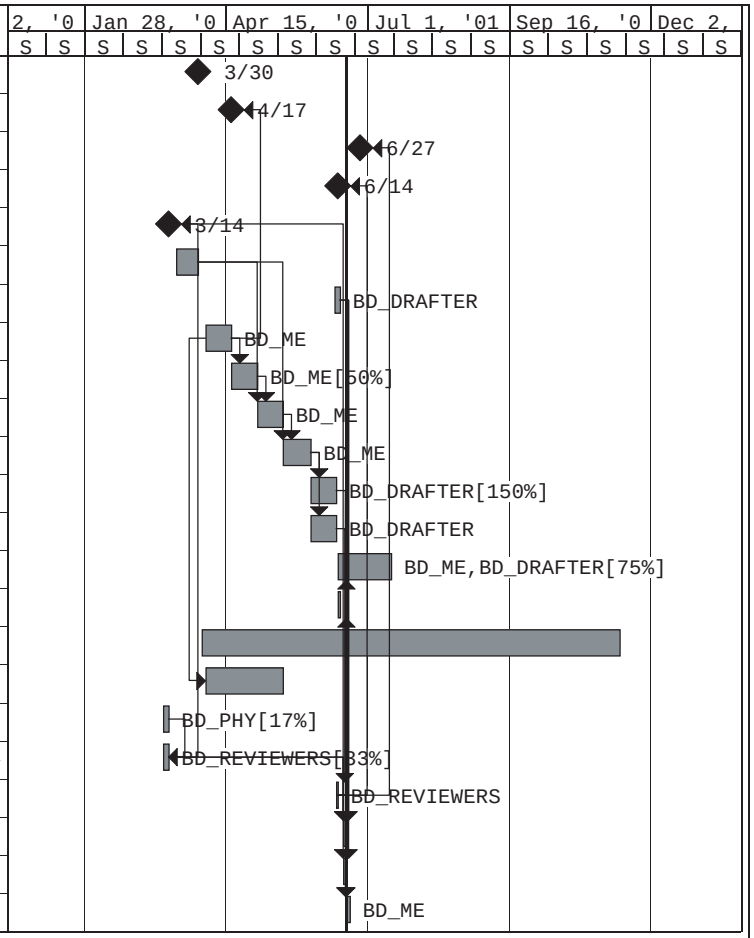
NuMI Vacuum Pipe WBS 1.1.4

Outline of this Review

- Engineering Issues (D. Pushka)
  - Vacuum Shell
  - Cooling
  - Upstream/Downstream Ends (Ed Chi)
- Radiation
- Alignment
- Installation
- Costs and Schedule

Where Are We Supposed to Be?

ID	Task Name
1	Physics Des Review of Outer Shielding Regions Compl
2	Finish ASME Vacuum Vessel Shell Calculations/FESHM Note
3	Valid Rvw of the Engineering of the Vac Decay Windows
5	Decay Pipe Engineering Review
6	Valid Rvw of Eng of Shielding for Absorb & Vac Decay
8	MARS Run for Energy Disposition Values in Windows
9	Prepare Dwgs for Labyrinth to Absorber Cavern
10	ASME Vacuum Vessel Shell Calculations/FESHM Note
11	ASME Vacuum Vessel Transition Calculations
12	D.S. Vacuum Window Calculation
13	U.S. Thin Window Calculation
14	Prepare Drawings for Vacuum Vessel Windows
15	Vacuum Vessel FESHM Documentation Drafting
16	Design Access Port for Remote Handling Repair Equipment
17	Decay Pipe Engineering Review
18	Define Shielding
19	Vessel & Window Calc & FESHM Note
20	Prepare Documentation for Shielding Review
22	Valid Rvw of the Eng of Shielding for the Absorber & Vacuum Deca
23	Valid Rvw of Engineering of Vacuum Decay Windows
24	Prep Purch Req for Sand Bags for Labyrinth to Absorber Cavern
25	Prep Purch Reqs for Steel Plate, Steel Bricks for Labyrinth
26	Prep Purch Reqs for Vacuum Window Material

