Pixel Support Tube Status

February 2002, CERN

Mechanics Session

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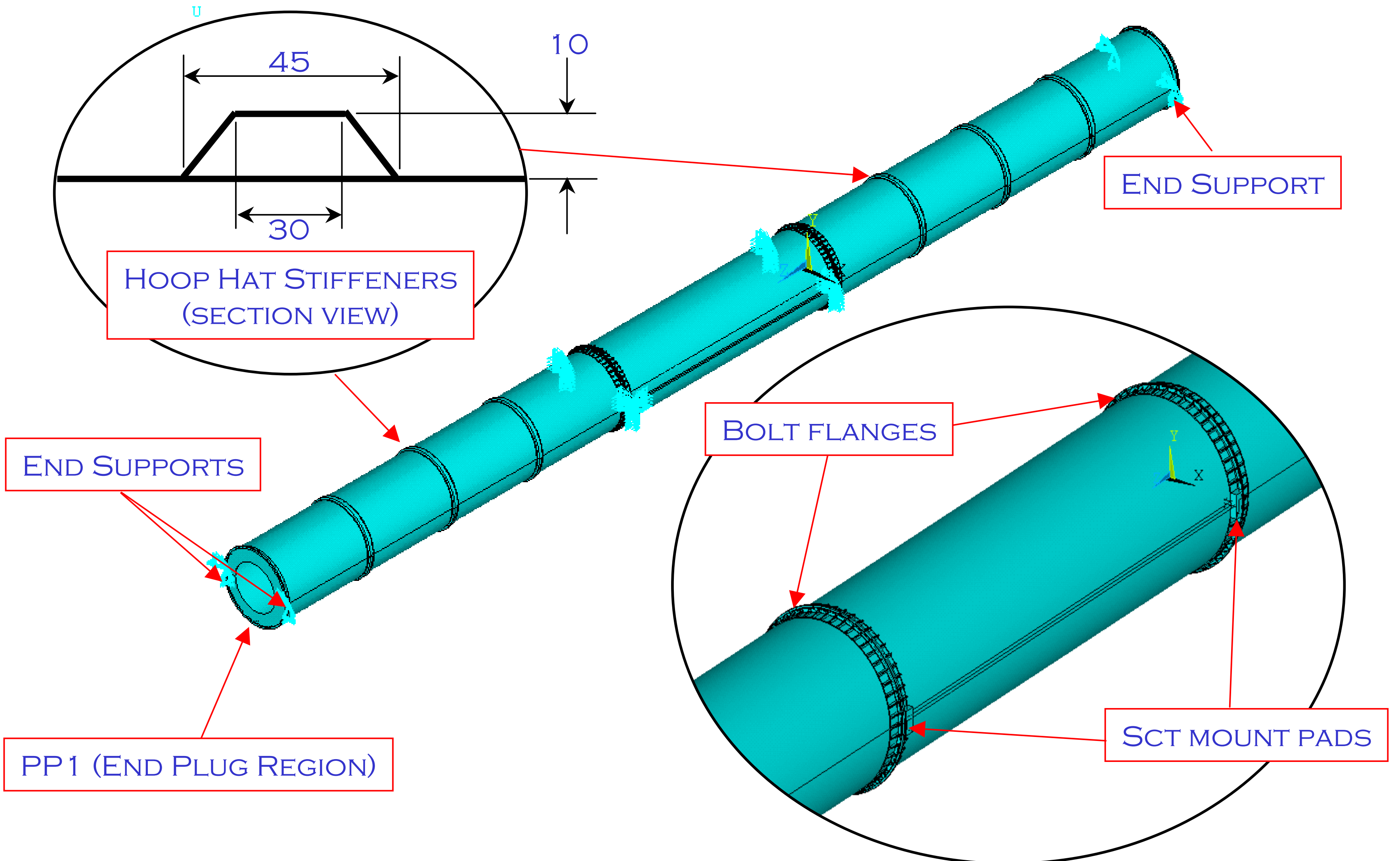
Pixel Detector

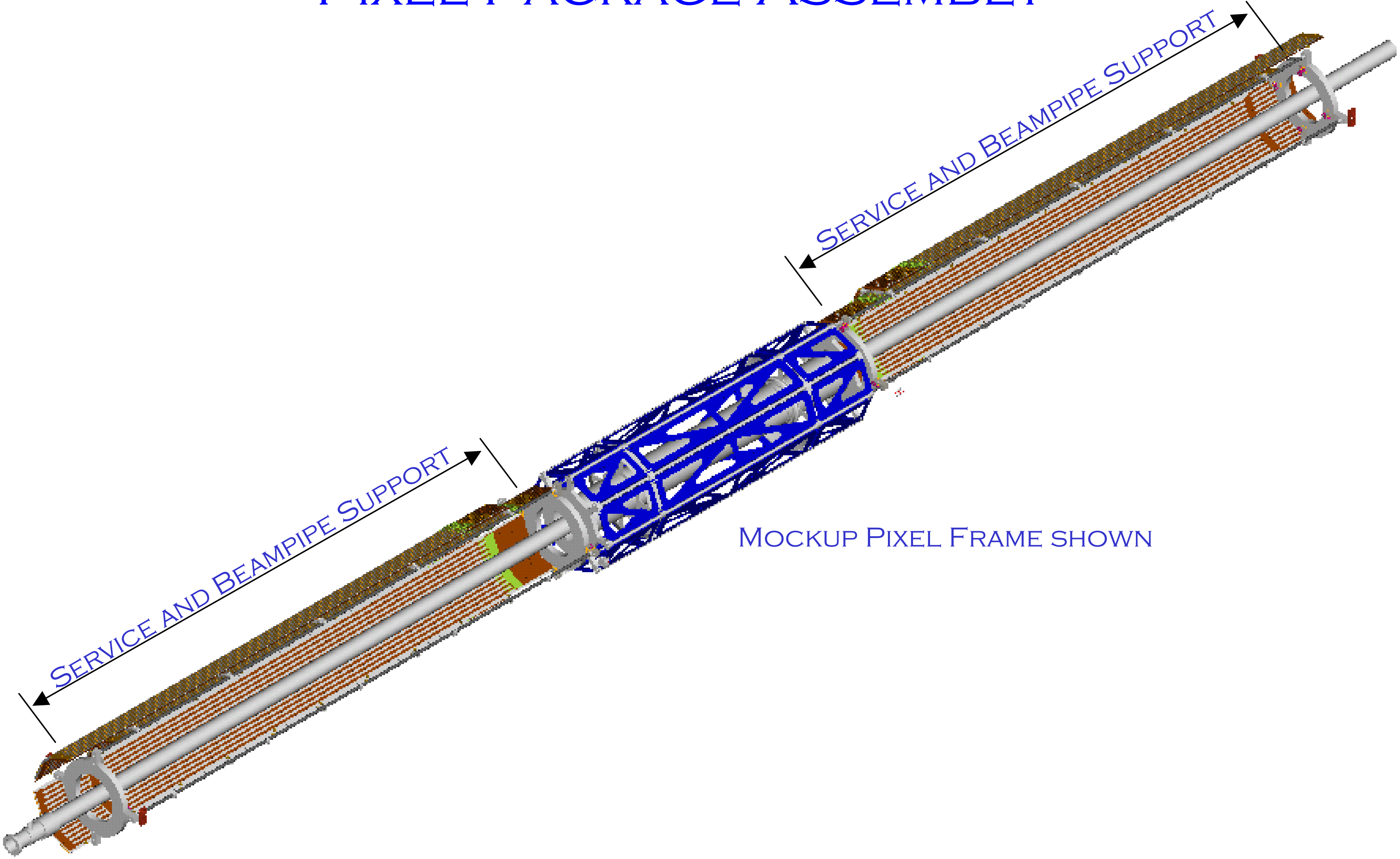
Status

- **Overview**
  - Reminder of Structures
- **PST mounts/SCT Integration**
- **PST Prototypes**
  - Material Selections
  - Heaters
  - Friction
  - Pixel Mounts
- **Beampipe Support**

PST Overall Layout

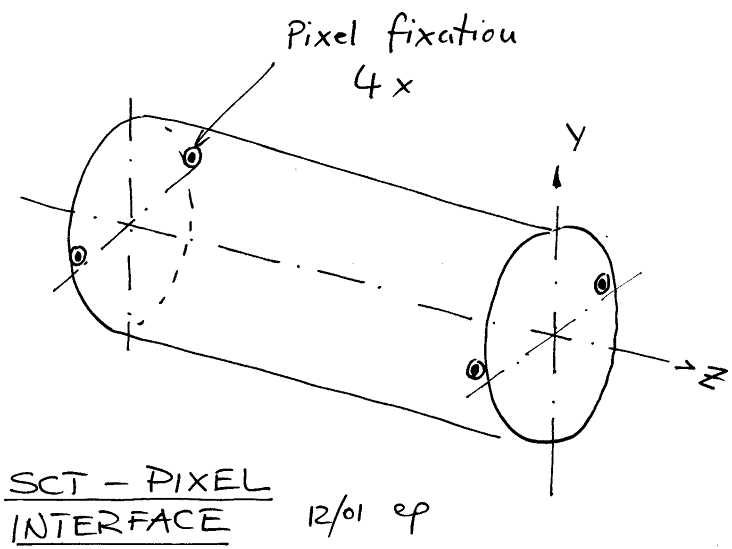


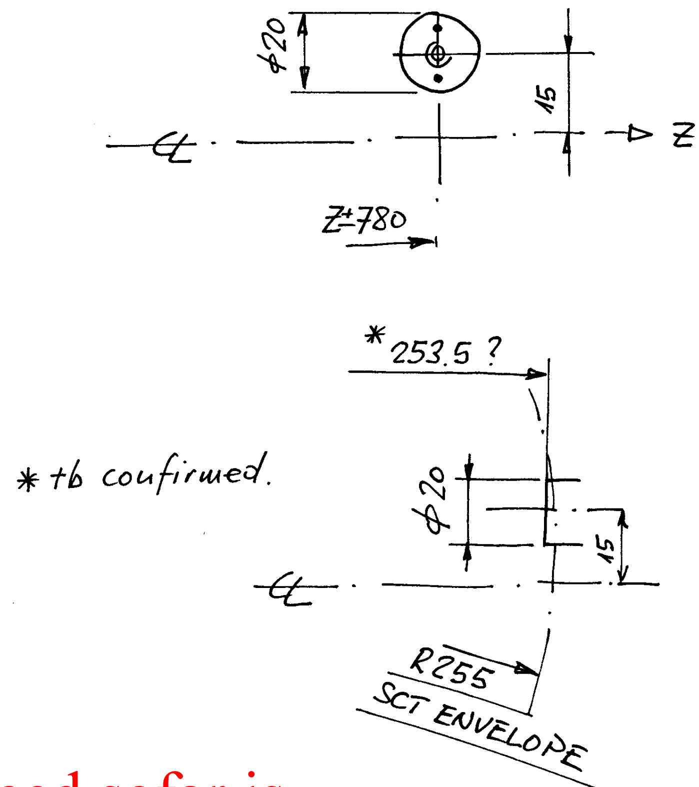
Pixel Package Assembly



Proposal for SCT - Pixel Interface

- 4 Blocks fastened to the SCT horizontal interlinks
- Adjustement, if needed, by shimming or machining spl. blocks



