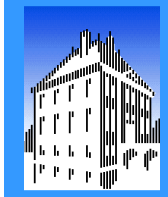
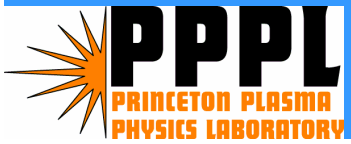



Collaborative Development and Test of an ITER Divertor Reflectometer

Peter H. Siegel, Caltech
Erich Schlecht/Ken Cooper/Imran Mehdi/Goutam Chattopadhyay/Robert Dengler/Frank Maiwald/John Ward/John Gill , Jet Propulsion Lab
N.C. Luhmann, Jr./C.W.Domier/K.C. Lee/Y.M. Shin, UC Davis
Tobin Munsat, University of Colorado
A.J.H. Donné, FOM Institute for Plasma Physics Rijnhuizen
Hyeon Park, PPPL



Proposed Collaborative ITER Divertor Reflectometer Development

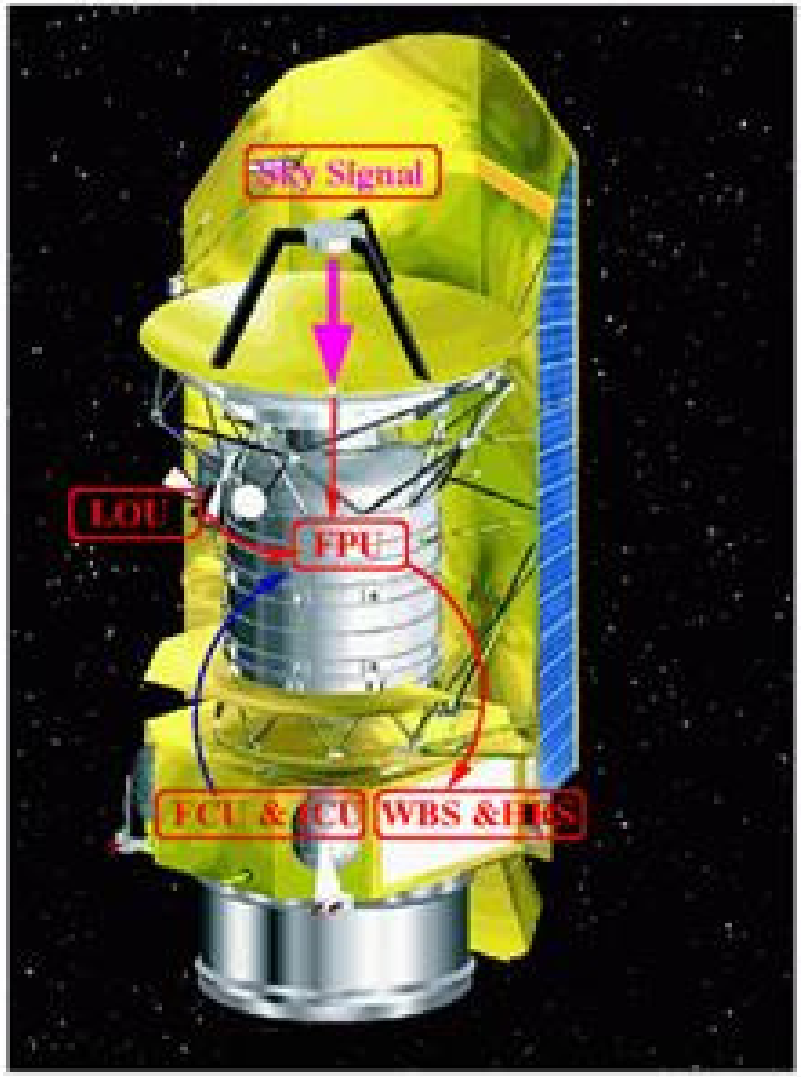
Build upon developments of space qualified high power millimeter wave power amplifiers, high power multipliers, and mixer technology

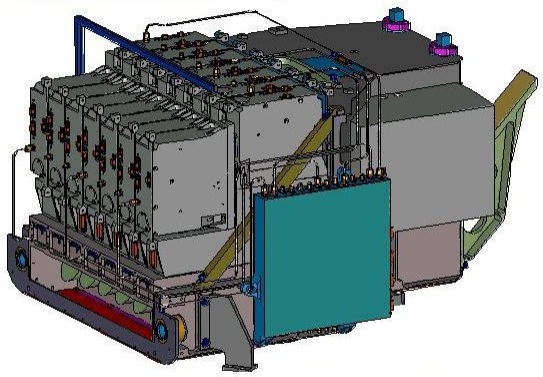
Build upon successful JPL development of a 600 GHz cw FM imaging radar

Leverage team's expertise in millimeter wave hardware developments

Test divertor reflectometers under realistic ITER conditions in the Magnum-PSI device at FOM

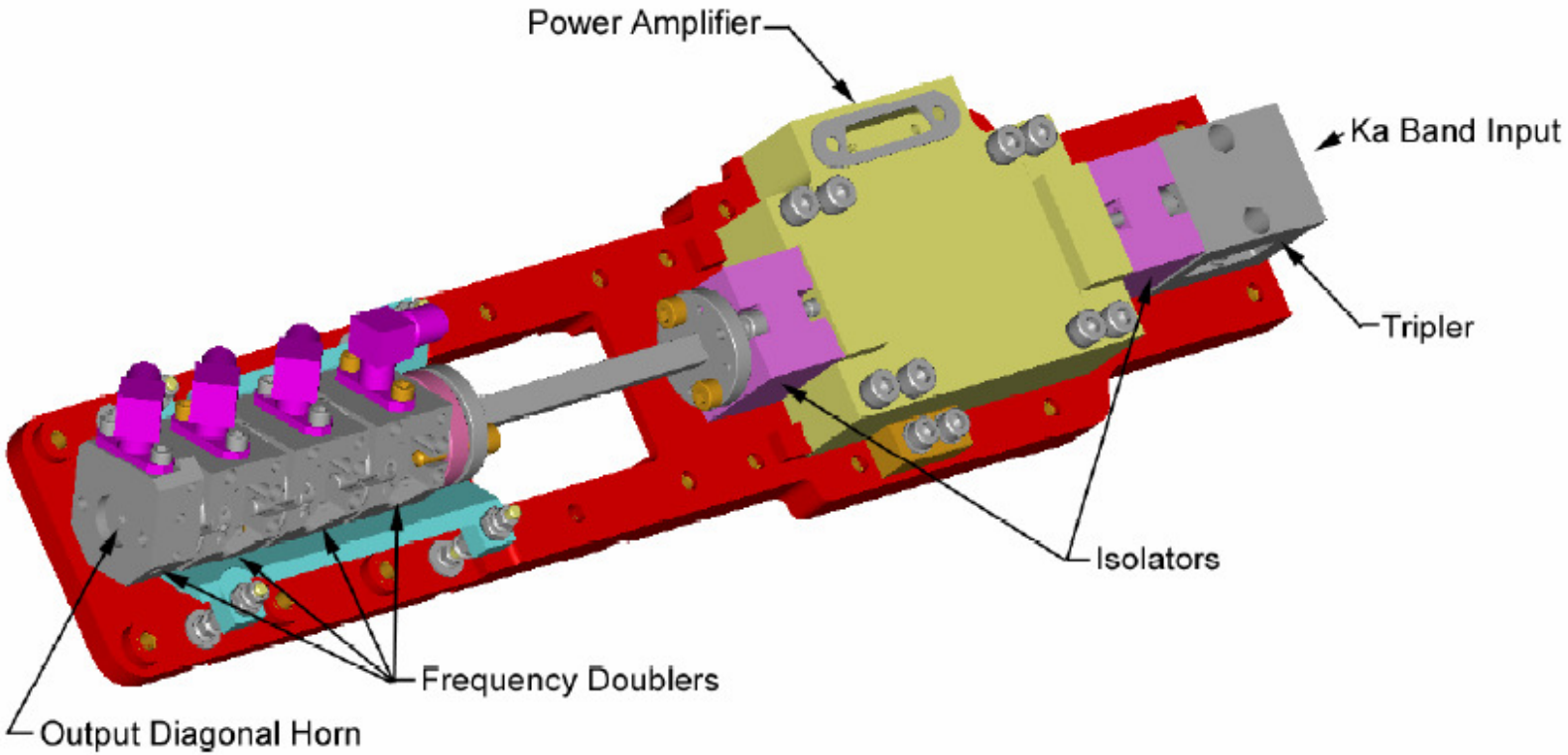
Herschel Space Observatory: Funded THz Source and Detector Developments





