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Secondary standards for ISOPHOT

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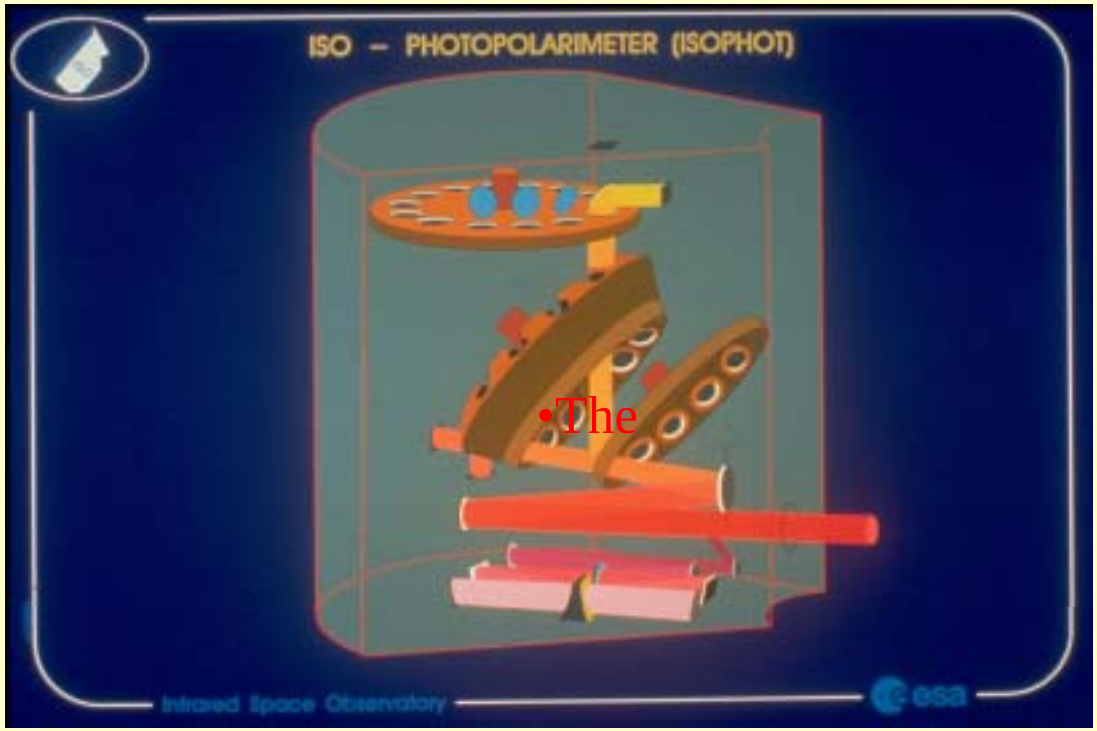
Introduction

- ISOPHOT: the photometer on-board the *Infrared Space Observatory*
- ISOPHOT was calibrated during the ISO mission by an expert group at VilSpa/Heidelberg (the work is documented, published)
- Legacy Archive was produced
- At Konkoly Observatory, Budapest, we work on further refinement of the ISOPHOT calibration
- Some of our methods/results might be interesting to the Herschel community



•The

Konkoly IR Space Astronomy Group

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- **Mid-2001 : ISOPHOT group established via ESA's PRODEX programme**
- **Today : 4 scientists, 1 PhD student, 3 graduate students**
- **2002-06 : Contract with the ISO Data Centre to produce "Highly Processed Data Products" (7 man-yr)**
- **2004 : 2 Spitzer GO proposals accepted**
- **2004-07 : ESA contract for contribution to the Herschel calibration (8 man-yr)**

Goals:

- **preserve ISOPHOT calibration knowledge**
- **maintain and develop ISOPHOT data reduction skills (PIA)**
- **help and collaborate with people working on ISOPHOT data**
- **encourage students to use ISOPHOT**

Methods:

- **very practical, down-to-the-earth methods**
- **intensive interactive data analysis**
- **close collaboration with MPIA**

Concept of “secondary standards”

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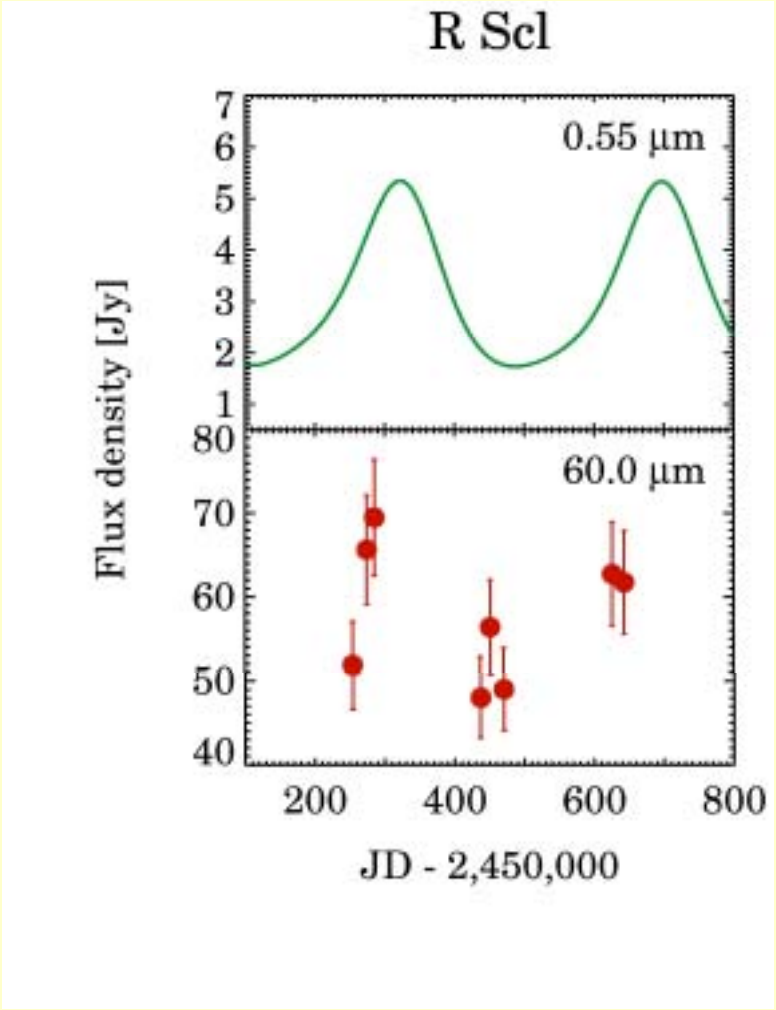
- ISOPHOT was calibrated using a library of stellar/asteroidal/planet models (primary standards). Not all objects were observed.
- Observations of these standards do not cover all measurement configurations, and all flux ranges
- Our strategy: (1) define a homogeneous ISOPHOT data set, (2) develop correction algorithms specifically for this data set.
- We need standard objects to check/validate/improve the photometry!
- Not enough dedicated standard observation in the selected data set? Collect science observations and use them as “secondary standards”!

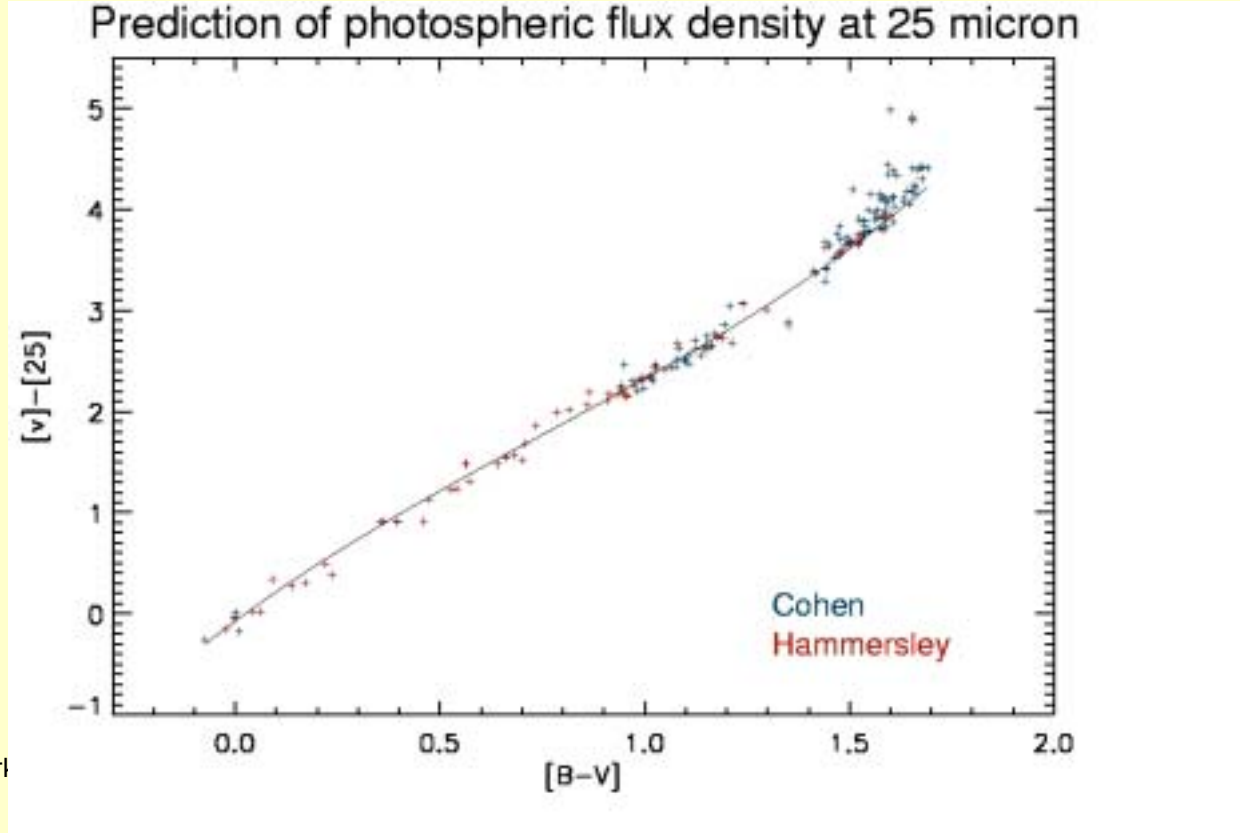
Which type of objects could be used?

