Convergent Evolution….

In evolutionary biology, convergent evolution is the process whereby organisms that are not monophyletic (not closely related) independently evolve similar traits as a result of having to adapt to ecological niches or similar environments.

Wikipedia

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EC Framework7 "RadioNet" Joint Research Activity

APRICOT:

All Purpose Radio Imaging Cameras On Telescopes

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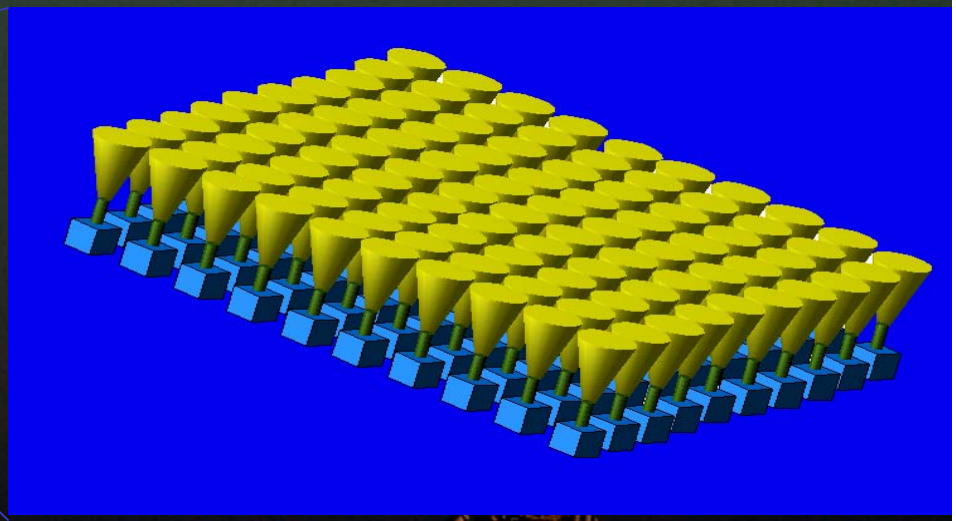

The APRICOT strategy: produce design studies and develop sub-systems to allow future cost-effective construction of large-format (100 beams) mid-frequency (30-50 GHz) horn arrays

