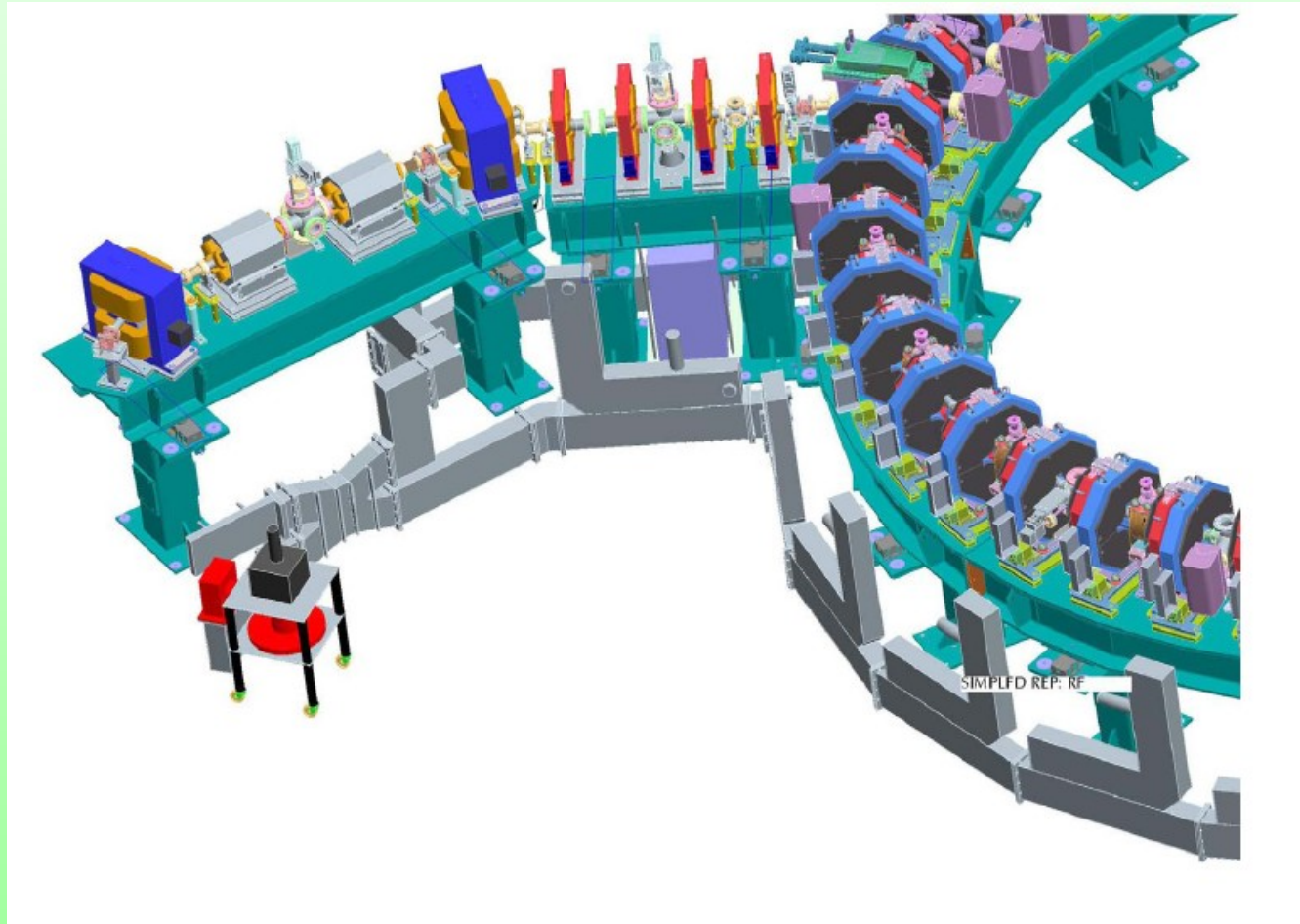


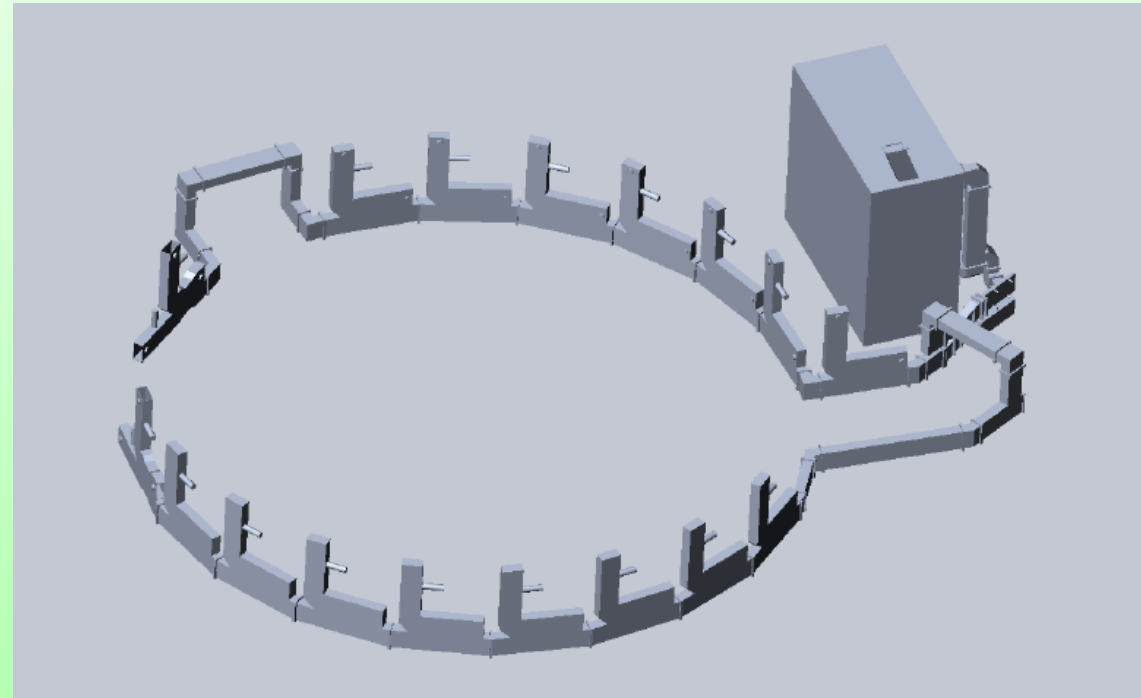
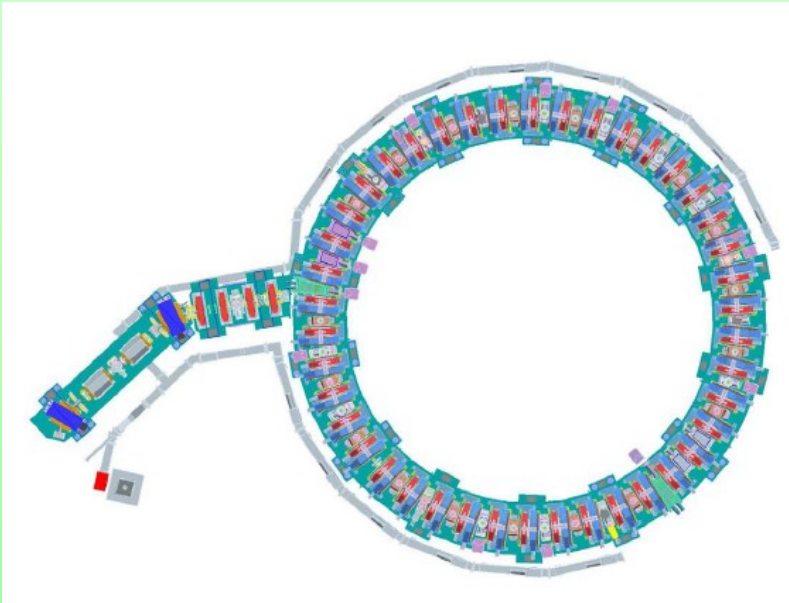
Scope of Work

