VO challenges for radio astronomy

CENTRE DE DONNÉES
ASTRONOMIQUES DE STRASBOURG

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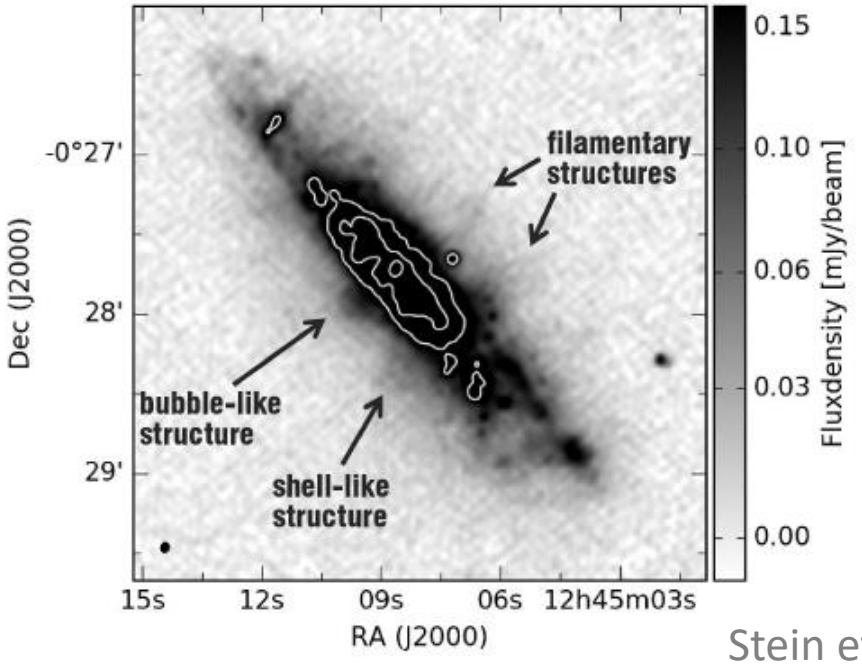
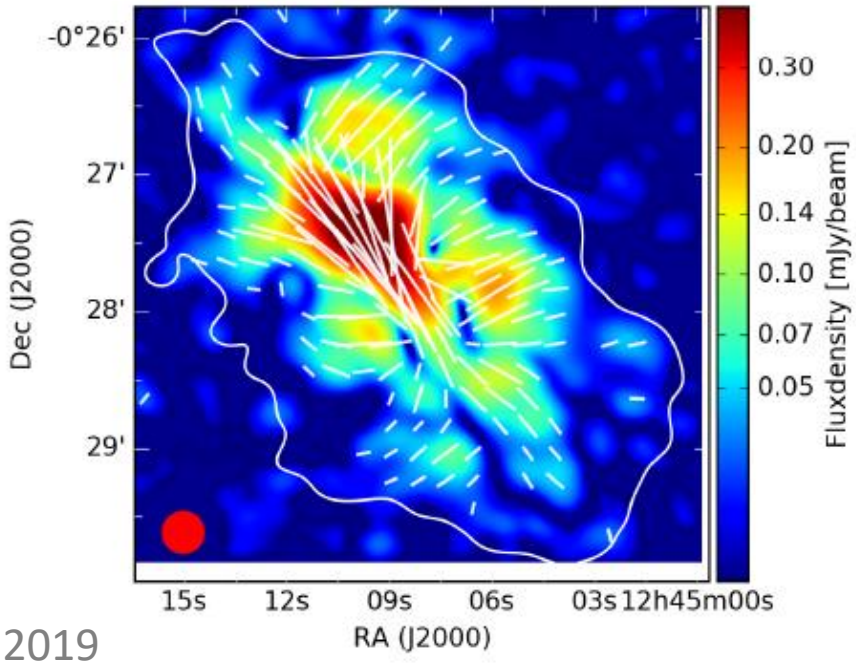
Workshop 28.02.2019

My perspective – radio astronomy

(EVLA, WSRT, GMRT, LOFAR, ATCA)





Stein et al. 2019

VLA ©Stein

My perspective – VO and radio

https://vizier.u-strasbg.fr/viz-bin/VizieR-4

Keywords: VIII/85A/spectra
Tables: VIII/85A ..spectra ..waste ..beam
Constraints
Preferences: max: 50; HTML Table; All columns; Compute
Mirrors: CDS, France

*The column **SED** is a link to a plot of the radio spectrum, and the column **Radio+Opt** is a link to an Aladin preview. The SED plot contains points from the cross-identification (spectra; red), from the waste basket (waste; yellow), and the fitted radio spectra as lines. The Aladin preview contains a DSS image together with NVSS contours (blue) and the points and associated beams of the radio spectrum (red); points and beams of the sources from the waste basket are hidden but can be made visible by clicking on the corresponding plane (yellow).*

VIII/85A/spectra — Post annotation

SPECFIND V2.0 Catalog of radio continuum spectra (Vollmer+ 2009)
The parameters of the radio spectra *(631736 rows)*

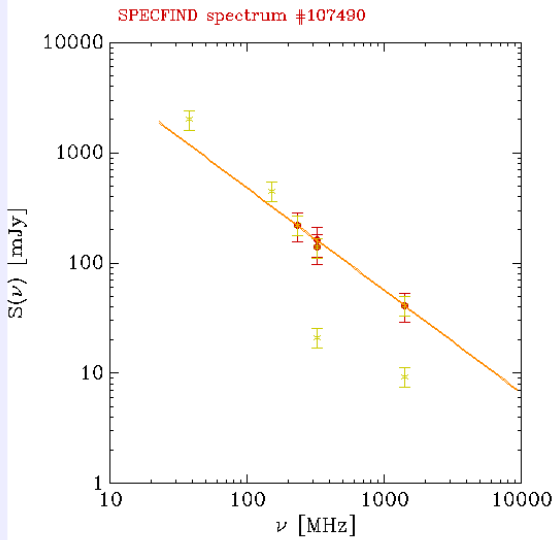
2010A&A...511A..53V ReadMe+ftp spectrum image

