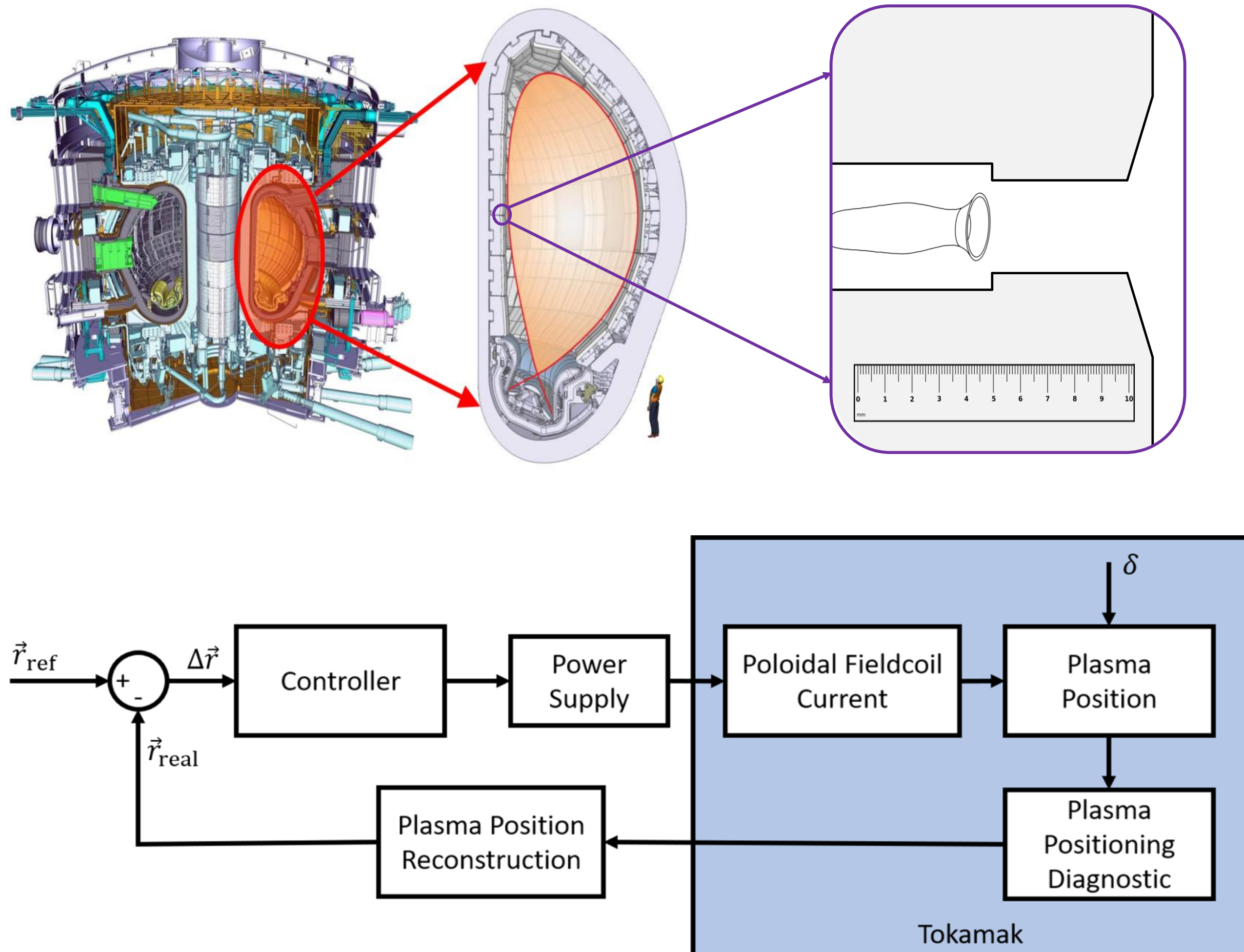


Antenna Optimization for Plasma Positioning Reflectometry in Blanket-Equipped Tokamaks

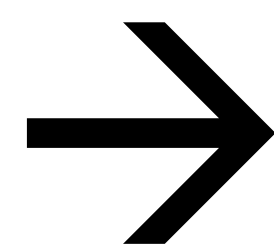
Johannes Lips, Stéphane Heuraux, Carsten Lechte, Burkhard Plaum

Plasma Positioning Control



Magnetic diagnostics

- ! Radiation Induced Conductivity !
- ! Radiation Induced EMF !
- ! Integrator drift !



