# *Exploring HI Density up to ~1 Mpc Around Lyman Alpha Emitters in HETDEX*

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*LSS meeting - 10/12/2023*

# *Content*

*Motive*

*Methods*

*Results*

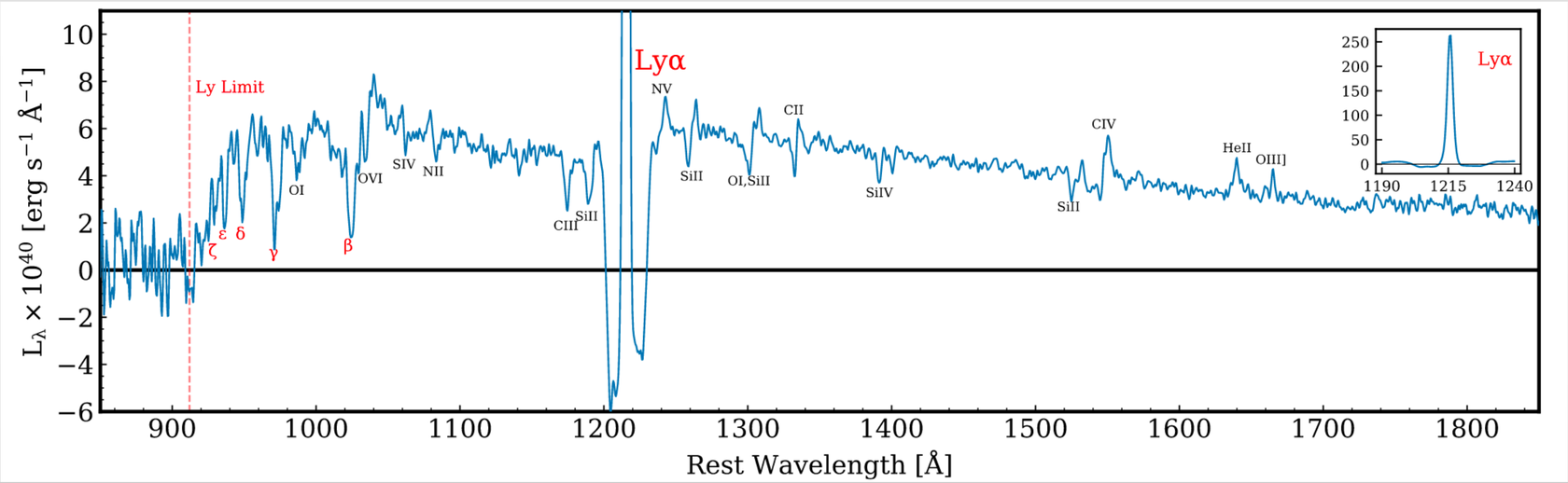
- *HI around LAEs*
- *HI between LAE pairs*

*Hydrogen gas is a fundamental building block of the cosmos*

*Understanding its distribution & kinematics near key sources like LAEs helps us with the dynamics and evolution of large scale structures*

*We study HI distribution near and between LAEs at z~1.9-3.5*

*Observational tool:*
*The Lyman Alpha absorption line*




*Davis et al. 2023*

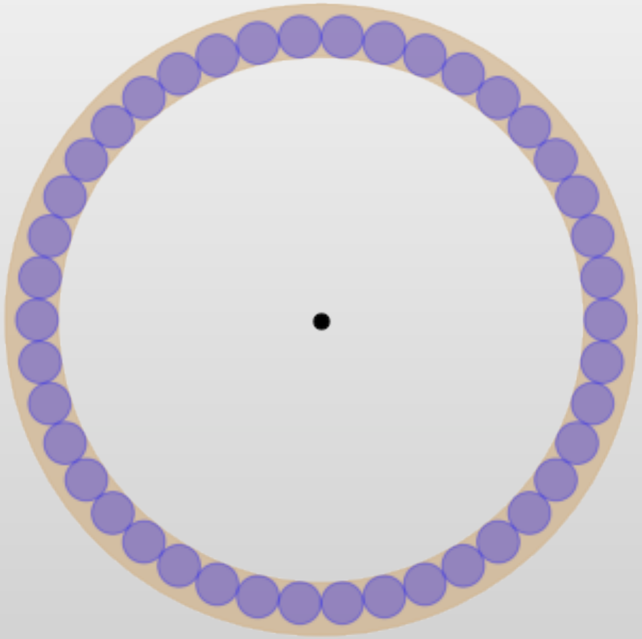
*Stacking spectra significantly boosts SNR and uncovers spectral details that are obscured by noise*

# *Procedure*

*We select LAEs from hdr3 based on SNR (5-6), Seeing, Linewidth, …*

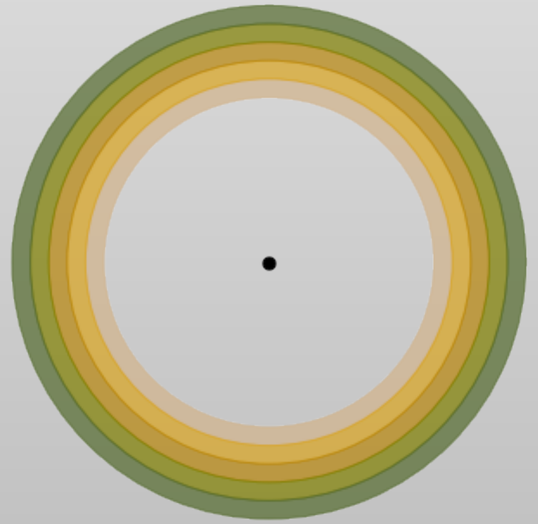
*For a single detection:*

- *Grab every fiber within a certain range from the center of the LAE using hetdex_api*
- *Get rid of very bright with two levels of filtering*
- *Get a median of all the fibers that pass the filters*
- *The end product is a single spectra*
- *Shift the spectra to it's rest frame*

