Beamline and corresponding Conventional Facilities at Fermilab:

Assumptions and Cost Estimates

Vaia Papadimitriou
Accelerator Division Headquarters, Fermilab
Manager of the LBNE Beamline
Engineering/Cost Working Group

LBNE Reconfiguration Workshop
Fermilab
25-26 April 2012

Outline

- Review of the Reference Design of the LBNE Beamline Facility and the associated costs.
- Cost Reduction Opportunities - Beamline to Homestake
  - Reference design with cost reduction opportunities
  - Alternate design for target/horns with cost reduction opportunities
  - For both options above assume that we want to keep the capability to upgrade the facility later from 708 kW to 2.3 MW of beam power
- Alternative to LBNE - NuMI Beamline at Low Energy configuration
  - Needed design work for 708 kW operation
  - Issues with beam power greater than 708 kW

Status of the LBNE Beamline Facility

- During March 26-30, 2012 the LBNE project went through a Director's Independent Conceptual Design and CD-1 Readiness Review.
- Very positive feedback (see next page)
- What we will discuss below includes either cost reduction opportunities that we were planning to pursue after CD-1, during the preliminary design phase, or design options that can be adequate for the first phase of the project in a staged scenario.
- This recent work was accomplished in the past couple of weeks and it will need to be further vetted and properly documented.

Director's CD-1 Readiness Review – Closeout Report

- The conceptual design of the Beamline is complete, appropriate for the conceptual design phase, and likely to meet LBNE requirements. Risks have been identified and largely mitigated. Value engineering has been applied where appropriate. All present level 4 sub-system designs draw on the extensive experience of the managers and their staff with construction and operation of the NuMI facility. We see no significant deficiencies or omissions within the conceptual design.

- Conventional Facilities (CF): Design documentation, project risks, cost estimates and related schedule plans are at a level of development beyond what would be expected for a conceptual design. There has been significant effort and banked savings from Value Engineering. This has led to an optimized project design and execution schedule.

Status of the LBNE Beamline Facility

- The Beamline and CF Teams considered over 20 value engineering proposals during the 16 month period prior to the Director's Review, out of which three affected the overall configuration. We considered a deep and a shallow beamline with beam extracted at the MI-60 extraction point of the Main Injector (MI) and a deep and a shallow beamline with beam extracted at the MI-10 extraction point of MI.
- After having pursued seriously two of the above designs (2 CDRs) for about 5 months we selected the MI-10, shallow configuration as a reference design in November 2011.

Beamline/CF Scope

- Primary Beam , Neutrino Beam , System Integration

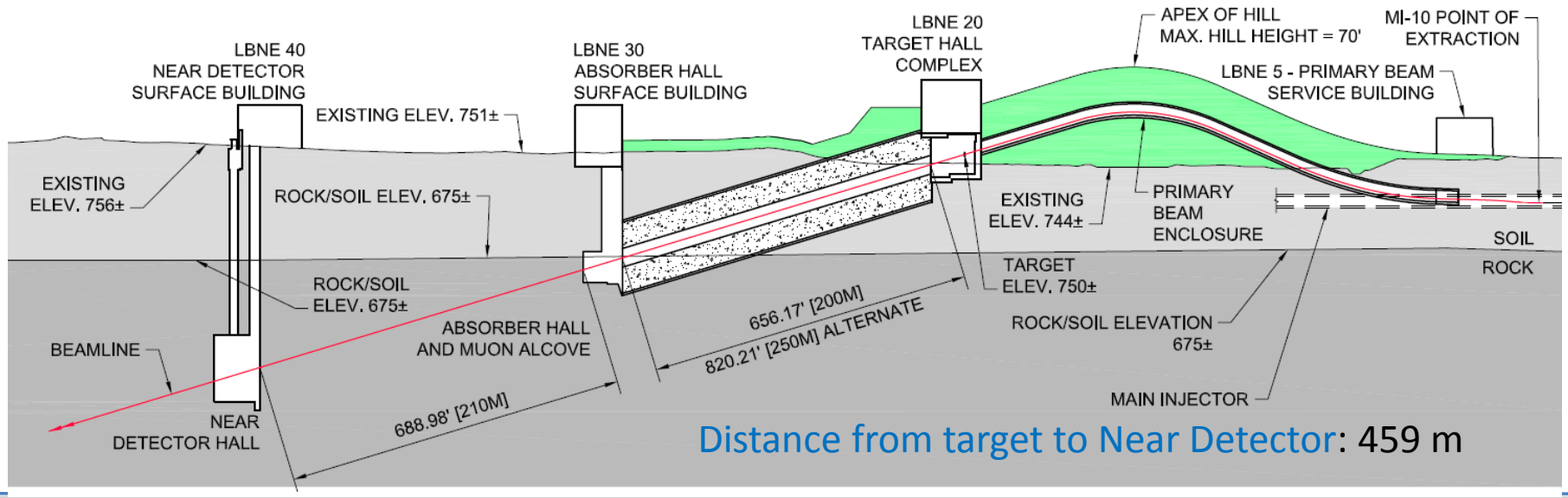
Providing specs for Conventional facilities (hall sizes, shielding thicknesses, distance between absorber and Near Detector, etc.)

At the surface:

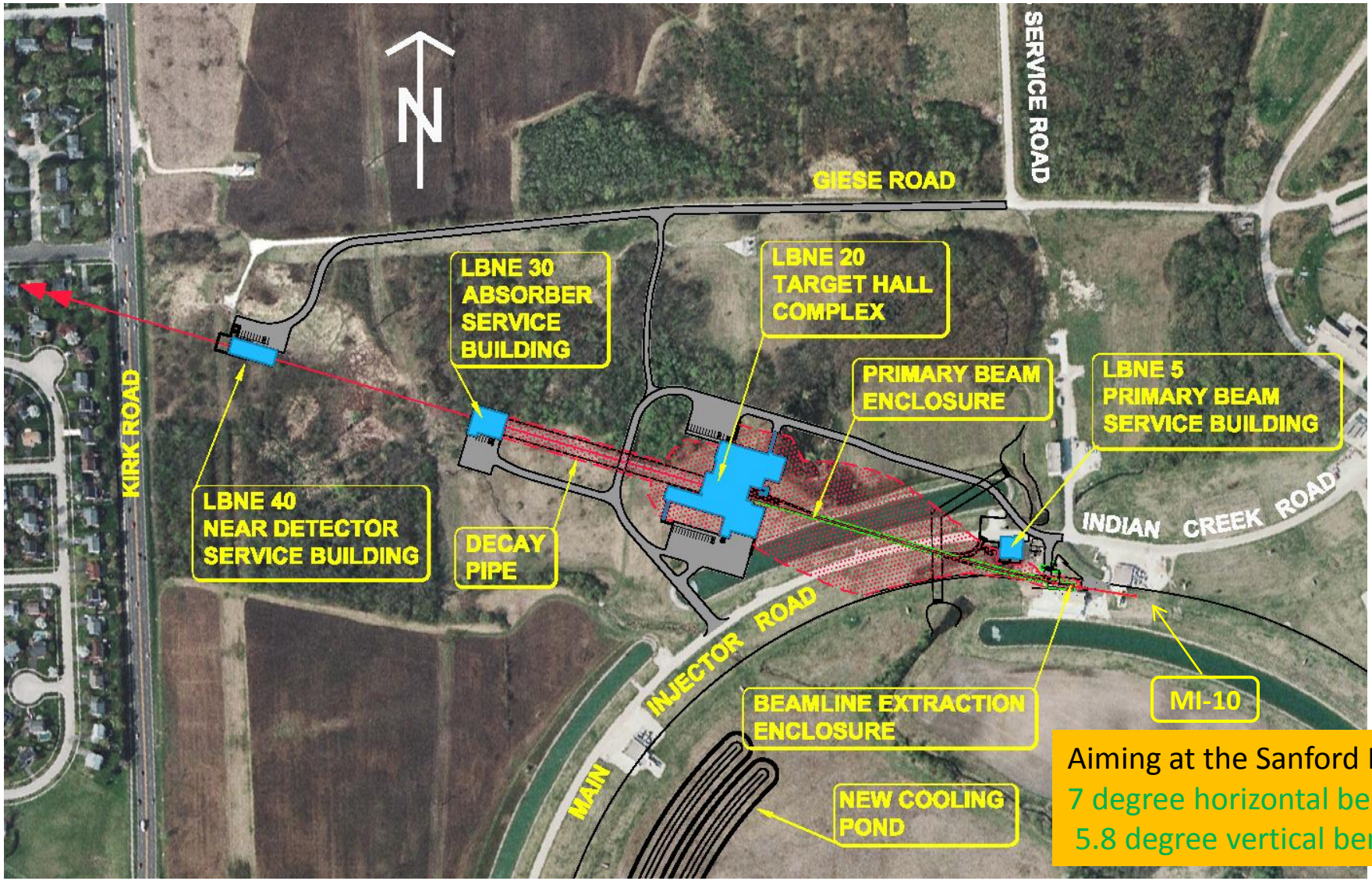
- LBNE 5 Primary Beam Service Building
- LBNE 20 Target Hall Complex
- LBNE 30 Absorber Hall Service Building

Underground:

- Beamline Extraction Enclosure
- Primary Beam Enclosure
- Decay Pipe
- Absorber Hall Complex

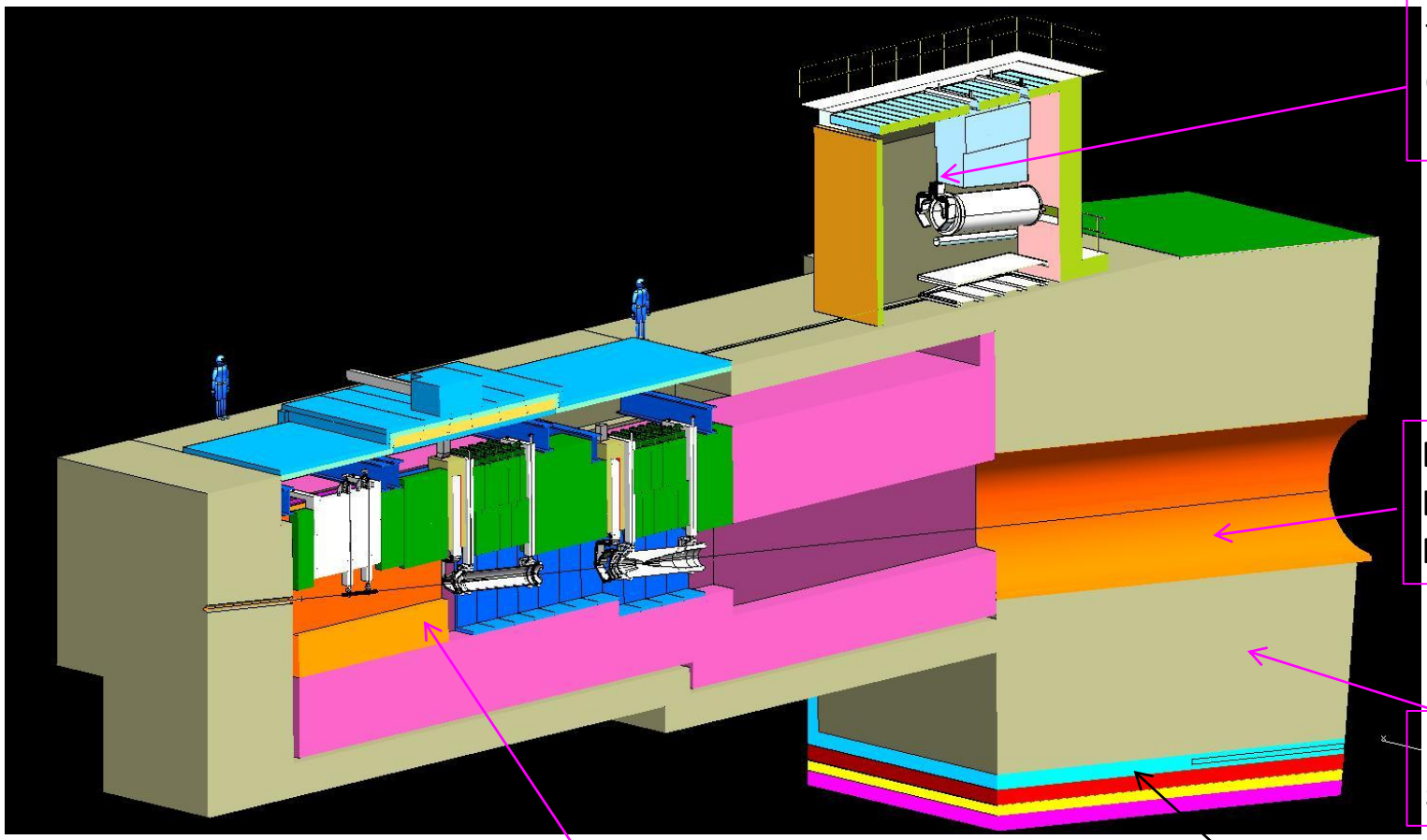


Beamline/CF Layout at Fermilab



Aiming at the Sanford Lab:
7 degree horizontal bend,
5.8 degree vertical bend

Target Hall/Decay Pipe Layout



Work cell to be used for replacement of components, primarily horns

Decay Pipe:
Length - 200 m
Radius – 2 m

Decay Pipe concrete shielding (5.5 m)

