Extending the Frequency Coverage of HERA for X-ray Heating Studies

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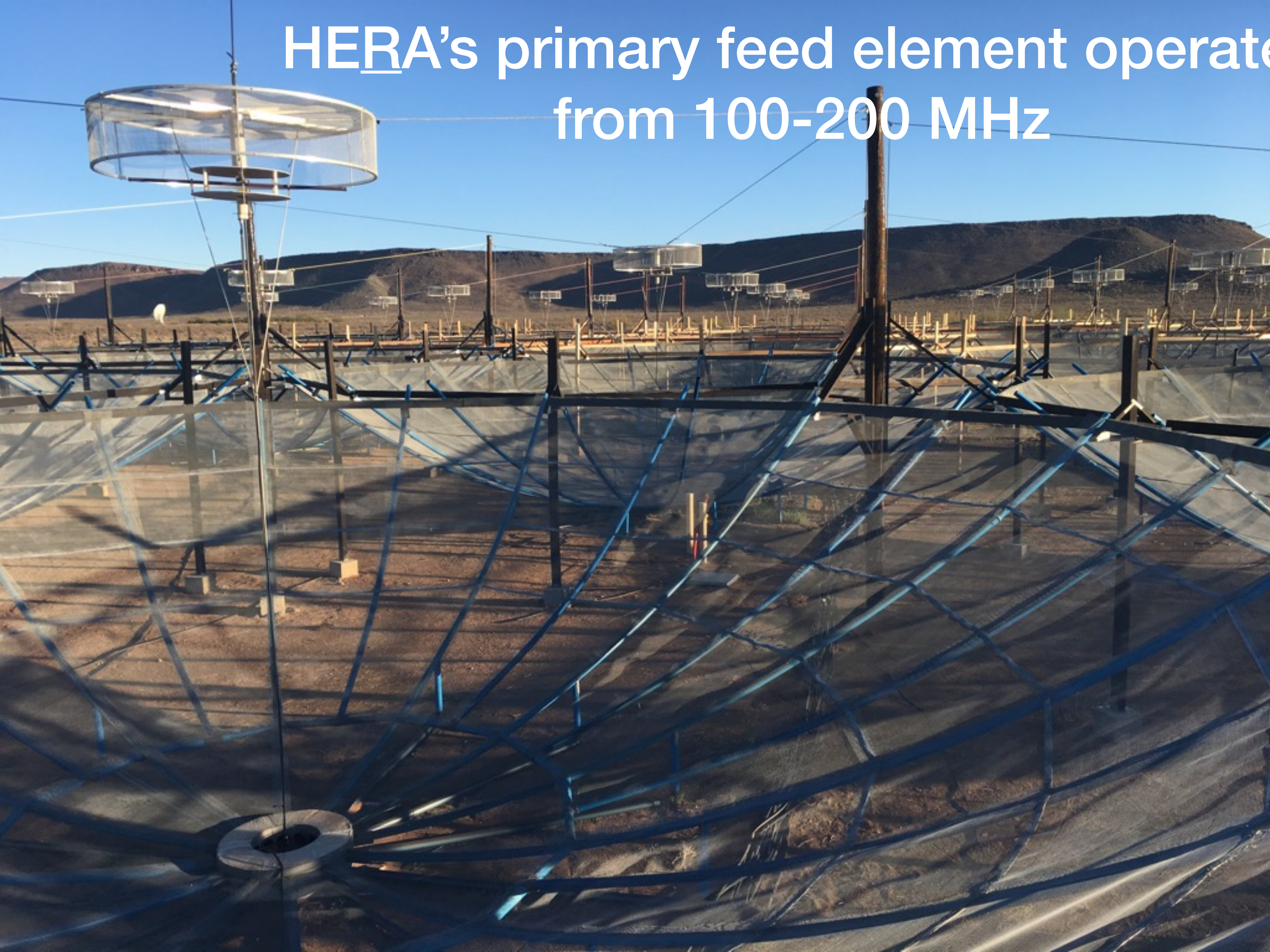
And the HERA Collaboration

