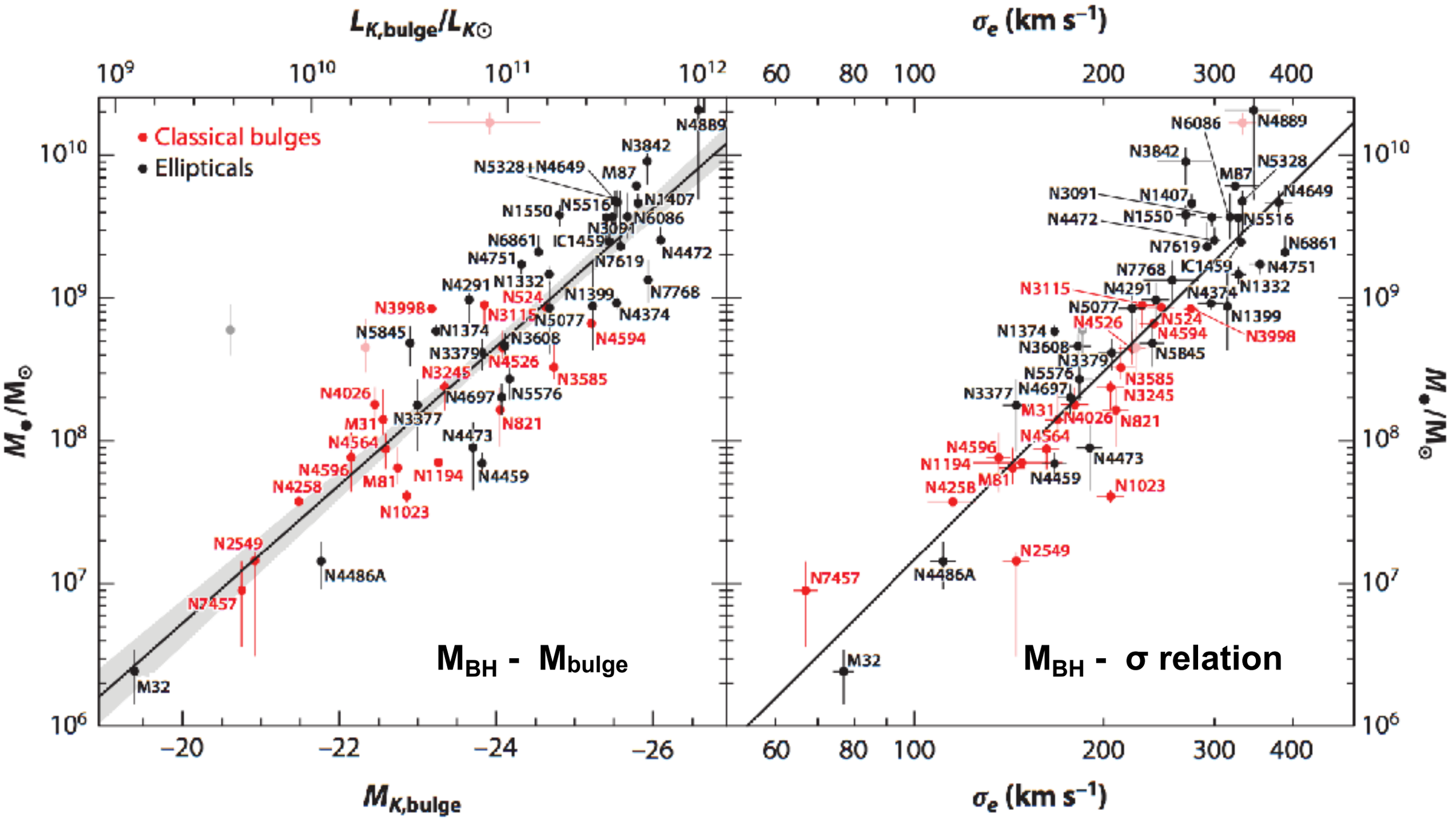
Feedback in local AGN and star-forming galaxies

Y. Terashima (Ehime U.)
SWG 2.3
co-chair G. Ponti, A. Ptak

Contents

- Importance of Feedback
- AGN outflows
- Starburst driven wind

Observational requirement for feedback

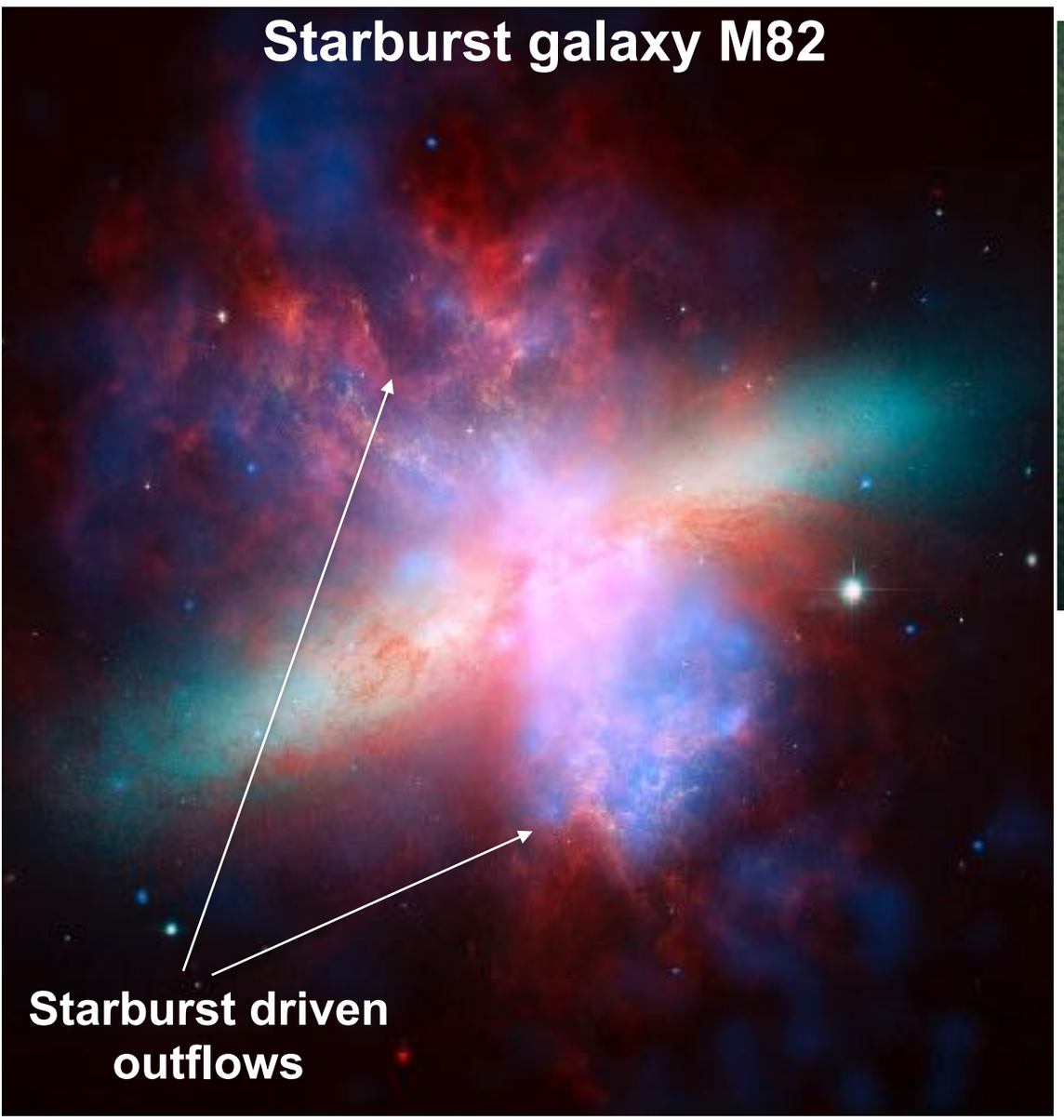


Ferrarese, Merrit +00; Gebhardt +00; Kormendy +01; Merrit +01; Haring & Rix 04; Kormendy & Ho 13