Reflectometry

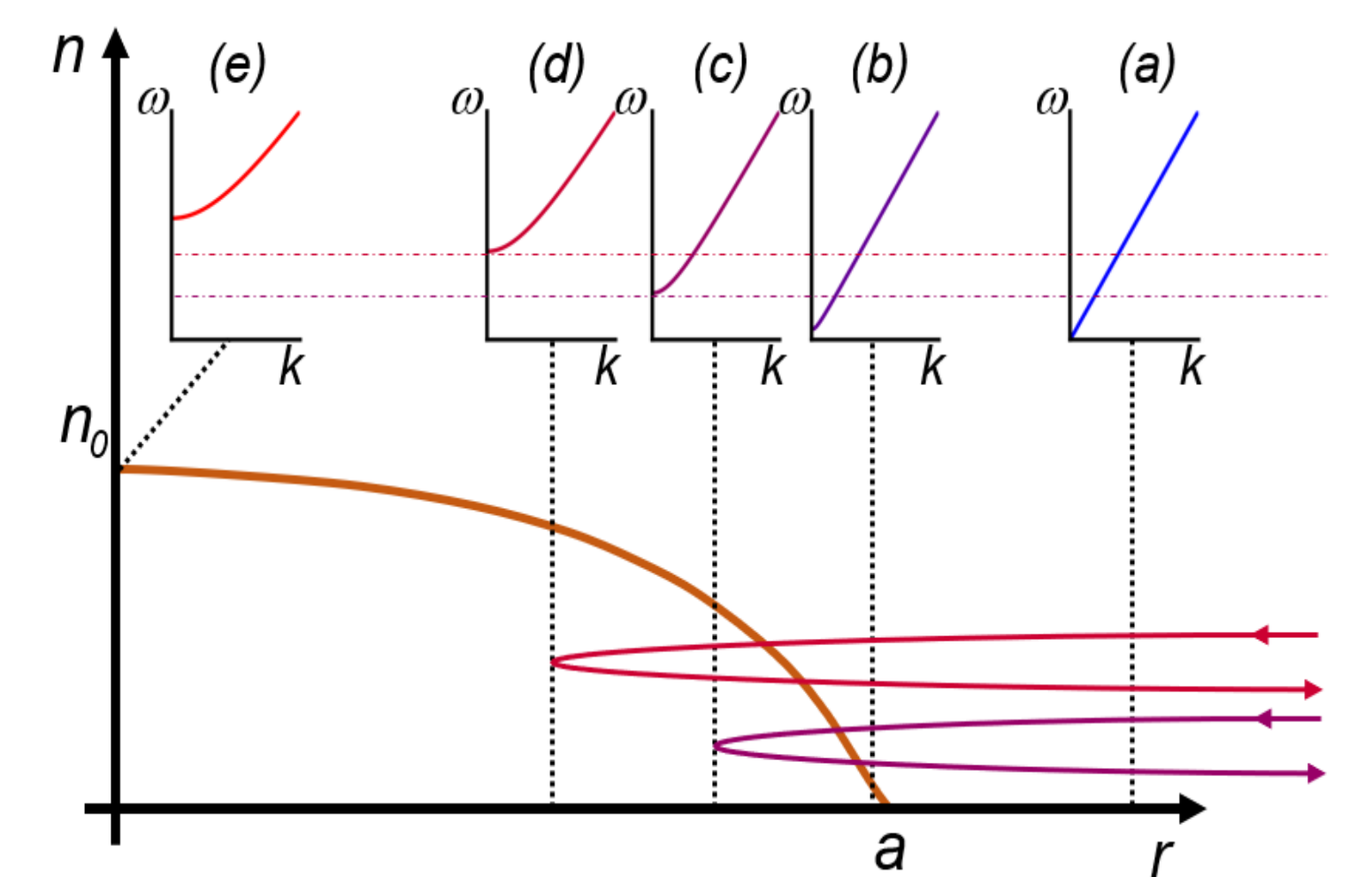
Plasma Positioning Reflectometry

- Radar-principle
- O-mode dispersion relation
- Plasma frequency

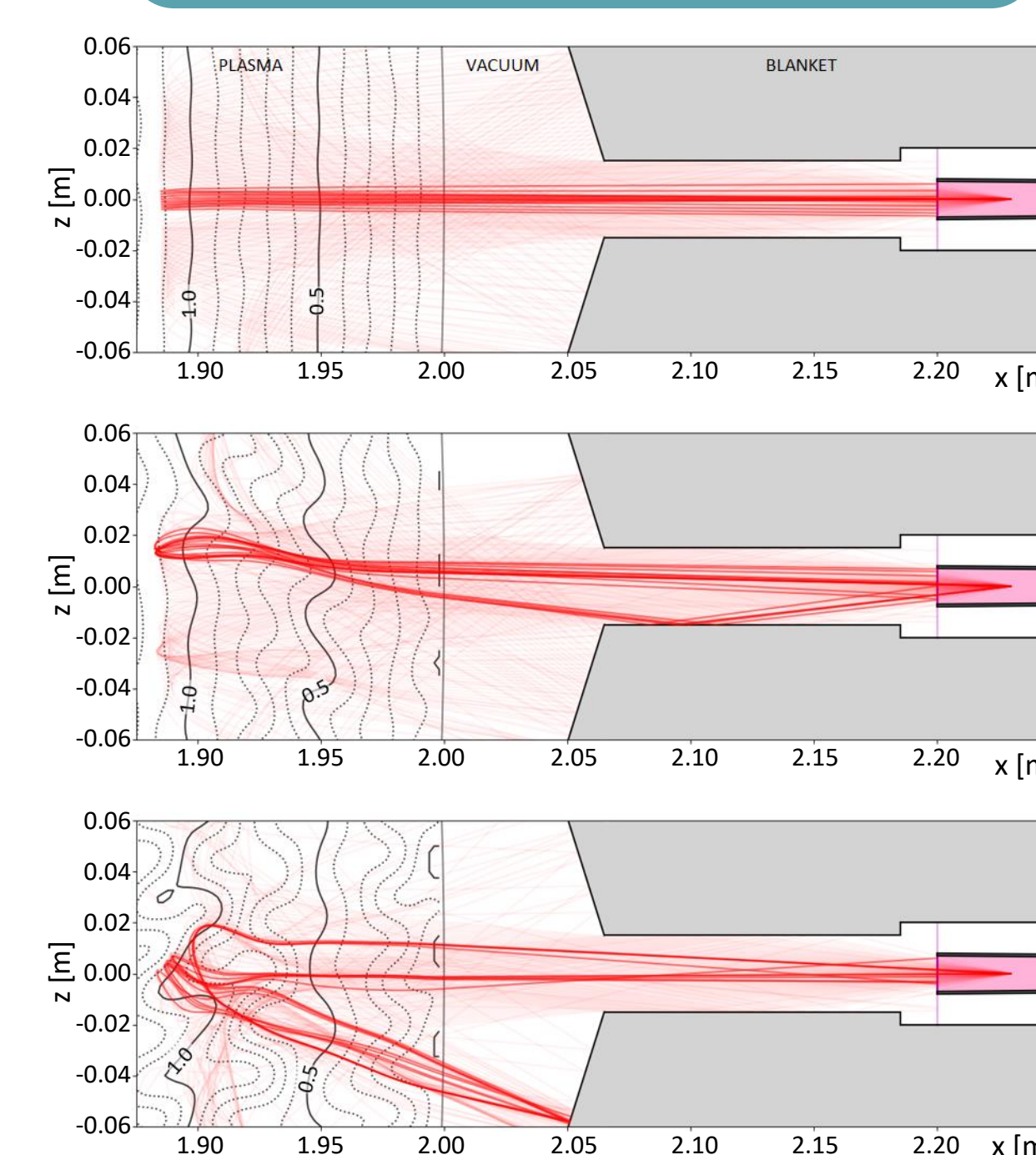
$$\omega^2 = k^2 c^2 + \omega_{pe}^2$$

$$\omega_{pe} = \sqrt{\frac{e^2 n}{\epsilon_0 m_e}}$$

- $\omega_{pe} = \omega \rightarrow$ cut-off density n_c
- 30 – 60 GHz sweep:
 $r = 0.74 a$ to $r = 0.94 a$

