ELSA
European Leadership in Space Astrometry

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- What is ELSA and what are its aims?
- Networking
- Selected science results
- Benefits from ELSA

European Leadership in Space Astrometry

FP6 Research Training Network

- Duration Oct 2006 – Sep 2010
- Links 14 partners in 12 countries
- Coordinated by Lund Observatory, Sweden
- Currently employs
  - 5 post-docs
  - 10 PhD students
- Strong connections to DPAC
- Research topics
  - global methods of space astrometry
  - instrument modelling
  - numerical analysis applications
  - data processing applications

Objectives of ELSA

1. Study the **principles** of astrometric, photometric and spectroscopic measurements from a self-calibrating space platform like Gaia, and characterize errors and limitations
2. **Model** in detail the output signal from Gaia, including the effects of radiation damage of the CCD detectors
3. Study the **numerical behaviour** of the very large systems of equations that appear in the Gaia data analysis (stability, error propagation, convergence, efficient computation)
4. Apply advanced methods of **data processing** and management, numerical methods and statistics to these problems in a contribution to the Gaia data processing system
5. **Train the next generation** of researchers in space astrometry and transfer experience from the Hipparcos project and early Gaia studies

ELSA fellows

Post-docs

Dr. Ummi Abbas	INAF/Torino
Dr. Alex Bombrun	Heidelberg
Dr. Paola Re Fiorentin	Ljubljana
Dr. Daniel Risquez	Leiden
Dr. Michael Weiler	Paris

PhD students

Ms. Maya Belcheva	Athens
Ms. Maria Czekaj	Barcelona
Mr. Aidan Fries	Barcelona
Mr. Berry Holl	Lund
Ms. Dagmara Oszkiewicz	Helsinki
Ms. Ester Pasquato	Brussels
Mr. Thibaut Prod'homme	Leiden
Ms. Tenay Saguner	INAF/Padova
Mr. Luca Santoro	CNRS/Nice
Mr. Mihály Váradi	Geneva

Research topics

Astrophysical modelling

- Resolved stellar populations in other galaxies
- Refining the universe model in the Gaia simulator
- Stellar brightness asymmetries
- Synthetic and observed stellar spectra
- Tests of new input physics in stellar atmosphere models

Modelling the Gaia instrument

- Modelling radiation damage effects in Gaia CCDs
- Gaia Point-Spread Function modelling for simulations
- Improved attitude modelling for Gaia

Global astrometric solution

- Characterization of astrometric errors
- Alternative astrometric solution methods for Gaia
- Gaia Sphere Reconstruction

Numerical, statistical and computational tools

- High-performance computing
- Variability in large photometric surveys
- Statistical asteroid orbit computation
- Automatic classification and astrophysical parameter estimation

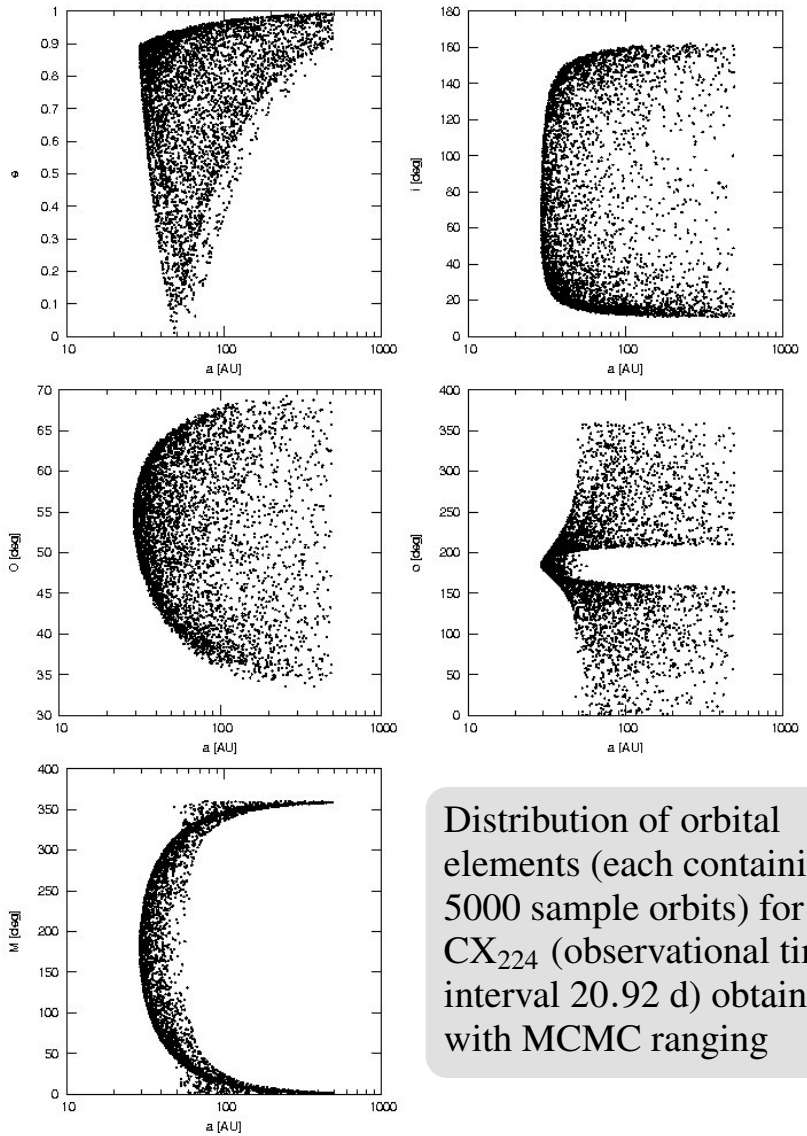
- Extended visits by fellows to other ELSA institutes to foster collaboration
  - in practice focused around specific topic, e.g., radiation damage to Gaia CCDs
- Close collaboration with DPAC
  - participation by fellows in DPAC meetings and workshops
- Contacts with industry
  - Dutch Space BV (ELSA partner): GRID computing and CCD modelling workshop
  - e2v on CCD modelling
  - EADS-Astrium on laboratory tests of Gaia CCDs
- Fellows attended various schools and scientific meetings
- Common tools, methodologies, and programming practices are used, making collaboration more efficient

