IEEE SW Test Workshop
Semiconductor Wafer Test Workshop

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Reinforcement of PCB using Advanced Stiffeners for High Pin Count Devices

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Overview

- Why Reinforce the PCB?
- Objective : Fight the Deflection!
- Customer Case Study
- Calculation using Analytical Techniques
- Analysis with FEA Simulation
- Reduce the Deflection with Advanced Stiffener & Pogo Modules Optimization
- Summary/Conclusion

Why Reinforce the PCB ?

- With Devices getting More Complex :
  - Need of increased Pin Count per Probe Head
  - Growing Need of Tester Channel Resources with more Pogo Module & Population
- By Definition the PCB is Subjected to Probe Force and Pogo Tower Load

- Risk : PCB Deflection Creates Probe Contact Issue with Wafer (Yield Drop, Opens…) & fatigue failure during lifetime.

Fight the Deflection!

Questions to resolve:

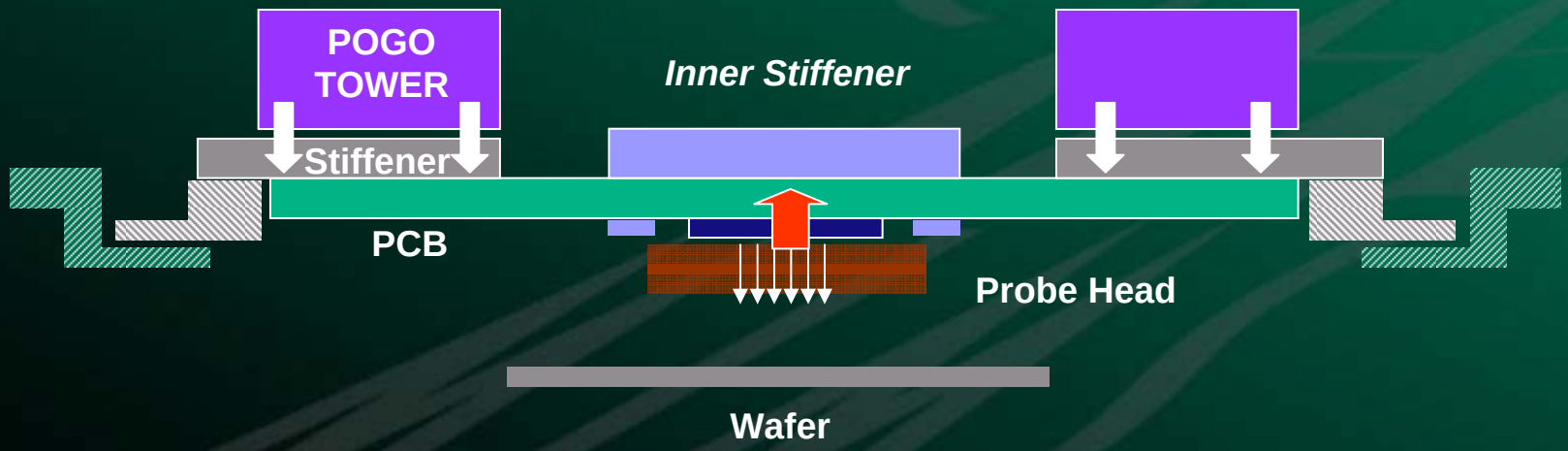
1. Is my standard stiffener (or added stiffener) good enough to reduce deflection generated from Pogo load & Probe force?
2. Where are the most critical deflection areas located on my PCB?
3. Can I quantify the maximum deflection value?
4. How do I define the best Advanced Stiffener parameters (thickness, spokes number, width…)?

➢ Let's go through a Customer Case Study

Customer Case Study

Issue:

"Probe Head planarity issue on the wafer: about 100µm (4mils) OD to get the full contact". Standard planarity should be 2 mils (50µm).

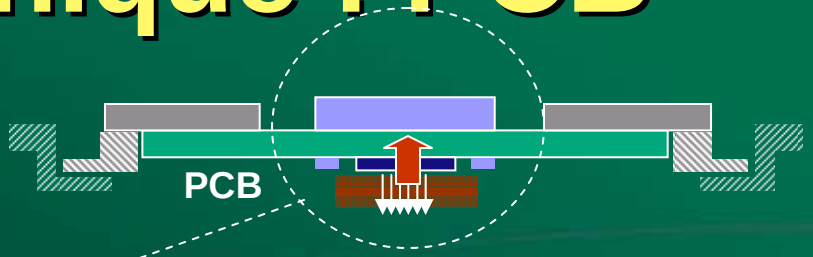


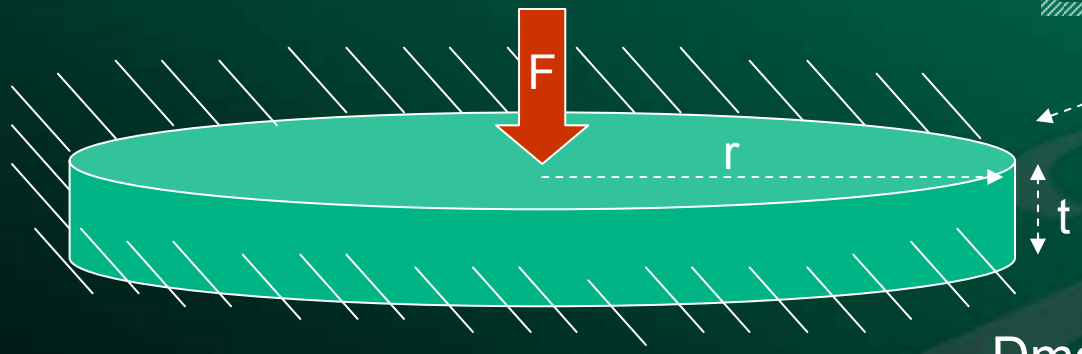
Test Description :

8300 Probes, 3 mils, Flat Tip, Room Temp, Prober Reliable.
PCB Thickness 4.75mm, Outer Diameter 280mm, Inner Diameter 180mm.
Stiffener Thickness 12.7mm

Analytical Technique : PCB

Based on Kirchhoff Theory





$$Dmax = -\frac{(10 \times F) \times r^2 \times 12(1-\sigma^2)}{16\pi \times E \times t^3}$$

$$Dmax = f\left(\frac{F \times r^2}{t^3}\right)$$

Dmax : PCB Max Deflection (mm)

F : Total Probe Force (Kg)

r : PCB Inner Radius (mm)

t : PCB Thickness (mm)

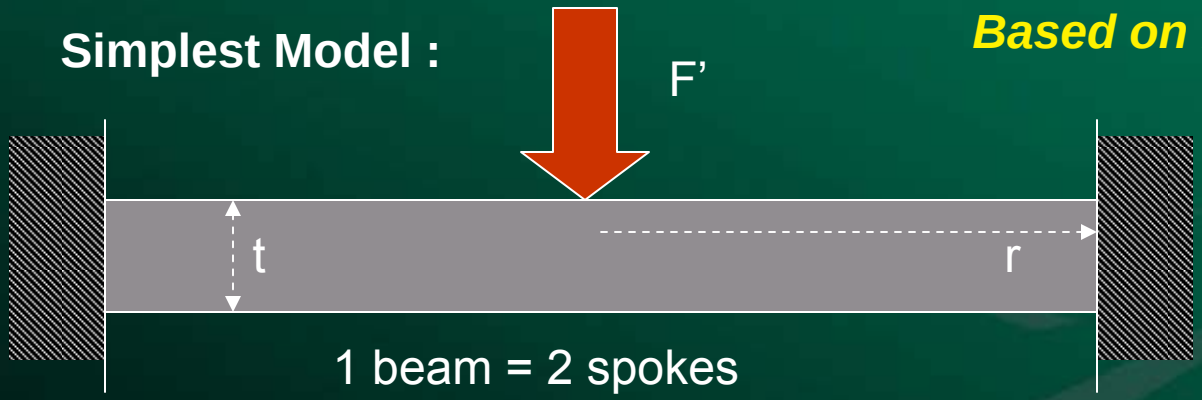
σ : PCB Poisson's Ratio

E : PCB Young's Modulus (MPa)

PCB Dmax = 556μm

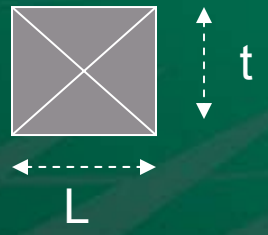
Analytical Technique : Stiffener

Simplest Model :



Based on Beam Theory

Spoke Section



$$Dmax = -\frac{(10 \times F') \times (2.r)^3 \times 12}{192 \times E \times L \times t^3}$$

With F’=F/(n/2)

$$Dmax = f\left(\frac{F \times r^3}{n \times L \times t^3}\right)$$

Dmax : Spoke Deflection Max (mm)
F : Total Probe Force (Kg)
F’ : Force on One Beam (Kg)
r : Spoke Length (mm)
t : Spoke Thickness (mm)
L : Spoke Width (mm)
n : Number of Spokes
E : Spoke Young’s Modulus (MPa)

Stiffener Dmax = 90µm (with n= 4 and L = 6mm)

Observation

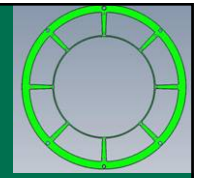
Analytical Technique Gives an idea of the Deflection of the Individual Entities such as the PCB or Stiffener Spokes, however :

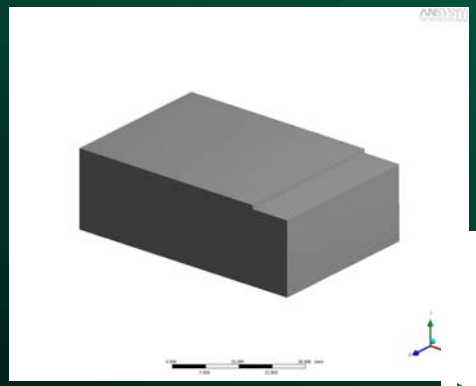
-It is a “2D Analysis” Estimating the Max Deflection

