ARA antennas studies

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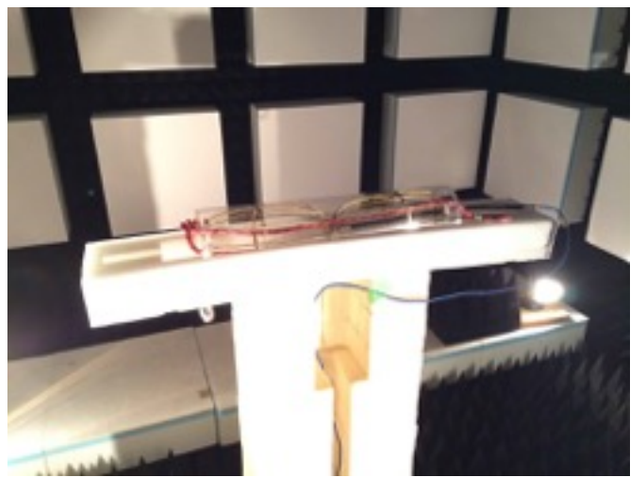
Outline

- **Frequency domain**
  - Vpol bottom
  - Vpol top
  - Hpol
- **Time domain**
  - Concept/method
  - Simulations
  - Measurement

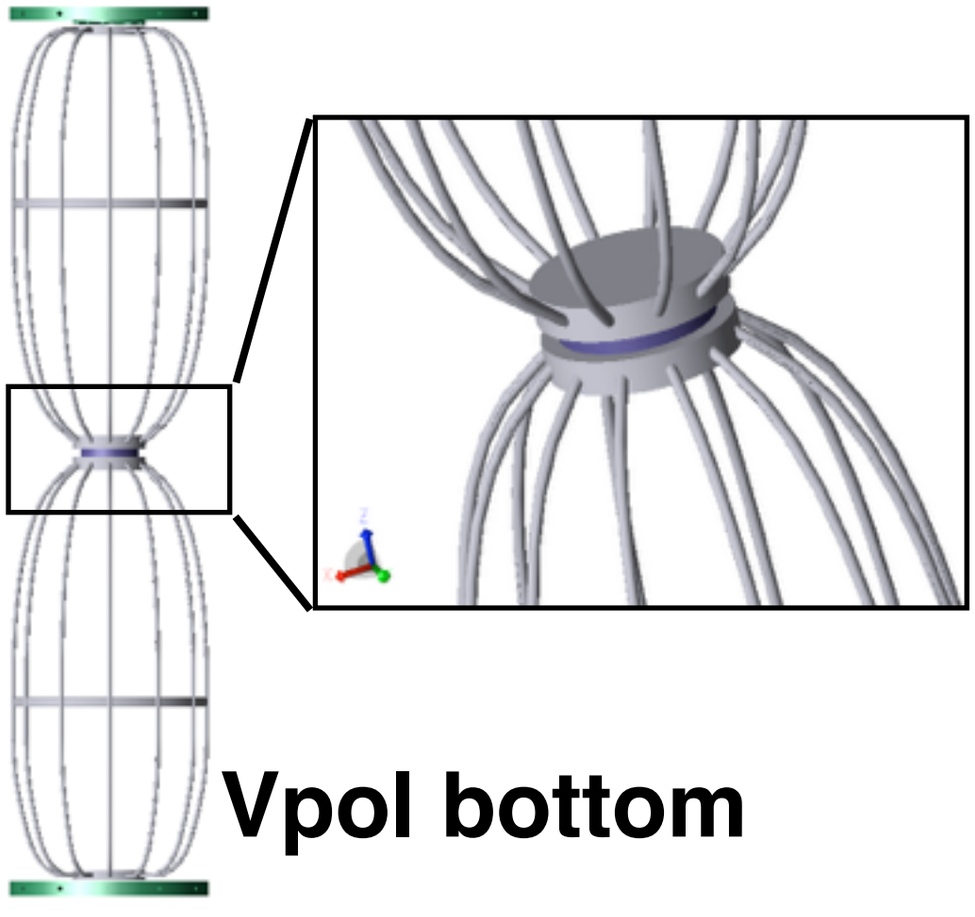
Frequency domain:Tools

- **Simulation**
  - XFDTD software
  - input CAD model
  - Input short pulse at the feed and look at the field in the FF
  - Compute FFT of the time domain simulation
  - Results: VSWR/Gain

- **Measurements**
  - Anechoic chamber (size: 4m x 3m x 2m)
  - Emitter: LPDA
  - Normalized with dipole gain
  - VSWR measured with NA



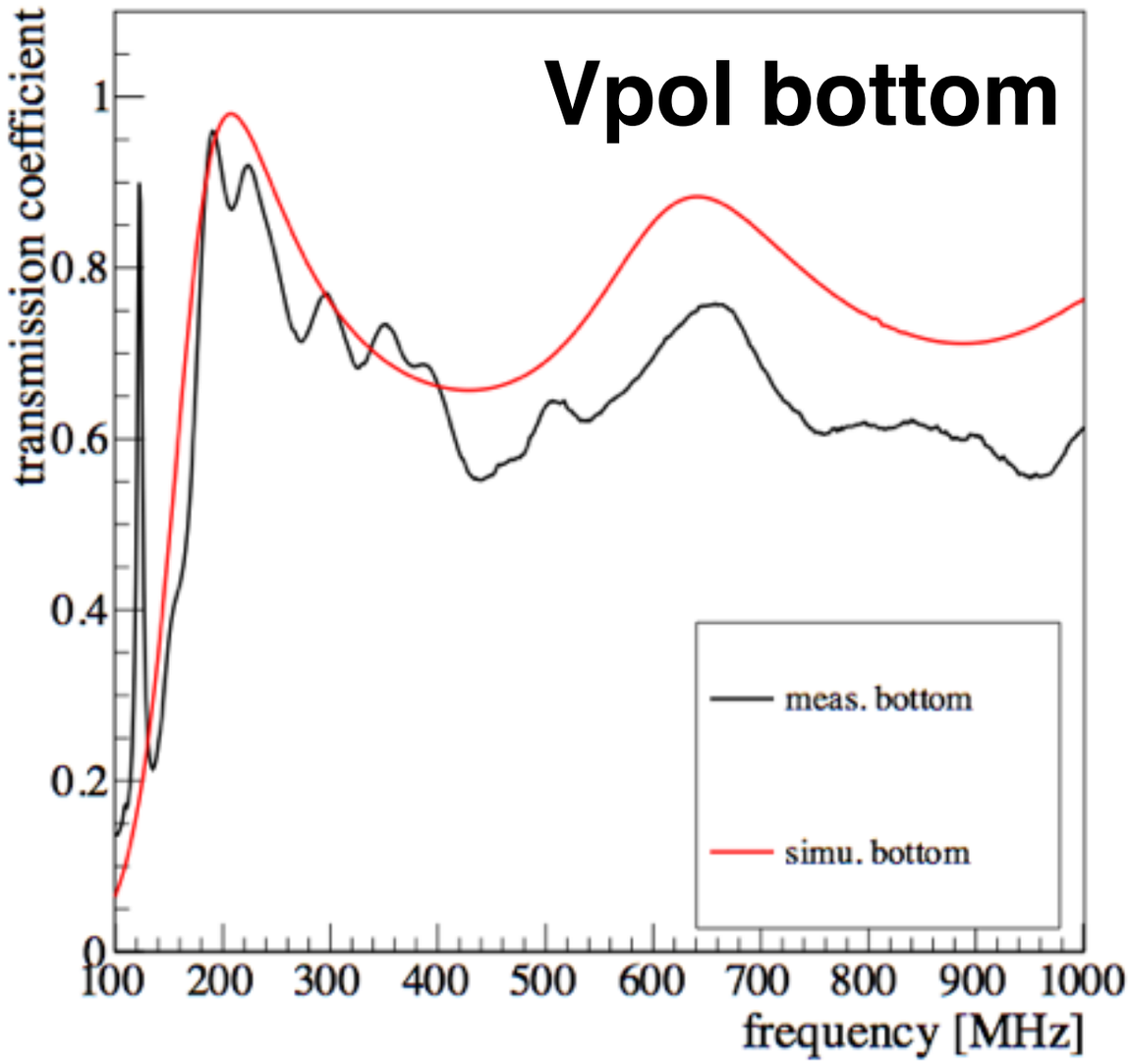
Vpol Bottom: model



Vpol bottom

- CAD file used for construction
- Input a gaussian pulse between the two “poles”

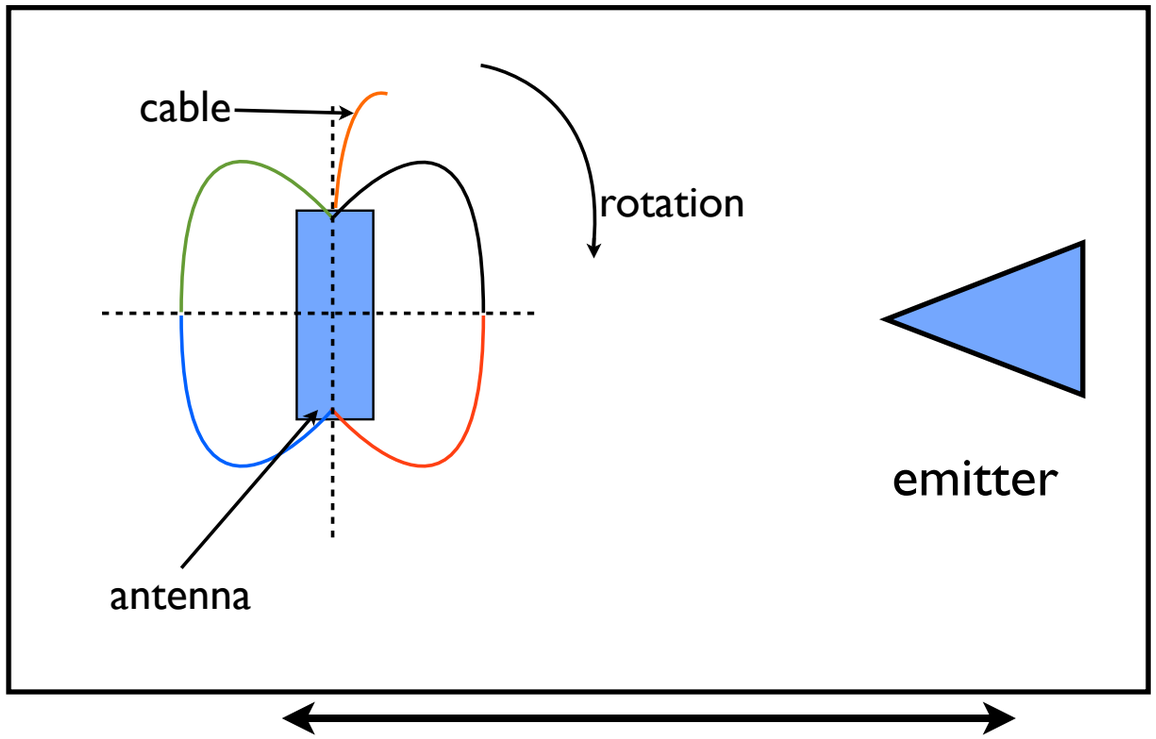
Vpol bottom:Transmission coeff

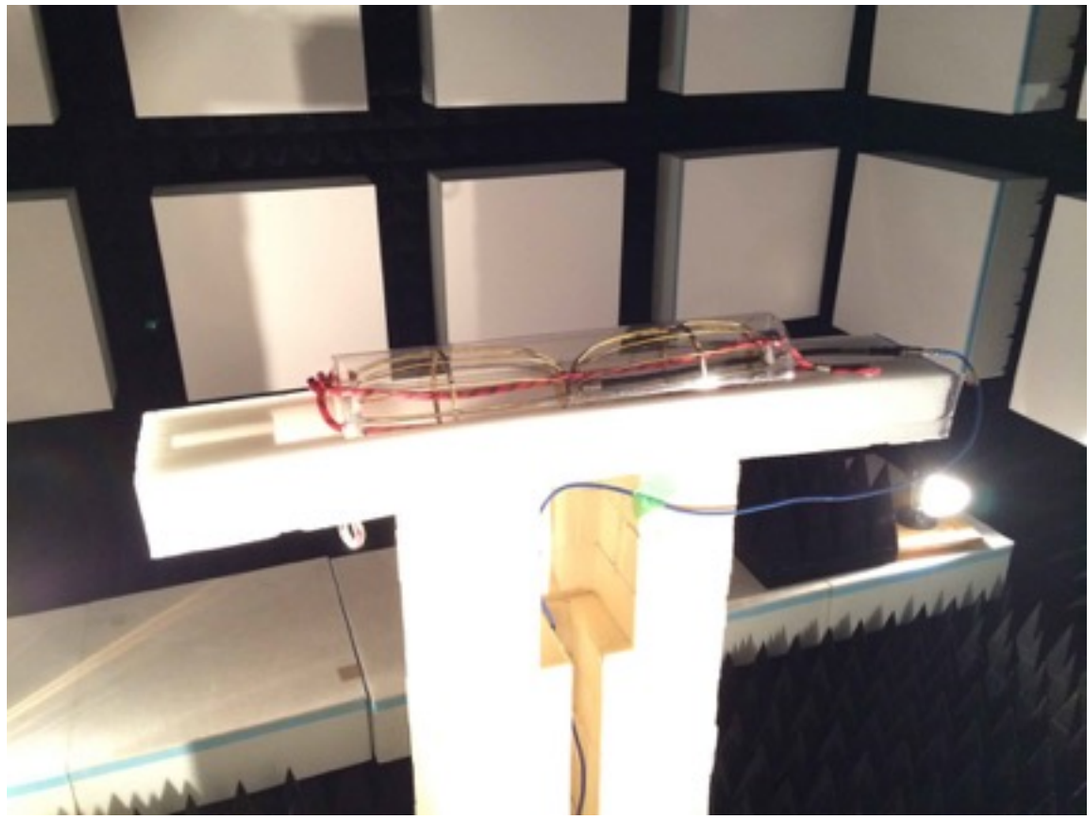


Reproduce main feature

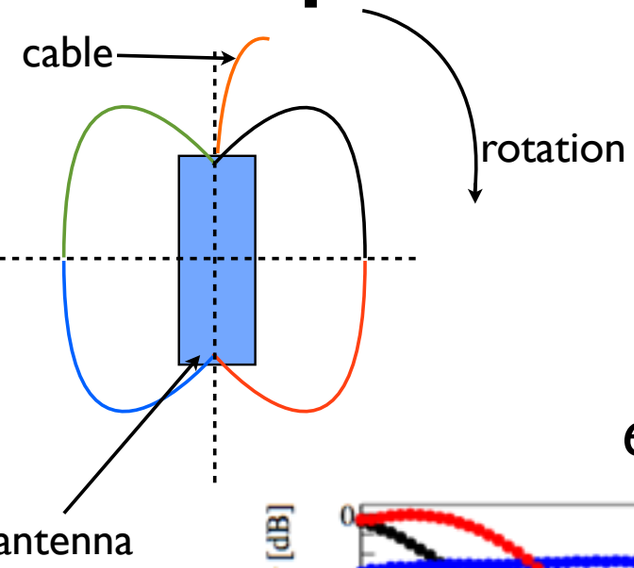
Still a remaining 15% error (in power transmission)

Vpol bottom: gain pattern

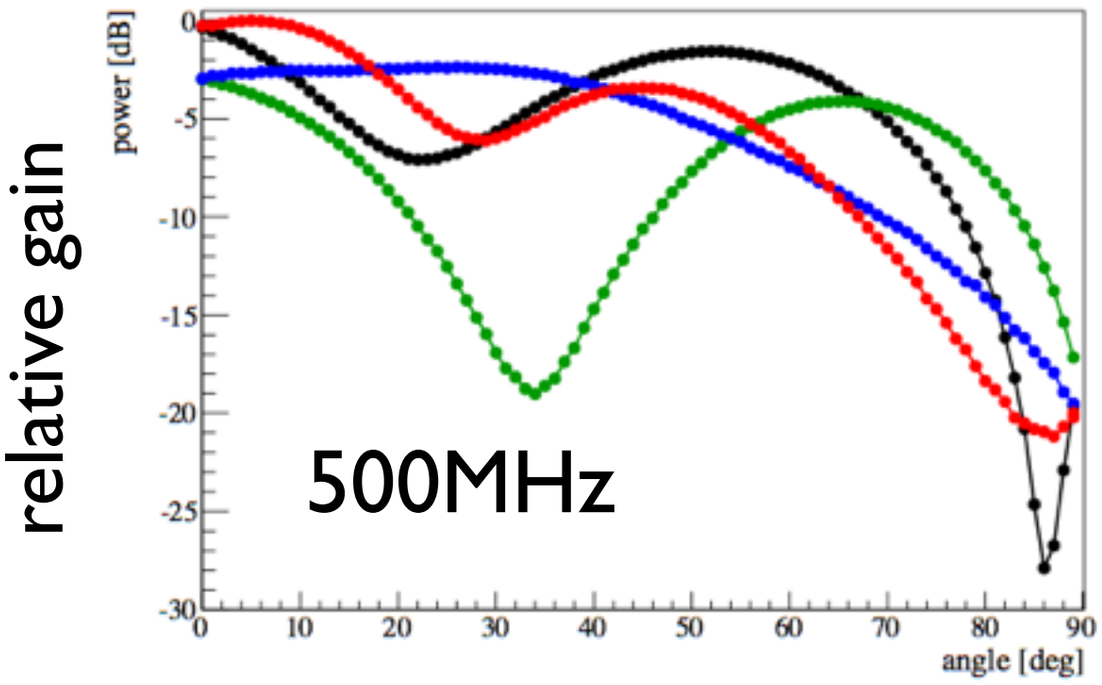


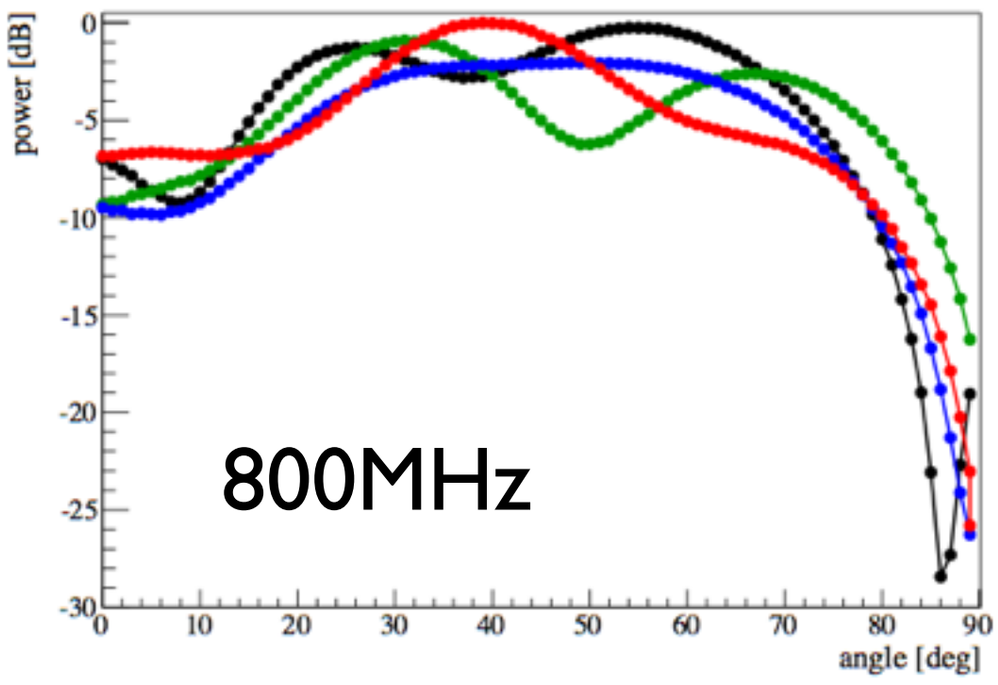


Vpol bottom: gain pattern



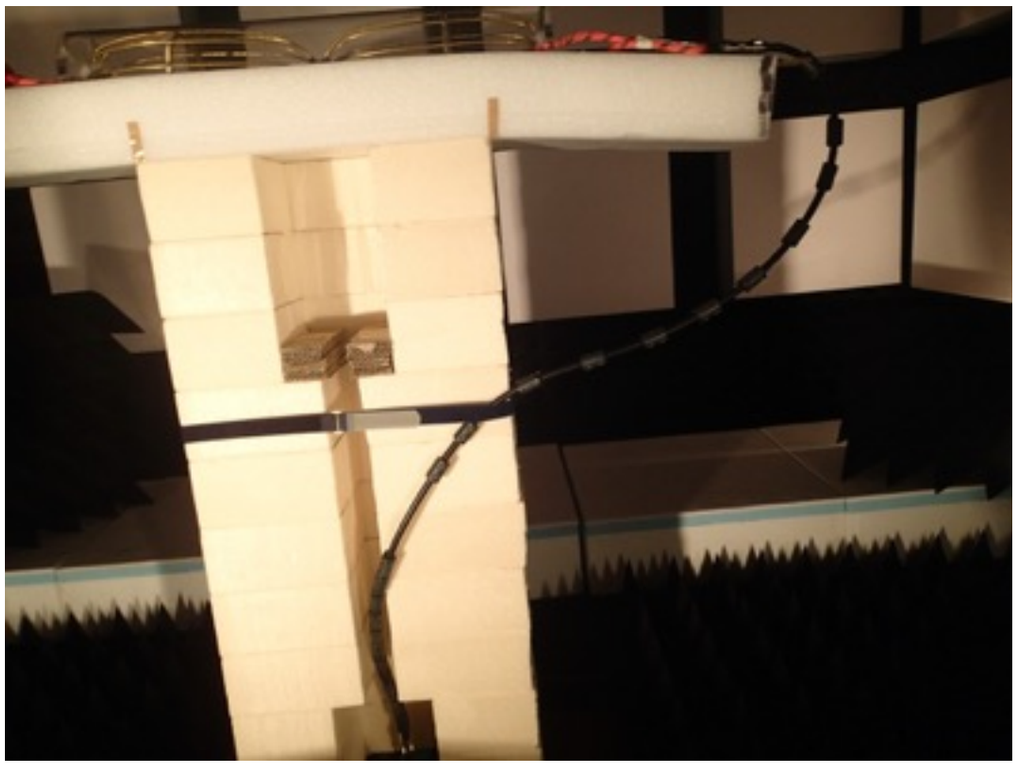
each color represents a quarter of the 360° pattern



