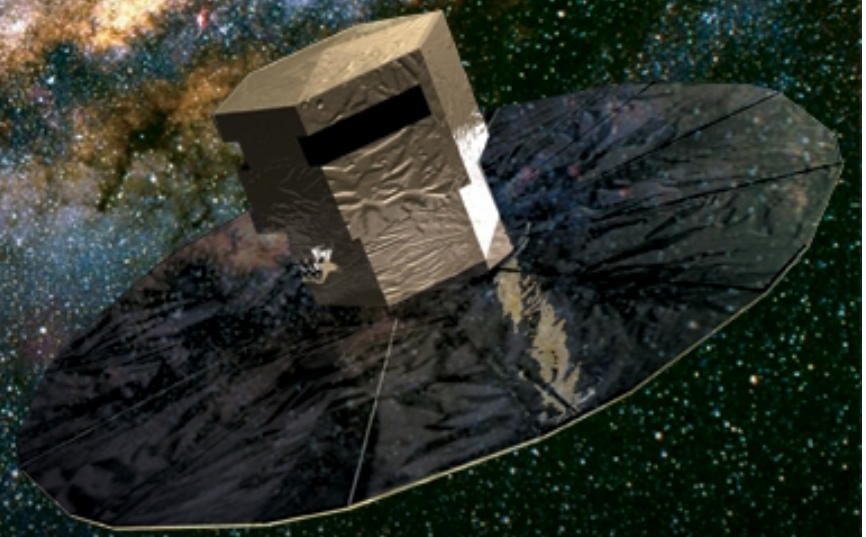
EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

MARIE CURIE ACTIONS

Status of GREAT and the GREAT Chemo-Dynamical Survey (GCDS)

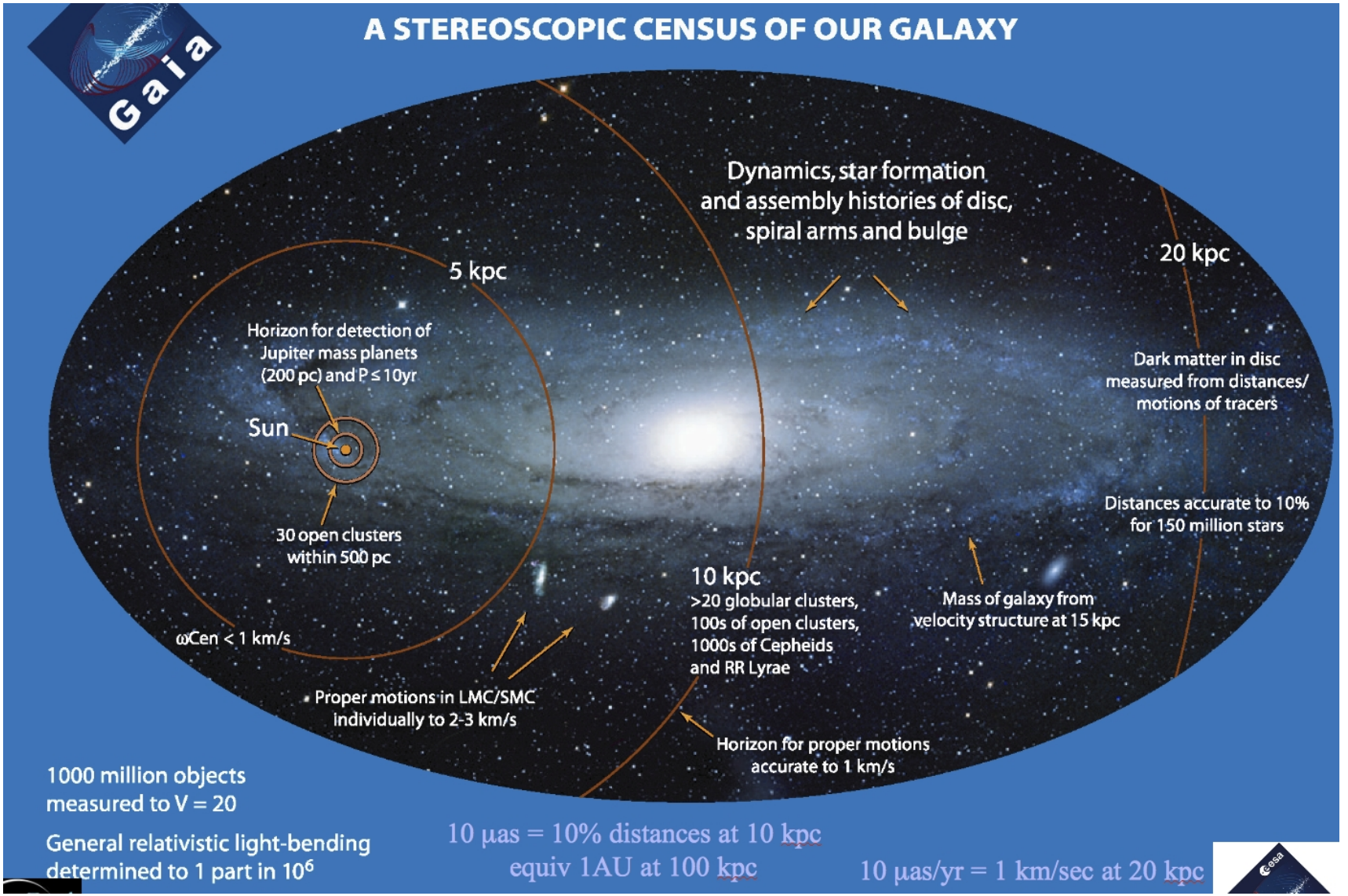
Nicholas Walton
(IoA, Cambridge, UK)



