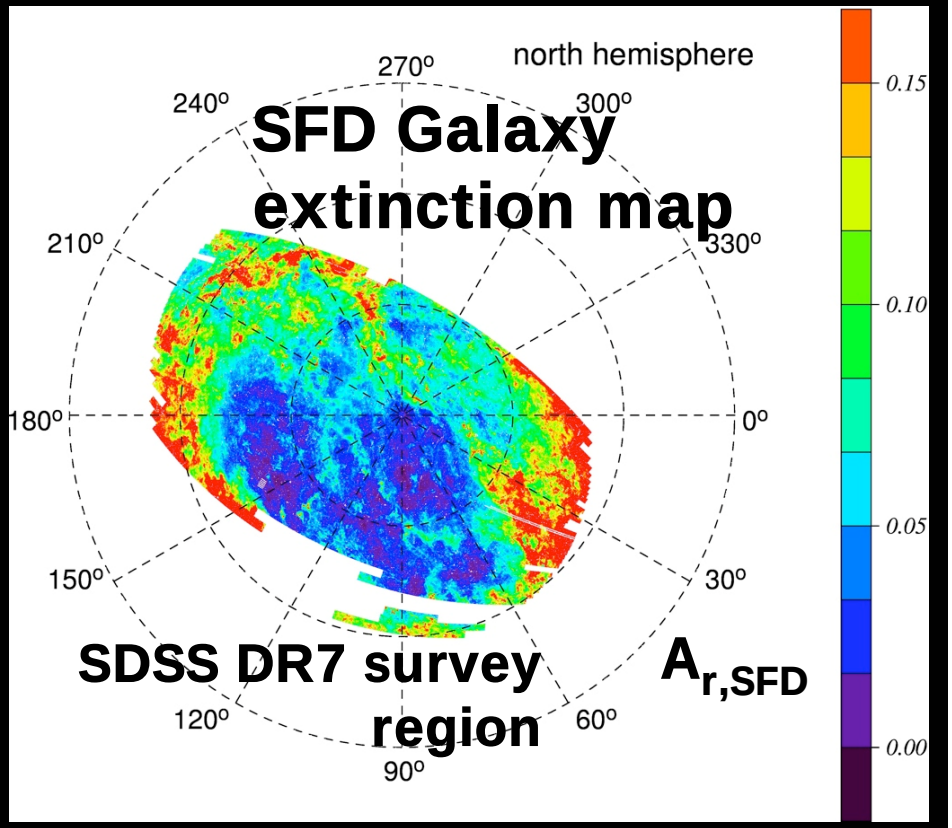
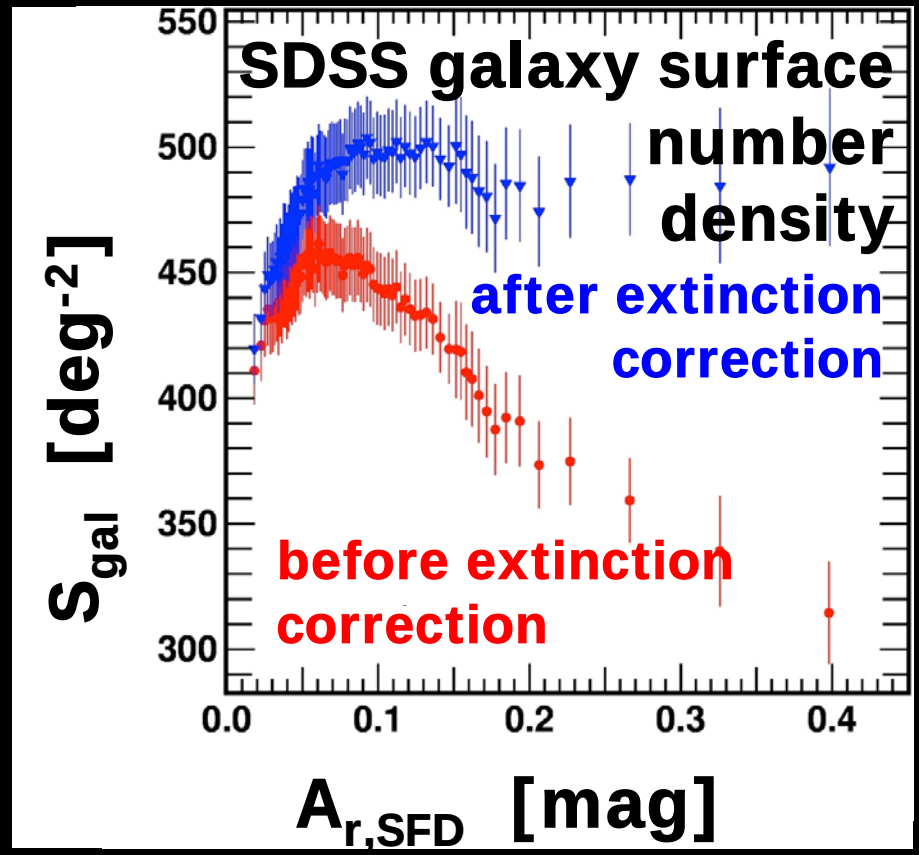
Anomaly in the SFD Galaxy extinction map and FIR emission from SDSS galaxies





