Manufacturing the pfRICH Outershell at Stony Brook

Stony Brook ,Yale, Henry Klest (ANL)

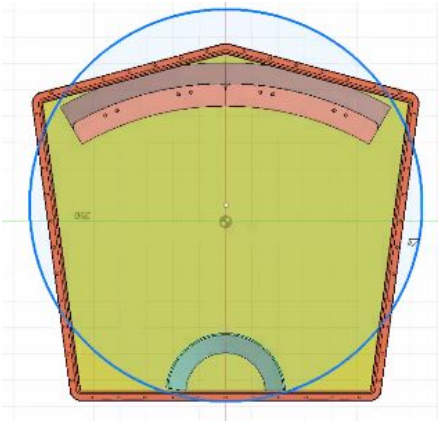
Sep 11, 2023

Consensus among all on Prototype construction (from the previously)

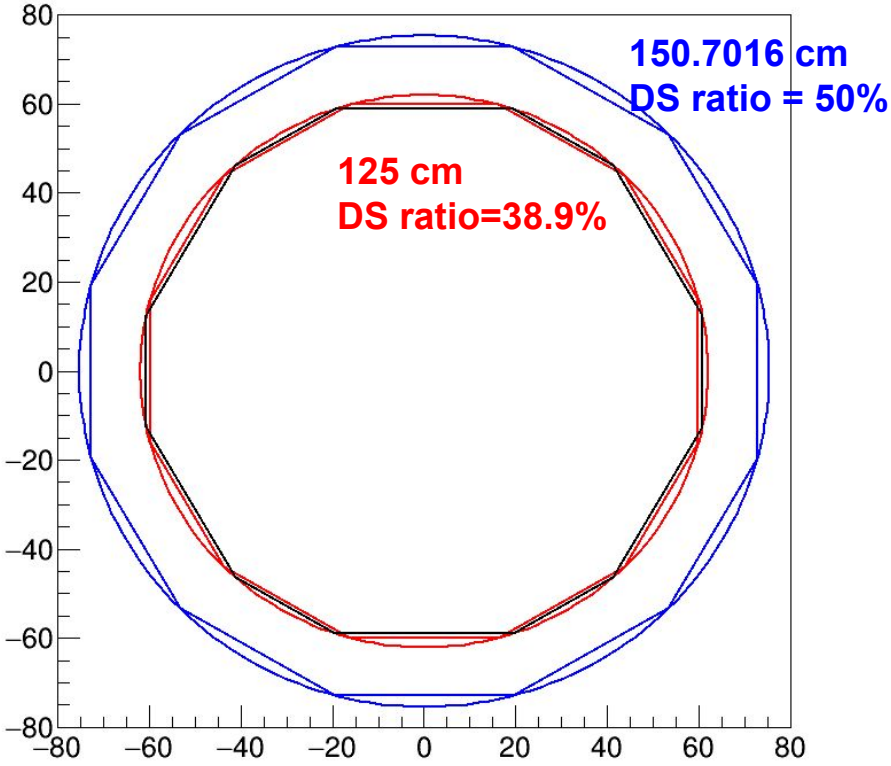
- **TPC style mandrel is the chosen technique to construct the prototype vessel.**

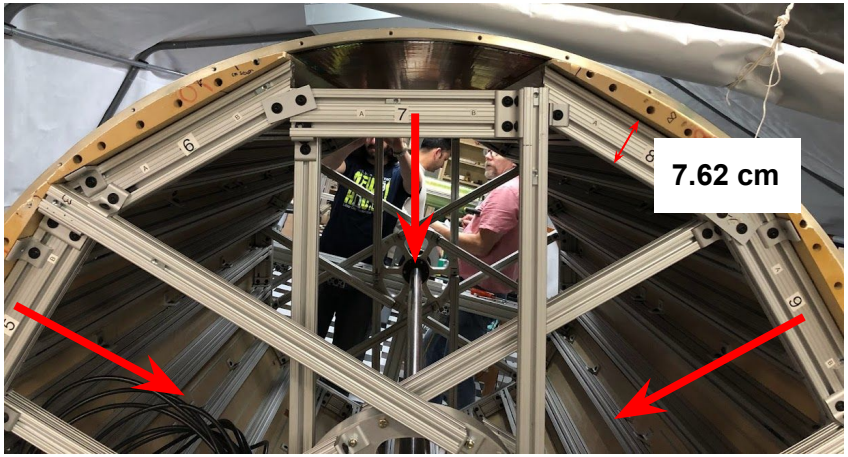
- **Preference to build a smaller vessel for for the prototype**
  - **Demonstrating the manufacturing technique**
  - **Disentangle the prototype vessel production from the constant revision of the actual TPC**
  - **75cm diameter vessel is the smaller we can go (enclosing all components)**

- **What is the path forward? Cost? Timeline?**
  - **We prepared several options. See the following slides.**



Exploration to build a mandrell with smaller radius of curvature

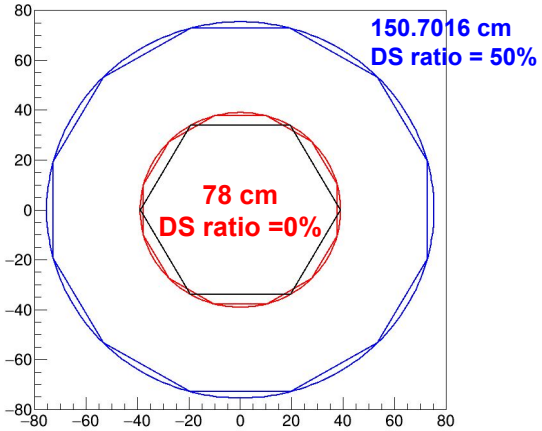


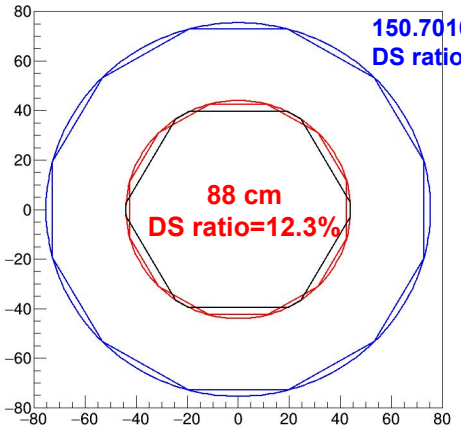


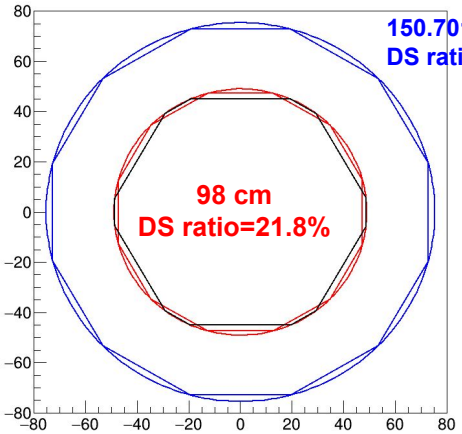
- Ability to pull back (ractangulat) is essential for the disassembly process

