

Mapping INAF Single Dish data into ObsCore

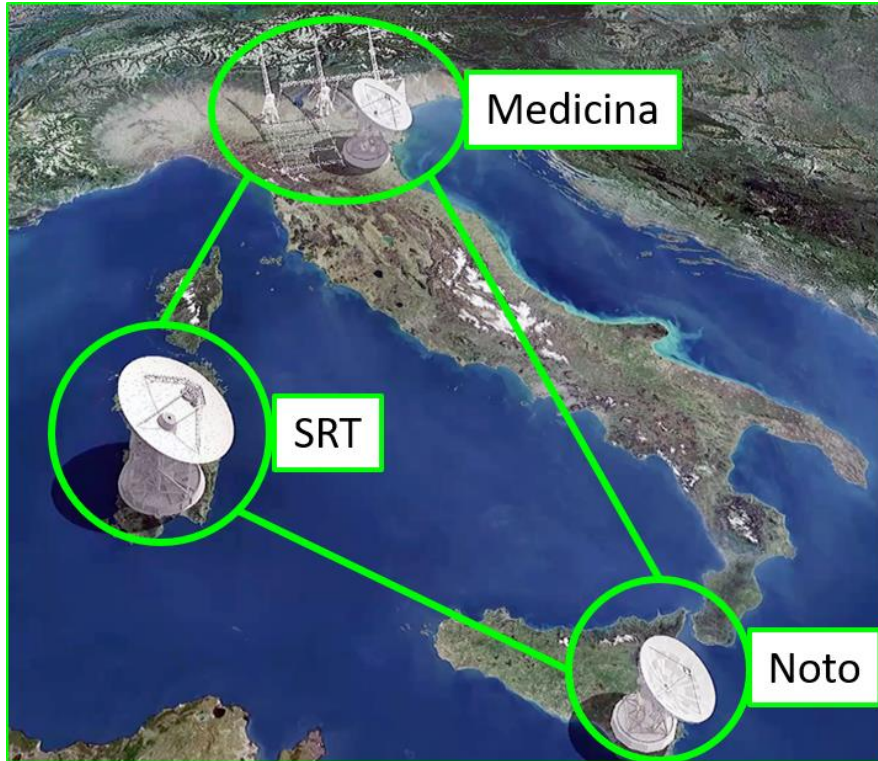
A Zanichelli - INAF radio data archive Working Group

Contributors: V. Galluzzi, M. Molinaro, C. Knapic, S. Righini, N. Calabria

IVOA Interoperability Meeting, April 28th, 2022



INAF radio telescopes



Observing modes:

SD

Pulsar

VLBI

Share the same control software
and data format

In operation: 300 MHz – 26(+) GHz
Total intensity, spectropolarimetry



https://www.radiotelesopes.inaf.it

Observing with the Italian radio telescopes

Welcome to the Italian radio telescopes users' page
Here you can access all of the resources needed to achieve successful single-dish and extra-EVN interferometric observations

[Contact us](#)

*Regular call is closed. The next deadline will be in October 2022.
Proposals for ToOs and DDT can be submitted anytime.
The offered instrumentation is [listed here](#).*

Pre- and post-observation COMMON TOOLS

Proposals How to submit your proposal in order to request observing time. GO	Planning Estimate the observing time you need and check the visibility of sources. GO	Schedules Learn how to prepare the observing schedules using our writer. GO	Calendars Allocated antenna time at the three observatories. GO
Ticketing Submit a ticket to inform us about problems and inefficiencies. ComingSoon	Post-obs feedback Let us know whether your observing session met your goals. GO	Data archive Retrieve your data and find details on their format. GO	Reduction tools Discover and download the available data reduction tools. ComingSoon

Observing with the SRT

SRT user's guide Online user's guide to the SRT control system. GO	Technical details SRT info, describing the available hardware. GO	Webcam Webcam showing the 64-m dish. GO	Weather monitor Check SRT's weather station online monitors. GO
Science with the SRT Read about the Early Science projects carried out with the SRT. GO	Information for observers Logistics and other useful information for observers. GO		



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WARNING!
It contains
only raw
data, at the
moment

<http://radioarchive.inaf.it>

radioarchive.inaf.it

67% Search

Help Your files Login

Simple search VLBIIT search SD search Pulsar search

File name

Name resolver: Object name Resolve

RA (J2000) hh.mm.ss.ss Dec (J2000) dd.mm.ss.ss Radius (arcmin) 14

Toggle all

Equinox Select...

