

Color term of PanSTARRS i-band

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Summary:

We noticed that the color term of $i_2(\text{HSC})-i(\text{PS1})$ vs $i-z(\text{PS1})$ of stars of HSC data of various fields calibrated with hscPipe differs from that used in hscPipe. By comparing $i(\text{PS1})$, $i(\text{SDSS})$, and $i_2(\text{HSC})$, we concluded that **the $i(\text{PS1})$ catalog magnitude is inconsistent with the official PS1 response curve**, and an empirical conversion $i'=i-(i-z)*0.046-0.012$ of the PS1 catalog magnitude makes the match with the model better. This affected hscPipe i_2 -band zero-point calibration by ~ 0.03 mag, since hscPipe uses PS1 catalog for the calibration.

Data:

HSC i/i_2 -band data for various studies: (M31, M33, M81, A1656, etc.)
 Reduced&measured by ourselves using hscPipe 8.
 Selected as Extendedness_flag=0, $18 < i(\text{or } i_2) < 19$. Bright (high S/N) but not yet saturated in HSC.
 ⇒ Cross-matched against public catalogs with $< 1''$ separation.
 SDSS DR16(DR7, DR12): SDSS Skyserver casjobs, PSFmag
 PS1 DR2: MAST PS1 casjobs, meanPSFMag, (the difference between PS1 DR2 and pv3_3pi(used by hscPipe) is negligible at $i < 19$)

Color models:

- **hscPipe v8 built-in color conversions** (PS1 → HSC, SDSS → HSC)
- **synthetic color of local stars**
 - HSC(Subaru Web) throughputs + Maunakea atmosphere model
 - SDSS(Doi+2010), PS1(Tonry+2012) throughputs
 - Castelli&Kurucz SEDs(ATLAS9 grid)
 - +parameters selected on Y^2 evolutionary tracks(Demarque+2004)
 - +MW extinction $A_v=0, 0.5, 1.0$ (Cardelli+1989, O'donnell 1994)
- **colors from PARSEC evolutionary tracks** (PS1,SDSS)
 $1 \leq \log g \leq 5$, $[\text{Fe}/\text{H}] \leq 0$ stars, rest frame.

Results:

Fig1 shows that PS1 shows different slope from the hscPipe model, while SDSS shows ZP offset.

Fit to residual from the hscPipe color term (Fig2 magenta lines) are

PS1: $\Delta i_2 = +0.144 - 0.046(i-z)(\text{PS1})$
 SDSS: $\Delta i_2 = +0.030 - 0.013(i-z)(\text{SDSS})$

- ⇒
- *PS1 shows a significant slope; redder stars are estimated to be fainter.
 - *The slope of SDSS is marginal, while the offset of ~ 0.03 mag is obvious.
 - *hscPipe calibrates ZP using PS1 catalog, and HSC-PS1 offset is 0 around median $i-z \sim 0.3$. It may partly explain HSC-SDSS offset.

Discussion:

- * Synthetic color and color term of hscPipe are consistent (Fig.1) ⇒ hscPipe color term OK.
- * In two color diagrams(Fig.3), PS1 shows offset to upper-left, while SDSS seems OK. Synthetic color and PARSEC model are comparable.
- * In PS1 vs SDSS(Fig.4), redder stars have smaller $i(\text{PS1})-i(\text{SDSS})$.
- * If ZP of HSC is -0.026 mag offset as suggested by SDSS, and $i'=i-(i-z)*0.046+0.014-0.026$ is used for $i(\text{PS1})$, data fits much better with model colors in HSC-catalog plot, two-color plot, and SDSS vs PS1 plot (Fig.5).
- * The conversion is derived from HSC-PS1 residual fit(Fig.2), while it makes PS1 two-color diagram, and SDSS vs PS1 better, too.

