

Primary Beamline Radio-Activated Water (RAW) Preliminary Design Review

Horns A, B, & C RAW Systems

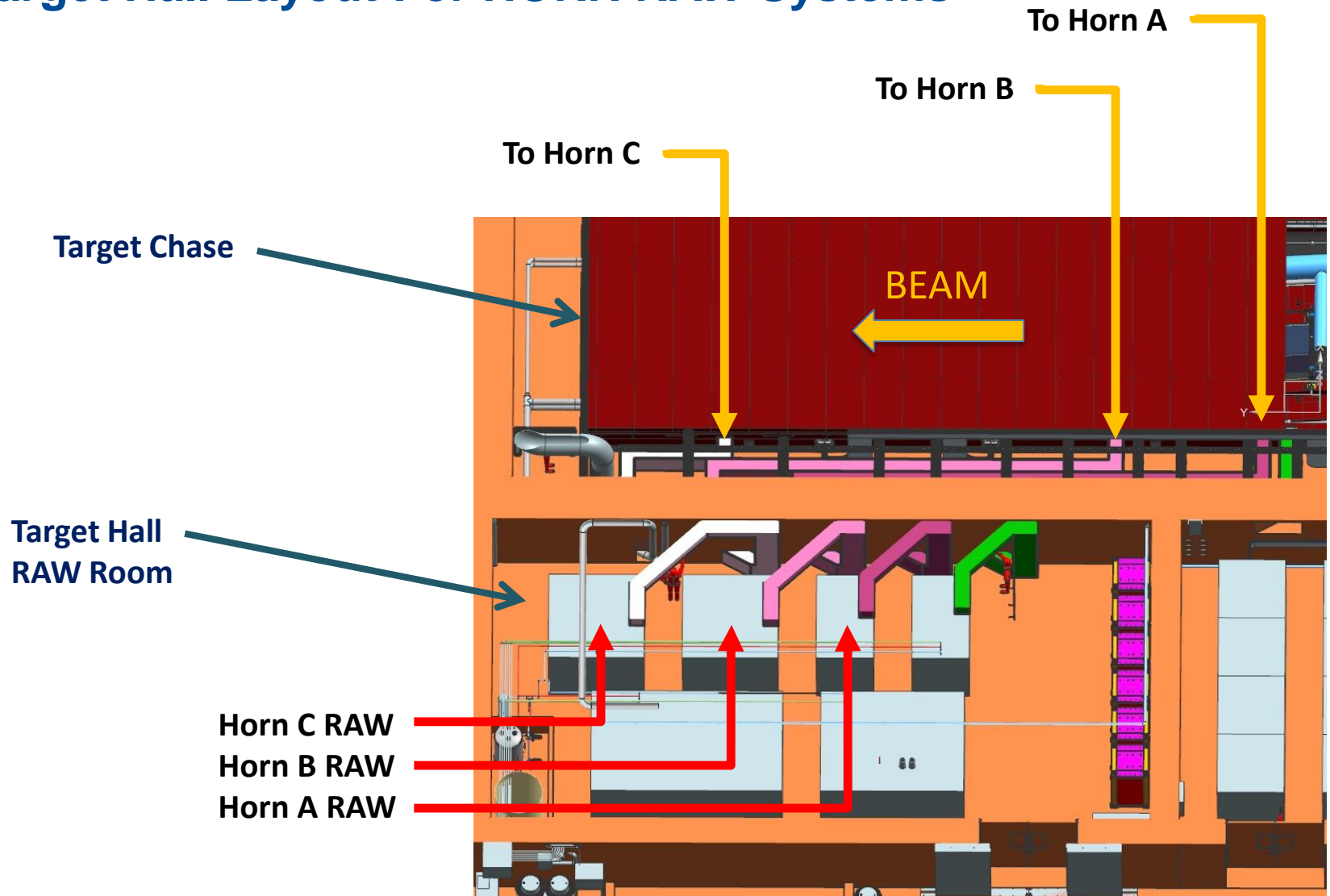
Karlon E. Williams, II

February 19, 2020



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Target Hall Layout For HORN RAW Systems



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Horns A, B, & C - General

Horns require many flow paths for cooling

- 4 manifolds each to feed spray nozzles
- 1 line each for hangers
- Those 5 lines drain to sump tanks below horns, and are pumped back to expansion tanks via ejector pumps

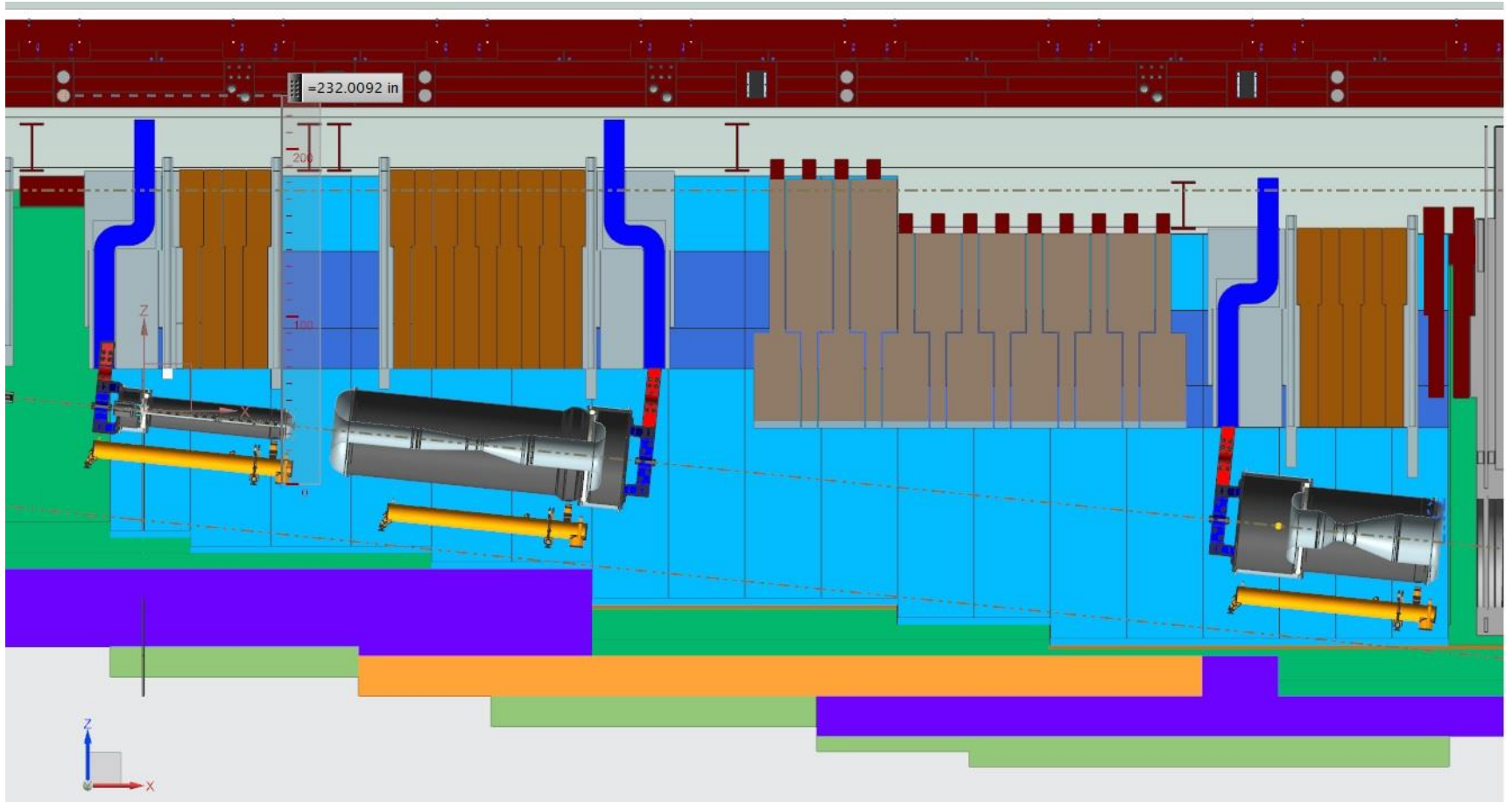
- 1 line each for cooling modules, returns to expansion tank

