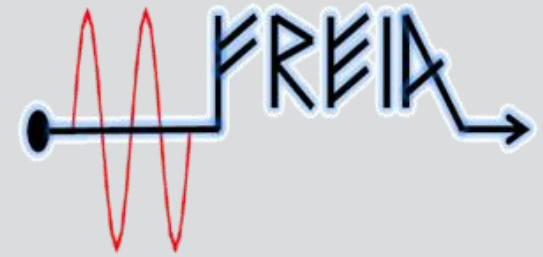




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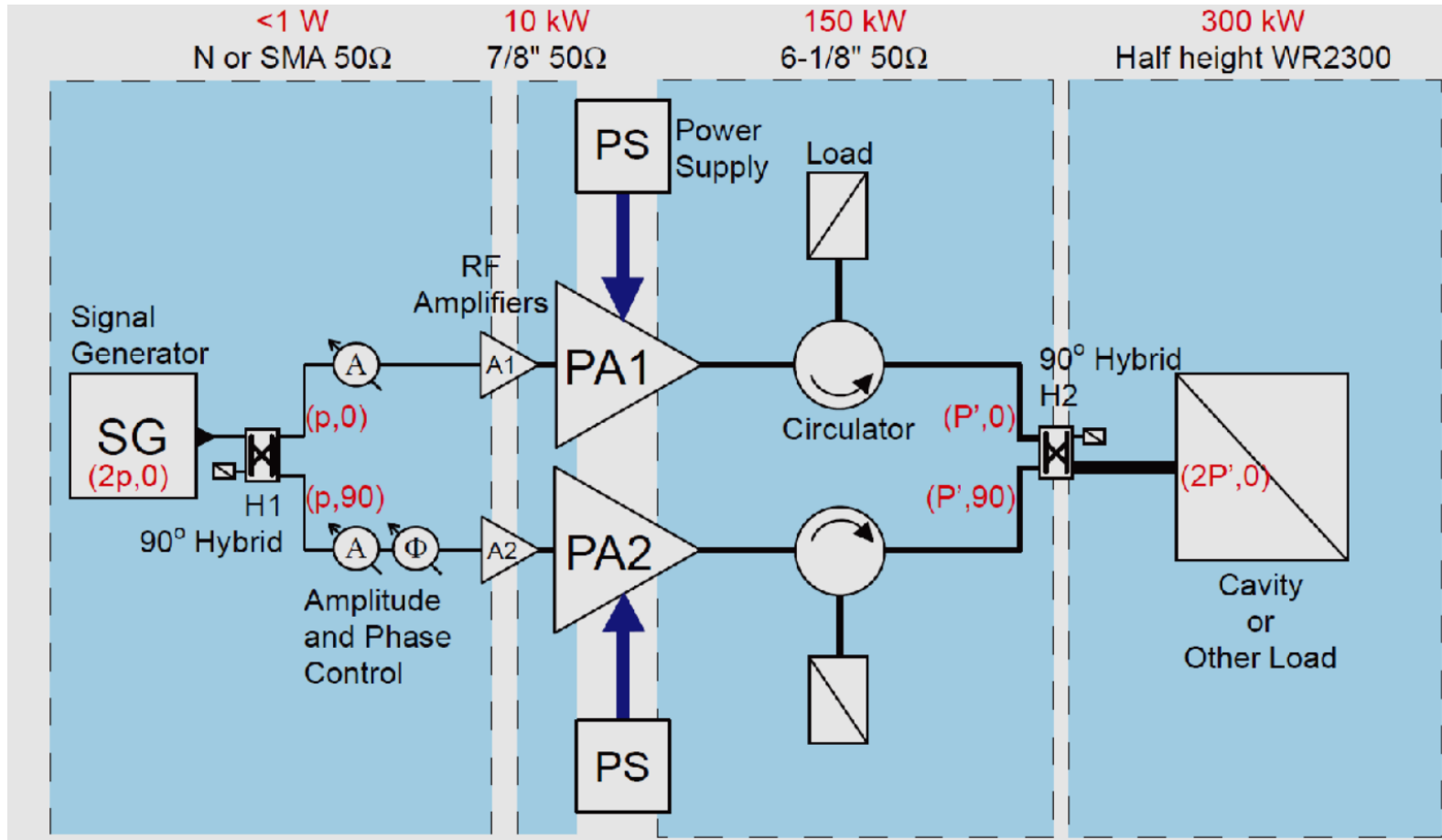
RF Distribution