A deep link between BH and host galaxy ➜ Feedback

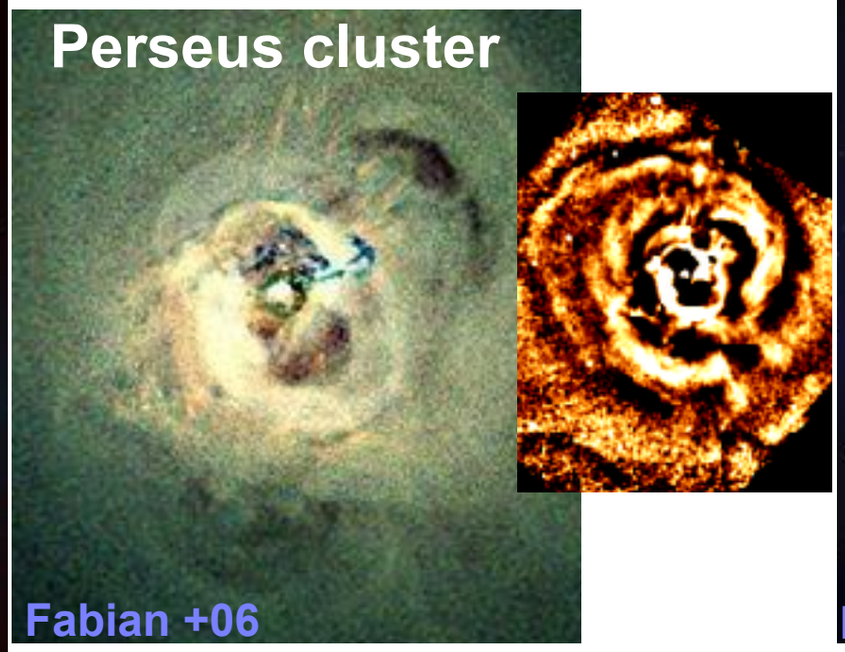
Different modes of feedback

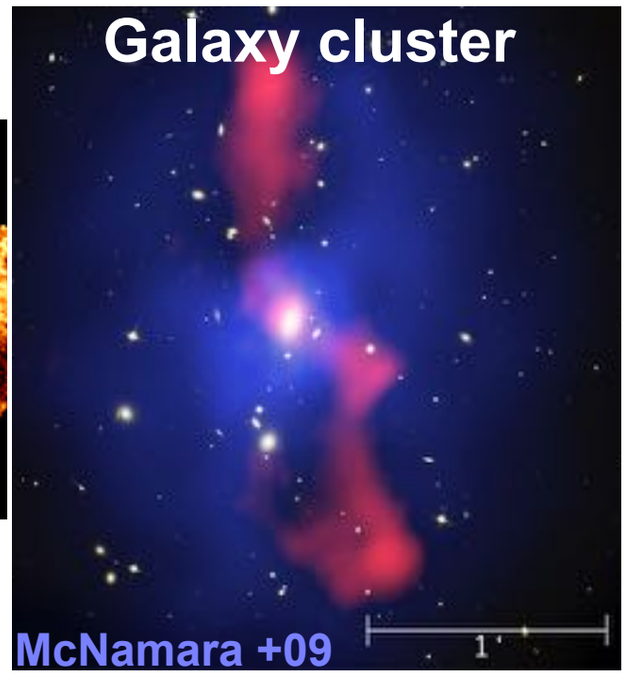
Starburst galaxies



AGN

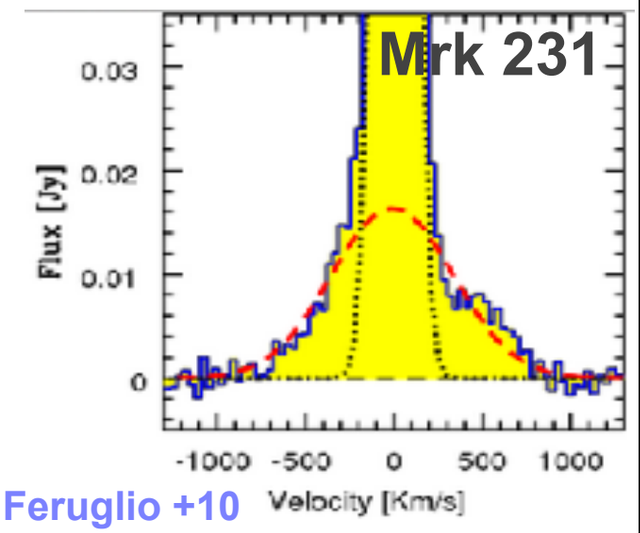
Radio mode

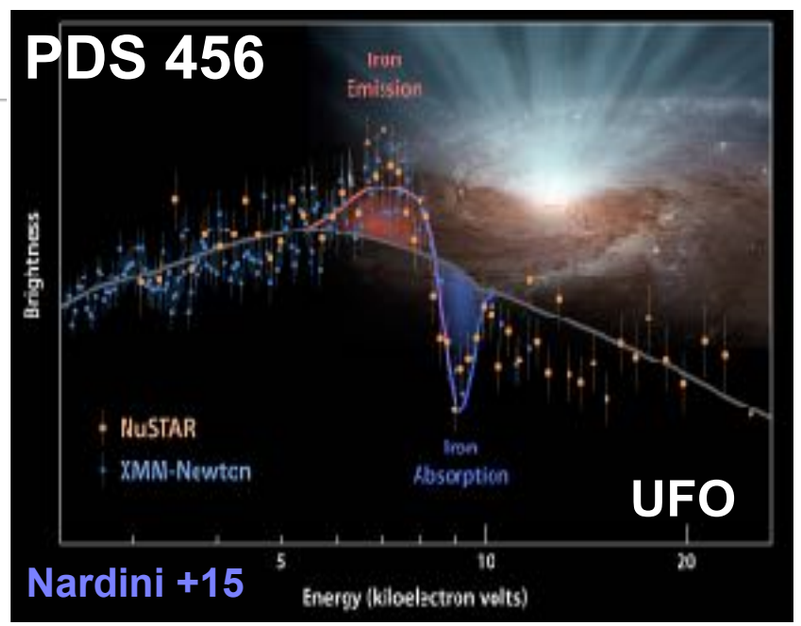




Quasar mode

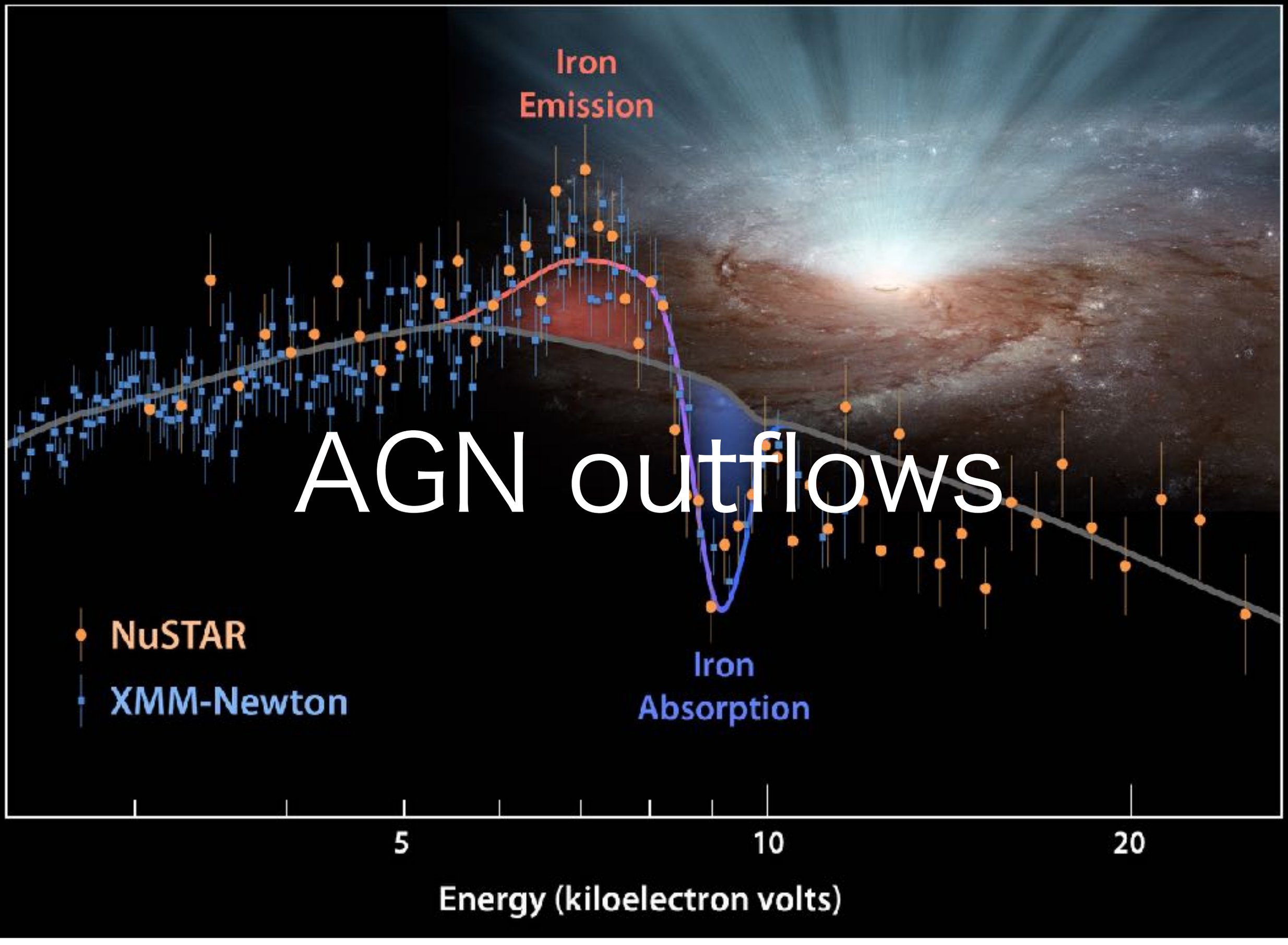
Lots of evidence for winds (BAL QSO, WA, X-ray obscurers, BLR?) But powerful enough?





Feedback in action!

AGN outflows



Overview

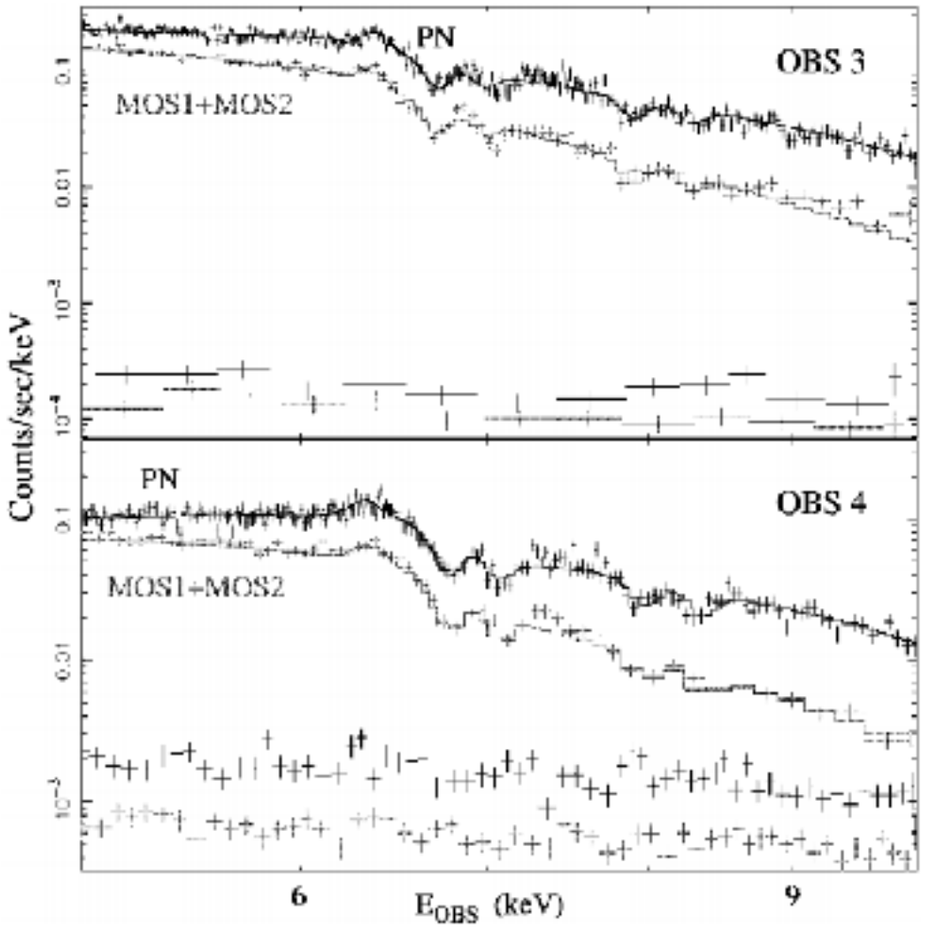
- AGN feedback is necessary to establish BH-host co-evolution

- massive/fast AGN outflows seen in X-rays are most probably provide feedback

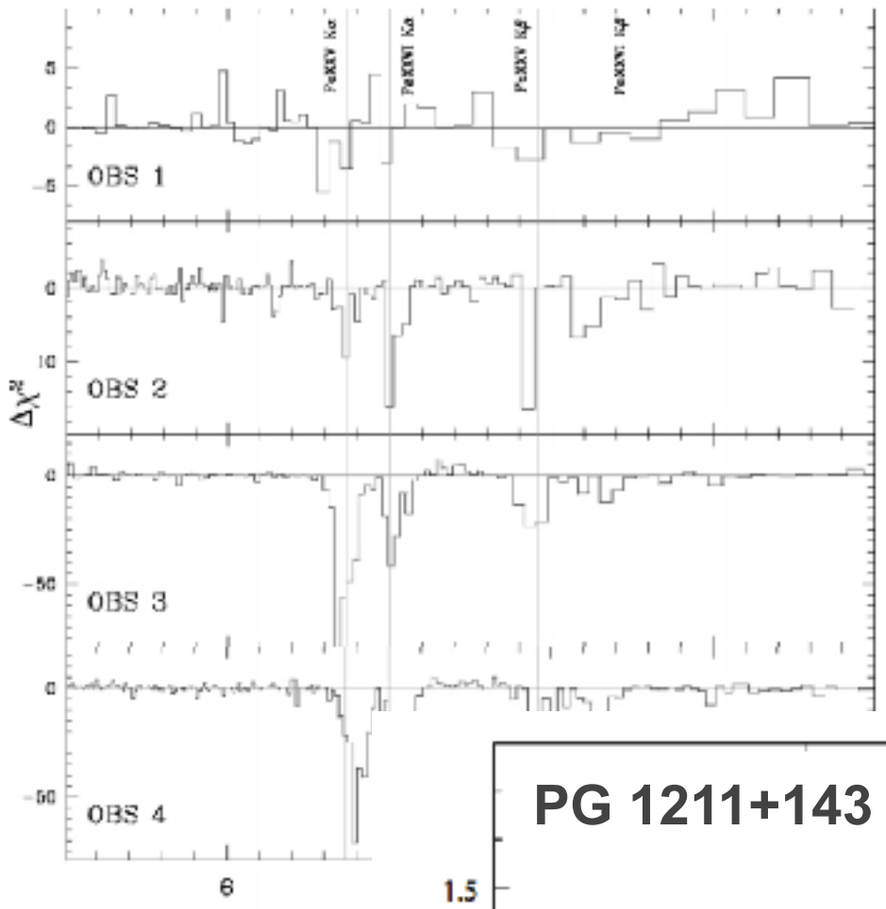
- Energetics/physical processes (how to regulate host star formation) are still unclear

Ultra Fast Outflows in AGN

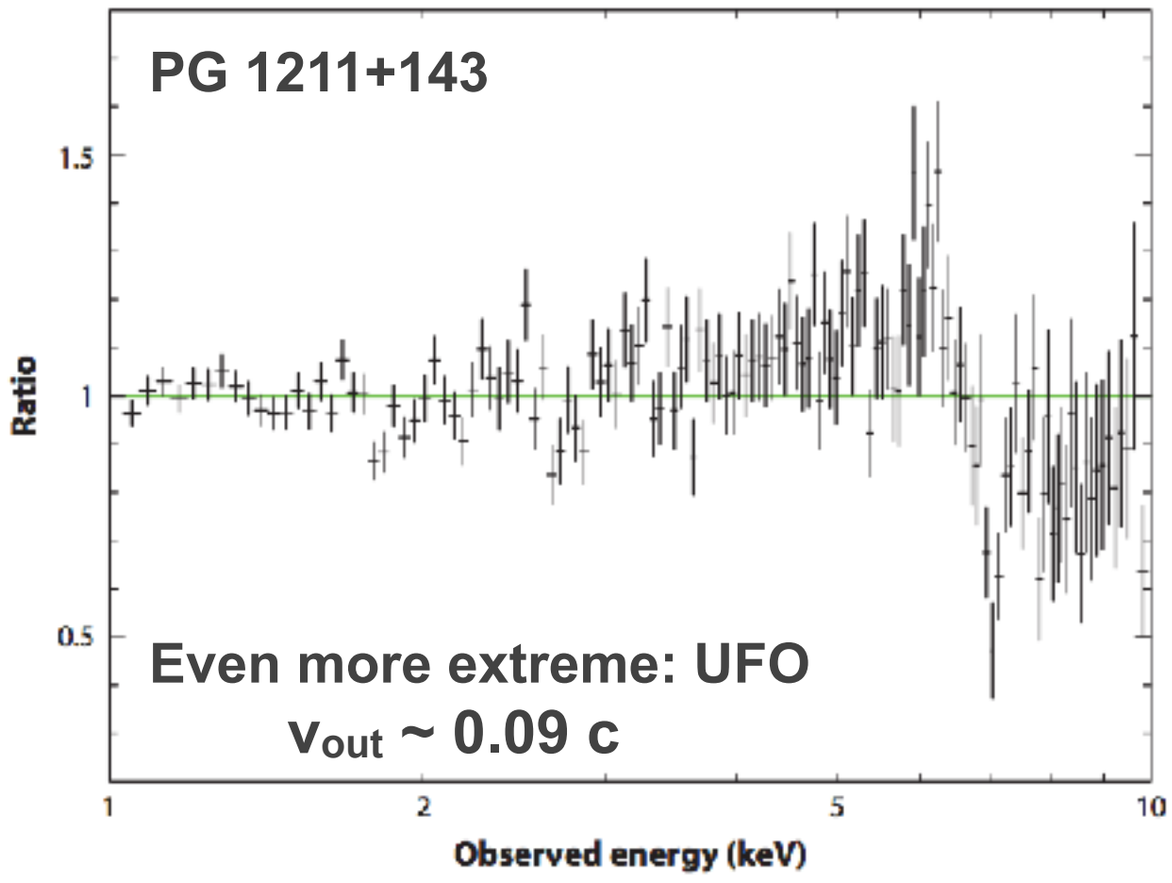
The extreme WA case of NGC 1365



Risaliti +05



Pounds +03; +06; 09; King +15



The Fe K band reveals an extreme high ionisation component of the WA

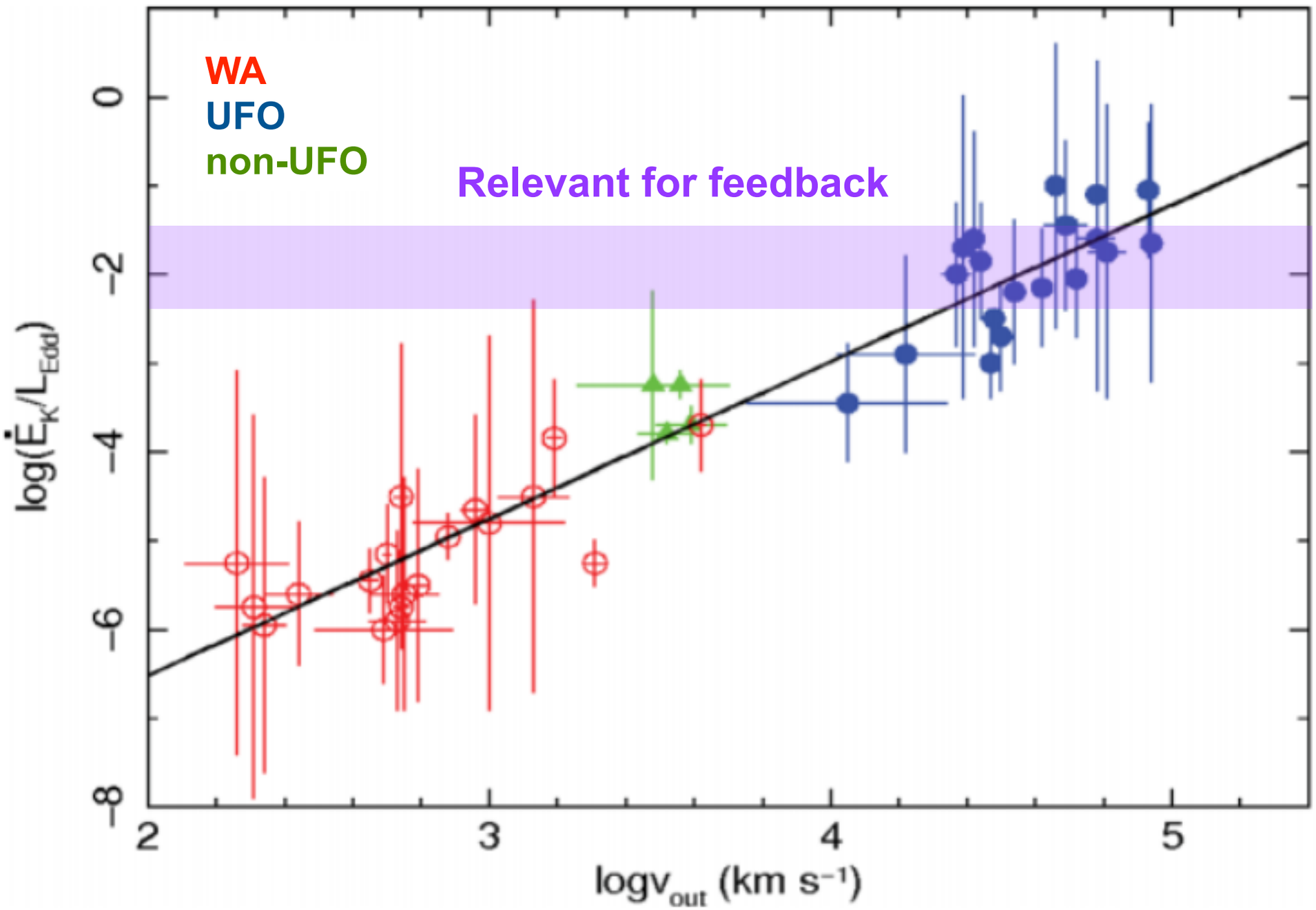
$v_{out} \sim 1\text{-}5\times10^3$ km s^{-1}