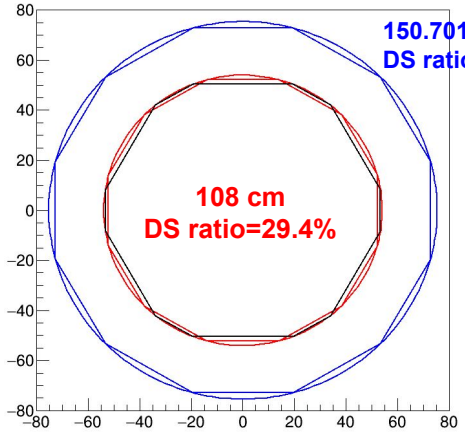
Diagonal surface (DS) ratio = Diagonal contact surface / circumference

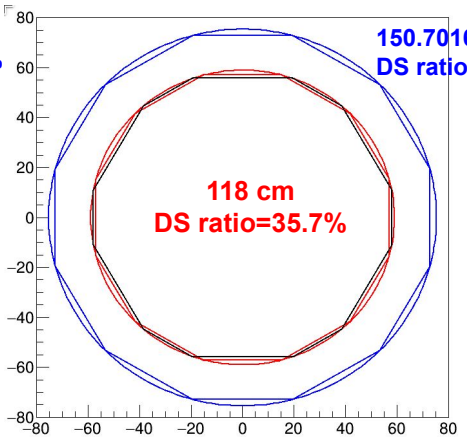
Exploration to build a mandrell with smaller radius of curvature

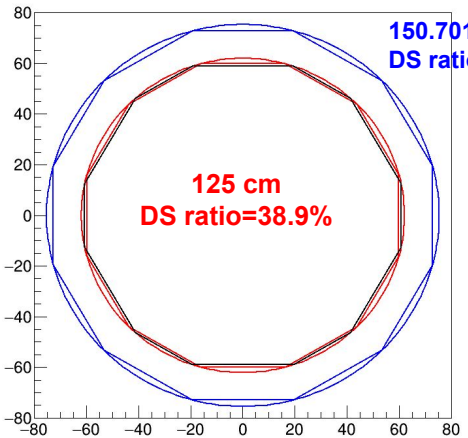












Exploration to build a mandrell with smaller radius of curvature

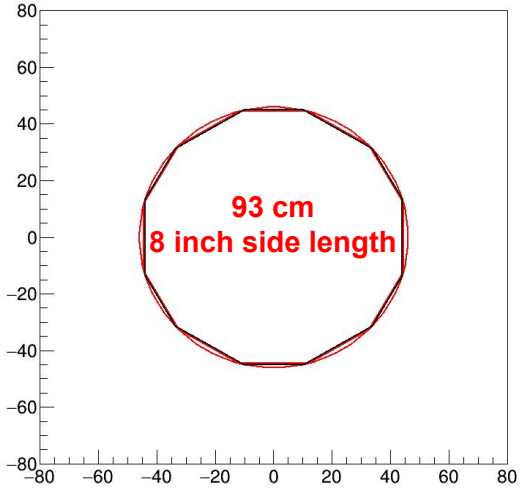
Diameter (cm)	Diagonal piece length (cm)	DS ratio (%)
78	0.00	0
88	7.38	12.3
98	13.08	21.8
108	17.64	29.4
118	21.42	35.7
125	23.34	38.9

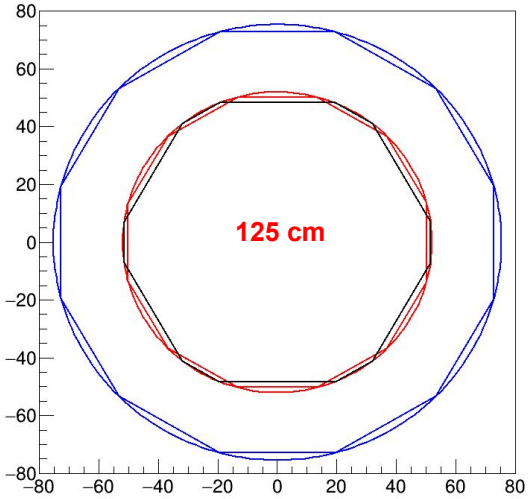
These are requires a new mandrel

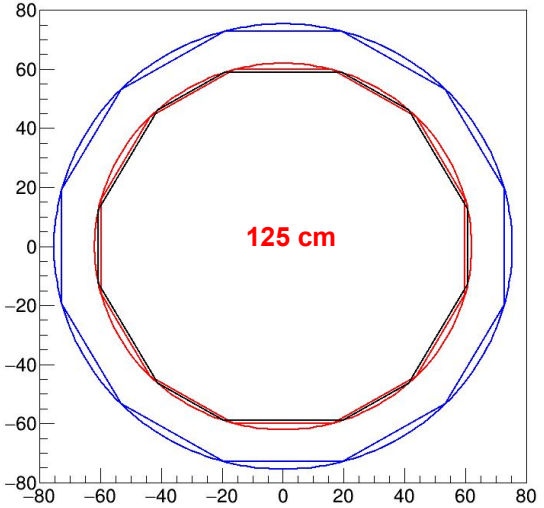
These are feasible options to adapt existing TPC mandrel parts

Prototype vessel mandrel options

- **Option 1: A brand new smaller mandrel for a vessel: 75-91 cm diameter**
  - Example vessel: 91.44 cm in diameter
- **Option 2: A modified existing mandrel for a vessel: 105 cm diameter**
  - Example vessel: 105 cm in diameter
- **Option 3: A modified existing mandrel for a vessel: 100-125 cm diameter**
  - Example vessel: 125 cm in diameter







Option 1 Cost Estimate (75-95 cm mandrel)

Item	Qty	Cost	Vendor	Comment
Machinable Foam Board	9	$3300	General Plastic	
~~End-ring~~	~~2~~	~~$24,000~~	~~Streck~~	~~Long lead item, which requires to be bid~~
Carbon Fiber Sheet (inner)	2	$1,400	ProTech	Matte and glossy. Cut to the specific sheet. To be quoted
Carbon Fiber Sheet (outer)	2	$1,400	ProTech	Matte and glossy. Cut to the specific sheet. To be quoted
Honeycomb	2	$700	Plastcore	Plascore Aramid Fiber Honeycomb, PN2 - 3/16 - 3.0 - OV -20D07 0.500x48.000x96.000 in
New Mandrel table (shorter length)		$4,400		Two new 8020 beams, One new SS shaft, One new lead screw, One new magnetic strip
80/20's and Epoxy+supplies,others		$ 2,000	3M	
~~Hardware pieces~~		~~$2,300~~		
Hardware Machining		$7,200		**18 days to machine, SBU machine shop lead tim, 6-8 weeks**
~~Total~~		~~$22,700~~		

