Writing Proposals and Scheduling

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Outline

- 1. How to plan an experiment
  - Scientific idea
  - Feasibility - choice of array - tools for planning
- 2. Writing an observing time proposal
  - Scientific justification – general suggestions
  - Proposal submission tools
- 3. Scheduling & observing file preparation
- 4. After the observations

1. How to plan an experiment

- Scientific idea
  - ~infinite variety of topics, methods, techniques
- Feasibility
- Choice of the array and its configuration
- Some useful tools for planning

Science ideas

- Why would you need more data?
  - test a scenario/prediction
  - validate/disprove a previous, uncertain, result - e.g. from imaging or statistics
  - just look at something “new”, or in a new way - do try and have an idea of possible outcomes
- **The science goal drives the choice of the instrument and the design of the experiment, not the other way around**

The proposal: science context

- Make a good search of the literature
  - it will help you understand the problem
  - it will avoid to repeat previous efforts
  - you will want others to do it after you publish!
  - (most?) referees will not be expert of the area

Different experiment designs

- Your goal will generally have a parameter of primary importance: sensitivity, angular/spectral/temporal resolution, field of view, polarisation

- study one/a few source(s) in great detail: multi-scale, multi-frequency, multi-epoch, full polarisation

- study many sources in lesser detail - let statistics rule

  - often need a lot of automation - sometimes can be scheduled as filler

The proposal

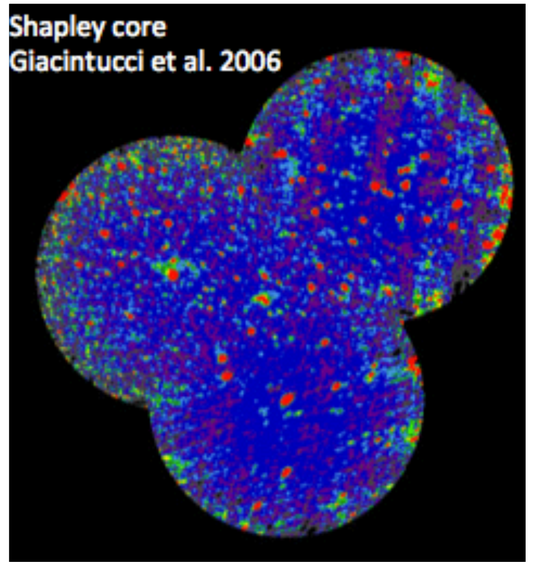
- After the context, define clearly what is the question that needs to be addressed, and its importance in the general picture
- When the general picture is clear, you can (have to!) focus on the details
  - what are the flux density, the size, the spectral & variability properties that you expect?
- Consider alternative scenarios - convince yourself and the referees that the one you pick is the most reasonable. Be quantitative as much as you can.
- Why is your target necessary? Or why do you need more than one? What significance will *n* new targets bring (often goes with sqrt(*n*))? Are more target useful just for statistics, or they sample a new region of the parameter space?
- This part needs to be **all about science**.

Angular resolution: VLBI

- flexibility (multi-frequency, irregular multi-epochs, fillers): VLBA
- sensitivity, real time: EVN, e-EVN
- southern targets: LBA
- extra sensitivity and resolution: Global VLBI(*)
- high frequency: 3mm, GMVA(*); 1.3mm, EHT(*)
  - (*) these are scarce resources so you need extra-strong science case to improve your chances

Angular resolution - others

- Sometimes you will not want too high angular resolution - you do not want to resolve out extended low surface brightness emission regions, or you want a wide field of view
- VLBI -> e-Merlin -> JVLA/ATCA/ALMA/GMRT -> LOFAR/MWA/…
- some instruments have different configurations/resolution: check the calendar!
- if you want both high angular resolution and wide field of view, you will have to do a “mosaic”
- supporting single dish or compact array data are also needed to remove artefacts due to very extended emission (“zero-spacings”)



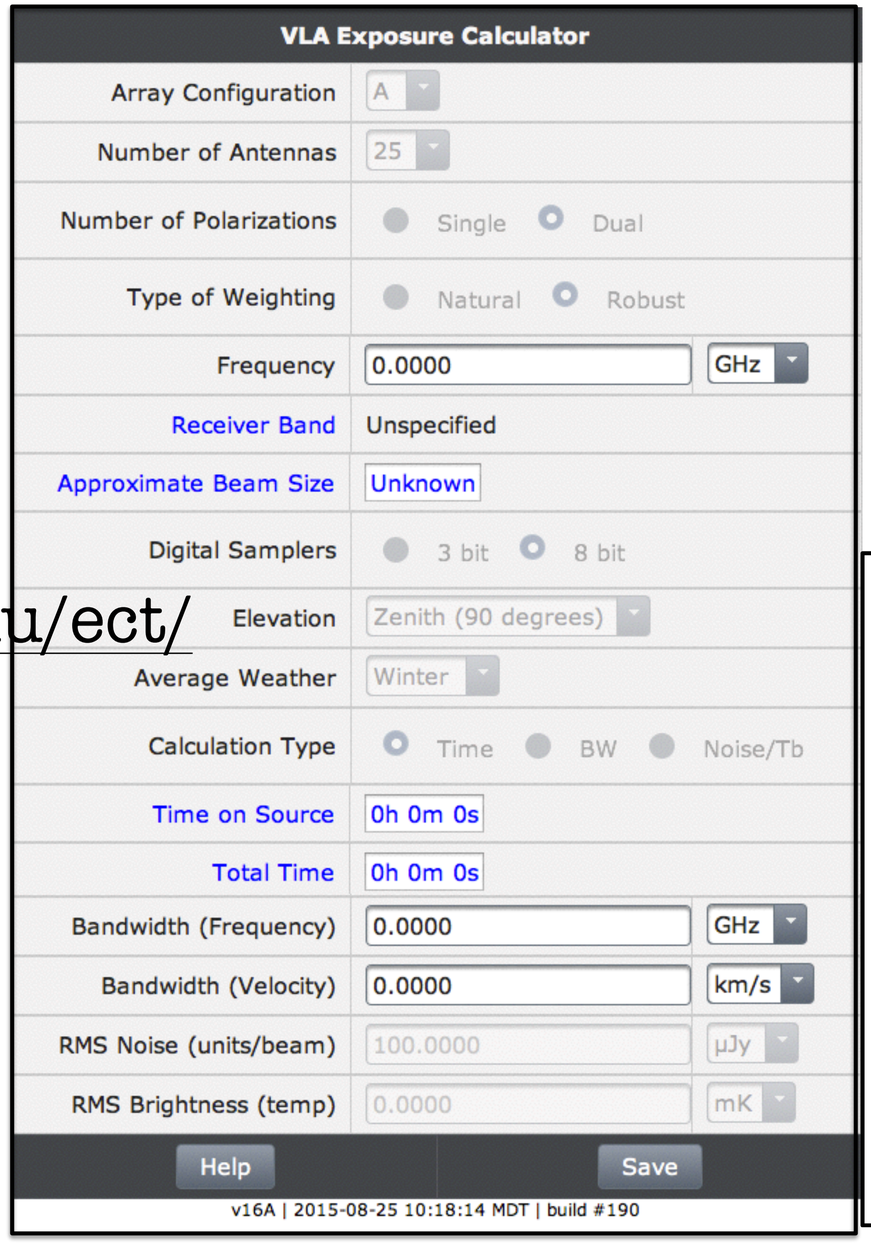
Sensitivity

- You can improve sensitivity though **collecting area**, **exposure time**, **bandwidth**
- Keep in mind the spectral properties of your source, and its declination. Steep (flat/rising) spectrum sources are best observed at low (high) frequency, e.g. with LOFAR (ALMA)

