Design for Electron Cloud Detectors in a Quadrupole Magnet

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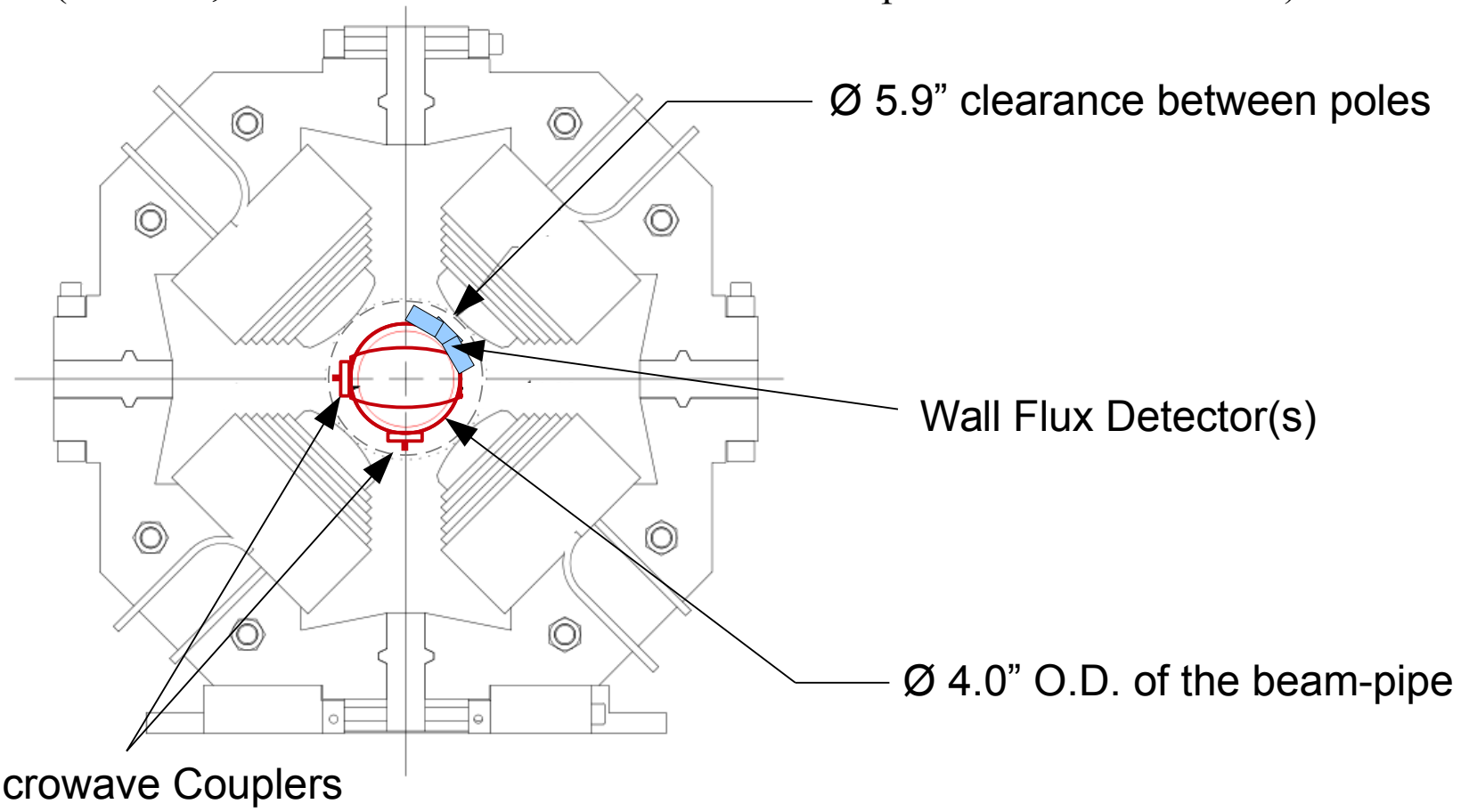
Quad Detector at 15W

Available Space for Wall Flux Detectors

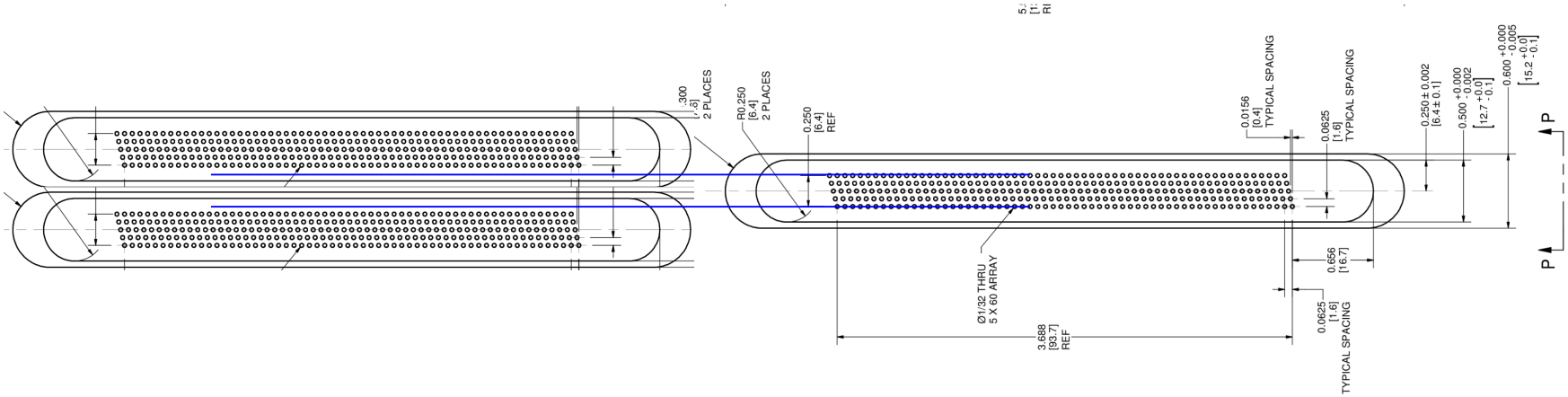
• If the quadrupole is modified in the same way as Q03W (2004), there is nearly one inch of clearance between the beam-pipe and the quadrupole iron. (~24 mm, so 20 mm tall detectors would have a pole clearance of 4 mm).



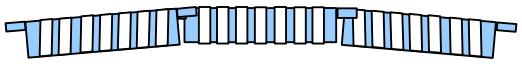
Quad Detector at 15W

A Wider Detector in Three Sections

- Use hole plates as in the design of 6085-206 sheet 9
- Need a detector that is three times as wide (azimuthally) as the original.
- Use three plates: one with perpendicular holes the others with an angle of 9.18°.
- Hole angles to follow magnetic field lines (approximately).
- Hole plates can be staggered longitudinally as shown below.

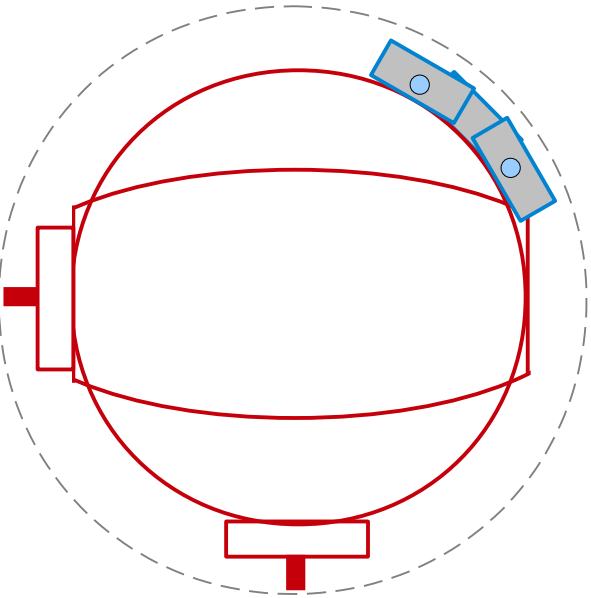


Effective Cross Section:

