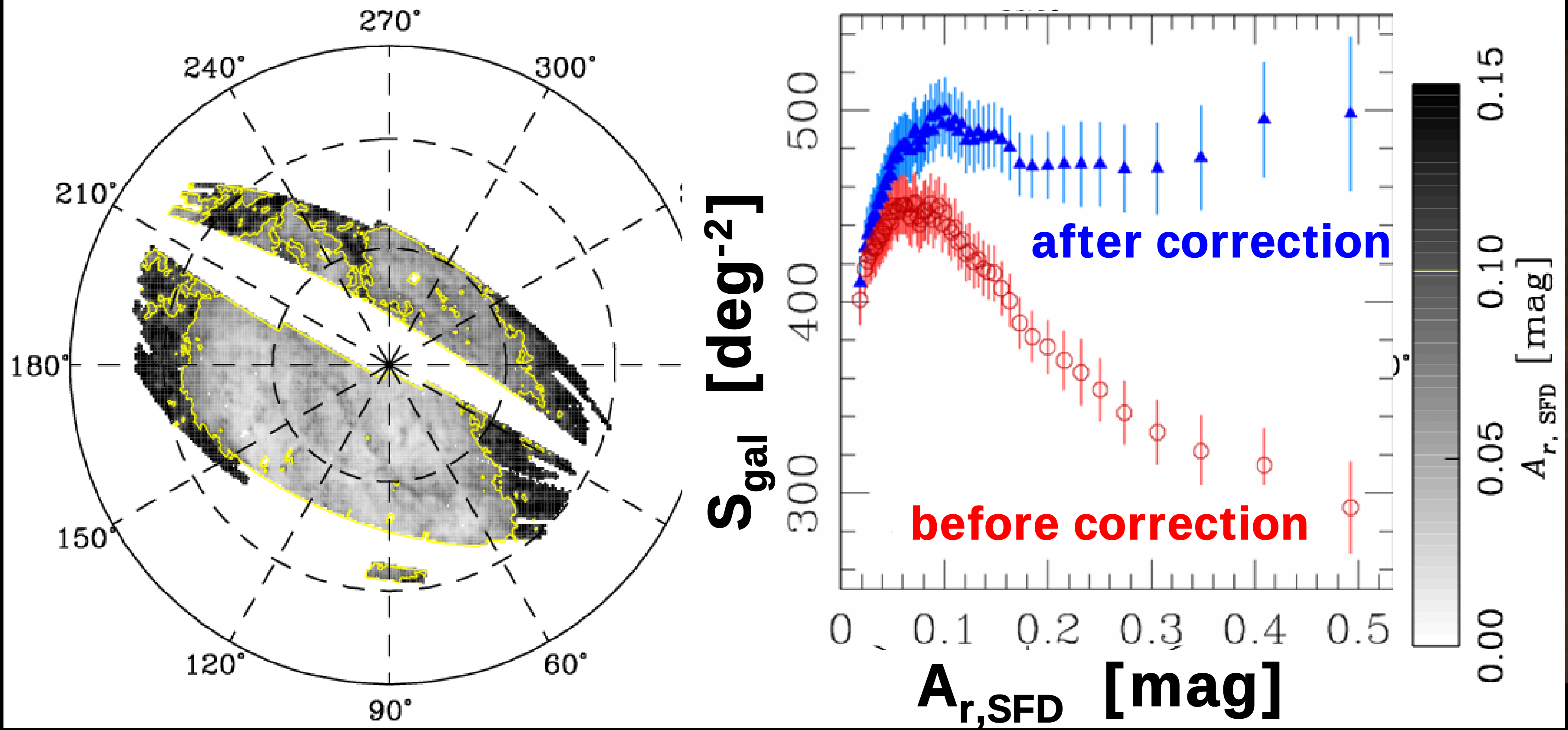
Galaxy clustering and Galactic extinction map



Yasushi Suto *Department of Physics, University of Tokyo*

Oct. 29, 2007 seminar@ The University of Nottingham School of Physics & Astronomy

Recent work of Observational Cosmology Group, University of Tokyo (1)

- **Dark halos and galaxy clusters**
  - triaxial modeling of dark matter halos (Jing & Suto 2002; Oguri, Lee & Suto 2003; Lee, Jing & Suto 2005)
  - Systematic bias of cluster temperature and H_0 from the SZ effect (Kawahara et al. 2006, 2007)
- **Warm/hot intergalactic medium (WHIM)**
  - a proposal of oxygen emission line search with DIOS (Yoshikawa et al. 2003, 2004)
  - feasibility of an absorption line search with XEUS along bright quasars and GRB afterglow (Kawahara et al. 2006)
- **Spectroscopy of transiting extrasolar planets**
  - constraints on planetary atmosphere (Winn et al. 2004; Narita et al. 2005)
  - detection of the spin-orbit misalignment using the Rossiter effect (Ohta, Taruya & Suto 2005, 2007; Winn et al. 2005, 2006, 2007; Narita et al. 2007)

Recent work of Observational Cosmology Group, University of Tokyo (2)

- Large-scale structure of the universe
  - Minkowski functionals and phase correlation of SDSS galaxies (Hikage et al. 2003,2004,2005)
  - constraints on the deviation from Newton’s law of gravity from SDSS galaxy power spectrum (Shirata et al. 2005, 2007)
  - Prospects to constrain modified gravity models from future surveys (Yamamoto et al. 2006, 2007)
  - Bispectrum and nonlinear biasing of galaxies (Nishimichi et al. 2007)
  - Perturbation theory approach to baryon acoustic oscillations (Nishimichi et al. 2007)
  - Galactic dust map against SDSS galaxy surface density (Yahata et al. 2007)

This talk is based on

The effect of FIR emission from SDSS galaxies on the SFD Galactic extinction map

K.Yahata, A.Yonehara, Y.Suto, E.L.Turner, T.Broadhurst, & D.P. Finkbeiner

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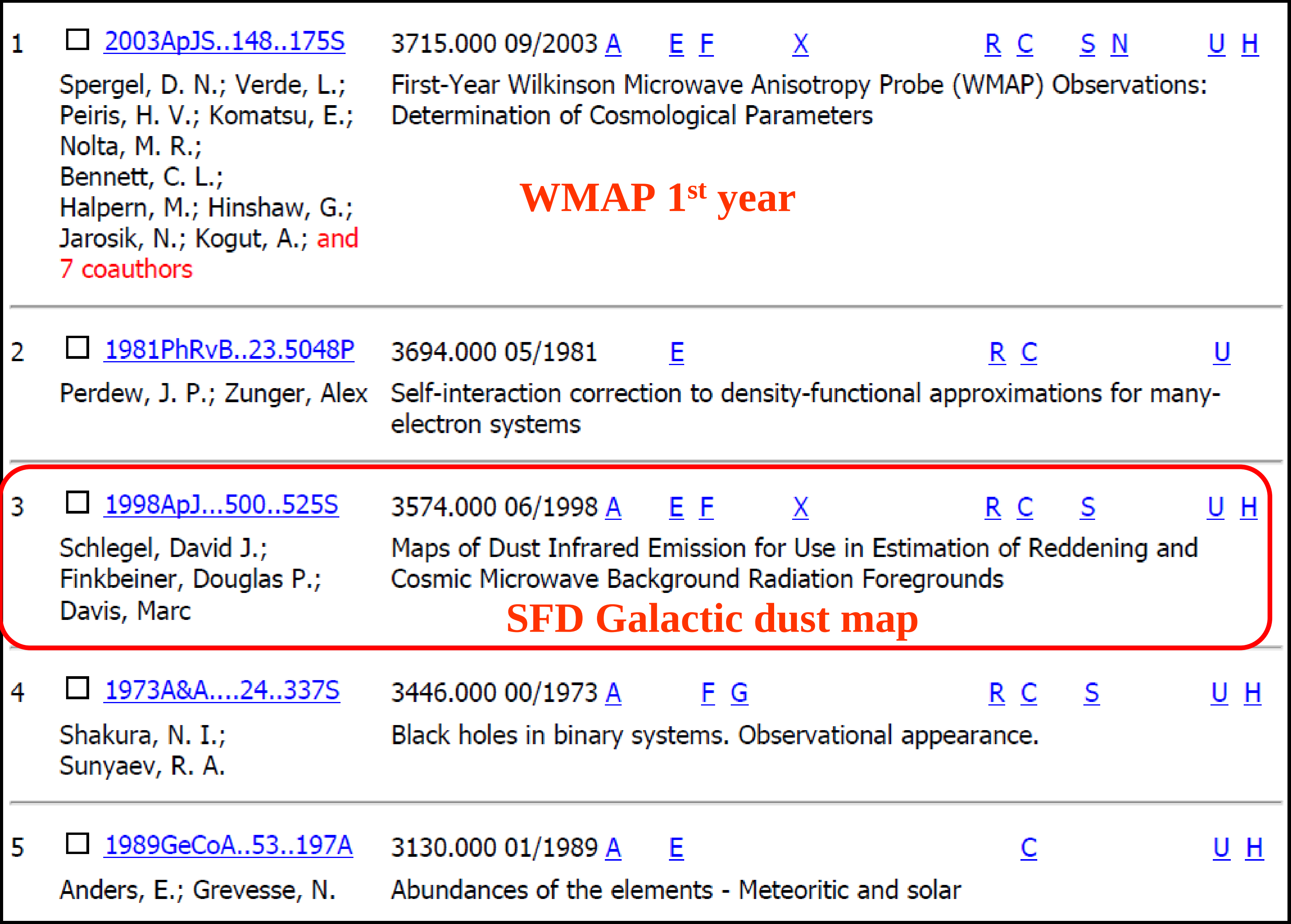
astro-ph/0607098

