Development of an ubercal simulation for LSST

F. Feinstein, D. Fouchez, CPPM-Marseille

J. Cohen-Tanugi, LUPM-Montpellier

LSST France meeting, March 20, 2017

LSST/DESC calibration goal

LSST DRP calibration requirements: 5 ~ 10 mmag

Does not match DESC needs, e.g. for SNe ~ 1 mmag

We propose to investigate specific methods to reach such accuracy

1st step: use of an external reference catalog: GAIA

c.f. Betoule et al. => estimated $\Delta Z_p < 0.5\ 10^{-3}$

2nd step: compare with standard methods ubercal, Forward Cal., …

=> build an ubercal simulation tool to study :

- dependence on various cadence strategies
- compare poorly constrained modes with those of GAIA
- optimize physics output vs photometric accuracy
- …

Ubercal simulation prototype

Take algorithm from Padmanabhan et al. 2008

Inputs: Gaia Universe Model (GUM) catalog, m_G 16 – 19 , full sky

750 M stars in 3072 HEALpix patches/files

Camera FOV description

Opsim cadence simulation: minion_1016

=> FOV *RA, Dec, angle* wrt N, *sky brightness, air mass, date*

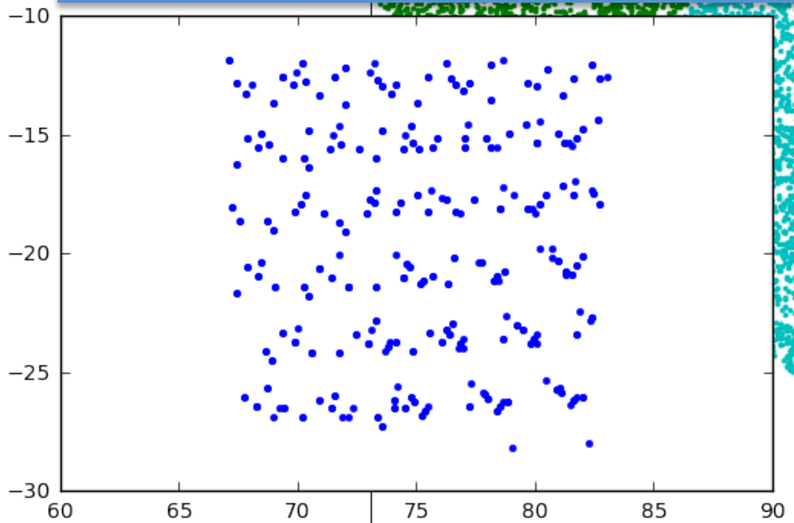
Outputs: Retrieved flat field parameters, atmosphere attn., Δm, repeatability, Fisher matrix, …

