EISCAT Scientific Association

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

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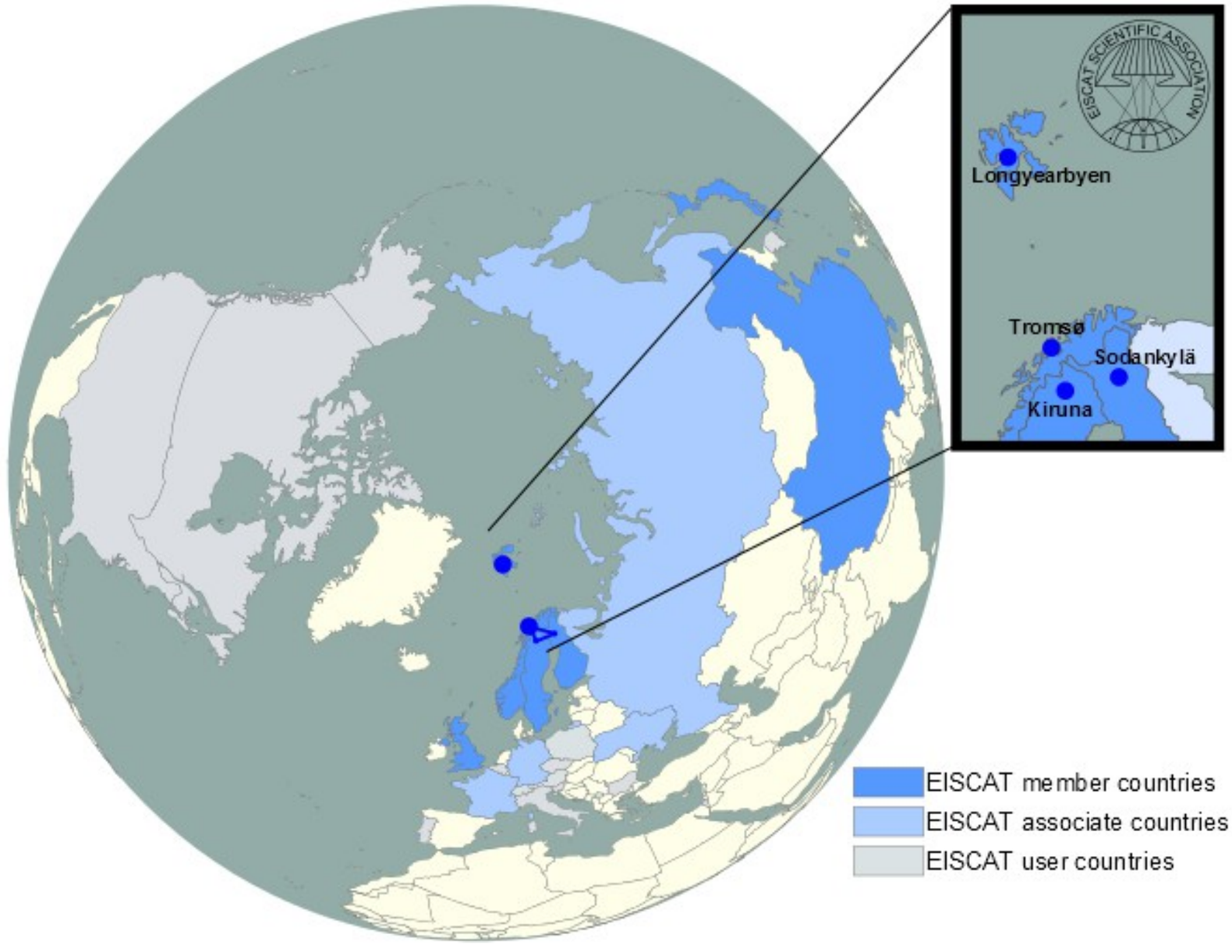
EISCAT multi-site research infrastructure