HIFI frequency coverage and band allocation

Band	Mixer type	LO Lower freq.	LO Upper freq.	Beam Size (HPBW)	IF Bandwidth
1	SIS	488.1 GHz	628.1 GHz	39"	4.0 GHz
2	SIS	642.3 GHz	792.9 GHz	30"	4.0 GHz
3	SIS	807.1 GHz	952.9 GHz	25"	4.0 GHz
4	SIS	967.1 GHz	1112.8 GHz	21"	4.0 GHz
5	SIS	1116.2 GHz	1241.8 GHz	19"	4.0 GHz
6 + 7	HEB	1412.2 GHz	1907.8 GHz	13"	2.4 GHz

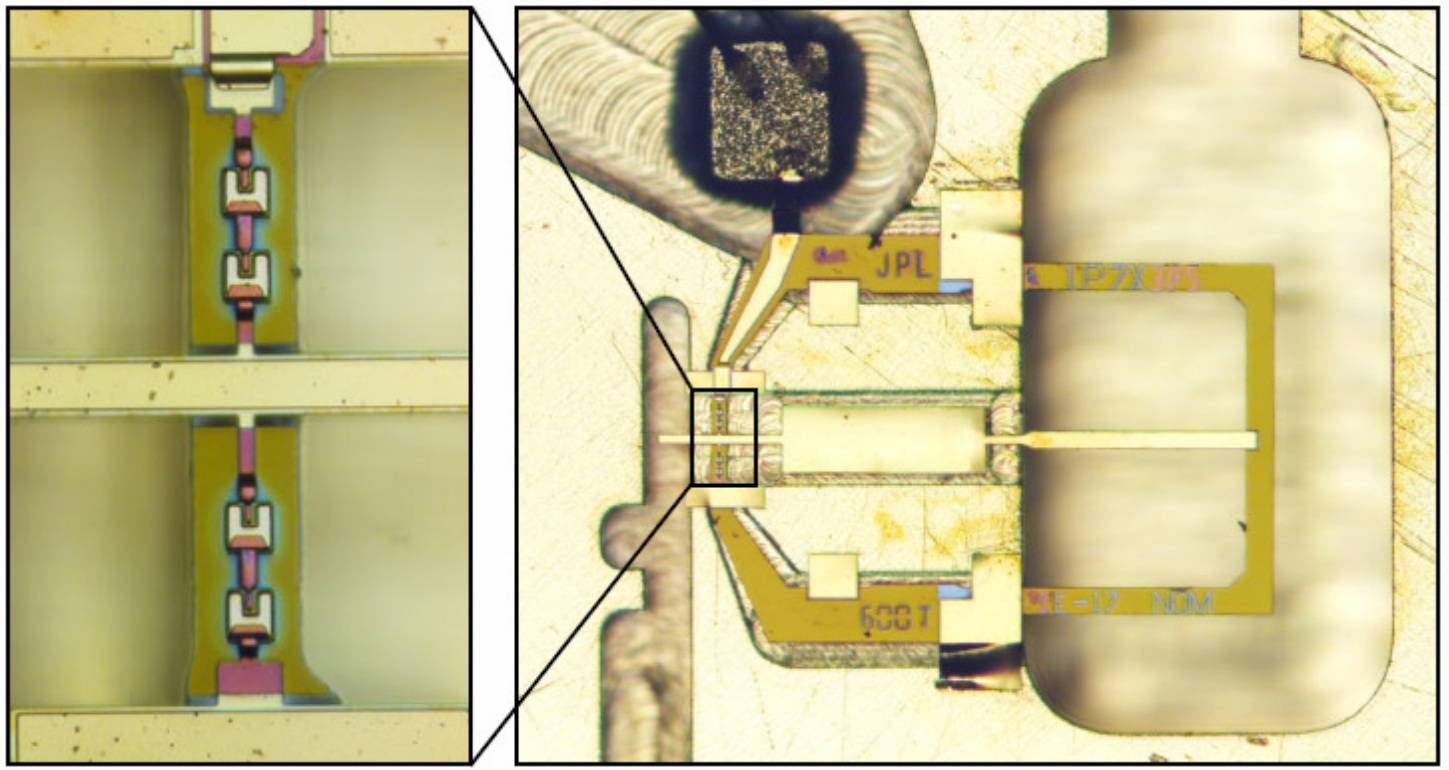


Four anode balanced 600 GHz tripler

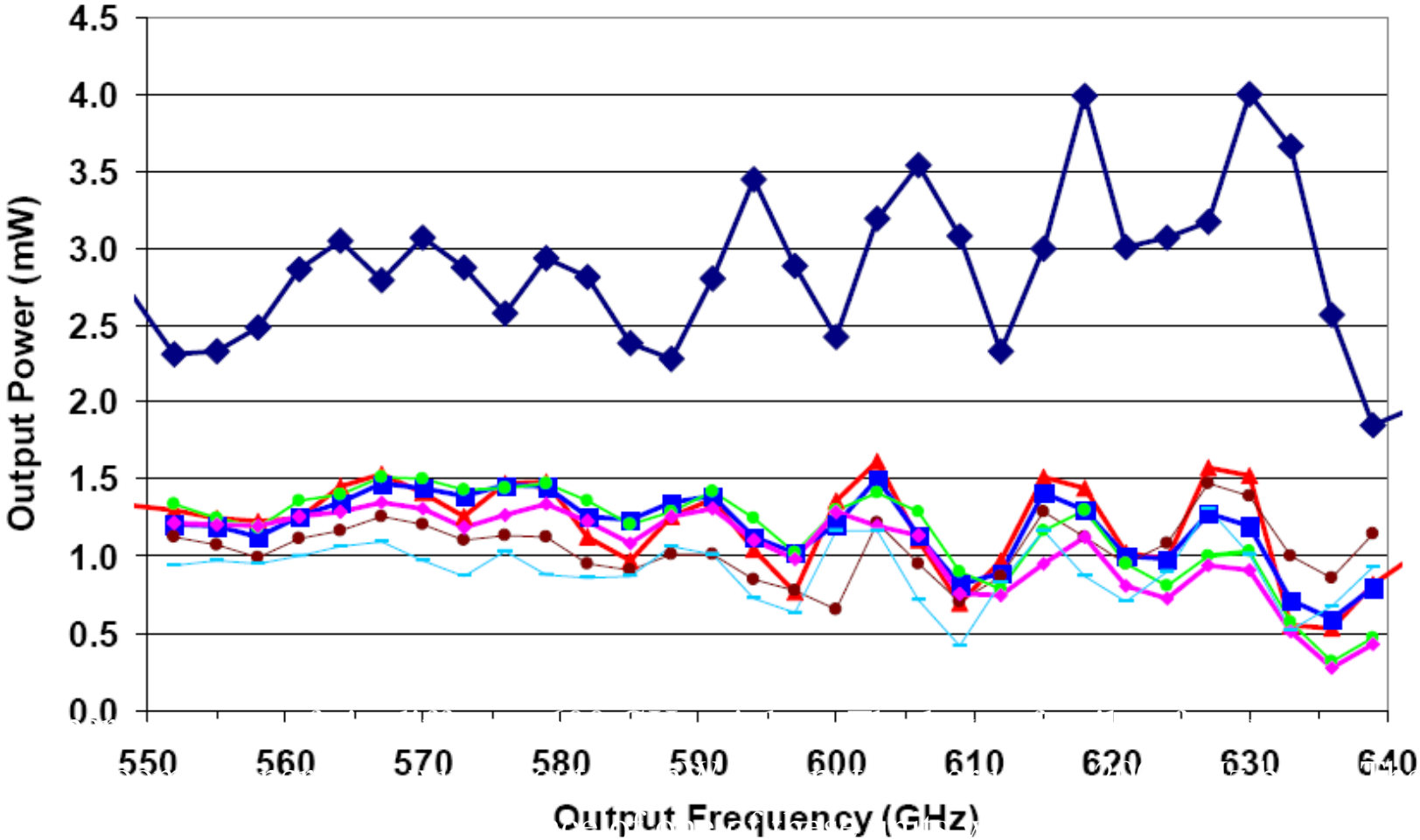
The device is about 1 mm long.