$$S_{rms} = \frac{2kT_{sys}}{A_{eff}\sqrt{N_A(N_A-1)t_{\rm int}\Delta\nu}}$$

$$\sigma_{\rm conf,Condon} = 1.2\left(\frac{\theta}{8''}\right)^{10/3}\left(\frac{\nu}{3.02\,\rm GHz}\right)^{-0.7}\ \mu{\rm Jy\ beam^{-1}}$$

- sensitivity could also be limited by **confusion** - so you are back to angular resolution consideration
- dynamic range is also important: it is hard to get to very low noise levels if there are strong sources in the field and the (u,v) coverage is not good
- note **polarised** emission is generally much fainter

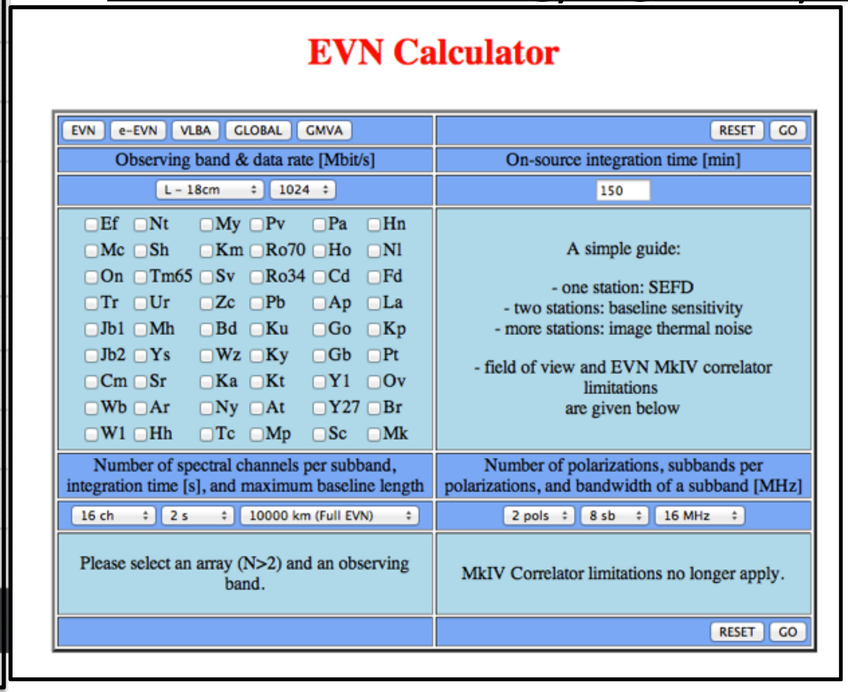


$$S_{rms} = \frac{2kT_{sys}}{A_{eff}\sqrt{N_A(N_A-1)t_{\rm int}\Delta\nu}}$$

$$\sigma_{\rm conf,VLSS} = 29\left(\frac{\theta}{1''}\right)^{1.54}\left(\frac{\nu}{74\,\rm MHz}\right)^{-0.7}\ \mu{\rm Jy\ beam}^{-1}$$

www.evlbi.org/cgi-bin/EVNcalc.pl

obs.vla.nrao.edu/ect/



https://almascience.eso.org/proposing/sensitivity-calculator

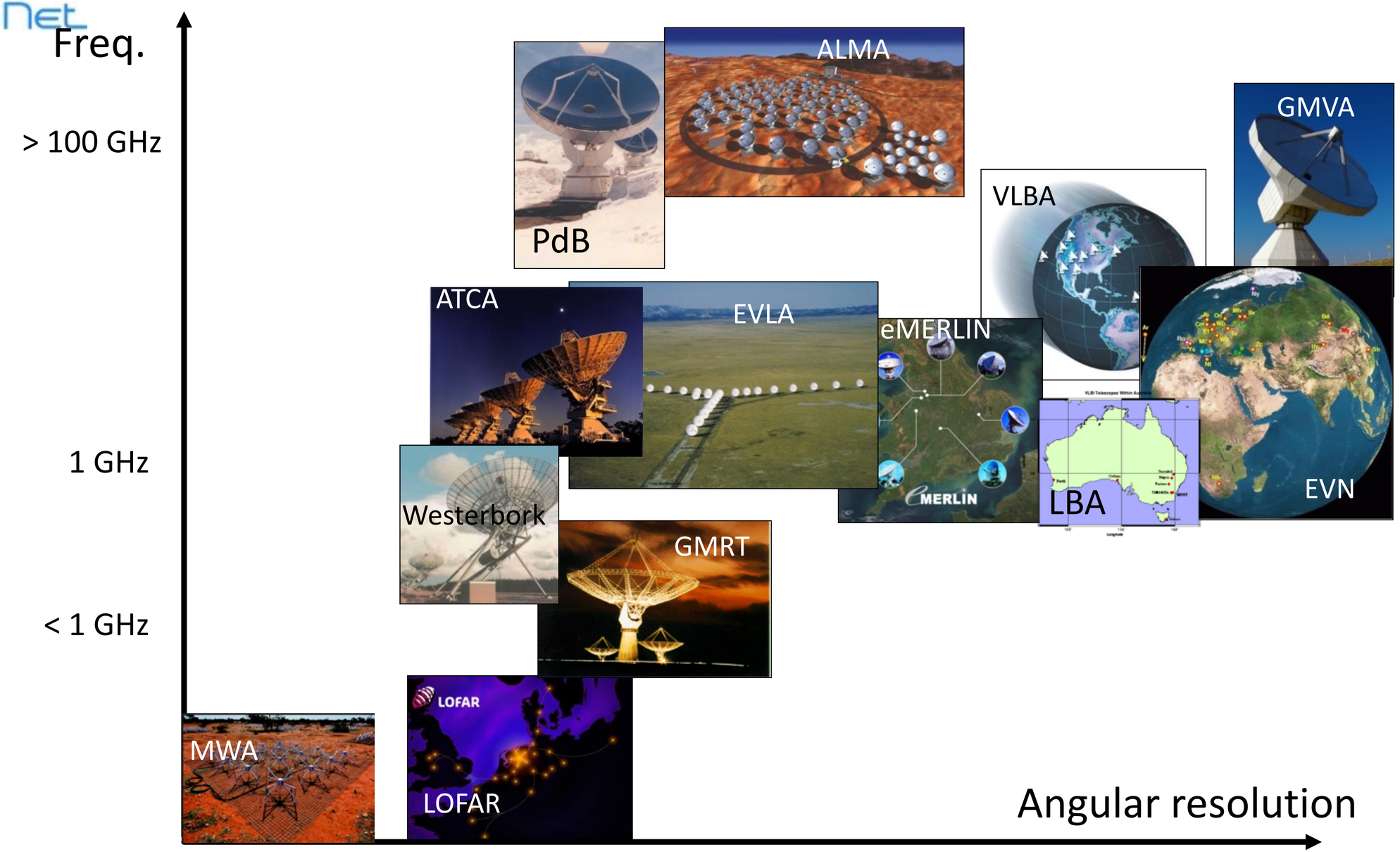
www.narrabri.atnf.csiro.au/myatca/interactive_senscalc.html

