Visualisation of radio data cubes using SODA, as preparation for the SKA archive

Ixaka Labadie García, Lourdes Verdes-Montenegro, Julián Garrido

IVOA November 2023 Interoperability Meeting

Instituto de Astrofísica de Andalucía

(IAA-CSIC)

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Contents

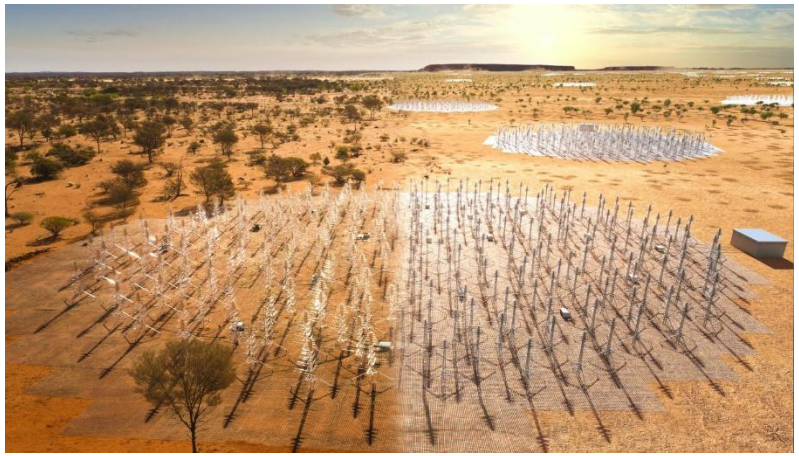
- Motivation
- 3D models
- Scientific archive
- Remote visualisations
- Summary

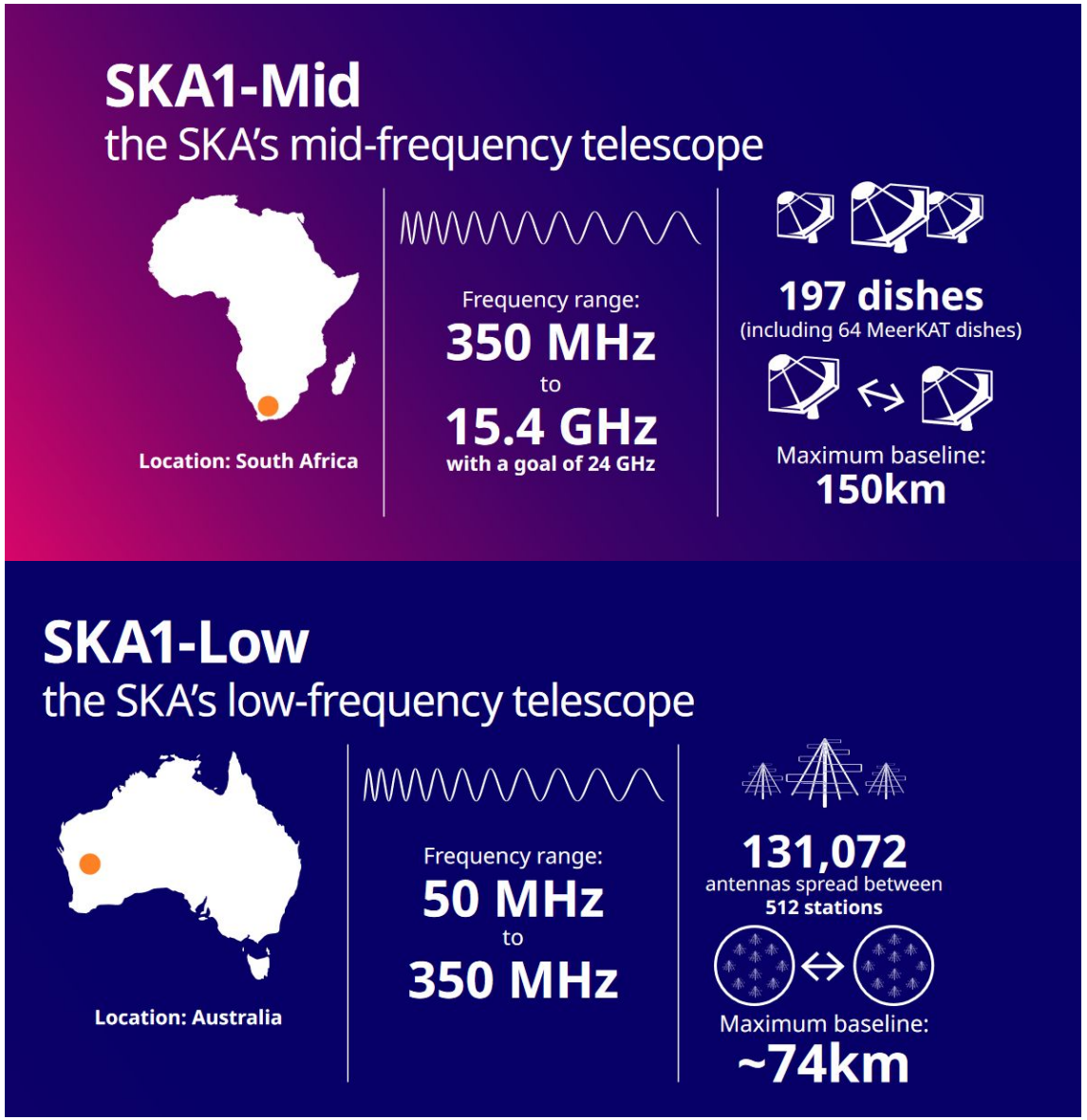
SKAO

SRC | Net

SKAO Regional Centre Network

esp | SRC





SRC | Net

SKAO Regional Centre Network

esp | SRC

SKA1-Mid
the SKA's mid-frequency telescope

Location: South Africa

Frequency range:
350 MHz
to
15.4 GHz
with a goal of 24 GHz

197 dishes
(including 64 MeerKAT dishes)

