Uncertainties in the spectral modeling of galaxies

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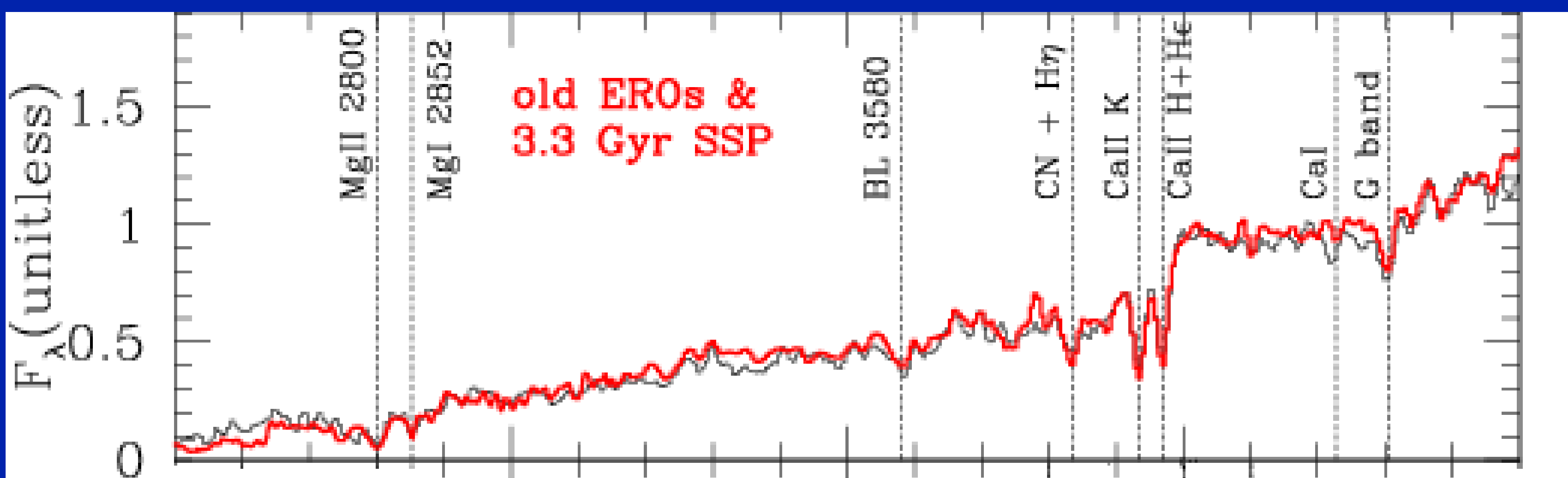
Spectral evolution models

- Powerful tool to interpret integrated light from galaxies
- Way to constrain physical parameters (masses, SFR, ages, metallicities, dust content) from large sample of observed galaxies (Brinchmann+, 2004, for SDSS)



Cimatti+, 2002

→

M_*
SFR
Z
age
τ

Uncertainties in spectral evolution modeling

- Little previous work on model uncertainties. Recent work by Conroy (2009,a,b, 2010) suffers from many limitations

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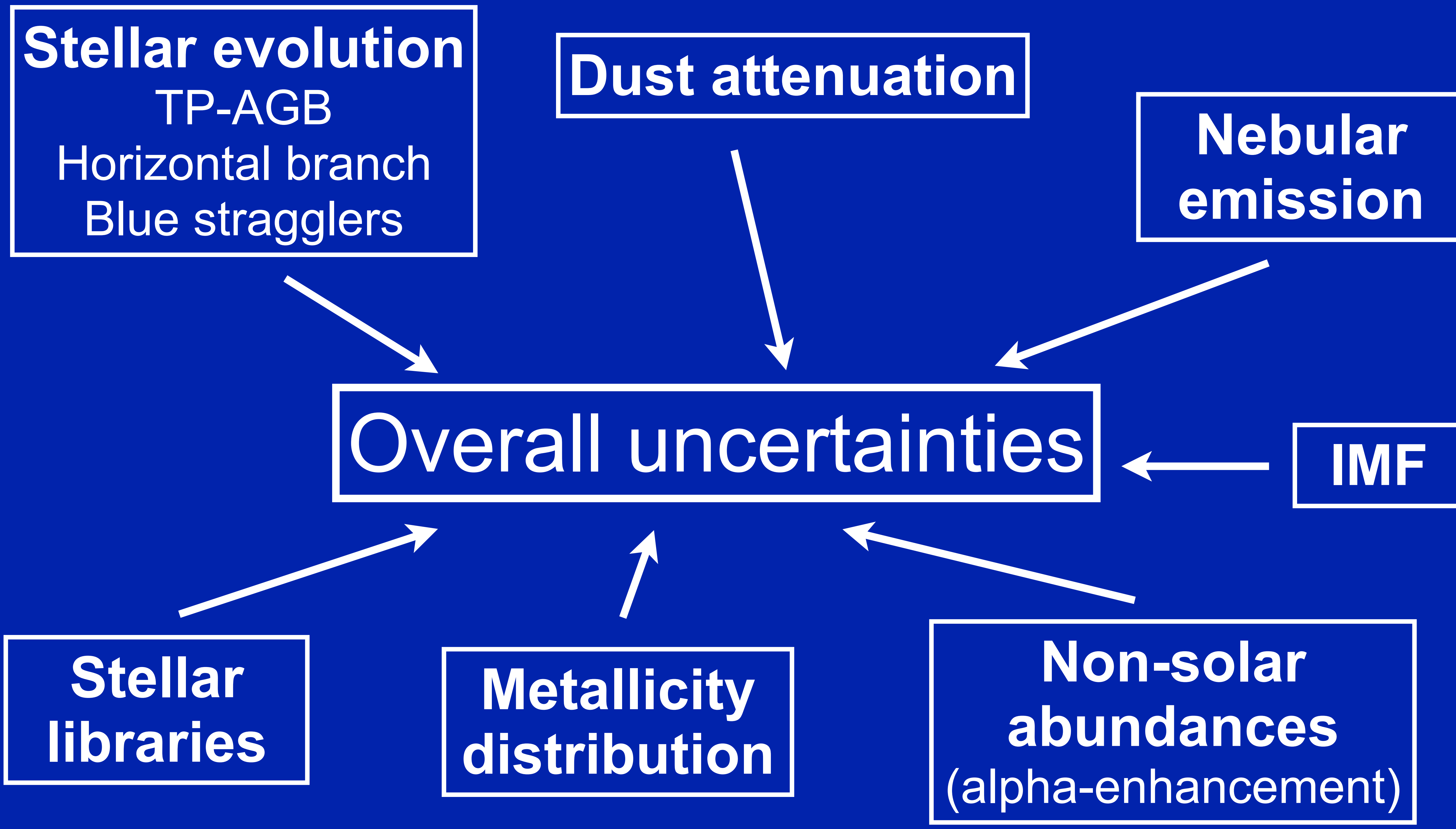
We miss a 'tool' based on a set of *physically motivated* prescriptions to assign realistic uncertainties to physical parameters derived from models

Uncertain ingredients in spectral models



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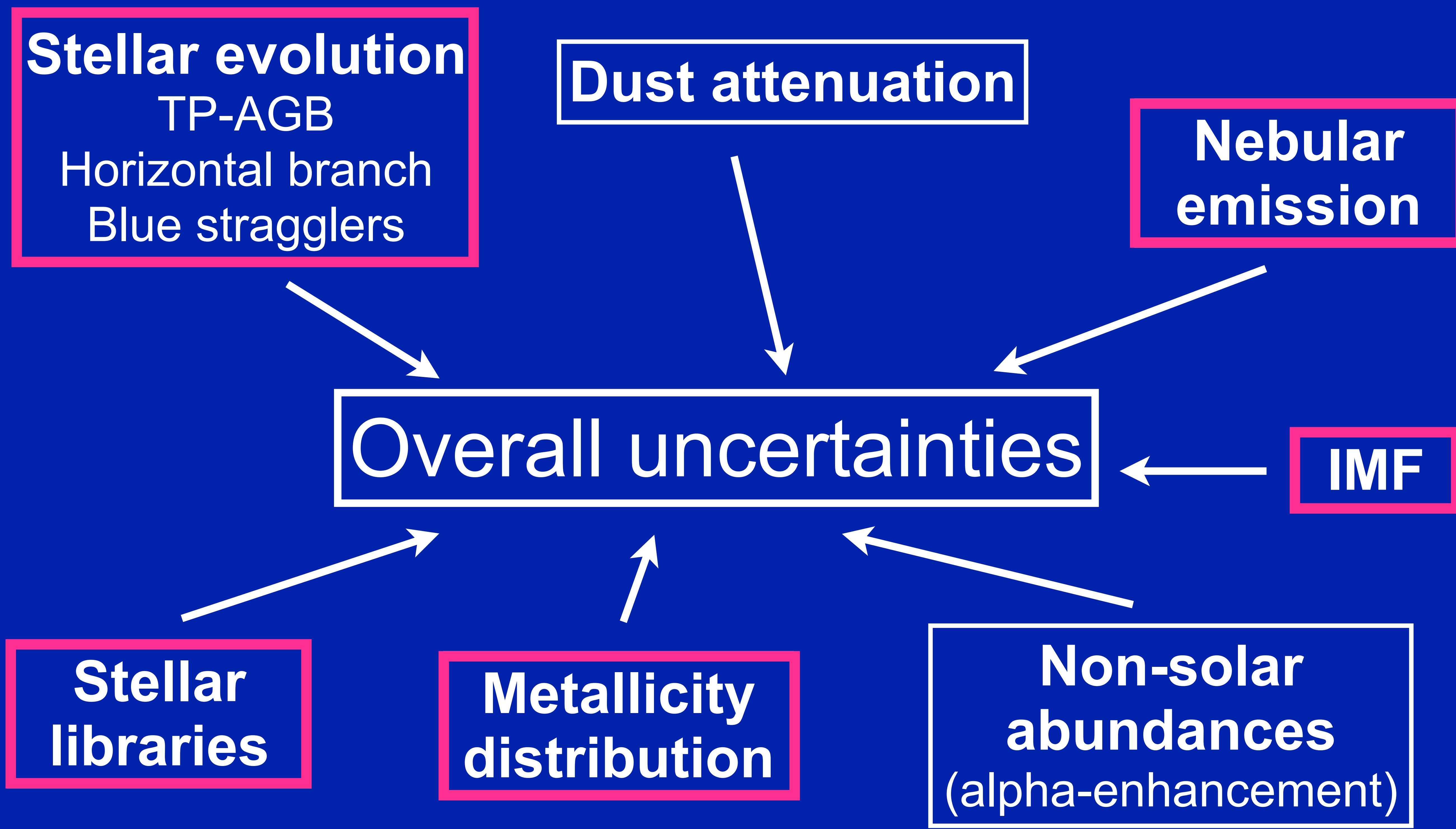

