Calibrating LSST Photometry with Gaia

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LSST goals for photometric precision

1 Repeatability each star (rms) : 5 mmag in *gri*, 8 mmag in *uzy*
2 Spatial uniformity (rms)   : 10 mmag in *gri*, 20 mmag in *uzy*
3 Band-to-band calibration   : 5 mmag, colors with *u* 10 mmag
4 Absolute calibration (rms)   : 10 mmag

1 & 2 : correct for changes in transmission with time, position
        => coherent relative calibration for each filter

3 & 4 : comparison to spectro-photometric standards
        => coherent colors and absolute fluxes over the survey

need to have stars with ~ 2 to 5 mmag precision
less than 10 to 25 mmag variability

Gaia catalog and specifications

Launched in dec. 2013, L2, five-year ESA mission

Astrometry : not considered in this talk

Photometric survey of all stars in G band [330-1050 nm] < 20

Performances estimated in July 2014

Photometric precision (all spectral types) in G band (70 passes, 5 y) :

G band	15	18	19	20
Error (mmag)	1	2	4	6
Error (1 y)	2,5	5	9	13

Measurement of astrophysical parameters : M, T_{eff}, log g, [Fe/H]

$\Rightarrow$ determination of spectral type

Detection of variability : 10 to 20 mmag over 0.5 to 1 year

LSST calibration stars

Stars must be

non-variable, visible through most filters, abundant:

=> sample of main sequence (MS) stars

bright enough to give photometry with 2 to 5 mmag precision

Detection threshold at m_b = 24.5 => Night Sky Background at 5 sigma

=> photometric precision due to NSB: 2 mmag at m_b = 19.5,

5 mmag at m_b = 20.5

not saturating the CCDs: m_b > 16.5

F too variable, M too faint

=> promising sample: G and K dwarves with $16 < m_b < 20$
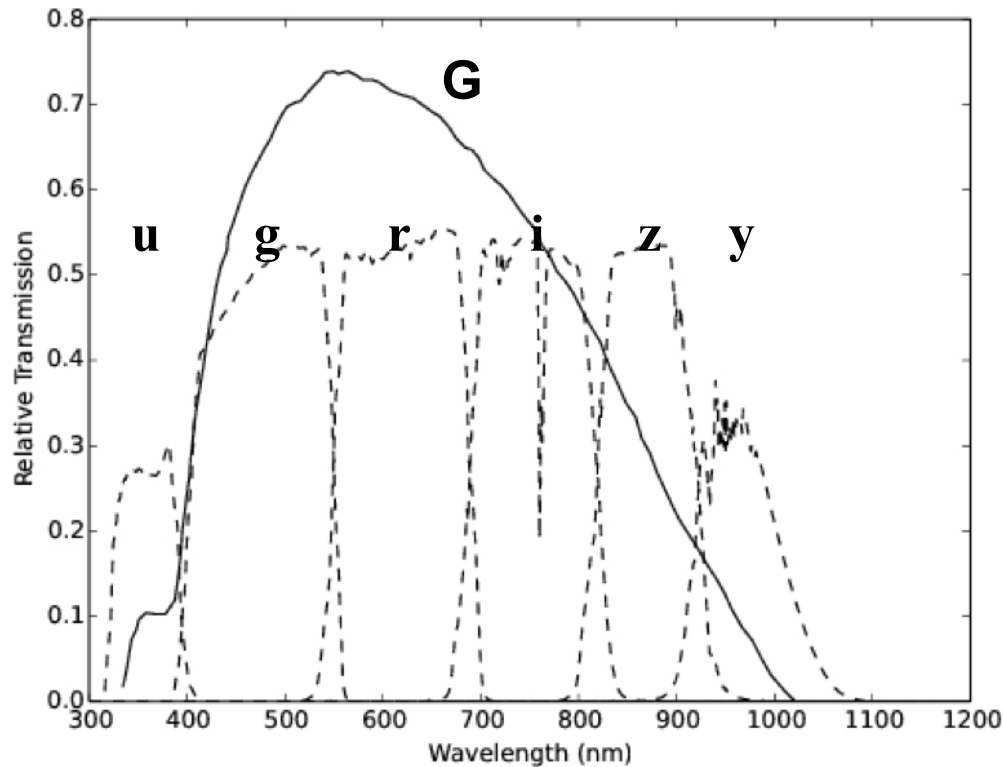
Comparison of G and LSST bands

Fig. 2.— Bandpasses for Gaia-G band (solid curve), and LSST u, g, r, i, z, and y bands

r (SDSS) ≈ G (Gaia)

Guess: non-variable stars in Gaia G band => same for LSST bands

Abundances of G and K stars

Non uniformely spread across the sky:
great variation from Galactic Poles to near the disk