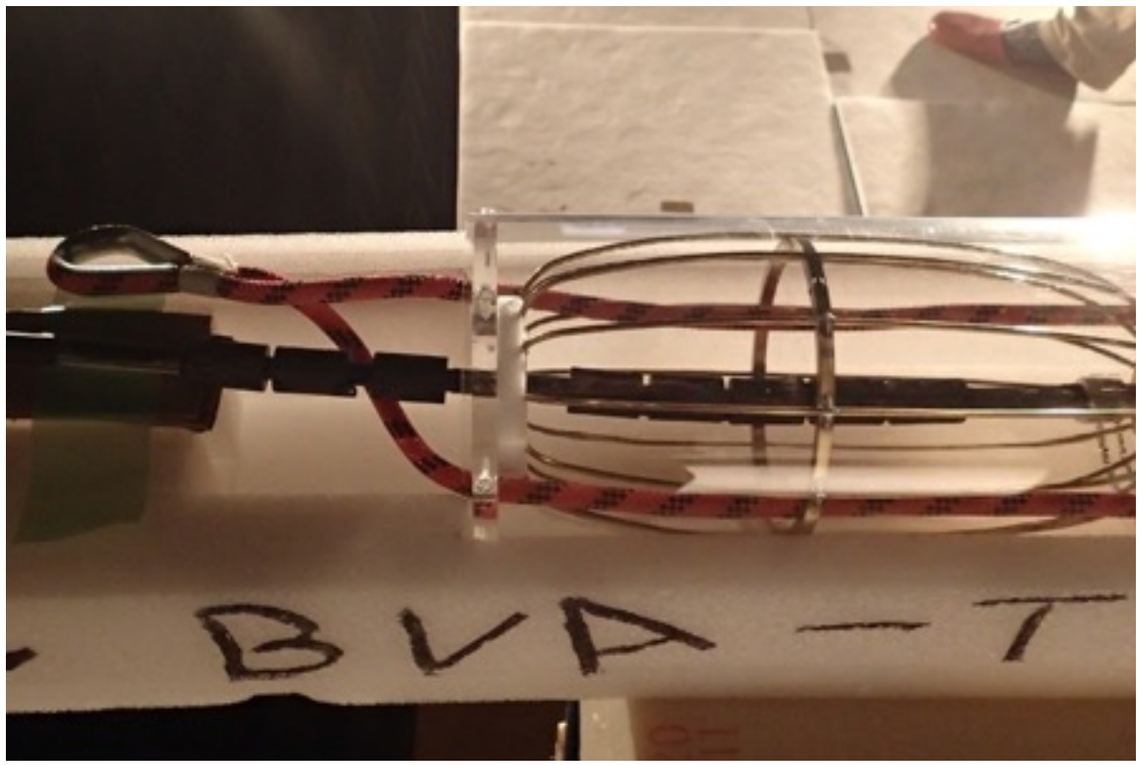


Talked with Andy and suggested to use ferrites

Vpol bottom: gain pattern



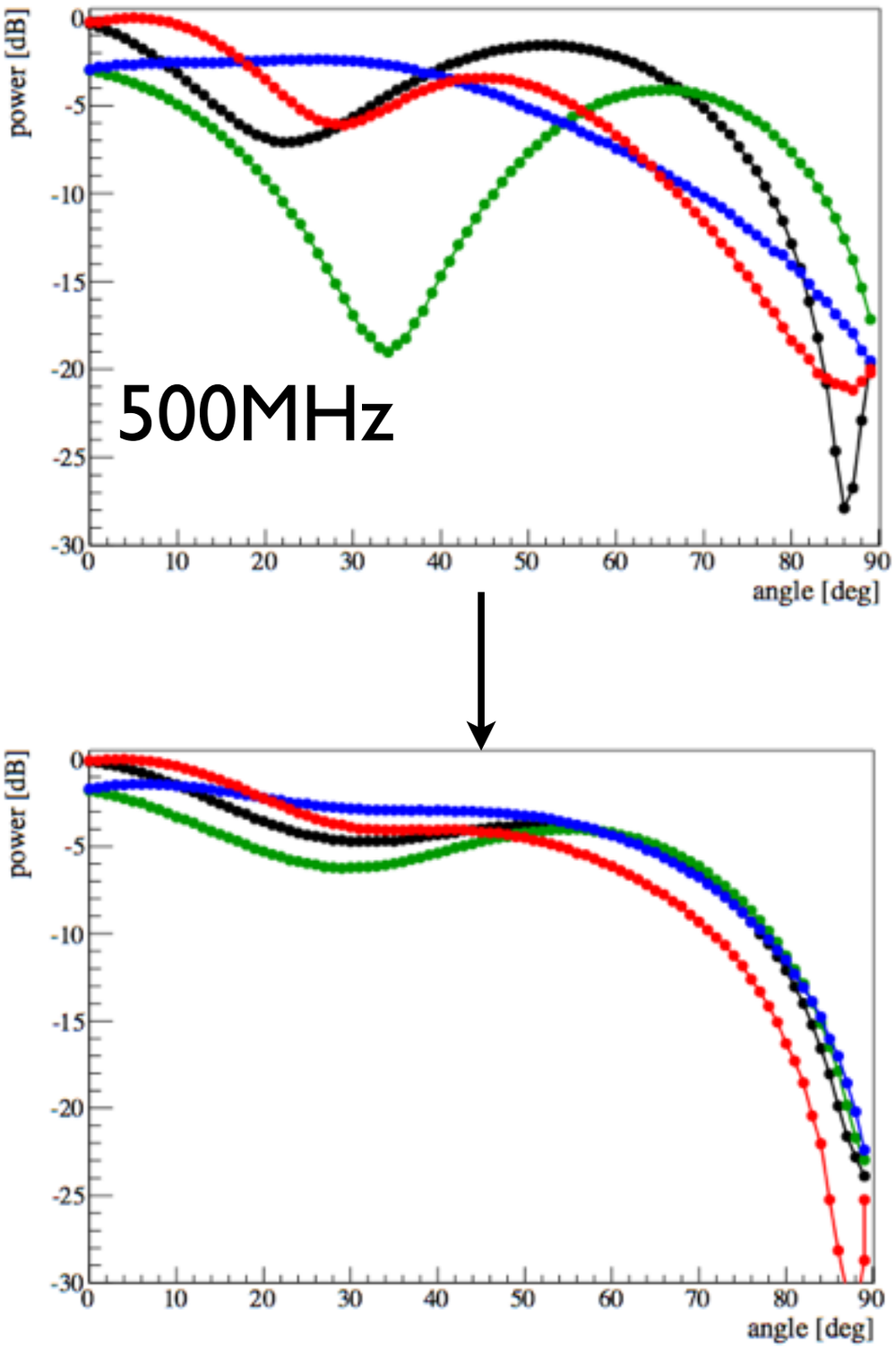
Ferrites around
the output cable

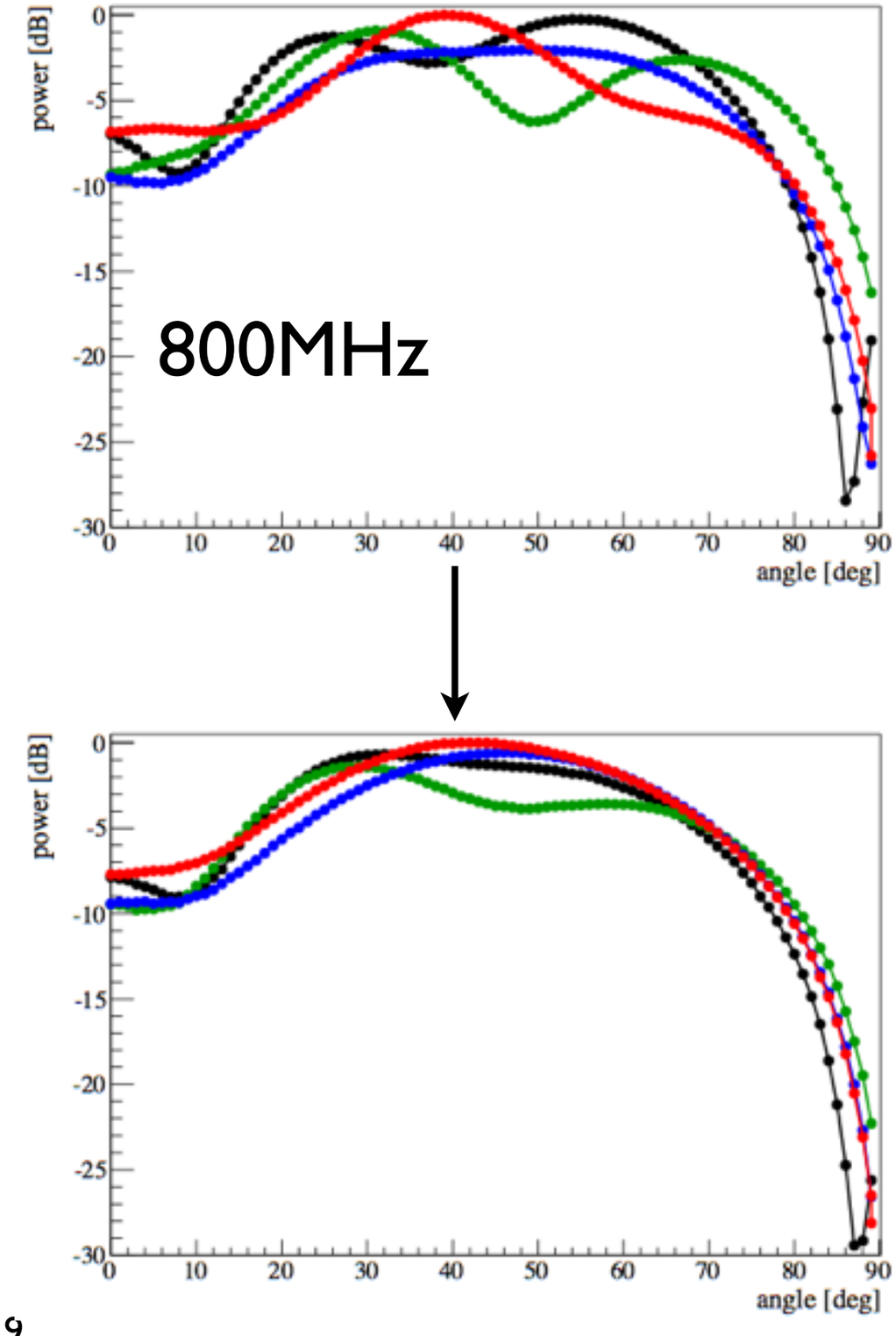


Ferrites inside the antenna

- Improve alignement and little things
- **Big improvement was to add ferrite bead around the feed cable**

