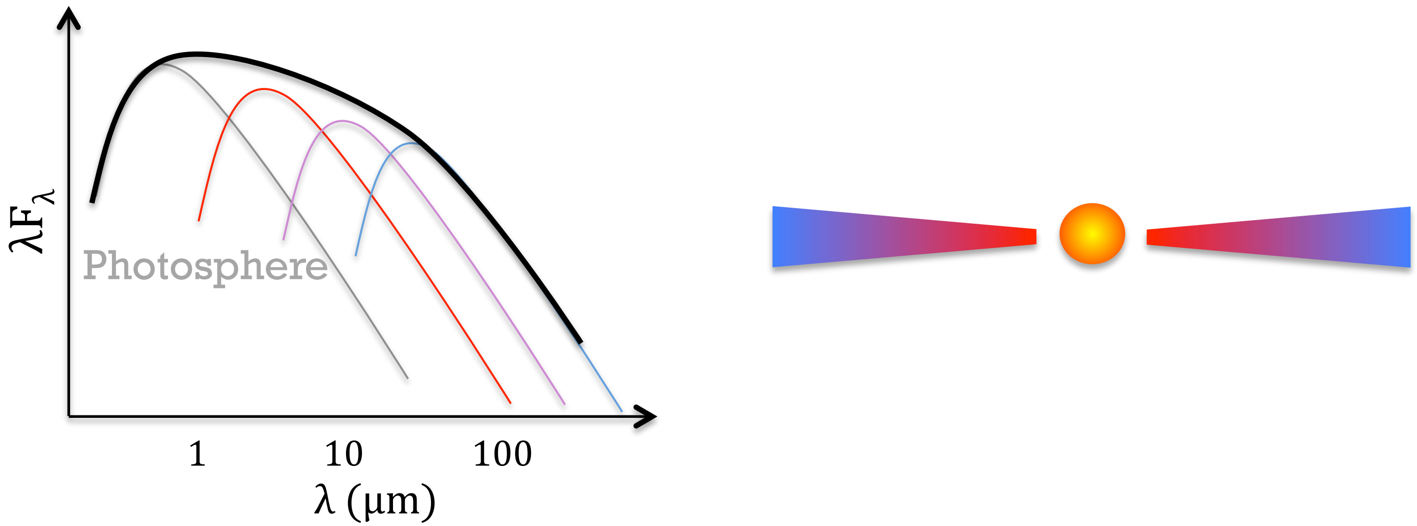
Modeling the outer regions of TRANSITIONAL DISKS *with* HERSCHEL

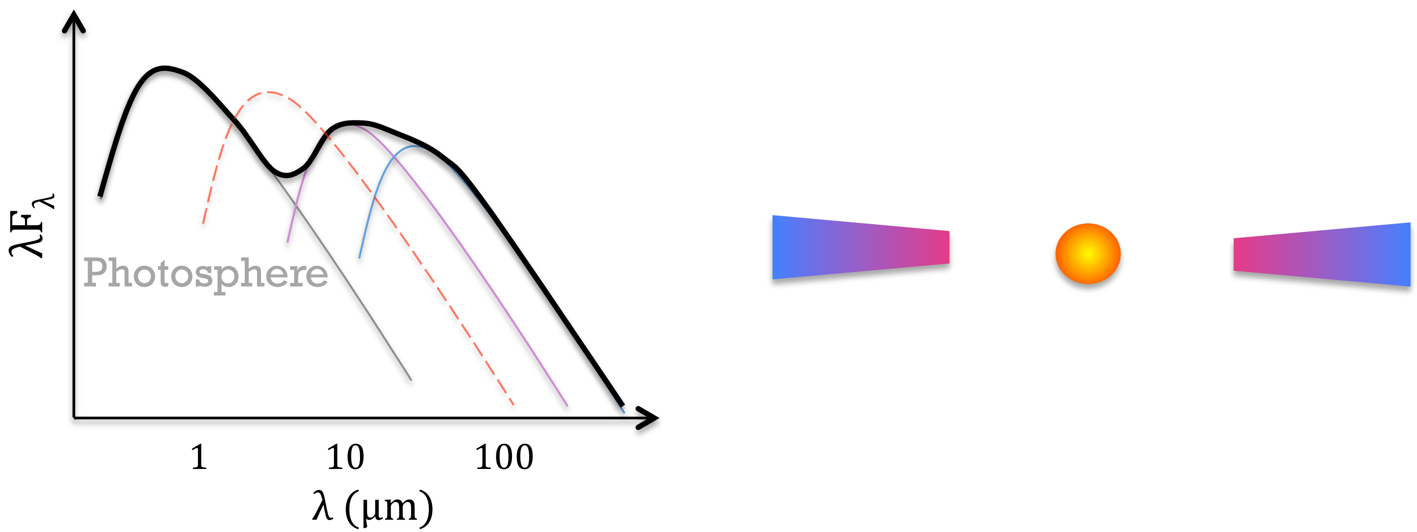
Álvaro Ribas (ESAC) @astroribas

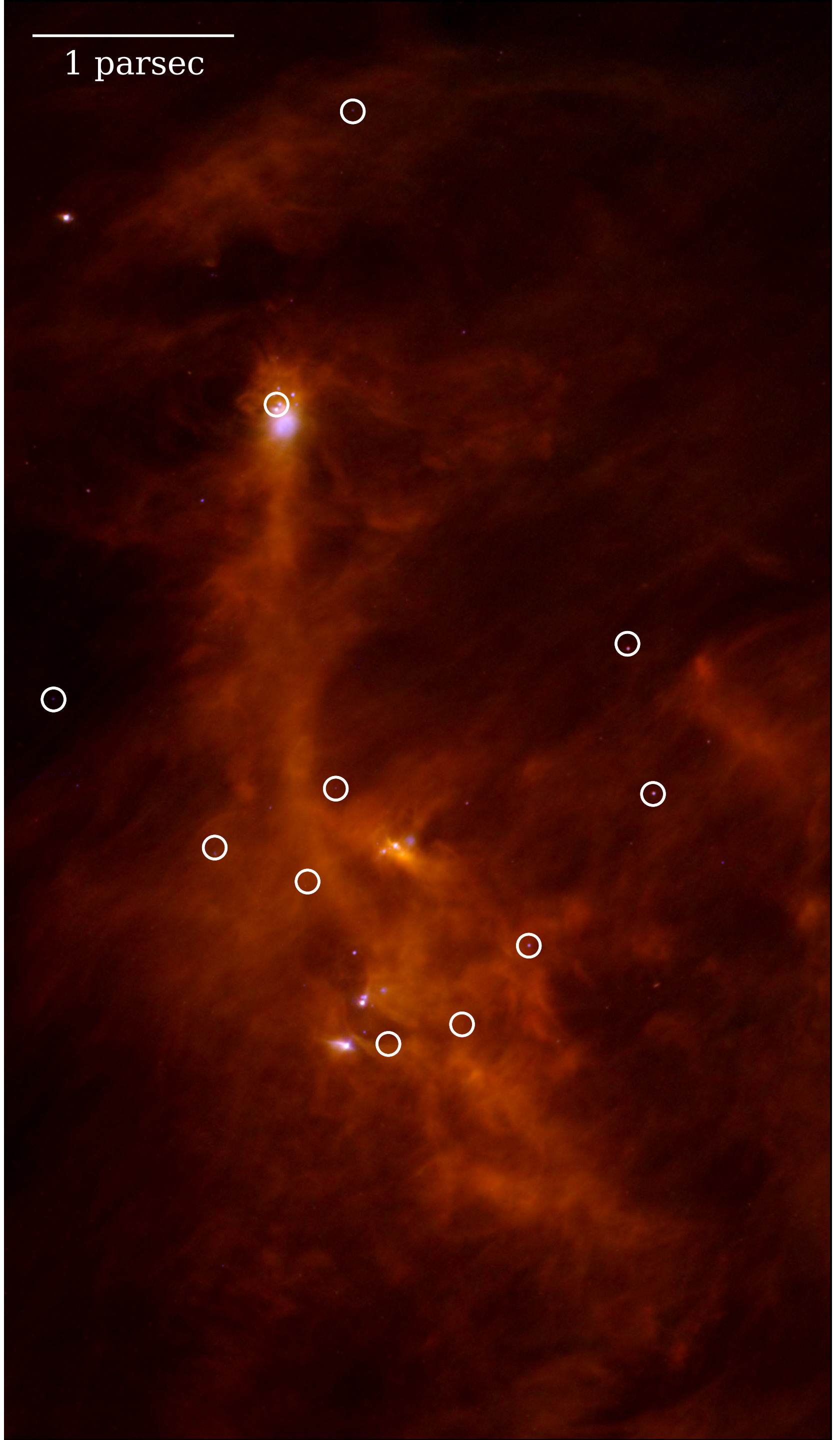
Bruno Merín (ESA, ESAC) *Hervé Bouy* (CAB, ESAC)
Isabel Rebollido (ESAC) *Gaspard Duchêne* (Berkeley) *Pablo Riviere* (ESA, ESAC)