Obs date From: yyyy-MM-dd To: yyyy-MM-dd

Frequency [MHz] From: To:

Project id

Telescope Select...

Frontend Select...

Bandwidth [MHz] From: To:

Exposure time [s] From: To:

LST From: hh.mm.ss.sss To: hh.mm.ss.sss

Scan type Select...

Spectral resolution [MHz] From: To:

Frequency bins

Wobbler Select...

Creator

Format version

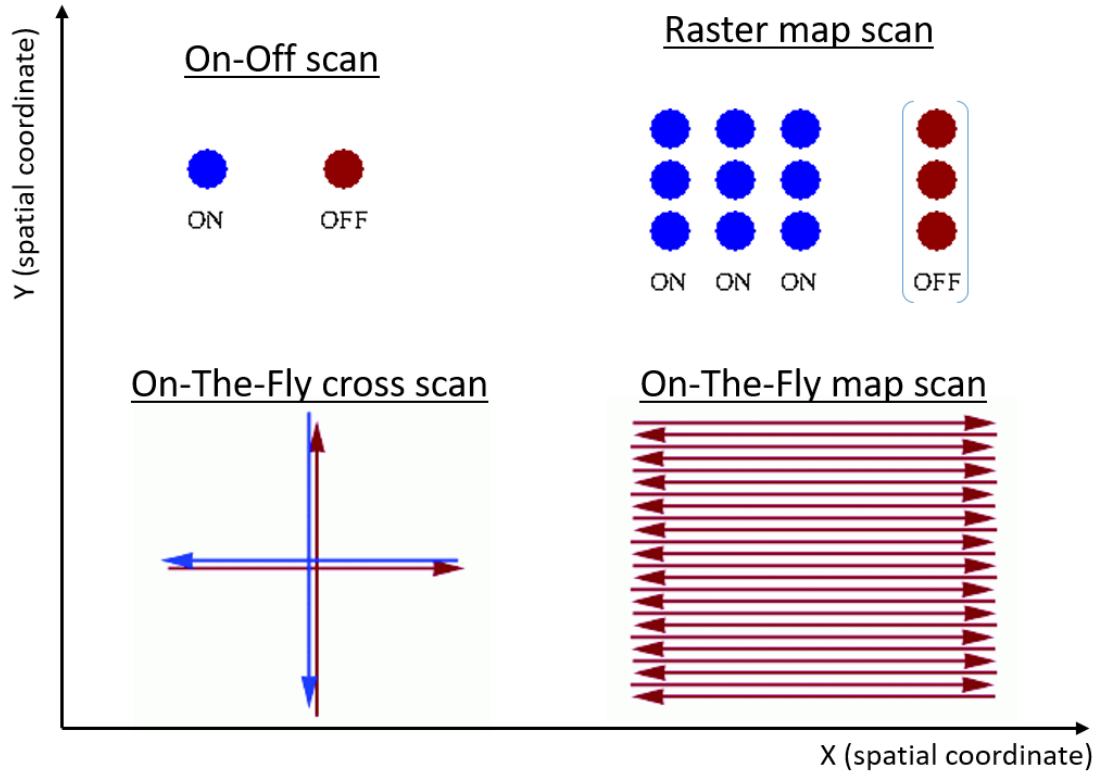
Backend Select...

Rest frequency [MHz]

Search Reset

Progressively
being
populated
with SD,
pulsar and
VLBI-IT data
(VLBI-IT =
software
correlated in
Bologna)

Single-Dish Observations: scan types (main/current)

