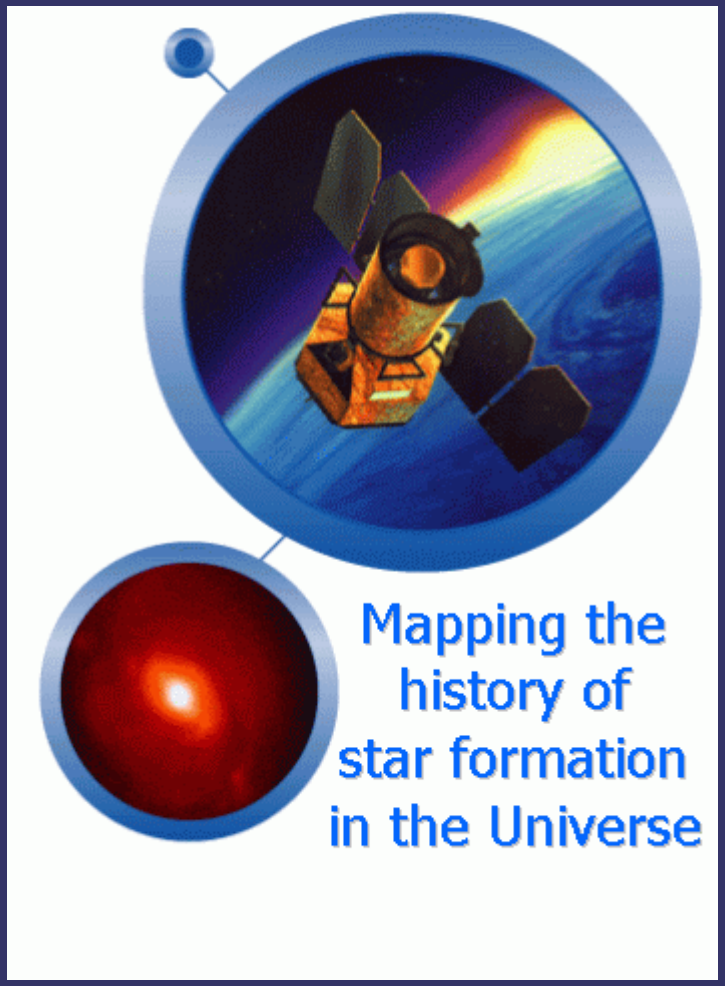
Star Formation in Galaxies from the UV and FIR Points of View.
Current Work and Perspectives

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GALEX Galaxy Evolution Explorer



- Launched on April 28 2003
- First light on May 21 2003
- Expected length of the mission: 29 months.
- Objective: Evolution of SFR in galaxies (but also secondary science).

Some Technical Data

Aperture: 50cm (primary mirror), 22cm (secondary mirror).

f/6.0 Ritchey-Chrétien design.

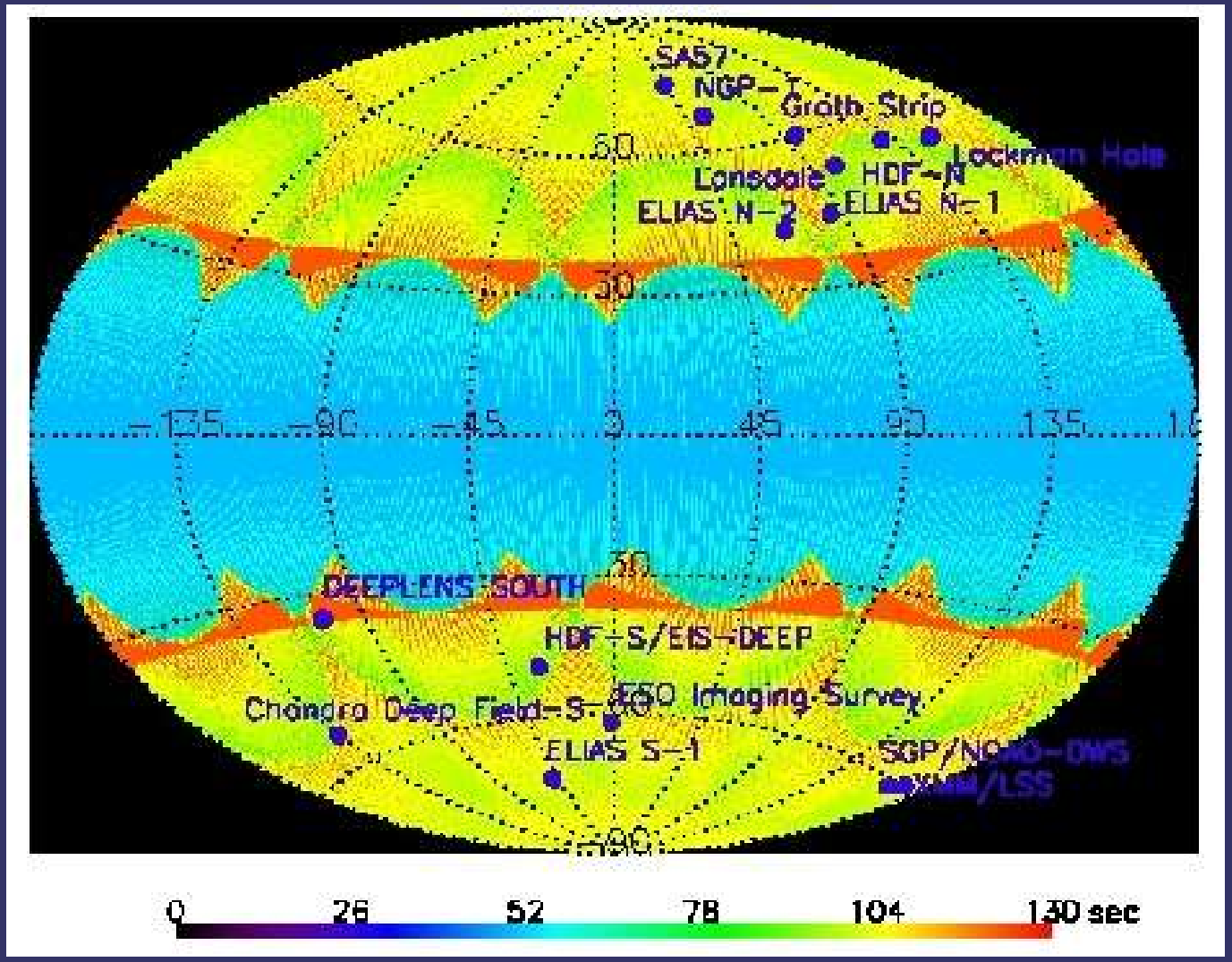
4 channels (2 imaging + 2 spectroscopy)

Field of view: 1.2 degrees, circular

	FUV channel	NUV channel
Band	1350 – 1750 Å	1750 – 2800 Å
Angular resolution	~ 4” (FWHM)	~ 6” (FWHM)
Spectral resolution	250 – 300	80 - 150

GALEX Surveys

- Imaging
  - All-sky Imaging Survey (AIS): NUV<21 mag.
  - Medium Imaging Survey (MIS): 1000 deg^2, NUV<23 mag.
  - Deep Imaging Survey (DIS): 80 deg^2, NUV<25 mag.
  - Ultra Deep Imaging Survey (UDIS): 4.5 deg^2, NUV<26 mag.
  - Nearby Galaxy Survey (NGS): μ_{NUV}<27.5 mag $arcsec^{-2}$, 200 gal.
- Spectroscopy
  - Wide-field Spectroscopic Survey (WSS): 80 deg^2 DIS frames, NUV<20 mag, S/N=10.
  - Medium-deep Spectroscopic Survey (MSS): 8 deg^2, central DIS fields, NUV<21.5-23 mag, S/N=10.
  - Deep Spectroscopic Survey (DSS): 2 deg^2, NUV<23-24.


SA57
NGP-I
Groth Strip
Lockman Hole
Lonsdale
HDF-N
ELIAS N-2
ELIAS N-1
60
30
-135
-90
-45
0
45
90
135
DEEPLENS SOUTH
HDF-S/EIS-DEEP
ESO Imaging Survey
Chandra Deep Field-S
ELIAS S-1
SGP/NOAO-DWS
0
26
52
78
104
130 sec

Motivations

- Both UV and FIR fluxes can be used to estimate SFRs, but are these estimations coherent?

(Calibrate different SFR estimators)

- Is it possible to properly correct for dust attenuation only with fluxes at UV wavelengths?

(Relation L_{UV} - A_{UV})

- Can we construct a SFR per unit volume distribution function?

(Bivariate Luminosity Function)

The procedure

- Selection of a **UV flux limited** sample of galaxies from GALEX data.
  - X-correlation with IRAS-FIR catalog (FSC, SCANPI).

and also

- Selection of a **FIR flux limited** sample of galaxies from IRAS catalog.
  - X-correlation with GALEX-UV catalog.