start AladinLite | plot the output | query using TAP/SQL

Full	RAJ2000 "h:m:s"	DEJ2000 "d:m:s"	Seq	n	Name	N	a	b [mJy]	nu MHz	S(nu) mJy	e mJy	RAJ2000 deg	DEJ2000 deg	zSim	SED	Radio+Opt	beam arcsec
1	21 44 13.968	+81 47 13.56	107498	7	WN B2146.0+8133A	3	-0.17	2.84	325	2.88e+02	5.8e+01	326.0582	+81.7871	zSim	SED	Radio+Opt	12.00
2	21 44 15.216	+81 47 20.40	107498	7	NVSS J214415+814720	3	-0.17	2.84	1400	2.08e+02	4.2e+01	326.0634	+81.7890	zSim	SED	Radio+Opt	45.00
3	21 44 10.896	+81 47 31.92	107498	7	MY 214550.7+814731.8	3	-0.17	2.84	232	2.80e+02	5.6e+01	326.0454	+81.7922	zSim	SED	Radio+Opt	150.00
4	21 39 27.984	+82 23 29.76	107497	1	WN B2141.5+8209	4	-1.08	4.65	325	7.30e+01	1.5e+01	324.8666	+82.3916	zSim	SED	Radio+Opt	12.00
5	21 39 35.016	+82 23 16.80	107497	1	WN B2141.5+8209B	4	-1.08	4.65	325	5.40e+01	1.1e+01	324.8959	+82.3880	zSim	SED	Radio+Opt	12.00
6	21 39 34.632	+82 23 15.36	107497	1	NVSS J213934+822315	4	-1.08	4.65	1400	1.74e+01	3.5e+00	324.8943	+82.3876	zSim	SED	Radio+Opt	45.00
7	21 39 49.008	+82 23 33.36	107497	1	MY 214156.2+822333.3	4	-1.08	4.65	232	1.40e+02	4.5e+01	324.9542	+82.3926	zSim	SED	Radio+Opt	150.00
8	21 35 01.128	+78 54 10.80	107496	0	WN B2135.5+7839B	3	-1.00	4.78	325	1.62e+02	3.2e+01	323.7547	+78.9030	zSim	SED	Radio+Opt	12.00
9	21 35 00.480	+78 54 11.16	107496	0	NVSS J213500+785411	3	-1.00	4.78	1400	4.29e+01	8.6e+00	323.7520	+78.9031	zSim	SED	Radio+Opt	45.00
10	21 34 43.296	+78 53 29.40	107496	0	MY 213528.5+785329.5	3	-1.00	4.78	232	2.60e+02	5.2e+01	323.6804	+78.8915	zSim	SED	Radio+Opt	150.00
11	17 00 34.656	+79 30 47.52	107495	5	WN B1703.9+7934B	4	-0.69	4.06	325	2.56e+02	5.1e+01	255.1444	+79.5132	zSim	SED	Radio+Opt	12.00
12	17 00 30.336	+79 30 48.24	107495	5	NVSS J170030+793048	4	-0.69	4.06	1400	7.47e+01	1.5e+01	255.1264	+79.5134	zSim	SED	Radio+Opt	45.00
13	17 00 25.800	+79 31 06.96	107495	5	MY 170342.8+793107.1	4	-0.69	4.06	232	2.60e+02	6.3e+01	255.1075	+79.5186	zSim	SED	Radio+Opt	150
14	17 00 46.608	+79 30 55.44	107495	5	MY 170403.6+793055.3	4	-0.69	4.06	232	2.20e+02	6.5e+01	255.1942	+79.5154	zSim	SED	Radio+Opt	150
15	16 08 15.600	+76 27 54.36	107494	1	WN B1609.9+7635A	3	-0.81	4.16	325	1.19e+02	2.4e+01	242.0650	+76.4651	zSim	SED	Radio+Opt	12
16	16 08 15.072	+76 27 53.28	107494	1	NVSS J160815+762753	3	-0.81	4.16	1400	4.13e+01	8.3e+00	242.0628	+76.4648	zSim	SED	Radio+Opt	45
17	16 08 11.712	+76 27 40.68	107494	1	MY 160944.7+762740.7	3	-0.81	4.16	232	1.90e+02	4.3e+01	242.0488	+76.4613	zSim	SED	Radio+Opt	150
18	15 41 54.768	+80 09 57.24	107493	0	WN B1545.0+8018A	3	-0.83	4.66	325	3.54e+02	7.1e+01	235.4782	+80.1659	zSim	SED	Radio+Opt	12
19	15 41 53.424	+80 09 59.76	107493	0	NVSS J154153+800959	3	-0.83	4.66	1400	1.13e+02	2.3e+01	235.4726	+80.1666	zSim	SED	Radio+Opt	45
20	15 42 04.896	+80 09 33.84	107493	0	MY 154452.5+800933.8	3	-0.83	4.66	232	5.20e+02	1.0e+02	235.5204	+80.1594	zSim	SED	Radio+Opt	150
21	14 25 22.056	+78 37 14.88	107492	0	WN B1426.1+7850	3	-0.74	4.14	325	2.34e+02	4.7e+01	216.3419	+78.6208	zSim	SED	Radio+Opt	12
22	14 25 22.368	+78 37 14.52	107492	0	NVSS J142522+783714	3	-0.74	4.14	1400	6.65e+01	1.3e+01	216.3432	+78.6207	zSim	SED	Radio+Opt	45
23	14 25 09.600	+78 37 13.08	107492	0	MY 142554.7+783713.1	3	-0.74	4.14	232	2.50e+02	5.3e+01	216.2900	+78.6203	zSim	SED	Radio+Opt	150
24	13 32 24.792	+84 01 37.56	107491	3	WN B1334.3+8417A	3	-0.87	4.35	325	1.44e+02	2.9e+01	203.1033	+84.0271	zSim	SED	Radio+Opt	12
25	13 32 24.024	+84 01 29.64	107491	3	NVSS J133224+840129	3	-0.87	4.35	1400	3.95e+01	7.9e+00	203.1001	+84.0249	zSim	SED	Radio+Opt	45
26	13 32 51.408	+84 02 03.84	107491	3	MY 133437.5+840203.8	3	-0.87	4.35	232	1.90e+02	4.3e+01	203.2142	+84.0344	zSim	SED	Radio+Opt	150
27	10 59 05.712	+81 50 23.64	107490	7	WN B1054.3+8206	4	-0.93	4.55	325	1.61e+02	3.2e+01	164.7738	+81.8399	zSim	SED	Radio+Opt	12
28	10 59 01.320	+81 50 26.16	107490	7	WN B1054.3+8206A	4	-0.93	4.54	325	1.39e+02	2.8e+01	164.7555	+81.8406	zSim	SED	Radio+Opt	12

