

# Diffuse Emission as a Probe of Galaxy and Reionization Physics

Lluís Mas Ribas

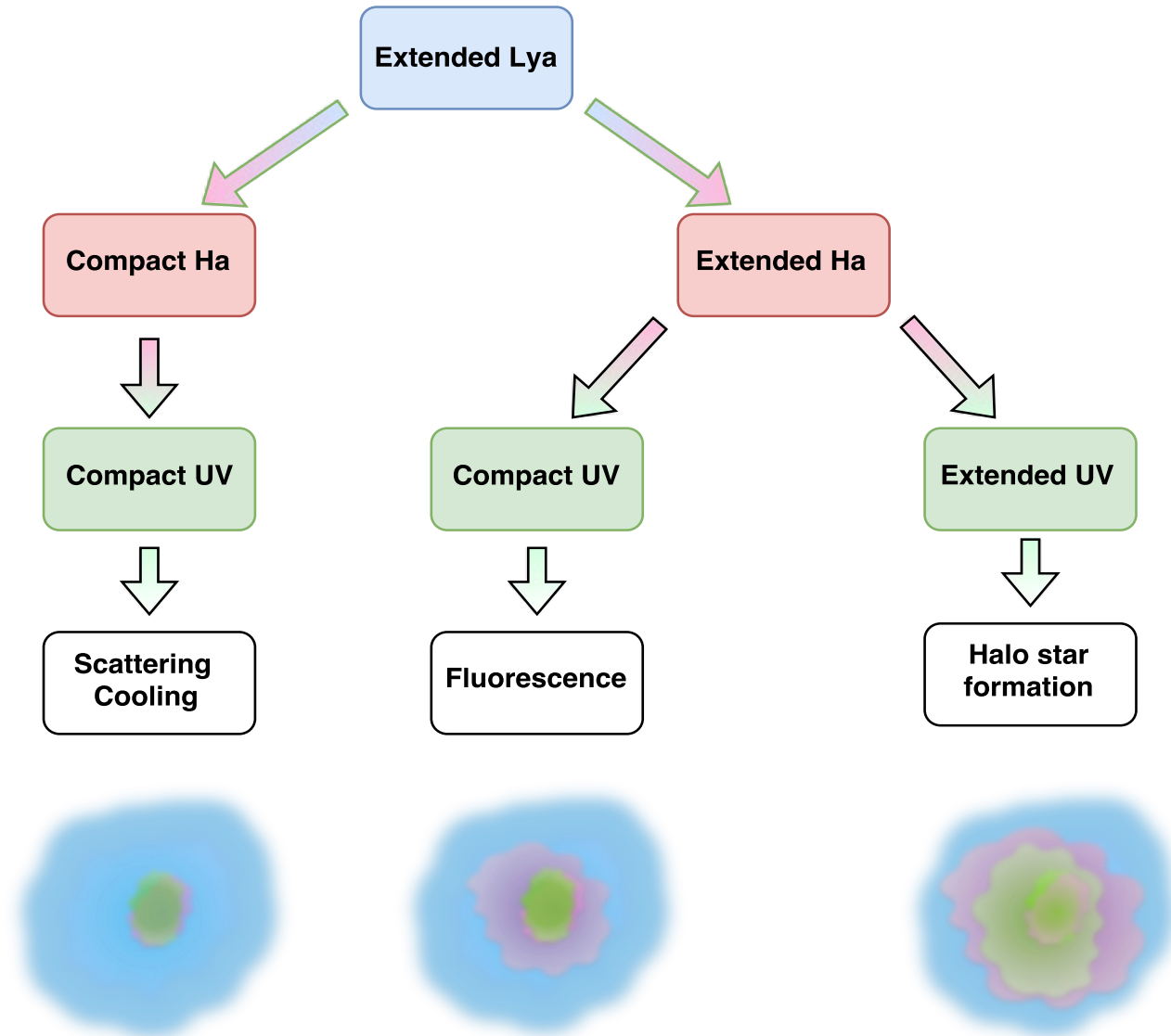
with Hennawi, Dijkstra, Davies, Trenti, Ouchi, Rix, Stern & Momose

