

LeMMINGs Planning Meeting

Rob Beswick

e-MERLIN status update

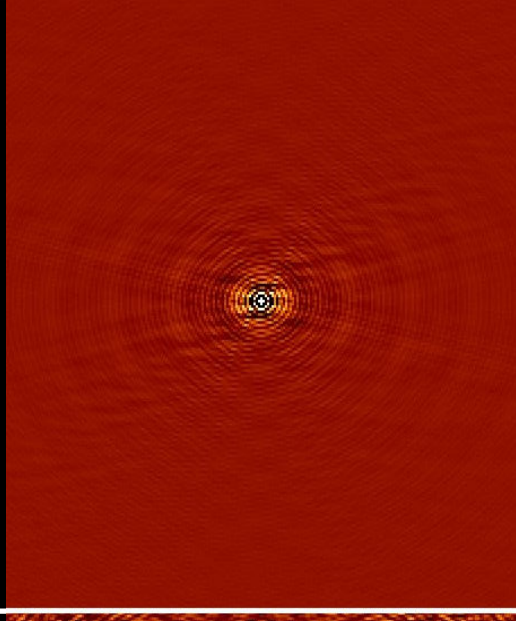
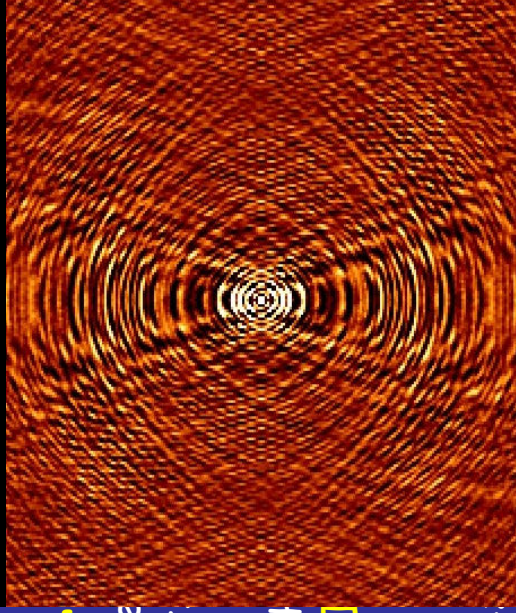
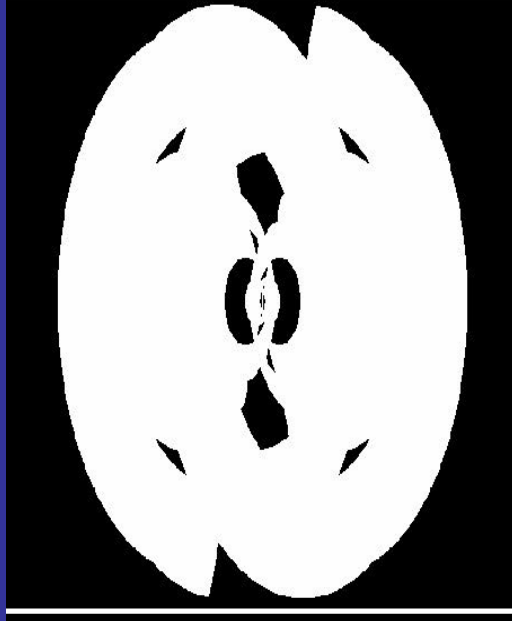
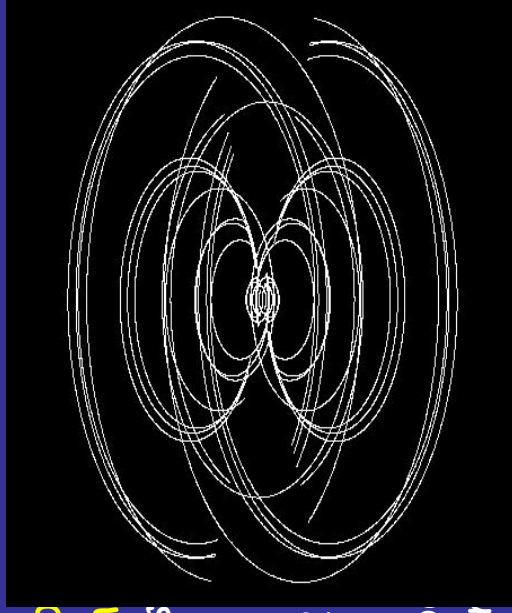
- Major upgrade to MERLIN array
- New optical fibre network connecting 7 telescopes to new correlator at Jodrell Bank Observatory
- Unique combination of 50-150 mas resolution and μJy sensitivity
- Crucial to resolve AU-scale star-formation processes in the Galaxy and kpc-scale regions at $z \sim 1$



Capabilities

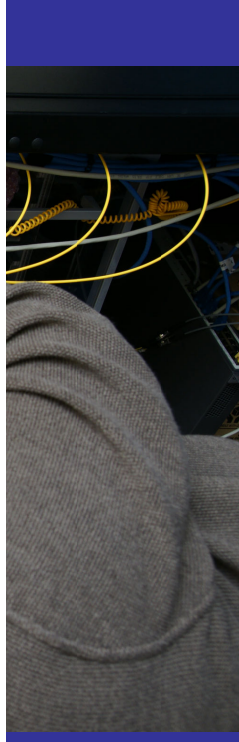
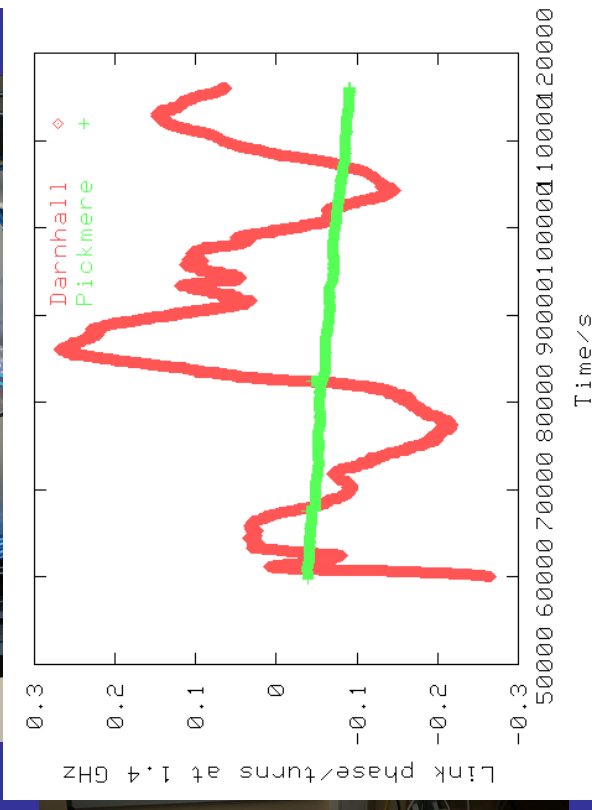
- 150, 40, 10 mas resolution
- ~ 2 μJy sensitivity in
 - < 1 μJy in deep fields
 - ~ 30 μJy in ~ 1 min
- Wide fields
 - Out to HPBW of 2
- Spectroscopy
 - 16 placeable sub-bands
 - Can mix/trade bands
 - Correlator almost
- Much improved aperture
 - Via frequency coverage
 - May help snapshot
- Spectral mapping
 - 1.3-1.7; 5-7/4-8 GHz
- Polarization (L,R $\rightarrow$ J)
- Astrometry
 - Goal is < 1 mas wrt delay (5cm error -