(Both approaches are complementary)

The Data

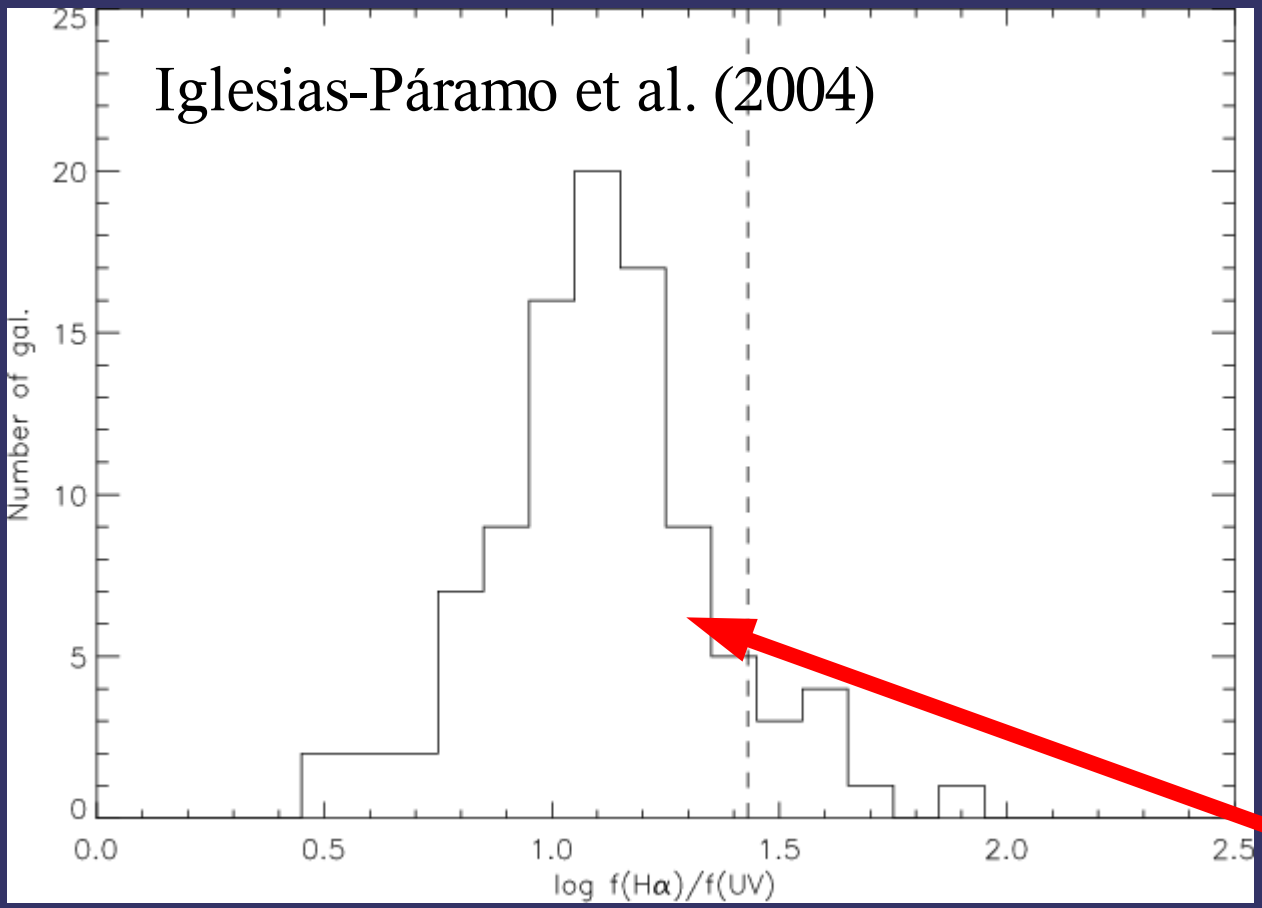
- **NUV selected sample**: 95 galaxies (NUV<16 mag) over 615 sq. degrees.
  - After removing active nuclei, ellipticals, cirrus>2 and pairs not resolved by IRAS...

62 galaxies

- **FIR selected sample**: 163 galaxies from the IRAS PSCz (f_{60}>0.6 Jy) over 509 sq. degrees.
  - After removing active nuclei, ellipticals, cirrus>2 and pairs not resolved by IRAS...

118 galaxies

Star Formation Rates



Scenario

- Constant SFR over ~10^8 yr
- Salpeter IMF

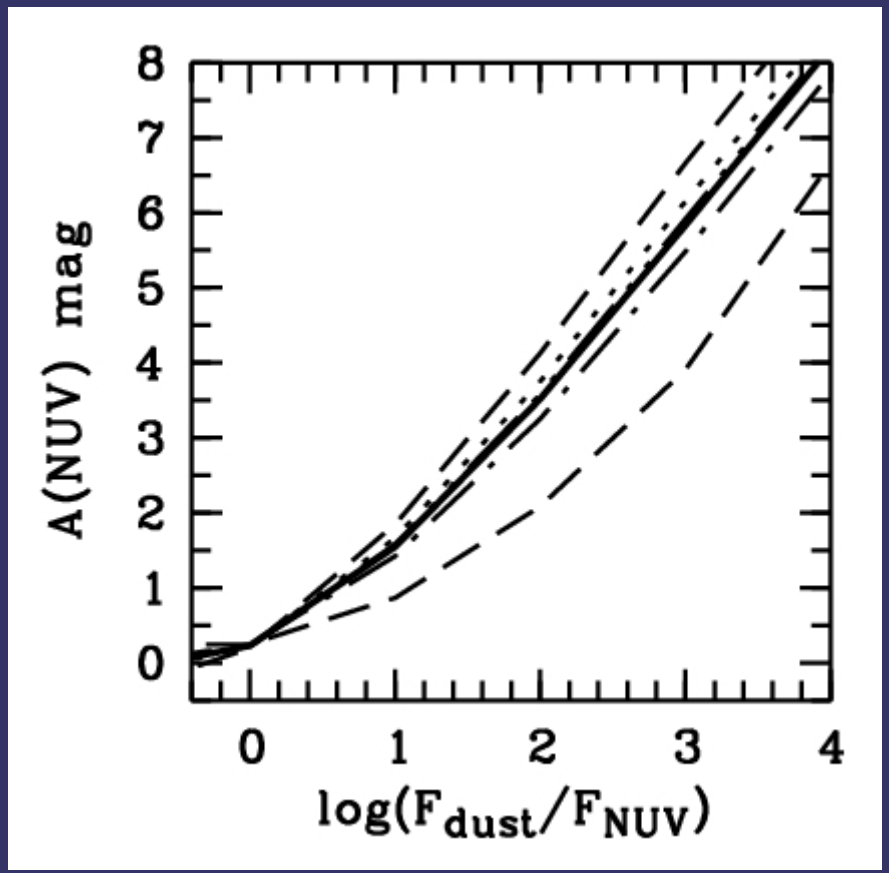
(0.1 < M < 100M⊙)

Seems reasonable!

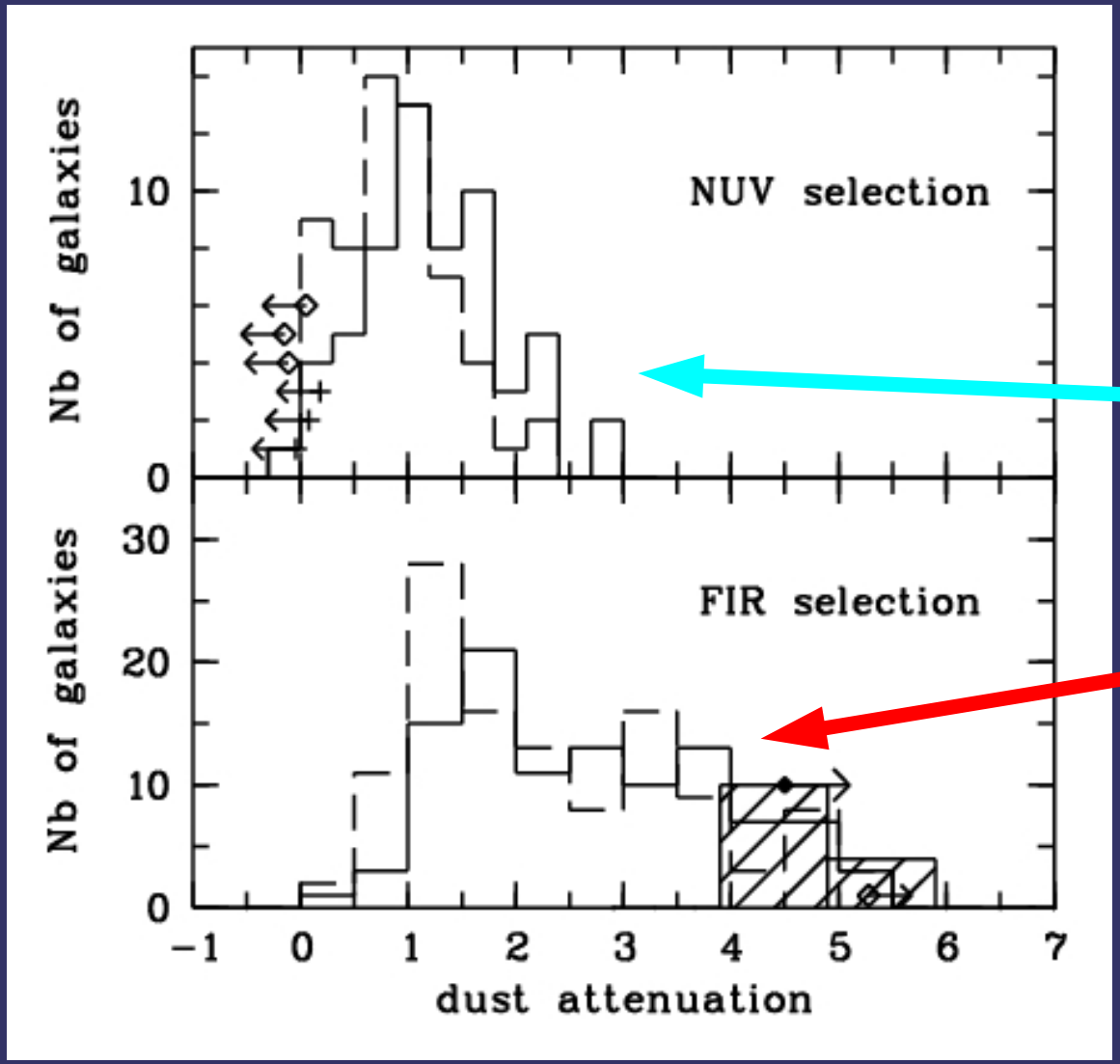
SFR from UV flux

- From the NUV flux:
  - $\log L_{NUV}\,(L\odot) = 9.73 + \log SFR_{NUV}\,(M\odot\ yr^{-1})$

Problem NUV1: Need to correct for dust attenuation!



