Development of a low material endplate for LP1 and ILD

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At previous meetings,

2010-03-04,
discussed the Aluminum-Carbon Fiber hybrid design
comparison of FEA with measurements on an LP1 endplate,

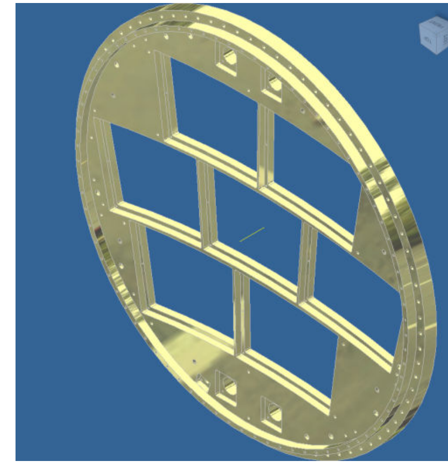
2010-03-18,
discussed the preliminary space-frame design.

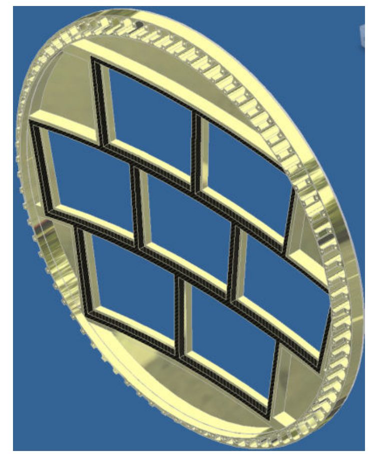
Now,
the space-frame design is significantly developed.

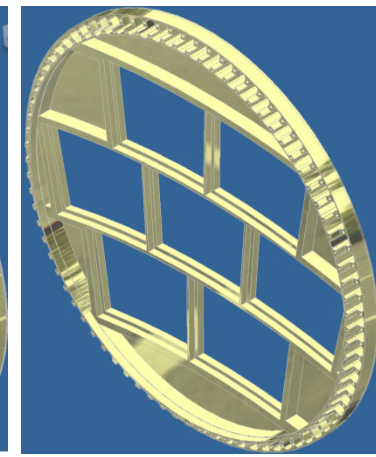
Comparison of candidate models

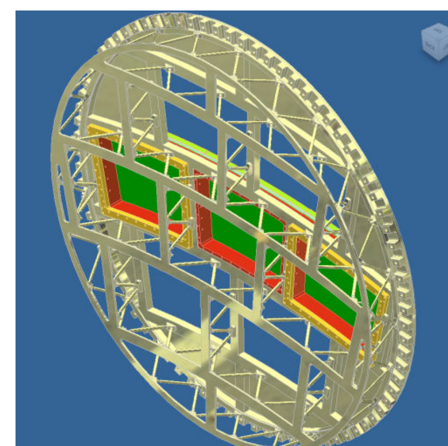
	mass kg	material $\%X_0$	deflection microns	stress Mpa (yield: 241)
LP1	18.87	16.9	33	1.5
Lightened (all aluminum)	8.93	8.0	68	3.2
Lightened (Al-C hybrid)	Al 7.35 C 1.29	7.2	< 168*	< 4.8*
Space-Frame	8.38	7.5	23	4.2

(* values for the aluminum only)









Material: space-frame has slightly more material than the Al-C hybrid.

Deflection: space frame is more rigid than LP1,
~3x more rigid than the lightened (all Aluminum),
and > 3x more rigid than the Al-C hybrid.

Space-frame model

Lightened outer rim

LP1 stiffening ring is removed.
Cut-outs in
radial machine tool direction
leave material for strut mount.

