New Robust Approaches to Designing Large Radio Research Instruments

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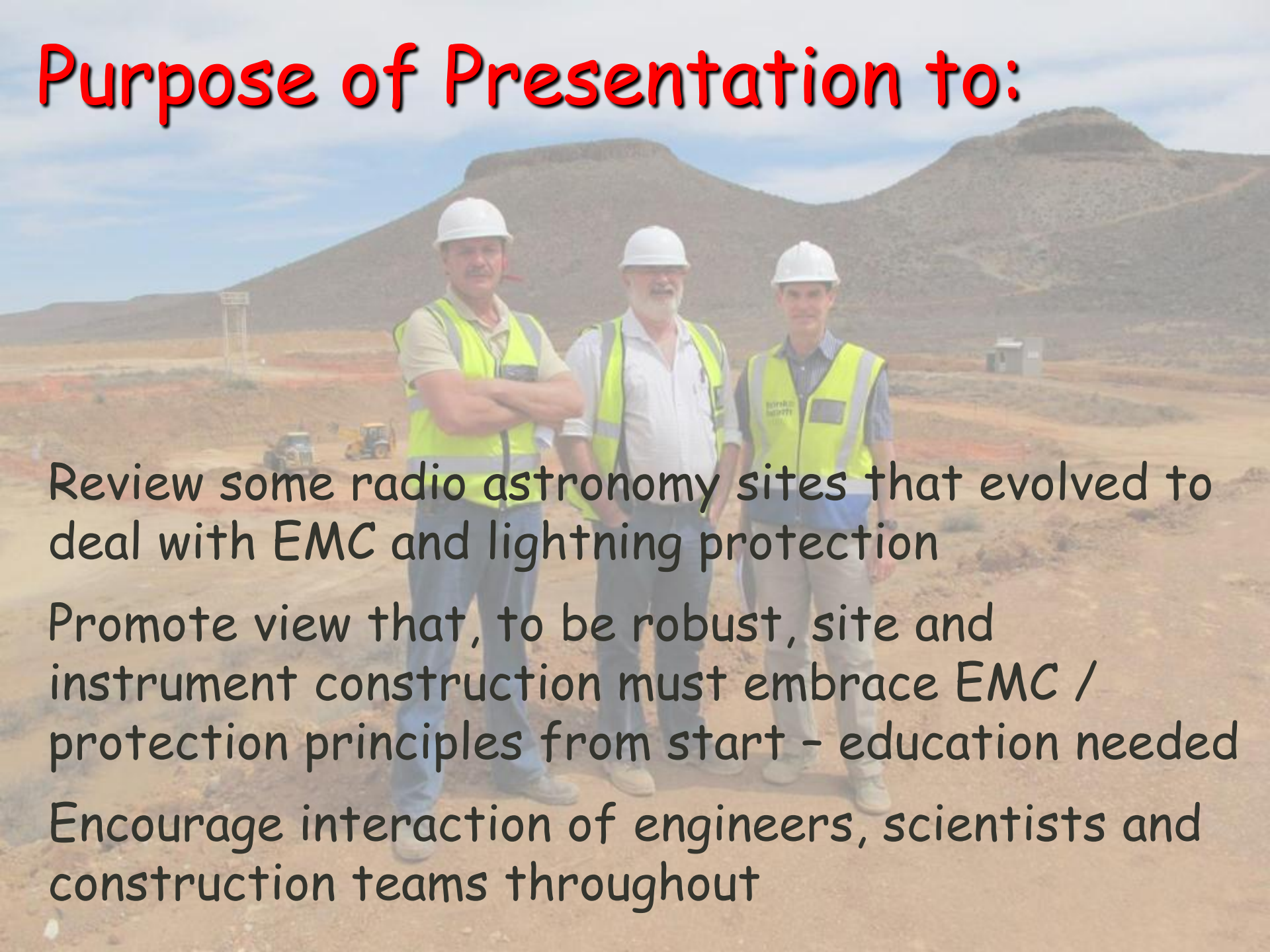
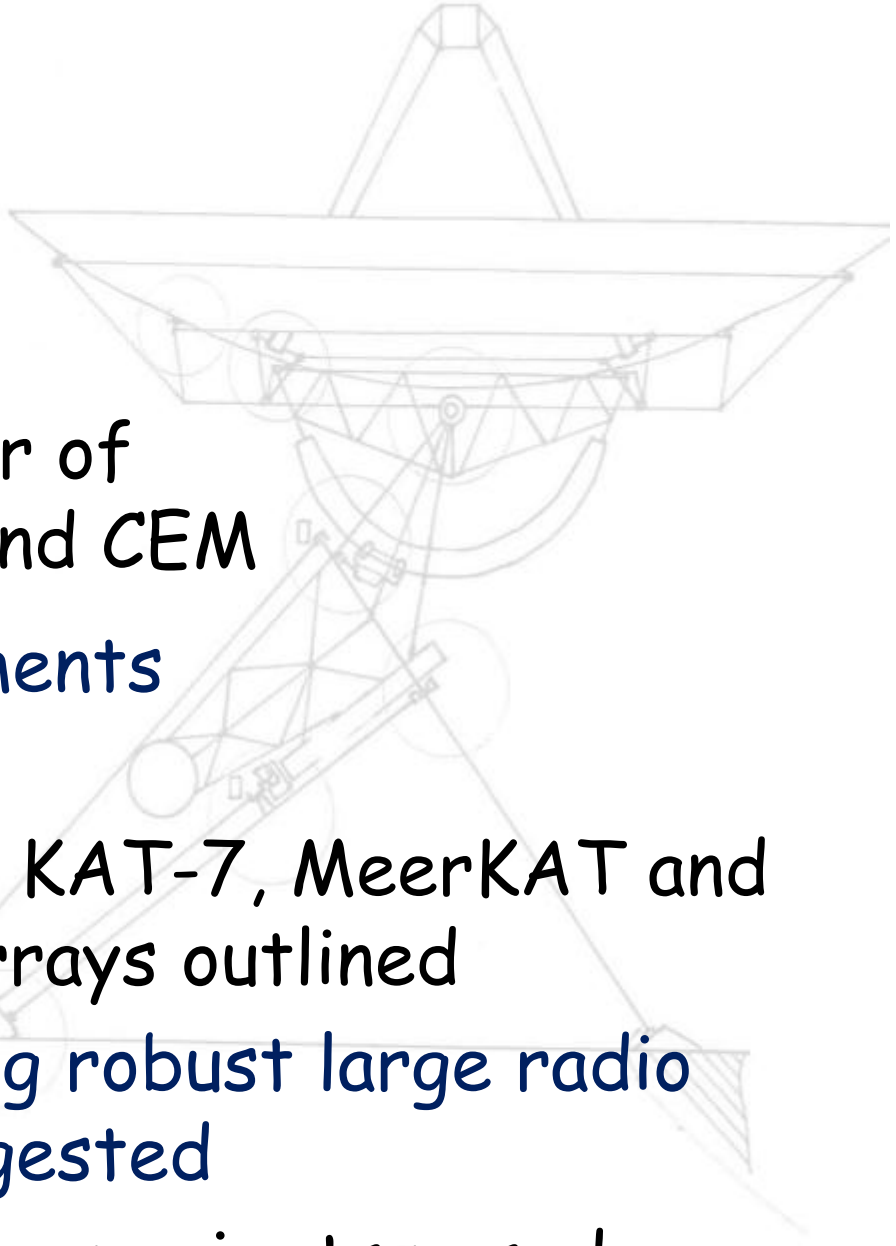
Purpose of Presentation to:



- Review some radio astronomy sites that evolved to deal with EMC and lightning protection
- Promote view that, to be robust, site and instrument construction must embrace EMC / protection principles from start – education needed
- Encourage interaction of engineers, scientists and construction teams throughout

Overview



EMC principles: Cook's tour of elementary experiments and CEM

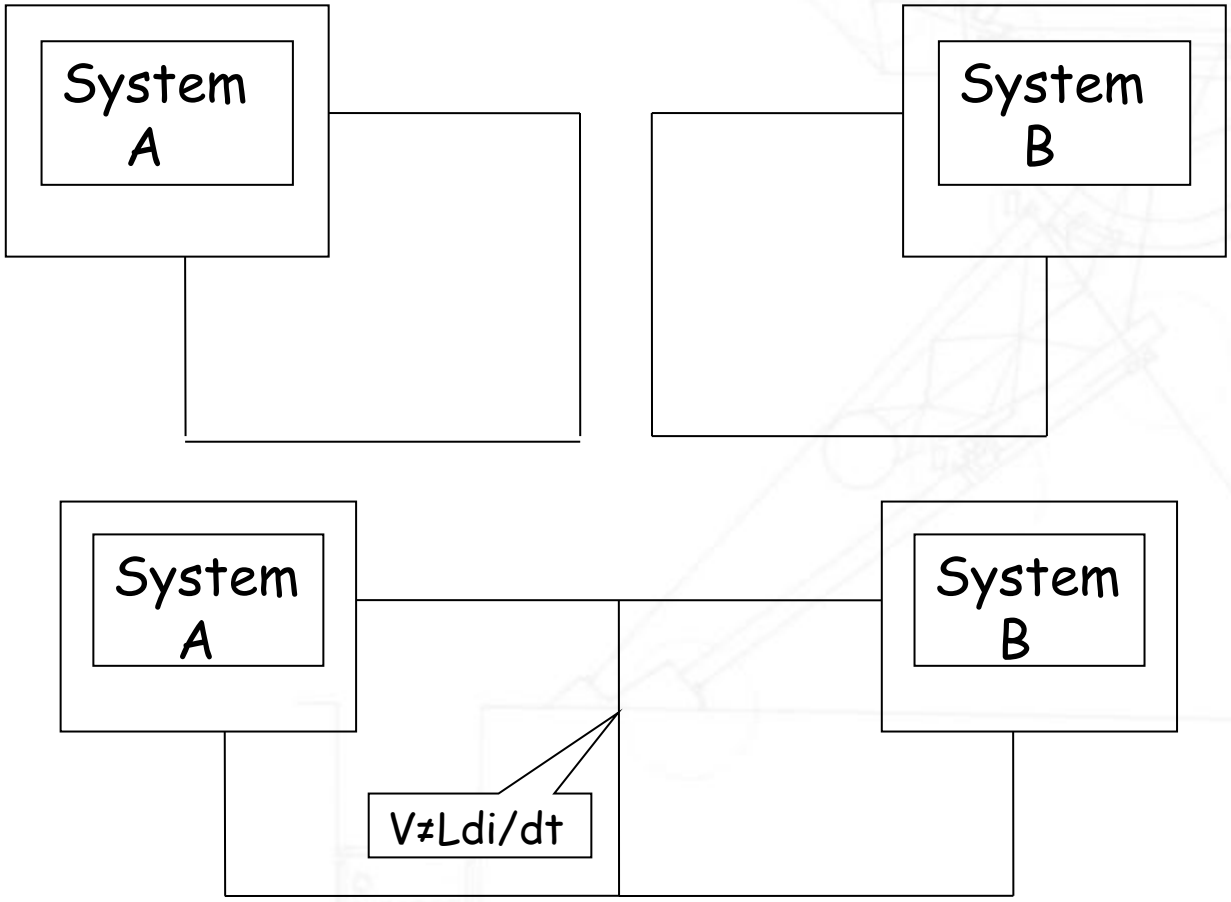
Various RA sites / instruments considered in this light

