2008 March 6
NP08
Mito

HARD COLLISIONS of SPINNING PROTONS

A. D. KRISCH
SPIN PHYSICS CENTER
Univ. of MICHIGAN

SPIN@J-PARC PROPOSAL

Analyzing Power A_n and A_{nn} in 30-50 GeV Very-High-$P_\perp^2$ Proton-Proton Elastic Scattering

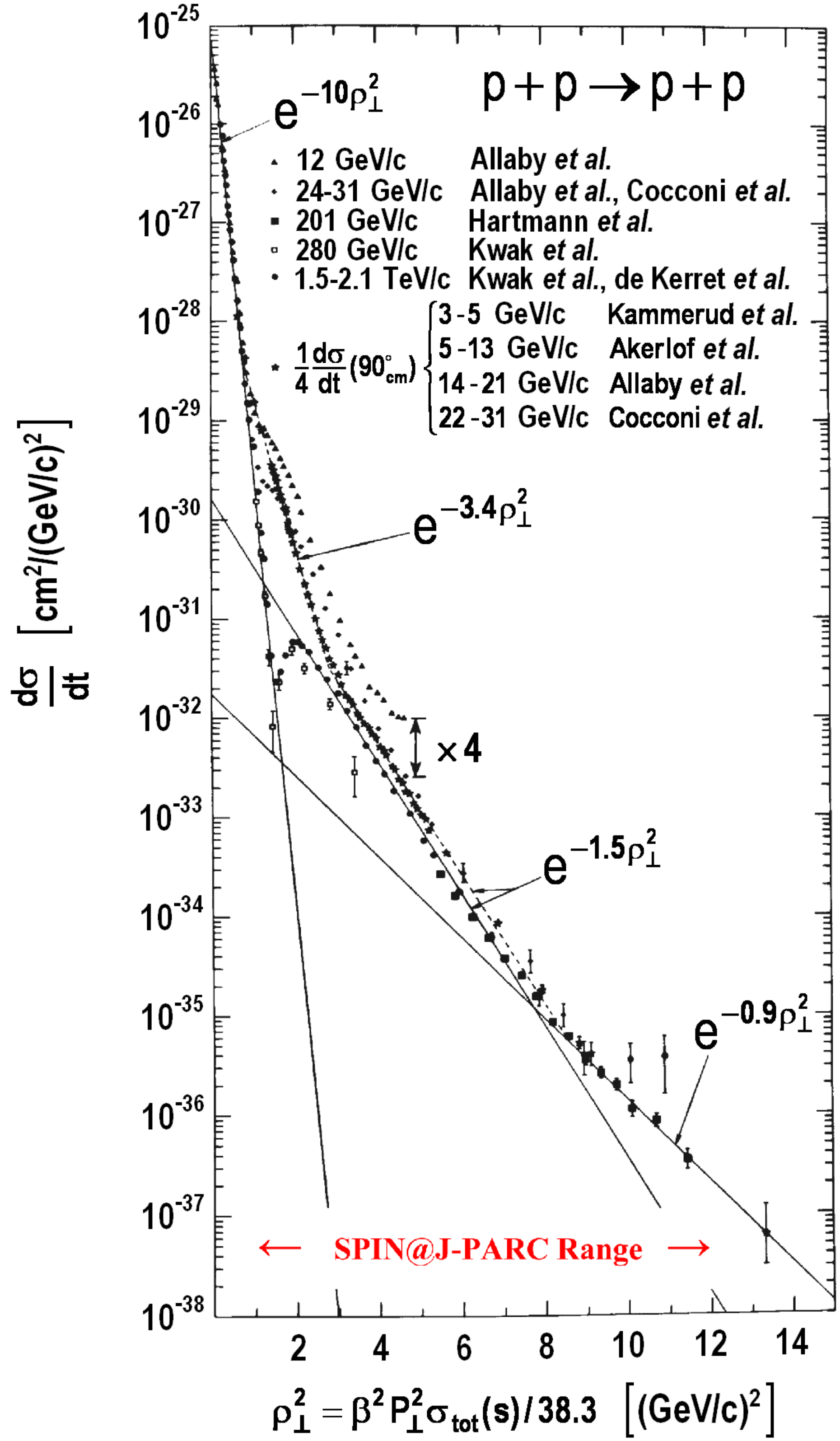
A.W. CHAO, F.Z. KHIARI[§], A.D. KRISCH*, M.A. LEONOVA, V.G. LUPPOV, V.S. MOROZOV, R.S. RAYMOND, D.W. SIVERS, and V.K. WONG	UNIVERSITY OF MICHIGAN, ANN ARBOR, USA
D.G. CRABB	UNIVERSITY OF VIRGINIA, CHARLOTTESVILLE, USA
J. R. O'FALLON[#]	U.S. DEPARTMENT OF ENERGY, USA
Y.S. DERBENEV	JEFFERSON LABORATORY, USA
K. YONEHARA	FERMILAB, USA
S. ISHIMOTO	KEK, TSUKUBA, JAPAN
K. HATANAKA and STUDENTS	RCNP, OSAKA, JAPAN
T.-A. SHIBATA	TOKYO INSTITUTE OF TECHNOLOGY, TOKYO, JAPAN
Y. SAKEMI	TOHOKU UNIVERSITY, JAPAN
G. FIDECARO[#] and M. FIDECARO[#]	CERN, SWITZERLAND
A. I. MYSNIK, A.F. PRUDKOGLYAD, S.M. TROSHIN, and M.N. UKHANOV	INSTITUTE FOR HIGH ENERGY PHYSICS, PROTVINO, RUSSIA
A.M. KONDRATENKO	GOO ZARYAD, NOVOSIBIRSK, RUSSIA
W.T.H. VAN OERS	TRIUMF, VANCOUVER, CANADA

* SPOKESPERSON, [#] RETIRED, [§] NOT YET CONFIRMED

PROTON-PROTON ELASTIC CROSS-SECTION

UNPOLARIZED $d\sigma/dt$ for all
$p + p \rightarrow p + p$ data above 3 GeV
PLOTTED vs. SCALED $P_\perp^2$ VARIABLE

NOTE: DIFFERENT SLOPES
1st EVIDENCE for
PROTON STRUCTURE
(Akerlof *et al.* 1966)



UNPOLARIZED BEAM and TARGET

$$\left\langle {d\sigma}/{dt} \right\rangle \propto \left(N_{\uparrow\uparrow} + N_{\uparrow\downarrow} + N_{\downarrow\uparrow} + N_{\downarrow\downarrow} \right)$$

EITHER BEAM or TARGET POLARIZED (ONE-SPIN)