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

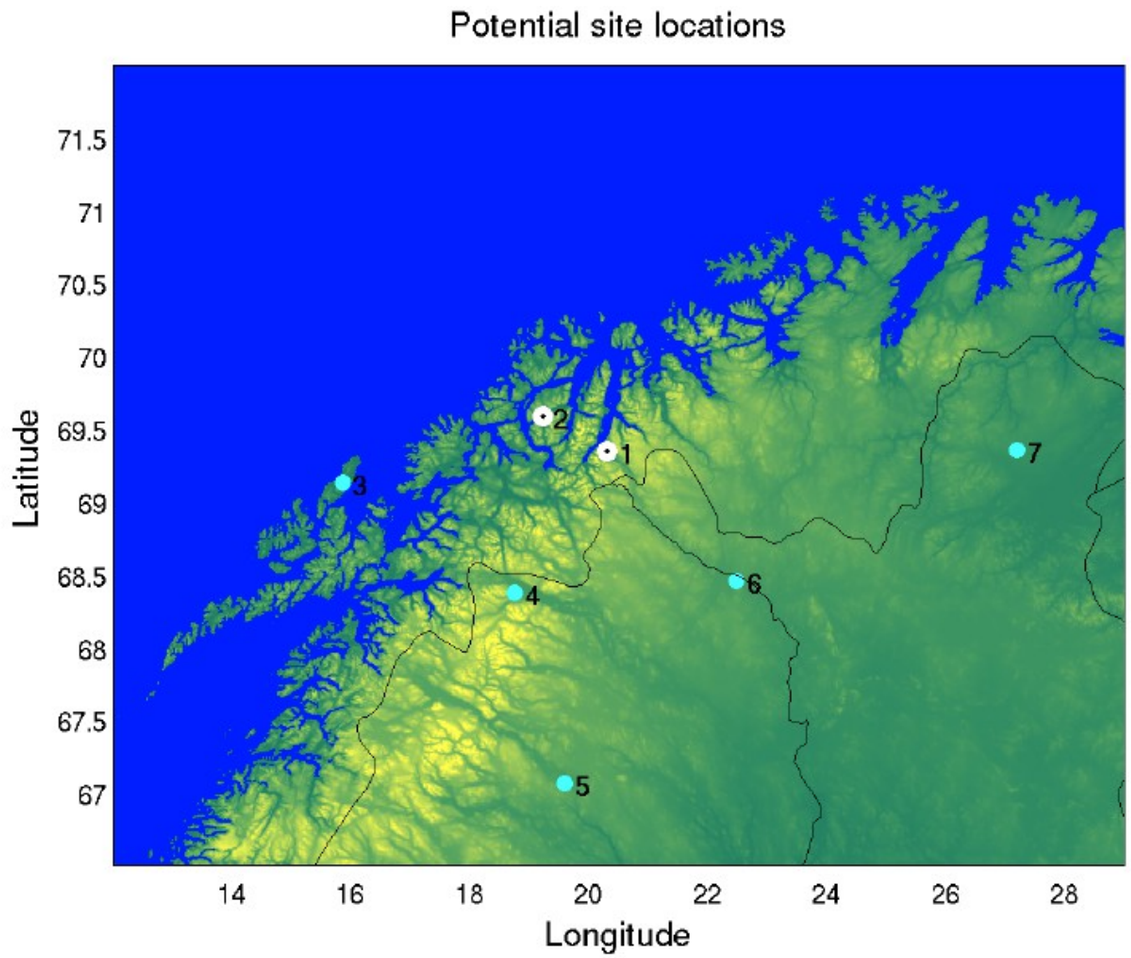


How will it look?