Experience with SA XDM, KAT-7, MeerKAT and some precursor LF SKA arrays outlined

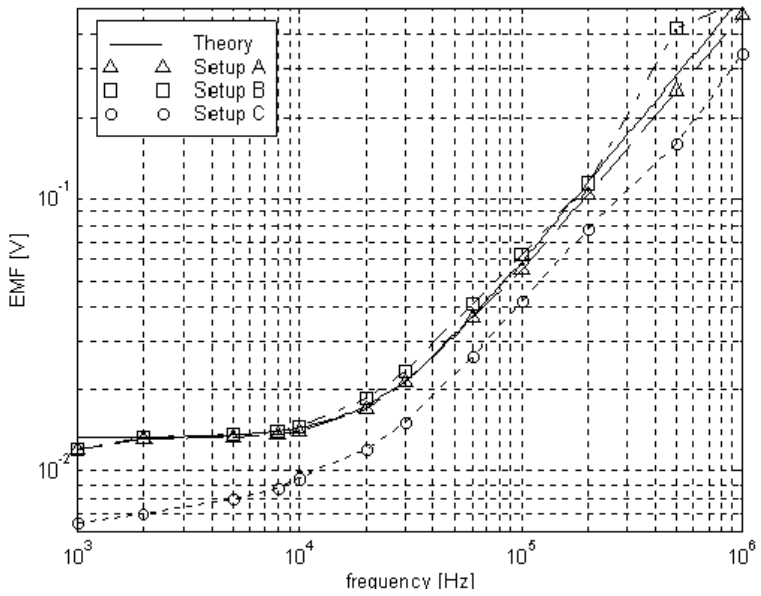
Requirements for designing robust large radio research instruments suggested

Challenges for large science projects posed

System analysis: cables, coupling and interfaces

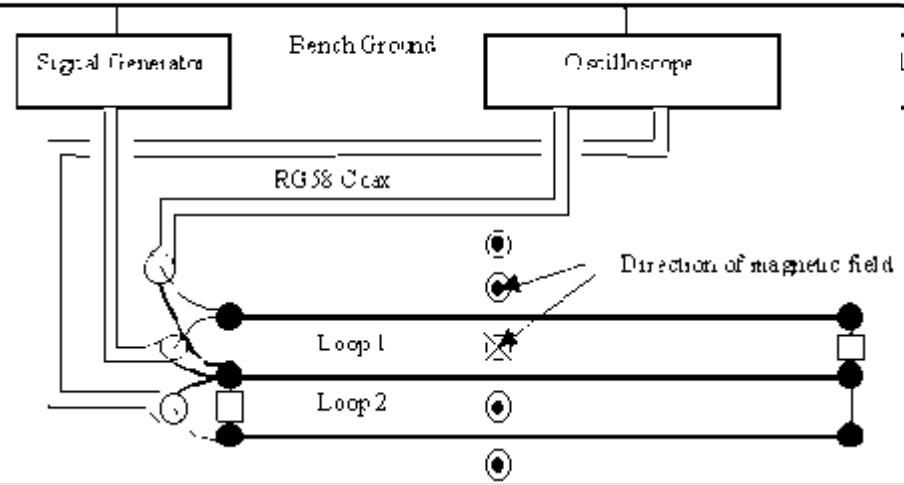


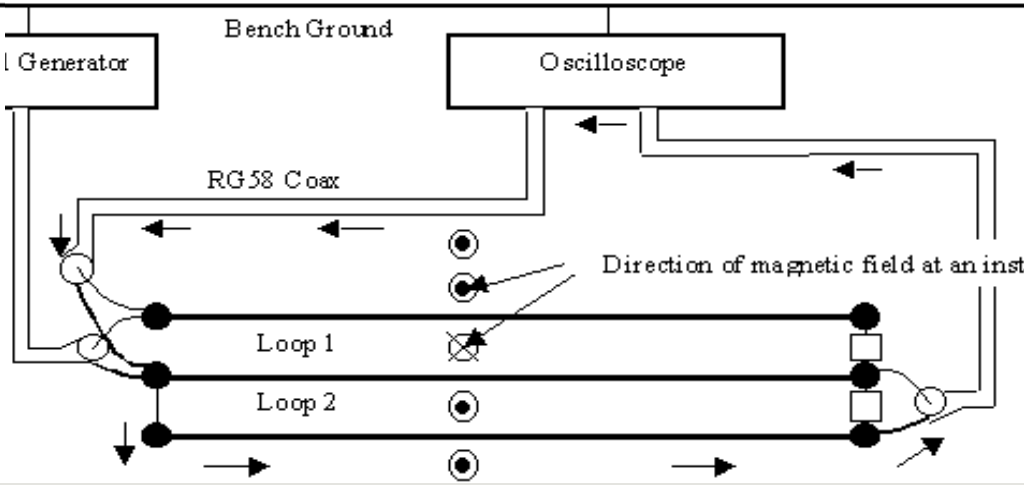
Coupled systems and metrology



SETUP A

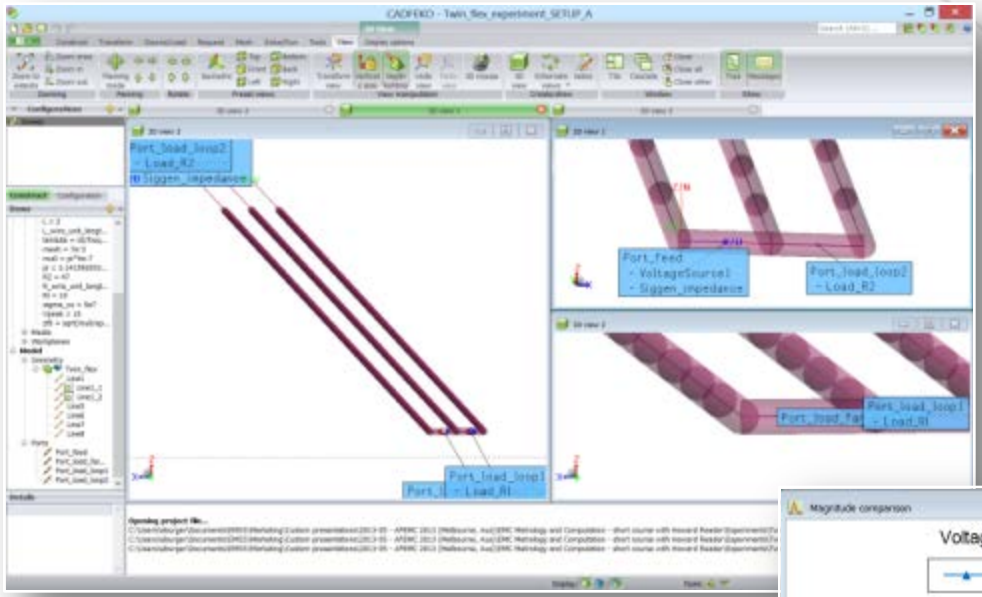
SETUP B

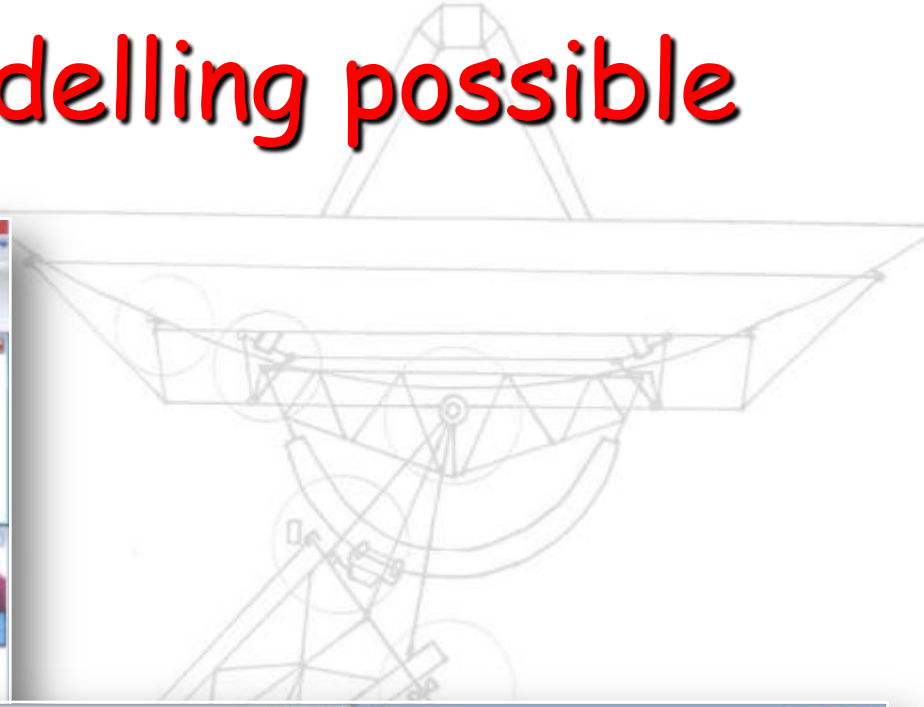


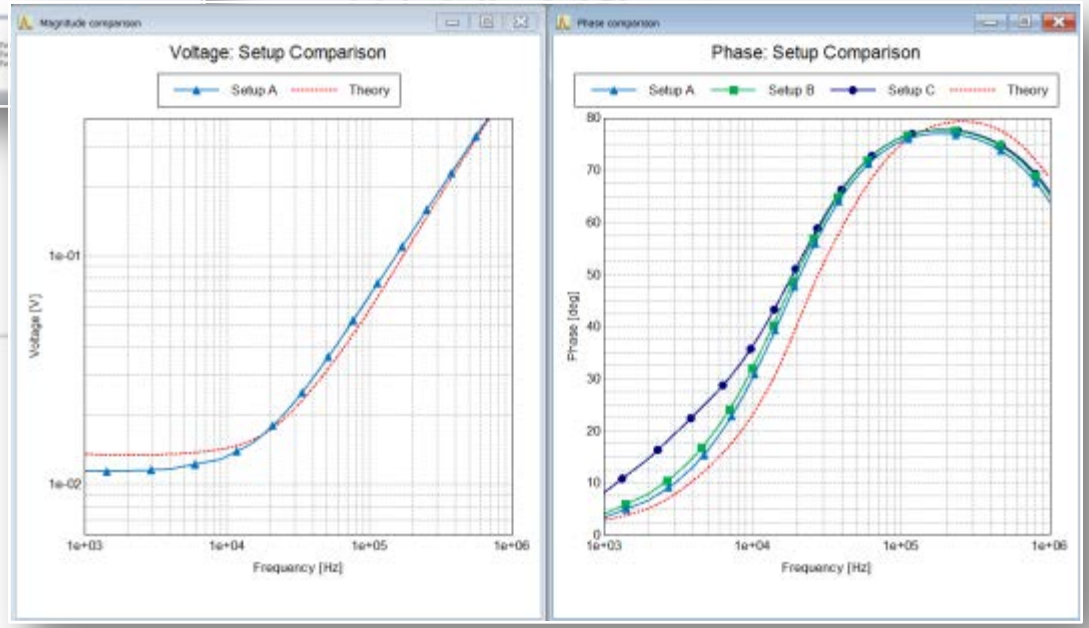


Measurements in setup B loops completely distort intended experiment which works as predicted in setup A