- Dust attenuation derived from a radiation transfer model (Buat & Xu 1995)
- Valid for different star formation histories representative of star forming galaxies.
- **Warning:** inclination difficult to take into account…

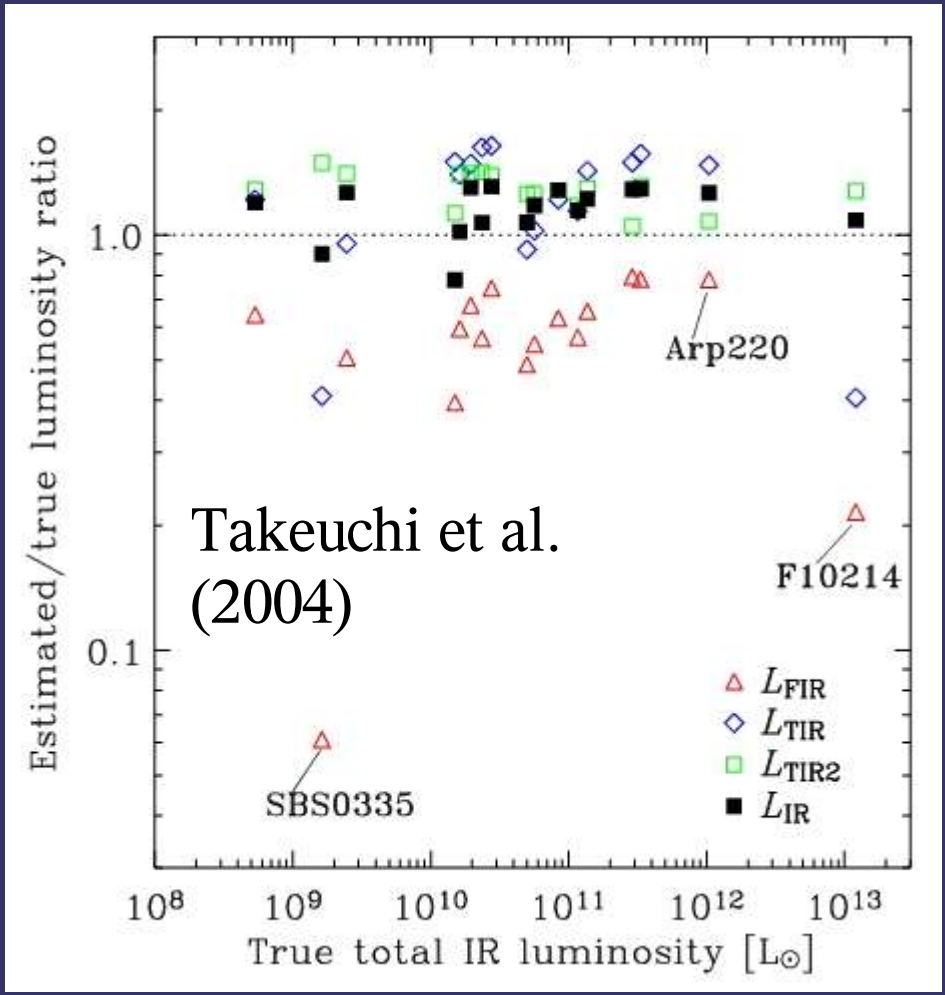


Results:

$\langle A_{NUV} \rangle \sim 1$ mag
for the NUV sample

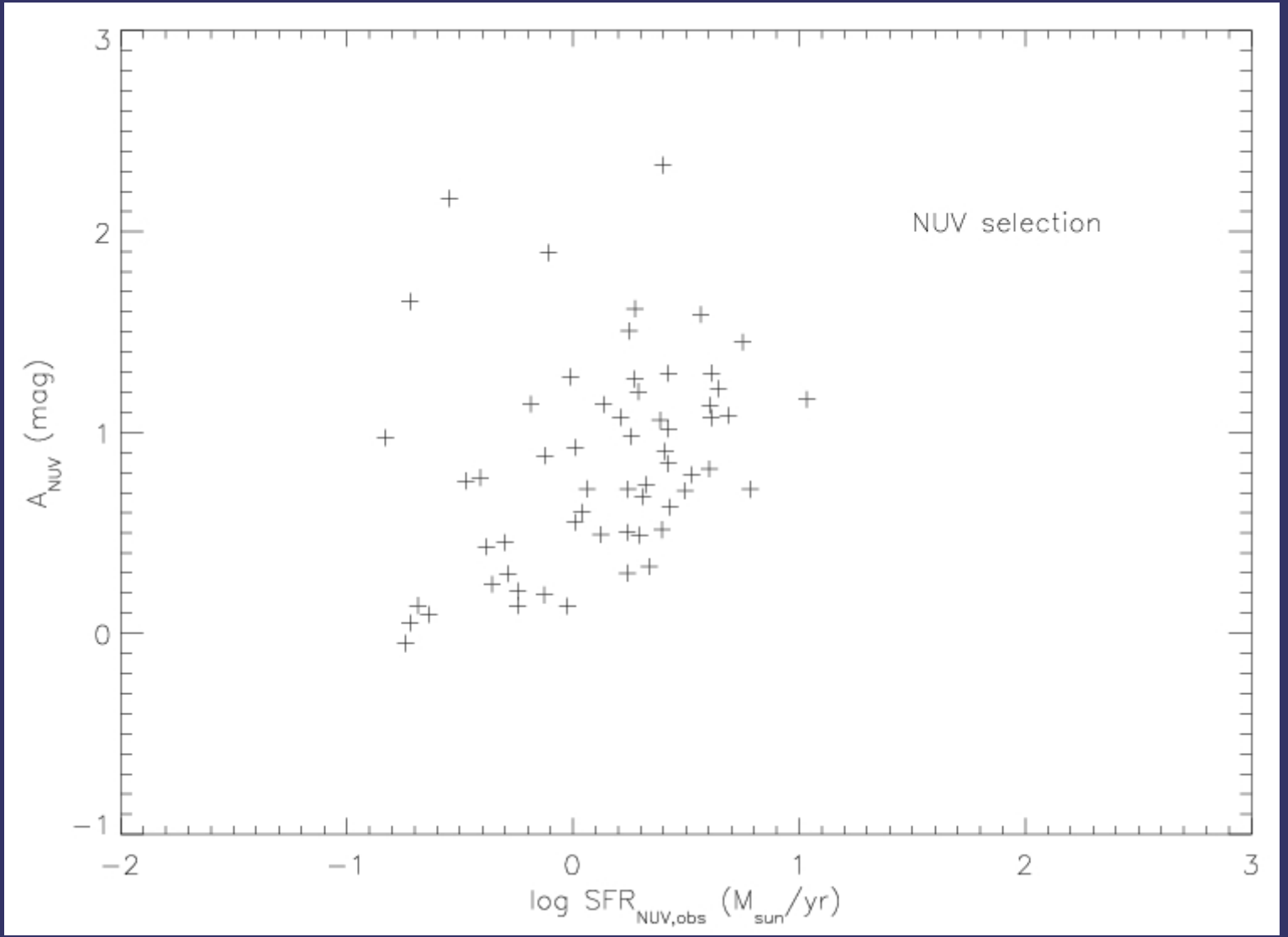
$\langle A_{NUV} \rangle \sim 2$ mag
for the FIR sample

