Star clusters before and after Gaia

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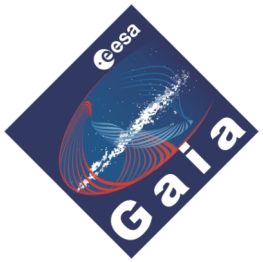


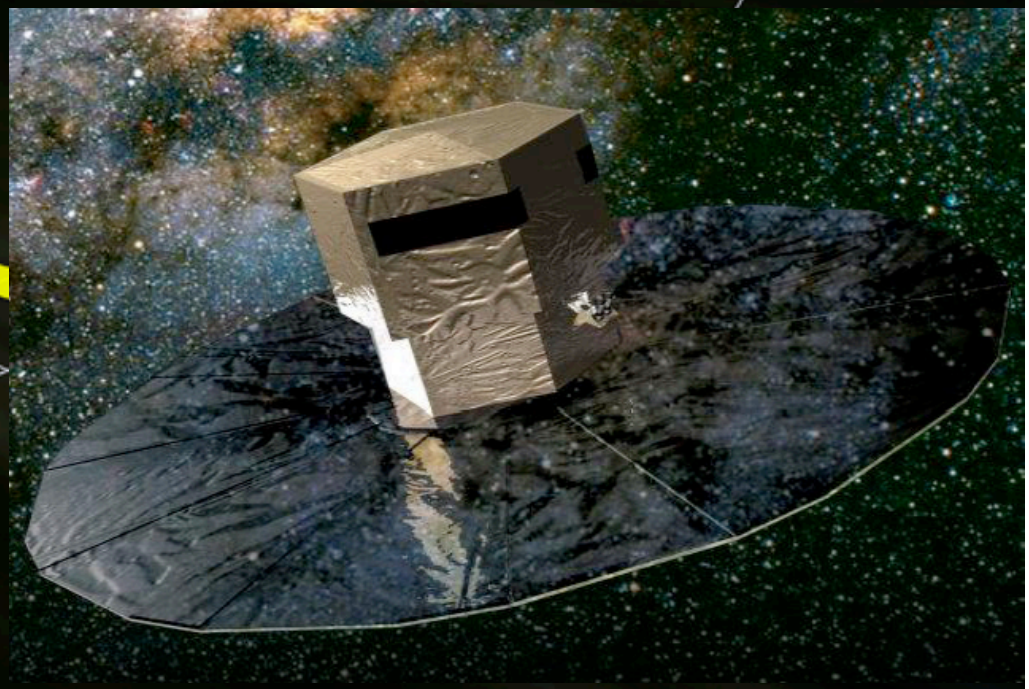
Outline

- Gaia mission overview
- Use of stellar clusters for calibration of stellar physical parameters
- Impact of Gaia data on cluster research