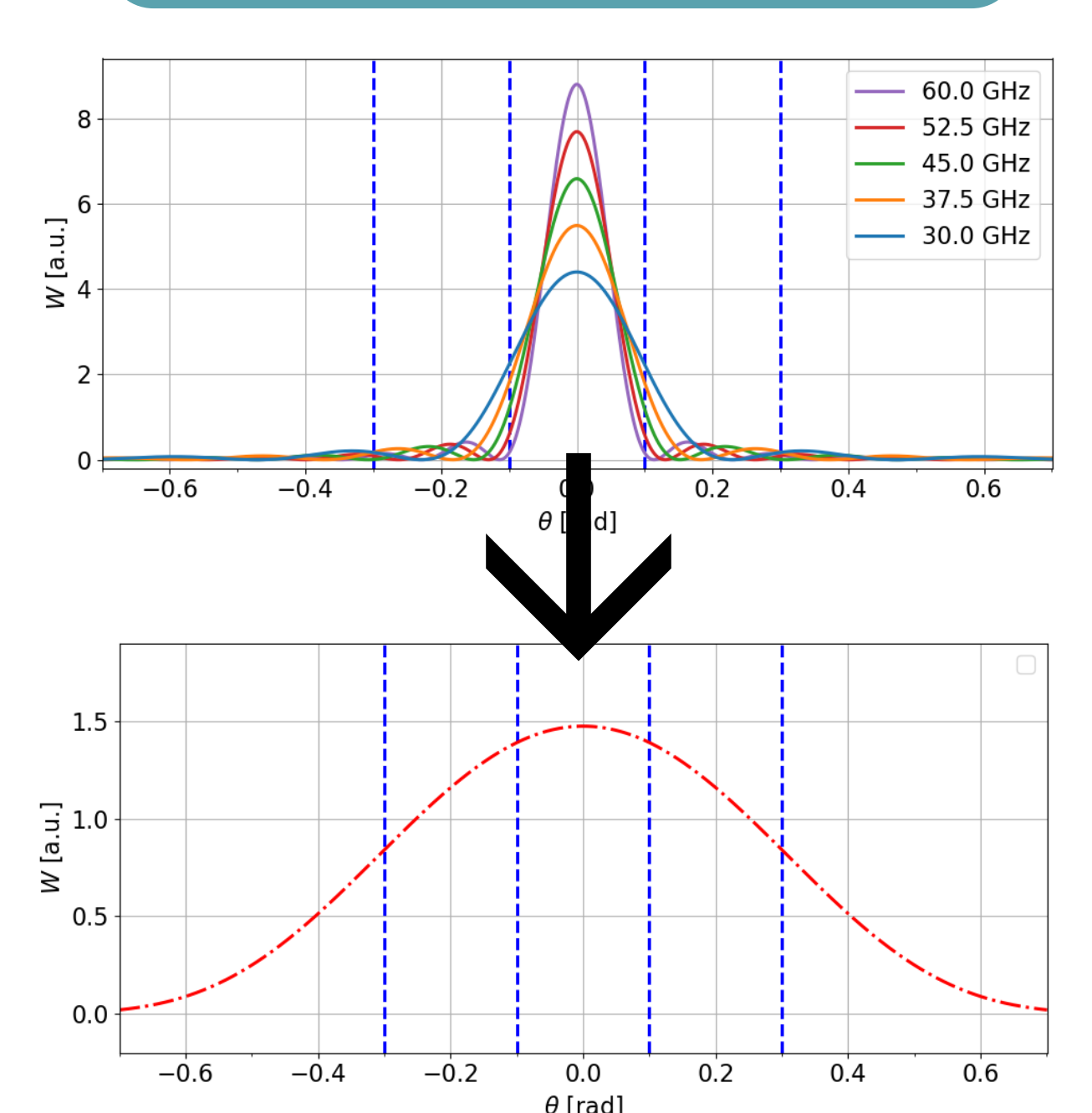


Multireflections



$\rightarrow$ Neural network reconstruction

f -dependency



$\rightarrow f$ -independent radiation diagram

Antenna Design

R2P2: Ray Tracing Reflectometry for Plasma Positioning

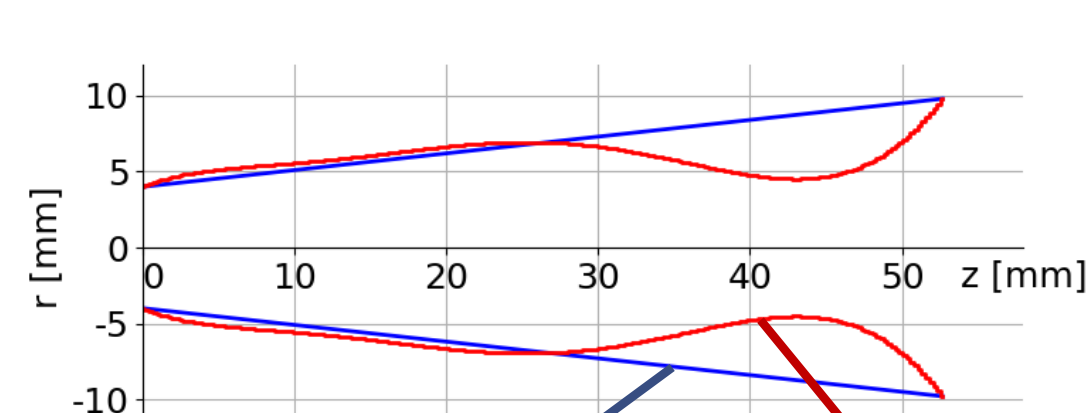
- 11 antenna diagrams: vary size, frequency-dependency, mode content
- Simulations at 30 to 60 GHz and 0% to 10% turbulence
- 400 simulations per (antenna, frequency, turbulence level)
