CSI-VEGA

Concept Study for an Interactive Visualisation Environment of the Gaia Archive

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some work presented done within the VA-4D Collaboration (Uninova; SIM, NComVA; King's College)

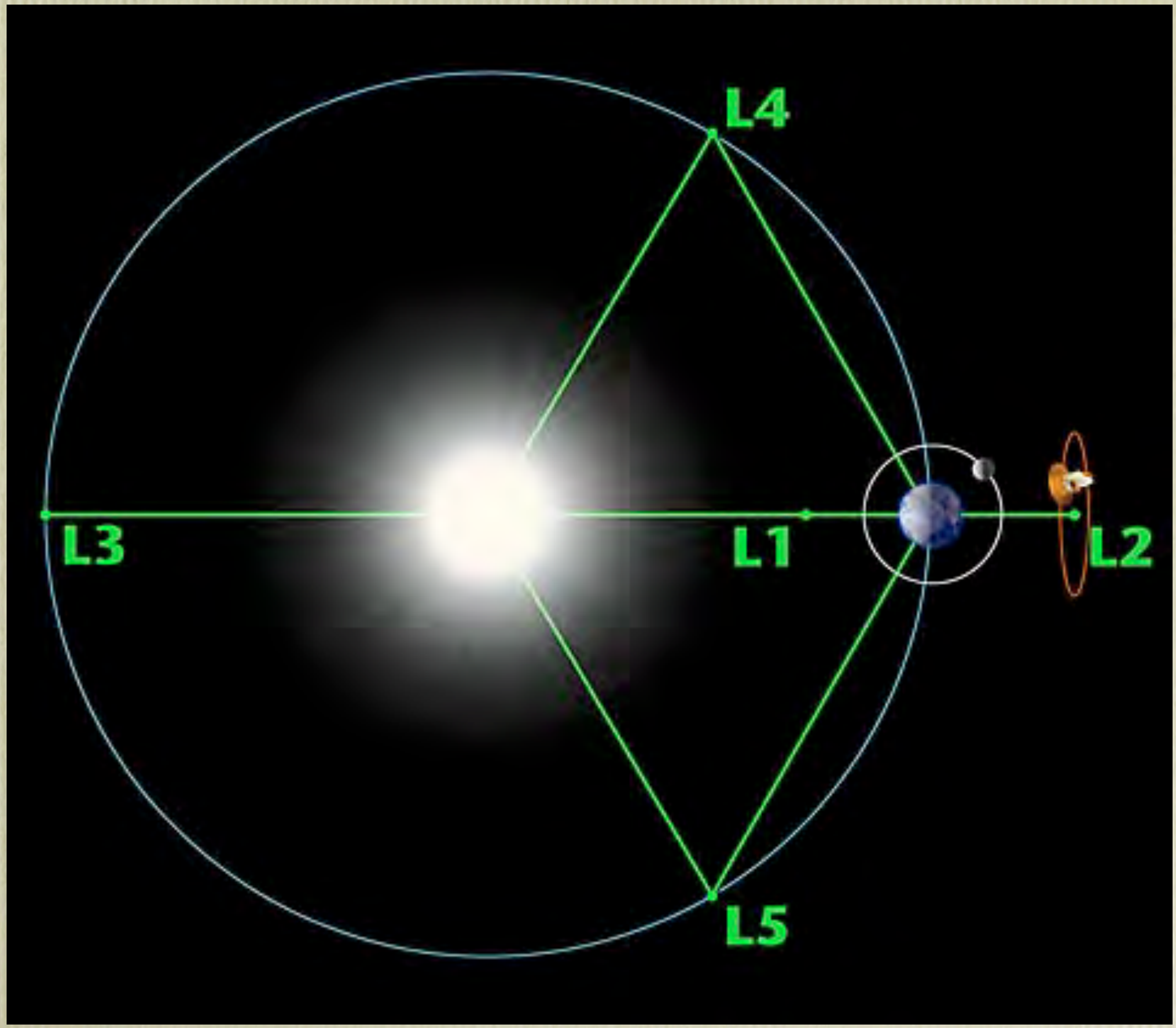
Overview

- Gaia in a nutshell
- Visualisation and the Big Data challenge
- Current work: the CSI-VEGA workbench
- Towards 2022

Gaia in a nutshell

Gaia

- Next ESA cornerstone mission. Launch 2013
  - Positions, distances, motions, spectral measurements (temperature, luminosity, surface gravity, composition, reddening,...) for more than 1 billion objects
  - Time resolved (~x 75)
  - ~7 micro arcsec accuracy
  - Science: Milky Way, stellar astrophysics, solar system, exoplanets, dark matter, general relativity, cosmology, ...

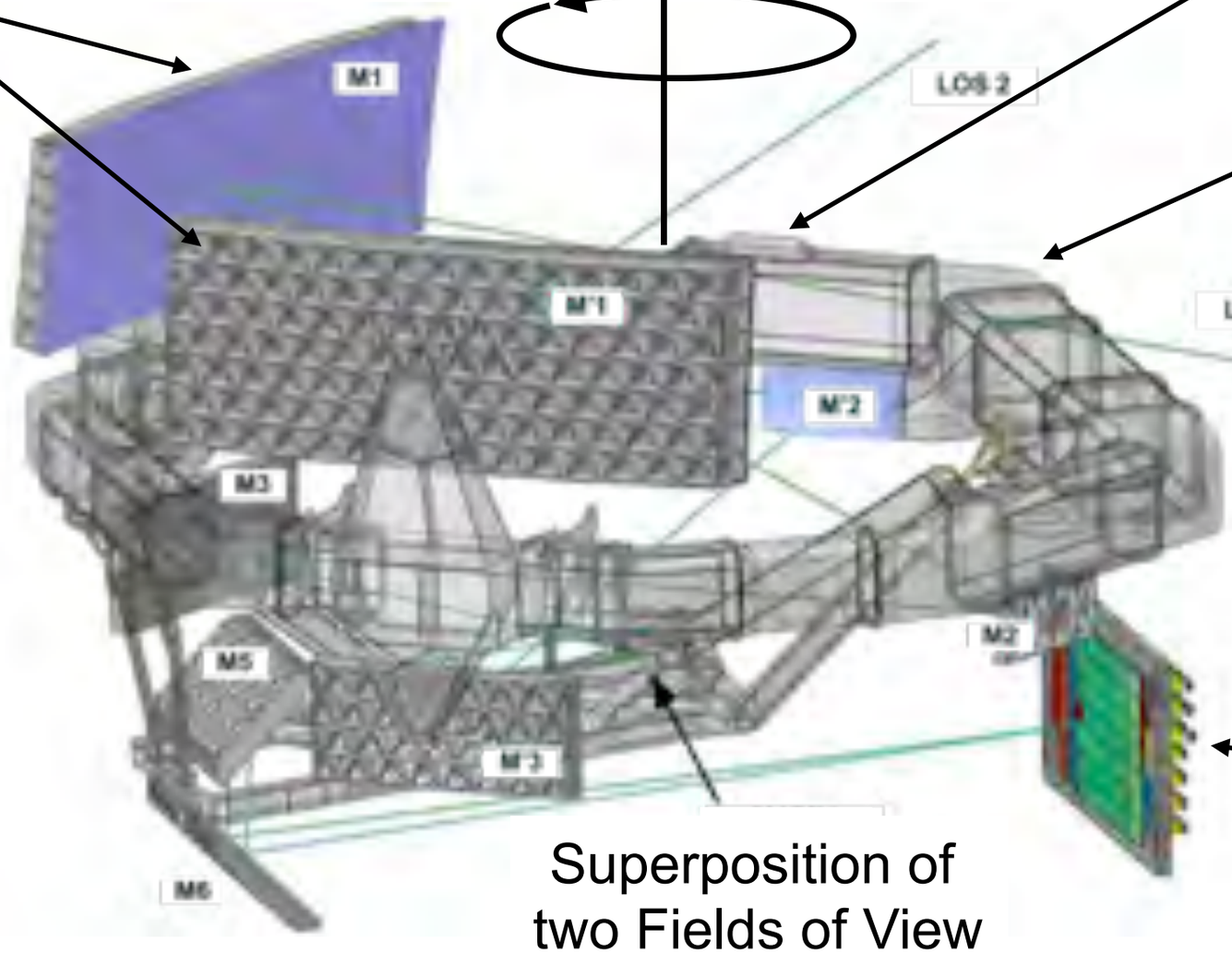

L4
L3
L1
L2
L5

Two SiC primary mirrors
1.45 × 0.50 m² at 106.5°

Rotation axis (6 h)