Lightened Uninstrumented Area

5mm thickness as in hybrid

Sheet back-plane

simple landing for strut mount
removes adjustment of back-plane

Between-Row Struts

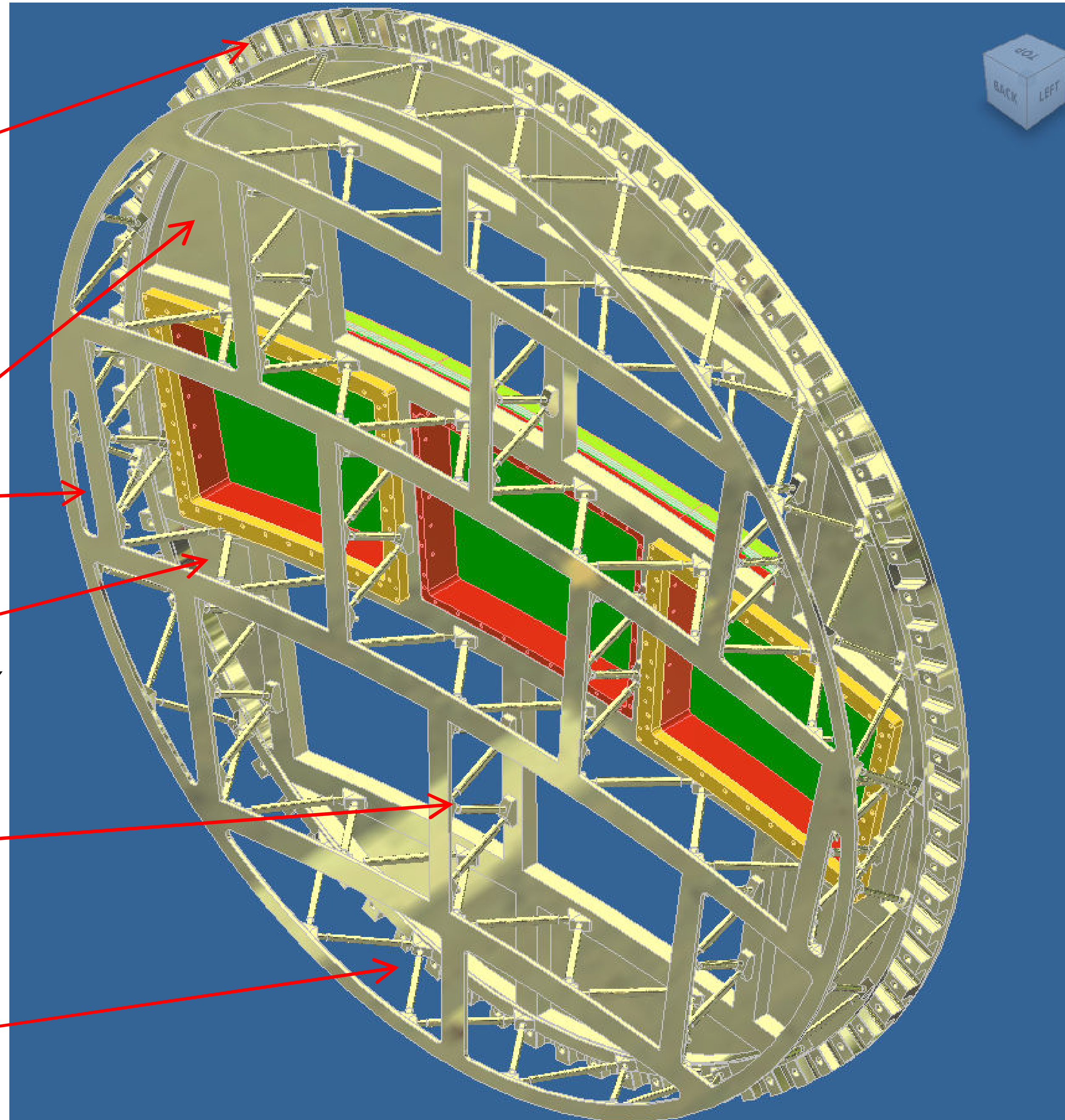
term change, these are now “struts”
not the major load carriers in the
ILD endplate
and can be low density

