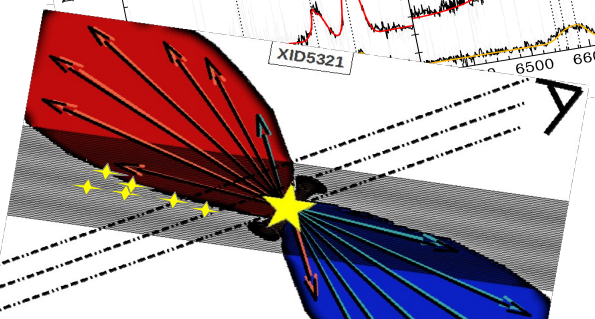
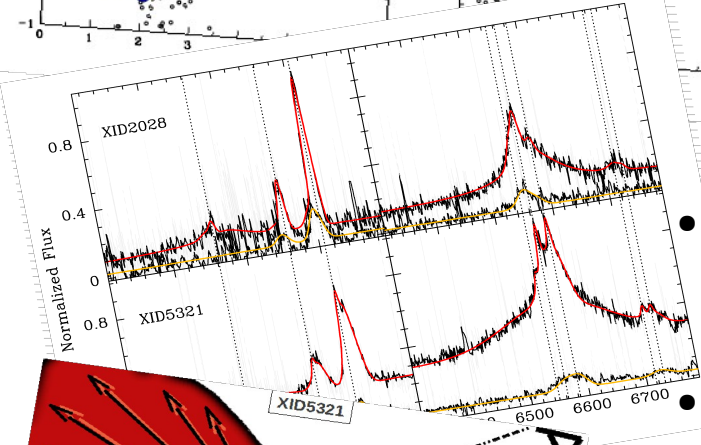
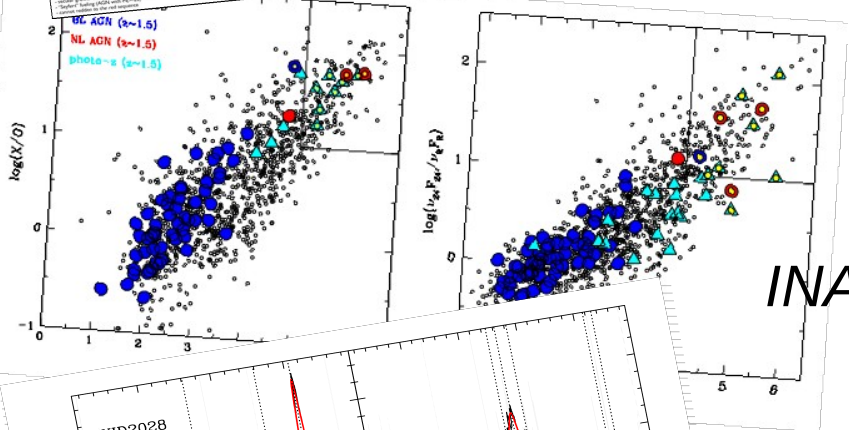
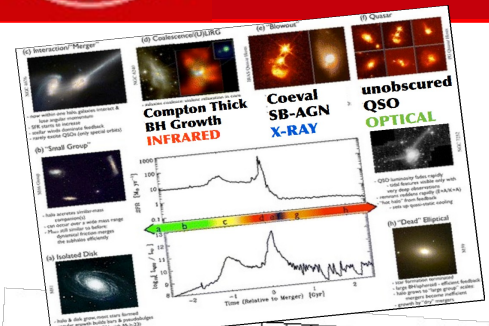


Powerful outflows in $z \sim 1.5$ X-ray obscured QSOs

Michele Perna

DIFA Università di Bologna

INAF Osservatorio Astronomico di Bologna



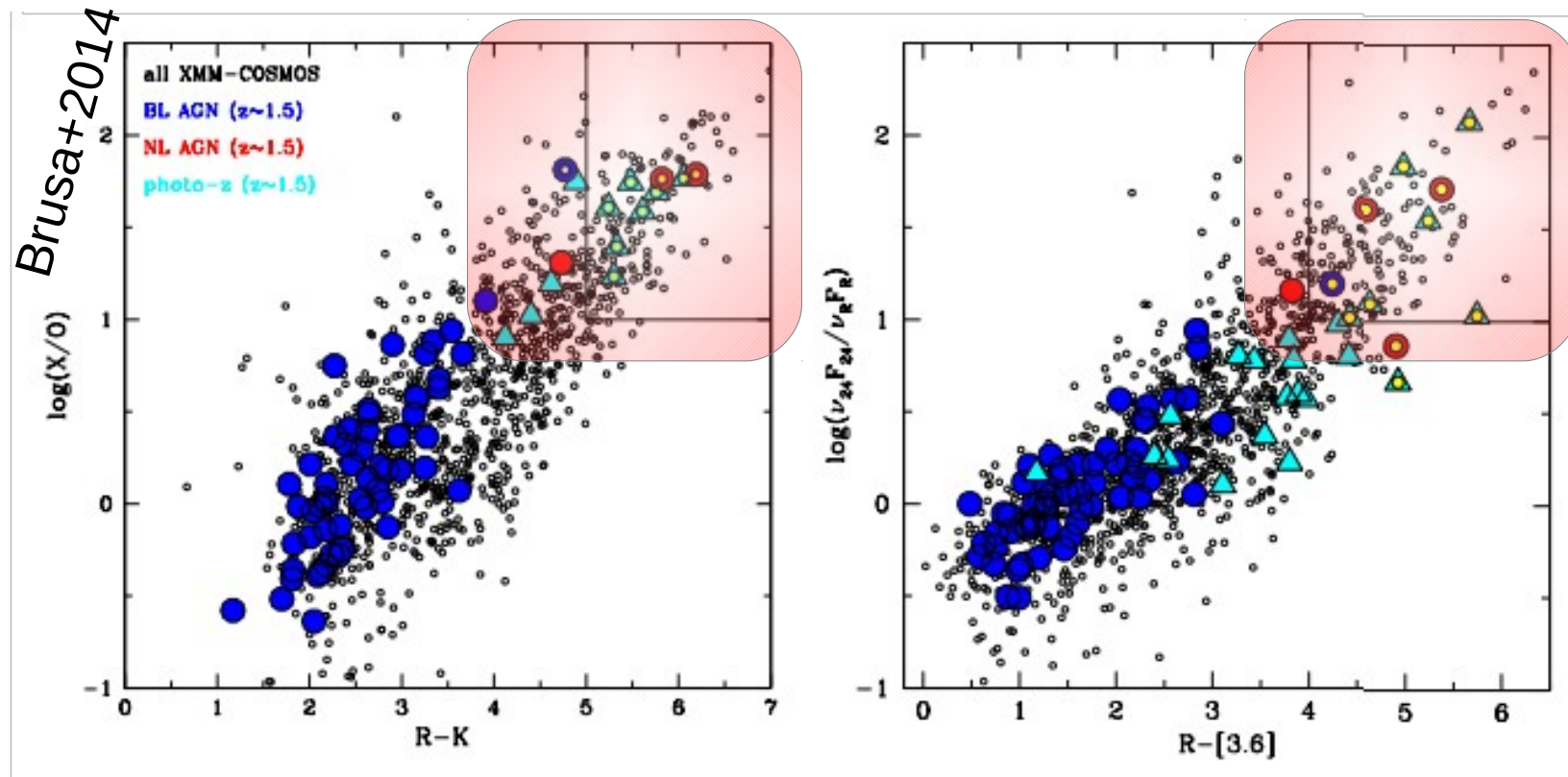
- Brusa, Bongiorno, Cresci, Perna et al., MNRAS, in press, arXiv:1409.1615
- Perna, Brusa, Cresci, Comastri, Lanzuisi et al., A&A submitted

Context

AGN in FEEDBACK/OUTFLOWS:

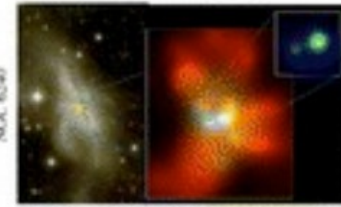
X-ray luminous, obscured and “dusty” at $z=1-3$

XMM-COSMOS obscured QSOs



Hopkins et al. 2008

(d) Coalescence/(U)LIRG



galaxies coalesce: violent relaxation in core

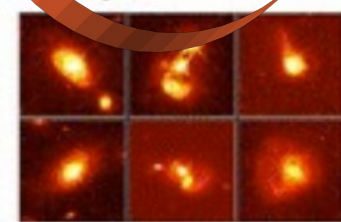
Compton Thick
BH Growth
INFRARED

(e) "Blowout"