UiO : Universitetet i Oslo

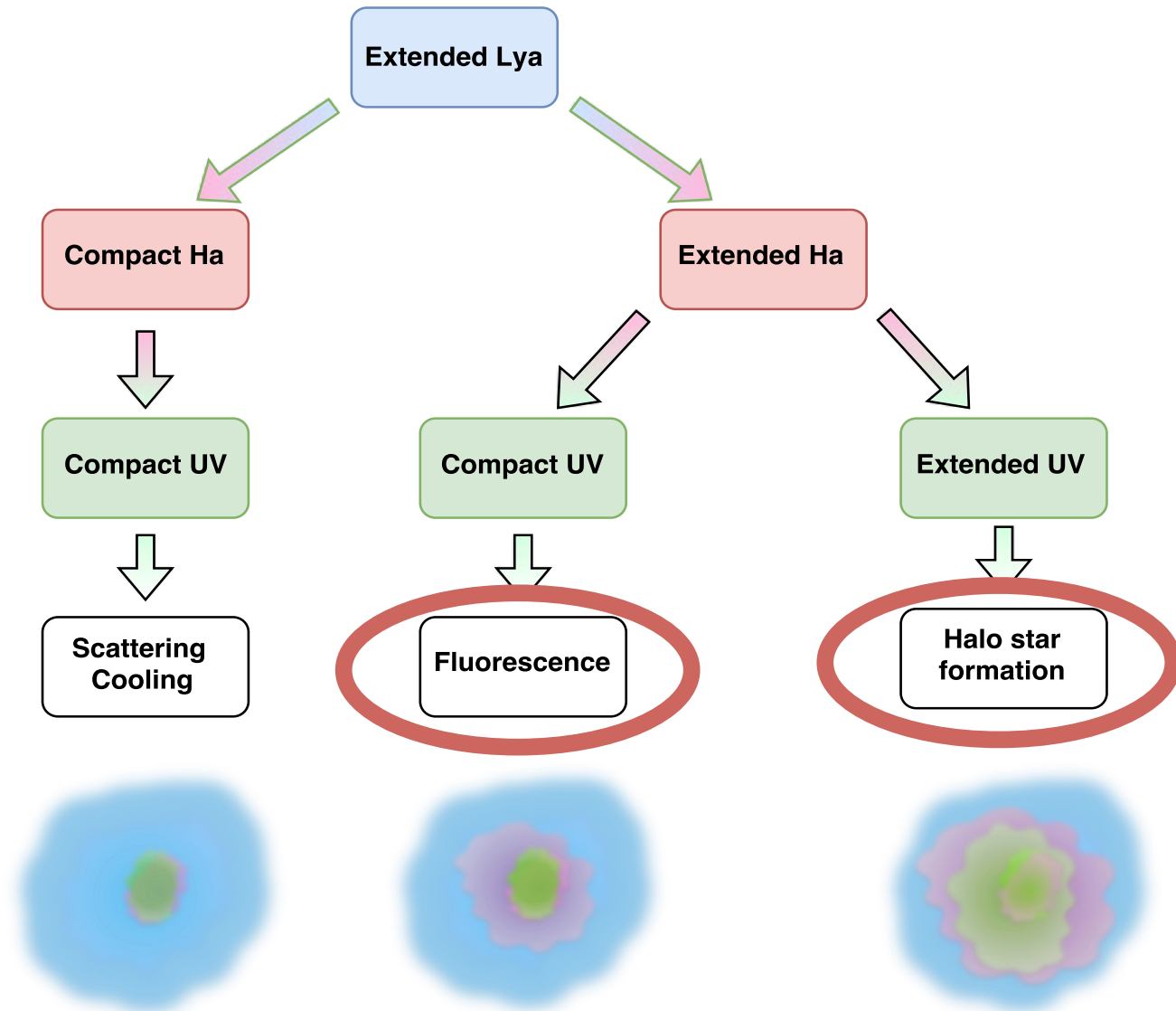


# Emission from the Cool CGM

# Origin of the Extended Halos



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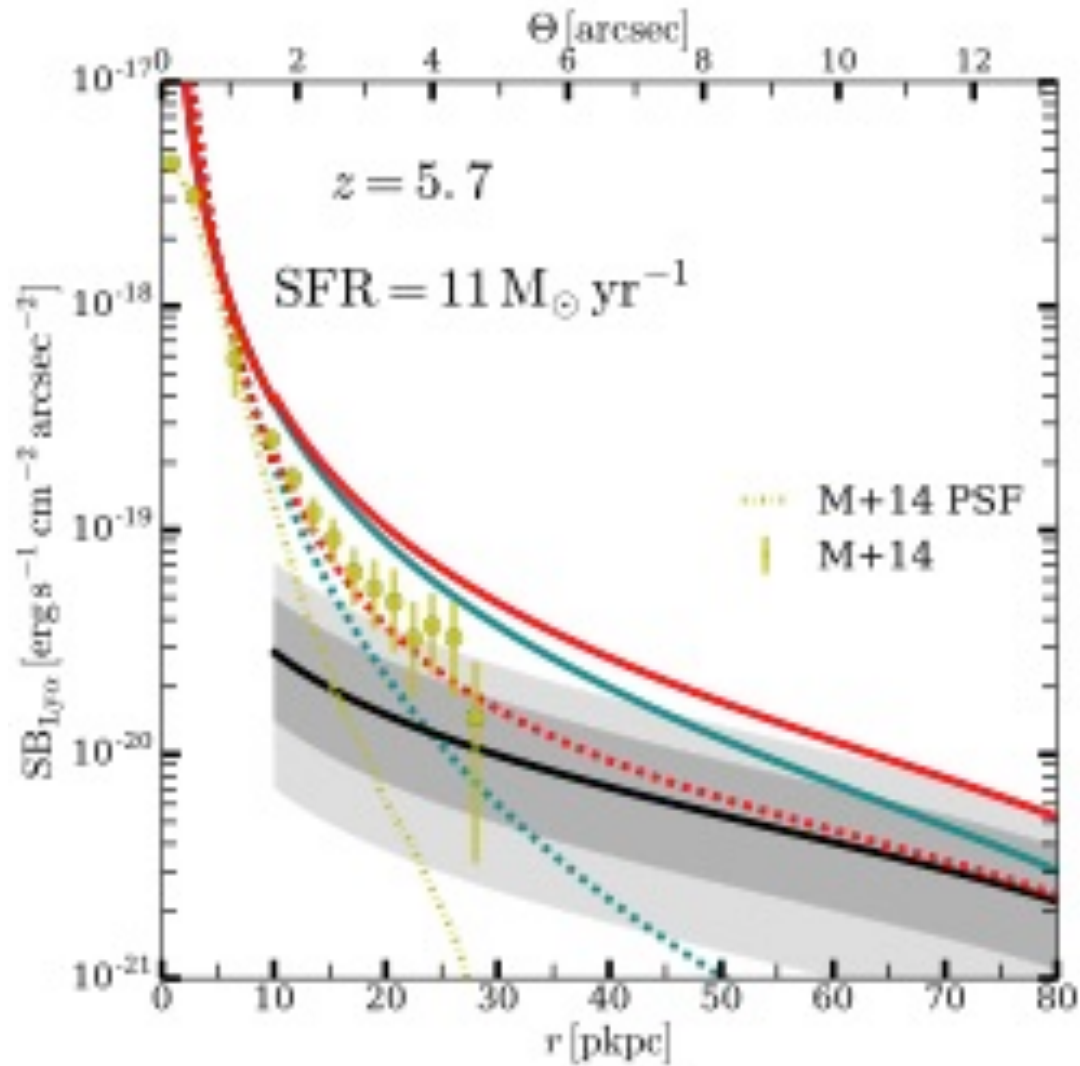