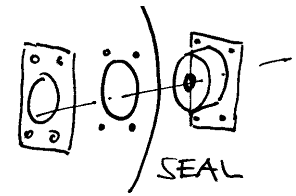


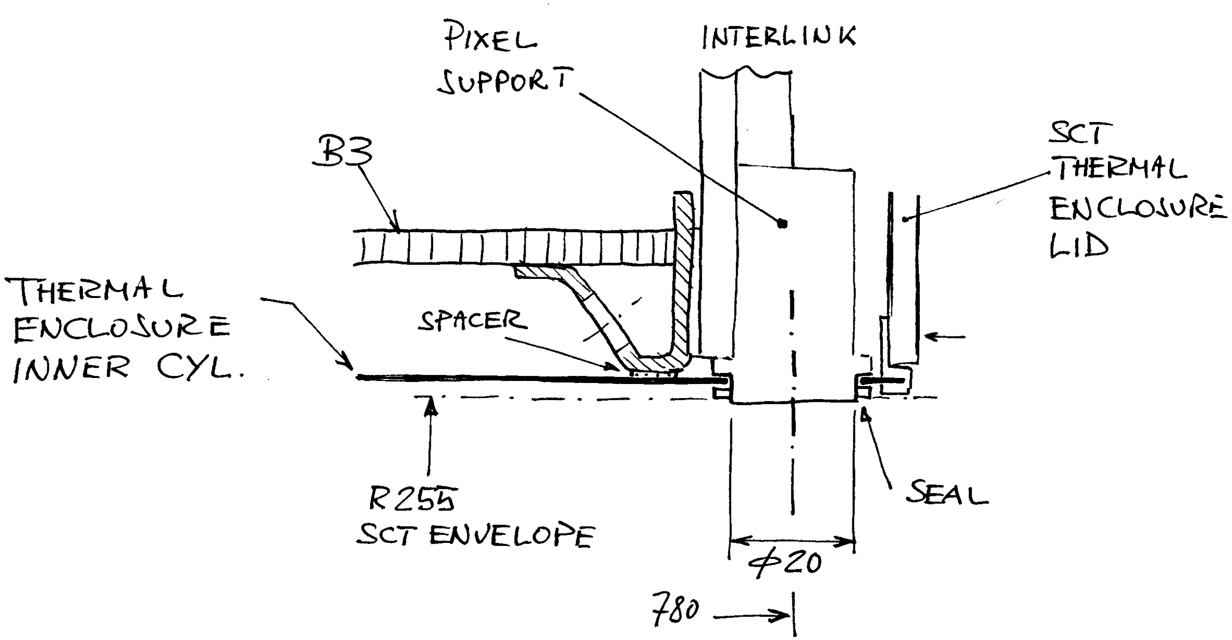
SLIDE FROM E. PERRIN

* The dimension 254 agreed sofar is penetrating the R255 envelope.

SCT Inner thermal enclosure

- Propose to fix the TE inner cylinder directly to Barrel 3
    - To save space.
    - To try to simplify penetrations and sealing.

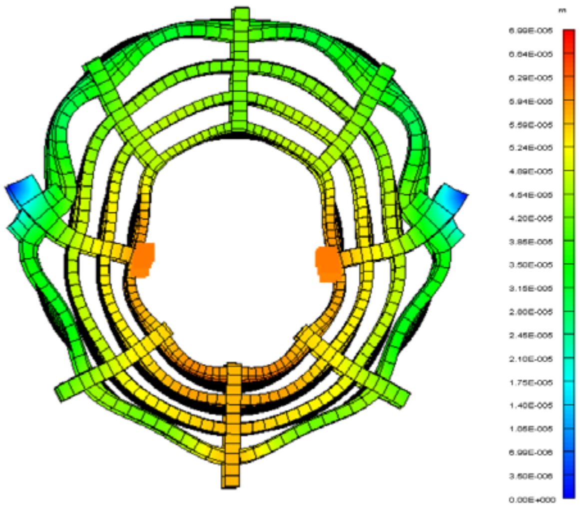




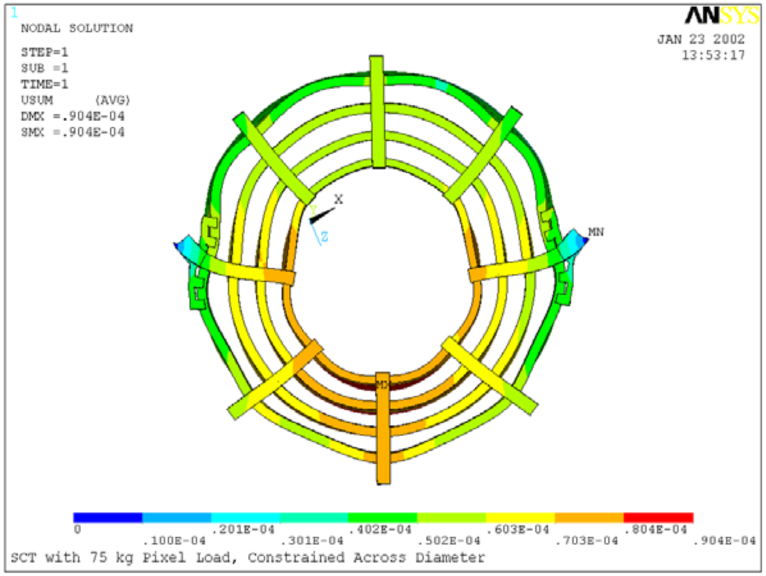
Slide from E. Perrin

Pixel Detector

Comparison of SCT Model [EPFL] with SCT Model [LBNL] for Gravity Sag under Pixel Load.



Displacements with Pixel Detector, max = 70 μM



Displacements with Pixel Detector, max = 90 μM

EPFL Assumptions:

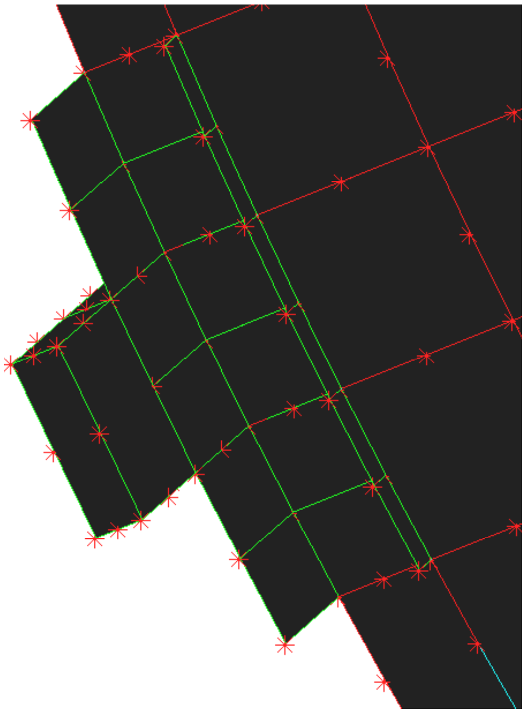
- Pixel Mass = 75 kg (over 4 points)
- SCT *not* fixed across Diameter (simple supports)??
- B6 Interlink Reinforcement

LBNL Assumptions:

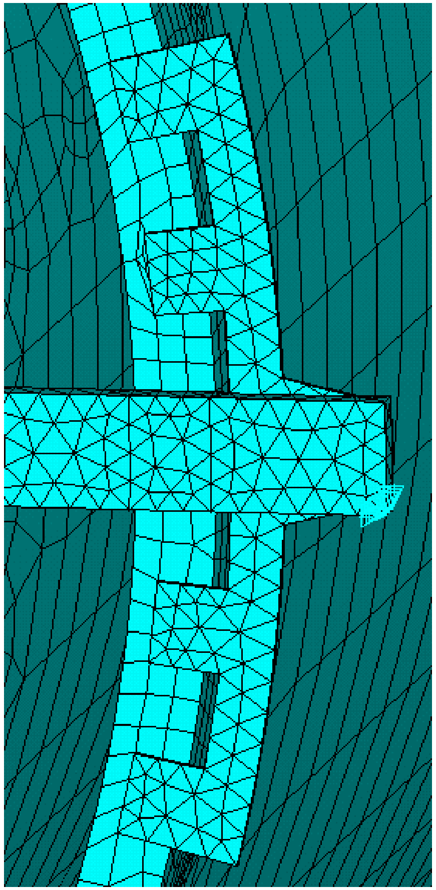
- Pixel Mass = 75 kg (over 4 points)
- SCT fixed across Diameter
- All SCT properties from EPFL model
- B6 Interlink Reinforcement

Pixel Detector

Comparison of SCT Model [EPFL] with SCT Model [LBNL] for Mesh density at B6 Reinforcement.



EPFL Model



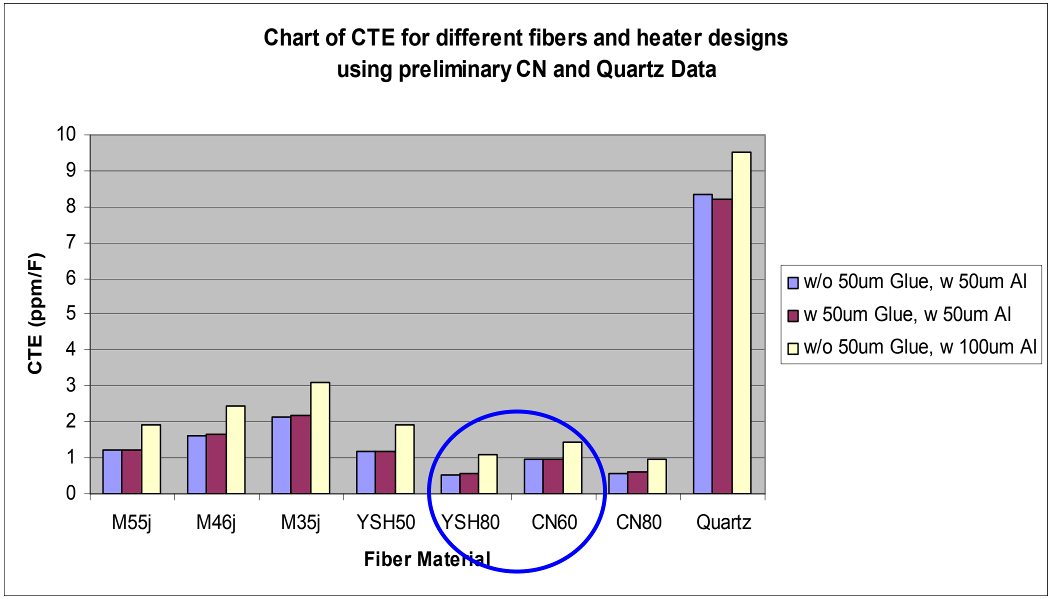
LBNL Model

Material Selection for PST

- All Laminates for Skins of PST will have heaters laminated to them
- Forward PST sections will have fiberglass skins to reduce stiffness
  - CTE not an issue, taken up by flexures at end of PST
  - Strength of Quartz fiber highest—simple choice of fiber
- Barrel will be high modulus graphite to best match the CTE of the SCT
  - CTE of fibers selected must be very negative to beat CTE of Aluminum in Heaters
  - Cost, Modulus, thickness all factors in selection
- Bryte ex1515 selected as matrix for all
  - 137C cure temp vs 180C for RS3
  - Proven radiation tolerance
  - Quick vendor turn around