Coeval
SB-AGN
X-RAY

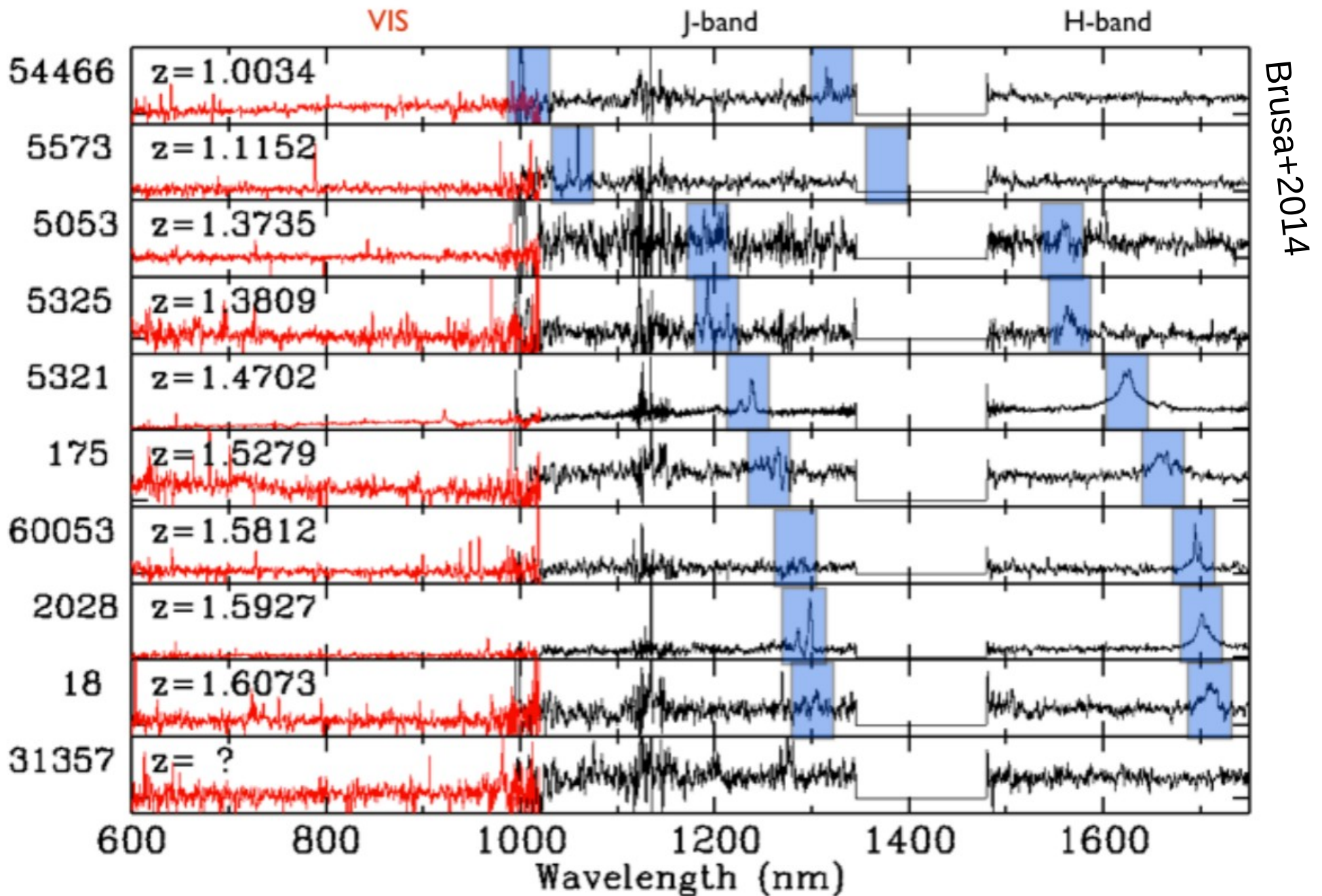
(f) Quasar



unobscured
QSO
OPTICAL

10 targets X-ray ($L_x > 44$) and K-band ($K < 19$) brightest objects at $z \sim 1.25-1.72$ observed in the VIS-NIR with VLT/X-shooter

XMM-COSMOS obscured QSOs



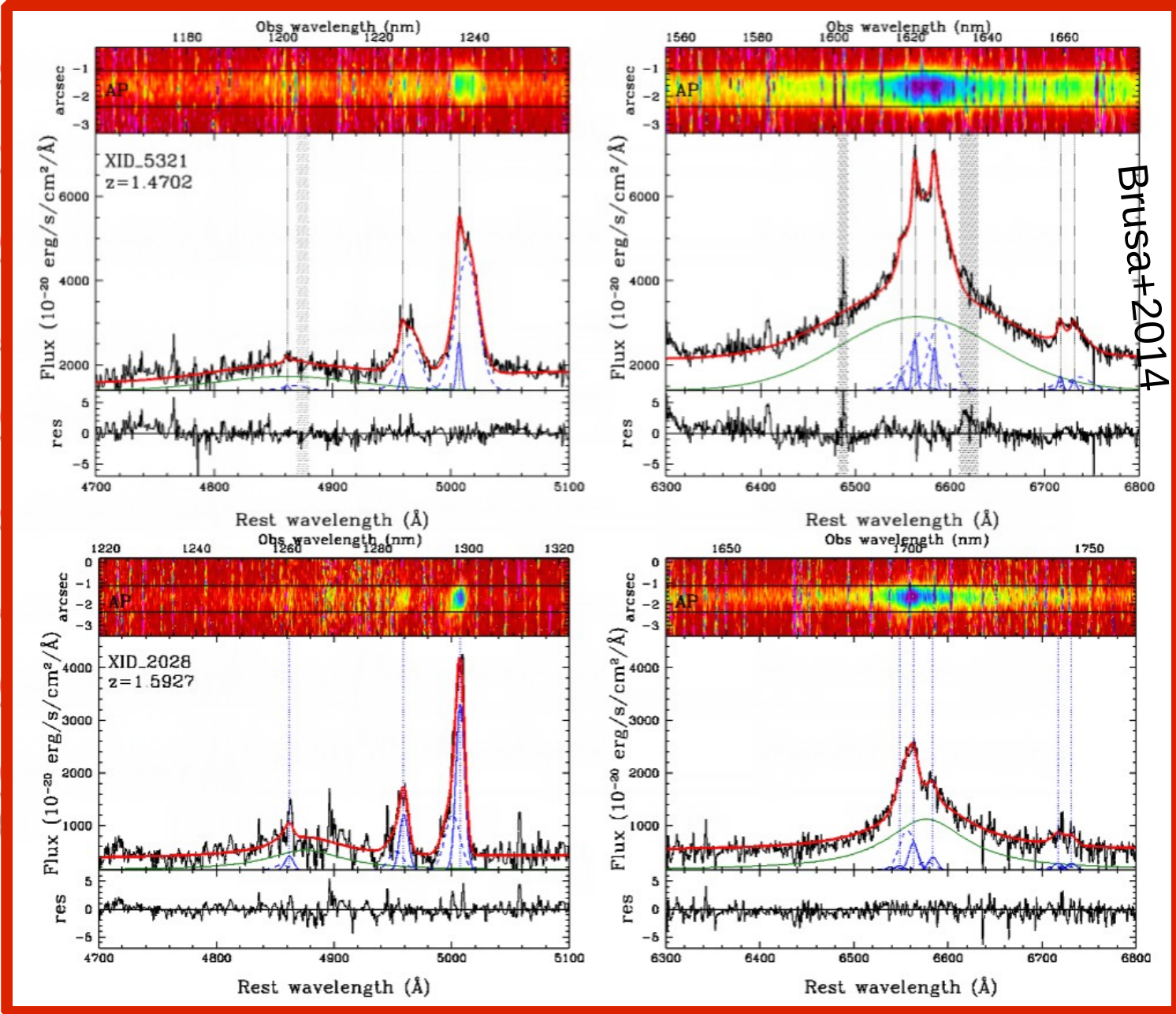
Brusa+2014

10 targets X-ray ($L_x > 44$) and K-band ($K < 19$) brightest objects at $z \sim 1.25-1.72$ observed in the VIS-NIR with VLT/X-shooter

XMM-COSMOS obscured qsos: single aperture Nuclear Spectra

54466	$z = 1.0034$
5573	$z = 1.1152$
5053	$z = 1.3735$
5325	$z = 1.3809$
5321	$z = 1.4702$
175	$z = 1.5279$
60053	$z = 1.5812$
2028	$z = 1.5927$
18	$z = 1.6073$
31357	$z = ?$

simultaneous multi-component fit:
systemic+BLR+outflow



XMM-COSMOS obscured QSOs: single aperture Nuclear Spectra

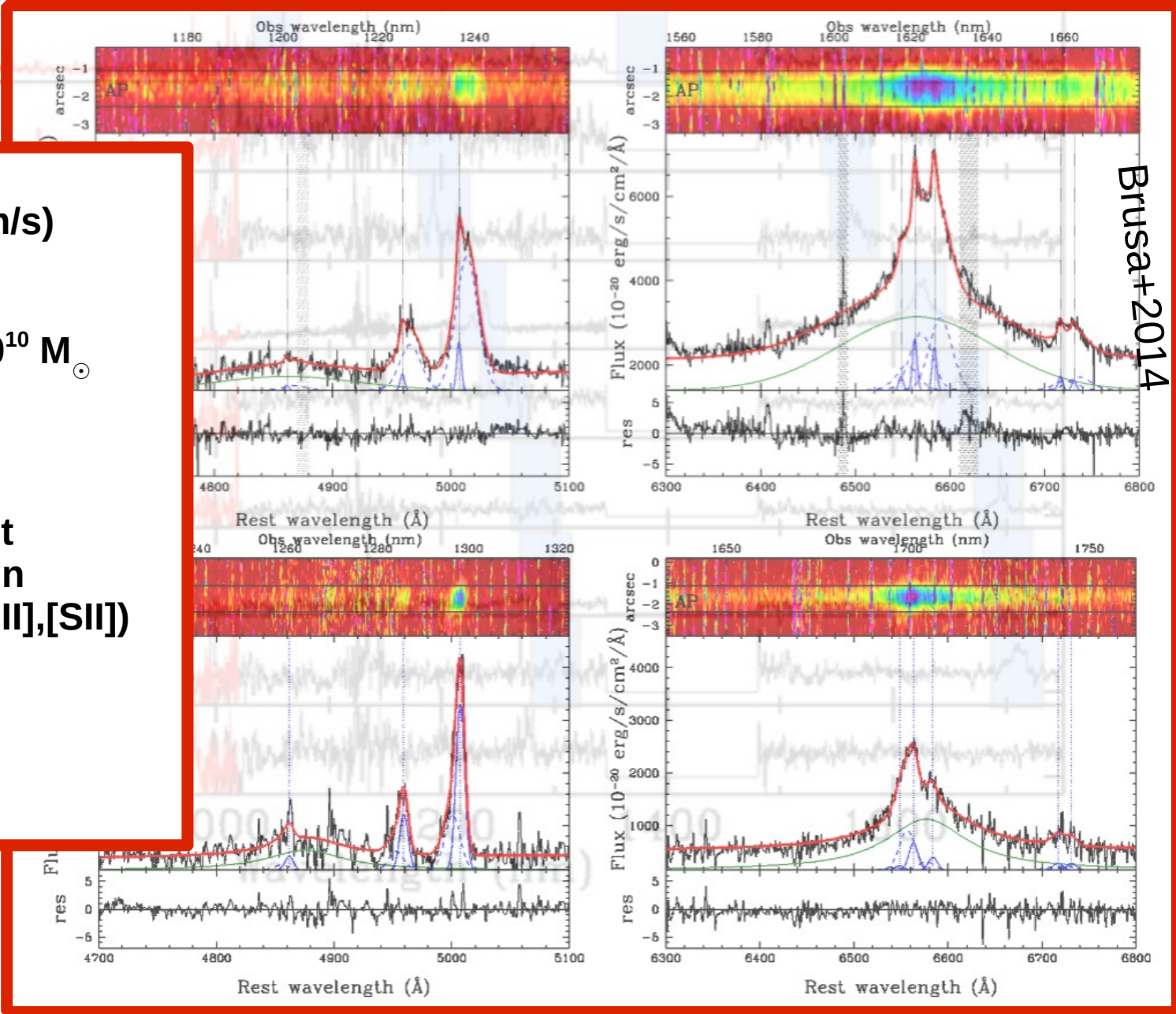
54466	$z = 1.0034$
5573	$z = 1.1152$
5053	$z = 1.3735$

simultaneous multi-component fit:
systemic+BLR+outflow

BLR H α (FWHM>2000 km/s) detected in 6/10

SMBHs with $M_{BH} = 10^8 - 10^{10} M_{\odot}$ (massive!) (Bongiorno+ 2014)

broad/shifted component (FWHM=900-1600 km/s) in forbidden lines ([OIII], [NII],[SII]) detected in 6/8 (75%) ascribed to outflows (Brusa+2014)