Vpol bottom: gain pattern



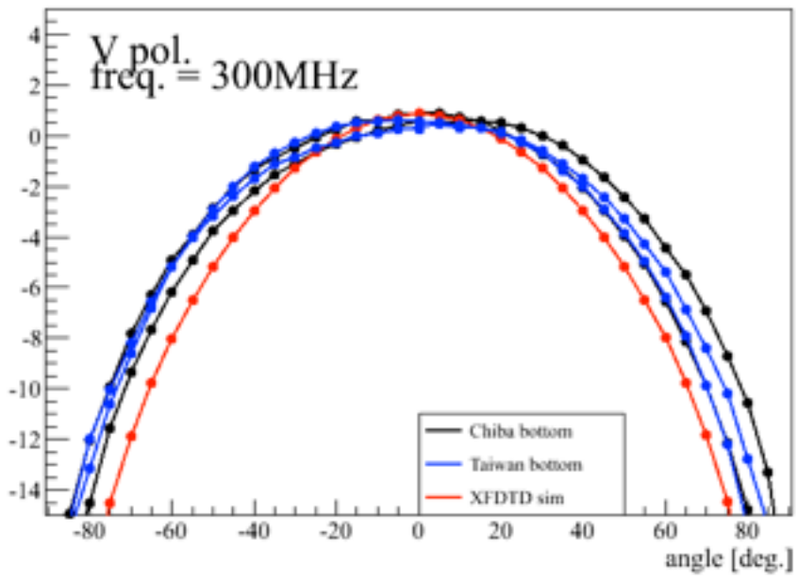


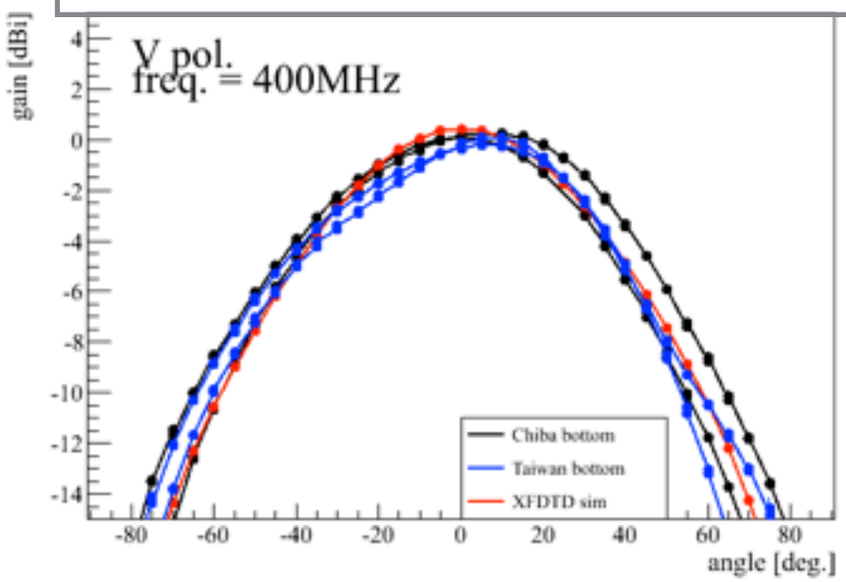
Vpol bottom:Data/sim

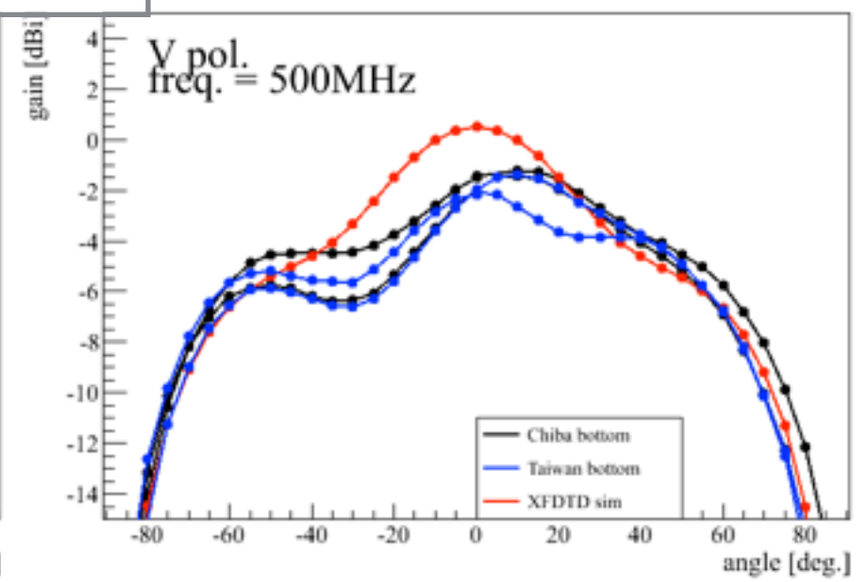
Black: Chiba production

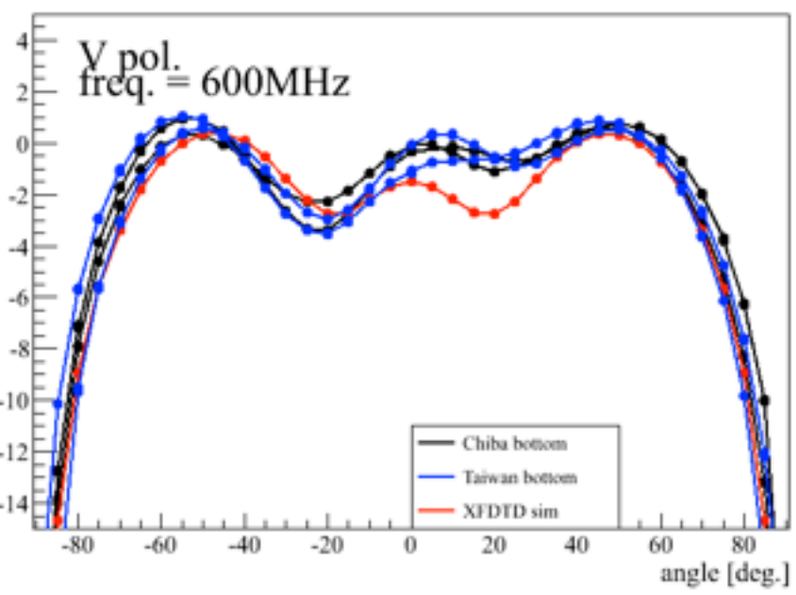
Blue: Taiwan production

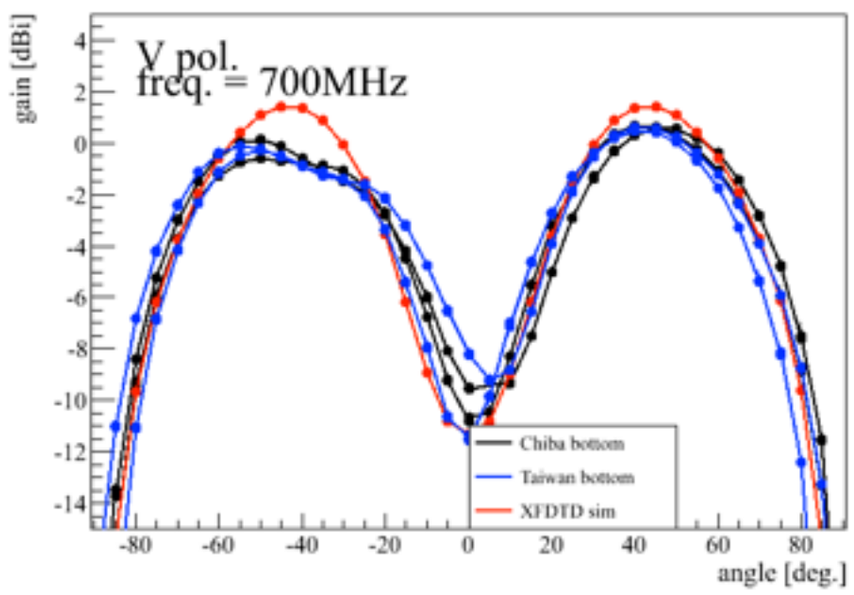
Red: simulation

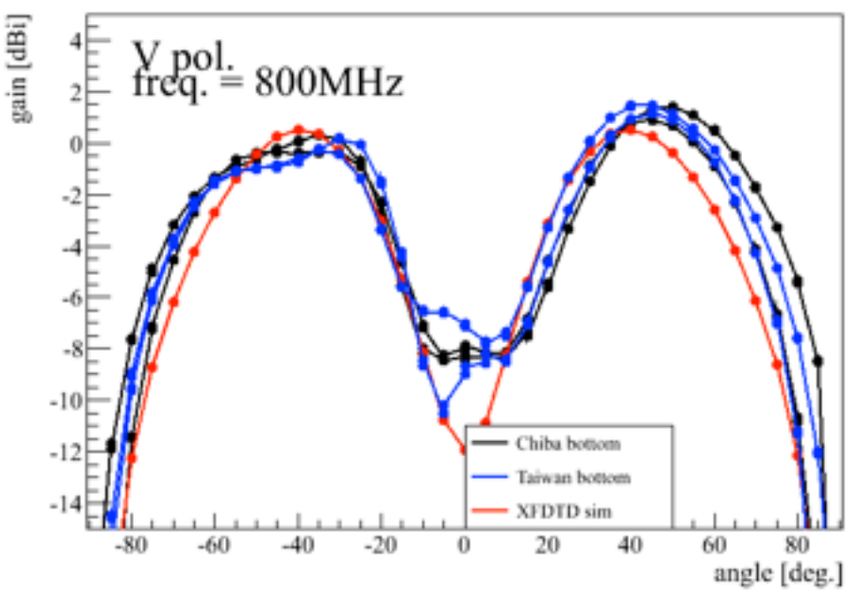




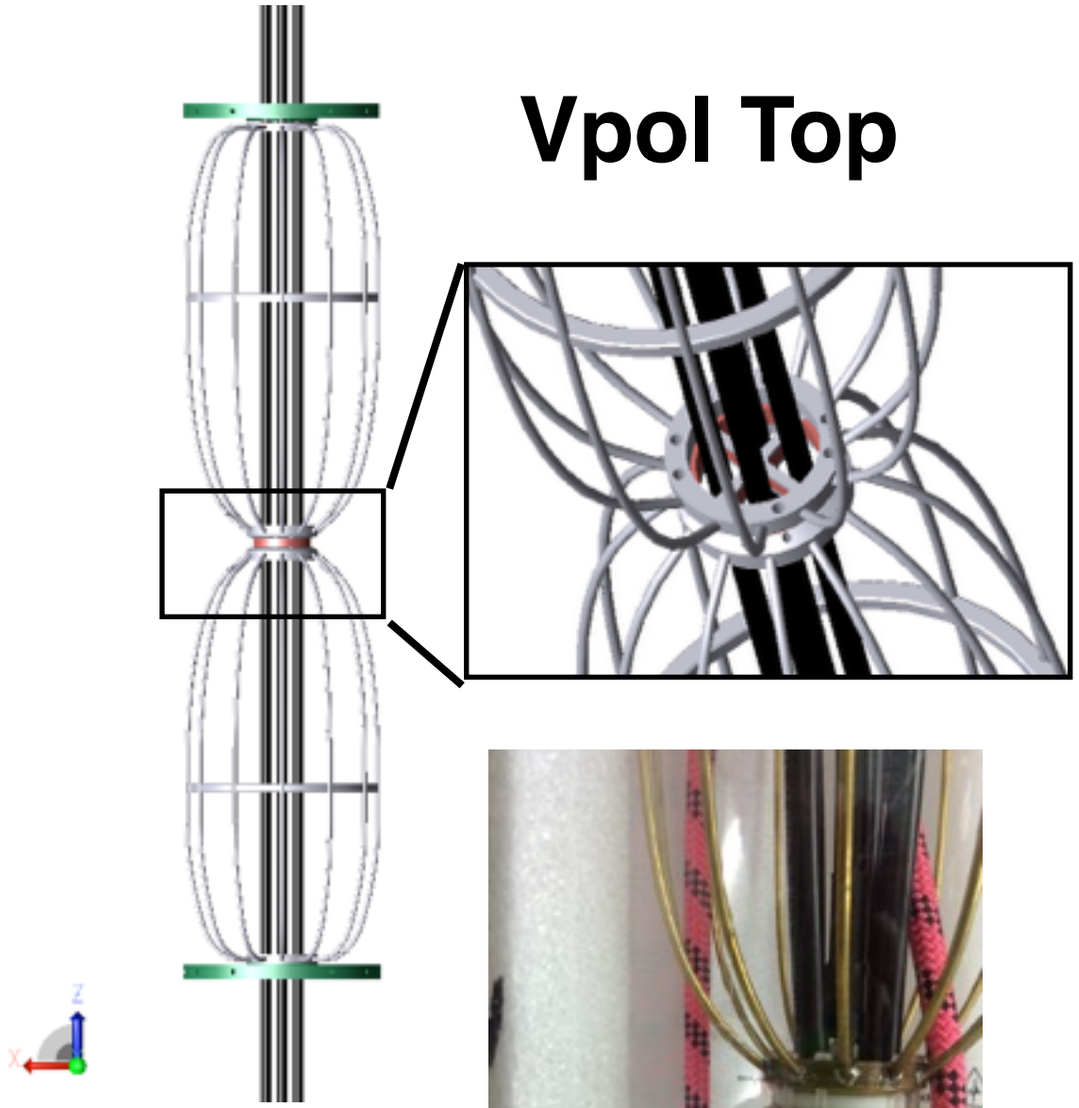






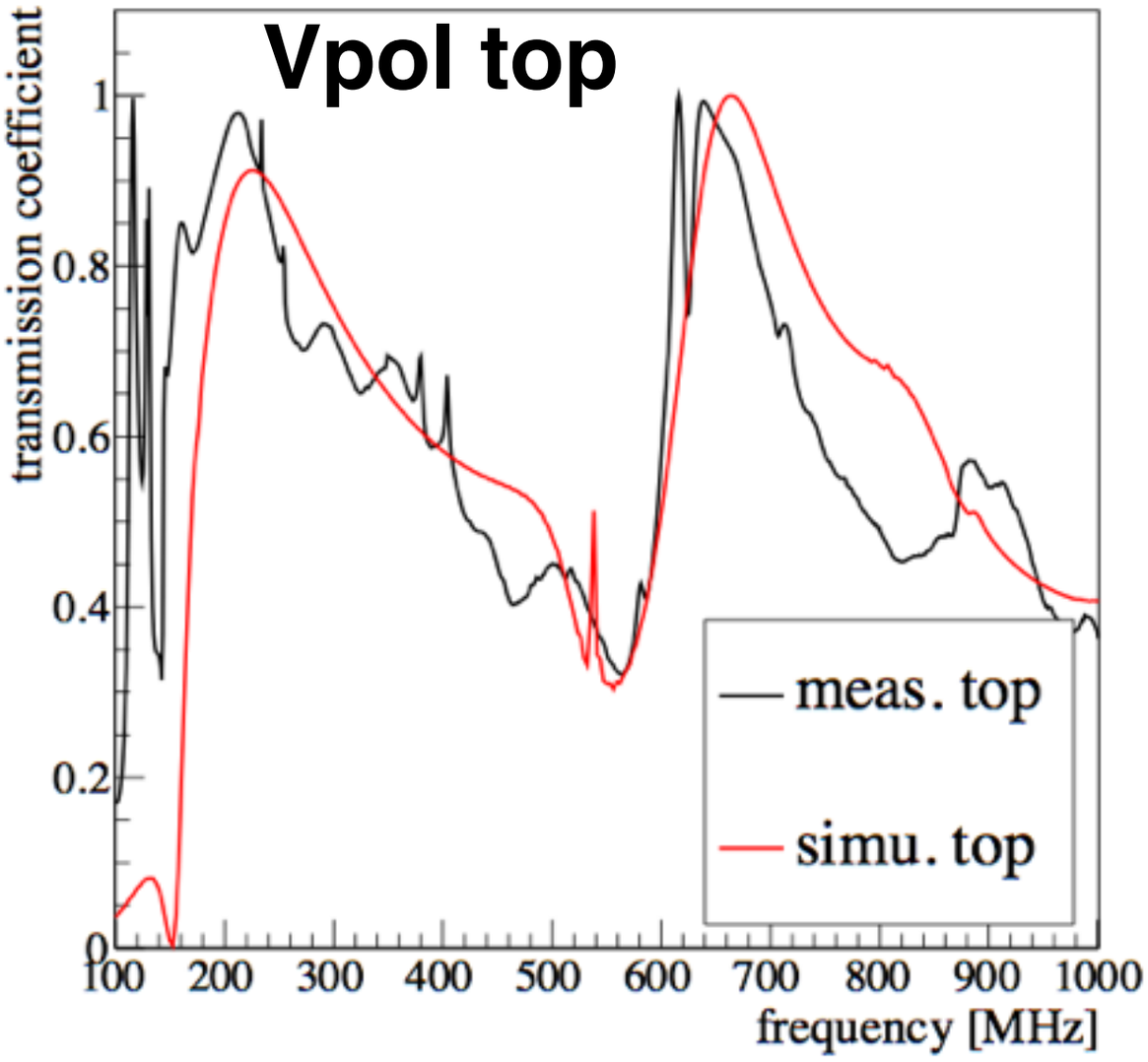


Vpol Top: model



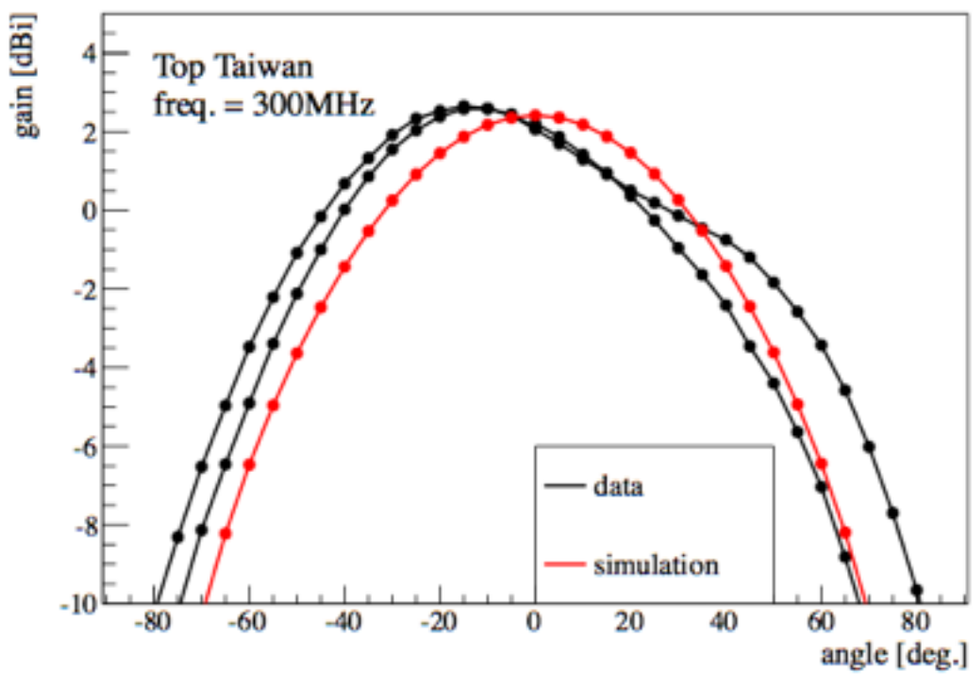
- Main difference with bottom:
  - 4 cables inside the antenna
  - central part is partly empty

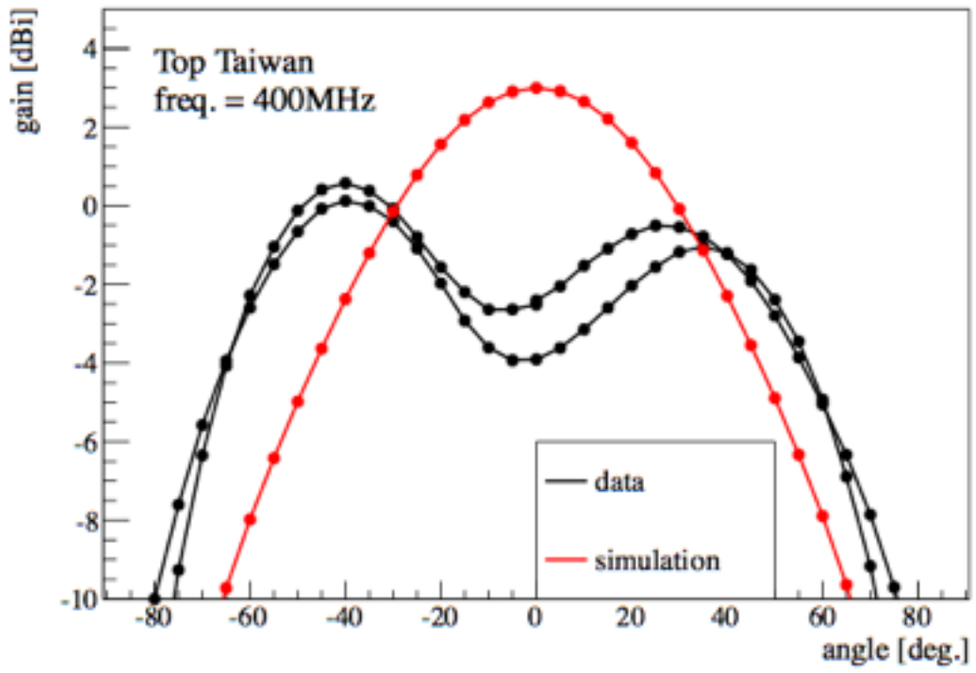
Vpol top:Transmission coeff

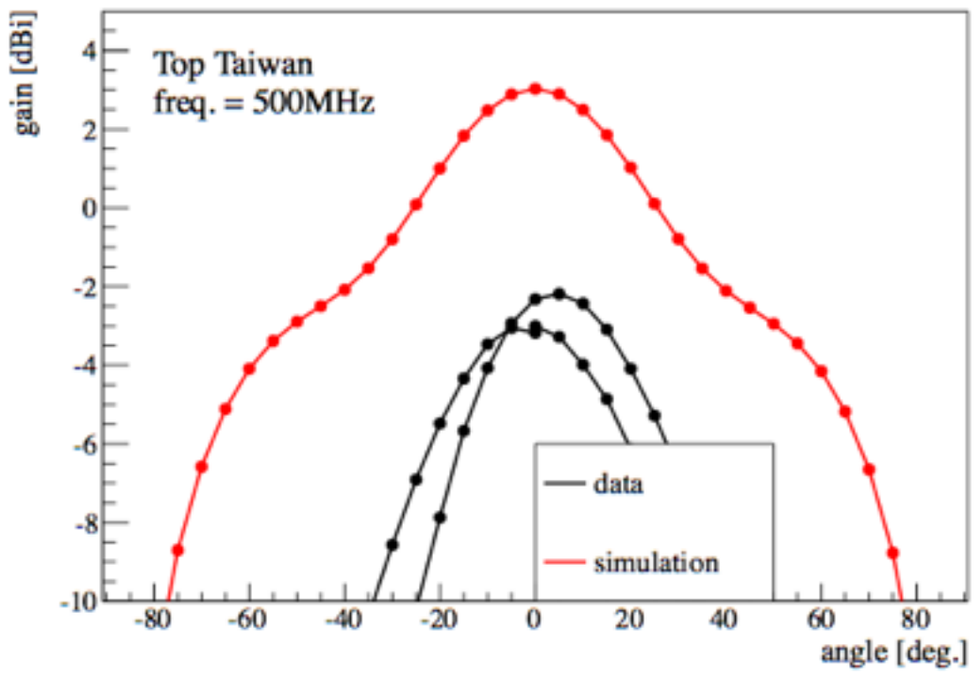


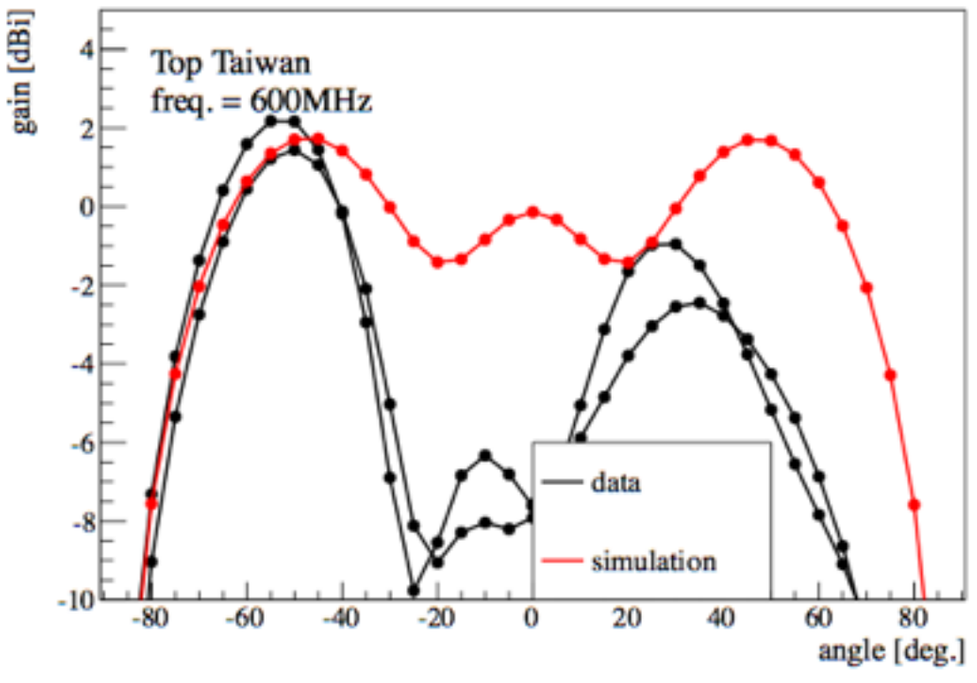
Does a very good job at least below 700MHz