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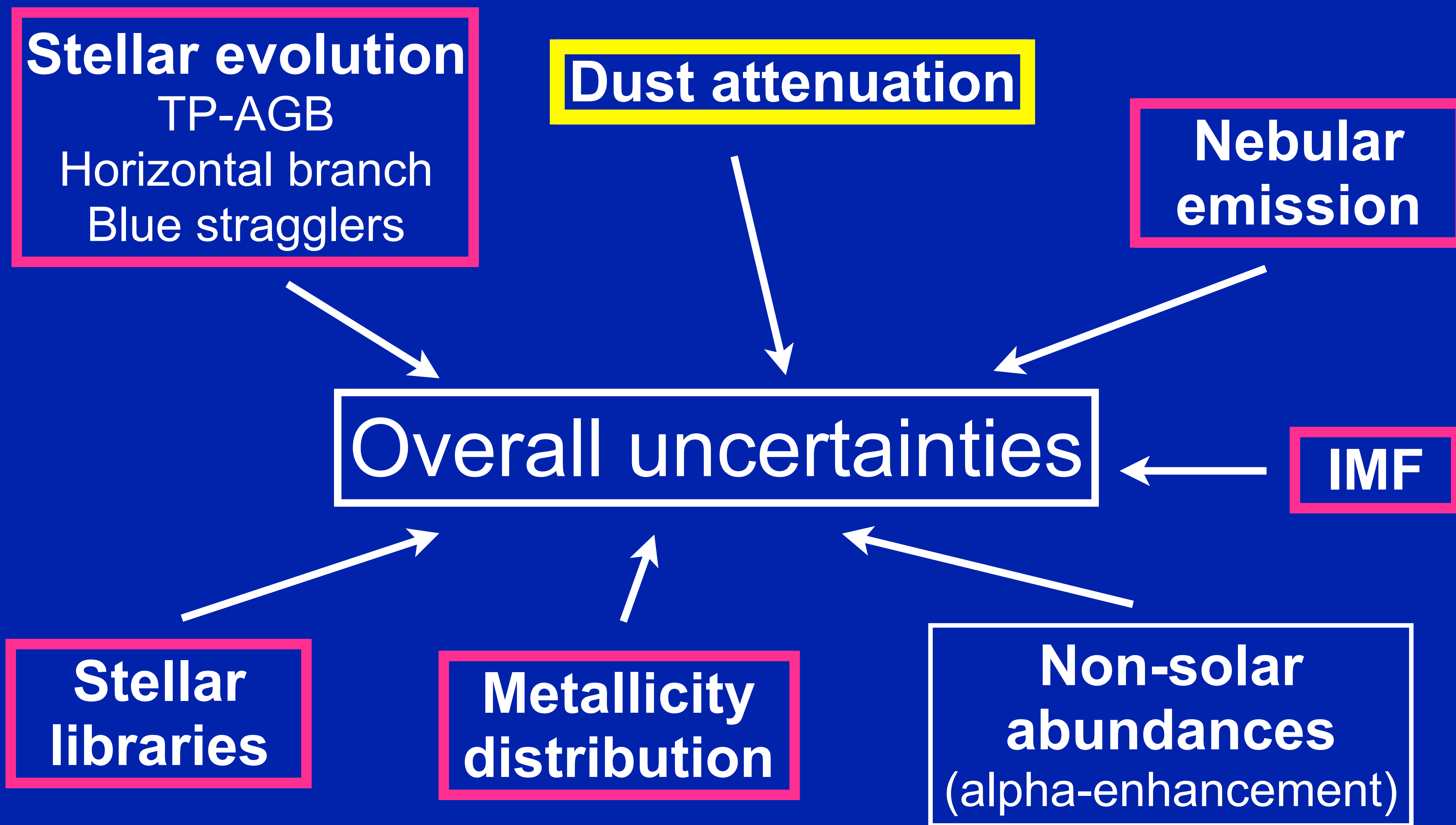

Dust uncertainty: inclination effects

$A(\lambda, i)$: absorption + scattering + geometry

Same dust properties, but different **distributions** of dust and stars → Different attenuation laws in the **bulge**, **thick** and **thin** disks.

Aim of my work: use main conclusions from **radiative transfer** (RT) models to improve dust attenuation prescriptions used in spectral analyses

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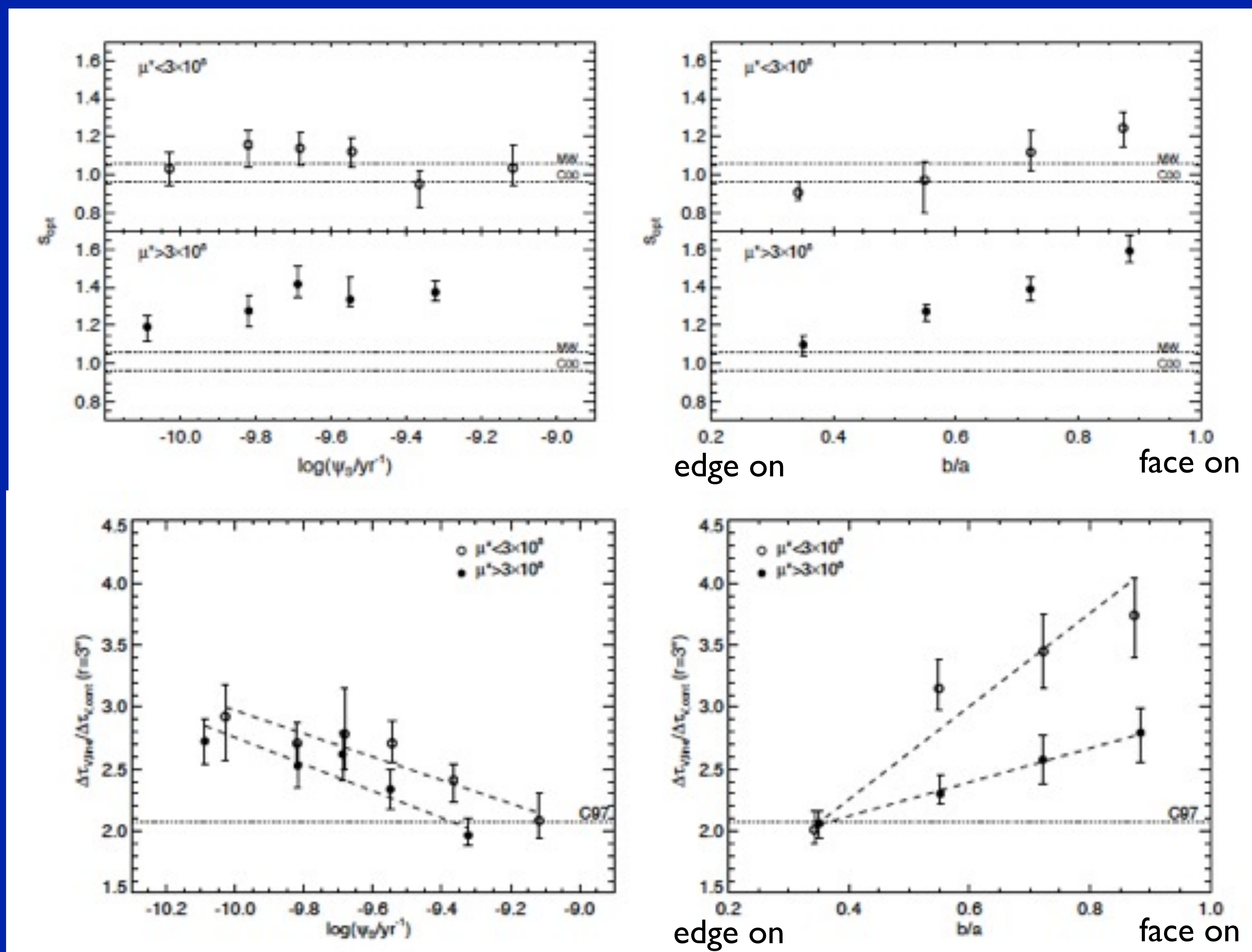
Includes **galaxy inclination** and different **stellar components**