XMM-COSMOS obscured QSOs: single aperture Nuclear Spectra

Quantifying the OUTFLOW ENERGETICS:

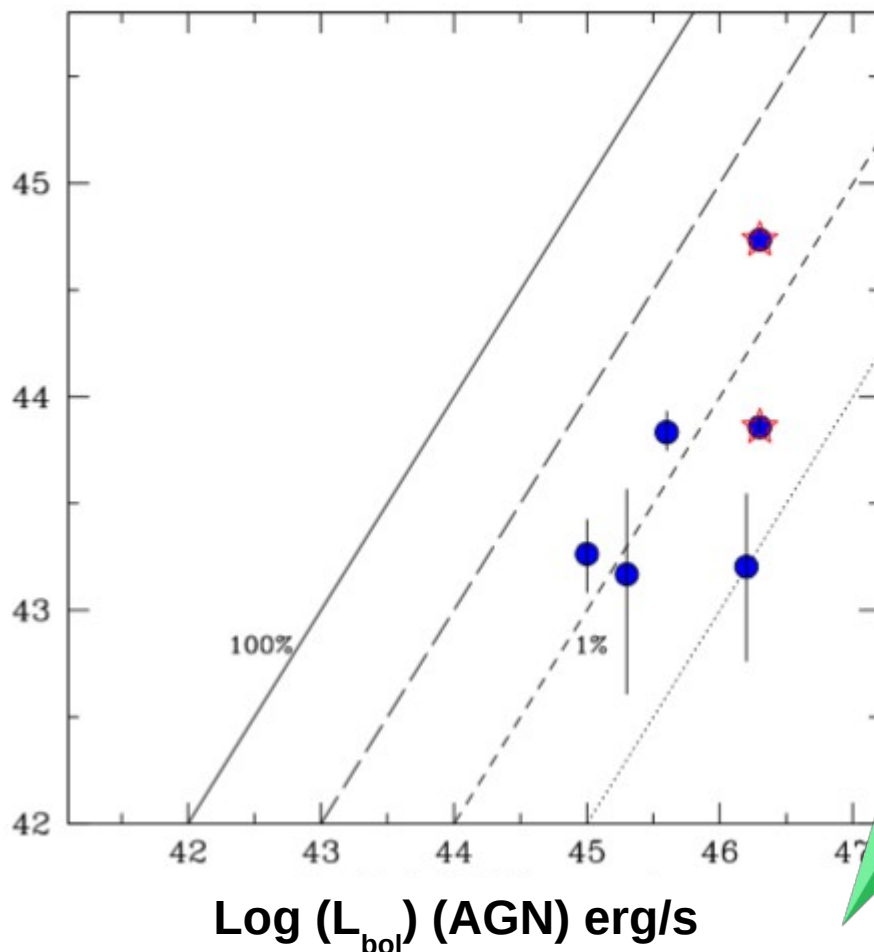
$$P_K^{ion} = 5.17 \cdot 10^{43} \frac{CL_{44}([OIII])v_{0,3}^3}{n_{e3}R_{kpc}10^{[O/H]}} \text{ erg s}^{-1}$$

Cano-Diaz+2012:

only ionized component → **LOWER LIMIT**

Estimates depend on radius, velocity, metallicity, density and [OIII] flux

Brusa+2014

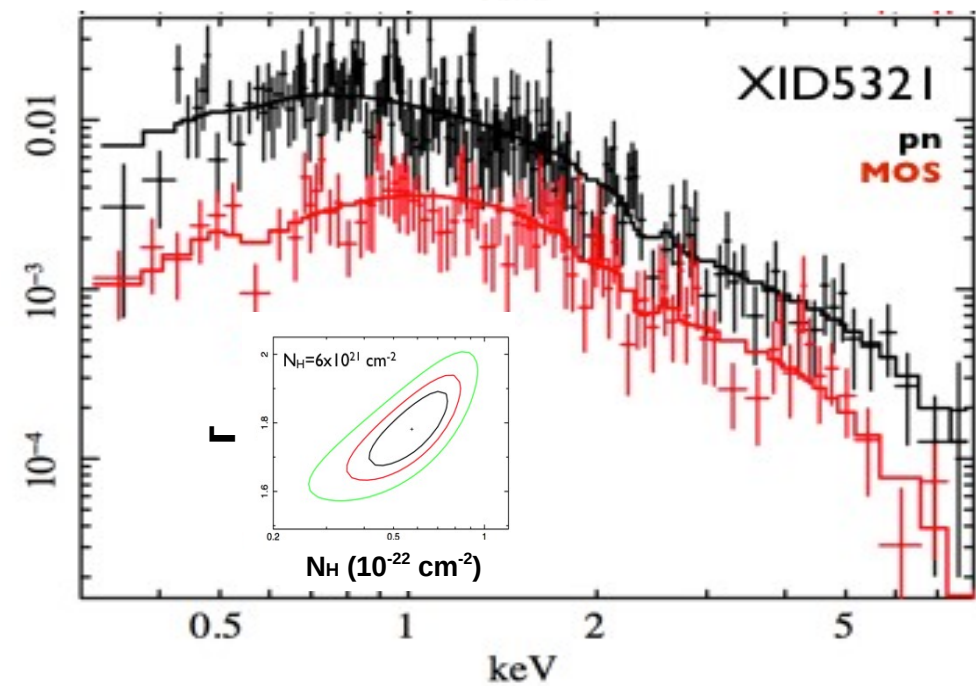
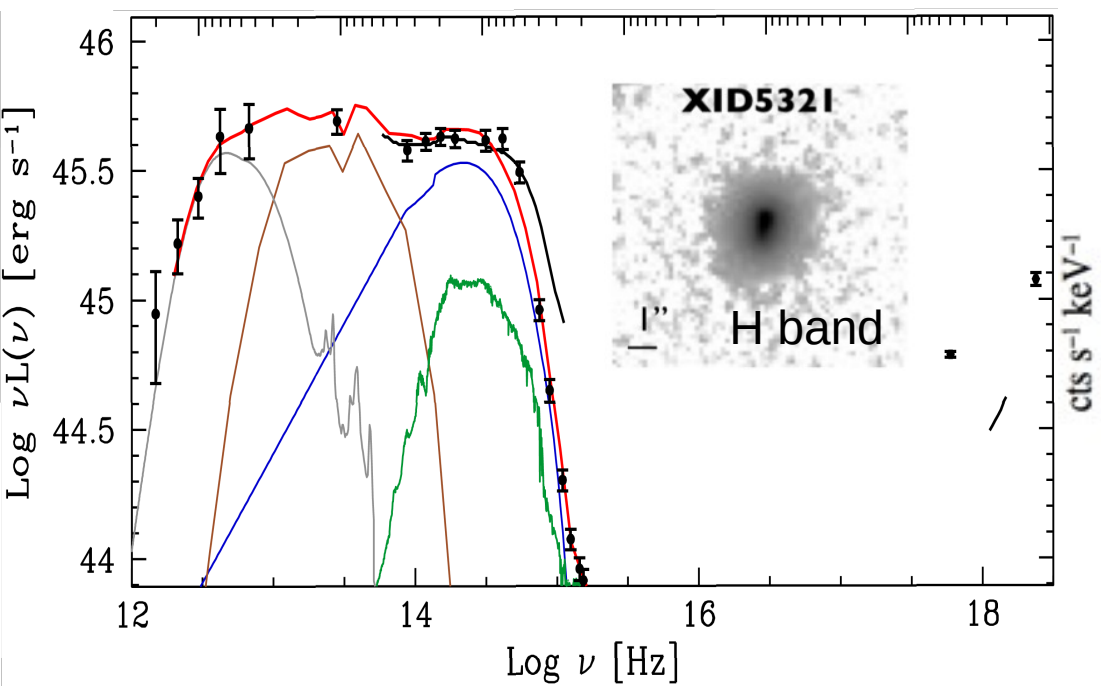
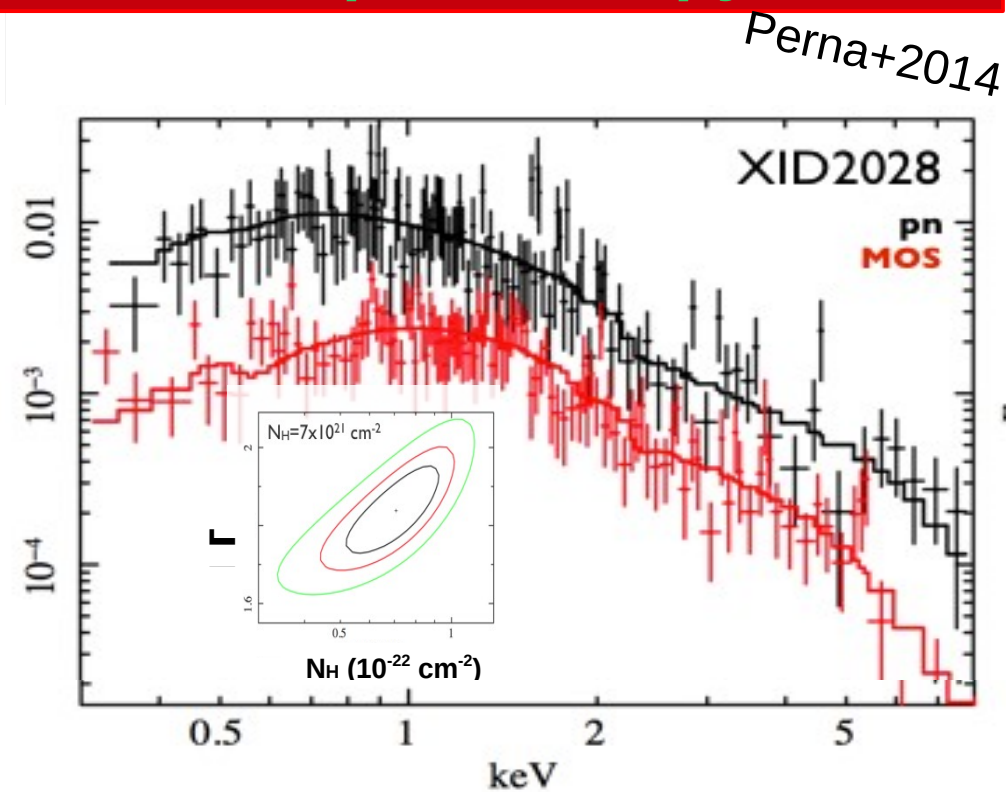
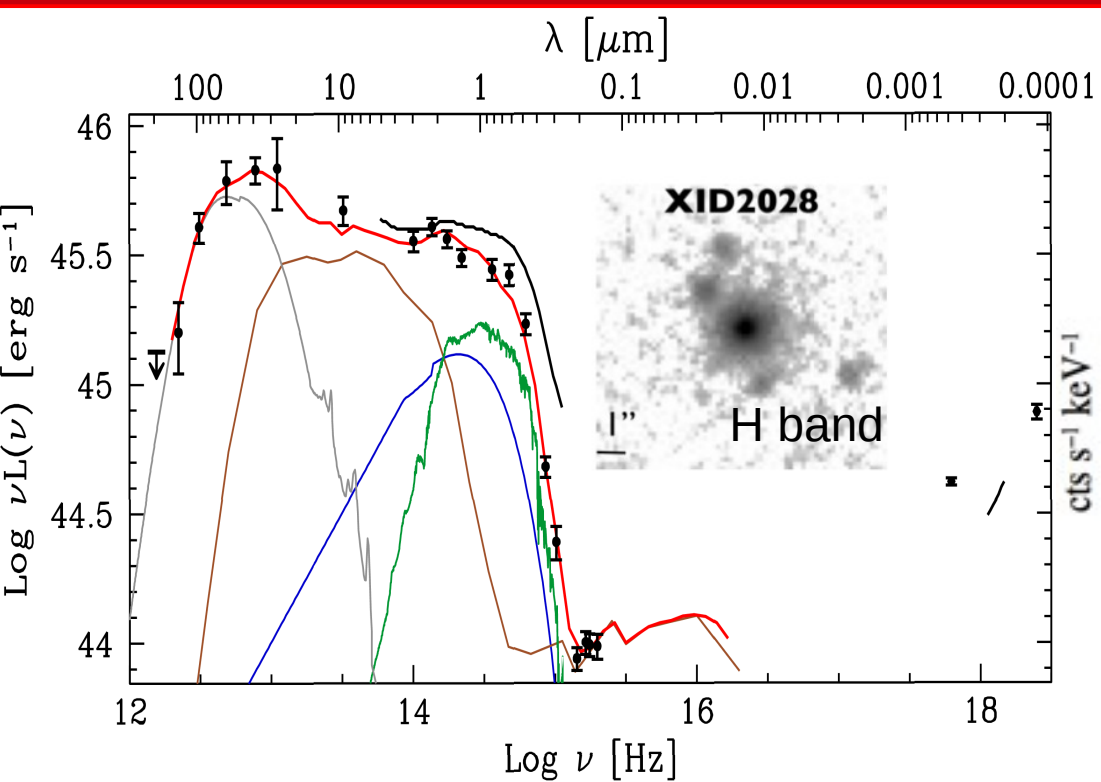