-Not Possible to do Complex Assembly Stack-up Studies

-Not Possible to Evaluate Multiple Load Cases

FEA Reminder





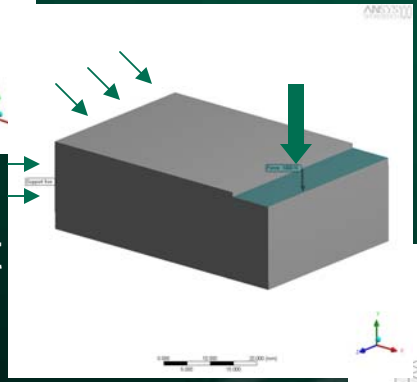
3D
Modeling

Force Load,
Boundary
Condition &
Material Properties

COSMOS

&

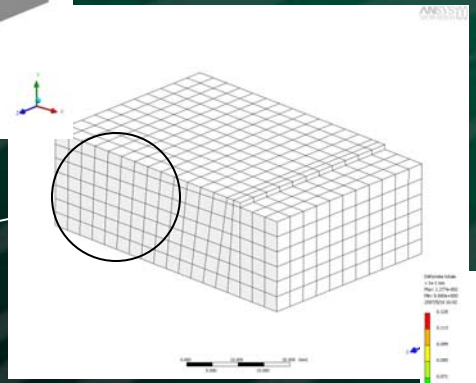
ANSYS
Workbench



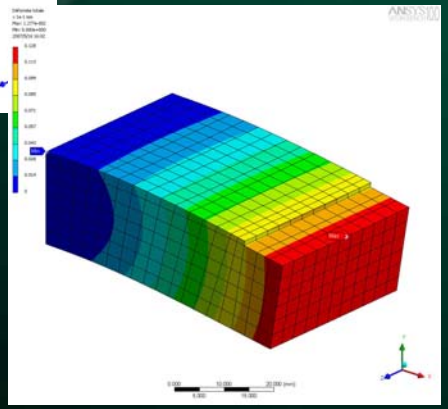
Ui = Displacement

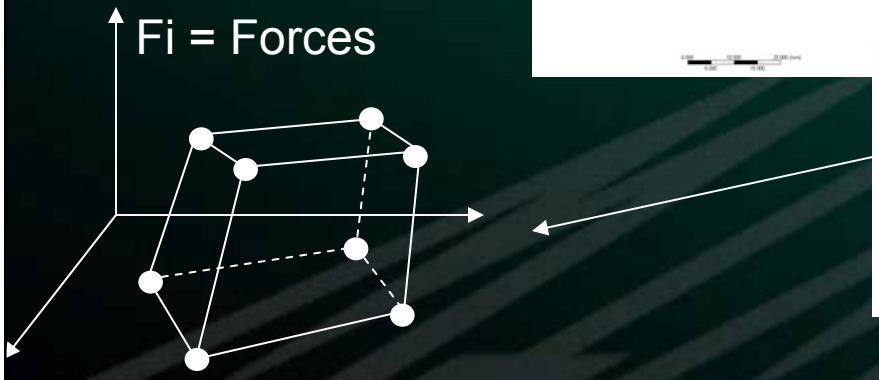
Fi = Forces

Meshing
Procedure



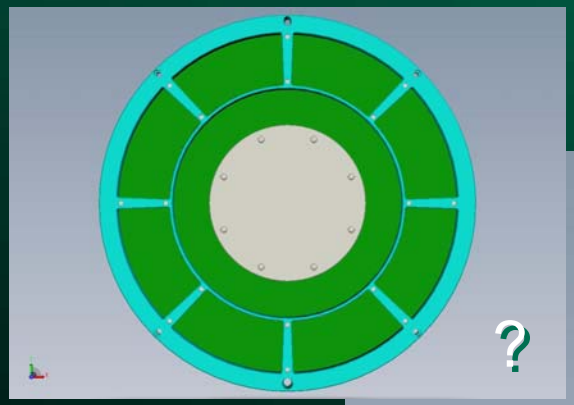
Computation &
Visualization