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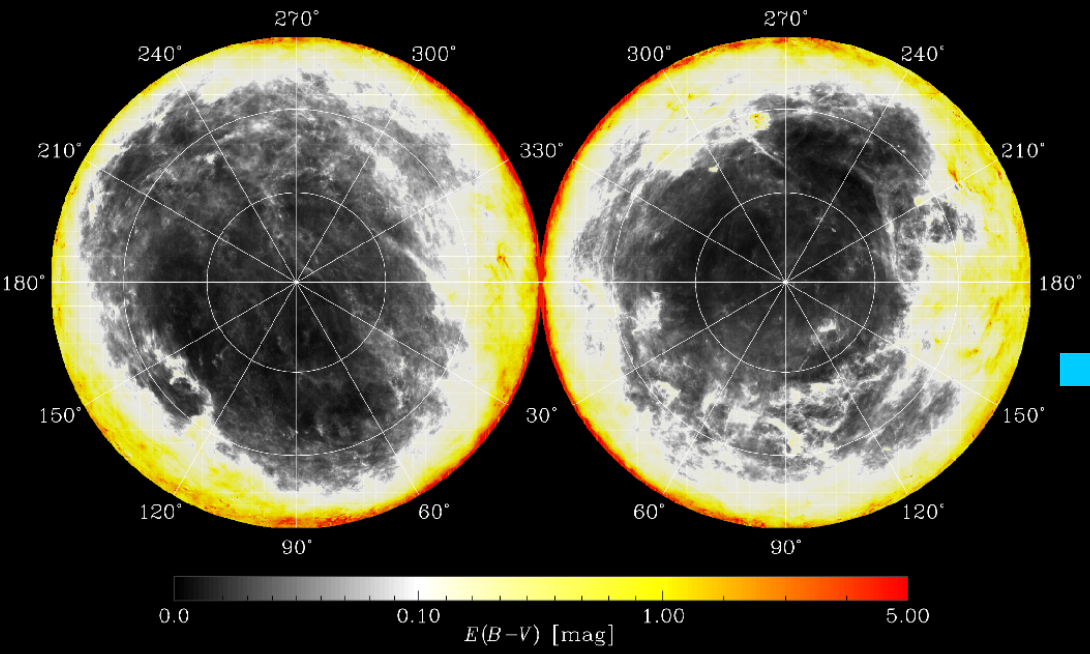
Collaborators

- The present talk is based on our on-going collaboration with **Toshiya Kashiwagi**, A.Taruya, I.Kayo & K.Yahara
- See also ***"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
  - Publ.Astron.Soc.Japan 59(2007)205
  - astro-ph/0607098

SFD Galactic extinction map and galaxy surveys



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

- The most fundamental dataset for any astronomical observation
- True large-scale structures revealed only after the extinction correction
- Its reliability is of vital importance in precision cosmology

SFD procedure to construct the Galactic extinction map

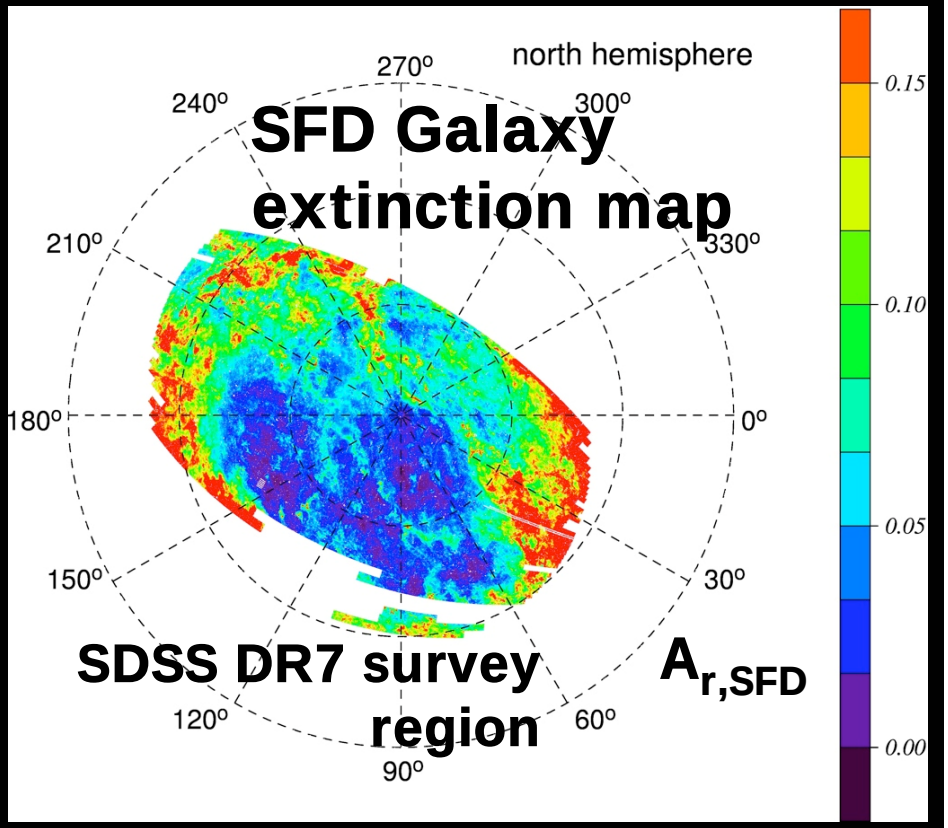
- COBE 100 μm+240 μm maps (0.7deg.pixel)
  - Remove zodiacal light and cosmic infrared background
  - Dust temperature map ⇒ temperature-dependent emissivity corrected 100 μm map
- Calibration of higher angular-resolution IRAS 100 μm map (5 arcmin. pixel)
- Assume

