A Comparison of the Gaia and LSST Surveys

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The Milky Way and the Local Group - Now and in the Gaia Era, Heidelberg, Germany

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Foreword

Plan of the talk

- Introduction
- Part I: The Milky Way
- Part II: The “variable Milky Way/Universe”

INTRODUCTION

Large multi-epoch optical surveys

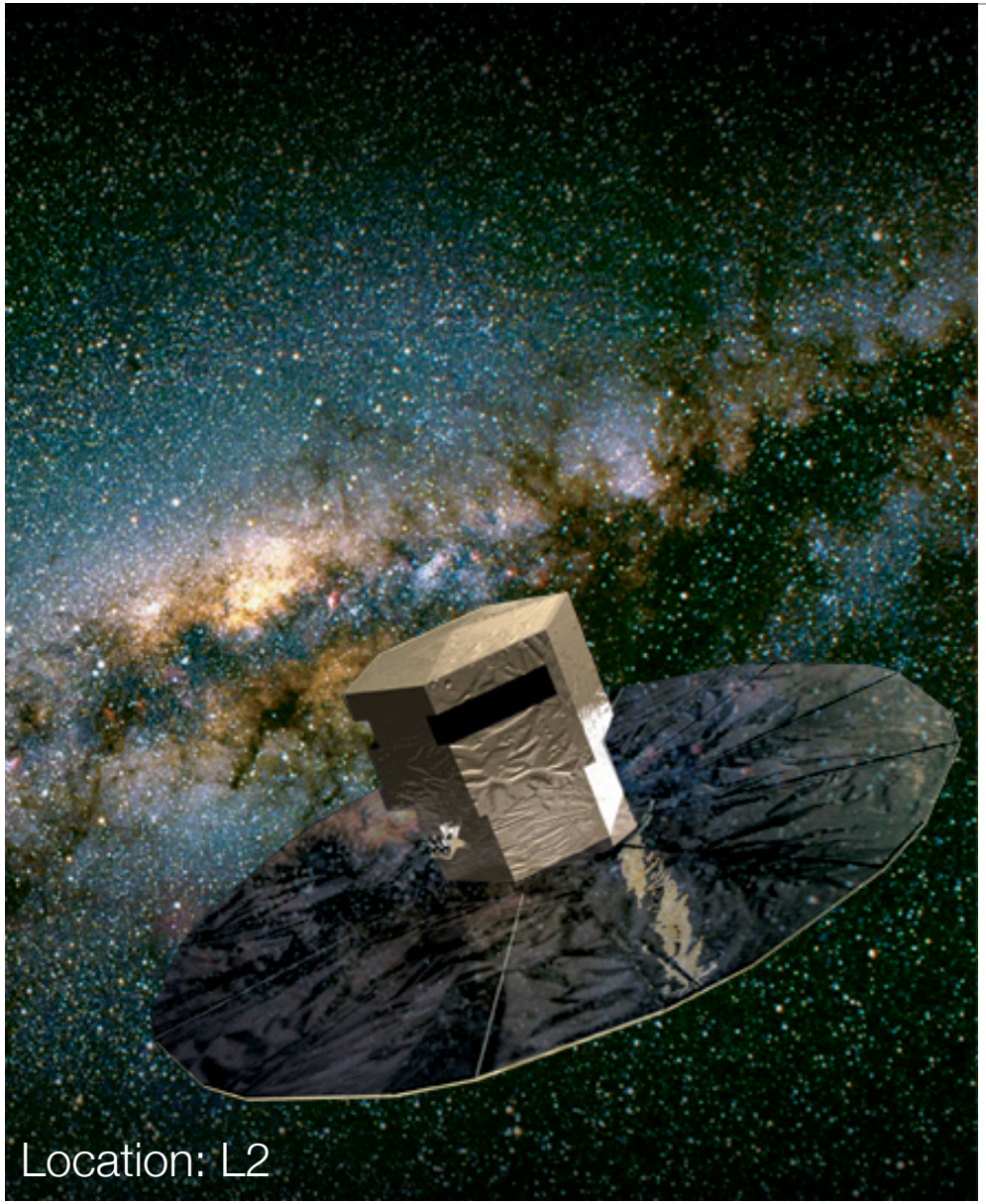
- Astrophysics is a science that has been often driven by large scale surveys

- In this coming decade several very large optical multi-epoch surveys are planned. Here we present two: Gaia and LSST

- They have in common several challenges:
  - technological
  - data reduction
  - sociological (400 people for Gaia, 250 for LSST)