Complement to VIII/85A

Source WN_B1054.3+8206: points from spectra and waste tables



My perspective – AENEAS

www.aeneas2020.eu

Aeneas
Advanced European Network of E-infrastructures for Astronomy with the SKA

… to develop a science-driven, functional design for a distributed, federated European Science Data Centre (ESDC).

Access and Knowledge Creation (WP5), e.g., user interface, tools, archive design
WP5.4 Integration with VO Interoperability Framework

Future SKA data products

Not clear yet which SKA data products will be available

- Radio continuum images
- HI moment cubes
- Calibrated visibilities
- Pulsar data: time series, transient candidates, …
- Catalogues of sources
- Rotation measure cubes
- …

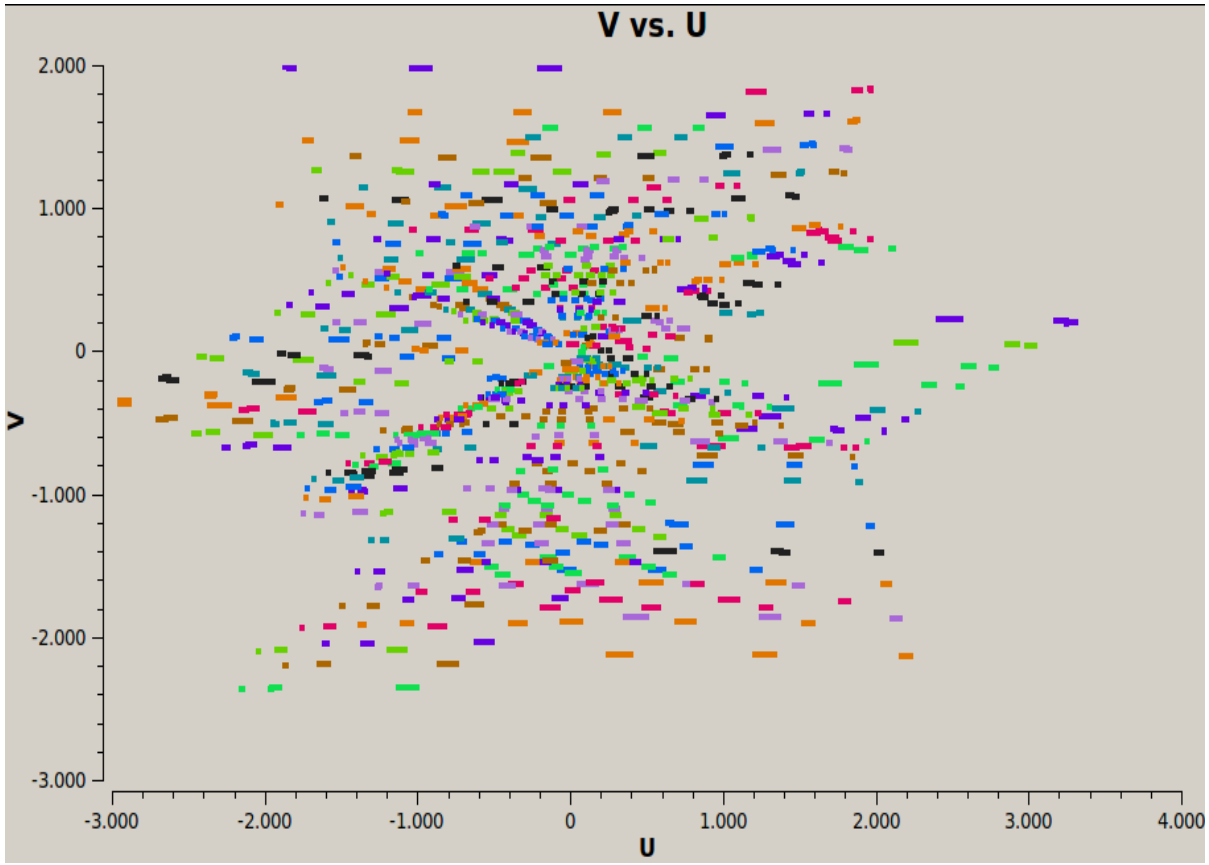
Future SKA data products- Science ready data

Radio astronomers do not trust science ready data naturally!