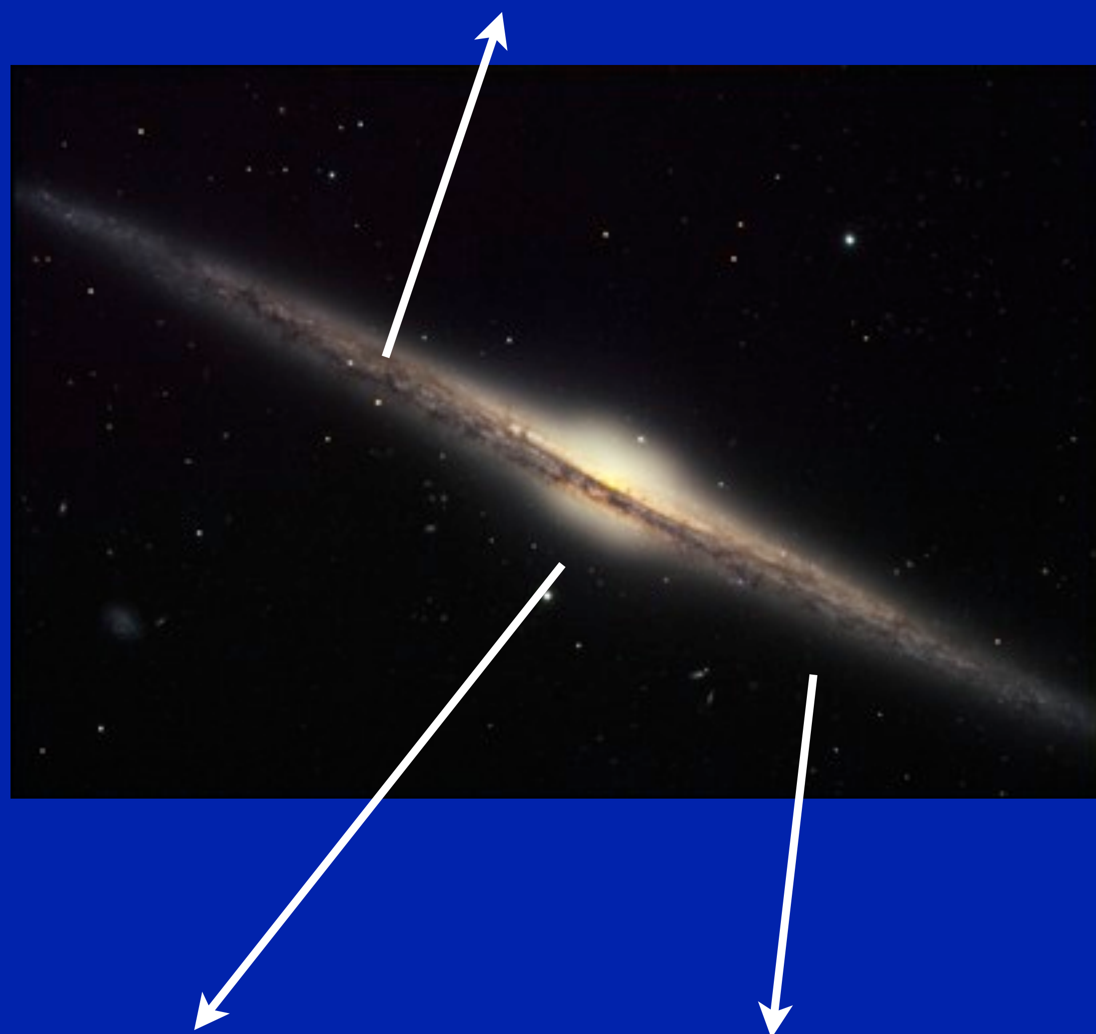
Dust uncertainty: inclination effects



Wild et al. (in publication)

- 23 000 star forming galaxies
- UV through NIR photometry (GALEX + SDSS + UKIDSS)
- Two subsamples based on mu*, the surface mass density:
  - ➡ high mu*: early spirals
  - ➡ low mu*: late spirals
- Can we explain the observed relations of the attenuation with inclination and SSFR?

Dust attenuation: modeling



$$F_{obs} = F_{em} * e^{-\tau}$$

$\tau < 1$ optically thin regime

$\tau > 1$ optically thick regime

- In real galaxies stars in different components (bulge, thin and thick disk, birth clouds) suffer different attenuation
- Moreover attenuation strongly depends on viewing angle of the galaxy

Dust attenuation: modeling

- Can we explain Wild et al. data with classical dust attenuation models?
- Comparison of different **radiative transfer models**:
  - ➡ Tuffs et al., 2004 (analytic, 3 comp.)
  - ➡ Pierini et al., 2004 (analytic, 2 comp.)
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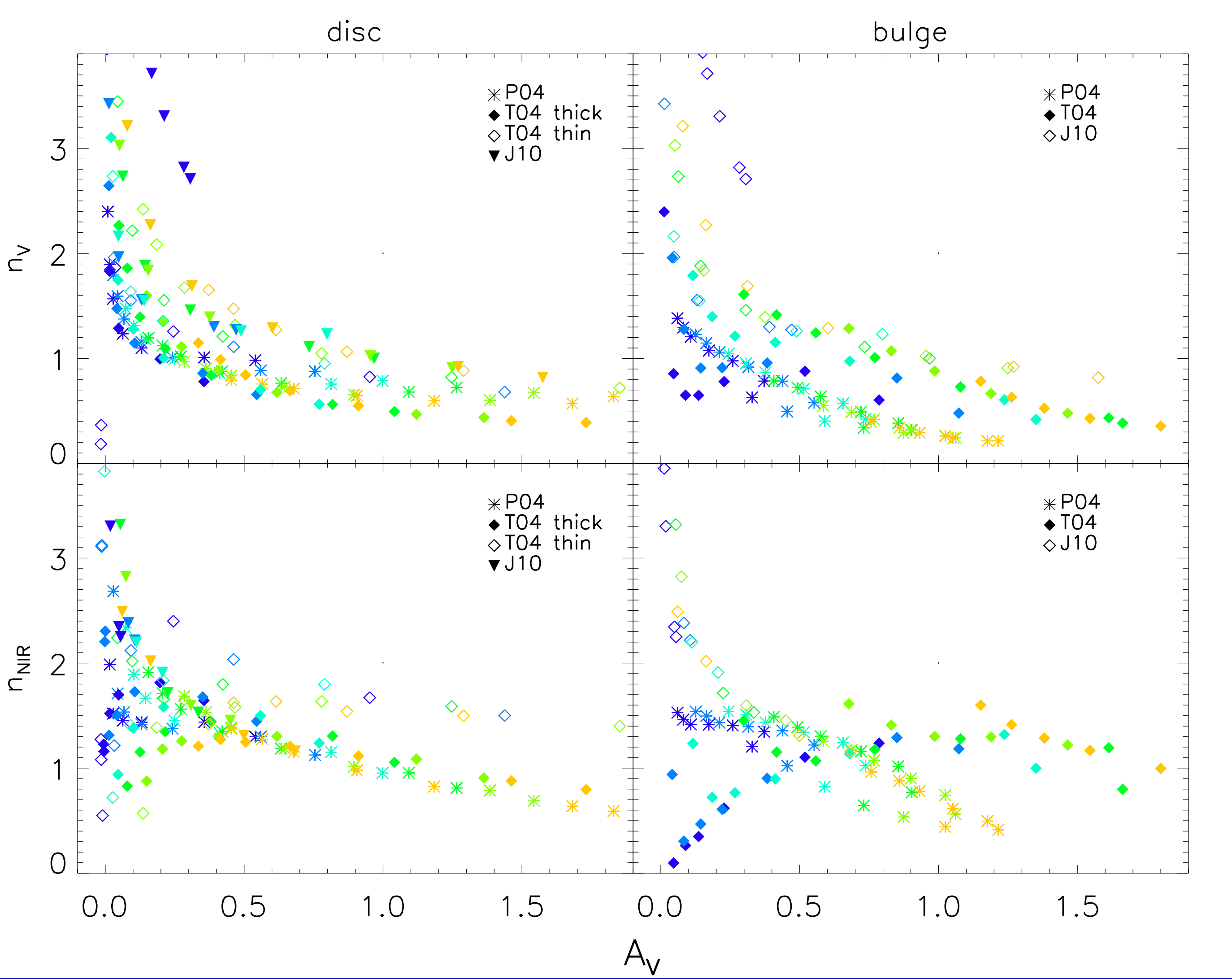

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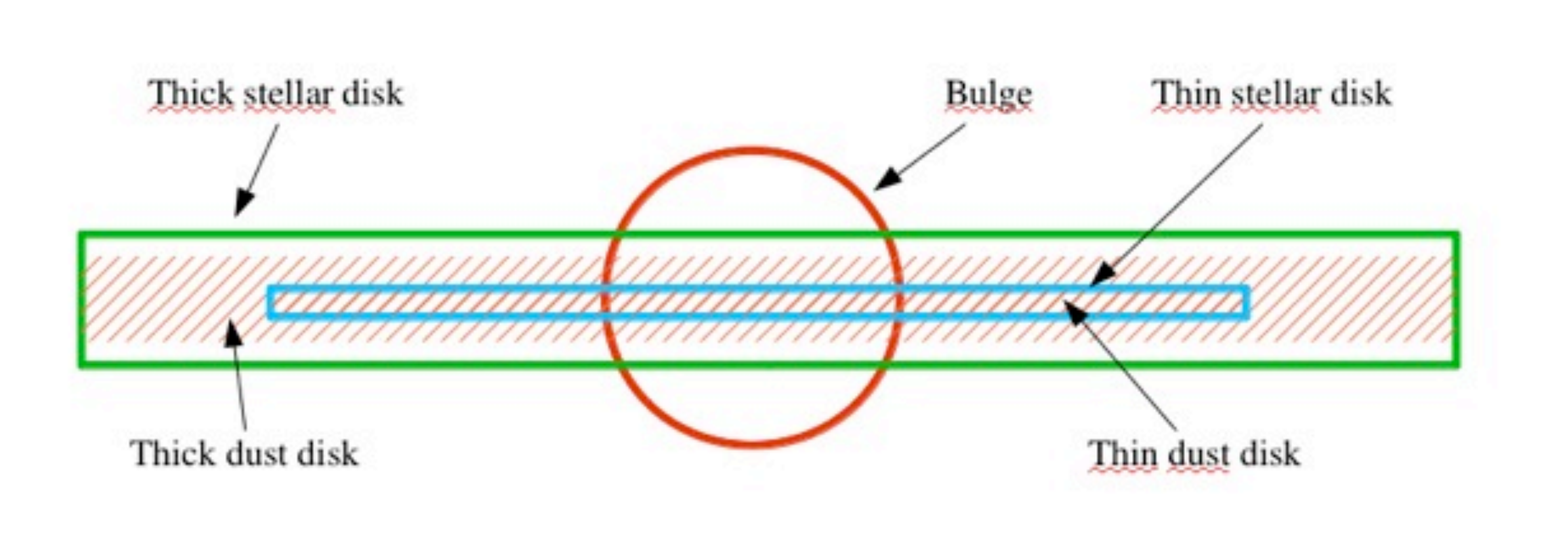
- Tuffs et al. models are the most flexible, since they are given for three separate geometrical components: a thick, a thin disk and a bulge