Galactic dust extinction map

- ***The*** most fundamental and important map to calibrate all astronomical and cosmological observations
  - Without the map, you cannot tell true luminosity of any objects
  - Large-scale structure that you discover may not be real but simply reflect the Galactic dust distribution …

ADS citation list as of Jan.2007 (1)



1 ☐ 2003ApJS..148..175S 3715.000 09/2003 A E F X R C S N U H

Spergel, D. N.; Verde, L.; Peiris, H. V.; Komatsu, E.; Nolta, M. R.; Bennett, C. L.; Halpern, M.; Hinshaw, G.; Jarosik, N.; Kogut, A.; and 7 coauthors

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2 ☐ 1981PhRvB..23.5048P 3694.000 05/1981 E R C U

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SFD Galactic dust map

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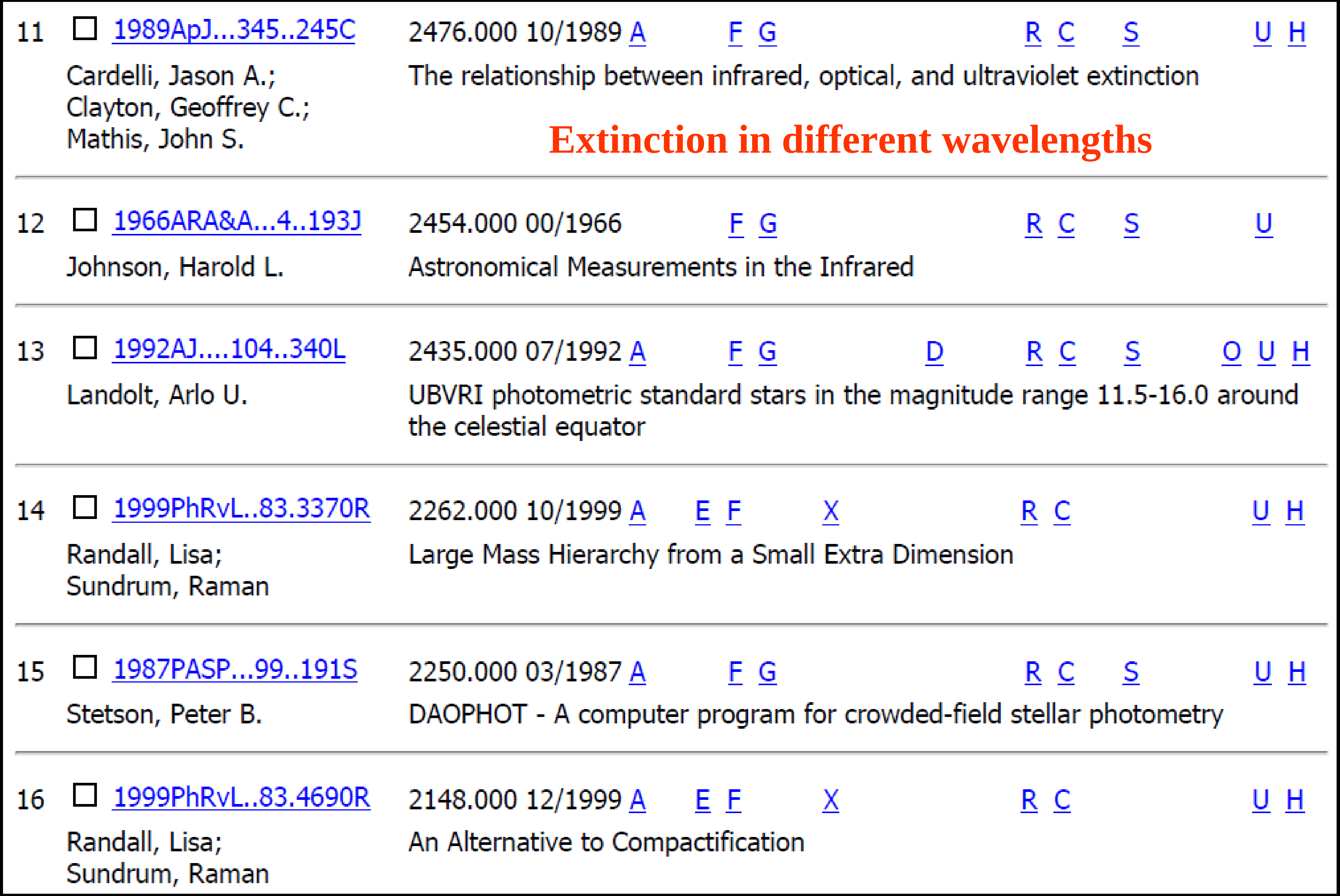

11 ☐ 1989ApJ...345..245C 2476.000 10/1989 A F G R C S U H

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Sundrum, Raman

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Sundrum, Raman

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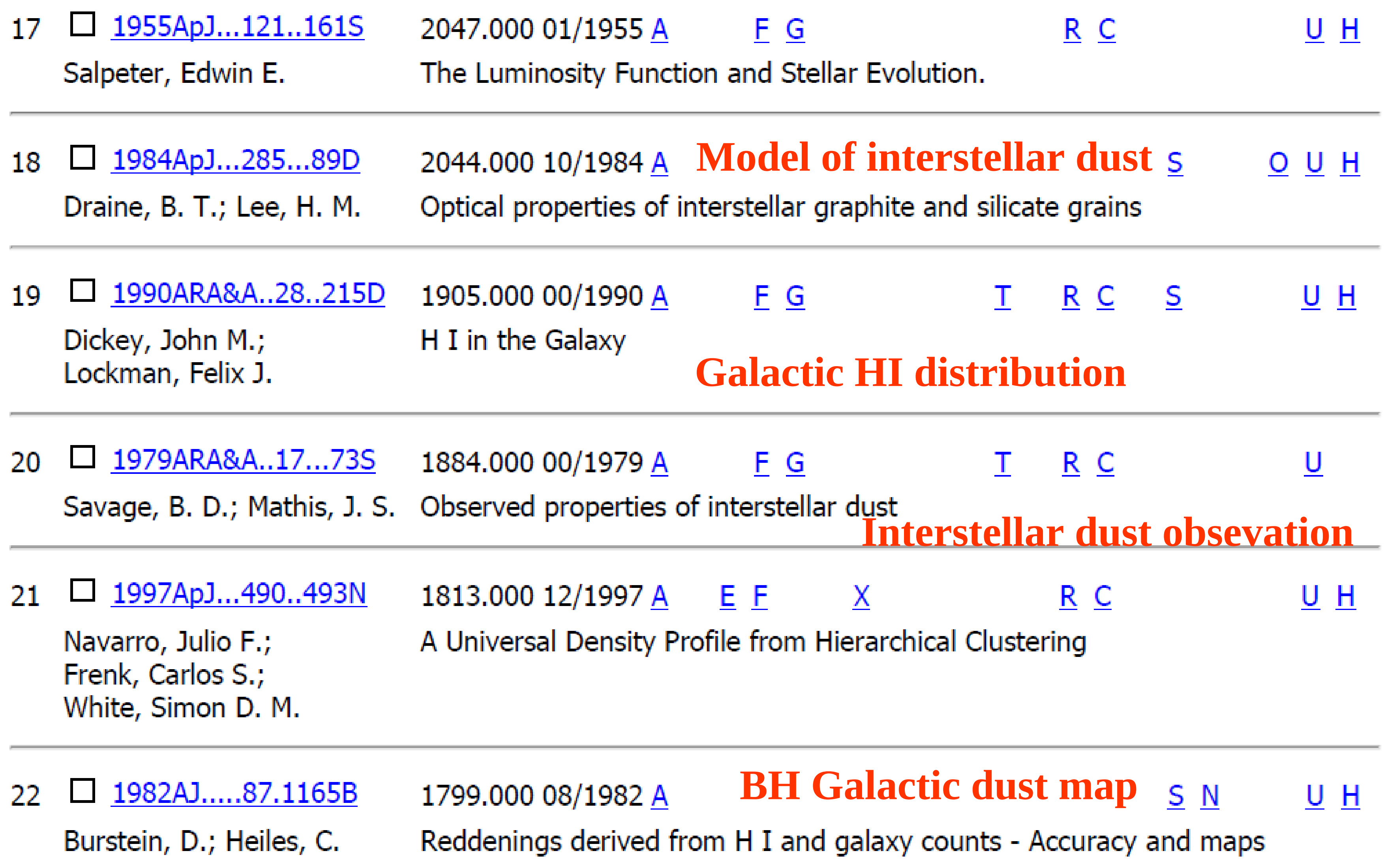
ADS citation list as of Jan.2007 (4)