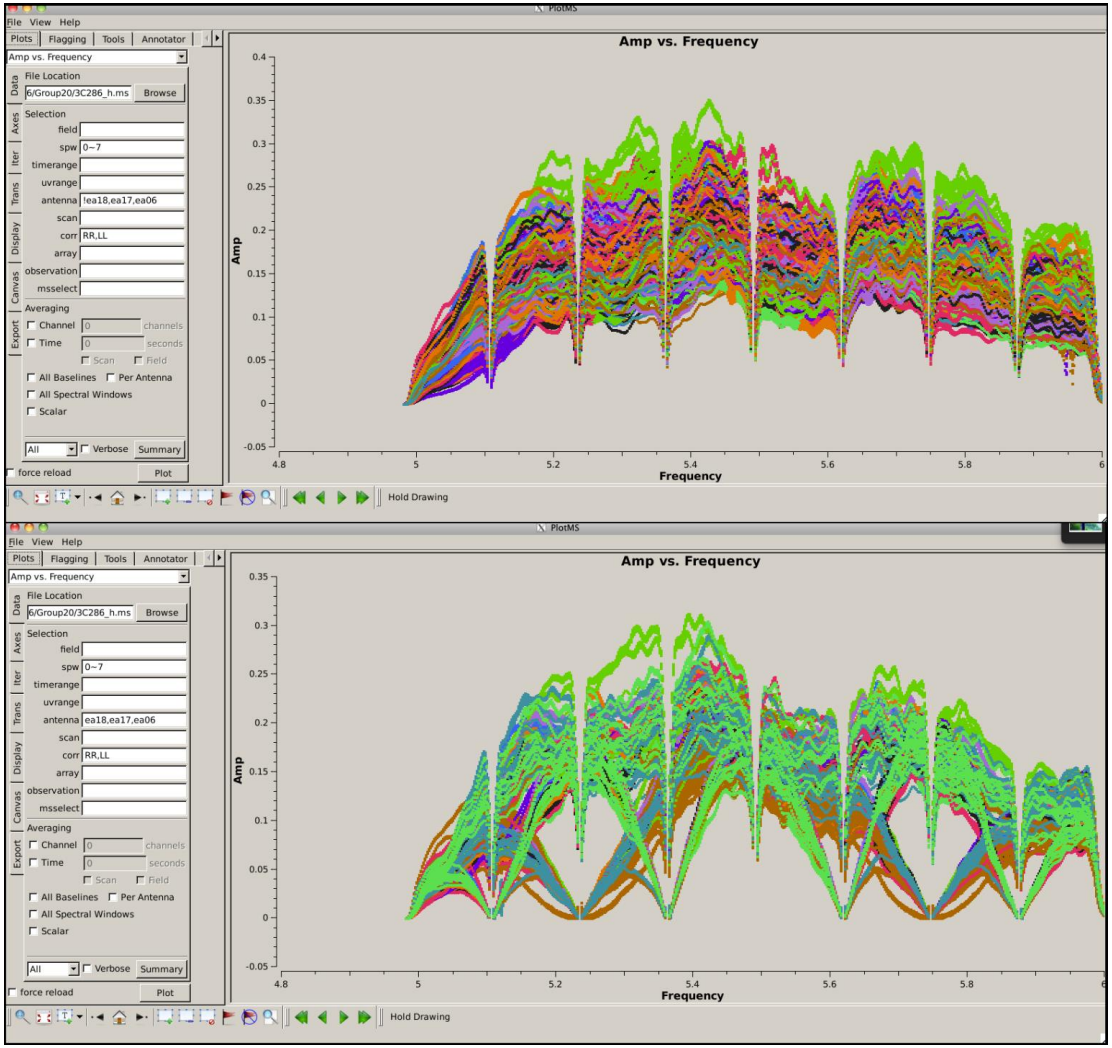
Trust via Metadata:

- Data reduction script or pipelines for calibration and/or imaging
- Check for the different calibration steps, e.g., flux calibration
- Plots of calibrated visibilities:
  amp vs. time
  amp vs. phase
  uv range
  uv coverage
- Weighting parameters

Uv coverage


V vs. U
2.000
1.000
0
-1.000
-2.000
-3.000
V
-3.000
-2.000
-1.000
0
1.000
2.000
3.000
4.000
U