The 200 GHz input signal enters from the upper right.

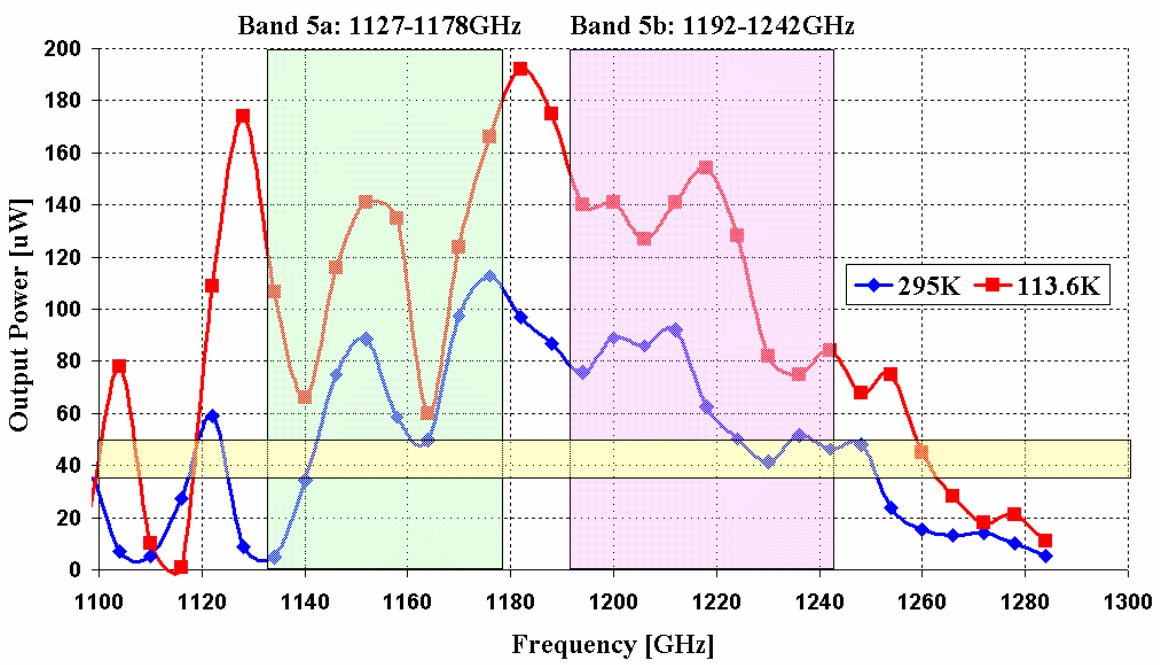
Four diodes lie near the output waveguide to the lower left.