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Commissioning

- New receivers/IF installed
 - wider bandwidth, improved Tsys, quick band-change
- Samplers & data transmission being installed (2 done)
 - 0.5 GHz (covers L-band) done, 2 GHz (NRAO) later this year
- Optical fibre network in place
 - 600 km leased + 100 km installed
- New timing system developed and being installed (2 done)
 - H-maser signal transferred on fibre + GPS at each telescope
- Prototype correlator (DRAO, Penticton) arrived over last few months
 - 2 station boards + 1 correlator board + Xbar
 - up and running
- New array control software -- up and running



Progress

- Huge effort over last few months to get first data back from telescopes using entire new signal chain

- receiver → IF → sampler → formatter ...
 - optical Tx → fibre → optical Rx → station board
 - correlator board

timing signals to and from telescope correlator, between correlator modules

- Correlator control code from DRAO+NRAO
 - grateful for assistance



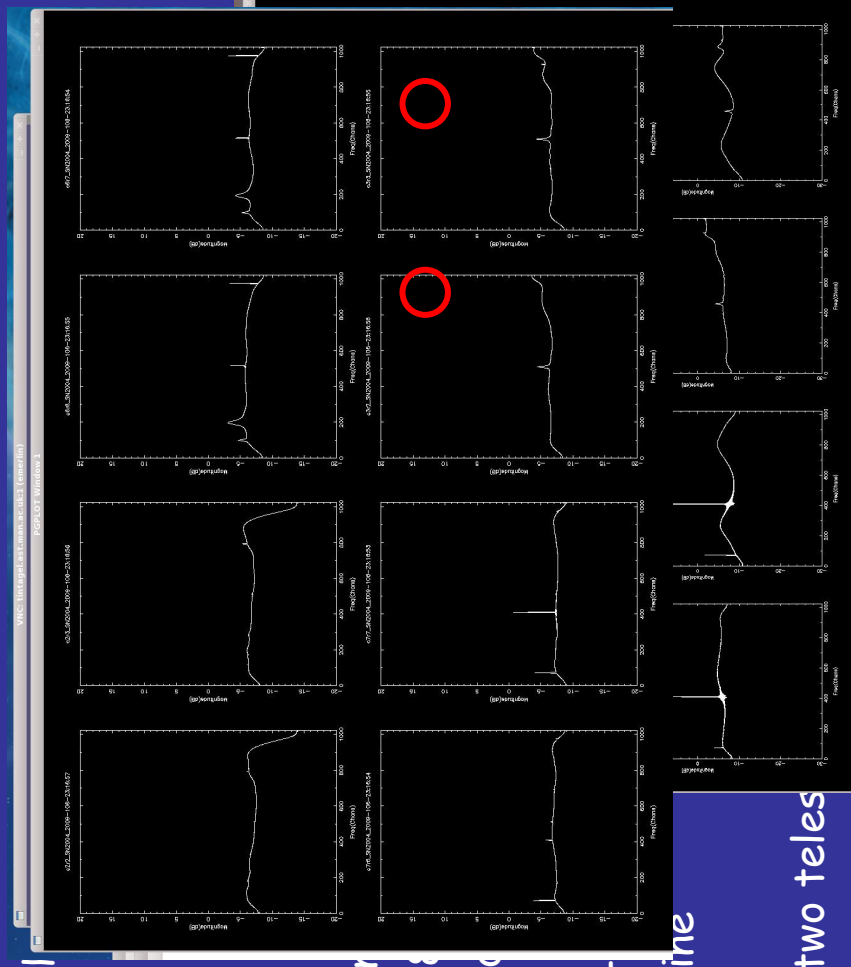
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Status today