Dust attenuation: data fitting

- To fit the observed relations of Wild et al. with Tuffs et al. dust models we use a Markov Chain Monte Carlo (MCMC) approach
- 4 parameters:
  - $\tau_{B,face\ on}$, central face-on B-band optical depth (indicates the total dust content)
  - μ , fraction of total attenuation arising from diffuse ISM
  - T_{thin}, age of stars in the **thin** disk (for T < T_{thin})
  - T_{bulge}, age of stars in the **bulge** component (for T > T_{bulge})
  - (Stars with T_{thin} < T < T_{bulge} are in the thick disk)

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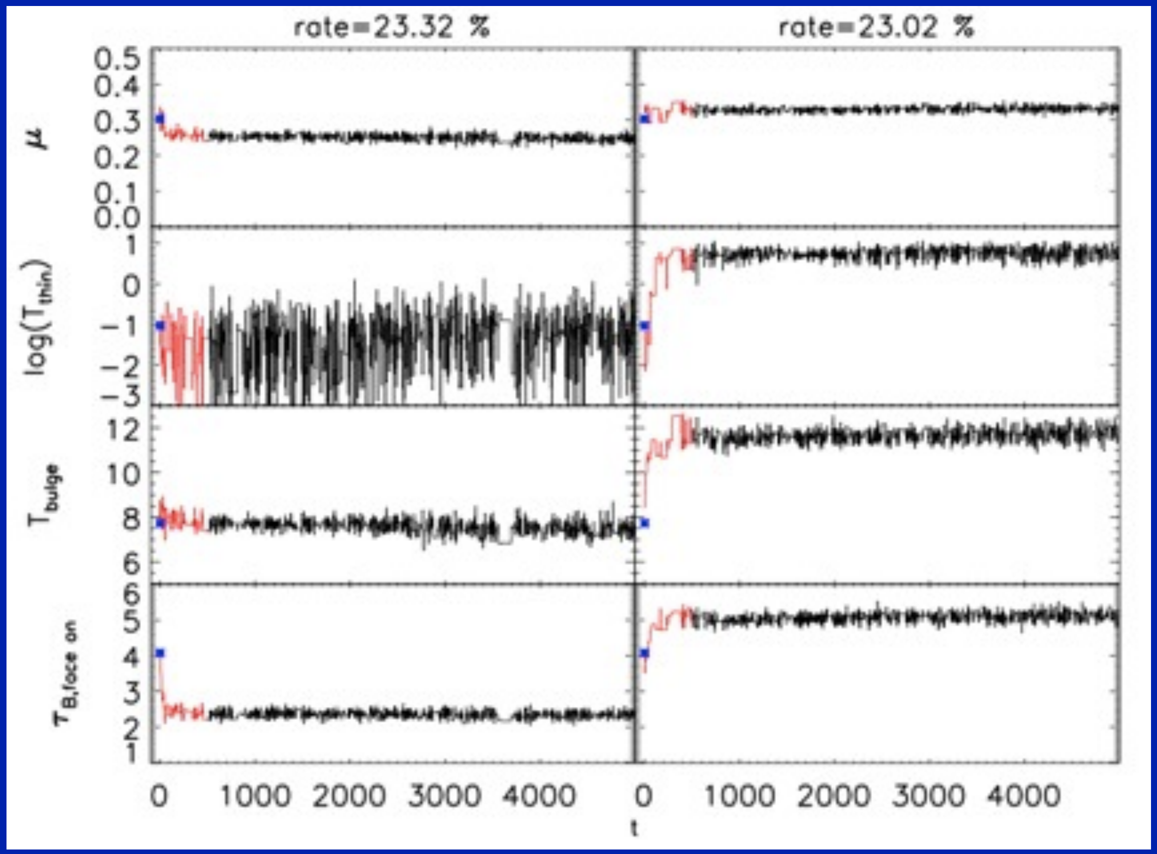
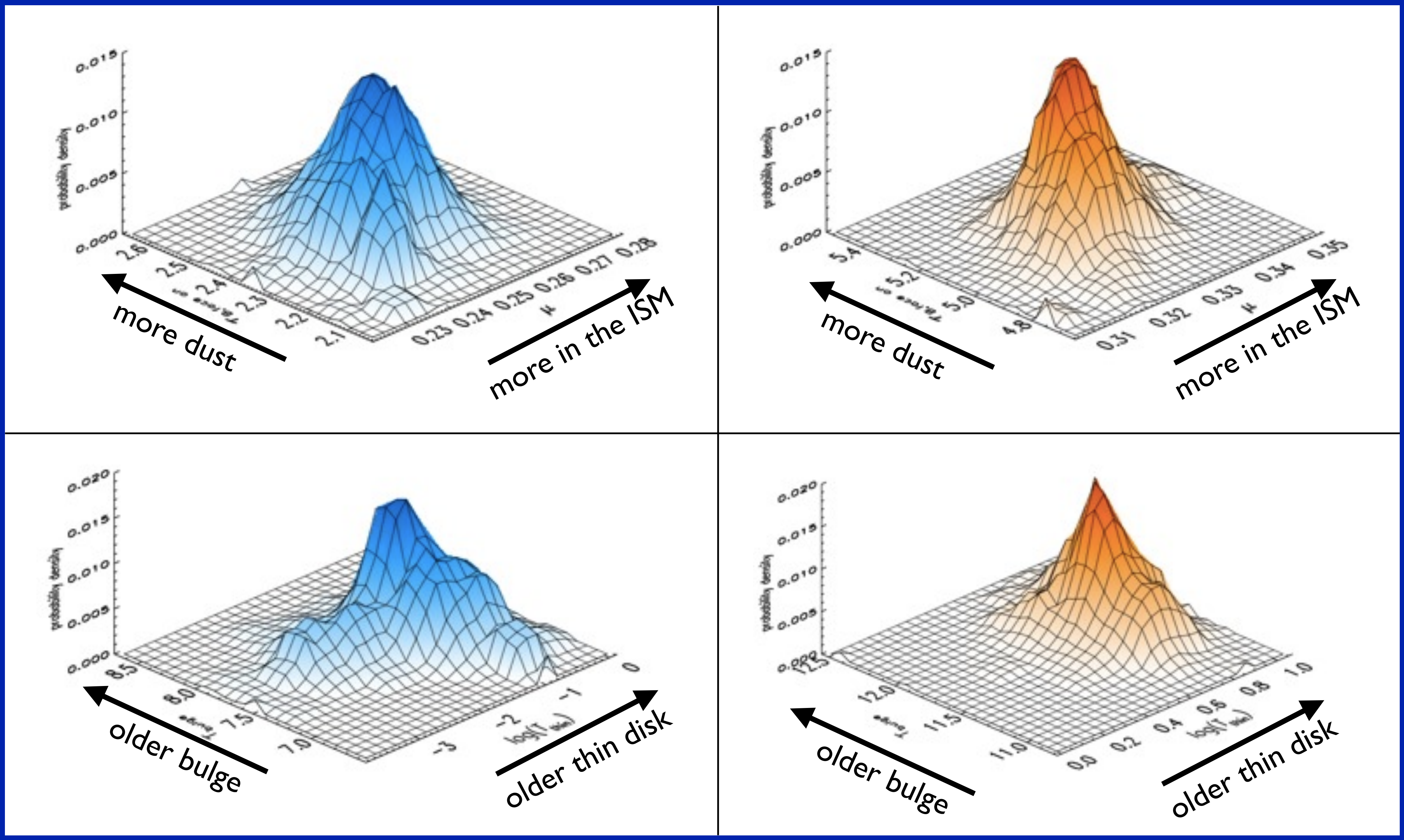


Dust attenuation: results

- MCMC = random walk in the parameter space
- Provides the whole 4-dim posterior distribution of $\tau_{B,face\ on}$, μ, T_{thin}, T_{bulge}

Late disks (no bulge) | Early disks (bulge dominated)



