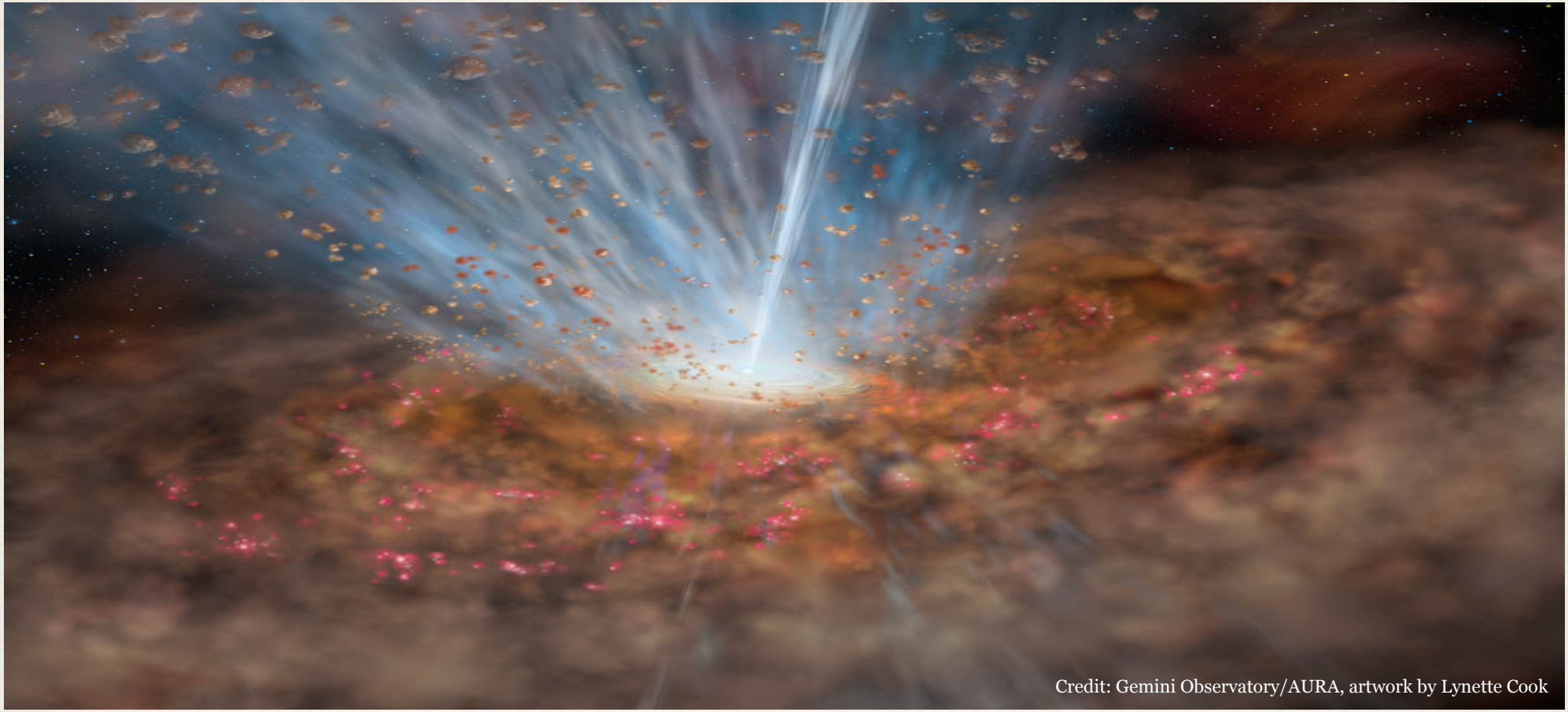

The Role of AGN in Galaxy Evolution

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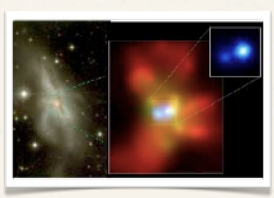
Charlotteville - 2014/08/06