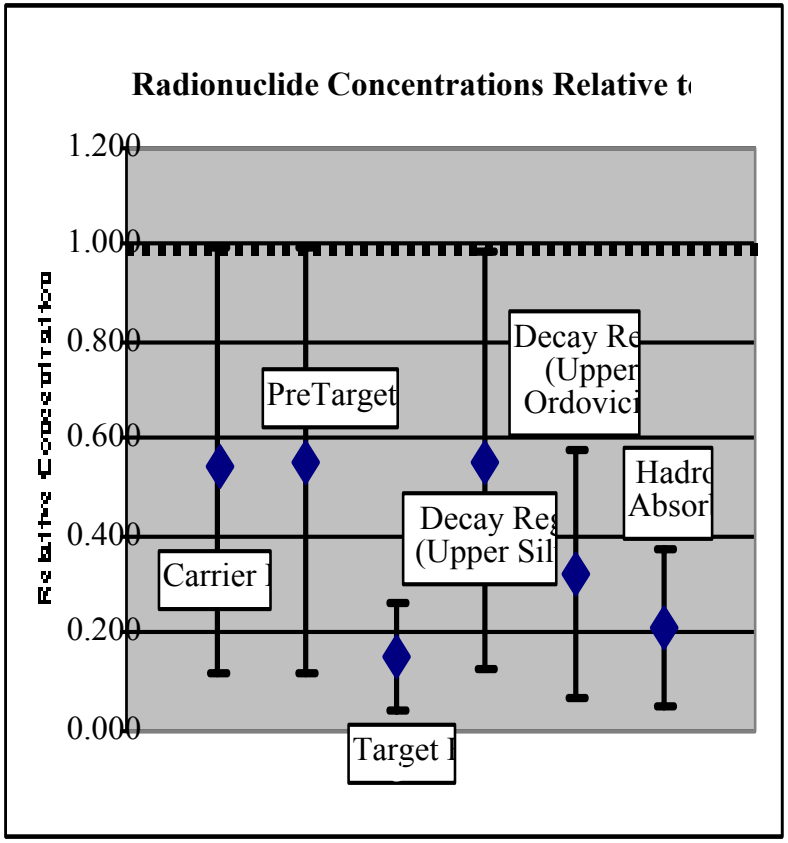


Main Changes

- Elimination of Seals
  - All Welds for Reliability
- PVC Pipe Around
  Cooling Pipe/Vacuum Pipe
  - Prevents galvanic action
  - Working on Details
- Supervisor Of Welding Process for QA
- Pump-Down Test Before Access Blocked

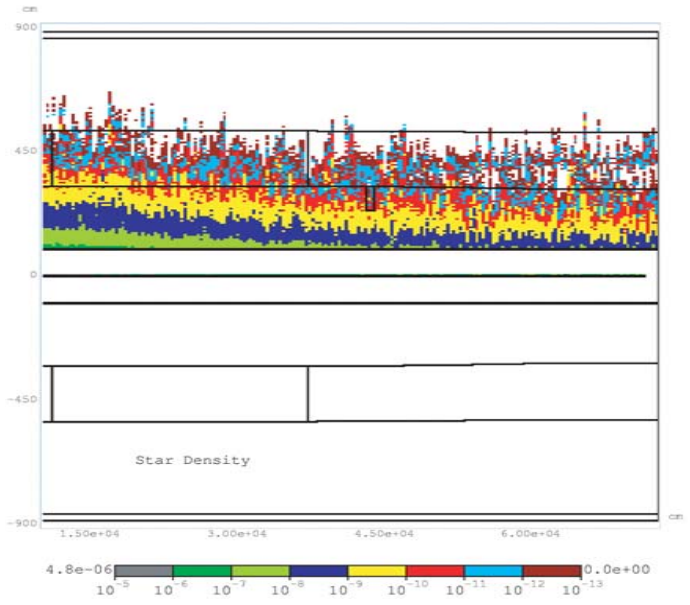
Radiation Levels

- Studied as Part of Overall Radiation Safety
- Below Limits
- Formal Memo in Preparation