Amp vs. Freq


PlotMS
File View Help
Plots Flagging Tools Annotator
Amp vs. Frequency
Data Axes Iter Trans Display Canvas Export
File Location
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Browse
Selection
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spw 0~7
timerange
uvrange
antenna !ea18,ea17,ea06
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corr RR,LL
array
observation
msselect
Averaging
Channel 0 channels
Time 0 seconds
Scan Field
All Baselines Per Antenna
All Spectral Windows
Scalar
All Verbose Summary
force reload
Plot
Amp vs. Frequency
Amp
Frequency
Hold Drawing
PlotMS
File View Help
Plots Flagging Tools Annotator
Amp vs. Frequency
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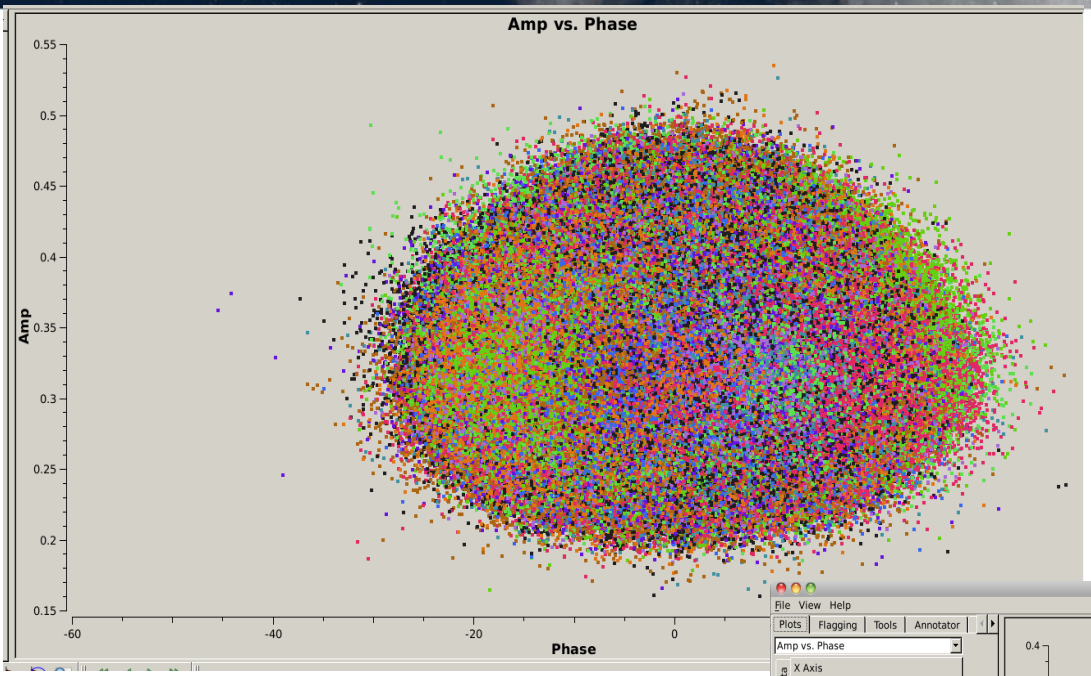
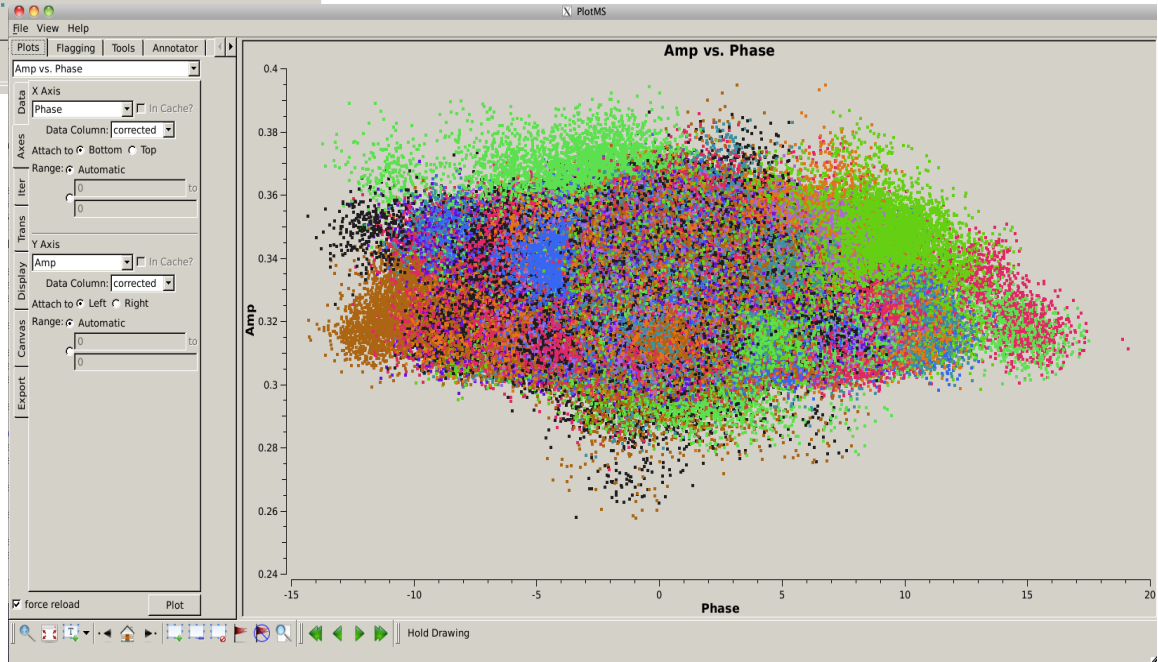
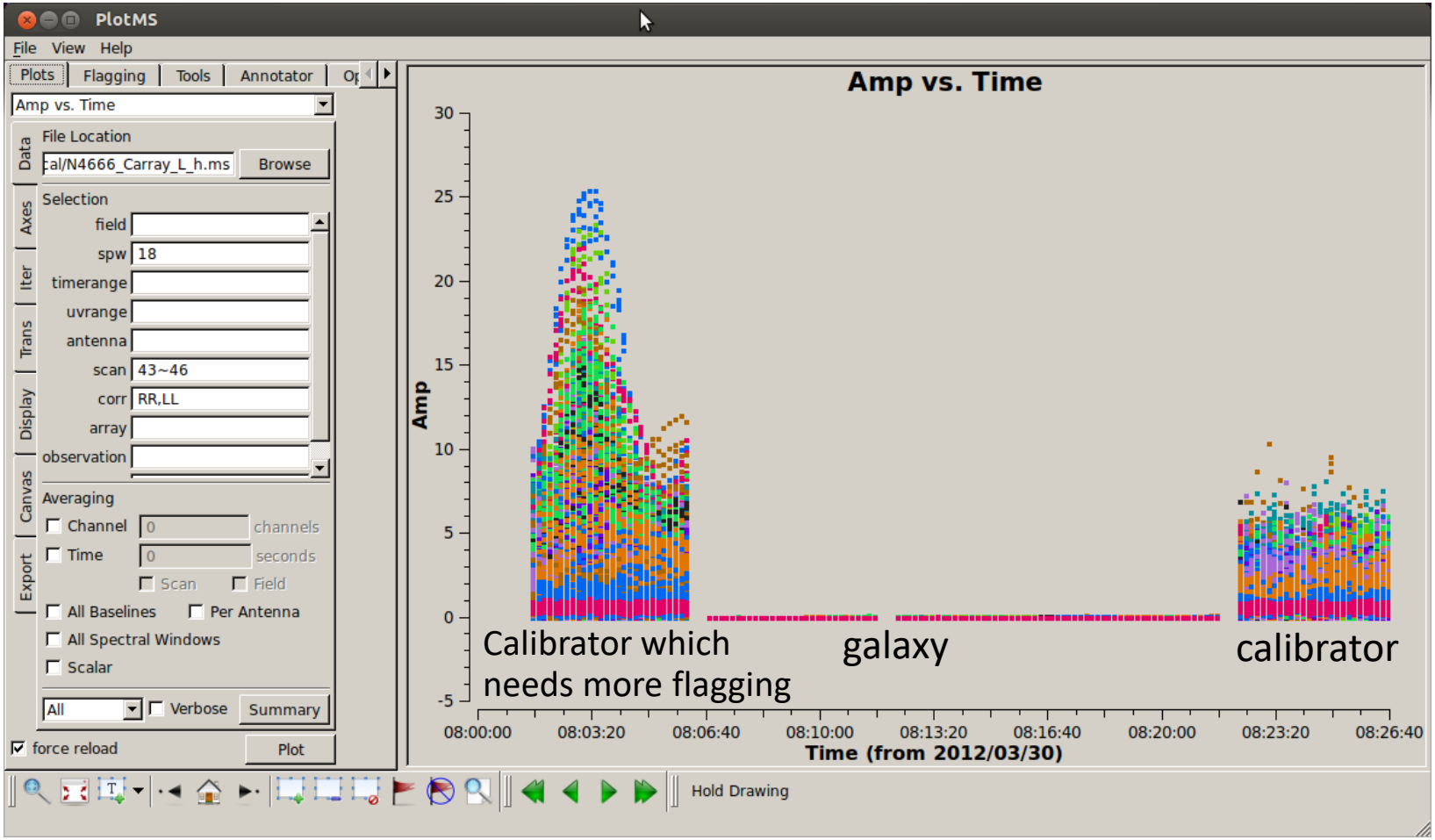
6/Group20/3C286_h.ms
Browse
Selection
field
spw 0~7
timerange
uvrange
antenna ea18,ea17,ea06
scan
corr RR,LL
array
observation
msselect
Averaging
Channel 0 channels
Time 0 seconds
Scan Field
All Baselines Per Antenna
All Spectral Windows
Scalar
All Verbose Summary
force reload
Plot
Amp vs. Frequency
Amp
Frequency
Hold Drawing