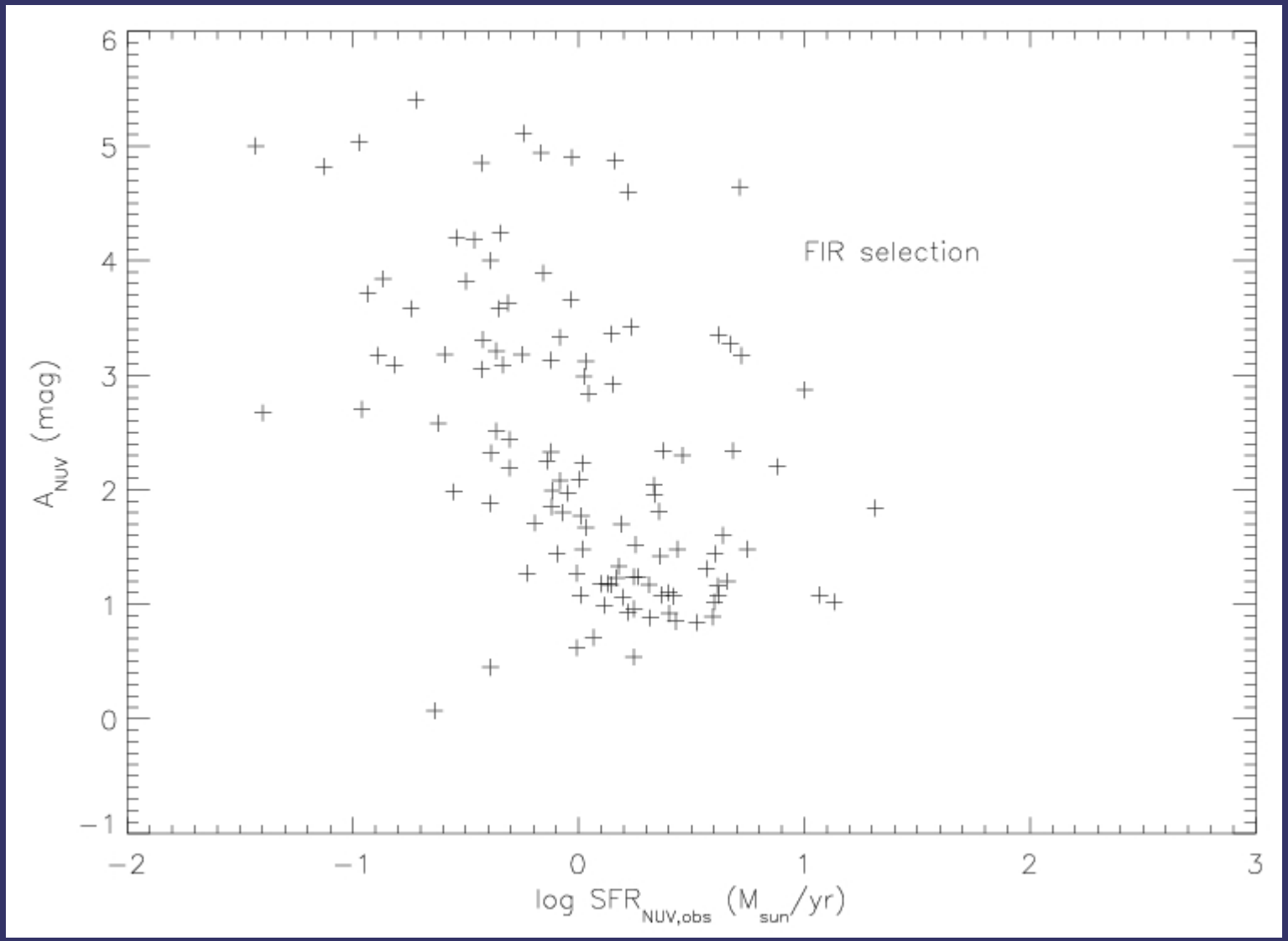
SFR from dust emission

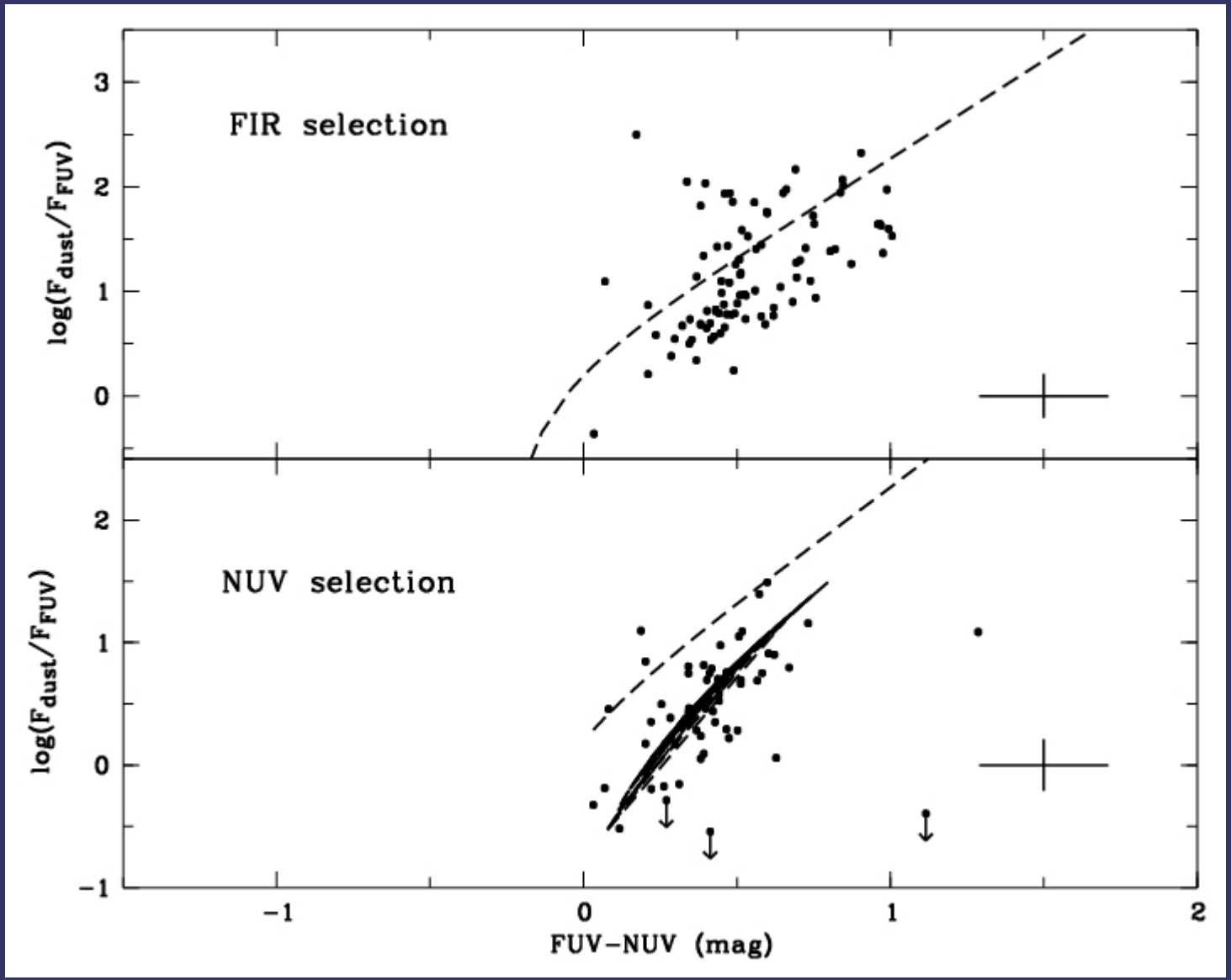


- Dust emission from 8 to 1000μm.
- Several estimators of L_{dust} from FIR and MIR fluxes:
  - Dale et al. (2001): Requires f_{60} and f_{100}.
- From the dust luminosity:
  - $\log L_{dust} (L\odot) = 10.17 + \log SFR_{dust} (M\odot\ yr^{-1})$

Problem FIR1: Neglects the contribution of the NUV flux!

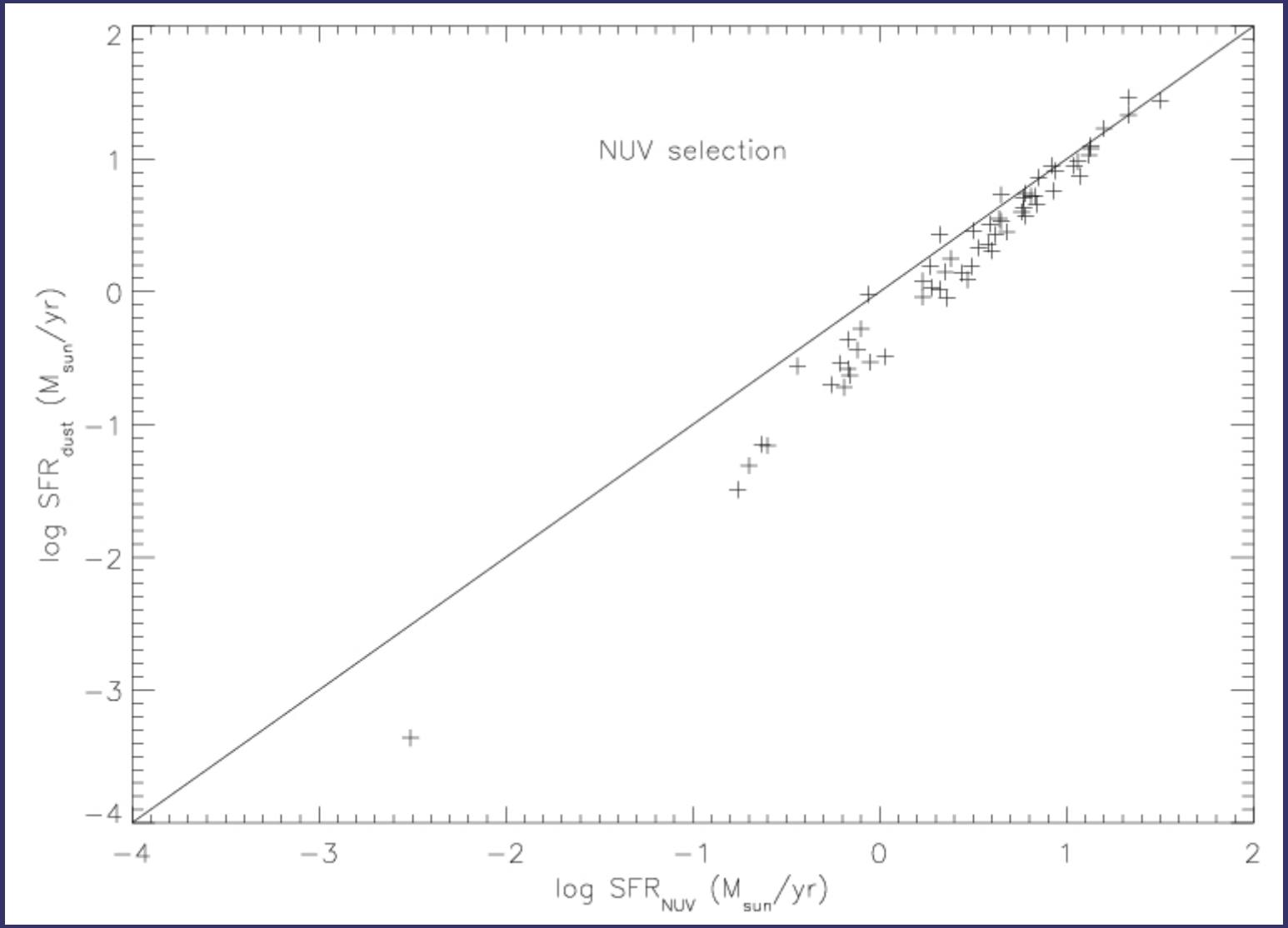

NUV selection
A_{NUV} (mag)
log $SFR_{NUV,obs}$ (M_{sun}/yr)
3
2
1
0
−1
−2
−1
0
1
2
3