ALMA/Herschel Archival Workshop 2015, Garching

Transitional disks *are protoplanetary disks with* gaps

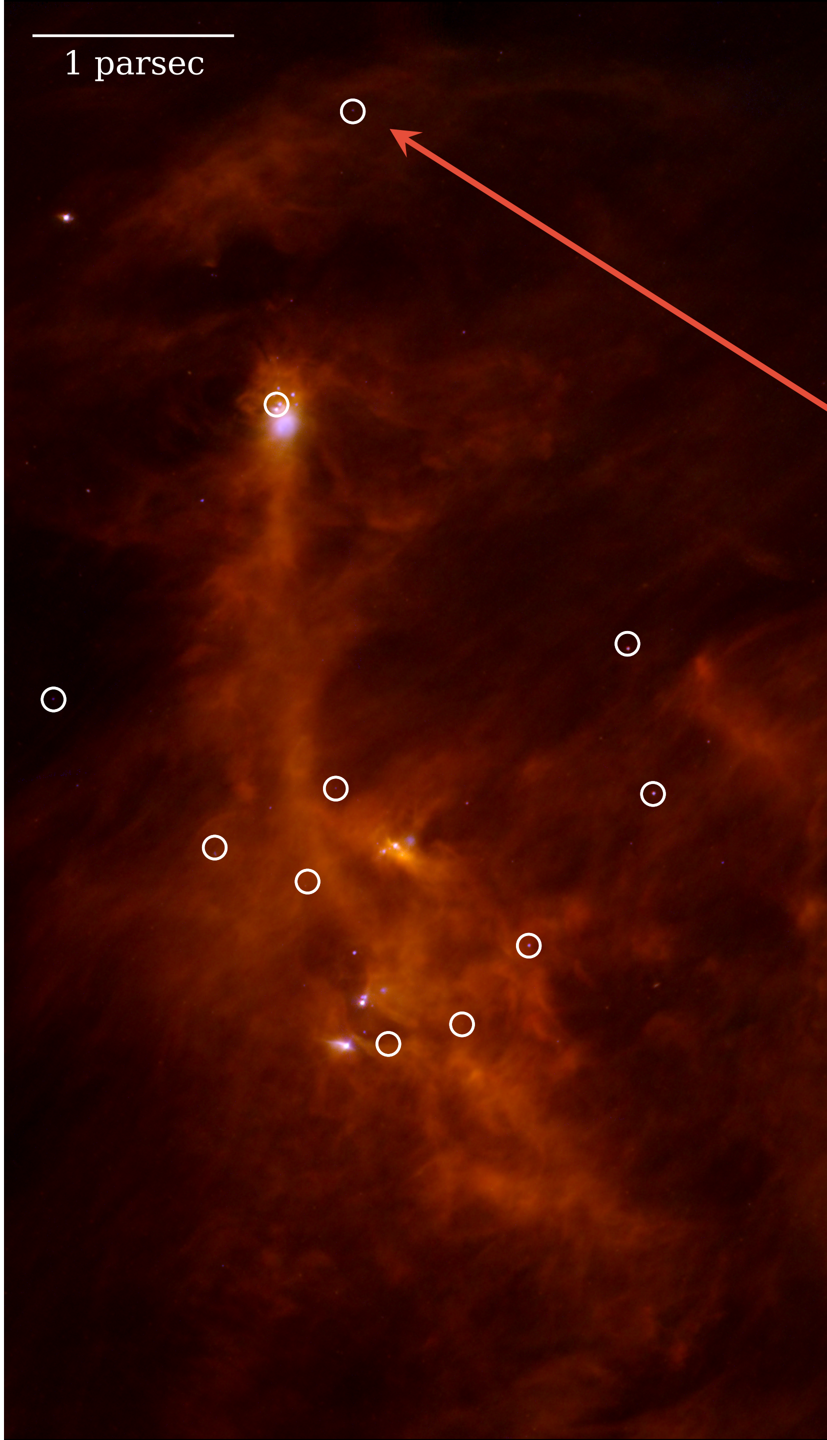




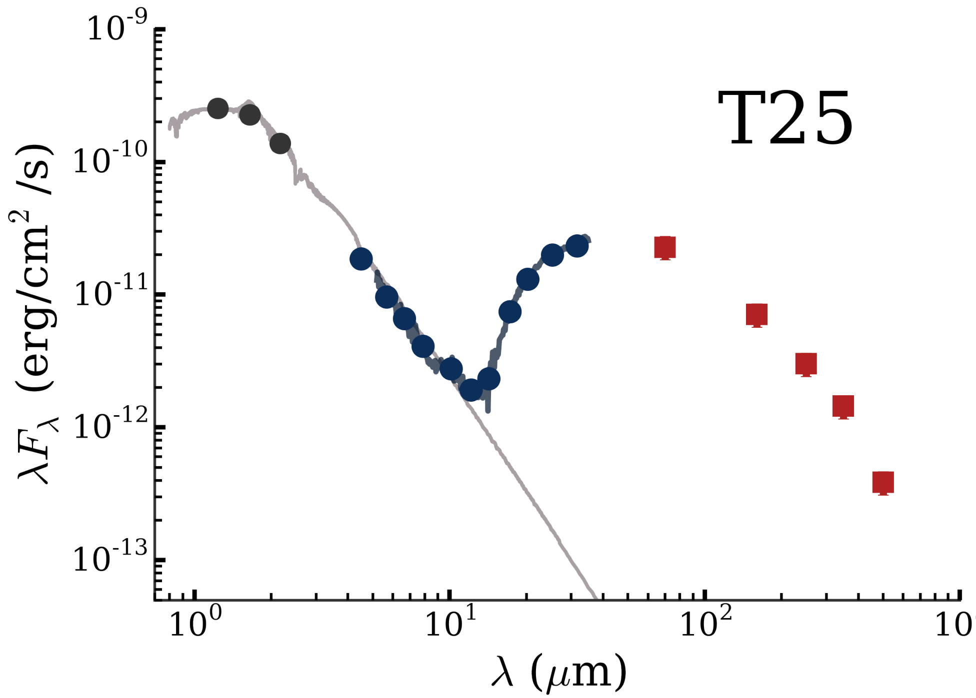


Transitional disks *in* Chamaeleon-I

Ribas et al. 2013



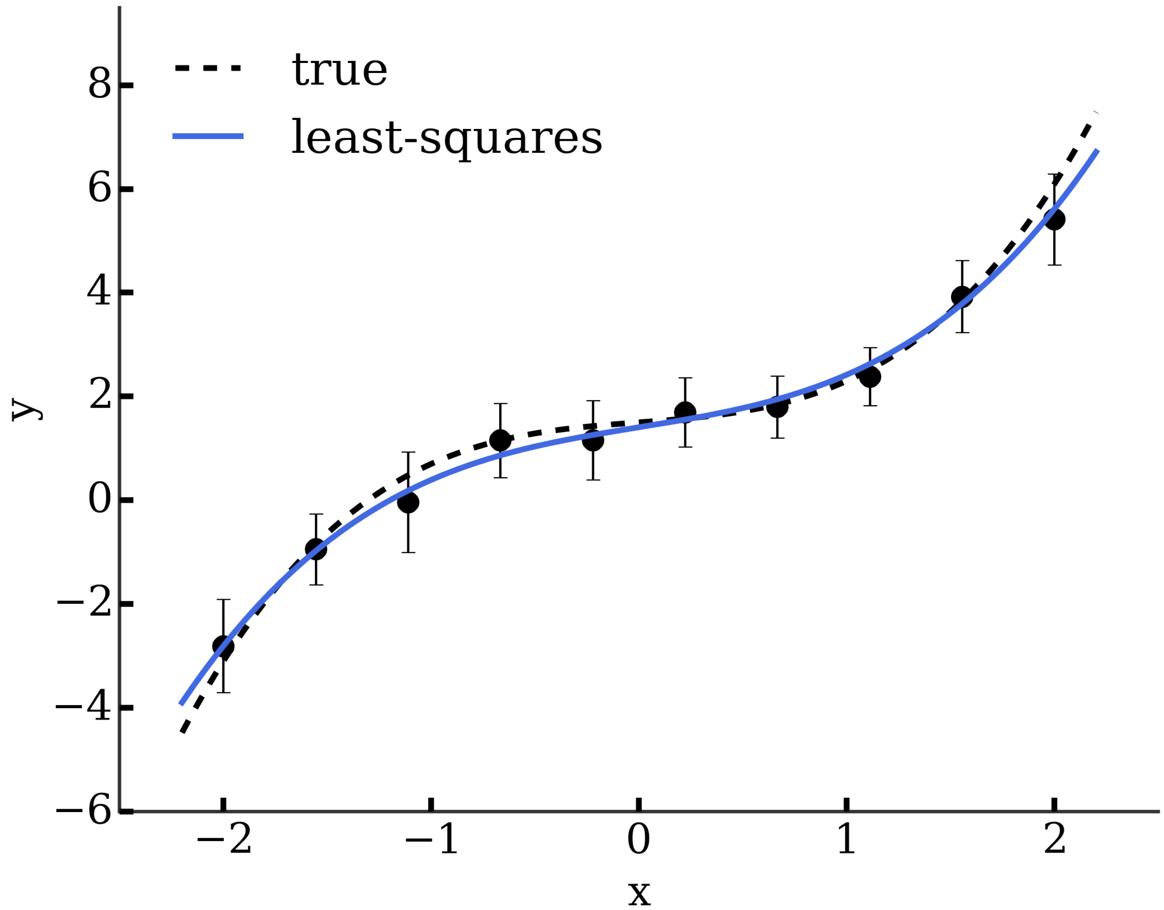
Transitional disks *in* Chamaeleon-I



Ribas et al. 2013

What is the real contribution *of* Herschel *to our knowledge of* transitional disks*?*

$$f(x) = a + b\,x + c\,x^3$$



$a\ (true) = 1.5$

$b\ (true) = 0.3$

$c\ (true) = 0.5$

Least-squares fit:

$a = 1.41$

$b = 0.65$

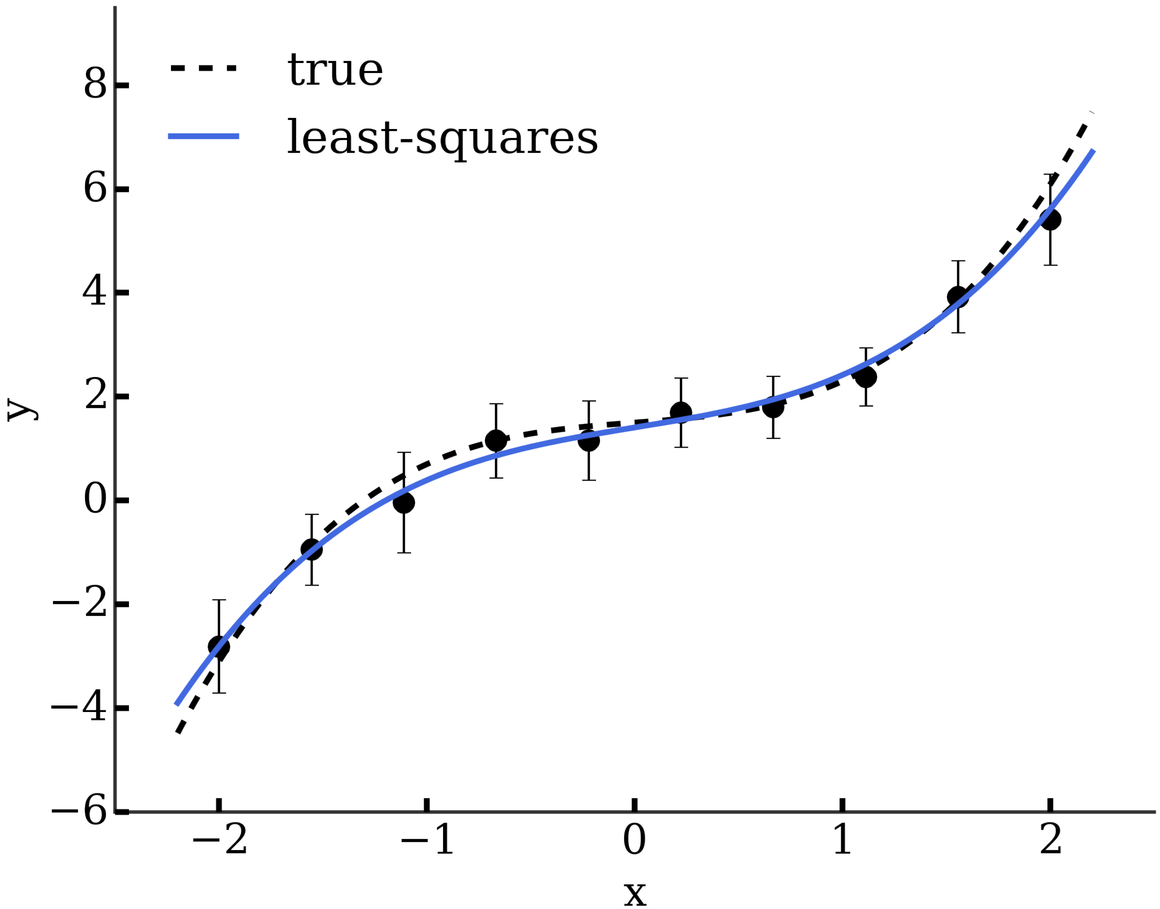
$c = 0.36$

$$f(x) = a + b\,x + c\,x^3$$

a (*true*) = *1.5*

b (*true*) = *0.3*

c (*true*) = *0.5*



Least-squares fit:

a = *1.41* ± *???*

b = *0.65* ± *???*

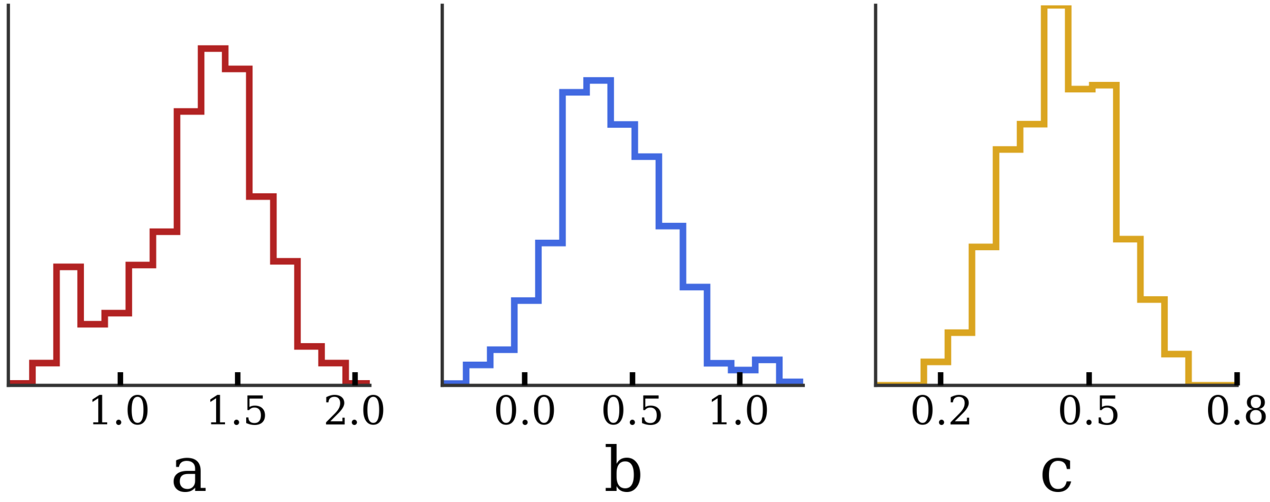
c = *0.36* ± *???*

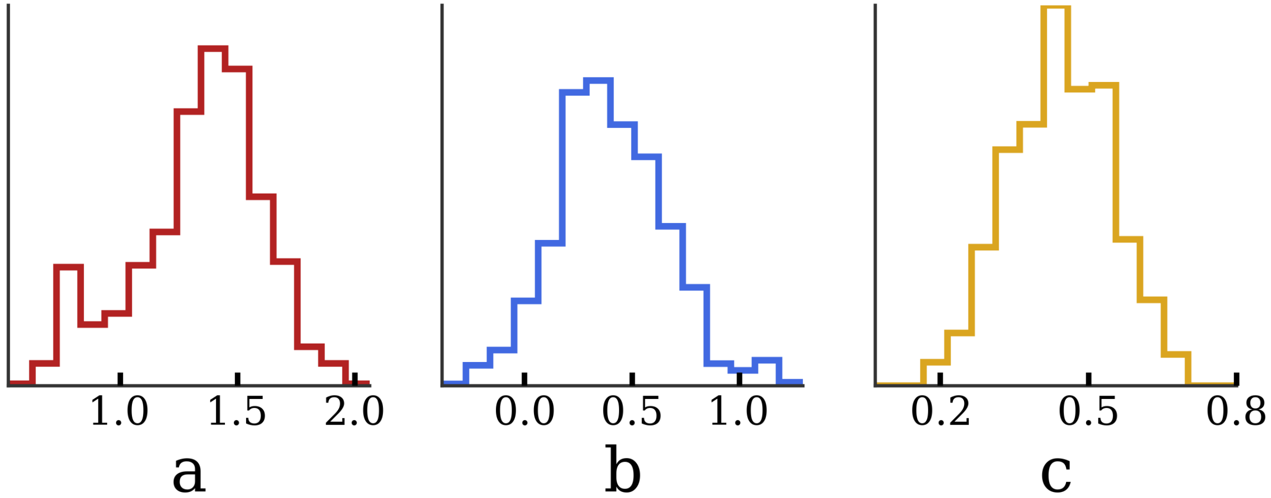
THIS IS CHEATING!