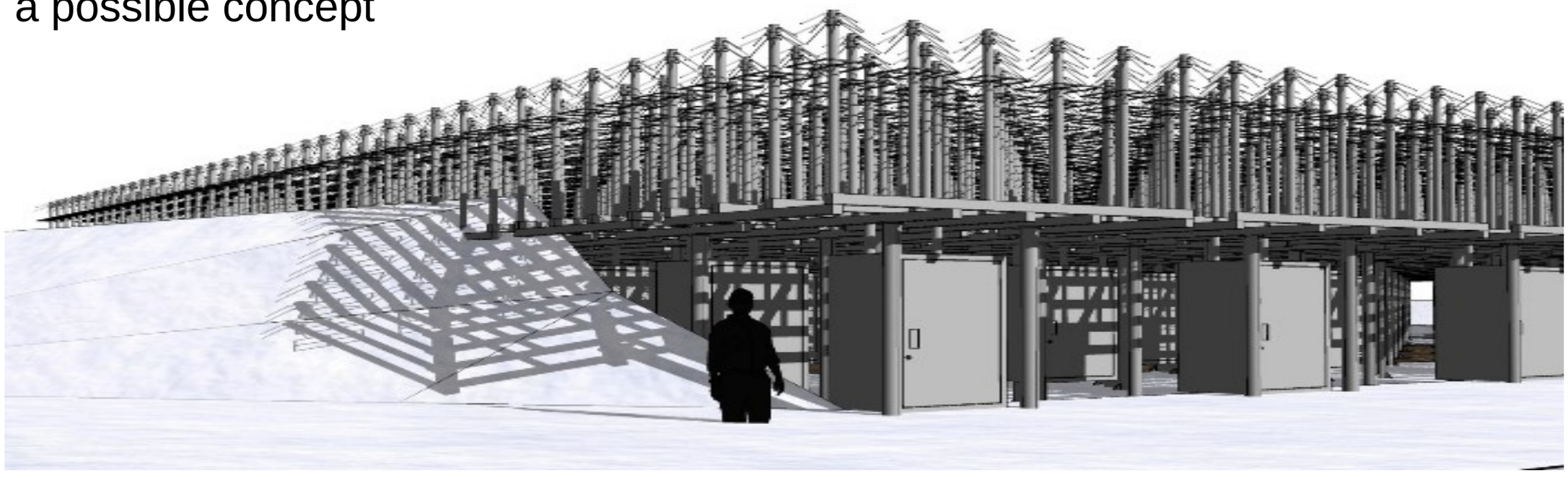
Baseline: core site & 4 remote sites

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

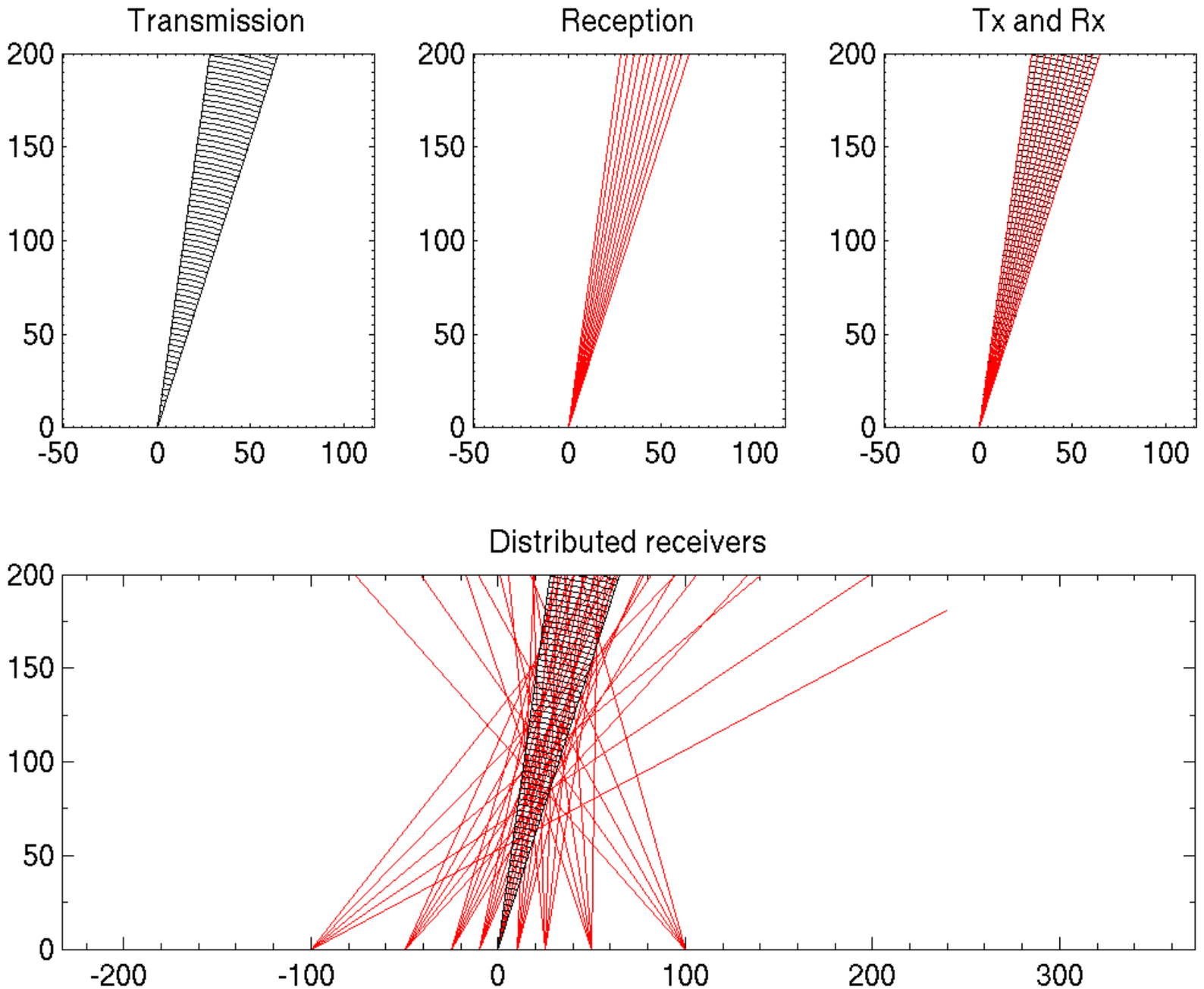
3) integration time, t for 1% accuracy ne, Te Ti; 1% accuracy $\underline{\mathbf{v}}$ at plasma density of 2 x 1011 m-3, within 100,000 km2 of core site, assuming five remote stations, same transmitter power as the current EISCAT