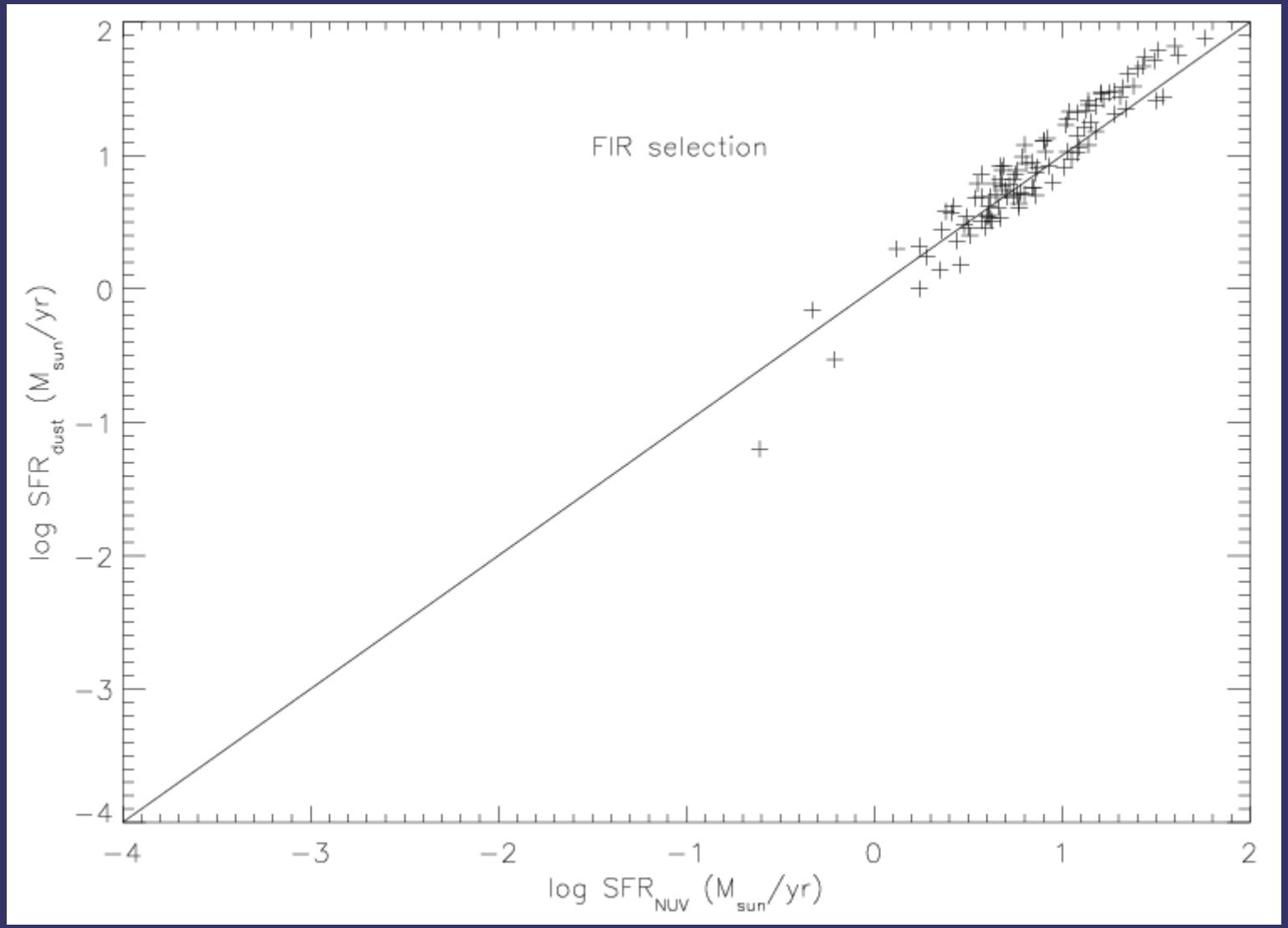

FIR selection
A_{NUV} (mag)
log $SFR_{NUV,obs}$ (M_{sun}/yr)
6
5
4
3
2
1
0
−1
−2
−1
0
1
2
3



Meurer et al. (1999)

Thus, we need fluxes at both wavelengths (UV and FIR) in order to make a proper analysis of the SFR.


NUV selection
log SFR$_{dust}$ (M_{sun}/yr)
log SFR$_{NUV}$ (M_{sun}/yr)
2
1
0
−1
−2
−3
−4
−4
−3
−2
−1
0
1
2

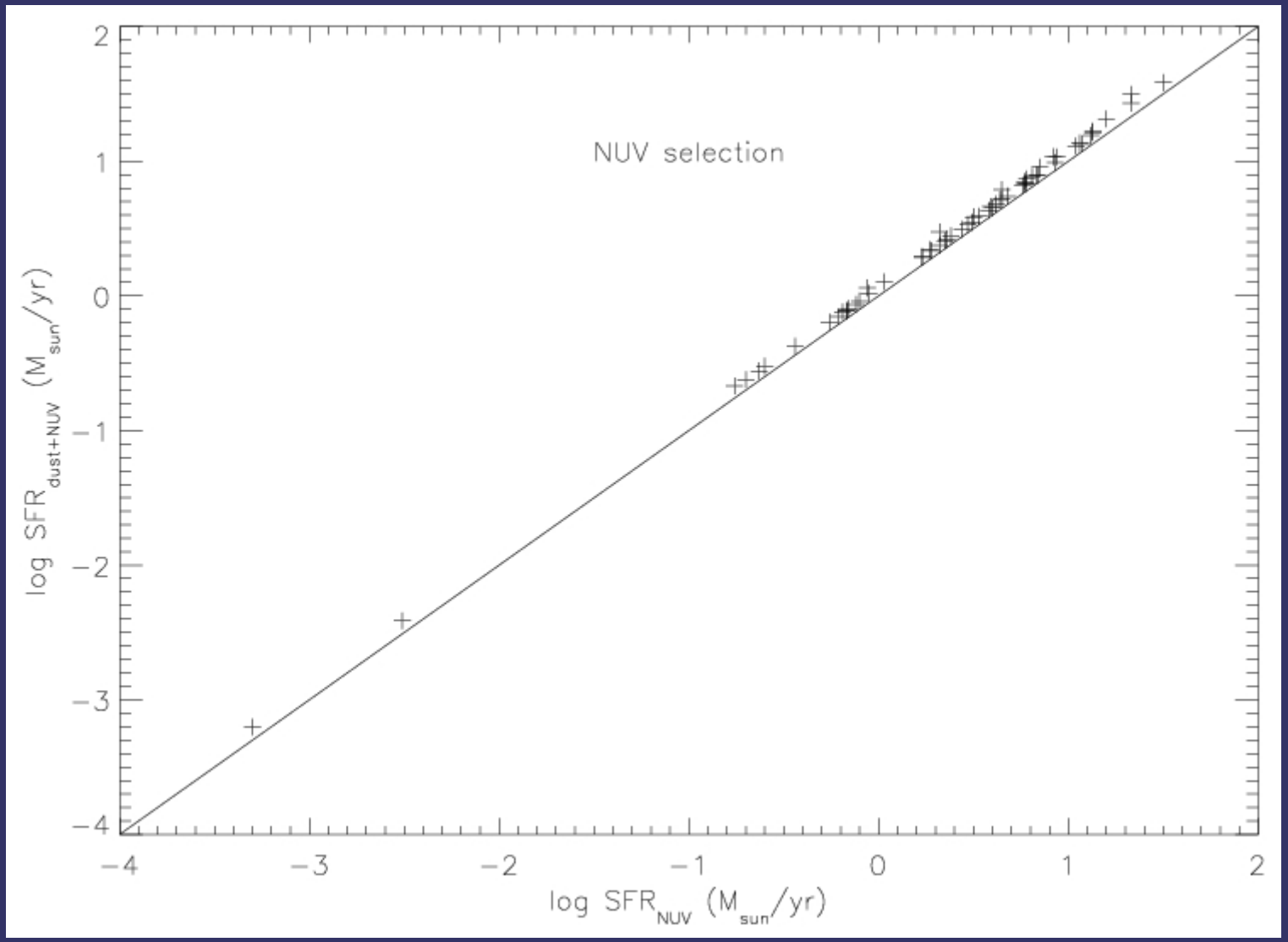

FIR selection
log SFR$_{dust}$ (M_{sun}/yr)
log SFR$_{NUV}$ (M_{sun}/yr)
2
1
0
−1
−2
−3
−4
−4
−3
−2
−1
0
1
2