Careful CEM modelling possible



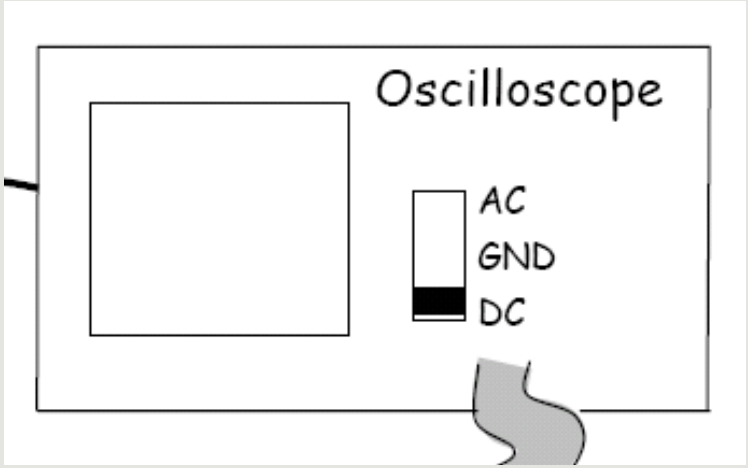


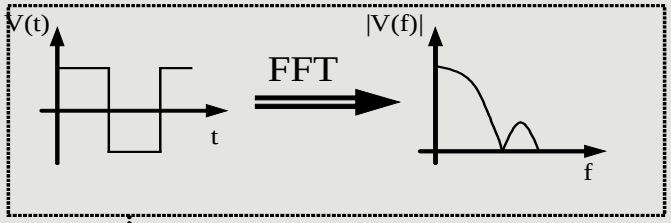


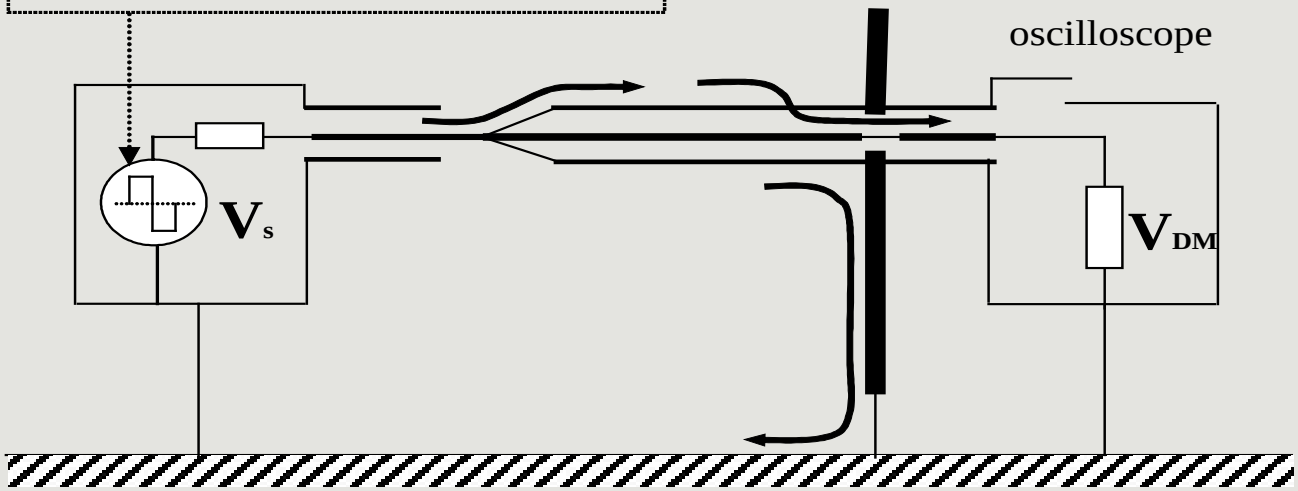
with thanks to Ernst Burger:
EMSS-SA

Cables and Equipment

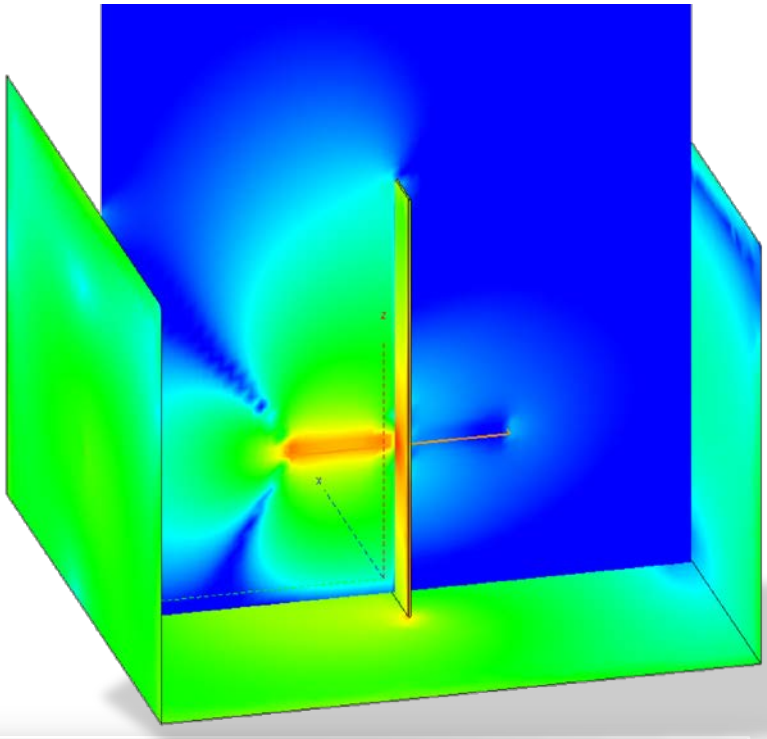
$$Zt = R + j\omega M$$

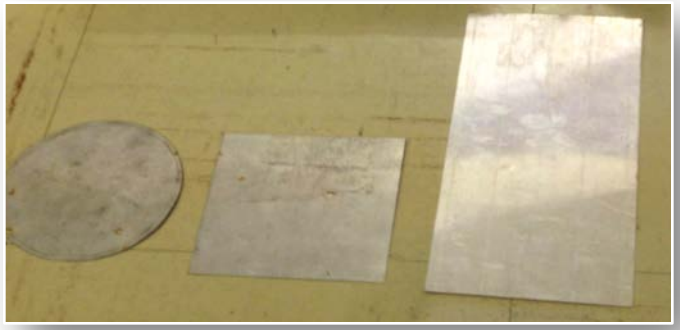


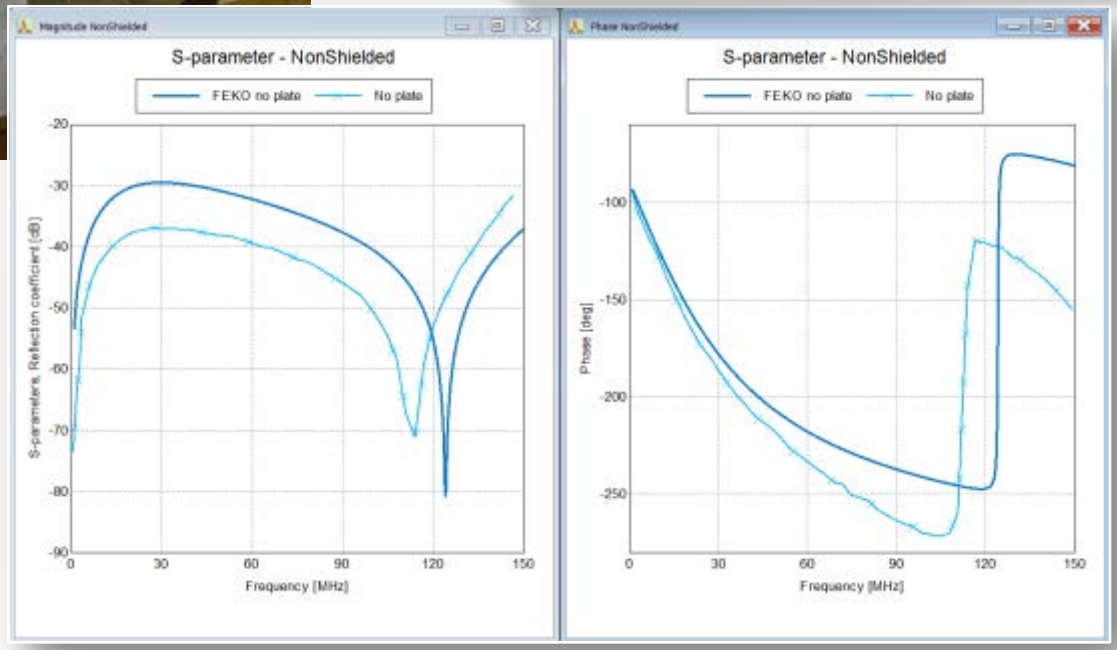




Shielding Plates:
Why, how, maximum ROI

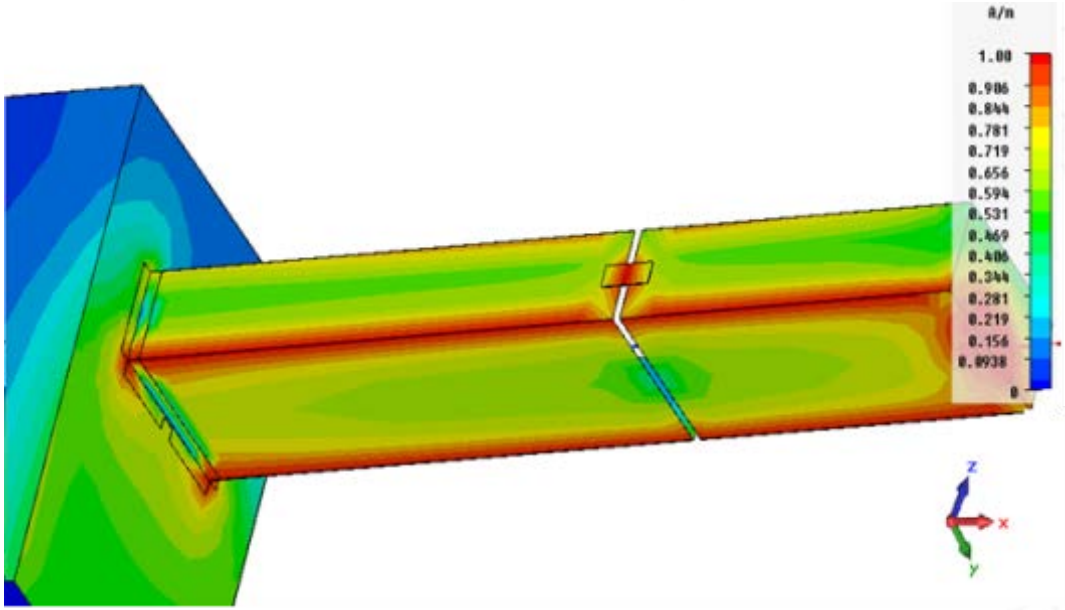


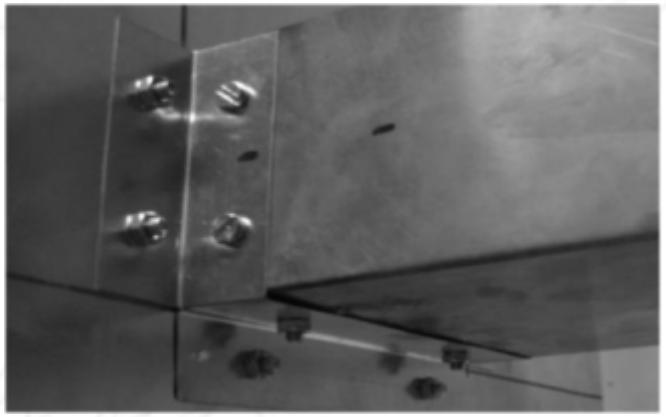