Basic angle
monitoring system

SiC toroidal
structure
(optical bench)



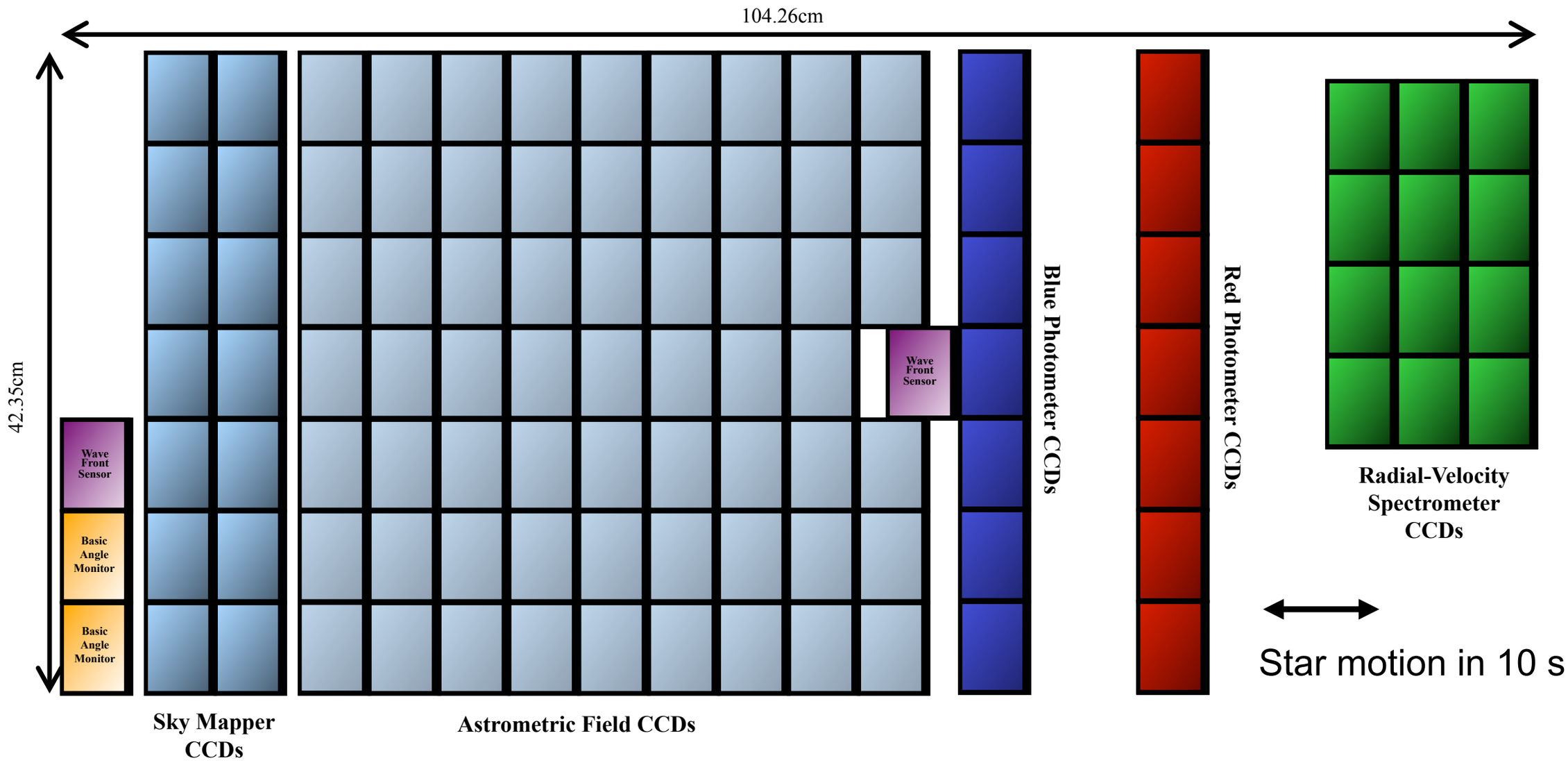
Combined
focal plane
(CCDs)

Superposition of
two Fields of View
(FoV)

Figure courtesy EADS-Astrium

Focal Plane - 1 billion pix

Figure courtesy Alex Short



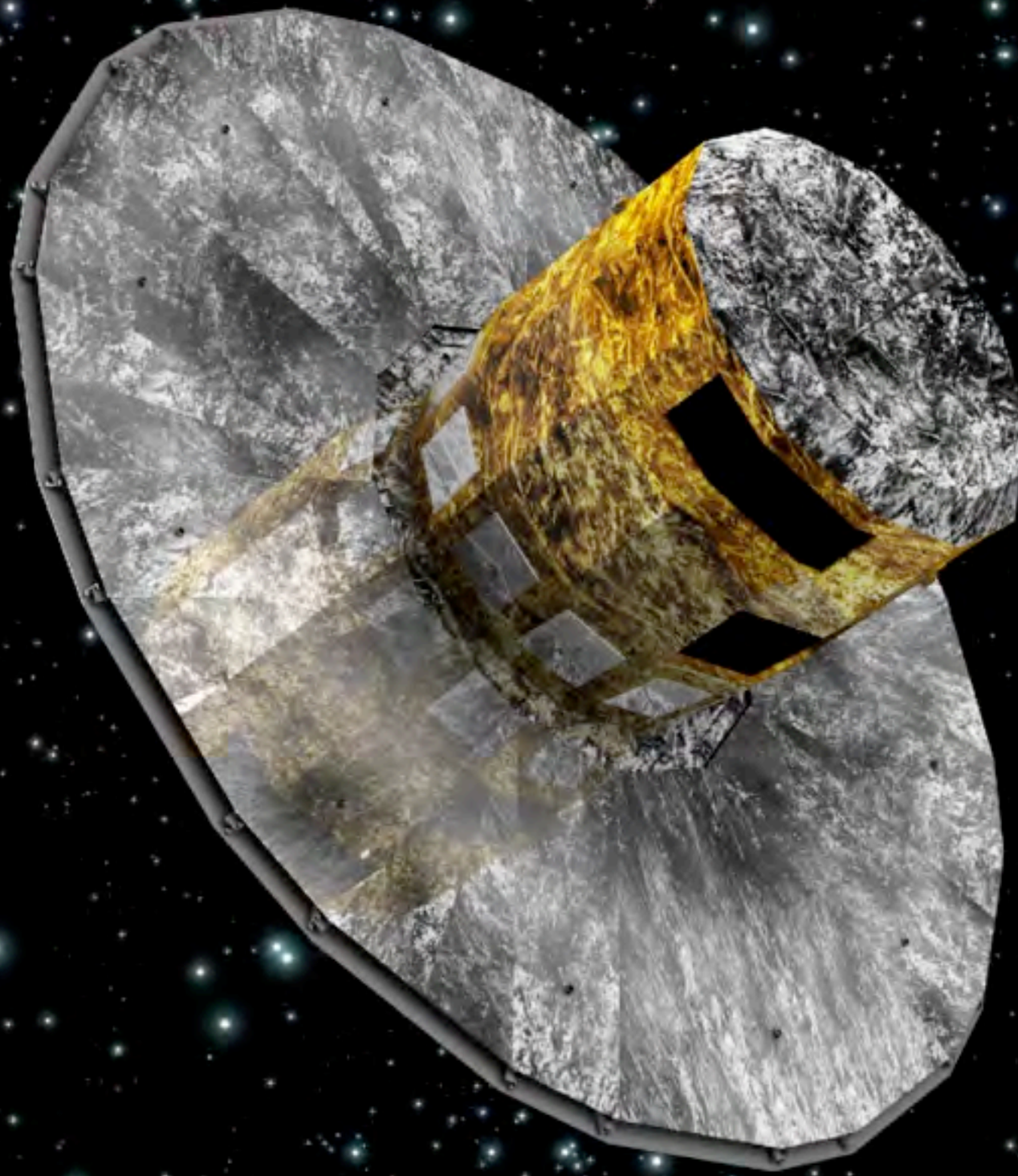
Total field:
- active area: 0.75 deg^2
- CCDs: 14 + 62 + 14 + 12
- 4500 x 1966 pixels (TDI)
- pixel size = 10 μm x 30 μm
  = 59 mas x 177 mas