$$\frac{L_{[OIII]}}{L_{HB}} \approx 10$$

$$\frac{P_{[OIII]}}{P_{HB}} = 0.008 \frac{L_{[OIII]}}{L_{HB}}$$

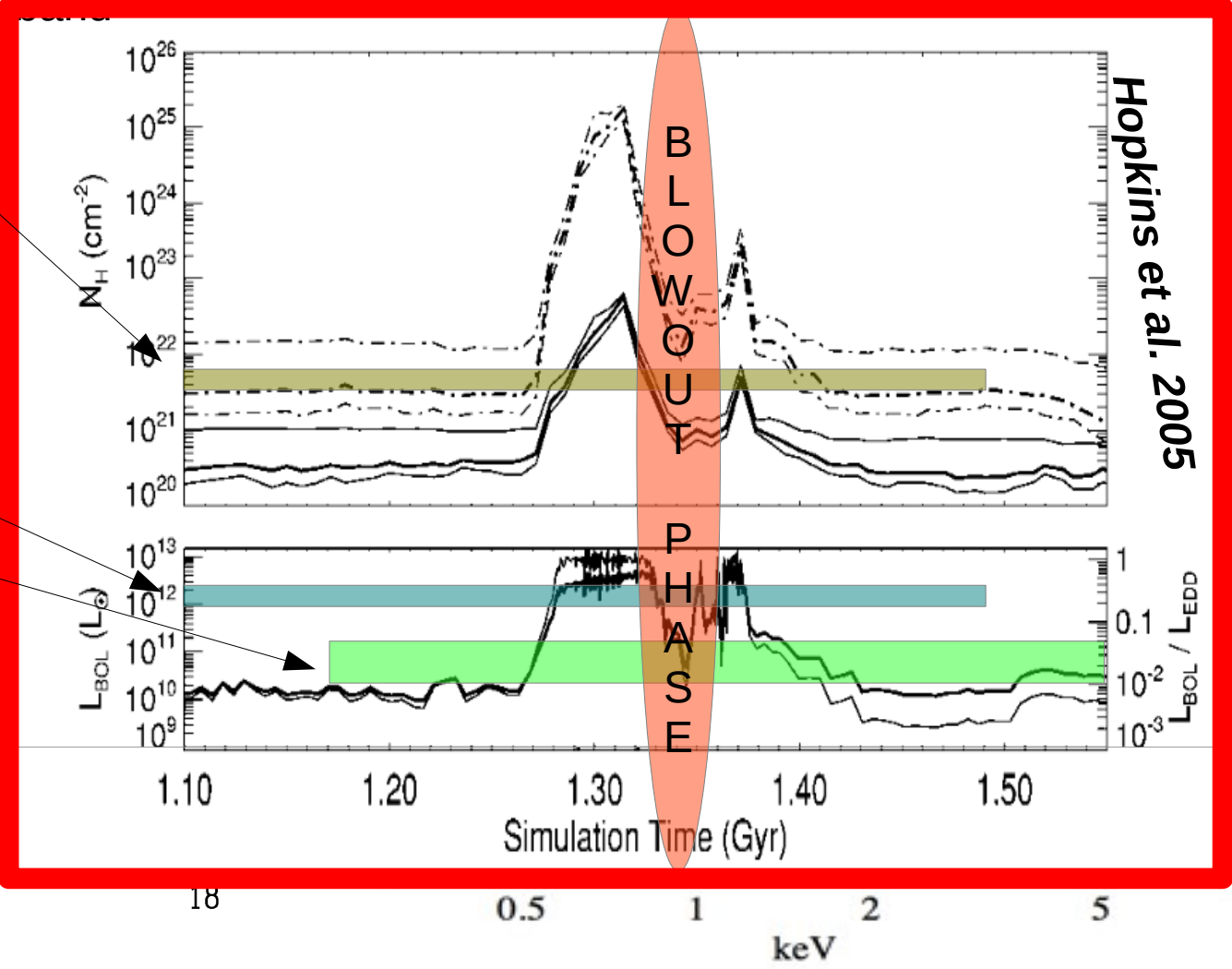
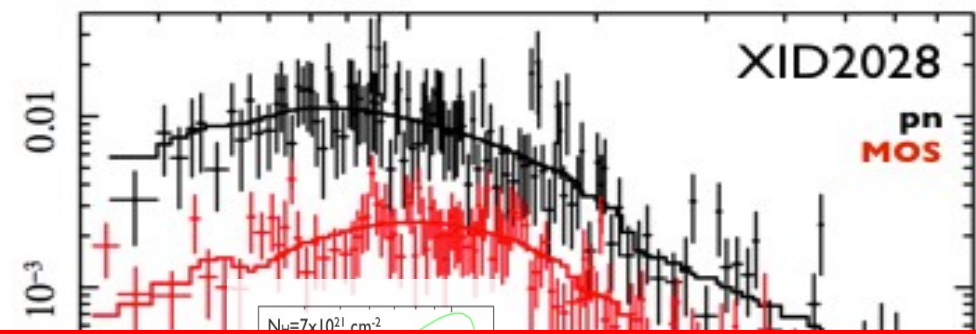
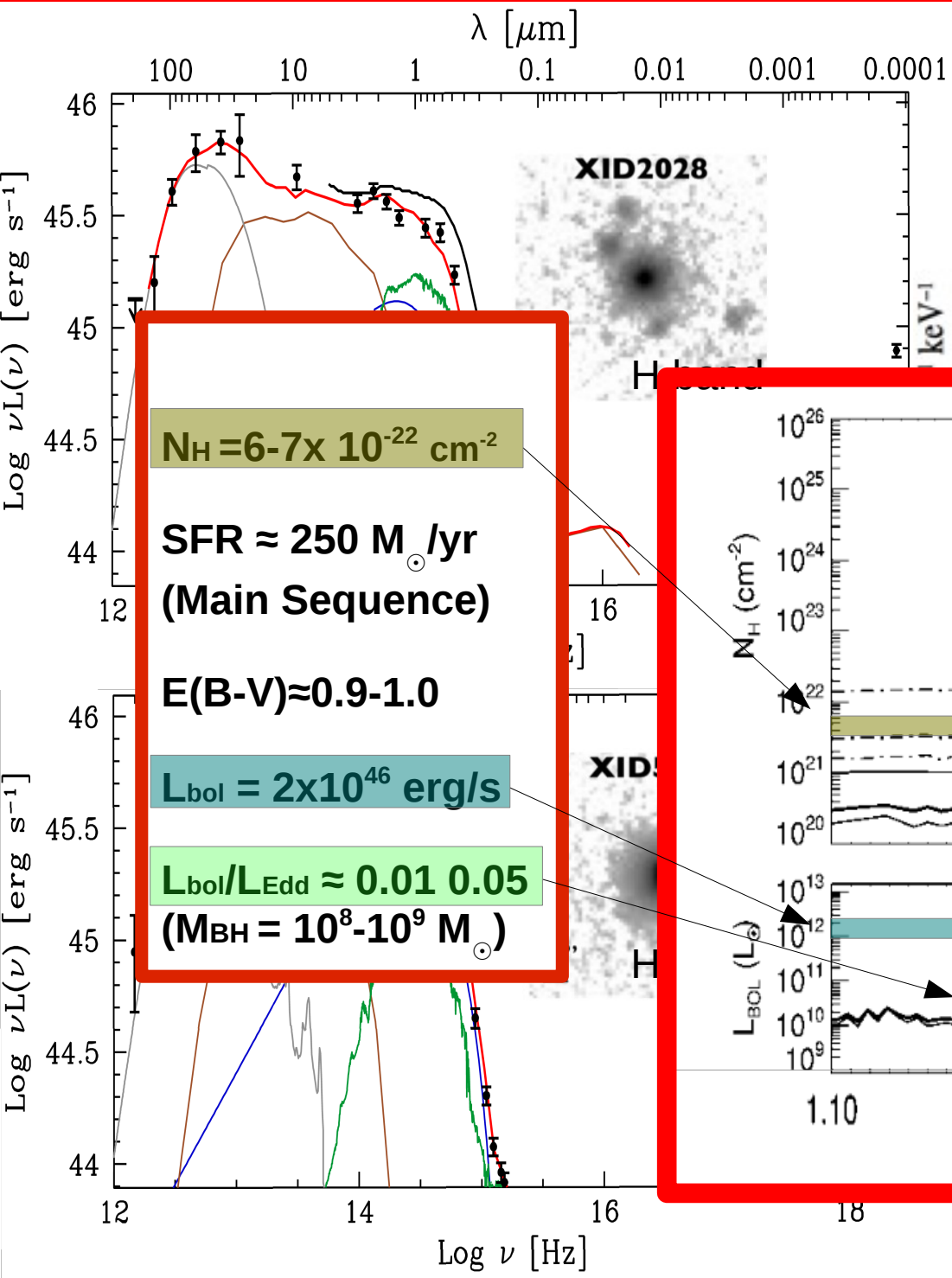
Kinetic powers consistent to the 0.1-5% coupling efficiencies, similar to that predicted by AGN feedback models (King 2005)