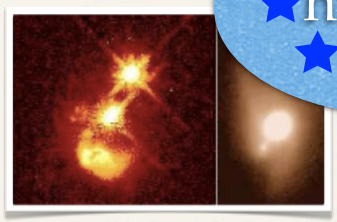
AGN-galaxy co-evolution

galaxy merger

gas inflow



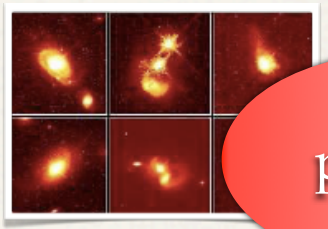
Starburst & buried QSO



high SF

transition/blow-out phase

Quenching AGN feedback



passive

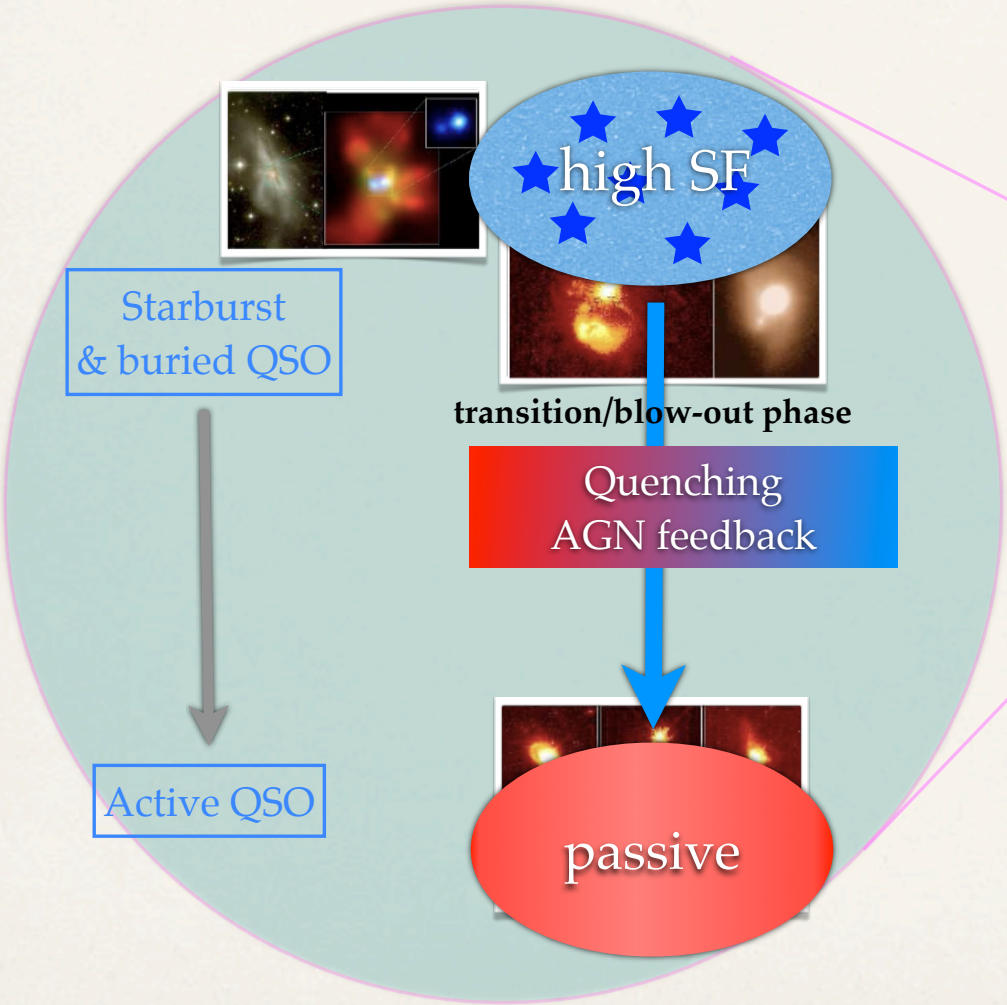
Active QSO

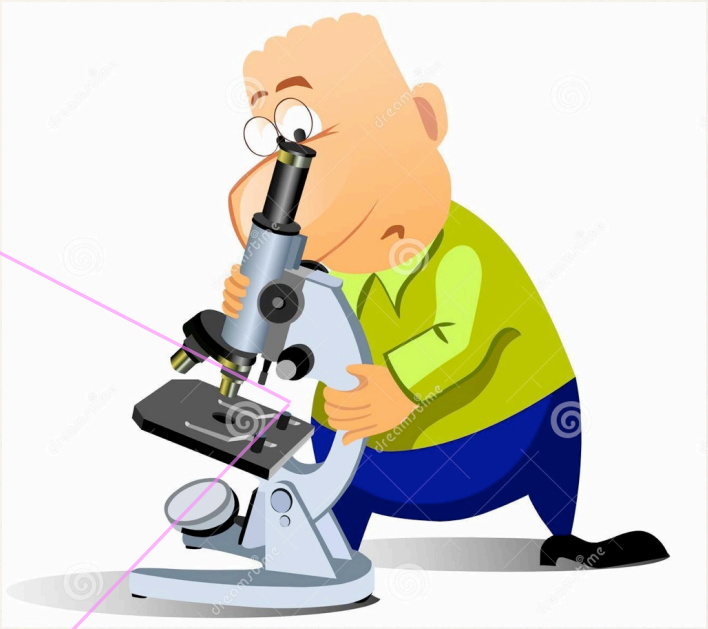
Hierarchical growth

Normal galaxy

(Adapted from Hopkins et al. 2008)

