Converting an **IDEA** into a **PROPOSAL**

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Goals

- Implementation of learning in RAS school
- Take you a step closer to becoming a successful Radio Astronomer (more specifically GMRT user!)

Outline

- Designing an experiment
  - Scientific idea
  - Feasibility study
  - Choosing the right telescope
  - Some useful tools for planning
- Writing a (good) observing time proposal
  - Scientific justification
  - Technical part
  - Proposal submission tools
- Schedule / observing file preparation
  - An example of a GMRT schedule

T. Savolainen

Why write proposals?

- Observations required to obtain scientific results from radio telescopes.
- Most cases, need to write observing proposal to telescopes available to all Astronomical Community.
- Not easy to get time as most telescopes oversubscribed.
- A telescope proposal is effectively your “visa application” to use any of the largest telescopes in the world. –C.J.Salter
- Without successful proposal: delay in thesis, affect future job prospects, or even the whole career!!!!

Proposal Deadlines

Telescope	Annual Deadlines
GMRT	15th January, 15th July
VLA/VLBA/GBT	1st February, 1st August
EVN	1st Feb, 1st June, 1st Oct
Ooty Radio Telescope	No fixed deadline
e-MERLIN	17th June 2013
CARMA	May and December
Effilsberg	9th Oct
WSRT	16th September
ATCA	15th June, 15th Dec
ALMA	Dec 2013

Prerequisites

- ABILITY TO GENERATE GOOD IDEAS
- COMMUNICATE THE IDEAS TO SOMEONE ELSE
  - communicating the idea means writing proposal and ensuring all the relevant information is present in a coherent fashion.

-- Judith Irwin

Begin with a Scientific Idea

- Your job is to come up with an Idea
- It could be anything: galaxy evolution, Active Galactic Nuclei, Radio Galaxies, Galactic Center, HI absorption, supernova remnants, pulsars, gamma ray bursts etc.

Some things to take care

- Is your idea clear to you?
- Is it worth pursuing?
- Has it been done previously?
  - literature search, ADS, NED, arXiv etc.
- What will you learn and achieve?
- Will it lead to some physical quantity or test a model?
- Does anyone care?
- Relevance in wider perspective?

List of targets

- Have they already been used?
  - GMRT ncra.tifr.res.in/~gmrtarchive
  - VLA/VLBA archive.nrao.edu
  - European VLBI Network archive.jive.nl
  - MERLIN www.merlin.ac.uk/archive
  - WSRT www.astron.nl/wsrt-archive/php
  - ATCA atoa.atnf.csiro.edu

Case 1: Observed previously

- If already published and confirms your scientific idea, think of a new idea!
- If not published, must analyse the “FREE” data.
- Can confirm your idea? Publish it and then think of a new idea!
- Don’t ignore the existing data.
- Why to observe again?
- Convince that you need further data

Case 2: Observed in some other EM band

- Try to connect with your scientific goals.
- If possible analyse the data prior to writing proposal or refer to existing publication, if any.
- Don’t ignore the existing data.
- Make your case stronger using the available data.

Case 3: Never observed

- Just because something is not observed previously is not a good enough reason to observe it now.
- Good Science is the prime motive.
- Fantastic Idea+Zero existing observations = Ideal Case ☺

Echo your idea

- Once you are convinced that your idea is great:
- Show it to expert in your field, show it to non-expert.
- Most important: Echo it to a theorist!
- Make collaborators!

Work on specifics

- Determining the relevant properties of the final data product you is looking for.
- Continuum versus Spectral line
- Whether you need a single dish telescope or a interferometry telescope

Target Sources

- Target sources variable or constant
  - One observation or several observations
  - How frequently to observe?
- Position of target sources
  - GMRT can look for sources in the declination range of -53^{o} to +90^{o}.
- Extent of the target source:
  - point source versus extended source