- 1 line each for motive flow supply to ejector pumps

- Plus one line for filtration

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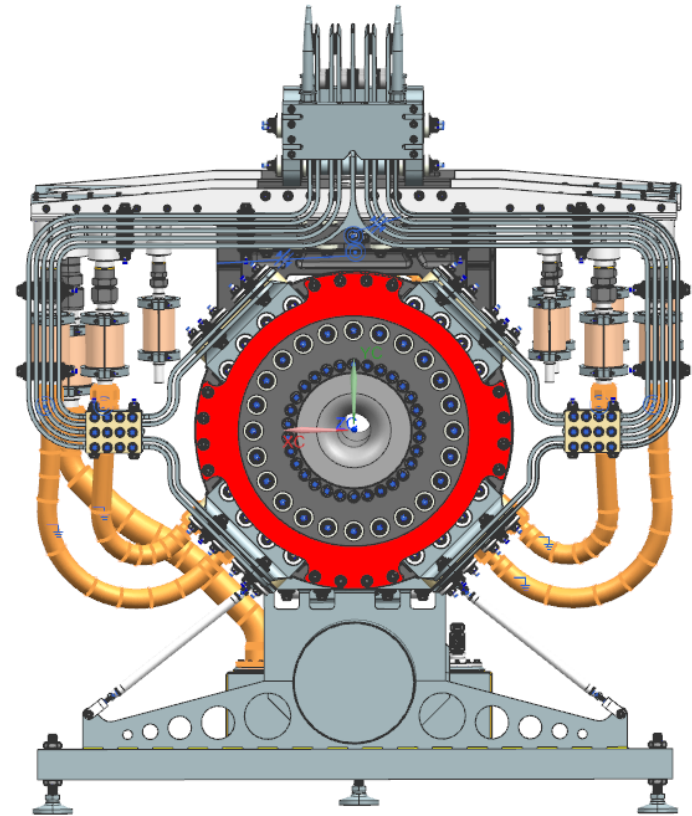
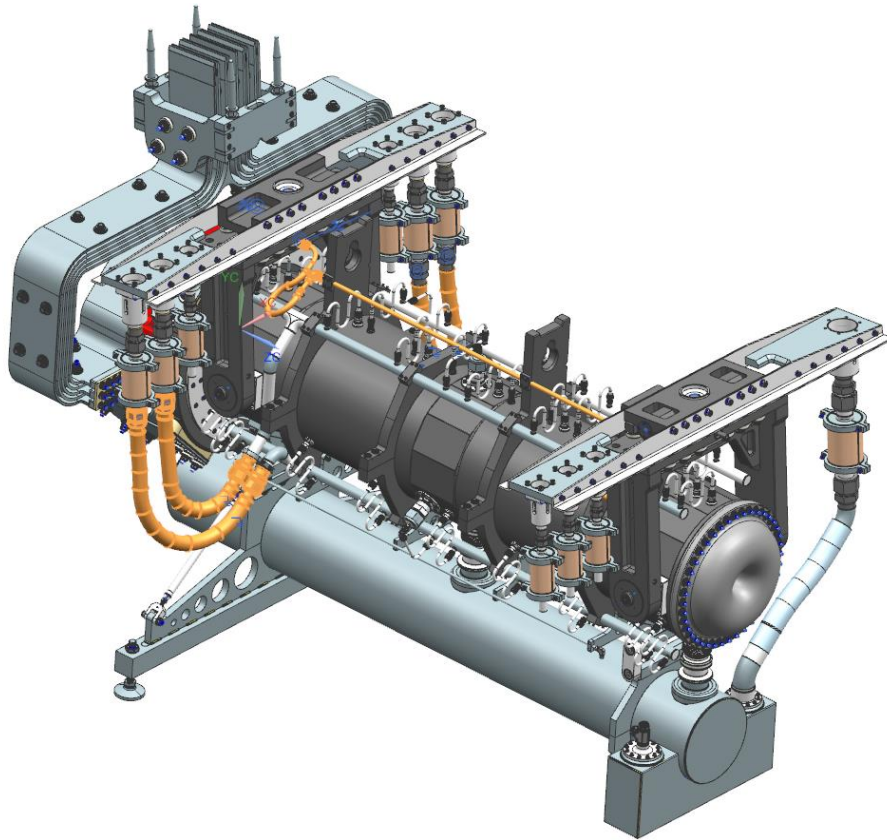
Position Of Horns In Chase



