Updates in Modeling the CIV Broad Line Region

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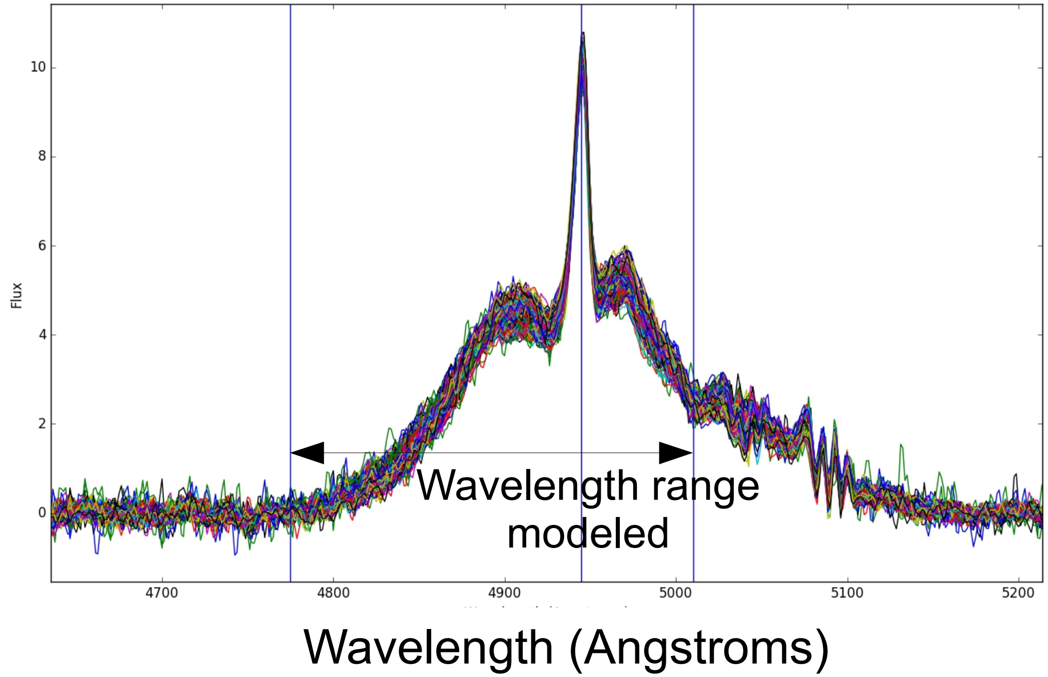
August 17-18, 2017 – AGN STORM Meeting

Review of 2016 results

- Simple BLR model is able to fit the Hβ data
  - Both line profile shape and integrated line flux
  - Using UV continuum
  - Not strongly dependent on choice of Goad or Pei-anomaly start date
  - **To do: get final version of data to use full red wing!**



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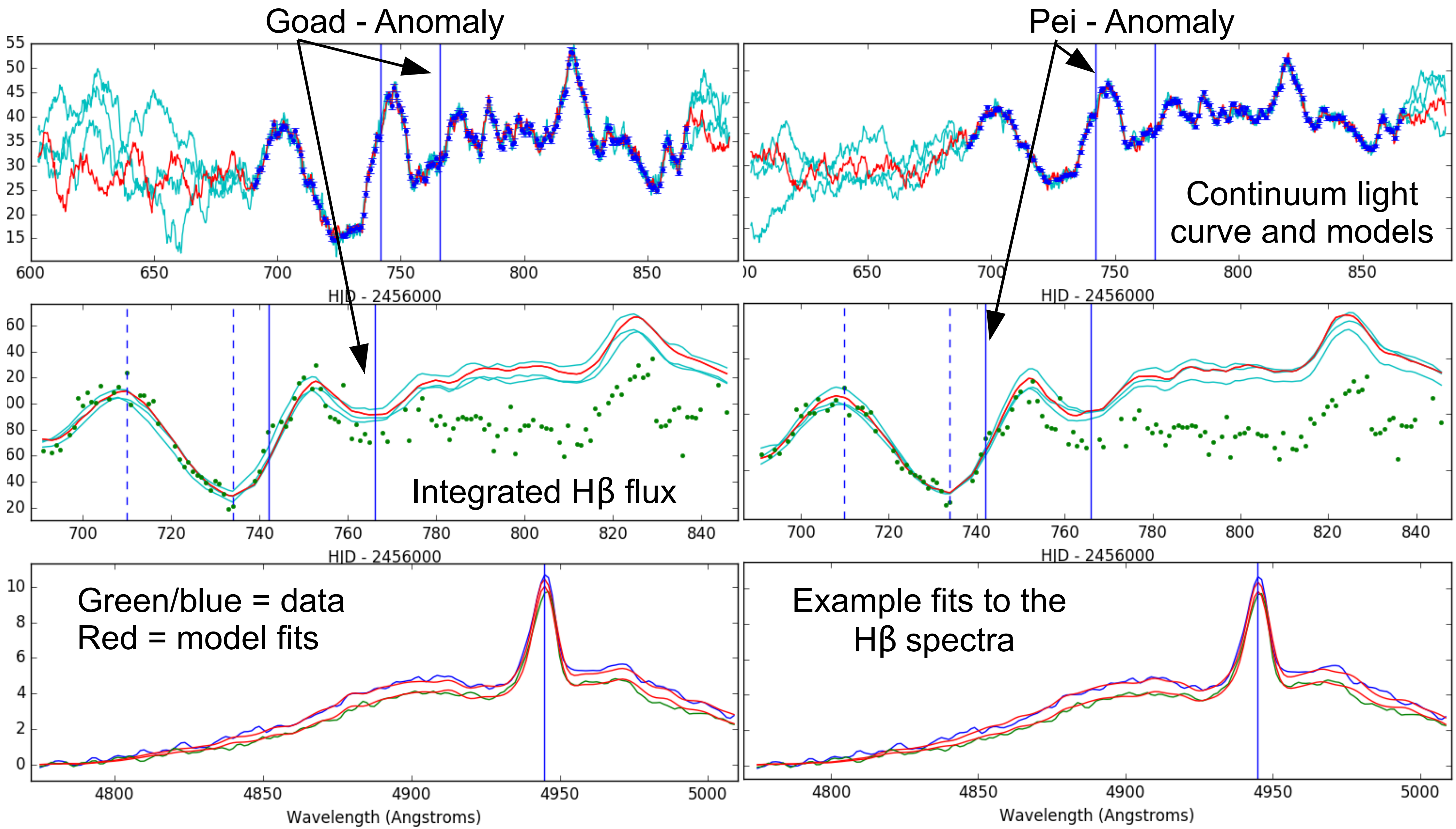
Model Fits to the Hβ Data



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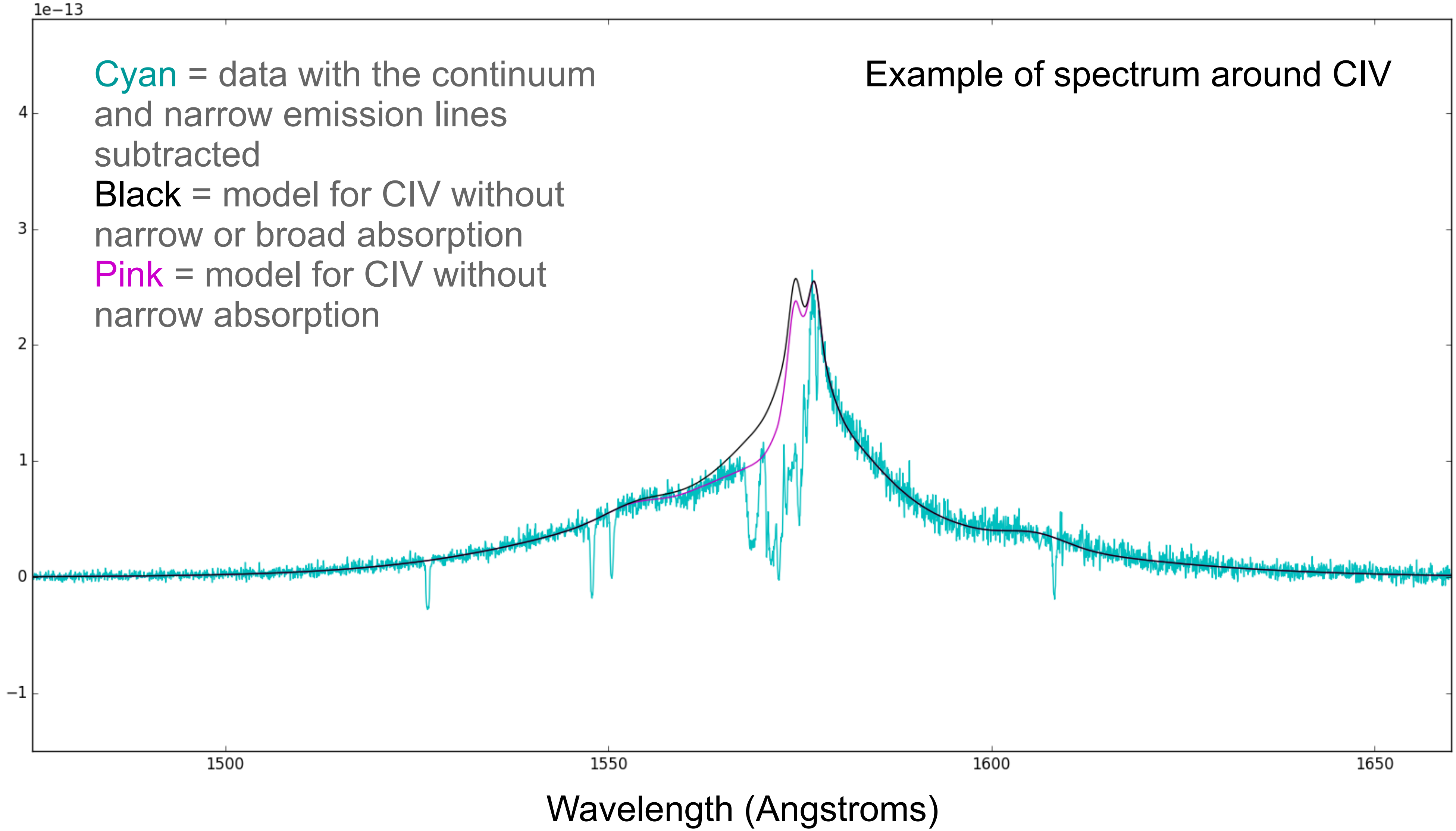
The CIV Data