$$\theta_{HPBW} = \frac{\lambda}{D}$$

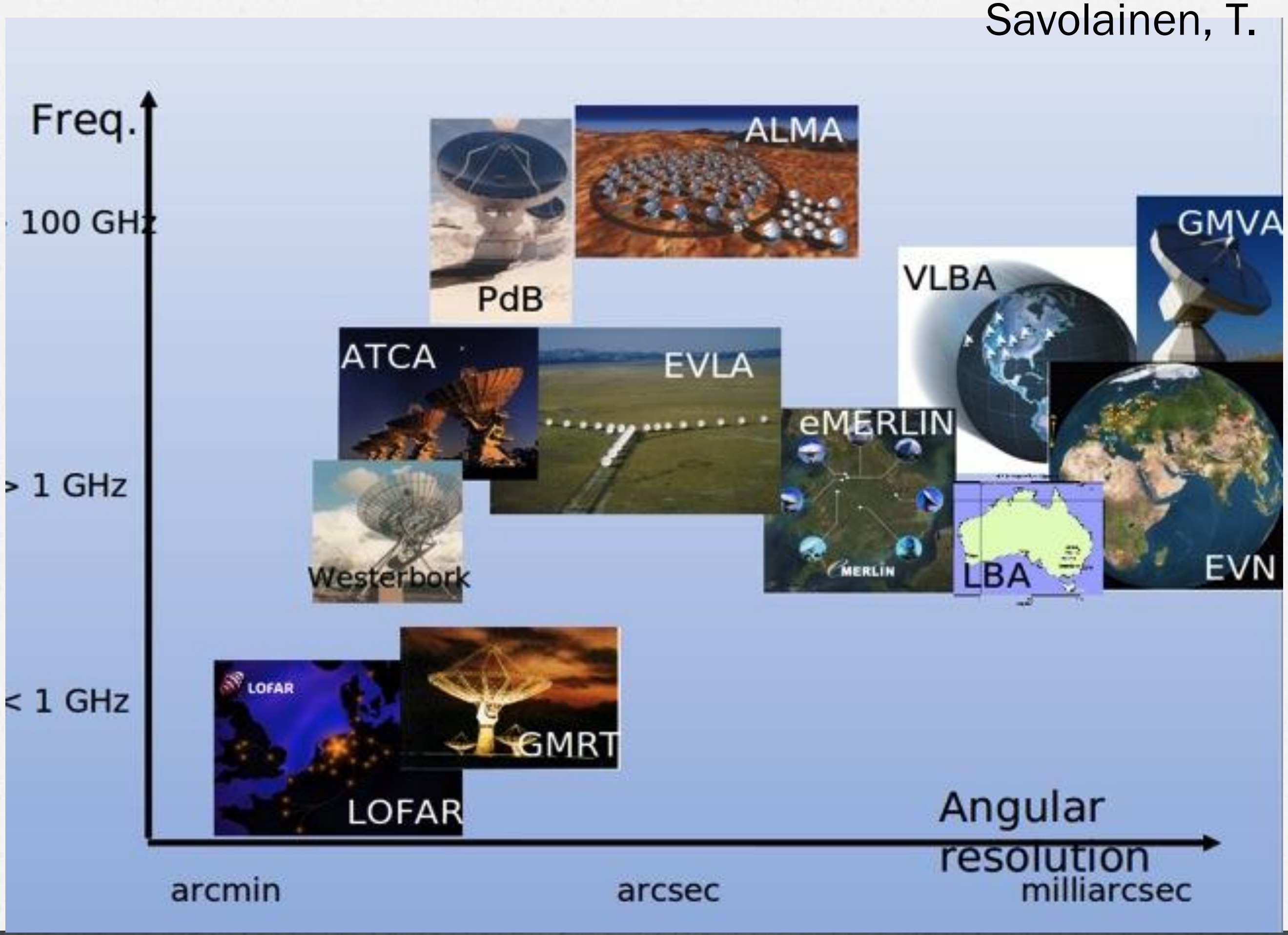
Target sources continued…

- Check NVSS: http://www.cv.nrao.edu/nvss/
- TGSS: http://tgss.ncra.tifr.res.in/
- FIRST: http://www.cv.nrao.edu/first/
- AT20G: http://www.atnf.csiro.au/research/AT20G/
- ATCA SGPC: http://www.atnf.csiro.au/research/HI/sgps/GalacticCenter/Home.html

Observing frequency

- Selecting observing frequency and bands
  - Keeping in mind the the available frequency coverage along with the sensitivity of telescopes in mind.

Telescopes and frequencies



GMRT

- Currently available feeds: 150, 325, 610/235, 1000-1450 MHz.
  - 1000-1450 MHz subdivided into 1060, 1170, 1280, and 1390 MHz feeds.
  - The 610 MHz and 235 MHz feeds are coaxial, allowing simultaneous dual frequency observations to be carried out at these two frequency bands.

Bandwidth

- Frequency band
  - Continuum (full band unless RFI is issue)
  - Spectral line (where the line is located)
    - E.g. z=0.008, freq~1408 MHz
    - bandwidth depending upon expected line width

GMRT- Bandwidth

- Currently maximum 32 MHz.
  - If you are making interferometric image mode observations, best to use maximum bandwidth.
  - Suggested to use lesser (6 MHz) at 150 and 235 MHz due to RFI.

For spectral line specific

- Total spectral channels in GMRT upto 512
- You must estimate the needed spectral resolution.
- For example if your narrow line is there and you want it to be spread in at least 30-40 channels, you need smaller bandwidth
- Larger bandwidth for broad line.

Spatial Resolution (synthesized beam size)

- For single dish, same as FoV $q_{HPBW} = \frac{l}{D}$

- For interferometer, determined by the maximum baseline length $q_{HPBW} = \frac{l}{B_{\max}}$

- Lowest resolution also matters with which extended sources are not resolved out

$$q_{LAS} = \frac{l}{B_{\min}}$$

GMRT- resolution

- 150 MHz – 20”
- 235 MHz – 13”
- 325 MHz – 9”
- 610 MHz – 5”
- 1280 MHz – 2”

(assuming full synthesis observation and all antennas working). Determine what resolution you need and what frequency you want to observe

GMRT- Field of view

- 150 MHz: 186′ ±6′
- 235 MHz: 114′ ±5′
- 325 MHz: 81′ ±4′
- 610 MHz: 43′ ±3′
- 1280 MHz: 26.2′ ±2′

Resolution

- The resolution needed for a particular scientific goal points towards a telescope.
- For arcminute resolution, a single disk telescope like GBT is best.
- For arcsec resolution GMRT or VLA.
- For milliarcsec resolution, VLBI is the telescope.
- Sometimes wide-range resolution required to see large scale as well as small scale structures, such as GMRT.
- For simultaneous observations say Chandra-VLA (A configuration) or GMRT are the best.

U-V coverage and time on source

- u-v coverage is important for complicated structure source.
- For example, you may want to observe a complicated structure source for the full synthesis to get a wider UV coverage.
- However, for point sources, snap shots or minimum time required to detect them should suffice.

Sensitivity

- Many telescopes limited by the receiver noise depending upon receiver capabilities at particular frequency as a function of time.

$$\Delta S = \frac{\sqrt{2} k T_{sys}}{\eta_a \eta_c A \sqrt{(n_b) n_{IF} \Delta \nu t}}$$

- You may be dynamic range limited.
- Limitation other than receiver noise are caused by instrumental effects and sky conditions.
- This limits image quality to a small fraction of the brightest radio source.
- dynamic range= peak brightness/rms of the map

GMRT - sensitivity

- The system temperature is
- 150 MHz: 615 K
- 235 MHz: 237 K
- 325 MHz: 106 K
- 610 MHz: 102 K
- 1280 MHz: 73 K

GMRT - sensitivity

- the antenna gain is
- 150 MHz: 0.33 K Jy^{-1} $Antenna^{-1}$
- 235 MHz: 0.33 K Jy^{-1} $Antenna^{-1}$
- 325 MHz: 0.32 K Jy^{-1} $Antenna^{-1}$
- 610 MHz: 0.32 K Jy^{-1} $Antenna^{-1}$
- 1280 MHz: 0.22 K $Jy^{-}1$ $Antenna^{-1}$