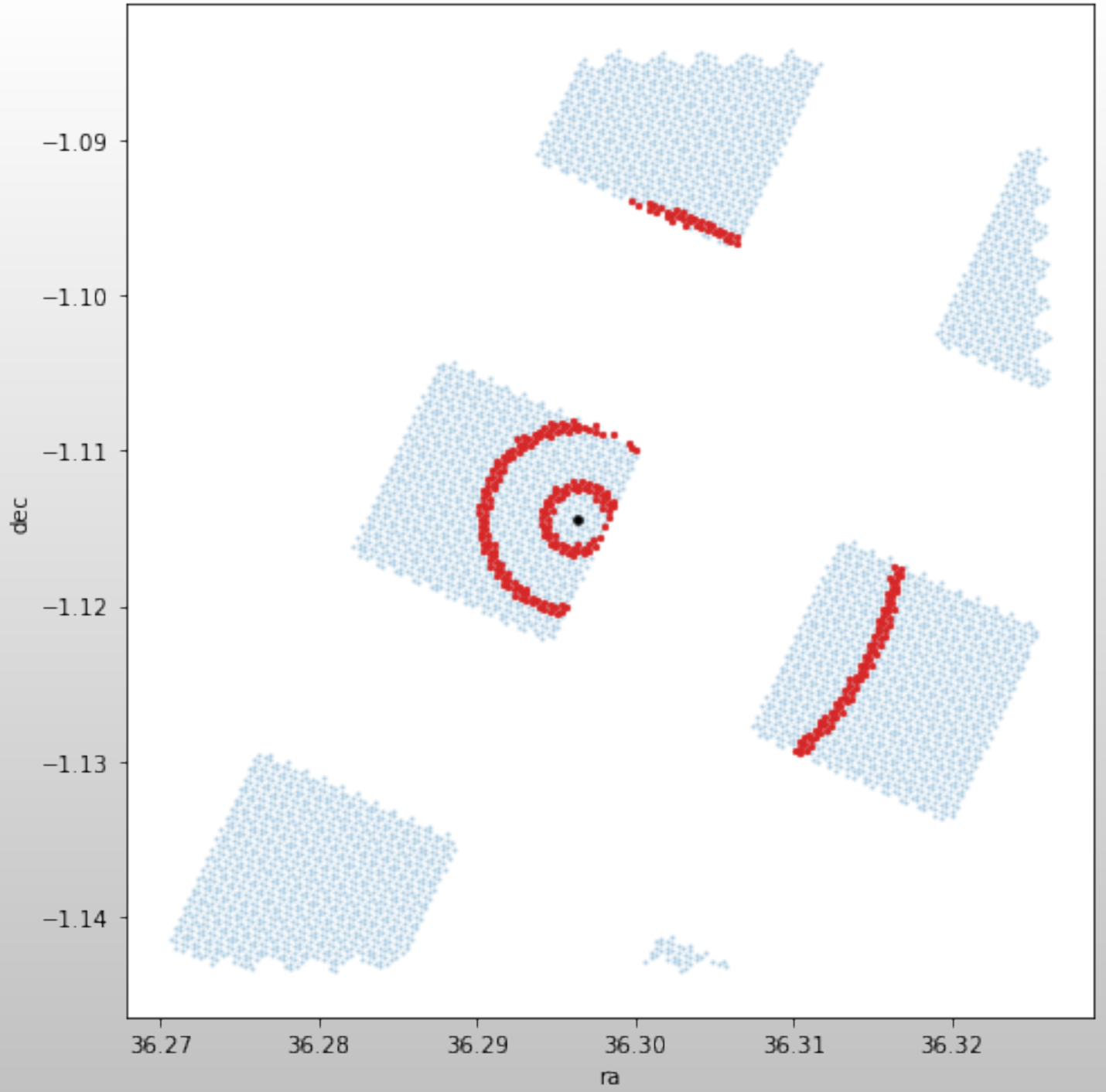


*We stack spectra from all detections using ELiXer*

*Repeat the procedure for the next annulus*

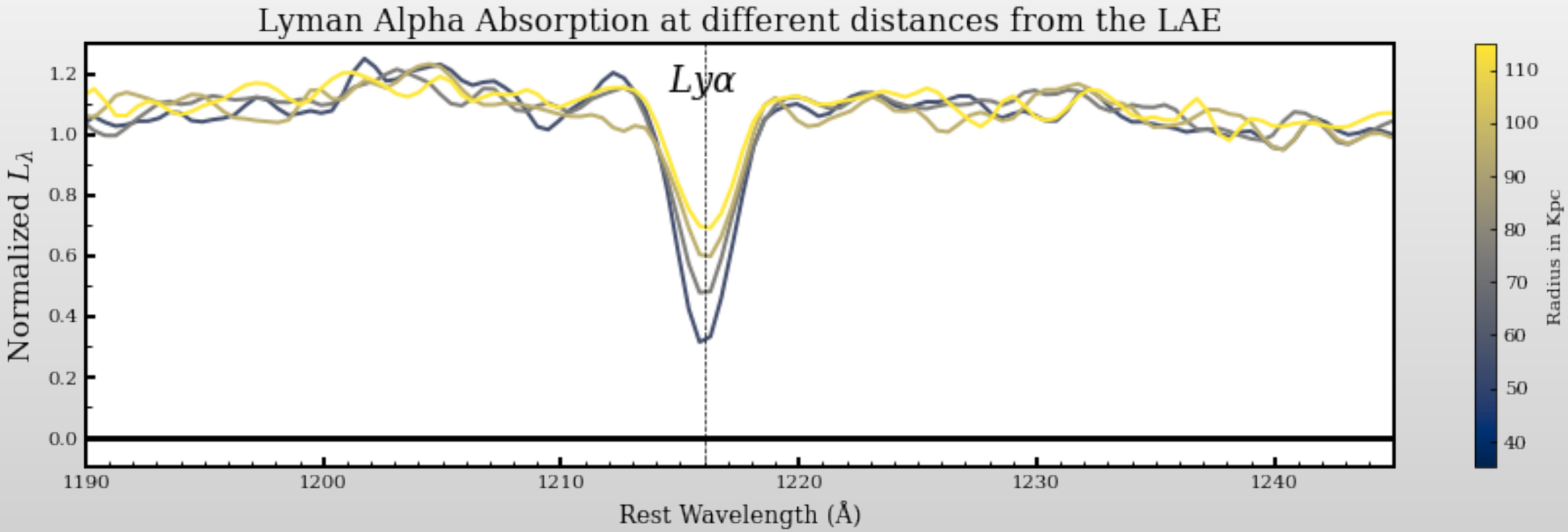


***fibers in the inner 3.5" are not used***


−1.09
−1.10
−1.11
−1.12
−1.13
−1.14
dec
36.27
36.28
36.29
36.30
36.31
36.32
ra

# *Stacking*

*56000 LAEs* *1-2 million fiber spectra* $L\lambda \sim 10^{39} ergs\,.\,s^{-1}\,.\,\text{Å}^{-1}$



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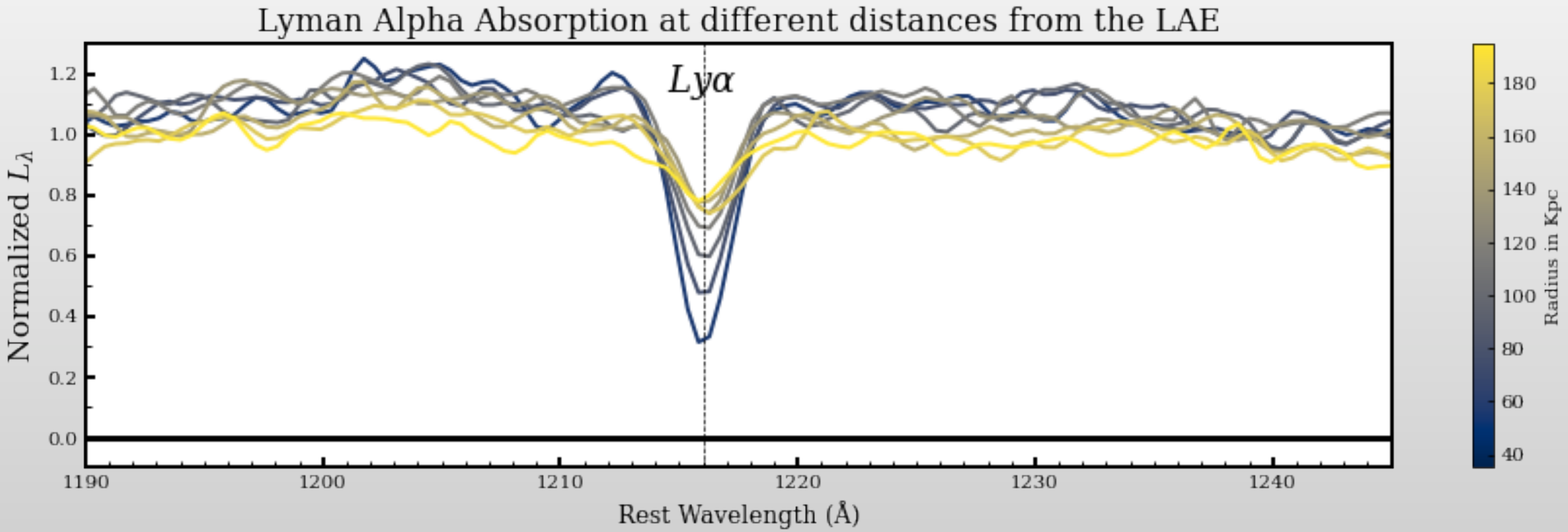

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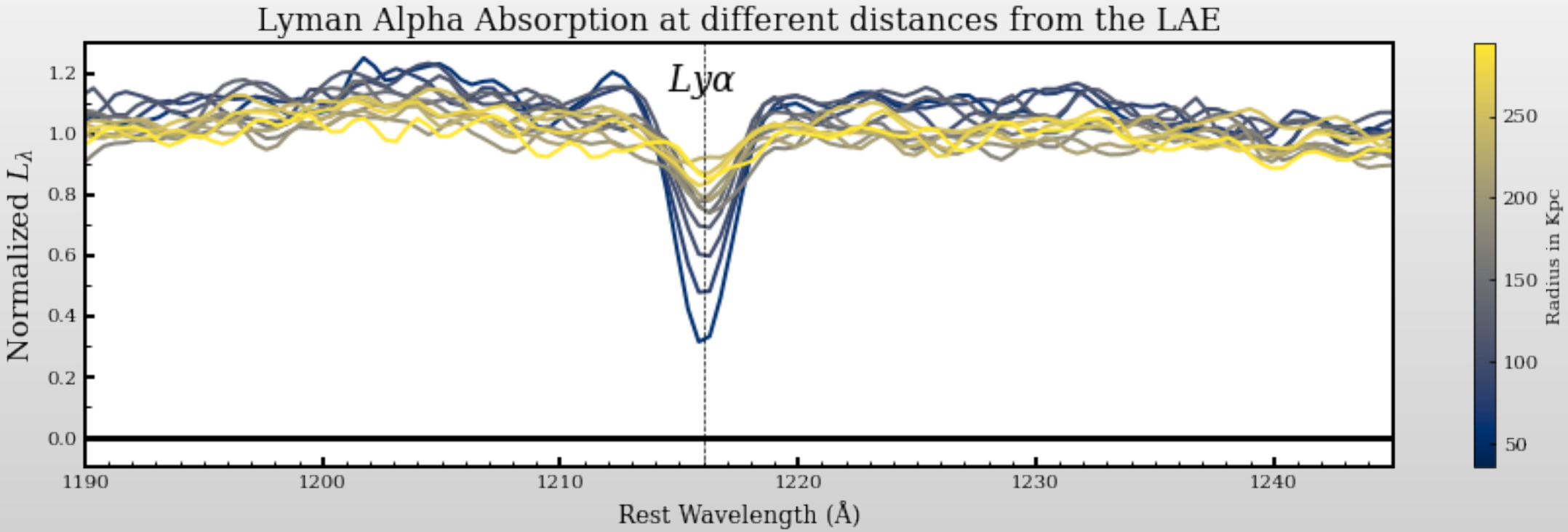