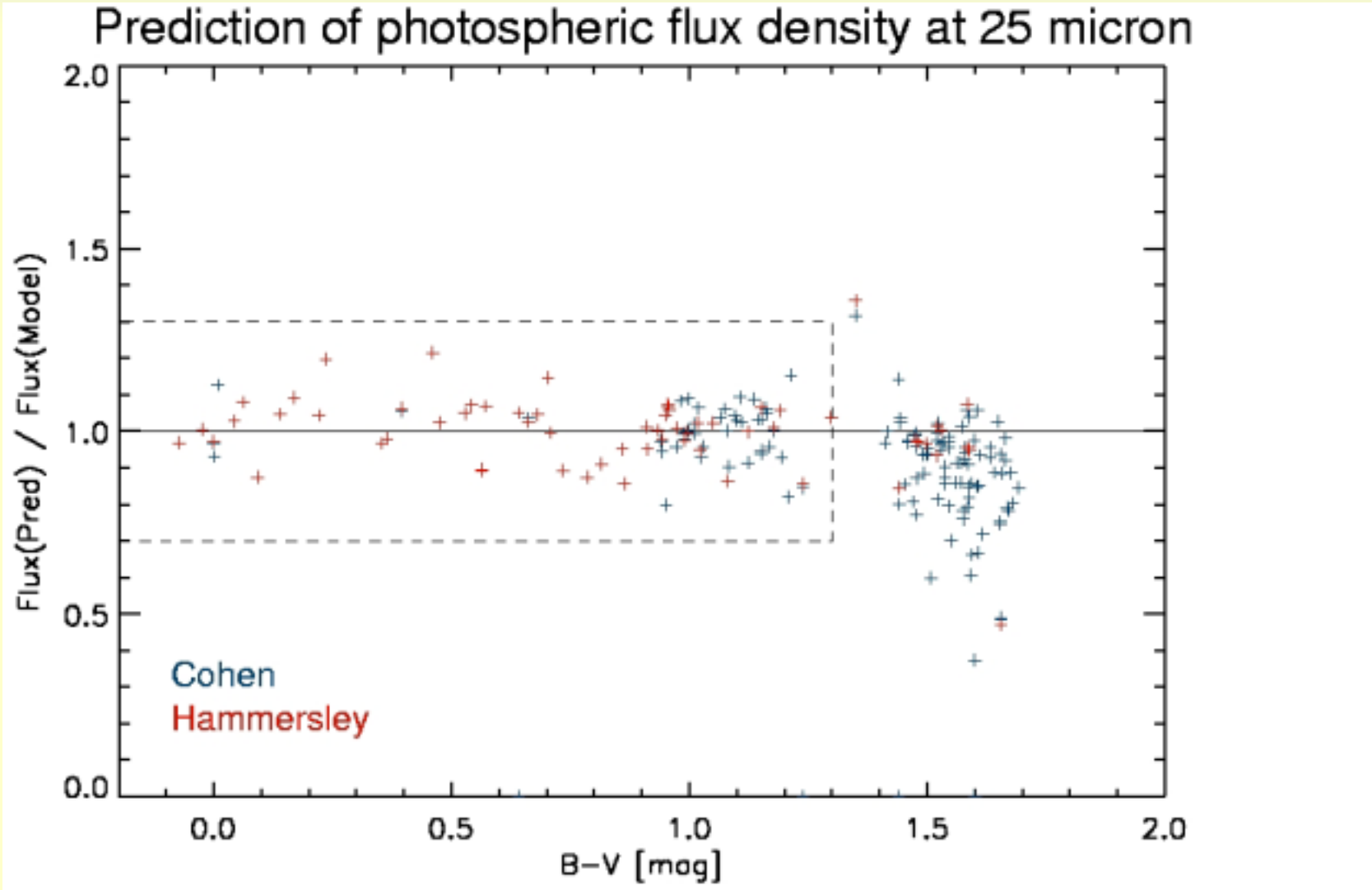
- Normal stars, from ISOPHOT debris disk programmes (but: possible excess, source confusion in crowded open clusters)
- Non-variable objects with good IRAS meas. (must be relatively bright and compact)
- At NIR/MIR wavelengths: non-variable objects with ground-based photometry
- Regular variable objects (e.g. Mira-stars)

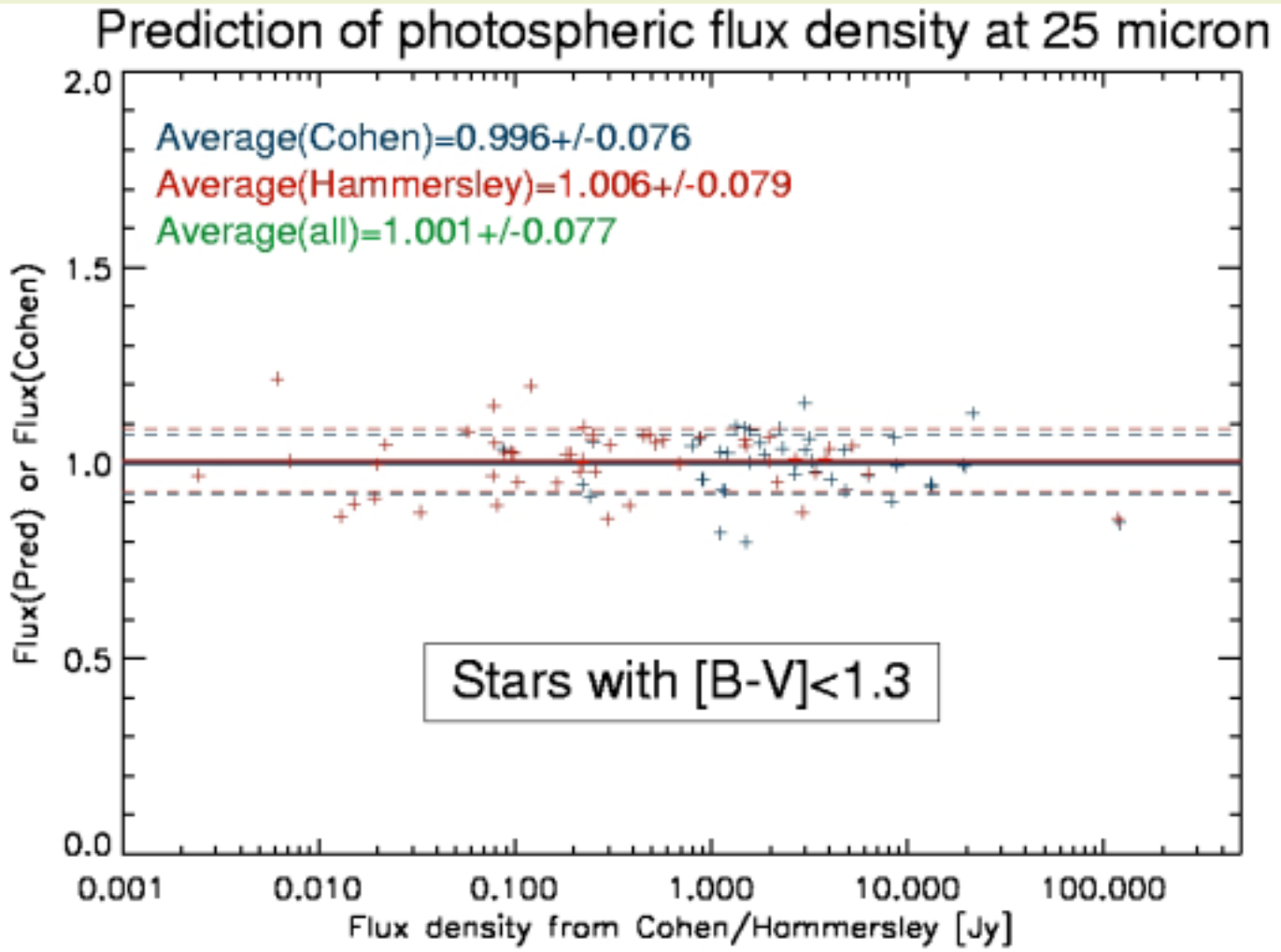


Flux prediction for normal stars from V-magnitude and [B-V] colour

- There is no Cohen template for each normal star...
- Habing et al. (Plets PhD) predicted photospheric fluxes in the IRAS bands from V-mag and B-V
- A similar method can be used to predict stellar fluxes in the ISOPHOT filter bands