GREAT

UNIVERSITY OF CAMBRIDGE

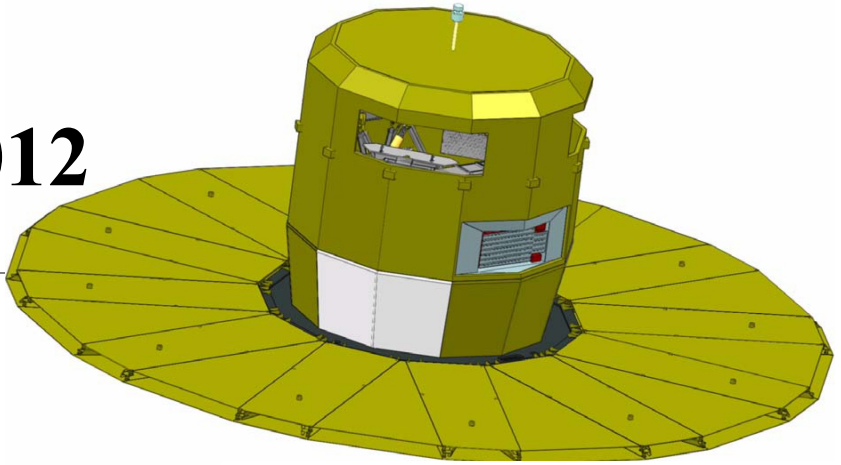
The Challenge of Gaia
transformational science



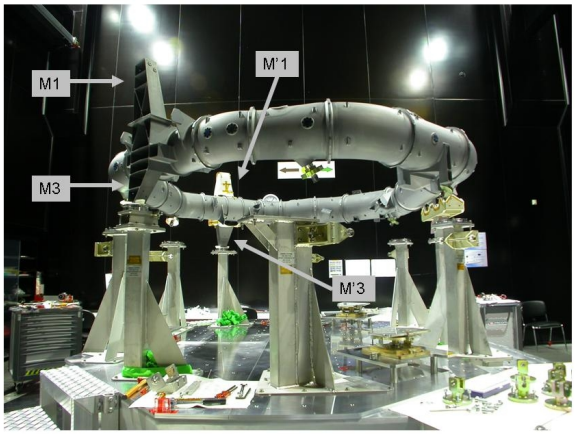
Gaia in a nutshell

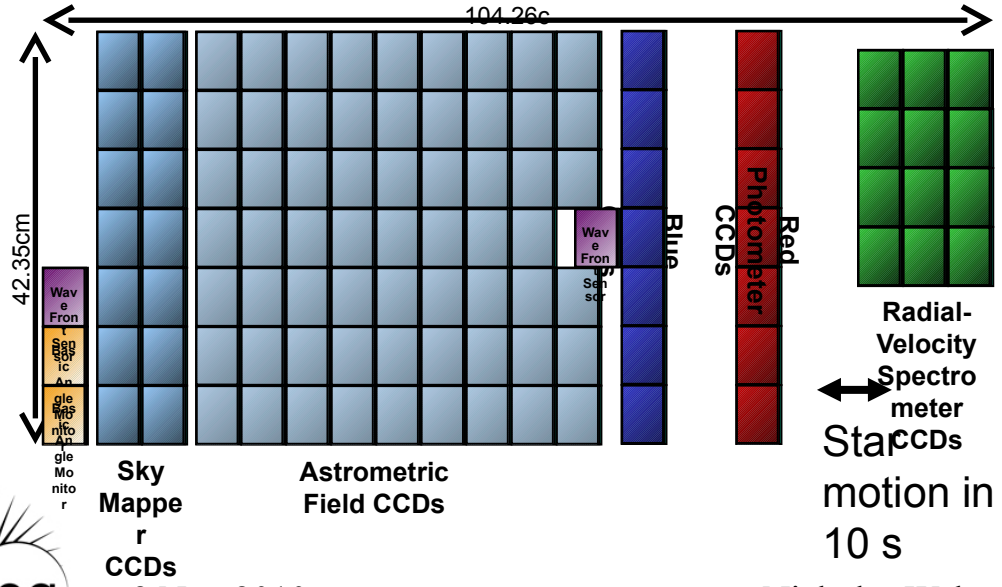
CDR complete: Launches Nov 2012

	Hipparcos	Gaia
Magnitude limit	12	20 mag
Completeness	7.3 – 9.0	20 mag
Bright limit	0	6 mag
Number of objects	120 000	26 million to V = 15 250 million to V = 18 1000 million to V = 20
Effective distance	1 kpc	1 Mpc
Quasars	None	5×10^5
Galaxies	None	$10^6 – 10^7$
Accuracy	1 milliarcsec	7 μarcsec at V = 10 10-25 μarcsec at V = 15 300 μarcsec at V = 20
Photometry	2-colour (B and V)	Low-res. spectra to V = 20
Radial velocity	None	15 km/s to V = 16-17
Observing	Pre-selected	Complete and unbiased