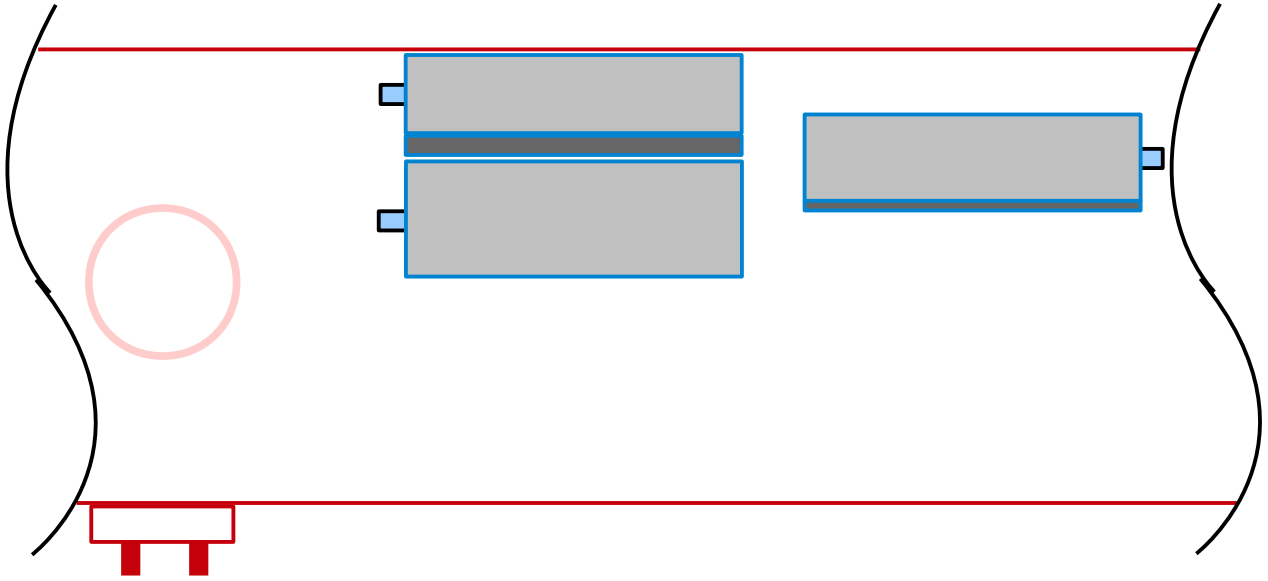


Quad Detector at 15W

Relative Placement of Detectors



Outside of Ring

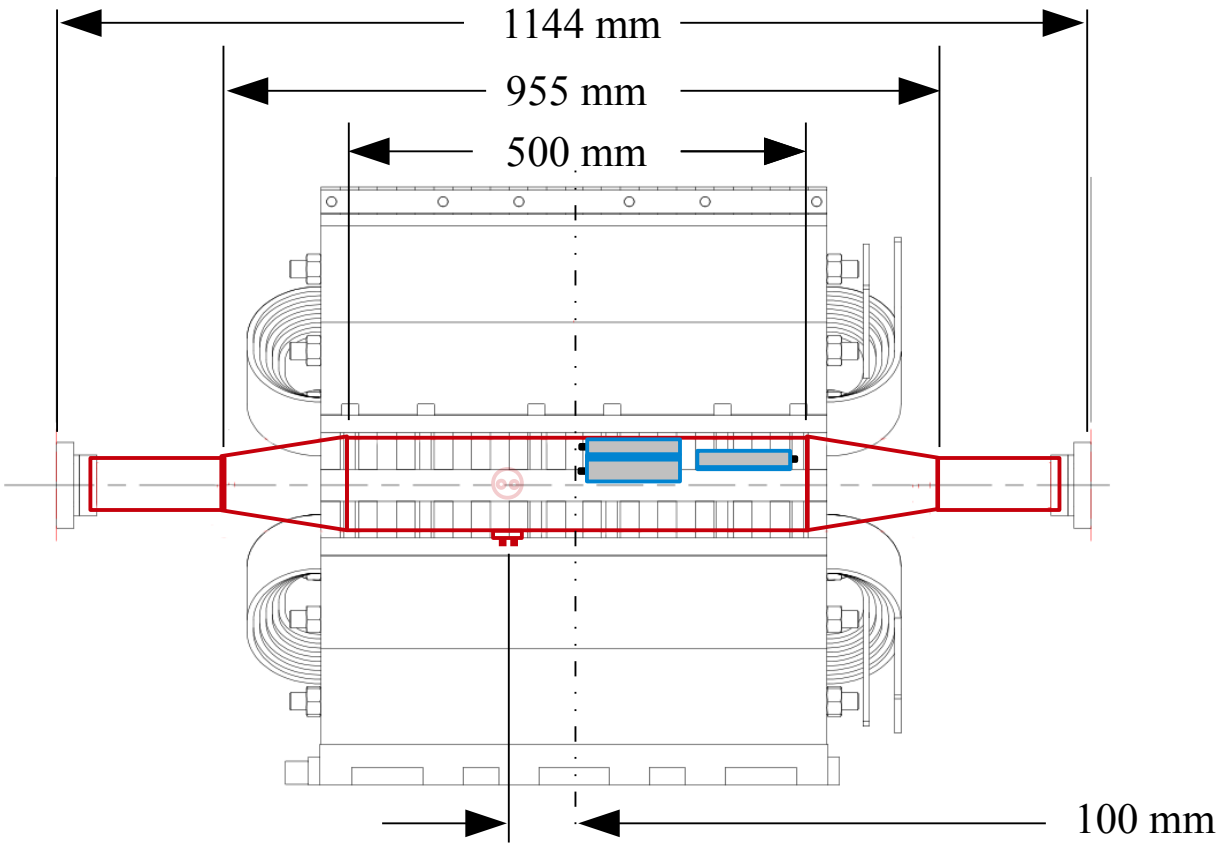


Side View

Quad Detector at 15W

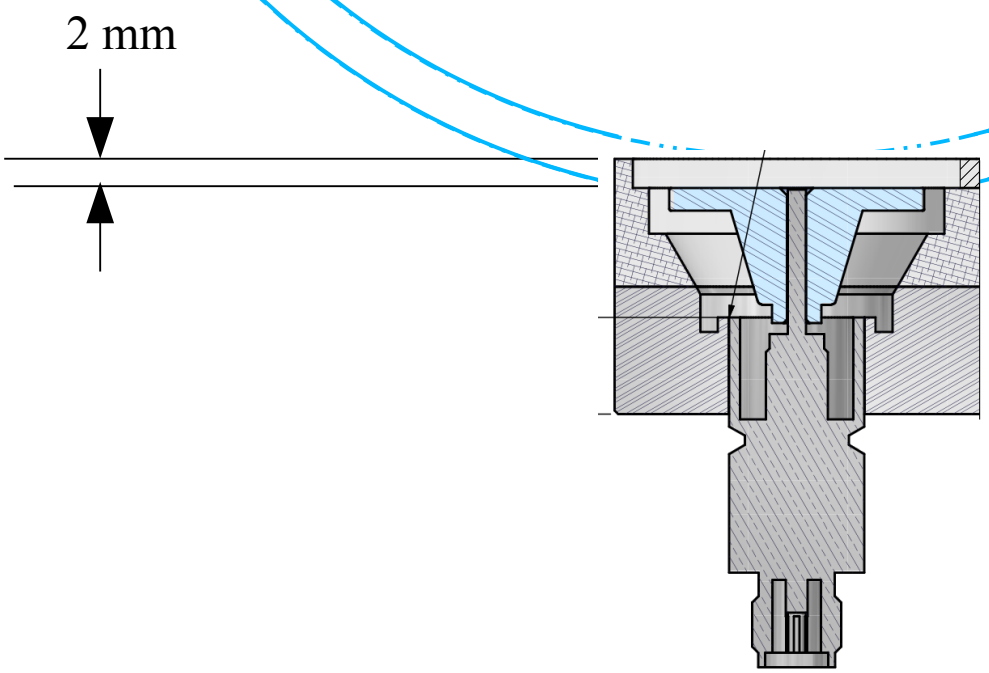
Overall Beam-pipe Shape

- Round beam-pipe with 95.5 mm I.D., 500 mm long (~19.7 inches)
- Round pipe tapers to standard CESR shape over approx 227 mm (~11.2 inches).
- Buttons 100 mm off center.



