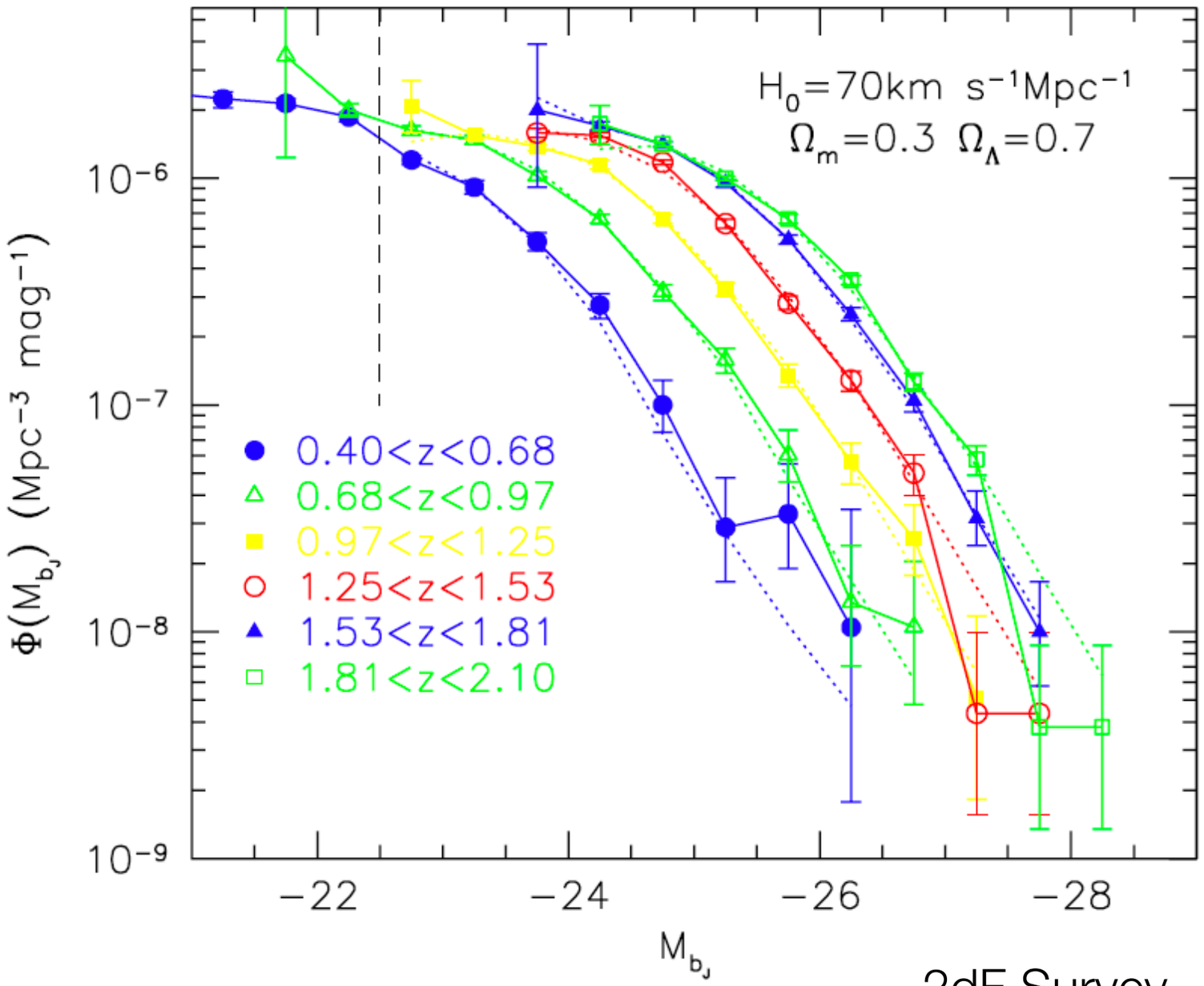
Updated Observational Constraints on Quasar Bolometric Luminosity Function

Xuejian(Jacob) Shen
Caltech

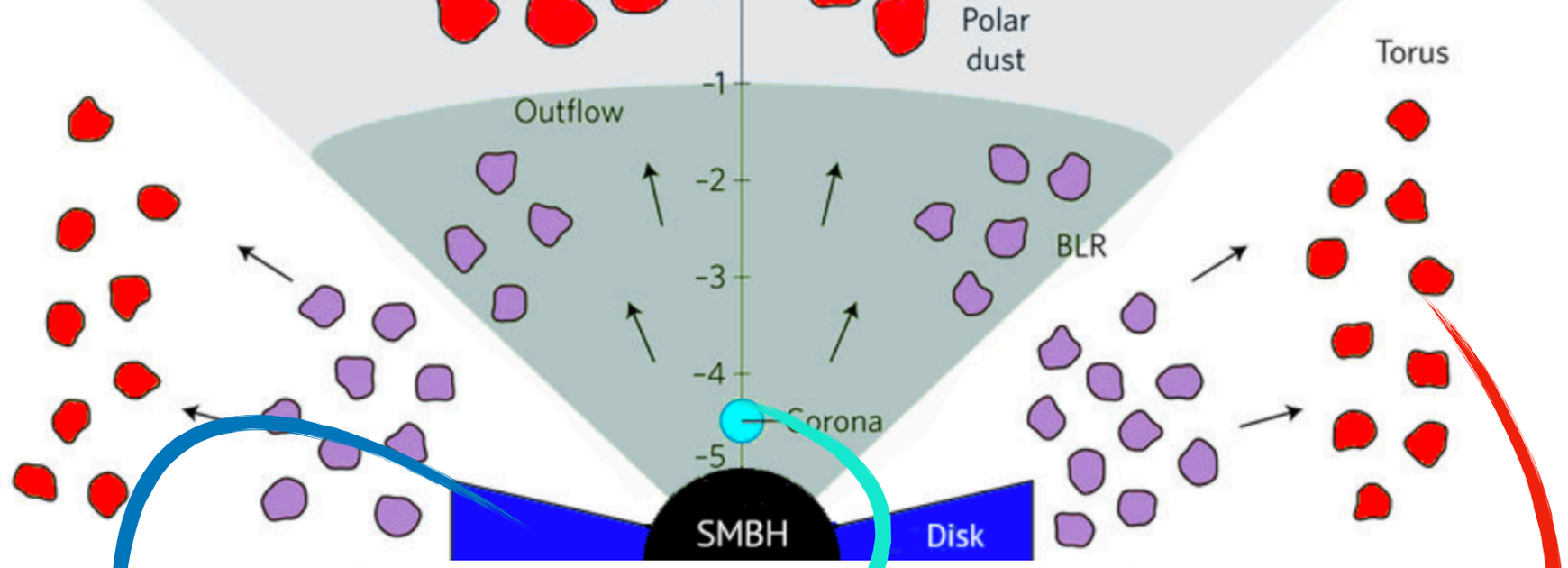
Robin Dienel / Carnegie Institution for Science