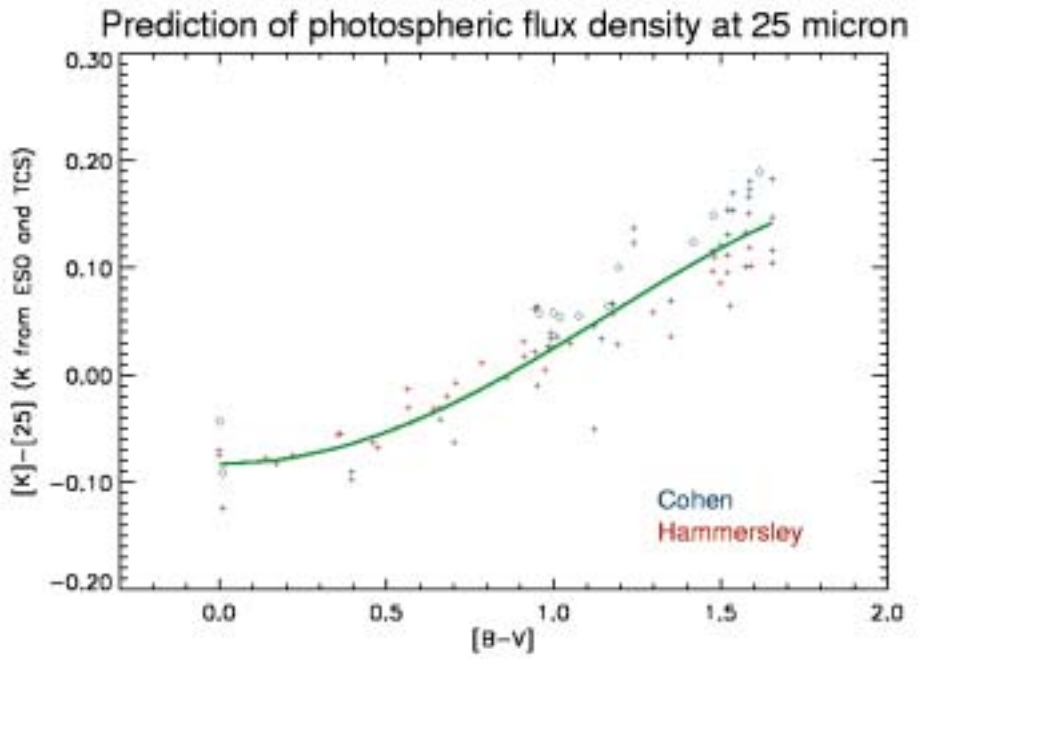


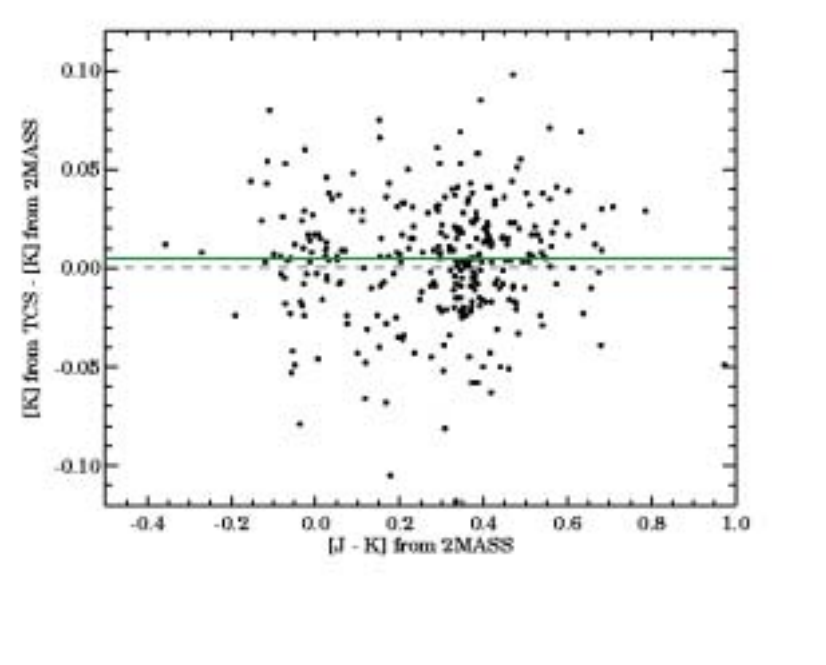

Prediction of photospheric flux density at 25 micron
Flux(Pred) / Flux(Model)
B−V [mag]
Cohen
Hammersley
0.0
0.5
1.0
1.5
2.0

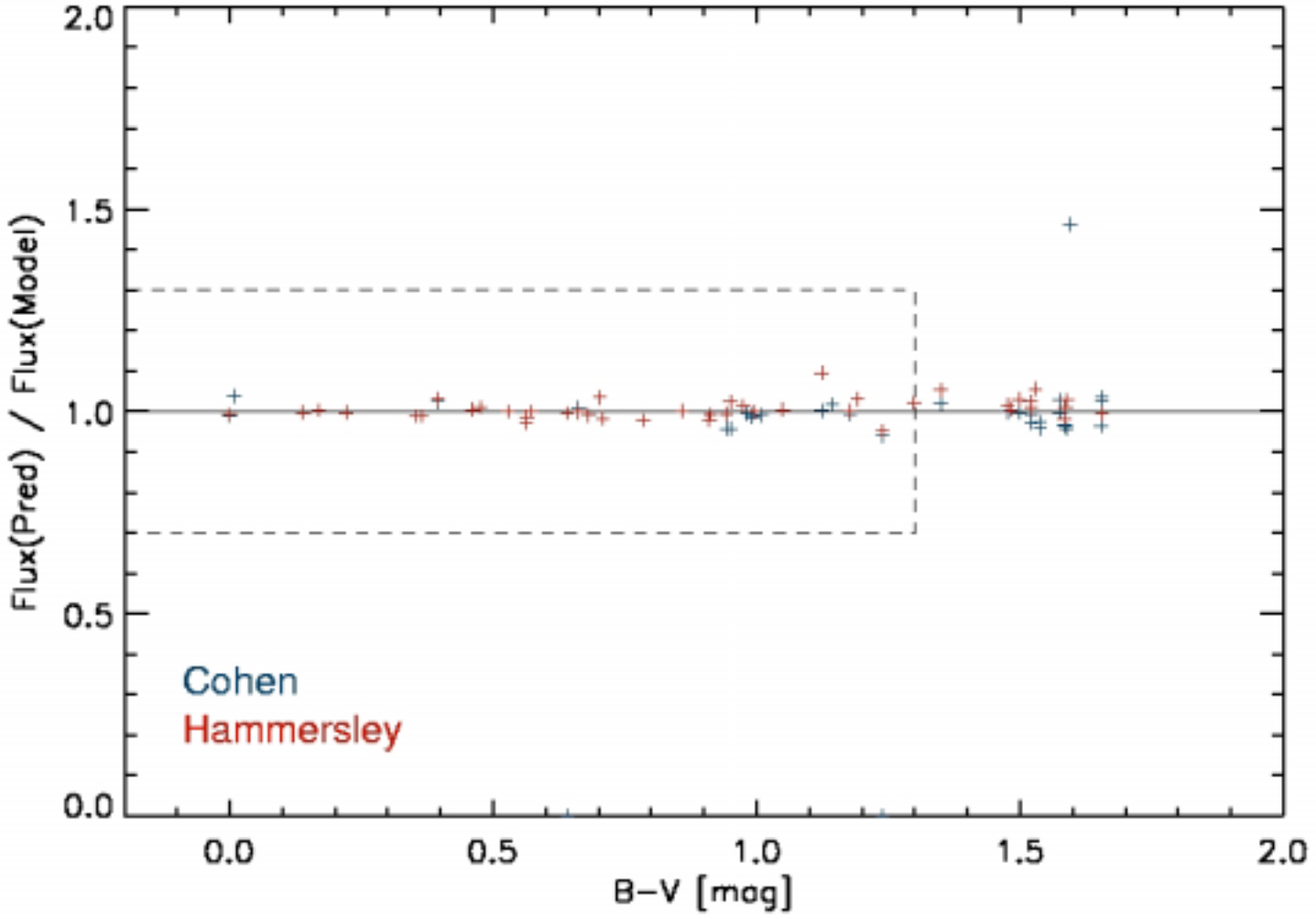

Prediction of photospheric flux density at 25 micron
Average(Cohen)=0.996+/-0.076
Average(Hammersley)=1.006+/-0.079
Average(all)=1.001+/-0.077
Stars with [B-V]<1.3
Flux(Pred) or Flux(Cohen)
Flux density from Cohen/Hammersley [Jy]
2.0
1.5
1.0
0.5
0.0
0.001
0.010
0.100
1.000
10.000
100.000