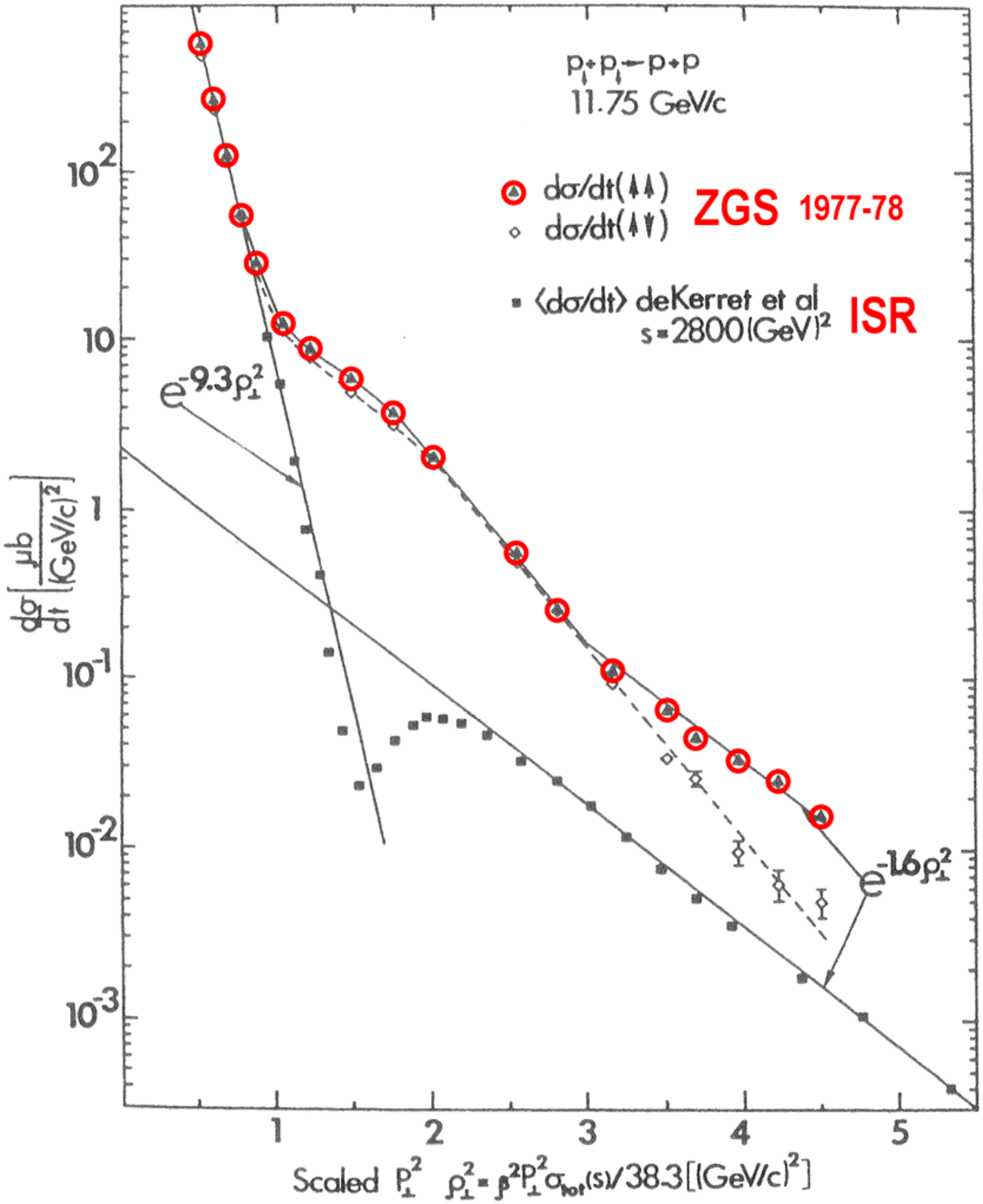
$$A_n = \frac{A_{meas}}{P_T} = \frac{\left(N_{\uparrow} - N_{\downarrow} \right)}{P_T \left(N_{\uparrow} + N_{\downarrow} \right)}$$

BOTH BEAM and TARGET POLARIZED (TWO-SPIN)

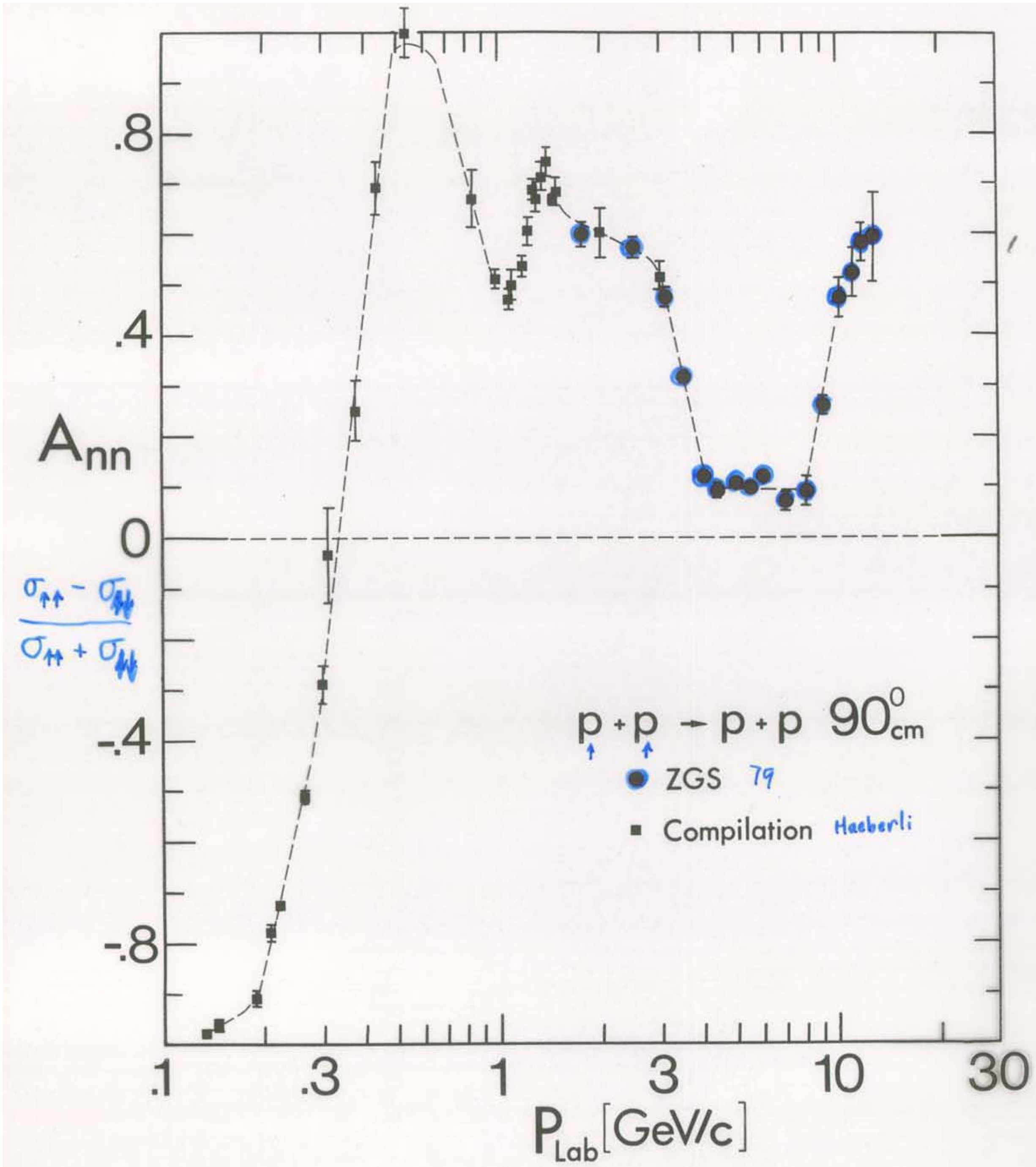
$$A_{nn} = \frac{A_{meas}}{P_T P_B} = \frac{\left(N_{\uparrow\uparrow} - N_{\uparrow\downarrow} - N_{\downarrow\uparrow} + N_{\downarrow\downarrow} \right)}{P_T P_B \left(N_{\uparrow\uparrow} + N_{\uparrow\downarrow} + N_{\downarrow\uparrow} + N_{\downarrow\downarrow} \right)}$$