Direct observable: luminosity functions

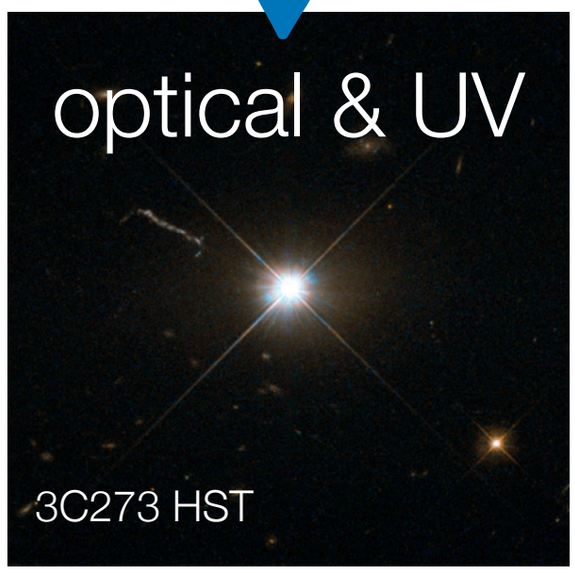
(comoving number density as a function of luminosity)



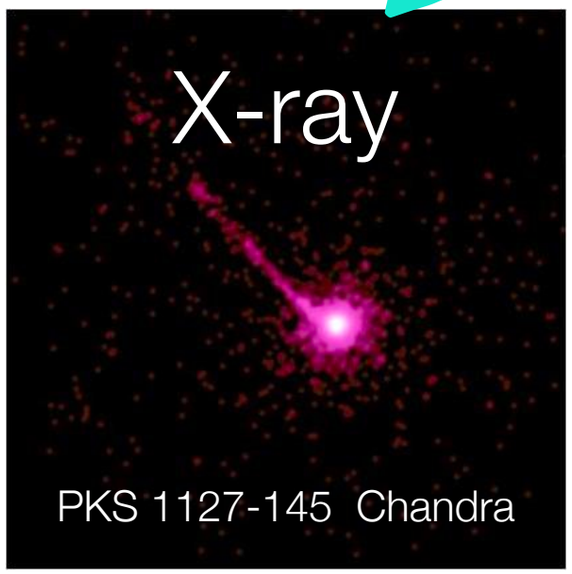
2dF Survey



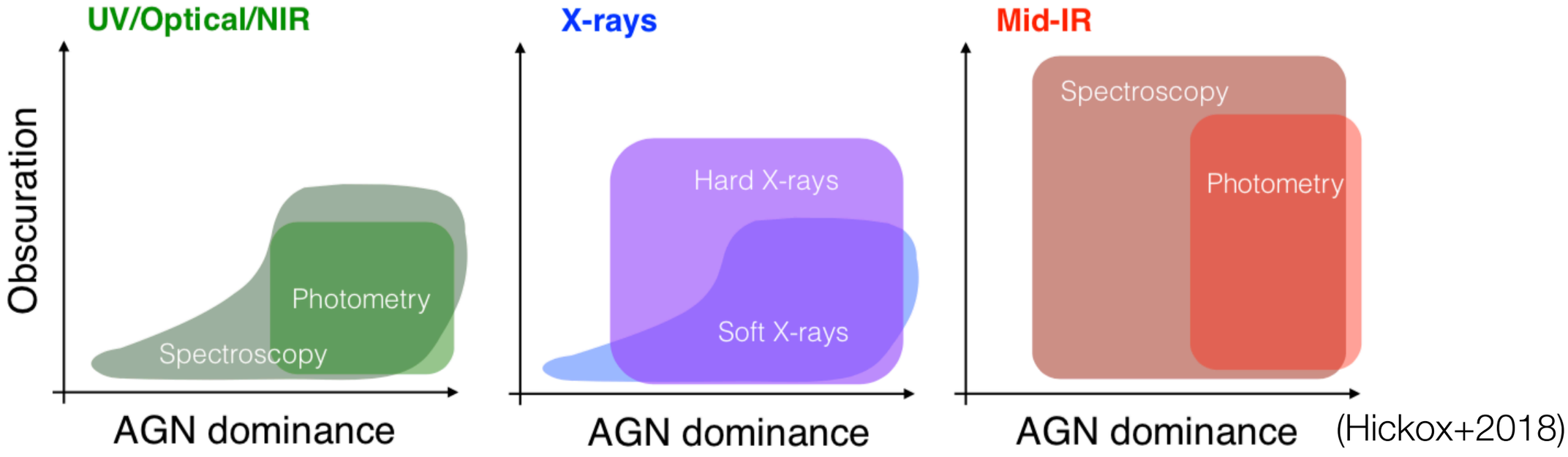
optical & UV



X-ray



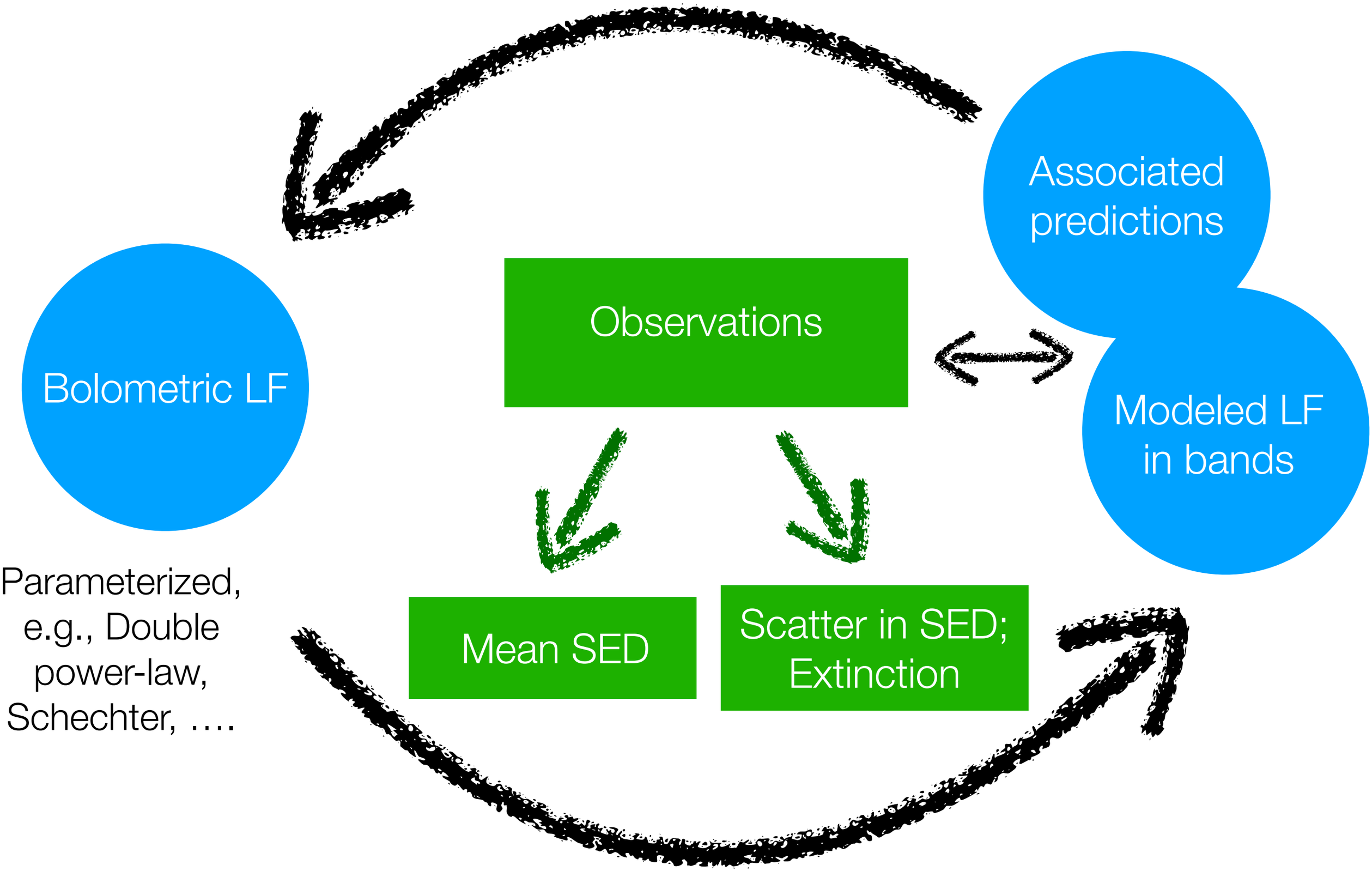
mid-IR



(Hickox+2018)

- Consistent with each other?