Target Chase: 64” wide, 29 m long

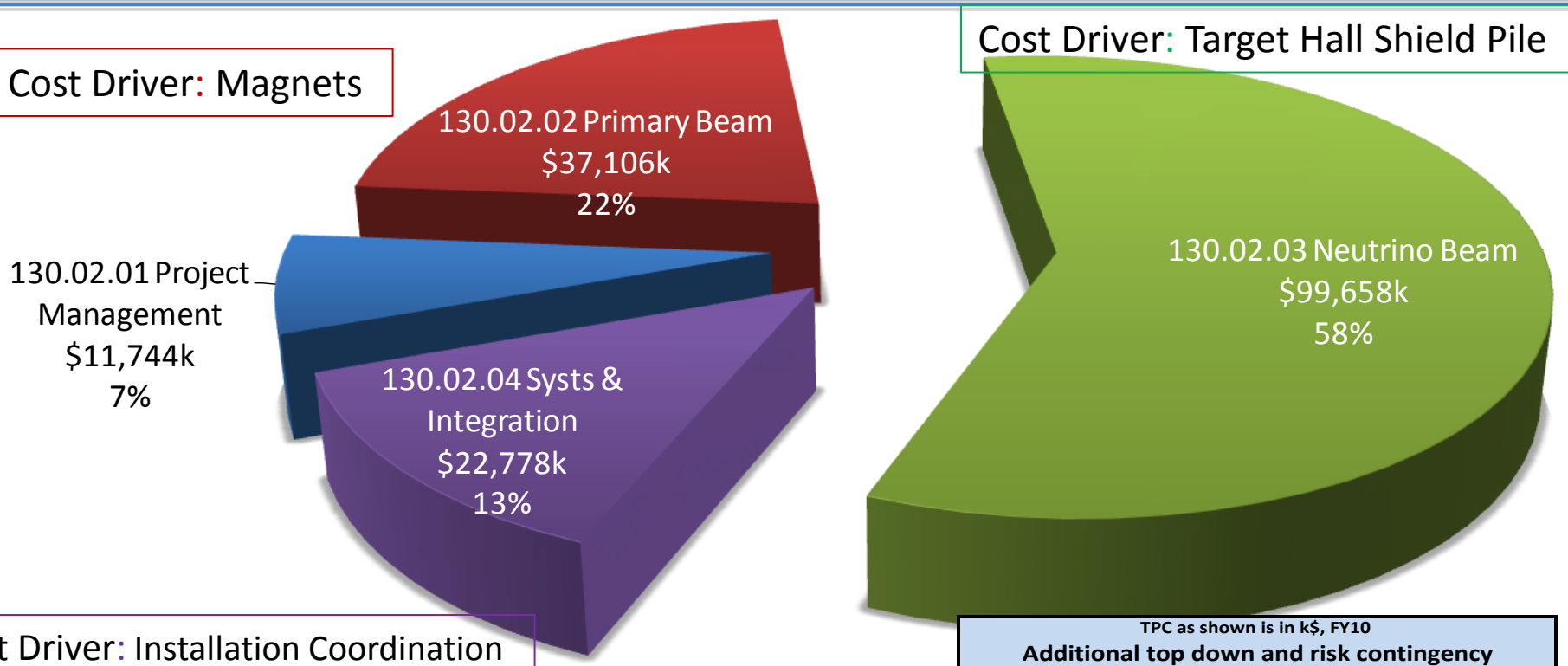
Geomembrane barrier system to keep groundwater out of decay region

Target inserted/mounted into Horn 1.

Beamline Cost Summary Chart

Cost Driver: Magnets

Cost Driver: Target Hall Shield Pile



Cost Driver: Installation Coordination

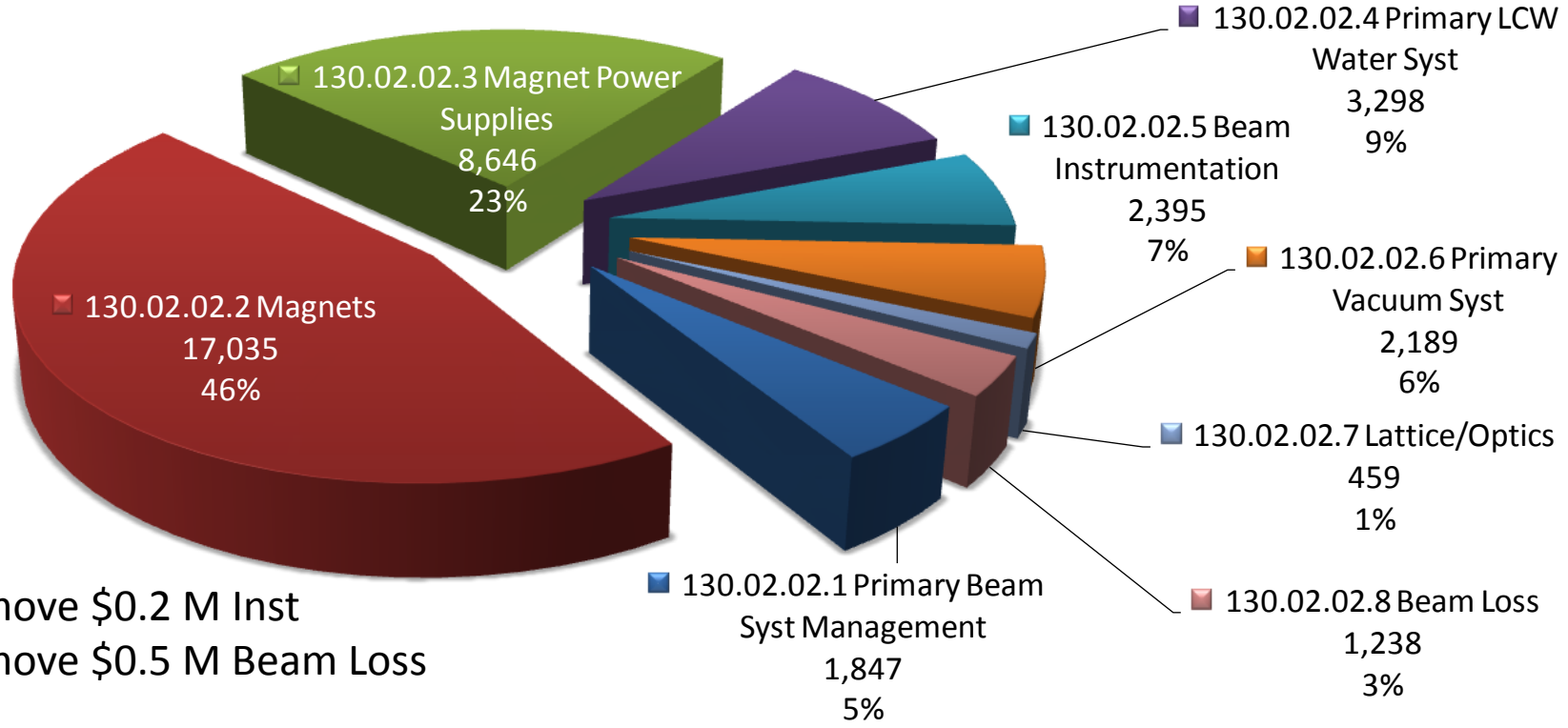
TPC as shown is in k$, FY10

Additional top down and risk contingency for 130.02 is 10,000 k$

132,907 k$

	Direct Cost		Indirect Cost		Estimate Uncertainty (E.U.) Contingency	TPC
	Labor	M & S	Labor	M & S		
130.02.01 Project Management	5,430	284	4,321	51	1,659	11,744
130.02.02 Primary Beam	7,368	14,617	6,334	2,319	6,469	37,106
130.02.03 Neutrino Beam	20,220	32,146	17,646	3,618	26,028	99,658
130.02.04 Systs & Integration	7,926	3,284	6,751	592	4,224	22,778
Grand Total	**40,943**	**50,332**	**35,052**	**6,580**	**38,380**	**171,286**

Primary Beam Cost Summary Chart

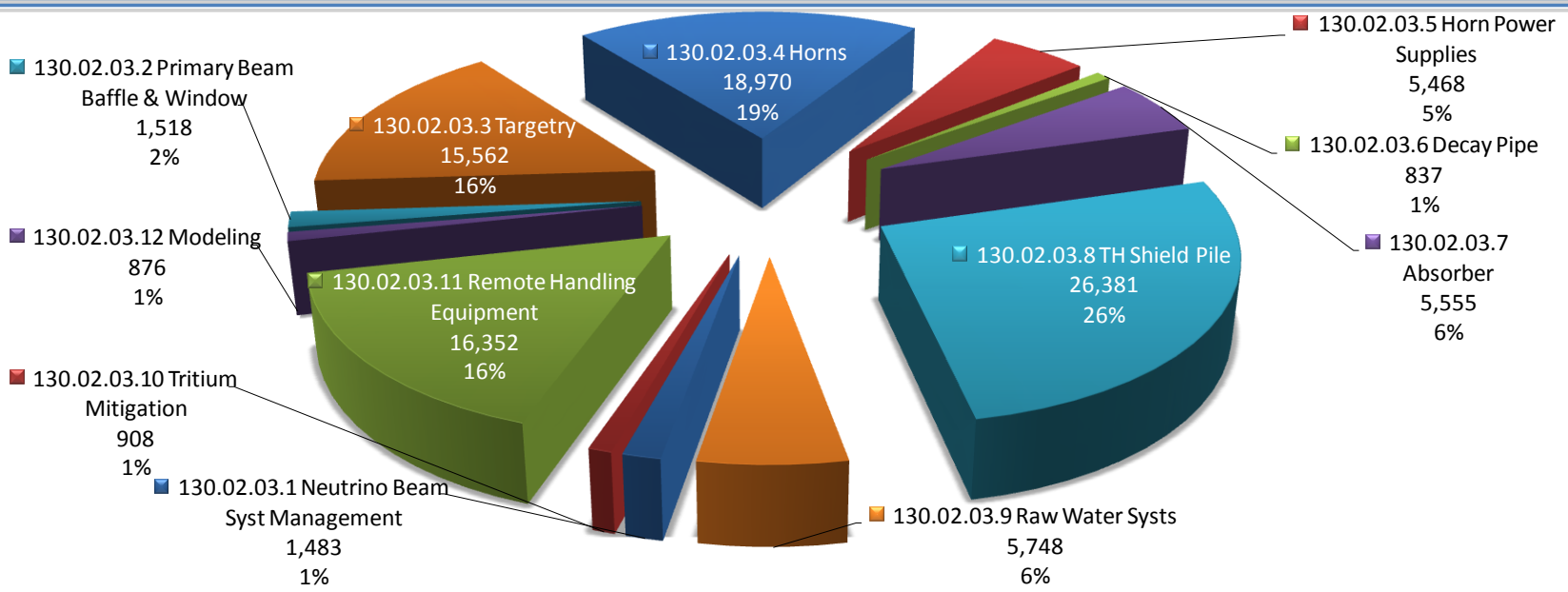


Remove $0.2 M Inst

Remove $0.5 M Beam Loss

WBS - Level 4	Labor (inc. cont.)	M&S (inc. cont.)	TPC	E.U. Contingency %
130.02.02.1 Primary Beam Syst Management	1,847		1,847	14.3%
130.02.02.2 Magnets	7,205	9,829	17,035	22.3%
130.02.02.3 Magnet Power Supplies	2,398	6,248	8,646	17.3%
130.02.02.4 Primary LCW Water Syst	1,066	2,231	3,298	40.1%
130.02.02.5 Beam Instrumentation	1,257	1,138	2,395	20.9%
130.02.02.6 Primary Vacuum Syst	1,258	931	2,189	16.1%
130.02.02.7 Lattice/Optics	459		459	5.2%
130.02.02.8 Beam Loss	1,238		1,238	16.6%
Total Project Cost (k$)	**16,729**	**20,378**	**37,106**	**21.1%**

