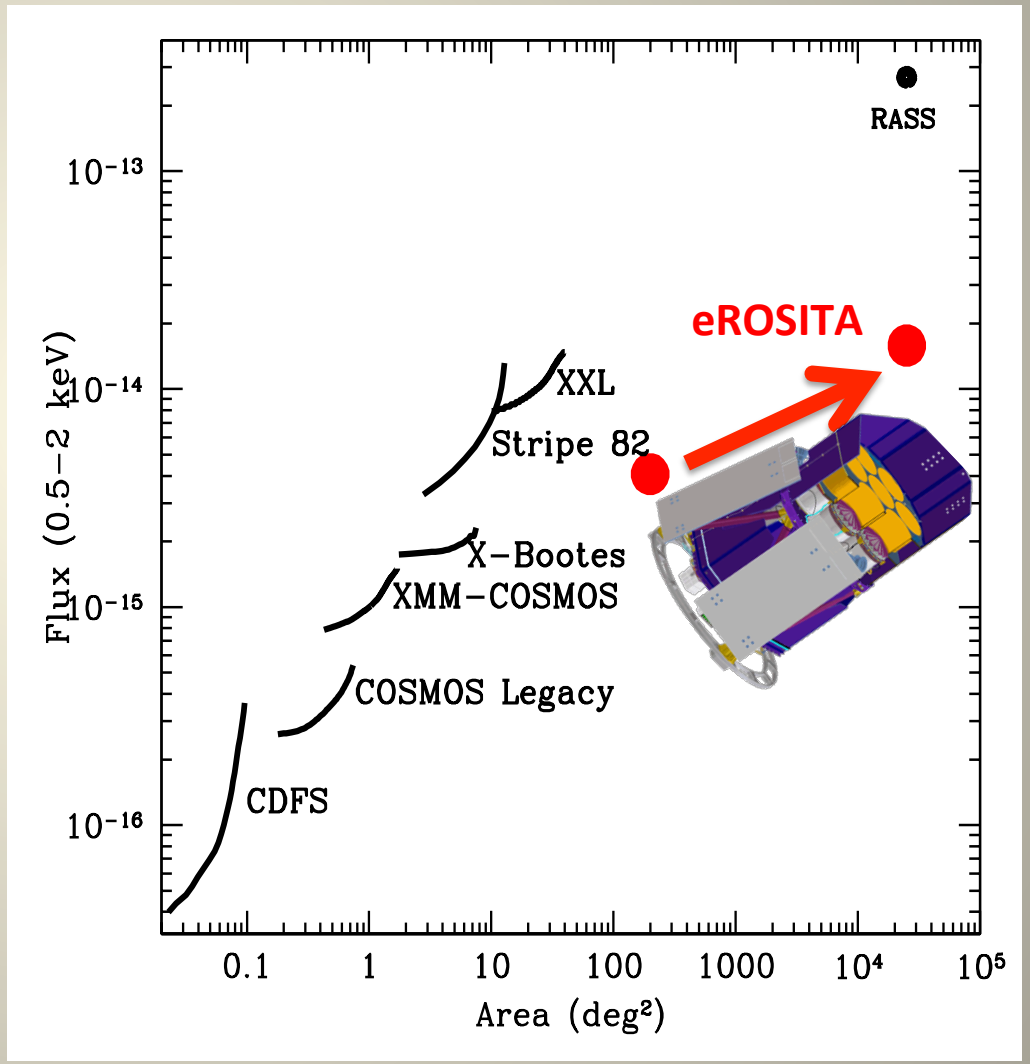
→ALL SKY SURVEY in the first 4 years

•20 times more sensitive than the ROSAT in the 0.5-2 keV

• First all sky survey in the 2-10 keV band

• **3 million AGN in soft band**

• Requires major efforts **multi-wavelength wide area surveys** in order to fully exploit the scientific potential of the X-ray data



Francesca Civano, VLA workshop

Looking at the Near Future

Long life to Chandra, XMM and NuSTAR!

2015: Astro-H
JAXA +US

Soft X-ray high resolution spectroscopy
+
HARD X-ray imaging 5-80 keV
Similar fov of NuSTAR

Looking at the very FAR Future

- **2028 launch**: The hot and energetic Universe will be the focus of one of two ESA's next large science missions (see **Athena+** concept)

→Brings the fluxes reached by Chandra in CDFS and COSMOS on 100x larger are**a**

- **2020s: SMART-X** mission concept (SAO) has Chandra resolution with 30x more effective area.

→ Will reach the 4 Ms CDFS fluxes in only 100 ks

Summary

- High energy surveys provide an unbiased census of AGN, including obscured sources missed by optical
- Satellites covering 0.5 keV to 10 GeV are healthy and working
- Providing statistical samples of sources allowing to study population properties
- Multiwavelength observations are vital for a full characterization of the detected sources
- NuSTAR, ASTRO-H, eRosita will carry us through 2020-2025
- Future missions are still very far but we are working hard to make the future bright…stay tuned!