Mas-Ribas & Dijkstra 2016

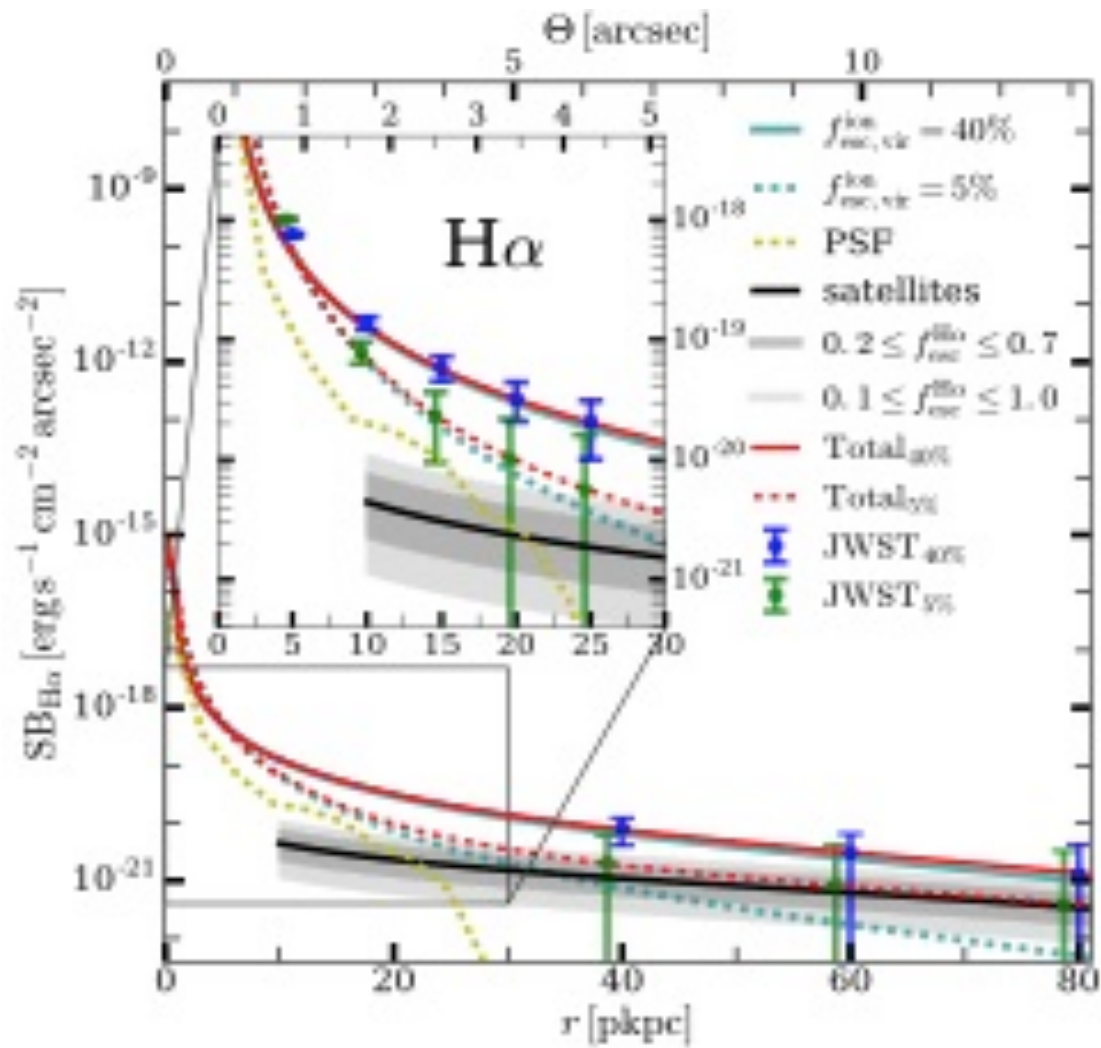
Mas-Ribas et al. 2017 a

# Epoch of Reionization

# Lya Halos at z=5.7



# Ha Halos at $z \sim 6$ (JWST $\sim 30$ h)



Emission from The Warm & Hot CGM



# Detection of Warm and Hot Gas

## **X-ray observations:**

Not sensitive to  $10^5 - 10^6$  K gas

Faint → large halo masses

→ stacking multiple observations

Low spatial resolution

Low redshifts  $z < 1$

Contaminant radiation sources

## **Thermal Sunyaev-Zel'dovich (Inverse-Compton scattering):**

Faint → large halo masses

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No spatial resolution

Contaminant thermal radiation by dust

Compton- $y$  parameter → pressure →  $n_e T_e$

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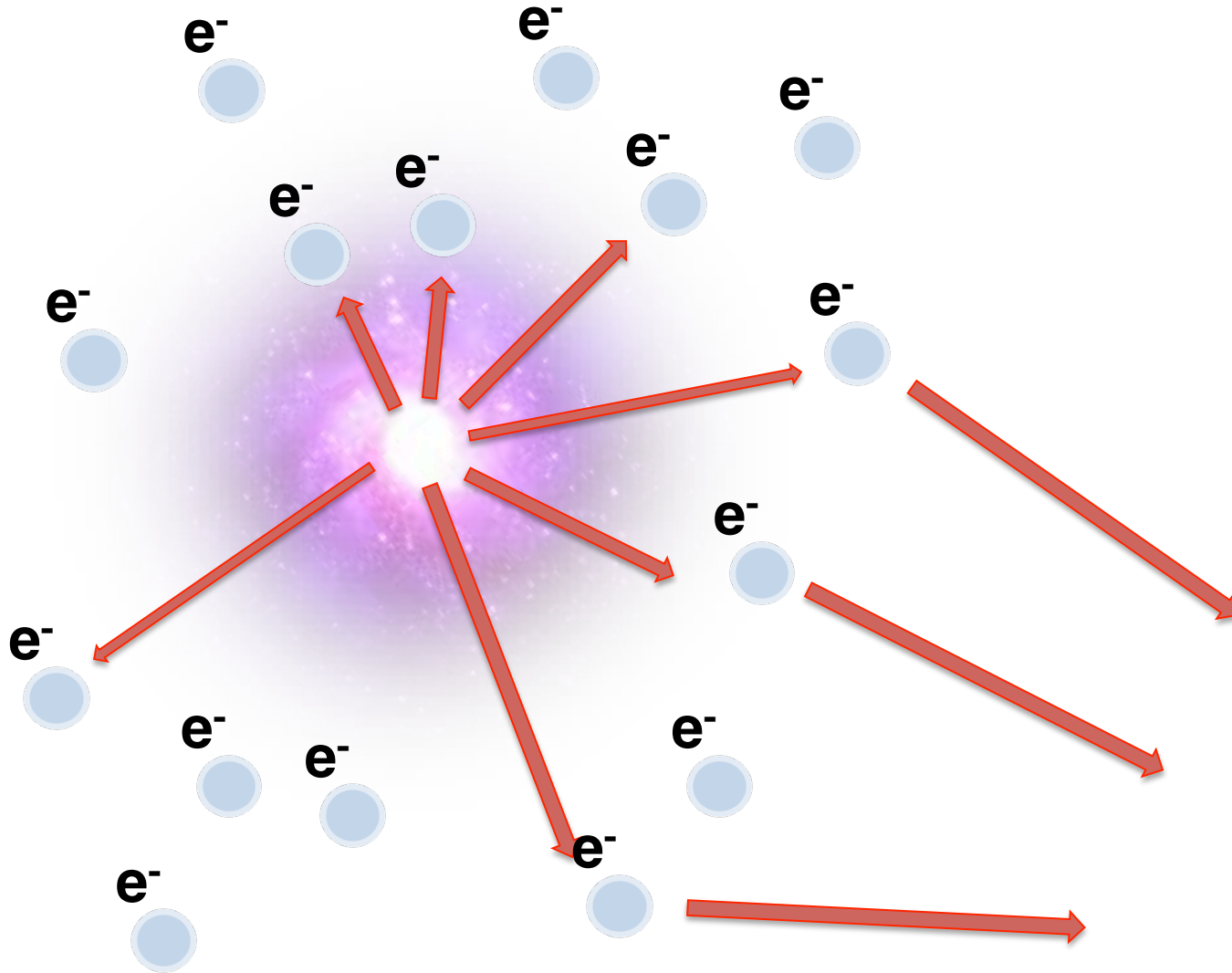
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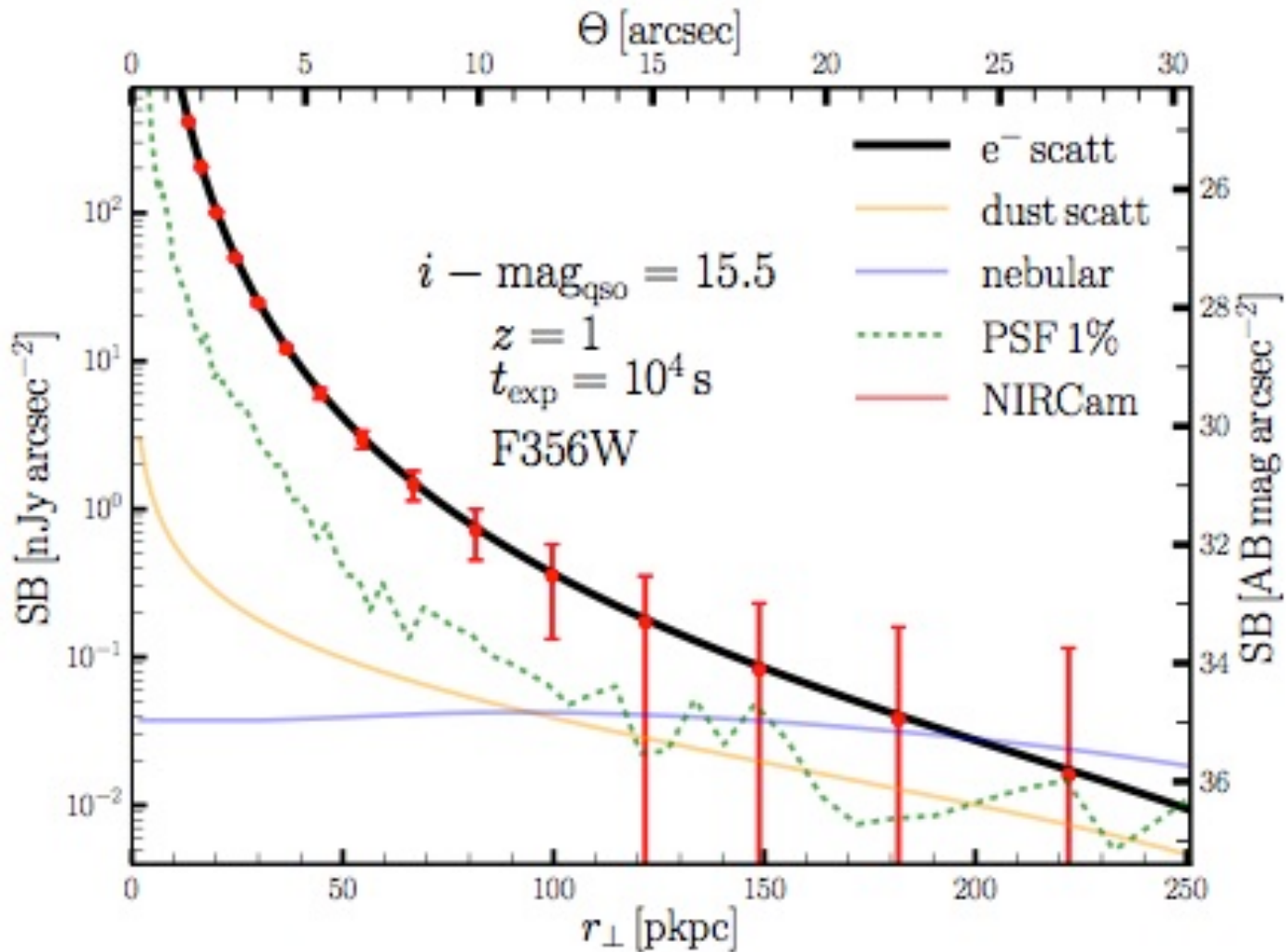
Contaminant thermal radiation by dust

Compton-y parameter  $\rightarrow$  pressure  $\rightarrow n_e T_e$

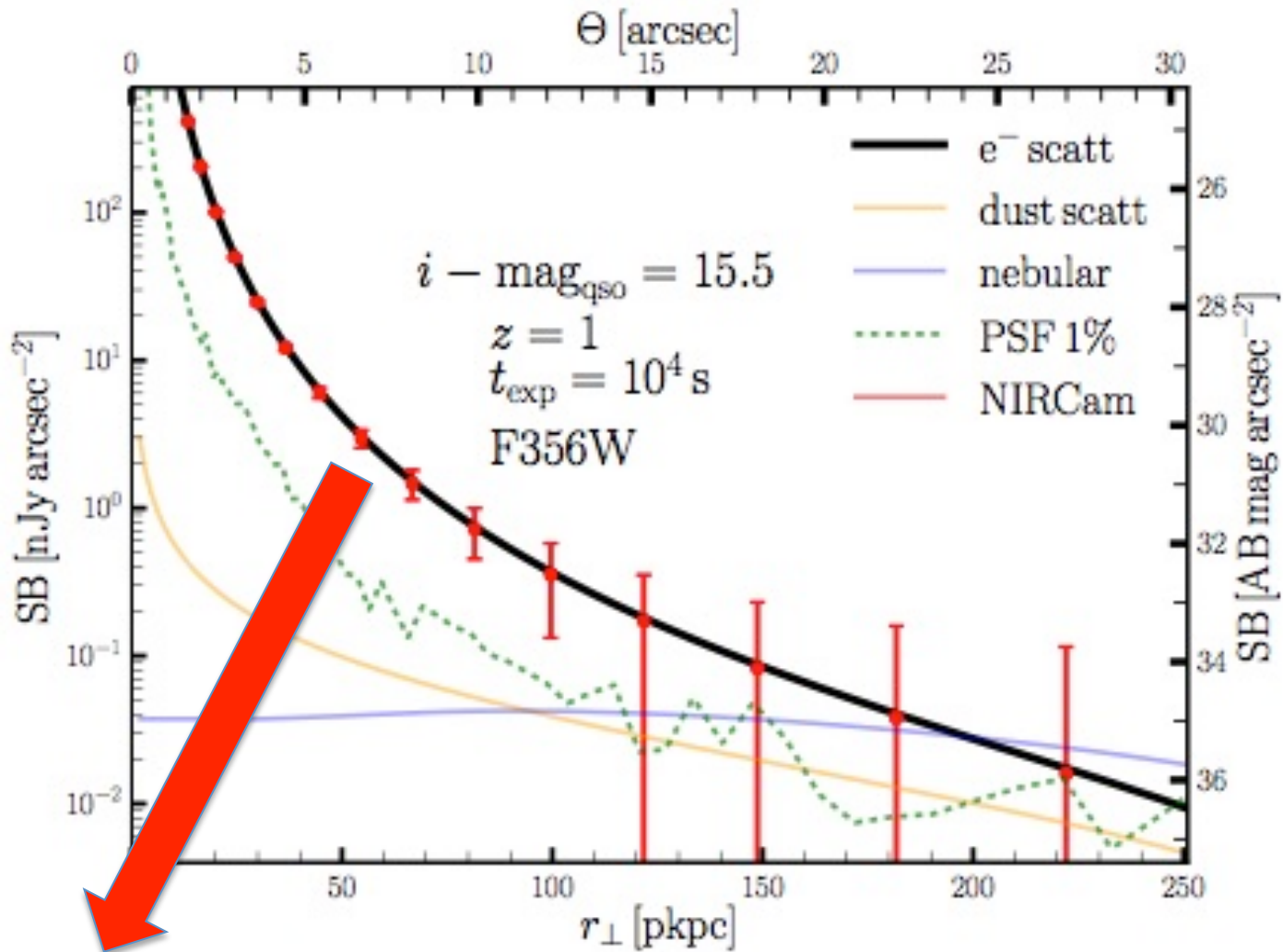
# Diffuse Thomson-scattered Hyper-luminous Quasar Radiation



