The Physical Model of Peaked-Spectrum Sources

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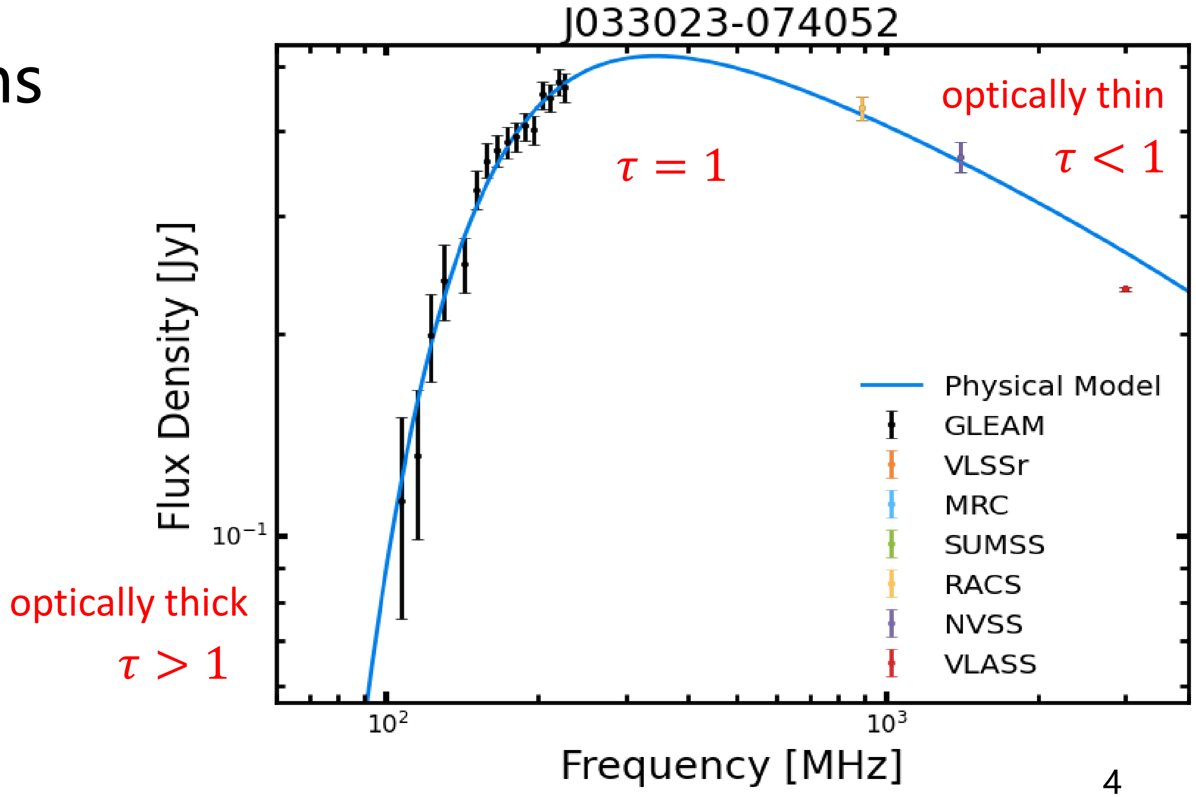
PART ONE

Background

Background

- Peaked-Spectrum (PS) sources are a type of AGN
- Described by frequency turnovers in spectra
- There are two possible explanations for the PS sources:
- The Youth Model
- The Frustration Model

