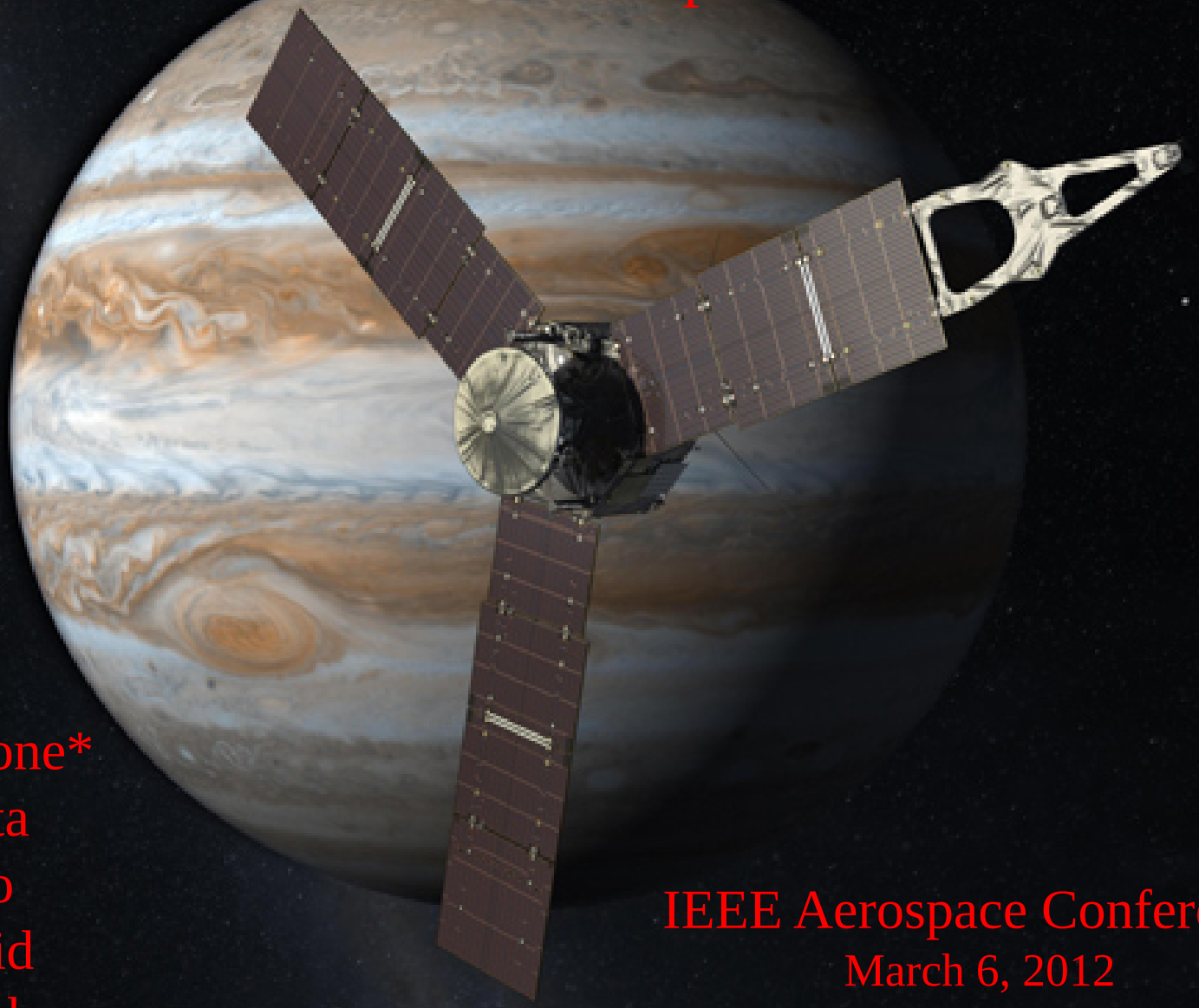
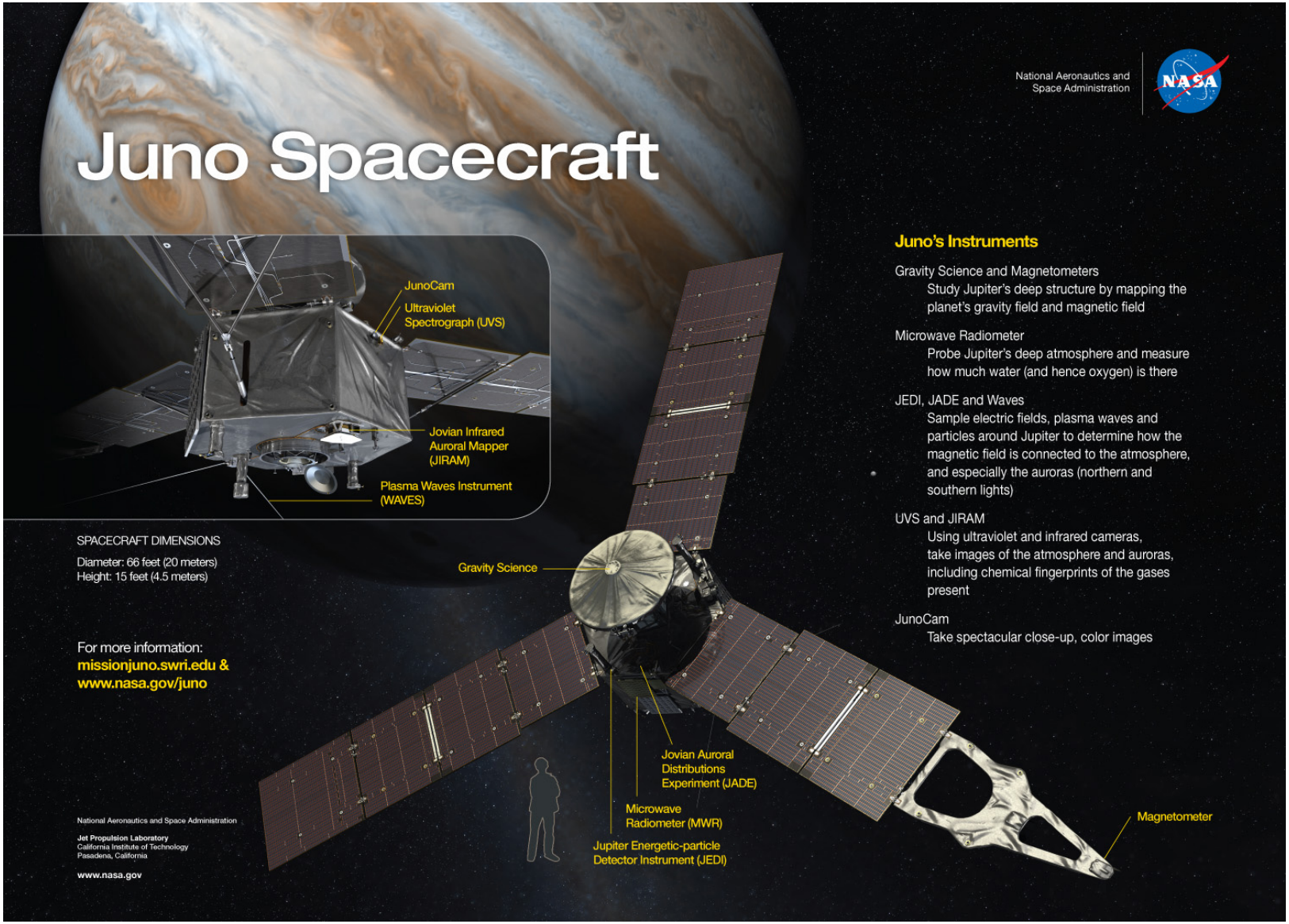
Telecommunication Antennas for the Juno Mission to Jupiter