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22 ☐ 1982AJ.....87.1165B 1799.000 08/1982 A S N U H
Burstein, D.; Heiles, C. Reddenings derived from H I and galaxy counts - Accuracy and maps

BH Galactic dust map

Parameter definitions

- Optical depth

$$I(\lambda) = I_0(\lambda)\exp[-\tau(\lambda)]$$

- Extinction

$$A(\lambda) = -2.5[\log I(\lambda) - \log I_0(\lambda)]$$

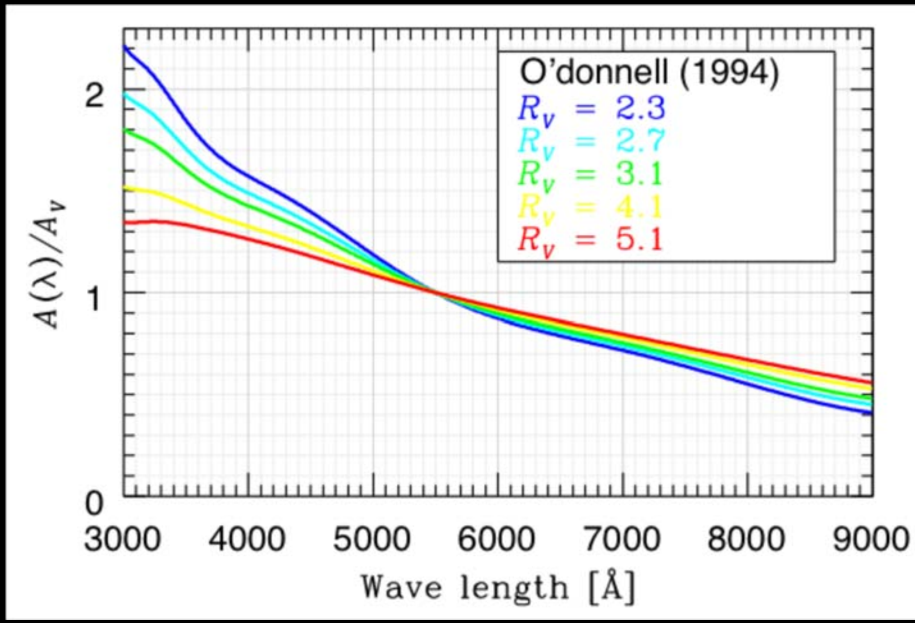
$$\approx 1.086\,\tau(\lambda)$$

- Color excess

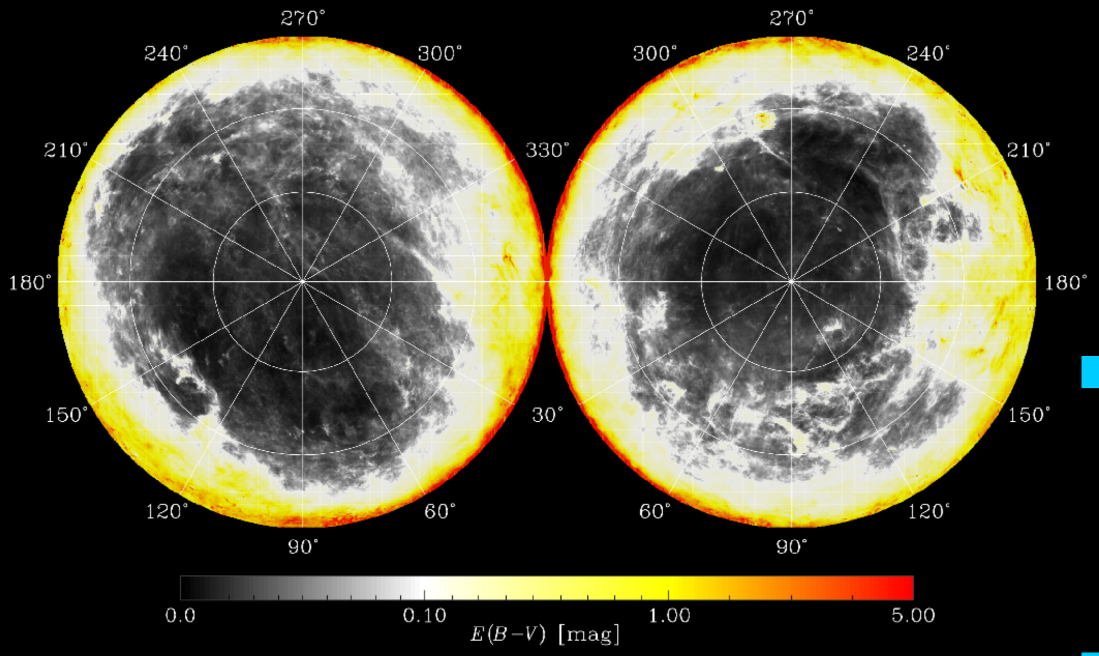
$$E(B-V) = A_B - A_V$$

- Extinction curve

$$R_V = \frac{A_V}{E(B-V)}(=3.1)$$



SFD Galactic extinction map

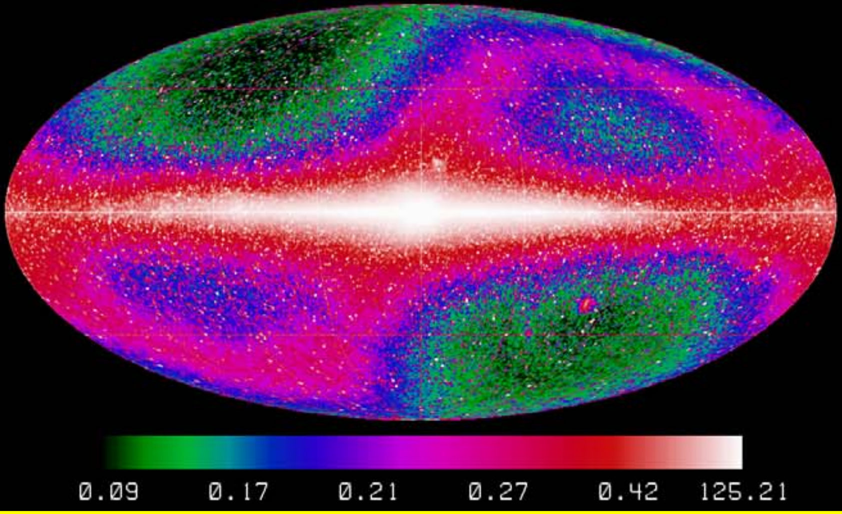


Galactic extinction E(B-V) map by Schlegel, Finkbeiner & Davis (1998: SFD)

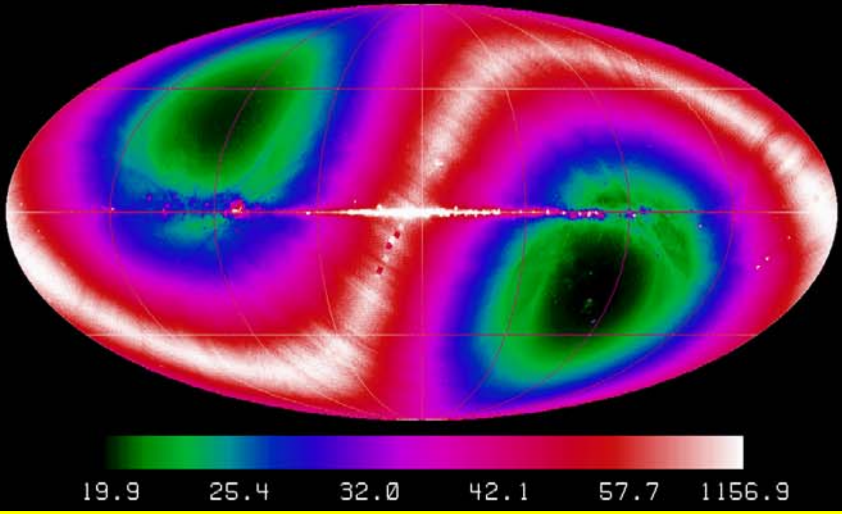
- dust extinction estimated from *FIR(100 μ m) emission*
- can be used for *absorption correction* ???
- independent consistency check is needed

