# The Einstein Observatory

*When X-ray observations became astronomy*



G. Fabbiano

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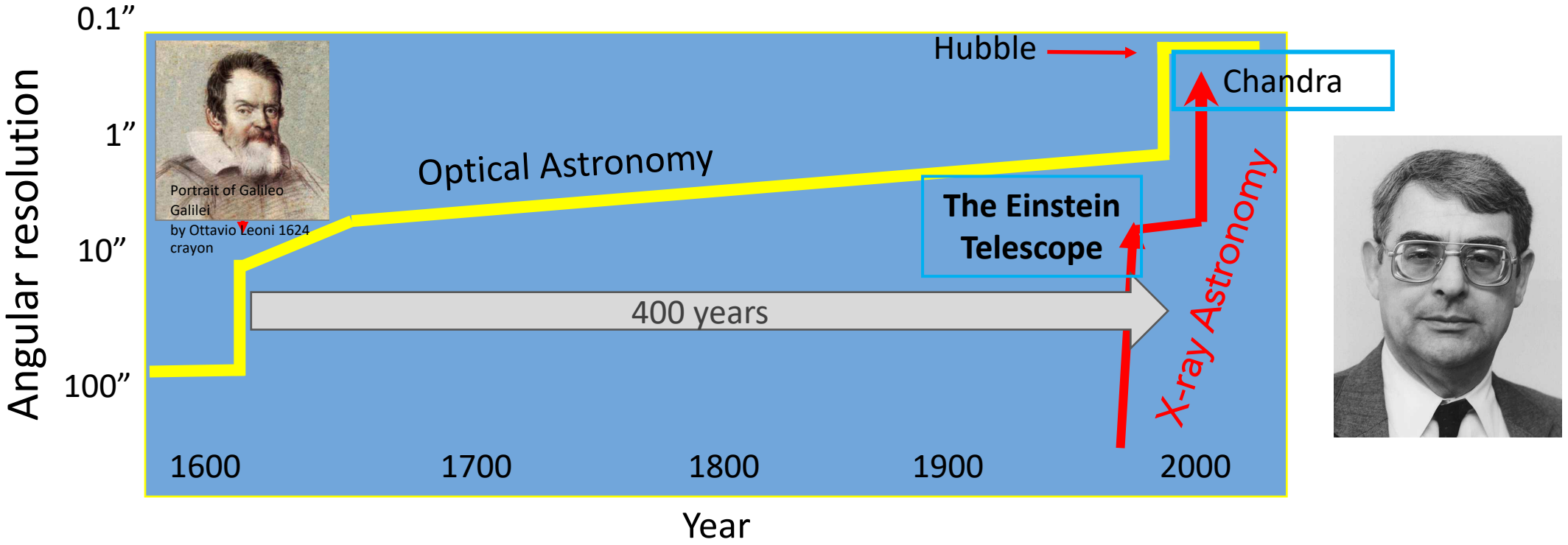
# Perspective