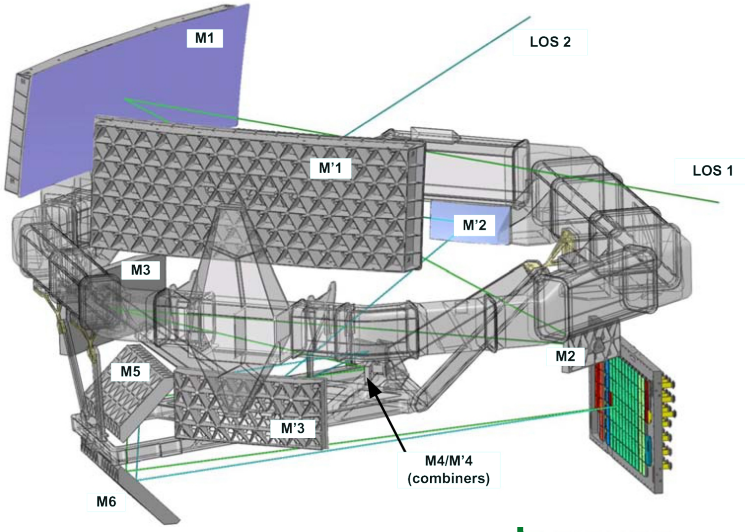


Images: ESA





Star motion in 10 s



… not so far away now …

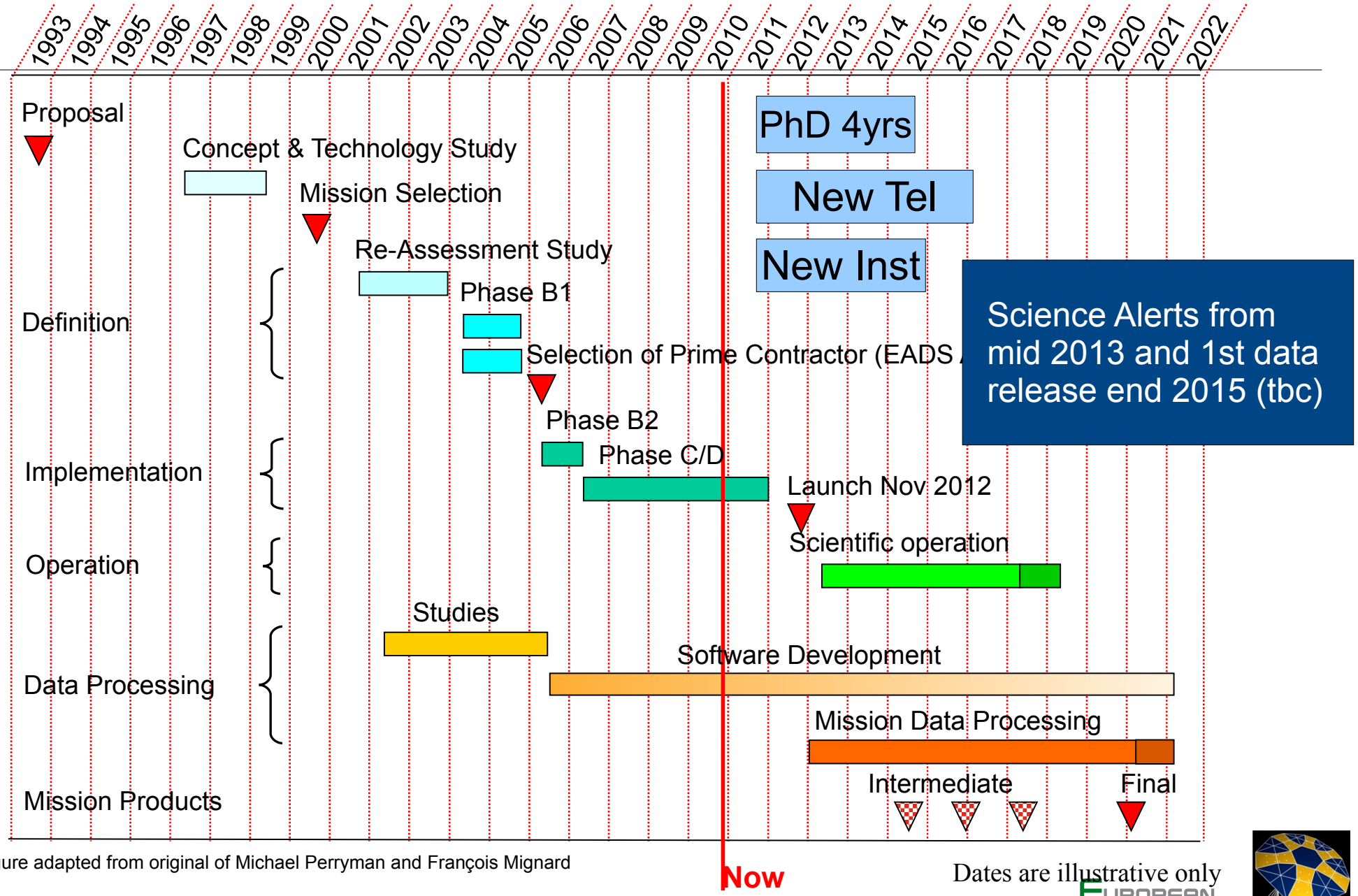
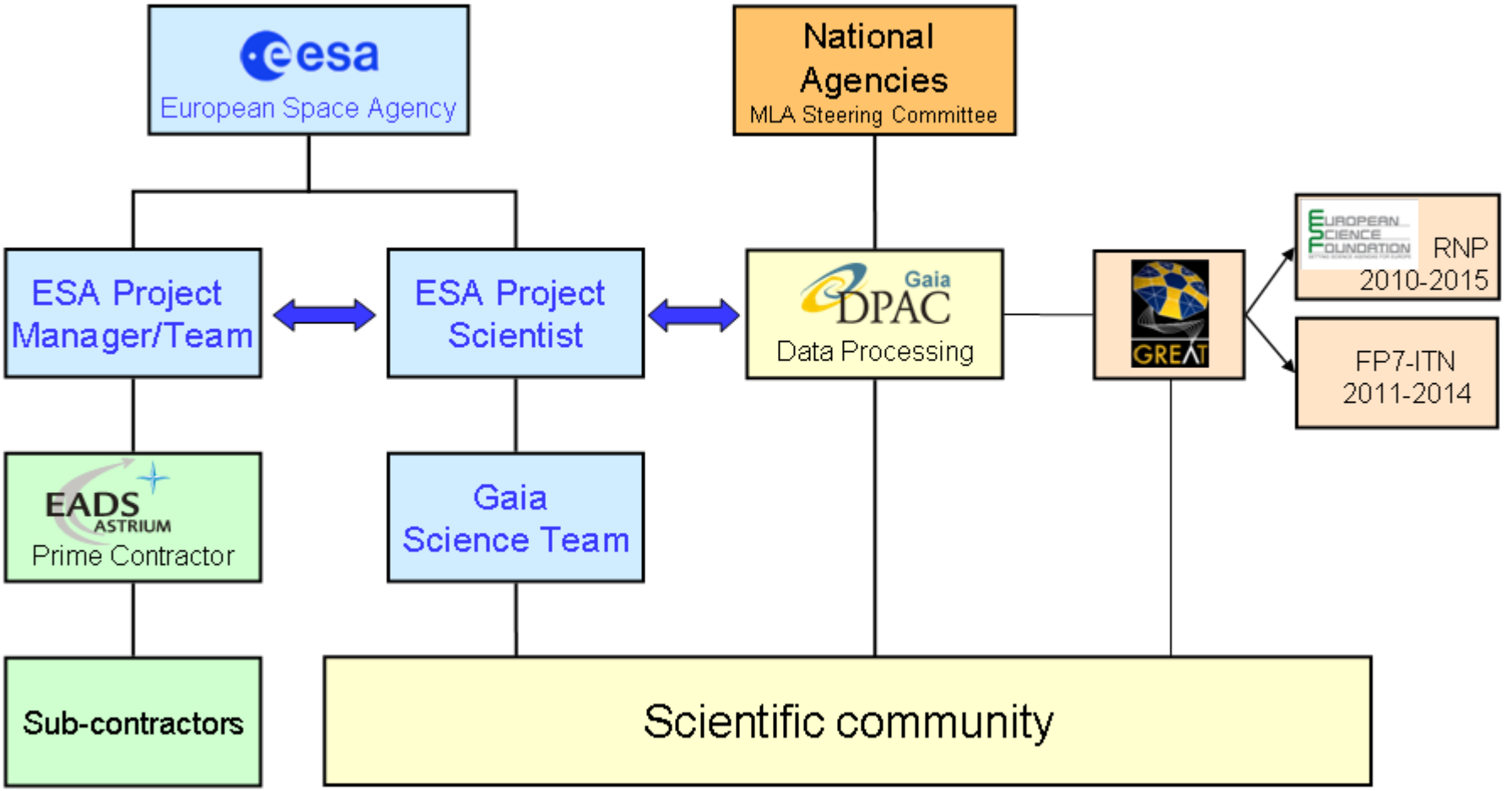


