Understanding the build-up of SMBH and Galaxies

Francisco J. Carrera
(IFCA, CSIC-UC, Spain)
A. Georgakakis (MPE, Germany), Y. Ueda (Kyoto U., Japan)
A. Akylas (NOA, Greece), G. Lanzuisi (OABo, INAF, Italy),
N. Castelló (Tel Aviv U., Israel)
(building on work by the Athena SWG2.2)

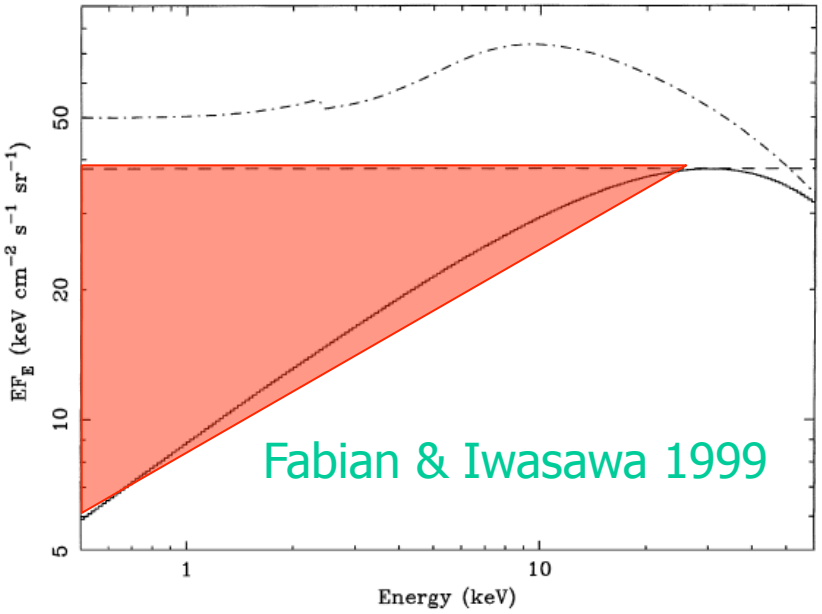
"Exploring the Hot and Energetic Universe", ESAC, Spain, 9-September-2015

Outline

- Why care?
- SWG 2.2 (SWG2.2-TN-0001_ASIE.pdf)
  - Heavily obscured AGN
  - Ionised absorption in AGN
  - Ultra-Fast Outflows in AGN
  - Moderate velocity outflows in AGN
  - Astrometry
- X-ray-only spectroscopic redshifts: survey/serendipitous
- Synergies/interactions between SWG (and the community)
- Summary

Why care?

- Most energy emitted from accretion in the Universe is obscured
- Relationship between build-up of SMBH and growth of host galaxies:
  - through obscured phase z~1-4



- Unclear (but significant) contribution of Compton Thick (CT) objects
- One possible mechanism of direct influence of AGN on host galaxy: outflows (also radiation and jets, but another SWG)
  - Warm absorbers (WA)
  - Ultra-Fast Outflows (UFO)

SWG2.2: Understanding the Build-up of SMBH and Galaxies

- Athena: wonderful capabilities
- At this stage: concentrating in (too?) simple requirements, uniform across topics
  - 10 objects/bin (~3 σ detection)
  - 5 σ detection of individual spectral features
  - …
- In SWG2.2: concentrating in z~1-4, L_X~L* and statistics of populations (other SWG for z< and z>)
  - Heavily obscured AGN: deep survey, WFI spcpy
  - Ionised absorption in AGN: wide survey, WFI spcpy
  - Ultra-Fast Outflows in AGN: wide survey, WFI spcpy
  - Moderate velocity outflows in AGN: dedicated, X-IFU spcpy
  - Astrometry