A_{meas} = MEASURED ASYMMETRY
P_T and P_B = TARGET and BEAM POLARIZATIONS
N_i and N_{ij} = NORMALIZED ELASTIC EVENT RATES

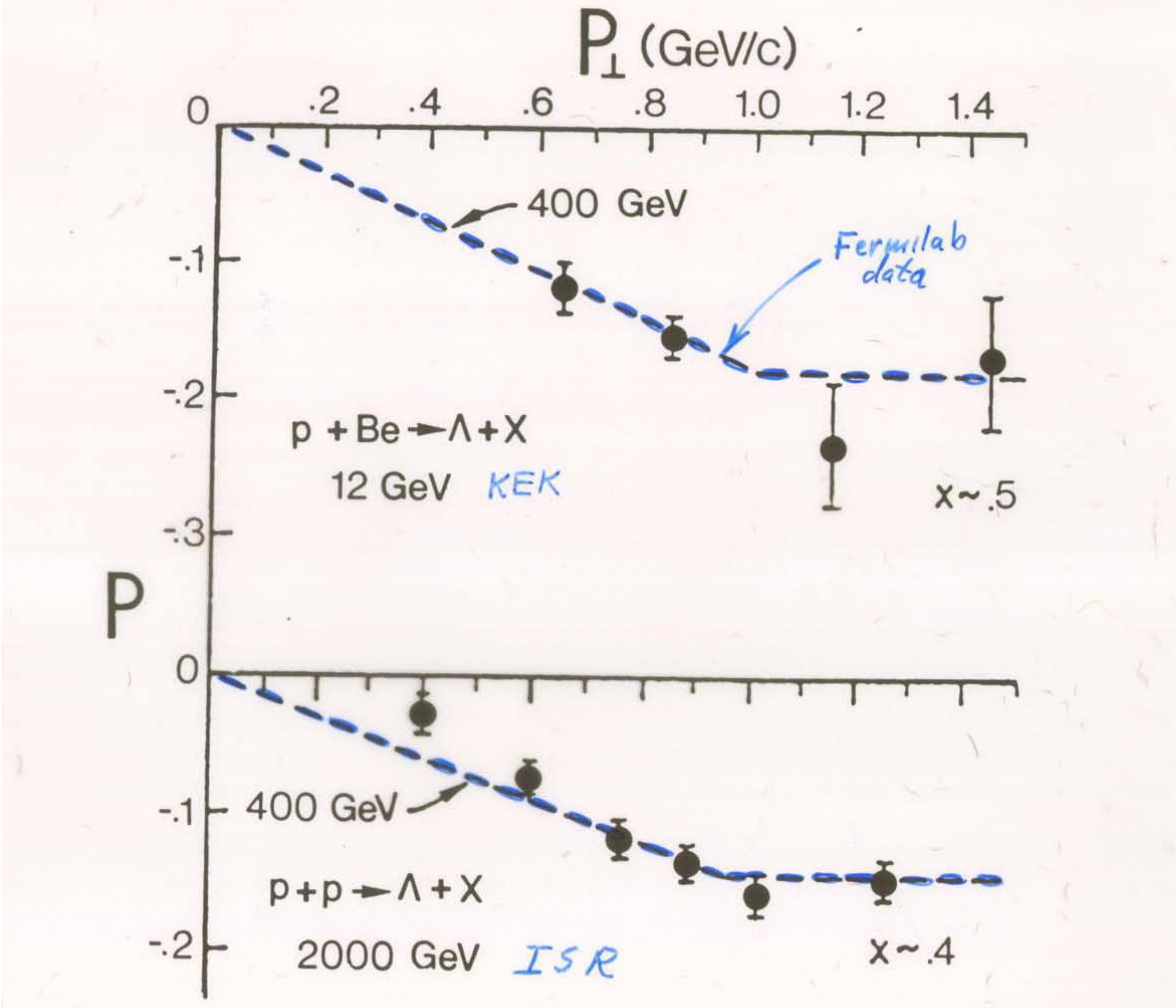
ZGS 2-SPIN PROTON-PROTON ELASTIC CROSS SECTION



