EISCAT Scientific Association

EISCAT_3D – European 3D imaging radar for atmospheric and geospace research

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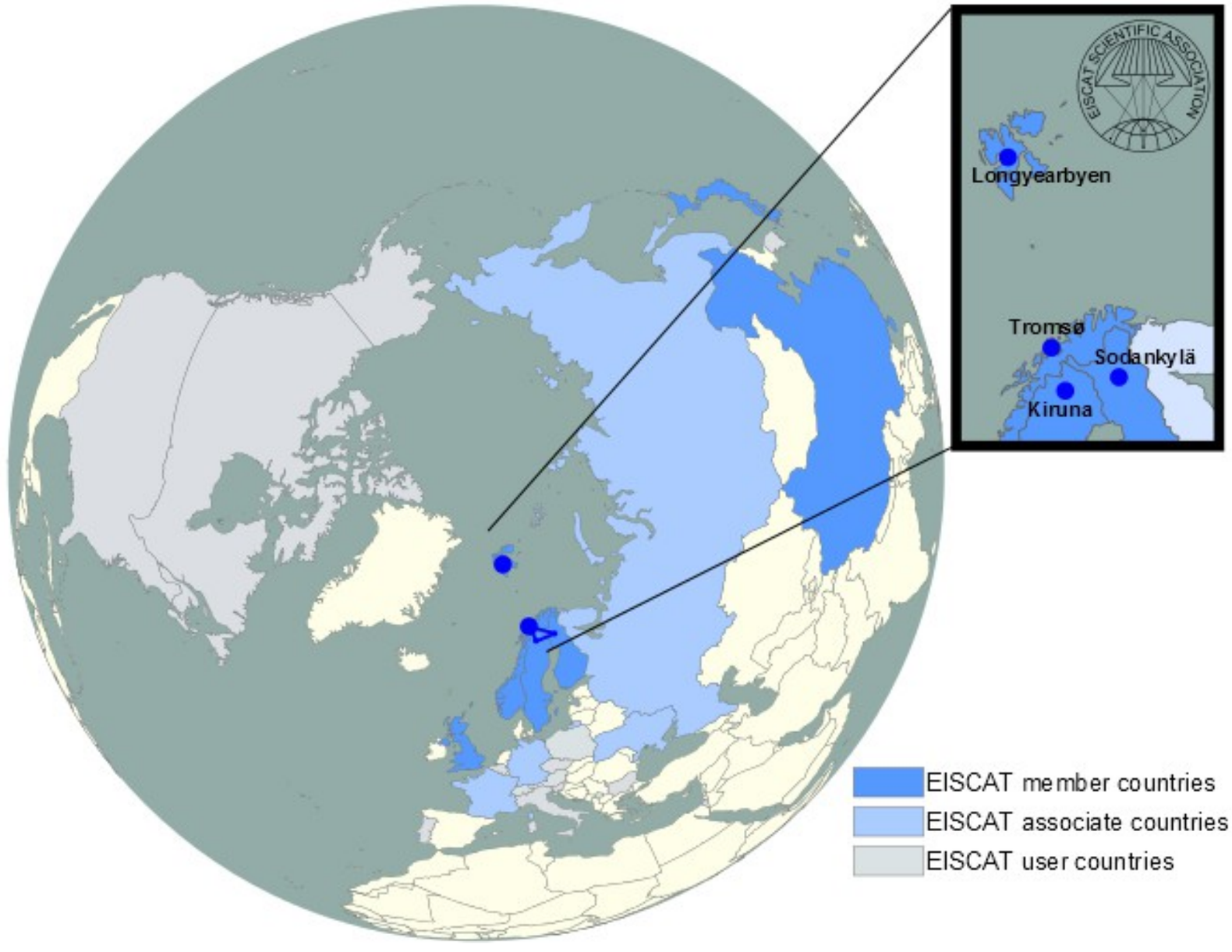
EISCAT multi-site research infrastructure