Joseph Vacchione*
Aluizio Prata
Luis Amaro
Ronald Kruid
Anthony Mittskus

IEEE Aerospace Conference
March 6, 2012



Juno's Instruments

Gravity Science and Magnetometers
Study Jupiter's deep structure by mapping the planet's gravity field and magnetic field

Microwave Radiometer
Probe Jupiter's deep atmosphere and measure how much water (and hence oxygen) is there

JEDI, JADE and Waves
Sample electric fields, plasma waves and particles around Jupiter to determine how the magnetic field is connected to the atmosphere, and especially the auroras (northern and southern lights)

UVS and JIRAM
Using ultraviolet and infrared cameras, take images of the atmosphere and auroras, including chemical fingerprints of the gases present

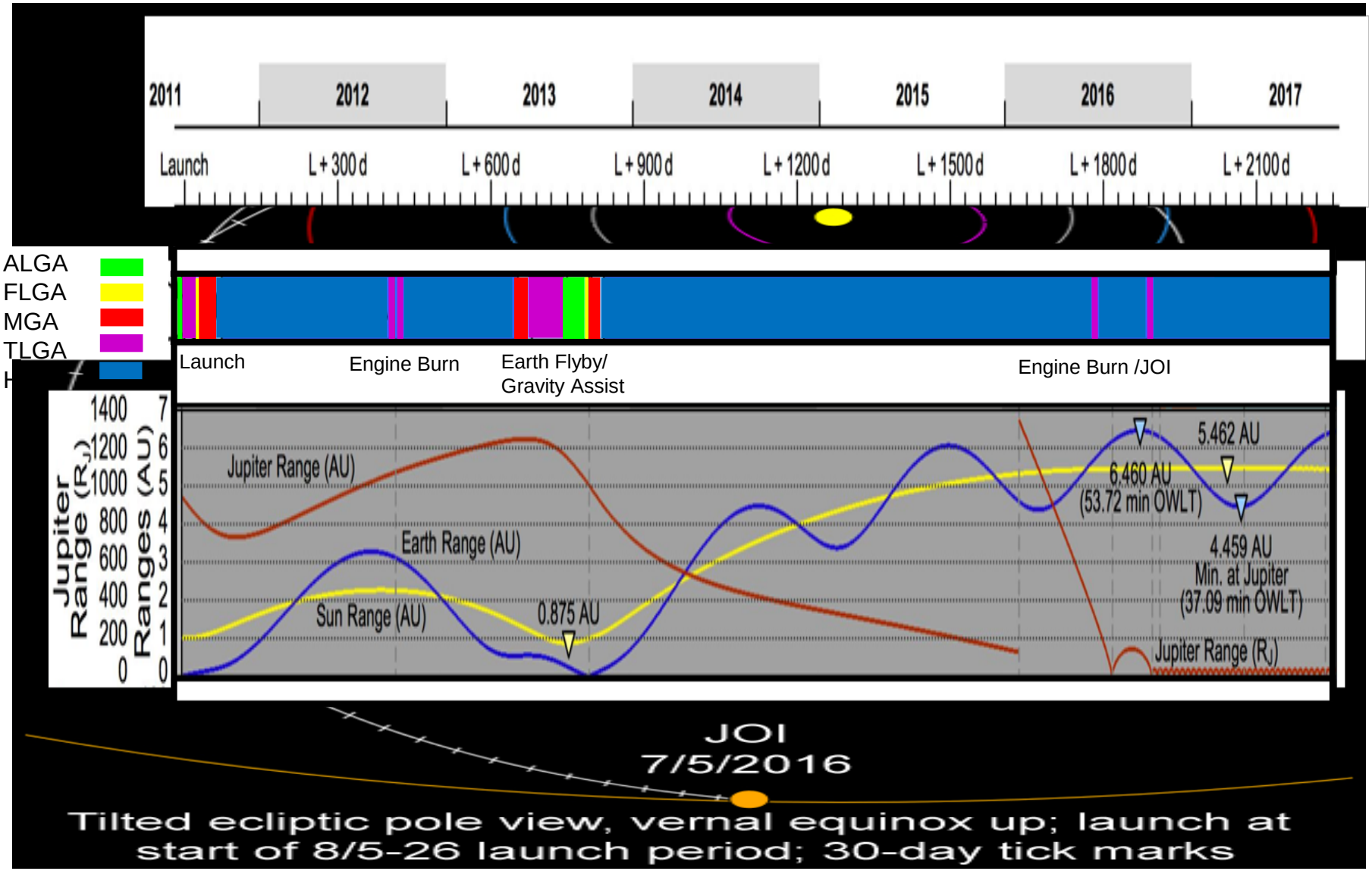
JunoCam
Take spectacular close-up, color images

Jet Propulsion Laboratory
California Institute of Technology

National Aeronautics and Space Administration
Goddard Space Flight Center

Aft Low Gain Antenna (ALGA)