The feedback or blow-out phase



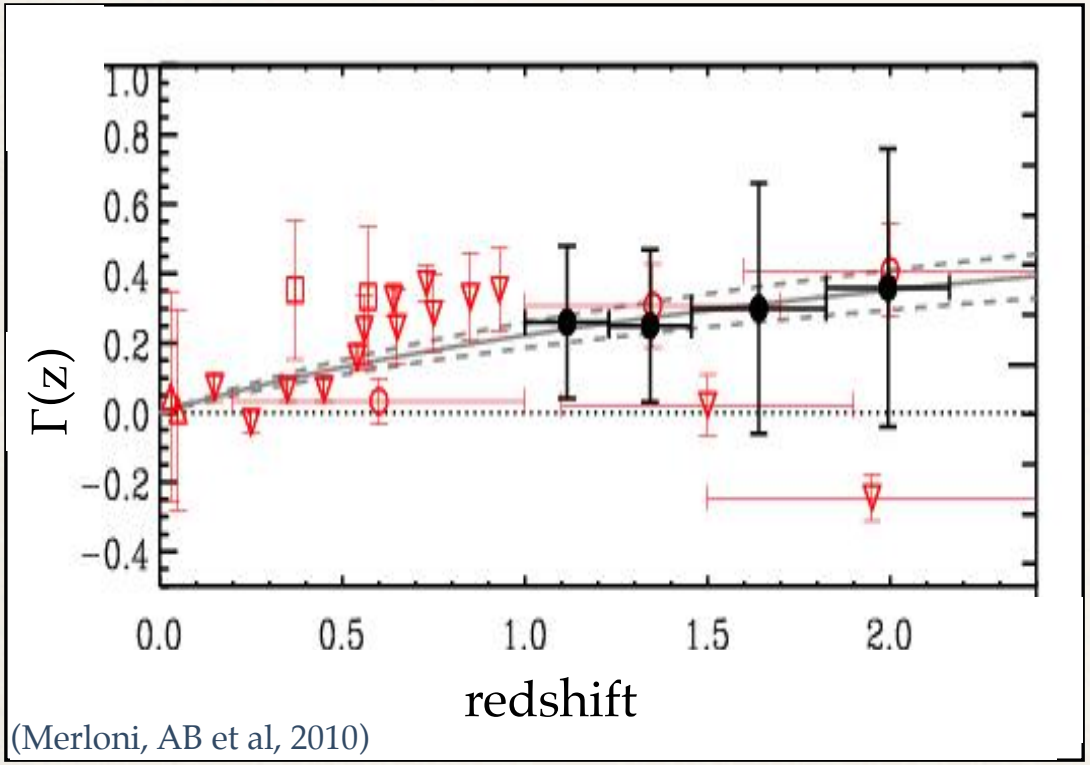


Which objects?

Red, luminous, X-ray obscured QSOs

Evolution of M_{BH}/M_*

Unobscured blue QSOs



(Merloni, AB et al, 2010)

$\Gamma(z)=\lg(M_{BH}/M_*)(z) - \lg(M_{BH}/M_*)(z=0)$

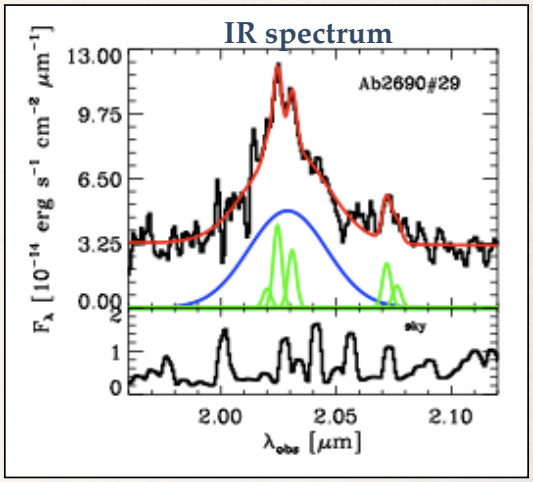
M_{BH}/M_* increasing with z

(see also Decarli et al, 2010)

Evolution of M_{BH}/M_*

Obscured red QSOs

- **Data very difficult to get: BH masses using the virial formula require the broad line**
  - rest-frame UV line (MgII) obscured
  - rest-frame optical line (Hα) redshifted in the IR

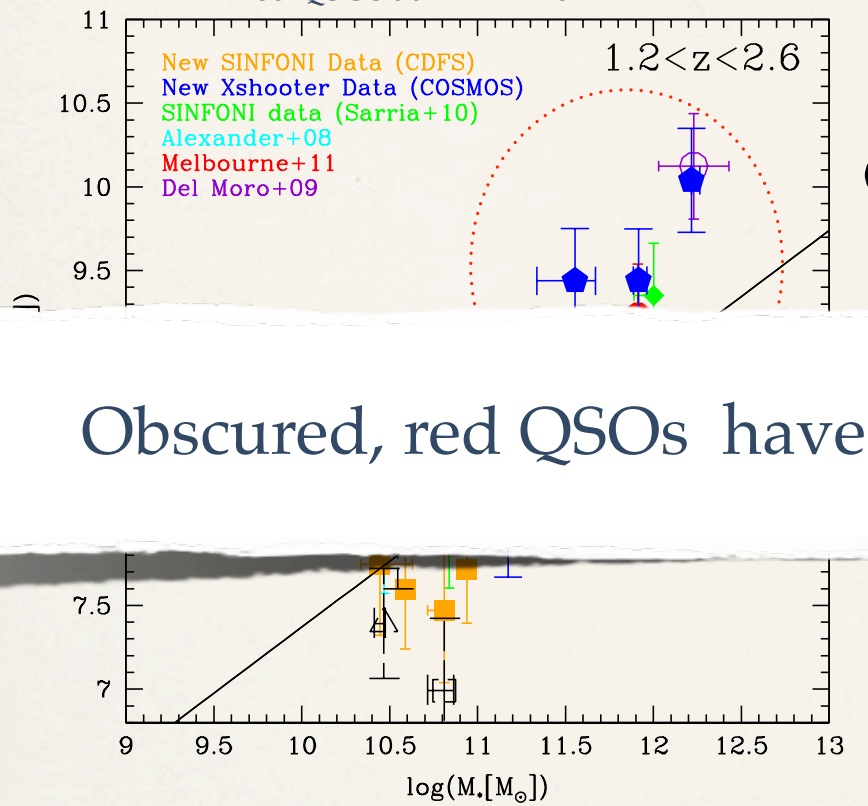


- **SAMPLE: 21 red, obscured QSO (L_{bol}~10^{12} $L_\odot$, R-K>5 & N_H>10^{22} cm^{-2})**
  - **12 objects from new observations:**
    - ✓ SINFONI obs: **3** H2XMM with broad Hα (Sarria+10)
    - ✓ new SINFONI obs - CDFS: **4** with broad Hα
    - ✓ new XSHOOTER obs - COSMOS: **5** with broad Hα
  - **9 objects taken from literature with similar properties**

