X-ray survey of H_2O maser galaxies

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Extragalactic H_2O masers

- Most observed line:
  - Rest frequency 22.23508 GHz (λ =1.3 cm)
    - $6_{16} \longrightarrow 5_{23}$ rotational transition
- Known extragalactic masers are **~ 100**
  - The majority are luminous (L_{H2O} can reach 23,000 L_{SUN}!!) and are found in dense and warm molecular clouds in the **central regions of AGN**, at a few parsec from nuclear engines
  - Have been discovered out to z=2.6!!!

(Impellizzeri, McKean, Castangia et al. 2008, Nature, 456, 927)

Extragalactic H_2O masers as astronomical tools

- H_2O masers can be mapped at high resolution with the Very Long Baseline Interferometry (VLBI) technique
  - They allow to study the structure and the dynamics of the gas in the inner parsecs of AGN:
    - Disk-maser studies → **Disk geometry and black hole masses** **(e. g. NGC 4258, Herrnstein et al. 1999)**
    - Jet-maser → **Evolution of the jet** **(e. g. Mrk348 Peck et al. 2003)**
- X-ray photons are produced in region even closer to the supermassive central object **(Risaliti et al. 2007)**
  - X-ray spectra can provide column densities and intrinsic luminosities

H_2O and X-rays

- **H_2O maser sources** associated with AGN tend to show a **high column density** ($N_H > 10^{23}$ cm^{-2}) or are even **Compton-thick** ($N_H > 10^{24}$ cm^{-2})

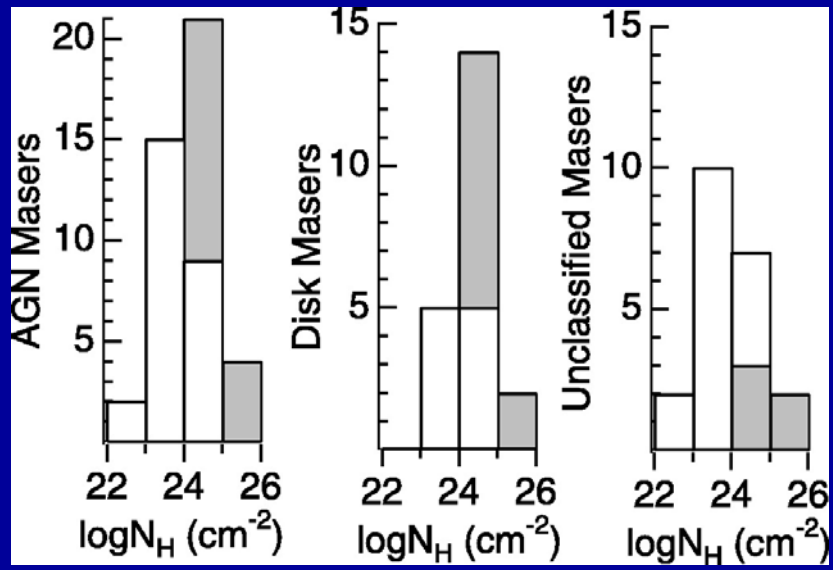
  (Zhang et al. 2006, Greenhill et al. 2008)

  – 76% of disk-maser are Compton-thick **(Greenhill et al. 2008)**

- **L_X** may shape the accretion **disk structure** (Tilak et al. 2008)

Statistics is <u>poor!</u>

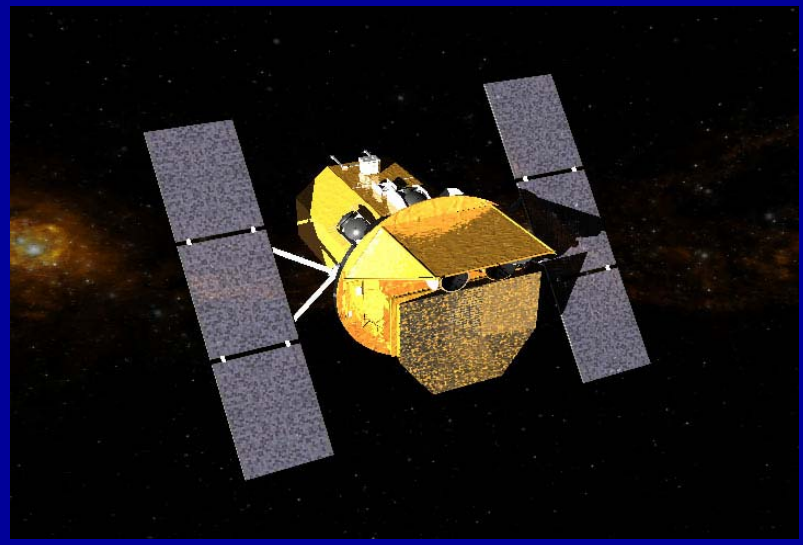
<u>Lack of X-ray data</u> for most of the known maser sources!



