

Alignment Considerations – Neutrino Production FNAL to China

This presentation is the result of Wieren Chou having asked me to consider the possibility of sending a neutrino beam to Beijing China.

The alignment of the great circle route to China has been roughly established.

An extraction point from the Main Injector has been postulated.

Rough arcs to target protons on the alignment to China have been postulated.

Sketches to provoke discussion have been created.

Discussion points have been listed.

Some initial consultation with tunneling experts has occurred.

Alignment from Fermilab to Beijing, China

Wes Smart provided me with the following alignment information for a chord through the earth lying in the plane of the great circle from Fermilab to a point in Beijing.

Azimuth: 340.7555 degrees Vertical: 47.7539 degrees

Wes compares this with the alignment of NuMI to Soudan, Minnesota.

Azimuth: 336.0942 degrees Vertical: 3.3402 degrees

Note: 360 degrees is local North, Vertical 90 degrees is into the center of the earth.

Thus: The alignment to Beijing is on the order of 4 degrees to the north(!) of shooting from FNAL towards Soudan!!!

Extraction from the Main Injector – Targeting

For the purposes of this discussion, I have chosen to use the existing NuMI extraction point at MI-60. In addition, I have chosen to take advantage of the existing NuMI “over bend.” This is a down bend of about 8.97 degrees that takes us down to good rock as fast as possible. I am assuming that at some point after the matching quads in the “rock carrier tunnel” we will have a compound curve that takes us the necessary 4.66 degrees further north and further 38.78 degrees down. I postulate using the same FODO lattice that takes us through the initial NuMI down bend – requiring an additional 26 B2 dipoles and 14 quads plus matching quads and a final focus. This down arc and final focus sets a location for the target for working purposes.

I note that at Proton Driver intensities an SNS-like liquid mercury target may be necessary.

FESS was asked to provide plan and elevation sketches

April 22, 2004

To: Ed Crumpley

From: Dixon Bogert

Subject: Considerations for the “Dig a Hole to China” Sketches

I attach to this document a sheet that Wes Smart gave to me of the pointing from Fermilab to some generic location in Beijing. For the purposes I have in mind we do not need more accuracy at this time. Wes's sheet is similar to a sketch that Wieren Chou gave me. In short, neutrinos produced at Fermilab and aimed at Beijing are oriented at an almost 48° down bend. One of the more fortuitous results of Wes's sheet is the observation that at Fermilab the great circle direction from Fermilab to Beijing is about 4° NORTH of the direction to Soudan, Minnesota. Thus, for the purposes of this set of sketches we are going to assume the NuMI extraction from the Main Injector at MI-60 and use a common line through the upper aquifer and start the additional horizontal and vertical bends from a point in the “rock carrier tunnel” after the first set of quads. At that point we will bend RIGHT (as the protons fly, looking downstream) which is more to the north and start the additional down bend. The carrier tunnel is just about 9° down slope now, so we need to down bend about 39° more in addition to the right bend. I assume that we will make this bend with a compound bend using rolled dipoles. For purposes of these sketches, however, I have not had an exact calculation made by a beamline physicist. I do assume, however, that the bend will have some sort of FODO lattice with a quad every four dipoles or so. The basic arc will be assumed to be similar to the down bend turning angle generated in the NuMI stub. This implies to me about 4.5 times the arc length of the 9° down bend generated in the NuMI stub. Then we will allow a short distance for a final focus and lay out the NuMI line on the China alignment. This means simply lifting the existing scroll layout and rotating it.

We'll probably save and print that simple version.

The next two pages contain a copy of the letter I wrote to FESS to define the sketches and ask for a little research.

FESS was asked to provide plan and elevation sketches (2)

Then we'll scratch our heads a little. This down slope makes for several interesting considerations. These include: what energy neutrinos is it correct to send to Beijing? We don't want to build the target hall any longer than necessary. Do we need a 650-meter decay pipe? If we must access the absorber for construction, could we do it like at CERN through the Decay Pipe? Or if we need a permanent access, is a shaft down to the absorber without the absorber access tunnel easier/cheaper? What is the nature of the near detector, if any? What sort of shaft to get down the order of half a mile to the near detector? (This is like the Soudan Mine!) I do not think we will have a decay pipe walkway on this slope (decay pipe staircase?)