Gaia mission objectives

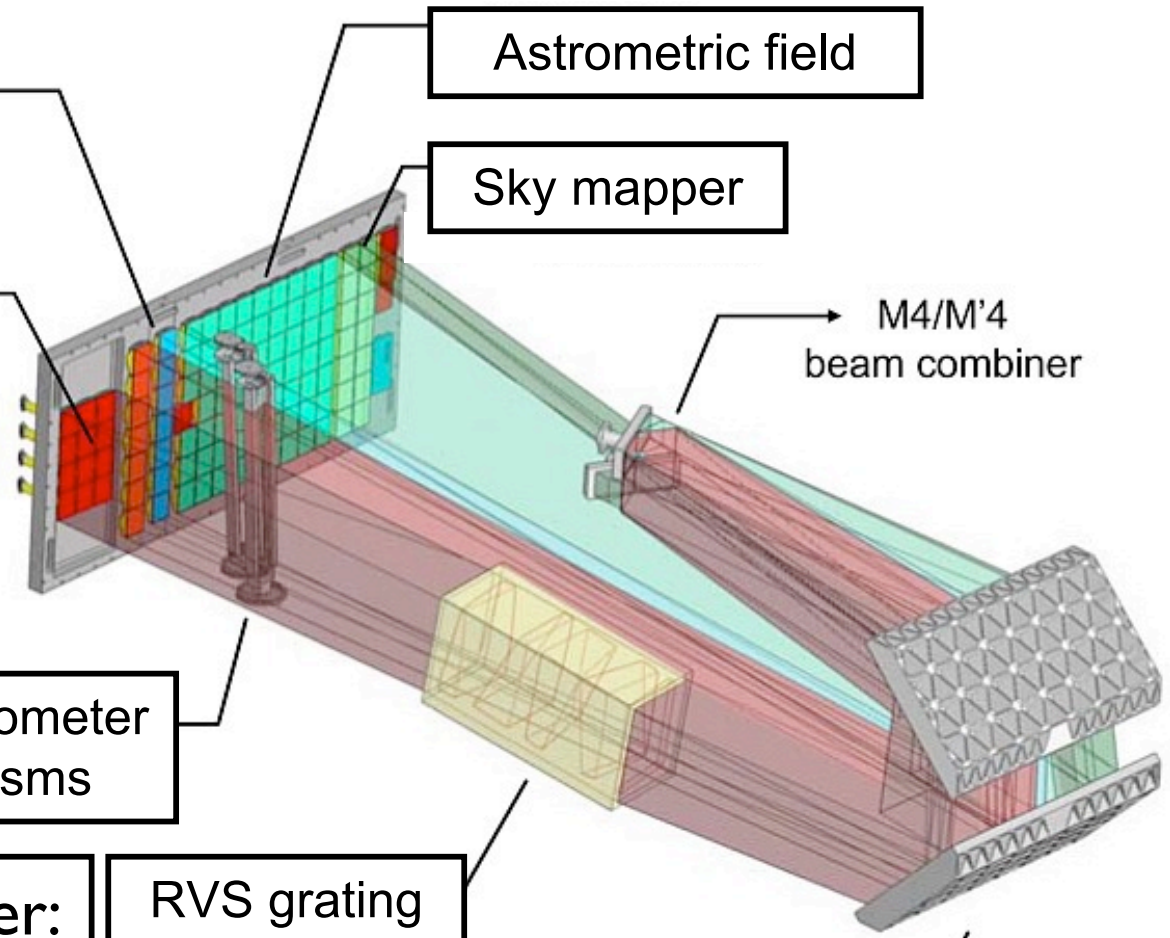
- Mapping the Milky Way Galaxy in **six dimensions**
- **Positions** of ~1 billion stars
  - scanning satellite with two viewing directions
  - limiting magnitude = 20
  - accuracy down to 20 μas
- **Space velocities** of Galactic stars
  - proper motions for all stars
  - radial velocities for objects brighter than 17th mag
- **Physical parameters** for all stars

Gaia mission characteristics



- ESA cornerstone mission
- Launch date: 2012
- Lissajous-type orbit around second Lagrange point
- Lifetime: 5 years