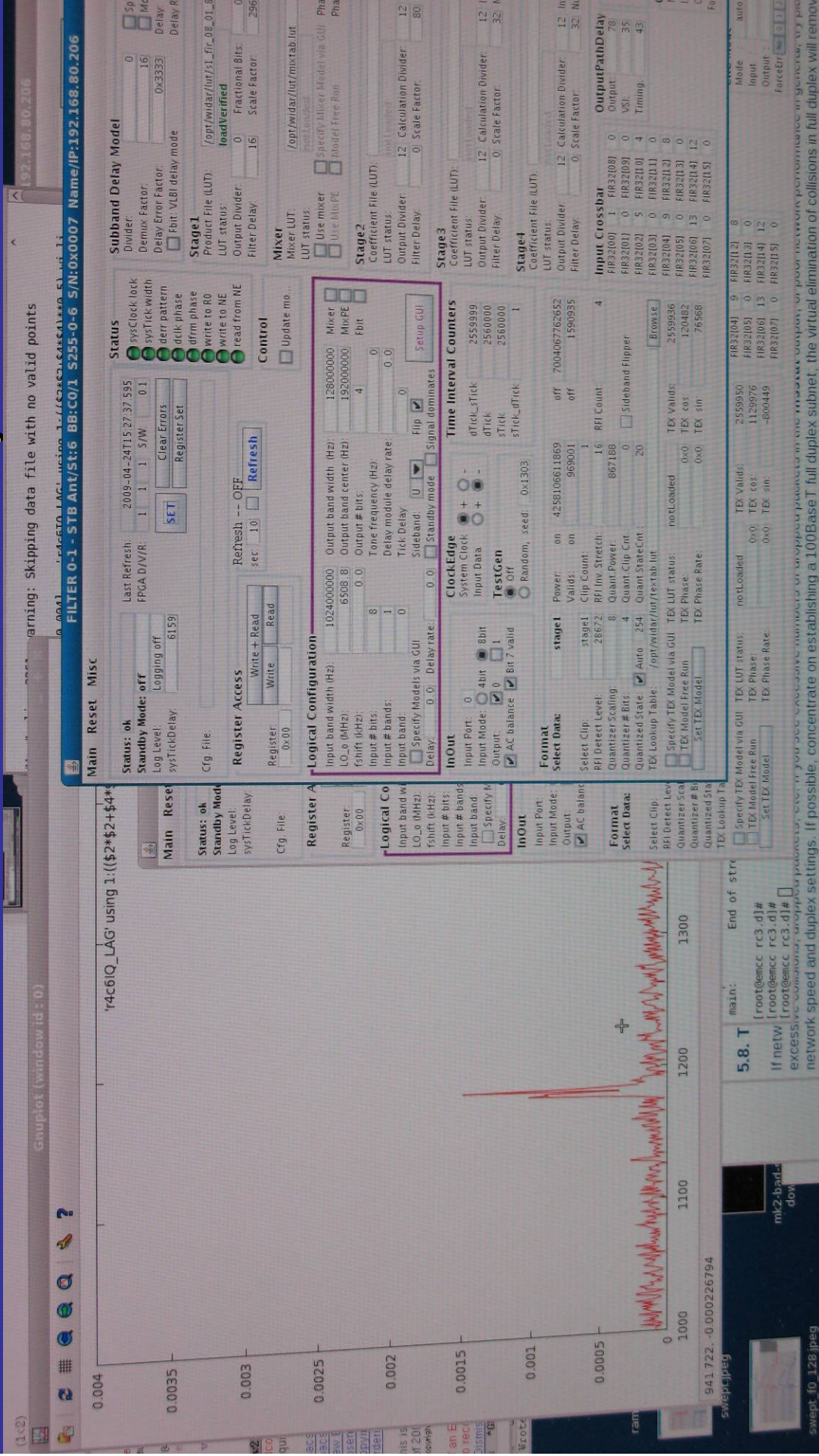
- <4 weeks ago
 - first 'analogue light' with 4 GPUs
- 3 weeks ago
 - first 'digital light' - 512 MHz
 - MERLIN has 15 MHz
- 2 week ago
 - autocorrelation of methanol line
 - 1024 channels across each of 8 telescopes
 - MERLIN does 16 channels across each of 8 telescopes
- 1 week ago
 - first remote telescope out-fit
 - auto correlation of methanol line
- last week
 - correlator synchronised with two telescopes
 - delay models running
 - started fringe search...

Last Friday

- First fringe on 3C84



e-MERLIN Status Update



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Coming months

- Fringe tests continue - next month
- 4 station tests
 - requires next Station Boards (being prepared now) and next production run of IF, digital boards: Summer 09
- Full array & full bandwidth
 - requires further SB, BB (Nov 09), 4 Gs/s samplers
 - regeneration electronic for last, most distant telescope at Cambridge (Dec 09)
- Engineering/commissioning obs through 2009
- Limited, shared-risk observations in 2010A
- Standard operations 2010B

Legacy programme

- Where does LeMMINGs fit in..

Legacy programme as a whole: Proposed projects

- Breadth of legacy proposals demonstrate the versatility of e-MERLIN
- Programme covers ~50% of e-MERLIN time in first 5 semesters
- In total ~10,000hrs of e-MERLIN time were proposed for
 - Well oversubscribed
- 325 individual investigators, from 119 institutes

Allocated programme:

GALACTIC PROJECTS:

- eTT - Pulsar interferometry
- PEEBLES
- Feedback processes in Massive SF
- Thermal jets from low mass stars
- COBRaS

- Vlemmings/Stappers et al. 160hrs **
 - Greaves et al. 72hrs **
 - Hoare/Vlemmings et al. 450hrs
 - Rodriguez et al 180hrs
 - Prinja et al. 294hrs

EXTRA-GALACTIC PROJECTS:

- LEMMINGS
- LIRGI
- Extragalactic Jets
- AGATE
- e-MERGE
- Gravitational lenses

- Beswick/McHardy et al. 810hrs
 - Conway/Perez-Torres et al. 353hrs
 - Laing/Hardcastle et al 375hrs
 - Simpson/Smail et al 330hrs
 - Muxlow/Smail/McHardy++ 918hrs
 - Jackson/Serjeant et al 228hrs **

TOTAL : 4170hrs

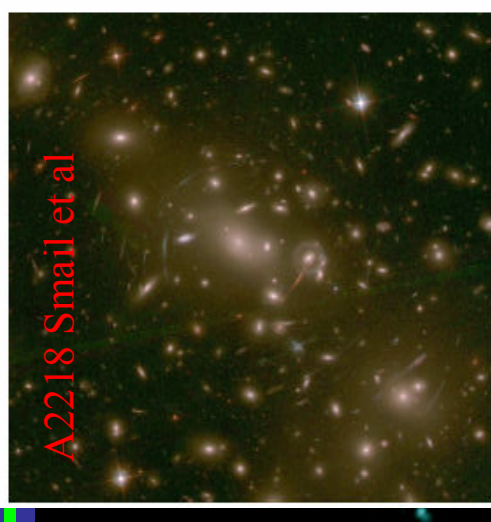
- **Up to 5000hrs can be allocated. Remaining 830hrs to be allocated by LSG to pre-identified projects pending initial results
- DETAILS OF ALL PROJECTS (inc Proposals allocations etc) ARE AVAILABLE AT <http://www.merlin.ac.uk/legacy/>

Legacy projects (1)

galaxy formation and evolution

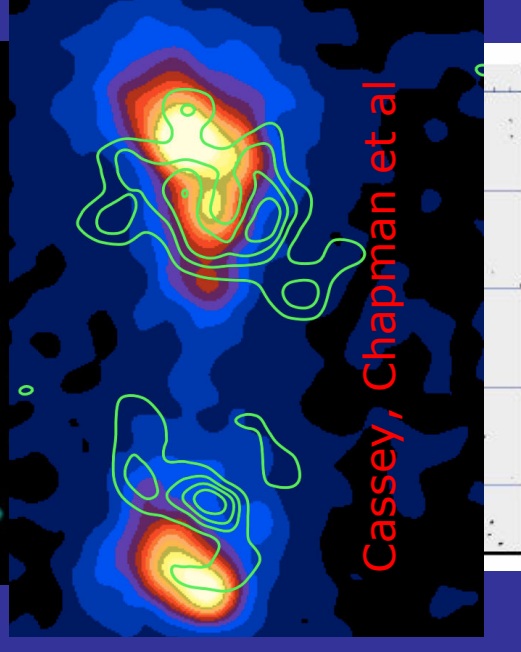
Galaxy formation (Grav lenses)