Out at Brookhaven those guys developed a proposal to send a long baseline beam to Homestake Mine in Lead, South Dakota. This is nothing like the down slope to China envisioned here, but they made an above ground roller coaster design. I'd like to get (or for you to get for me?) a copy of whatever engineering sketch they have of this thing to see what it would mean translated to this discussion. I think it probably is irrelevant, but "leave no stone unturned."

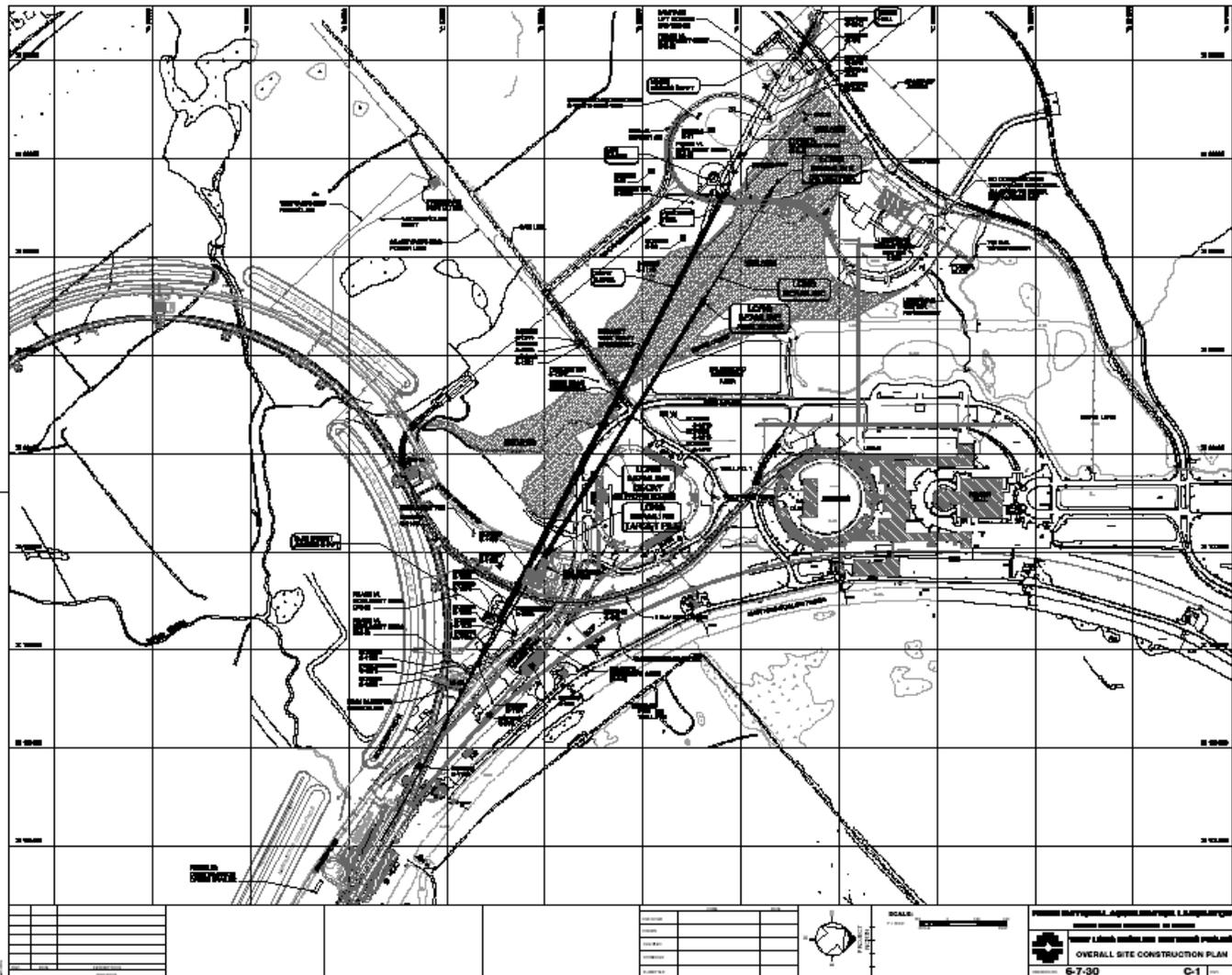
At this time I will NOT address issues of how we actually construct a target pile, horn supports, etc. on this wild orientation. I will use these sketches to PROVOKE such discussion.