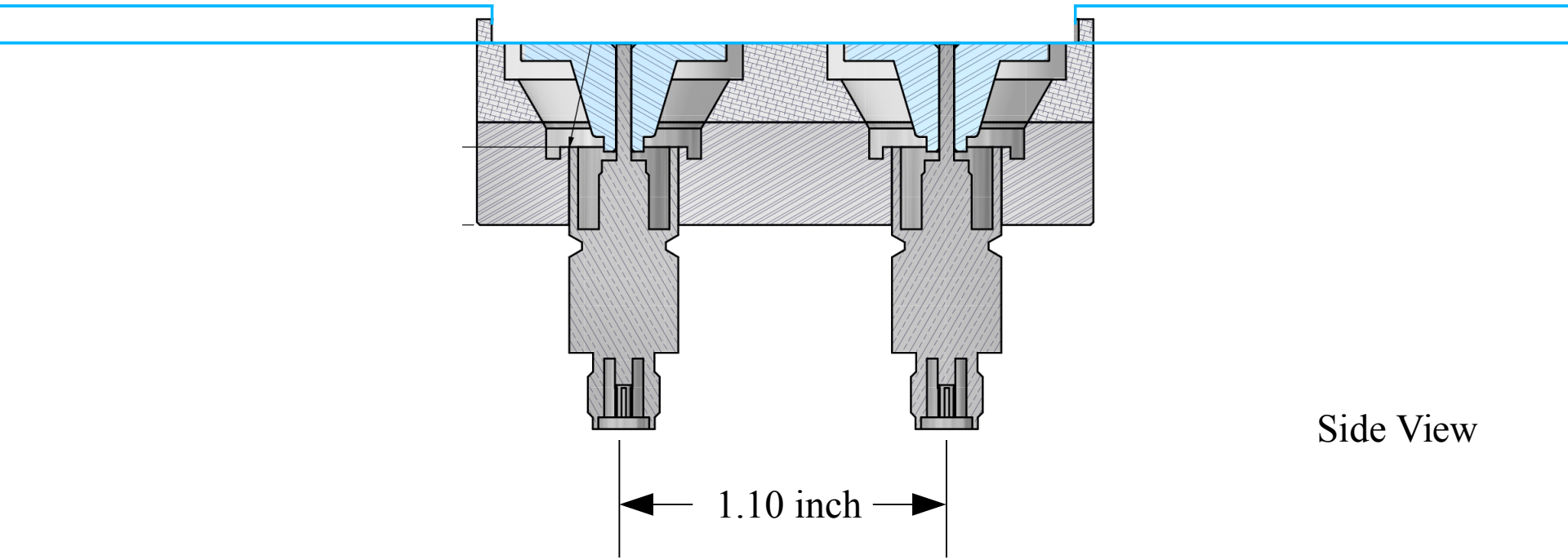
Quad Detector at 15W

BPM Detail: Button recessed 2 mm from I.D. of pipe



Quad Detector at 15W

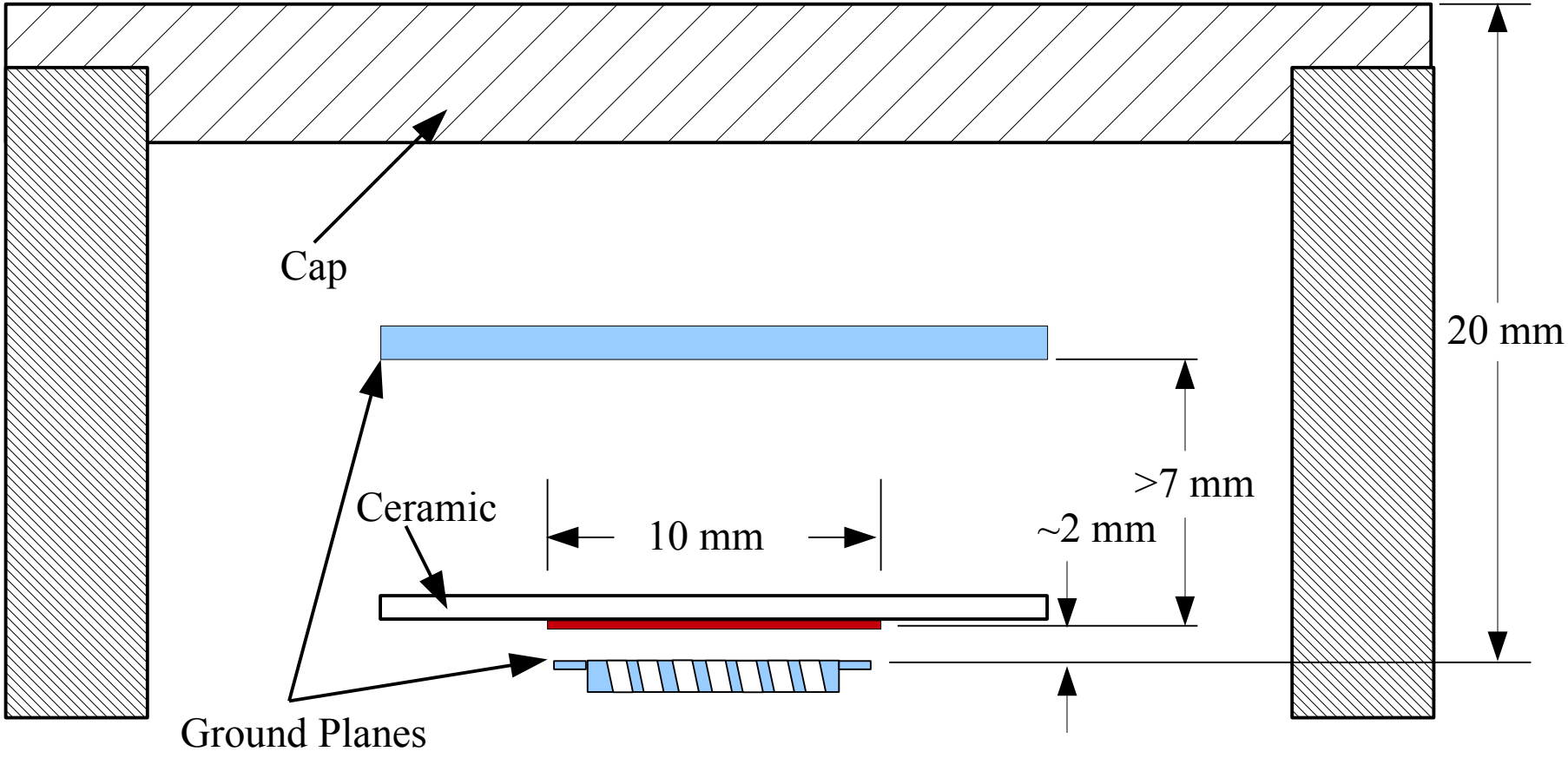
BPM Detail: showing bottom button spacing



Side View

Inside the Box: Stripline Impedance

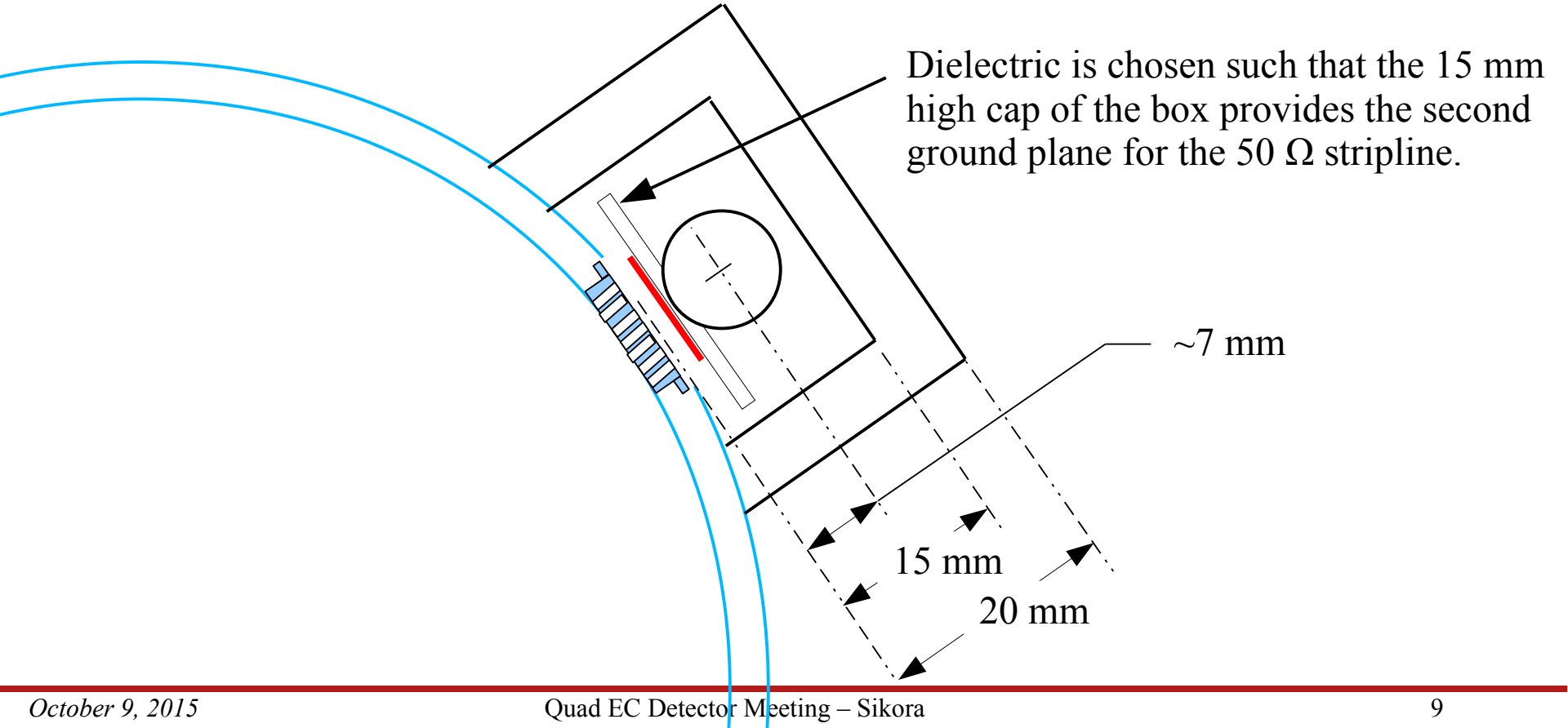
1) The distance from the holes to the collector should be 2 or 3 mm.
2) The impedance calculation must include both the upper and lower ground planes.
3) With NO dielectric the lower/upper gaps would be 2 mm and 7.1 mm (50 Ω)
4) Adding ceramic will give 50 Ω with larger gap to the upper ground plane.



Quad Detector at 15W

Physical Layout and Constraints

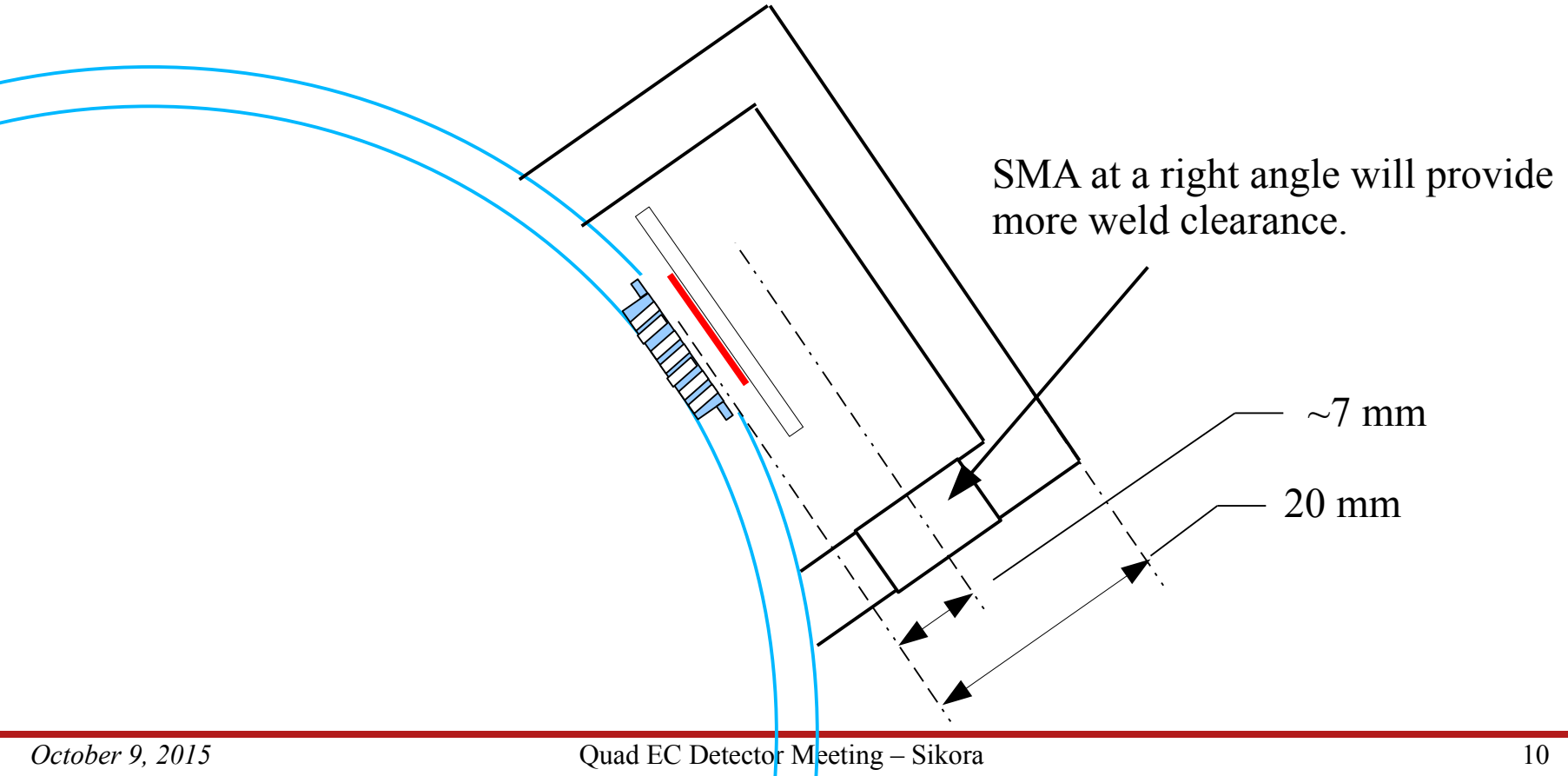
1) SMA Feedthrough 9.45 mm dia. (what is weld clearance?)
2) Detector height clearance limited to 20 mm from O.D. of the beam-pipe.
3) Wall thickness?
4) Stripline 10 mm wide; Dielectric 20 mm wide (?)