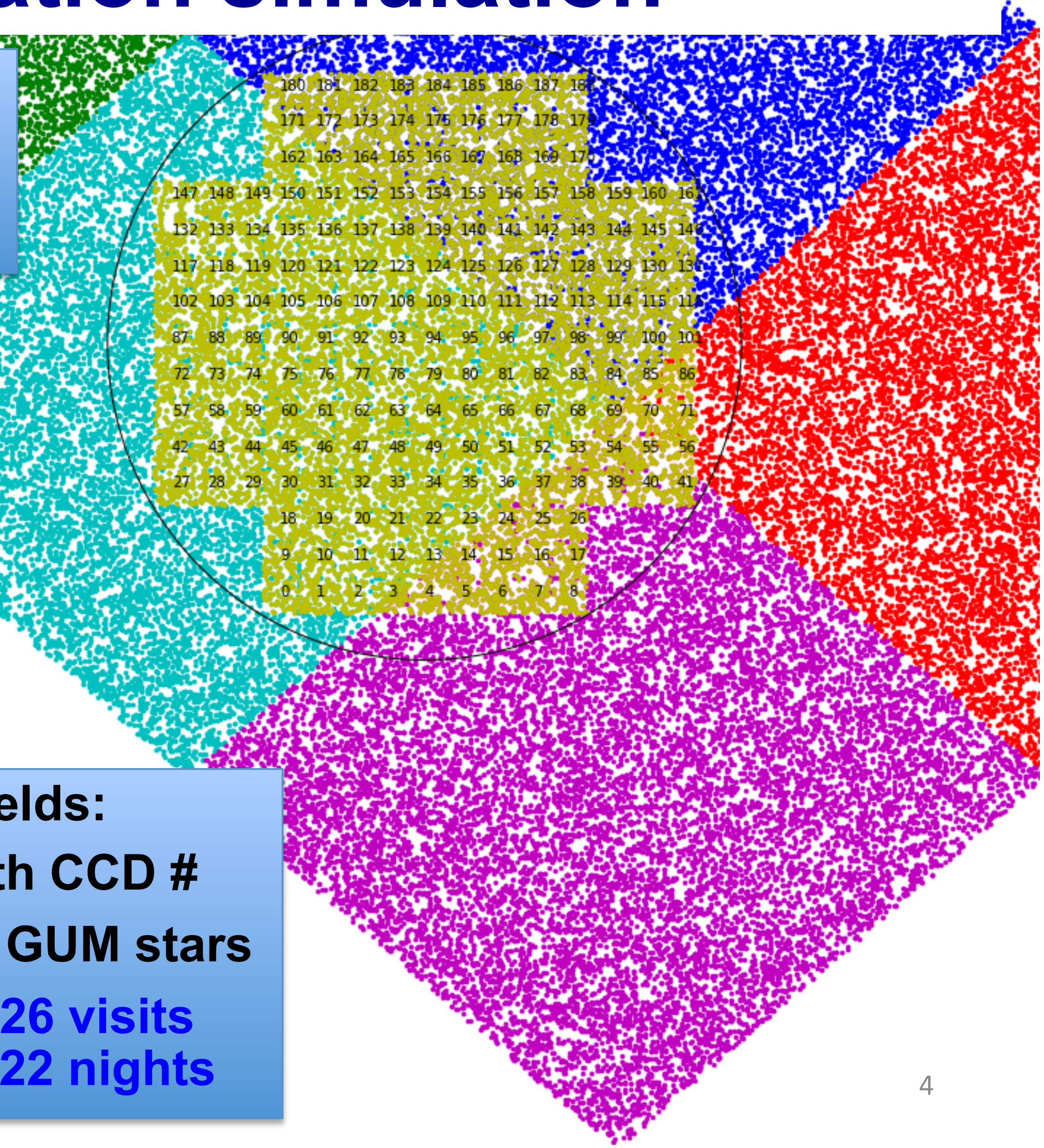
Observation simulation

Opsim pointing, dithering

250 deg2 patch (1/100th sky)

night #: from 100 to 400





Simulated camera fields:

LSST focal plane with CCD #

HEALpix patches of GUM stars

=> star list for 426 visits over 22 nights

Parameter variation

$m_{obs} = m_{true} + kx + Zp_{CCD} + a$

22 "photometric" nights:
- k[night] x x[visit]