- Gravitational lenses - test CDM models (halo substructure) and probe central ~ 10 pc
 - Requires **e-MERLIN** sensitivity & resolution/astrometry
- New survey (>1000 lenses)
 - Herschel - SCUBA2 - e-MERLIN
 - **e-MERLIN** vital for confirmation (**CLASS** experience)



Galaxy evolution (e-MERGE, AGATE)

- **Ultra-deep** (cluster lenses): star-formation in normal galaxies at $z \sim 5$
- **Deep** (0.25 dg^2): star-formation history $z \sim 0.5-3$ (extinction-free; AGN; sub-mm quiet **SFG**)
- **Environmental** impacts on galaxy evolution: clusters;
 - **e-MERLIN** required to resolve typical few-kpc star-forming regions at $z \sim 1$ and identify/separate AGN (HDF experience)



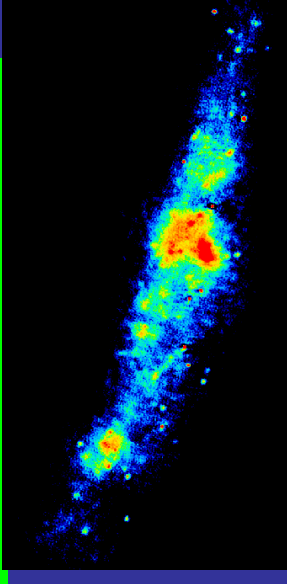
Legacy projects (2)

From galaxies to Star and planet formation

Birth & death of stars in the Local Universe

(LeMMINGS, LIRGI)

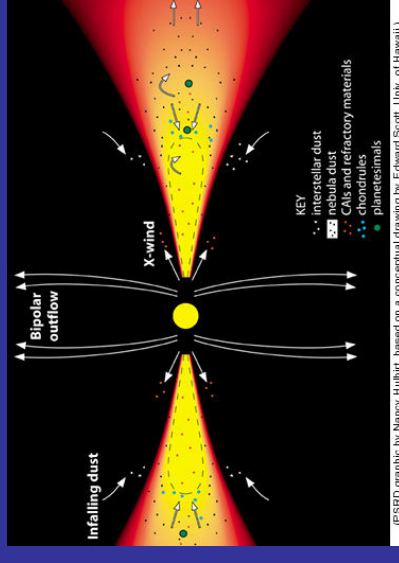
- Add to multi- λ Nearby galaxy samples (SINGS, KINGFISH, GOALS...)
- Super star clusters; determination of IMF via SN rates
- Census of AGN; identify intermediate-mass black holes; ULX
- Magnetic field in LIRGS
- RSN detection & AGN separation in LIRGS
 - **e-MERLIN resolution essential to resolve SSC, SNR, AGN (M82 experience)**



Physical processes of star-formation

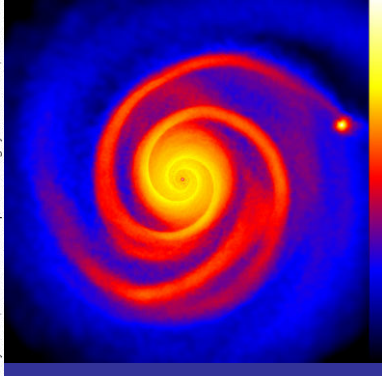
(Massive star-formation, stellar jets, CoBRAS)

- Trace onset of feedback processes by jets/winds during early stages of massive star formation.
- First direct test of the X-wind model for protostellar jets
 - **e-MERLIN can resolve key physical processes**



Formation of planetary systems (PEEBLES)

- Detect cm-sized particles in planet-forming disks $\sim 1 \text{ AU}$, $\sim 1 M_{\oplus}$
- Astrometric detection of Jupiter-mass planets around low-mass stars
 - **e-MERLIN required for spatial and spectral separation of emission components**

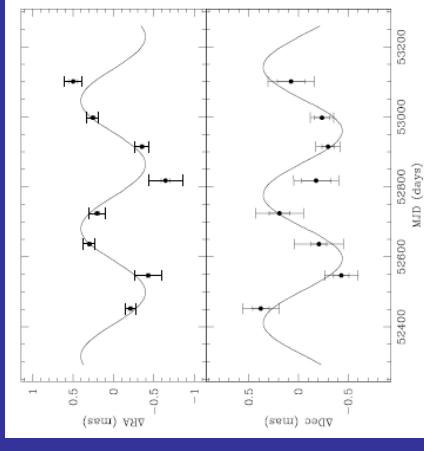


Legacy projects (3)

Extreme environments

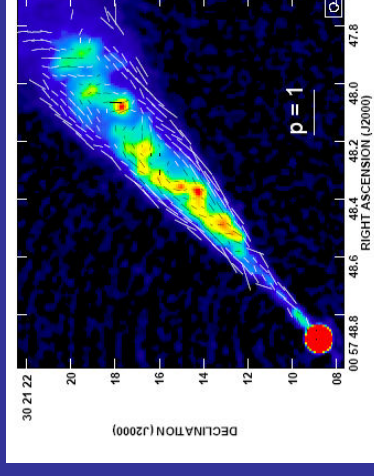
Pulsar proper motions (eTT)

- Proper motions of many pulsars
- Physics of neutron star formation during SNe
- Double the number of pulsars with accurate distances & velocities
 - **e-MERLIN resolution essential, multi-epoch proper motions**



Extragalactic Jets

- Dynamics of jets, low luminosity radio jet deceleration on sub-kpc scales
- Magnetic field configuration surrounding jets
- Particle acceleration in hotspots
- Polarisation and faraday rotation across e-MERLIN bands
 - **e-MERLIN can resolve the key physical processes**



General legacy programme management etc

- **Legacy management group (Chaired by Hoare)**
 - Including all Legacy PIs + e-MERLIN director.
 - This group will act to oversee the running of the programme and facilitate communications between teams
 - This will be chaired by Melvin Hoare.
 - First kick-off meeting of this group was held in March
- **Technical working group (coordinated by Beswick/Fenech)**
 - Including Technical representatives from all legacy teams + e-MERLIN science staff
 - Aims to coordinate all technical activities & share developments between teams. Plus to allow communication of technical developments from the project to the teams.
 - Group currently being set-up -
 - LeMMINGs members - Beswick, Klockner (also Fenech [CoBRaS] & Muxlow [eMERGE])