Vpol top: data/sim

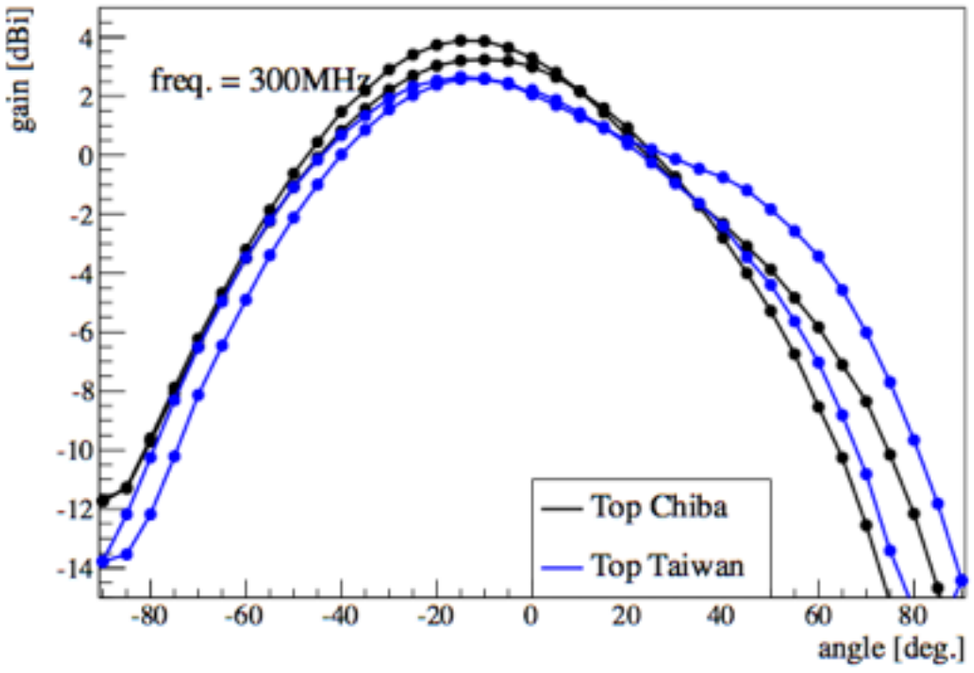


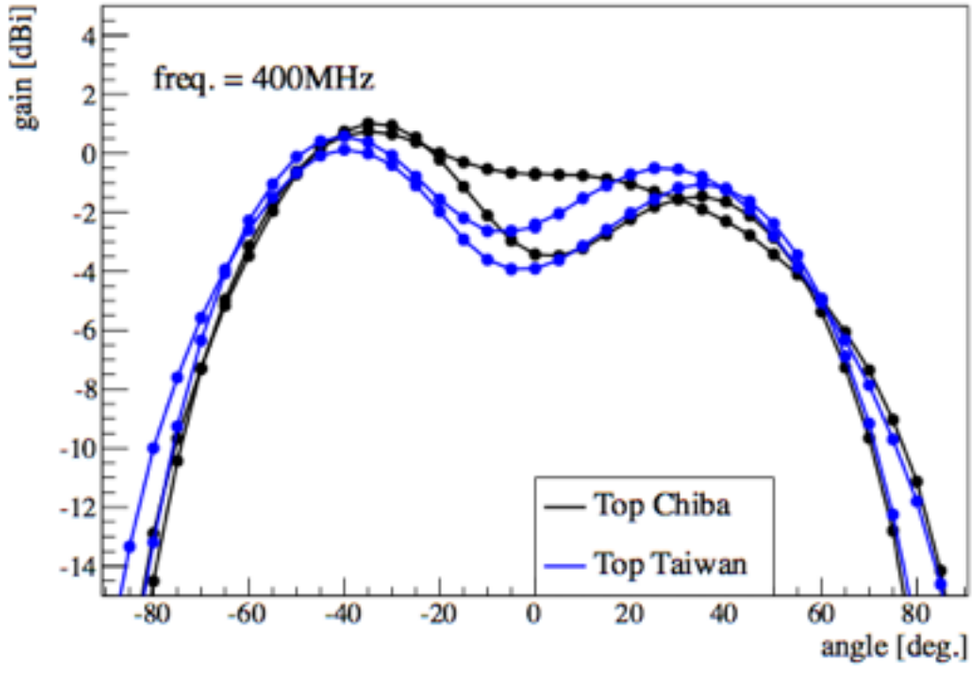


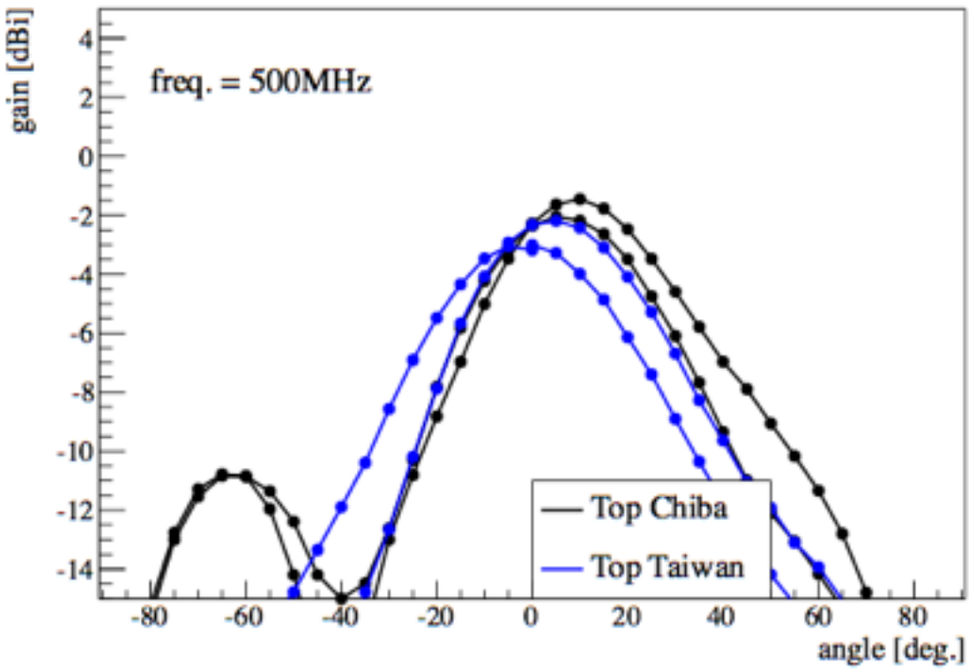


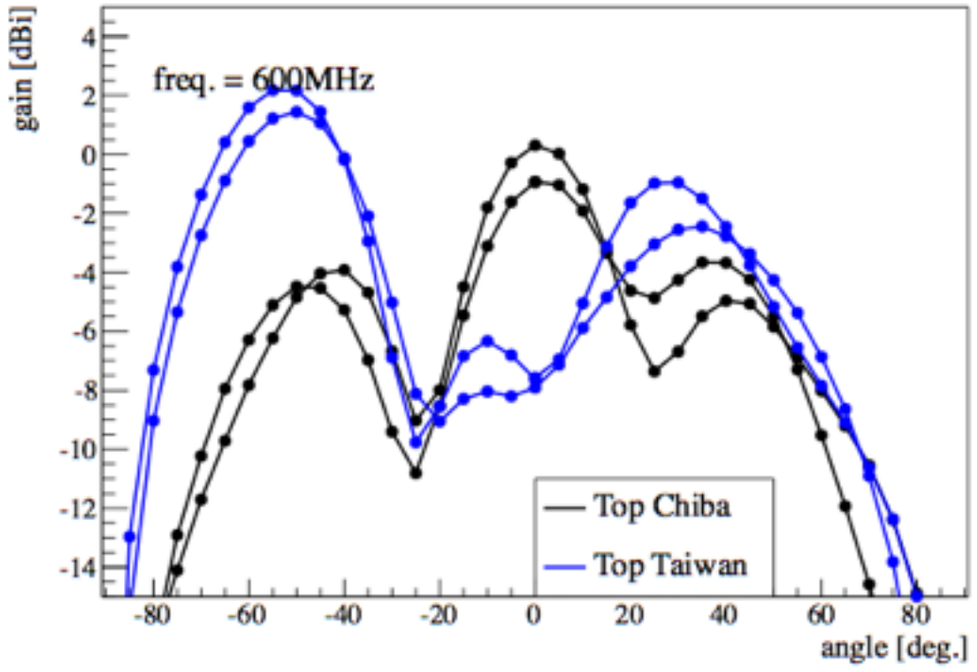


Vpol top: Taiwan/Chiba









Vpol conclusion

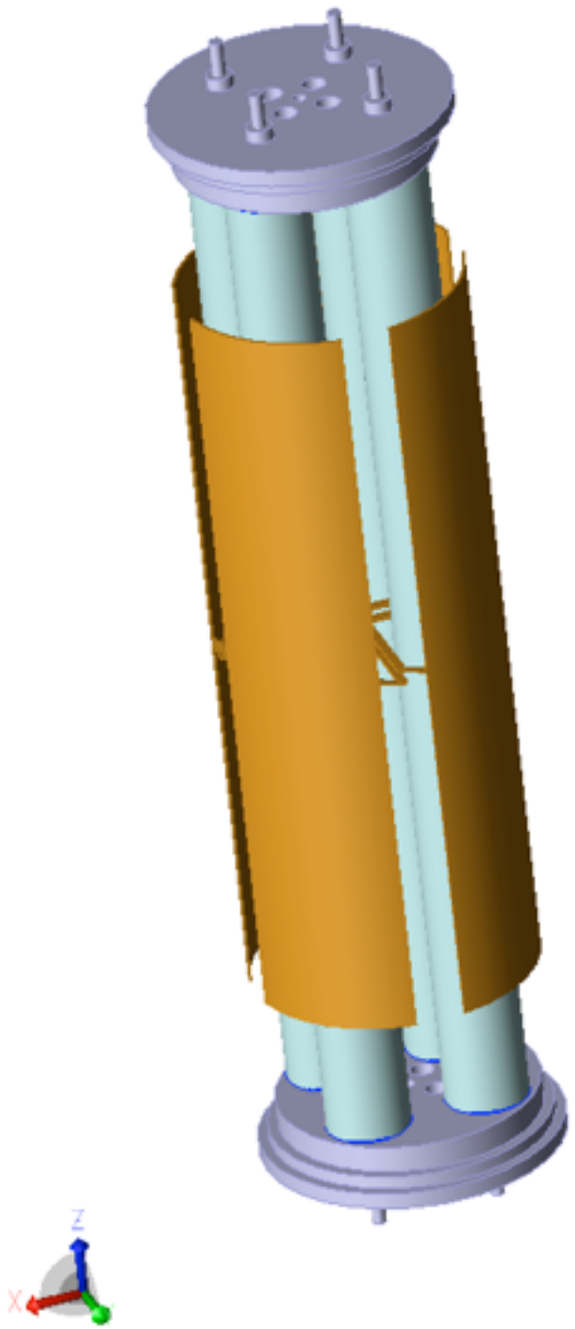
- Vpol bottom: well understood when we have ferrites around the feed cable

  ➡ Do we have some cable effect in ice ?

- Vpol top: not able to reproduce gain pattern

- Still working on the cable simulation

Hpol: model

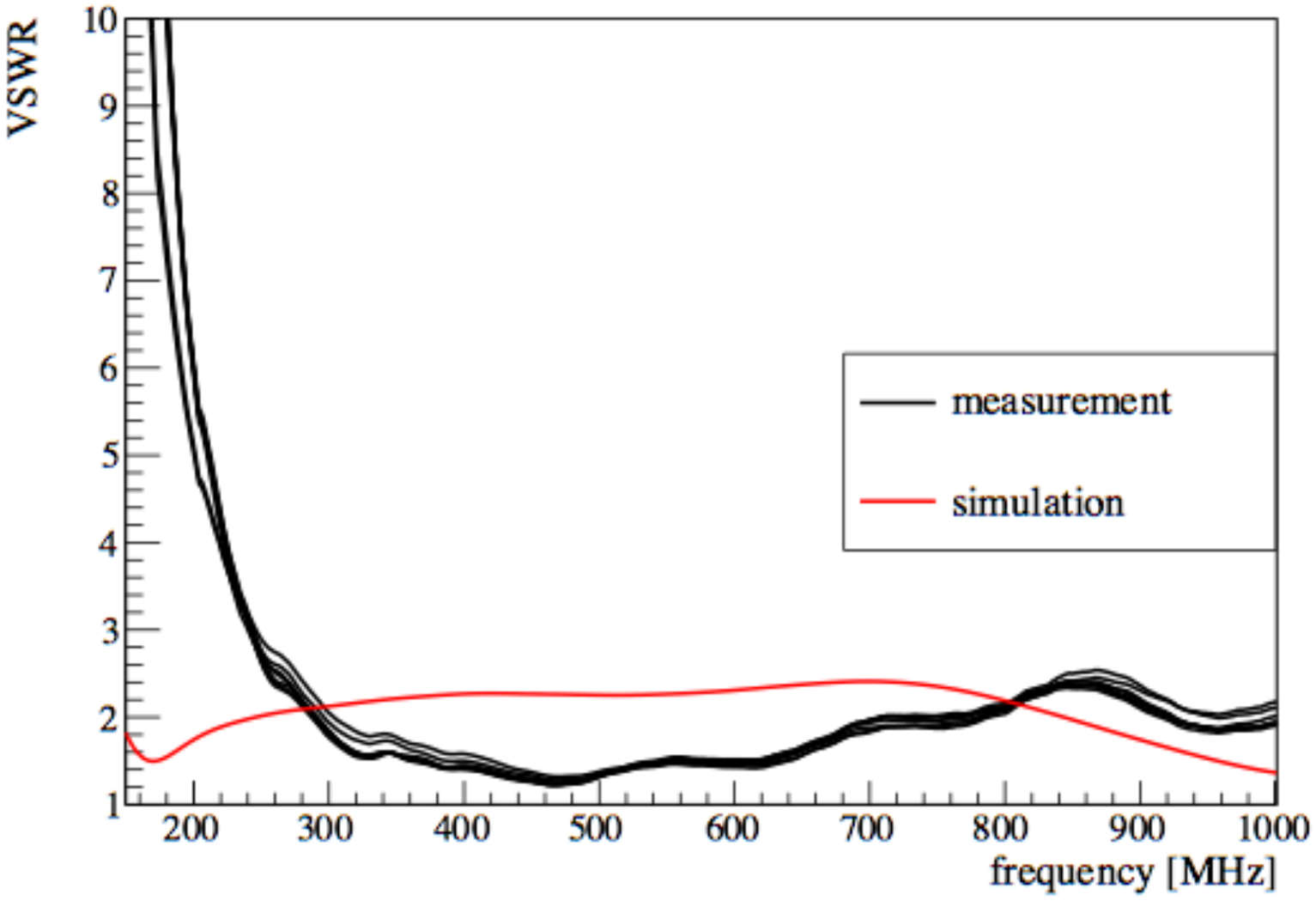


- Model provide by Andy
- Quad slot antenna with ferrites inside

Hpol: VSWR

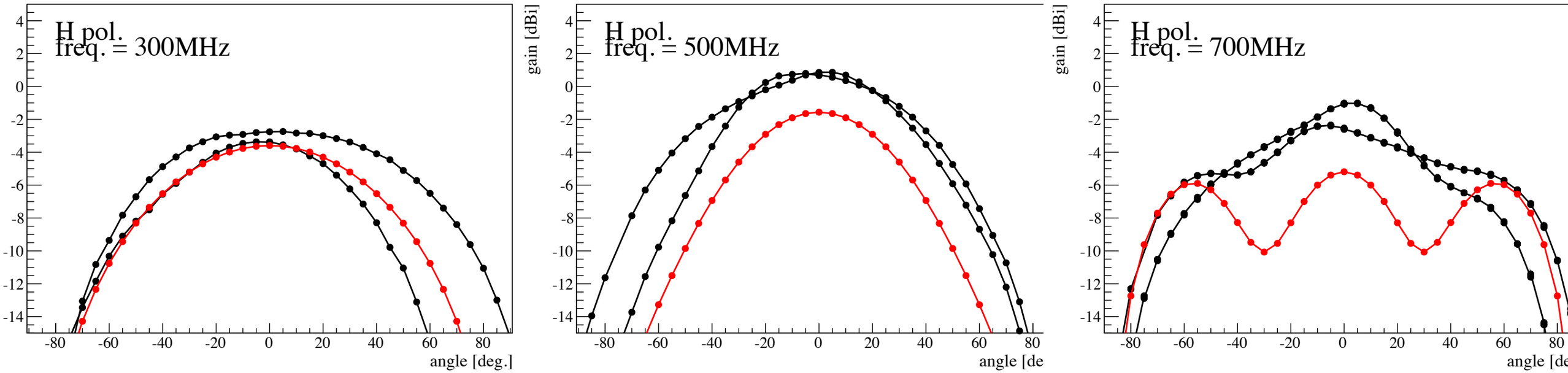
We have 8 Hpol antennas built by a company here in Japan.

The VSWR meas. were made in anechoic chamber.



They are all very consistent with each other but not with the simulations.