Star Density Along Pipe

- Examined Star Density *vs.* Position
- MARS14 Calculation
- Errors from Estimate for Hydrodynamic Flow, *etc*



Decay Pipe Alignment

V. Bocean, R. Bernstein

- Scope
  - Align the decay pipe on the correct line with respect to the designed geometric beam trajectory
  - Fermilab alignment task during the construction phase is to check the contractor's work
- Requirements
- Alignment Phases
  - Phase 1: during construction phase
  - Phase 2: post construction phase

Alignment Requirements

Physics dictates alignment tolerances (see W.Smart's detailed analysis in Technical Design Report 3.6).

Two important requirements specified :

1. With respect to the ideal beamline, the maximum error of the decay pipe centerline, in both horizontal and vertical planes, must not exceed ± 25 mm (1σ) at the downstream end. This error should be considered proportionally for the 675 m long pipe.

2. With respect to the effective decay pipe aperture, the effective radius, for the entire length of the pipe, must not exceed ± 20 mm (1σ) from the designed value.

Alignment Phases

Two alignment phases:

1. During construction phase: alignment support for the decay pipe installation.

2. Post construction phase (after the shielding fill): survey the "as built" position and dimensions of the decay pipe.

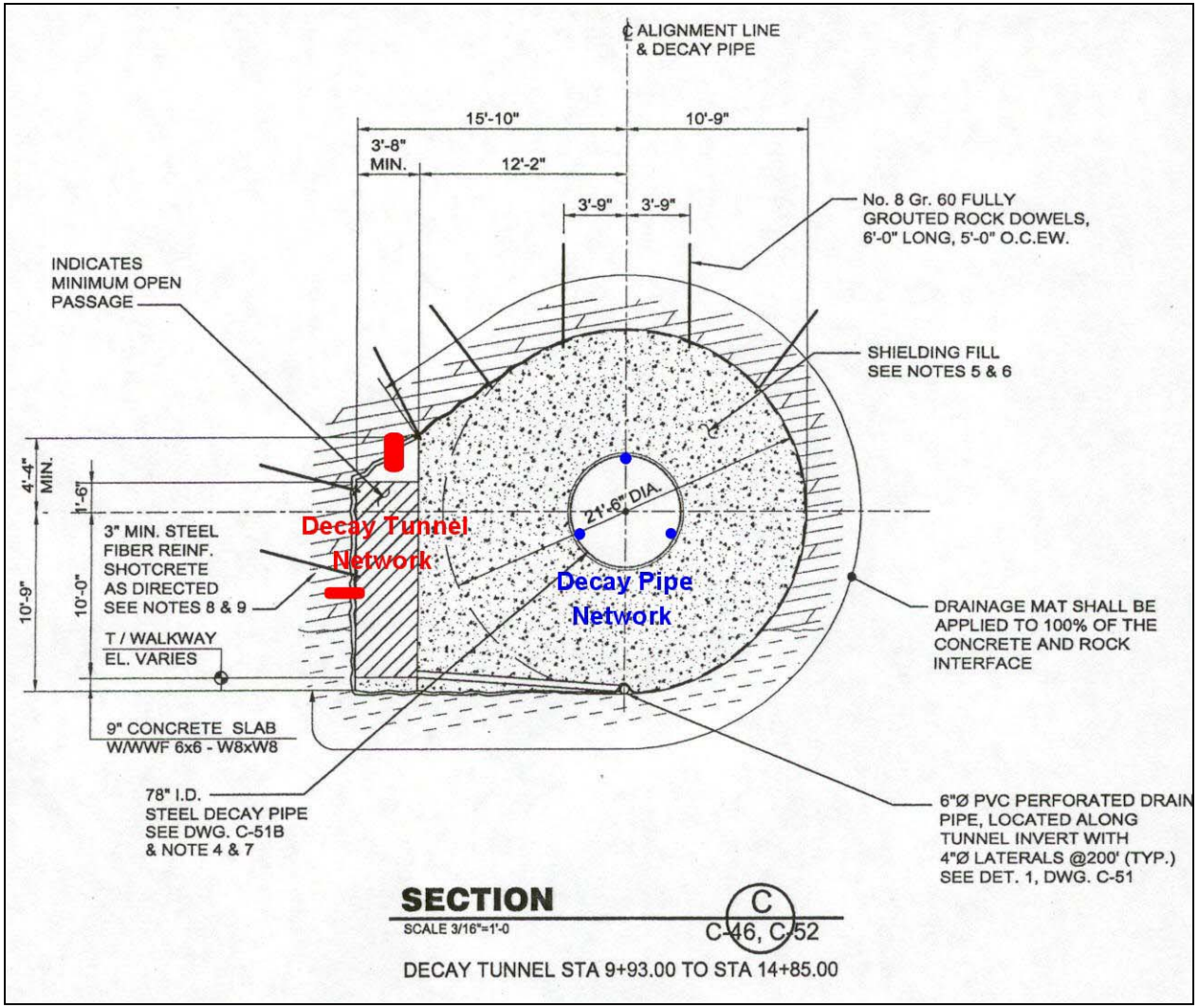
During Construction Phase

Establish control network throughout the decay tunnel:

- Materialized and measured by the contractor's surveyor.
- Points with x,y,h coordinates no farther than 50 m.
- Constrained on both ends of the decay tunnel (Target Hall and respectively Absorber Hall) on precision points transferred from surface.
- Coordinate errors $\leq \pm 6$ mm (1σ) achievable using classical surveying techniques and instrumentation.

- Fermilab's task is to check the network for correctness and level of accuracy achieved. For an objective assessment, the network determination will be performed at least twice as accurately as the contractor.