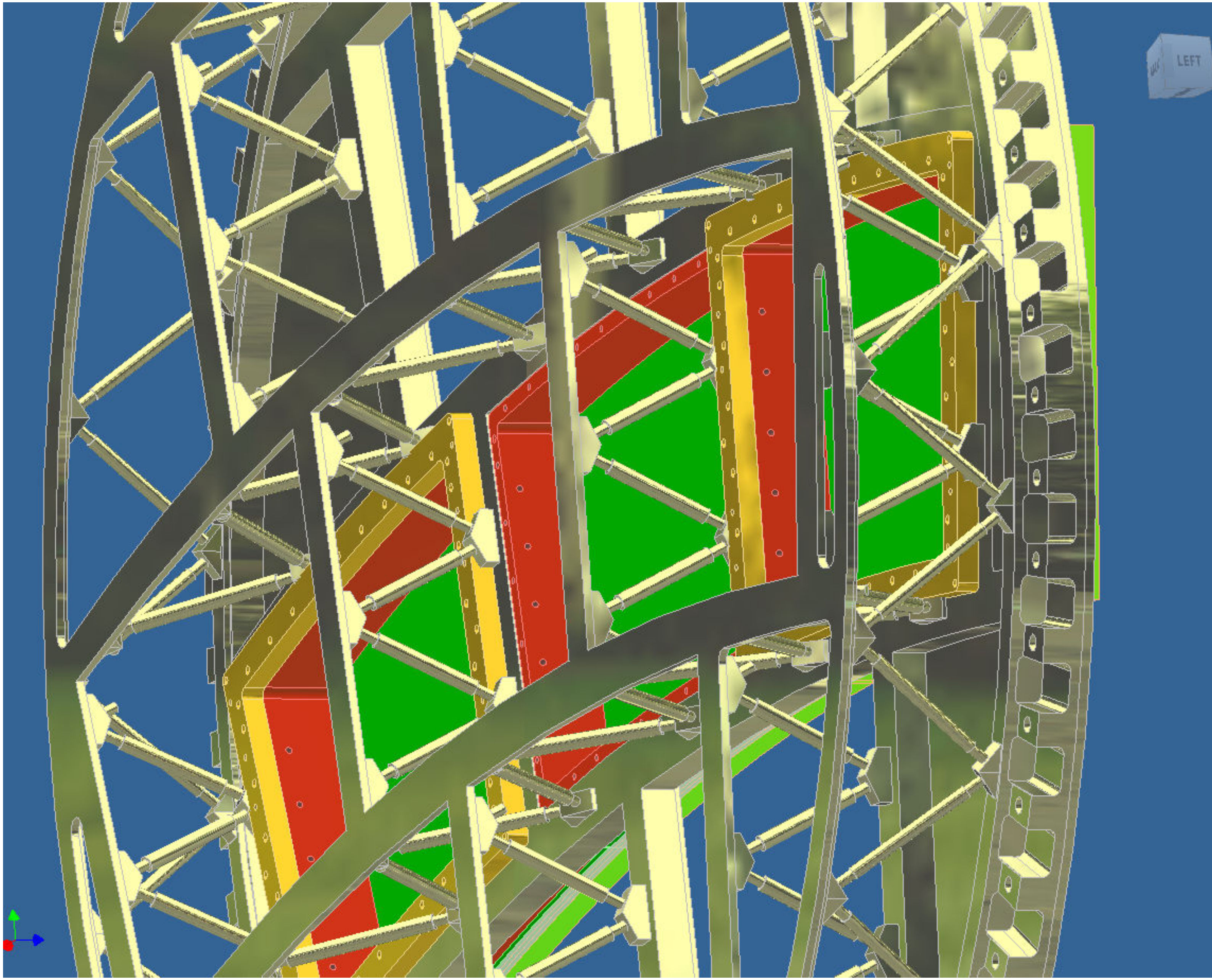
In-Row Struts

major load carriers in ILD
higher density

Outer circumference struts

termination as in ILD





This figure provides a different perspective and may be more clear.

