

SPIN@U-70: An Experiment to Measure the Analyzing Power A_n in Very-high- P_{\perp}^2 p - p Elastic Scattering at 70 GeV*

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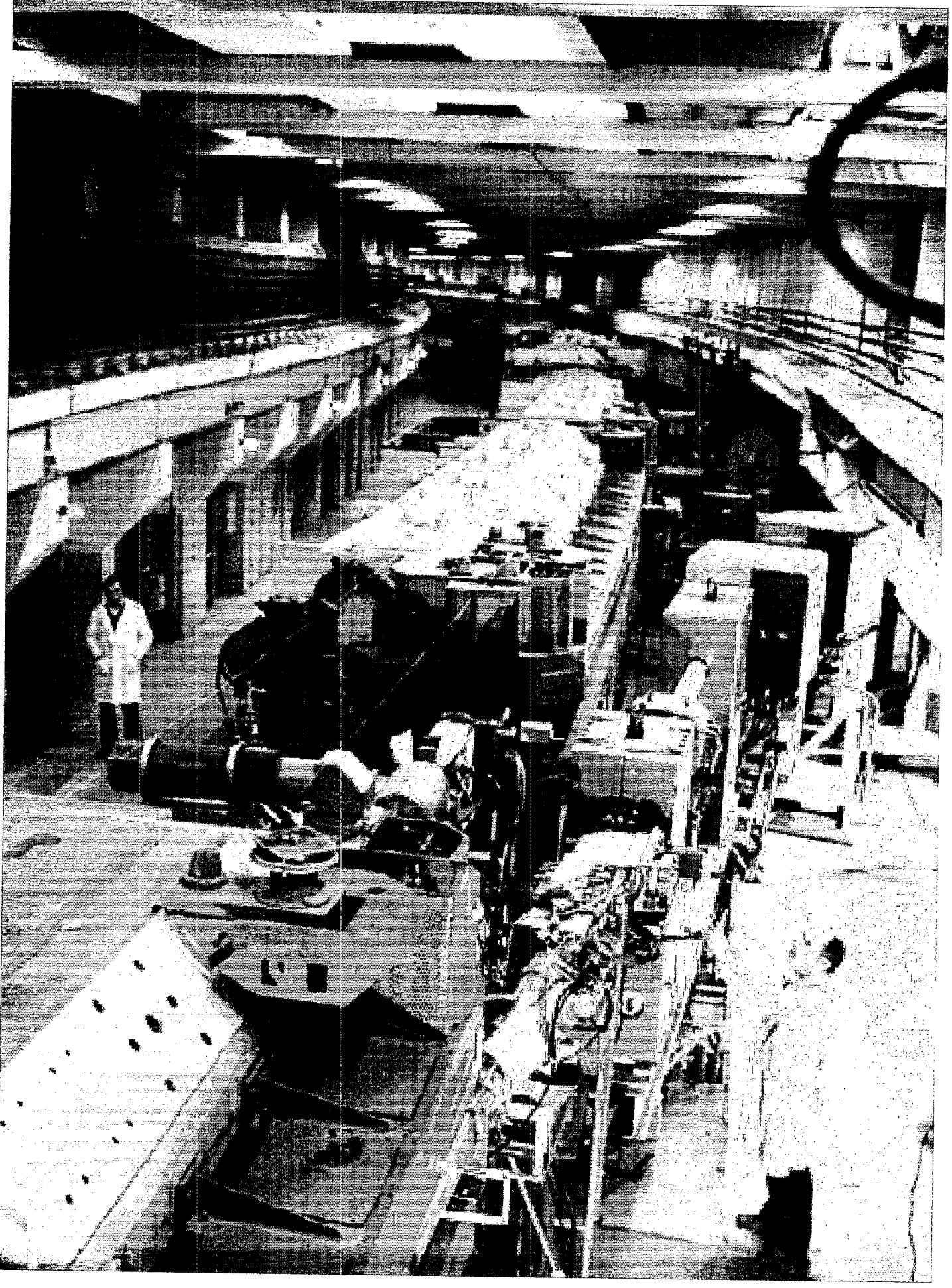
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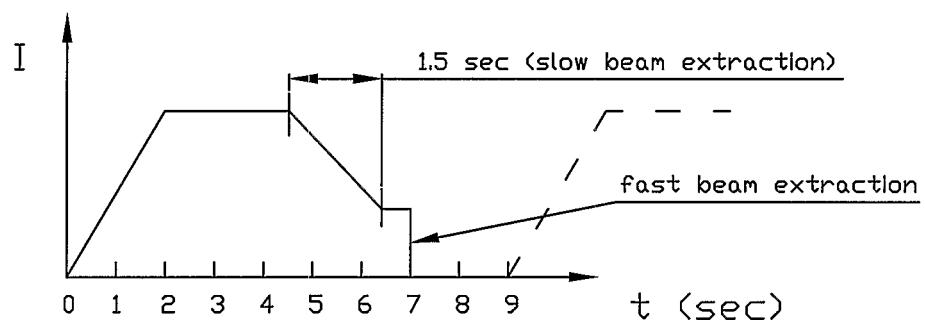
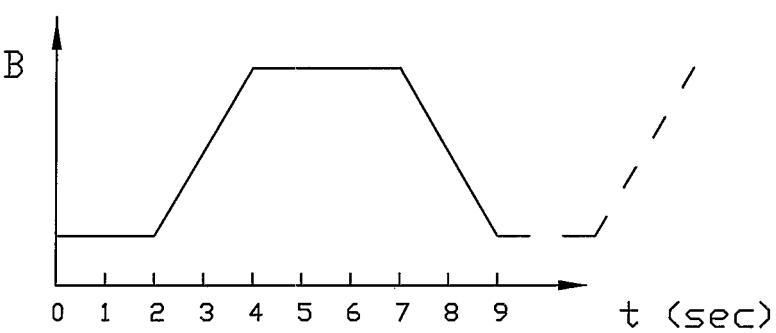
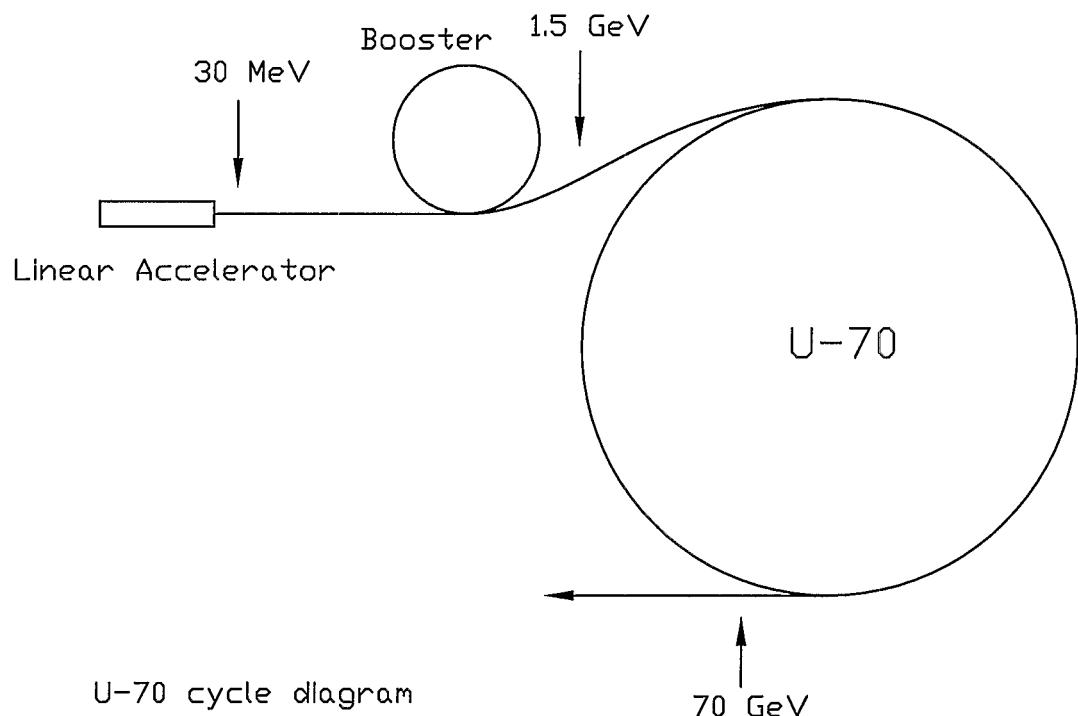
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70 GeV Proton Synchrotron (2×10^{13} protons/pulse)

