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NuMI Target Systems AIP FY20 Q3 Updates

Yun He

Proton PMG / AEM Meeting, July 9, 2020

Outline

- Project overall status (being productive despite Telework + COVID protocols)
- Status of 2020 summer shutdown
  - Horn 1 module drive mechanism changeout
  - Horn 1 I MW PH1-05 installation
  - HVAC duct system for stripline air diverter T-block

  } Critical path for 1MW Beam operation
  - Absorber intermediate RAW system – install a redundant heat exchanger
  - Tritium mitigation – separate MI-65 AHU condensate waste piping from building drain sys
- Accomplishments in other activities
  - MARS / FEA for Decay pipe
  - Target autopsy
  - Hadron beam monitor calibration test stand
- Project performance June 2020 report (schedule / cost)
- Summary

More details are available at the project SharePoint:

https://web.fnal.gov/project/TargetSystems/NuMI-AIP/

Project Overall Status

Financials	
Budget	$5.6 M
FY20 Budget	$3.635 M
Remaining	$1.73 M

Project kickoff: Jan. 2019
Mid-term milestone: 2019 summer shutdown
2020 Q3 Telework: Procurements, work planning
Current focus: 2020 summer shutdown

Completed

New activity added

Tasks	FY19	FY20	Status
MARS/FEA simulations	Complete	Decay pipe Hadron absorber	Complete
Pre-target Be window			EBW by Sciaky
1 MW Target	Complete		Closed
1 MW Horn 1			2020 summer installation
Stripline air diverter T-block			2020 summer installation
Target / horn 1 module drives		Installation	2020 summer installation
RAW skids	Complete	Absorber Hall RAW	2020 summer installation
Target hall chiller/air handling	Complete	MINOS Surface Chiller	Design, procurement, installation
Target chase shielding	Complete		Closed
Tritium mitigation			2020 summer installation
Decay pipe window			Drawing package generation
Hadron monitor & absorber			Fabrication by U of Texas
Target autopsy		New task	Procurement & implementation

Status of 2020 Summer Shutdown (Marty Murphy / TSD Team)

Summer shutdown activities started on June 15

Critical path for 1 MW beam operation

July 12

Readiness review mid-Aug

Ending Oct. 2

Week #	4	5	6	7	8	9	10	11	12	13	14	15	16
Horn 1 module drives changeout /Horn 1 installation	TA-03 to C0	PH1-05 pulse test Horn 1 module prep											
Stripline air diverter HVAC													
Absorber Intermediate RAW													
Tritium mitigation													

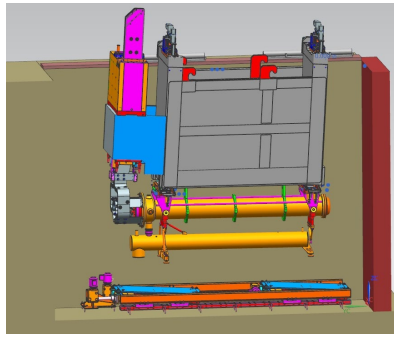
NuMI-AIP Shutdown SharePoint (NuMI-AIP specific)

TSD Shutdown SharePoint (include other TSD target systems maintenance activities)

PH1-04 moved from Hot Cell to Big Storage room at C0 RHF - July 7

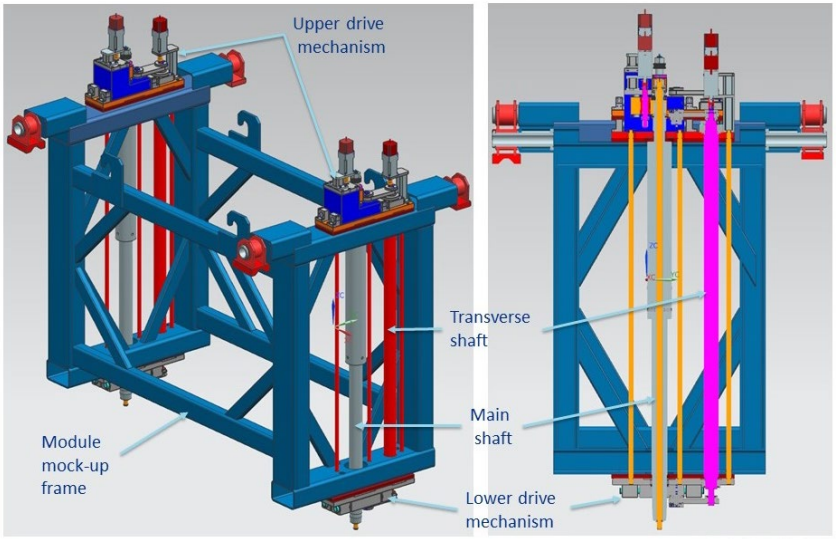
PH1-03 is to be moved to C0 Hot Cell on July 12

PH1-05 to be installed at MI-65 mid-August



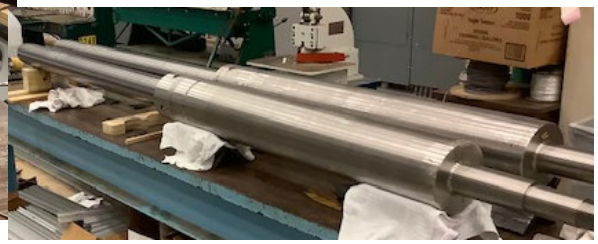
Horn 1 Module Drives Prep at MI-8 (Vladimir Sidorov / Keith Anderson)