⇒ k parameters of 22 nights

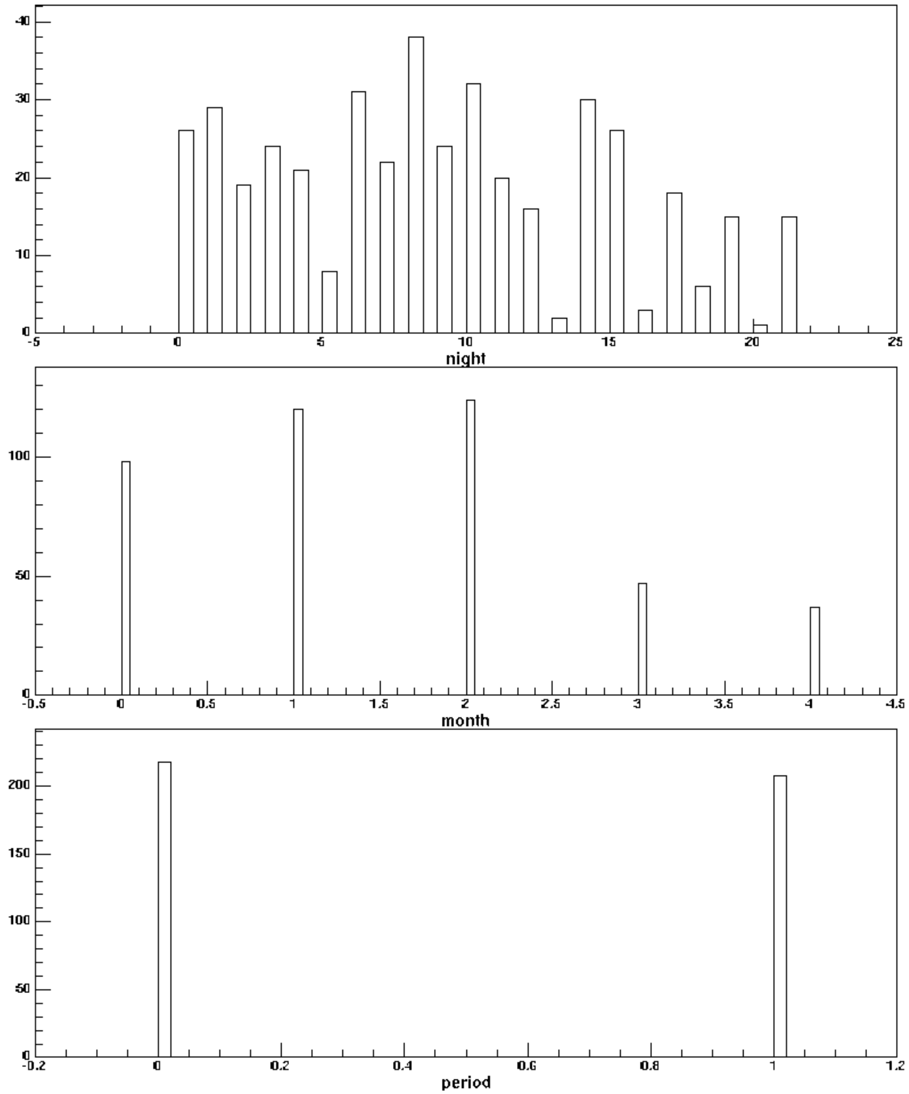
5 months : Zp_{CCD}[month][0 to 188]

⇒ 5 x 189 Zp_{CCD} parameters – 1

2 periods: throughput a[period]

