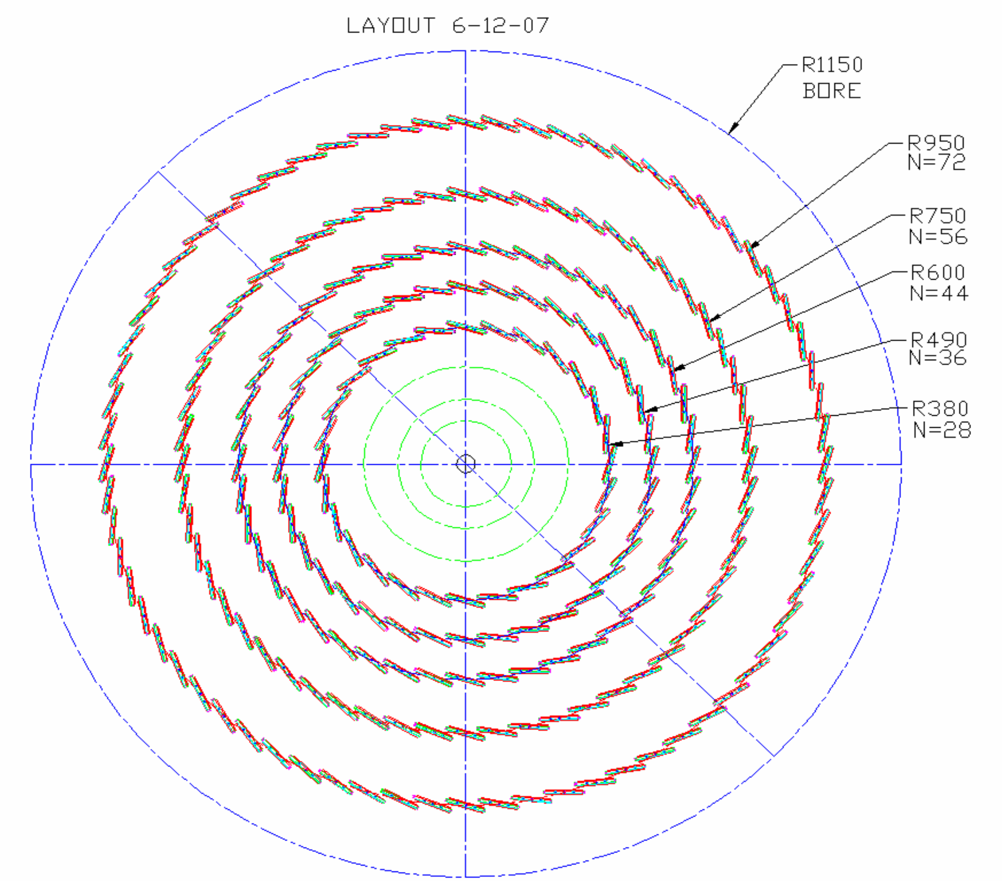
Cost Estimate for Integrated Stave Mechanics/Cooling

The cost estimate is based on the barrel layout shown below.



The number of 1m staves is 2x(28+36+44)=216. The number of 2m staves is 2x(56+72)=256. The approximate total area is then .105x(216+2x256)=76 m^2. The disk area is taken as 23m^2, which is based on the area from "strawman layout 7" times a factor of 1.1 for overlaps. Thus the total area is roughly 100m^2. We take a wastage factor of about 1.2, which yields a total area of about 120m^2.

The total area of facing material needed is thus 2x120xwaste factor(1.25) = 300m^2
The total area of core material needed is thus about 150m^2
The total number of cooling circuits for the barrel is 216+256=472. For the disks we did not make a count but simply scale by the ratio of area to get 143. Thus the total number of cooling circuits is about 615xwaste factor(1.15) or about 700.

We take 335 g/m^2 as the area-density of the facings, based on prototype construction for 3-ply facings. Thus the total weight of facing material is 300x0.335 kg=100 kg. The cost of K13D2U fiber for 10lbs was $1360/lb +2500 setup. Neglect setup. For 100kg this would be $300K. One should expect a cost reduction for large quantities or a cheaper fiber. Guess $1000/lb, which would be $220K.