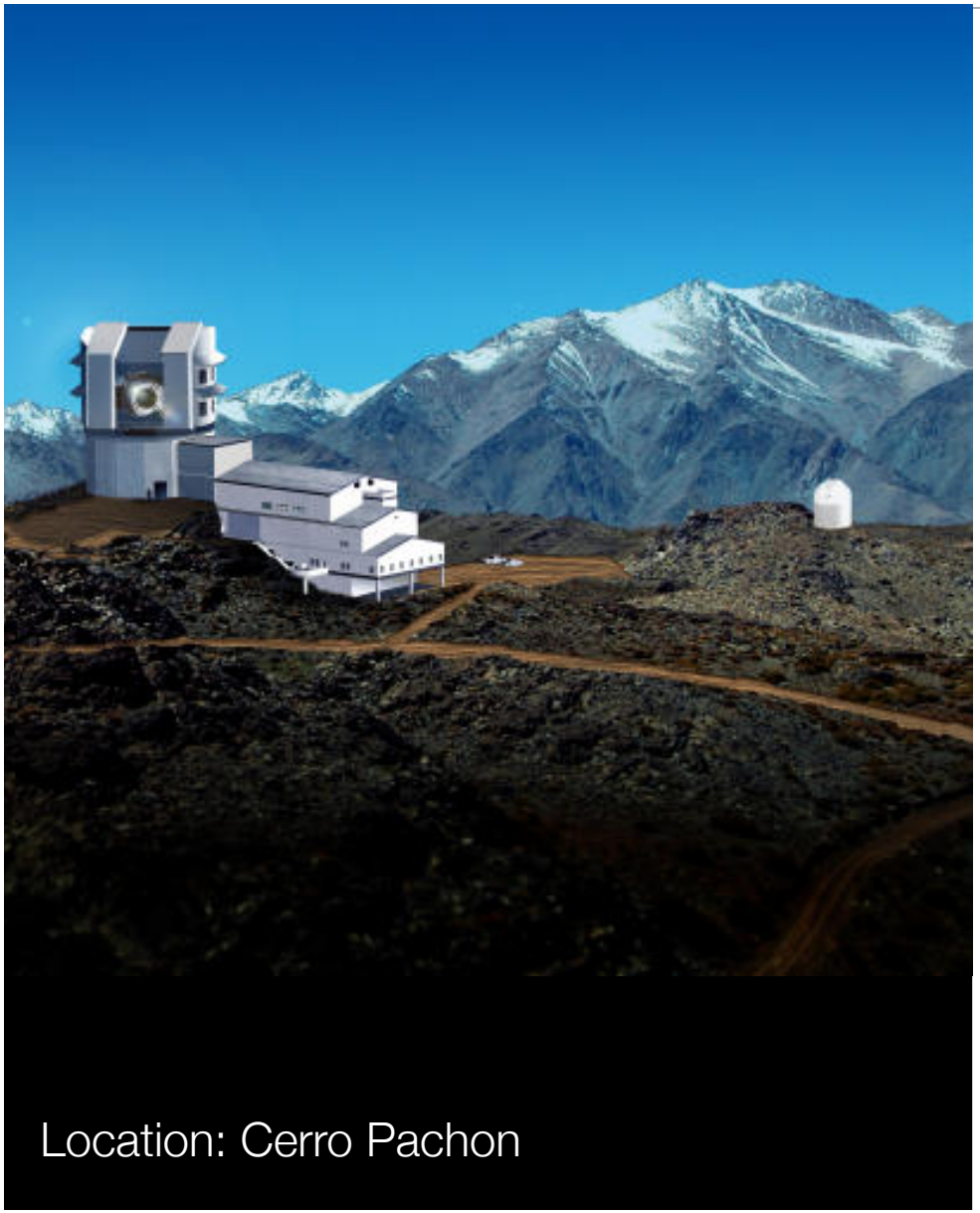
- They will both impact deeply Astrophysical sciences: Solar System Bodies, Stellar Physics, Galactic Structure, and Cosmology

Gaia a space mission of ESA



- Satellite of the European Space Agency
- Observations of all the objets brighter than V~20
- 1 billion stars
- Measurement of positions, brightness, colours and of radial velocities
- Length: 5 (+1) years (70 times the whole sky)
- Launch (Soyuz rocket, Kourou) 2012

LSST: Large Synoptic Survey Telescope



- Ground based telescope
- Observations of all the objets brighter than a certain limit (24.5-27)
- 10 billion stars, 10 billion galaxies
- Measurement of positions, 5 Sloan+ 'y' bands
- Length: 10 years (1000 times half of the sky)
- First light: 2015

Gaia, LSST Instruments

Quantity	Gaia	LSST
Sky Coverage	whole sky	half of the sky
Mirror	1.45m x 0.45m	diam. 8.4 Effective diam 6.7
Field of view (Sq. deg)	0.7 x 0.7	9.6
Pixel count (billion)	1	3.2
PSF (arcsec)	0.14 x 0.4	0.7 x 0.7
Pixel (Sq. micron / Sq. mas)	10 x 30 / 59 x 177	10 x 10 / 200 x 200
CCD pixels	4500 x 1966	4000 x 4000

PART I
The Milky Way

Modelling the Milky Way

- Where are stars?

  Position, distance

  Astrometry, photometry (photometric distance)

- How do they move?

