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Accommodating Future Expansion Main Ring/Transport Line Crossing

S. Dixon

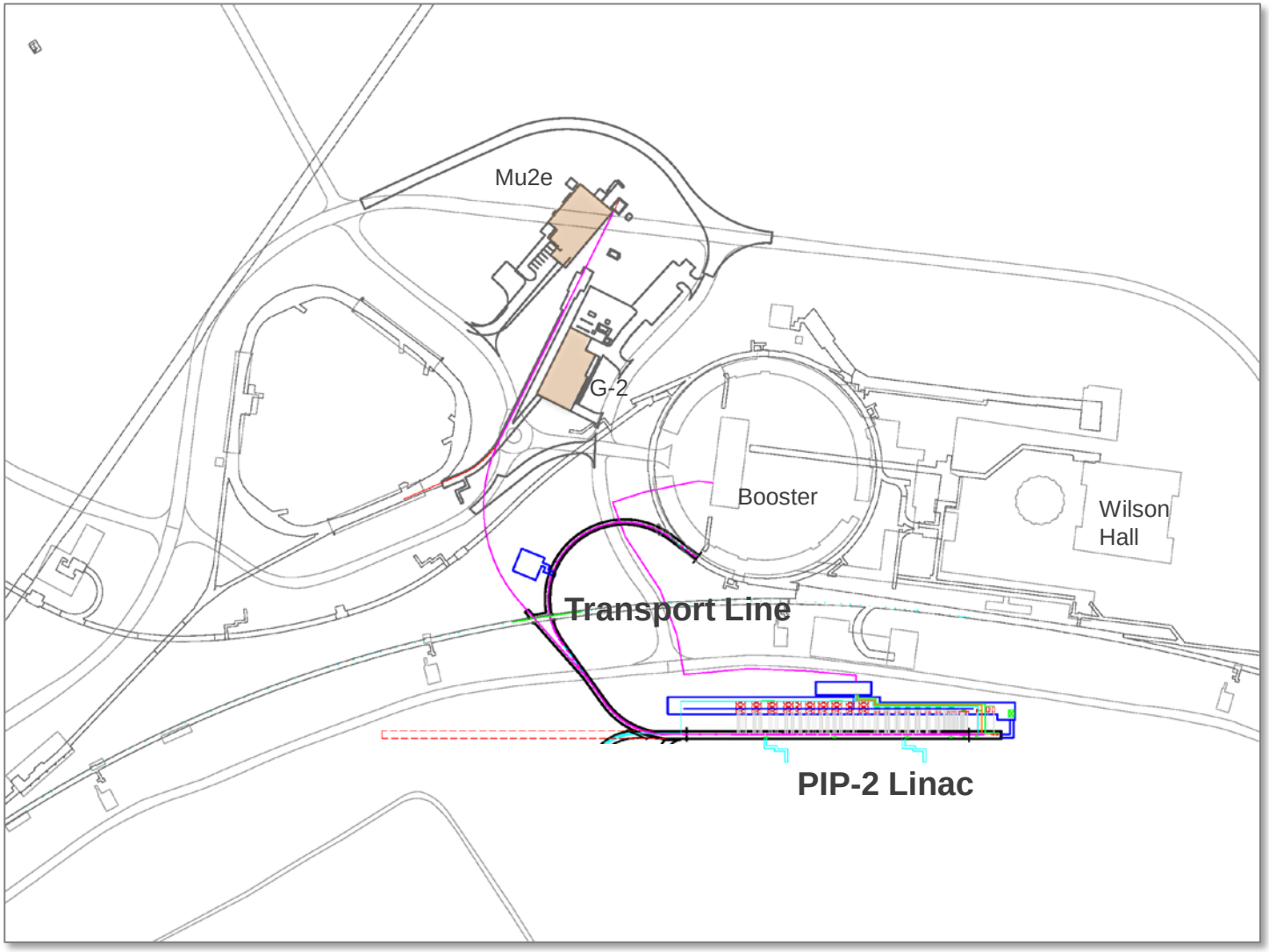
Technical Board Meeting

30 November 2015

Agenda

- Accommodating Future Expansion(s)
  - Linac Extension
  - Extracted Beam for Muon Campus
- Options for Main Ring/Transport Line Crossing
  - Through Main Ring Tunnel
  - Above Main Ring Tunnel
  - Below Main Ring Tunnel