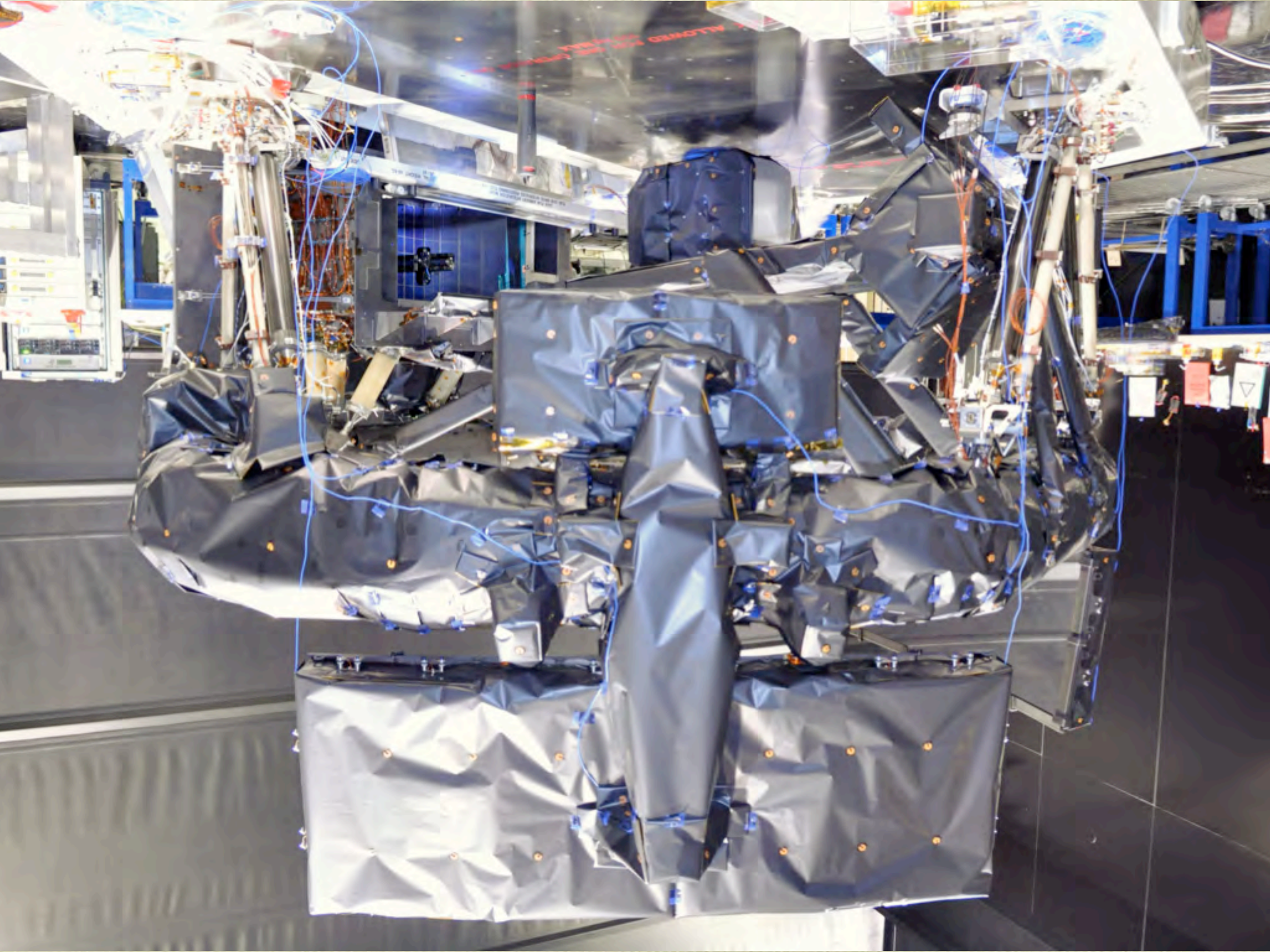
Sky mapper:
- detects all objects to 20 mag
- rejects cosmic-ray events
- FoV discrimination

Astrometry:
- total detection noise: 6 e$^-$

Photometry:
- two-channel photometer
- blue and red CCDs

Spectroscopy:
- high-resolution spectra
- red CCDs





Visualisation and the Big Data challenge

The beginnings of data exploration

http://stat-graphics.org/movies/prim9.html John Tuckey and Prim-9

Aspects of visualisation

- **Exploring the Gaia (Big Data) archive**
  - Overall view of contents or statistics
  - Quality assessment
  - Detailed views. Maps, diagrams
  - Interacting with the catalogue
    - Navigation
    - Selecting and linking views
  - Analysing the data. What built in functions?

Aspects of visualisation

- **Presenting results**
  - Professional papers and talks
  - General public at home
  - General public at venues

- **Collaboration**
  - Building research. Interactive or not
  - Story telling

Aspects of visualisation

- **Analytics: what kind of representations**
  - 2D, 3D, scatter, histograms, multi-view, etc
  - glyphs, volumes, uncertainty, etc

- **Ultimately defined by use cases**
  - Scientists: Gaia Data Access Scenarios
  - General public at home
  - General public at venues

Challenges

- 2D is relatively simple even for Big data (pre-processing a la Google maps).
- What about 3D? Is this really necessary?
- How do we select arbitrary regions in 3D?
- How do we load or at least cope with large data sets in 3D with common computers?
- More, later

Current work

Some background

VA-4D - Visual Analysis of 4-Dimensional Fields, Processes & Dynamics

"Design a conceptual model for an intelligent Visual Analysis tool for large datasets of 4-Dimensional fields "

- 5 scenarios: Space Science; Climate Changes influence in Floods/Habitats/Vector borne diseases; Natural Hazards (for) Disaster Management
- Visual analytics; Computer science

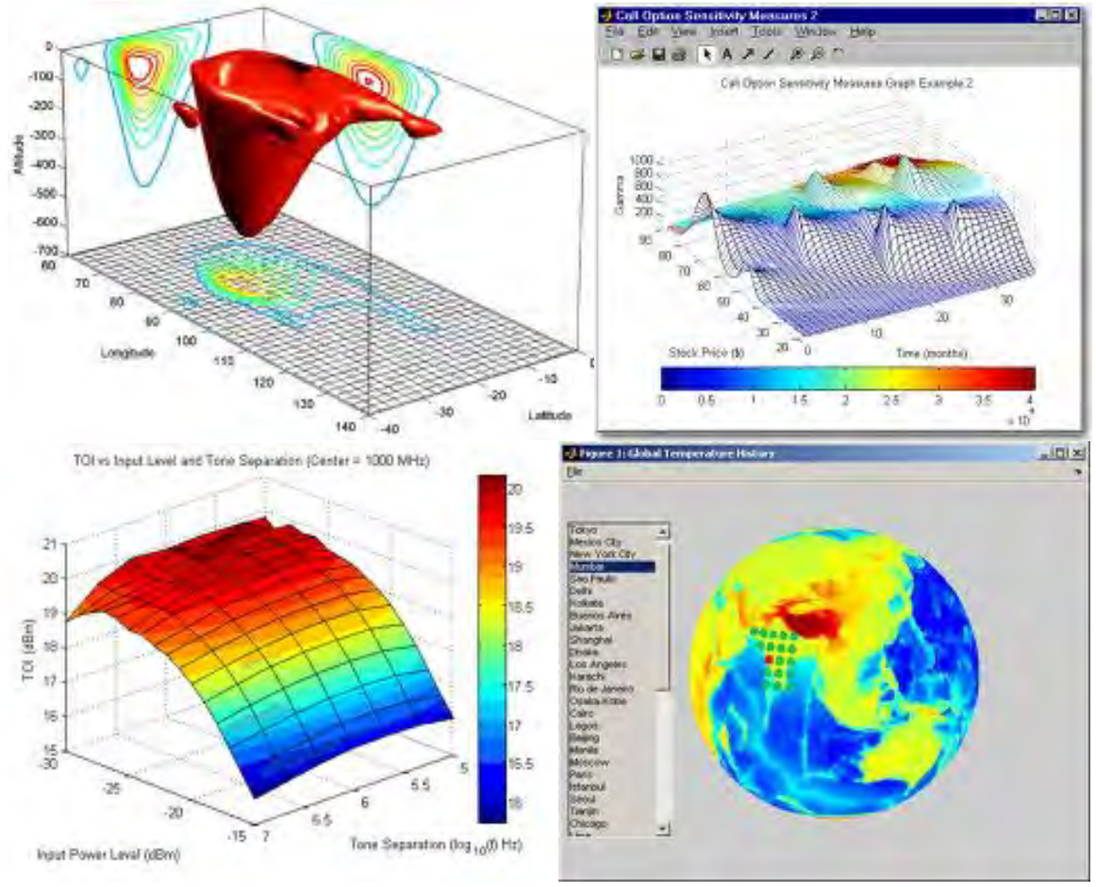
Requirements

- Functional
- Visualisation
- System interface
- Architecture
- Software engineering
- Performance
- Security