Pre-assembling on module mock-up frame,
[Module work planning and docs SharePoint]



Managed to make significant progress w/ proper COVID protocols – inventory, procurement, modifications, dicronite coating, hardcoat anodizing

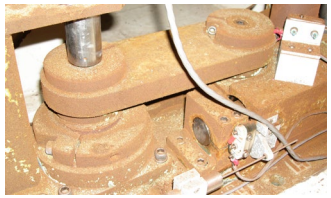
Shrink fit Graphalloy bushings to shafts



Pre-assembling
- Shimming
- Main shaft motion
- Vertical / rotation

Horn 1 Module Training at MI-8 (Vladimir Sidorov / Keith Anderson)

- Module change-out procedure
- Mock-up training mid-July
- Fabrication of casks in progress
- Technical readiness review mid-August



Corroded condition

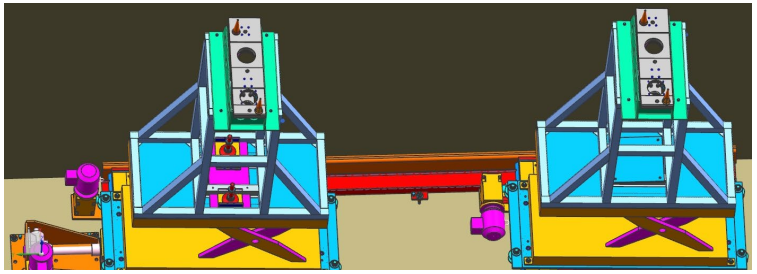
Change-out in Hot cell

Challenging task

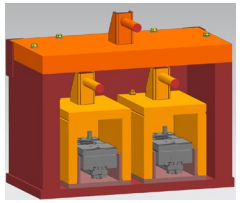
ALARA Plan

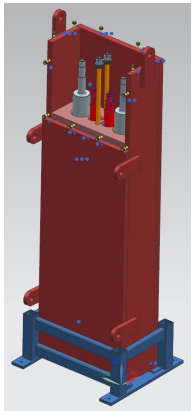
Horn-1 module Assembly stand

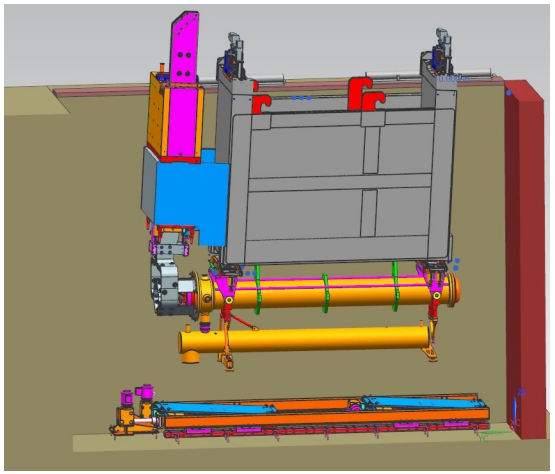
Lower drive mechanism frame



Casks







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Horn 1 PH1-05 Stripline Change-out (Kris Anderson)

- Stripline pre-assembling, ceramic boss silver plating, assemble stripline to PH1-05
- PH1-05 work planning and photos SharePoint
- A delicate team work! w/ COVID precautions

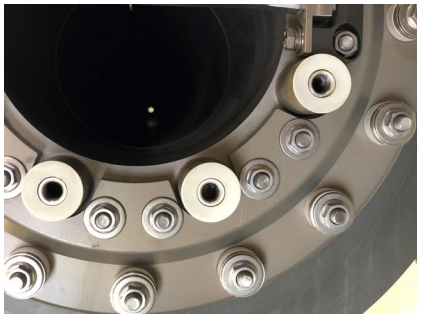
– Clay Leonard, Jim Zahurones, Keith Anderson, Meredith Lee

Effective communications during Telework

Task	Time Estimate	Date Planned	Date Completed	Notes
Dry assemble PH1-05 1 MW stripline · Measure dimension between inner and outer conductor flags on PH1-05 horn and 1MW stripline · Calculate required thickness of stripline spacers	1 day	6/8	6/8	6/26: Four different spacers of different thicknesses are needed due to relatively large variation in the distance between bosses.
Sanding and silver plating horn terminal surfaces	4-5 days	6/29-7/2	6/30	Horn Silver Plating Procedure Cross Hatch Test Results 6/26: Cross hatch test on silver-plated coupon

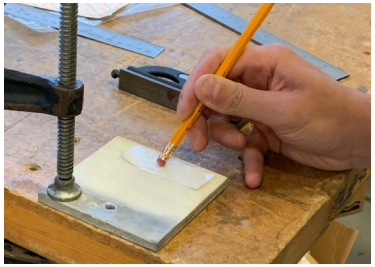
Dry assemble 1 MW stripline

- Measure dimensions
- Determine thickness of spacers



Silver brush plating of elec. connecting surfaces, cross hatch coupon tests

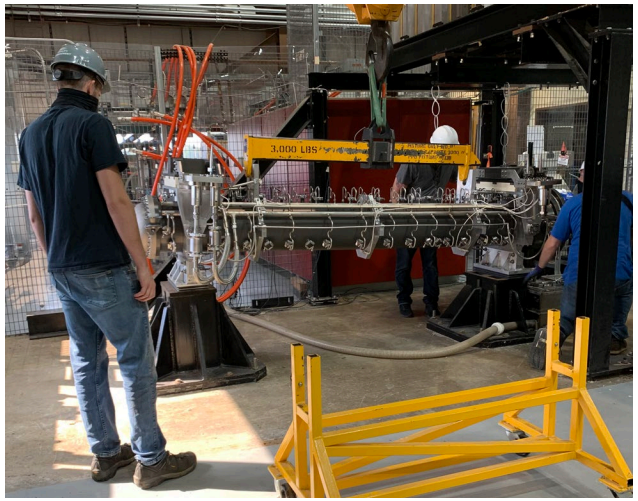
- High conductivity
- Corrosion resistance
- Abrasion resistance



