From Gaia to Gaia-NIR: the INAF and Italian technological contribution

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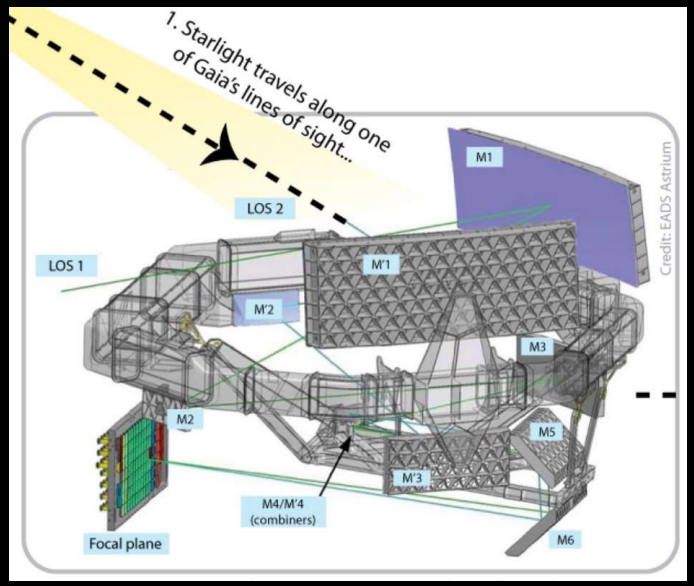
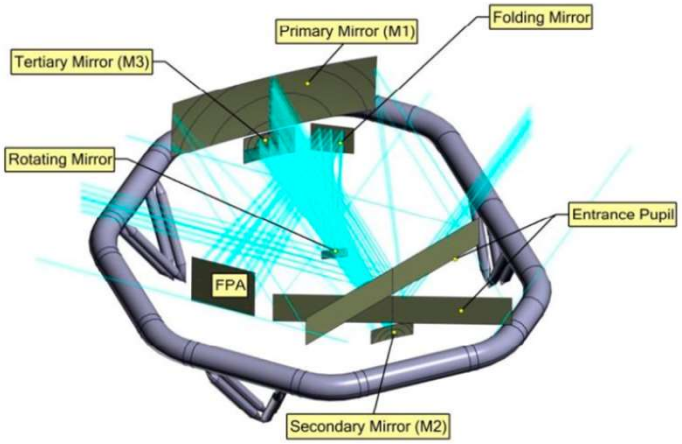
INTRODUCTION

- Some remarks and brainstorming on Gaia and GaiaNIR
- Potential INAF and Italian technological contributions
- Critical points

Actually GaiaNIR based on a off-axis f=35m Korsch telescope as is Gaia with a few differences.



Gaia optical surfaces and light path



Credit: Hobbs's talk

Figure 5-34: GaiaNIR optical surfaces and the light path

- Global astrometry needs to observe at the same time two field of views separated by what it is called Base Angle ⟶ it needs to be stable or calibrated at μas level.

Gaia teaches that having an instrument dedicated to monitoring and calibrating the base angle variations independently of the stars is fundamental.

- Increase the depth of the survey
  - A slow the scan rate or wider detectors or larger mirrors for a deeper survey – would be feasible? All is under studies
- Need for Spectrograph??
- Now L-class ⟶ More detailed studies of a new design for GaiaNIR are ongoing – possible to include both filter and spectral photometry options in the studies
- About 10 or 12 billion stars for H or K-band cut-off's ⟶
  crowding also an issue for astrometry, read-out strategy, potential telemetry issues *but* it will be a challenge also from the point of the view of the data management and data processing.

- PSF larger than Gaia since GaiaNIR works in the infrared – lost in angular resolution enhance crowding issues - better for PSF astrometric calibration ⟶ need a trade-off

- Scanning law and TDI mode introduces an AC-rate dependent modulation in the PSF (a drift scan PSF distortion) across-scan drift rate correlates strongly with the along-scan parallax factor - in Gaia we model the effect in the PSF - for GaiaNIR under investigation solutions for mitigate the effects since the read-out strategy on board

⬇ *but*

- Raw sample data, acquired on board, need to be transmitted to ground. On board processing to be avoid as much as possible.

The raw data needs for PSF calibration improvement which as Gaia teaches is a continuous process from one data release to the next. Now we have downlink options more powerful compared to Gaia (e.g. Euclid X band) (Hog et al 2023)

and more and more …..

In which area can contribute INAF «technological» community?

in almost all them if there are the proper conditions

Raw picture of INAF technlogical community expertise

In the last 15 years INAF has significantly increased its expertise for space and ground projects in:

1. Optical design, analysis, specification, integration, alignment of optical-infrared instrumentation
2. VIS-NIR FPAs development and response calibration and PSF characterization
3. Thermal and Cryogenic Engineering
4. Mechanical Design and FEA, testing and characterization
5. Mechanical metrology for alignment
6. Electronic design
7. Low-level and high-level Instrument control sw and electronics
8. Electronics and detectors: design, development and characterization
9. Space-based new technologies for electronics, cameras, opto-electronics, cryogenics, opto-mechanics
10. Innovative materials for astrophisycs applications
11. Design, development and management of science ground segments: Data analysis infrastructure design and maintenance - Data modeling and big data management and analysis – Data storage and distribution – Data processing – sw design and optimization for data reduction and E2E simulation (high level and low level design)
12. Databases architecture and linking services for data reduction and exploitation - Data Science and data QA techniques strategy designer
13. Commissioning e Instrument Operations

Raw picture of INAF technlogical community

gaia

esa
euclid

ARIEL
Atmospheric Remote-sensing Infrared Exoplanet Large-survey

Raw picture of INAF technlogical community

gaia

SDC - IT

esa
euclid

ARIEL
Atmospheric Remote-sensing Infrared Exoplanet Large-survey

Raw picture of INAF technlogical community

gaia

and the Italian industry with which we collaborate closely

- IT

esa
euclid

ARIEL
Atmospheric Remote-sensing Infrared Exoplanet Large-survey

2023 to end 2024 – detector studies

- Confirmation that TDI like mode is possible with IR detectors

Oct 2023: MW-Gaia COST Action GaiaNIR report

Q3-Q4 2023: GaiaNIR interest call + work team themes

Detector assessment underway Q1/24 to Q2/25

- Best size of pixels for APD detectors → limiting magnitudes

End 2024 to mid 2025: ESA reprofile baseline GaiaNIR

- Opens up options to design in additional payload instrumentation
- Go deeper (e.g., larger mirrors)
- Spectrophotometry and/ or radial velocities and/or chemistry

2024-2025 / update science cases

- Input from MW-Gaia DN science case studies (2023-2027)
- Exoplanet atmosphere/ Galactic ecosystem outcomes

2025-2026 / gain National Agency support

2026-2028 / GaiaNIR conceptual design

- Includes role of national contributions

2029 / GaiaNIR adoption

A few critical points:

- Strict interaction with the ESA/Industry during instrument design, development and tests
- Clear interfaces from the beginning
- Build a publication policy that values everyone: engineers, physicists, sw developers, astronomers…..
- INAF has leading roles in several of the area listed previously and it would be appropriate to maintain those leading roles as most as possible