HERA

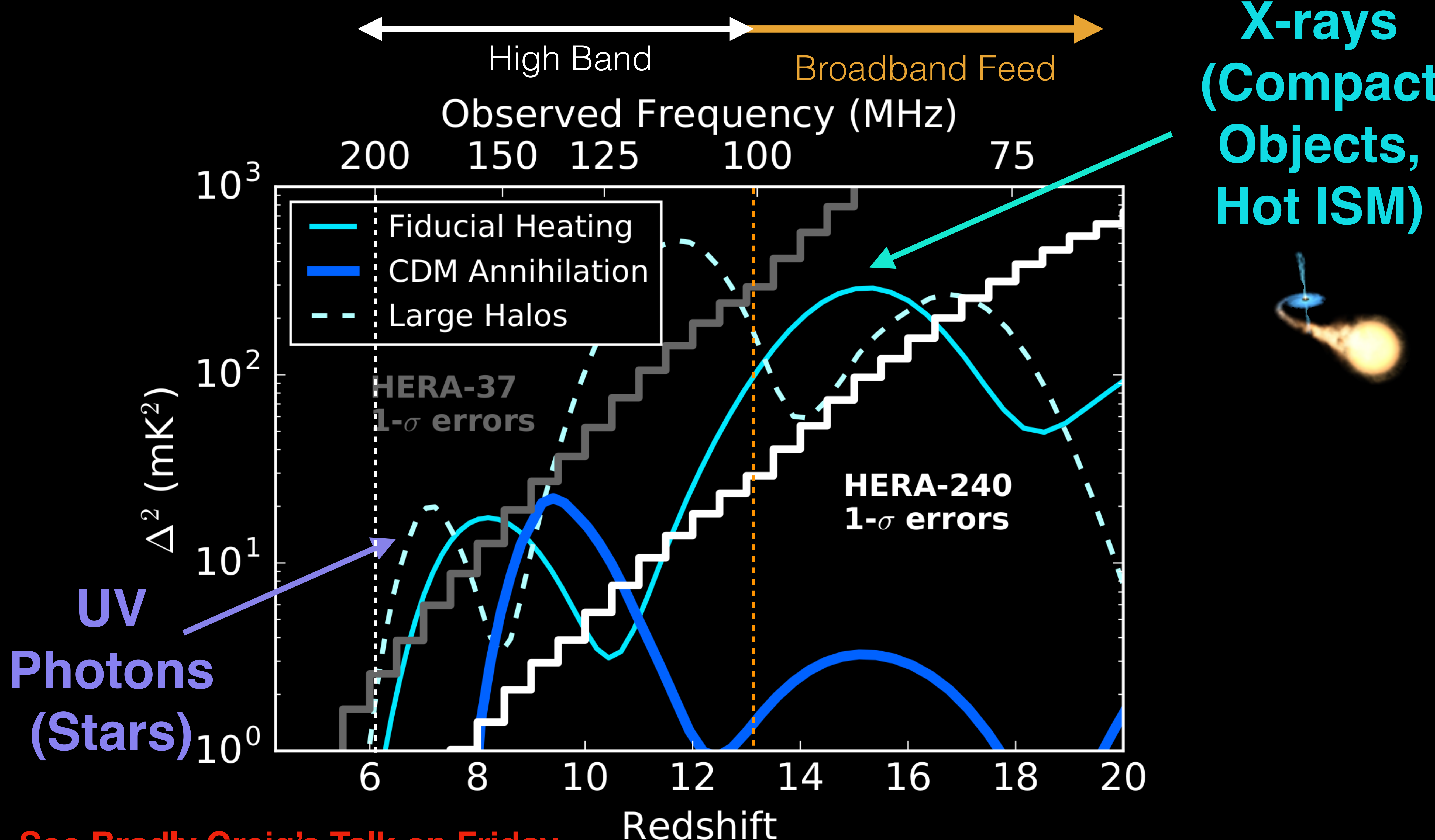




See Gianni's Thursday talk. Zaki's Commissioning Poster


HERA's primary feed element operate
from 100-200 MHz

Extending this bandwidth allows us to study higher redshifts



See Bradly Greig's Talk on Friday

Mesinger, EW+ 2014

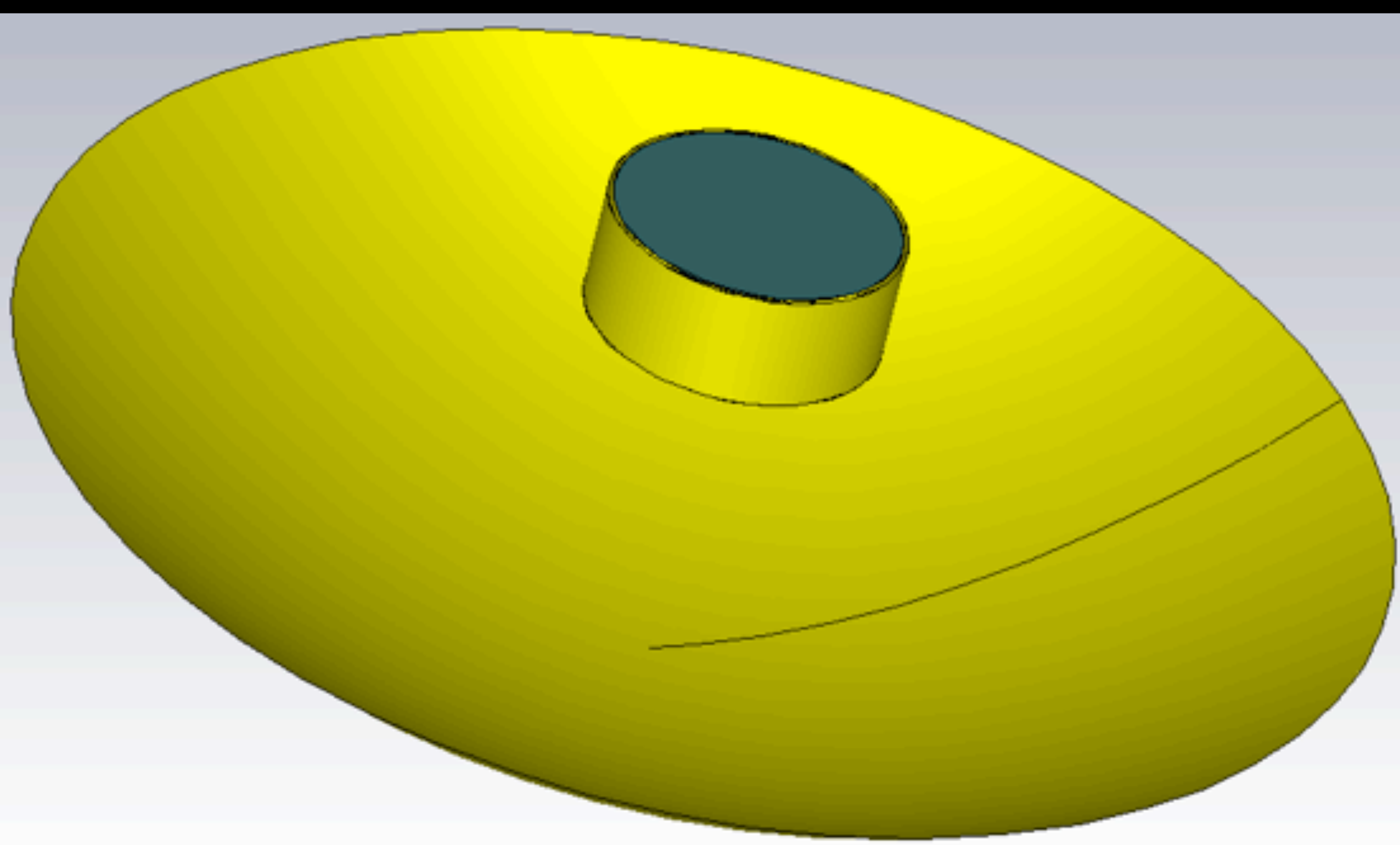
Narrowband Option

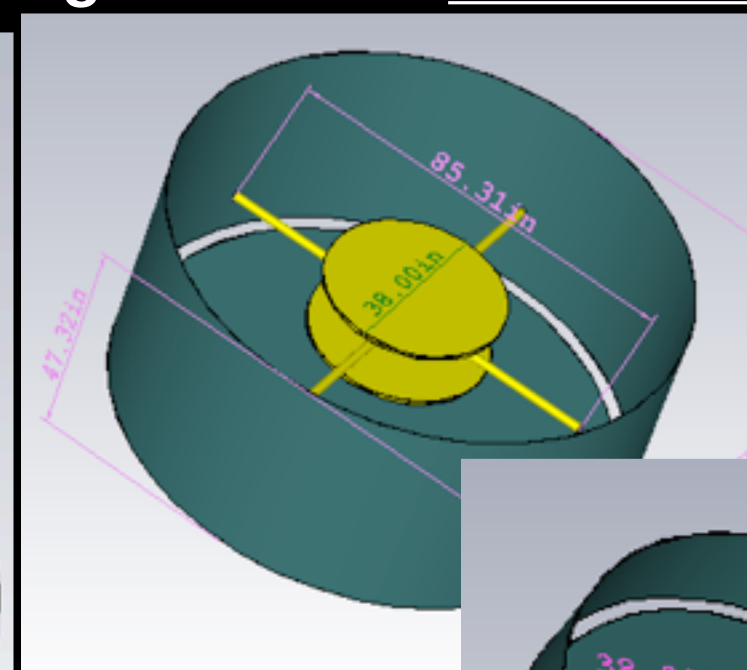
Replace high-band feed for separate low-frequency observations

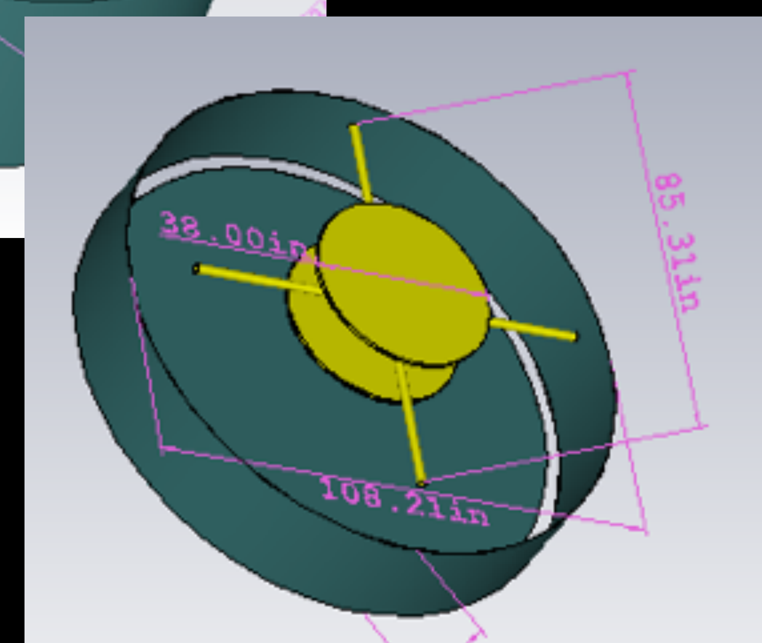
Narrowband Backup

Narrow-band Dipole based on Cosmic Twilight Polarimeter (Nahn+ 2017)

- **Backplane for high directivity**
- **Cylinder**
  - **mitigate cross-coupling**
  - **good polarization match**
- **Would require separate low-band observing season so this is a backup.**

