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E781 Hyperon Spectrometer Constants

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This is a discussion of the physical measurements, sizes, distances and magnetic fields of the Hyperon Spectrometer Magnet and its components. Some we get from construction drawings (like the target dimensions) and others from measurements in differing coordinate systems. Included also are the properties of the hyperon productions targets used in E781.

The Hyperon Magnet

The Hyperon Magnet was constructed in 1979 for a series of hyperon beam experiments starting with E497. Figure 1 shows the magnet during construction. Note that upper and lower halves consisted of steel slabs, which were bolted together and then welded. The aluminum coils (Figure 1) are water cooled and the turn to turn insulation is provided by glass tape and epoxy. The fact that there were no failures in almost 20 years of operation attests to its ruggedness. The proton beam will come from the left which already has the steel top section installed. Shown is the author and Jonathon Thron who was to get his thesis from one of the first experiments using this magnet.

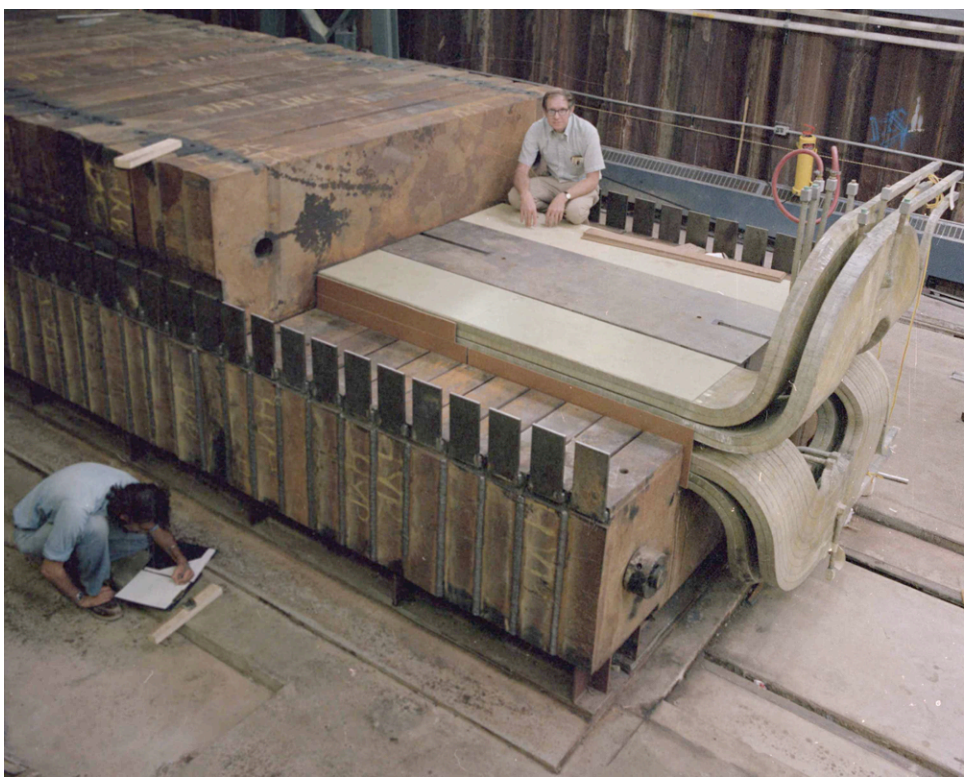

Figure 1
The Hyperon Magnet under construction

Figure 2 is taken from the downstream end of the magnet. It shows Y. W. Wah, another graduate student, and the rectangular aperture which will later house the tungsten channel. On the top and bottom of the aperture are the steel pole tips. On either side of the channel aperture are lead plugs designed to absorb hadrons and degrade muons.

Figure 2
The Hyperon Magnet showing the region of the channel

Figure 3 shows one of the three removable channel sections. Note the steel pole tips separated by brass spacers. In the channel the magnetic field at full current (about 3600 A) was 35 kG. Within the channel sintered tungsten plates for the channel.