XMM-COSMOS obscured QSOs: *slit-resolved spectroscopy*



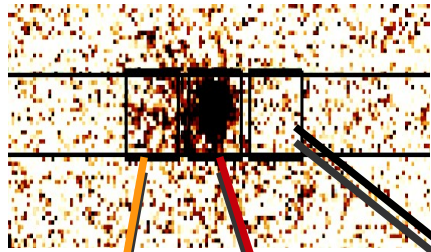
XMM-COSMOS obscured QSOs: *slit-resolved spectroscopy*

Perna+2014



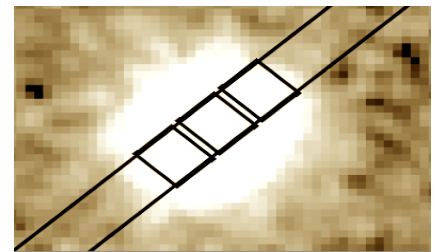
Evidences of large-scale outflows from X-shooter slit-resolved spectroscopy of two $z \sim 1.5$ obscured QSO in COSMOS

HST-ACS I-band

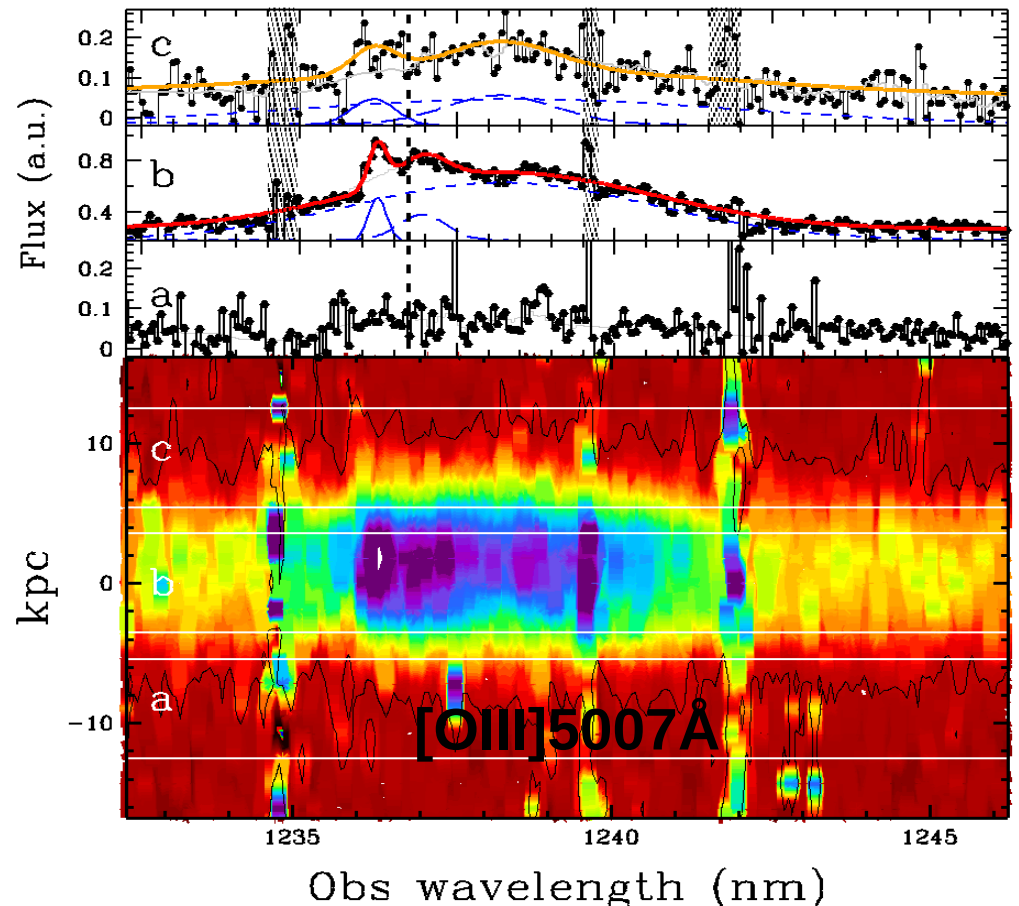
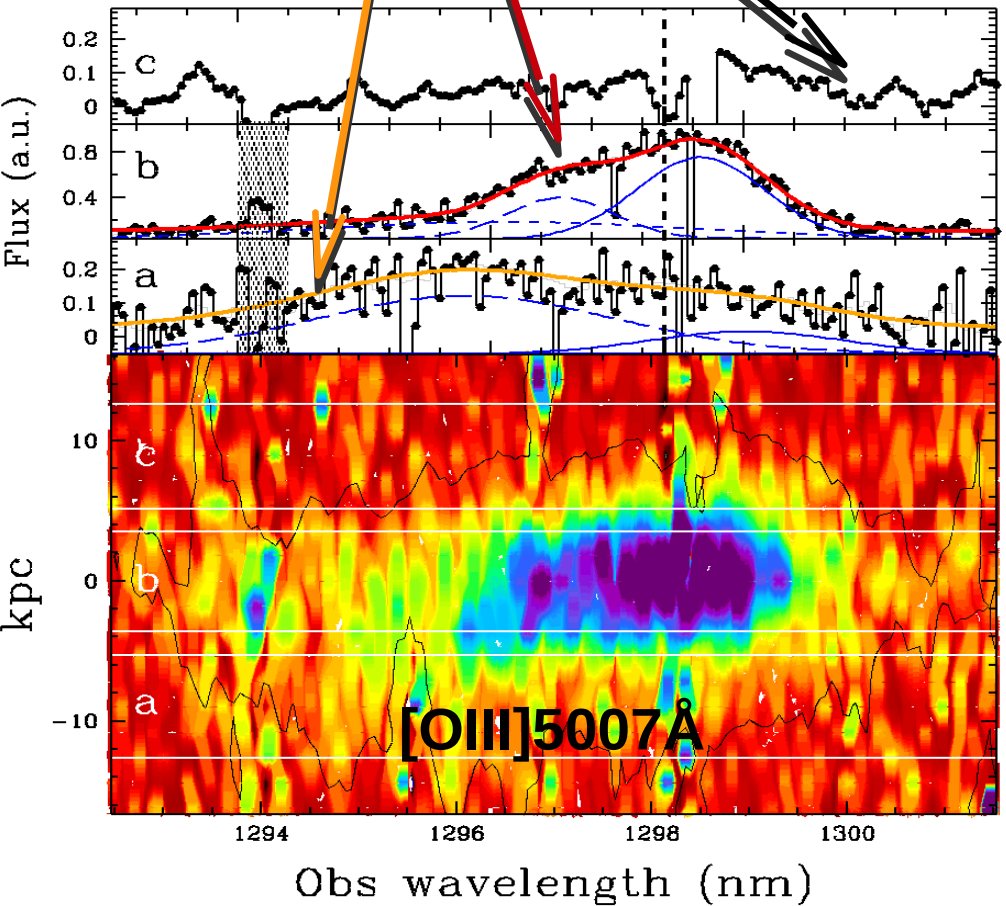


ID2028

UltraVista J-band

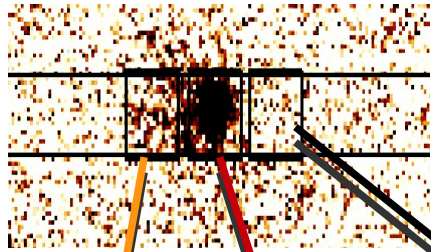


ID5321



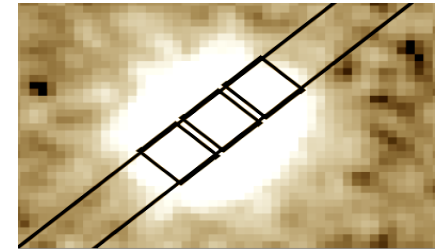
Evidences of large-scale outflows from X-shooter slit-resolved spectroscopy of two $z \sim 1.5$ obscured QSO in COSMOS