Horn 1 PH1-05 Pulse Testing (Kris Anderson/ Katsuya Yonehara)

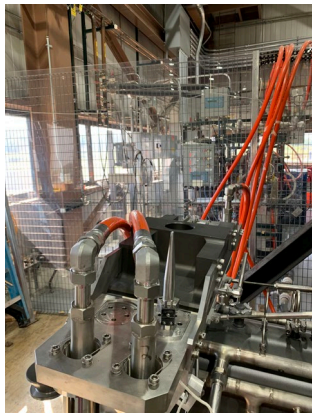
- Horn test stand prep, assemble stripline to PH1-05
- Pulse testing to be started mid-July

Remove water tank from Horn 1



Move Horn 1 to test stand, install stripline with new spacers (various thicknesses)

Water line connection / chiller replacement



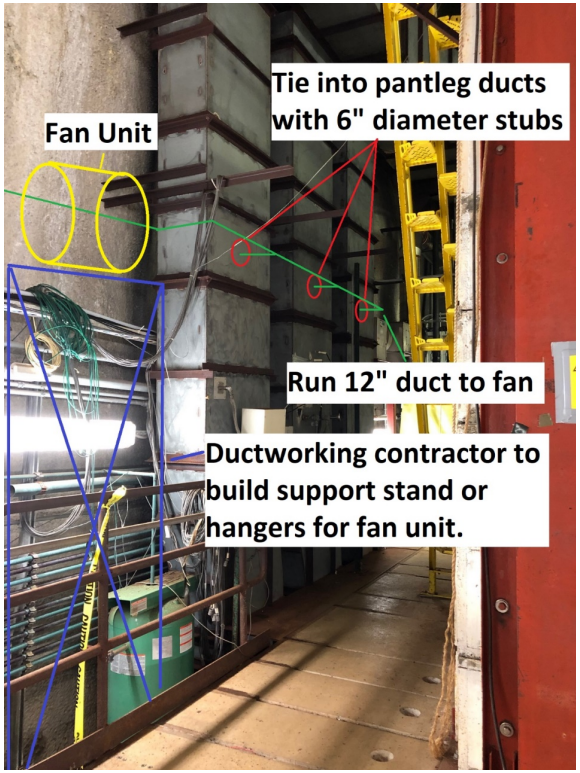
Pulse testing goal

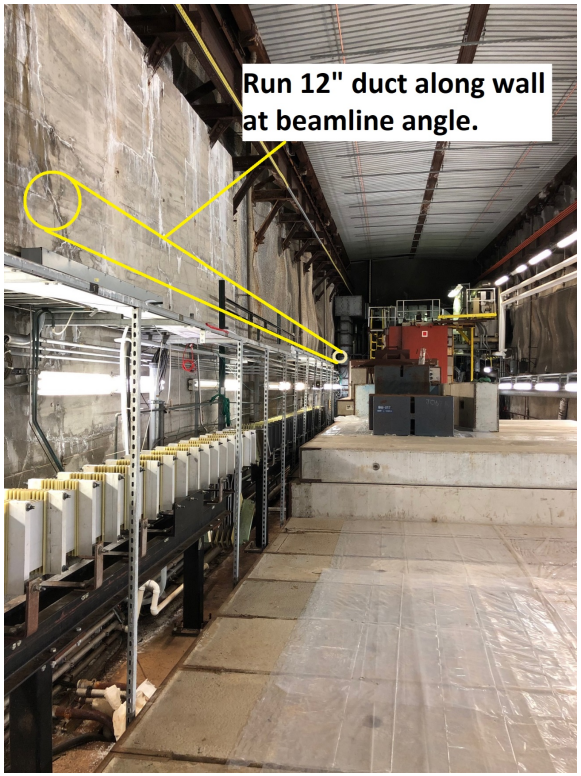
- 150,000 pulses at 200 kA with a 1.2 second cycle time.
- Run attended for 2 days, 6 hours per day -> 36,000 cycles
- Run overnight for 3 nights, 16 hours each night -> 144,000 cycles

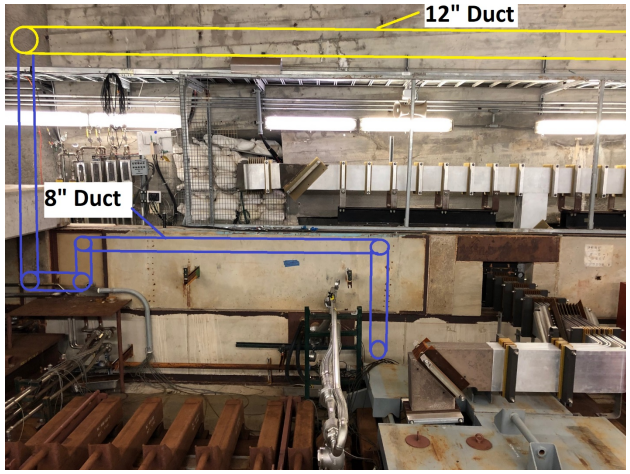
Air Diverter T-block HVAC Work (George Lolov / Jim Zahurones)