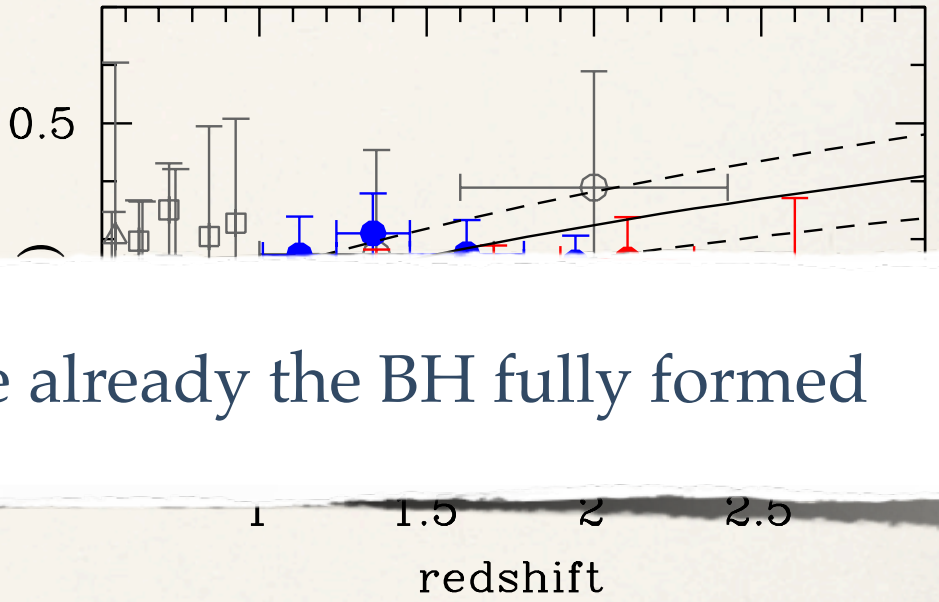
Evolution of M_{BH}/M_*

Obscured red QSOs

21 red QSOs at 1.2<z<2.6



Blue unobscured QSOs vs red obscured QSOs



Obscured, red QSOs have already the BH fully formed

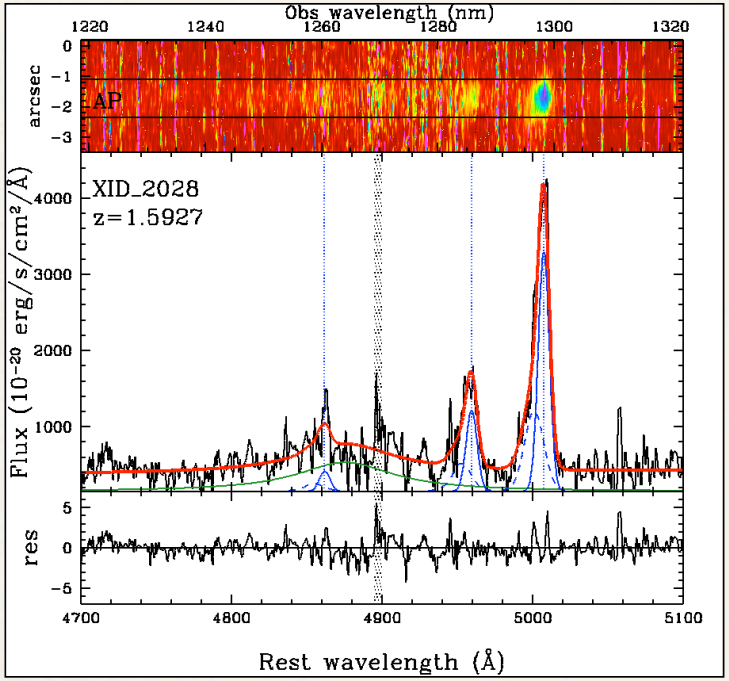
- Obscured red QSOs are located around the local relation (big scatter).
- most massive objects are located above

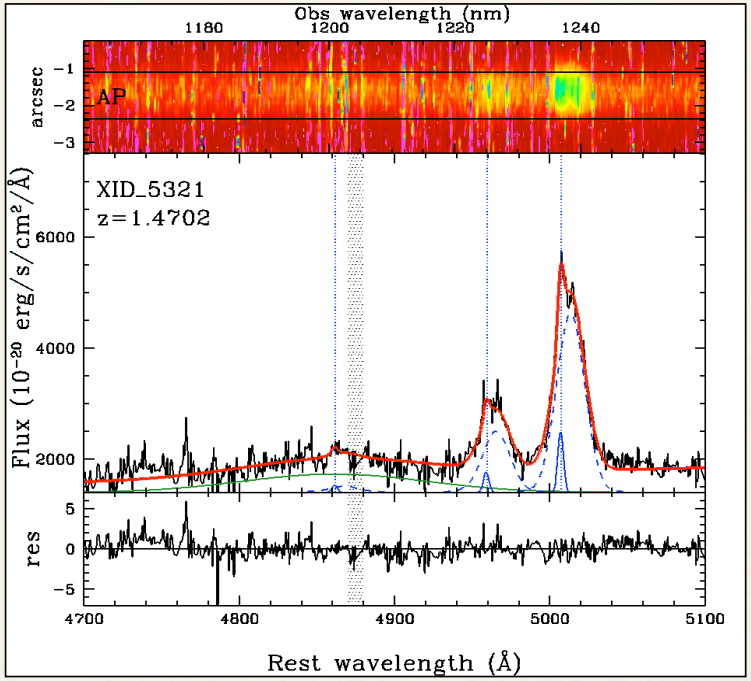
(Bongiorno et al, 2014)