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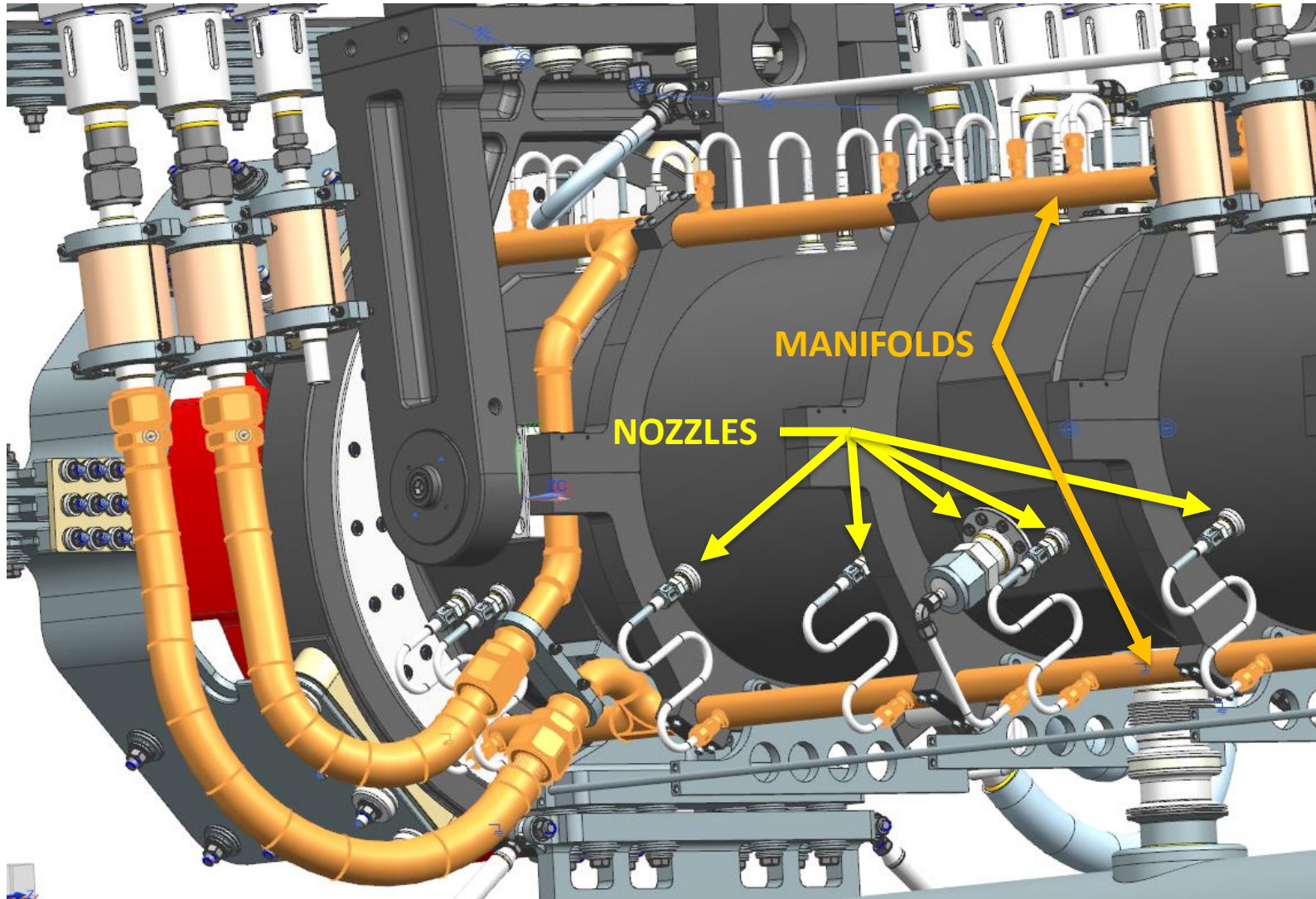
Horn A Close-Up

- Main water manifold flex lines.
- Hanger cooling line routing.
- Module & SLB spacing confirmation.



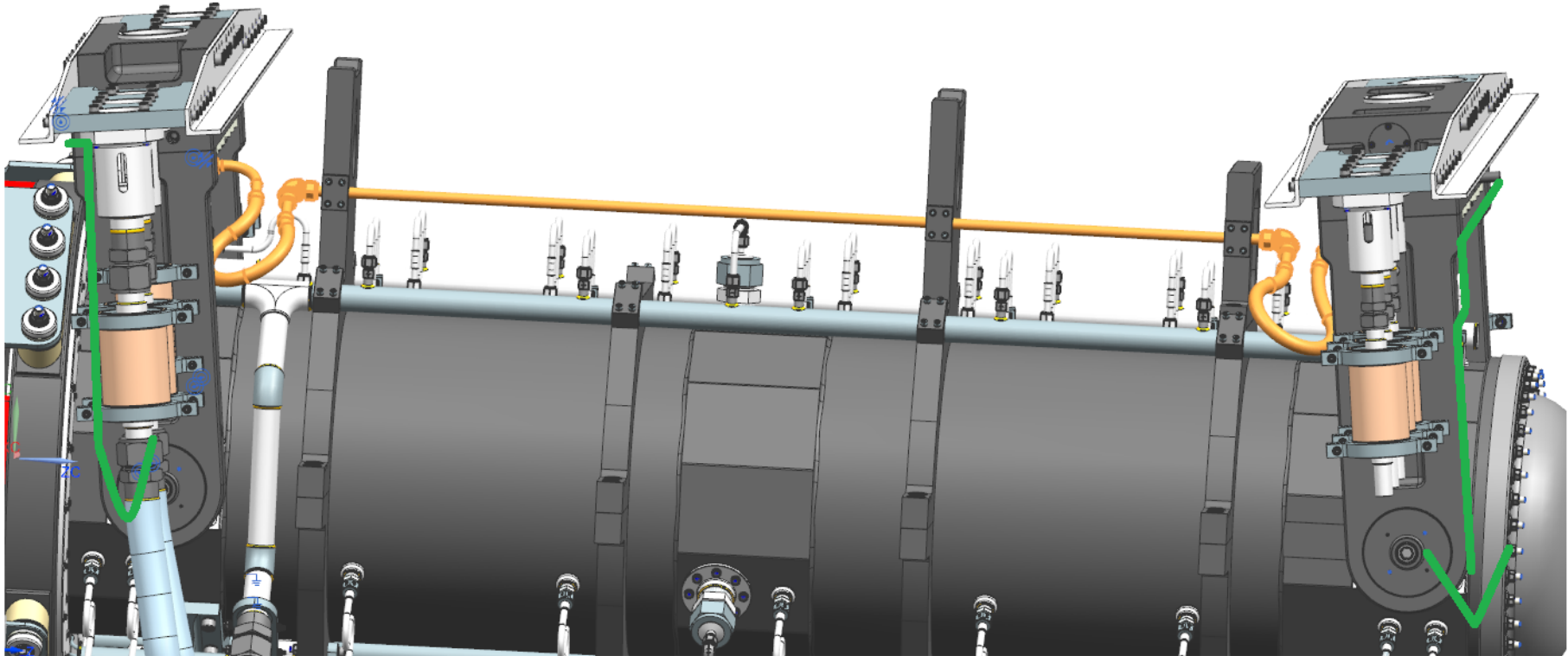
Slide used courtesy Cory Crowley, Mike Campbell