Strut properties

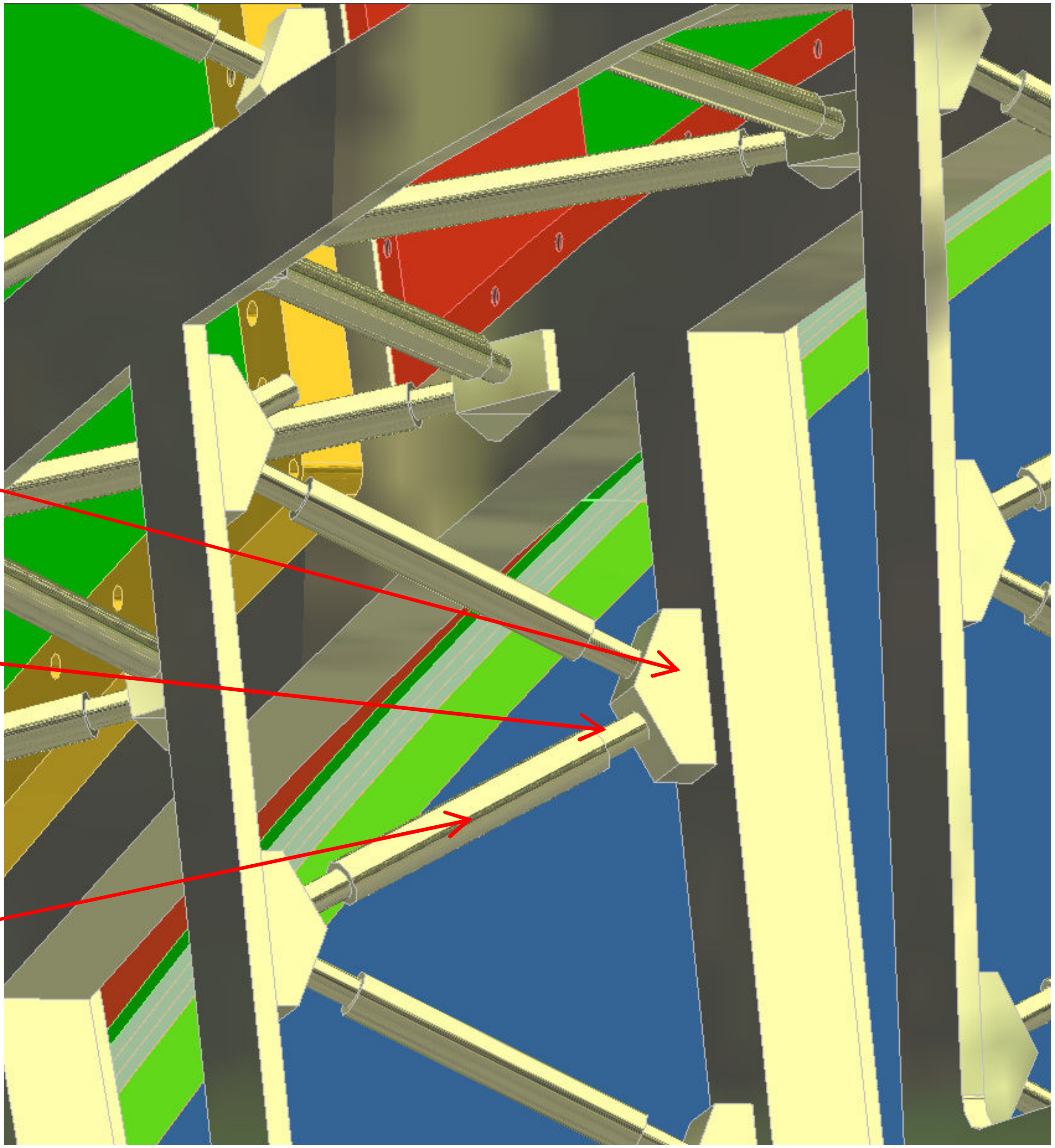
All struts are adjustable.