a ~ *1.41*

b ~ *0.65*

c ~ *0.36*

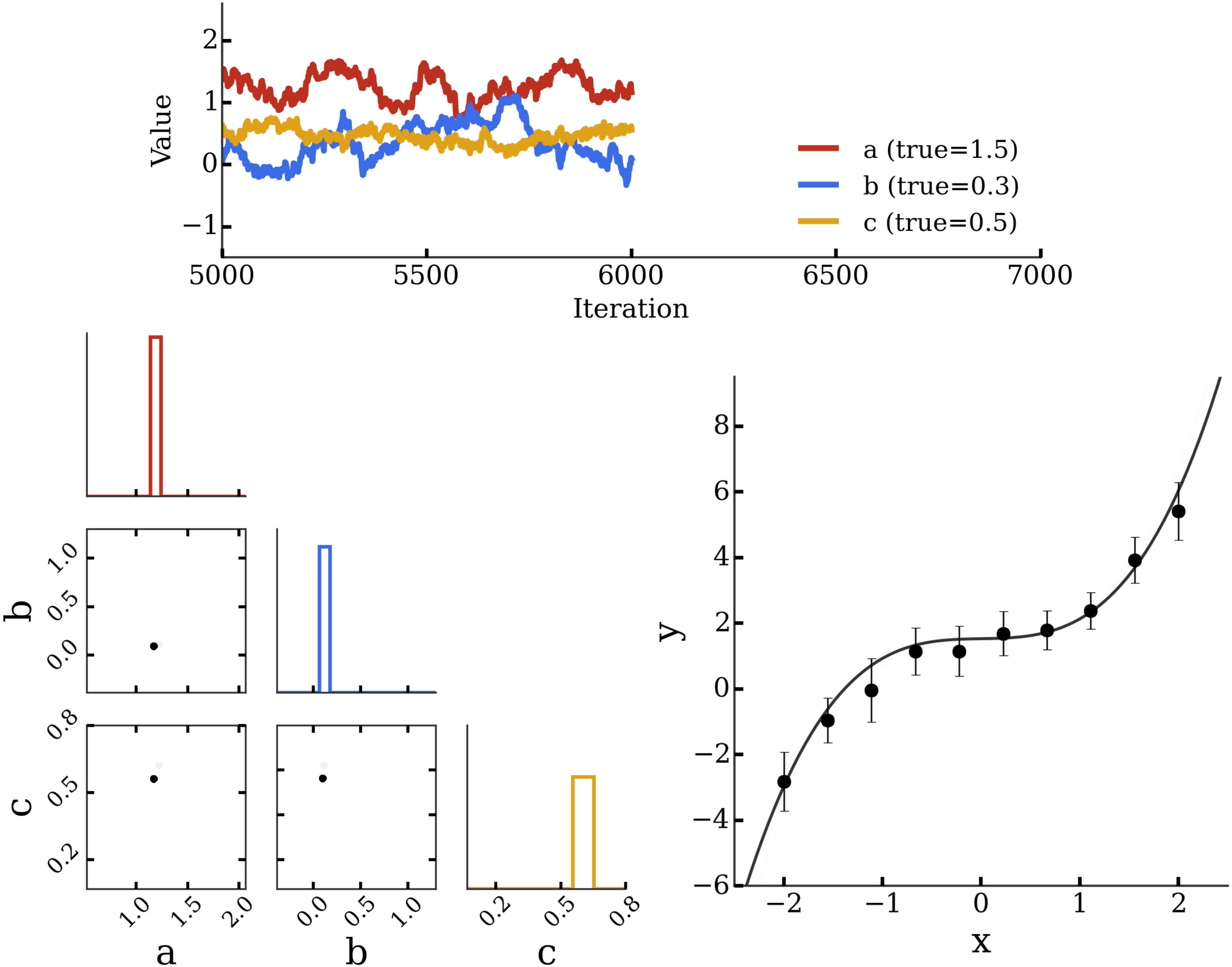

1.0
1.5
2.0
a
0.0
0.5
1.0
b
0.2
0.5
0.8
c



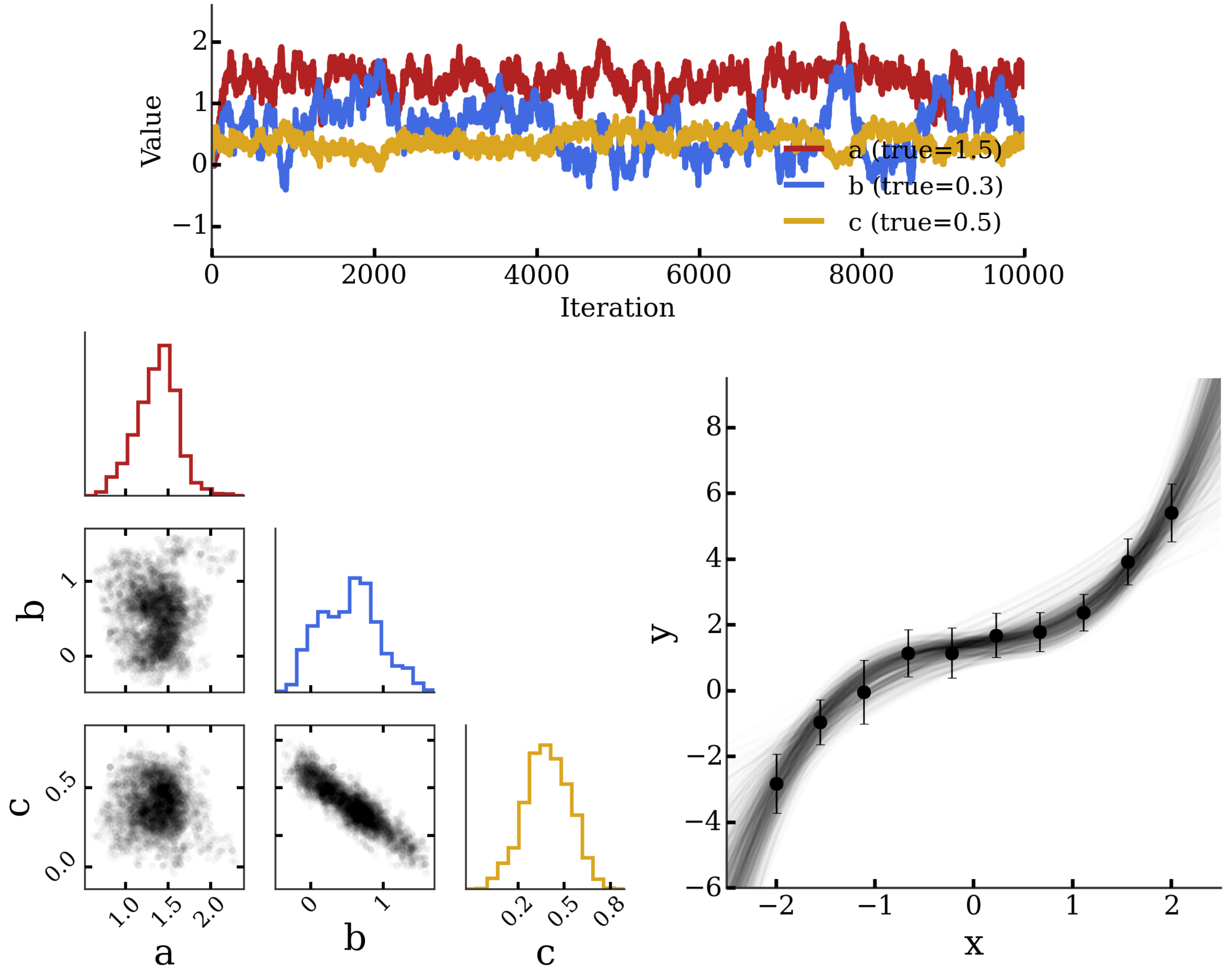
BAYESIAN ANALYSIS

+

MONTE CARLO
MARKOV CHAINS



Value
Iteration
a (true=1.5)
b (true=0.3)
c (true=0.5)
a
b
c
x
y



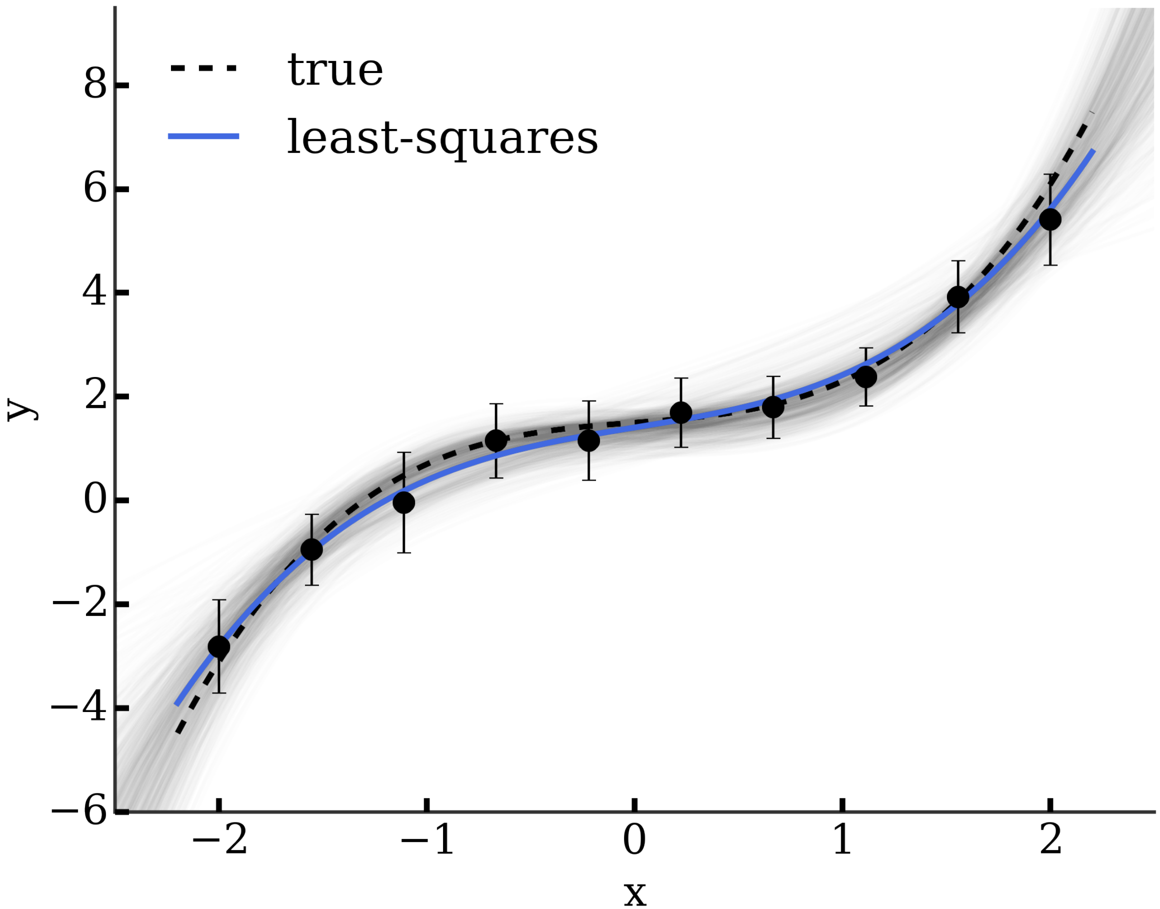
Value
Iteration
a (true=1.5)
b (true=0.3)
c (true=0.5)
0
2000
4000
6000
8000
10000
−1
0
1
2
a
b
c
1.0
1.5
2.0
0
1
0.0
0.5
0.2
0.5
0.8
x
y
−2
−1
0
1
2
−6
−4
−2
0
2
4
6
8

$$f(x) = a + b\,x + c\,x^3$$

$a\ (true) = 1.5$

$b\ (true) = 0.3$

$c\ (true) = 0.5$



Least-squares fit:

$a = 1.41 \pm ???$

$b = 0.65 \pm ???$

$c = 0.36 \pm ???$

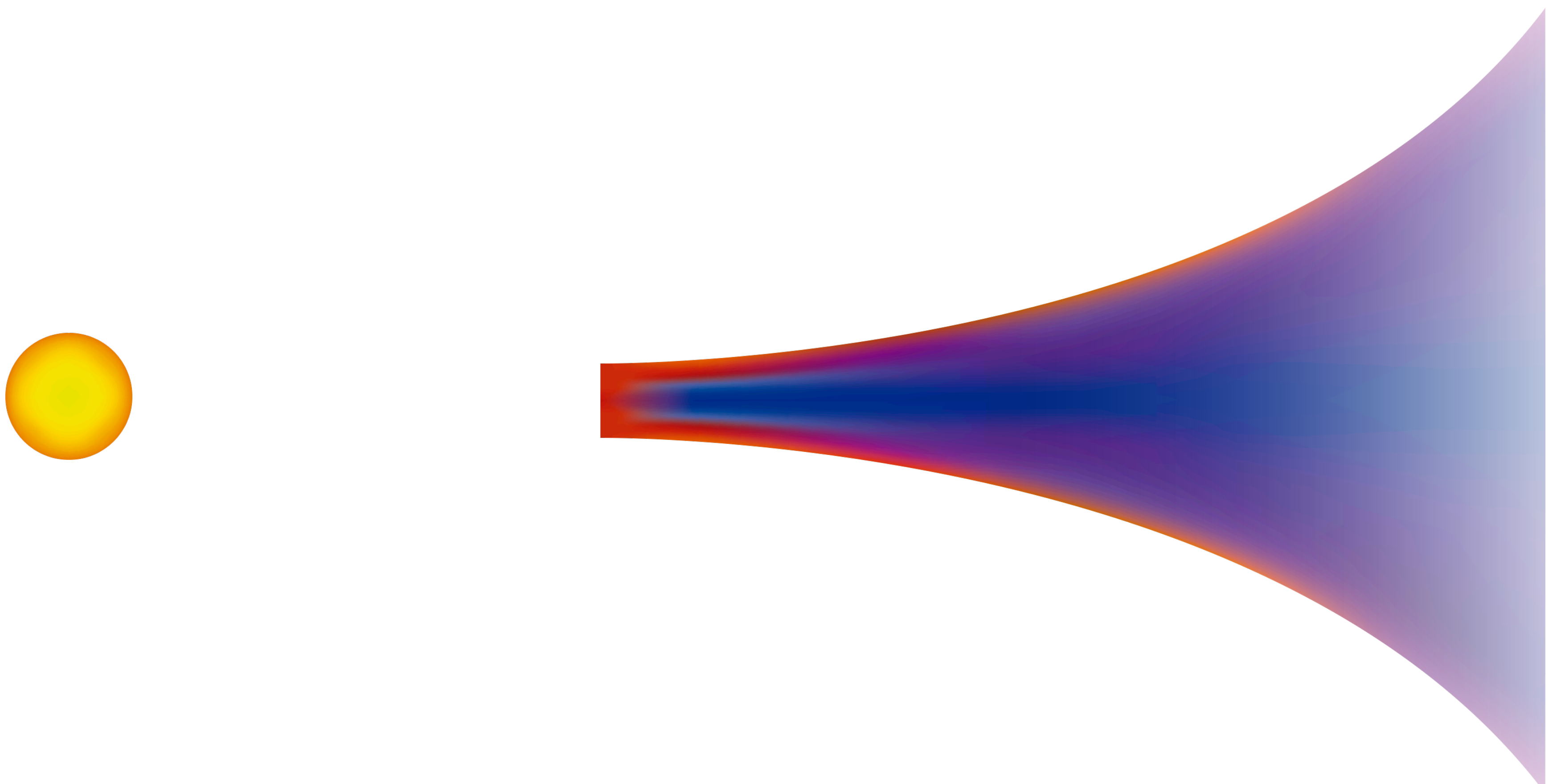
MCMC fit:

$a = 1.39^{+0.22}_{-0.29}$

$b = 0.57^{+1.03}_{-0.50}$

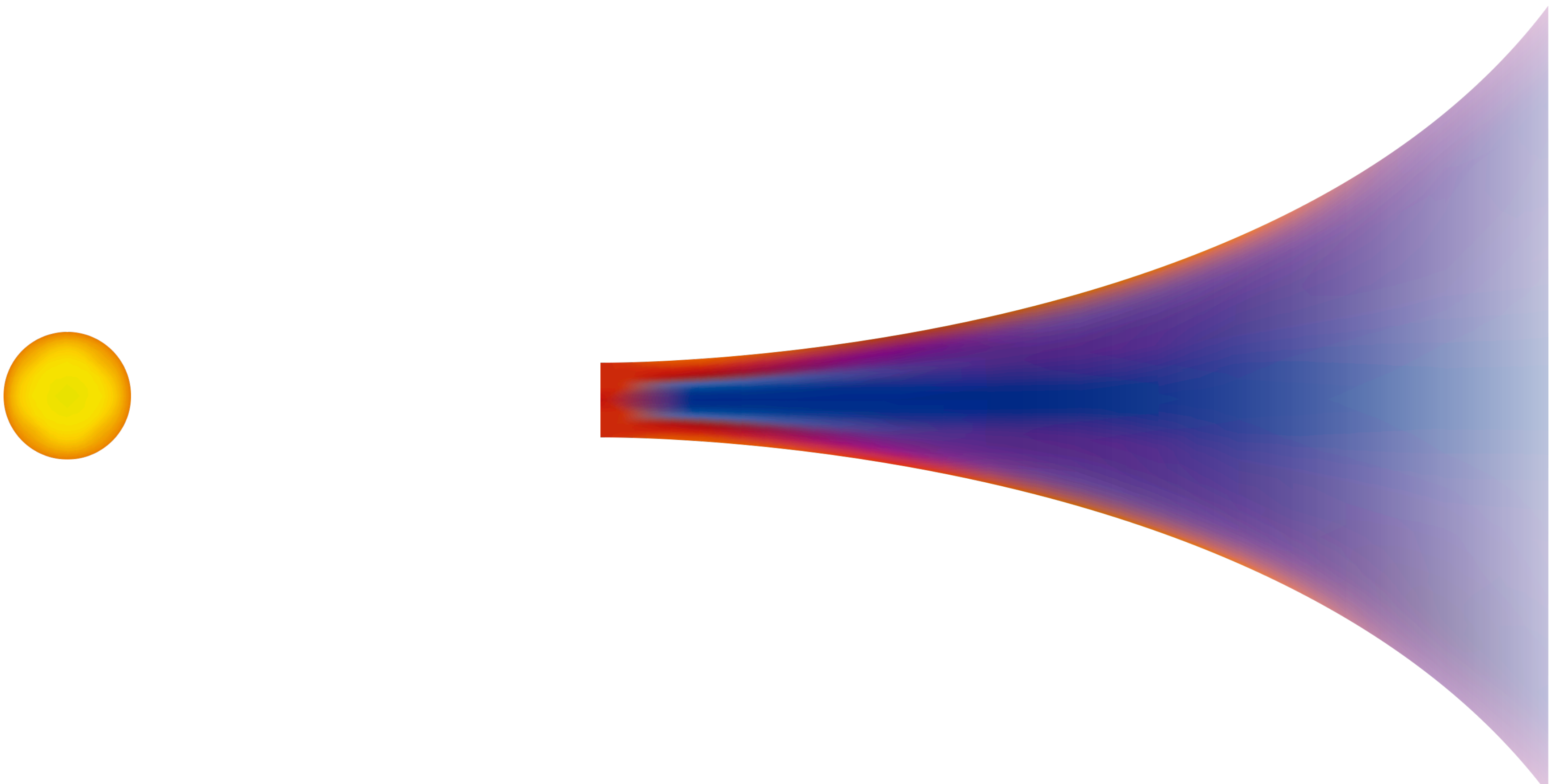
$c = 0.39^{+1.21}_{-0.15}$

A simple disk model



A simple disk model

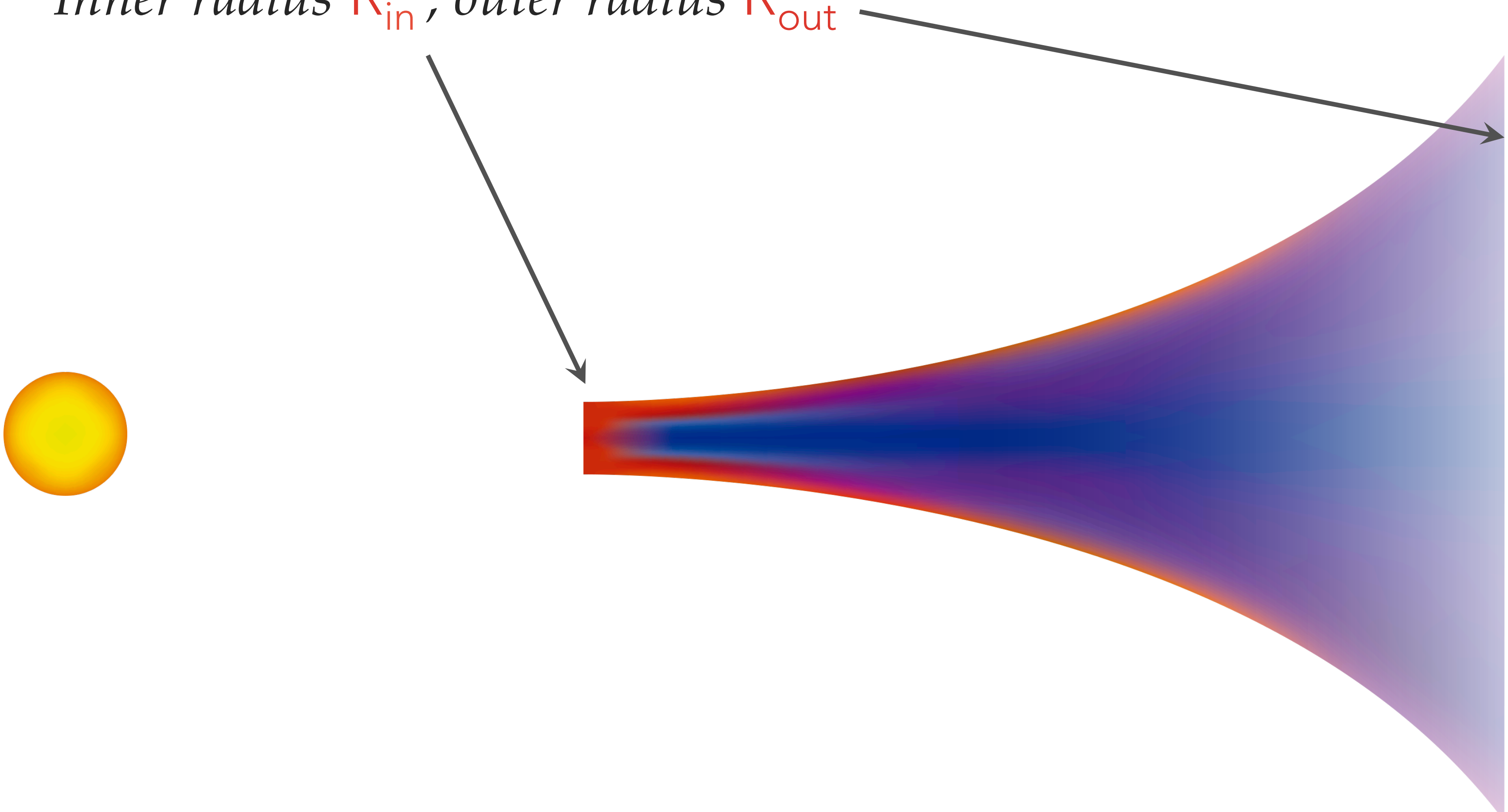
Dust mass M_d



A simple disk model

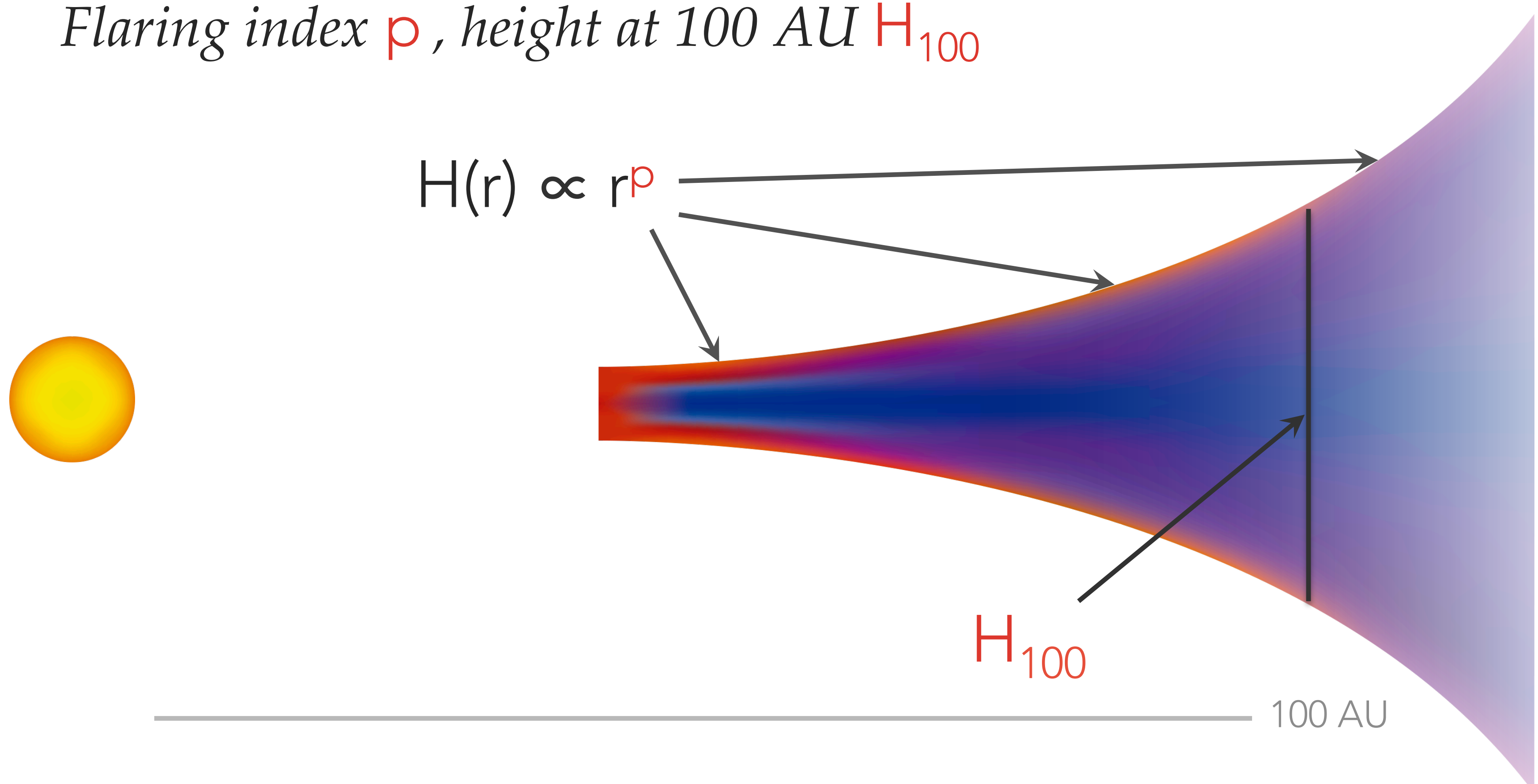
Dust mass M_d

Inner radius R_{in} *, outer radius* R_{out}



A simple disk model

Dust mass M_d
Inner radius R_{in} *, outer radius* R_{out}
Flaring index p *, height at 100 AU* H_{100}