Toroidal Low Gain Antenna (TLGA)


2011
2012
2013
2014
2015
2016
2017
Launch
L + 300 d
L + 600 d
L + 900 d
L + 1200 d
L + 1500 d
L + 1800 d
L + 2100 d
ALGA
FLGA
MGA
TLGA
Launch
Engine Burn
Earth Flyby/
Gravity Assist
Engine Burn /JOI
Jupiter Range (R_J)
Ranges (AU)
Jupiter Range (AU)
Earth Range (AU)
Sun Range (AU)
0.875 AU
5.462 AU
6.460 AU
(53.72 min OWLT)
4.459 AU
Min. at Jupiter
(37.09 min OWLT)
Jupiter Range (R_J)
JOI
7/5/2016
Tilted ecliptic pole view, vernal equinox up; launch at start of 8/5-26 launch period; 30-day tick marks

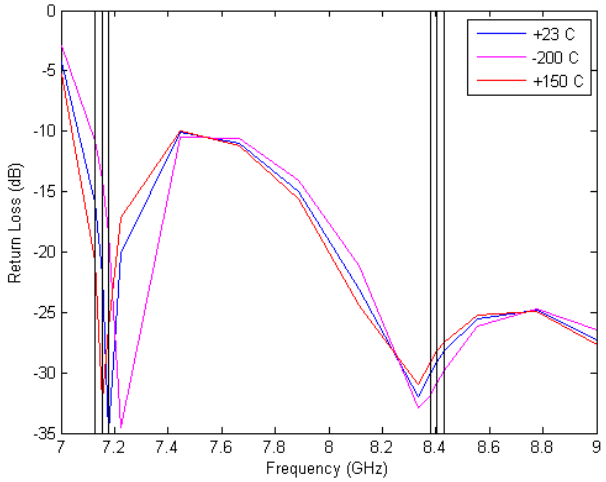
Outline

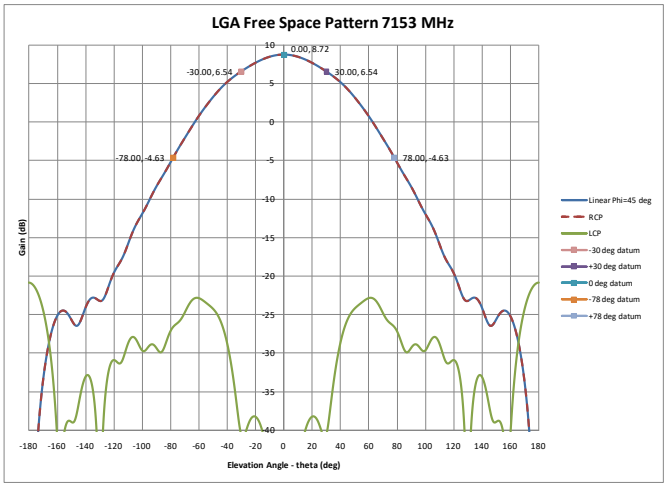
- Brief Description of Horn Antennas
- Toroidal Low Gain Antenna
  - Design
  - Construction
  - Performance
- High Gain Antenna
  - Design
  - Performance