Fiber Selection Candidates

- CTE of Barrel primary driver in material selection
- CTE of laminates include Heater layer laminated together in skin
- 100micron Al is thicker EMI shield material
- 50microns glue is for lamination of heaters (goes to Zero with co-cured heaters)
- COST per candidate also considered



CTE of SCT Barrel is ~1.2 to 1.5 ppm/C so our target is on the order of 1ppm. Will consider CTE mismatch of less than 0.5ppm 'Zero' (relative mismatch for temperature change on order of 20micron)

Pixel Detector

Cost Sensitivity

- **Production Plans and design can affect cost**
  - Full flange is flange cut from solid blank plate
  - Annular flange is a plate laid up with out fiber in the middle
- **Not much difference between plans 2–4 in cost**
- **CN60 is an excellent candidate, but need to verify that it's modulus and CTE are as advertised**
- **CN60 thickness a question…**
- **No big cost hit to make shell from YSH80 if necessary**

Production Plan 1: YSH80 w/ full flanges						
Material	Part Mass or Area	w/ Extra (waste, etc.)	Minimum	Cost/Unit	Order Amt.	Order Cost
AQ II	9.31	13.96652513	1.8	770	13.97	$10,754.22
CN60 UDT	N/A	N/A	2.27	704	N/A	N/A
YSH80 UDT	3.19	4.7848398	1.8	1485	4.78	$7,105.49
CN60 Cloth	9.57088	14.35632	10	550	14.36	$7,895.98
Glass Mat	7.05925615	10.58888423	9.3	140	10.59	$1,482.44
					Total $ =	$27,238.13

Production Plan 2: CN60 w/ full flanges						
Material	Part Mass or Area	w/ Extra (waste, etc.)	Minimum	Cost/Unit	Order Amt.	Order Cost
AQ II	9.31	13.96652513	1.8	770	13.97	$10,754.22
CN60 UDT	3.19	4.7848398	2.27	704	4.78	$3,368.53
YSH80 UDT	N/A	N/A	1.8	1485	N/A	N/A
CN60 Cloth	9.57088	0	10	550	10.00	$5,500.00
Glass Mat	7.05925615	10.58888423	9.3	140	10.59	$1,482.44
					Total $ =	$21,105.20

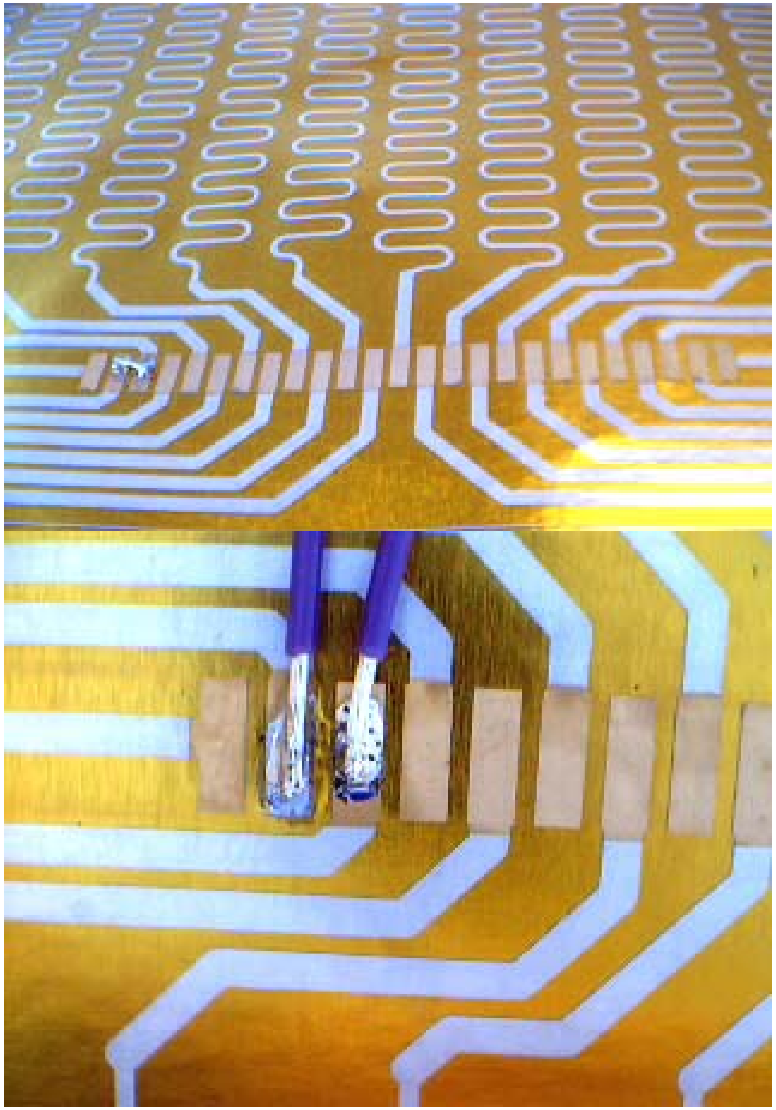
Production Plan 3: YSH80 w/ annulus flanges						
Material	Part Mass or Area	w/ Extra (waste, etc.)	Minimum	Cost/Unit	Order Amt.	Order Cost
AQ II	9.31	13.96652513	1.8	770	13.97	$10,754.22
CN60 UDT	N/A	N/A	2.27	704	N/A	N/A
YSH80 UDT	1.38	2.0719872	1.8	1485	2.07	$3,076.90
CN60 Cloth	1.39372	0	10	550	10.00	$5,500.00
Glass Mat	7.05925615	10.58888423	9.3	140	10.59	$1,482.44
					Total $ =	$20,813.57

Production Plan 4: CN60 w/ annulus flanges						
Material	Part Mass or Area	w/ Extra (waste, etc.)	Minimum	Cost/Unit	Order Amt.	Order Cost
AQ II	9.31	13.96652513	1.8	770	13.97	$10,754.22
CN60 UDT	1.38	2.0719872	2.27	704	2.27	$1,598.08
YSH80 UDT	N/A	N/A	1.8	1485	N/A	N/A
CN60 Cloth	1.39372	0	10	550	10.00	$5,500.00
Glass Mat	7.05925615	10.58888423	9.3	140	10.59	$1,482.44
					Total $ =	$19,334.75

Material Tests

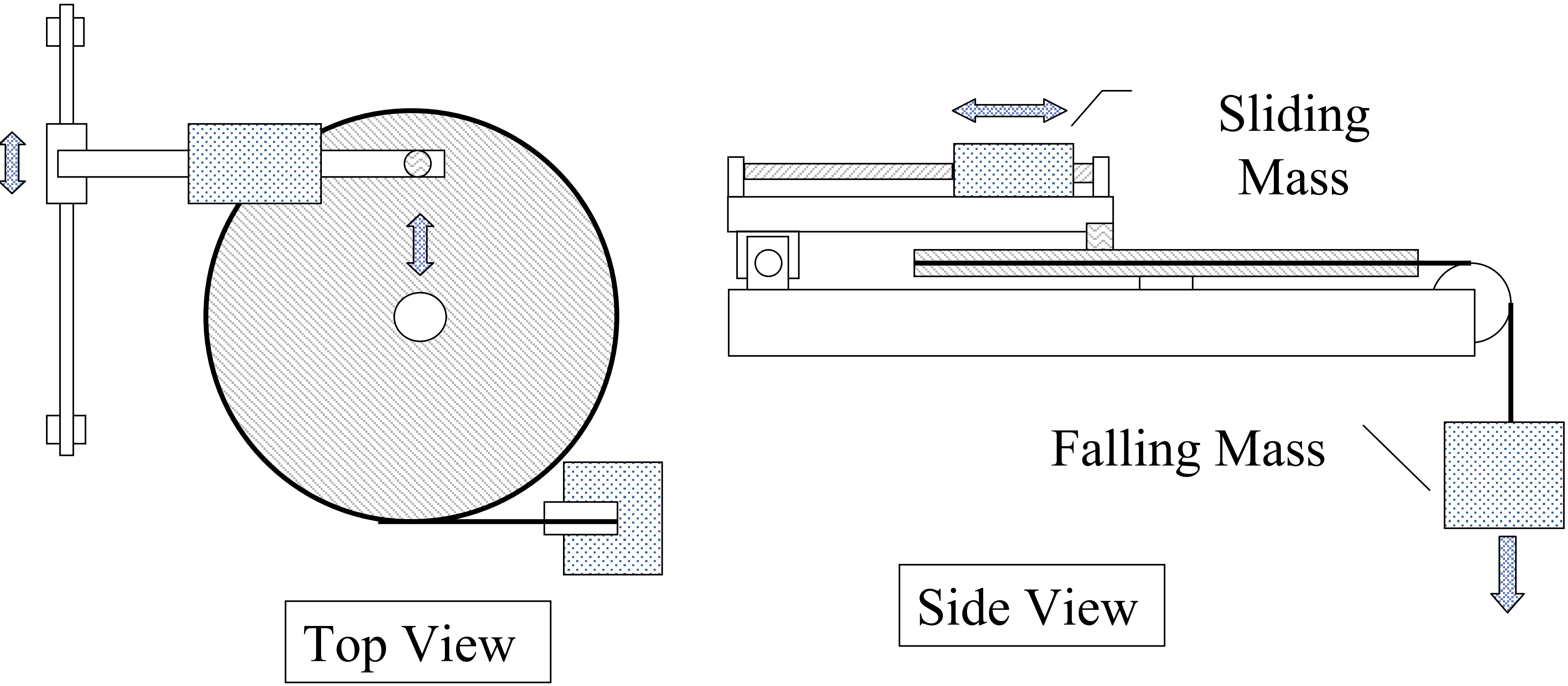
- **Cured Ply Thickness test—results today**
  - Determines both CPT and Net Resin content (no bleed)
- **Bleed studies**
  - Need to ascertain optimal bleed technique to achieve proper resin content
  - Co-curing of heaters means no bleeding of pre-preg
  - Thick flange laminate will be bled according to these results
- **Full panels, nominal laminate (8-ply quasi-iso) All materials, with and without heaters**
  - Determine modulus and resin content by external vendor
  - Determine CTE of macro panel with and without heaters using in-plane capability of TVH system
- **Will use results of these tests to select final materials for PST, and use property data as input for SCT/PST modeling effort**
- **Foot-Long Mandrel Prototype fabrication follows**

Aluminum on Kapton Heaters



- **Heaters with solderable connection pads have been developed at LBNL**
  - 50micron Kapton substrate
  - 12micron heater Al
  - 50micron EMI Foil Al
  - 10micron adhesive layers
    - Epoxy–verified radiation tolerant to 50+Mrad
  - 25micron coverlay
- **Heaters generate ~0.05W/cm2 @ 1A current**
- **Connections can be ganged as desired**
- **Perforated for off-gassing of pre-preg during co-cure**

Friction Test Apparatus (Tribometer)



- Gravity provides constant torque
- Load adjustments can be made by sliding the top mass along the arm