HST-ACS I-band

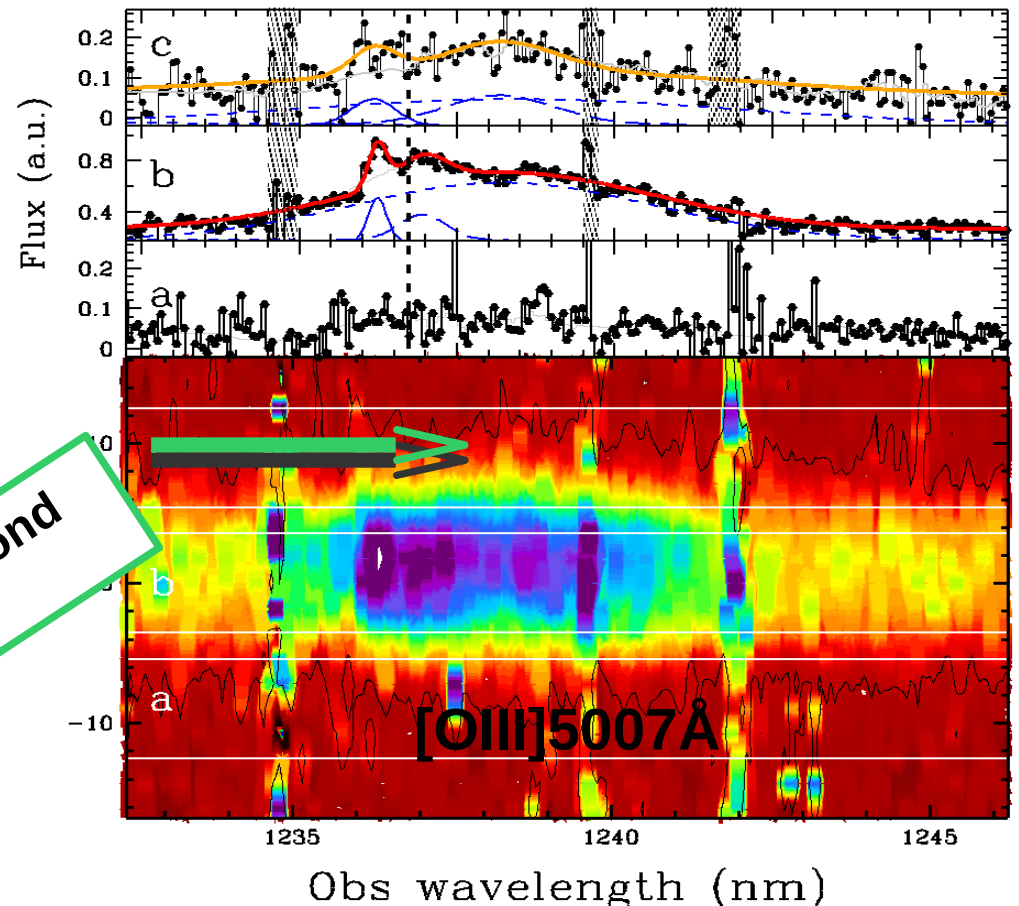
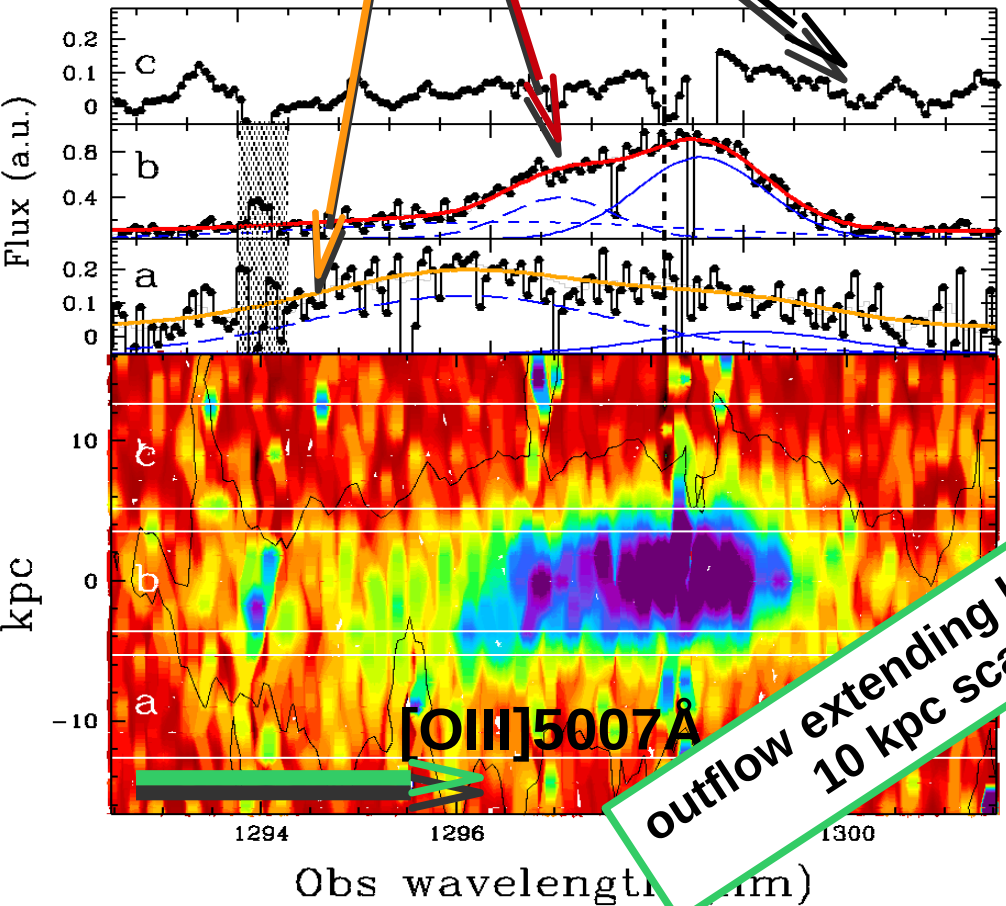