Quick look at SDSS star samples :
4 deg^2 around the North Galactic Pole
4 deg^2 around 54° to the South Galactic Pole
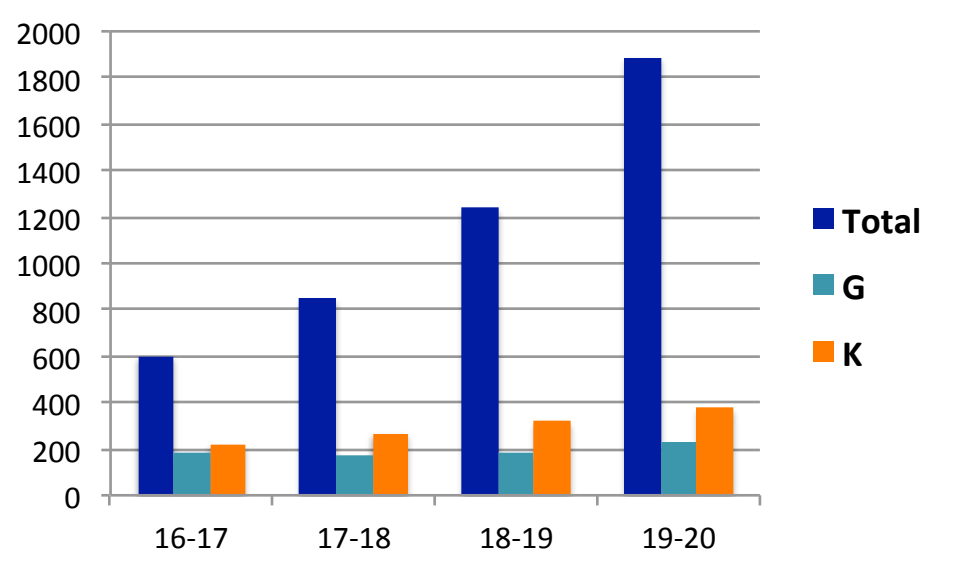
r (SDSS) ≈ G (Gaia) => SDSS samples with 16 < r < 20

Color identification of G & K tuned on Catalog of Nearby Stars (CNS)

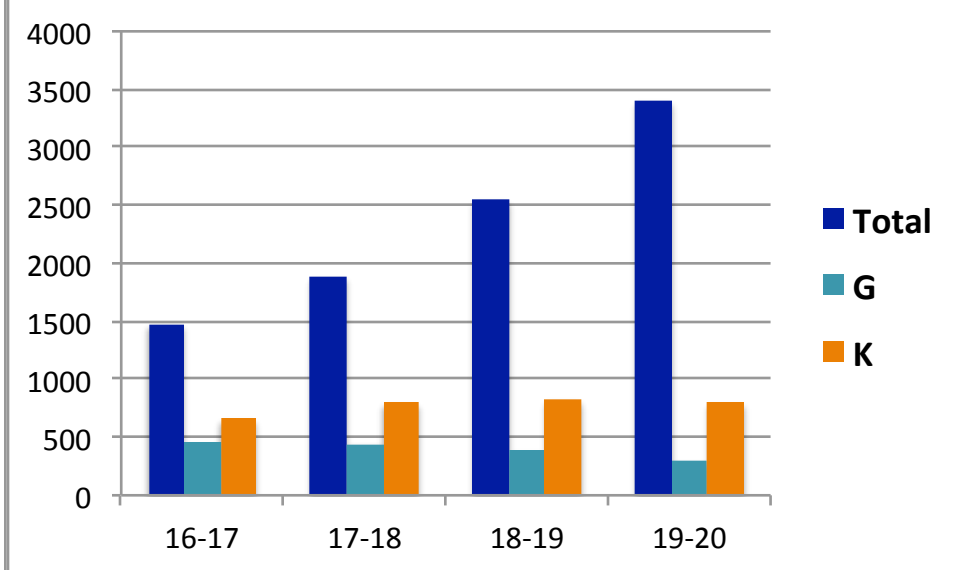   **0.38 < g – r < 0.58**   **=> G stars**
        0.58 < g – r < 1.24   **=> K stars**

Candidates for calibration stars

North Galactic Pole

54° to the South Galactic Pole

130 G&K * / deg² / 1 mag

300 G&K * / deg² / 1 mag

G&K are a factor 9 to 4 less than in calibration papers: 3600 / deg²

Possible uses of Gaia catalog

Gaia will provide a catalog with precise photometry of G & K stars identified as non-variable

Potential uses:
⇒ correct for changes in transmission with time, position for each exposure
⇒ provide some absolute standards
⇒ verify the whole calibration procedure
⇒ use Gaia stars as starting point for overall calibration χ^2 fit

Open questions:
correction for grey extinction short-time variation (15 s scale) ?
Non uniform spread of standards across the survey: problem ?