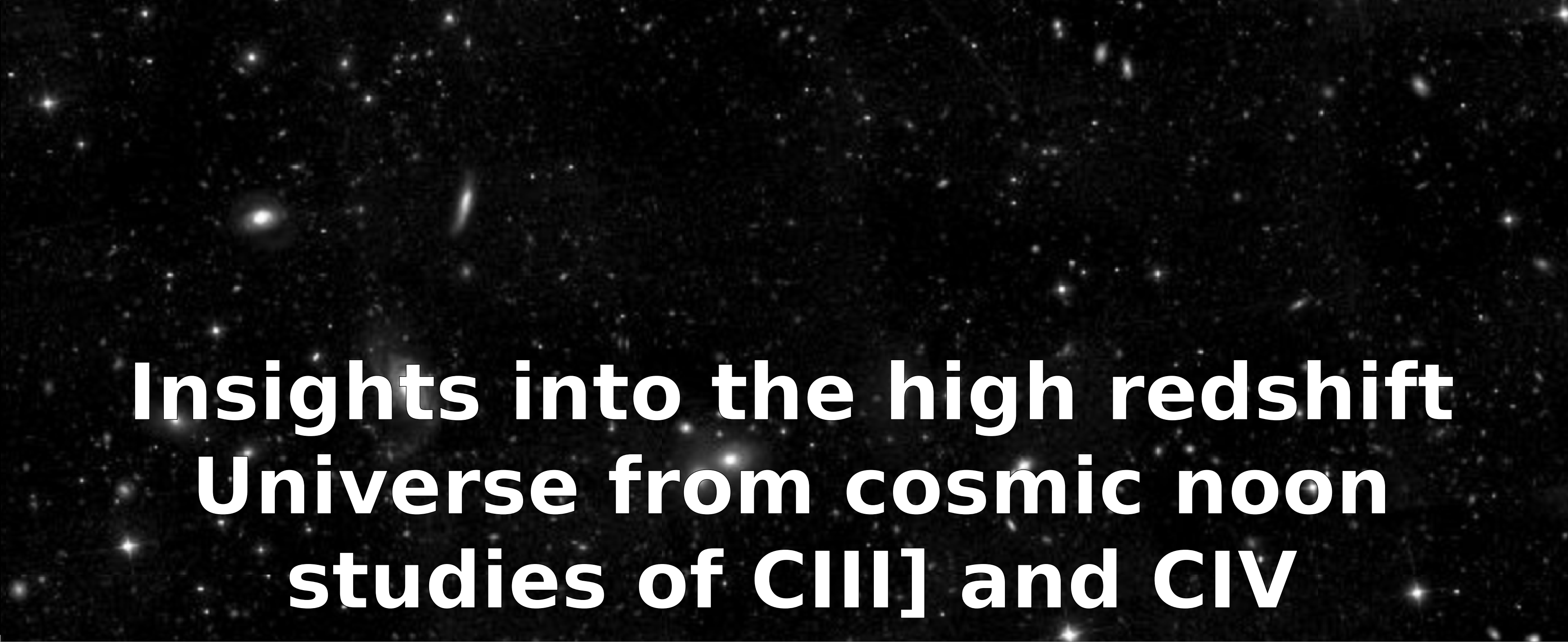


Insights into the high redshift Universe from cosmic noon studies of CIII] and CIV

Andra Stroe
Clay Fellow @ CfA
andra.stroe@cfa.harvard.edu
Twitter: @Andra_Stroe
hea-www.cfa.harvard.edu/~astroe

CENTER FOR ASTROPHYSICS HARVARD & SMITHSONIAN

David Sobral, Jorryt Matthee, Joao Calhau, Ivan Oteo

Extremely Big Eyes on the Early Universe, Rome, 10 Sep 2019

Why CIII] & CIV?