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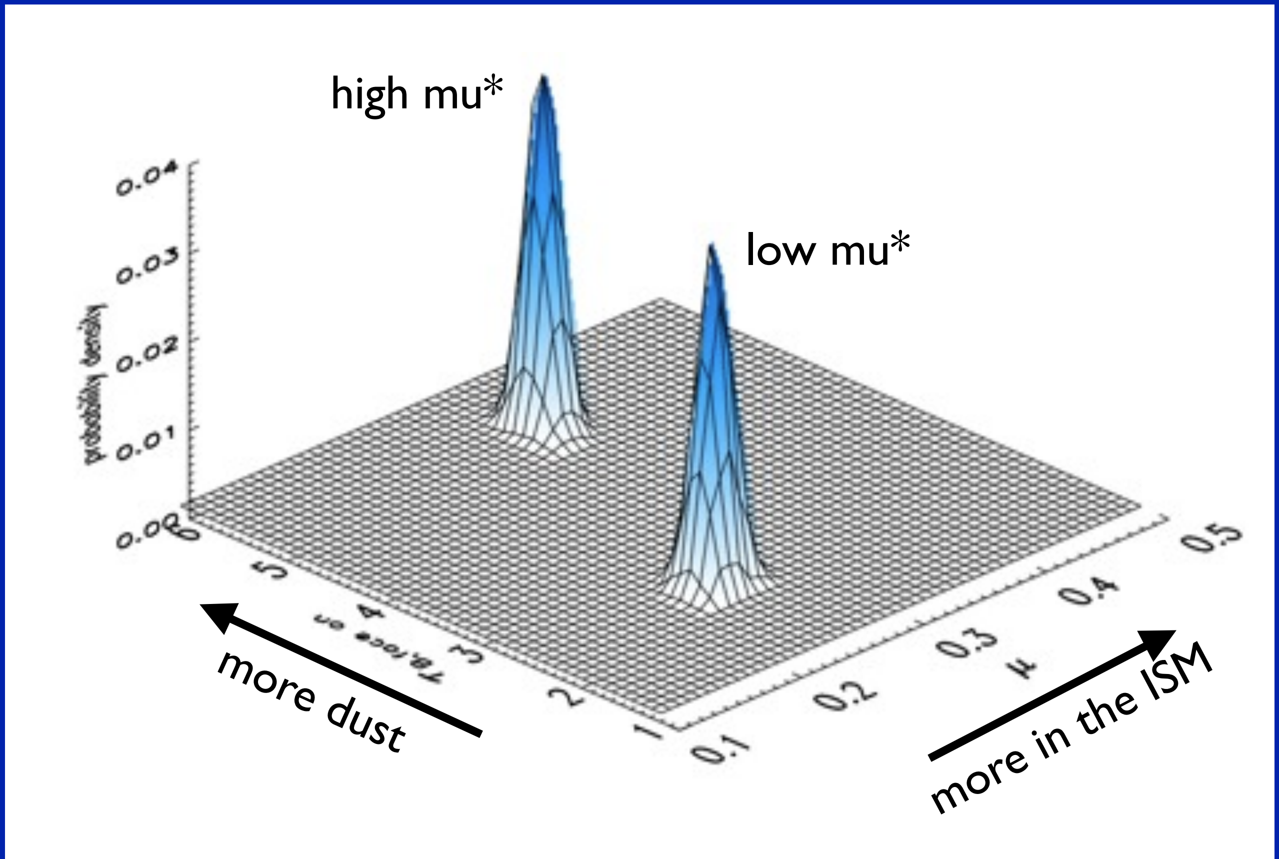
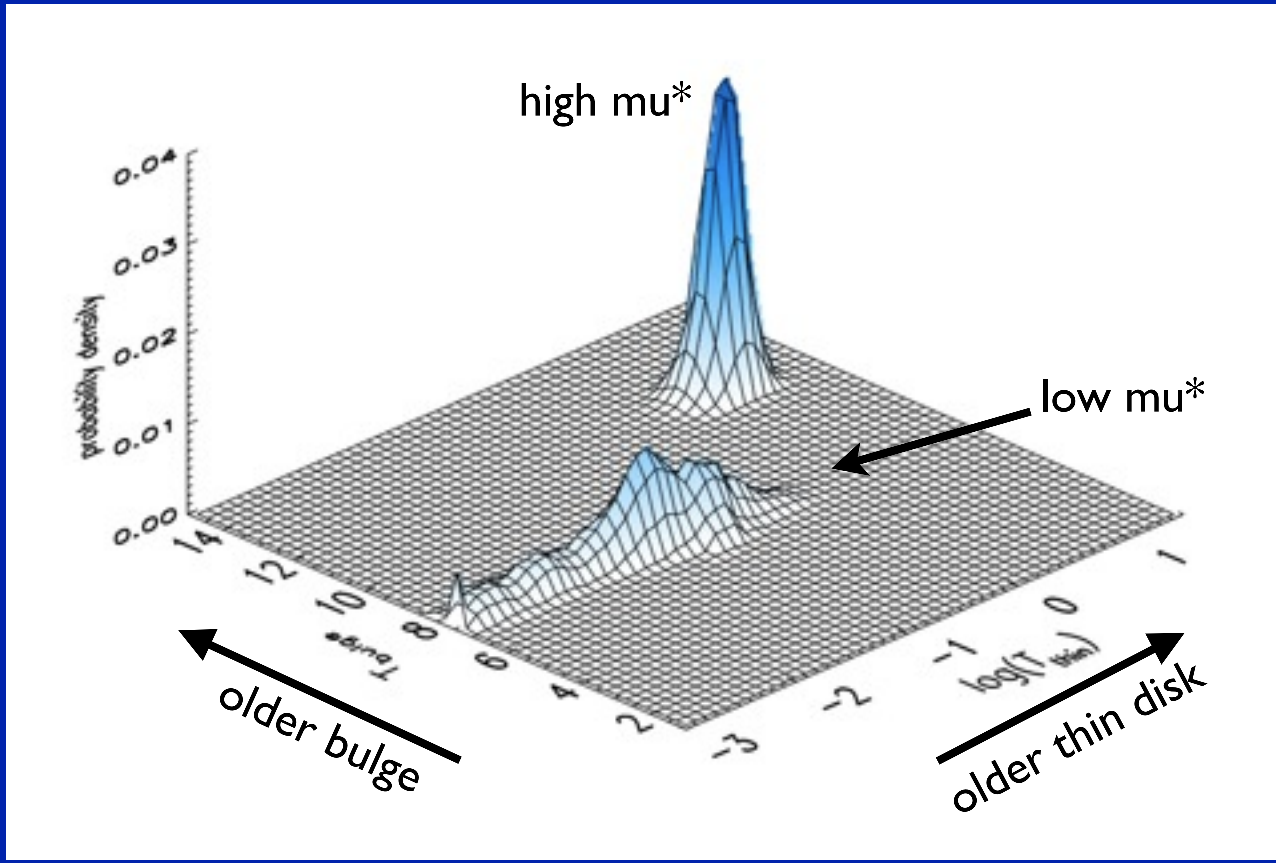




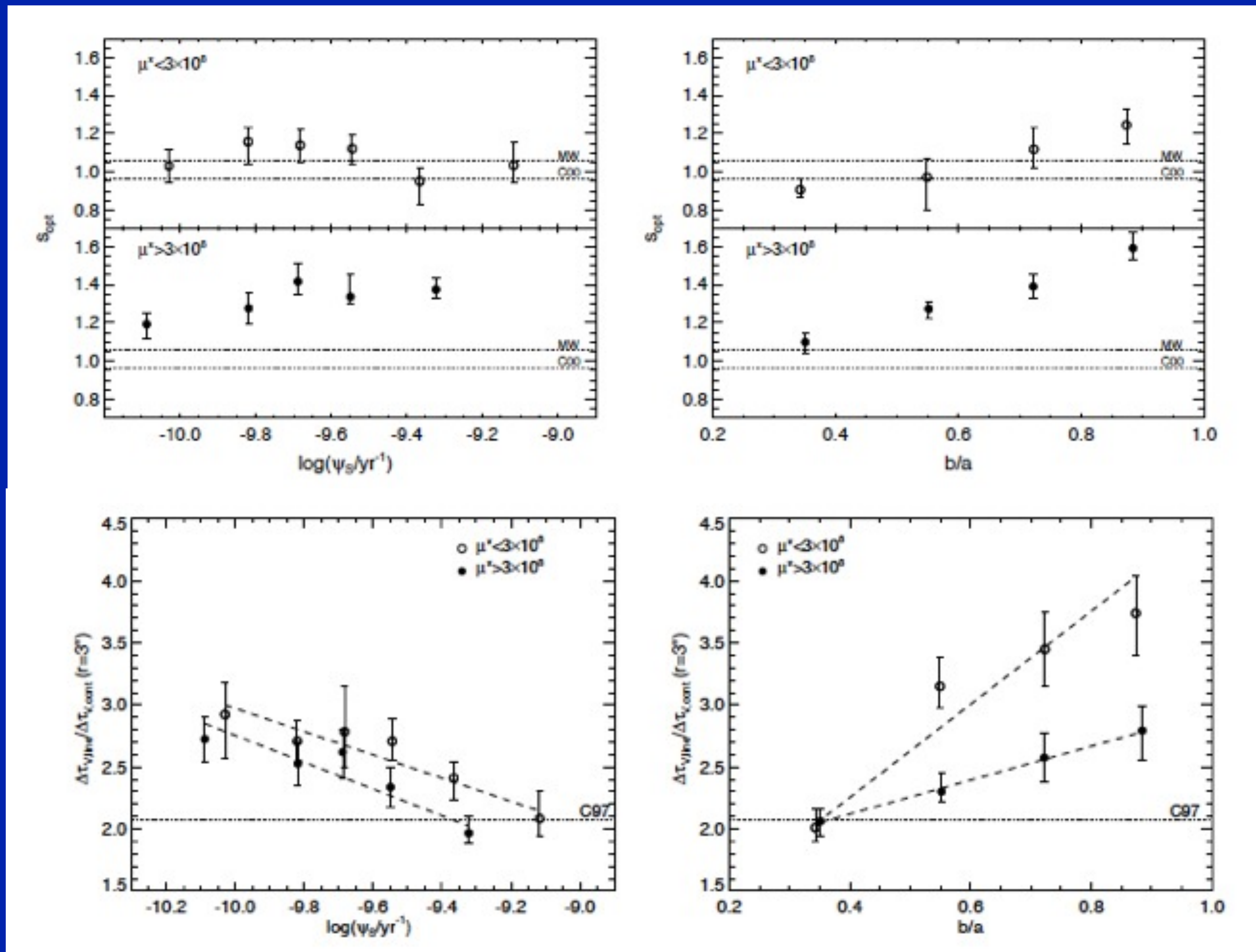
Dust attenuation: results

- Observed relations can be well fitted by our dust models
- Can account for physical origin of trends as a pure **geometrical effect**
- Both the line-to-continuum attenuation AND the optical slope are well reproduced