Figure adapted from original of Michael Perryman and François Mignard

Dates are illustrative only

The ESA Gaia Project Organisation
GREAT: network to increase Gaia's science impact



GREAT ESF RNP
Scientific Community Building

- Development led by team from ESA Gaia Science Team and Gaia DPAC Executive
- Proposal to ESF included 90 groups in 17 countries
  - The ESF RNP is supported by 16 funding agencies
- Key science remit inclusive across Gaia science
  - Origin, structure, evolution of the Milky Way
  - Stellar Astrophysics
  - Galactic Dynamics
  - Galactic Archaeology
  - Star formation and evolution
  - Fundamental physics
  - Extrasolar planets
  - Solar system
  - The IT data challenge



The GREAT ESF Research Network Programme

- Provides funds for the GREAT research network:
  - Feb 2010 – Jan 2015 with a budget of ~€750K
- The Programme provides financial support for the following activities:
  - Science meetings (workshops, conferences or schools) organised either by the Programme Steering Committee or following an open call for proposals
  - Grants for short and exchange visits awarded following an open call for applications
  - Publication of information brochures and leaflets, scientific books and meeting proceedings etc

ESF Research Network Programme 2

- ESF networking programmes are 'Open'
  - Encouraged to involve the wider community
  - Ideal for the concept of including those that are not co-applicants in other network activities
- Period of call is science over 2010 – 2015
  - Thus, can factor in access to 'early' Gaia data releases
  - Access to Gaia science alert streams
  - Can also consider science programmes requiring preparatory work (theory, simulations, observational)
- All calls published at http://www.great-esf.eu
  - **Next Workshop/ Exchanges call deadline 21 Dec 2010**

GREAT ESF RNP meetings

- From 1st two calls: 2 confs, 6 workshops, 1 summer school and a number of exchange visits approved
- *Ground-based observations and theoretical analysis for the Gaia Science on Open Clusters and Young Associations*
  - http://www.oact.inaf.it/ocya2010/
- *Gaia Science Alerts Workshop*
  - http://www.ast.cam.ac.uk/research/gsawg/index.php/Workshop2010:main
- *Workshop on Comparative Stellar Spectrum Modelling*
  - http://www.univie.ac.at/galagb/workshop.shtml
- List of upcoming meetings (including this one!) at http://camd08.ast.cam.ac.uk/Greatwiki/GaiaScienceMeetings
  - Covering distance scale, QSOs, modelling, asteroids, GCDS, etc

GREAT Initial Training Network
network funded research training

- FP7 Initial Training Network Proposal
  - 13 main nodes: IoA Cambridge, Leiden, Lund, Barcelona, Heidelberg, MPIA (Heidelberg), Leuven, Geneva, PKU (Beijing), CAUP (Porto), CNRS (Bordeau/Bescancon), INAF (Bologna, Padua), AMU (Poznan)
  - 19 Associate nodes (of which 4 are industrial partners)
  - €4.3M : Funds ~20 Early Stage Researchers
  - **4 year duration**: 1 March 2011 – 28 February 2015
  - Much of the research relevant to GCDS and this meeting
- GREAT ITN complementary to GREAT ESF RNP
  - Opportunity for joint networking activities
- Negotiation Phase with the EC now concluded.

GREAT Working Groups

http://camd08.ast.cam.ac.uk/Greatwiki/CategoryWorkgroups

Workgroup	co-facilitator	co-facilitator
WGA1GaiaModel	Céline Reylé	Daisuke Kawata
WGA2SurveyCensus	GeorgeSeabroke	ArnaudSiebert
WGA3ChemicalTagging	Sofia Feltzing	Nicholas Walton
WGA4LocalGroup	Vasily Belokurov	Michele Bellazzini
WGA5GaiaAlerts	Simon Hodgkin	Gerry Gilmore
WGA6GaiaExtragal	Mary Kontizas	tbd
WGA7NewStats	Will O'Mullane	NicholasWalton
WGA8DistanceScales	Gisella Clementini	Xavier Luri & Enzo Brocato
WGB1OpenClusterYoungAssociation	AlessandroLanzafame	AntonellaVallenari
WGB2StellarVariability	Joris De Ridder	Laurent Eyer
WGB3BinariesAndMultipleSystems	Dimitri Pourbaix	Frederic Arenou
WGB4StellarAtmospheres	UlrikeHeiter	Alex Lobel
WGB5MassiveStars	JanetDrew	Ronny Blomme
WGB6EndStatesOfStellarEvolution	DuncanFyfe	Stefan Jordan
WGC1ExoPlanets	Alessandro Sozzetti	Don Pollacco
WGC2AstrometryReferenceFrame	Marieteresa Crosta	tbd
WGC3Quasars	Sonia Anton Castillo	tbd
WGC4SolarSystem	Paolo Tanga	Alberto Cellino

ioa

GREAT

GREAT On-line

- Supporting a science community
  - A focal point on line presence
  - An on-line discussion and workspace
- GREAT http://www.great-esf.eu
  - http://www.esf.org/great (GREAT at the ESF)
  - http://www.great-itn.eu (ITN specific pages)
  - http://camd08.ast.cam.ac.uk/Greatwiki (interactive wiki)
- On-line resources:
  - Working and discussion group areas
  - Mailing lists