Gaia instruments



Blue photometer:
330–660 nm
Red photometer:
650–1000 nm

Radial Velocity Spectrometer:
847–874 nm (CaII triplet)
resolution 11,500

Data processing and analysis

50 GB/day

Gaia Main Data Base

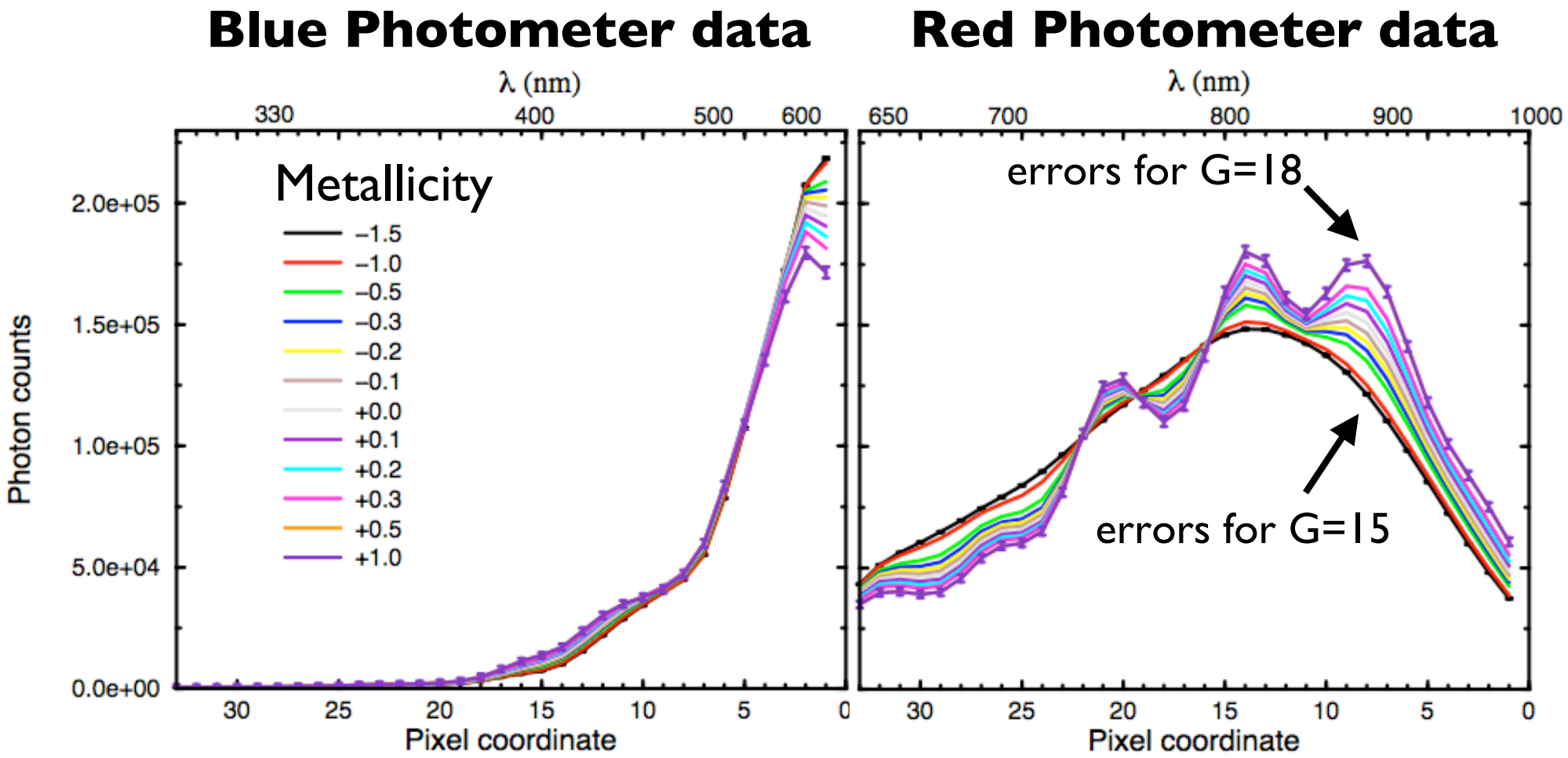
Gaia DPAC

Data Processing and Analysis Consortium

Raw data ≈100 TB

Scientifically meaningful data

Simulations for T_{eff}=3500K



Figures: Carme Jordi et al.