Alternative Right Angle Orientation of Feedthrough

1) The curvature of the beam-pipe can be used to obtain more weld clearance (and clearance in general).

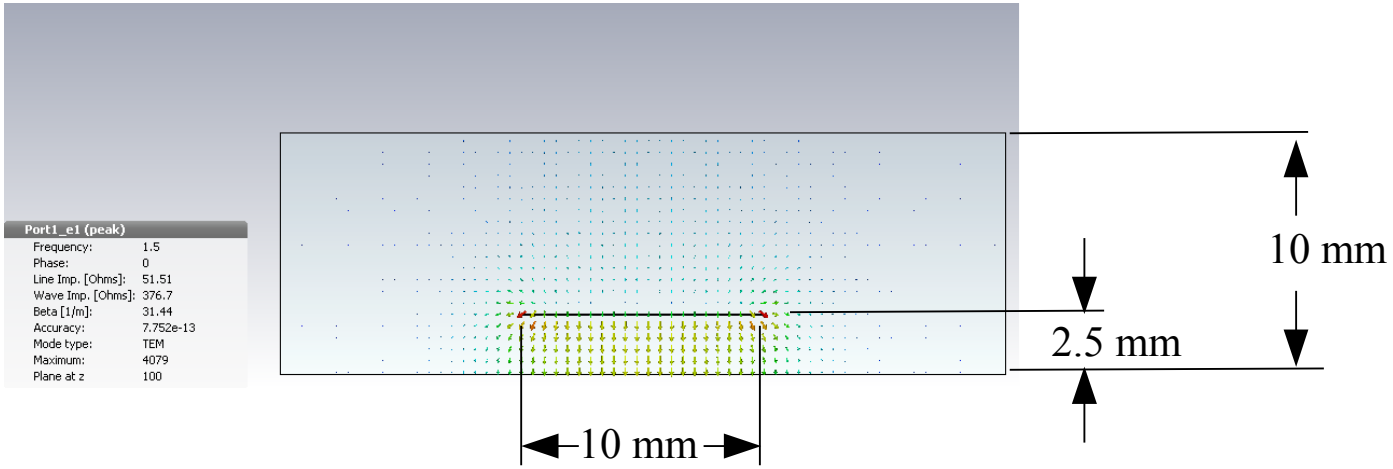
2) The box would be extended on the side where the feedthrough(s) are welded.



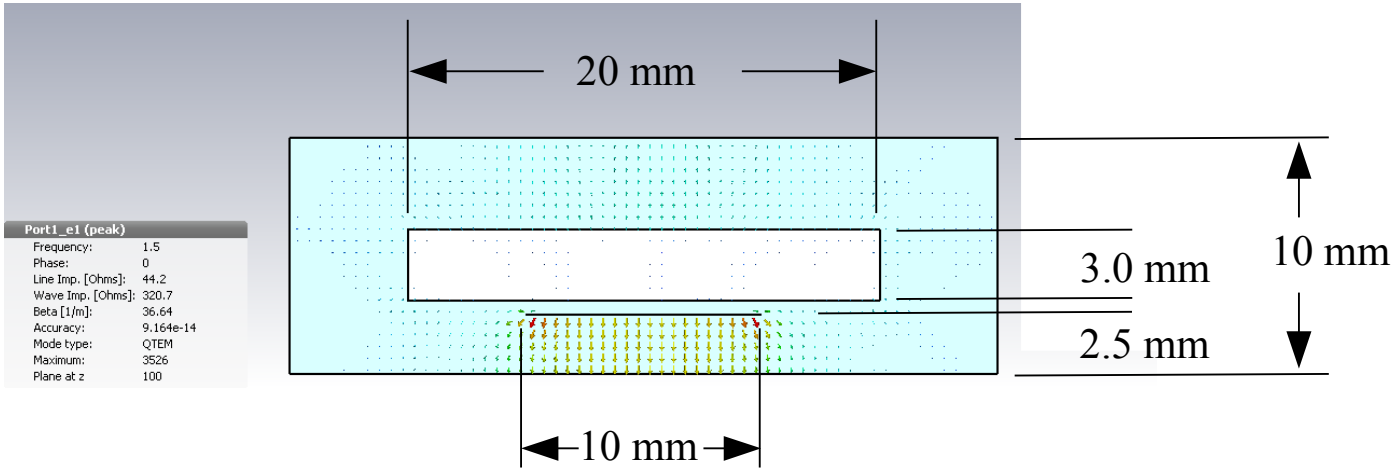
Quad Detector at 15W

Stripline Simulations: Begin with a 10 mm tall box, 100 mm long, where a 50 Ω stripline can be made without dielectric.

Without ceramic
51.5 Ω



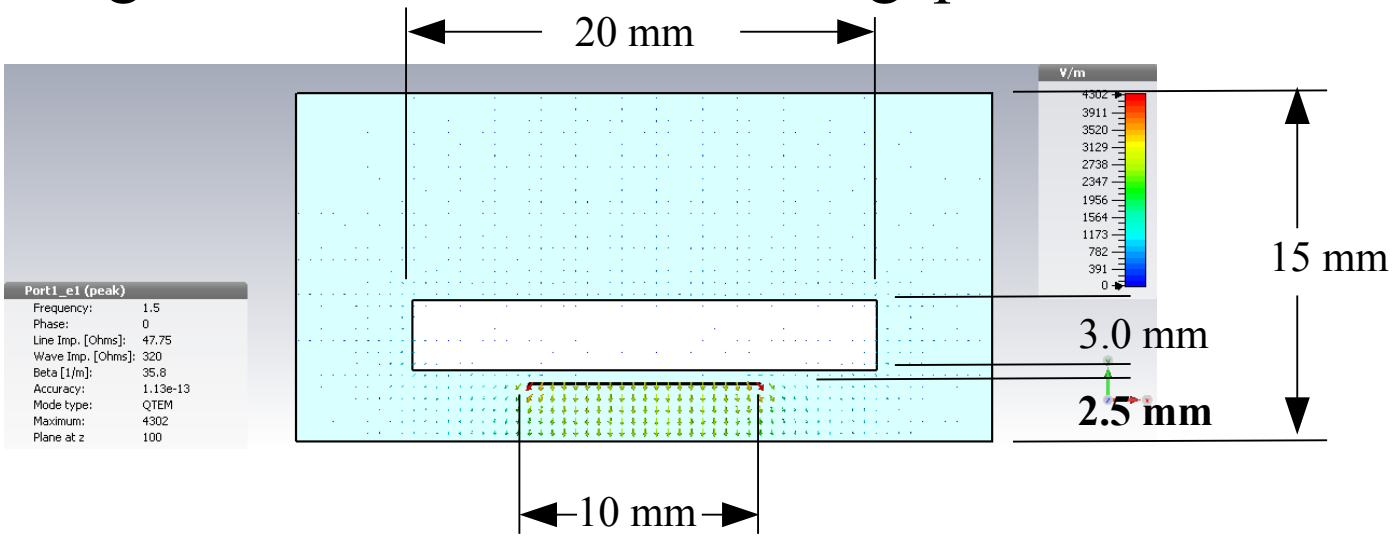
With 3 mm ceramic
44.2 Ω



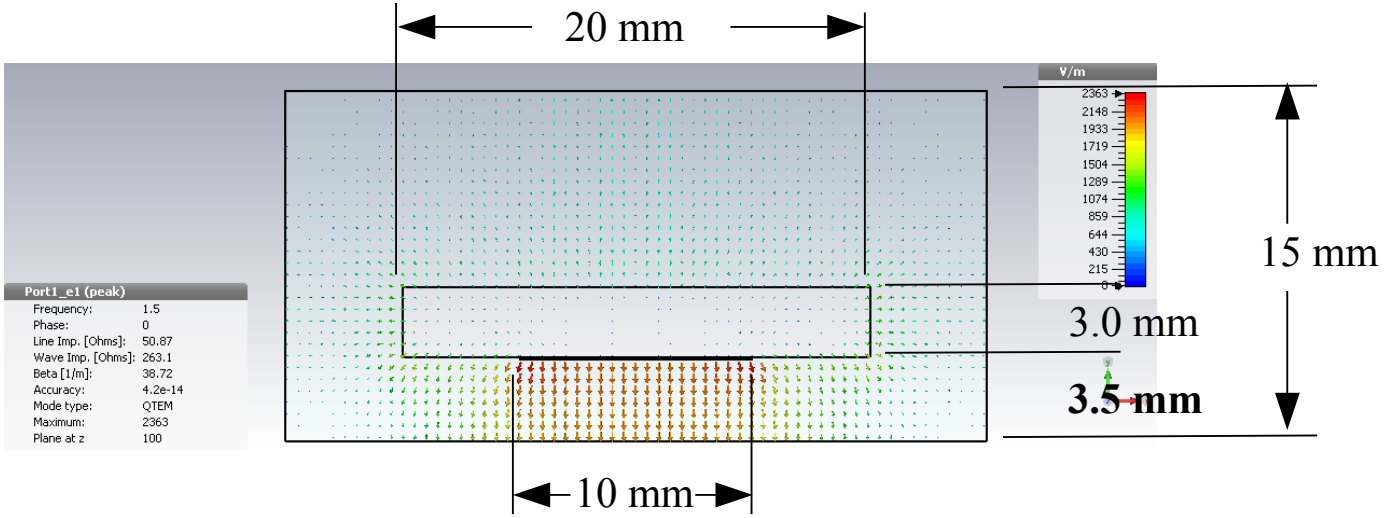
Quad Detector at 15W

Stripline Simulations: Adding 3 mm thick ceramic results in 15 mm total height and a 3.5 mm collector gap for 50 Ω.