GMRT Parameters

	Frequency (MHz)				
	151	235	325	610	1420
Primary beam (HPBW, arcmin)	186 ±6	114 ±5	81 ±4	43 ±3	(24 ±2)×(1400/f)
System temperature (T_{system}, K)					
Receiver temperature (T_R)	295†	106†	53	60	45
Typical T_{sky} (off Galactic plane)	308	99	40	10	4
Typical T_{ground}	12	32	13	32	24
T_{system} (= $T_R + T_{sky} + T_{ground}$)	615	237	106	102	73
Antenna gain (K Jy^{-1} $Antenna^{-1}$)	0.33	0.33	0.32	0.32	0.22
Synthesised beam (FWHM)					
– Full array (arcsec)	20	13	9	5	2
– Central square (arcsec)	420	270	200	100	40
Largest detectable structure (arcmin)	68	44	32	17	7
Usable frequency range					
– observatory default (MHz)	150–156	236–244	305–345	580–640	1000–1450
– allowed by electronics (MHz)	130–190	230–250	305–360	570–650	1000–1450
Fudge factor (actual to estimated time)					
– for short observations	10	5	2	2	2
– for long observations#	5	2	2	1	1
Best rms sensitivies achieved (mJy)‡	0.7	0.25	0.04	0.02	0.03
Typical dynamic range achieved	>1500	>1500	>1500	>2000	>2000

† With default solar attenuator (14 dB).
# For spectral observations fudge factor is close to 1.
‡ So far known to us!

Estimation of total observing time, interval and span

- Determine sensitivity required and on the basis of that total observing time.
- Is source fixed or variable.
- How many observations, how frequent.
- Hours are expensive!!!!!!

Some concerns

- Time average smearing
  - Shorter correlator integration time
- Band width smearing
  - Higher spectral resolution
- However, this can generate lots of data.
  Keep those constraints in mind.

Low frequency observations

- RFI – night time observations

High Frequency Observations

- Dependence on elevation

RADIO TELESCOPES

http://www.astro.uni-bonn.de/~rcbruens/links/world_map.html

After selecting a telescope

- Read and understand the "rules and regulations".
- Understand the telescope.
- Become acquainted with the latest developments
- Is this the Right Proposal at the Right Telescope?

GMRT

- The GMRT consists of an array of 30 antennae, each of 45 m diameter, spread over a region of 25 km diameter.
- Hybrid configuration with14 of its 30 antennas located in a central compact array with size ~1.1 km and the remaining antennas distributed in a roughly ‘Y’ shaped configuration, giving a maximum baseline length of ~25 km.
- The GMRT can also be configured in array mode, where it acts as a single dish by adding the signals from individual dishes.

GMRT

- Elevation limit 17degrees.
- Declination range -53degrees to 90 degrees.
- Antennas can slew at the speed of 20 degrees per minute
- Wind limit 40 km/hr.

3 components of a proposal

- Cover sheet: Essential facts such as title, details of target sources, your affiliation, collaborators etc. Abstract goes here.
- Scientific Justification: Your idea comes here.
- Technical Justification: Details of observations.

- Poor scientific justification may be due to poor writing skills but poor technical justification smacks to incompetence. --Judith Irwin

You have to write:

- 1. Abstract- The only thing all reviewers will read
- 2. Introduction : Why is this science interesting? What are the open questions? Big picture?
- 3. Scientific Justification: Why is your observation interesting? How will you achieve the goal?
- 4. Technical Feasibility: Prove that the observation is doable,

Rule of thumb: If the 1st page is not interesting and does not state what you want, your proposal will not get accepted.

Scientific Justification

A good scientific justification is…

- Clear and concise
- Includes the necessary background material needed to understand the scientific goal – but not more
- Clearly explains how the scientific goal is achieved by making the proposed observations.
- Refer to latest references.
- Have good English and clear sentences.
- Avoid unnecessary repetition
- Don't use buzzwords : such as path breaking, holy grail, missing-link etc.

Scientific Justification

- If this work will lead to further research, describe briefly the expected developments
- If part of a larger project, describe briefly what other observations are being made, where, and their status.
- If multiwaveband proposal, explain status
- Possible evidence which you can provide that these observations will yield the expected science.
- Evidence to show that you have the capacity (knowledge and resources) to analyse these data and do the science.

Scientific Justification

- Previous observations at radio and other bands relevant to your goals.
  - If more observations, then explain why you need more observations.
  - If most of the goals can be achieved from previous observations, rejection!

Technical Justification

- A clear and concise elaboration and justification of the technical choices, (receiver, frequencies, special requests, RFI considerations, target list, etc.)
- COMPLETE consistency between the cover sheet and technical justification
- Show how you intend to analyse the data and expertise in your team.

Technical Justification continued….

- Demonstrate that you will reach the required signal-to-noise ratio in the time requested
- Include expected overheads (e.g. setup time, slew time, calibration time, position switching time etc).
- Specify experimental parameters to enable cross checking, i.e.total bandwidth, channel width, u-v coverage
- If non-standard setups or a very stringent scheduling is needed, then consult the observatory staff beforehand

General Considerations

- NEVER exceed your page (or figure) limits
- There is an abstract in the cover sheet, so do not repeat it at the head of the proposal body.
- Get somebody to proof read your proposal.
- Do not use jargon, undefined acronyms.
- If you are a student and observations are part of your thesis, MENTION it.

From reviewer's perspective

Telescope program committees don't like…

- Poorly justified sample size
  - Why do you want to observe 5 sources? Why not 1 or 10?
- Fishing trips
  - "We would like to observe this source to see if there is something interesting there."
- "Old hats" – unnecessary repeating of old experiments
- Vague claims
  - No clear logical path from the observations to the astrophysical goal advertised by the proposers.
- Non-scientific (i.e. political) arguments
- Proposer not adhering to the given page limit!

T. Savolainen

Very Imp

- Not uncommon to have very well written proposal, well justified but the actual data have very little bearing on it.
- Not uncommon to see proposers asking for time under a configuration which does not exist on the telescope!

Proposal submission tool

- Electronic submission via web-based tools is now the norm (an exception is for example IRAM PdB)
- GMRT (naps.ncra.tifr.res.in)
- EVN, WSRT, eMERLIN: NorthStar (proposal.jive.nl)
- VLBA, EVLA: NRAO PST (my.nrao.edu)
- ALMA Observing tool (download from www.almascience.org)
- ATCA (opal.atnf.csiro.au)
- Usually possible to modify the proposal until deadline. Submit early, modify and re-submit!