studies how Earth’s atmosphere is coupled to space

is uniquely located for studies into arctic ionosphere

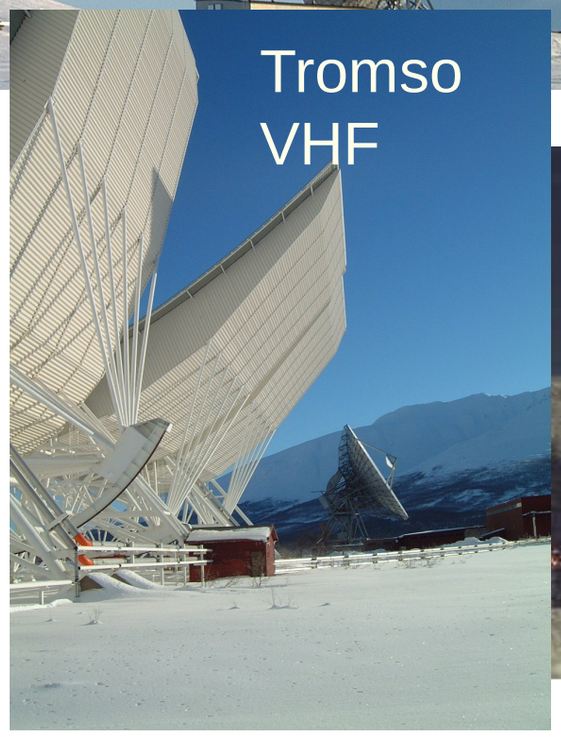
current members

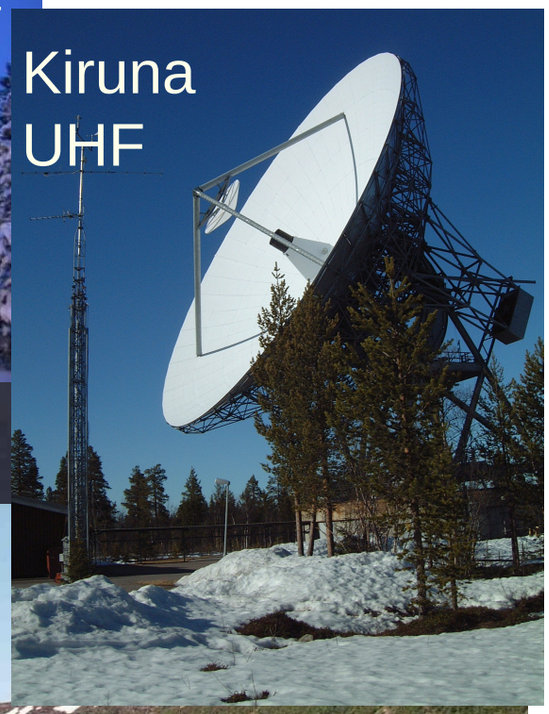
- China
- Finland
- Japan
- Norway
- Sweden
- United Kingdom



Contributing:

EISCAT Incoherent Scatter Radars





- 3 Incoherent Scatter Radars
- HF Heating Facility
- 2 Dynasondes

Annual operation 3.2 M€

EISCAT Svalbard Radar

EISCAT_3D
is Research Infrastructure for the Environment on ESFRI Roadmap

offers the link to other environmental research

helps extending user community

helps attracting new member countries

enhances chances for international collaboration for the association and for individual users

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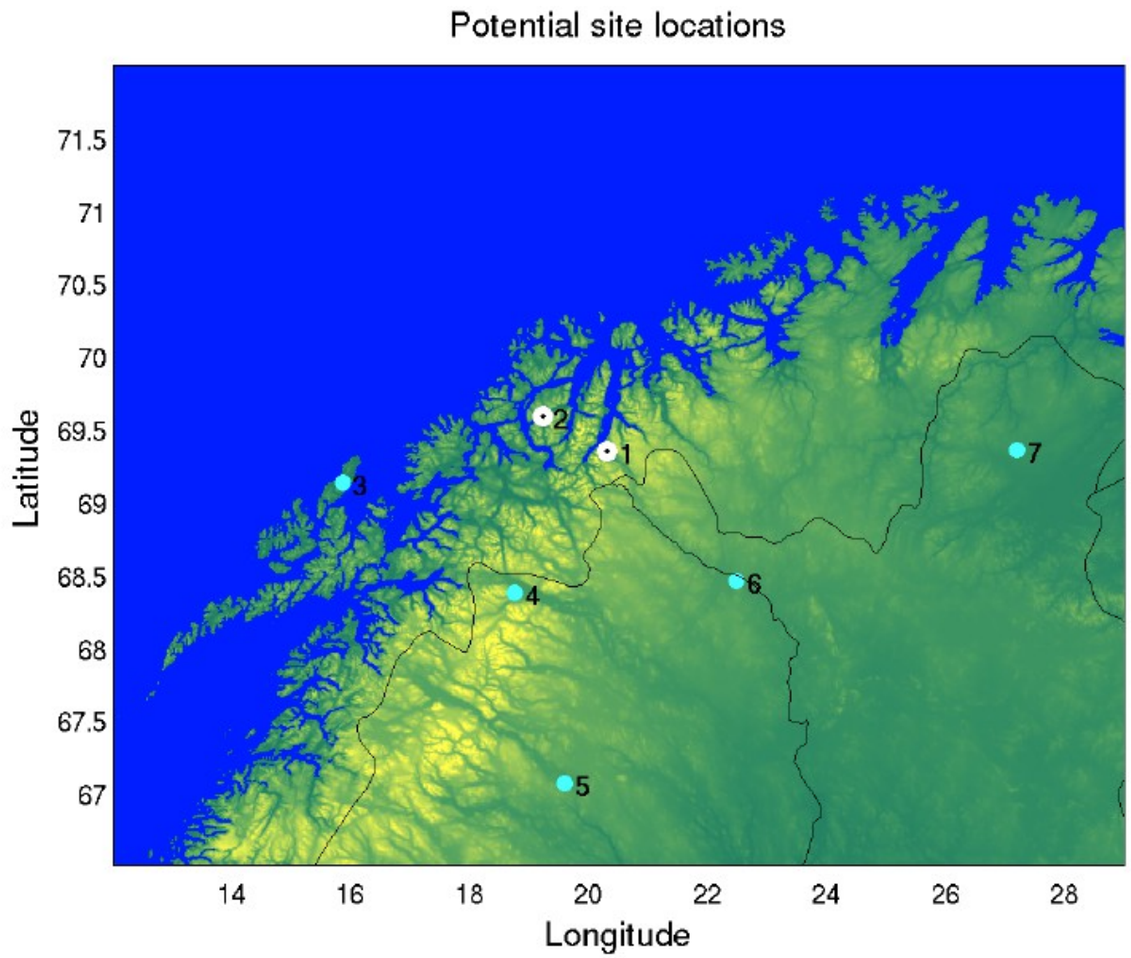
How will it look?