Flux prediction from K-magnitude

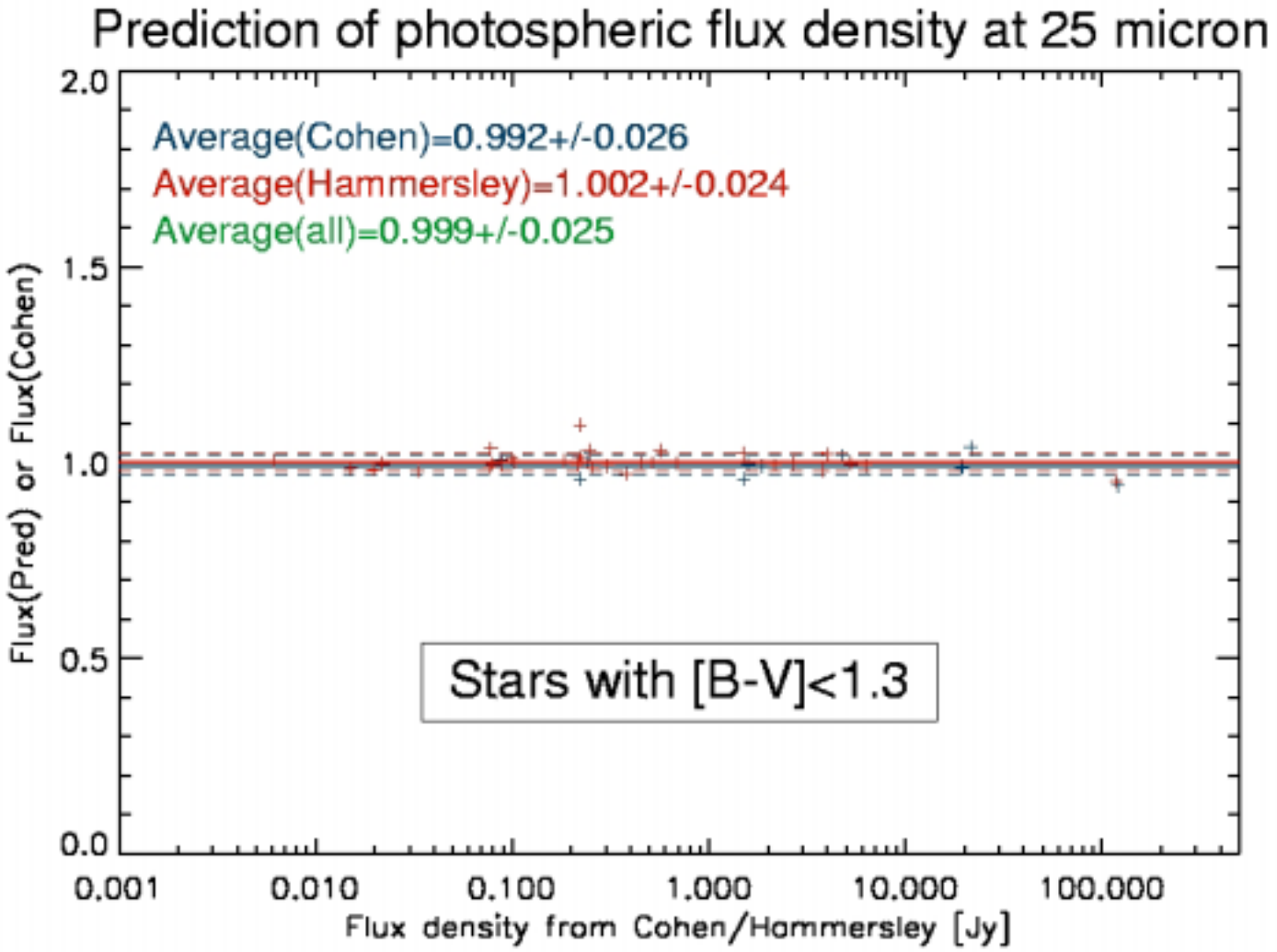
- Higher accuracy can be achieved with the K-mag + [B-V] relationship
- From 2MASS accurate Ks-magnitudes are available at K>4.5 mag
- For brighter stars check e.g. ISO GBPP (TCS, ESO)
- 2MASS - TCS transformation



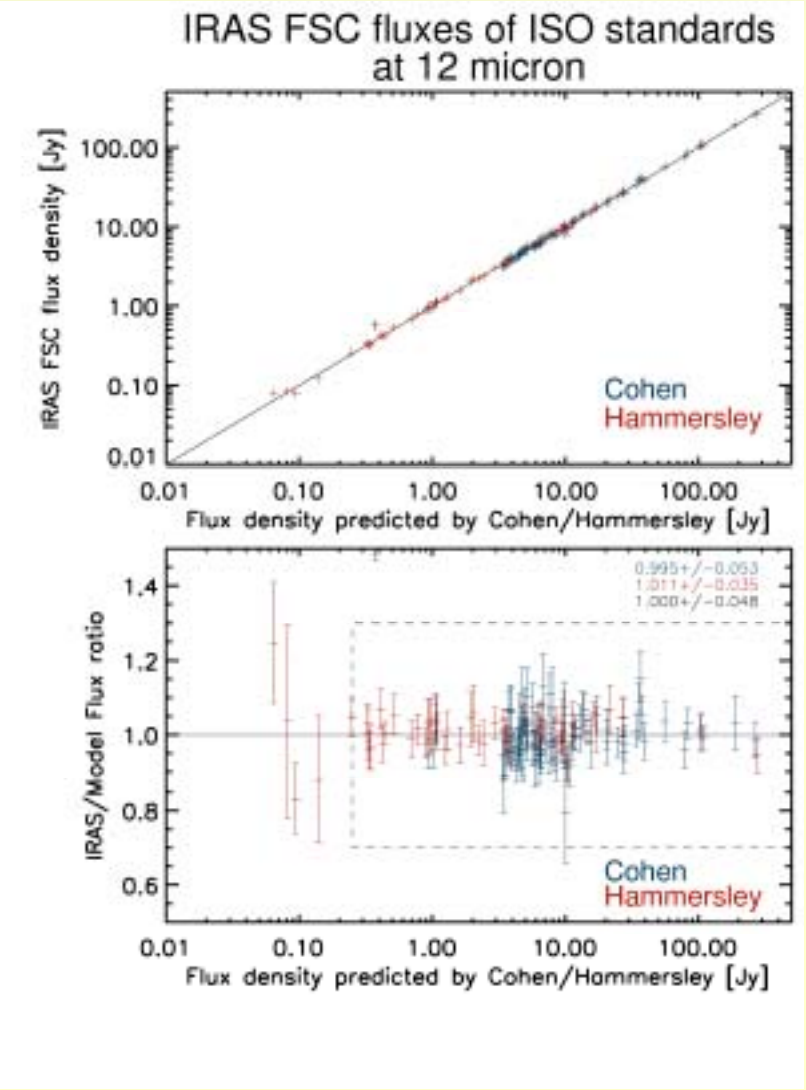


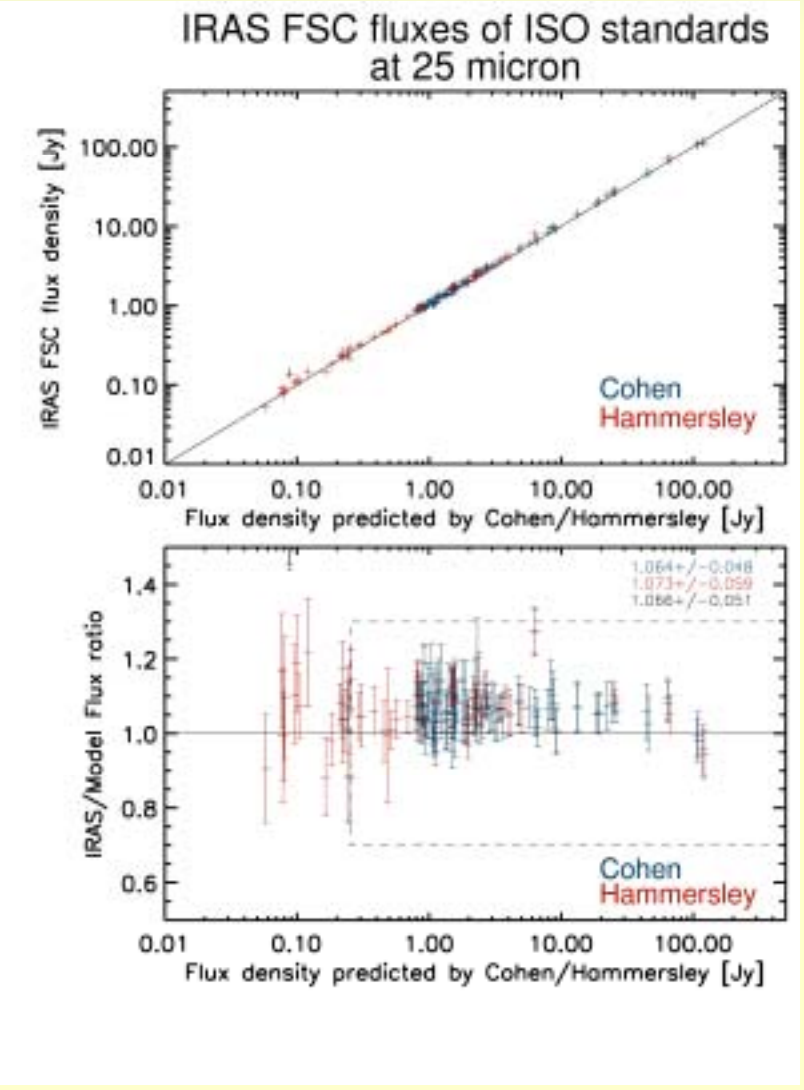

Prediction of photospheric flux density at 25 micron
Flux(Pred) / Flux(Model)
2.0
1.5
1.0
0.5
0.0
Cohen
Hammersley
0.0
0.5
1.0
1.5
2.0
B−V [mag]

Her


Prediction of photospheric flux density at 25 micron
Average(Cohen)=0.992+/-0.026
Average(Hammersley)=1.002+/-0.024
Average(all)=0.999+/-0.025
Stars with [B-V]<1.3
Flux(Pred) or Flux(Cohen)
2.0
1.5
1.0
0.5
0.0
0.001
0.010
0.100
1.000
10.000
100.000
Flux density from Cohen/Hommersley [Jy]