- Layout and general concepts
- Complete module
- Directional couplers
- Hybrids
- Phase shifters
- Phase shift motors etc
- Output cables
- End launch transitions
- Terminations / Balance loads
- Waveguides
- Factory Test



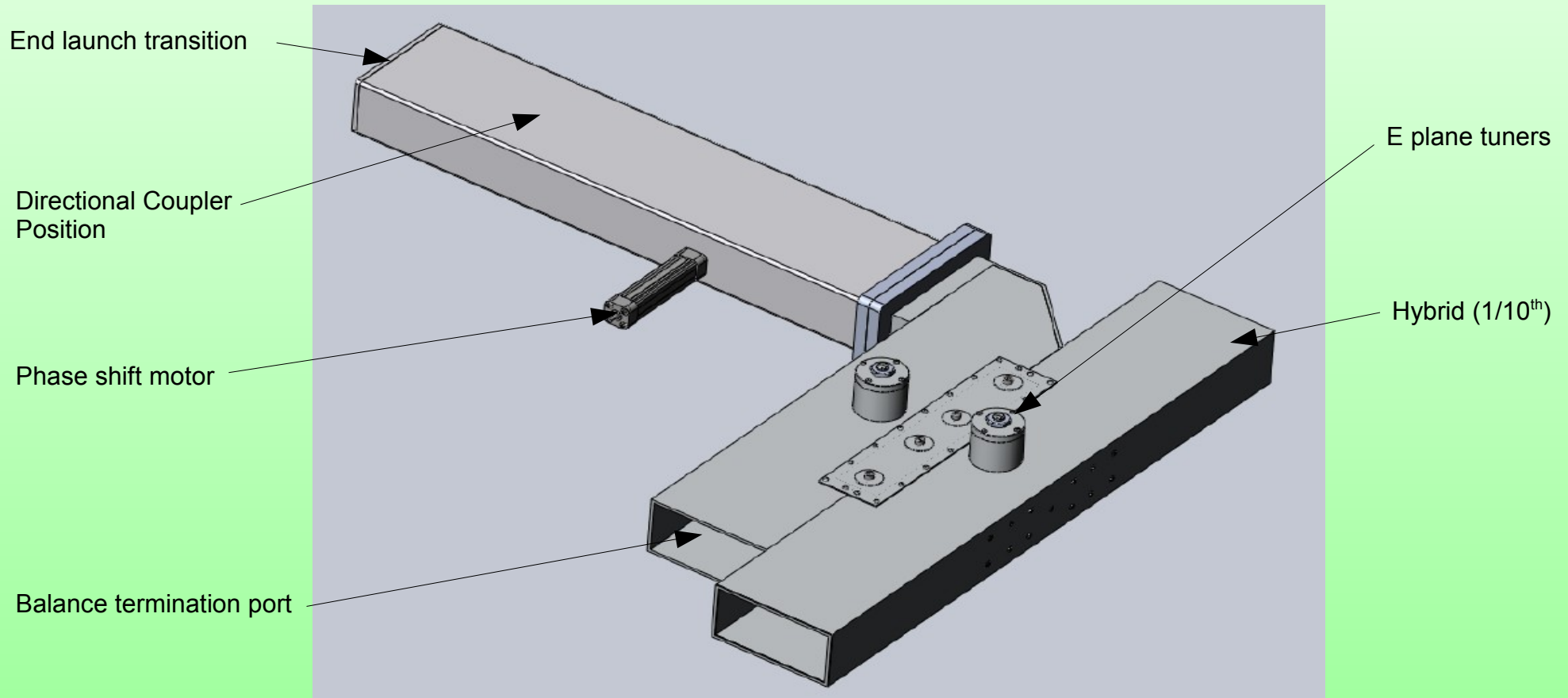
Layout

- Layout supplied courtesy of STFC
- We will feedback our models as the design progresses



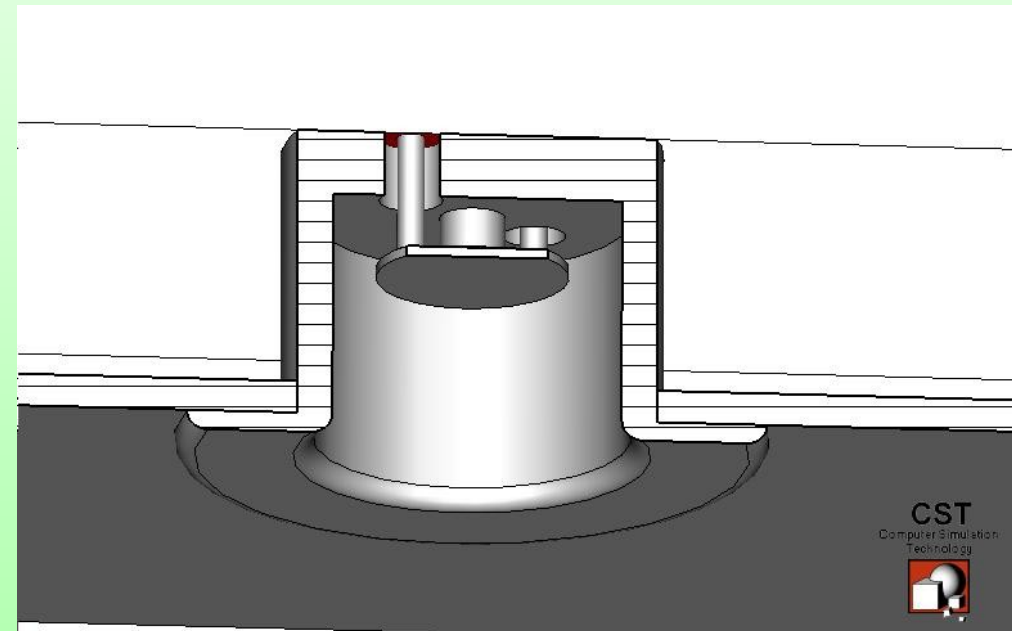
Complete Module

Contains hybrid, phase shifter, directional couplers and end launch transitions.