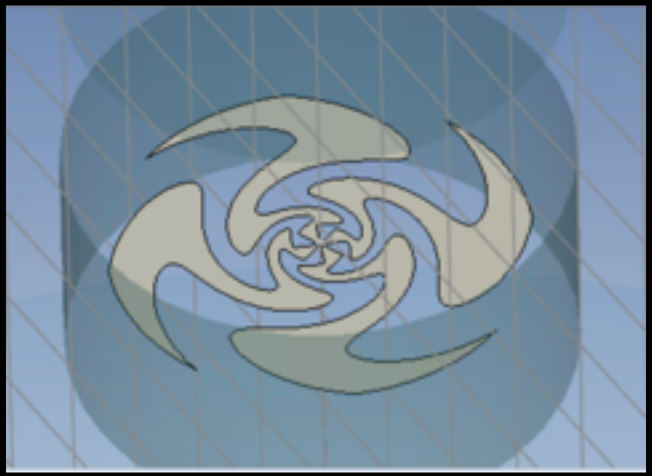




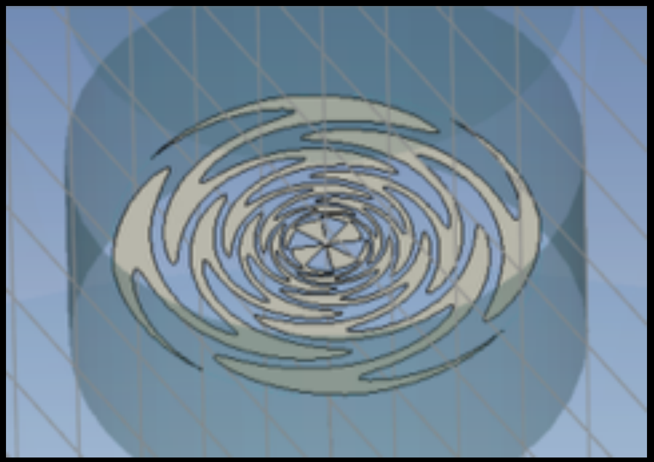


Broadband Options

Two designs



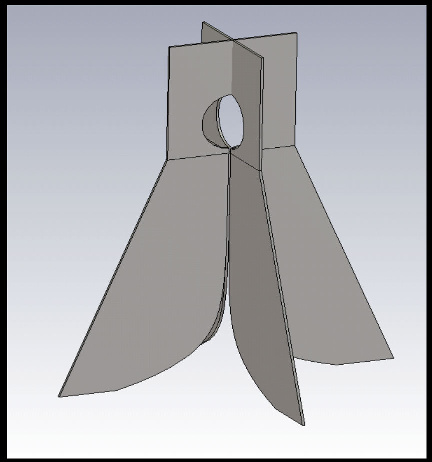
Sinuous Feed



MIT - Li+ in Preparation

Explored the impact of

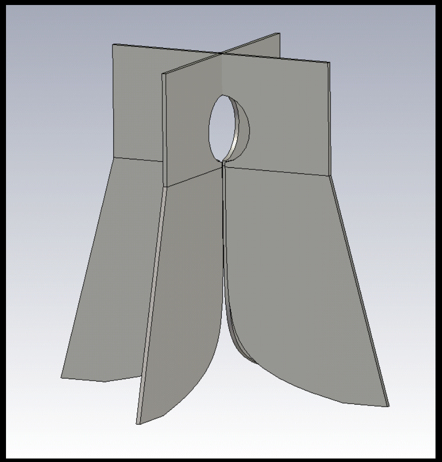
- **Sinuous Growth Rate**
- **Backplane**
- **Resistive band**

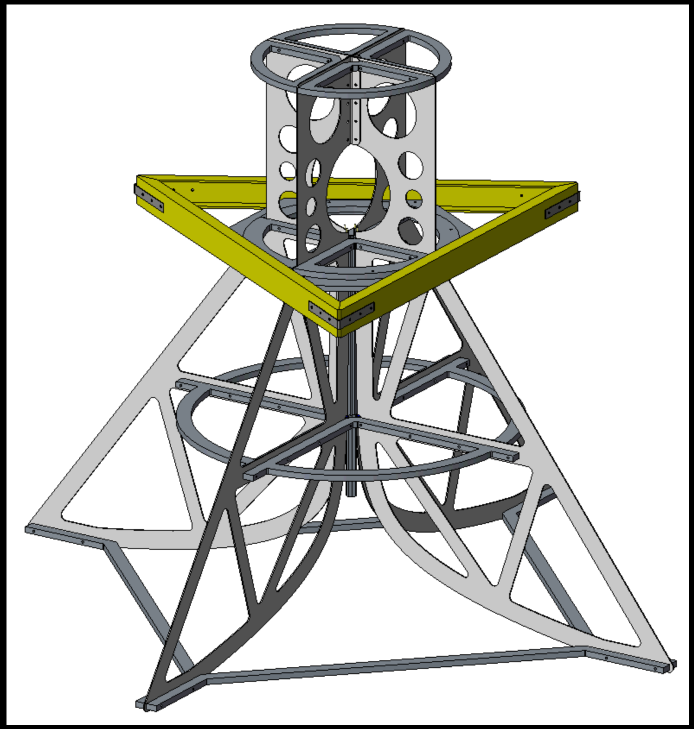


Vivaldi Feed

Nicolas Fagnoni+ in prep.

Cambridge UK





Vivaldi feed is naturally directional without need for a backplane

UK team designed feed with co-simulation of HERA front-end (Fagnoni+ 2015)

<u>Design still be optimized</u>
so all performance figures are preliminary (Fagnoni+ in prep)

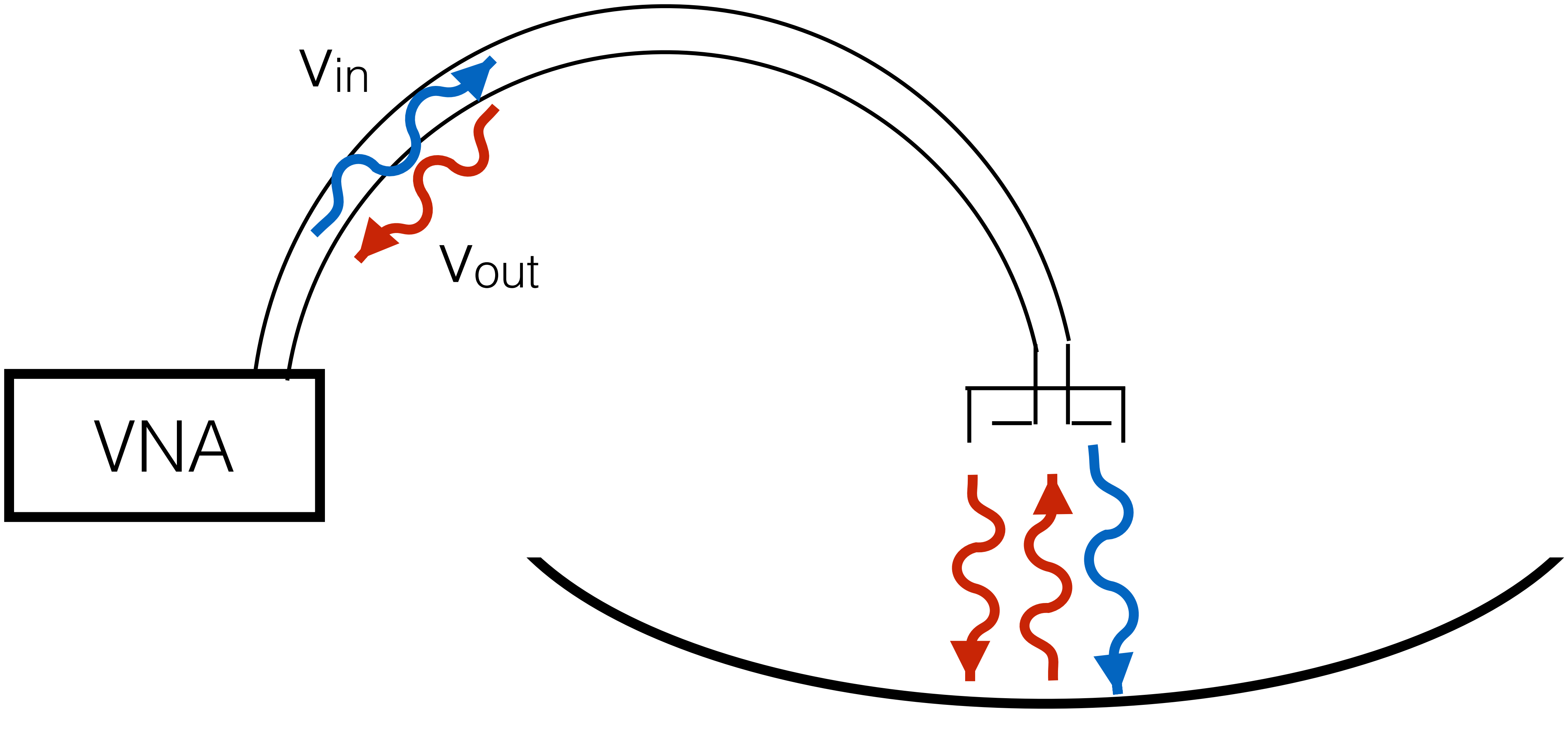
We study feed performance through simulations