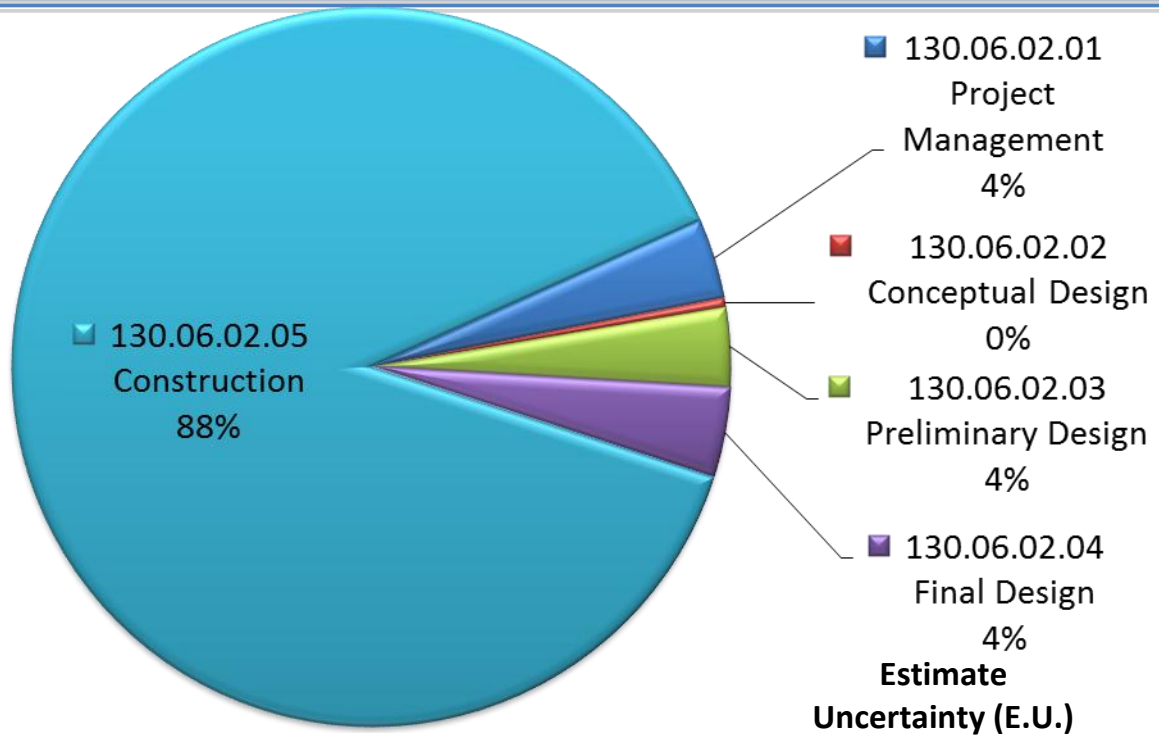
Neutrino Beam Cost Summary Chart



WBS - Level 4	Labor (inc. cont.)	M&S (inc. cont.)	TPC	E.U. Contingency %
130.02.03.1 Neutrino Beam Syst Management	1,483		1,483	13.5%
130.02.03.10 Tritium Mitigation	696	212	908	19.2%
130.02.03.11 Remote Handling Equipment	9,131	7,220	16,352	43.3%
130.02.03.12 Modeling	557	319	876	12.6%
130.02.03.2 Primary Beam Baffle & Window	964	554	1,518	25.0%
130.02.03.3 Targetry	11,162	4,400	15,562	51.9%
130.02.03.4 Horns	12,301	6,669	18,970	36.4%
130.02.03.5 Horn Power Supplies	4,376	1,091	5,468	25.4%
130.02.03.6 Decay Pipe	773	64	837	25.4%
130.02.03.7 Absorber	567	4,988	5,555	25.4%
130.02.03.8 TH Shield Pile	6,187	20,194	26,381	29.0%
130.02.03.9 Raw Water Systs	3,403	2,345	5,748	40.0%
Total Project Cost (k$)	**51,601**	**48,057**	**99,658**	**35.4%**

Near Site Conventional Facilities Level 4

Beamline Conventional Facilities Costs only: $218.8 M



	Direct Cost		Indirect Cost		Estimate Uncertainty (E.U.) Contingency	TPC
	Labor	M & S	Labor	M & S		
130.06.02.01 Project Management	5,647		2,736		1,466	9,848
130.06.02.02 Conceptual Design		1,024		165		1,189
130.06.02.03 Preliminary Design		7,982		90	1,614	9,687
130.06.02.04 Final Design		8,965		180	1,829	10,974
130.06.02.05 Construction	3,803	182,170	1,851	477	52,824	241,126
Grand Total	**9,450**	**200,141**	**4,587**	**913**	**57,733**	**272,823**

TPC as shown is in k$, FY10

Cost reduction opportunities

- Beamline to Homestake
  - All cost savings indicated are TPC in $FY2010
  - For modified designs we have considered estimate uncertainty contingencies of mostly 30% but occasionally up to 60%
- Alternative to LBNE - NuMI Beamline at Low Energy configuration

Beamline to Homestake

- Can we consider areas where we can add shielding later to allow for upgradability at 2.3 MW?
  - Costs related to primary beam soil shielding (reduce thickness by 1.5', from 25' in reference design to 23.5').In addition, updated Monte Carlo simulations indicate that 21.5' of soil is sufficient for 708 kW operation.
    - Savings of $1.1 M in FY2010 TPC
  - Costs related to Target Hall roof concrete shielding (reduce thickness by 1.5').
    - Savings of $0.3 M in FY2010 TPC
  - Do not install target chase water-cooling panels which were installed for shielding purposes for 708 kW but would be water cooled only at 2.3 MW operation. Use instead carbon steel filler plates.
    - Savings of $2.2 M in FY2010 TPC

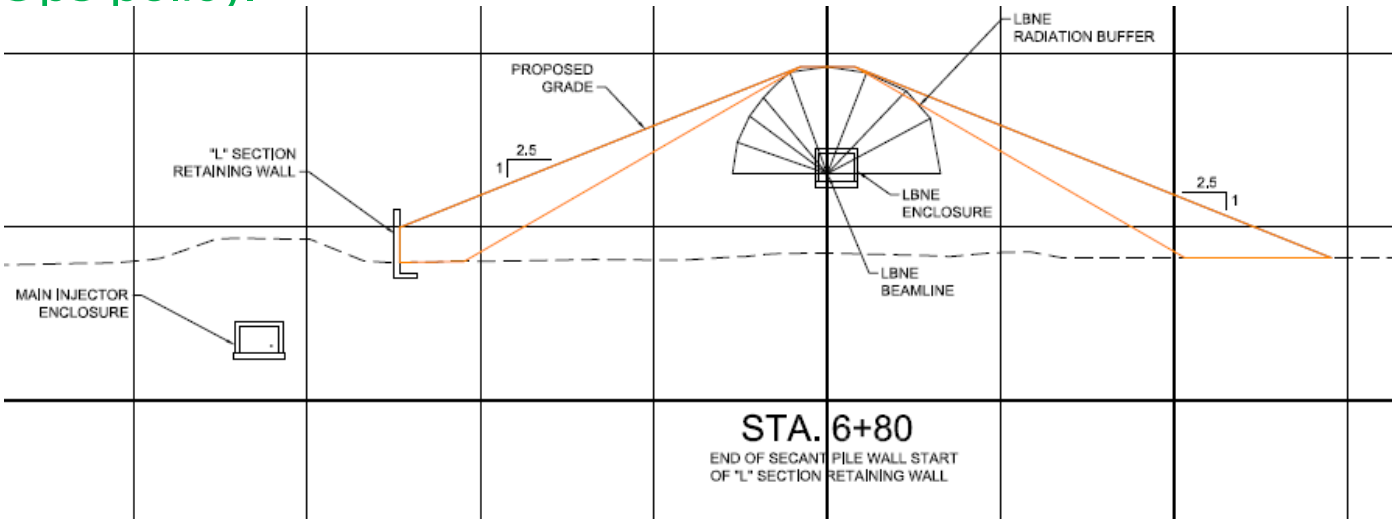
Beamline to Homestake – Primary Beam

- Install only a fraction of the planned magnets and limit the beam energy to <120 GeV until we can afford more?
  - The main body of LBNE primary beamline has 12 IDA/IDB 6m dipoles and 12 IDC/IDD 4m dipoles paired as 12*(6m+4m)
  - A possibility would be to remove all 12 4m dipoles limiting the maximum energy to ~72 GeV which would not enable 708 kW operation (~650 kW).
    - Eliminating 12 IDC/IDD dipoles would save about $3.3 M in FY2010 TPC.
- Eliminate the OTR 2D exit window profile monitor?
  - Have only 1D distributions and miss on correlations
    - Savings of $0.2 M in FY2010 TPC
- Re-optimize labor in beam loss calculations.
    - Savings of $0.5 M in FY2010 TPC

Beamline to Homestake – Primary Beam

- Can we increase the Embankment Slope to 30 degrees (1.7:1 side slope)?
  - Reference Design has a 2.5:1 side slope on the embankments (21.8 degrees)
  - Lab (FESS/Ops) “policy” for maintenance/safety, “angle of repose” issue, is for 3:1 side slopes (18.4 degrees)
    - Possible savings of $0.8 M in FY2010 TPC but against FESS/Ops policy.