(Greenhill et al. 2008)

Swift survey

- **Swift intruments:**
  - **UVOT 170 – 650 nm**
  - **XRT 0.2 -10 keV**
  - **BAT 15 -150 keV**



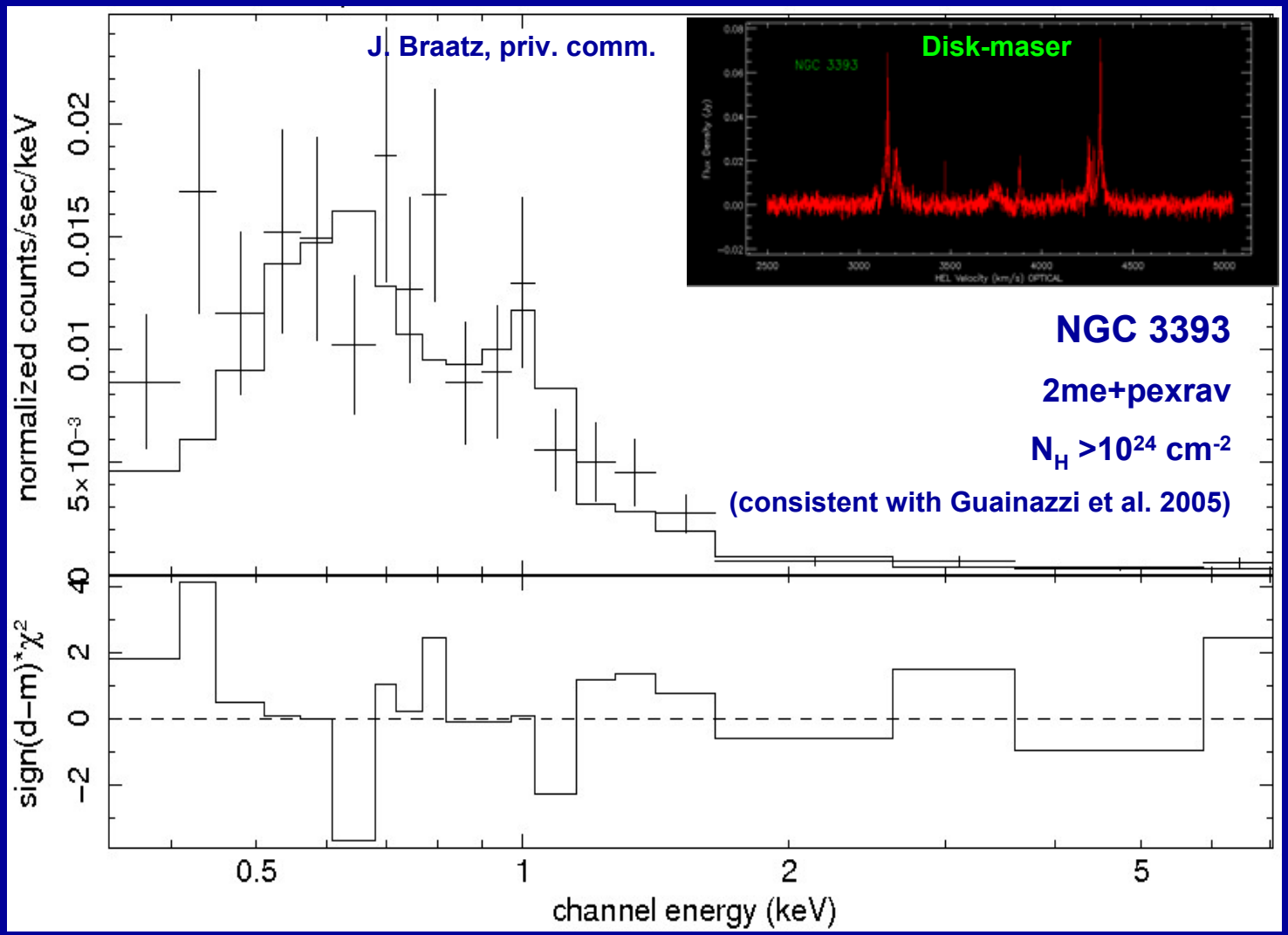
- **The sample: 95 galaxies** where H_2O emission is believed to be associated with AGN activity
  - **41** have no published N_H
- **Fill-in project**
  - 10 ks per galaxy