Spectral lines

- Find an instrument with a frequency coverage good for your line - and with the adequate spectral resolution
- If the source is extragalactic, keep the redshift in mind!
- Are there other lines that you can get “for free”?

Frequency

- Choosing the right frequency is essential - not only when spectral lines are concerned
- Frequency determines the angular resolution, and the sensitivity
  - directly, because of the telescope/receiver performance
  - indirectly, because of the source spectrum
- It also has implications on how to design calibration
- Multi-frequency is often very informative on the physics but it has a price
  - some instruments are frequency agile or intrinsically broadband, others are less flexible
  - again, you may have to do trade offs


Freq.
> 100 GHz
1 GHz
< 1 GHz
PdB
ALMA
GMVA
VLBA
ATCA
EVLA
eMERLIN
Westerbork
GMRT
LBA
EVN
MWA
LOFAR
LOFAR
Angular resolution
arcmin
arcsec
milliarcsec

JVLA/VLBA bands

Band	Range[1] (GHz)
4 m (4)	0.058-0.084
90 cm (P)	0.23-0.47[2]
20 cm (L)	1.0-2.0[3]
13 cm (S)	2.0-4.0
6 cm (C)	4.0-8.0
3 cm (X)	8.0-12.0
2 cm (Ku)	12.0-18.0
1.3 cm (K)	18.0-26.5
1 cm (Ka)	26.5-40.0
0.7 cm (Q)	40.0-50.0

also EVN bands

When you know what you want…

- Make sure it is not already there!
- during the literature search you may already have some surprise
- but a lot of good quality data do not get published - or data are published but not in the context of what you are interested in
- so go look at the archives!
- even if you still need to propose for new observations, you could
  - find useful information (improve your guesses, pick calibrators, ecc.)
  - convince the referees that you know what you are doing

Archives – more in tomorrow's lecture

EVN, eVLBI	`archive.jive.nl`
(J)VLA, VLBA	`archive.nrao.edu`
MERLIN	`www.merlin.ac.uk/archive`
GMRT	`naps.ncra.tifr.res.in/goa/mt/search/basicSearch`
WSRT	`wow.astron.nl`
ATCA	atoa.atnf.csiro.au/

- this is where your data will end up eventually… you generally have one year to publish!

About your co-investigators…

- Choose them carefully - alert them well in advance and make sure they are happy to cooperate
- You will find very different characters and skills - try to understand them, do not be surprised (people are strange!), know what and when each of them can contribute best (sometimes it's after the submission)
- Do not do all on your own - but do not expect them to do everything for you (or even something)

In summary

1) Type of experiment (continuum, spectral line, polarisation)
2) Resolution, field of view, largest angular scales
3) Frequency
4) Brightness sensitivity
5) Source location in the sky (declination)

... lead to the choice of

a) the array (if VLBI => choice of the telescopes)
b) observing band
c) observing setup
d) total time on-source

