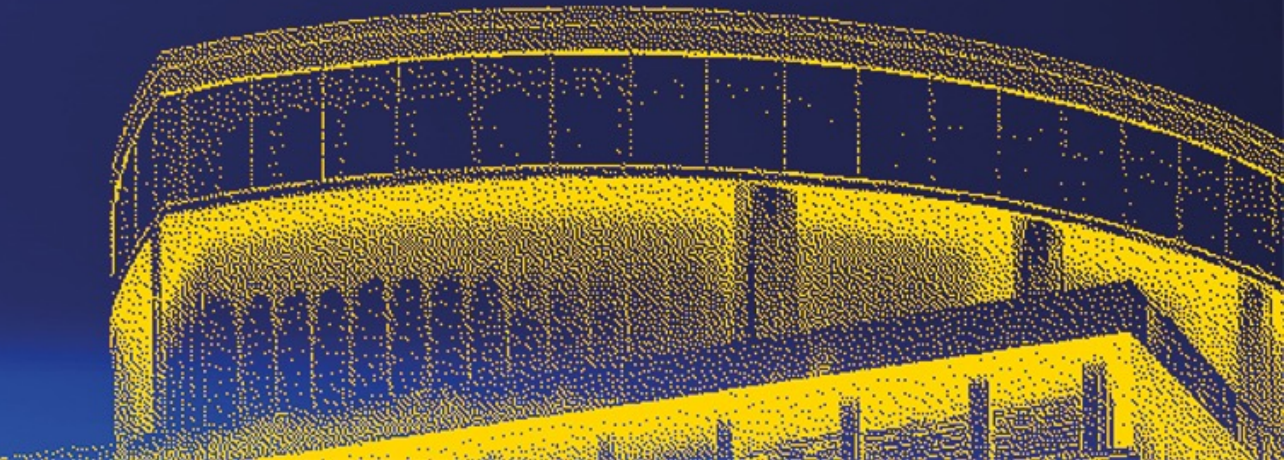
big science sweden

SWEDISH BIG SCIENCE FORUM



POWER AND RF SYSTEMS

Carlo Rossi
Senior Accelerator Physicist
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Team Leader Specialist Engineering Teams
SKA

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Swedish Big Science Forum

Power and RF Systems at CERN

C. Rossi on behalf of the SY/RF and SY/EPC Groups

31-01-2024

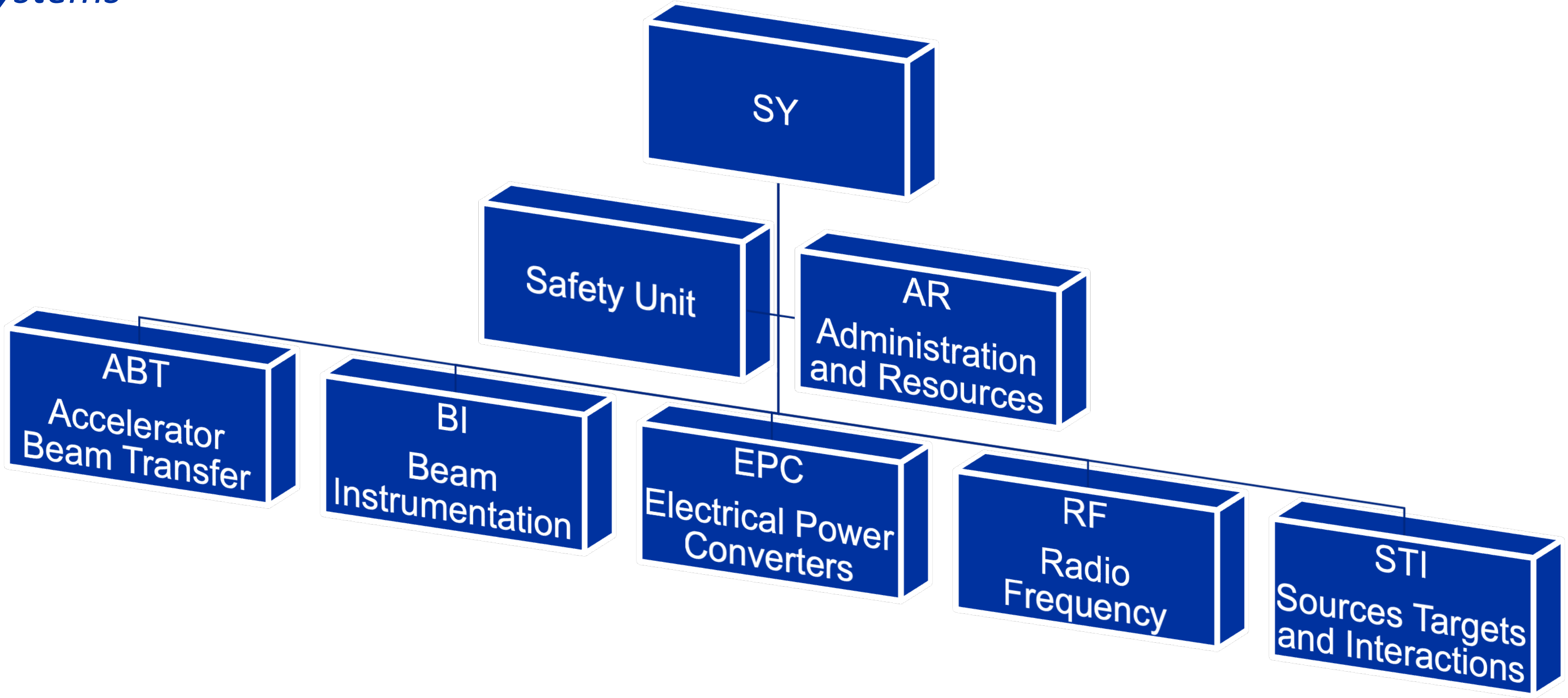
Outline

- Organization
- Power and RF systems in the Accelerator Complex
- Consolidation of existing accelerators and test areas
- Near future and beyond
- Conclusions

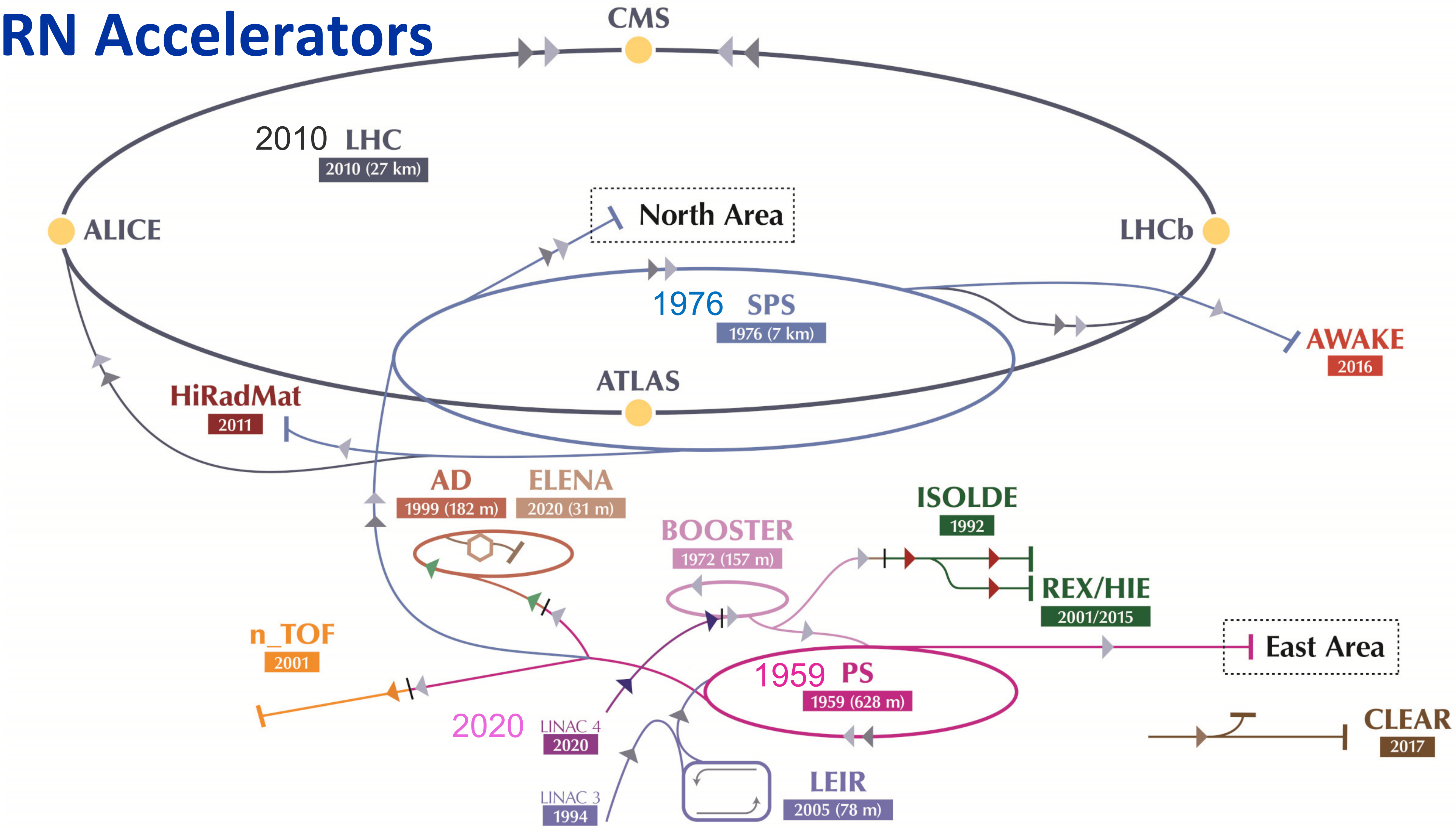
Structure and Mandate

In CERN’s Organization, the Accelerator and Technology Sector (ATS) is in charge of the operation and exploitation of the whole accelerator complex.

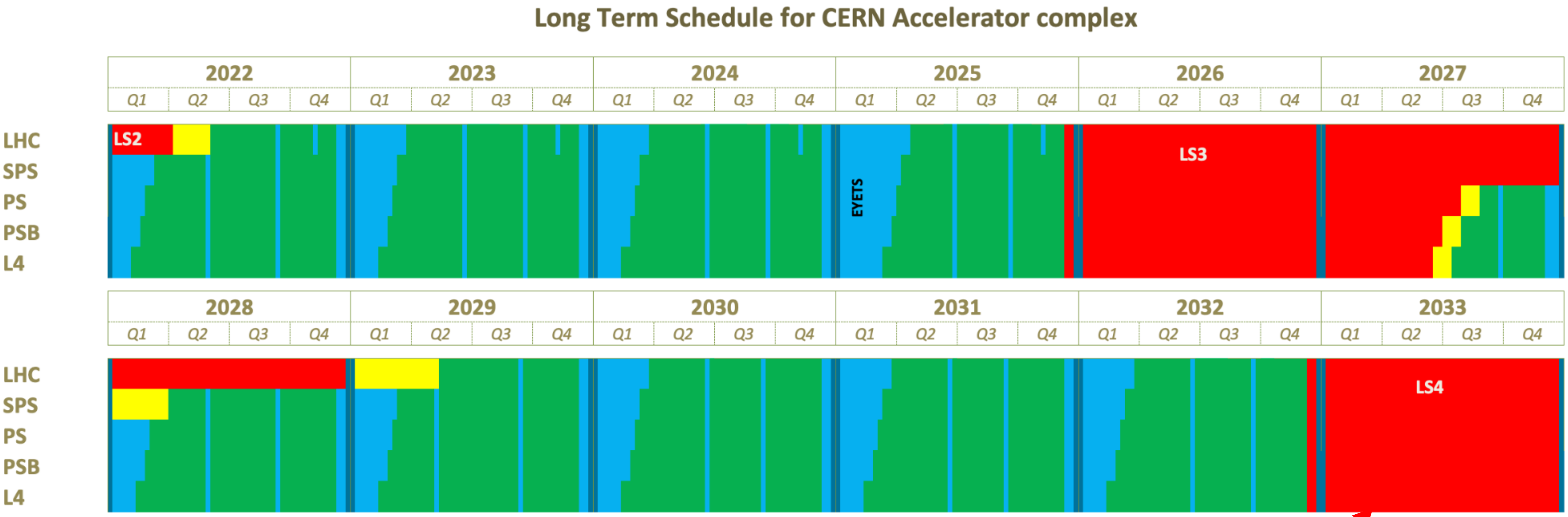
Within ATS, the Accelerator System Department (SY) *“ … is responsible for the accelerator beam-related technical systems”*



CERN Accelerators



CERN facilities - Operating cycles



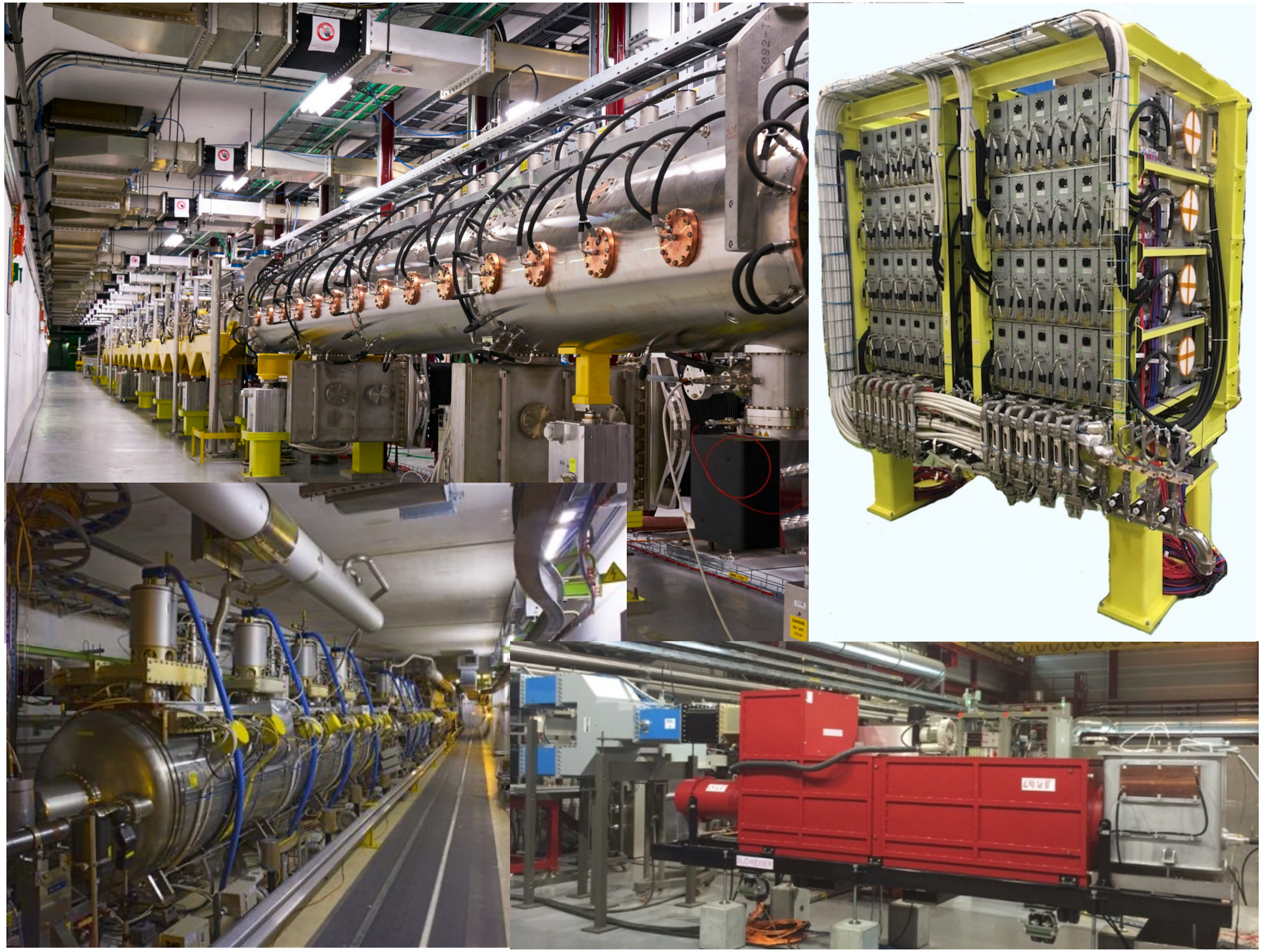
The accelerators operate for about 6000 hrs/yr
With system availabilities (all systems) > 90%

Major interventions performed during long shut-downs

Radio Frequency Systems (RF)

The RF Group is in charge of the design, construction or procurement, operation, consolidation and maintenance of RF cavities, RF power amplifiers, LLRF, and RF controls for all present and future accelerators at CERN:

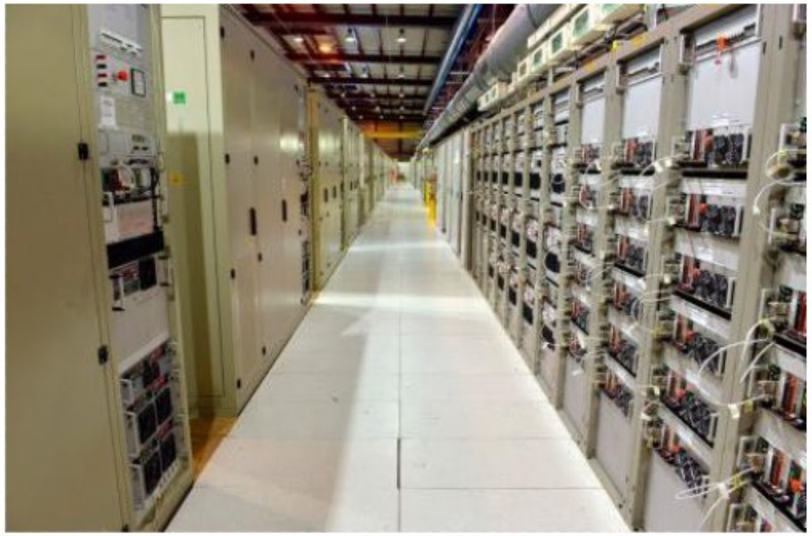
- *Warm and superconducting cavities;*
- *Klystrons, IOTs, Tetrode-based, solid-state amplifiers;*
- *Power converters in few cases;*
- *Low power RF (LLRF) and controls;*
- *Beam pick-ups and associated electronics.*

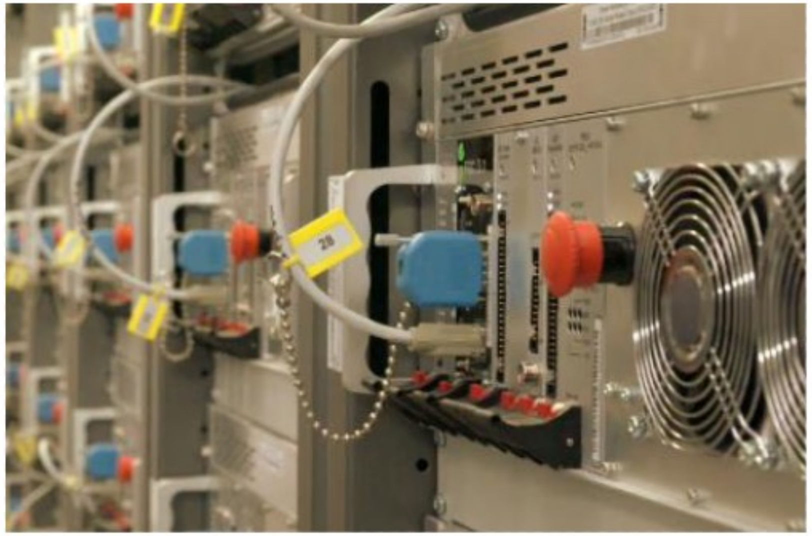


Electronic Power Converters (EPC)

The EPC Group is in charge of the electrical power converters for all accelerators, transfer lines, experimental areas and tests facilities at CERN:

- *Solid-state modulators for RF klystrons;*
- *High-voltage power converters for RF amplifiers and particle sources;*
- *Power converters from 100W to 100MW for DC, cycling or pulsed magnets;*
- *Static VAR compensators and harmonic filters.*





Linac3 RF Consolidation

Linac3

Final and Driver amplifiers + LLRF replaced

101 MHz – 350 kW_{peak}

Pulsed 1 ms @ 10 Hz

Proton Synchrotron RF & EPC Consolidation

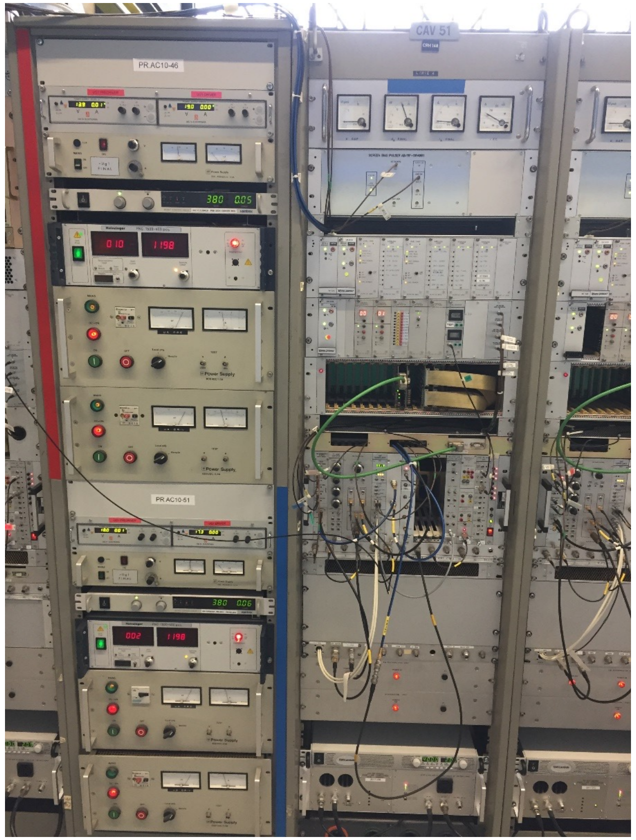
Proton Synchrotron

5 x 25 kV – 4 A power converters

Replaced by 5 x 25 kV – 8 A

I_{peak} = 50 A during < 1 ms

Proton Synchrotron Controls Consolidation



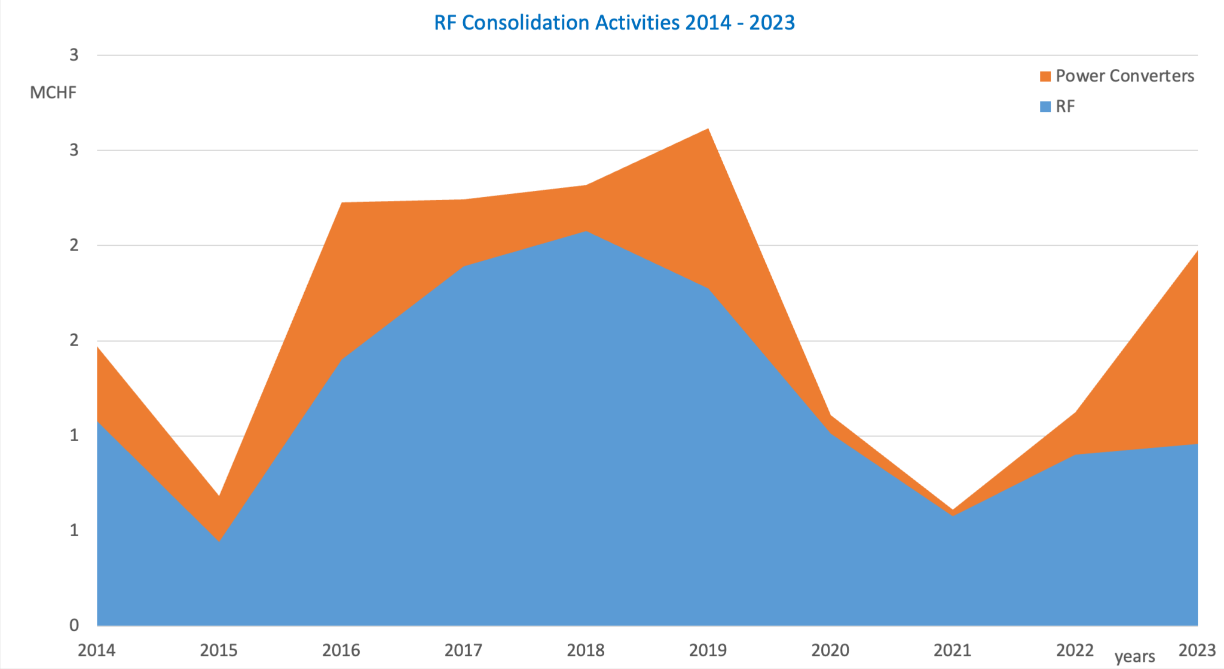
Proton Synchrotron (PS)