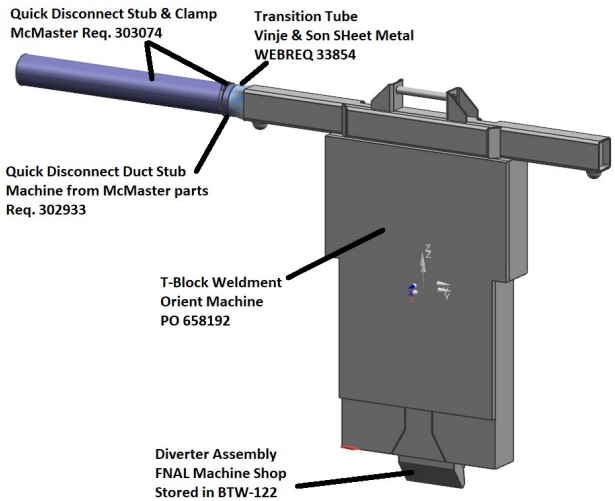
Install a HVAC duct system to provide air cooling to NuMI Horn 1 stripline, routed through the shielding penetration.

Installation: to be started late-July









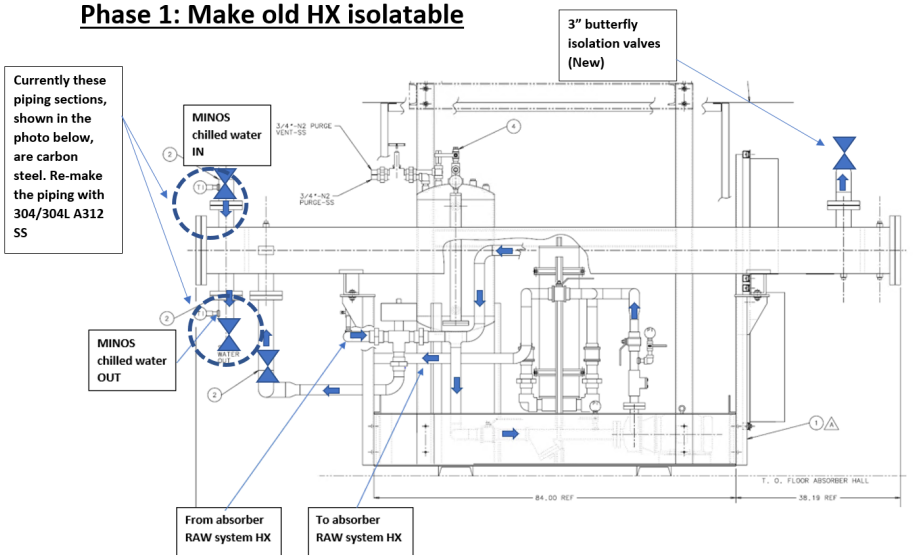
Absorber Intermediate RAW System (Abhishek Deshpande)

- Install a new HX, which can be valved in when the old HX starts to show signs of reduced efficiency or develops a leak. The existing HX is hard to repair, service, or replace.