Main Manifold Flex lines



Slide used courtesy Cory Crowley, Mike Campbell

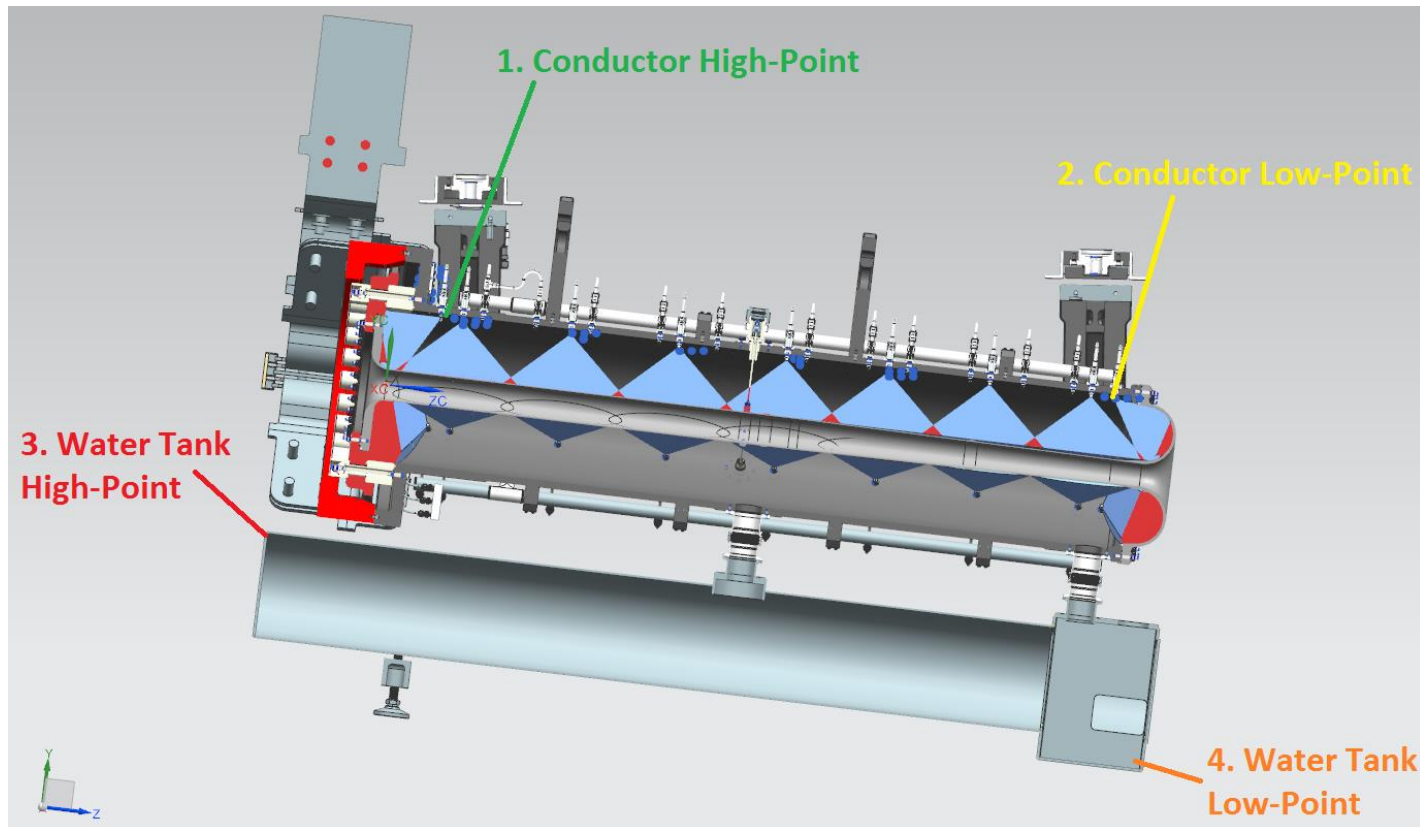
Hanger Cooling Union Line



Slide used courtesy Cory Crowley, Mike Campbell

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Interior view of horn with spray nozzle patterns



Slide used courtesy Cory Crowley, Mike Campbell

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Horns A, B, & C – Heat Loads

LBNF Horn RAW Systems – Heat Loads (units kW)						
	Horn A		Horn B		Horn C	
Heat Source	1.2MW	2.4MW ₁	1.2MW ₁	2.4MW ₁	1.2MW ₁	2.4MW ₁
Manifold A	8	16	7	14	4.5	9
Manifold B	8	16	7	14	4.5	9
Manifold C	8	16	7	14	4.5	9
Manifold D	15	30	12.5	25	8.5	17
Modules	3.3	6.6	3	6	6	12
Hangers	1.5	3	1	2	1	2
Ejector Pump Supply	n/a	n/a	n/a	n/a	n/a	n/a
Filter/DI Loop	n/a	n/a	n/a	n/a	n/a	n/a
Recirc Pump	18.6	29.8	37.2	37.2	29.8	29.8
SYSTEM TOTAL	62.4	117	74.7	91.2	58.8	87.8

1 – The horn & module heat load numbers for all three horns are based on actual EDEP analysis for 1.2MW. All 2.4MW numbers are 1.2MW X 2. They are fairly accurate and not actually scaled off of Horn A.

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Horns A, B, & C - Flows

LBNF Horn RAW Systems – Required Flows (units gpm)						
	Horn A		Horn B ₂		Horn C ₂	
Flow Source	1.2MW	2.4MW ₁	1.2MW ₁	2.4MW ₁	1.2MW ₁	2.4MW ₁
Manifold A	8.1 ₂	16.2	24.3	24.3	16.2	16.2
Manifold B	8.1 ₂	16.2	24.3	24.3	16.2	16.2
Manifold C	8.1 ₂	16.2	24.3	24.3	16.2	16.2
Manifold D	15.1 _{2,4}	30.2	45.3	45.3	30.2	30.2
Modules	34	34	34	34	34	34
Hangers	3 ₂	3	3	3	3	3
Ejector Pump Supply	52	100	142	142	100	100
Filter/DI Loop	10	10	20	20	20	20
SYSTEM TOTAL (Recirc Pump)	140	242	314	314	242	242

1 – Based on scaling of Horn A at 1.2 MW

2 – Values add to produce total flow required by ejector pump suction flow

3 – Horns B and C, system size governed by horn spray flow required, not heat removal

4 – Flow includes Target Mount @ 2.9 gpm

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Horns A, B, & C - Design Maturity

Horns on a later maturity schedule than most TH/AH components

- EDEP modeling done for all 3 horns at 1.2MW
- Work on Horn A prototype in progress
- Horns B and C to follow later
- Horn design for 2.4MW operation may be different than 1.2MW

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Horns A, B, & C – RAW System Design

Horn RAW System design strategy:

- Preliminary design of Horn A for 1.2MW
 - Includes EDEP, spray nozzle flows, as required of RAW system
 - Includes hangers, modules, ejector pump
- Complete prototyping of ejector pump

- EDEP for cooling requirements completed for Horns B & C
- Heat loads are doubled for 2.4MW operation
- Flows are scaled as Horn B = 3 x Horn A, Horn C = 2 x Horn A
- Use this model for basis of Horns B and C design
- Prototype ejector pump work will include requirements for all 3

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Horns A, B, & C

- Heat loads are similar between the 3 horns
 - Original estimates had Horns B & C greater than Horn A
 - Horn B is about 90% of horn A, Horn C is about 65% of Horn A
 - The hangers and modules vary some as well
 - Driving item is flow required for even spray within the horn interiors
 - Significant contributor to heat load is recirculation pump
- Horn A, heat load is dominant design requirement
 - By value engineering, may be outfitted with smaller recirc pump and heat exchanger for 1.2MW beam
- Horns B & C, flows for inner horn spray wands are dominant design requirement
 - Require same system for either 1.2MW or 2.4MW beam power

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Horns A, B, & C

- To evacuate Horn Water Tanks, Ejector (jet) Pump sizing becomes key
- Motive flows required for Ejector Pumps are approximately 1.5 times that as being removed from the Horn Water Tanks
 - Water from internal spray wands collects in water tanks (troughs) below the horns
 - Must then be suctioned out by ejector pumps (AKA eductor or jet pumps)
 - System total flow = spray wand flow + motive flow + filtration
 - Approx. total system flows = 2.5 to 3 times Horn spray wand flows
 - Because of high pressure and flow requirements of the motive flow stream, recirculation pumps are much larger than required for simple supplying the horn cooling flows