Decay Tunnel and Decay Pipe Networks (draft)



During Construction Phase

Alignment to support the decay pipe installation:

- From the total error budget of ± 25 mm, network errors of ± 6 mm (added in quadrature) will allow to more than ± 20 mm to be accounted by survey alignment errors, pipe positioning and installation errors, pipe stability errors, pipe deformations from manufacturing or transportation, etc.

- Fermilab's task is to check the correctness of the installed pipe by measuring multiple interior cross sections, at no more than 10 m intervals, and evaluate the results (i.e. the axis and the residuals of the fitted cylinder) with respect to required alignment tolerances.

Post Construction Phase

Takes place after the shielding fill. Represents the final survey of the "as built" position and dimensions of the decay pipe assuming that, after the initial installation, the pipe will suffer deformations and/or displacements caused by casting the concrete shielding in place.

Establish control network throughout the decay pipe:

- Materialized and measured by Fermilab.
  - The points consist of 0.75×0.5×0.5 inch metal stubs having a 0.25 inch precision hole to receive a nest holding a target or retro reflector and welded in at 0°-120°-240° with respect to the circular pipe cross section (similar with those used for the Hadron Hose).

Post Construction Phase

- Points with x,y,h coordinates spaced at 50 m
- Constrained on both ends of the decay tunnel (Target Hall and respectively Absorber Hall) on precision points transferred from surface.
- Simulations show that point errors ellipses $\leq \pm 4$ mm (1σ) can be obtained rather quickly and with relatively moderate effort using conventional surveying methods and instrumentation (the Geodimeter robotic total station, the precision Gyrotheodolite, and precise leveling).
    - The absolute error ellipses for each point and relative error ellipses between points computed at 95% confidence level (2.45 σ for two-dimensional normal distribution).