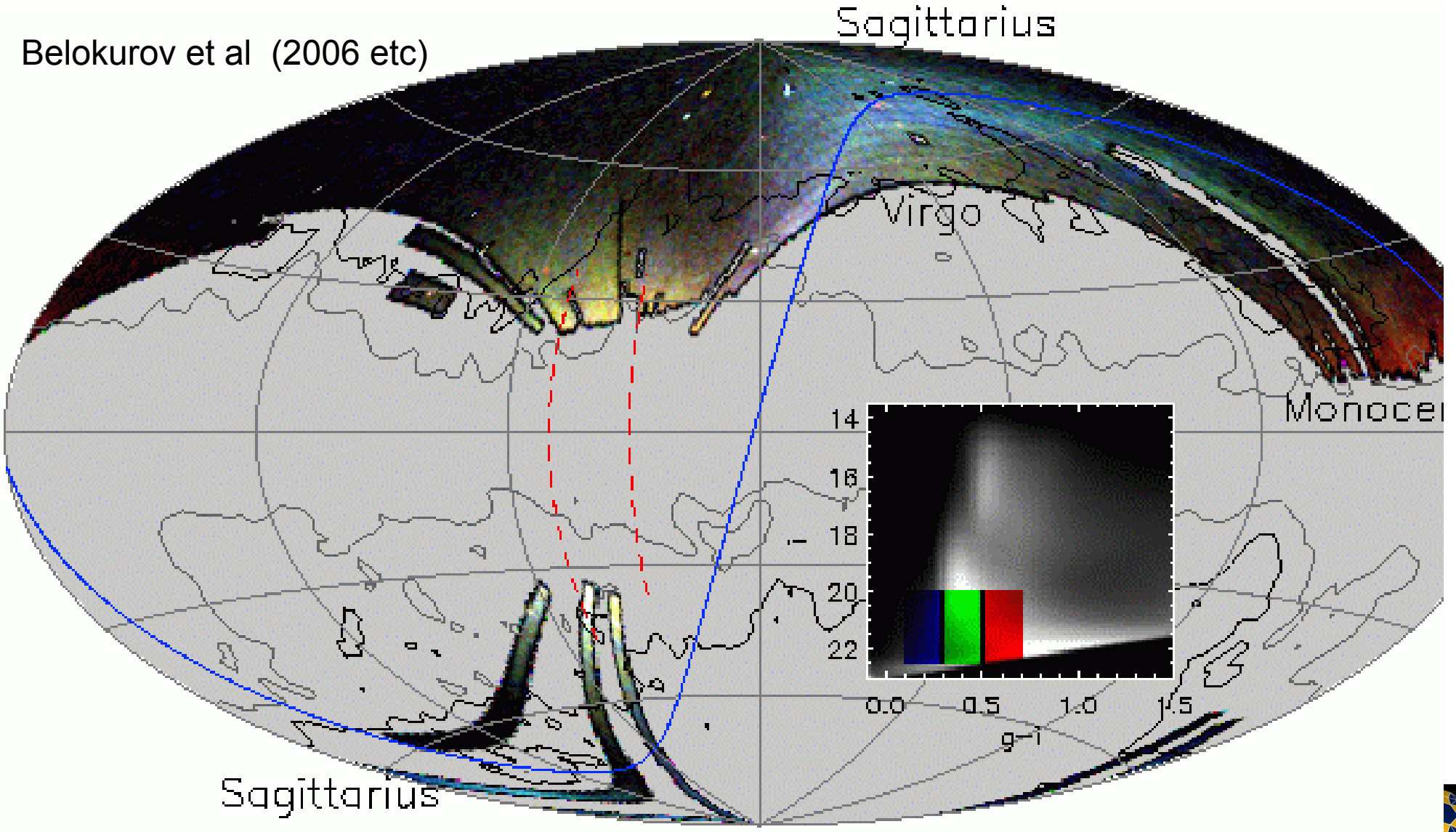
GREAT Chemo Dynamical Survey: Background & Rationale

- March 2009 Cambridge GREAT kick-off meeting
  - http://www.ast.cam.ac.uk/GREAT/events/cam-mar09/cam-mar09.html
- GREAT WGA3 Chemical Tagging Working Group
  - http://camd08.ast.cam.ac.uk/Greatwiki/WGA3ChemicalTagging
- Discussion identified need for High Resolution Spectroscopy
  - In context of Gaia: amount and type of data required
  - Key science drivers
  - Routes to obtain data
  - Need for associated theory
- In order to determine the chemistry of large samples of stars – a large collaborative effort is required

