ESA Science Archives Architecture Evolution

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Science Archives Team
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Outline

- Introduction: ESA Science Archives

- Archives Architecture Evolution
  - User Interfaces and the Web 2.0
  - Application Frameworks
  - Databases, Spatial Indexing and Big Data

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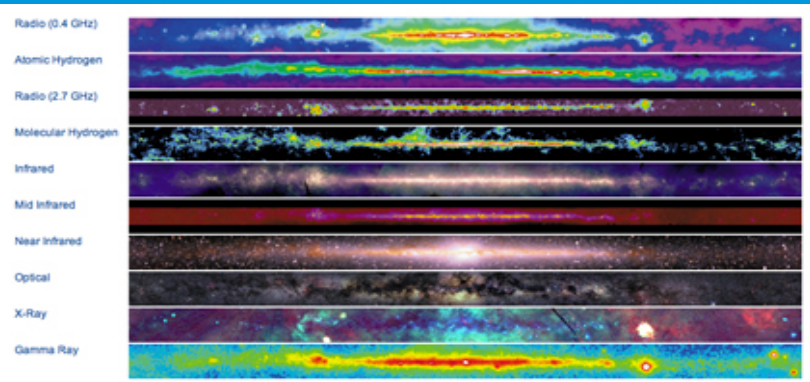
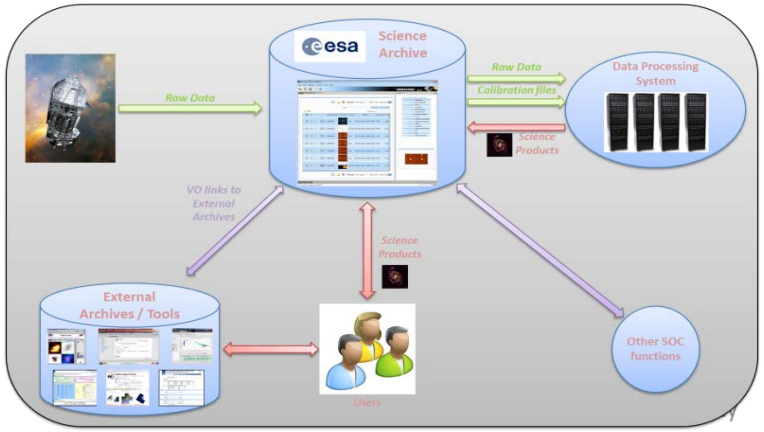
ESAC Science Archives Strategy

- Large set of science archives co-located at ESAC are a major research asset for community.
- Need to be kept readily available for future users and novel uses.
- Thus, must plan now for next 5–20+ years.
- Planning based around 3 major goals:
  - Enable maximum scientific exploitation of data sets,
  - Enable efficient long-term preservation of data, software and knowledge, using modern technology
  - Enable cost-effective archive production by integration in, and across, projects.