Point error ellipses

XY PLANE STATION 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES:
(VARIANCE FACTOR KNOWN) = 2.4484 σ

STATION	SEMI-MAJOR AXIS	SEMI-MINOR AXIS	AZIMUTH OF SEMI-MAJOR AXIS	AREA OF ELLIPSE
P1	.00478	.00114	90 0 0	.17064D-04
P2	.00652	.00227	90 0 0	.46432D-04
P3	.00767	.00337	90 0 0	.81245D-04
P4	.00848	.00435	90 0 0	.11586D-03
P5	.00904	.00513	90 0 0	.14576D-03
P6	.00940	.00568	90 0 0	.16757D-03
P7	.00957	.00596	90 0 0	.17904D-03
P8	.00957	.00596	90 0 0	.17904D-03
P9	.00940	.00568	90 0 0	.16757D-03
P10	.00904	.00513	90 0 0	.14576D-03
P11	.00848	.00435	90 0 0	.11586D-03
P12	.00767	.00337	90 0 0	.81245D-04
P13	.00652	.00227	90 0 0	.46432D-04
P14	.00478	.00114	90 0 0	.17064D-04

Relative error ellipses between points throughout the decay pipe

RELATIVE 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES:
(VARIANCE FACTOR KNOWN) = 2.4484 σ

FROM	TO	SEMI-MAJOR	SEMI-MINOR	AZIMUTH MAJOR	DISTANCE	PRECISION	STD.DEV. ADJ.DISTANCE	STD.DEV ADJ.AZIMUTH
P1	P2	.00478	.00140	90 0 0	50.00000	1: 10452	.00195	2.36
P1	P3	.00652	.00263	90 0 0	100.00000	1: 15339	.00266	2.21
P1	P4	.00767	.00370	90 0 0	150.00000	1: 19553	.00313	2.08
P1	P5	.00848	.00457	90 0 0	200.00000	1: 23582	.00346	1.92
P1	P6	.00904	.00519	90 0 0	250.00000	1: 27653	.00369	1.75
P1	P7	.00940	.00553	90 0 0	300.00000	1: 31931	.00384	1.55
P1	P8	.00957	.00559	90 0 0	350.00000	1: 36582	.00391	1.35
P1	P9	.00957	.00537	90 0 0	400.00000	1: 41808	.00391	1.13
P1	P10	.00940	.00489	90 0 0	450.00000	1: 47897	.00384	.92
P1	P11	.00904	.00418	90 0 0	500.00000	1: 55306	.00369	.70
P1	P12	.00848	.00330	90 0 0	550.00000	1: 64853	.00346	.51
P1	P13	.00767	.00234	90 0 0	600.00000	1: 78215	.00313	.33
P1	P14	.00652	.00149	90 0 0	650.00000	1: 99706	.00266	.19

Post Construction Phase

Determine the "as built" position and dimensions of the decay pipe:

- Survey cross sections throughout the pipe at 5-10 m station intervals, measuring 8 points per profile.
- evaluate the results of the fitted cylinder through all cross sections with respect to required alignment tolerances
  - the cylinder axis with respect to the designed beamline azimuth and the slope
  - the residuals to the fitted cylinder surface to the designed effective decay pipe aperture

Installation/Vacuum Test

- We Should Check the Vacuum Prior to Constructing Hadron Absorber and Chase
- Need to Work Through Installation Schedule
- No Major Problem Foreseen

Costs

- Elimination of Seals
- Addition of Oversight ($22K)
- PVC Cooling Cover ($.A. Healy) -- this will be biggest change