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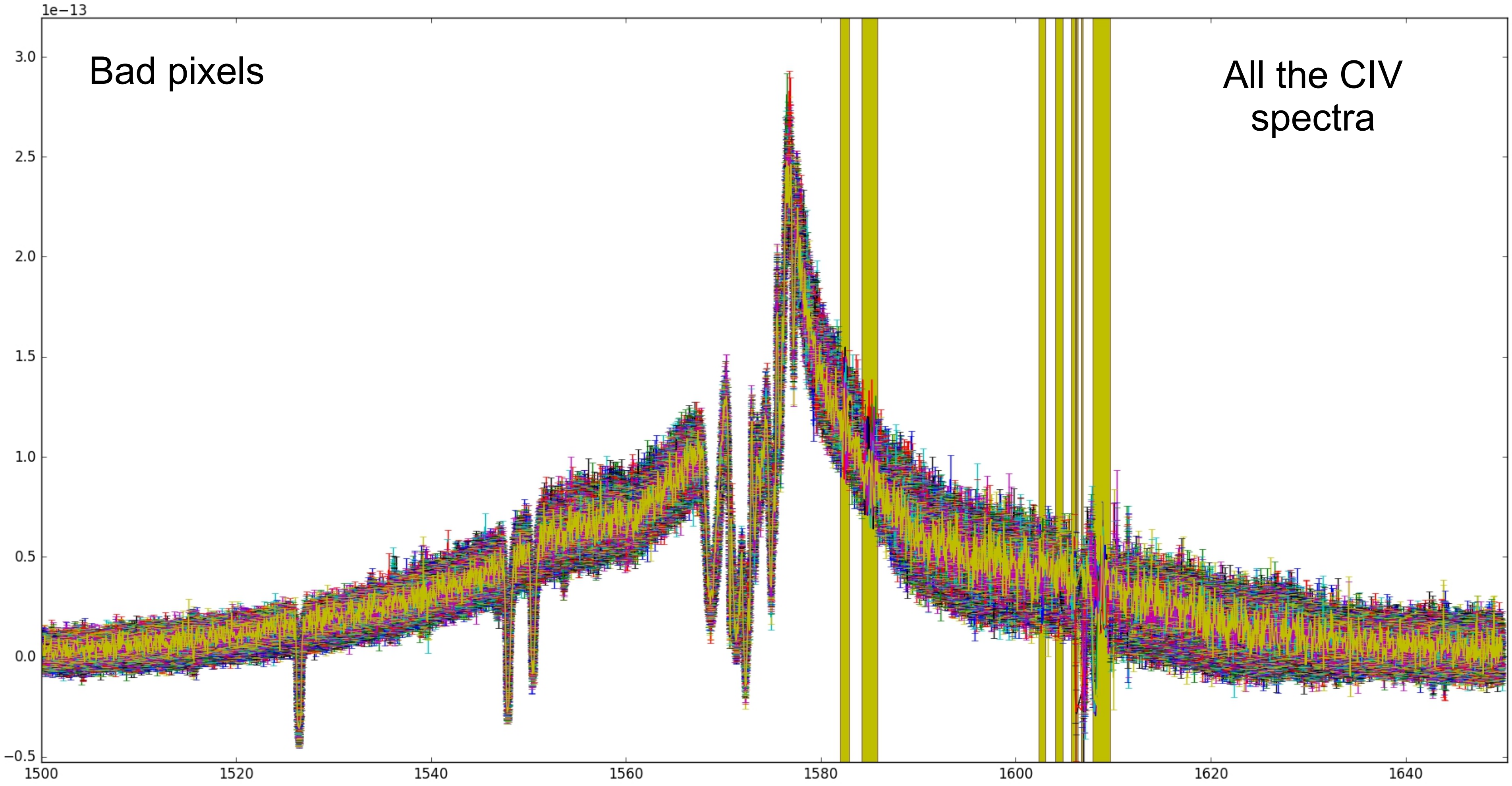
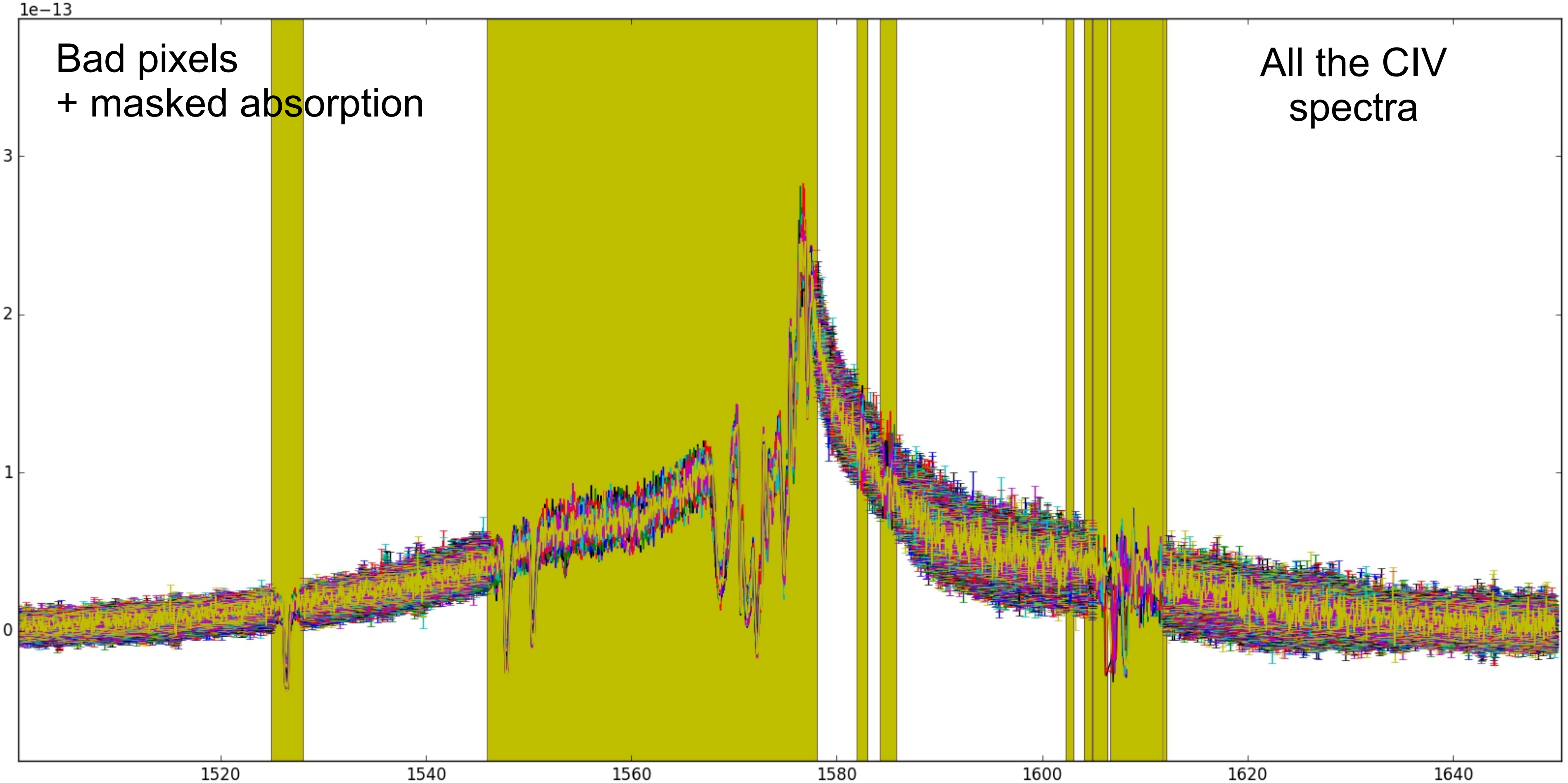
The CIV Data



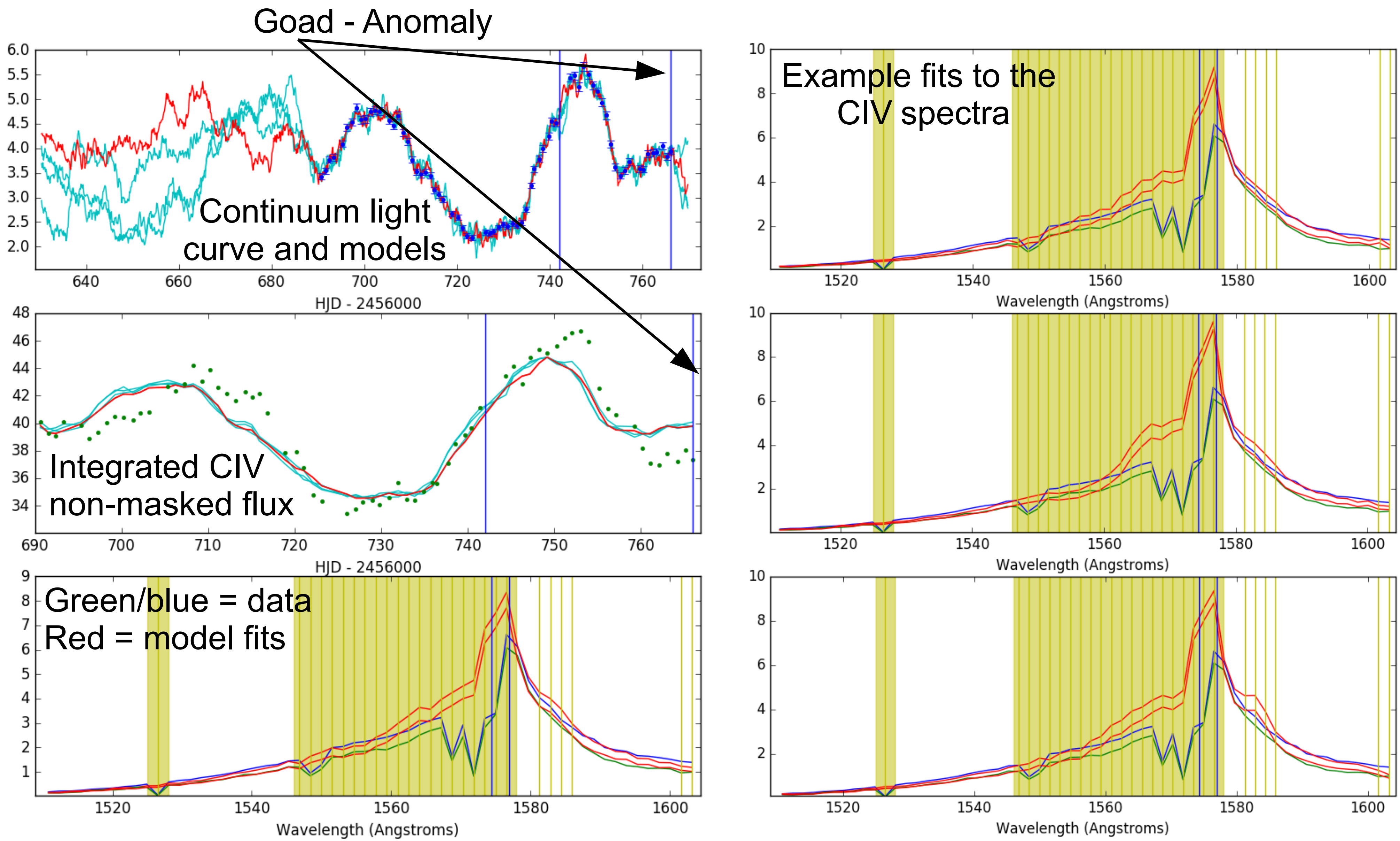
Wavelength (Angstroms)

The CIV Data



Wavelength (Angstroms)

Model Fits to the Masked CIV Data



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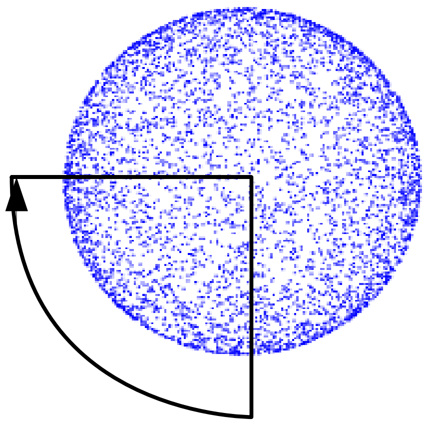
Overview of 2017 results