Lovell telescope access fee application

April '09

- From legacy programme 67% (2784/4170hrs) of observation require LT time.
- The LT is a University of Manchester instrument and its inclusion in the e-MERLIN is dependent on available access fees.
- Over the legacy period (2.5yrs) this equates to 70days/year of LT required
- **Total request = 175days@2.52k/day = 441k + 1% FeC (Hoare)**
 - Not covered by current STFC access fees (c.f. PATT MERLIN observations total 10-20day/yr currently).
- The 9 Legacy teams that need LT prepared a joint standard grant app to STFC (submitted April 7th) for these access fees.
 - Proposal lead by Melvin Hoare - Co-Is include Beswick, McHardy, Smail, Muxlow, Mundell, Jackson, Serjeant, Prinja, Hardcastle, Greaves, Richer, Garrington

29th April 2009

Some Aims of today...

- O) get a people together - talking/planning/thinking;-)
- 1) discuss and confirm(?) observing source lists & strategies
 - How do we split what we have and what do we observe to get the best results we can...?
 - What order to observe?, How soon to start?
 - Any more e-MERLIN obs needed/desired??
- 2) follow-up observations:
 - What is needed? Who will lead what? What is already in hand? How do we want to handle follow-ups?
- 3) Plans of how we get data calibrated
 - Who will be involved/form core team of people
 - Data (for analysis/calibration/distribution) centres
- 4) Project management/organisation?
 - Tech working groups, science areas/working groups etc etc
- 5) Other funding routes??
 - Are there any we should explore → always manpower poor..
- 6) Data releases/publication rights etc
 - Ultimately where we need to head....

The LeMMINGs project

- Summary of what we proposed
- Summary of what we were allocated

Legacy e-MERLIN Multi-band Imaging of Nearby Galaxy Sample (LeMMINGs)

- Proposal submitted requested ~1140hrs of e-MERLIN time over 5 semesters
- Two depth tier project
 - 48min 'multi-cut, snapshot' survey of the complete Palomar BGS (Dec>20deg)
 - 250 Galaxies
 - rms~40 & 15 μ Jy/bm @ L & C respectively
 - Deep, nearby 5hr survey
 - Superb multi-wave coverage SINGS/KINGFISH/THINGS ++++
 - 41 Galaxies of all types (inc. M82 etc)
 - rms ~ 8 & 3 μ Jy/bm @ L & C respectively

AIM to provide a systematic radio census of star-formation products and AGN activity in the local Universe.

29th April 2009

Legacy e-MERLIN Multi-band Imaging of a complete Nearby Galaxy Sample (LeMMINGs)

Coordinators:

R. J. Bewick (Robert.Bewick@manchester.ac.uk) & I. M. Hardy (imb@astro.soton.ac.uk)

Addresses:

R. J. Bewick, Jodrell Bank Centre for Astrophysics, The University of Manchester, M13 9PL, UK
I. M. Hardy, School of Physics & Astronomy, University of Southampton, SO17 1BJ, UK

Abstract: The two processes which dominate the appearance of our universe are star-formation and accretion. Star-formation (SF) is fundamental to the formation and evolution of galaxies whilst accretion provides a major power source in the universe, dominating the emission from distant quasars as well as from nearby X-ray binary systems. The feedback between these two processes is also crucial, e.g. in reconciling the observed galaxy luminosity function with the predictions from the standard hierarchical clustering models. Radio observations provide by far the best single diagnostic of these two processes, providing a direct view of SF even in dusty environments and allowing detection of AGN and measurement of their accretion rate at bolometric luminosities far below anything detectable at higher energies. A large, statistically complete, sample of galaxies such as we propose here, provides the perfect laboratory to study for the first time not only these two processes, but also to quantify how they interact in different types of galaxies. e-MERLIN is perfectly tuned to such studies as, even at low frequencies, its pe-scale resolution, coupled with spectral information, allows almost unambiguous discrimination of even faint AGN inside large SF regions. Specifically here we will carry out a complete census of SF and AGN activity as a function of galaxy mass, morphology and spectral type, black hole mass and luminosity. We will thus calibrate other SF indicators, e.g. IR and H α luminosity, and constrain patterns in jet strength compared to merger histories. Additionally, we will determine whether ultra-luminous X-ray sources may come from intermediate mass black holes.

The broad philosophy of this legacy programme will be to provide the definitive parse-scale, μ Jy sensitivity radio images of a large sample of well-known galaxies in the nearby universe. As such this project will both address numerous key science questions regarding SF and activity in galaxies and is specifically designed to be a lasting Legacy data-set for the wider community, with the sample selected to maximize multi-wavelength coverage and consequently the amount of future legacy science achievable.

Full list of team members:

Susanne Aalto (Ondra Space Observatory, Sweden),	Anton Alberdi (IAA, Spain)
Paul Alexander (Cambridge),	Megan Argo (Curtin, Australia)
Willen Baan (ASTRON, The Netherlands),	Rob Bewick (JBCA, Manchester)
Elias Brinks (Herfordshire),	John Conway (Ondra Space Observatory, Sweden)
Stephane Corbel (CEA Saclay, France),	Phil Diamond (JBCA, Manchester)
Tom Dwelly (Southampton),	Janine van Eymeren (JBCA, Manchester)
Danielle Fenech (UCL),	Jay Gallagher (Wisconsin, USA)
Jack Gallimore (Bucknell, USA),	Dave Green (Cambridge)
Melvin Hoare (Leeds),	Sebastian Jester (MPIA Heidelberg, Germany)
Rob Kenaout (Cambridge),	Hans-Rainer Krichner (Oxford)
Johan Knapen (IAC, Tenerife, Spain),	Christian Knigge (Southampton)
Elnar Kording (Southampton/Saclay, France),	Ian M. Hardy (Southampton)
Tom Maccarone (Southampton),	Jon Marziani (Valencia, Spain)
Sara Markoff (Amsterdam, The Netherlands),	Ivan Martí-Vidal (Valencia, Spain)
Carole Mundell (LJMU),	Tom Muxlow (JBCA, Manchester)
Alison Peck (ALMA, Chile),	Alan Pedlar (JBCA, Manchester)
Miguel Perez-Torres (IAA, Spain),	Cristina Romero-Canizales (IAA, Spain)
D. J. Salis (NCRA, India),	Eva Schinnerer (MPIA Heidelberg, Germany)
Ralph Spencer (JBCA, Manchester),	Ian Stevens (Birmingham)
Ian Stewart (JBCA, Manchester),	Michele Thornley (Bucknell, USA)
Philip Uttley (Southampton),	Fabian Walter (MPIA Heidelberg, Germany)
Martin Ward (Durham),	Jeremy Yates (UCL)