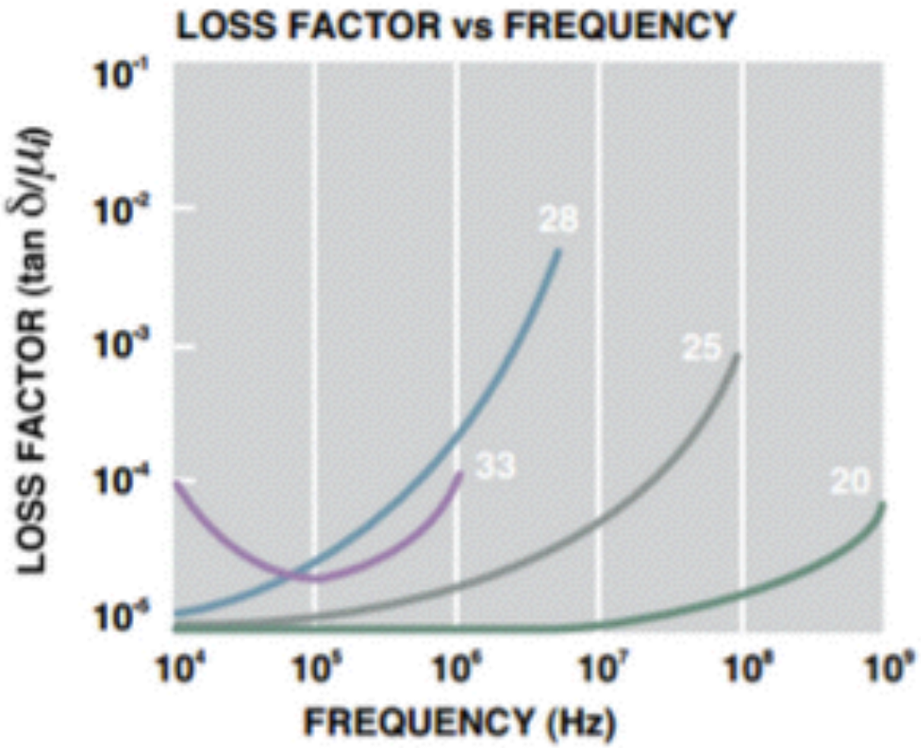
Hpol: data/sim

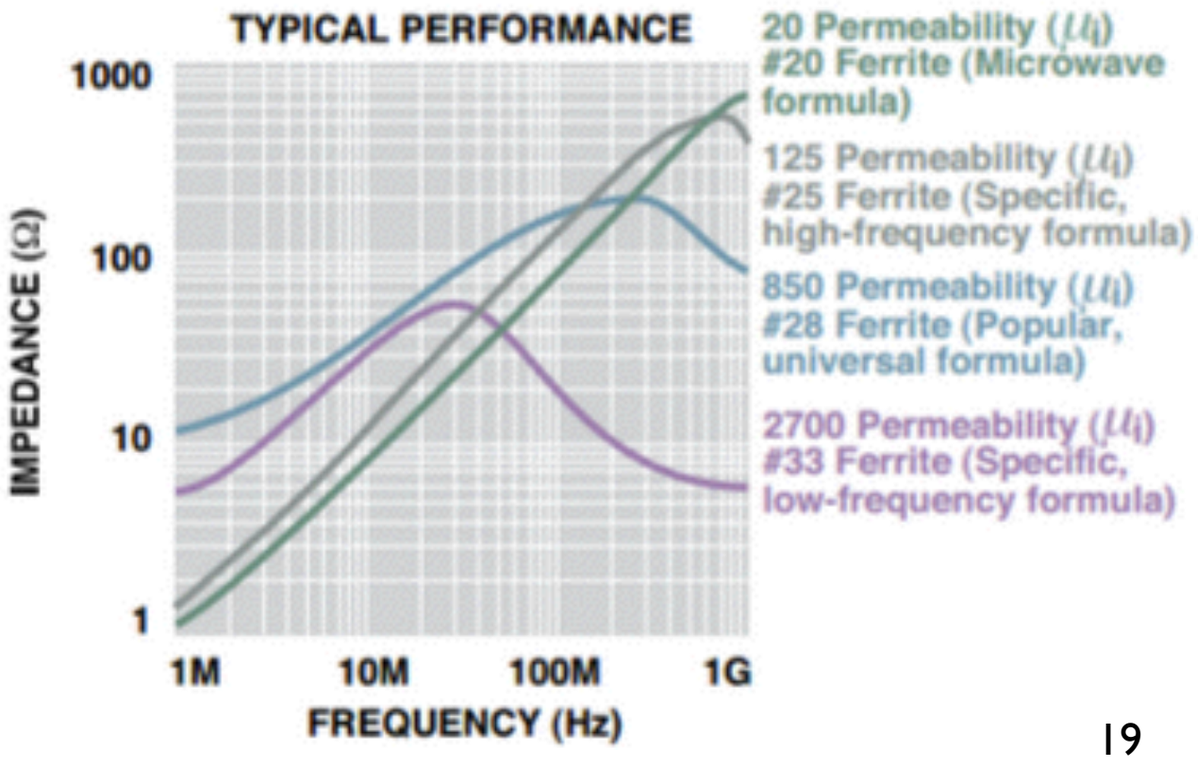


- Simulation are quite off from data
- Measurement show a larger gain than simulation

➡ Model is incorrect: the ferrite parameters may be in cause

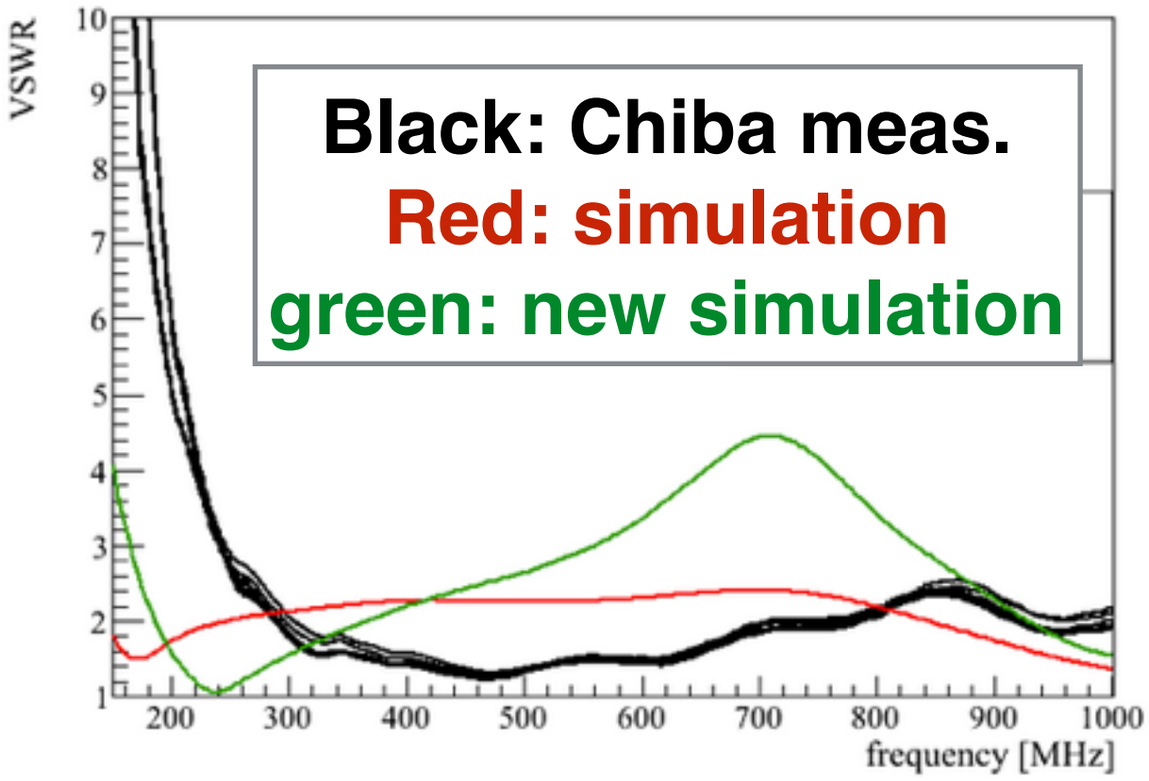
Hpol: ferrites characteristics

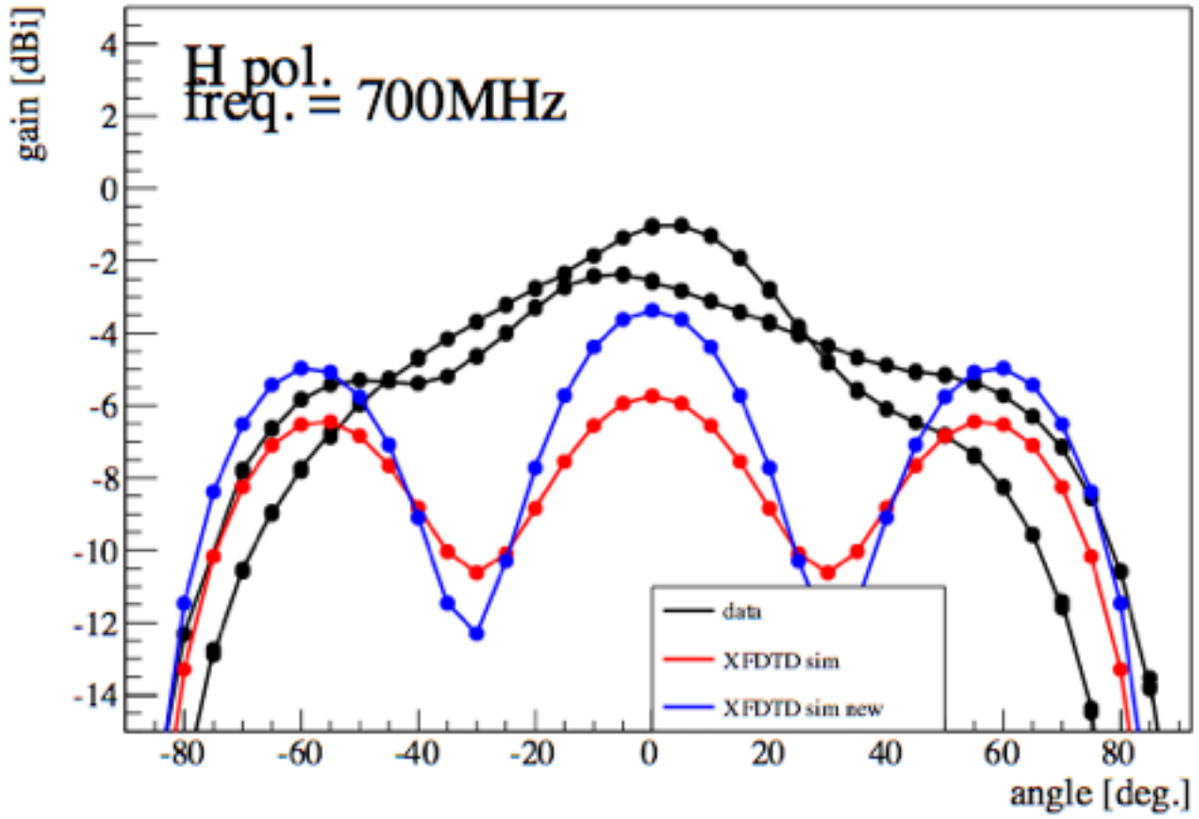




- Not very precise curve from data sheet
- According to Andy, these are in fact just indication !

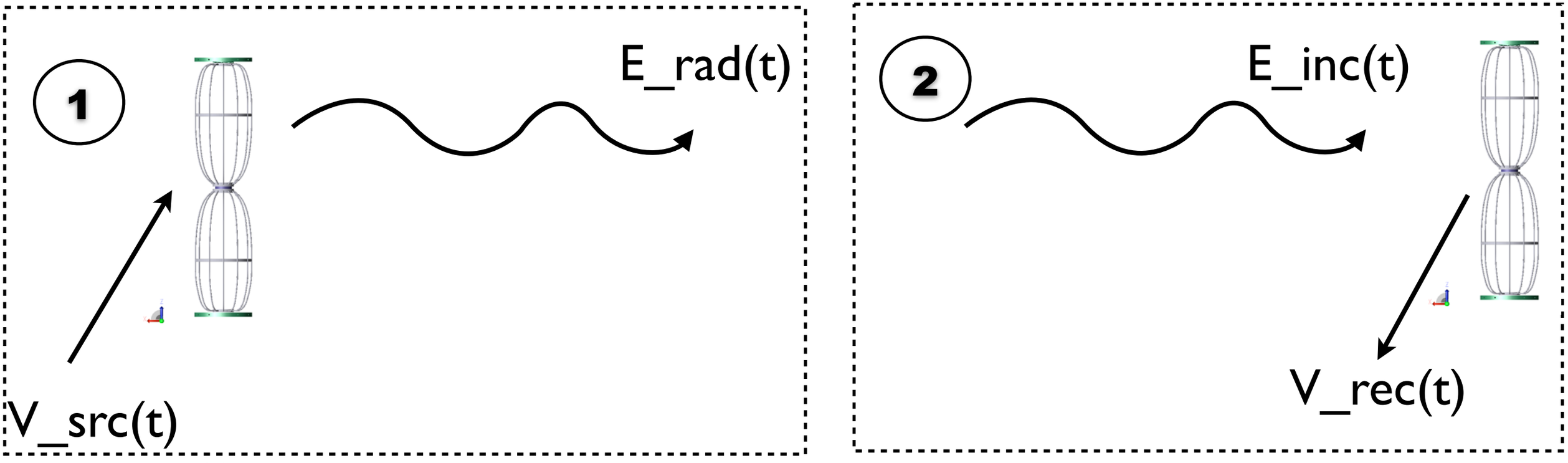
Hpol: ferrites characteristics





- Can see a change in the VSWR and gain
- But still not compatible with data
- Discussed with Andy on some possible ways to measure these ferrites characteristics

Time Domain: method



1

$$\frac{E_{rad}(t)}{\sqrt{377\ \Omega}} = \frac{1}{2\pi c r} h_N(t) \circ \frac{dV_{src}(t')/dt}{\sqrt{50\ \Omega}} \qquad t' = t - r/c$$

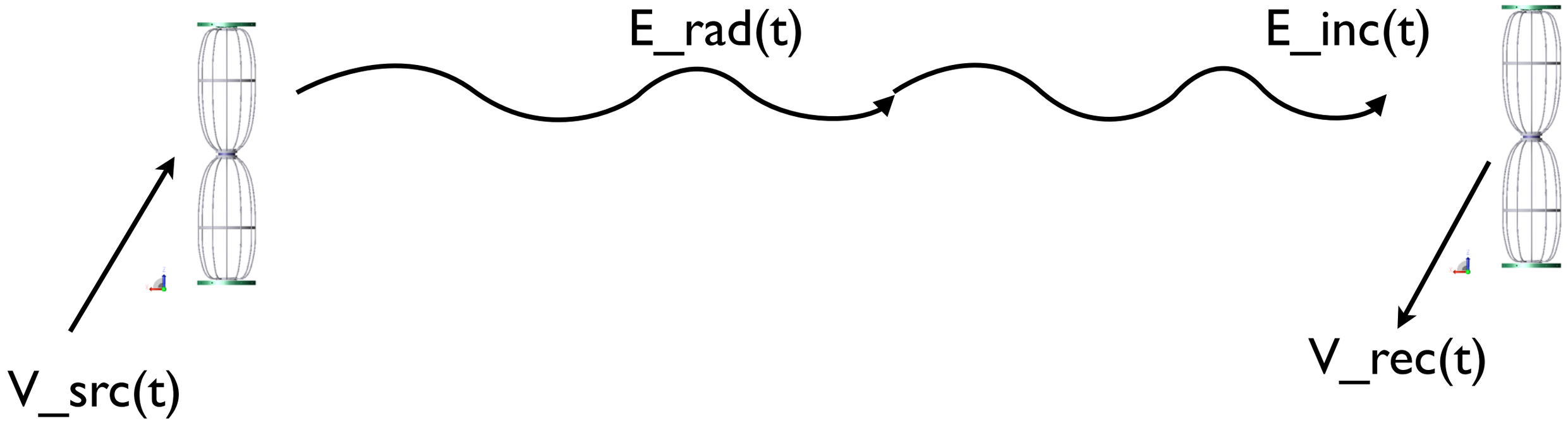
2

$$\frac{V_{rec}(t)}{\sqrt{50\ \Omega}} = h_N(t) \circ \frac{E_{inc}(t)}{\sqrt{377\ \Omega}}$$

Can express the radiated field from emitter or received voltage in time domain with the same function h(t)

http://www.farr-research.com/biblio.html (note 555)
General Properties of antenna: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=00990707
Arianna paper: http://arxiv.org/pdf/1406.0820.pdf
PRD 74, 043002 (2006) Time domain measurement of broadband coherent cherenkov radiation

Time Domain: method



$$\frac{V_{rec}(t)}{\sqrt{50\,\Omega}} = \frac{1}{2\pi c r}\, h_{N,RX}(t) \circ h_{N,TX}(t) \circ \frac{d\,V_{src}(t')\,/\,dt}{\sqrt{50\,\Omega}} \qquad t' = t - r/c$$

with $h_{N,RX} = h_{N,TX}$

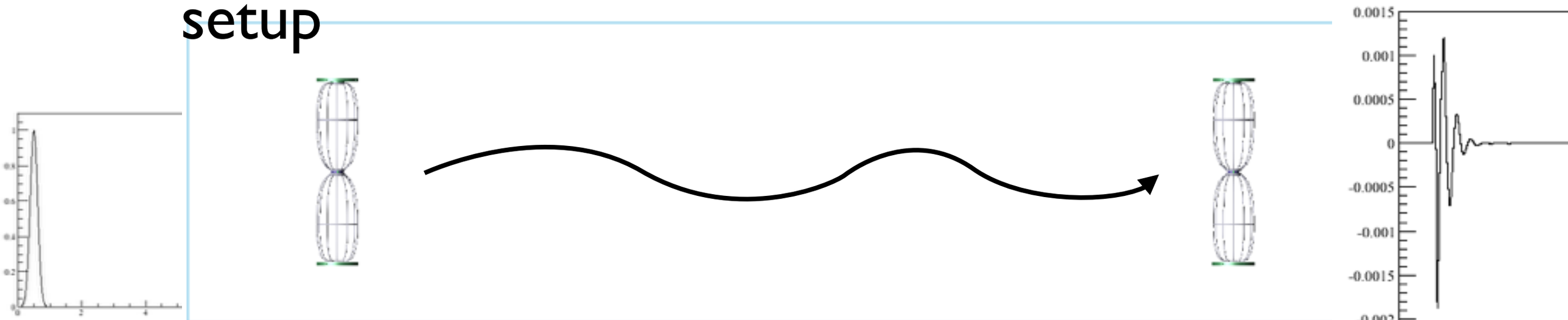
$$h(\omega) = \sqrt{\frac{2\pi c r}{j\omega \cdot exp(-jkr)} \cdot \frac{V_{rec}(\omega)}{V_{src}(\omega)\cdot}}$$

Difficulties

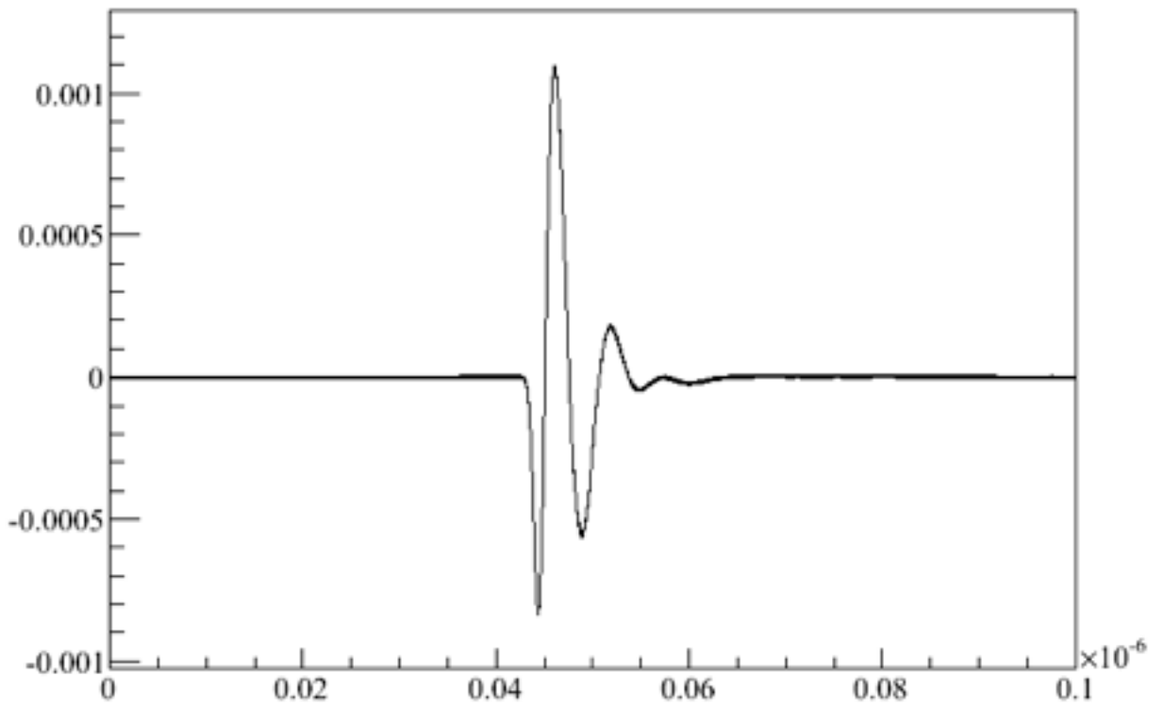
- after division of FFT (some freq. are arbitrarely large)
- square root of FFT:
  (phase unwrapping needed)