Horn Antennas
Fore and Aft Low & Medium Gain Antennas
Heritage Designs

Model description of LGA Antenna

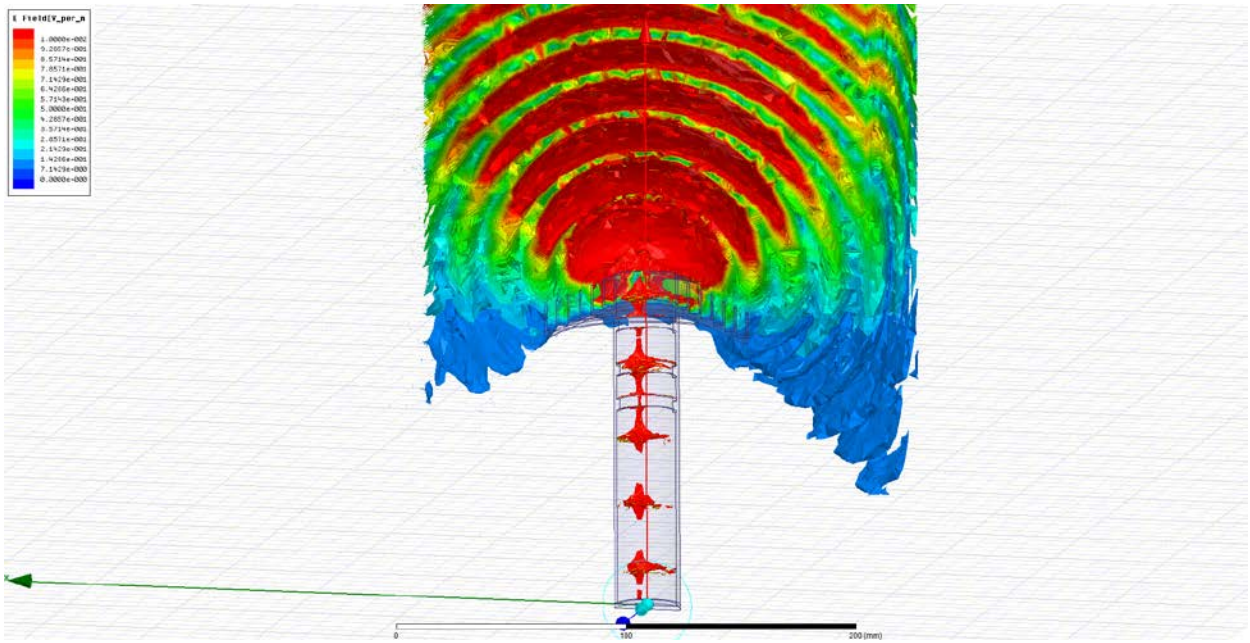
7.7 dBi @ 7.1 GHz
8.7 dBi @ 8.4 GHz





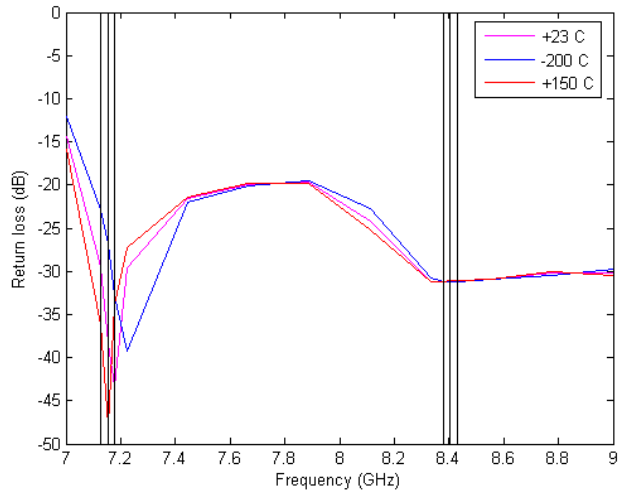
Horn

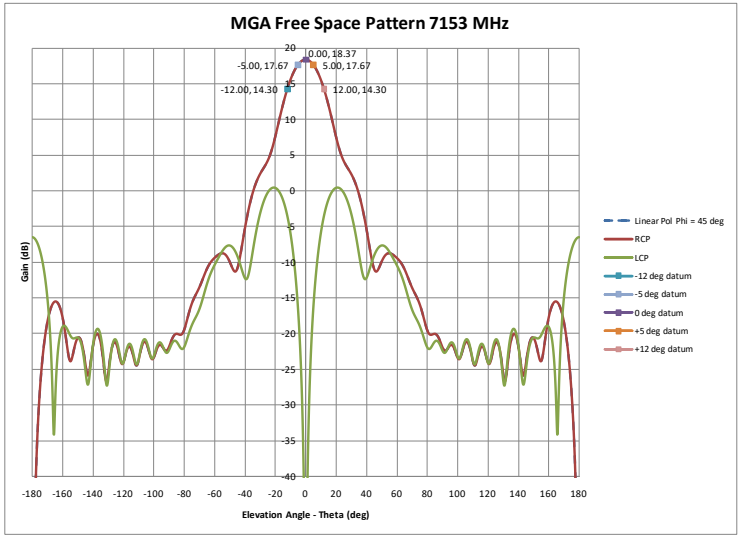
Polarizer



Model description of MGA Antenna

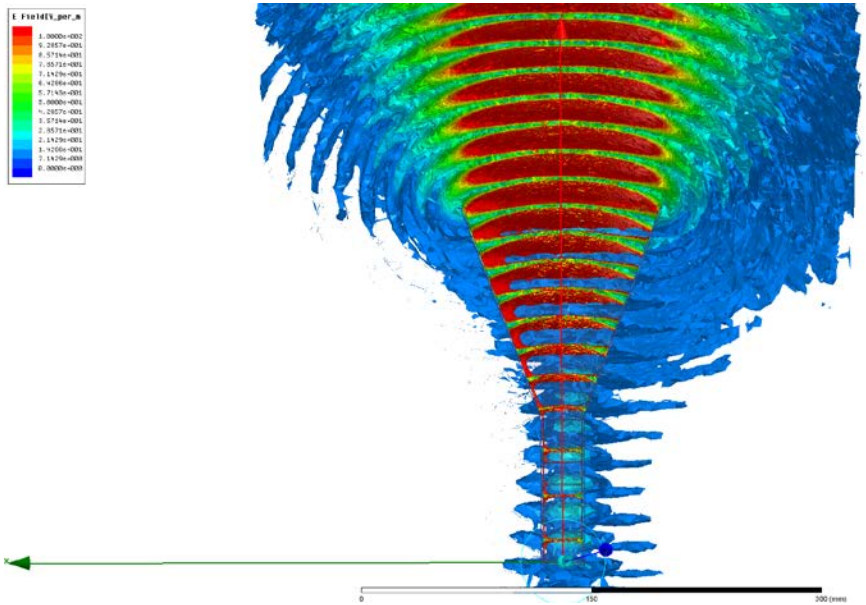