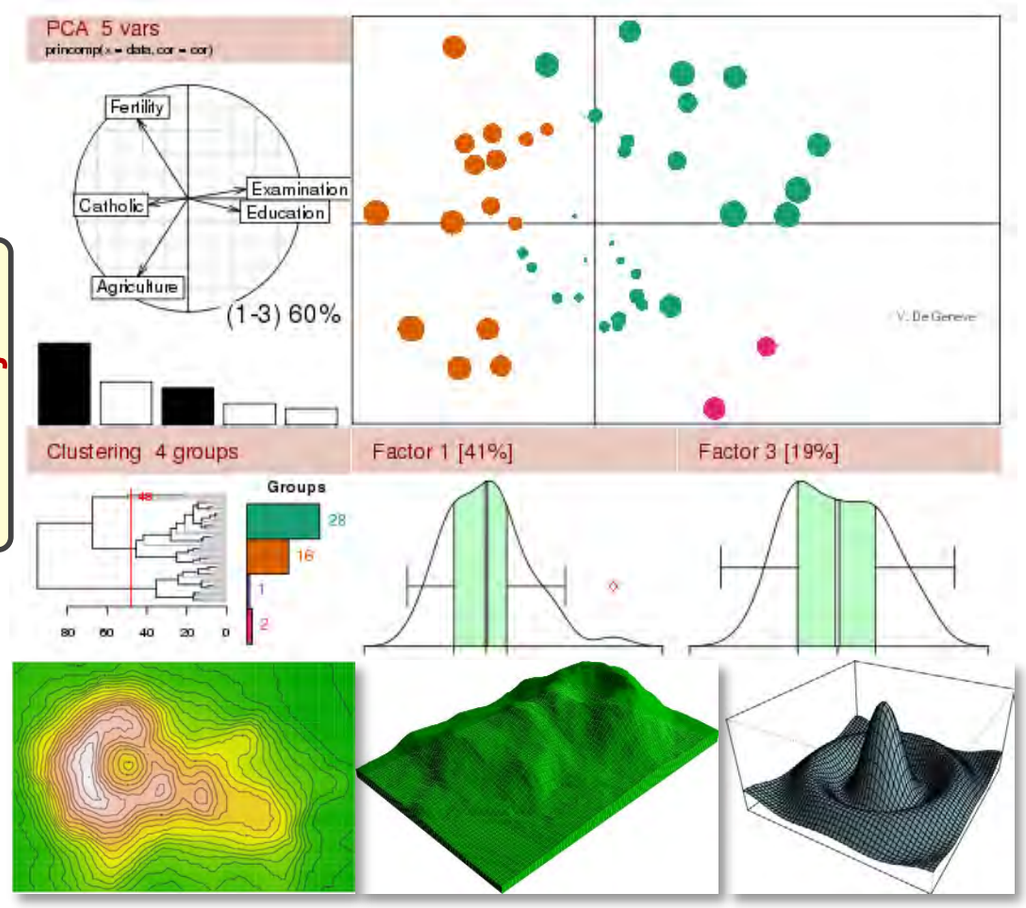
- > 200 high level reqs
- > 100 FW identified

Visualization Frameworks, Toolkits, Systems (cont.)