- $\rightarrow$ Ensemble allowing for statistical interpretation of results
- $\rightarrow$ Frequency-independent antennas have good PPR performance
- $\rightarrow$ Fundamental Gaussians have best performance
- $\rightarrow$ Larger aperture improves performance

Optimal Antenna Design

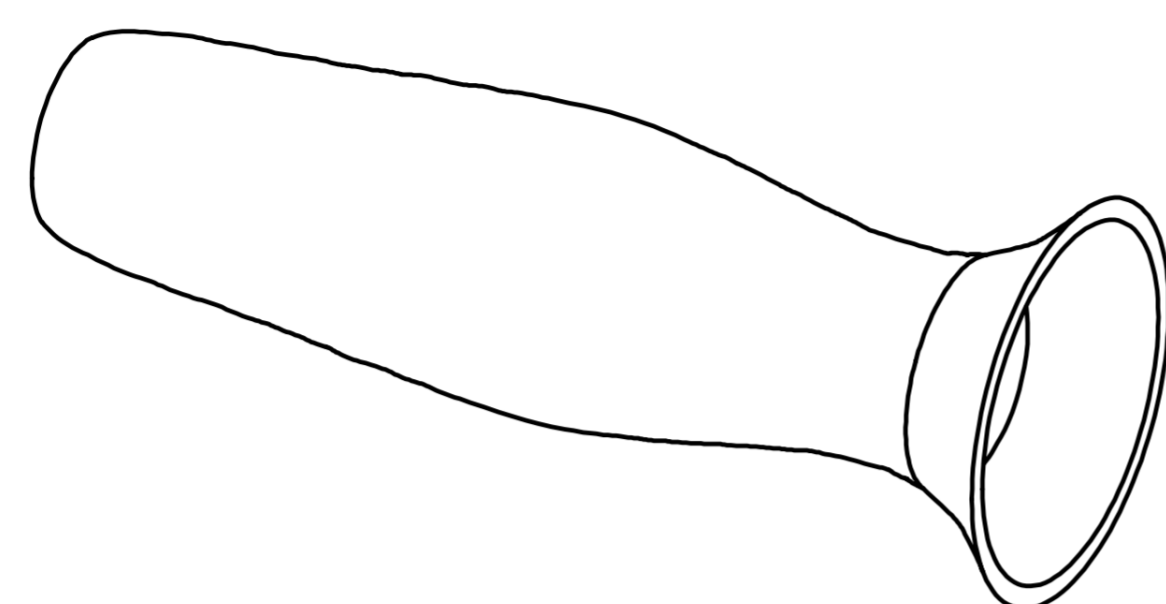
- Fundamental Gaussian
- Frequency independent
- ITER spatial constraints: 30 mm – tolerances
 $\rightarrow D = 14$ mm