COBE DIRBE maps

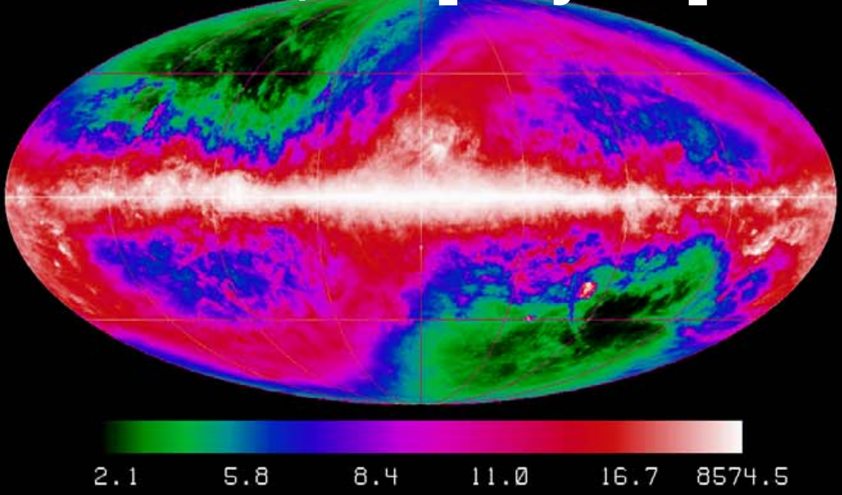
DIRBE 3.5 MICRONS, MJY/SR



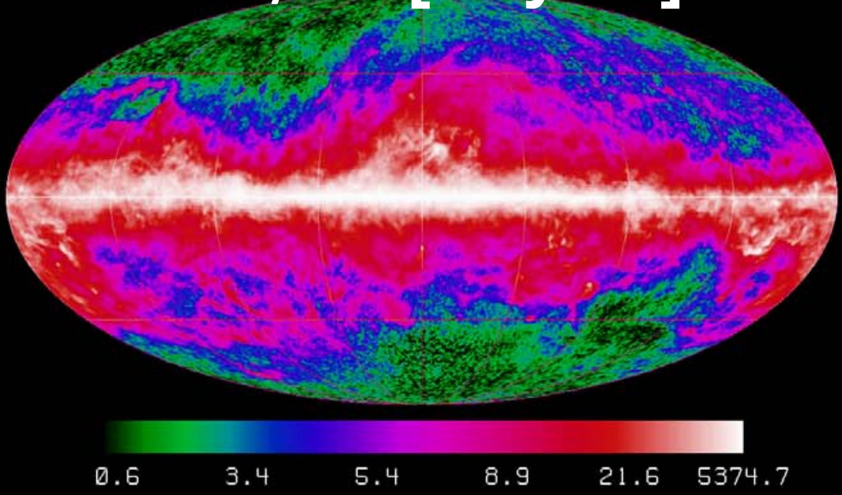
DIRBE 25 MICRONS, MJY/SR



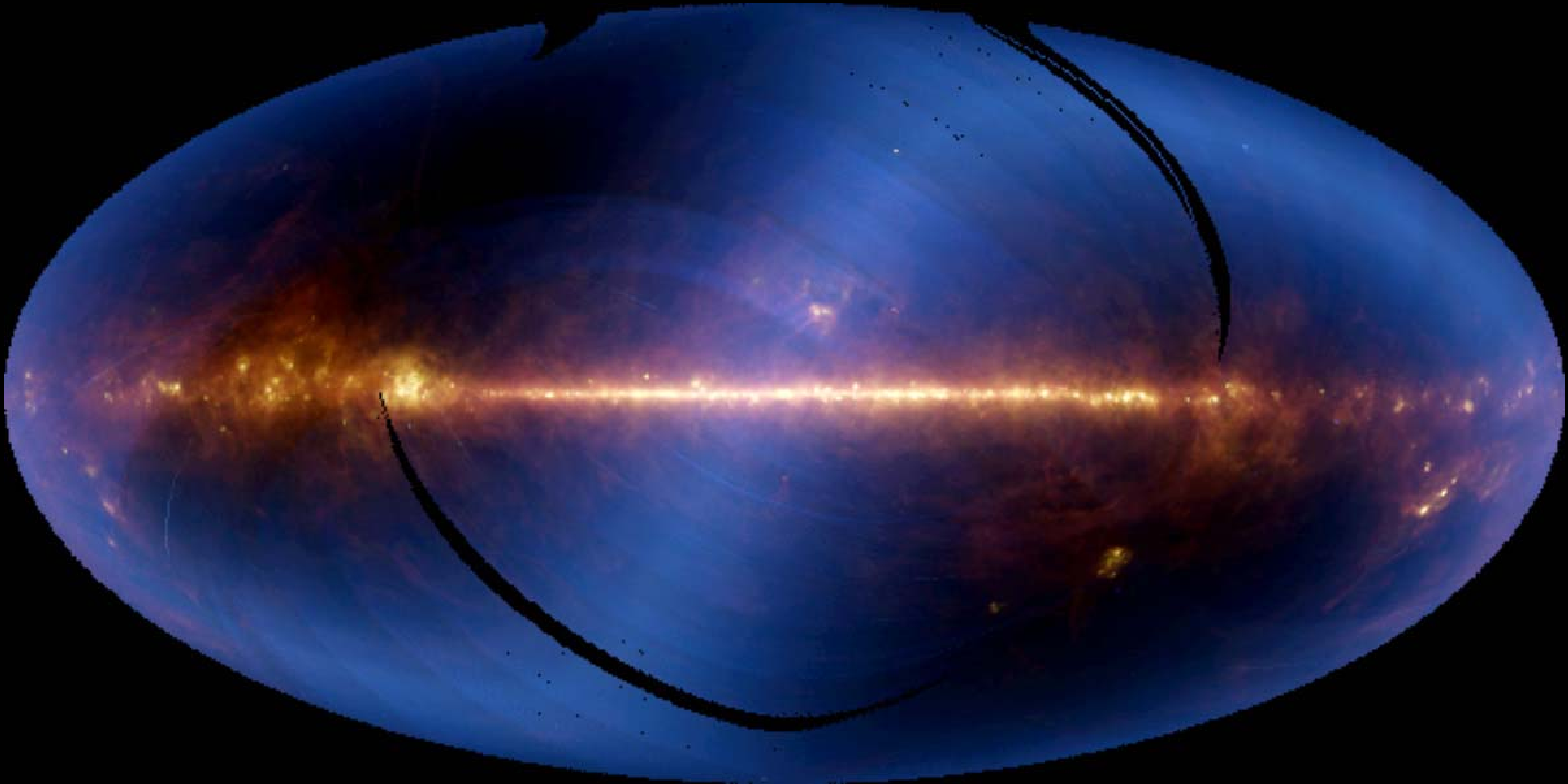
100 μ m [MJy/sr]



240 μ m [MJy/sr]



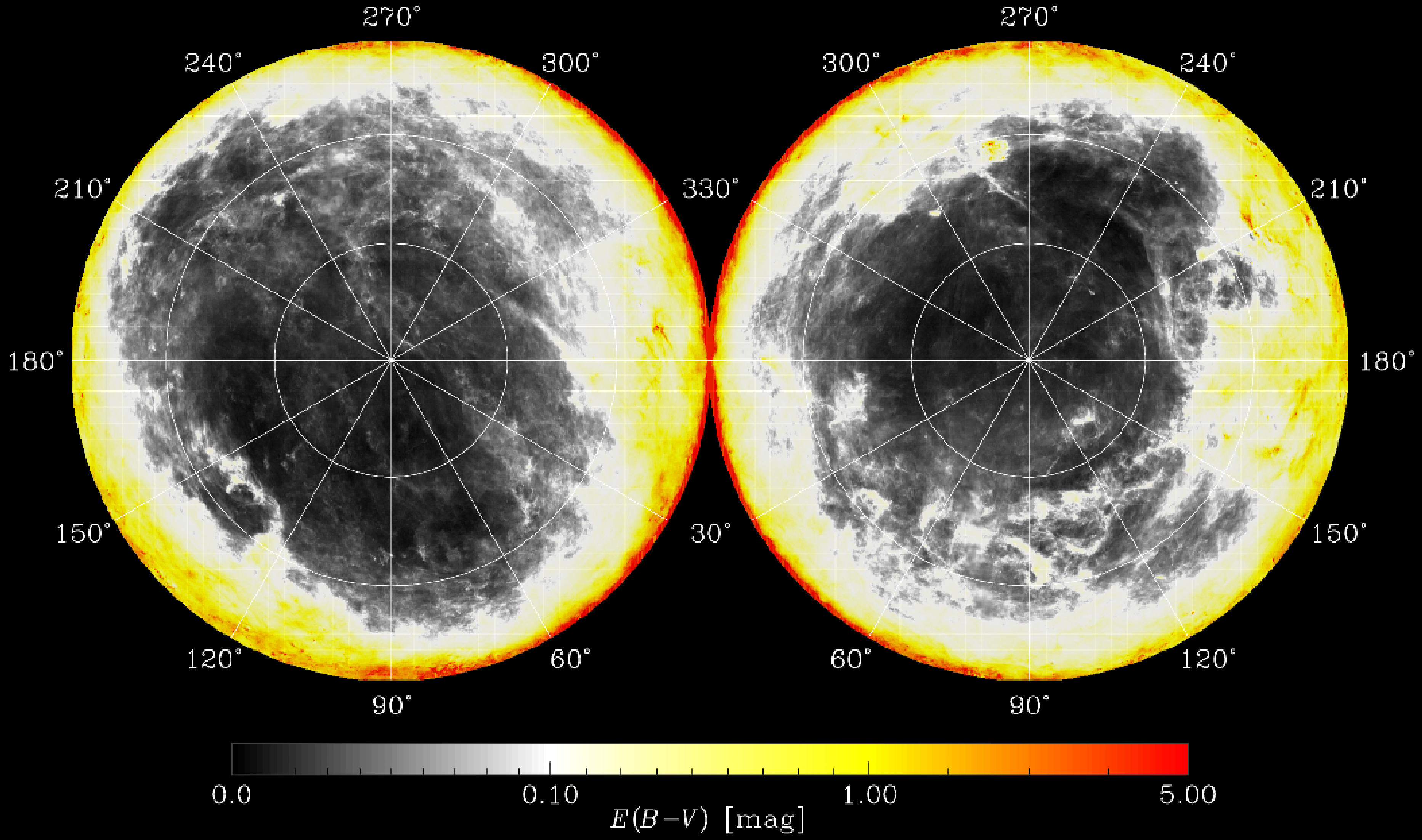
IRAS 100μm map



SFD method to create the extinction map

1. Remove zodiacal light and cosmic infrared background from COBE 100 μm+240 μm maps and create dust temperature map
2. Then create the temperature-dependent emissivity corrected 100 μm map
3. It is used to calibrate the higher angular-resolution IRAS 100 μm map
4. Assume that $E(B-V)=p \times (100\,\mu\text{m flux})^T$ at each pixel of the map and determine p and T from the data
5. Convert E(B-V) to A_{band} adopting SED of ellipticals and the extinction curve $A(\lambda)$ (with $R_V=3.1$)