## *Einstein* - The Galilean telescope for X-ray Astronomy

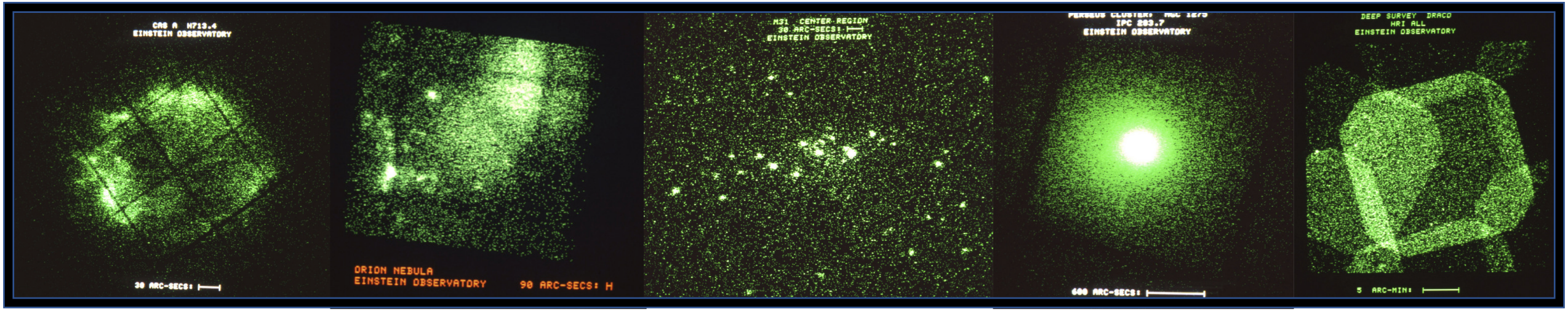



**Imaging (~5”- 40”)**
Wide spectral range: ~0.4 – 20 keV

**NASA HEAO-2 (the Einstein Observatory)**
**Launch**: 13 November 1978
**Re-enter & burn-up**: 25 March 1982

**HRI** - High Resolution Imaging camera, 0.15-3 keV
**IPC** - Imaging Proportional Counter, 0.4 to 4 keV
**SSS** - Solid State Spectrometer, 0.5 to 4.5 keV
**FPCS** - Bragg Focal Plane Crystal Spectrometer
Coaxial instrument **MPC** - Monitor Proportional Counter, 1-20 keV

# In ~3.5 years, Einstein revealed the hot universe




SNRs | Stars | Galaxies | Clusters | AGNs & Deep Surveys

Stellar evolution and its end products

Hot ISM
Baryon evolution
Dark Matter

X-ray bkg



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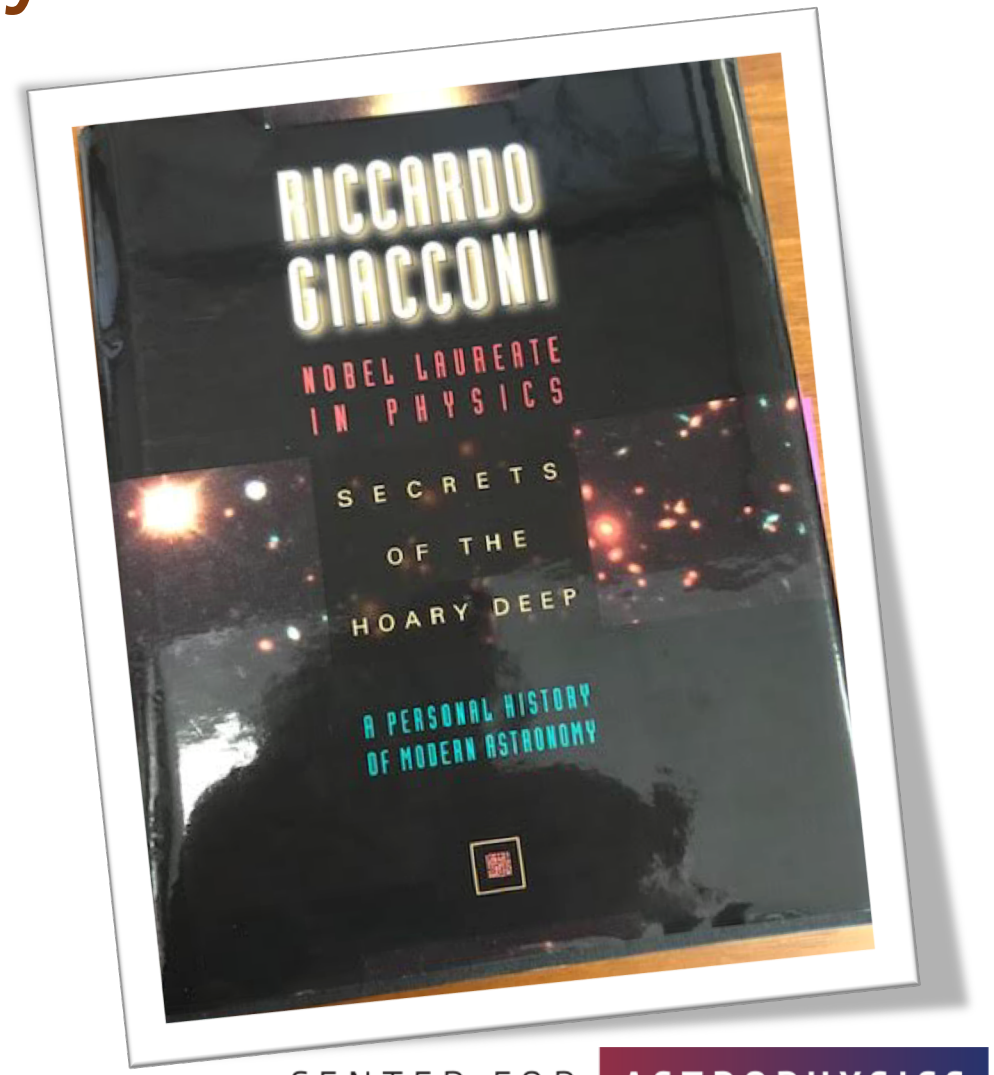
# With the *Einstein Observatory* began Riccardo Giacconi's Cultural Revolution in Astronomy