And we are verifying the accuracy of these simulations with measurements

Use Reflectometry to Verify Simulations

$s_{11} = V_{out}/V_{in}$

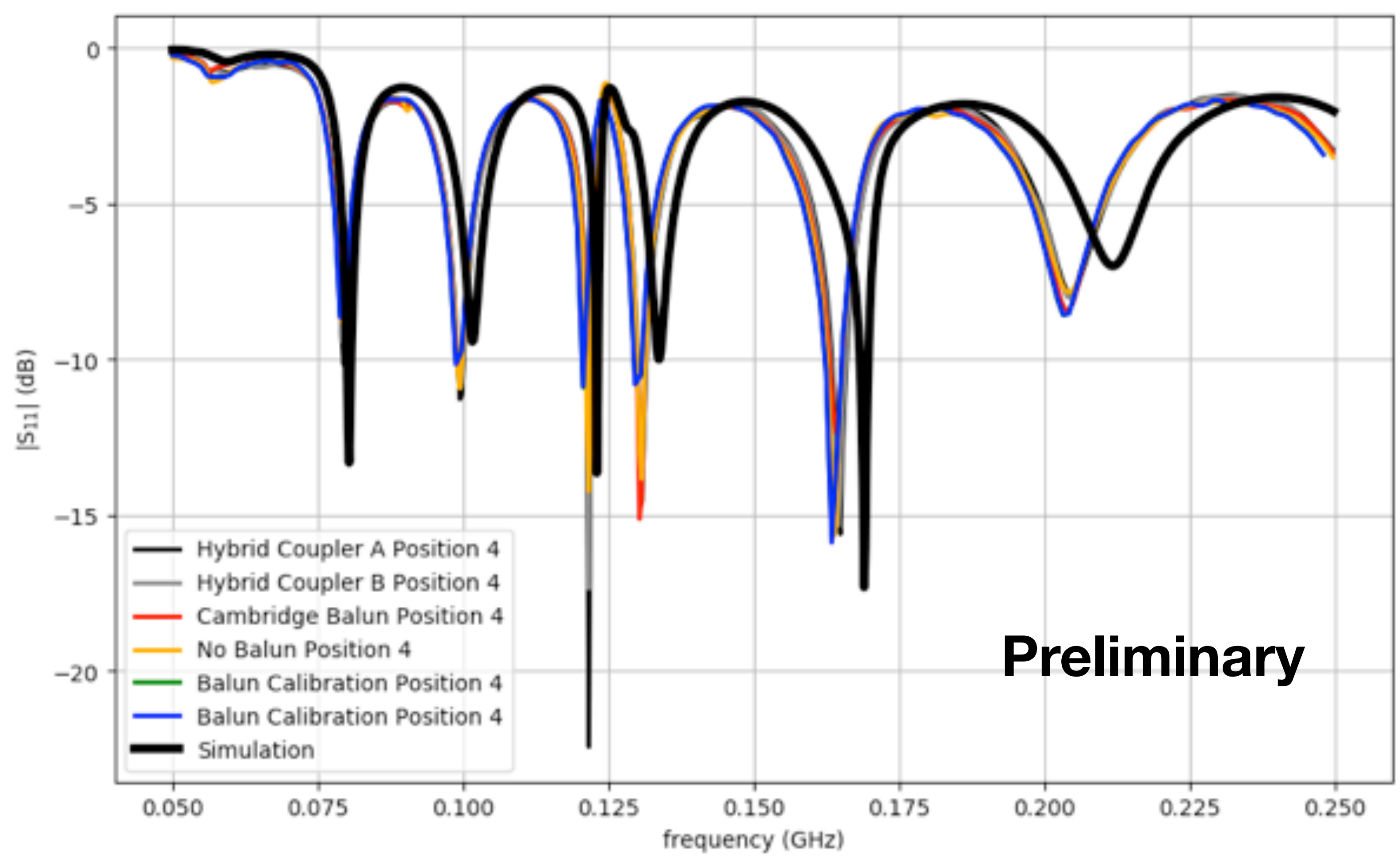
Can be related to delay-kernel



Patra+2017

We employ reflectometry to verify simulation results.