~~New mandrel specific cost (see backup slides for detail)~~

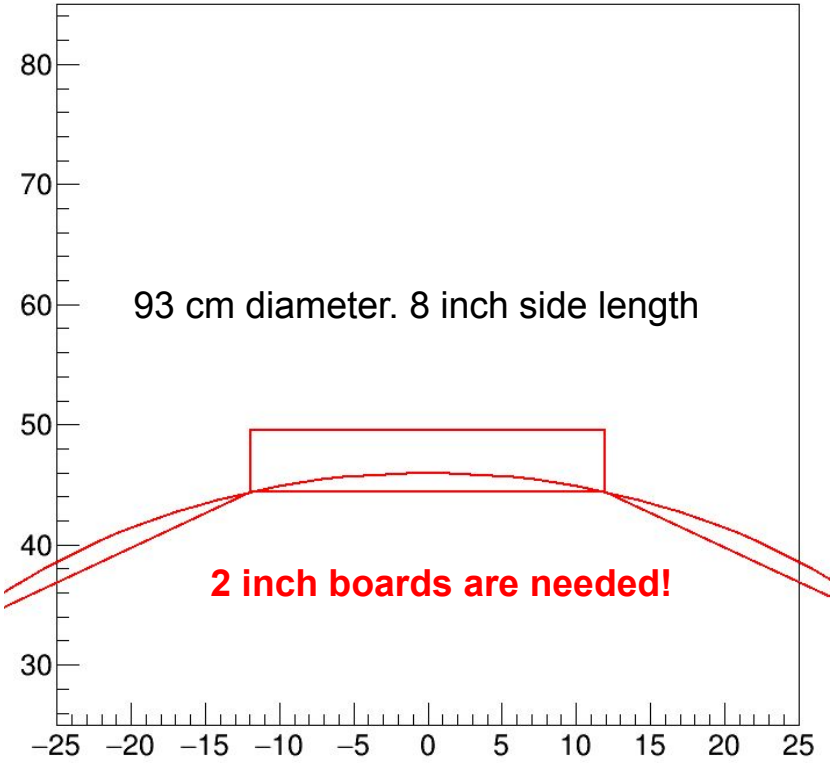
Option 2 Cost Estimate (105 cm mandrel)

Item	Qty	Cost	Vendor	Comment
Machinable Foam Board	12	$4,900	General Plastic	
~~End ring~~	~~2~~	~~$24,000~~	~~Streck~~	~~Long lead item, which requires to be bid~~
Carbon Fiber Sheet (inner)	2	$1,600	ProTech	Matte and glossy. Cut to the specific sheet. To be quoted
Carbon Fiber Sheet (outer)	2	$1,600	ProTech	Matte and glossy. Cut to the specific sheet. To be quoted
Honeycomb	3	$1,000	Plastcore	Plascore Aramid Fiber Honeycomb, PN2 - 3/16 - 3.0 - OV -20D07 0.500x48.000x96.000 in
New Mandrel table (shorter length)		$4400		Two new 8020 beams, One new SS shaft, One new lead screw, One new magnetic strip
80/20's and Epoxy+supplies, others		$2000	3M	
8020 and machining		$500		
Total		$16,000		

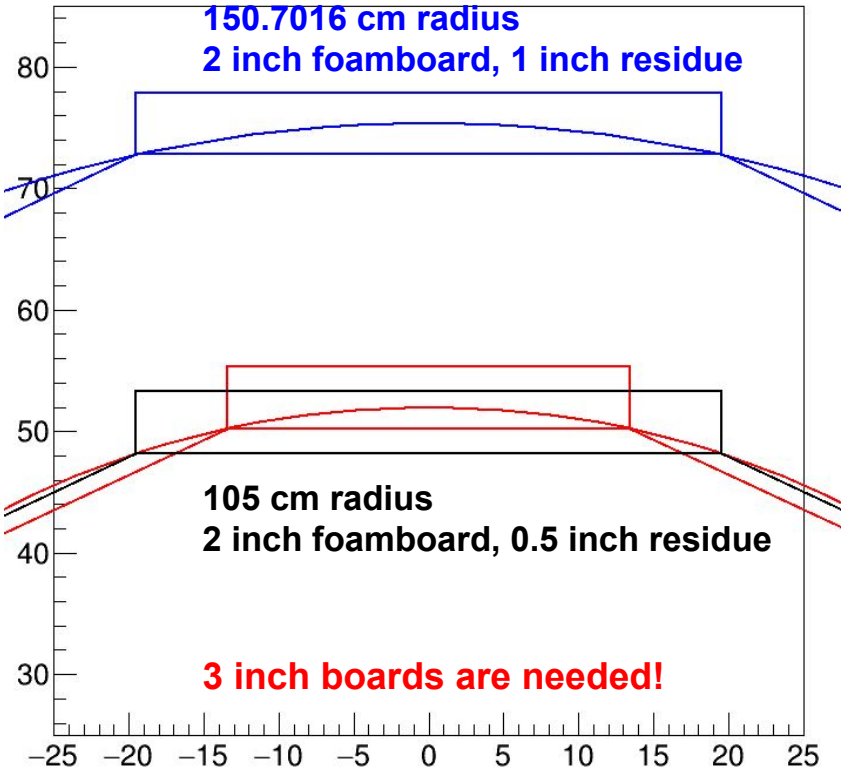
Option 3 Cost Estimate (125 cm mandrel)