All parts are Aluminum.

Machined mount
bolted to the front and back plates

Adjustment screw
10-24 (m4.8-1.06) on one end
10-32 (m4.8-0.91) on the other end
sensitivity is 150 micron/turn
As modeled, the screw is 4mm, which
is approximately the stress diameter.

Spanning Rod
As modeled, is 6mm solid,
but could be 8mm hollow.



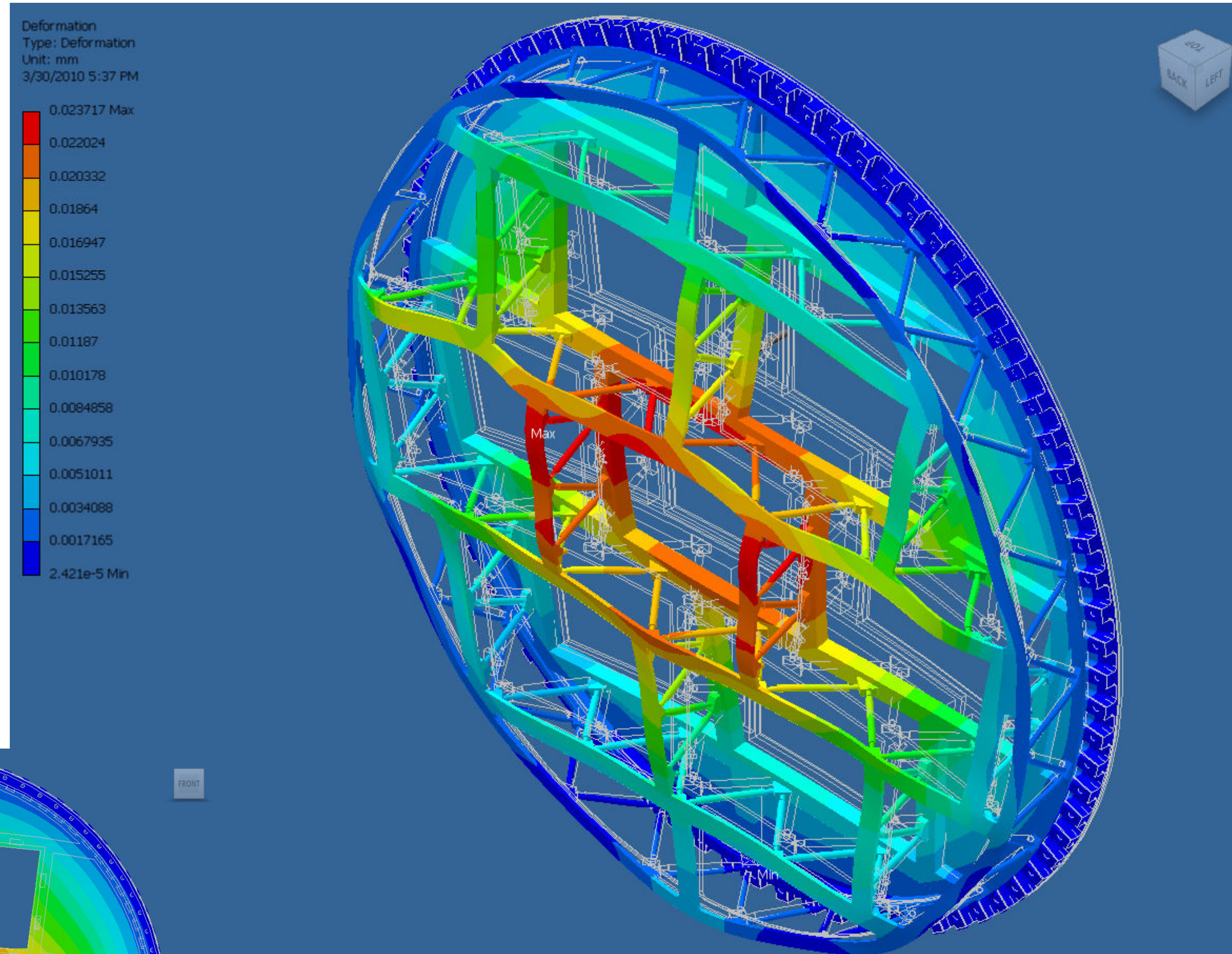
Deflection

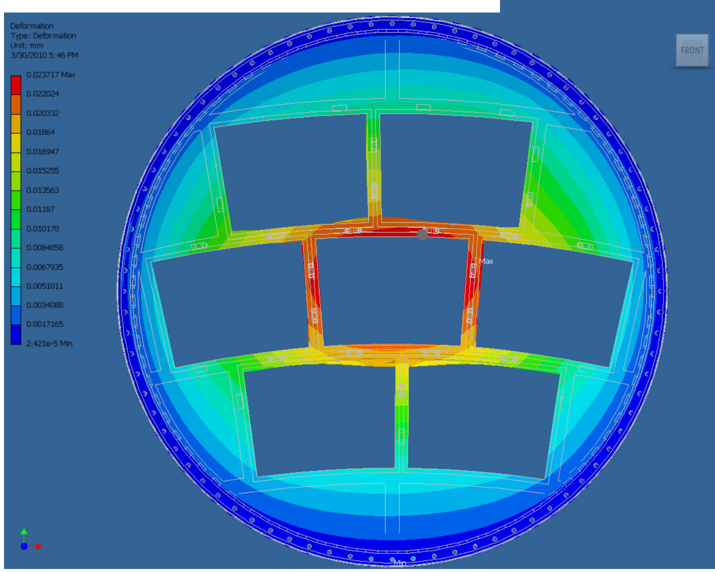
Maximum is 23 microns

Back-plane locally warps
±5 microns