Schematic of U-70 Accelerator Complex.



27 November 1996
29 November 2000

SPIN@U-70 PROPOSAL

to

IHEP-Protvino

Analyzing power A_n in 70 GeV Very-high- P_\perp^2
proton-proton elastic scattering

by

SPIN@U-70 Collaboration:

Michigan, Virginia, IHEP-Protvino, TRIUMF

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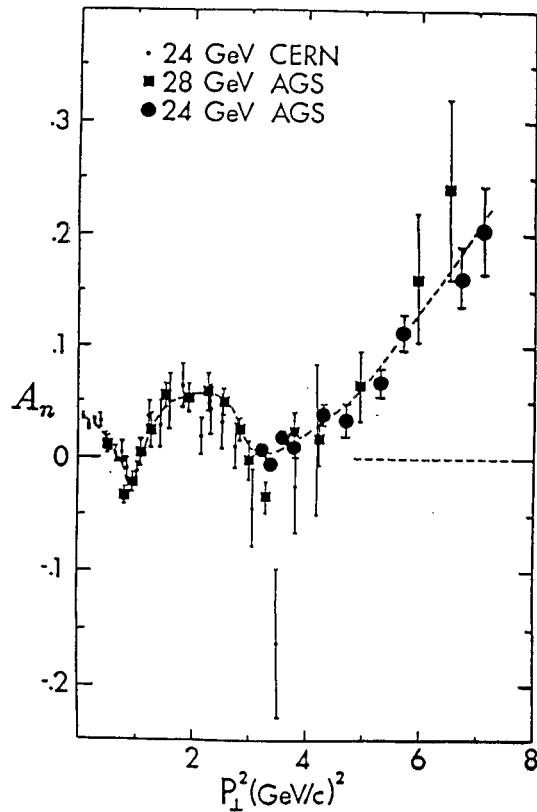
SPIN@U-70

This experiment is proposed to measure the analyzing power A_n in $p+p \xrightarrow{\uparrow} p+p$ at large- P_{\perp}^2 , at U-70 with a 70 GeV unpolarized extracted proton beam. We would scatter the high intensity beam from a polarized proton target and measure the analyzing power:

$$A_n = A_{\text{mea}} / P_T = (1/P_T) [(N(\uparrow) - N(\downarrow)) / (N(\uparrow) + N(\downarrow))],$$

where A_{mea} is the measured asymmetry, P_T the target polarization, and $N(\uparrow)$ and $N(\downarrow)$ are the normalized elastic event rates with the spin up and spin down, respectively.

Our main goal is to determine if the unexpected large value of A_n , discovered in large P_{\perp}^2 proton-proton elastic scattering at the AGS, persists to higher energy and larger P_{\perp}^2 .



As shown on this figure, the spin analyzing power A_n (at 24 GeV) was found to be $20.4 \pm 3.9\%$ near P_{\perp}^2 of 7 (GeV/c) 2 . This large and unexpected spin effect has been difficult to reconcile with the conventional models of strong interactions, such as Perturbative Quantum Chromodynamics (PQCD).

This proposed 70 GeV experiment would increase the maximum P_{\perp}^2 for A_n data by a factor of about 1.7; it would also increase the maximum energy by a factor of about 2.5.

Table 1. Michigan Solid PPT Specifications.

(PPT was used at A GS)

1. Cryostat Temperature	<u>1 K</u>
2. Cooling Fluid	<u>He^4</u>
3. Cooling Power	0.927 watt
4. Operating Magnetic Field	<u>5.0 T</u>
5. Field Uniformity Region	10^{-4} in 4 cm ϕ and 3 cm high
6. $\int B \cdot dl$	1.17 T· m
7. Power Supply Voltage	3 V
8. Superconducting Current	66 A
9. Microwave Frequency	<u>≈ 140 GHz</u>
10. NMR Frequency	(213.000 ± 0.300) MHz
11. Vertical Angular Acceptance	$\pm 6^\circ$
12. Horizontal Angular Acceptance	$\pm 34^\circ$
13. Target Size	<u>3.6 cm long, 2.0 cm ϕ</u>
14. Target Material	<u>Irradiated NH_3 beads</u>
15. Max. Beam Current @ 24 GeV/c	$2 \cdot 10^{11}$ p/1 s pulse/2.4 s cycle
16. Max. Polarization	<u>96 %</u>
17. Average Operating Polarization	<u>85 %</u>