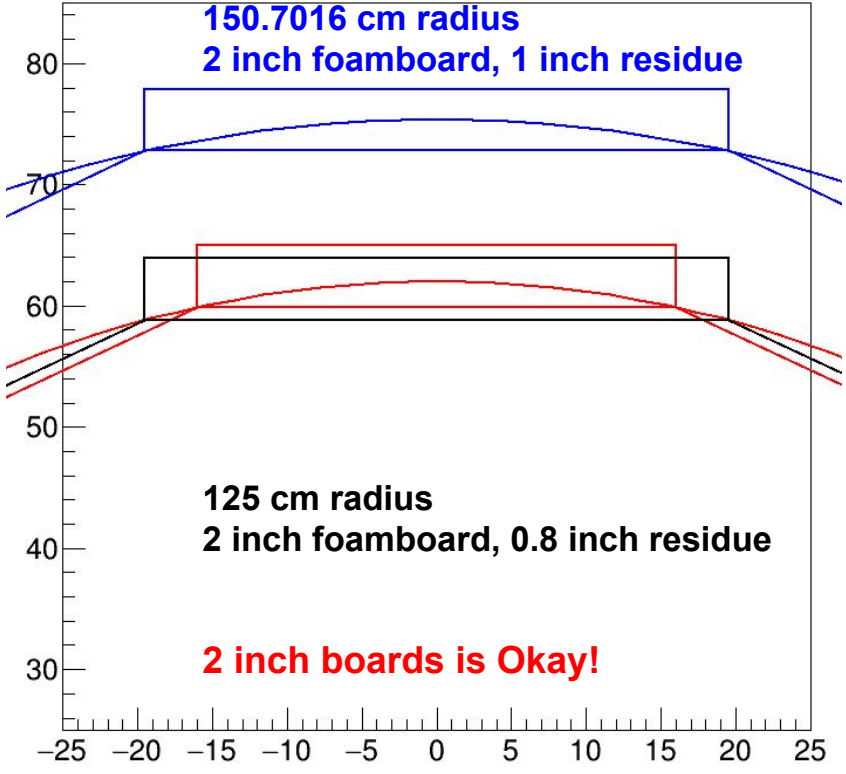
Item	Qty	Cost	Vendor	Comment
Machinable Foam Board	12	$4500	General Plastic	
~~End ring~~	~~2~~	~~$24,000~~	~~Streck~~	~~Long lead item, which requires to be bid~~
Carbon Fiber Sheet (inner)	2	$1,700	ProTech	Matte and glossy. Cut to the specific sheet. To be quoted
Carbon Fiber Sheet (outer)	2	$1,700	ProTech	Matte and glossy. Cut to the specific sheet. To be quoted
Honeycomb	3	$1,000	Plastcore	Plascore Aramid Fiber Honeycomb, PN2 - 3/16 - 3.0 - OV -20D07 0.500x48.000x96.000 in
New Mandrel table (shorter length)		$4400		Two new 8020 beams, One new SS shaft, One new lead screw, One new magnetic strip
80/20's and Epoxy+supplies, others		$2000	3M	
8020 and machining		$500		
Total		$15,800		

Foamboard Depth (Cost Influencer)



Foamboard Depth (Cost Influencer)





Longer time to machine, more material needs to be cut

Summarizing

	New hardware	Cost ($)	Construction time	Adapt for real pdRICH vessel use?
Option 1	Yes	22.7k	June 2024	No
Option 2	No	16.0k	April 2024	Yes
Option 3	No	**15.8k**	April 2024	Yes