Time Domain: simulation

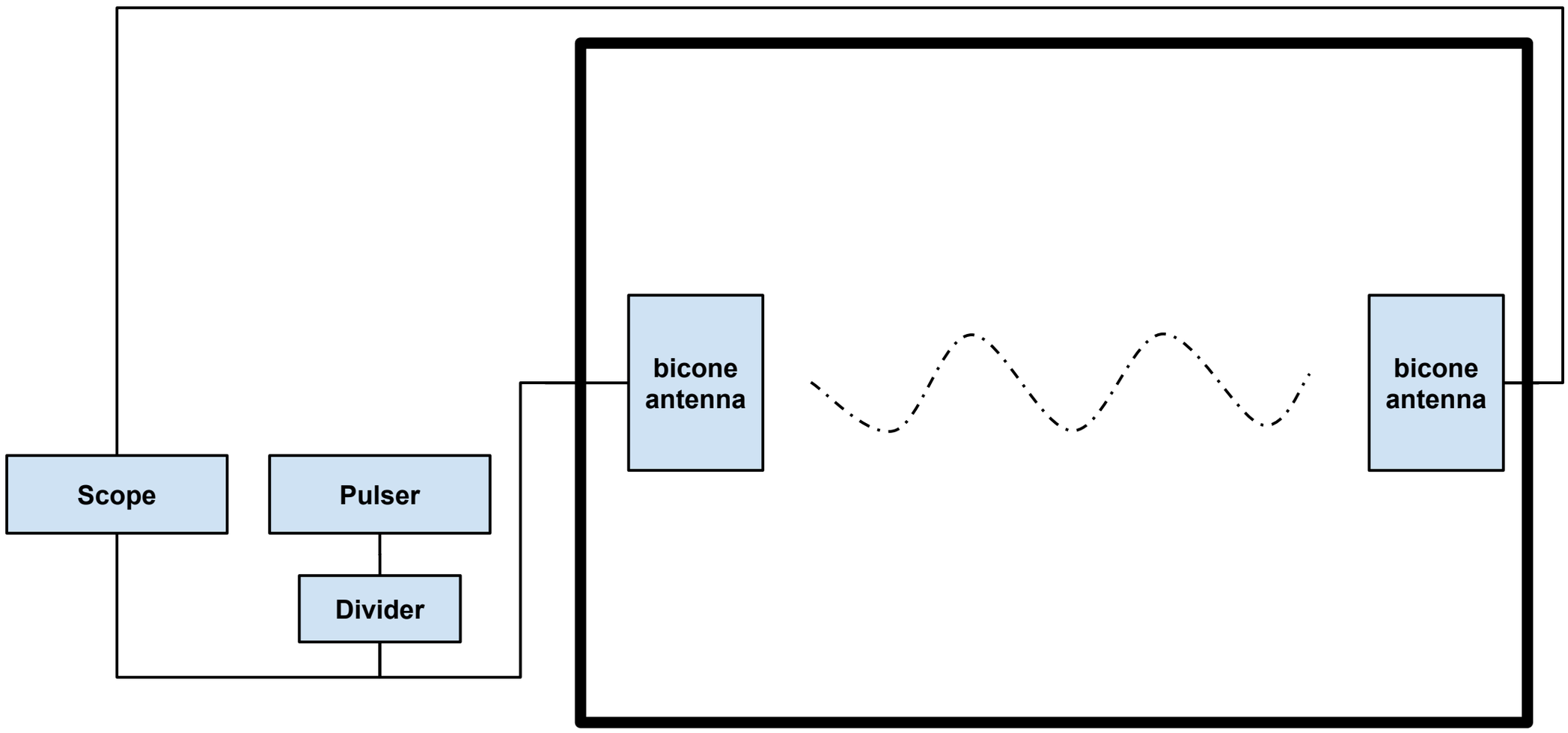
setup



Example of response input: bipolar pulse

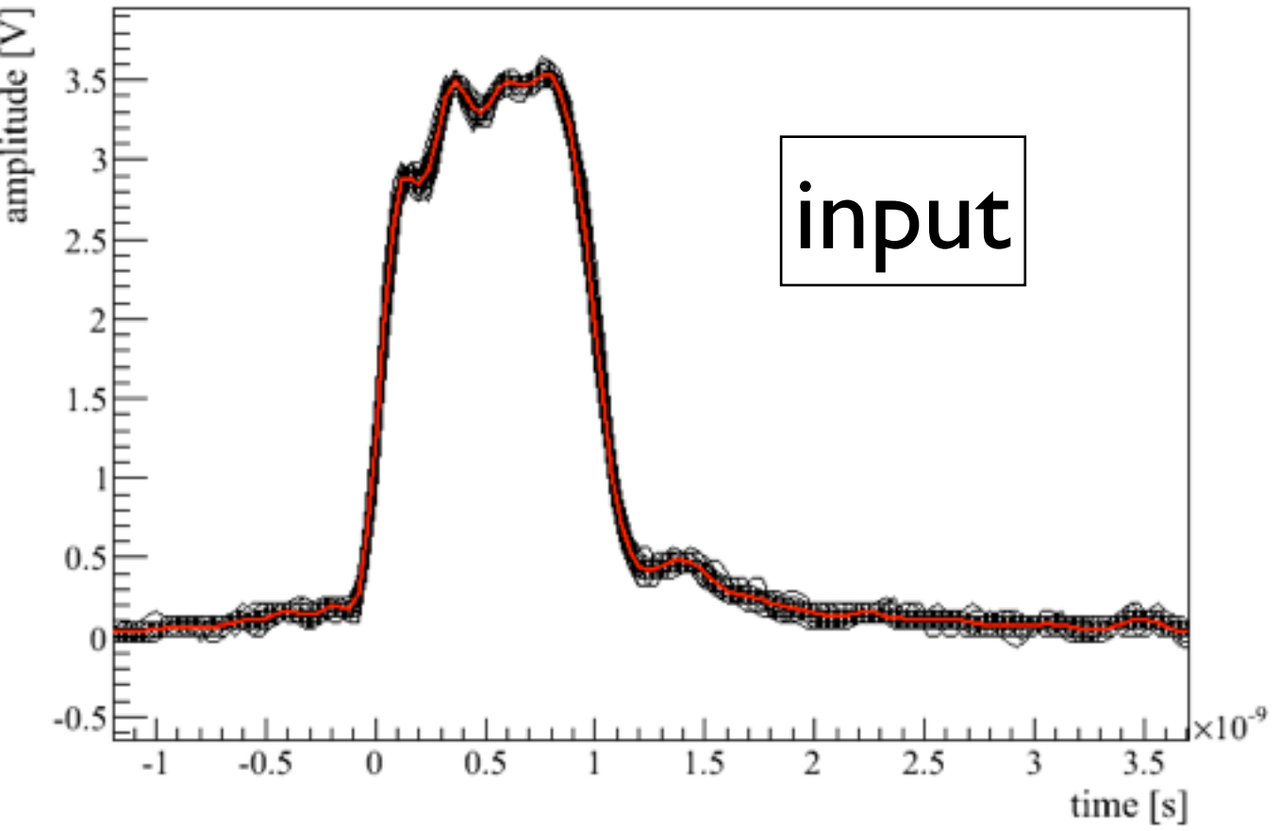


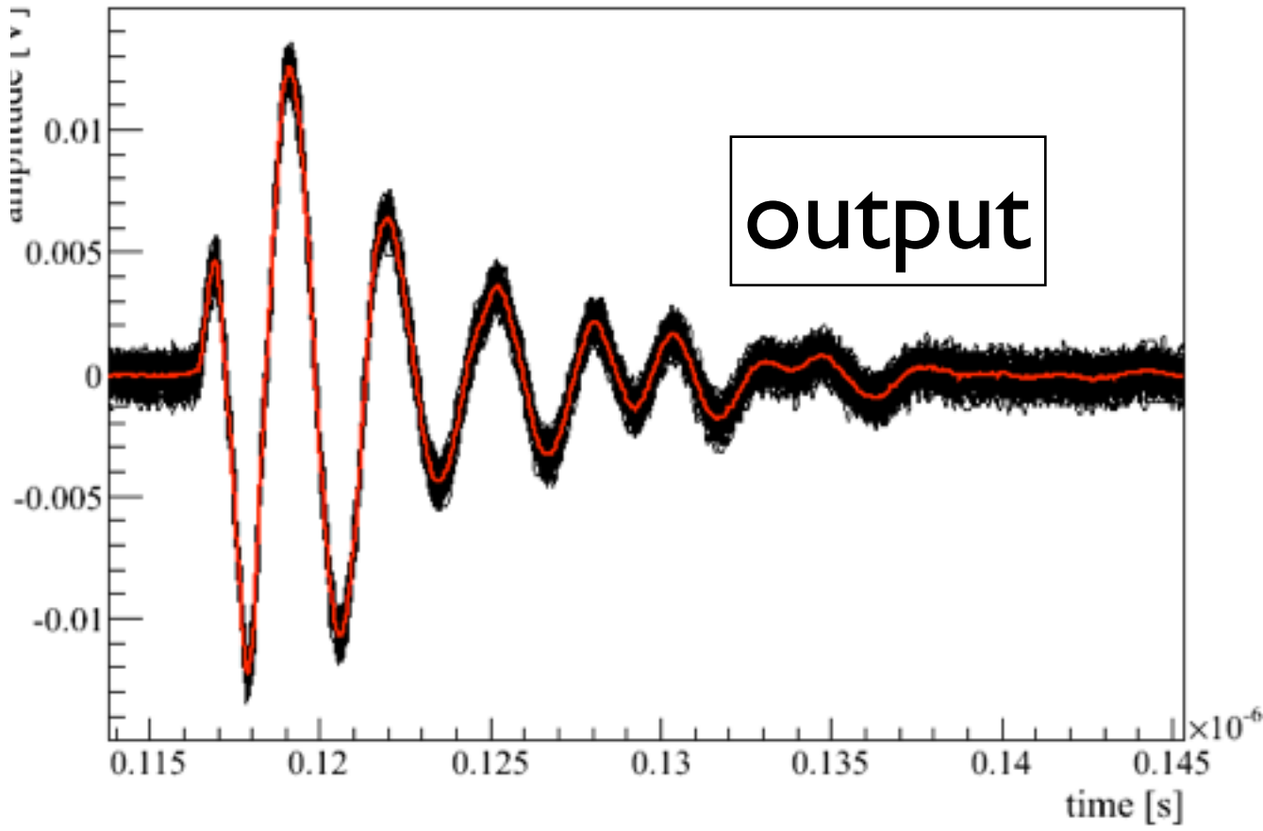
Time domain measurement



- Took data with
  - bicone - bicone
  - bicone - ARA Vpol (bottom/top/Taiwan/Chiba)
  - bicone - ARA Hpol

Time domain: type of data

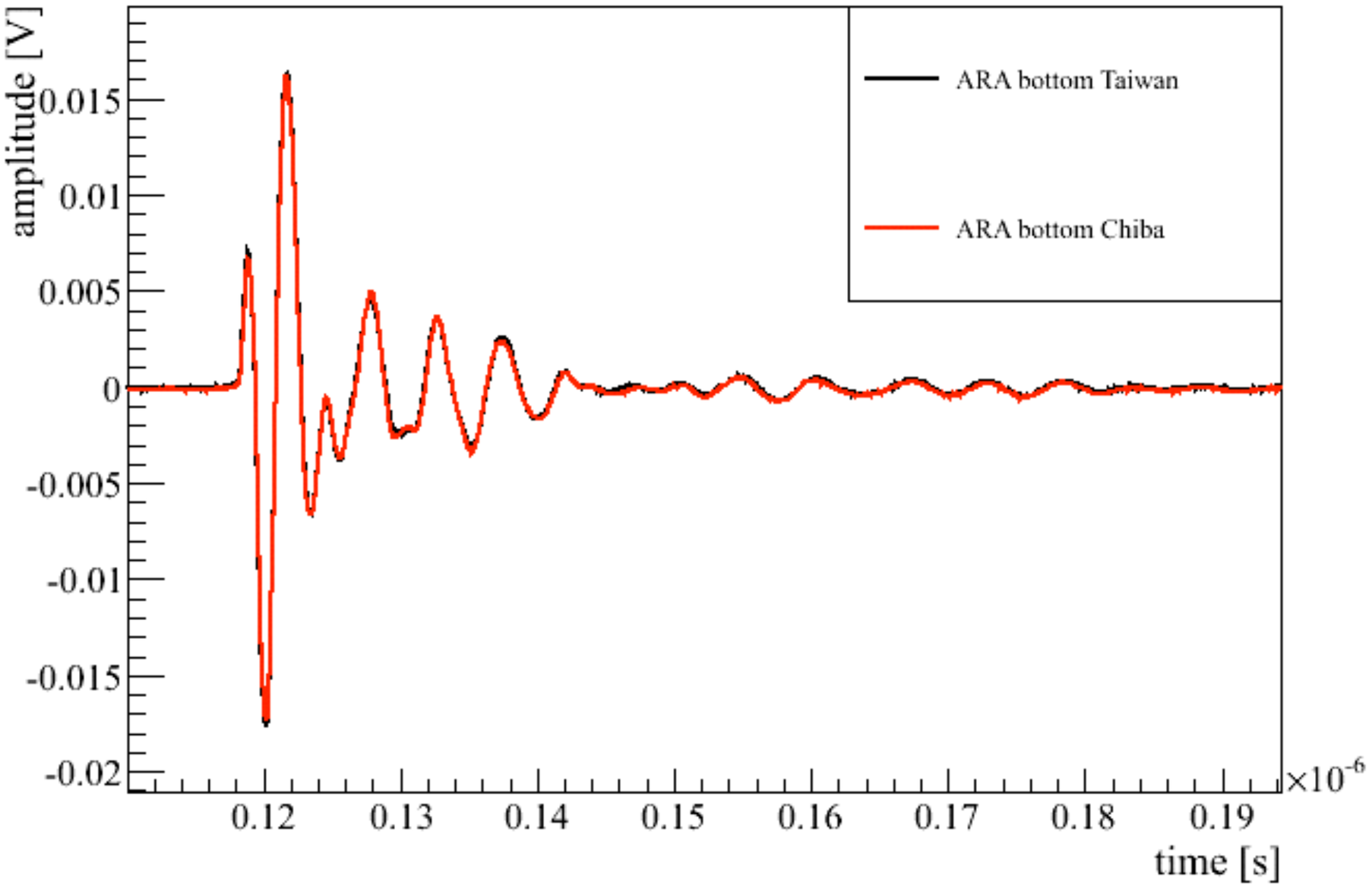




- Input: ~1ns pulse/ 3.5 V
- Output: radio signal twice convoluted with an antenna response

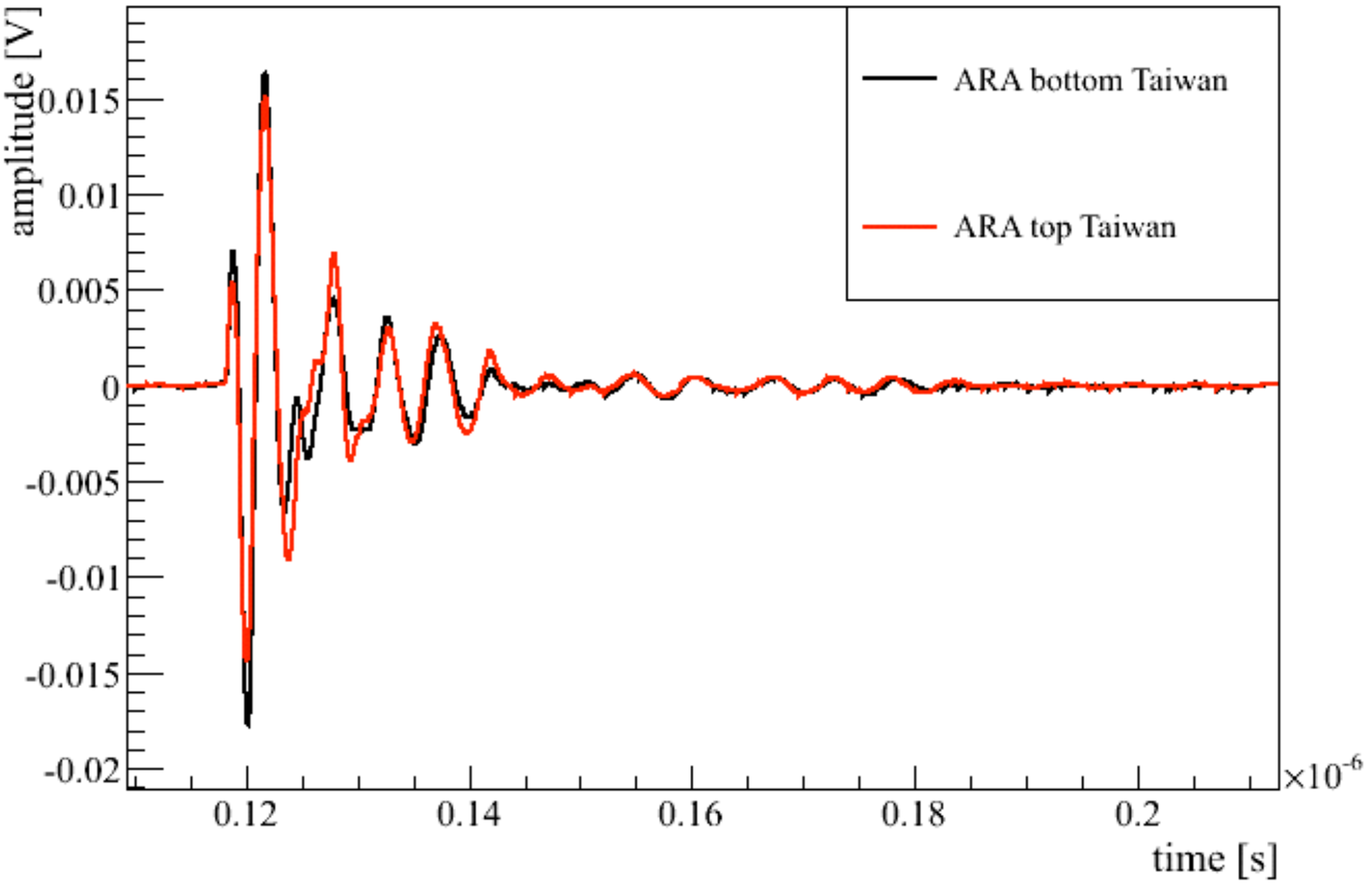
- Input signal very stable, output more noisy → <u>averaging needed</u>

