

Gaia Science Status

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Science Capabilities

- Astrometry
  - μarcsec accuracy only achievable from space
- Photometry
  - required for astrometric colour correction and science
- Spectroscopy
  - the lesson learnt from Hipparcos
- Survey
  - global accuracy



Science Volume

- Astrometry & Photometry for at least one billion stars (1% of the stars in the Milky Way)
- One billion objects observed on the average 70 times over 5 year mission is 40 million stars a day (and more than 400 million measurements a day)
- Spectroscopy of 150 million stars
- 40 times over 5 years with 3 CCDs is 10 million spectra a day of 3.3 million stars!



Gaia vs. Hipparcos

- 12 mag
  - Hipparcos limit and in Gaia astrometry still a bright star
- The brightest stars 0 vs. 6 mag
- Completeness 9 vs. 20 mag
- Effective distance 1 kpc vs. 50 kpc
- Number of objects 120 000 vs. $25 \cdot 10^6$ at 15 mag, $250 \cdot 10^6$ at 18 mag and 10^9 at 20 mag
- Gaia 10^6 galaxies and 500 000 quasars



Science Topics

- Structure and dynamics of the Galaxy
- The star formation history of the Galaxy
- Stellar astrophysics
- Binaries and multiple stars
- Brown dwarfs and planetary systems
- Solar system
- Galaxies, Quasars and the Reference Frame
- Fundamental physics: General relativity



Science Scene

- Ground based spectroscopy surveys under construction: millions of stars domain rather than 150 million stars
- Ground based photometry surveys will cover many Gaia areas except: spatial resolution, wavelength/ temporal coverage and spectrophotometry
- NASA 1 μarcsec mission SIM not recommended in the decadal survey: Gaia bright star astrometry will remain unique far into the future
- Astrometry, unlike photometry and spectroscopy, cannot be improved with a better ground based measurement