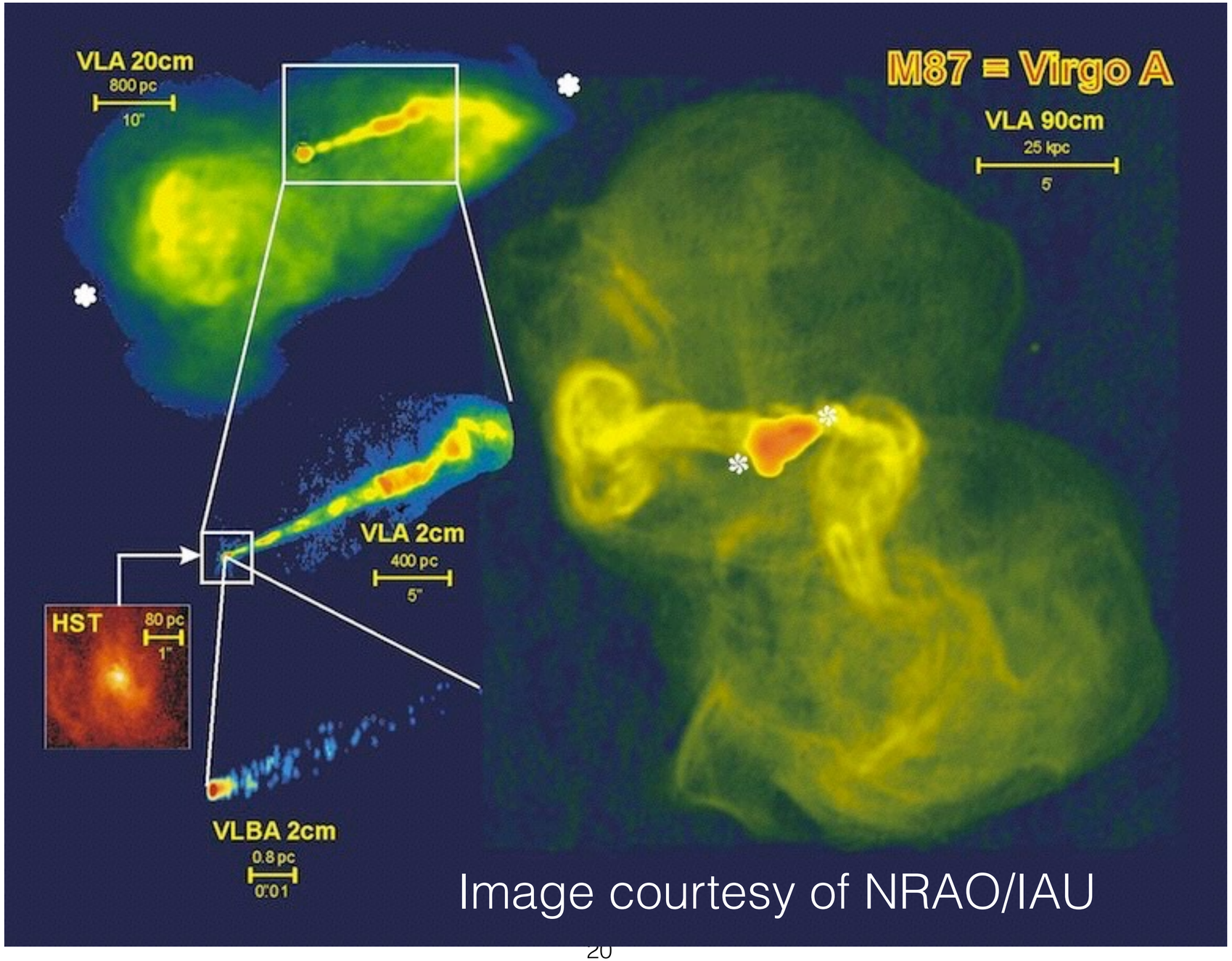
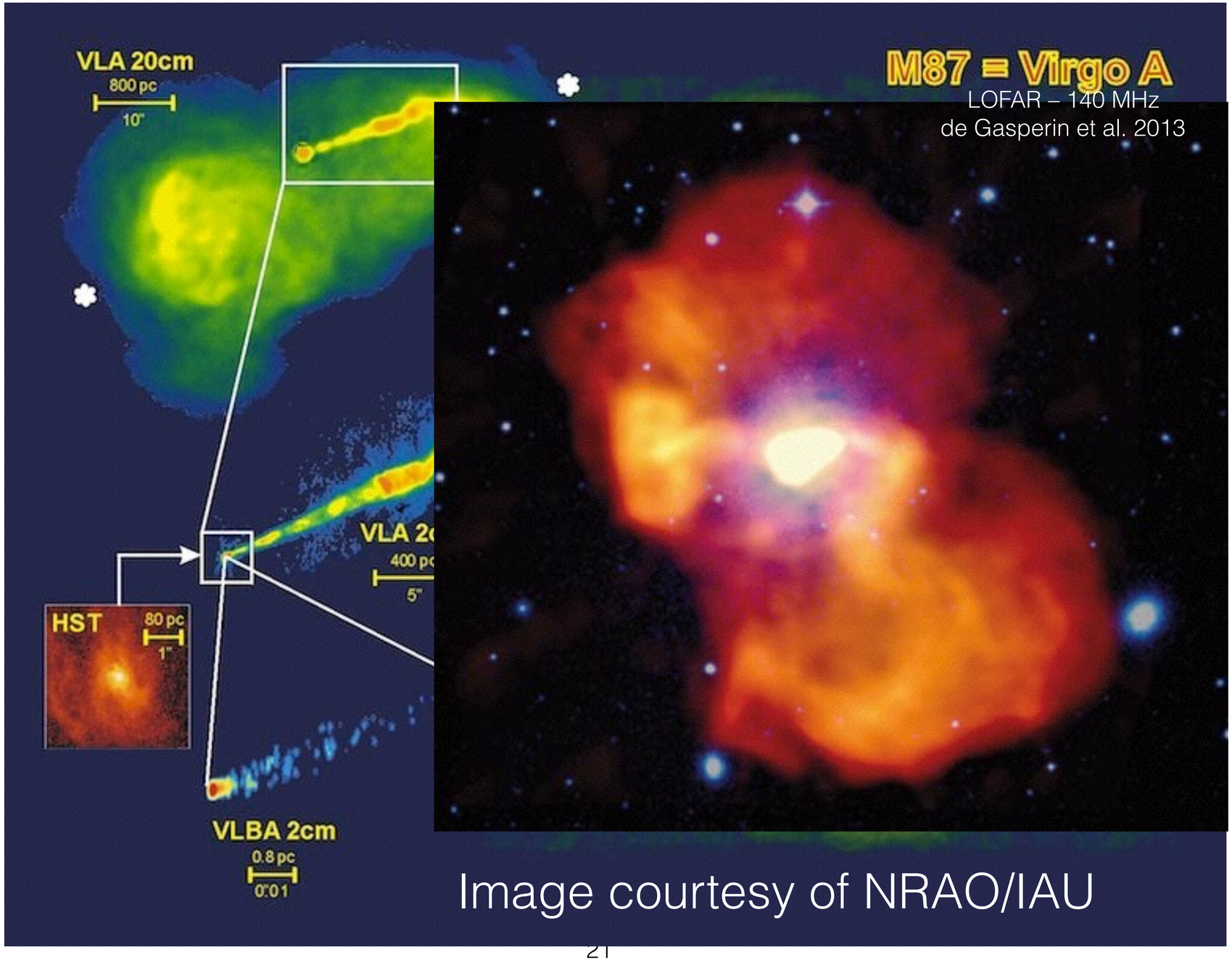


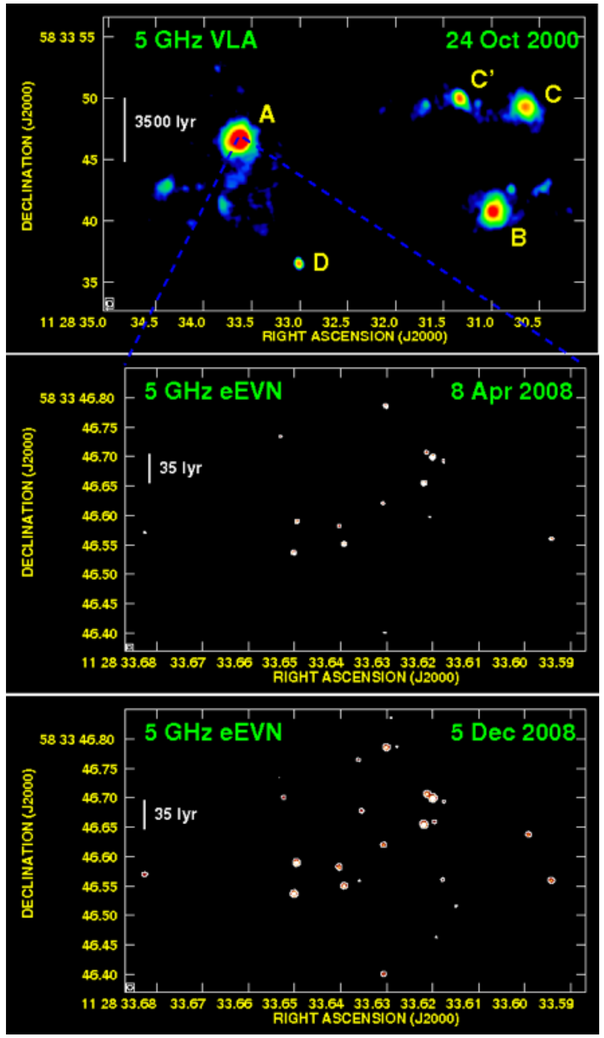
Image courtesy of NRAO/IAU


VLA 20cm
800 pc
10"
M87 = Virgo A
LOFAR – 140 MHz
de Gasperin et al. 2013
VLA 2c
400 pc
5"
HST
80 pc
1"
VLBA 2cm
0.8 pc
0.01
Image courtesy of NRAO/IAU