SPIN@U-70 Spectrometer

Q1,Q2,Q3,Q4 are quadrupoles

M1,M2,M3 are dipoles

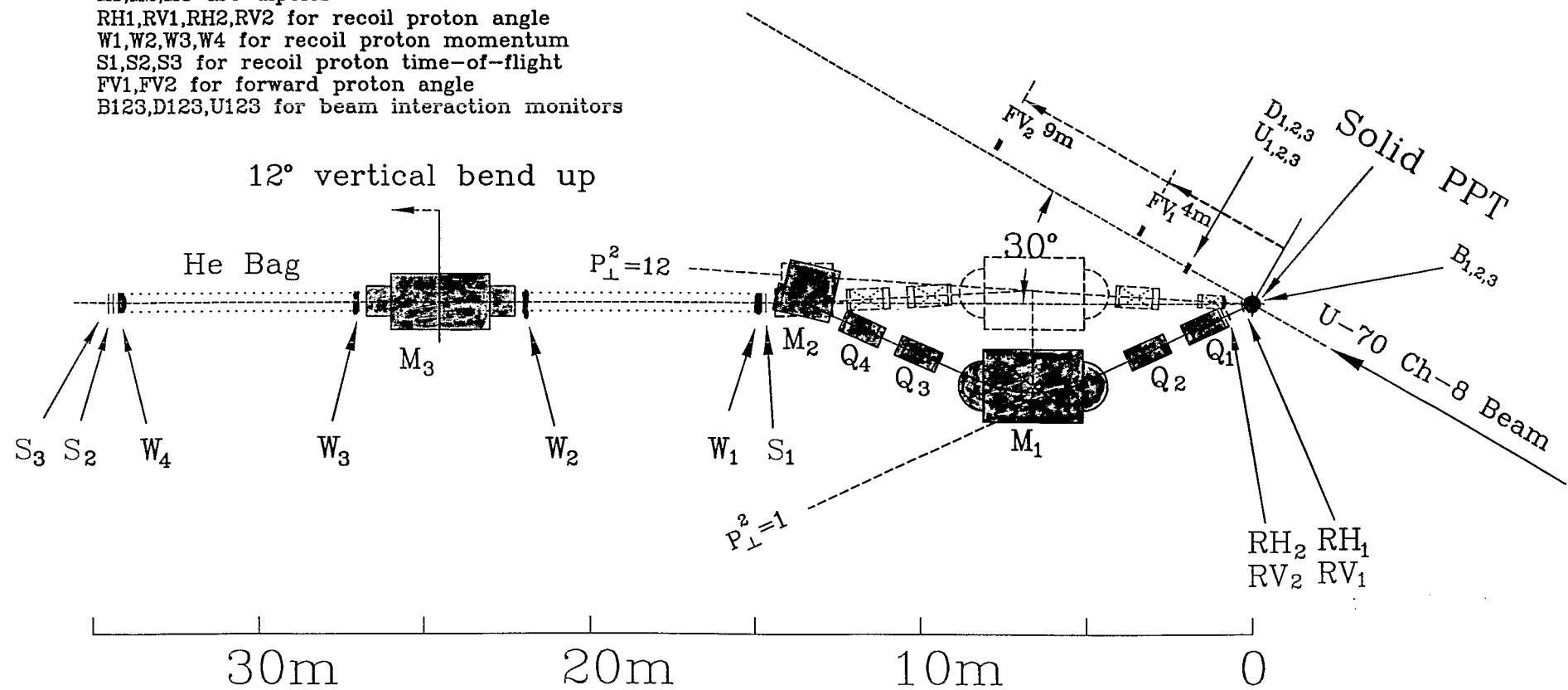
RH1,RV1,RH2,RV2 for recoil proton angle

W1,W2,W3,W4 for recoil proton momentum

S1,S2,S3 for recoil proton time-of-flight

FV1,FV2 for forward proton angle

B123,D123,U123 for beam interaction monitors



70 GeV/c, 30°, $P_{\perp}^2 = 6.0$, $P_R = 4.196$, $\pm 11 \text{ mr} \times \pm 70 \text{ mr}$, $\Delta P/P = \pm 3.7 \%$
 PPTM: bend left, Target: $\Delta X = \pm 0 \text{ mm}$, $\Delta Y = \pm 0 \text{ mm}$

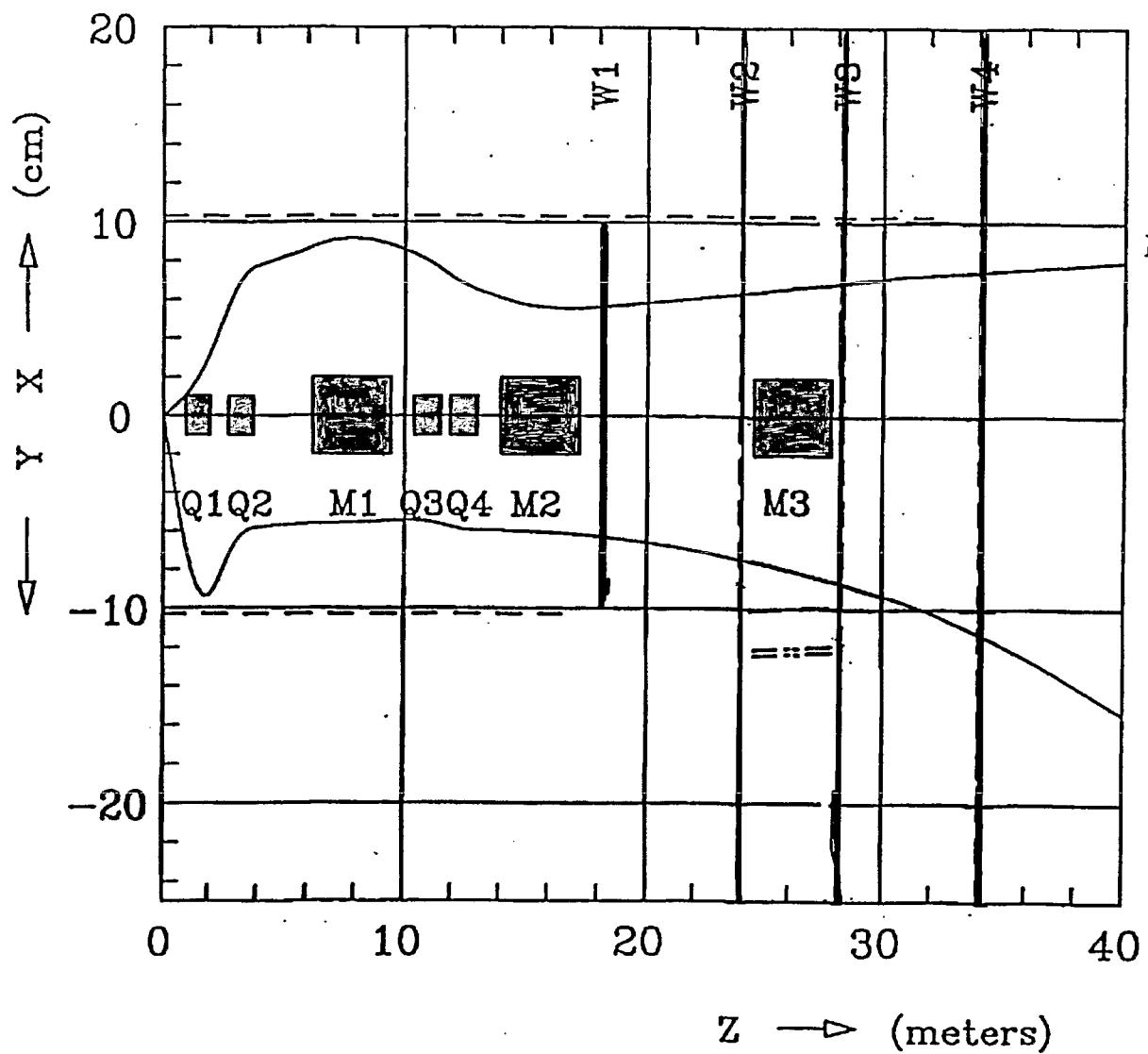


Figure 6. The beam envelopes obtained from TRANSPORT for the recoil protons at $P_{\perp}^2 = 6 \text{ (GeV/c)}^2$ for a point target.