- Rest-frame UV emission lines – diagnostics of gas metallicities, temperature, strength of ionosing field (Shapley et al. 2003, Osterbrok & Ferland 2006)
- CIII]$_{1907,1909\text{Å}}$ – strongest UV line after Lyα in LBGs (Shapley et al. 2003), 10% of Lyα in lensed galaxies at $1.5 < z < 3$ (Stark et al. 2014)
- CIV$_{1549,1551\text{Å}}$ – just as strong as CIII] at solar metallicities (Gutkin et al. 2016, Feltre et al. 2016)
- Used to be associated with AGN – require high radiation field and high T

CIII] & CIV at high redshift

- Renewed interest – they can trace star formation! (Rigby et al. 2015, Bayliss et al. 2014, Jaskot & Ravindranath 2016, Stark et al. 2014; Mainali et al. 2017; Schmidt et al. 2017)
- At high redshift!
  - Lyα escape fraction drop at the highest redshifts (over z ~ 6-7, Tilvi et al. 2016)
  - Difficult to spectroscopically confirm candidates through Lyα (e.g. Vanzella et al. 2014)
  - Use CIII] and CIV to confirm, prominent in young, sub-solar metallicity star forming galaxies (e.g. Stark et al. 2014, 2015a, b)
  - Detect at z > 6 (e.g. stark 2015a, Schmidt et al. 2017, Mainali et al. 2017)
  - Detailed physical characteristics hard to constrain at z~6-7…

Blind survey for CIII] and CIV

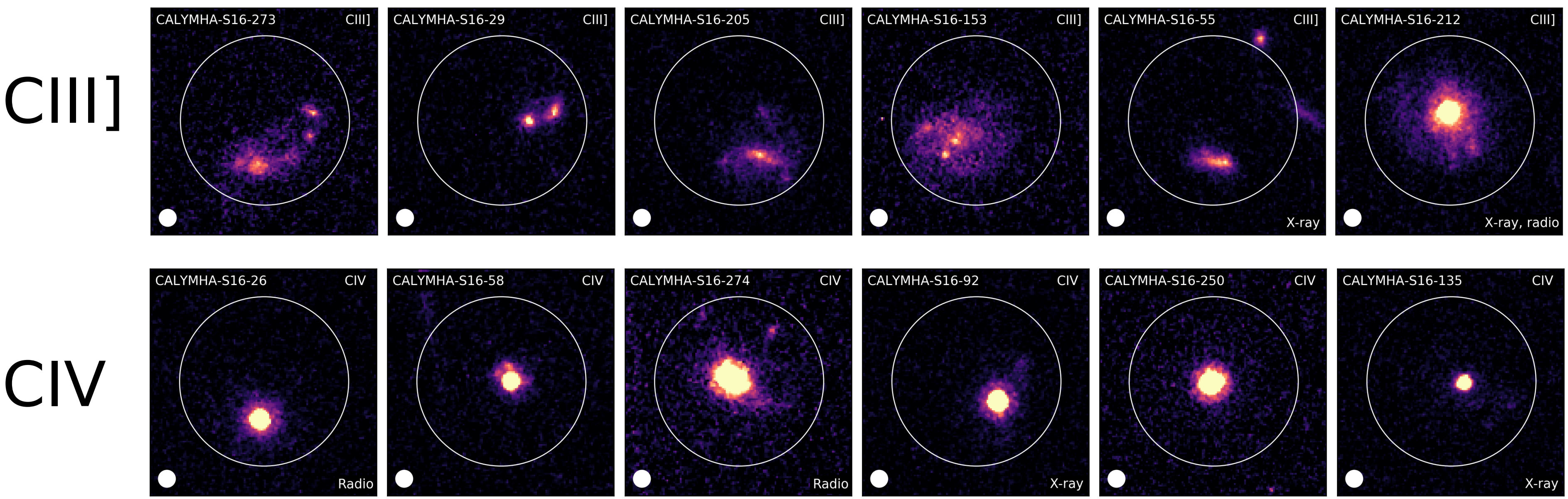
- Narrow band survey on 2.5-m telescope – CALYMHA over COSMOS and UDS
- Large area, not as deep: area: 1.4 deg^2; flux limit: 4×10^{-17} erg/s/cm^2; observed EW limit: 16Å
- Detect:
    - Lyα at z~2.23 (Matthee et al. 2016, Sobral et al. 2017)
    - **CIII]~1.0, CIV~1.5 (Stroe et al 2017a, b)**
- Complementary to work by Du et al. (2017), Maseda et al. (2017), Nakajima et al. (2017)

Isaac Newton Telescope

No blind detections!
UH OH!