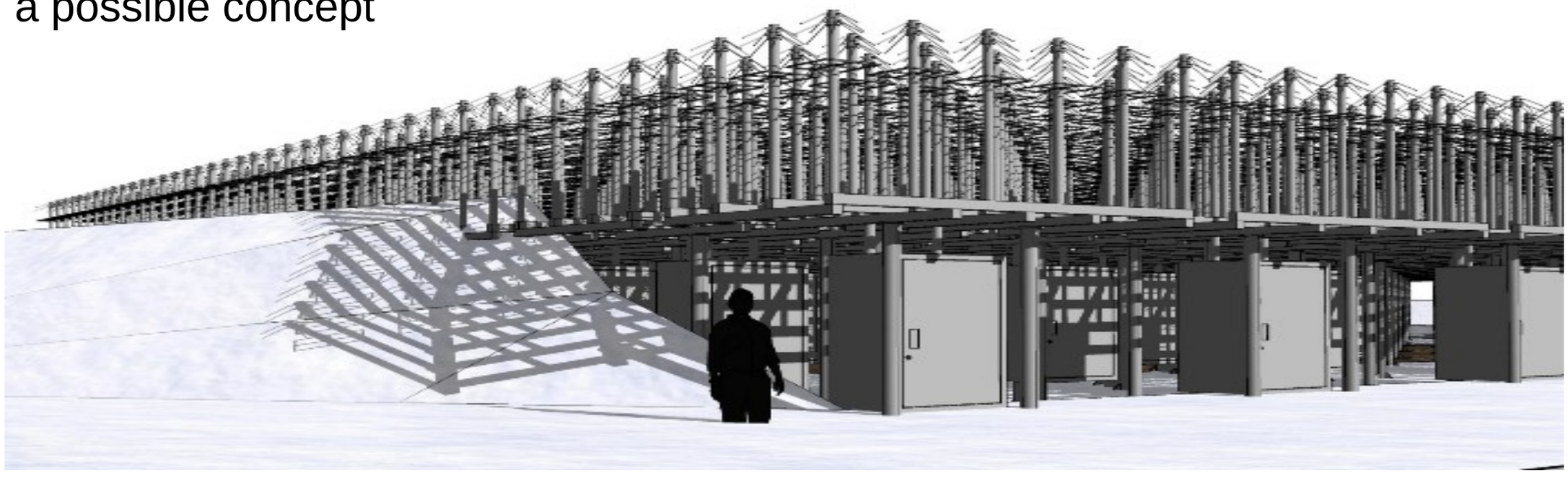
Baseline: core site & 4 remote sites

community agrees on list of 7 potential sites

will permit observations combined with rocket flights from Andoya in Norway and Esrange in Sweden



a possible concept



Measurement Capability Comparison			
Measurement Type	Current UHF t/s	Future E3D t/s	Improvement Factor* better than:
Isotropic parameters: 110 km altitude	1.0	0.1	10
Isotropic parameters: 300 km altitude	5.0	0.2	25
Vector velocities: 110 km altitude	500.0	10.0	50
Vector velocities: 300 km altitude	2000.0	25.0	80
Monitoring standard data products at 70 - 1200 km: n_e,T_e T_i,$\underline{\mathbf{v}}_i$			