Voltage units



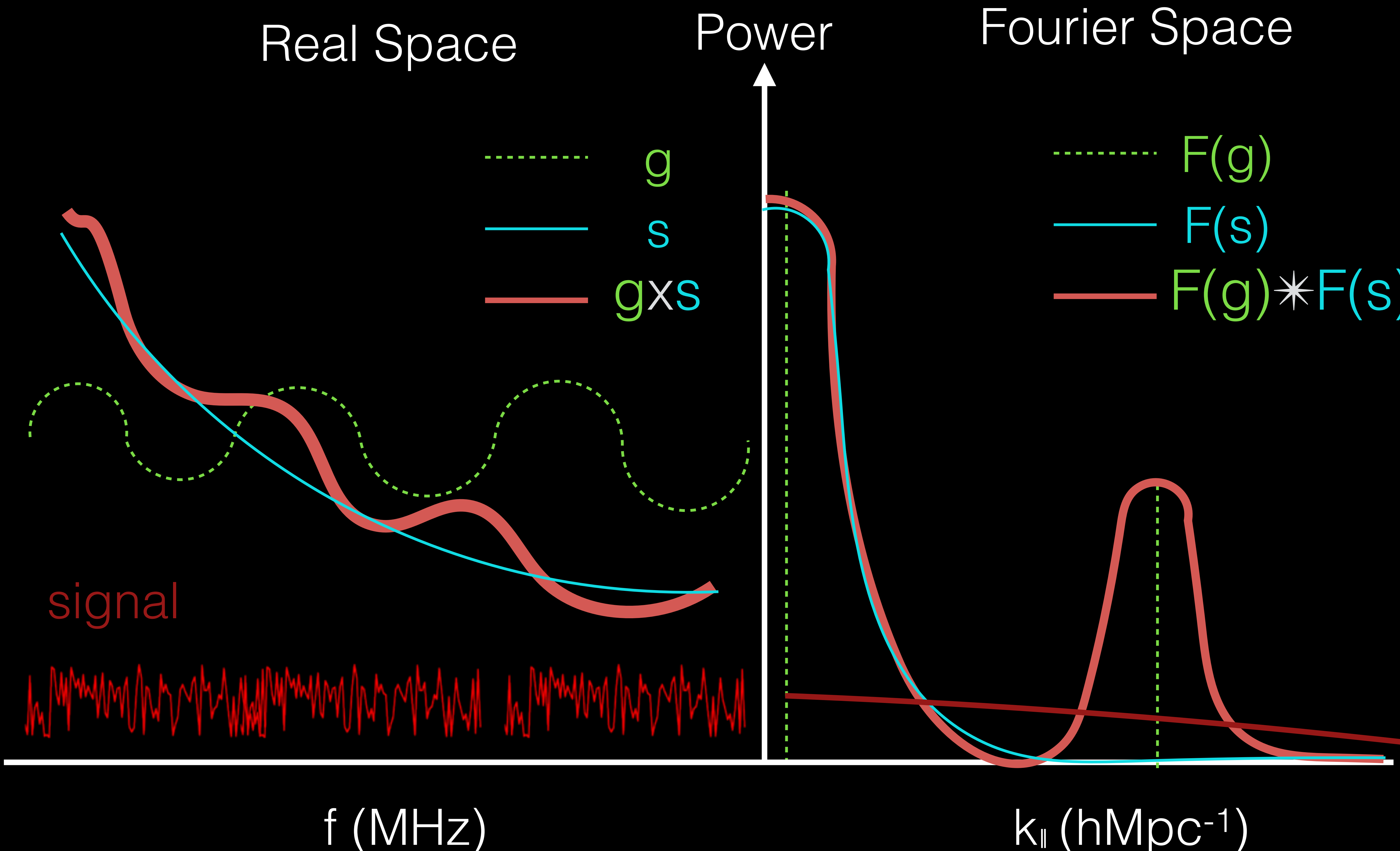
Preliminary

Sinuous Feed
Growth-Rate = 0.8
100 Ohm termination

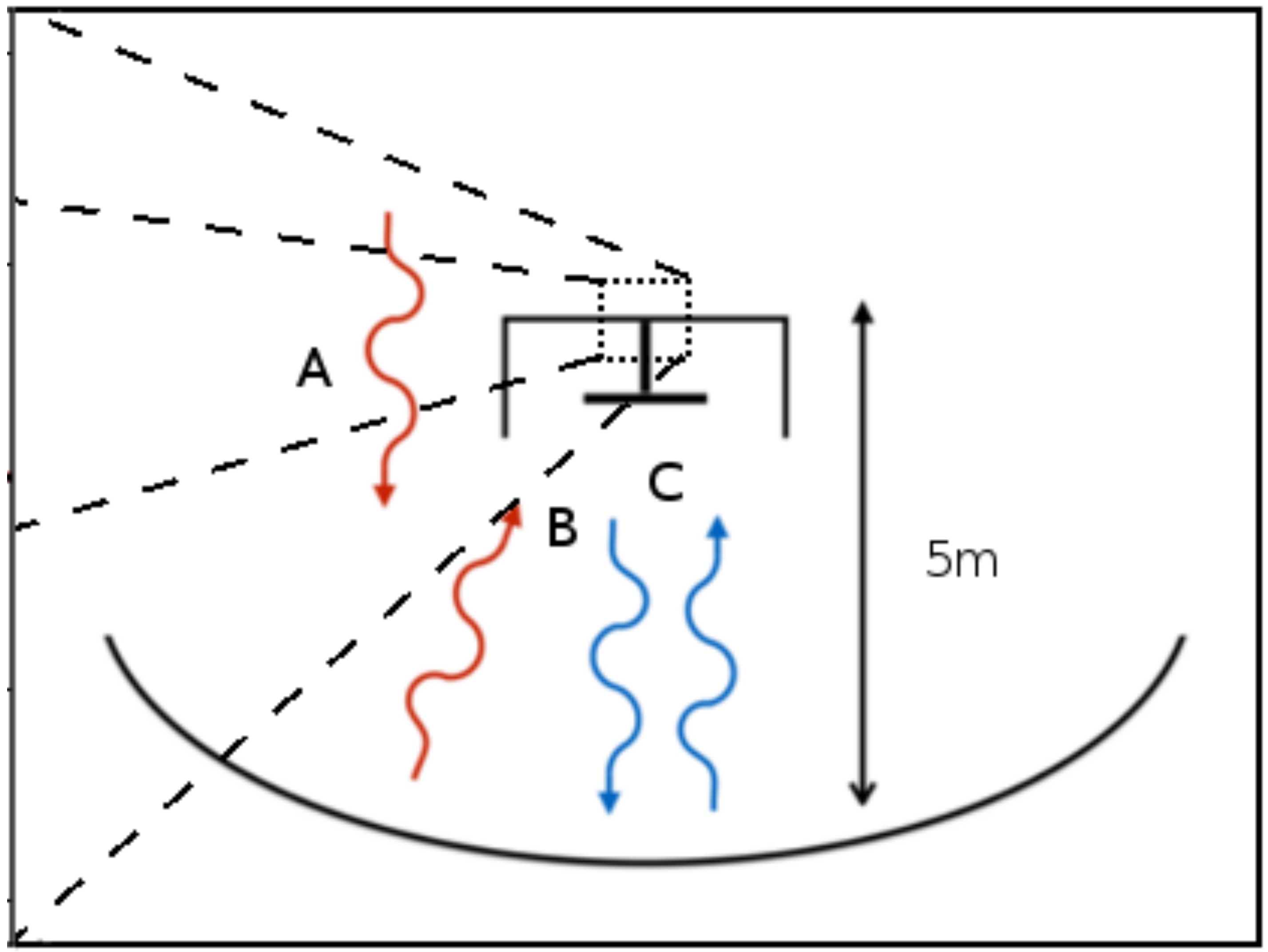
Feed Performance

Derived from Electromagnetic Simulations of our Feed Designs

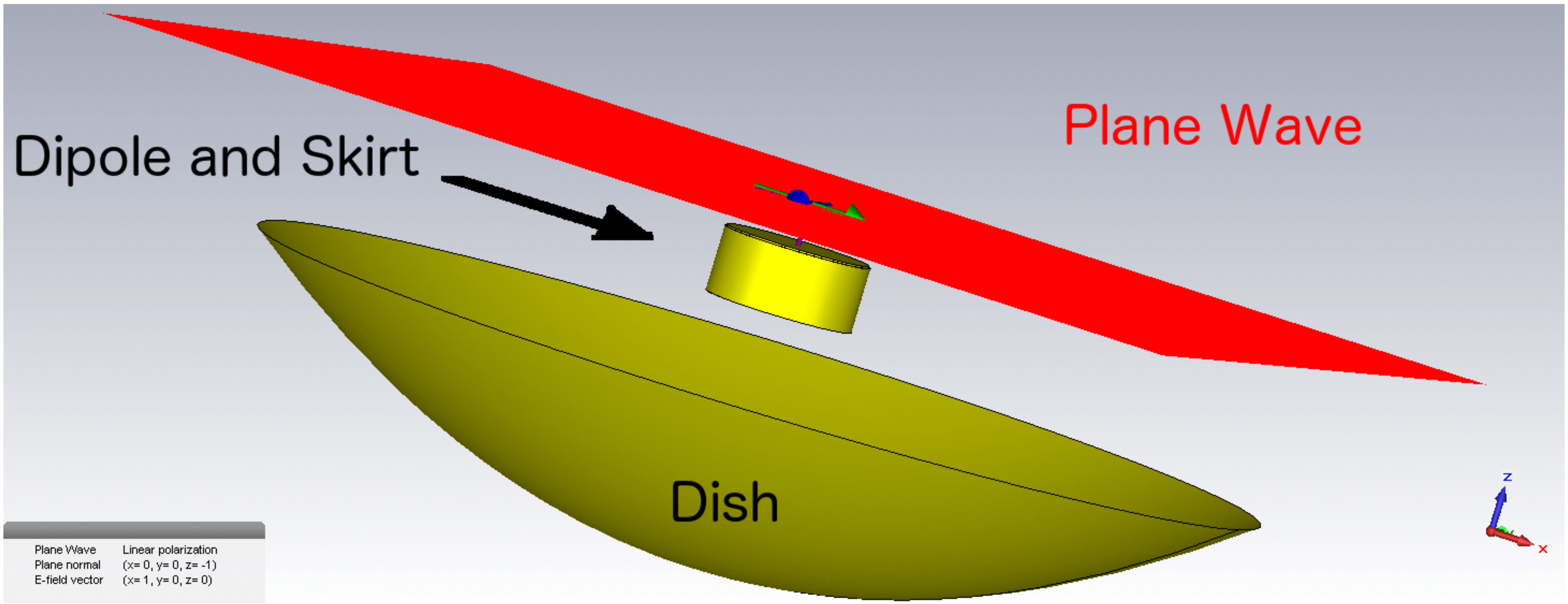
Our main performance-indicator is **spectral smoothness**