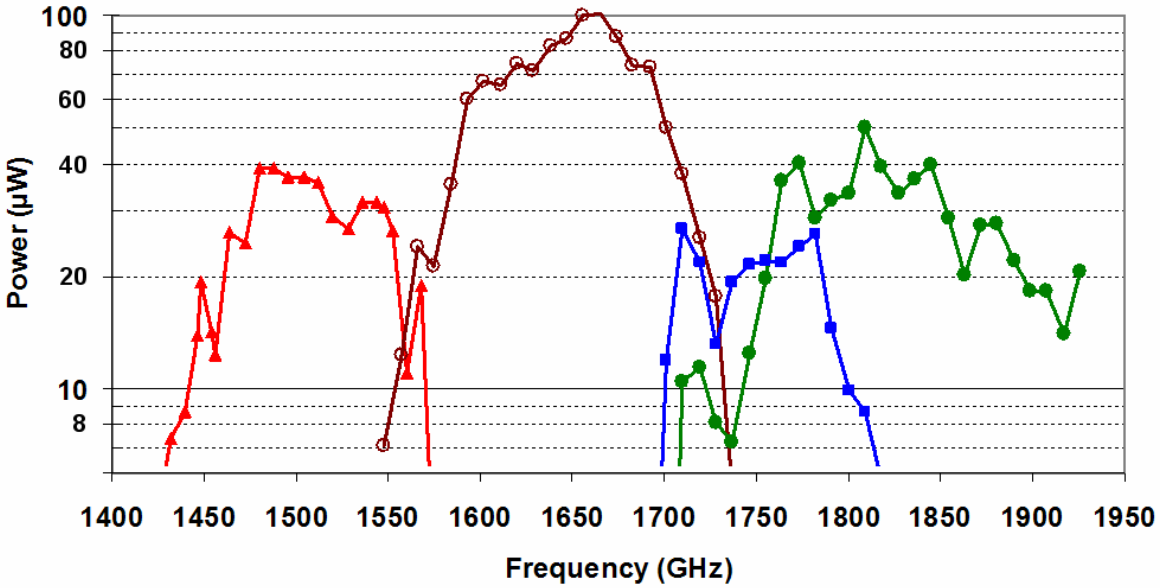


600 GHz Tripler



Broad Band Multiplier Chains above 1 THz



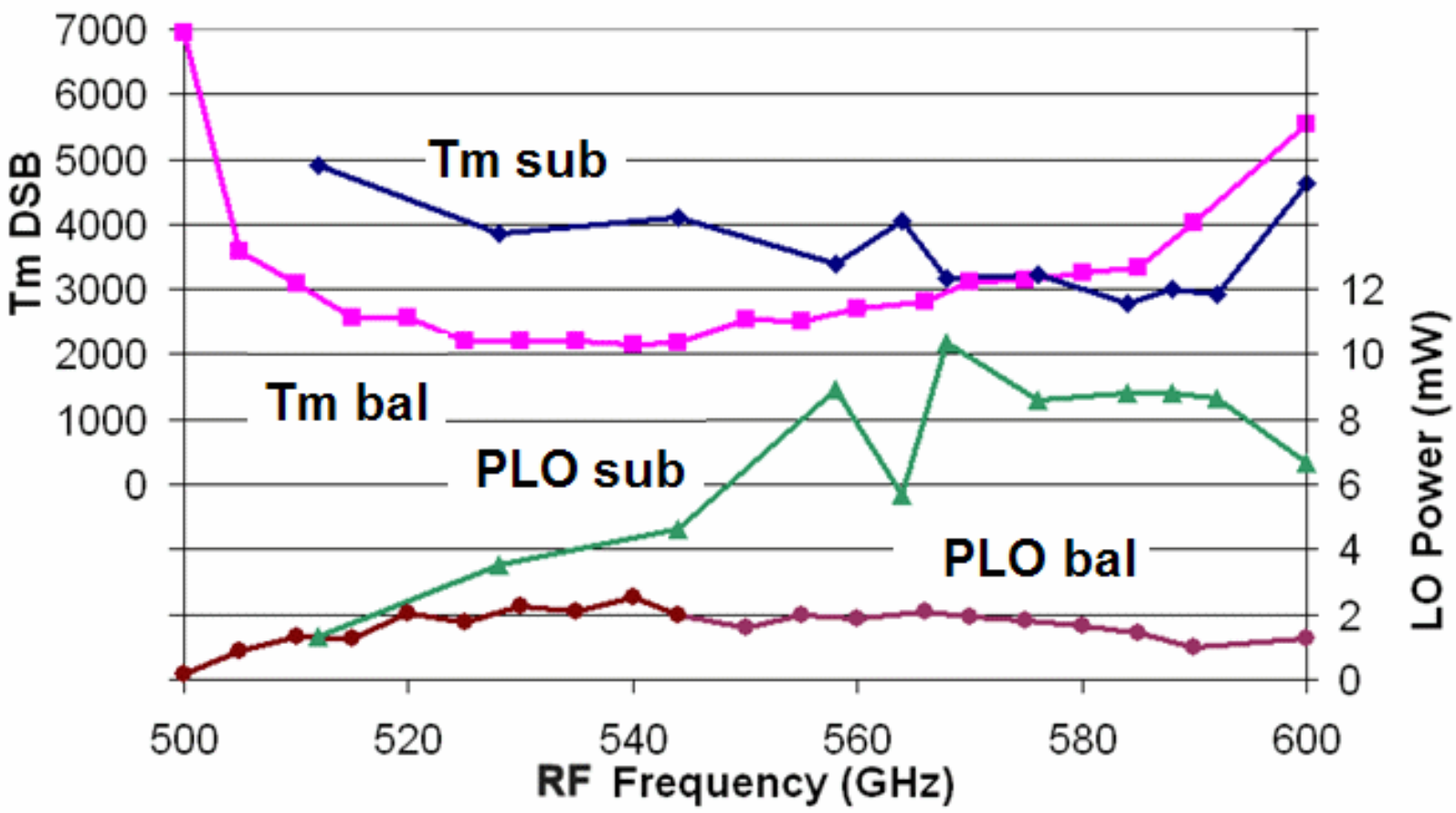


Chains for
1.12 – 1.26 THz

Chains for
1.5 – 1.9 THz

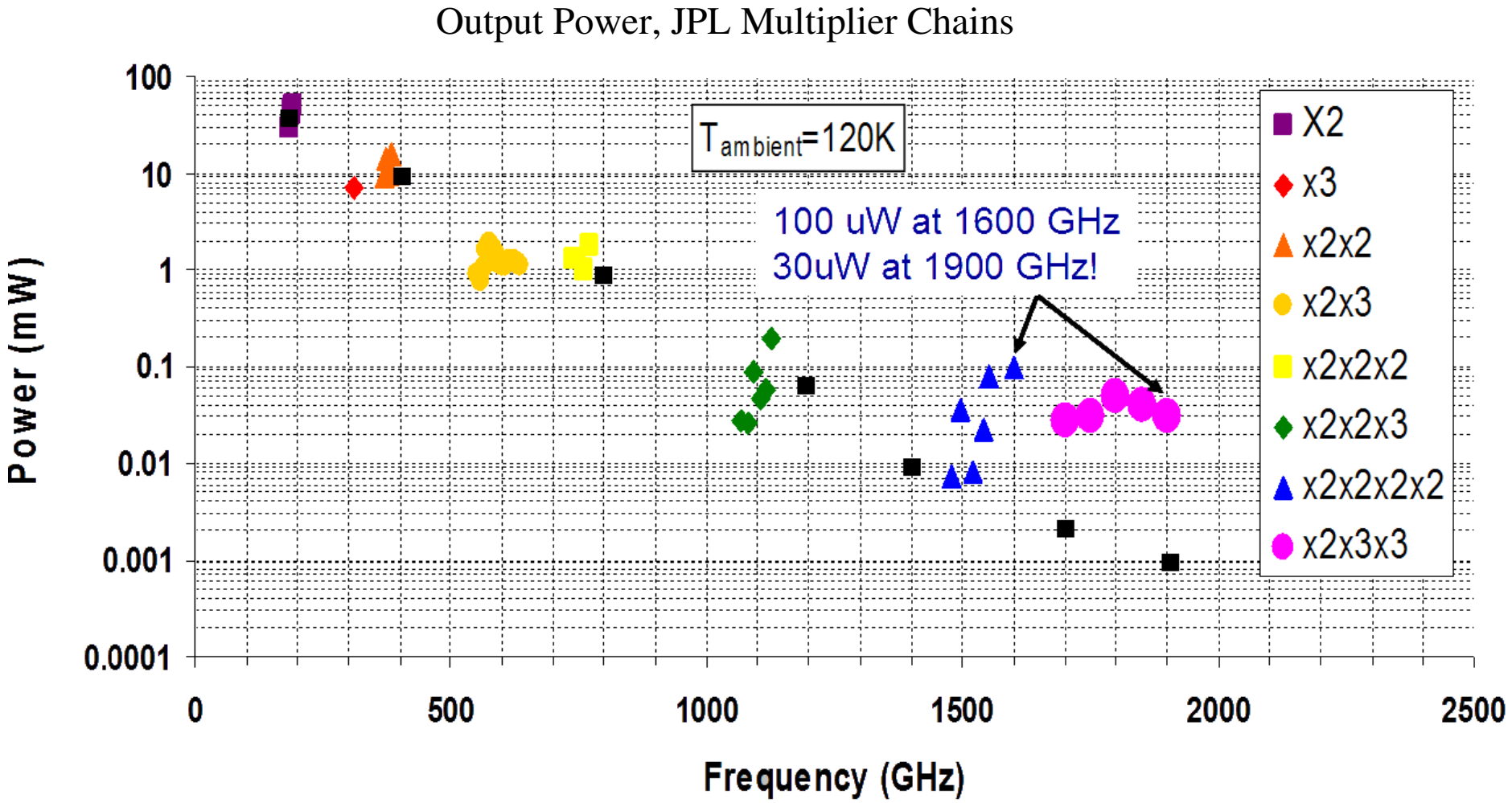
600 GHz Schottky Downconverters

New Fundamental Balanced Mixers and older Subharmonically Pumped Devices

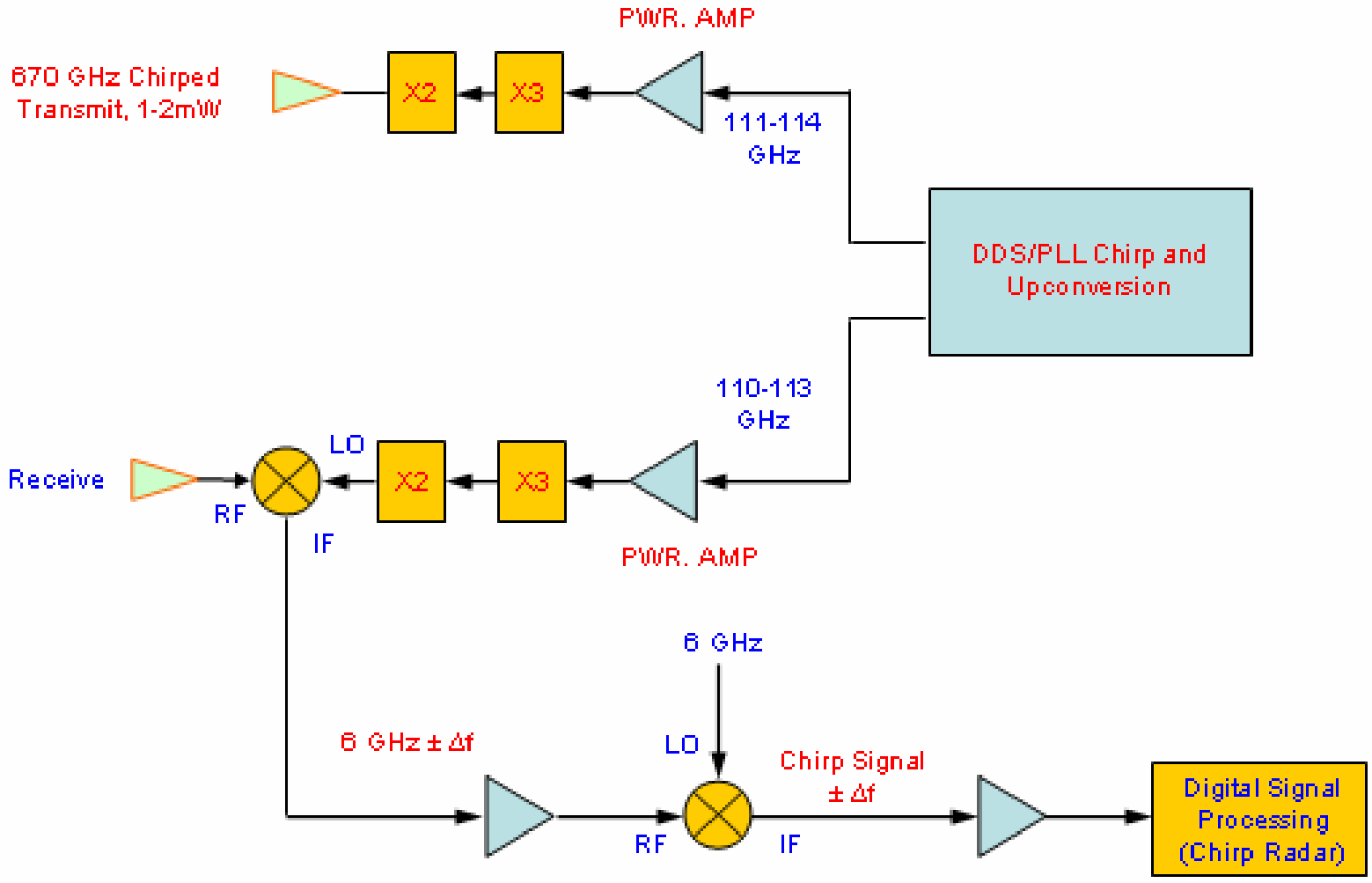