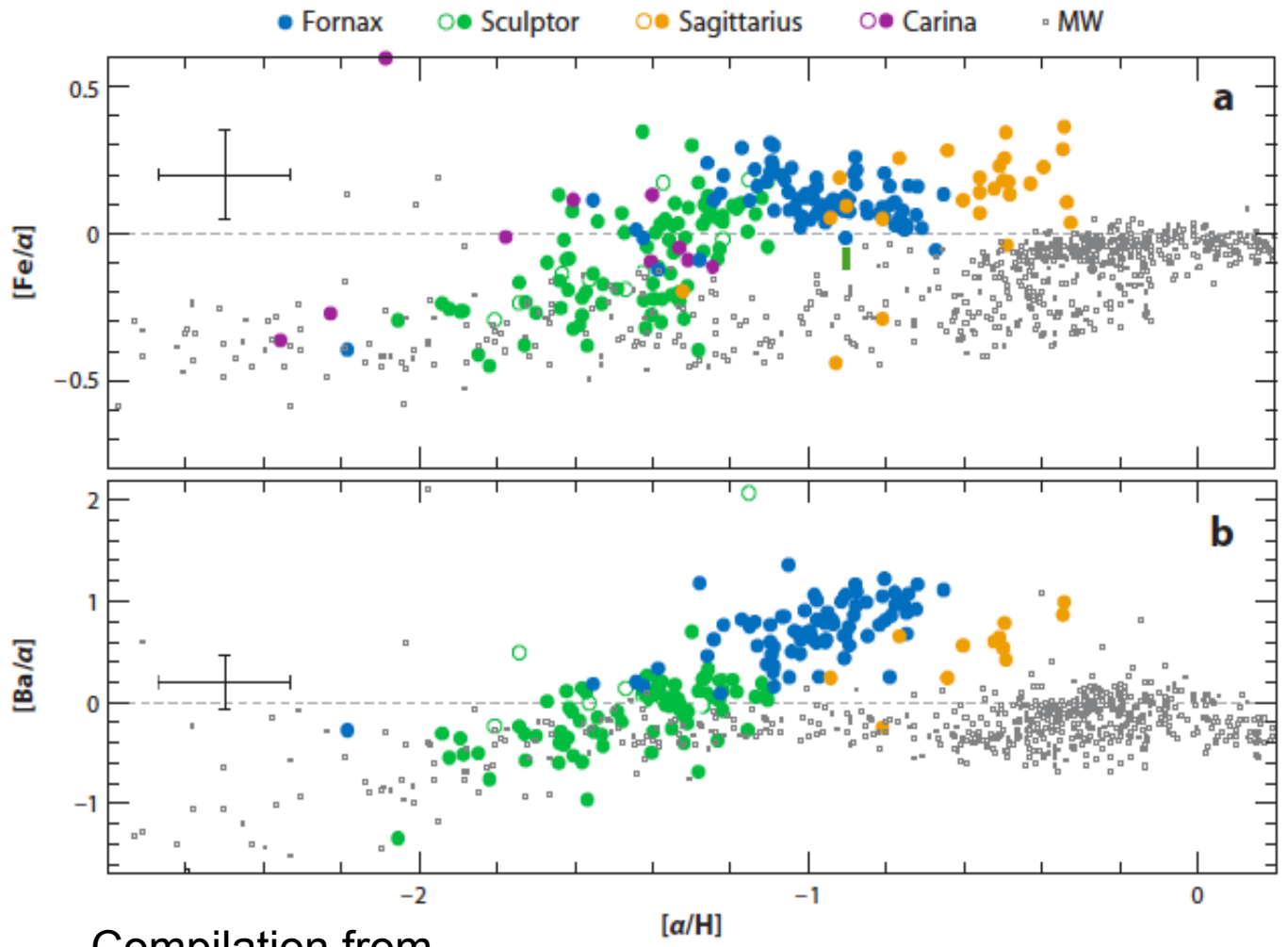
GCDS: Galactic Science Drivers
understand how the Galaxy formed

- relative importance of mergers and accretion in building the disk(s) and bulge
- chemo-dynamic structure of Galactic components
  - interface between disk, bulge/bar, halo
  - importance of radial mixing in the disk(s)
  - ancient dissolved and surviving substructures, streams
- fossil record of chemical evolution of stellar pops
  - chemical signature of ancient accretions
  - properties of metal-poor popIII stars
- evolutionary history of stellar components
  - IMF, SFH, tagging the chemical development
  - the role of star clusters
- detailed chemo-dynamics of surviving satellites