G64 interface and cabled interlock

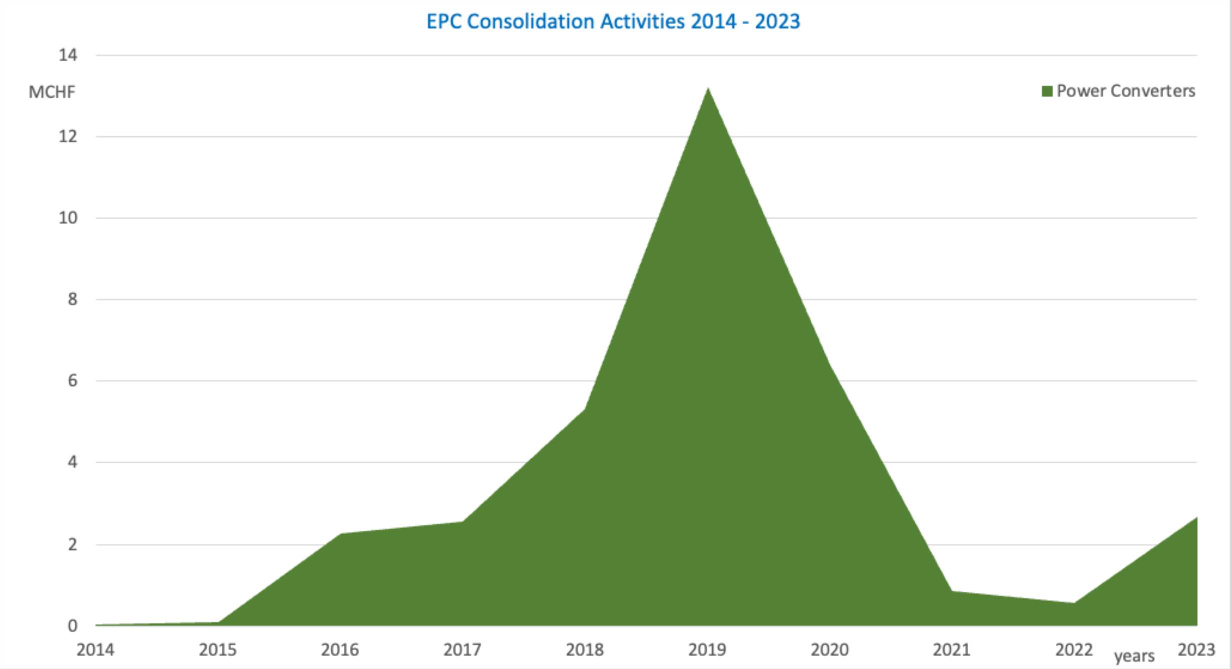
Replaced by modern industrial PLCs

Consolidation investments in 2014 - 2023

RF



EPC



Total of RF investments:

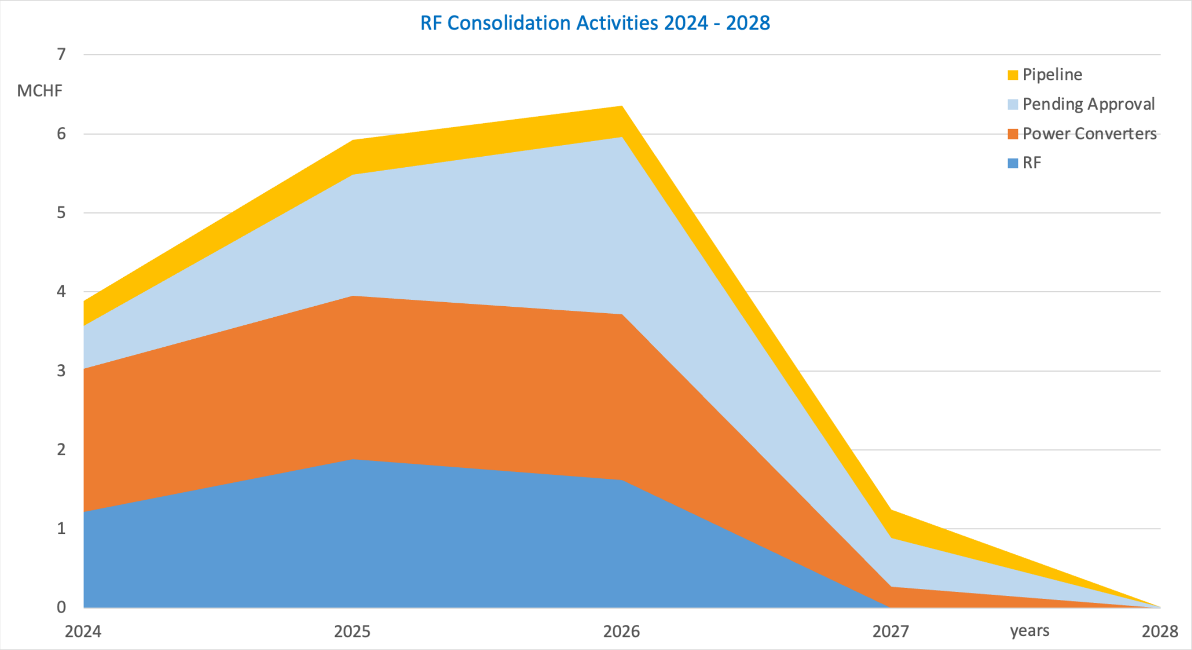
RF = 12 MCHF
Power Converters for RF = 4 MCHF

Total of EPC investments:

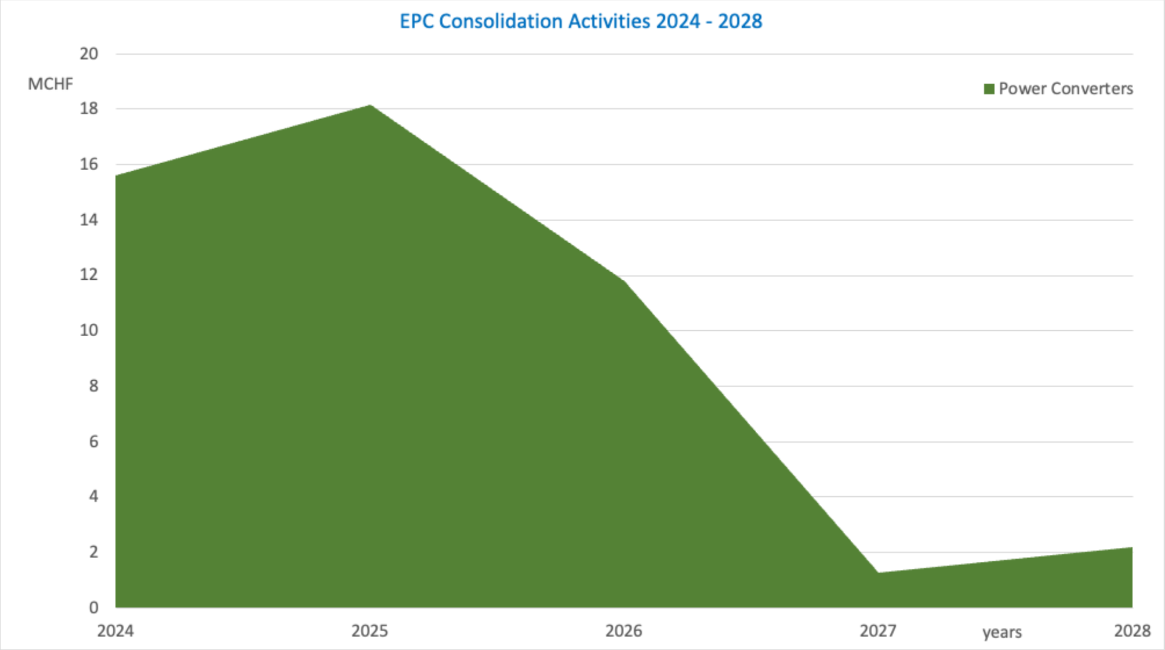
Power Converters = 34 MCHF

Future Consolidation investments 2024 - 2028

RF



EPC



Approved RF consolidation activities : 11 MCHF

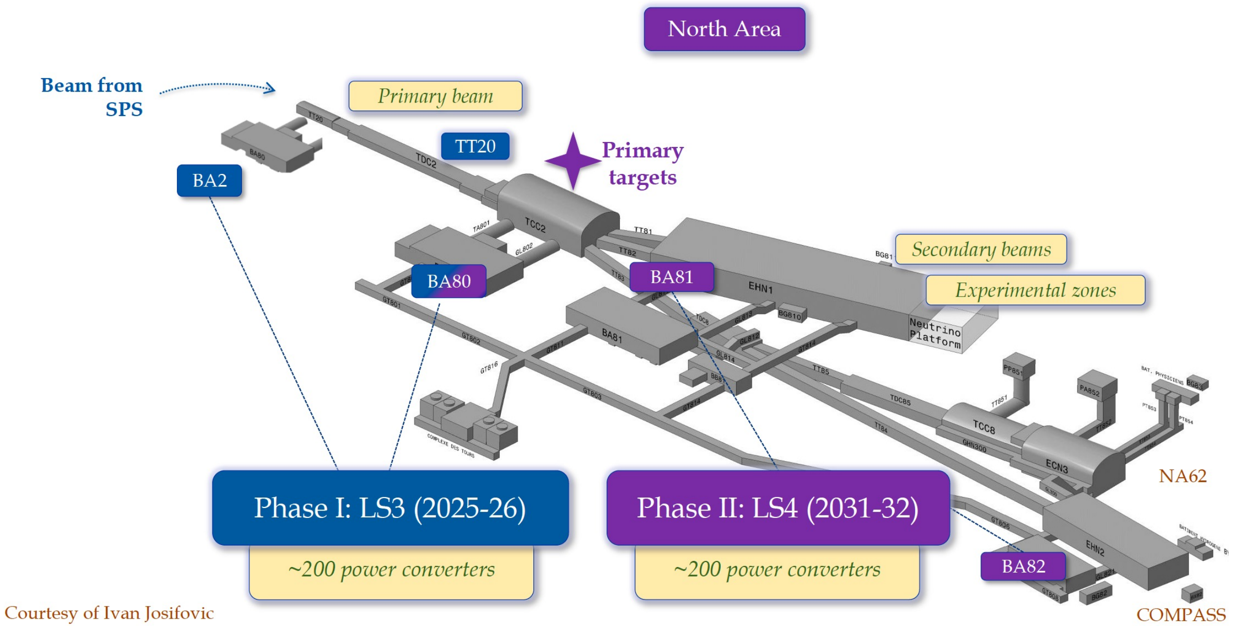
Approved EPC consolidation activities: 49 MCHF

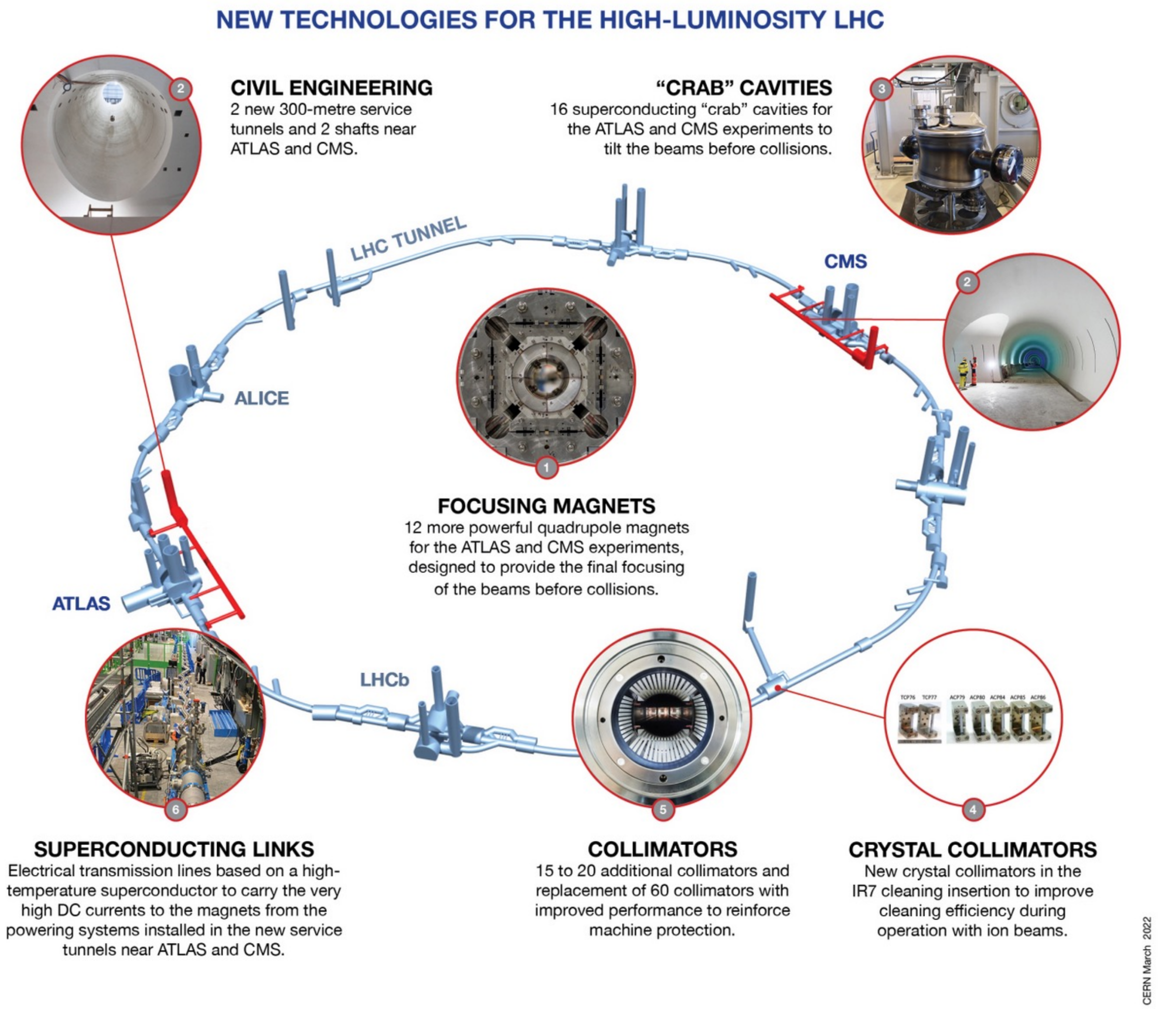
Pending and “pipeline” activities for 6.5 MCHF.

Near future activities

The High Luminosity LHC

The consolidation of the SPS North Area





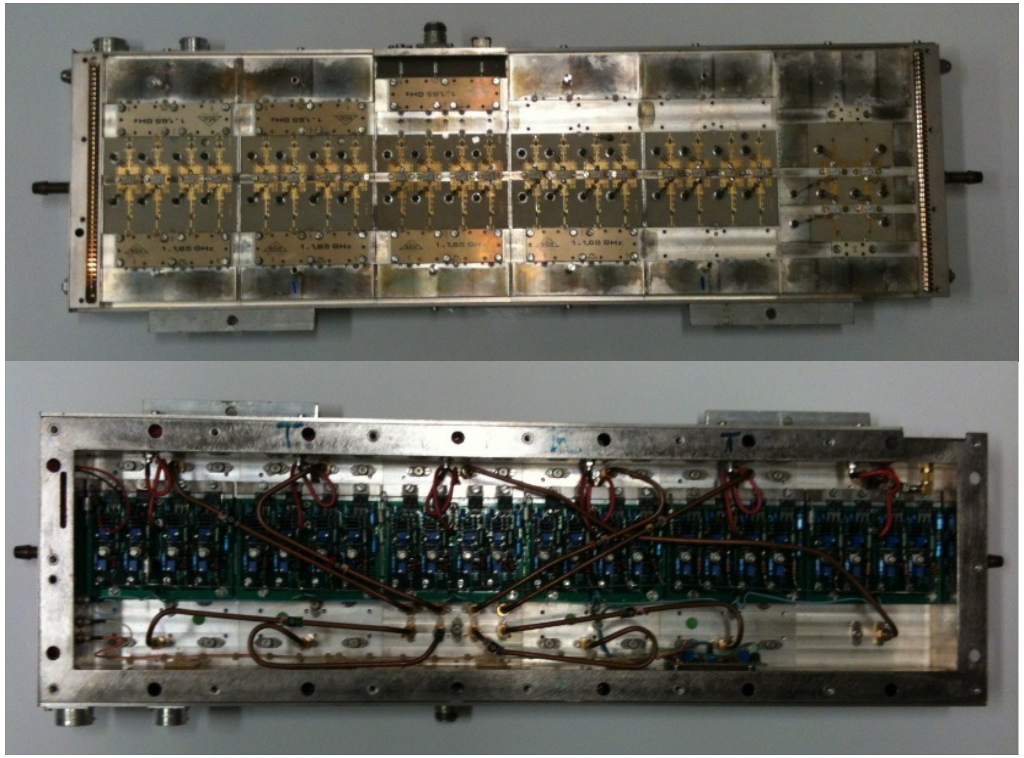
… and regular consolidation of our other facilities

Upcoming RF Consolidation activities

AD Stochastic cooling RF Amplifiers

48 x 100 W amplifiers

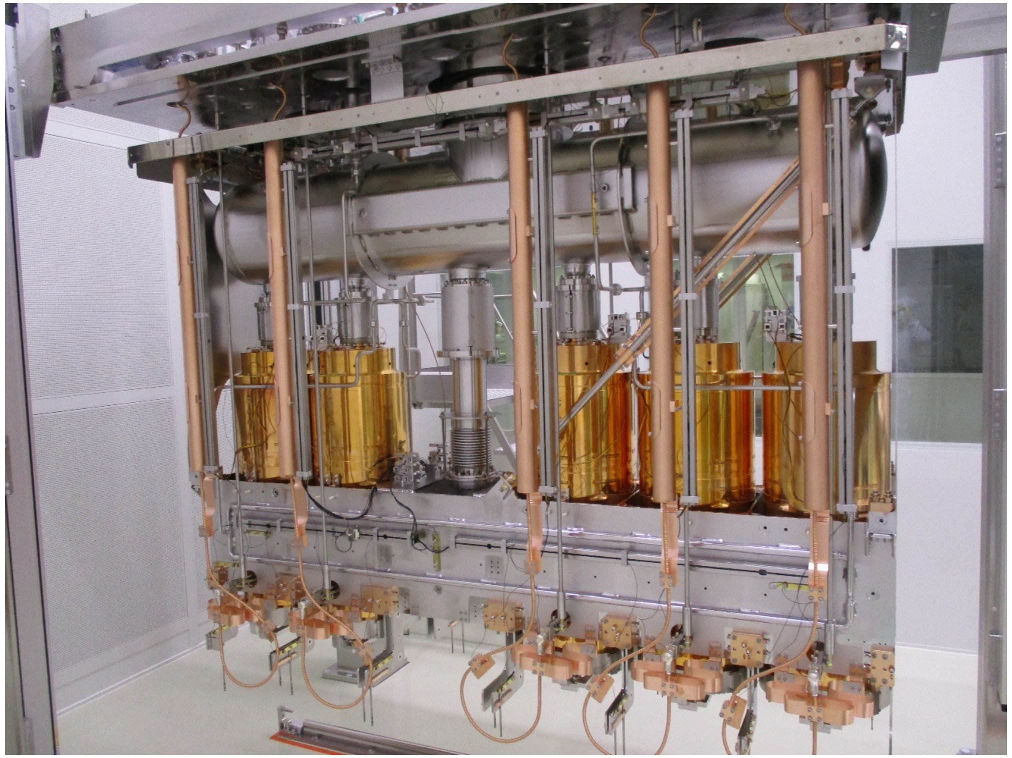
900 MHz to 1800 MHz (GaAs to GaN ?)