Proposals with GMRT

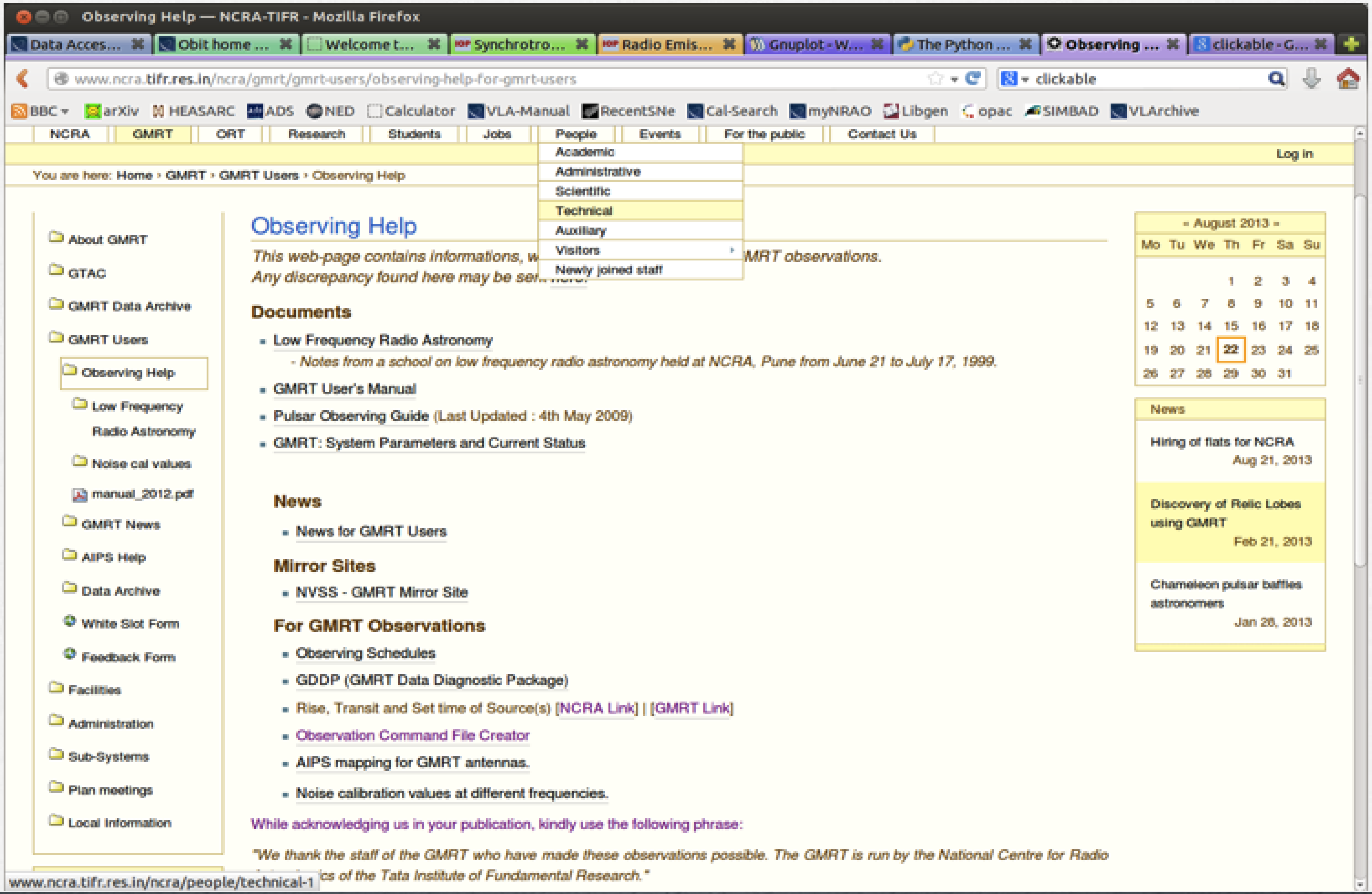
- The GMRT Time Allocation Committee (GTAC) invites proposals for two Cycles (April to September and October to March).
- The deadline for receiving these proposals is January15, and July 15.
- All proposals are to be submitted online via NAPS, available at http://naps.ncra.tifr.res.in ,
- The proposals may be submitted only by the PI.
- All co-I's also need to be registered users of the system.
- All proposals are processed by GTAC with external refereeing as needed with inputs from the GMRT Observatory on technical issues and the proposers are sent intimations of the time allocation.

Proposal Accepted! Hurrah!

- Preparation of the required observing files using observatory-specific tools
- Planning observations carefully.
- Read the manual.
- For GMRT http://www.ncra.tifr.res.in/ncra/gmrt/gtac
- Observing file contains:

- Receiver setups
- Correlator setup
- Scans of targets and calibrators
- Constraints for dynamic scheduling