PROFUSION Optimization

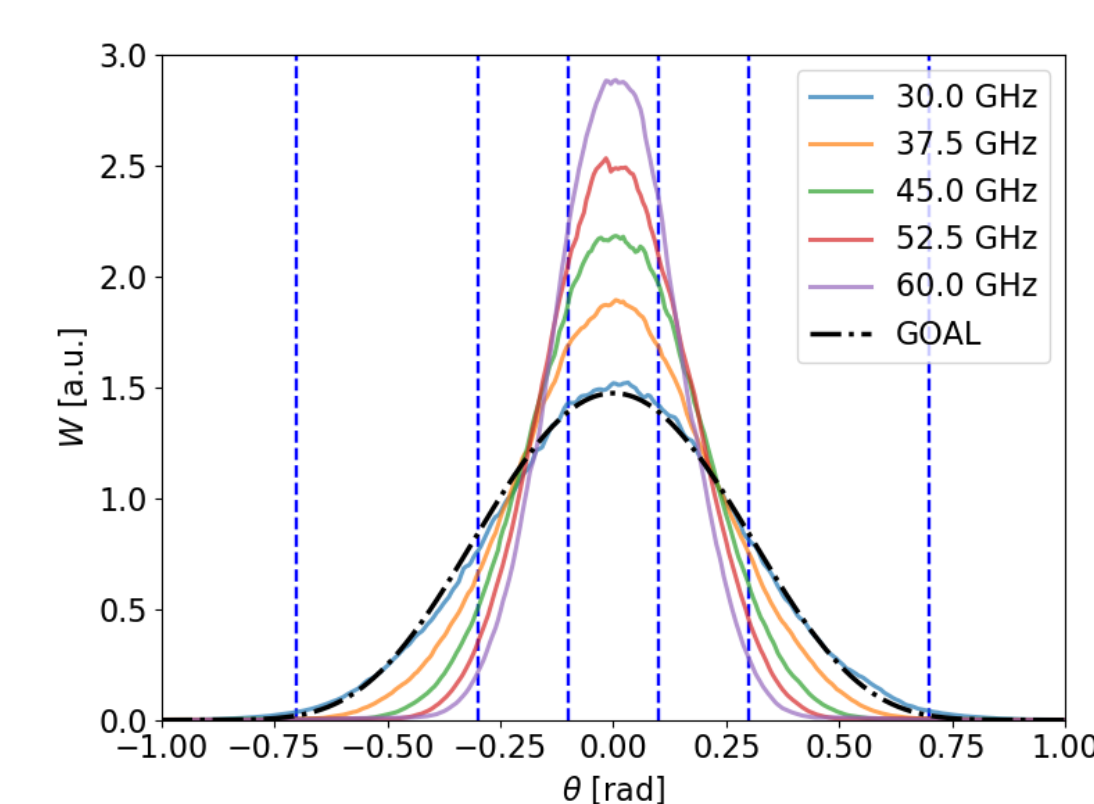
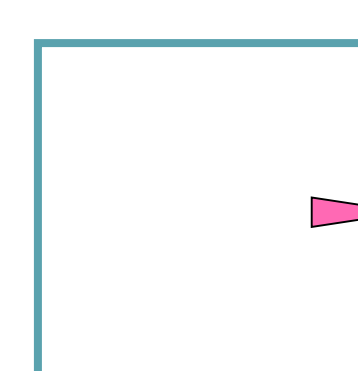
- Simulated annealing + downhill simplex method search global minimum + search local minimum
- No guarantee to find good optimum
- $D = 14$ mm $\rightarrow D = 20$ mm
- 98.33 % overlap with optimization goal
- 1% TE₂₁ at antenna input: up to 1.5° offset in radiation diagram