Simulated RVS data

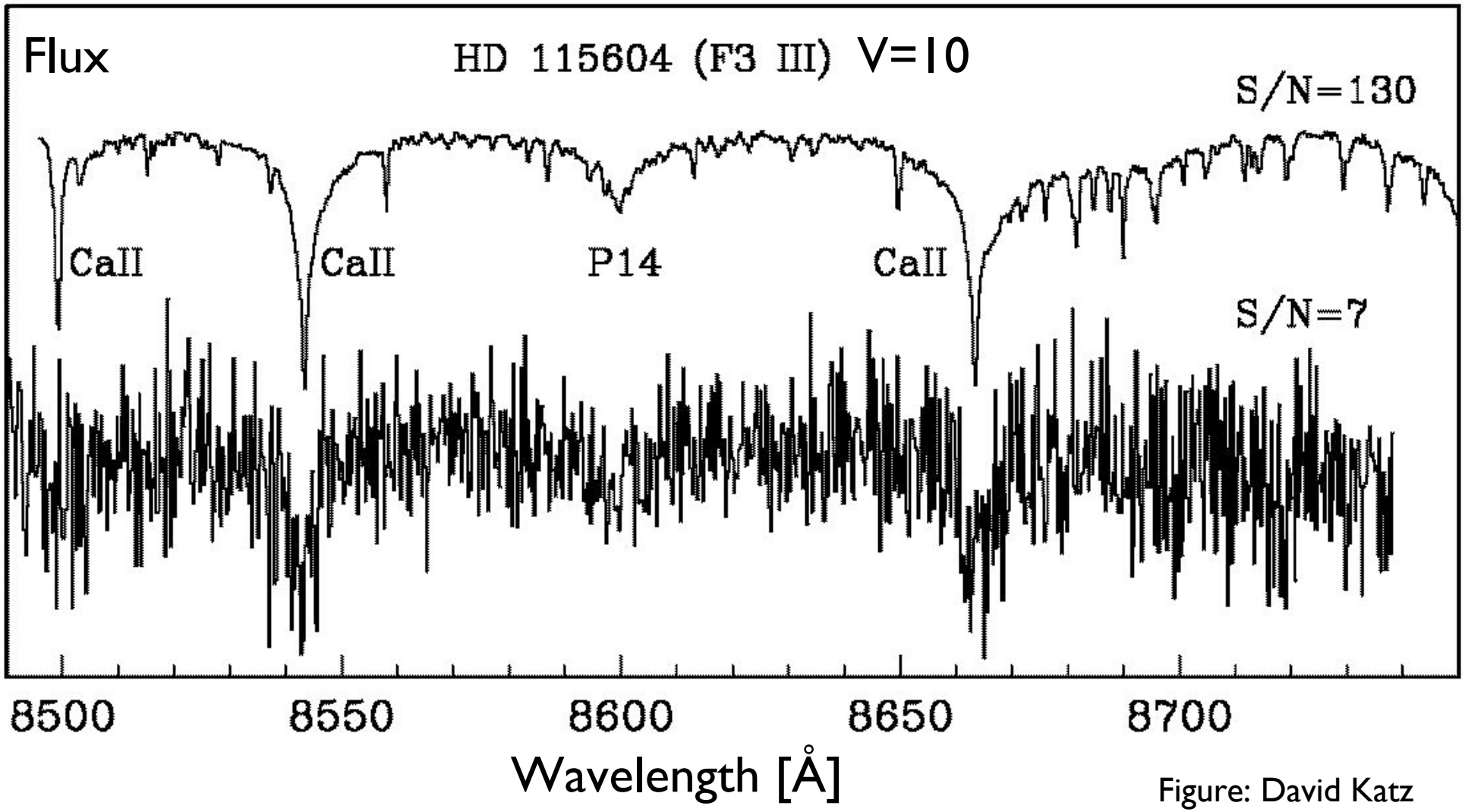


Figure: David Katz

Physical properties of Gaia sources

- **Classification** of all sources → probabilities for single star, binary, galaxy, quasar, asteroid, etc.
- **Astrophysical parameters** for stars:
  T_{eff}, log g, metallicity, α elements, interstellar extinction
- ***Software development*** based on ***model spectra***
- ***Testing*** and ***calibration*** of algorithms using sets of stars with observed spectra and known parameters
- Spin-off: improved model spectra and stellar atmosphere models