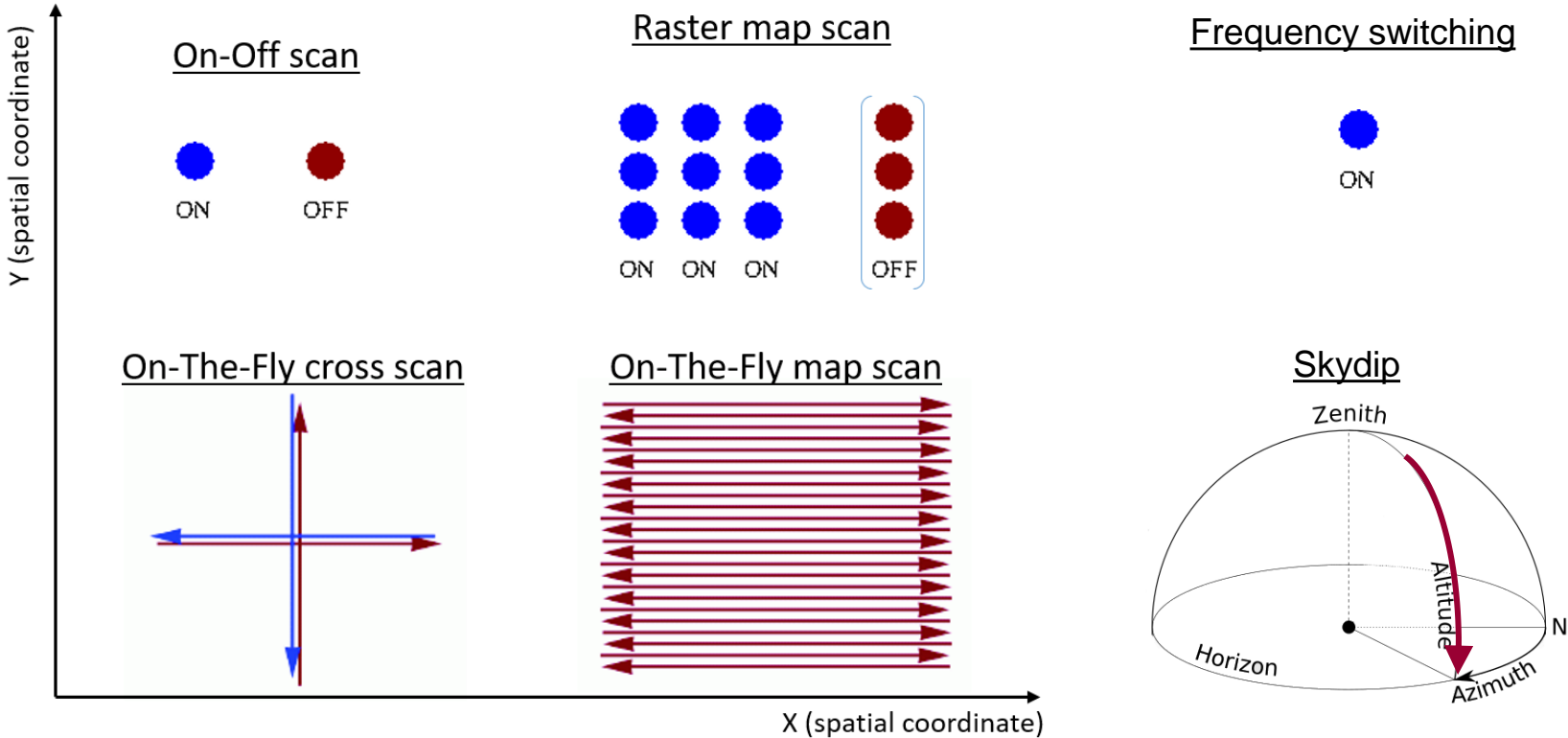


Measured quantity:

raw counts(x,y,lambda,Pol).

at a given sampling rate
 δt

Single-Dish Observations: scan types (main/current)



Single-dish data format

```
tyrann:~/home2/escs/archivioDati/extendedata/20190415-120831-19-18-0528+134> ls
20190415-120831-19-18-0528+134_023_002.fits 20190415-121134-19-18-0528+134_023_011.fits
20190415-120851-19-18-0528+134_023_003.fits 20190415-121154-19-18-0528+134_023_012.fits
20190415-120911-19-18-0528+134_023_004.fits 20190415-121215-19-18-0528+134_023_013.fits
20190415-120932-19-18-0528+134_023_005.fits 20190415-121235-19-18-0528+134_023_014.fits
20190415-120952-19-18-0528+134_023_006.fits 20190415-121255-19-18-0528+134_023_015.fits
20190415-121012-19-18-0528+134_023_007.fits 20190415-121316-19-18-0528+134_023_016.fits
20190415-121033-19-18-0528+134_023_008.fits 20190415-121366-19-18-0528+134_023_017.fits
20190415-121053-19-18-0528+134_023_009.fits Sum_20190415-120831-19-18-0528+134.fits
20190415-121113-19-18-0528+134_023_010.fits
tyrann:~/home2/escs/archivioDati/extendedata/20190415-120831-19-18-0528+134>
```

One Scan: folder containing...