$N_H \sim 10^{23}$ cm^{-2} d ~ 100-200 r_g

Risaliti +05

Properties of X-ray AGN winds

Tombesi +10;+11;+12;+13



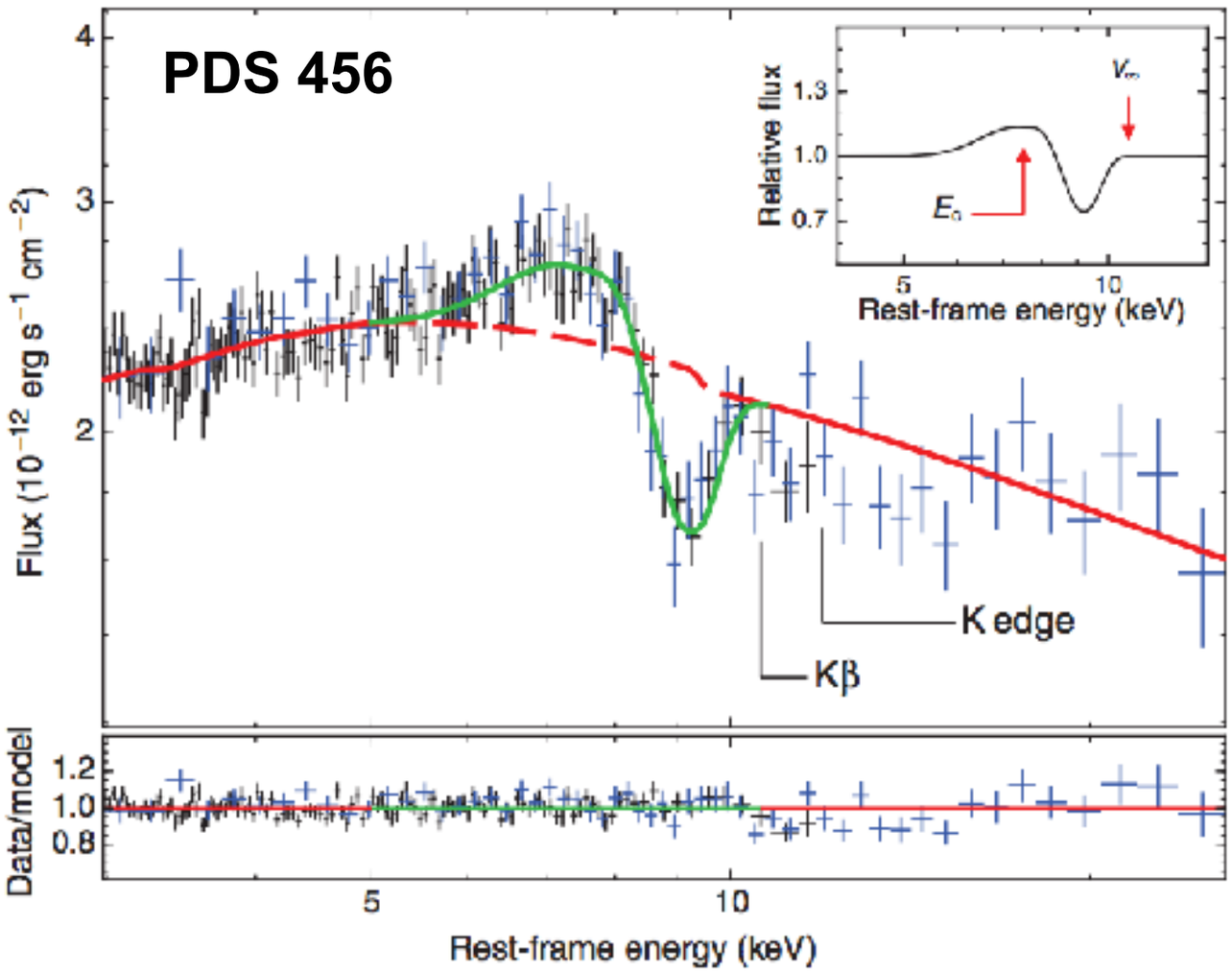
Kinetic luminosity of UFO is typically higher than 0.5-5 % L_{Edd}

Di Matteo +05; Hopkins +10;

➜ UFO produce feedback

Building a coherent picture of AGN winds

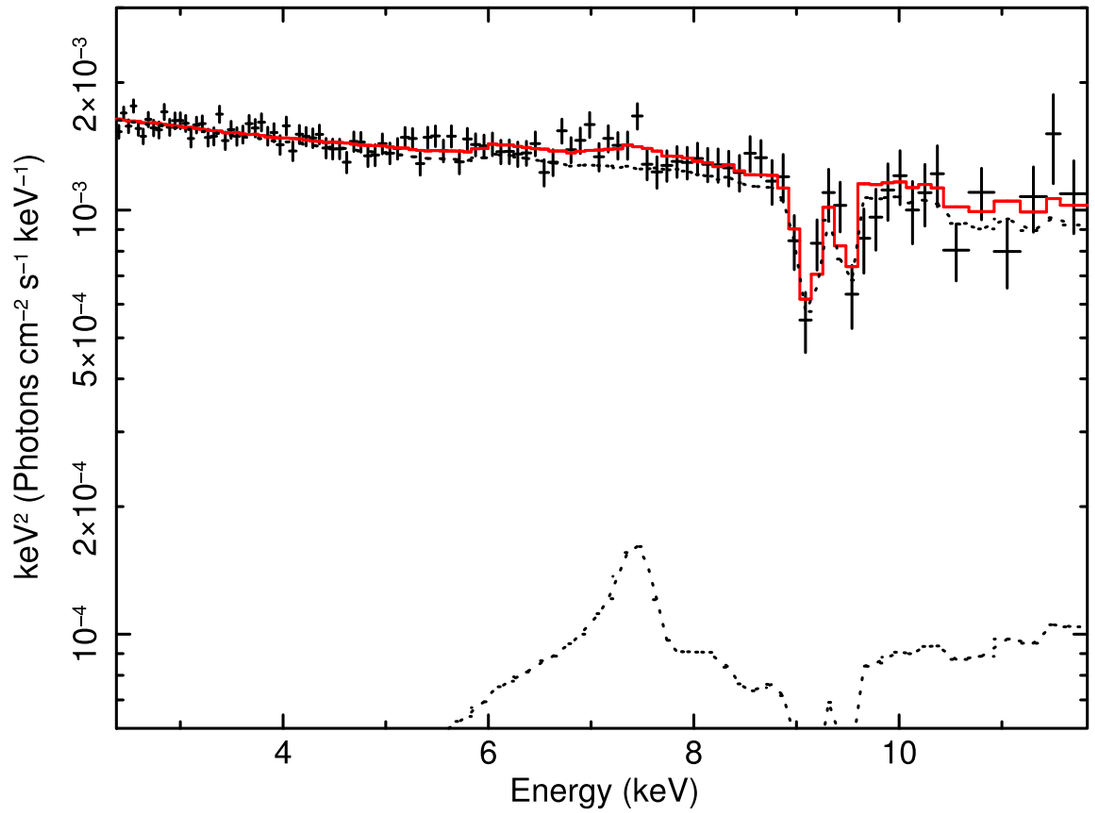
Nardini +15



Highly significant detection

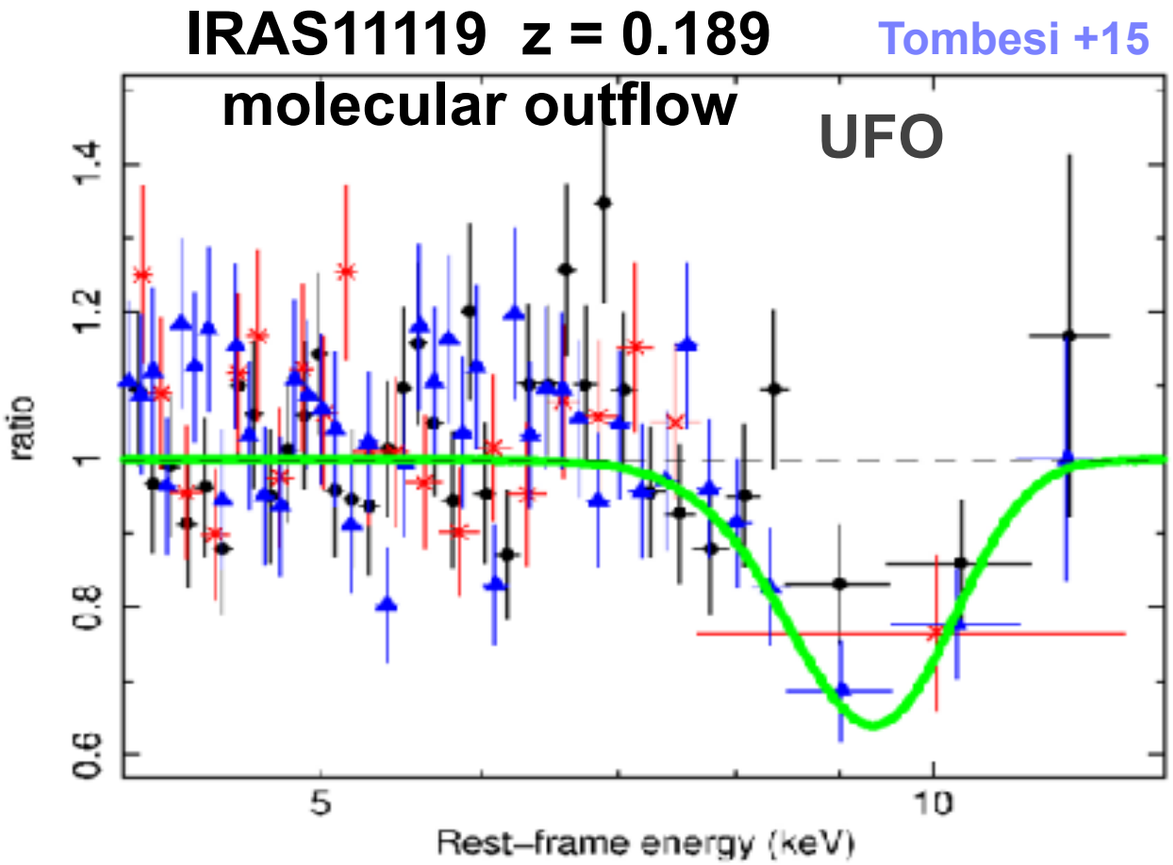
➜ UFO is a real phenomenon!