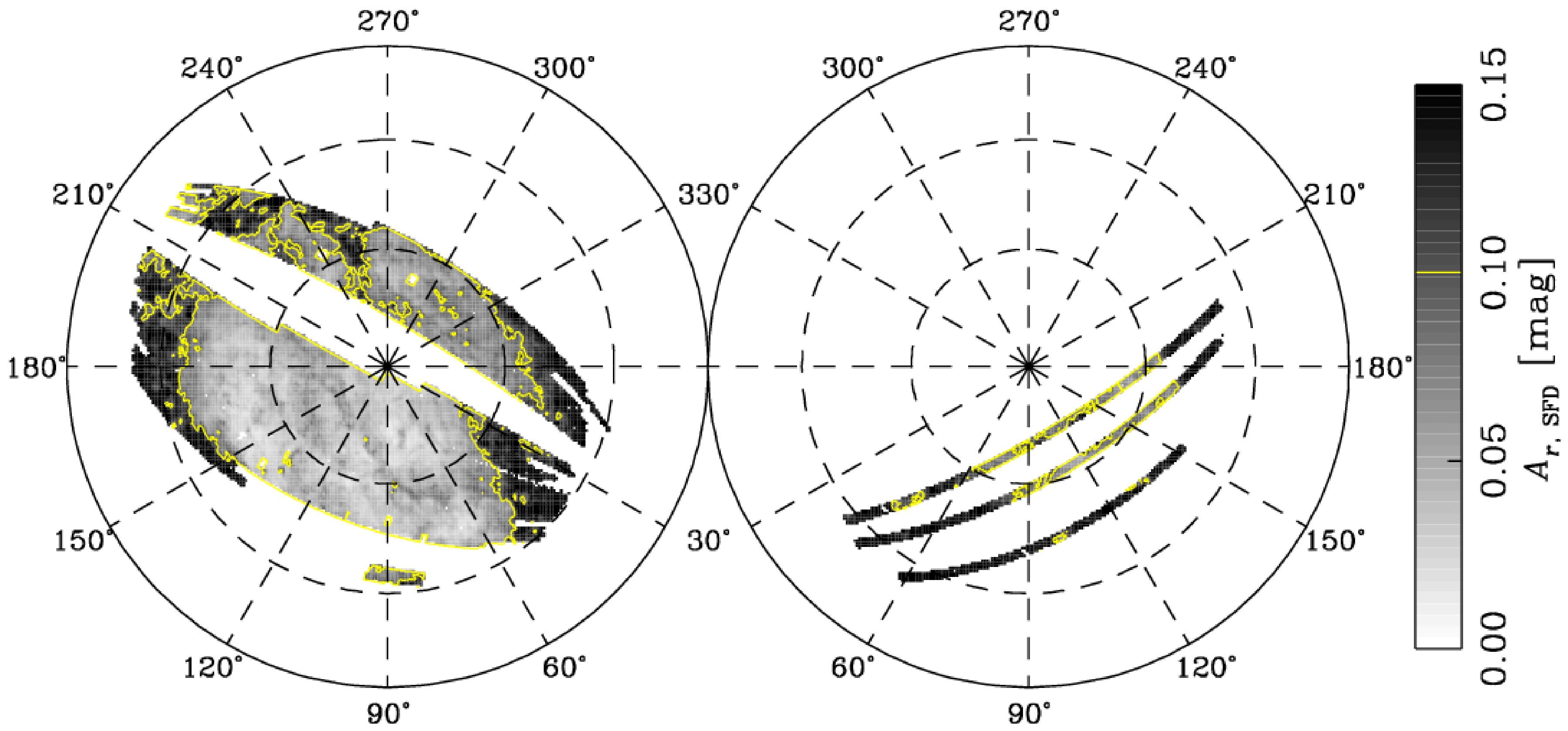
SFD E(B-V) map


270°
240°
300°
210°
330°
180°
150°
30°
120°
60°
90°
270°
300°
240°
210°
180°
150°
60°
120°
90°
0.0
0.10
1.00
5.00
$E(B-V)$ [mag]