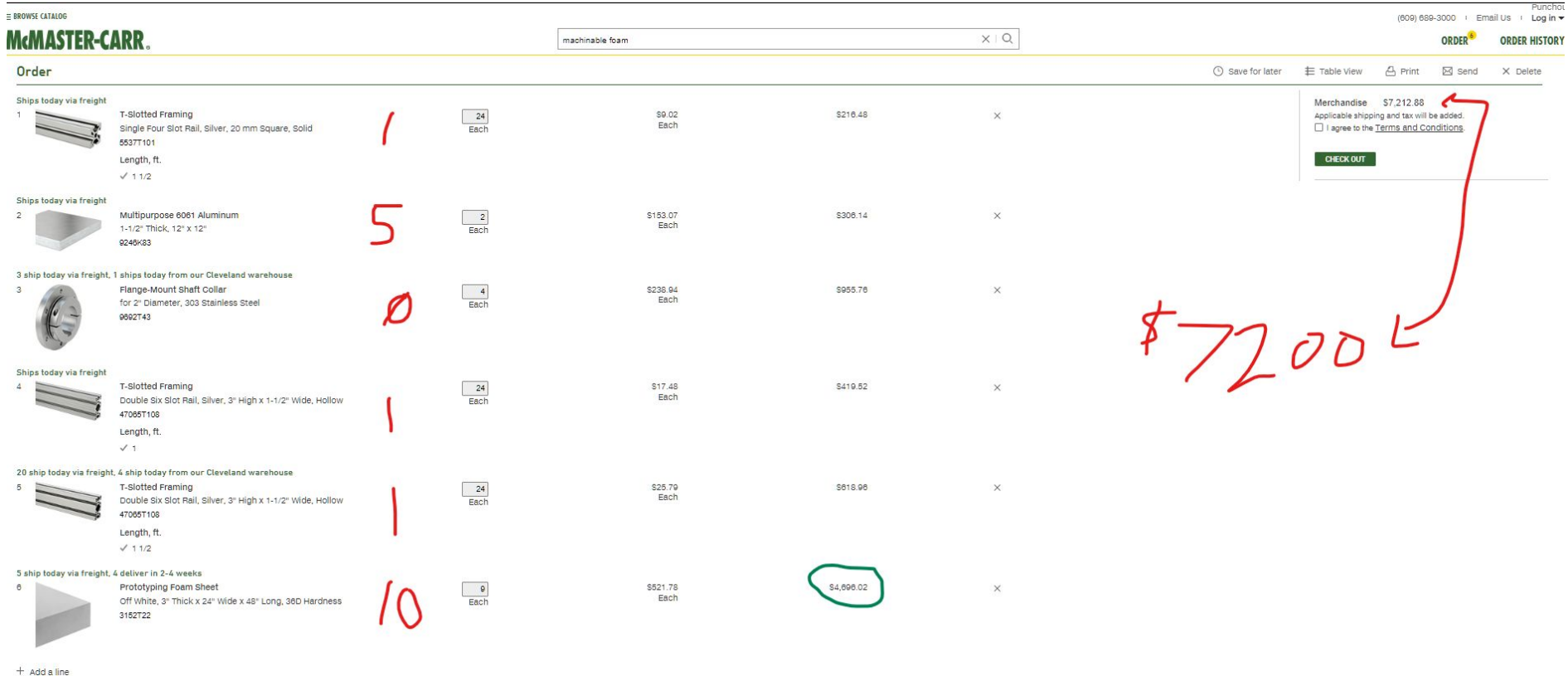
Without endring insertion

Extra time = SBU workshop lead time (6-10 weeks) + Machining time

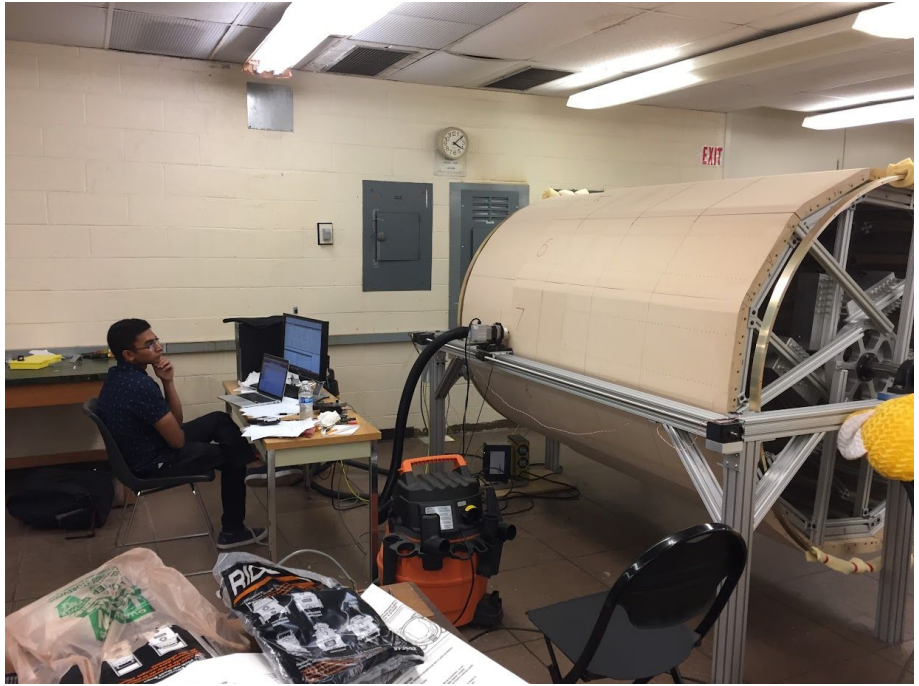
- Option 1 carries a risk factor of completion time.
- If option 2 & 3 is chosen, the final mandrel can be produced under 10k.

Backup

Option 1 Hardware and machining cost detail



The Mandrel Conceptual Design



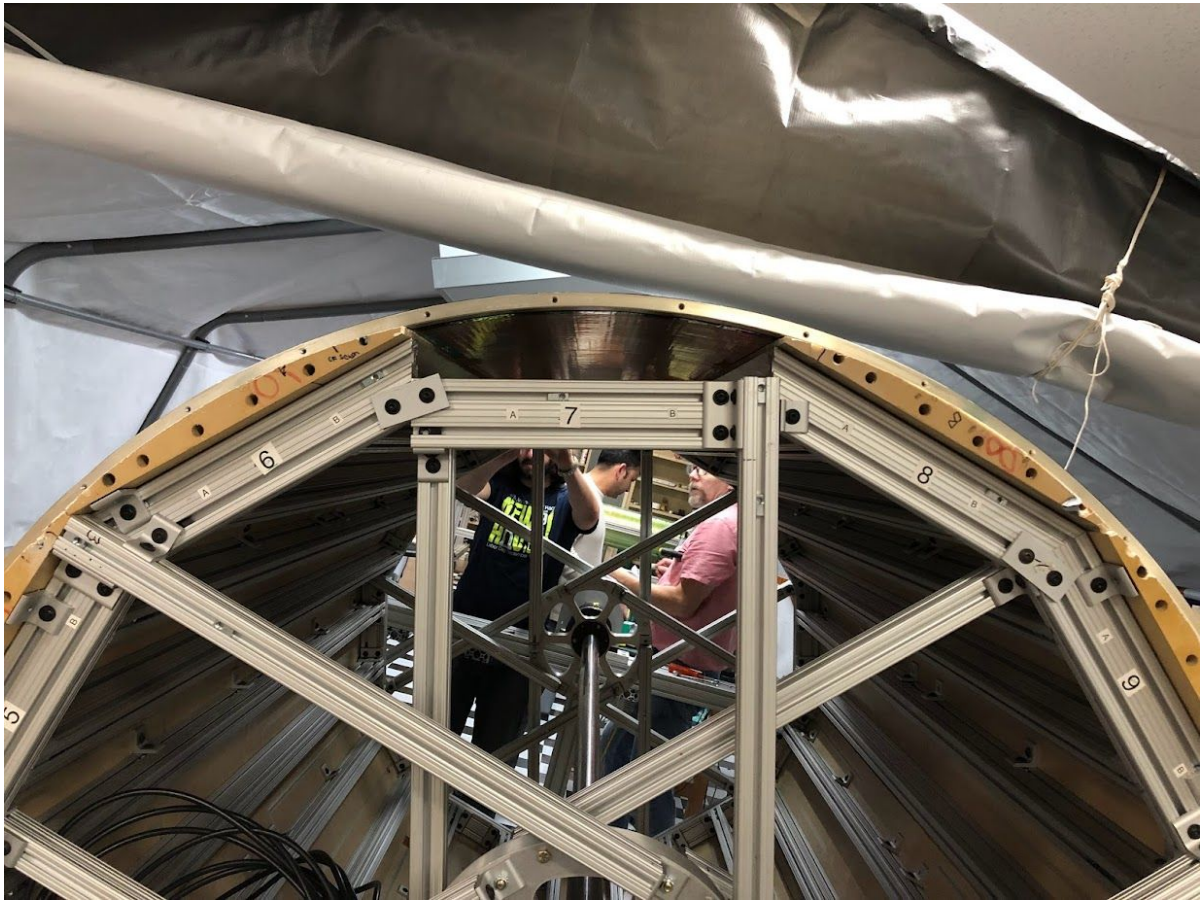
Consensus and Questions

- **Consensus**
  - **If we have a mandrel, the outer shell is relatively easy to construct.**

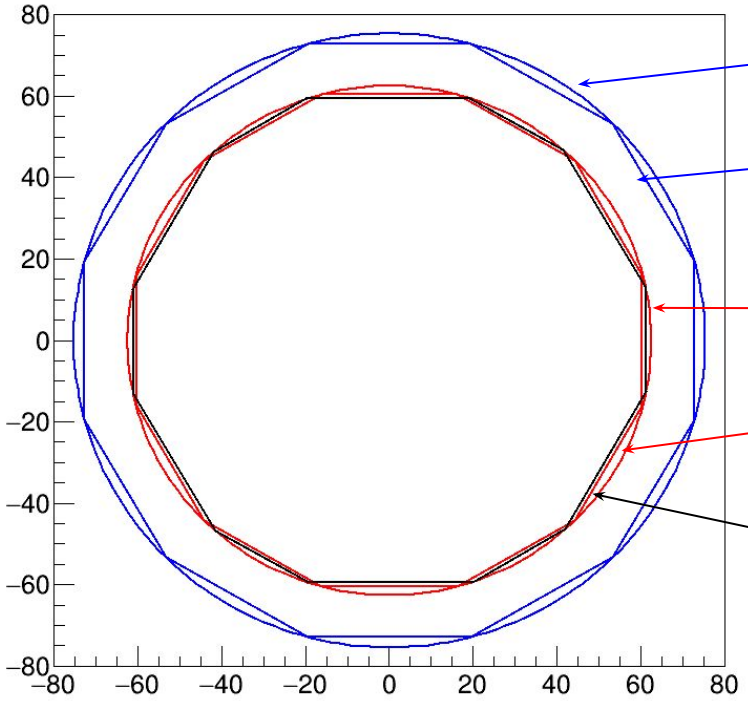
- **Questions and concerns:**
  - **What kind commitment/resources that is needed to construct the pfRICH mandrell?**
  - **How long it will take ? (In time for the beam test in 2024?)**
  - **What if the project changes the radius of curvature in the last minute?**