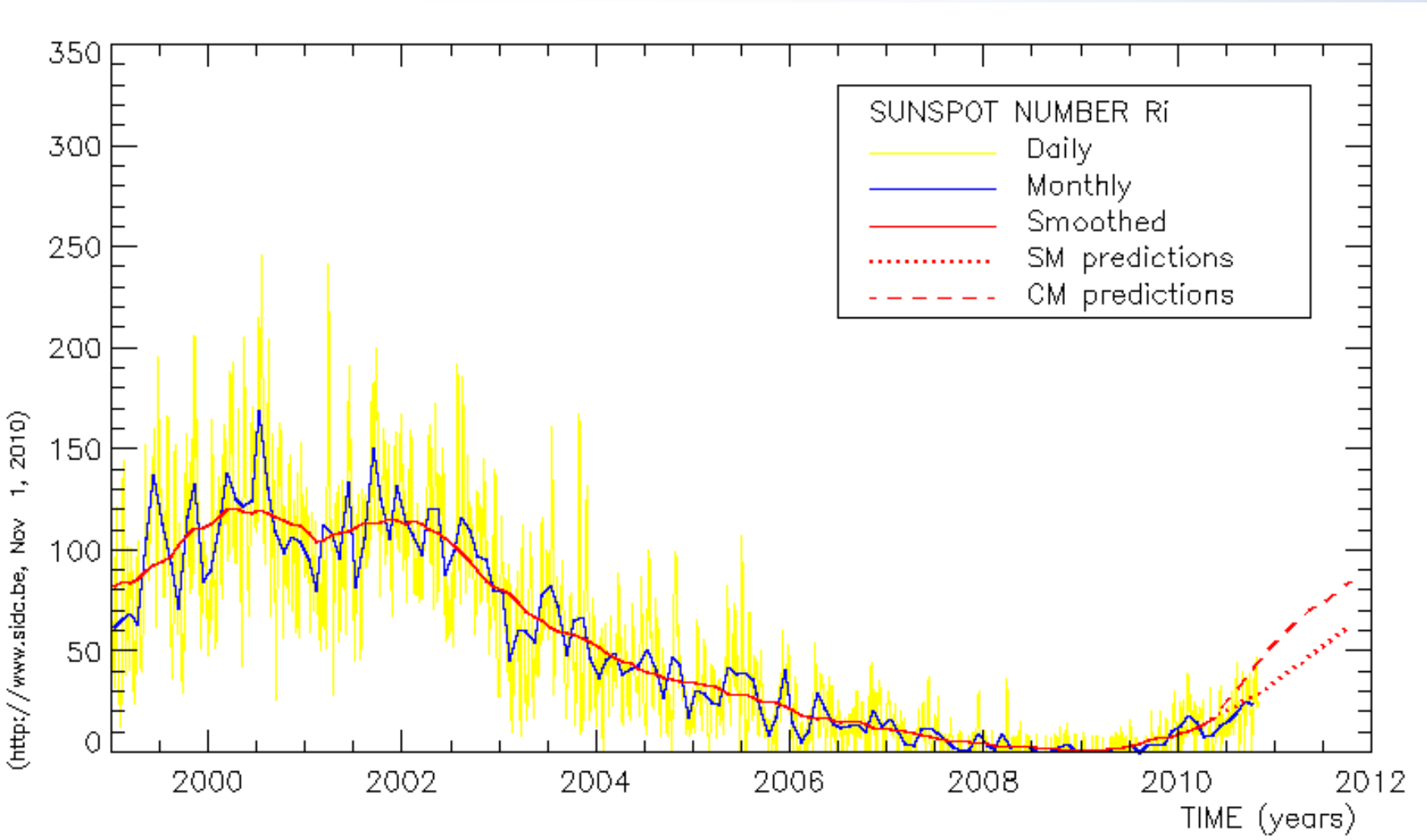


Scientific Performance

- Scientific performances evaluated by Astrium in formal ESA reviews
- Main effort by scientists was spent on the payload module critical design review (PLM CDR) in spring 2010
- Spacecraft CDR (1 July - 15 October 2010) consolidated the performances
- All known effects quantified; including radiation calibration



Solar activity



Photometry

- Photometry:
  - All requirements (8-20mmag) met (B1V, G2V and M6V at V=15mag): 4-16mmag
- Science:
  - Effective stellar temperatures to 200 K
  - Gravities and metallicities to 0.2 dex
  - Broad-band variability at mmag level