  Proper motion, radial velocities

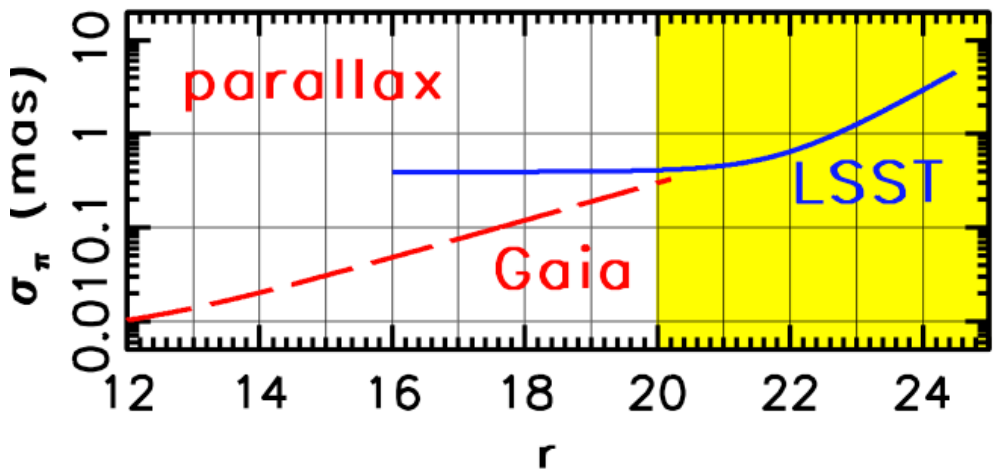
  Astrometry, spectroscopy

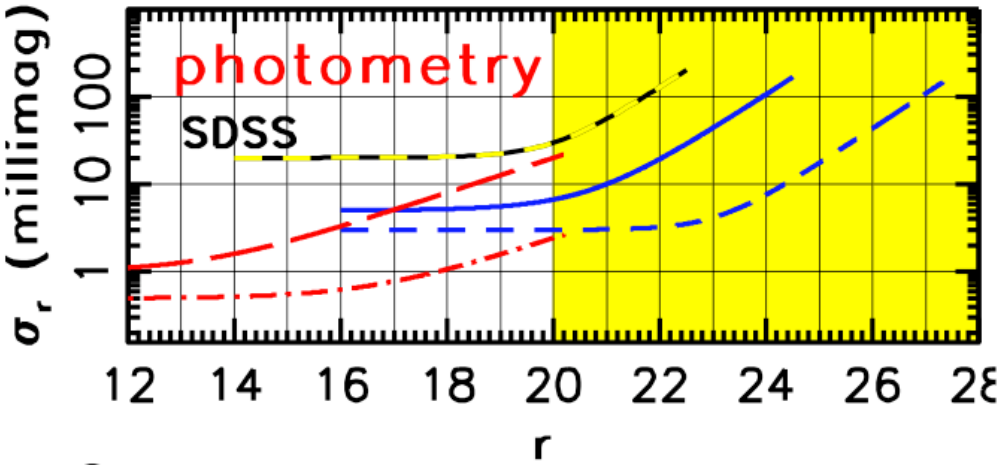
- What are their properties?

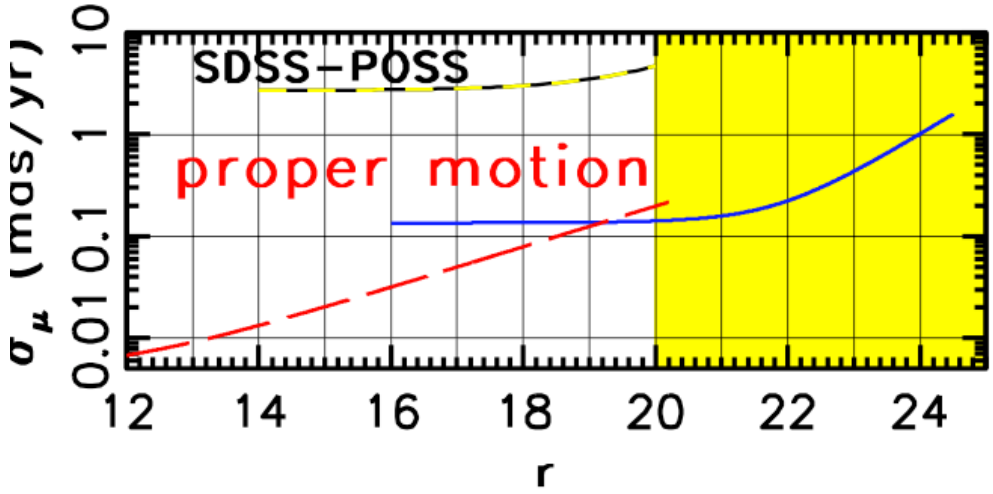
  Mass, age, Fe/H, α/Fe (Teff, L, log(g))