Methodology

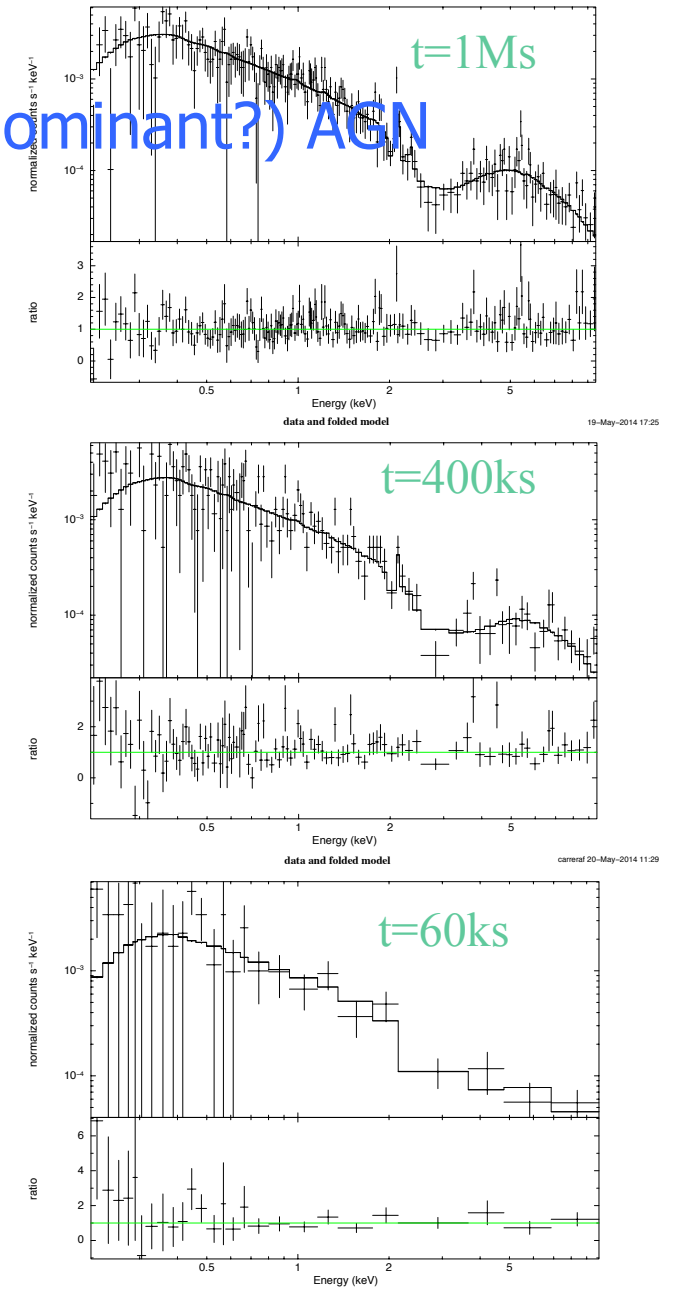
- Divide parameter space in bins (hyper-cubes):
  - z, L_X, N_H, ξ , $v_{turbulence}$…
- Explore different exposure times:
  - Survey geometry (~proposal: 4×1Ms+10×400ks+235×60ks )
  - Dedicated
- Analysis of (many) spectroscopic simulations to quantify:
  - Exposure time needed to get a given quality in a given parameter bin
  - Area/Exposure time needed to get a given number of sources
  - (Impact of de-scoping options)
  - …

Heavily obscured (CT) AGN

- Complete census of heavily obscured (dominant?) AGN
- Recovering within 30% L_X and N_H (CT: $\log(N_H/cm^{-2})=24.5,25.5$) using only WFI spectrum and z
- Brightman&Nandra'11 torus
- Gilli+07 CXB model
- Can do it for L* for z≤3
- Need ≥400ks exposure
  - If different model/bins
  - If $L_X=10^{44}$ erg/s,z=1