Swift survey
First results

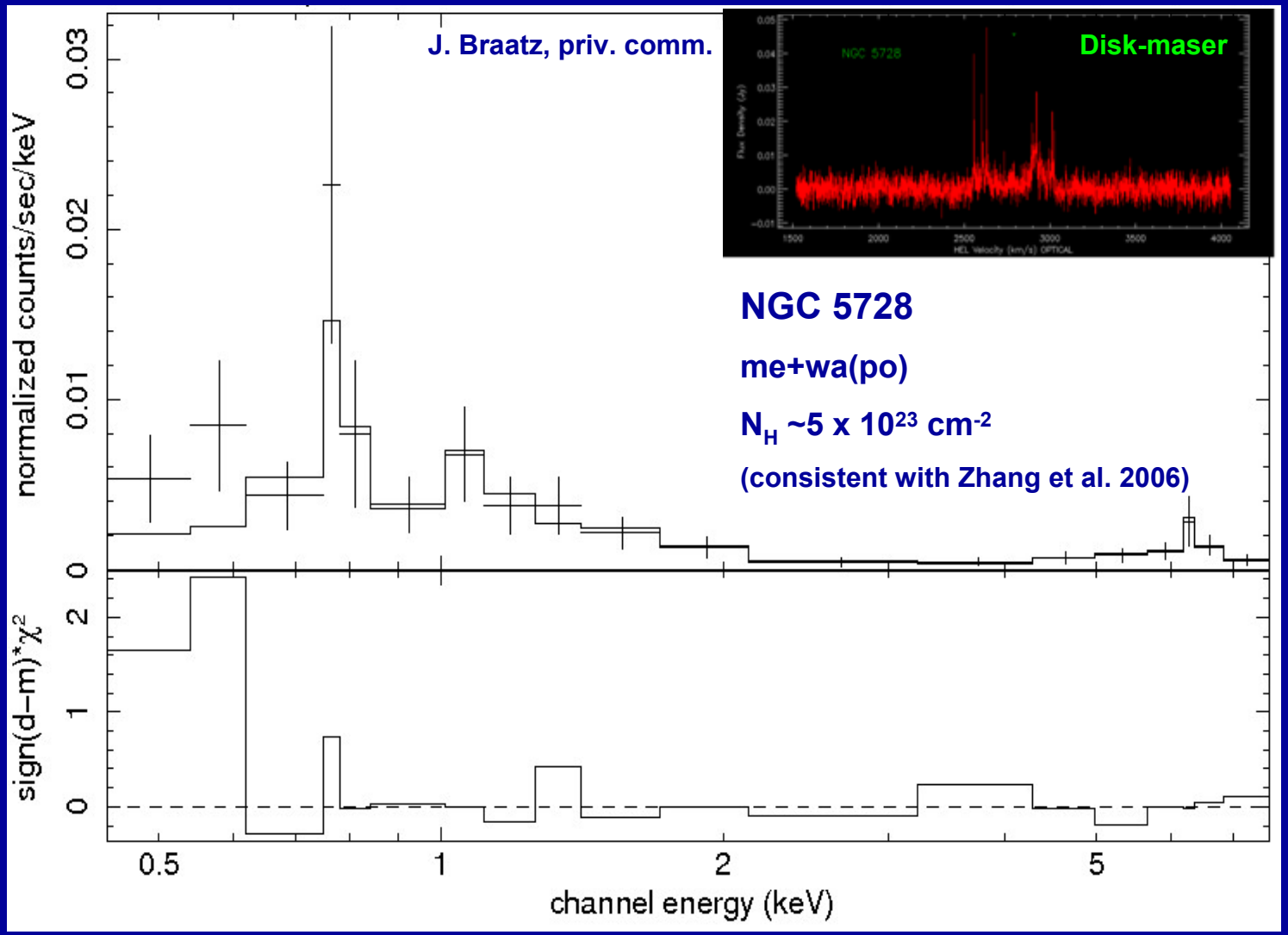
- Observations have been completed and ~ 70% of the data have been reduced

- Preliminary results:
  - **XRT 43/69 detections**
    - **14 new detections**
  - **BAT 26/91 detections**