- What has happened since last year:
  - Ideas for the BLR geometry from MEMEcho
  - Finalized UV models to unmask CIV
- Goals:
  - Try to match the CIV variability in more detail
  - Compare results from masked and modeled CIV
- Tests completed:
  - Default CARAMEL model
  - Default + variable outer radius + hot spot
  - Constant spectral component = mean spectrum
  - Constant spectral component = Gaussian mixture model (GMM)

Default BLR model

- Geometry



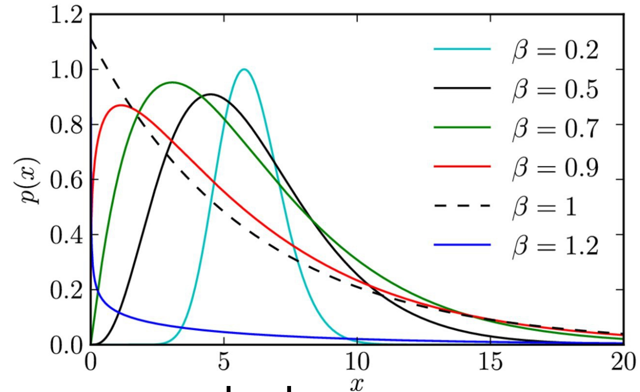
Opening angle
(sphere → disk)

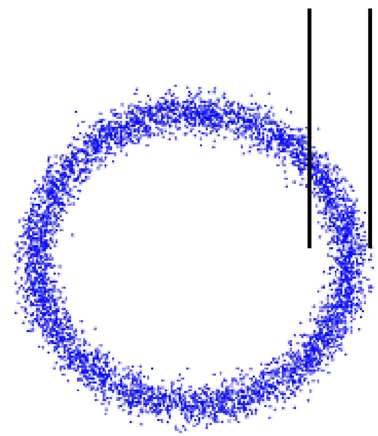
Transparent → opaque mid-plane

More emission from near or far side

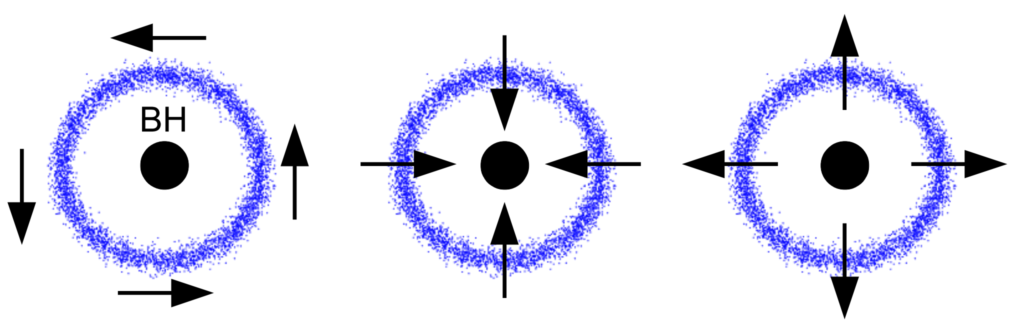
Disk → cone

Radial profile of emission:
Gamma distribution





- Dynamics



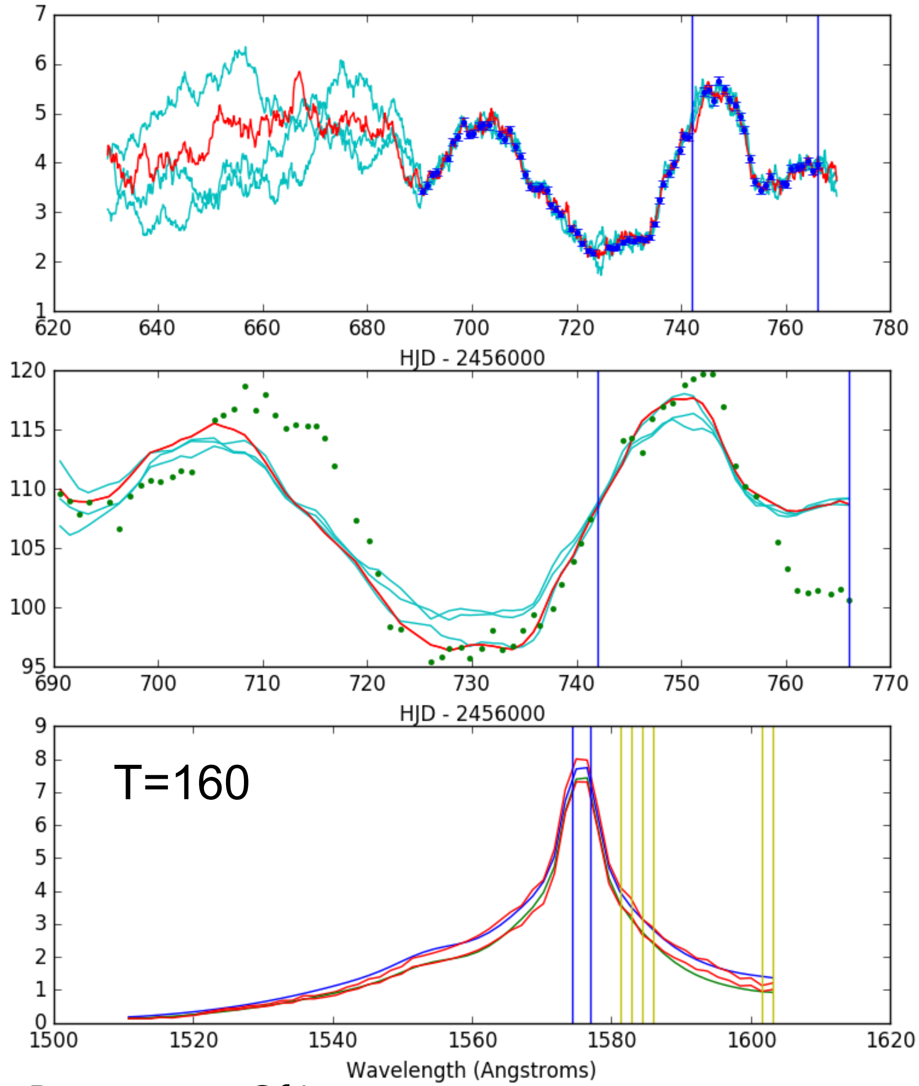
Near-circular Inflowing Outflowing

Model spectrum is made entirely from variable flux!

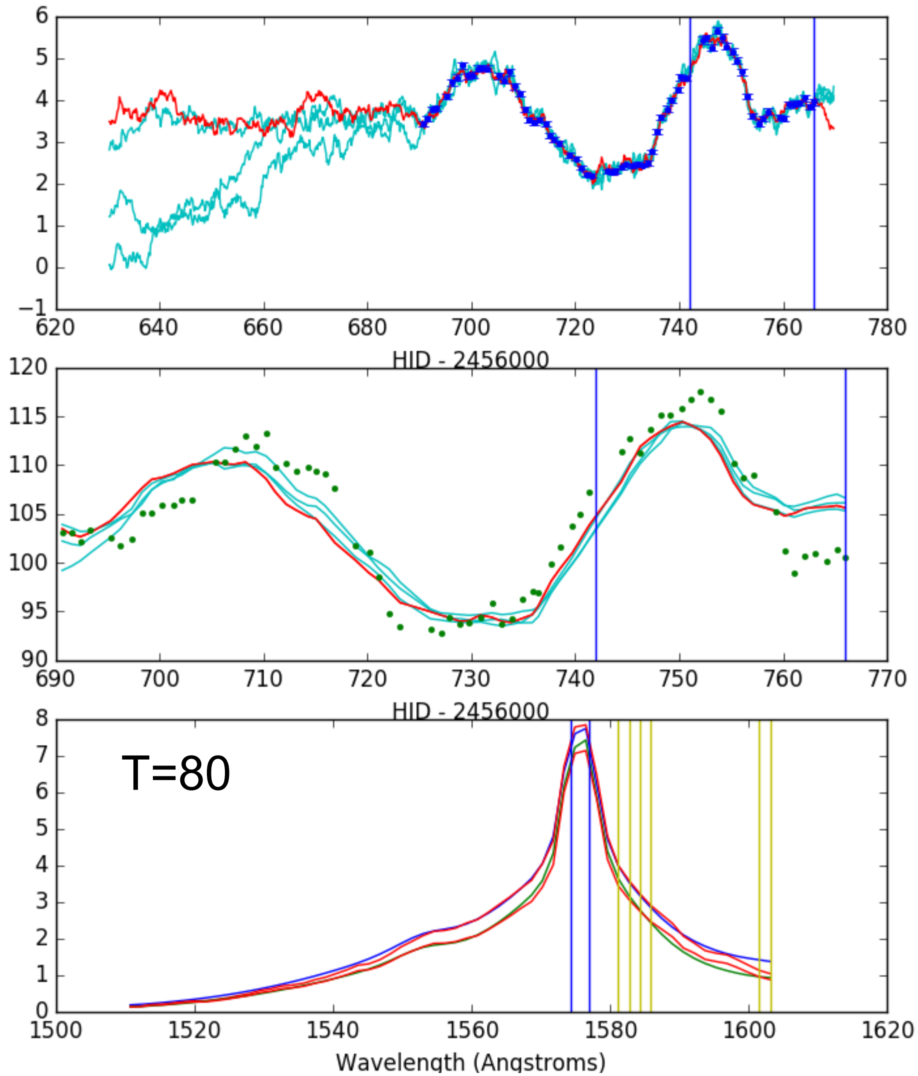
Pancoast, Brewer, & Treu 2014

Results from the default BLR model

Modeling the full CIV line
(broad + narrow absorption)