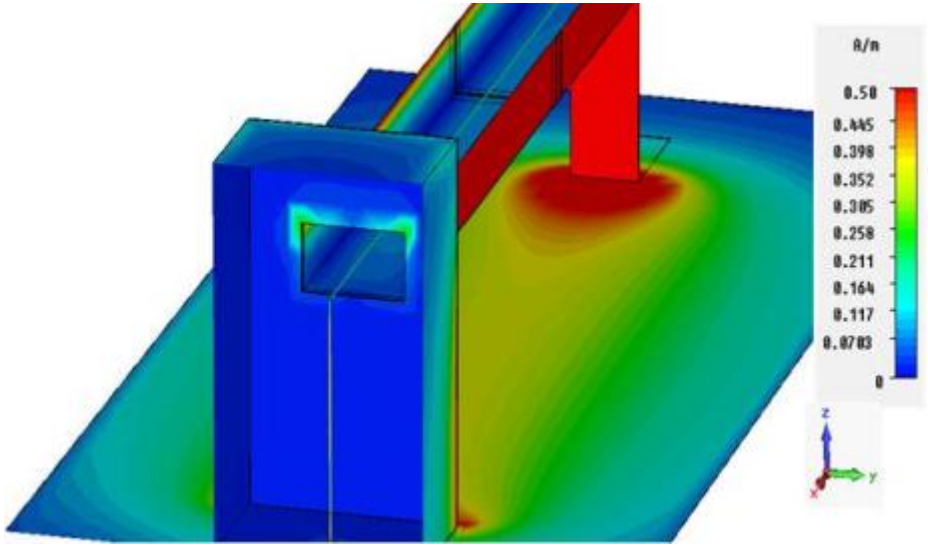


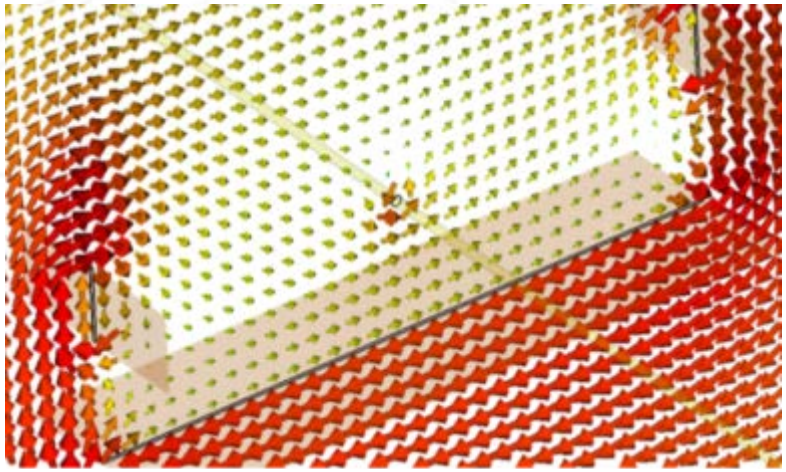
with thanks to Ernst Burger

Cable Trays and Connections

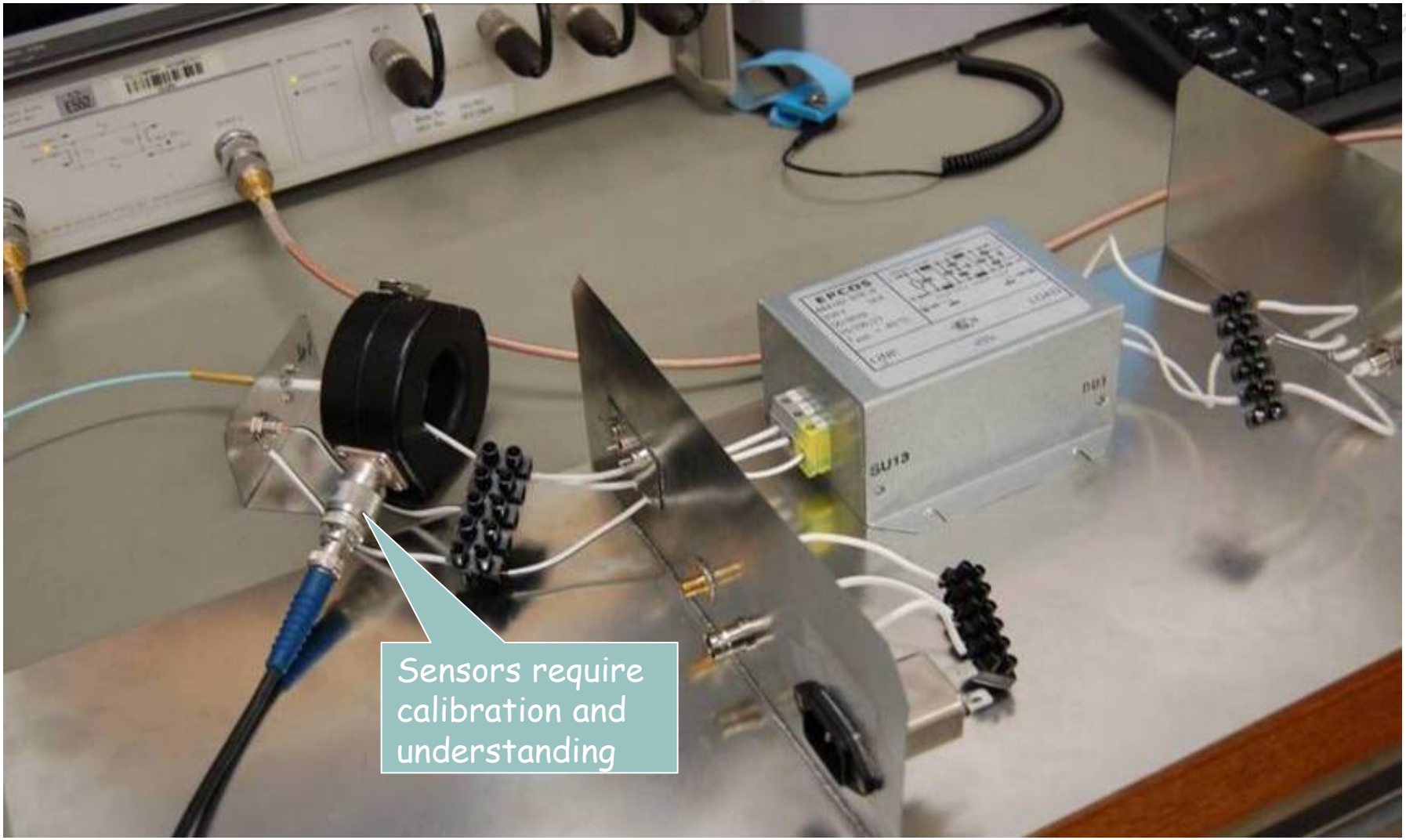








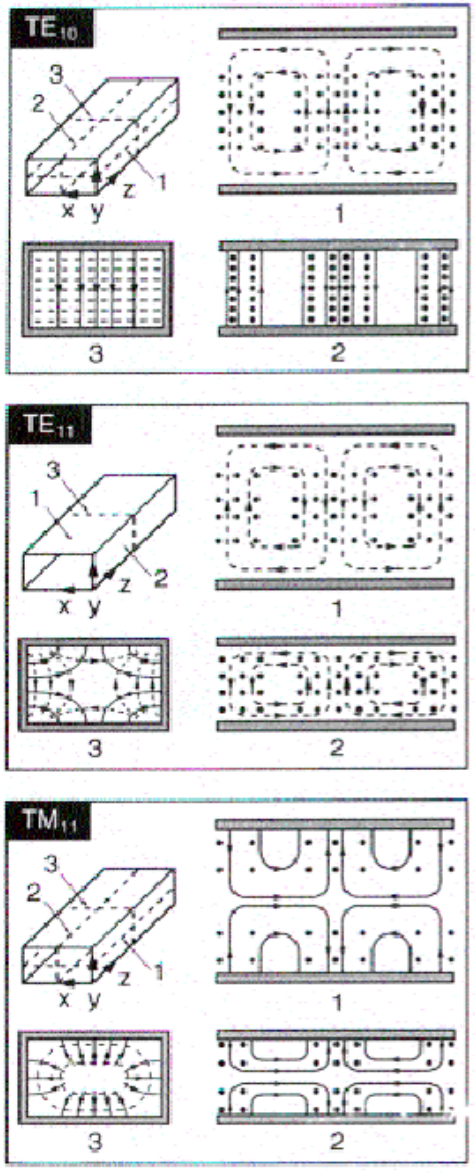
EMC "Cabinet" and Interface Principles



Integrated systems: How does one start?

MESA Solutions (Pty)Ltd

Enclosure Modes with Dielectric Loading



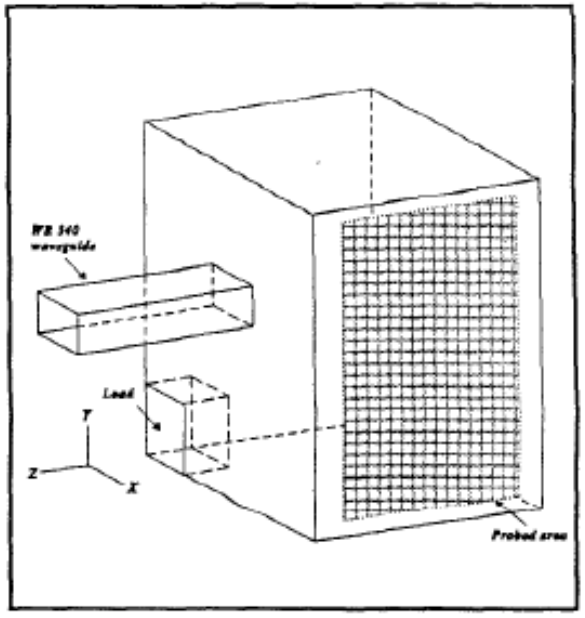
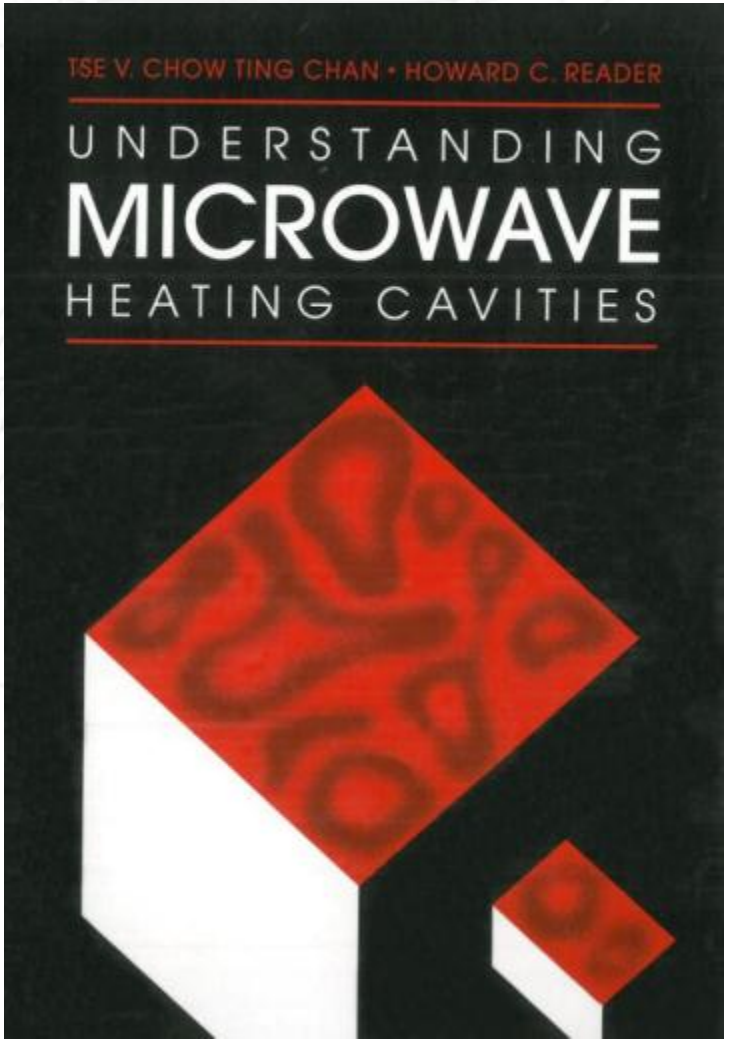


Fig. 1. Cavity with a block of perspex or container with water.