## From the *Einstein Observatory*

It Propagated to
*Hubble Space Telescope, ESO, Chandra, ALMA, ….*

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# Riccardo Giacconi and the Cultural Revolution in Astronomy

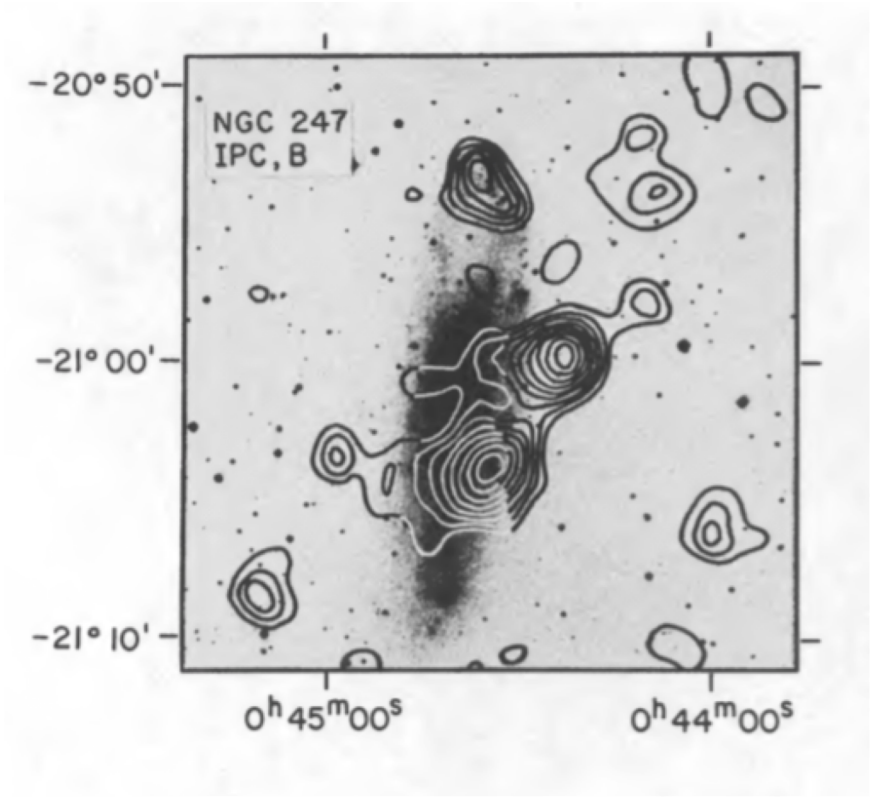
- A 'business model' for astronomy teams
  - Scientific leadership and management
  - Integrated science-technical teams, with scientists doing both functional

**Astronomers have embraced the use of multi-wavelength observations from radio to X-rays**

- Data Centers
  - Einstein Observatory Guest Observer Program
  - Einstein Users committee
  - Data Archives
  - People were very nervous at the time….