Maximum baseline:
150km

SKA1-Low
the SKA's low-frequency telescope

Location: Australia

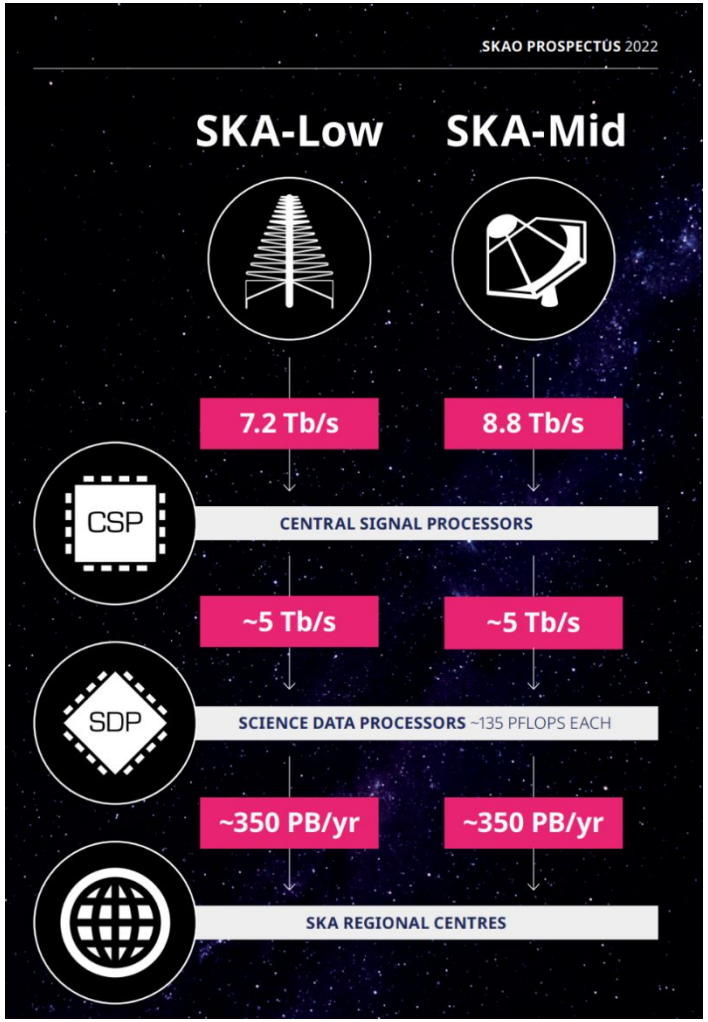
Frequency range:
50 MHz
to
350 MHz

131,072
antennas spread between
512 stations

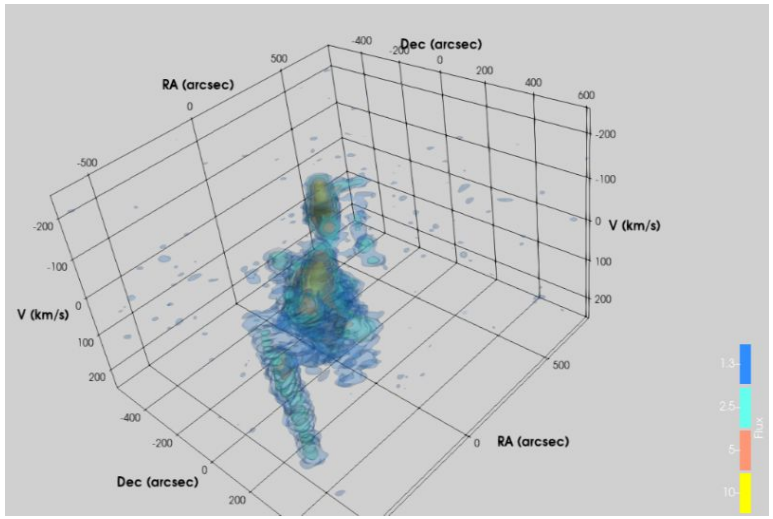
Maximum baseline:
~74km

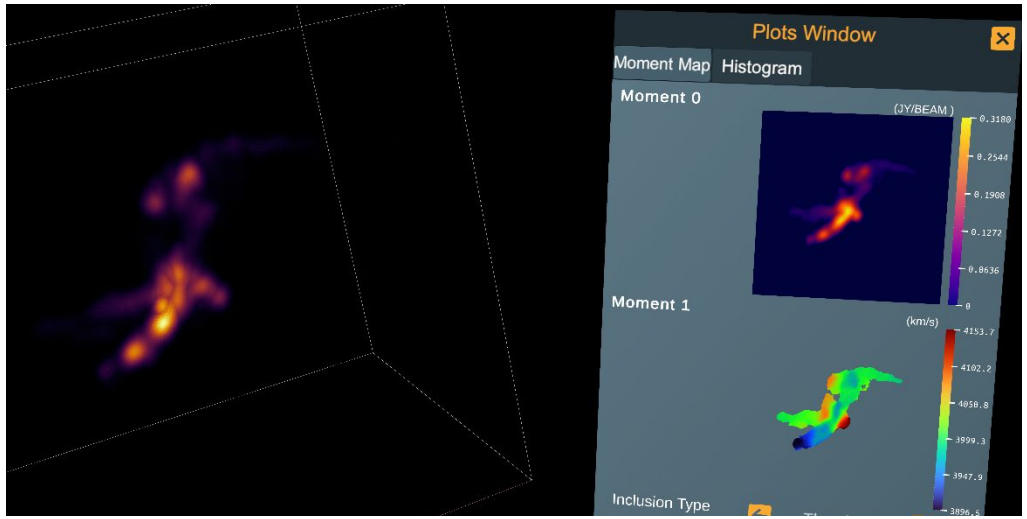
SRC | Net
SKAO Regional Centre Network

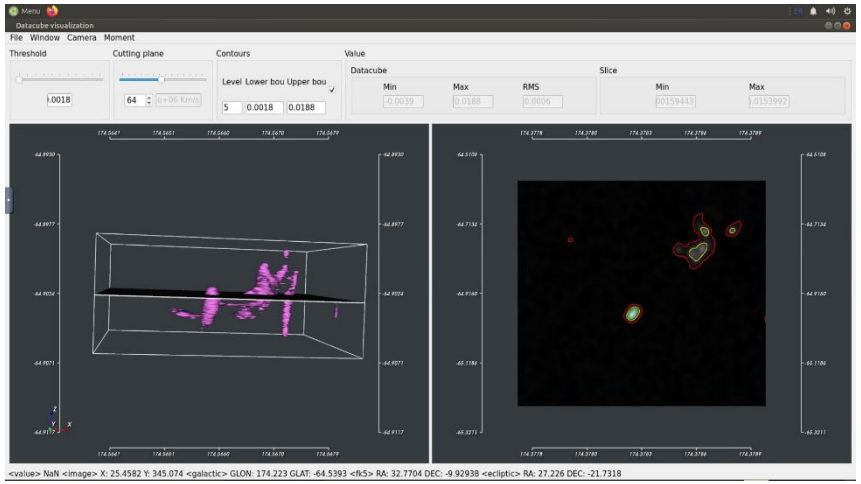
esp | SRC

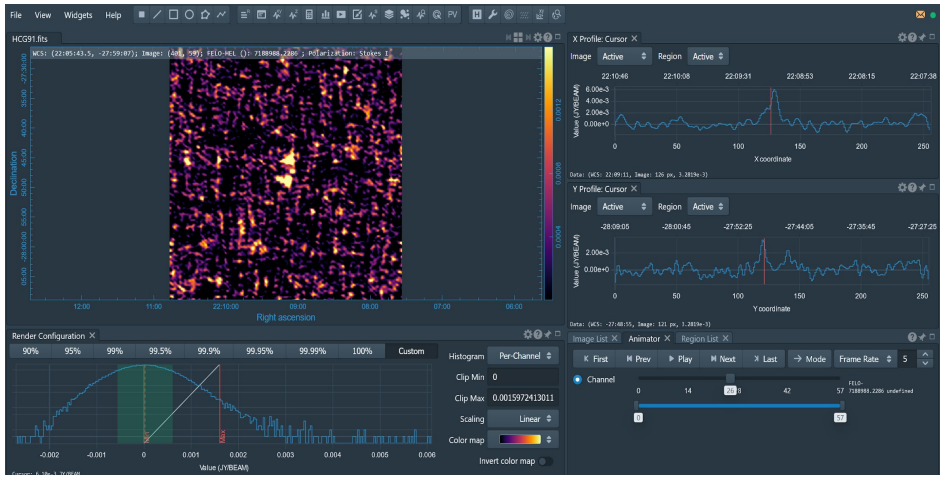


Explore existing tools for 3D visualization



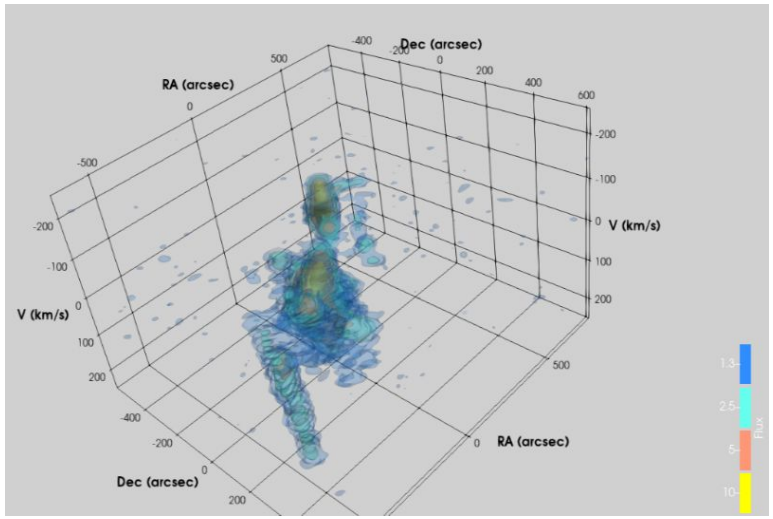


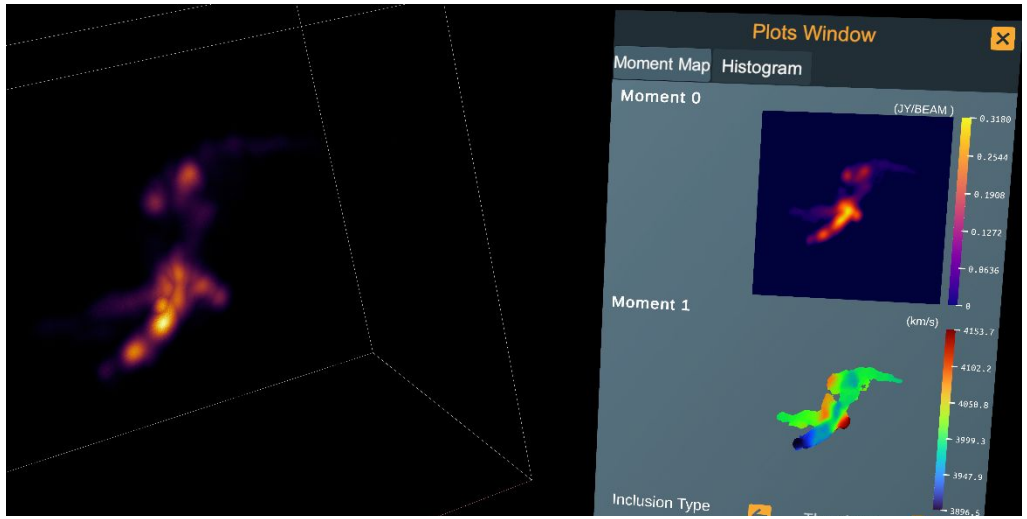


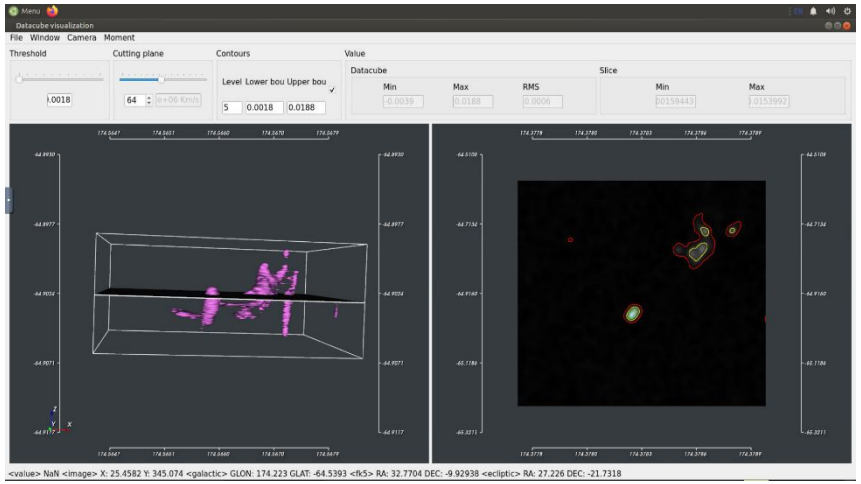


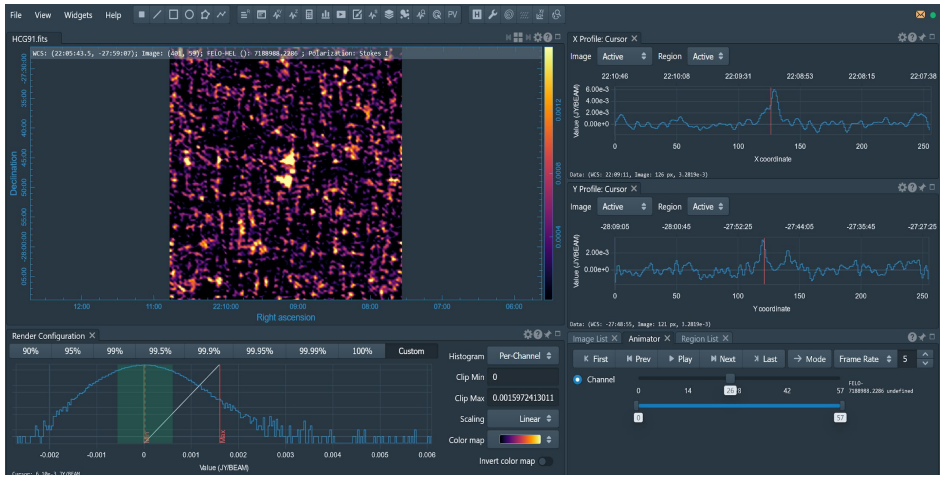
Explore existing tools for 3D visualization