  ⇒ +(3-10)×700ks
- Of course, in "real life" synergies with multi-λ data

$\log N_H=24.5$
$L_X(2\text{-}10keV)=5\times10^{44}$ cgs z=2



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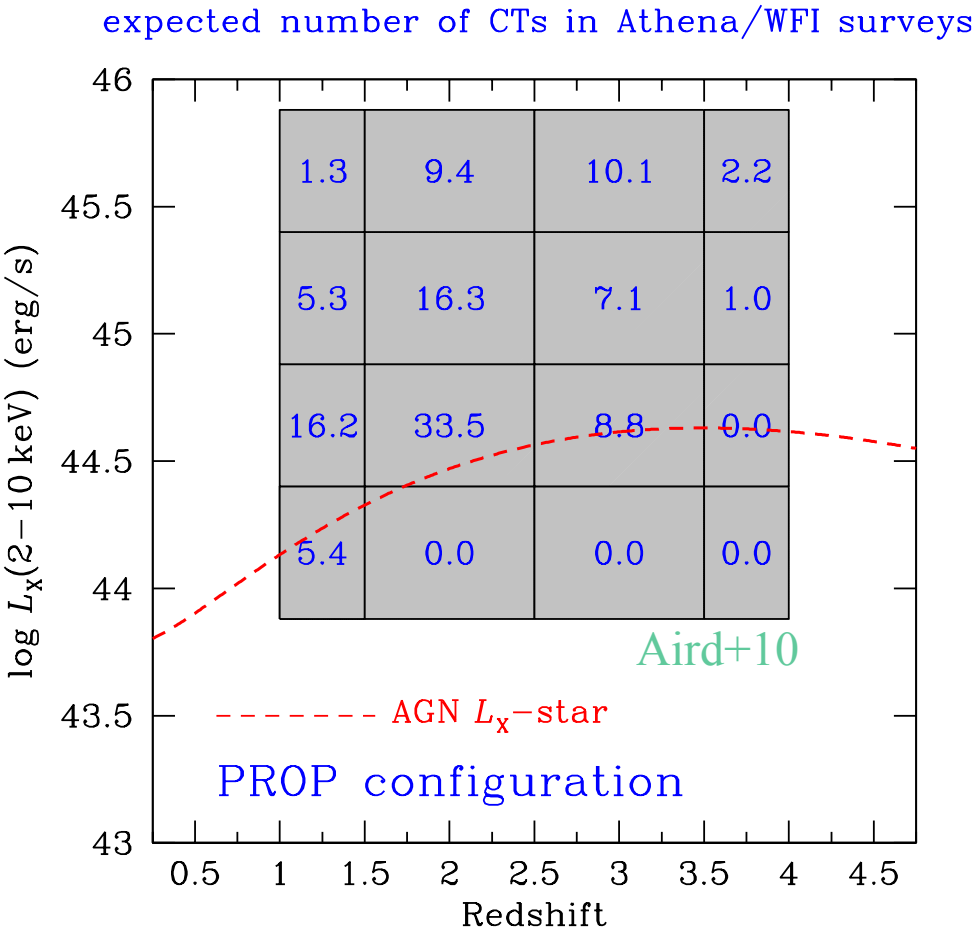
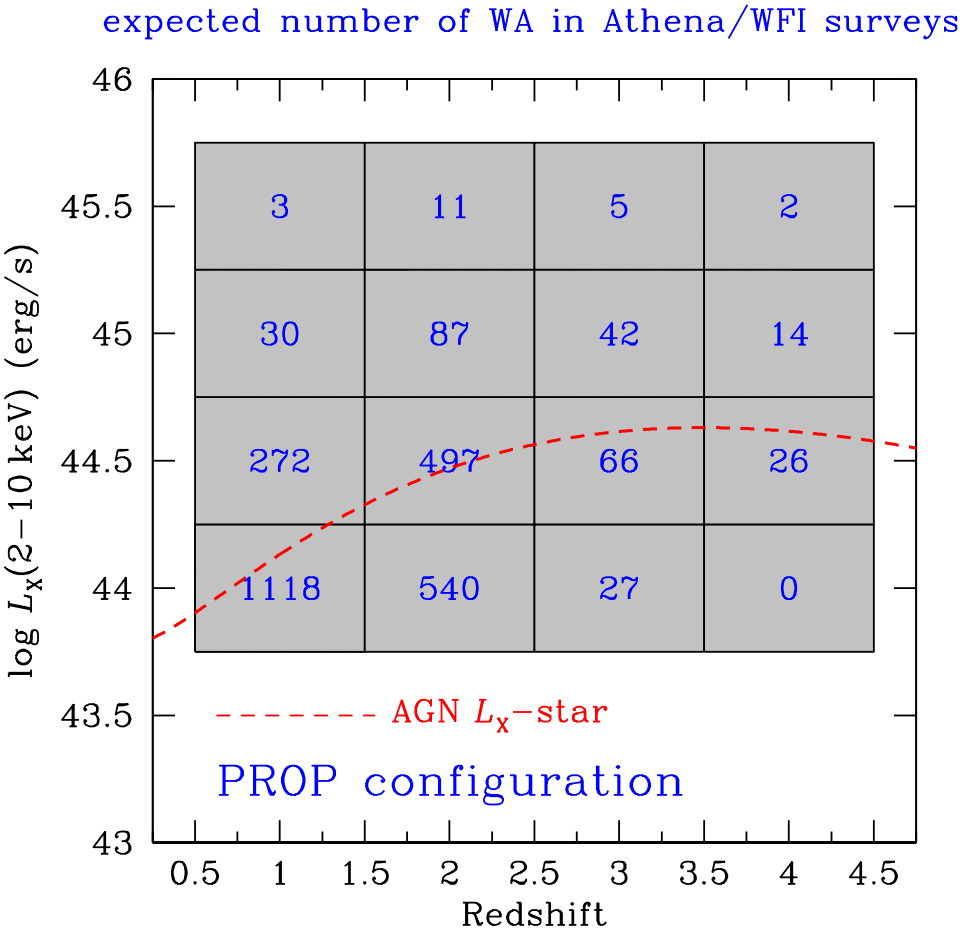