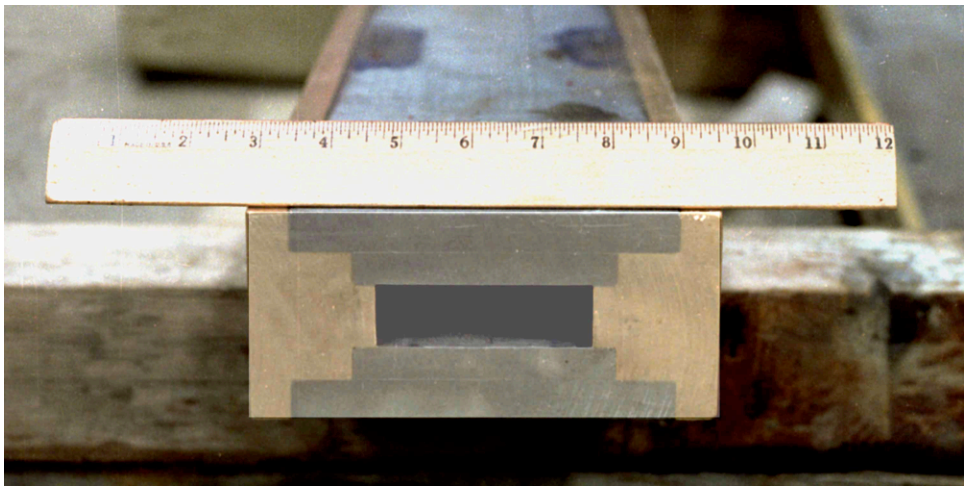

Figure 3
One of the three removable sections of the hyperon channel

Length of the hyperon channel?

The hyperon channel is composed of a 12 foot upstream section and two 6 foot downstream sections. The total channel length should be 24 feet. A good check is to look at the survey measurements of the entrance and the exit of the channel. These were done at 8 points on the entrance and the corresponding 8 points at the exit. These are shown on the attached figures 2 and 3. You can then calculate the difference as shown in Table 1. This table is a spread sheet which starts from survey measurements (in a rather obscure system) and known brass survey plug positions. It transforms them into quantities useful for physics analysis

Channel Length measurements done on 8/3/95

1 to 1	288.227 inches	=	24.019 feet	=	732.096 cm
2 to 2	288.197 inches	=	24.016 feet	=	732.020 cm
3 to 3	288.197 inches	=	24.016 feet	=	732.020 cm
4 to 4	288.228 inches	=	24.019 feet	=	732.099 cm
5 to 5	288.156 inches	=	24.013 feet	=	731.916 cm
6 to 6	288.130 inches	=	24.011 feet	=	731.850 cm
7 to 7	288.130 inches	=	24.011 feet	=	731.850 cm
8 to 8	288.156 inches	=	24.013 feet	=	731.916 cm

Table 1 Channel Length Measurements

The deviation from 24 feet in probably due to the small gaps between the three channel sections. The junction of these sections can be seen in the magnetic field plot (Figure 5) which follows.

What were the sizes of the hyperon production targets?

The hyperon production targets used during the run were:

Target dimensions from Drawing E781 shop drawings

Tgt	X in	X cm	Y in	Y cm	Z in	Z cm	Drawing
Cu	0.040	0.102	0.080	0.203	5.927	15.055	9220.781-MC-327330
Be	0.040	0.102	0.080	0.203	16.020	40.691	9220.781-MC-327333