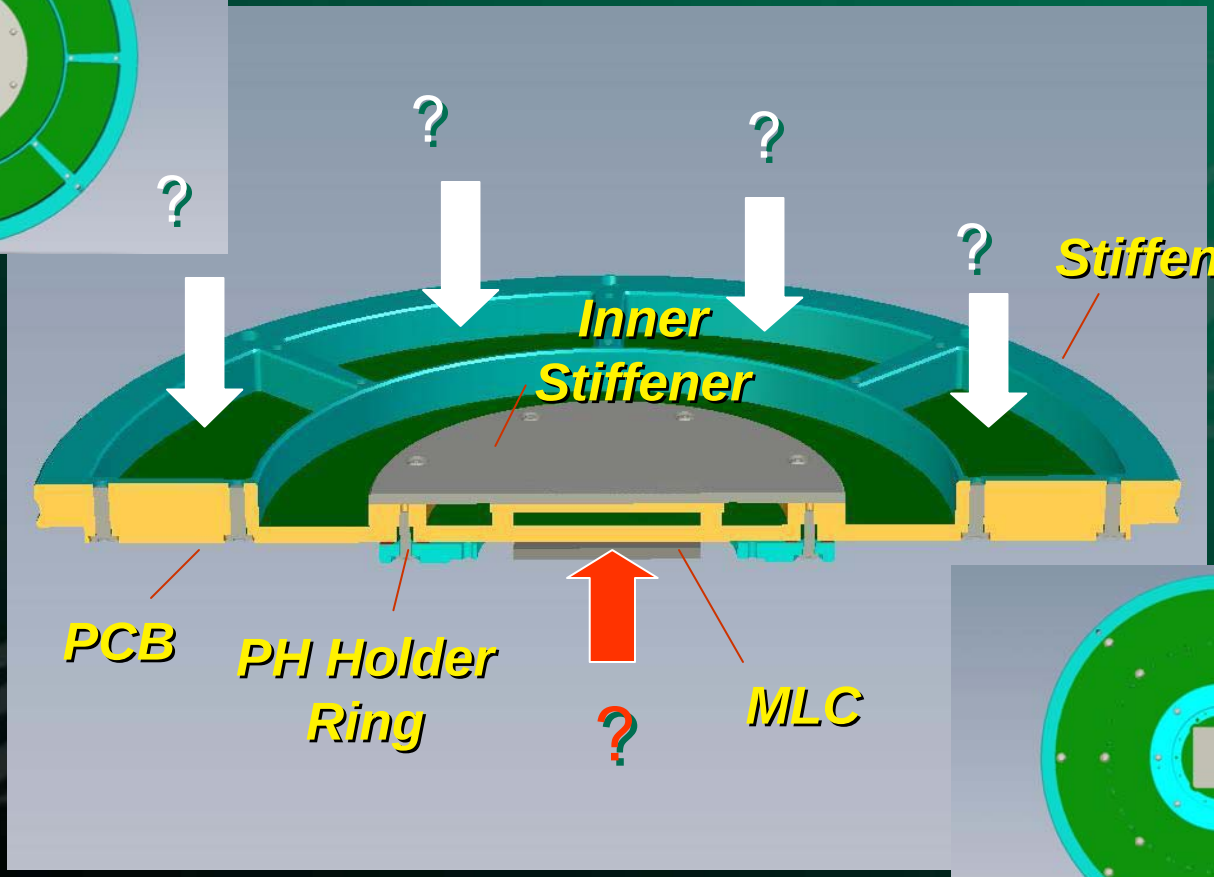


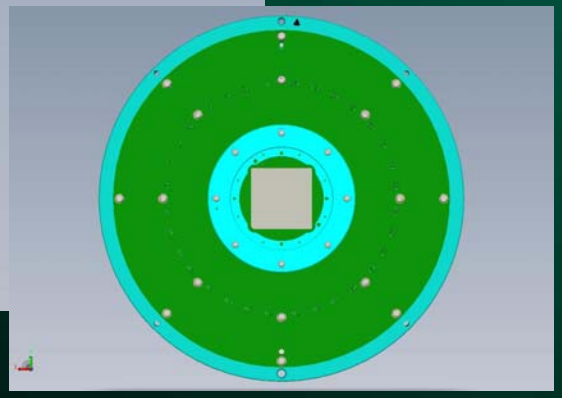


Break the Model up into Small
Element with Nodes

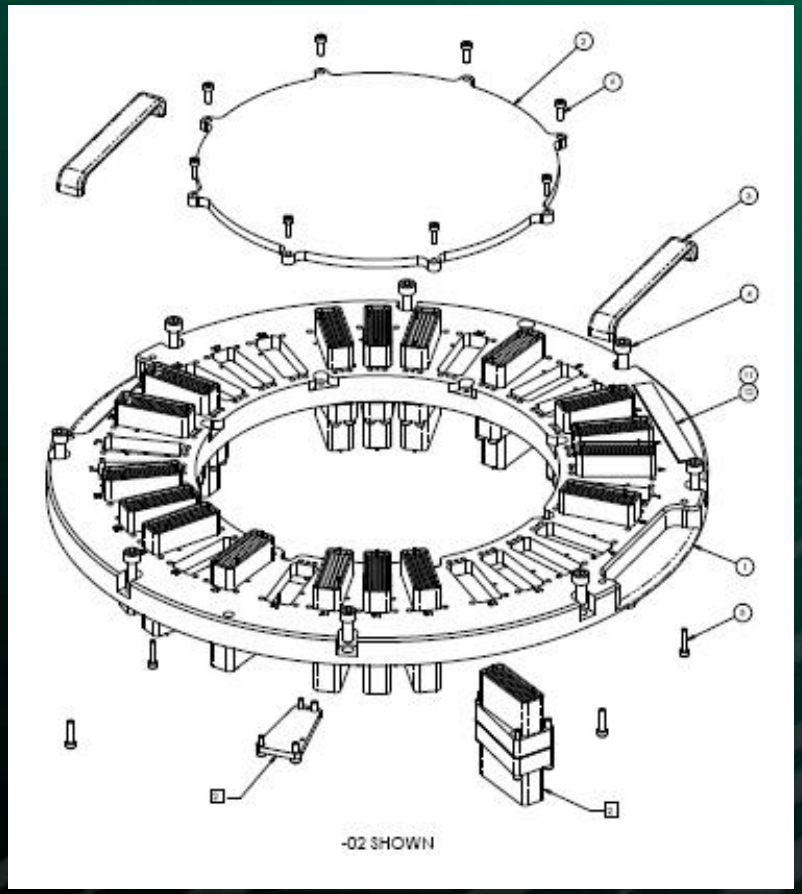
3D Space Modeling

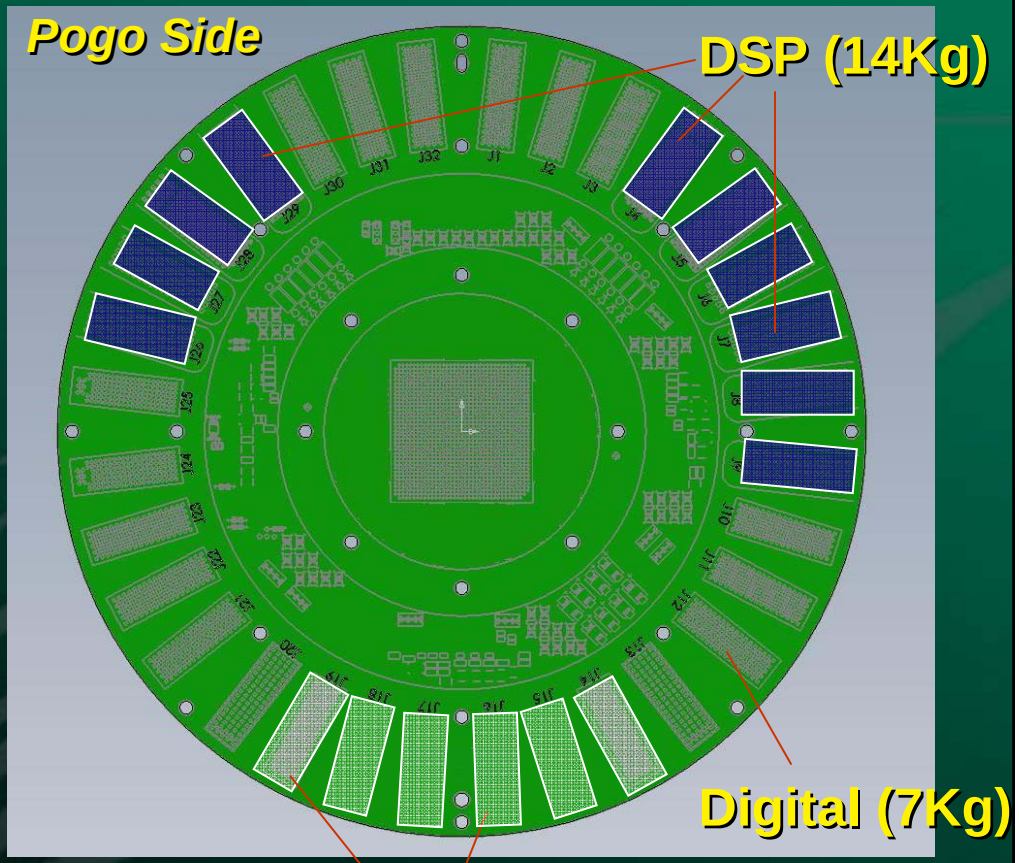






Pogo Module Load on PCB



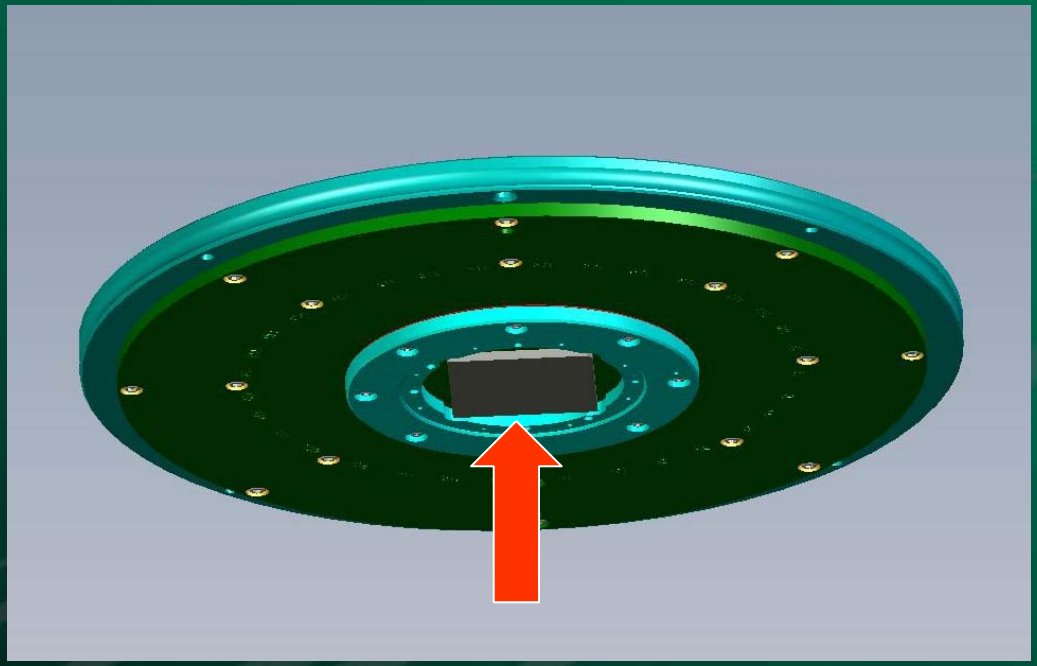


Total = 255Kg

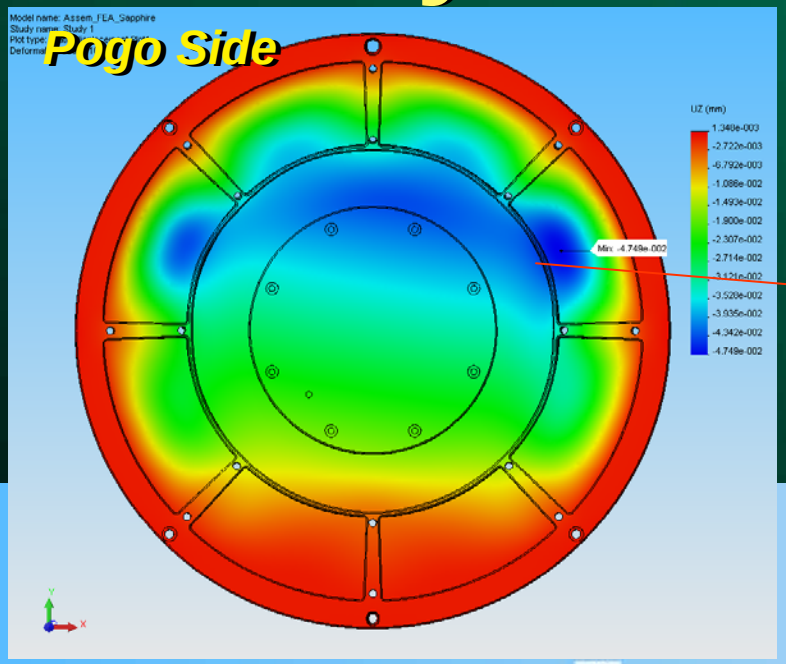
Probe Load on PCB

- 8300 Probes
- 3 mils Probes
- 2.5g/mils
- 5 mils Overdrive

Total = 103Kg

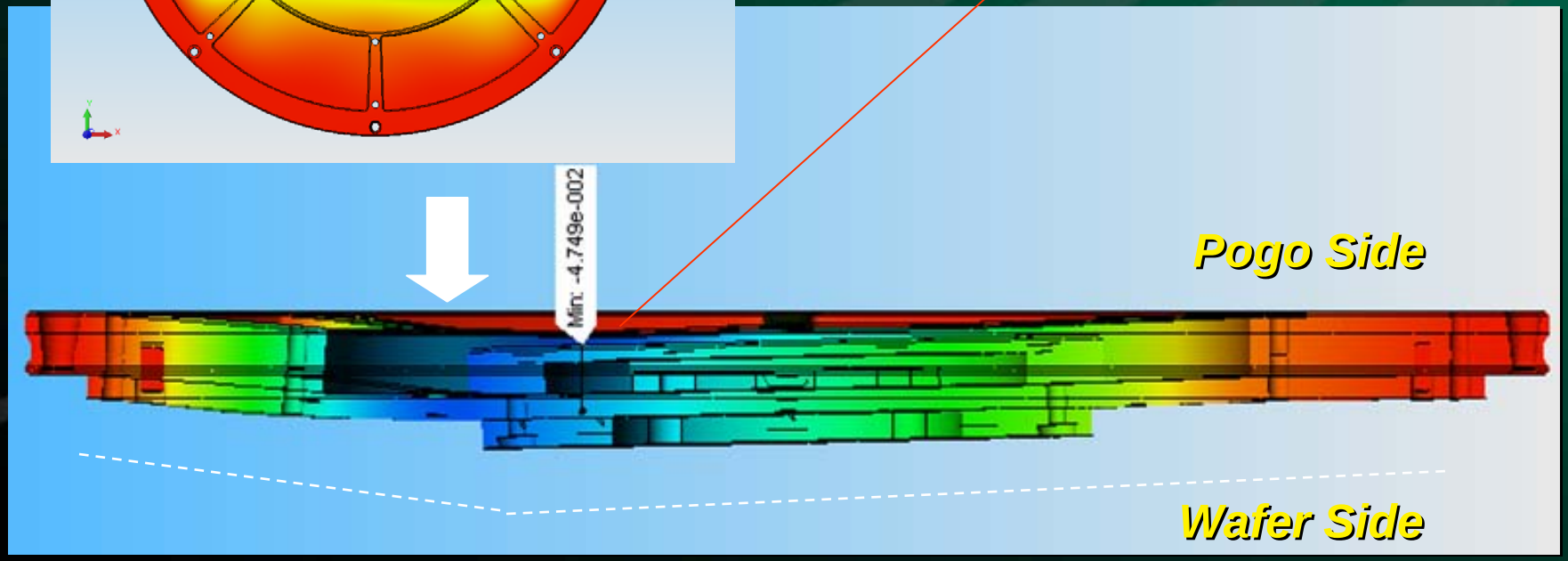