⇒ $N_{CT}\gtrsim$10 L* z≤4, L*/10 z≤2

Ionised absorption in AGN

- Aims:
  - Determine incidence of WA in general population of AGN
  - Provide targets for detailed X-IFU studies
- Recovering within 50% $\log \xi$ (2-4) and $N_{H,ion}$ ($\log(N_{H,ion}/cm^{-2})$=22-24) using only WFI spectrum
- Ueda+03 XLF, 40% WA (Blustin+05)
- Using wide (60ks) tier of survey
- Can do it for L* for z≤4



Ultra-Fast Outflows in AGN

- Determine incidence, duty cycle and energetics of UFOs
- Detecting 6.7keV abs. feature at >5σ using only WFI spectrum
- $\log \xi$ =3.5, $\log(N_{H,ion}/cm^{-2})$=24), v_{turb}=3000 km/s, v_{out}=0.1c Lanzuisi +12
- Ueda+03 XLF, 30% UFO (Tombesi+10)
- Using wide (60ks) tier of survey: transient
- Can do it for $\log(L_X/erg/s)\geq 44$ for $z\leq 4$

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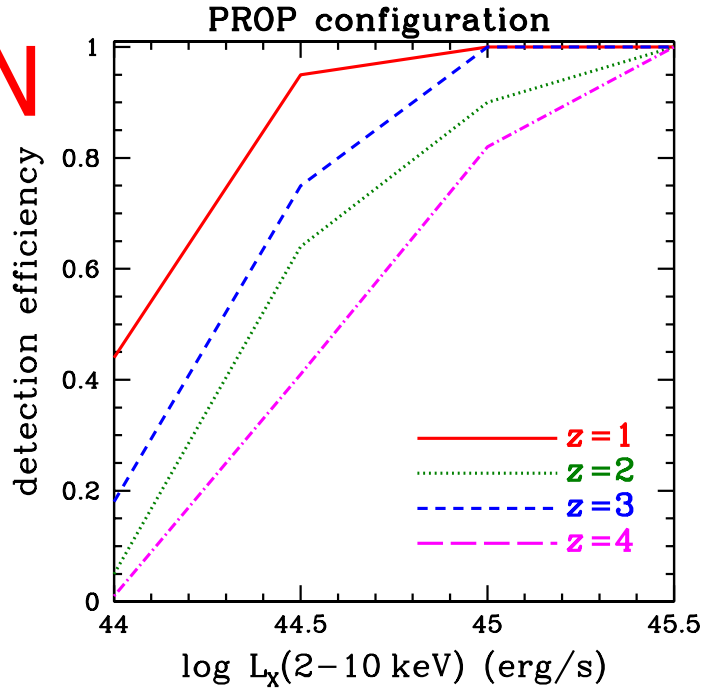