Implementation Time Line 2014 - 2021

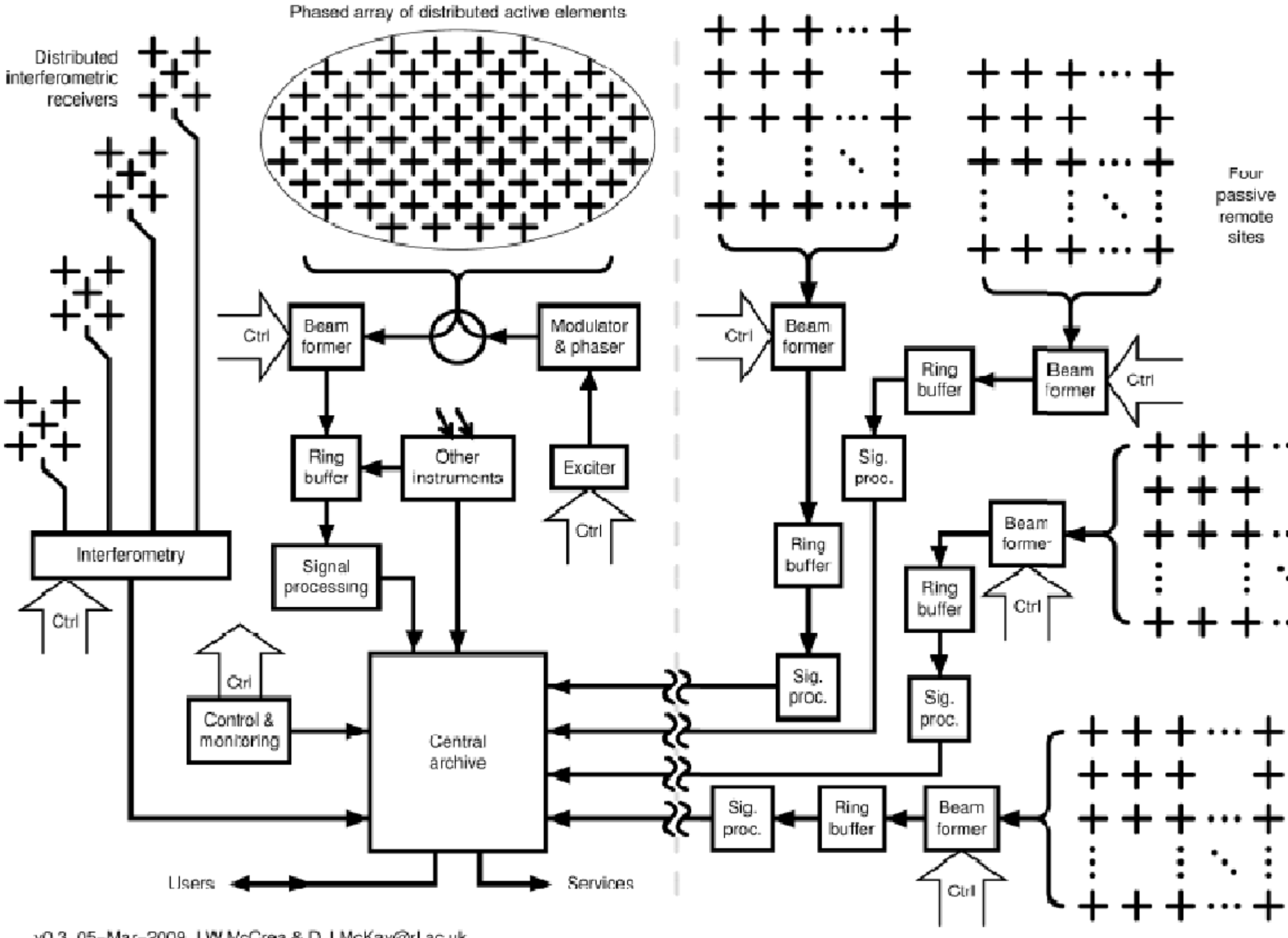
2014	2015	2016	2017	2018	2019	2020	2021
Preparation							
		Construction					
				Commission			
Total Funding Profile Investment including staff for installation work							
4 M€	32M€	38M€	33M€	16M€	4M€	4M€	4M€
EISCAT Operational Costs including regular staff							
3.4M€	6M€	7M€	7.2M€	8.3M€	8.7M€	9.2M€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