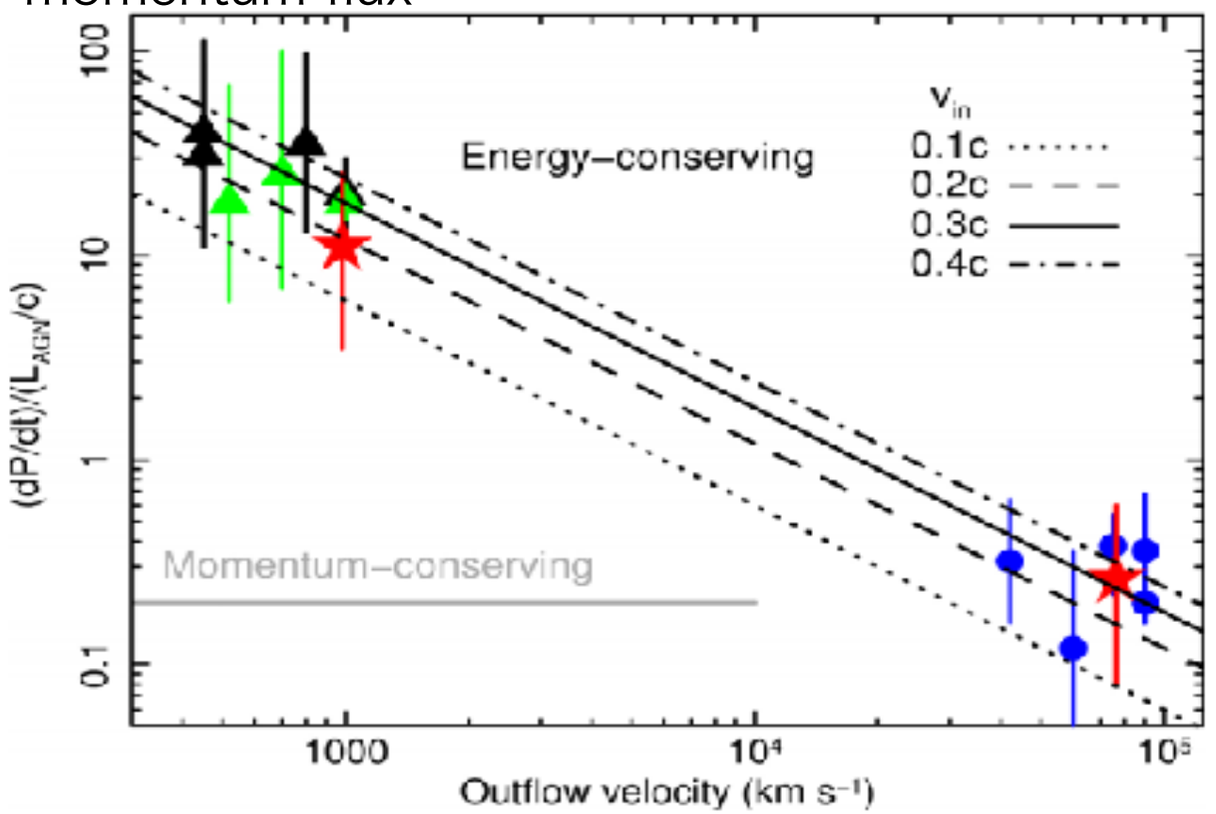
Hagino+ +15



- Monte Carlo prediction of reprocessed emission fitted to Suzaku data

Building a coherent picture of AGN winds



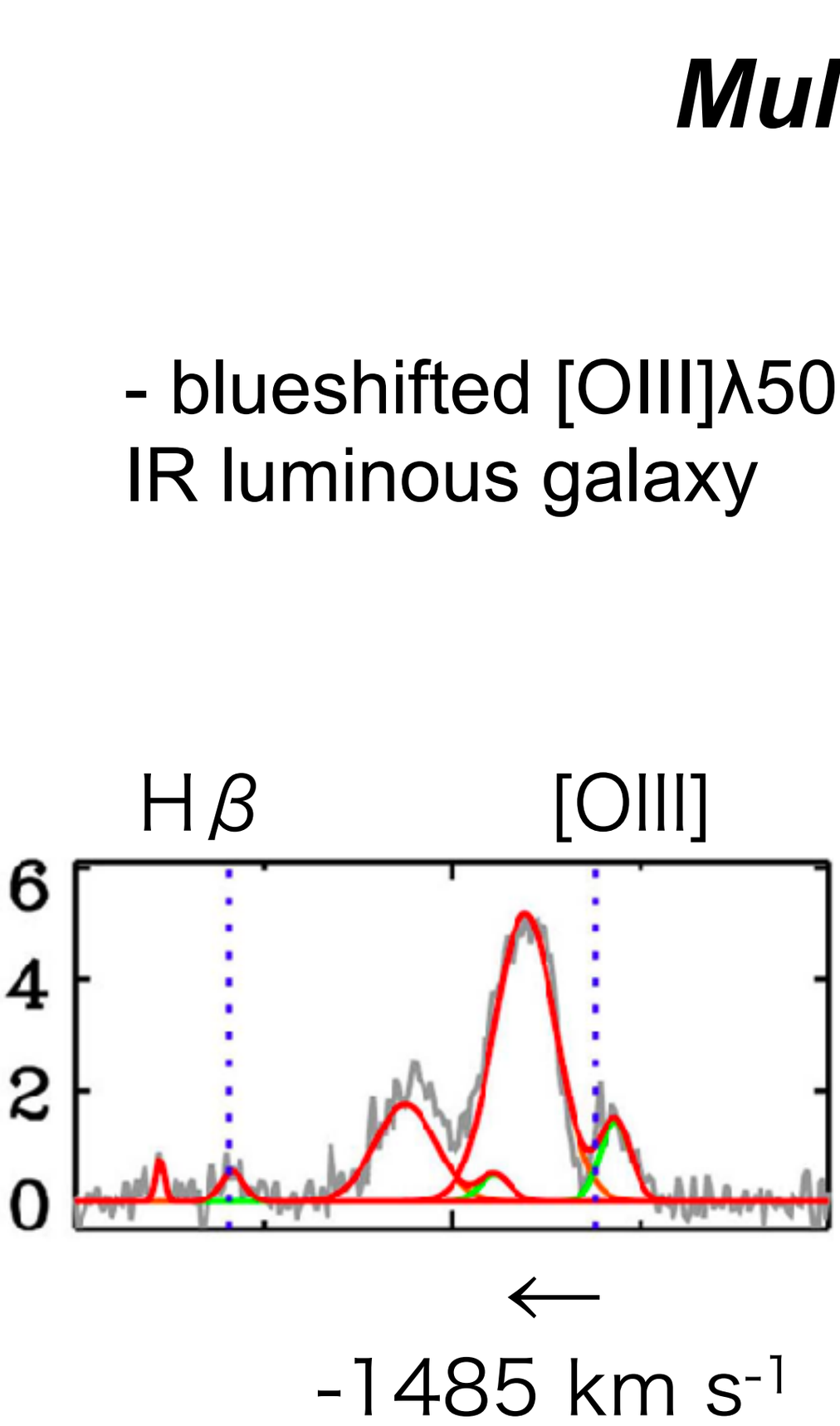


➜ UFO and molecular outflow parts of the same wind

➜ Energy conserving flow

Multi-λspectra

- blueshifted [OIII]λ5007 but NO molecular outflow in IR luminous galaxy

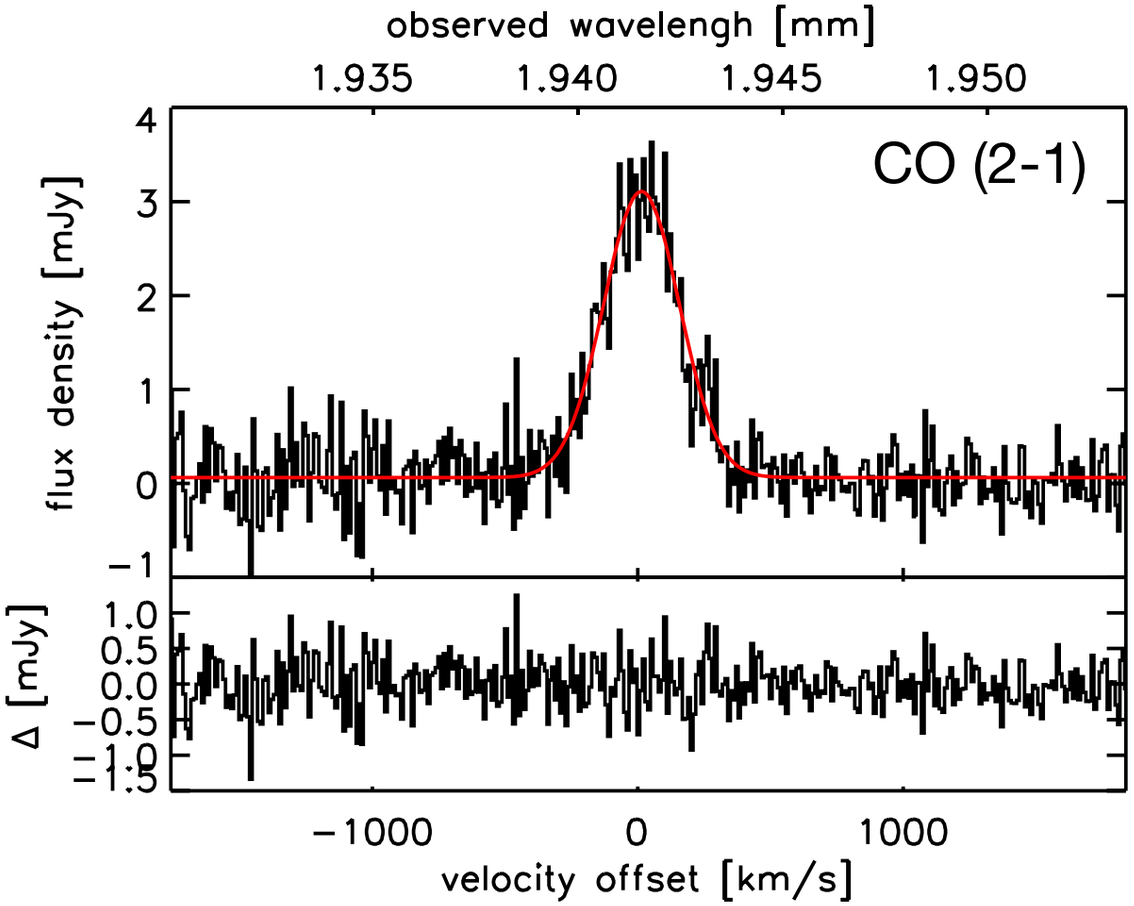


←

-1485 km s^{-1}

WISE1029

Toba+17a, b



FWHM~350 km/s

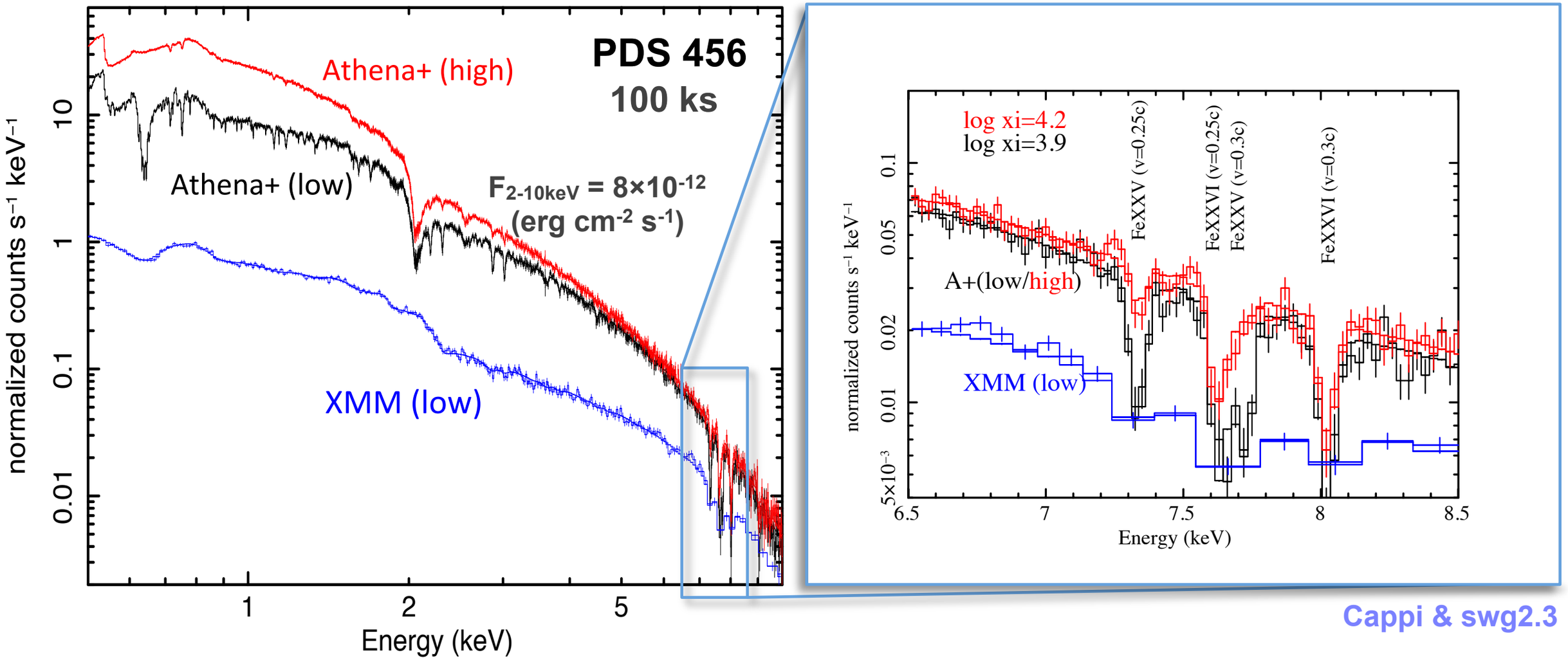
Prospects of Athena for AGN feedback

Main science drivers of SWG 2.3

Athena shall measure the kinetic energy in nearby AGN outflows and understand how accretion disks around SMBH launch winds and outflows

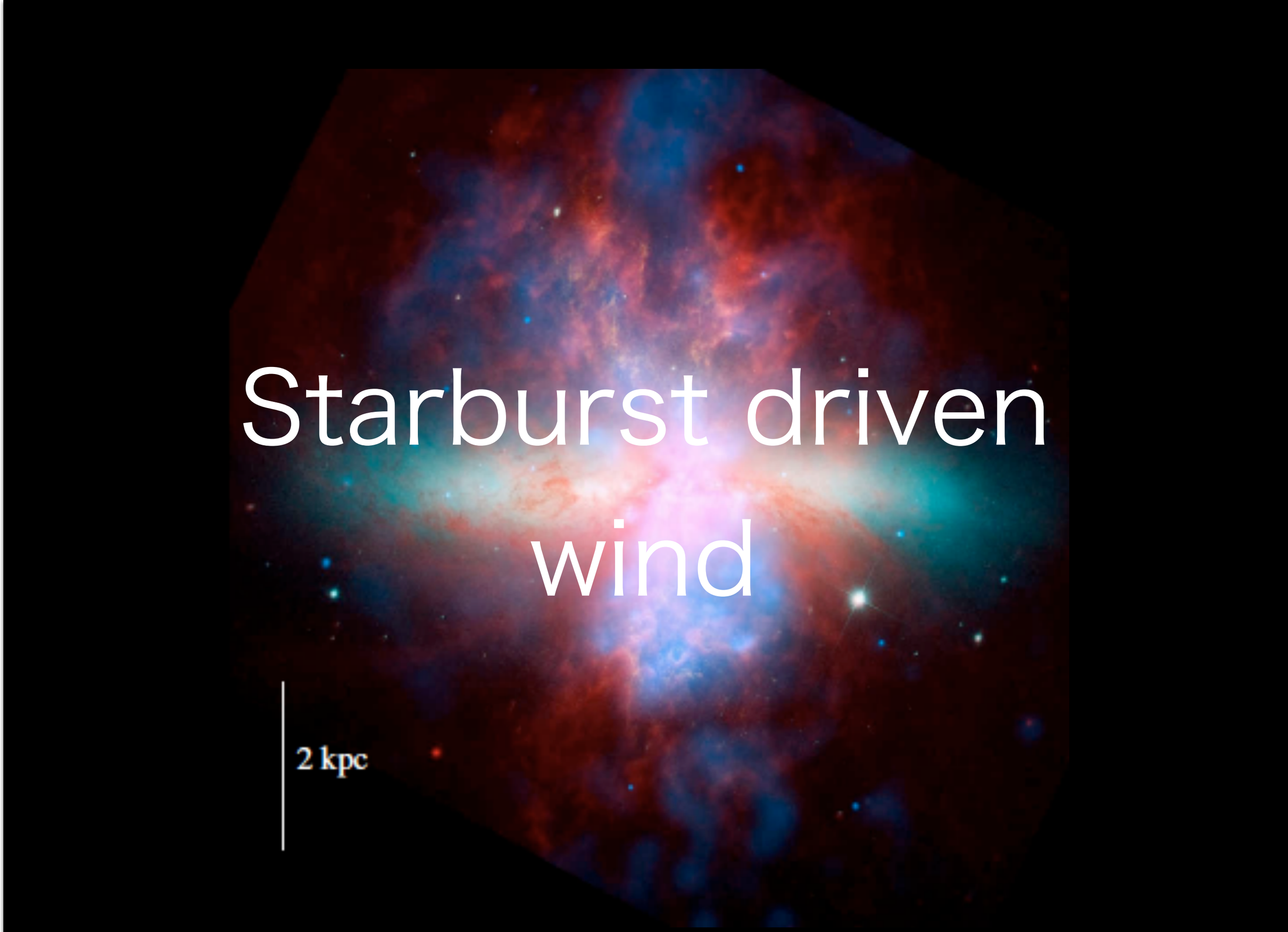
Athena shall probe the interaction of winds with their surroundings in local galaxies to understand how gas, metals and energy accelerated by winds are transferred into the IGM