# (my) Einstein Archival Research

- An X-ray Catalog and Atlas of Galaxies
  Fabbiano, Kim & Trinchieri 1992
  - 450 nearby galaxies found in Einstein observations (238 detection , 212 upper limits)
- Follow-up spectral properties
  Kim, Fabbiano & Trinchieri 1992a, b




*Einstein archival work provided*
*The basis for our understanding of the X-ray emission of galaxies*



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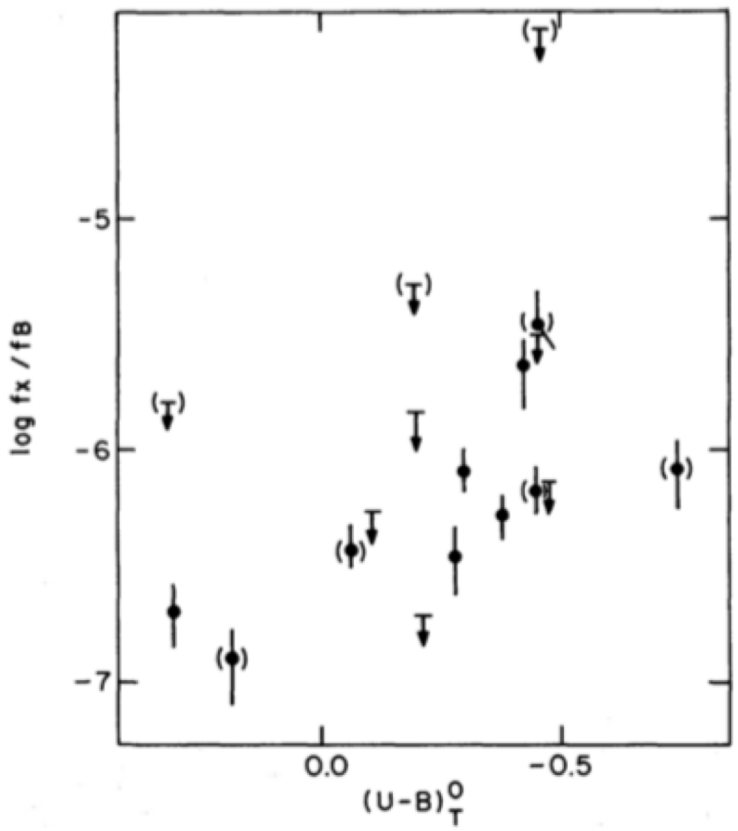
# *The basis for our understanding of the X-ray emission of galaxies*