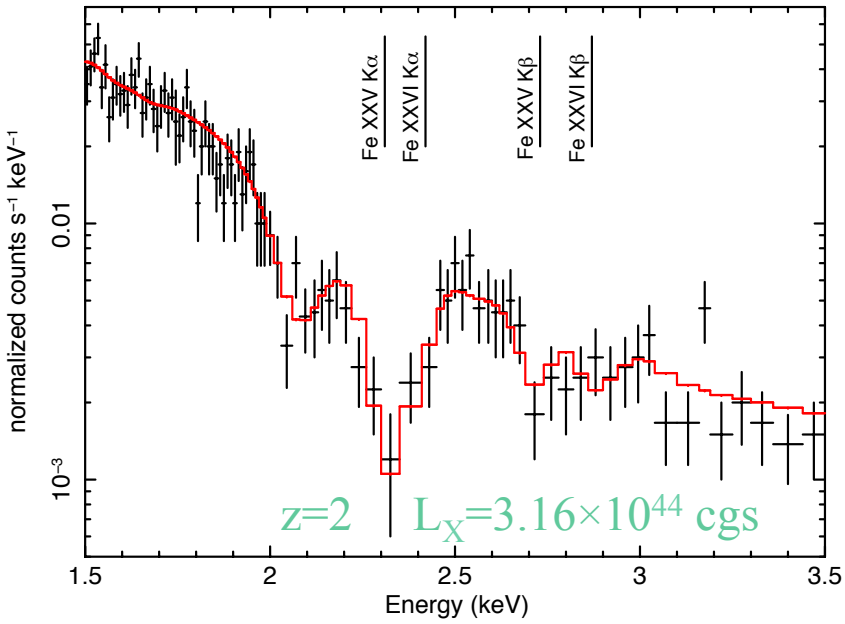

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