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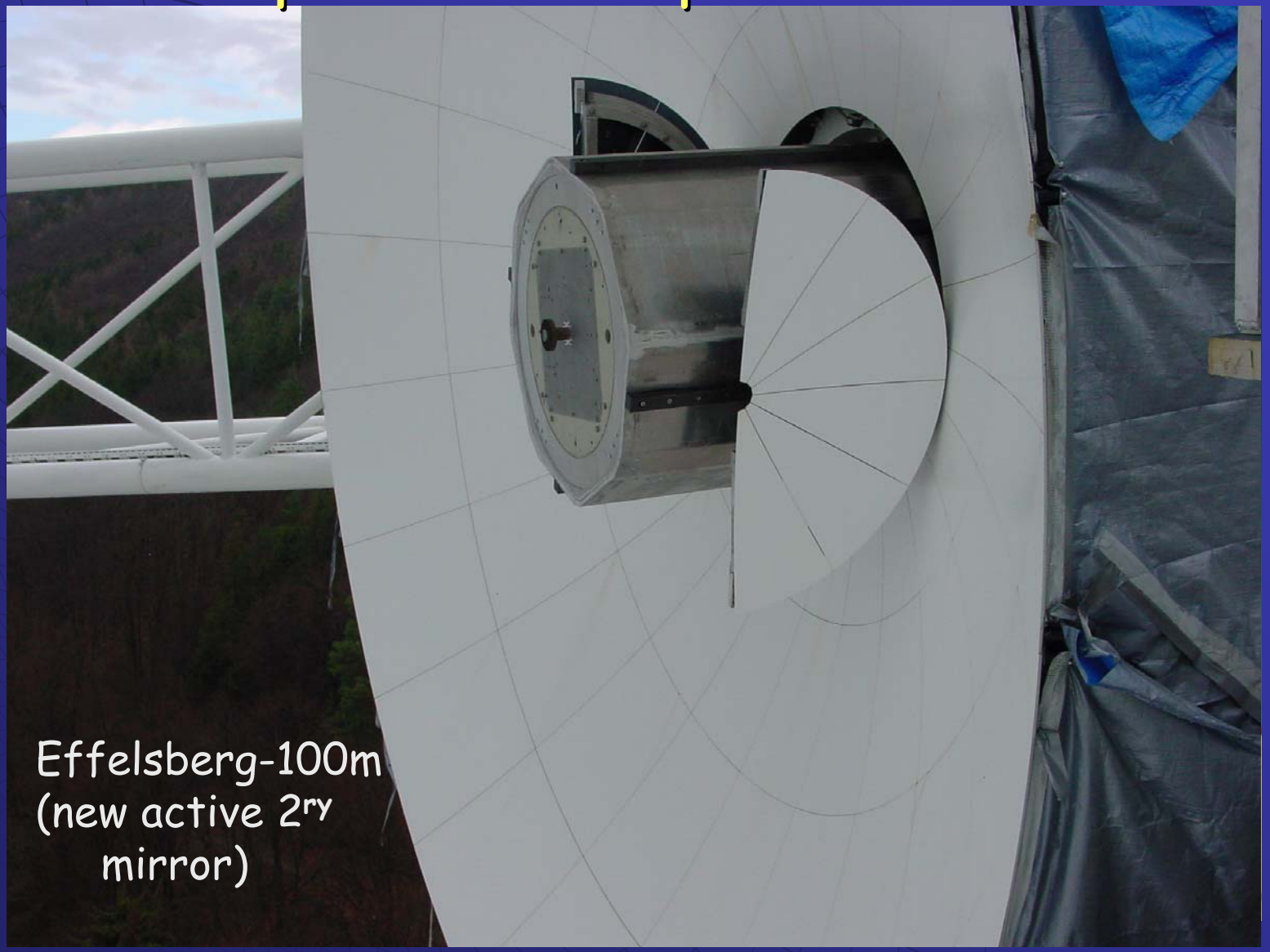
Some European telescopes for 30-50 GHz



Effelsberg-100m (new active 2ry mirror)

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The APRICOT Partners

UMAN, IRA, (& MECSA) MPIfR, CAY, (& Cantabria) TCfA

- Operate the target telescopes
  - With extensive receiver operations experience
- Long-established RF design expertise
  - Of active and passive sub-systems in proposed band
- Established MMIC design & testing expertise
  - With one "foundry" within the partnership