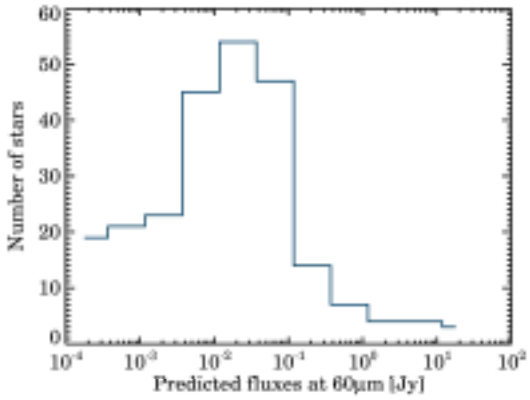
Fluxes predicted via IRAS

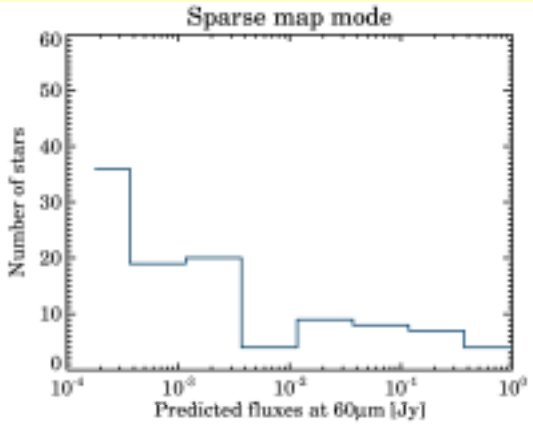




Census of normal star observations

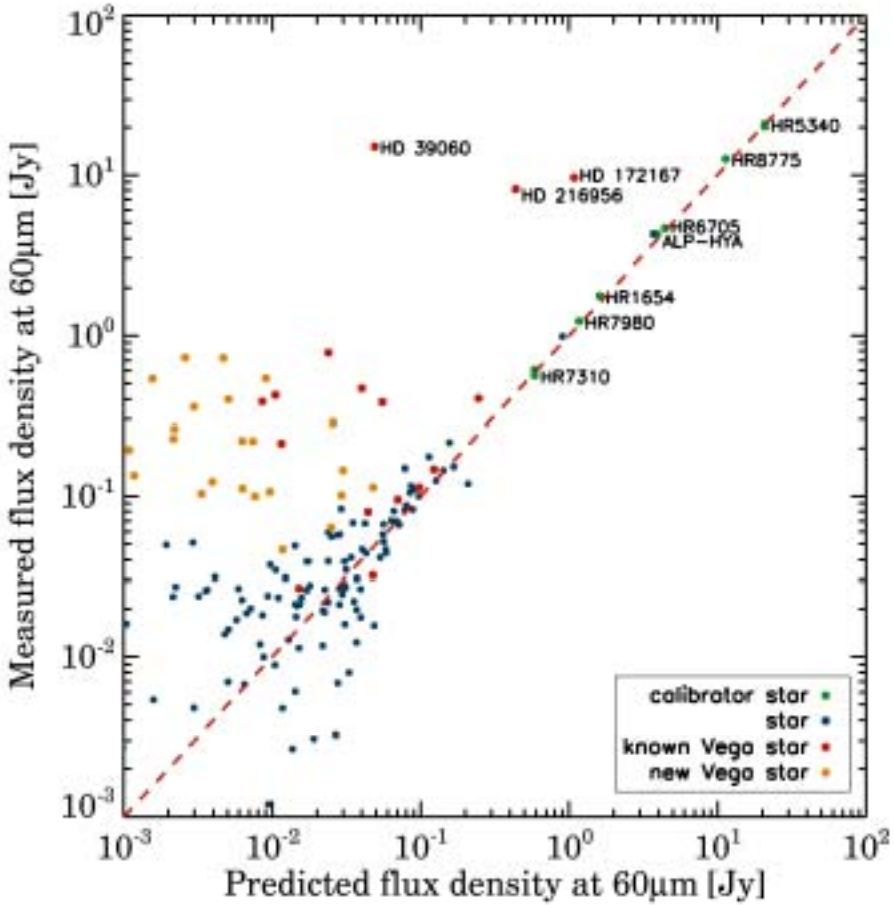
		B	A	F	G	K	M
Main-sequence	Mini-map	16	19	66	57	26	0
	Sparse map	8	21	28	37	7	0
Giant	Mini-map	1	1	0	3	10	4
	Sparse map	0	1	0	3	15	1
No lum., class	Mini-map	6	7	12	10	3	0