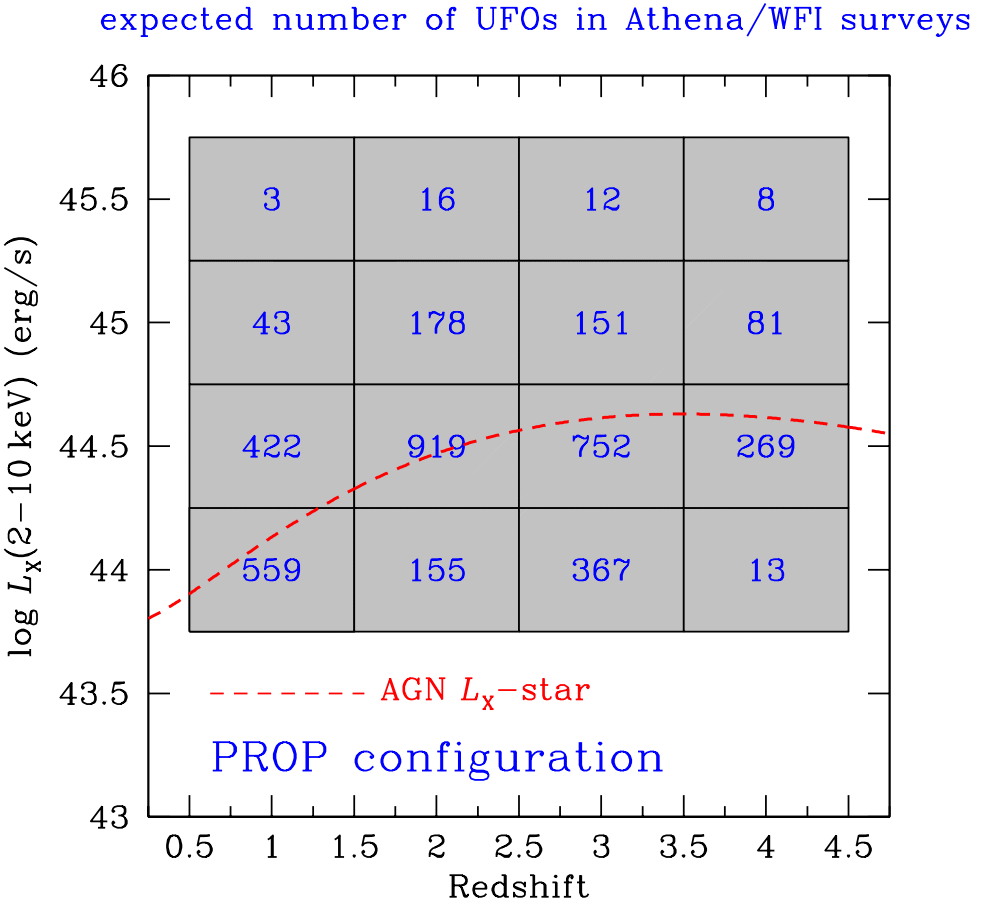
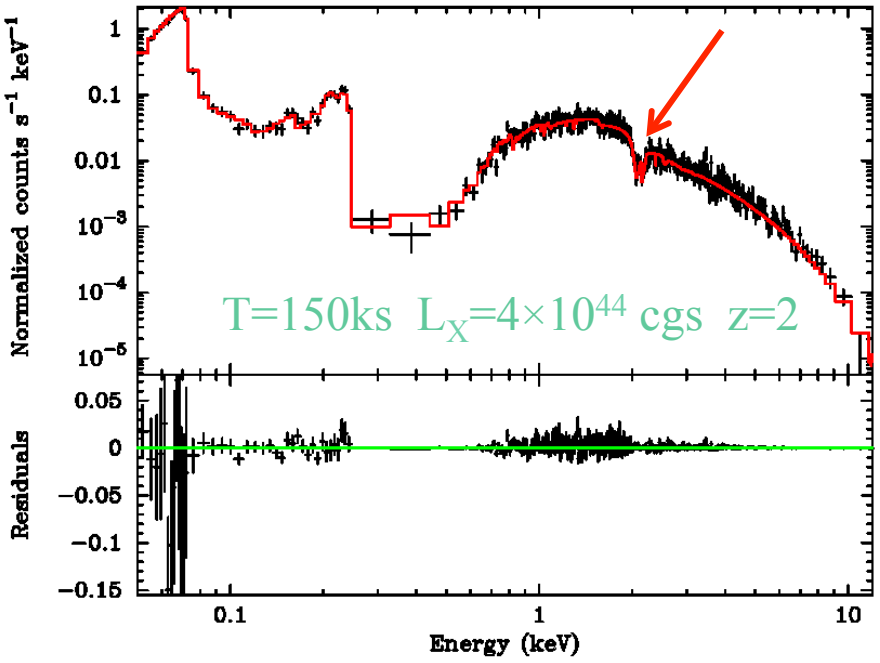
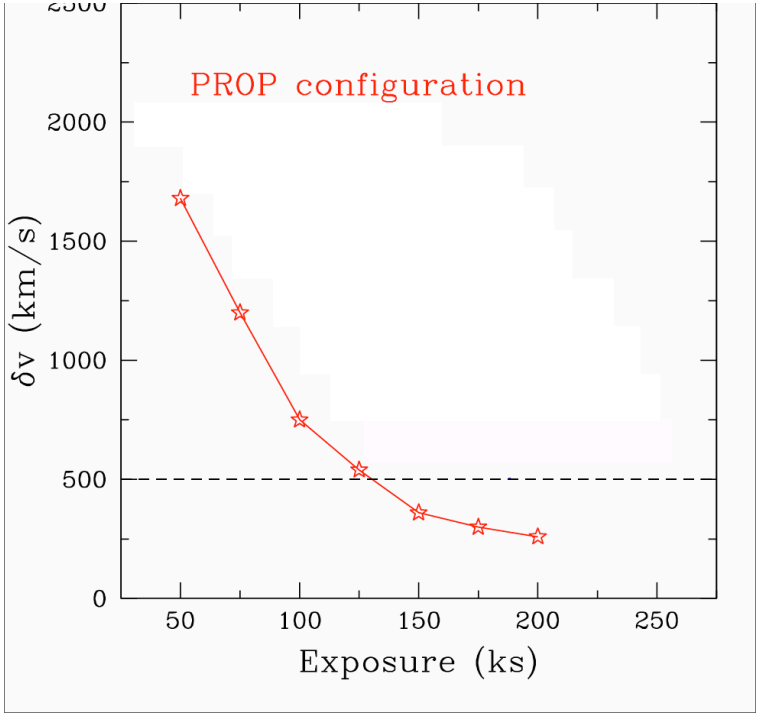