XRB populations
(LMXB, HMXB)
and their relation with SFR &
stellar mass

See Fabbiano 1989, ARAA




X-ray luminosity is enhanced with active star formation

Fabbiano et al. 1982

# *The basis for our understanding of the X-ray emission of galaxies*

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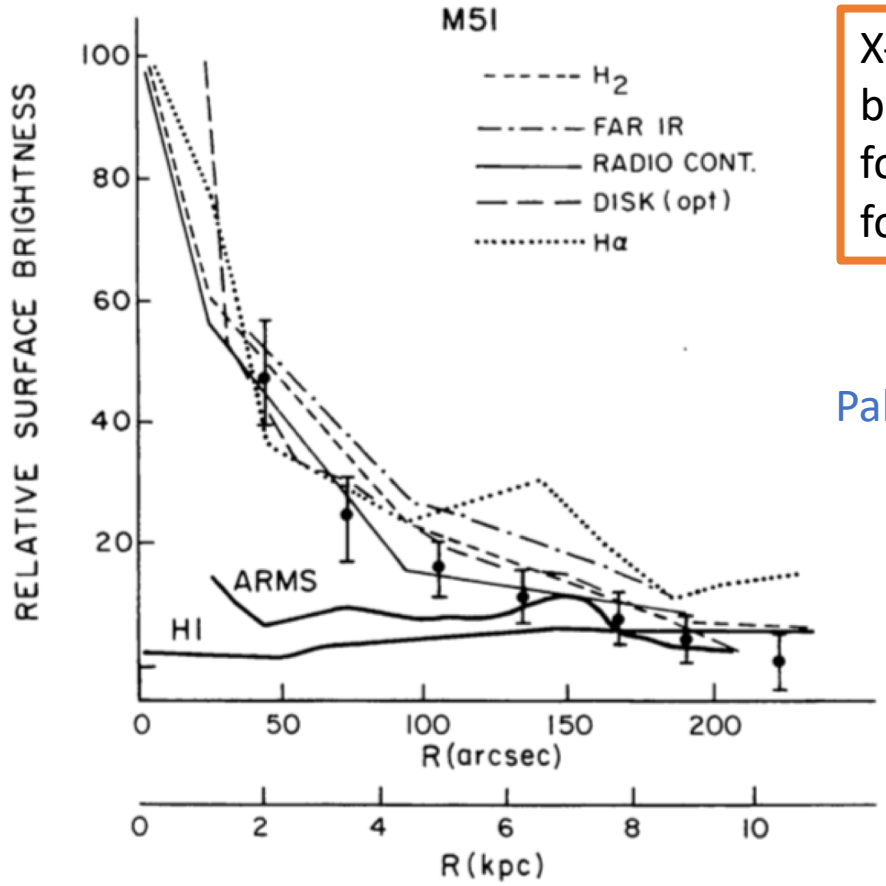


X-ray surface brightness of star-forming galaxies follows stellar light

Palumbo et al. 1985



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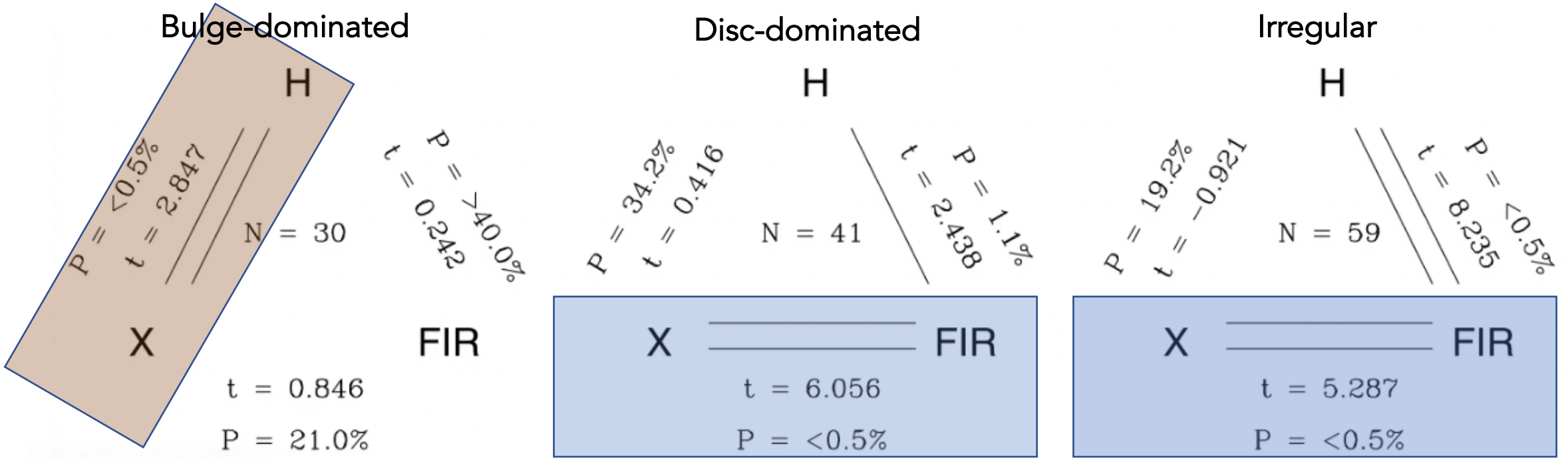
# *The basis for our understanding of the X-ray emission of galaxies*