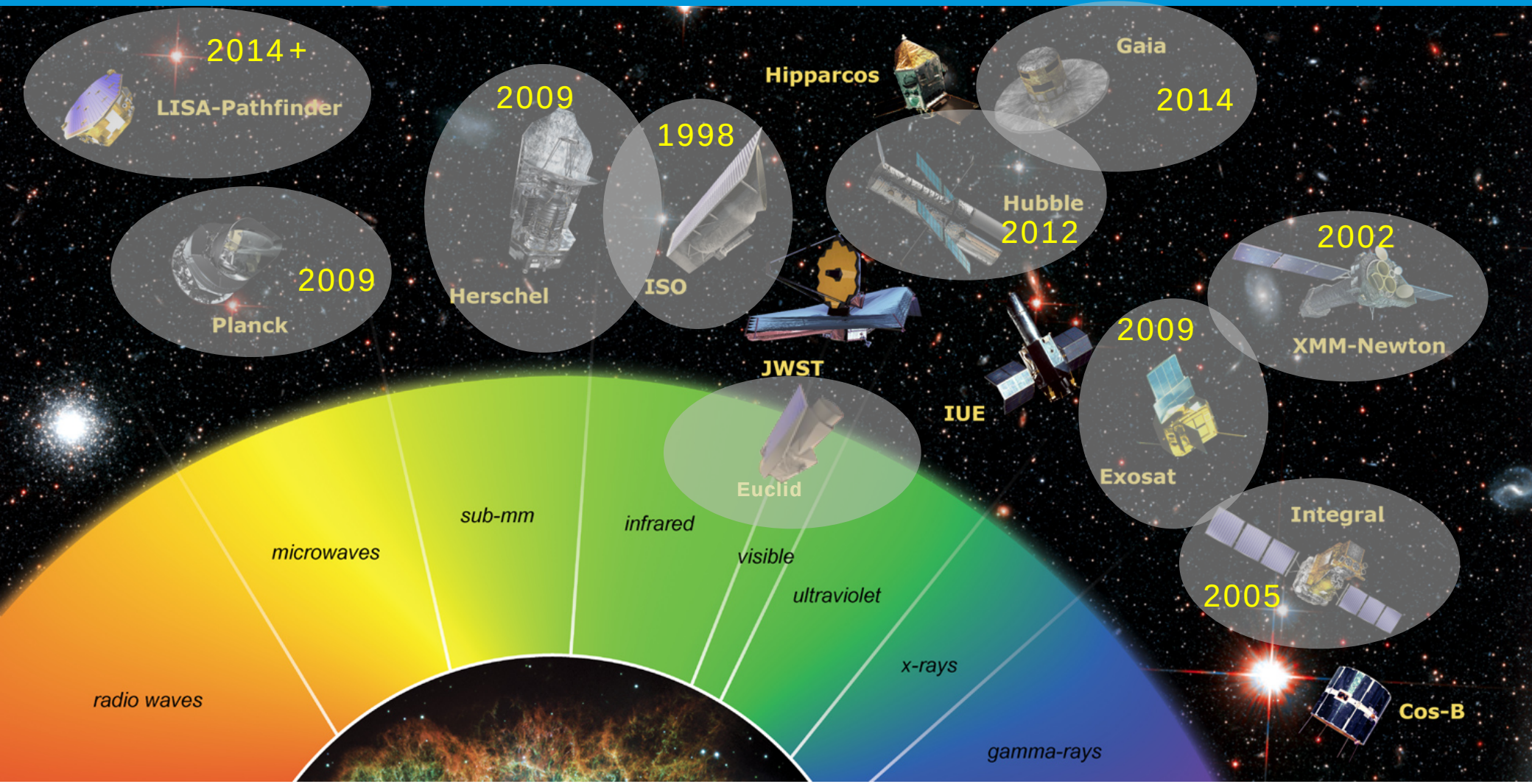




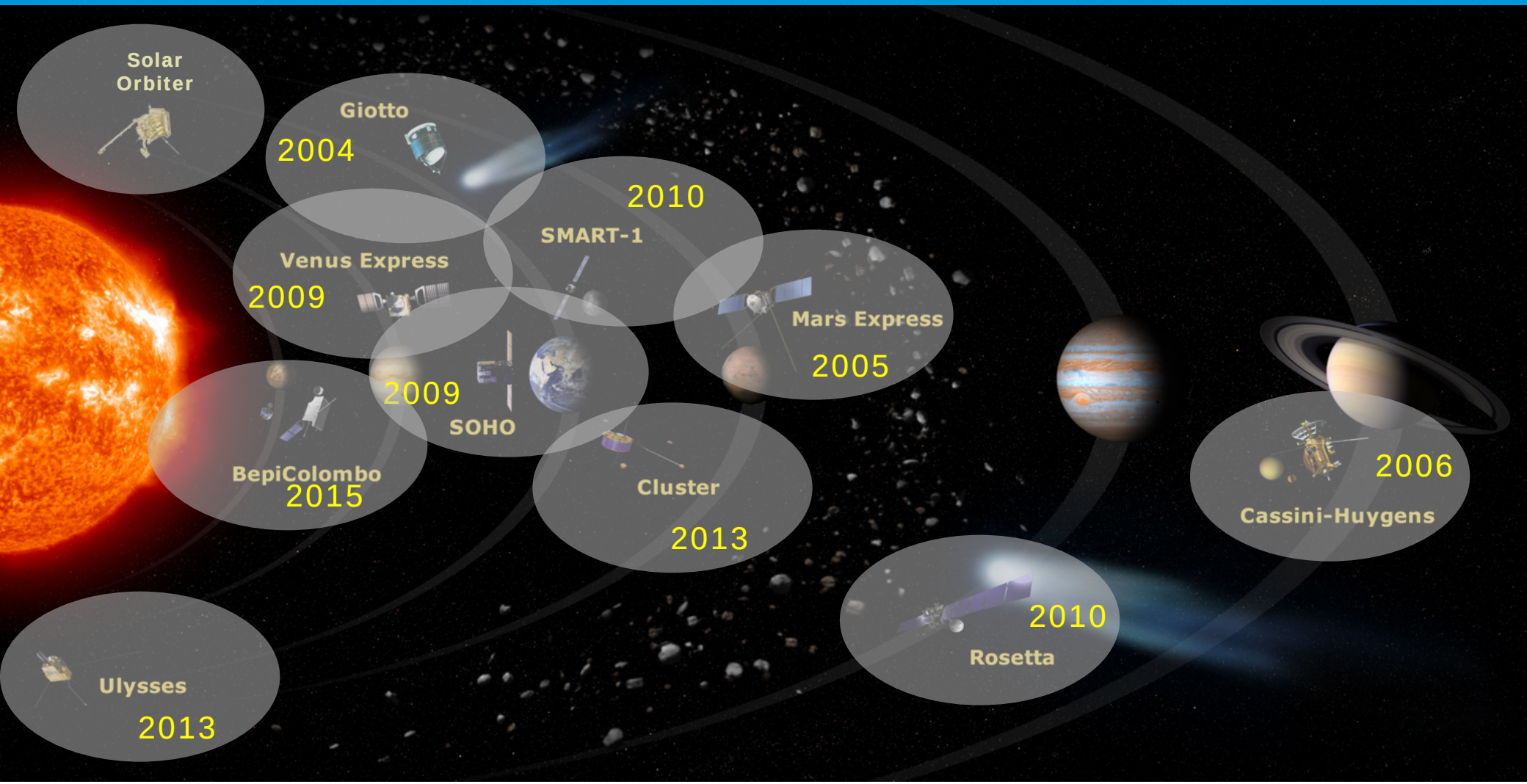
Introduction: ESA Science Archives

- Different types of
  - Missions: Astronomy, Planetary, Solar System, ...
  - Data: Raw data, calibrated processed data, high level data products, ...
  - Users:
    - Scientific Community (public access)
    - PI team and observers (controlled access)
    - Science Operations Team (privileged access)
- Common Architecture and Look and Feel
  - Better corporate image for ESA

ESA Science Archives - Astronomy

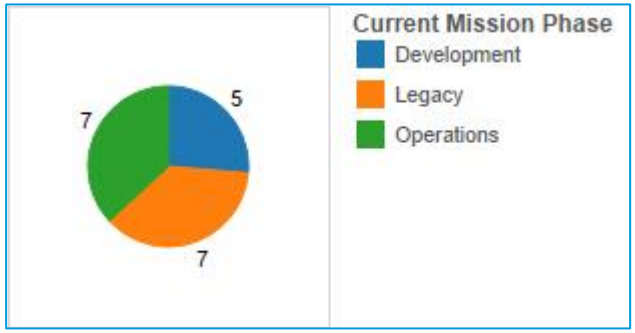


ESA Science Archives – Planetary & Solar System



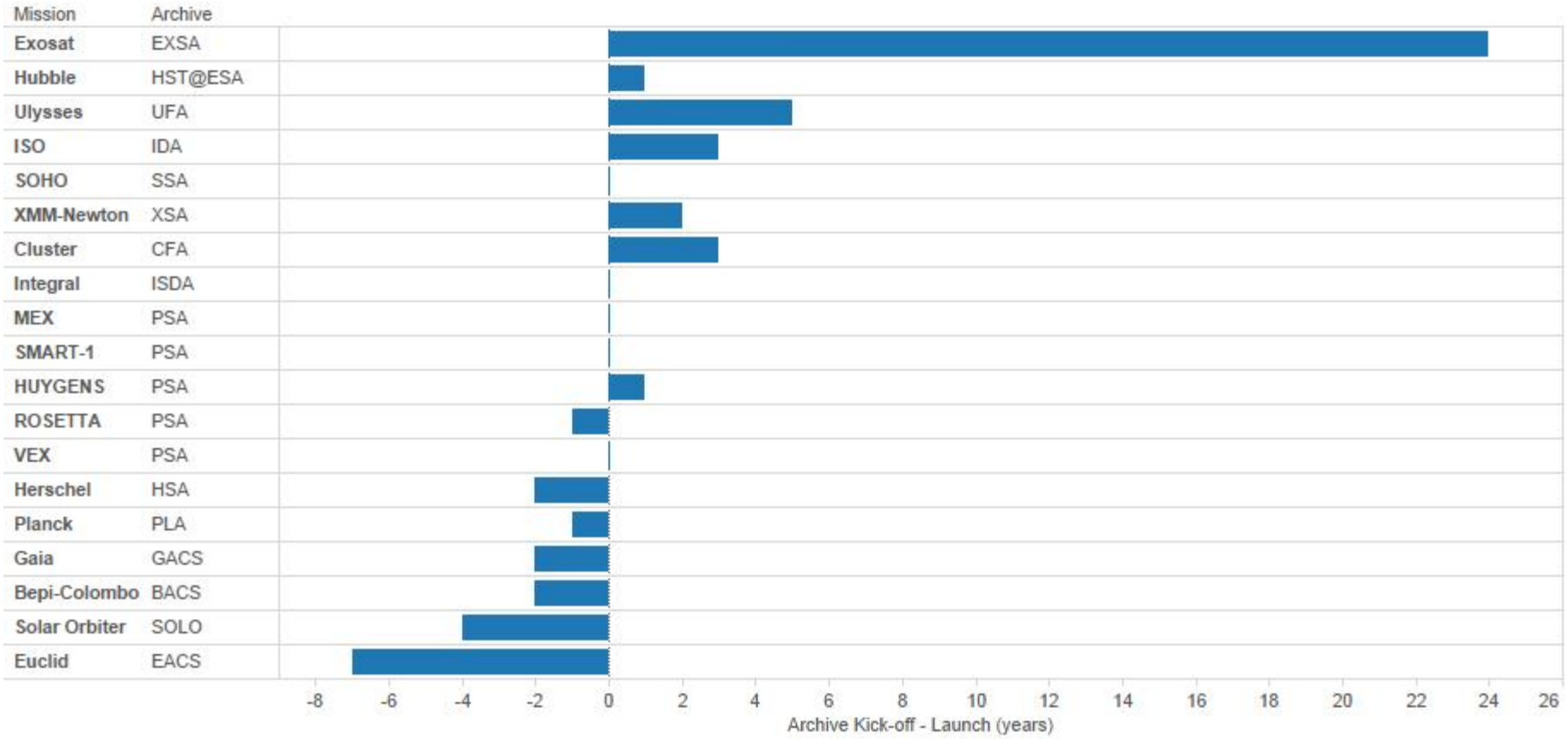
ESA Science Archives - Mission Phases Support

- ESA Science Archives support missions in different phases
  - Development
  - Operations (EOP, CP, PVP, SDP, RP...)
  - Post-operations and Legacy Archive



- Early start of archiving activities within the mission phases

Archive Kick-off vs Launch



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ESA Science Archives Architecture Evolution

- Technology has evolved enormously since 1998.
- Also, new and heterogeneous requirements had to be addressed:
  - Different mission types: multi-wavelength astronomy, solar and planetary
  - Increasing number of archives
  - New network and security policies
- That resulted into 3 different generation of archives:

• **ISO** Data Archive
• **INTEGRAL** Science Data Archive
• Planetary Science Archive
  • **MEX**
  • **VEX**
  • **ROSETTA**
  • **HUYGENS**
  • and others
	• **SOHO** Science Archive
	• **EXOSAT** Science Archive
	• **Planck** Legacy Archive
	• **Herschel** Science Archive
	• **Cluster**
		• **Ulysses** Final Archive
		• **XMM-Newton** Science Archive
		• ESA **Hubble** Science Archive
		• **Euclid**
		• **GAIA**
		• **Solar Orbiter**
		• **Bepi Colombo**