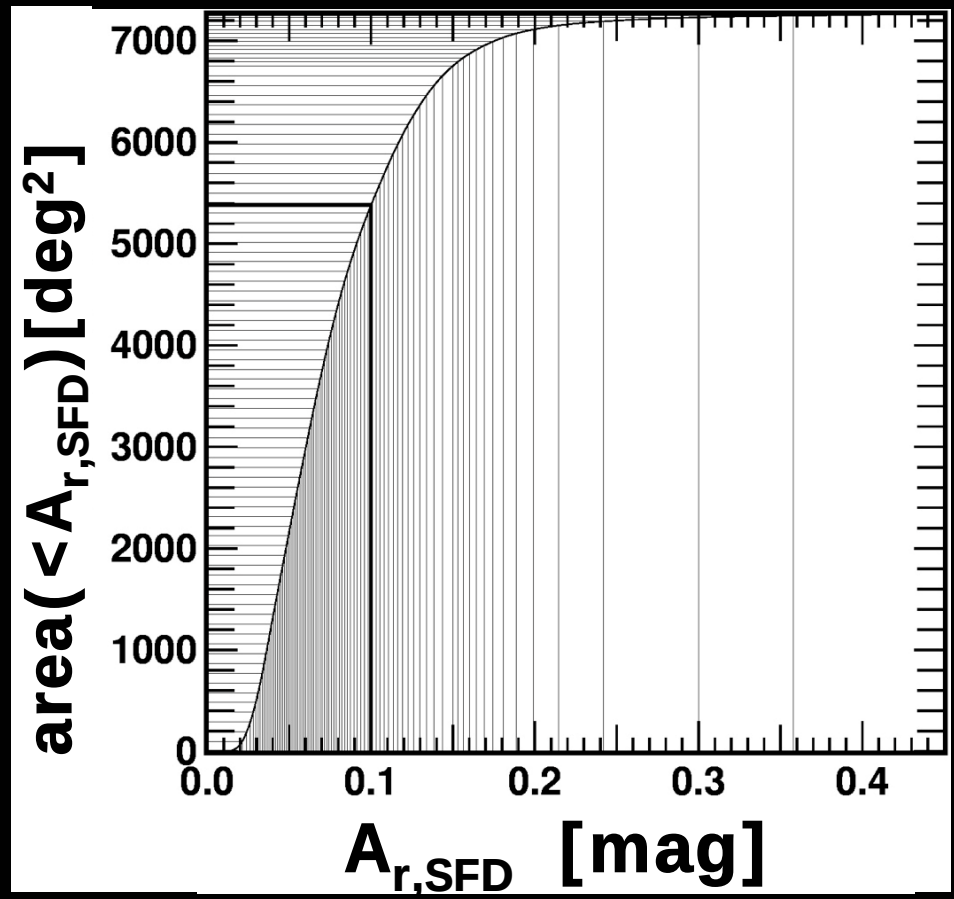
  $E(B-V)=p\times(\text{IRAS } 100\,\mu\text{m flux})^{T}$; $T\sim1$

  at each region and determine p and T from the data
- Convert E(B-V) to A_{band} adopting SED of ellipticals and $R_V=A_V/E(B-V)=3.1$

A_{SFD} map in SDSS DR7 survey region

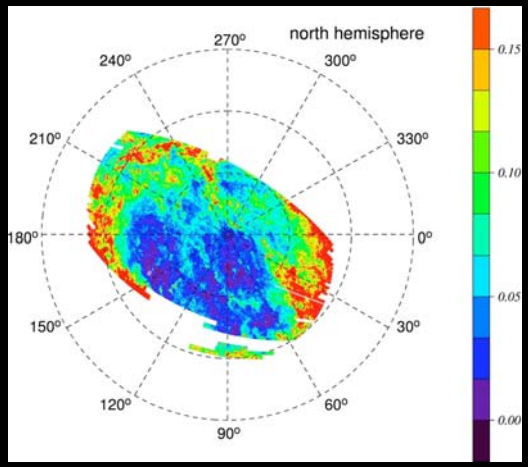
3.6x10^6 galaxies (17.5<r<19.4) in 7270 deg^2 from SDSS DR7 photometric catalog