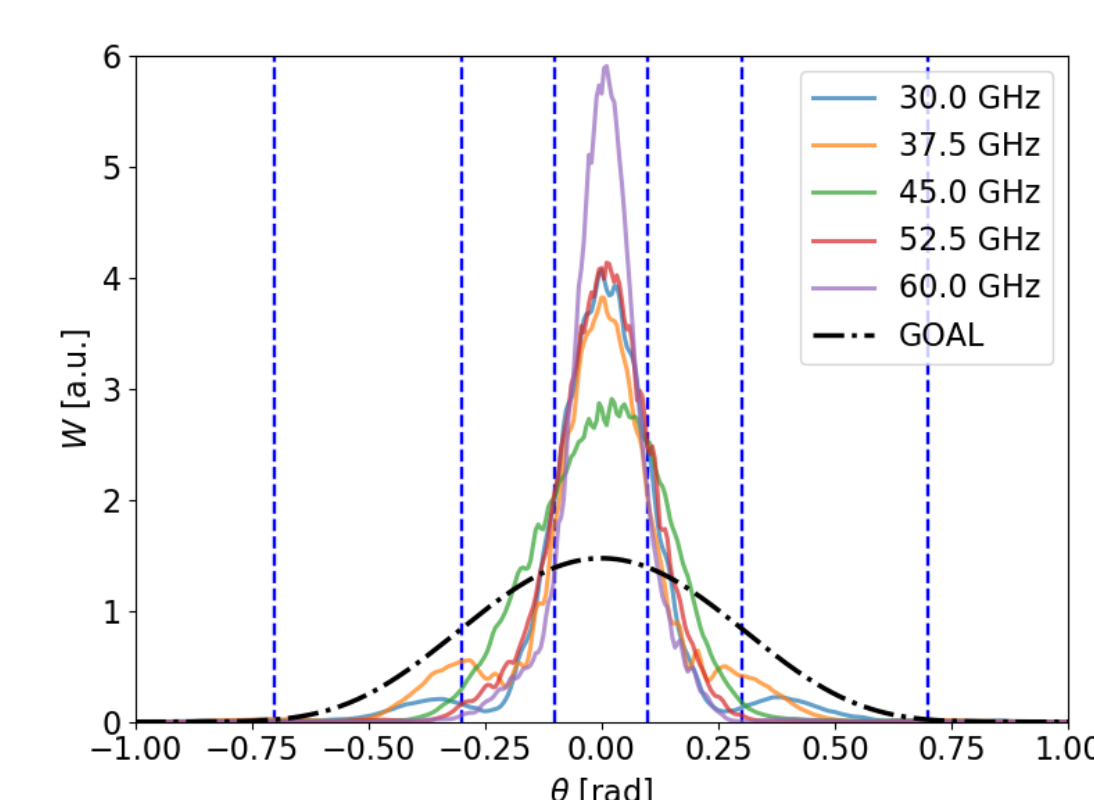
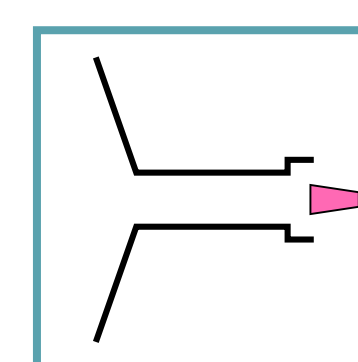
Conical reference antenna Optimized antenna



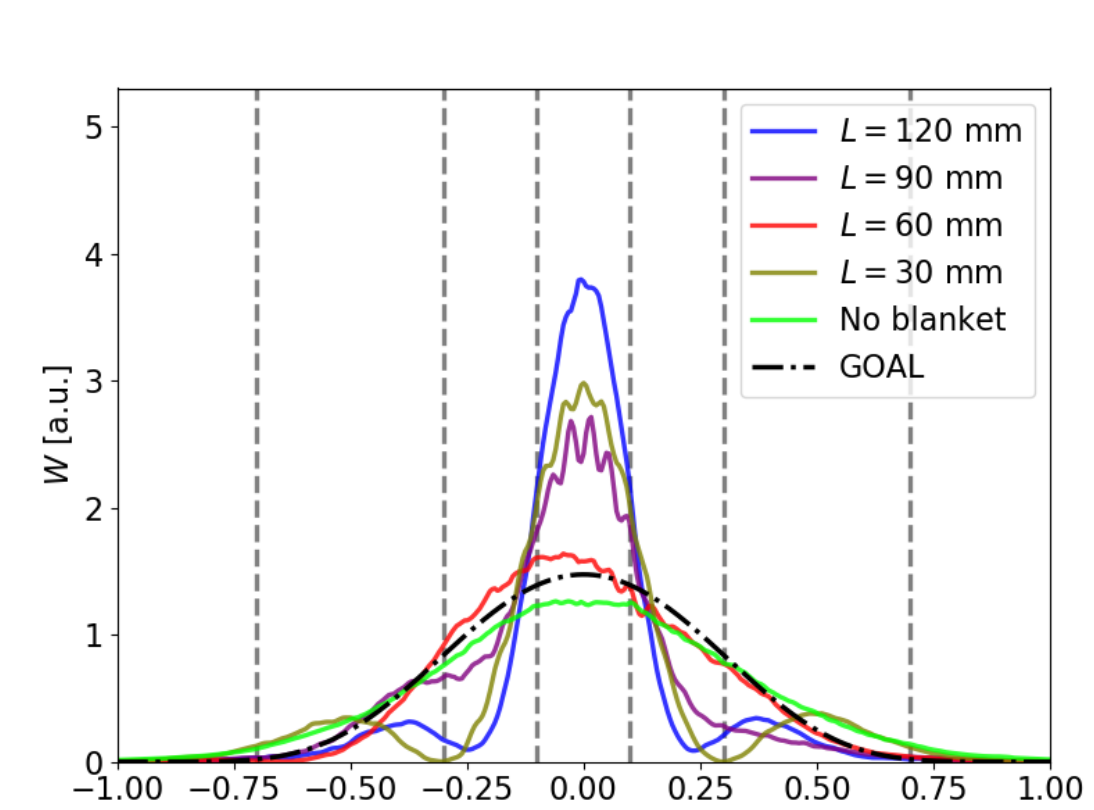
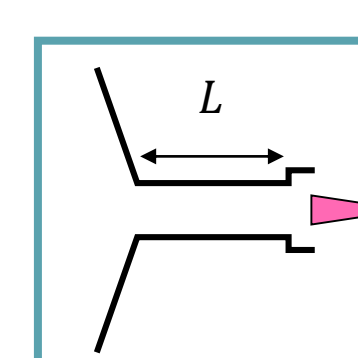
Experimental Results