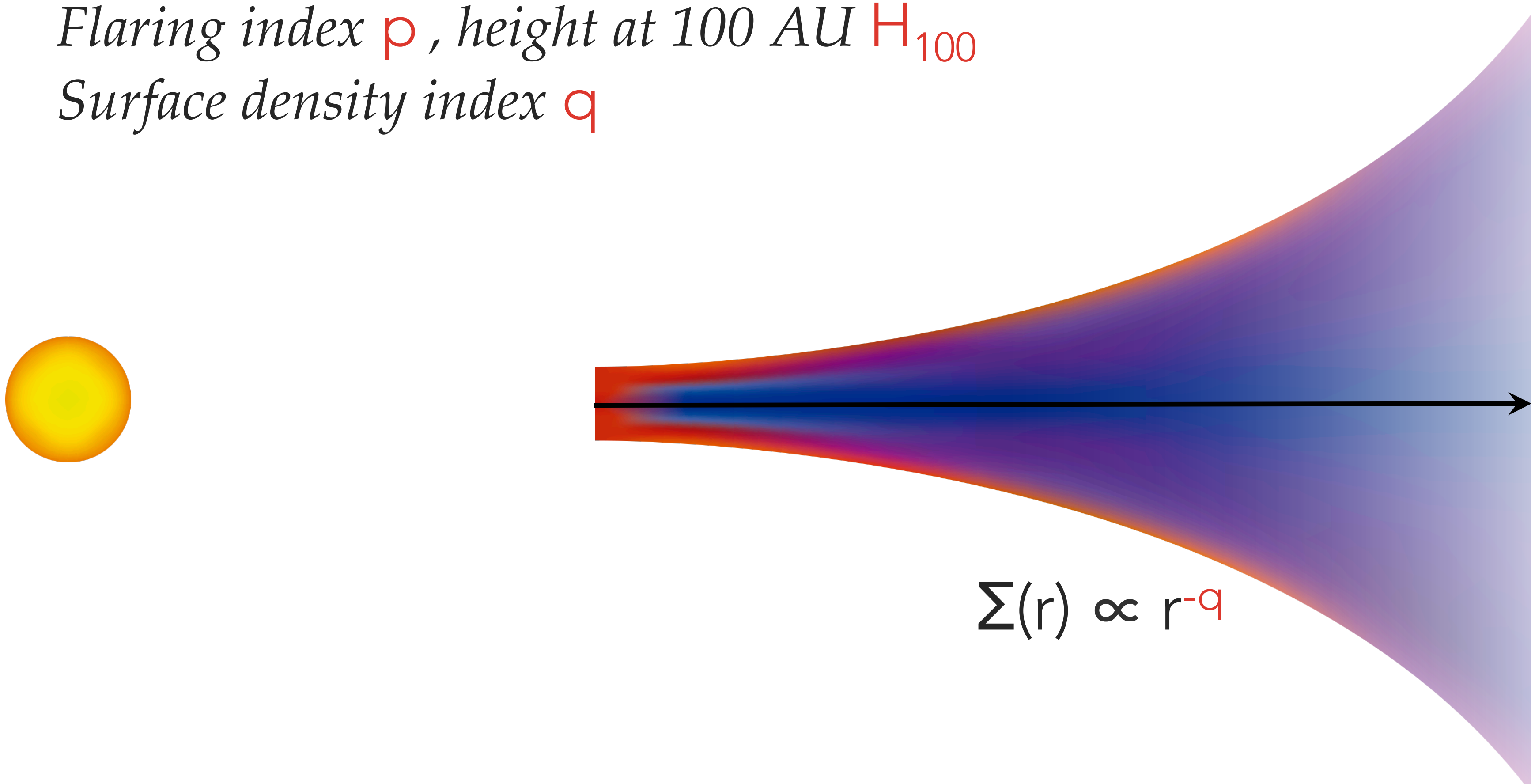
A simple disk model

Dust mass M_d

Inner radius R_{in} *, outer radius* R_{out}

Flaring index p *, height at 100 AU* H_{100}

Surface density index q



A simple disk model

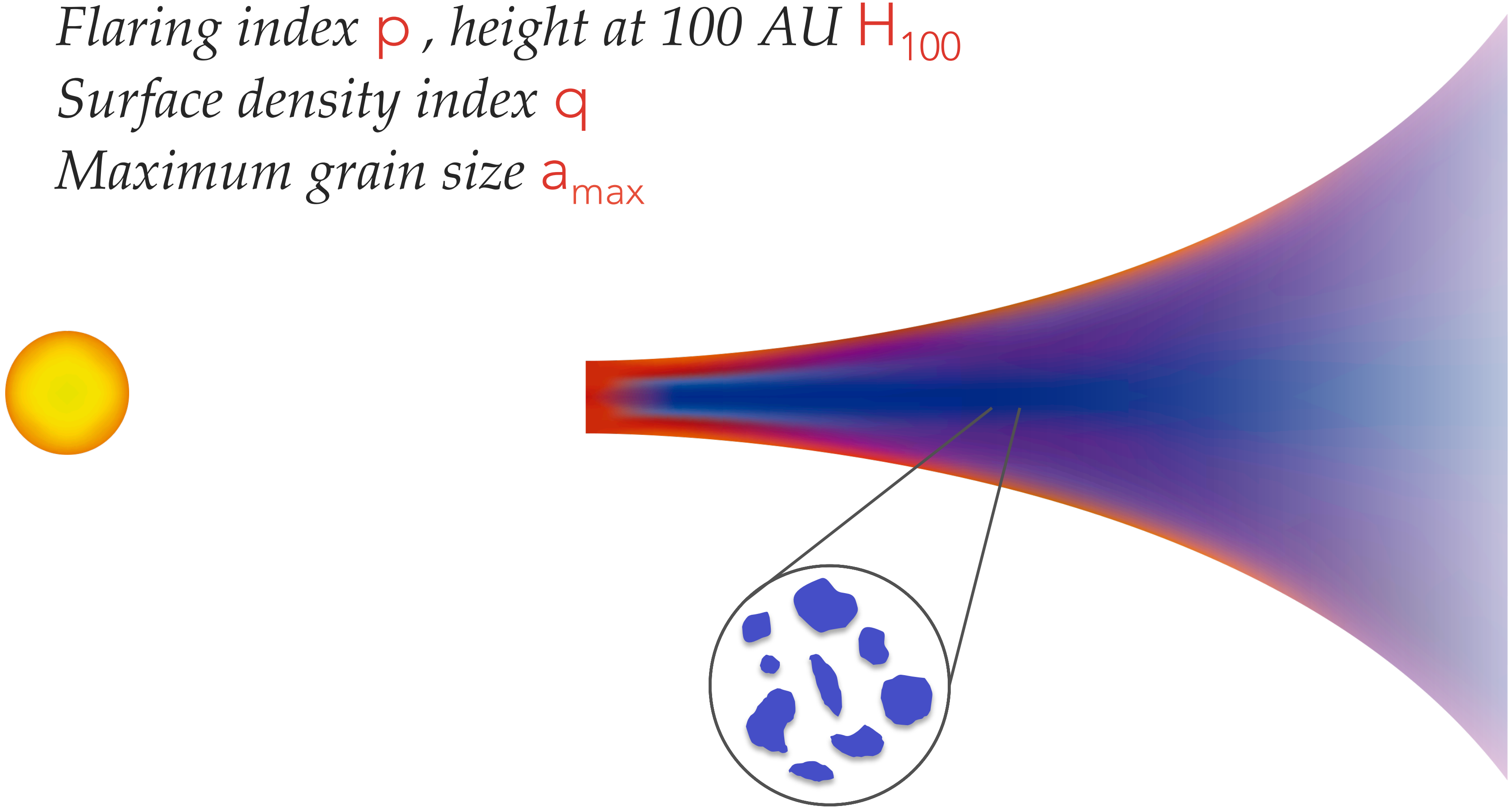
Dust mass M_d

Inner radius R_{in} *, outer radius* R_{out}

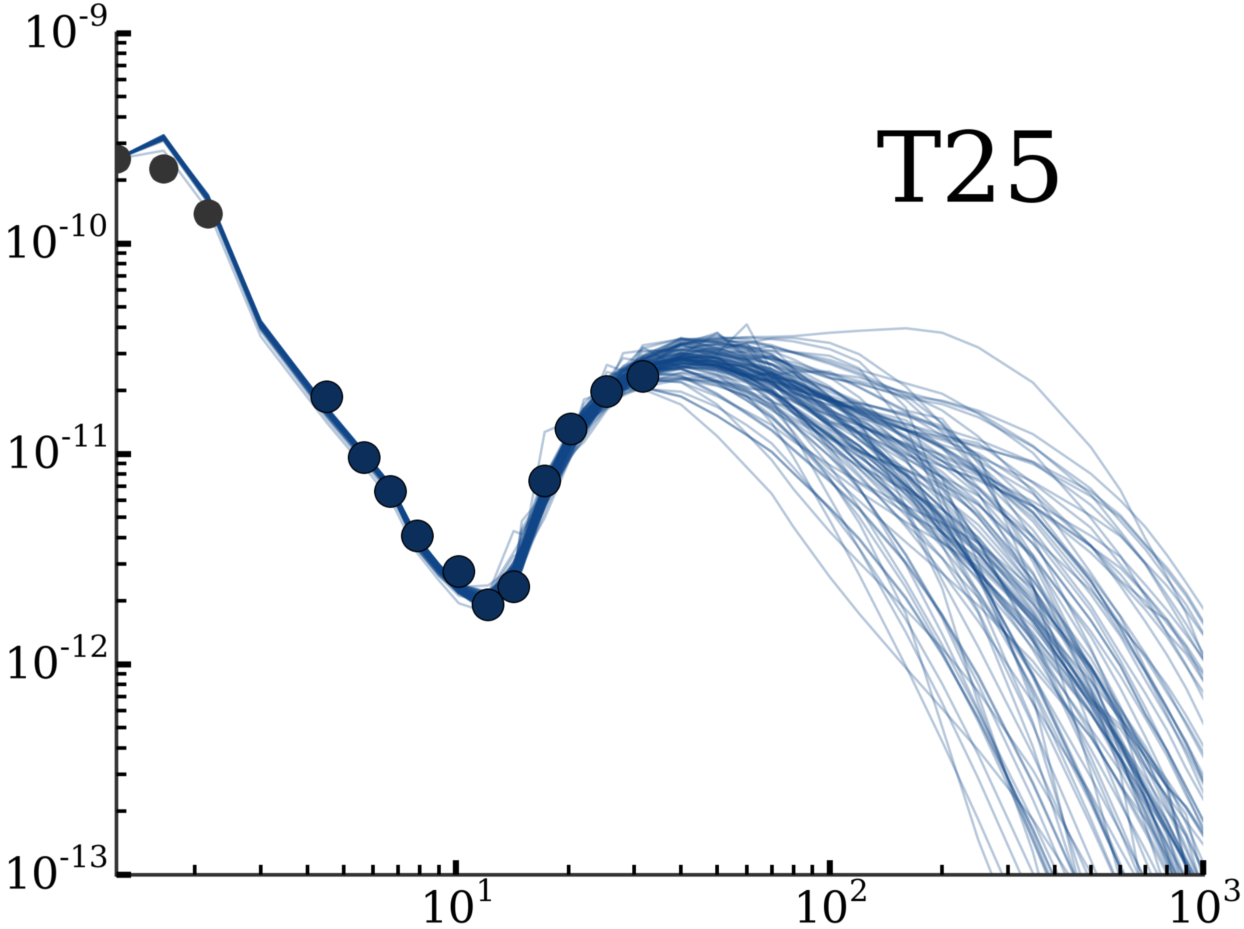
Flaring index p *, height at 100 AU* H_{100}