- Explain them simultaneously with a unified model ?
- Any physical properties of the quasars? e.g., bolometric luminosity, accretion rate

The workflow



(Hopkins+2007)

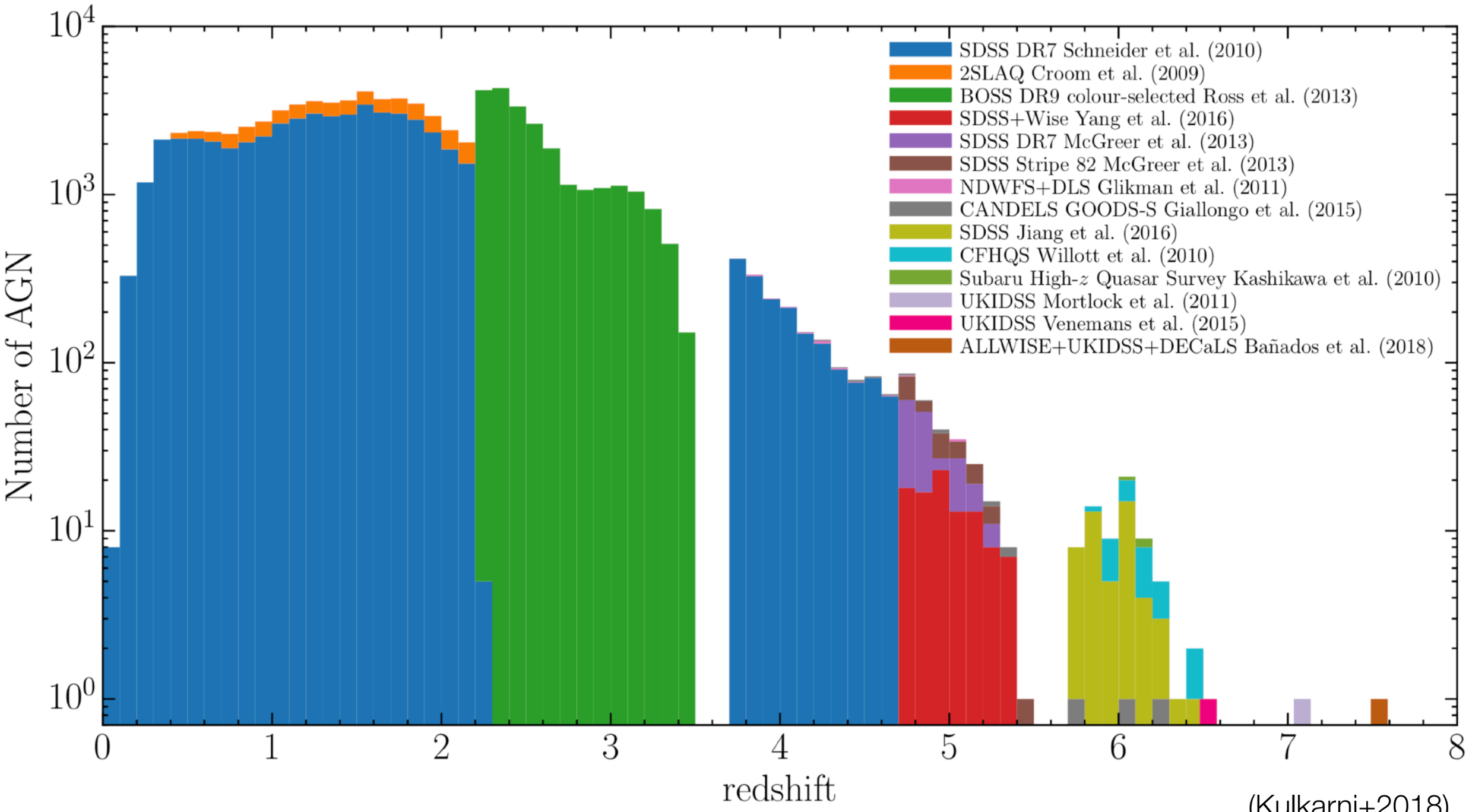
Problems of the 2007 LF model

- Big uncertainty limited by data available by 2007 and inconsistent with recent measurement at z>~3