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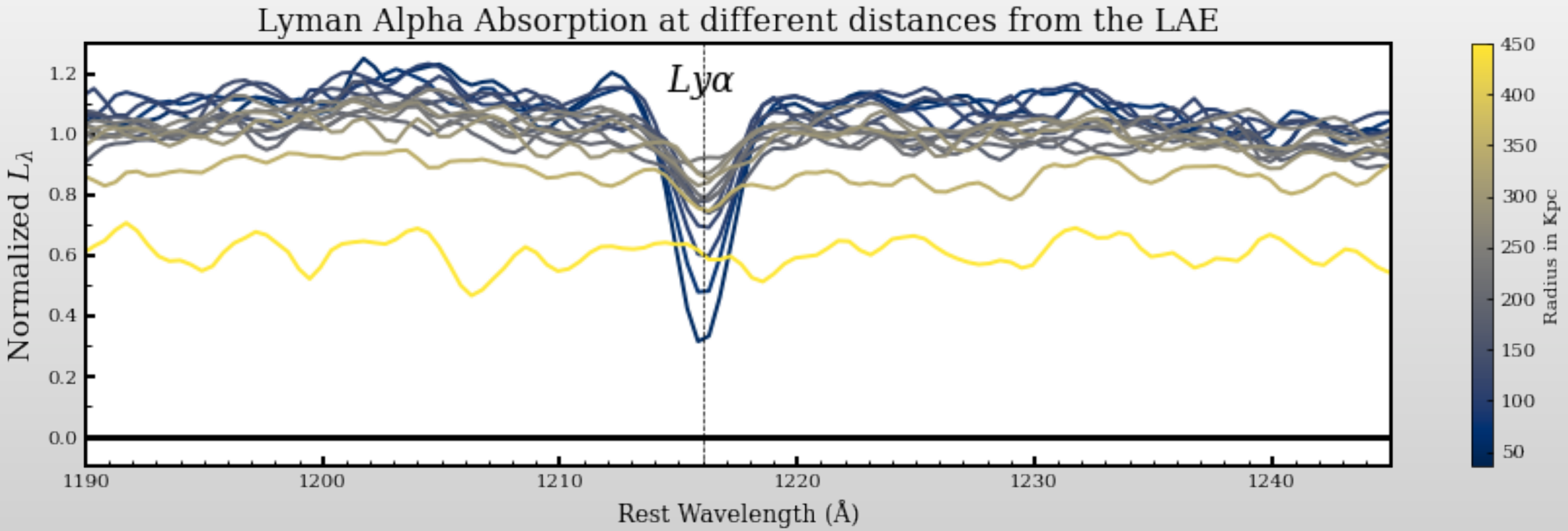
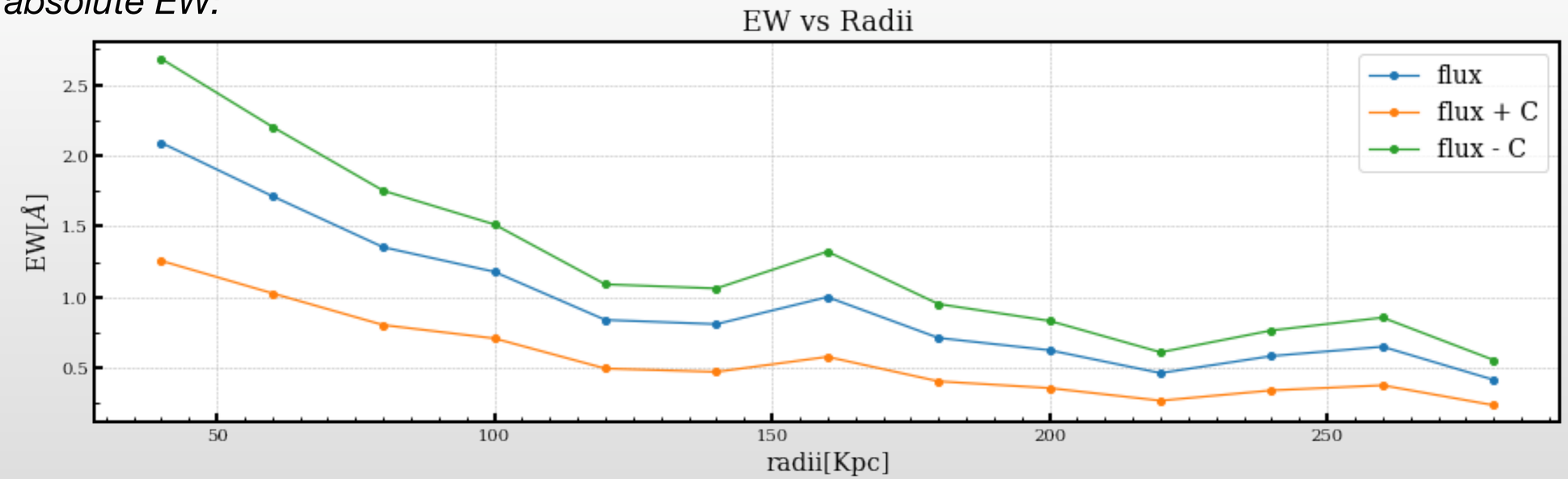