SPIN@U-70 Event Rates

Beam intensity: $I = 10^{11}$ protons s^{-1}

Target thickness: $T = N_0(\rho)t$

$$= 6.02 \cdot 10^{23} / \text{gm} (0.1 \text{ gm/cm}^3) 3.6 \text{ cm} = 2.1 \cdot 10^{23} \text{ polarized protons } \text{cm}^{-2}$$

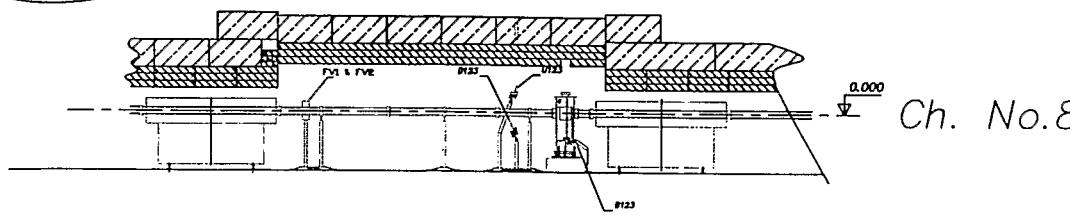
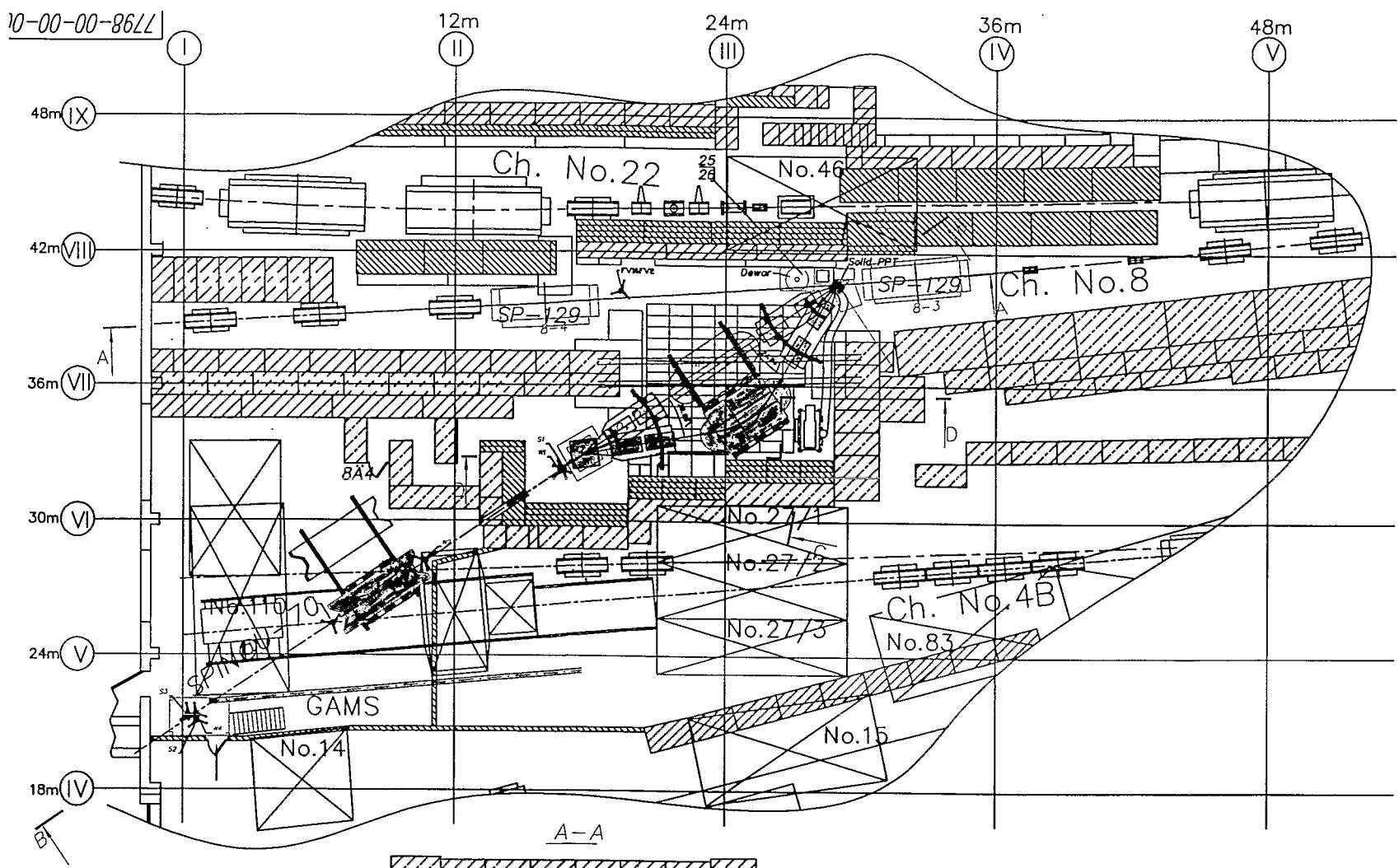
Luminosity: $L = I \times T = 2.1 \cdot 10^{34} \text{ cm}^{-2}s^{-1}$

$$\text{Rate} \left(\frac{\text{Events}}{\text{hour}} \right) = L \frac{d\sigma}{dt} \Delta t \cdot \frac{\Delta\phi}{2\pi} \epsilon \frac{3600 \text{ s}}{\text{hr}} = 6 \frac{d\sigma}{dt} [\text{nb}] \Delta t \cdot \Delta\phi[\text{mr}],$$

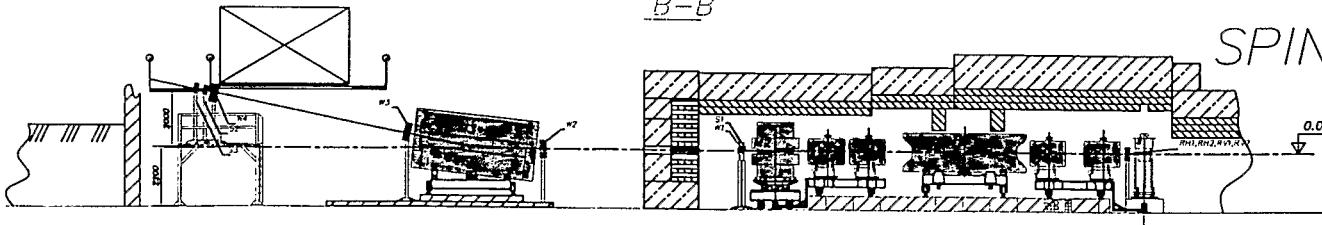
where $\epsilon = \text{efficiency} = 50\%$

P_\perp^2 (GeV/c) ²	Δt (GeV/c) ²	$\Delta\phi$ mr	$d\sigma/dt$ $\frac{\text{nb}}{(\text{GeV}/c)^2}$	Events per hour	hours	Events (N)	ΔA_n $[.85\sqrt{N}]^{-1}$
1.0	0.06	159	4000	230000	100	$2.3 \cdot 10^7$	0.03%
2.0	0.09	177	90	8600	100	$8.6 \cdot 10^5$	0.1%
3.0	0.25	194	19	5500	100	$5.5 \cdot 10^5$	0.2%
4.0	0.35	210	4.0	1800	100	$1.8 \cdot 10^5$	0.3%
5.0	0.45	225	0.9	550	100	$5.5 \cdot 10^4$	0.5%
6.0	0.56	240	0.22	180	200	$3.6 \cdot 10^4$	0.6%
.....
7.0	0.67	254	0.055	56	200	$1.1 \cdot 10^4$	1.1% Super Q₁
8.0	0.79	268	0.016	20	300	$6.0 \cdot 10^3$	1.5%
9.0	0.92	282	0.0047	7.3	400	$2.9 \cdot 10^3$	2.2%
10.0	1.06	296	0.0017	3.2	600	$1.9 \cdot 10^3$	2.7%
12.0	1.25	324	0.0003	0.73	800	$5.8 \cdot 10^2$	4.9%
Total hours =				3000			+ 500 (tune-up)