Our samples CIII] and CIV

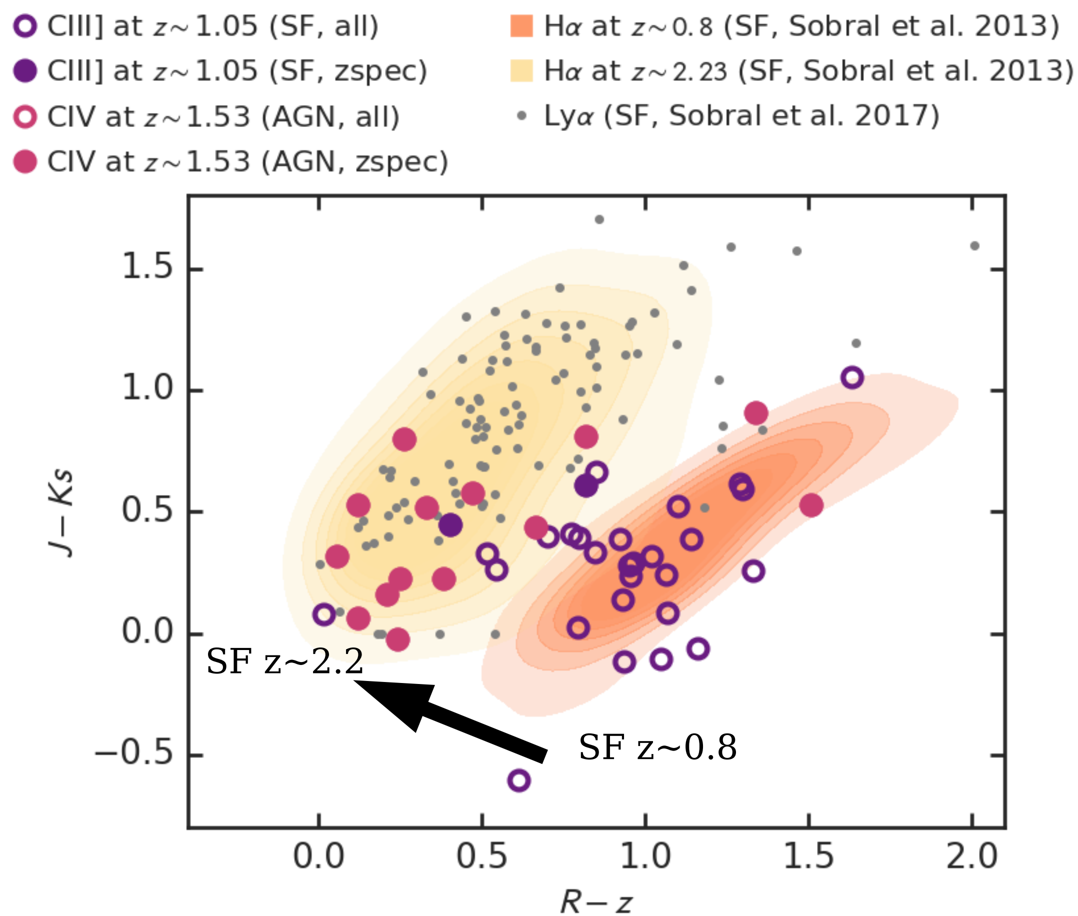
- 34 CIII] emitters at z ~ 1
  - Range of star-forming morphologies, interacting galaxies, possibly some Seyferts
- 17 CIV emitters at z ~ 1.5
  - Point-like, quasar-like morphologies



Stroe et al. (2017a)