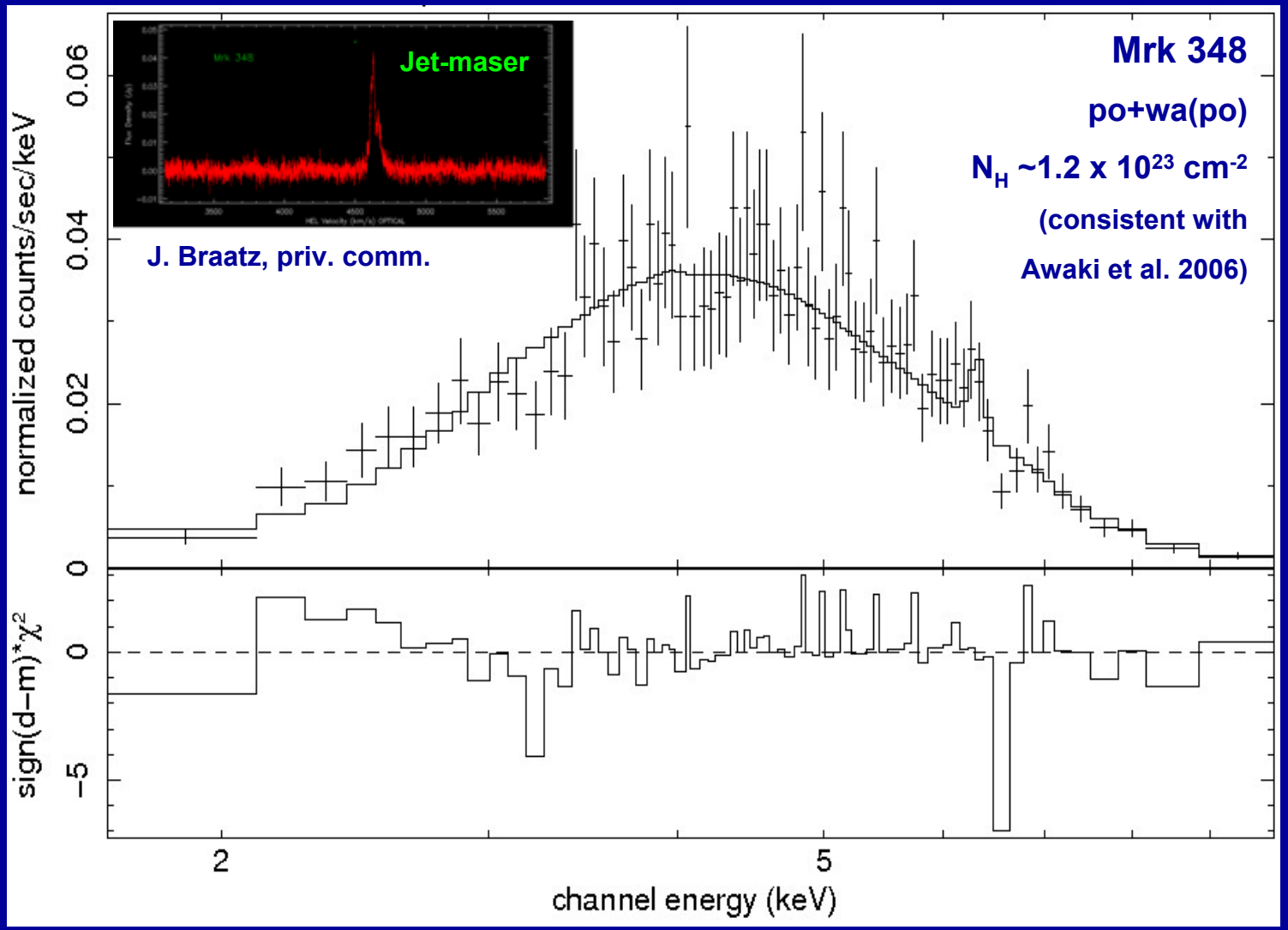
XRT spectra


J. Braatz, priv. comm.
Disk-maser
NGC 3393
NGC 3393
2me+pexrav
$N_H > 10^{24}$ cm^{-2}
(consistent with Guainazzi et al. 2005)
normalized counts/sec/keV
5×10^{-3}
0.01
0.015
0.02
sign(d−m)*χ^2
−2
0
2
4
0.5
1
2
5
channel energy (keV)