http://www.ncra.tifr.res.in/ncra/gmrt/gmrt-users/observing-help-for-gmrt-users



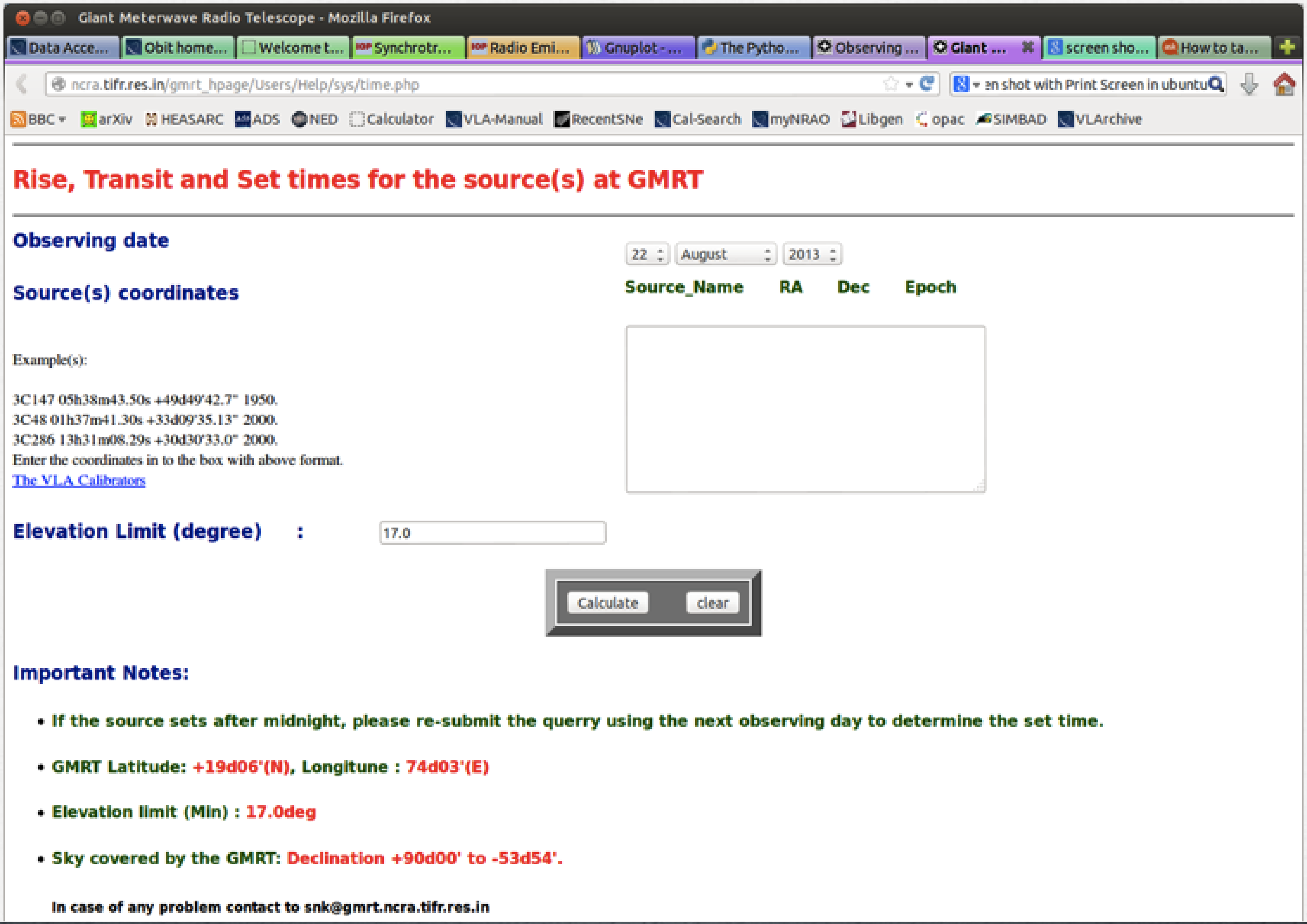
Observing feasibility

- Calibration strategy
  - Phase calibrators / phase-reference sources , flux calibrators, bandpass calibrators
  - Polarization observations
- Scheduling Constraints
  - Need quite ionosphere, night observations
  - Dry atmosphere?
  - Coordinated observations with other instruments
- Convey to the observatory support staff

GMRT calibrators

- The flux density calibrators, 3C 48 (0137+331, J2000), 3C 147 (0542+498, J2000) and 3C 286 (or 1331+305,J2000) are used for both, amplitude and bandpass calibration. Together these three calibrators almost coverthe entire 24 hr observing run. The flux density scale used for for the observing bands at GMRT is based onthe Baars et al. (1977 Astron. Astrophys., 61, 99) scale.

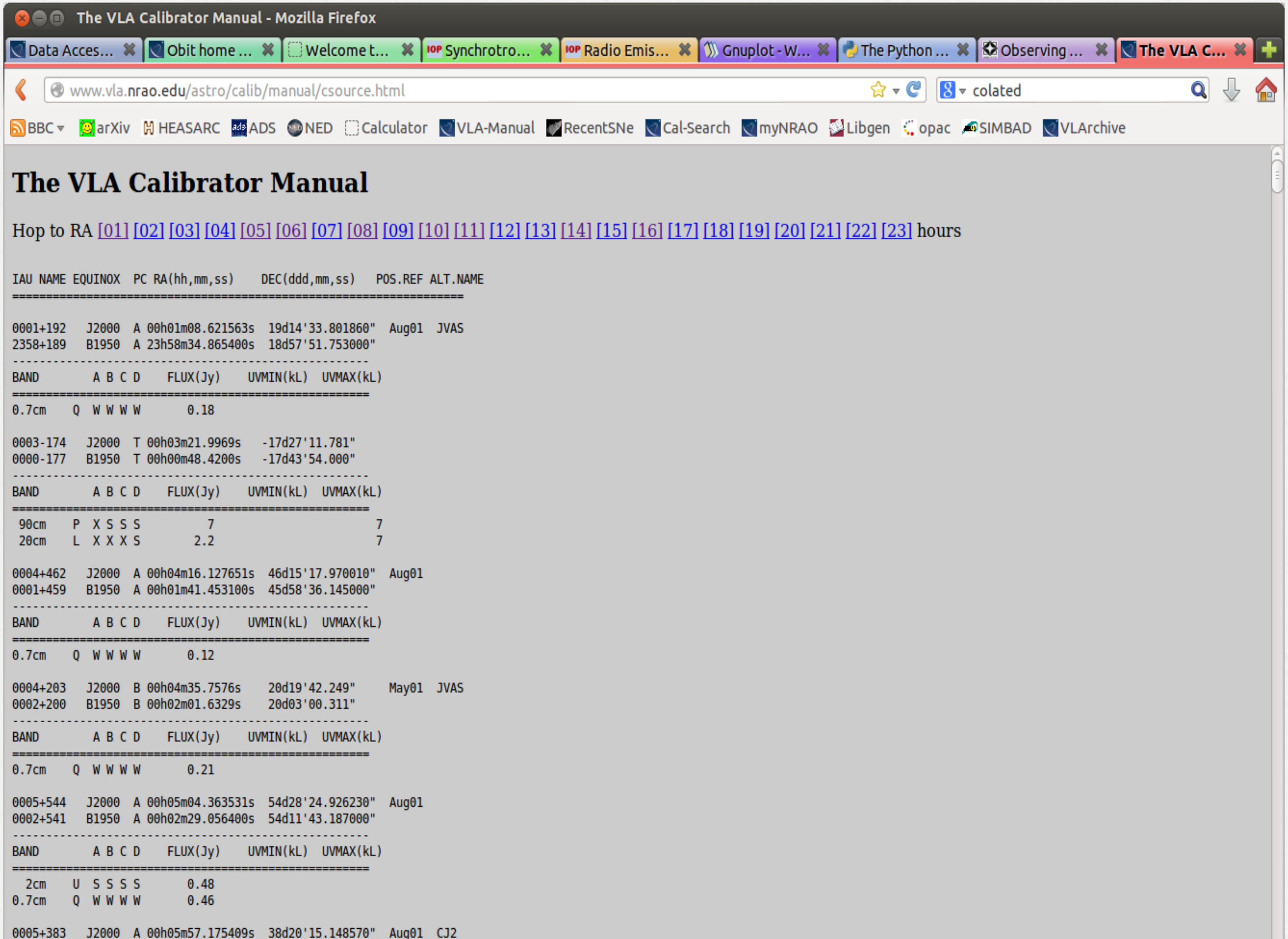
http://ncra.tifr.res.in/gmrt_hpage/Users/Help/sys/time.php