E3D New Measurement Capabilities

- instantaneous, adaptive control of beam positions
- simultaneous multiple beams/interlaced beams
- high-resolution coding of polarisation, phase and amplitude
- aperture synthesis imaging – small-scale 3D imaging(sub-beam-width)
- multi-beam volume imaging – large-scale 3D imaging
- full-profile vector measurements – large/small-scale 3D vector imaging
- high-speed object tracking

* estimated for 3 MW Tx: improvement at least x 10 better

3) integration time, t for 1% accuracy ne, Te Ti; 1% accuracy $\underline{\mathbf{v}}$ at plasma density of 2 x 1011 m-3, within 100,000 km2 of core site, assuming five remote stations, same transmitter power as the current EISCAT

Anticipated Funding Applications

in competition with Research Infrastructures from other fields

Baseline design 135 MEU*

Norway: proposal October 2012

Sweden: proposal March 2013

Finland: roadmap proposal February 2013

Japan: roadmap proposal March 2013

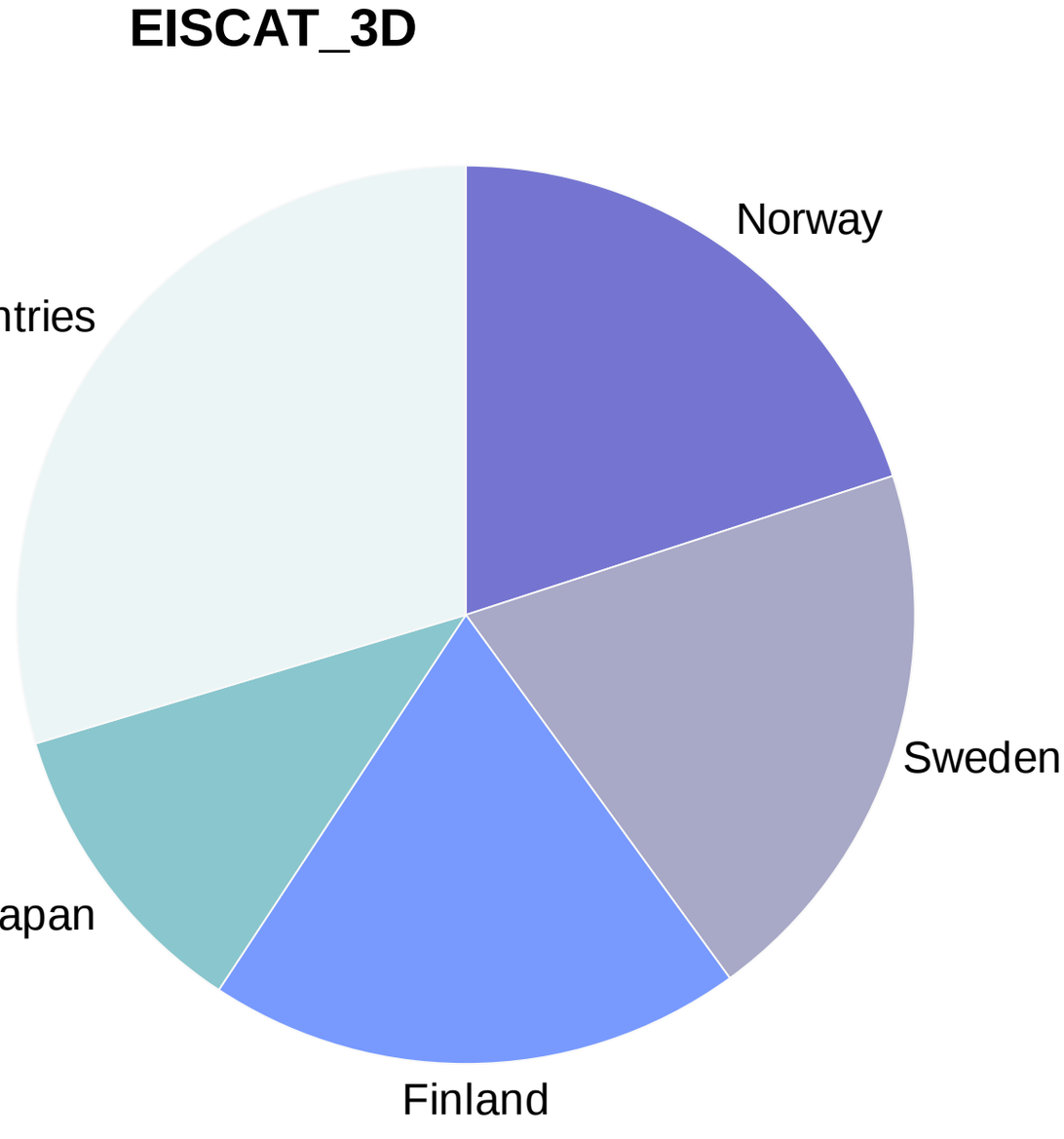
UK included EISCAT_3D on roadmap

other milestones

finalize new EISCAT agreement November 2013

EISCAT_3D preliminary design review October 2014

(*10% contingency)