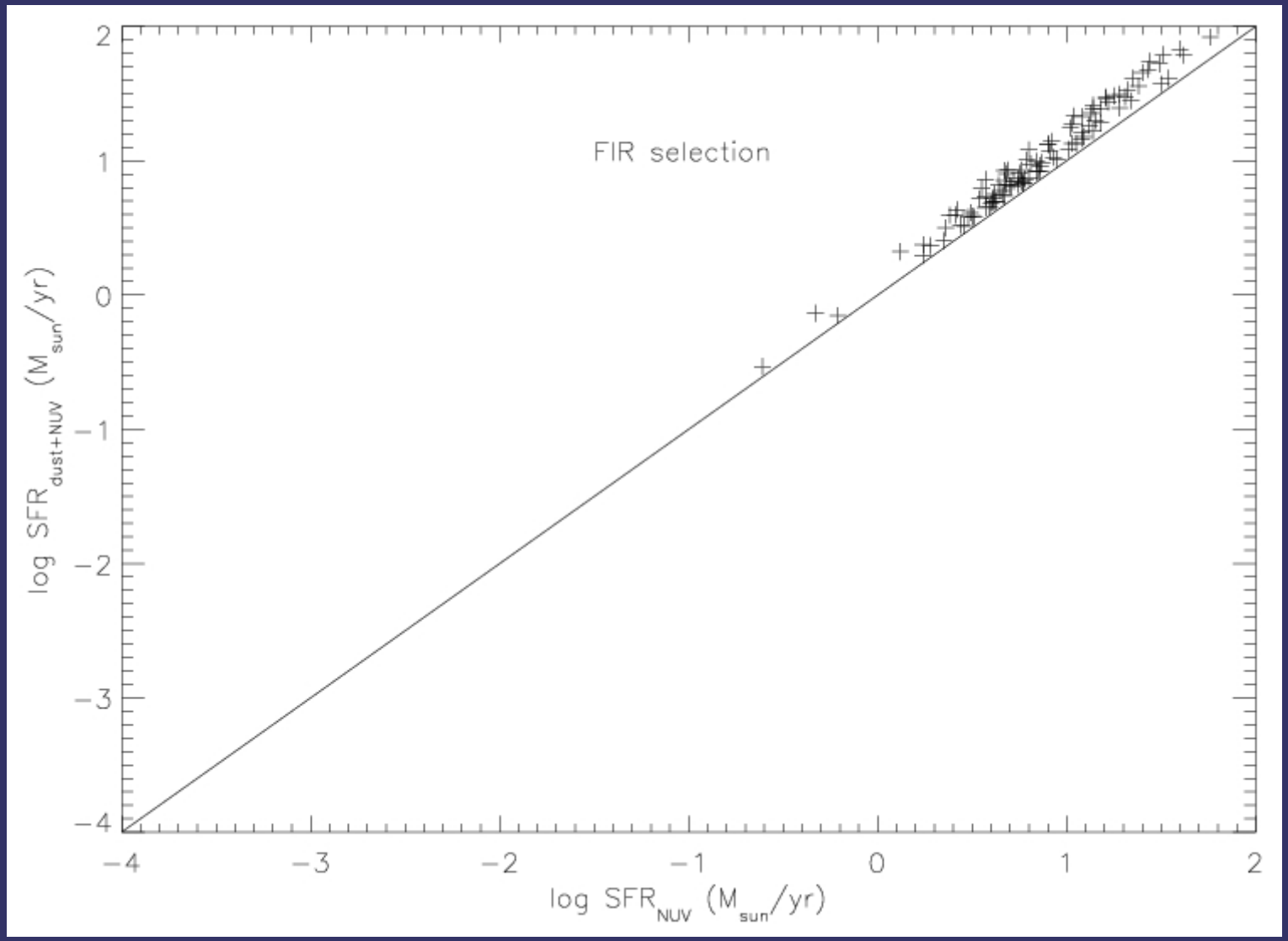
Combining both estimators...

- Using the NUV **observed** flux + dust emission:
  - $SFR_{NUV+dust} = SFR_{NUV} + SFR_{dust}$

Warning: UV flux is not isotropic!

(Approximation valid from statistical point of view)


NUV selection
log SFR$_{dust+NUV}$ (M_{sun}/yr)
log SFR$_{NUV}$ (M_{sun}/yr)
2
1
0
−1
−2
−3
−4
−4
−3
−2
−1
0
1
2


FIR selection
log SFR$_{dust+NUV}$ (M_{sun}/yr)
log SFR$_{NUV}$ (M_{sun}/yr)
2
1
0
−1
−2
−3
−4
−4
−3
−2
−1
0
1
2

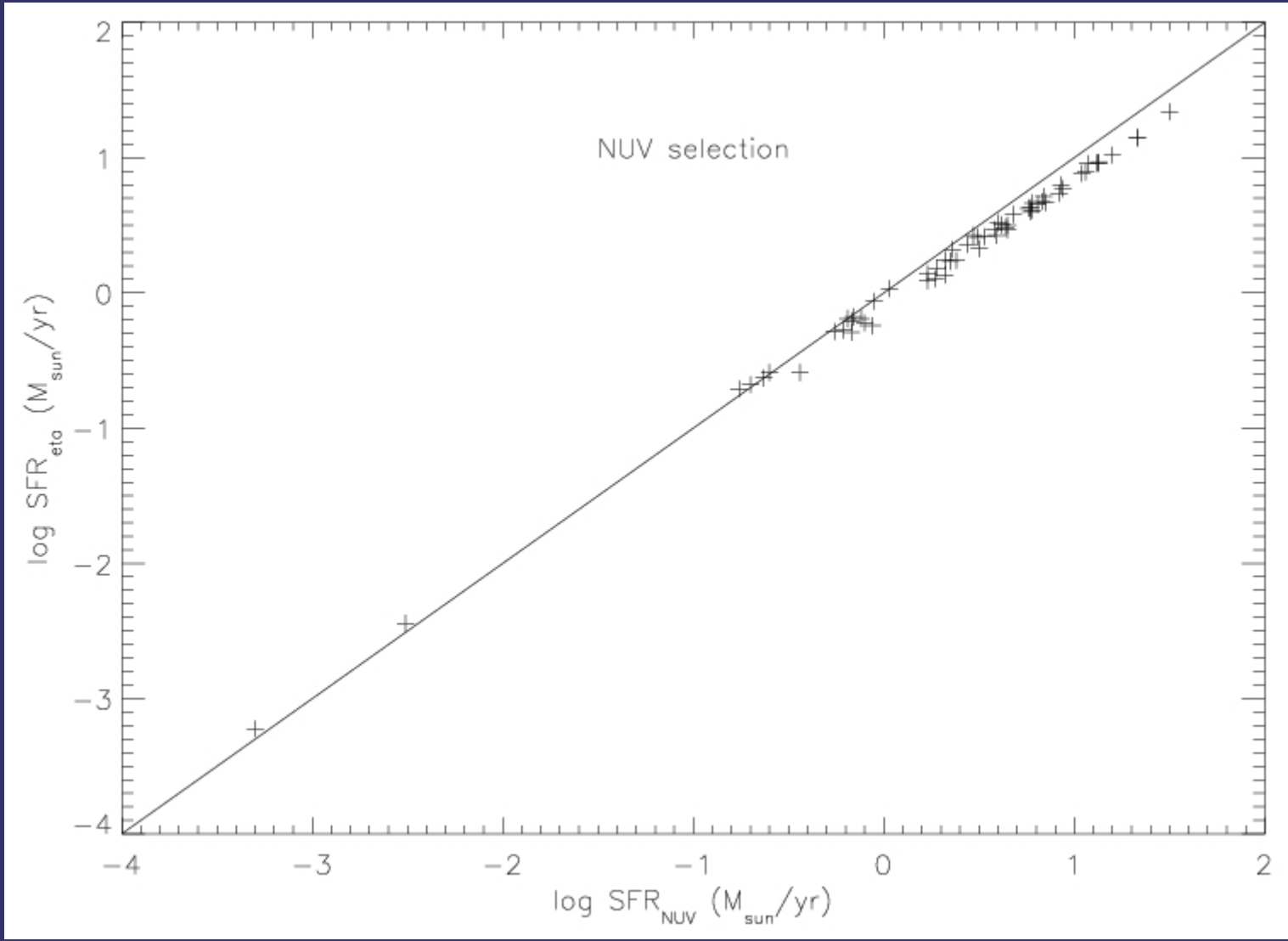
The η Approximation

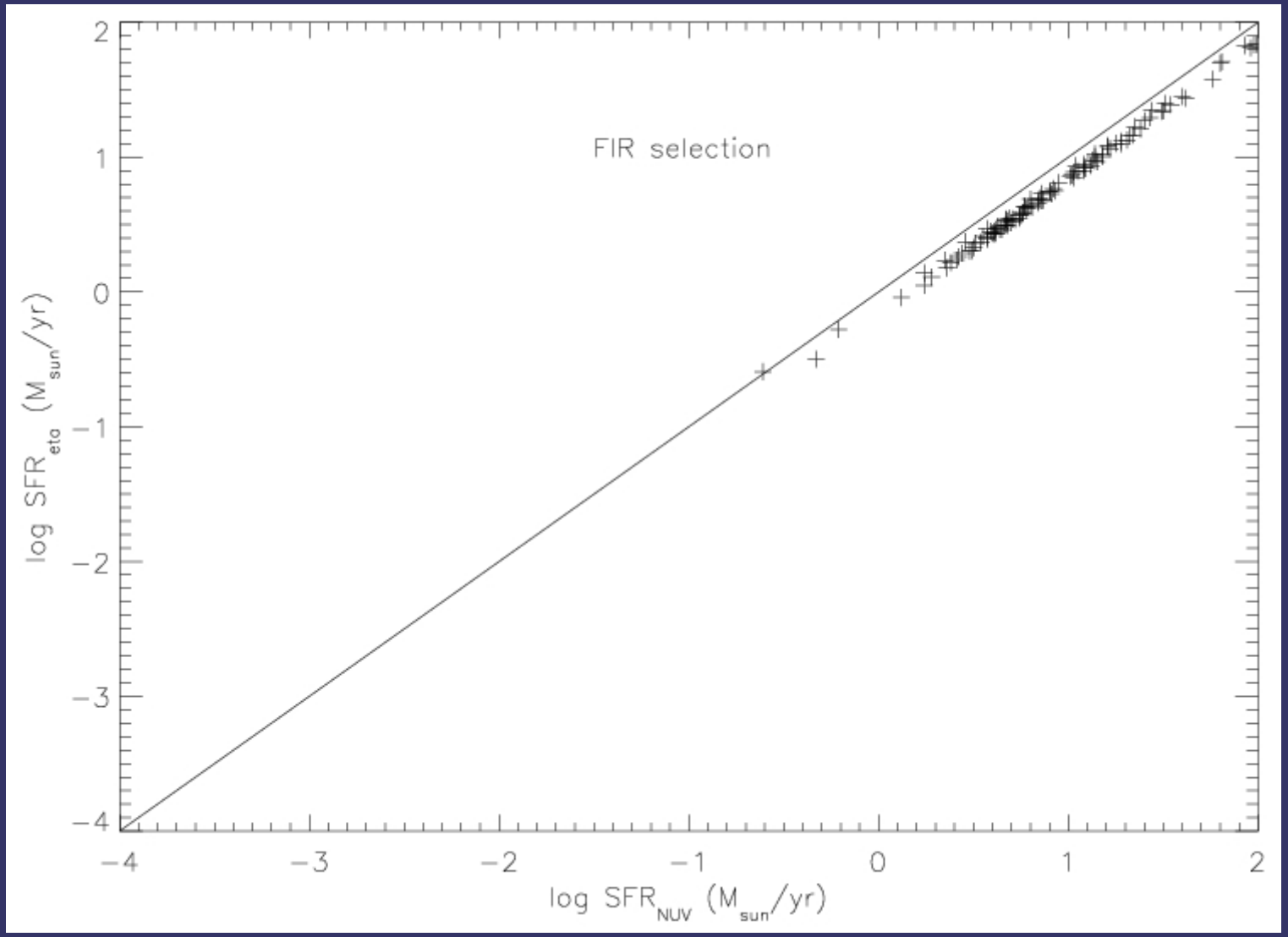
Problem FIR2: NOT all the dust emission comes from young stars!