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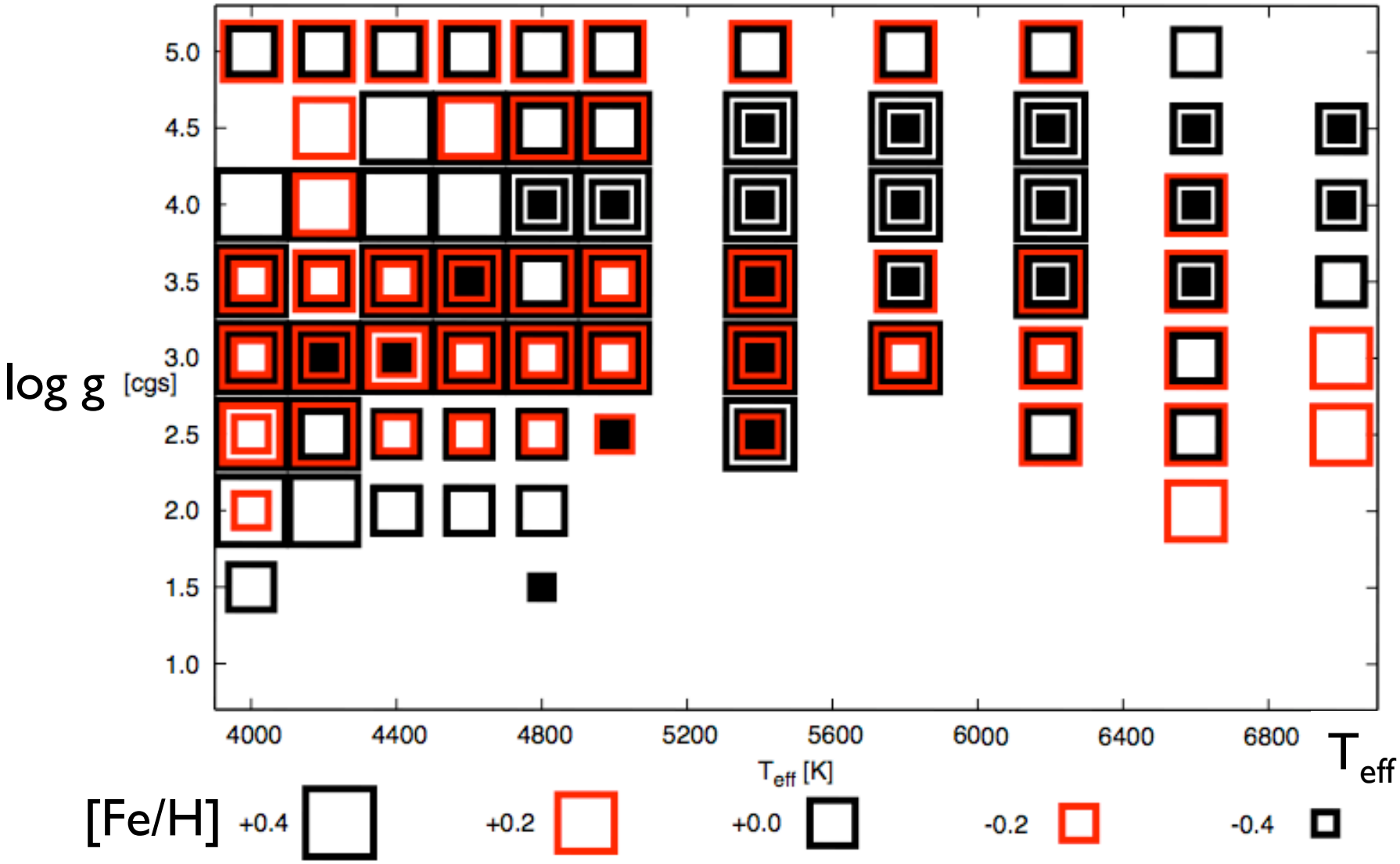
Sources for calibration stars

- **Bright stars** (6 < V < 14) for algorithms based on RVS data → field stars from stellar parameter catalogues
- **Faint stars** (10 < V < 18) for photometer algorithms
  - stars in **open and globular clusters**
  - **open clusters** selected using WEBDA (described in posters by Paunzen et al. and Baumann & Paunzen)
  - metallicity ← Twarog et al. (1997), Gratton (2000)
  - age, reddening, distance ← Paunzen & Netopil (2006)
  - **globular cluster** parameters from Harris (2003)

Calibration stars in open clusters

Name	[M/H]	Distance	Age	North/South
NGC 2506	−0.4	far	old	S/N
NGC 2660	−0.2	far	old	S
Melotte 111	+0.0	nearby	young	N/S
IC 4756	+0.0	nearby	young	N/S
IC 2395	+0.0	nearby	young	S
NGC 2682	+0.0	nearby	old	N/S
NGC 6819	+0.0	far	old	N
Berkeley 18	+0.0	far	old	N
NGC 6791	+0.2	far	old	N
Melotte 25	+0.2	nearby	young	N/S
NGC 6067	+0.2	far	young	S
NGC 6253	+0.4	far	old	S

Faint stars in southern open clusters



Ground-based observations of calibration stars

- Need homogeneous set of low- and high resolution spectra – new or from archives
- Purpose
  - input spectra for testing algorithms
  - parameter determination of calibration stars
- Observing programmes planned, with C. Soubiran (Bordeaux), F. Thévenin (Nice), Y. Frémat (Brussels), A. Vallenari (Padova)