➜ template for higher z universe



Cappi & swg2.3

Starburst driven wind



Overview

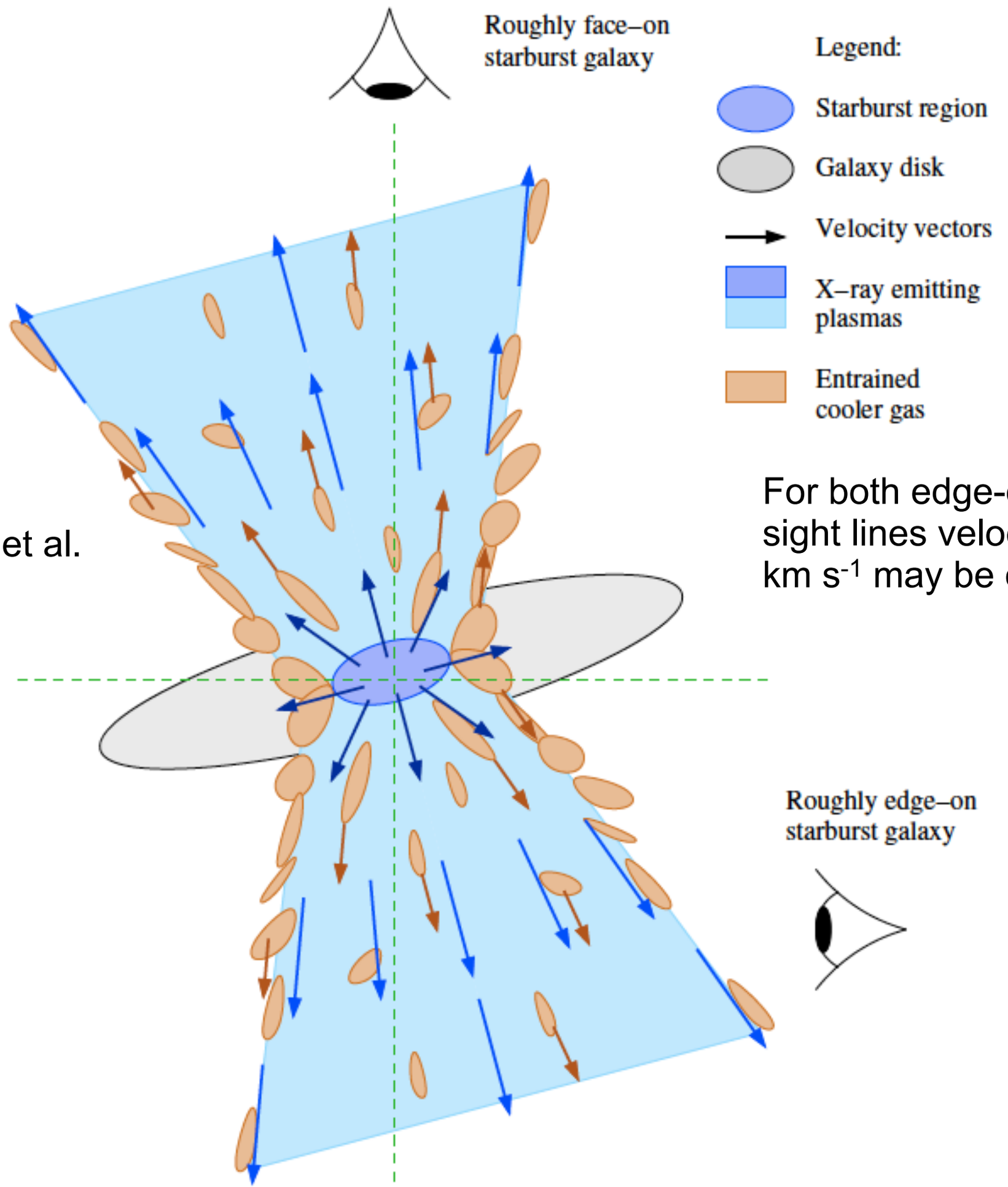
- “Feedback” in the form of starburst outflows plays an important role in galaxy evolution, particularly regulating star formation

  How energetic are starburst winds, especially superwinds?

  How efficiently do starburst winds transport metals to the IGM?

- Starburst outflows are directly seen in UV absorption and molecular gas studies but most energy is in the hot “fluid” which potentially stays hot out into galaxy halos

From Strickland et al. (2009)

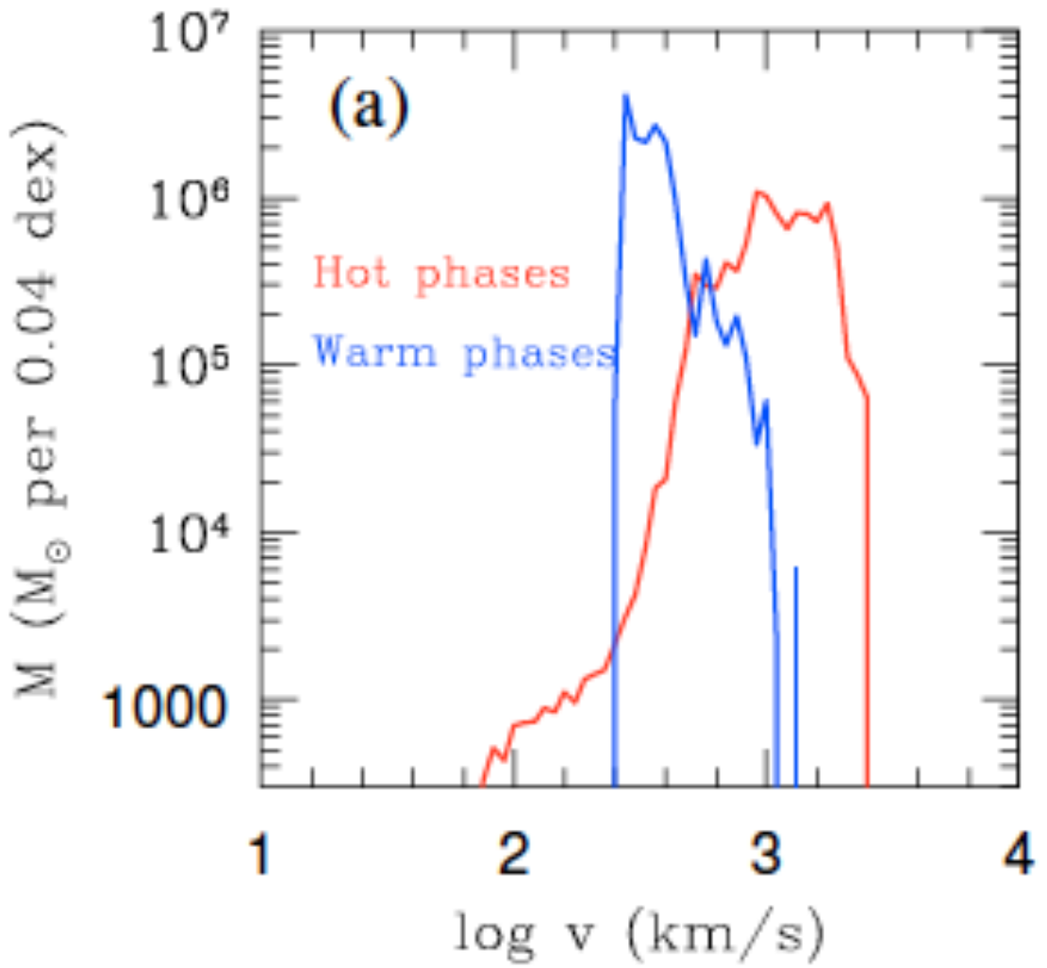


For both edge-on and face-on sight lines velocities of > 1000 km s^{-1} may be observed

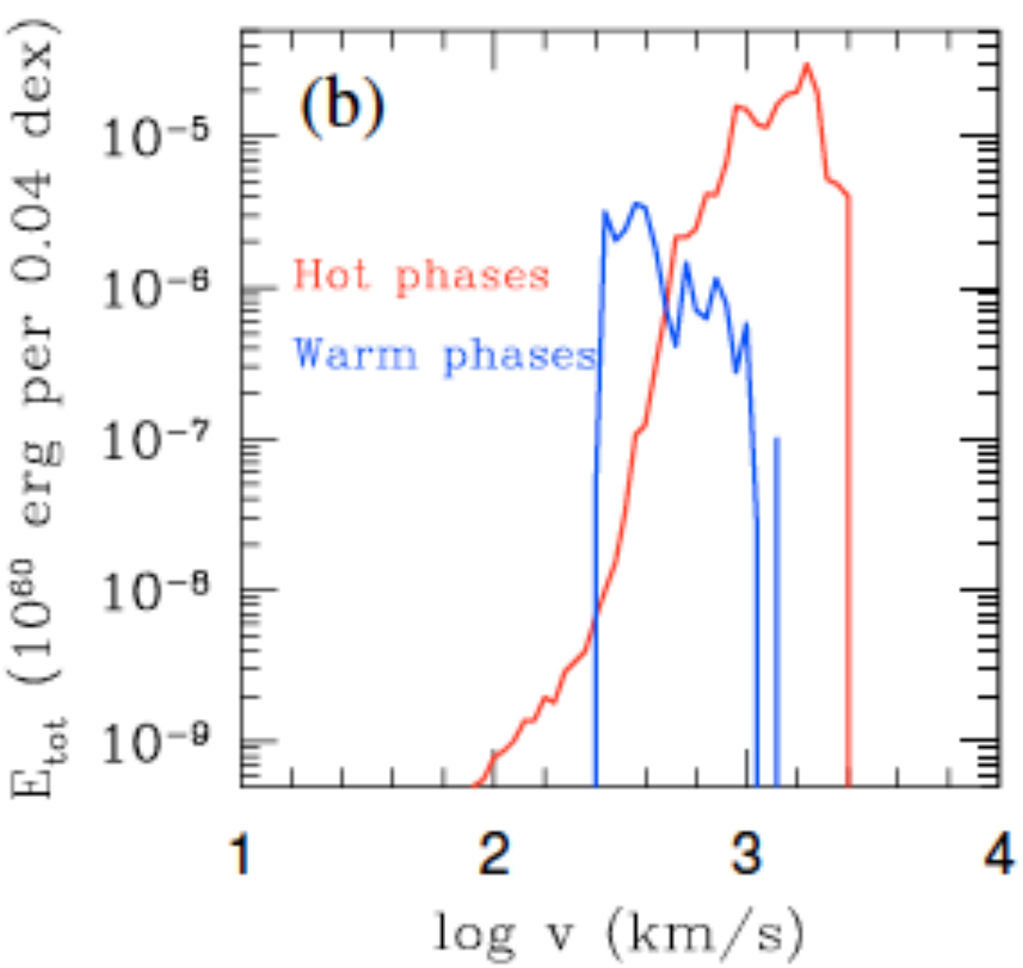
How Important is the Hot Wind Fluid?

From Strickland et al. 2009 IXO White paper
See also Melioli et al. (2013)