Time domain: type of data
Chiba vs Taiwan



very small difference

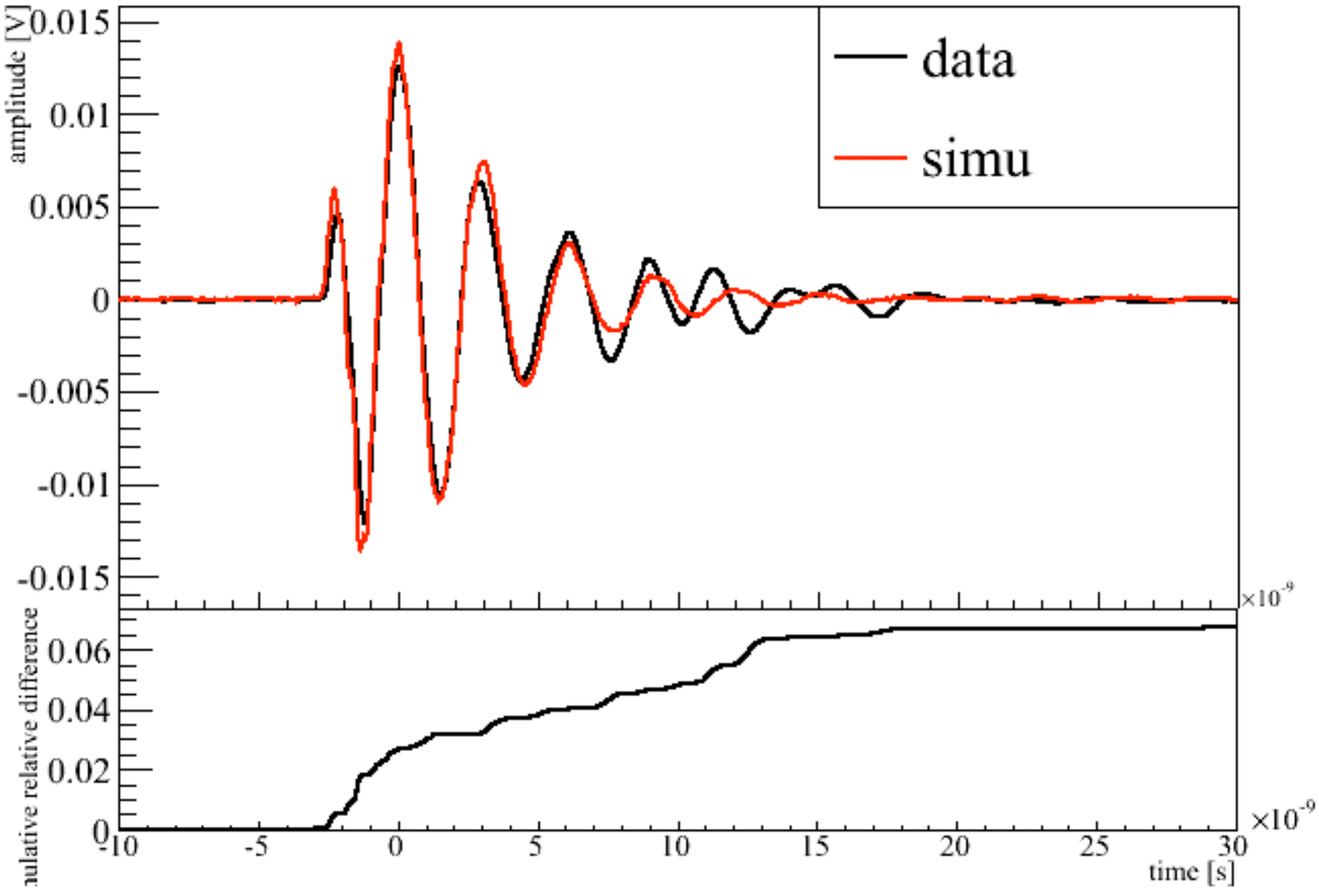
Time domain: type of data
Top vs Bottom



The top/bottom the difference are not that important

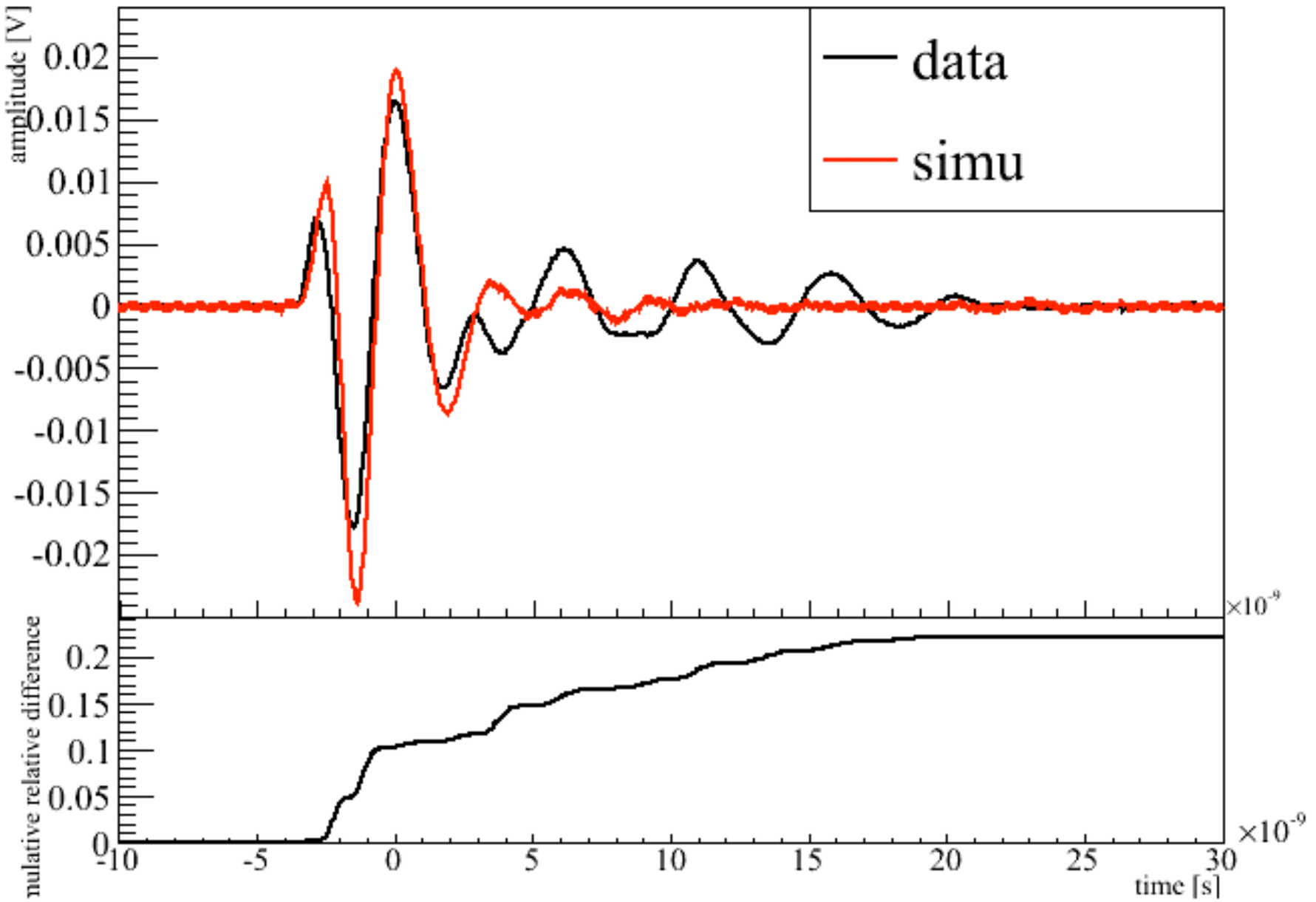
data/simulation: Bicone→ bicone

- For simulation: take the simulated antenna response
- Input the measured input pulse.



- Difference data/simuation in the integrated power: **~8%**

Comp with simulation: Bicone→ ARA antenna



- here we see more difference in the main pulse but also the late part
  - Difference data/simuation in the integrated power: **< 25%**

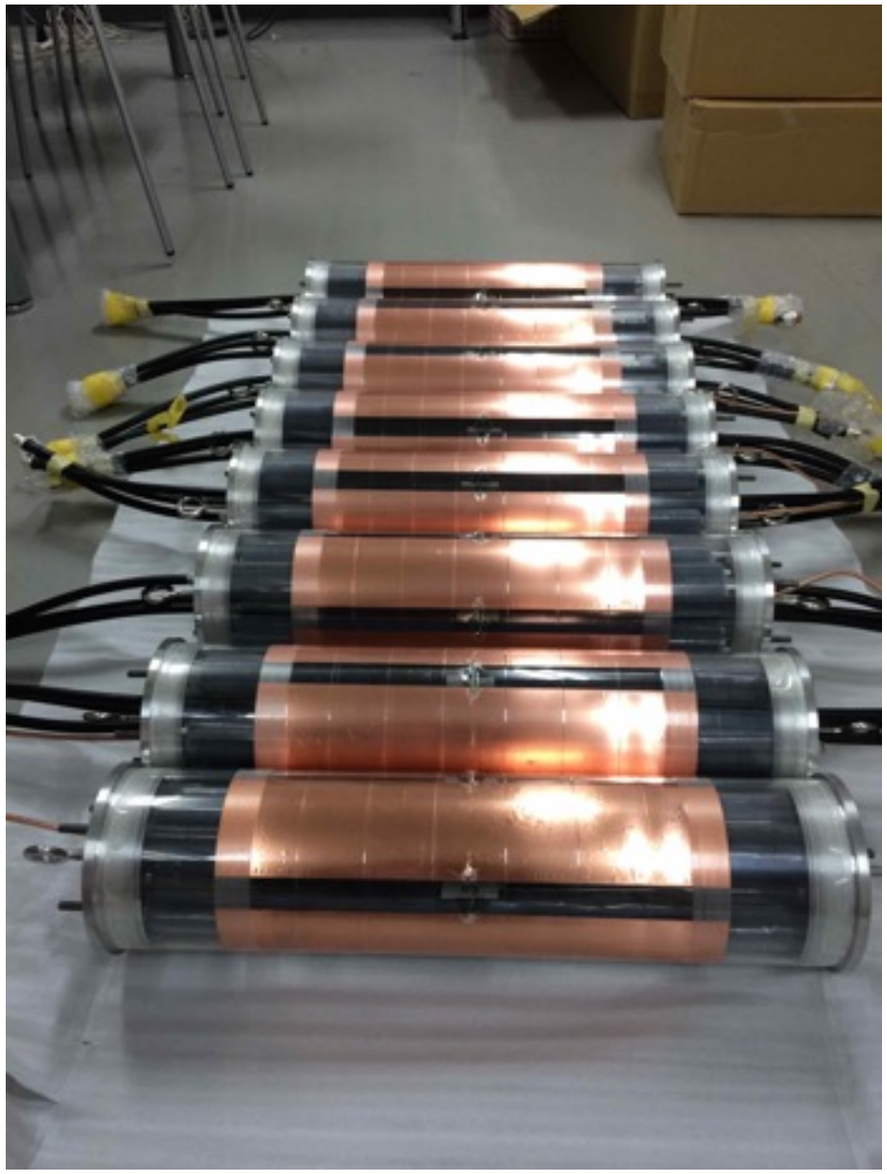
conclusion

- Vpol: cable effect needs to be checked in simulation
- Hpol: better modeling of ferrite
- Time domain:
    - See some discrepancies between data/sim
    - Maybe better than freq. to compare wide band response

➡ Once model are validated in air, we need to switch the simulation to ice

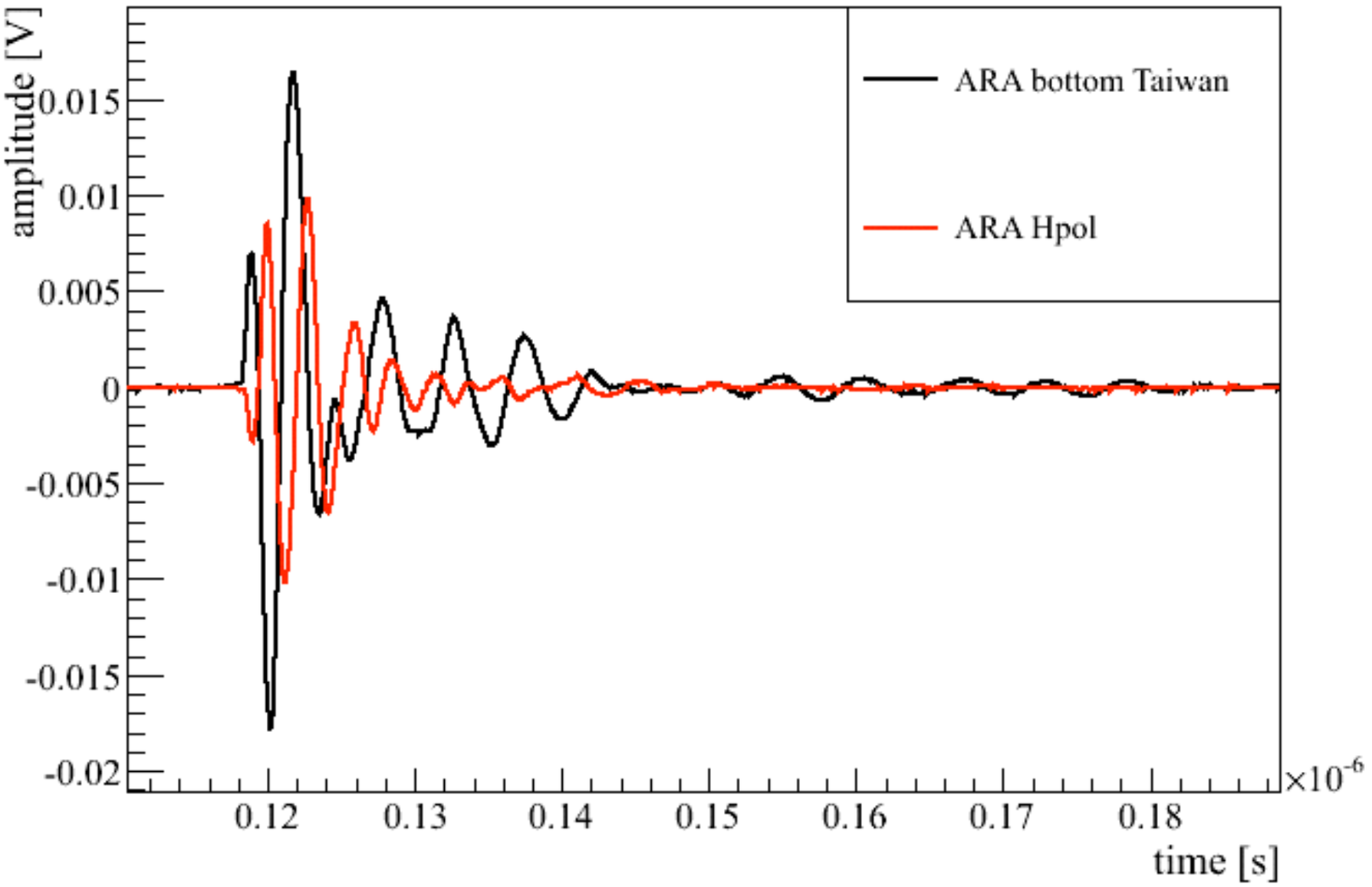
➡ Want to have a look at the Cal Pulser data and would need some help on that