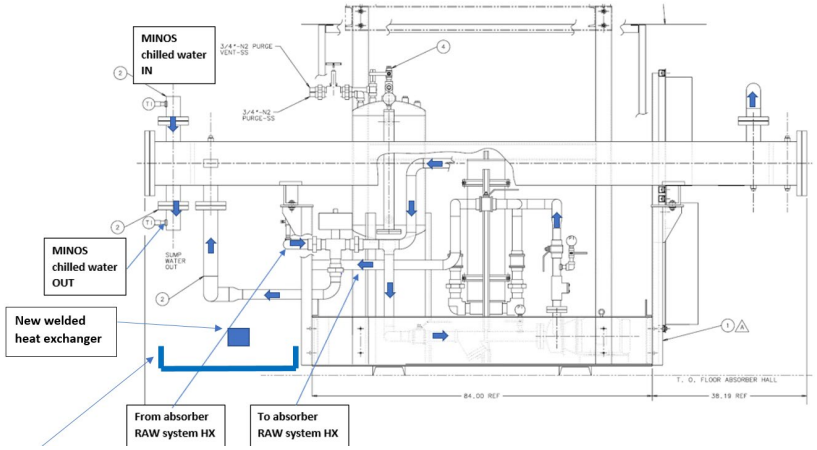
Existing shell and tube HX

Installation to be started: July 20

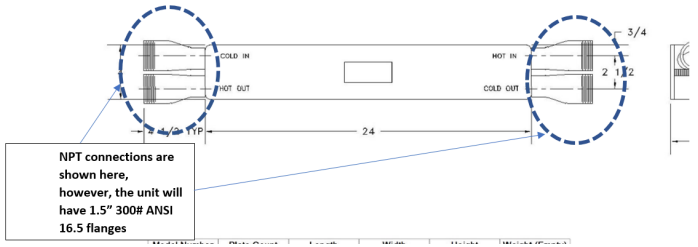
Phase 1: Make old HX isolatable



Phase 2: Install secondary containment

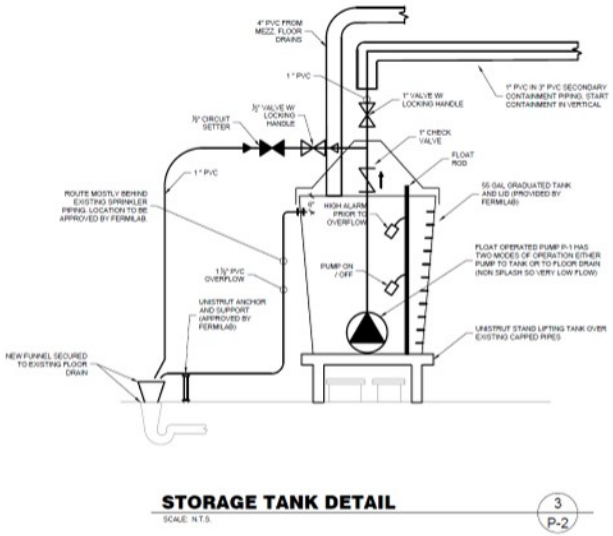


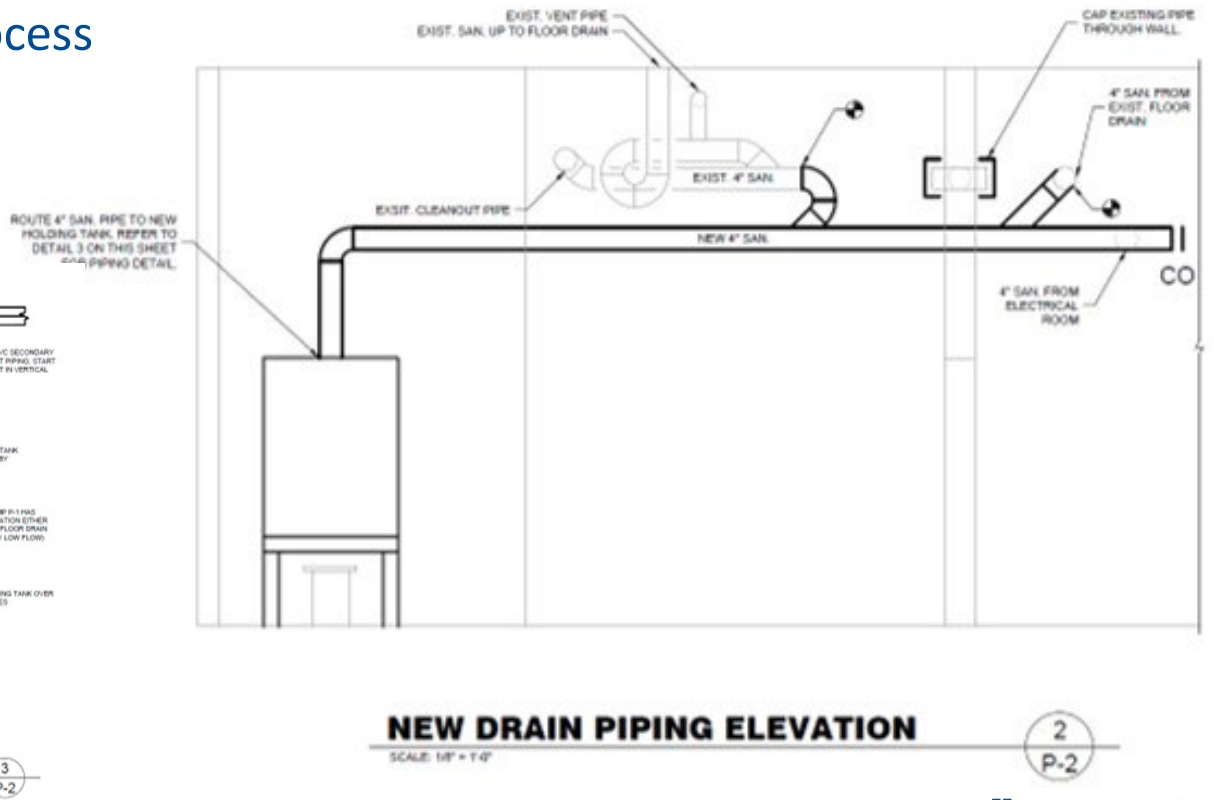
Phase 3: Connect the new HX to the 1.5" valves described in Phase 1



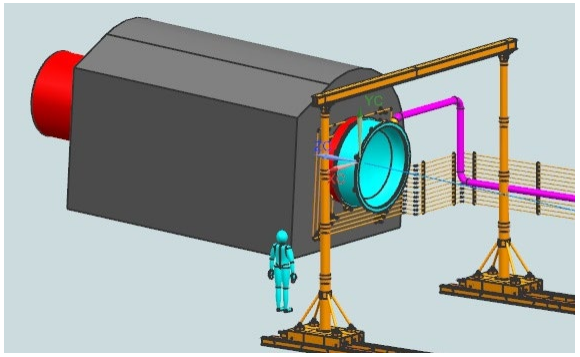
Tritium Mitigation (Adam Taylor)

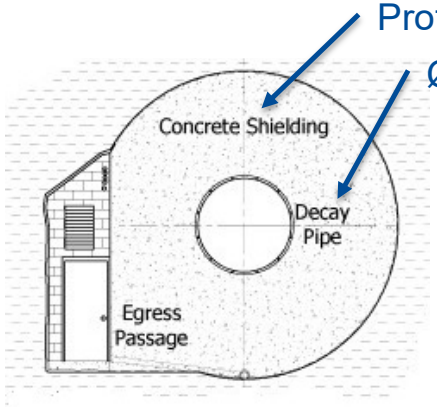
- Rerouting existing condensate pipe to new holding tank.
  - to separate the AHU condensate waste piping from building waster drain system, to prevent evaporated air from re-condensing on the MI-65 roof
- Water in tank to be tested for tritium.
  - If levels are too high, water is pumped to tritium boiler tank.
  - If levels are low enough, water is pumped to sanitary sewer
- On contract bidding process