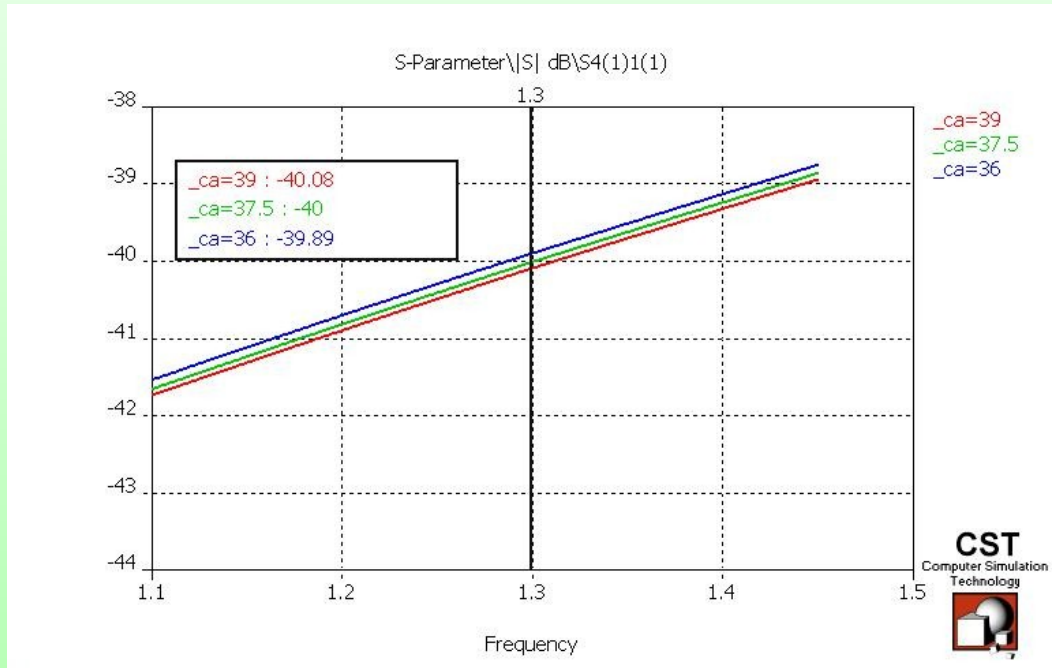


Directional Couplers – waveguide based – model

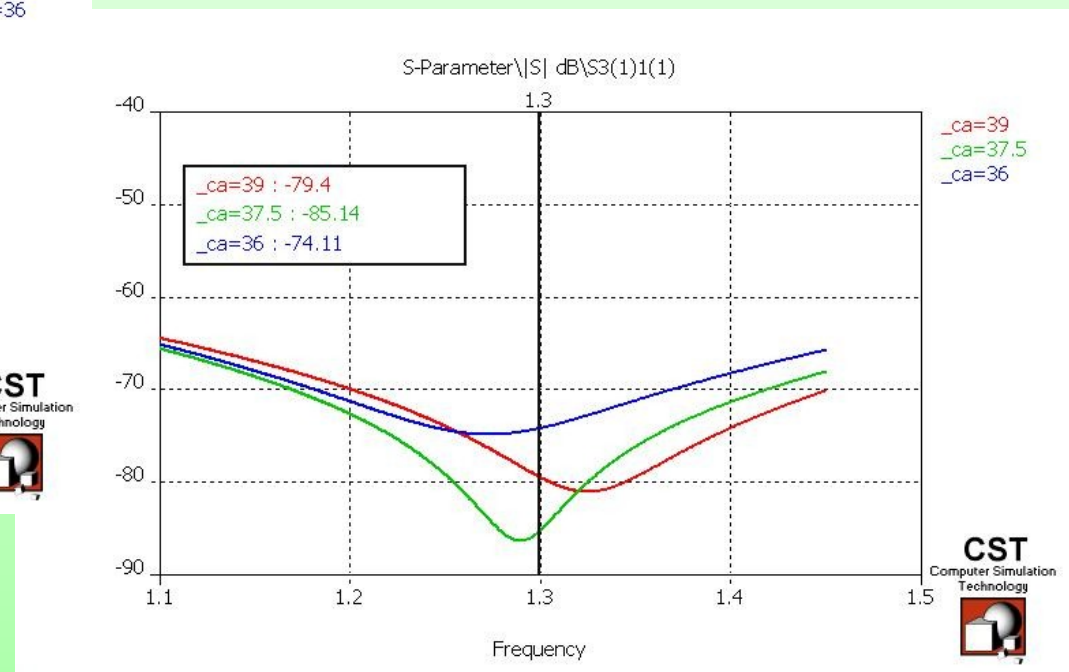
- Dual directional – built in termination.
- Based on coupled TEM line.
- Pair will be fitted in the waveguide after the phase shifter.
- Could not achieve 40 dB directivity with bought in component.



Directional Couplers – waveguide based – results



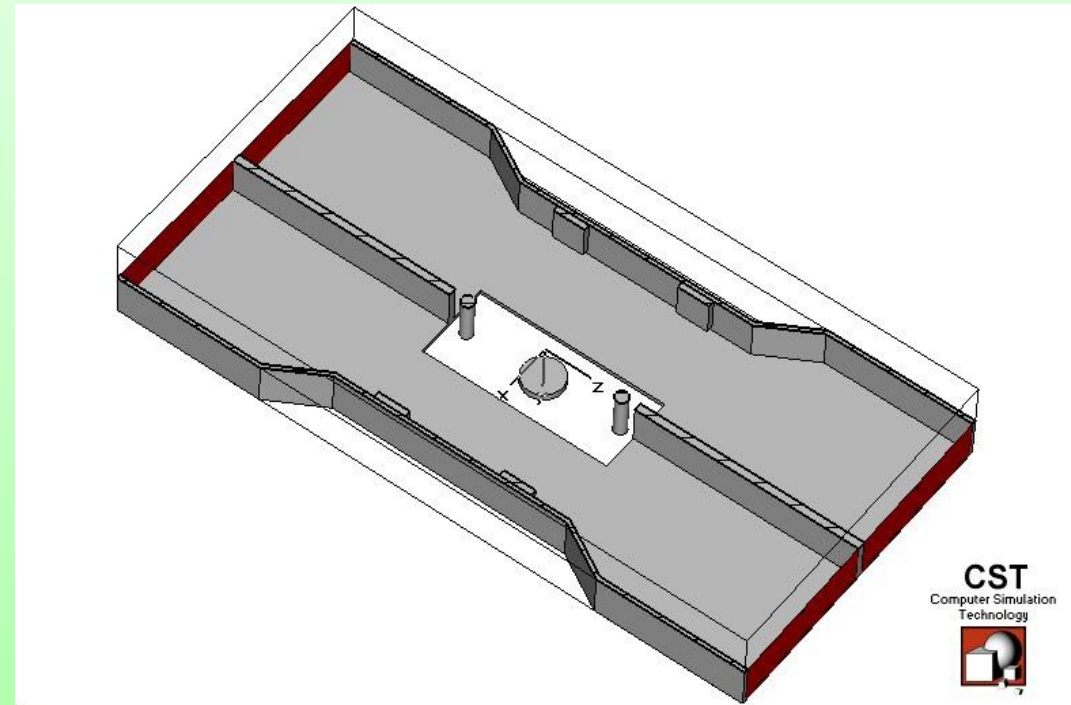
Coupling (40 dB desired)



Directivity (-40 dB to coupled i.e. -80 dB desired)

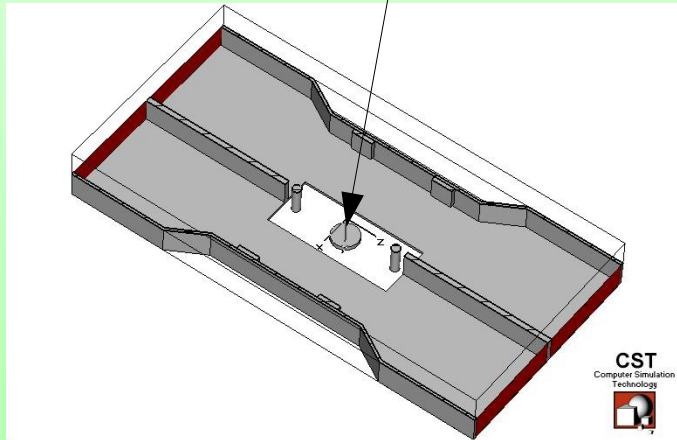
Hybrids

- Three types – H plane coupling method.
- Power coupling level varies from $1/10^{\text{th}}$ (first) to $1/2$ (last).
- Three controls of coupling, match and isolation.
- Coupling width and length tunable.
- Capacitive E plane tuner.