LeMMINGs Science objectives

Three main science themes:

1. To measure levels of SF activity in galaxies of all morphological, luminosity and spectral population mix. These measurements, and in particular the resulting systematic and unbiased census of individual SF products (R_{SN}, SNR, HII regions and alike), will be used as a direct extinction-free tracer of SF, and hence be used to help calibrate commonly used SFR indicators such as IR and H α
 - Deep (for details and ultimate sensitivity) & Shallow (providing context but this is still an order of mag more sensitivity than already exists - so lots of new stuff too)
2. A complete census of AGN activity and jet structures in galaxies of all optical types, including LINERs and absorption line galaxies as well as broad line AGN, which will be cross-correlated against levels of ongoing SF
 - Shallow statistical tier is most important here
3. A serendipitous parsec-scale imaging survey of the cold ISM using its HI absorption and maser emission. This survey will constrain the content and composition of cold gas present in the immediate nuclear region of galaxies as well as its kinematics. Both of which are basically unknown on these size scales and can be addressed with e-MERLIN well before ALMA or the SKA are fully operational.
 - Can only be done in Deep Tier

Allocation and implications:

- Bottom line:

All of statistical tier =
760hrs*

*291 gals (the 250 gals orig. requested in this mode with 30 made up from deep tier → total = 280 not 291 sources - within Dec limits, and sample)

5 sources in deep tier =
50hrs**

**some miss-calculation here as 5 sources = 60hrs;-) But slightly more hours given in statistical tier if only original 280 gals done (~30hr)).

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11 Rob Beswick

Detailed radio observations of star formation and AGN in nearby galaxies provide a crucial benchmark for radio-based studies of galaxy evolution in the distant Universe. Therefore the e-MERLIN LSG felt that this project has a clear legacy value. It was also recognised that the experienced team associated with this project was well-placed to make the most of the datasets that would result from the proposed observations. The proposal was graded highly by the external reviewers and the LSG.

Of the two tiers presented in the proposal (deep and shallow), the reviewers were most enthusiastic about the shallow tier, because it was felt that such observations would provide the best sample for examining the correlations between star formation and AGN activity, and the morphological dependence of the radio/far-IR correlation. Moreover, while less deep than the proposed deep tier observations, it was noted that the shallow tier observations would nonetheless go almost an order of magnitude deeper than any previous radio survey of local galaxies, allowing a start to be made on the more detailed SN/star formation aspects for nearby galaxies. Therefore it has been recommended to the Steering Committee that 760hr be allocated to make shallow tier observations of all 291 accessible galaxies in the PBGS.

Although it was recognised that deep e-MERLIN observations of nearby galaxies will provide important laboratories for investigating the detailed star-forming processes, as well as the elements that contribute to the radio/far-IR correlation, it was felt that the need for 41 such laboratories had not been sufficiently justified. Therefore the LSG has recommended a reduced allocation of 50hr to make deep tier observations of 5 sources.

Source lists & strategies

- Shallow-Tier - Time granted for all
 - Complete sample all Palomar BGS gals
 - Dec >20
 - 280 galaxies*
 - * in the original proposal 250 were in snapshot mode +30 were part of deep tier
 - Allocation notes " ..make shallow observations of all 291 accessible galaxies in the PBGS."
- (suggest we stick to our well defined sample...)

Shallow tier cont:

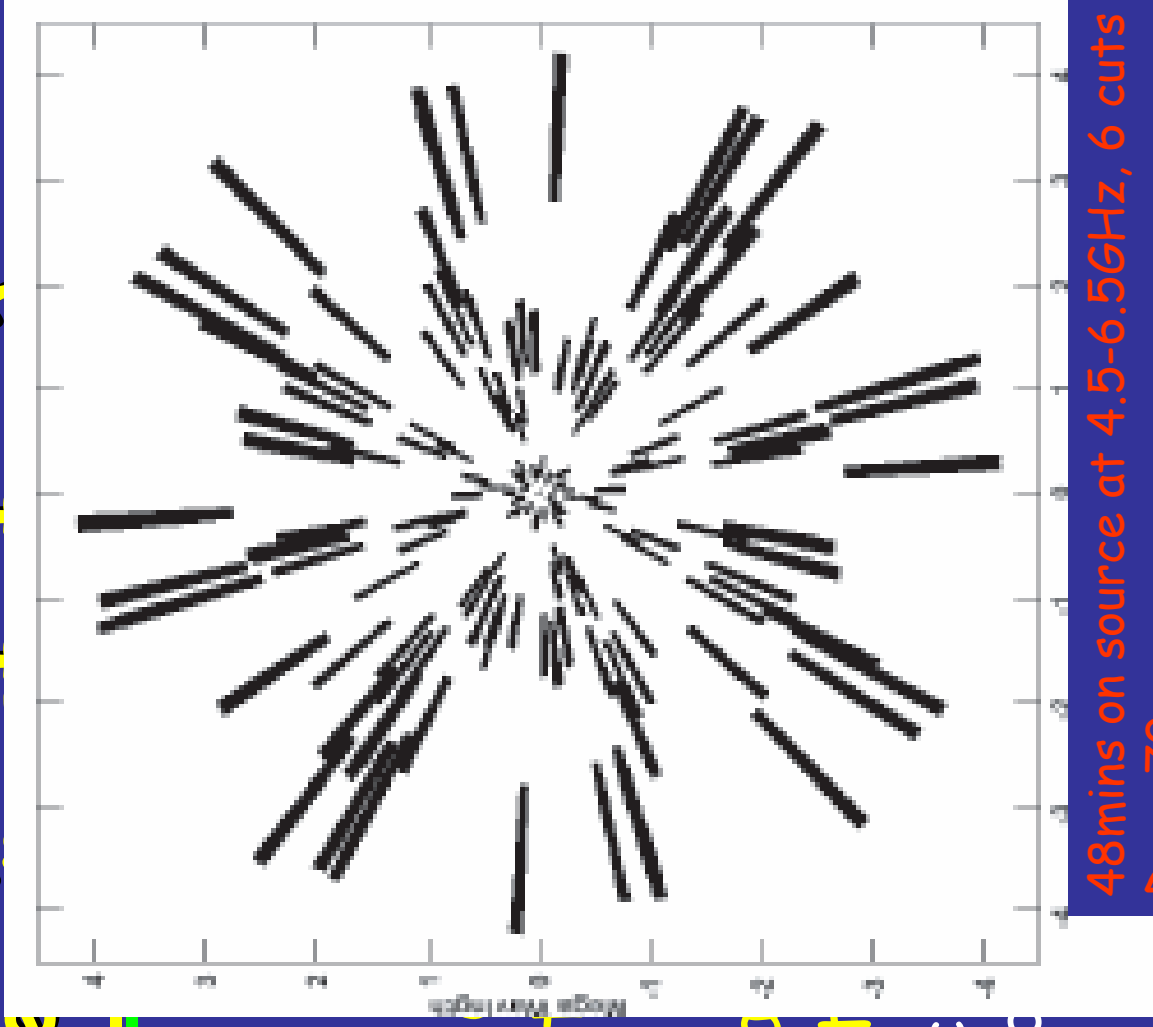
- Observing strategies (allocated 760hrs - all time requested+)