Colours

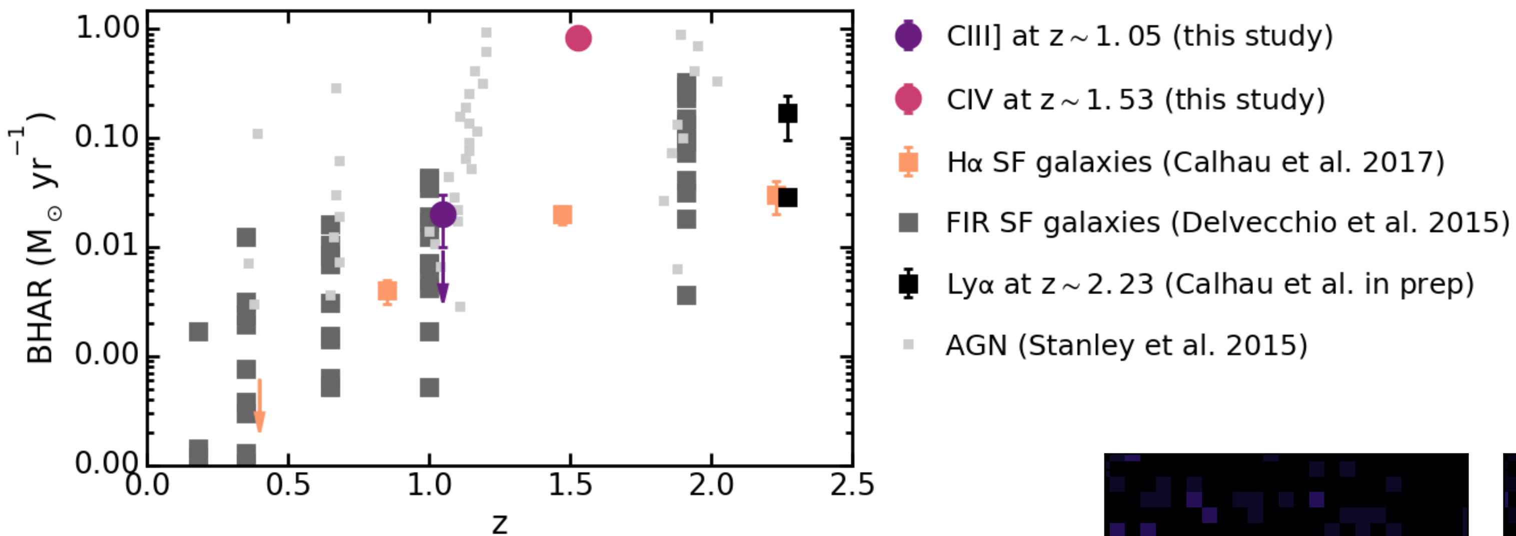
- CIII] – consistent with z~0.8-1.0 star-forming galaxies, blue restframe UV
- CIV – unusual colours, do not look like star-formers at z~1.5, mimic Lyα/star-forming galaxies at z~2.2

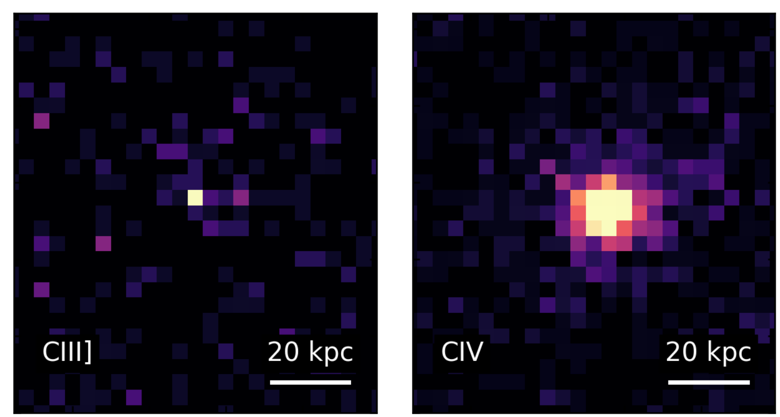


Stroe et al. (2017a)

Black-hole accretion rate

- X-ray stacking to unveil AGN activity
- CIII] – low BHAR, likely dominated by star-forming galaxies with a very minor AGN contamination
- CIV – large BHAR, consistent with AGN activity