- Obscured red QSOs and blue QSOs populate the same region of the plane

Physics of AGN in the "transition phase": obscured red QSOs from XMM-COSMOS

XShooter observations:



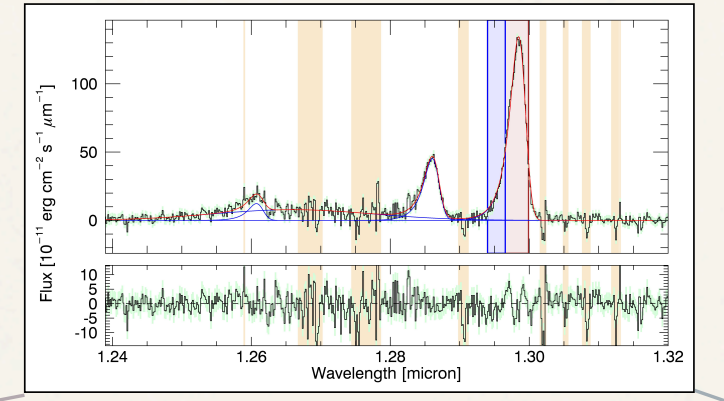


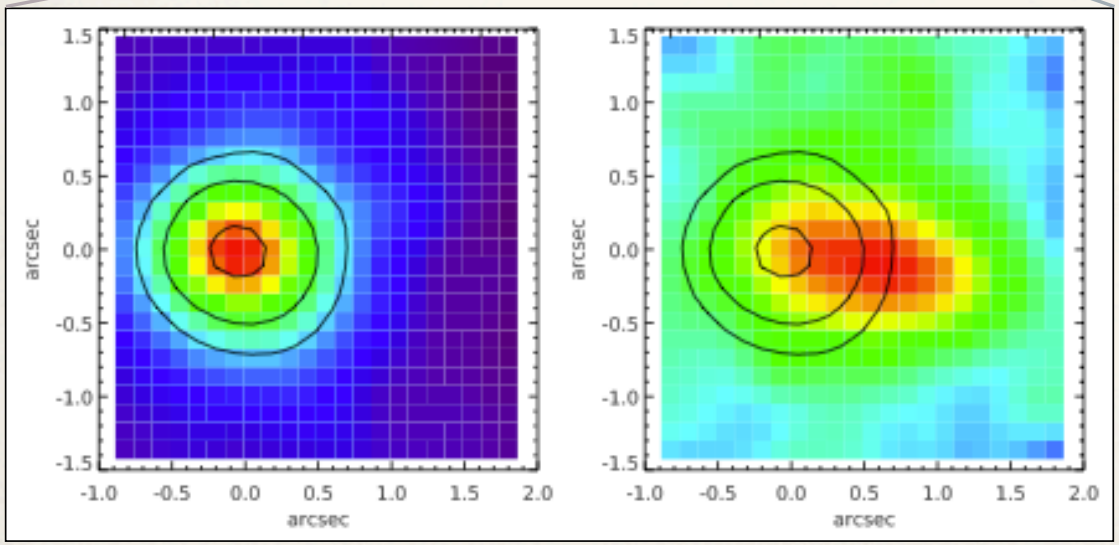
- **Broad** (FWHM=900-1600 km/s) and **shifted** (Δv=300-500 km/s) components in the **ionized lines** ([OIII],[NII]) clearly revealed in 4/5 targets
- They can be ascribed to outflows!

(Brusa, AB, submitted ; Perna et al, in prep)

Physics of AGN in the "transition phase": XID2028 an obscured red QSO at z=1.6

SINFONI observations: **XID2028 - radio quiet - L_{bol} =2 x 10^{46} - z=1.6**





large scale OUTFLOW in [OIII]