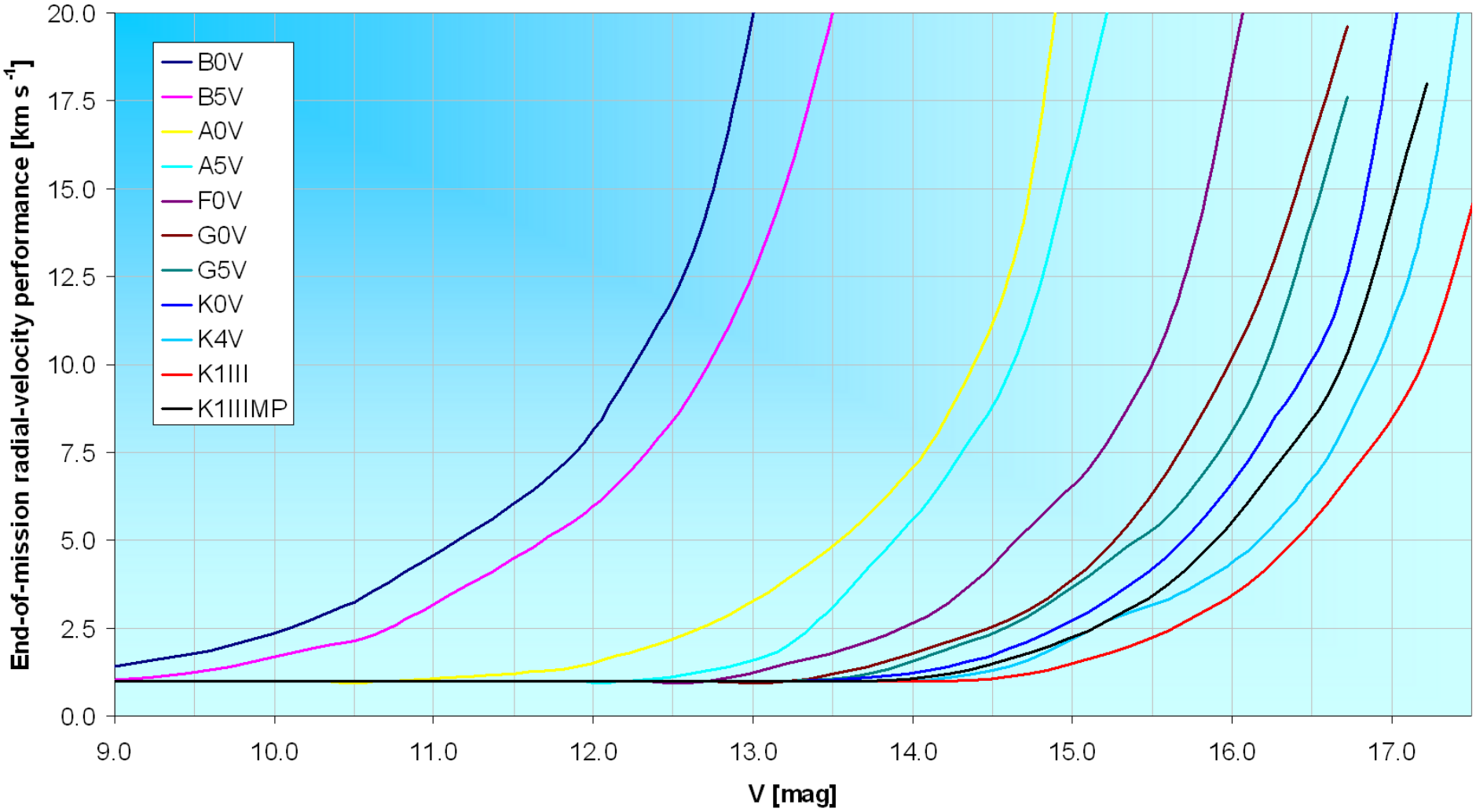


Radial Velocities

- Radial Velocities:
  - All sensitivity requirements met
  - B1V (V=7mag), G2V (V=13mag) and K1IIIMP (V=13.5mag) 0.6km/s (requirement 1km/s)
  - B1V (V=12mag), G2V (V=16.5mag) and K1IIIMP (V=17mag) 8.5km/s, 12.8, and 13.3 km/s respectively (requirement 15km/s)
- Bright stars (10 mag) in high resolution mode for detailed astrophysical analysis