- Remove the cirrus emission...
  - $SFR_{NUV+dust} = SFR_{NUV} + (1 - \eta) \times SFR_{dust}$
- For a sample of optically selected SF galaxies $\langle\eta\rangle=0.4$

(Hirashita, Buat, Inoue 2003).

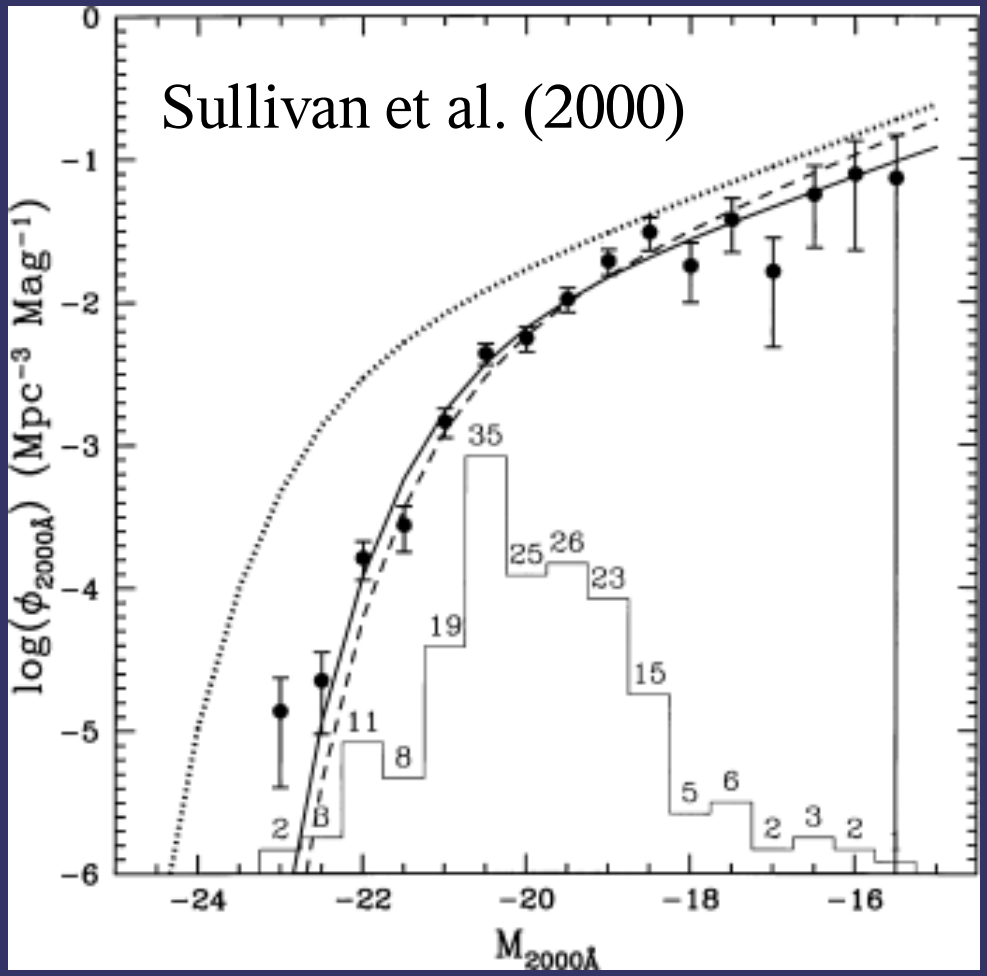
- What about for our NUV and FIR selected samples?

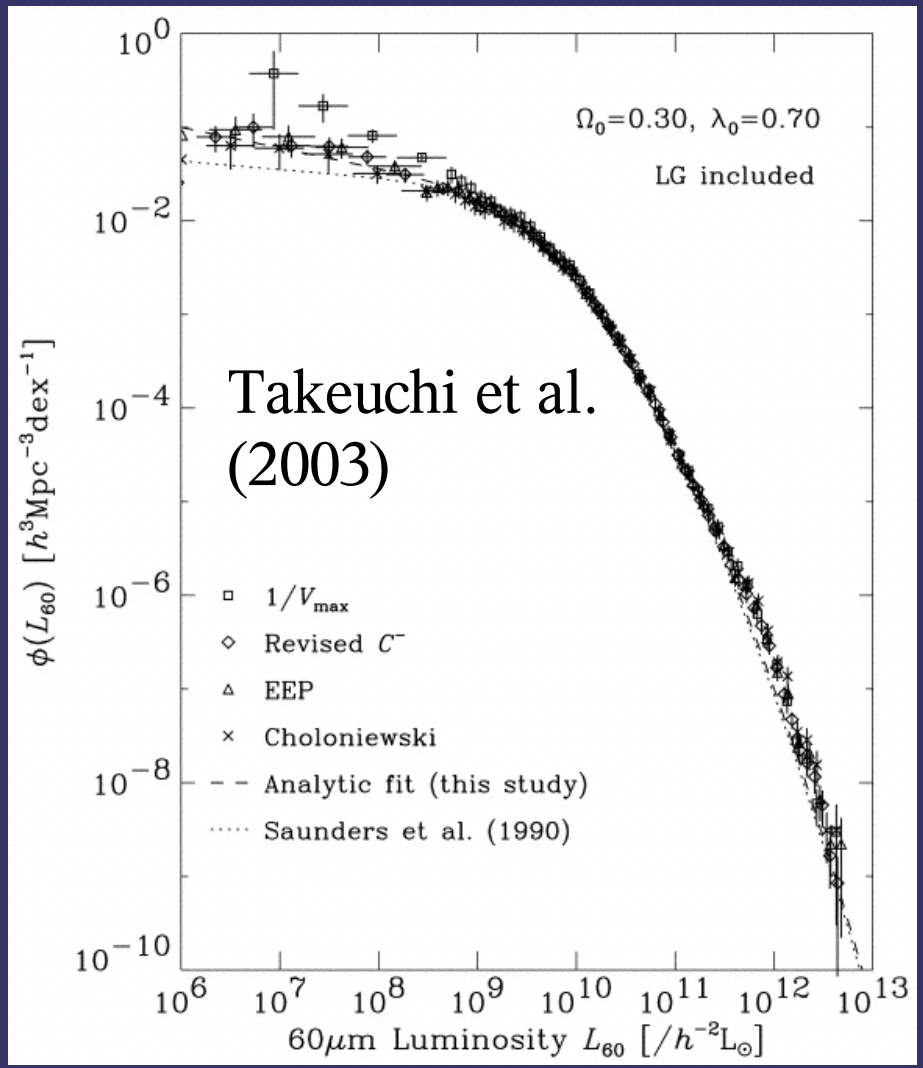

NUV selection
log SFR$_{eto}$ (M$_{sun}$/yr)
log SFR$_{NUV}$ (M$_{sun}$/yr)
2
1
0
−1
−2
−3
−4
−4
−3
−2
−1
0
1
2


FIR selection
log SFR$_{eta}$ (M$_{sun}$/yr)
log SFR$_{NUV}$ (M$_{sun}$/yr)
2
1
0
−1
−2
−3
−4
−4
−3
−2
−1
0
1
2

Conclusions

- Need for a consistent calibration of the SFR.
- No way of estimating the SFR density from single wavelength surveys...