- CARTA
- SlicerAstro
- Paraview
- Plotly
- ViaLactea
- VisIt
- Aladin
- VR
- Others…





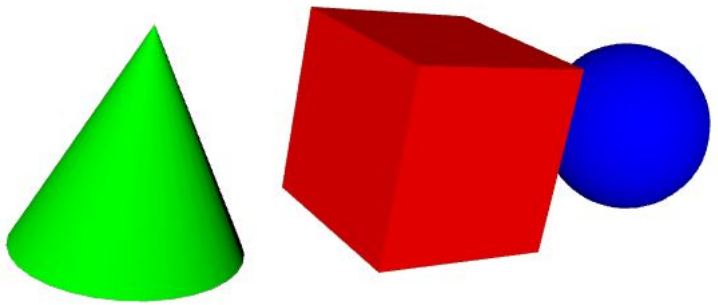




X3D-X3DOM

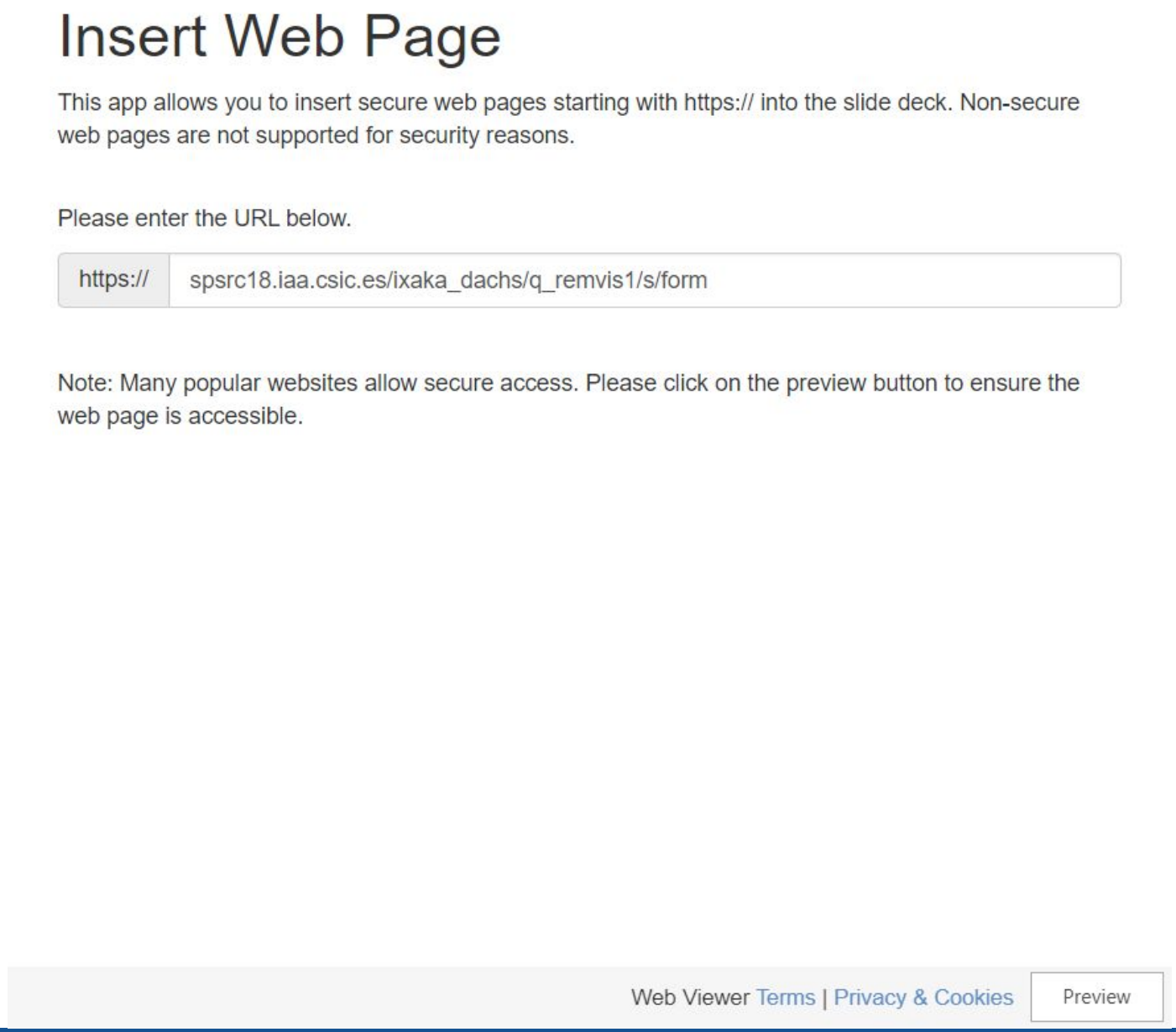
- X3D: Royalty-free open standard
- Mantained by Web3D consortium
- X3DOM: HTML integration
- 3D model written with python, without specific libraries
- Optimized
- Plot iso-surfaces:

  reduce size and calculations



GAVO – DaCHS

- Services to publish data: tables, images, spectra
- Allows queries
- Easy to follow IVOA standards
- Datalink for complementary resources
- Server-side Operations for Data Access (SODA)
  - Make cutouts…
  - Can be used to customize visualizations