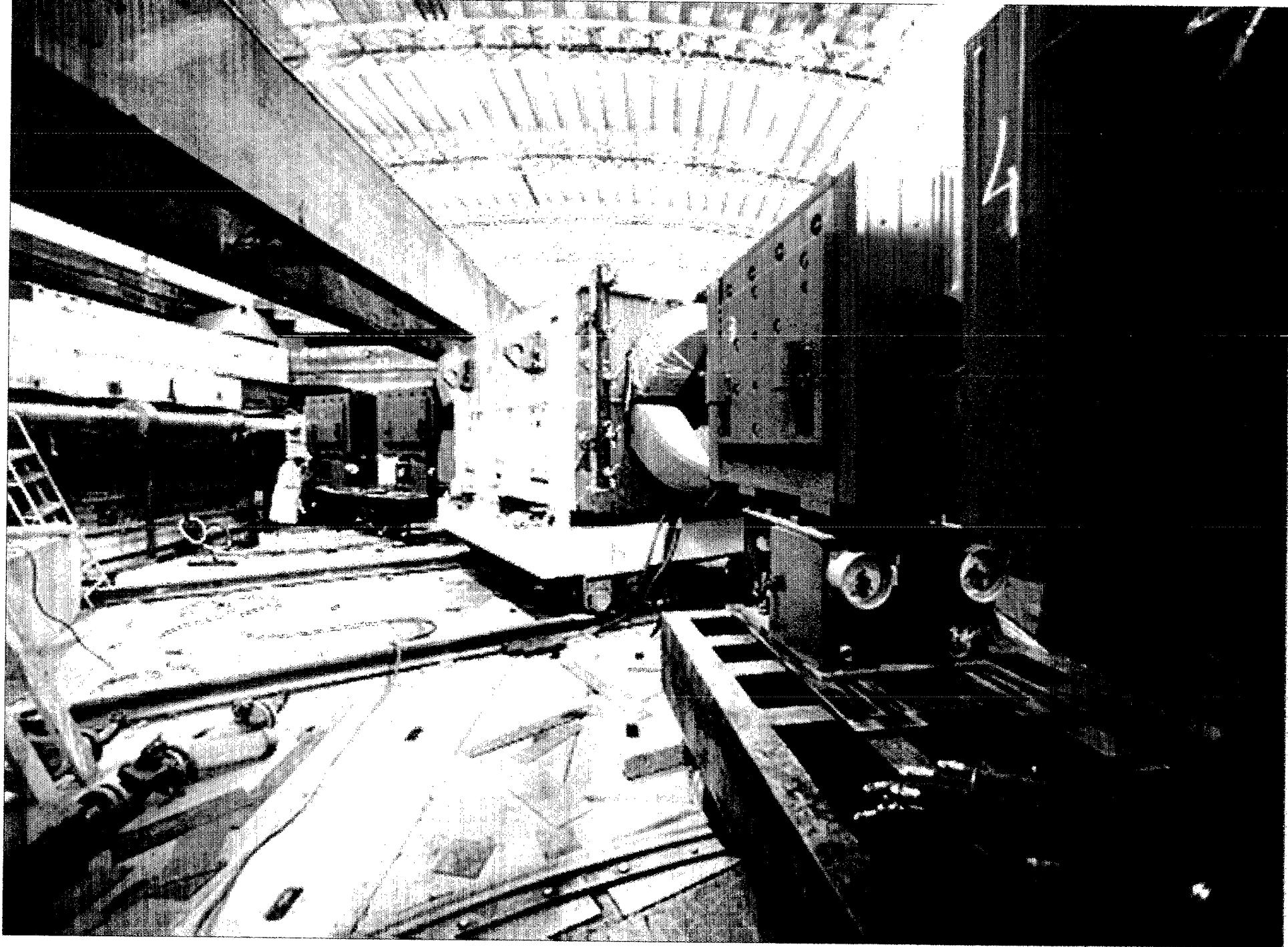
Table C2 Event rates and errors in A_n for $p-p$ elastic scattering at U-70.



B-B



SPIN@U-70



Unpolarized SPIN@U-70 Spectrometer (April 2002 Run)

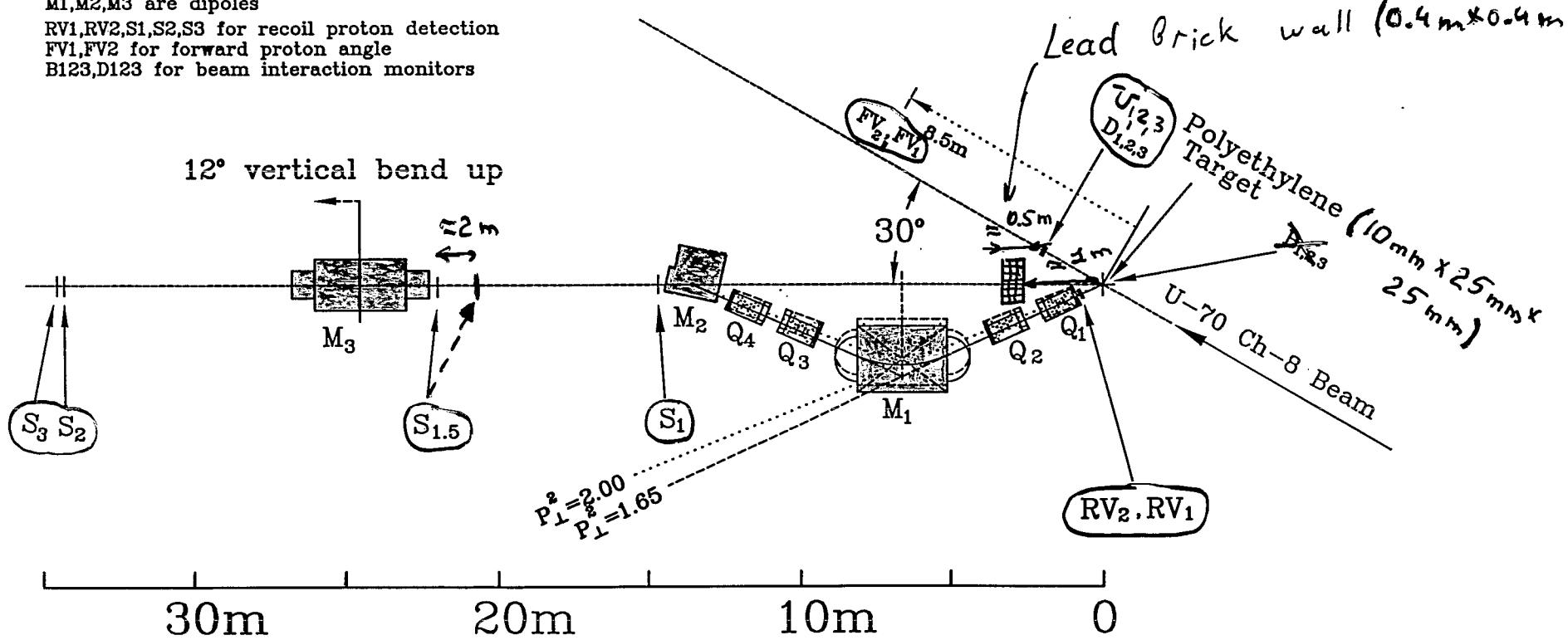
Q1,Q2,Q3,Q4 are quadrupoles

M1,M2,M3 are dipoles

RV1,RV2,S1,S2,S3 for recoil proton detection

FV1,FV2 for forward proton angle

B123,D123 for beam interaction monitors



A.M.T. Lin, 09Apr2002

Proton Beam

- 70 GeV proton beam extraction from U-70 ring to channel 8 is carried out by a bent single crystal within ~ **1.5 sec**
- Beam losses along the channel 8 to our target are less than 1%
- During November 2001 Run beam vertical rastering was successfully tested
- According to profile meter measurements, the beam size on the target during April 2002 run was an approximate circle a few mm in diameter
- Typical beam intensity on the target was between **(1- 4)x10¹¹ protons/pulse**