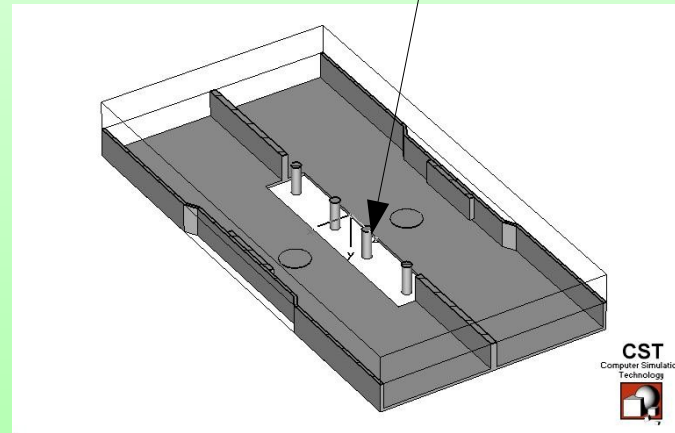
Hybrids – three types according to coupling

E plane tuner(s)



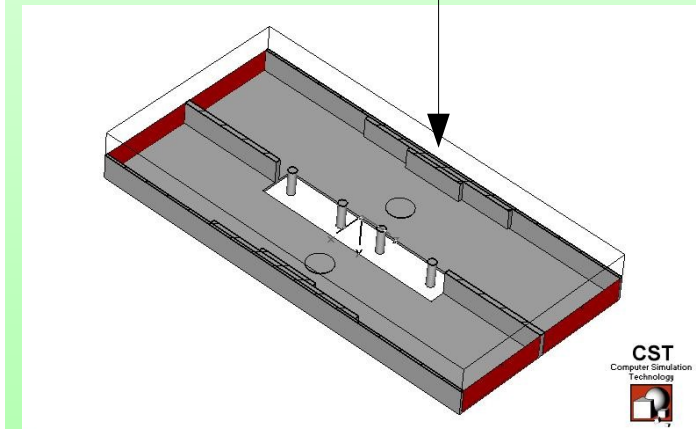
$\frac{1}{2}$ power coupling –
two shorting bars

Shorting bars control
coupling region length(s)



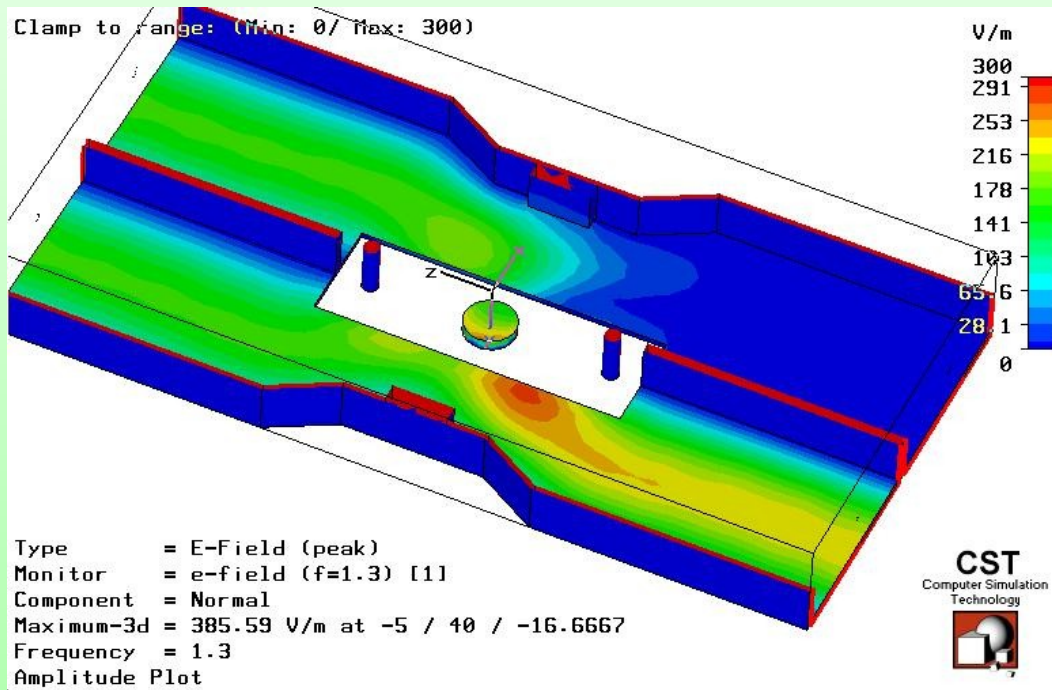
Intermediate coupling
($\frac{1}{5}$ th shown) four bars.

Side walls have
adjustable plates to
control coupling region
widths.

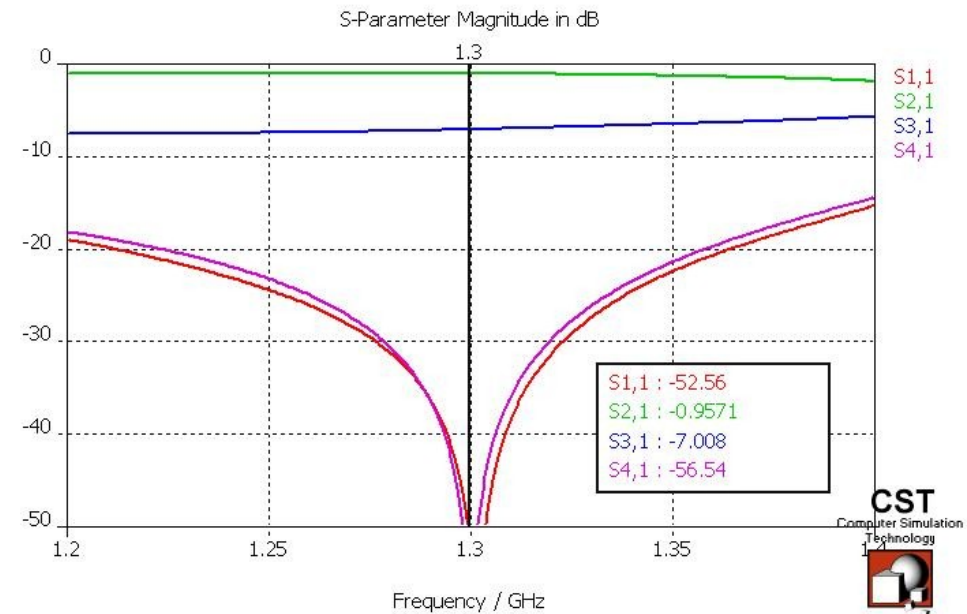


Low coupling ($\frac{1}{9}$, $\frac{1}{10}$ th).
No side cut outs.

Hybrids – typical results



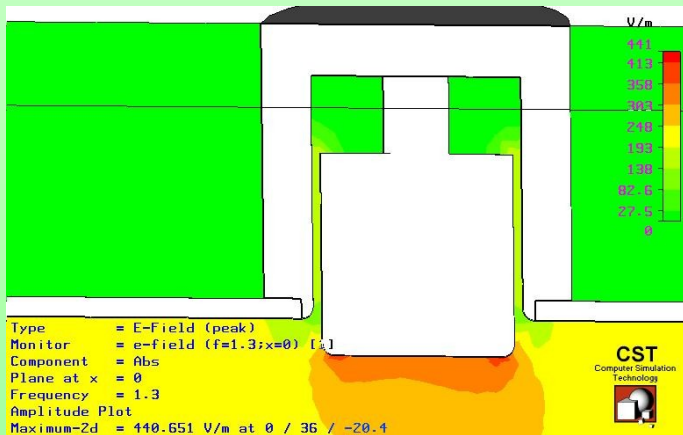
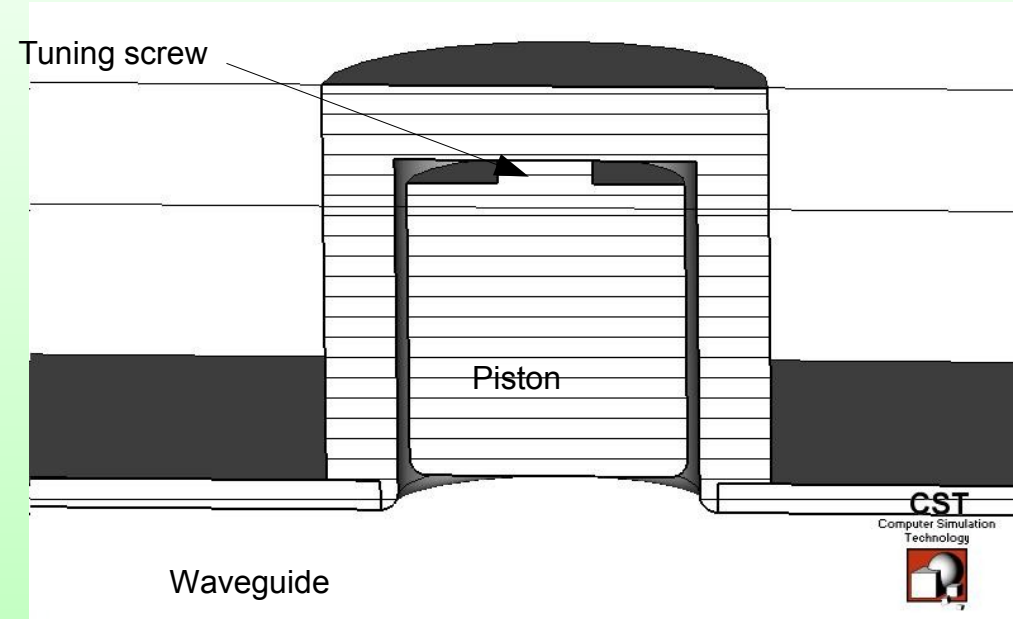
Electric field intensity