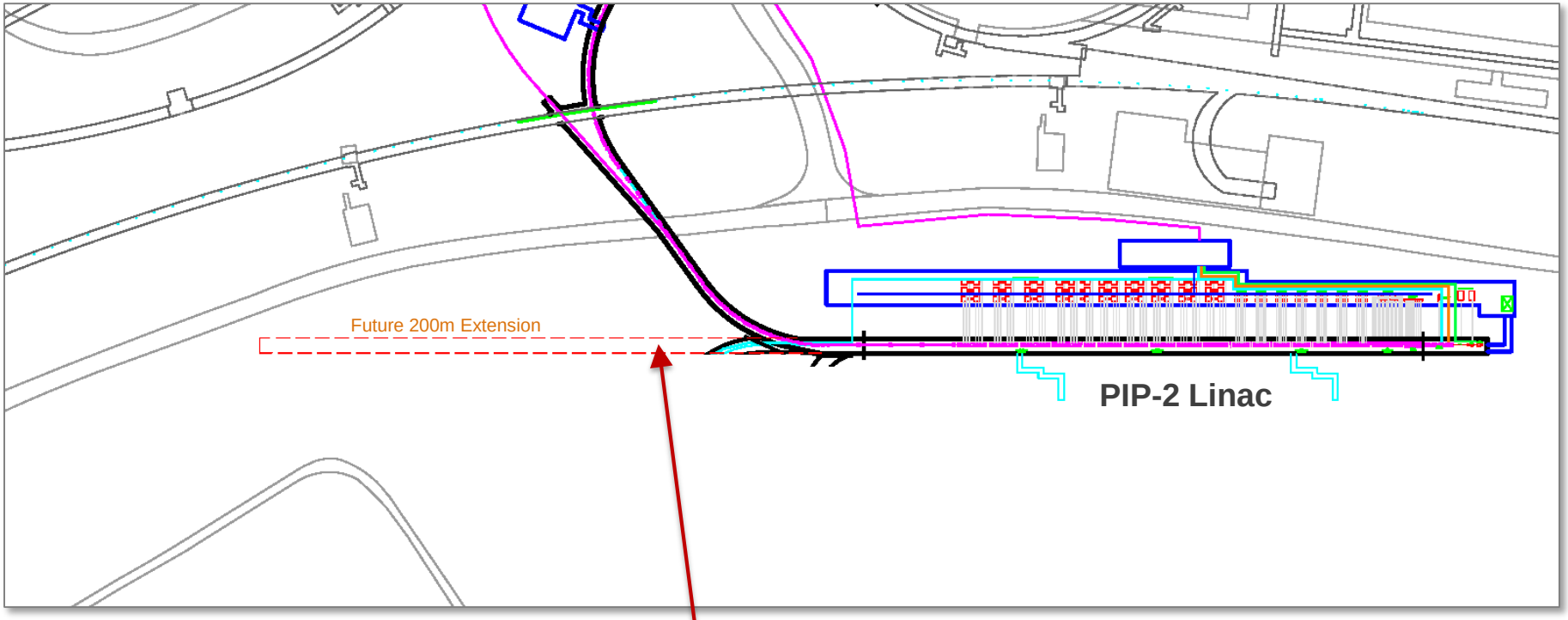
Latest Beamline Arrangement



Accommodating Future Expansion

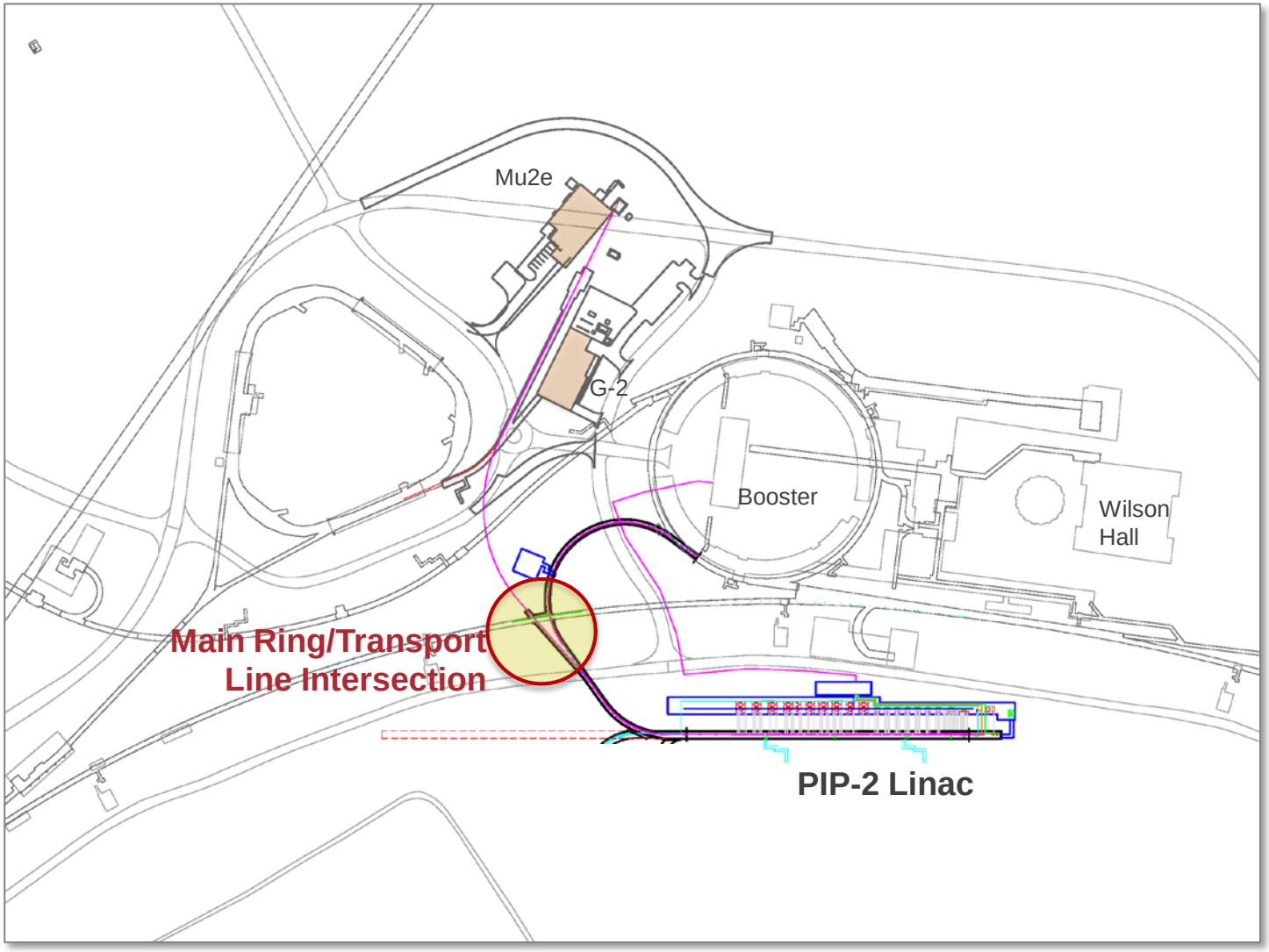
- Linac Extension
- Extracted Beam for Muon Campus