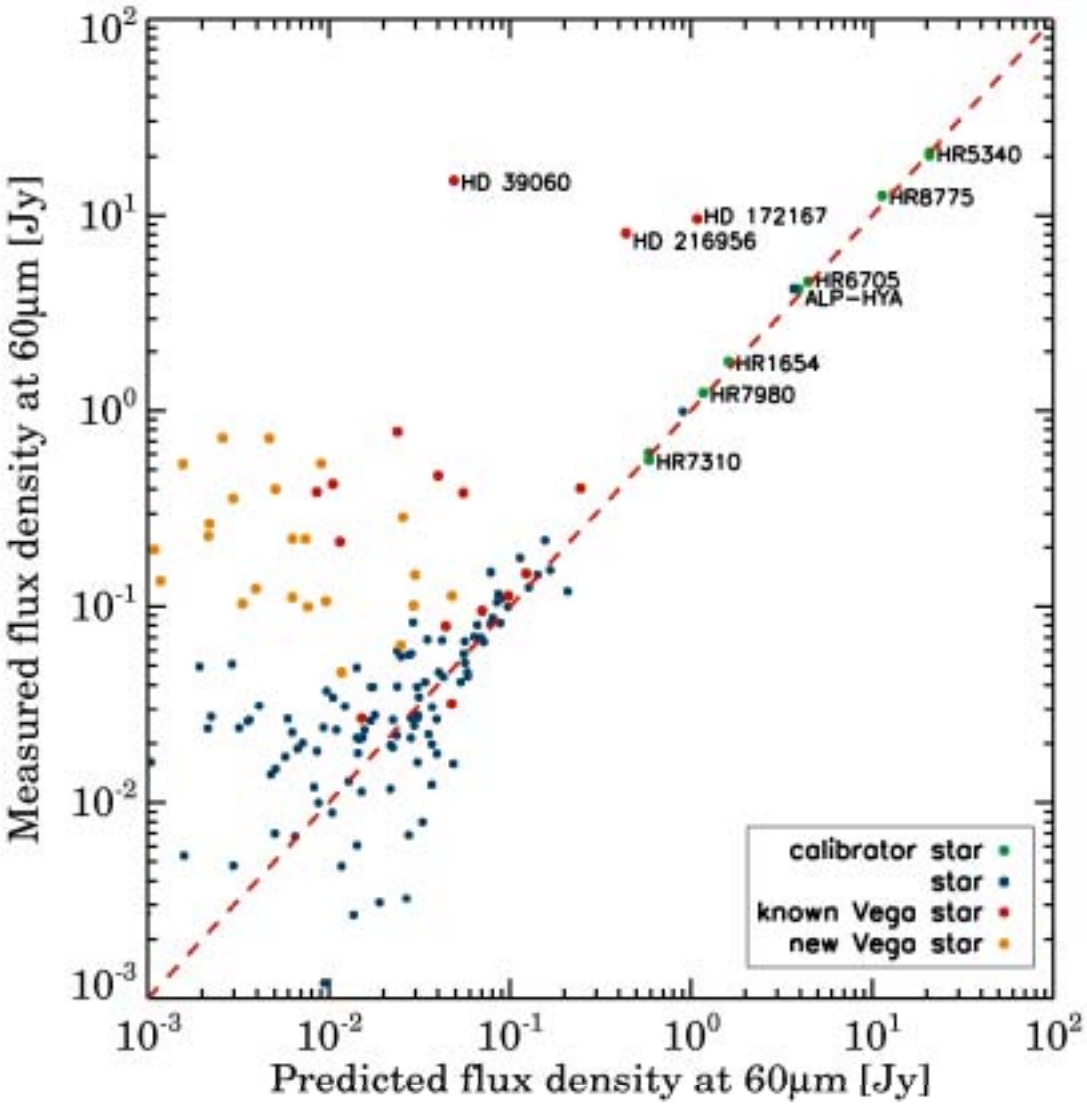


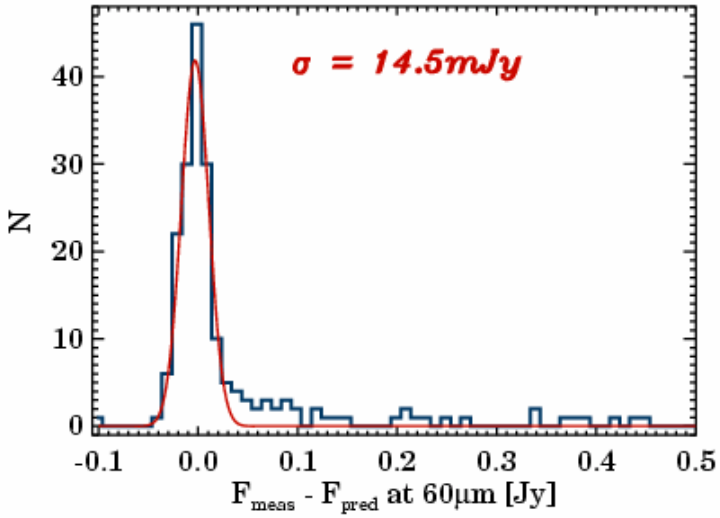


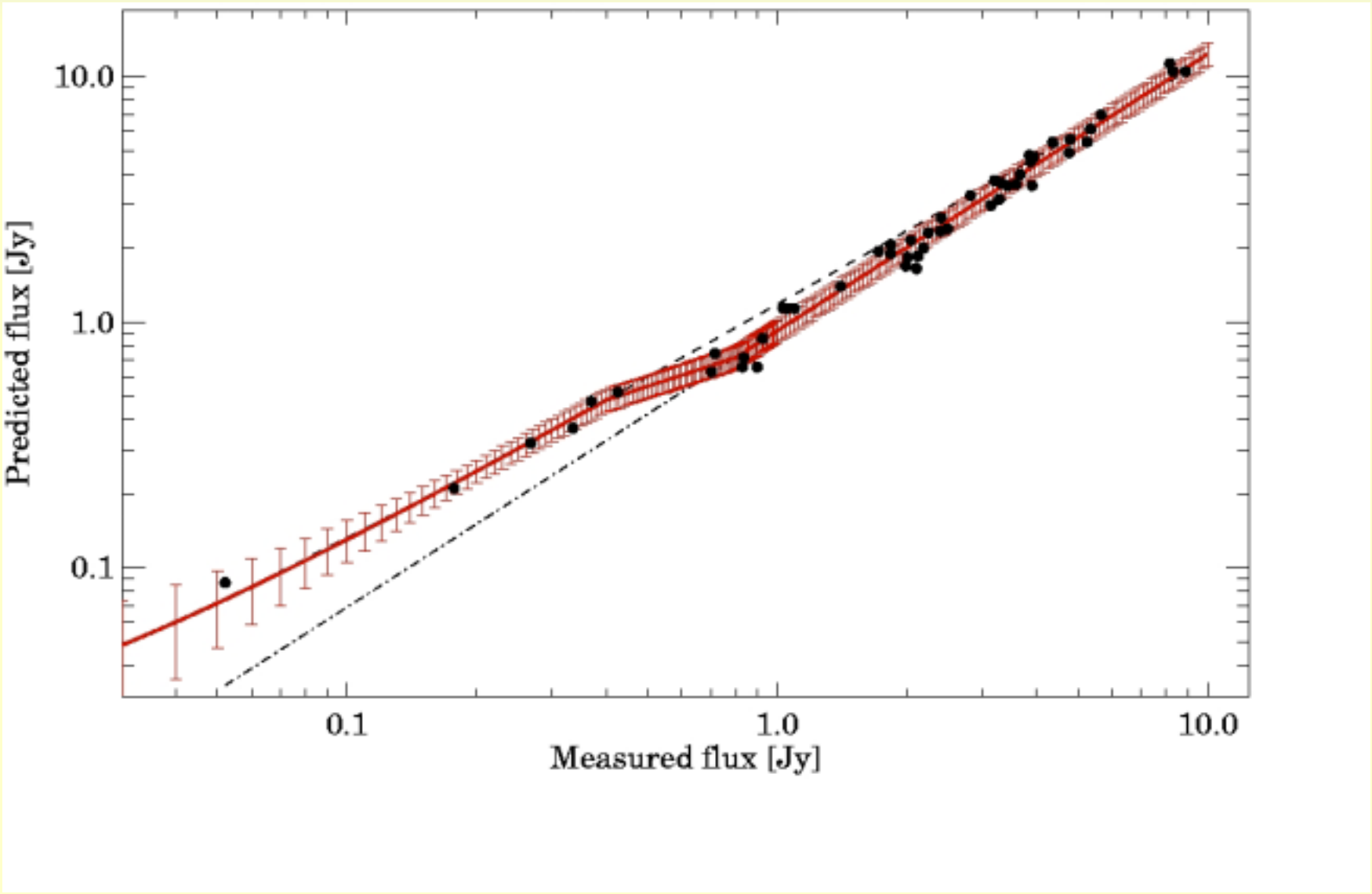
How to utilise secondary standards?

- Process the selected "secondary standards" (normal stars), using the best possible data reduction
- E.g. ISOPHOT mini-maps: transient correction, correction for slow baseline variation, PSF photometry with measured beam profile
- Perform error analysis with special care; derive reliable uncertainties
- Compare measured and predicted fluxes
- Fit systematic trend




Measured flux density at 60μm [Jy]
Predicted flux density at 60μm [Jy]
HD 39060
HD 172167
HD 216956
HR5340
HR8775
HR6705
ALP-HYA
HR1654
HR7980
HR7310
calibrator star
star
known Vega star
new Vega star


σ = 14.5mJy
N
F meas - F pred at 60μm [Jy]


10.0
1.0
0.1
Predicted flux [Jy]
0.1
1.0
10.0
Measured flux [Jy]

Could ISOPHOT verify stellar models?

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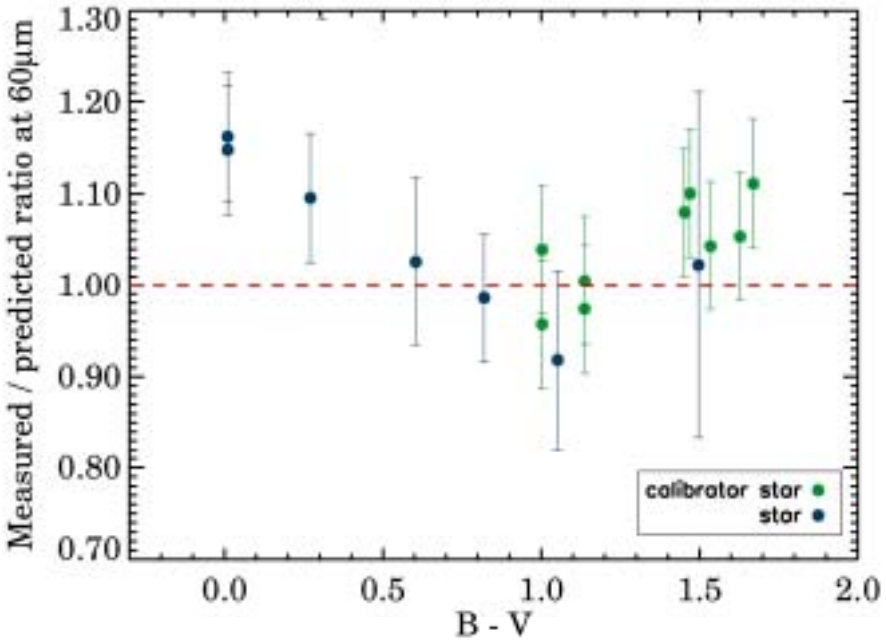
- The measured fluxes are not absolute; they are valid relative to the main stream
- But: systematic differences among stellar groups could be studied!



Candidates for Herschel standard stars

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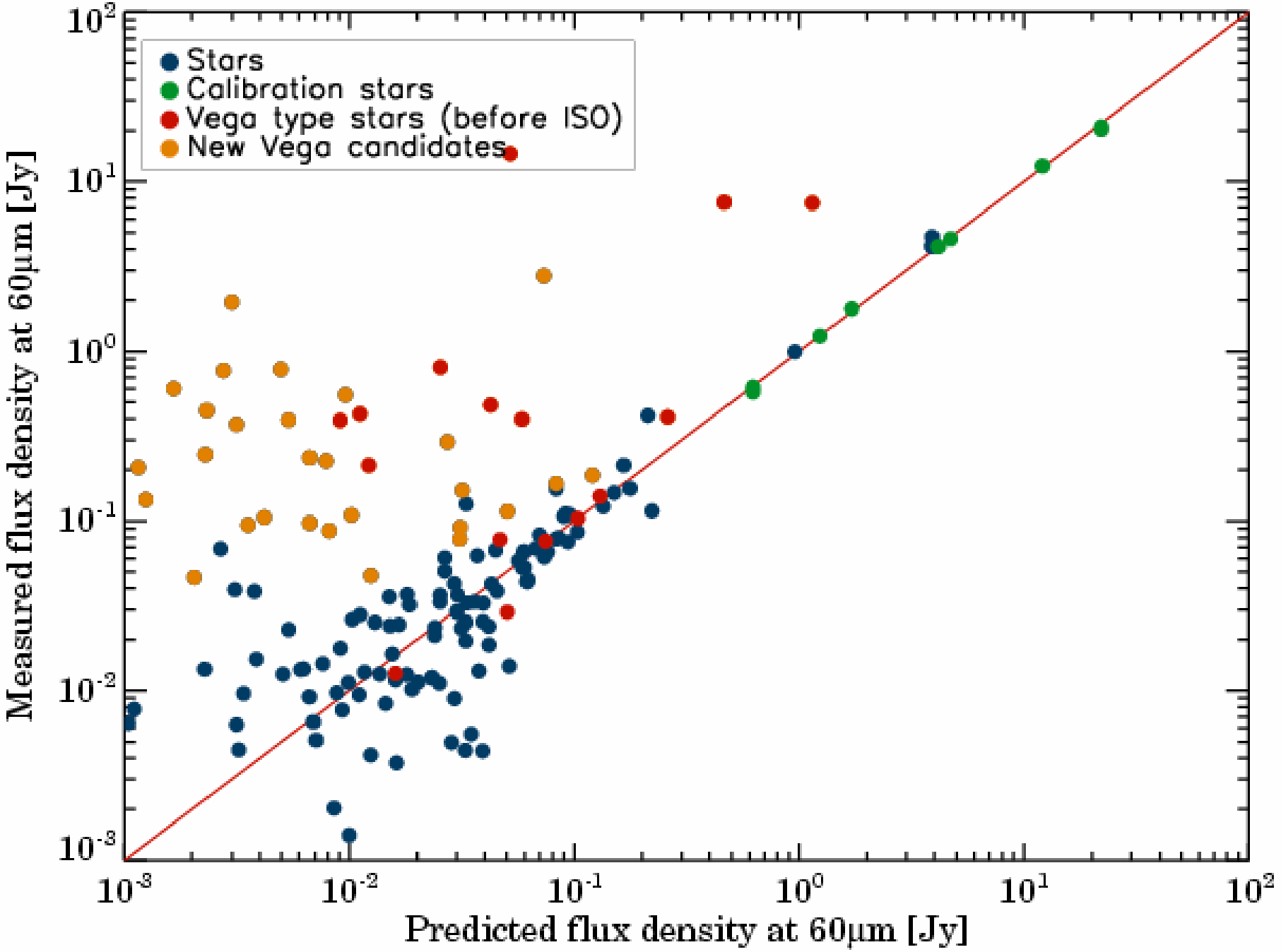
- No detectable far-infrared excess

  check if the star is situated “in the crowd”