- Unphysical behaviors in the evolution of LF, e.g.extrapolating the model to z~8 leads to diverged integrated luminosity at bright end; an assumption that number density normalization is always constant

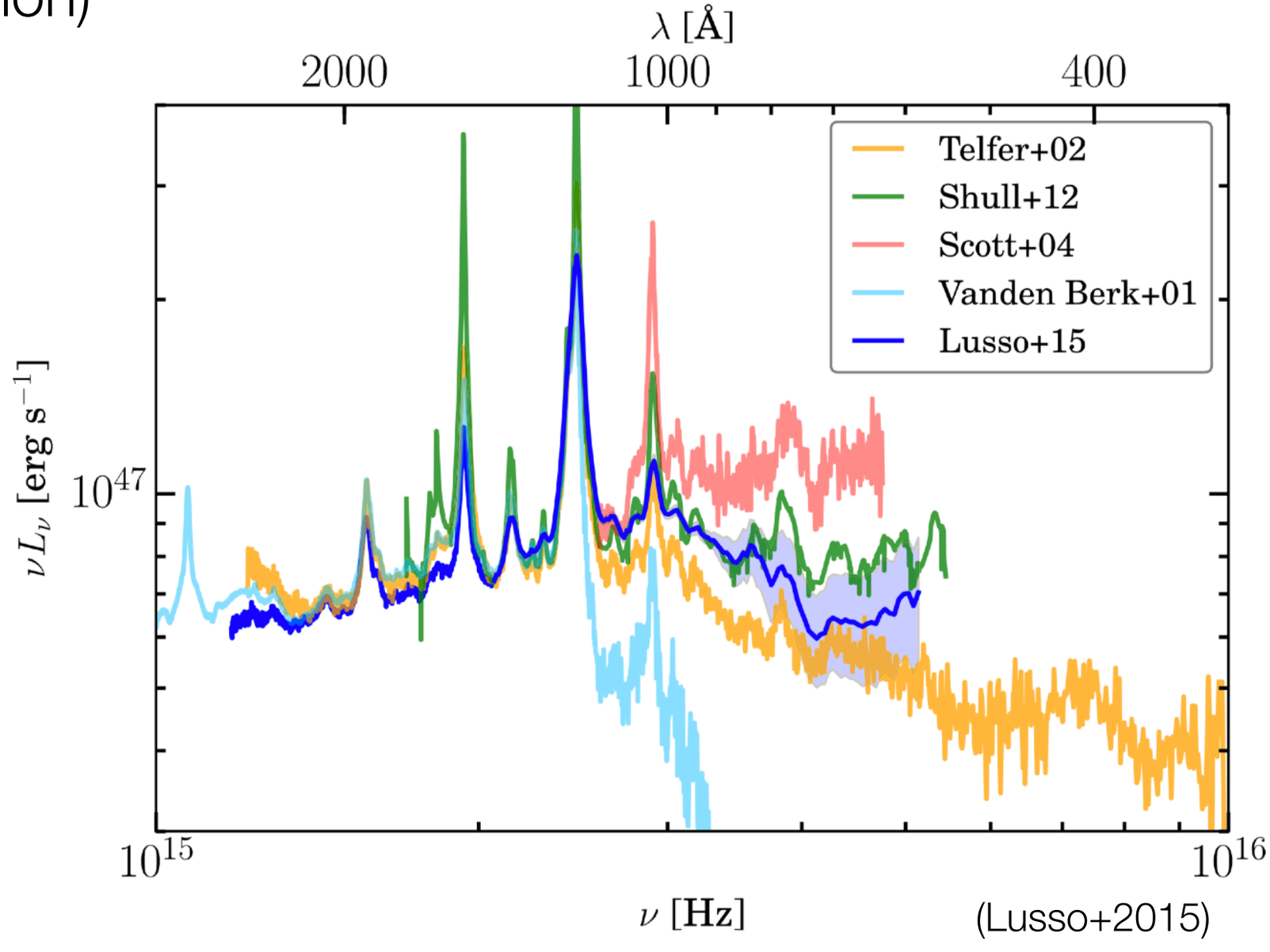
Updates in the recent decade

- More data at high redshift



(Kulkarni+2018)

- New channels in ultra-hard Xray band, e.g. *NuSTAR*
- Updated SED
- Updated column density measurement
  (compton thick fraction)



