

Multidimensional Data in the Virtual Observatory

José Enrique Ruiz – Grupo AMIGA
Instituto de Astrofísica de Andalucía – CSIC



- **Contextual History**
 - **AMIGA**
 - **Catalogue**
 - **Archives**
 - **Software**

- **Multidimensional Data**
 - **MultiD Astronomy**
 - **Data: Typed vs. Generic**
 - **Services: Discovery vs. Access**
 - **Virtual Data**
 - **BODEGA Archive**

- **Scientific Workflows**
 - **Description**
 - **Proposals**

Analysis of the interstellar Medium of Isolated GALaxies

**PI : Lourdes Verdes-Montenegro
IAA-CSIC, IRAM**

**Obs. Marseille, Obs. Paris, CfA, ASIAA, MPIfA, IAC,
Univ. Alabama, Mc Donald Observatory, Arcetri, UNAM,
Kapteyn Astronomical Institute, ESO.**

2003 – 2011

Coordinated projects with IRAM Granada since 2005

**Statistical baseline of isolated galaxies to compare
with the behaviour of galaxies in denser environments**



Multi λ study ~1000 galaxies

<http://amiga.iaa.es>

AMIGA CATALOGUE

Frequently updated

Search criteria and properties

Source name, coordinated, velocity, distance, morphology, magnitudes, isolation parameters, FIR fluxes, radio emission, activity

Output format

HTML, ASCII, VOTable, VOTools

Access from VOTools

Aladin, Topcat

ConeSearch Service

**Euro-VO DCA Census of European Data Centres
IVOA Registry**

AMIGA CATALOGUE

Instituto de Astrofísica de Andalucía | CSIC
Analysis of the Interstellar Medium of Isolated GALaxies

AMIGA

Home

The Project

Science

Technical development

Team and collaborators

Results & Ongoing Work

Publications

Conferences

Public Data

VO Interface

ASCII Files

Links

VO Interface

[Query by name](#) [Query by parameters](#)

Search by name

Object Name

(Ex: CIG 4, UGC 00297, CIG 4%, etc..)

Or/and Input a File

(Text file with a name per line)

Output Options

Fields

Coords Optical Velocity Morphology FIR Isolation

Equinox:

Image preview? Yes No


Dpt. Astronomía Extragaláctica
Instituto Astrofísica Andalucía
Camino Bajo de las Campanas
18008 Granada
Spain

AMIGA PUBLIC DATABASE SEARCH RESULTS

CIG 155

Alias names (Simbad Name Resolver Service)

CIG 155



Red image of CIG155, with a size of 05 x 05 arcmin, from DSS2

Basic Data

Coordinates

RA J2000	DEC J2000	RA B1950	DEC B1950
74.33875	78.1908	72.42666	78.1112

Velocity

Vr	V3K	Distance
1556	1507	20.1

Morphology

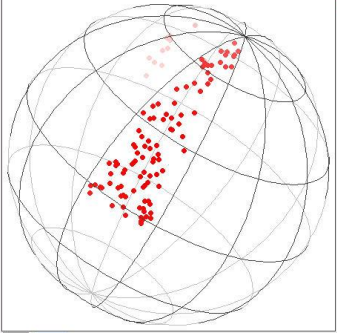
Morph	Morph rc3	Conf morph	Bar	Int
Scd	6		Y	?

Multiwavelength Information

Optical

Spherical Plot

File Export Plot Rendering Subsets Marker Style Help



Main

Data

Table: t: AMIGA_VOTable.25-06-08.1214383393.xml

Longitude Axis: RA J2000 degrees

Latitude Axis: DEC J2000 degrees

Radius Axis: Log

Potential: 111 Included: 111 Visible: 111

20	707	478	10.7	Sc (8)															
35	381	179	7.8	Sm (4), IB(s)m (7)															
27	856	750	10.6	SB(s)m pec? (3), Sd (4), SB(s)m pec: (7)															
95	1711	1643	21.9	S0	-2			0.232	5	-3.234	-3.287	-3.234	-3.287						
	5.86158	75.2959	-20.14	12.383	10.01	2461	2398	32.0	Sb	3	y		-2.268	-2.272					
	-7.74820	-2.0032	-18.32	14.249	9.28	2515	2451	32.7	Sbc	4	y	?	1.591	5	-2.915	-3.160	-2.929	-3.174	
	-4.33875	78.1908	-19.29	12.222	9.67	1556	1507	20.1	Scd	6	y	?	0.925	5	-3.196	-3.394	-3.196	-3.394	
	-7.67920	0.4083	-19.41	13.462	9.72	2821	2819	37.6	Sab	2	y	?	1.181	5	-3.276	-3.408	-3.310	-3.449	
	-6.35387	72.3564	-18.33	12.435	9.28	1089	1062	14.2	Sb	3									
	-6.39504	73.6092	-16.61	14.167	8.59	1099	1071	14.3	Sa	1	?								

Data Models: RADAMS

Radio Astronomy DAta Model for Single-dish telescopes

- **First model for radio VO compliant archives**
 - **Based on existing IVOA standard models**
 - **Initially conceived for DSS-63 antenna**
 - **Revised and improved for IRAM 30m**
 - **RADAMS VO Archives**
 - **Robledo DSS-63**
 - **TAPAS IRAM 30m**
 - **Interest**
 - **ATCA: Radiocuasars Archive**
 - **LOFAR: Radiointerferometric extension**
- IVOA Note – J. D. Santander-Vela et al. 2007
- Building a VO compliant Radio Astronomical DAta Model for Single-dish radio telescopes
2010 J. D. Santander-Vela et al. A&A submitted.
- TAPAS, a VO radio archive at the IRAM-30m telescope.
2010 S. Leon et al. A&A submitted.

Robledo DSS-63

Antenna

- **Madrid Deep Space Communication Complex" (MDSCC)**
- **Deep Space Network (DSN) of JPL-NASA**
- **70m in Robledo de Chavela (Madrid)**
- **5% operational time for observations**
- **K band Spectra (18 - 26 GHz)**
- **H₂O Masers, methanol, NH₃,...**

Datafiller

- **Python scripting**
- **FITS Headers parsing**
- **FITS Conversion**

Archive Maintenance

- **LAEFF-INTA**



TAPAS - IRAM 30m VO Archive

Telescope Archive for Public Access System

Antenna

- **IGN (Spain), CNRS (France), MPI (Germany)**
- **Bolometric observations, maps, spectra**
- **Rotational molecular transitions**
- **~200 scientific projects / year, 1TB**