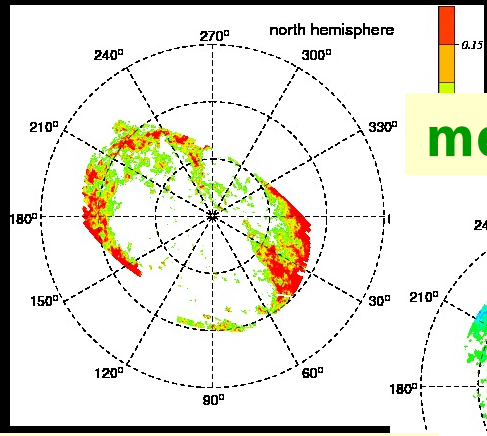




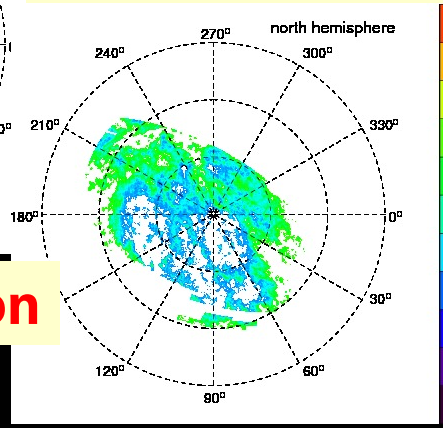
Estimating Galactic extinction from SDSS galaxy surface density

SDSS DR7 survey area (color coded according to A_{SFD})



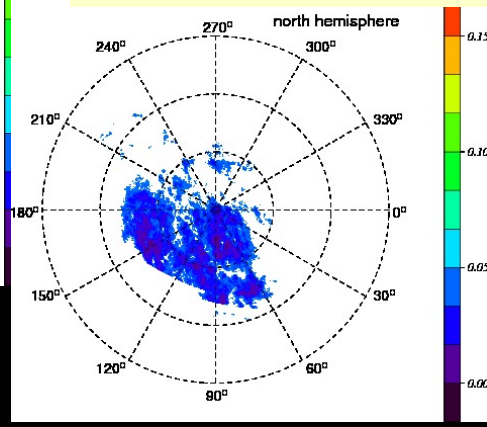


medium extinction



high extinction

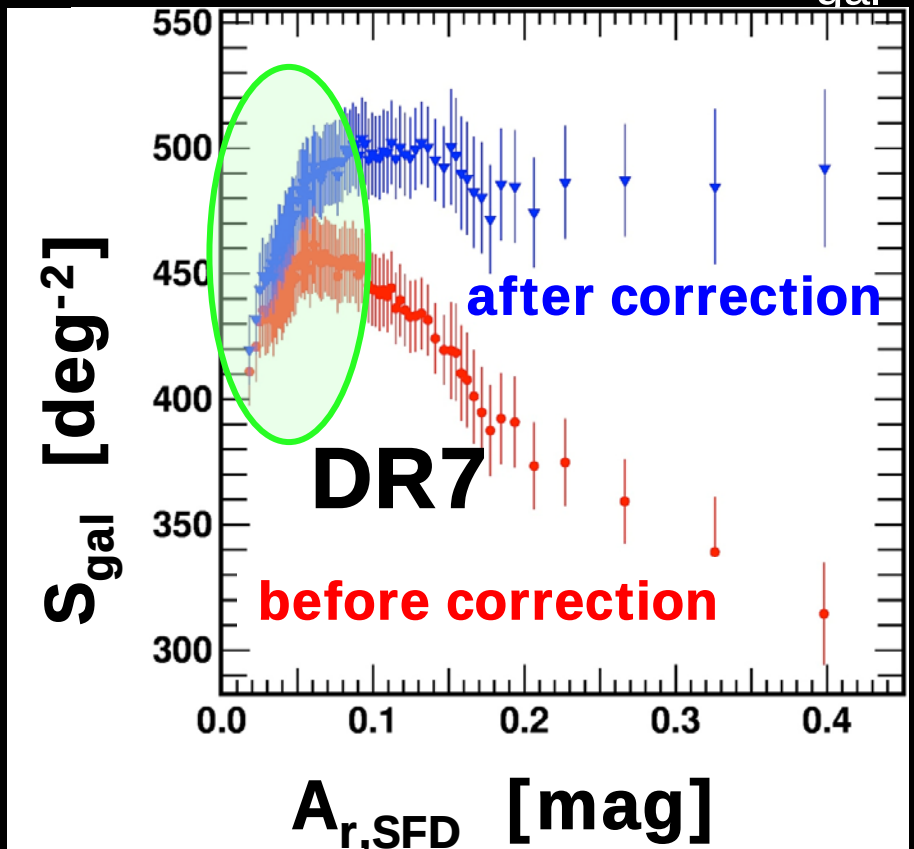
low extinction



- divide the SDSS DR7 survey area into many small regions according to A_{SFD}
- combine those un-contiguous regions into 84 bins with ~100 deg^2 each
- compare the galaxy number density S_{gal} for those bins