2.5 mm gap with 3 mm ceramic 47.75 Ω



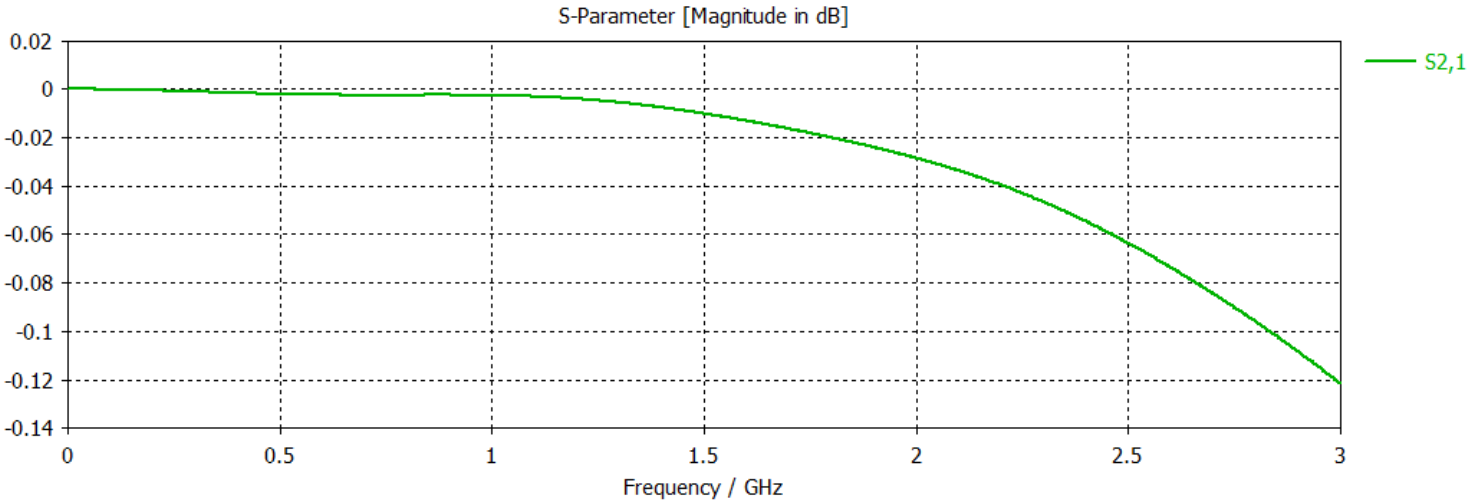
3.5 mm gap with 3 mm ceramic 50.9 Ω



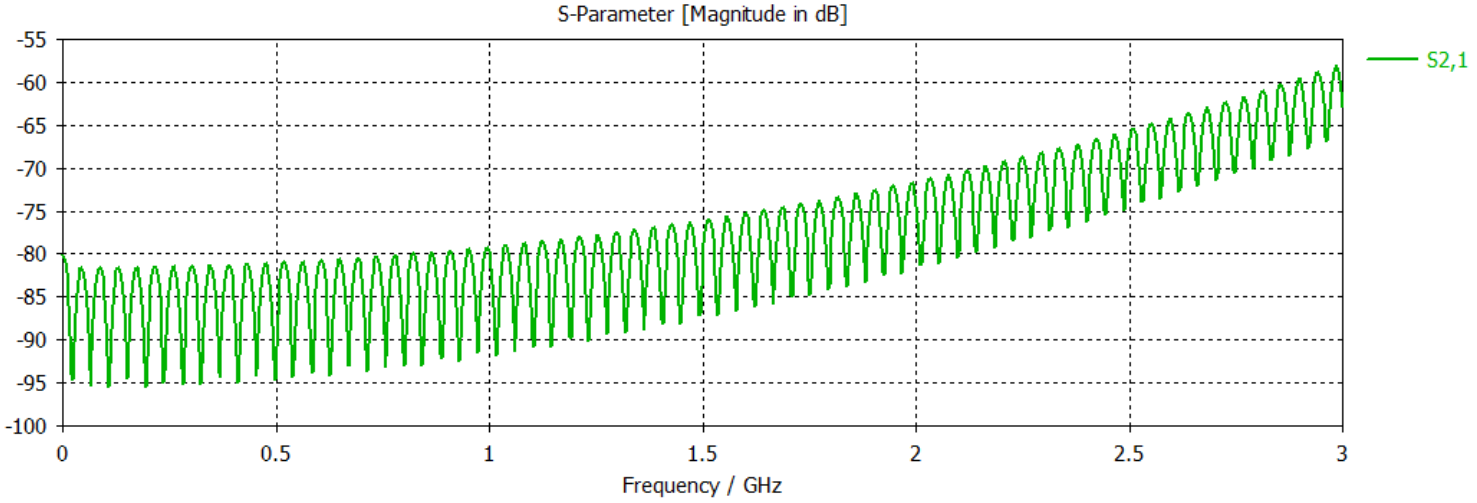
Does the ceramic have its own modes?

S_{21} Parameter of Box with Ceramic, with/without Stripline

3 mm Ceramic with Copper stripline



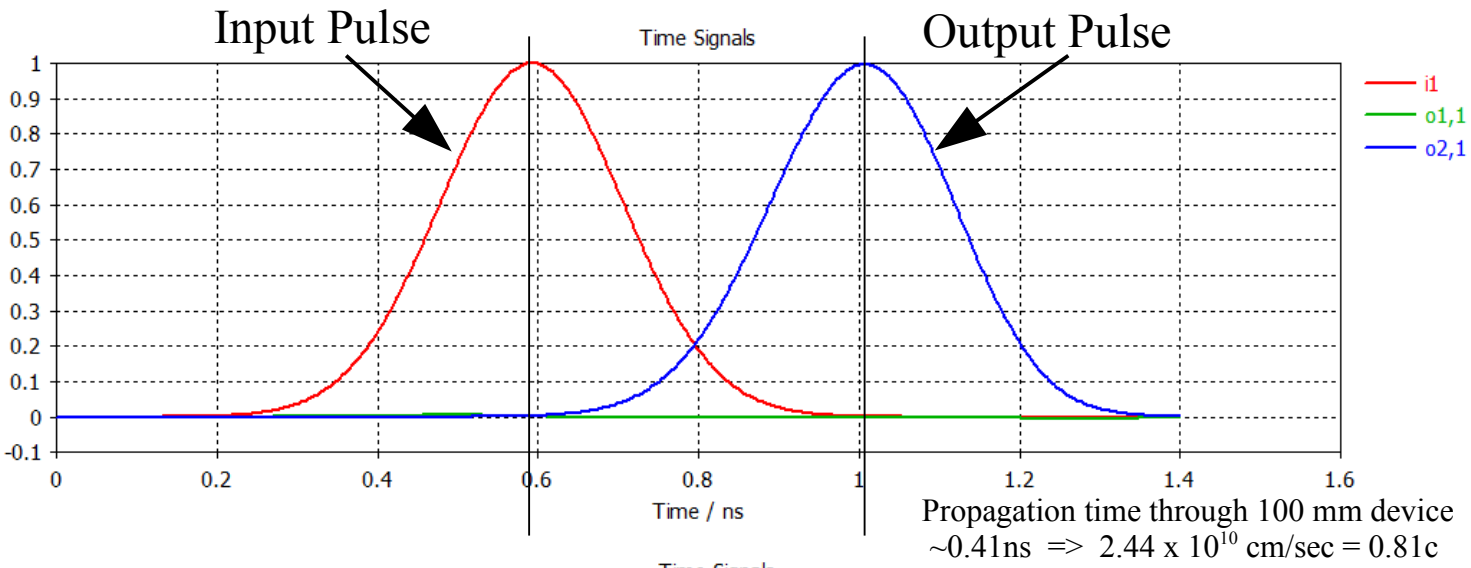
Ceramic without Stripline



Does the ceramic have its own modes?