The inside surface is smooth.

Back-plane twists at 3-point intersections. This feature will carry over to the ILD.

Not optimized:
- back-frame distance
- back-frame thickness
  - vs strut density (spacing)
- strut thickness





Observation:
The higher density of the <u>in-row struts</u> is required to maintain the straightness of the back-plane between modules in the same row.

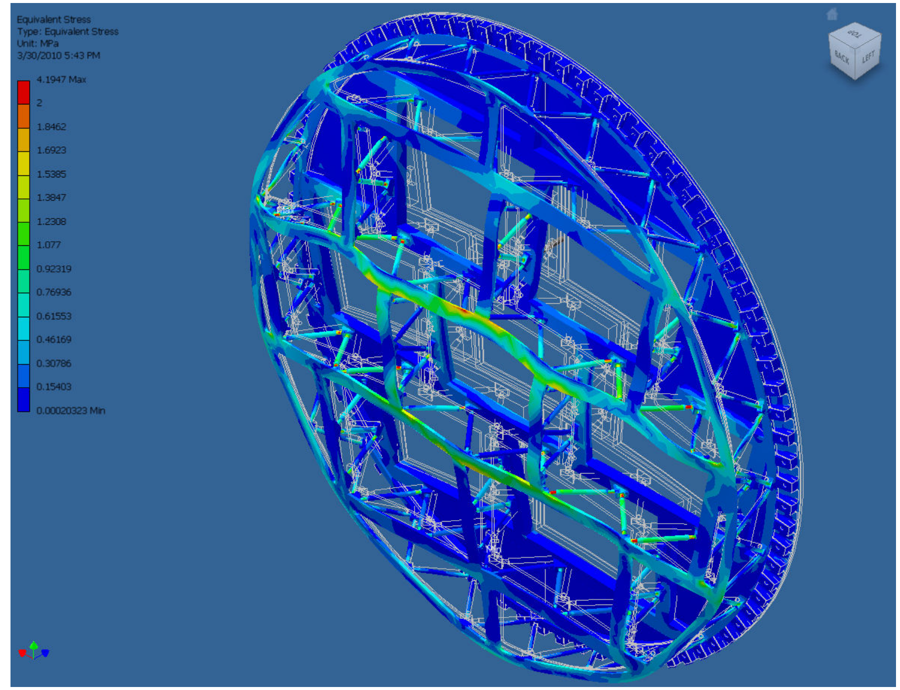
With only one pair per side,
the back-plane warps and the deflection increases.