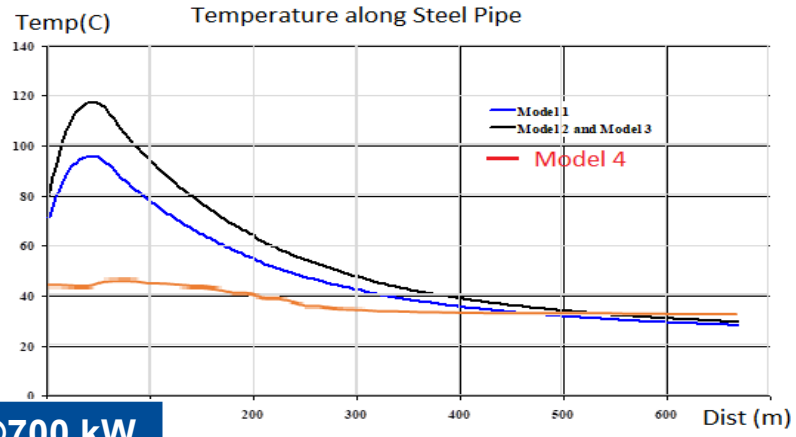
MARS/FEA Simulations for Decay Pipe (Igor Rakhno / Zhijing Tang / Des)





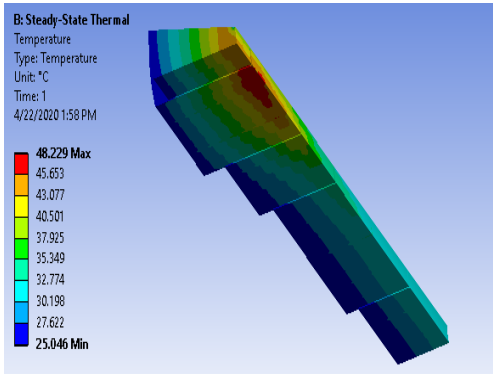
Protect groundwater (varying from Ø4.6m to Ø6.3m)

Ø2 m A36 steel pipe, 0.375" thick, 670m



- RAW system capacity
- MARS simulations / FEA of the entire Decay pipe

	@1 MW	@2.3 MW	@400 kW	@700 kW
Steel pipe	103 kW	390 kW	63 kW	110 kW
Concrete shielding	144 kW	360 kW	52 kW	91 kW



Model 2.3 MW case	Max. Steel Pipe Temperature (°C)	Max. Concrete Temperature (°C)	Max. Steel Pipe Hoop Stress- (ksi)	Max. Steel Pipe Axial Stress – (ksi)	Max. Concrete Stress- (ksi)
1	96	96	-17.3	-22.1	5.4
2	117	116	-1.7	-23.7	8.9
3	117	116	-25.9	-30.6	6.9
4	46.10	48.23	-16.92	-10.59	3.14

Conclusion: thermal stress will not cause the yield nor buckling of the steel pipe.

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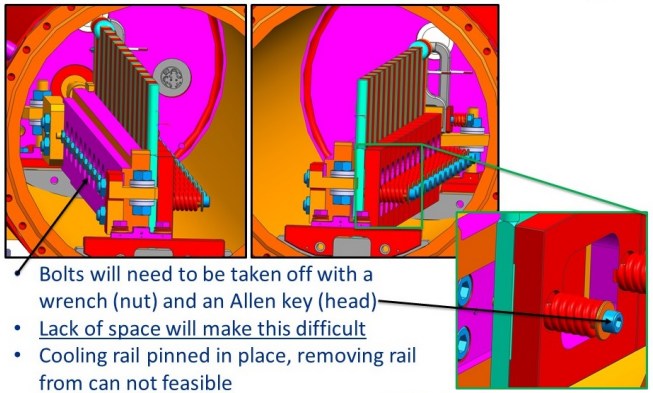
Target Autopsy (George Lolov / Meredith Lee)

Progress on Target autopsy, teamed with Keith Anderson, Mike Stiemann

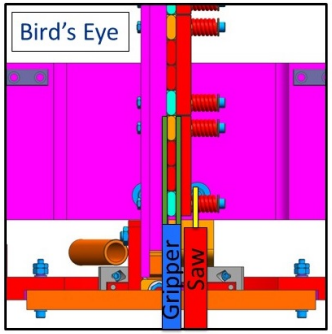
- C0 Hot Cell Inspection – existing motors / controls /cameras and DVR are all functional
- Procurement – cameras, Vilros Raspberry / Arduino Starter Kit, Cooling Rail C-Channel Mock-Up
- Evaluation of space and methods
- Proposals for Fins extraction

Removing Fins with all Parts Intact Will be a Challenge



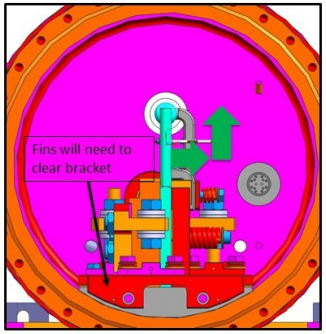
- Bolts will need to be taken off with a wrench (nut) and an Allen key (head)
- Lack of space will make this difficult
- Cooling rail pinned in place, removing rail from can not feasible

Fin Extraction Scenario 1: Cutting off Bolts



- Cutting device will cut off the bolts + springs as close to the pressing plates as possible
- Plates will be slid off and extracted

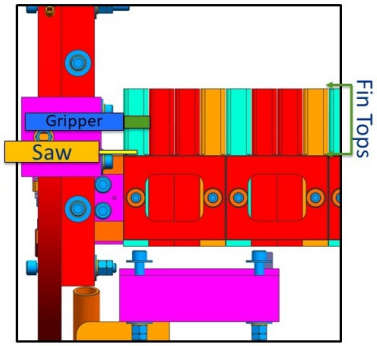
Can bolts + springs be left in the can?