Modeling the CIV narrow
absorption lines



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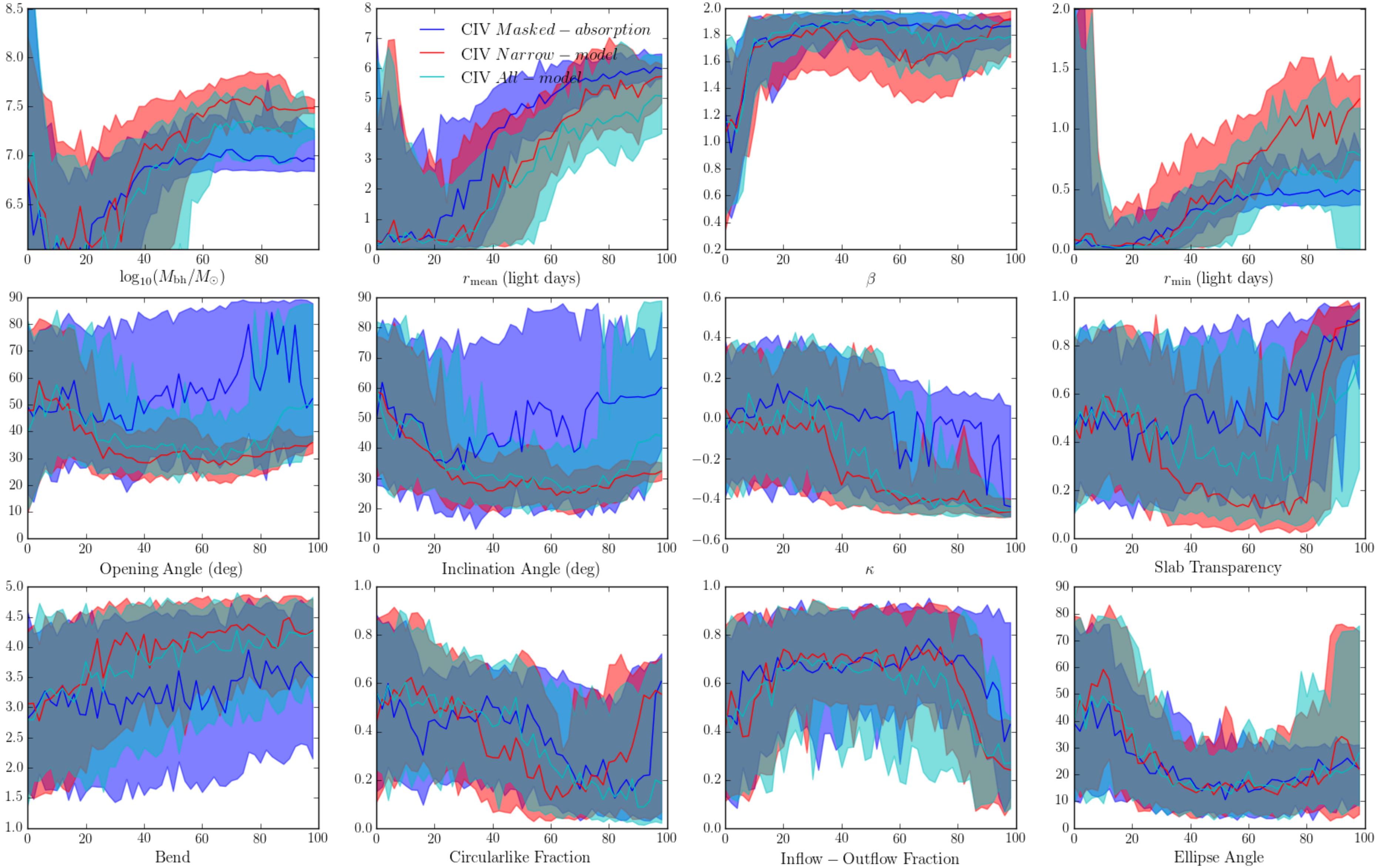
Results from the default BLR model



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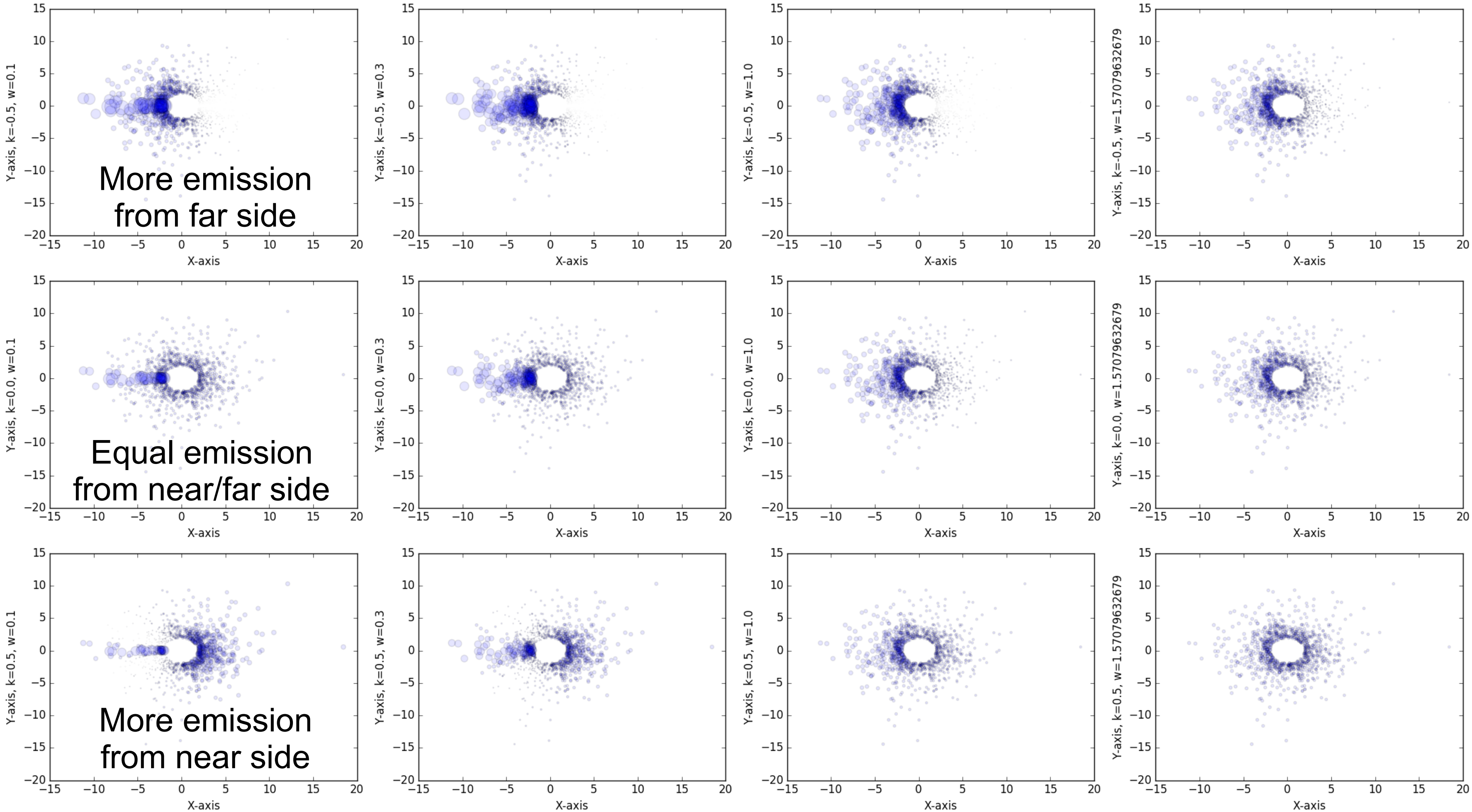
Summary of default results

- When absorption is masked, black hole mass is lower and inclination/opening angles are higher and poorly constrained
  - Following results focus on un-masked CIV!
- Convergence fairly good, but more likelihood levels could be explored

Adding a variable maximum radius + hot spot



Increasing width of hot spot

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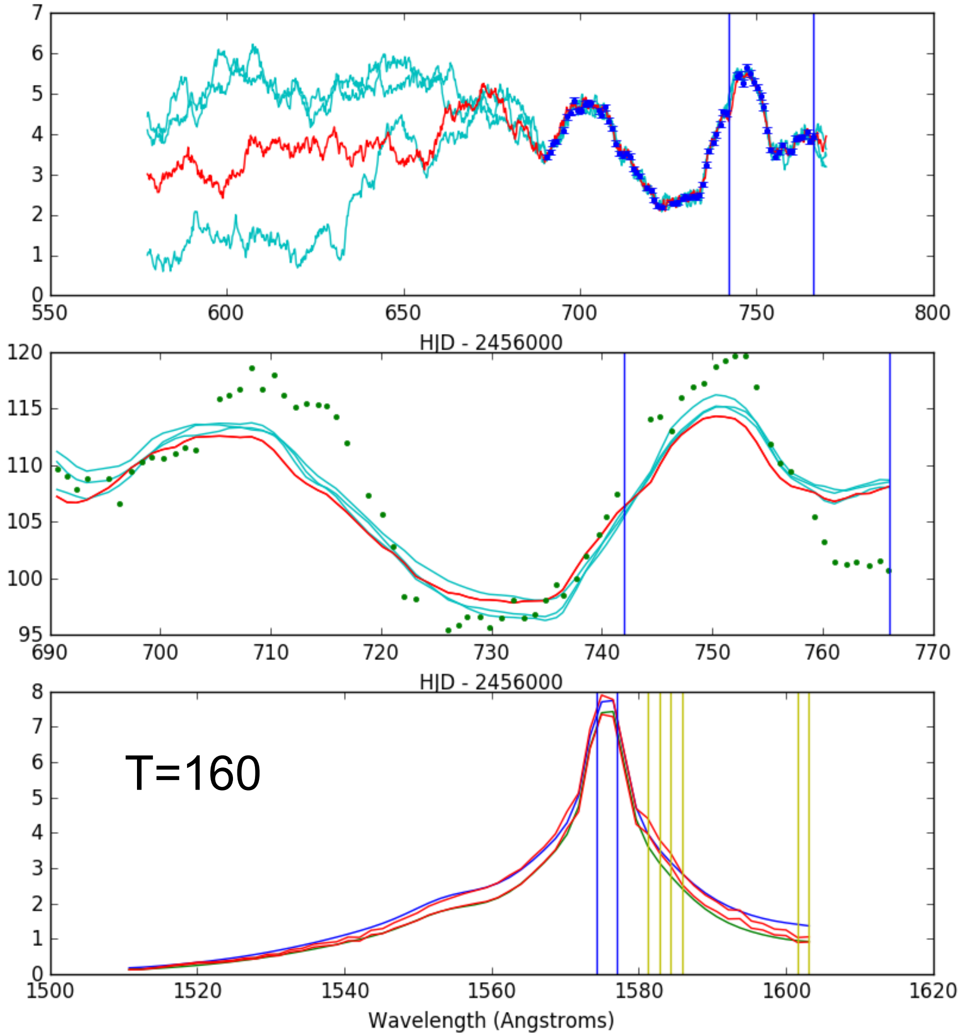
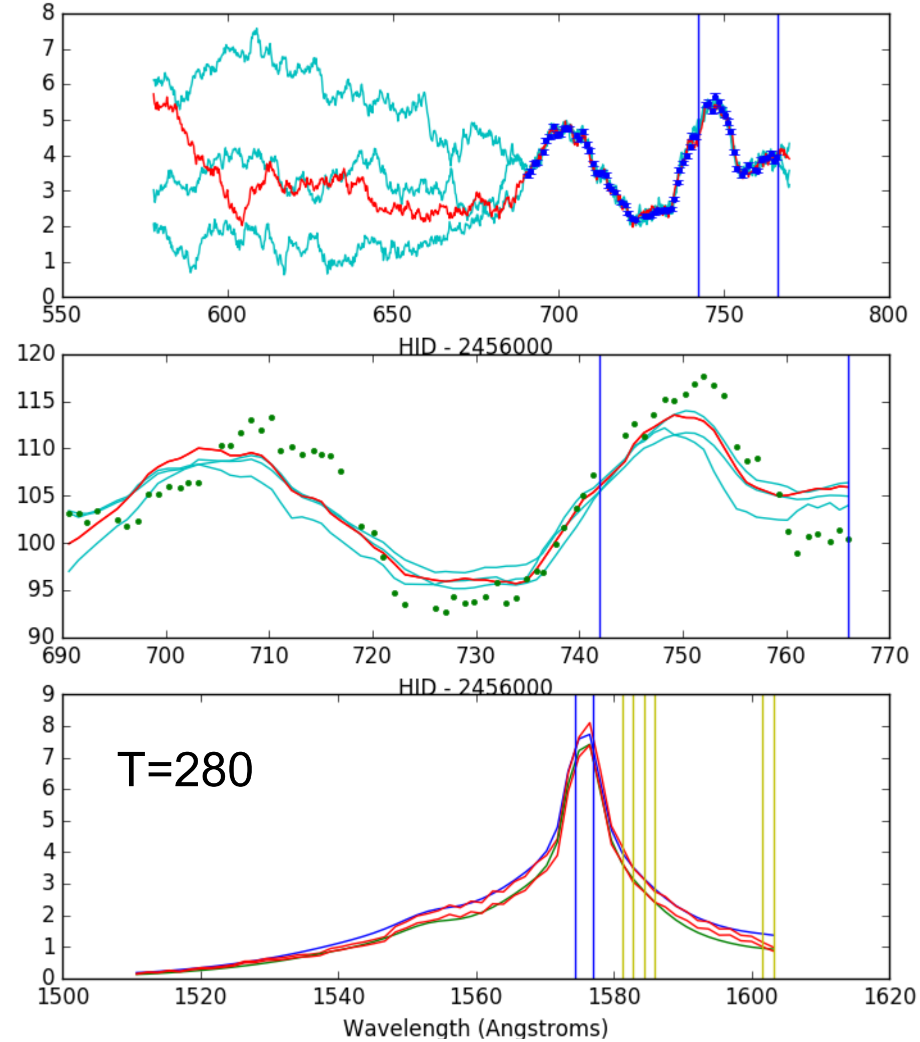
Results from adding a variable maximum radius + hot spot