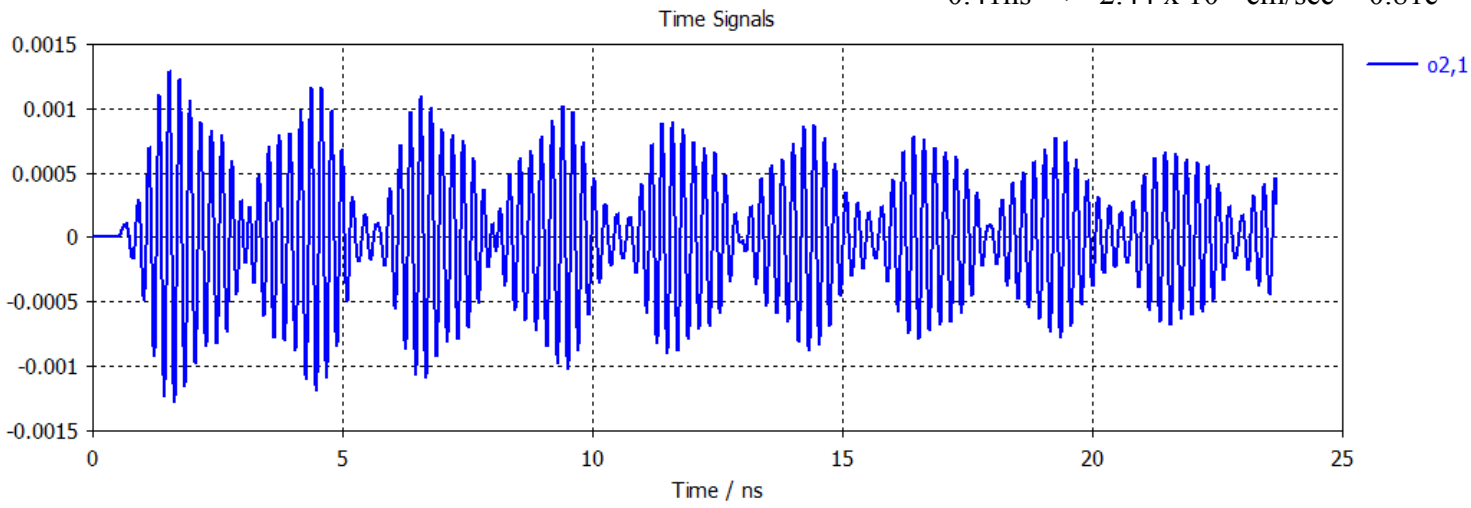
Pulse Response, with/without Stripline

With Copper stripline and 3 mm Ceramic



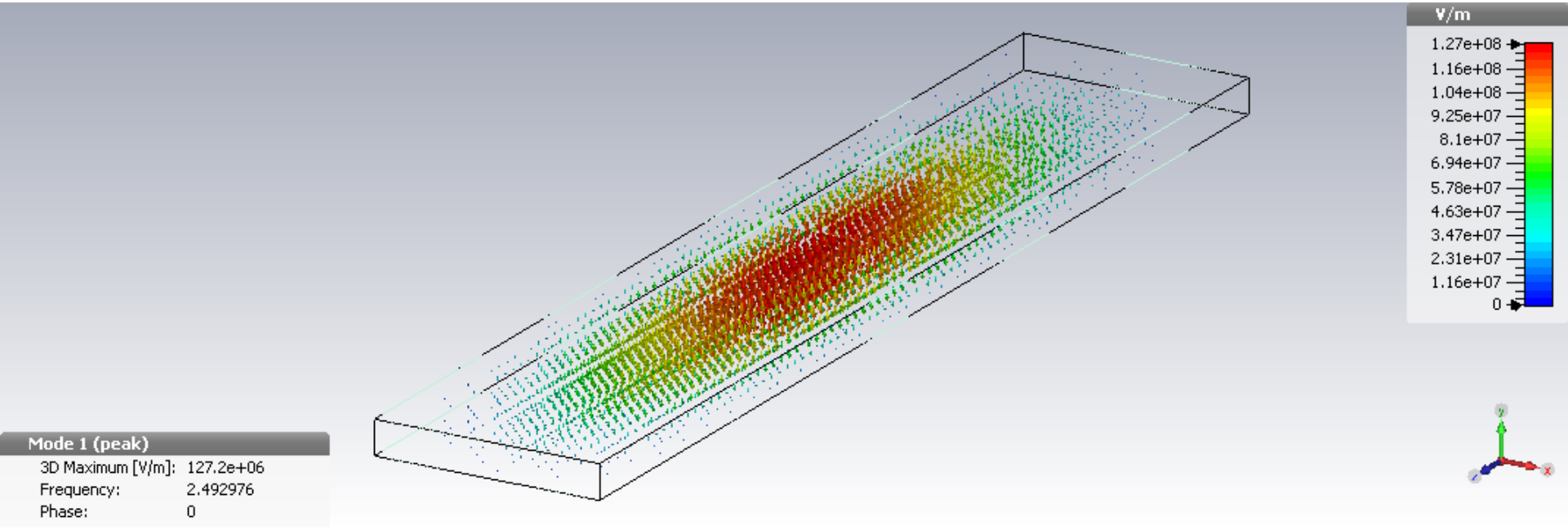
Propagation time through 100 mm device
~0.41ns => 2.44 x 10^{10} cm/sec = 0.81c

Ceramic without Stripline (same input pulse)



Does the ceramic have its own modes?

Ceramic Only (no box)

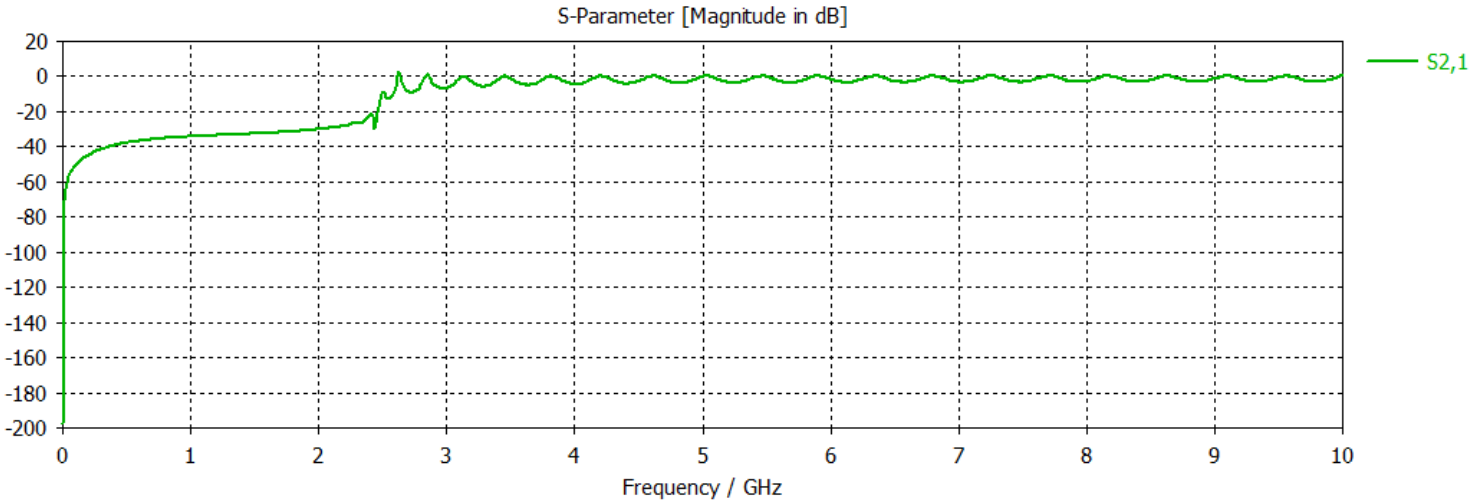


With the ceramic in empty space, the first resonant mode is at 2.5 GHz
(3 mm thick, 10 mm wide, 100 mm long)

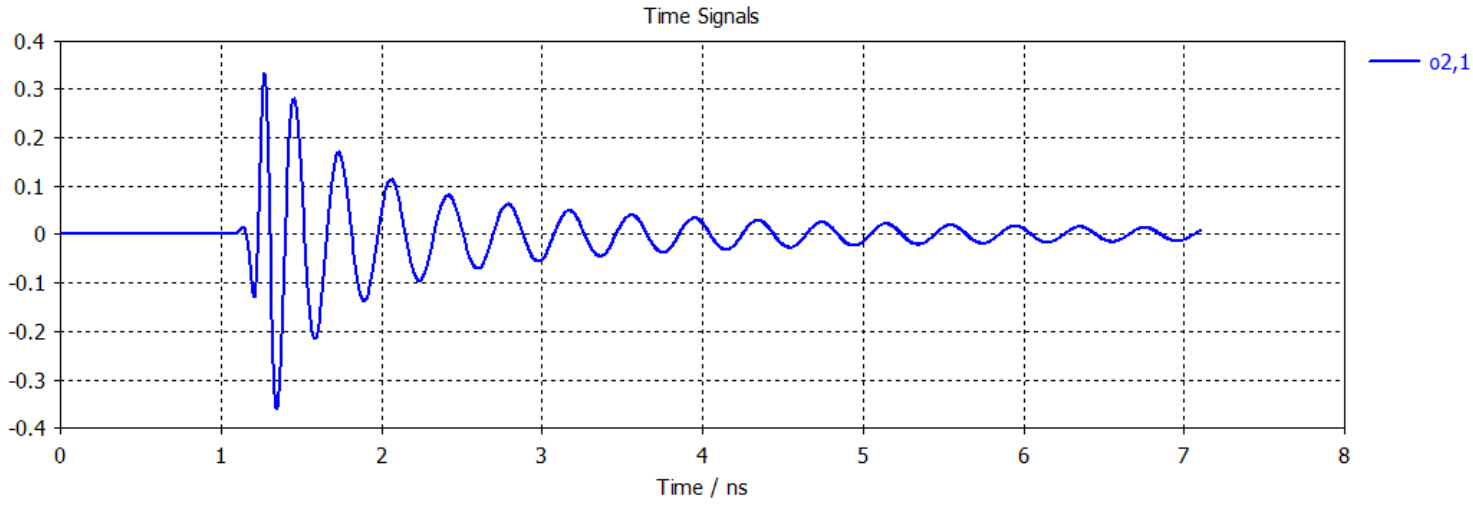
Does the ceramic have its own modes?