  Photometry, spectroscopy, stellar models

Precision as a function of magnitude







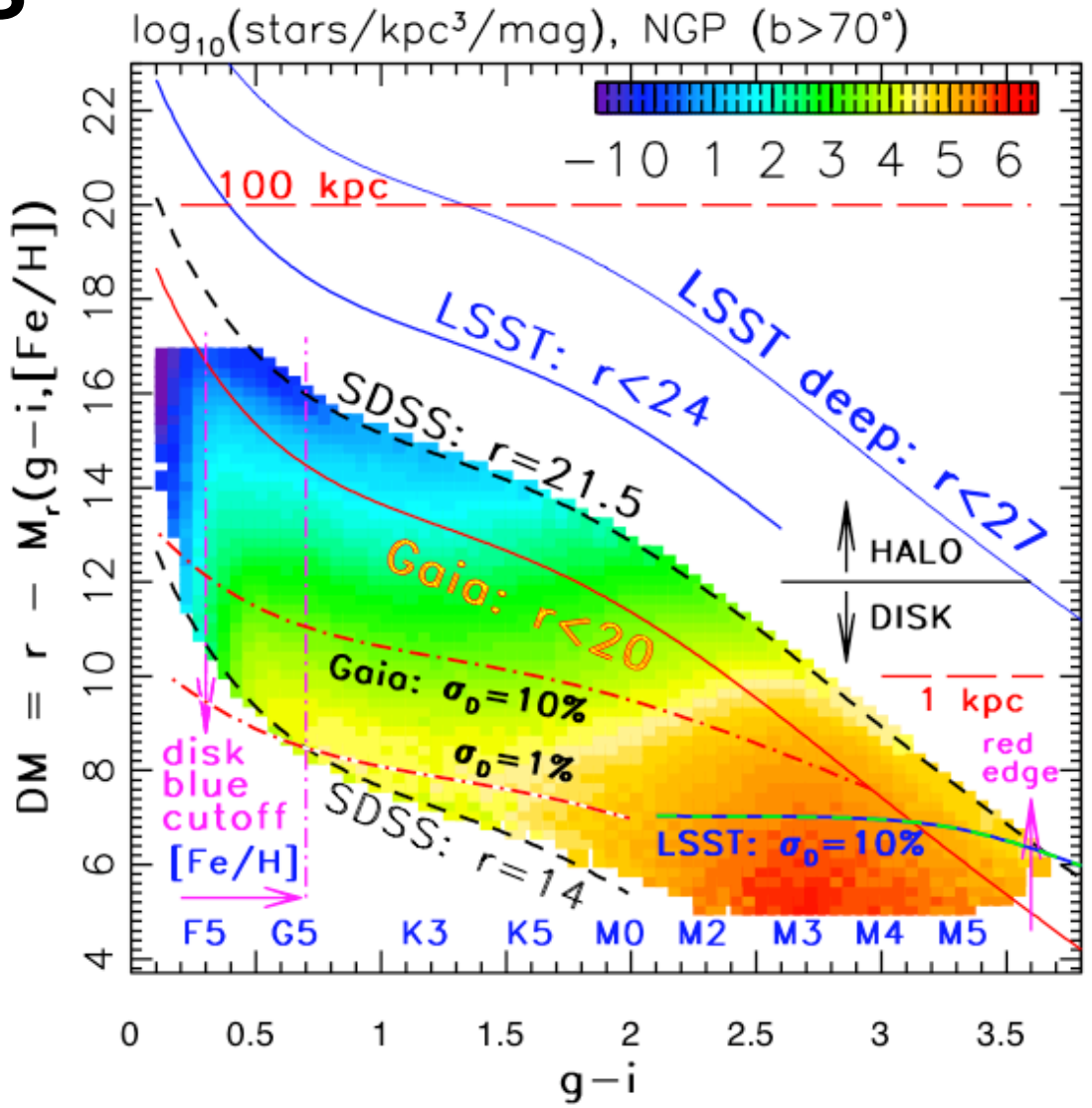
Gaia and LSST precisions complement each other very well !

How do these precisions relate to the Milky way ?