Galaxy substructure and satellite accretion



Building (parts of) the Halo

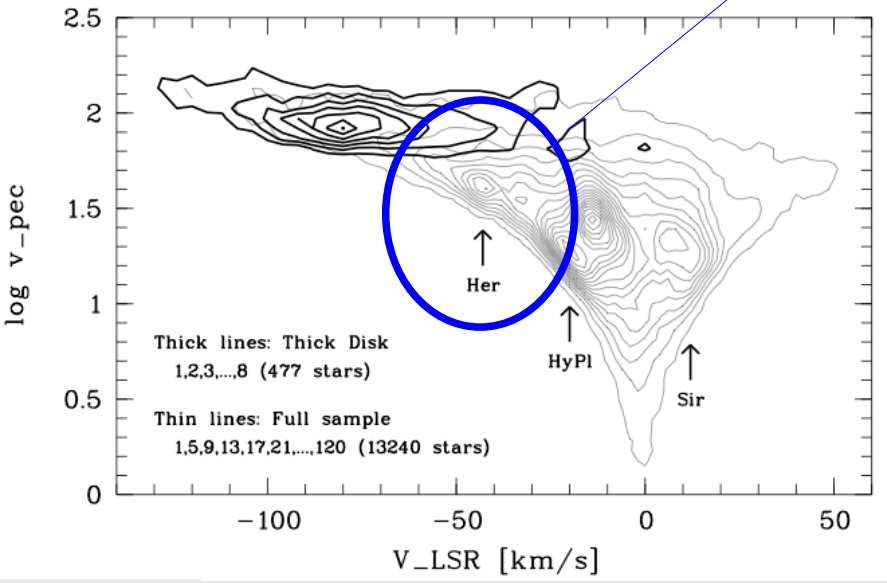


Compilation from Tolstoy et al 2009

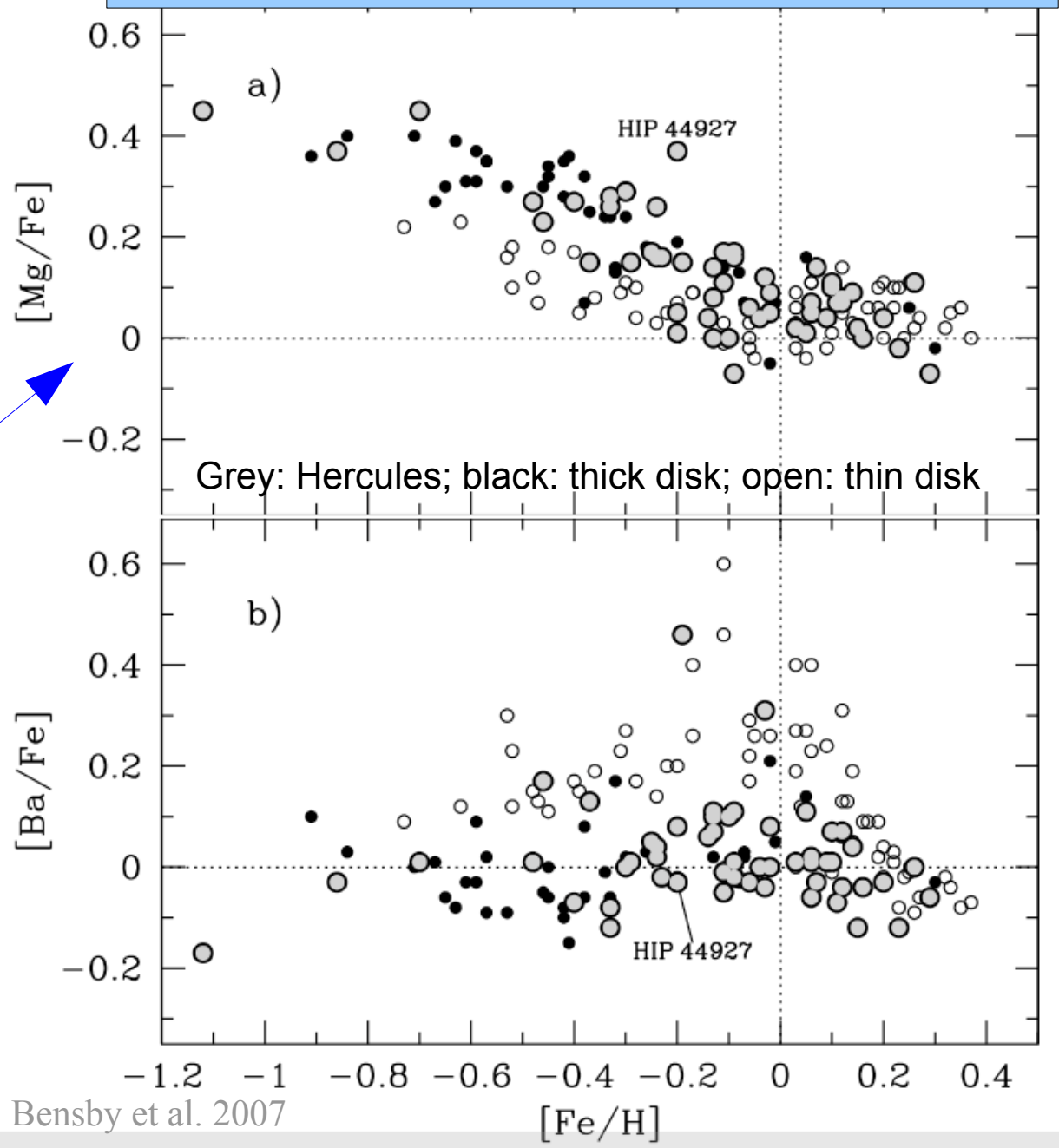
- Fossil record from chemistry
- 0.2 dex required
- R=20,000 and S/N ~50 required

Chemo-Dynamical Encoding

Hercules star chemistry similar to field stars thus a dynamical group, not a group with a common chemical birth site



Famaey et al. 2005



Bensby et al. 2007

The Initial GCDS Survey Concept

see http://camd08.ast.cam.ac.uk/Greatwiki/GreatCds

- Low Resolution Component
  - R=5000 – Chemo-Kinematics – 5 x 10^6 stars
    - Map the thick/thin Disk / Halo / Bulge components
    - Radial velocities to ~2–3 kms^{-1} and [Fe/H] to 0.2 dex
- High Resolution: (< 1kms^{-1} and ~0.05 dex in [Fe/H])
  - good wavelength coverage eg. 4800-6800A; abundances: light elements, alpha-elements, r- s-process and heavy elements
  - R=20000 – Halo: 5 x 10^4 (Chemical-Labelling)
  - R=20000 – Bulge: 5 x 10^4
  - R=40000 – Disk: 2 x 10^5 (Chemical-Tagging)
    - Field Disk & Open clusters

AMBITIOUS SCALE

GCDS Survey Strategy (A)
inclusive, multi-component, long duration

- 4-m spectrograph build:
  - 4+1 yr – 2015 on WHT and/or CFHT and/or VISTA
  - 5 yr survey – 1000 nights in N/ 1000 nights in S
  - Complete survey by 2019 – matched to release of Gaia
- 2000 night 4-m survey defines scope for disk/halo/bulge components
- Potential 4-m programmes now as pilot with current facilities

NEW KIT: TAKES TIME

GCDS Survey Strategy (B)

- 8-m component – via ESO large programme
- 500 nights over three years (1500 over 9 years)
- FLAMES/ GIRAFFE
  - 1-2 hr exposures – 1-2 sq deg/night – 1-2000 stars/ night
  - 1000 nights > 1-2x10^6 stars by 2018 (V~17/ R=20000)
  - 500 nights > for R=5000 = 1x10^6 stars (V~18/ R=5000)
- Thus – 3x very large programmes
  - Split 1:2 for R=5000:20/40000
  - Bulge/ Disk/ Halo components
- Combined with 4-m studies … compulsive science

GREAT Chemo-Dynamical Survey

GCDS Kick-off meeting (27 Apr 2010)

http://camd08.ast.cam.ac.uk/Greatwiki/GreatCds/GcdsParisApr2010

- The Science Experiments
  - SE1: Mass Distribution of the Galaxy
  - SE2: Galaxies formation and evolution traced by chemistry
  - SE3: Clusters and star formation and evolution
  - SE4: Additional and Legacy Science
- Development of these proceeding – see
  - http://camd08.ast.cam.ac.uk/Greatwiki/GreatCds/GcdsSe1
  - http://camd08.ast.cam.ac.uk/Greatwiki/GreatCds/GcdsSe2
  - http://camd08.ast.cam.ac.uk/Greatwiki/GreatCds/GcdsSe3
  - http://camd08.ast.cam.ac.uk/Greatwiki/GreatCds/GcdsSe4

THE INCLUSIVE ELEMENT of GCDS

Some of the Groups Involved

sign up now!