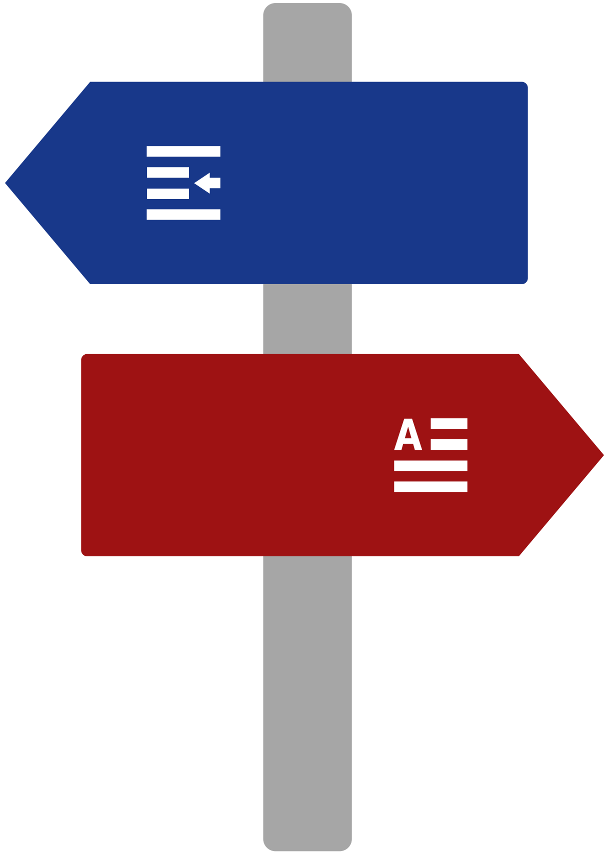


Youth or Frustration Model?

Youth Model

- Early stages of massive radio-loud AGN
- Explained by synchrotron self-absorption (SSA)
- Popular in the past
- However, there are too many PS sources compared to large AGNs