v = -1500 km/s

d ~ 13 kpc from the black hole

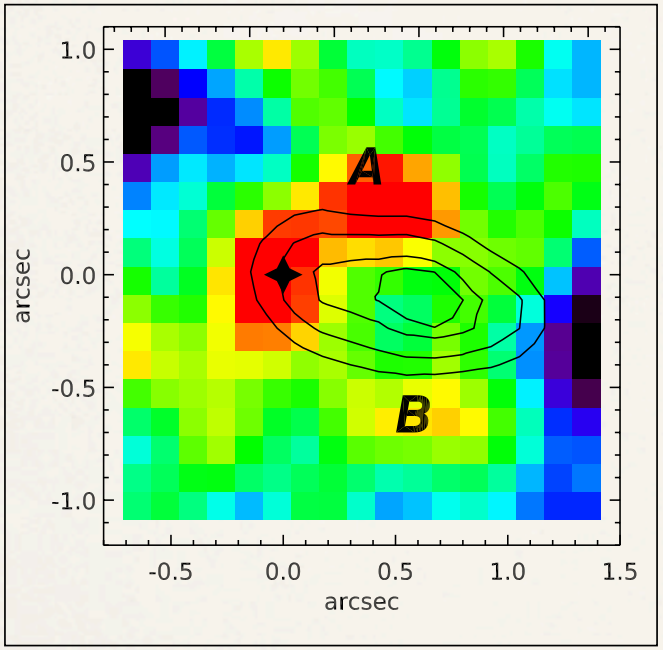
$\dot{M}_{out} > 1000\ M_\odot/yr$

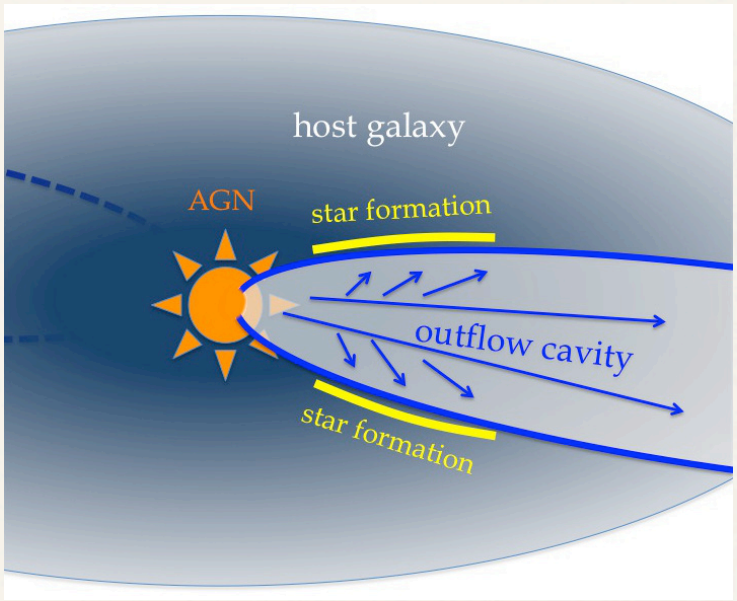
SFR ~ 300 $M_\odot/yr$

(Cresci et al. submitted)

Physics of AGN in the "transition phase": XID2028 an obscured red QSO at z=1.6

Is AGN feedback influencing the host galaxy properties?



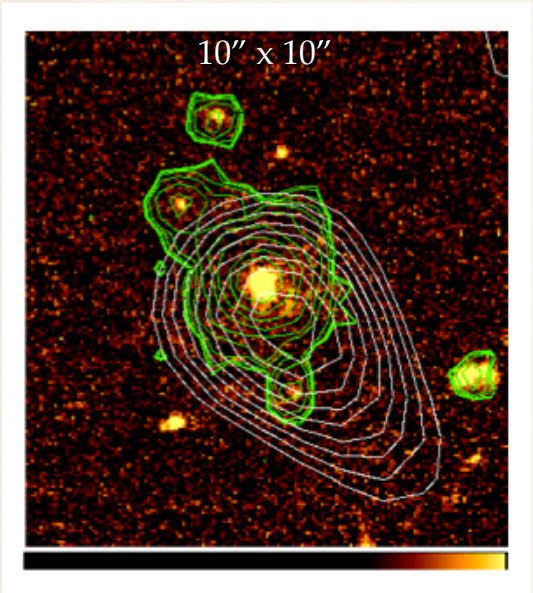


- The outflowing material is sweeping the gas along the outflow core ('negative feedback')
- The outflowing material is compressing the gas at its edges inducing star formation ('positive feedback')

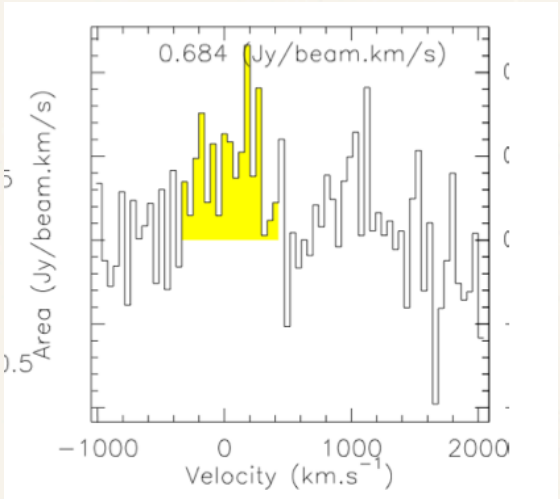
(Cresci et al. submitted)

Physics of AGN in the "transition phase": XID2028 an obscured red QSO at z=1.6

PdBI observations: CO(3-2)



green: K-band (galaxy)
white: CO map



- observed @133.37 GHz with PdBI
- CO(3-2) emission line detected at ~ 5σ
- No blue/red/broad wings ascribed to the outflow detected due to low S/N

ALMA observations required!