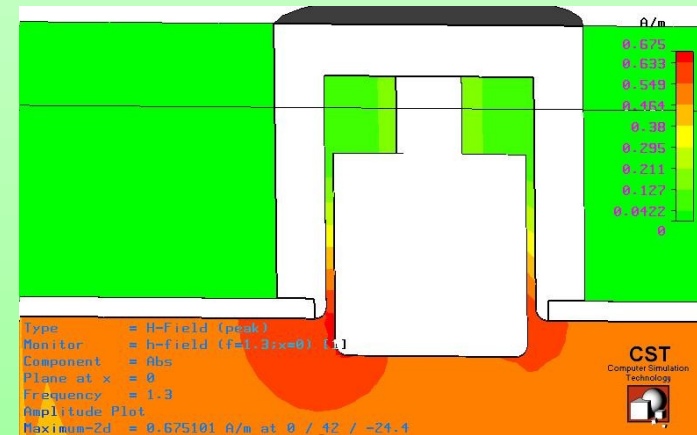
Coupling, return loss and isolation

Hybrid E plane tuner

- RF short circuited piston.
- Construction avoids threads in high field regions and sliding joints.
- Gives -1 to + 7 % reflection coefficient correction.
- Electric fields under control (139 V/mm for 100 kW)
- Low current in short circuit.