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Horns A, B, & C

- Why ejector pumps?
 - No moving parts to wear, all SS
 - No electrics to burn out
 - Ability to be mounted above modules for easy access & maintenance
- Prototyping
 - Will test single pump, and dual pumps in parallel
 - Will test accurate mock-up of suction tube and fittings for realistic assessment of losses in actual circumstances
 - May affect pump chosen
 - May affect current suction line design

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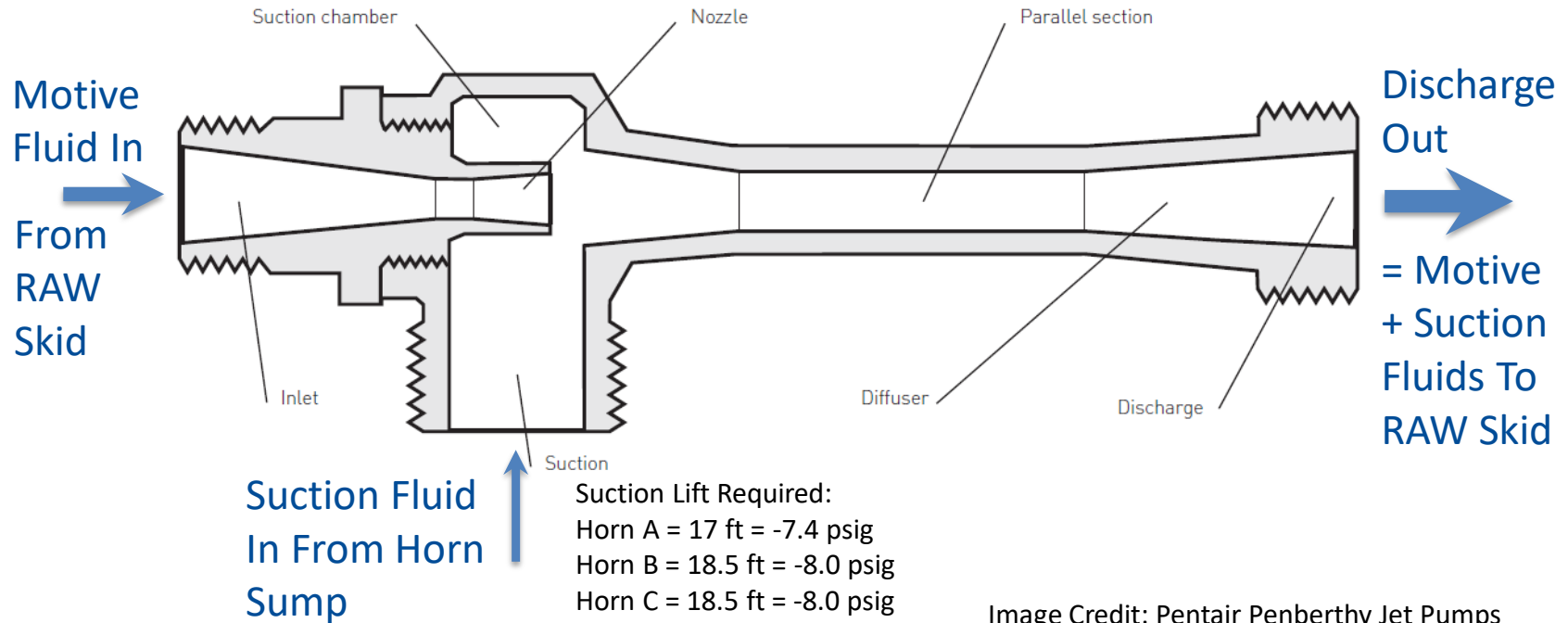
Horns A, B, & C

- Suction lifts required are 17' for Horn A, 18.5' for Horns B, & C
 - Add approx. 5' for friction head loss
 - Sum of lift losses greatly affects ejector performance
 - Discharge back pressure = 11 psid = 25'
 - Require higher pressures of motive flow to acquire lift, and to overcome backpressure to return to RAW reservoir
 - Motive supply pressure to ejector of 100psig or greater
 - Ejector pumps will be below the hatch covers, above the modules
 - Requires refinement of engineering, and prototype installation testing, which is in planning stages by J. Chikelu

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Horns A, B, & C

Ejector Pump Basics:



- To increase suction lift head, must increase motive (input) pressure and flow, and/or decrease discharge backpressure
- To increase suction flow, must increase motive pressure and flow, decrease backpressure, and/or reduce required suction lift head
- At our needs, motive flow required >> suction fluid flow desired

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Horns A, B, & C – AFT Fathom Modeling

Complex system to model

- Manifolds - modeled each manifold with spray nozzles as a single entity with a system curve
- Suction line - modeled multiple sections & sizes of suction line, from horn capture tank to ejector, as a single entity with a system curve
- Discharge line - verified discharge line from ejector to expansion tank with a model
- Substituted manifold and suction curves into Fathom system model

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Horns A, B, & C – AFT Fathom Modeling (cont.)

- Must “fool” the model at times
 - AFT Fathom models a symbolic ejector with only a suction and a discharge line, not all 3 lines
 - Supply to motive line is to pressure node
 - Flow from nozzles cannot be tied directly to horn capture tank
 - Make links between the above entities by setting up “design alerts” if conditions between junctions or pipes are not met, then iterate until alerts are met

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Horns A, B, & C – AFT Fathom Modeling (cont.)

Files at Dune DocDB 17873

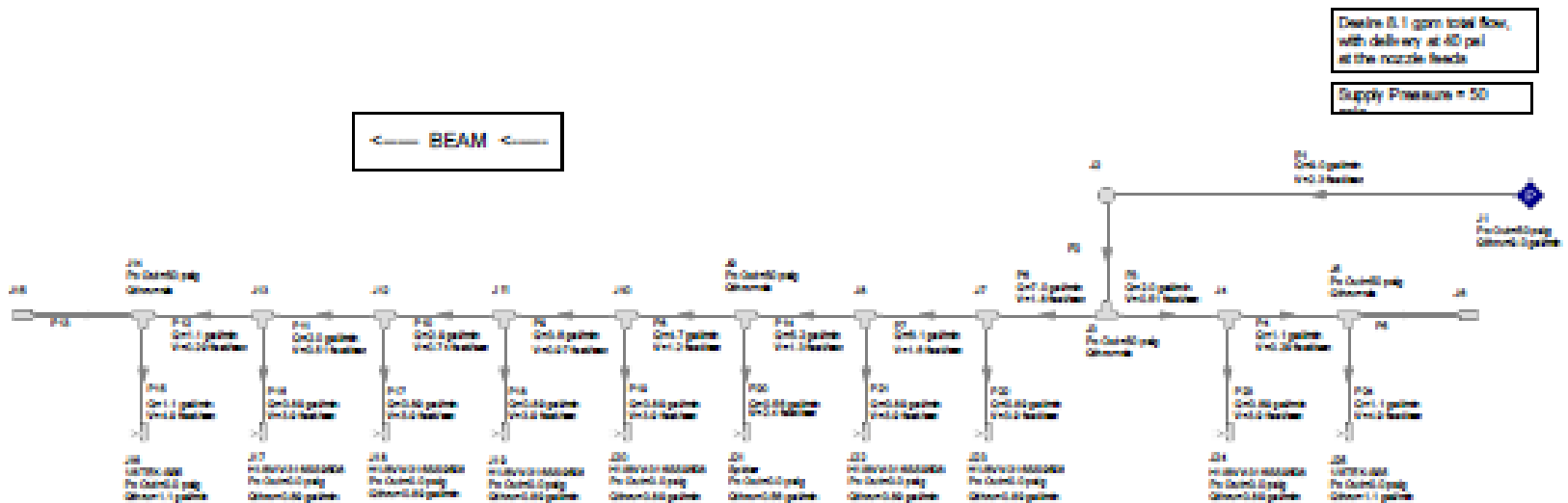
<https://docs.dunescience.org/cgi-bin/private/AddFiles>