Only with Pogo Force

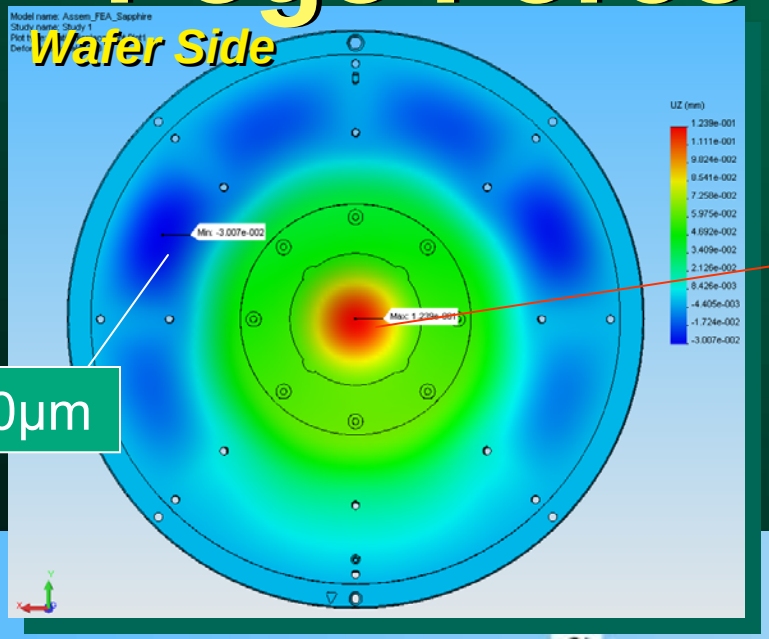


Maximum Displacement
(on Wafer Side Direction):

50µm



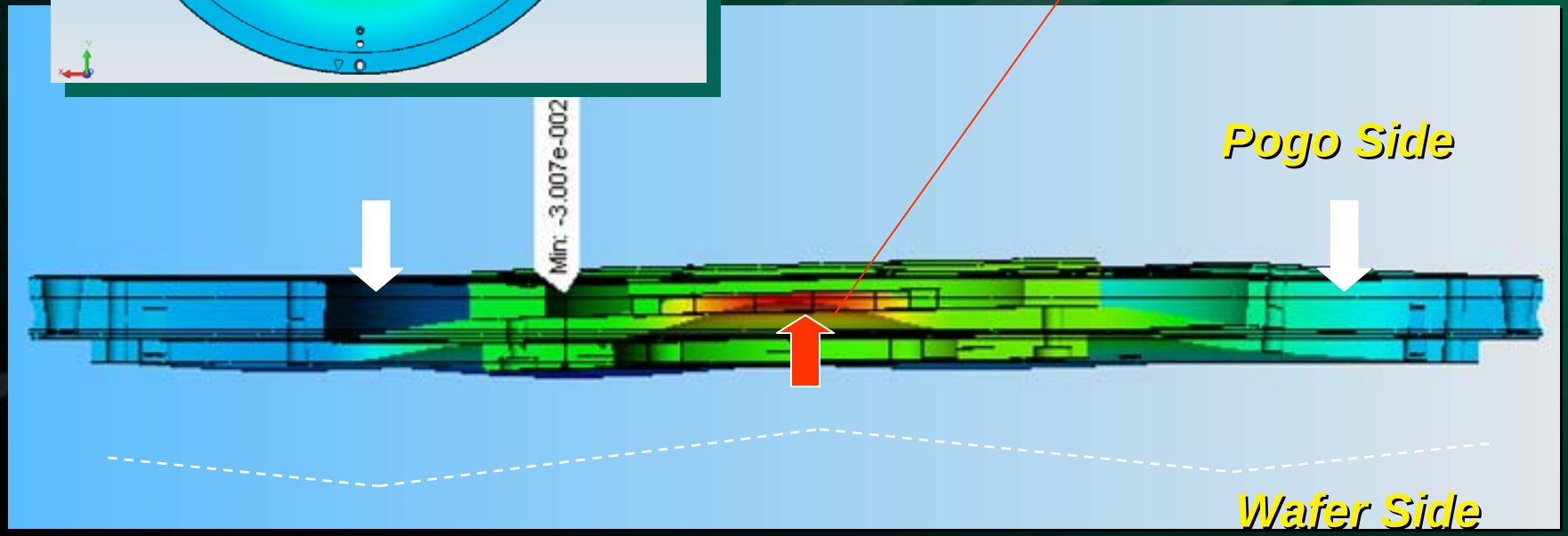
Pogo Force & Probe Load



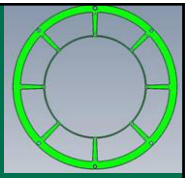
-30µm

Maximum Displacement (on tester side direction) :

120µm



Observation



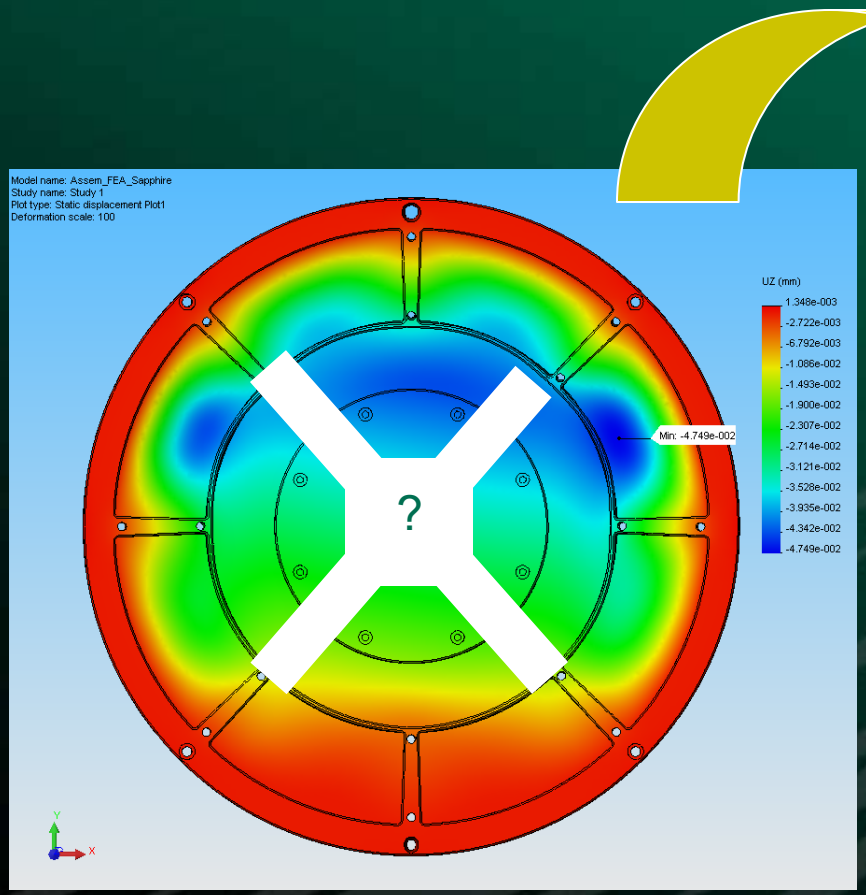
Pogo Force Creates a 50µm Deflection of the PCB Top Area:

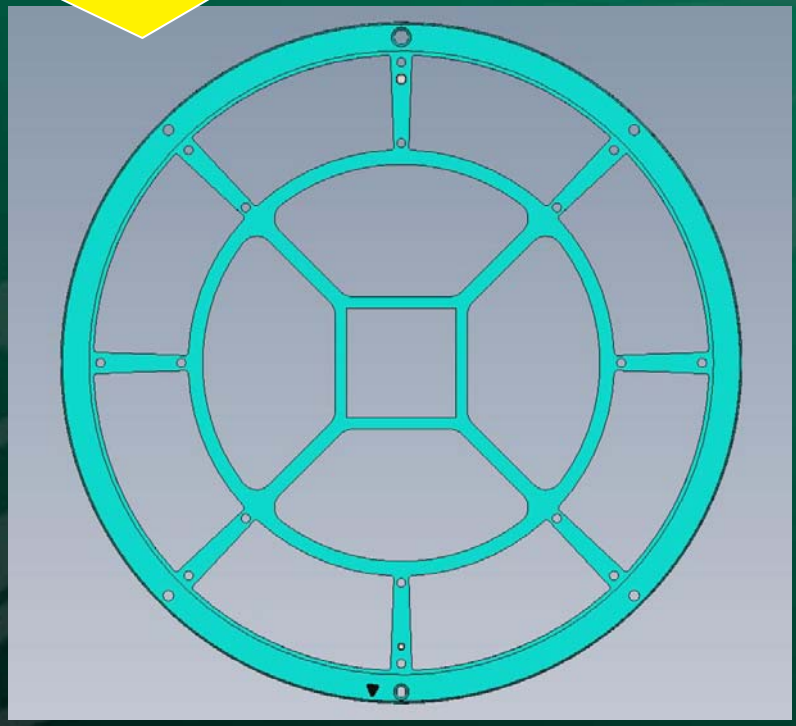
- Unbalanced Pogo Module Force Repartition