Surface density index q

Maximum grain size a_{max}

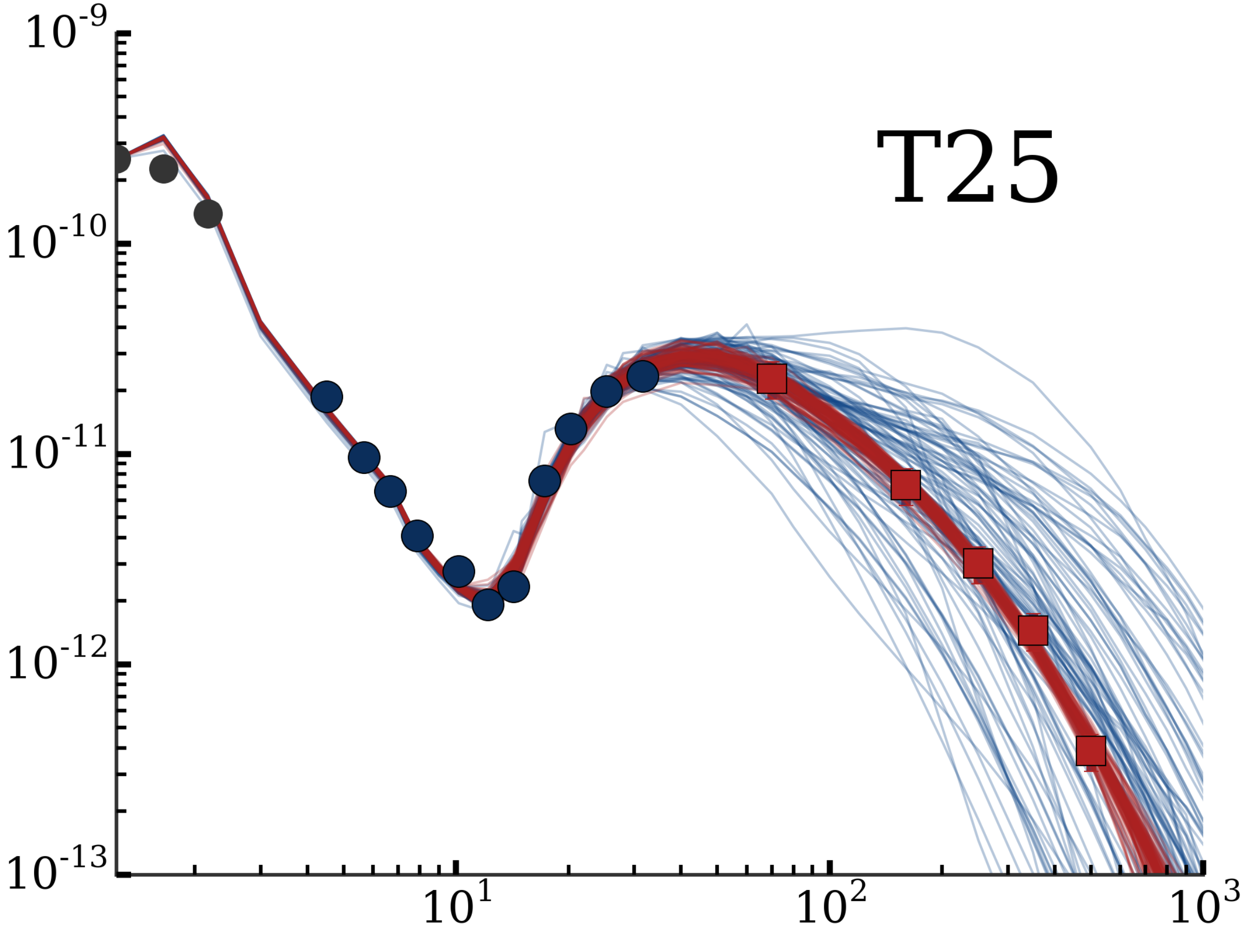


Free parameters: M_d R_{in} R_{out} p H_{100} q a_{max}



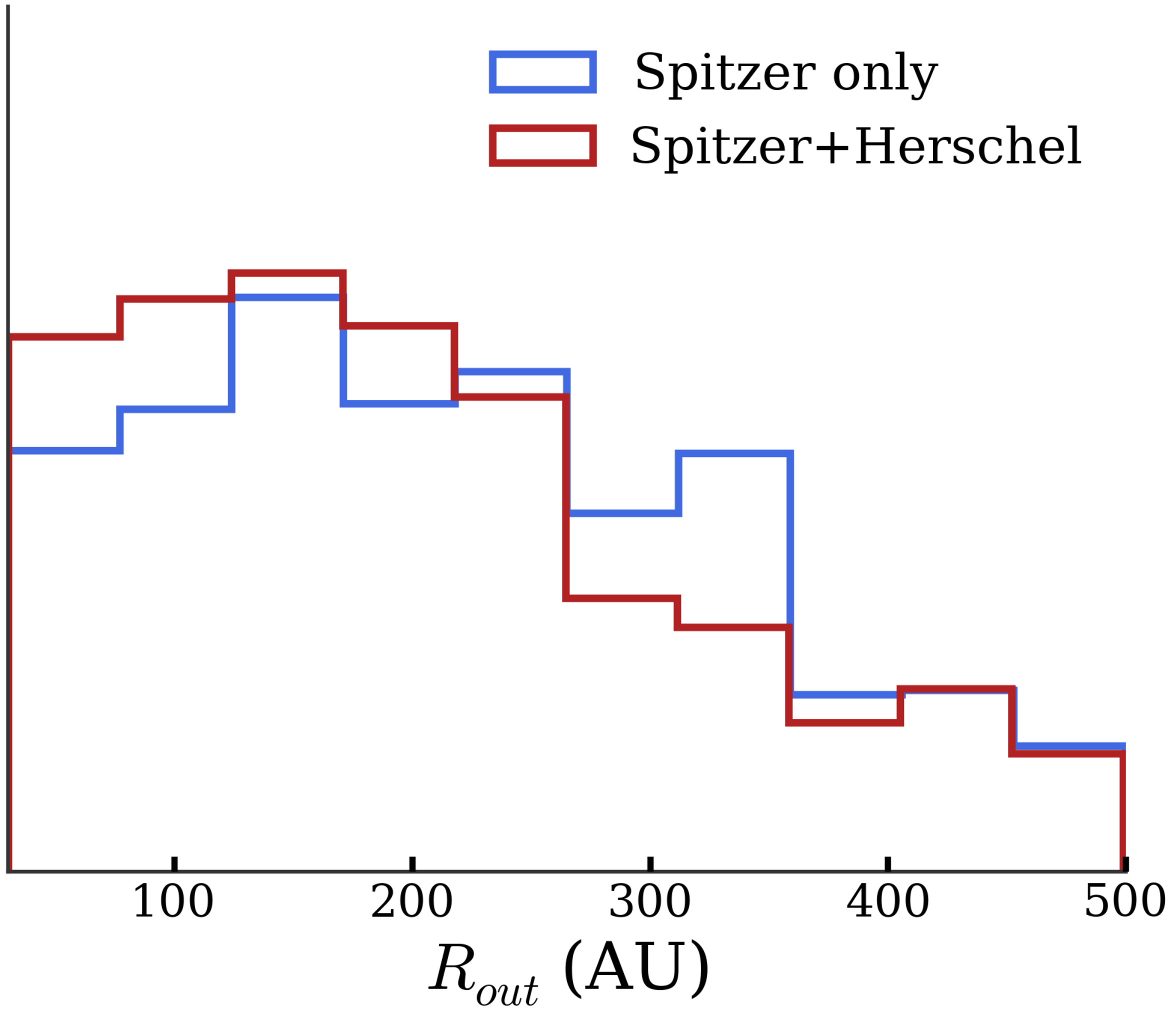
Ribas et al. in prep

Free parameters: M_d R_{in} R_{out} p H_{100} q a_{max}



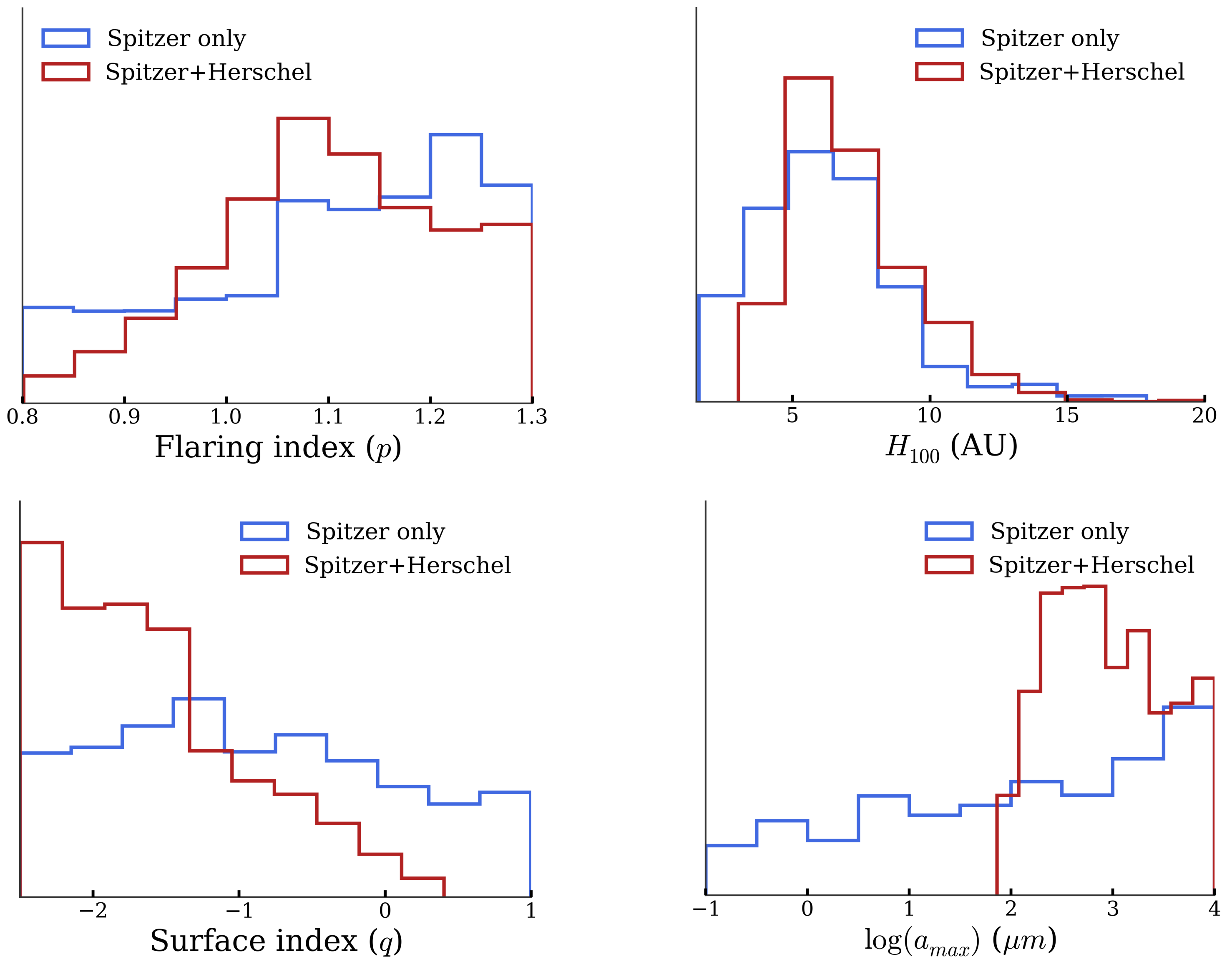
Ribas et al. in prep

Unconstrained: M_d R_{in} R_{out} p H_{100} q a_{max}

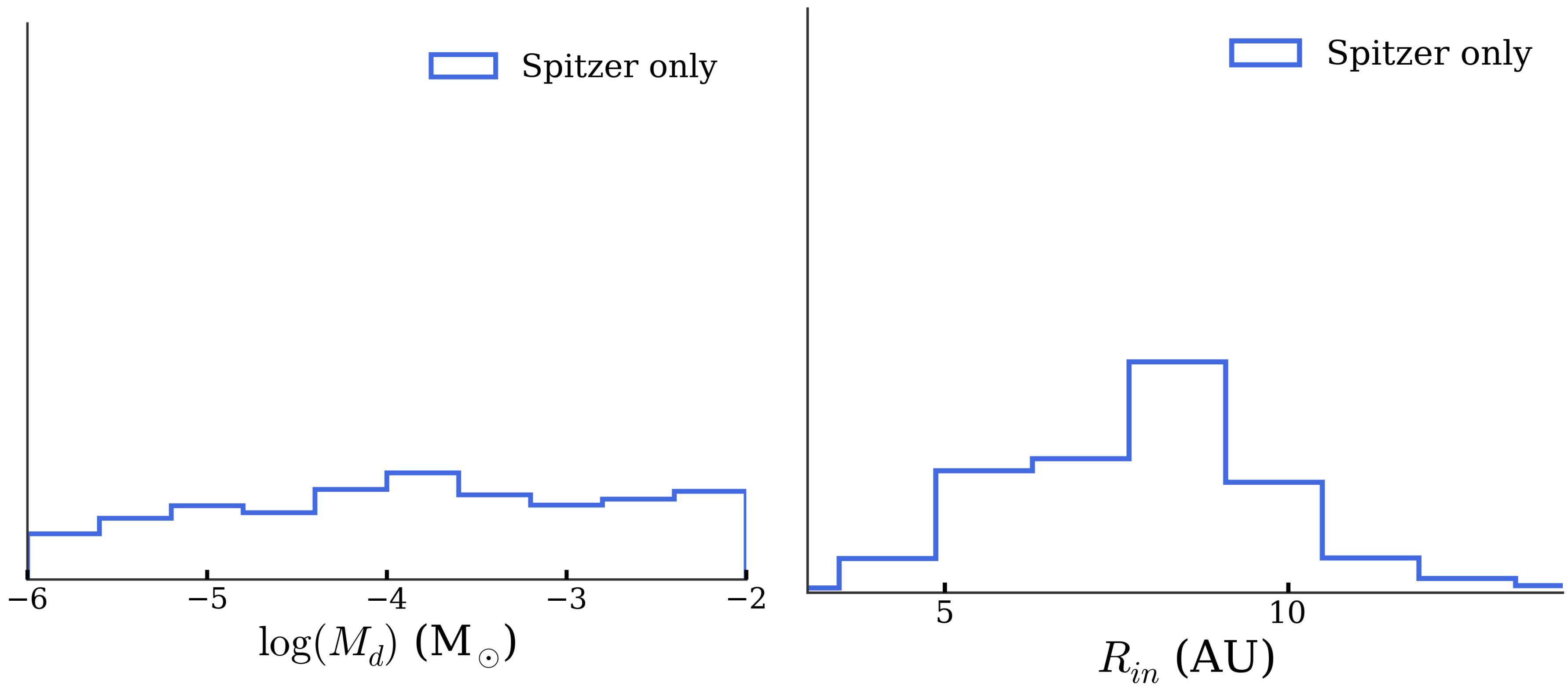


Ribas et al. in prep

Not bad: M_d R_{in} R_{out} p H_{100} q a_{max}



Sexy: M_d R_{in} R_{out} p H_{100} q a_{max}



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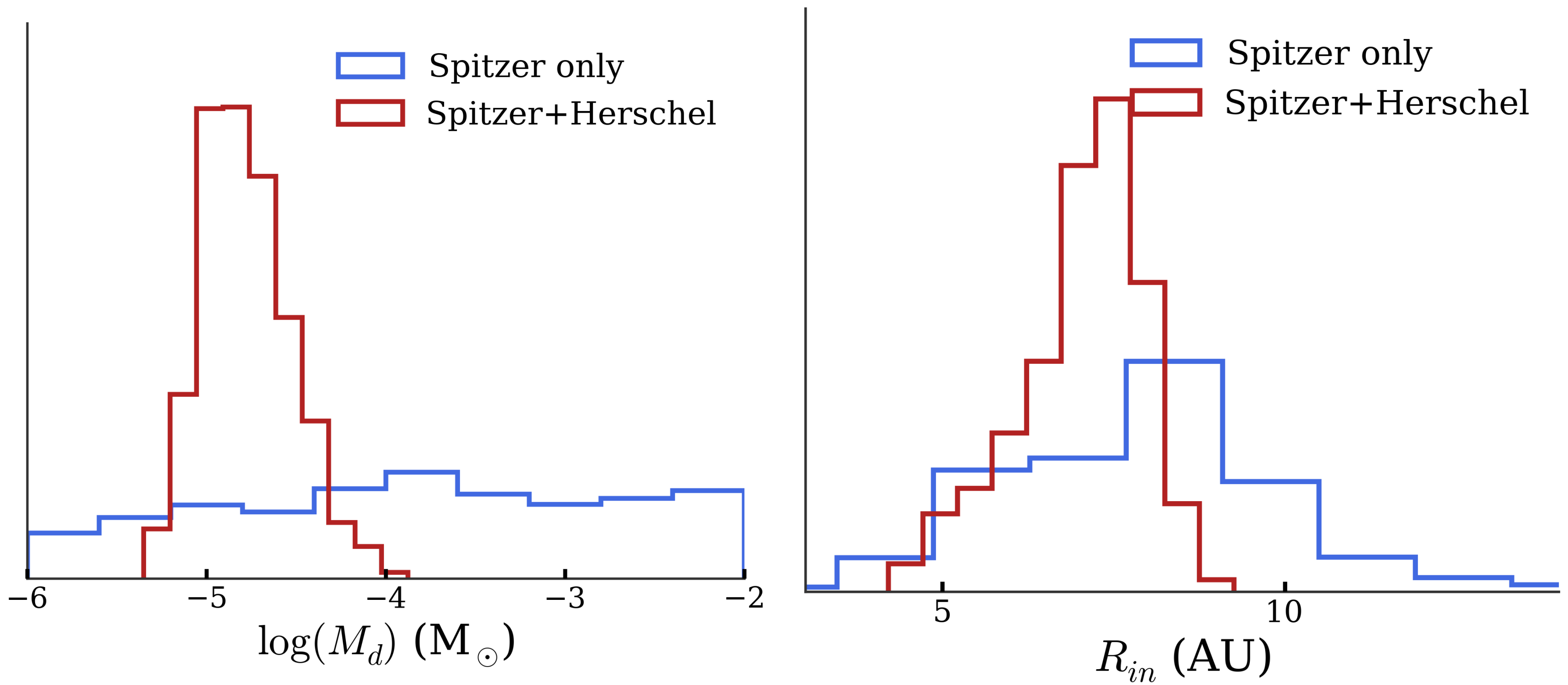
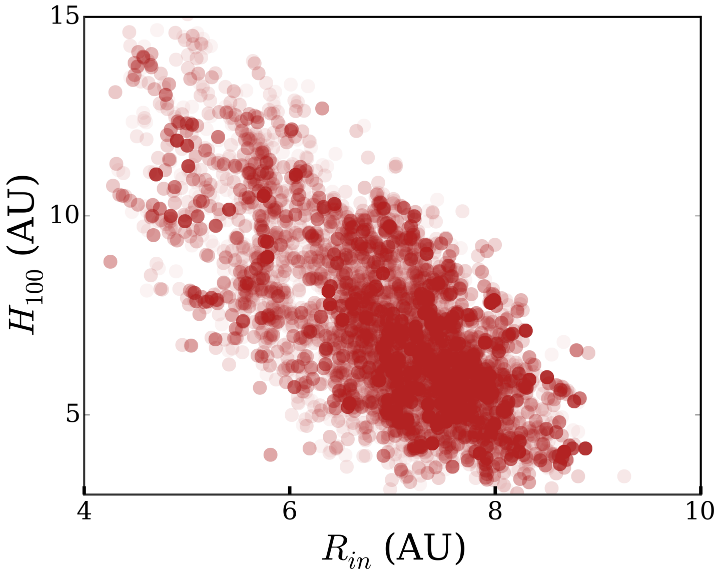
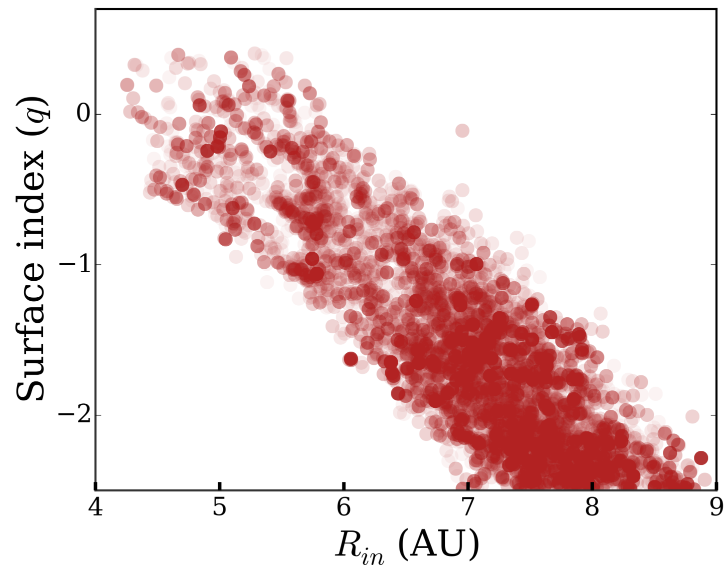
Sexy: M_d R_{in} R_{out} p H_{100} q a_{max}