Anomalous behavior of SDSS galaxy surface density S_{gal} as a function of A_{SFD}

- ***If A_{SFD} is perfect, we expect that***
  - Before correction: S_{gal} should monotonically decrease as a function of A_{SFD}
  - After correction: S_{gal} should be constant



- OK for A_{SFD} >0.1, but *quite the opposite for A_{SFD} <0.1*
  - ~70% of the SDSS survey area has A_{SFD} <0.1 !
- First pointed out by Yahata et al. (2007) for DR4, and confirmed by Kashiwagi (2011) for DR7

Origin of the anomaly

- A_{SFD} is estimated **assuming that the reddening is proportional to the FIR 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 + galaxies**
  - contamination by the FIR emission from galaxies proposed by Yahata et al. (2007)

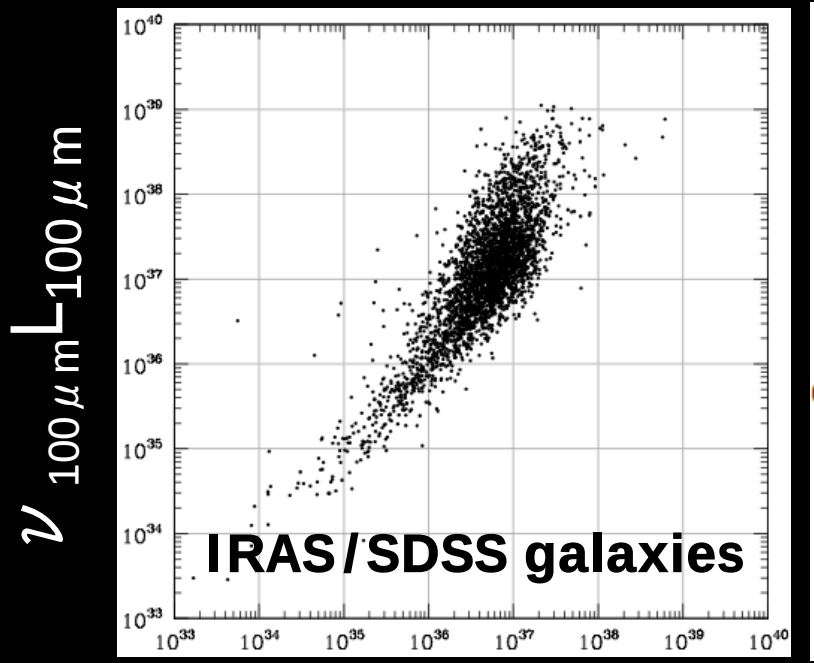
Mock simulations to test the hypothesis

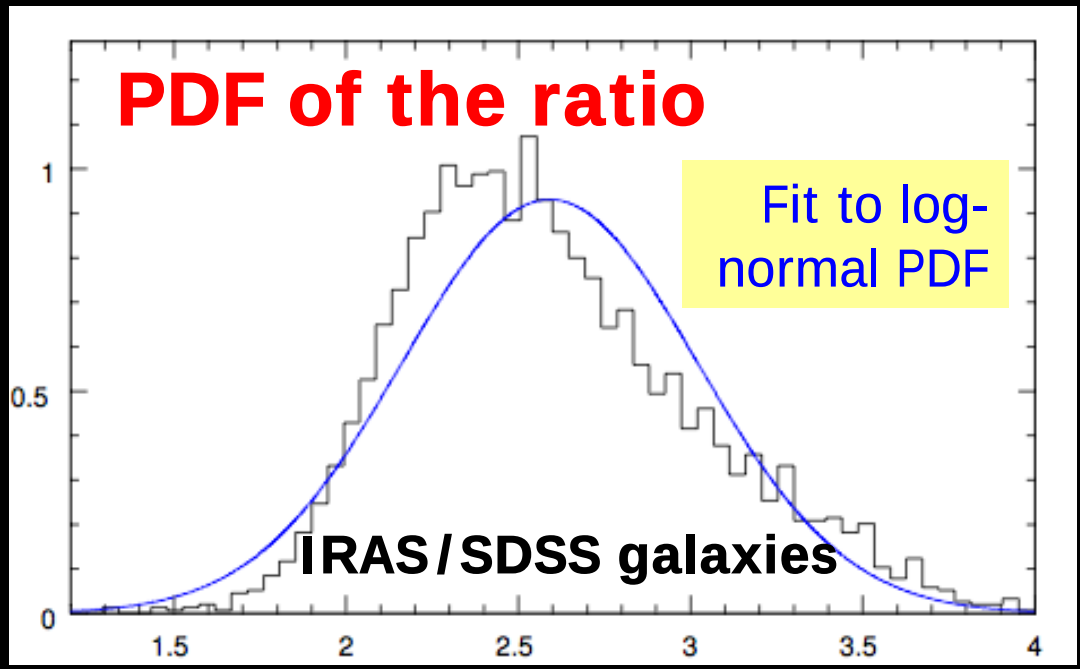
- Distribute random particles over the DR7 region
  - the same number and the same r-band magnitude distributions as SDSS galaxies
- Assign 100 μm flux to each particle sampled from the log-normal distribution of $L_{100\,\mu m}/L_r$
- Add those 100 μm flux to the original SFD map and compute the extinction