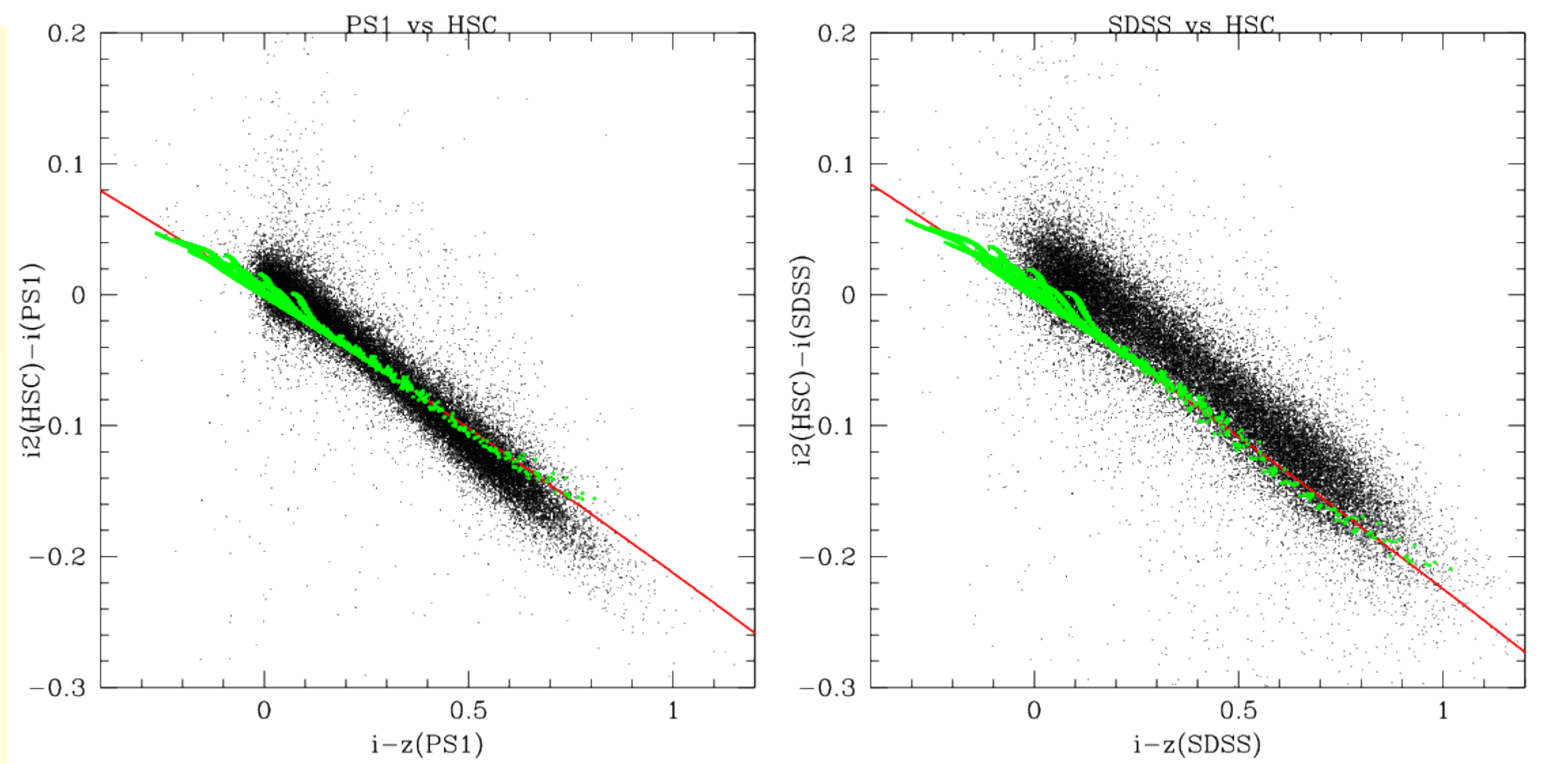


Fig.1: Catalog color vs HSC i_2 -catalog. PS1(left) and SDSS(right). Black dots: hscPipe output. Red line: hscPipe built-in color term. Green: synthetic color of local stars.