Modeling the full CIV line
(broad + narrow absorption)



Modeling the CIV narrow
absorption lines



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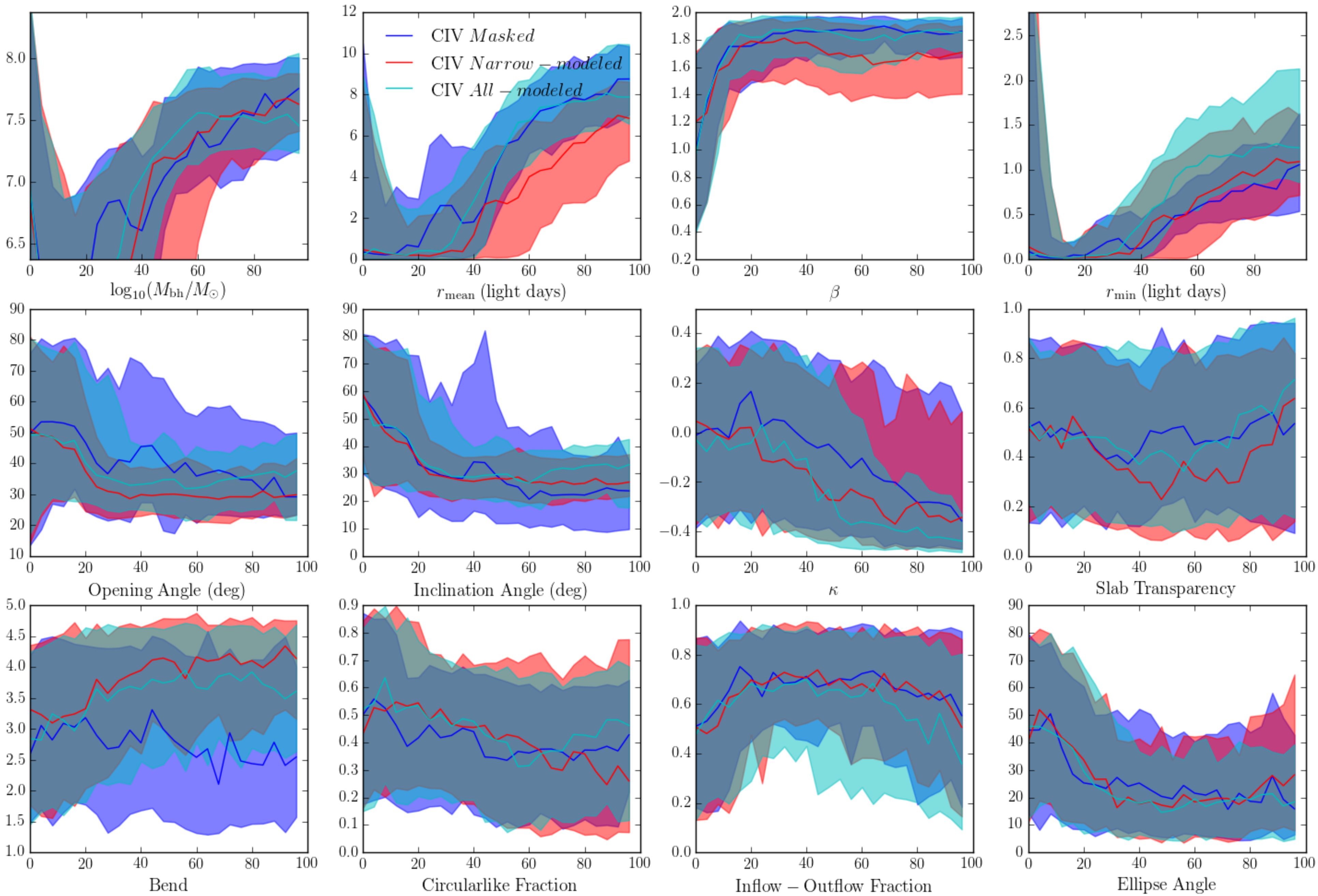
Results: variable r_{max} + hot spot



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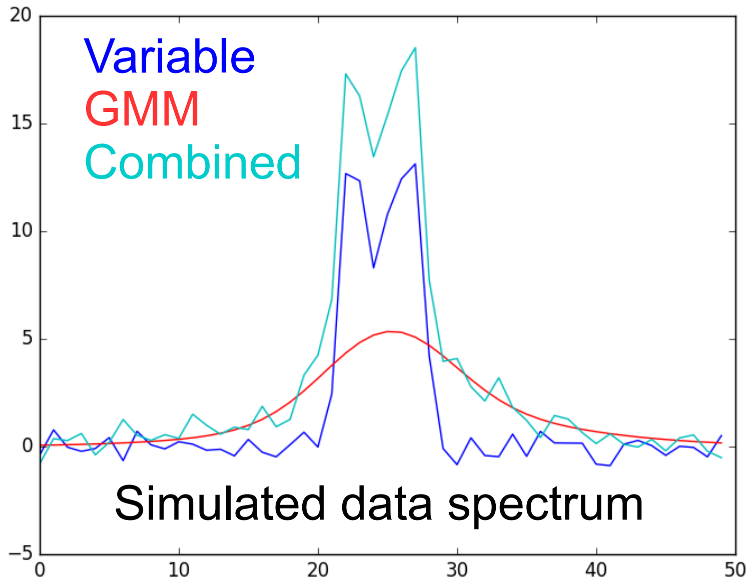
Summary of variable radius + hot spot results

- Hot spot parameters not well determined
- Maximum radius parameter pulled to highest values (~50 ld)
- More likelihood levels would help (shown for 100 levels, 120 looks similar)
- These changes to BLR geometry do not dramatically improve model fit!

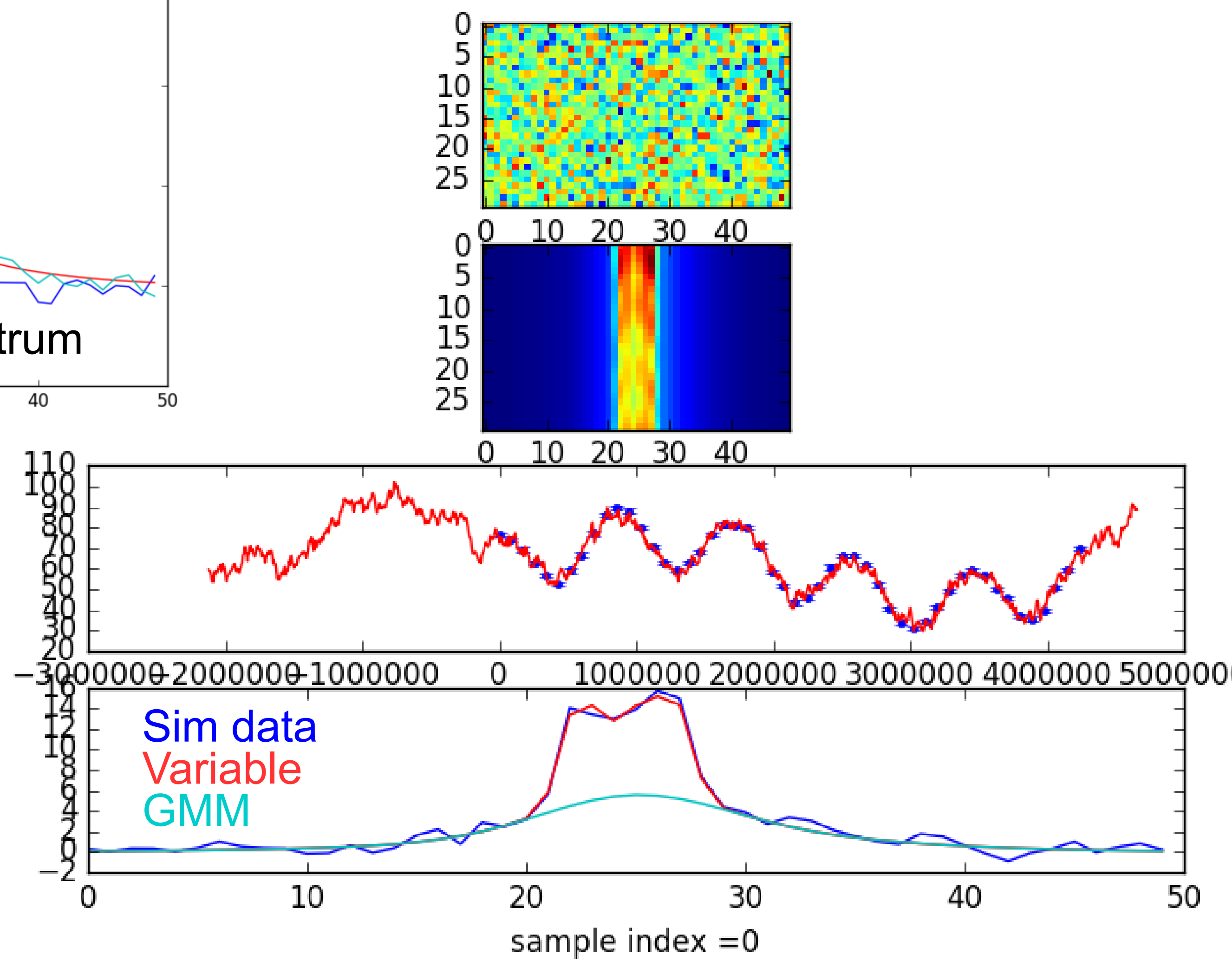
Results from adding a constant spectral component = means spectrum

- The amplitude of the constant spectral component is inferred to be very small, so it is **not** affecting the model fit!
- Adding a constant component in the model for other AGN has sometimes affected the results, so there is reason to try other constant component models

Adding a constant spectral component = Gaussian mixture model (GMM)