↓

Valuable constraints on the amount AND geometry of dust attenuation

Dust attenuation: results



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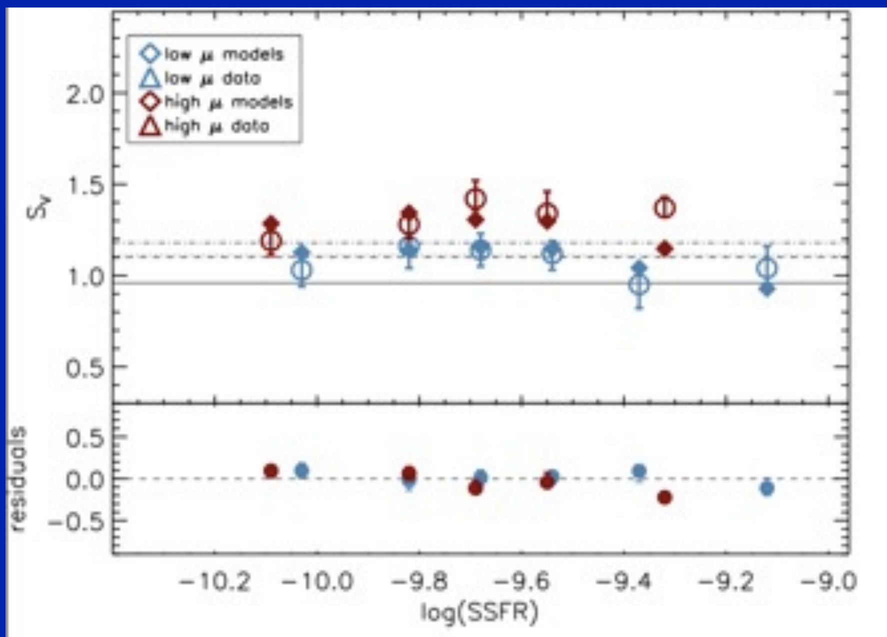