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User Interfaces and Web 2.0

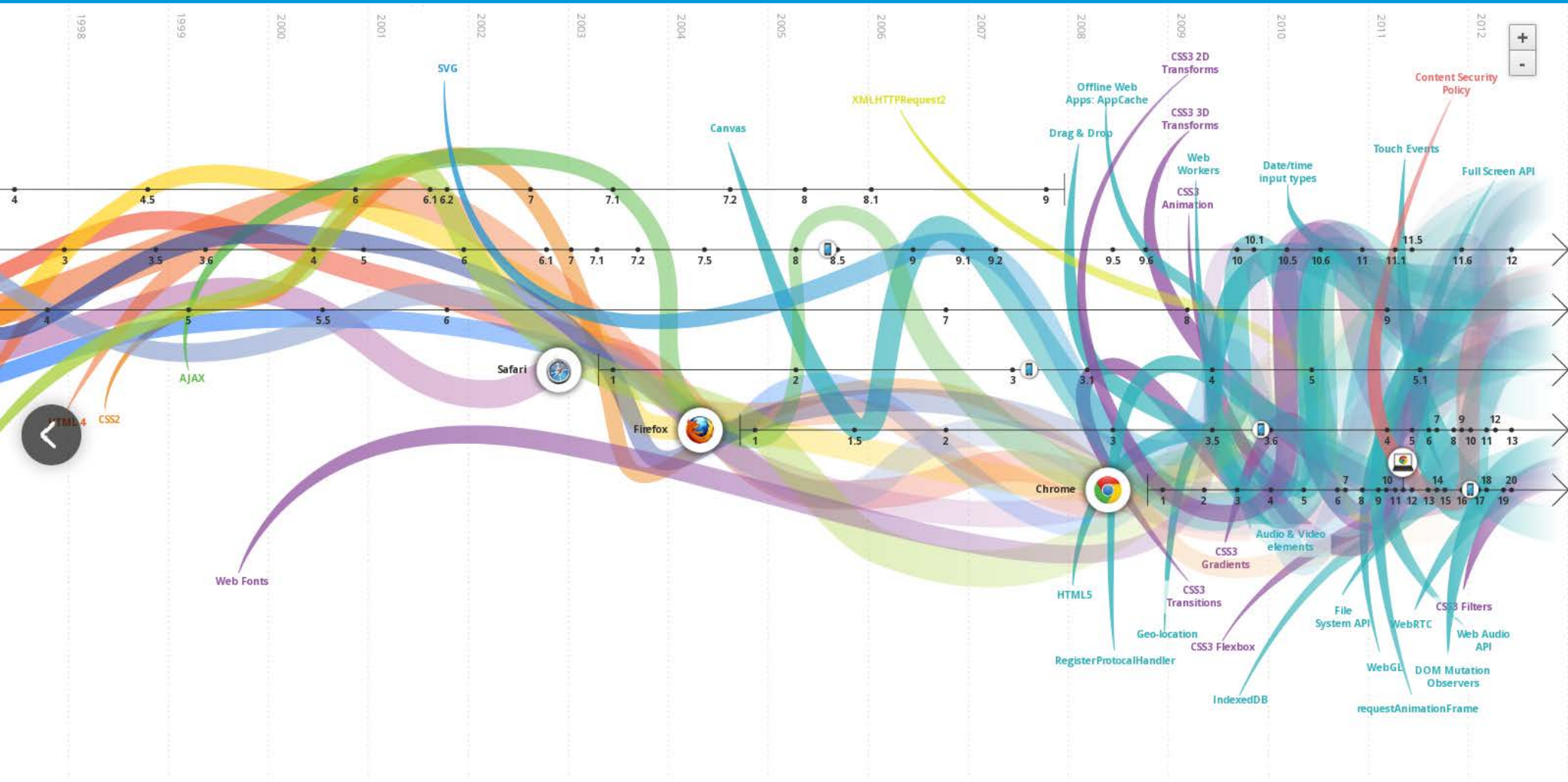
- **Year 1998**: First generation of ESA Science Archives (ISO)
  - HTML 3, Netscape and IE
  - Web could not satisfy user requirements
    - visualization
    - dynamic content
  - Small and dynamic applications could run from a browser using plug-ins
    - Flash, Java Applets

- **2006**: Second generation of ESA Science Archives (SOHO, EXOSAT,..)
  - Java Applets replaced by Java Web Start Technology (JNLP)
  - Desktop application
  - Java Version updating and Pack200 compression
  - Security enhancements

User Interfaces and Web 2.0

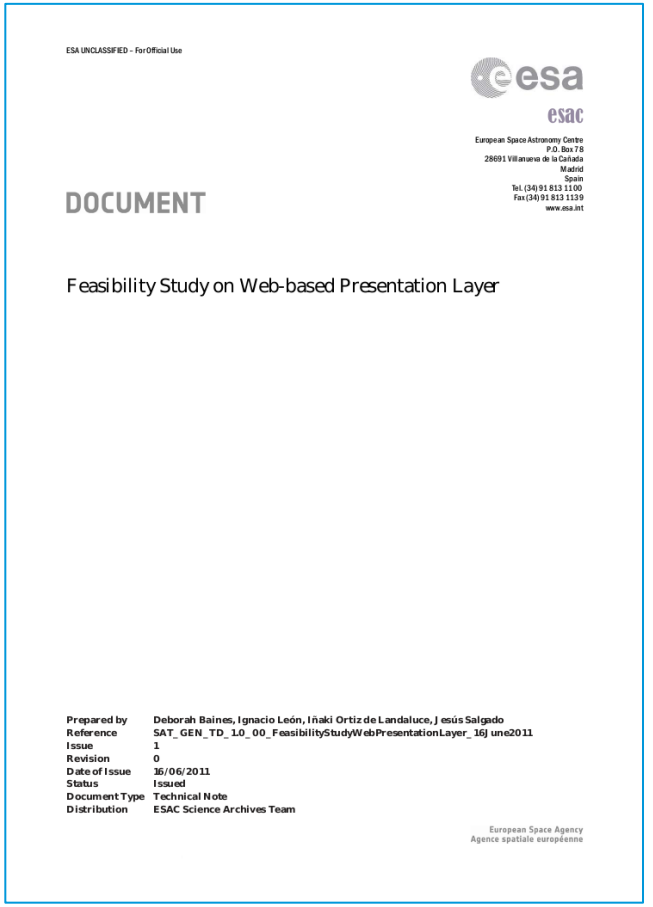
- **The web revolution**: From Dot-com to Web 2.0 and beyond
  - Fully-featured dynamic contents (HTML5, CSS3, AJAX)
  - Video and Audio support
  - No plug-ins required
  - 2D/3D Graphics Rendering (WebGL)
  - Ubiquity, The Web becomes social

User Interfaces and Web 2.0



User Interfaces and Web 2.0

- **2011:** Third generation of archives kick-off
  - Feasibility study to implement Web-based Archive User Interfaces
    - Web-based technologies assessment
    - Impact on current ESA Archives Architecture
    - SWOT Analysis
    - Analysis of existing web-based archives: HEASARC, CDS ASDC, ISDC, Spitzer, Hubble, CADC, ESO, PDS, SDSS
  - GWT is the selected technology
    - Small learning curve for Java developers
    - Long Term Support expected (it's Google)
    - Wide community
- **2013:** Release of first web-based ESA Science Archives
  - Ulysses Final Archive
  - XMM-Newton Science Archive



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DOCUMENT

Feasibility Study on Web-based Presentation Layer

Prepared by	Deborah Baines, Ignacio León, Iñaki Ortiz de Landaluce, Jesús Salgado
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European Space Agency
Agence spatiale européenne

User Interfaces Evolution

1st Generation

- Applet
- Java 1.1+ Abstract Window Toolkit
- In-house RPC connection through TCP/IP

2nd Generation

- Web Start
- Java 1.5+ Java Swing, JGoodies
- spring
- Inter-operability

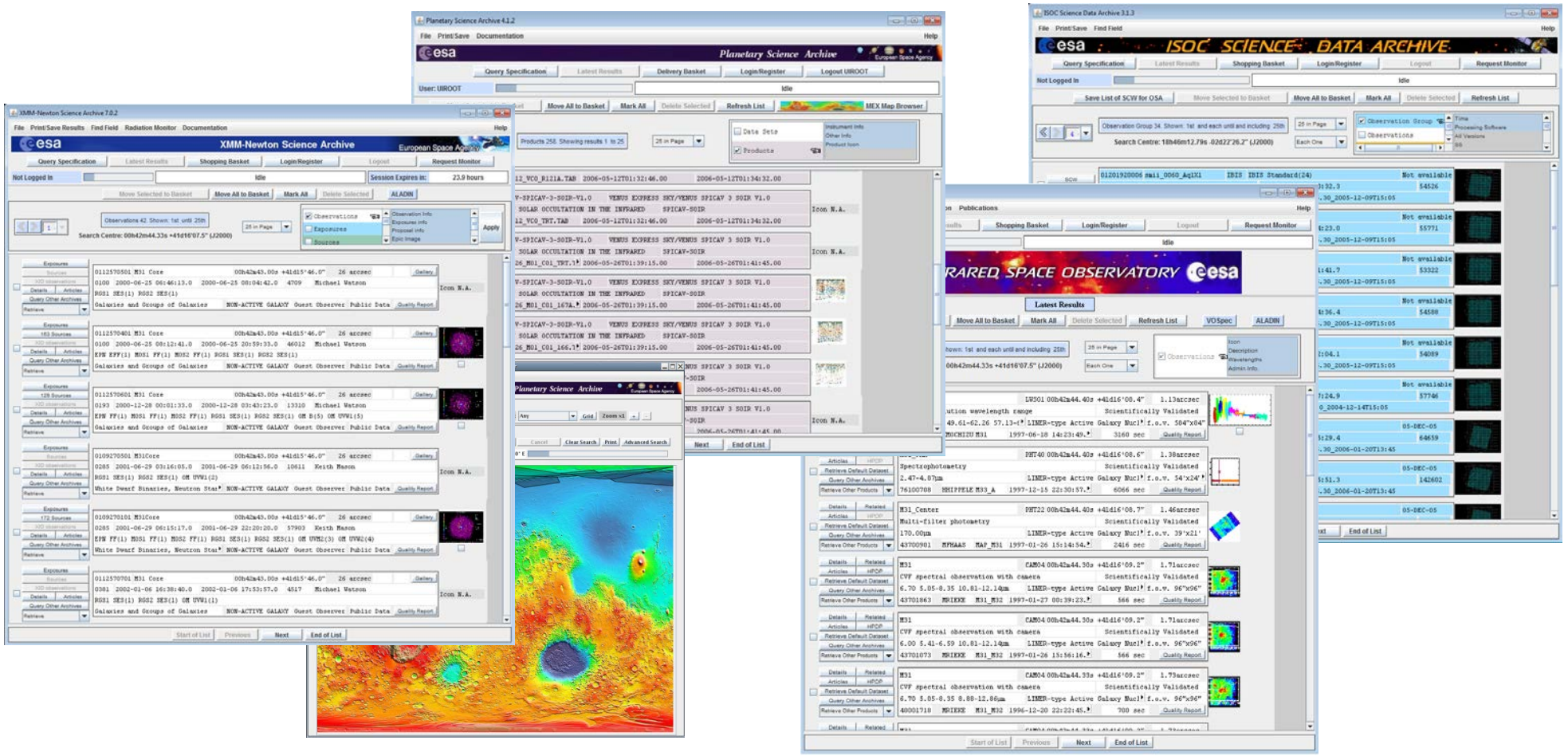
3rd Generation

- Web based
- G
- HTTP
- Inter-operability (Web Profile)