- Horn A main 2-18-20.pdf
- Horn A manifolds A-B-C 2-18-20.pdf
- Horn A manifold D 2-18-20.pdf
- Horn A suction line 2-18-20.pdf
- Horn A discharge line 2-18-20.pdf

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Horns A, B, & C – AFT Fathom Modeling (cont.)

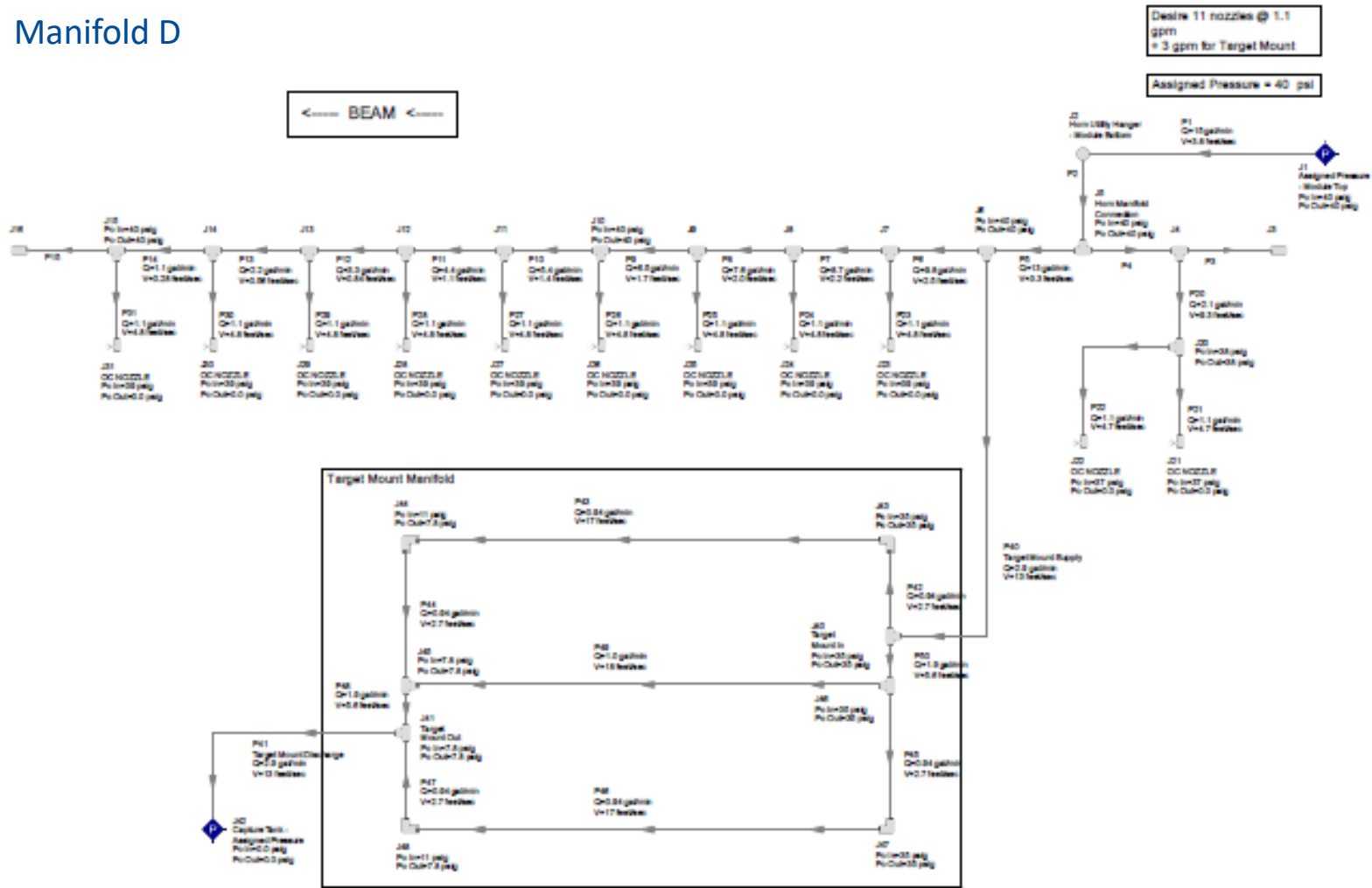
Manifolds A, B, C



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Horns A, B, & C – AFT Fathom Modeling (cont.)