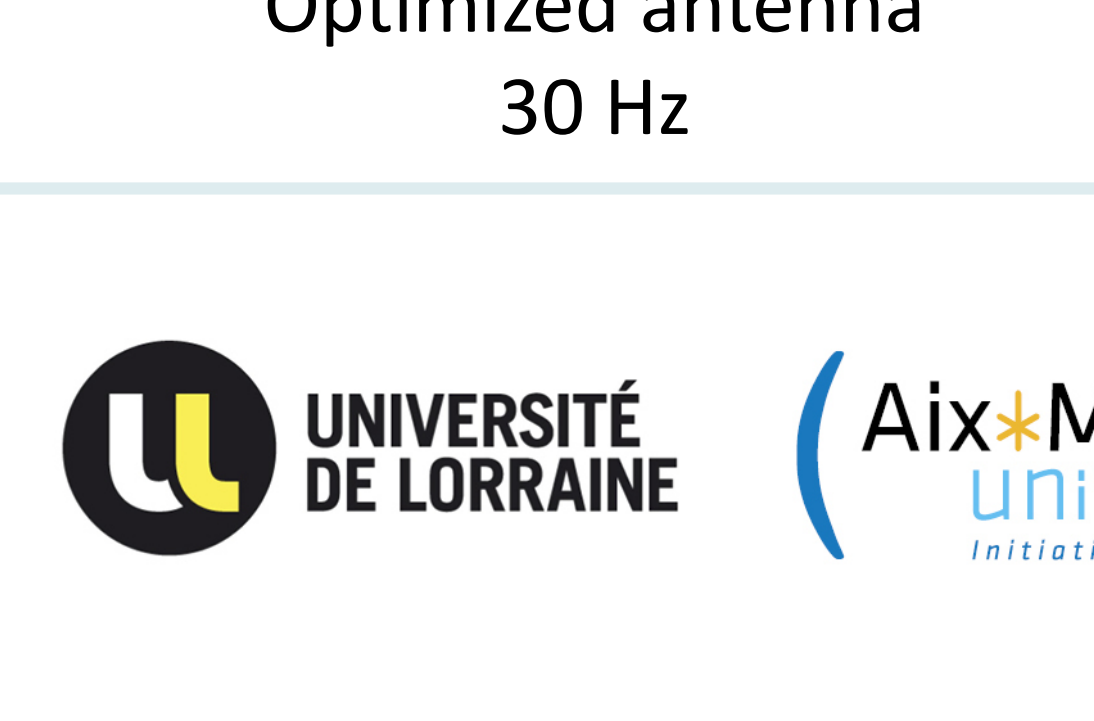
Reference antenna



Optimized antenna



Reference antenna with blankets



Optimized antenna with blankets

Optimized antenna 30 Hz

Optimized antenna 52.50 Hz