Embankment section

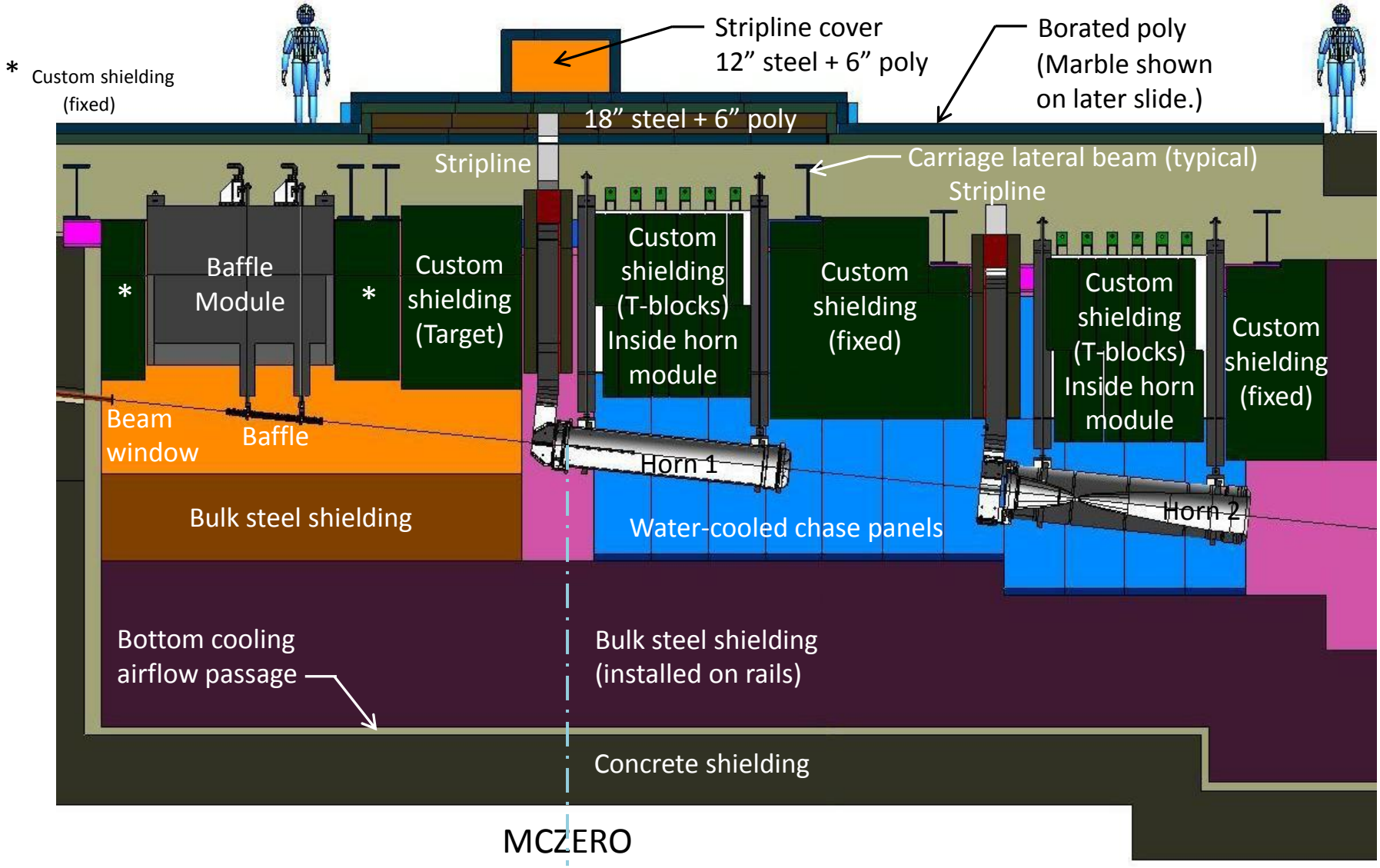


Beamline to Homestake – Neutrino Beam

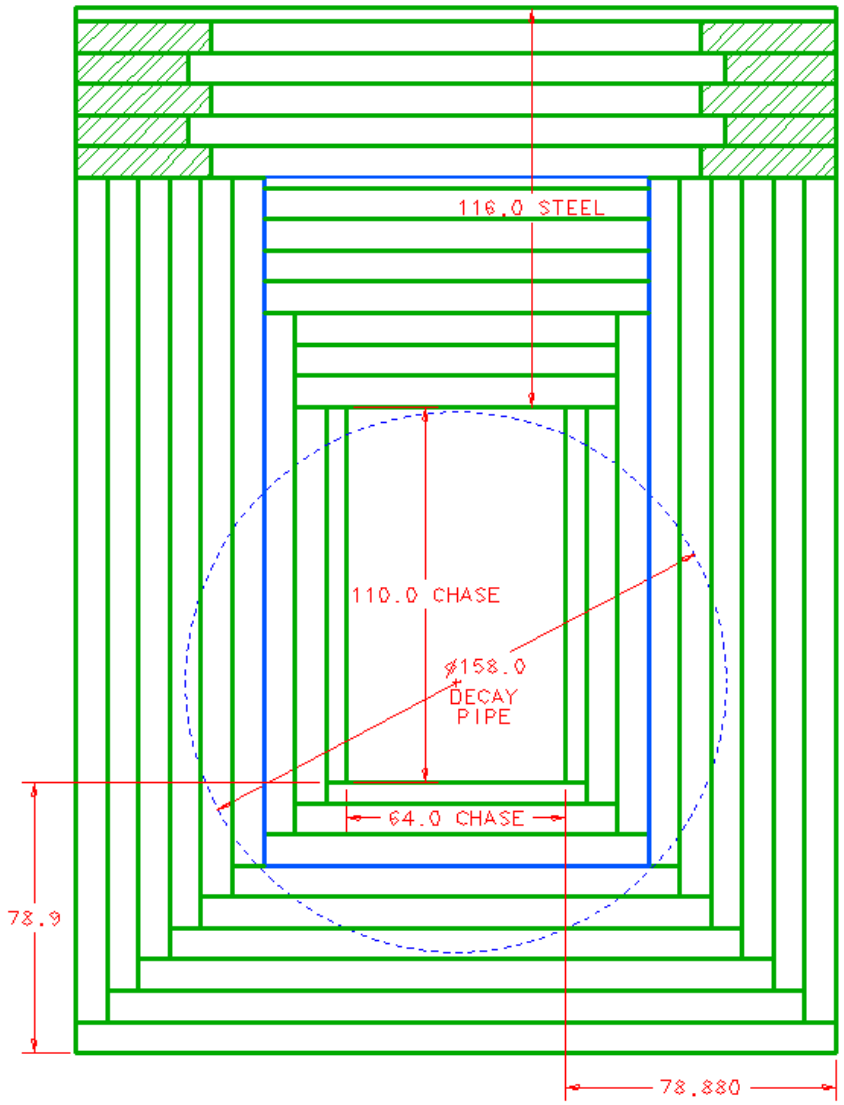
- Can we consider areas where we can reduce shielding due to improved knowledge?
  - Possibility of building a dependable, impermeable bath tub for the target pile allows for reduced shielding of the bath tub.
  - Remove 24” of steel from the walls and floor of the steel shield pile and reduce correspondingly the Target Hall width.
    - $5 M savings in FY2010 TPC, coming from $4.4 M savings in steel and $0.6 M in CF construction. LBNE doc # 5839

- Can we consider areas where we can make the shielding cheaper?
  - Build the target shield pile by reusing onsite steel
    - $1.25 M savings in FY2010 TPC, LBNE doc # 5839

Target Hall Shield Pile Design



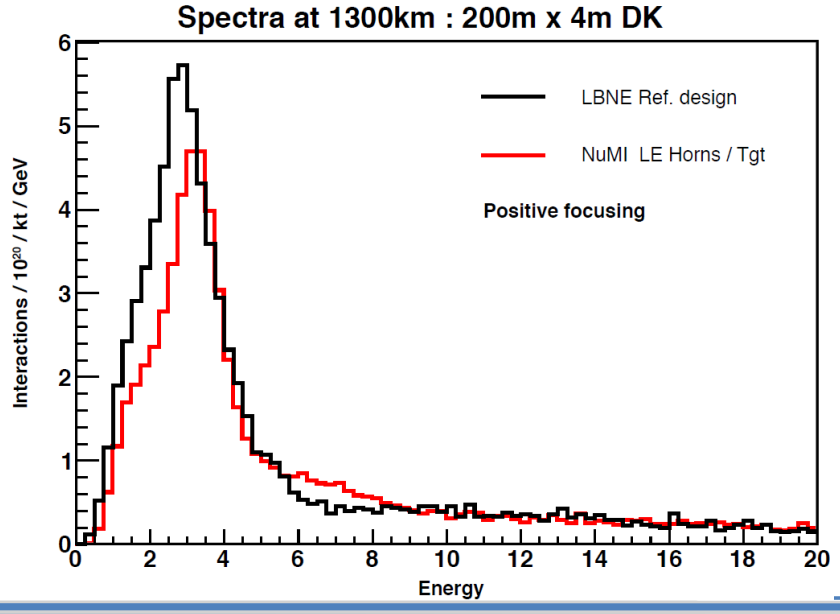
Target chase cross section



Dimensions in inches

Beamline to Homestake – Neutrino Beam

- Use existing NUMI horn designs and either NuMI or NOvA targets in the first phase of LBNE?
  - Accept that the neutrino spectrum will be less optimal for the first phase of the experiment
  - Take advantage of the fact that the NuMI design allows for a movable target, and therefore for tuning the neutrino energy spectrum, which can then help with the study of systematics.



NUMI style Low Energy beam at 708 kW

- Members of the Beamline Team have made a very preliminary evaluation of the feasibility of an upgraded NuMI style target that could run at a low energy neutrino spectrum configuration with beam power of 708 kW; (LBNE doc # 5843).
- This evaluation was based on a quick extrapolation of earlier FEA studies that indicate that by building a modified NuMI LE target, a 708 kW LE beam could be run with the existing NuMI horns, either at a new LBNE beam-line or in the NuMI beam-line. (Using the LBNE target would overheat and overstress the NuMI horn).
- The main problem is mitigating the overheating of the downstream helium containment tube of the NuMI target, for which switching from aluminum to beryllium appears to be a robust solution. The modified target would have very similar fins to the existing NuMI LE 400 kW target and the NOVA-ANU target being built for 708 kW beam.

Possible use at 700 kW by LBNE of Horn1 and target of NuMI Style

Compare three scenarios (out of infinite possibilities) for cost comparison:

	LBNE CDR	LBNE new beam-line but NUMI horns	Re-use NUMI beam-line as-is in LE configuration
Beam power	700 kW	700 kW	700 kW
Horn 1 shape	Mini-Boone style	Parabolic	Parabolic
Horn current	300 kA	200 kA	200 kA
Distance between horns	6 m	10 m (but could instead do 6 m)	10 m
Target	IHEP cylindrical	Modified MINOS	Modified MINOS
Horn power supply	New	Re-use NUMI P.S.	Re-use NUMI P.S.
Target "carrier"	New handler, target attaches to horn	Re-use NT-08 target carrier	Re-use NT-08 target carrier

Beamline to Homestake – NuMI style baffle, target & horns

- Updated cost estimate for this system:
  - Using NuMI style Horns
    - Savings of $13.7 M in FY2010 TPC
  - Using NuMI Horn Power Supplies (just installation costs)
    - Savings of $5.1 M in FY2010 TPC ($5.47 M (reference design)-$0.40 M in installation)
  - Developing an upgraded NuMI style target with a NuMI style carrier&module for the baffle and target and copying some of the NuMI target hall instrumentation
    - Savings in targetry of $4.2 M in FY2010 TPC (see next page for more details)
  - Removing the baffle module from the Baffle WBS
    - Savings of $0.8 M in FY2010 TPC