Reflection Risk

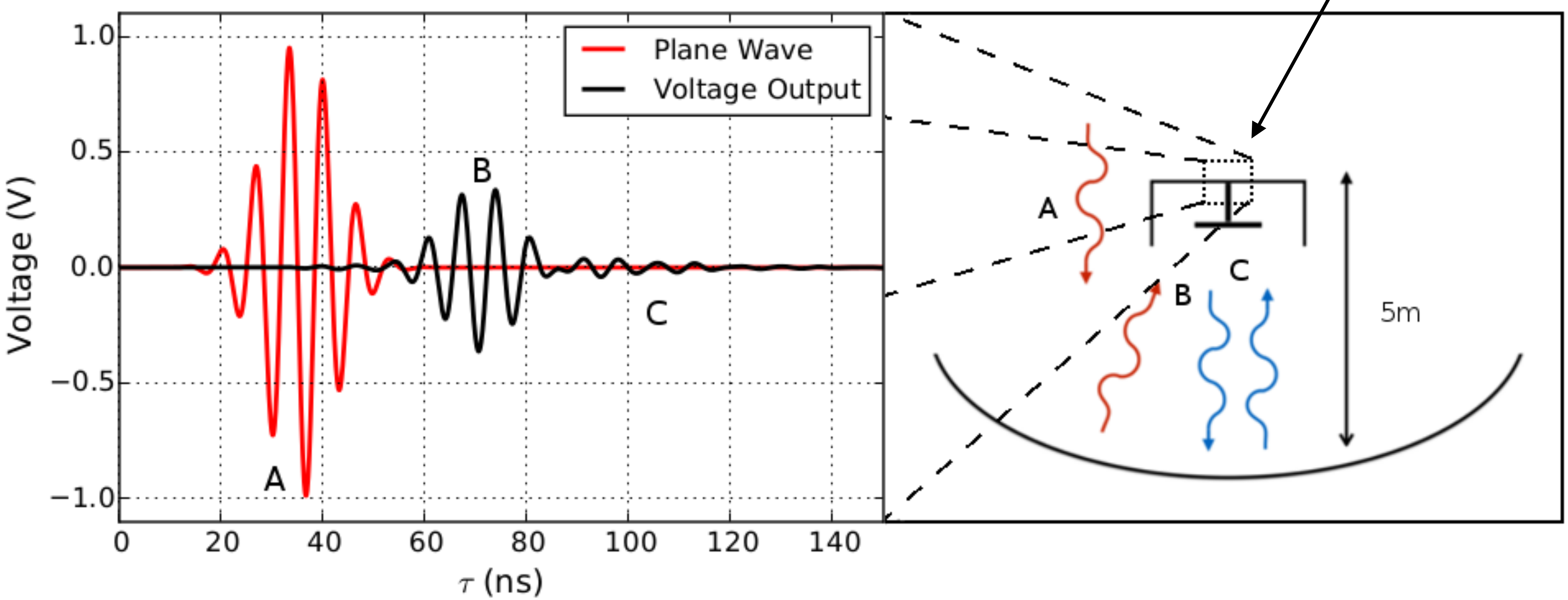


EW+2016


Plane Wave
Dipole and Skirt
Dish
Plane Wave
Linear polarization
Plane normal
(x= 0, y= 0, z= -1)
E-field vector
(x= 1, y= 0, z= 0)
z
x