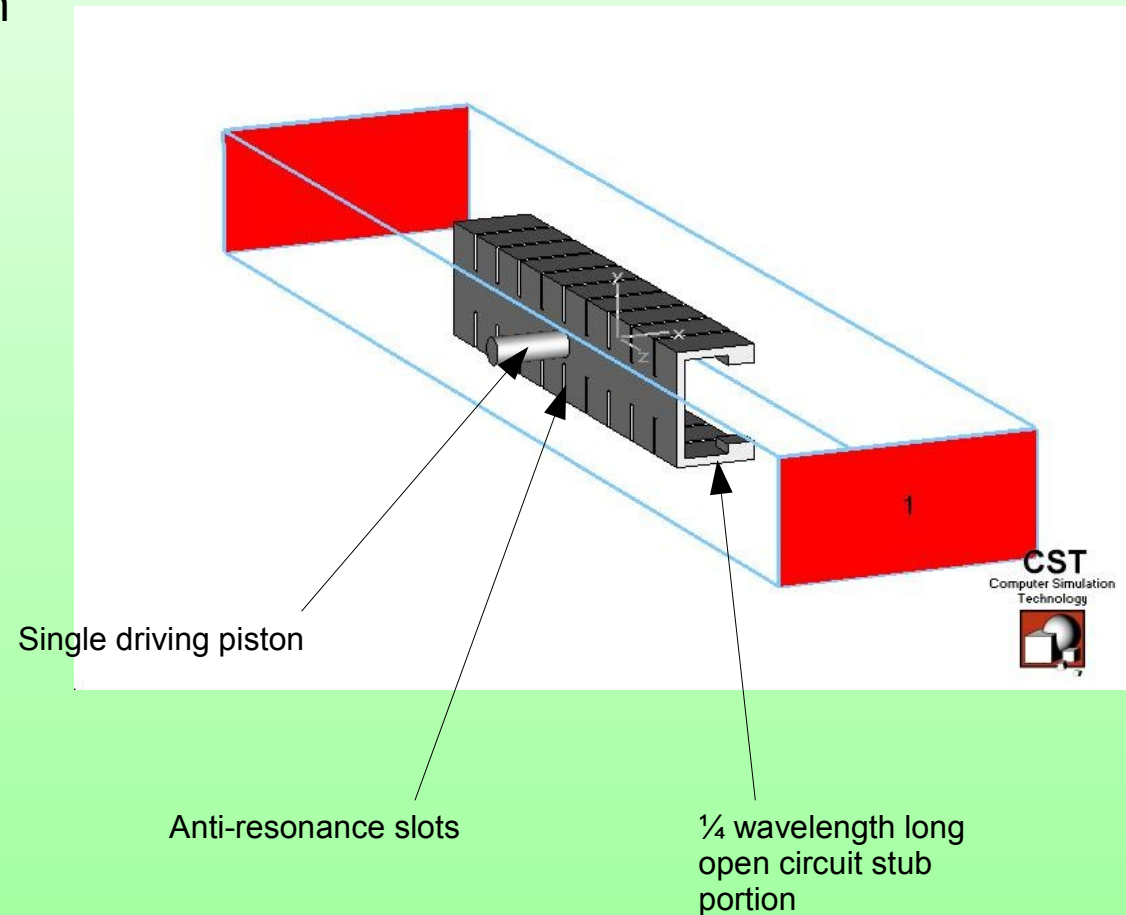
Electric fields



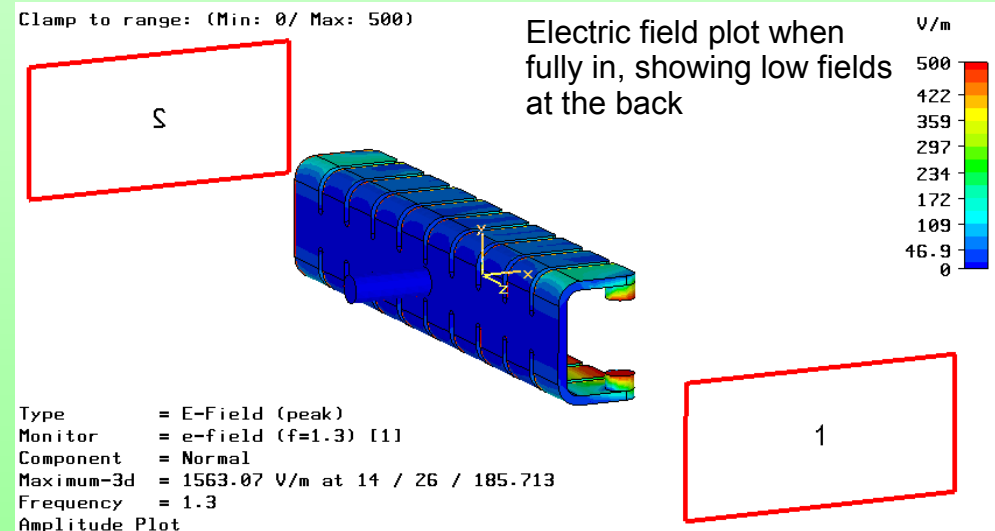
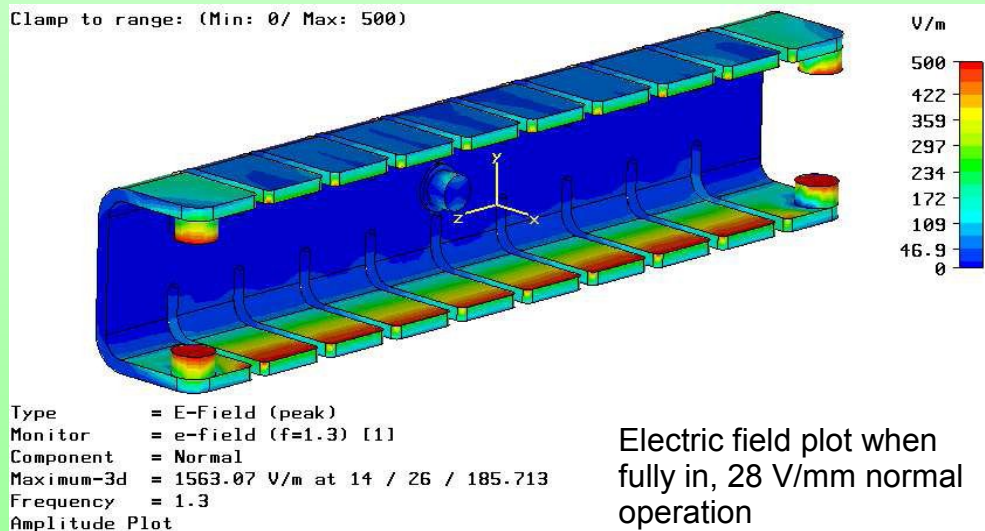
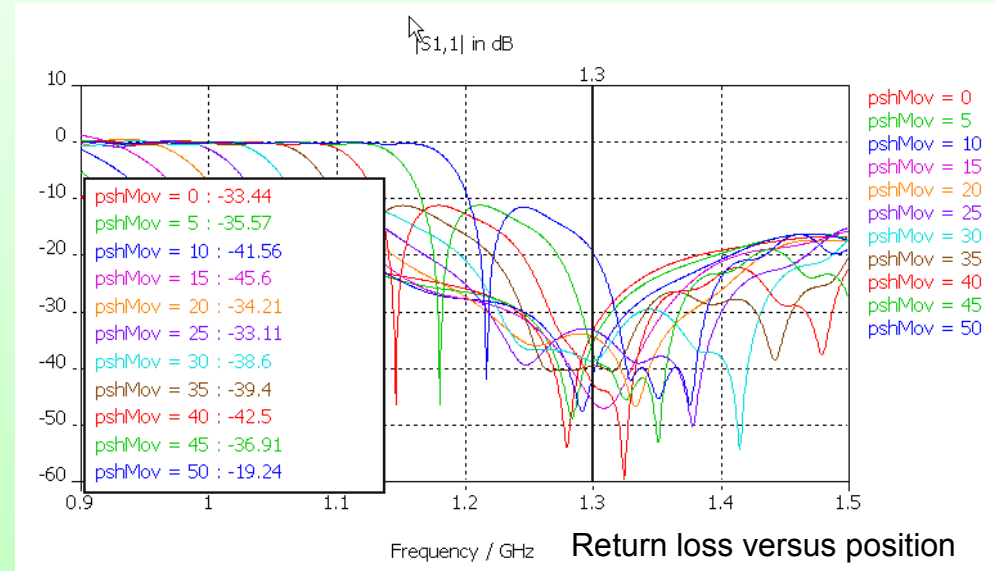
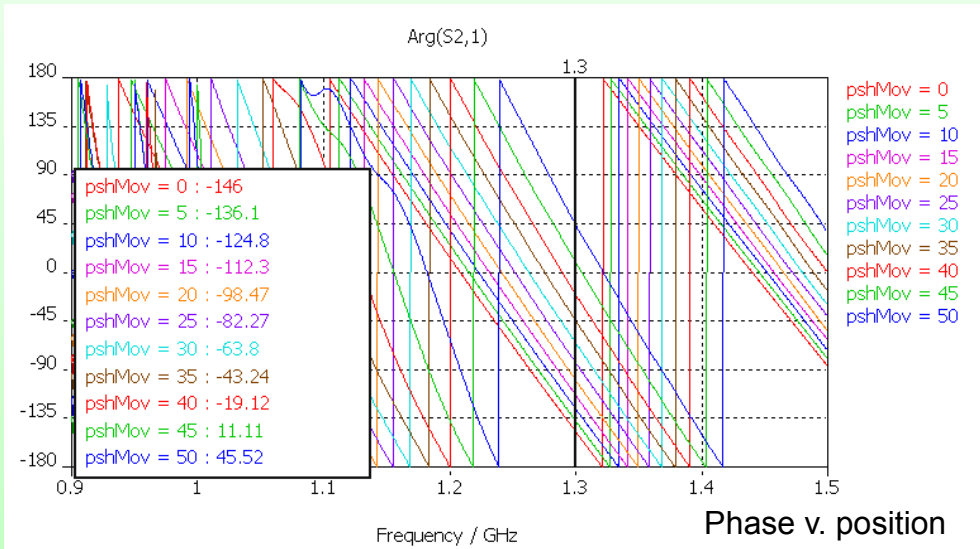
Currents

Phase Shifter - model

- Guide width is made variable using an RF short circuited piston.
- This changes cut off frequency hence guide wavelength and phase.
- 180 degrees phase change possible over 400 mm long.
- Calculated return loss better than 26 dB.
- Generous clearances



Phase Shifter - results



Phase Shift Motors, Actuators and Controllers

Controllers

- McLennan preferred
- Combined motor / controller under investigation
- Incremental only
- RS485 suggested (can be daisy chained)



Motors

- Stepper type
- High resolution

Actuator

- Exact type to be agreed
- Origa preferred (good looks, compatible)



Output Cables

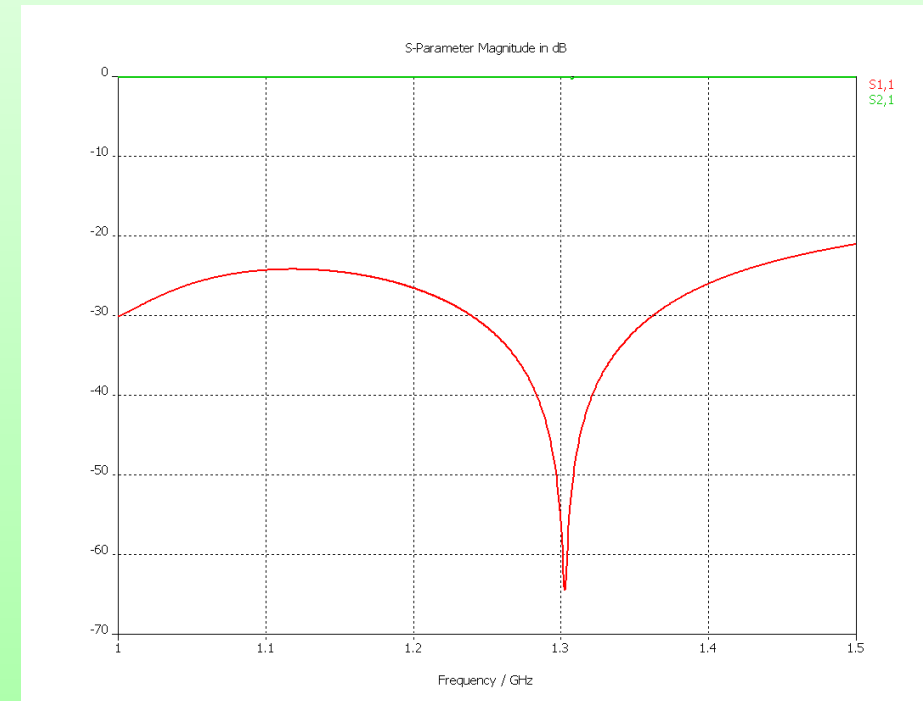
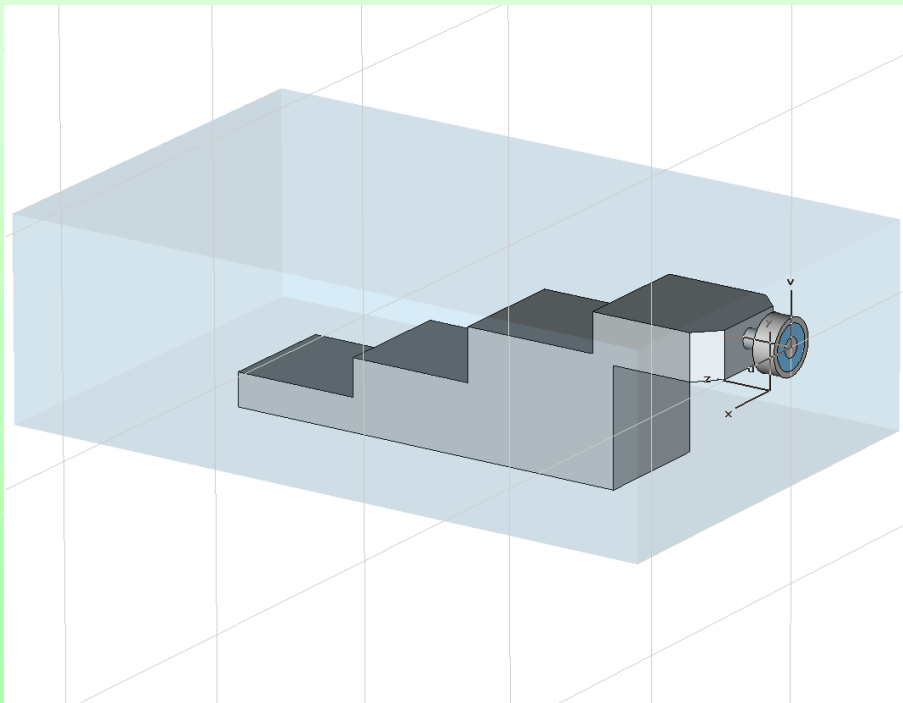
RFS cable chosen