1 Summary FITS file

n subscan FITS files

```
fv: Header of Sum_20190415-120831-19-18-0528+134_00.../19-18/data/20190415/20190415-120831-19-18-0528+134/
File Edit Tools Help
Search for: Find Case sensitive? No
SIMPLE = T / file does conform to FITS standard
BITPIX = 32 / number of bits per data pixel
NAXIS = 0 / number of data axes
EXTEND = T / FITS dataset may contain extensions
CREATOR = 'DISCOS' / Software (incl. version)
FITSVER = 'V 1.11' / FITS version
PROJID = '19-18' / ProjectID
TELESCOP = 'Medicina' / Telescope name
HIERARCH ScheduleName = '19-18 K_a_scd' / Name of the schedule
DATE-OBS = '2019-04-15T12:08:32.123' / Observation time
LST = 8914.6269 / Local sidereal time
HIERARCH RightAscension = 1.44399990196576 / Target right ascension (radians)
HIERARCH Declination = 0.23617954379873 / Target declination (radians)
EQUINOX = 2000.00 / Equinox of Ra, Dec
OBJECT = '0528+134' / Target source name
SCANATYPE = 'CROSSSCAN' / Scan astronomical type
EXPTIME = 229.71998 / Total integration time (seconds)
HIERARCH ReceiverCode = 'FKC' / Receiver name
HIERARCH BackendName = 'TotalPower' / Backend name
NUSECOND = 2 / Number of sections
FREQ1 = 23500.000000 / Start frequency of the Nth section (MHz)
BWID1 = 1200.00000000 / Bandwidth of the Nth section (MHz)
HIERARCH POLATYPE1 = 'LCP' / LCP, RCP, HLP, VLP, stokes type of the Nth sect
HIERARCH FREOBINS1 = 1 / Number of spectral bins of the Nth section
HIERARCH FREQRESOL1 = 1200.0000 / Frequency resolution of the Nth section (MHz)
HIERARCH RESTFREQ1 = -999.000 / Rest frequency of the Nth section (MHz)
FREQ2 = 23500.000000 / Start frequency of the Nth section (MHz)
BWID2 = 1200.00000000 / Bandwidth of the Nth section (MHz)
HIERARCH POLATYPE2 = 'RCP' / LCP, RCP, HLP, VLP, stokes type of the Nth sect
HIERARCH FREOBINS2 = 1 / Number of spectral bins of the Nth section
HIERARCH FREQRESOL2 = 1200.0000 / Frequency resolution of the Nth section (MHz)
HIERARCH RESTFREQ2 = -999.00000 / Rest frequency of the Nth section (MHz)
QMAXDEG = -999.000000000 / Scan start x coordinate (degree, optional)
YMAXDEG = -999.000000000 / Scan start y coordinate (degree, optional)
VMAXIPA = -999.000000000 / Scan end x coordinate (degree, optional)
HIERARCH ScheduleName = '19-18 K_a_scd' / Name of the schedule
```

1 Scan = 1 ObsCore entry

Mapping SD data into ObsCore

OK

calib_level

obs_collection

obs_id, obs_publisher_did

access_url, access_format

access_estsize

target_name, s_ra, s_dec

t_min, t_max, t_exptime

(*pol_states*), pol_xel

(*facility_name*), instrument_name

Focus on

dataprodtype

s_fov, s_region, s_xel1, s_xel2

t_resolution, t_xel

em_res_power, em_min, em_max

dataprodect_type (1)

On-Off, frequency switching: `dataprodect_type = spectrum` (*but see next slides*)