Two road



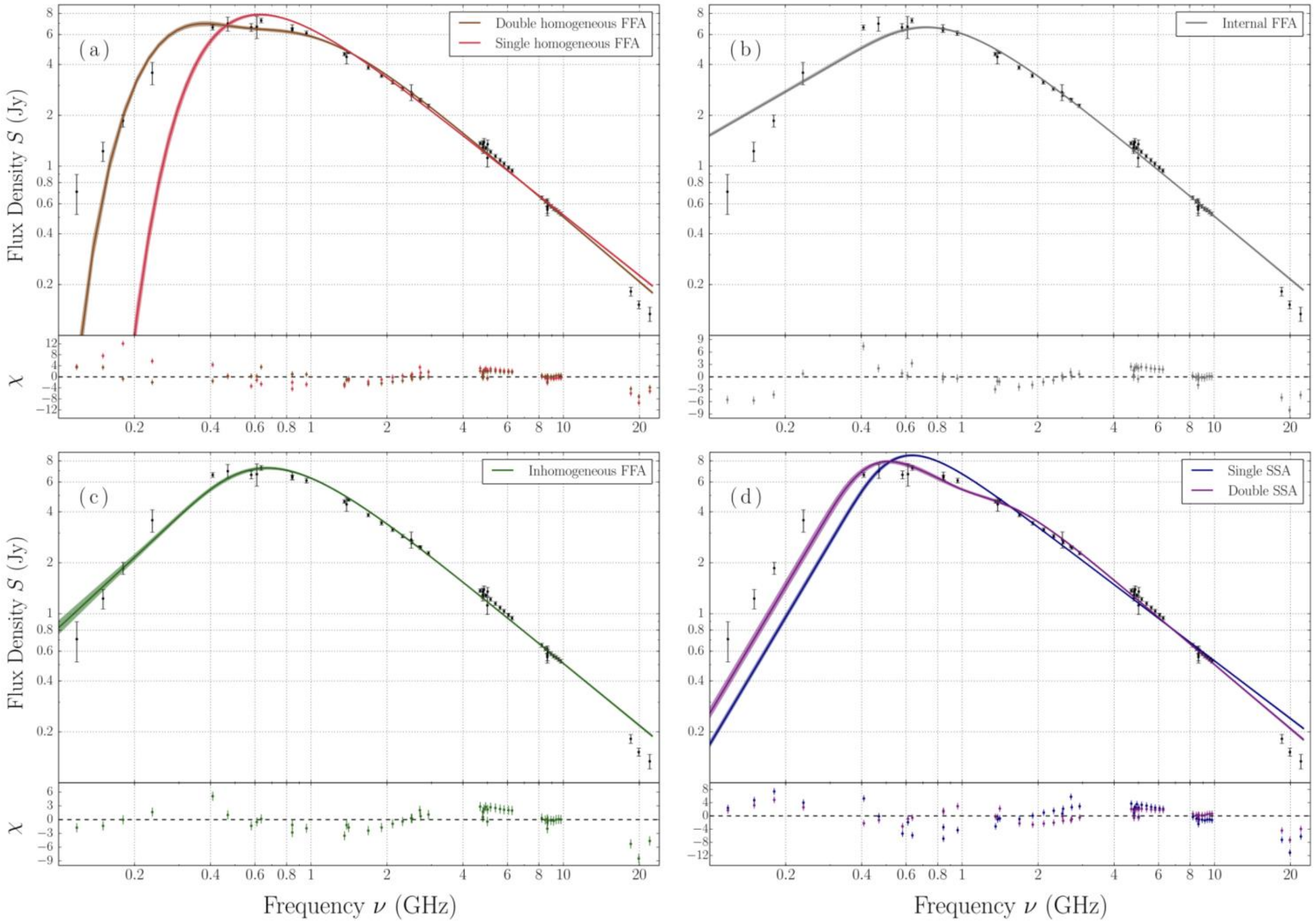
Frustration Model

- Extremely dense gas in AGN central environment
- Explained by free-free absorption (FFA)
- Recently gained a lot of attention

Background

- There are three different types of FFA and one SSA
- The fit of all four models is not ideal
- Some models (spectral aged) achieved a good fit, but they require extreme physical environments to explain.
- So later, many papers used general curve models
- Why not try to combine them?

Source PKS B0008-421



Callingham et al. 2015

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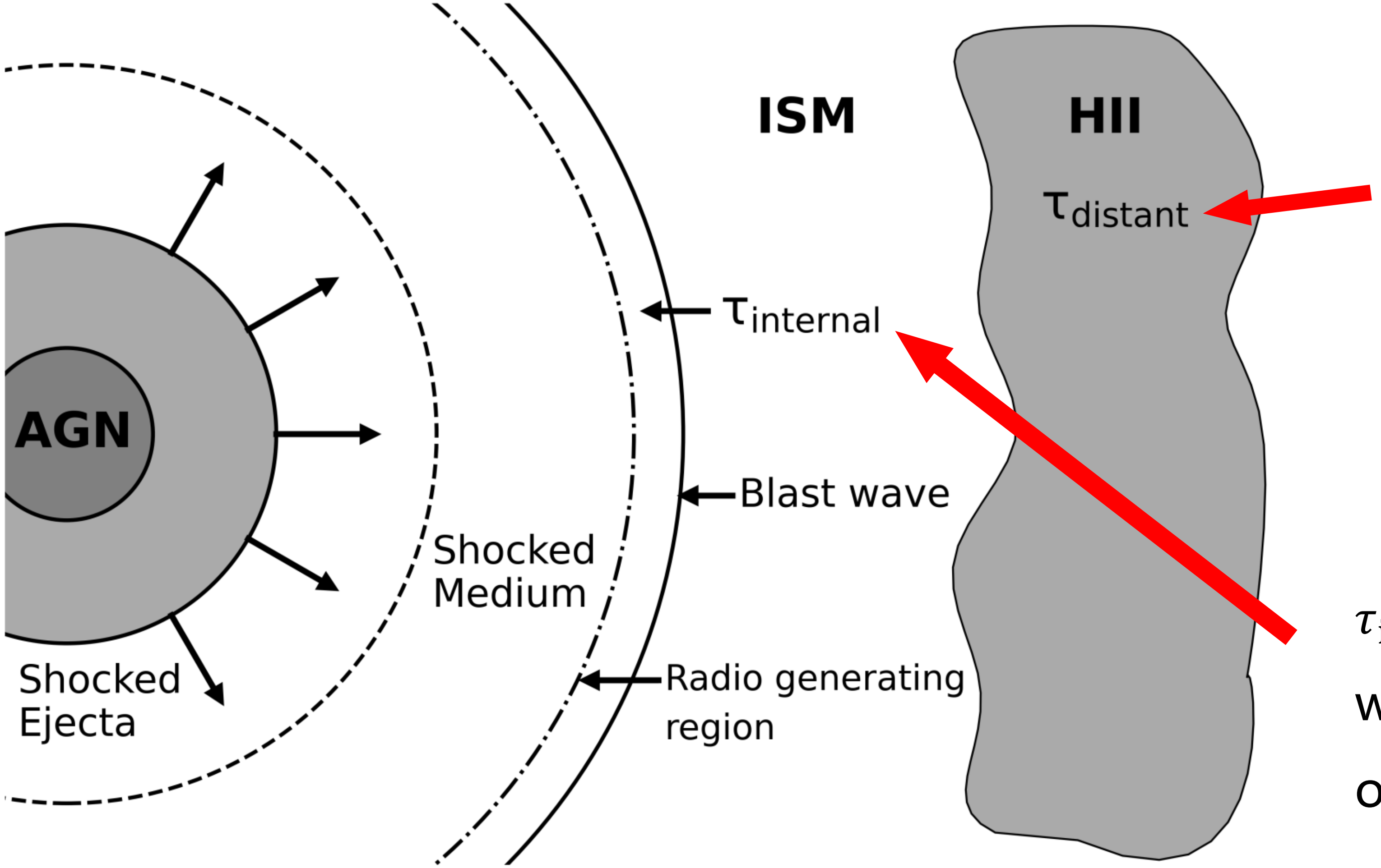
PART TWO