- Type LCF78-50JFNA
- Low halogen jacket
- Foam dielectric, solid copper outer conductor
- Copper tube centre conductor
- Attenuation 0.0445 dB / m at 1.25 GHz
- Peak power 83 kW
- Simple connector assembly
- Minimum bend radius 250 mm (repeated)



Transitions

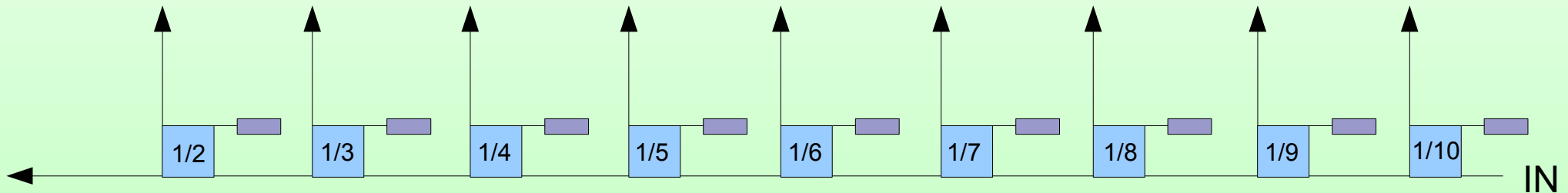
Stepped transition from 7/8 IEC to waveguide



End launcher optimised for 1.3 GHz

Termination Power Analysis

Half Ring Schematic Diagram



Assume cavities perfect match

Balance load powers depend on:

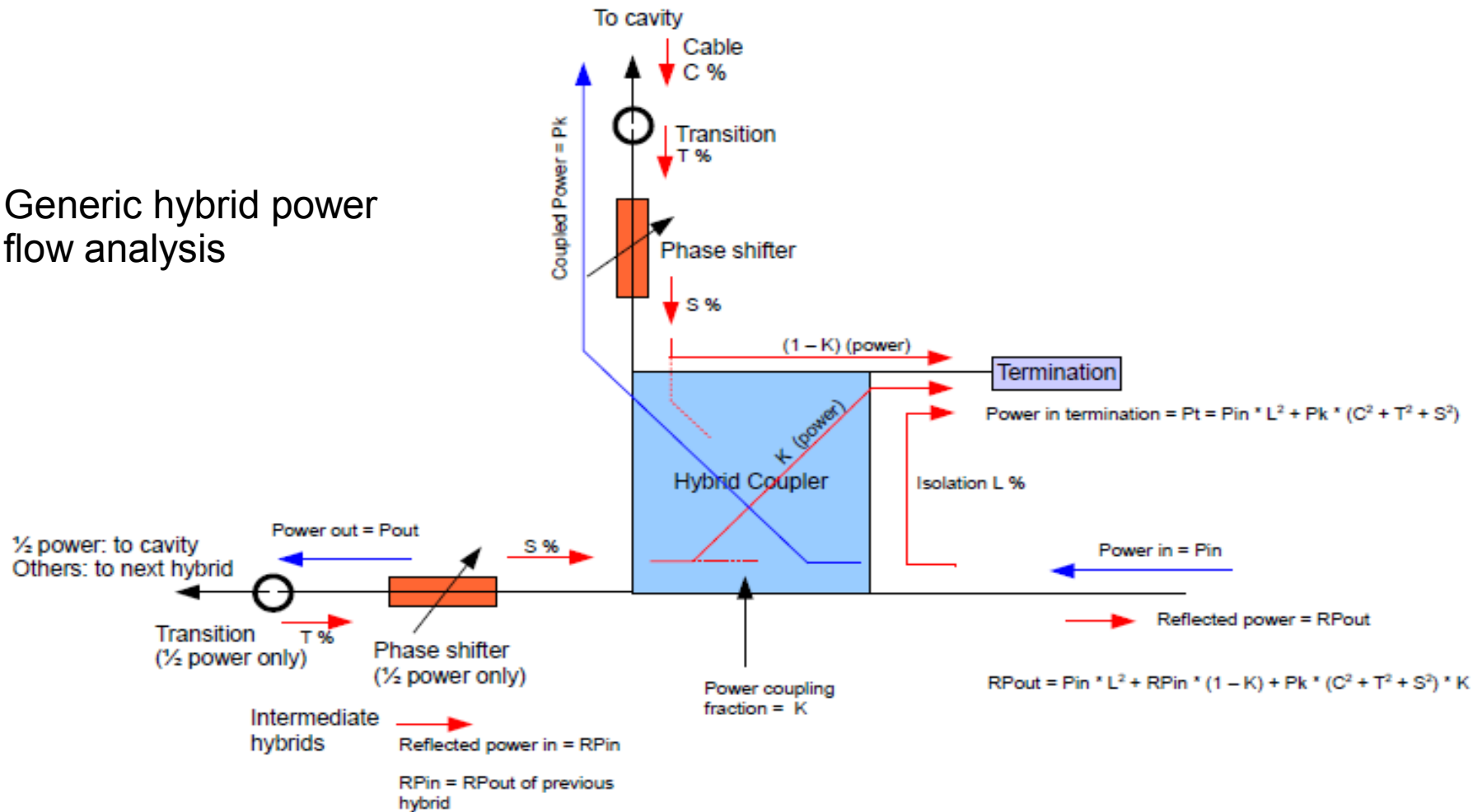
- Reflection from hybrids down the chain arising from contributions within each hybrid eg:
 - Transition
 - Phase shifter
 - Cable
 - Mistuning of isolation
- Reflections from waveguide bends

For each hybrid typical values are:

- 3 % reflection coefficient from the transition
- 5 % from the phase shifter at worst case setting
- Isolation 40 dB (this also will be the reflection coefficient for a good design) or 1 % reflection
- 5 % for the cable.