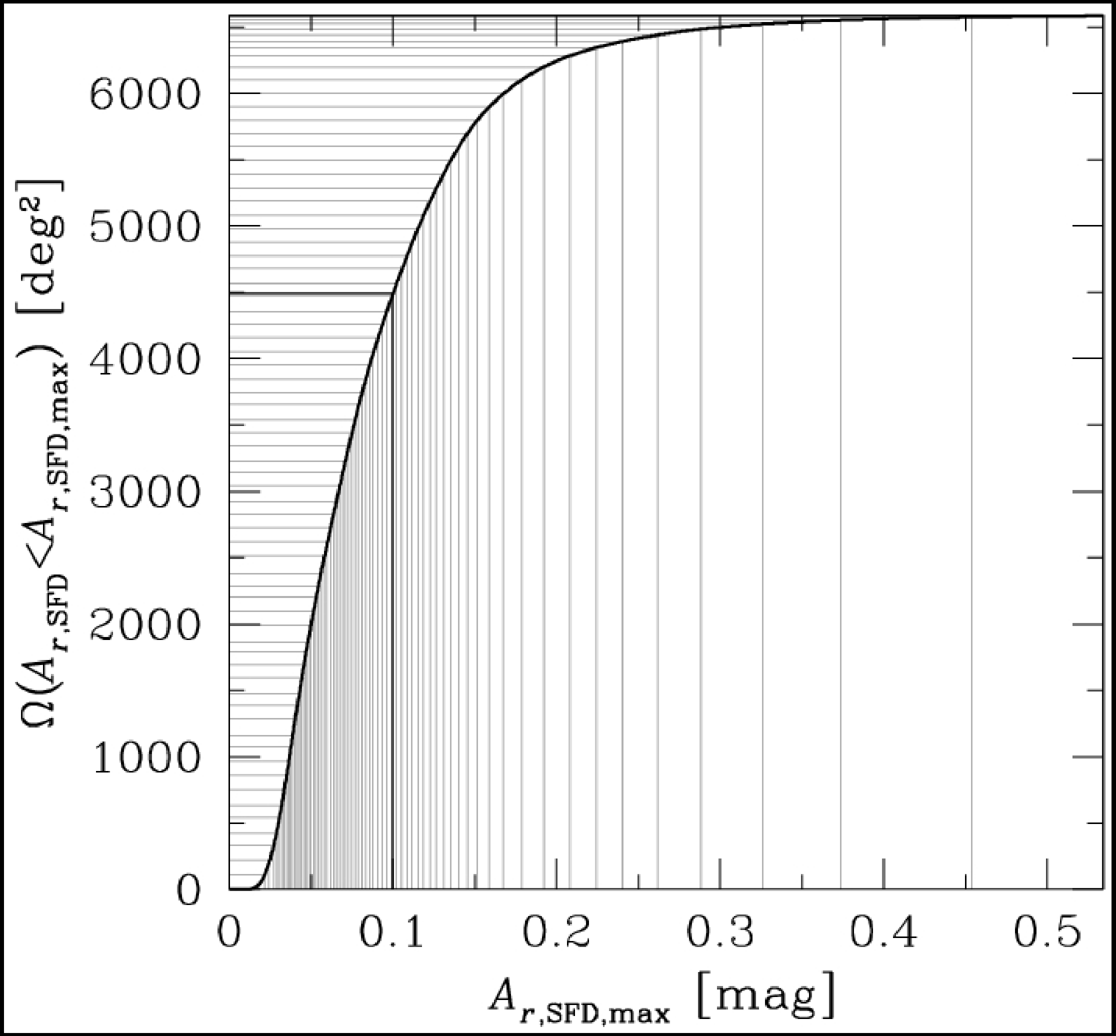
DR4 survey area vs. A_{SFD}

SDSS DR4 photometric catalogue

~10^7 galaxies, 6600 deg^2



Cumulative distribution function of $A_{r,\mathrm{SFD}}$



68 % of the survey area has $A_{r,\mathrm{SFD}} < 0.1$

30 % of the survey area has $A_{r,\mathrm{SFD}} < 0.05$

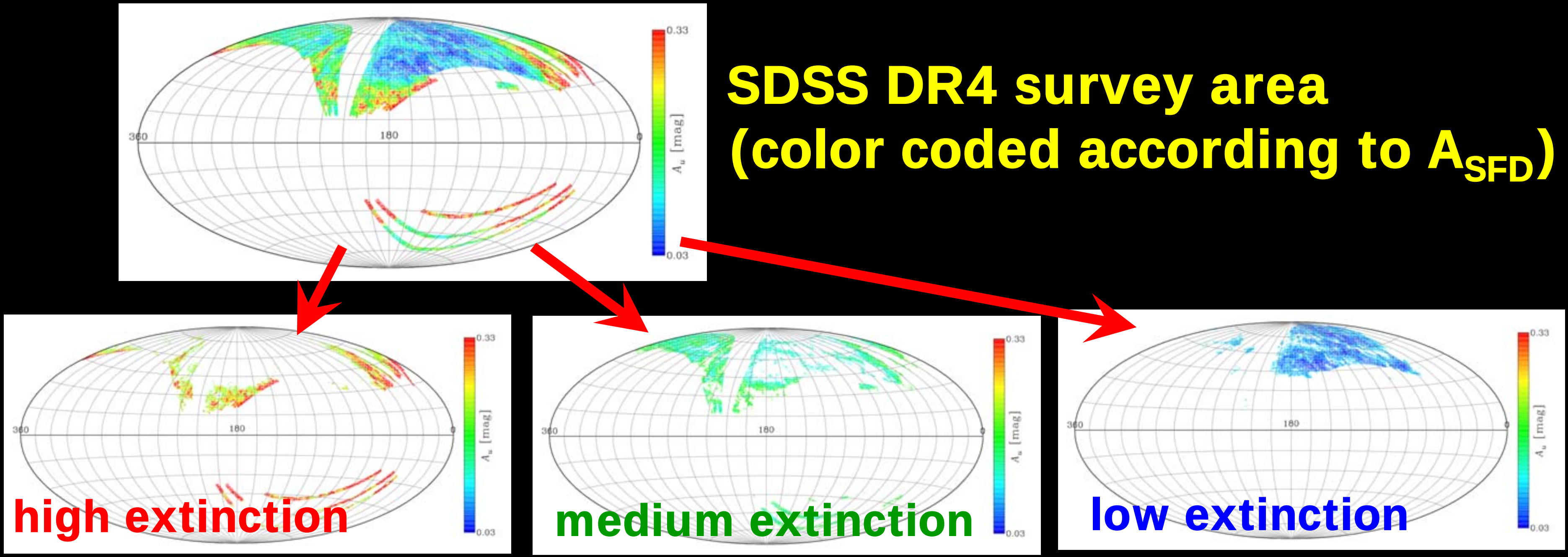
Effect of extinction on galaxy surface density


low extinction


high extinction

In reality, intrinsic clustering of galaxies exists !
⇒ smoothing over large scales are needed to identify a possible systematic effect of the dust map

Estimating Galactic extinction from SDSS galaxy surface density

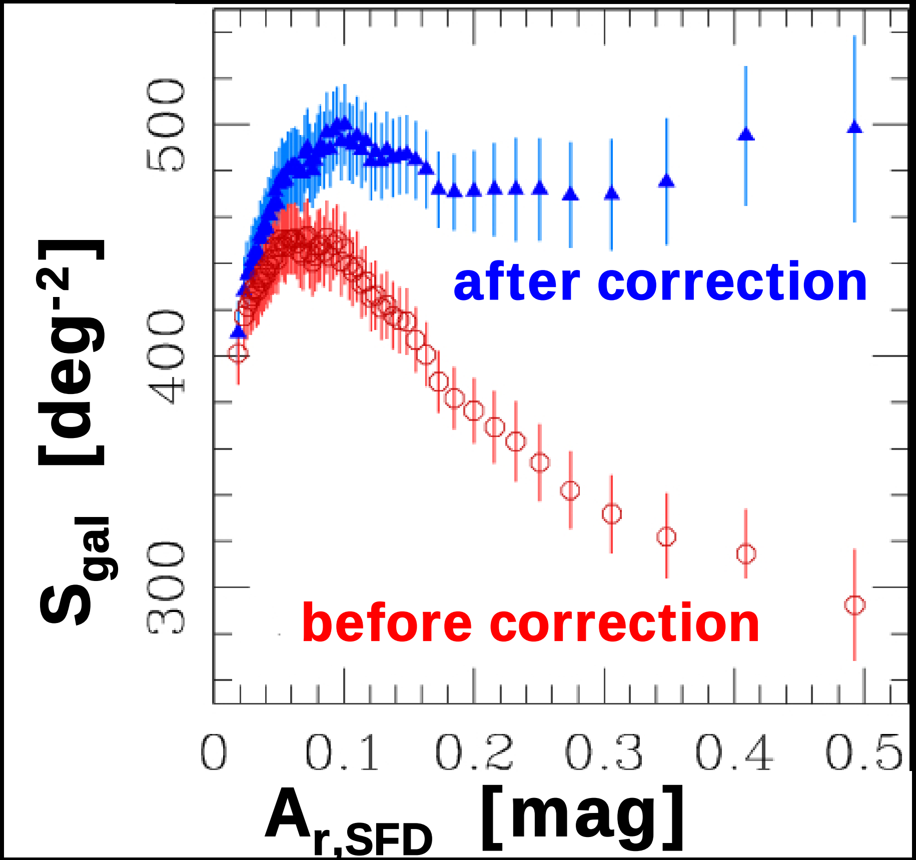


SDSS DR4 survey area (color coded according to A_{SFD})

- divide the SDSS DR4 survey area into many small regions according to A_{SFD}
- combine those un-contiguous regions into 69 bins with ~100 deg^2 each
- compare the galaxy number density S_{gal} of a given magnitude range in different bands

SDSS photometric galaxy surface density S_{gal} vs. SFD extinction A_{SFD}

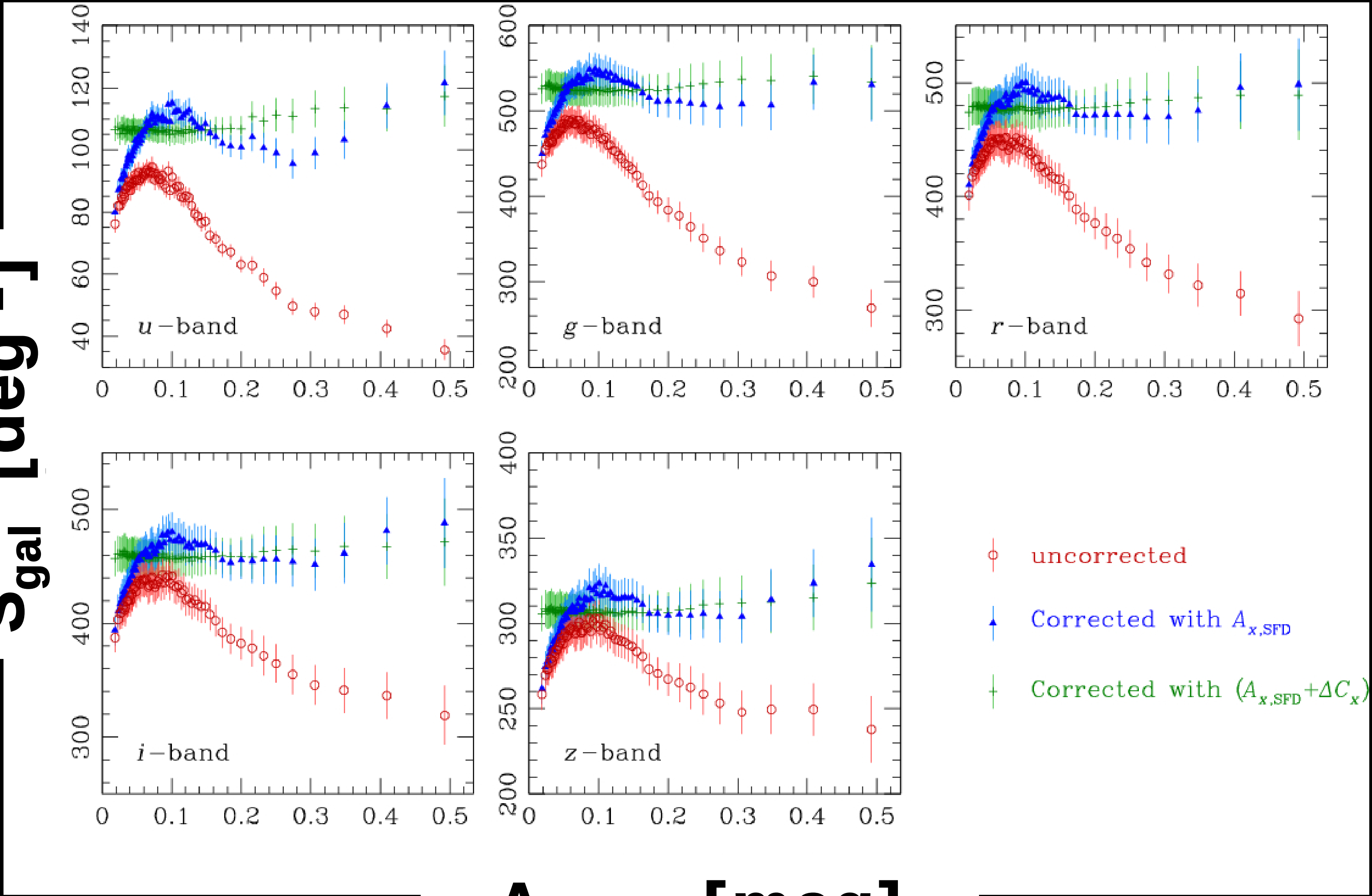
- ***If A_{SFD} is perfect, one expects***
  - **smaller S_{gal} at larger A_{SFD} before correction**
  - **constant S_{gal} after correction**