Institute	Department	Contact	Participants	Areas of Interest
University of Cambridge	Institute of Astronomy	Nicholas Walton	Vasily Belokurov, Wyn Evans, Andrea Font, Gerry Gilmore, Simon Hodgkin, Mike Irwin, Floor van Leeuwen, Sergey Koposov, Ian Parry, Jorge Penarrubia, Sakurako Okamoto, Jenny Richardson, Matthew Walker	
Lund University	Department of Astronomy and Theoretical Physics, Lund Observatory	Sofia Feltzing	Thomas Bensby, David Hobbs, Lennart Lindegren, Nils Ryde + TBD	
University of Heidelberg	Zentrum für Astronomie der Universität Heidelberg	Eva Grebel	Martin Altmann, Ulrich Bastian, Norbert Christlieb, Sonia Duffau, Andreas Just, Hans-Günter Ludwig, Sarah Martell, Stefano Pasetto, Andreas Quirrenbach, Rainer Klement	SE1, 2, 3, 4; TWG 1, 2, 3, 5
Oxford University	Oxford Physics	James Binney	James Binney, John Magorrian, Paul McMillan, Francesco Firmani	
Max Planck Institute for Astrophysics	(MPA)	Martin Asplund	Martin Asplund, Maria Bergemann, Luca Casagrande, Karin Lind, Fernanda Nieva, Ivan Ramirez, Luca Sbordone, Ralph Schoenrich	
Observatory of Paris	GEPI	Piercarlo Bonifacio	Frédéric Arenou, Carine Babusiaux, Piercarlo Bonifacio, Elisabetta Caffau, Mélanie Guittet, Ana Gomez, Misha Haywood, David Katz, Hélène Posbic, Noel Robichon, Frédéric Royer, Paola Sartoretti, Catherine Turon	
Uppsala University	Department of Physics and Astronomy, Division of Astronomy and Space Physics	Andreas Korn	Ulrike Heiter, Paul Barklem, Bengt Edvardsson, Kjell Eriksson, Bengt Gustafsson, Oleg Kochukhov	SE1, 2 & 3; TWG 4 & 5
University College London	Mullard Space Science Laboratory	Daisuke Kawata	Mark Cropper, Steve Boudreault, Ignacio Ferreras, Daisuke Kawata, Curtis Saxton, George Seabroke, Kinwah Wu	
University of Edinburgh	Institute for Astronomy & the ATC	Annette Ferguson	Mike Barker, Edouard Bernard, Chris Evans, Nigel Hambly, Ken Rice	
University of Groningen	Kapteyn Institute	Amina Helmi	Eline Tolstoy, Bertrand Lemasle, Stefania Salvadori, Teresa Antoja, Else Starkenburg, Maarten Breddels	SE1, 2; TWGs TBD
University of Hertfordshire	Centre for Astronomy, STRI	Janet Drew	Janet Drew, Phil Lucas + TBD	SE1, 3; TWGs TBD
Observatoire de la Côte d'Azur	CASSIOPEE	Vanessa Hill	Patrick de Laverny, Georges Kordopatis, Christophe Ordenovic, Alejandra Recio-Blanco, Clare Worley	SE2 & 1; TWG1, 2 & 3
Leiden University	Sterrewacht Leiden	Anthony Brown	Simon Portegies Zwart + TBD	SE2+3, FWG TBD
Astrophysical Institute Potsdam	AIP	Matthias Steinmetz	Roelof de Jong, Mary Williams, Corrado Boeche	
Royal Observatory of Belgium	Astronomy and Astrophysics	Ronny Blomme	Ronny Blomme, Yves Fremat, Martin Groenewegen	SE1+3, FWG1
Observatoire Astronomique de Strasbourg		Benoit Famaey	Olivier Bienayme, Rodrigo Ibata, Arnaud Siebert	SE1 & 3

GCDS: status updates – to Oct 2010

- In the recent few months, a number of advances
- May 2010: WHT spectro upgrade development
- July 2010: ESO issued call for large (300 night) spectroscopic surveys (LoI deadline 15 Oct 2010)
- July 2010: ESO issued call for spectroscopic instrument upgrades
- The GREAT community involved in these
  - Response to the ESO survey call (Gilmore & Randich)
  - 4-m MOS spectrographs for WHT (WEAVE: Dalton) and VISTA (4mMOSST: De Jong) (with associated surveys)
  - 8-m VLT (FLAMES-IR: Bonifacio)

Where is GCDS now:
responses to the ESO Large Survey Call

- Concept of science experiments (SE) established
- Each SE defined their survey requirements/ needs
  - Completed over the summer of 2010
- Merge of SE requirements
  - Looked for synergies and developed a unified survey plan
  - Agreement of key priorities: mid Sept 2010
  - Two complementary programmes resulted: GCDS-MW (PI: Gilmore – next talk) and GCDS-OC (PI: Randich)
- 15th Oct 2010 – submission of GCDS LoIs to ESO
  - Full proposals due March 2011
  - 3 year surveys start Oct 2011

GCDS-MW: Key Outcomes

The Gaia-ESO survey: Galactic Astrophysics via VISTA Imaging, Gaia Astrometry, and Eso SpectrOscopy

- Combines key cases from:
  - SE1: Mass Distribution of the Galaxy
  - SE2: Galaxies formation and evolution traced by chemistry
- Key aims: kinematic studies of the halo, chemistry of the disk
  - Quantify thick disk and halo abundance and kinematic gradients
  - Distribution functions due to the inner bar and spiral arms
- Determine the relative importance of assembly and accretion
- Bulge-disk interface: (secular) origin of the thick disk
- Halo-disk interface: (merger) origin of the halo & thick disk
- Direct constraints on the disk and halo potential

GCDS-OC: Key Outcomes

Open Star Clusters: the path from molecular clouds to the MW disc population

- Key science from
  - SE3: Clusters and star formation and evolution
- Key aims: kinematic and chemical studies of a large sample of Open Clusters and cluster members – to:
  - understand how clusters form; evolve, dissolve, and populate the Milky Way
  - calibrate complex physics that affect stellar evolution;
  - measure the Galactic metallicity gradient at different ages with unprecedented accuracy, thereby setting constraints on models of disc formation

GCDS Scorecard to date

GCDS Community	progressing	GCDS	Science at this meeting
4-m surveys (N)/ new MOS	progressing	WHT/ La Palma	Possible via NL/E/UK + +?
4-m surveys (S)/ new MOS	progressing	ESO/ VISTA	LoI approved
8-m surveys	progressing	ESO – Flames	Two LoIs submitted
GREAT Support	In hand		ESF and ITN

Next steps: for discussion last session tomorrow