  $A_{SFD} \Rightarrow A_{SFD} + \Delta A_{mock}$ at each pixel (5'x5')
- Compute particle surface density as a function of $A_{SFD} + \Delta A_{mock}$ at each pixel

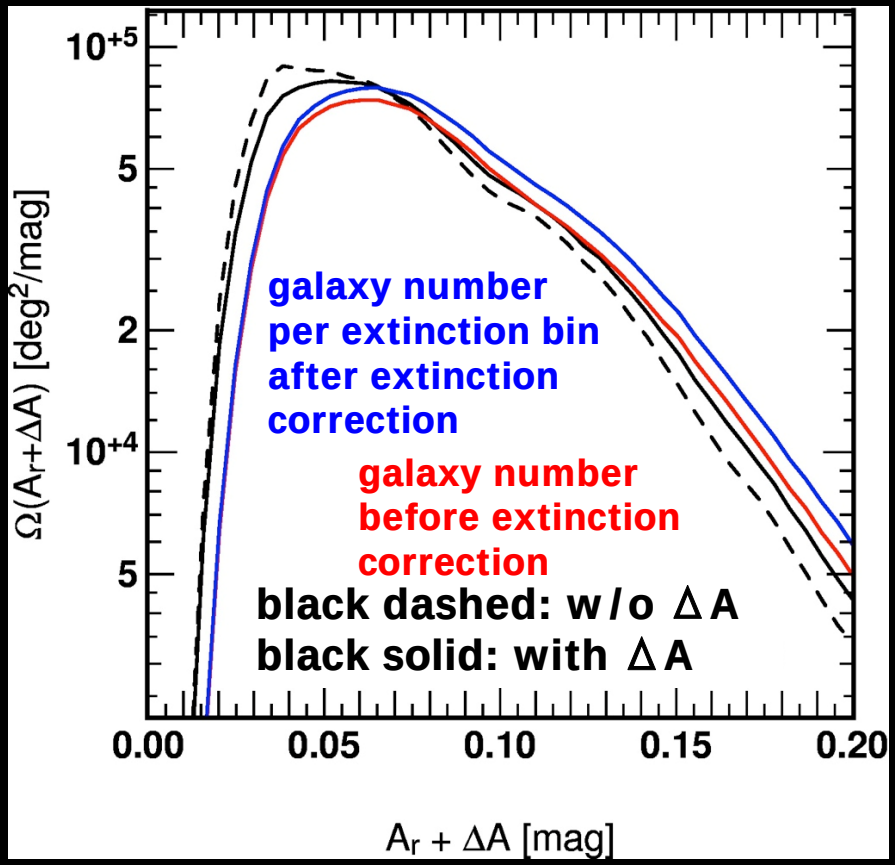
Observed correlation between $L_{100\,\mu m}$ and L_r