ID2028

UltraVista J-band



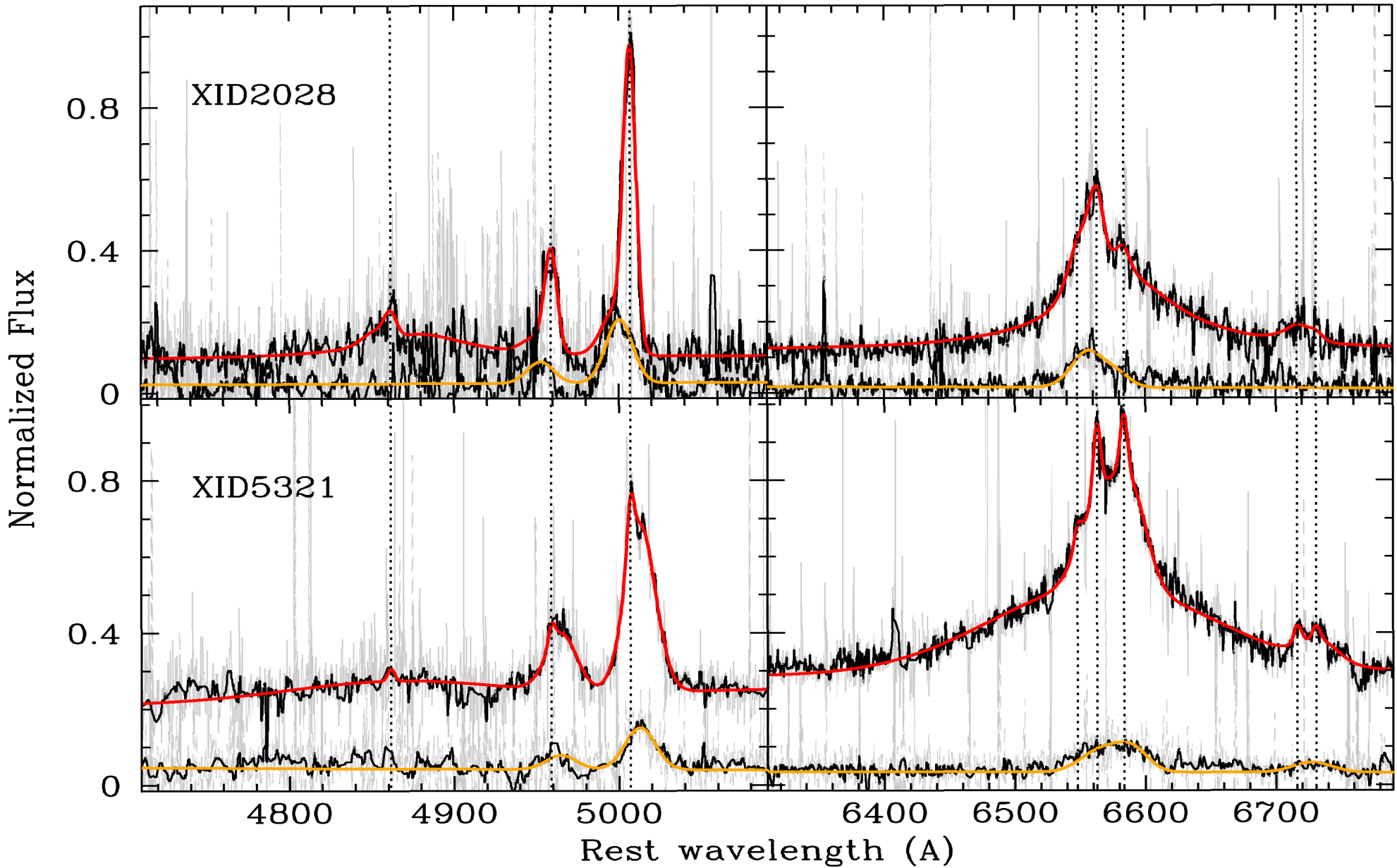
XID5321



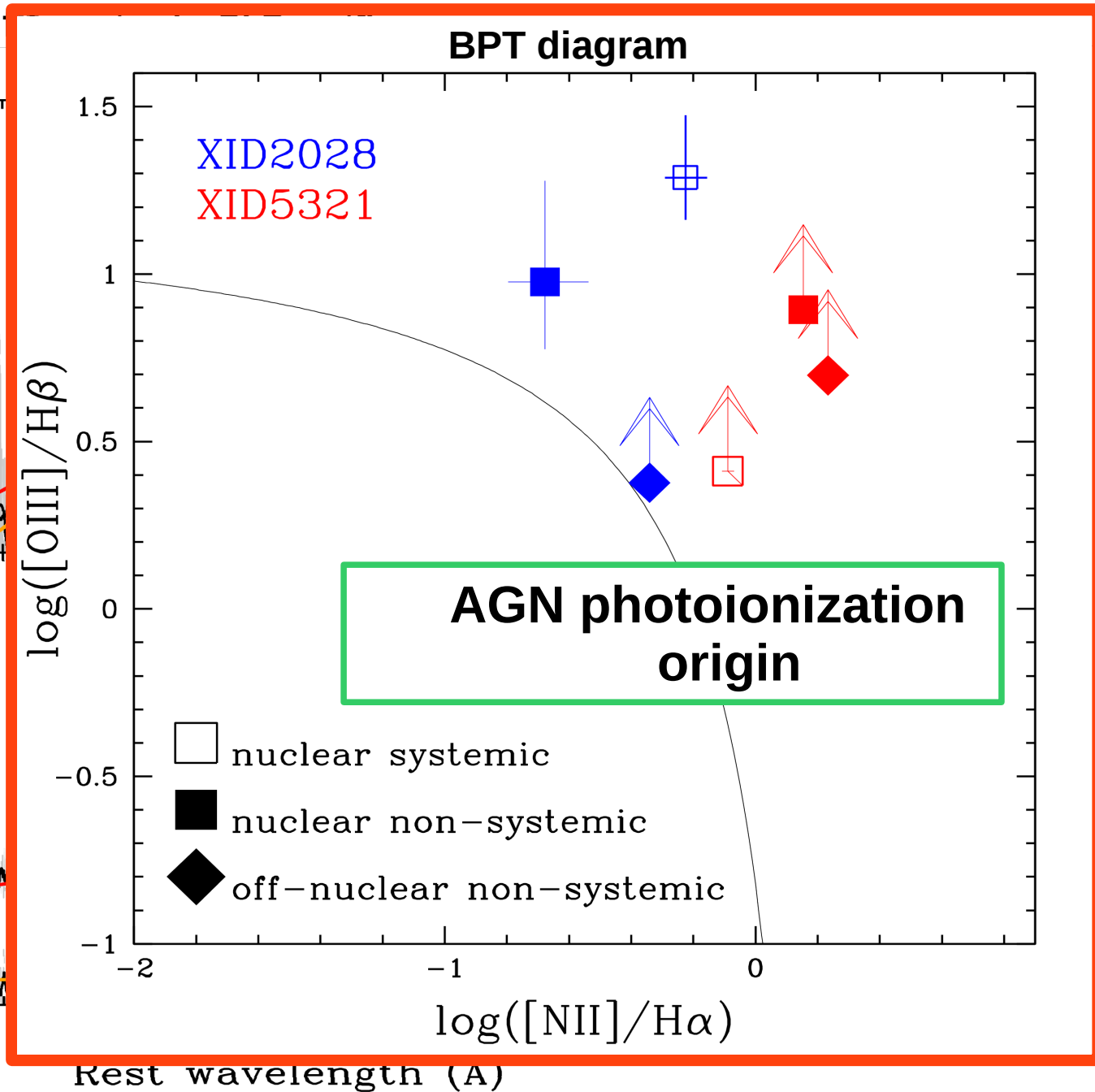
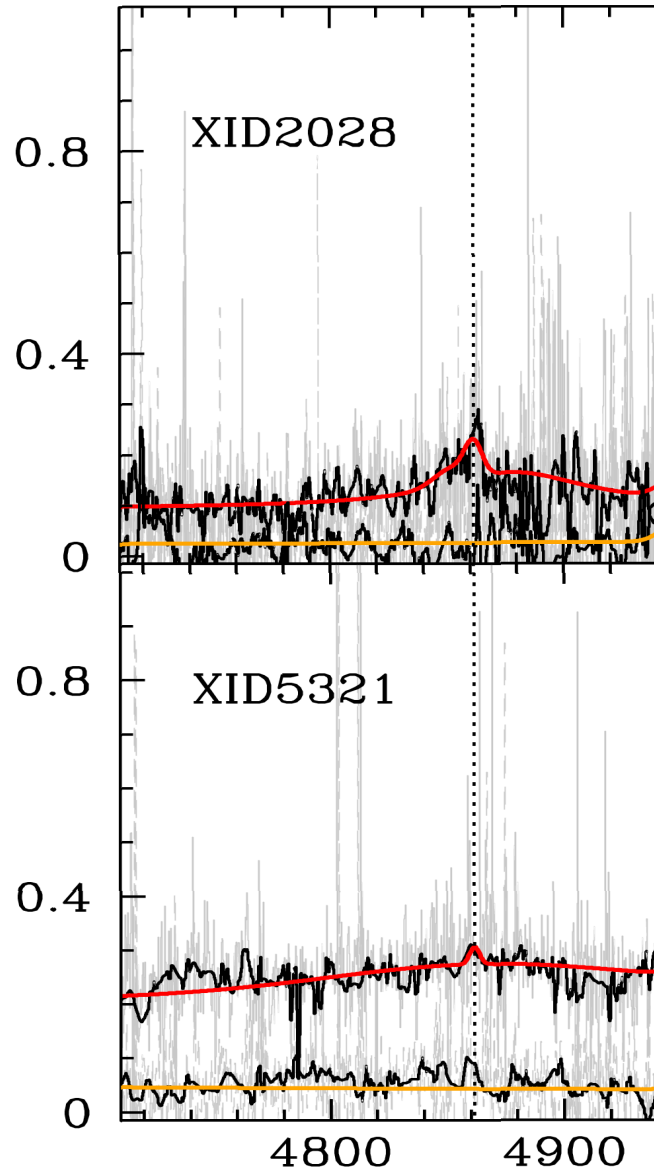
outflow extending beyond 10 kpc scale!

Fluxes & Velocities:

simultaneous multi-component fit: systemic+BLR+outflow



Fluxes & Velocities: simultaneous multi-component



XMM-COSMOS obscured QSOs: *slit-resolved spectroscopy*

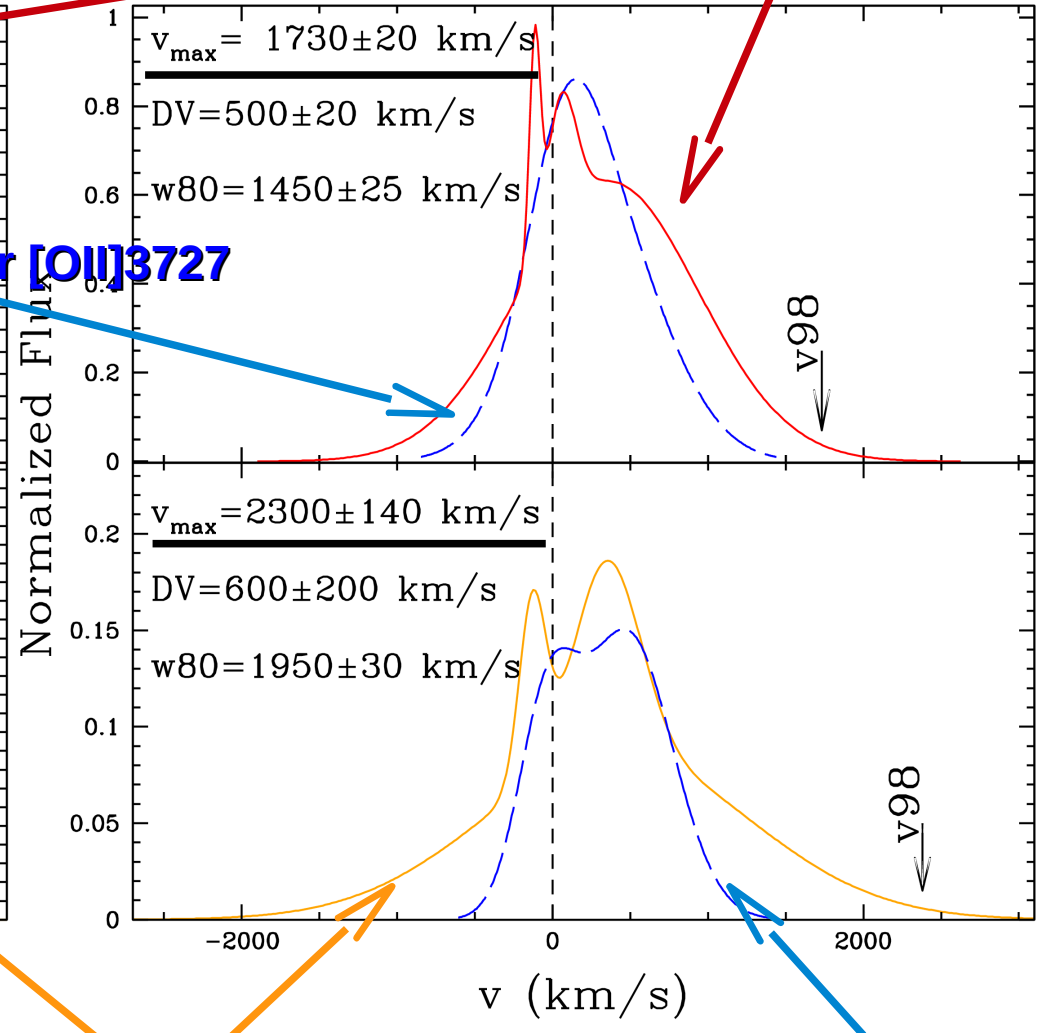
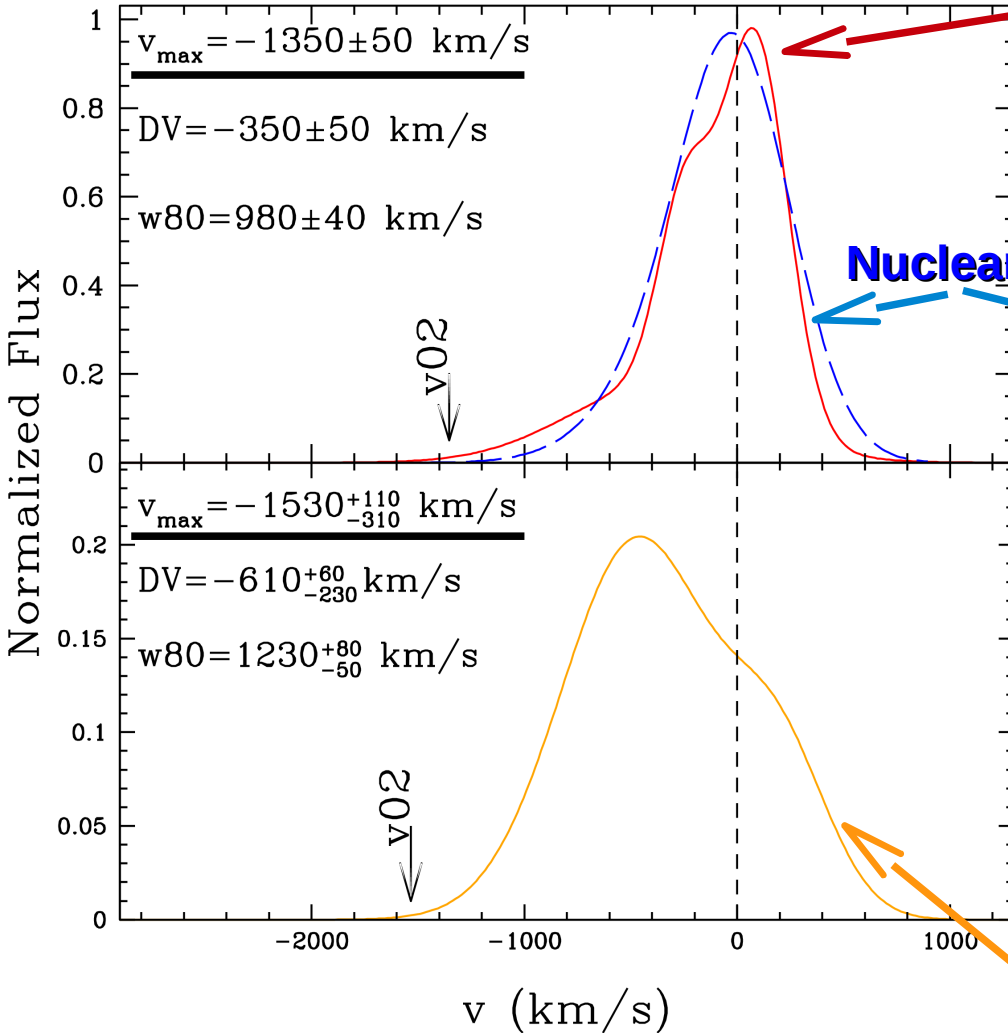
Perna+2014