Experimental System

- **Instrument**
  - The rotary Friction Test Stand was used to determine static C.O.F.
- **Accuracy**
  - The Instrument has an experimental Accuracy of about 4%
  - Al on Steel was used as a Control
  - NEMA was used as the sliding surface material in every other test
- **Method**
  - Tests were repeated over the same NEMA track multiple times to determine wear behavior

Test Materials:

Vespel SP-1

Vespel SP-21

Vespel SP-3

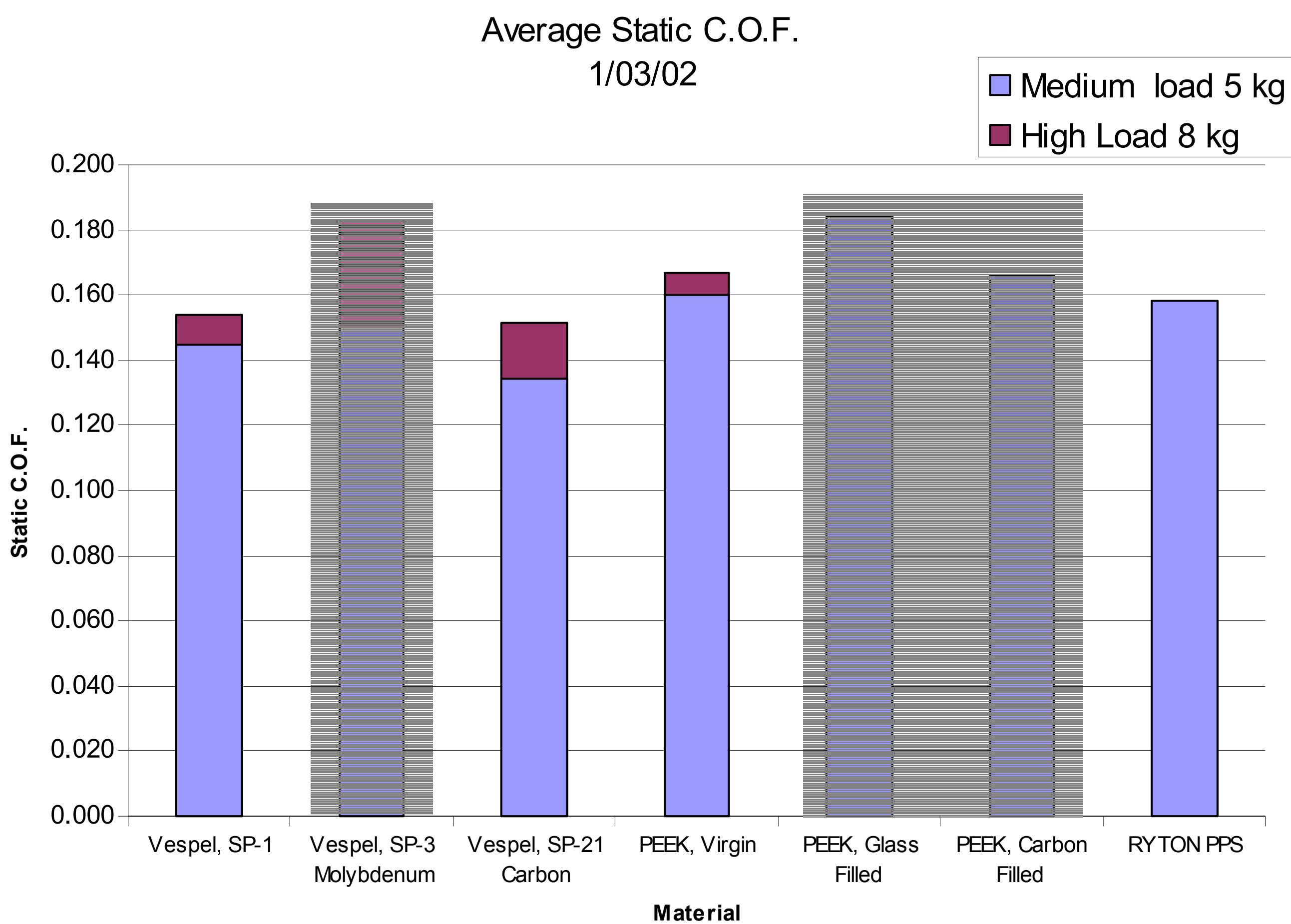
PEEK

PEEK Glass Filled

PEEK Carbon Filled

Ryton

Results of Static Test – C.O.F.



Best Materials:

Vespel SP-1

Vespel SP-21

~~Vespel SP-3~~

PEEK

~~PEEK Glass Filled~~

~~PEEK Carbon Filled~~

Ryton

Good

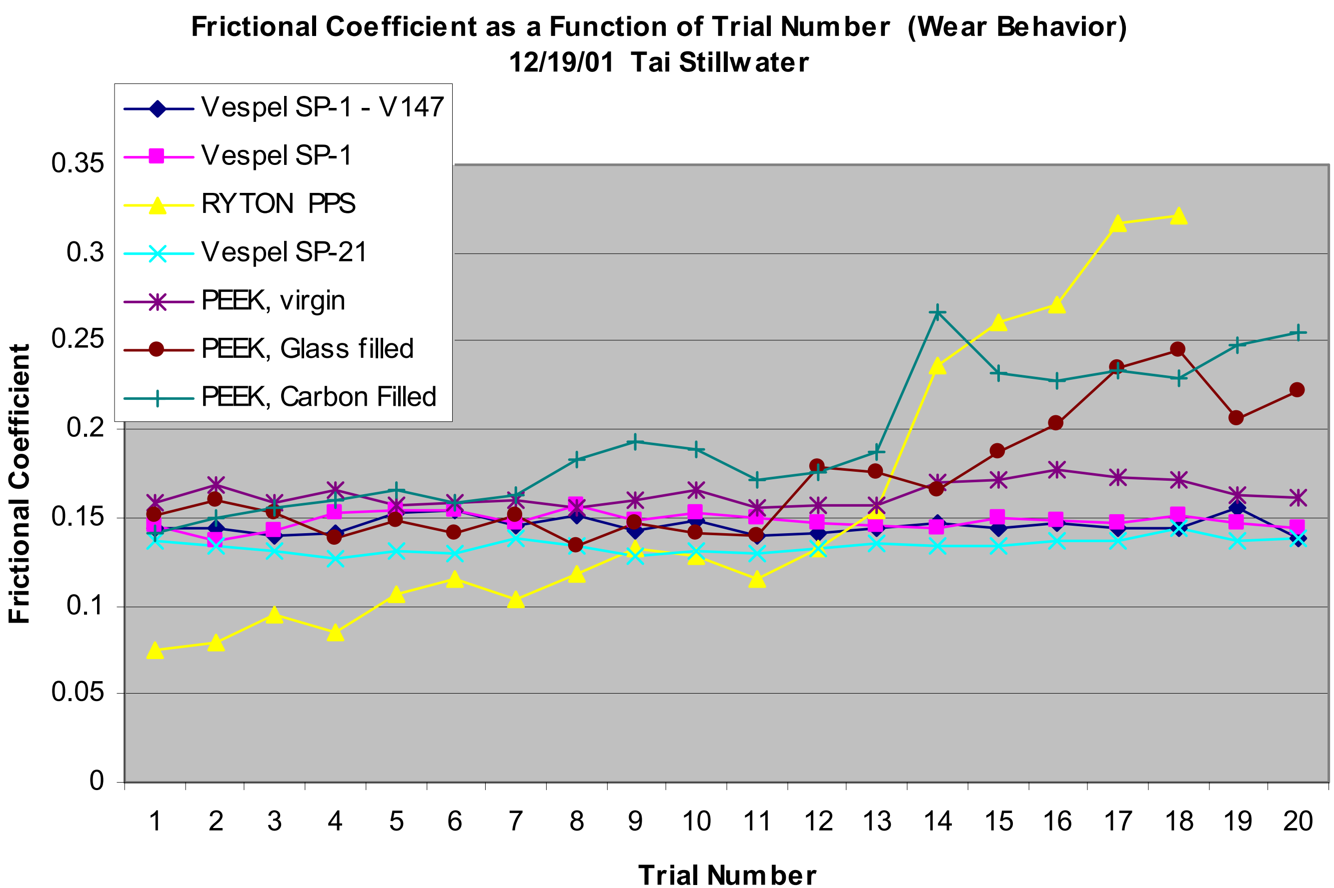
~~Maybe~~

~~Bad~~

Results of Static Test – C.O.F. Data Table

Material1	Material2	Average coefficient of friction	Average coefficient of friction @Load 2	Statistical Uncertainty +/-	Notes	Force (kg) +/- 1 kg
Vespel, SP-1-V147	NEMA	**0.144**	0.154	0.002		5.2
Vespel, SP-3 Molybdenum	NEMA	**0.150**	0.183	0.002		4.3
Vespel, SP-21 Carbon	NEMA	**0.134**		0.002		5.9
PEEK, Virgin	NEMA	**0.160**	0.167	0.003		5.0
PEEK, Glass Filled	NEMA	**0.184**		0.016	rapid wear	4.5
PEEK, Carbon Filled	NEMA	**0.166**	0.223	0.012	rapid wear	5.2
RYTON PPS	NEMA	**0.158**		0.055	rapid wear	6.5
Aluminum	Steel	**0.560**		0.047	Reference of 0.61	4.2

Results of Static Test- Wear



Best Materials:

Vespel SP-1	**Good**
Vespel SP-21	~~Maybe~~
~~Vespel SP-3~~	~~Bad~~
PEEK	
~~PEEK Glass Filled~~	
~~PEEK Carbon Filled~~	
~~Ryton~~	

Discussion of Wear Behavior

- Modulus of Samples related to wear of sliding material (NEMA) due to similar moduli
- Visible scratching of surface of NEMA for harder samples
- Virgin PEEK has borderline hardness, but the COF changes vary little at higher loads—this may imply better wear behaviour

Material	E (GPA)	Relative Wear Order
Vespel SP-21(Carbon)	2.3	1
Velpel SP-1 (Virgin)	2.4	1
Vespel SP-3 (Moly-D)	2.4	1
PEEK, Virgin	3.4	2
PEEK-Glass	5.5	3
Ryton	5.5	5
PEEK-Carbon	11.0	4
NEMA	12.0	

Recommendations

- The Vespel SP-1 and SP-21 and unfilled PEEK are promising candidates and should be further tested.
  - PEEK →0.160
  - Vespel →0.145
- Vespel SP-21 is questionable because of the Carbon content.
  - Vespel Sp21 →0.135
- Glass, Carbon filled PEEK, and Ryton should be ***rejected*** due to unfavorable wear behavior
- Filled PEEKs ***rejected*** due to high C.O.F.
- Vespel SP-3 should be ***rejected*** due to the increasing C.O.F at 8 kg Loads

Best Materials:

Vespel SP-1

~~Vespel SP-21~~

~~Vespel SP-3~~

PEEK

~~PEEK Glass Filled~~

~~PEEK Carbon Filled~~

~~Ryton~~

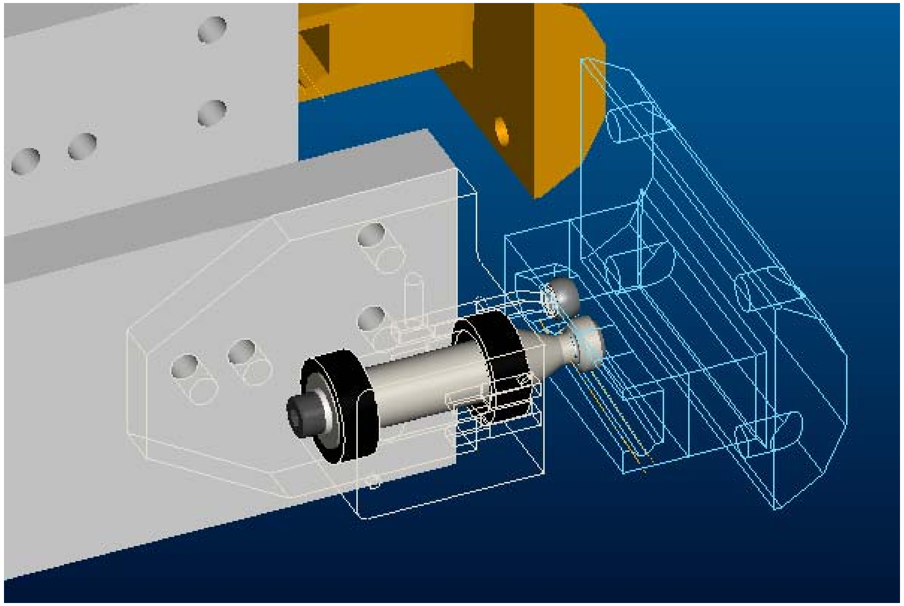
Good

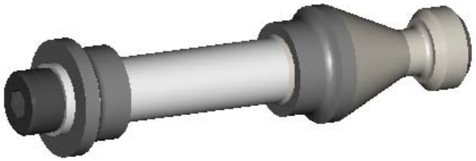
~~Maybe~~

~~Bad~~

PIXEL FRAME MOUNTS

- **PROTOTYPE OF PIXEL MOUNTS DEVELOPED**
- **AXLE AND BEARING DESIGN REFINED**
  - 15 ANGULAR CONTACT BEARINGS
  - CURRENTLY ALL IN TOOL STEEL
  - CERAMIC RACE OPTIONS EXIST
  - CERAMIC BALLS IN HAND
  - TITANIUM SHAFT NEXT STEP
- **CONTACT ANALYSIS SHOWS ONE BALL CAN TAKE FULL DETECTOR LOAD**
- **STATISTICAL ANALYSIS SHOWS 5 OR MORE BALLS IN CONTACT**

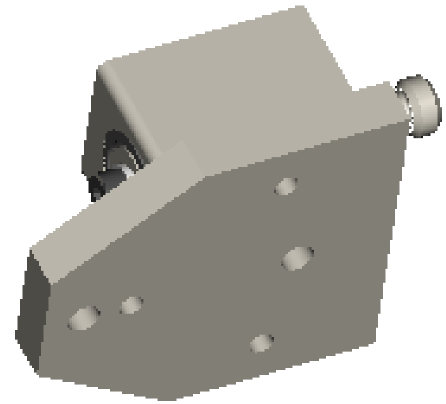


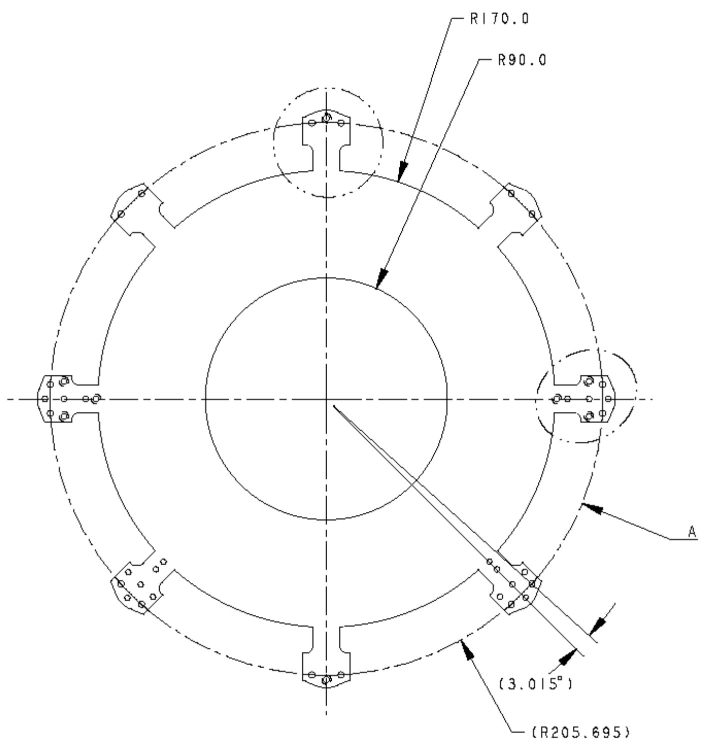


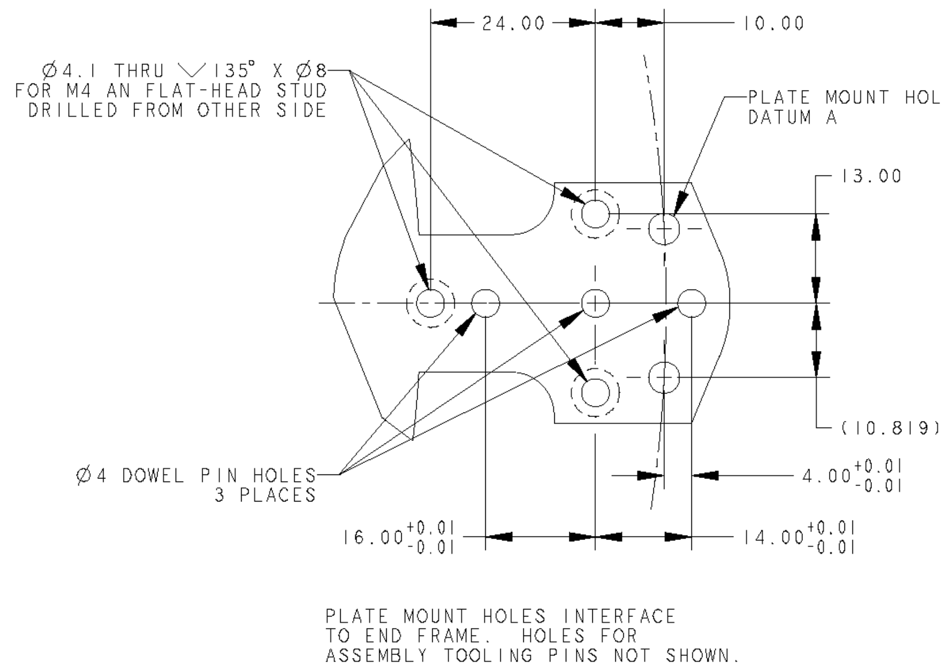
Pixel Detector

Interface to Endplate Defined

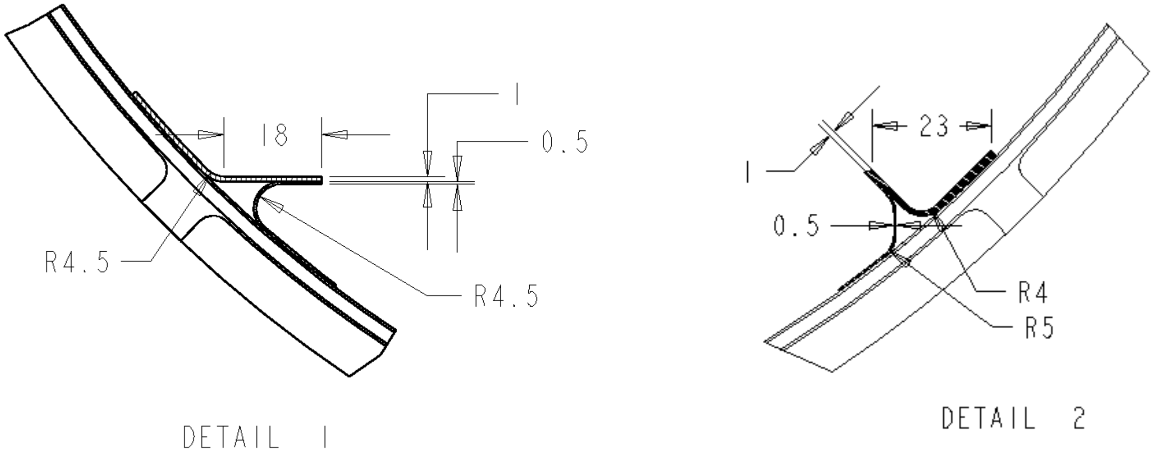
- Three mounts fixed, One adjustable vertically
- Two dowel pins, Three mounting screws
- Holes machined in Ears of Endplate
- Endplate registered to End frame by tight shoulder screws in same ear