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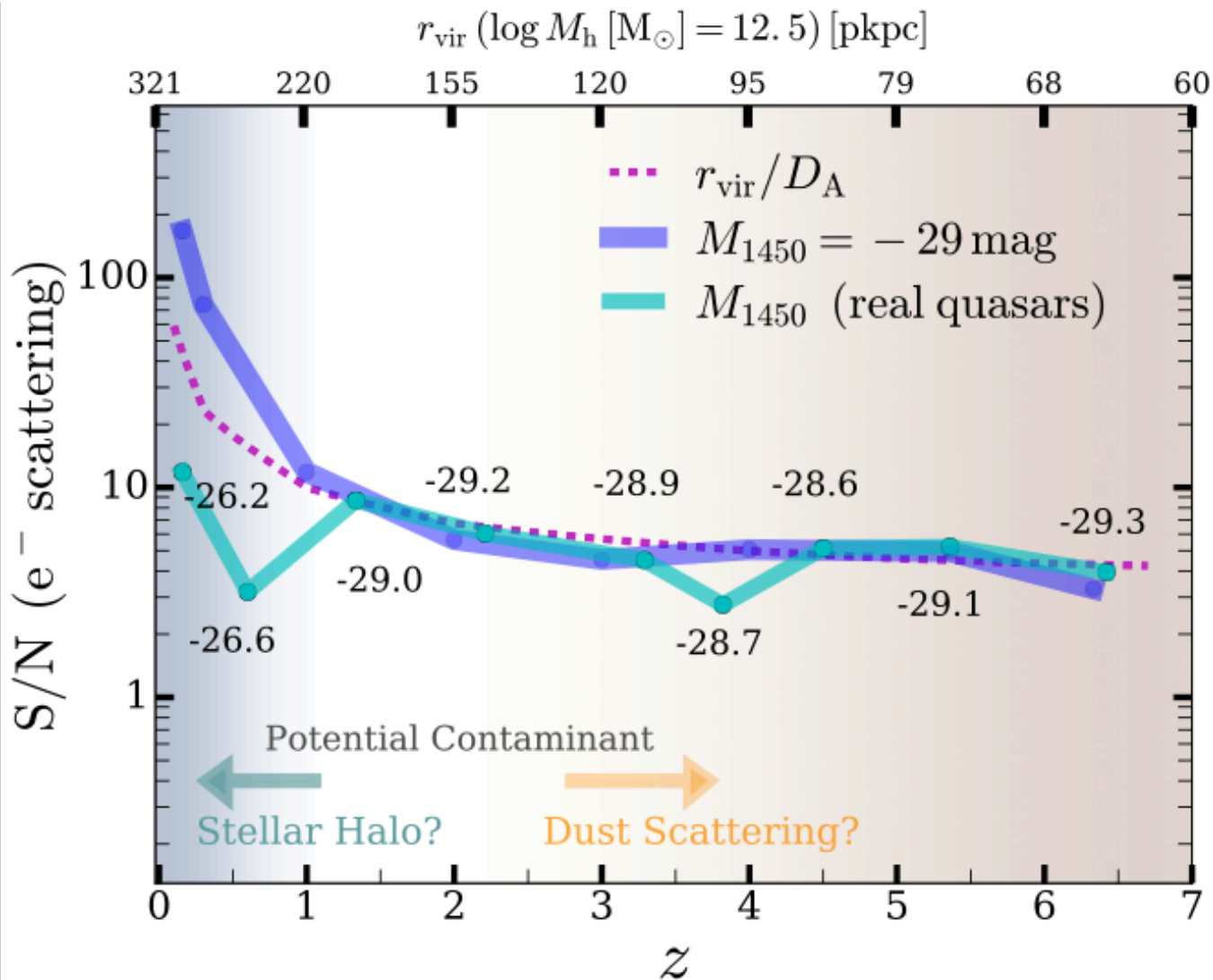