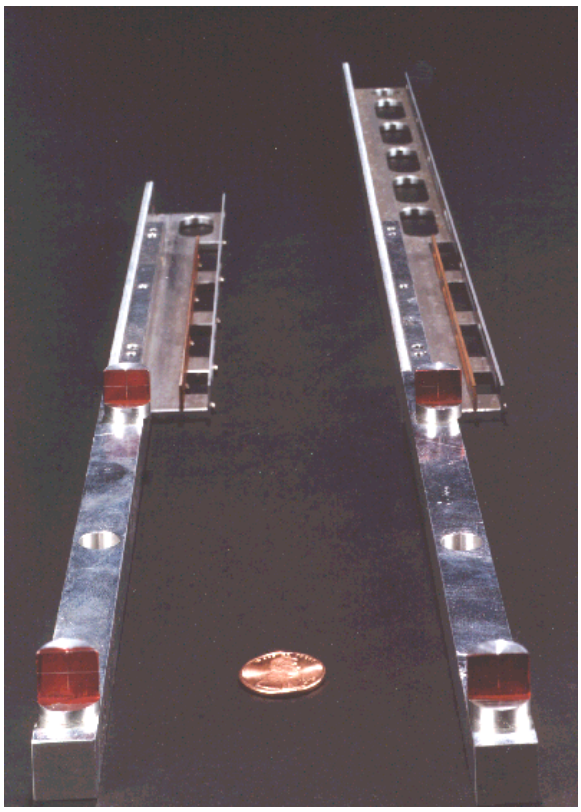

Figure 4
E781 Target assemblies

Note that the targets were machined using English units and the above are the full (not 1/2 scale) dimensions. They were made in inches not cm. There were two target assemblies made for E781. Each contained both a Be and a Cu target. On each of them the Cu targets were the same size but on one the Be target was 1/2 of the length indicated in the above table. Both target assemblies are shown in Figure 4. Only the longer one (on the right) was used in the E781 run.

What is the magnetic field of the Hyperon magnet?

See H-763, E781 Hyperon Target Magnet Field Map, J. Lach and E. de Oliveira, 1/19/96.

The field map (Figure 5) is shown below. This origin is at the upstream face of the hyperon magnet which is also the upstream end of the hyperon production targets. This map was produced by pulling a tiny Hall probe through the channel. Probe was then calibrated in a SSC superconducting magnet over the full magnetic field range used. These measurements were done at 3250 amps (the 'set to current' on the magnet readout). The channel is made in three sections. The channel section edges are also indicated below. Note there is a dip at the edges probably due to the very small gap between the sections. Note also the significant fringe field beyond the physical channel pieces. The upstream horizontal fringe field is a correction to the proton beam position at the target and was compensated by the beam tuning magnets, PC3H1 and PC3H2. The downstream fringe field contributes to the hyperon beam deflection.

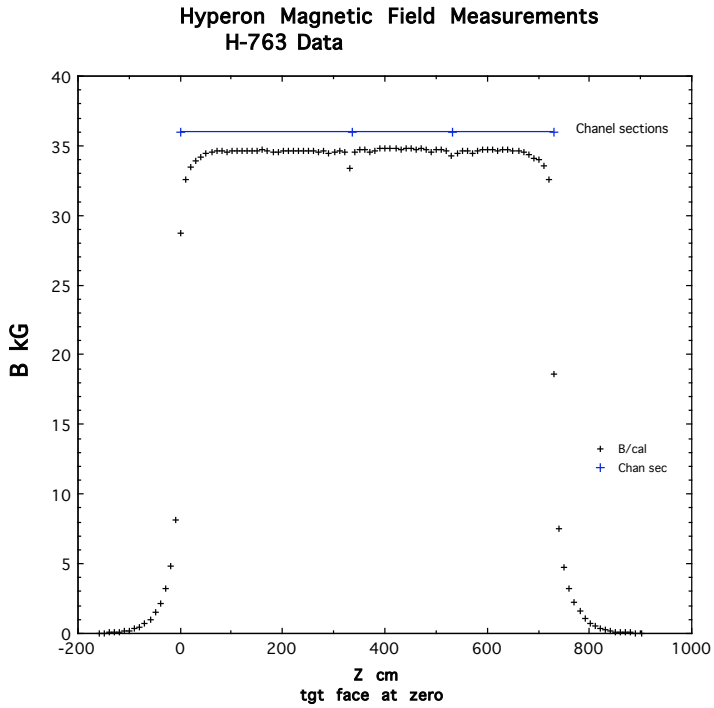

Figure 5

What is the fringe magnetic field of the Hyperon Magnet?

This is shown in Figure 6 (also at full field, 3250 Amps). Note the this is the vertical component (the major one) only and was measured with a Hall probe. It is a rescaling of Figure 5 that is the fringe field at the downstream end of the Hyperon Magnet.