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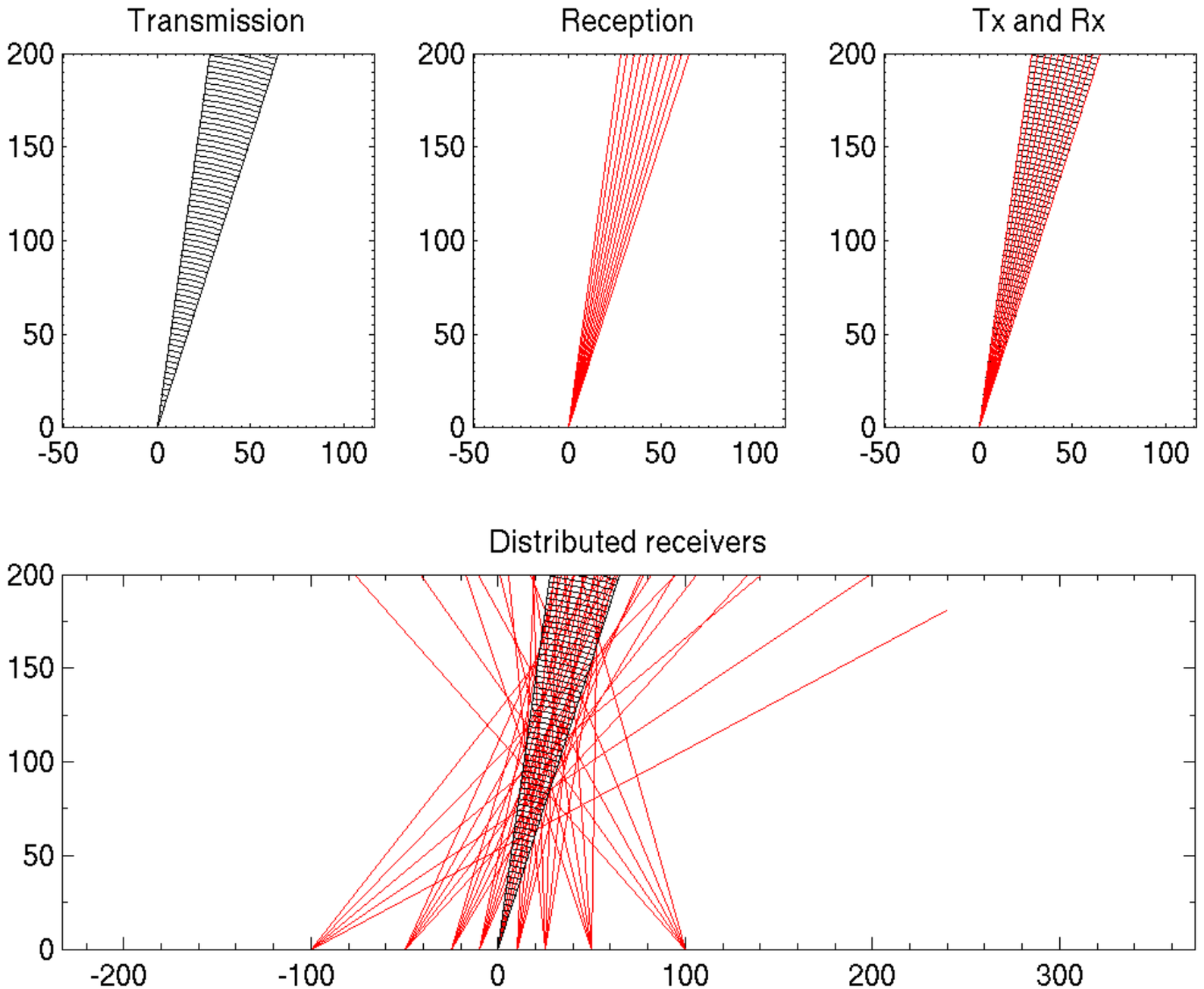
Implementation Time Line 2014 - 2021