*Size of the HI gas that an average LAE (z~2.6) resides in*

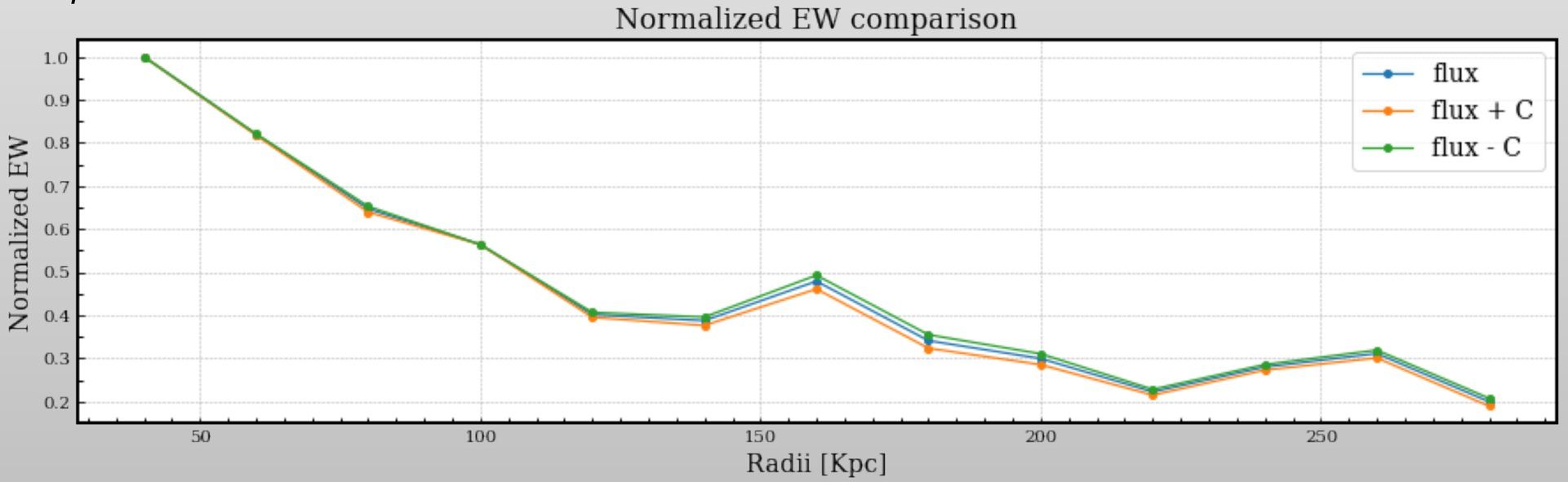
*Caveat: Continuum measurement*

# *Equivalent Width*

*Can’t give an absolute EW:*




*But a relative EW is plausible:*

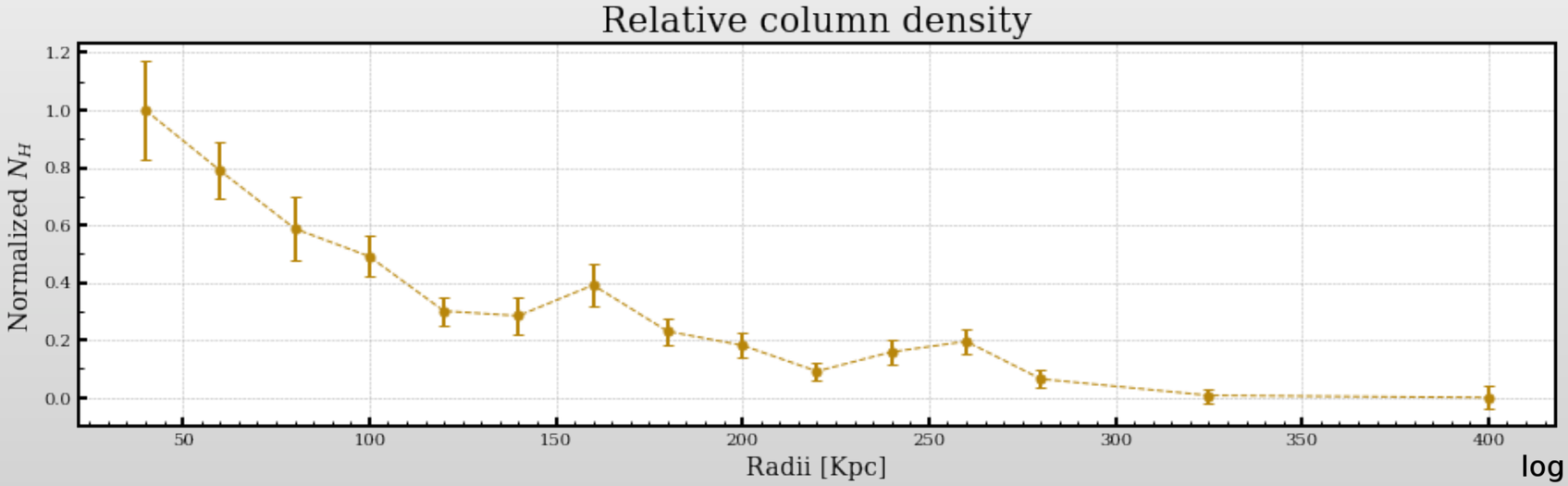


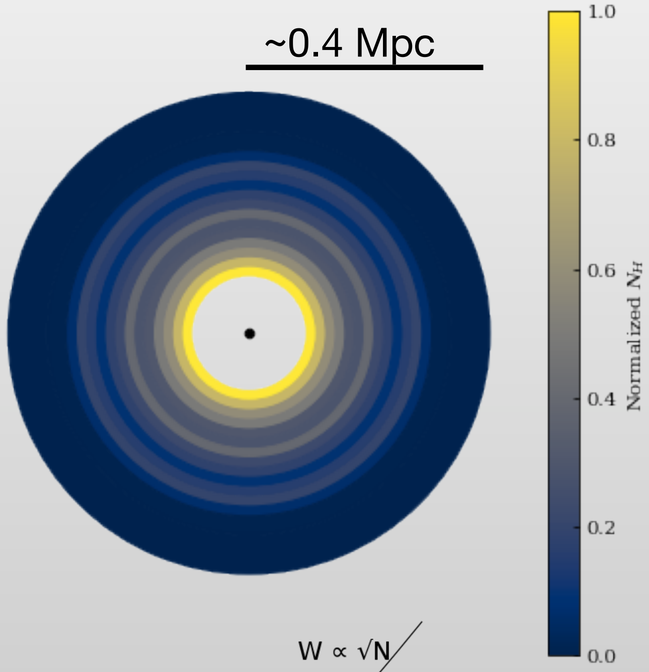
# Column Density

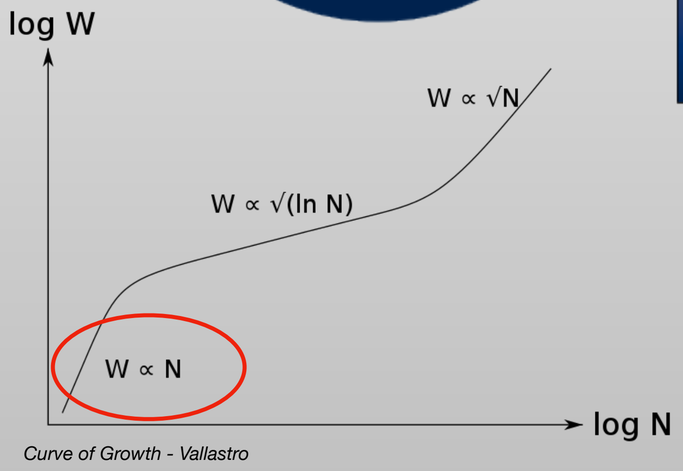
*So we can have relative densities:*

$$N_\ell = 1.8 \times 10^{12}\,\mathrm{cm}^{-2}\left(\frac{W_\lambda}{0.01\,\text{Å}}\right) \qquad [\tau_0 < 1].$$