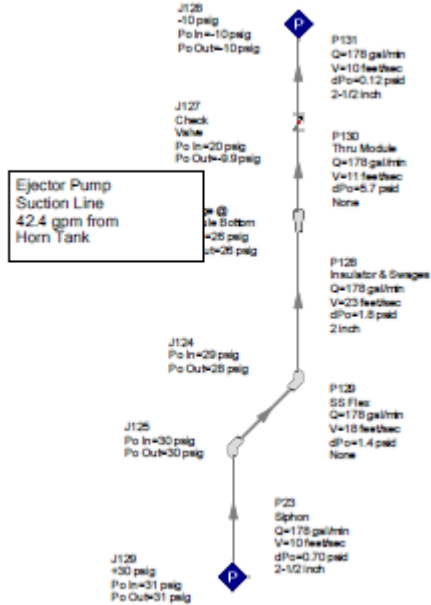
Manifold D



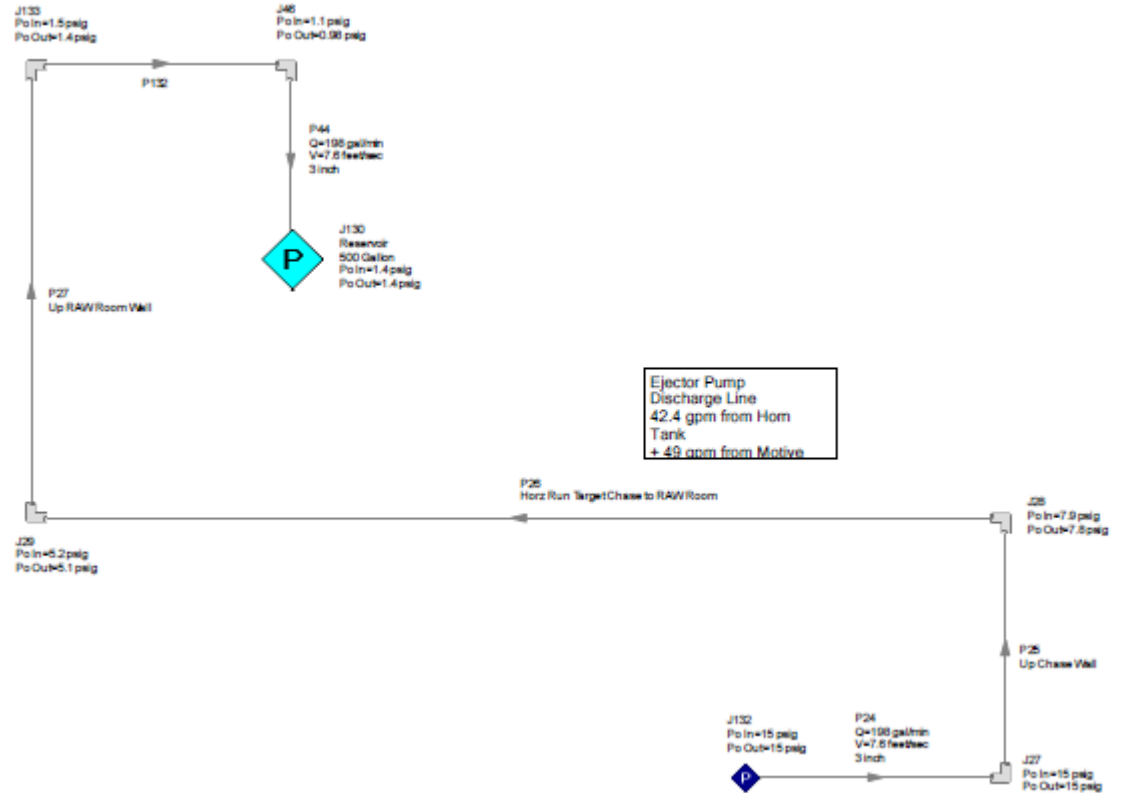
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Horns A, B, & C – AFT Fathom Modeling (cont.)

Suction Line



Discharge Line



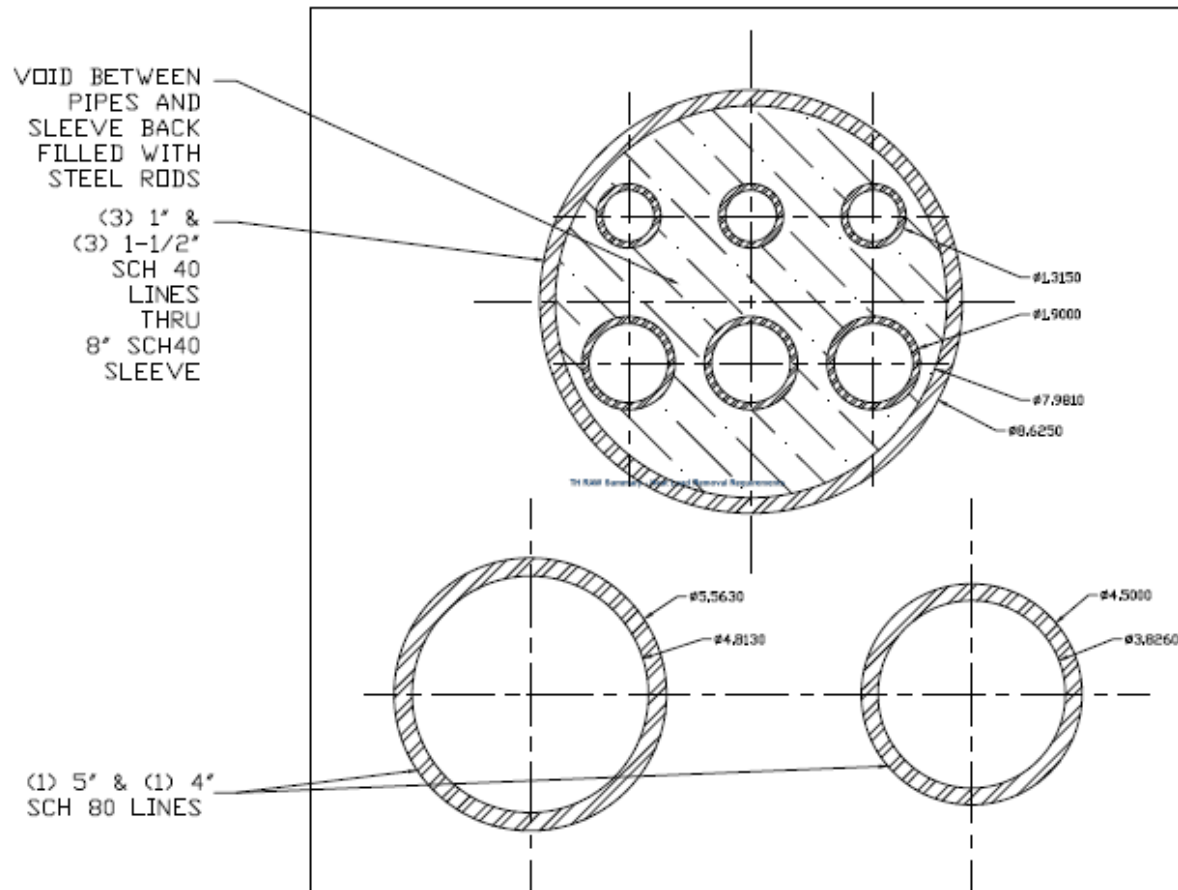
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Horns A, B, & C - Piping Runs

- Designed for all pipes to fit into envelope 18”h x 18”w
 - 4 manifold lines
 - 2 module lines
 - 1 hangers line
 - 1 ejector supply line
 - 1 ejector return line
 - 2 argon circulation gas lines
 - 1 spare line
- Fully welded SS, from RAW system in RAW Room, through penetration to Target Hall, along aisle and thru penetration at battlement into Target Chase
- Removable sections inside Chase flanged at battlement
- All isolation valves, flow controls, at system in RAW Room