Moderate velocity Outflows in AGN

- Measure mechanical energy of moderately ionised outflows for $L_X \geq L^*$ at z=1,2
- Outflow veloc. uncertainties <500km/s, 5σ detection of $v_{out} \geq 2500$km/s using only X-IFU spectrum
- $\log \xi = 2.5$, $\log(N_{H,ion}/cm^{-2}) = 23.5$, $v_{turb} = 100$ km/s
- Need ≥125ks
- Pointed observations: ~3Ms for 10 sources in each of $\log(L_X/cgs) = 44.5, 45, 45.5$ and z=1,2





Requirements on astrometry

- Fractional increase f in the uncertainty in the number of objects in some bin is below some level
- Using Poisson statistics

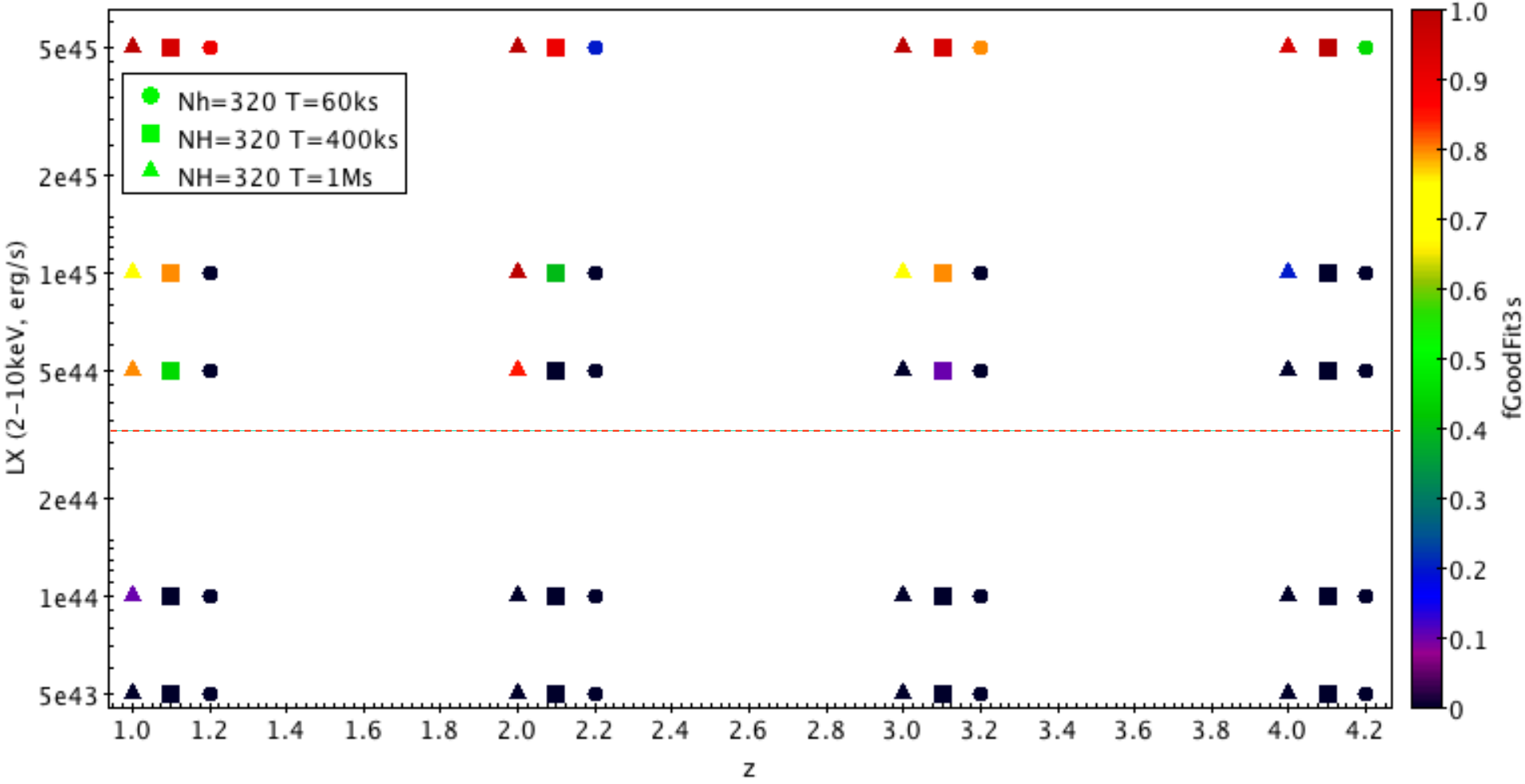
$$f = \sqrt{2 - e^{-\pi\mu R^2}} - 1$$

  - μ: sky density of spurious counterparts
  - R: positional uncertainty radius
- For CT AGN, z=3.5:
  - SED NGC6240: K~21.4 ⇒ μ~51000 deg^{-2}
  - For R=3arcsec (requirement): f=5% Good
  - For R=1arcsec: f<1% Excellent