# Diffuse Thomson-scattered Hyper-luminous Quasar Radiation

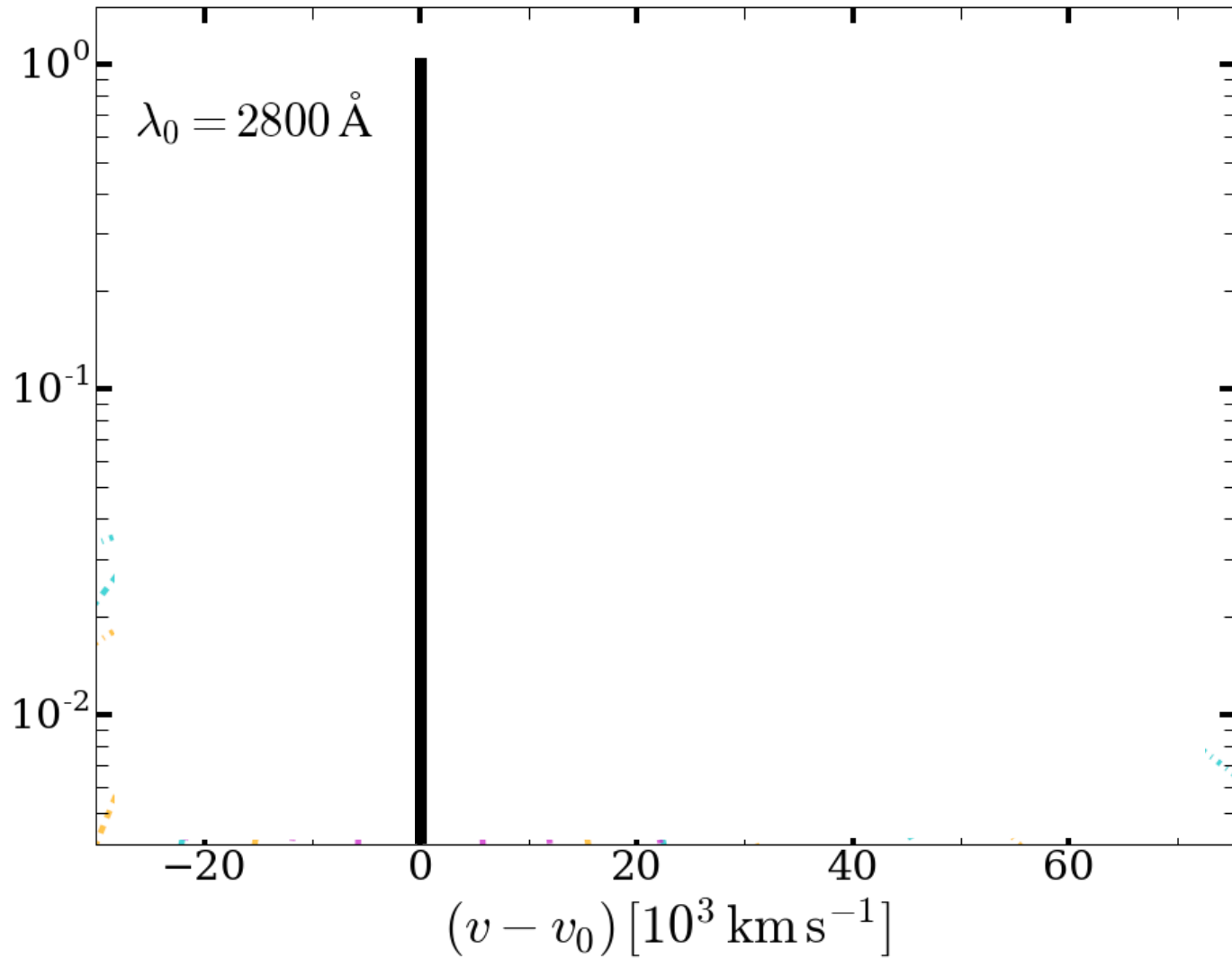


**SB  $\propto n_e \rightarrow$  Break degeneracy !**

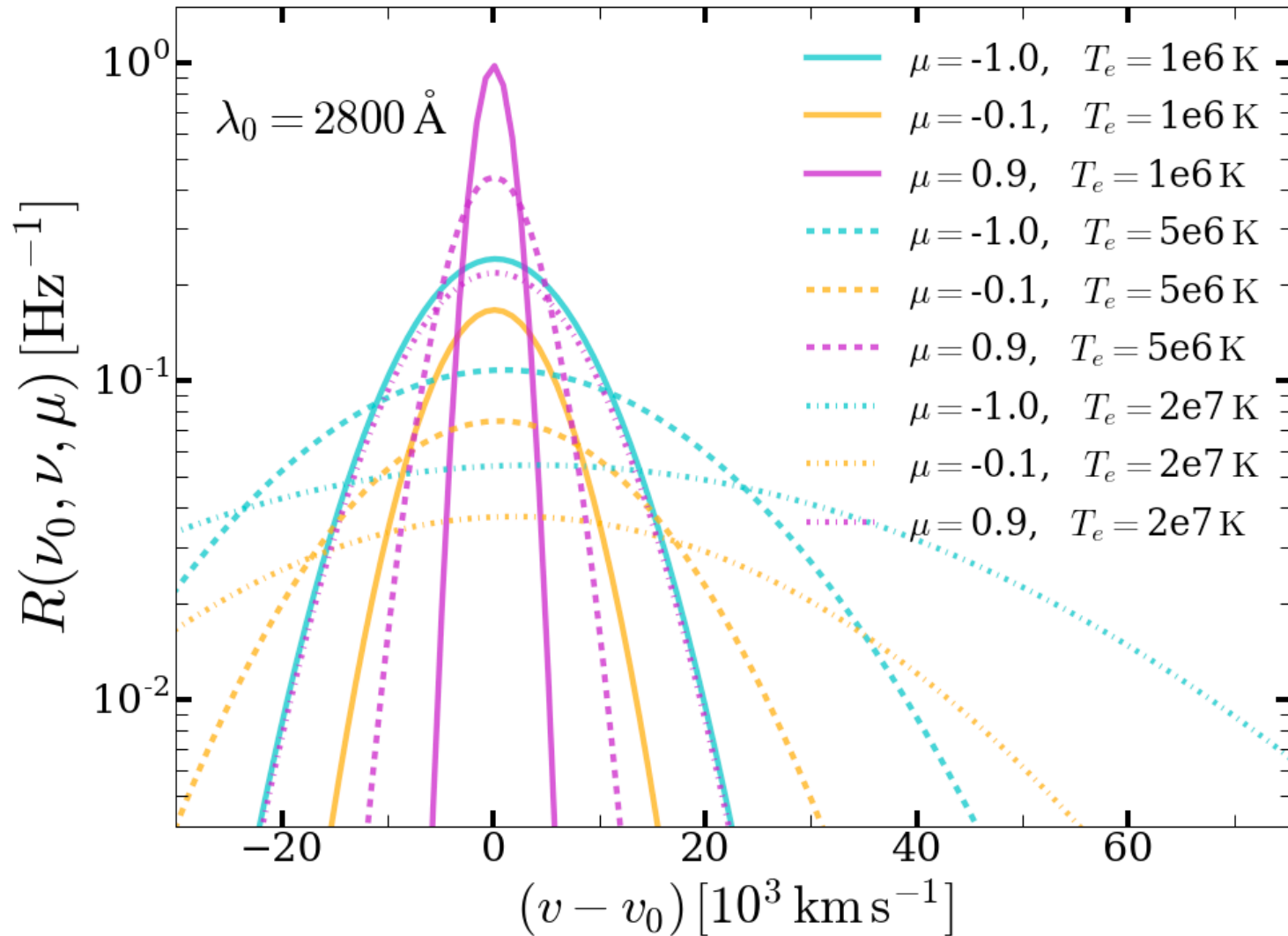
# Redshift Independent



# Line Broadening

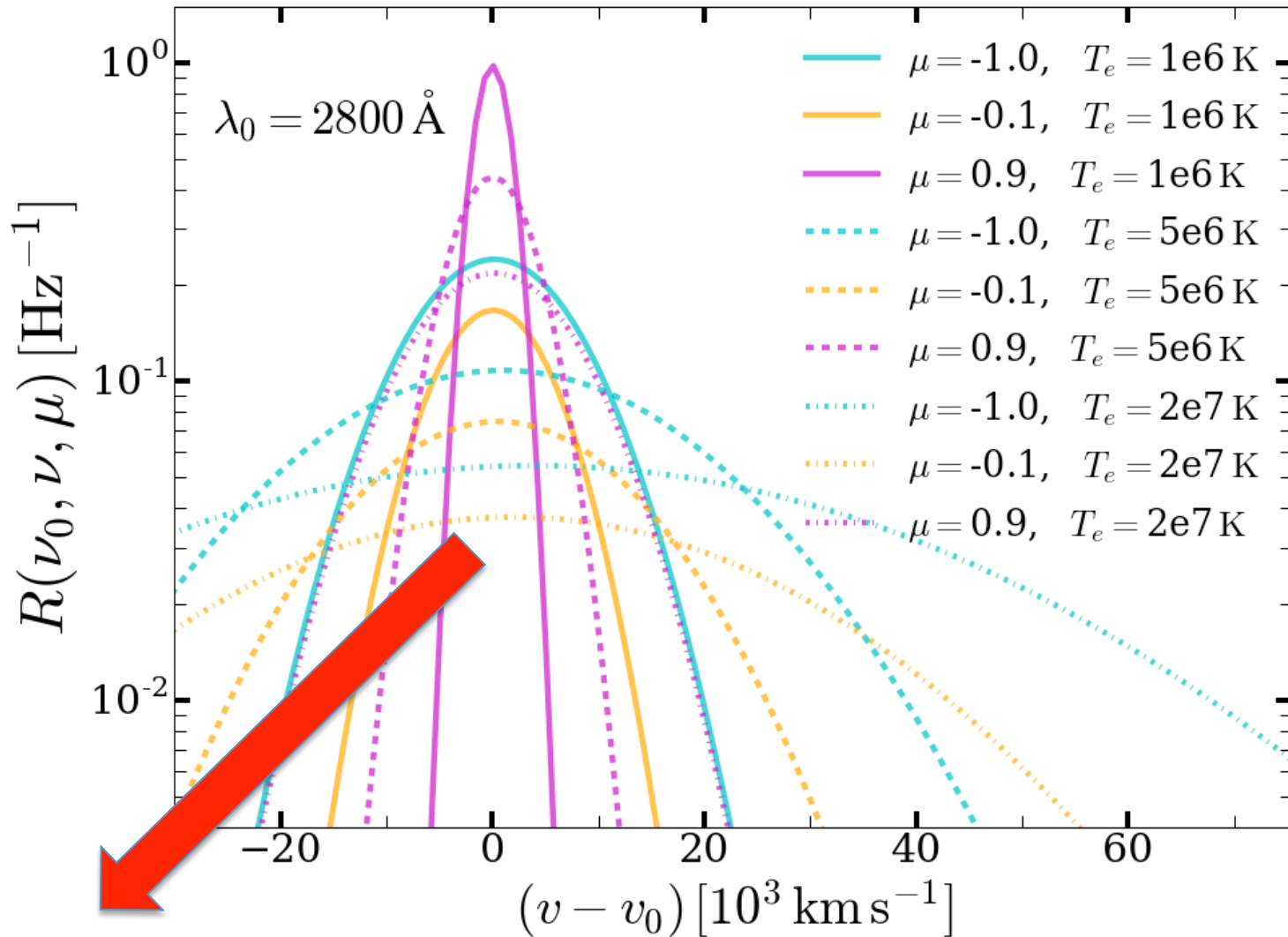


# Line Broadening



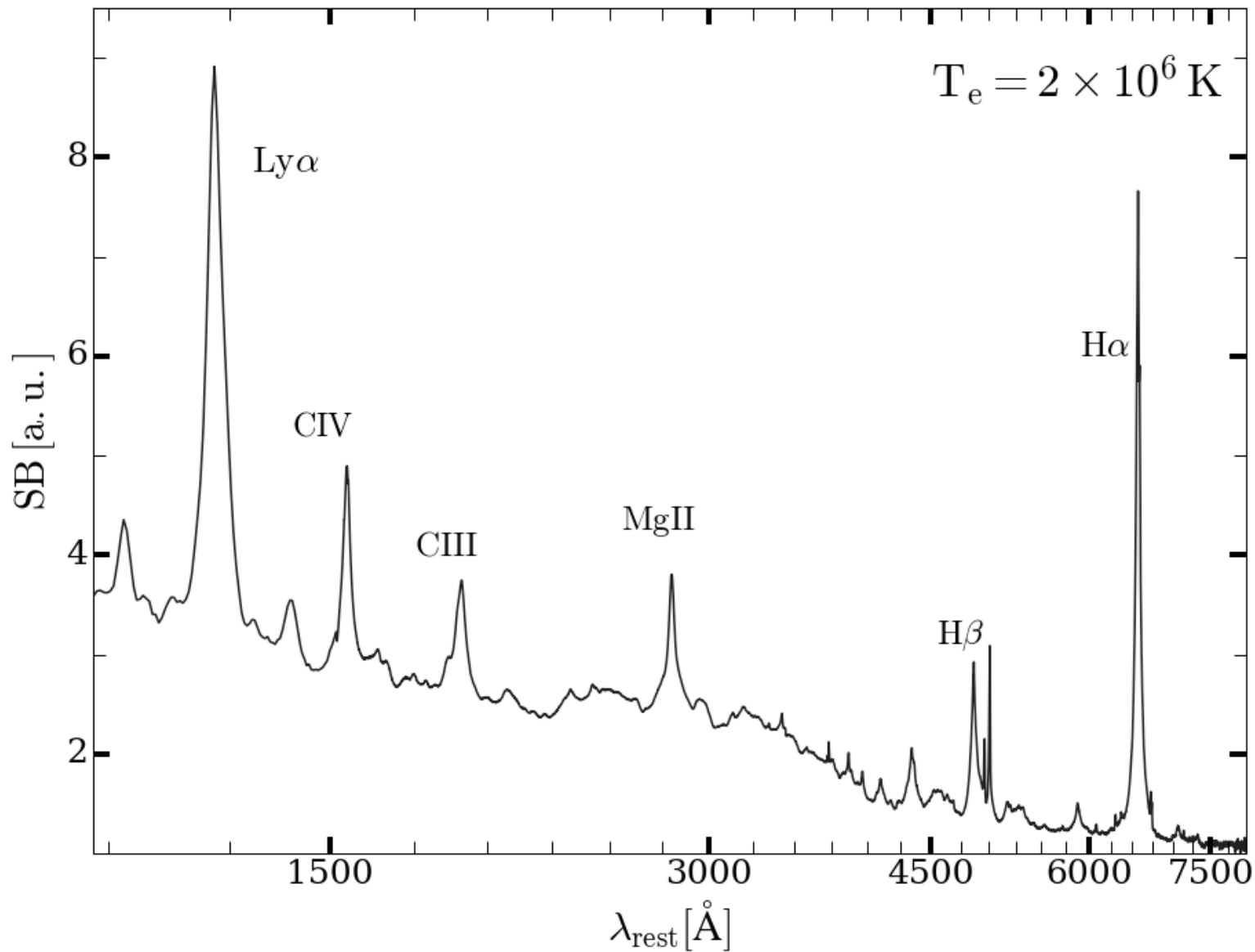


# Line Broadening

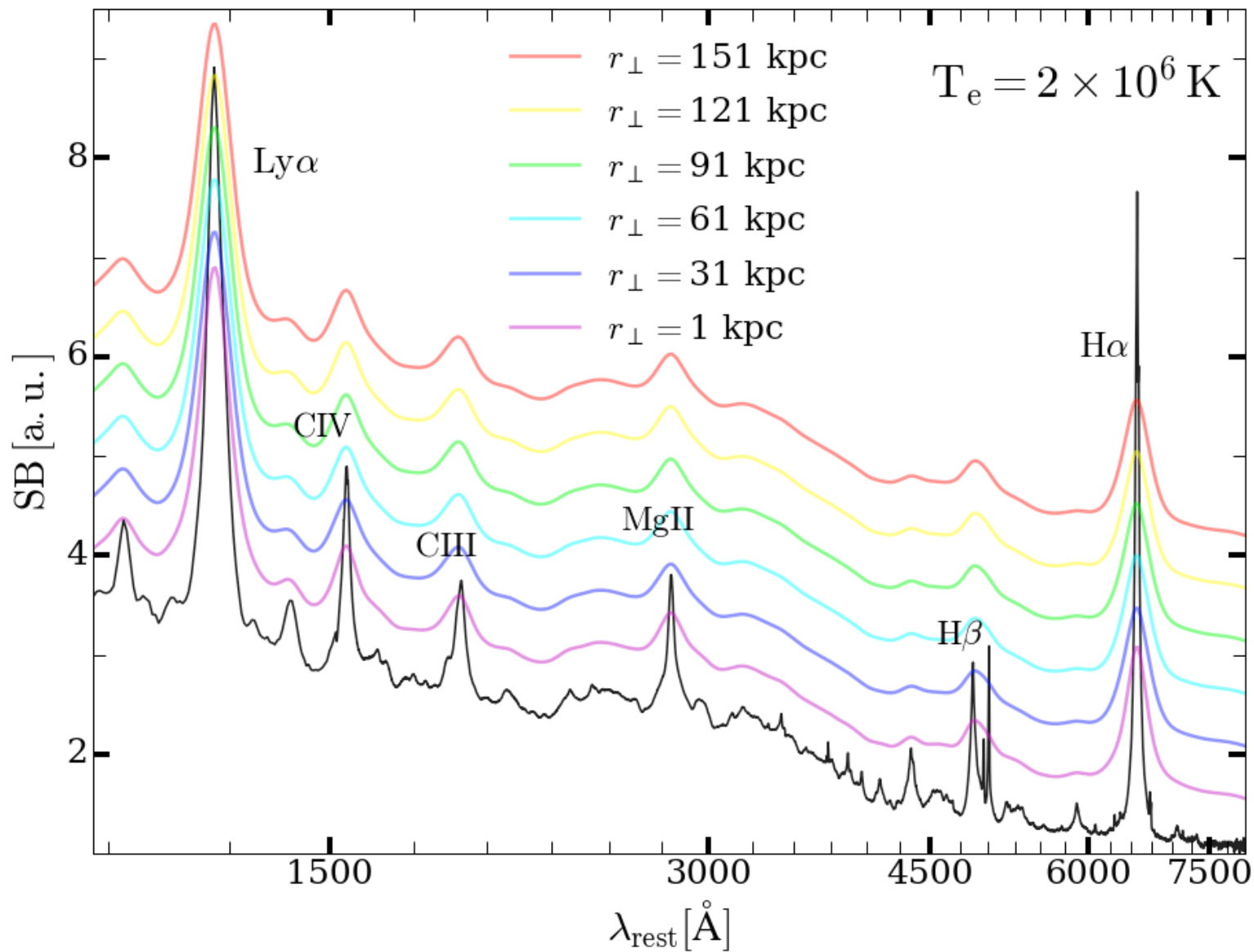


**$T_e$  only!**

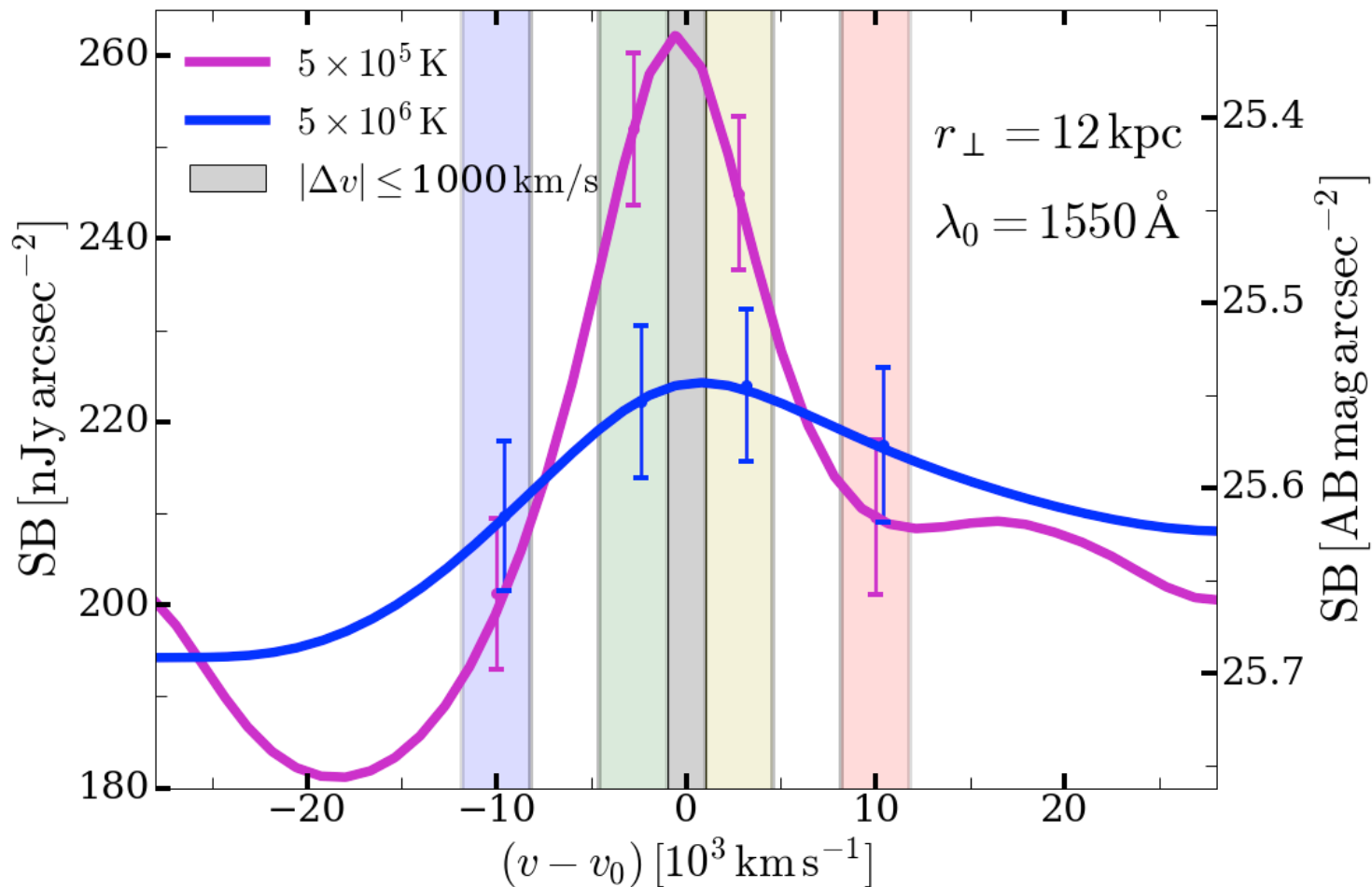