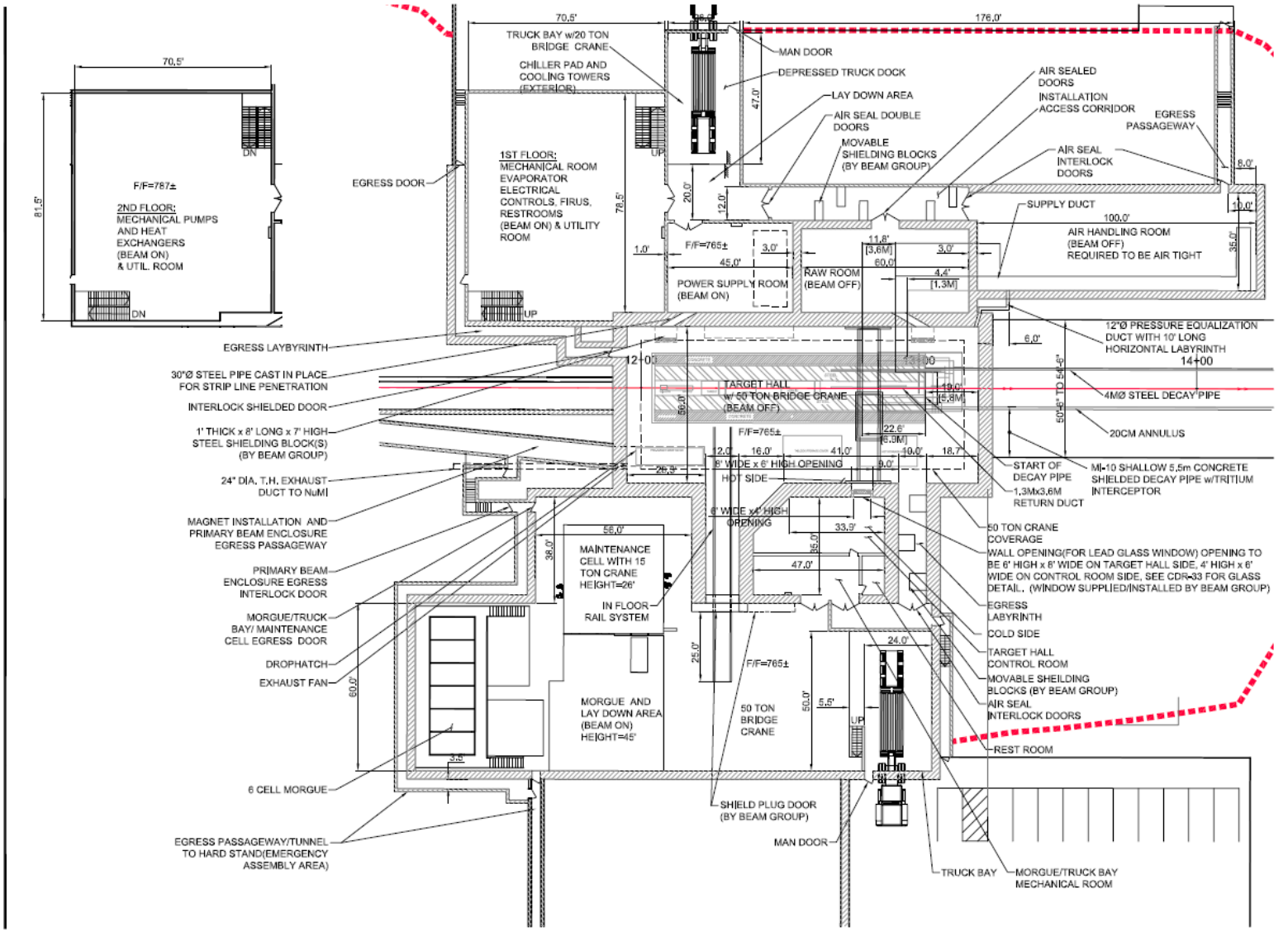
Beamline to Homestake – NuMI style targetry

- Preliminary cost estimate for this system:
  - Developing an upgraded NuMI style target
    - $4.7 M in FY2010 TPC, assuming same costs as for the LBNE target after eliminating the $2.5 M needed for developing an option for a Be target and an alternate graphite target.
  - Copying some of the NuMI Target Hall Instrumentation
    - Savings of $1.7 M in FY2010 TPC
  - Developing a NuMI style carrier, module and carriage for the baffle and target
    - $1.5 M in FY2010 TPC (same cost as currently assumed for the LBNE target module)

Beamline to Homestake – Remote Handling

- Build some of the Remote Handling Equipment later? Change the way the target is mounted on the horn?
  - Eliminate the in-chase target handler and use a NuMI style carrier instead. This implies eliminating as well the Maintenance Cell in LBNE-20 with its 15 ton crane, reconfiguring the Target Hall complex, allowing for some reduction of wall thickness (3' to 1') in appropriate support room areas, etc.
    - Savings of $7.7 M in RH and $6.9 M in the corresponding CF in FY2010 TPC
    - Impact: target replacements take 2-3 days longer (out of ~2 weeks per replacement) and we will need ~two replacements per year at 708 kW operation.
  - Downgrading and combining vision systems
    - Savings of $0.7 M in FY2010 TPC
    - Will require two additional days for every remote handling job to relocate needed equipment at the job location

Target Hall Complex

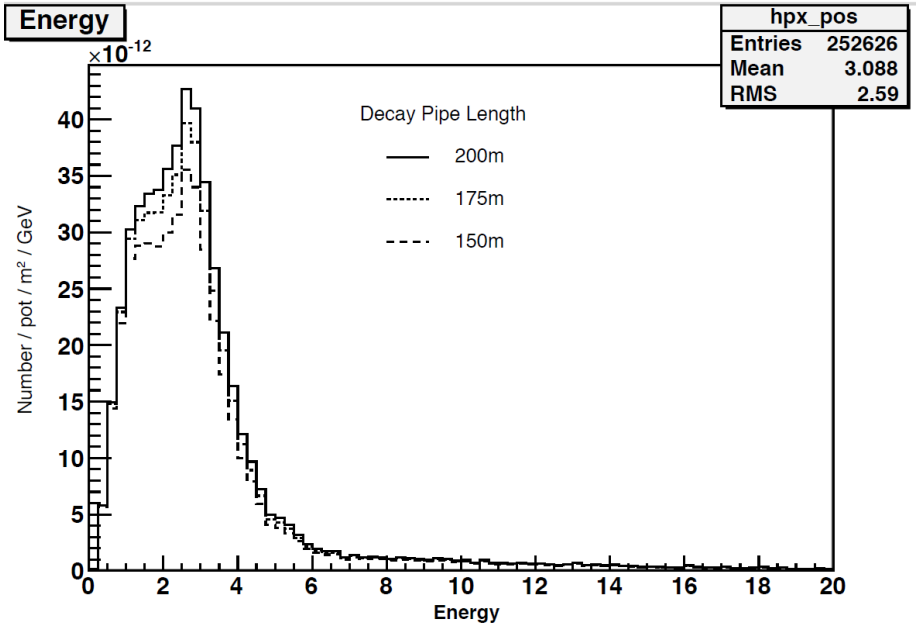


Beamline to Homestake – Target Hall

- Can we eliminate more space in the Target Hall area?
  - Eliminate the downstream magnet installation tunnel at Target Hall and the Pre-target Drop Hatch.
    - Savings of $1.2 M ($1.1 M + $0.1 M) in FY2010 TPC
    - Impact: Have to install all magnets from upstream
  - Various VE proposals discussed earlier, reduced space in the Target Hall complex. A change in cooling design philosophy together with the overall target complex area reduction led to the elimination of the 2nd floor Mechanical support room.
    - Savings of $1.4 M in FY2010 TPC

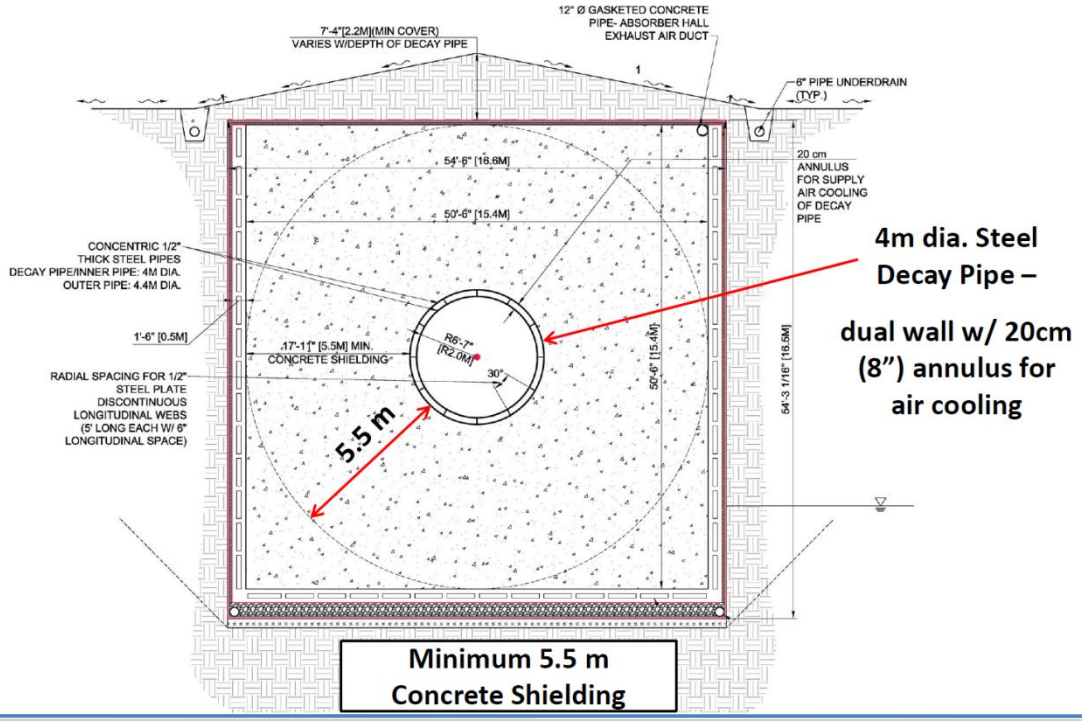
Beamline to Homestake – Decay Pipe

- Is there any room to shrink the decay pipe any further?
  - The costs here are mainly Conventional Facility (CF) costs.
  - So far we had considered 200-250 m in length and 3 to 6 m in diameter, the reference design being 200 m in length and 4 m in diameter.
  - We are exploring in addition 150 and 175 m with a diameter of 4 m.



Beamline to Homestake – Decay Pipe

- It is very possible that the gravel drainage layer and the geo-membrane barrier system around the decay pipe combined with the dryness of the soil there may allow us to eliminate the extra redundancy provided by the tritium interceptors
  - Potential savings of $1.5 M in FY2010 TPC



Beamline to Homestake – Primary Beam Targeting Optics

- Can we limit the flexibility of the LBNE final focusing optics (tunability for spot sizes between 1-3 mm; 60-120 GeV, 708 kW-2.3 MW, graphite/Be)?
  - Assume a reduction of ~170' in primary beam length and that we can move the target hall complex, the decay pipe and the absorber upstream, ~17' vertically upwards. This implies fewer drilled piers for the primary beam, longer drilled piers for the target hall complex but less rock excavation and less rock grouting for the decay pipe and absorber.
    - Potential savings of $4.6 M ($1.7 M - $2.8 M + $4.0M + $1.7M) in FY2010 TPC
    - Impact: Loosing flexibility and having to move magnets around if a change of configuration is needed.
    - Note: Optics will have to be worked out and apertures of dipoles looked at carefully to decide if this is feasible and if it allows for upgradability at 2.3 MW.

Beamline to Homestake – Summary

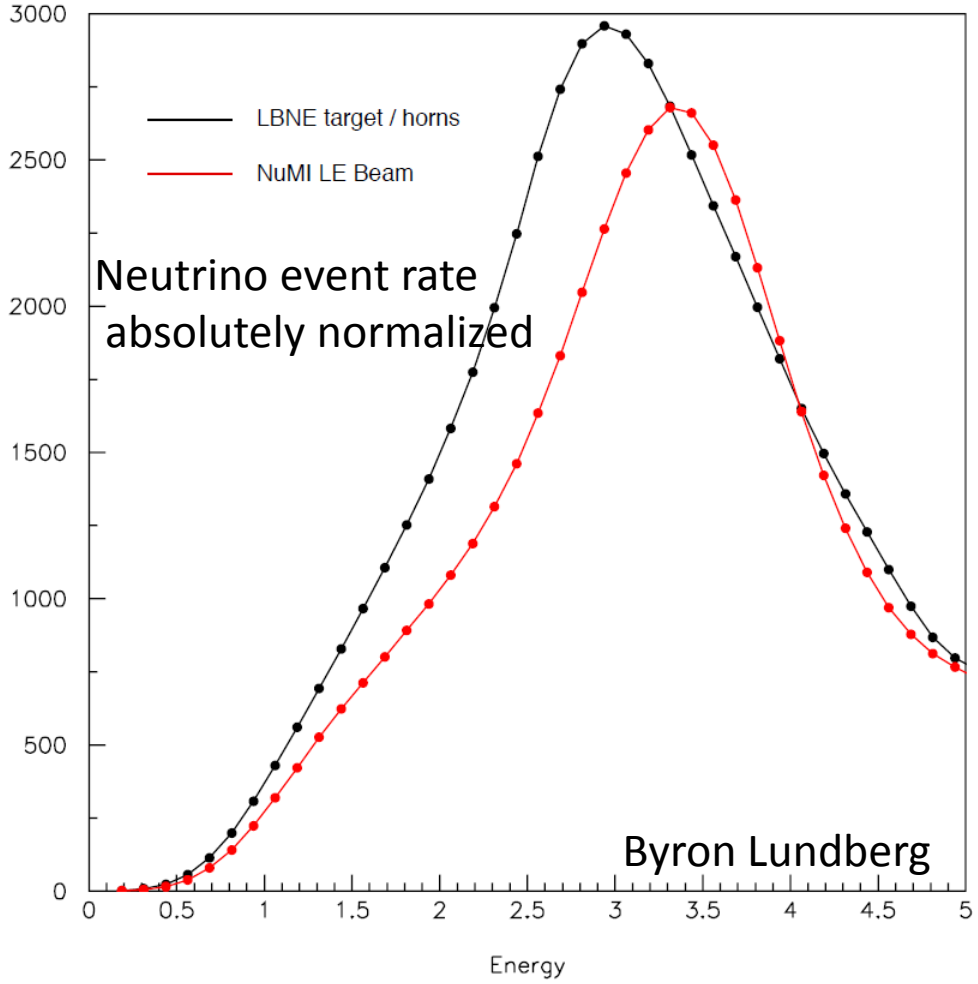
- We will look in more detail at all the items listed above but the potential cost savings assuming we will implement all of them are:
  - $62.5 M in FY2010 TPC consisting of:
    - $18.2 M in Beamline Conventional Facilities and
    - $44.3 M in Beamline Technical Components

Alternative to LBNE - NuMI Beamline

- Needed target modification for 708 kW operation as described earlier. (~ $4.7M FY2010)
- When moving the 2nd NuMI horn to the medium energy location for NOvA running, the “nest” for the horn at low energy configuration will be left intact but the horn 2 water cooling line will be cut and rerouted, and the top shielding of the T-block storage area above the shielding will move. This will have to be undone to go back to the low energy horn configuration and can take 1-2 months. ($0.3-1.0 M)
- Invest on improving the long term reliability of the NuMI line (e.g. decay pipe cooling).