Spare cryomodule for HIE - ISOLDE

5 SRF cavities operating at 4.5 °K

Gradient 6 MV/m, dissipated power 50 W



EPC participation into HL-LHC and North Area

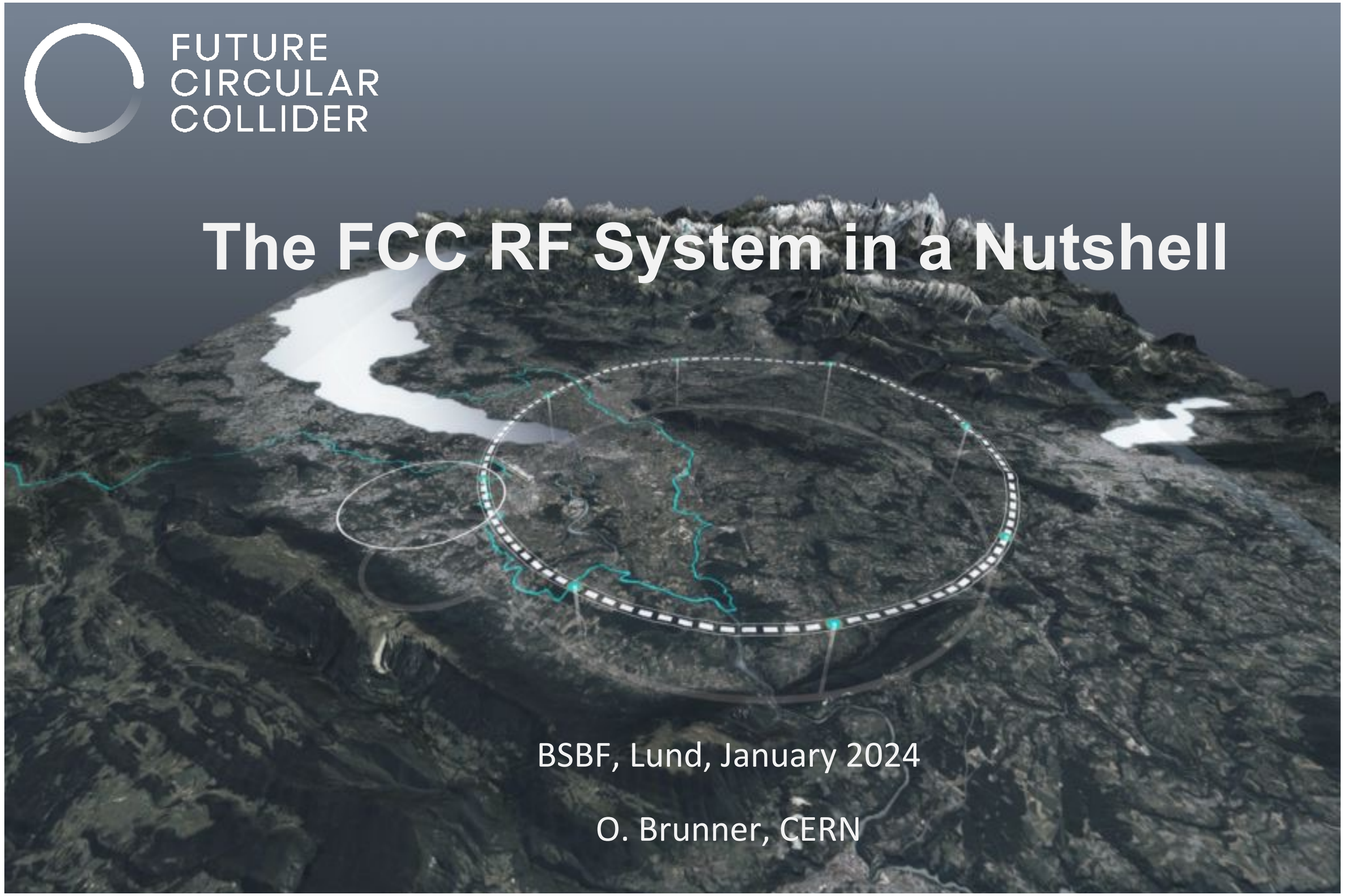
Manufacture & Test
build-to-print equipment

Power Modules

Integration / Cabling

… and beyond

The FCC project



See the presentation by O. Brunner

Conclusions

[Doing business with CERN]

[Forthcoming Tenders]

Forthcoming Tendering Procedures

Forthcoming tendering procedures expected to exceed 200k CHF are listed below. Except if specified otherwise, the firms that have the right to reply to the Market Survey are only the ones which country of origin of supplies and services is one of CERN Member States.

If you would like to know more about a specific procedure, please, click on one of the following procedures. In case you are interested in a specific Market Survey, you will find the related document under "Available action". However, if the Market Survey documents have not been released yet, you are invited to express your interest by sending an email to the email address depicted in the same section.

Firms may reply as long as the tendering procedures are still on this page. Therefore, in case the deadline for replies indicated in the Market Survey cover letter is over, disregard the date on the cover letter but please send your reply to the Market Survey as soon as you can.

If you have any questions, please address them to procurement.service@cern.ch or to the procurement or technical officers in charge of the corresponding market survey.

Finally, we invite you to consult this page frequently as the status of each procedure is regularly updated.

Type keywords e.g. Magnets, Software, Civil Engineering, ...

200k 750k 5M 10M ∞
Cost Range (CHF)

More Filters | Share Search Results | Reset Filters

Publication date	Type of contract	Reference	Description	Cost Range (CHF)	Status	Next step
01/06/2022	Supply	MS-4782/SCE	Framework Market Survey for the provision of roof renovation works on the Swiss or French part of the CERN site.	200k - 750k	Market Survey	Invitation to Tender 06/2022
30/05/2022	Supply	MS-4797/EN	Replacement of ten personnel lifts serving the SPS accelerator underground facilities	750k - 5M	Announcement	Market Survey 09/2022
30/05/2022	Supply	MS-4796/RCS/NEUTPLAT	Supply of the tertiary membrane components for the DUNE/LBNF detector cryostats	750k - 5M	Announcement	Market Survey 06/2022
30/05/2022	Supply	MS-4757/SY	Supply of POLARIS low voltage transformers	750k - 5M	Announcement	Market Survey 09/2022
24/05/2022	Services	MS-4789/TE	Provision of Technical Support Services on the CERN site	> 10M	Announcement	Market Survey 09/2022
19/05/2022	Experiments	MS-4768/EP/ATLAS	Supply of photomultiplier tubes for the Phase-2 Upgrade of the Tile Calorimeter of the ATLAS detector	750k - 5M	Market Survey	Invitation to Tender 08/2022
18/05/2022	Services	MS-4778/TE	Provision of vacuum services on the CERN site	5M - 10M	Announcement	Market Survey 06/2022
13/05/2022	Supply	MS-4779/SCE	Provision of the civil engineering works for the installation of a 66kV underground power line between LHC P6 and LHC P5 in France.	750k - 5M	Announcement	Market Survey 09/2022
10/05/2022	Supply	MS-4776/IT	Framework Market Survey concerning the supply of Servers and Storage for Physics Data Processing, Acquisition and Control Systems	> 10M	Market Survey	Invitation to Tender 06/2022
03/05/2022	Supply	MS-4727/EN	Supply of Optical Fibre microducts and protected microducts	200k - 750k	Announcement	Market Survey 07/2022

Thank You for your Attention

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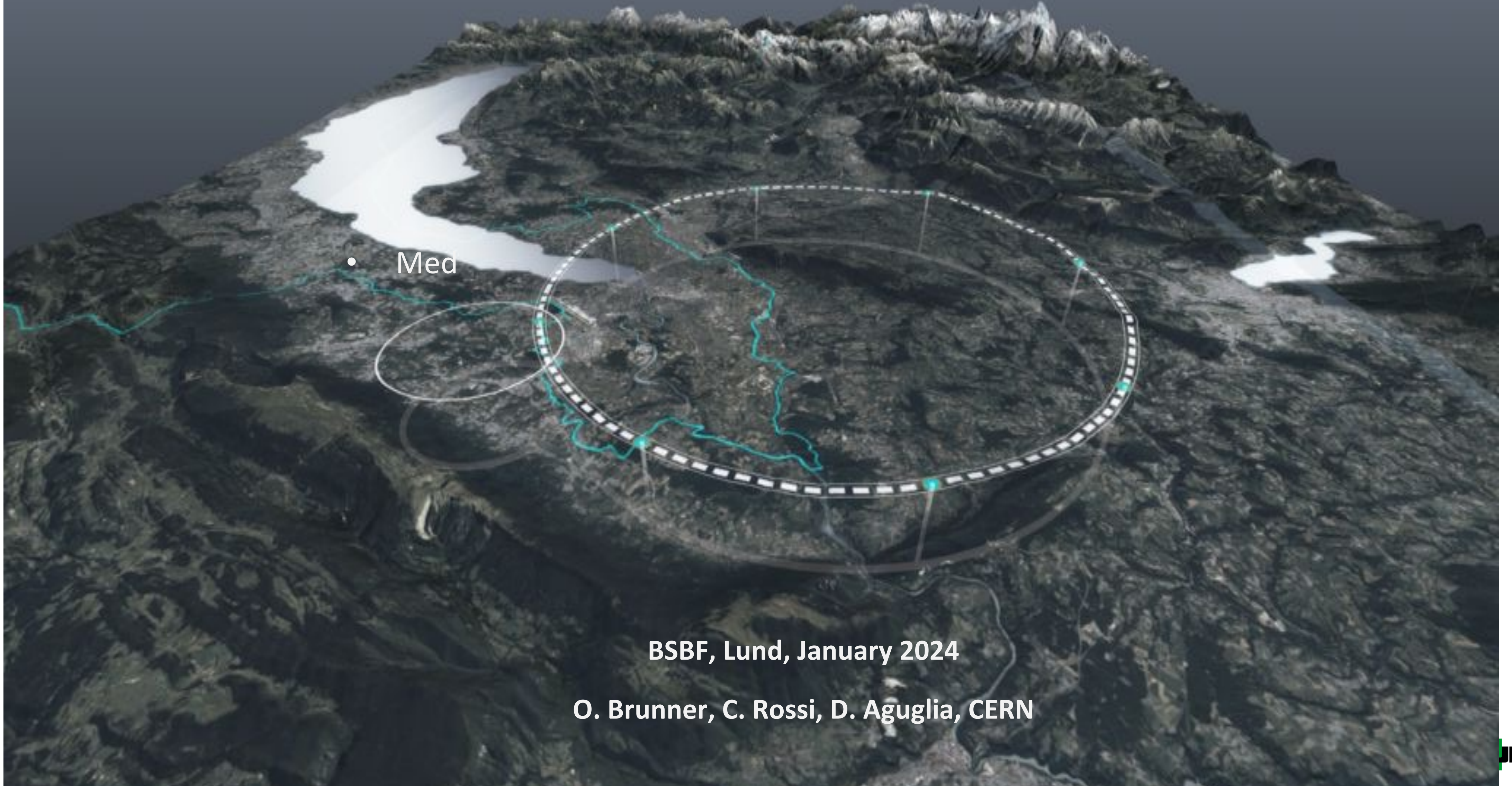
FUTURE CIRCULAR COLLIDER

The FCC RF System in a Nutshell



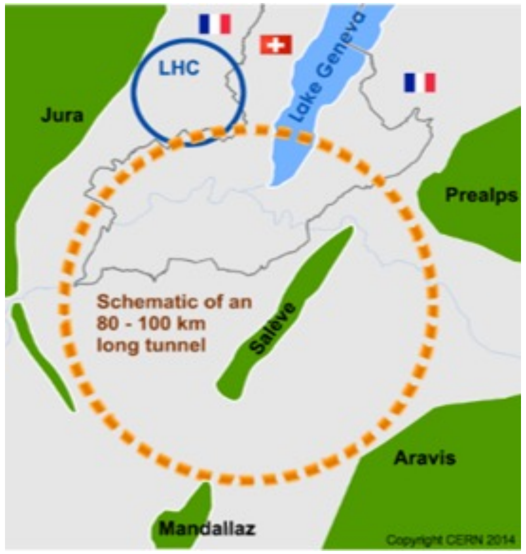
BSBF, Lund, January 2024

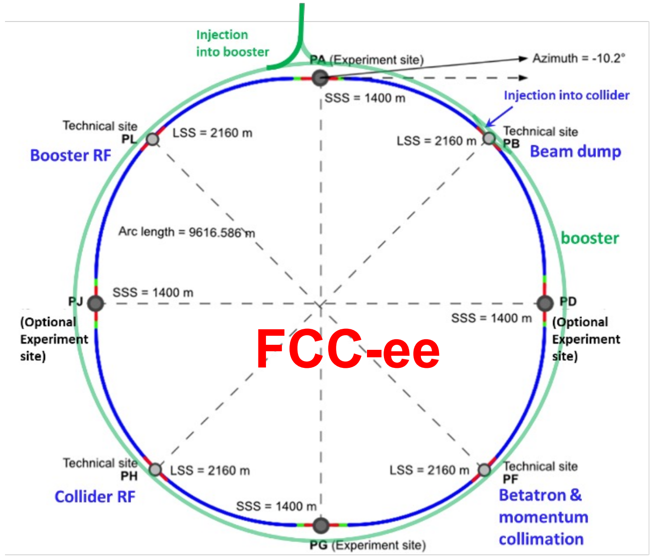
O. Brunner, C. Rossi, D. Aguglia, CERN

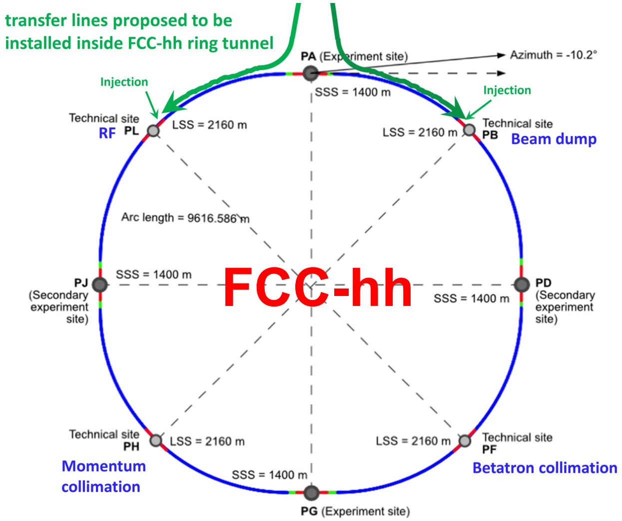
A century of physics

Comprehensive long-term program maximizing physics opportunities

- stage 1: FCC-ee (Z, W, H, $t\bar{t}$) as Higgs factory, electroweak & top factory at highest luminosities
- stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, pp & AA collisions; e-h option



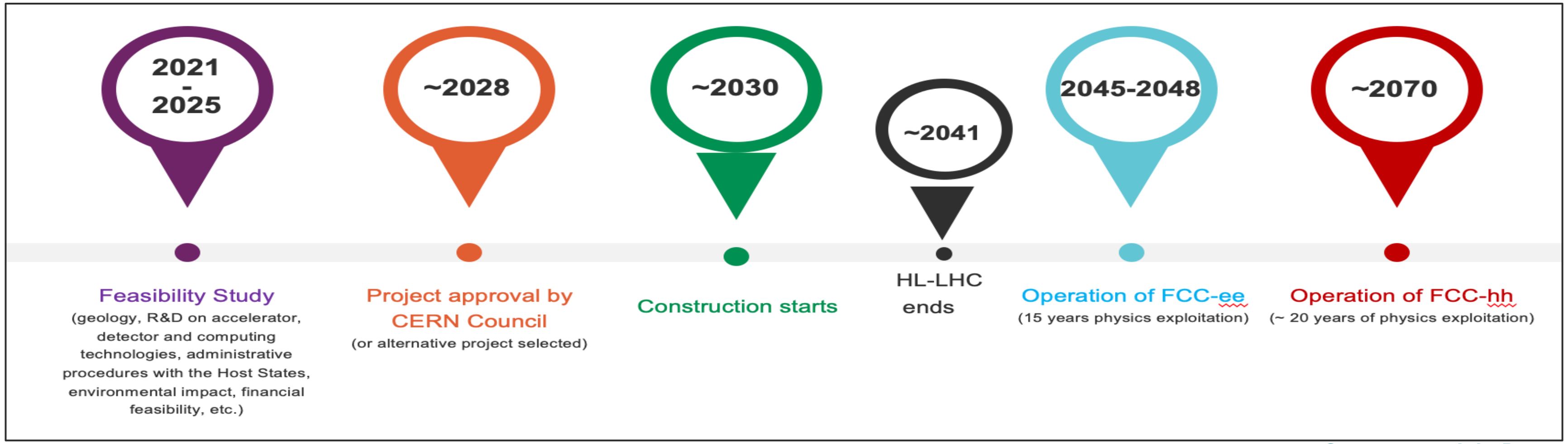




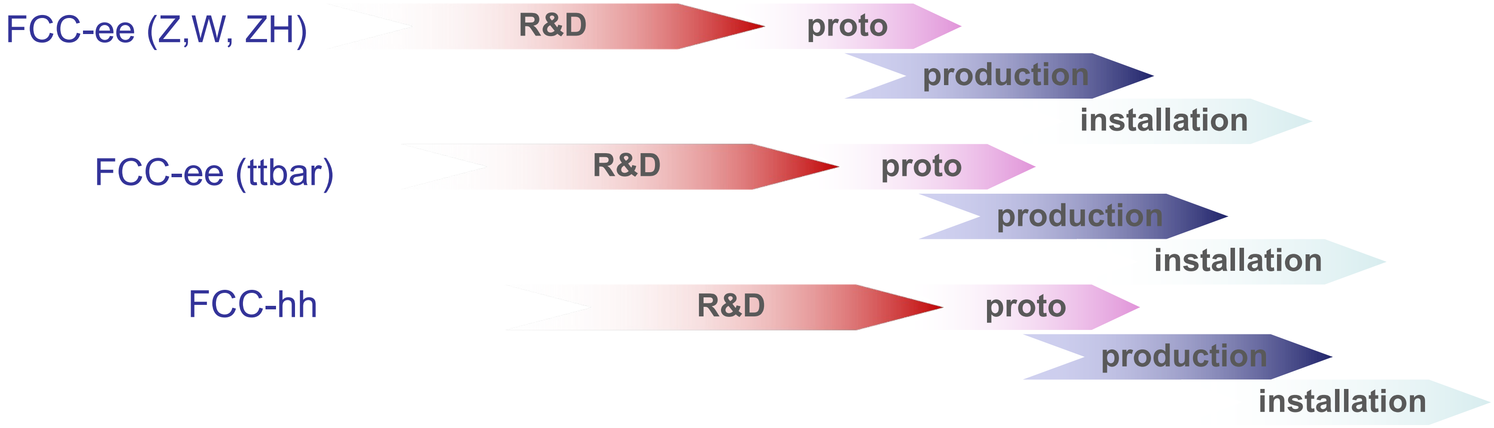
2020 - 2046 | 2048 - 2063 | 2074 -

Courtesy, M. Benedikt, CERN

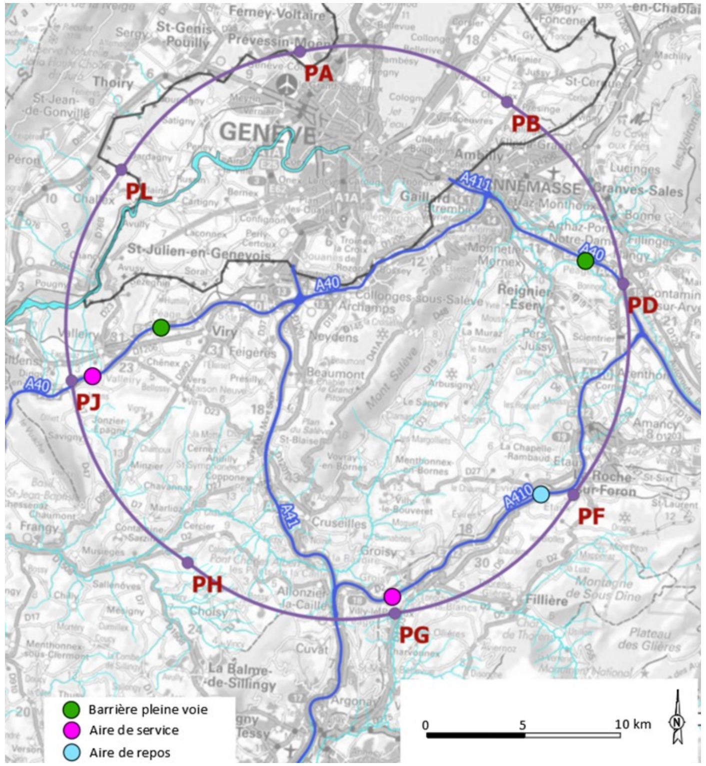
FCC integrated program - timeline

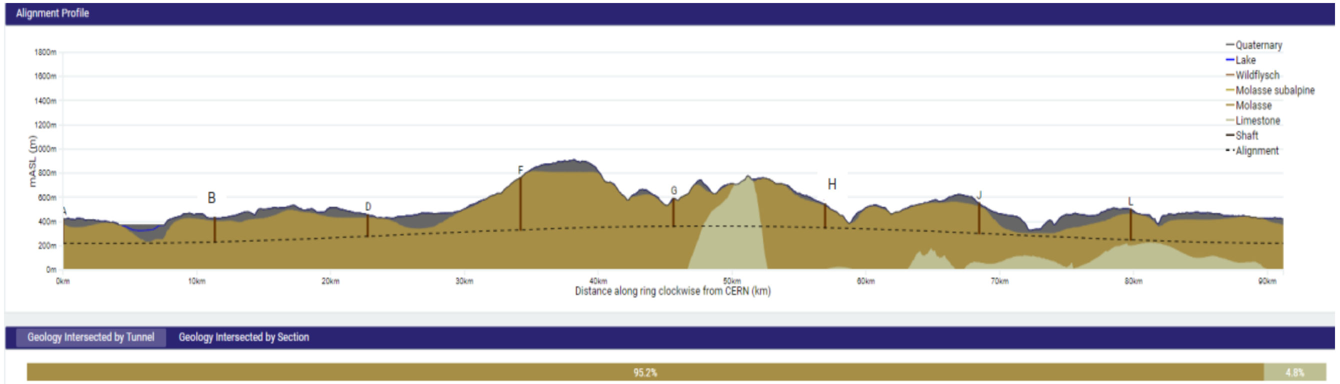


Courtesy, M. Benedikt, CERN



Optimized implementation





Courtesy, M. Benedikt, CERN

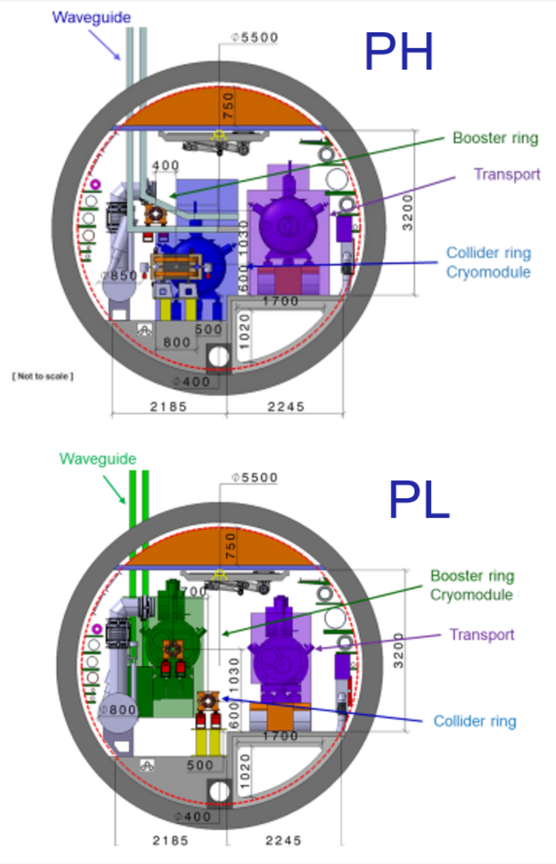
- Layout chosen out of ~ 100 initial variants, based on geology and surface constraints (land availability, access to roads, etc.), environment, (protected zones), infrastructure (water, electricity, transport), machine performance etc.
- Tunnel implementation →aim at minimising tunnel construction risks