## Fabbiano & Shapley 2002 - Statistical Study of **234 S0-Irr normal galaxies**

$L_X$ of disk and irregular galaxies ~ $L_{FIR}$ (i.e., star formation) – **HMXB populations**
$L_X$ of bulge spirals ~ $L_H$ (integrated stellar mass) – **LMXB populations**



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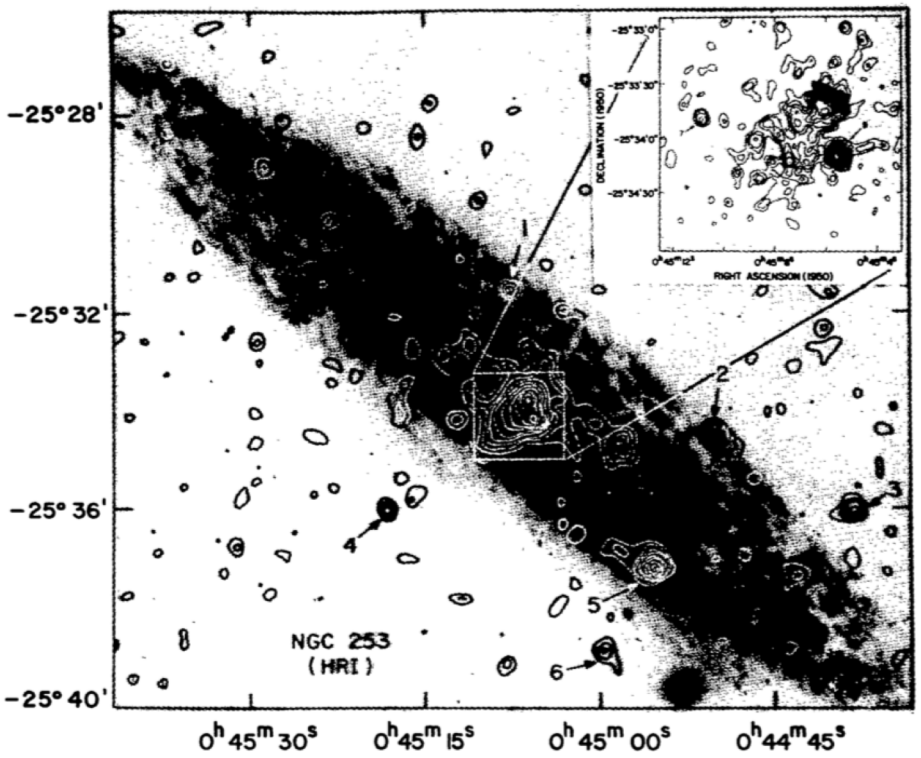
# *The basis for our understanding of the X-ray emission of galaxies*