18.1 dBi @ 7.1 GHz
18.8 dBi @ 8.4 GHz





Horn

Polarizer

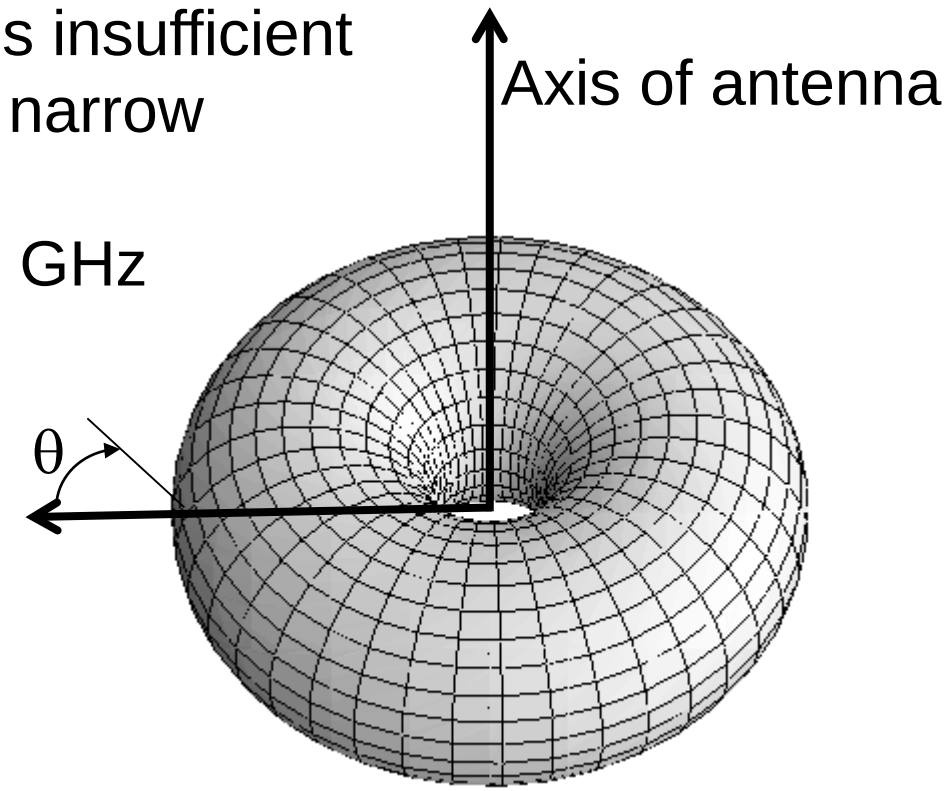


Toroidal Low Gain Antenna
New Development for Juno

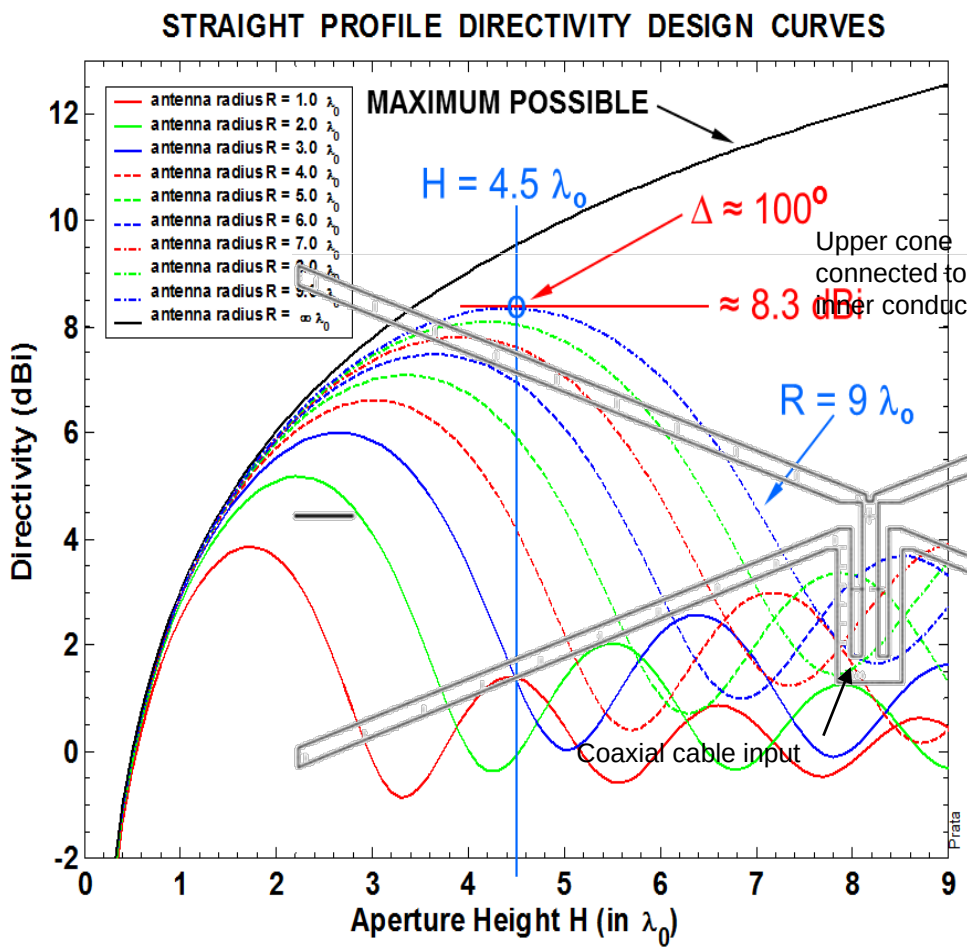
Toroidal Low Gain Antenna Requirements

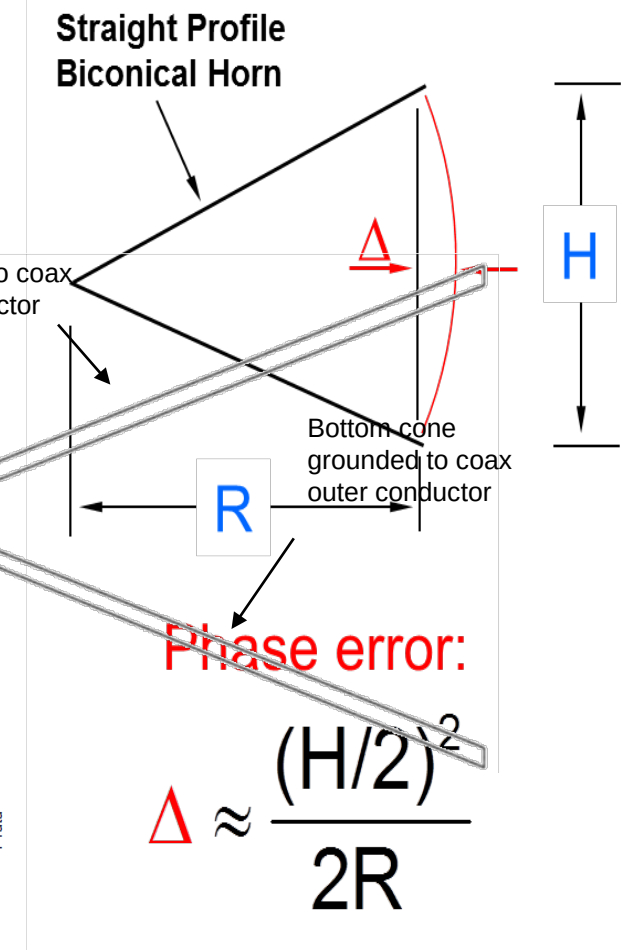
Dipole is candidate Antenna
But the ~2 dB gain is insufficient
And band width too narrow