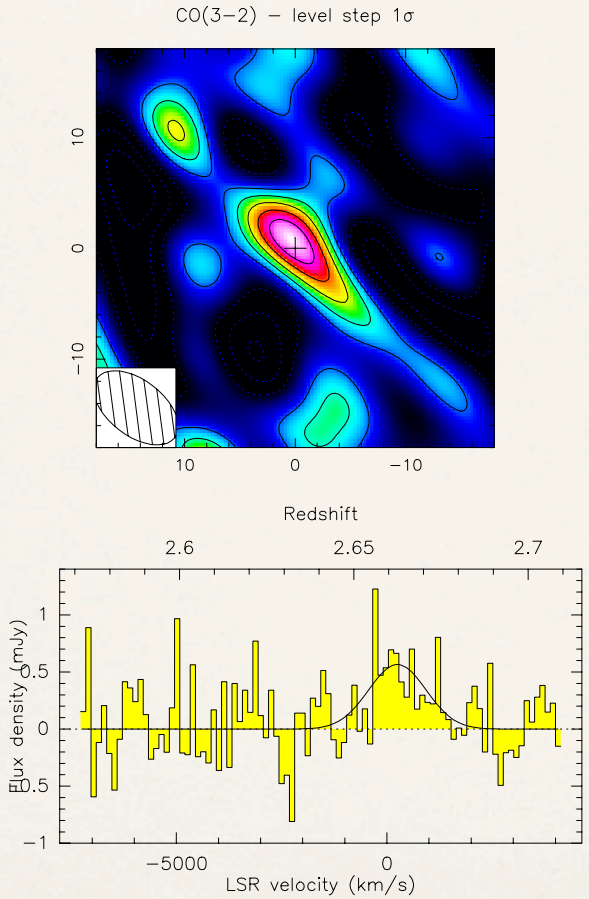
- $L'_{CO} = 1.9 \times 10^{10}$ K km/s pc^2
- $L_{FIR} = 2.9 \times 10^{10}\ L_\odot$
- **SFE = L_{FIR}/L'_{CO} ~160**

- **Molecular gas mass: $M(H_2) = 1.5 - 6 \times 10^{10}\ M_\odot$**
- $M_\star \sim 4.5 \times 10^{11}\ M_\odot$
- $f_{gas} = M(H_2)/M_{tot} = 3\ \% - 15\%$

(Brusa al. in prep.)

Physics of AGN in the "transition phase": ULAS1539+0557 an hyper luminous red QSO at z=2.658

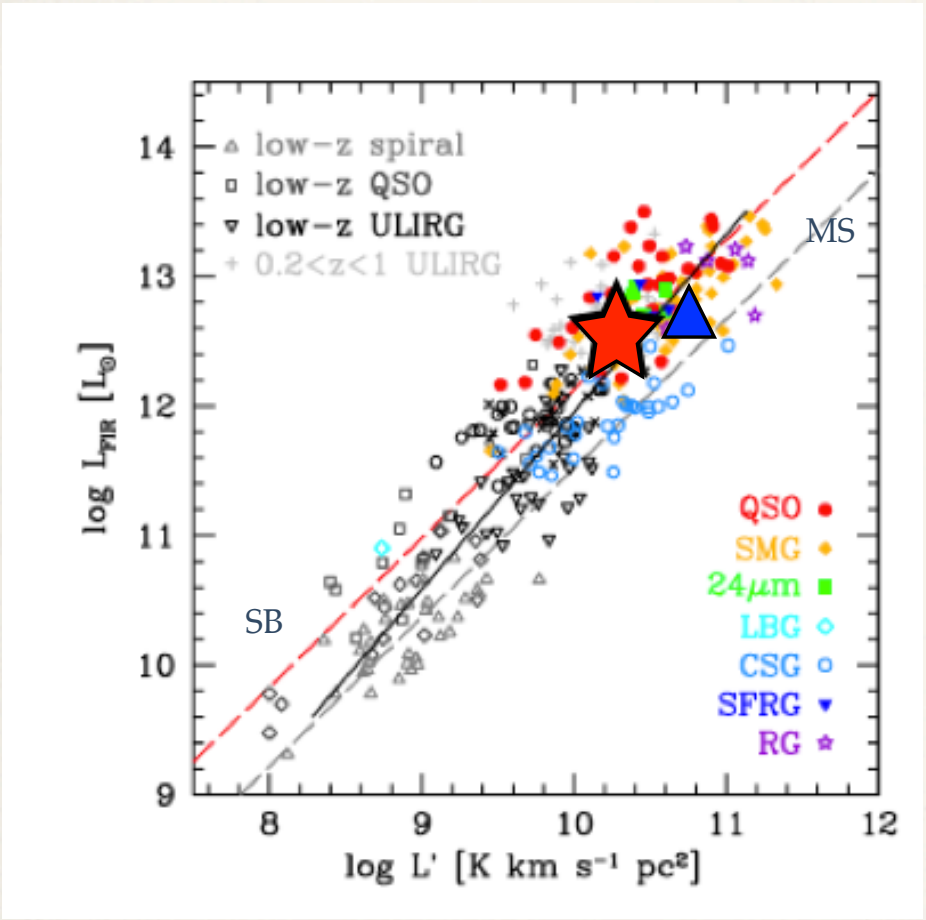
PdBI observations: CO(3-2)