COMPILATION: Proton-Proton Elastic A_{nn} at 90^{o}_{cm} 10 MeV to 12 GeV

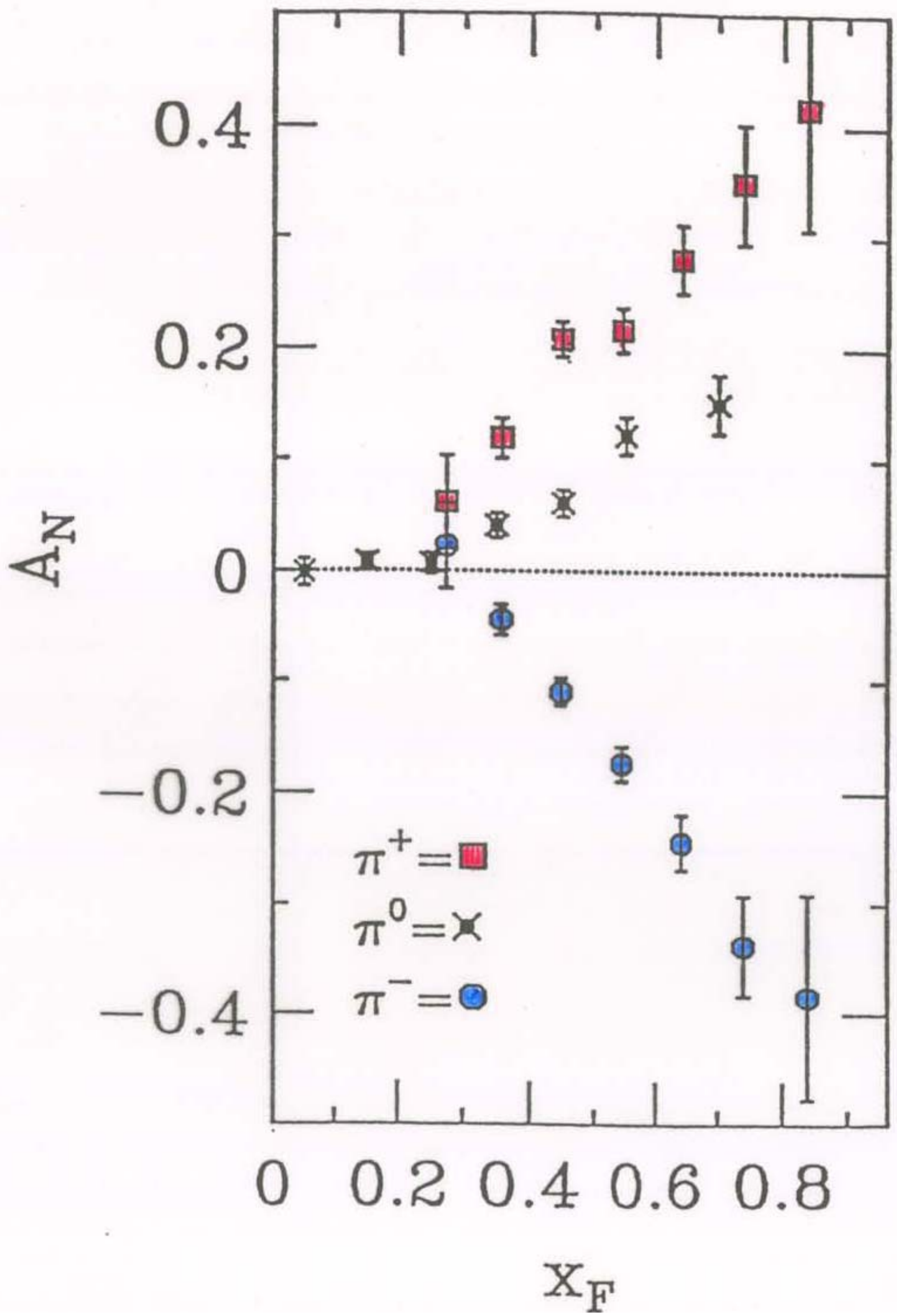


FERMILAB HYPERON POLARIZATION



FERMILAB: INCLUSIVE PION A_n from 200 GeV POLARIZED PROTONS

Yokosawa et al. ~1990



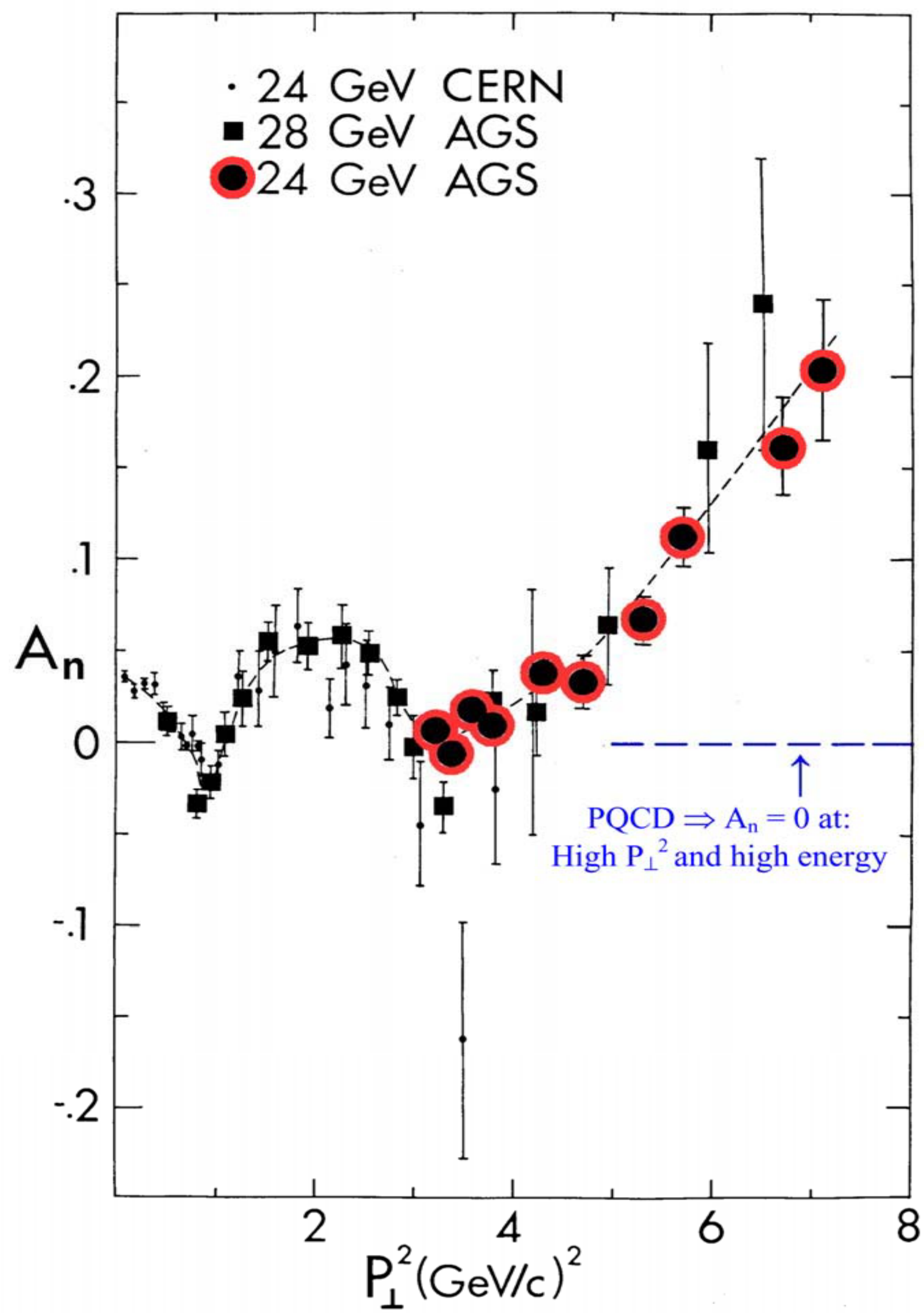
AGS A_n DATA

PERTURBATIVE QCD $\Rightarrow$
$A_n = 0$ at HIGH $P_\perp^2$ and HIGH ENERGY

$A_n \neq 0 \Rightarrow$
PROBLEM WITH PQCD?