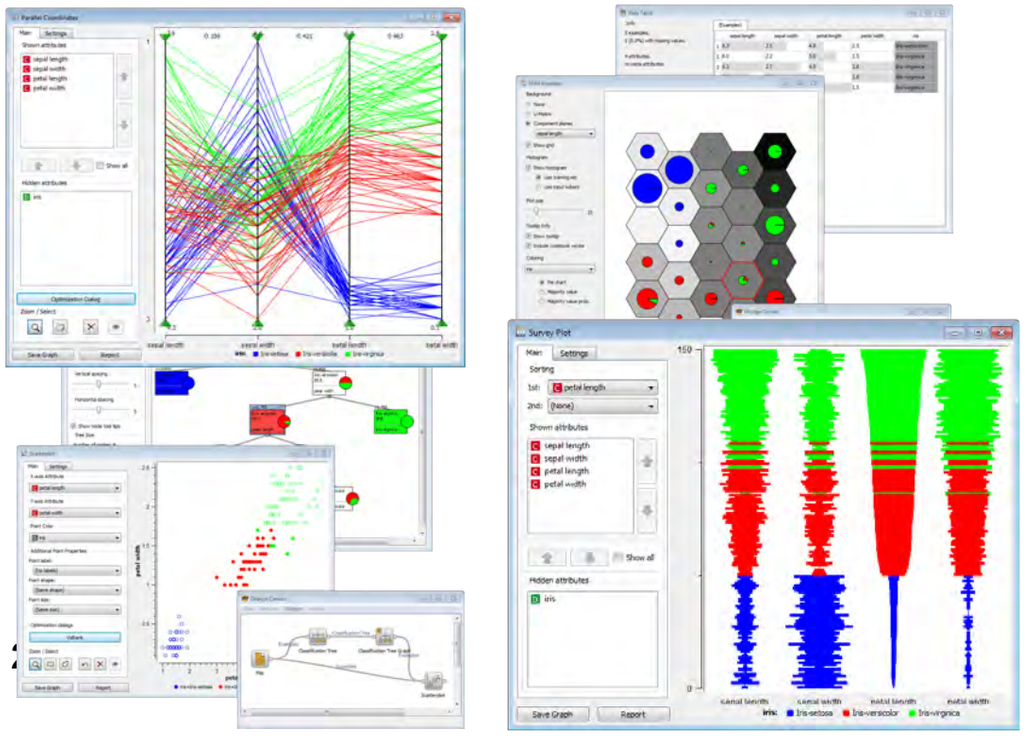
Matlab



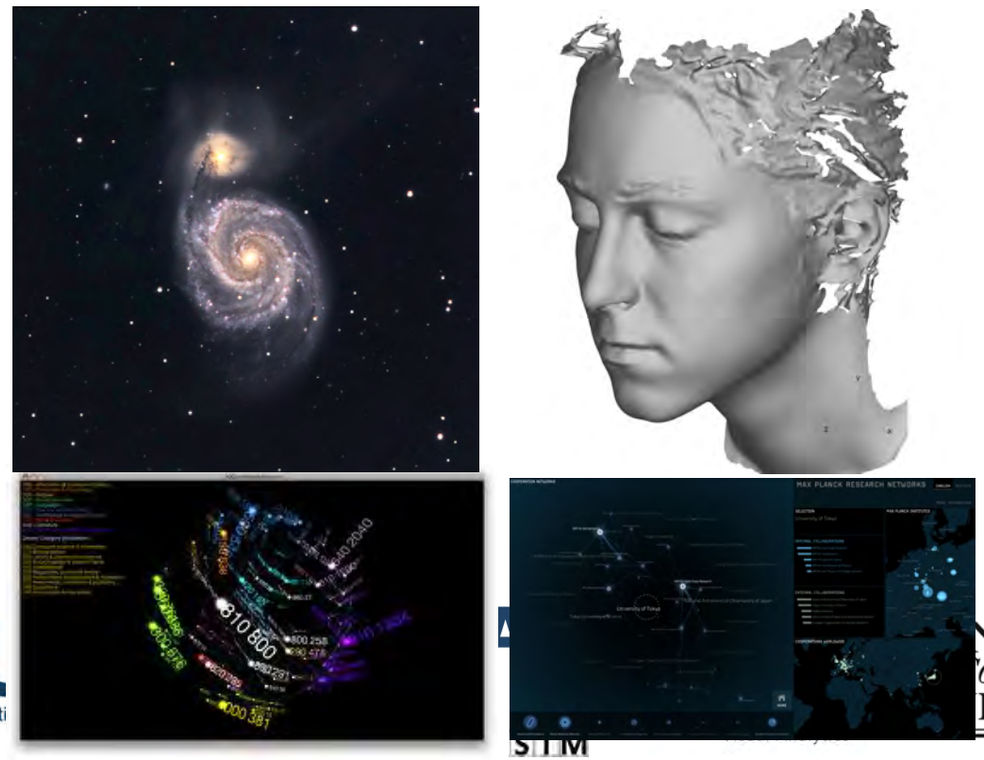
R Project



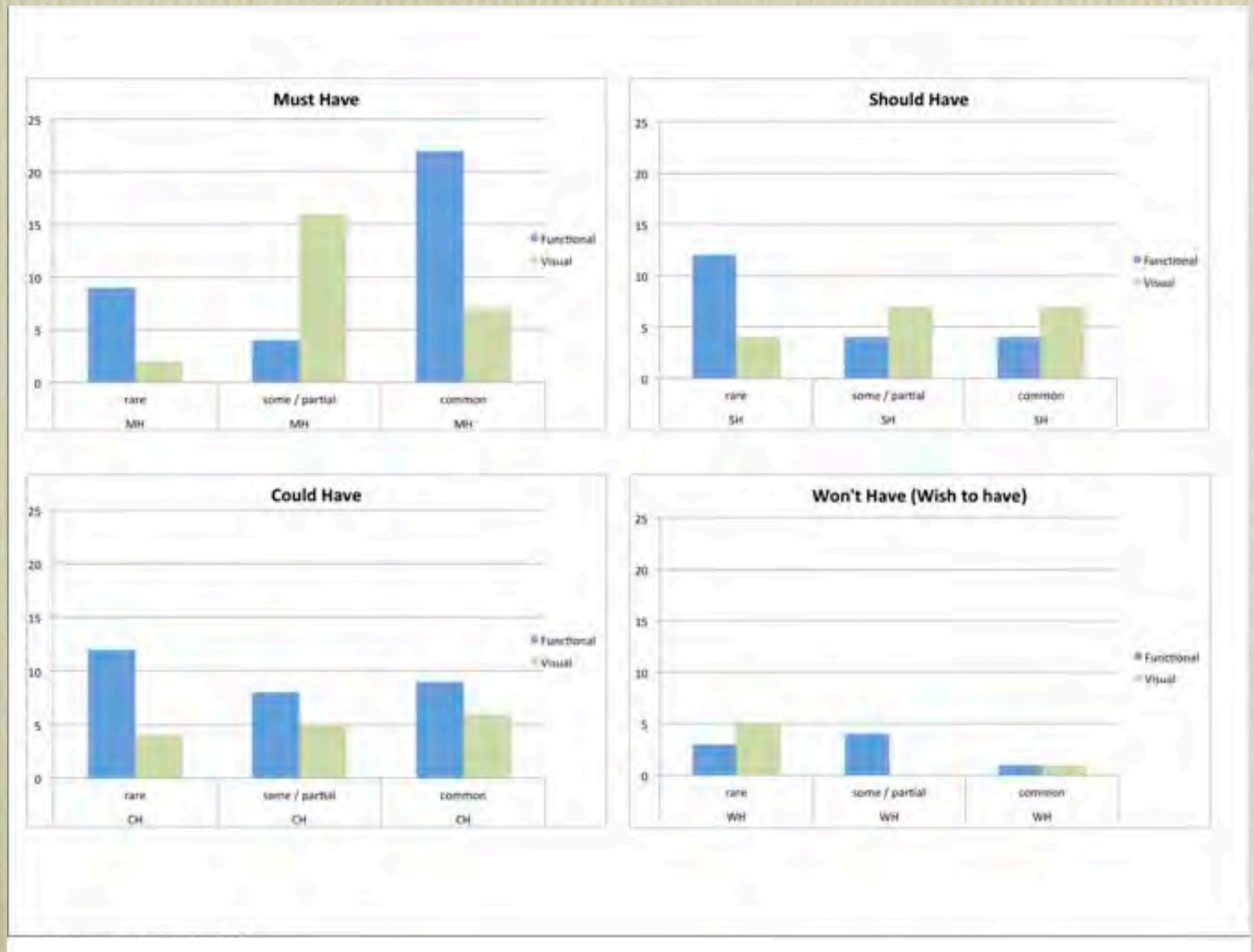
Orange



Processing



- **Gap assessment highlights:**
  - Most missing important requirements are functional



- **Gap assessment highlights:**
  - Adequate representation of the errors: Propagation. Clutter even in moderate sets
  - Large datasets: What to plot and what to render. Performance
  - Limited mathematical tools. Interoperability (python, java,VO, ..) preferred.
  - 3D interactivity: Measuring and selecting. Interfaces.
  - Collaborative environment. Story telling and publishing.

CSI-VEGA

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http://www.youtube.com/watch?v=qhWnUp_HirU Hipparcos flyby

Gaia General
- Home
- Science Performance
- DPAC
- Gaia vacancies
- Contact us

Gaia Resources
- Who's who in Gaia?
- Calendar of meetings
- Library & Livelink
- Tools, data & software
- Related sites

Gaia Outreach
- Flyers
- Posters
- Information sheets
- Presentation material
- Image & movie gallery
- Gaia in the media
- Educational material

Restricted Items
- IT Services
- Document Portal
- My Portal

Logged in as amoitinh

Logoff

Search

GO

Advanced Search

Bookmarks
- Make this my Home Page
- Bookmark this page in My Personal Links
- Popup MyPortal links

Picture of the Week

Space flyby with Gaia-like data

Credits:

- SIM - University of Lisbon (www.sim.ul.pt)
- CA3 - UNINOVA (http://www.ca3-uninova.org)

Download the mov file (198M) to see the complete movie.

Gaia will produce a stereoscopic catalogue of a billion stars and other bodies in our Galaxy and beyond. In addition to the huge task of processing the Gaia observations, we will face the challenge of how to visualise such a large multidimensional data set. This will be one of the tasks of the future Catalogue Access Coordination Unit (CU9).

Picture of the Week archive

2013
- 02/11: Gaia payload testing
- 01/04: Space flyby with Gaia-like data

2012
- 12/10: DPAC OR#2. Testing with Planck
- 11/05: Galaxy detection with Gaia
- 10/09: Plot of part of the GUMS-10 catalogue
- 07/23: "Gaia" meets at Gaia
- 06/29: The Sky as seen by Gaia
- 05/31: Panorama of BAM clean room
- 03/29: GREAT school results
- 03/12: Scanning-law movie
- 02/21: Astrometric microlensing and Gaia
- 02/03: BAM with PMTS
- 01/12: FPA with all the CCDs and WFSs

2011
- 12/14: Deployable sunshield
- 11/10: Earth Trojan search
- 10/21: First Soyuz liftoff from the French Guiana
- 09/20: Fast 2D image reconstruction algorithm
- 09/05: RVS OMA
- 08/10: 3D distribution of the Gaia catalogue
- 07/13: Dynamical Attitude Model
- 06/22: Gaia's view of open clusters
- 05/27: Accuracy of the stellar transverse velocity
- 05/13: Vibration test of BAM mirrors
- 04/18: L. Lindegren, Dr. Honoris Causa of the Observatory of Paris
- 01/19: Detectability of stars close to Jupiter
- 01/05: Delivery of the WFS

2D and 3D navigator

Performance

- No 3D: perfect 24fps @ 1366x768; ~22fps @ 1920x1080
- 3D: 15 fps @ 1366x768 (twice the triangles)
- 100-150 Eur graphics card should handle 10x more stars