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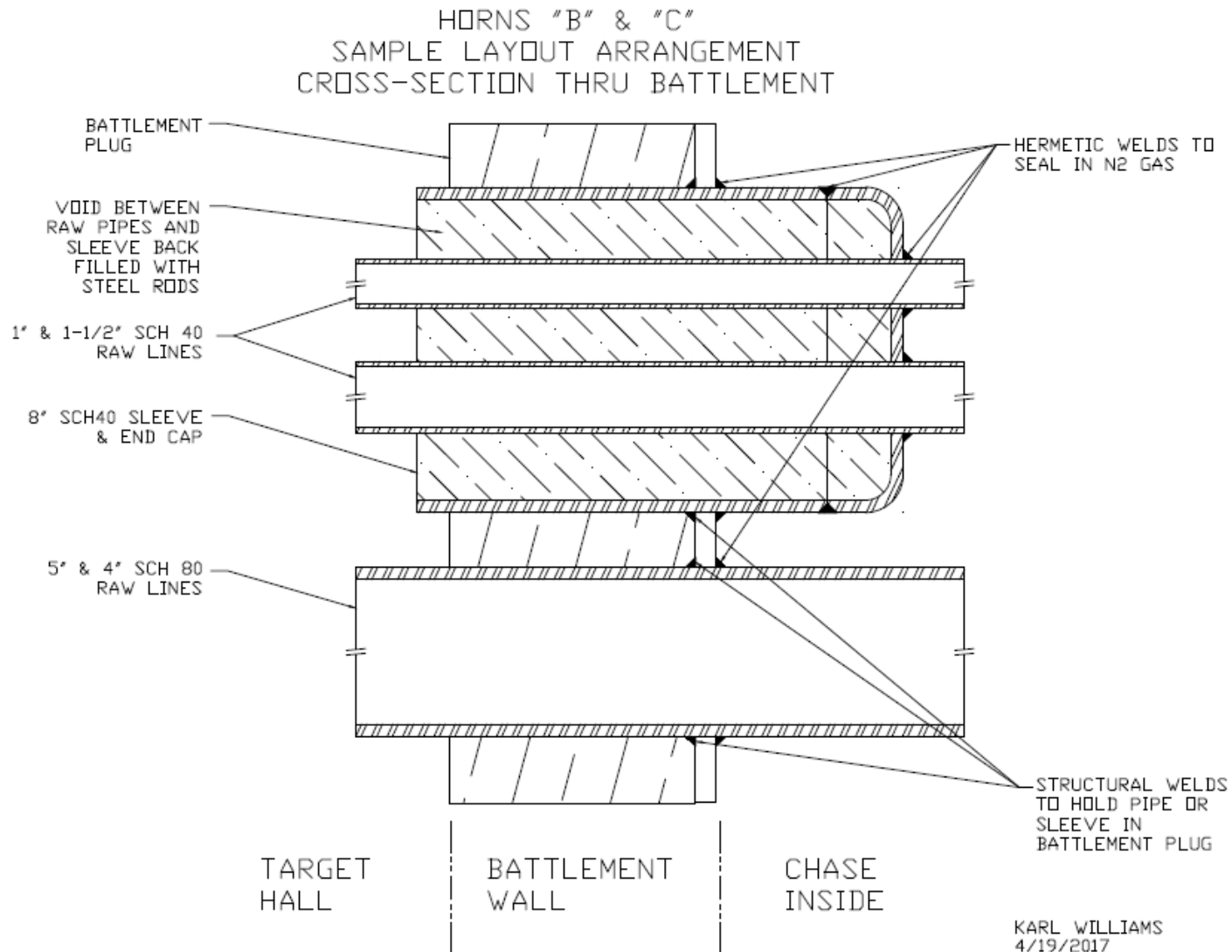
HORNS "B" & "C"
SAMPLE LAYOUT ARRANGEMENT THRU BATTLEMENT
18" X 18" SQUARE



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4/17/2017

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Hermetic Seal At Battlement Penetration



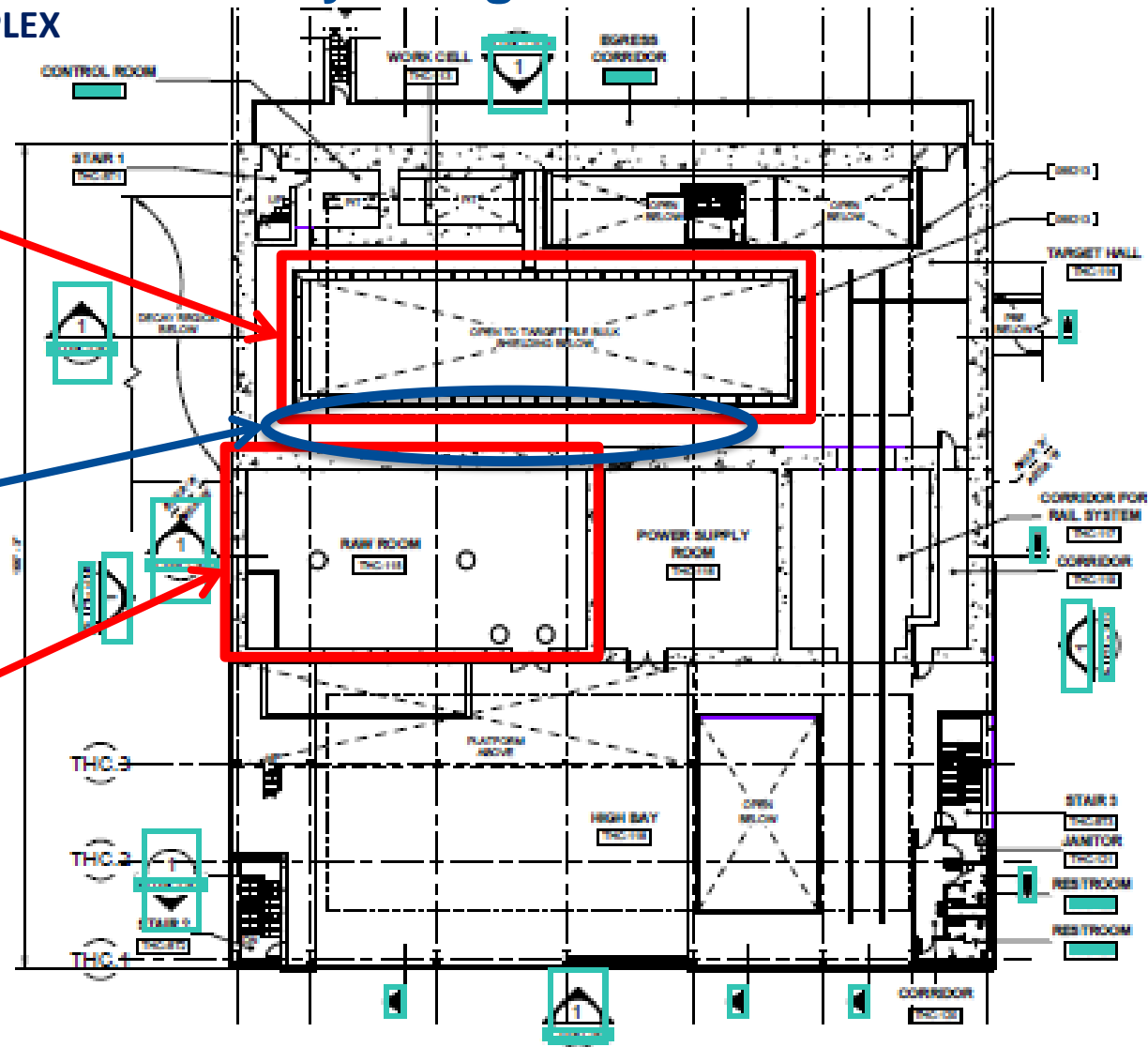
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TARGET HALL COMPLEX

Target Chase

Piping Path Envelope

Target Hall RAW Room



MAIN LEVEL OVERALL PLAN @ EL. 765.00'

SCALE: 1/8" = 1'-0"

2
A-THC-101

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Horns A, B, & C

Questions?