- **Answers are provided.**

The TPC Mandrel Design



The Mandrel Conceptual Design



TPC Inner Diameter: 150.7106 cm
(Radius 75.3553 cm)

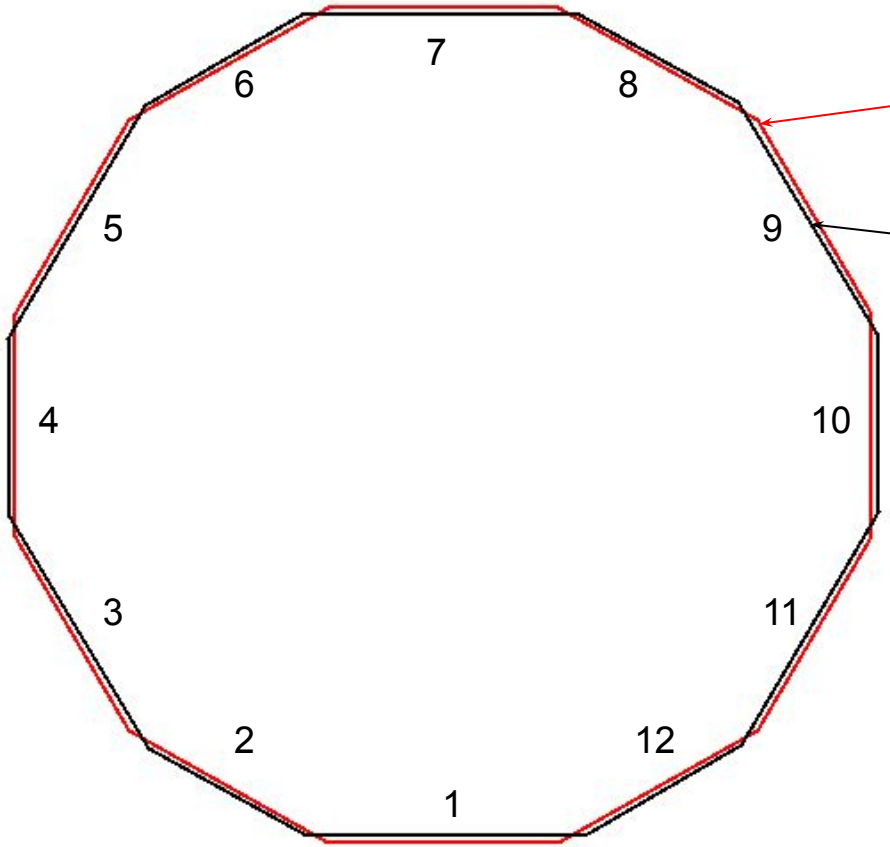
TPC Foam board layout

pfRICH Inner Diameter: 125.06 cm
(Radius: 62.53 cm)

pfRICH Foam board layout (if we scale proportionally)

pfRICH Foam board layout New design !

The Mandrel Conceptual Design detailed look



pfRICH Foam board layout (if we scale proportionally)

pfRICH Foam board layout New design !

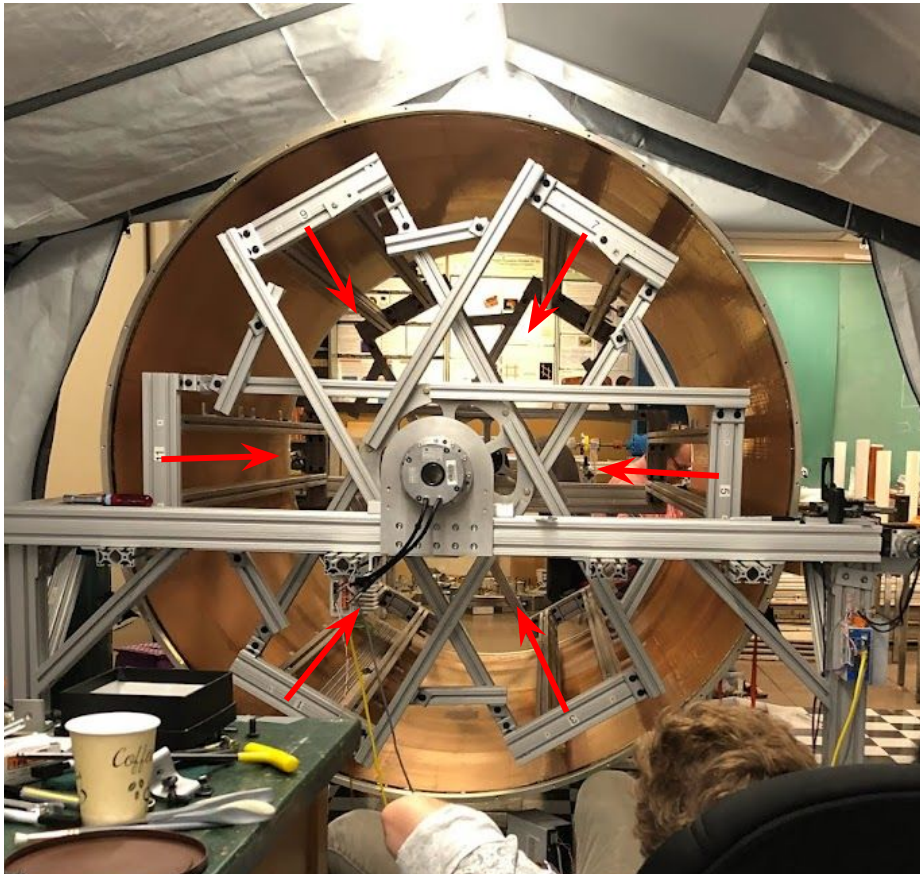
New design:

- Odd numbered foam boards are longer (same length as the TPC ones)
- Even numbered foam boards are shorter

Implication:

- **60% of the TPC mandrel structure is reusable!**

The pfRICH Mandrel is not hard!