UID	WBS	*M&S*	*SWF*	*Description*	
58	1.1.4.2.1.2.1	$0	$3,840	ASME Vacuum Vessel Shell Calculations/FESHM Note	
59	1.1.4.2.1.2.2	$0	$1,920	ASME Vacuum Vessel Transition Calculations	
60	1.1.4.2.1.2.3	$0	$3,840	D.S. Endcap Calculation	
61	1.1.4.2.1.2.4	$0	$3,840	U.S. Thin Window Calculation	
3138	1.1.4.2.1.2.5	$0	$3,360	Prepare Drawings for Vacuum Vessel Endcaps	
187	1.1.4.2.1.2.6	$0	$2,240	Vacuum Vessel FESHM Documentation Drafting	
74792	1.1.4.2.1.2.8	$0	$1,920	FESHM Note for U.S. Endcap	
74793	1.1.4.2.1.2.9	$0	$3,840	FESHM Note for D.S. Endcap & Access Port	
74279	1.1.4.2.1.2.7	$0	$11,040	Design Access Port for Remote Handling Repair Equip	
74293	1.1.4.3.1.5.3	$0	$1,536	Oversight of Decay Access Port Fabrication	
73526	1.1.4.3.1.5.1	$0	$2,304	Oversight of Decay Endcap Fabrication	
73527	1.1.4.3.1.5.2	$0	$1,920	Oversight of Decay Endcap Installation	
74324	1.1.4.3.2.2.5.12	$20,000	$224	Construct Downstream Access Port Assy	
73283	1.1.4.3.2.3.2	$16,000	$0	Endcap Material Deliveries	
3143	1.1.4.3.2.3.3	$0	$2,240	Upstream Endcap Fabrication	
74557	1.1.4.3.2.3.8	$20,000	$0	Deliver Downstream Access Port Assy	
3144	1.1.4.3.2.3.4	$0	$2,240	Downstream Endcap Fabrication	
74892	1.1.4.3.2.4.3.4	$0	$0	Install Decay Pipe cooling pipe manifold	
3336	1.1.4.3.2.4.3.2	$0	$5,520	Install Upstream Endcap	
3335	1.1.4.3.2.4.3.1	$1,250	$5,520	Install Downstream Endcap	
74332	1.1.4.3.2.4.3.3	$1,250	$0	Install Access Port	
TOTAL		$58,500	$57,344		$115,844

Costs as of This Morning

UID	WBS	M&S	SWF	Description
58	1.1.4.2.1.2.1	$0	$3,840	ASME Vacuum Vessel Shell Calculations/FESHM Note
59	1.1.4.2.1.2.2	$0	$1,920	ASME Vacuum Vessel Transition Calculations
60	1.1.4.2.1.2.3	$0	$3,840	D.S. Endcap Calculation
61	1.1.4.2.1.2.4	$0	$3,840	U.S. Thin Window Calculation
3138	1.1.4.2.1.2.5	$0	$3,360	Prepare Drawings for Vacuum Vessel Endcaps
187	1.1.4.2.1.2.6	$0	$2,240	Vacuum Vessel FESHM Documentation Drafting
74792	1.1.4.2.1.2.8	$0	$1,920	FESHM Note for U.S. Endcap
74793	1.1.4.2.1.2.9	$0	$3,840	FESHM Note for D.S. Endcap & Access Port
74279	1.1.4.2.1.2.7	$0	$11,040	Design Access Port for Remote Handling Repair Equip
74293	1.1.4.3.1.5.3	$0	$1,536	Oversight of Decay Access Port Fabrication
73526	1.1.4.3.1.5.1	$0	$2,304	Oversight of Decay Endcap Fabrication
73527	1.1.4.3.1.5.2	$0	$1,920	Oversight of Decay Endcap Installation
74324	1.1.4.3.2.2.5.12	$12,982	$2,240	Construct Downstream Access Port/DS Endcap
3143	1.1.4.3.2.3.3	$12,982	$2,240	Upstream Endcap Fabrication
74892	1.1.4.3.2.3.8	$0	$0	Deliver Downstream Access Port Assy
3336	1.1.4.3.2.4.3.4	$0	$0	Install Decay Pipe cooling pipe manifold
3335	1.1.4.3.2.4.3.2	$1,250	$5,520	Install Upstream Endcap
74332	1.1.4.3.2.4.3.1	$1,250	$5,520	Install Downstream Endcap
		$0	$22,000	Decay Pipe Welding Oversight
TOTAL		$28,464	$79,120	

$107,584

Comments on Costs

- Unburdened Cost Estimate $115K
- Access Port costed at $56,000

  large over-estimate; needs redo
- Have BOE from Grozis on Endcaps

  also overestimate, but < $few K
- For WBS 1.1.4, Cost Will Shrink Some
- TPC will Increase from Cooling =>

  WBS 1.1.7