⇒ 2 parameters – 1

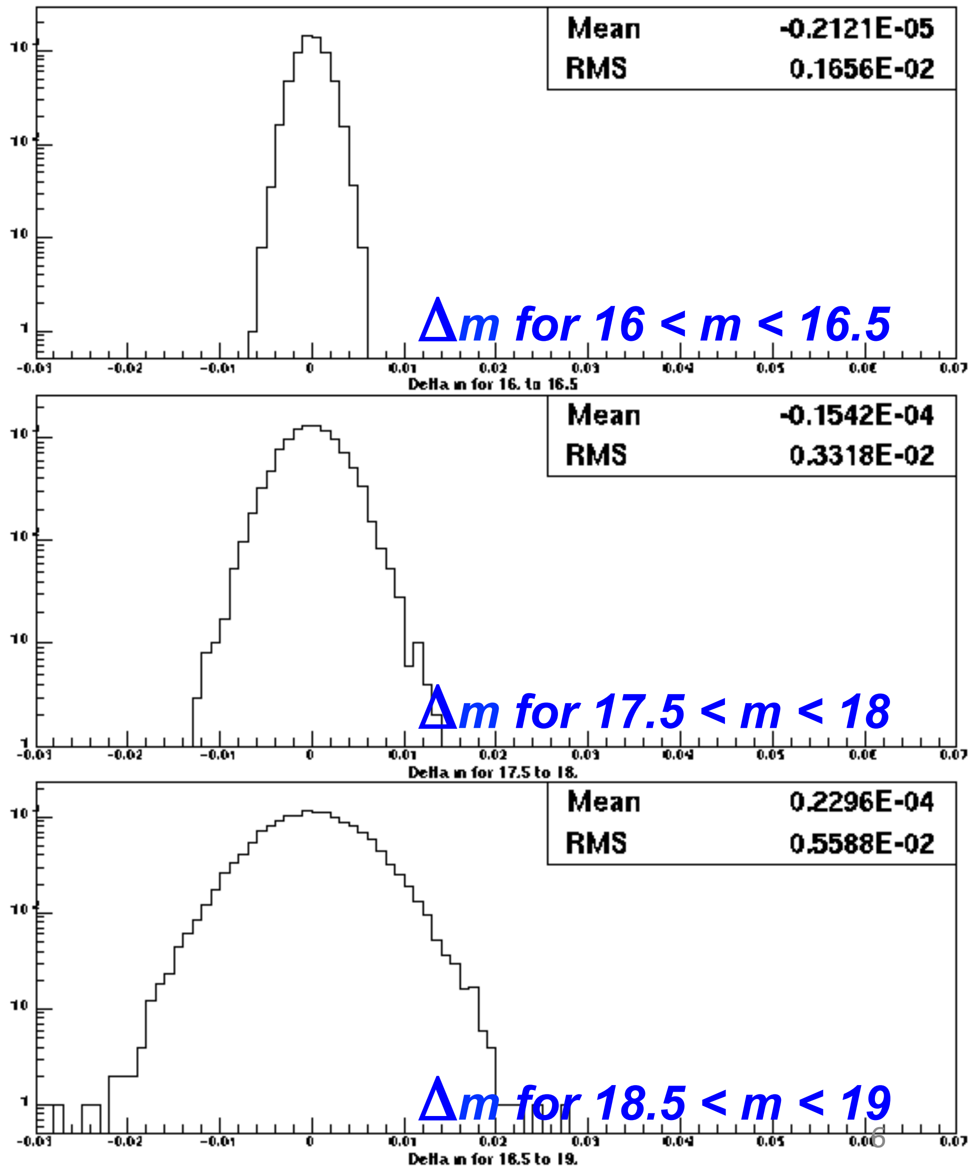
⇒ 967 parameters to fit



Corrected magnitudes

$$m_{corr} = m_{obs} - a_{fit} - k_{fit}\, x - Zp_{CCDfit}$$

$$\Delta m = m_{corr} - m_{true}$$



Technical issues

Ubercal on full observed sky per filter:

5 10^8 stars x 100 obs. = 5 10^{10} obs.

~100 B data per obs. in matrix => 5 TB of data in memory

This issue + computing time :