State-of-the-Art RT Mixers flown in space at 180, 240, 640 and 2520 GHz

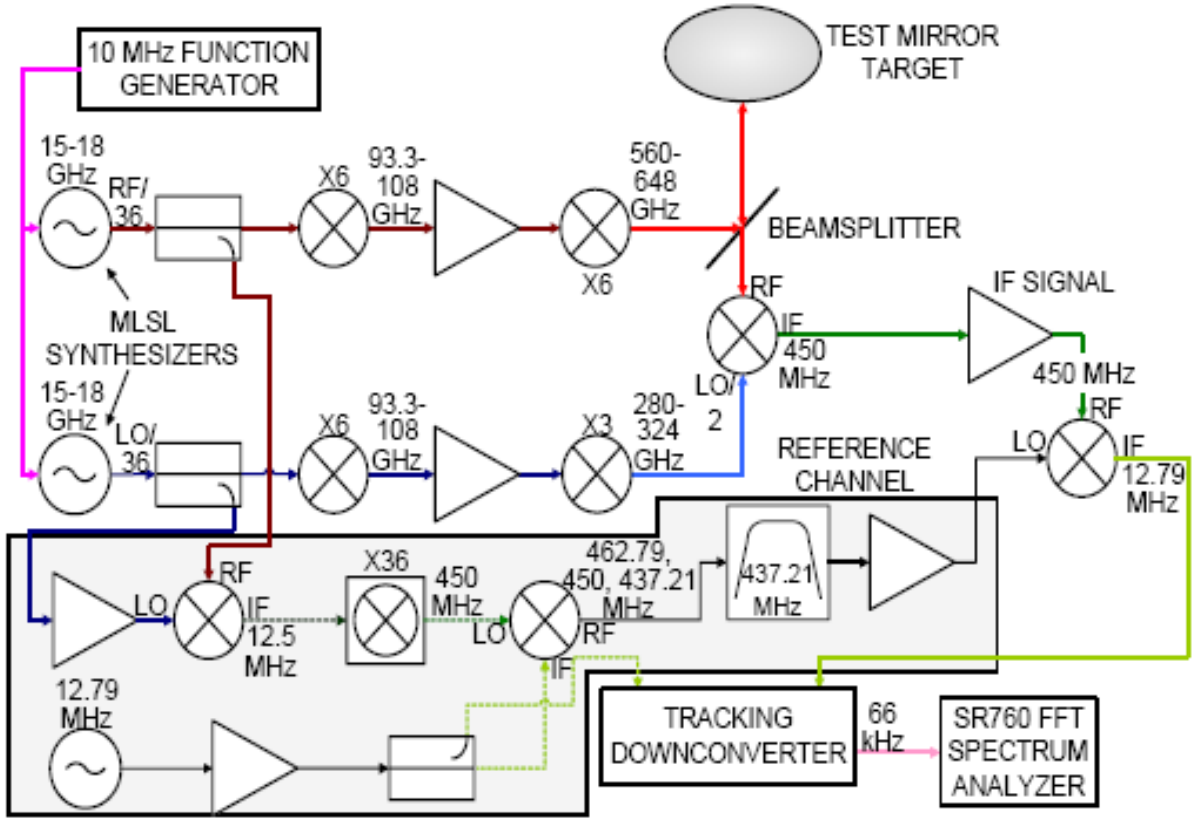
Schottky Multipliers State of the Art



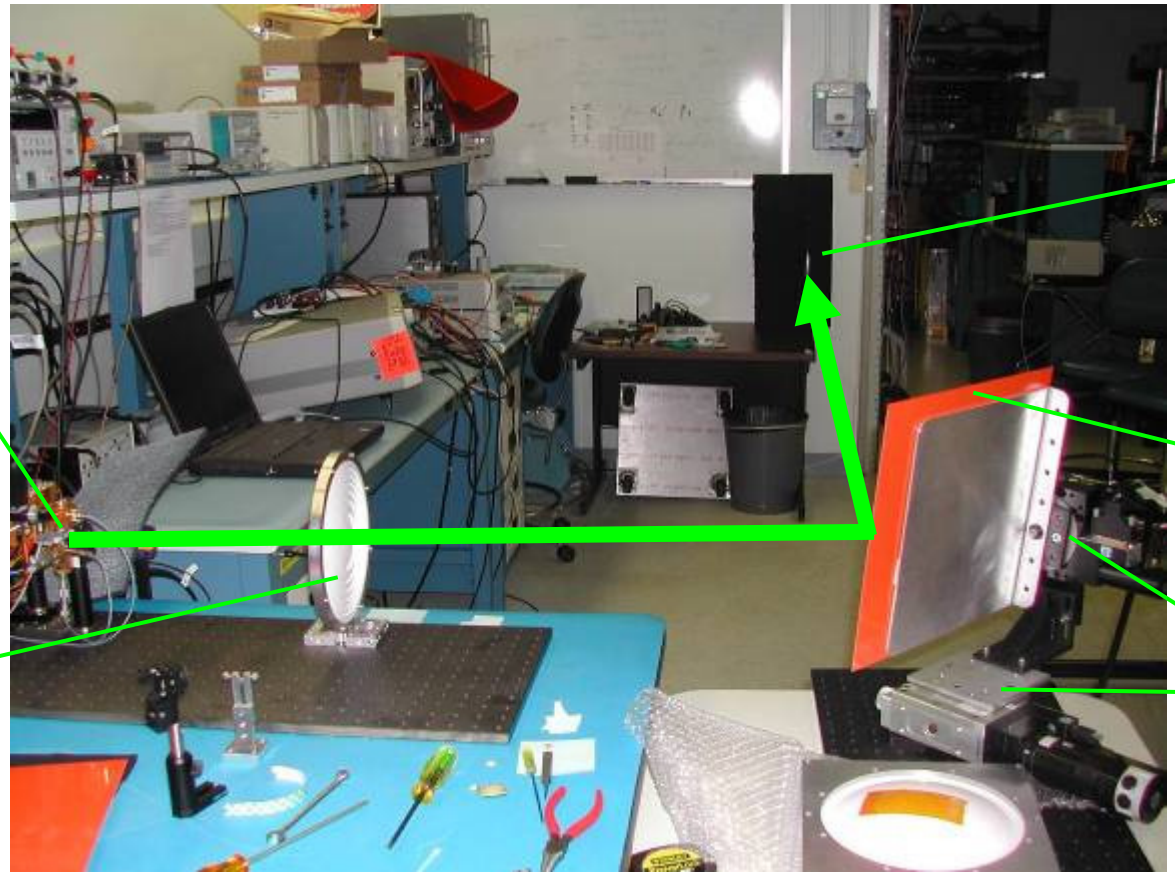
JPL Imaging Radar System Design



600 GHz Imaging Radar with 2 cm Range Resolution



Scanning Imaging Radar



Major System Objectives

Transmit power: >1 mW at 670 GHz atmospheric window

Chirp bandwidth: >15 GHz, yielding sub-cm range resolution

Aperture diameter: <1m lens, giving sub-cm angular resolution at many meter standoff distances

System noise temperature: <10,000 K, receiver-mixer dominated

FMCW repetition rate: video-rate imaging

Initial Radar Measurements

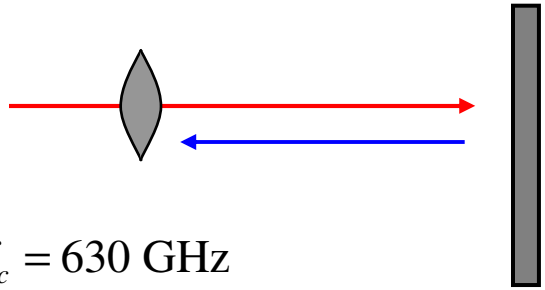
$$f_{IF} = f_0 + \frac{2KR}{c} = f_0 \pm 470 \text{ Hz}$$