Gas mass



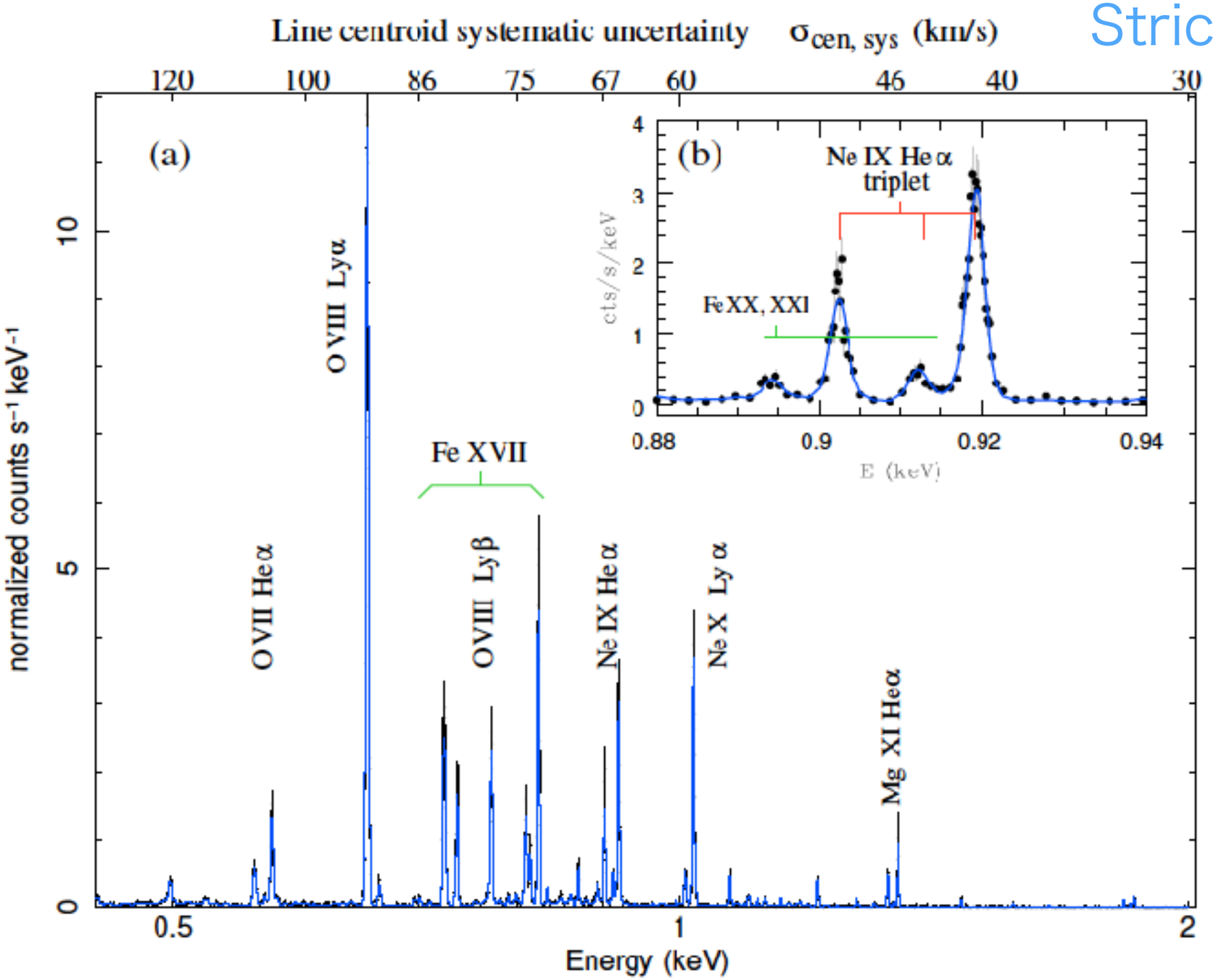
Total energy



Simple model

single-kT, wind dominated

Strickland+09

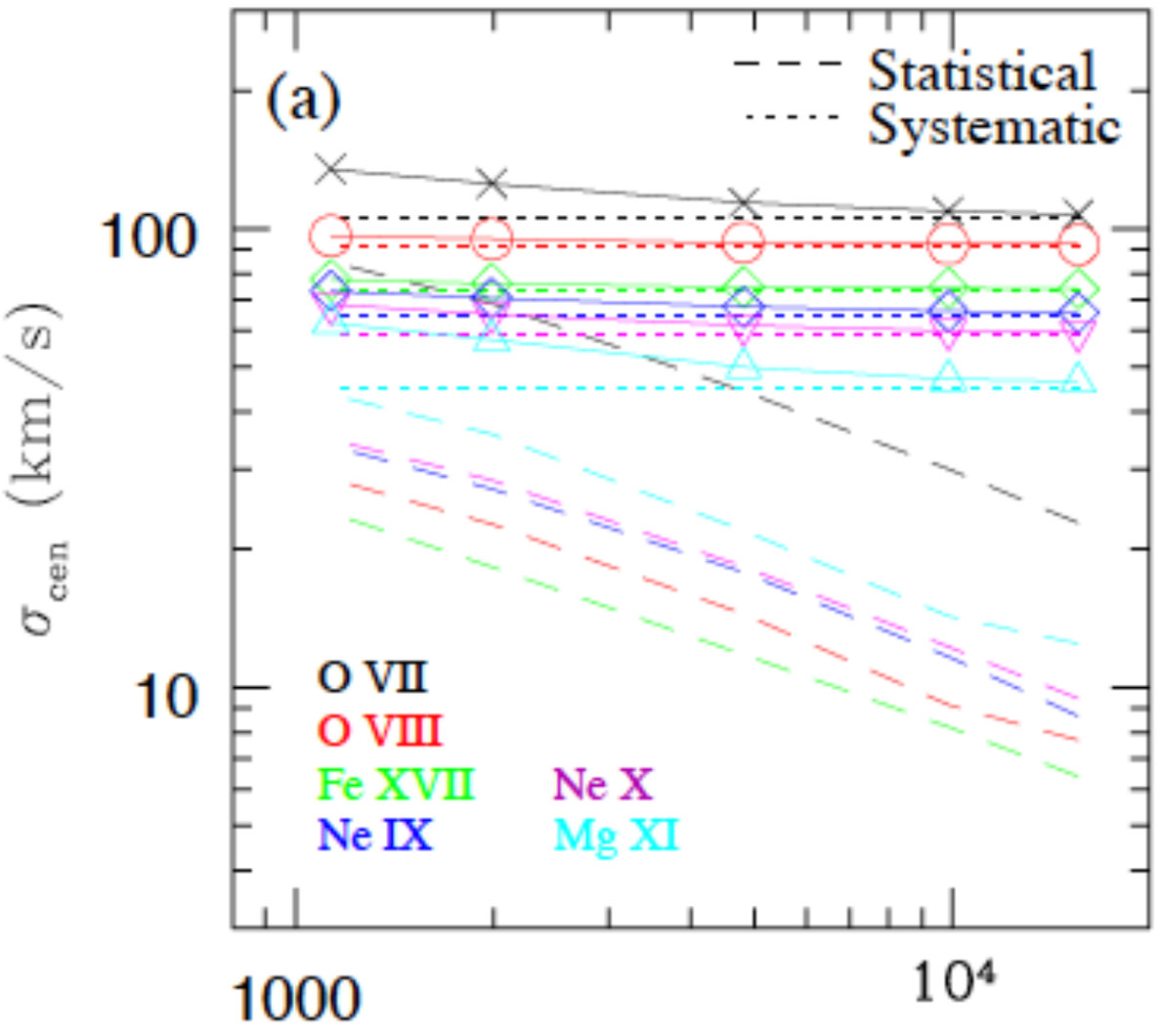


16,000 count spectrum of SN-II enhanced 0.4 keV plasma

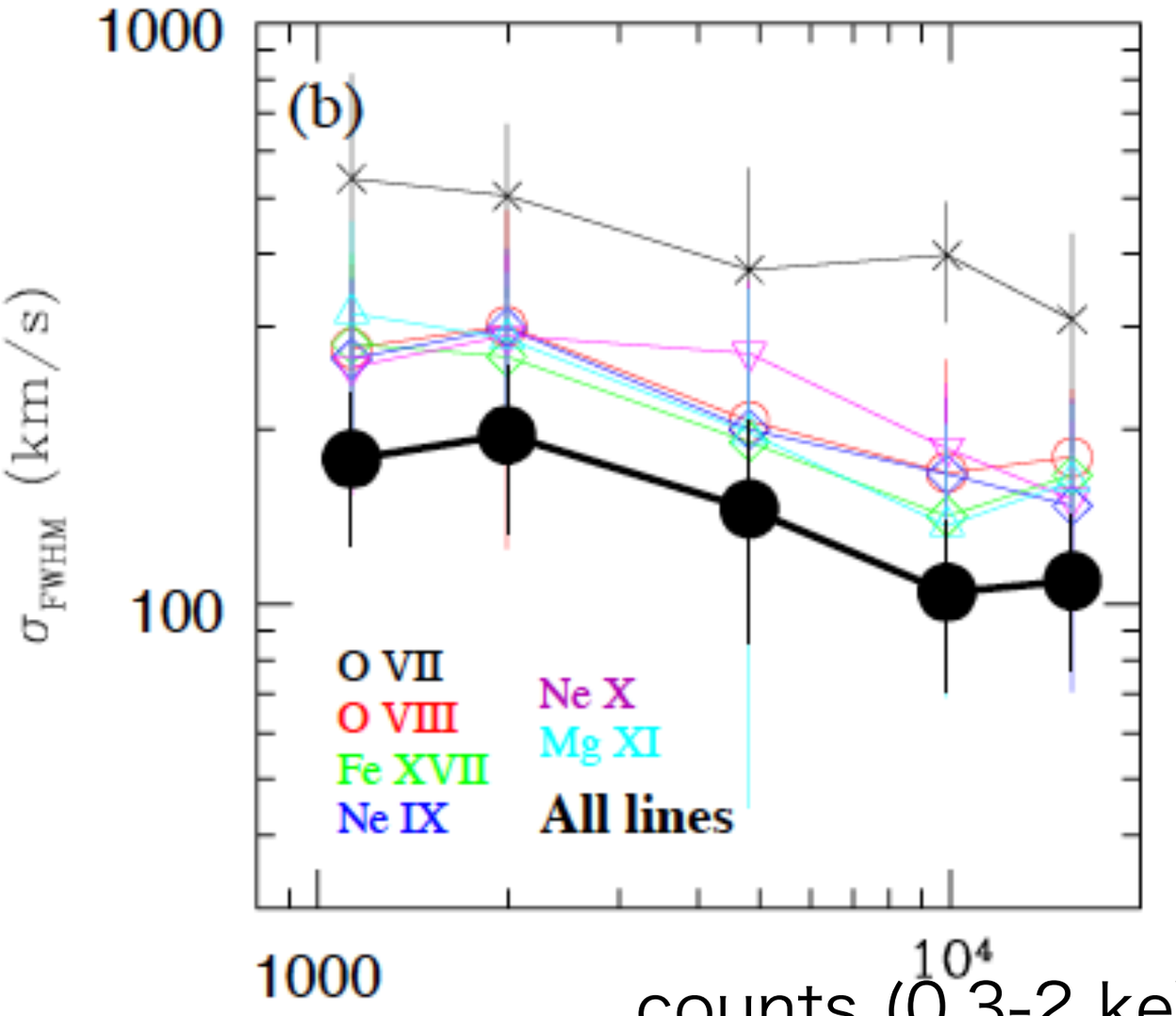
2.5 eV resolution

Line Velocity Diagnostics

Line centroid



Line width

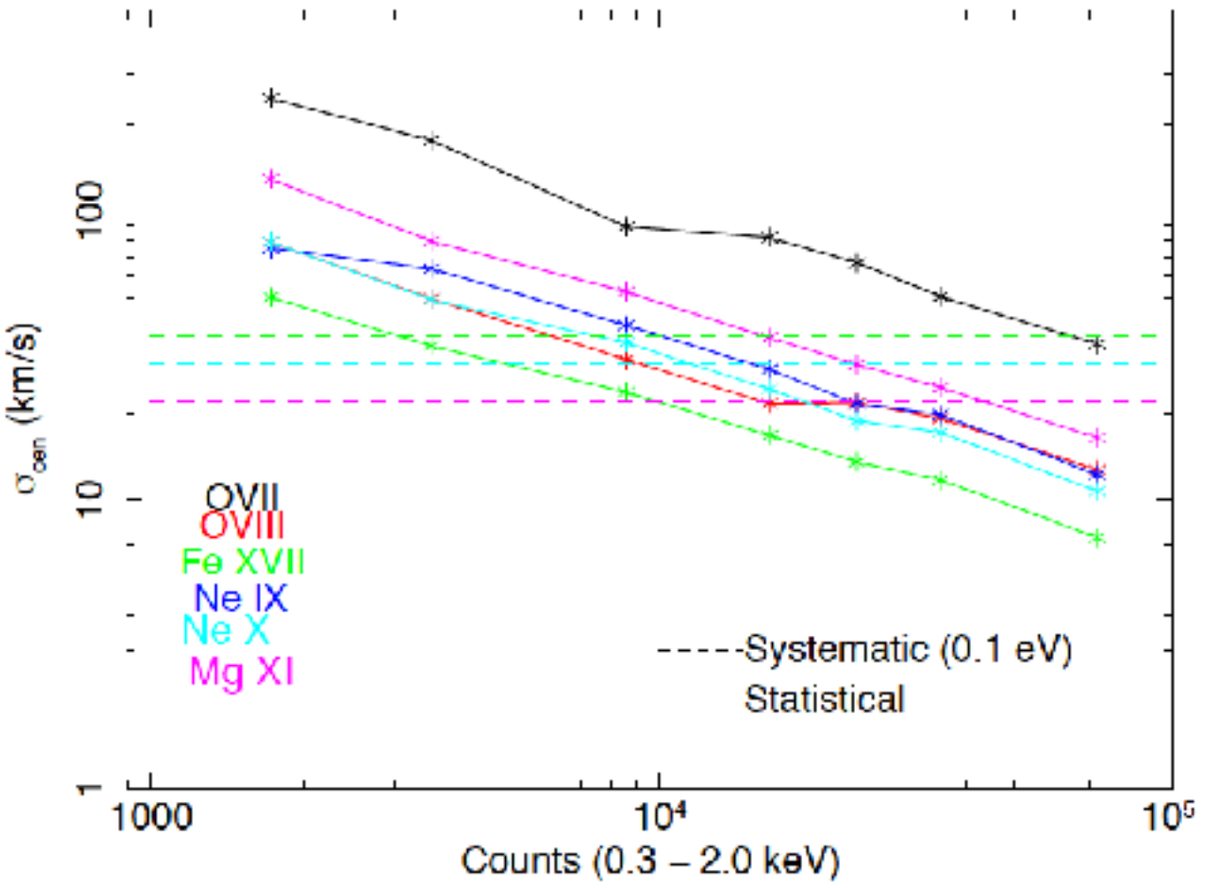


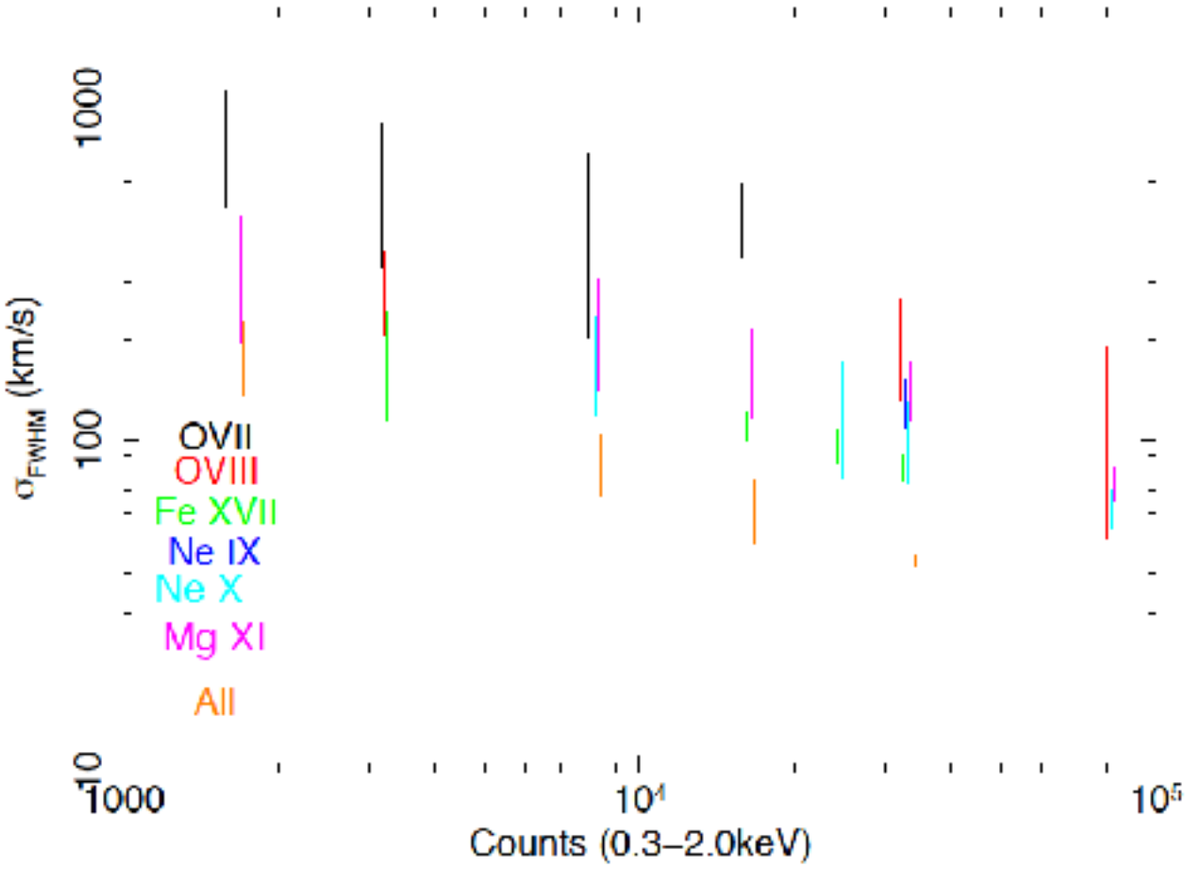
Simulations by D. Strickland, starting with narrow lines

For ~ 2 eV spectral resolution, ~ 10^3 / 10^4 counts are required to constrain velocity centroid / width to within 50-100 km s^{-1}.