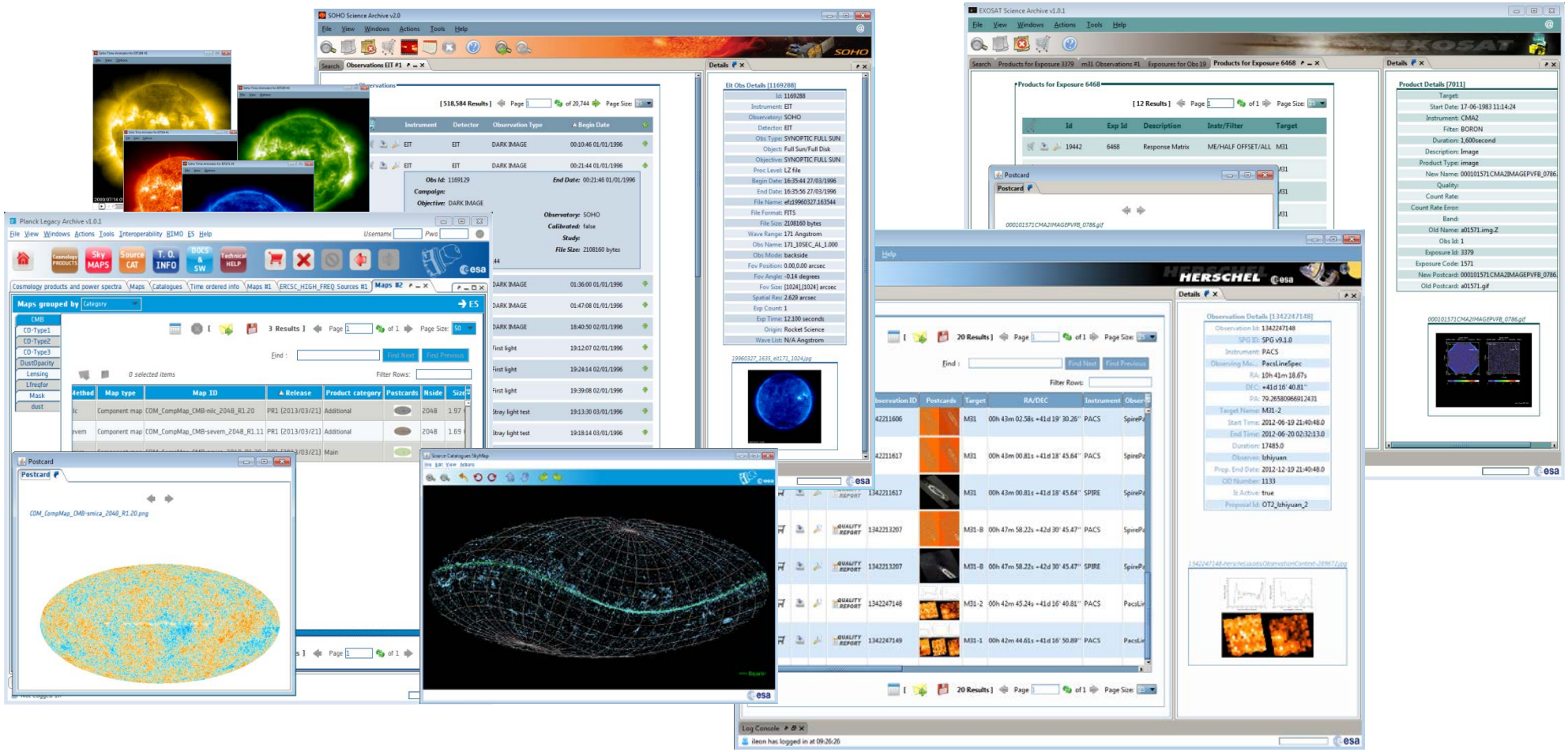
In Progress

- WebGL
- Enhanced visualization tools

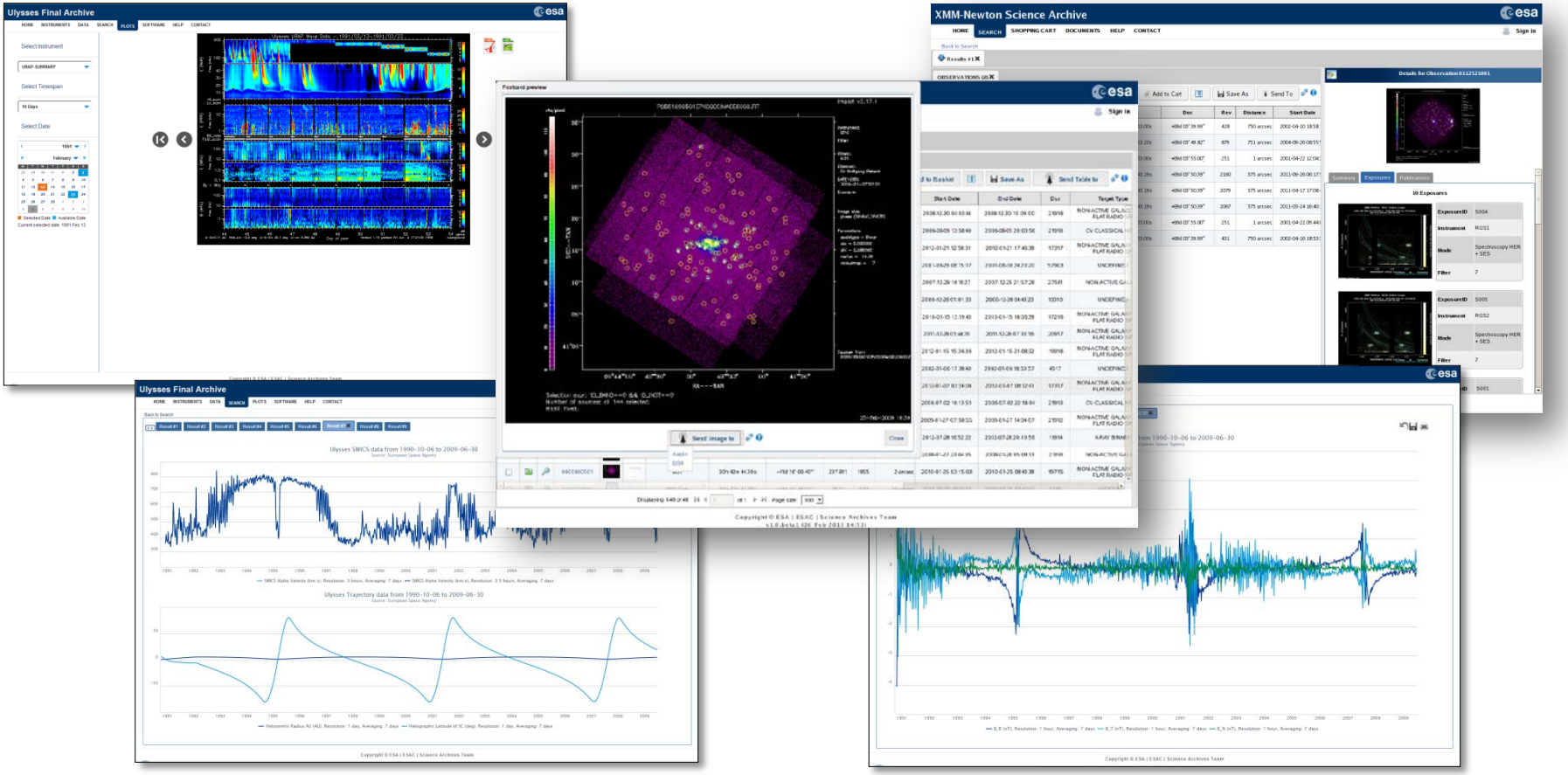
User Interfaces - 1st Generation of ESA Science Archives – Applets