Datafiller

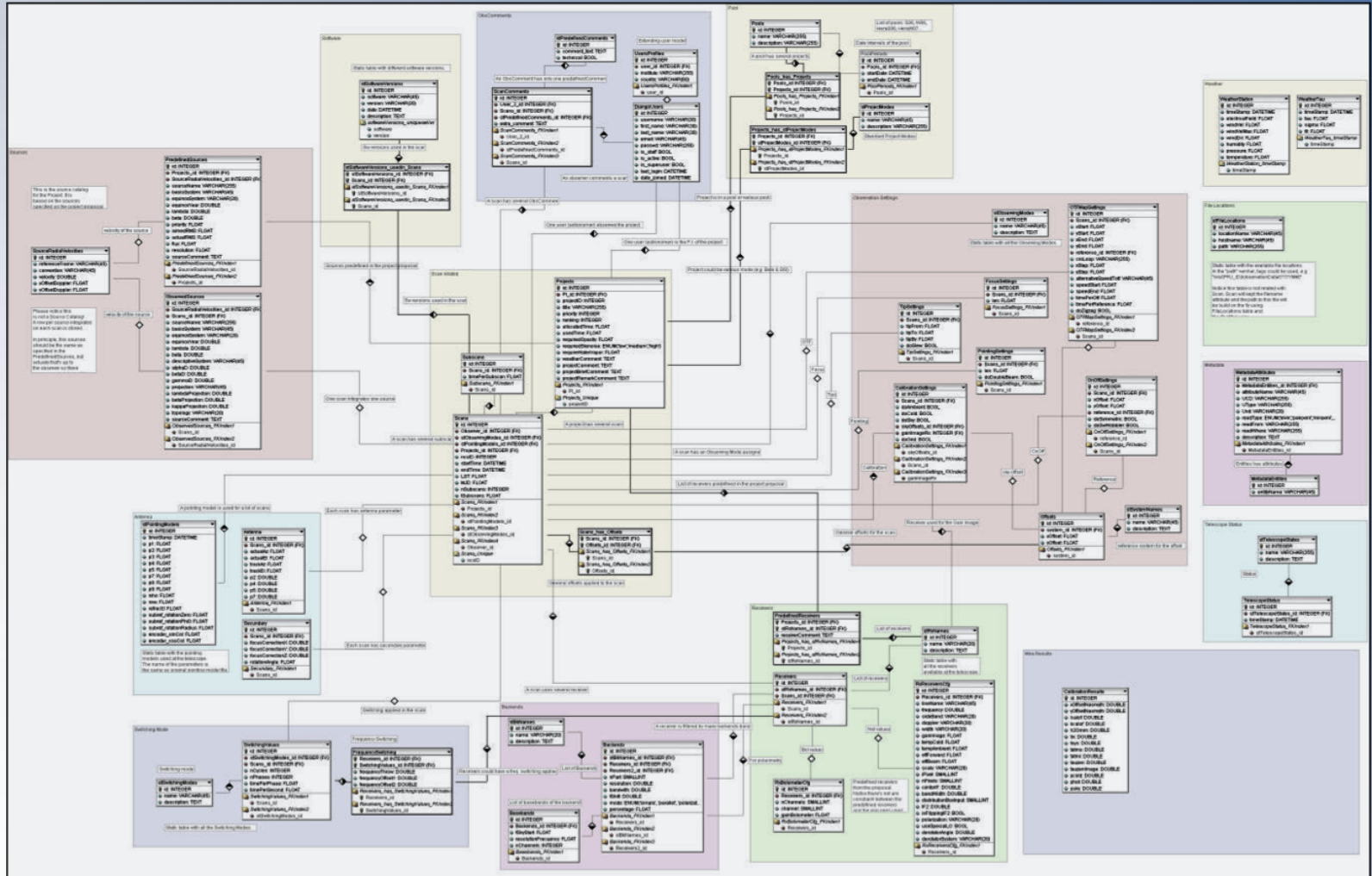
- **BDD insertions in real time**
- **Python scripting**
- **XML parsing**

Archive Maintenance

- **Web Interface for Data Management**
- **IRAM 30m**



TAPAS - IRAM 30m VO Archive Telescope Archive for Public Access System



MOVOIR

MOdular VO Interface for Radio astronomy applications

J.D. Santander-Vela

¿What is it?

API for adding VO functionality to legacy software

¿How?

Combines “open source” VO Tools

- **Astrogrid Runtime**
- **SAMP Client Library**
- **Starlink Tables Infrastructure Library**

¿Where?

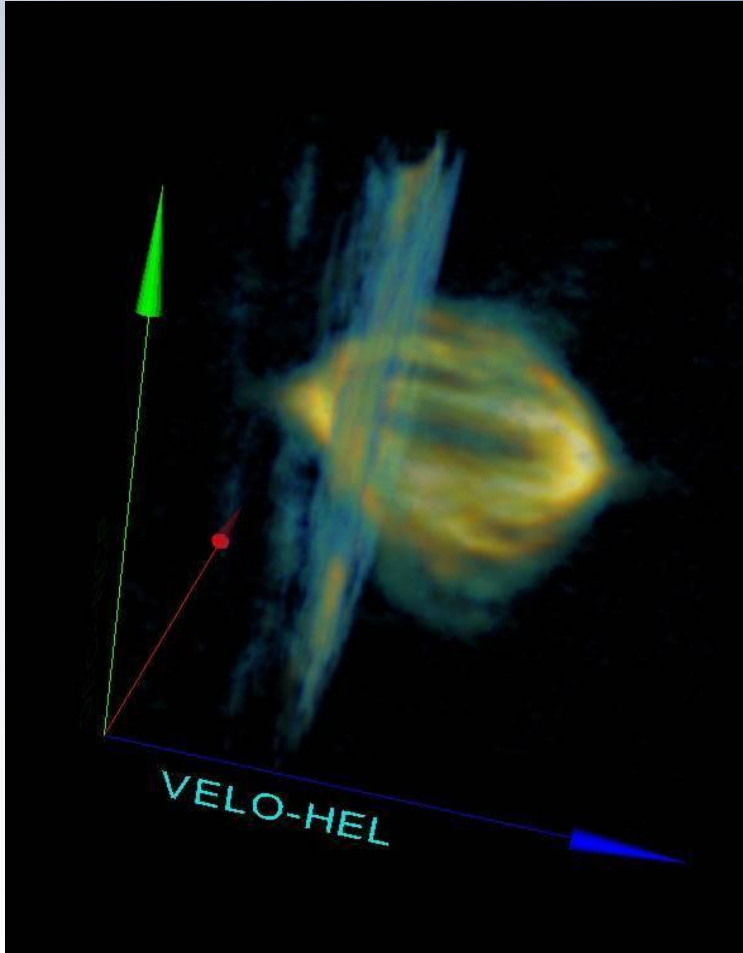
MASSA: MAdrid Simple Spectral Analysis

MADCUBA: MAdrid CUBe Analysis

Jesús Martín Pintado – DAMIR - CSIC

GIPSY

Groningen Image Processing SYstem



Connectivity

- **ALMA/CASA**
- **VO Archives**
- **VO Software**

Accessible

- **Usability GUI**
- **VO 3D Services**

Specifications

- **Web Survey**
- **3D Multi λ community**

Kapteyn Institute
IAA – CSIC

Kinematical 3D Analysis

GIPSY GUI

Python development
CASA connection - data format compatibility

ch25 = -54.0 km/s ch29 = -37.2 km/s ch33 = -20.4 km/s ch37 = -3.6 km/s ch41 = 13.2 km/s

ch45 = 30.0 km/s ch49 = 46.8 km/s ch53 = 63.6 km/s ch57 = 80.4 km/s ch61 = 97.2 km/s

ch65 = 114.0 km/s ch69 = 130.7 km/s ch73 = 147.5 km/s ch77 = 164.3 km/s ch81 = 181.1 km/s

ch85 = 197.9 km/s ch89 = 214.6 km/s ch93 = 231.4 km/s ch97 = 248.2 km/s

Workflow

```
DISK INSET=AURORA;
DIMINISH INSET=AURORA STOKES 0;
VELSMD INSET=AURORA FELO -10:15;
```

TASKS RECIPES

Search task:
div

ADD
CBLANK
CLIP
COMIN
CONDIT
COPY
DECIM
DIMINISH
DIV
ELLINT
EXTEND
GALMOD
INSET
INSPECTOR

TASK DIV

Purpose: Divides a series of input subsets by one or another series of subsets.

Category: COMBINATION

File: aid.shl

Author: M. Vogelaar

Keywords:

INSET= Input set (and subsets).
Maximum number of subsets is 2048.

BOX= Frame for input subsets.
(entire subset)

SETX= Set name and subset(s) which operate on the input set.
DIV divides subsets in two different modes:
A: One 'SETX' subset works on all 'SET' subsets
B: All given 'SETX' subsets work pairwise on all 'SET' subsets of 'SET'

Depending on the number of user given 'SETX' subsets, the program selects the mode of operation.