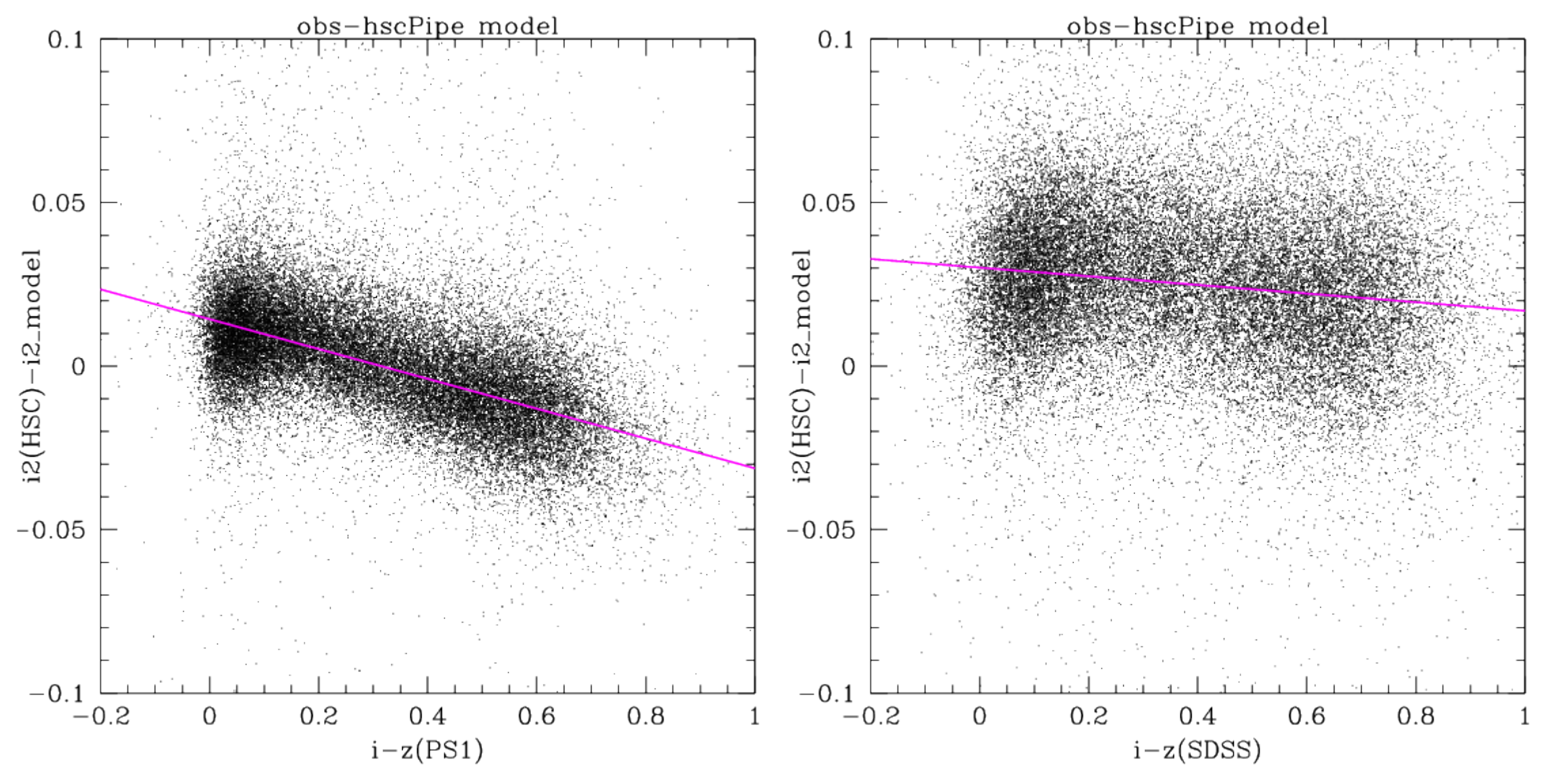


Fig.2: Residual of HSC i_2 - converted i_2 mag from PS1(left) and SDSS(right) using hscPipe v8 color term. Black dots: residual. Magenta line: linear fit to the residual.