- confirmed for A_{SFD} >0.1, but ***opposite for A_{SFD} <0.1***
  - 68% of the SDSS survey area has A_{SFD} <0.1 !
- ***What's wrong ?***

Yahata et al. (2007)

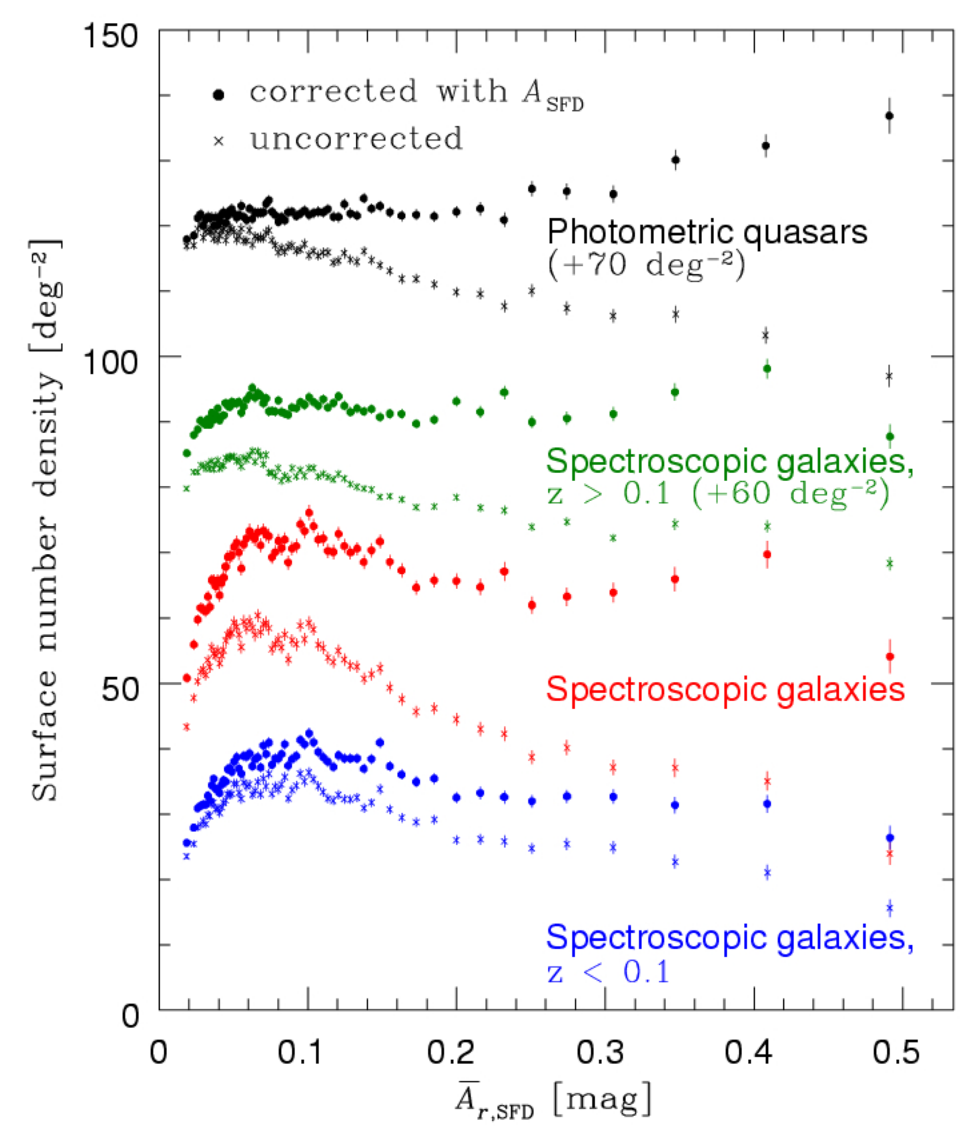
S_{gal} vs. $A_{r,SFD}$ in different bands



S_{gal} [deg^{-2}]

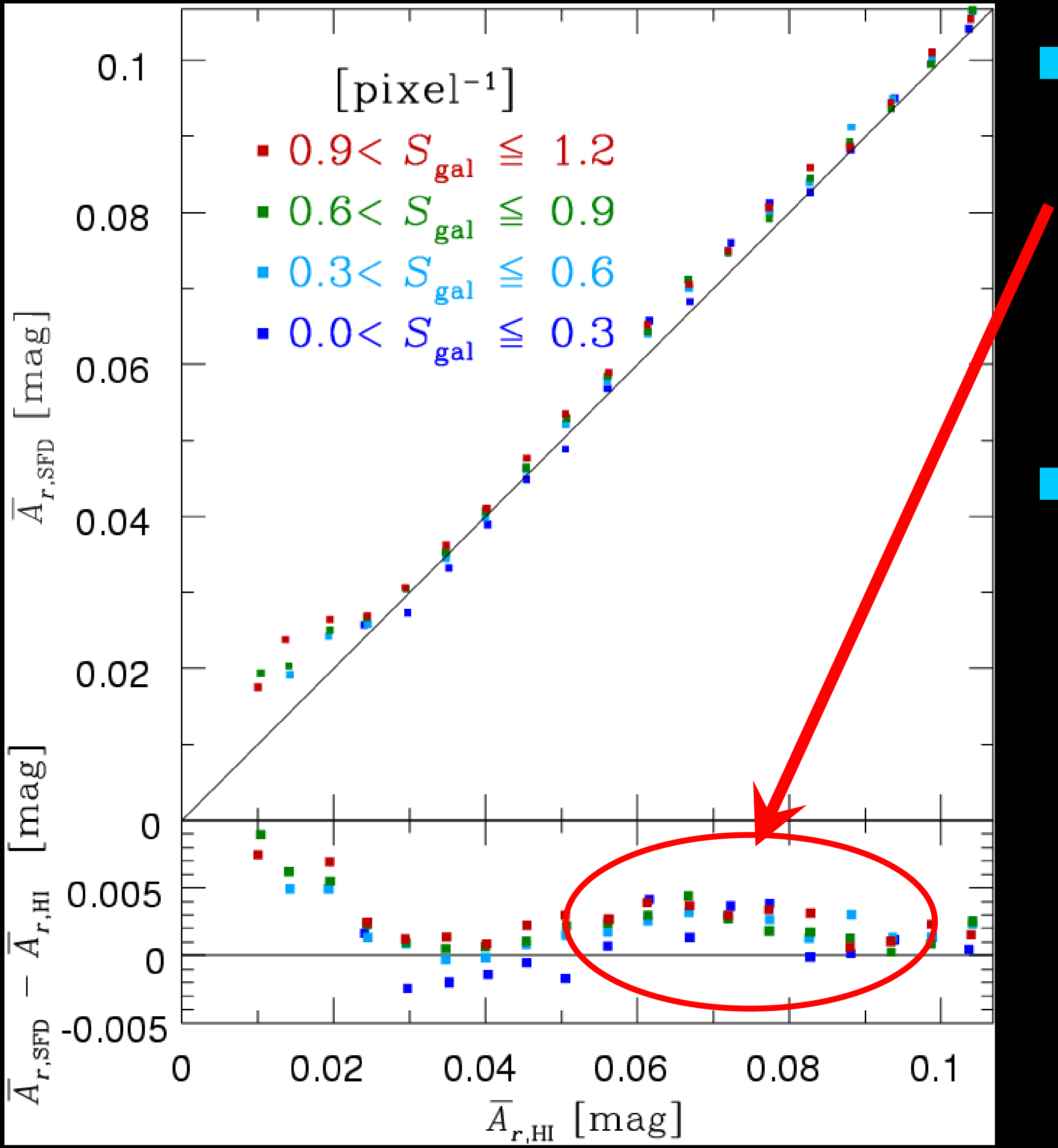
$A_{r,SFD}$ [mag]

Comparison with other SDSS data



- QSO results exhibit no anomaly
- Spectroscopic galaxy samples do show the similar anomaly
- stronger for the lower z sample (?)
- **The anomaly can not explained by Galactic dust or IGM, but should be related to galaxies themselves.**