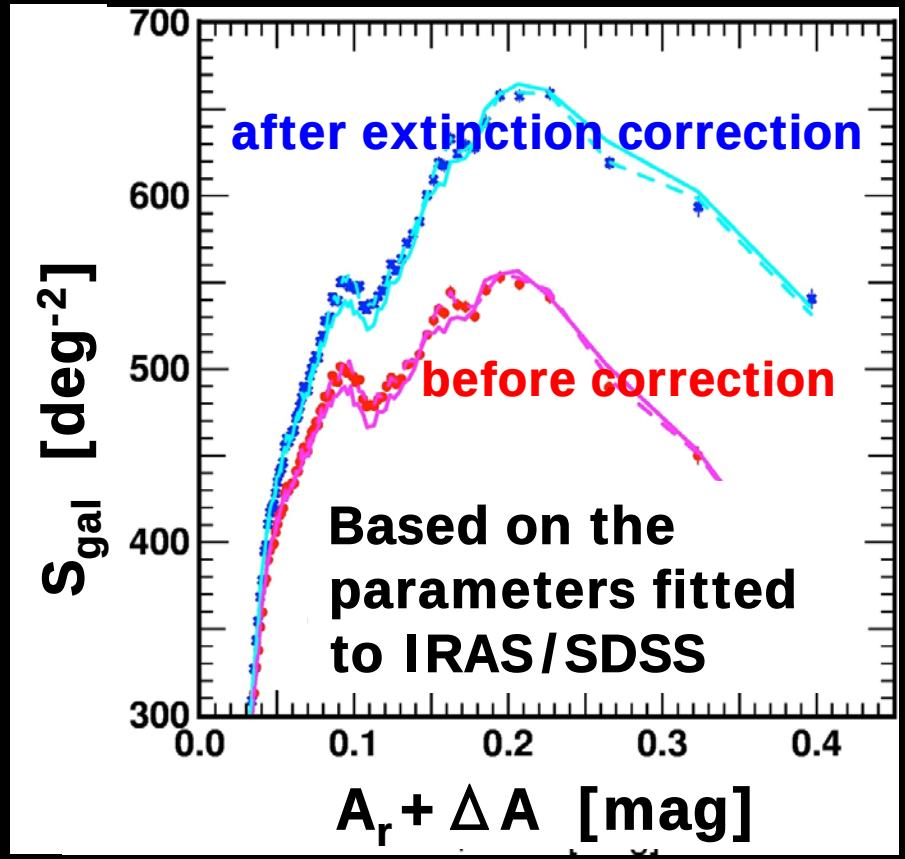
- Distribution function of galaxy luminosities in IRAS 100 μm vs. SDSS r-band for overlapped (bright) galaxies (~3700)
- Not necessarily true for all SDSS galaxies





Mock simulation result





- the observed anomaly is reproduced qualitatively, but too strong if the mean and standard deviation of the ratio $L_{100\,\mu m}/L_r$ of IRAS/SDSS are assumed

An analytic model for surface density

$P_1(\Delta A)$ PDF of extra extinction ΔA due to FIR flux of one galaxy

$$P_N(\Delta A) = \int_0^{\Delta A} dx\, P_1(x) P_{N-1}(\Delta A - x)$$

Conditional PDF that a pixel with N galaxies has the total extra extinction ΔA

$P(N \mid \bar{N})$ PDF of N galaxies per pixel given its expectation value $\bar{N}$

Area and galaxy number after contamination

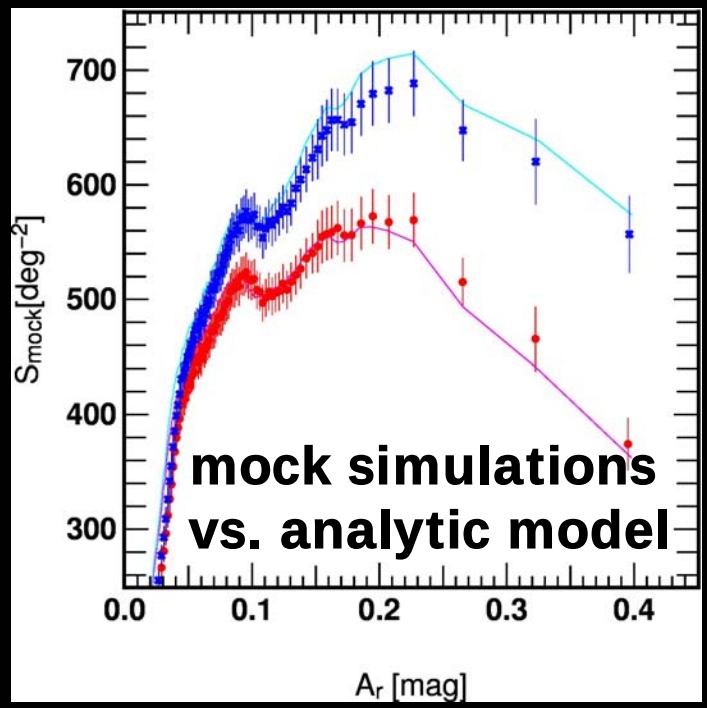
$$\Omega'(A) = \sum_{N=0}^{\infty} \int_0^A d(\Delta A)\, \Omega(A - \Delta A) P_N(\Delta A) P(N \mid \bar{N})$$

$$N'_{gal}(A) = \sum_{N=0}^{\infty} \int_0^A d(\Delta A)\, N \frac{\Omega(A - \Delta A)}{\Omega_{pixel}} P_N(\Delta A) P(N \mid \bar{N})$$