Inference of simulated data



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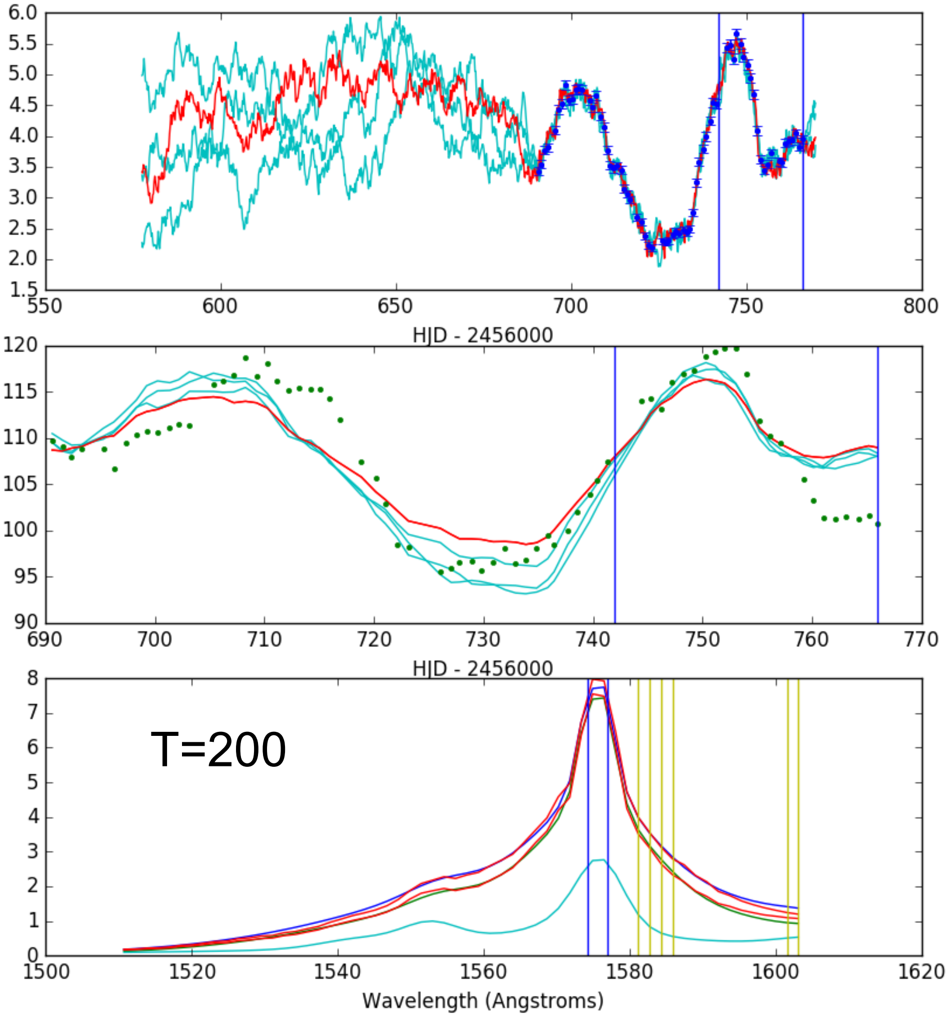
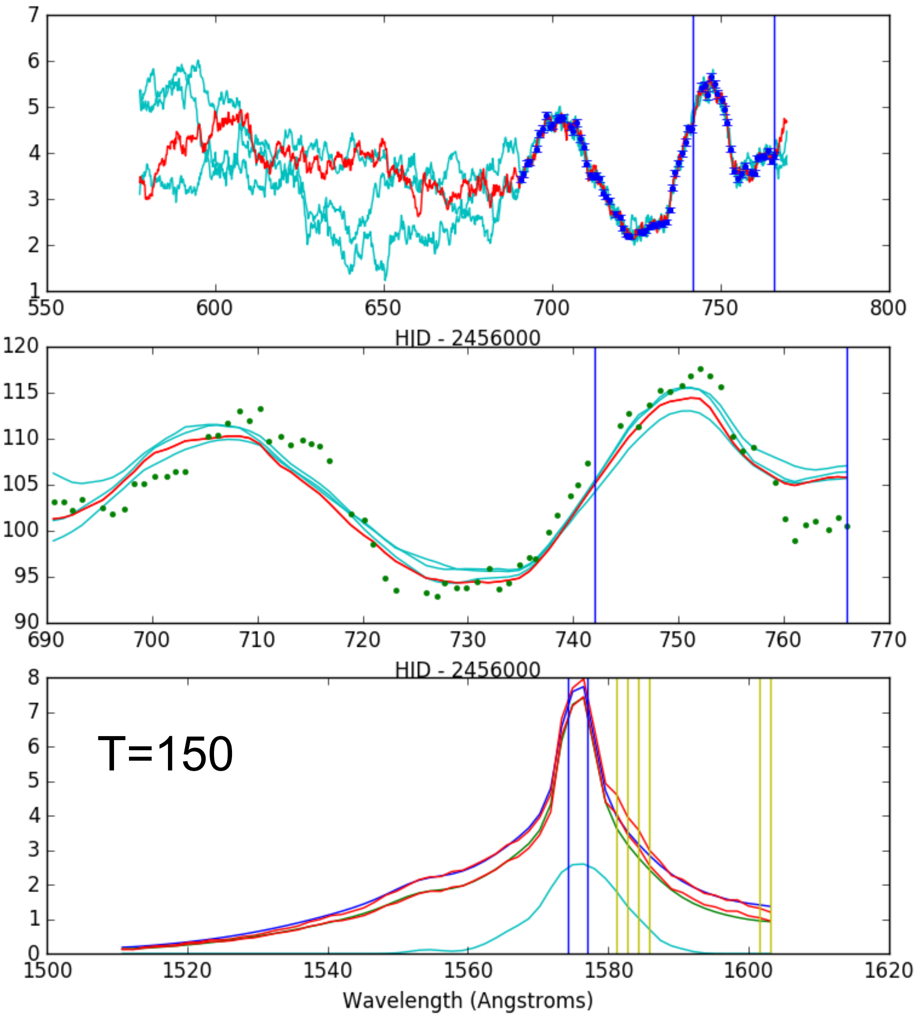
Results from adding a constant spectral component = GMM

Modeling the full CIV line
(broad + narrow absorption)



Modeling the CIV narrow
absorption lines



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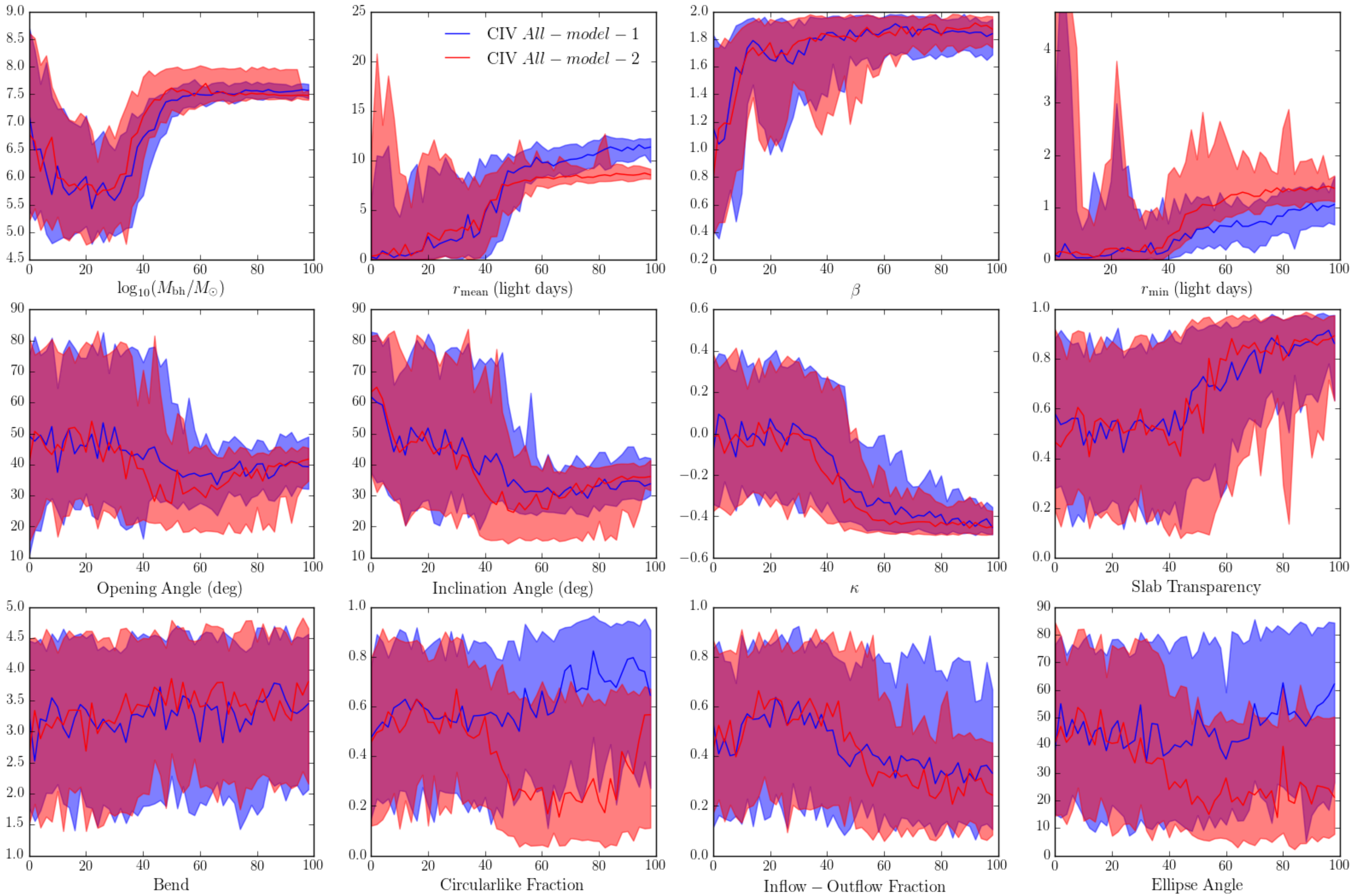
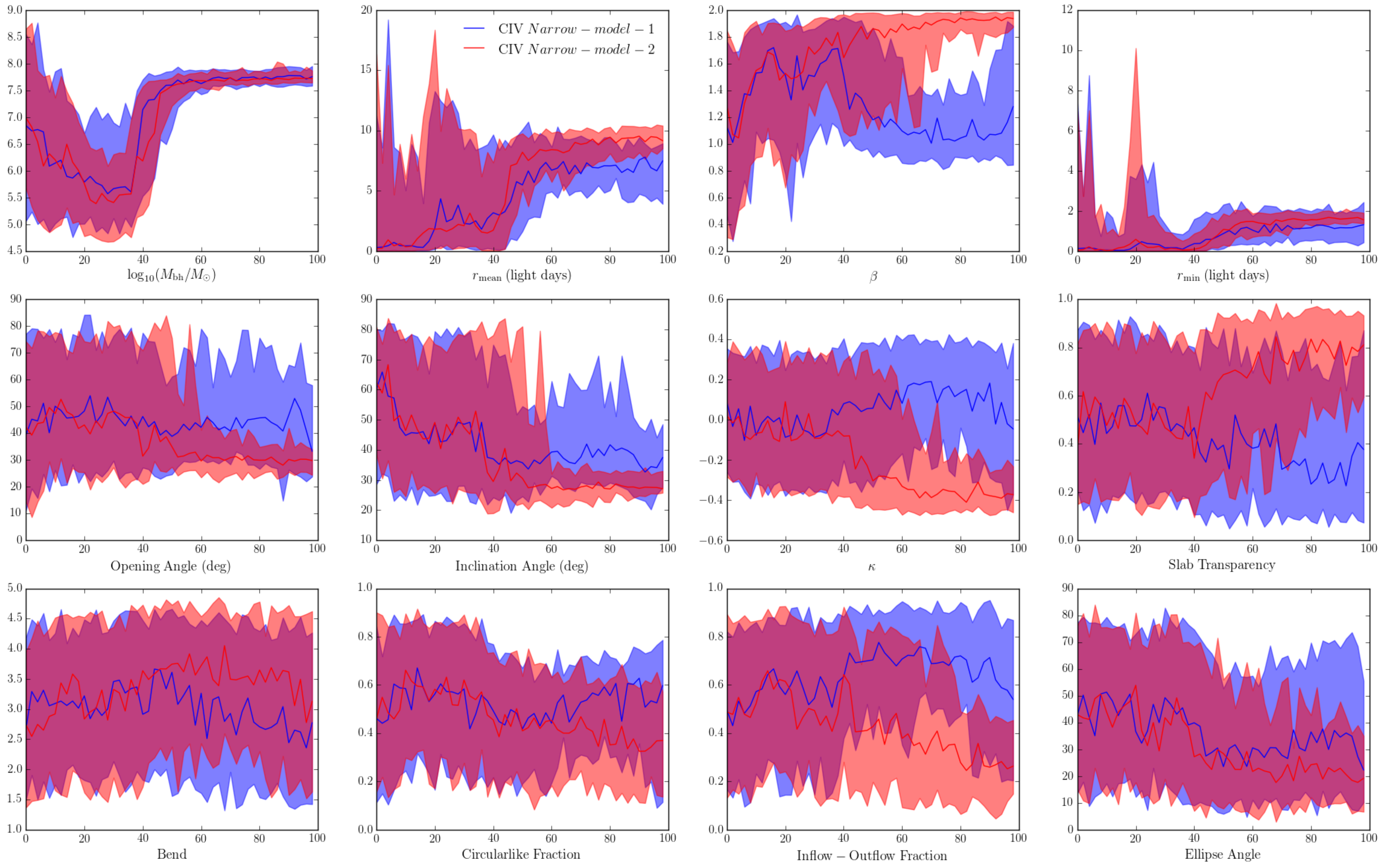
GMM results: model all absorption