Hot ISM and its properties

See Fabbiano 1989, ARAA




Hot outflows from starburst nuclei
NGC 253

Fabbiano & Trinchieri 1984

# *The basis for our understanding of the X-ray emission of galaxies*

Hot ISM and its properties

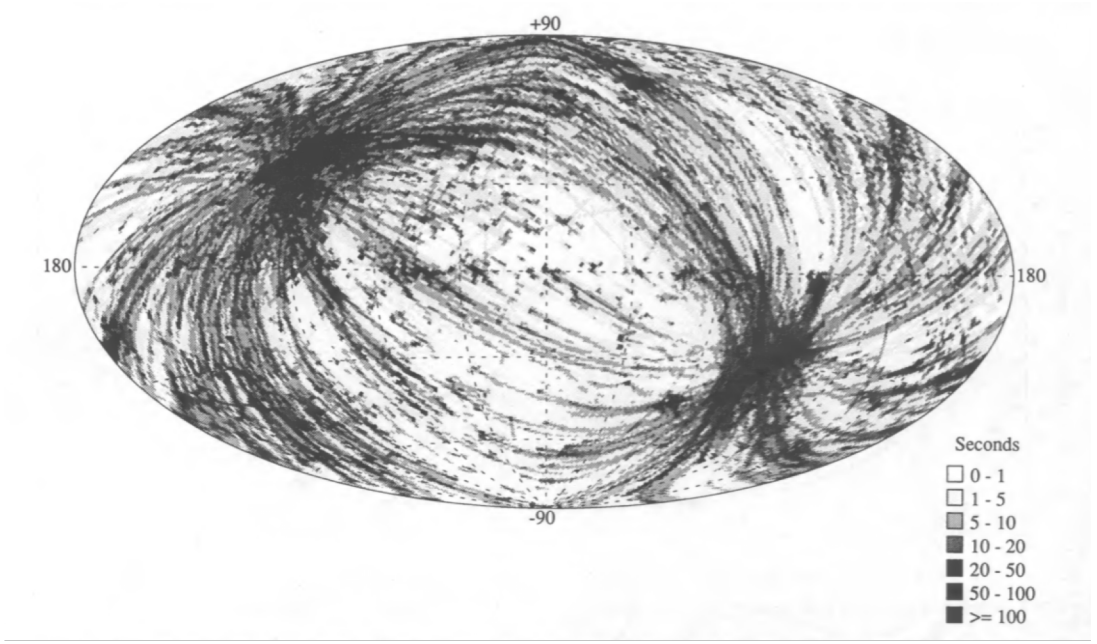
And now with Chandra we can study
LMXB populations &
'clean full range of hot ISM

Boroson et al. 2011

# Einstein Data Repurposing: the Slew Survey

Elvis et al. 1992

- Catalog of 819 sources detected during Einstein slews in between targets
- 313 not previously known
- Data distributed on CD-ROM
- Many are TeV Gamma ray sources



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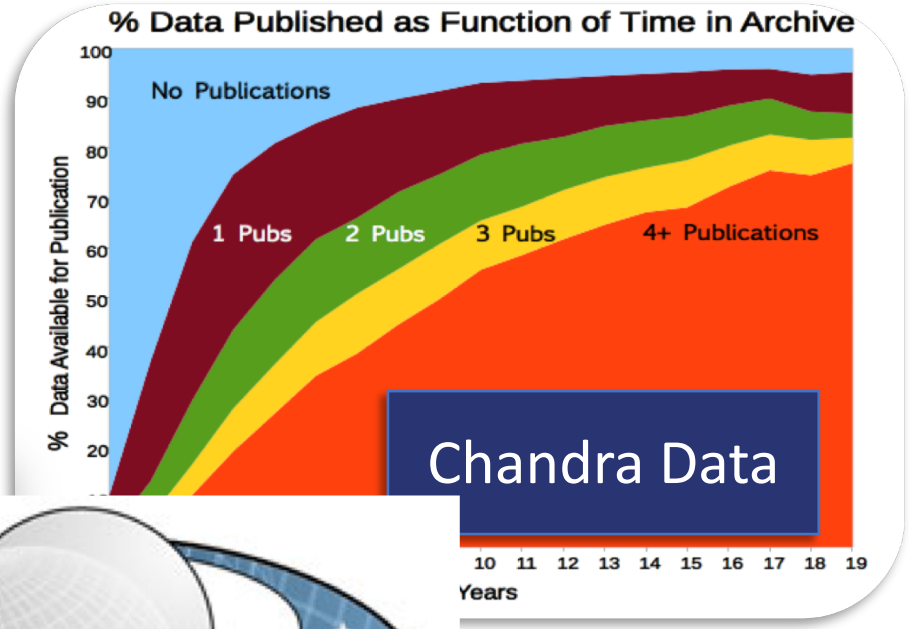
# Riccardo Giacconi and the Cultural Revolution in Astronomy

## Data beyond the end of the project

- Archival data get re-used, increasing their discovery potential with time




- The adoption of data interoperability standards for astronomy is a result of this philosophy
- Developed by the **International Virtual Observatory Alliance**

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# The legacy of Riccardo Giacconi and of the Einstein X-ray Observatory lives on, in

- Our understanding of the 'hot' universe
- The way we do astronomy