This is the
continuation
of the letter
to FESS.

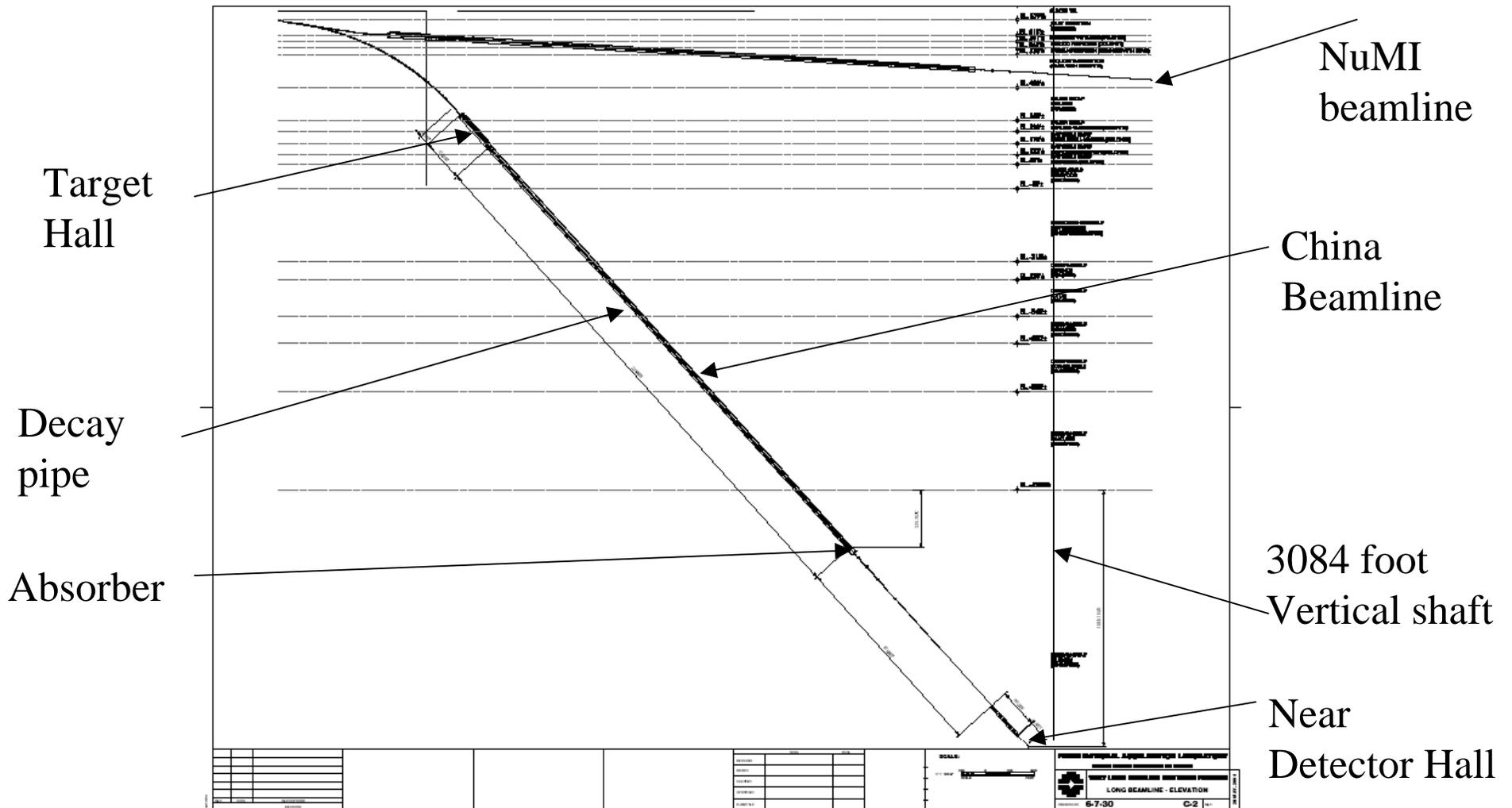
*China
Baseline*

The "Plan View" Sketch for Very Long Baseline Neutrino Project

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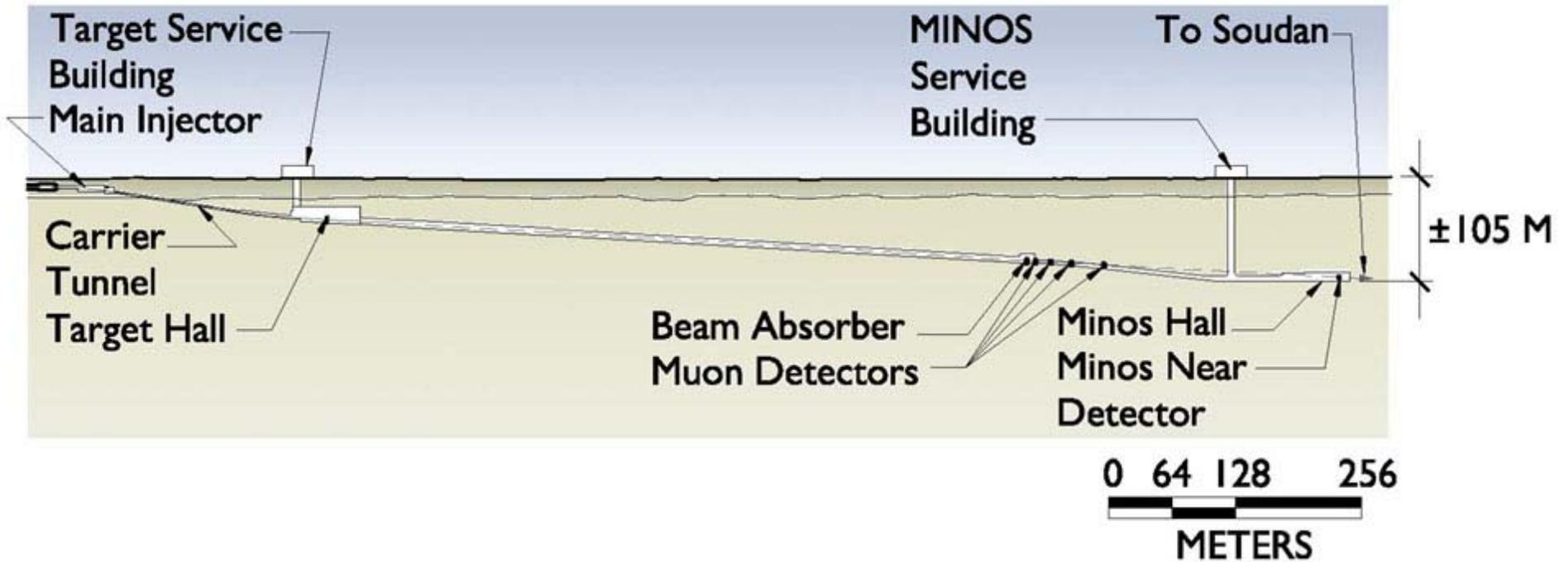
China Baseline The “Elevation View” Sketch for Very Long Baseline Neutrino Project



*China
Baseline*

The Sketch is based upon a Rotation of the Existing NuMI Beam

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There are, however, many Questions that can be asked...