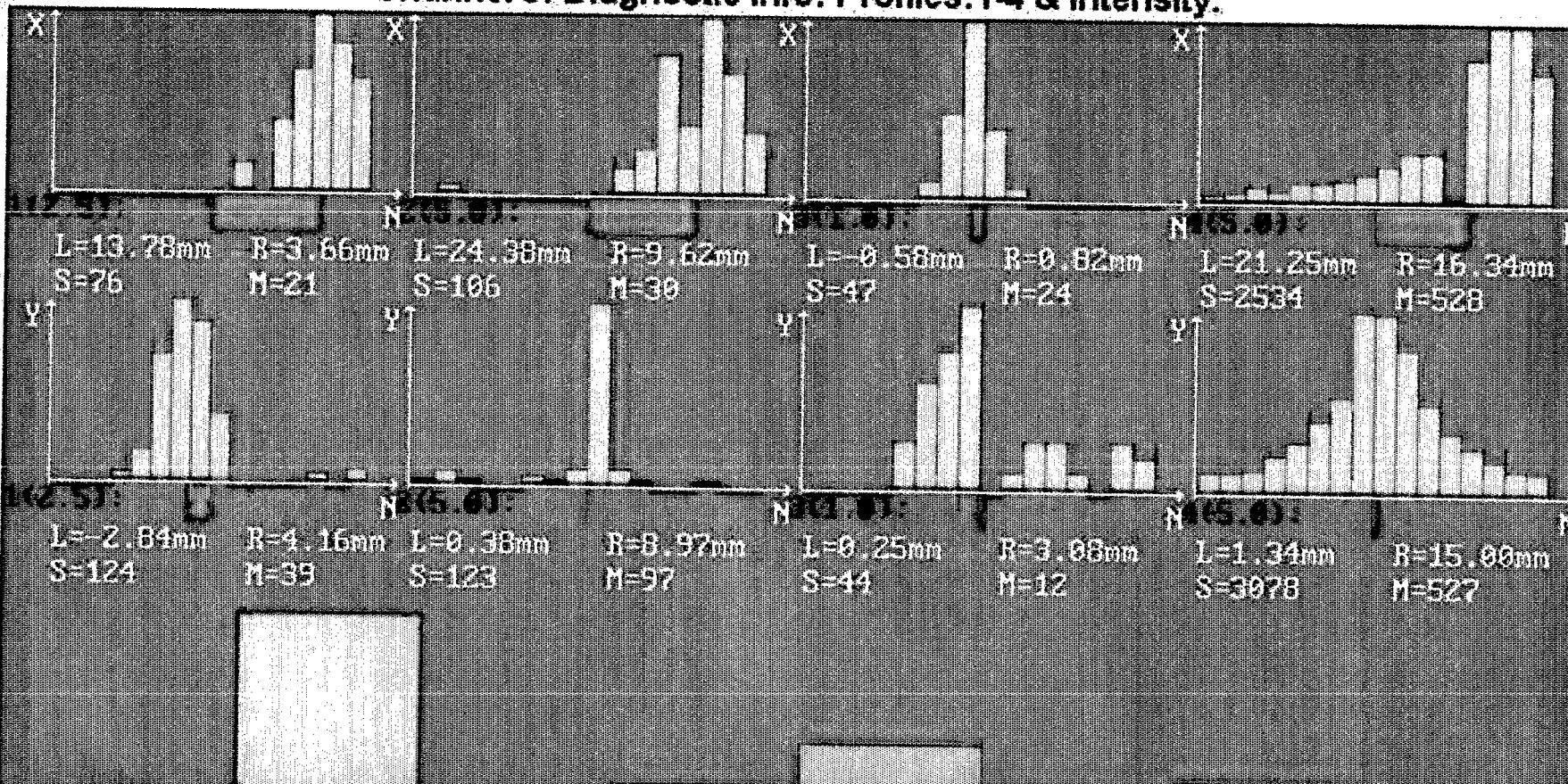
Адрес: http://www.oku.ihep.su/web_u70/data/u70view/u70view.htm

Переход

Каналы U-70

Канал 8: Профили 1-4, Интенсивность

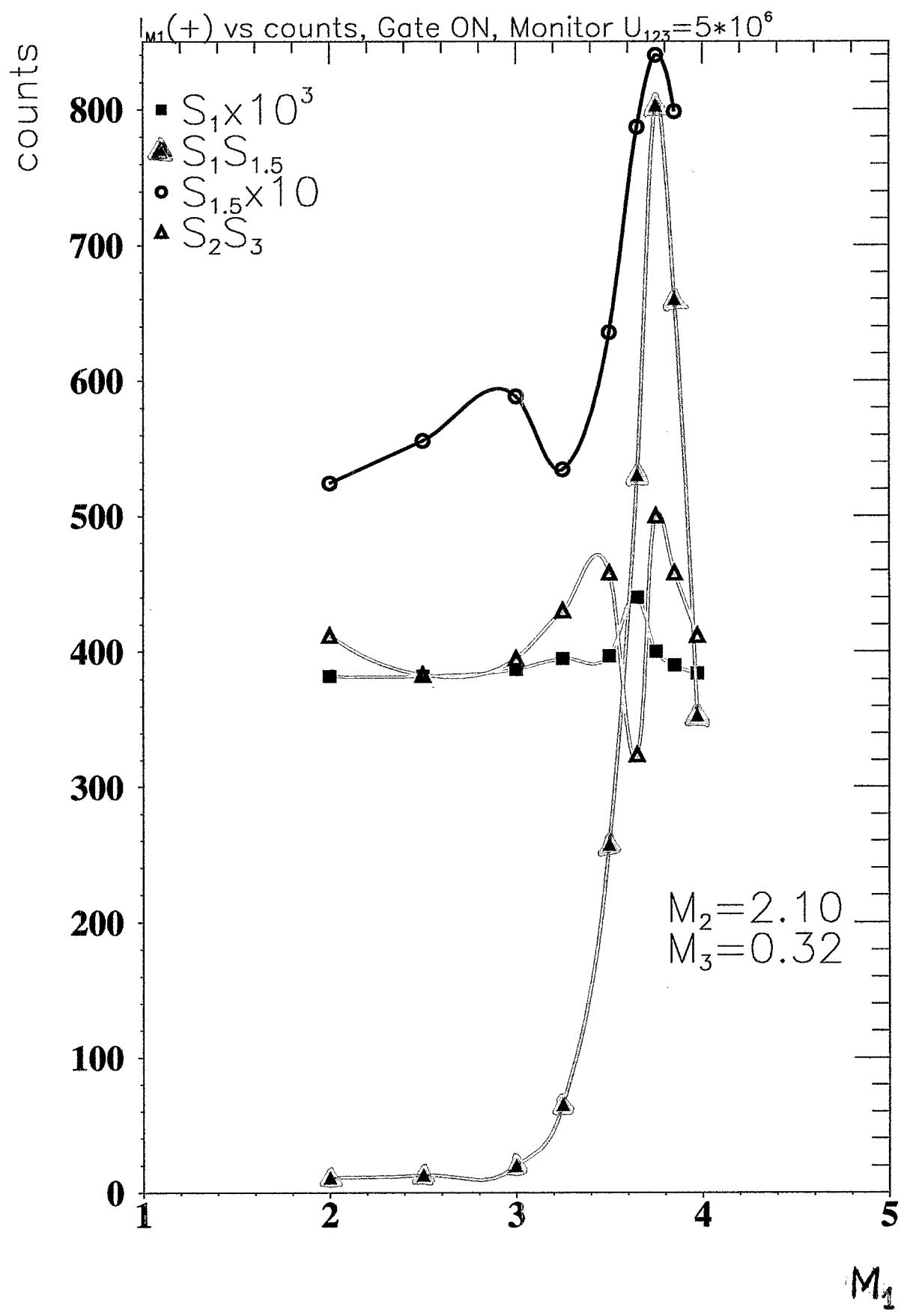
Channel 8: Diagnostic info: Profiles:1-4 & Intensity.