theoretical prediction

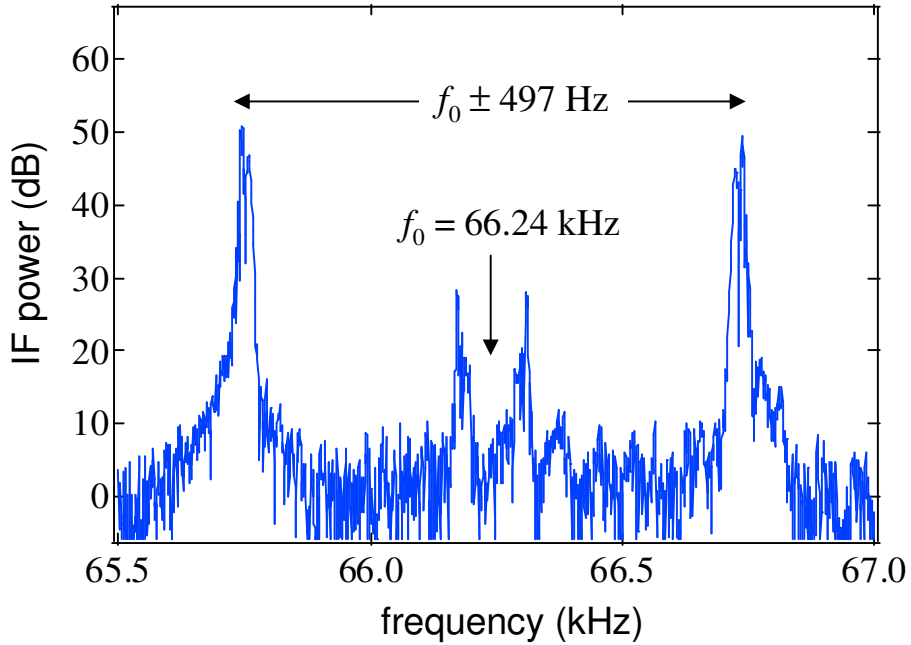
$f_0 = 66.24$ kHz $R = 4.4$ m

$K = \pm \frac{8 \text{ GHz}}{0.5 \text{ s}}$ $c = 3e8$ m/s

experiment

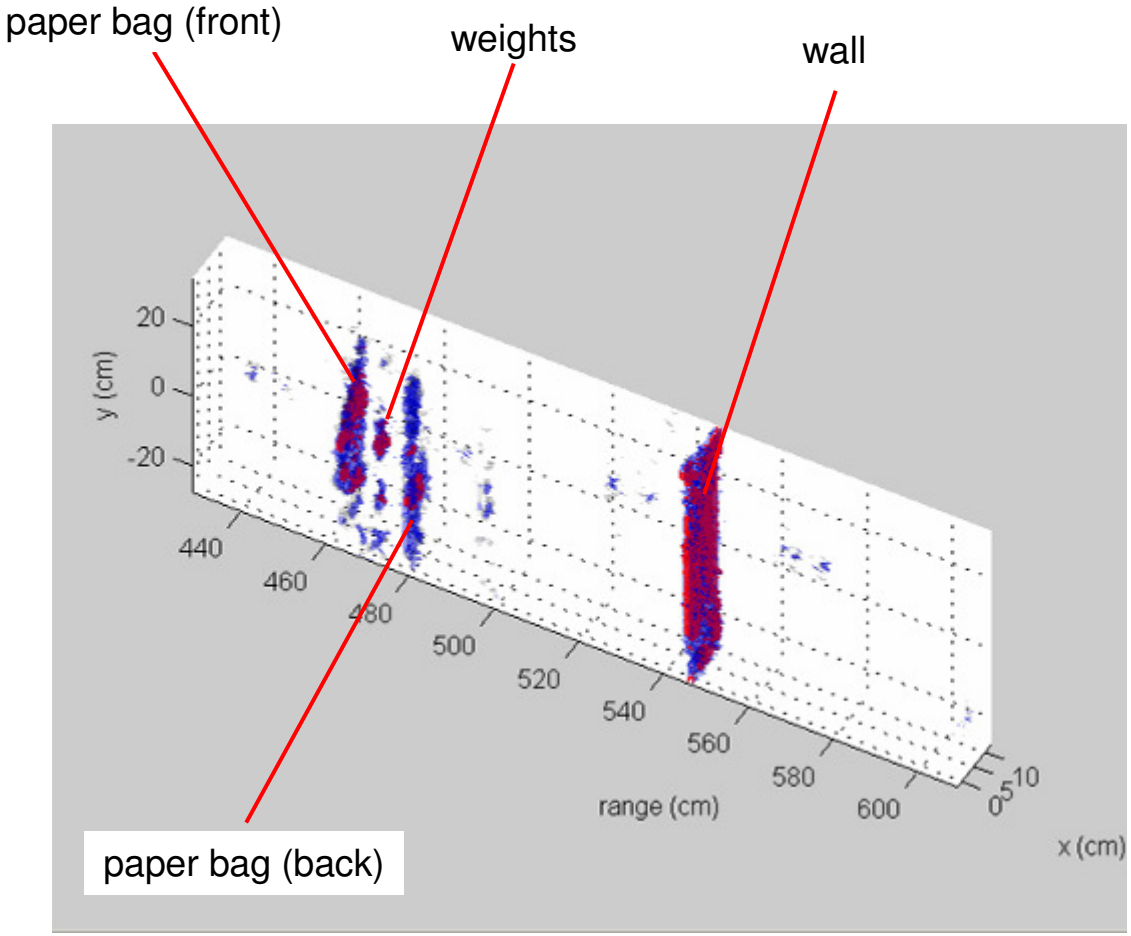


$f_c = 630$ GHz



Detection of Weights Concealed by Paper Bag

High range-resolution permits concealed objects to be imaged.