Stars
Calibration stars
Vega type stars (before ISO)
New Vega candidates
Measured flux density at 60μm [Jy]
Predicted flux density at 60μm [Jy]
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}

Candidates for Herschel standard stars

Konkoly Observatory

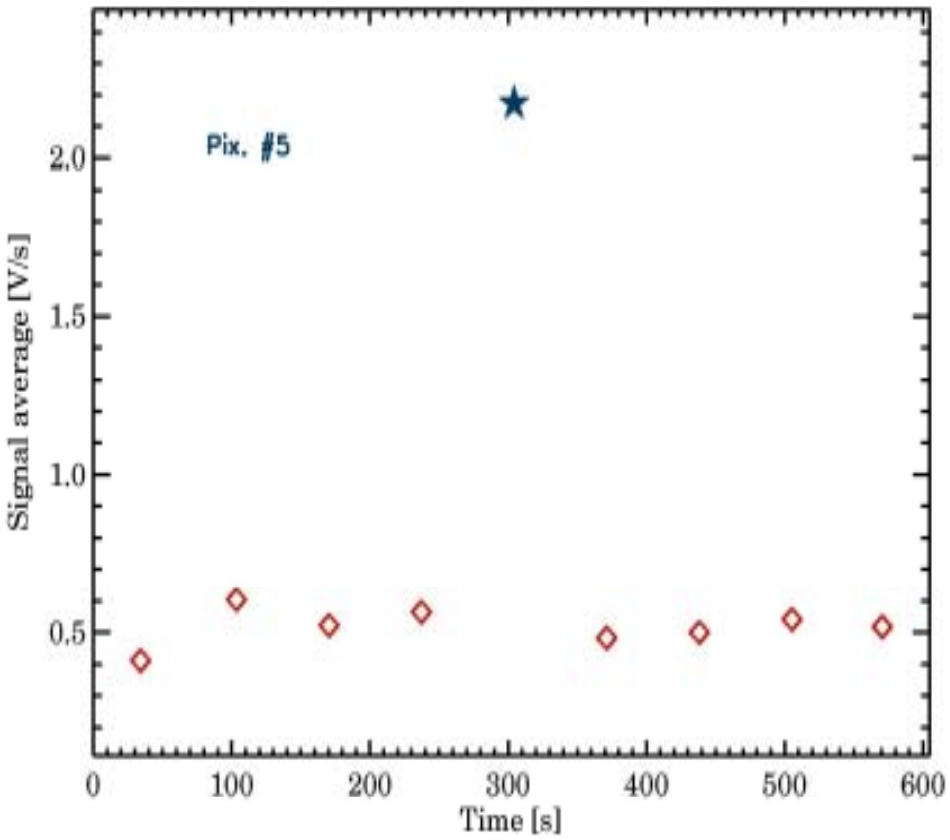
- No detectable far-infrared excess

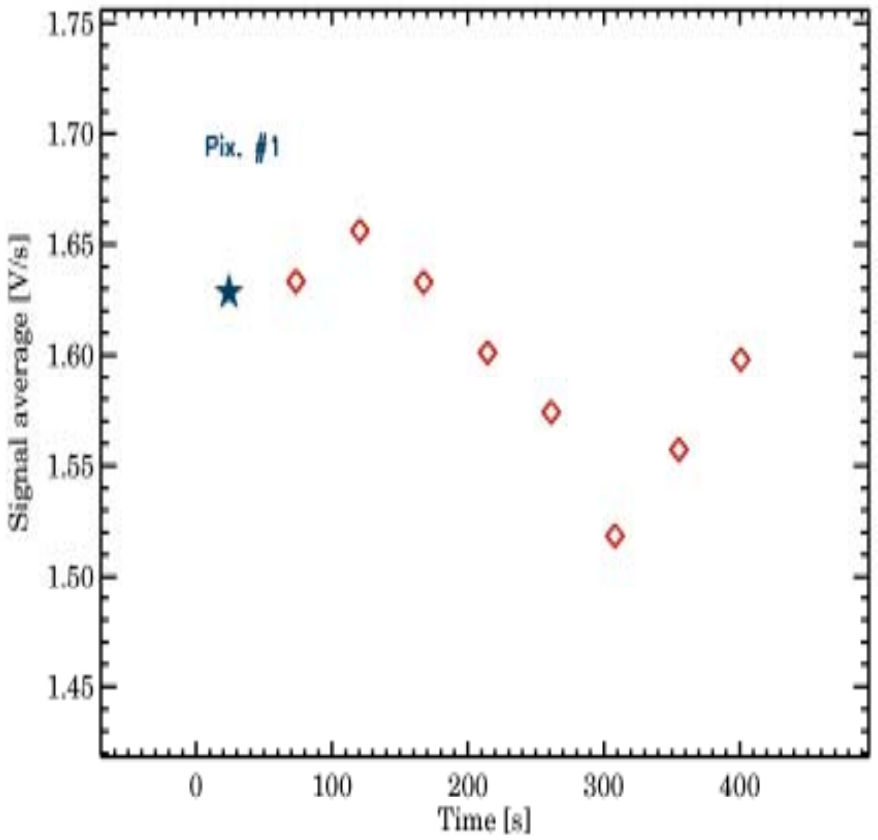
  check if the star is situated “in the crowd”

- Smooth sky background

  look at ISOPHOT maps and mini-maps

Sky background towards Sirius





Candidates for Herschel standard stars

Konkoly Observatory

- No detectable far-infrared excess

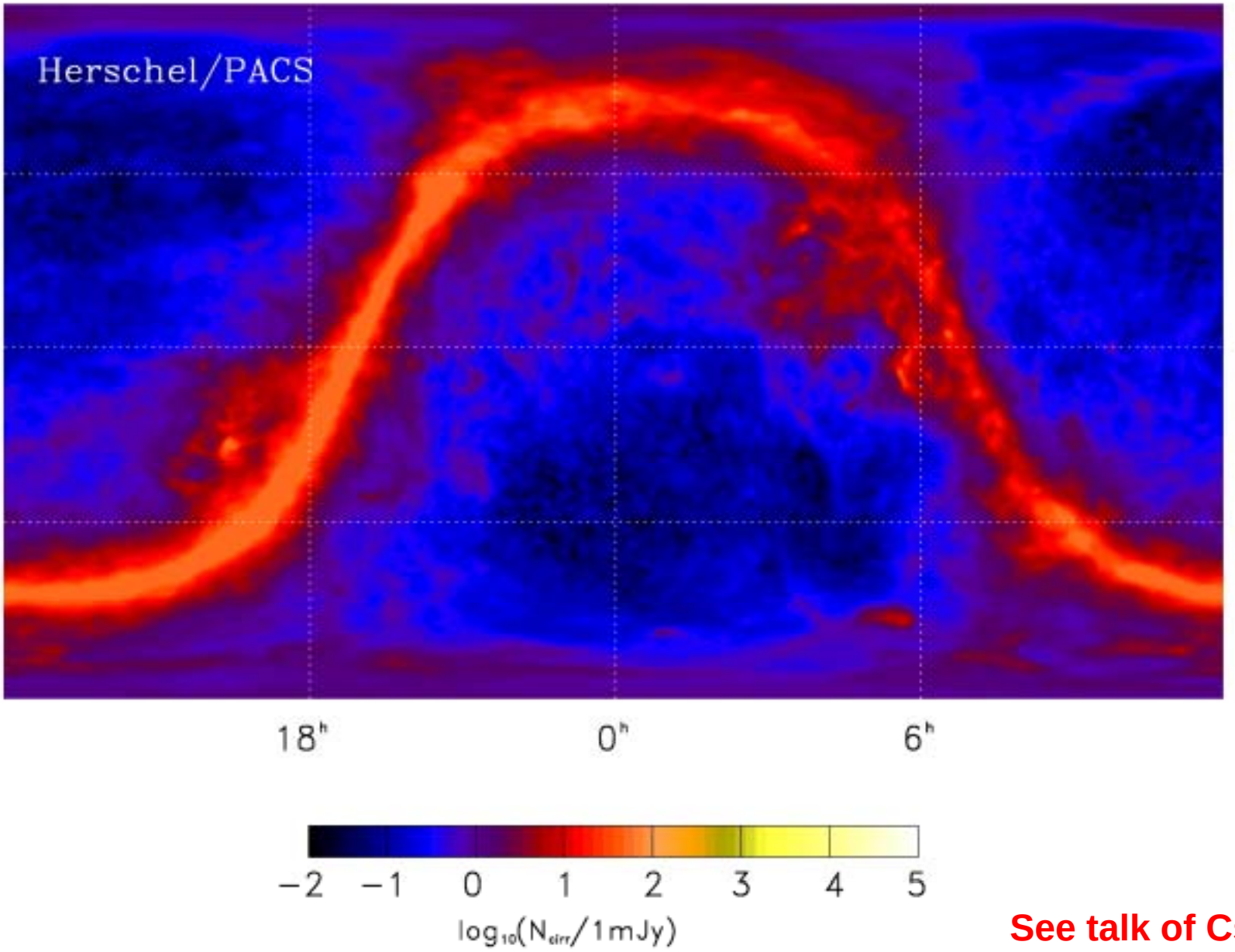
  check if the star is situated “in the crowd”

- Smooth sky background

  look at ISOPHOT maps and mini-maps

- Low predicted sky confusion noise

  check e.g. the all-sky maps of Cs. Kiss



See talk of Cs. Kiss.