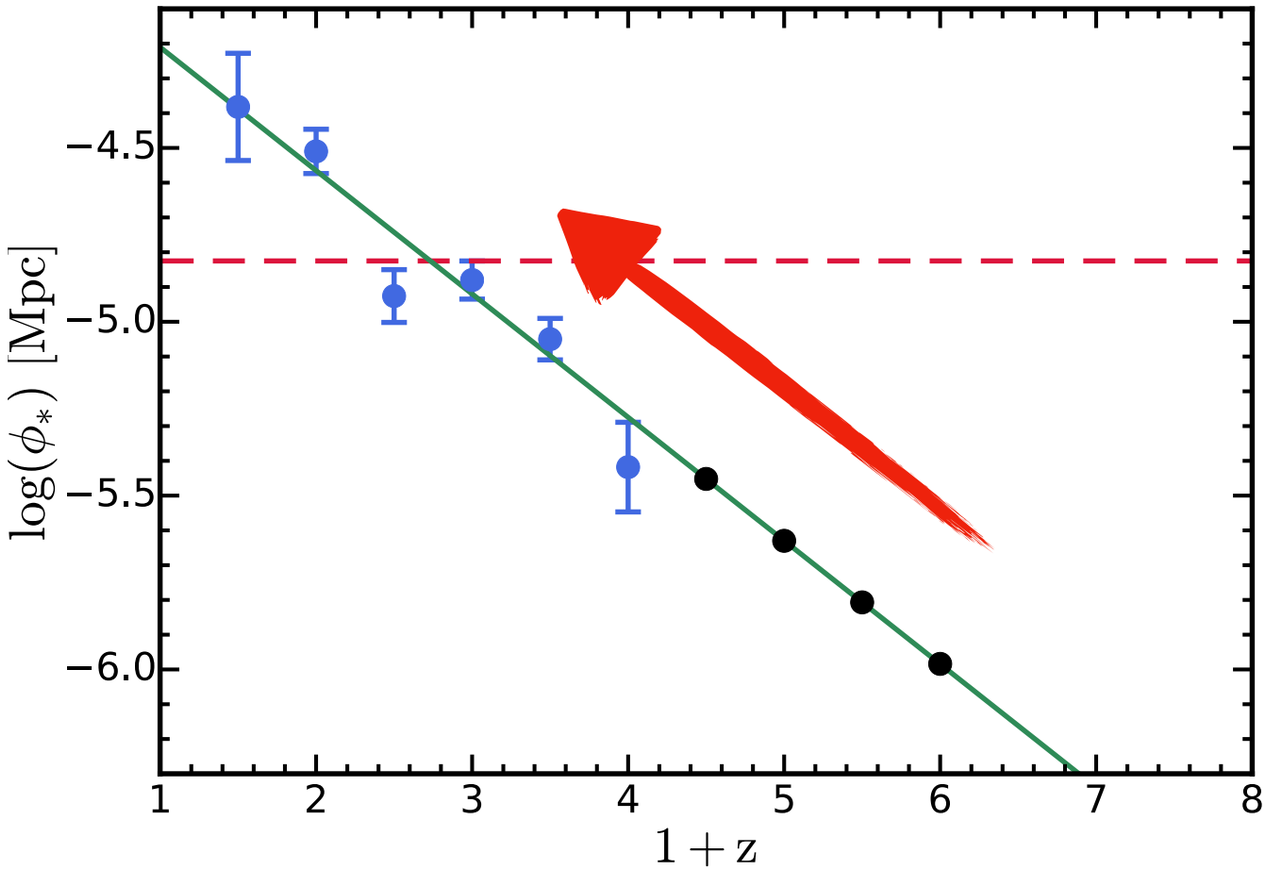
(Lusso+2015)

Preliminary results

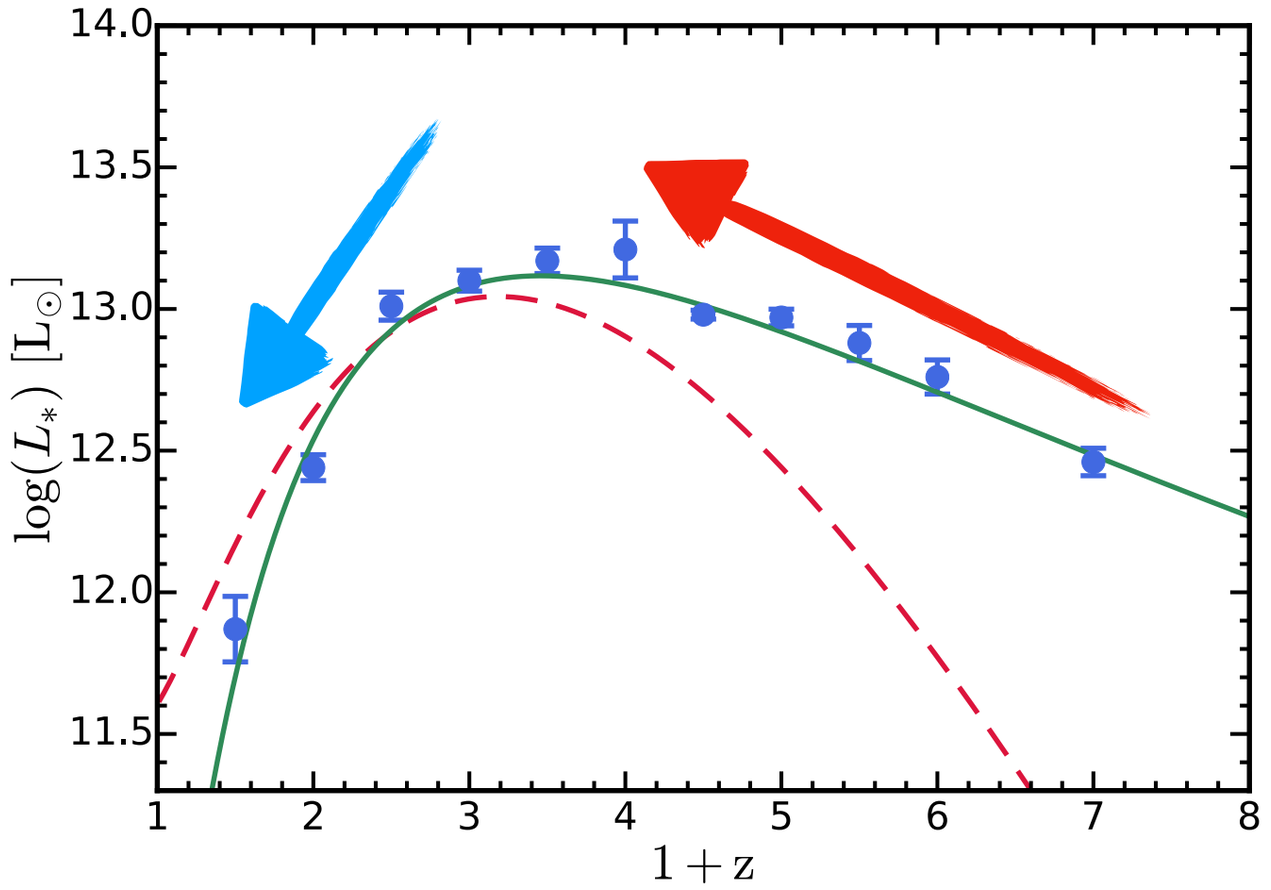
- A double-power law with redshift evolving parameters

$$\frac{\mathrm{d}\phi}{\mathrm{d}\log L}(z) = \frac{\phi_*(z)}{(\frac{L}{L_*(z)})^{\gamma_1(z)} + (\frac{L}{L_*(z)})^{\gamma_2(z)}}$$