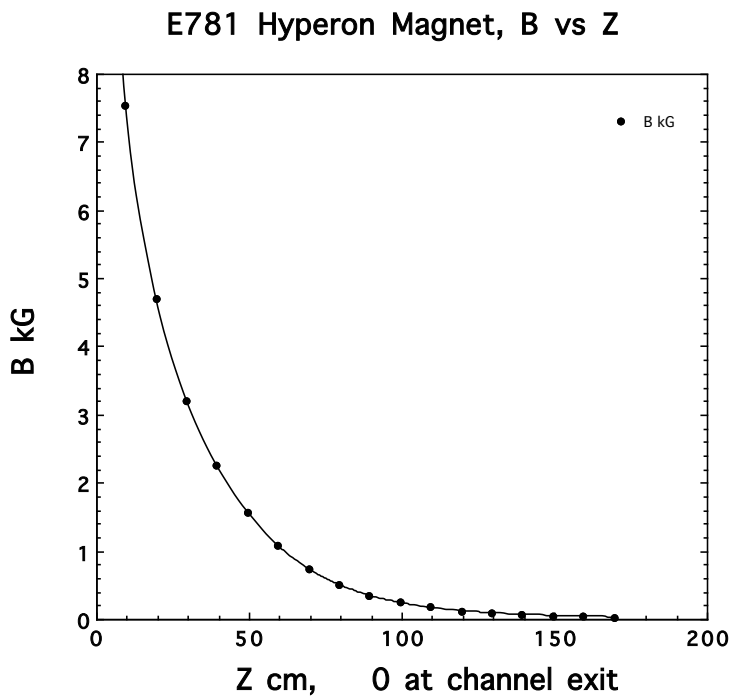

Figure 6
Hyperon Magnet fringe field

What is the field integral and Pt bend of the Hyperon Magnet?

From the data shown in Figure 5, we can compute the field integral of the hyperon magnet. We can integrate over the particle trajectory starting from the downstream fringe field. This integral (transformed to a Pt deflection) is plotted in Figure 7 as a function of z. This is effectively the field integral from -infinity to z converted to Pt. One sees that from the upstream end of the target, the Pt deflection is 7.621 GeV/c compared to the value 7.575 in the 29-July-1996 OCS table.

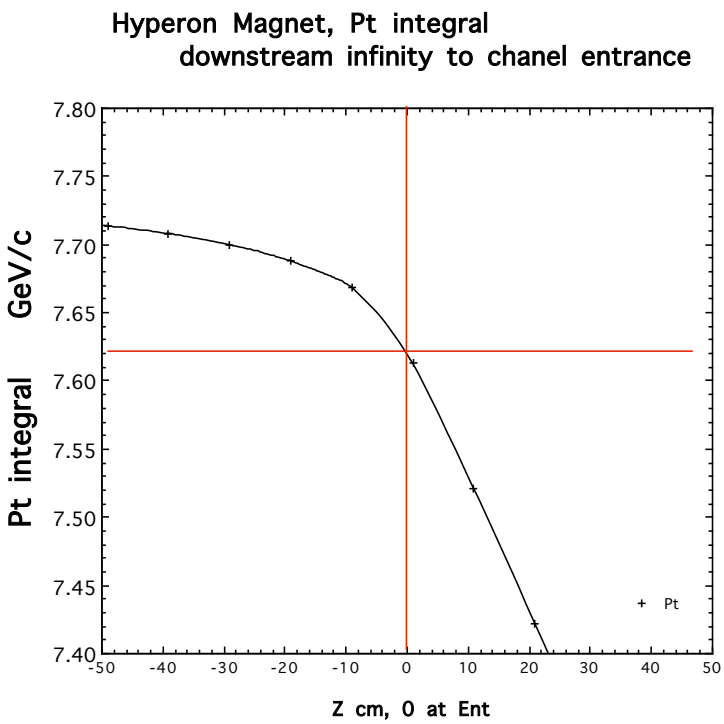

Figure 7
Pt deflection of the Hyperon Magnet at 3250 Amps

What is the effective bend point of the Hyperon Magnet?