How much worse is NUMI standard LE spectrum than LBNE CDR design ?

It would take about a year of downtime to build a new nest for Horn 2, 6-7 m from Horn 1 in the NuMI line (highly radioactive area)



LBNE CDR components
cylindrical/parabolic horn 1
300 kA
6.6 m between horns
PLACED IN NUMI
675 m L x 2 m D decay pipe

Compared to

NUMI standard LE
200 kA
10 m between horns
675 m L x 2 m D decay pipe

NuMI Beamline – Issues with higher Beam Power

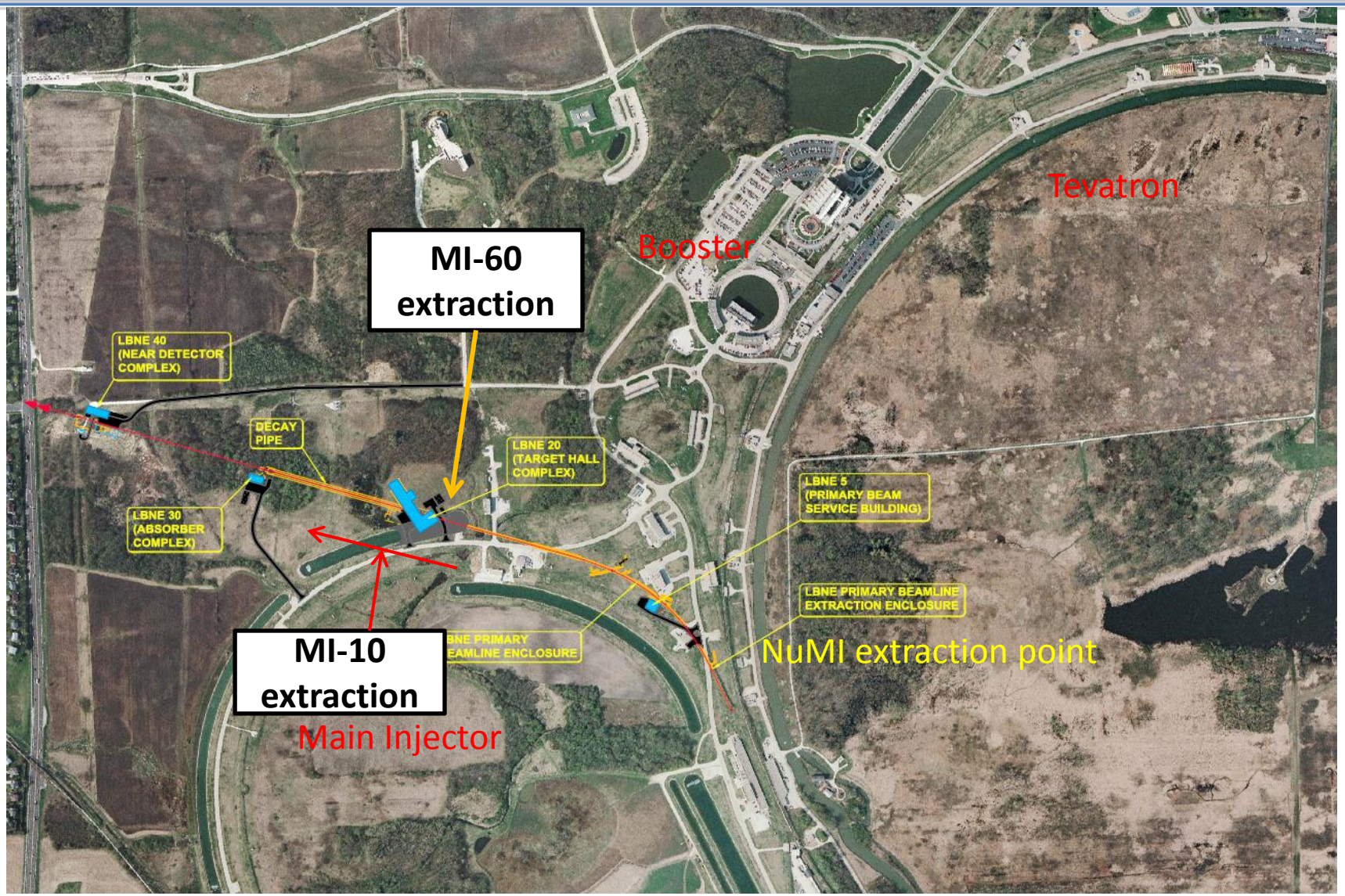
- The possibilty for upgrading the NuMI beamline to handle up to 1.2 MW of beam power has been considered between 2005-2007 within the SNuMI context.
- Systems that will need attention/redesign for 1.2 MW operation (if available) include:
  - Target
  - Horns
  - Cooling of the target chase

Acknowledgments

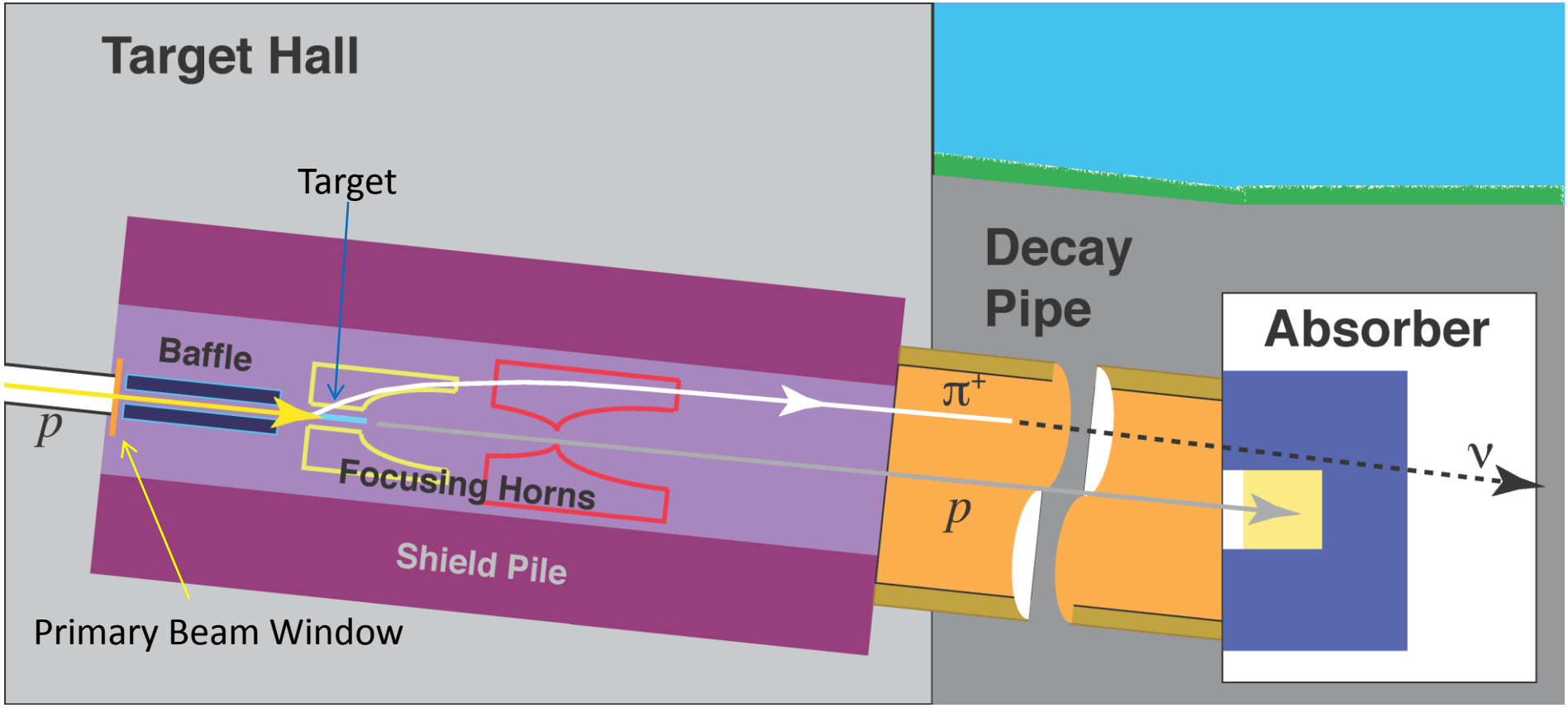
- Many thanks to the entire Beamline and Conventional Facility Teams for producing the reference design we have just been reviewed for.
- For the intense effort of the past two weeks on putting together and contributing on costing of additional Value Engineering proposals special thanks to:
  - K. Anderson, K. Bourkland, A. Chen, S. Childress, C. Crowley, M. Gardner, J. Johnstone, D. Harding, L. Hammond, S. Hays, J. Hylen, P. Hurh, B. Lundberg, T. Lundin, M. McGee, B. O'Sullivan, J. Sefcovic, A. Stefanik, K. Vaziri, G. Velev, K. Williams, T. Wyman, B. Zwaska,…..

BACKUP

The LBNE Neutrino Beamline Facility at Fermilab
Four configurations considered



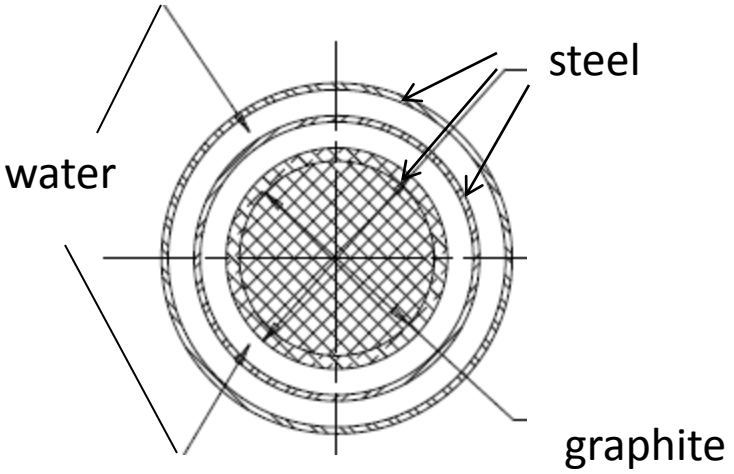
Major Components of the Neutrino Beam

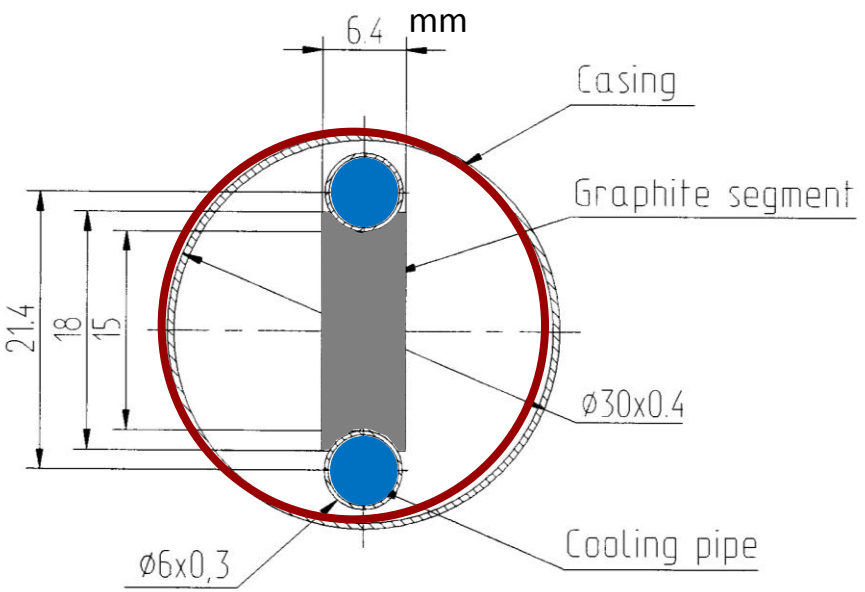


Target inserted/mounted into Horn 1. Upstream end of target at -5 cm relative to the upstream face of Horn 1.