High level RF requirements

	Energy (GeV)	Current (mA)	RF voltage (GV)
Z	45.6	1280	0.080
W	80	135	1.05
H	120	26.7	2.1
ttb	182.5	5	11.3

High current machine

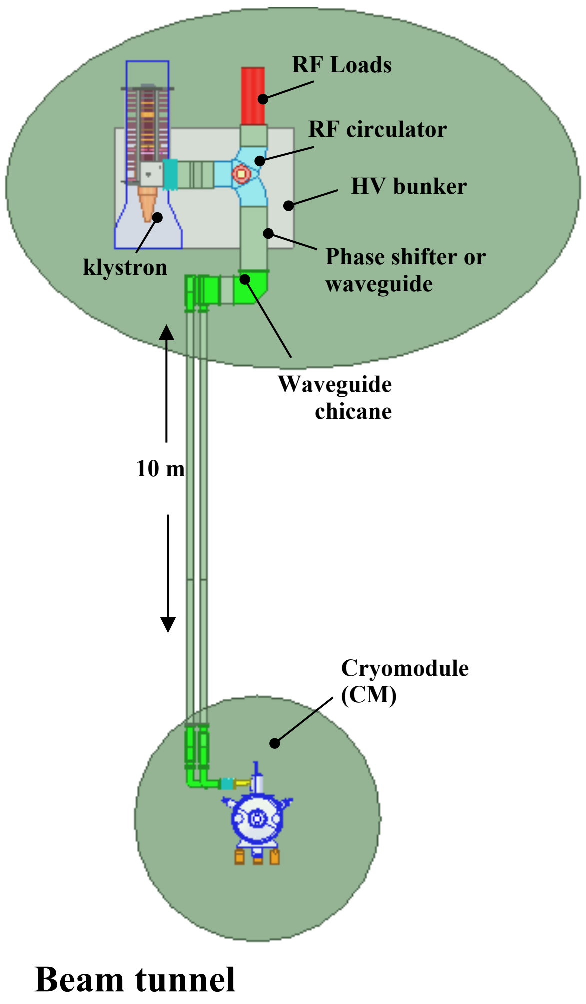
High gradient machine



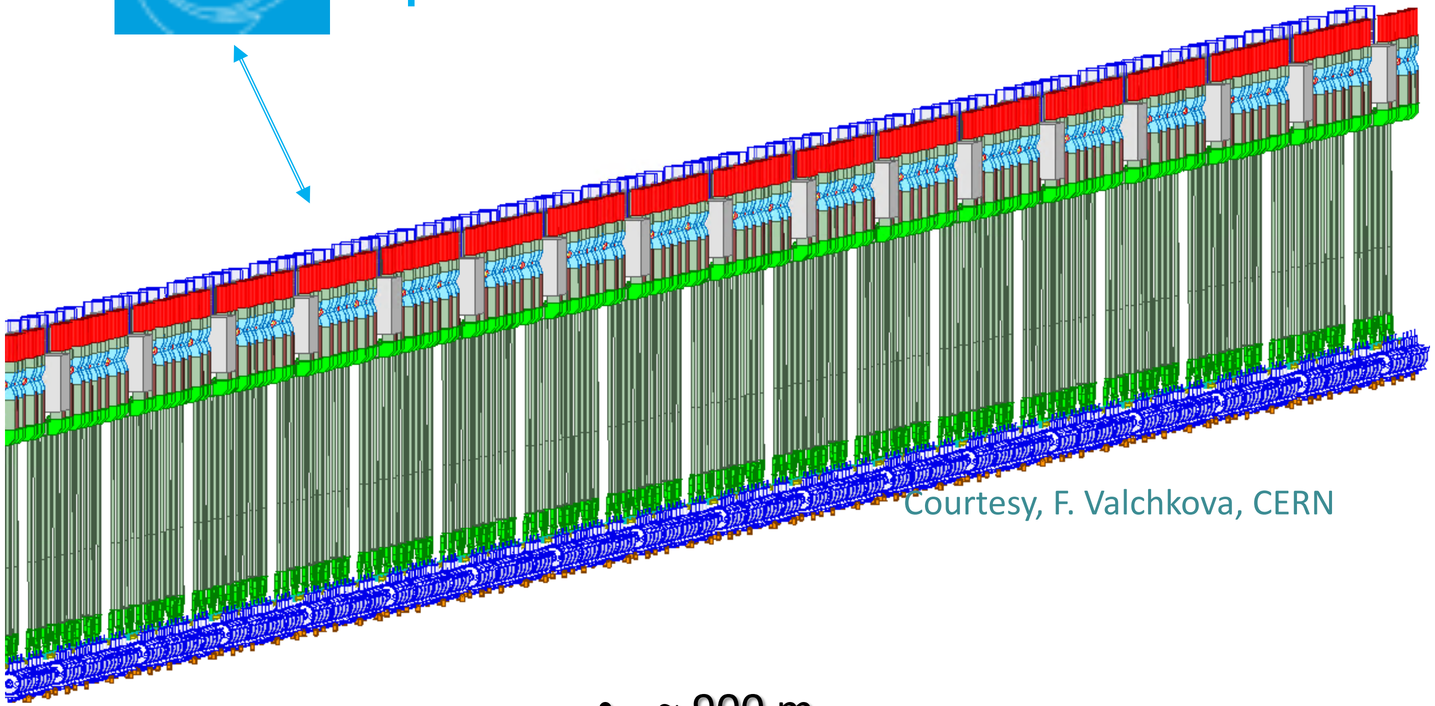
Courtesy, F. Valchkova, CERN

- Collider (2 rings): 100 MW of RF power in CW (50 MW per ring) to compensate losses by synchrotron radiation
- Booster (3rd ring) to accelerate from 20 GeV to the final energy with 10% beam current and 15% average duty cycle
- Availability in operation of 80%

RF system configuration for the Higgs factory



Equivalent to ≈ 2 x the ESS SRF linac

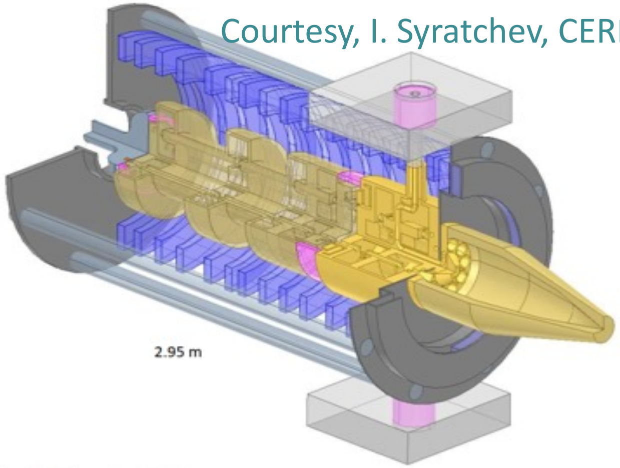


Courtesy, F. Valchkova, CERN

- ≈ 900 m
- hundreds of RF power amplifiers
- 272 superconducting cavities
- 66 cryomodules
- control systems, …

RF power amplifiers

Courtesy, I. Syratchev, CERN



- **Higher energy efficiency (HE) power systems is a must for all machines**
- **Impressive CERN-driven progress in High Efficiency Klystron technologies in recent years**
  - Large efforts to demonstrate > 80% efficiency (~20% improvement)
  - Demonstrated on x-band klystron in 2023
  - Klystrons are needed for 'all' high RF power & high frequency systems
  - Thales (France) is the only European supplier for high-power klystrons
- **Strong demand for solid-state high-power modulators and RF systems**
  - ScandiNova Systems (Sweden), Ampegon (UK), Jema (Spain)
  - Europe is by its break-through technology a world leader
- **Solid state amplifiers are the go-to for many accelerator power systems:**
  - Examples: SOLEIL 4×190kW 352 MHz, SPS 32×135kW 200 MHz (w. Thales Gérac)
  - SSA needed for FCC_ee

Continuous demand for new HE RF power sources (incl. replacement of obsolete technologies)

Powering the FCC-ee

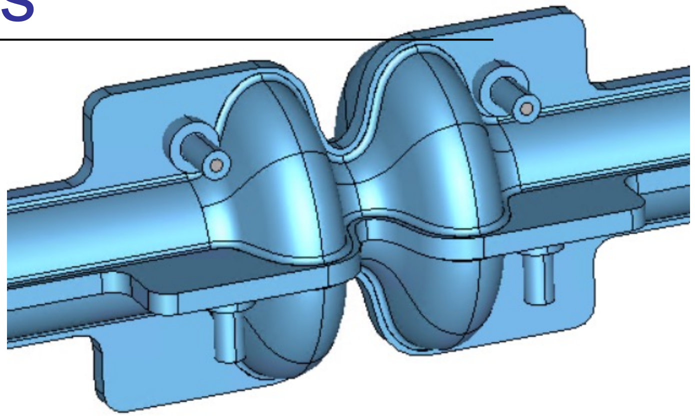
- **RF powering**
- **160 MW of HV power (~70 kV DC)**
- **Centralized solution via a Modular Multilevel Converter (MMC)**
- **R&D needs for this special application**
  - High efficiency
  - Individual DC voltage regulation capabilities for each klystron

Courtesy, D. Aguglia, CERN

- **Magnet powering**
- **35'000 circuits: ~ 100s of W to ~MW level**
- **Main challenges:**
  - Minimize the losses (new power converter structures and/or wide bandgap technologies)
  - Global optimization (CAPEX+OPEX) for optimal converter location (w.r.t. magnets)
  - Design compromises with civil engineering (volumes), cooling and ventilation (losses and their locations), magnets (number of turns, etc.), and many others.

At these power levels, every % in efficiency has a big impact

Superconducting cavities



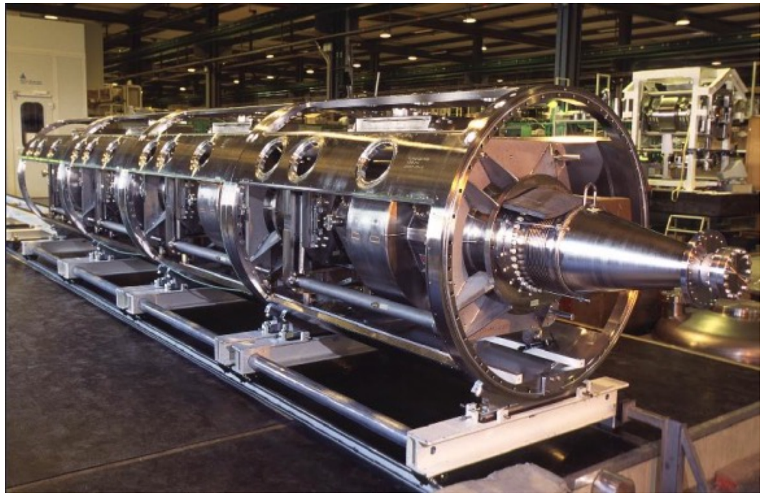
Courtesy, F. Peauger,
S. Gorgi Zadeh , CERN

- **Based either on copper with a Nb coating, or made from bulk Niobium**
  - Highly pure base material: 3D-forged OFE copper, high-purity Nb
  - Tight tolerances (e.g.: parallelism =50 µm, shape accuracy =0.4 mm)
  - Removal of surface damage layer (100-200 µm) by chemistry (electro-polishing)
    - Final surface roughness ~0.1 - 0.2 µm.
  - Need VERY HIGH quality Nb coating (few µm)
- **Prototyping is typically done at CERN, then the technology is exported to industry**
- **Today, there are only 2 companies in Europe, which can manufacture complete bulk Nb cavities (Zanon (I), RI (D))**

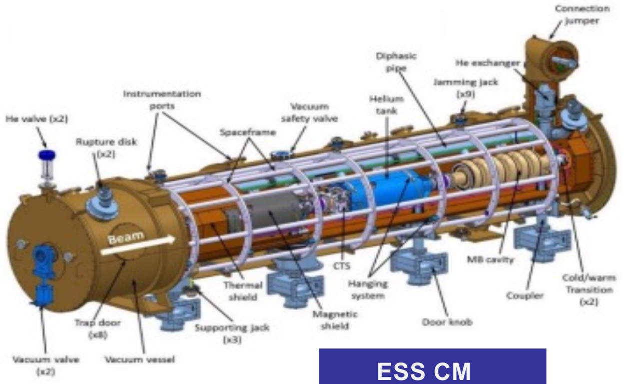
Seamless & cost-efficient technique would be used for thousands of cavities in institutes all over the world (LHC, ILC, ESS, CERN FCC)

Production of cryomodules (CM)

- **Superconducting cavities must be housed in complex, state-of-the-art helium-cooled CM (operating temperatures 1.6 K to 4.5 K)**
- **Large variety of CM designs, many common features:**
  - Integration and simulations studies
  - Vacuum vessel with thermal and magnetic shielding
  - Cold mass supporting system, alignment, tuning system, cryostat & piping
  - Beam vacuum gate valves, pressure relief devices
  - Instrumentation and cables (RF, temperature, pressure)
  - RF power couplers, HOM couplers
- **Manufacturing of mechanical parts and assembly (mostly done in clean rooms) are usually subcontracted to external companies**



LHC CM



ESS CM

All major scientific projects require tens or even hundreds of cryomodules

Thank you for your attention

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EISCAT Association

Current Associates

Forskningsrådet, Norway

Suomen Akatemia, Finland

Vetenskapsrådet, Sweden

CRIRP, PRC

NIPR, Japan

NERC
UKRI, U.K.

Affiliates

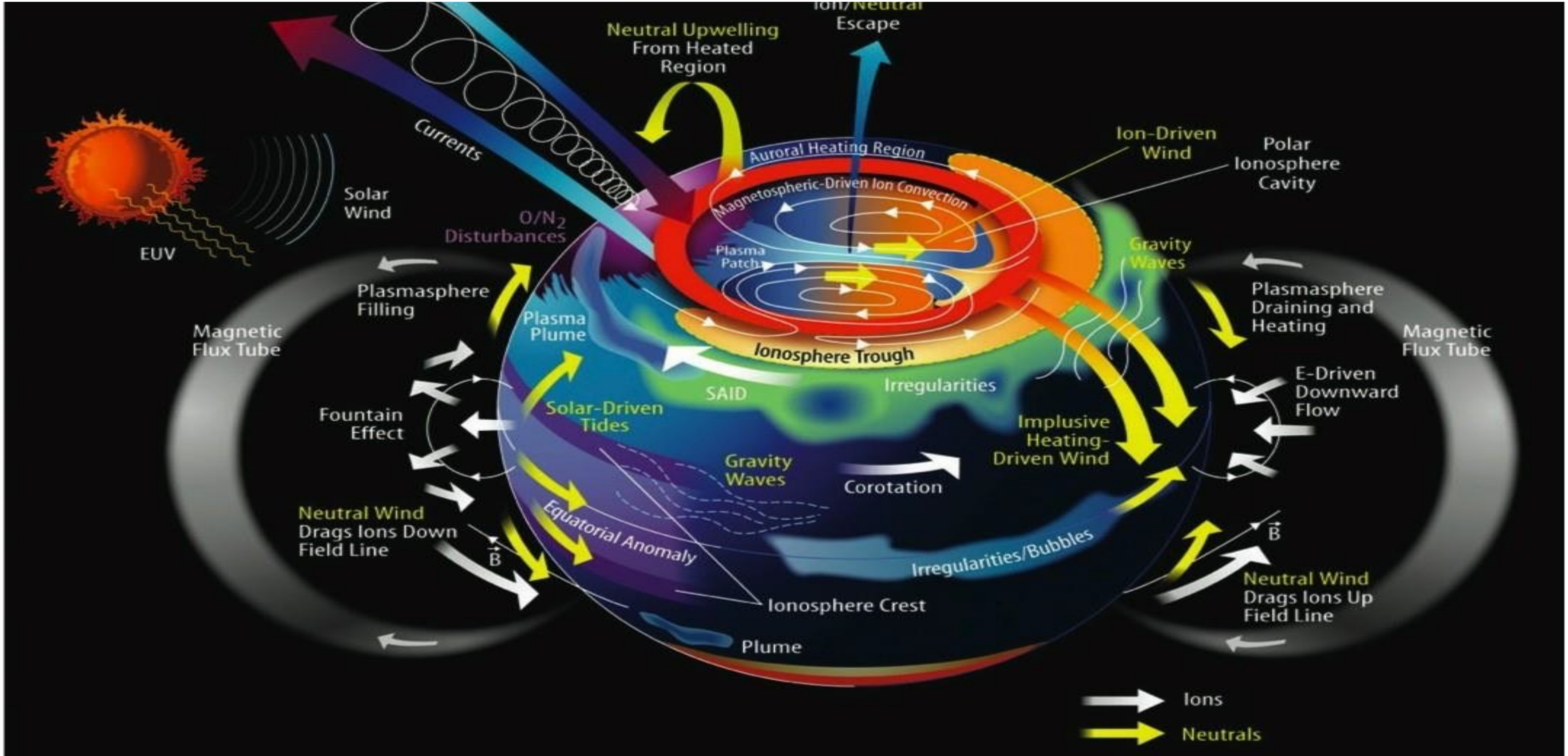
KOPRI & KASI, S. Korea

DLR-SO, Germany

IRA, Ukraine

METI Int, U.S.

Science


Ion/Neutral
Escape
Neutral Upwelling
From Heated
Region
Currents
Solar
Wind
EUV
O/N2
Disturbances
Auroral Heating Region
Magnetospheric-Driven Ion Convection
Ion-Driven
Wind
Polar
Ionosphere
Cavity
Plasma
Patch
Gravity
Waves
Plasmasphere
Filling
Plasma
Plume
Magnetic
Flux Tube
Ionosphere Trough
Plasmasphere
Draining and
Heating
Magnetic
Flux Tube
SAID
Irregularities
E-Driven
Downward
Flow
Fountain
Effect
Solar-Driven
Tides
Implusive
Heating-
Driven Wind
Gravity
Waves
Corotation
Neutral Wind
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Equatorial Anomaly
Irregularities/Bubbles
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Neutral Wind
Drags Ions Up
Field Line
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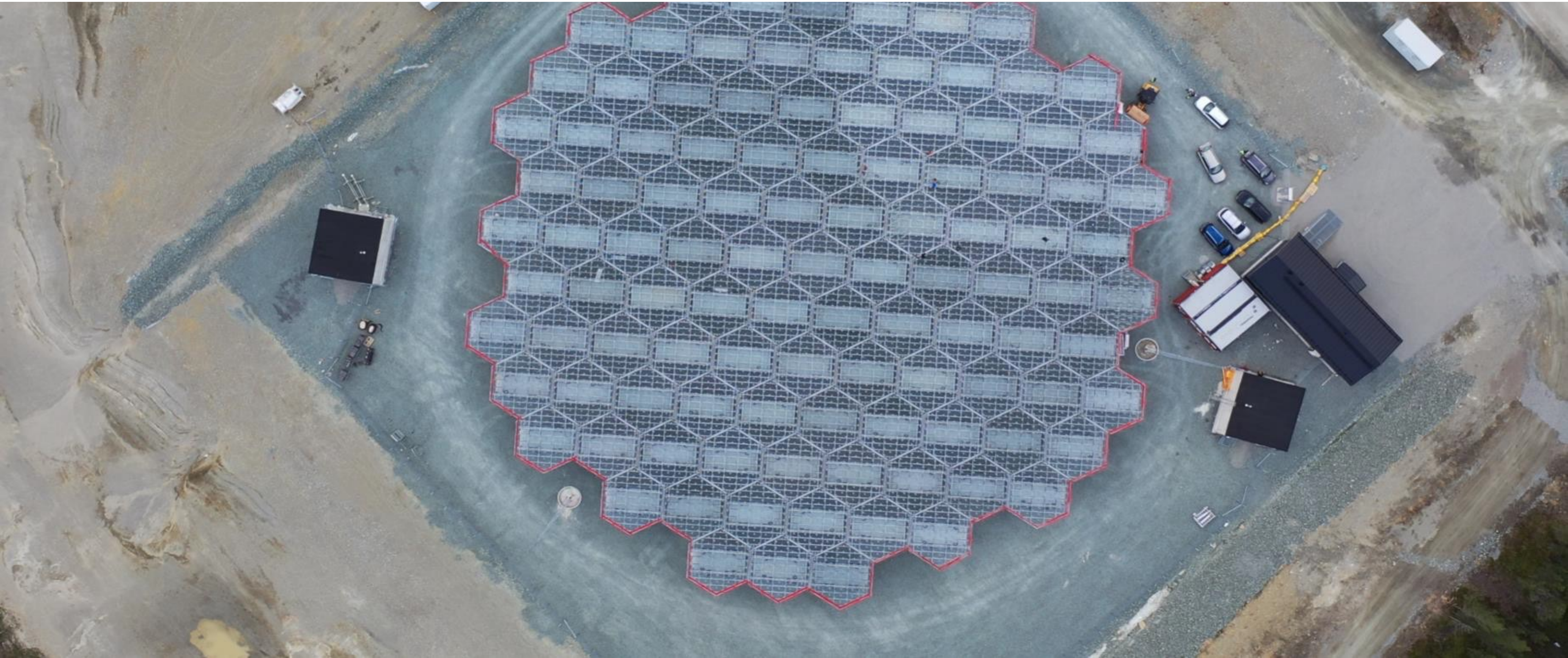
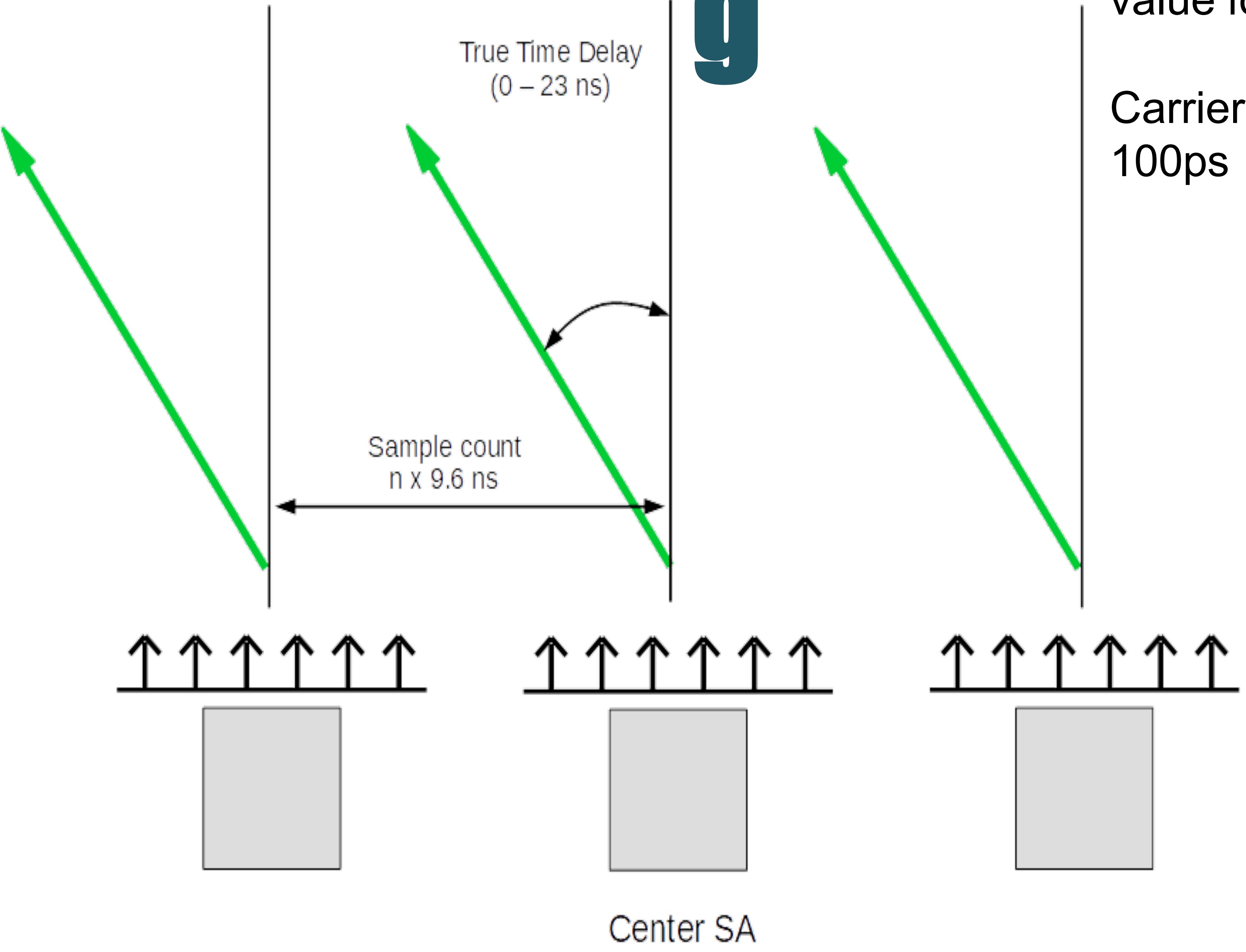
Skibotn, Norway