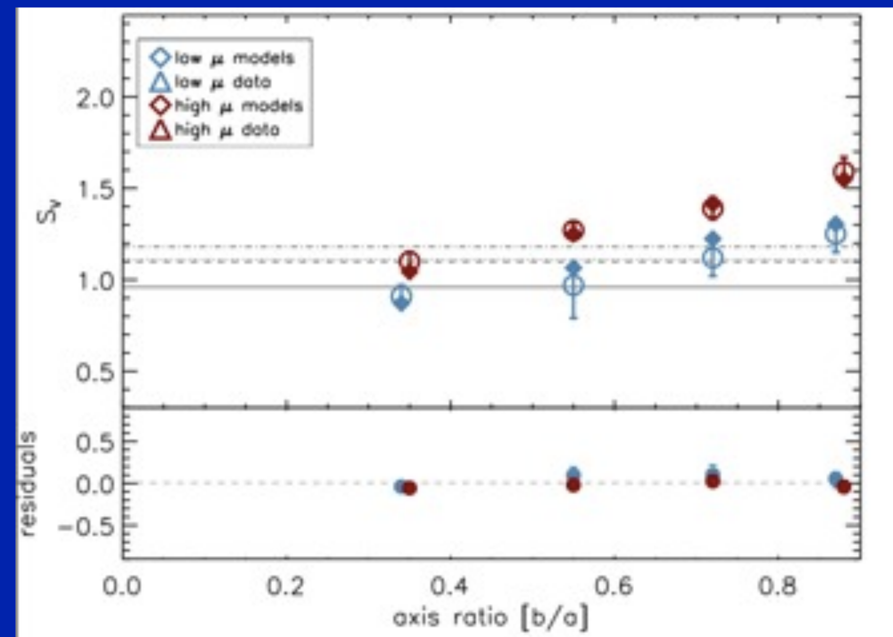

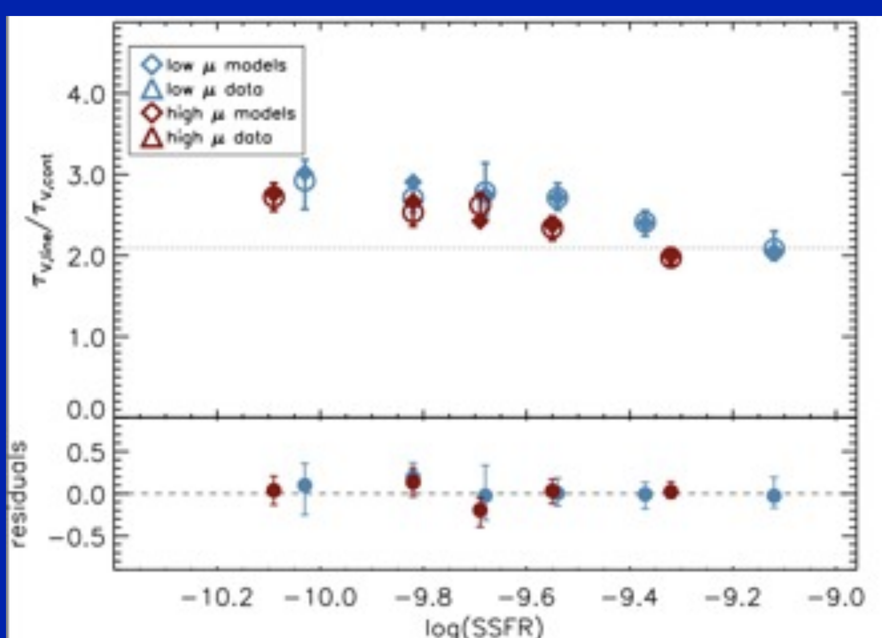

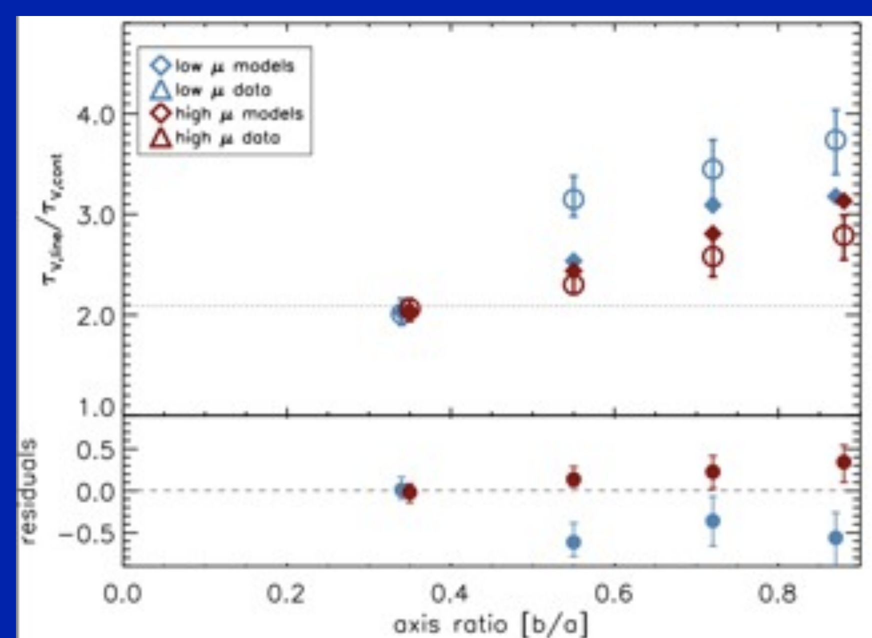

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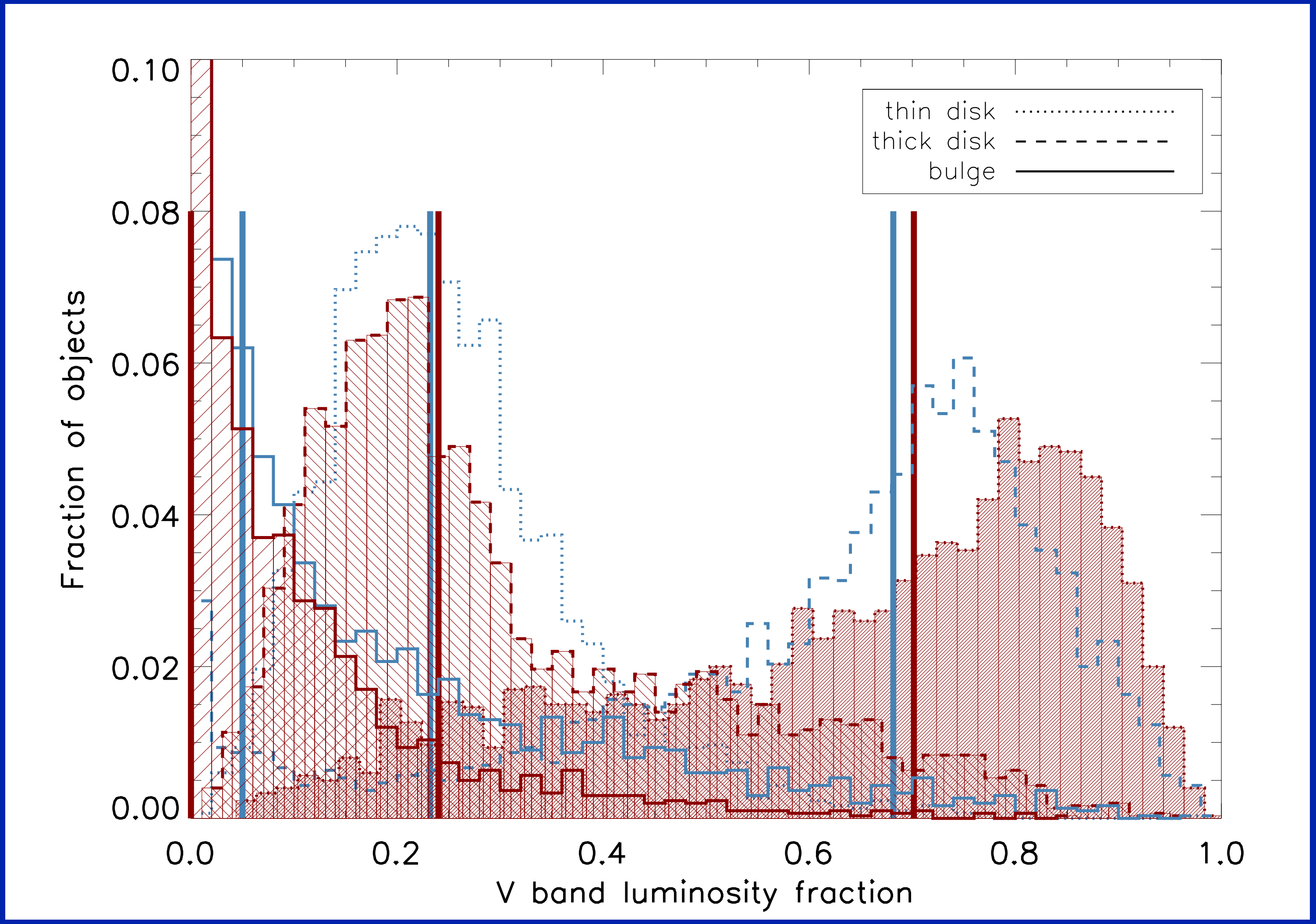

- Our analysis indicates that early / late type spirals have different dust distributions
- High mu* sample: thin disk-like geometry, so stars and dust are well mixed
- Low mu* sample: thick disk-like geometry, so stars have a larger scale height than the dust disk

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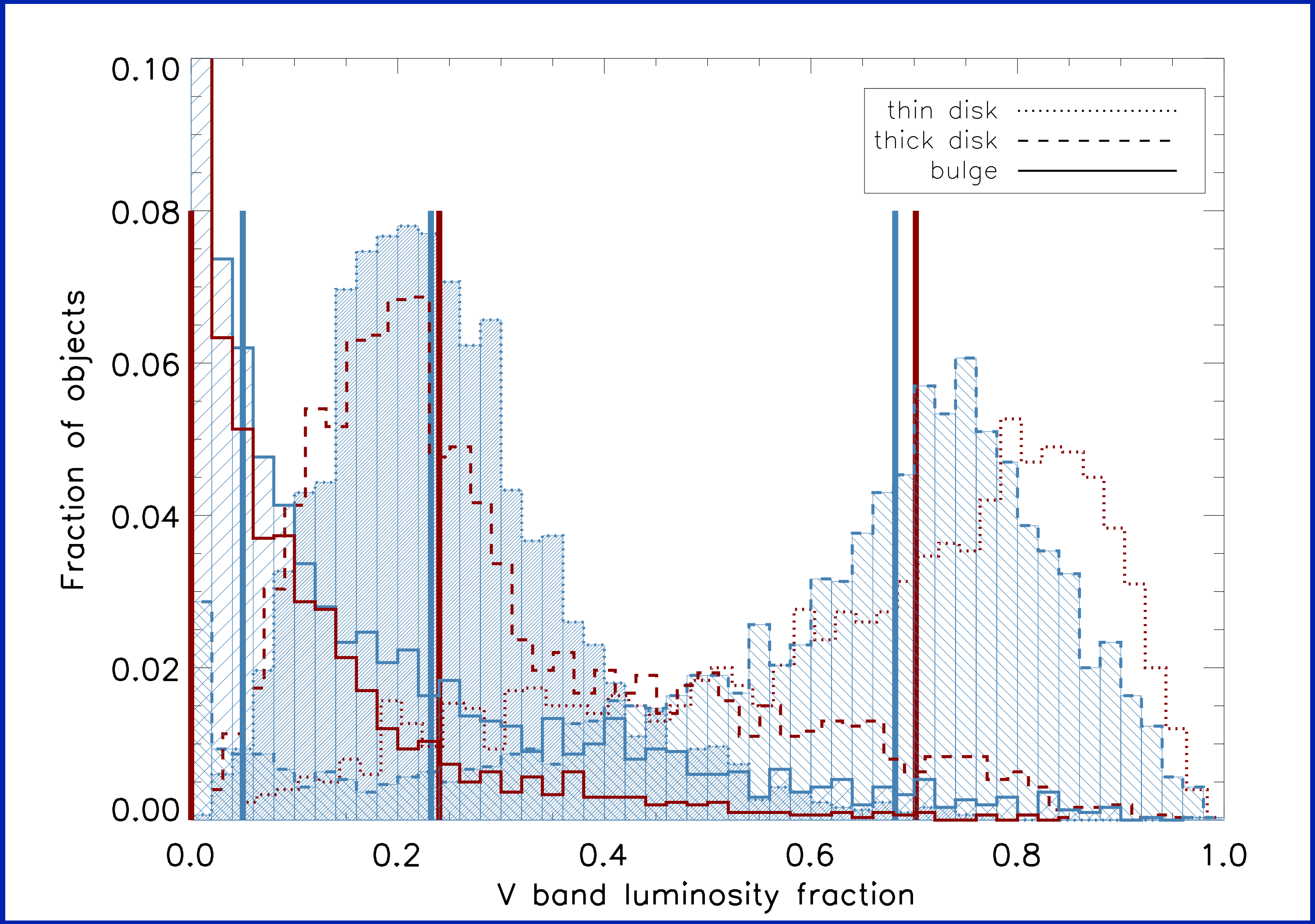

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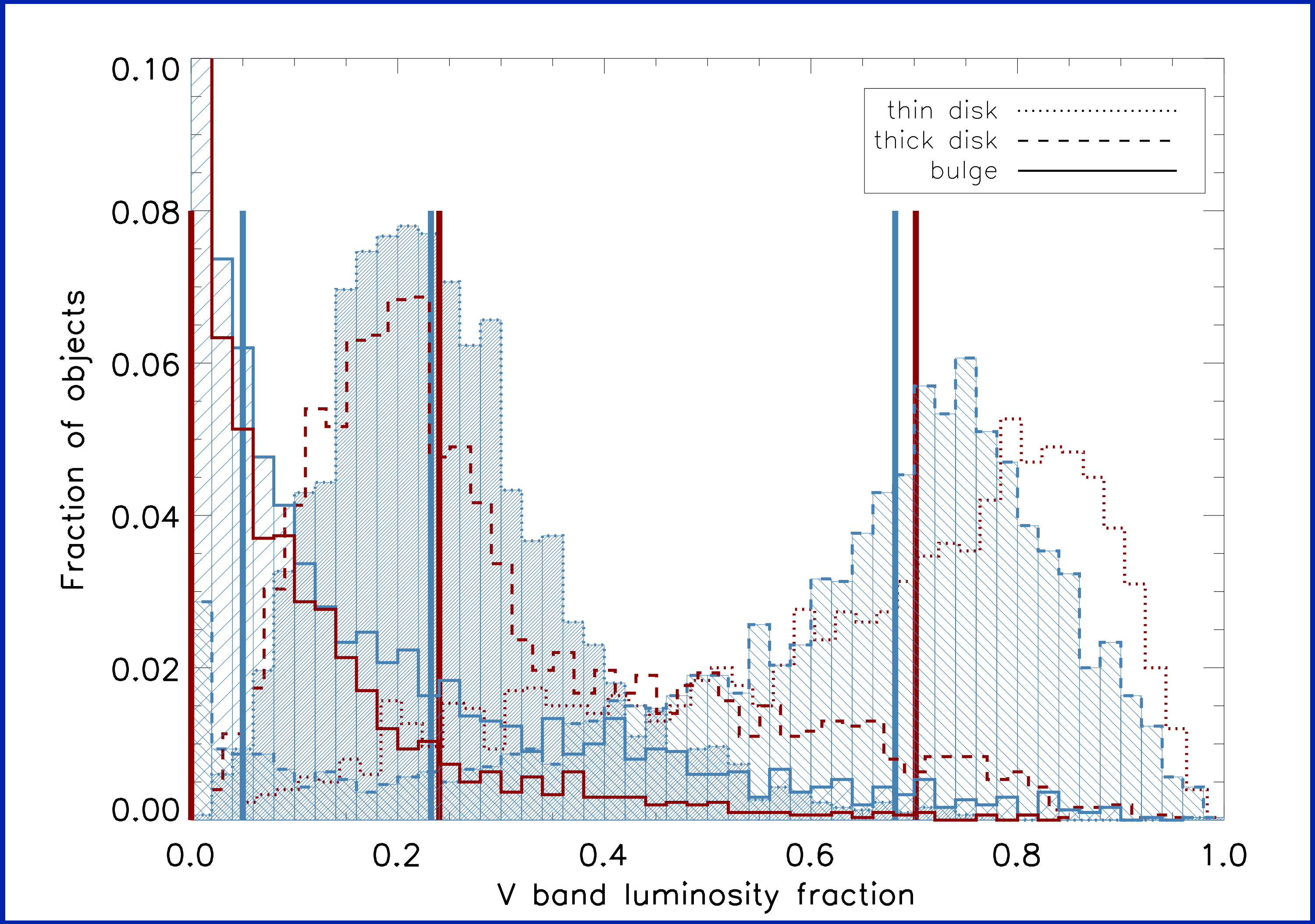