Precision reported for the Milky Way

Galactic pole SDSS data

Two major points:
Gaia has accurate distances
LSST goes faint and far

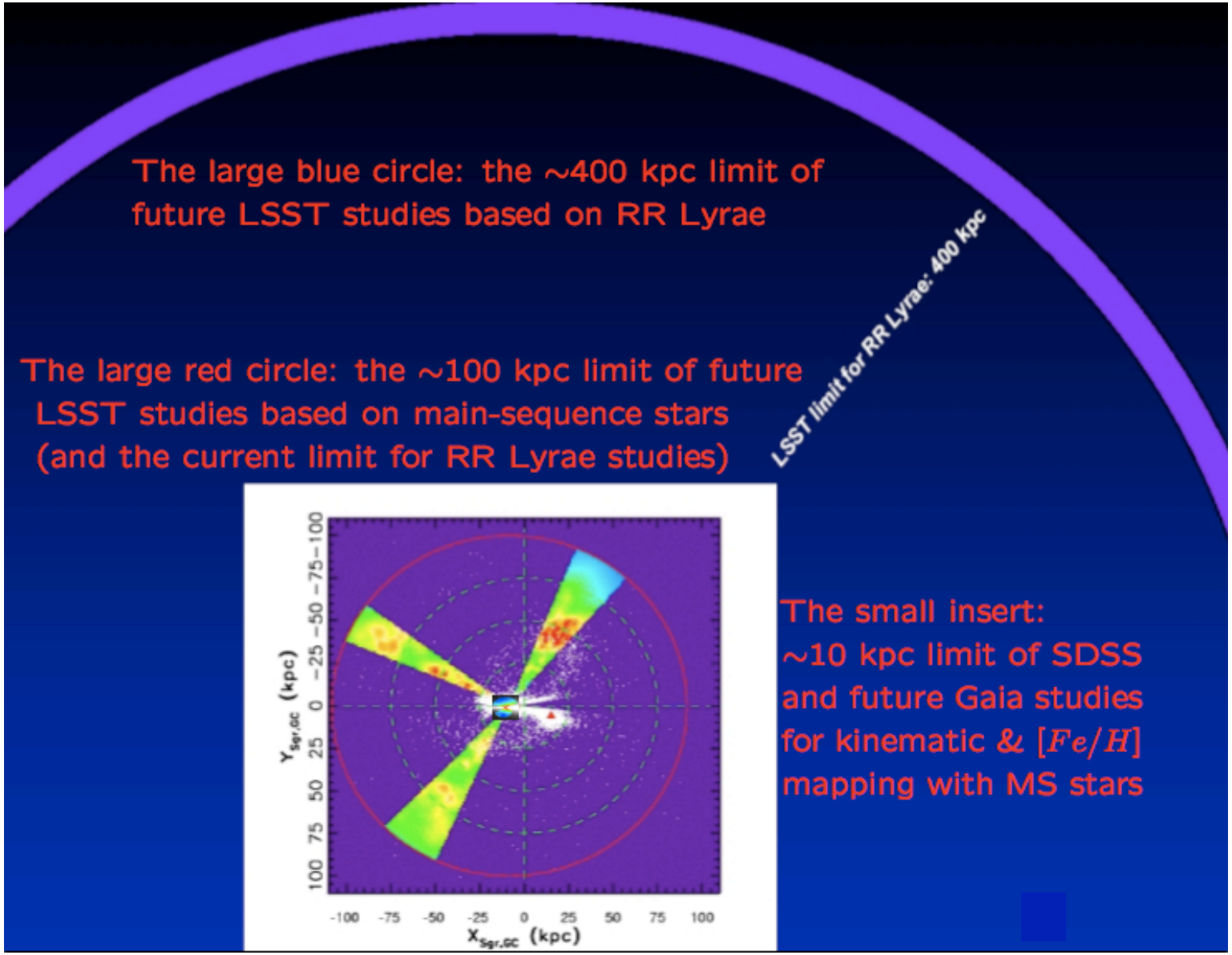


The halo structure: SDSS-Gaia-LSST

Halo was quite dull

Tidal streams
Newberg et al. (2002),
Ivezic et al. (2003),
Majewski et al. (2003),
Belokurov et al. (2006)
&
Overdensities
(Juric et al. 2008)

Gaia:
Thousands of RR Lyrae will be calibrated at better than 10%



Astrometric and Photometric Precision

Quantity	Gaia	LSST
Duration (yr)	5 (+ 1)	10
Wavelength	320-1050 nm	ugrizy
Depth (mag)	20	23.5; 27
Bright limit (mag)	6	16-17
Error floor (mag)	0.001	0.003,0.005
Error floor (mas)	0.007	0.40
Error floor (mas/yr)	0.004	0.14

Note Gaia: Radial velocities 1-10 km/s for about 150 million stars to 16-17

PART II
The “variable Milky Way”

The variable Universe

- Why an object is variable? What is the physical origin of its variability?

  - Global properties of the objects L, Teff, Fe/H, ...