Need 4.5 dBi @ 7.1 GHz
& 6 dBi @ 8.4 GHz



Standard Bicone Antenna

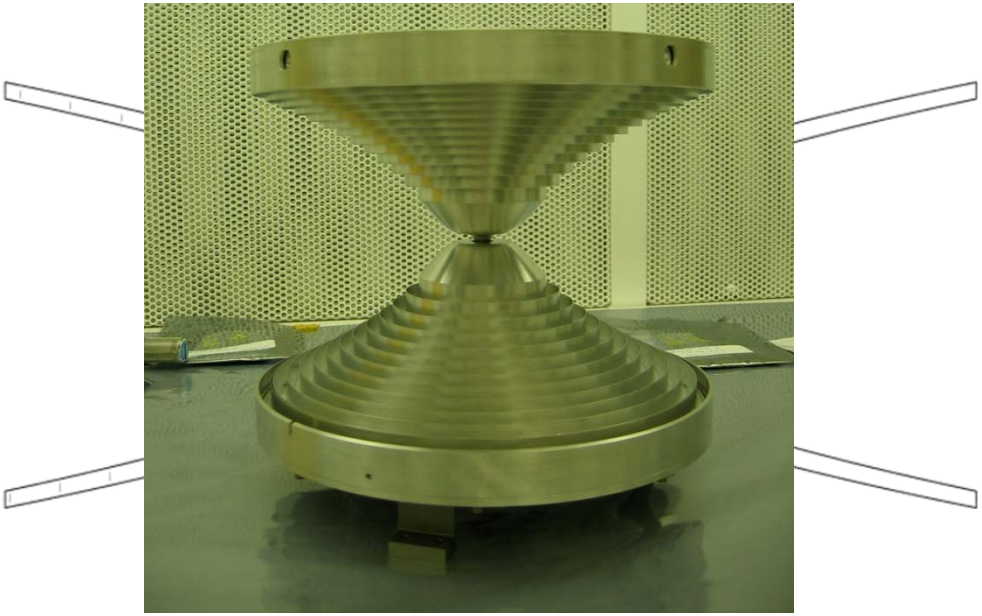


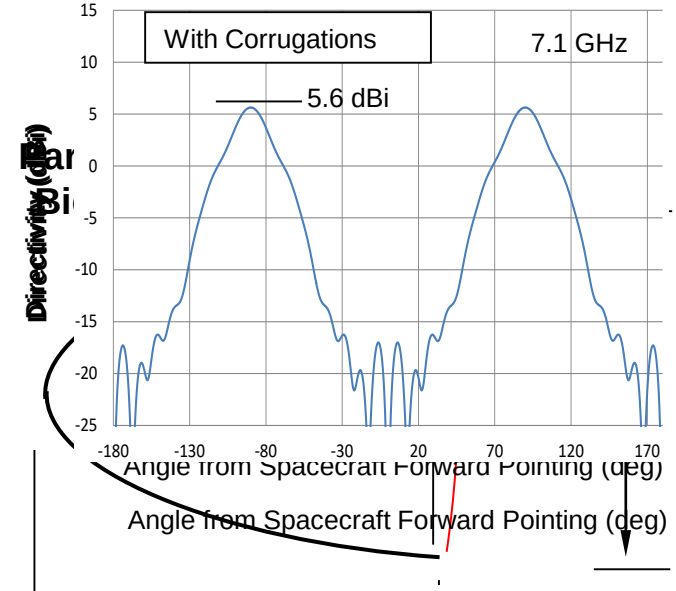


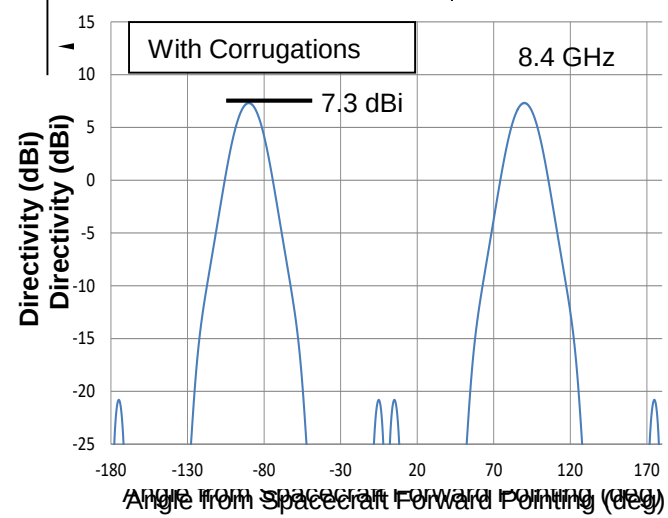
Phase error:

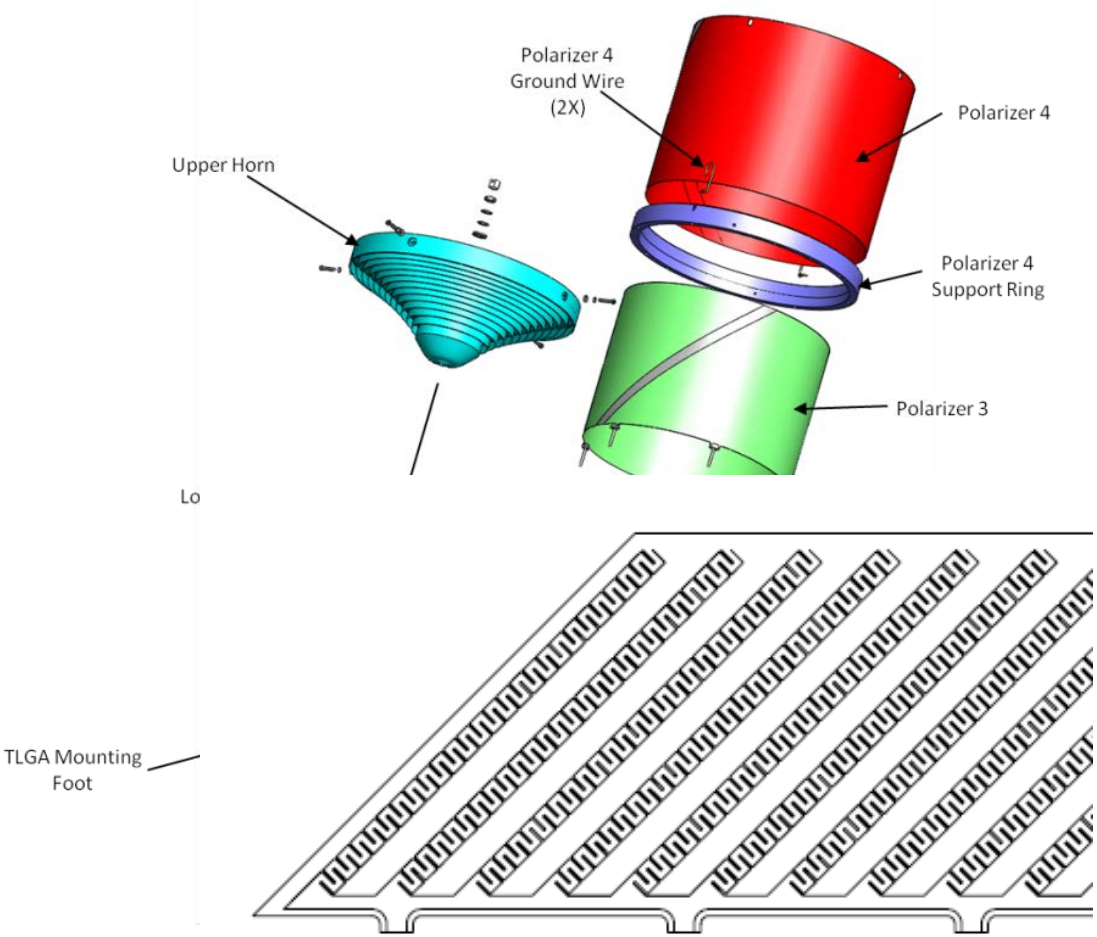
$$\Delta \approx \frac{(H/2)^2}{2R}$$

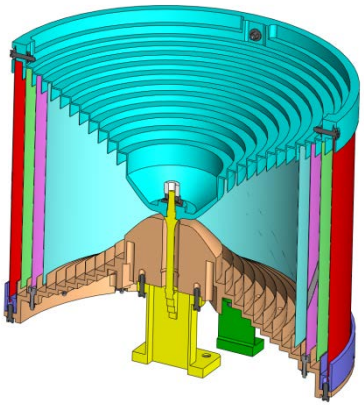
Parabolic Bicone Antenna

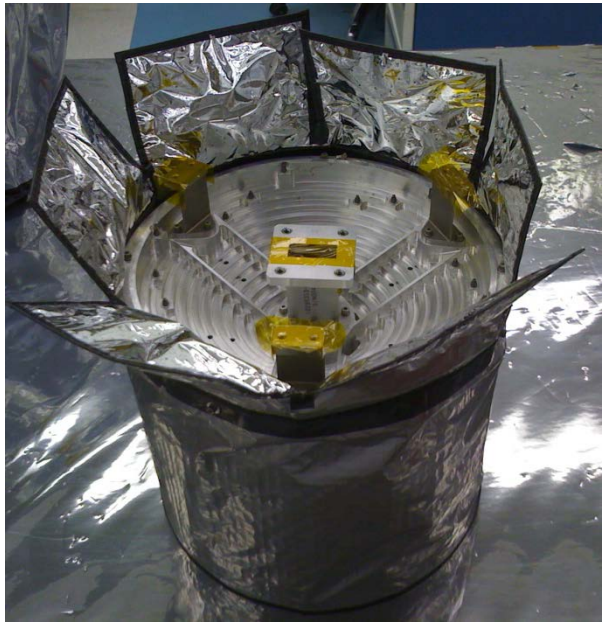







Polarizer 4
Ground Wire
(2X)
Polarizer 4
Upper Horn
Polarizer 4
Support Ring
Polarizer 3
Lo
TLGA Mounting
Foot





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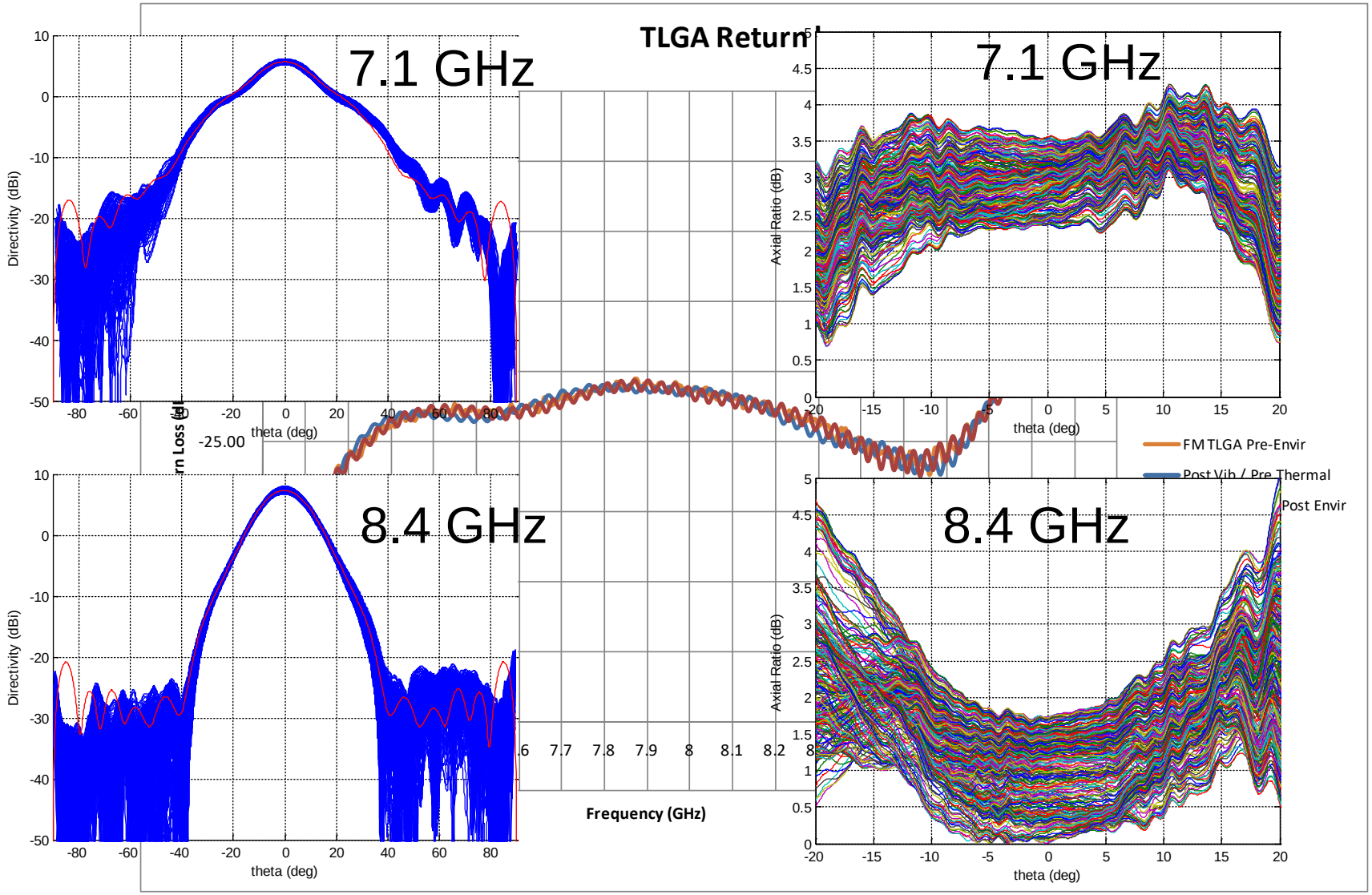
TLGA Perfomance