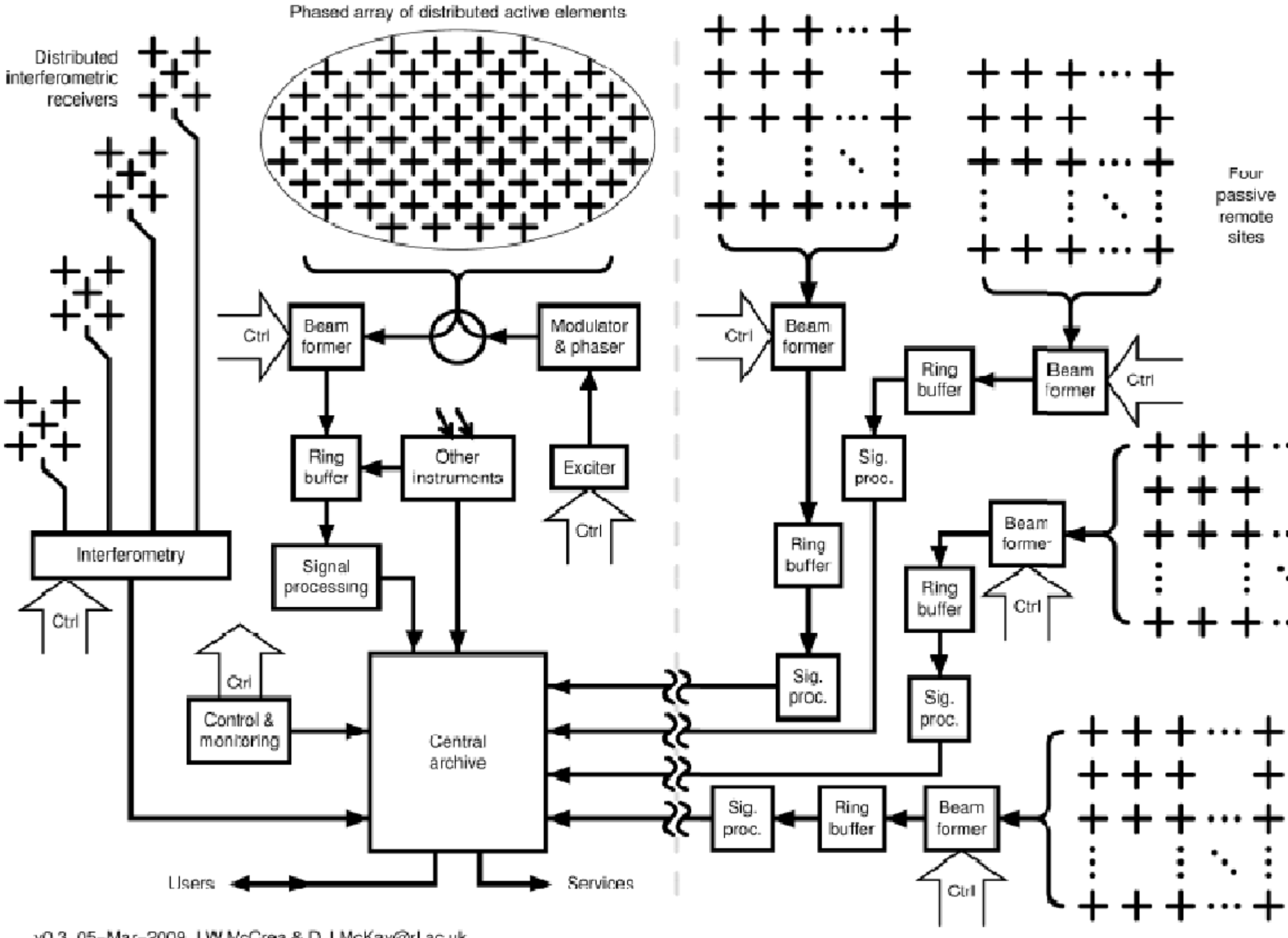
2014	2015	2016	2017	2018	2019	2020	2021
Preparation							
		Construction					
				Commission			
Total Funding Profile Investment including staff for installation work							
4 M€	32M€	38M€	33M€	16M€	4M€	4M€	4M€
EISCAT Operational Costs including regular staff							
3.4M€	6M€	7M€	7.2M€	8.3M€	8.7M€	9.2M€	9.3M€

EISCAT_3D (in 2D)

- Transmission
  - 10MW
  - High modulation
  - Radial resolution
- Reception
  - Multiple narrow beams
  - Angular resolution
- Tx+Rx
  - Volumetric data
- Multisite
  - Distrbuted receivers
  - Wind fields