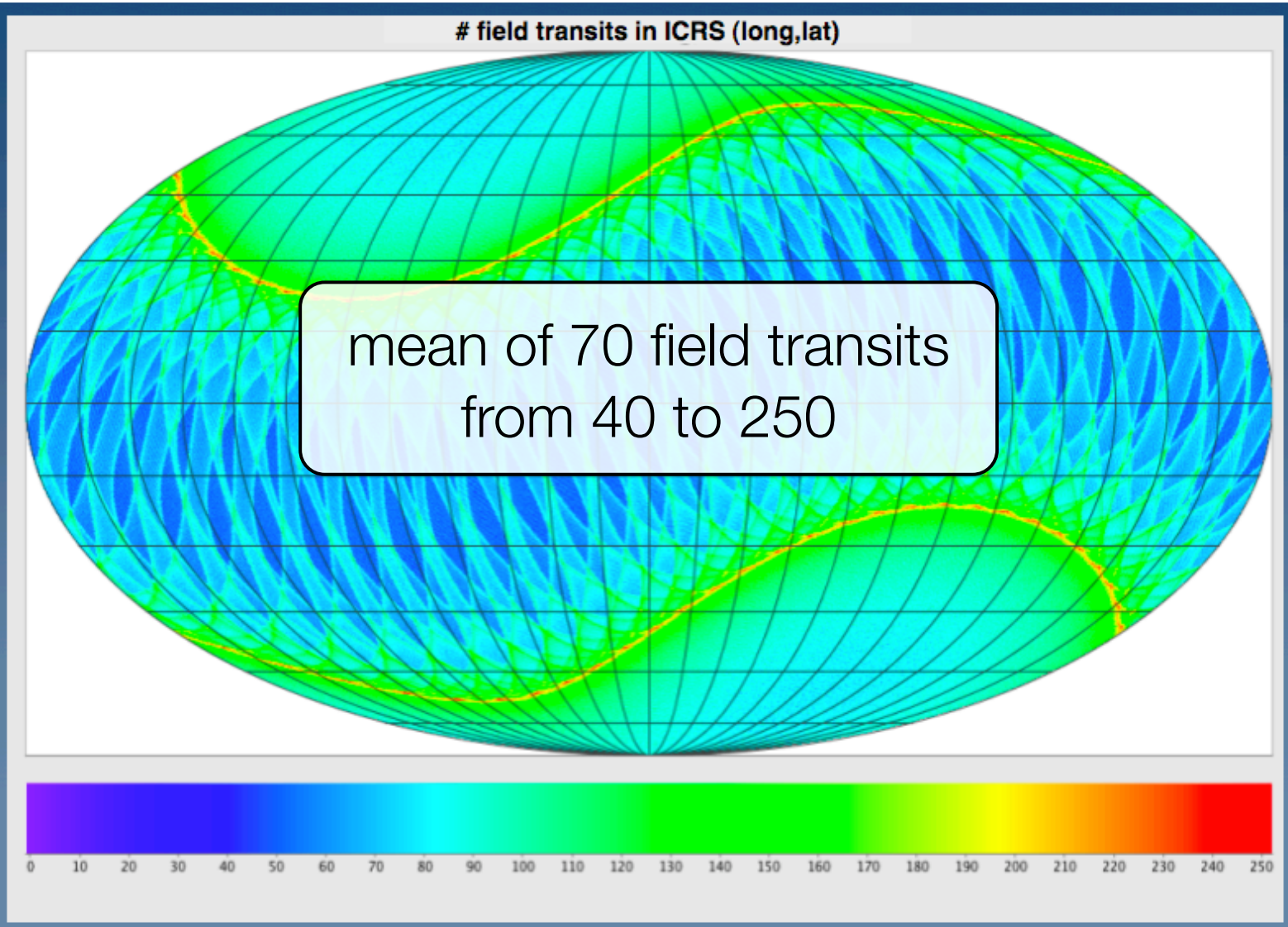
  - Time series of observable quantity

Photometry: band, “colour”

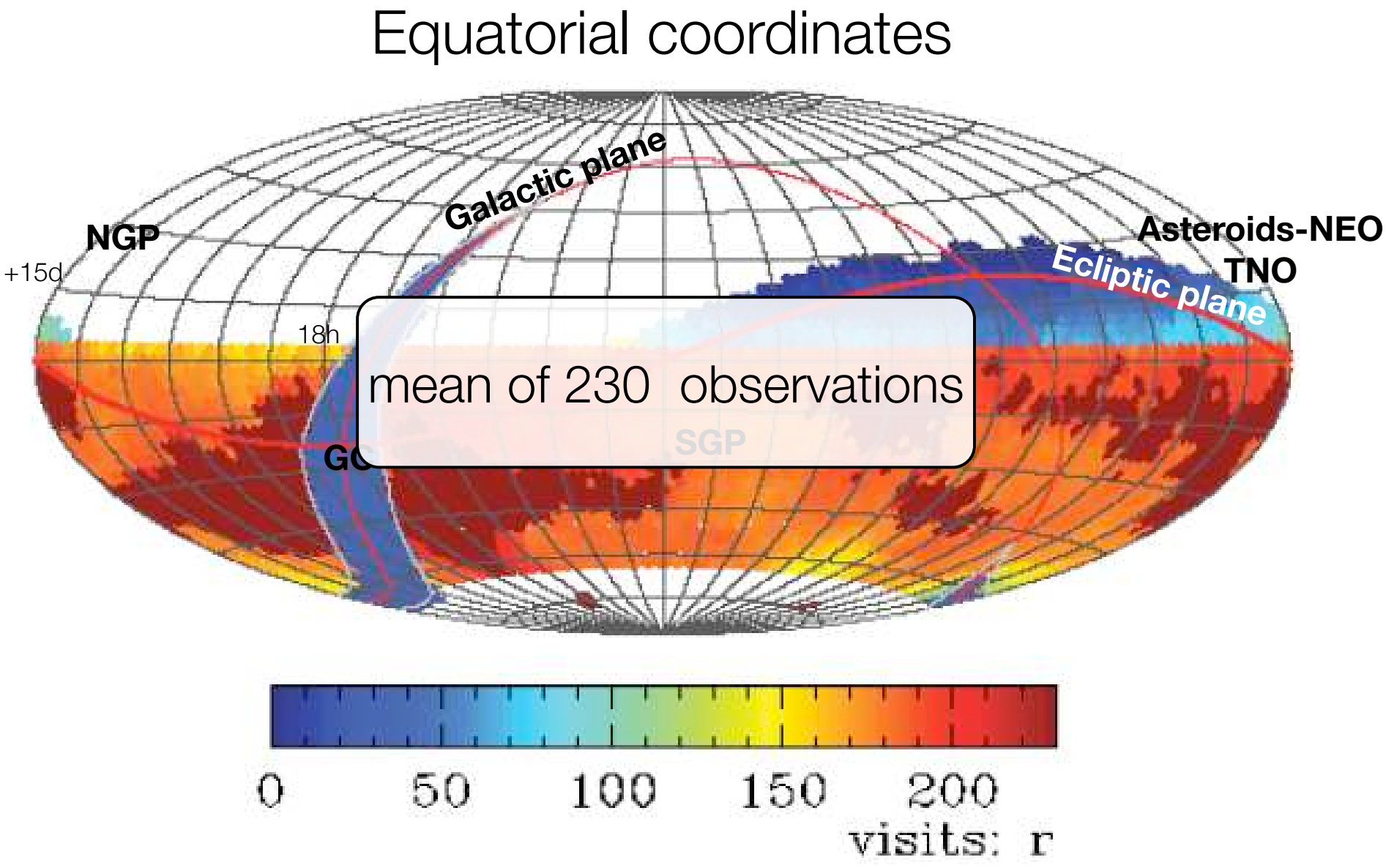
Spectroscopy: radial velocity,
line profile variation