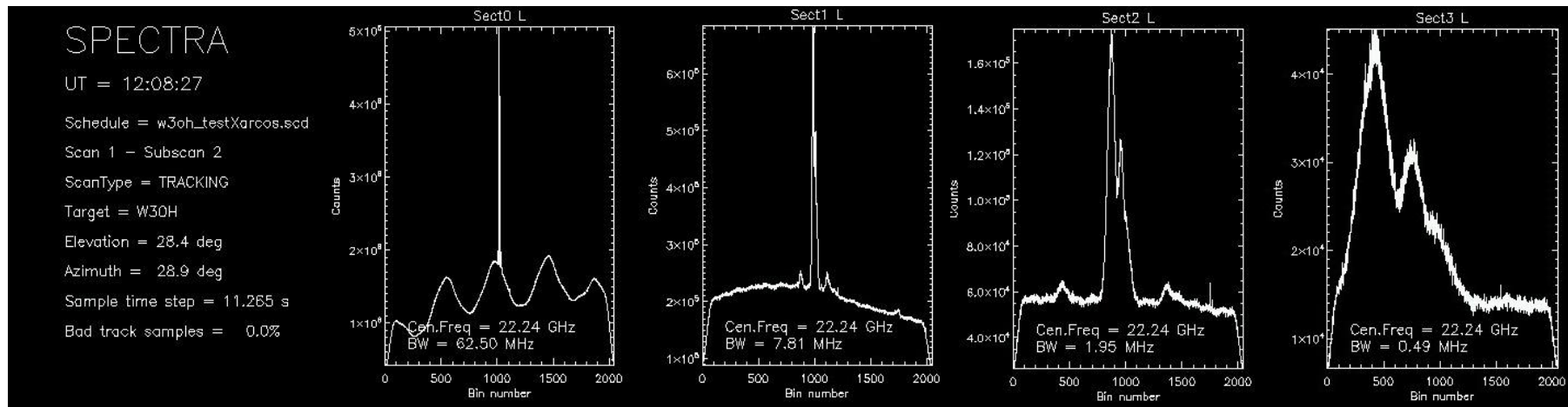
Raster/OTF map: `dataprodect_type = cube` (*but see next slides*)

OTF cross scan, skydip scan: new value for `dataprodect_type` = *spatial-profile?*

dataproduuct_type (2)

It is possible to have more than one spectral window in the same scan, differing in bandwidth and spectral resolution. Examples:

- each spectral window is centered at a different frequency
- spectral windows at same frequency with increasing resolution (“zoom mode”)



Multifrequency setup

Wobbler

Creator

Format version

Rows displayed: 2

[Download](#) [Edit query](#)

<input checked="" type="checkbox"/>	<input type="checkbox"/> File name	Policy	Proj id	RA	Dec	Obs date	Freq min [MHz]	Freq max [MHz]	Bandwidth [MHz]	Spec res [MHz]	Rest freq [MHz]	Freq bins	Pol
<input type="checkbox"/>	20190406-040544-13-19-G358.93-0.03.tar	FREE	13-19	17:43:10.020	0-29:51:45.80	2019-04-06T04:05:55	22235.18475	22242.99725	7.8125	0.0038146973	22235.07985	2048	LCP
<input type="checkbox"/>	20190419-025725-13-19-G358.93-0.03.tar	FREE	13-19	17:43:10.020	0-29:51:45.80	2019-04-19T02:57:36	22235.18475	22242.99725	7.8125	0.0038146973	22235.07985	2048	RCP
<input type="checkbox"/>	20190422-013655-13-19-Skydip.tar	FREE	13-19	13:14:18.508	27:15:49.20	2019-04-22T01:36:56	22238.1144375	22240.0675625	1.953125	9.5367432E-4	22235.07985	2048	LCP
<input type="checkbox"/>	20190422-014516-13-19-3C286.tar	FREE	13-19	13:31:08.280	30:30:33.12	2019-04-22T01:45:17	22238.1144375	22240.0675625	1.953125	9.5367432E-4	22235.07985	2048	RCP
<input type="checkbox"/>	20190422-015546-13-19-G358.93-0.03.tar	FREE	13-19	17:43:10.020	0-29:51:45.80	2019-04-22T01:55:57	22238.8468594	22239.33514065	0.48828125	2.3841858E-4	22235.07985	2048	LCP
							22238.8468594	22239.33514065	0.48828125	2.3841858E-4	22235.07985	2048	RCP
							22207.841	22270.341	62.5	0.030517578	22235.07985	2048	LCP
							22207.841	22270.341	62.5	0.030517578	22235.07985	2048	RCP