Future Expansion – Linac Extraction

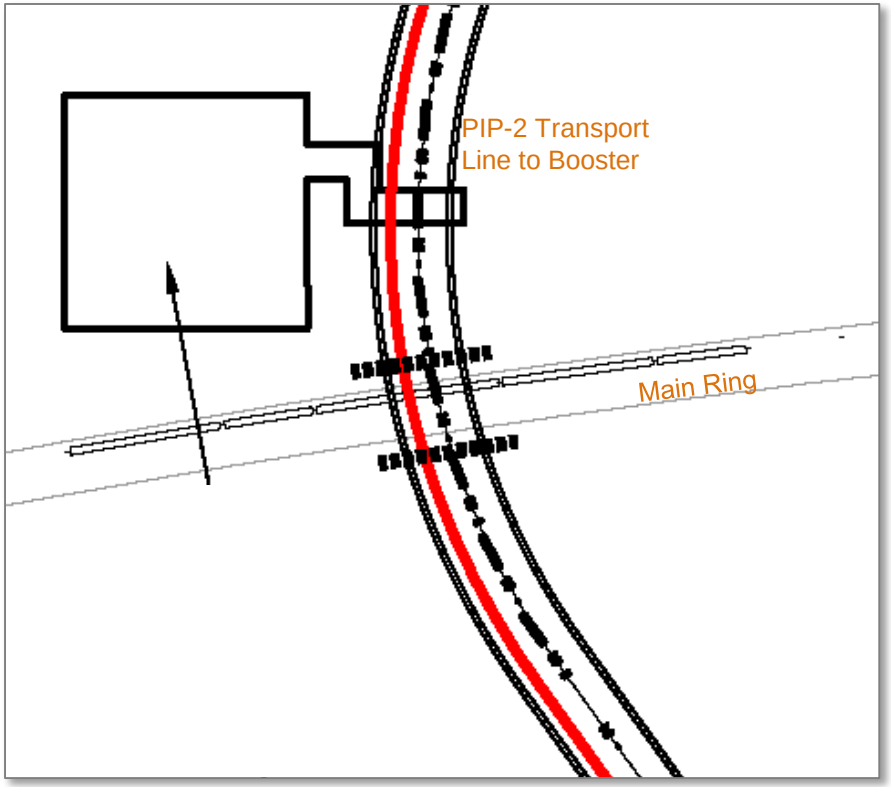


Construct ~30 foot long Enclosure Stub for potential Linac Extraction

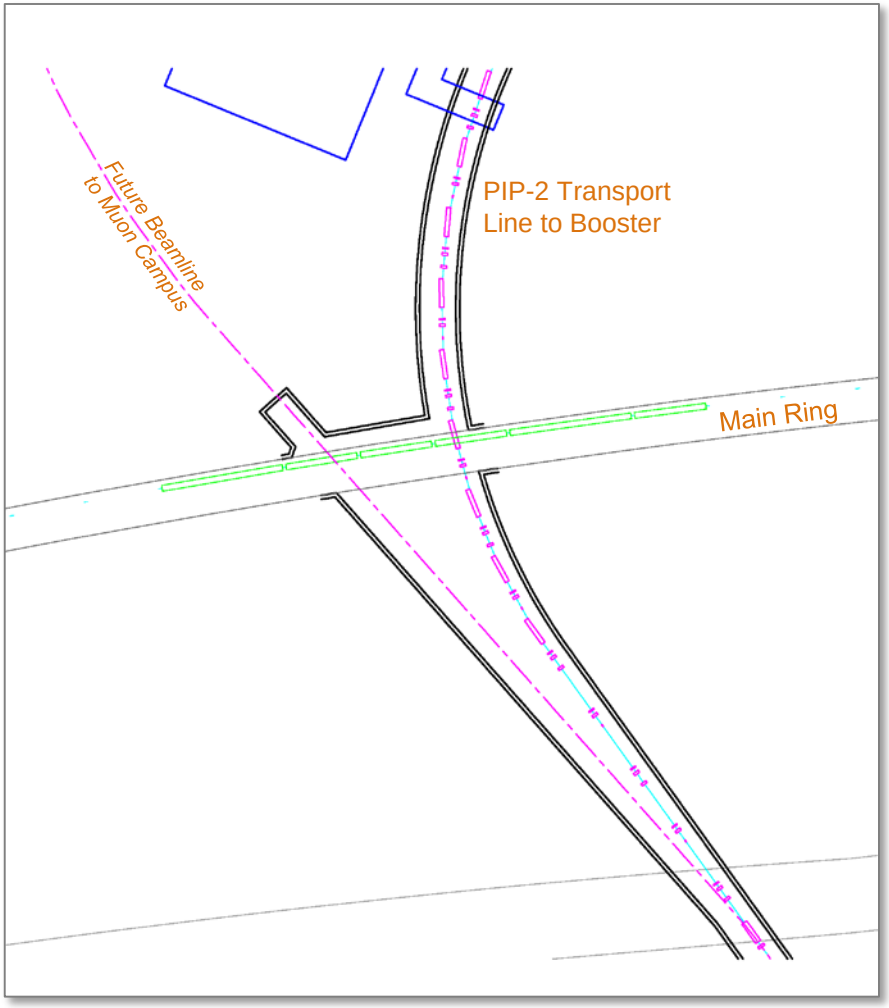
Future Expansion – Muon Campus Beamline



Future Expansion – Muon Campus Beamline

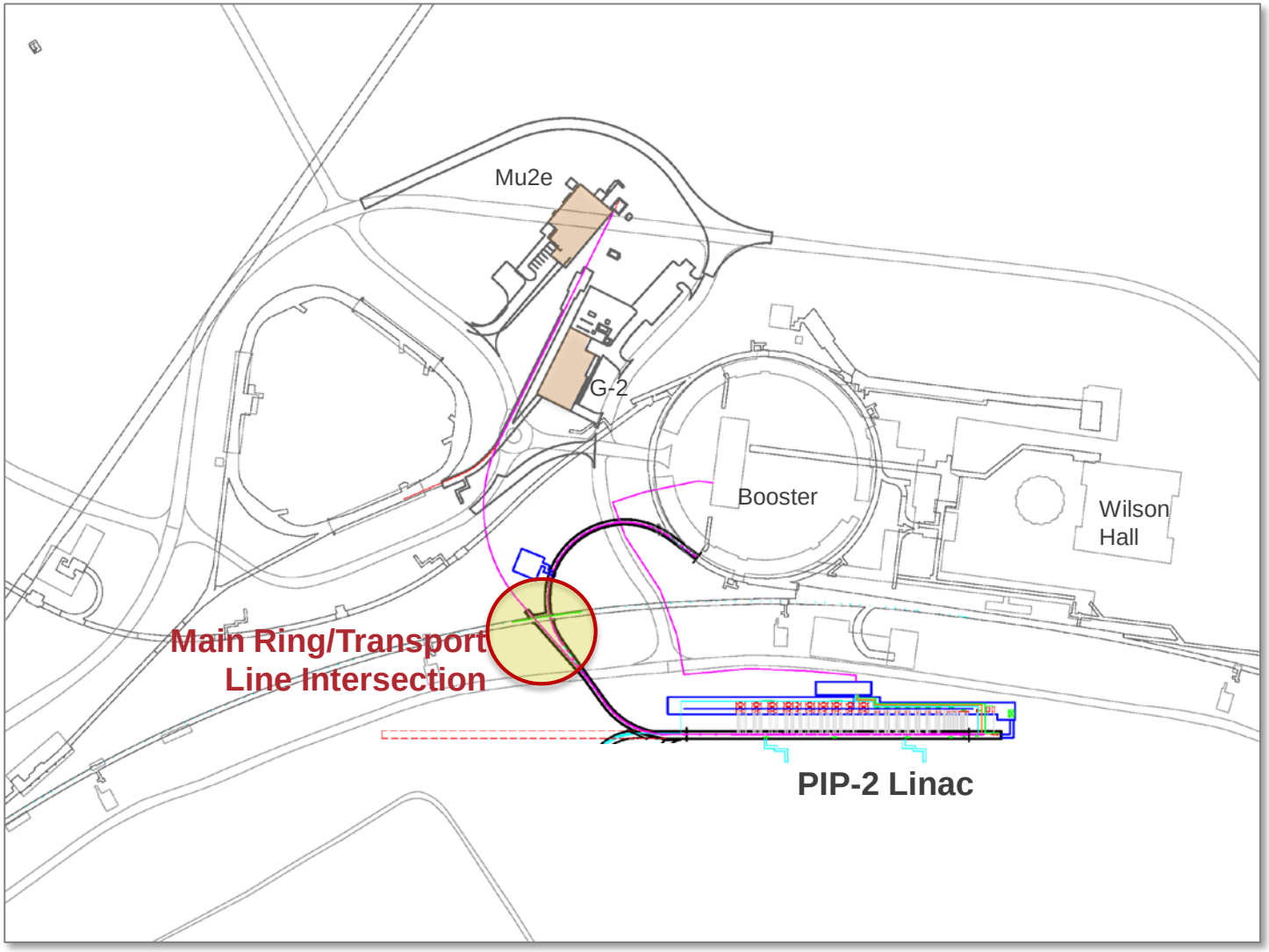


Baseline Configuration

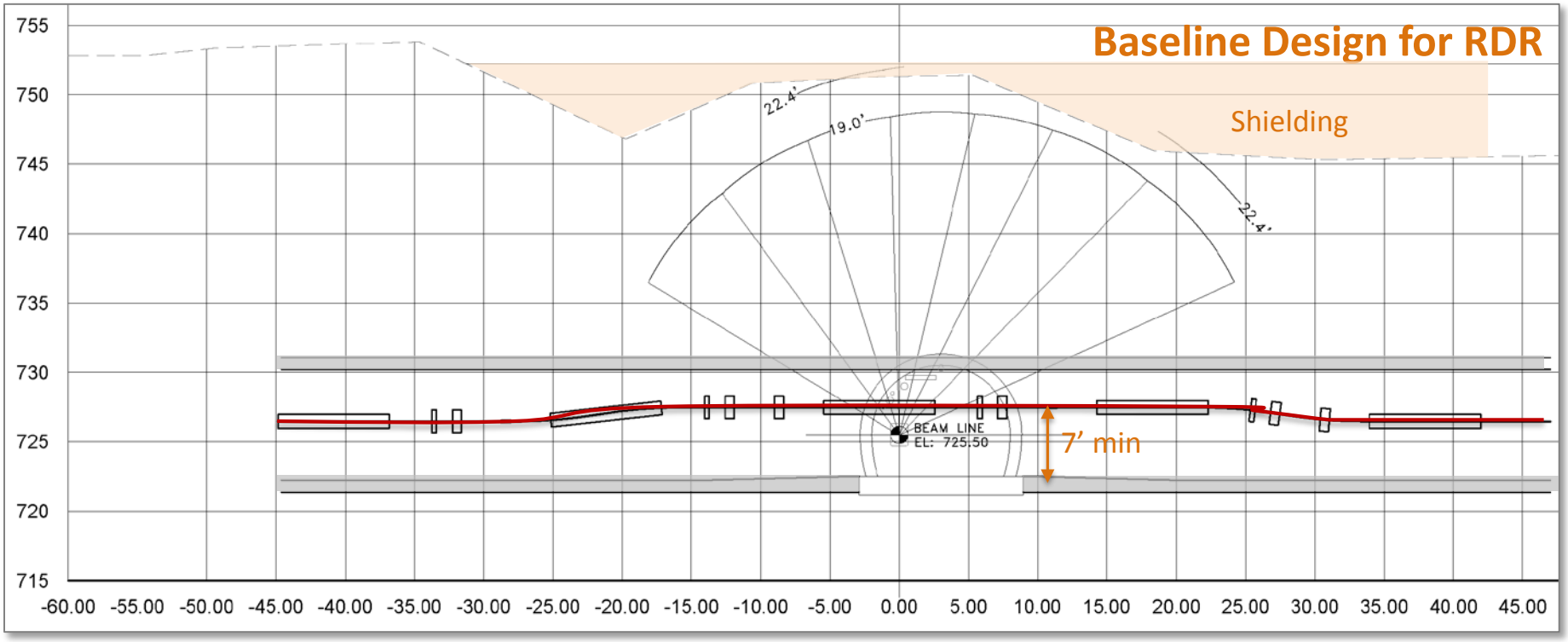