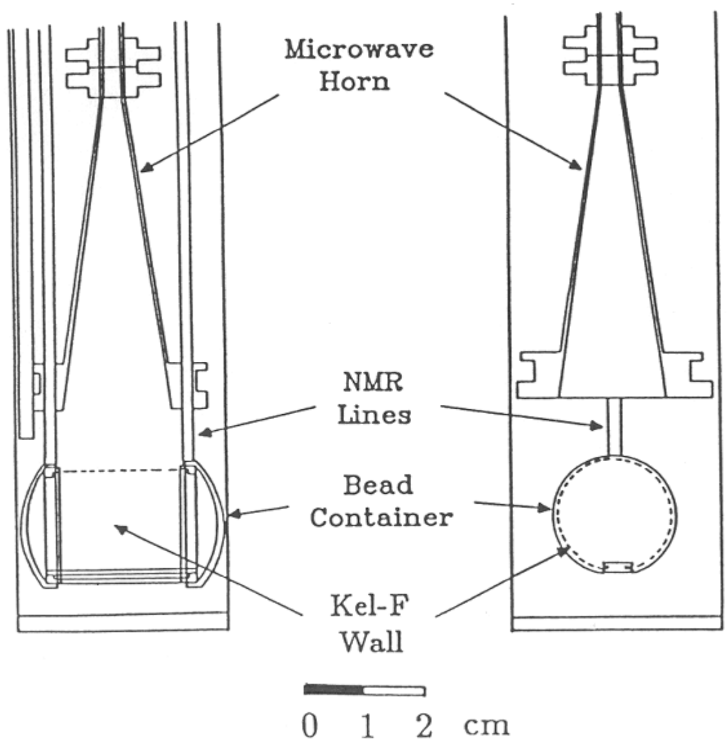
NO MODEL CAN EXPLAIN ALL
HIGH-$P_\perp^2$ SPIN EFFECTS (A_n & A_{nn})

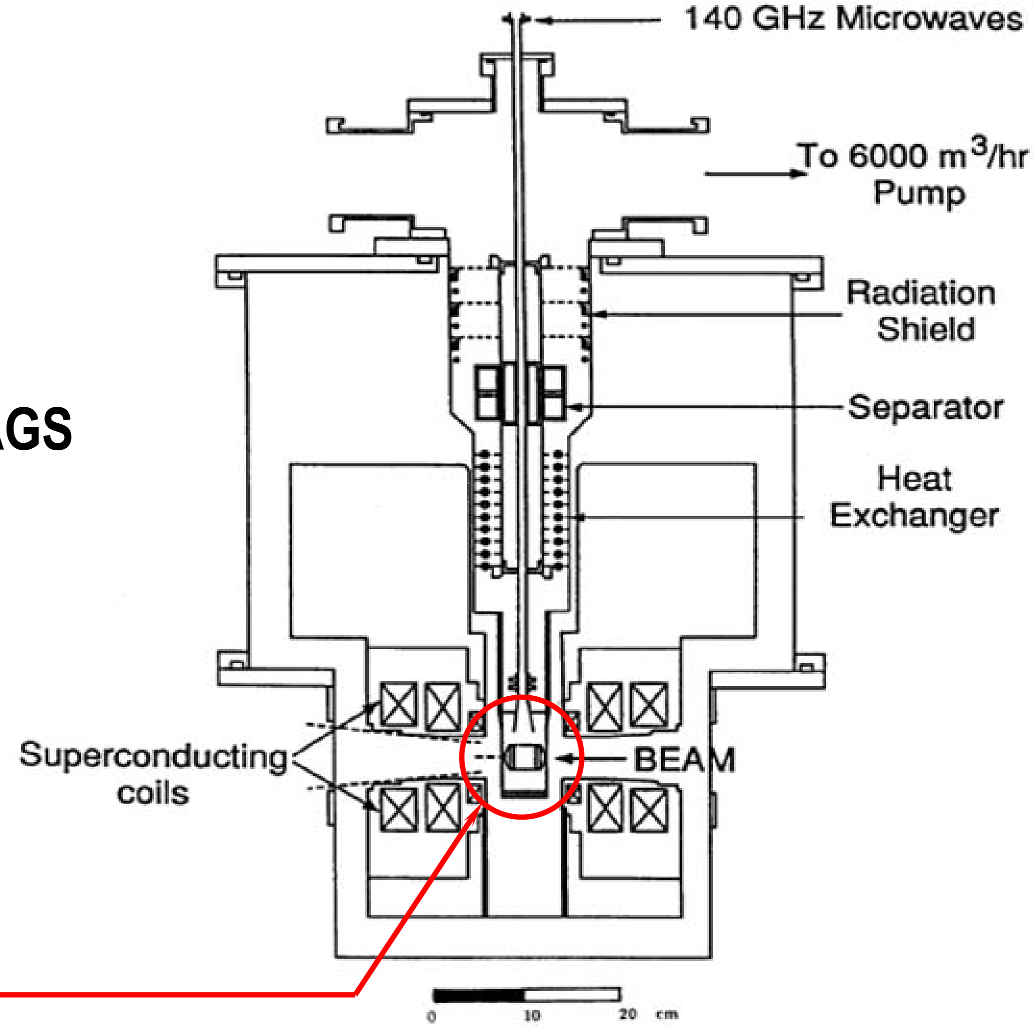
GOAL at J-PARC
MEASURE A_n (and A_{nn})
up to $P_\perp^2 = 12\ (GeV/c)^2$