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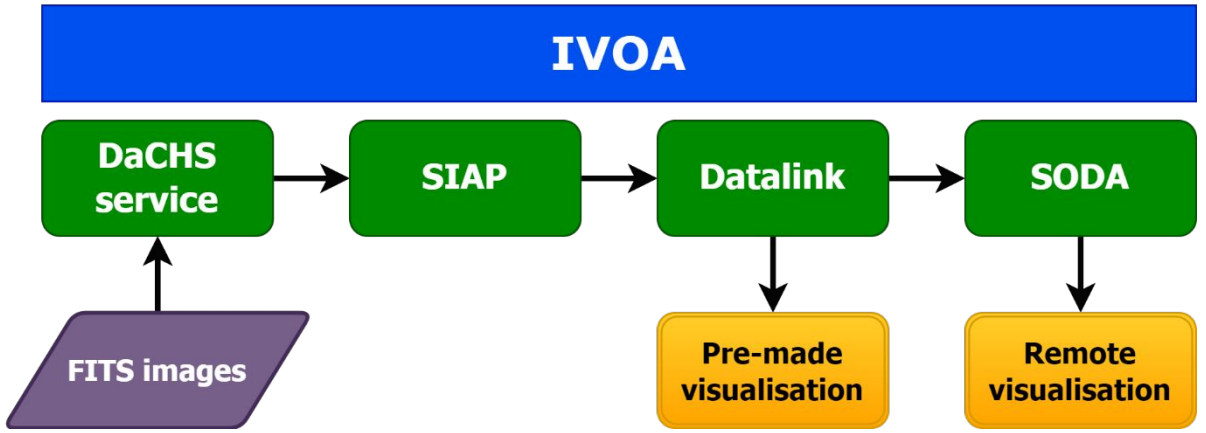
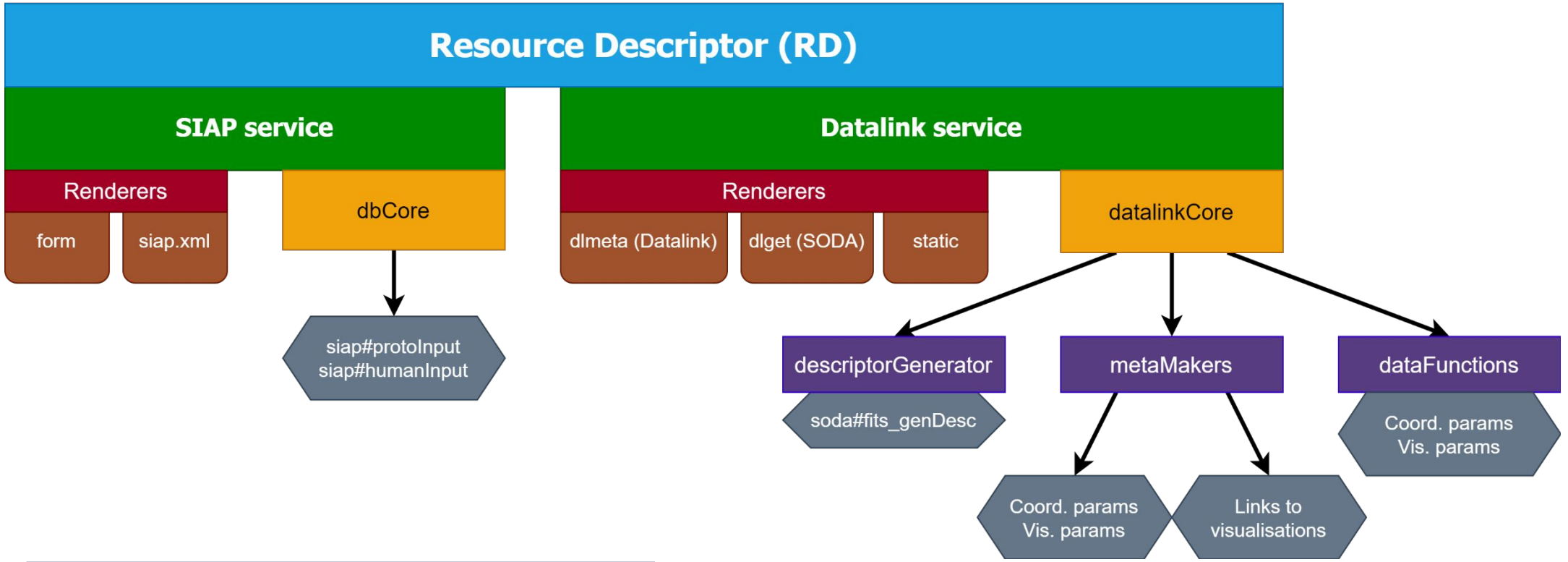
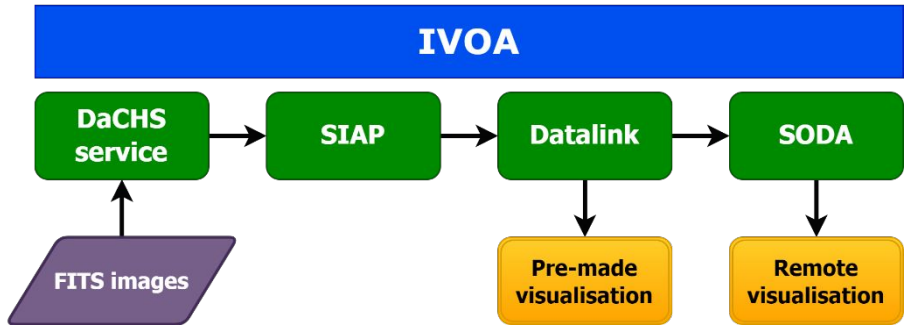
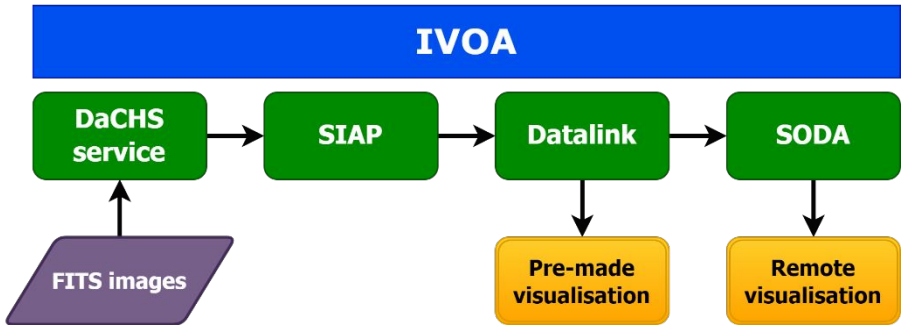



Resource Descriptor (RD)
SIAP service
Renderers
form
siap.xml
dbCore
siap#protoInput
siap#humanInput
Datalink service
Renderers
dlmeta (Datalink)
dlget (SODA)
static
datalinkCore
descriptorGenerator
soda#fits_genDesc
metaMakers
Coord. params
Vis. params
Links to
visualisations
dataFunctions
Coord. params
Vis. params


IVOA
DaCHS
service
SIAP
Datalink
SODA
FITS images
Pre-made
visualisation
Remote
visualisation