User Interfaces – 2nd Generation of ESA Science Archives – Java Web Start



User Interfaces – 3rd Generation of ESA Science Archives – Web applications



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Application Frameworks

1st Generation

- In-house developed java server in non standard ports
- In-house RPC connection through TCP/IP
- In-house developed load balancing
- File retrieval through port 21
- VO data access protocols (SIAP, SSAP, SLAP)

2nd Generation

- Apache
- spring
- Use of standard ports and protocols
- File retrieval through port 80

3rd Generation

- Single software in servlet container
- HTTP

In Progress

- High availability
- Load balancing
- + VO compatible interfaces (TAP, VOSpace)

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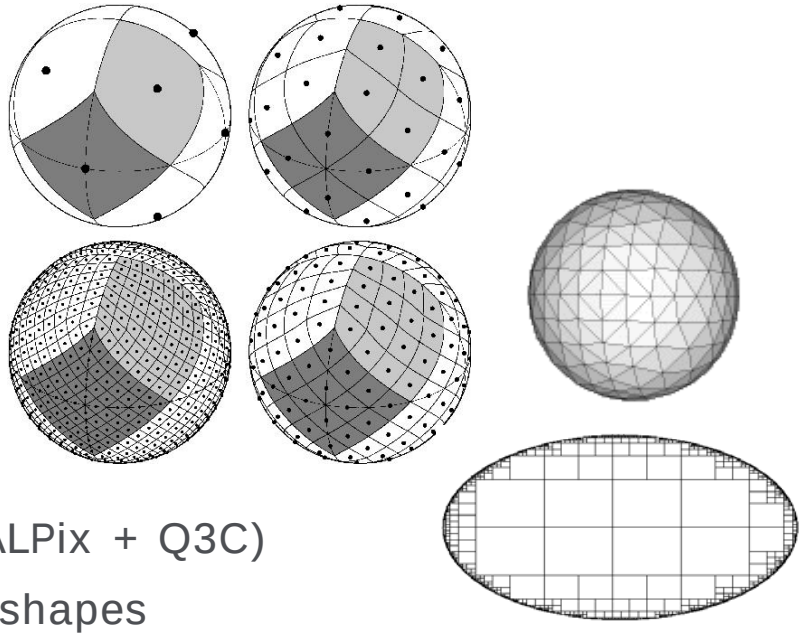
Databases

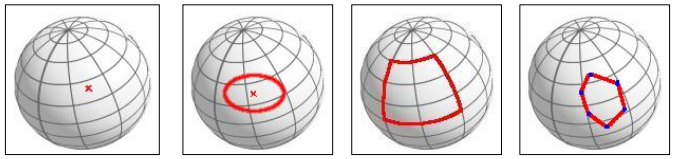
1st Generation	2nd Generation	3rd Generation (In Progress)
SYBASE, ORACLE	PostgreSQL	Postgres-XC, Greenplum
JDBC Access	HIBERNATE	hadoop, HIVE
In-house developed connection pooling	Standard connection pooling (c3p0)	High Availability
Non standard, ad-hoc pagination	Standard Pagination (Hibernate + Postgresql)	
	EHCACHE	
	Spatial indexing (q3c, h3c, pgSphere)	

Spatial Indexing

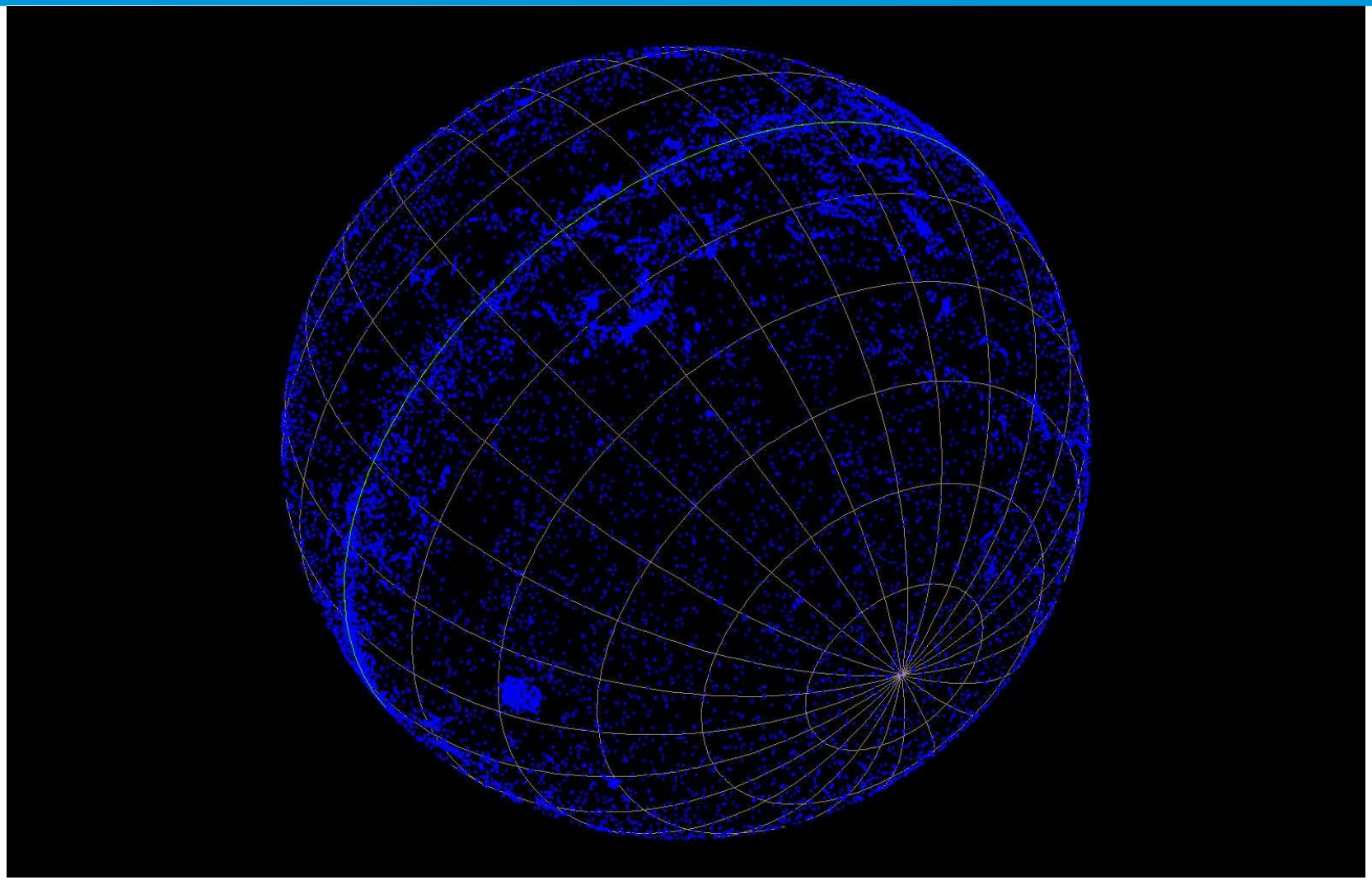
- Allows better performance on complex geometrical queries
  - Cone-Search, X-Match
  - Complex FOV overlap operations
- Avoids squaring ROI and post-processing overhead
- Some Sky-Pixelation schemas
  - HEALPix: Hierarchical Equal Area Iso Latitude
  - HTM: Hierarchical Triangular Mesh
  - Q3C: Quad Tree Cube