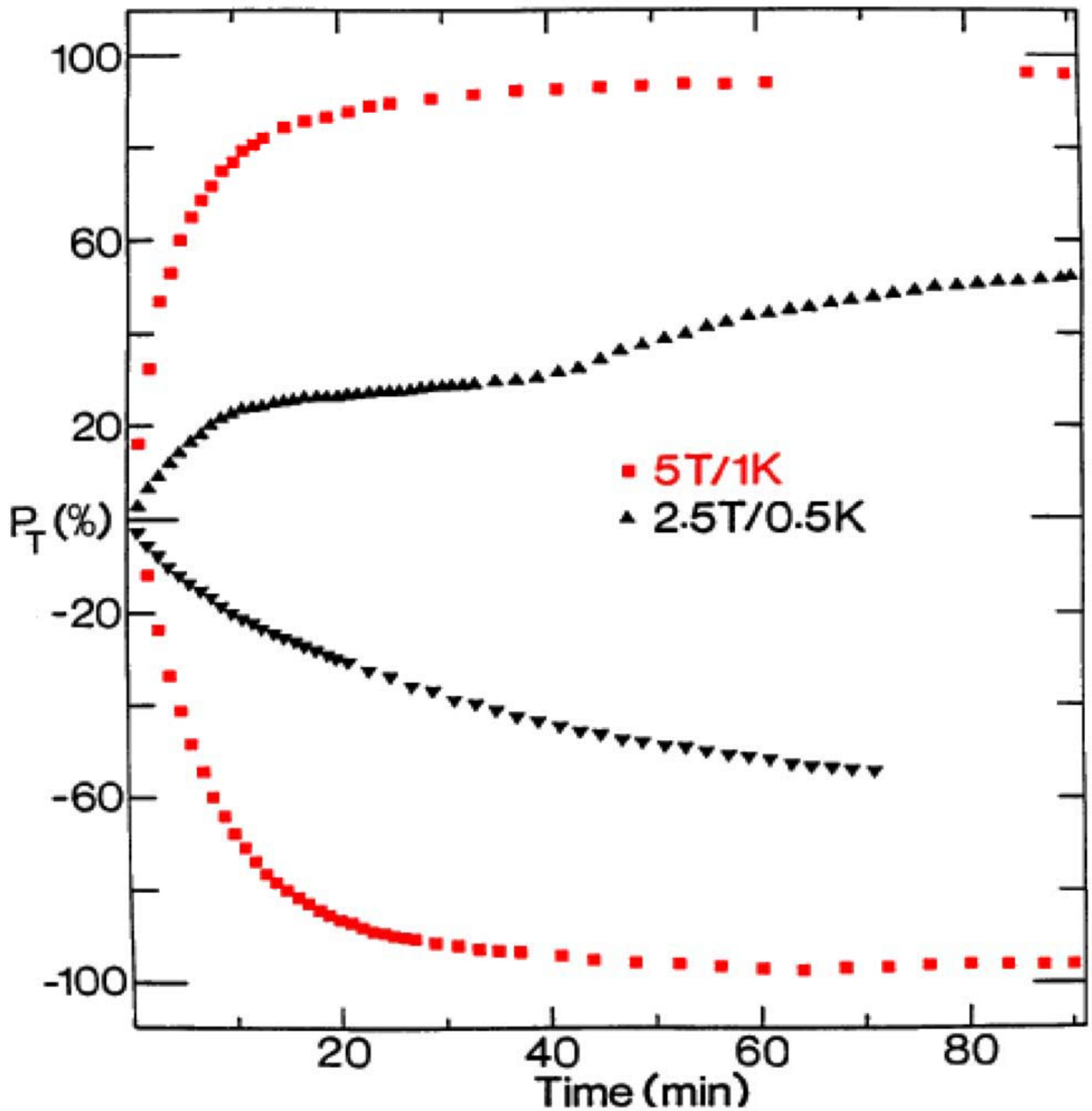
MICHIGAN SOLID POLARIZED PROTON TARGET
NOW at KEK

- Highly uniform 5 T field
- 1 W of cooling power at 1 K
- 140 GHz / 20 W microwaves
- NH_3 in target cavity
- 96% proton polarization in NH_3
- 85% average over 3-month at AGS