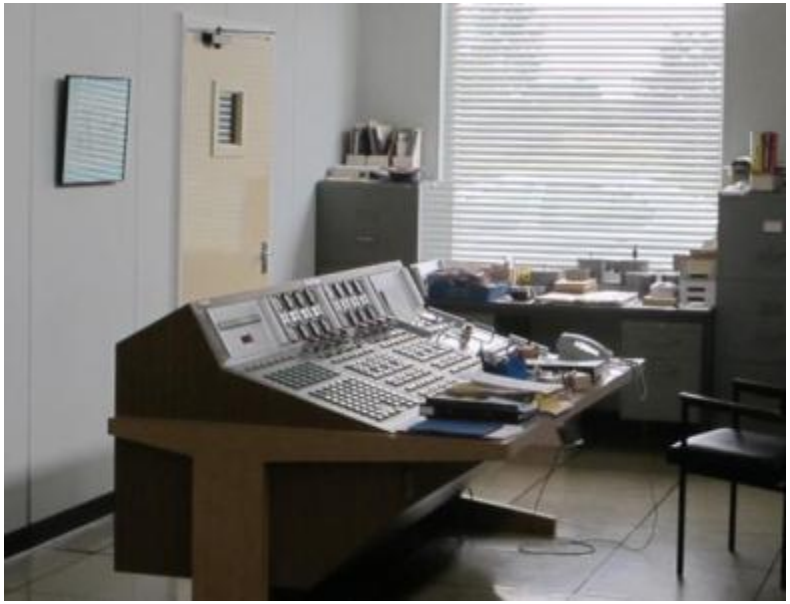
Enclosures I

Well-made enclosures pay attention to seams, door and cable interfaces.

Any post-installation additions should be carefully reviewed and tested (common-mode currents tests are good for this) so as not to break enclosure integrity.

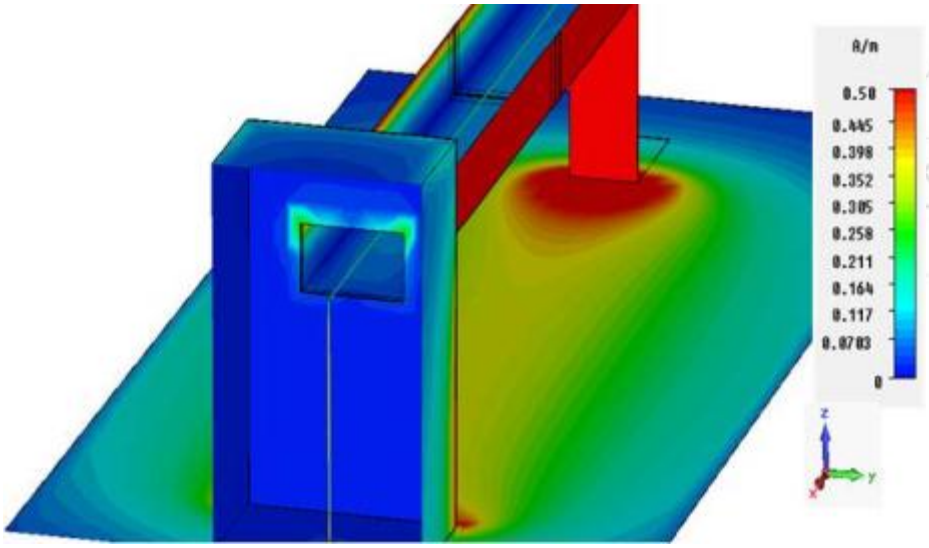
Next slide illustrates typical problems in this regard.