Antenna production



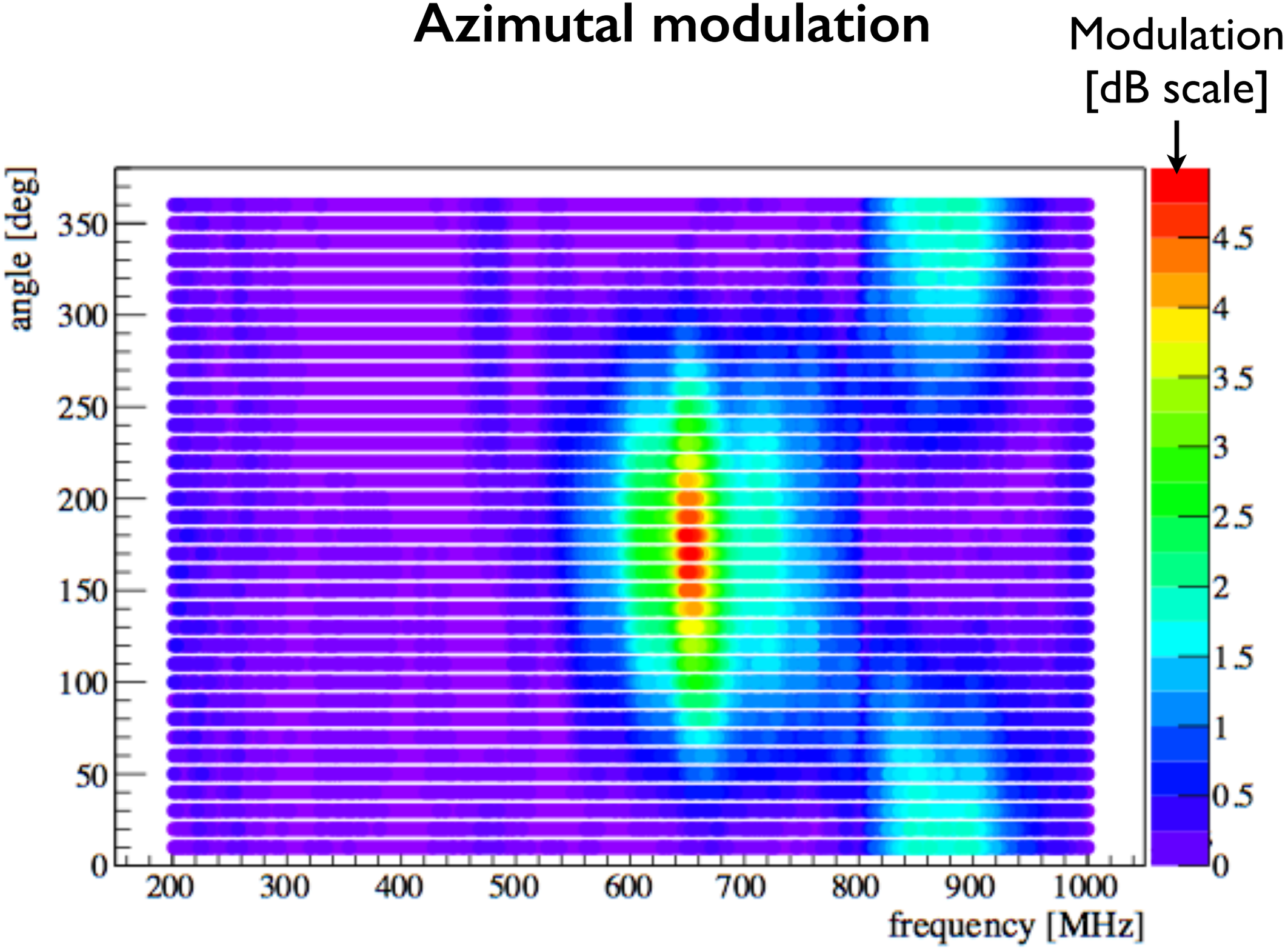
Back up

Time domain: type of data
Bottom vs Hpol

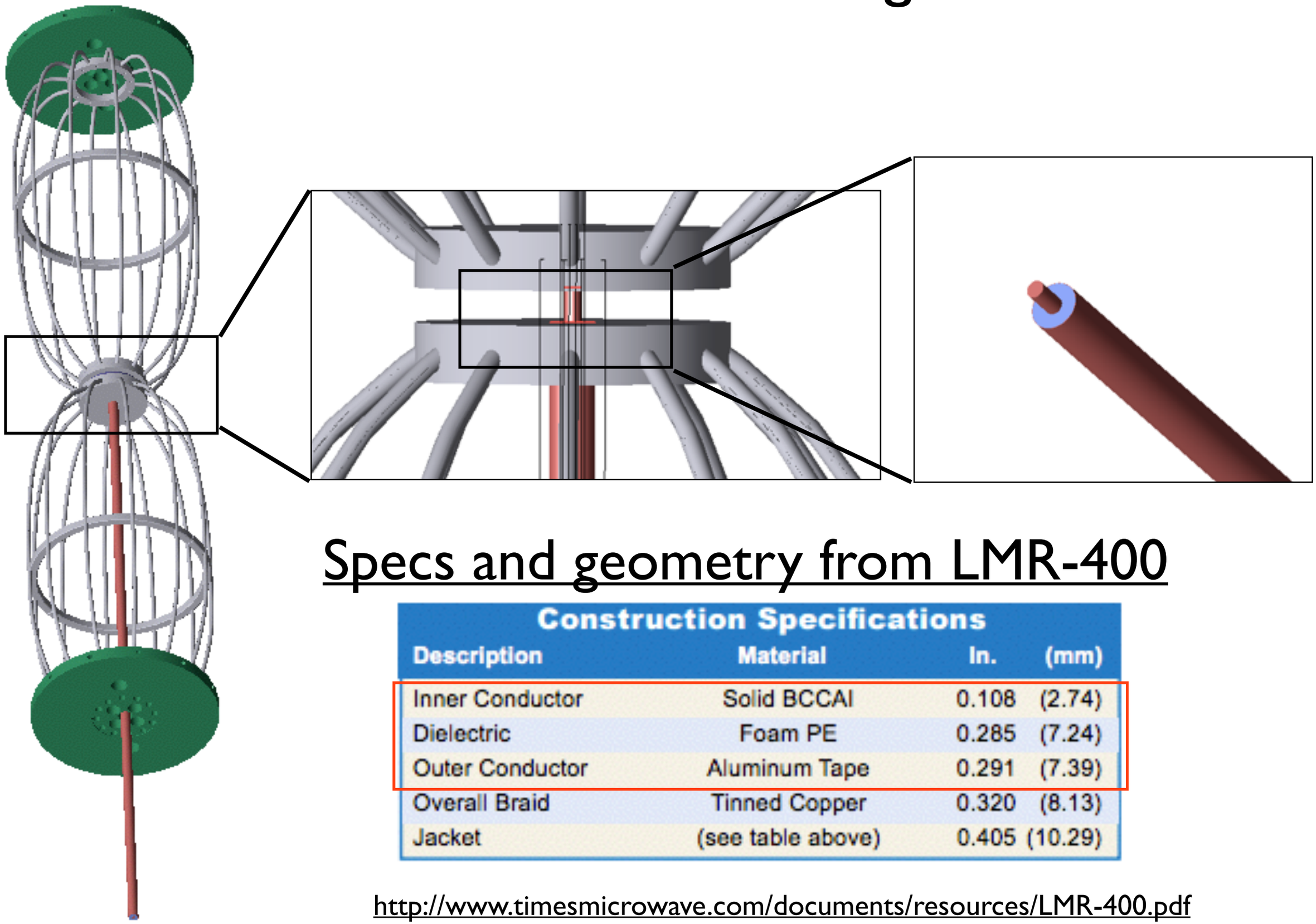


Some (expected) differences between Vpol and Hpol

Azimutal modulation



Cable simulation: design

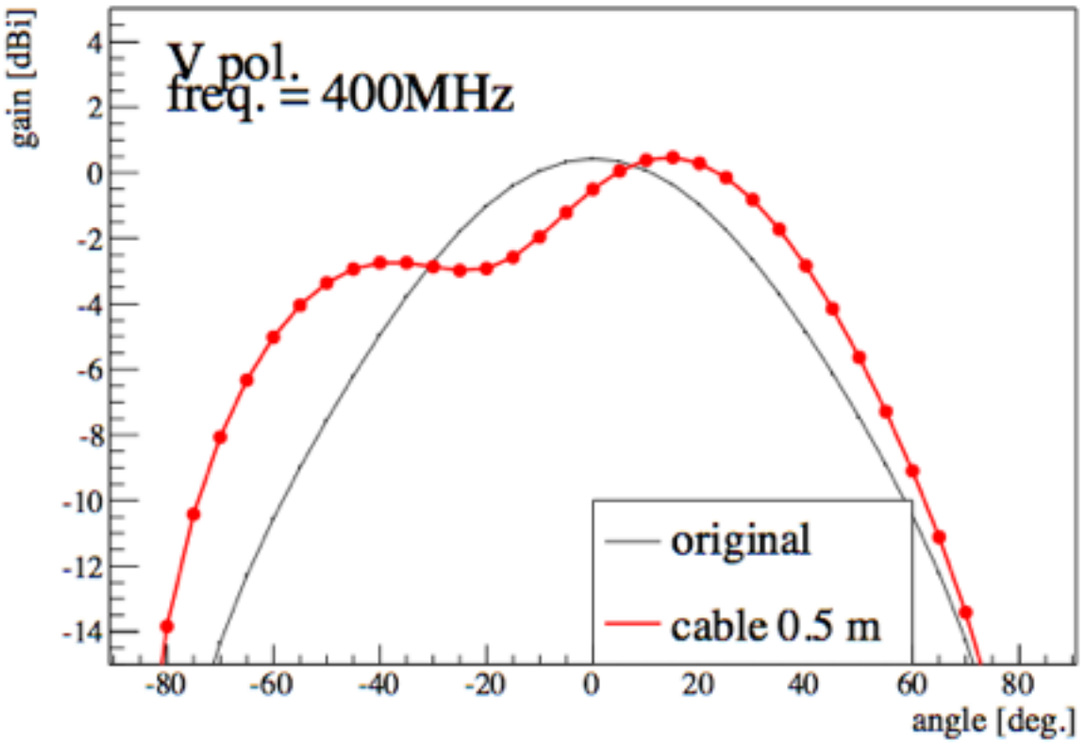


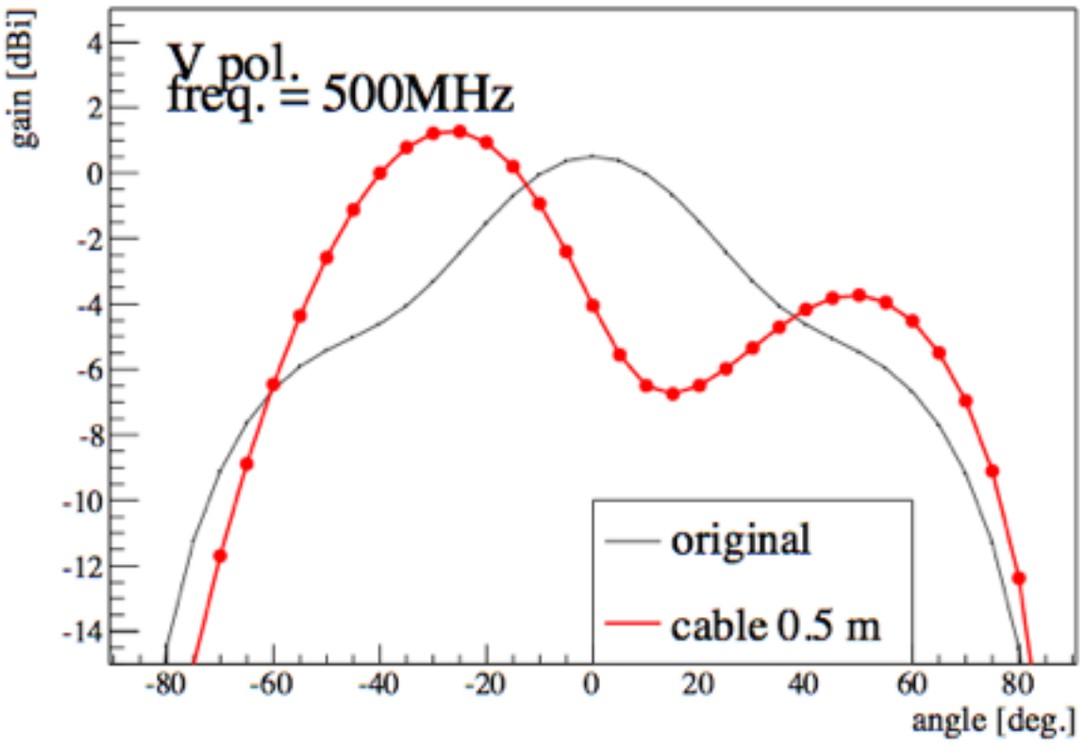
Specs and geometry from LMR-400

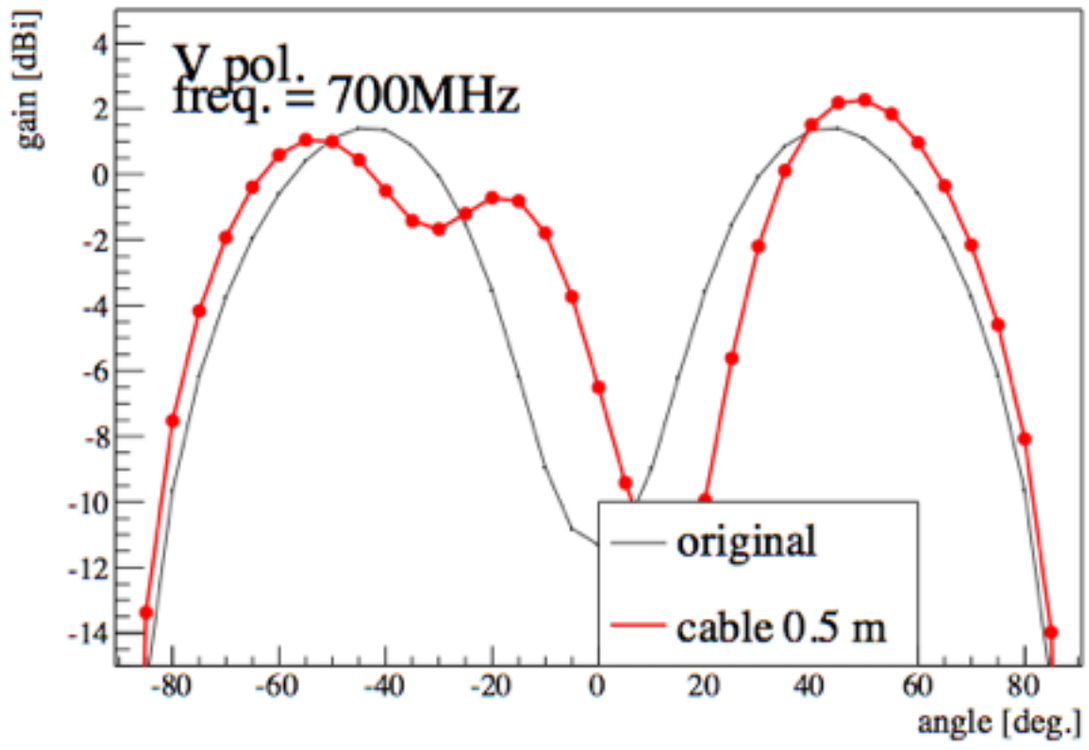
Construction Specifications			
Description	Material	In.	(mm)
Inner Conductor	Solid BCCAl	0.108	(2.74)
Dielectric	Foam PE	0.285	(7.24)
Outer Conductor	Aluminum Tape	0.291	(7.39)
Overall Braid	Tinned Copper	0.320	(8.13)
Jacket	(see table above)	0.405	(10.29)

http://www.timesmicrowave.com/documents/resources/LMR-400.pdf

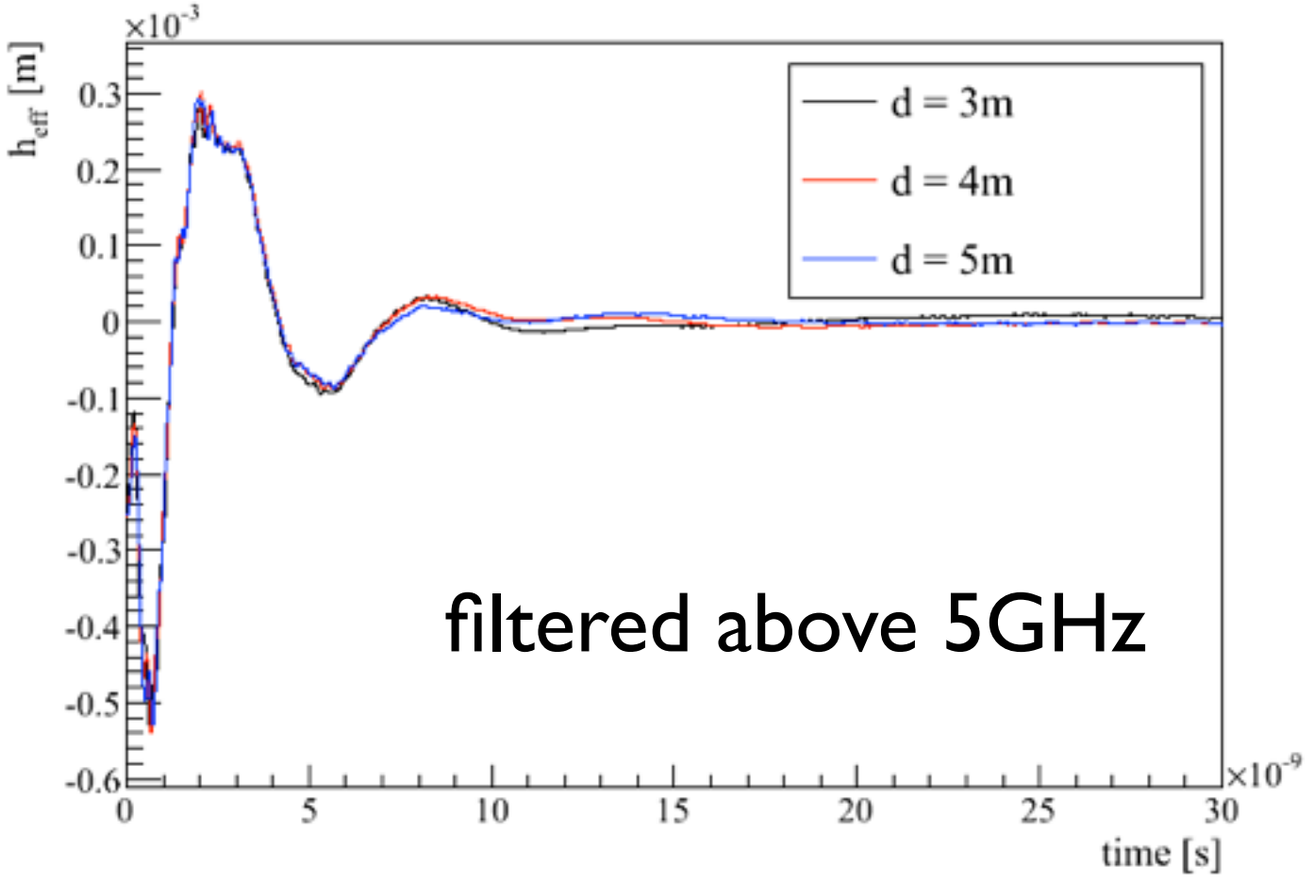
Cable simulation: results





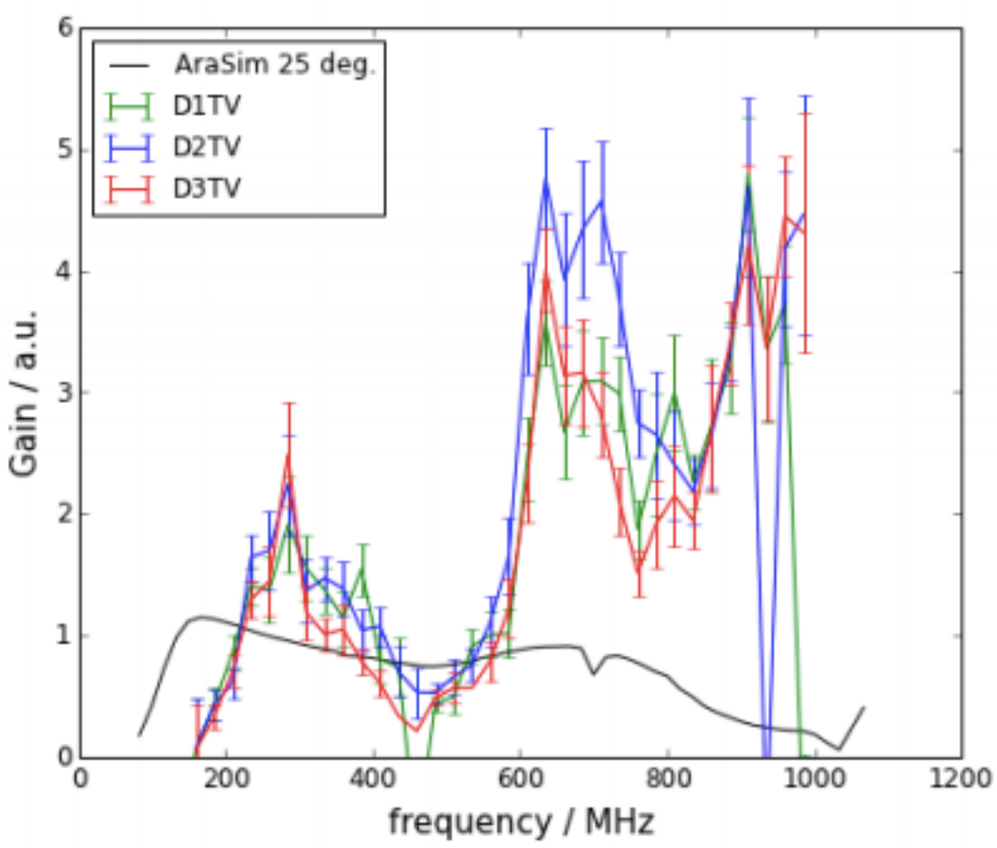


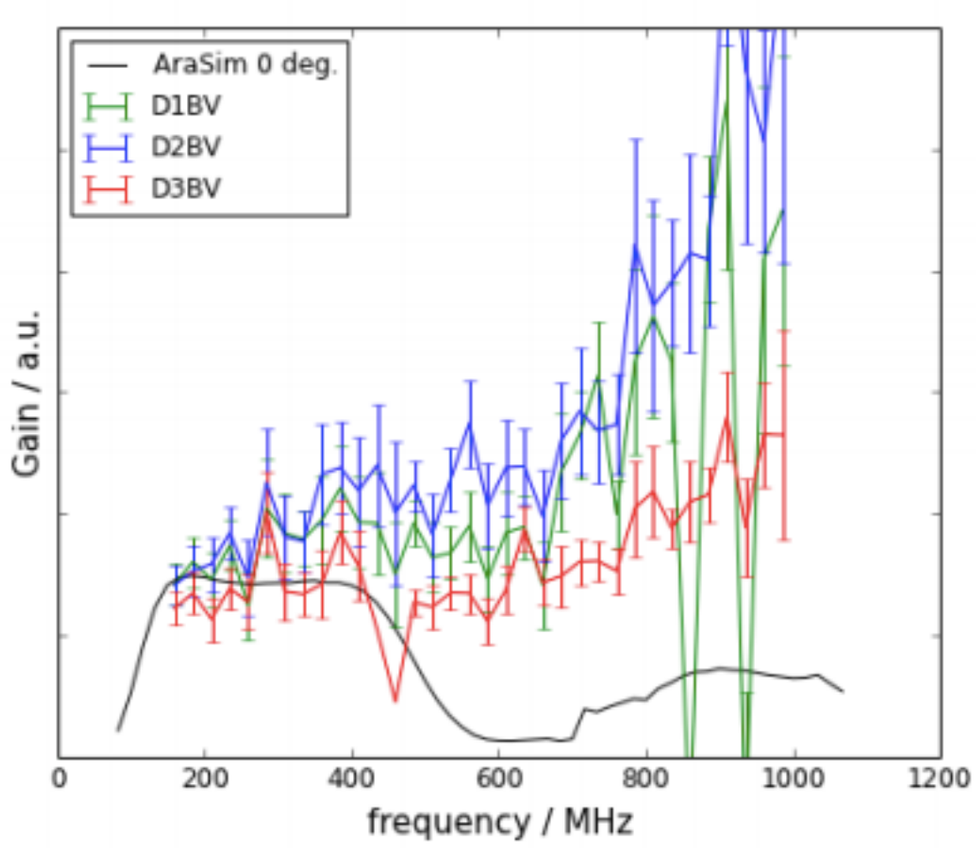
Simulation in XFDTD



Far field check

Thomas calibration





This calibration was done in ice
(cf Thomas's paper)