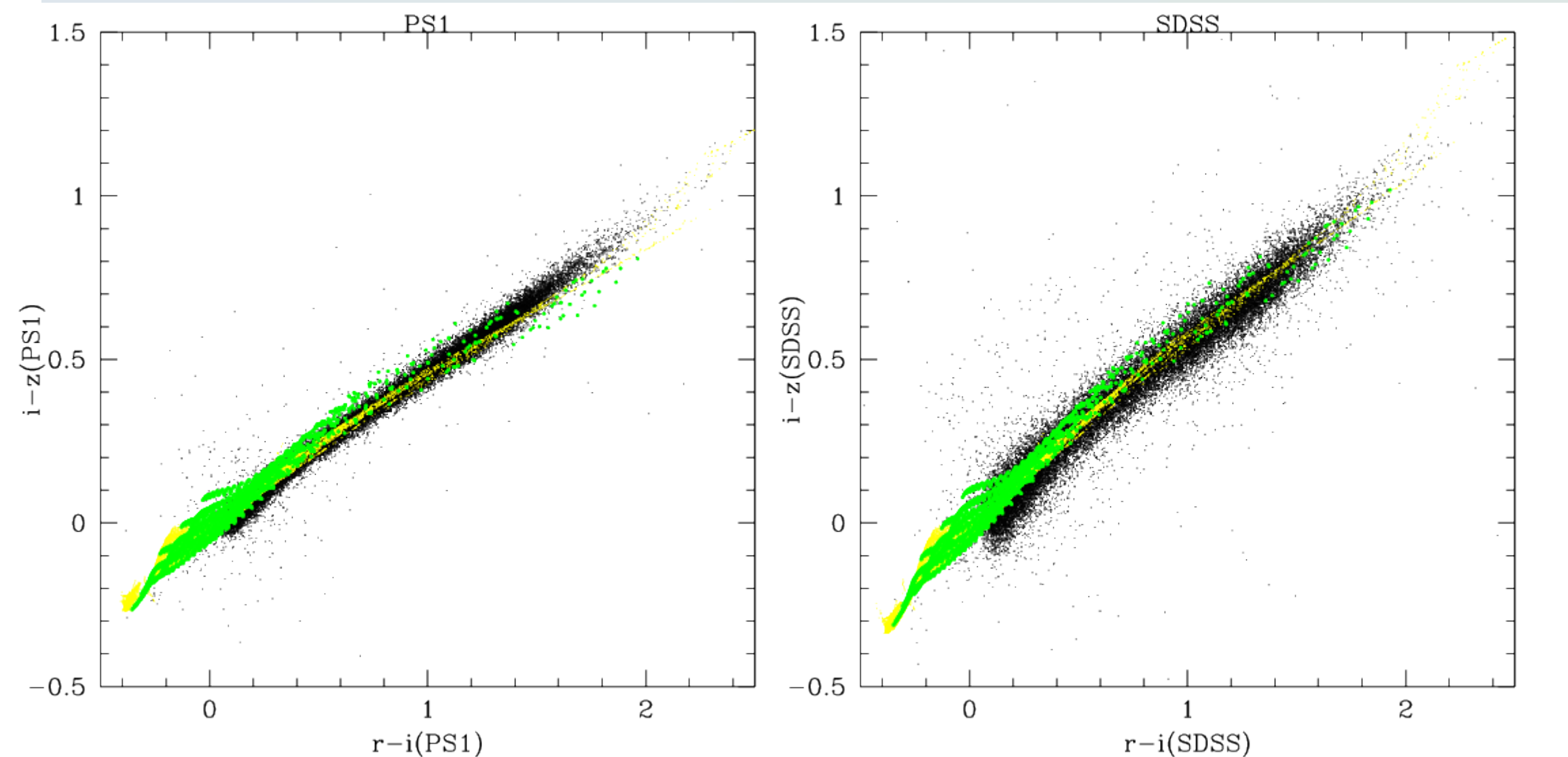


Fig.3: $(r-i)$ vs $(i-z)$ two color diagram of stars in PS1(left) and SDSS(right). Black dots: catalog magnitude. Only stars that matched with our HSC data and $18 < i_2 < 19$ are used. Yellow dots: PARSEC. Green points: synthetic colors.
 If i -band in the catalog is fainter, the data points should offset to the upper left. The redder part in PS1 plots shows this trend relative to the model colors.