Proposed Configuration

Main Ring/Transport Line Crossing



Option 1 – Crossing at Main Ring Elevation



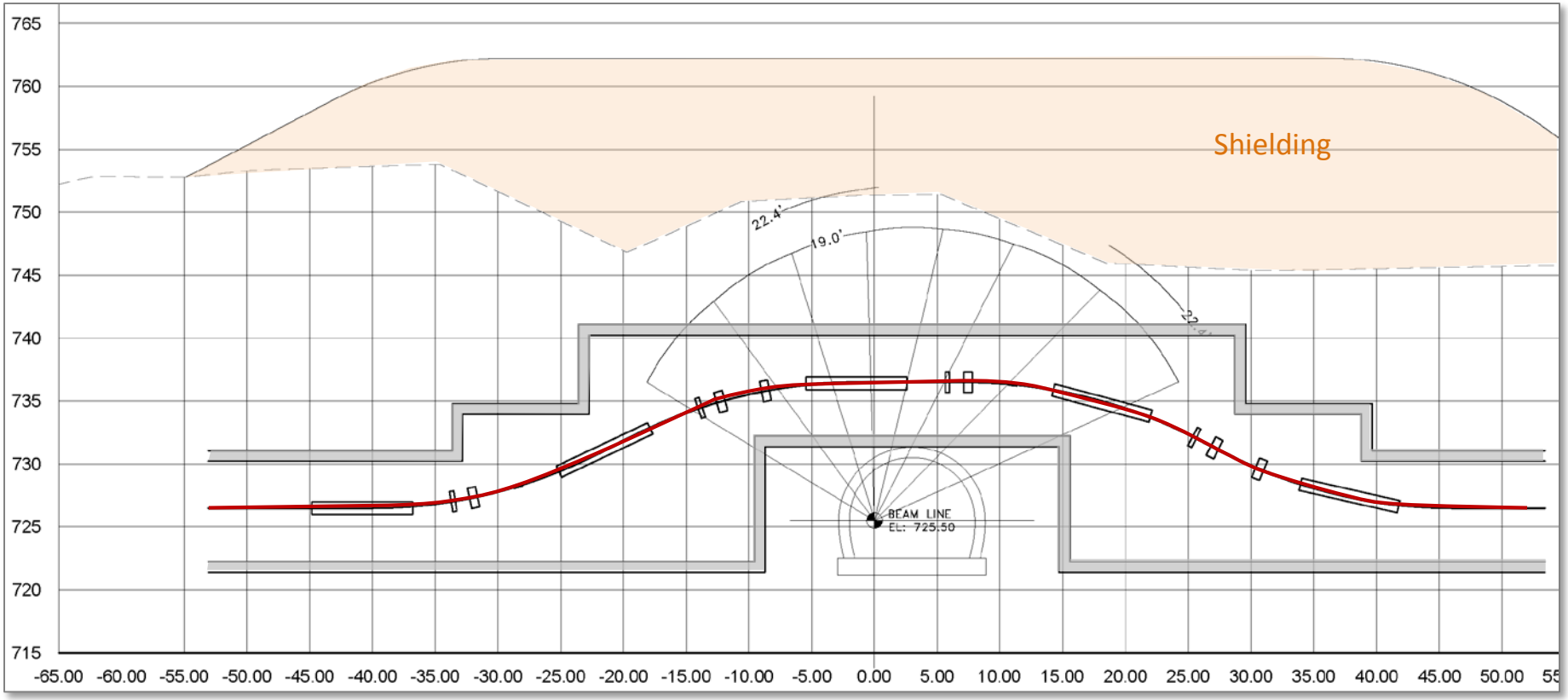
Pros

- Smaller Beamline Optics Change
- Less Change to Baseline Design

Cons

- Requires Relocation of beamline equipment/utilities in Main Ring
- Clearance Issues
- Equipment Transport (N-S, E-W)
- HVAC Isolation Complications