Object selection

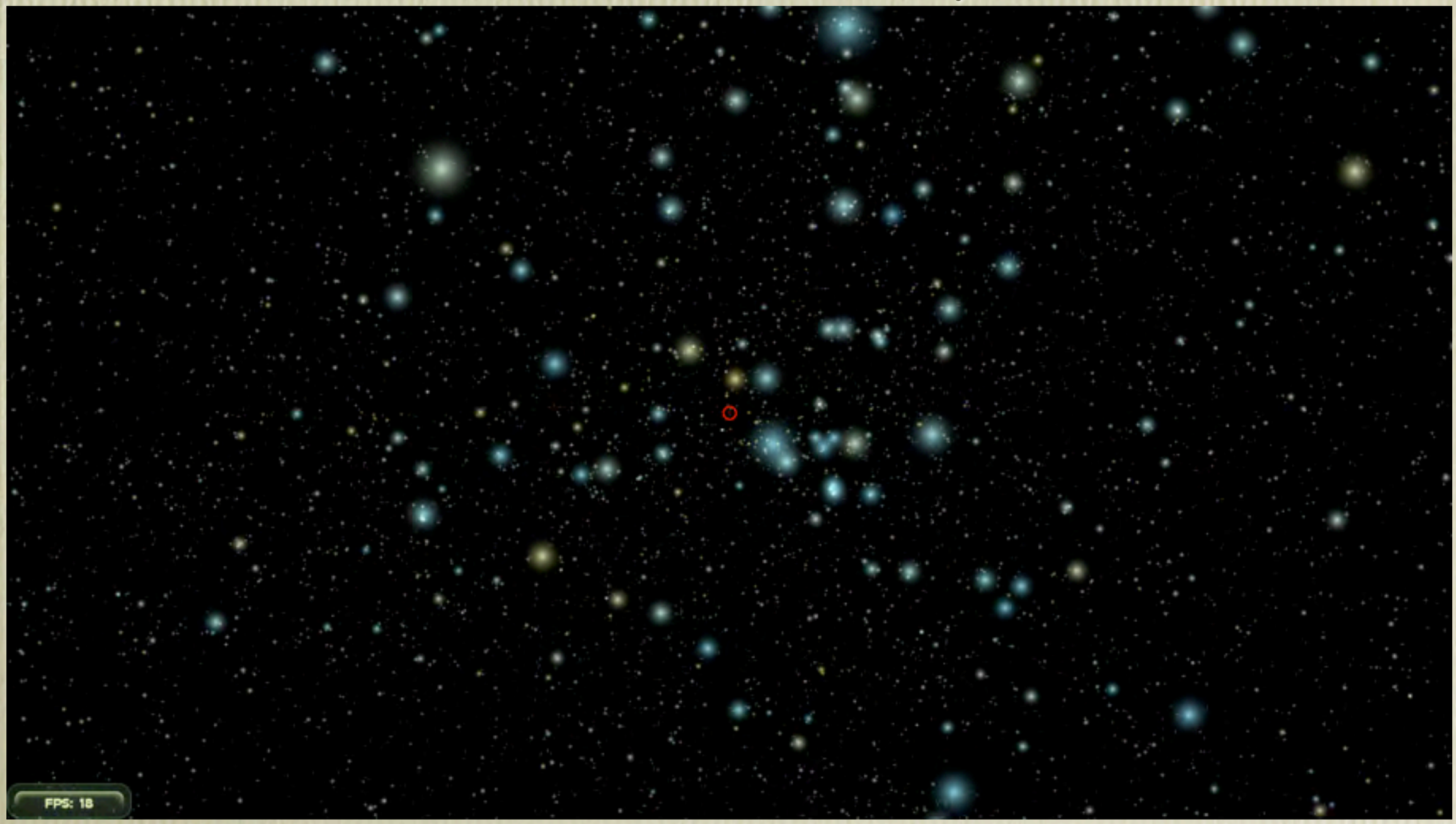
- Ray cast works well in 2D with perspective
- Very hard in 3D (as selection in general)
- Further research is being carried. Also on volume selection.

Engines

- OGRE - tested. Expandable (kinect). C++ w/OpenGL/DirectX. **Multi platform**
- Unity3D: easier, but more limited. Multi platform
- Unreal Developement Kit (UDK). Very complete. Only win and macosx.