⇒ need for parallelisation

We have a HPC (28 nodes 0.5 to 1.5 TB) machine available

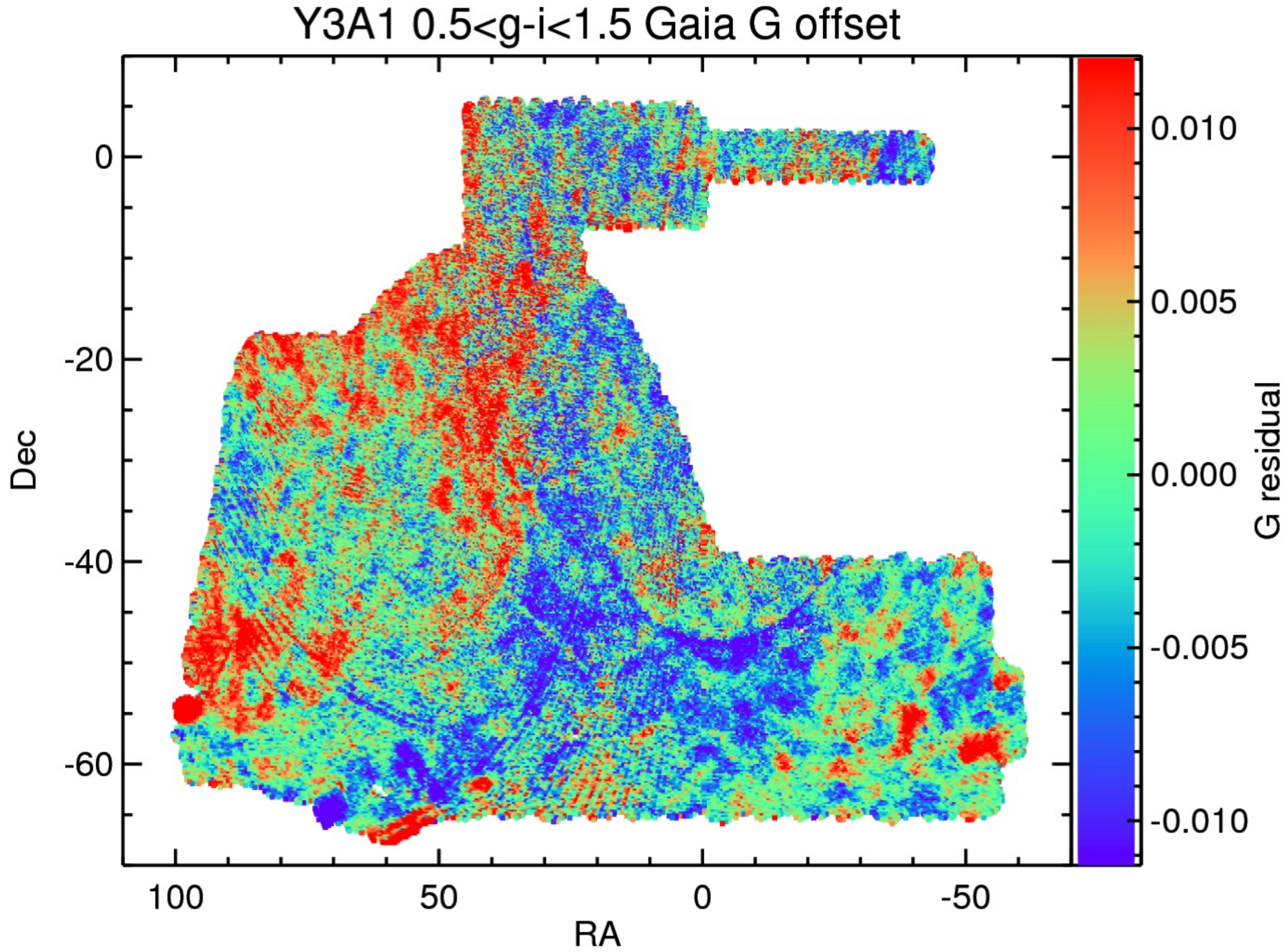
=> 100 zones 212 sq. deg. each should be feasible