The Physical Model

The Physical Model

The key is understanding the optical depth τ



External FFA

without emission,

mainly composed of HII

$\tau_{\text{internal}} = \tau_{\text{SSA}} + \tau_{\text{FFA}}$

with emission,

occurring in the same place

not to scale

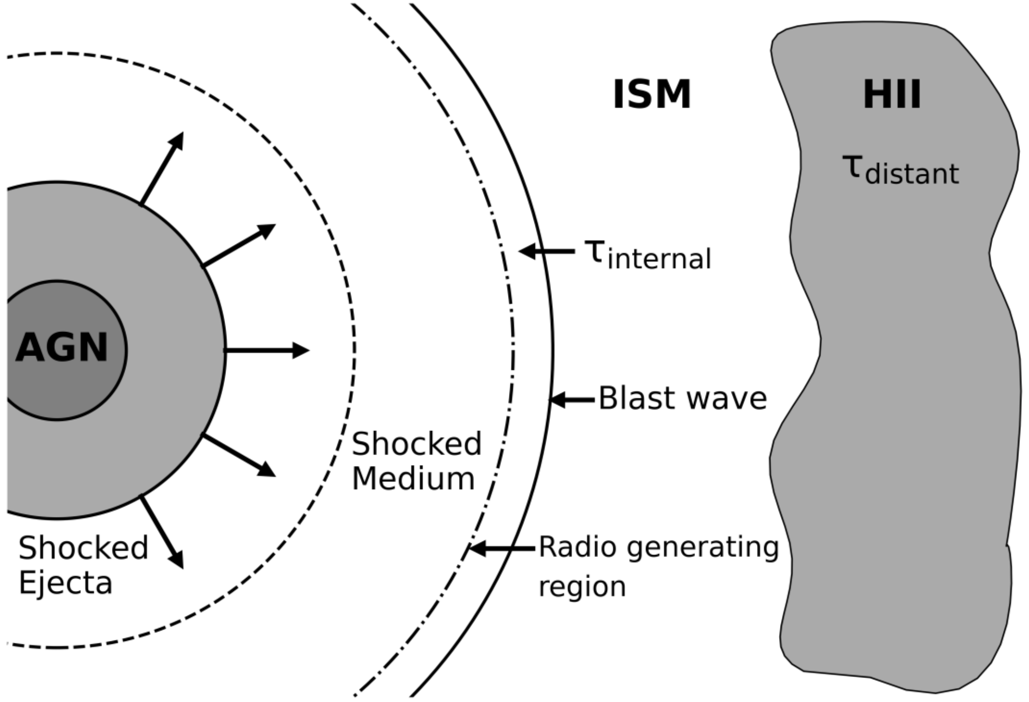
The Physical Model

Considering the effects of these three optical depths τ (τ_{distant}, τ_{SSA}, τ_{FFA}) together, we get the following equation:

$$S_\nu\,(\mathrm{Jy}) = K\left(\frac{\nu}{\mathrm{MHz}}\right)^{\alpha_{\mathrm{thin}}} e^{-\tau_{\mathrm{distant}}}\left(\frac{1-e^{-\tau_{\mathrm{internal}}}}{\tau_{\mathrm{internal}}}\right)$$

Emission　　External FFA　　Internal absorption

$$\tau_{\mathrm{internal}} = \tau_{\mathrm{SSA}} + \tau_{\mathrm{FFA}}$$



- K: the normalization constant of flux density
- α_{thin}: the spectral index of the optically thin region