Option 2 – Crossing Above Main Ring



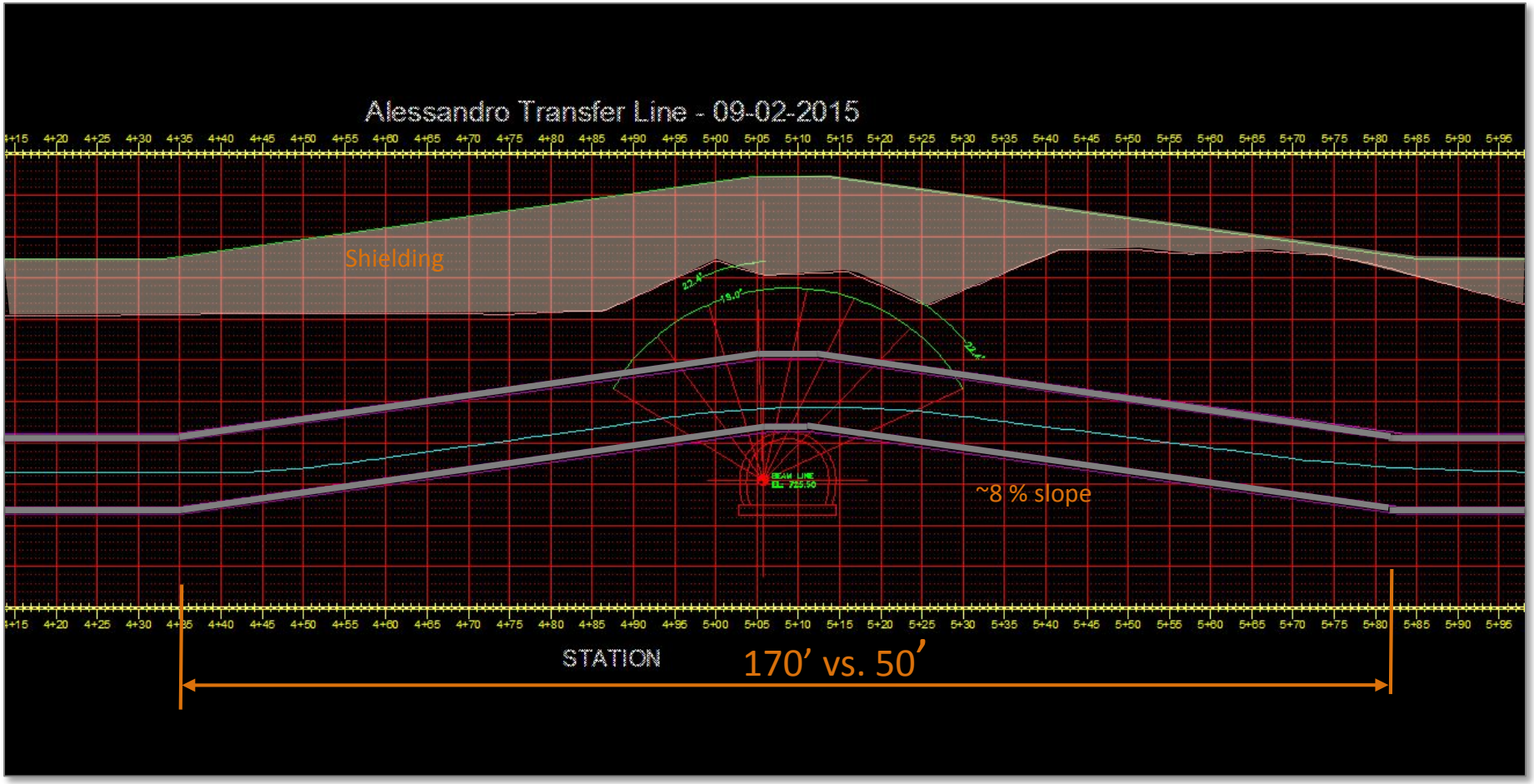
Pros

- Less Impact to MR components
- Good Solution for HVAC Isolation

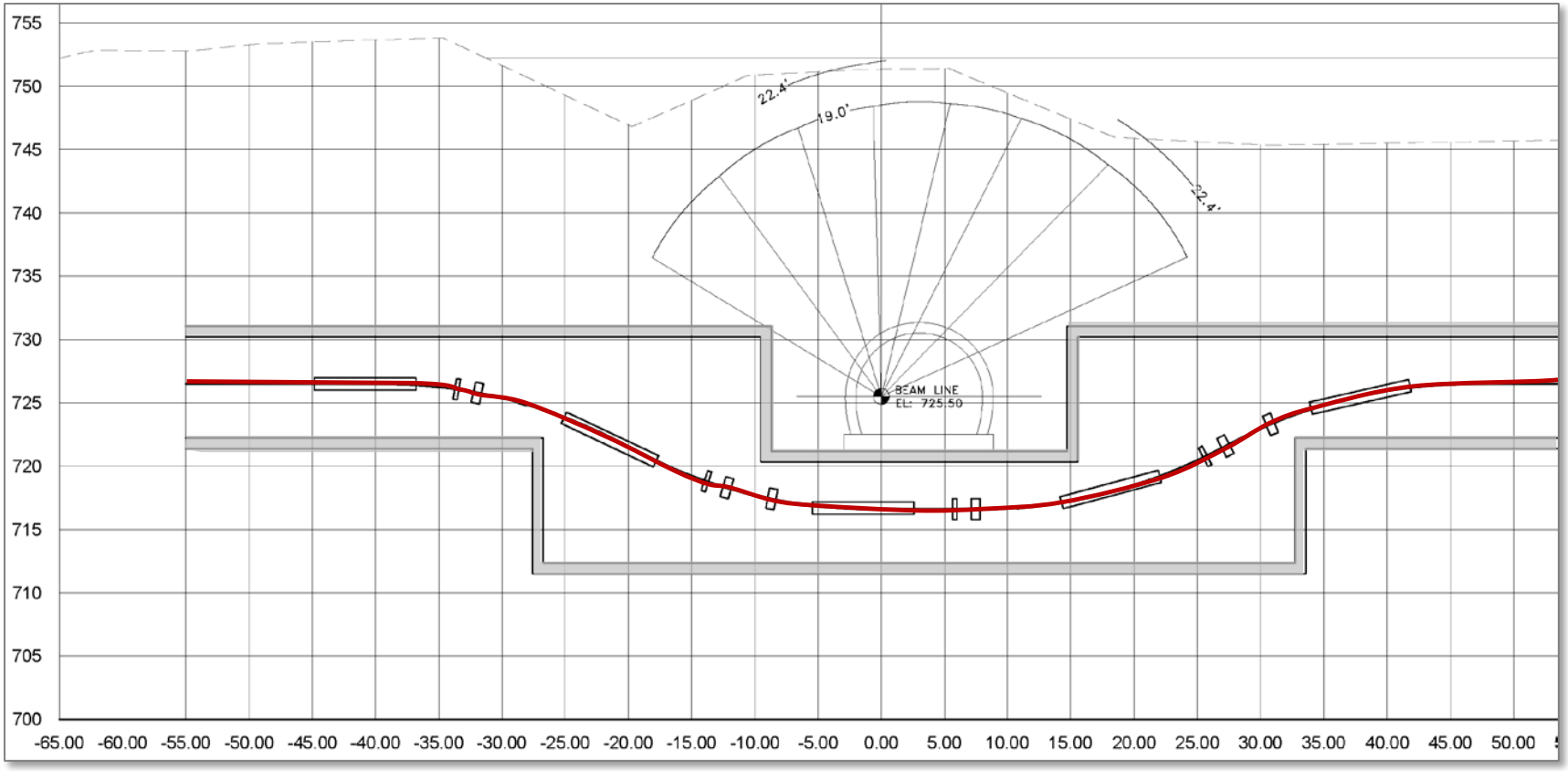
Cons

- Increased Shielding
- Equipment Transport Complicated
- Structurally Complex

Main Ring/Transport Line Crossing – Option 2 (Reality)



Option 3 – Crossing Below Main Ring



Pros

- Good Solution for HVAC
- Shielding Remains the Same

Cons

- Requires Relocation of beamline equipment/utilities in Main Ring
- Equipment Transport
- Structurally VERY Complex
- Deep Excavation

Feedback from D. Augustine (1 of 2)

- **Concern #1** – Main Ring F-Sector would be inaccessible anytime beam is received by Booster/MI/MINIBoonNE/NUMI/LBNF. This would be a new mode of operation for us. Traditionally, we have always had access to F-Sector while we continued beam to Booster/Main Injector/MINIBooNE/NUMI. Beamline Operations coordinators would need to be made aware of this as a potentially significant limitation and interruption to site-wide beam operations. Perhaps shielding would alleviate this?
- **Concern #2** – PIP-II transport line (and potentially Main Ring F-Sector) would become ODH areas if an ODH barrier is not installed to isolate PIP-II SC LINAC from transport line. (An ODH barrier has been proposed by Conventional Facilities)
- **Concern #3** – The PIP-II LINAC Gallery, Service Building, and beamline enclosure are currently located where Main Ring Ponds from F4 to A1 are currently located. What will happen to these ponds? They are currently being used by F-Sector (F4) and Mu2e Cryo Pump Room (A0). Valerie