Amp vs. phase


Amp vs. Phase
Amp
Phase
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
-60
-40
-20
0


PlotMS
File View Help
Plots Flagging Tools Annotator
Amp vs. Phase
Data
Axes
Iter
Trans
Display
Canvas
Export
X Axis
Phase
In Cache?
Data Column: corrected
Attach to Bottom Top
Range: Automatic
Y Axis
Amp
Attach to Left Right
force reload
Plot
Amp vs. Phase
Amp
Phase
0.4
0.38
0.36
0.34
0.32
0.3
0.28
0.26
0.24
-15
-10
-5
0
5
10
15
20
Hold Drawing

Amp vs. time (observational setup)



Use and Access

Findable, Accessible, Interoperable and Reusable (FAIR) via an Archive/VO tools:

- Cone search
- Cutout tool (see slides of F. Bonnarell)
- HiPS, data link to cubes (velocities, RM)
- …

Meanwhile – raw visibilities

What is needed if we find raw data (visibilities) in the current archives?

- Retrieve the visibilities
- Metadata info: telescope configuration, recommended cell size, image size (related to FoV), …
- Additional metadata: data link to calibrators
- Observational setup

Wishlist of keywords

The usual: Telescope, Obsdate, projectID, central frequency, …

Additional:

Configuration of array → give different resolutions and uv coverage

Bandwidth, channelwidth

Resolution: restored beam: BMIN, BMAX, PA (in fits header)

Weighting parameter (e.g. robust weighting 2)

Field of view: prim beam, usually not in the fits header but if you have the prim beam corrected images you see the circle of the beam

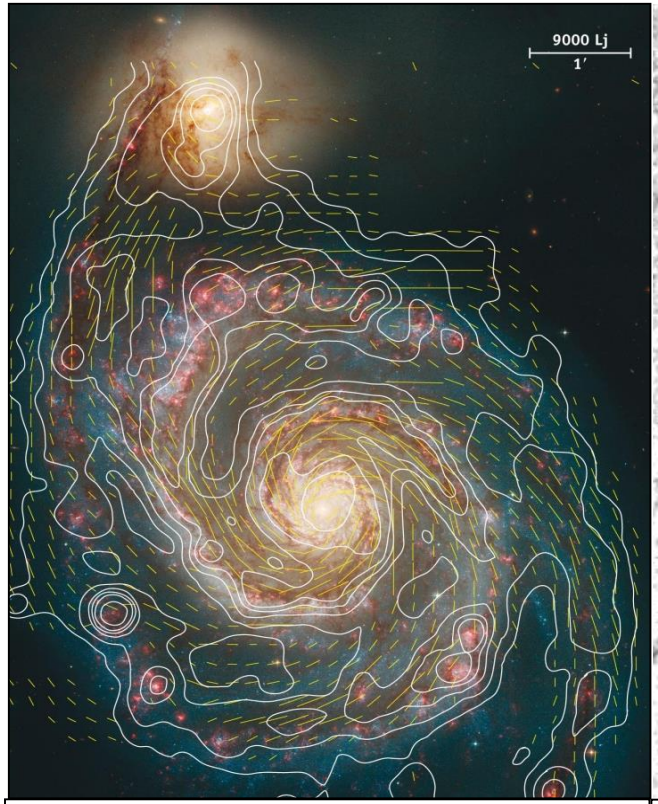
- Useable for fluxes: up to HPBW
- Maybe useable for number searches without quantitative use: total FoV