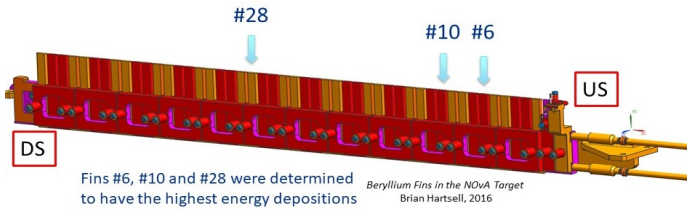
- Robotic gripper to extract fins
- Gripper will grab 4 fins at a time and will need 3 axis motion to extract

Fin Extraction Scenario 2: Cutting off top of Fins

- Gripper will hold the top half of the fins
- Use a saw to cut off the tops of the fins (most of the radiation effects will be near the beam spot)
- Gripper will extract sawed-off fin pieces
- Easiest and quickest method but fins won't be intact



Which Fins Need to be Extracted: TA-01?



From Previous Meeting:

- Fin at Highest Energy Deposition
- Fin at Shower Max
- Fin DS
- Budal?

TA-01 Metrics Per FY16

- Max Beam Power: 540 kW
- POT: 1.116e21 at 120 Gev
- Proton beam spot σ varied 1.1 mm RMS - 1.3 mm RMS

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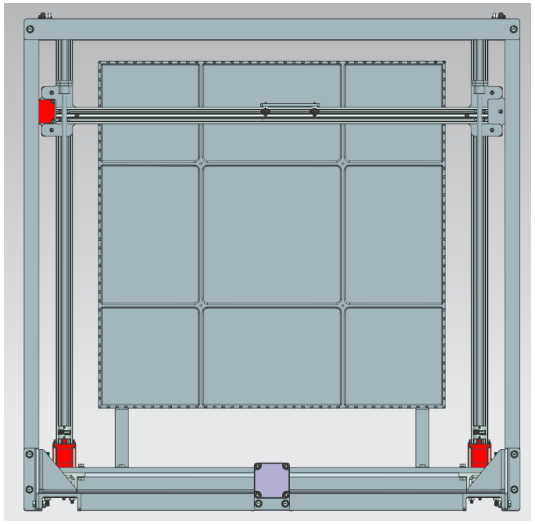
Hadron Monitor Calibration Stand (Katsuya Yonehara / Nnamdi Agbo)

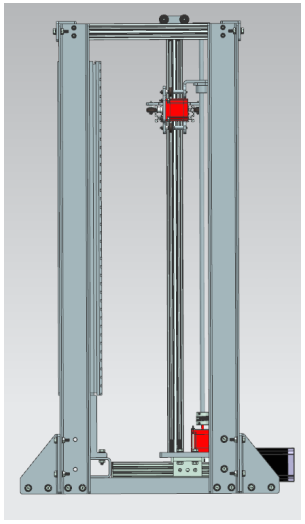
Allows for XYZ displacement of the radioactive source (Cs-137)

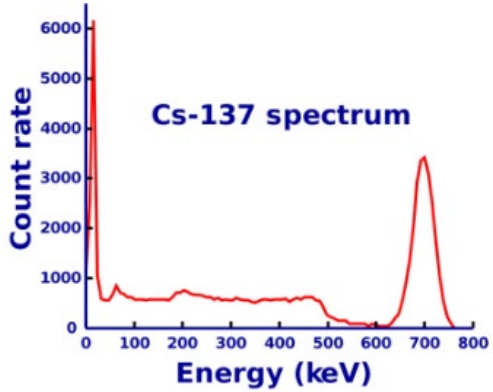
- Calibrate each pixel of HM

  Estimated ion pair production in a pixel with Cs-137 (1,108 uCu): 2.7e4 x A/4π

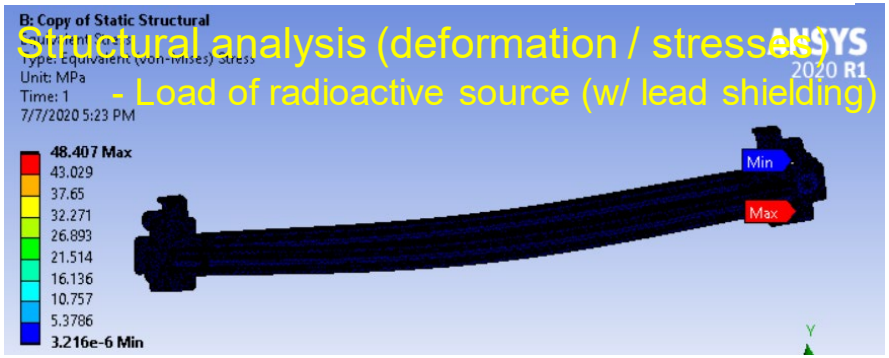
- Estimate ionization rate in helium gas