Multifrequency setup

Wobbler

Creator

Format version

Download

<input checked="" type="checkbox"/>	File name	Policy	Proj id	RA
<input type="checkbox"/>	20190406-040544-13-19-G358.93-0.03.tar	FREE	13-19	17
<input type="checkbox"/>	20190419-025725-13-19-G358.93-0.03.tar	FREE	13-19	17
<input type="checkbox"/>	20190422-013655-13-19-Skydip.tar	FREE	13-19	13
<input type="checkbox"/>	20190422-014516-13-19-3C286.tar	FREE	13-19	13
<input type="checkbox"/>	20190422-015546-13-19-G358.93-0.03.tar	FREE	13-19	17

Freq min [MHz]	Freq max [MHz]	Bandwidth [MHz]	Spec res [MHz]	Rest freq [MHz]	Freq bins	Pol
22235.18475	22242.99725	7.8125	0.0038146973	22235.07985	2048	LCP
22235.18475	22242.99725	7.8125	0.0038146973	22235.07985	2048	RCP
22238.1144375	22240.0675625	1.953125	9.5367432E-4	22235.07985	2048	LCP
22238.1144375	22240.0675625	1.953125	9.5367432E-4	22235.07985	2048	RCP
22238.8468594	22239.33514065	0.48828125	2.3841858E-4	22235.07985	2048	LCP
22238.8468594	22239.33514065	0.48828125	2.3841858E-4	22235.07985	2048	RCP
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dataprodect_type (2)

It is possible to have more than one spectral window in the same scan, differing in bandwidth and spectral resolution. Examples:

- each spectral window is centered at a different frequency
- spectral windows at same frequency with increasing resolution (“zoom mode”)

When multiple frequency setups are present, need to «advertise» it (scientific content is relevant!) without confusing the user with too many details during first discovery.

New values for dataprodect_type = *multifrequency* (...or?)

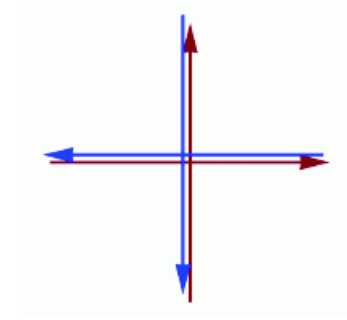
Geometry: s_{fov} , s_{region} , s_{xel1} , s_{xel2}

Peculiar cases in the radio domain [not a typical (x,y) image]