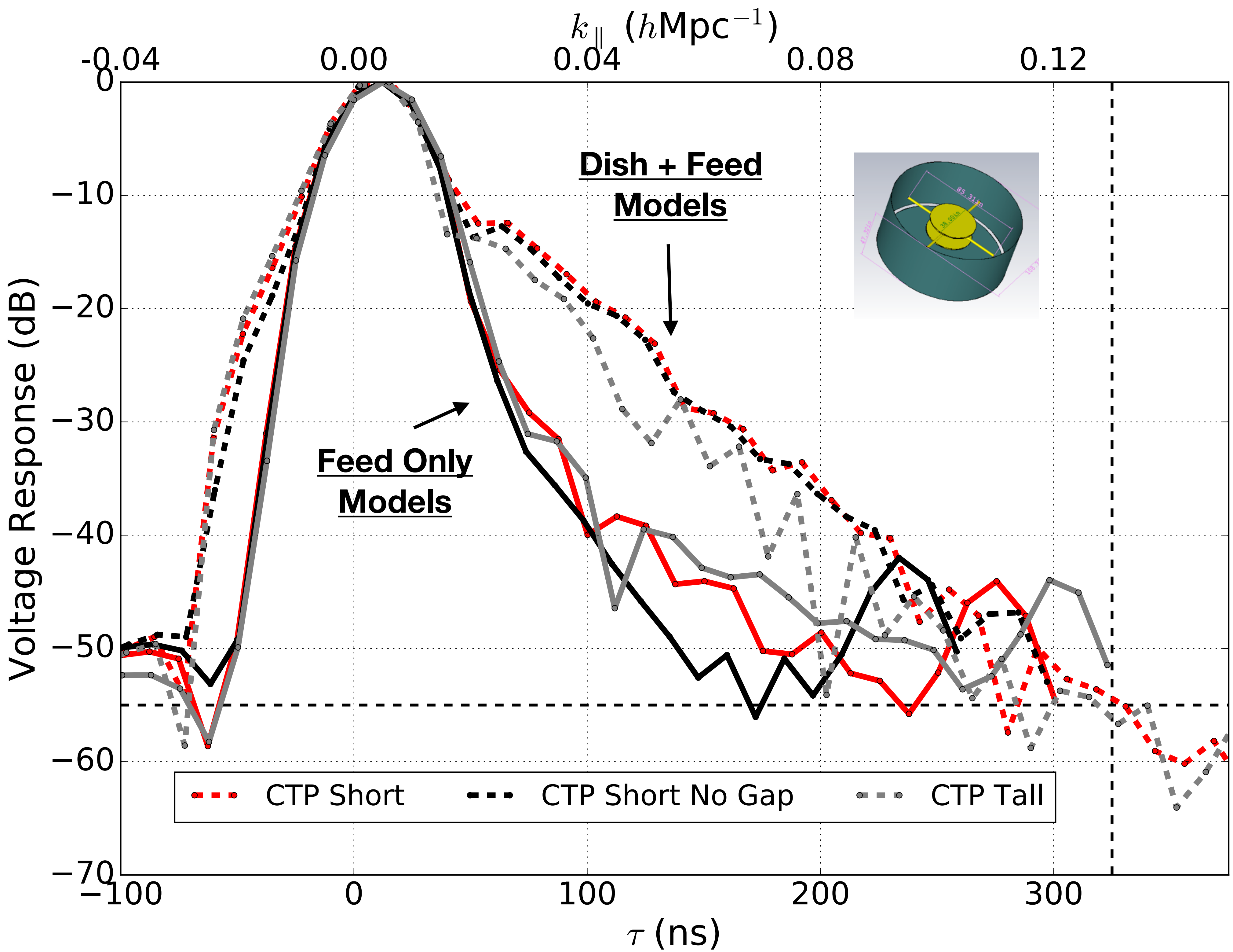
EW+2016

Termination Affects Reflection Amplitudes

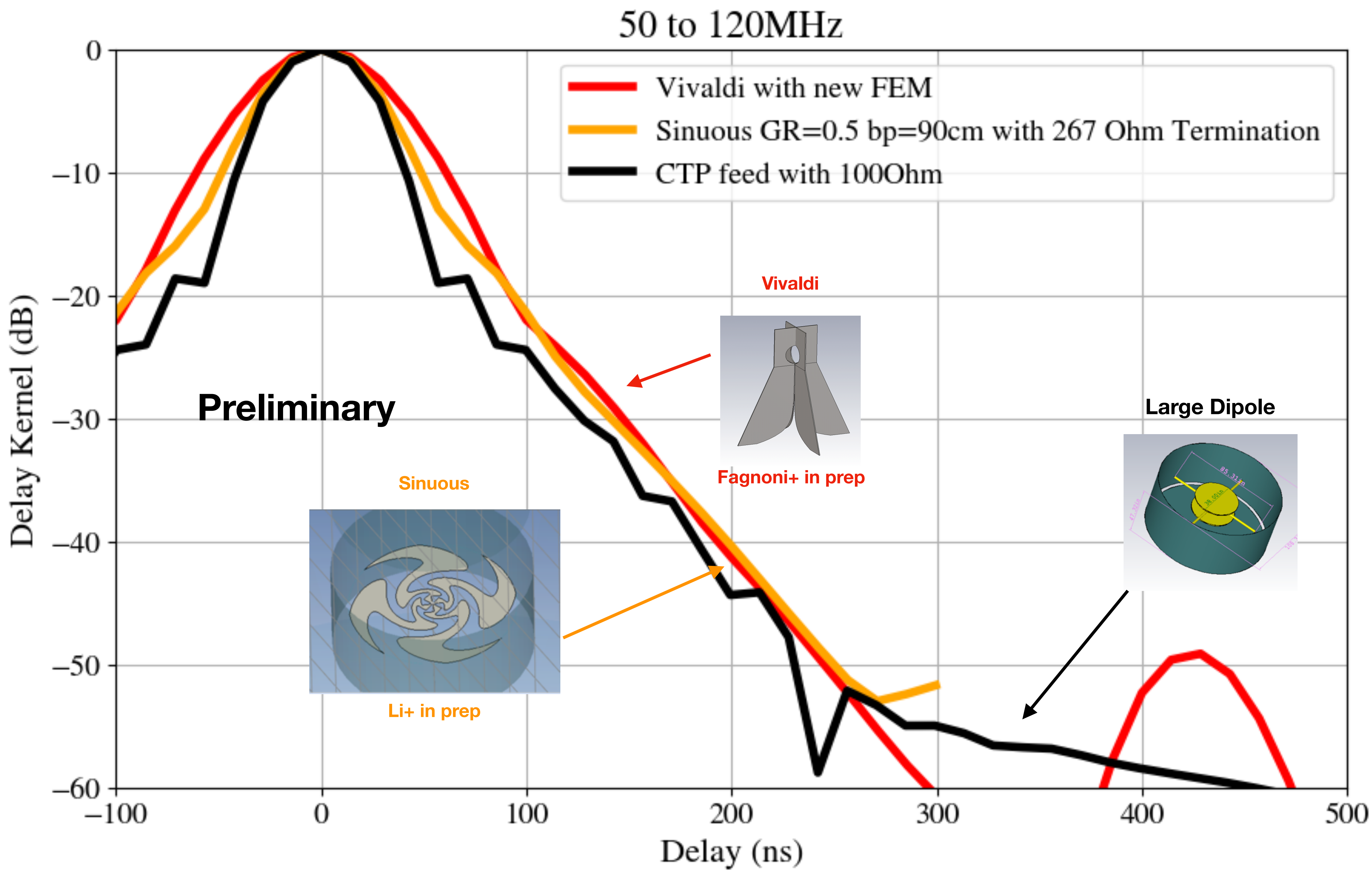


EW+2016

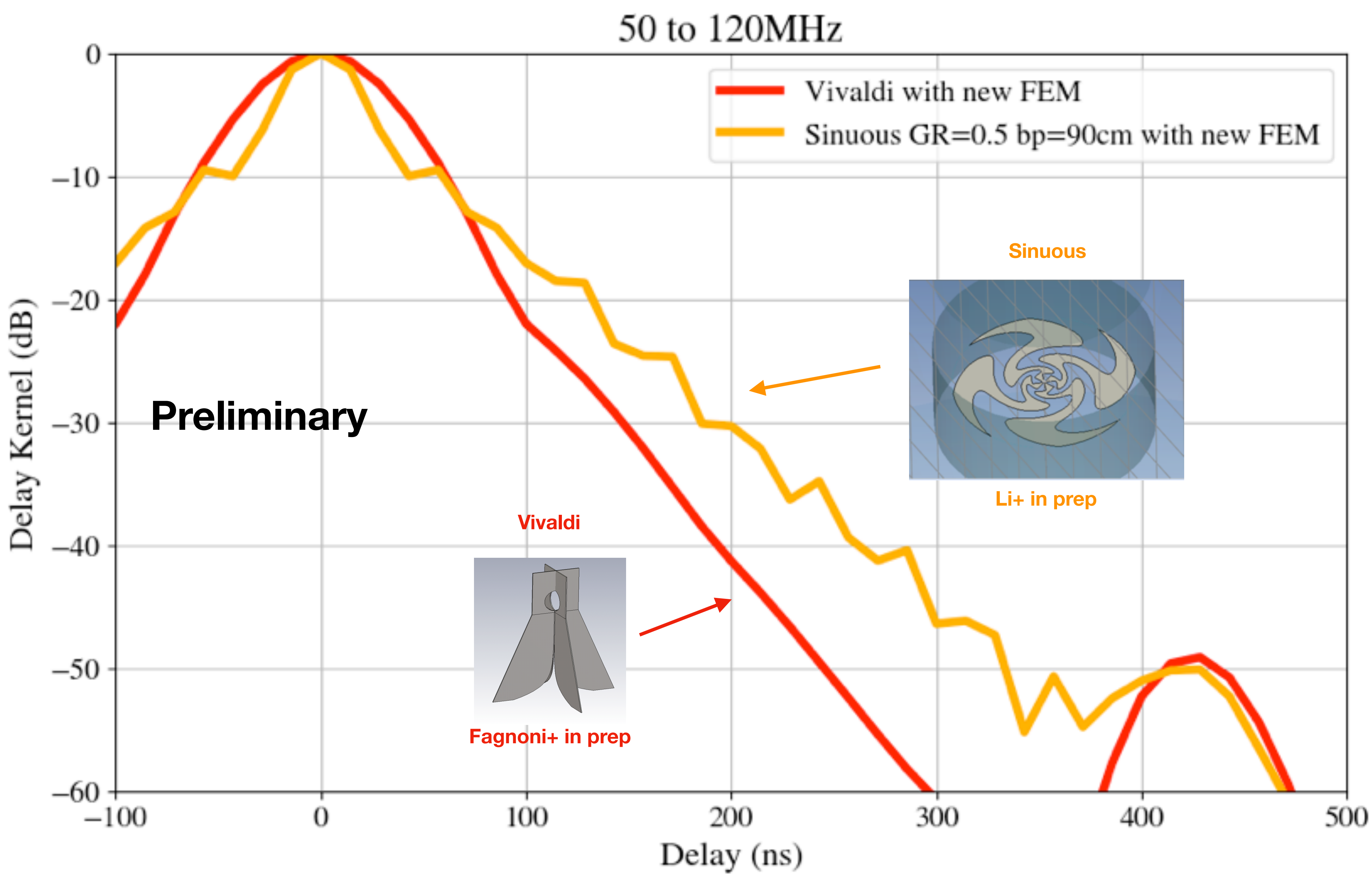
Delay-Response of feed+Dish is dominated by reflections