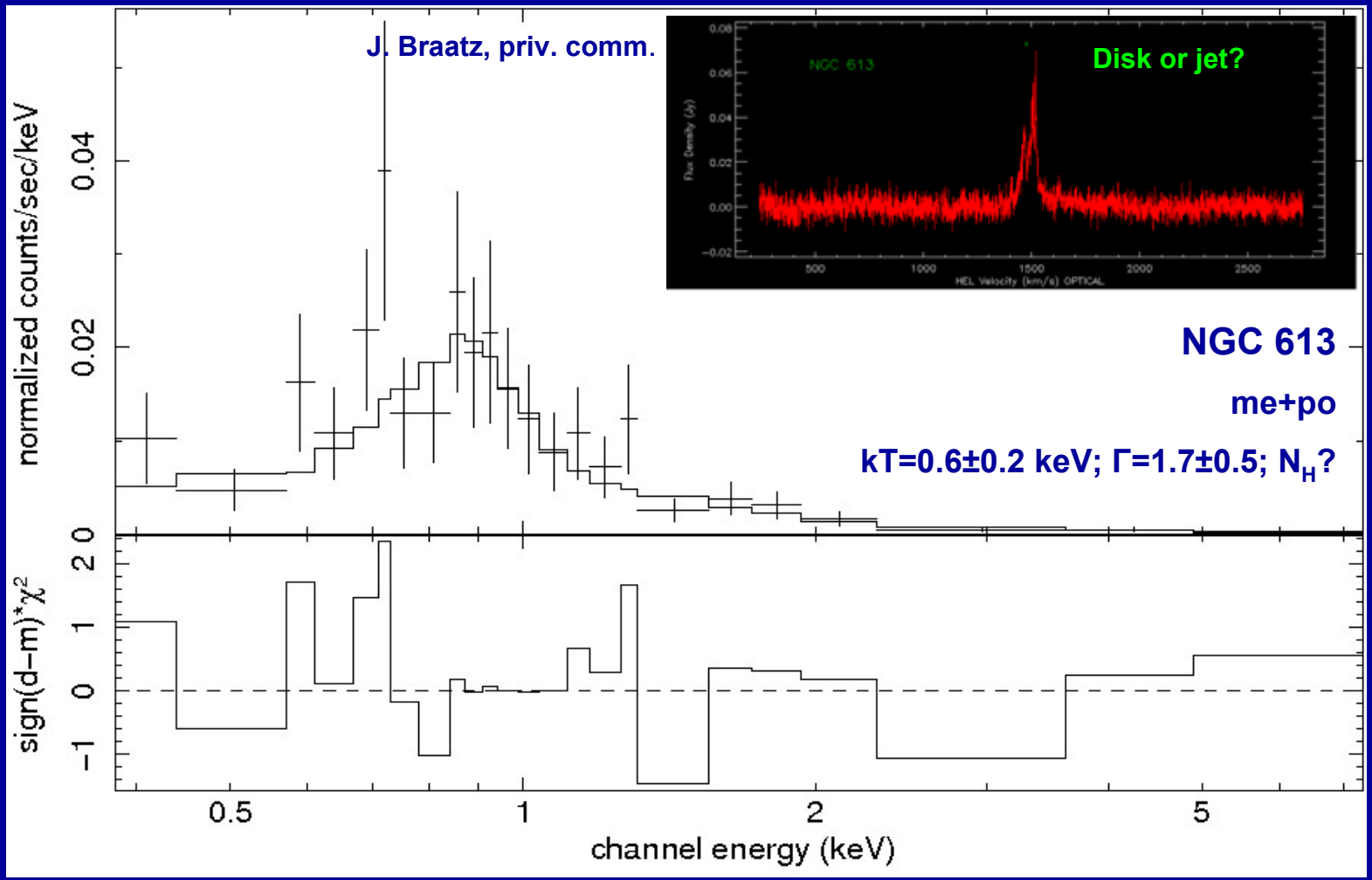
XRT spectra


J. Braatz, priv. comm.
Disk-maser
NGC 5728
me+wa(po)
N_H ~5 x 10^{23} cm^{-2}
(consistent with Zhang et al. 2006)
normalized counts/sec/keV
0.03
0.02
0.01
0
sign(d–m)*χ^2
2
1
0
0.5
1
2
5
channel energy (keV)