SODA code

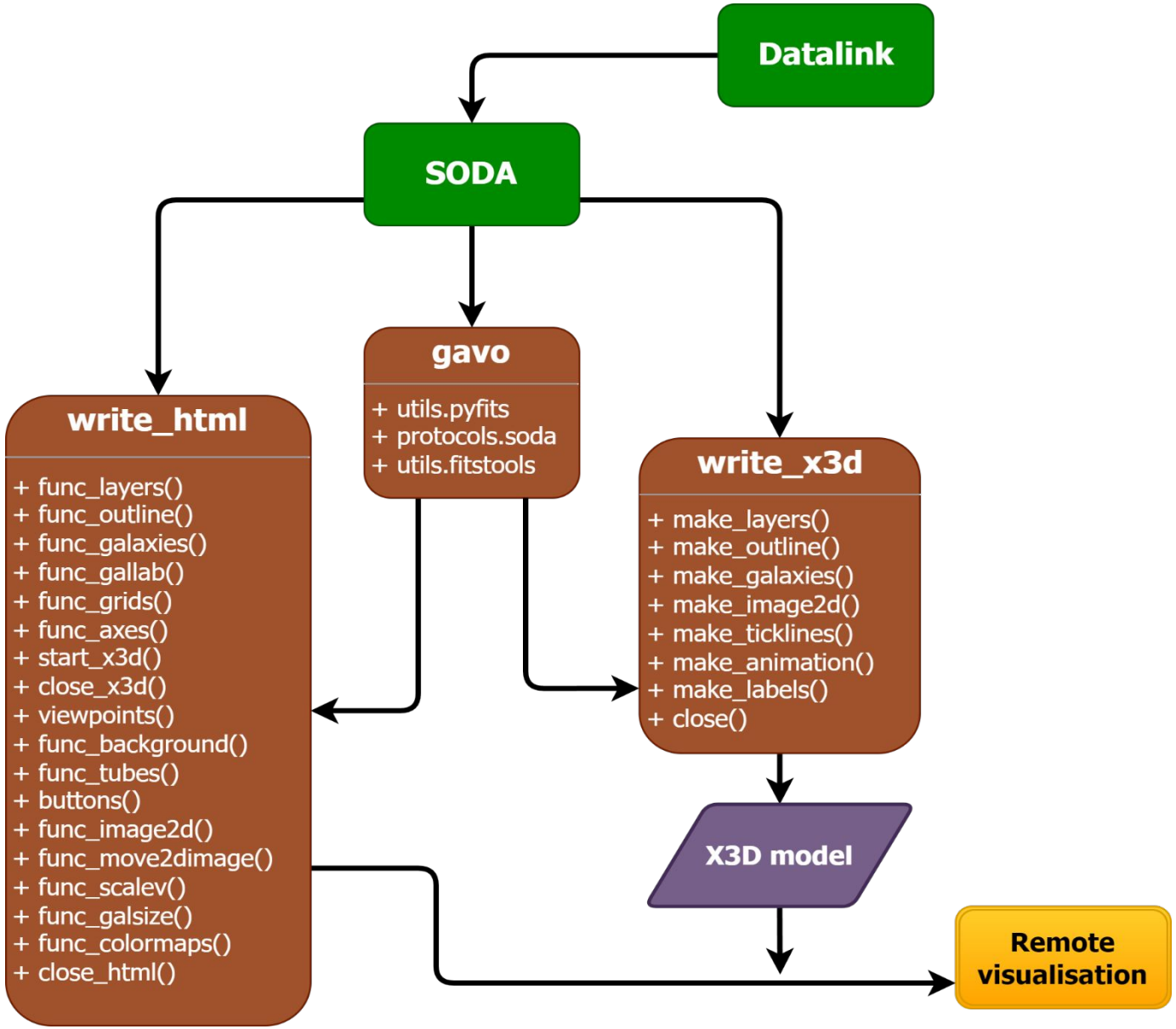


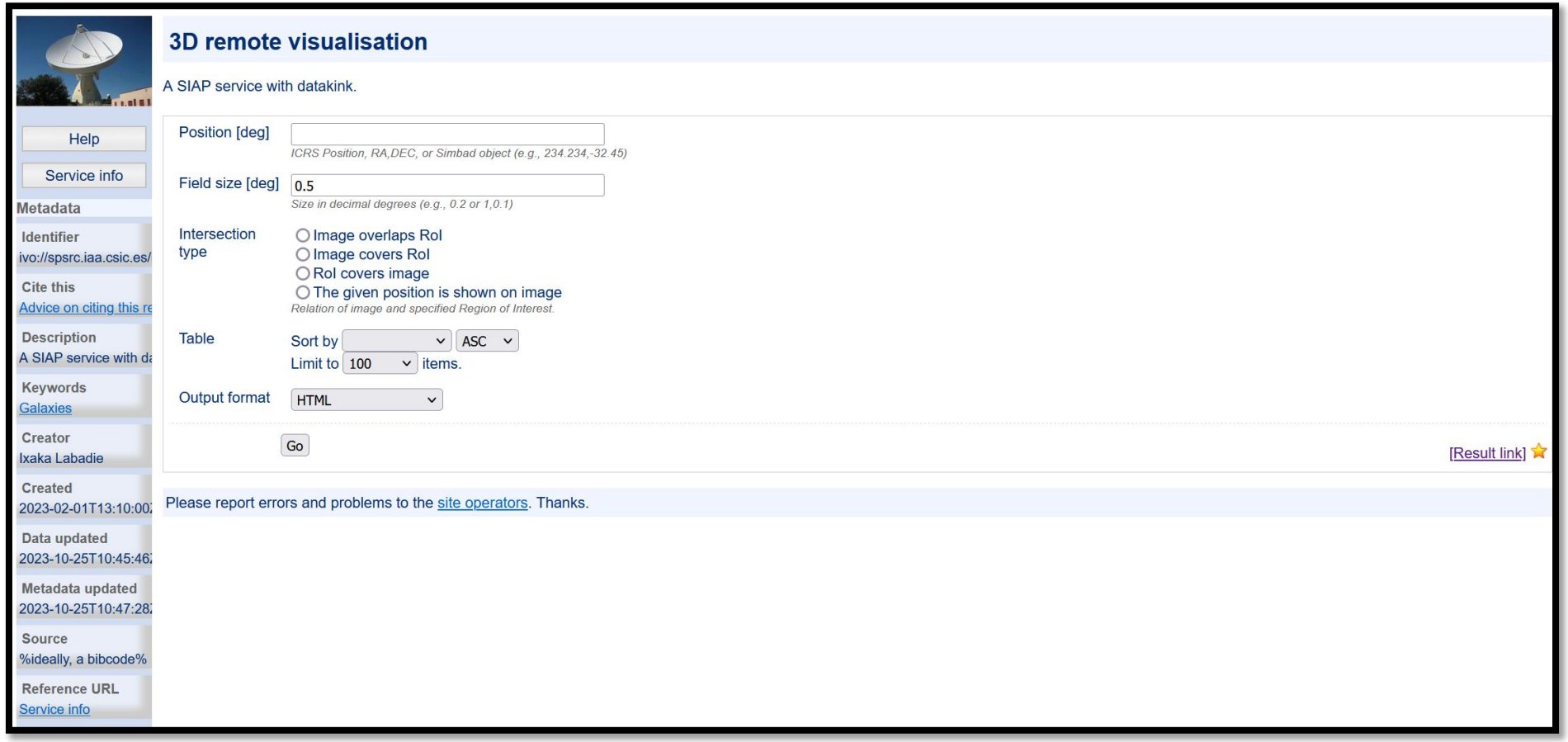
Python packages:

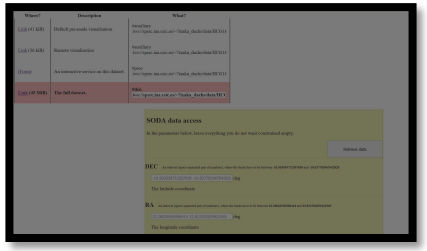
- Astropy
- scikit-image
- Matplotlib
- Astroquery
- NumPy

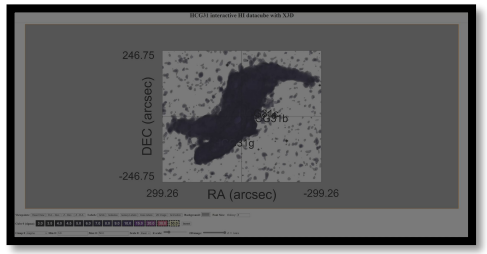
JS scripts:

- x3dom
- js-colormaps
- LaTeXMathML




3D remote visualisation
A SIAP service with datakink.
Help
Service info
Metadata
Identifier
ivo://spsrc.iaa.csic.es/
Cite this
Advice on citing this re
Description
A SIAP service with da
Keywords
Galaxies
Creator
Ixaka Labadie
Created
2023-02-01T13:10:00
Data updated
2023-10-25T10:45:46
Metadata updated
2023-10-25T10:47:28
Source
%ideally, a bibcode%
Reference URL
Service info
Position [deg]
ICRS Position, RA,DEC, or Simbad object (e.g., 234.234,-32.45)
Field size [deg]
0.5
Size in decimal degrees (e.g., 0.2 or 1,0.1)
Intersection type
Image overlaps RoI
Image covers RoI
RoI covers image
The given position is shown on image
Relation of image and specified Region of Interest.
Table
Sort by
ASC
Limit to 100 items.
Output format
HTML
Go
[Result link]
Please report errors and problems to the site operators. Thanks.

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DEC (arcsec)
-246.75
299.26
RA (arcsec)
-299.26

Help

Service info

Metadata

Identifier
ivo://spsrc.iaa.csic.es/

Cite this
Advice on citing this re

Description
A SIAP service with da

Keywords
Galaxies

Creator
Ixaka Labadie

Created
2023-02-01T13:10:00

Data updated
2023-10-26T10:18:49

Metadata updated
2023-10-26T12:18:49

3D remote visualisation

Parameters

- Field size: 0.5
- Output format: image/fits

Result

Matched: 3

Product key	File size [byte]	Datalink	Ctr. RA [deg]	Ctr. Dec [deg]	Axes Lengths [pix]	Scales [deg/pix]
HCG91.fits	14.5MiB	dlmeta	332.29333	-27.79861	[256, 256, 58, 1]	[0.0027777778, 0.0027777778]
HCG16.fits	44.8MiB	dlmeta	32.54712	-10.27135	[315, 280, 133, 1]	[0.0016666725, 0.0016666694]
HCG31.fits	252.8MiB	dlmeta	75.40417	-4.25708	[500, 500, 265, 1]	[0.00041666668, 0.00041666668]

Query Form

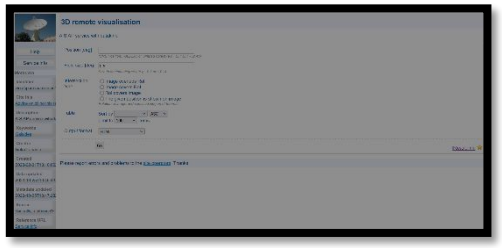
A SIAP service with datakink.

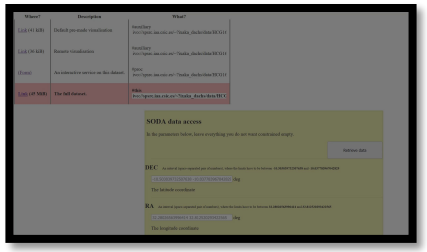
Position [deg]

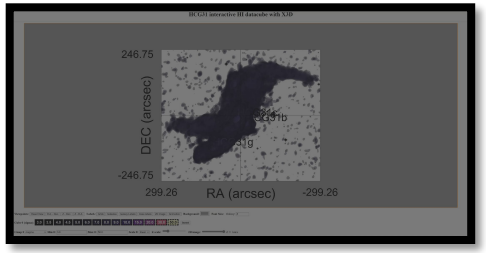
ICRS Position, RA,DEC, or Simbad object (e.g., 234.234,-32.45)

Field size [deg] 0.5

Size in decimal degrees (e.g., 0.2 or 1,0.1)







Where?	Description	What?
Link (41 kiB)	Default pre-made visualisation	#auxiliary ivo://spsrc.iaa.csic.es/~?ixaka_dachs/data/HCG1€
Link (36 kiB)	Remote visualisation	#auxiliary ivo://spsrc.iaa.csic.es/~?ixaka_dachs/data/HCG1€
(Form)	An interactive service on this dataset.	#proc ivo://spsrc.iaa.csic.es/~?ixaka_dachs/data/HCG1€
Link (45 MiB)	**The full dataset.**	**#this ivo://spsrc.iaa.csic.es/~?ixaka_dachs/data/HCG**

SODA data access

In the parameters below, leave everything you do not want constrained empty.