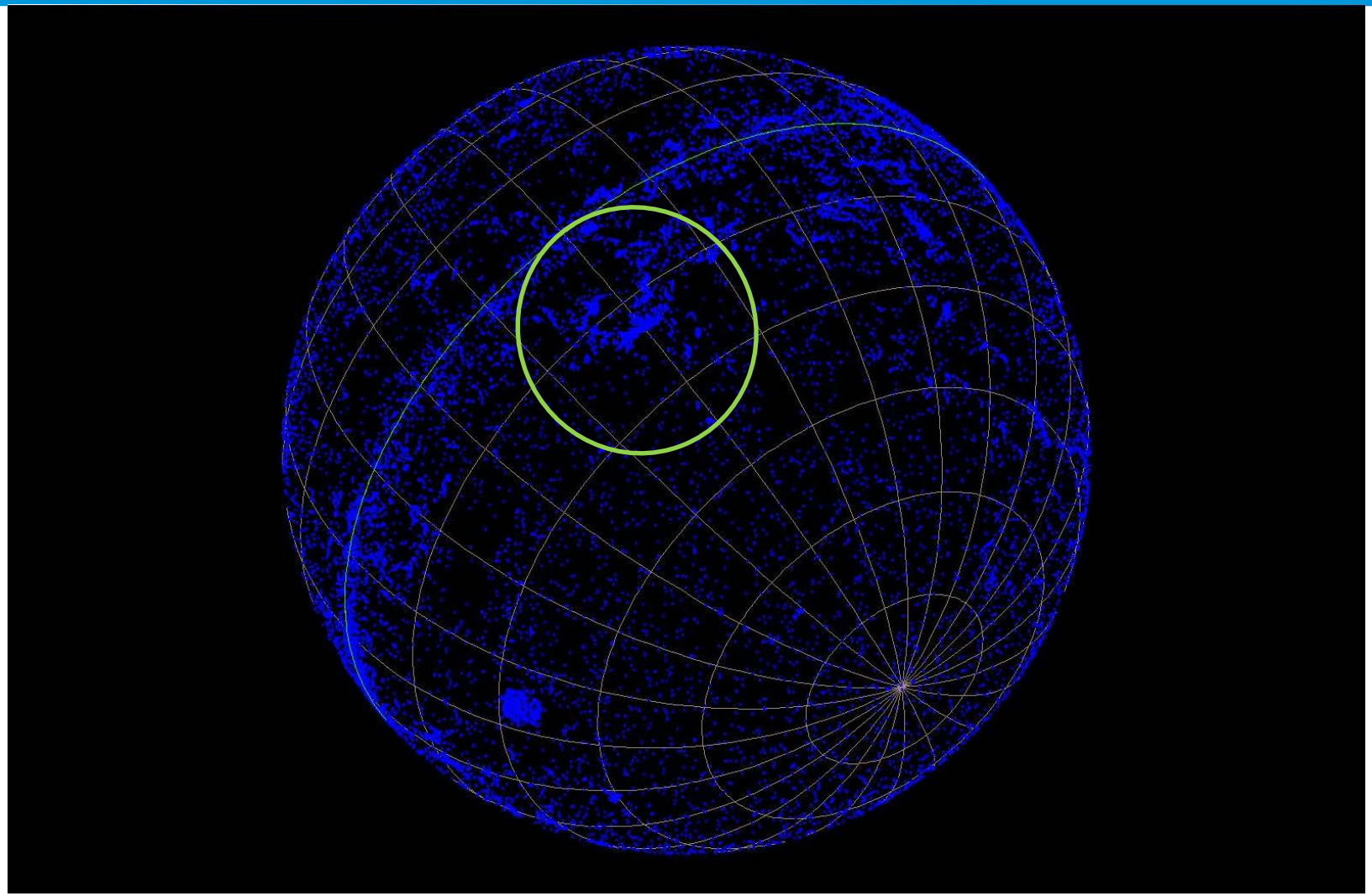
- PostgreSQL Plug-ins: PgSphere, Q3C and H3C (HEALPix + Q3C)
  - Database manages Geometrical operators and shapes
  - FOVs of stored observations are pre-computed



Spatial Indexing



Spatial Indexing



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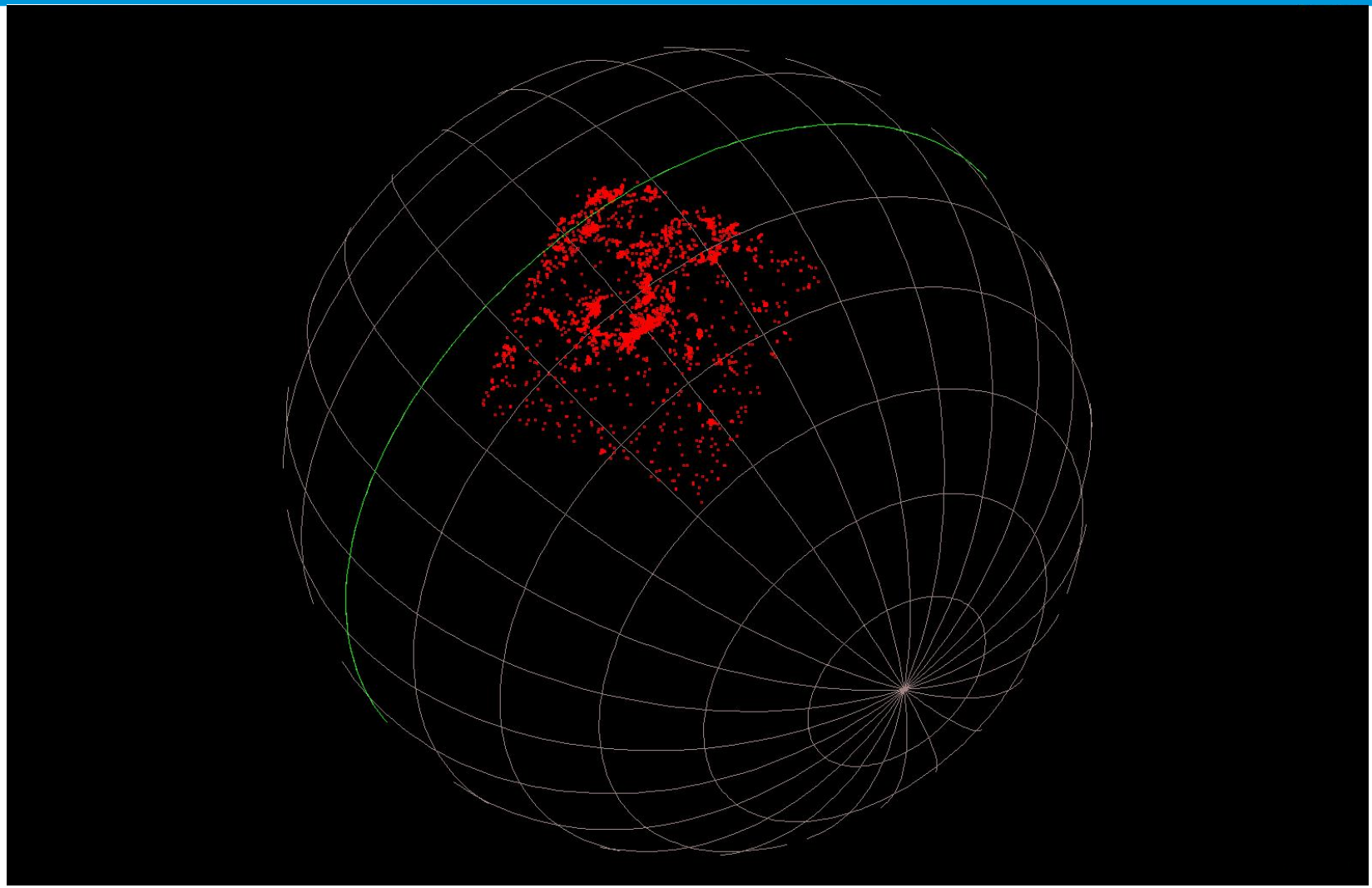