March 17, 2004

To: Weiren Chou

From: Dixon Bogert

Subject: Questions Relative to the Proton Driver and Neutrino Extraction to Beijing

- 1) What neutrino energy(s) should the beam provide? (In asking this question I am asking in comparison to the “low” – “medium” – “high” energy options provided in the NuMI neutrino production for the Soudan MINOS experiment.)
- 2) It is possible that shielding requirements might be reduced if production originated from a lower energy proton beam. Should this be a serious consideration?
- 3) The flux at Beijing will be reduced in comparison to that at Soudan for MINOS proportional to the square of the relative distances. What event rate is required by the experimentation in Beijing, and what fraction of the offset in the loss of flux to geometry is recovered by: A) Increase in proton intensity on the target? B) Increased efficiency of production (i.e. more horn, Hadron Hose, whatever)? And C) Increase in detector mass?
- 4) What power is the target going to receive? #Protons on Target? Rep rate? Single turn extraction?
- 5) Is a near detector required?
- 6) Must the neutrino energy be variable?
- 7) Must the targeting geometry be variable? Narrow band beam? Off axis production?
- 8) Length of decay pipe?
- 9) Diameter of decay pipe?
- 10) Muon monitors?
- 11) Access to Absorber, near detector, etc.
- 12) Access to target hall/service and reconfiguration of production geometry?
- 13) Is simultaneous operation of NuMI and Beijing envisioned?
- 14) May I have some money for some drafting sketches in FESS and for consultation with Chris Laughton, etc.?
- 15) May I have access to some help from Beam line designers?

I have talked with Gordon Koizumi About Availability of Magnets left over from the Main Ring

This design postulates the use of B2 dipoles.

There are probably enough in adequate number to support such a design.

The design postulates the use of the same quads as in the NuMI down bend. This is an open question.

Obviously, some advantage in the elevation of the target is achieved by the use of superconducting magnets, but...

FESS found published sketches of the BNL “Rollercoaster” but did not find BNL design drawings...

I reproduce here a sketch from the BNL article. Note the “small” hill is as high the high rise, or half as high as our MINOS shaft is deep!!! This is for a 204 meter decay pipe length; note NuMI is 675 meters decay pipe. If scaled the hill becomes noticeable, even for an 11 degree down angle.

The neutrino superbeam from the AGS

W T Weng, D Beavis, M Brennan, M Diwan, R Fernow, J Gallardo, S Kahn, H Kirk, D Lowenstein, W Marciano, I Marneris, W Morse, Z Parsa, R Palmer, D Raparia, T Roser, A Ruggiero, J Sandberg, N Samios, Y Semertzidis, N Simos, N Tsoupas and B Viren

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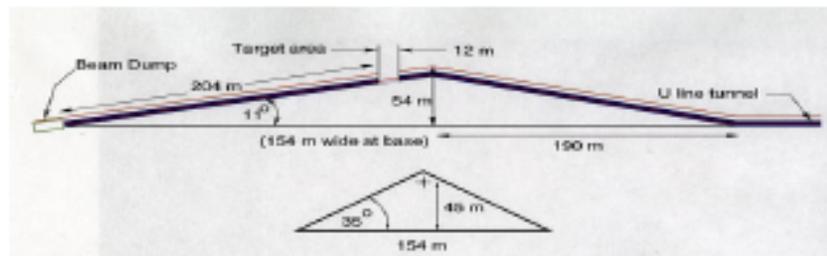


Figure 4. Elevation view of the neutrino beam line to Hornestake, South Dakota.

I have shown the sketches to
Chris Laughton. Chris is providing
commentary in the next presentation.

My personal comment is that it MIGHT be possible to build such a beam if it is required to have the parameters assumed in the sketches. It is an obviously VERY expensive piece of tunneling.

Chris postulates we would drop a vertical shaft at the end of the works and mine uphill.

It will be difficult. A 3000' deep shaft is a large undertaking in the best of circumstances. The shaft alone in my personal estimation will cost on the order of the entire NuMI excavation.

These will NOT be the best of circumstances. Chris will tell us that some of the sandstone is VERY difficult to work in. This project as sketched traverses major aquifers.