GIPSY GUI

The screenshot shows the GIPSY GUI interface. The menu bar at the top includes **File**, **Edit**, **Display**, **Task**, **VO**, and **Help**. The workspace contains a grid of spectral line plots for various channels, with their corresponding velocities listed below each plot:

- ch45 = 30.0 km/s
- ch49 = 46.8 km/s
- ch53 = 63.6 km/s
- ch57 = 80.4 km/s
- ch61 = 97.2 km/s
- ch65 = 114.0 km/s
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- ch73 = 147.5 km/s
- ch77 = 164.3 km/s
- ch81 = 181.1 km/s
- ch85 = 197.9 km/s
- ch89 = 214.6 km/s
- ch93 = 231.4 km/s
- ch97 = 248.2 km/s

The right-hand panel displays the **TASKS** and **RECIPES** section, with the **DIV** task selected. The task details are as follows:

TASK DIV

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- INSET= Input set (and subsets). Maximum number of subsets is 2048.
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Depending on the number of user given 'SETX' subsets, the program selects the mode of operation.

The **Workflow** section at the bottom left contains the following commands:

```
DISK INSET=AURORA;
DIMINISH INSET=AURORA STOKES 0;
VELSMD INSET=AURORA FELO -10:15;
```


GIPSY GUI

The screenshot shows the GIPSY GUI interface. The main workspace contains several panels:

- Python development**
CASA connection - data format compatibility
- Modular and extensible**
- Improved user-friendliness**
Contextual help
Use Cases recipes
- Workflow**

```
DISK INSET=AURORA;
DIMINISH INSET=AURORA STOKES 0;
VELSMD INSET=AURORA FELO -10:15;
```

The right-hand panel displays a list of tasks, with 'DIV' selected. The details for the 'TASK DIV' are as follows:

Purpose: Divides a series of input subsets by one or another series of subsets.

Category: COMBINATION

File: aid.shl

Author: M. Vogelaar

Keywords:

- INSET= Input set (and subsets). Maximum number of subsets is 2048.
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GIPSY GUI

Python development
CASA connection - data format compatibility

Modular and extensible

Improved user-friendliness
Contextual help
Use Cases recipes

Structured session work

ch65 = 114.0 km/s ch69 = 130.7 km/s ch73 = 147.5 km/s ch77 = 164.3 km/s ch81 = 181.1 km/s

ch85 = 197.9 km/s ch89 = 214.6 km/s ch93 = 231.4 km/s ch97 = 248.2 km/s

Workflow

```
DISK INSET=AURORA;
DIMINISH INSET=AURORA STOKES 0;
VELSMD INSET=AURORA FELO -10:15;
```

TASKS RECIPES

Search task:

ADD
CBLANK
CLIP
COMIN
CONDIT
COPY
DECIM
DIMINISH
DIV
ELLINT
EXTEND
GALMOD
INSERT
INSPECTOR

TASK DIV

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Depending on the number of user given 'SETX' subsets, the program selects the mode of operation.

GIPSY GUI

The screenshot shows the GIPSY GUI interface. On the left is a 'Browser' pane showing a file tree for 'Session_A' with folders like SETS, TABLES, COLA FILES, IMAGES, and INFO. The main workspace contains several windows: 'SET_PL96', 'plot-cub.col', 'rotcur.table', 'plot-unblank-cube.jpg', and 'DIV Task'. The central panel features handwritten notes in yellow boxes: 'Python development', 'CASA connection - data format compatibility', 'Modular and extensible', 'Improved user-friendliness', 'Contextual help', 'Use Cases recipes', 'Structured session work', and 'Workflow oriented'. Below these notes are four spectral plots showing intensity vs. velocity, with labels: 'ch85 = 197.9 km/s', 'ch89 = 214.6 km/s', 'ch93 = 231.4 km/s', and 'ch97 = 248.2 km/s'. At the bottom, a 'Workflow' section is circled in red, containing the following code:

```
DISK INSET=AURORA;
DIMINISH INSET=AURORA STOKES 0;
VELSMD INSET=AURORA FELO -10:15;
```

 On the right, a 'TASKS' pane shows a list of tasks with 'DIV' selected. Below it, the 'TASK DIV' details are displayed, including its purpose, category, file, author, and keywords.

GIPSY GUI

The screenshot shows the GIPSY GUI interface. A red circle highlights the 'VO' menu, which includes options: TOPCAT, ALADIN, VOSPEC, VO search, and Sent to ...

Python development
CASA connection - data format compatibility

Modular and extensible

Improved user-friendliness
 Contextual help
 Use Cases recipes

Structured session work

Workflow oriented

VO Connection: software and archives

Below the text are four small spectral plots with labels: ch85 = 197.9 km/s, ch89 = 214.6 km/s, ch93 = 231.4 km/s, and ch97 = 248.2 km/s.

Workflow

```

DISK INSET=AURORA;
DIMINISH INSET=AURORA STOKES 0;
VLSMD INSET=AURORA FELO -10:15;
    
```

TASKS RECIPES

Search task: div

ADD
 CBLANK
 CLIP
 COMIN
 CONDIR
 COPY
 DECIM
 DIMINISH
DIV
 ELLINT
 EXTEND
 GALMOD
 INSERT
 INSPECTOR

TASK DIV

Purpose: Divides a series of input subsets by one or another series of subsets.

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Keywords:

INSET= Input set (and subsets). Maximum number of subsets is 2048.

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Depending on the number of user given 'SETX' subsets, the program selects the mode of operation.

GIPSY GUI

The screenshot shows the GIPSY GUI interface. On the left, a 'Task' menu is open, listing various tasks such as MOMENTS, ROTCUR, GALMOD, VELFI, ELLINT, POTENTIAL, INSPECTOR, ROTMAS, XGAUFIT, and XGAUPROF. The central area contains a list of features and capabilities, each in a yellow box. On the right, a 'TASKS' panel shows a search for 'div' and details for the 'DIV' task, including its purpose, category, file, author, and keywords.

Task Menu (circled):

- MOMENTS
- ROTCUR
- GALMOD
- VELFI
- ELLINT
- POTENTIAL
- INSPECTOR
- ROTMAS
- XGAUFIT
- XGAUPROF

Feature List:

- Python development
CASA connection – data format compatibility
- Modular and extensible
- Improved user-friendliness
Contextual help
Use Cases recipes
- Structured session work
- Workflow oriented
- VO Connection: software and archives
- No reduction tasks
Allows edition of datasets
GIPSY modeling tasks strength
Integration of legacy GUIs

Task Details (DIV):

Purpose: Divides a series of input subsets by one or another series of subsets.