Phase calibrators

- The assumption goes that sky conditions are same for target source and phase calibrator.
- Phase calibrator should be nearby, preferably within 15 degrees for 1420 and within 20 degrees at lower frequencies.
- So far we use VLA calibrator.
- How frequently to use.

http://www.vla.nrao.edu/astro/calib/manual/csource.html



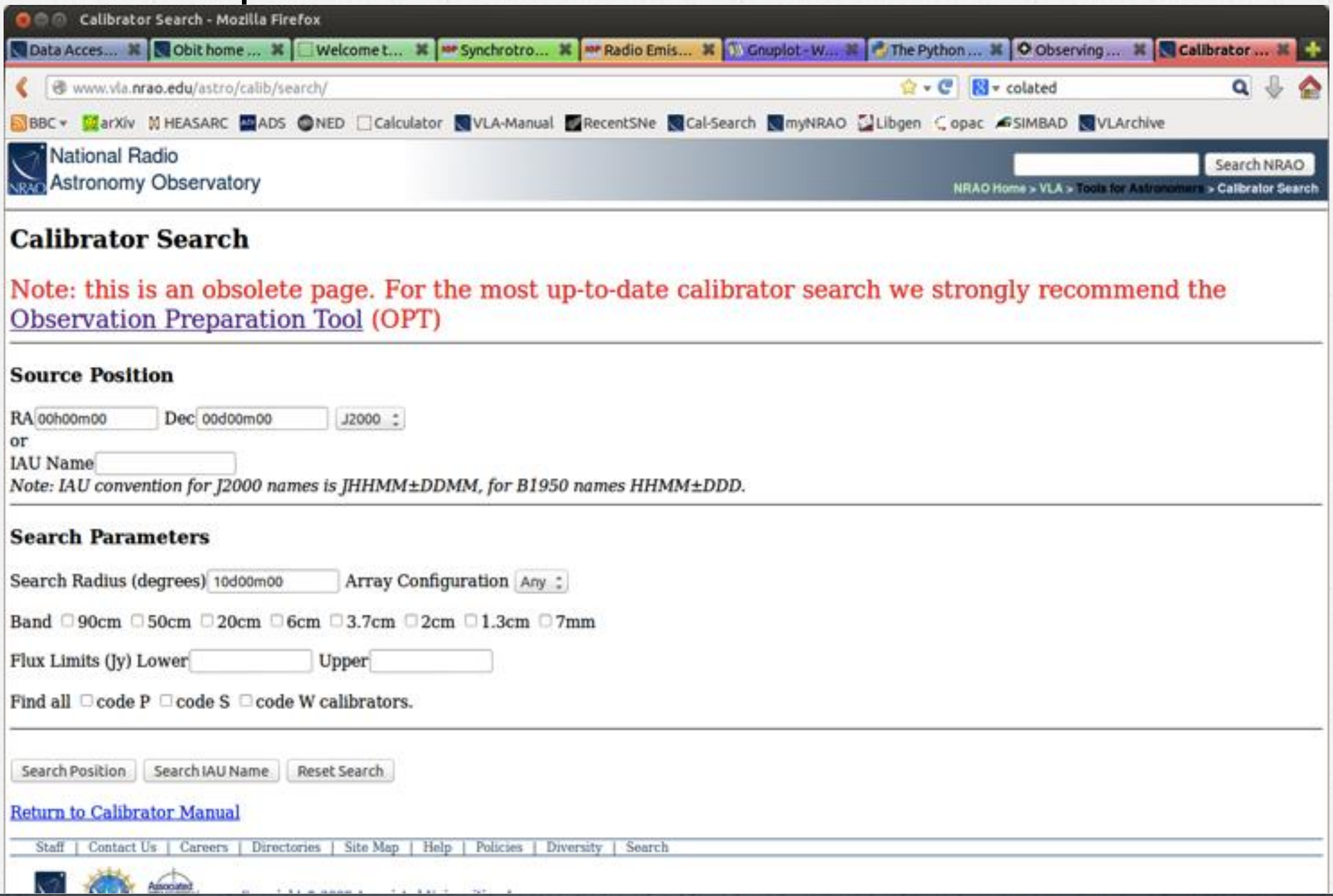
The VLA Calibrator Manual

Hop to RA [01] [02] [03] [04] [05] [06] [07] [08] [09] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] hours

```
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"
-----------------------------------------------------
BAND        A B C D    FLUX(Jy)    UVMIN(kL)  UVMAX(kL)
=====================================================
  2cm    U  S S S S      0.48
0.7cm    Q  W W W W      0.46

0005+383   J2000  A 00h05m57.175409s  38d20'15.148570"  Aug01  CJ2
```