Termination Power Analysis

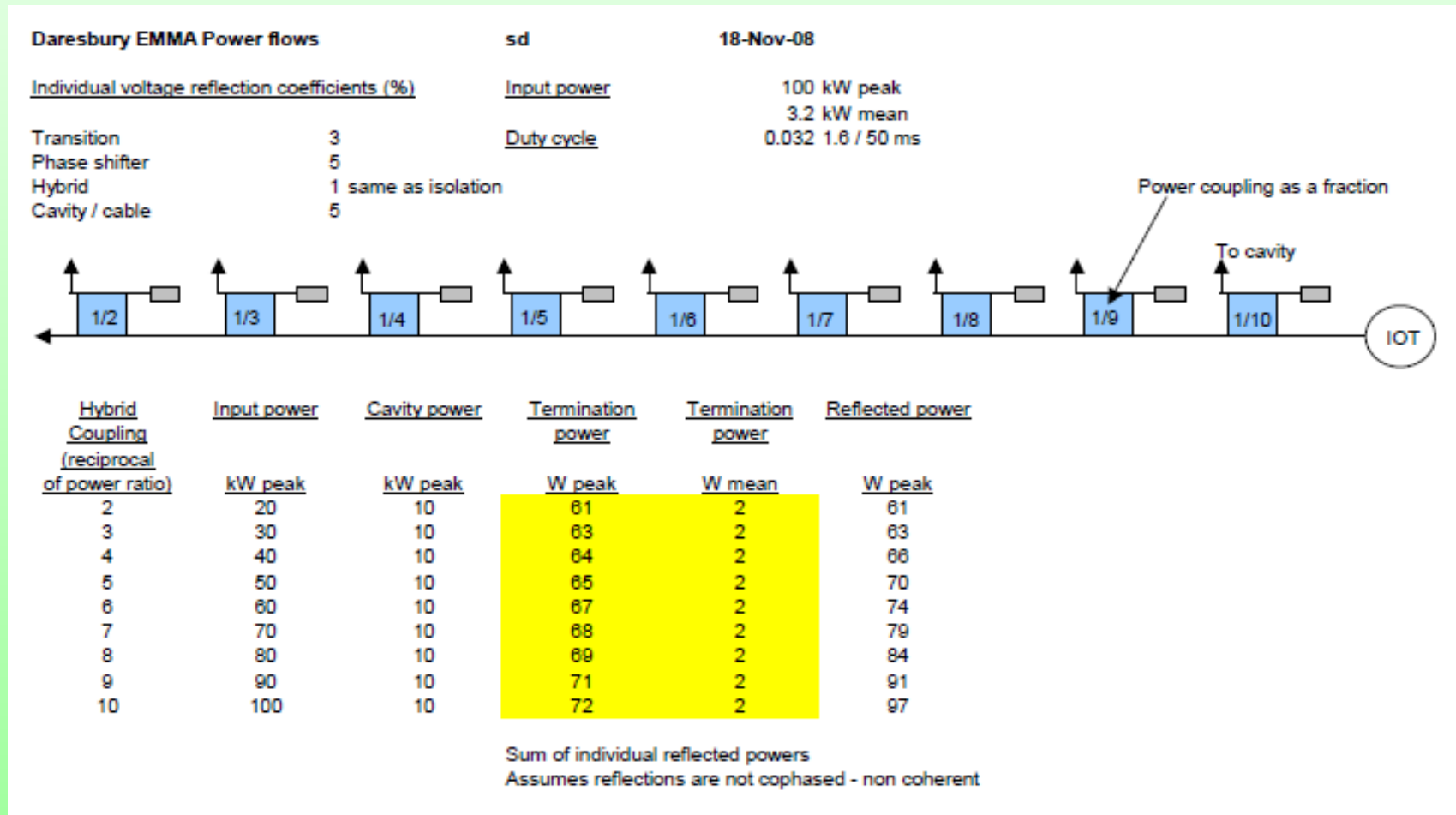
Generic hybrid power flow analysis



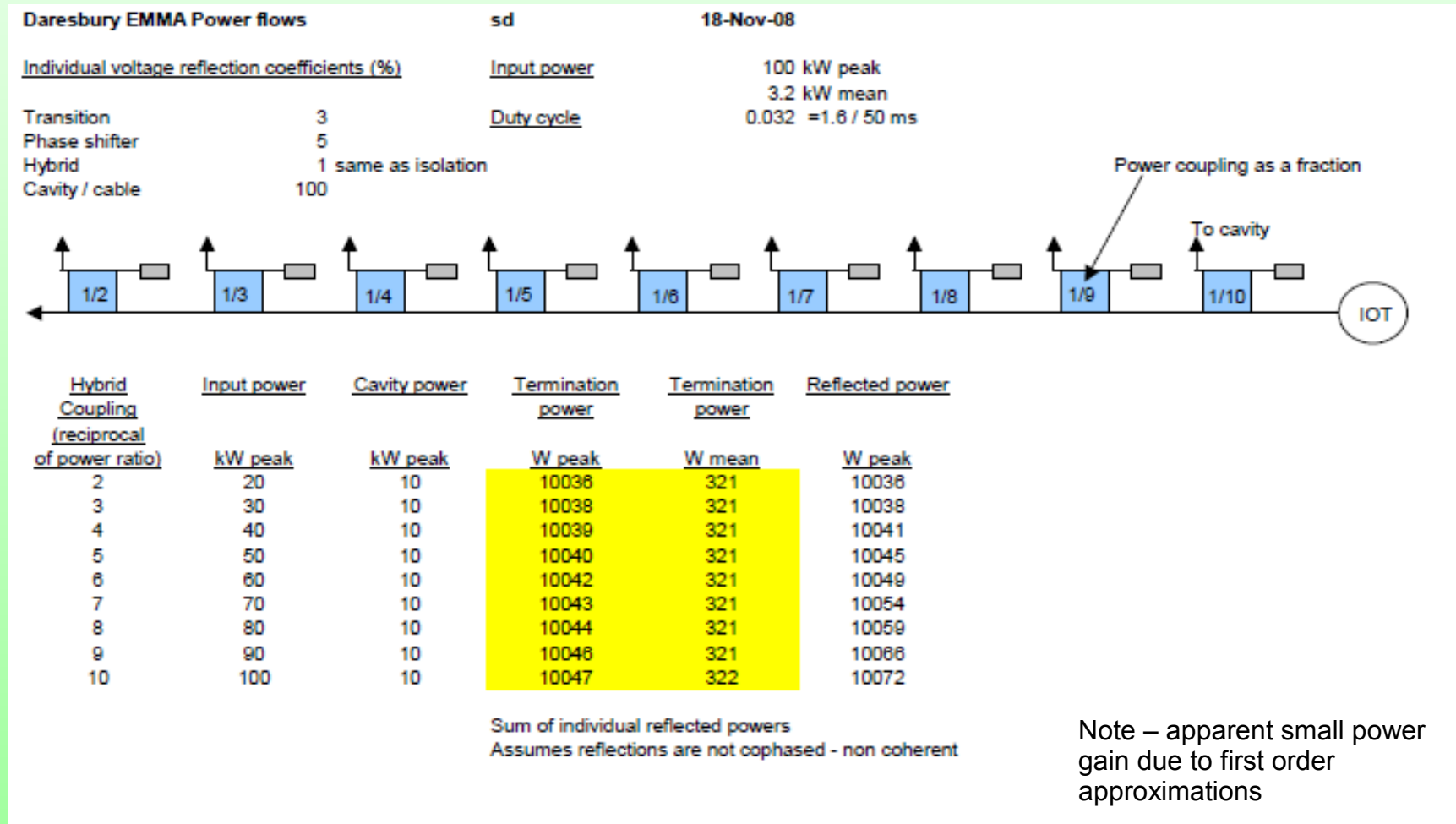
D1616 / SD / 18 Nov 2008

Termination Power Analysis – normal operation

EXCEL model using equations above



Termination Power Analysis – cavity open circuit



Terminations

- Coaxial 50 ohm
- Normal operation very low power - ~ 2 Watts mean
- 10 kW peak rating in fault conditions, mean power 320 W for 100 ms
- Oil filled have the best peak rating
- Will be mounted off the hybrid balance load port
- Example here is a Bird 8201 oil filled 500 W rated load.
- Connectors will be 7/8 IEC.
- Final type under investigation.



Waveguide and Flanges

- 60 metres of WG5Q ordered and received
- Material for flanges received, and prototype manufacture done
- Adhesive bonding of flanges under trial.
- Gasket designed



Before,
loose bolts



After bolts
tightened