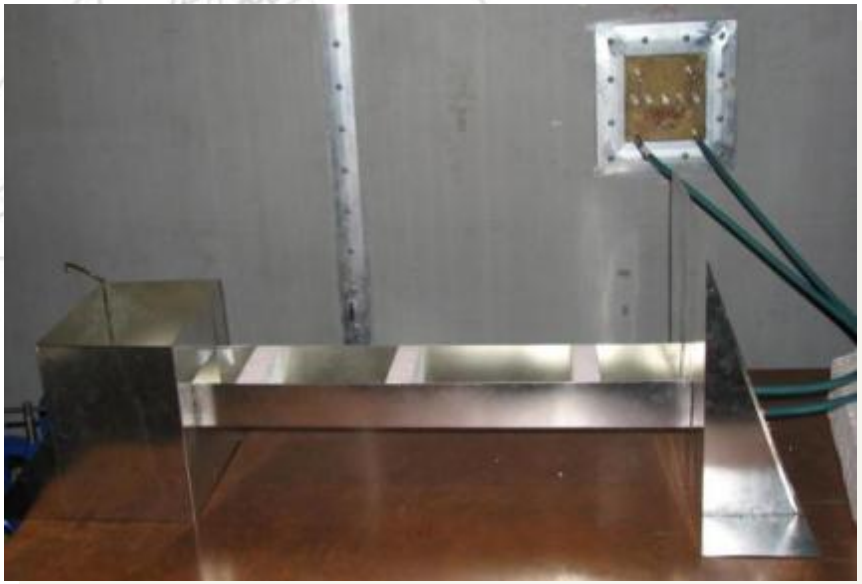
Enclosures II

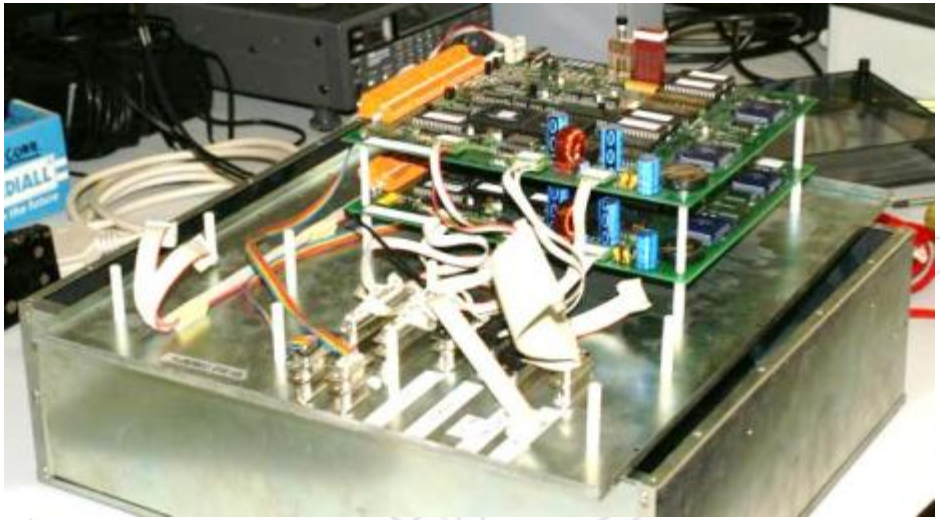


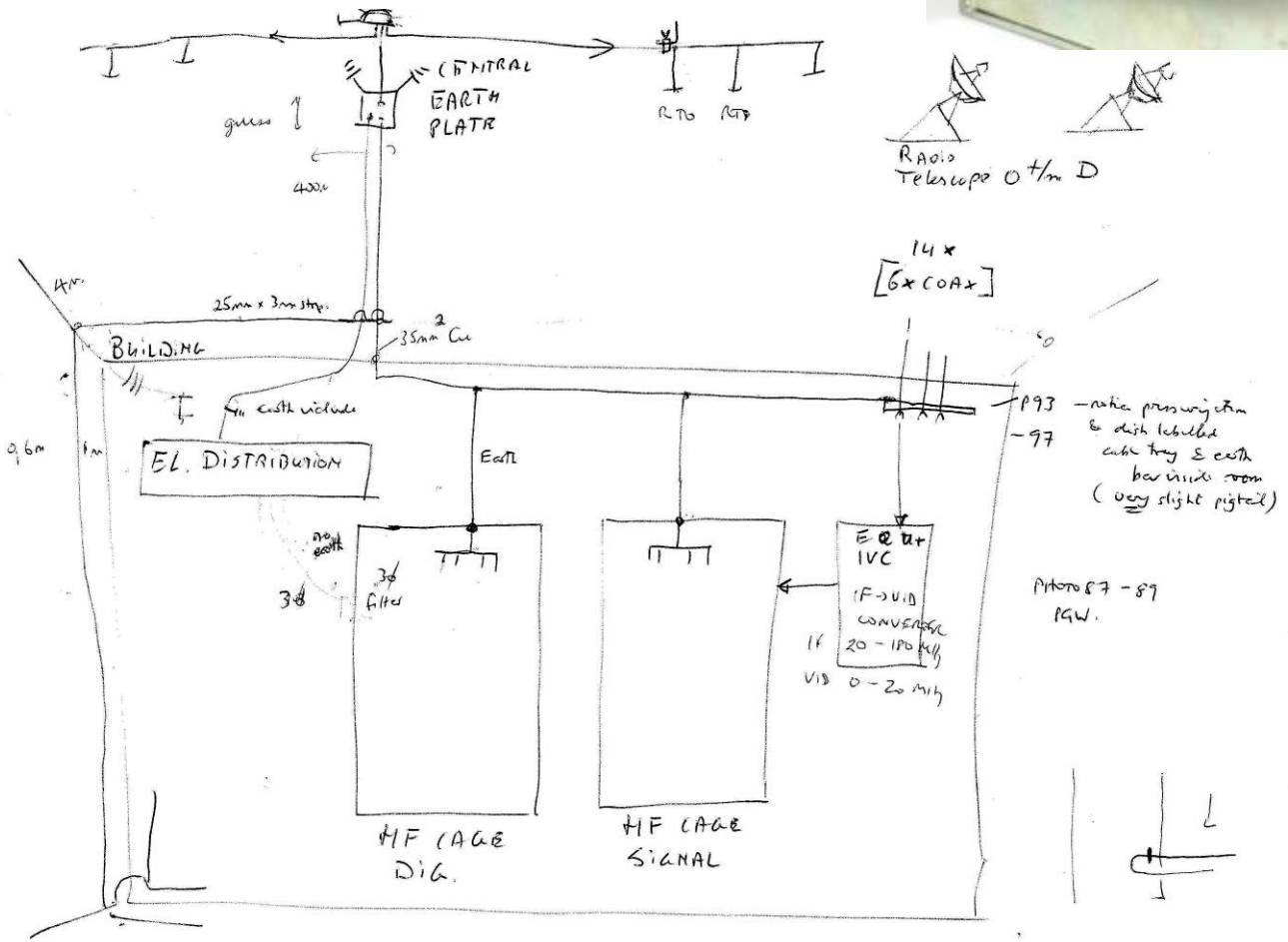
Detail at each level

cable tray issues below





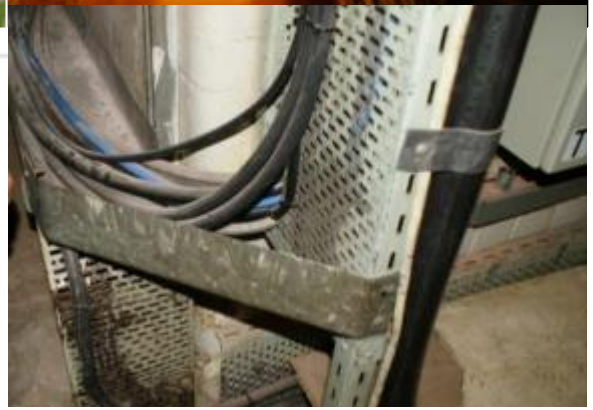




Westerbork Control Room

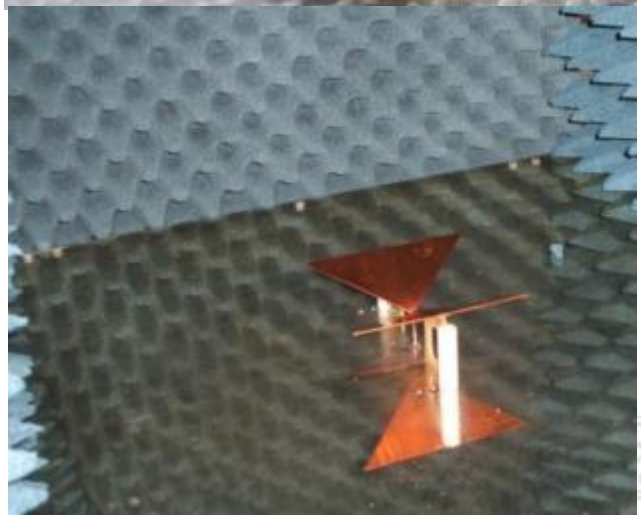
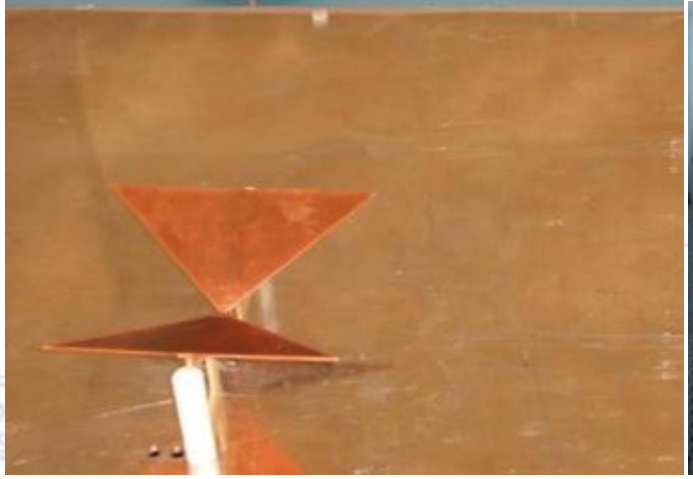
excellent measures seen, but some interface and enclosure issues remain

Jodrell Bank



Development of Array Elements I



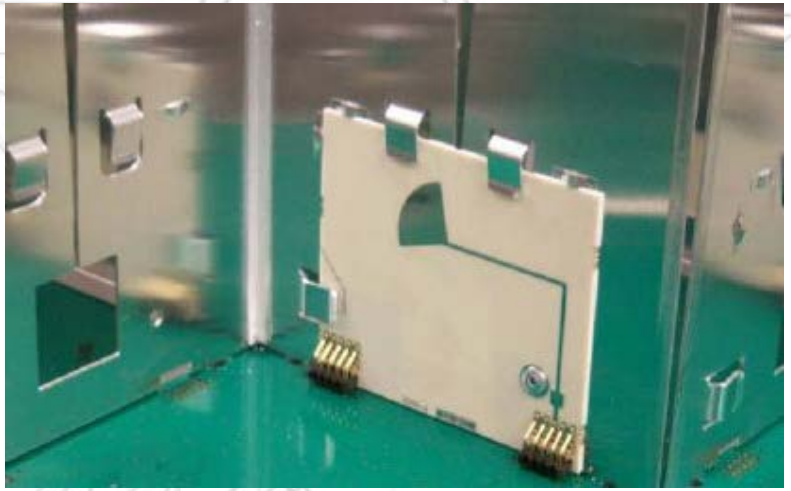




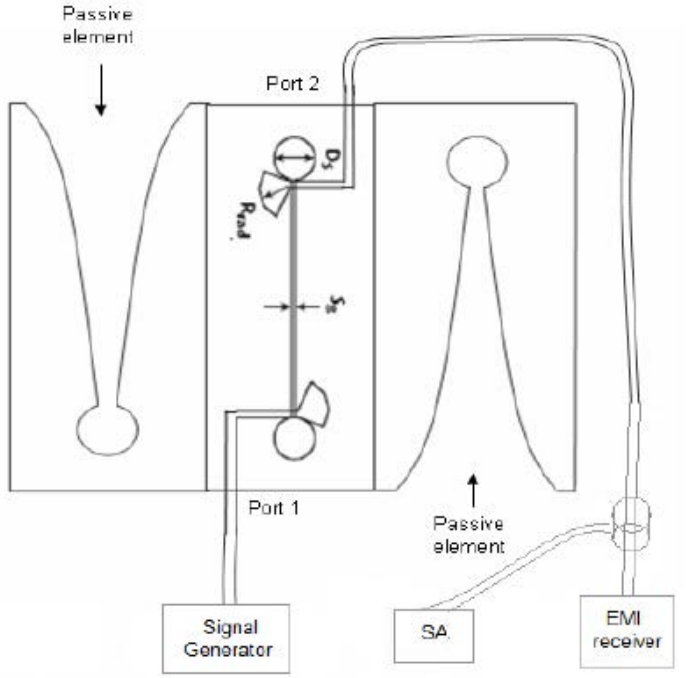

Development of Array Elements II

Development of Array Elements III

Cautionary note: grating lobes only reliably picked up by near field scans: UAV's

Developed Aperture Arrays



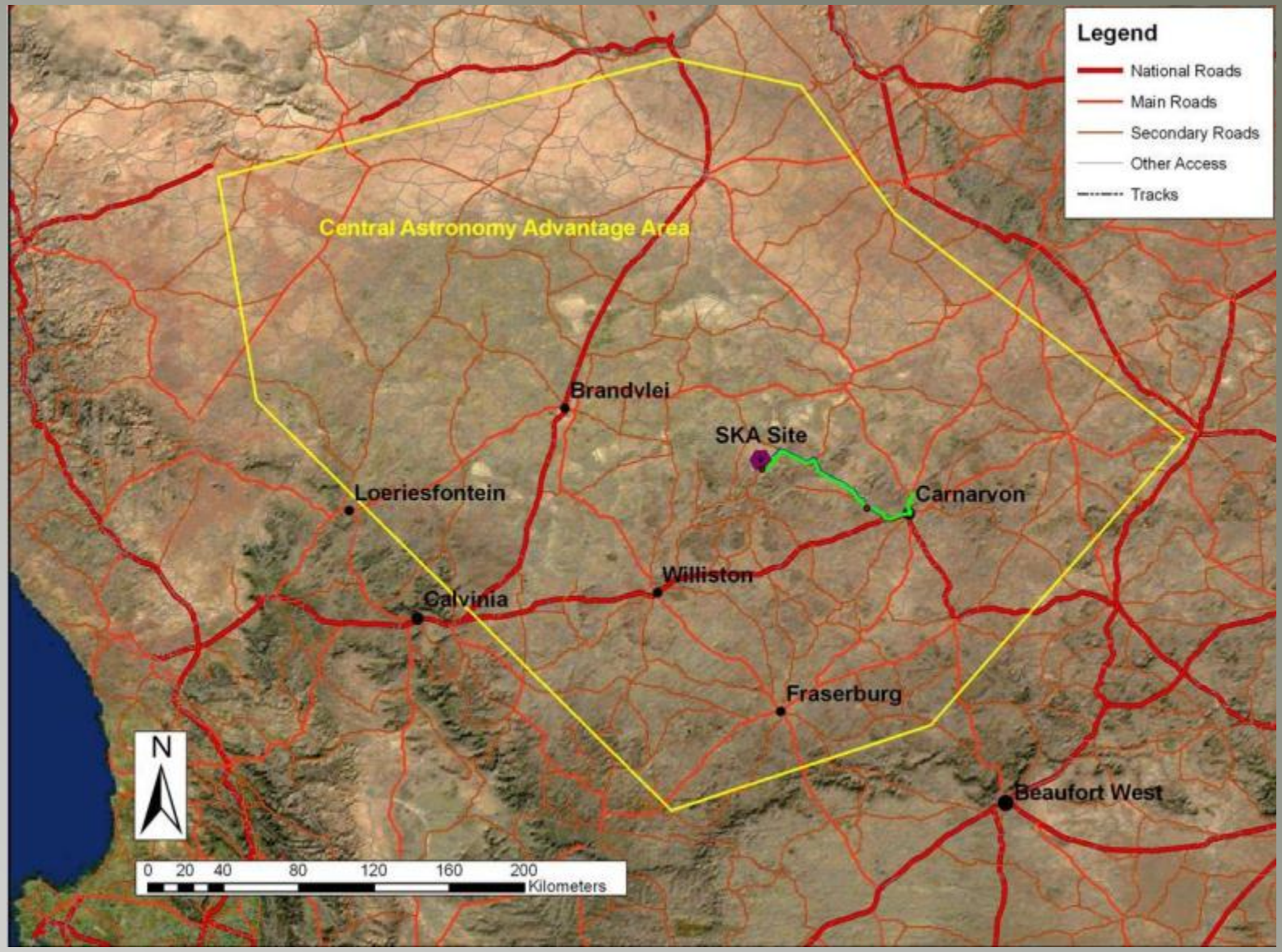


Early LOFAR: lightning rod; cabling above ground. Earthing, protection, dry climates?