Searching the right phase calibrator

http://www.vla.nrao.edu/astro/calib/search/

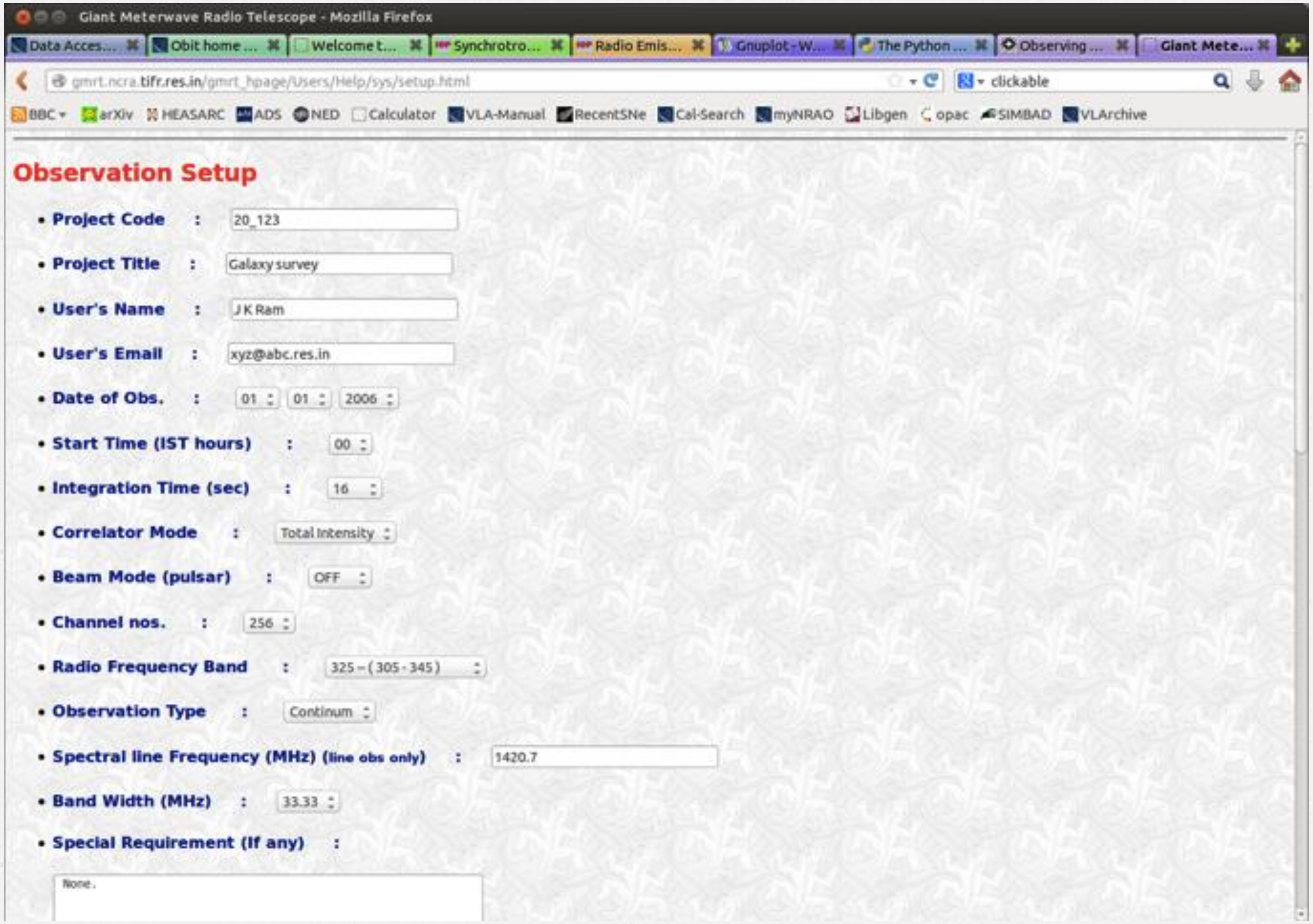


RFI is a concern

- Significant below 1 GHz.
- If your observation calls for low frequency, try to schedule them in the night or weekends as
- Activities are much less at this time.
  - Mobile phone signals around 950 MHz.