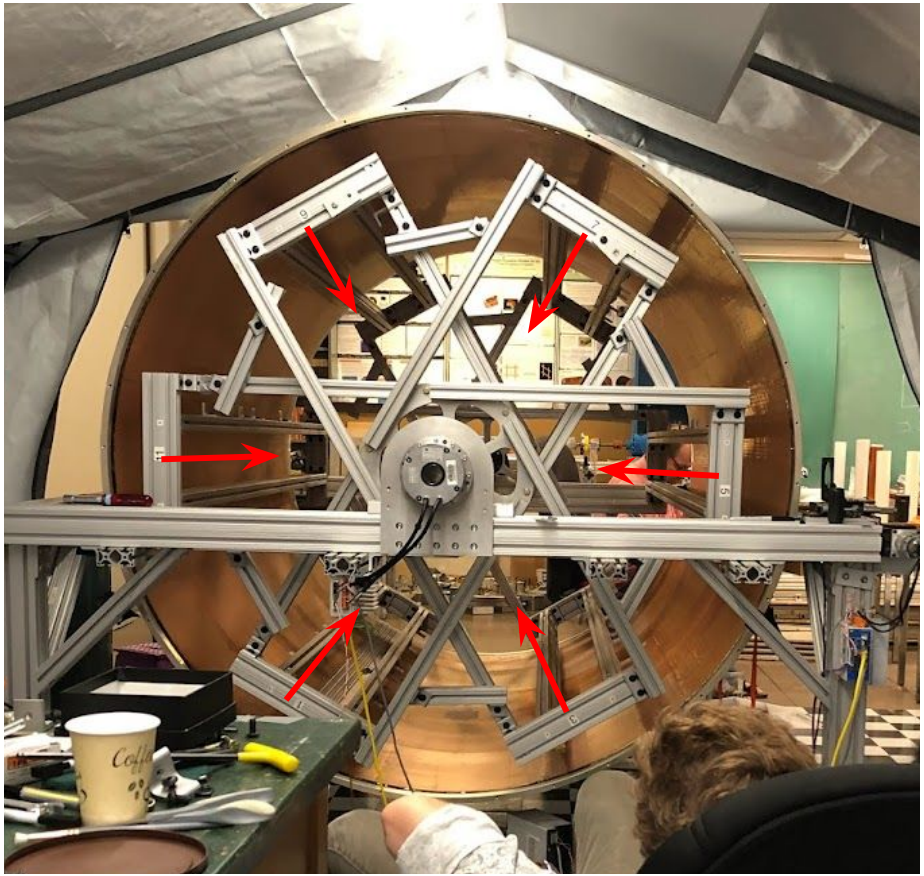


- 60% of the TPC mandrel structure is reusable! (everything shown in the picture)
- only the diagonal pieces need to be made.
  - 12 customized 80/20 pieces are needed
- Re-assembly is needed to start now!

How much it will cost?

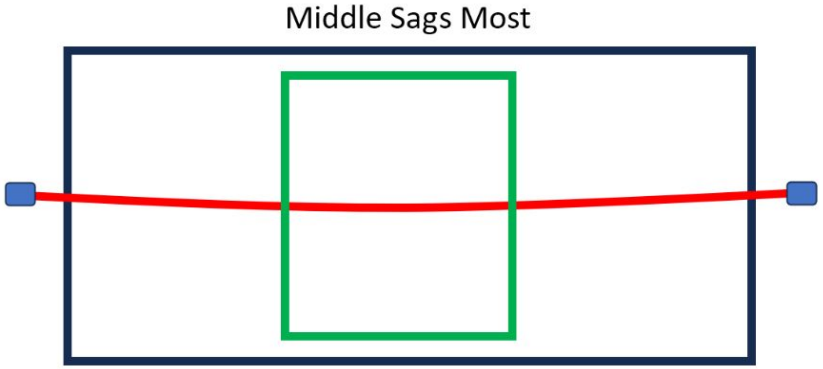
Item	Qty	Cost	Vendor	Comment
Machinable Foam Board	14	$5,200	General Plastic	
End-ring	2	$24,000	Streck	Long lead item, which requires to be bid
Carbon Fiber Sheet (inner)	2	$1,700	ProTech	Matte and glossy. Cut to the specific sheet. To be quoted
Carbon Fiber Sheet (outer)	2	$1,700	ProTech	Matte and glossy. Cut to the specific sheet. To be quoted
Honeycomb	3	$1,000	Plastcore	Plascore Aramid Fiber Honeycomb, PN2 - 3/16 - 3.0 - OV -20D07 0.500x48.000x96.000 in
New Mandrel table (shorter length)		$4400		Two new 8020 beams, One new SS shaft, One new lead screw, One new magnetic strip
80/20's and Epoxy+suplies, and others		$ 2000	3M	
Total		$40,000		

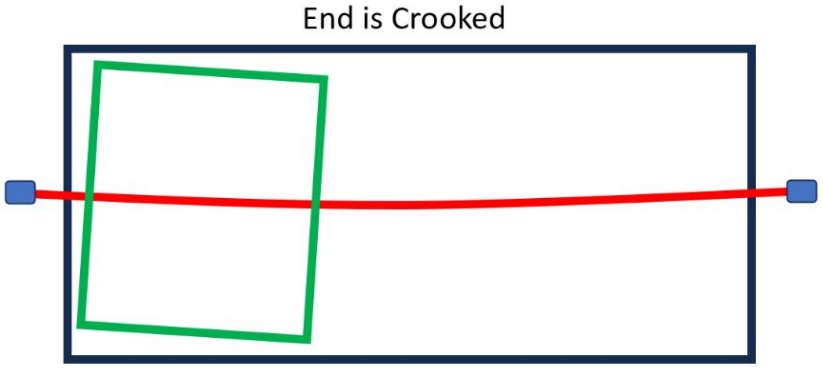
Timeline



- Placing the orders immediately! Except the end-rings.
- BNL engineer to provide certified blueprints for the end-ring. Then bidding process starts (Nov 2023)
- Stony Brook team will assemble/restore the TPC mandrel immediately. Completing the assembly by March 2024 with the end ring)
- April 2024, foam board machining begins.
- June 2024, gluing Carbon Fiber, Honeycomb, Carbon Fiber.

Length of the table





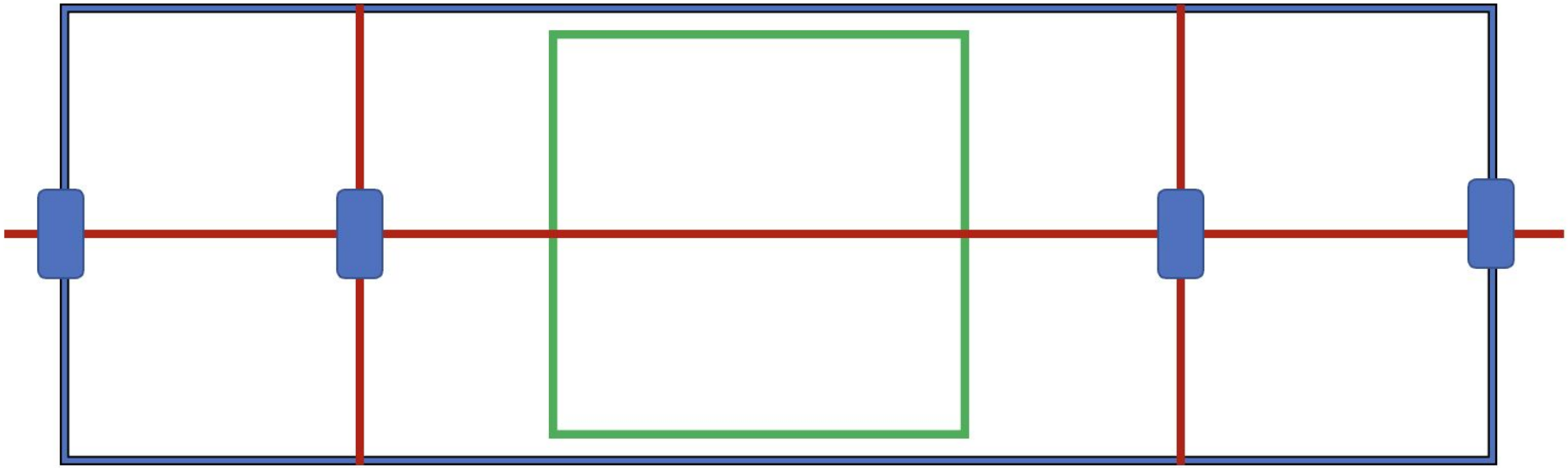
- **Existing TPC mantrel table is too long**
- **Sagging or crookedness is unavoidable**
- **We strongly suggest to purchase a new mandrel table at a shorter length**