Interferometry

Gaia: Number of field transits over 5 years

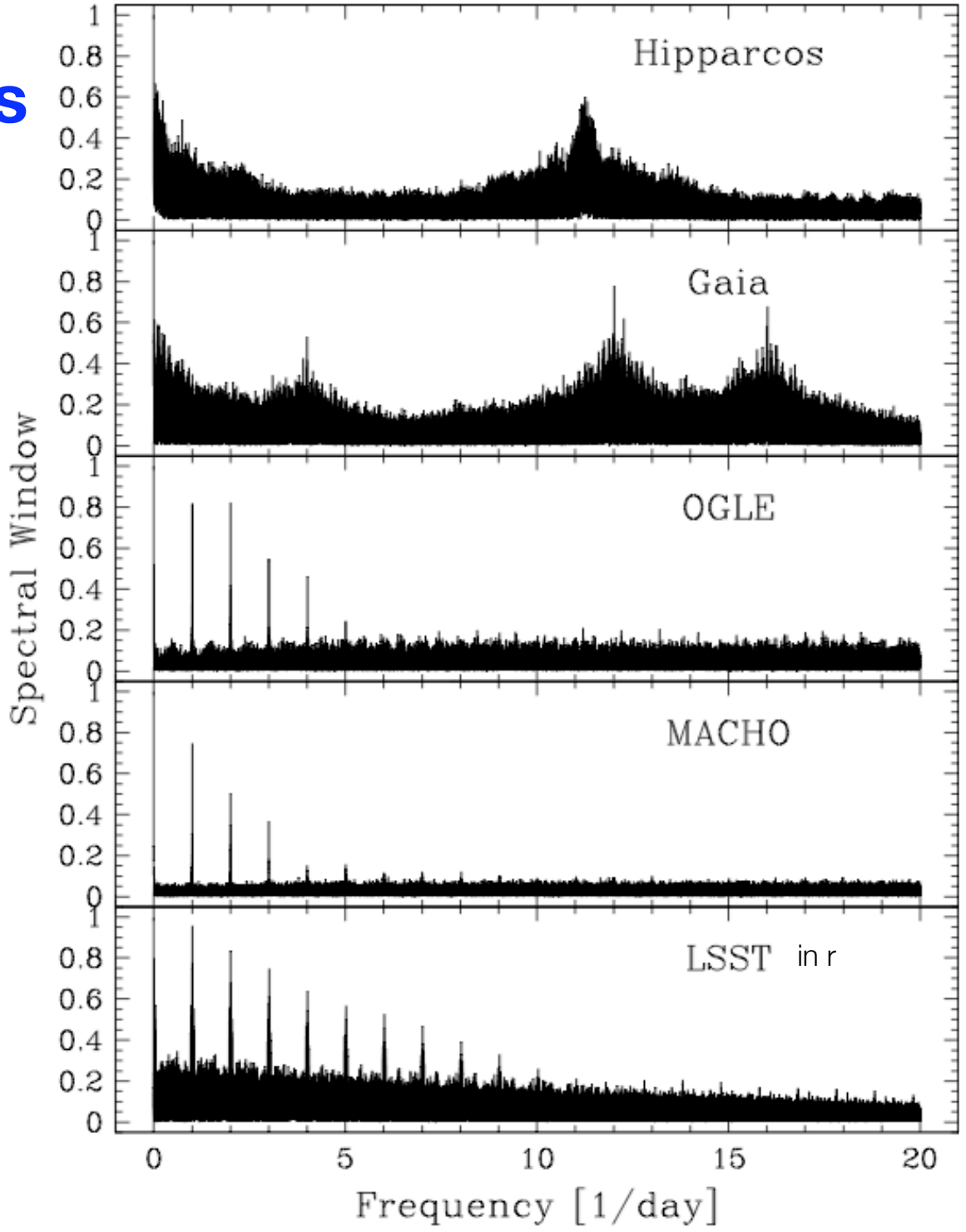


LSST: Number of observations in r-Sloan band over 10 years



Sampling Properties
Spectral windows

Time domain: t	Frequency domain: ν
Signal(t) Sampling(t)= window function	Signal(ν) Sampling(ν) = Spectral window
Observed signal:	
Product	**Convolution**