…. more thinks to add

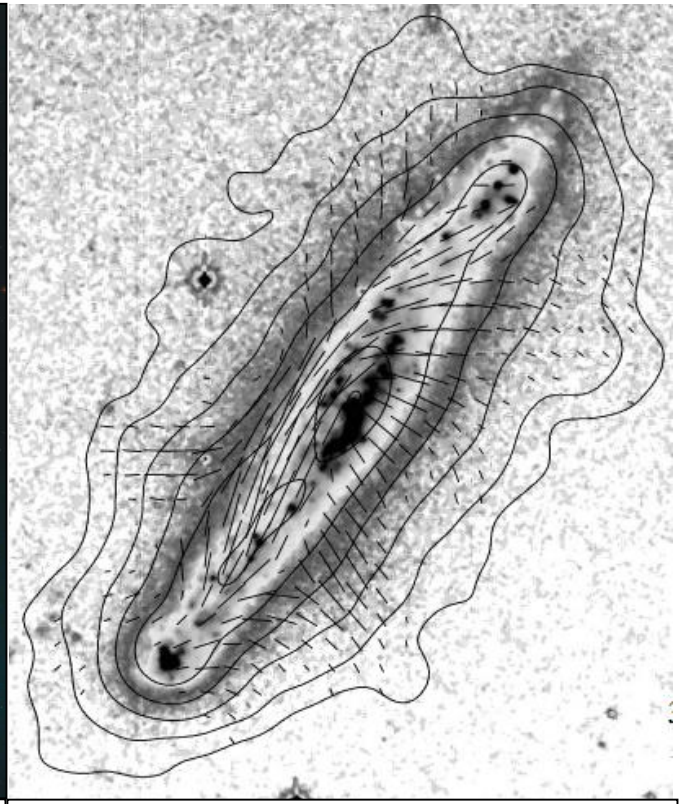
…. more thinks to add

Magnetic fields in Spiral Galaxies

- Observations show large scale magnetic fields in spiral galaxies
- Investigating CR transport processes
- Explaining the existence of magnetic fields in spiral galaxies (10 – 15 µG)
- The magnetic field of the earth at the surface: 0.4 G



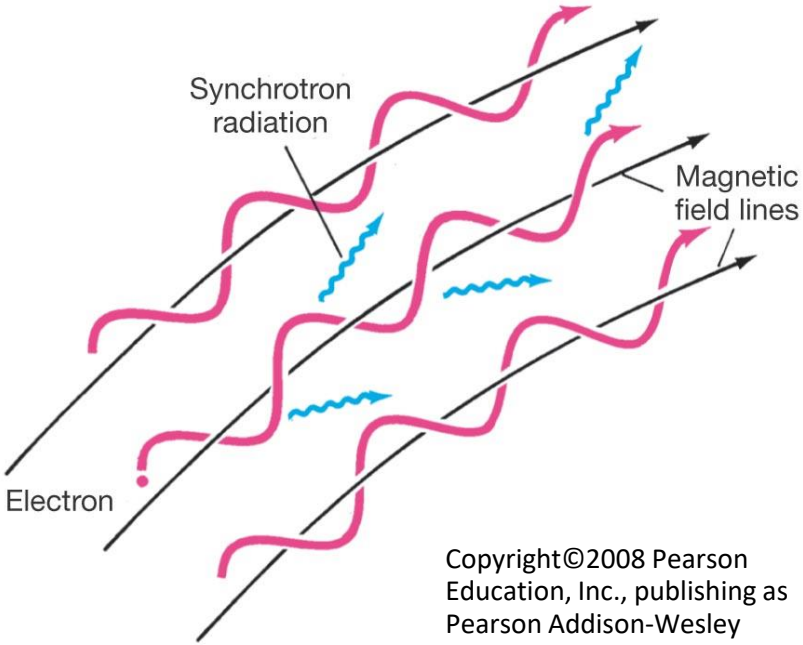
Spiral galaxy M51 (total and polarized intensity), VLA + Effelsberg telescope at 6 cm wavelength, Optical background: HST
© A. Fletcher (MPIfR Bonn)



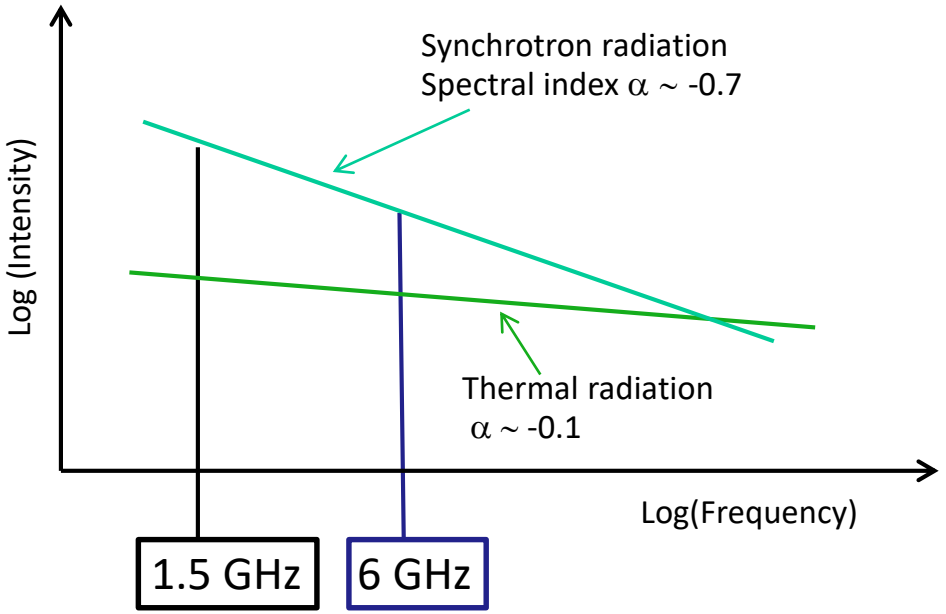
Edge-on spiral galaxy NGC 5775 (total intensity and B-vectors), VLA at 6 cm wavelength, Halpha background (Tüllmann et al.2000)

Synchrotron Radiation

- Relativistic electrons (cosmic ray particles) gyrate around the magnetic field lines and radiate in the line of sight
- Synchrotron radiation is polarized perpendicular to the orientation of the magnetic field
- The regular magnetic field perpendicular to the line of sight is observed via the polarised intensity and the polarisation angle
- The regular and turbulent magnetic field contribute to the total intensity