- **ELSA School on the Science of Gaia**
  - Leiden Nov 2007
  - focus on scientific motivation for Gaia
  - 19 invited lectures, fellow posters presentations, afternoon exercises
- **ELSA Workshop on Software Engineering and Numerics**
  - Barcelona Sep 2008
  - included two days of fellow presentations with feedback on presenting skills by outside professional
- **ELSA School on the Techniques of Gaia**
  - Heidelberg Sep 2009
  - technical challenges of Gaia instruments, mission operations
- **ELSA Conference: Gaia At the Frontiers of Astrometry**
  - Paris, 7–11 June 2010
  - International conference presenting results obtained by ELSA, status of Gaia, complementary theoretical tools, ground-based work, and related missions

Asteroid orbital inverse problem

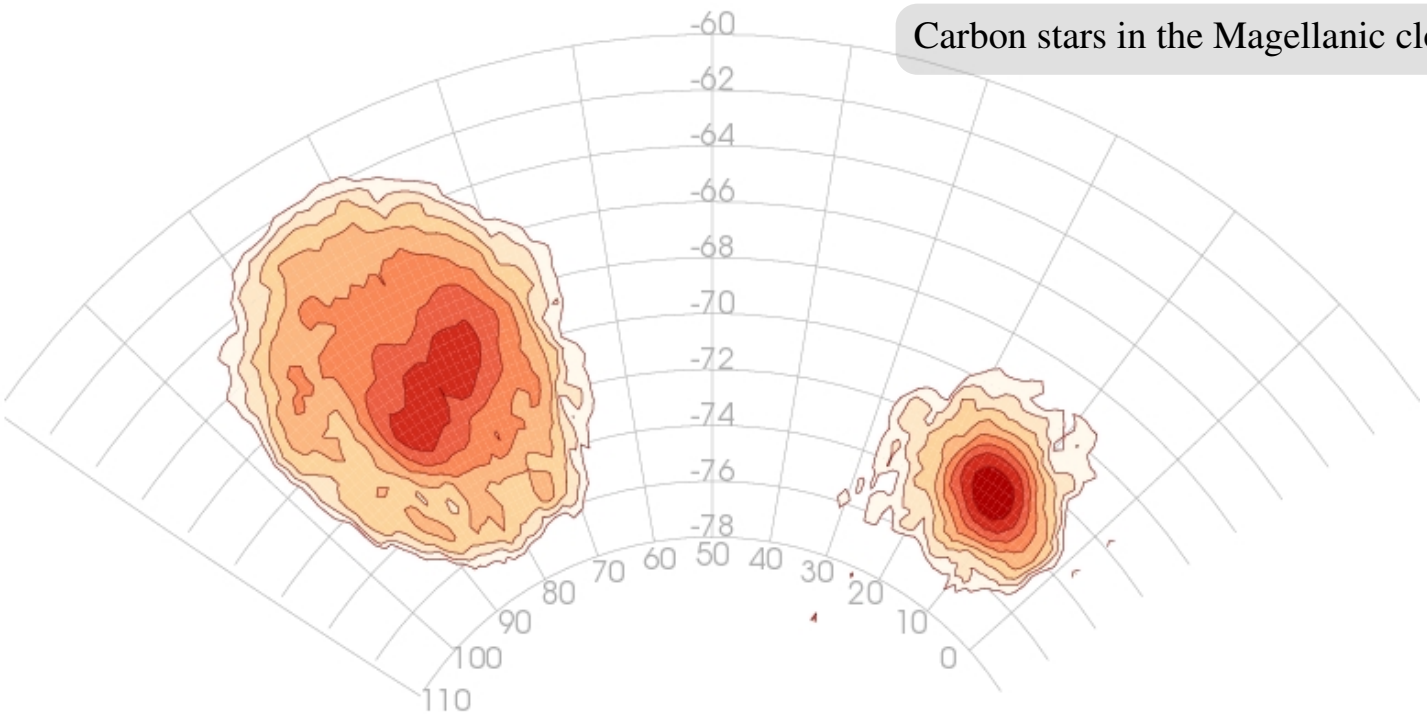
- Development of novel asteroid orbit computation method
  - Markov-Chain Monte Carlo ranging, capable of dealing with very few observations
- Method will be employed in CU4 processing
- Other applications include: computing collision probabilities, dynamical classification, performing the recovery of lost objects.