About calibration

- Designing a good calibration may seem unnecessary at the time of proposal preparation - but it is in fact very useful to get things right from the beginning
  - do not discover that what you proposed for can not actually be done!
  - save you a lot of time when your observations will be scheduled
- Some examples:
  - VLBI: is there a suitable reference source? look at www.vlba.nrao.edu/astro/calib/ and if it is not there maybe ask for a short e-VLBI observation (can be done at any time)?
  - polarisation: is the parallactic angle coverage good enough to determine leakages?

- Calibration strategy
  - Phase calibrators/phase-reference sources (see VLBI talk)
  - Special needs: Astrometry/Polarimetry (antenna leakage terms, EVPA)
- Scheduling constraints
  - Fixed or dynamic?
  - Need for dry atmosphere (at high freq.) or quiet ionosphere (at low freq.)?
  - Distance from the Sun
  - Coordinated observations with other instruments



Perez-Torres et al.

In practice…

- Radio astronomical facilities announce a call for proposals one (i.e. ALMA, e-MERLIN), two (VLBA, GMVA, VLA, GMRT, WSRT, LOFAR, ATCA), or three (e-EVN, Global VLBI) times per year
- Targets of Opportunity (ToO, sometimes called Director's Discretionary Time, DDT) are accepted at any time
- Different over-subscription factors at different observatories and at different LST ranges – keep this in mind
- **Consult observatory web pages and read the call for proposal!**

The proposal itself

- Generally consists of three parts

1. a **cover sheet**

   It includes basic information, i.e. authors & affiliation, source list, requested time and a technical summary. It is generated by the web-based proposal submission tool.

2. a **science justification**

3. a **technical justification**

The science justification

- Usually uploaded as a pdf file
- Be clear and concise: include the necessary background material needed to understand the scientific goal, but not more
- Clearly explain how the scientific goal is achieved by making the proposed observations
- Use clear, appropriate and readable **figures**
- Avoid unnecessary repetition and jargon

- **TAC Committees usually dislike**
  - Poorly justified sample sizes (why 10, or 20, or 100?)
  - Blind fishing
  - Vague statements
  - Non-astronomical statements
  - Proposals exceeding the given page limits

The technical justification

- Sometimes also uploaded as pdf (separate or included with the science part) - sometimes in a dedicated web interface
- Justify the requested time and setup
  - Required rms
  - Required u-v coverage/selected array
  - Required dynamic range
  - Time needed for calibration
  - Observational constraints

Proposal submission & submission tools

- Electronic submission via web-based tools is now the norm
- Different tools for different observatories
  - EVN, eMERLIN, LOFAR: NorthStar (proposal.jive.nl)
  - VLBA, VLA: NRAO PST (my.nrao.edu)
  - ALMA Observing tool (download from www.almascience.org)
  - ATCA: OPAL (opal.atnf.csiro.au)
  - GMRT: naps (naps.ncra.tifr.res.in)
- Cover & technical justification to be filled on web, scientific justification to be uploaded.
- Changes are possible until the very last minute

Future proposal deadlines

- e-Merlin: 16 Nov 2017
- ATCA: 15 Dec 2017
- GMRT: mid Jan 2018
- EVN, JVLA, VLBA, GMVA: 1 Feb 2018; Radioastron (Space VLBI) ~Jan'18
- LOFAR: ~March 2018?
- ALMA: Spring 2018?
- IRAM PdB: mid March 2018
- **GOOD LUCK WITH YOUR PROPOSAL PREPARATION!**

Useful tools and links

- EVN sensitivity calculator: `www.evlbi.org/cgi-bin/EVNcalc`
- ALMA sensitivity calculator: `http://almascience.eso.org/proposing/sensitivity-calculator`
- VLA exposure calculator: `https://obs.vla.nrao.edu/etc/`
- ATCA CABB sensitivity calculator: `www.narrabri.atnf.csiro.au/myatca/interactive_senscalc.html`
- GMRT users observing help: `www.gmrt.ncra.tif.res.in/gmrt_hpage/Users/Help/help.html`
- Sched (useful for planning VLBI experiments): `www.aoc.nrao.edu/~cwalker/sched/`
- LOFAR tools: `www.astron.nl/radio-observatory/lofar/lofar-tools/lofar-tools`
- VLA Calibrator Manual: `www.aoc.nrao.edu/~gtaylor/csource.html`
- GMRT calibrator search page: `www.gmrt.ncra.tifr.res.in/~astrosupp/calib/vlacal.html`

Sometimes after the deadline…

- The proposal is **accepted** 😀
  - Preparation of the required observing files using observatory specific tools
  - Observatory staff checks the observing files and schedules the observations (either on a fixed date or dynamically)
- The proposal is **rejected** 😥
  - read the feedback comments - sometimes they can really be annoying but sometimes they are really useful
  - be humble - know your limits and resources, too
  - keep in mind the annoying referee might still be there - or someone like him/her
  - remember the oversubscription of your call; did you just need an ε or you failed miserably?