Pogo Force with Probe Force Load gives a Deflection of about 120µm on the Center PCB Area :

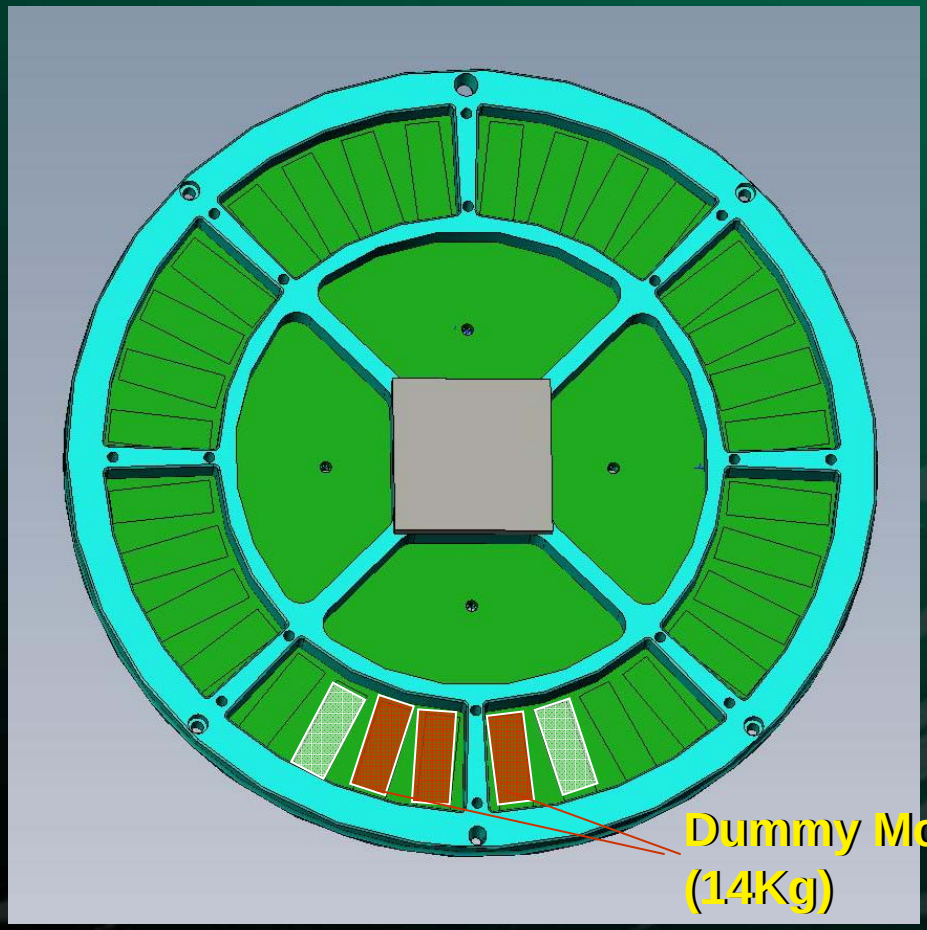
- Inappropriate Standard Stiffener Design

Reduce Deflection - Phase 1





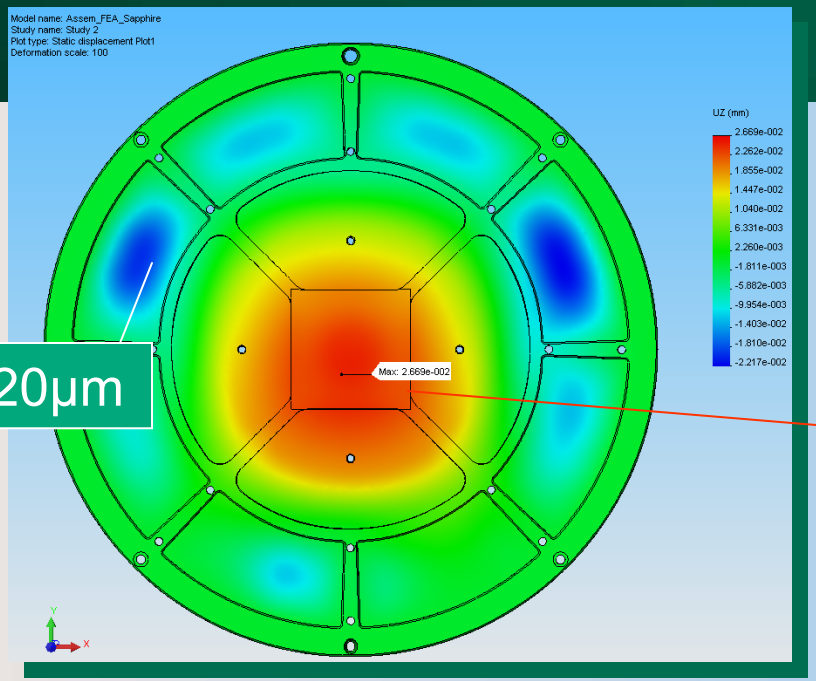
4 Spokes & Dummy Pogo



- Stiffener Thickness : 12.7mm
- Spoke Number : 4
- Spoke Width : 6.76mm
- Dummy Pogo Modules added to Balance the Force over the PCB

Total = 296Kg

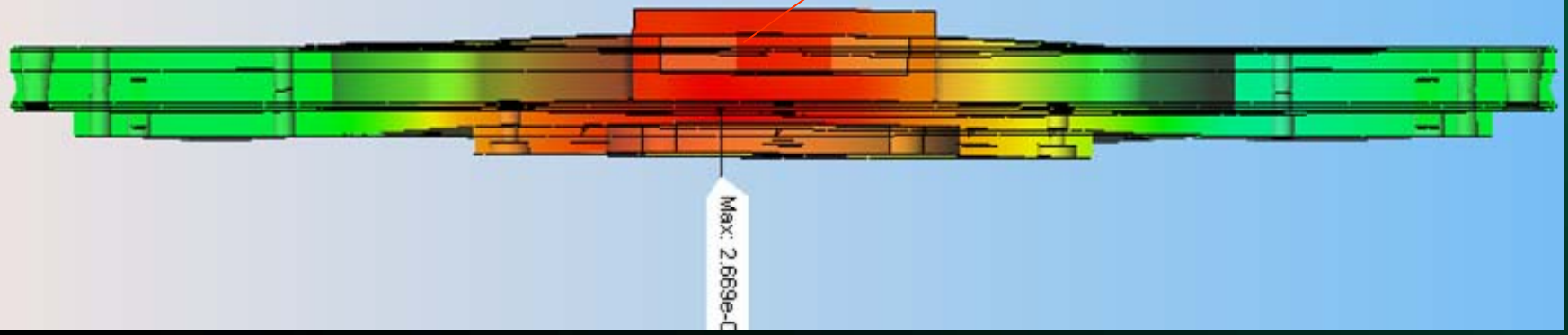
Z Deflection



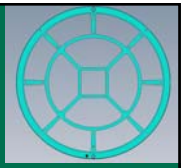
-20µm

Maximum Displacement (on Tester Side Direction) :