- Number density normalization



- Break luminosity



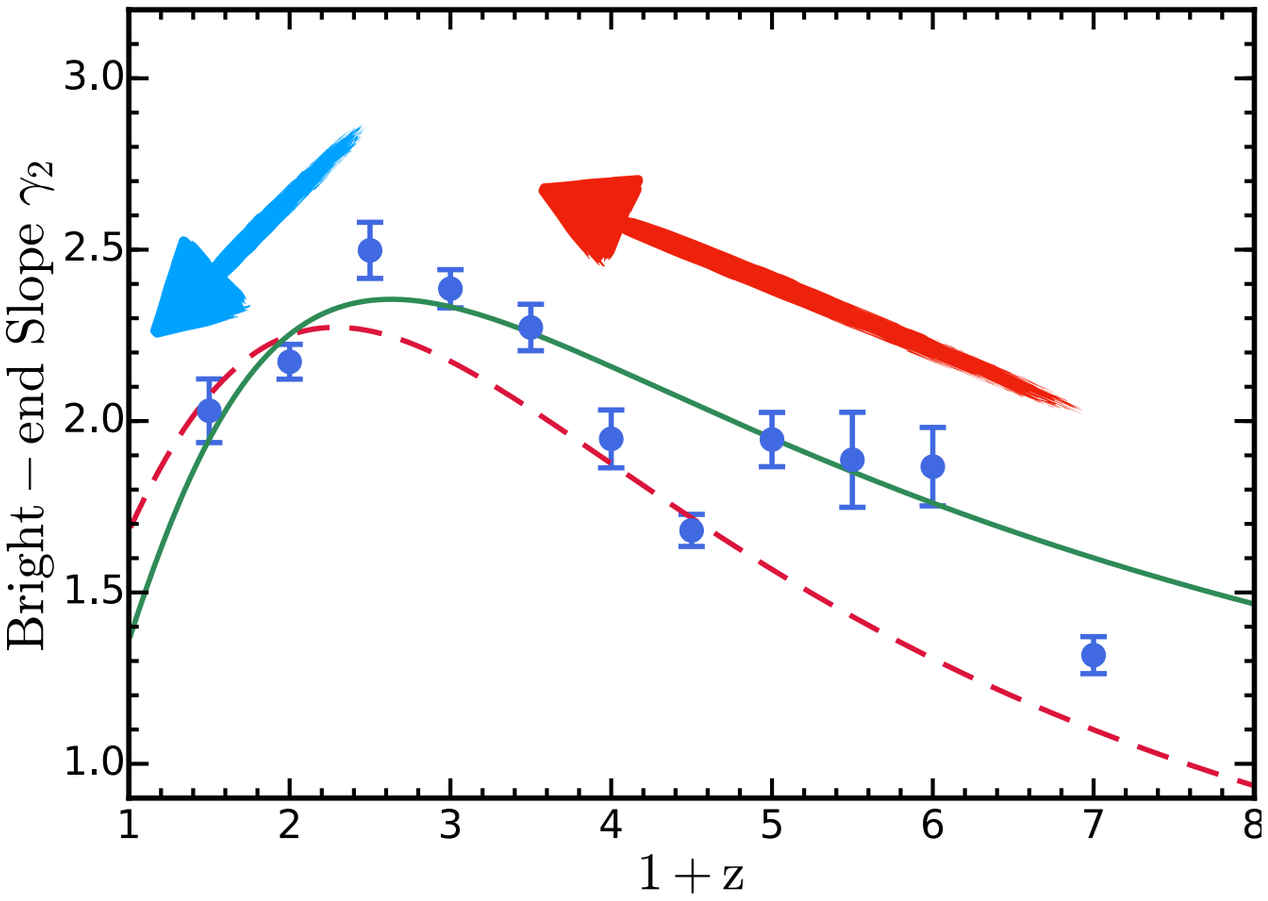
A double-power law shape evolution of bright-end slope; also peaks at z =2

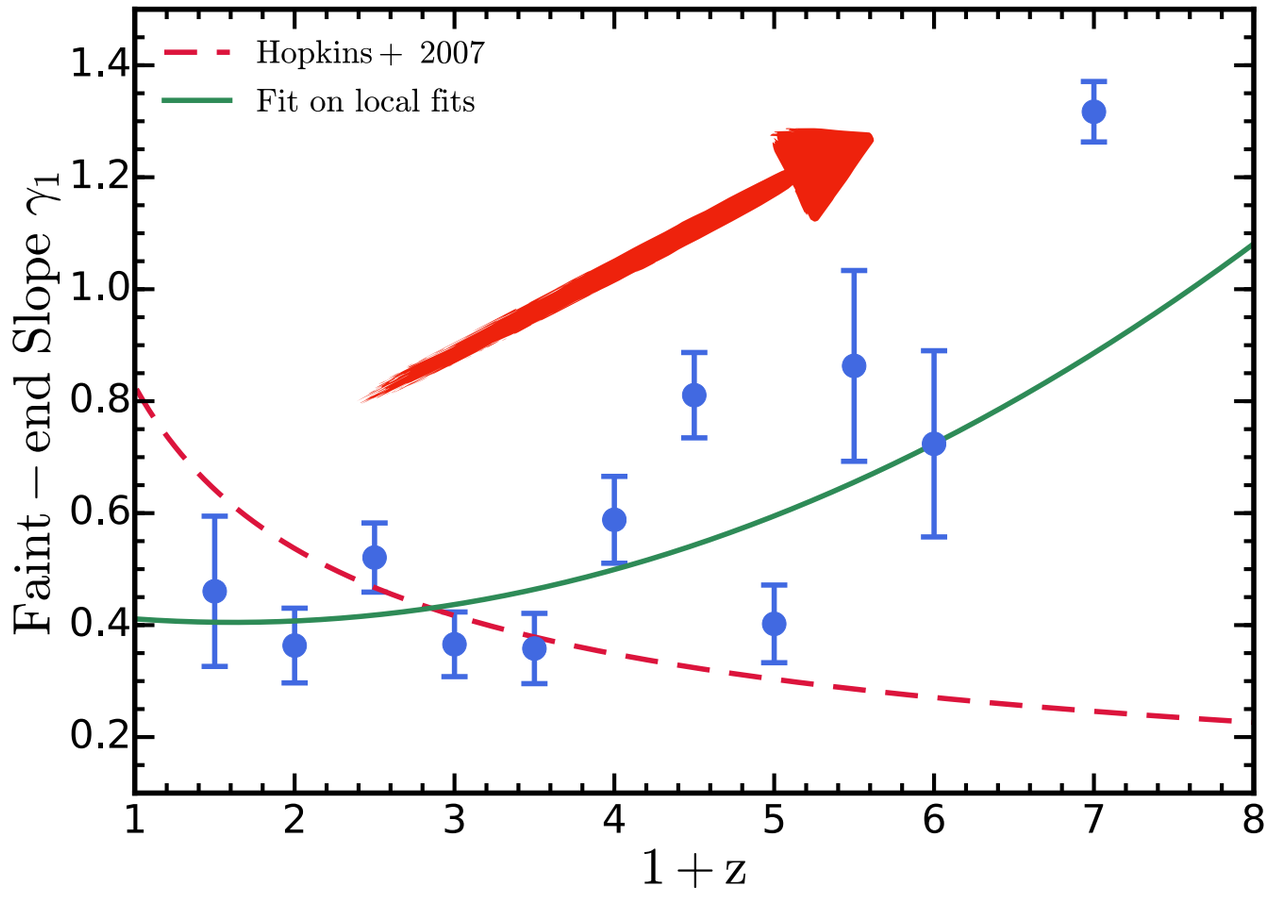
?