Stress

The maximum stress in the space-frame is 4.2 MPa, which, compared to the yield at 241, is tiny.

Maximum stress points are in the adjustment screws.

Other high stress points in the back-plane can be reduced with fillets.



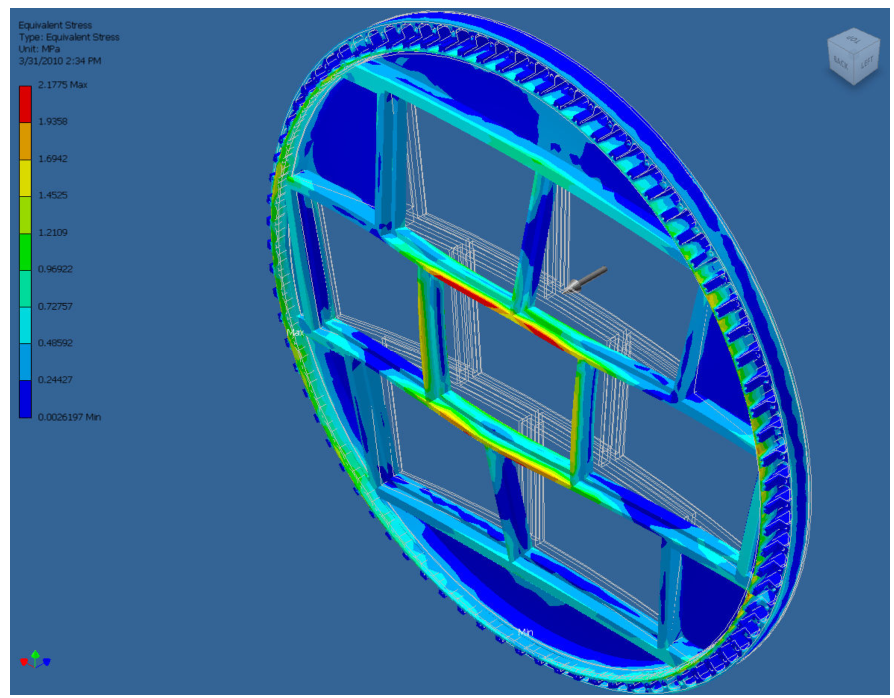
The maximum stress in the lightened all-aluminum is 3.2 Mpa, which is tiny.

Maximum stress points are on the mullions.

Near-maximum stress is found in the lightened outer stiffening ring.

This shows that the stiffening ring could be providing more rigidity. (The full LP1 stiffening ring would decrease the deflection from 68 to 51 microns.)

This is the cheaper vertical machine tool method of lightening. The radial machine tool lightening would improve the rigidity.



Al-C Hybrid design

The current design has 43% of the material of the current LP1
and slightly less material than the space-frame.
The deflection is somewhere around 140 microns, which might be OK.

Small prototyping is required to understand the strength of the hybrid.

A significant concern about the hybrid design is that
it does not scale well to the ILD endplate: 77cm -> 350cm.
More material will be required to maintain this rigidity at ILD.

Space-frame design

The current design has 44% of the material of the current LP1.
The deflection is 23 microns, less than LP1 at 33 microns.
This design is scalable to the ILD; strength can be maintained
by moving the back-plane further away.

This design is buildable and can be aligned. (It does not involve messy epoxy.)

A significant concern about the space-frame design is that
the strength of the joints may not be accurately modeled.
Small prototyping is required to understand the threaded joints.