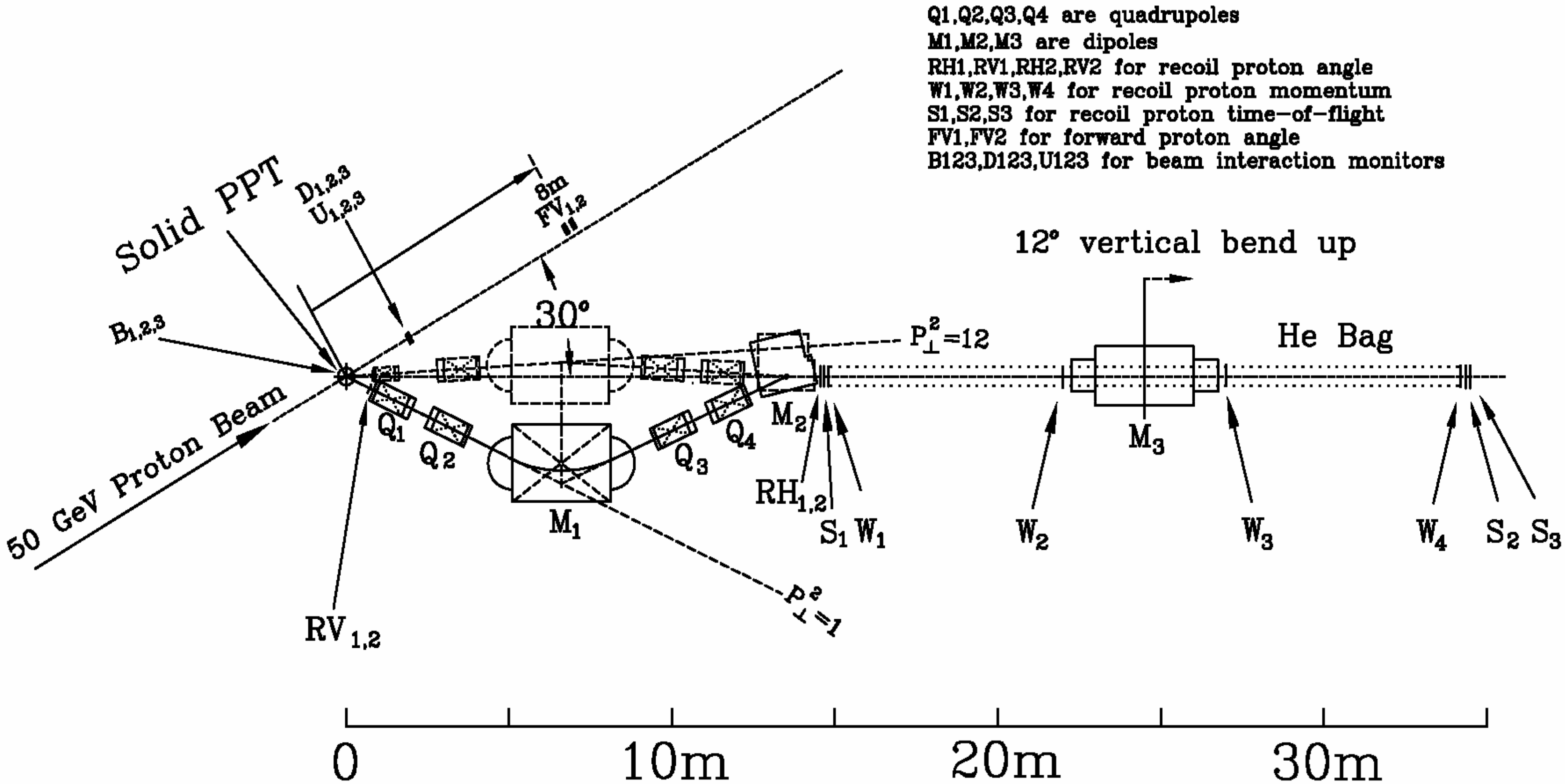




POLARIZING TIME for IRRADIATED NH_3



PROPOSED SPIN@J-PARC SPECTROMETER



MAGNET PARAMETERS

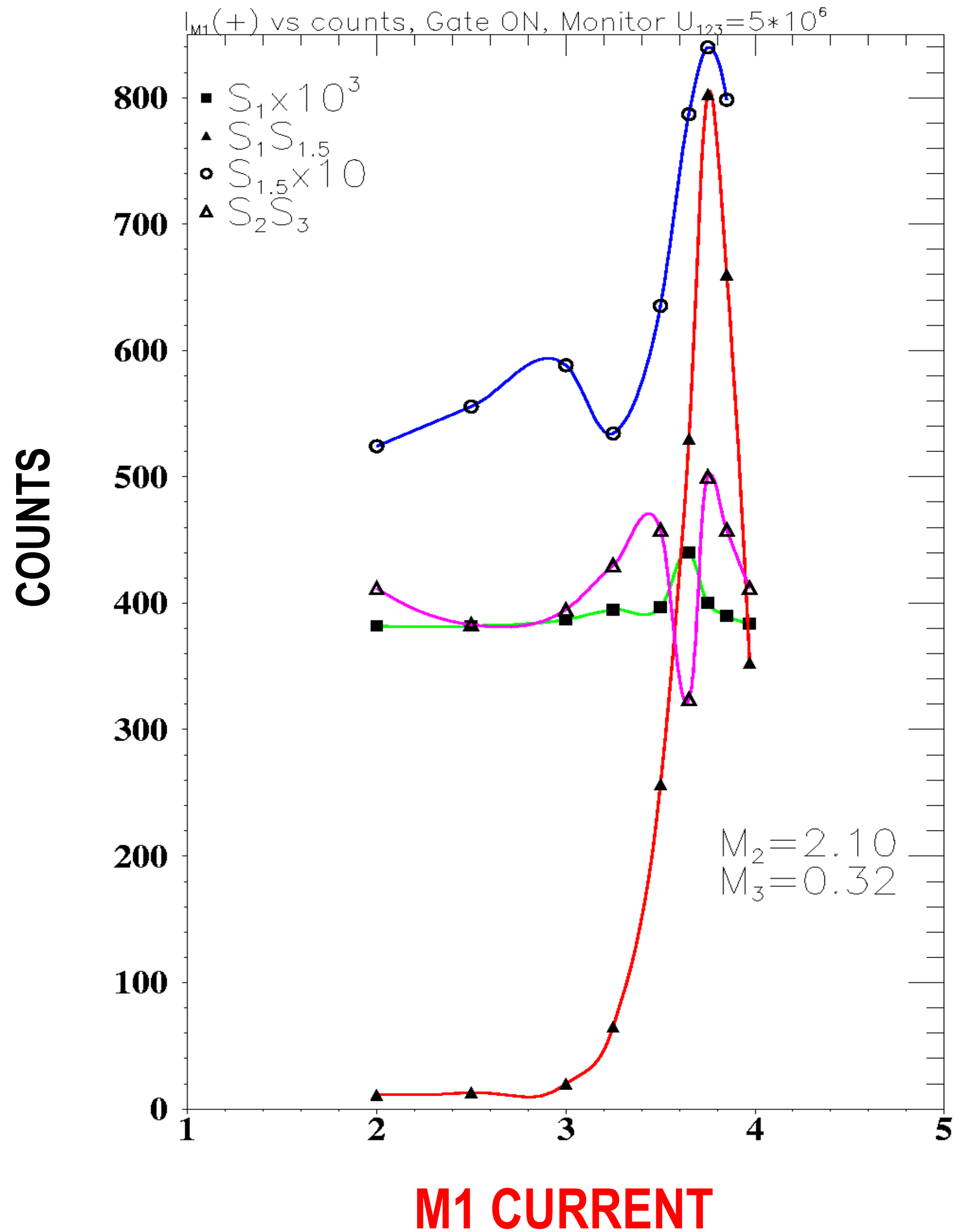
MAGNET	LENGTH (m)	DIAMETER OR GAP (cm)	B'_{MAX} (T/m)	B_{MAX} (T)
Q_1,Q_2,Q_3,Q_4	1.00	20	14.8	
Q_1^{SUPER}	0.60	10x16	60.8	
M_1,M_3	3.00	20		1.8
M_2	1.50	20		1.8