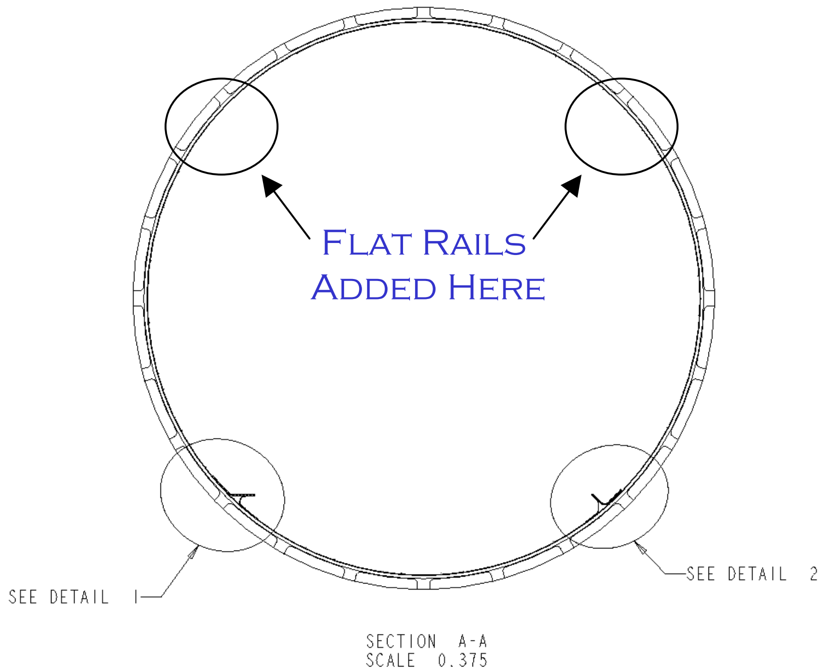


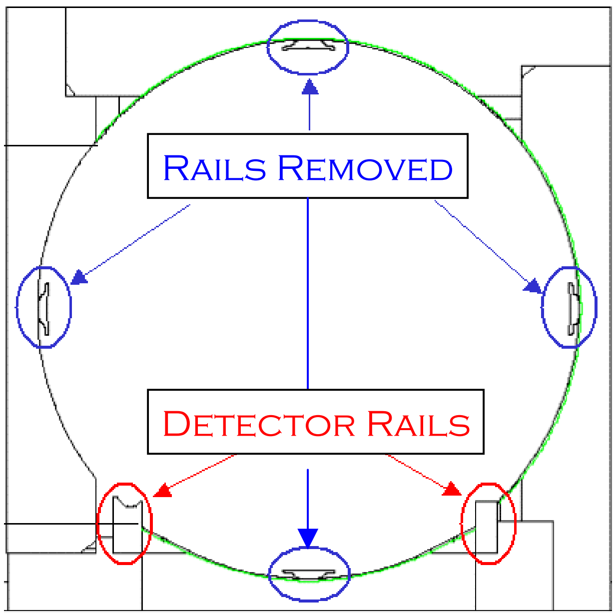
Rail Design in Support Tube



'Service Rails' Removed

Will use V and Flat rails to support Service/Beampipe support Structures

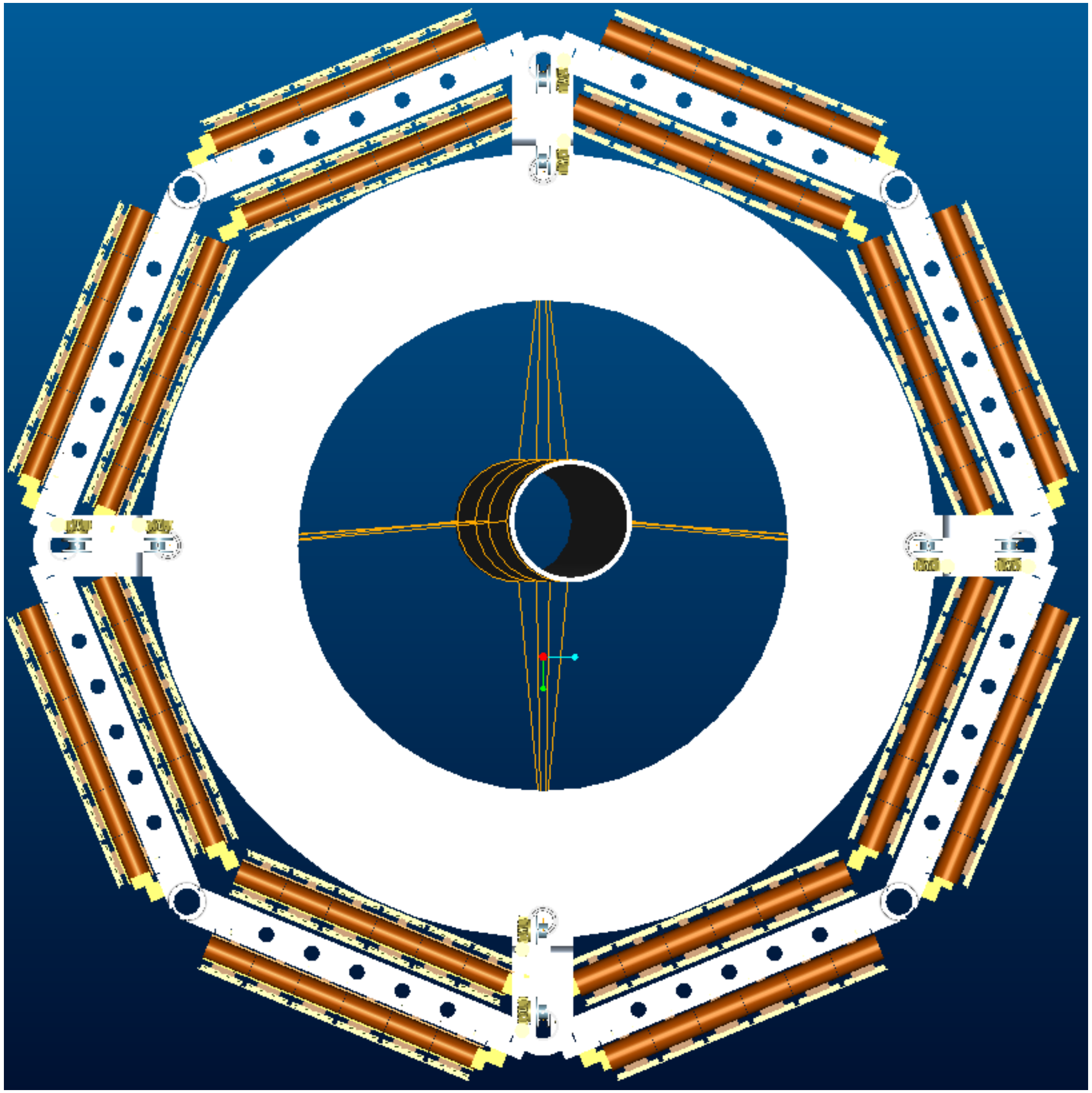




Mockup

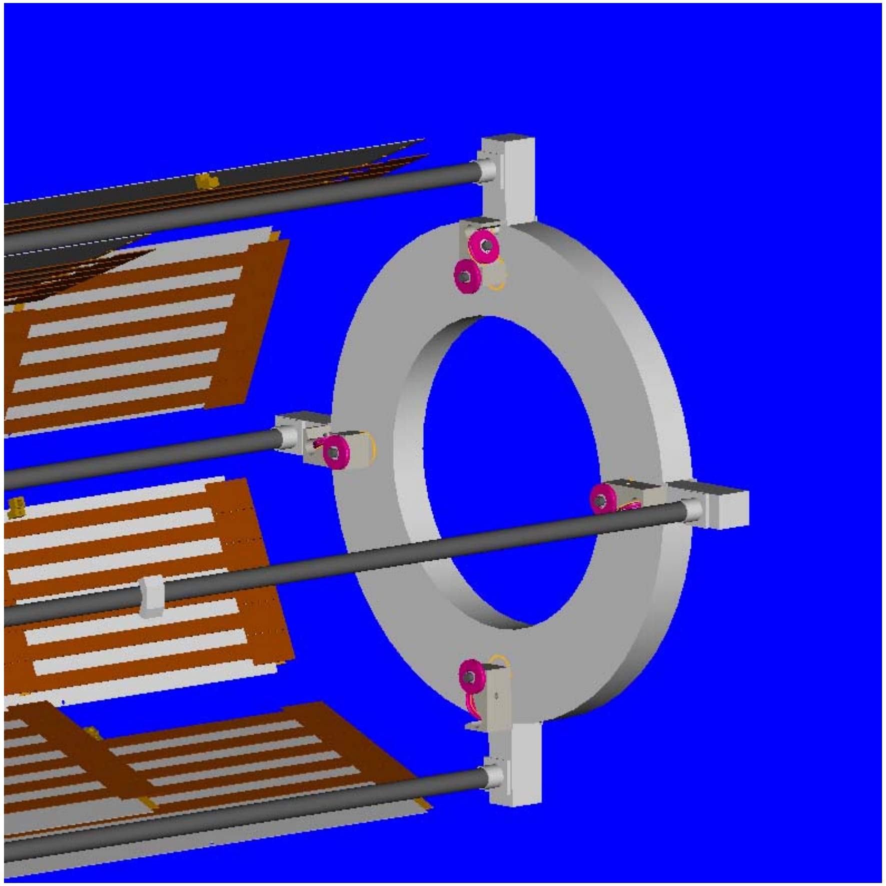
Pixel Detector

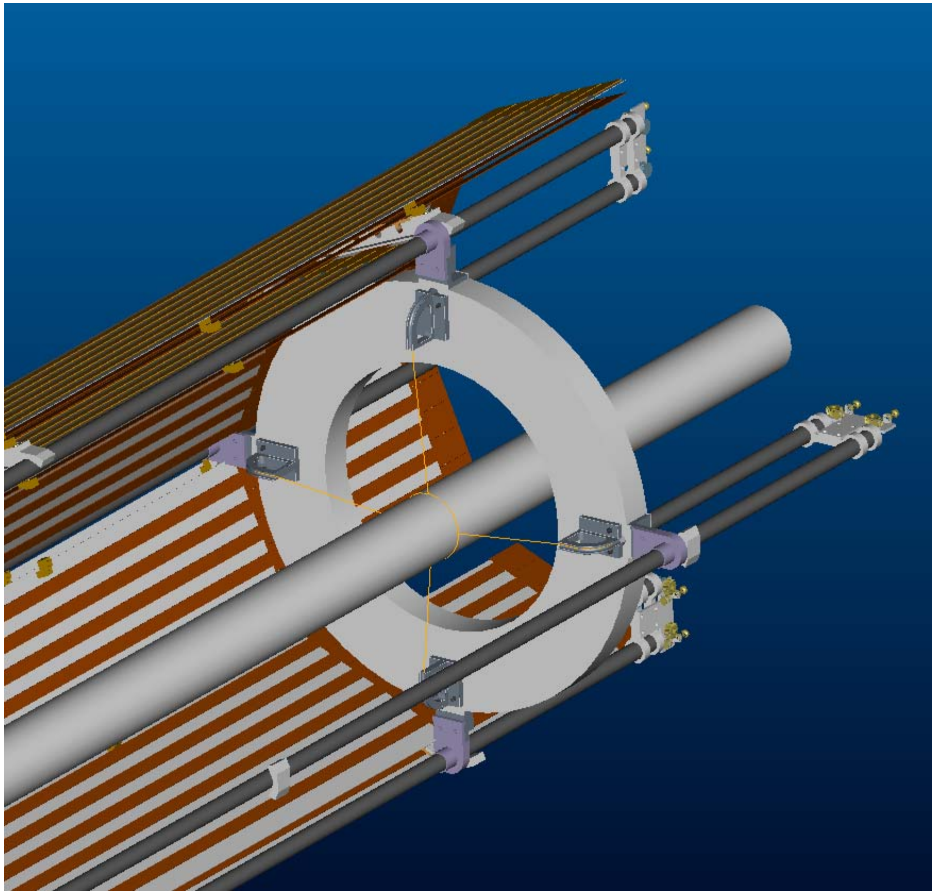
Beam Pipe adjusted full range



- **Beampipe shown with ends at:**
  - C: +10, +10
  - A: -10, +10
- **Design adjustment not limited by support**
  - B-Layer envelope allows only 9mm radial adjustment maximum
- **Survey Access**
  - Limited by B-Layer–cannot see clear through
  - Limited by flanges and End-plug (PP1)