Retrieve data

DEC An interval (space-separated pair of numbers), where the limits have to be between **-10.503039732507638** and **-10.037783967042829**

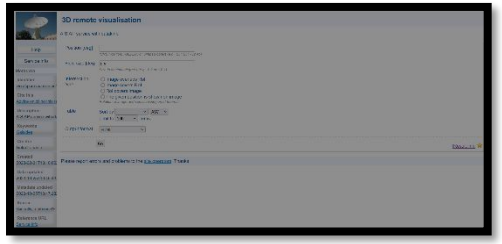
-10.503039732507638 -10.037783967042829 deg

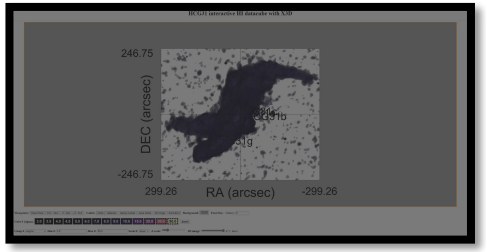
The latitude coordinate

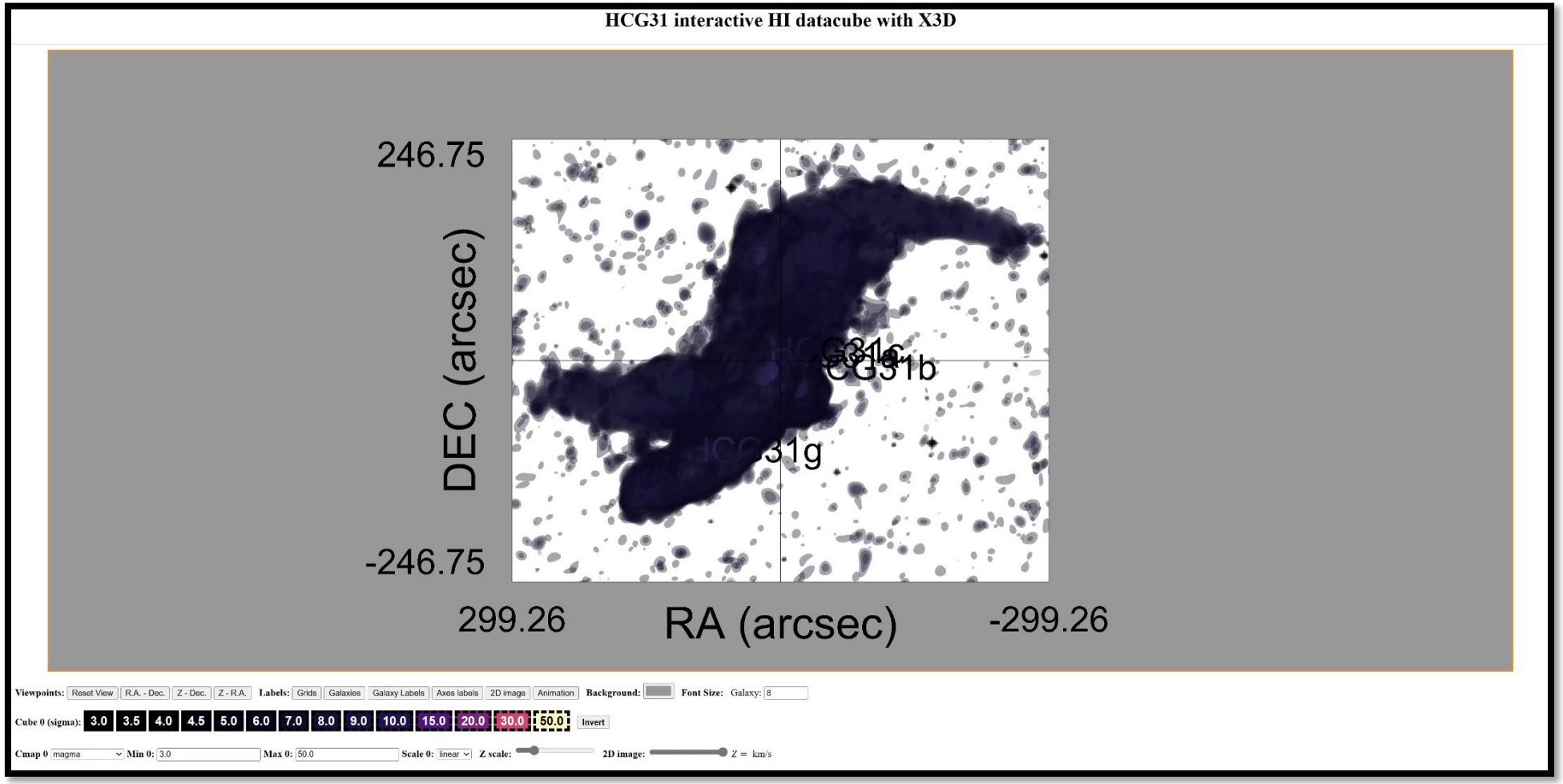
RA An interval (space-separated pair of numbers), where the limits have to be between **32.28026563996414** and **32.812520293422565**

32.28026563996414 32.812520293422565 deg

The longitude coordinate






HCG31 interactive HI datacube with X3D
246.75
DEC (arcsec)
-246.75
299.26
RA (arcsec)
-299.26
HCG31c
HCG31b
HCG31g
Viewpoints: Reset View R.A. - Dec. Z - Dec. Z - R.A.
Labels: Grids Galaxies Galaxy Labels Axes labels 2D image Animation
Background:
Font Size: Galaxy: 8
Cube 0 (sigma): 3.0 3.5 4.0 4.5 5.0 6.0 7.0 8.0 9.0 10.0 15.0 20.0 30.0 50.0
Invert
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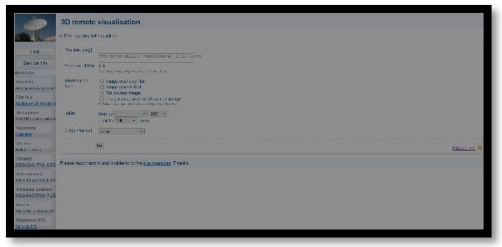
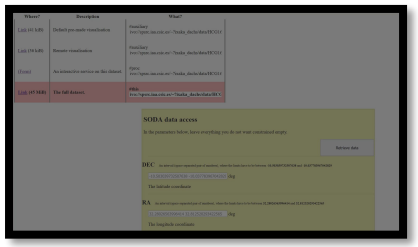
Min 0: 3.0
Max 0: 50.0
Scale 0: linear
Z scale:
2D image:
Z = km/s





Insert Web Page

This app allows you to insert secure web pages starting with https:// into the slide deck. Non-secure web pages are not supported for security reasons.

Please enter the URL below.

https:// spsrc18.iaa.csic.es/ixaka_dachs/q_remvis1/dl/static/HCG31_custom.html

Note: Many popular websites allow secure access. Please click on the preview button to ensure the web page is accessible.

Web Viewer Terms | Privacy & Cookies

Preview

SUMMARY

Motivation:

- Big Data of SKAO size
- 3D visualisation
- Interactive options

Solution:

- 3D iso-surface models (X3D)
- Web integration (X3DOM)
- Remote visualisation in SRC (DaCHS + Datalink + SODA)

Further work:

- Interface (Datalink & webpage)
- Study scalability
- RAM efficiency
- Implement for other wavelengths or other data types

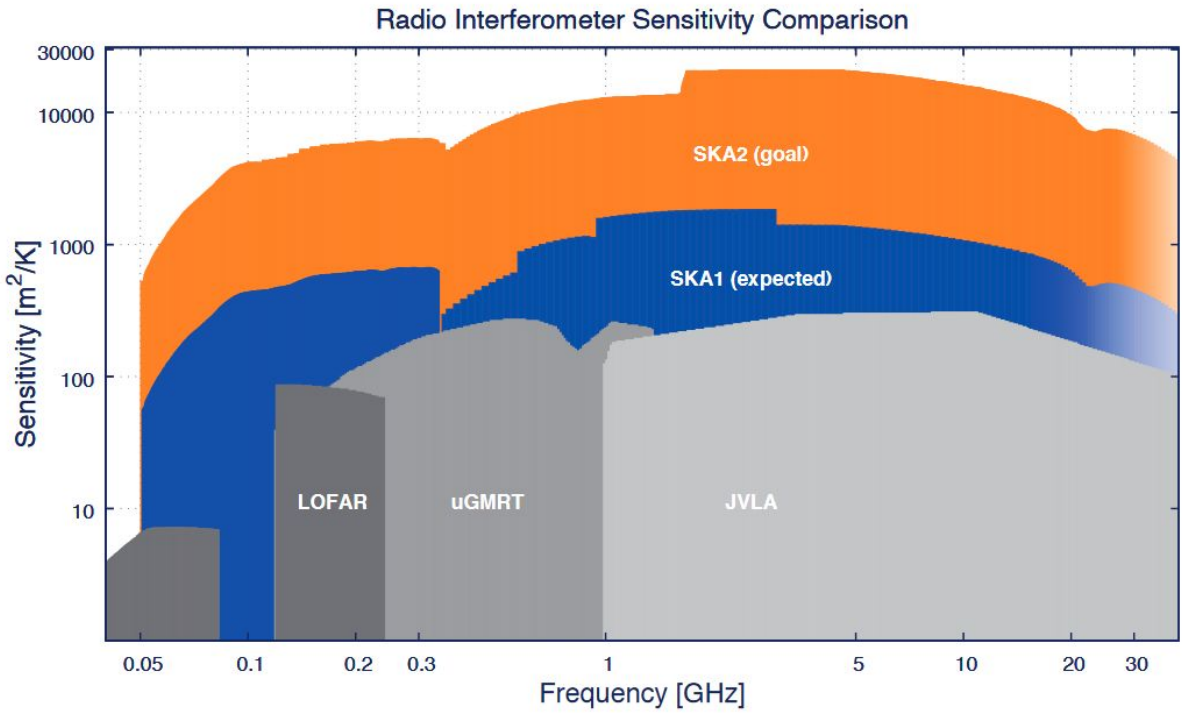
SKA1 Telescope Expected Performance – Imaging