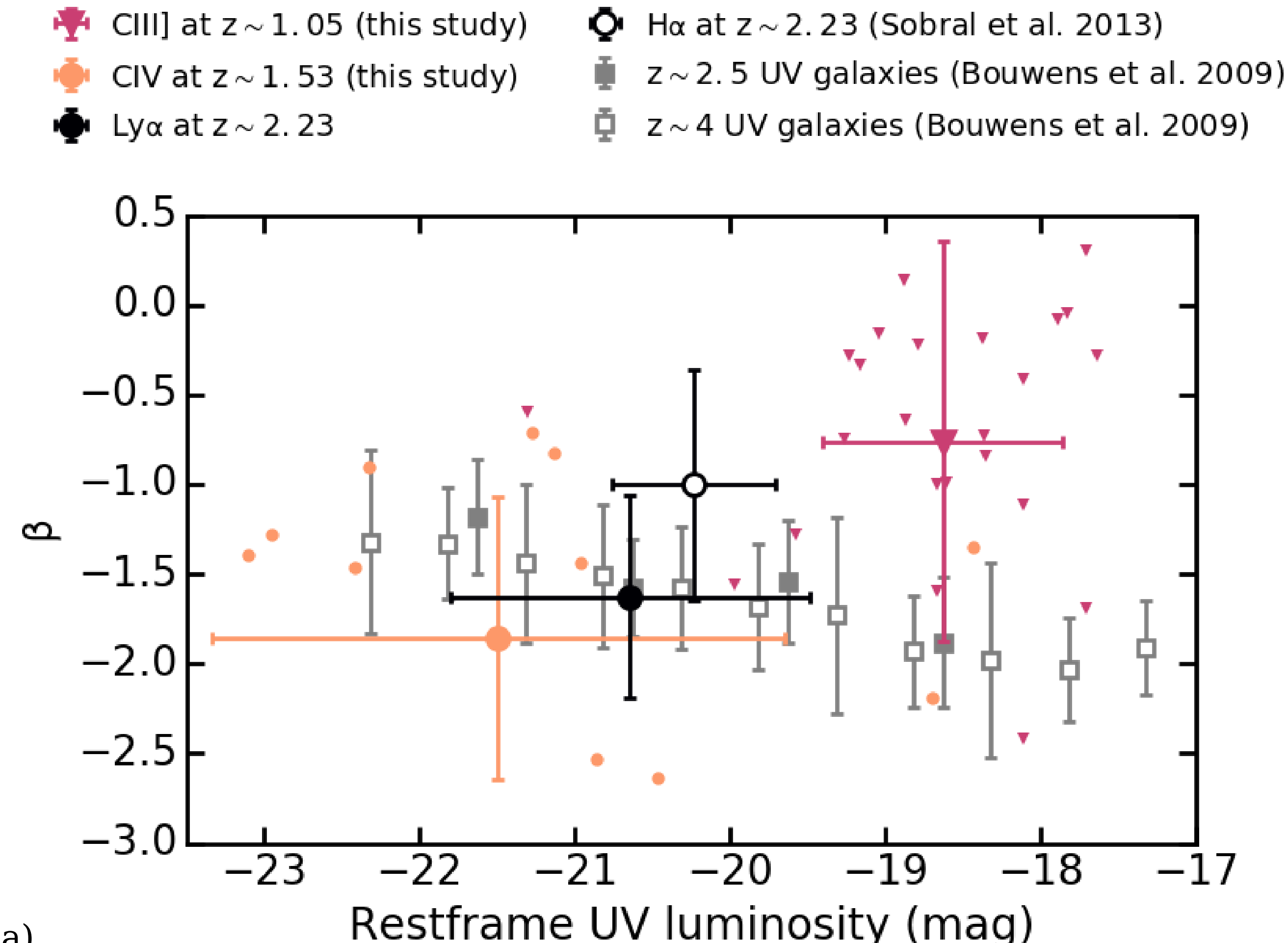




Stroe et al. (2017a)

Dust in the restframe UV

- CIV – steep UV continuum, indicative of young, dust-free quasars
- CIII] – redder UV continuum, representative of a general star-forming population



Stroe et al. (2017a)

Equivalent widths

- Very large!
- CIV explained if they are powered by AGN
- CIII]
  - Largest EW measured to date, even larger than at high-z
  - Correlates with offset from UV continuum