Category: COMBINATION

File: aid.shl

Author: M. Vogelaar

Keywords:

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- BOX= Frame for input subsets. [entire subset]
- SETX= Set name and subset(s) which operate on the input set. DIV divides subsets in two different modes:
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Workflow:

```
DISK INSET=AURORA;
DIMINISH INSET=AURORA STOKES 0;
VELSMD INSET=AURORA FELO -10:15;
```


GIPSY GUI

The screenshot displays the GIPSY GUI with several key components:

- Menu:** A red circle highlights the 'Task' menu, which includes options like MOMENTS, ROTCUR, GALMOD, VELFI, ELLINT, POTENTIAL, INSPECTOR, ROTMAS, XGAUFIT, and XGAUPROF.
- Browser:** Shows a tree view of the current session, including SETS (SET_PL96), TABLES, COLA FILES, IMAGES, and INFO.
- Main Plot:** A large central plot showing a 2D intensity map with a red arrow pointing to a feature. The plot is titled 'subset[23]. grid +0 = 1 (TICK)'. Below it are controls for Speed (5.0), Frame (23), and a table with columns for GRID, VALUE (JY/BEAM), HMS, and DMS.
- Top Right Panel:** Contains a 'FILE| INTP| DINTP| HELP|' menu, a 'Fine' control, a 'Position' dial, and input fields for 'Sam.len' (199.7), 'Sam.sep', 'Int.wid' (0.0), and 'Int.sep' (1.0). It also displays 'P.A.: 40.2 deg -- Im. size: 199 samples x 63 subsets'.
- Bottom Right Panel:** Features a 'Line graph' with 'ON/OFF' toggle, a 'Panel 2:' section with 'ON/OFF' toggle, 'Offset P.A.' (90), 'Sam.len', and 'Ratio' (1.0) with a 'COUPLE' button. It also displays 'P.A.: 130.2 deg -- Im. size: 283 samples x 63 subsets'.
- Bottom Right Text:** A text box explains the 'BOX=' and 'SETX=' parameters, detailing how they operate on input subsets and how the program selects the mode of operation based on the number of 'SETX' subsets.

Python development
CASA connection - data

Modular and extensible

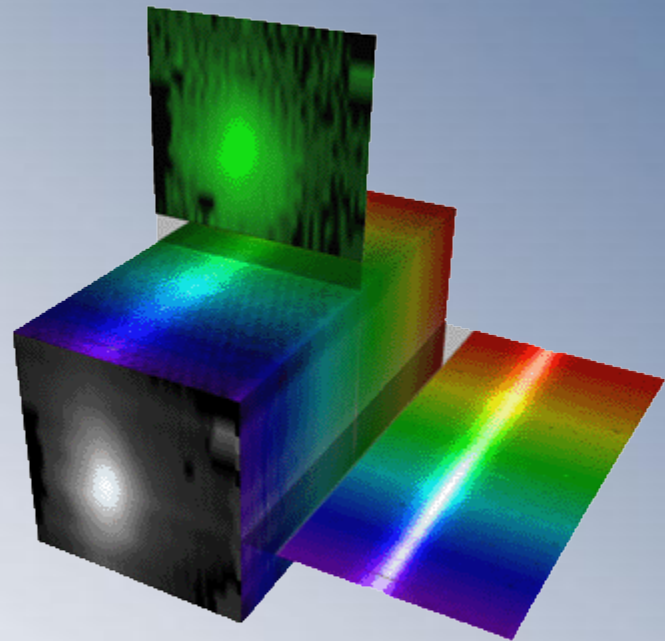
Improved user-friendliness

marks
are
sets
is strength
GUIs

MULTI-D ASTRONOMY

Observational Techniques

- **Radiointerferometry**
- **Integral Field Spectroscopy**
- **Multi Object Spectroscopy**
- **Fabry-Perot Instruments**
- **Tunable Filters**
- **OTF Imaging**



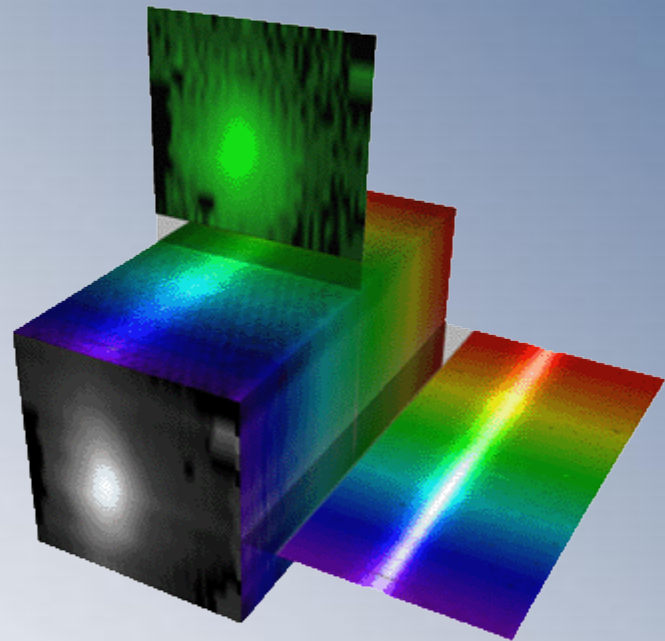
Credit
Stephen Todd and Douglas Pierce-Price

MULTI-D ASTRONOMY

Observational Techniques

- **Radiointerferometry**
- **Integral Field Spectroscopy**
- **Multi Object Spectroscopy**
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+ POLARIZATION



Credit
Stephen Todd and Douglas Pierce-Price

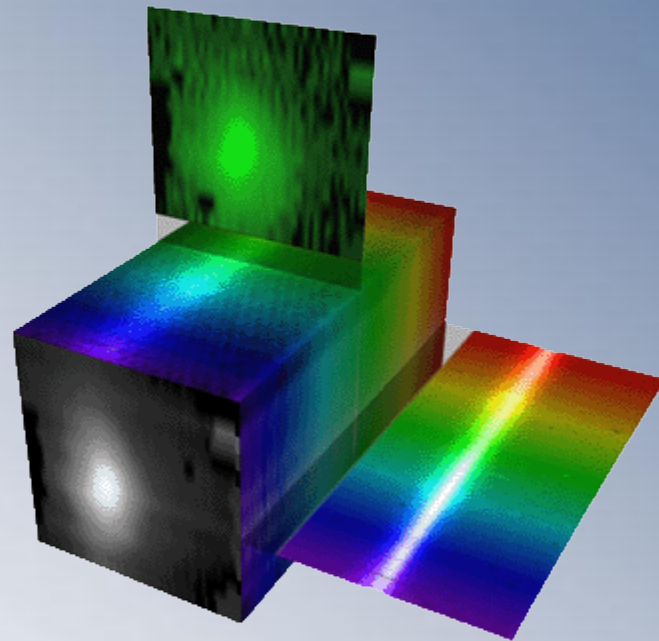
MULTI-D ASTRONOMY

Observational Techniques

- **Radiointerferometry**
- **Integral Field Spectroscopy**
- **Multi Object Spectroscopy**
- **Fabry-Perot Instruments**
- **Tunable Filters**
- **OTF Imaging**

+ POLARIZATION

+ TIME



Credit
Stephen Todd and Douglas Pierce-Price

DATA: TYPED VS. GENERIC

Typed Data

- **Tabular Data**
- **1D Spectra**
- **2D Images**
- **3D Cubes**
- **Time series**

- **DAL Protocols**

Parameter based queries

- **Models**

Complete characterization

DATA: TYPED VS. GENERIC

Typed Data

- **Tabular Data**
- **1D Spectra**
- **2D Images**
- **3D Cubes**
- **Time series**
- **DAL Protocols**
- **Parameter based queries**
- **Models**
- **Complete characterization**

Generic / MultiTyped Dataset

Complex data associations of different individual types

Survey Field

- **spectral data cube**
- **2D projections/extractions of the cube**
- **source catalog computed from the 2-D continuum**
- **some extracted spectra of objects in the field**

SERVICES: DISCOVERY VS. ACCESS

Discovery

- **ConeSearch**
- **QueryData Method in DAL protocols**
- **Parameter based queries**
- **RA, DEC, SR, POS, SIZE, BAND, TIME, POL**
- **Output: List of results fulfilling the filter criteria**