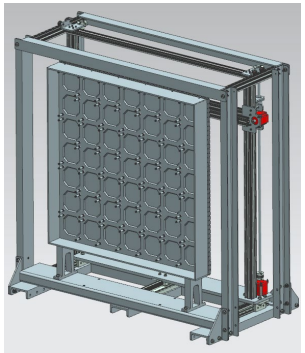


- Fermilab own 137Cs
- 1,108 uCu = 4.100e7 Bq
- Peak 0.6617 MeV
- 241Am emits 60 keV γ
  - Energy may be too low for calibration



Structural analysis (deformation / stresses)
- Load of radioactive source (w/ lead shielding)

- 4 stepper motor
- 2 acme screws/nuts
- a pulley / belt drive system
- Arduino microstepping stepper drive



Status:

HM fabrication, Qty. 3, 5 x 5 array: by U of Texas at Austin

Calibration stand drawing package

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Project Performance June 2020 Report (Alyssa Payleitner)

Work Package.WBS (2) / Work Package.WBS (3) / ITEM (1)	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION		
	BUDGETED COST		ACTUAL	VARIANCE		BUDGETED COST		ACTUAL	VARIANCE		BUDGETED	ESTIMATED	VARIANCE
	WORK SCHEDULED (2)	WORK PERFORMED (3)	COST WORK PERFORMED (4)	SCHEDULE (5)	COST (6)	WORK SCHEDULED (7)	WORK PERFORMED (8)	COST WORK PERFORMED (9)	SCHEDULE (10)	COST (11)	(14)	(15)	(16)
A1901.01 Project Management	17,204	17,204	19,326	0	(2,122)	401,711	401,711	361,299	0	40,412	515,653	475,241	40,412
A1901.02.01 Pre-Target Beam Window	0	0	0	0	0	39,435	33,830	21,900	(5,605)	11,930	39,435	27,386	12,050
A1901.02.02 Target Baffle/Core	0	0	0	0	0	277,495	277,495	284,686	0	(7,191)	277,495	284,686	(7,191)
A1901.02.03 Target Autopsy	12,970	65,518	5,026	52,548	60,493	129,189	123,628	25,753	(5,562)	97,875	253,987	157,241	96,745
A1901.03.01 Horn 1	12,212	14,168	49,025	1,956	(34,857)	445,620	421,997	404,317	(23,622)	17,681	445,620	577,939	(132,319)
A1901.03.02 Air Diverter T-Block	2,091	15,362	534	13,271	14,828	212,007	179,192	100,137	(32,815)	79,055	229,977	152,460	77,517
A1901.03.03 Modules	55,049	32,720	60,555	(22,329)	(27,835)	1,164,850	983,687	884,871	(181,163)	98,816	1,533,629	1,927,700	(394,071)
A1901.04.01 RAW System	23,639	21,933	9,827	(1,706)	12,107	367,644	353,562	344,666	(14,082)	8,896	449,418	440,762	8,657
A1901.04.02 Target Chase Chiller	12,823	6,055	3,091	(6,767)	2,965	408,533	367,344	390,386	(41,189)	(23,043)	445,626	466,544	(20,918)
A1901.04.03 Target Chase Shielding	0	0	0	0	0	116,419	116,419	130,459	0	(14,041)	116,419	130,459	(14,041)
A1901.04.04 Tritium Mitigation	33,934	0	897	(33,934)	(897)	120,704	21,985	52,464	(98,718)	(30,479)	120,704	148,460	(27,756)
A1901.05.01 Decay Pipe and Window	0	0	2,990	0	(2,990)	217,808	155,500	83,085	(62,309)	72,415	217,808	150,725	67,084
A1901.06.01 Hadron Monitor	5,790	20,194	8,680	14,404	11,514	353,451	287,445	260,290	(66,005)	27,155	405,760	373,686	32,074
A1901.06.02 MARS Modeling	0	0	934	0	(934)	80,104	79,453	74,976	(650)	4,478	80,104	75,626	4,478
d. UNDISTRIBUTED BUDGET											0	0	0
e. SUBTOTAL	175,713	193,155	160,885	17,443	32,270	4,334,969	3,803,249	3,419,289	(531,720)	383,960	5,131,635	5,388,913	(257,278)
f. MANAGEMENT RESERVE											0		
g. TOTAL	175,713	193,155	160,885	17,443	32,270	4,334,969	3,803,249	3,419,289	(531,720)	383,960	5,131,635		

Once the tasks for 2020 shutdown are completed, the remaining fund will be used for:

- Target autopsy
- MINOS surface dry cooler
- Fabrication of target module drive mechanism
- Drawing package of Decay pipe US window changeout procedure

Summary

- Team has been productive despite Telework + COVID protocols
- Plans for 2020 summer shutdown
  - Horn 1 module drives changeout
  - Horn 1 PH1-05 installation
  - HVAC duct system for stripline air diverter T-block
  - Absorber intermediate RAW system
  - Tritium mitigation – rerouting existing MI-65 condensate pipe to new holding tank
- Horn 1 PH1-05 is on test stand, will be ready for pulse testing mid-July
- Horn 1 module drives changeout is the most challenging task. A technical readiness review will be held in mid-August to decide if the PH1-05 will be installed
- Since the 1MW target TA-05 installation, the maximum operational beam power has been set for 777 kW
- By the time when the 1MW Horn 1 PH1-05 is installed, NuMI neutrino beamline system will be able to accept beam power up to 1 MW
- If PH1-05 is not ready, the installation of Horn 1 stripline air diverter T-block would allow the beam to run at max. 850 kW

Thank you, the TSD / NuMI-AIP team!