RV performance

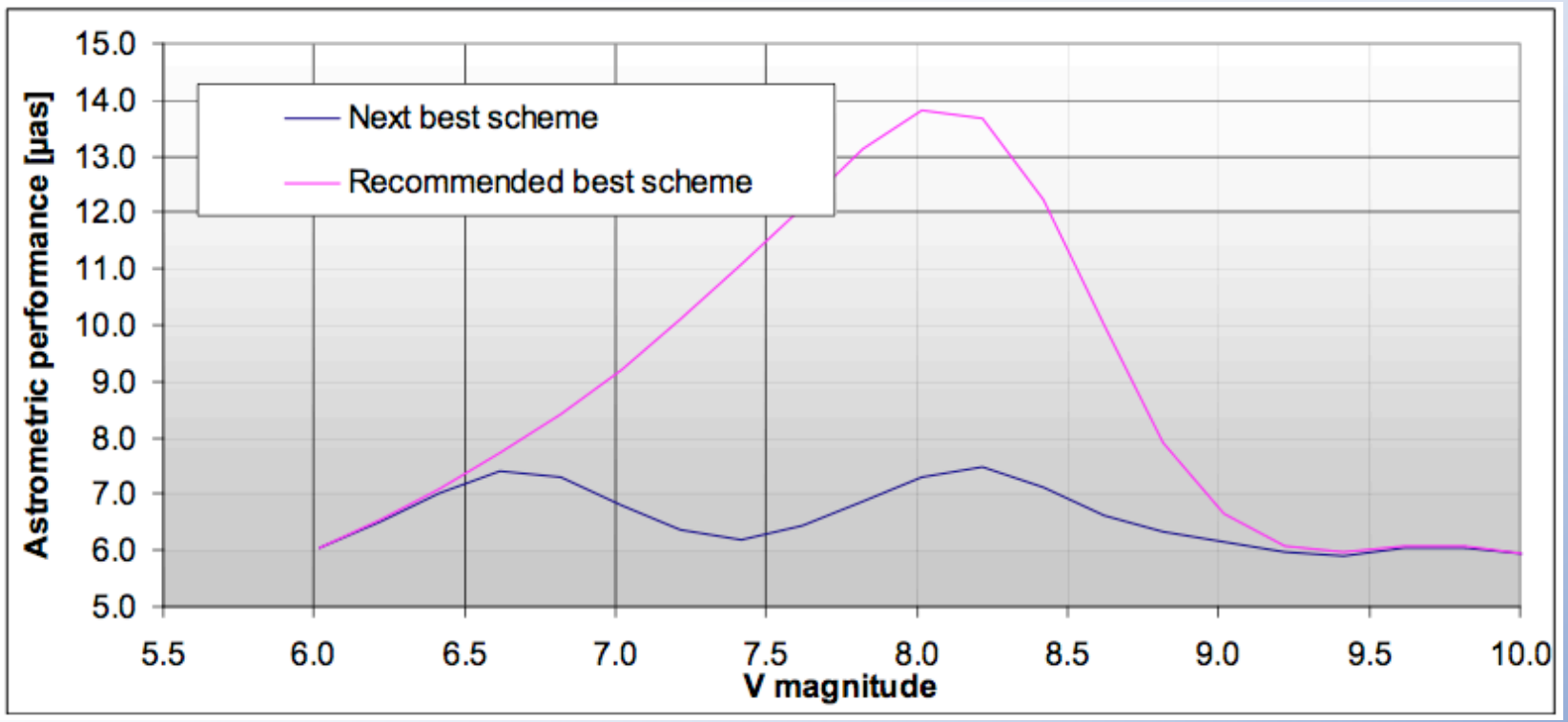


Astrometry

	Vmag	μas	Spec μas
B1V	<10	8.3	<7
	15	26.2	<25
	20	326.3	<300
G2V	<10	8.5	<7
	15	24.2	<24
	20	290.2	<300
M6V	<10	10.4	<7
	15	9.2	<12
	20	96.6	<100

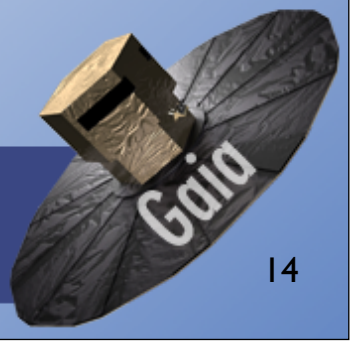


Gate scheme


Astrometric performance [μas]
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
Next best scheme
Recommended best scheme
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
V magnitude

Parallax

- Closest star 1.3 pc parallax 769 mas
  - Gaia: 1.30xxx±0.00001pc
- Galactic Centre 8.5 kpc parallax 118 μas
- (Sagittarius Dwarf 24 kpc 42 μas, but brightest star 14 mag)
- Large Magellanic Cloud 48 kpc 21 μas



Exoplanets

- Fast moving field with 492 known planets today
- With a set of "standard" assumptions Gaia performing to the requirements for bright stars gives about 5000 exoplanets while the current non-compliances may halve the number
- Still a unique and statistically significant sample with a different method than used in transit and doppler studies



Science and CDR

- All sensitivity related photometric and radial velocity requirements met and astrometric requirements met partially
- No surprises in CDR
  - As expected given the spirit of openness and discussion experienced over the years with Astrium
- Main Gaia science goals on Milky Way structure and dynamics intact



Conclusions

- The main science goals of Gaia can be achieved
- All science areas planned to be addressed by Gaia can be addressed although the non-compliances have a quality impact in some specific topics
- Astrium has reached the scientific maximum within the boundaries of the current design and the scientific community is looking forward with trust to see the same high level of engineering maintained in future activities
- The current Gaia scientific performance is promising a revolution in astronomy when the Gaia catalogue becomes available