*Physics of the Interstellar and Intergalactic Medium*
*Bruce T. Draine*




*Curve of Growth - Vallastro*

*Results:*

*Estimating the size of HI around an average LAE*

*Having an empirical density profile of HI around an average LAE*

# *LAE Pairs*

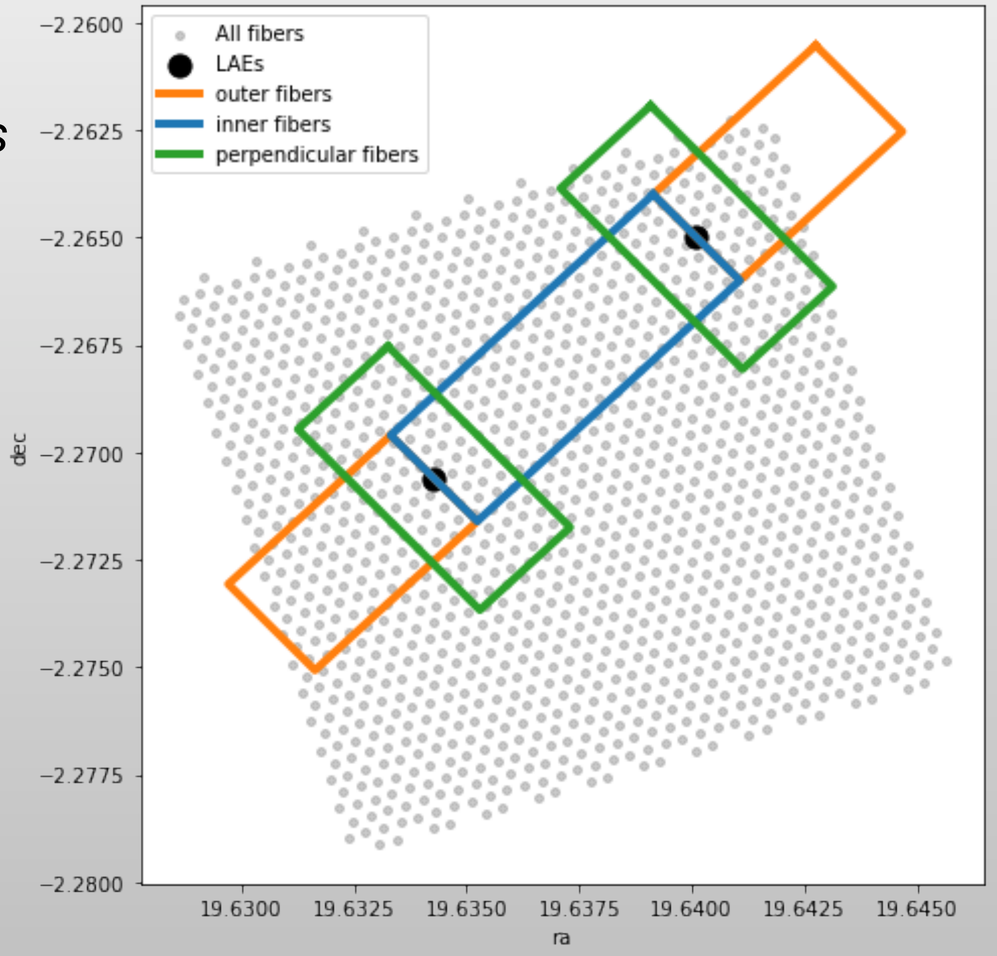
# *Procedure*

*We search for LAEs in hdr3*

*Filtering detections just like Annuli work*

*Close pairs: dz<0.002 10”<dR< 36” 1260 close pairs*

*Distant pairs: dz<0.002 80”<dR< 120” 2550 distant pairs*

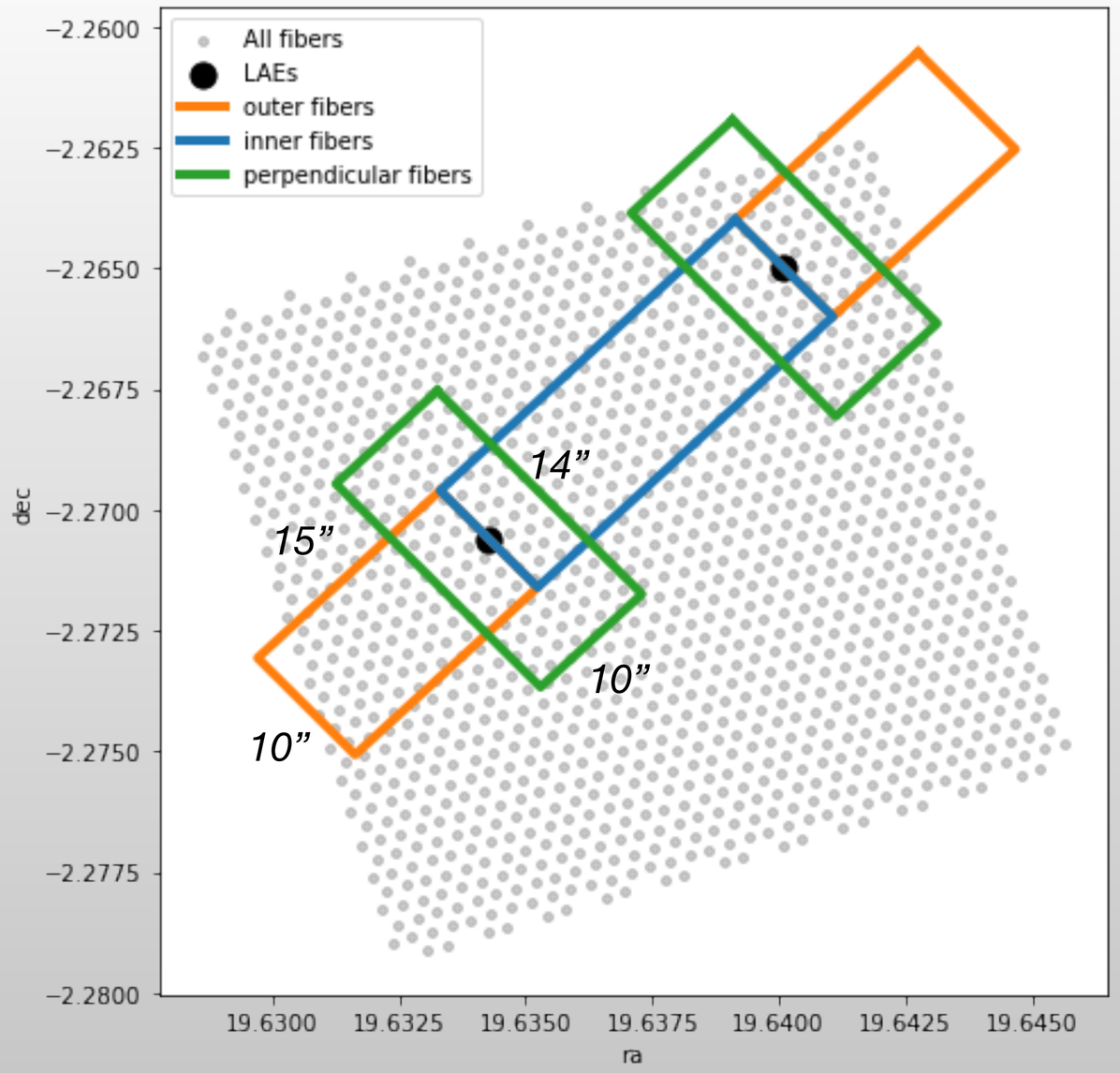