- Horn 1
  - Radius outer conductor: 30 cm
  - Radius inner conductor: 2.0 cm (neck), then parabolic
  - Length: 336 cm, neck: 100 cm

LBNE CDR target versus NUMI LE target

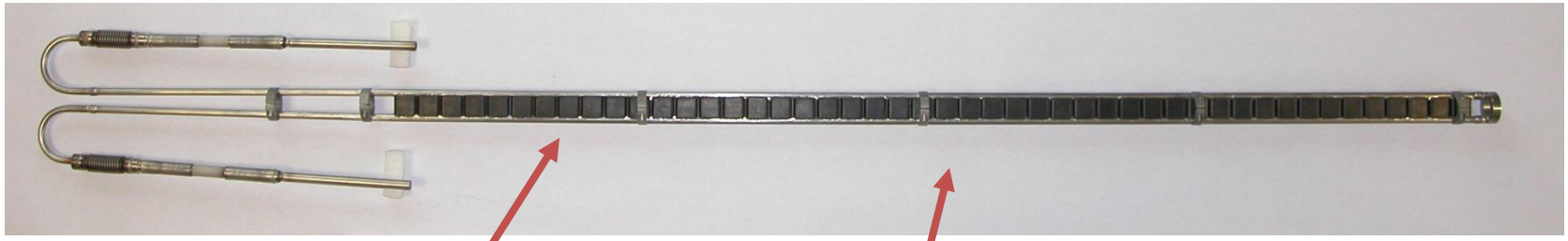




- LBNE target design is on a path to a 2.3 MW target
- LBNE target traps the graphite, so may last longer in beam against radiation
- NUMI target has less material
- Monte Carlo says NUMI target deposits only half as much beam energy in horn inner conductor
- NUMI target as-is will not take 700 kW beam

NuMI Target

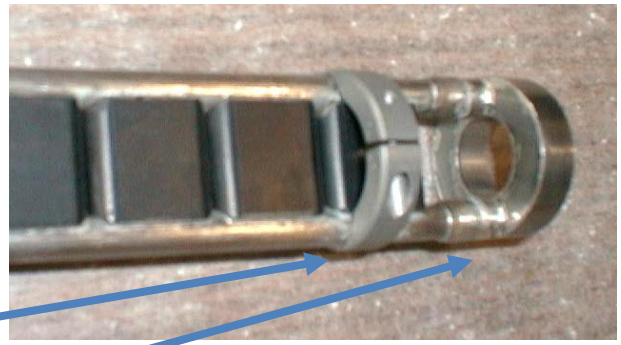
long, thin, slides into horn without touching



Graphite Fin Core, 2 int. len.

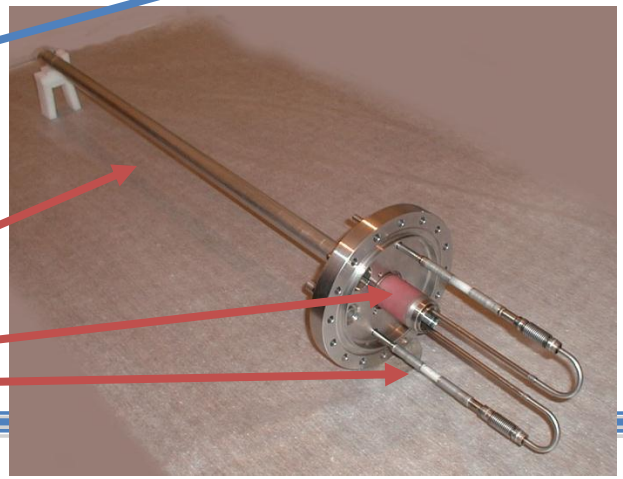
(*6.4 mm x 15 mm x 20 mm) x 47*

Water cooling tube also provides mech. support



Anodized Al spacer (electrical insulation)

Water turn-around at end of target



0.4 mm thick Aluminum vacuum/Helium tube

Ceramic electrical isolation

Problem of NUMI horn + LBNE target at 700 kW

- Beam energy over-heats horn inner conductor, Aluminum creep problematic
- Combination of 300 kA joule heating, magnetic loading and beam heating give stress that is on edge for fatigue lifetime of 1 year

Possible solution

- Use lower mass NUMI style target to cut beam energy deposition in horn
  - Reducing peak temperature from 124 deg C to 85 deg C
  - Also reducing beam-heating induced stress in horn
- Use NUMI-style 200 kA beam current to reduce magnetic loading

Additional modifications to the NuMI Low Energy, 700 kW target

- Switch from steel to titanium cooling tube
- Switch from 6.4 mm wide fin to a 7.4 mm wide fin
- Some target R&D might allow us to switch to beryllium fins instead of graphite

NUMI-style target

Problems of using NUMI LE target at 700 kW

- Downstream aluminum tip holding beryllium window will overheat
- Increased differential temperature of water between top and bottom cooling lines causes more warp

Possible solutions for a 700 kW NUMI-style LE target

- Make outer helium containment tube from Beryllium instead of Aluminum,
  - Like Mini-Boone (more expensive)
- Combination of higher pressure to push water through cooling line faster, possible increase in cooling line diameter, and/or accepting larger warp.

Other modifications for the NUMI LE 700 kW target

- Switch from steel to titanium cooling tube
  - Had successfully prototyped this last year
  - Is better for the “water hammer” issue from beam heating (RAL study)
  - The beryllium outer tube removes the problematic issue with the titanium tube that it did not cool the downstream aluminum tube as well as the steel

- Switch from 6.4 mm wide fin to a 7.4 mm wide fin
  - Match the change made for NOVA target fins for 700 kW

    accommodating 20% more POT/spill with 20% wider spot size

- Some target R&D might allow us to switch to beryllium fins instead of graphite
  - Substantially increasing target lifetime

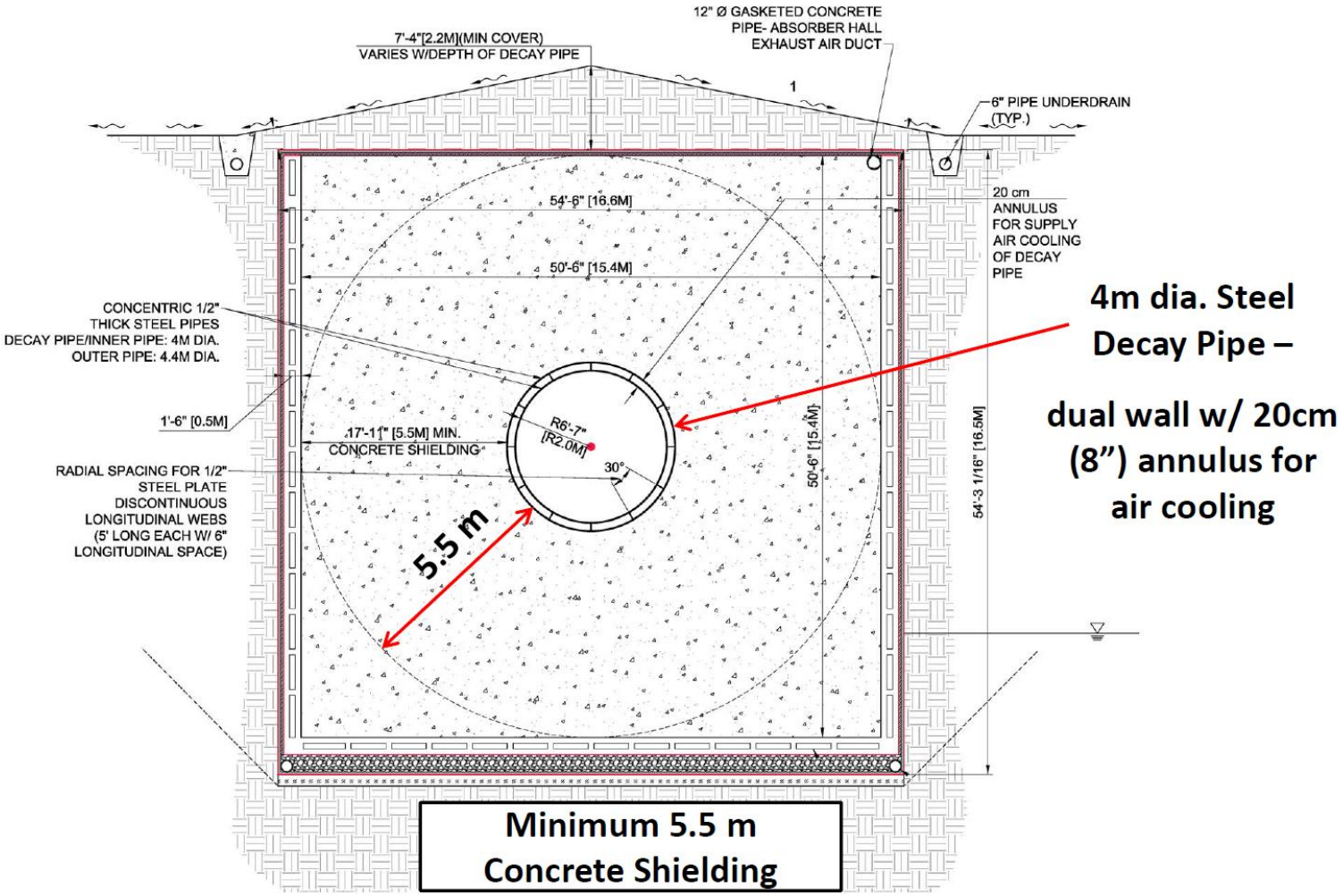
Horn + Horn Module cost savings

	LBNE BOE Horn Cost	Notes		NuMI Horns for LBNE	Notes
Task Management	**486,000**			**150,000**	Reduced management due to decrease in work involved
Horn 1 & Prototype	**8,172,000**	Includes new design and building a prototype and production horn with relocated stripline		**1,000,000**	Current NuMI Horn 1 Cost. No prototype, inner conductor welding development, or cooling tests needed
Horn 1 Support Structure	**3,599,000**	Includes completely new module and stripline block designs. Production of both. New test stand included		**1,500,000**	Use NuMI Module and stripline block design. Design must be re-worked and built new for LBNE angle. No longer includes test stand cost or prototyping. Need to look at possible shielding issues
Horn 2	**3,705,000**	Includes new design and building a production horn with relocated stripline		**1,100,000**	Current NuMI Horn 2 Cost.
Horn 2 Support Structure	**3,008,000**	Includes completely new module and stripline block designs. Production of both.		**1,500,000**	Use NuMI Module and stripline block design. Design must be re-worked and built new for LBNE angle. Need to look at possible shielding issues
TPC in FY10	**18,970,000**			**5,250,000**	