Site Photograph with the NuMI Underground Facility located

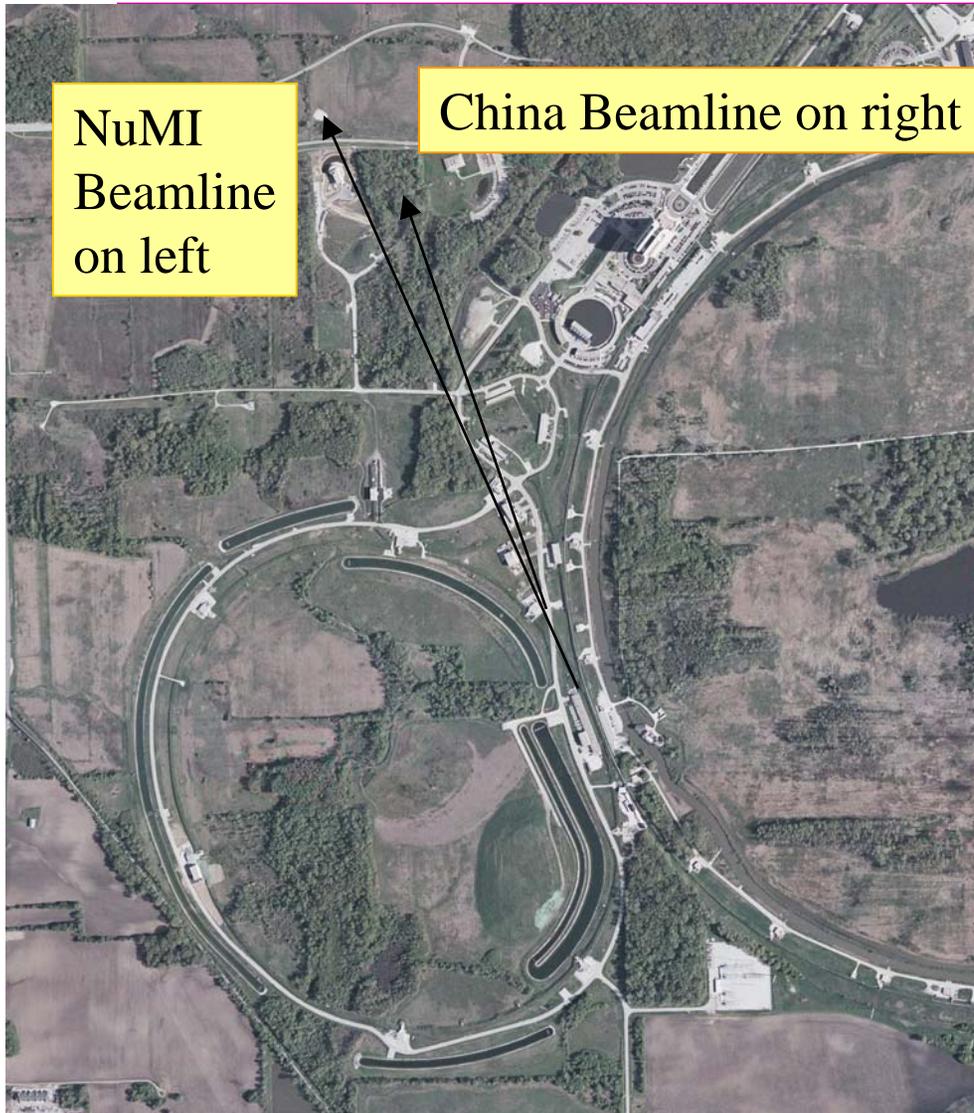


The location of the existing NuMI Beamline is shown on this recent site photograph. The extraction point at MI-60 is the “tail” of the arrow, and the downstream end of the MINOS Hall is about 345 feet below ground at the point of the arrow.

*China
Baseline*

Site Photograph with the NuMI
Underground Facility shown and
relative alignment of the China baseline

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The locations of the existing NuMI Beamline and the approximate orientation of the China beamline are shown on this recent site photograph.