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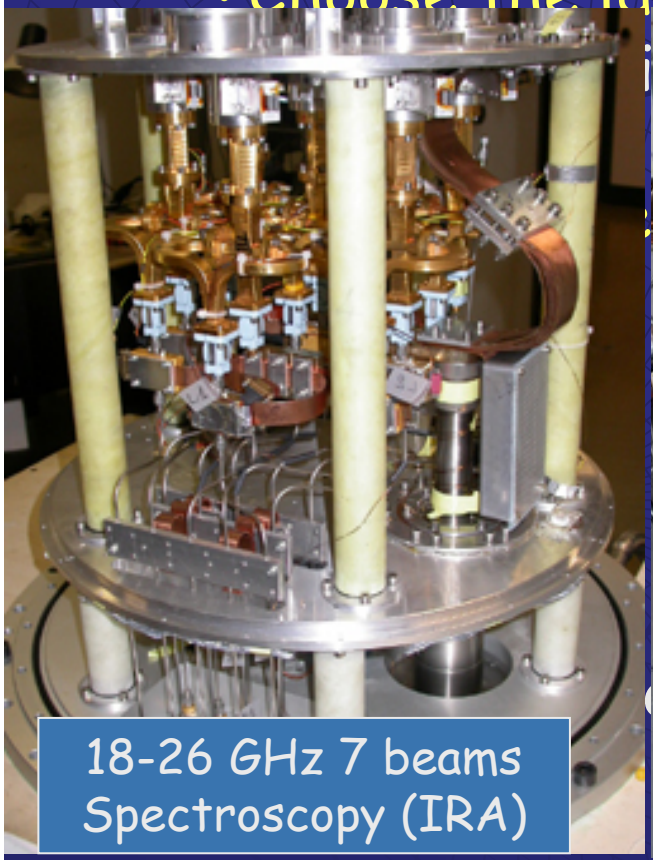
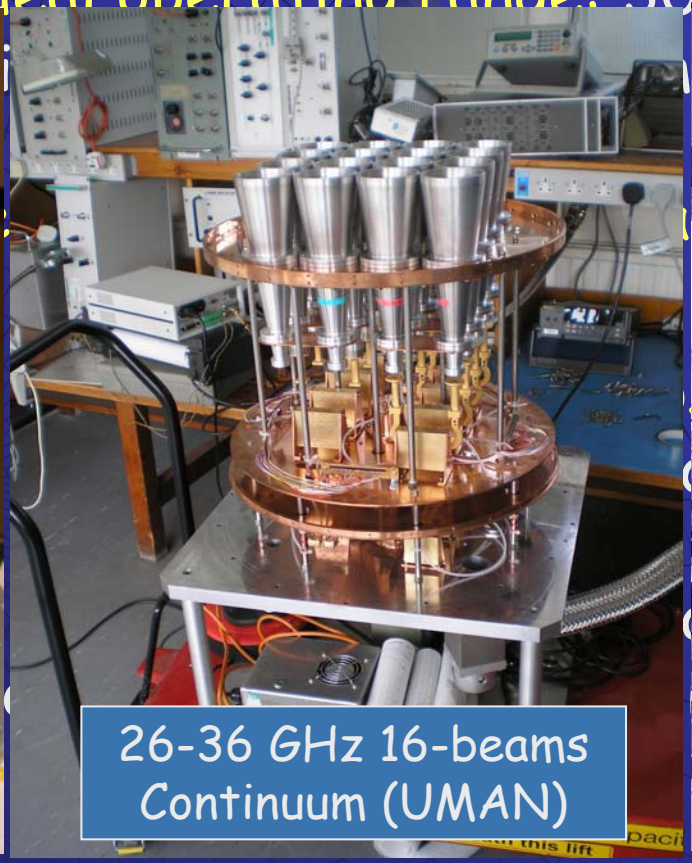
Moving on from current array receivers

- Increase the array size: to improve productivity
- Choose the ideal operating range: 30-50 GHz is



18-26 GHz 7 beams
Spectroscopy (IRA)



26-36 GHz 16-beams
Continuum (UMAN)

9-mm 7-beam (MPIfR)

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Molecular Line Spectroscopy

- Star-forming regions & circumstellar envelopes
  - Imaging plus modelling → temperature & density
  - Many carbon-chain species in the 30-50 GHz band (HC_nN n=3,5,7; C_nH n=5,6; C_nS n=1,3,5) diagnostic of cold dense quiescent gas
  - Other species:

With large format cameras could survey complete clouds in one day

- Blind surveys in redshifted CO (1-0)
  - Distances & mass estimates of dusty galaxies

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Continuum Studies

- Surveys for discrete sources (in polarisation)
  - Find new types of AGN e.g. youngest CSOs
    - follow-up with mm-VLBI & VSOP-2 imaging
    - follow-up of GLAST transients
  - Provide net of calibration sources for EVLA and mm-VLBI
  - Support of *Planck* and all high-sensitivity CMBR experiments
- Surveys for/of clusters of galaxies via the S-Z effect
- Surveys of diffuse Galactic emission (in polarisation)
  - Synchrotron; free-free; anomalous dust; thermal dust
  - Need to dissect out the contributions: for ISM astrophysics and CMBR polarised foregrounds
  - In compact regions e.g. YSOs - diagnostics of dust agglomeration in protoplanetary disks