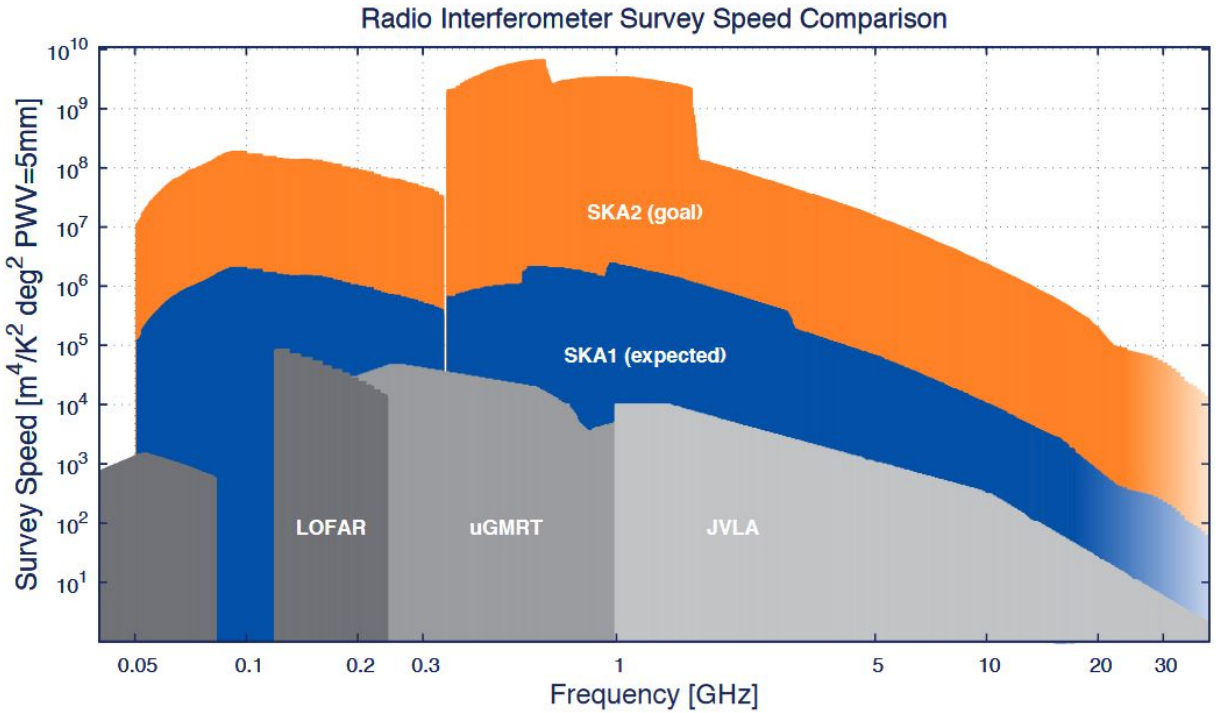
Nominal frequency	110 MHz	300 MHz	770 MHz	1.4 GHz	6.7 GHz	12.5 GHz
Range [GHz]	0.05-0.35	0.05-0.35	0.35-1.05	0.95-1.76	4.6-8.5	8.3-15.4
Telescope	Low	Low	Mid	Mid	Mid	Mid
FoV [arcmin]	327	120	109	60	12.5	6.7
Max. resolution [arcsec]	9.7	3.5	0.7	0.3	0.06	0.03
Max. bandwidth [MHz]	300	300	700	810	3900	2 x 2500
Cont. rms, 1hr [μJy/beam] [a]	26	14	4.4	2	1.3	1.2
Line rms, 1hr [μJy/beam] [b]	1850	800	300	140	90	85
Resolution range for cont. & line rms [arcsec] [c]	12-600	6-300	1-145	0.6-78	0.13-17	0.07-9
Channel width (uniform resolution across max. bandwidth) [kHz]	5.4	5.4	13.4	13.4	80.6	80.6
Narrowest bandwidth, zoom mode [MHz]	3.9	3.9	3.1	3.1	3.1	3.1
Finest zoom channel width [Hz]	226	226	210	210	210	210

Key project milestones
(as per SKA Construction Proposal: June 2021)

	SKA-Low	SKA-Mid
Start of construction (T0)	JULY **2021**	JULY **2021**
Earliest start of major contracts (C0)	AUGUST **2021**	AUGUST **2021**
Array Assembly 0.5 finish (AA0.5) SKA-Low = 6-station array SKA-Mid = 4-dish array	FEBRUARY **2024**	MARCH **2024**
Array Assembly 1 finish (AA1) SKA-Low = 18-station array SKA-Mid = 8-dish array	FEBRUARY **2025**	FEBRUARY **2025**
Array Assembly 2 finish (AA2) SKA-Low = 64-station array SKA-Mid = 64-dish array, baselines mostly <20km	FEBRUARY **2026**	DECEMBER **2025**
Array Assembly 3 finish (AA3) SKA-Low = 256-station array, including long baselines SKA-Mid = 133-dish array, including long baselines	JANUARY **2027**	SEPTEMBER **2026**
Array Assembly 4 finish (AA4) SKA-Low = full Low array SKA-Mid = full Mid array, including MeerKAT dishes	NOVEMBER **2027**	JUNE **2027**
Operations Readiness Review (ORR)	JANUARY **2028**	DECEMBER **2027**
End of construction	JULY **2029**	JULY **2029**