X-ray spectroscopic z

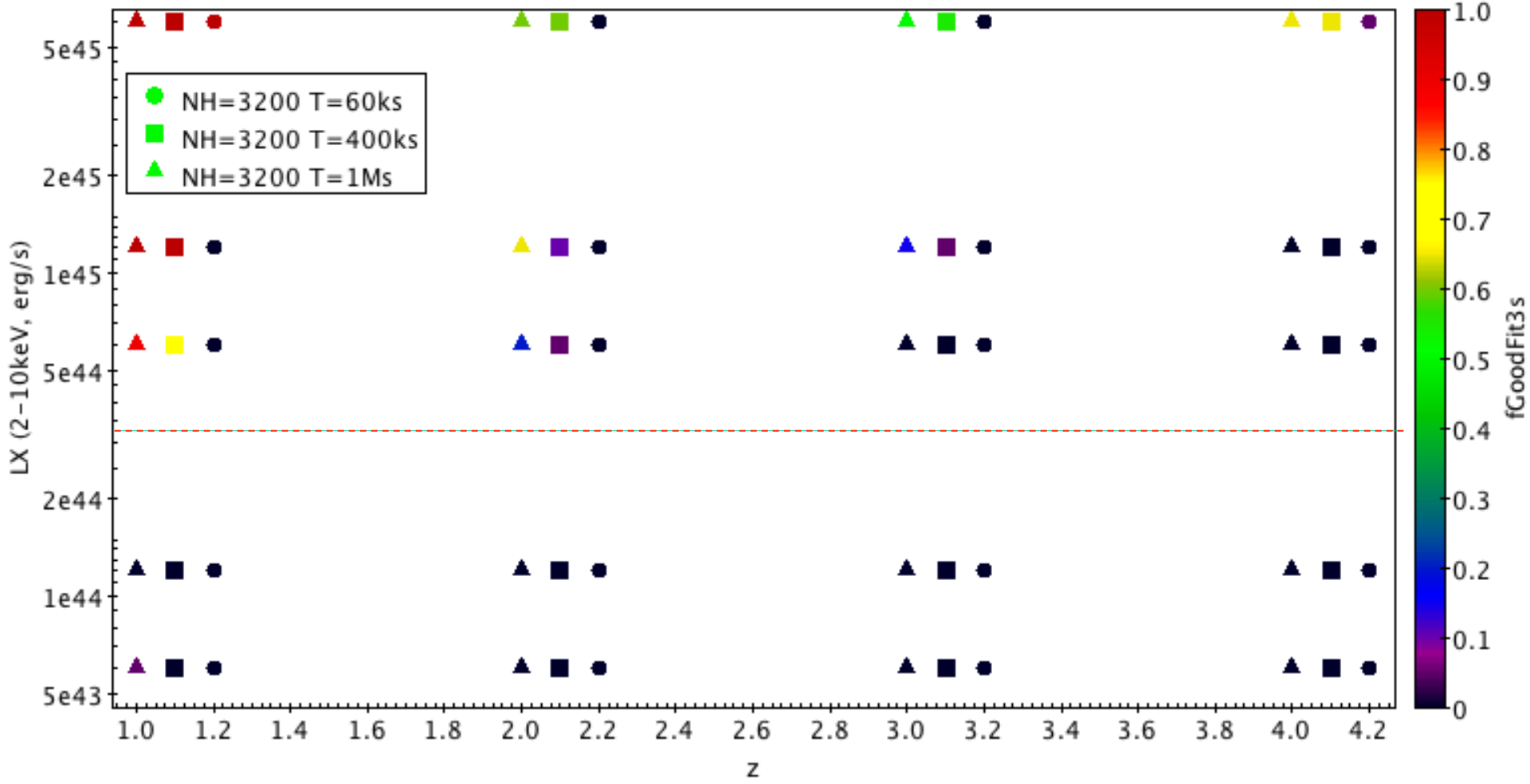
- Using method of Castelló+11, essentially:
  - FT analysis of ratio between spectrum and simple model, to look for peaks of emission
  - Spectral fit with FT peak energy as initial input for line
- Preliminary tests with simulated CT AGN spectra
  - Estimated fraction of sources in each z,L_X bin for which fractional error in line redshift ≤10%
  - Different values of N_H,T_{exp}

X-ray spectroscopic z: $\log(N_H/cm^{-2})=24.5$



- ● T_{exp}=60ks: ≳50% for L≥5×10^{45}erg/s for z≤4
- ■ T_{exp}=400ks: ≥50% for L≥10^{45}erg/s for z≤2
- ▲ T_{exp}=1Ms: ≥70% for L>L* for z≤2

X-ray spectroscopic z: $\log(N_H/cm^{-2})=25.5$



- ● T_{exp}=60ks: >80% for L>5×10^{45}erg/s for z≤1
- ■ T_{exp}=400ks: ≥50% for L≥5×10^{45}erg/s for z≤4
- ▲ T_{exp}=1Ms: ≥50% for L≥10^{45}erg/s for z≤2

Synergies/interactions between SWG

- Related activities in other SWG: coordination?
  - SWG 2.1: Formation and growth of earliest SMBH: z>>
  - SWG 2.3: Feedback in local AGN and SF galaxies: z<<
  - SWG 3.5: Multi-wavelength synergy
  - SWG 1.3: AGN feedback in gal. clusters and groups: acc. modes
  - Instrument: MWG 5.2 (background), MWG 5.4 (end-to-end simulations), MWG 5.5 (Advanced analysis tools)
- Main open issue:
  - Good (and scientifically active) membership
  - Engaging them into SWG 2.2 activities

Summary

- Athena wonderful machine
- SWG2.2: Understanding the Build-up of SMBH and Galaxies
  - Relevant for assembly and evolution of galaxies
  - Concentrating in z~1-4 and L_X~L*
  - Statistics of populations
  - Spectroscopic simulations and analysis
  - Requirements (simple)
- Different aspects:
  - Complete census of heavily obscured AGN: deep WFI survey
  - Determine incidence of warm absorbers in AGN: wide WFI survey
  - Determine incidence, duty cycle and energetics of UFOs: wide WFI survey
  - Measure mechanical energy of moderately ionised outflows: dedicated X-IFU
- Interactions with other SWG: z>, z<, multi- λ ...
- Need to engage the community: concrete tasks and long-term