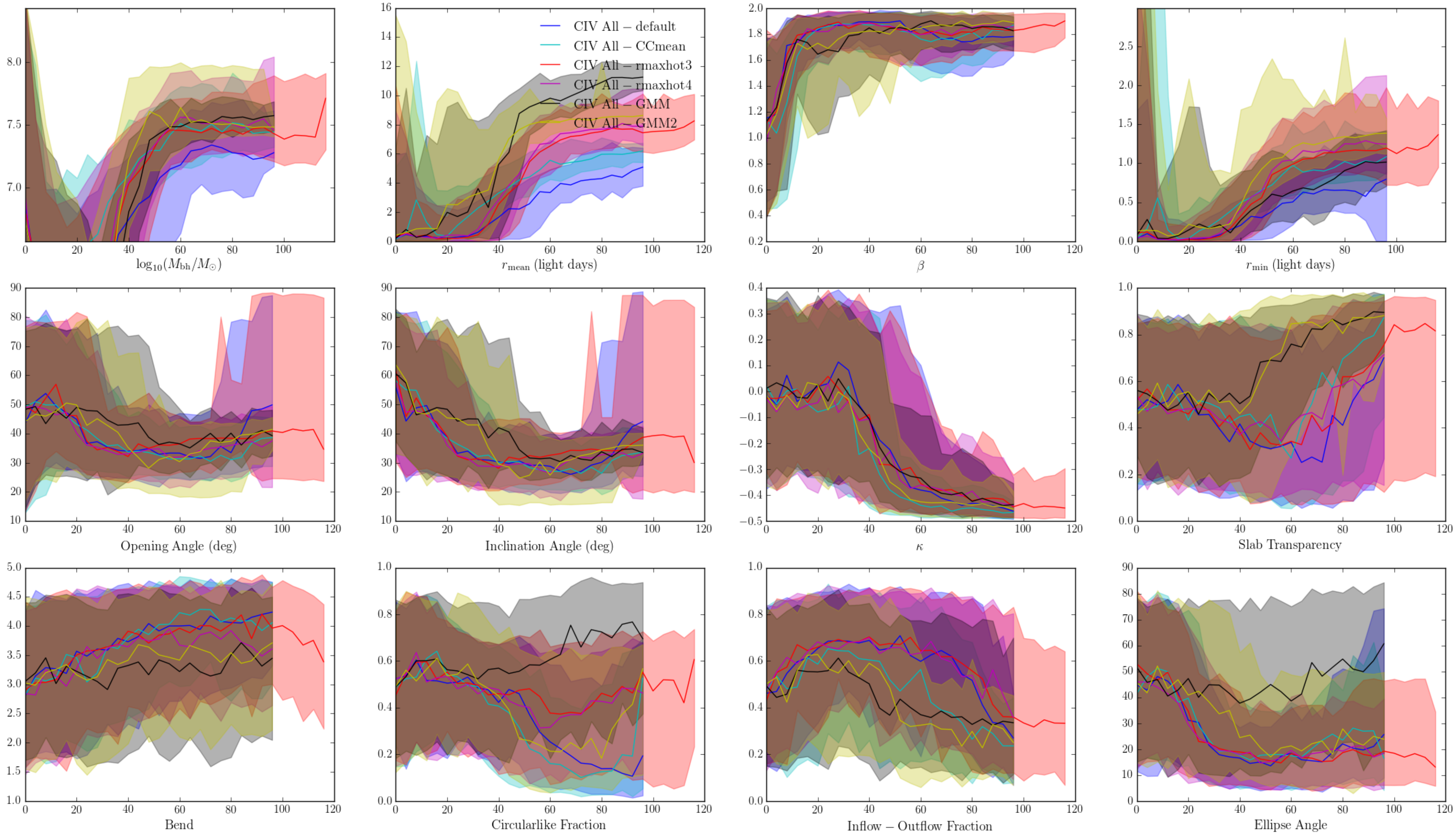
GMM results: model narrow absorption



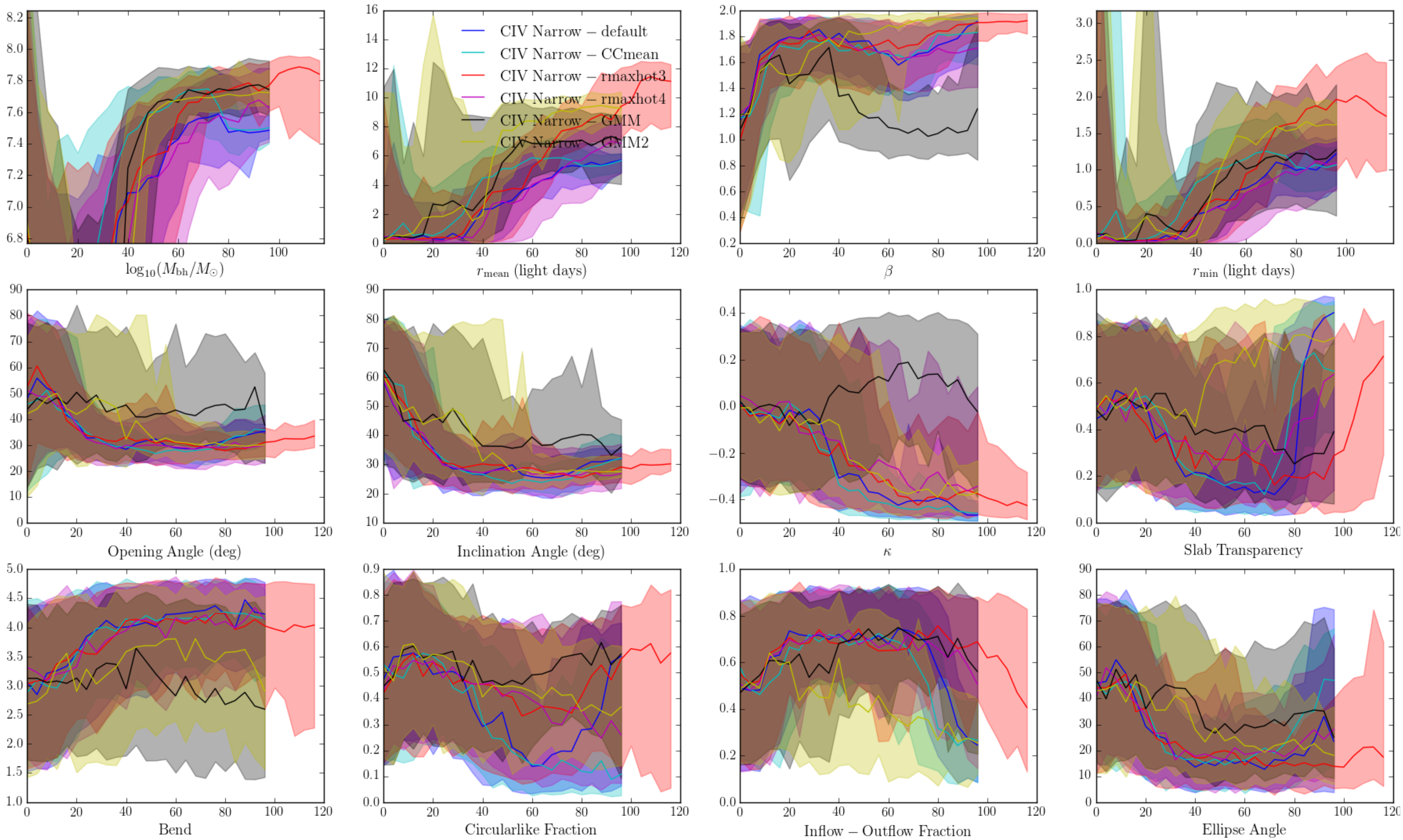
Summary of GMM results

- CIV does prefer some constant spectral component
- Convergence is still an issue for dynamics parameters
- More likelihood levels are needed to try getting better fit to CIV variability and more consistent GMM models