- Bright-end slope

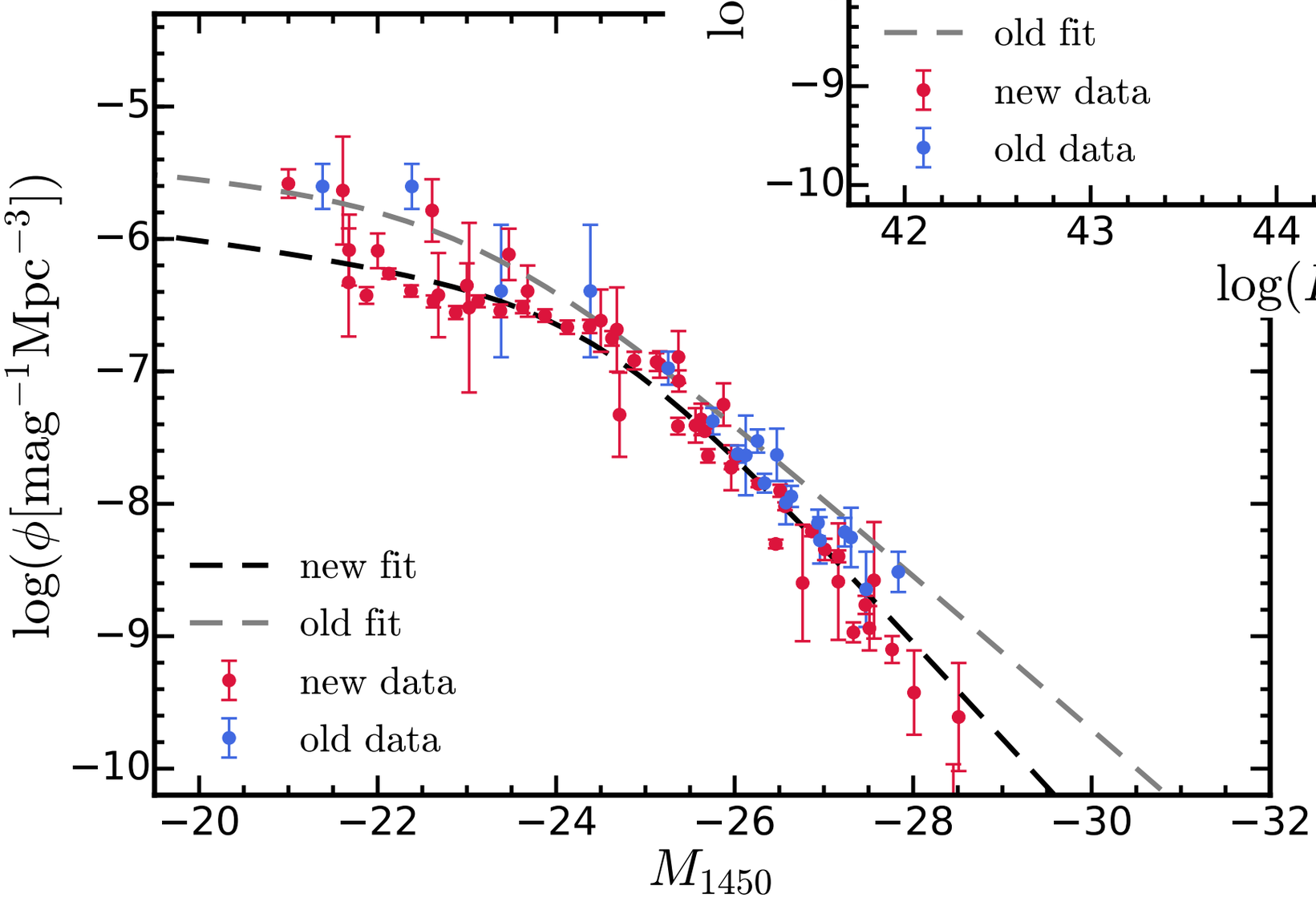
A steeper fainter-end slope towards higher redshift (similar trend as found in galaxy UVLF)