Here we compute (ray trace) the trajectory of a particle going upstream along the z axis starting from - infinity to some z. From its trajectory, we can find its angle change and displacement and compute the bend point z. This is plotted in Figure 8 as a function of z. Note that at the start of the target (z=.0), the effective bend point is 370.0 cm. The geometrical midpoint of the magnet is 365.8 cm. This difference, 4.2 cm, is the shift of the magnetic center of trajectories originating at the beginning of the hyperon production target.

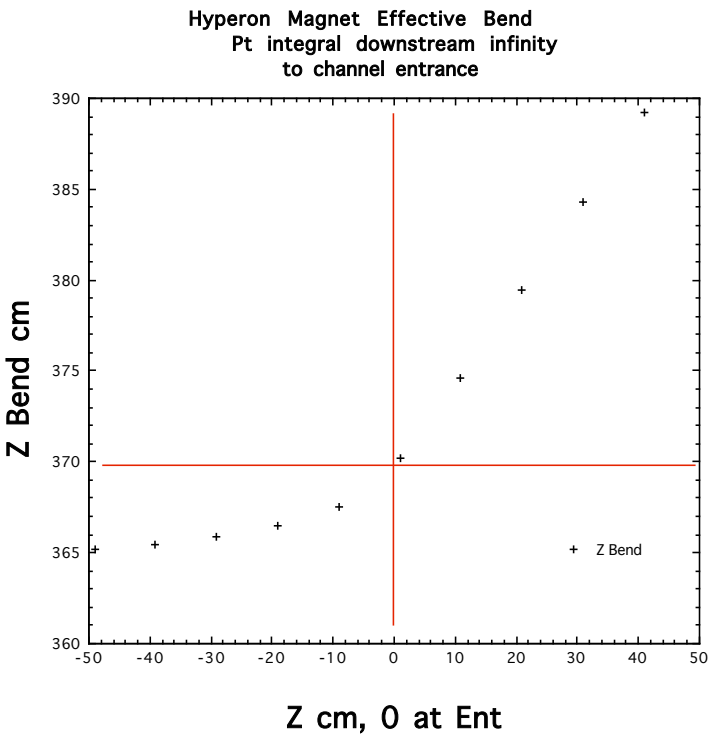

Figure 8
Effective bend point of Hyperon Magnet

Where are the silicon detectors on the Granite block?

A survey was made of the positions of the Beam #1, Beam#2, and Vertex#1 silicon chambers on the Granite block on 3/19/97. This was recorded in the Proton Center survey log on page 38 of BK 32. This survey gives us the x and z coordinates of these chambers relative to brass plugs on the PC4 floor. The following spread sheet (Table 2) shows how one goes from the survey report to the z positions of the chambers relative to the brass plug, PH5530C, embedded in the concrete floor. This plug was one of the primary survey points for E781 and is on the old E761 hyperon beam line.

Chamber Positions from Survey BK 32-7, page 38, 3/19/97			
Z positions Only			
	Move downstream from PH5530C		
Beam #1		15.243	inches
		8.000	
	subtotal=	23.243	now at first horizontal line
		12.758	
		-0.957	
	subtotal=	11.801	ruler measurement, now at 2nd horizontal line
		2.309	
		3.125	
	subtotal=	5.434	2nd line to dwsface of Beam #1
	Total=	29.610	inches from PH5530C to downstream face of Beam#1
		0.750	Thickness of plate (JL and Jim Russ checked)
	Total=	28.860	inches from PH5530C to upstream face of Beam#1
		73.304	cm from PH5530C to upstream face of Beam#1
		1.905	cm Thickness of monument block
Beam #2			
		10.058	
		8.125	
	subtotal=	18.183	from 2nd horizontal line to ups face of Beam #2
	Total=	53.227	inches from PH5530C to upstreamstream face of Beam#2
		135.197	cm from PH5530C to upstreamstream face of Beam#2
		1.905	cm Thickness of monument block
		137.102	cm from PH5530C to downstream face of Beam#2
Vertex #1			
		8.117	in From Survey
		44.125	in
	subtotal=	52.242	2nd line to 3rd line
	Total=	87.286	inches from PH5530C to upstreamstream face of Vertex#1
		221.706	cm from PH5530C to upstreamstream face of Vertex#1

Table 2

The coordinates of these plugs are well measured and documented as are those in PC3. These were measured in the Fermilab wide coordinate system which has its origin some where near the beam extraction point from the main ring. We can thus tie these in with the coordinates of the Hyperon Magnet and the hyperon production targets.