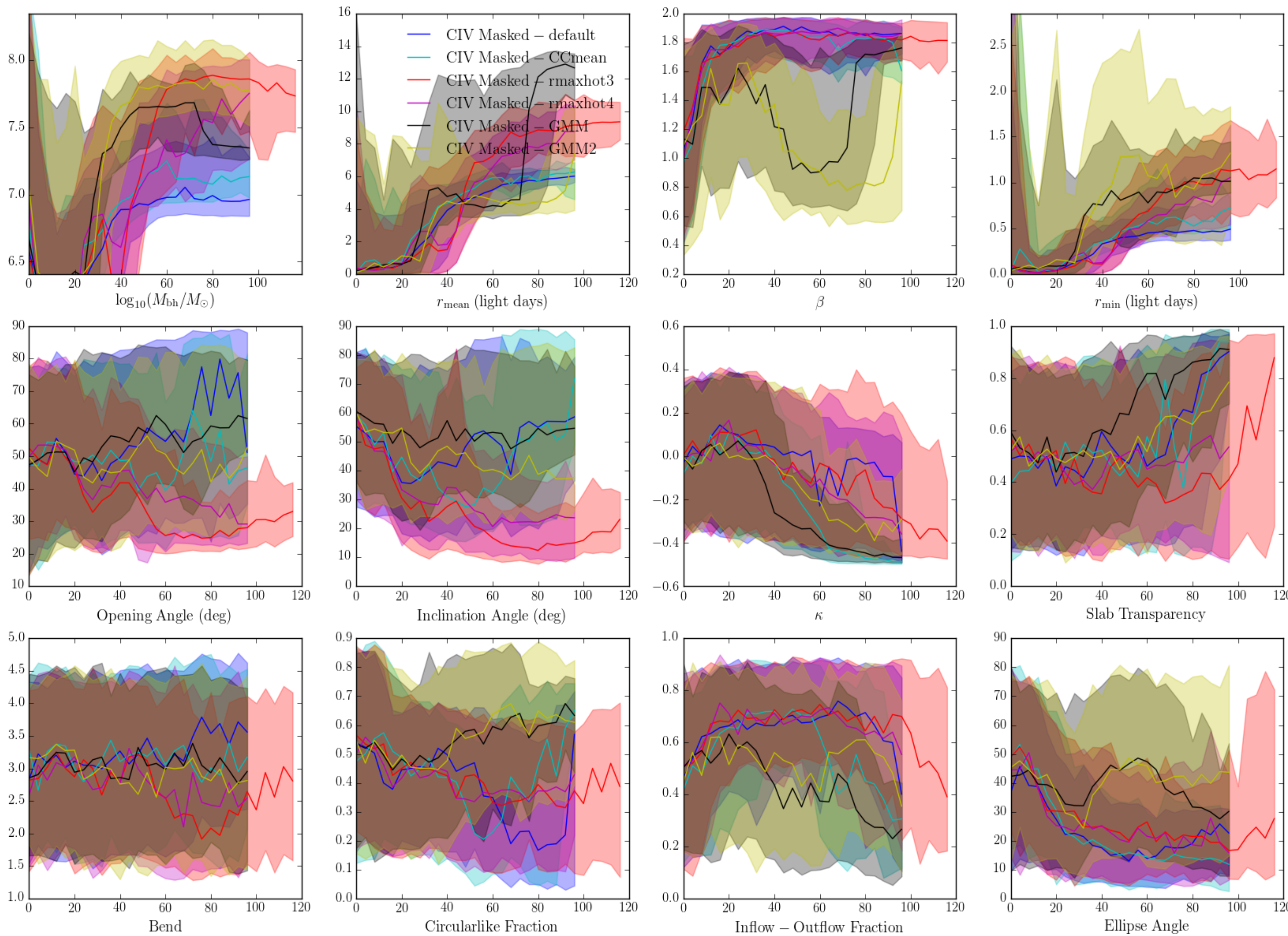
Run comparison for CIV modeling all absorption

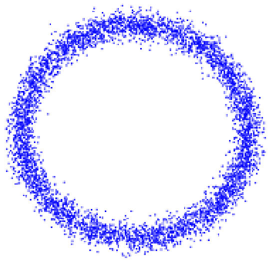


Run comparison for CIV modeling narrow absorption

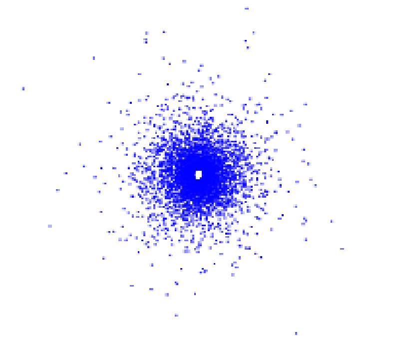


Run comparison for masked CIV





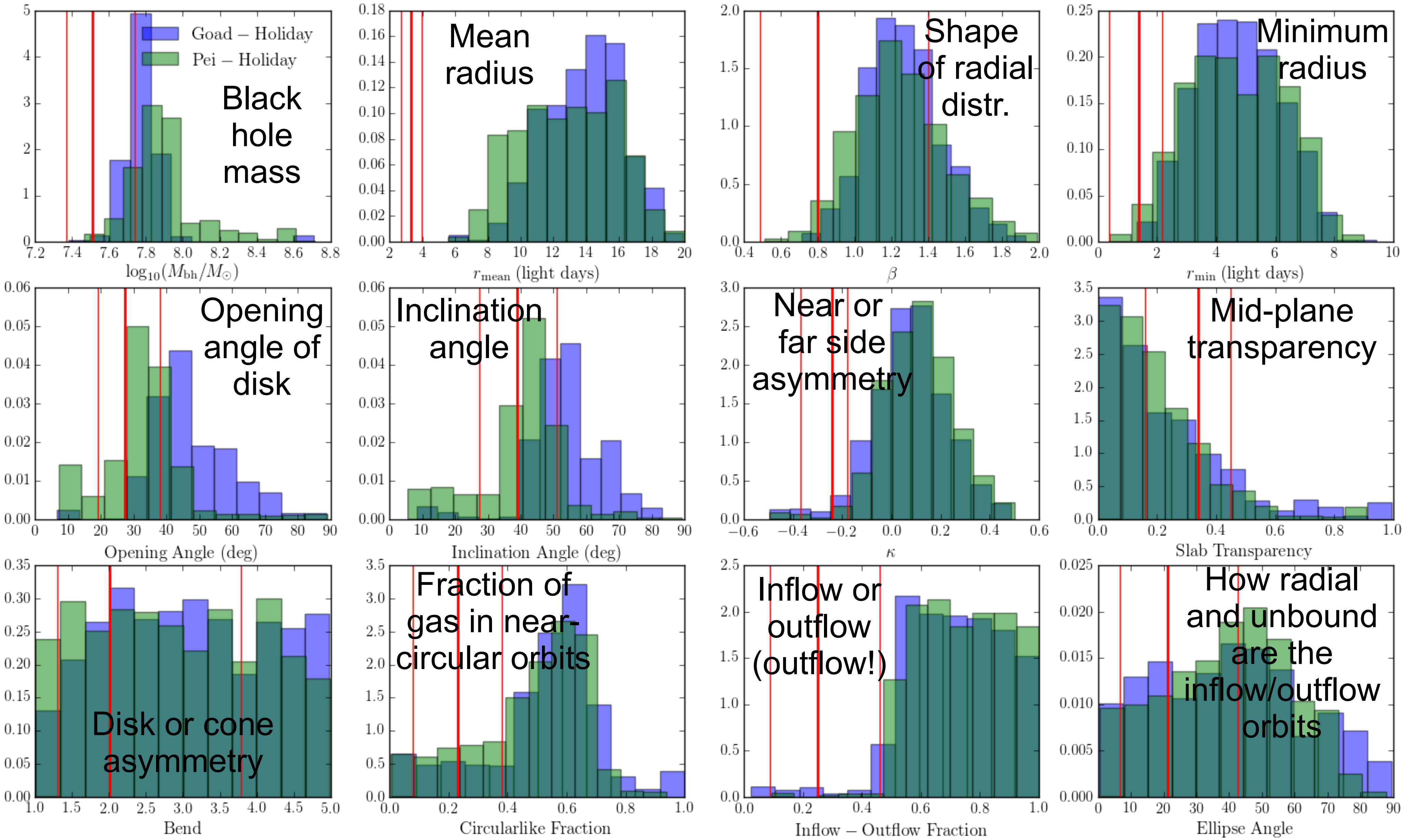
Conclusions



- Simple BLR model is able to fit the Hβ data
  - *Although still need to model the full red wing!*
- CIV variability has been harder to model
  - Un-masking the data has provided more constraints
  - Adding geometry parameters and a constant spectral component don't significantly improve the fit
  - Longer runs with more likelihood levels are still needed, but challenging due to computational constraints (e.g. run time limits on supercomputers)
- *Suggestion welcome!*

Constraints on Hβ BLR Model Parameters

Red lines show median and 68% confidence intervals from LAMP 2008 for Hβ



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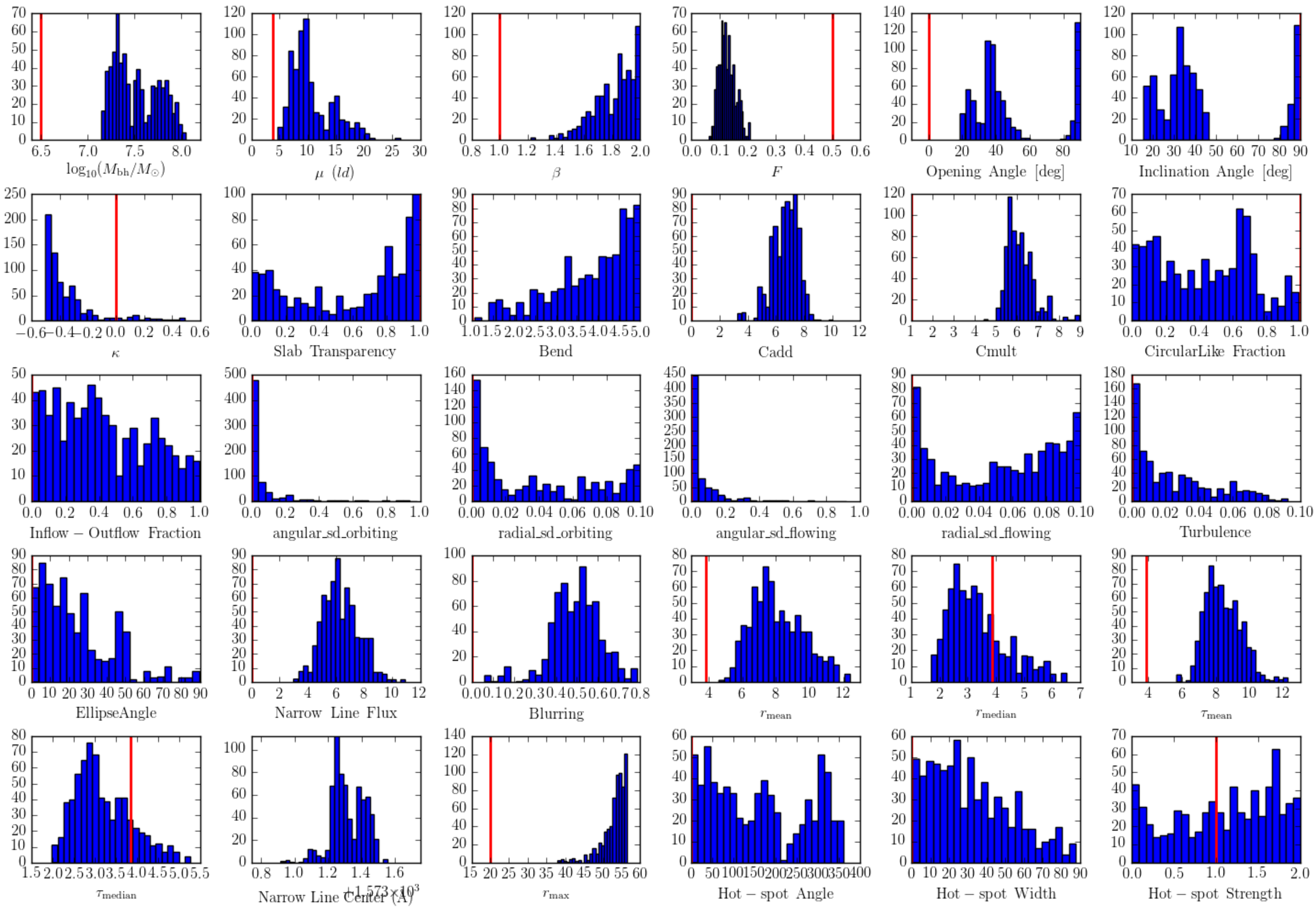
Example posterior PDFs



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Results from adding a constant spectral component = GMM