Data flow

- Each antenna
  - 30 Msamples/s (120MB/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

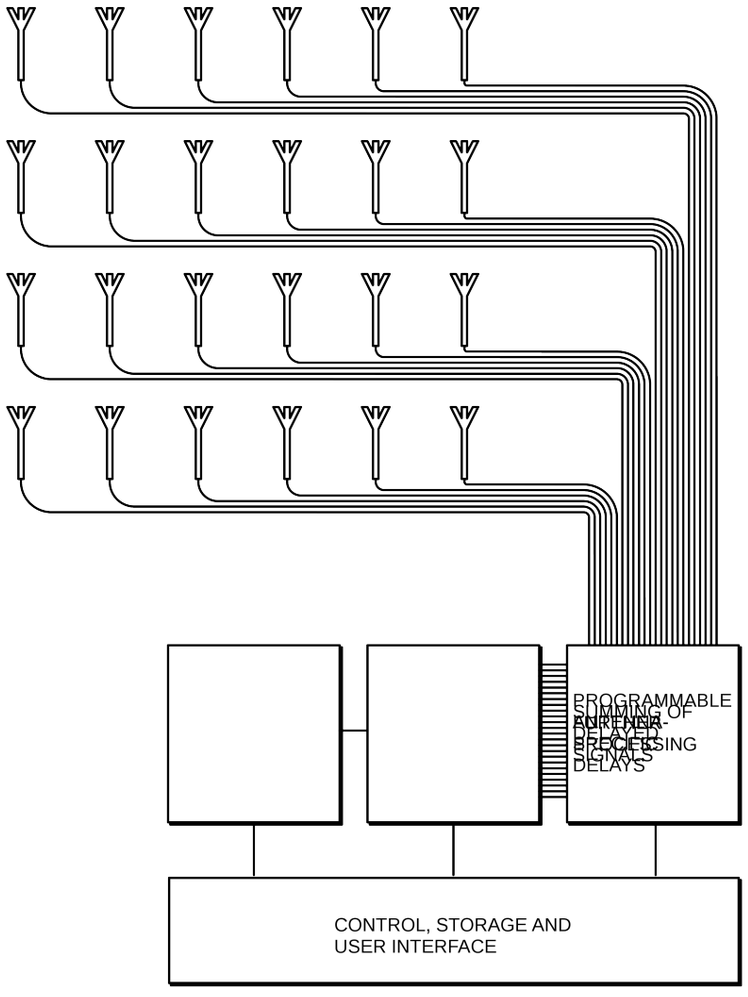
- 2nd stage beamforming
  - 160 antenna groups → 100 beams
    - Decimation to 1MHz
    - More or less continous sampling 32bit words (I/Q)
  - 100*1e6*2*32 → 1GB/s
  - Two 10MHz bands correlated data → 2GB/s
  - In total 10TB/h to be stored in archive