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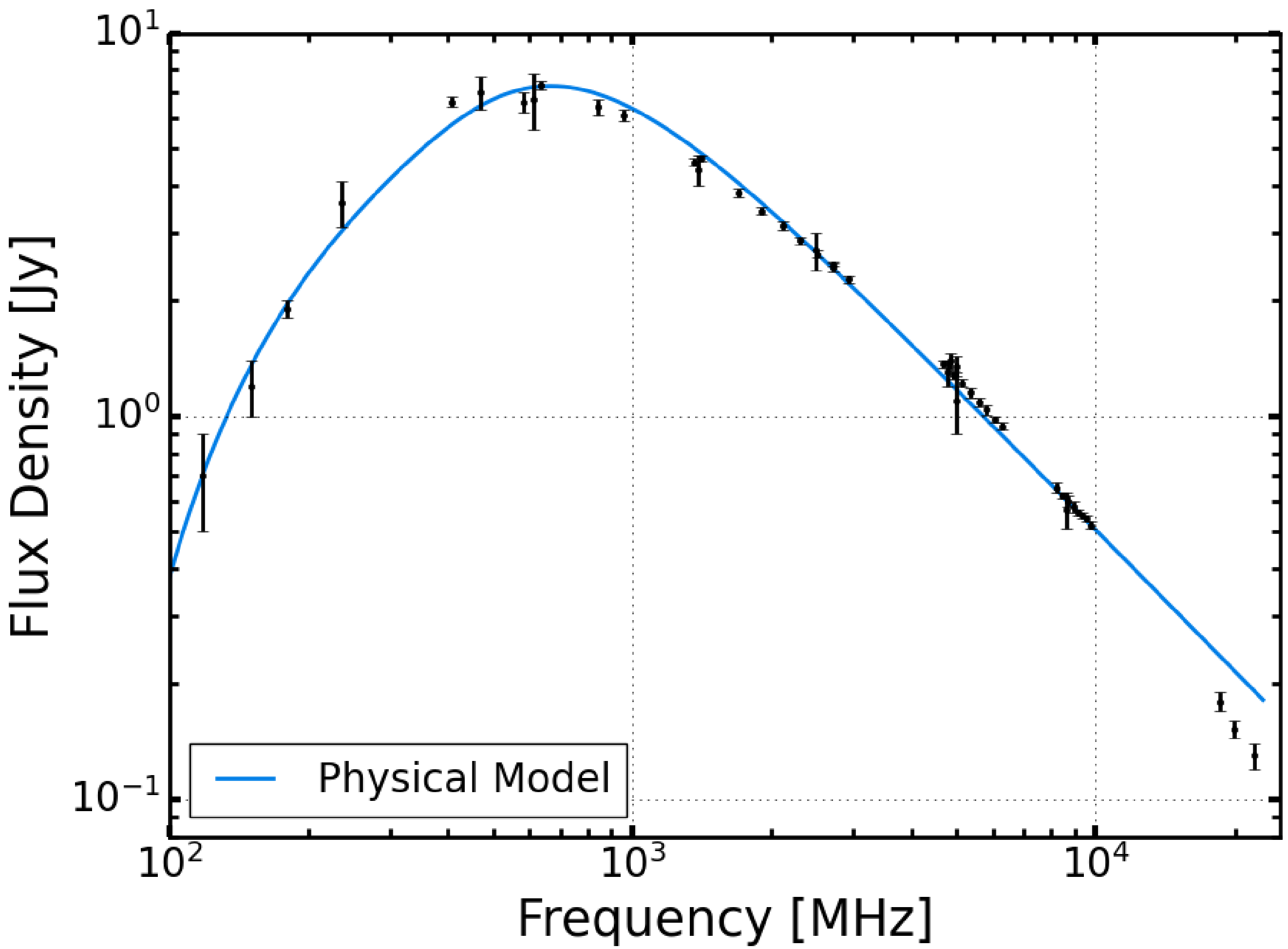
PART THREE

Results

Results

- Our model can fit this source well
- No extreme physical scenarios are needed
- Then…
- We applied the new model to the catalog of the GLEAM survey, cross-verification with other surveys, and identified 4,036 well-observed PS sources out of 304,942 sources.