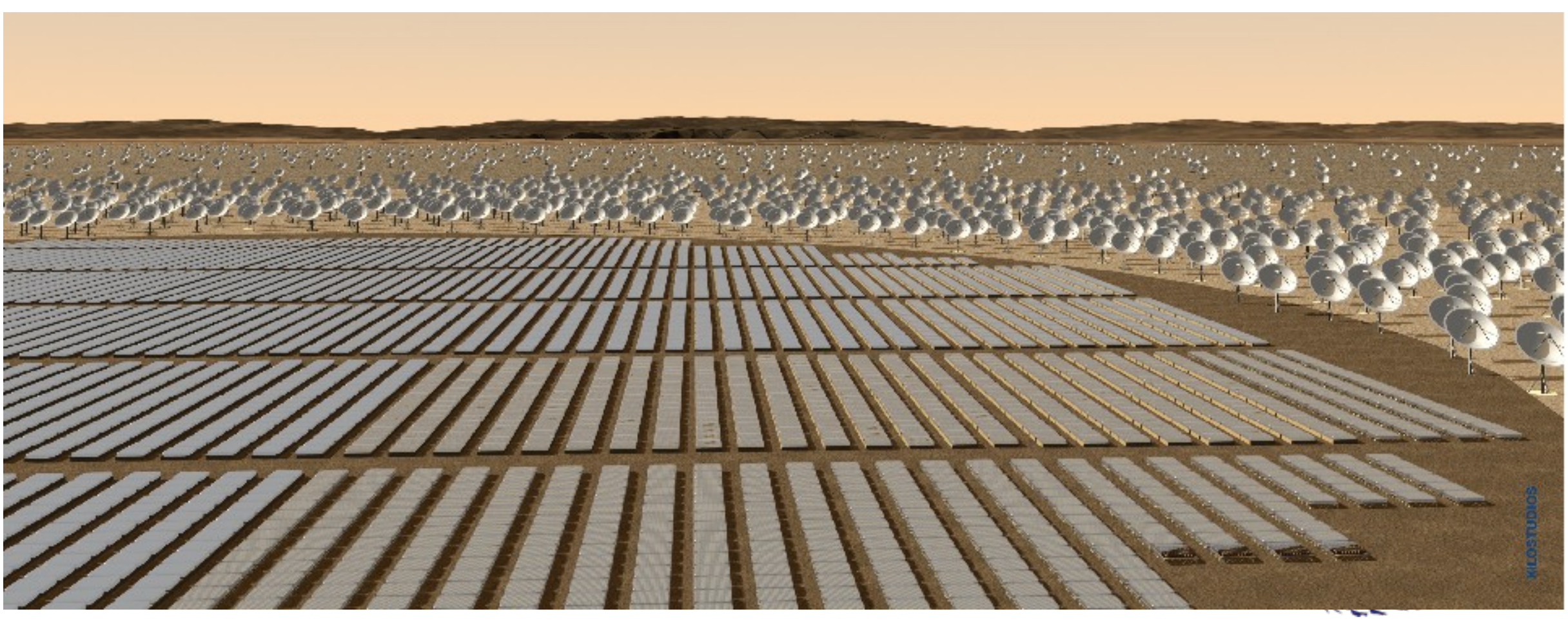
Design Study: system diagram



v0.3, 05-Mar-2009, I.W.McCrea & D.J.McKay@rl.ac.uk

Similarity to modern radio astronomy

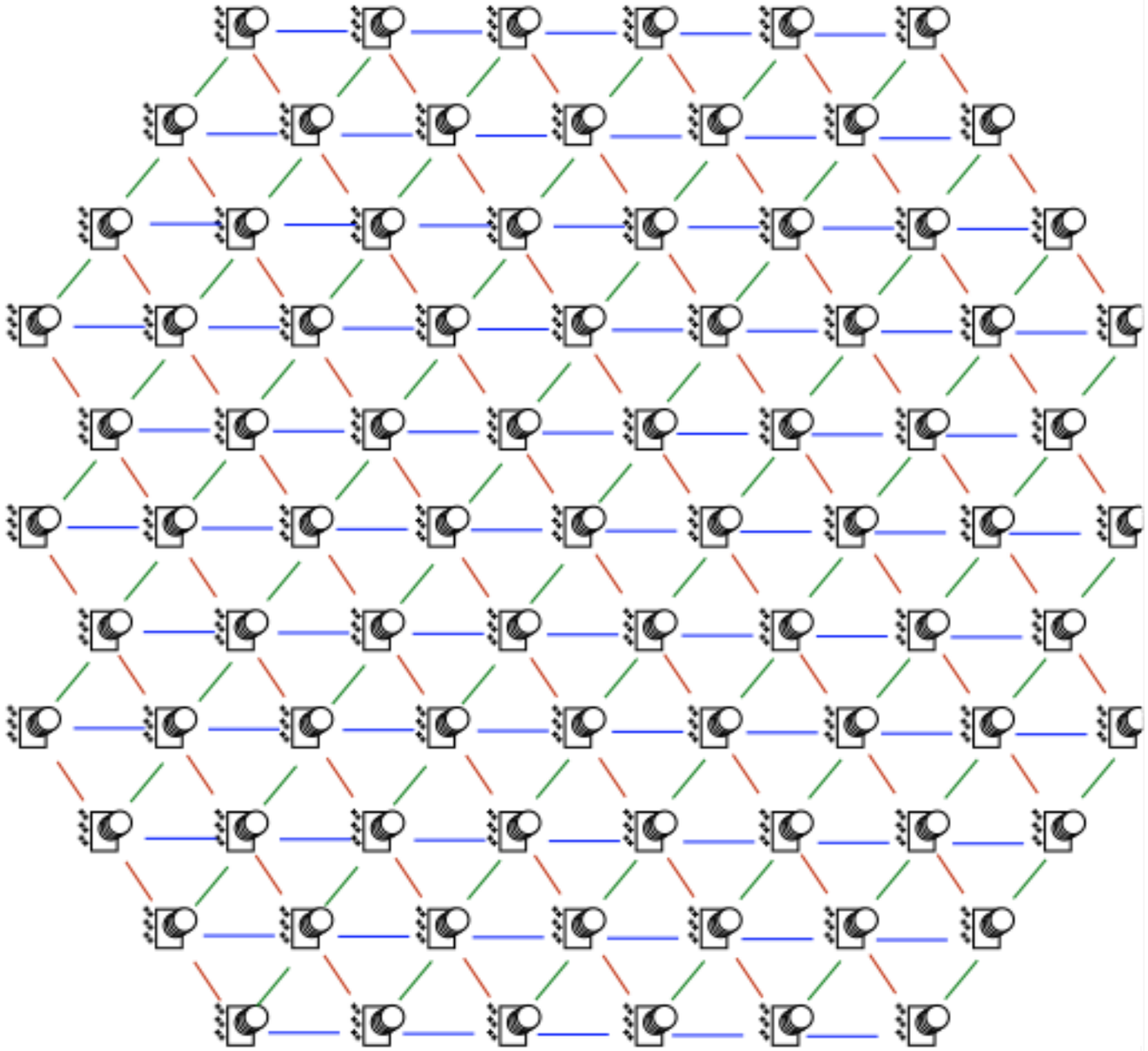
- SKA project
  - artist image below
- LOFAR (Low Frequency Array)
  - in fact one LOFAR international site have been installed as a test and technology prototyping receiver site for EISCAT_3D in Northern Finland in 2012.
- But EISCAT_3D has an additional dimension!



Level 2 beamforming is done in a computer network

notes

- Each Level 1 unit is connected to 6 neighors by 10G ethernet lines.
- 3 independent streams of $10G/80M/16 \approx 7.8$ full speed data can be routed for beamforming sums.
- totalling 23 beams.
- with band-limited data, much more, eg. for 5 MHz, 8*23=184 simultaneous beams



Data flow

- Each antenna
  - 30 Msamples/s (30MB/s)
- Antenna group (core site)
  - Computes a number of (broad) beams from a small number of antennas (FPGAs)
  - 100 antennas → 1 beam 2 polarisations
    - At 30 MHz IQ this is 32 * 30 * 2 = 2 Gbit/s/group
  - These data are stored in a ringbuffer
    - 160 groups → 125 TB/h

Data flow

- 2nd stage beamforming
  - 160 antenna groups → 100 beams