Skibotn, Norway



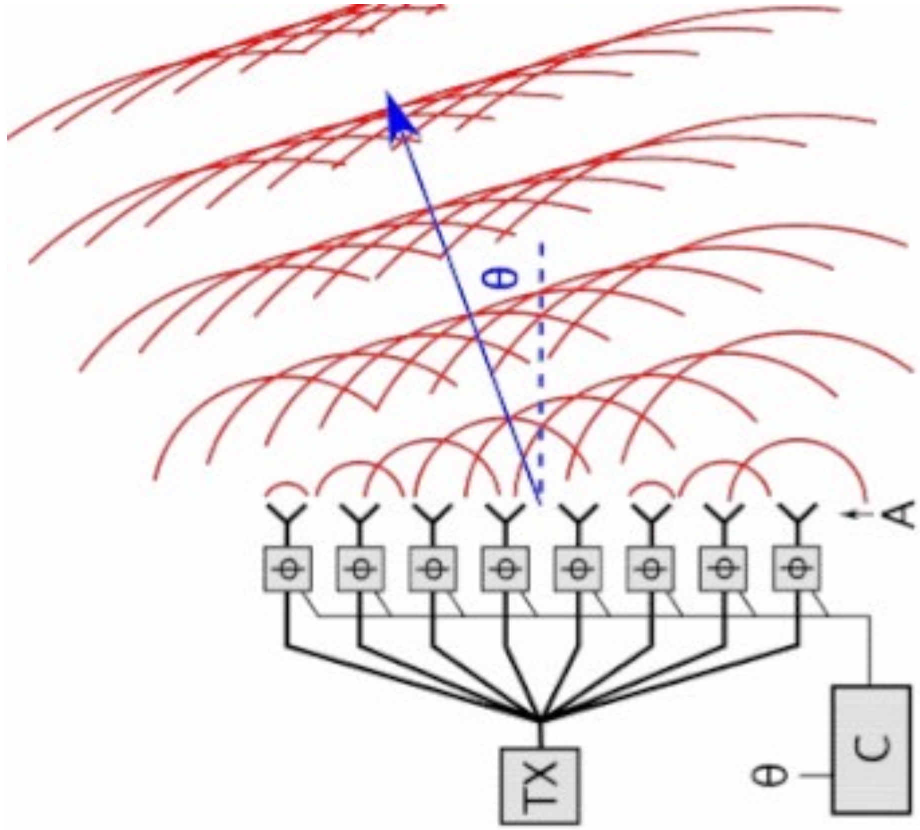
Karesuvanto, Finland

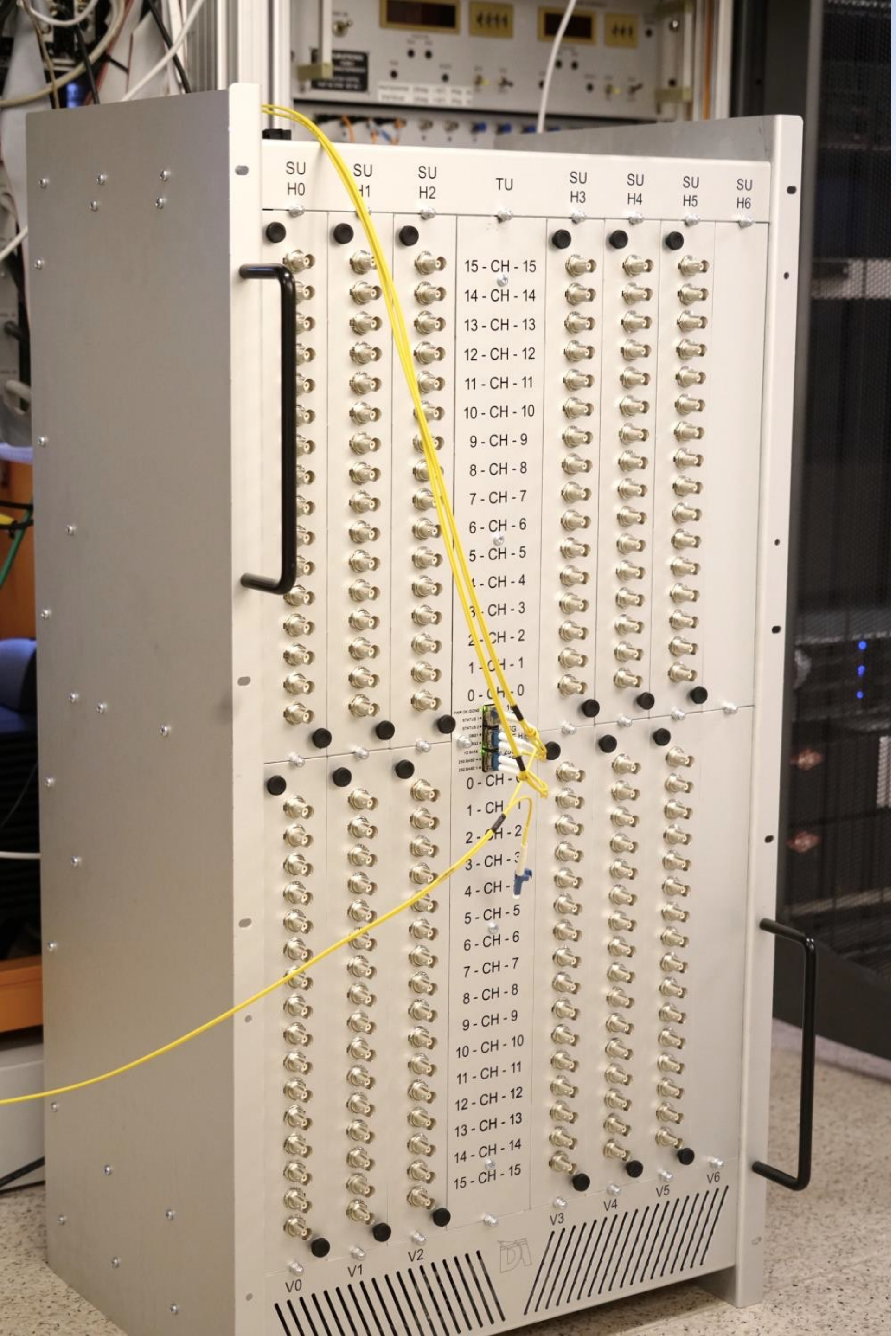
Beamformin g



Each antenna in a subarray has specific delay value for all pointing directions.

Carrier 233 MHz phase difference <10 deg -> 100ps





Receiver

- 91 antennas and 2 polarizations = 182 channels
- 233 MHz +/- 15 MHz analog bandwidth
- First level of beamforming in FPGA
- 10 simultaneous beams
- One 25 GbE link for each polarizations
- True Time Delay filters 0-25 ns, 100 ps resolution
- White Rabbit network synchronization

Transmitters, SAT

- 500W peak 25% duty cycle
- Including Tx/Rx switch

Exciter, PSCU

- 16 channels arbitrary waveform generator with independent phasing
- White Rabbit timing
- Can be included into transmitters

Future Developments

Extend Skibotn transmitters

- Stage 1: From 3 MW to 5 MW
- Stage 2: From 5 MW to 10 MW

Extend Sweden and Finland sites from 55 subarray to 109

- 54 receivers having 182 channels each, or other combinations
- Sub nanosecond synchronization

Build new sites 4 and 5 to Sweden and Norway

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CERN

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SKA Telescopes: a RF overview

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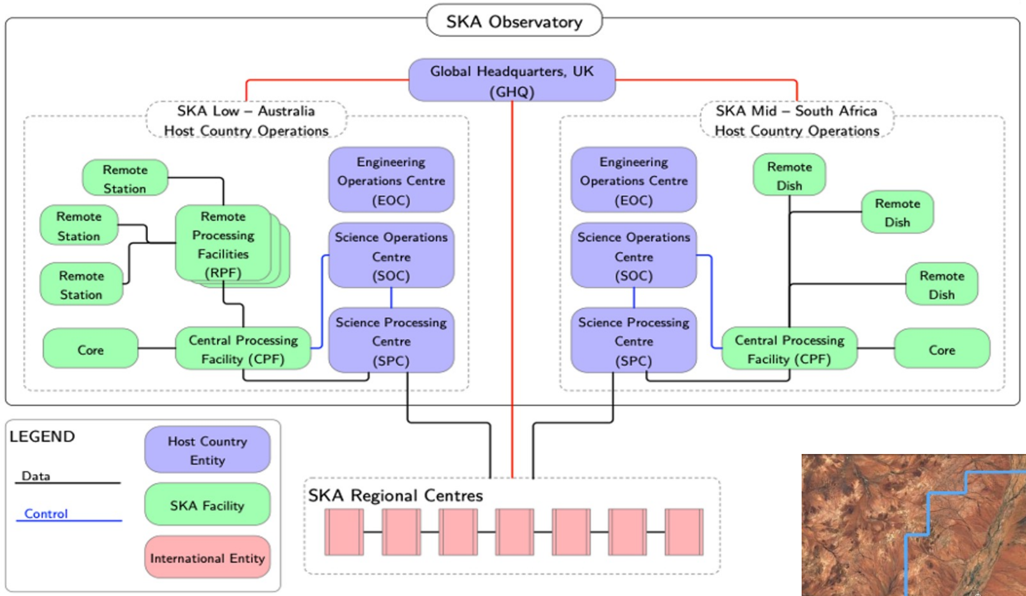
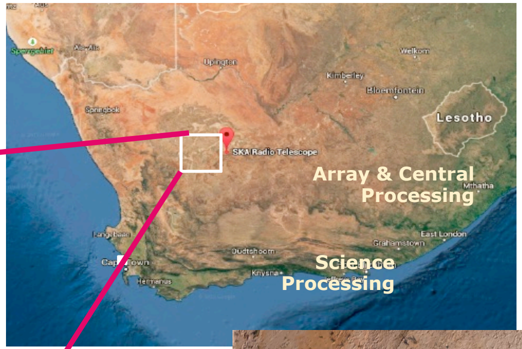
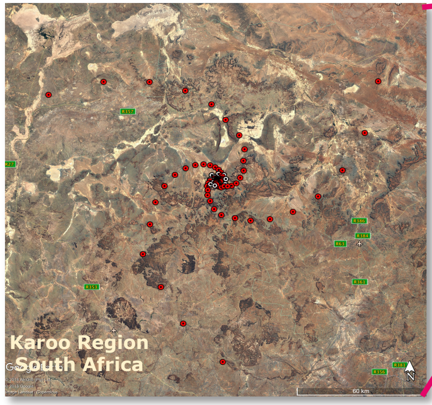
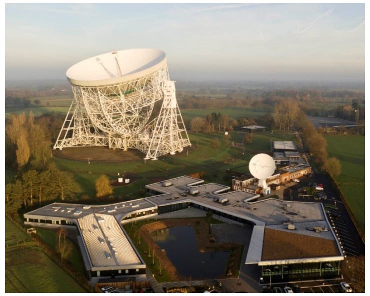
Overview: SKA Observatory

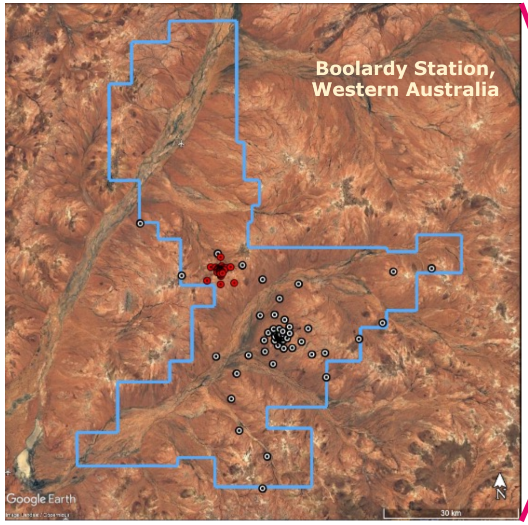








1 Observatory
2 Telescopes
3 Host countries
SKAO Headquarters in Jodrell Bank (UK)



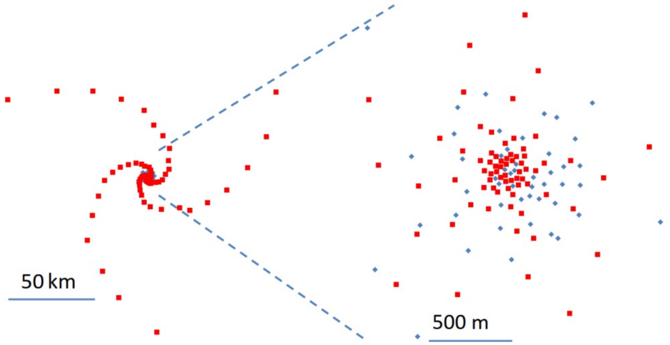
SKAO Mission

"The SKAO's mission is to build and operate cutting-edge radio telescopes to transform our understanding of the Universe and deliver benefits to society through global collaboration and innovation."

MID Telescope

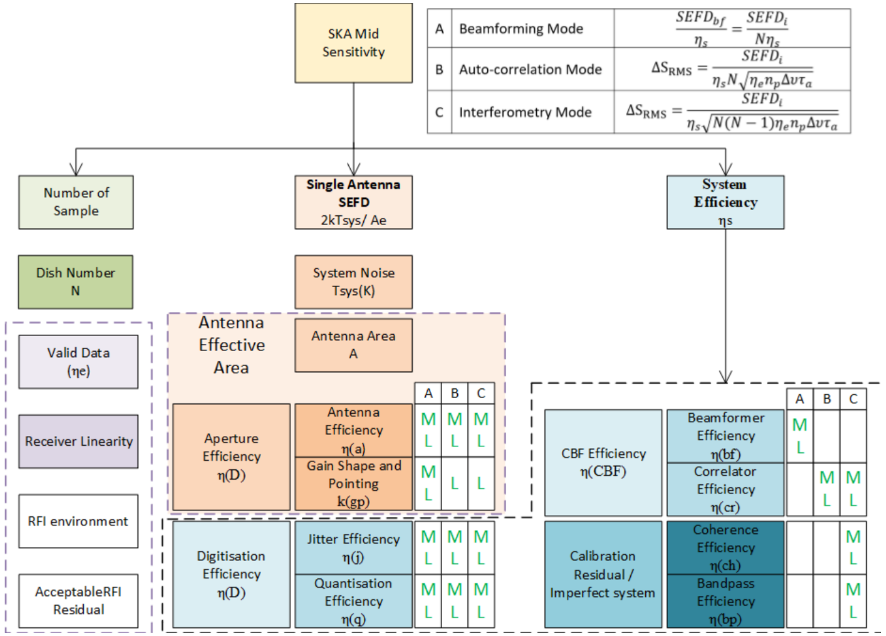
Karoo region of the Northern Cape Province of South Africa

The Mid Telescope consists of 133 SKAO dishes plus 64 MeerKAT dishes. The array is arranged in a dense core with quasi-random distribution, and spiral arms going out to create the longest baselines that go up to 150km.
The telescope will cover the range from 350 MHz up to 15.4 GHz.

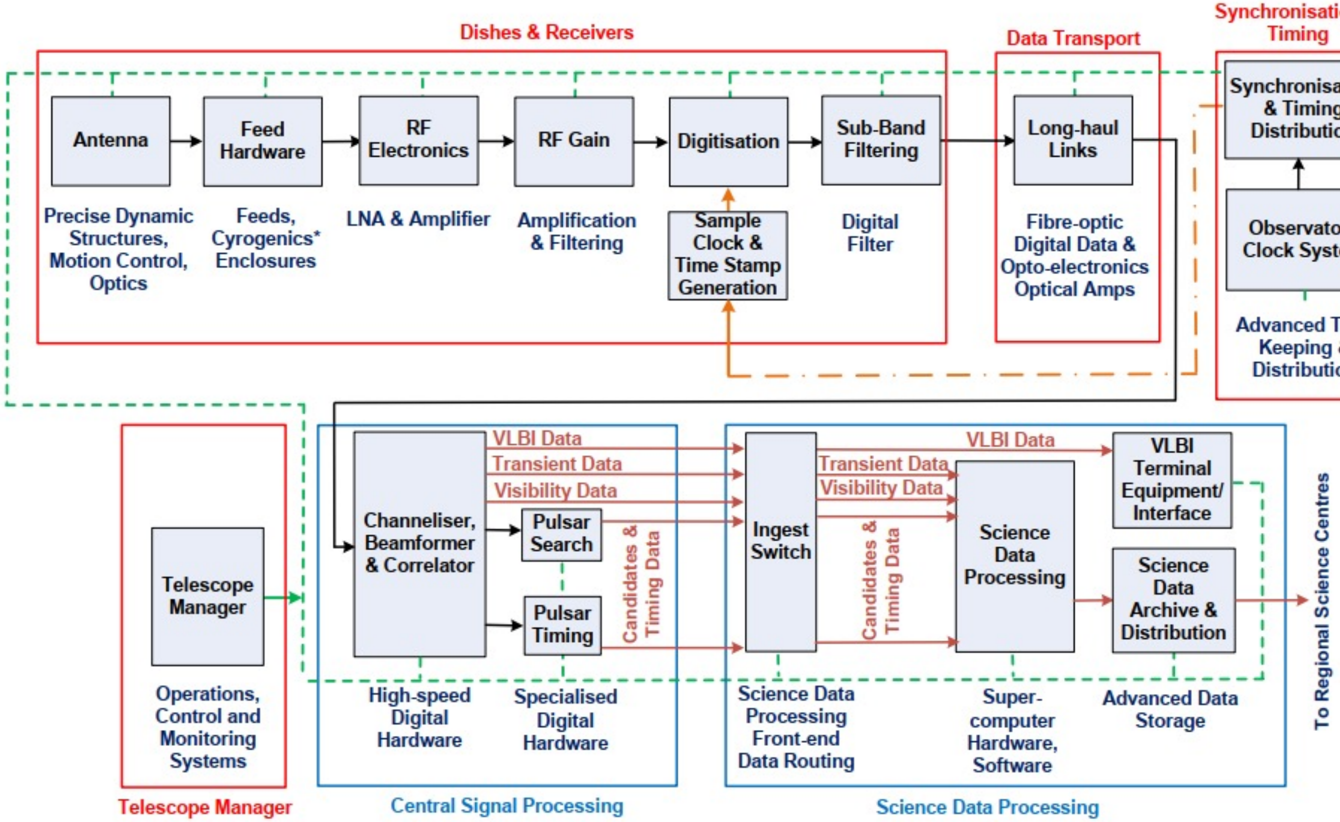


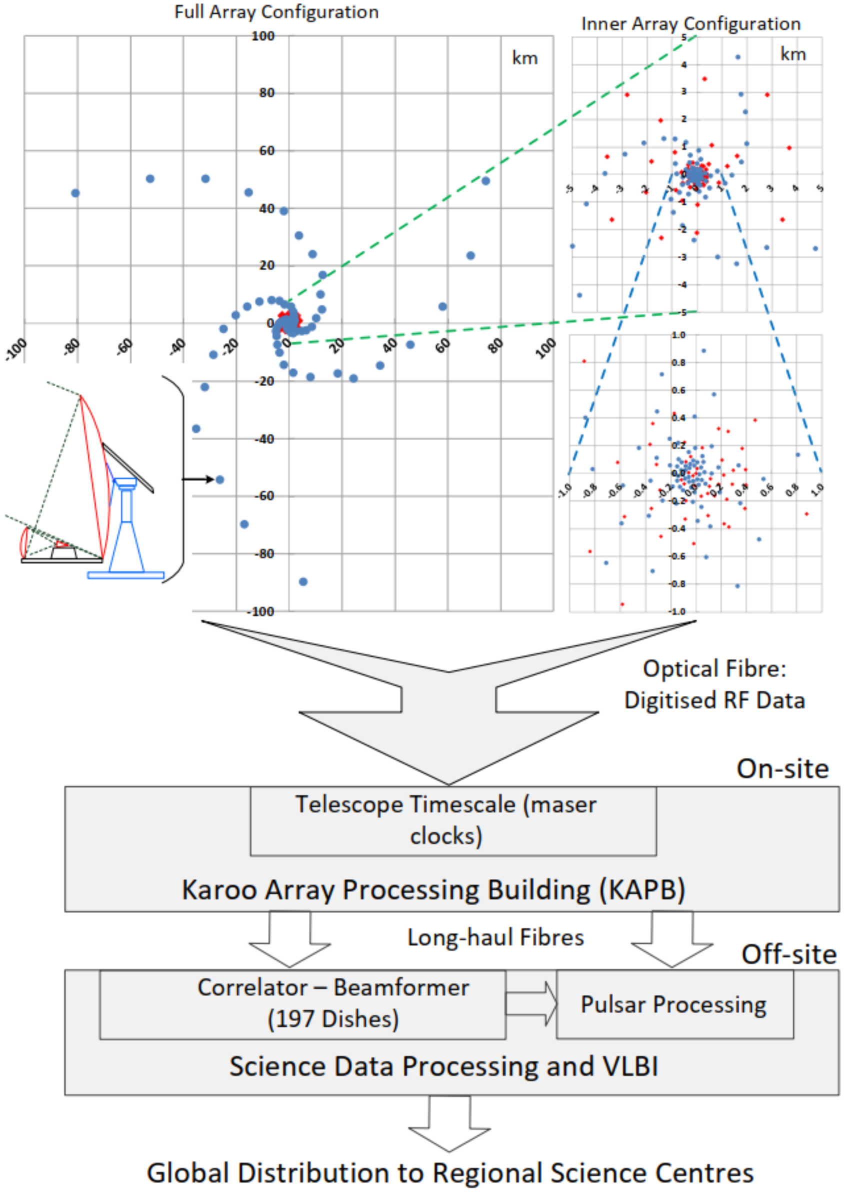
Sensitivity is the primary design driver.