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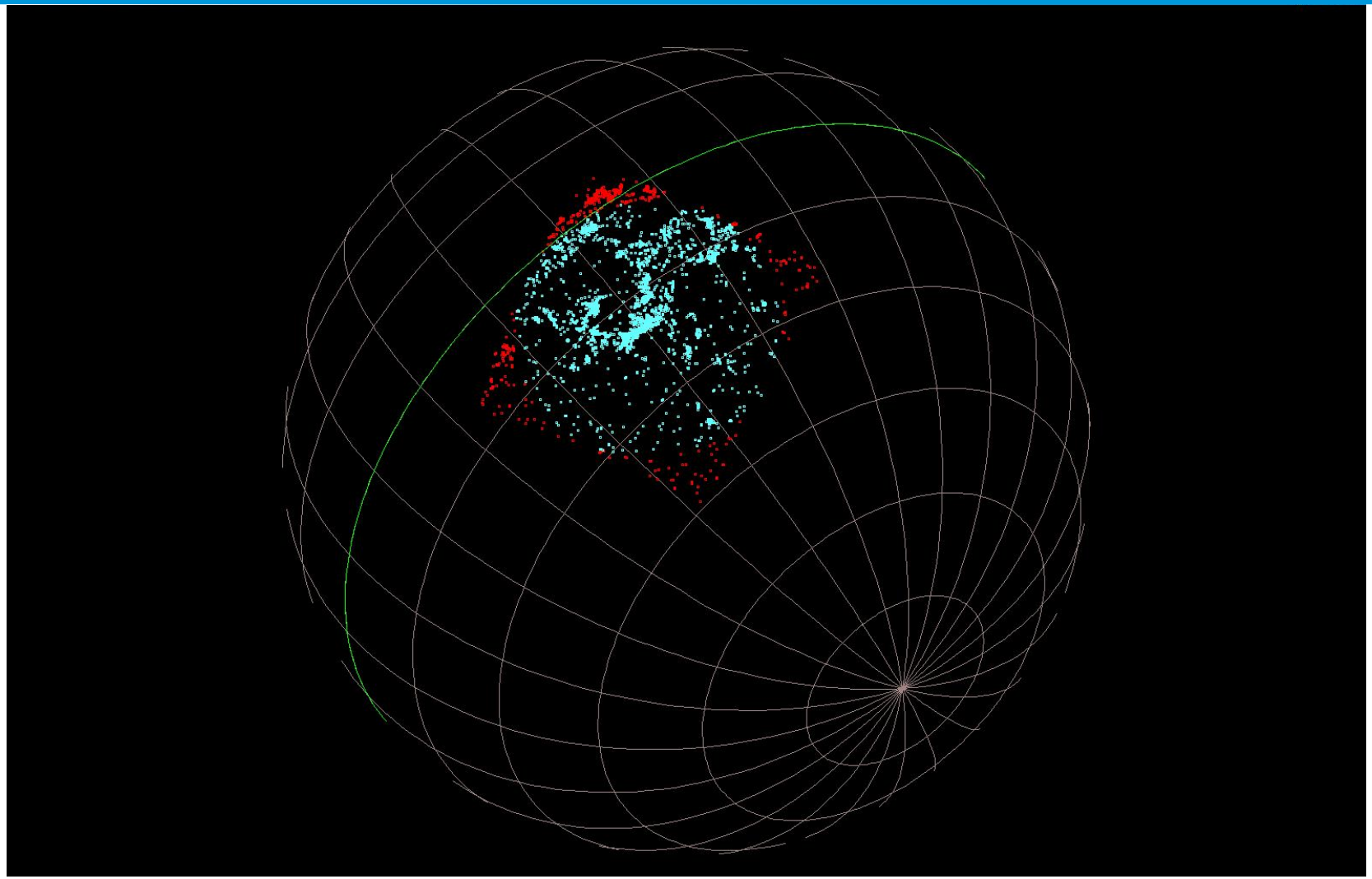
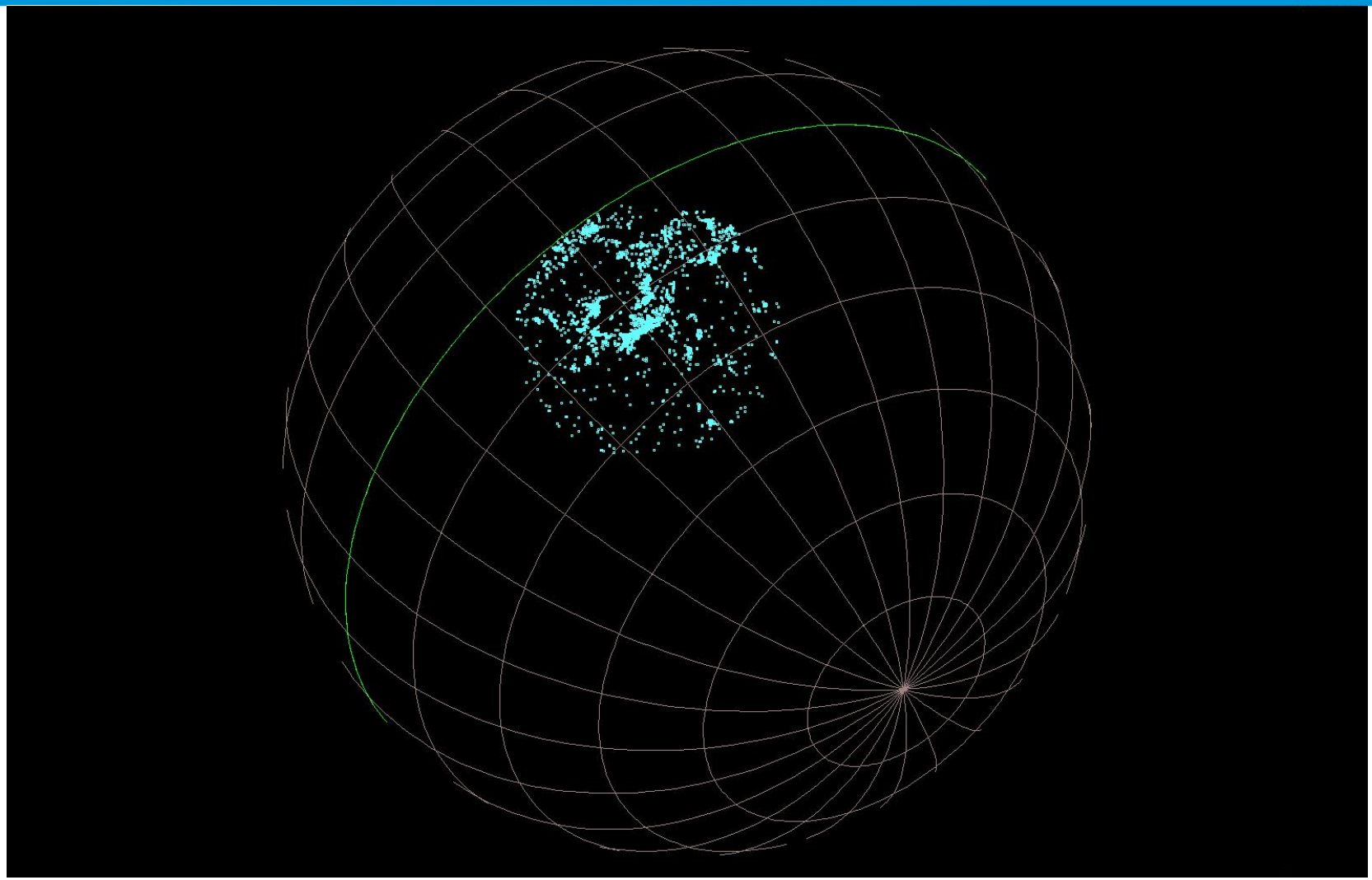
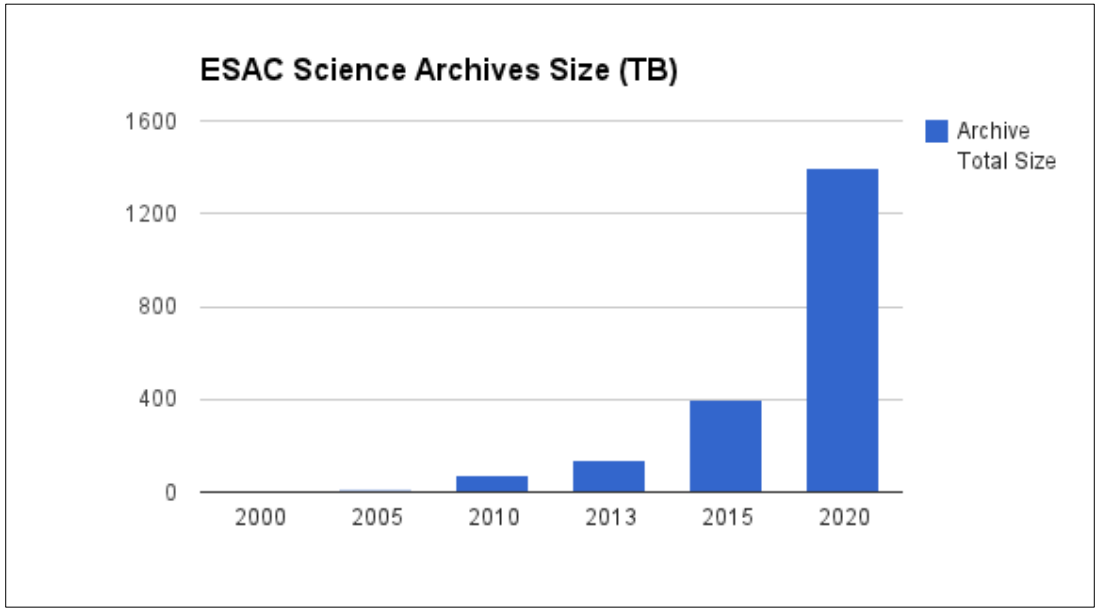


Spatial Indexing



Big Data

- ESA Science Archive data volume increasing exponentially



Big Data

- ESA Science Archive data volume increasing exponentially
- GAIA:
  - 1 billion sources
  - GUMS catalogue (synthetic) ~2 billion sources
  - Map-Reduce paradigm applied to PostgreSQL RDBMS
  - Hadoop cluster for advanced applications
  - Some numbers
    - Positional + Magnitude X-Match
      - GUMS Stellar Sources Catalogue ~2 billion sources
      - Fuzzy Synthetic Catalogue ~100 million sources
      - **1 degree radius, 9 seconds**

Query:

```
SELECT g.*, m.*, f.* FROM g10_ss_noclust AS g, test_xmatch_table AS m,
g10_fuzzy_100000000 AS f
WHERE g.source_id=m.g10_id AND m.id=f.source_id
AND g.source_id IN (
     SELECT g10_id FROM test_xmatch_table WHERE id = f.source_id
     ORDER BY (dist+mag_diff) ASC LIMIT 1
)
AND g.pos @ scircle'<(266.41683d, -29.00781d), Rd>'
```

Service times – Interactive Query

	GACSDB01 - fresh	GACSDB01 - cached	Output size
R=0.1d	3.7 s	96 ms	100 rows
R=0.5d	3.4 s	84 ms	100 rows
R=1d	4.4 s	148 ms	100 rows

Service times – Full output

	GACSDB01 - fresh	GACSDB01 - cached	Output size
R=0.1d	7 s	198 ms	372 rows, 428 KB
R=0.5d	150 s	2.2 s	9628 rows, 11 MB
R=1d	678 s	8.6 s	44210 rows, 50 MB