# Intrinsic Quasar Spectrum



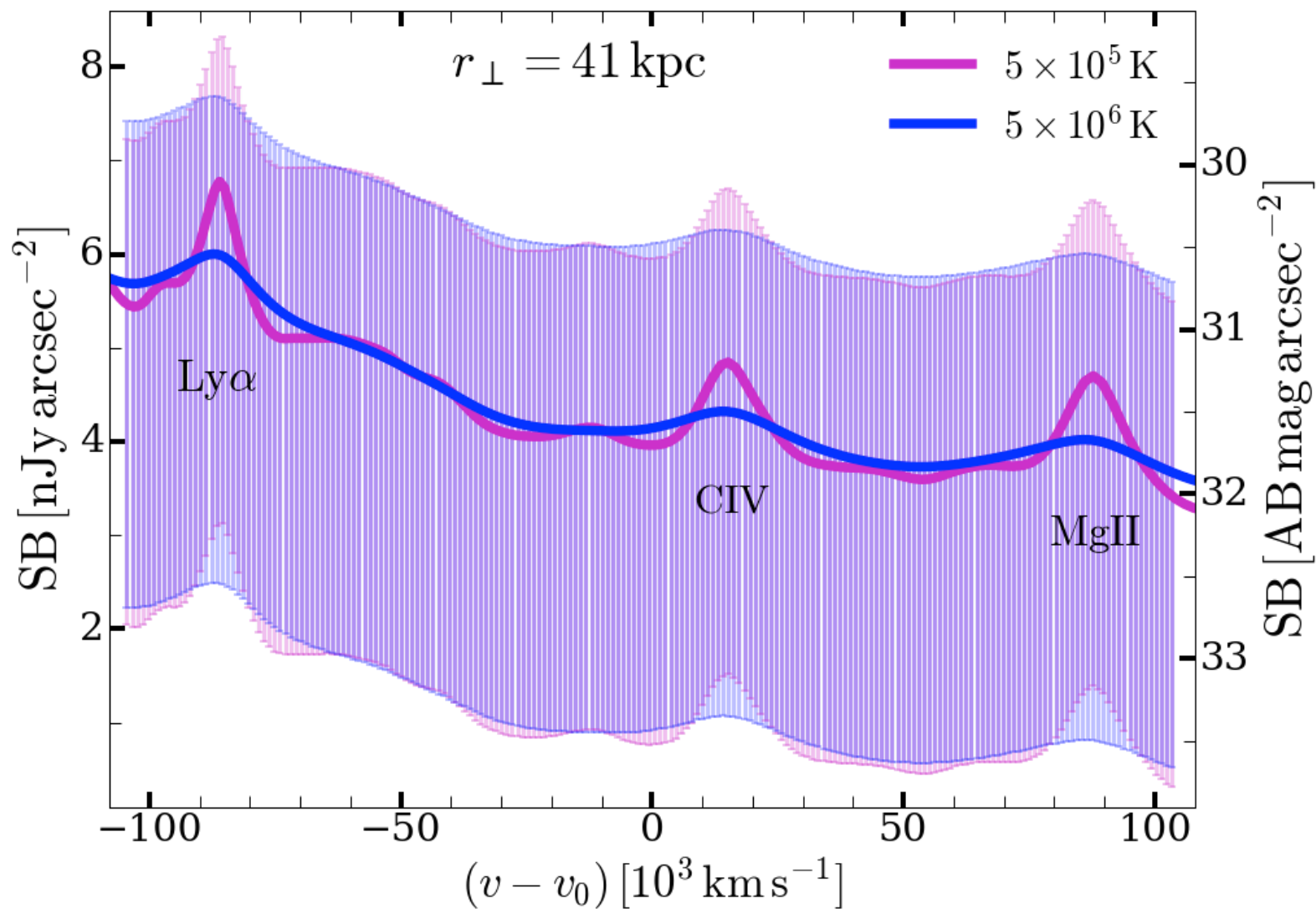
# Broadening vs Impact Parameter



# JWST IMAGING 4 FILTERS

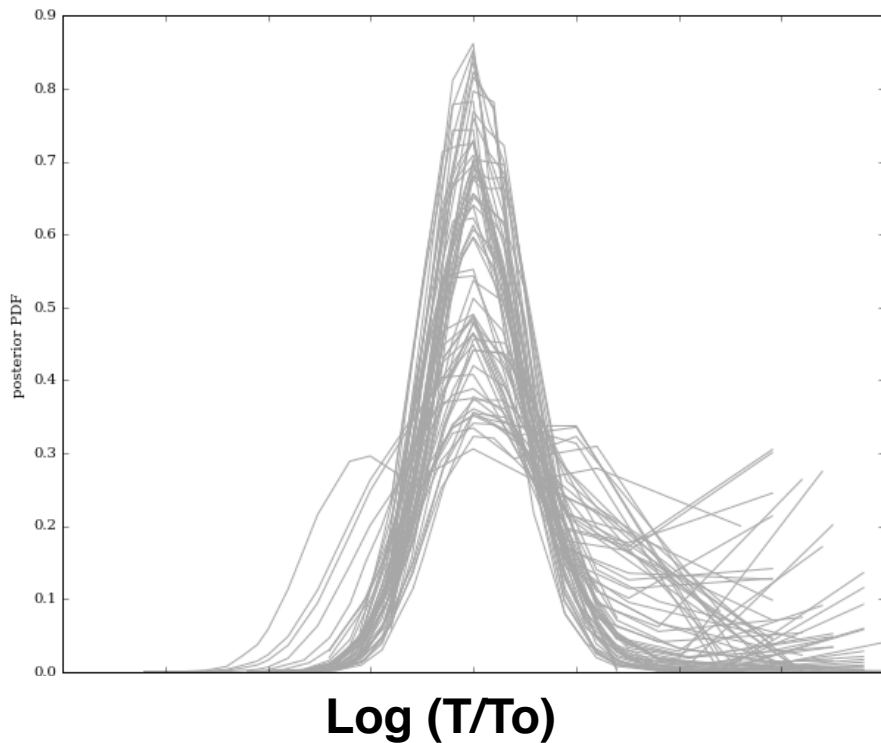


# GROUND IFU R~100



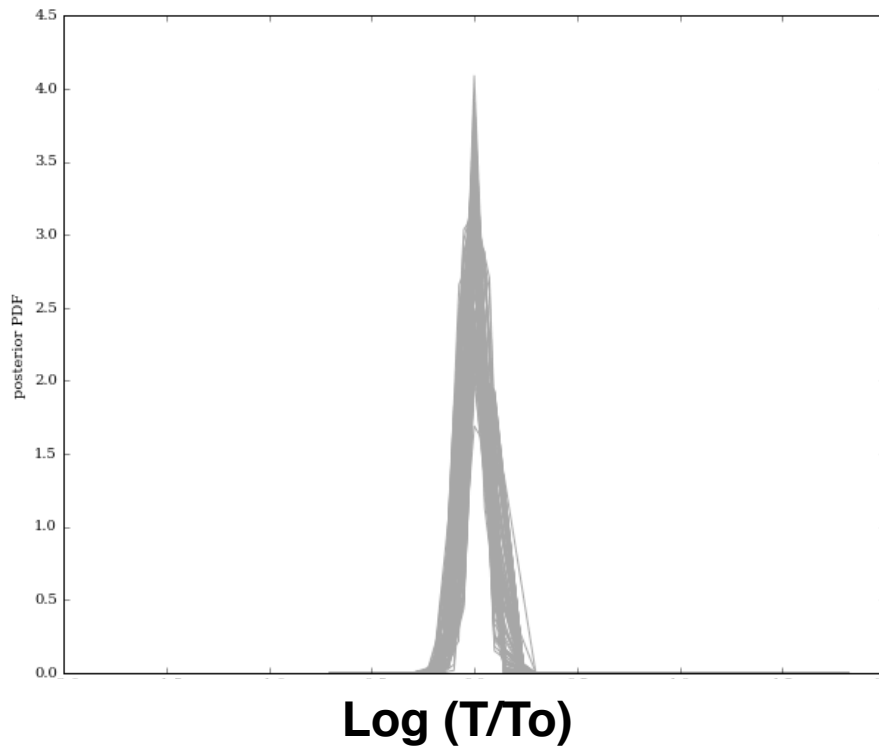
# Te constraints

## JWST 4 FILTERS



**Uncertainty better than a factor of 3**

## GROUND IFU R~100



**Uncertainty better than 65%**

## Cool CGM

Halo Star Formation

Reionization Sources