Extensive design and qualification have been carried out to optimise single-pixel feeds, reflector structure and feed optics to achieve low system temperature and high efficiency.
The LNAs are cryogenically cooled (except for Band 1) using a helium system to provide low system noise



The Mid Telescope Architecture



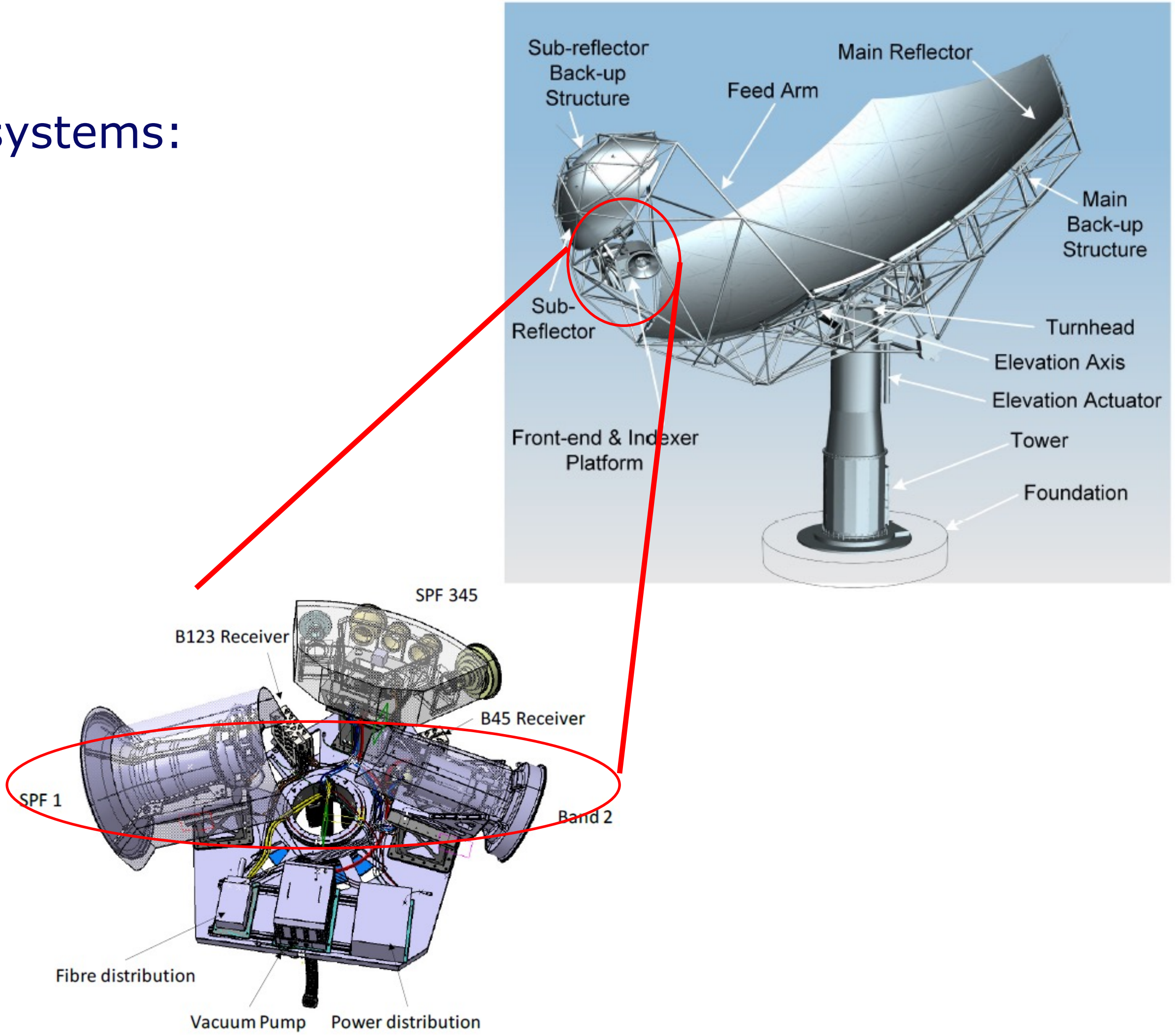


MID Dish System

An overview of the status and progresses of the Dish system and sub-systems development is shown in this presentation.

The MID Dish system consists of the following sub-systems:

- Dish Structure
- Band 1 Single Pixel Feed (SPF B1)
- Band 2 Single Pixel Feed (SPF B2)
- Band 345 Single Pixel Feed (SPF B345(6))
- SPFRx
- Helium services
- SPF Services (SPF Controller & Vacuum Services)
- Dish Fibre Network (DFN)
- Local Monitoring & Control (LMC)



Estimated Single Dish Performance

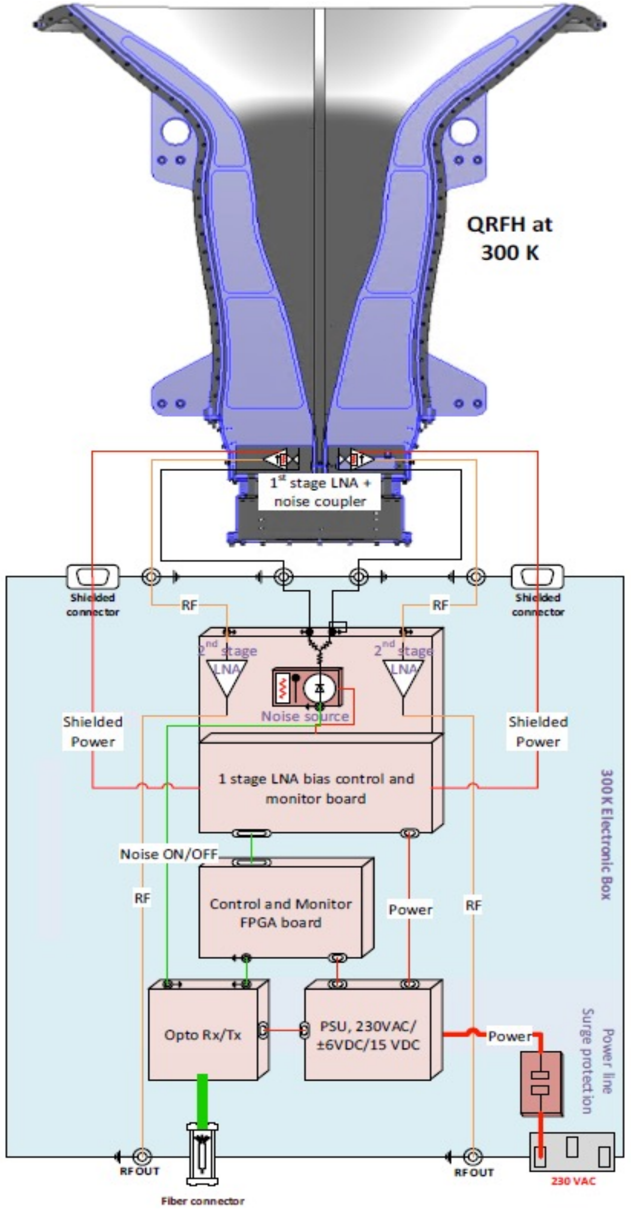
- Sensitivity, efficiency and feed and receiver noise of the single SKA dish have been estimated
- Band 1 and Band 2 data are estimated around the mid-band frequency at an elevation of 45°
- Band 5 data are averaged across the band with the dish pointing at zenith

Parameter	Band 1	Band 2	Band 5a	Band 5b
Frequency (GHz)	0.7	1.4	Average	Average
Cosmic Background (K)	2.73	2.73	2.73	2.73
Galactic (K)	4.53	0.67	0.01	0.002
Atmosphere (K)	2.2	2.6	2.0 [a]	4.3 [a]
Spillover (K)	3	0.9	0.8 [a]	0.2 [a]
Total $T_{antenna}$ (K)	12.5	6.9	5.5 [a]	7.2 [a]
$T_{receiver}$ (K) [b]	13.5	5.6	7.4	9.2
$T_{structure\ and\ backend}$ (K)	1	1	1.6	1.6
T_{System} (K)	27	13.5	14.5 [a]	18.0 [a]
Aperture Efficiency, η [c]	0.81	0.90	0.84	0.83
Effective area, A_e, (m^2)	143.1	159	148.4	146.7
A_e/T_{sys} (m^2/K)	5.3	11.8	10.2 [a]	8.1 [a]

a Referred to zenith
b Includes the feed and vacuum window contributions
c Assuming perfect optics, i.e. excluding mechanical tolerance of the structure and surface extensions resulting from mechanical considerations

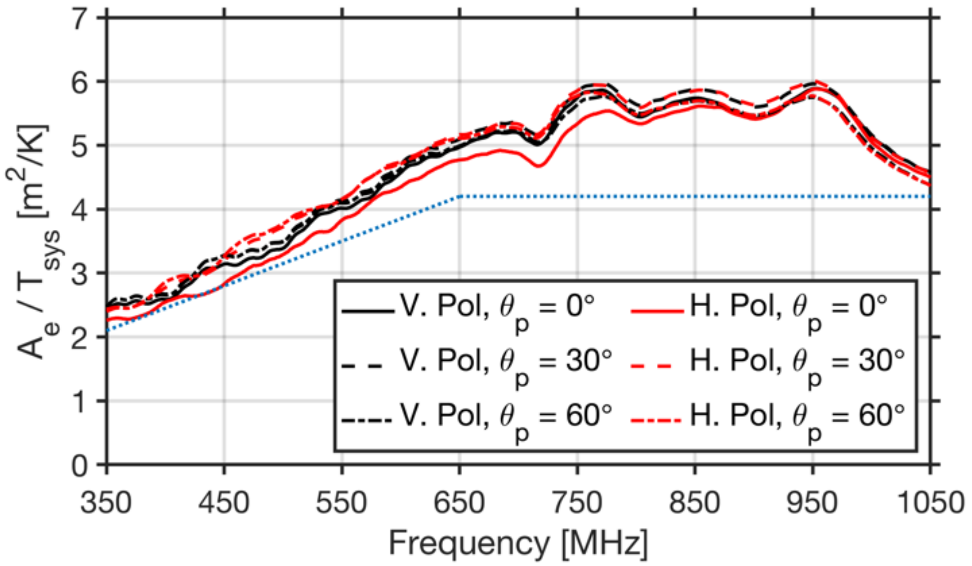
SPF Band1

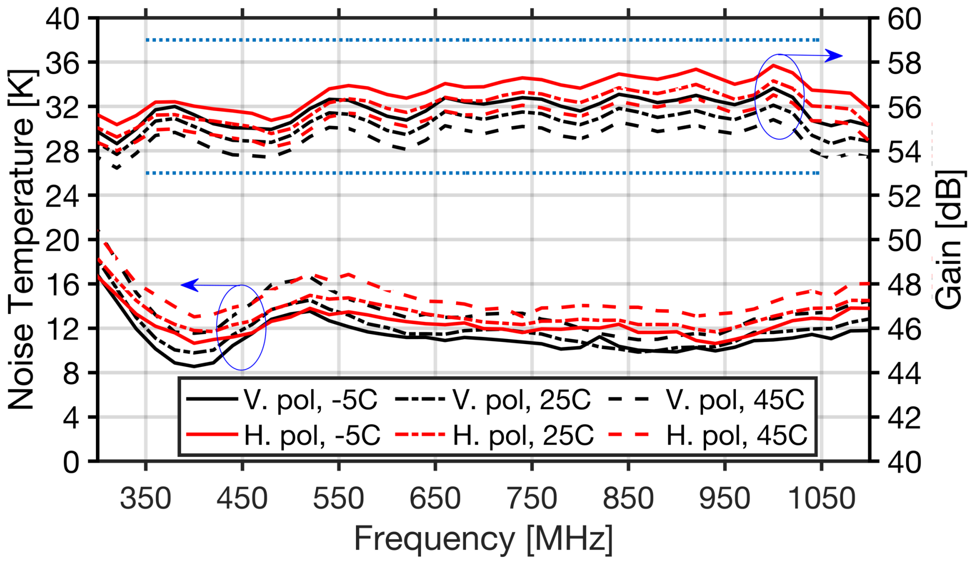
- **AAC Omnisys** has been awarded the contract for the production of 80 SPF Band 1.
- The SPF B1 is a room temperature system operating over the frequency band 0.35 to 1.05 GHz
- Dual linear pol Quad Ridged Feed Horn (QRFH) of overall length of 1.5 m.
- Two room temperature LNAs (Low Noise Factory) integrated in the ridges close to the feed pins of the two orthogonal polarisations.
- Noise-injection coupler and LNAs are combined in single assembly. The calibration signal is injected prior to the first amplification stage.
- 2nd stage LNAs, calibration noise diode, monitor and control electronics, etc. are located in the feed-controller enclosure mounted on the rear of the feed horn.
- A polycarbonate radome protects the aperture of the horn, while the feed is made moisture proof. An environmental shield protects the feed package from rain and direct sunlight.
- The feed is over a meter high and weighs about 180 kg



SPF B1 Prototype developed by Onsala Observatory

SPF Band1 – expected performance

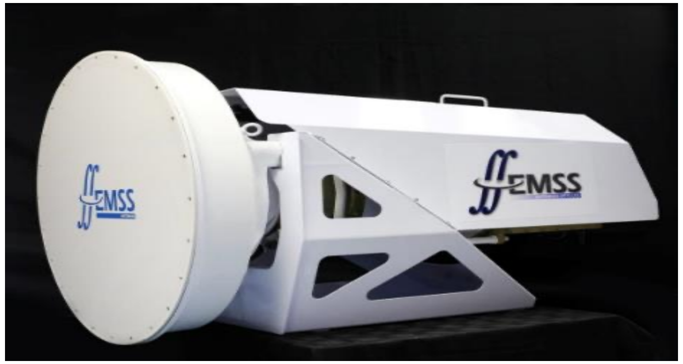


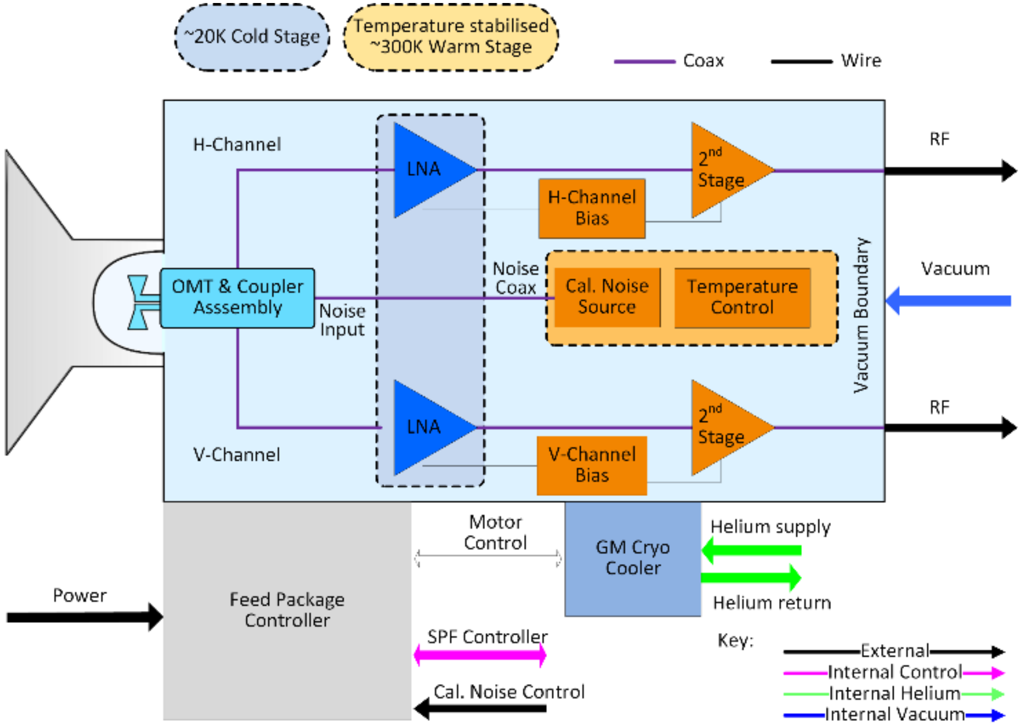


A combination of lab tests, on dish tests and simulations have been used to estimate the expected performance

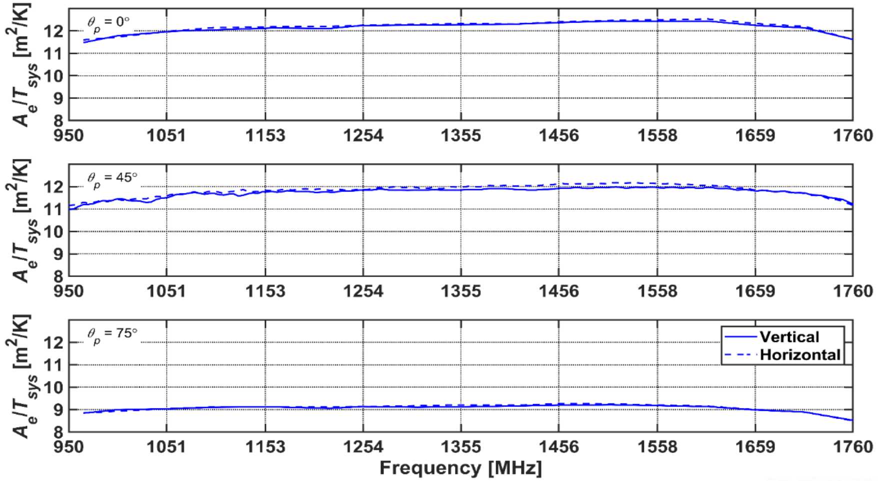
SPF Band2

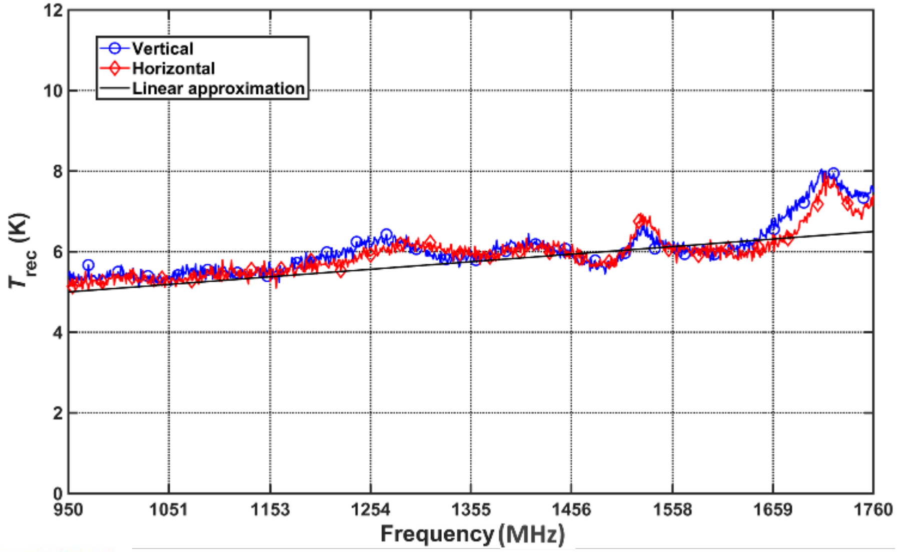
- **EMSS** has been awarded with the production of 64 SPF Band 2.
- Originally developed by EMSS Antennas, operates over the frequency band 0.95 GHz - 1.76 GHz.
- The feed package consists of:
  - an ambient temperature wide flare angle axially corrugated conical horn,
  - a cryogenic OMT (pair of orthogonal dipoles),
  - LNAs cooled to below 20 K and a room temperature amplification and matching stage.
- The waveguide is at ambient temperature with a High Density Polyethylene (HDPE) dome over the cryogenic dipoles. The calibration noise source is thermally stabilized at ambient temperature inside the cryostat.
- A sun shield reduces solar heating and provides protection against direct rain. Moisture collection is limited by protecting the horn aperture with a hydrophobic radome membrane and desiccator breather