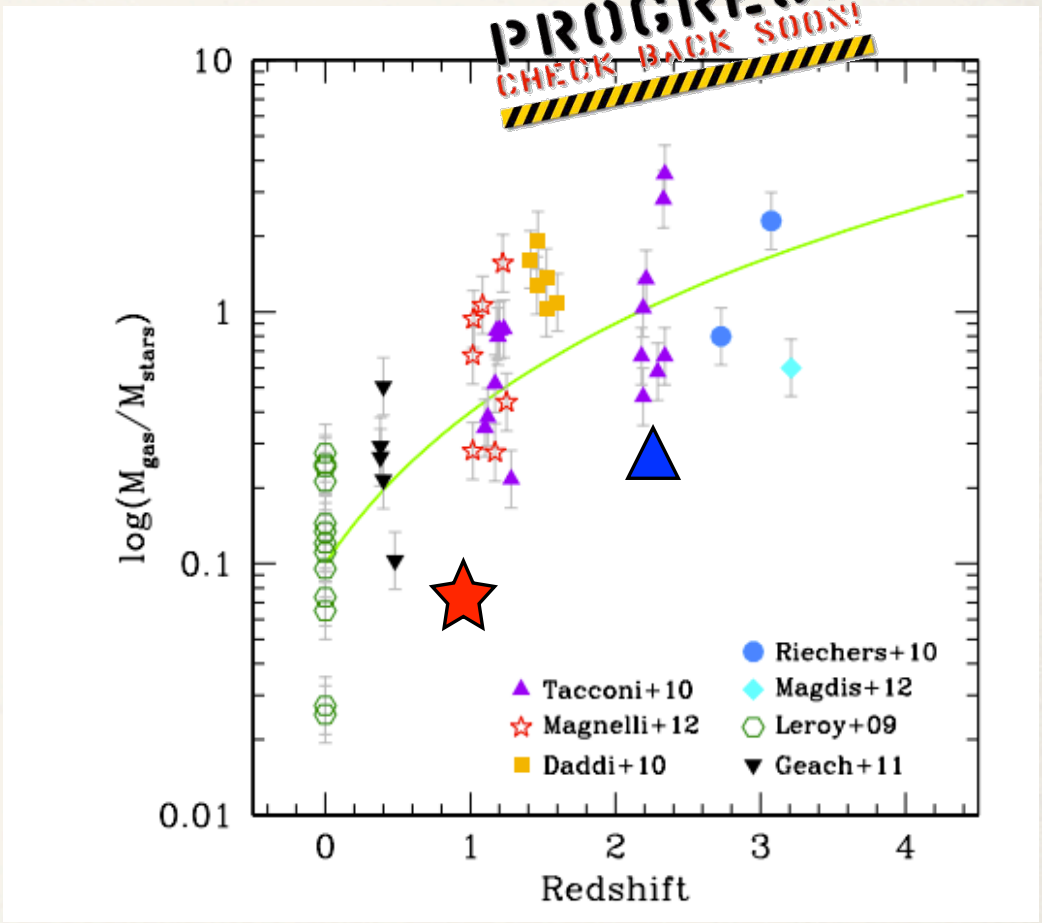


- observed @94.5 GHz with PdBI
- CO(3-2) emission line detected at 5.4σ
- $L'co = 5.1 \times 10^{10}$ K km/s pc^2
- Molecular gas mass: **$M(H_2) = 4.1 \times 10^{10}\ M_\odot$**
- $M_\star = 3 \times 10^{10} - 3 \times 10^{11}\ M_\odot$
- $f_{gas} = M(H_2)/M_{tot} = 12\% - 57\%$
- $M_{dyn} = 1 - 5 \times 10^{10}\ M_\odot$
- $M(H_2)/M_{dyn} = 0.4 - 0.1$
- **SFE = $L_{FIR}/L'co$ ~25 - 350**

(Feruglio, AB et al. 2014)

Physics of AGN in the "transition phase"





(Carilli & Walter, ARA 2013)

What's next? ALMA

ALMA Cycle 2: program accepted as filler:

SAMPLE: objects selected from the Weedman et al. (2012) sample (All Sky WISE selected sample cross-correlated with the SDSS catalog)

- They are the most luminous type-1 AGN sample in the Universe at z>1.5
- They are unbiased against dusty object
- Best candidate for QSO feedback in action!

OBSERVATIONS:

- CO(3-2) for z~3 QSOs and CO(4-3) for z~ 3.5 - 3.8 QSOs
- CII and 160um continuum

GOALS:

- M(H2) , f_{gas}
- study the gas dynamics and search for AGN driven outflows
- measure SFR --> SFE

Summary

- Obscured, luminous, red, QSOs are believed to undergo the brief **transitional phase** from a heavily enshrouded phase of SMBH growth to the blue unobscured QSOs.
- **M_{BH}/M_*:** Intermediate Mass objects at z>1.2 still lie on the local M_{BH} - M_* relation (big scatter) while High Mass objects are located above the local relation.
- **M_{BH}/M_*:** At z > 1.2 obscured red QSOs are located in the same region of the M_{BH} - M_* plane as unobscured blue QSOs. Their BH is already fully formed!
- **OUTFLOW:** Detailed analysis of the XMM-COSMOS red QSOs revealed the presence of outflow in the ionized gas component ([OIII] and [NII] lines).
- **OUTFLOW**: In XID2028 we resolve the outflow in the ionized component and find extended (>10 kpc scale) and powerful ($\dot{M}_{out} > 1000\ M_\odot/yr$) outflow and evidence of both **`positive'** and **`negative' feedback**
- **CO obs:** No sign of molecular outflow in XID2028 (low S/N). ULAS1539 and XID2028 have low gas fraction .i.e. the AGN driven outflow has been already efficient in cleaning the gas and dust surrounding the nuclear source
- **ALMA:** Alma program to study the molecular gas content and search for AGN driven outflow in the most luminous red QSOs in the sky - selected from the Weedman sample (WISE-SDSS)