Scheduling and observing file preparation

- Observing file contains:
  - Array configuration
  - Receiver setups
  - Correlator setup
  - Scans of targets and calibrators
  - Constraints for dynamic scheduling
- Remember to:
  - Check the visibility of the targets and calibrators, and their separation on the sky
  - Duty cycles
  - Be extra careful if using non-standard receiver setups.
  - Be sure to observe all the required calibrators (flux, phase, polarization leakage and evpa, bandpass, fringe finder in VLBI observations…)

Search for calibrators

The VLA Calibrator Manual

Hop to RA [01] [02] [03] [04] [05] [06] [07] [08] [09] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21]

```
IAU NAME EQUINOX  PC RA(hh,mm,ss)    DEC(ddd,mm,ss)   POS.REF ALT.NAME
=================================================================

0001+192   J2000  A 00h01m08.621563s  19d14'33.801860"  Aug01   JVAS
2358+189   B1950  A 23h58m34.865400s  18d57'51.753000"
-----------------------------------------------------
BAND        A B C D    FLUX(Jy)    UVMIN(kL)  UVMAX(kL)
=====================================================
0.7cm    Q  W W W W       0.18

0003-174   J2000  T 00h03m21.9969s   -17d27'11.781"
0000-177   B1950  T 00h00m48.4200s   -17d43'54.000"
-----------------------------------------------------
BAND        A B C D    FLUX(Jy)    UVMIN(kL)  UVMAX(kL)
=====================================================
 90cm    P  X S S S         7                        7
 20cm    L  X X X S       2.2                        7

0004+462   J2000  A 00h04m16.127651s  46d15'17.970010"  Aug01
0001+459   B1950  A 00h01m41.453100s  45d58'36.145000"
-----------------------------------------------------
BAND        A B C D    FLUX(Jy)    UVMIN(kL)  UVMAX(kL)
=====================================================
0.7cm    Q  W W W W       0.12

0004+203   J2000  B 00h04m35.7576s    20d19'42.249"     May01   JVAS
0002+200   B1950  B 00h02m01.6329s    20d03'00.311"
-----------------------------------------------------
BAND        A B C D    FLUX(Jy)    UVMIN(kL)  UVMAX(kL)
=====================================================
0.7cm    Q  W W W W       0.21

0005+544   J2000  A 00h05m04.363531s  54d28'24.926230"  Aug01
0002+541   B1950  A 00h02m29.056400s  54d11'43.187000"
```

Continuum phase calibrators should be:

- Compact
- Strong at the observing frequency
- As close as possible to the target

VLBA Calibrators Search Form

RA :	0h0m0.0s	Examples: RA = 6h45m10.76s DEC = 16d41'57.82" RA = 06H45M DEC = 16d42' RA = 06:45:10.76 DEC = 0.2914594 *A '*' for RA or DEC will not restrict the search on that axis.*
DEC :	0d0'0.0	
Search Radius :	10d	*The default search radius is 10 degrees.* *The maximum search radius is 45.0 degrees.*