One can now used the measured chamber positions and known silicon plane positions. These are in H771, E781 Beam Silicon Detector Alignment Procedure and Data Base, Ken Nelson and Charles Newsom, for the beam chambers and H764, E781 Vertex Silicon Detector Alignment Procedure and Data Base, Prakash Mathew and James Russ. We can now compute the positions for a few of the silicon planes. This is shown in Table 3, the following spreadsheet, Summary of z positions.

In this spreadsheet, Summary of z positions (Table 3), we have measured the z positions choosing PH5530C as zero, as it was for the E761 coordinate system, and as it was for E781 where PH5530C=-215.789 defining the origin (number from Sasha). Also listed are the values from the OCS table and the difference between the OCS values and our measurements. We see that for the silicon planes the differences are on the order of 1/2 mm. This is well within the expected measurement errors.

From Table 1 spreadsheet one has the z positions of the Channel Exit and the Channel Entrance. Note that the hyperon production targets are mounted (Figure 8) so that their upstream end is at the start of the channel entrance. Table 3 compares these to the OCS table values. Note that the channel entrance (start target) differs significantly from the OCS table. This may have been intentional since the target center may have been used. **However, propose that we use the upstream end of the target and the corresponding value for the bend point.** These are also

in Table 3. This has the advantage that they would be the same for both the Be and Cu targets since they have their upstream end at the same z. The table also contains the bend point from Figure 8 and the comparison with the current OCS table (14-Feb-1997 version) value.

Summary of z positions					
		Z cm	Z cm	OCS	Del (OCS-Z)
		0 at PH5530C	E781 Global	cm	cm
PH5530C		0.000	-215.789		
BEAM #1 Upstream face		73.304	-142.485		
BEAM #1 Downstream face		75.209	-140.580		
add H771	0.4205+1.66				
BSSD_ST1_U		77.290	-138.499	-138.433	0.0661
add H771	4.81535+1.66				
BSSD_ST1_X		81.685	-134.104	-134.038	0.0662
BEAM #2 Upstream face		135.197	-80.592		
BEAM #2 Downstream face		137.102	-78.687		
add H771	2.633+1.66				
BSSD_ST2_Y		141.395	-74.394	-74.358	0.0364
add H771	4.8112+1.66				
BSSD_ST2_X		143.573	-72.216	-72.180	0.0362
Vertex #1 Upstream face		221.706	5.917		
Vertex #1 Downstream face		223.611	7.822		
add H764	-2.025				
VS_SSD1X(1)		219.681	3.892	3.957	0.0646
Channel Exit		-167.358	-383.147	-383.144	0.0030
Bend point		-528.878	-744.667	-745.25	-0.5830
Chan Entrance & start target		-898.878	-1114.667	-1110.95	3.7170
Note:Sasha says 1.66 cm must be added to H-771 Table 1 Z numbers and I did.					

Table 3

What are the x and z positions of the hyperon production targets?

Table 1 has measurements of the upstream channel aperture positions. Figure 8 shows how the targets are positioned relative to this aperture. With the knowledge of the target lengths we can Table 4 containing the target positions.