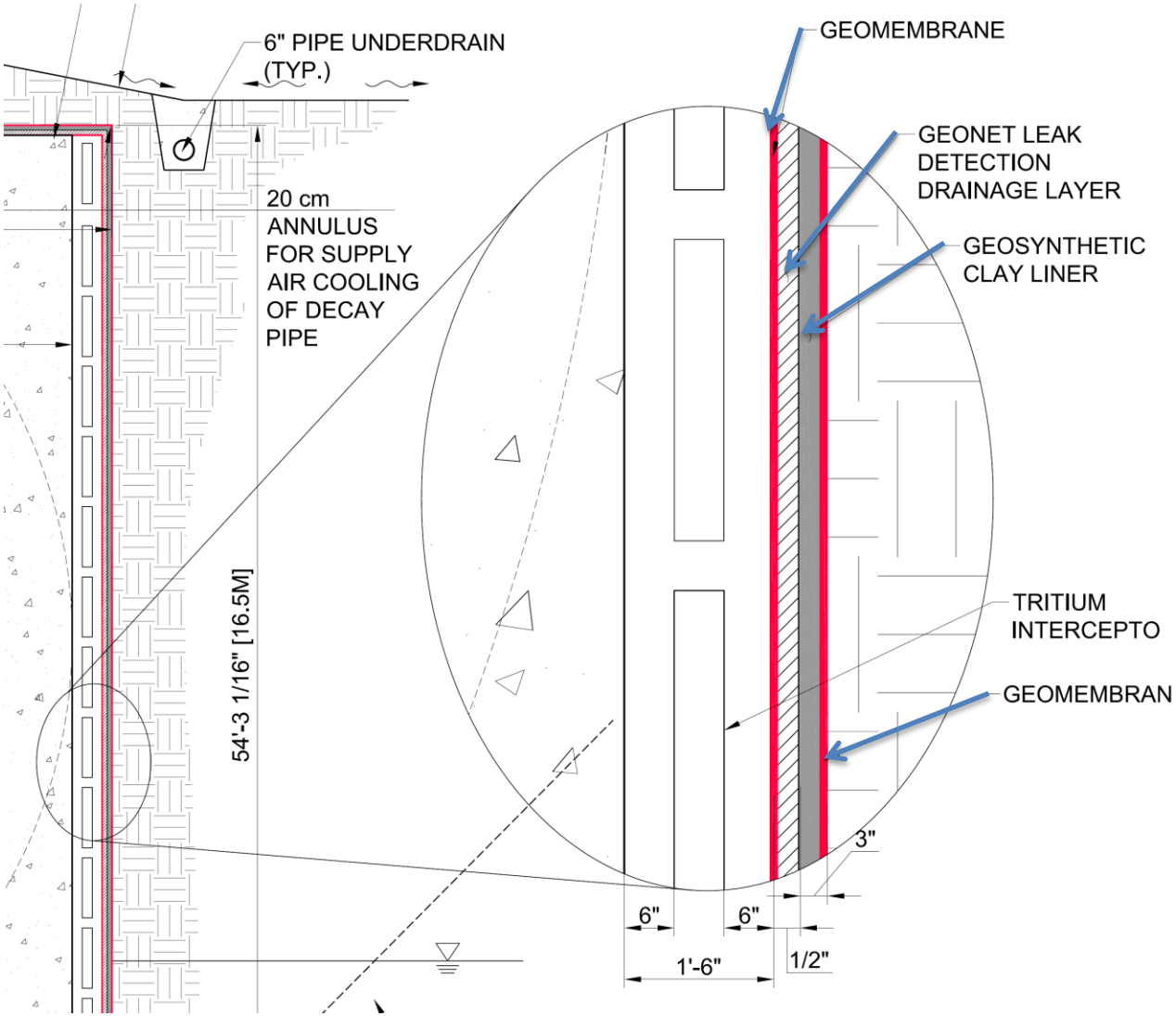
Beamline to Homestake – Remote Handling

- Build some of the Remote Handling Equipment later? Change the way the target is mounted on the horn?
  - Eliminate the in-chase target handler and use a NuMI style carrier.
    - Savings of $2.54 M in FY2010 TPC
  - Eliminate the Maintenance Cell in LBNE-20 (no target processing) and reconfigure the Target Hall complex.
    - Savings of $3.83 M in RH and $6.1 in corresponding CF in FY2010 TPC
  - Eliminate the Target Hall Work Cell manipulators and lead glass windows.
    - Savings of $0.92 M
  - Reduce the labor associated with planning and mock-up
    - Savings of $0.39 M in FY2010 TPC
  - Downgrading and combining vision systems
    - Savings of $0.73 M in FY2010 TPC

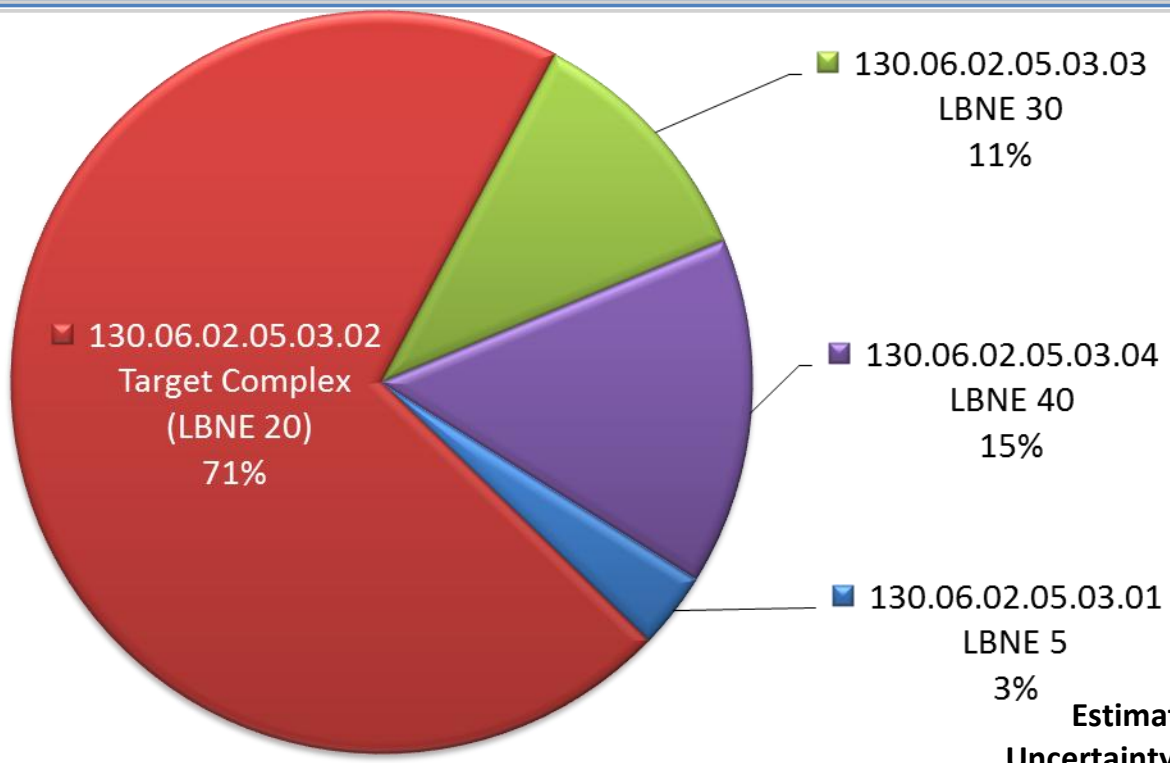
Decay Region Cross Section



Geomembrane Barrier System



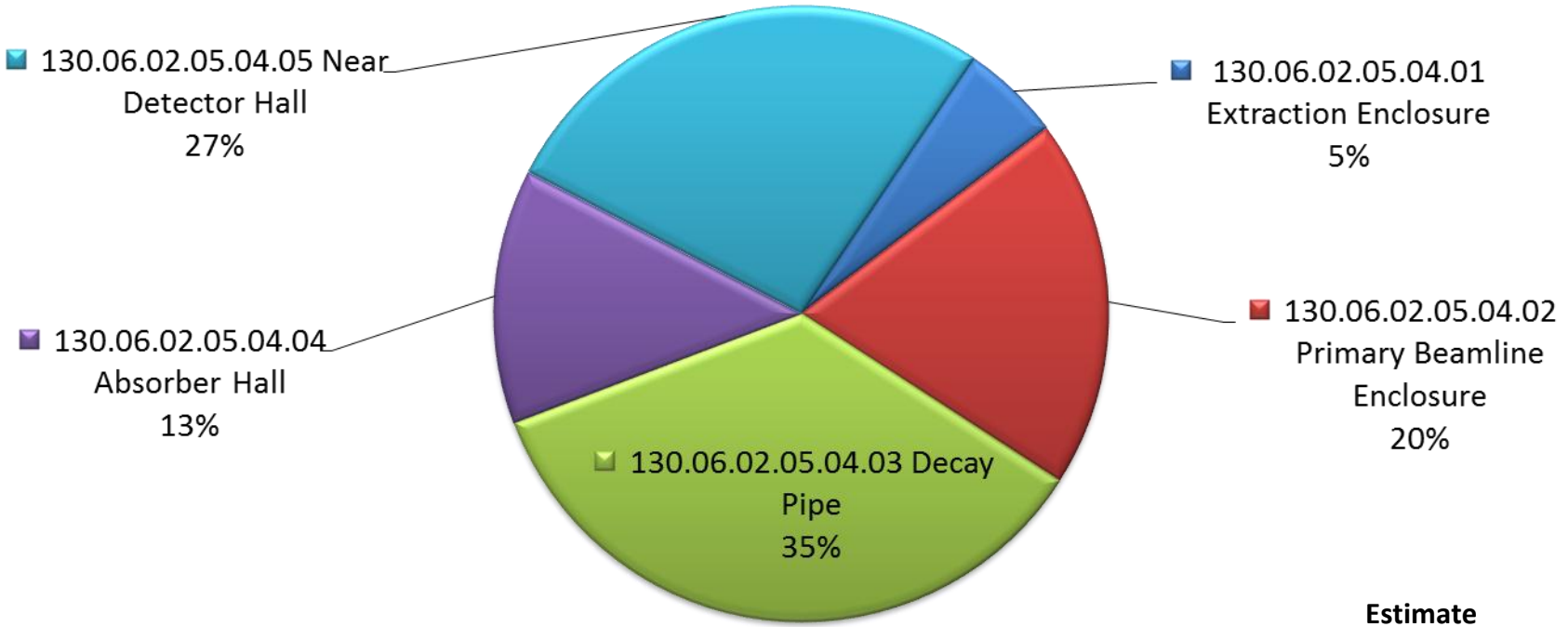
Level 6 Near Site CF Construction Site Infrastructure and Buildings



	Direct Cost		Indirect Cost		Estimate Uncertainty (E.U.) Contingency	TPC
	Labor	M & S	Labor	M & S		
130.06.02.05.03.01 LBNE 5		2,078			623	2,701
130.06.02.05.03.02 Target Complex (LBNE 20)		44,015			13,204	57,219
130.06.02.05.03.03 LBNE 30		6,855			2,056	8,911
130.06.02.05.03.04 LBNE 40		9,446			2,834	12,279
Grand Total		**62,393**			**18,718**	**81,111**

TPC as shown is in k$, FY10

Level 6 Near Site CF Construction Tunnels and Halls



	Direct Cost		Indirect Cost		Estimate Uncertainty (E.U.) Contingency	TPC
	Labor	M & S	Labor	M & S		
130.06.02.05.04.01 Extraction Enclosure		4,051			1,215	5,266
130.06.02.05.04.02 Primary Beamline Enclosure		14,994			4,498	19,492
130.06.02.05.04.03 Decay Pipe		26,916			8,293	35,209
130.06.02.05.04.04 Absorber Hall		10,339			3,102	13,441
130.06.02.05.04.05 Near Detector Hall		20,698			6,209	26,908
Grand Total		**76,998**			**23,318**	**100,316**

TPC as shown is in k$, FY10