Technical issues 1

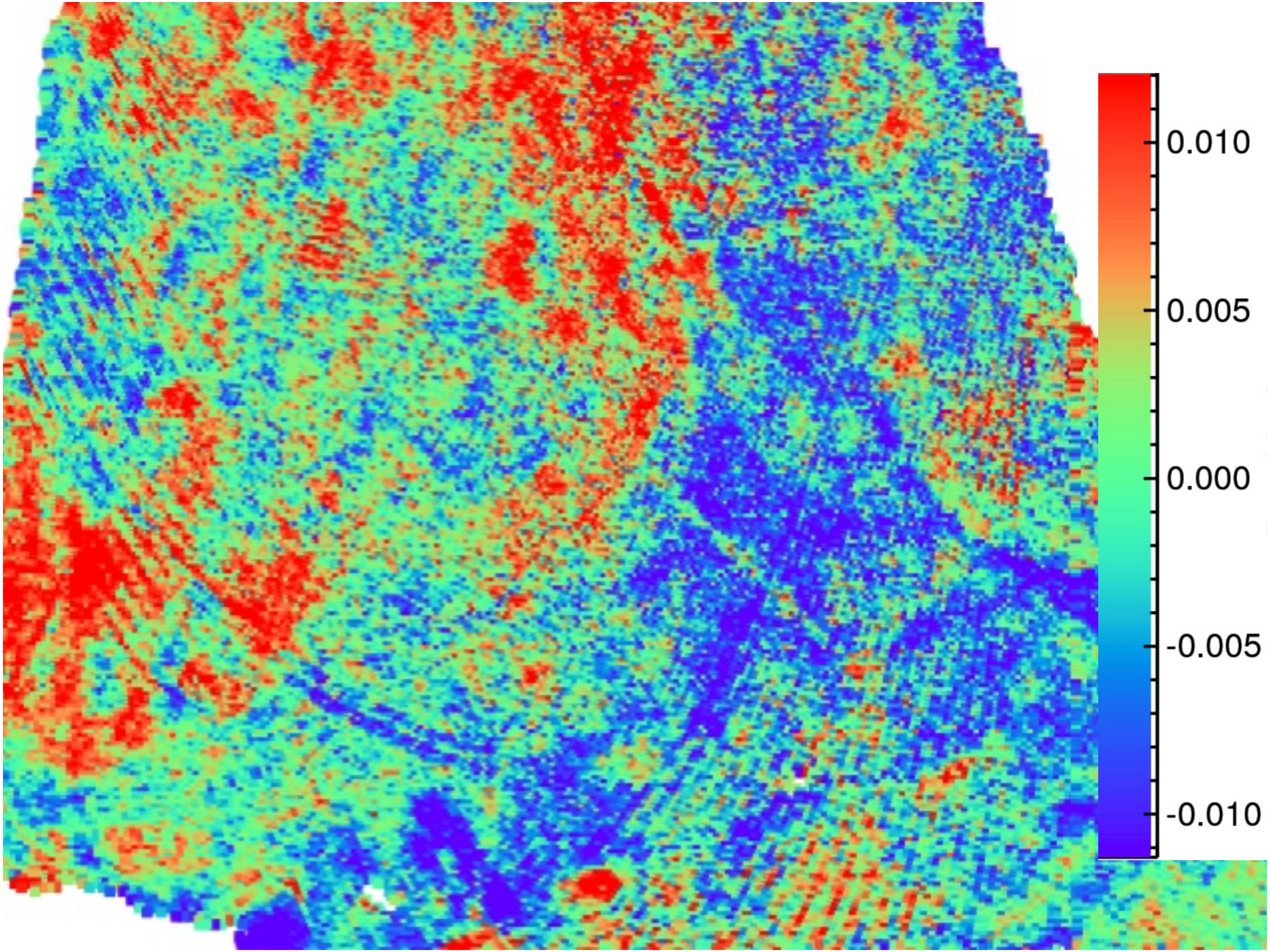
How can we ensure that we reach the precision:
alleged (GAIA) vs required (e.g. for SN, phZ …)