Core material can be carbon foam or honeycomb+a small amount of foam. Verbal estimates for foam are in the range \$2000-3200 per m^2. So 150 m^2 would be \$300-480K. Prototype honeycomb costs were \$14.5K/m^2 for small quantities, with tight spec on thickness and stiff M46J material. This would imply a cost of about \$2M. However, ROM estimates from the same company for large quantities, but with similar specs, are \$3300/m^2, which implies a cost similar to the upper range of the foam, namely \$495K, call it \$500K in round numbers.

We assume round aluminum tubes. For the 1m staves, we estimate \$20 per bare tube, \$50 per fitting and \$50 per fitting attach eg. welding(not this would not be needed for flare fittings) for a total of \$220 per 1m stave. For 2m staves, not clear that off-the-shelf tubing exists. So assume custom extrusion with \$15K setup and \$50 per tube + same fitting and attach costs or \$15K + \$250 per tube. We take 250 tubes for 1m barrel staves or \$55K. We take 300 for 2m staves or \$90K. This totals to \$145K for the barrel. In the case of flare fittings, the numbers would be \$30K and \$60K, or a total of \$90K for the barrel Including the disks, the numbers roughly become about 30% higher or \$190K and \$120K.

Mount material and fabrication(to the support shells). We do not have a design for this. A very rough guess would be \$50 per mount and 2500 mounts or \$125K.

Equipment, fixtures and tooling will be needed. We assume two production sites. It's likely that a press or autoclave would be used at each site but have not investigated the rough cost of this in detail and have used engineer's estimates. We arbitrarily take \$300K per site for press + 100K for other equipment, tooling materials(but not labor). A lower estimate would be to assume press/autoclave for one site + other equipment ie. 400K. And an upper estimate would be to assume for two sites + additional equipment ie. \$1M.

Glues and other consumables will be needed. Compliant thermally conducting paste/glue for coupling the tube to foam is not cheap. We estimate a total of 130K for consumables.

Shipping of the staves to the module attachment sites is required. We take \$65K for shipping as low estimate and twice this as high.

These non-labor costs are summarized below, taking low and high estimates. A contingency of 50% is included in the table. From this one can conclude that the materials+equipment cost is in the approximate range of \$2-4M.

	Low	High
Facings	220	300
Core	300	500
Tubes	120	190
Mounts	125	250
Equip/tooling	400	1000
Consumables	130	200
Shipping	65	130
Subtotal	1360	2570
Prototype/preproduction	204	386
Subtotal	1564	2956
Contingency	782	1478
GRAND TOTAL	2142	4048

We have also estimated the labor needed. A rough model is to take two sites, two year production, one year of preproduction and one year(effectively) of prototype. For the engineering we take 1FTE for 5 years to lead the design for interfacing to other work and 1 FTE year of designer for detailed design, both at each site. Thus 10 FTE engineer years and 2 FTE designer years. We recognize this is more engineering than needed for just design but reflects the reality of production at two sites. If engineering only at one site, then take 6 FTE years and keep same designer time.

We estimate the technical labor as follows at each site(implicitly assuming equal division, although a more realistic division would be barrel at one site and disks at another) during the two year production phase.

- Tubes – 1-1.5 FTE/yr for bending, leak checking, QC, fittings checking, vendor interactions. Total 2-3 FTE years
- Facing fabrication/QC – 0.5-1 FTE/yr. Total 1-2 FTE
- Core fabrication/QC – 0.5-1 FTE/yr. Total 1-2 FTE
- Assembly and QC – 1.5-2 FTE/yr. Total 3-4 FTE
- Survey – 0.5-1 FTE/yr. Total 1- 2 FTE
- Coordination – 0.5-1 FTE/yr. Total 1- 2 FTE

So in the production phase at each site 3+2+2+4+2+2=15 FTE years for upper estimate and 2+0.5+0.5+3+1+1=8 FTE years for lower estimate. For preproduction we take ½ of this or 4-7 FTE years and for prototyping ¼ or 2- 4 FTE years. Thus total at each site is 14-24 FTE years or for two sites 28-48 FTE years.

Summary of cost estimate

- Materials and equipment: $2-4M
- Engineering labor: 8-12 FTE years
- Technical labor: 28-48 FTE years