BM1 = 30 BM2 = 2452 BM3 = 2 BM4 = 208 BM5 = 784 BM6 = 219 BM7 = 318 BM8 = 63

I=0.00e+00 K=0.00 Cycle:14420 G10X Int:1500 Profile:1 At:Thu Apr 25 15:20:44 2002 .
BM-beam loss monitor, L-beam offset(mm), R-RMS(mm), S-sum, M-max, N-plate numb

2002/04/29 19.44



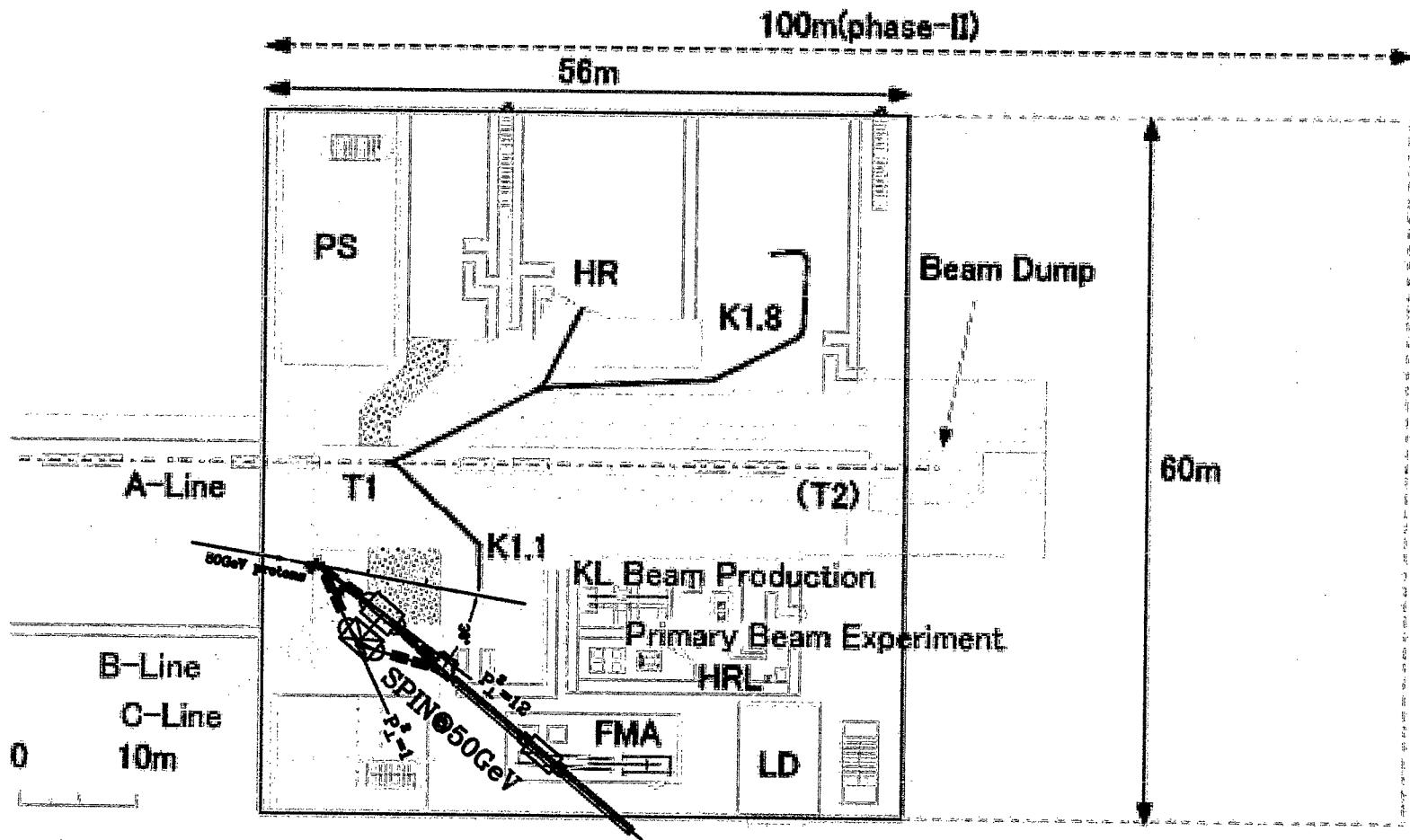
Proposed Schedule for SPIN@U-70 experiment:

- FY2002 run (Nov-Dec 2001 or Mar-Apr 2002)
 - Polarized Target, Beam and Recoil Spectrometer tune-up
 - Data runs at higher-rate smaller- P_{\perp}^2 points [1 and 2 (GeV/c)²]
- FY2003 run (Nov-Dec 2002)
 - Data runs at medium- P_{\perp}^2 points [3, 4, 5, and 6 (GeV/c)²]
- FY2004 run (Nov-Dec 2003)
 - New high-gradient superconducting quadrupole at Q_1
 - Tune the Beam, the Polarized Target, and the Recoil Spectrometer
 - Data runs at high- P_{\perp}^2 points [7, 8 and 9 (GeV/c)²]
- FY2005 run (Nov-Dec 2004)
 - Data runs at very high P_{\perp}^2 points [10 and 12 (GeV/c)²]
(Long runs at low rates)

50 GeV-PS, Tokai, Japan (2007)

Attachment 2: Present Design for the Slow-Extracted Beam Lines (K-Hall)

(1st Phase)