    - Decimation to 1MHz
    - More or less continous sampling 32bit words (I/Q)
  - 100*1e6*2*32 → 1GB/s
  - Two 10MHz bands correlated data → 2GB/s
  - In total 10TB/h to be stored in archive

On-site computation

- 2nd stage beamforming
  - 160 antenna groups → 100 beams
    - Decimation to 1MHz → 200 Gflop/s
    - Final beams → 5-10 Tflop/s
- Lag profile inversion
  - 2-3 Tflops/s/beam
- Total
  - 5-10 + beams*(2-3) Tflops
    - 8-13 Tflops for 1 beam
    - 200-300 Tflops/s for 100 beams

Datastaging

- One want occasionally do offline work on the ringbuffer data
  - Need transfer to HPC
    - Link or physical transport
      - 1Tb/s → 1 month, better to do the calcs on-site?
    - 125 TB/h * 1 day → 3 PB
    - In total ~10PB storage at HPC (72h data)
  - HPC computing
    - Higher resolutions (spatial and time)
    - 4Pflop/s*24h → 10^5 Pflop

EISCAT needs from EUDAT/HPC

- Now, EISCAT
  - Small, EISCAT archive (1981-2013) 60TB
- EISCAT_3D 1st stage (2018)
  - Moderate, EISCAT archive 1PB/year
  - HPC for detailed studies/developments
    - Storage 1PB, 1Pflop/run
- EISCAT_3D 2nd stage (2023)
  - High, EISCAT archive 10PB/year (EUDAT?)
  - HPC, Storage 10PB, 1000 Pflop/run