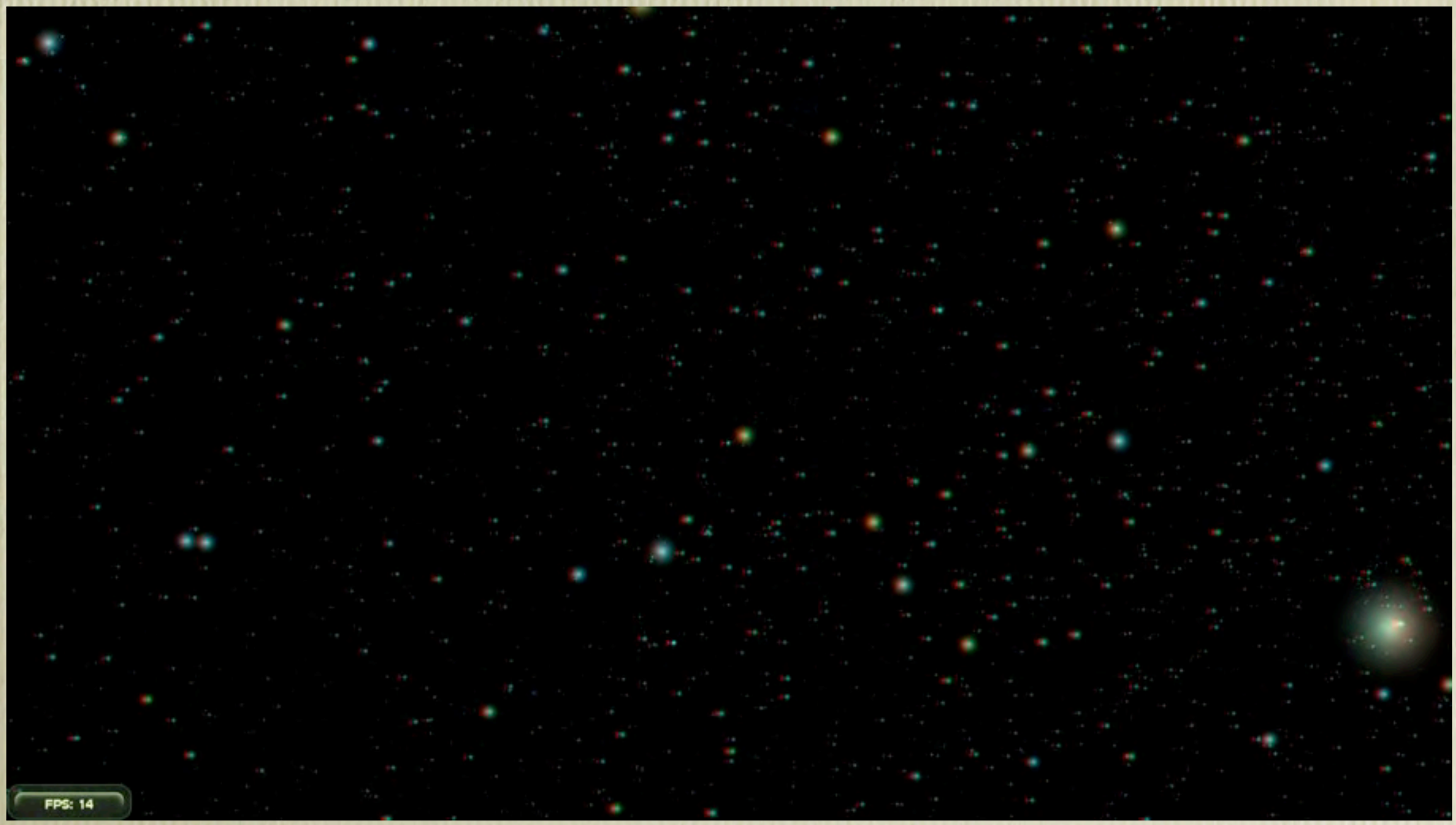
2D and 3D navigator

Sun seen from the back side of the Hyades



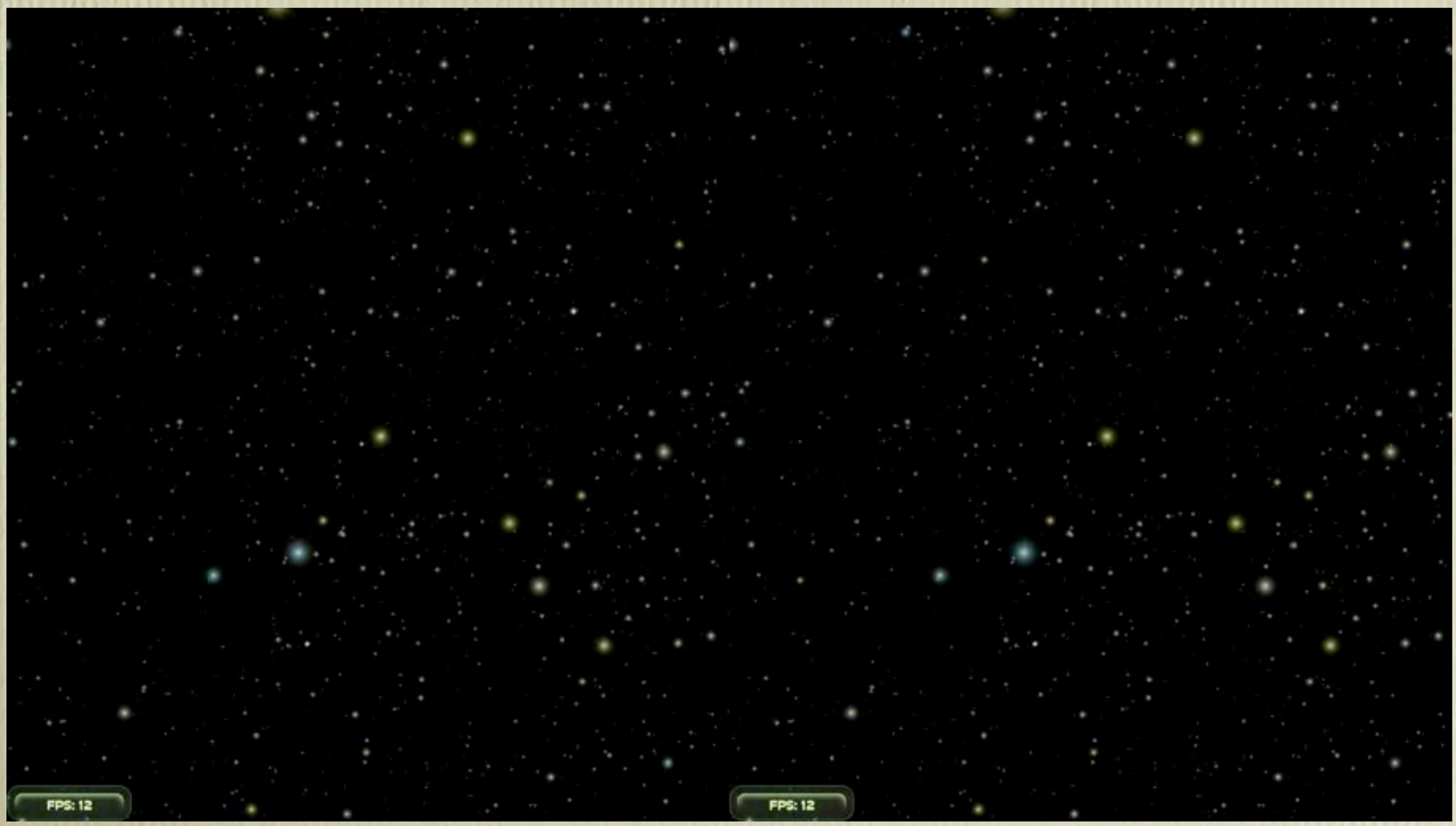
For free: Stereo 3D navigator

3D: red + cyan anaglyph



For free: Stereo 3D navigator

3D: full colour side by side

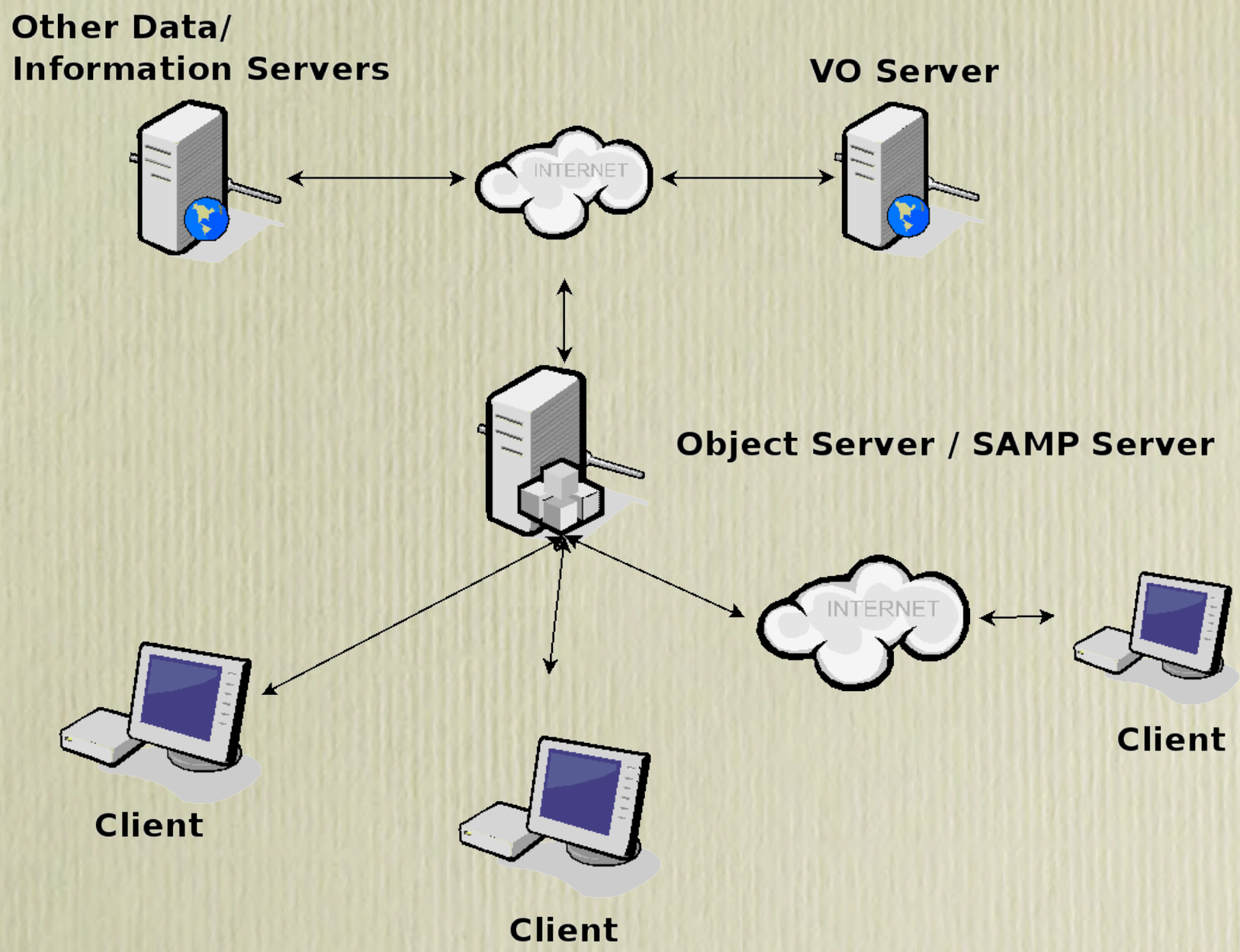


+ interlaced, dual head

Architecture

- Client/Server with some P2P
- Modular/Plugin based architecture: everything is a plugin
- Clients handle visualization
- Object server handles data pre-processing

Architecture



Architecture: Client

- Client, feature driven

Basic

- Display 3D point data
- Selecting data in 2D
- Display volumetric models
- Display 4D point data (Position@Time)