*For each pair:*

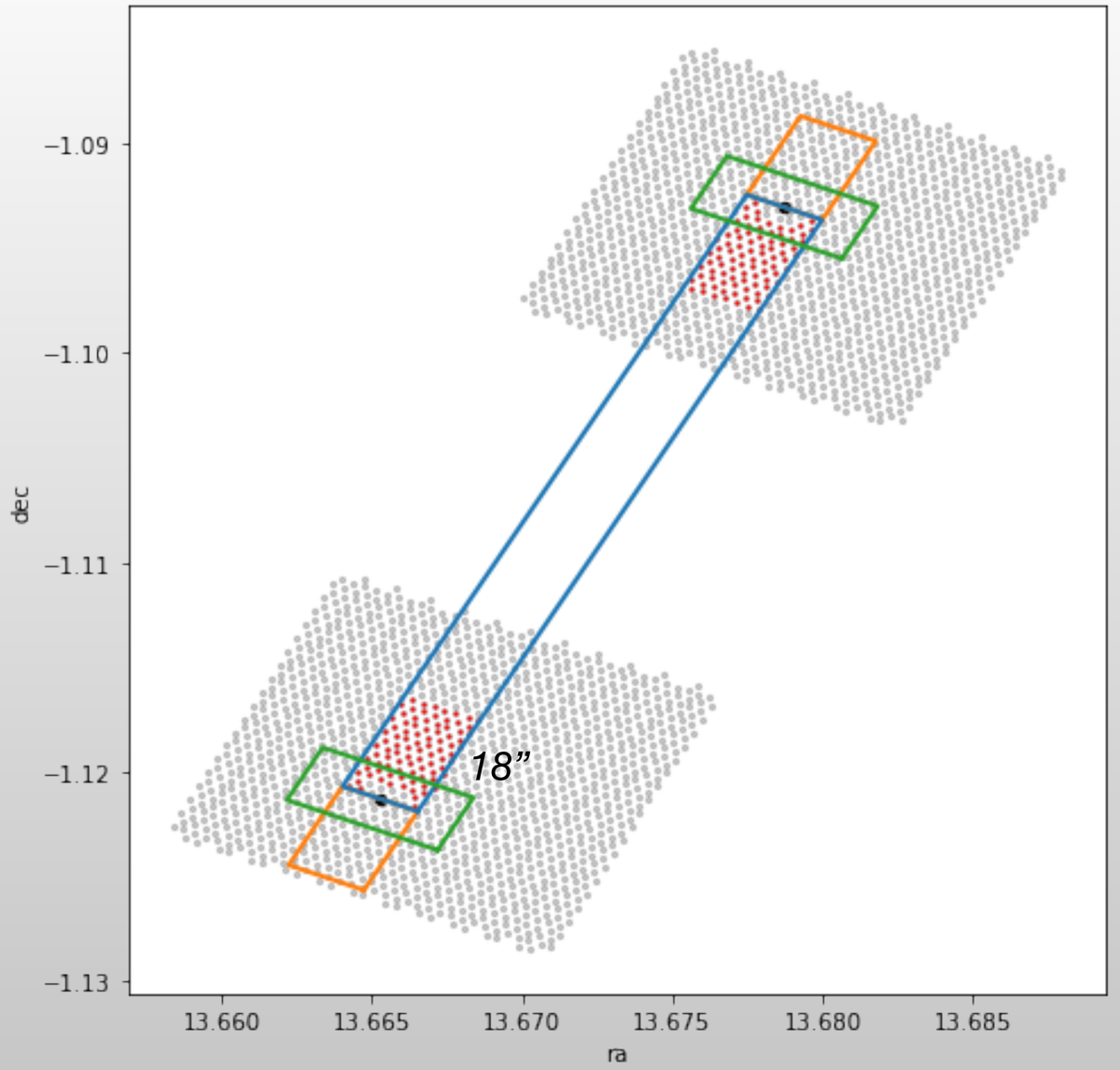
- *Grab every fiber for a certain region*
- *Get rid of very bright fibers with two levels of filtering*
- *Get a median of all the fibers that pass the filters*
- *The end product is a single spectra*
- *Shift the spectra to it’s rest frame (z1+z2)/2*

*We stack spectra for all pairs using ELiXer*

# *Example of a close pair*




# *Example of a distant pair*

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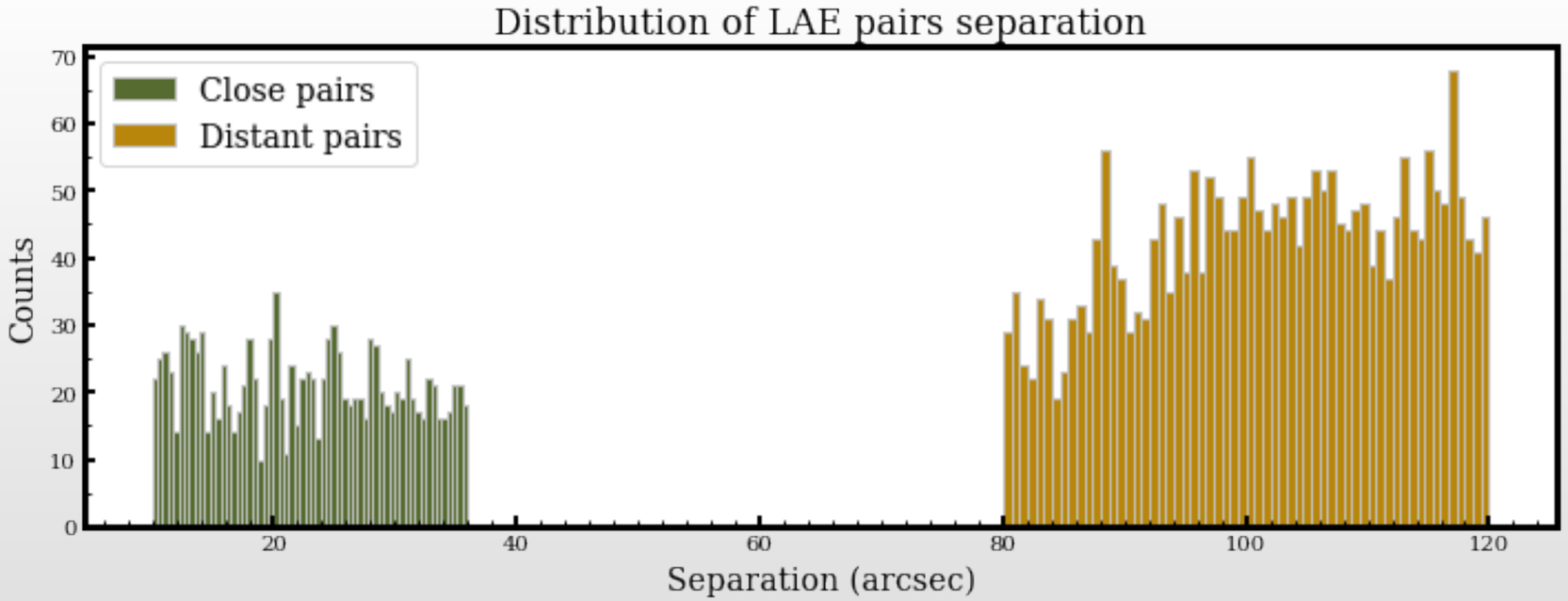
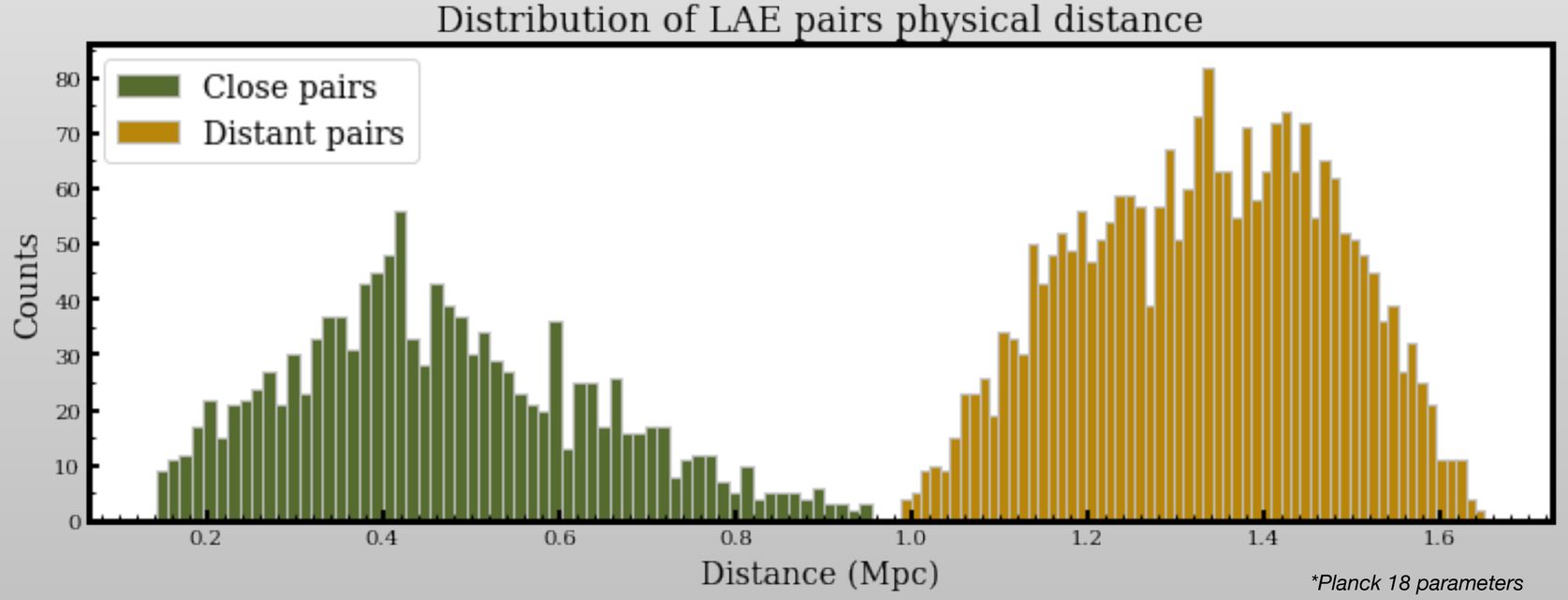