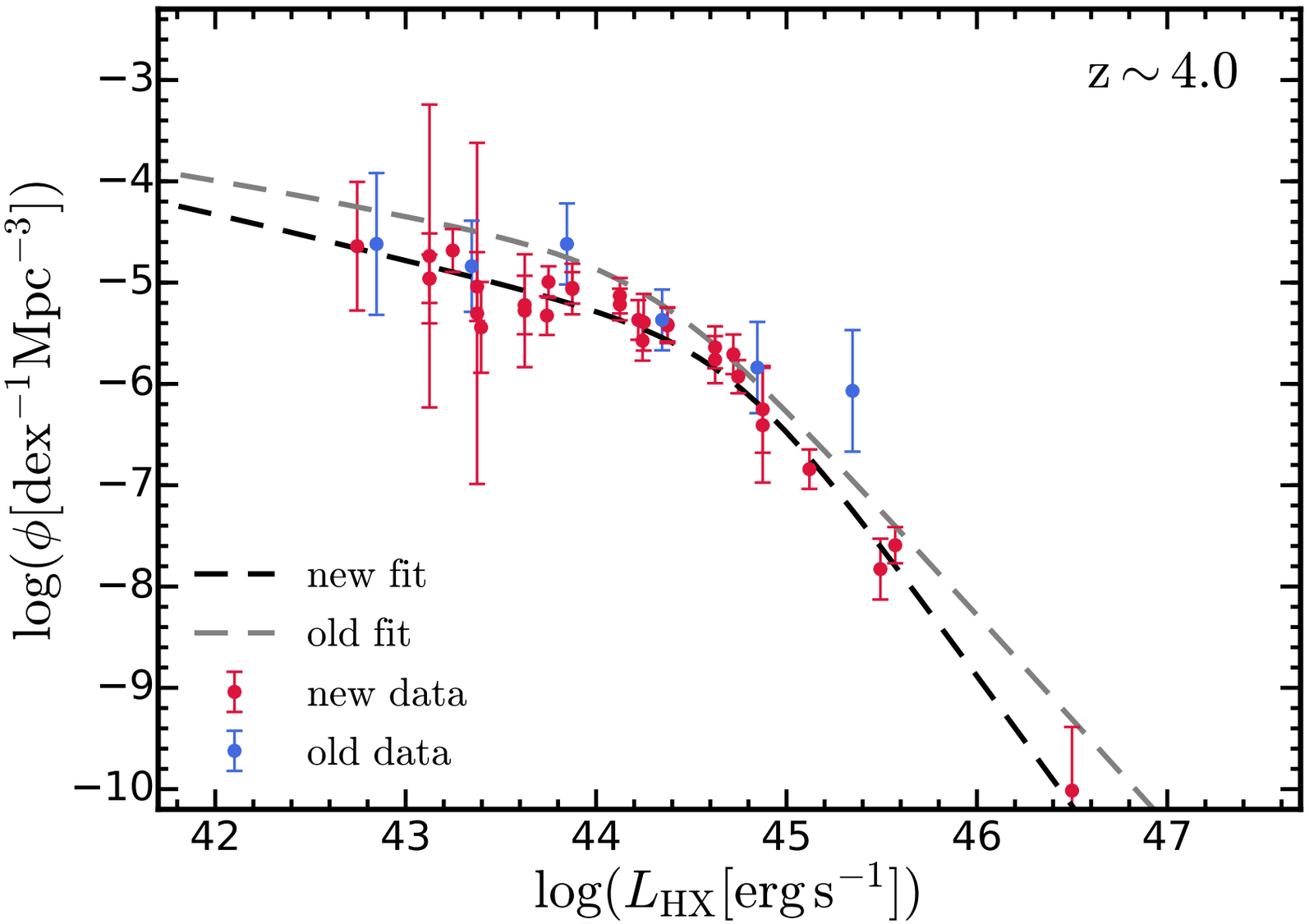
- Faint-end slope





- Performance at z=4





Implications

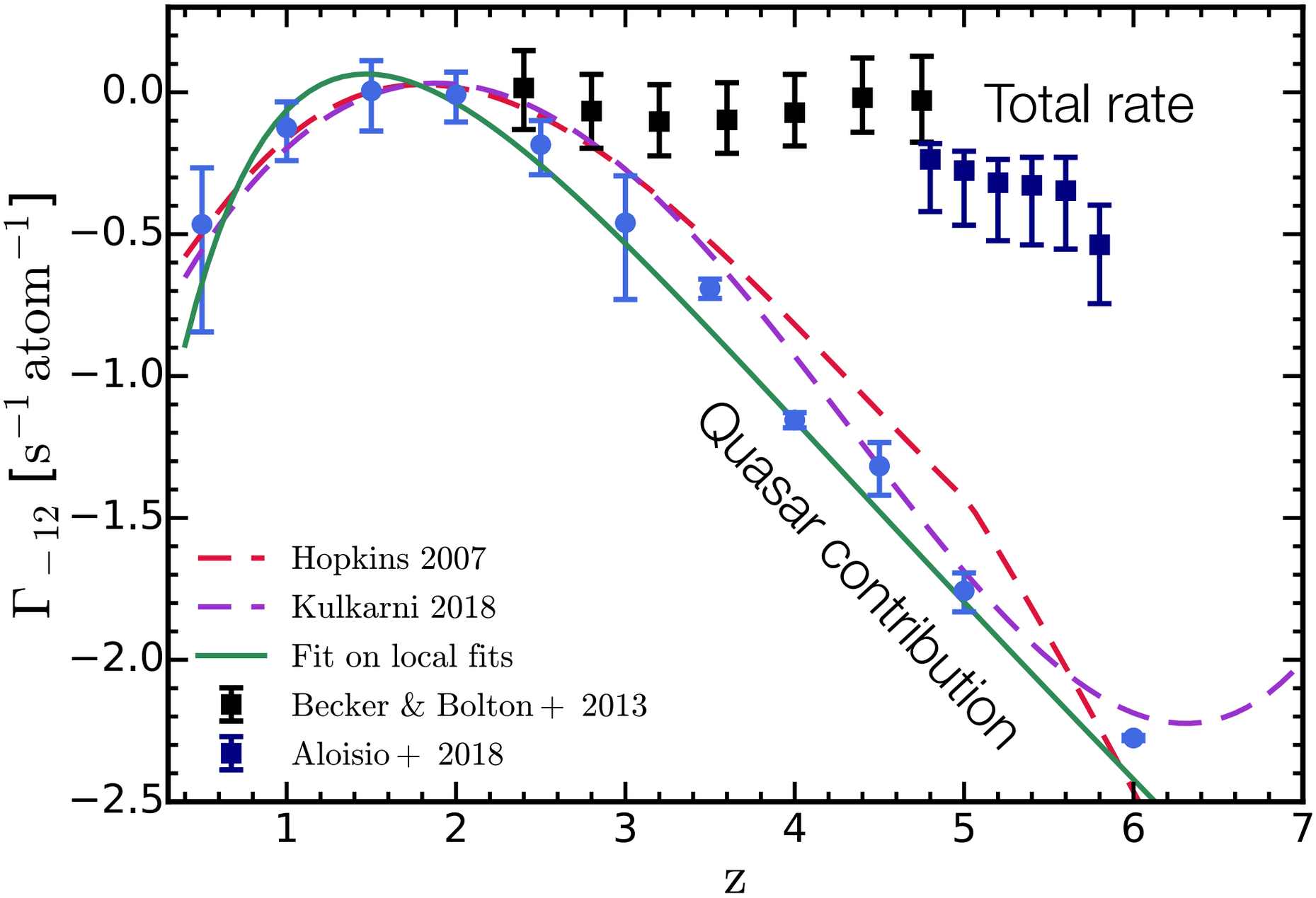
- Ionizing photon production; quasar's role in reionization of hydrogen and helium

- SMBH growth history, especially at the dawn of first SMBHs

- Cosmic X-ray & IR background

Ionizing Photon Production Rate

- Can quasars alone ionize the universe ?
- When did quasars' contribution to ionizing photons become important?



Future

- Polish the pipeline (model, data)
- BH mass function?
- Connection with galaxy formation?