R.A. Yogi

ESS RF Group Unit Leader for Spoke Power and RF Distribution

FREIA Group Unit Leader

Schematic of high power RF distribution system



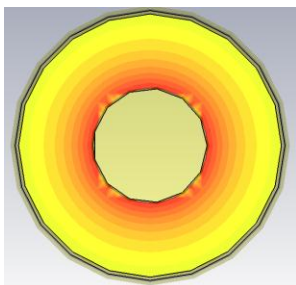
Frequency = 352.21 MHz

Waveguide comparison

Frequency = 352 MHz, Power = 300 kW

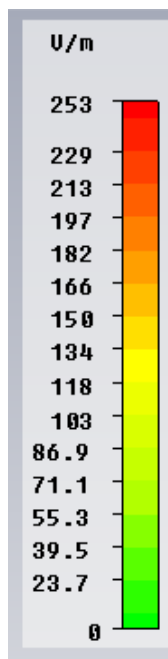
Waveguides (WR2300 hf ht) or coaxial lines (6-1/8 inch, 50 Ω)?

For coaxial line $E \propto 1/r^2$

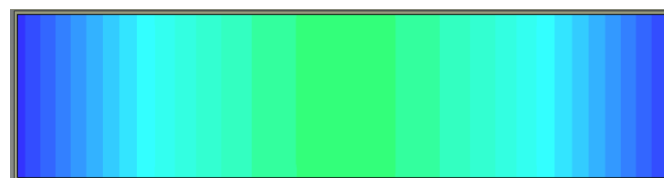


$P_{max} = 6 \text{ MW}$

- Assembly difficult
- High loss 0.01 dB/m
- Use of Teflon / ceramic
- Cooling difficult
- i/c material: Copper
- o/c material: Aluminum
- Circulator doesn't exist.

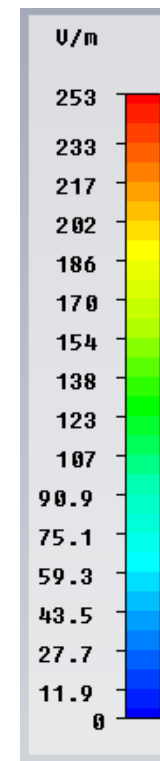


For WR2300 half height



$P_{max} = 60 \text{ MW}$

- Assembly easy
- Low loss 0.002 dB/m
- No ceramic
- Cooling easy
- Material: Cu or Al ?



Hence WR2300 half height selected !



Main emphasis: Low loss in RF Distribution System

For Cu waveguide: loss = 0.002 dB/m,

For Al waveguide: loss = 0.003 dB/m

Density of Cu = 3 density of Al : More weight
Copper is costlier : More cost

Material : Aluminum 6061 – T6 !

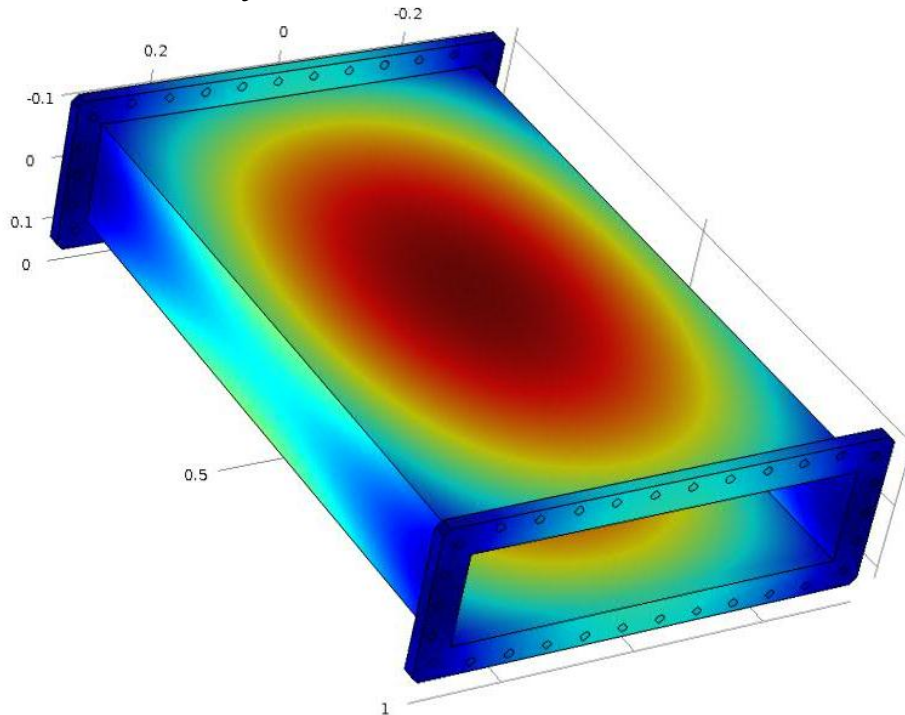
Aluminum easily gets oxidized

- Protective Aluminum oxide film (about 2.5 nm thick)
- Corrosion resistance of aluminum depends upon this protective oxide film
- Protective film is stable in aqueous media when the pH is between about 4.0 and 8.5.
- Waveguides if operated and stored indoors, less prone to corrosion and don't need any additional coating.