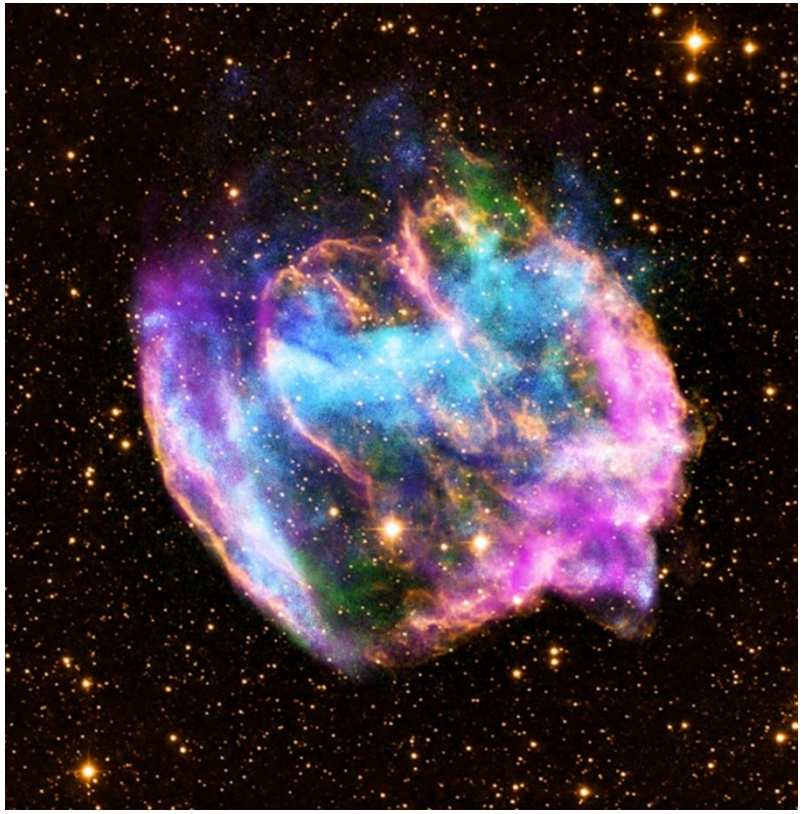


Synchrotron emission



Spectrum in the radio continuum at CHANG-ES frequencies

Cosmic Rays

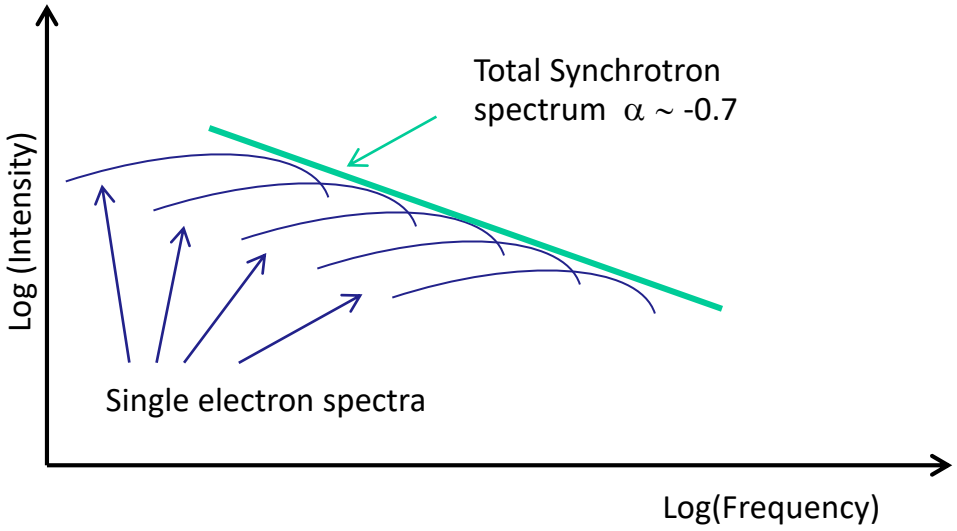


Supernova Remnant W49B, Credit: NASA

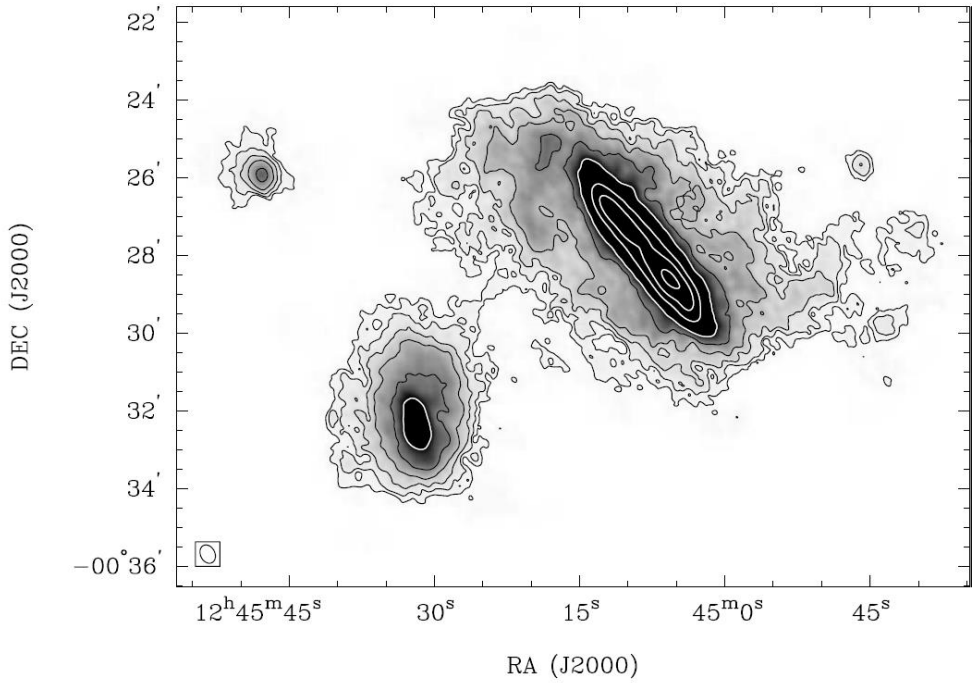
- Directly measured on Earth
- Cosmic ray particles are probably accelarated in Supernova explosions or AGN

  → Electrons gain relativistic velocities
- Superposition of Single electron spectra leads to the observed radio spectrum
- Travel away from their origin

  → Transport processes



NGC 4666 – HI



Walter et al. 2004