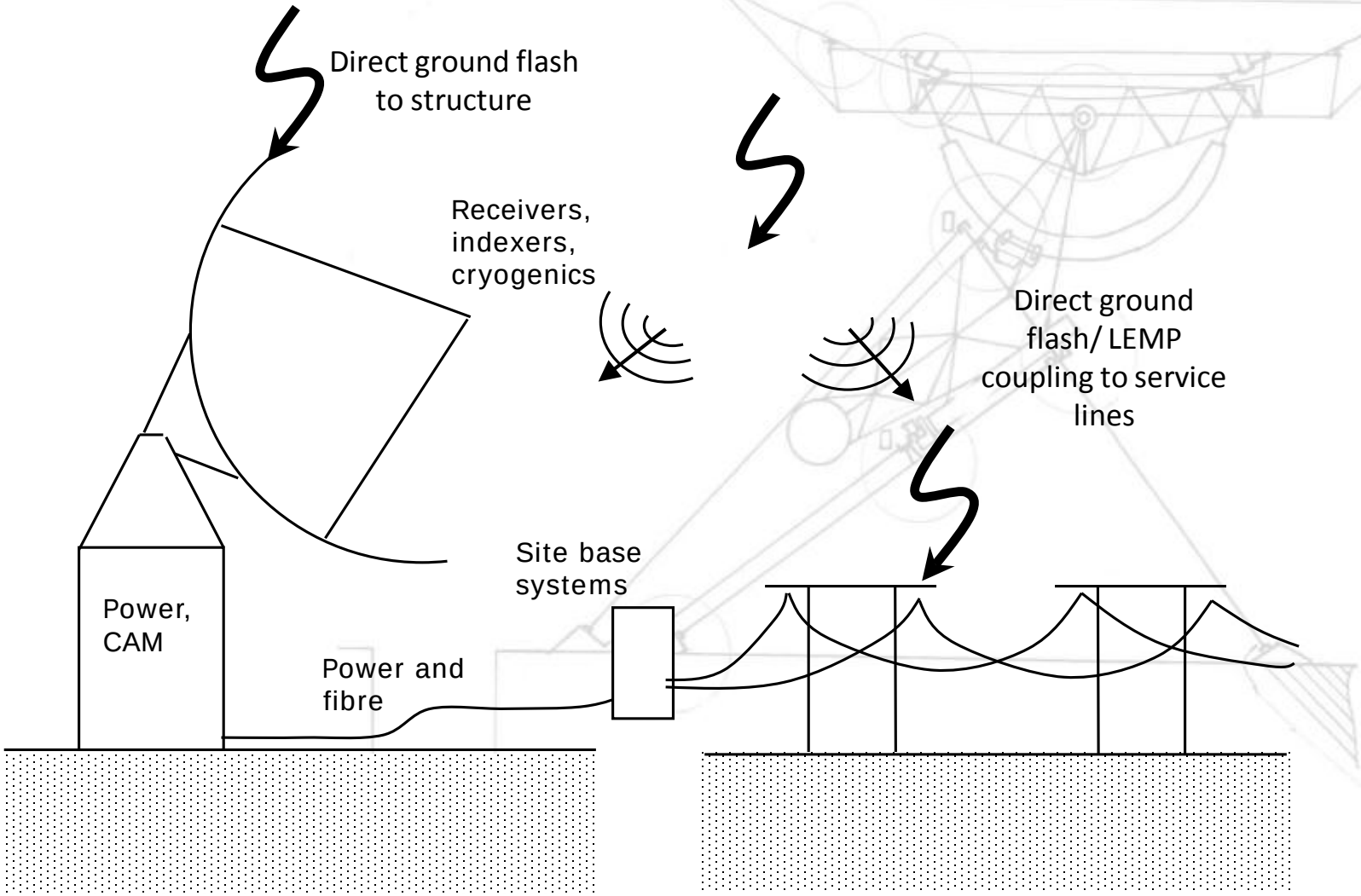
Evolved LOFAR

- No lightning rod
- Cables Buried
- CM currents from elements to cabinet tested

Consider full protected region

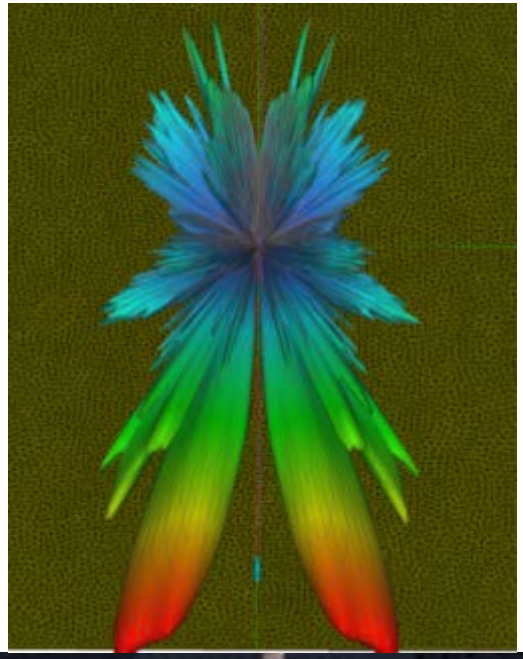


Visualise Whole System



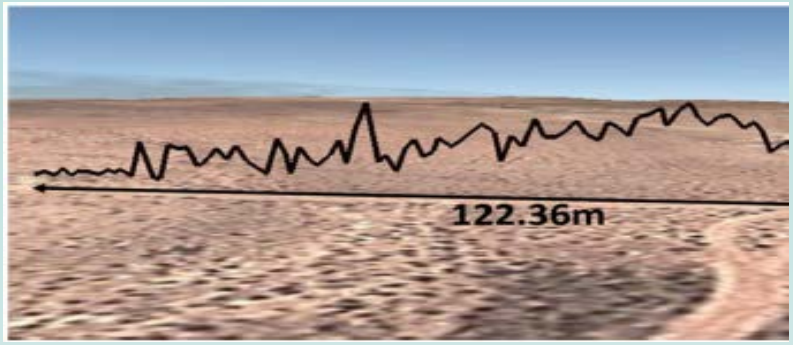
Design to prevent sparking (not corona)

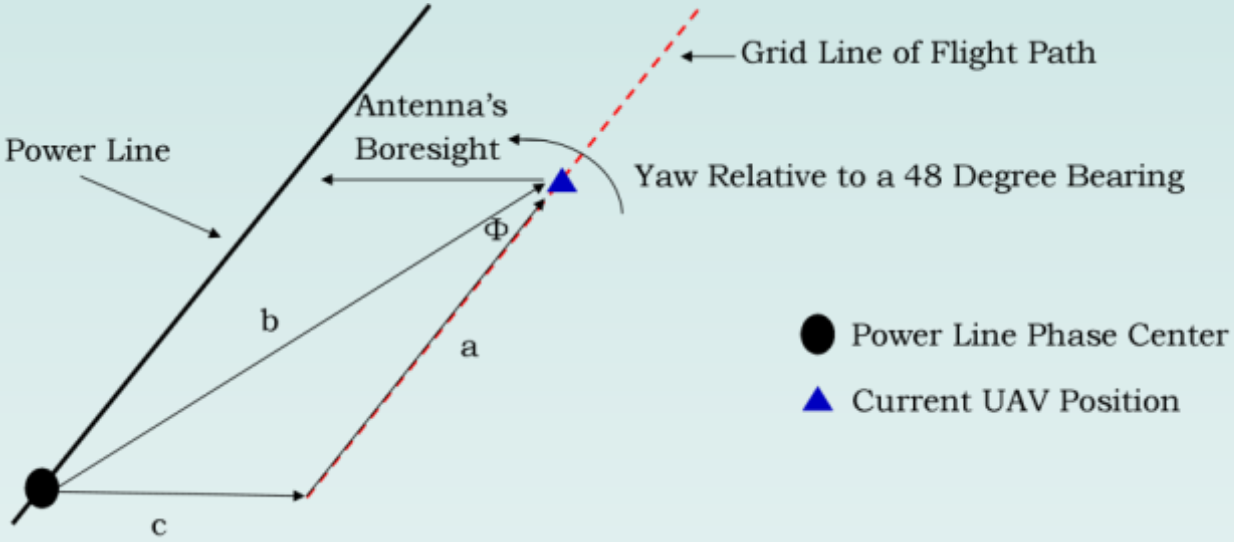
Sparking Radiation Patterns and Controlled Lab tests



Metrological techniques: continual re-definition

according to evolving project



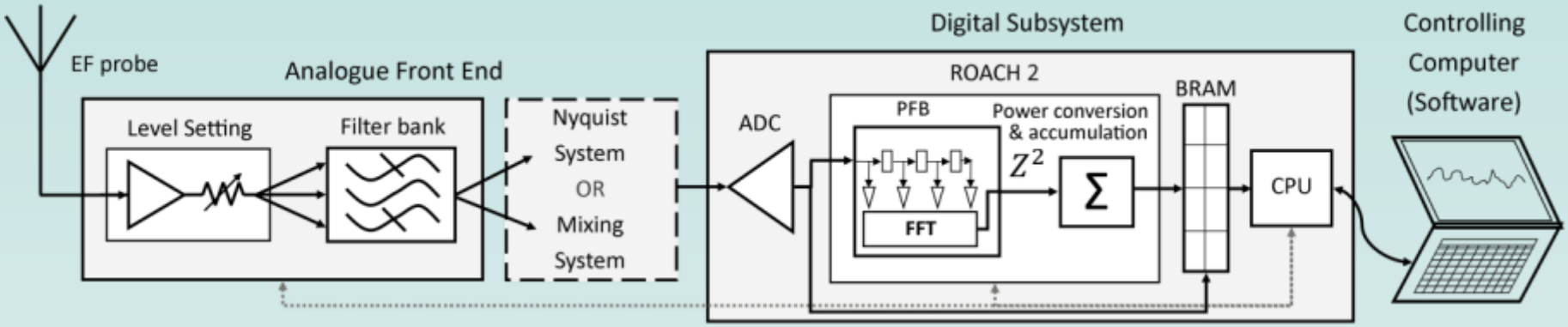


UAV, SA, EMC issues, resistive dipole

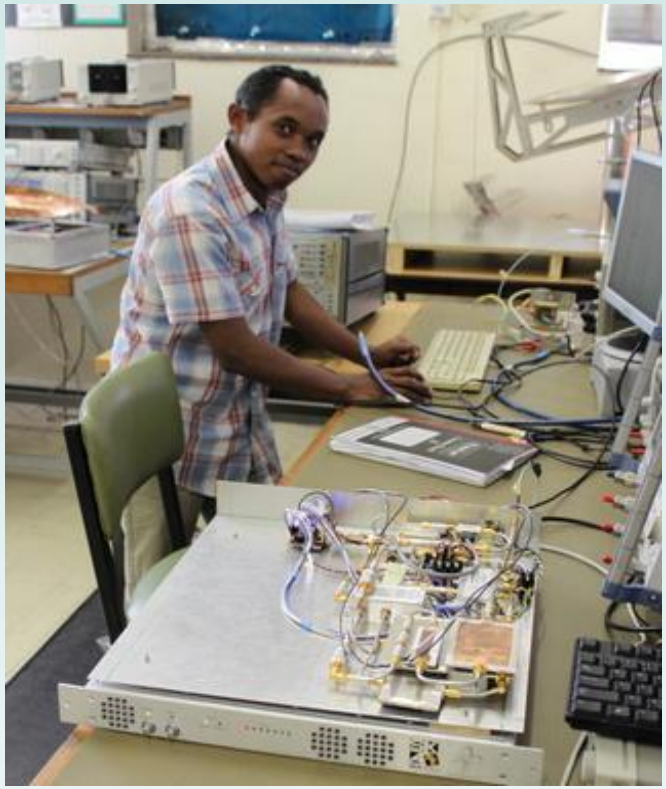
Thanks: Matthew Groch, Hardie Pienaar

Real-time Analyzer:

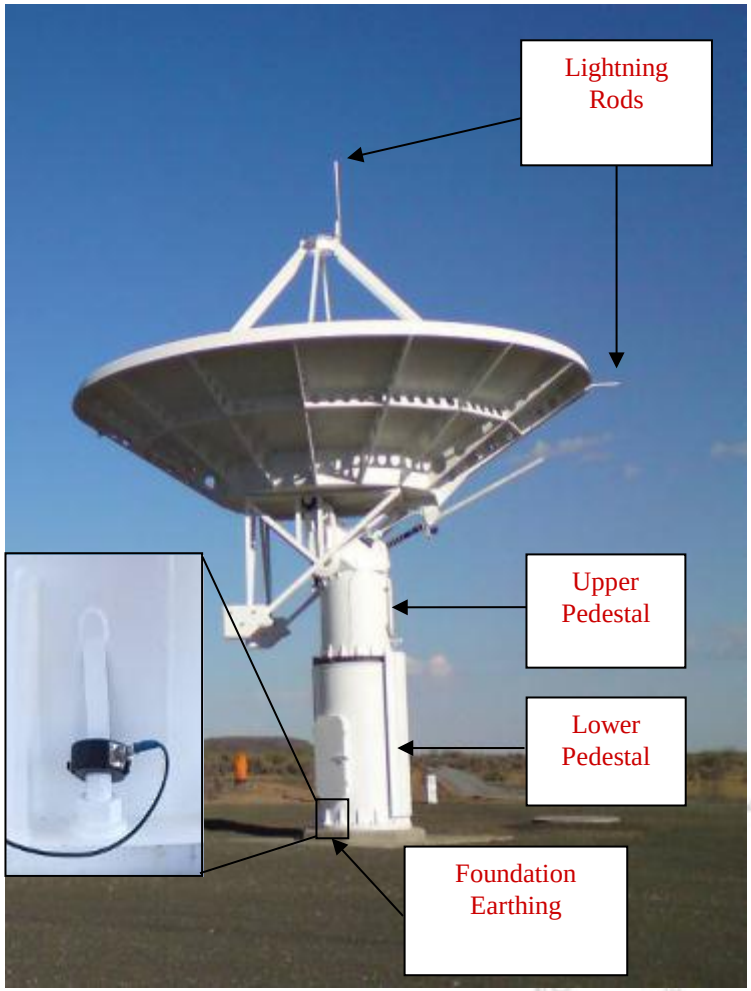
"RATTY": Being used to capture transients over 1400 MHz BW with 52 dB dynamic range which can be adjusted for max level

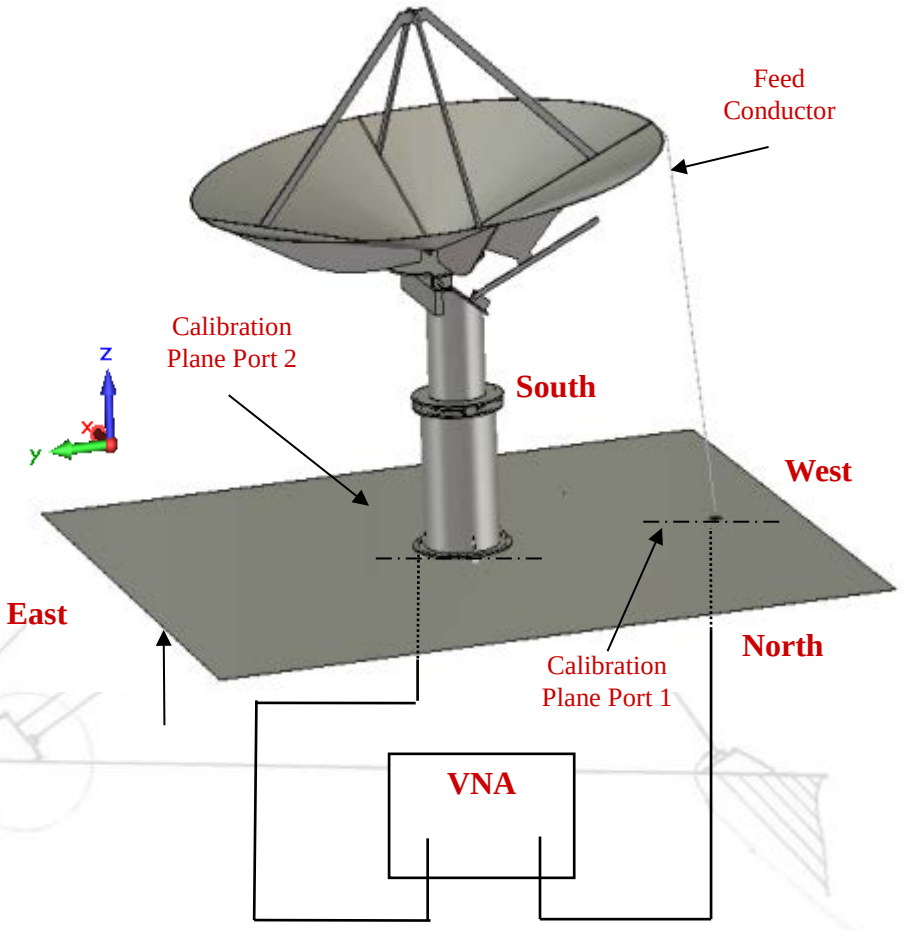


Antheun Botha, Paul van der Merwe, Petrie Meyer, SKA DBE, RRS, EMRIN-G



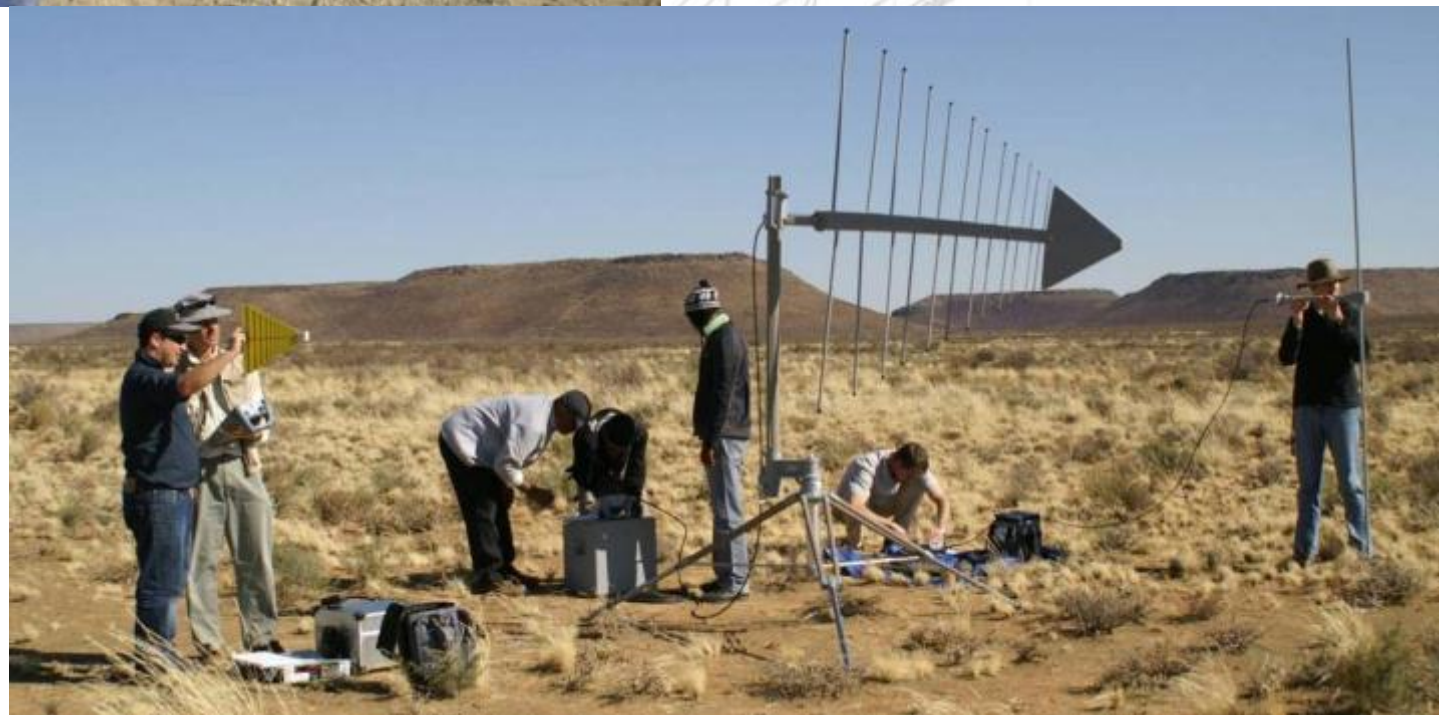
Can we "see into" what is going on?



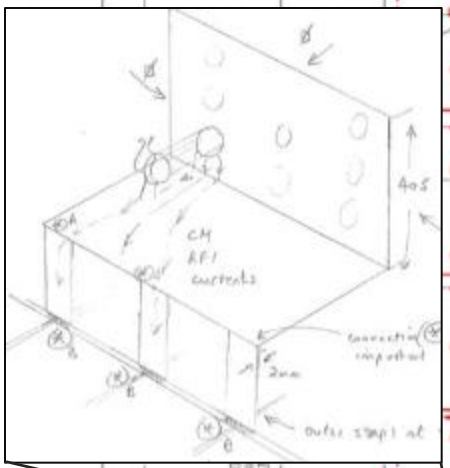


Tests on scale models and real system undertaken by EMRIN group and MESA Solutions; relates to lightning protection zones: IEC 62305

Do RFI experiments from other vantage points agree?



A Reasonable Earthing/Interface Policy



Work with opportunities; continuous interaction between engineers, scientists & construction teams

Continually update and consider layout implications:

How accurate is this artist's impression now?
Where is the cabling?
Lightning protection?

Before concluding

Acknowledgements

- The SKA(SA) office: too many engineers and scientists to individually name
- National Research Foundation (SA)
- ESKOM's Tertiary Education Support Programme and Stellenbosch University's OSP
- ASTRON – Prof Arnold van Ardenne ; Truus van den Brink
- EUT – Prof PCT van der Laan and Dr Lex van Deursen
- **All research students** since 2000 are acknowledged for collaborative contributions to research effort.
- Wessel Croukamp, Wynand Van Eeden, Lincoln Saunders and Rob Anderson are thanked for their sustained technical input
- EMSS (SA) FEKO and CST
- Eloy de Lera Acedo and Nima Razavi-Ghods at the Cavendish Labs
- Colleagues in EE Engineering and MESA Solutions

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Final Remarks

- Increasingly-sensitive RA "instruments" must pay attention to EMC and protection
- Focus has been on broad site; same lens should apply to electrical/electronic systems at "antennas"
- Dialogue between engineers, scientists and building teams throughout not a "nice to have"; is essential.
- Ongoing education and training needed
- Leads to robustness and uncompromised science
- On small-scale robust policies achievable; international-scale: varied parties, contractual agreements - can yield compromise.