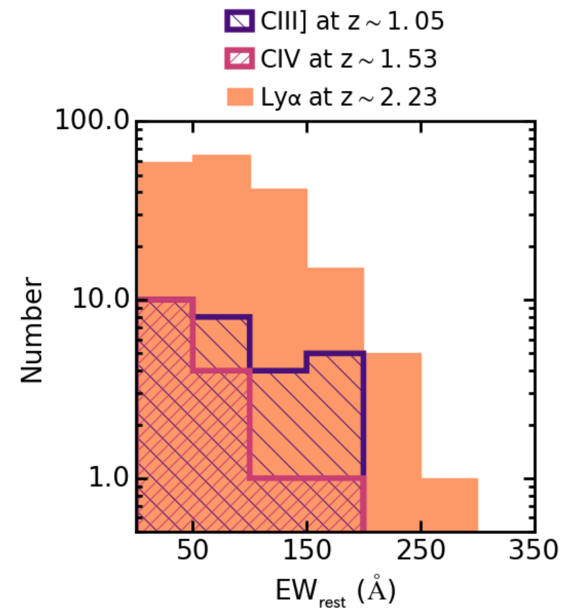
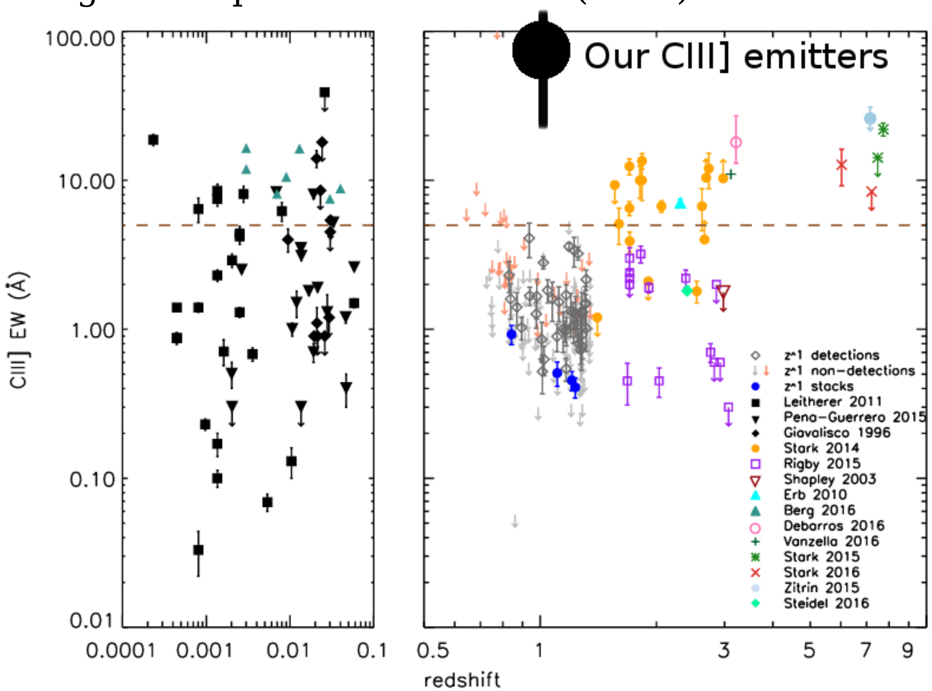
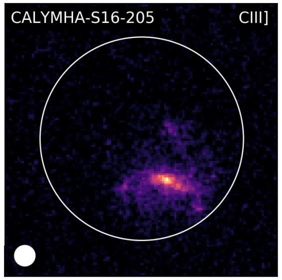
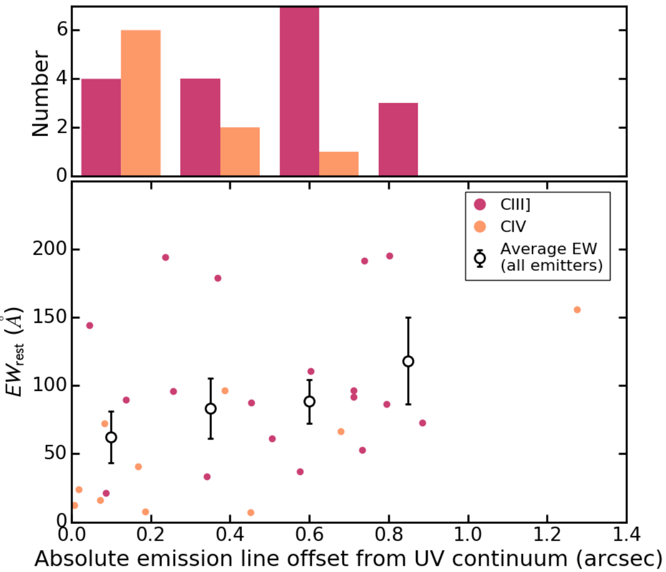