SERVICES: DISCOVERY VS. ACCESS

Discovery

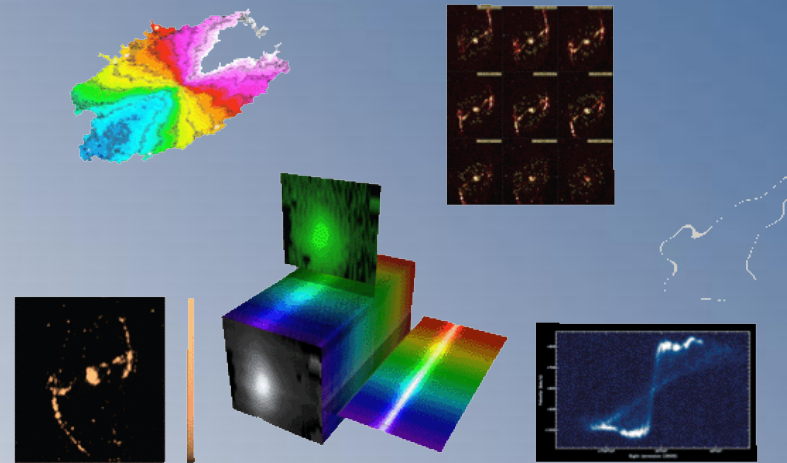
- **ConeSearch**
- **QueryData Method in DAL protocols**
- **Parameter based queries**
- **RA, DEC, SR, POS, SIZE, BAND, TIME, POL**
- **Output: List of results fulfilling the filter criteria**

Access

- **AccessData Method in DAL2 protocols**
- **On-line processing and analysis services**
- **Provide on-the-fly generated data**
- **They should provide self-descriptive methods in order to be used as components of internet-based workflows (*universal access*)**
- **Implemented in GRID environments**

VIRTUAL DATA

- **Cutout**
- **Resample**
- **Spectrum extraction**
- **2D slice extraction**
- **Dimensional reduction**
- **Filtering/Flagging**
- **Moments**
- **Complex transformations**



- **Solve latency transfer issues**
- **ALMA, LOFAR, EVLA produce GB spectral cubes**

Below 0 DEgrees GALaxies

PI: D. Espada

- **Spectral cubes of a sample of ~100 galaxies**
- **Observed with SMA radio interferometer**
- **Molecular gas properties in the circumnuclear regions**
- **Southern galaxies**
- **Migration of GIPSY kinematical modeling tasks to AccessData methods for 3D VO Services**

BODEGA ARCHIVE

BODEGA
Below zero degrees galaxies

About Team Publications Sample

Basic data

Target

- Name: **NGC5247**
- Class: **Galaxy**

Coordinates

- RA J2000: **13:38:3.00** hh:mm:ss.ss
- DEC J2000: **-17.88** deg

Velocity

- V: **1319.98** Km/s
- Redshift: **0.00440299**

Extended data

Provenance

- Telescope: **SMA**
- Bandpass: **Millimeter bandwidth**
- Beam Major Axis: **0.000982176** deg
- Beam Minor Axis: **0.000892319** deg
- Beam Position Angle: **-66.64** deg

Spatial

- Aperture angular size (width x height): **0.025 x 0.025** deg
- Spatial bin size (width x height): **8.3e-05 x 8.3e-05** deg

Spectral

- Spectral coord value: **1319.98** Km/s
- Width of spectrum: **999986.33** Km/s
- Start in spectral coordinate: **579.99211293** Km/s
- Stop in spectral coordinate: **1579.97844337** Km/s

Flux

- Flux min: **0.0175** Jy/Beam
- Flux Support Extent (max): **0.7208** Jy/Beam
- Flux Support Extent (min): **0.0175** Jy/Beam

Download Fits file

Right click and "Save Link As" to download

Number of points: 2250000.0
Size: 9011520.0 Kbs
Open this with Aladdin Applet

AMIGA

Wf4Ever

Advanced Workflow Preservation Technologies for Enhanced Science

**Funded as STREP proposal under FP7 ICT-2009-6
iSOCO, UPMadrid, U. Manchester, Poznan PSNC, U. Oxford,
Leiden U. Medical Center**

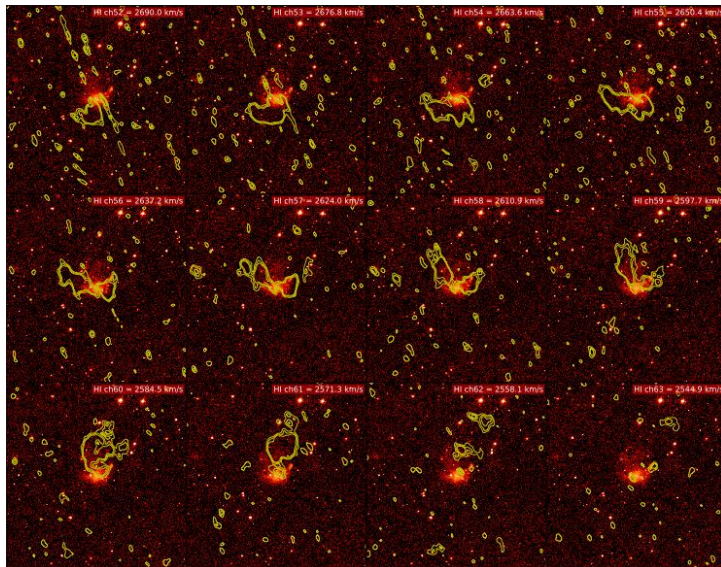
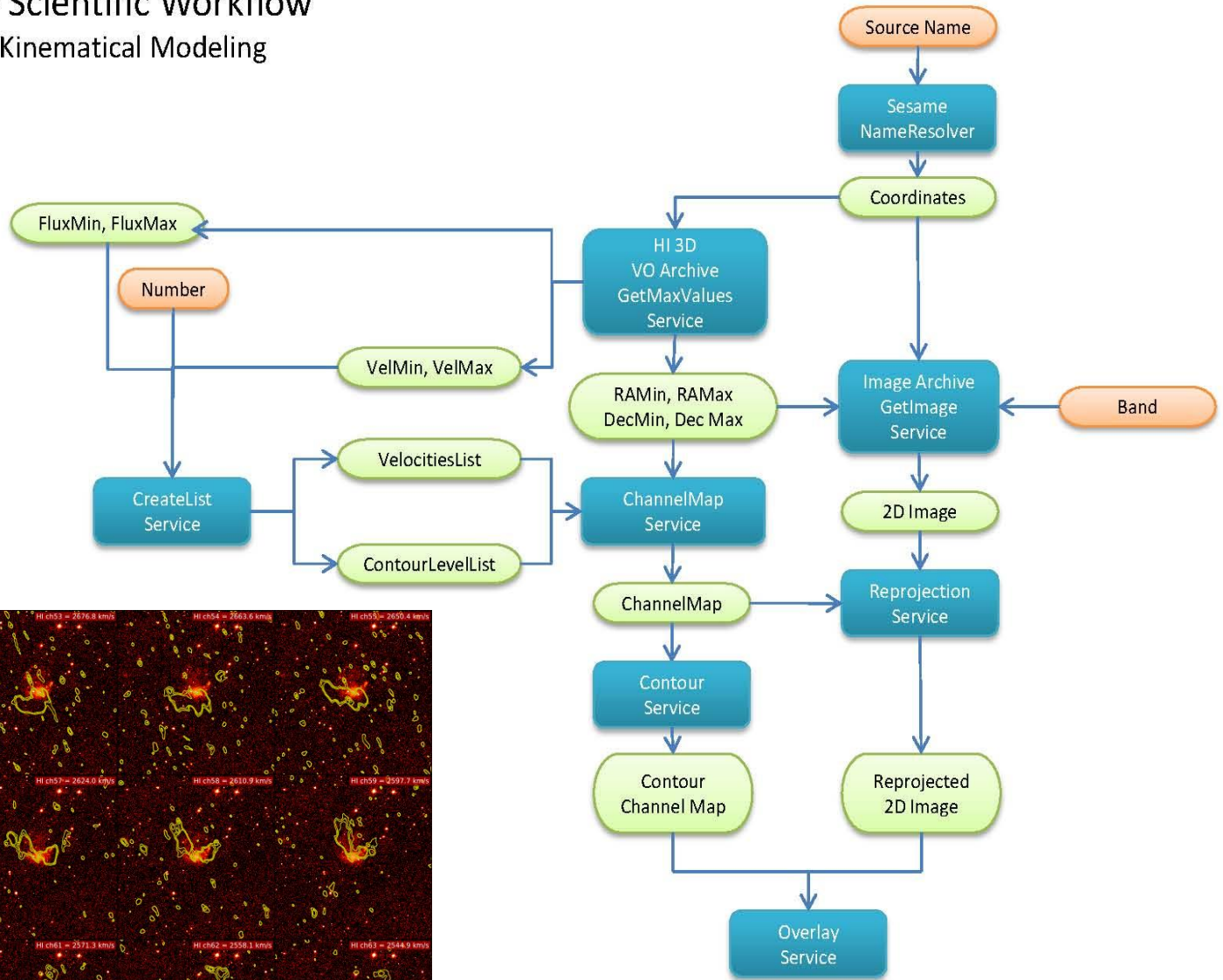
Scientific workflow