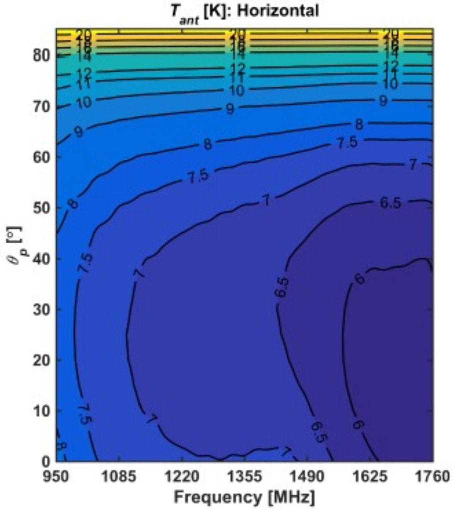


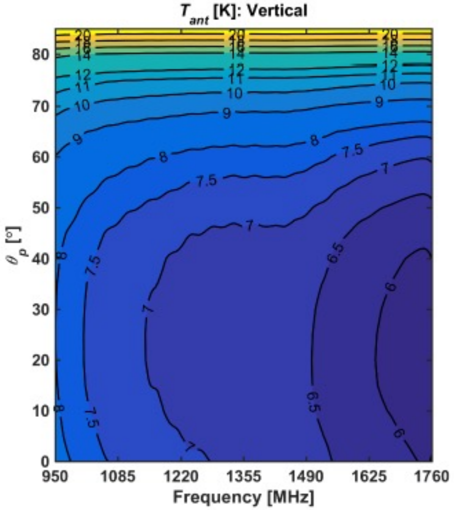


SPF Band2 – expected performance





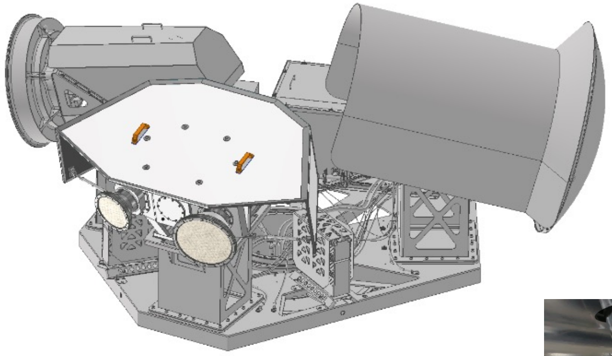


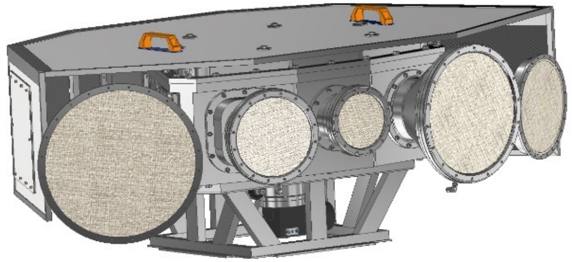


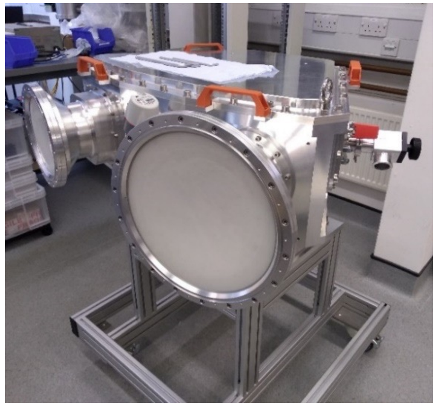
A combination of lab tests and simulations have been used to estimate the expected performance

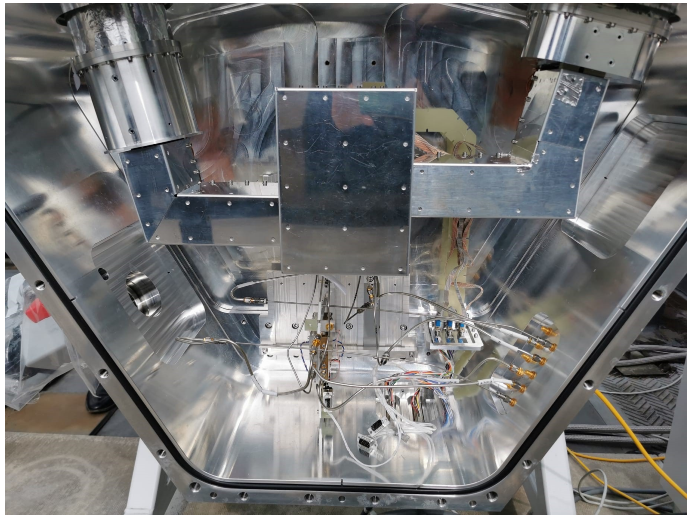
SPF Band345(6)

- SPF Band 345(6) feed package, designed and qualified at the **University of Oxford**
- Provision to house up to 5 horns for Band 3 (1.65-3.05 GHz), 4 (2.80-5.18 GHz), **5a (4.60 – 8.50 GHz), 5b (8.30 – 15.40 GHz)** and 6 (15.00-24.00 GHz) in a single modular cryostat.
- Currently populated with higher science priority Band 5a and 5b feed horns, OMTs and RF chains.
- Band 5a and Band 5b horns were designed by JLRAT/CETC54, China. Both (quad-ridged type) Band 5a and Band 5b OMTs have been designed and manufactured by University of Oxford.
- Wide flare-angle corrugated horns are cooled to ~80K. OMTs and LNAs cooled to ~12 K (second stage). Warm RF chain and noise source are temp controlled
- Horns placed behind a Mylar sheet supported by polyethylene foam. Weather/sun shield in place

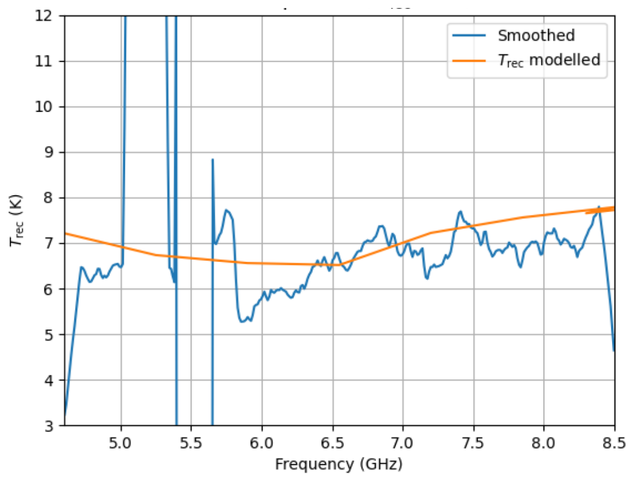


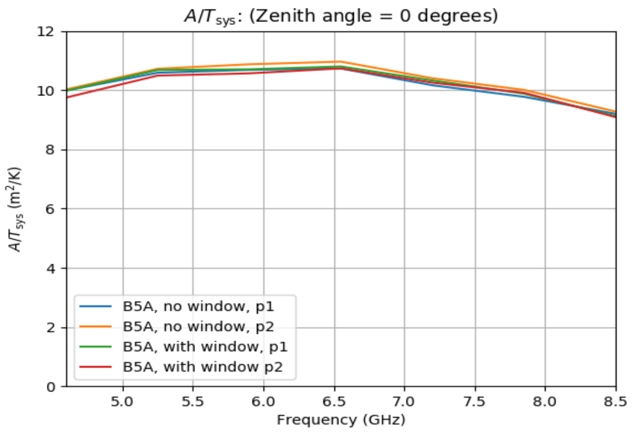


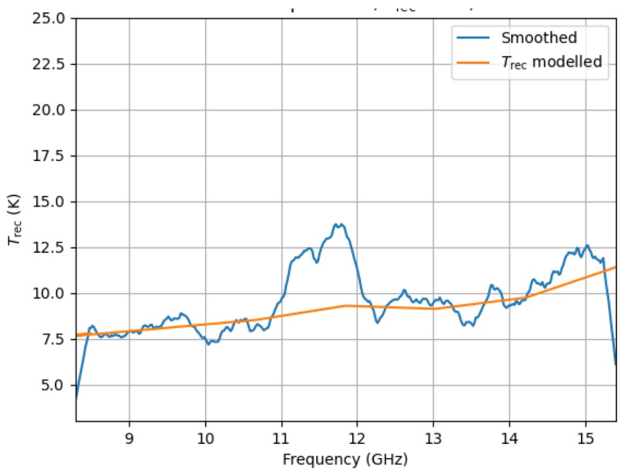


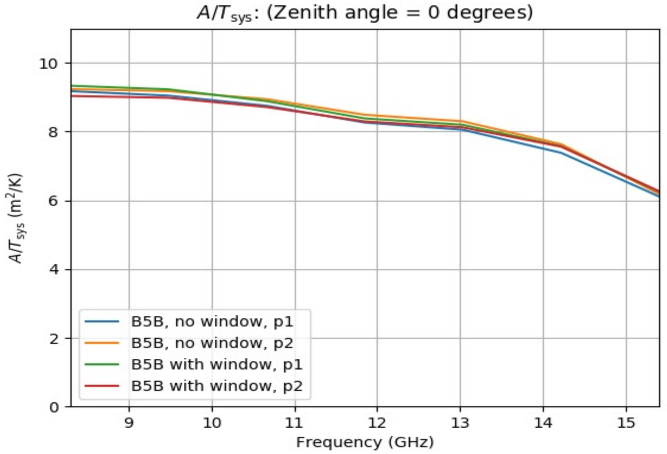


SPF Band345(6) – expected performance







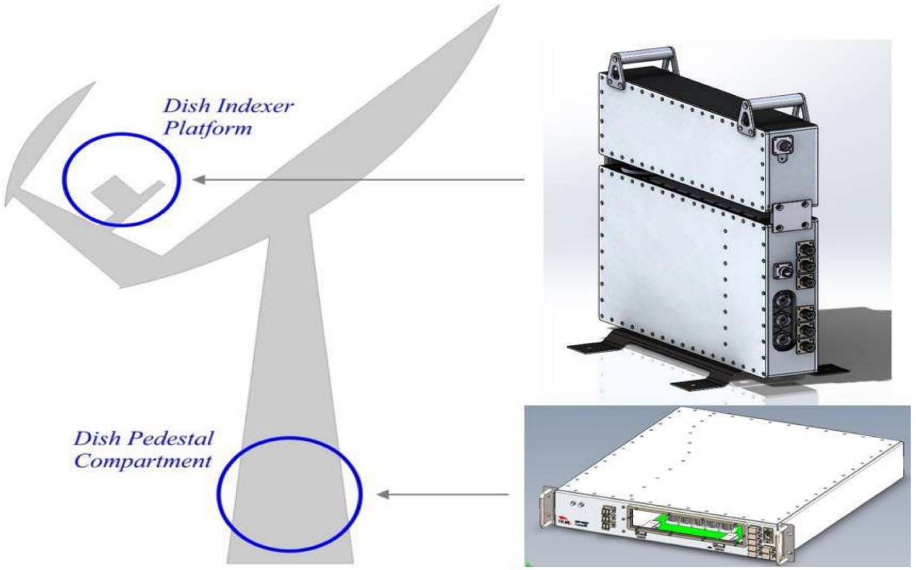


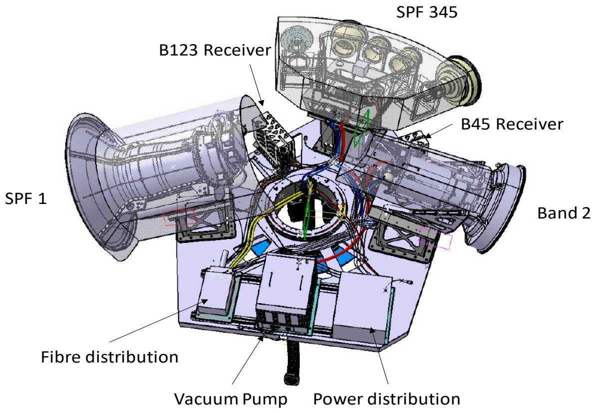
A combination of lab tests and simulations have been used to estimate the expected performance

SPFRx Architecture

Objectives have led to **three sectional design** of SPFRx:

- Two EMI shielded enclosures at the dish indexer - **RXS123** (contract awarded to **Qamcom Research & Technology**) and **RXS45** (under development at **LAB**) - include the analog components, ADCs with minimal digital support circuitry.
- One shielded unit in the pedestal of the antenna – **RXPU** (sw/fw contract planned with **National Research Council Canada**) – includes digital signal processing hardware, which tends to emit high levels of EMI, is in the multiple layered shielded dish pedestal unit.





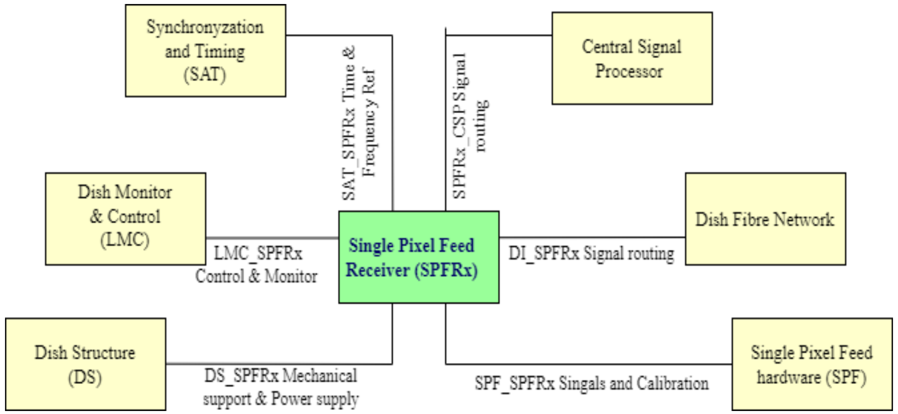
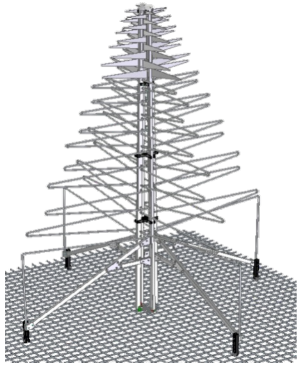


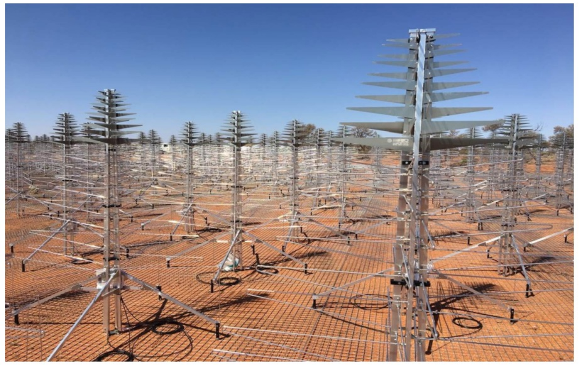
Figure: SPFRx Device Locations on Dish (left), Layout of the Dish Indexer showing the RXS123 and RXS45 enclosure positions (mid), Interface of SPFRx with other systems

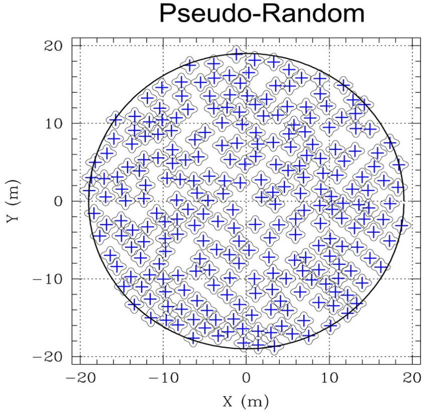
LOW Telescope

In the fully deployed stage, the Low Telescope consists of 512 field stations. Each station consists of 256 closely spaced antennas for a total of 131072 antennas. The telescope operates over a frequency range from 50 MHz to 350 MHz.

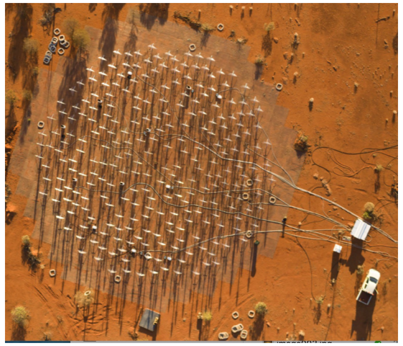


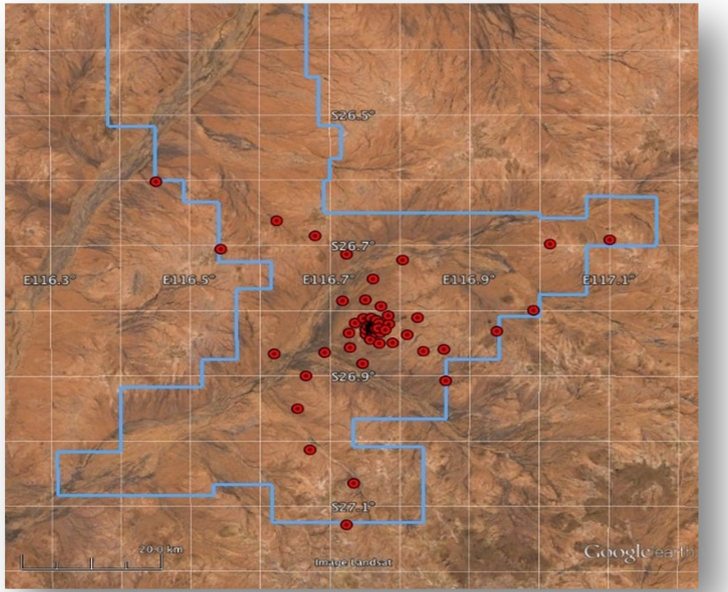
Antenna type,
Antenna Design,
Design Improvements