Candidates for Herschel standard stars

Konkoly Observatory

- No detectable far-infrared excess

  check if the star is situated “in the crowd”

- Smooth sky background

  look at ISOPHOT maps and mini-maps

- Low predicted sky confusion noise

  check e.g. the all-sky maps of Cs. Kiss

- No source confusion in the far-infrared

  check ISOPHOT or Spitzer/MIPS maps

Source confusion towards HR 6132

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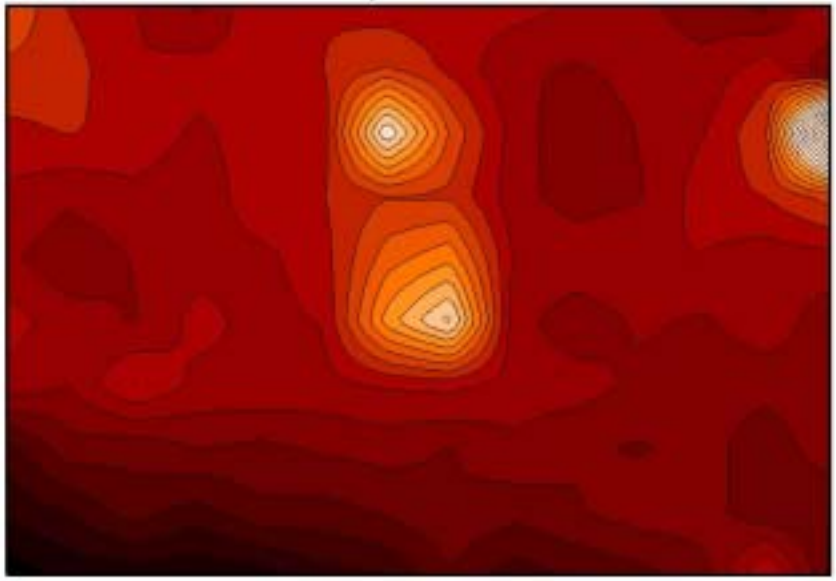
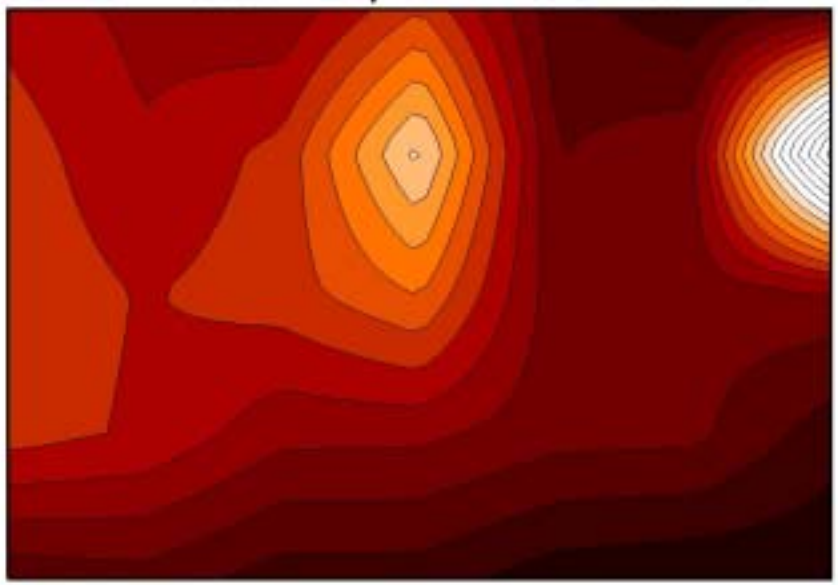
ISOPHOT raster map of HR 6132 at 90 micron



Data reduction: no drift correction, interpolation to a finer grid

PA 16-Nov-96

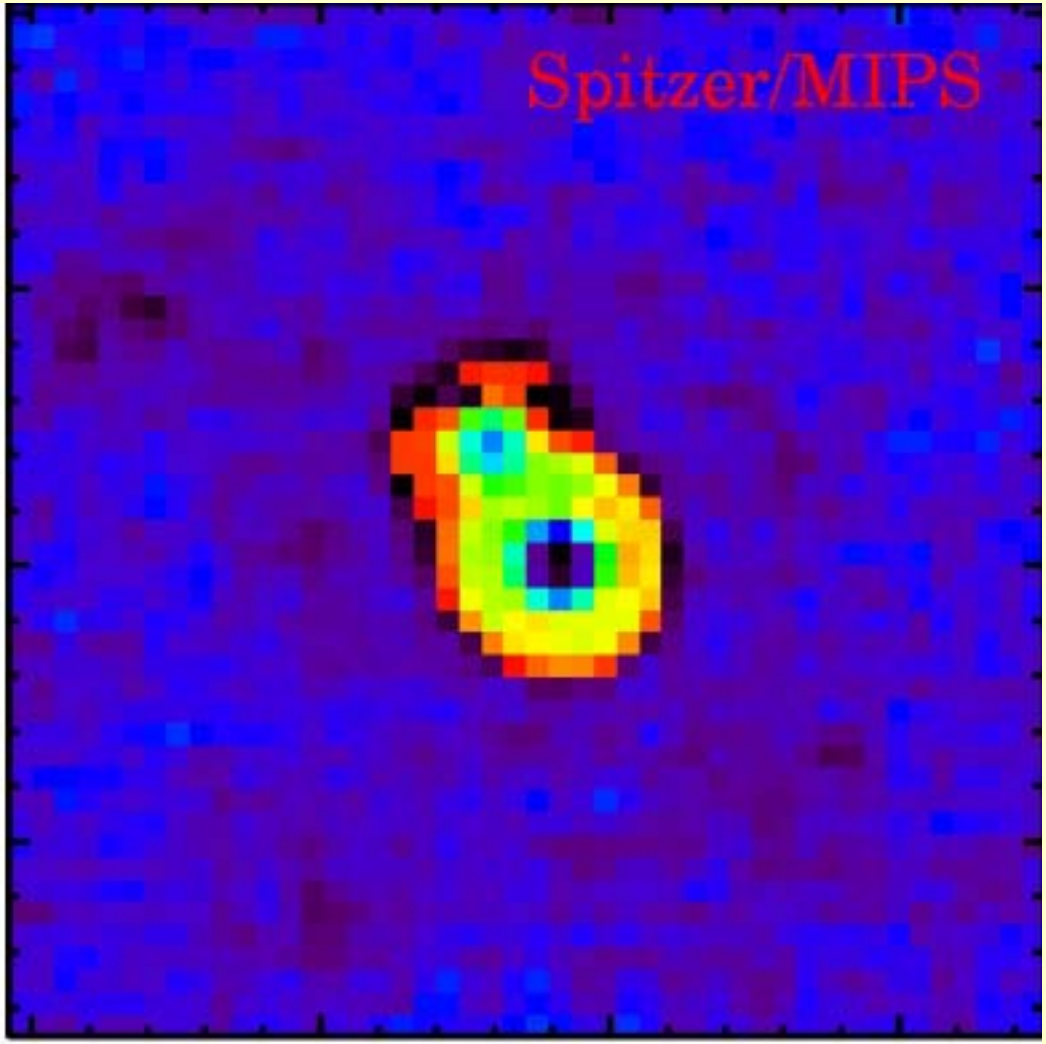
ISOPHOT raster map of HR 6132 at 175 micron



Data reduction: no drift correction, interpolation to a finer grid

PA 14-Nov-96

Source confusion towards an F-star



Candidates for Herschel standard stars

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- No detectable far-infrared excess

  check if the star is situated “in the crowd”

- Smooth sky background

  look at ISOPHOT maps and mini-maps

- Low predicted sky confusion noise

  check e.g. the all-sky maps of Cs. Kiss

- No source confusion in the far-infrared

  check ISOPHOT or Spitzer/MIPS maps

On the basis of ISOPHOT data a list of standard star candidates for Herschel could be compiled.

Could Spitzer help to choose standards?

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- Debris-disk programmes will provide lists of non-excess stars
- MIPS maps available in the Spitzer archive could help to avoid source confusion
- Dedicated HSC proposals to check the environment of (faint) standard star candidates

Summary

- In order to refine the calibration of selected ISOPHOT observing modes also scientific targets have to be utilised as “secondary standard”
- Best objects are normal stars, mainly from the debris disk programmes
- Flux prediction from 2MASS Ks and [B-V] gives satisfactory accuracy at far-infrared wavelengths
- In mini-map mode the photometric uncertainty is 14 mJy for faint objects and 10% for brighter objects (60 micrometer)
- These kind of analyses cannot verify theoretical models in absolute sense, but could give hints whether the models worked equally well for different classes
- Several important aspects of choosing good faint standards for Herschel can be checked from ISOPHOT data. We could prepare a list of suitable candidates
- Spitzer measurements (existing or new ones) could help to avoid source confusion and far-infrared excess

Thank you for your attention!

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