Waveguide Temperature

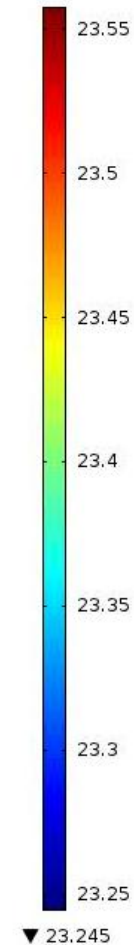


Frequency = 352 MHz, Power level = 300 kW
Insertion loss = 5%, Average Power = 18 kW
Power loss density = 24 W / m²



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▲ 23.557



Increase in temperature = 3° C
Considering safety margin of 50 % \approx 4.5 ° C
No water cooling is needed !



Transmission lines 150 kW and 10 kW



Frequency = 352 MHz, Power = 150 kW

- Coaxial lines (6-1/8 inch, 50 Ω)
- Size of circulator: 0.6m x 0.6m x 0.5m

Frequency = 352 MHz, Power = 10kW

- Coaxial lines (7/8 inch, 50 Ω)
- Pmax = 100 kW

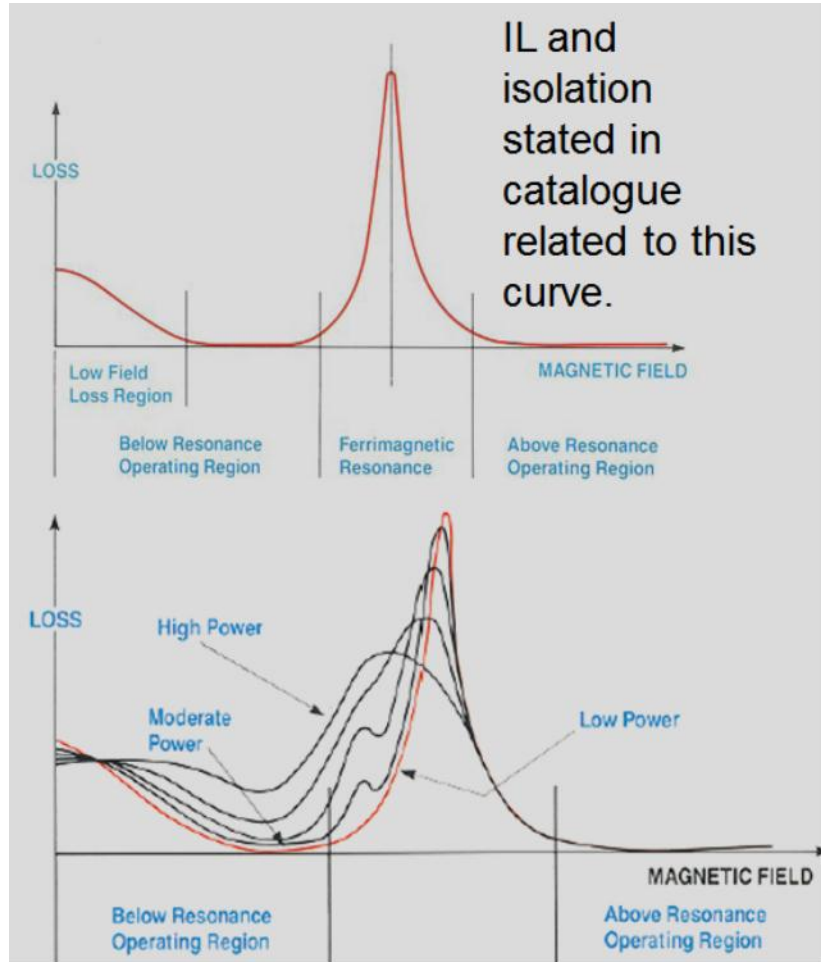
Type of transmission line



Peak Power level	Type of transmission line	Maximum peak power (kW)
1 W	sma	
10 kW	Coaxial 7/8 inch, 50 Ω	100
150 kW	Coaxial 6-1/8 inch, 50 Ω	600
300 kW	Half height WR 2300	40000