Credit: Dagmara Oszkiewicz



Distribution of orbital elements (each containing 5000 sample orbits) for TNO CX_{224} (observational time interval 20.92 d) obtained with MCMC ranging

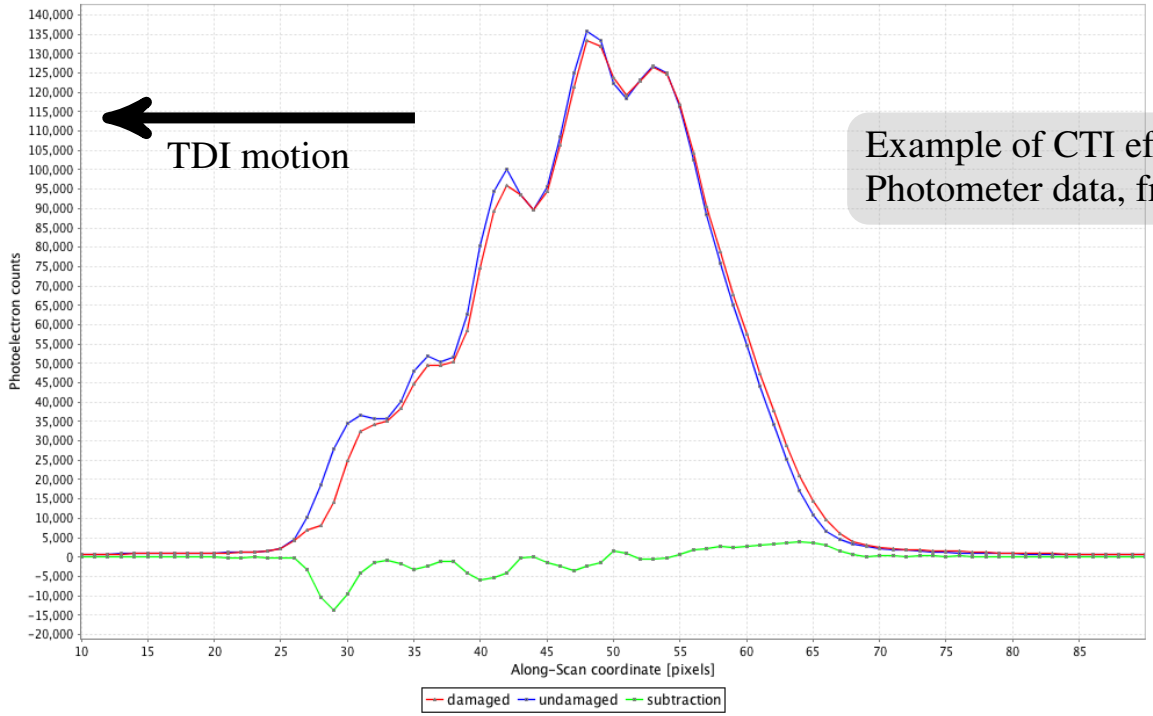
Stellar populations in nearby galaxies



- Obtain the spatial distribution of stellar components in nearby galaxies which are resolved in stars by Gaia
- Distribution for Magellanic Clouds obtained from current catalogues
- Results will adapted to Gaia resolution and introduced into universe model