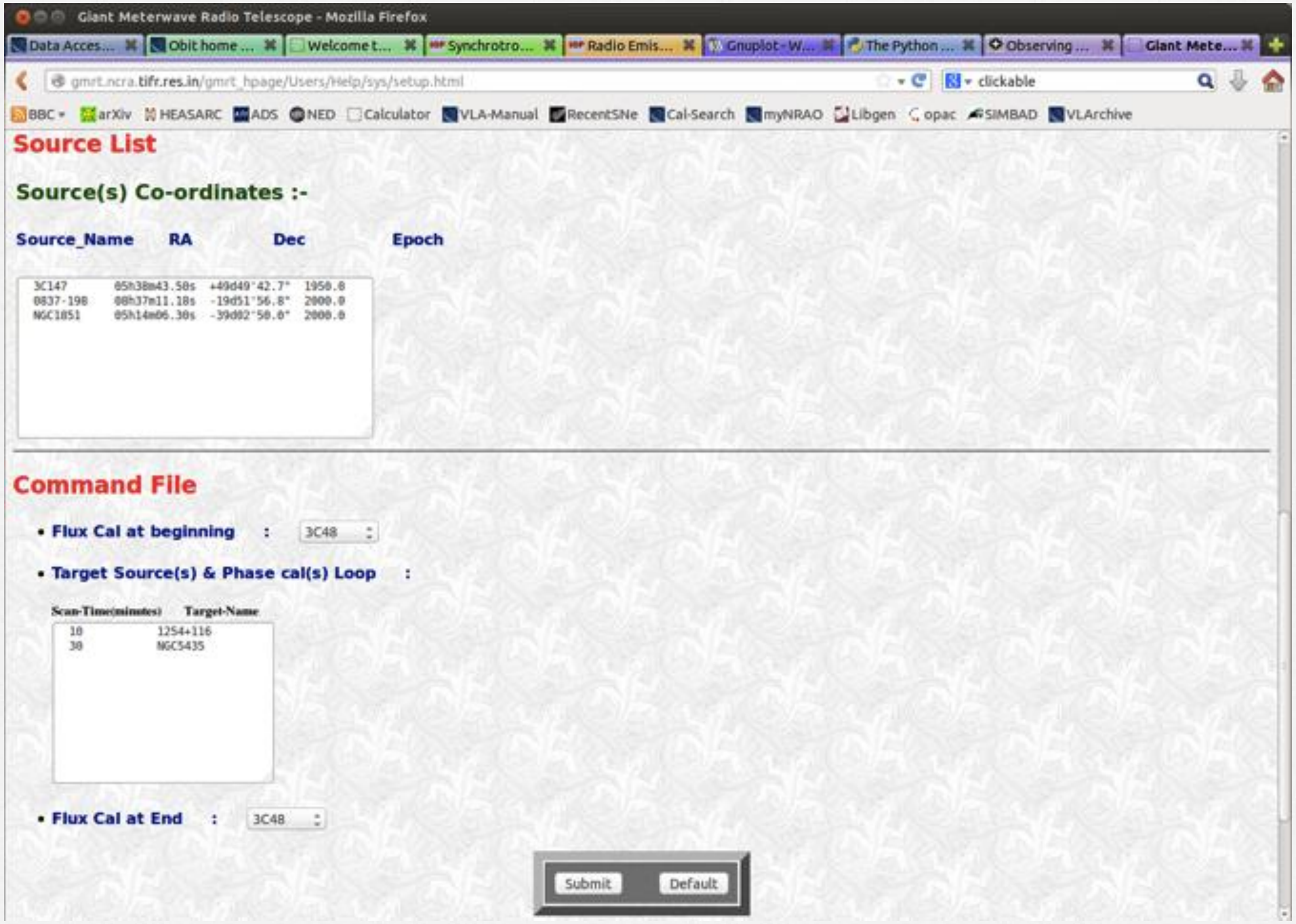
Preparing Command file

http://gmrt.ncra.tifr.res.in/gmrt_hpage/Users/Help/sys/setup.html



Preparing Command file

http://gmrt.ncra.tifr.res.in/gmrt_hpage/Users/Help/sys/setup.html



Pulsar observations

- A Pulsar observing manual, for more details, is available athttp://www.ncra.tifr.res.in/gmrt_hpage/Users/Pulsar/PULSAR_MANUAL.pdf.

If rejected- Resubmitting

- Don’t get disheartened
- Resubmit
- make sure that you have answered the referees’ questions
- Check your writing style, improve clarity
- Don’t remove important points!
- Improve technical justification

Final Checklist

-(Judith Irwin)

- Is this a well-justified scientific idea?
- Have you included a brief introduction and put your project in broader context for the non-expert?
- Have you argued that this project will significantly advance the field?
- Have you been specific about the goals of this particular observing run and how they relate to the broader significance of the project?

Final Checklist continued…

- Will the observations result in hard science?
- Is your scientific team well balanced?
- Have you justified the choice of the telescope?
- If supplementary observations are required at another telescope, have you indicated the status and also alternate if they are unsuccessful?
- Is the observing strategy well justified and planned?

Final checklist continued....

- Have you justified the choice of sources, frequencies, lines, settings, time on source etc?
- Have you indicated how the data will be analysed?
- Can the technical set up as described in your proposal achieve the stated goals of the observations?

Walk through an example

- Idea: Very high energy sources (H.E.S.S)
- Counterparts in other waveband help understanding acceleration mechanism.
- A SNR which has been seen in TeV energies.
  - How?
  - Acceleration process?

Questions to Answer

- When do particle energies reach maximum?
- How cosmic rays escape and how energies evolve with time?
- What is the primary population producing gamma ray emission

Goals

- The first two questions are intimately connected with the intensity of the magnetic field hence with the maximum acceleration energies which are constrained by radiative losses and synchrotron radiation and hence by radio emission.

Continued….

- The third one can be traced efficiently thanks to the detection of gamma rays in the high energy range (HE) with the Fermi-LAT or in the very-high-energy (VHE) energy range (100 GeV–100 TeV).
- Multiwavelength data, and especially radio and gamma-ray data, are thus crucial to understand the nature of these efficient particle accelerators in our Galaxy.

Multiwaveband proposal?

- GMRT + Fermi?
- Fermi data already exists?
- Mention it.

Planning the experiment

- Radio emission since it comes from synchrotron
  - Acceleration and magnetic field.
  - Link between radio emission and the emission at high energies.
- Role of SNRs in CR production.
- By product: Mystery source nearby

Designing the experiment

- SNR XXX detected in HESS
  - TeV emission (10^{xx} erg/s)- excellent source
  - One of the youngest SNR.
  - 0.5 degrees size.
  - Parkes 64m dish radio data at L band exists.
  - ATCA Galactic survey data exists.
  - X-ray data exists. Prominently non-thermal
  - No sensitive radio measurements.

Testing the models

- Laptonic model: gamma-ray emission produced through IC cooling of ambient photons.
- Gamma ray emission produced by proton-proton interaction.
  - In this second scenario, the total energy injected into electrons is very small in comparison to the kinetic energy of the SN. These low energy electrons radiate in the radio band: accurate radio data are therefore crucial to help constrain the injected spectrum.

Observations

- 325 and 1420 MHz bands.
- One pointing needed in 325 MHz.
- 3 pointings in 1420 and using Parkes data available.
- Shell morphology as well as small scale filaments.
- Morphological comparison in other bands (unique case as other HESS SNRs are much smaller).

Technical Justification

- 0.5 degrees wide.
- 325 MHz, one pointing.
- 1420 MHz, 3 pointings.
- Expected rms 1 mJy @325 MHz (dynamic range limited)
- Features as small as 3-5 mJy.
- L band 70 uJy rms. So weaker features.
- Spectral index study.
- Minimum RFI as large structure so need to have shorted baseline. Night time.
- Complicated structure so U-V coverage also needed.
- Total time 8*3=24 hours

Final thoughts

- Know about telescopes around the world (Niruj Mohan's talk)
- Make collaborators. RAS is a good opportunity.

Thanks to

- Divya Oberoi
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- Jayant Murthy
- Ed Fomalont