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Technology: WP1 Architecture

- Combine continuum and spectroscopic capabilities with multiple-pixels: high reliability & low cost

  - Modular design with well-defined interfaces
  - Design for mechanical and cryogenic stability
  - Optimise layout for maintenance/fault-fixing
  - Design of monitor, control and calibration systems
  - Integration of direct detection and heterodyne systems
  - LO generation and distribution
  - Design, packaging and integration of RF, IF, LO systems
  - Establish capability to batch-produce RF, IF modules

Deliverables are mainly design study reports

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Technology: WP2 passive components

- Highly integrated chain with OMT, hybrids, transmission sections etc
- Low-loss, low size/weight, low cost, ease of manufacture
  - Standard waveguide technology too expensive
  - Needs technology shift
    → Planar technology, microstrip transmission lines and filters etc

Deliverables - design study reports
- few pixel hardware comparing performance of conventional and innovative approaches (with WP1 and WP3)

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Technology: WP3 MMICs

- To develop and secure European supply of world-standard MMIC devices for astronomy
- To seek *improved* noise performance in the band 30-50 GHz - performance gains will translate to other bands.
- To achieve increased levels of integration

- Previous un-coordinated procurements with Euro foundries
- APRICOT will coalesce the effort within a coherent strategy with AMSTAR+

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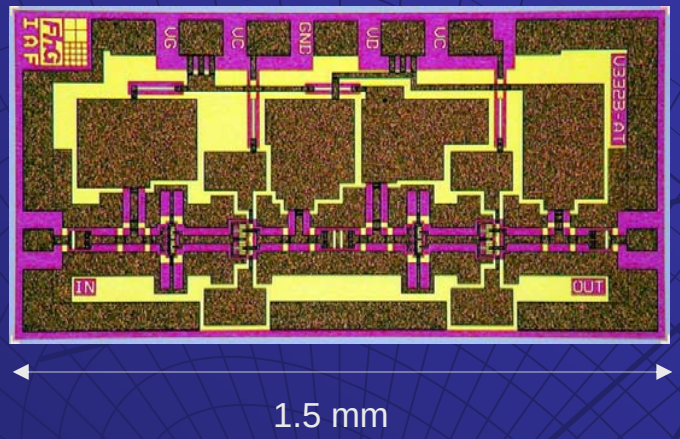
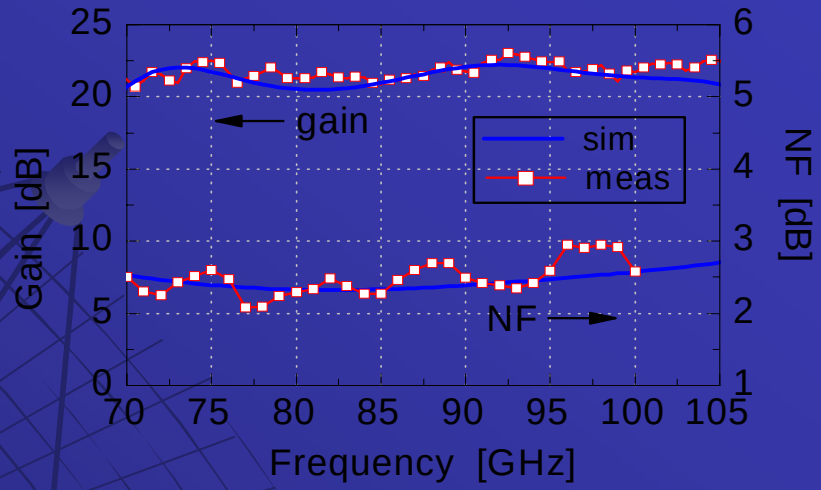
The MMIC Foundries