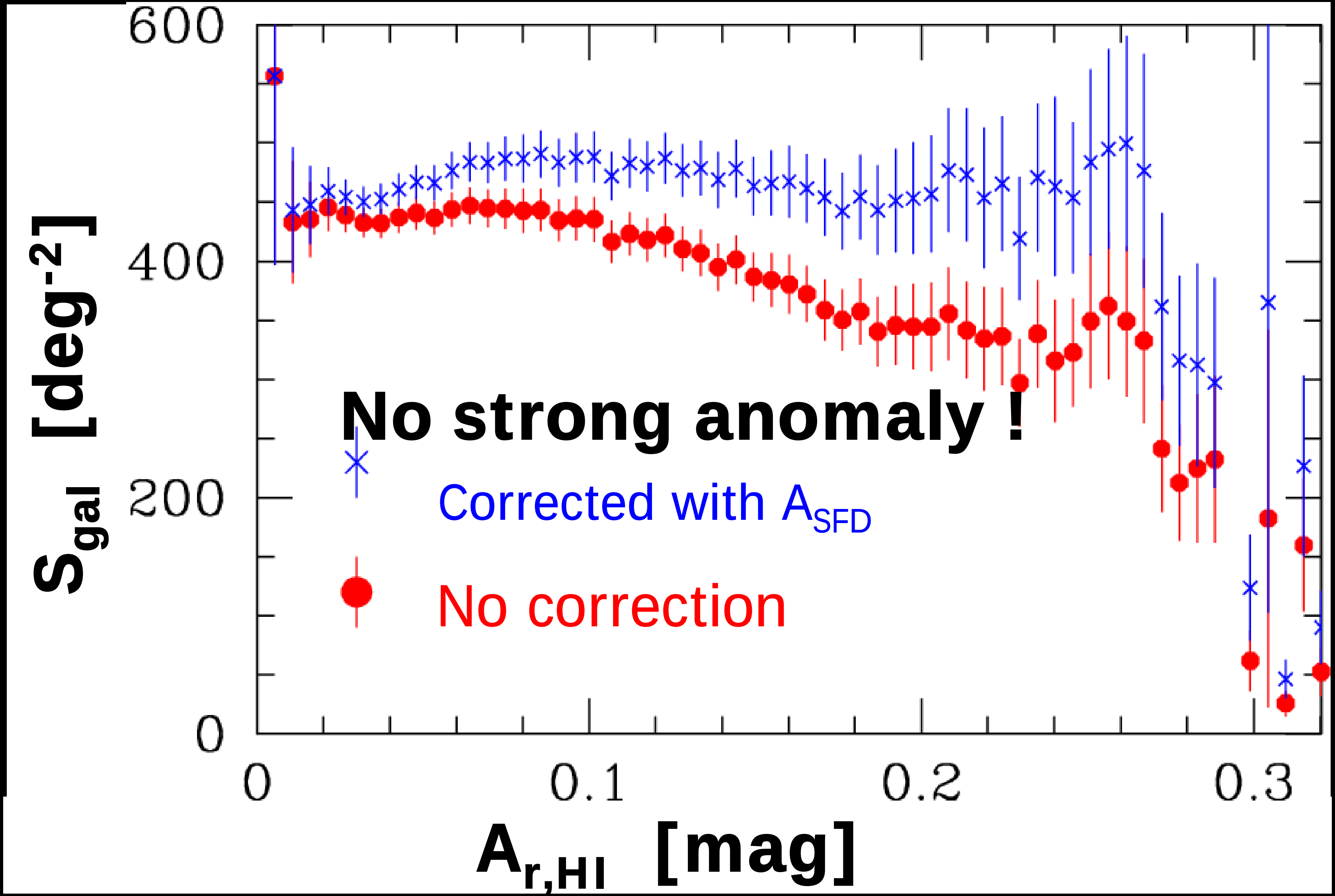
$A_{r,SFD}$ vs. A_{HI} from HI (21cm) map



- $A_{SFD} > A_{HI}$ for $A_{SFD} < 0.1$
  - Feature at $A_{SFD} < 0.02$ is an artifact due to binning effect
- stronger trend for larger S_{gal} regions
  - Again indicating the extragalactic origin (21cm comes from galactic clouds)

Yahata et al. (2007)

SDSS galaxy surface density S_{gal} vs. HI extinction A_{HI}



No strong anomaly !

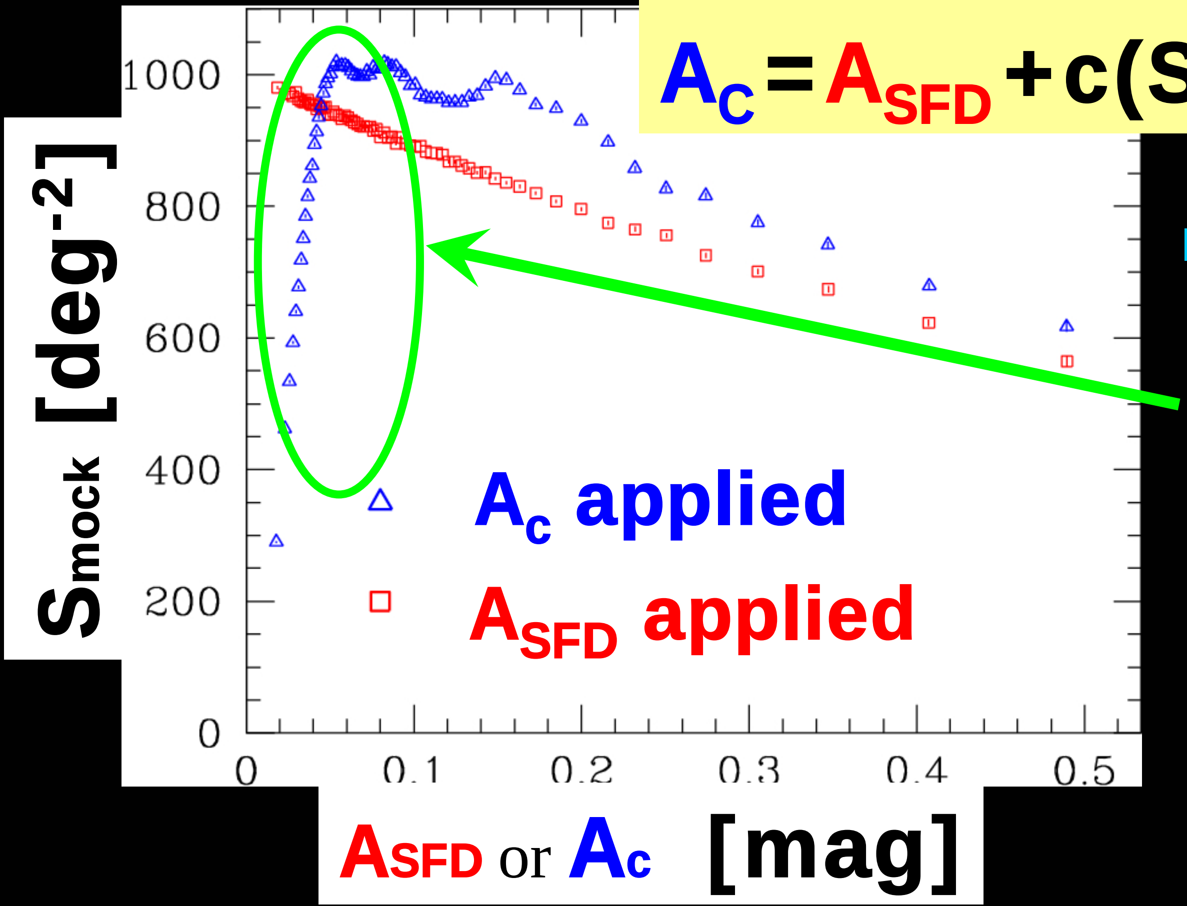
Origin of the anomaly ?

- A_{SFD} is estimated assuming that the reddening is proportional to the Far-infrared emission flux (100 μ m)
  - the anomaly indicates the positive correlation between galaxy surface density and the FIR flux at least where the real extinction is small
- **100 μ m flux = Galactic dust + FIR from galaxies**
  - contamination by the FIR emission from galaxies ???

A simulation to test our hypothesis

- Poisson distributed galaxies in each pixel over the entire survey area
  - ***assume that*** A_{SFD} = true Galactic extinction, and ***add*** galaxy FIR contribution according to

$$A_C = A_{SFD} + c(S_{mock} - \langle S_{mock} \rangle)$$



- The use of A_C indeed reproduces the observed trend !

Yahata et al. (2007)

Tiny but systematic error in A_{SFD}

- **a typical amplitude of the systematic error in A_{SFD} is ～0.01mag**
  - c.f., mean flux of the background IR which was removed in making the SFD map is ～0.04 mag
- **this is tiny, but systematic**
  - S_{gal} ↑⇒ A_{dust} ↑⇒ $S_{gal,corrected}$ ↑↑ becomes even larger after correction for A_{dust}
  - systematically overestimates the contrast of real cosmic structure
- **maybe important for precision measurements of cosmological parameters**

Future work

- Quantitative comparison between our interpretation and the expect FIR fluxes of the SDSS galaxies (assign FIR fluxes to each galaxy statistically + photo-z)
- Evaluate possible effects on LSS statistics using the simulation data
- Unfortunately the precise correction for the effect is difficult without both deeper spectroscopic galaxy data and the reliable SED

world all dust

Conclusion：世 皆 塵

- A typhoon is coming, but don’t worry and just laugh; everything in the world is dust after all.

風前一笑世皆塵