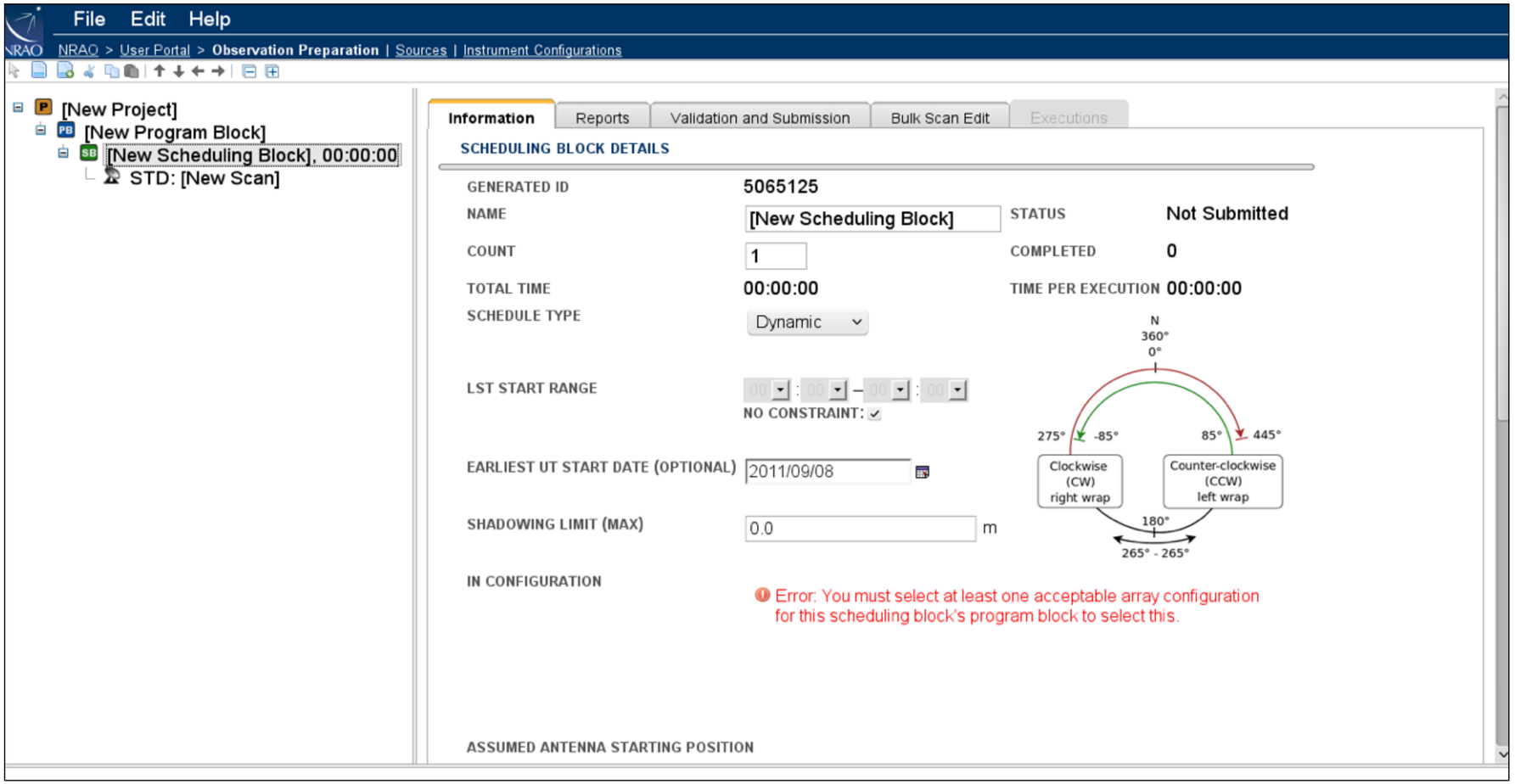
Maximum Number of sources returned: 5

Sort the Resulting list by: Distance

SEARCH

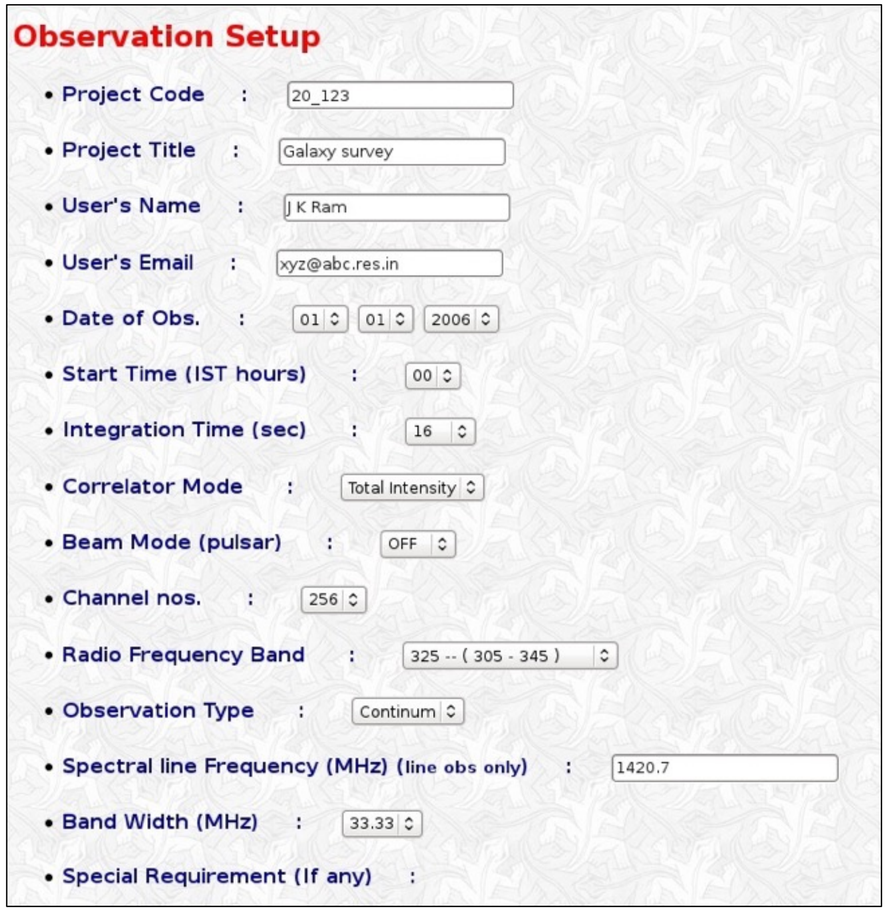
Check images on NVSS, FIRST, VLSS image surveys

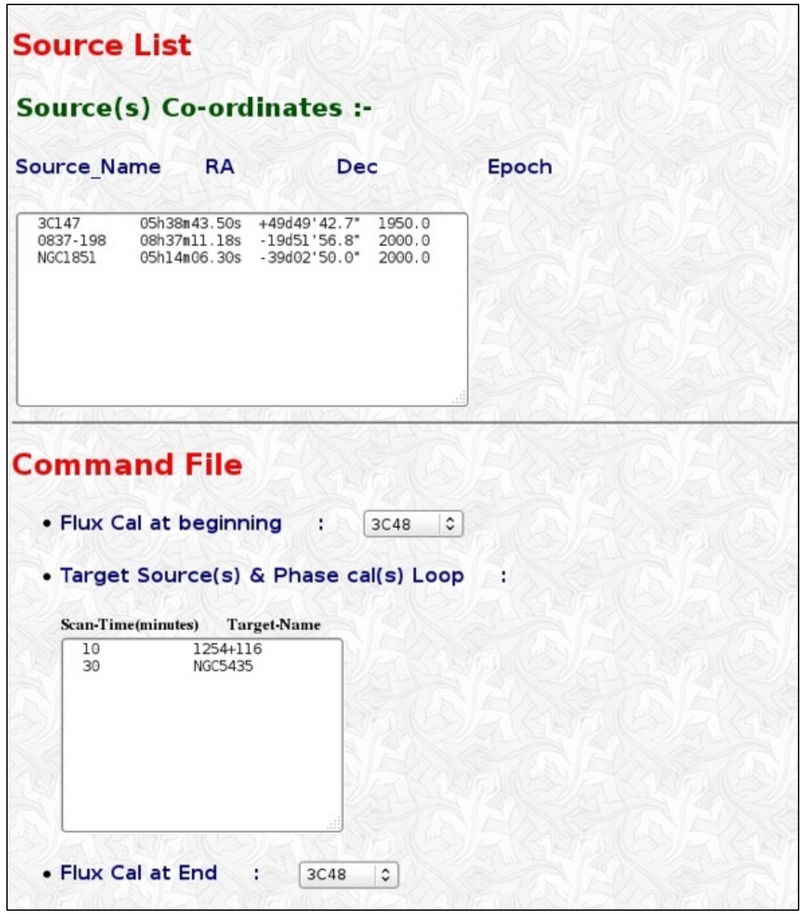
Examples of observing file preparation tools OPT for EVLA