Fluxes & Velocities: Non-parametric analysis

XID2028

XID5321

Nuclear [OIII]5007



Nuclear [OII]3727

Off-Nuclear [OII]3727

Off-Nuclear [OIII]5007

Quantifying the outflow mass rate:

$$M_{\text{out}}^{\text{ion}} = 5.33 \times 10^7 \frac{C L_{44}([\text{OIII}])}{\langle n_{e3} \rangle 10^{[\text{O}/\text{H}]}} M_{\odot}$$

Cano-Diaz+2012:

only ionized component; \longrightarrow **LOWER LIMIT** \longrightarrow O^{+2} form

$$L_{[\text{OIII}]} / L_{\text{H}\beta} \approx 10$$

$$\dot{M} = 3 M_{\text{out}} v_0 / R$$

- $R = 10 - 12$ kpc
- $L([\text{OIII}])$ from nuclear & off-nuclear regions, and corrected for the extinction (Balmer decrements)
- $N_{e3} = 120 \text{ cm}^{-3} / 10^3$ from off-nuclear [SII] emission
- $v_0 = v_{\text{max}}$
- Solar metallicity

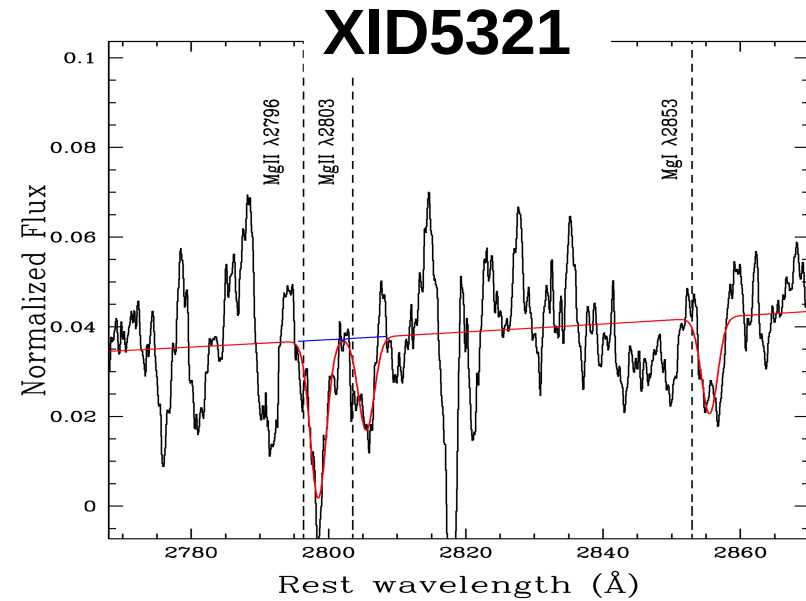
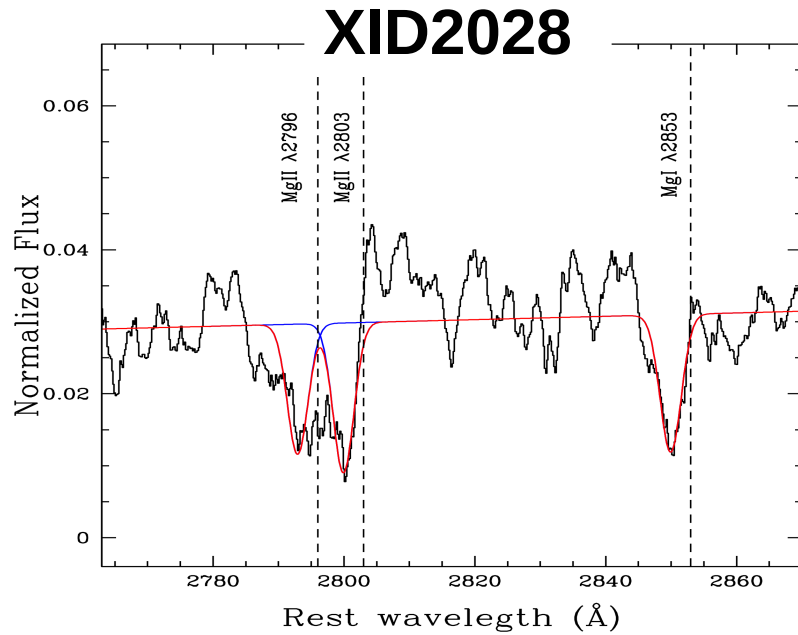
$$\dot{M}_{\text{out}}^{\text{ion}}(2028) \approx 550 M_{\odot} \text{ yr}^{-1}$$

$$\dot{M}_{\text{out}}^{\text{ion}}(5321) \approx 500 M_{\odot} \text{ yr}^{-1}$$

XMM-COSMOS obscured QSOs: *slit-resolved spectroscopy*

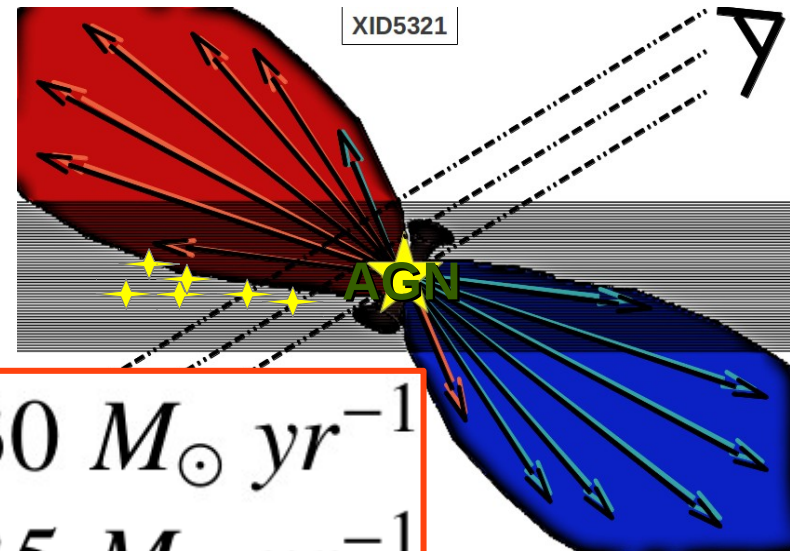
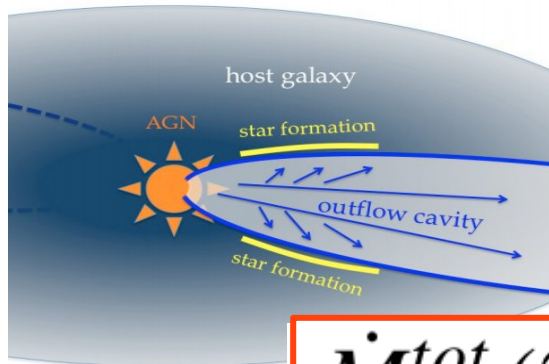
Perna+2014

Neutral component:
sodium NaD $\lambda\lambda$ 5890,5896, magnesium MgII $\lambda\lambda$ 2796,2803 and MgI λ 2853 absorption lines



All the absorption lines show shifts nearly like those observed in the emission lines.

Cresci+2014



$$\dot{M}_{out}^{tot}(2028) > 630 M_{\odot} yr^{-1}$$

$$\dot{M}_{out}^{tot}(5321) > 535 M_{\odot} yr^{-1}$$

Weiner et al. (2009)
neutral component:

(1) Selection does work!

large scale (>10 kpc) outflow present in X-ray luminous, obscured XMM-COSMOS QSOs

---> inferred for 6 sources from [OIII] widths & shifts in integrated X-shooter spectra

---> confirmed by X-shooter slit-resolved spectroscopy (XID5321, XID2028)

(and directly detected in SINFONI/IFU data (XID2028; Cresci et al. 2014))

(2) Outflows are most likely AGN-driven

---> “fiducial” outflow kinetic power exceeds kinetic output from SN winds

---> consistent with predictions in feedback models (5% of $L_{\text{bol,AGN}}$)

---> confirmed by BPT diagram and momentum fluxes (XID5321, XID2028),

consistent with “momentum boost” observed in local ULIRGs dominated by

AGN & in luminous QSO, and required to reproduce the normalization of the $M_{\text{BH}} - \sigma$ relation