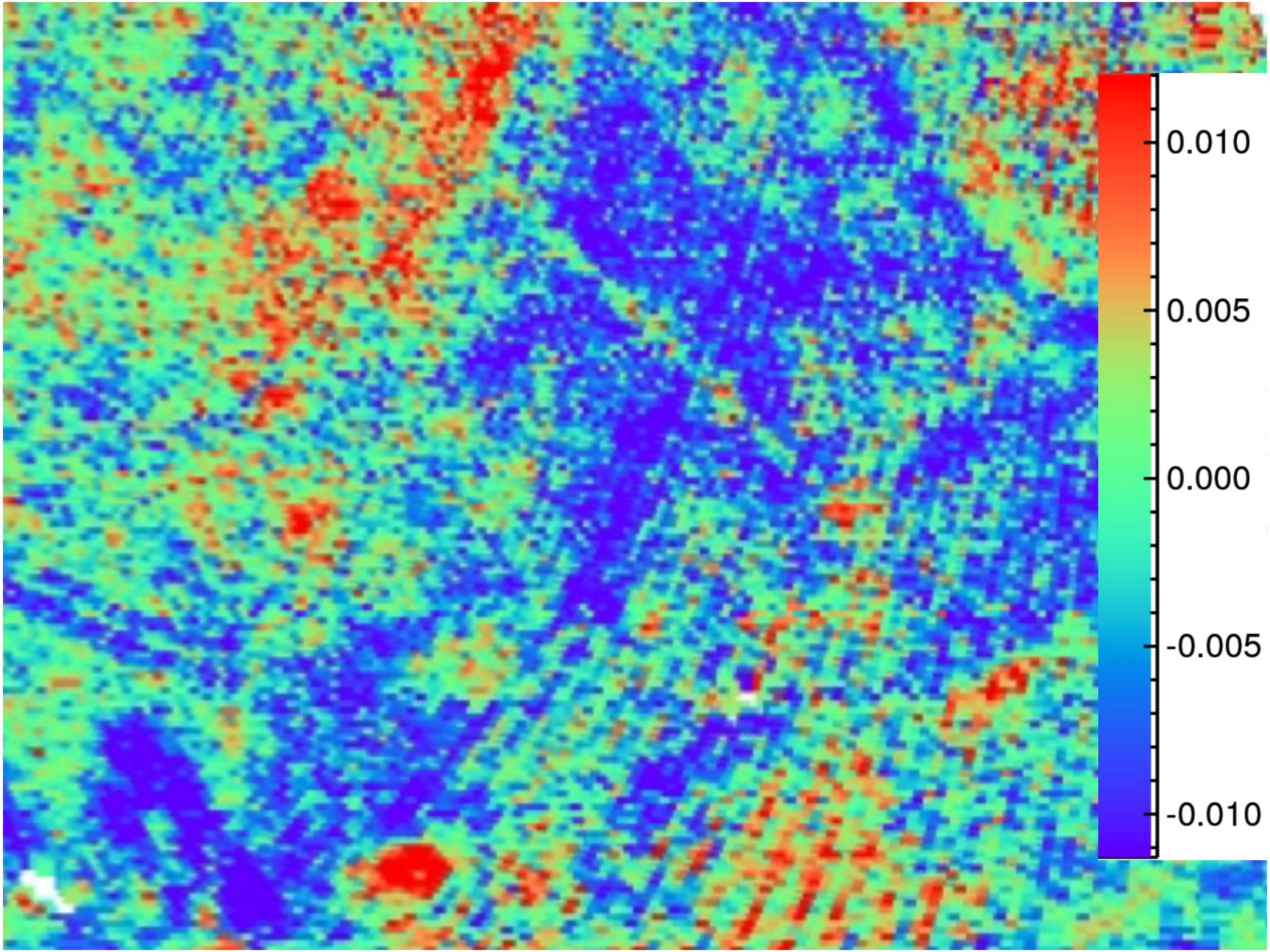
⇒ compare results from independent methods

DES Forward calibration vs GAIA DR1 (E. Rykoff)



Y3A1 0.5<g-i<1.5 Gaia G offset
Dec
RA
G residual
0
-20
-40
-60
100
50
0
-50
0.010
0.005
0.000
-0.005
-0.010


0.010
0.005
0.000
-0.005
-0.010


0.010
0.005
0.000
-0.005
-0.010

Computer time

10 M obs of 1 M stars ~ 1000 parameters

simulate visits ()	**one core :**	**0’45”**
build matrix	**one core :**	**4’08”**
solve system	**multicore :**	**2’45”**
total		**7’38”**

factors to gain:

x100 on stars, x2 to x10 on # of years, x20 to x100 on parameters

=> 4000 to 100 000 more time (50 M s = 1,5 y!)

potential gain of 1000 on multicore/multinode => < 1 day

Next steps

- Test errors and Fisher matrix eigen values
- Pursue the development of the ubercal simulation tool
  move from 200 to 2000 sq. deg. then 20 000 sq. deg.
- Add the star *m* as a parameter
- Adapt tool for parallelisation and use sparse matrix techniques
- Get closer to reality
  add outliers and incremental filters
  test on real data and compare to GAIA DR1
- Quantify effects of cadence on calibration precision
- Prepare for GAIA Data Release 2 (Blue & Red photometer info)