Proposal request (Tech):

- Snapshot imaging (No Lovell Tel)
- C + L band in full wide-field continuum
- 48min on-source integration split in cuts at different HA.
- Total = 1.3hrs/source/band = $280 \times 2 \times 1.3 = 728\text{hrs}^*$
 - » * some additional overheads.. cals (flux/band etc) will be needed.
 - » Time assumes 3-8-2m cycle some extra drive time will potentially be need (4-8-2m?) → 1.4hrs/source/band=784hr
- Estimated rms : L-Band $\sim 38\mu\text{Jy/bm}$
C-Band $\sim 15\mu\text{Jy/bm}$

Tier 2: observation

- Scheduling:
- Multiple cuts (6 per
- Quasi-simultaneous or prefer to complete starting the next?
- Ordering of observations complete if forced to
 - Suggest start with certain declination range and



48mins on source at 4.5-6.5GHz, 6 cuts
Dec +70 source

29th April 2009



Tier 1 : Deep

- **Original plan:**
 - Deep(er) observations at L&C-band
 - 8uJy/bm (L-band), 3uJy/bm (C-band) **all inc LT.**
 - 41 galaxies (30 of which contribute to shallow 280 gals)
 - Dec > 0, Dist < 25 Mpc
 - Spectral lines also observed** (H1, OH[*4], H2CO, excited OH?) -
 - Choice of spectral configurations (chan widths, etc etc)
 - Selection aims to broadly cover range of galaxy types, best examples, with best multi-wave coverage
 - Total time = 6hrs/source/band = $41 \times 2 \times 6 = 492$ hrs
- **Allocation for just 5 sources (50hrs)**
 - Need to decide which sources?

Selections

- 30/41 will be part of shallow regardless.
- 280 gals in shallow = ~760hrs (leaving ~50-80hrs for deep)
- Choose (>)5 for deep tier.
 - May be able to choose more if overlap with shallow
- WHAT DO WE DO IF NO LT AVAILABLE...??
 - → factor of ~2-3 reduction in sensitivity.
 - A) how do we rescope? - Less gals, or take sensitivity hit
 - B) Other routes to fund LT access?
- Choice of targets - see source lists for discussion

Deep Scheduling

- **Observe a few(?) as early as possible?**
 - Help to justify Shallow-tier schedule
 - Justify number of cuts etc
 - Early science results
 - Needed...
 - Potential multi-epoch follow-up (do we save some for latter, do we hold final decision on sources pending results from shallow?)
 - Spec line - get for 'free' but adds complications..
 - Which ones?
 - Dec>20 → part of shallow tier
 - Dec<20 → deep obs. Only
 - Are more objects/epochs needed -(coordinated PATT proposals?)

General Science objectives

- See proposal!
 - Star-formation products
 - AGN census
 - Gas (deep obs only)

Some existing follow-up:

- Data sets in Hand:
 - Deep tier selected to have lots of overlap:
 - IN-HAND: Spitzer, Herschel, HST, GALEX, VLA HI, WSRT, JCMT, CO (BIMA, IRAM +)
 - UKIRT, Lots Ground based optical, Chandra, XMM etc
 - Choice of Targets is critical in maximising this.
 - Shallow-tier: Extensive ancillary exists (need to fully confirm what)
 - Further follow-ups plans

A snapshot of some existing observations

(incomplete)

Optical data

- GHASP: 19%
- ANGST: 3%
- Palomar/Las Campanas: 0.7%
- 11HUGS: ?
- HST: (deep lots), shallow?

UV data

- GALEX: 29%

CO data

- BIMA SONG: 10%

X-ray

- ~50% existing Chandra
(proposal submitted for remainder)

IR data

- ISO: 4%
- 2MASS: 44%
- SINGS: 9%
- NICMOS Snapshot Survey: 14%
- LVL: ?
- Spitzer: ~57% (photometry),
~50% (spectroscopy)
- Herschel:

Radio data

- THINGS: 7%
- Little THINGS: 2%
- VLA ANGST: 0.4%
- WHISP: 3%
- GMRT/VLA/EVLA/LOFAR/VLBI:

Follow-up observations

- **So Far:**
 - Large Chandra proposal submitted to augment and complete existing X-ray coverage. (PI: McHardy)
 - LOFAR (via NGS section of surveys KSP + overlaps with Magnetism KSP - Conway/Beswick++)
 - Plan for ~30 'hand-picked sources' plus 30 to make up a statistical sample → probably based on SINGS sample or alike, and overlapping with LIRGI/LeMMINGS → (see lists)
 - Overlaps with planned proposals
 - Eg KINGFISH (Herschel), KINGFISHER (EVLA) etc
- **MORE...?.. What...??**