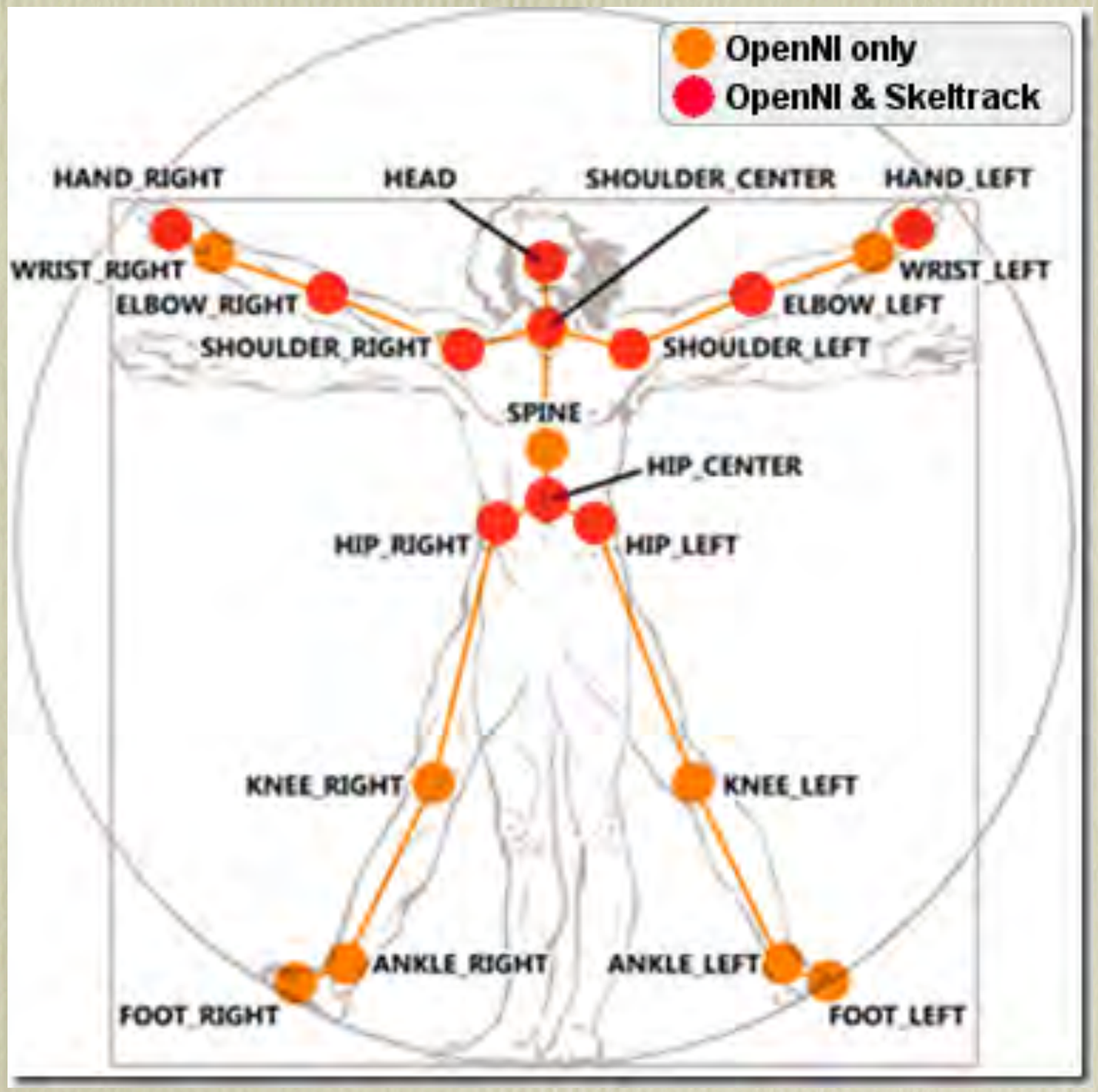
full

- Selecting data in 3D (Kinect™ / LEAP™)
- Support 3D display technologies
- Peer-2-Peer communication

(3D) interfaces

- Support mouse, keyboard, joystick, multitouch, kinect, leap…
- Depth sensor (Kinect and LEAP) are implemented as an abstraction of Multi-Touch
- Kinect is based on Joint movement
- LEAP is based on Finger movement
- In essence Kinect is better for presentations and LEAP better for desk based work

(3D) interfaces



Architecture: Server

- Also based on a Modular/Plugin based architecture (plug new functionalities)
- Data preparation
- Virtual Observatory (queries and table handling, SAMP)

- Data cache
- Volumetric object generation
- Communication hub / cloud storage

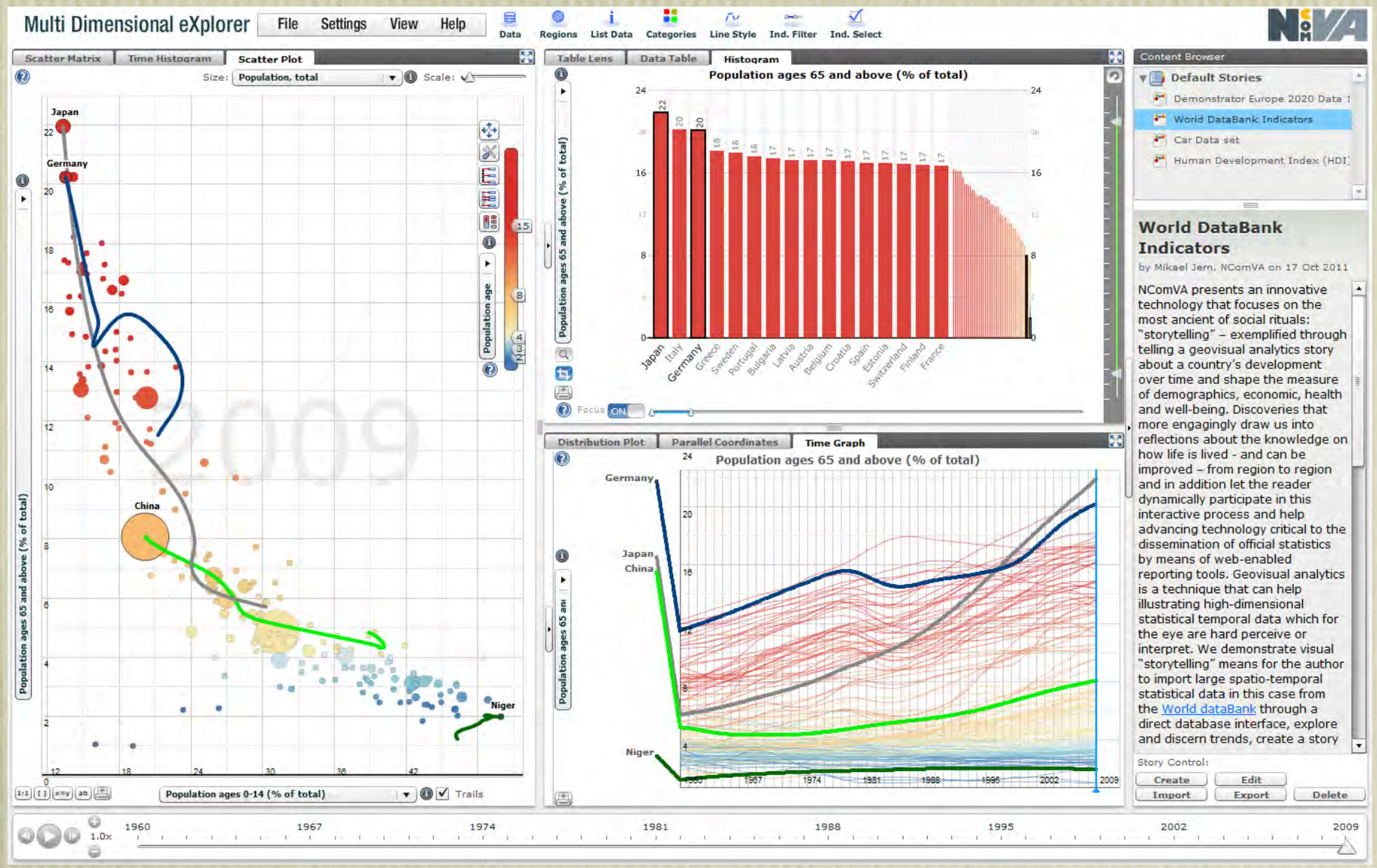
Architecture: Server

- Multi-threaded
- Shared cache pool
- API supports Text or Protocol Buffers
  - Text used primarily for communication
  - ProtoBuf is used primarily for data

Towards 2022

Collaborative visualisation

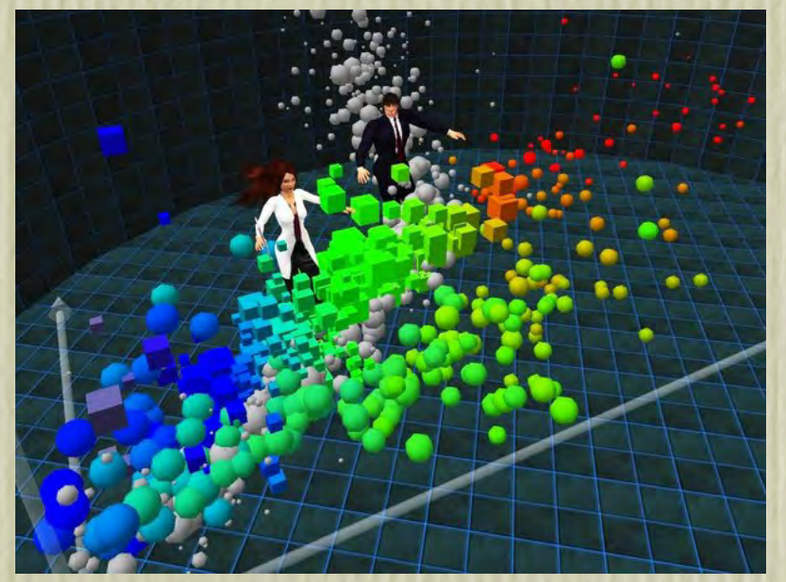
GAV Flash - Story telling



Visualise, analyse, collaborate, annotate, click-to-publish on the web

Collaborative visualisation

MICA - Meta Institute for Computational Astrophysics (SL/OpenSim)



Immersive data exploration and interaction

Seminars.

(With the family tree of variable astronomical sources by Eyer & Molawi !)