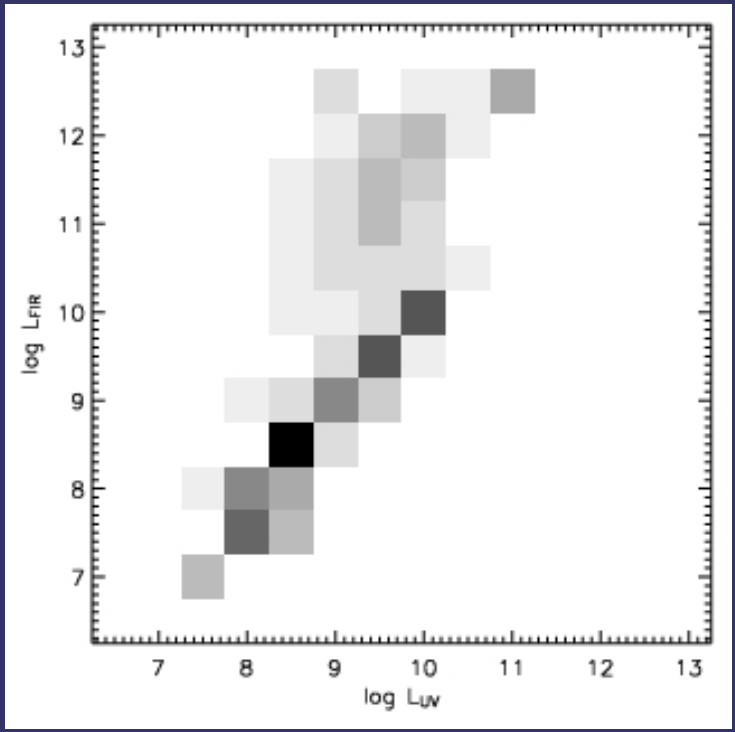


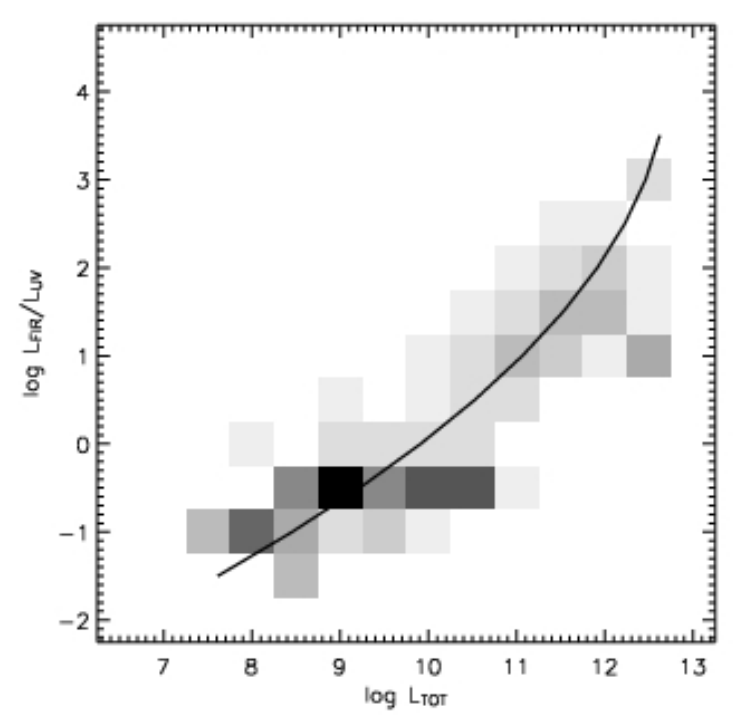


Solution?

- Is the bivariate LF the solution to this problem?

(No large statistics at the moment…)



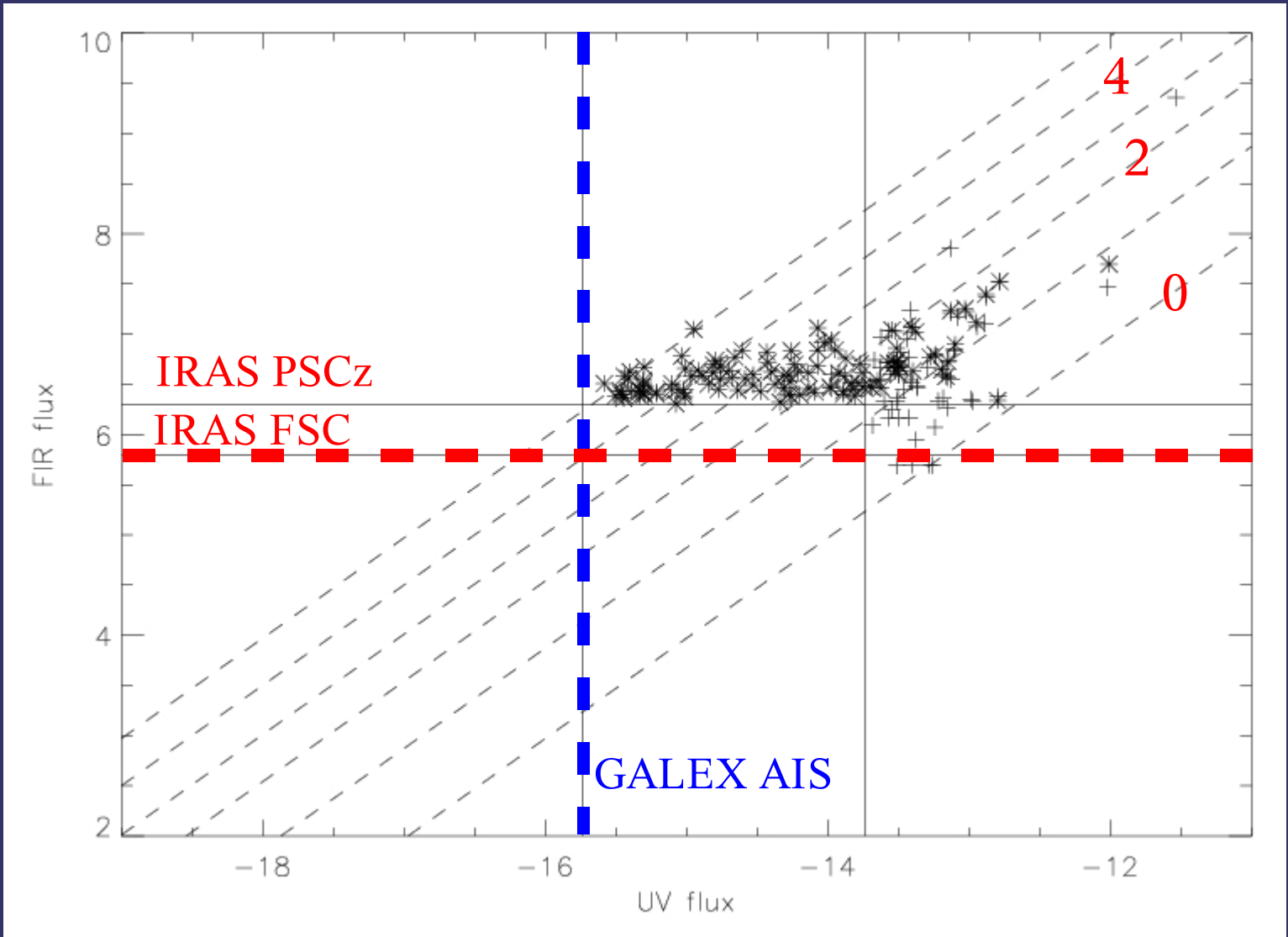


Martin et al. (2005)

Perspectives I

Present: GALEX + IRAS (UV + FIR all sky surveys)

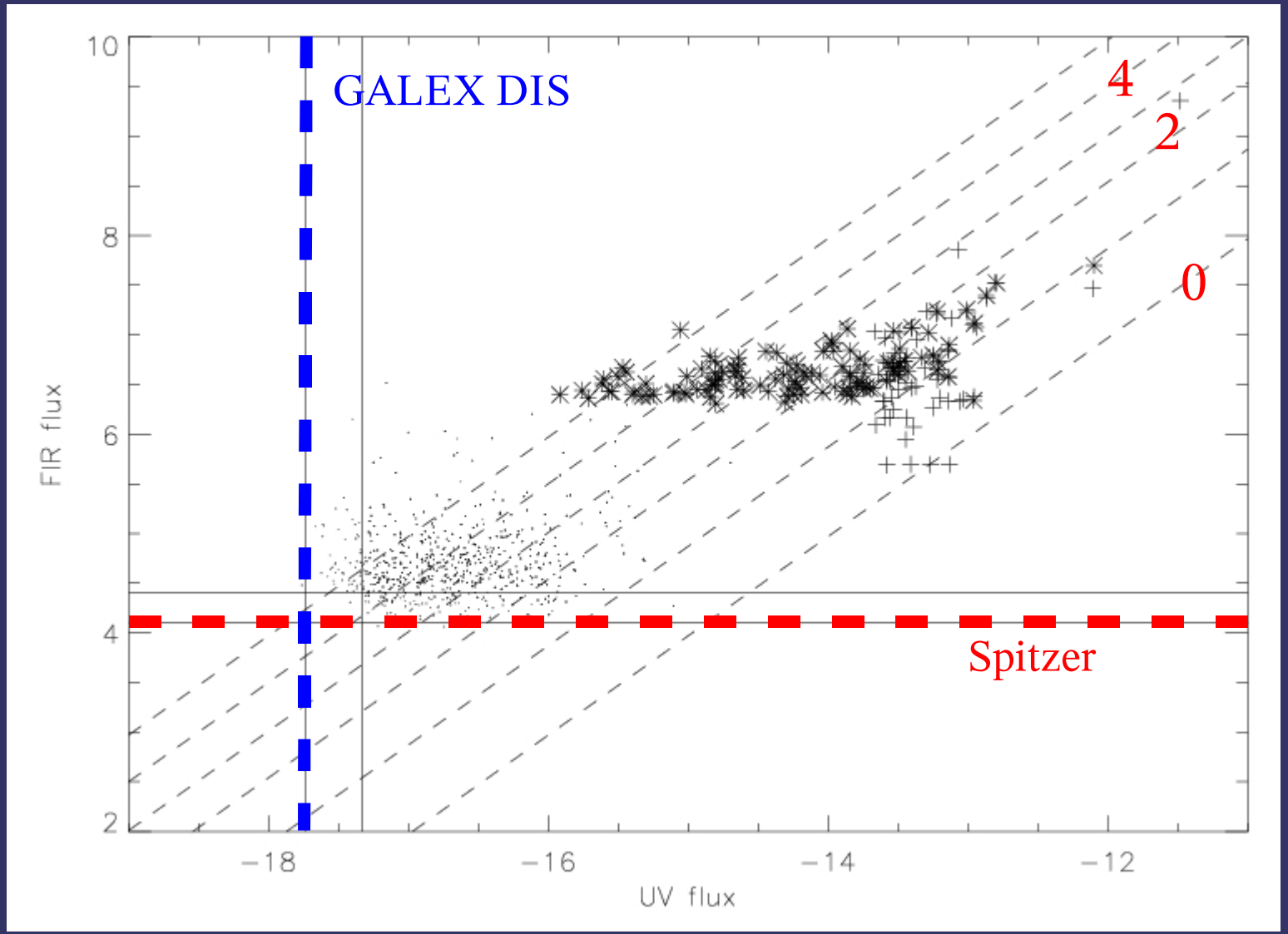
Dust attenuation + SFRs at z=0



Perspectives II

Near future: GALEX + Spitzer (Selected deep fields)

Evolution of dust attenuation with redshift



Perspectives III

Far future: GALEX + ASTRO-F (all sky surveys)

Bivariate LF