25µm



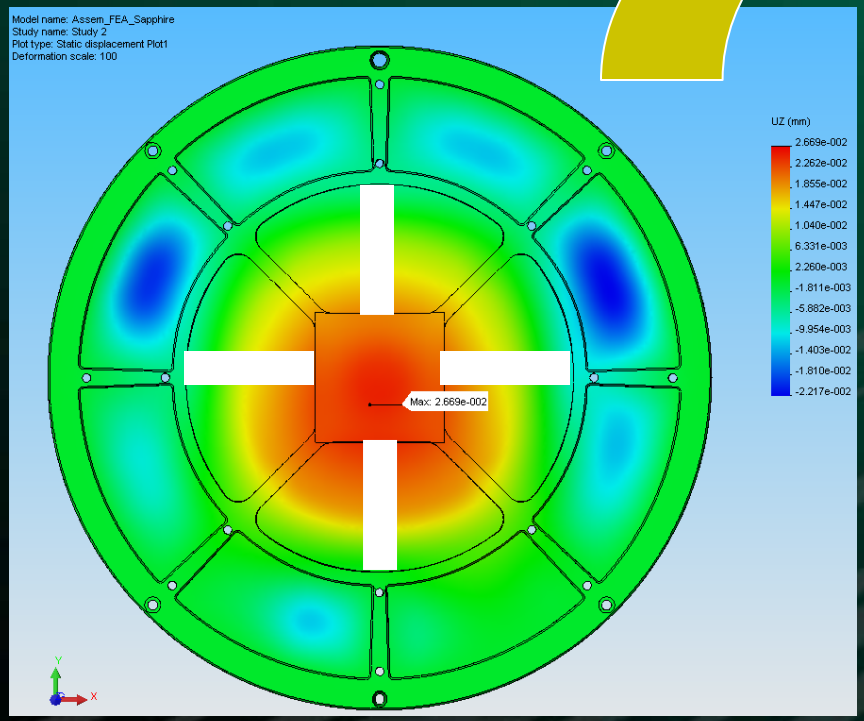
Observation

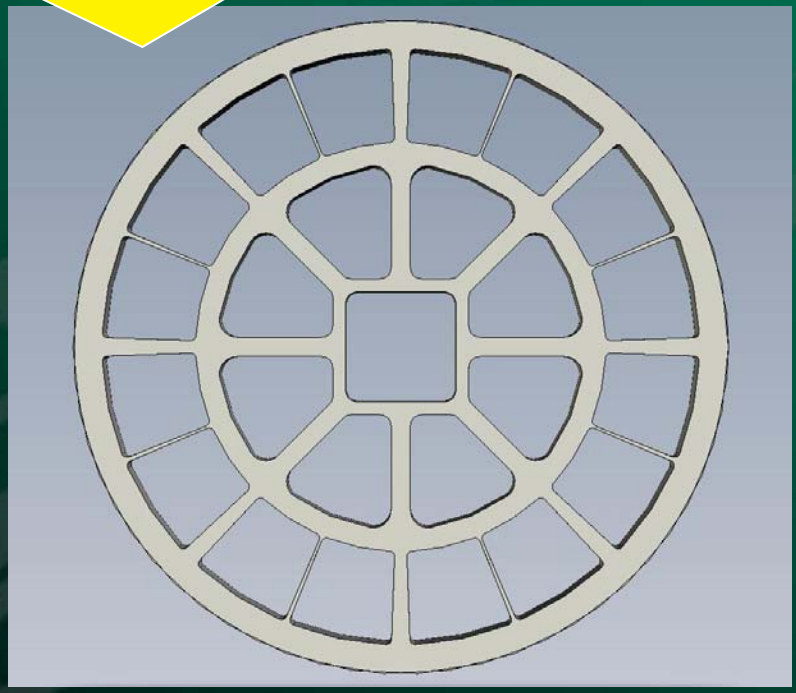


- 4 Spoke Stiffener Reduced the Maximum Deflection from 120µm to 25µm (5 times) and Total Deflection is more evenly Spread out

- Dummy Pogo Module can Help to Balance the Deflection over the PCB but has Limitation (add more load and max deflection still not in center of PCB)

Reduce Deflection - Phase 2



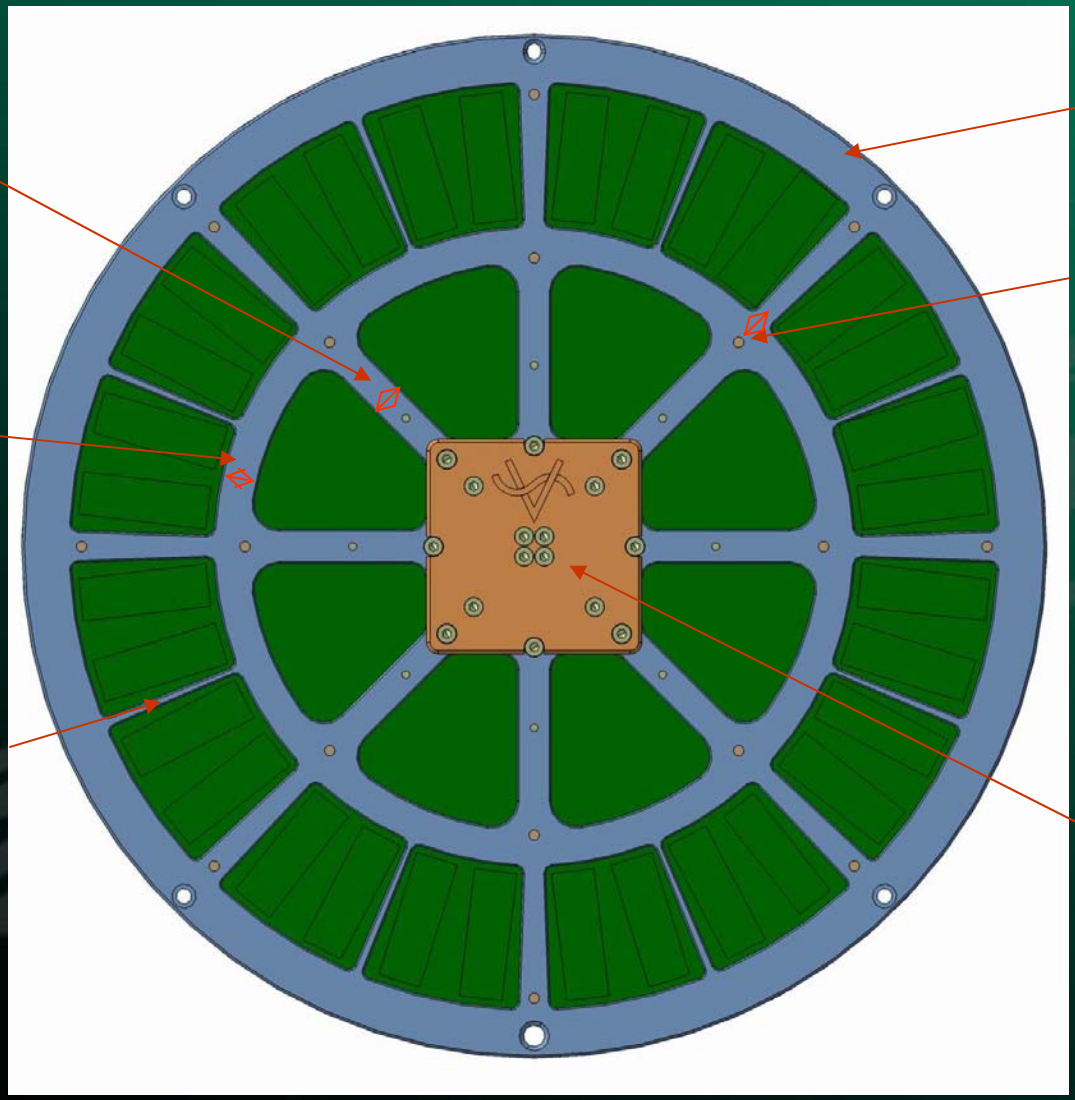


8 Spoke Stiffener

X8 extra Inner Spokes (10mm Width)