Big Data

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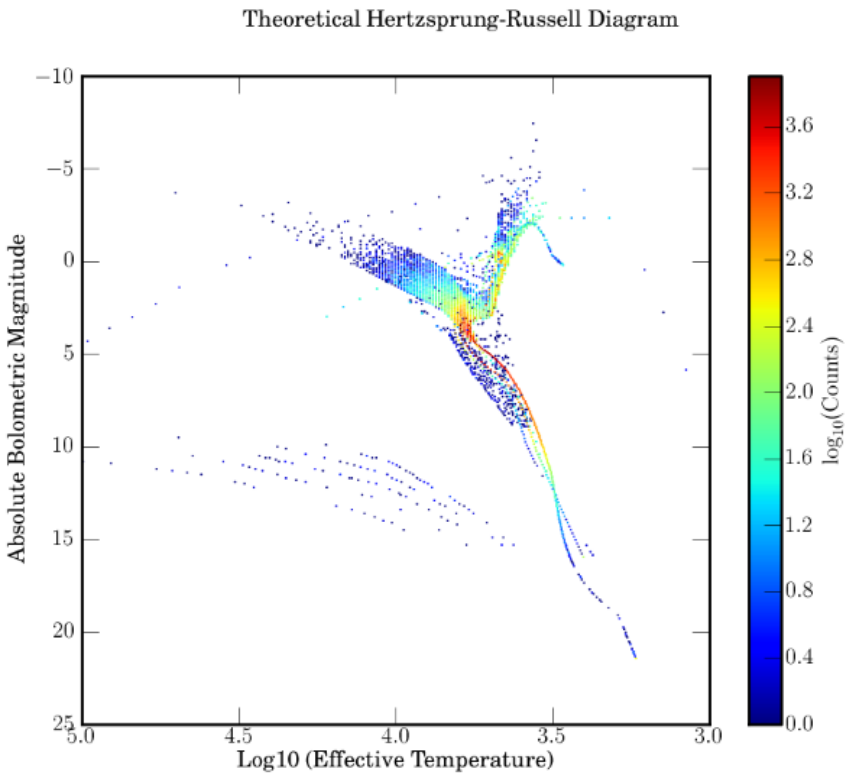
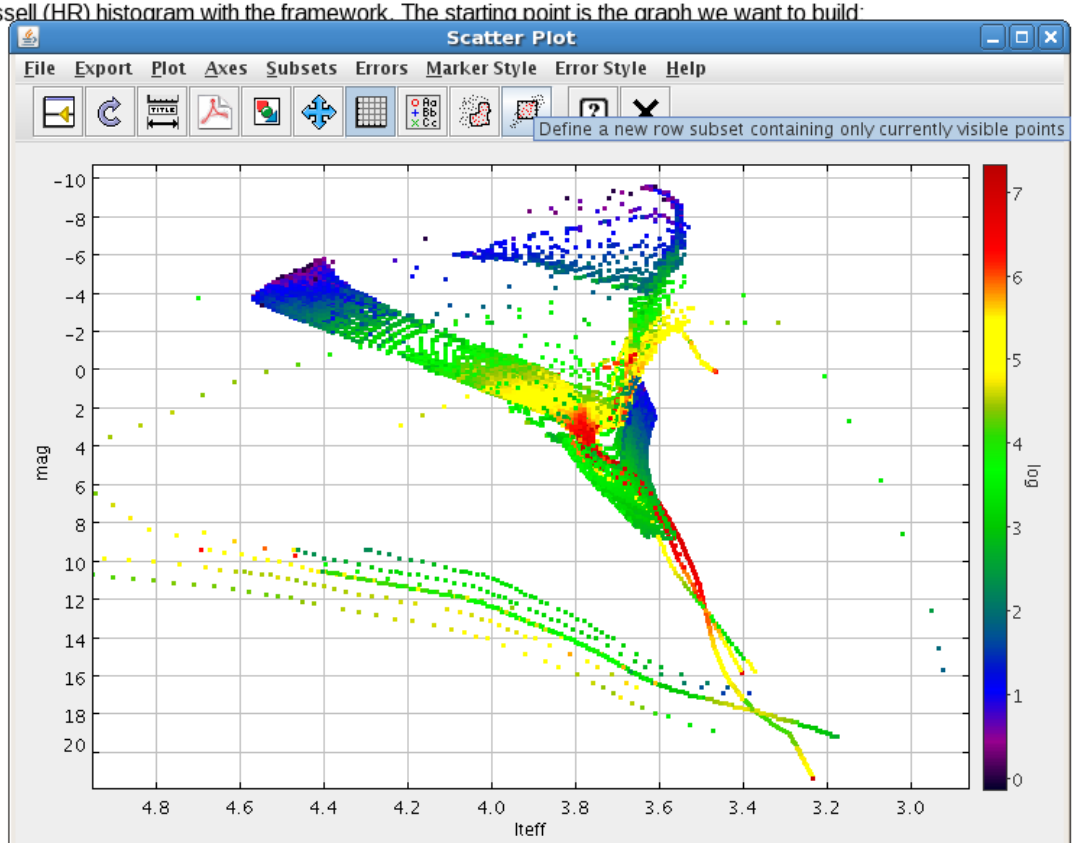
      - **1 degree radius, 9 seconds**
    - H-R Diagram, Full GUMS catalogue
      - **30 minutes**

Theoretical Hertzsprung-Russell histogram example

In this section, we will go through the steps needed for computing a theoretical Hertzsprung-Russell (HR) histogram with the framework. The starting point is the graph we want to build:





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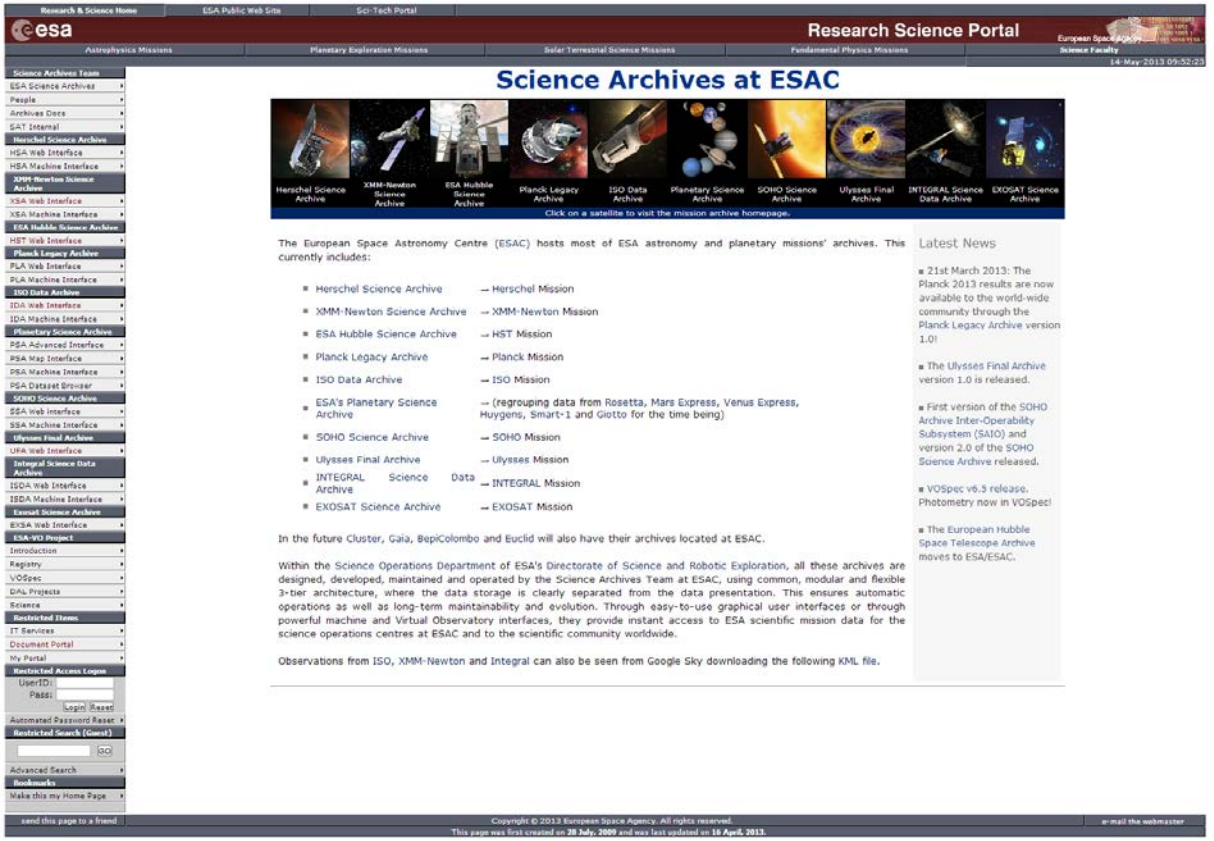

THANK YOU

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