Figure adapted from Du et al. (2017)



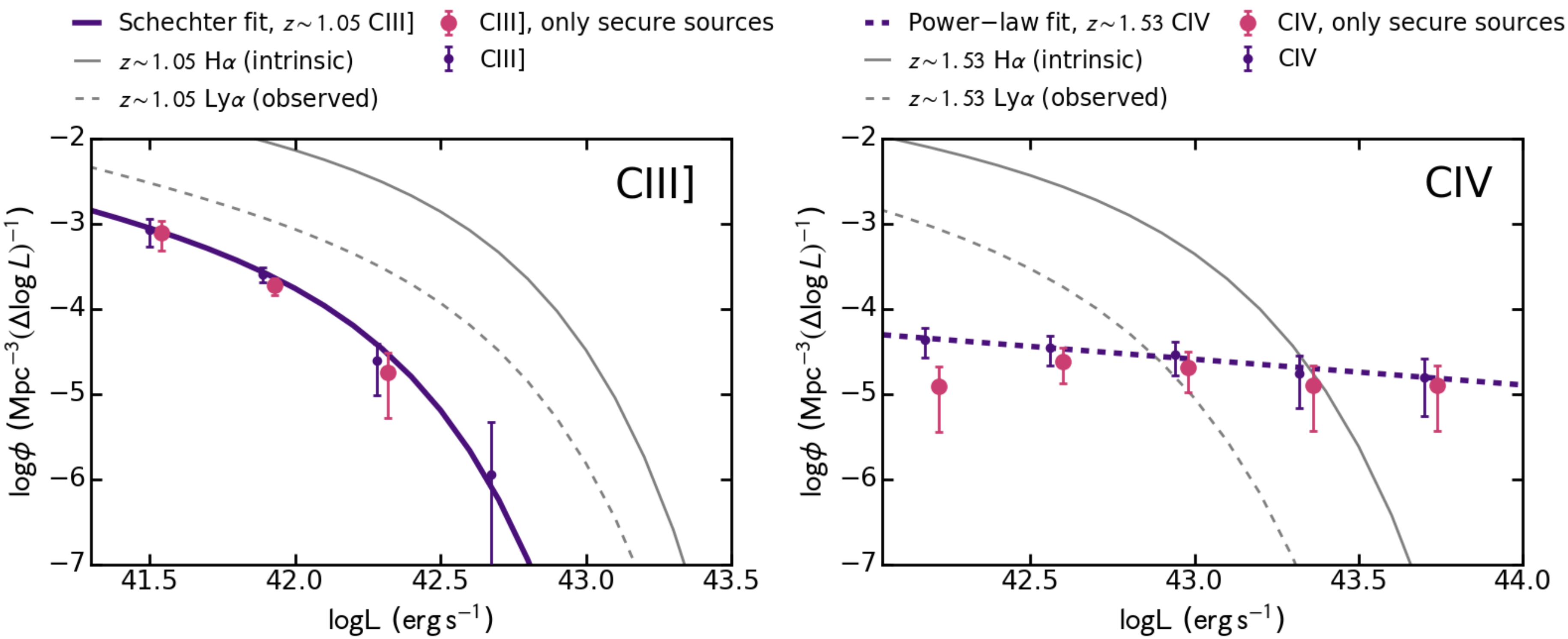




Stroe et al. (2017a)