- U. Manchester
  - 100nm InP HEMT technology
  - innovation in materials and architecture for low-noise
  - rapid response to new design inputs
- Fraunhofer Institute (IAF) Freiburg
  - 100 nm GaAs mHEMT technology
  - Multi-function MMICs
  - Established 50 nm and experimental 35nm processes
  - Now interested in low-noise at cryo temps
- OMMIC company
  - 70nm GaAs mHEMT technology

Link with MPIfR and AMSTAR+

IAF: Two-Stage W-Band MHEMT Low-Noise Amplifier





- Gate width: 2 x 30 µm
- Gate length: 50 nm
- Coplanar waveguide technology

- Gain: 23 dB @ 94 GHz
- Noise figure: 2.4 dB @ 94 GHz
- Power dissipation: 36 mW

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WP4: Device Testing

- Accurate measurement of noise temperature and gain fluctuation of devices at cryo temperatures is not easy !
- Results from well-respected labs often differ !
- MMIC assessment requires the precise inter-comparison of devices from different foundries and of different designs

APRICOT partners will pool knowledge and work with a standard testing site (CAY)

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WP5: Data handling

- Spectroscopic data rates are high !
  - Combination of spatial and spectral resolution will produce >>10x more data than existing systems
- Spectrometer hardware NOT part of APRICOT
  - R&D in "UNIBOARD" FP7 JRA
- Mapping in lines and continuum
  - "On the fly" gridding and mapping
  - Use of multi-pixels for atmospheric WV subtraction
  - Observing strategies and data presentation in images
  - Back-end and computational hardware scalability

How the data are produced and how the user interacts with them is a vital part of the overall design picture.

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WP Leadership

WP1: Receiver Architecture

- MPIfR; IRA, UMAN, CAY, TCfA

WP2: Passive Components

- IRA; MPIfR, UMAN

WP3: MMIC Procurement

- UMAN; IRA; MPIfR; CAY

WP4: Device Testing

- CAY; UMAN; MPIfR, IRA

WP5: Data Handling

- TCfA: UMAN, IRA, MPIfR

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Summary: FP7 JRAs

APRICOT : Technology readiness for multi-purpose large format cameras in 30-50 GHz band
: Development of European low-noise MMIC capability for astronomy
: Deliverables are studies and sub-systems

[AMSTAR+: develop 90 GHz heterodyne FPA technology with IAF for MMICs

[UNIBOARD: general purpose digital board – 4Tops]

EC funding from 1 Jan 2009 – 31 Dec 2011

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[Proposed] Centre for Radio and TeraHertz Technology (CRT^2) in Manchester

Aims: to develop, build and test complete and highly integrated source/receiver sub-systems and systems involving:

Innovative development of generic technologies
- Active Devices - designed for purpose
- Passive components and systems
- High-speed digital signal processing

Overall system design
- Mechanical design and construction
- Rapid testing

- Close analogy with Caltech/JPL thinking
- Good environment for graduate research training

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Technological Symbioses

Astronomical Applications		Wider Economy Applications
Square Kilometre Array – large format digital phased arrays "software radio" (decimetre wavelengths)	⟷	• New generation of low-noise systems for mobile telecoms • Intelligent arrays for satellite TV and mobile ground-sat equipment • Space-ground communications • Ultra-Wide Band comms systems
Large format radio "cameras" (mm and sub-mm wavelengths) the "THz" regime	⟷	• e-THz security and inspection applications both passive and active (with additional high power sources) • Advanced car radars • Point-to-point broad-band comms systems within cities. • Biological/medical non-ionising inspection