Centroid error likely dominated by calibration error above ~ 1000-2000 counts

Broad Line Diagnostics





Input model:
kT=0.4 keV, velocity width=500 km/s Z_{Fe}= 0.5, Z_{α} = 1.5

Systematic error of 0.1 eV shown as dashed lines
Simulations done by M. Yukita

Toy Starburst Model

$$\beta = \frac{\dot{M}}{SFR}$$

- Thompson et al. (2016) superwind with various β (mass-loading) values

- 6 kpc x 2 kpc diameter exponential hot disk ISM with kT=0.4 keV, v_{rot}=250 km/s

- Cold exponential disk absorber

- Beta-model hot halo with beta=0.5, kT=0.2, 0.3 solar, scale heights of 5 kpc x 4 kpc

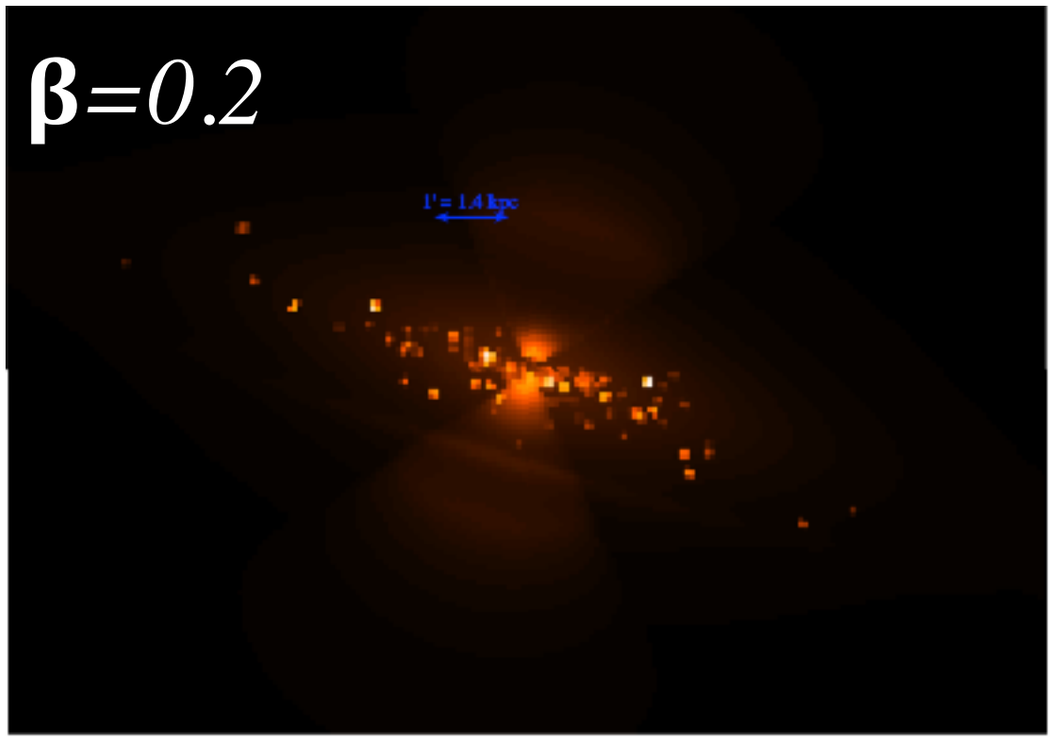
- X-ray binaries distributed with power-law XLF along disk

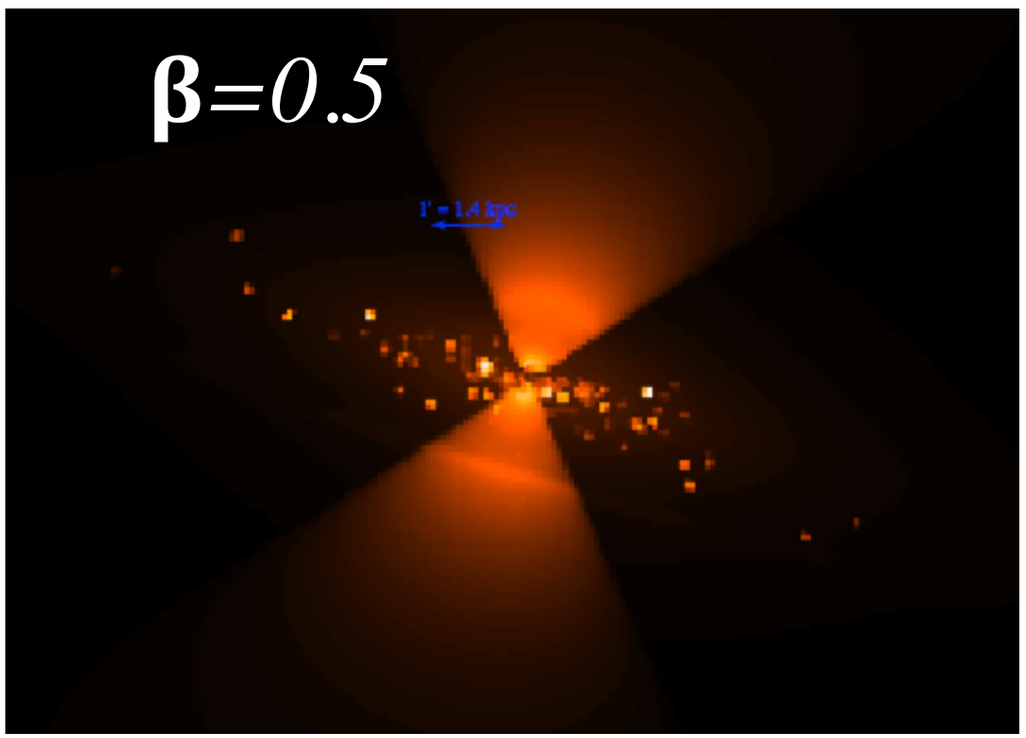
- Soft X-ray background model from Henley & Shelton (2013)

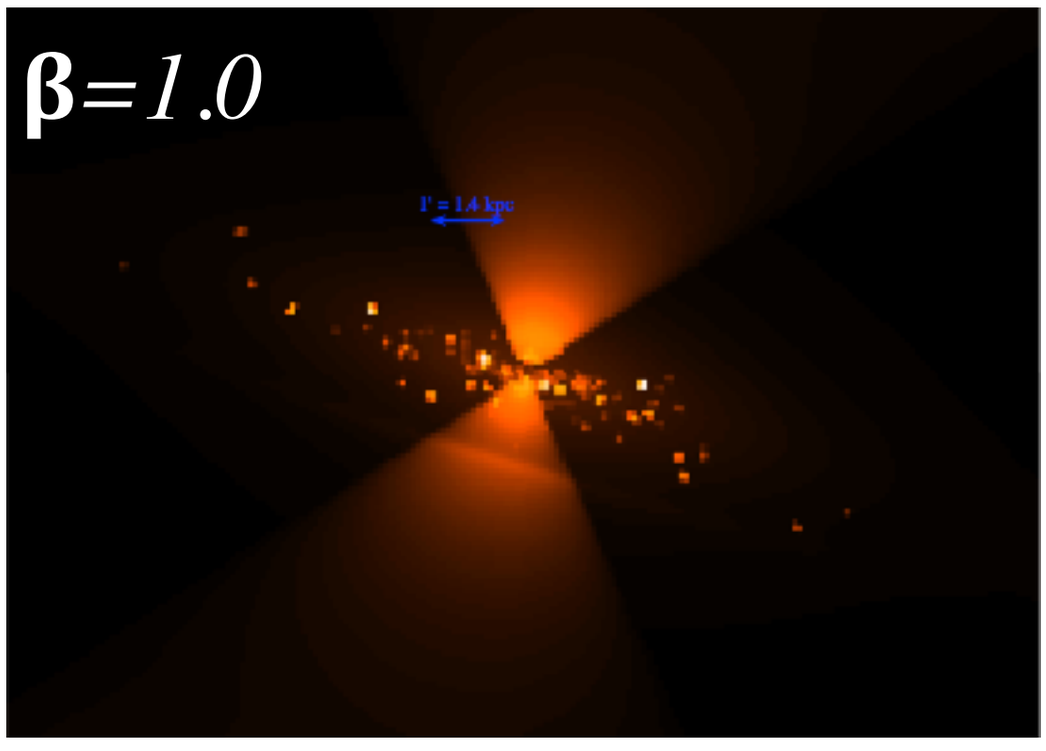
- Simulated starbursts at 5 Mpc

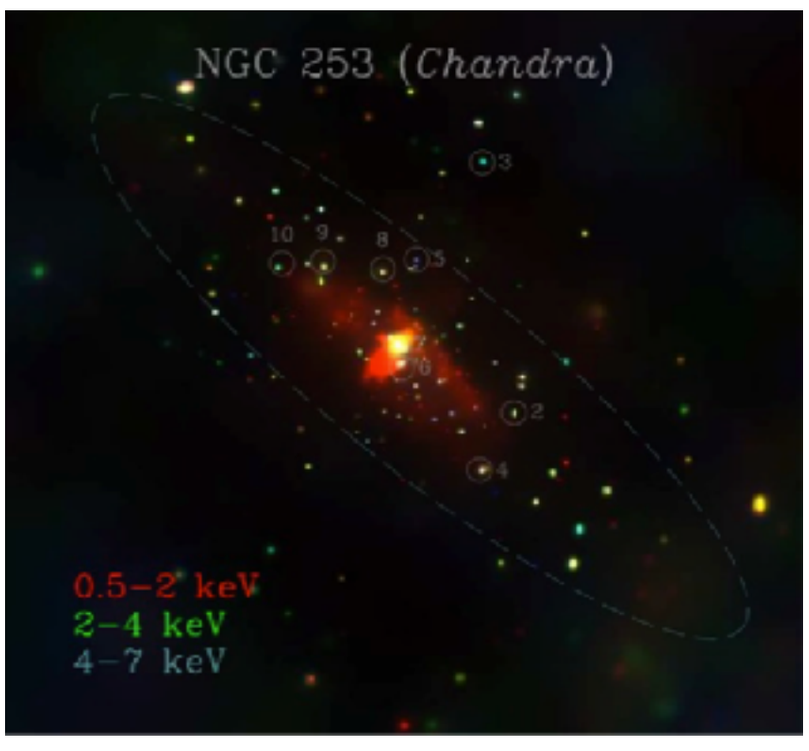
Model and simulations by Edmund Hodges-Kluck

Toy Starburst Model





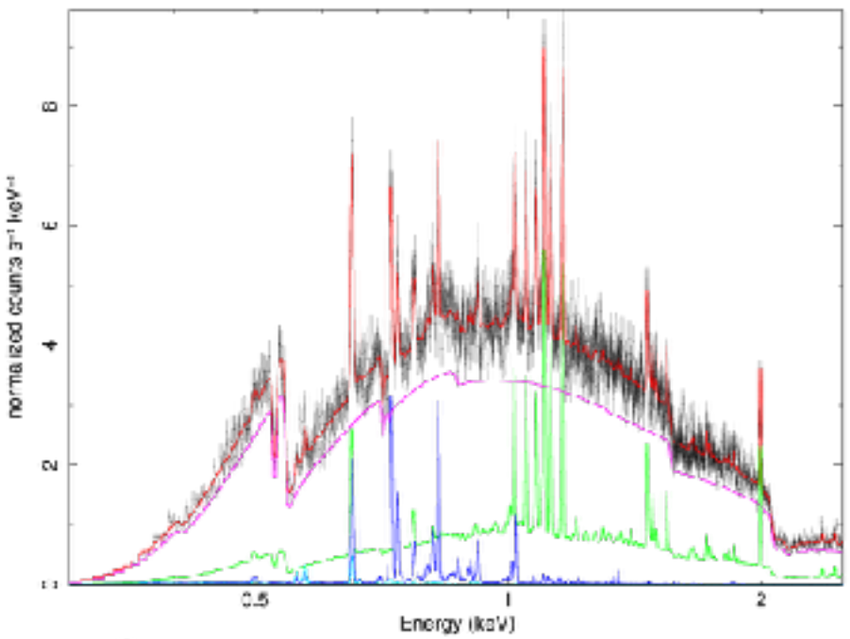




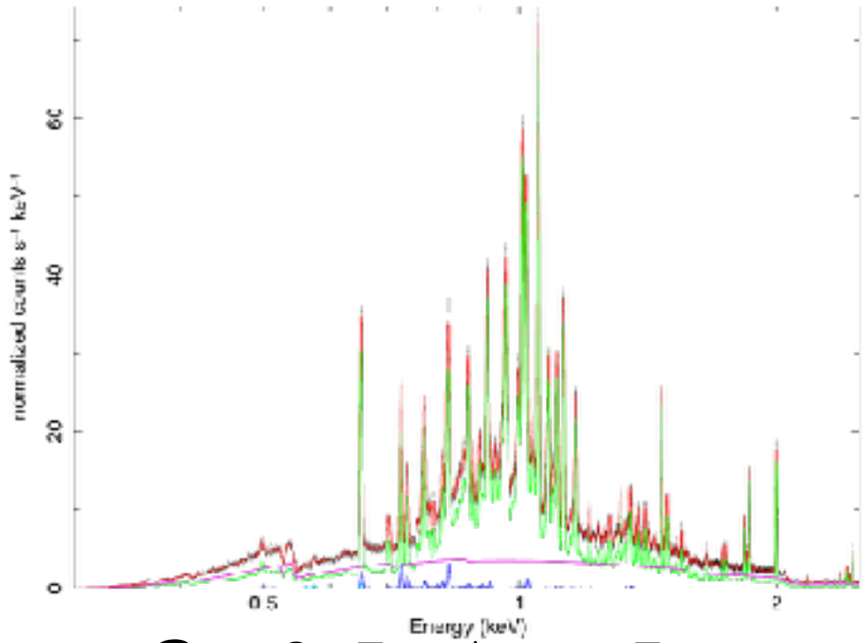
NGC 253
Chandra

Lehmer et al. (2013)