Credit: Maya Belcheva

Theoretical and empirical modelling of CTI

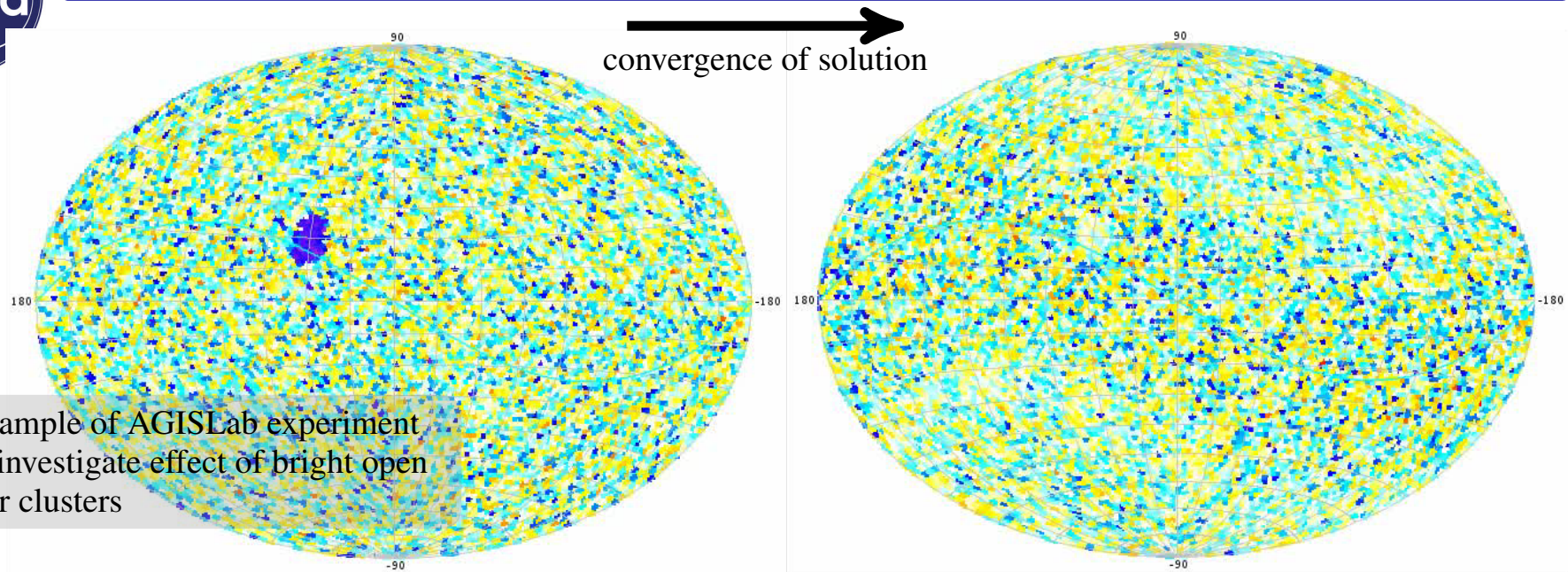


Example of CTI effects on Red Photometer data, from CEMGA model

- Realistic Monte Carlo simulations of radiation damaged CCDs
- MC model will include results from detailed CCD pixel modelling
- Macroscopic models tested as part of Gaia simulator
- Part of large collaboration on radiation damage mitigation
- Results essential to success of Gaia

Credit: Thibaut Prod'homme, Michael Weiler

Astrometric solution



Example of AGISLab experiment to investigate effect of bright open star clusters

- Scaled down version of AGIS developed; AGISLab
- Conjugate Gradients shown to drastically improve AGIS convergence
- Non-feasibility of a direct astrometric solution has been demonstrated
- AGISLab also used for: variability detection studies, stellar surface structure effects, error propagation and correlations
- Results already incorporated into real AGIS

Credit: Berry Holl, Alex Bombrun

Benefits from ELSA

- Important scientific research gets done for which DPAC has no time
  - several results already incorporated into DPAC developments
  - essential to success of mission
- Incorporation of non-astronomical expertise into Gaia project
- Interface between those preparing/running the mission and the 'scientists' improved
- Next generation space astrometry experts
- Example of how Gaia stimulates astronomical research now already

http://www.astro.lu.se/ELSA/