Frequency = 352.21 MHz

Circulators



Specifications:

$S_{11} > 30$ dB,

$S_{21} < 0.1$ dB,

Isolation > 23 dB



General specifications for waveguide components:

$$S_{11} > 30 \text{ dB}$$

$$S_{21} < 0.05 \text{ dB}$$

Dual Directional Coupler:

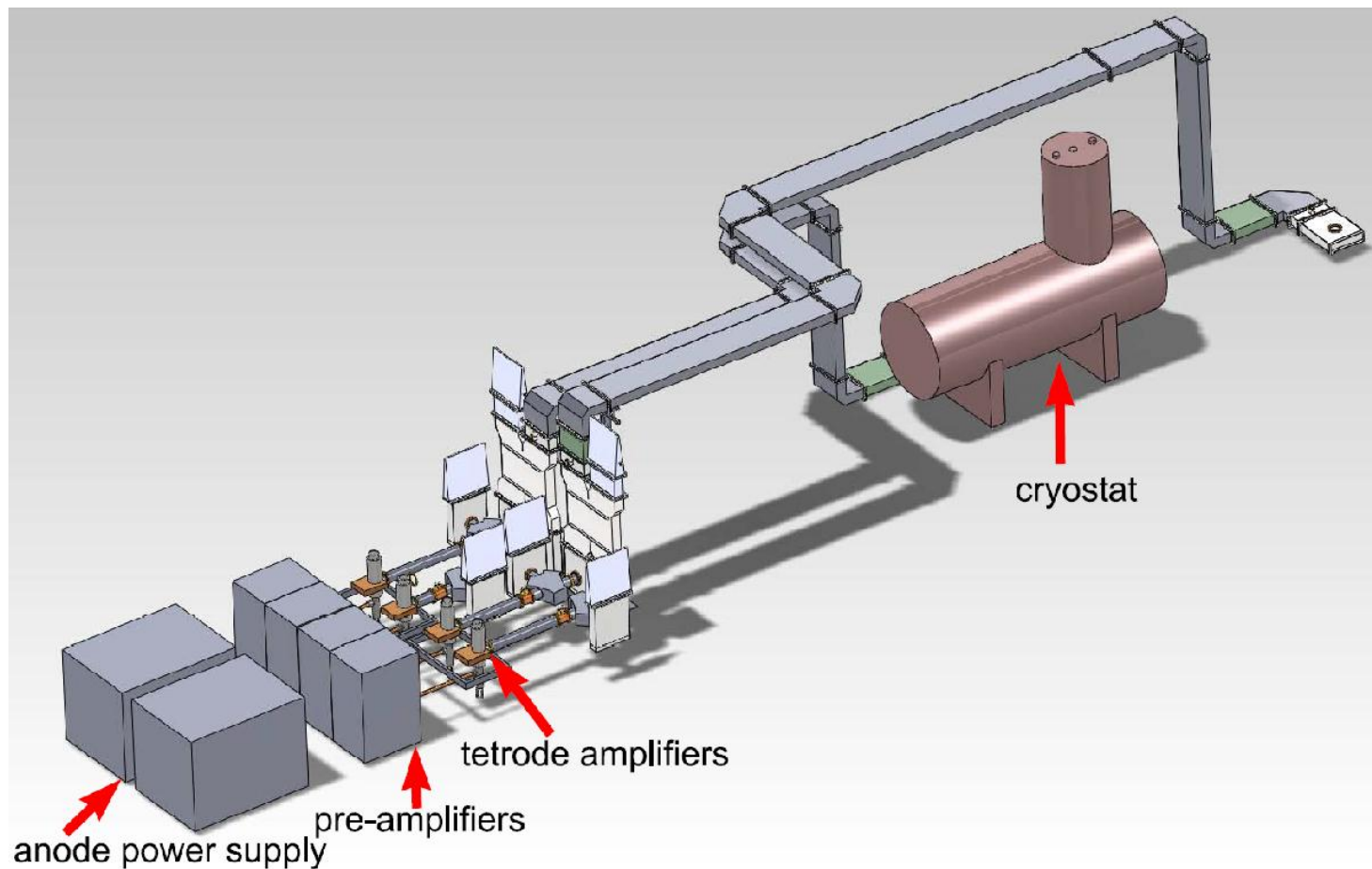
$$S_{11} > 30 \text{ dB}$$

$$S_{21} < 0.05 \text{ dB}$$

Coupling : 50 – 70 dB

Directivity: 27 dB

RF distribution layout



Layout of high power RF system with anode power supplies, pre-amplifiers, tetrode amplifiers and wave guides.



Thank You.