Describes a reliably sequence of operations to compose and execute a series of computational or data manipulation steps connecting data and processes (*scientific methodology*)

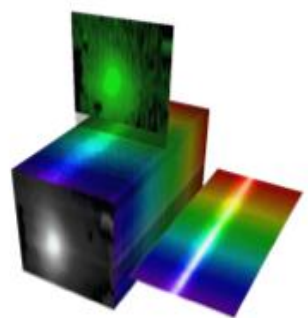
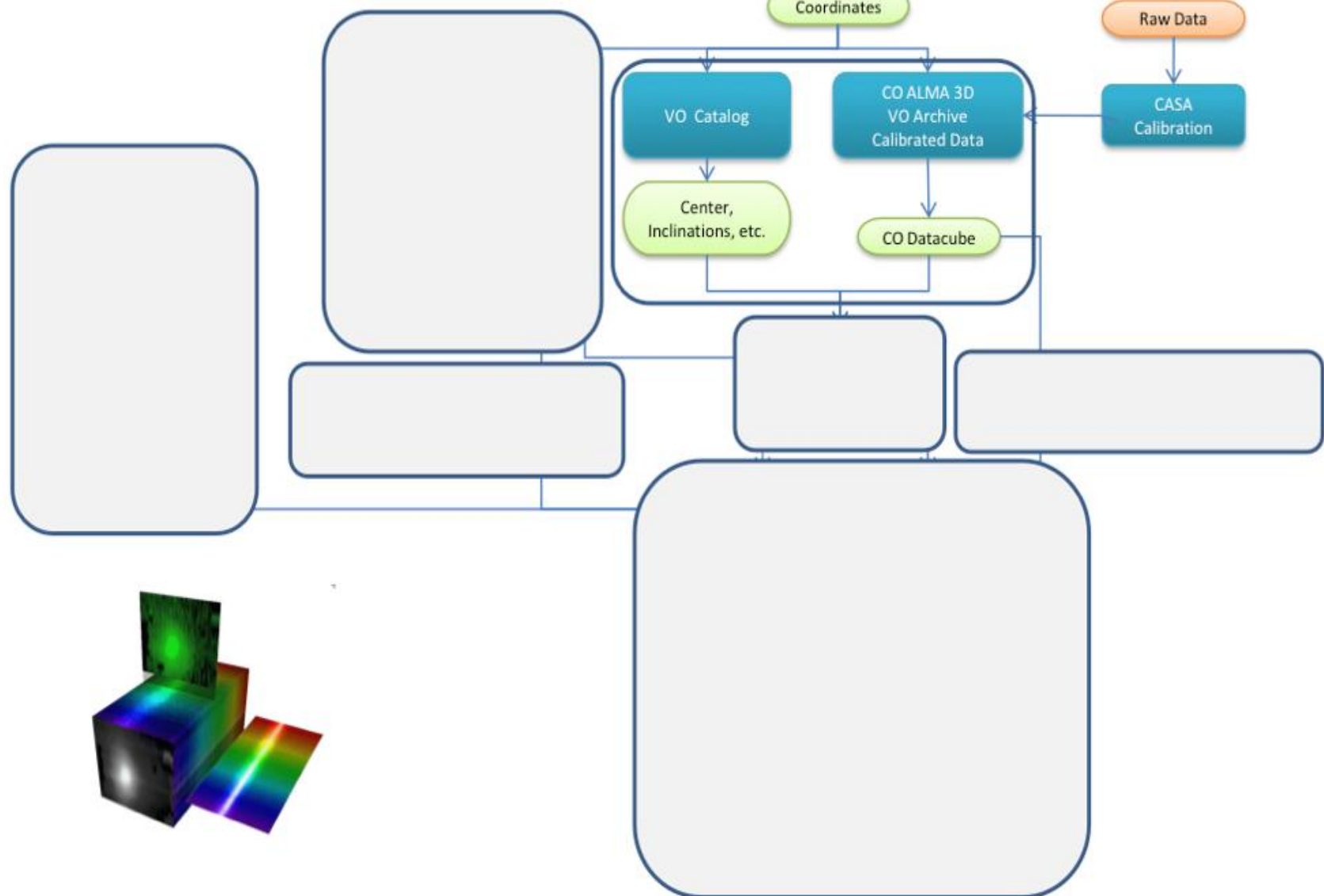
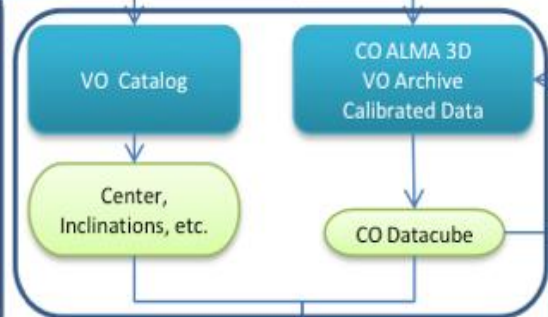
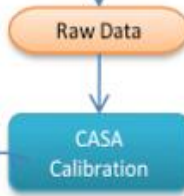
Standards for workflow digital descriptions allow the existence of software that Create/Edit/Open/Run workflows, which ensures:

- **Reproducibility**
- **Community Sharing**
- **Extremely Formative**

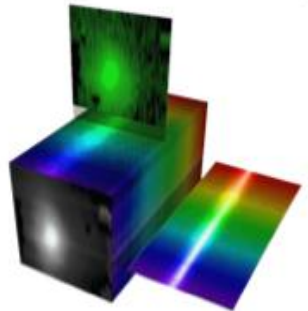
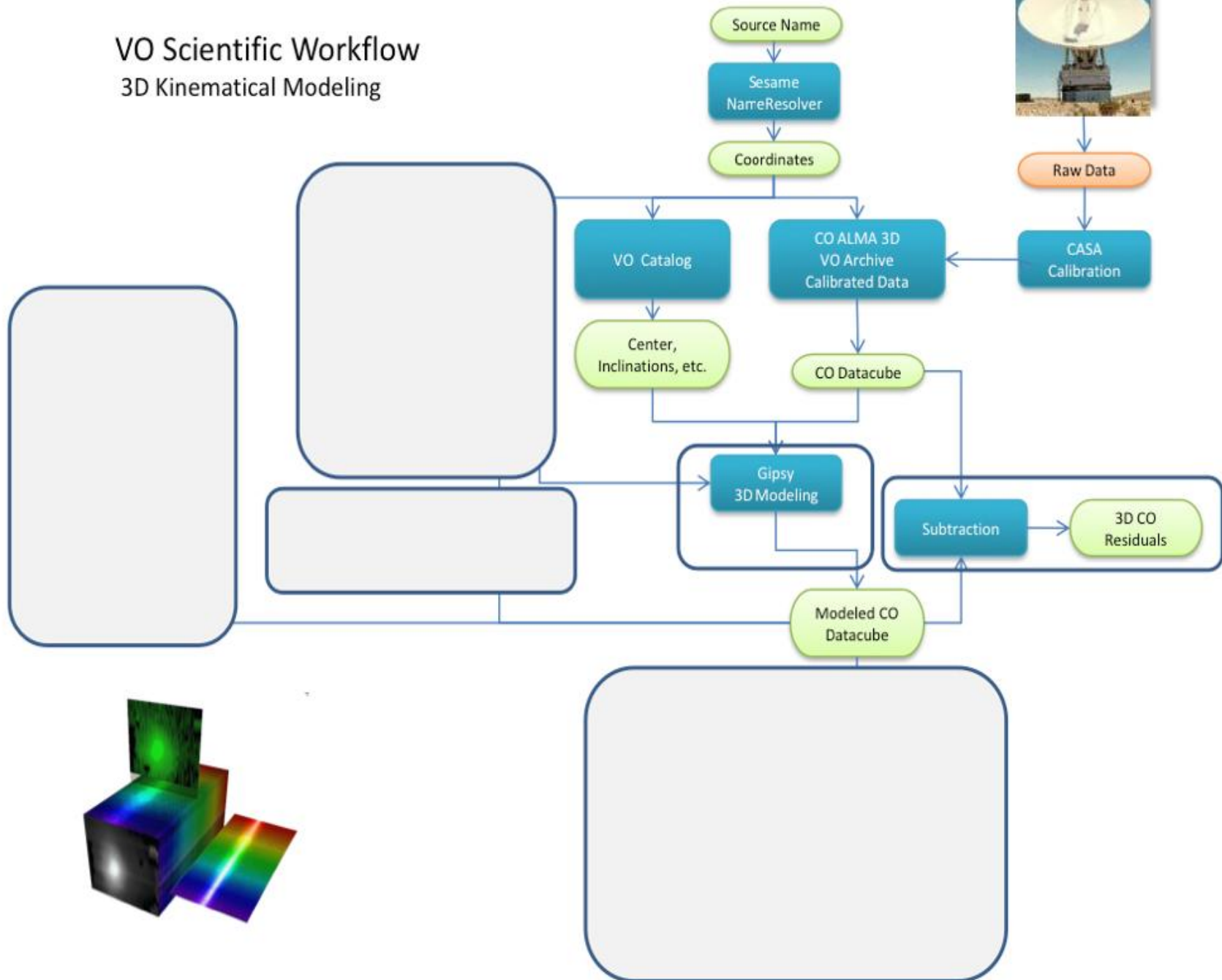
VO Scientific Workflow 3D Kinematical Modeling



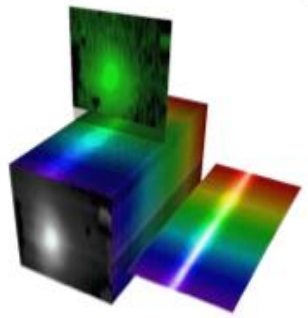
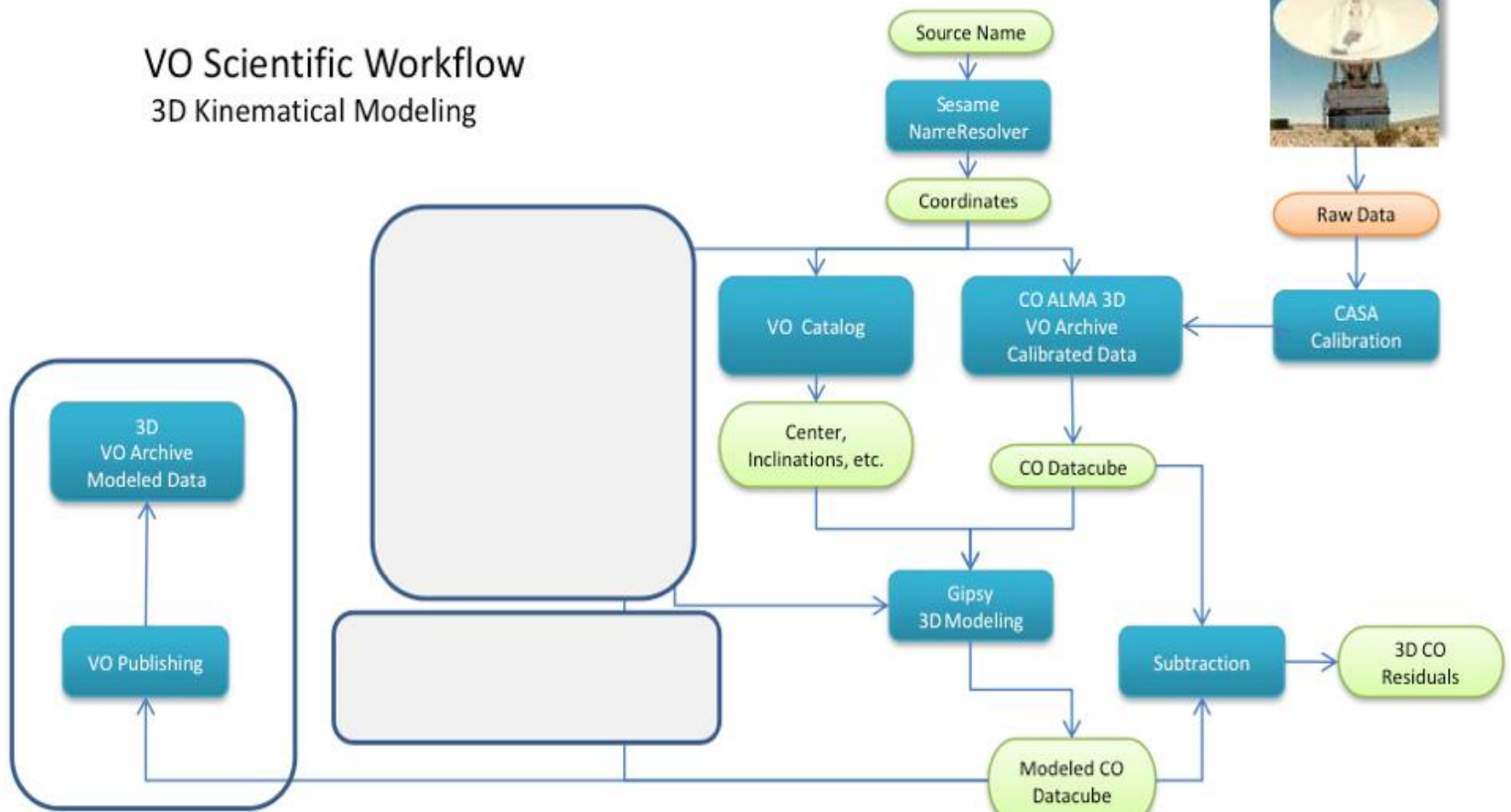
VO Scientific Workflow 3D Kinematical Modeling