	Z cm	X cm
	E781 Global	E781 Global
Be, Cu tgt upst	-1114.854	-4.941
Be middle	-1094.514	-4.651
Cu middle	-1107.330	-4.834
OCS	-1110.950	-4.656
Simon 4/6/98		-4.558

Table 4

Some comments are now in order. The OCS values do not agree with the measured x and z target positions. The x positions have a significant correlation with the z position. The reconstructed particle trajectories, hence the reconstructed target x position, which also depend on the assumed Pt and effective bend point assumed for the hyperon magnet**. I urge that the consistent set of these values developed here be tried.**

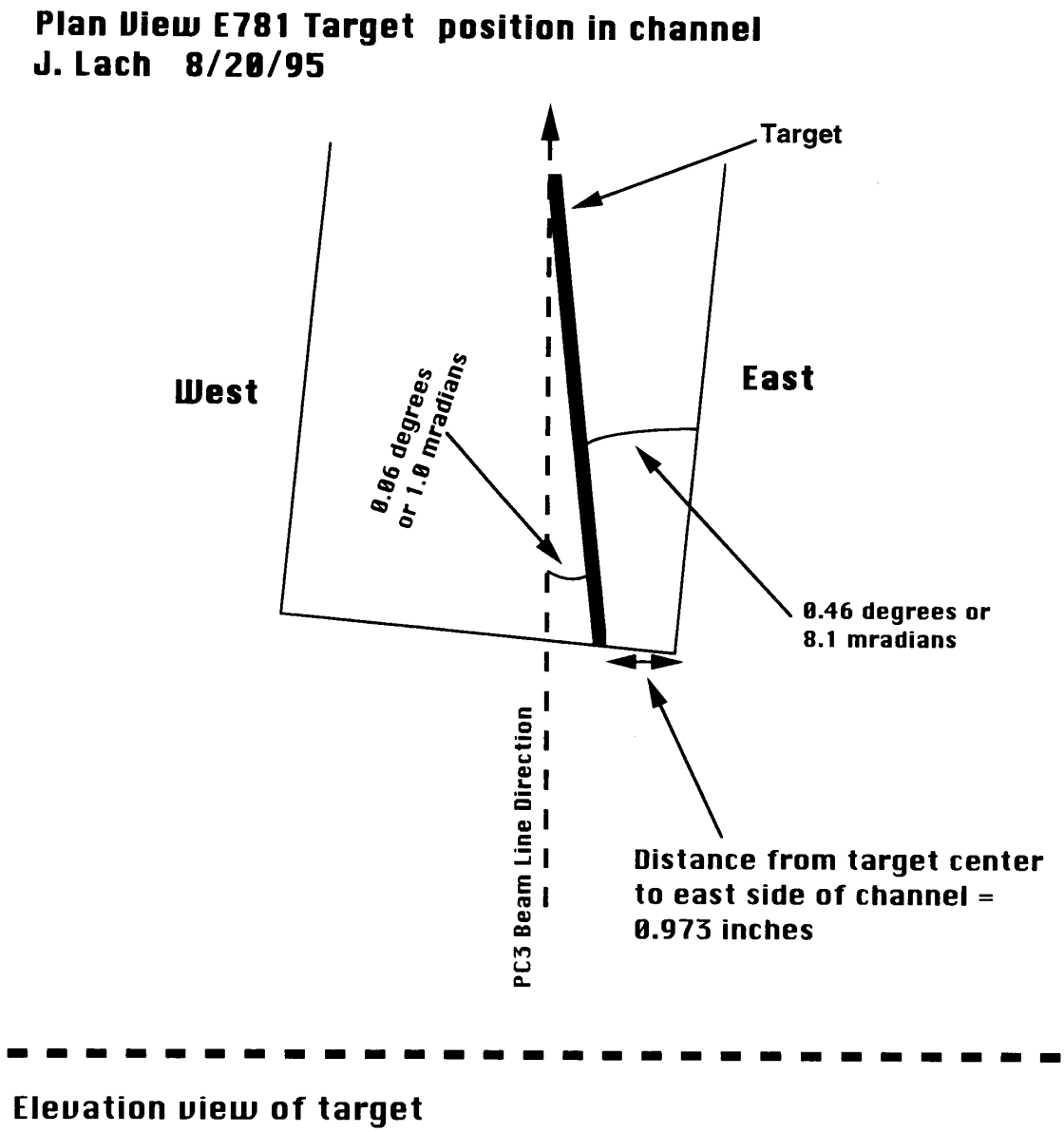

Figure 9
Target Positioning Instructions