Station Layout

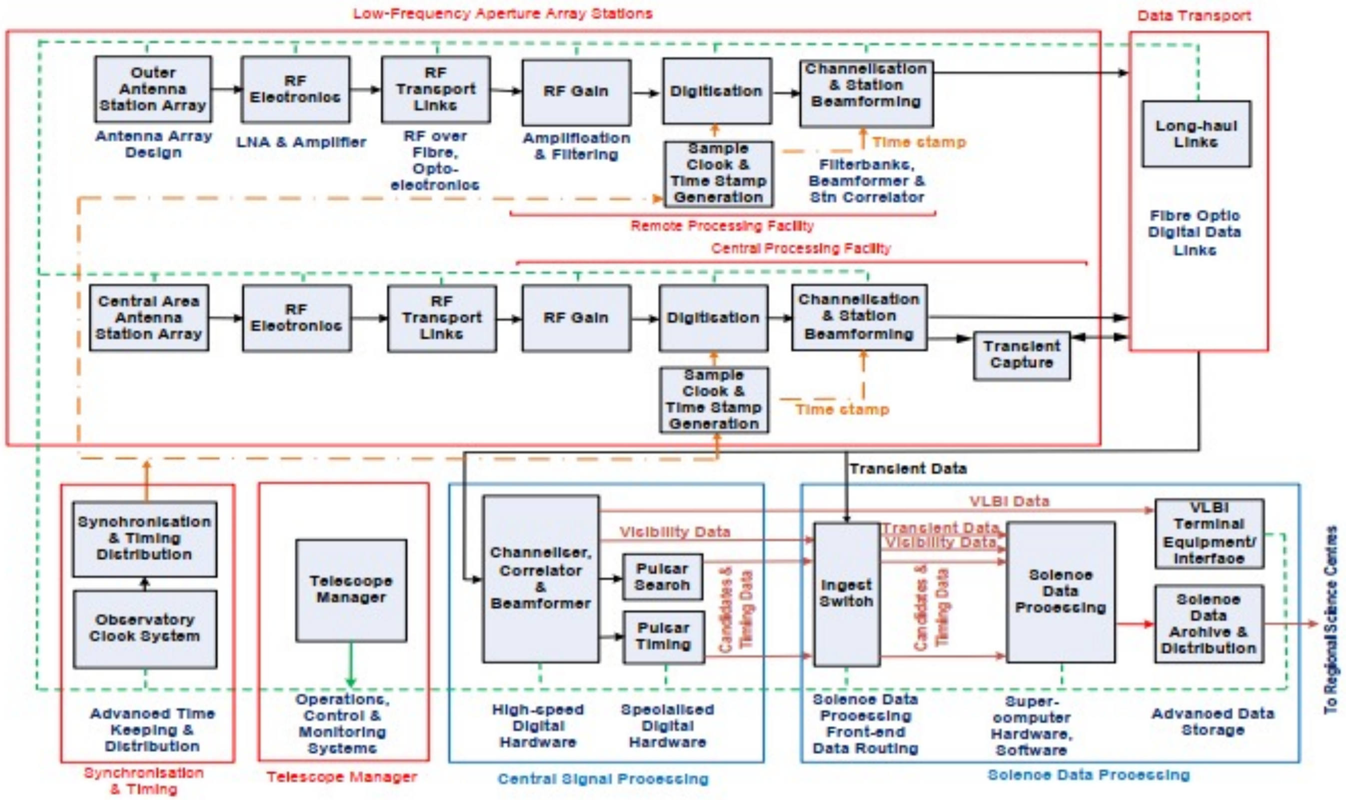


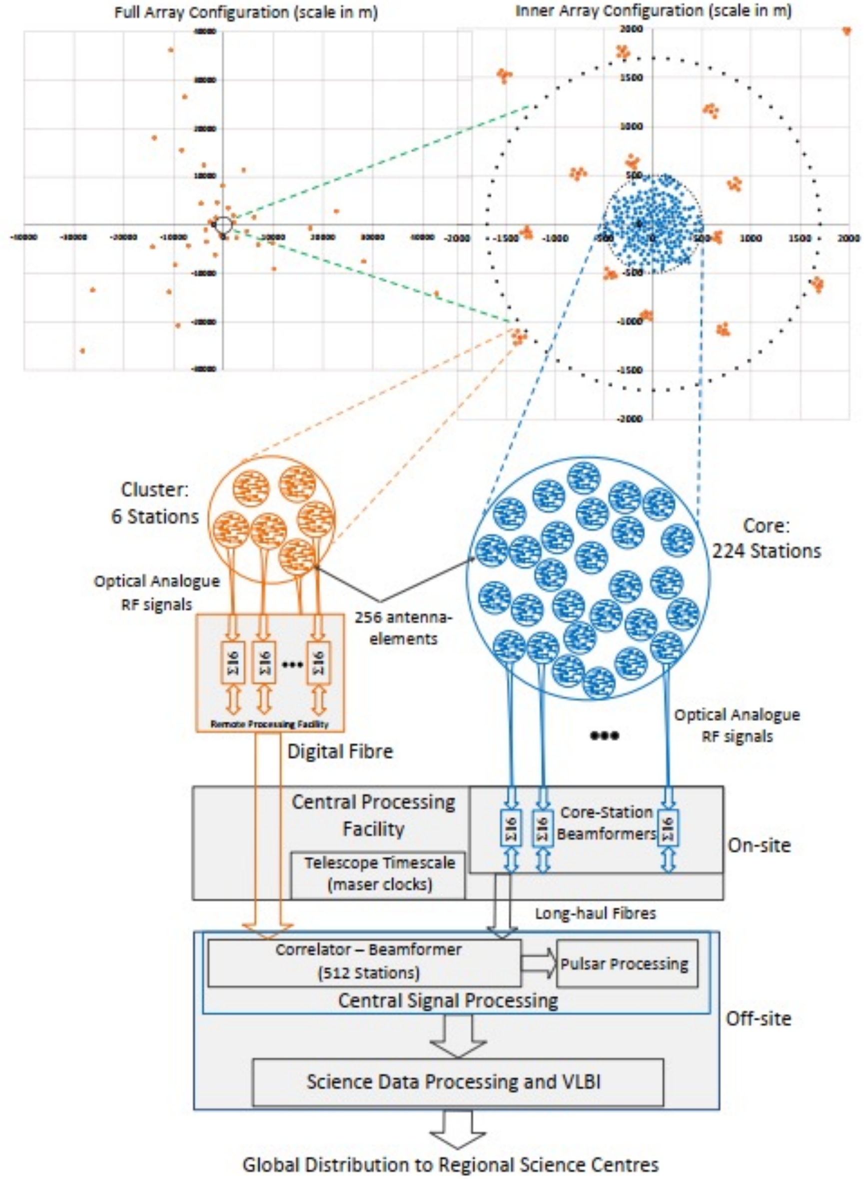


SKA-Low Field Stations

Murchison Radio Observatory site at Boolardy in Western Australia

The Low Telescope Architecture

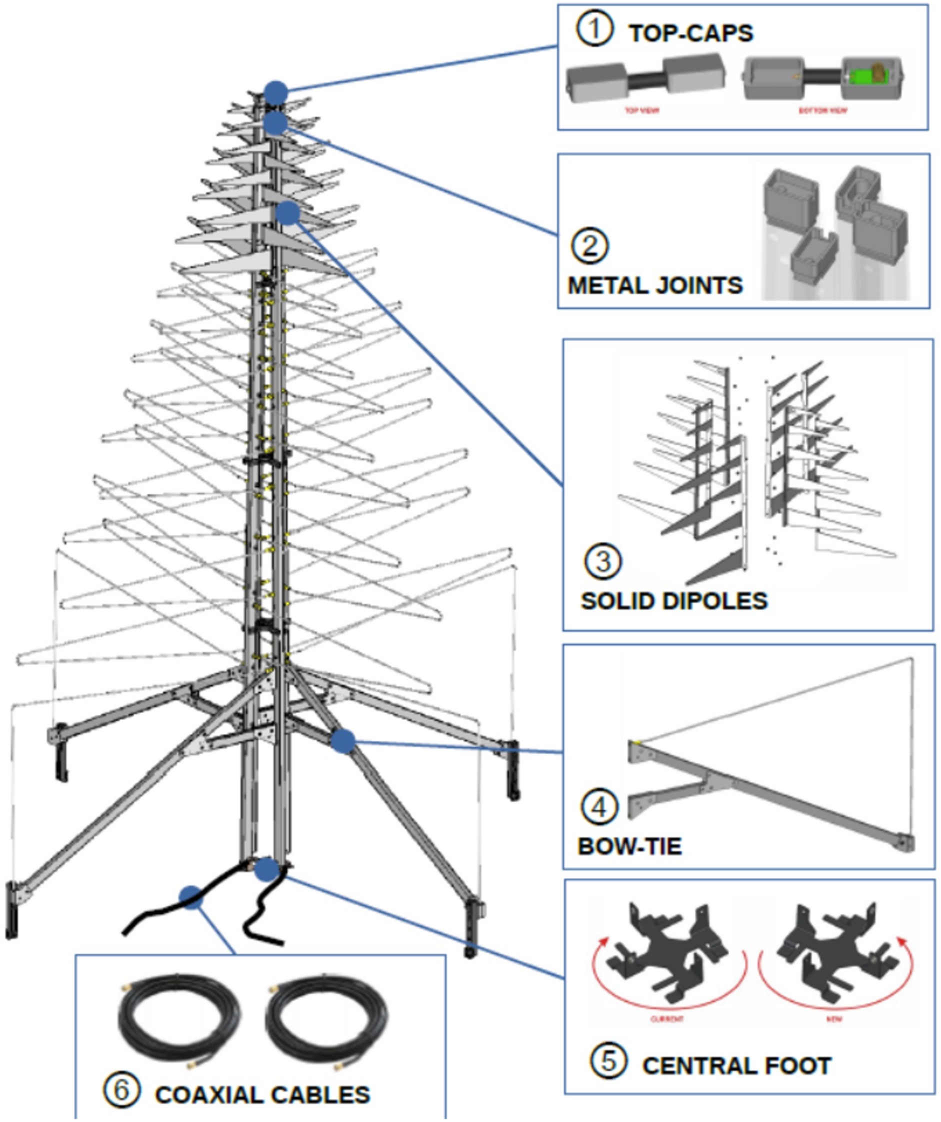




Antenna Design

Characteristic	
Material	AA6060 + AA5754(for solid dipoles)
Dimensions	1.6 x 2.1 m (width x height)
Weight	<10KG
Bandwidth	50MHz -350MHz
Input Return Loss	<-13 over the band
Amplifier Gain	45 dB Typical
Gain flatness	3 db Typical
Architecture	Two LNAs on top of the antenna located inside the top caps
Antenna feeding	Single-ended with 50-ohm impedance

While the noise temperature of the antenna is below 40K, the sky is the main contributor to the overall noise, therefore the design drivers are cost and reliability



UK LNA under evaluation. Improved S22 matching on SMB connector and improved environmental sealing

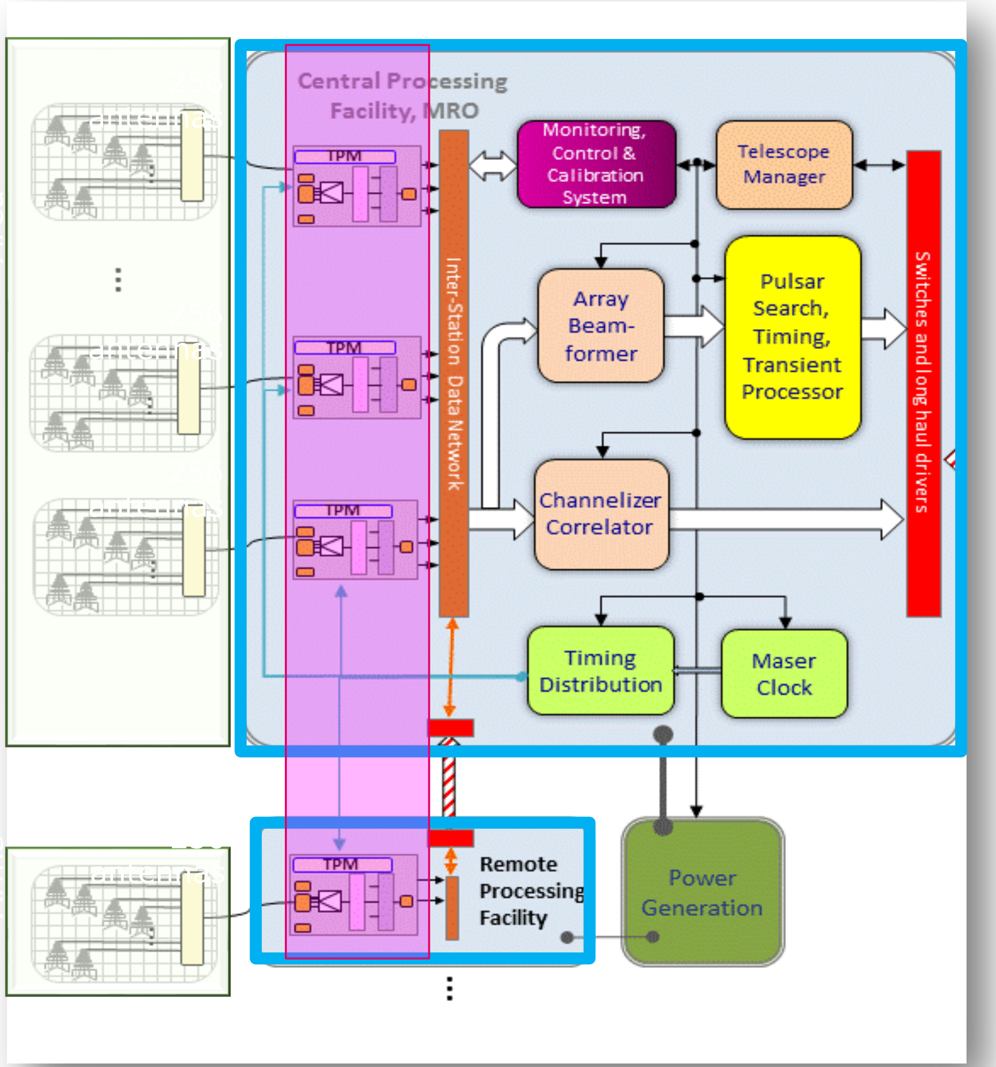
Metal Joints modification to improve environmental sealing and simplify assembly and maintenance

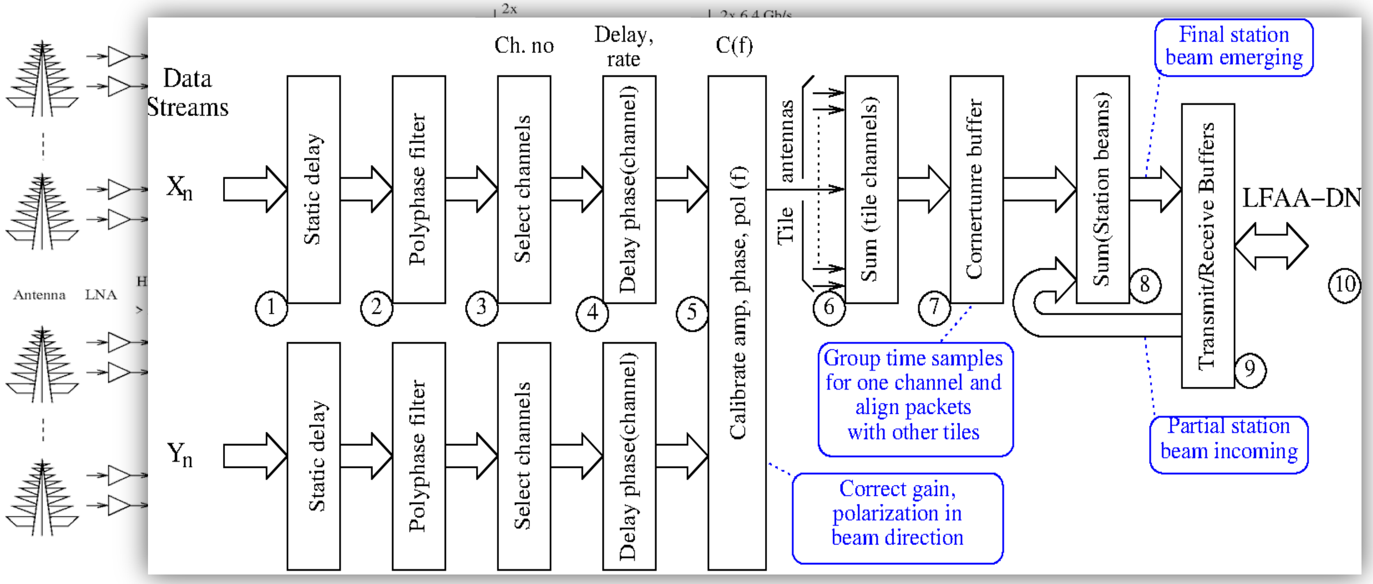
Screws on solid dipoles to be replaced by automated mig welding to reduce assembly time.

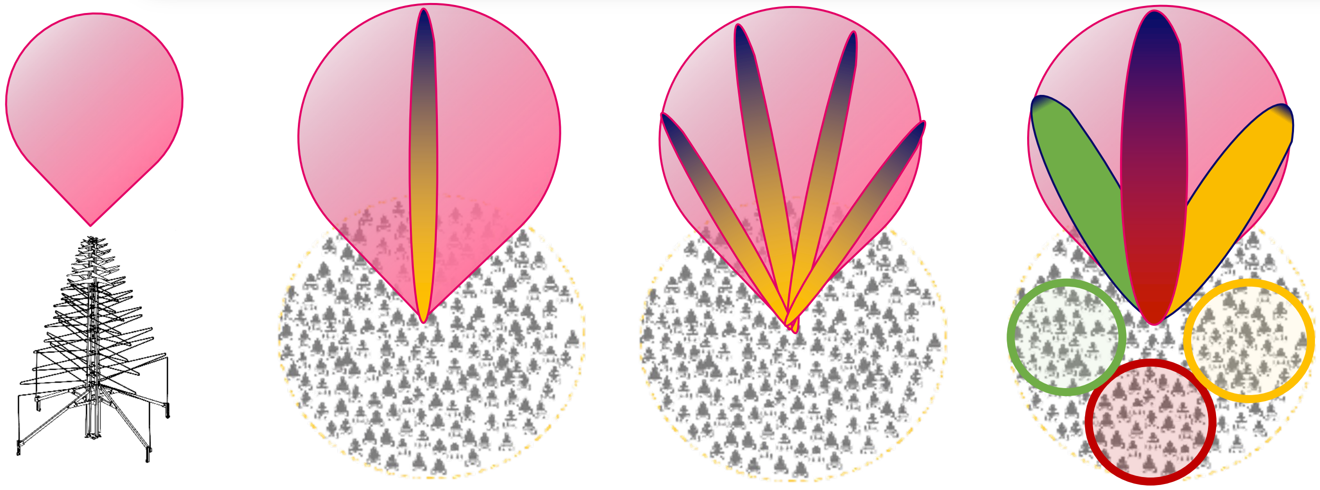
Rivets on the bow tie elements to be replaced by automated MIG welding for mass production.

Mirroring the baseplate to improve installation on ground plane

A very complex beamformer …….



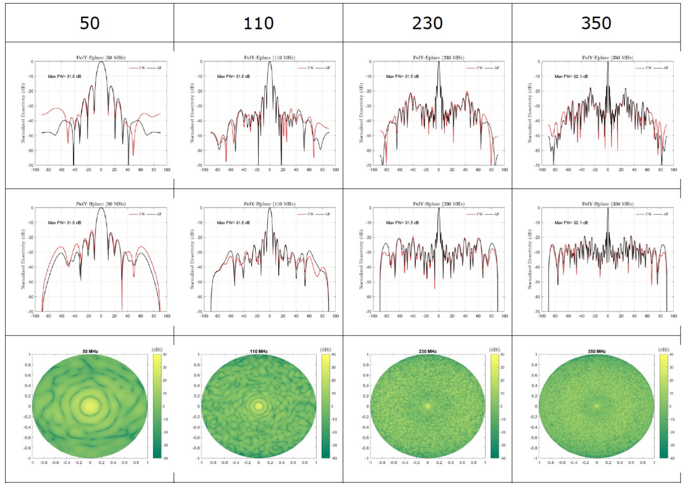




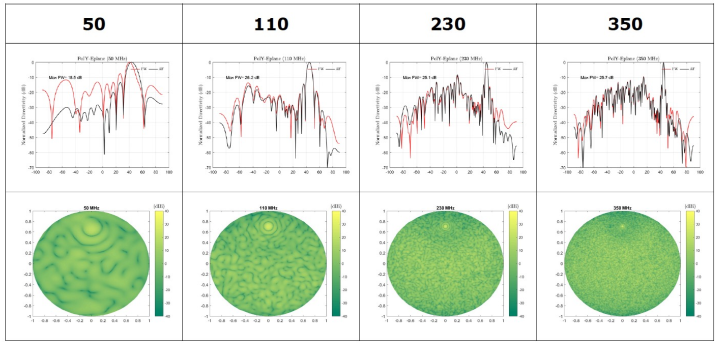
Antenna Beam | **Station Beam** | **Station Multi-Beams** | **Sub-Stations Beams**

Expected Performance

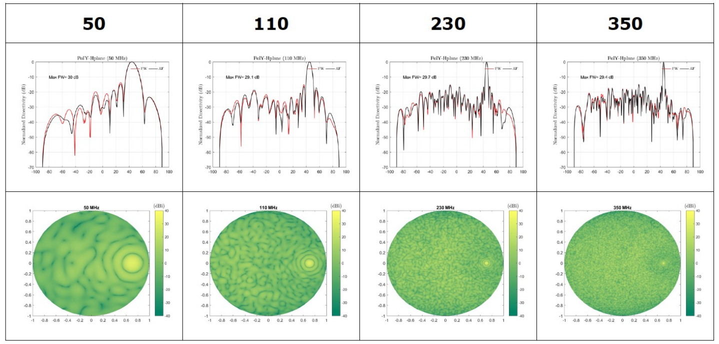
The Low station system is electrically large and operates over a very wide frequency bandwidth, it is extremely computationally intense and great care is put in the optimisation of it



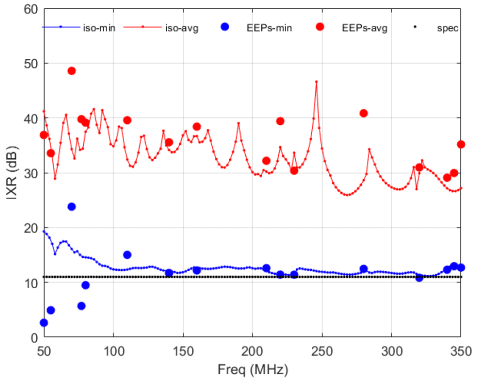
Stations Beam patterns at zenith (E and H planes)



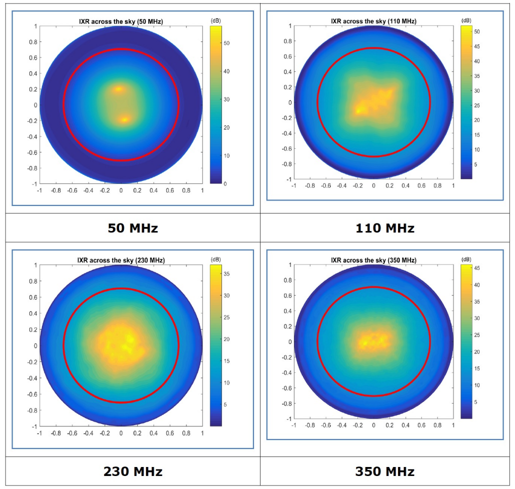
Stations Beam patterns at 45deg (E plane)



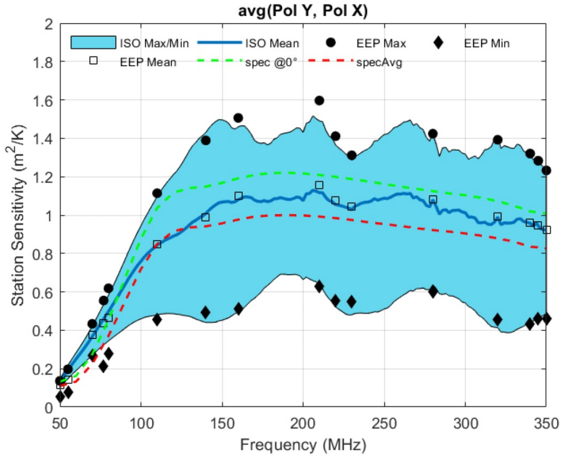
Stations Beam patterns at 45deg (H plane)



Station minimum, average IXR within the frequency range. This is computed both considering and isolated antenna, and also taking into account the embedded element patterns (EEPs) for several frequencies



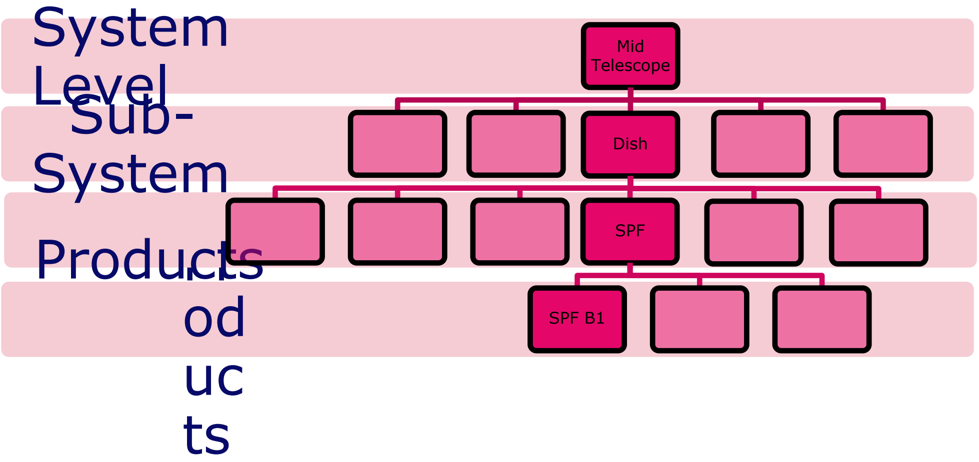
Station IXR maps

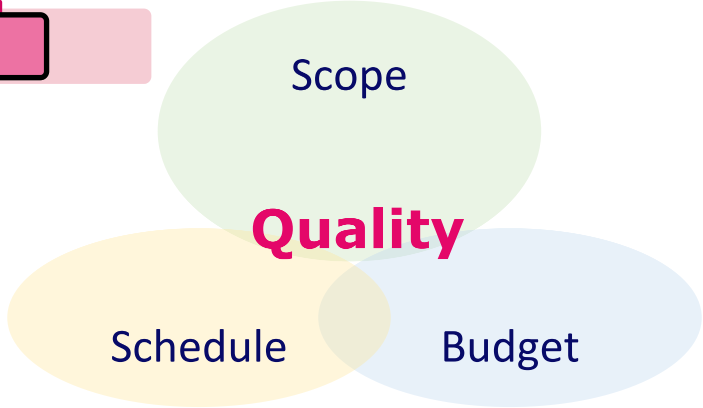


Estimated sensitivity for the full array

What does SKAO need from the suppliers?

- SKA is a complex project that involves multiple contractors and suppliers around the globe





- Challenging deadlines are met only if each contractors, suppliers, partners and institutions deliver on time for integration and verification at telescope level

- SKA Low RF design is finalized and consolidated
- SKA Mid RF front end and Structure are largely finalized, SPF Band345 has recently undergone qualification tests.

Thank you - Questions?

We recognise and acknowledge the Indigenous peoples and cultures that have traditionally lived on the lands on which our facilities are located.

SKAO

www.skao.int

POWER AND RF SYSTEMS

Carlo Rossi
Senior Accelerator Physicist
CERN

Olivier Brunner
Researcher
CERN

Alice Pellegrini
Team Leader Specialist Engineering Teams
SKA

Harri Hellgren
System Integration Engineer
EISCAT

BREAK

Swedish fika – refreshments with opportunities for informal networking and 1-to-1 meetings