Observing capabilities





The Spanish prototype of a SKA Regional Centre - SPSRC

Beyond a computing cluster

Hardware

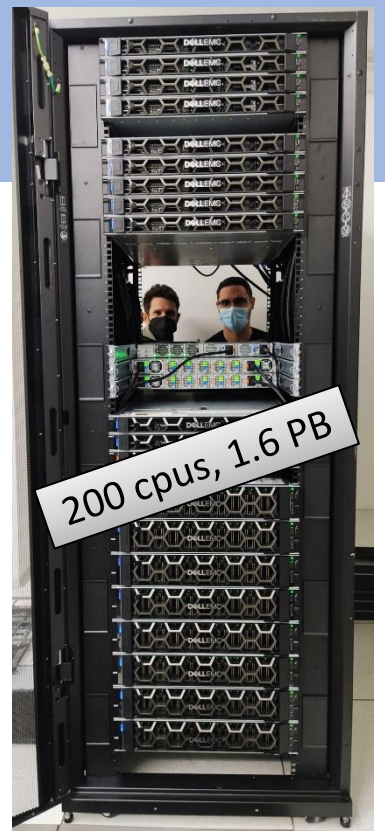
A cloud-computing service
Storage

Software **Services**

VO Archive
Collaborative analysis tools

User support

Training:
radioastronomy,
software, Open Science



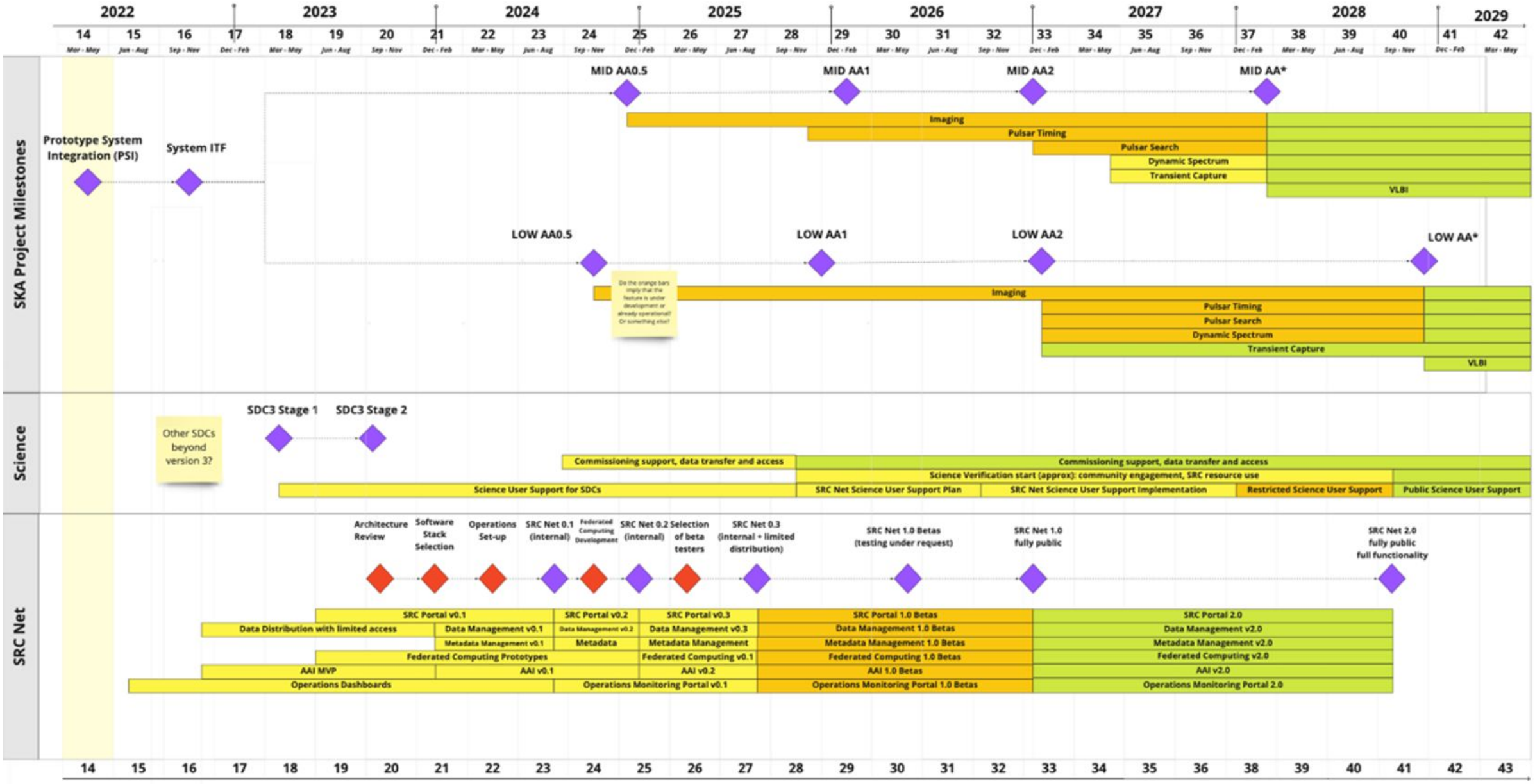
Interoperable

Become the host of an SKA Regional Centre

Support **preparatory scientific activities** for SKA Key Science Projects with precursors/pathfinders

Following best practices:
Open Science and **FAIR** principles

Transversal, wavelength agnostic


2022
2023
2024
2025
2026
2027
2028
2029
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
Mar - May
Jun - Aug
Sep - Nov
Dec - Feb
Mar - May
Jun - Aug
Sep - Nov
Dec - Feb
Mar - May
Jun - Aug
Sep - Nov
Dec - Feb
Mar - May
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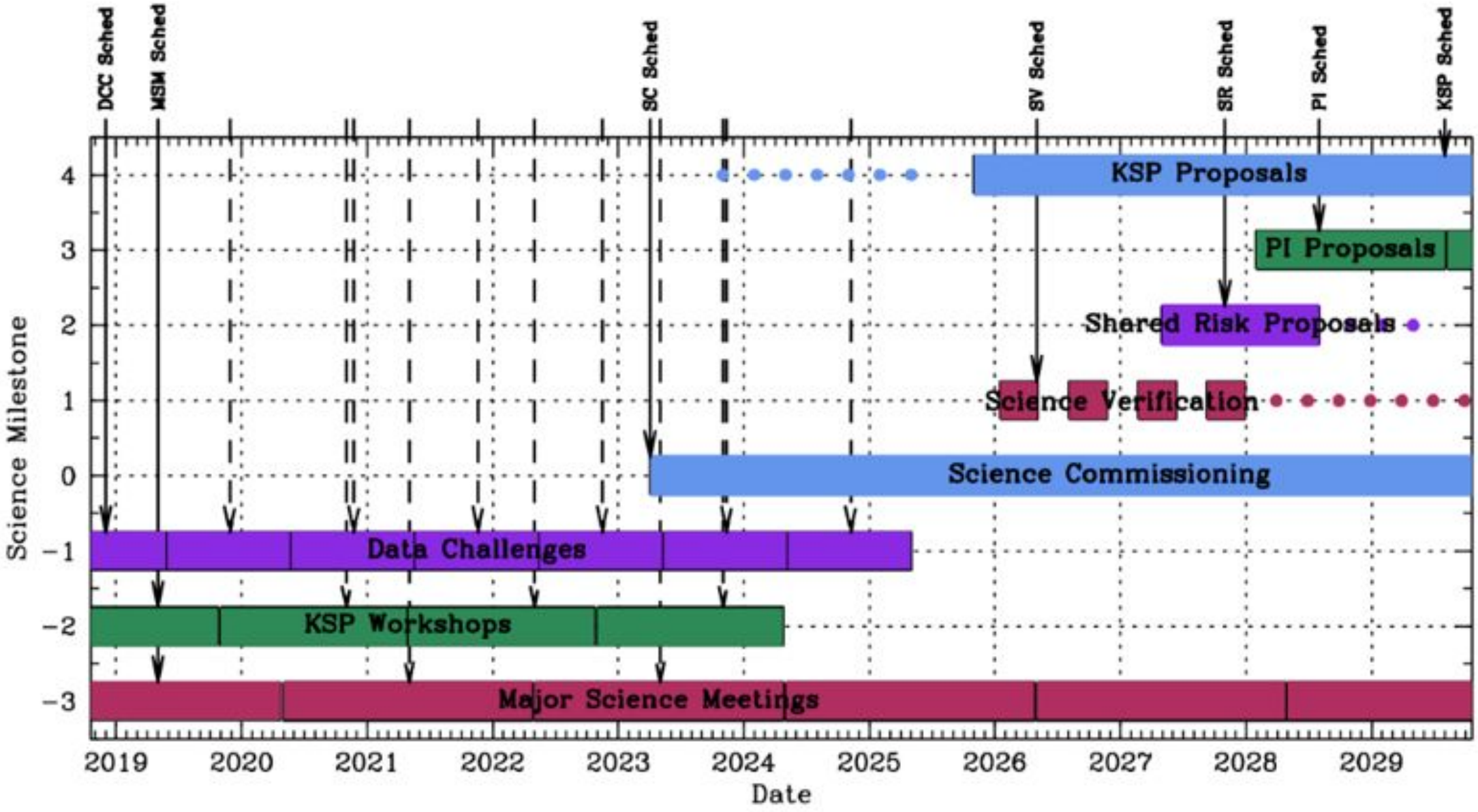
Mar - May
Jun - Aug
Sep - Nov
Dec - Feb
Mar - May
SKA Project Milestones
Prototype System Integration (PSI)
System ITF
MID AA0.5
MID AA1
MID AA2
MID AA*
Imaging
Pulsar Timing
Pulsar Search
Dynamic Spectrum
Transient Capture
VLBI
LOW AA0.5
LOW AA1
LOW AA2
LOW AA*
Do the orange bars imply that the feature is under development or already operational? Or something else?
Imaging
Pulsar Timing
Pulsar Search
Dynamic Spectrum
Transient Capture
VLBI
Science
Other SDCs beyond version 3?
SDC3 Stage 1
SDC3 Stage 2
Commissioning support, data transfer and access
Commissioning support, data transfer and access
Science Verification start (approx): community engagement, SRC resource use
Science User Support for SDCs
SRC Net Science User Support Plan
SRC Net Science User Support Implementation
Restricted Science User Support
Public Science User Support
SRC Net
Architecture Review
Software Stack Selection
Operations Set-up
SRC Net 0.1 (internal)
Federated Computing Development
SRC Net 0.2 (internal)
Selection of beta testers
SRC Net 0.3 (internal + limited distribution)
SRC Net 1.0 Betas (testing under request)
SRC Net 1.0 fully public
SRC Net 2.0 fully public full functionality
SRC Portal v0.1
SRC Portal v0.2
SRC Portal v0.3
SRC Portal 1.0 Betas
SRC Portal 2.0
Data Distribution with limited access
Data Management v0.1
Data Management v0.2
Data Management v0.3
Data Management 1.0 Betas
Data Management v2.0
Metadata Management v0.1
Metadata
Metadata Management
Metadata Management 1.0 Betas
Metadata Management v2.0
Federated Computing Prototypes
Federated Computing v0.1
Federated Computing 1.0 Betas
Federated Computing v2.0
AAI MVP
AAI v0.1
AAI v0.2
AAI 1.0 Betas
AAI v2.0
Operations Dashboards
Operations Monitoring Portal v0.1
Operations Monitoring Portal 1.0 Betas
Operations Monitoring Portal 2.0
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 38 39 40 41 42 43


DCC Sched
MSM Sched
SC Sched
SV Sched
SR Sched
PI Sched
KSP Sched
KSP Proposals
PI Proposals
Shared Risk Proposals
Science Verification
Science Commissioning
Data Challenges
KSP Workshops
Major Science Meetings
Science Milestone
4
3
2
1
0
−1
−2
−3
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
Date