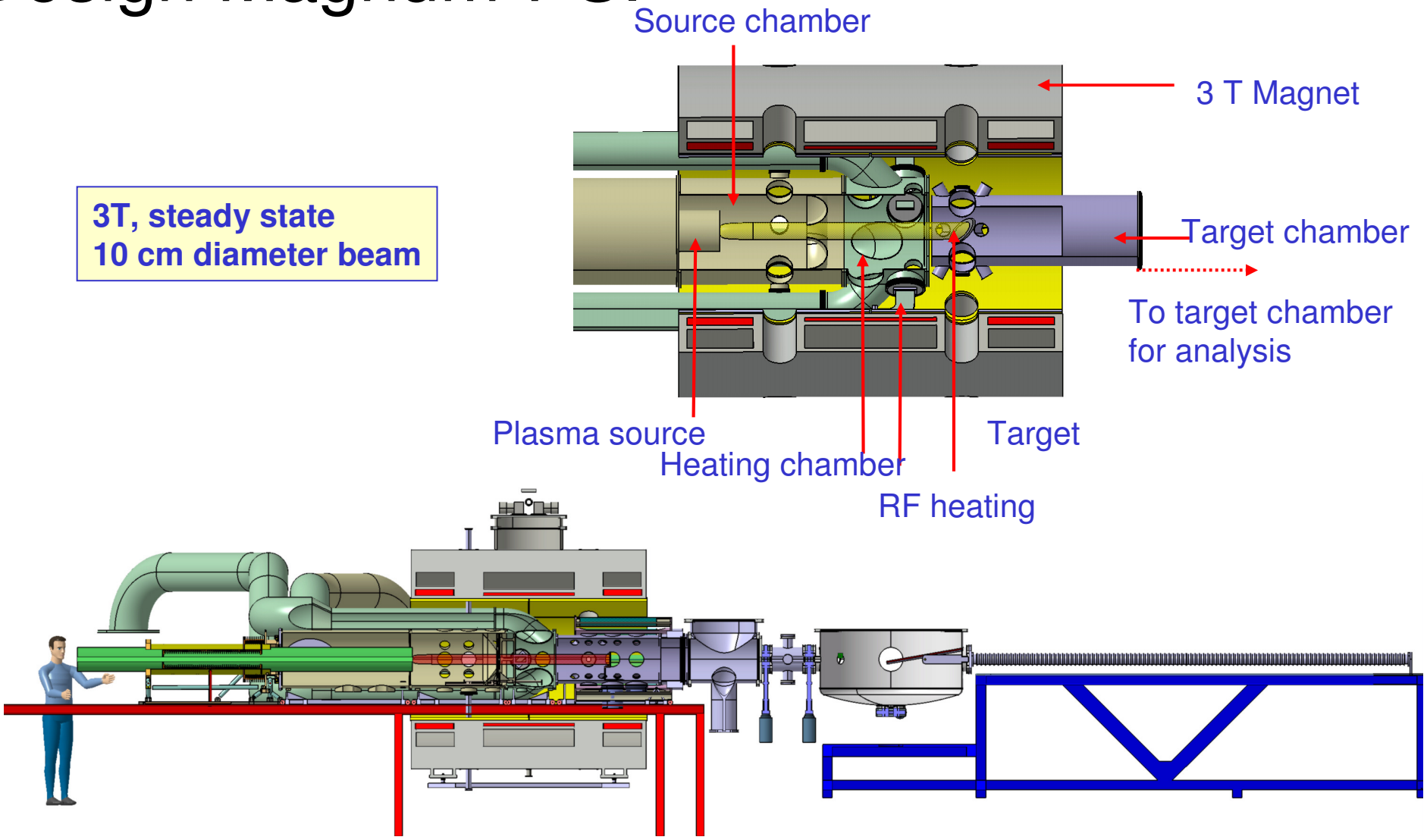


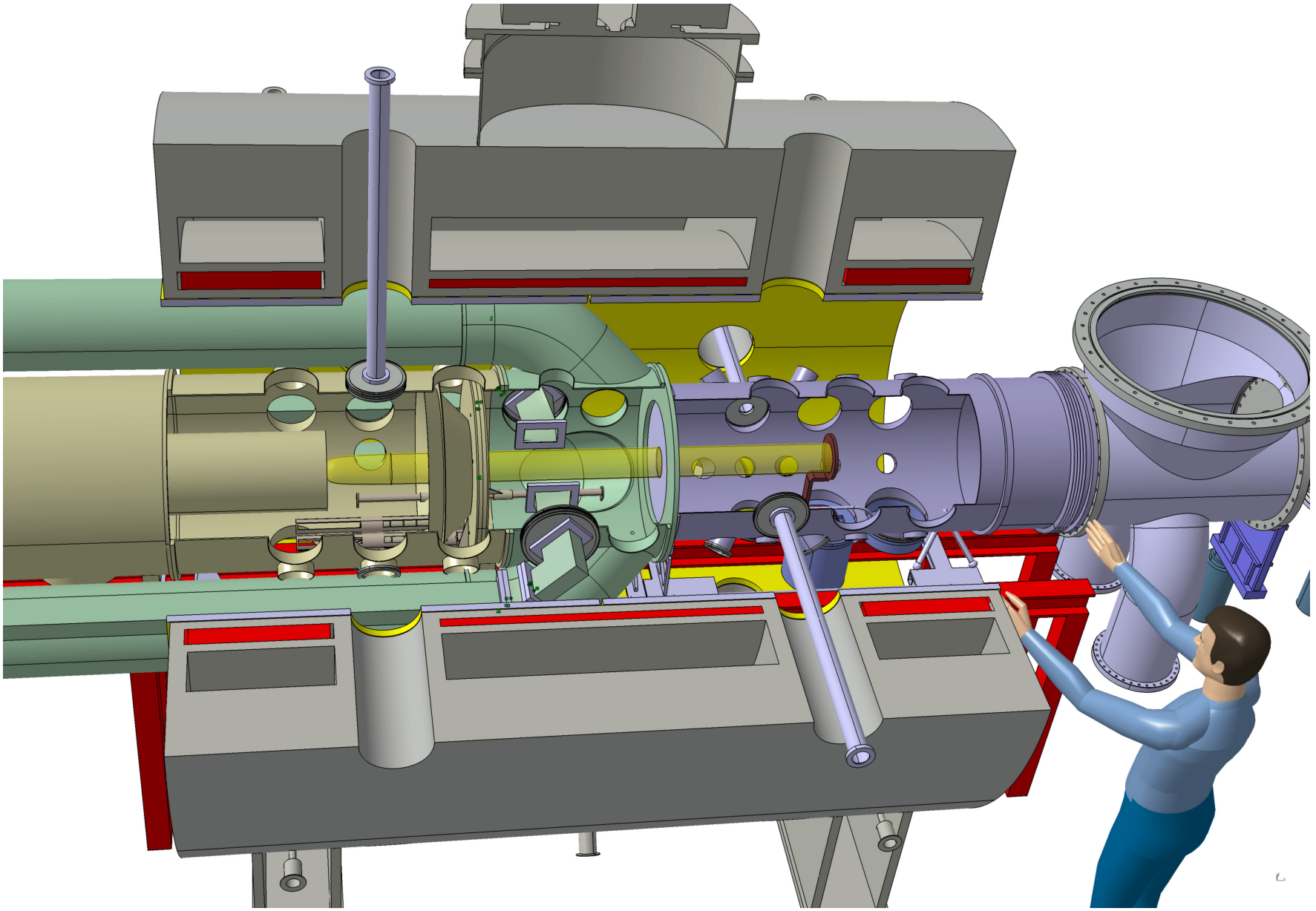
Magnum-PSI: an ITER divertor simulator – ideal for testing divertor diagnostics

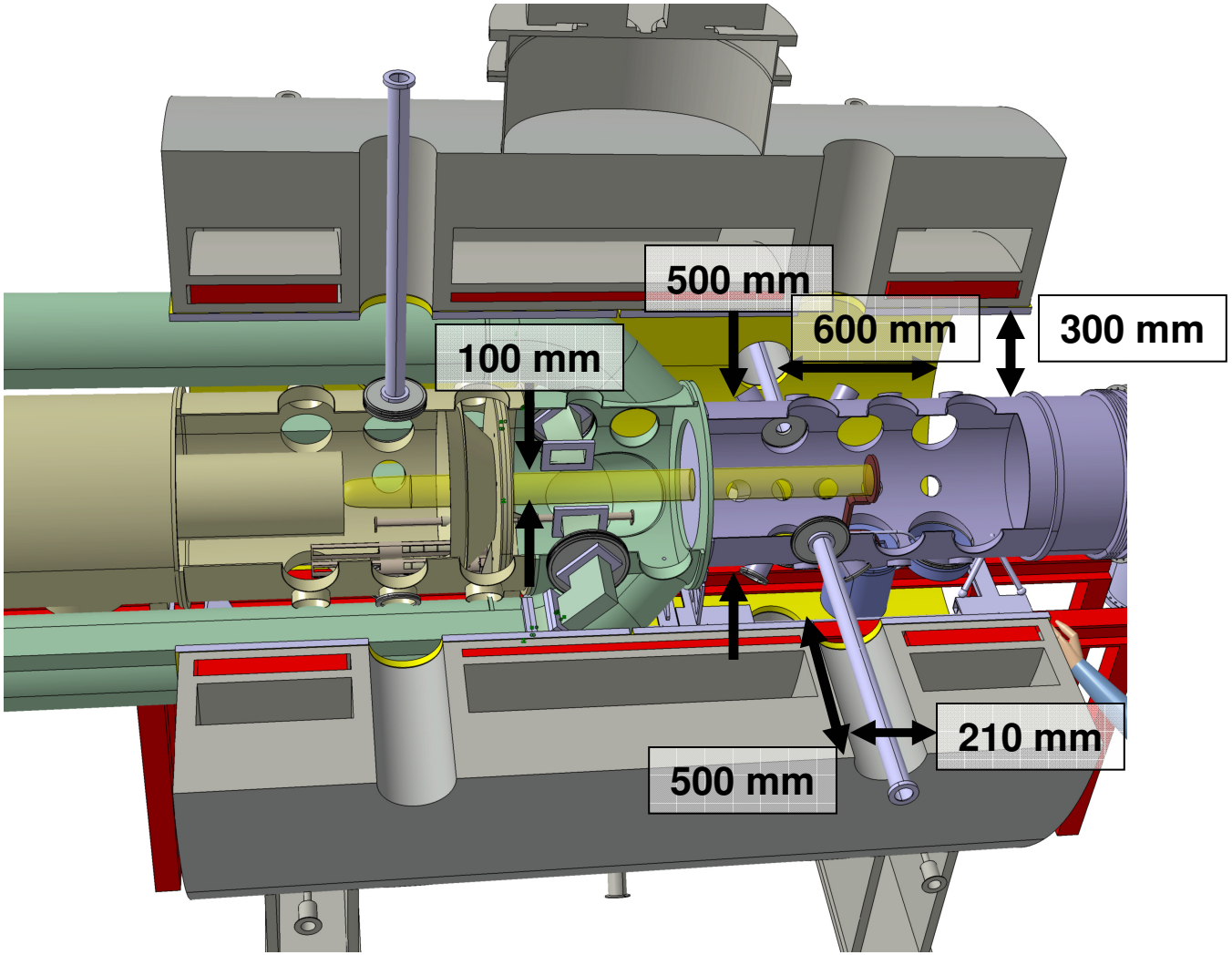
Pulse duration	**Steady-state operation**
Magnetic field	**3 T, variable**
diameter beam	**10 cm, variable**
Pressure at target	**3 Pa**
Plasma heating	**> 3 eV (Ohmic + Helicon wave)**
Particle flux density	**10^{24} hydrogen ions $m^{-2}s^{-1}$**
Energy flux density	**10 MW/m^2**
Target manipulator	**angle: variable**
	40 kW cooling capability
Surface analysis	**In situ**
In operation	**~ mid 2009**

Design Magnum-PSI

3T, steady state
10 cm diameter beam






500 mm
600 mm
300 mm
100 mm
210 mm
500 mm

Summary

- Powerful sources are nowadays available to realize an ITER divertor reflectometer with frequencies up to 1 THz
- A consortium of 6 institutes is prepared to pick this up
- MAGNUM-PSI is an ITER relevant divertor simulator that is in particular suited to test a range of ITER divertor diagnostics:
  - Reflectometry, interferometry, erosion monitor, Thomson scattering, etc.