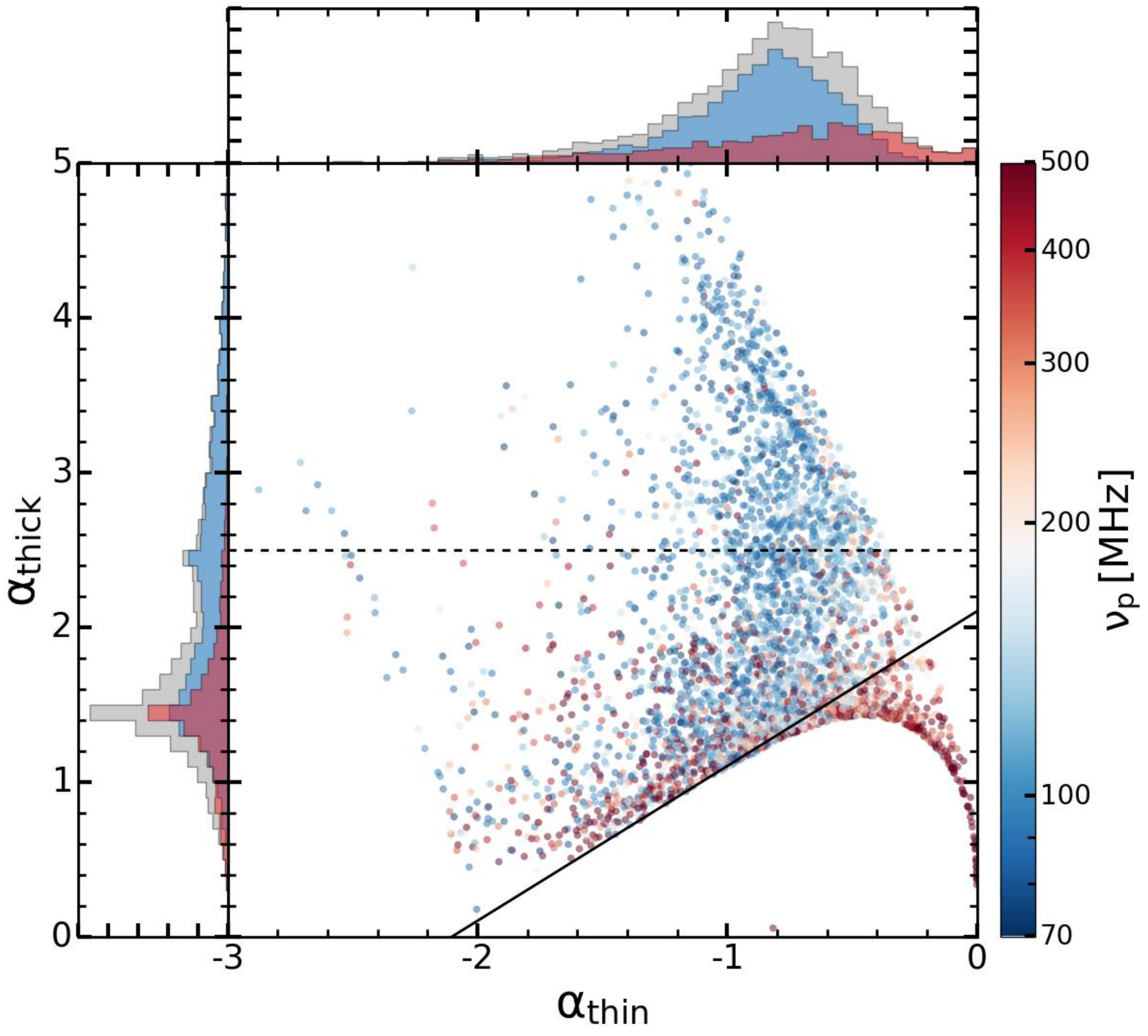
Source PKS B0008-421



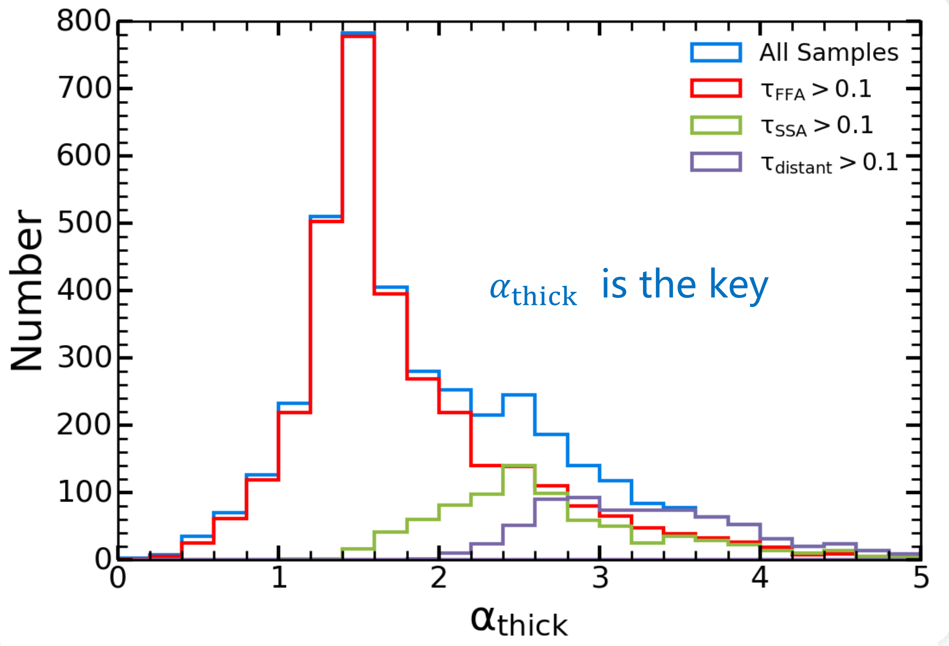
Results

- α_{thin}: the spectral index of the optically thin region
- α_{thick}: the spectral index of the optically thick region
- ν_{p}: the frequency at the peak

- α_{thin}-α_{thick} shows a remarkable regular distribution
- Sources with lower ν_{p} have larger α_{thick}
- Sources with higher ν_{p} have smaller α_{thick} and more dispersed α_{thin}

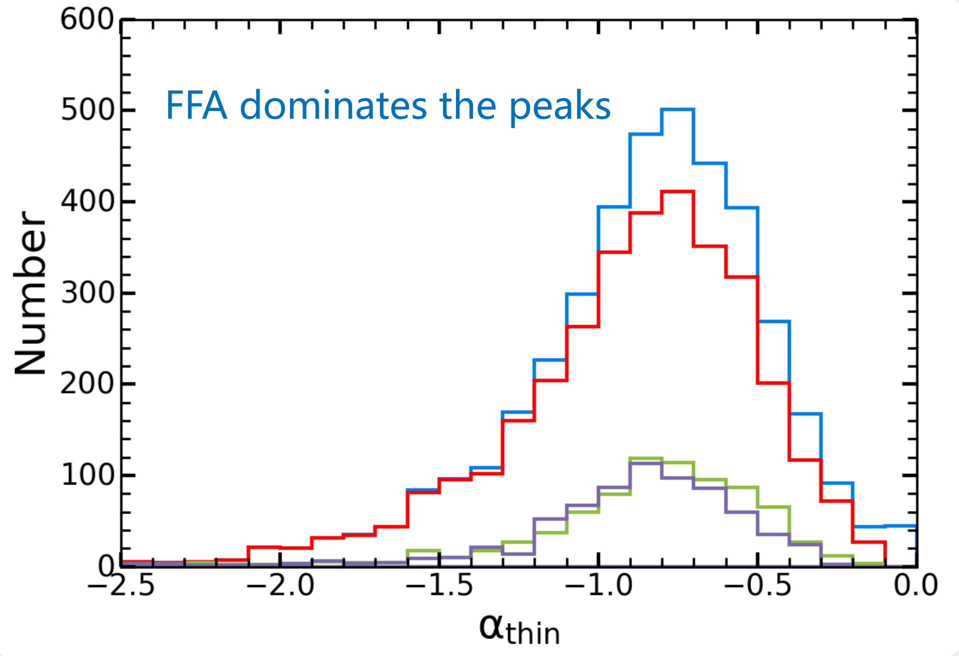


Results



α_{thick} distribution

Different mechanisms of optical depth dominate different α_{thick} distribution



α_{thin} distribution

There are no significant differences between the different α_{thin} distribution

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PART FOUR

Conclusions

Conclusions

- We propose a model with good fit and physical explanation.

- Sources with lower ν_{p} have a larger α_{thick}
  The sky of ultra-long wavelength might be darker

- Internal FFA dominates the peaks of most PS sources
  The "Frustration" Model seems to be the better choice

- α_{thick} is the key to distinguishing different absorption mechanisms

- Hope the HongMeng project (DSL) can make significant contributions in the future

Thank you for your attention!