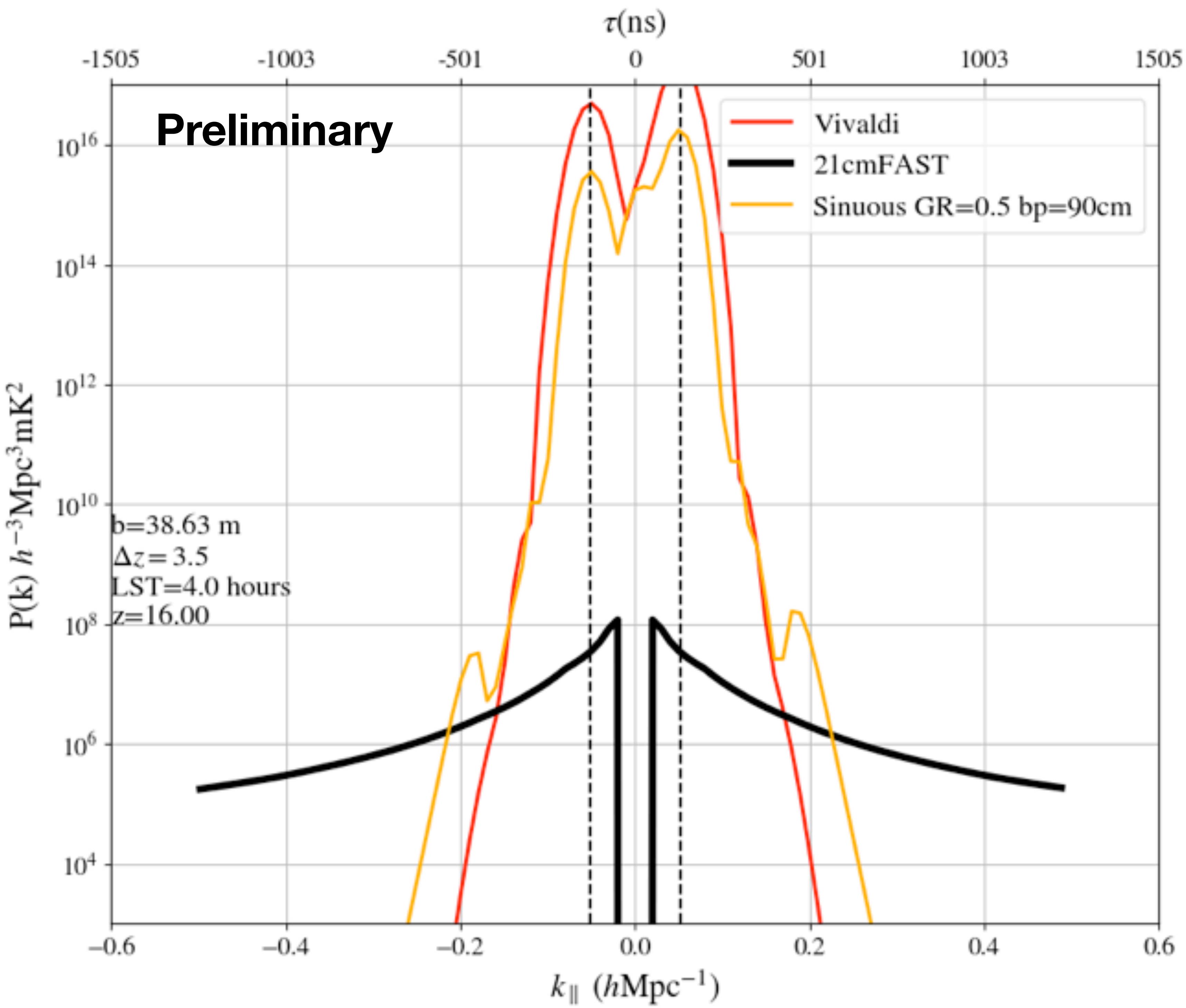
All feeds achieve similar delay-performance with different terminations



Introducing a more-realistic termination favors the Vivaldi



Foreground Leakage Simulations with PRISIM



65-100 MHz

Aperture Efficiency - Lowers Foreground Amplitude

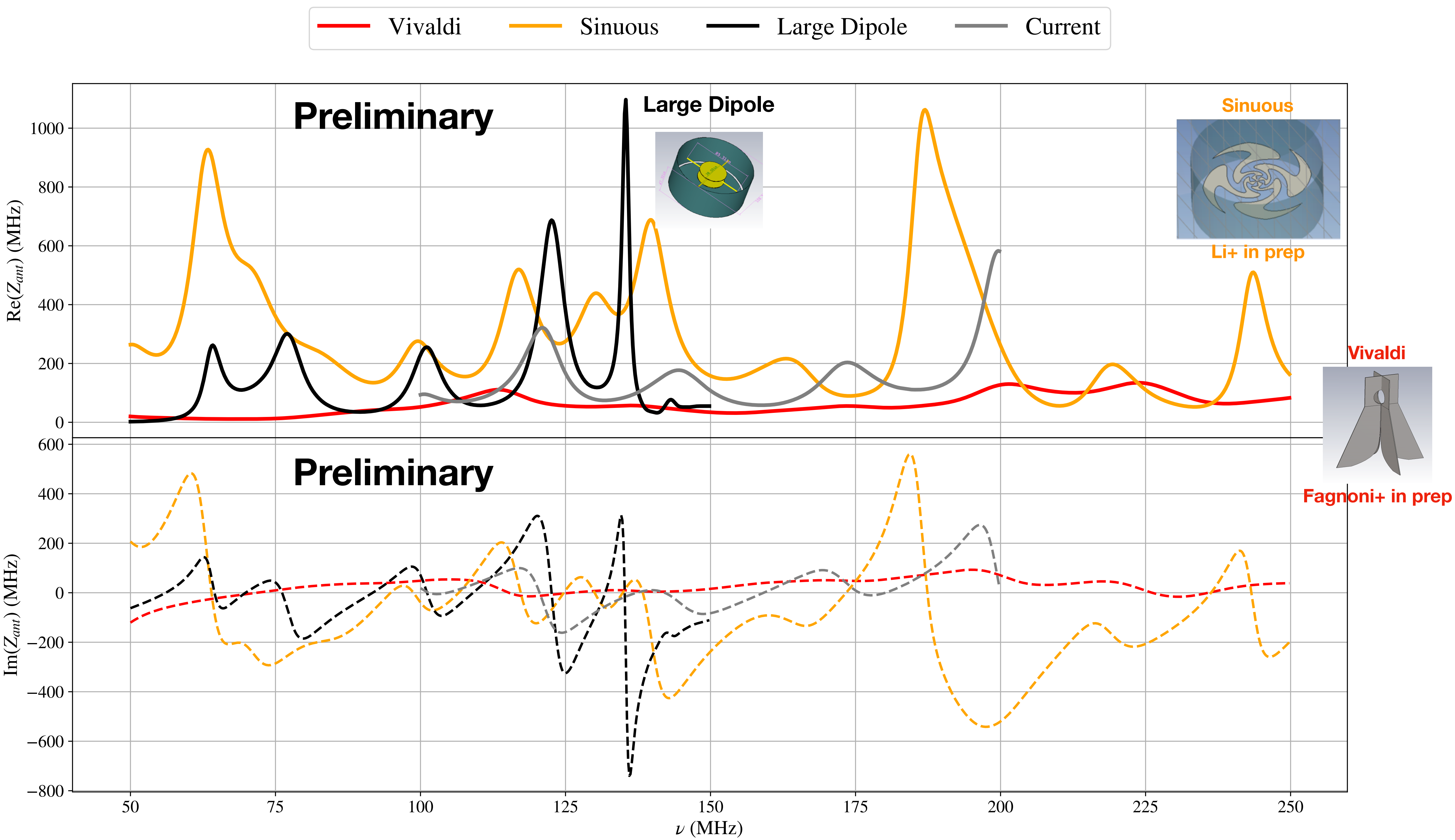
Delay-Performance - Widens Foregrounds

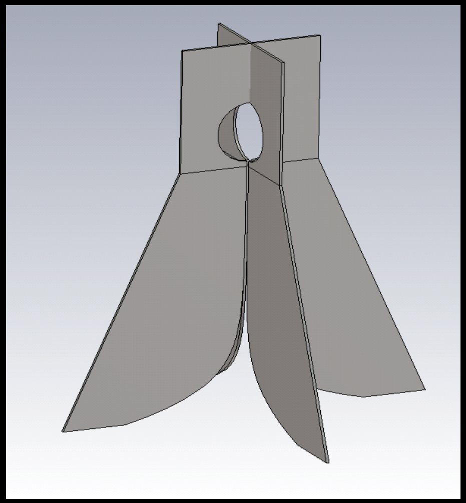
With Frontend Module

Cambridge UK Co-Simulation

Delay performance is heavily impacted by the antenna Impedance (which sets reflection amplitudes)

The Vivaldi stays close to the front-end system which is 50-100 Ohms





The match of the Vivaldi closely follows ~100 Ohms over the entire band which leads to better delay-performance

We have selected the Vivaldi feed primarily because of the ease with which it can be matched and obtain smooth spectral-performance

Moving Forward

- Finalizing the Mechanical design (December)
- Constructing prototypes (January)
- Orbcomm characterization of the beams (similar to Neben+ 2016)
- Commissioning starting with a three-Element array in South Africa (February)