Wider Section

x8 Spokes between Pogo Modules

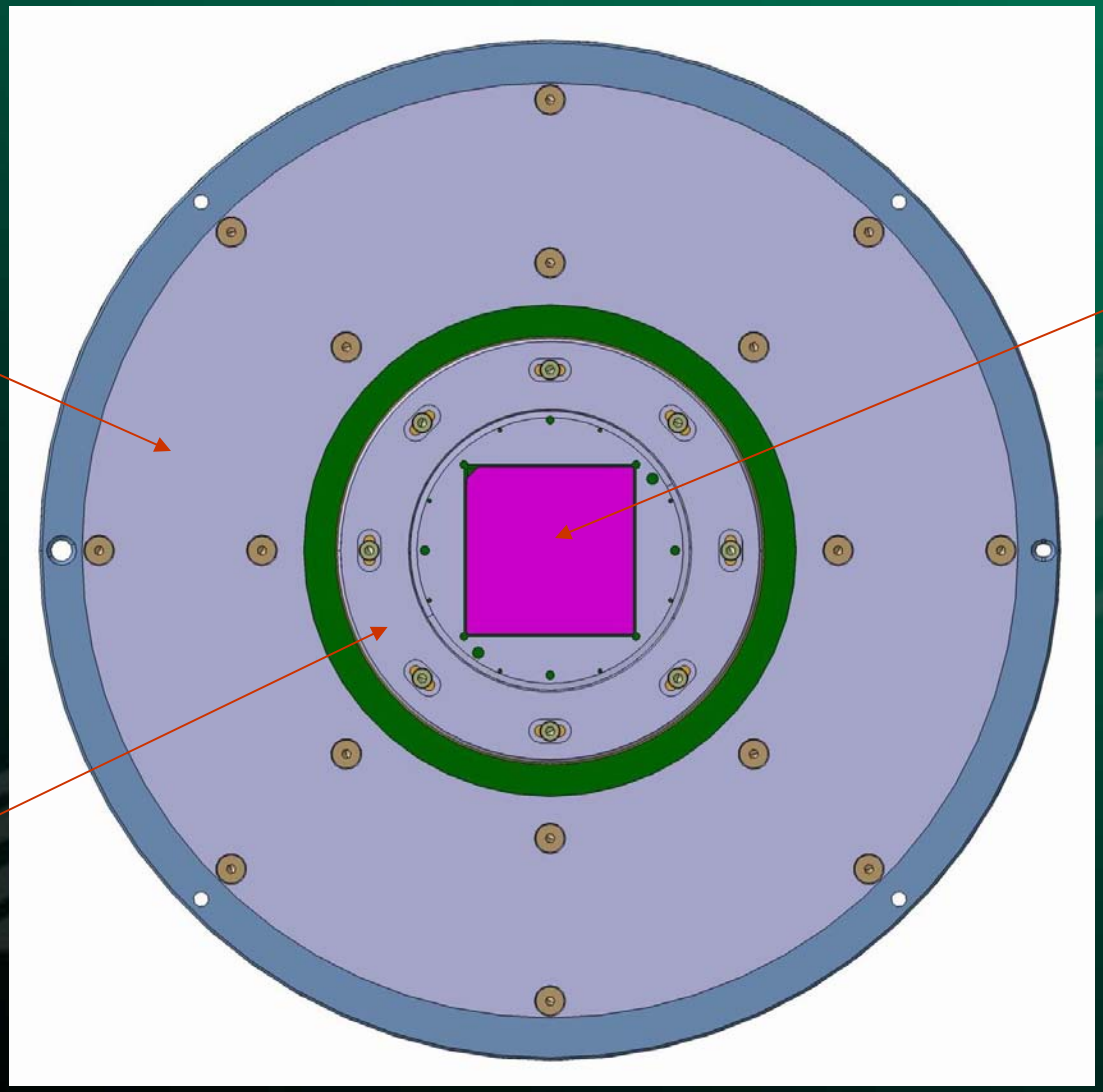


.6inch (15mm) Thickness

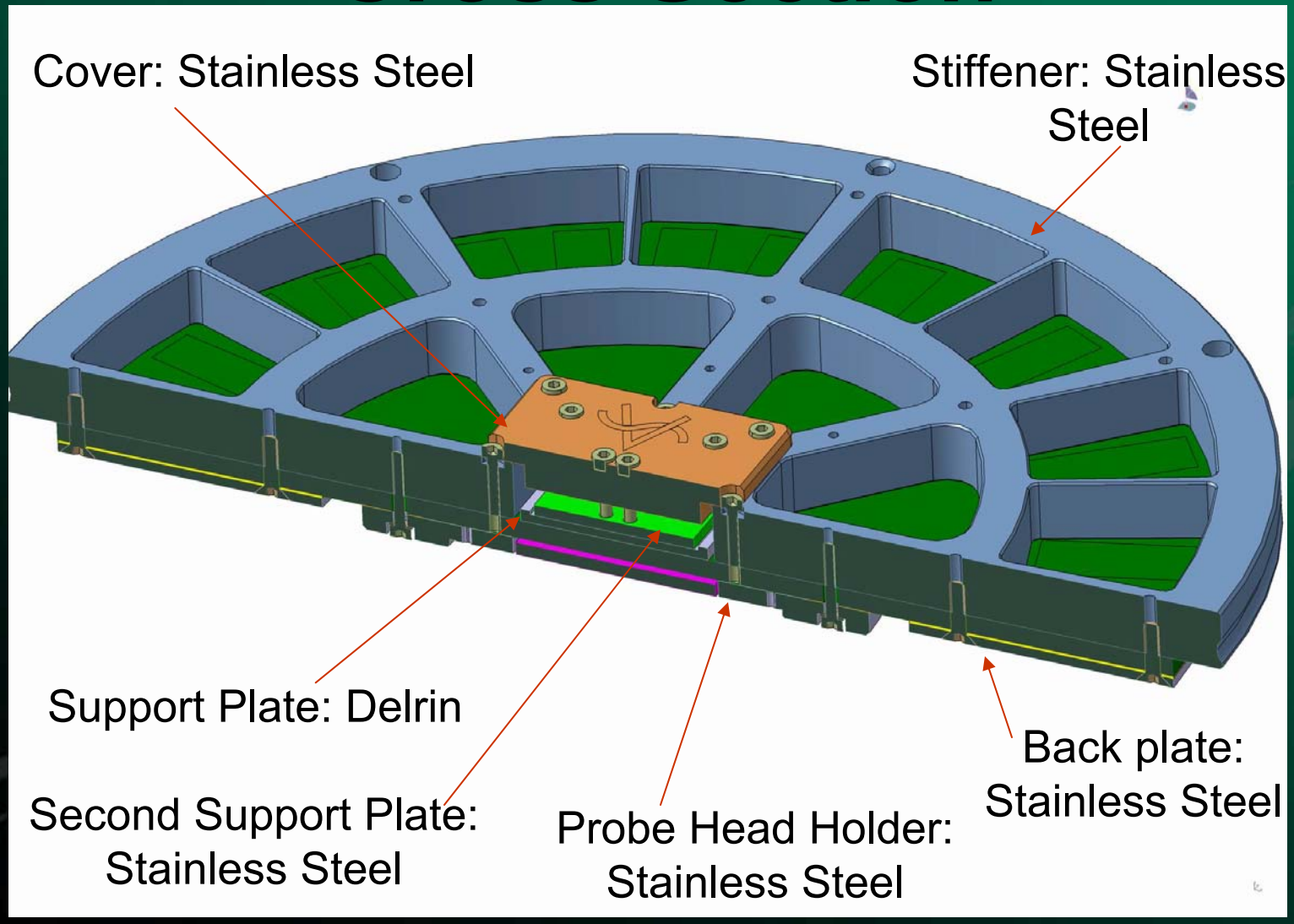
Shift of Screw Position to a Wider Spoke Area