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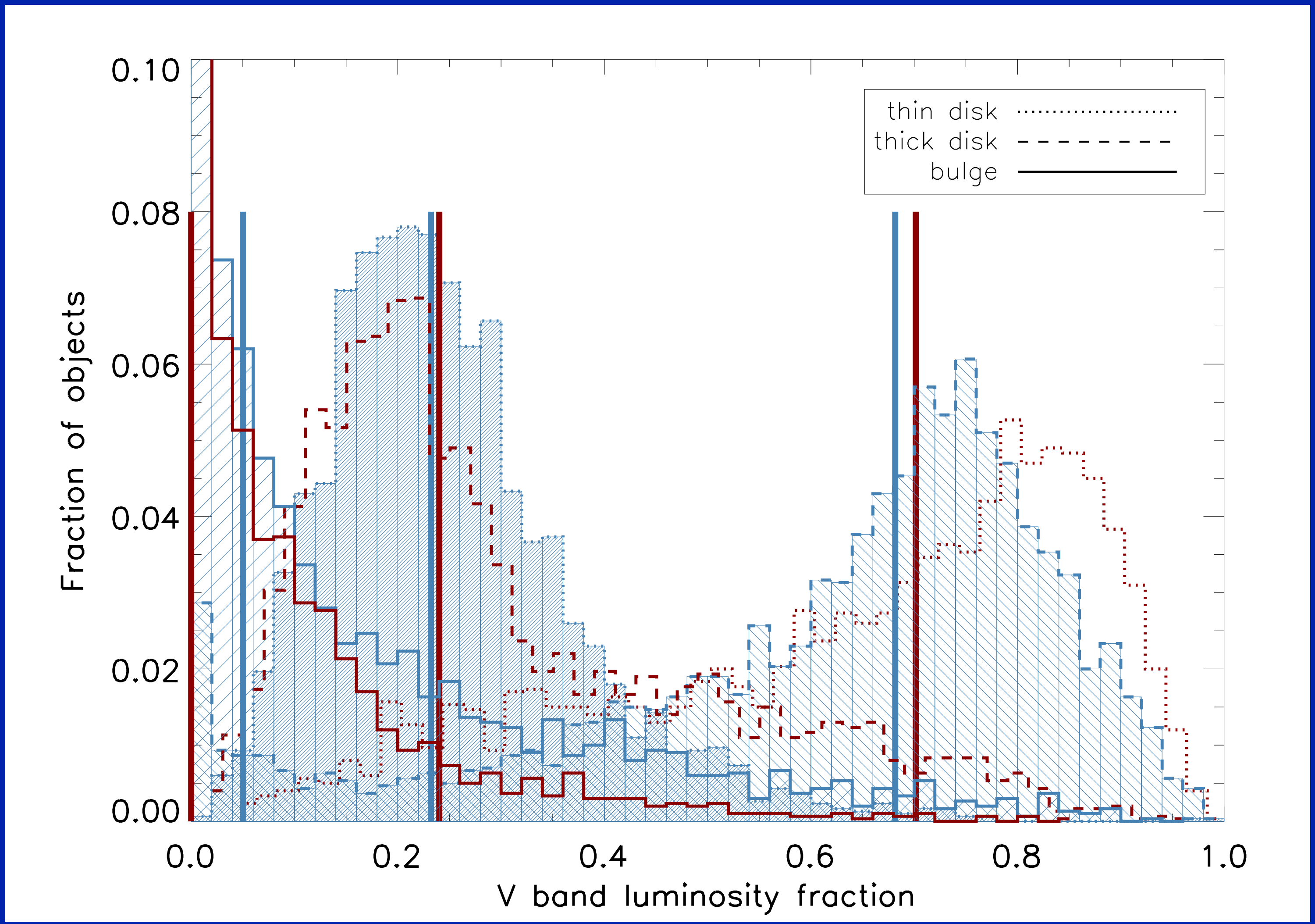
Dust attenuation: results



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Ongoing work, possible explanations:

- Effect of the bulge
- Related to the past mass assembly (quiescent vs starbursting)
- Gas / dust physics (turbulence, formation and disruption of dust lanes)

Dust attenuation: effect on galaxy colors

Which is the effect of such dust prescriptions on galaxy colors?
Use the already built model library!

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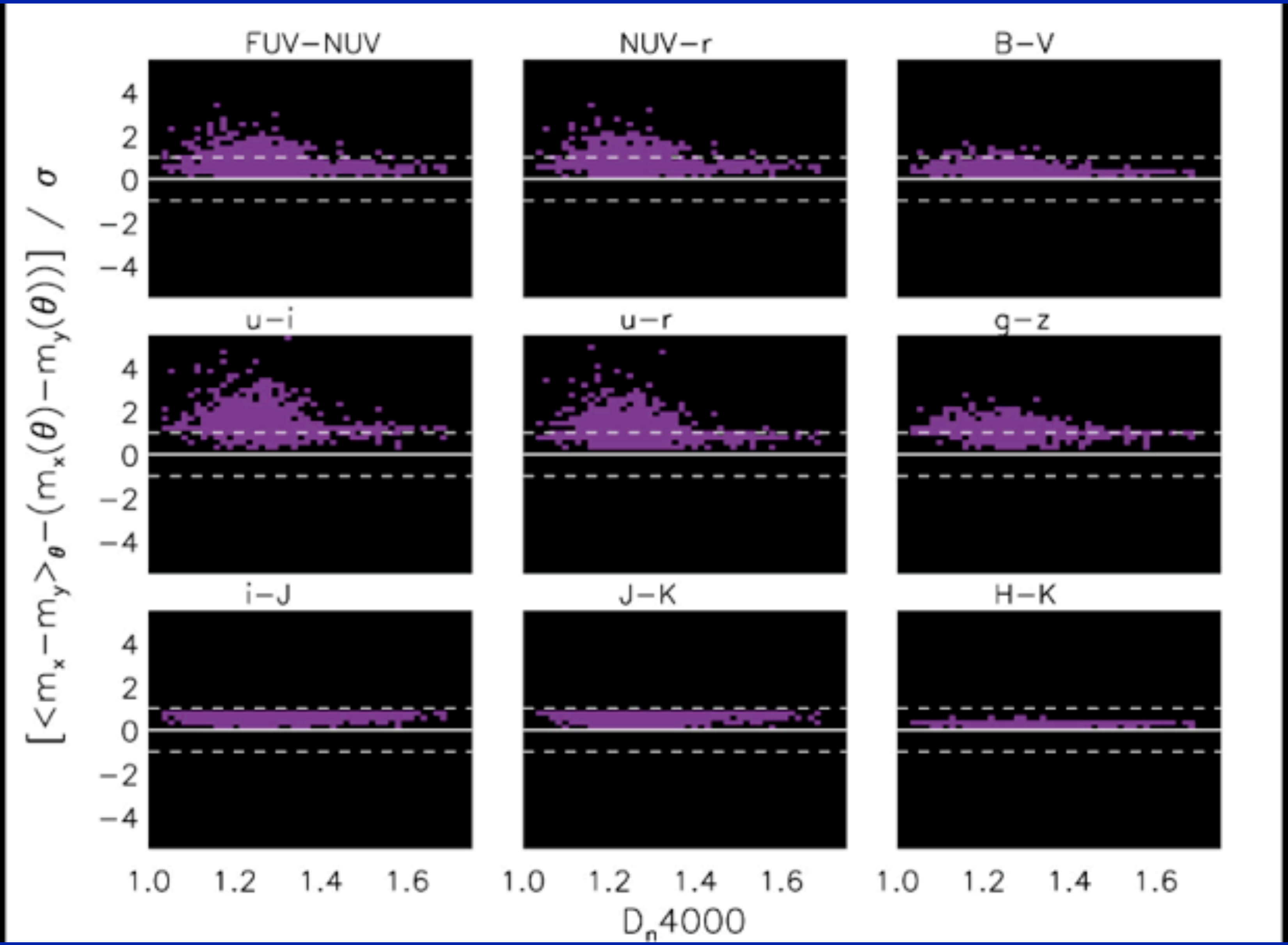

Dust attenuation: conclusions and future work

Conclusions:

- Observations have revealed for the first time a clear trend between the slope of the attenuation curve and galaxy inclinations
- Spectral evolution models coupled with radiative transfer calculations can explain such trend as a pure geometrical effect:
  - ➡ Late spirals: dust distributed in lanes
  - ➡ Early spirals: dust and stars well mixed
- The inclusion of such new prescriptions in spectral models will improve the physical parameter estimates, or, for instance, reduce the errors in photometric redshift determinations

Future work:

- Find the physical origin of the different dust spatial distributions

Summary / objectives (1)

- Spectral evolution models are standard tools to interpret observed galaxy spectra, but *their uncertainties have not been precisely evaluated*
- Need to evaluate the contribution by all basic ingredients of the models to the final error budget, in a “physically” motivated way
- New generation of spectral evolution models will include tools to quantify their uncertainties in any specific application

Summary / objectives (2)

- **Dust**: geometry strongly modifies the attenuation laws, needs to take into account this effect
- **Dust**: new set of prescriptions soon published in a paper
- **IMF**: use of optical absorption to constraint the IMF in distant galaxies (with M. Koleva, G.Bruzual, J. Silk, SC and P. Prugniel)
- **Spectral libraries:** calibration and coverage of parameter space: which is the best one?

Thanks!