suggested moving the SC LINAC campus more east, thereby keeping the ponds intact and avoiding interference. Would pond dredging be required? Another option is to build an adjacent new pond to replace F4 to A1 ponds. New underground Pond piping would be required.
- **Concern #4** – Crossing at Main Ring Elevation (Option 1) – Magnet movers in the Main Ring require an 8 foot (9 ft?) clearance. Access through this area would be a major concern for enclosure operations, beamline coordinators, and support technicians.

Feedback from D. Augustine (2 of 2)

- **Concern #5** – Crossing above/below Main Ring (Option 2 or Option 3) would create beam intensity limitations. Any future upgrades of beam intensities may require replacing dipole magnets and/or utility upgrades. This problem was encountered during construction of Tevatron C0 and D0 collision halls.
- **Concern #6** – Crossing above/below Main Ring will create significant magnet installation and support stand challenges. A solid budget estimate for engineering and CAD drafting (EDIA) would be needed. This is not an impossible issue. However, a challenge nonetheless that must be considered. – Sloped tunnel @ 8% grade might help.
- **Concern #7** – Crossing above/below Main Ring will result in significantly limited access. PIP-II Transport line (West) would only be accessible from Booster high bay in the AD footprint Cross Gallery. Pip-II Transport line (East) would only be accessible from PIP-II LINAC Center Service Building High Bay. Is this a problem? Probably not. But maybe an inconvenience when bringing heavy, large equipment to the transport enclosure.