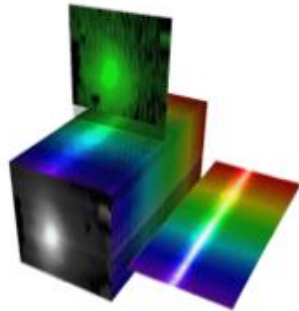
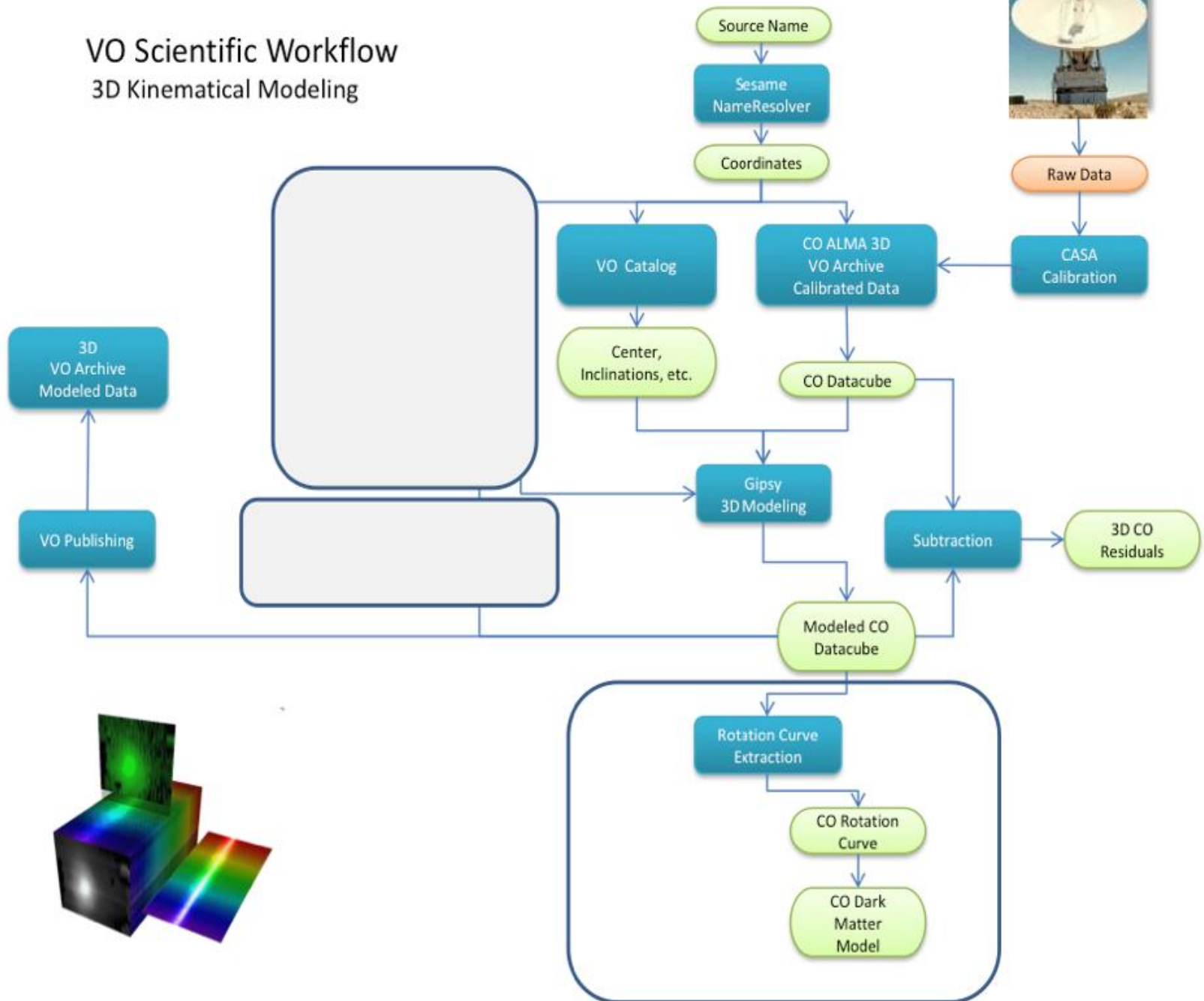
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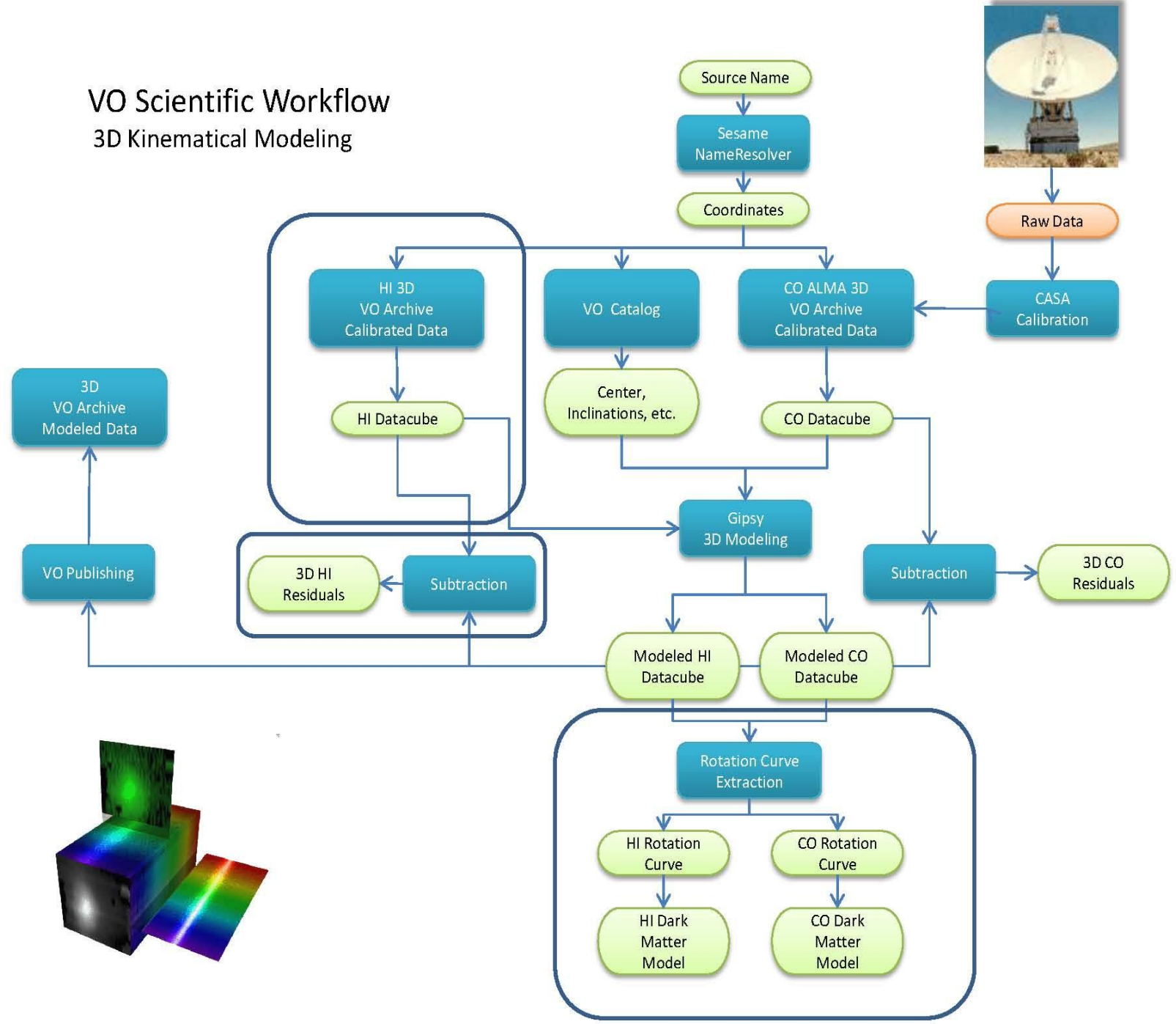


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3D Kinematical Modeling



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