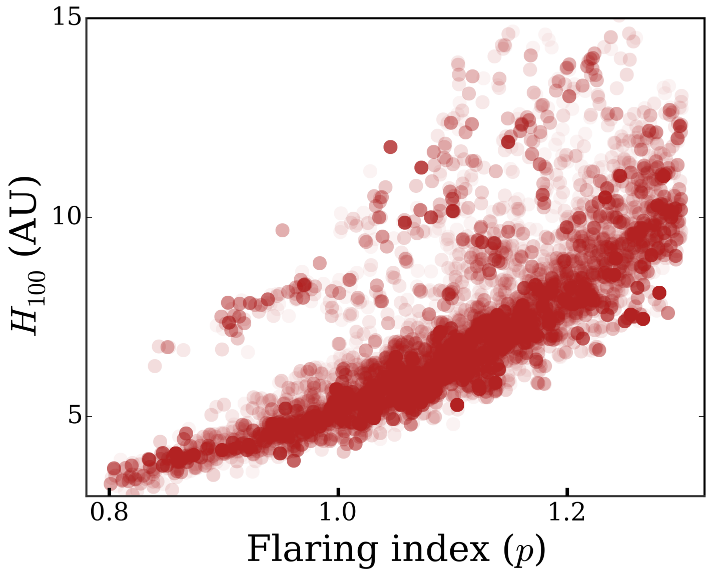


Ribas et al. in prep

And some correlations too







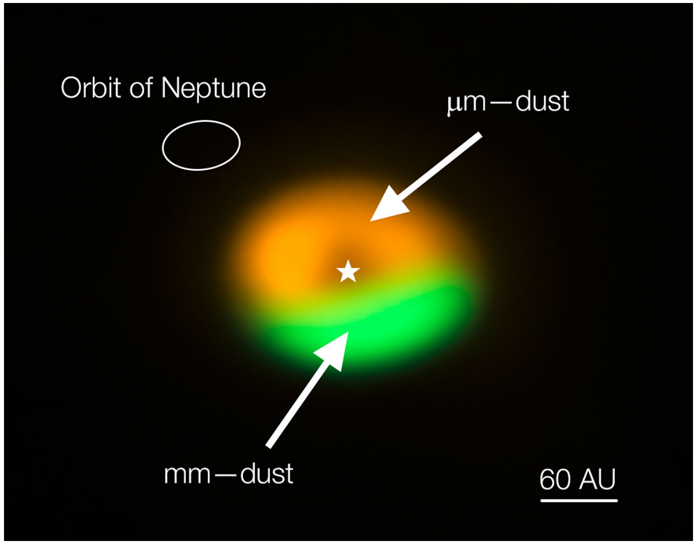
Ribas et al. in prep

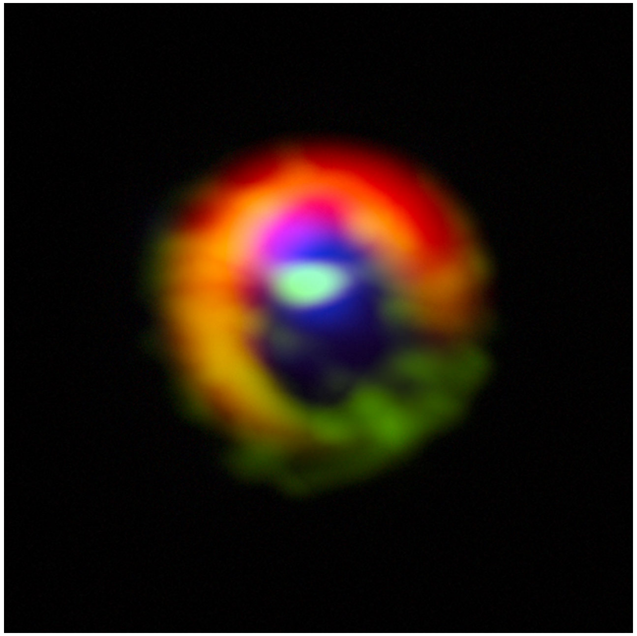
Herschel *improves or knowledge of* transitional disks

poorly for the outer radius
moderately for flaring, density *and* a_{max}
greatly for the dust mass *and* inner radius

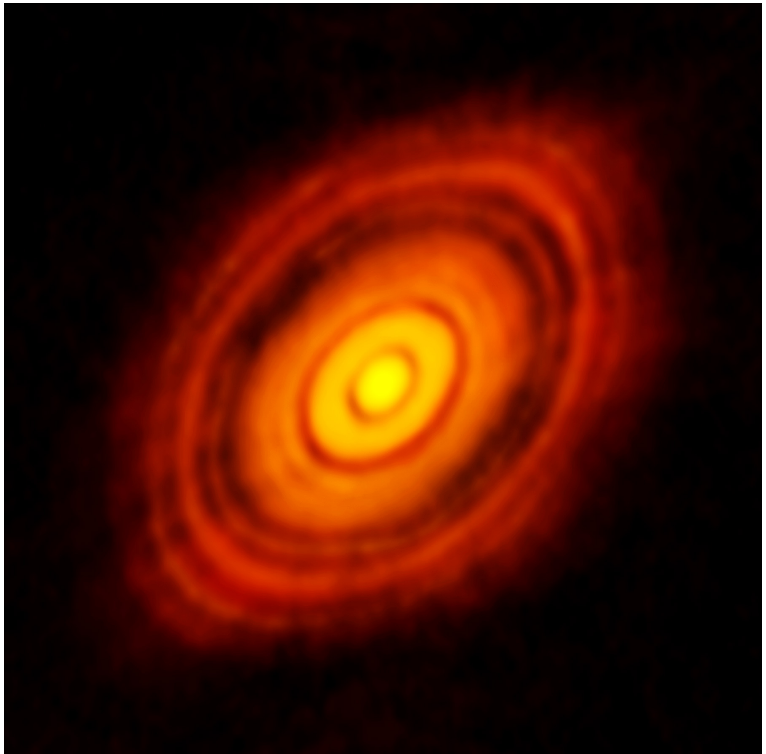
GIVE US ALMA

Van der Marel et al. 13:
Dust trap in IRS 48





Casassus et al. 13:
gas flows in the gap
of HD142527



HL TAU
several rings?
NOT EVEN A
TRANSITIONAL
DISK!

Combined with a large database of YSOs, *it can have a* great impact *on* planet formation theories

key	name	ra_touse	dec_touse	adopt_spt	region
806	Luhman2003_236	56.1459045410156	32.1492614746094	M4.75	IC348
862	AlvesdeOliveira2013_4	56.0479393005371	32.3026275634766	M8.25	IC348
864	AlvesdeOliveira2013_6	56.0753326416016	31.9499988555908	M5.5	IC348
871	AlvesdeOliveira2013_13	56.2768402099609	31.9942817687988	M6	IC348
910	Mortier2011_36	243.215377807617	-38.7043762207031	M8.5	Lupus
9	HD17332a	41.8640937805176	19.3720149993896	G1	ABD
69	HD152555	253.533966064453	-4.34022283554077	G0	ABD
83	HIP110526a	335.871032714844	32.4592781066895	M3	ABD
40	CD-262425	86.0557174682617	-26.104097366333	K2	ABD
41	HD38497	86.4218597412109	-14.7751159667969	G3	ABD
42	HD39576	88.0666122436523	-28.6569137573242	G3	ABD
46	CD-352722M	92.3300933837891	-35.8253059387207	M1	ABD
47	CD-352749M	92.9821319580078	-35.4869003295898	K1	ABD
48	HD45270	95.6290435791016	-60.2186698913574	G1	ABD
49	G88940426	96.4837875366211	-60.0576057434082	M3	ABD
51	CD-472500	99.6896133422852	-47.2382431030273	G5	ABD
52	CD-611439	99.9584808349609	-61.4782676696777	K7	ABD
53	AC3372872	100.327072143555	-38.3433456420898	K2	ABD
54	G85441037	101.972373962402	-57.2255592346191	K4	ABD
55	CD-571654	107.710929870605	-57.6128845214844	G2	ABD
60	HD64982	116.398300170898	-79.6689071655273	G0	ABD
66	HD113449	195.956985473633	-5.16177606582642	K1	ABD
67	HD139751	235.118362426758	-18.6961269378662	K4	ABD
68	HIP81084	248.423400878906	-9.55324745178223	M0	ABD
645	Luhman2003_73	56.2563133239746	32.1809120178223	K0	IC348
666	Luhman2003_94	56.0469055175781	32.1033706665039	M0	IC348
39	AC3511952	85.3097305297852	-41.2996063232422	K4	ABD
37	47790394	84.7359771728516	-6.41138982772827	G8	ABD
672	Luhman2003_100	56.1249656677246	32.1558456420898	M2.5	IC348
673	Luhman2003_101	56.0898170471191	32.171516418457	M1.5	IC348
690	Luhman2003_118	56.1272621154785	32.1082725524902	M0.5	IC348
33	CD-481893	84.2295761108398	-47.9633674621582	K6	ABD
926	Mortier2011_52	242.090850830078	-39.0726318359375	M4.5	Lupus
935	Sz91	241.798294067383	-39.0632057189941	M0.5	Lupus
955	2MASSJ1608149	242.062408447266	-38.9540405273438	M4.7	Lupus
961	RXJ1507.2-3505	226.811737060547	-35.083194732666	K0	Lupus
994	RXJ1526.4-3638	231.607452392578	-36.6493377685547	M2.5	Lupus
76	BD-034778	301.205627441406	-2.65565609931946	K1	ABD
77	HD199058	313.587829589844	9.04000568389893	G5	ABD
78	AC422524	313.616668701172	9.1018590927124	K4	ABD
79	HD201919	318.271942138672	-17.4868602752686	K6	ABD
80	BD+224409	322.757141113281	23.3354072570801	K4	ABD
81	HD207278M	327.202178955078	-39.4859886169434	G7	ABD
93	CD-292360	83.746826171875	-29.9011402130127	K3	ARG
95	CD-422906	105.47248840332	-42.4656066894531	K1	ARG

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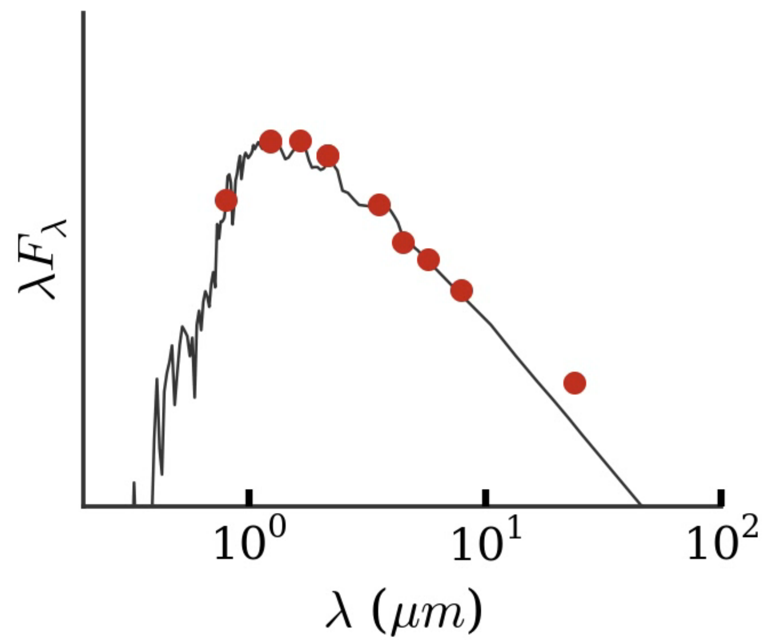
more than 2300 YSOs (~100 transitionals)

in 22 nearby star-forming associations

35 photometric bands

SpT, Av, stellar mass, disks, …



Ribas et al. 2014, 2015