Exploring the periodic behaviours
Period recovery for strictly periodic signals

Random choice of frequencies

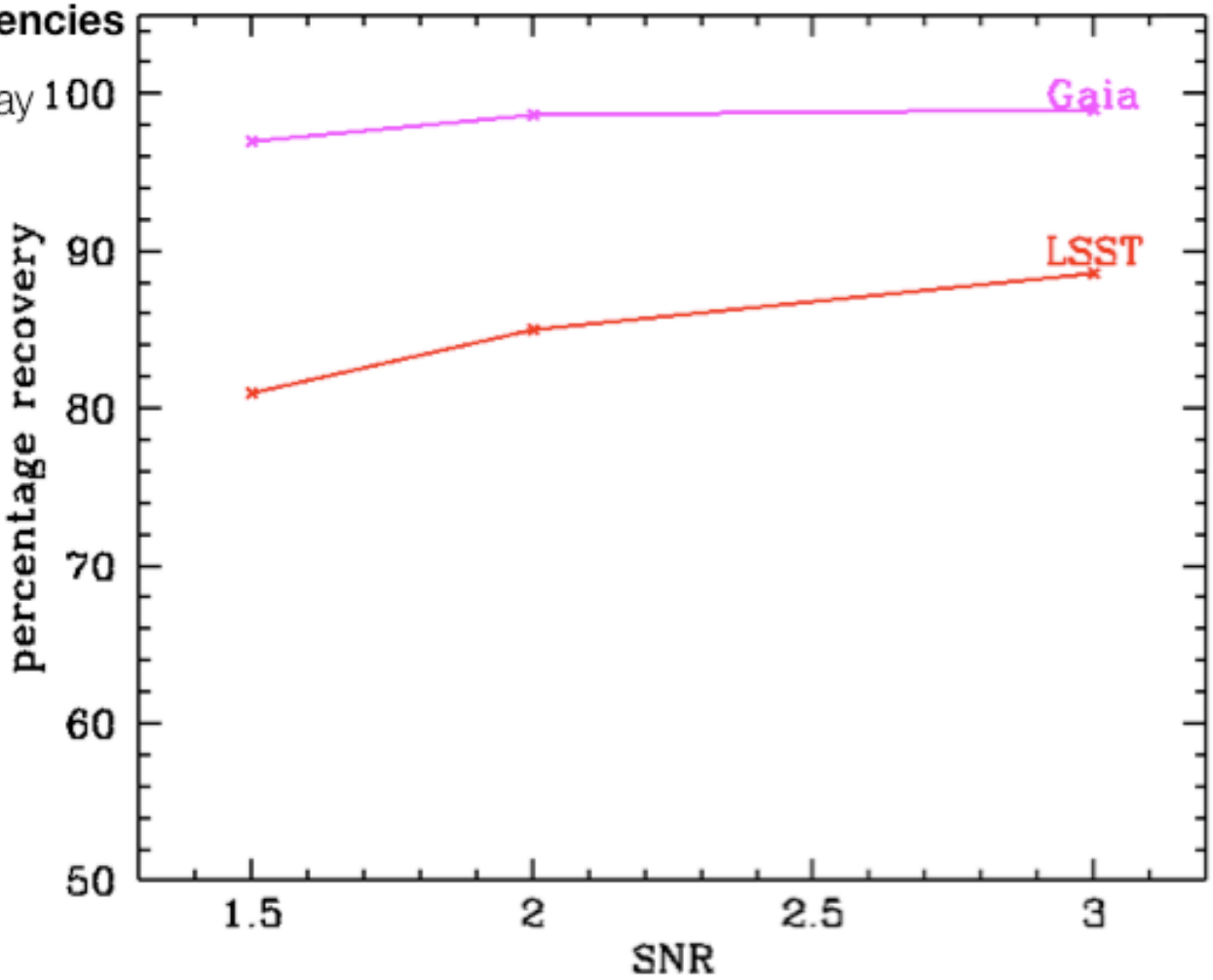
0 < frequency < 2.5 1/day

freq(input)

Sine function

Deeming

freq(output)



Note: very short periods (down to tens of seconds) are detectable with Gaia

Strictly periodic Signal: Gaia has very high performances

Non strictly periodic Signal: LSST performance is more robust

Exploring the “irregular variable sky” and the optical “transient sky”

- AGN
- LPVs
- RCB
- ...

- Super novae
- γ-ray bursts
- novae
- erruptive stars (FU Ori, γ Cas, UV Ceti stars)
- microlensing
- ...

LSST will be very good to detect such objects

Gaia will have some ‘fair’ capabilities

Nature of Time series

Quantity	Gaia	LSST
Sky Coverage	whole sky	half of the sky
Nb of epochs	70 in 5 years	1000 in 10 years
Nb of observations (Gaia: SM,G,BP,RP,RVS)	70*4 +40 =320	1000
Duration [yr]	5+1	10
Wavelength	320-1050 nm	ugrizy
Depth [mag]	20	24.5; 27
Bright limit [mag]	6	16-17
Integration [s]	4.4	30
Error floor [mag]	0.001 (G band)	0.003,0.005
Radial velocity Time series [km/s]	1-10 up to 14-15 mag	-

Conclusions

- Gaia and LSST are two extraordinary and ambitious projects
- We gathered information on the estimated performances of both projects
- We started to establish the strengths of each project
- In many cases Gaia and LSST will be complementary
- Initial step to explore how by combining Gaia-LSST data, we can improve the science output

Thank you
for your attention!