On-site computation

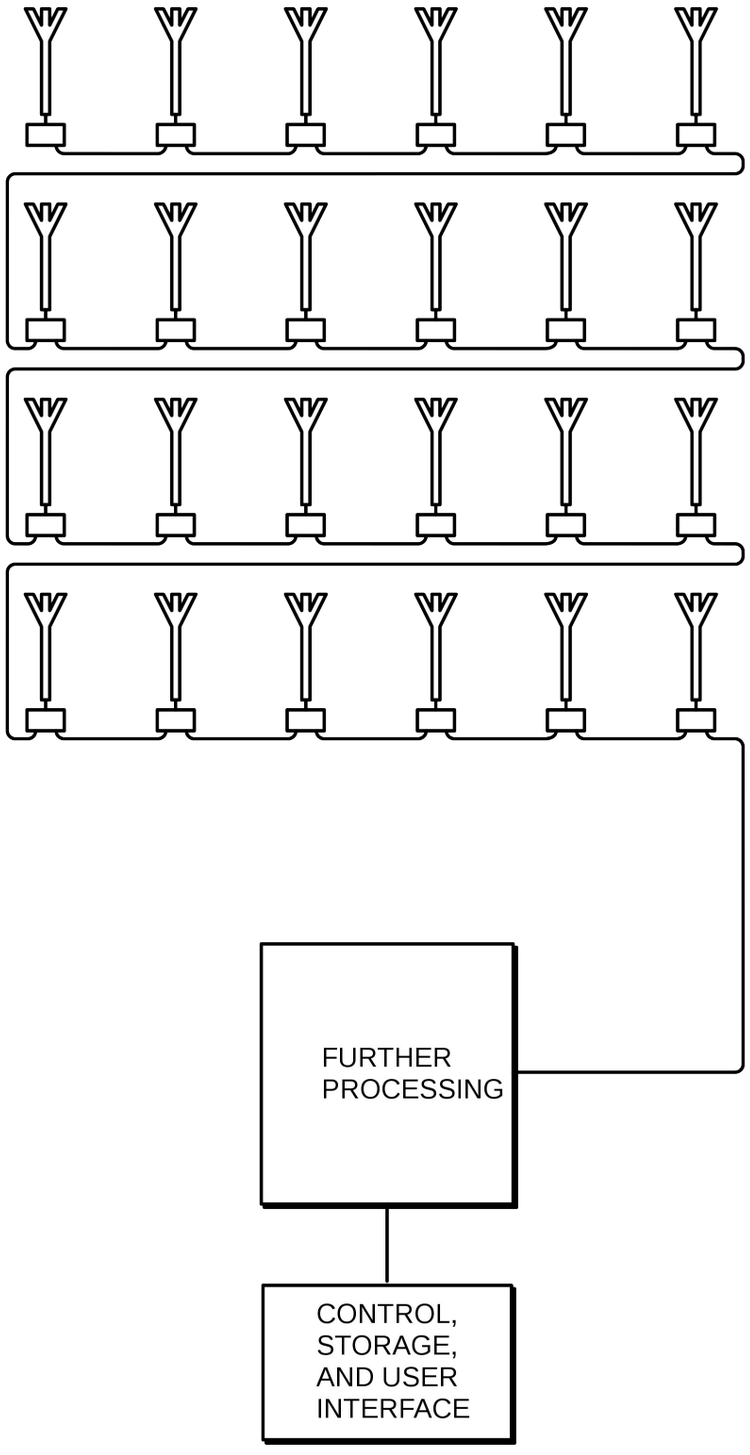
- 2nd stage beamforming
  - 160 antenna groups → 100 beams
    - Decimation to 1MHz → 200 Gflop/s
    - Final beams → 5-10 Tflop/s
- Lag profile inversion
  - 2-3 Tflops/s/beam
- Total
  - 5-10 + beams*(2-3) Tflops
    - 8-13 Tflops for 1 beam
    - 200-300 Tflops/s for 100 beams

On-site computation

Central computing
CPU/GPU



Distributed computing
(FPGA?)



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

- Now, EISCAT
  - Small, EISCAT archive (1981-2013) 60TB
- EISCAT_3D 1st stage (2018)
  - Moderate, EISCAT archive 1PB/year
    - 2-3 Mirrors (North + South Europe+Japan)
      - Analyis software + Search engines
  - HPC for detailed studies/developments
    - Storage 1PB, 1Pflop/run
- EISCAT_3D 2nd stage (2023)
  - High, EISCAT archive 10PB/year
  - HPC, Storage 10PB, 10 Eflop/run

EISCAT data

- 4 levels of data
  - Raw antenna (group) data
    - 1 day ringbuffer, 10 PB
  - Voltage beam formed data
    - 10 PB/year
  - Correlated data
    - 1 PB/year
  - Analysed data
    - 1GB/year (in ENVRI)
- Formats in disussion within CoopEUS
  - hdf5

Archive software

- To go to higher levels of data
  - Beamforming 1->2
  - Lag profiling 2->3
  - Fitting to physical quantities 3->4
- Search engines for all levels of data
  - Find specific signatures
    - At all levels
    - Plasma features, meteors, space debris, astronomical features
- Redo steps
  - New information from searches or external sources
  - Software bugs