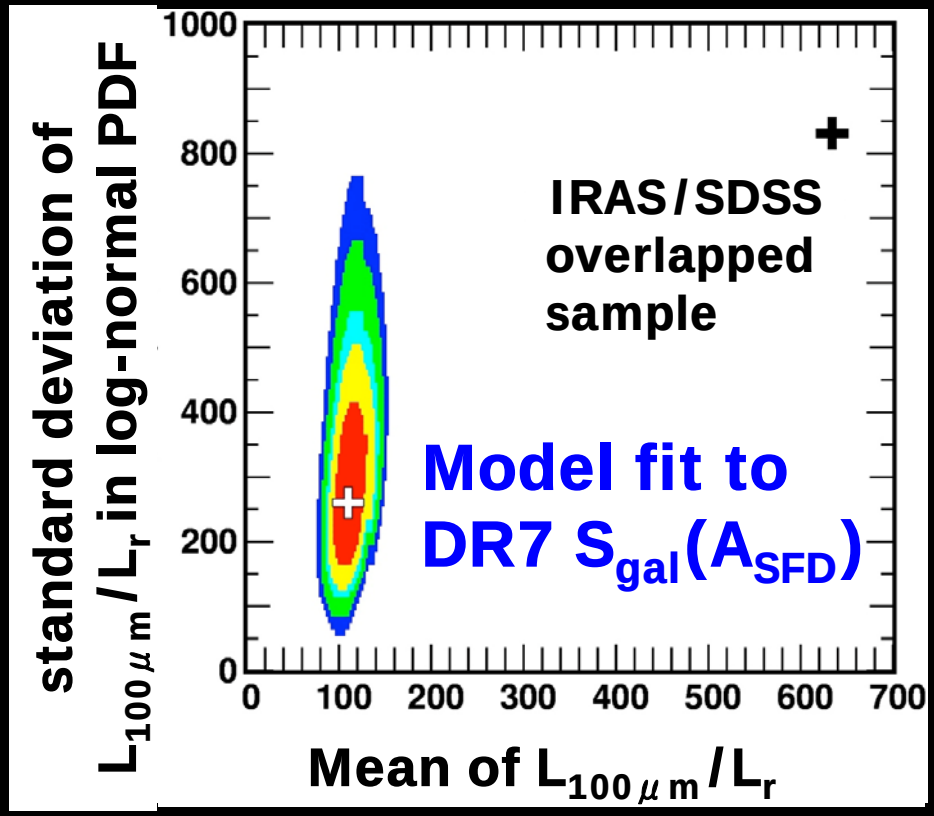
$\times 10^{\gamma(\Delta A - A)}$ without correction

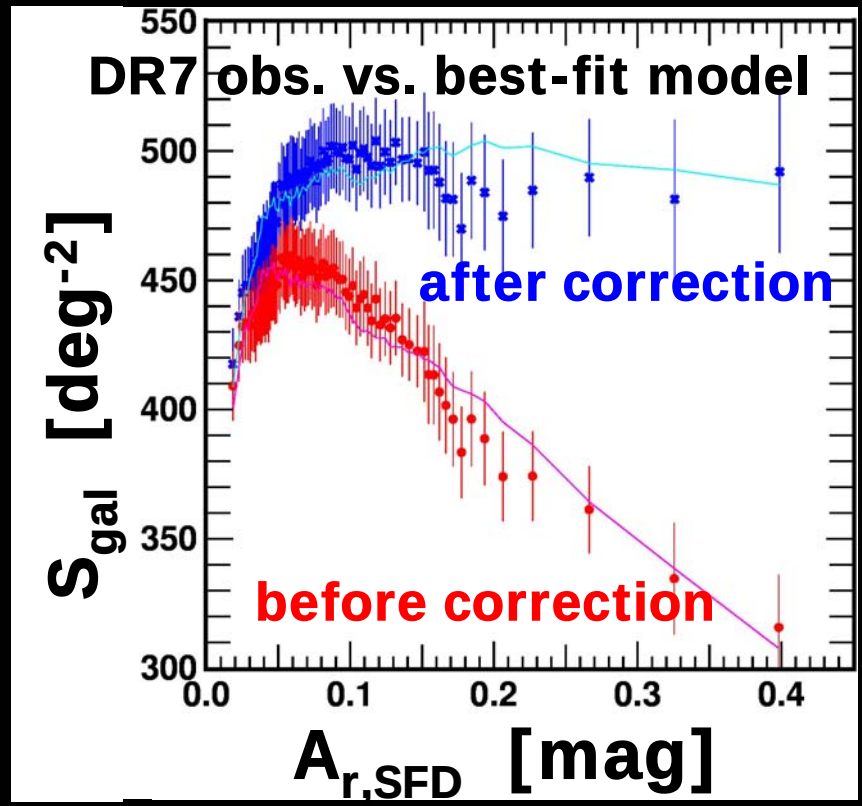
$\times 10^{\gamma(\Delta A)}$ with correction

$$\Rightarrow S'_{gal}(A) = N'_{gal}(A) / \Omega'(A)$$



Fit to the observed anomaly using an analytic approximation model





- Basic trend is well reproduced with the model
- 1/5 of the mean ratio $L_{100\mu m}/L_r$ of IRAS/SDSS overlapped sample, maybe reasonable

Conclusions

- An anomaly in the SFD Galactic extinction map is confirmed with SDSS DR7 analysis
- The anomaly would be due to FIR emission from galaxies
  - Implications on precision cosmology remain to be studied
- More accurate Galactic extinction map with higher angular resolution AKARI IR map and/or Planck IR/temperature map