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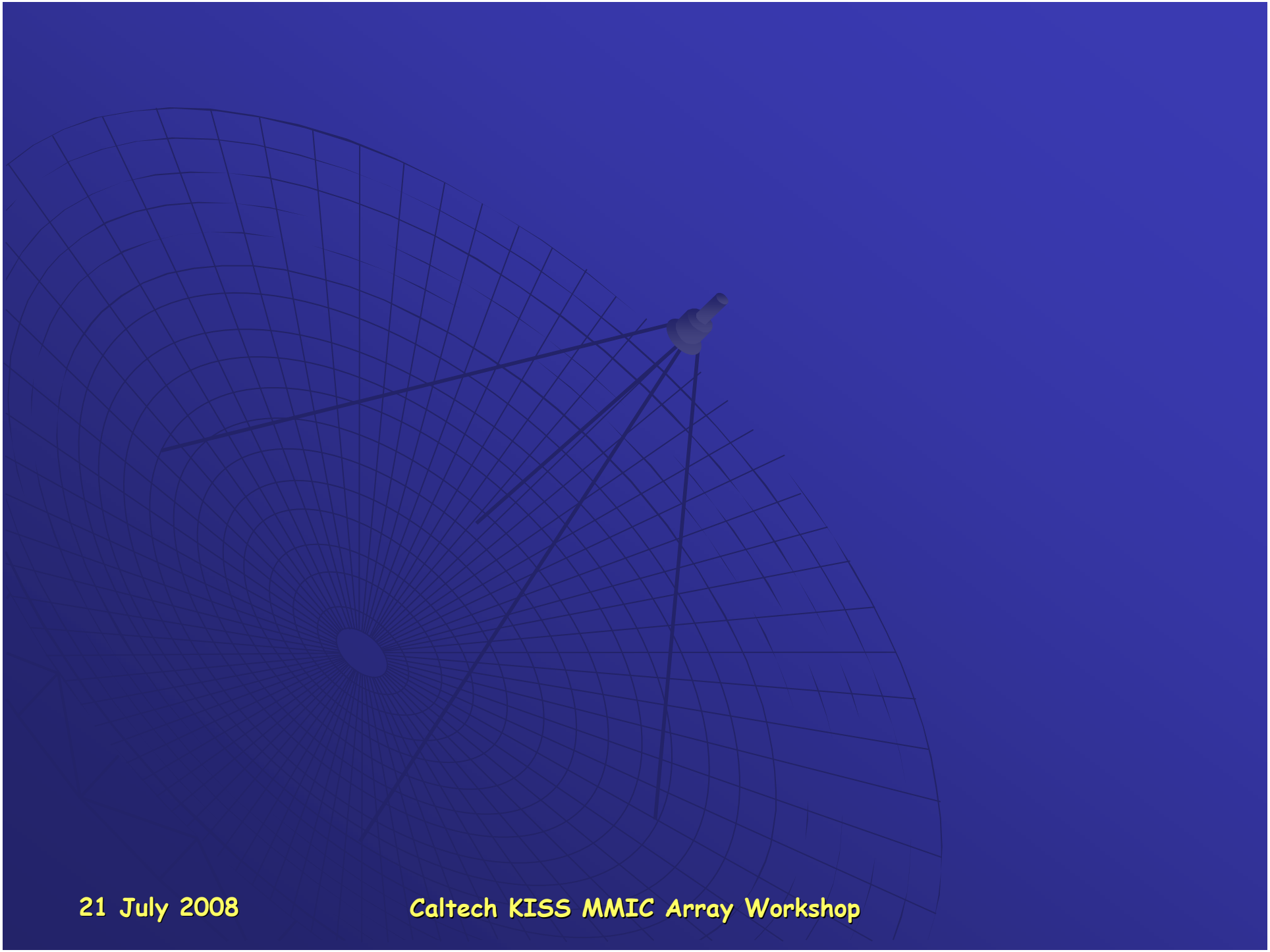
EC funding: 36 months from 1 Jan 2009



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Basic Science Strategy

- "Cameras" enable these telescopes to make new surveys at 30-50 GHz – scientifically rich range
  - In "intermediate" gap between SKA and ALMA
  - Follow-up with EVLA, VLBI, VSOP-2
  - Continuum and spectroscopy: observations in different weather conditions