Luminosity function

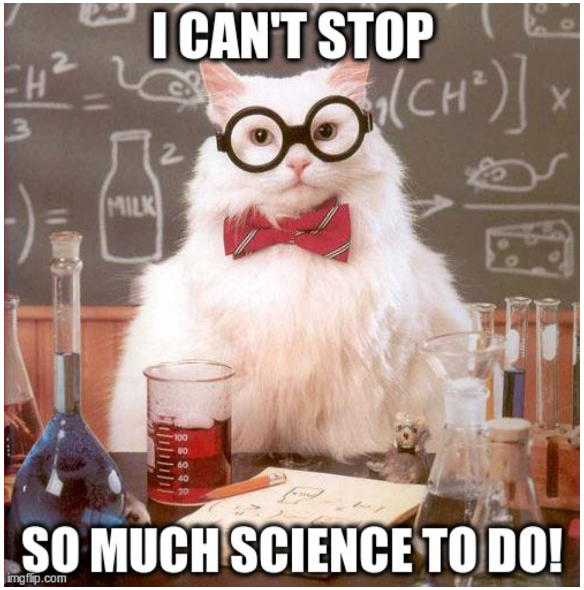
- CIII] LF – scaled down version of Hα LF
- CIV LF – power law, quasar-like LF
- Very low intrinsic CIII] & CIV cosmic average line ratios
  - To Hα: 2-5%
  - To Lyα: <1 %



Stroe et al. (2017b)

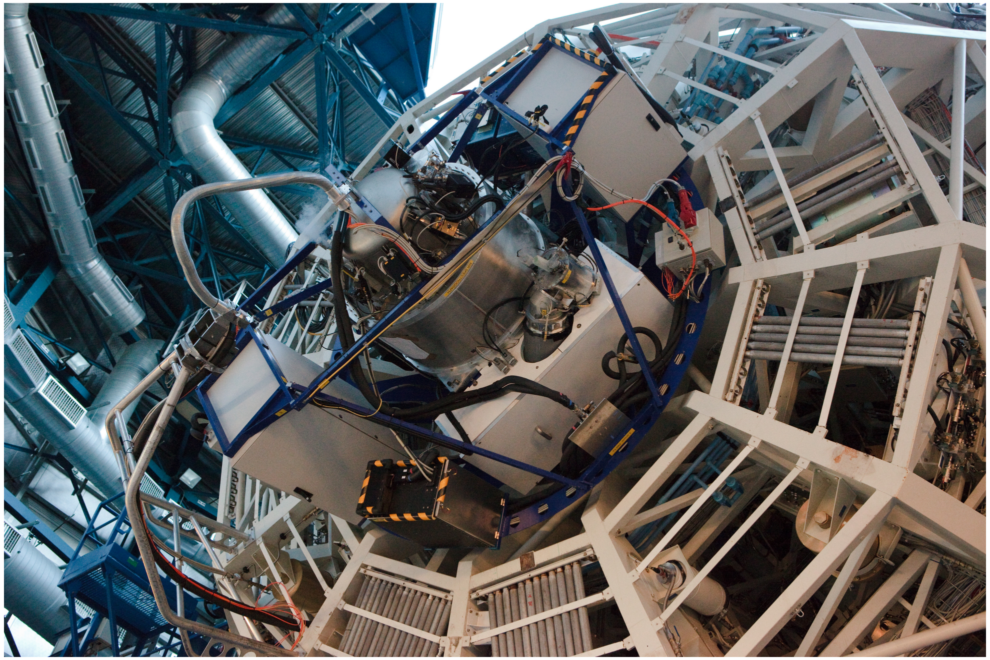
Nature of CIII] & CIV?

- **CIV @ z~1.5**
  - Very blue/dust-free **quasars** with high EW
  - ...but, mainly driven by star-formation at low EW (e.g. Stark et al 2014)
- **CIII] @ z~1**
  - Selects a wide range of **star-forming galaxies**, span a range of EWs
  - ...but, mainly at low metallicities, binary stars? (e.g. Rigby et al. 2015, Stanway et al. 2016)
  - ...but, modelling shows star-formation can only power up to 25 A (Jaskot & Ravindranath 2016)
- Our prediction for high-z:
  - CIII] and CIV are intrinsically very weak compared to Lyα
  - Could be an avenue to pursue only in the case of extremely low Lyα escape fractions <<1 %



Future plans?

- X-SHOOTER spectroscopy – confirm the large CIII] EW, measure physical properties
- Large scale facilities to measure CIII] and CIV at z>6



Take away messages

- **CIV @ z~1.5** are very blue/dust-free **quasars** with high EW
- **CIII] @ z~1** selects a wide range of **star-forming galaxies**, span a range of EWs
- CIII] and CIV are intrinsically **very weak compared to Lyα**