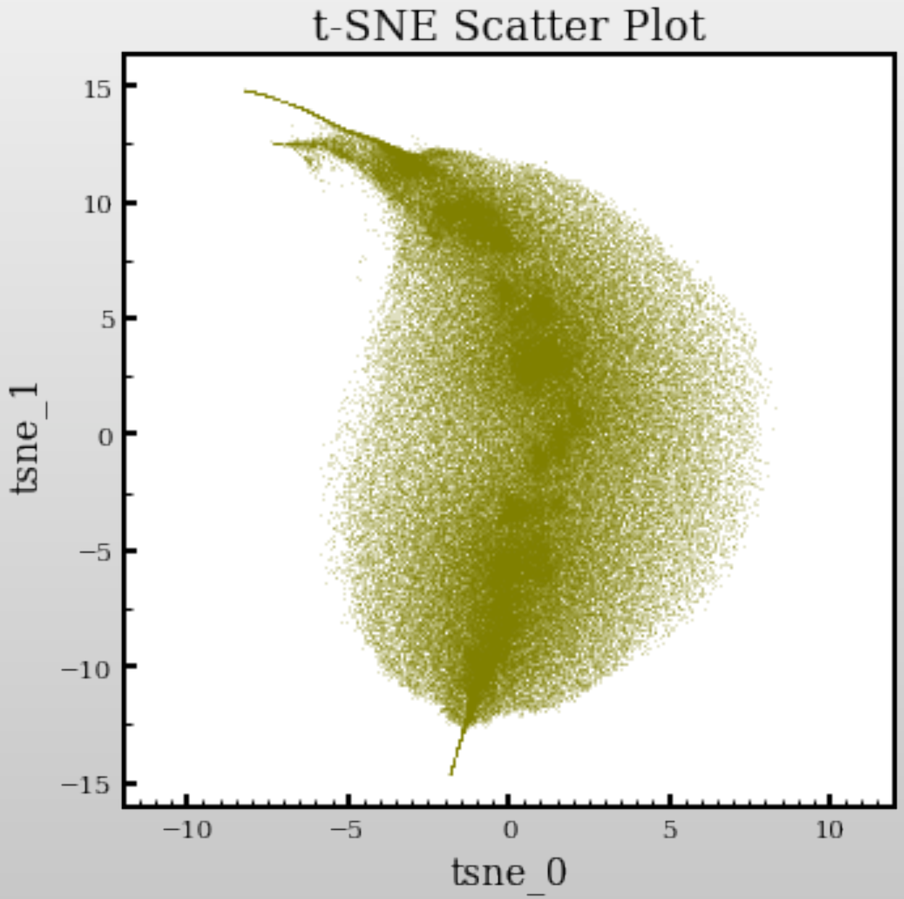




*Planck 18 parameters

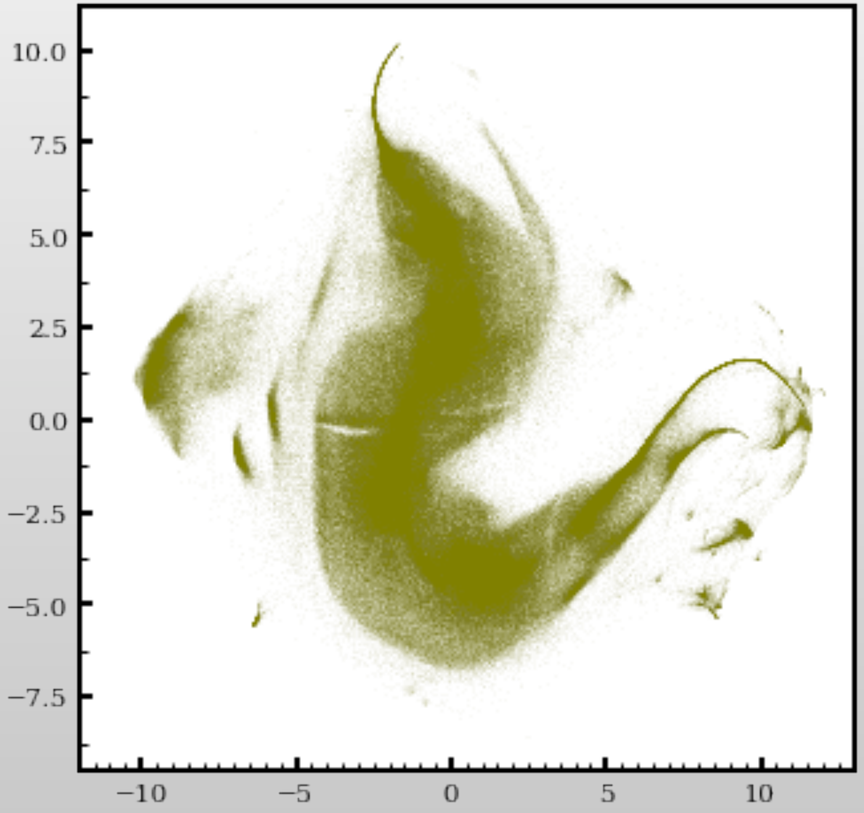
# *Machine Learning*

*Refinement in LAE selection, reducing false positives*

*Our selection for LAE pairs*



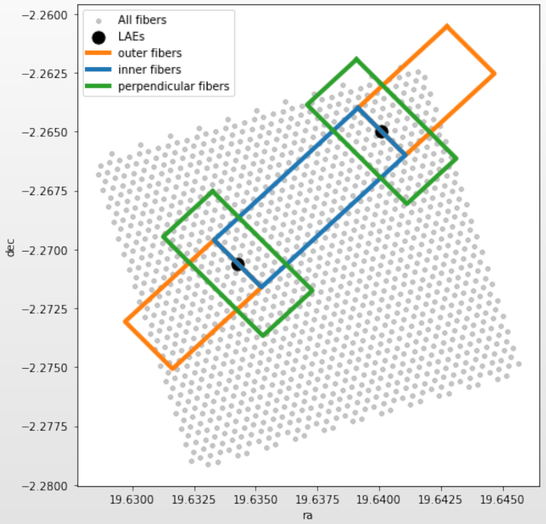

*HDR4 faint sources*

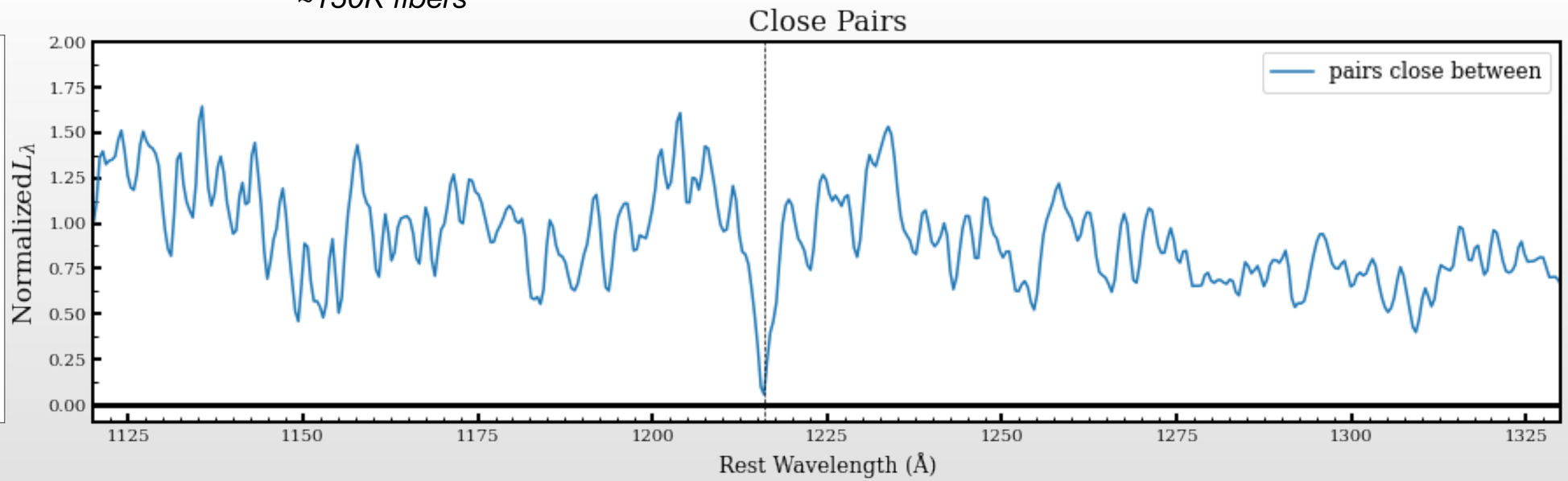



*https://github.com/mahanmkh/Machine-Learning-in-HETDEX*

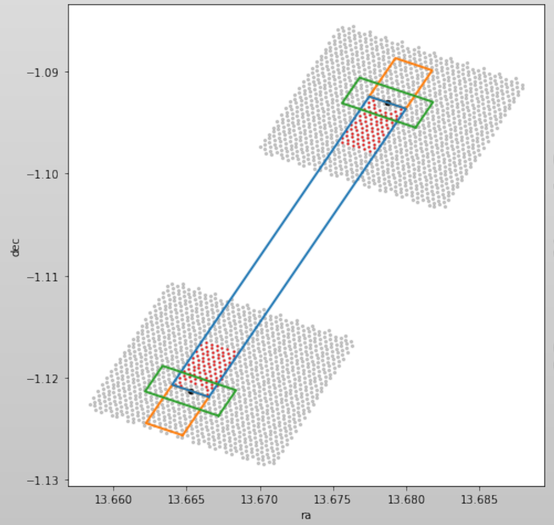
*1260 close pairs*
*~150K fibers*

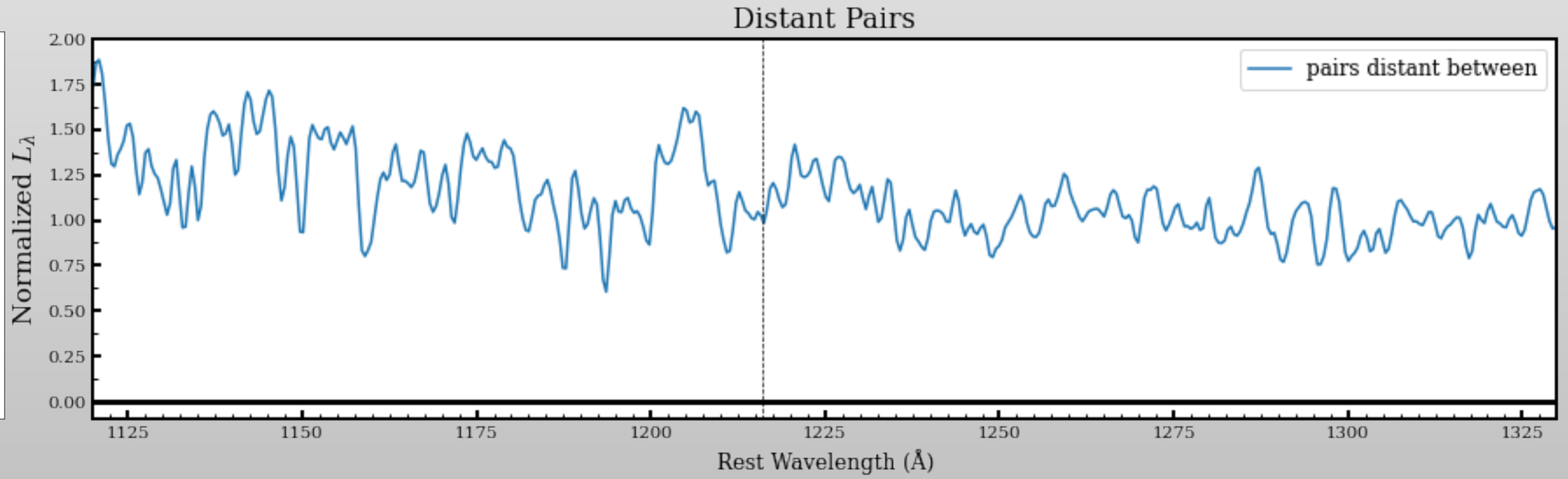
$L\lambda \sim 10^{39} ergs\,.\,s^{-1}\,.\,\text{Å}^{-1}$




*2550 distant pairs*
*~350K fibers*



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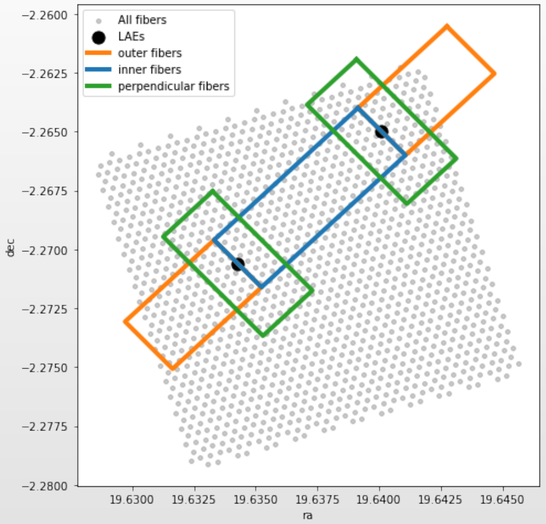


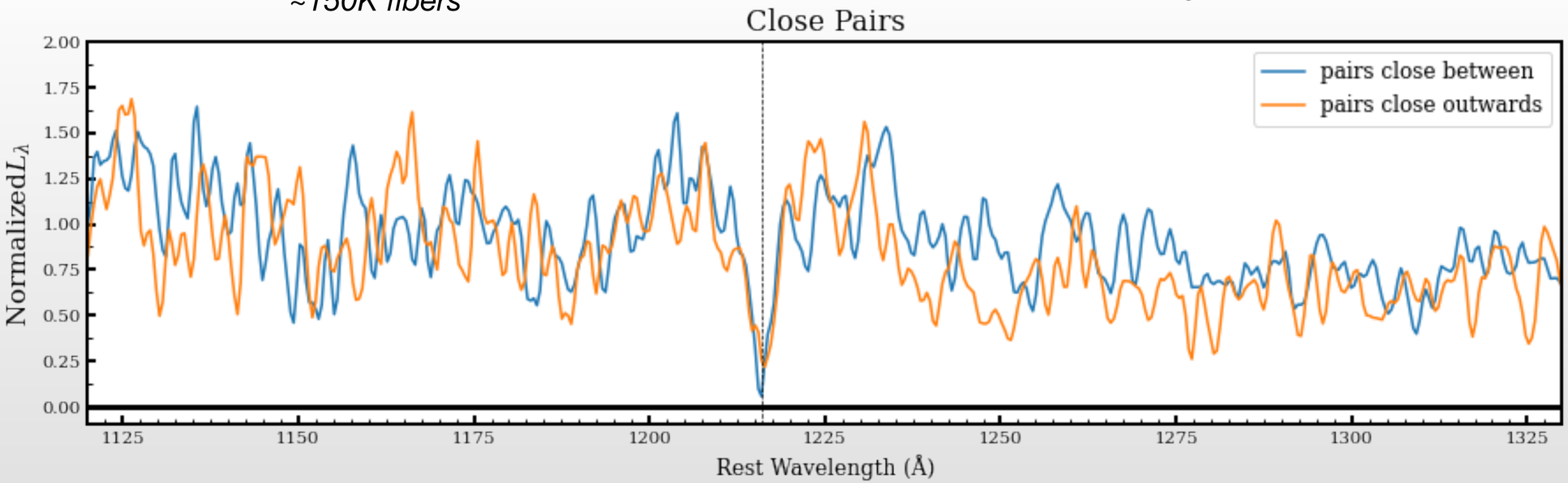


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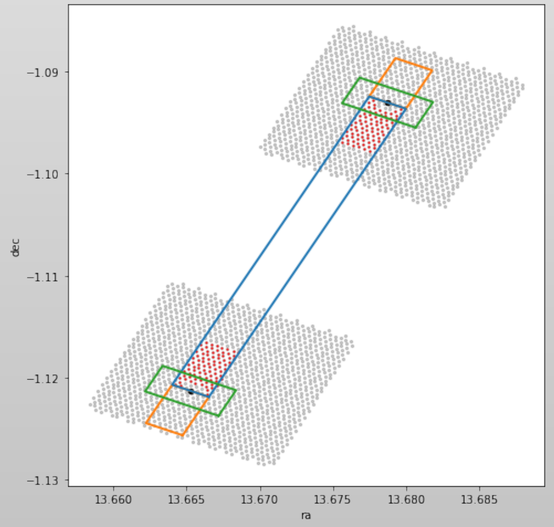