ON-OFF: two fixed positions

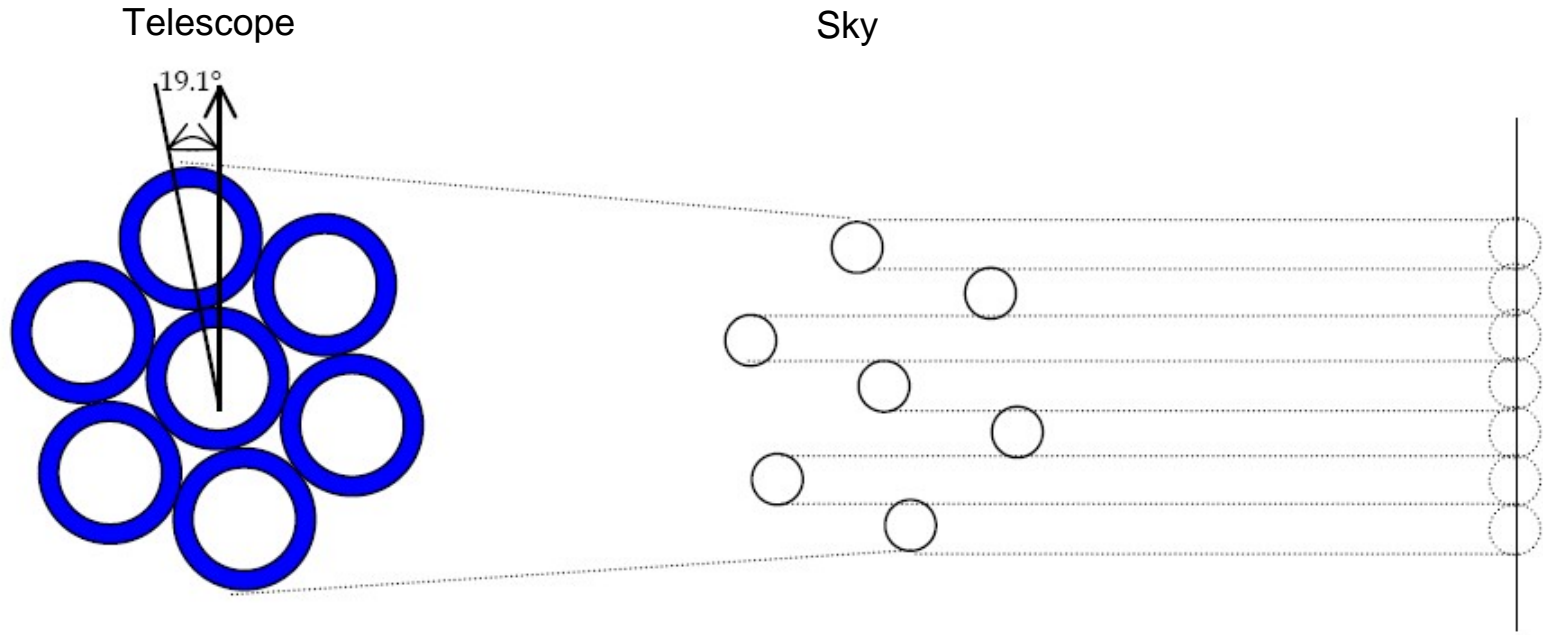


OTF Cross Scan: axes lengths have not the same geometrical meaning as in a typical image.



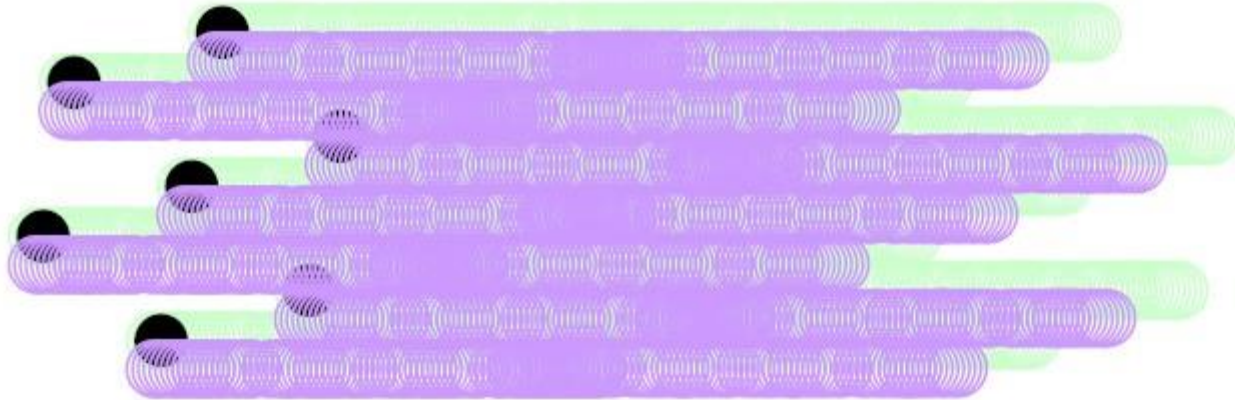
Multi-feed receivers (typically used for mapping and nodding): requires computations on the feed geometry during mapping.

SRT 7-feed receiver: mapping strategy



SRT 7-feed receiver: mapping strategy

Moving on sky



Time in SD data: t_resolution

t_resolution is defined as the temporal resolution FWHM, not meaningful for SD?

SD: (x,y) positions measured at a fixed sampling rate delta_t. Sampling rate does not vary in a scan. Measured: raw counts(x,y,lambda,Pol)

t_resolution = NULL

Multifrequency

The presence of many spectral windows affects `em_min`, `em_max`, `em_res_power/em_resolution` but also `s_resolution`, `s_region` and `s_fov`.

Multiple values, give the best (more representative) one

`em_res_power`: it is defined as the optical resolving power (adimensional, $\Delta\lambda/\lambda$).

The radio domain uses the frequency resolution: for SD data we will set `em_res_power=NULL` and use `em_resolution` (in units of frequency, possibly).

Could this parameter become at some point mandatory in ObsCore?

Summary

- Single-Dish metadata allow a complete ObsCore mapping
- Peculiarities: field of view, multifeed, multifrequency
- Some new values for dataproduct_type to describe the scan types
- Spectral resolution in terms of frequency: em_resolution (mandatory?)
- Ongoing discussion within the RadiolG very helpful in solving/defining cases
- INAF radio data almost ready to be discoverable in the VO!