- Log in at `e2e.nrao.edu`

Examples of observing file preparation tools
Observing file creator for GMRT



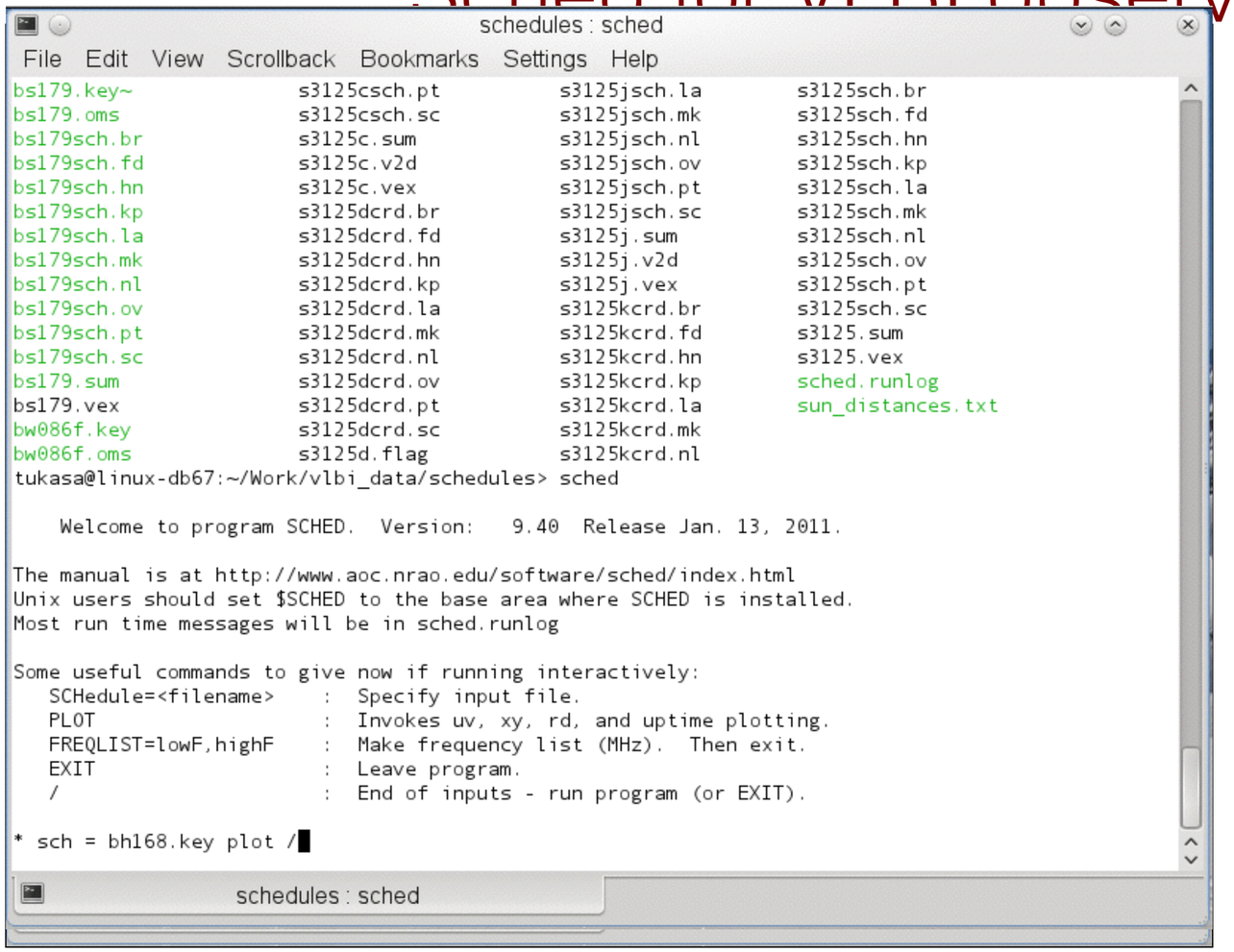


- Go to `www.gmrt.ncra.tifr.res.in/gmrt_hpage/Users/Help/sys/setup.html`

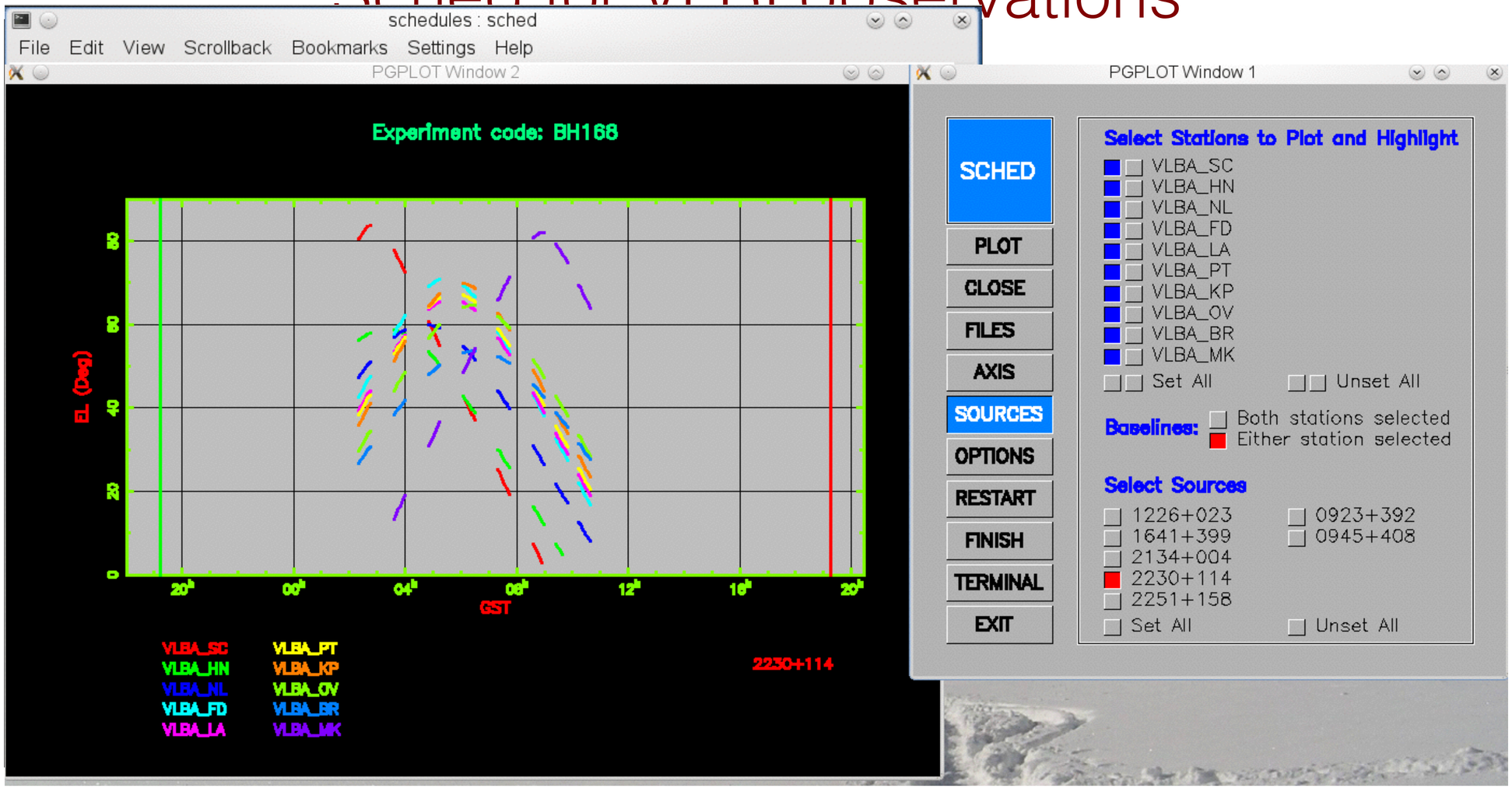
Sched for VLBI observations

- VLBI observing file (schedule) is prepared with a program called Sched, which makes control files for all the individual telescopes : www.aoc.nrao.edu/~cwalker/sched/
- Sched handles automatically a lot of things like calculating the slewing times of different telescopes
- Since VLBI telescopes are distributed around the world, your source transits at different times at different telescopes sites. The schedule has to match the allocated UT slot, which corresponds to the requested GST range. Use sched to check source uptimes already when planning the experiment.
- If preparing VLBI schedule for the first time, seek help from an experienced user/JIVE staff; if EVN, Bob will contact you first with instructions and patches
- Remember to schedule strong and compact “fringe-finder” sources several times during the observation. Try to schedule these when they are observable from all the antennas.

Sched for VLBI observations



Sched for VLBI observations



Summary

- Writing a proposal is the first step for a new project
  - an exciting moment your research but also a decisive place where things can go wrong
  - these guidelines can help you to avoid some mistakes - but your style and experience will do the rest
  - if you fail - understand why; if you succeed, profit of your good planning
- *RadioNet has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562*