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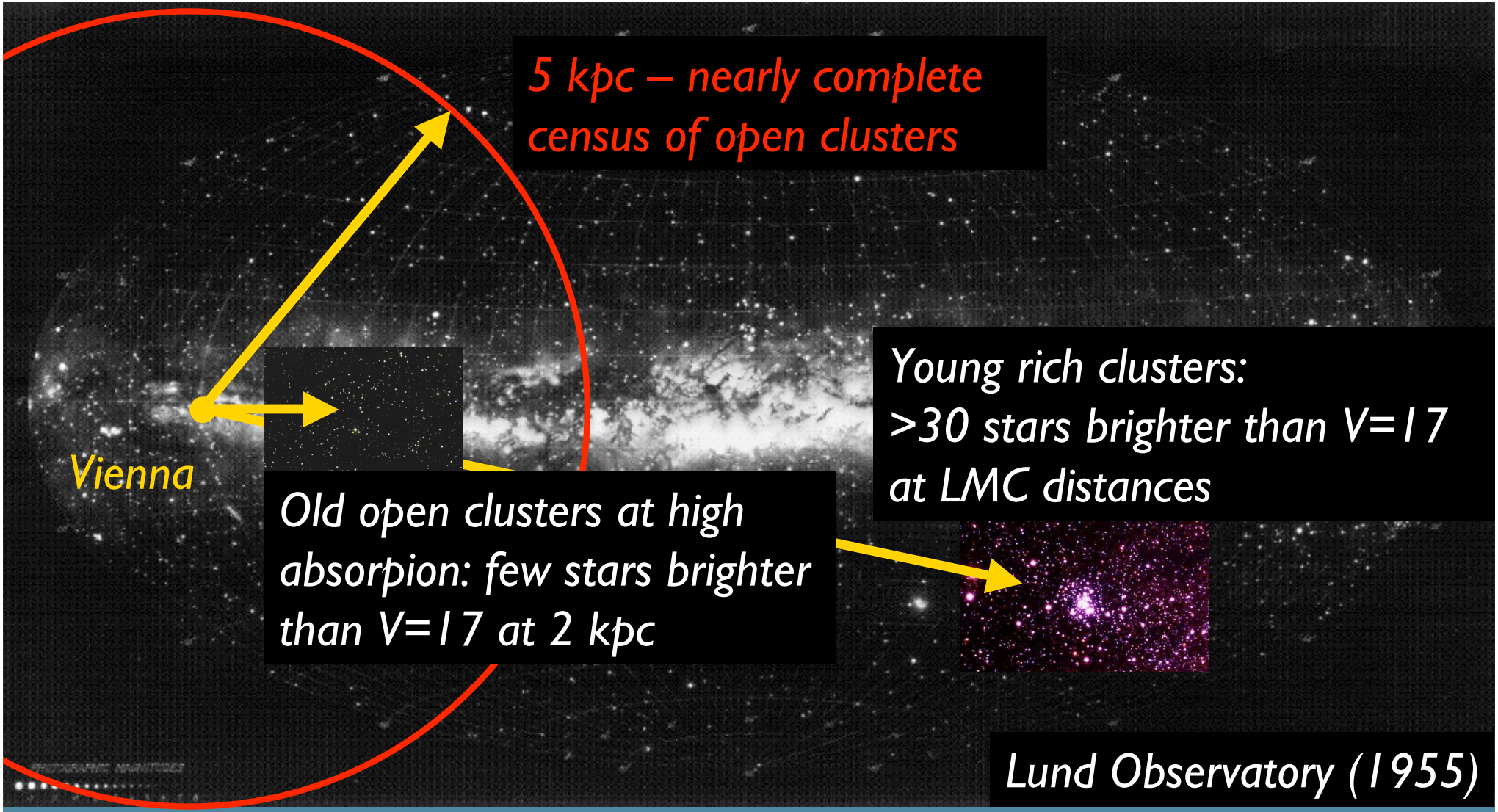
  – from Gaia Concept and Technology Study (ESA, 2000)

Open clusters

- Gaia will observe all known open clusters, with mean distances to better than 1%
- Will discover thousands of new ones
- Detection possibility depends on intrinsic parameters
  - total number of members, age, space velocity
- and relative parameters
  - distance, interstellar absorption number of members brighter than V = 17 or V = 20
  - velocity relative to local standard of rest

Cluster detection



Galactic globular clusters

- Complete census of member stars in non-central parts of all globular clusters
  - 1/3 of clusters fully observed by Gaia
  - 2/3 thirds observable at $\geq$ 3 central radii
- Mean distances to better than 1% for ~3/4 of all globular clusters,
  mean distances to better than 5% for all clusters
  $\rightarrow$ Calibrate distances of external globular clusters

What will we learn from cluster data?

- Stronger constraints for stellar models
- New insight in spatial and chemical structure of galactic disk from open clusters
- Absolute ages for globular clusters to better than 1 Gyr $\rightarrow$ resolution of age conflict?
- Mass of the Milky Way halo to within ~20 percent from globular cluster proper motions
- New lower limit to age of Universe from globular cluster ages

Conclusions

- Gaia is a versatile space mission, but data processing is a challenge
- Star clusters play a crucial role for Gaia data calibration
- Gaia data will advance research done on and with stellar clusters