National Aeronautics and Space Administration
Goddard Space Flight Center

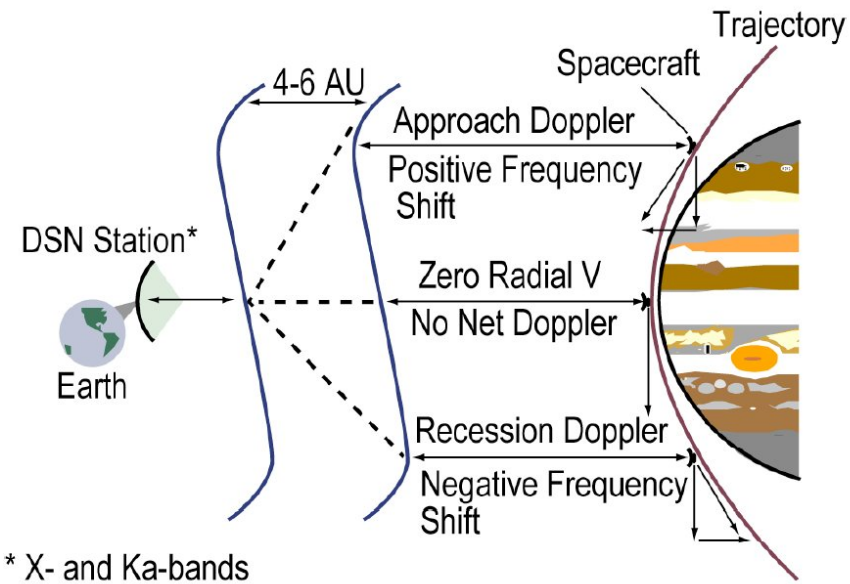


High Gain Antenna
New Development for Juno

High Gain Antenna Requirements

For Telecommunications
41.5 dBi @ 7.1 GHz
43.0 dBi @ 8.4 GHz

For Gravity Science
42.7 dBi @ 34.3 GHz
41.0 dBi @ 32.1 GHz



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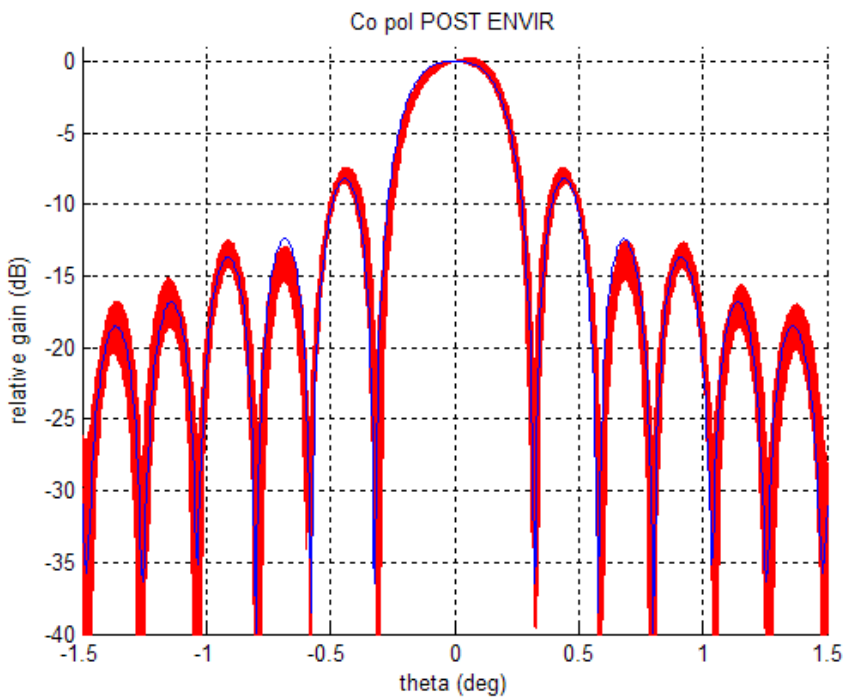
High Gain Antenna
HGA Optics Design

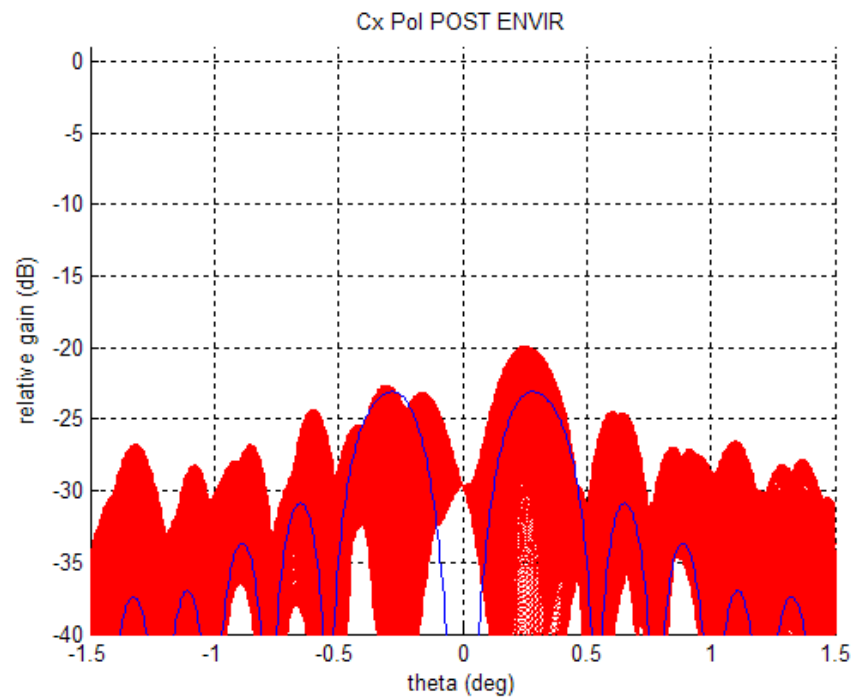
High Gain Antenna Performance X-band

34 GHz

RCP



LCP



Conclusions

- Typical NASA Spacecraft Require multiple Antennas; 5 in this case
- Often need to expand on existing off the shelf technology
- As of now all 5 antennas have be in operation on the spacecraft and all are working according to plan