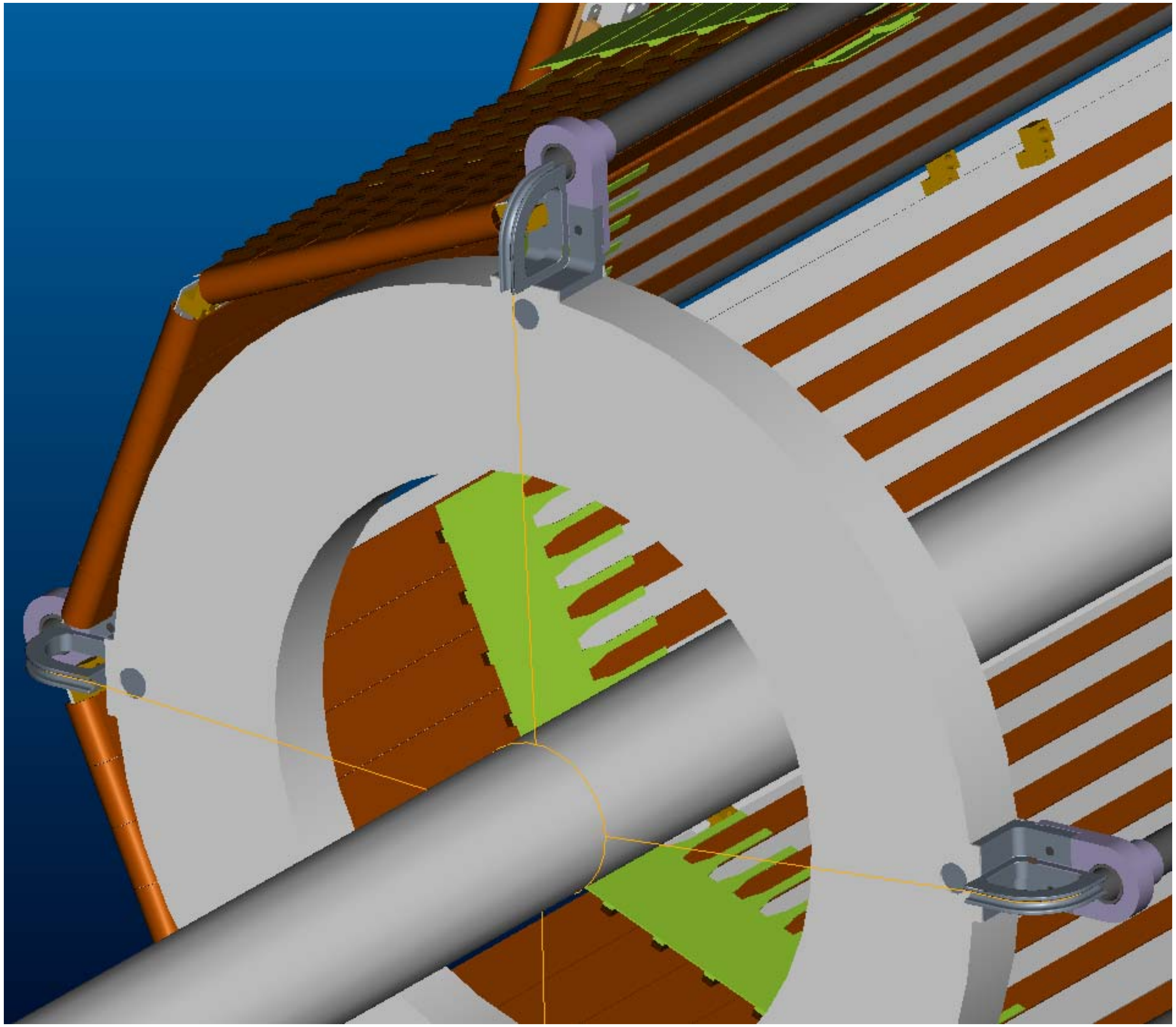
Forward End moved and pulleys re-designed