Escape of Ionizing Photons

## Warm/Hot CGM

Extended emission  $\rightarrow$   $n_e$

Line broadening  $\rightarrow$   $T_e$

# CGM/IGM in Absorption



# OMG

**Origin of Metals around Galaxies**

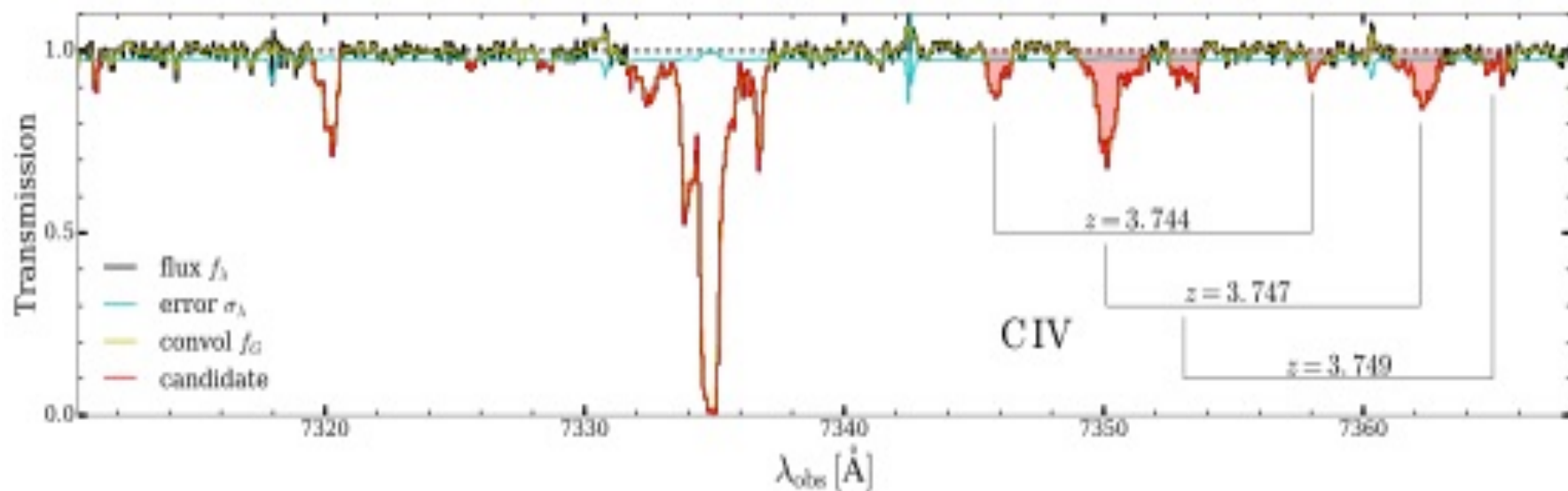
with Miralda-Escudé, Pérez-Ràfols, Riemer-Sørensen, Hennawi, O'Meara, Webb & Murphy

# OMG-I



~700 R>30,000 Quasar spectra UVES/HIRES

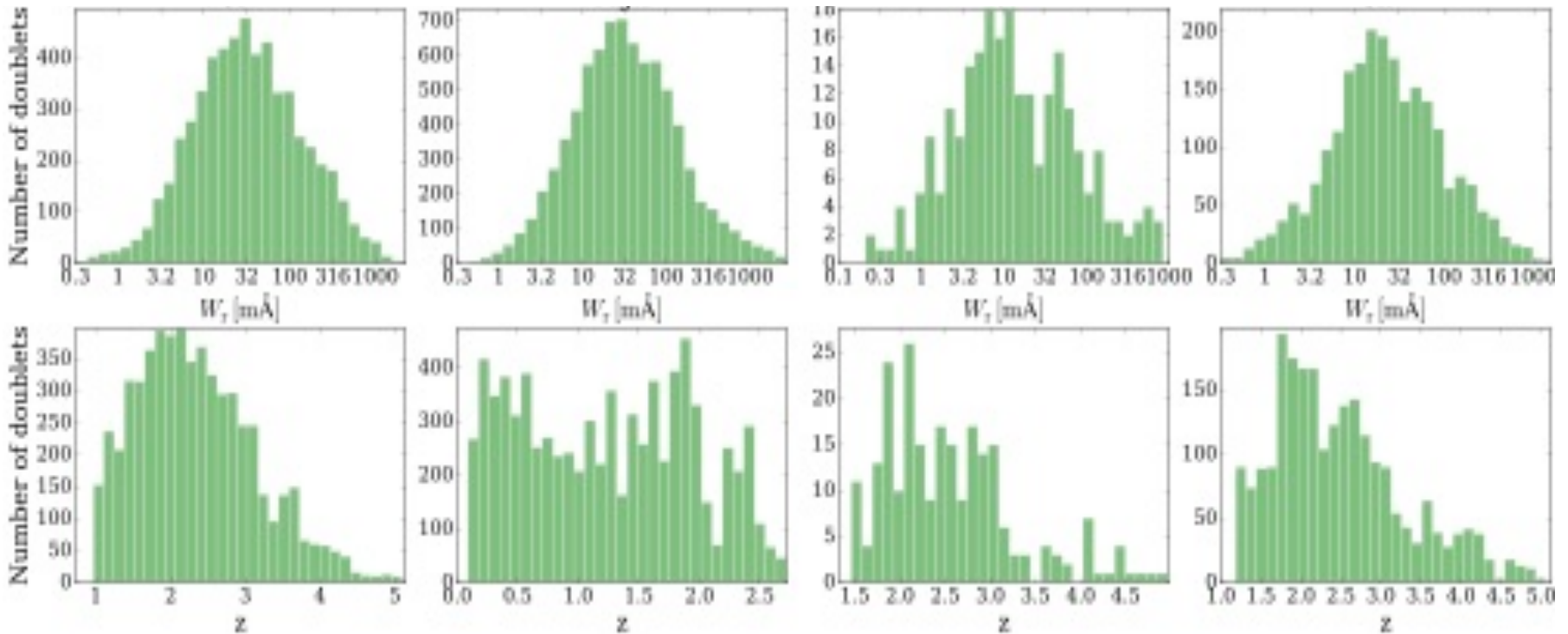
KODIAQ



Search for CIV, SiIV, NV & MgII Doublets

# OMG-I

Mas-Ribas et al. 2018 a



**C IV**  
**~5,600**

**Mg II**  
**~7,900**

**N V**  
**~240**

**Si IV**  
**~2,200**

Use them!

freely available at [github.com/lluism](https://github.com/lluism) and/or ask me!

## OMG

High-res Metal-doublet Catalogs on github (OMG I)

weak CIV - Ly $\alpha$  forest x-correlation (OMG II)

BOSS doublets: stacks (OMG III)

## BALs

Everything You always Wanted to Know

but Nobody Analyzed for you (coming soon)