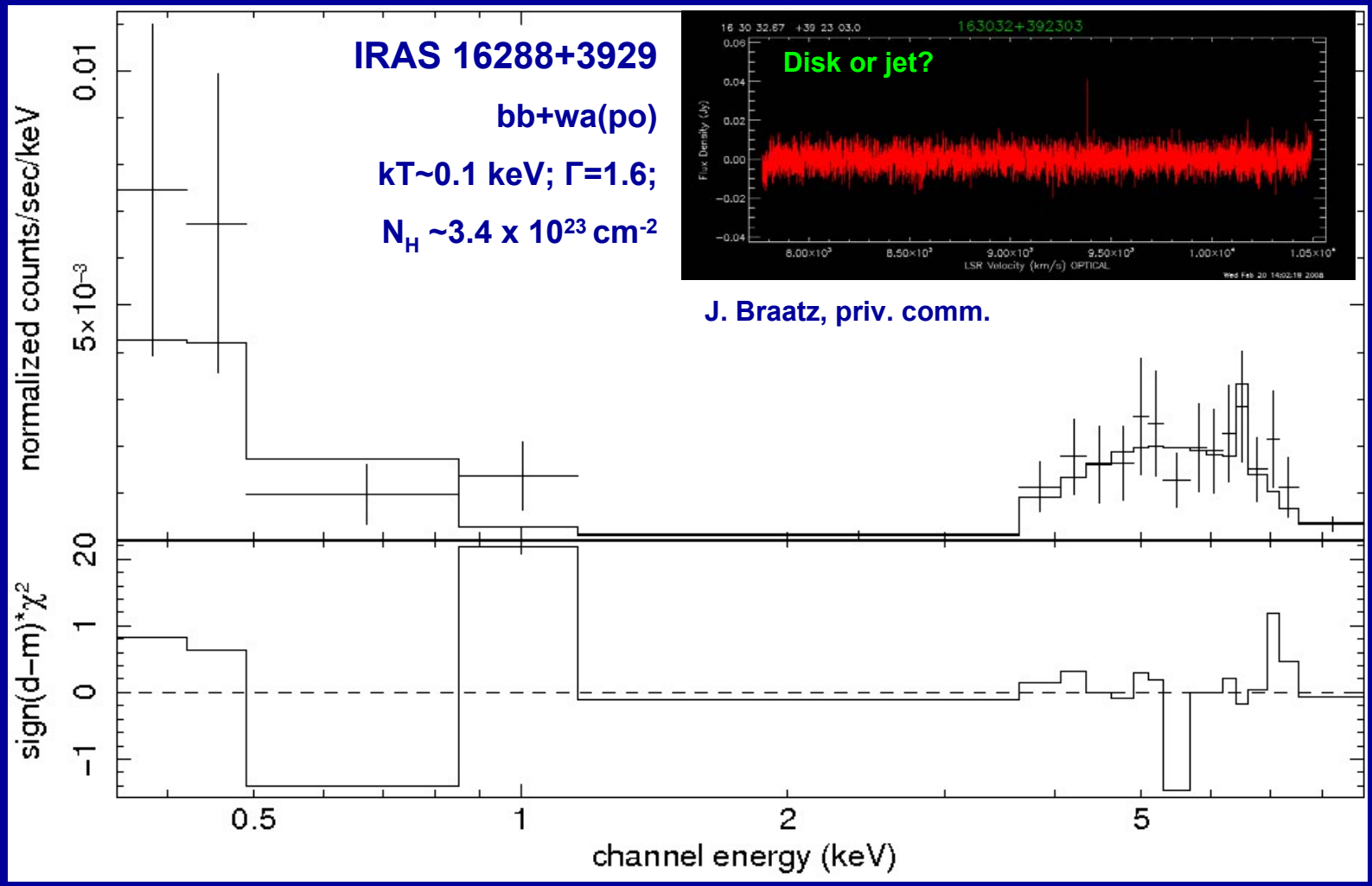
XRT spectra


Jet-maser
J. Braatz, priv. comm.
Mrk 348
po+wa(po)
N_H ~1.2 x 10^{23} cm^{-2}
(consistent with
Awaki et al. 2006)
normalized counts/sec/keV
0.06
0.04
0.02
0
sign(d–m)*χ^2
0
−5
2
5
channel energy (keV)

XRT spectra: new detections



XRT spectra: new detections



Summary and future work

- We have performed a survey of all AGN water masers using Swift
  - 30% increase of the number of H_2O sources with X-ray data
- Future work
  - Complete data reduction and spectral fitting including BAT information
  - Follow-up new detections with Swift or other X-ray telescopes
  - Analyze the statistical result of the entire sample (N_H distribution, L_X versus R_{H2O}, ect.)