Ceramic Only (no box)

S_{21} vs. Frequency



Pulse Response



Original Kapton Flex Circuit Stripline

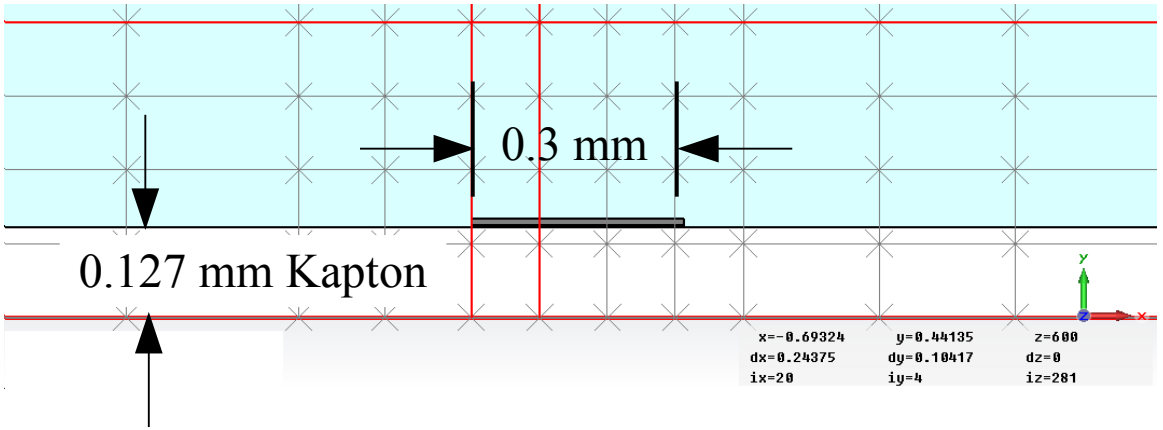
Comparison with Original (Flex Circuit) Detector

I created a two models:

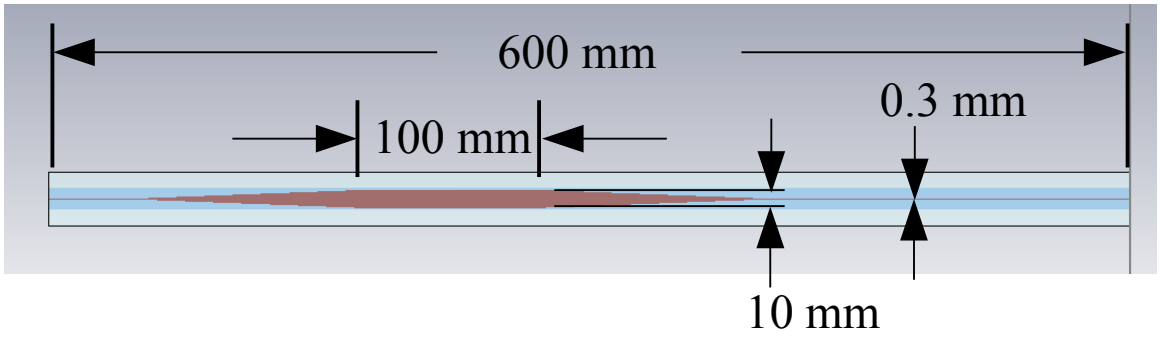
- A uniform stripline 0.3 mm wide on .127 mm thick Kapton
- A similar stripline but with tapers to a 10 mm wide electrode (as in the original flex circuit detector)

This is shown in the sketches below.

Cross-section of uniform stripline on a Kapton substrate



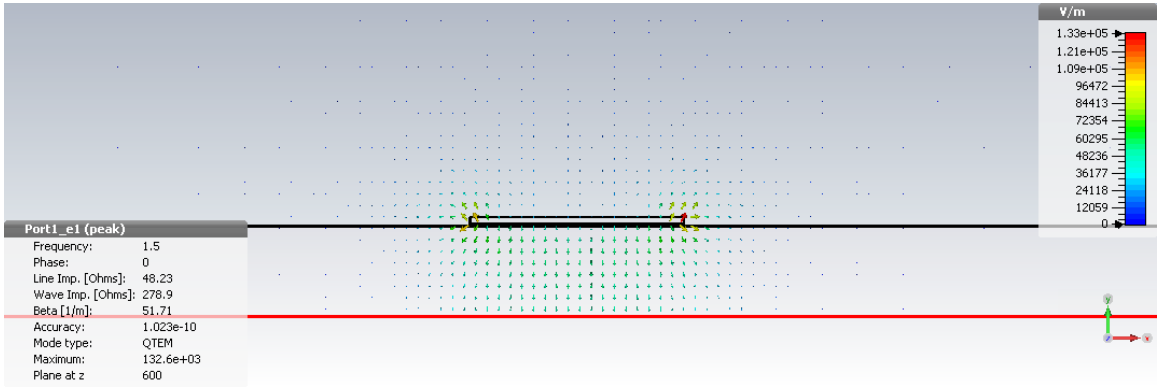
Top view of stripline with tapers to a 10 mm wide electrode on a Kapton substrate



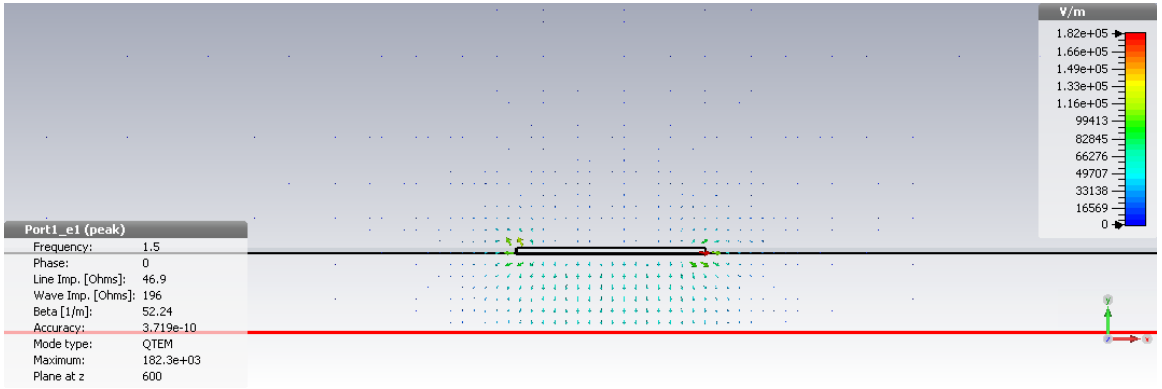
Original Kapton Flex Circuit Stripline

Port modes for both striplines have 46 Ω Impedance

Uniform 0.3 mm stripline on a Kapton substrate



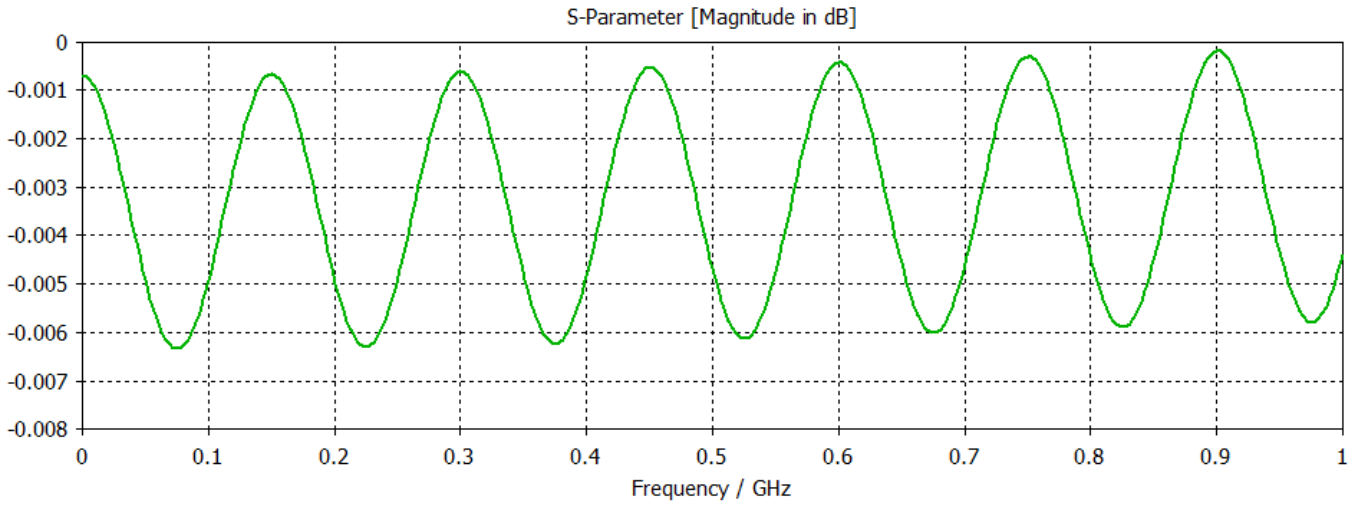
Stripline with tapers to 10 mm electrode on a Kapton substrate