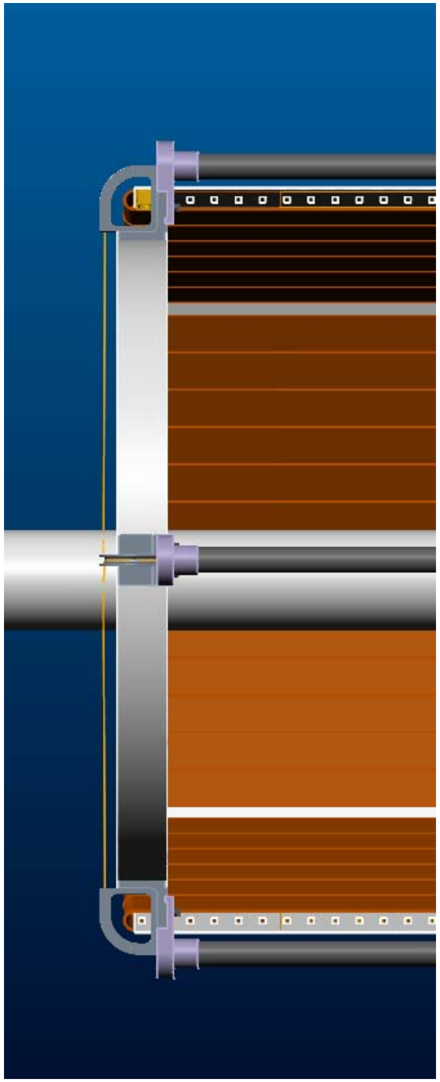




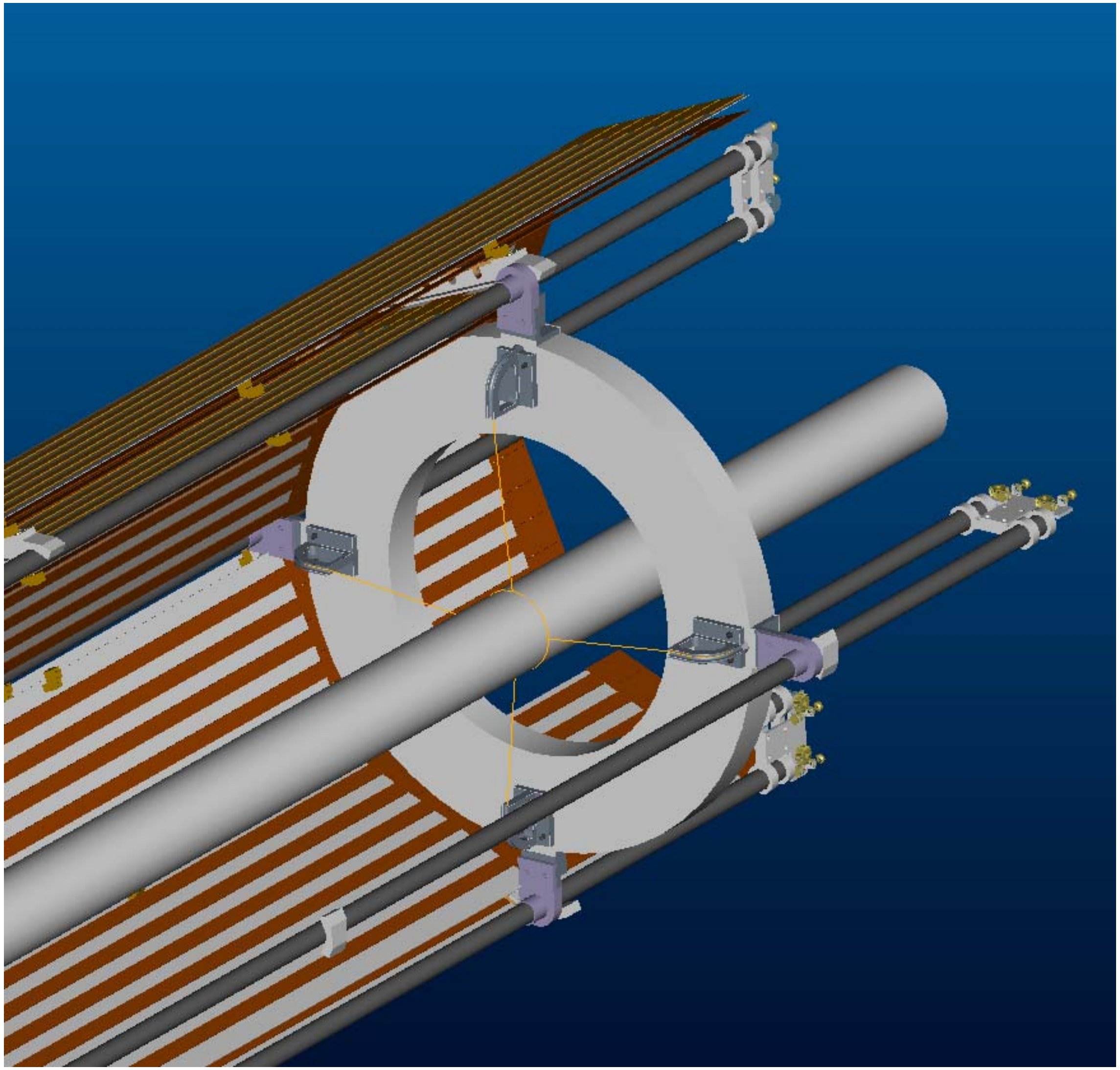
Pixel Detector

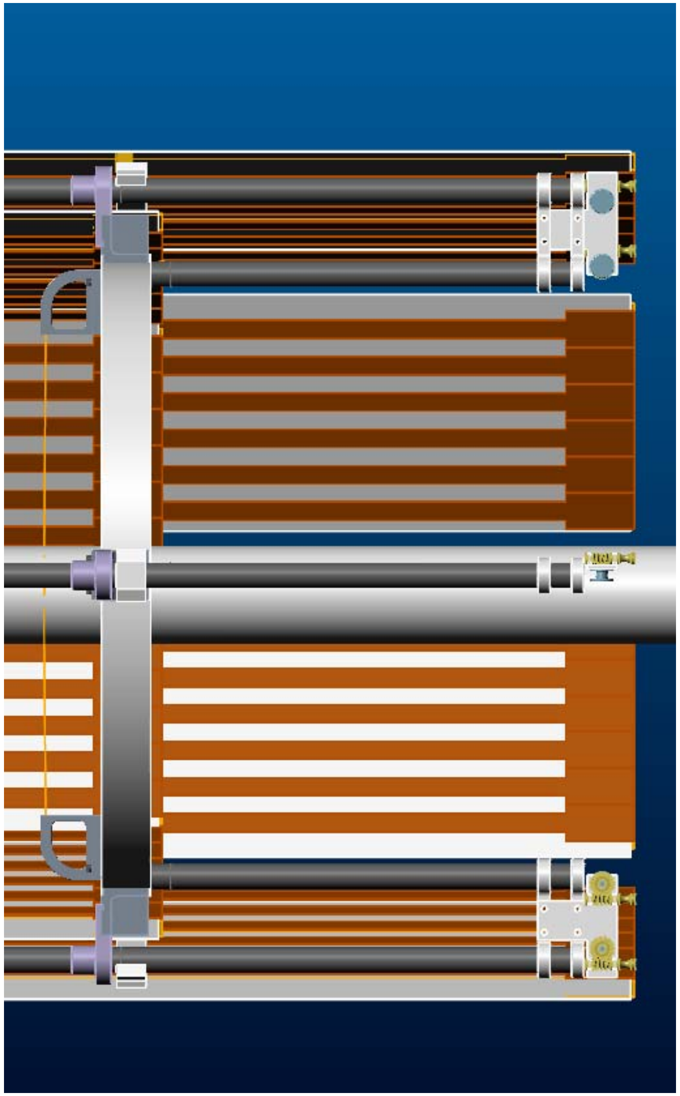
Barrel End Geometry



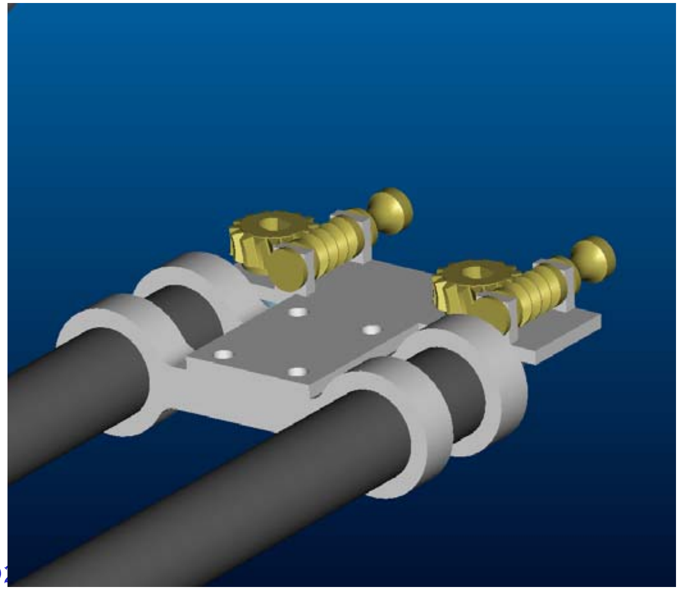


Forward End Geometry

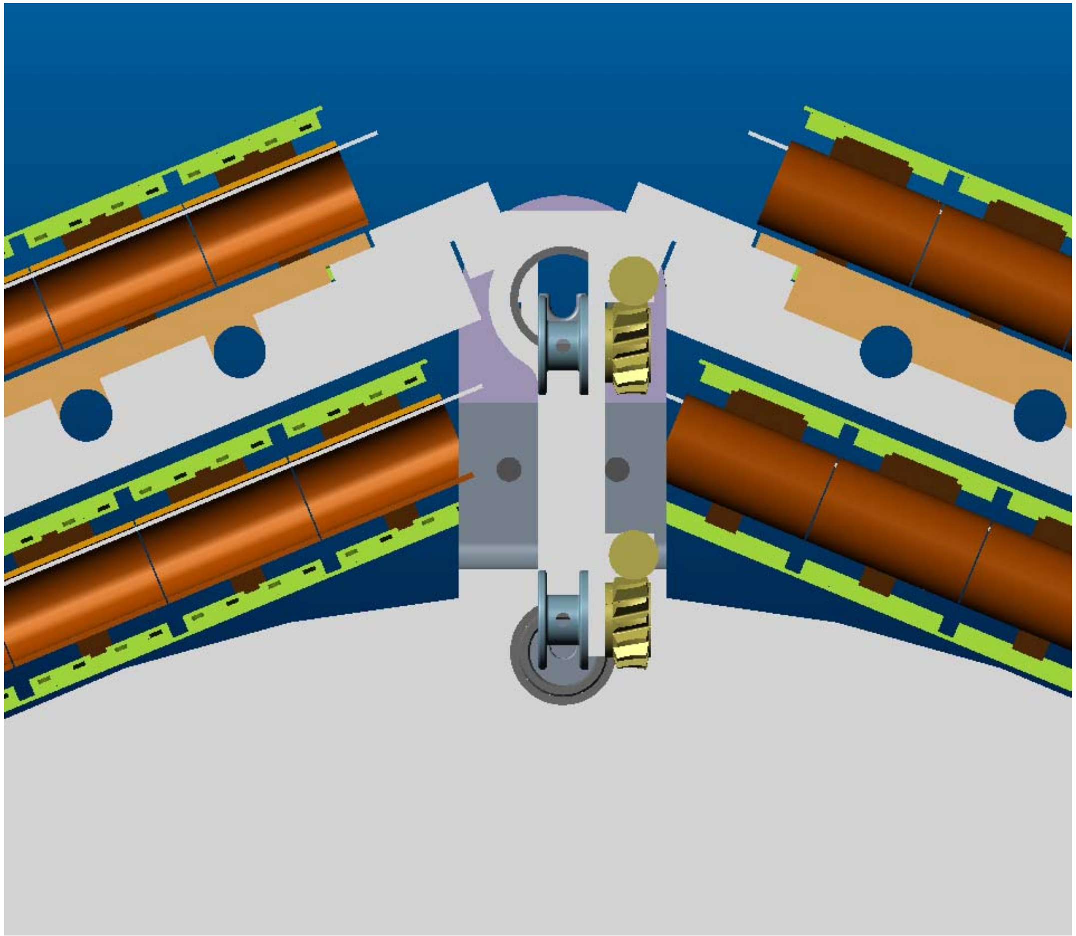


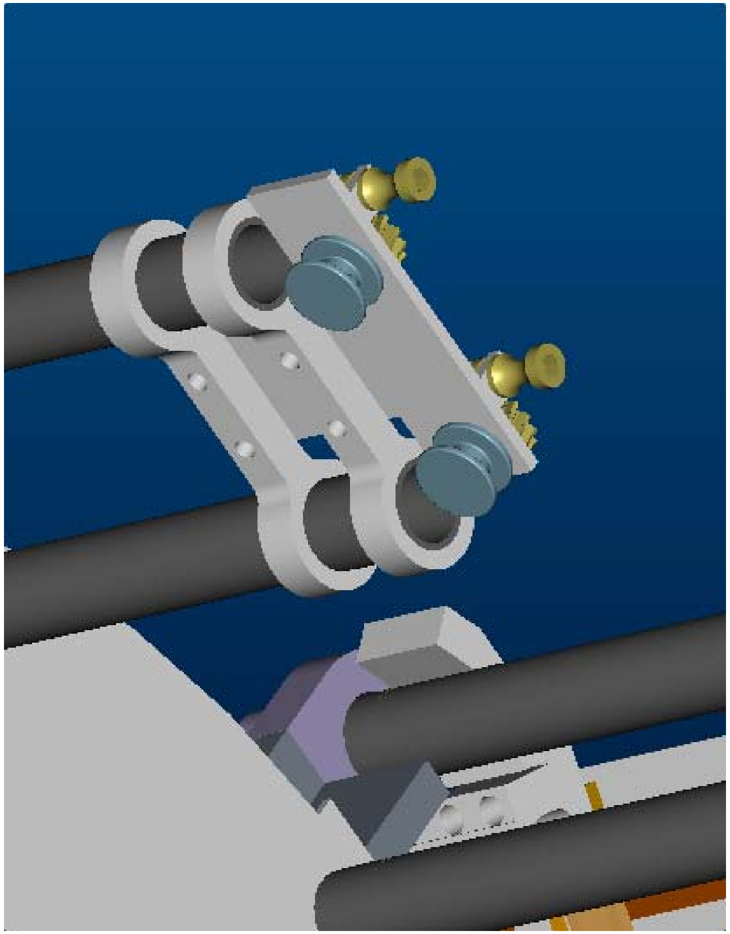


Use "Tuning Engine" Design

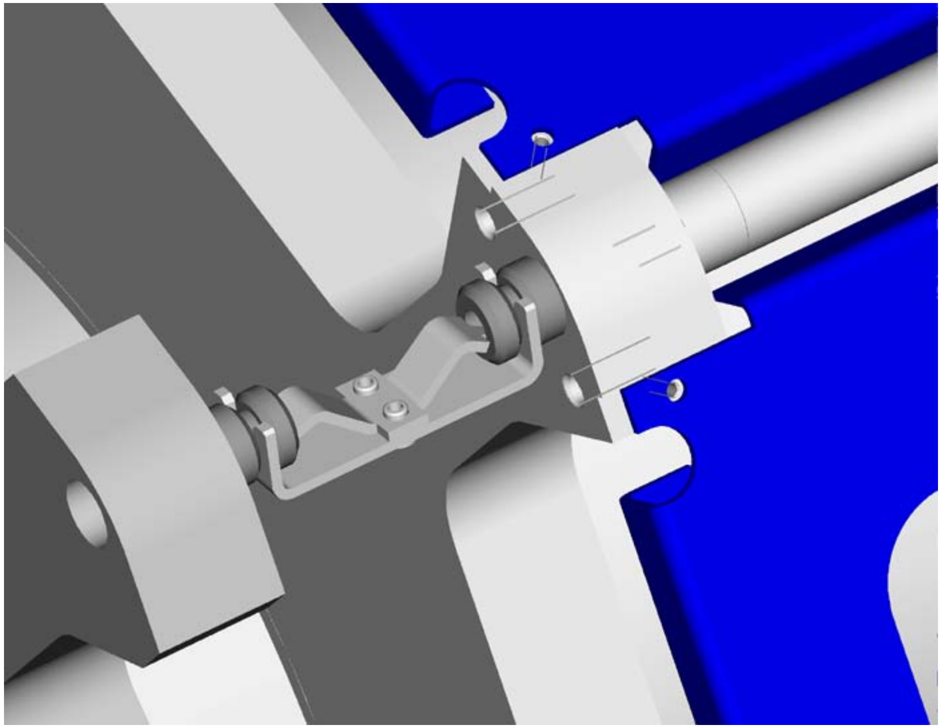


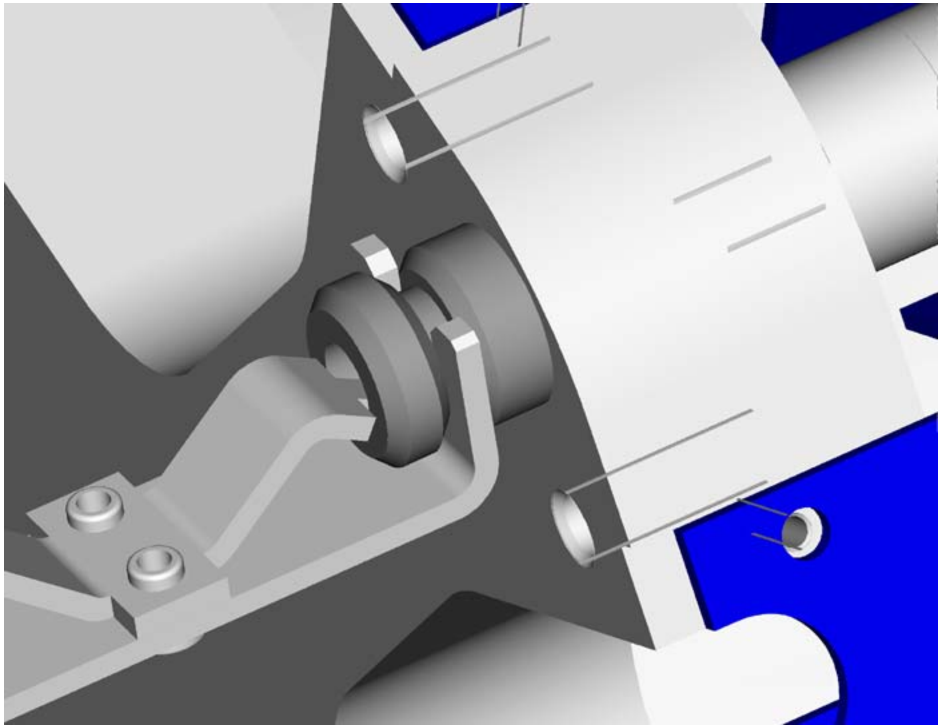
Tuning engine alignment





Tension/Compression Transmission through structures not services





Clips register to Buttons on Frame and Service/Beampipe support structure

Gaps allow 'Phi' offsets of up to +/- 1mm while only 0.25mm longitudinally

Pixel Detector Integration
E. Anderssen LBNL