Summary

	Option 1	Option 2	Option 3
	(At MR)	*(Above MR)*	*(Below MR)*
Relocation of Main Ring Components	All	Some	All
Clearance Concerns at Main Ring	Yes	No	No
Equipment Installation Concern	Yes	Yes	Yes
HVAC Isolation	Limited	Yes	Yes
Increased Shielding (over Baseline)	No	Yes	No
Construction Complexity	Low	High	Very High
Magnet Support Impact	Average	Complex	Complex

Cost Summary – Transport Line

	Without Muon Campus Stub	With Muon Campus Stub
Option 1 (At Main Ring)	**$5.51**	**$6.29**
Option 2 (Above Main Ring)	**$5.68**	**$6.85**
Option 3 (Below Main Ring)	**$6.04**	**$8.03**

(values in millions)

Note: Base Cost shown above are for comparison only and include construction costs only and do not include Overhead and Profit (OHP), Contingency, EDIA or Indirect Costs

Action

- Decision on Linac Expansion Stub
- Decision on Muon Campus Beamline Stub
- Decision on Main Ring/Transport Line Crossing Strategy

Backup

Estimate – Option 1

PIP-II
CONVENTIONAL FACILITIES - TRANSFER TUNNEL
OPTION 1 - AT MAIN RING TUNNEL ELEVATION

9/24/2015
BY: JWH

Item Description	Quantity	Units	Unit Price	Extended Price	Totals
ESTIMATED TRANSFER TUNNEL CONSTRUCTION AMOUNT =					**$5,509,985**
ESTIMATED TRANSFER TUNNEL CONSTRUCTION AMOUNT W/ MU2E STUB =					**$6,291,985**
SURFACE WORK				**SUBTOTAL=**	**$264,700**
Erosion Control	2.0	ACRE	$8,000	$16,000	
Pond Dewatering	2	DAY	$1,200	$2,400	
Clear and Grub Dense Brush	0.33	ACRE	$10,000	$3,300	
Strip and Stockpile Topsoil	5,000	CY	$12	$60,000	
Remove Existing Pavement	3,000	SY	$9	$27,000	
Remove/Relocate Existing Utilities	1	L SUM	$100,000	$100,000	
Fine Grading and Seeding	2	ACRE	$3,000	$6,000	
Survey Monuments	1	L SUM	$50,000	$50,000	
ROADS				**SUBTOTAL=**	**$142,000**
New Access Road	1,500	SY	$60	$90,000	
New Ditches Along Access Road	800	LF	$15	$12,000	
Temporary Roadway Including Signage	1	L SUM	$40,000	$40,000	
TRANSPORT TUNNEL ENCLOSURE (1,003 LF)				**SUBTOTAL=**	**$4,598,285**
Excavation	41,400	CY	$15	$621,000	
Mud Slab	330	CY	$250	$82,500	
Cast in Place Enclosure (includes reinforcement)	2,430	CY	$800	$1,944,000	
Dampproofing	10,430	SY	$70	$730,100	
Crushed Stone Fill Around Enclosure	8,200	CY	$45	$369,000	
Drainage	1,003	LF	$20	$20,060	
Backfill	58,800	CY	$4	$235,200	
Sump Pump and Pit @ 1 per 500 Feet	3	EACH	$40,000	$120,000	
Cable Tray	1,003	LF	$100	$100,300	
Electrical Outfitting	1,003	LF	$175	$175,525	
Fire Protection/Detection	1,003	LF	$125	$125,375	
Mechanical HVAC	1,003	LF	$75	$75,225	
MODIFICATIONS FOR TRANSFER LINE & MAIN RING INTERSECTION				**SUBTOTAL=**	**$155,000**
Demolition (enclosure walls, top slab, etc.)	800	SF	$50	$40,000	
New Walls for Air Separation	1	LS	$50,000	$50,000	
Mechanical HVAC	1	LS	$15,000	$15,000	
Protection of Existing Utilities/Infrastructure	1	LS	$50,000	$50,000	
ACCESS STAIRS TRANSFER LINE (NOT AT BUILDINGS)				**SUBTOTAL=**	**$200,000**
Access Stairs Transfer Line (Not at Buildings)	2	EACH	$100,000	$200,000	
ALCOVES AT APPROXIMATLY 300' ALONG LINAC AND TRANSPORT				**SUBTOTAL=**	**$150,000**
Alcoves at Approximately 300' Along Transport	2	EACH	$75,000	$150,000	

MU2E TUNNEL ENCLOSURE "STUB"				**SUBTOTAL=**	**$782,000**
Excavation	2,500	CY	$15	$37,500	
Mud Slab	40	CY	$250	$10,000	
Cast in Place Enclosure (includes reinforcement)	400	CY	$800	$320,000	
Steel Structural Supports for Larger Spans	1	LS	$200,000	$200,000	
Dampproofing	1,700	SY	$70	$119,000	
Crushed Stone Fill Around Enclosure	900	CY	$45	$40,500	
Drainage	150	LF	$20	$3,000	
Backfill	3,000	CY	$4	$12,000	
Sump Pump and Pit @ 1 per 500 Feet	1	EACH	$40,000	$40,000	

Transfer Tunnel Crossing Options.xlsx, Same Elev.