Example Spectra

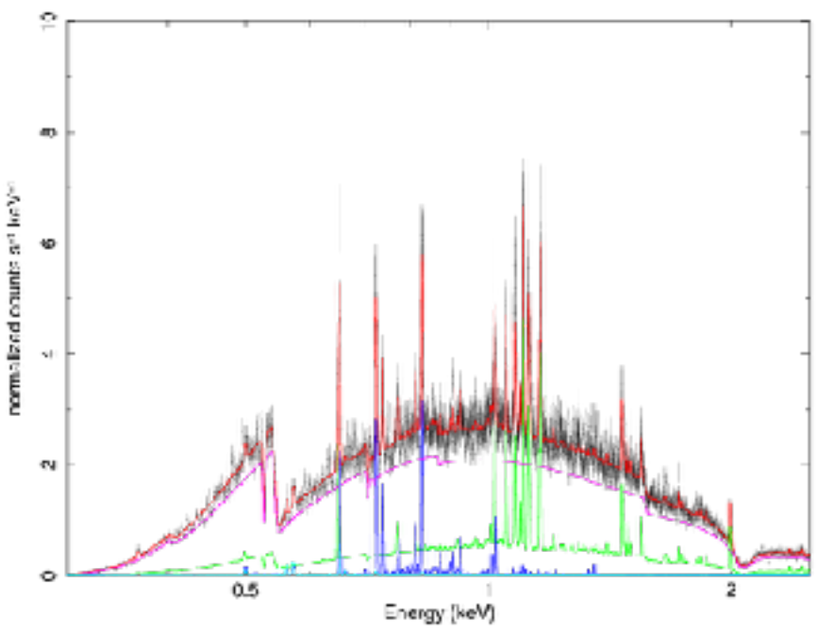


$\beta=0.2,\ \Delta E=5\ eV$



$\beta=0.5,\ \Delta E=5\ eV$

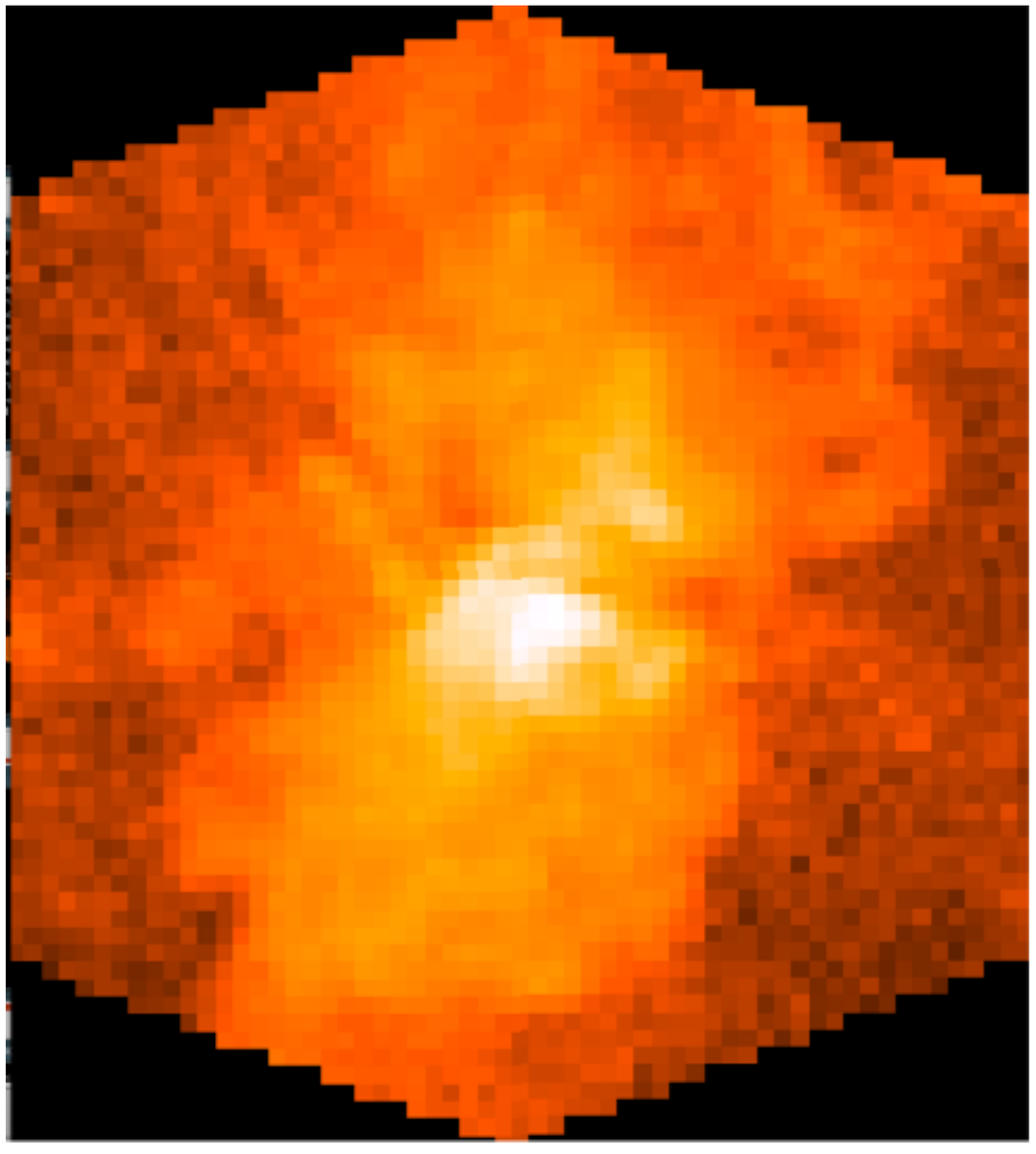
Black –Simulated data
Red – Total model
Green - Wind emission
Blue – Disk
Light Blue – Halo
Magenta - XRBs



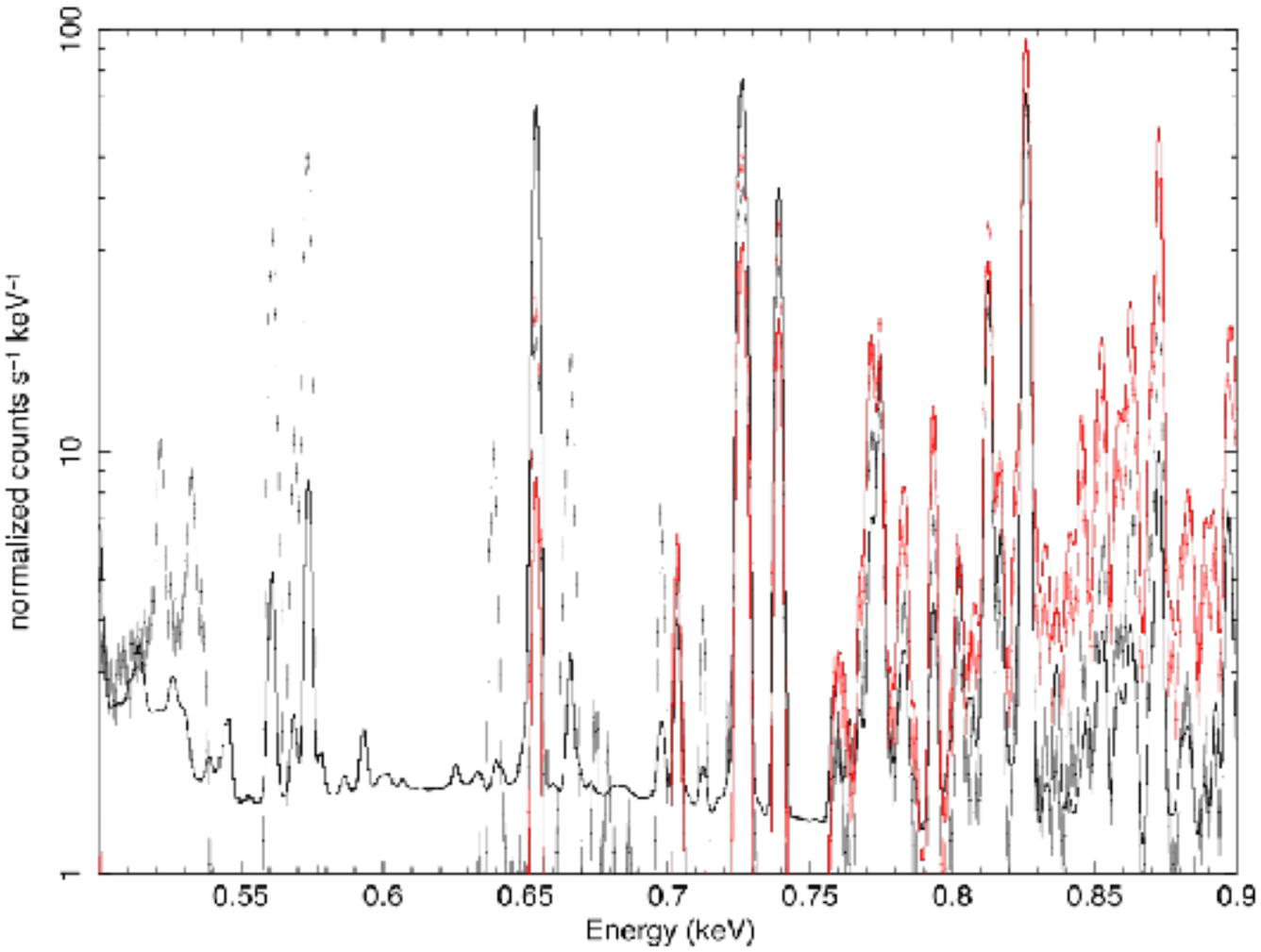
$\beta=0.2,\ \Delta E=2.5\ eV\ (X\text{-}IFU)$

50 ks Simulations for an M82-like starburst at 5 Mpc, 30” diameter region 1’ along minor axis

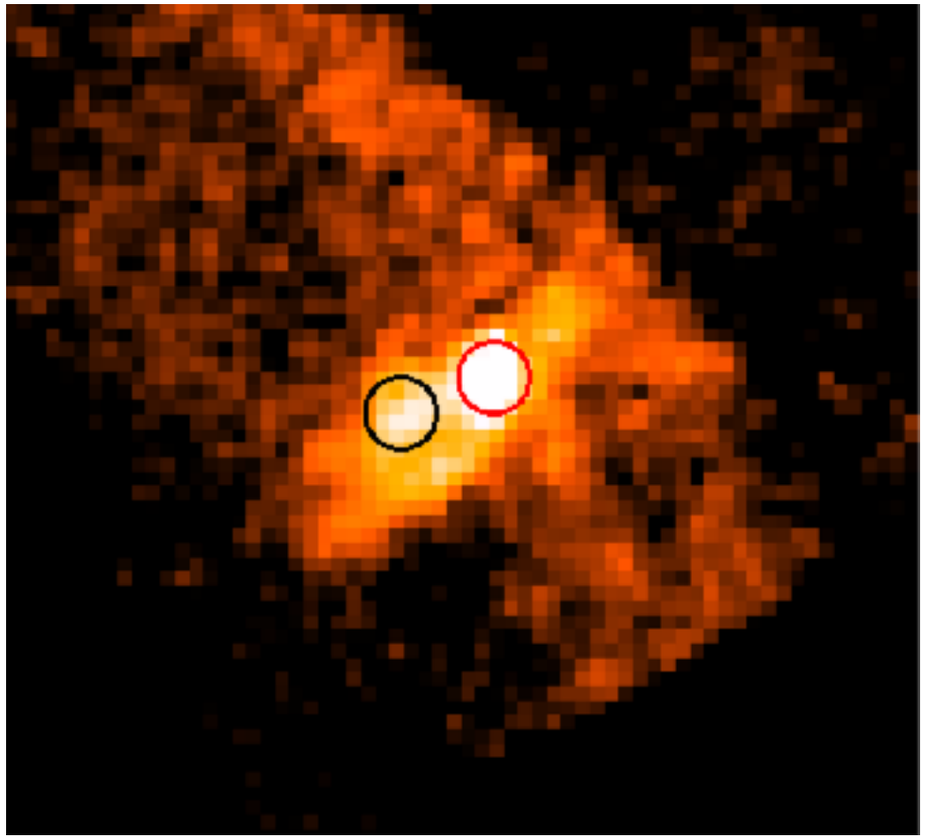
M82 Diffuse-only X-IFU



NGC 253 X-IFU 100 ks Simulation



ed



What will the Athena Starburst Sample Look Like?

	1.4 m^2 at 1 keV		2.0 m^2 at 1 keV	
Galaxy	X-IFU Surface Brightness	5σ Exp. (ks)	X-IFU Surface Brightness	5σ Exp. (ks)
NGC 3256	16.7	9.6	24.0	6.7
Henize 2-10	8.4	19.1	12.1	13.2
NGC 3310	6.4	25.3	9.1	17.5
VV 114	6.1	26.4	8.8	18.3
etc				

5σ Exposure gives exposure time to get 10,000 counts in a 15”x15” region
X-IFU Surface Brightness is in counts s^{-1} $arcmin^{-2}$ based on total diffuse X-ray luminosity and source extent. Total includes bgd. which is < 10% of counts in most cases.

For mock observing plan, also included ULIRGS to have a total of 34 galaxies requiring 15 (10) Ms for 1.5 (2.0) m^2 at 1 keV.

Prospects of Athena for starburst winds

- Athena X-IFU observations promise to directly map out the diffuse X-ray flux in a sample of ~ 30 nearby starburst and ULIRG galaxies

  Spectral modeling needs to include background, updated estimates on achievable systematic energy calibration error

- Velocity/metalicity structure and energetics in winds will be quantitatively constrained. - Input to IGM/ICM