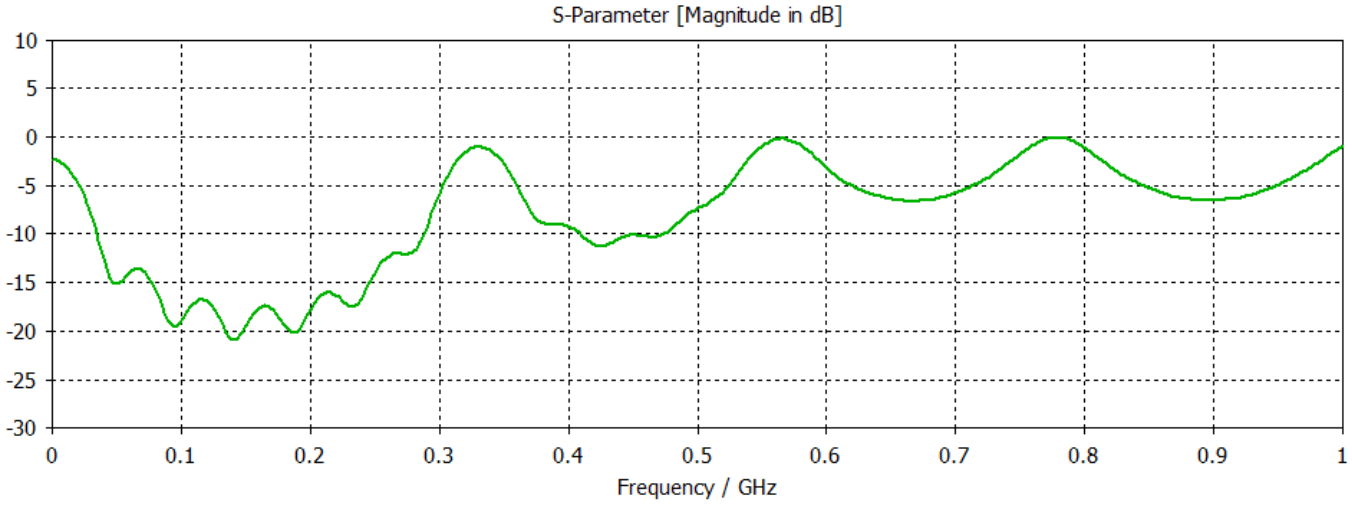
Original Kapton Flex Circuit Stripline

But S_{21} versus frequency is very different

Uniform 0.3 mm stripline on Kapton



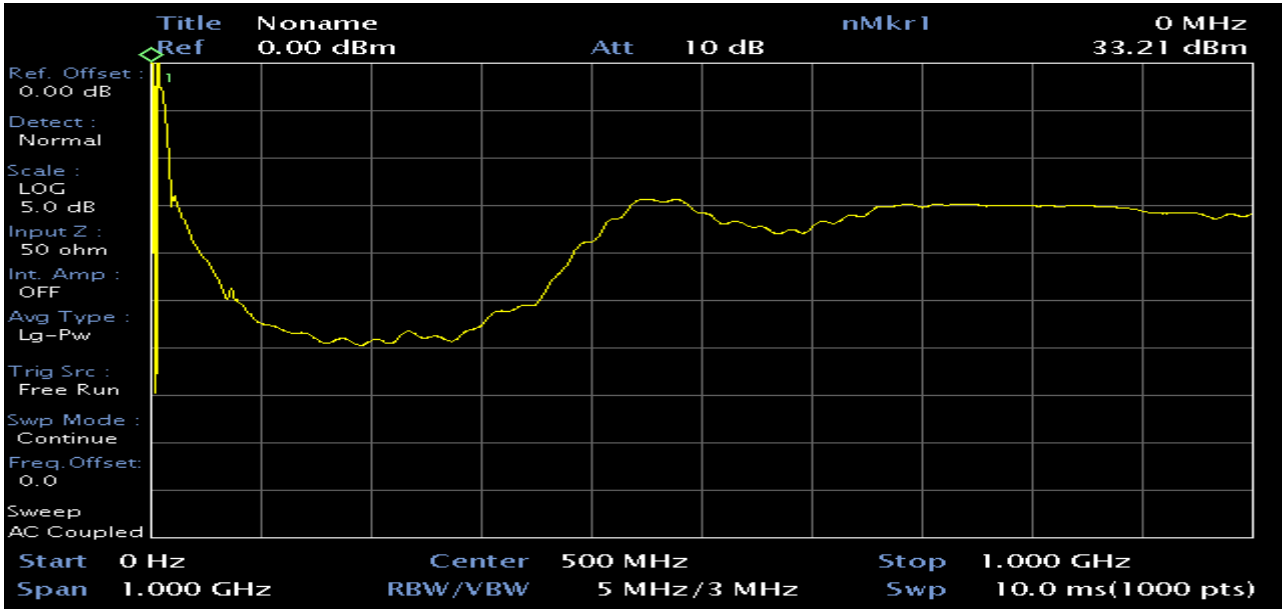
Stripline with tapers to 10 mm electrode on Kapton



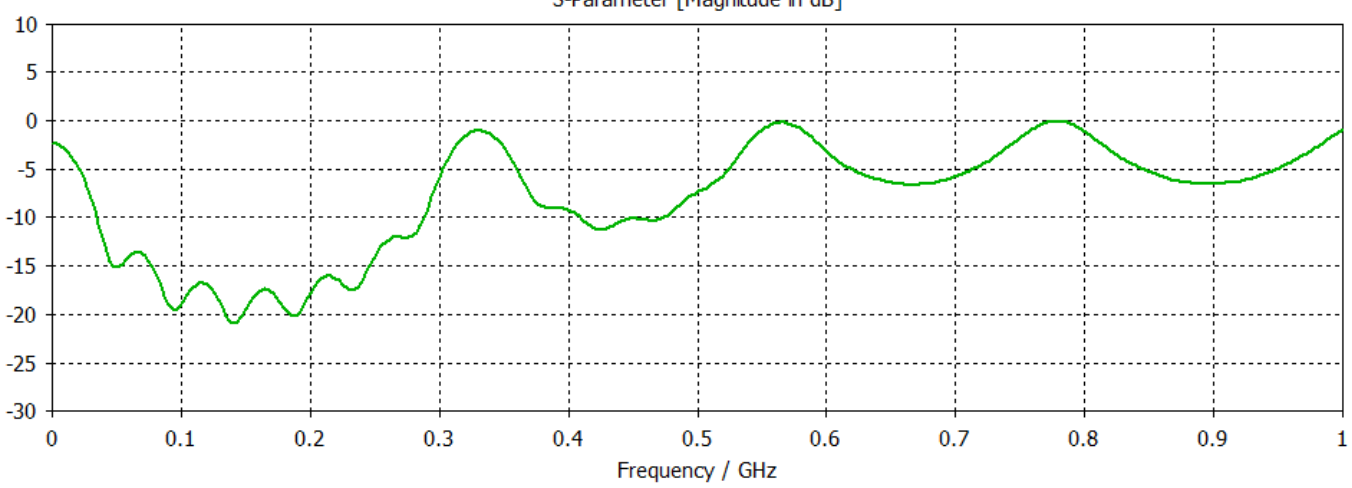
Original Kapton Flex Circuit Stripline

S_{21} is very similar to the measured response of the detector

Measured response of the stripline detector with 10 mm electrode (5 dB/div)



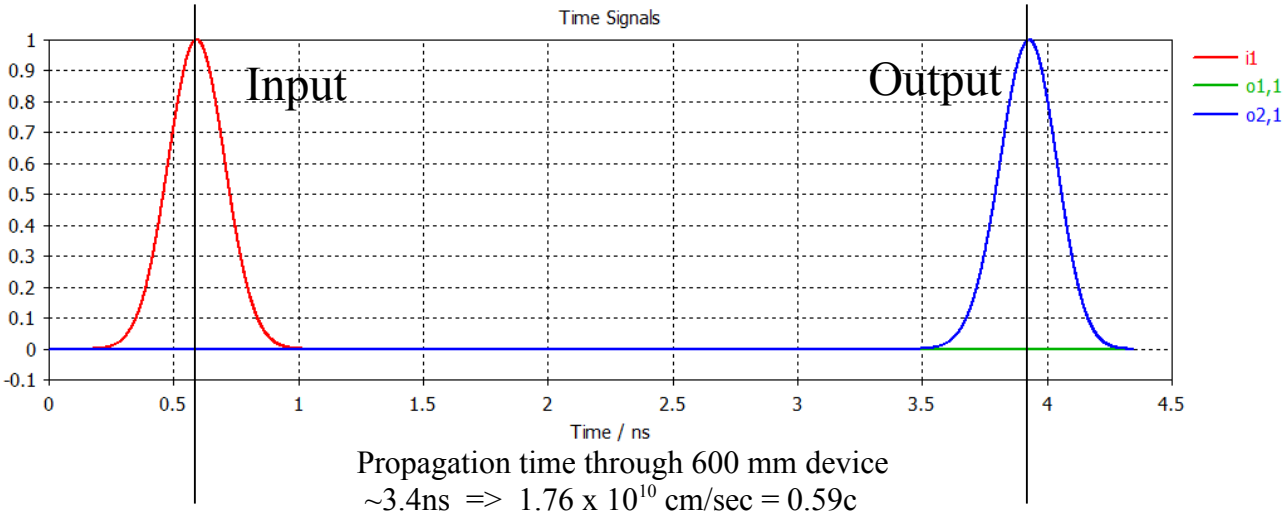
Simulated S_{21} of the stripline detector with 10 mm electrode (5 dB/div)



Original Kapton Flex Circuit Stripline

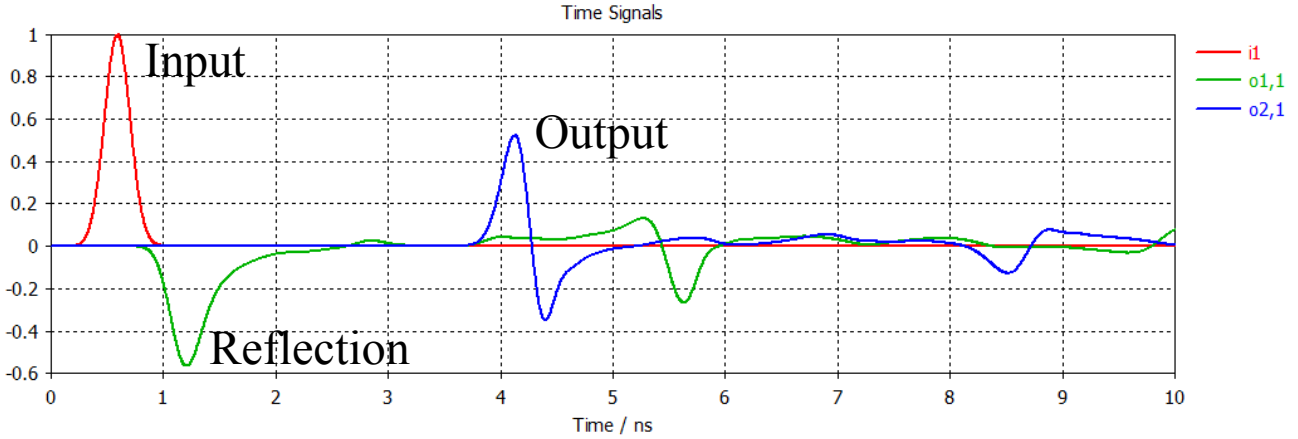
Pulse response comparison

Uniform 0.3 mm stripline on Kapton



Propagation time through 600 mm device
~3.4ns => 1.76 x 10^{10} cm/sec = 0.59c

Stripline with tapers to 10 mm electrode on Kapton



Quad Detector at 15W

Summary

- Detector radial size is limited to about 20 mm beyond the O.D. of the pipe.
- The SMA feedthrough may not fit if aligned longitudinally. This will depend upon the required wall thickness and weld clearance.
- If the SMA does not fit longitudinally, a right angle may be needed.
- Adding a ceramic dielectric 3 mm thick ($\varepsilon_r = 9.6$), the overall height can be increased to 15 mm (the top of the box is the second ground plane).
- Final dimensions will need to be optimized.
- The simulated stripline S parameters do not show signs of resonance.
- The ceramic by itself has resonances only above 2.5 GHz.
- Simulations show that the new stripline should have better frequency characteristics than the original flex circuit detector.