Estimate – Option 2

PIP-II
CONVENTIONAL FACILITIES - TRANSFER TUNNEL
OPTION 2 - ABOVE MAIN RING TUNNEL ELEVATION

9/24/2015
BY: JWH

Item Description	Quantity	Units	Unit Price	Extended Price	Totals
ESTIMATED TRANSFER TUNNEL CONSTRUCTION AMOUNT =					**$5,428,930**
ESTIMATED TRANSFER TUNNEL CONSTRUCTION AMOUNT W/ MU2E STUB =					**$6,593,130**
SURFACE WORK				**SUBTOTAL=**	**$264,700**
Erosion Control	2.0	ACRE	$8,000	$16,000	
Pond Dewatering	2	DAY	$1,200	$2,400	
Clear and Grub Dense Brush	0.33	ACRE	$10,000	$3,300	
Strip and Stockpile Topsoil	5,000	CY	$12	$60,000	
Remove Existing Pavement	3,000	SY	$9	$27,000	
Remove/Relocate Existing Utilities	1	L SUM	$100,000	$100,000	
Fine Grading and Seeding	2	ACRE	$3,000	$6,000	
Survey Monuments	1	L SUM	$50,000	$50,000	
ROADS				**SUBTOTAL=**	**$142,000**
New Access Road	1,500	SY	$60	$90,000	
New Ditches Along Access Road	800	LF	$15	$12,000	
Temporary Roadway Including Signage	1	L SUM	$40,000	$40,000	
TRANSPORT TUNNEL ENCLOSURE (974 LF)				**SUBTOTAL=**	**$4,504,230**
Excavation	39,700	CY	$15	$595,500	
Mud Slab	320	CY	$250	$80,000	
Cast in Place Enclosure (includes reinforcement)	2,410	CY	$800	$1,928,000	
Dampproofing	10,030	SY	$70	$702,100	
Crushed Stone Fill Around Enclosure	8,100	CY	$45	$364,500	
Drainage	974	LF	$20	$19,480	
Backfill	58,000	CY	$4	$232,000	
Sump Pump and Pit @ 1 per 500 Feet	3	EACH	$40,000	$120,000	
Cable Tray	974	LF	$100	$97,400	
Electrical Outfitting	974	LF	$175	$170,450	
Fire Protection/Detection	974	LF	$125	$121,750	
Mechanical HVAC	974	LF	$75	$73,050	
STRUCTURAL MODIFICATIONS TO PROTECT MAIN RING AT INTERSECTION				**SUBTOTAL=**	**$168,000**
Cast in Place Structural Bridge Over Existing Main Ring Tunnel	140	CY	$1,200	$168,000	
ACCESS STAIRS TRANSFER LINE (NOT AT BUILDINGS)				**SUBTOTAL=**	**$200,000**
Access Stairs Transfer Line (Not at Buildings)	2	EACH	$100,000	$200,000	
ALCOVES AT APPROXIMATLY 300' ALONG LINAC AND TRANSPORT				**SUBTOTAL=**	**$150,000**
Alcoves at Approximately 300' Along Transport	2	EACH	$75,000	$150,000	

MU2E TUNNEL ENCLOSURE "STUB"				**SUBTOTAL=**	**$1,164,200**
Excavation	2,300	CY	$15	$34,500	
Mud Slab	40	CY	$250	$10,000	
Cast in Place Enclosure (includes reinforcement)	400	CY	$800	$320,000	
Steel Structural Supports for Larger Spans	1	LS	$200,000	$200,000	
Cast in Place Structural Bridge Over Existing Main Ring Tunnel	320	CY	$1,200	$384,000	
Dampproofing	1,700	SY	$70	$119,000	
Crushed Stone Fill Around Enclosure	900	CY	$45	$40,500	
Drainage	150	LF	$20	$3,000	
Backfill	3,300	CY	$4	$13,200	
Sump Pump and Pit @ 1 per 500 Feet	1	EACH	$40,000	$40,000	

Transfer Tunnel Crossing Options.xlsx, Above

Estimate – Option 3

PIP-II
CONVENTIONAL FACILITIES - TRANSFER TUNNEL
OPTION 3 - BELOW MAIN RING TUNNEL ELEVATION

9/24/2015
BY: JWH

Item Description	Quantity	Units	Unit Price	Extended Price	Totals
ESTIMATED TRANSFER TUNNEL CONSTRUCTION AMOUNT =					**$5,891,430**
ESTIMATED TRANSFER TUNNEL CONSTRUCTION AMOUNT W/ MU2E STUB =					**$7,877,630**
SURFACE WORK				**SUBTOTAL=**	**$264,700**
Erosion Control	2.0	ACRE	$8,000	$16,000	
Pond Dewatering	2	DAY	$1,200	$2,400	
Clear and Grub Dense Brush	0.33	ACRE	$10,000	$3,300	
Strip and Stockpile Topsoil	5,000	CY	$12	$60,000	
Remove Existing Pavement	3,000	SY	$9	$27,000	
Remove/Relocate Existing Utilities	1	L SUM	$100,000	$100,000	
Fine Grading and Seeding	2	ACRE	$3,000	$6,000	
Survey Monuments	1	L SUM	$50,000	$50,000	
ROADS				**SUBTOTAL=**	**$142,000**
New Access Road	1,500	SY	$60	$90,000	
New Ditches Along Access Road	800	LF	$15	$12,000	
Temporary Roadway Including Signage	1	L SUM	$40,000	$40,000	
TRANSPORT TUNNEL ENCLOSURE (974 LF)				**SUBTOTAL=**	**$4,534,730**
Excavation	42,000	CY	$15	$630,000	
Mud Slab	320	CY	$250	$80,000	
Cast in Place Enclosure (includes reinforcement)	2,410	CY	$800	$1,928,000	
Dampproofing	10,030	SY	$70	$702,100	
Crushed Stone Fill Around Enclosure	8,100	CY	$45	$364,500	
Drainage	974	LF	$20	$19,480	
Backfill	57,000	CY	$4	$228,000	
Sump Pump and Pit @ 1 per 500 Feet	3	EACH	$40,000	$120,000	
Cable Tray	974	LF	$100	$97,400	
Electrical Outfitting	974	LF	$175	$170,450	
Fire Protection/Detection	974	LF	$125	$121,750	
Mechanical HVAC	974	LF	$75	$73,050	
MODIFICATIONS FOR TRANSFER LINE & MAIN RING INTERSECTION				**SUBTOTAL=**	**$600,000**
Removal and Reconstruction of Existing Main Ring Tunnel/New Intersect.	1	LS	$600,000	$600,000	
ACCESS STAIRS TRANSFER LINE (NOT AT BUILDINGS)				**SUBTOTAL=**	**$200,000**
Access Stairs Transfer Line (Not at Buildings)	2	EACH	$100,000	$200,000	
ALCOVES AT APPROXIMATLY 300' ALONG LINAC AND TRANSPORT				**SUBTOTAL=**	**$150,000**
Alcoves at Approximately 300' Along Transport	2	EACH	$75,000	$150,000	

MU2E TUNNEL ENCLOSURE "STUB"				**SUBTOTAL=**	**$1,986,200**
Excavation	2,700	CY	$15	$40,500	
Mud Slab	40	CY	$250	$10,000	
Cast in Place Enclosure (includes reinforcement)	400	CY	$800	$320,000	
Steel Structural Supports for Larger Spans	1	LS	$200,000	$200,000	
Removal and Reconstruction of Existing Main Ring Tunnel	1	LS	$1,200,000	$1,200,000	
Dampproofing	1,700	SY	$70	$119,000	
Crushed Stone Fill Around Enclosure	900	CY	$45	$40,500	
Drainage	150	LF	$20	$3,000	
Backfill	3,300	CY	$4	$13,200	
Sump Pump and Pit @ 1 per 500 Feet	1	EACH	$40,000	$40,000	

Transfer Tunnel Crossing Options.xlsx, Below