Square Center with Screws to Reduce Deflection above the MLC

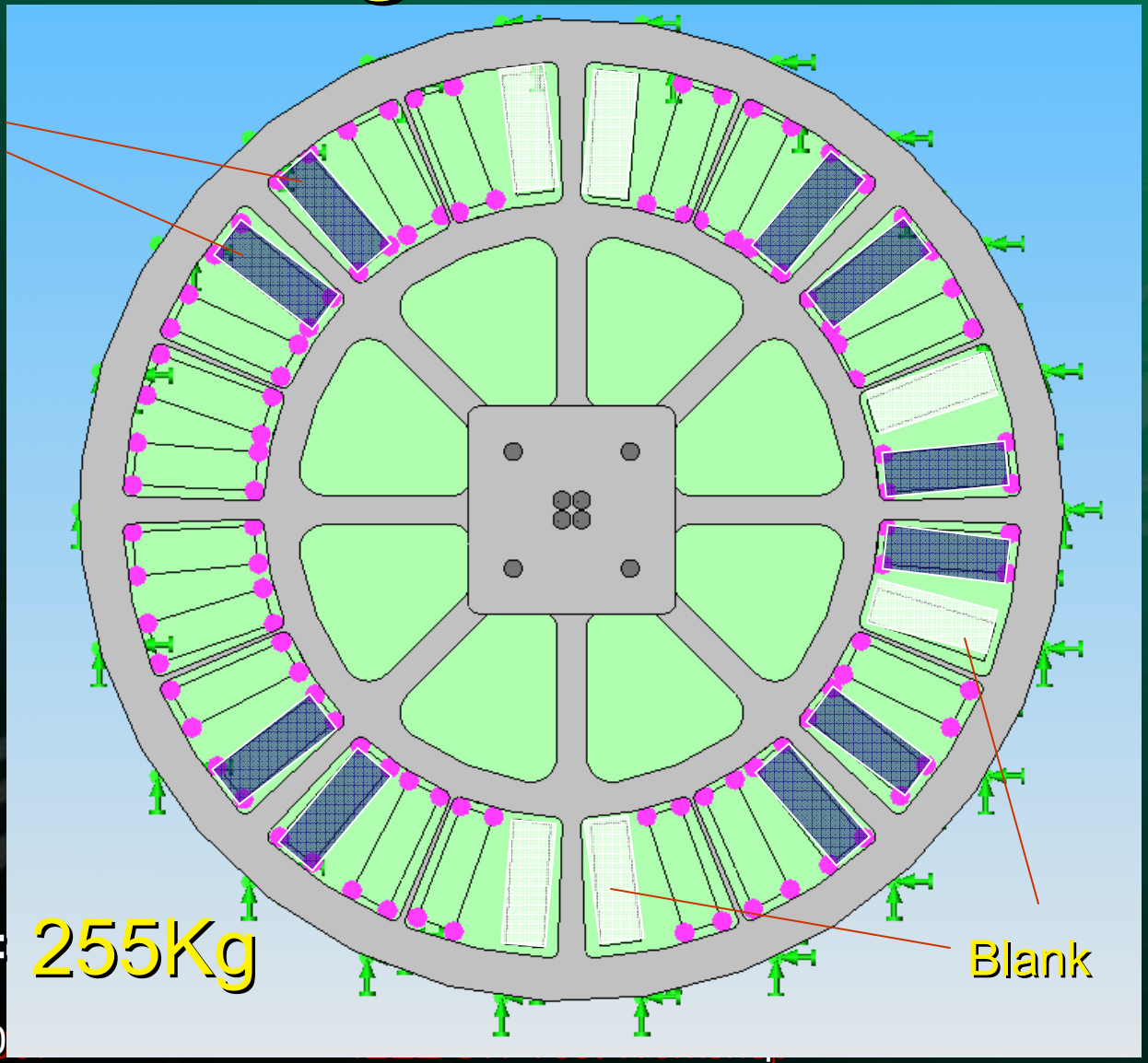
Back Plate Stiffener



Cross Section

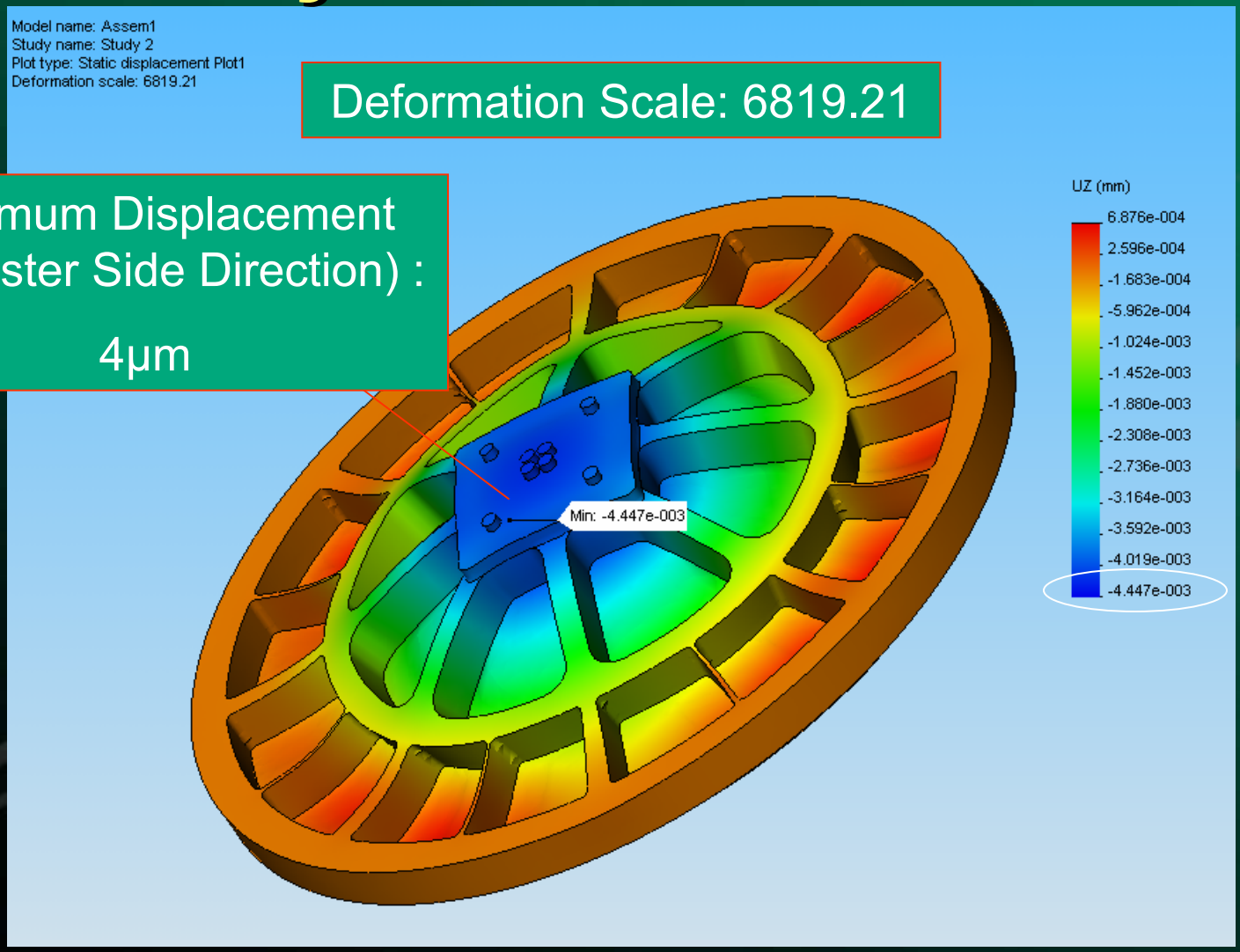


New Pogo Module Load

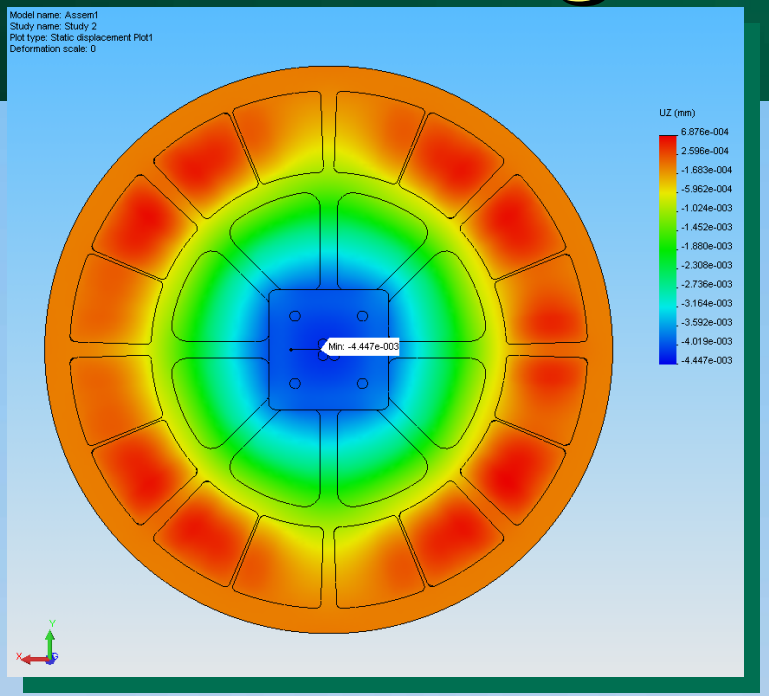


Total = 255Kg

Very Low Deflection

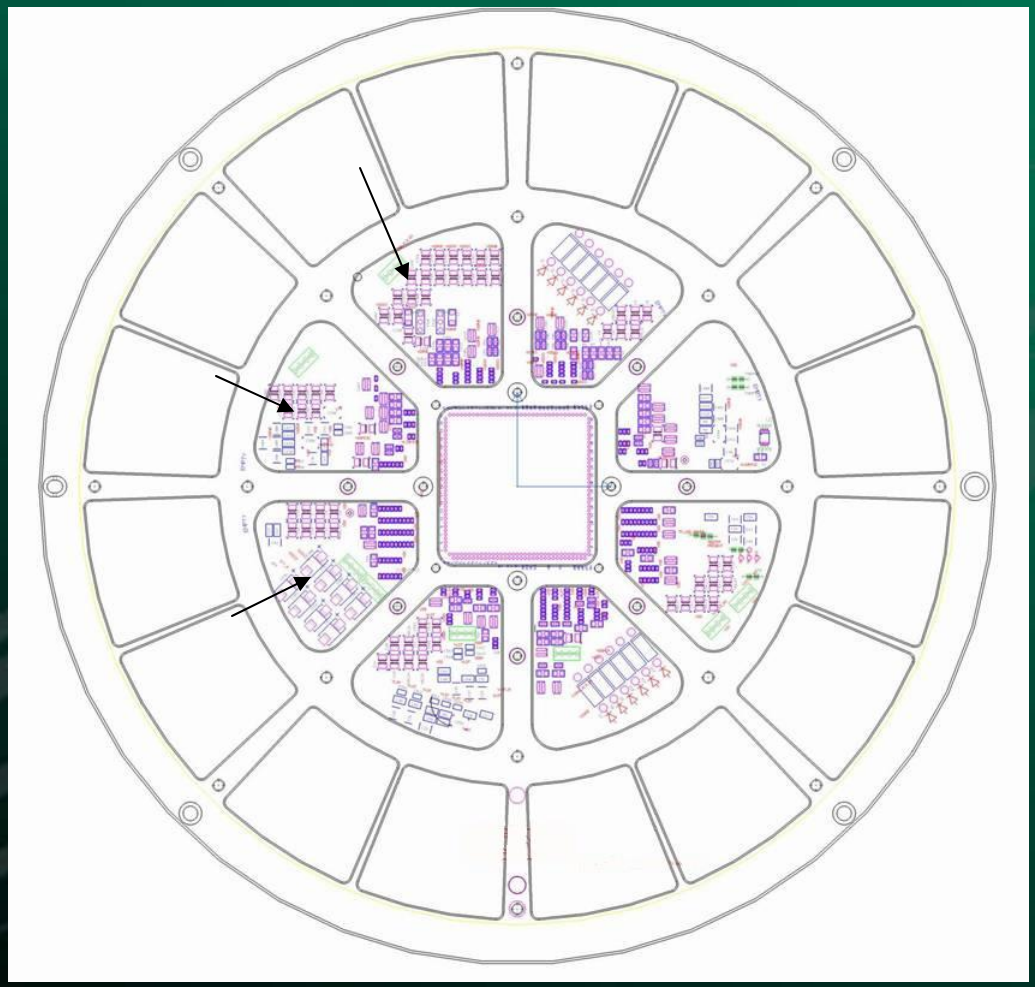


Homogenous Deflection



Last Thing to Check…

✓Enough Room for Component Placement !



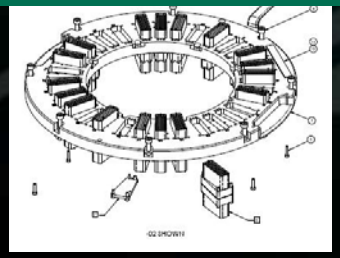
Summary

	Analytical Calculations	Standard Design	☑ 4 Spokes ☑ Dummy Module	☑ 8 Spokes ☑ Back Plate ☑ New Pogo Configuration
Max Deflection	>500µm (Only PCB) 90µm (4 spokes)	120 µm	25 µm	4 µm
Comments	Only Estimation	High Deflection and Unbalanced Load	x5 time Reduction	x30 time Reduction 

Conclusion

- Use Analytical Solution to Evaluate the Deflection Range. Deflection is Inversely Proportional to Thickness (Power of 3), Spoke Width and Spoke Number.
- FEA to Understand the Root Cause and Reduce Deflection:
  - Define a 3D Model with Appropriated Load and Boundary Condition
  - Find the Critical Areas and Quantify the Max Deflection
  - Optimize the Spoke Parameters and Pogo Population

Pogo Module Optimization



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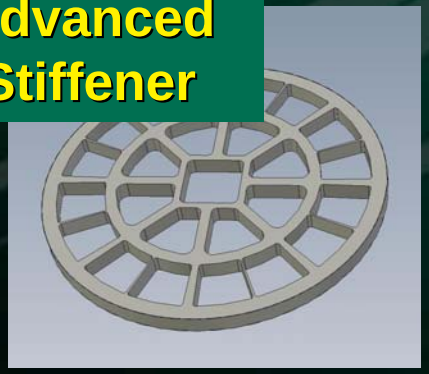
Advanced Stiffener



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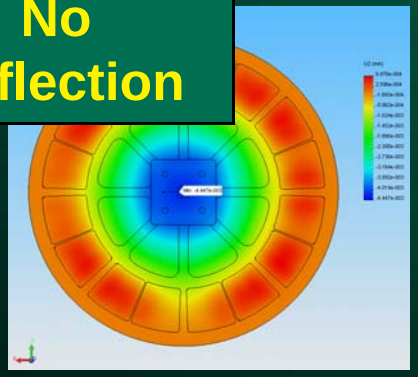
No Deflection



Thanks for Your Support !

SV Probe Team : JB Hollstein, Isabelle Garidi, Karen Lynch, Pete Rogan, Bahadir Tunaboylu, Rehan Kazmi, JM Leger.

QUESTIONS ?