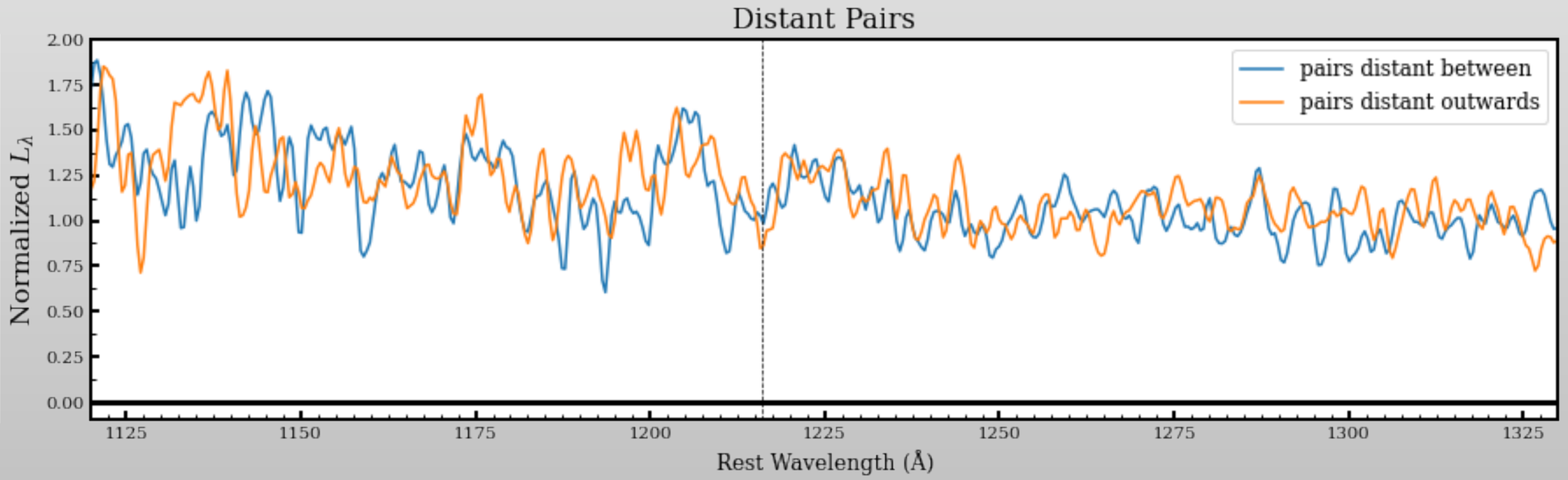

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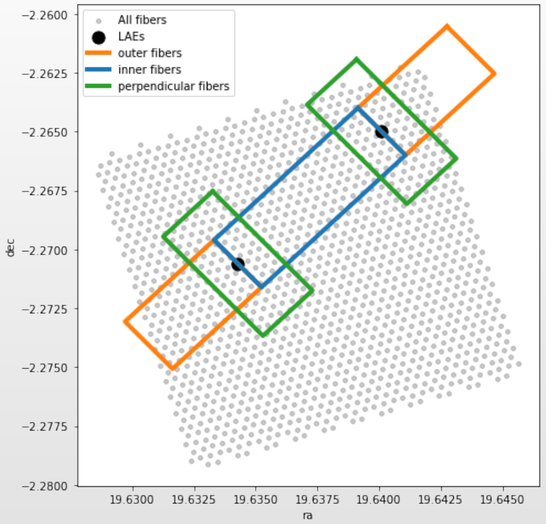


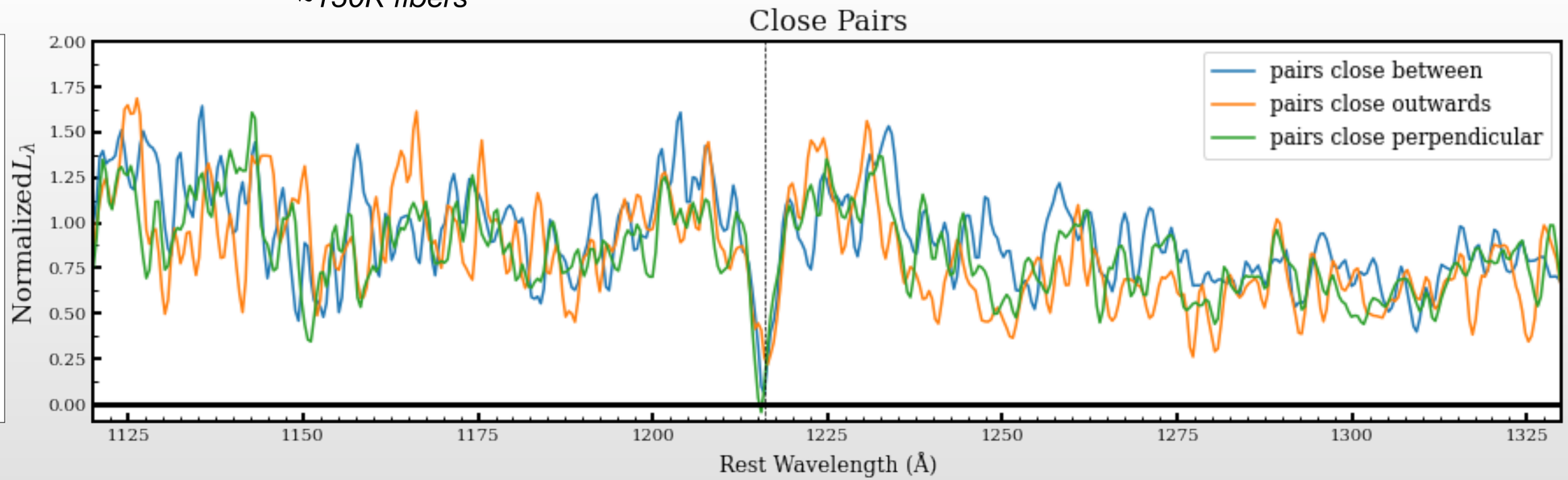


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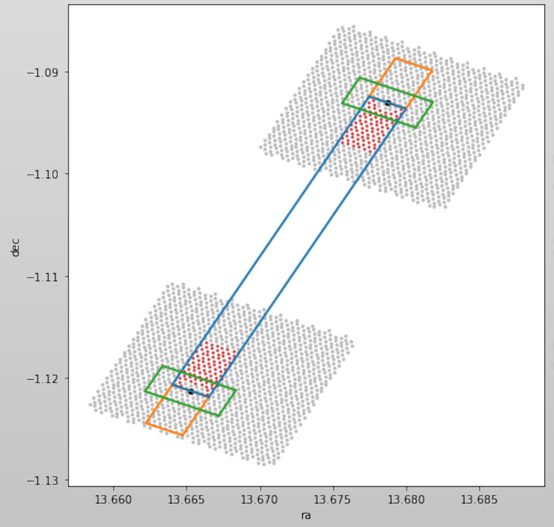


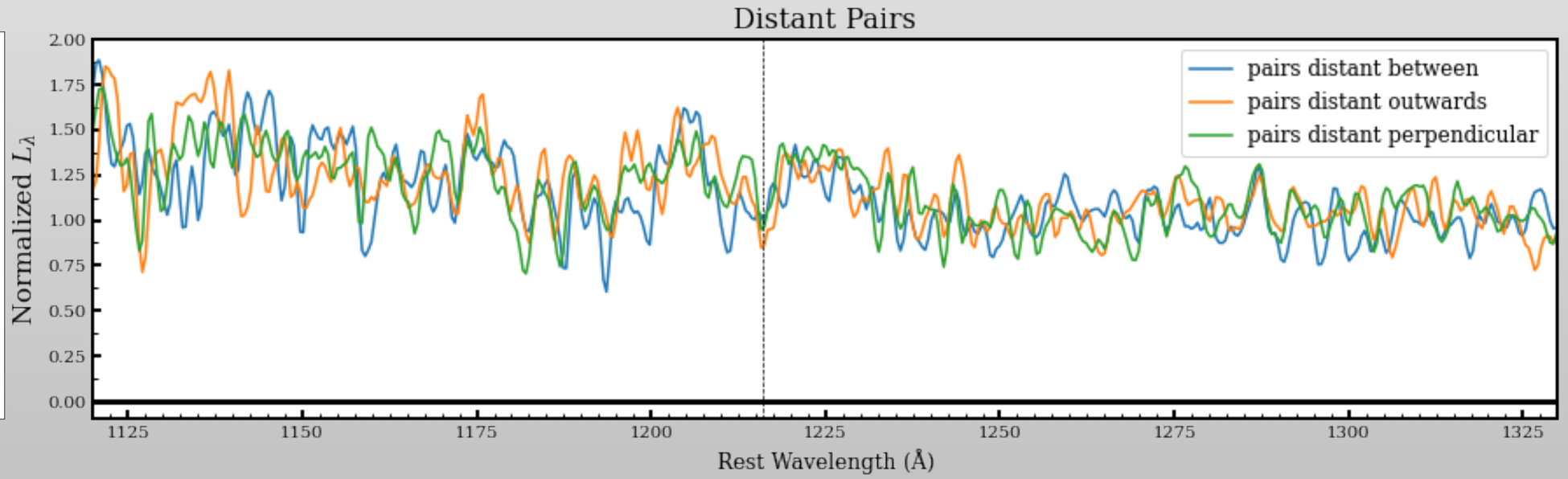

# *Summary*

*We estimate the size of HI around an average LAE at z~2.6*

*We provide an empirical density profile of HI around an average LAE*

*We show that close pairs exhibit the strongest absorption by far, showcasing HI dense regions*

# *Next step*

*Figure out a signal-to-noise ratio where we can statistically claim that we have no absorption*

*See if we can find a way to get continuum values to give absolute column densities*

*Possibility of creating an HI density profile between an average LAE pair*

*Binning based on redshift*

*Thank You!*