Follow-ups continued

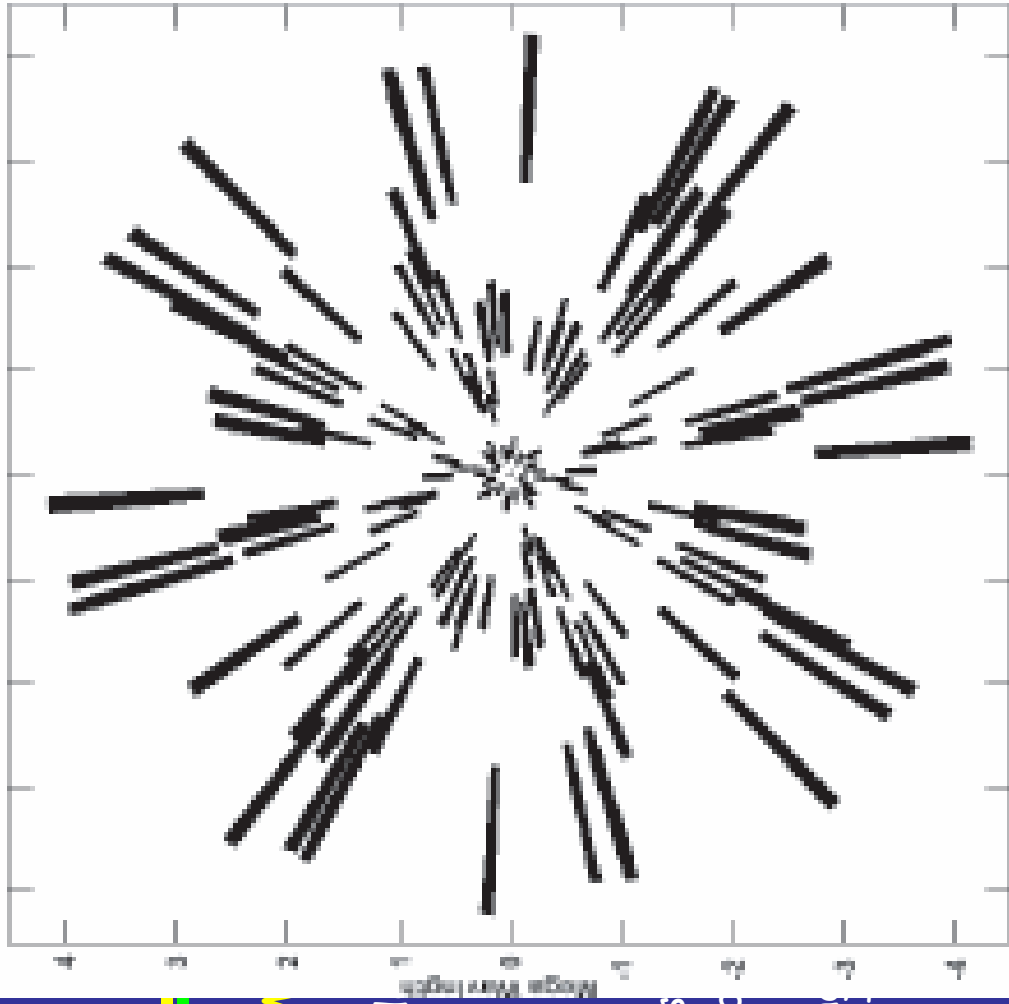
- **Optical** -
 - do we need more imaging/spectroscopy for shallow-tier targets?
 - Is existing adequate?
 - HST, WIYN, GranTeCan, GHaFaS
- **mm-**
 - Single dish, interferometry, multi-lines -Some CO done but incomplete (for shallow - complete for deep depending on choice of sources) - more lines??
- **Radio**
 - Some planned (EVLA, LOFAR etc) but do we want more?
 - More eMERLIN for deep tier source we miss?
 - Or do we just leave this to individuals?, timing of an coordinated approach
- **IR**
 - Deep tier covered by SINGS/KINGFISH
 - Shallow tier some obvious overlaps
- **UV**
 - Lots covered by GALEX NGS sample?

Data processing/technical contributions

- Danielle - to highlights broad issues + some of the developments already underway.

LeMMINGS

- Most Technical issues with LeM
 - Dynamic range, calibration, wideband flagging, Data rates, confusing at L-band)
- Shallow-tier
 - No Lovell - Makes life a bit easier
 - Snap-shot imaging (using multiple antennas to improve fidelity etc)
 - Need to have robust scheduling
 - Direct comparisons with deep tier
- Deep Tier
 - Higher Dynamic range issue
 - Inc Lovell → so issues with different baselines
 - Spec line portion
 - Different sub-band/correlator configuration



48mins on source at 4.5-6.5GHz, 6 cuts
Dec +70 source

Data releases/publications etc etc..

- Data releases:
 - What do we release?
 - Best images, spec line cubes, Spectral index (curvature) maps, polarisation?, point-source catalogues
 - Calibrated uv data?
 - when do we want to make public?
 - Raw data will be public 18mths after end of each semester.
 - 'enhanced data sets' - Need a delivery plan?
 - How? (inc resources)
 - Data centres?

Data reduction/tech

- As a team we need to:
 - 1) set-up some focussed groups to work on the problems
 - 2) develop reduction/analysis pipelines (contributions to eMERLIN generally)
 - The relatively key areas (compared to other Legacy projects) inc:
 - Routine cont short 'snapshot' imaging
 - Spec line work in deep (also LIRGI + MSF)
 - Other areas we can contribute to?
 - Analysis & extraction of data
 - 3) public data products

Team Management:

- Two PIs of the proposal (Ian & Rob)
- Define some specific working groups?
 - Technical area (needs to start soon/now)
 - Obs planning & Scheduling
 - Beswick, McHardy, Muxlow, van Eymeren, Koerding.....
 - Algorithms/pipeline development
 - Fenech, Stewart, Beswick, Klockner, Muxlow....
 - Cont imaging
 - Beswick, Muxlow, Stewart, Conway, Green, Gallimore, Fenech, Koerding, Marti-Vidal, van Eymeren,
 - Spec line:
 - Argo, Baan, Beswick, Brinks, Conway, Gallimore, Klockner, Peck, etc etc...
 - Science exploitation (not so urgent - but we should discuss too...)

Manpower resources

- PhDs - current guess is ~6 planned or in post (a few in post where LeMMINGs may be a part of project)
- PDRAs - ~10 PDRAs currently associated with LeMMINGs
- Staff: ~34 involved at present

Data releases/publications etc etc..

- Publications (some thoughts) etc:
 - Any pre-survey papers we could write?
 - E.g. Survey/sample description?
 - One/two large papers describing project?
 - All to author
 - Specific science papers (lots one hopes)
 - Authors on merit - general policy??

Other funding/resources?

- EU :
 - Encourage Marie-curie fellows?
 - EU Network (c.f. ANGLES etc)?? Lots of work..
- STFC
 - PDRAs etc from Rollers/standard grants
- Other:
 - Non-UK options?
 - Leverhulme, RS etc etc??

AOB

- ? What have I missed (yes a lot but we only had one day!)??

END

- Danielle/Jeremy : Where's the nearest Pub?? I need a drink!