The 96" magnetic stripe was $231.
The shaft at long length was $395
The 8020 is $77.42 each.

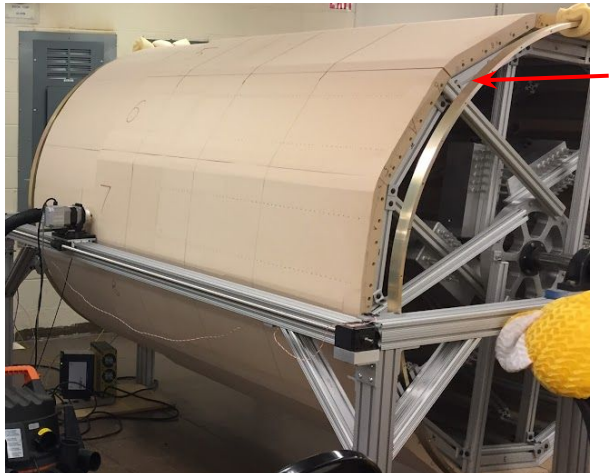
So a rough guide to the additional cost of making the mandrel table shorter
Is:

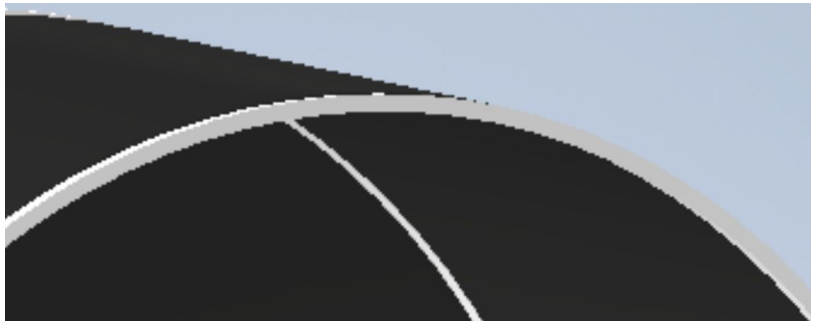
- $3612 + $231 + $395 + $154.84 = $4395.84

Long vs shorter Table for the pfRICH



Urgently item: end ring

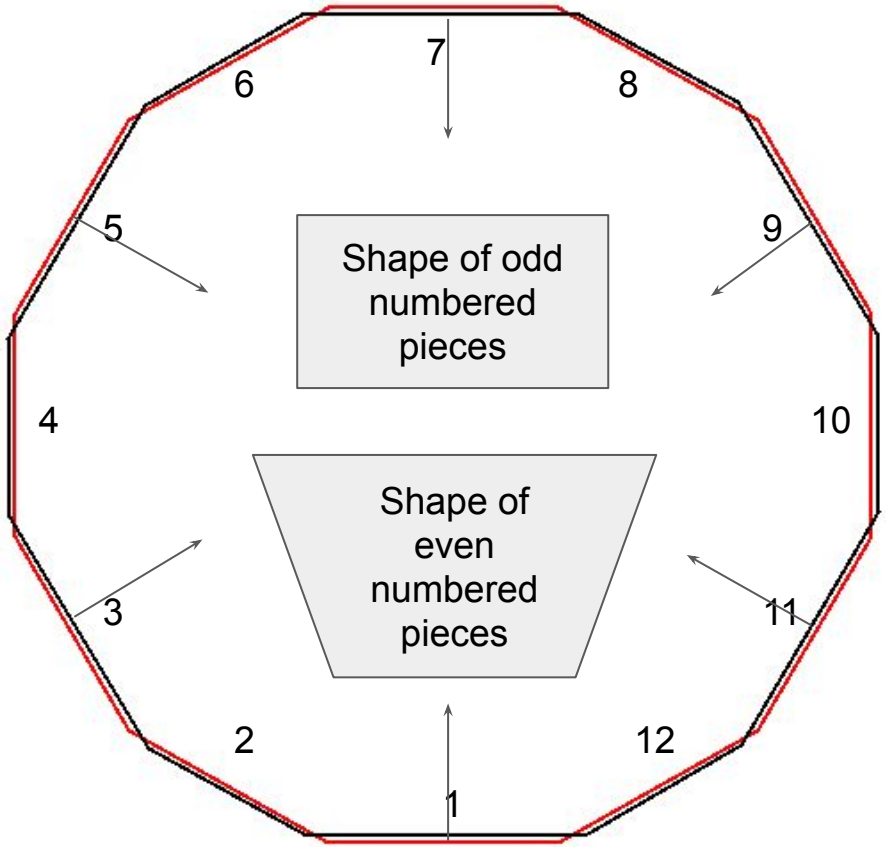




- **End-ring need to be part of the assembly on day 1 (as the machinable foam is mounted): Match 2024**

- **Current end-ring-wall design requires revision immediately!**
  - End-ring need to be enclosed between the carbon fiber sheets.
  - The carbon fiber thickness is not currently taken into account (2 x 10 mil)

In case of change in pfRICH radius



- **We just pull back the odd pieces**
- **Make new even numbered pieces accordingly.**
- **Change the length of the axles**
- **Repeat the same exercise.**

- **New foam boards …..**
- **New end rings ….**
- **New Carbon Fiber sheet …**
- **Total: $~35k**

Other foreseeable detailed:

- **Leakiness of Carbon Fiber:**
  - **Gas leak:**
    - Vessel is purged with N_2
    - Potential solution: Do nothing
    - Sealing layer
  - **Photon leak:**
    - Potential solution: mylar layer outside and inside.
    - Paint?
    - We have time to resolve this.
- **Geometrical tolerance**
  - That is our requirement