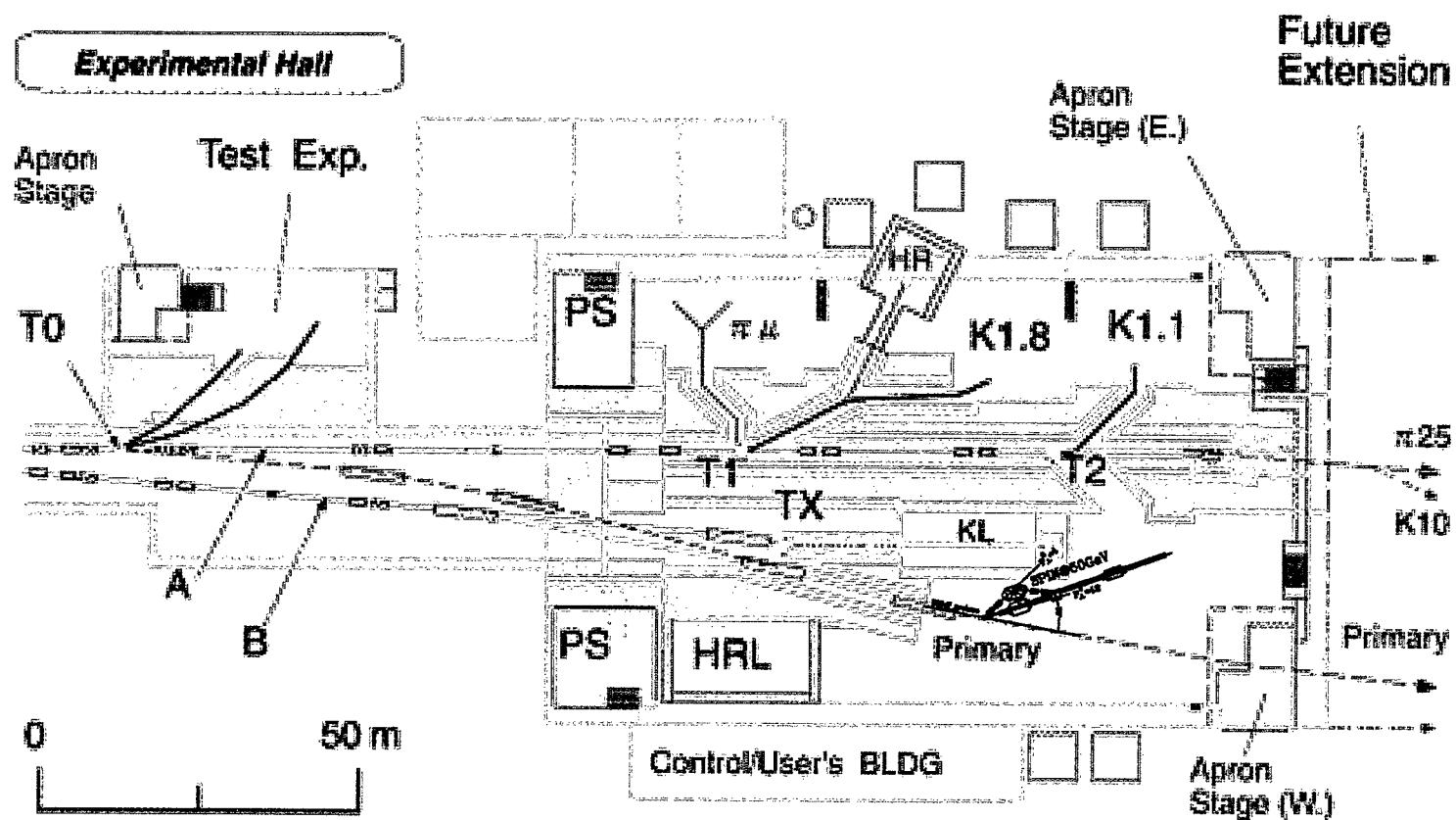
HRL: High Radiation Laboratory

FMA: Field Measurement Area

LD: Loading Deck

PS: Power Supply Stage

(2nd Phase)

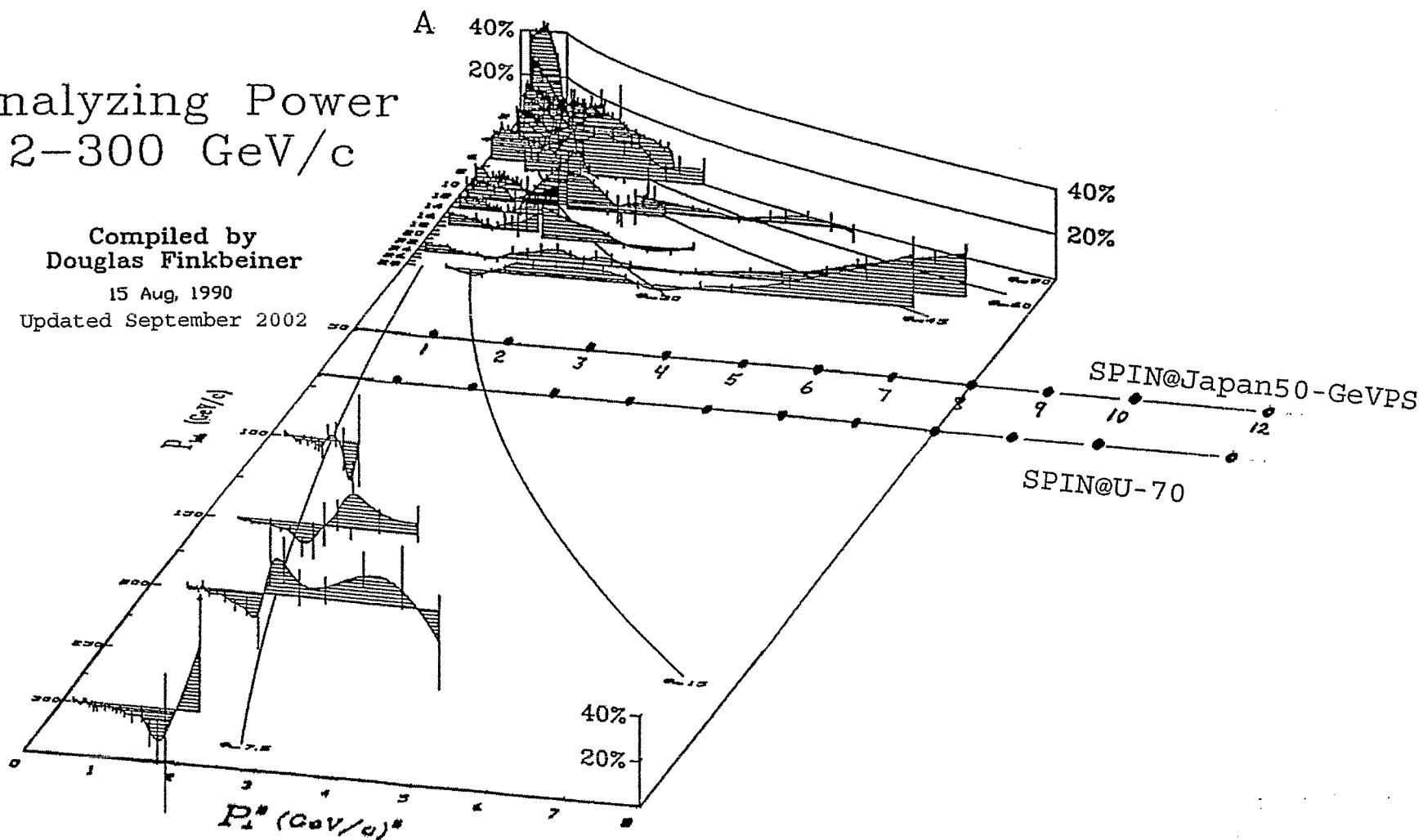


Analyzing Power 2-300 GeV/c

Compiled by
Douglas Finkbeiner

15 Aug, 1990

Updated September 2002



Proton-proton Elastic Analyzing Power from 2 to 300 GeV/c plotted against P_{lab} and P_{\perp}^2 .