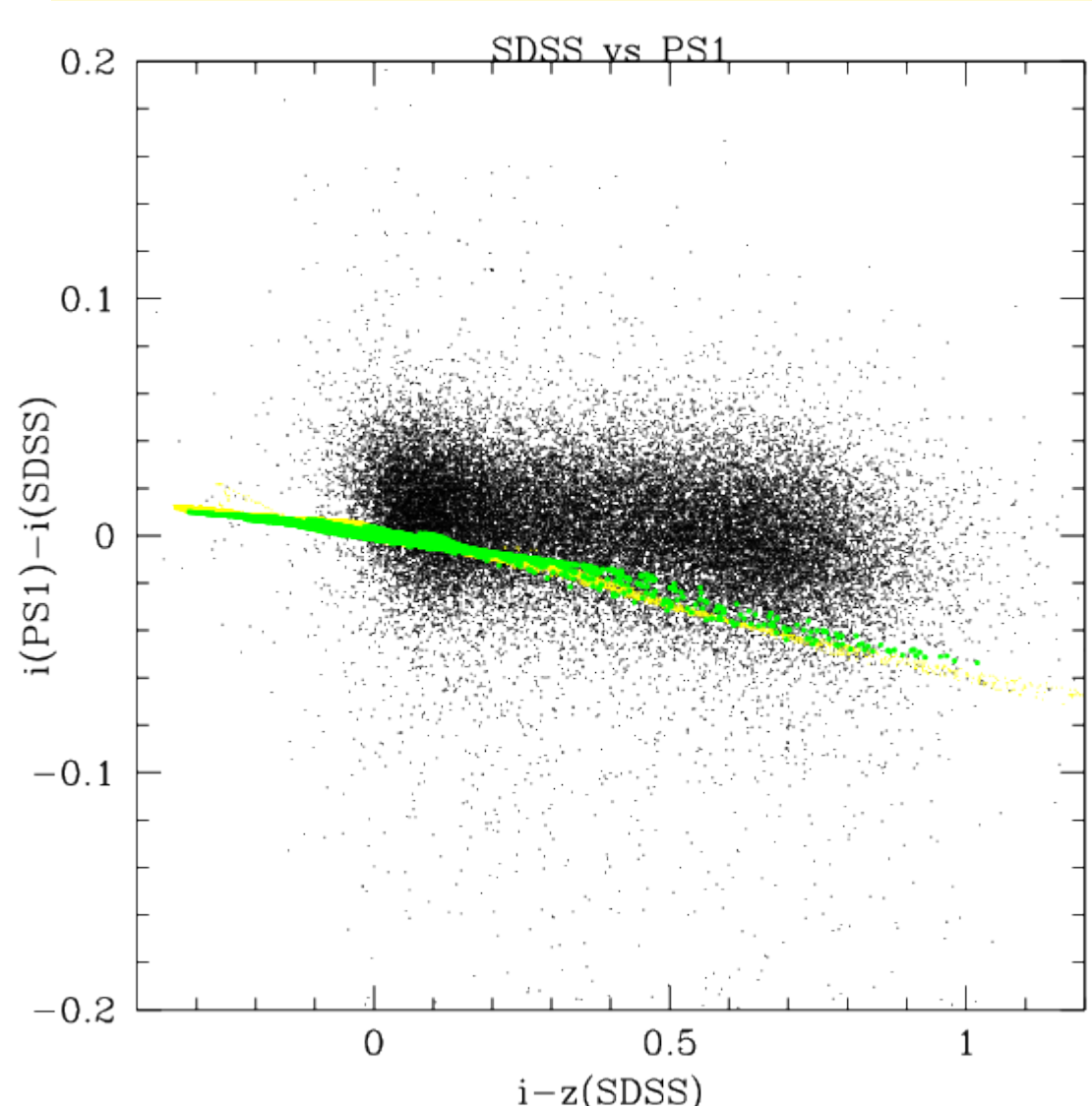


Fig.4: SDSS $(i-z)$ vs $i(\text{PS1})-i(\text{SDSS})$
 Symbols are the same as Fig 3.
 Red stars are fainter in PS1 than model.

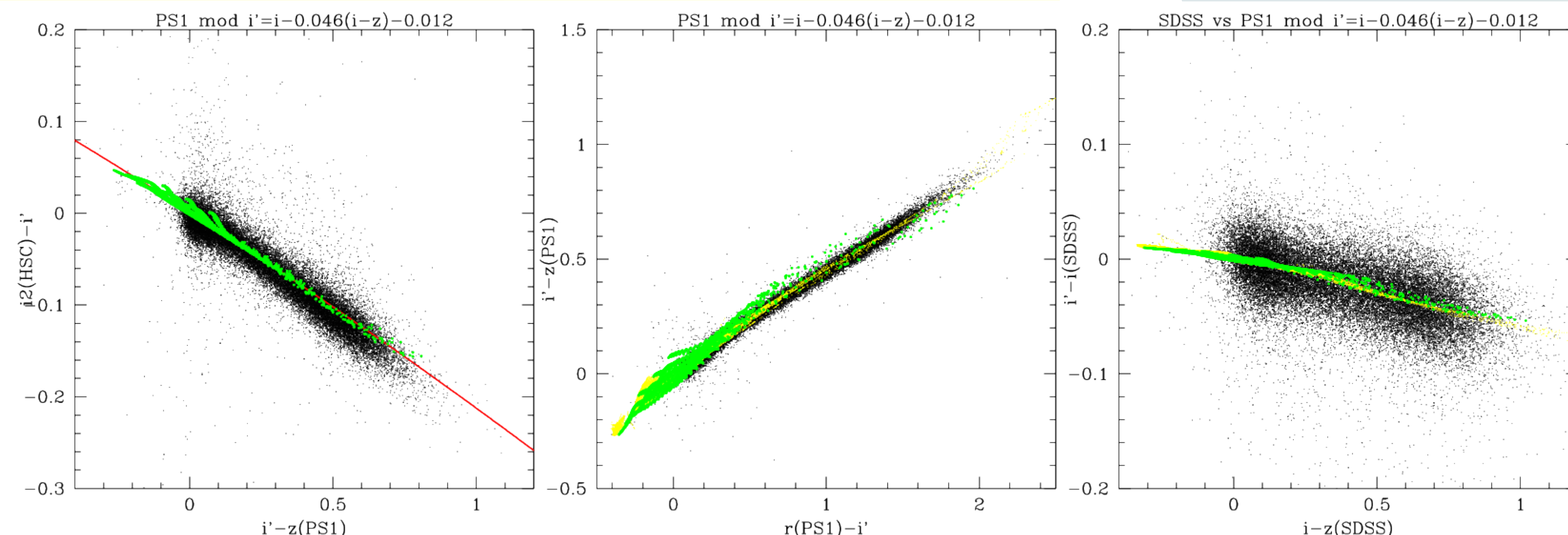


Fig.5: Using modified i' ($i'=i-(i-z)*0.046-0.012$) instead of $i(\text{PS1})$ and -0.026 ZP offset in HSC i_2 . Modified from Fig1(left), Fig3(center), and Fig4(right), respectively. All match better with models.

References:

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- Castelli & Kurucz 2003, IAUS 210, A20
- Doi et al. 2010, AJ, 139, 1628
- O'Donnell 1994, ApJ, 422, 158
- Tonry et al. 2012, ApJ, 750, 99
- Demarque et al. 2004, ApJS, 155,667

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