SPIN@U-70 SPECTROMETER

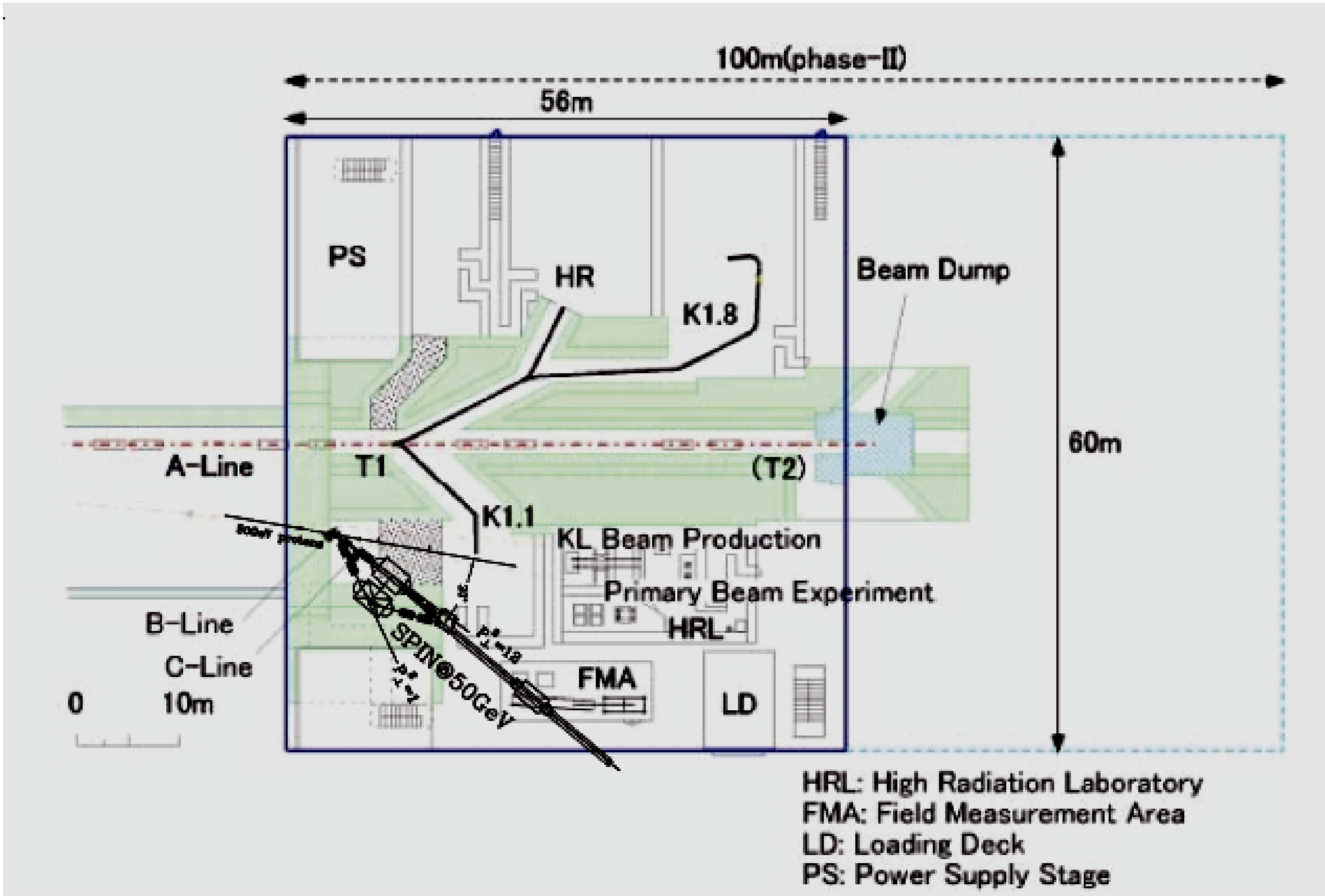
SPIN@U70 TEST RUN

with ONLY FIRST HALF of RECOIL SPECTROMETER

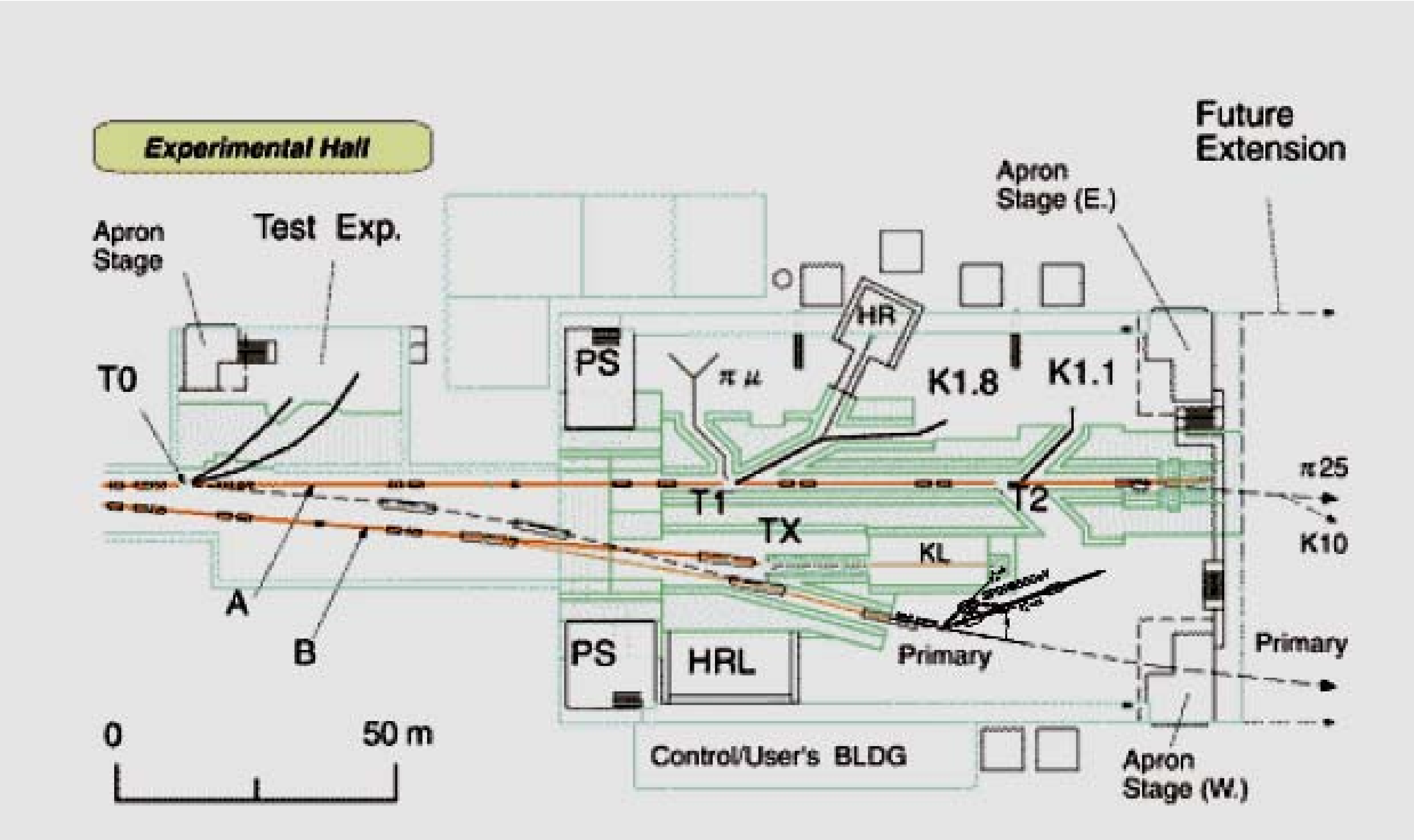
SIGNAL : BACKGROUND ~ 80 : 1



POSSIBLE SPIN@J-PARC PLACEMENT



2nd POSSIBLE SPIN@J-PARC PLACEMENT



PROTON-PROTON ELASTIC CROSS-SECTIONS

PPT THICKNESS:

$T = N_0 \cdot \rho \cdot 3.2\text{ cm} \cong 2\ 10^{23}$ protons cm^{-2}

BEAM INTENSITY:

$I_B = 10^{11}$ protons / s

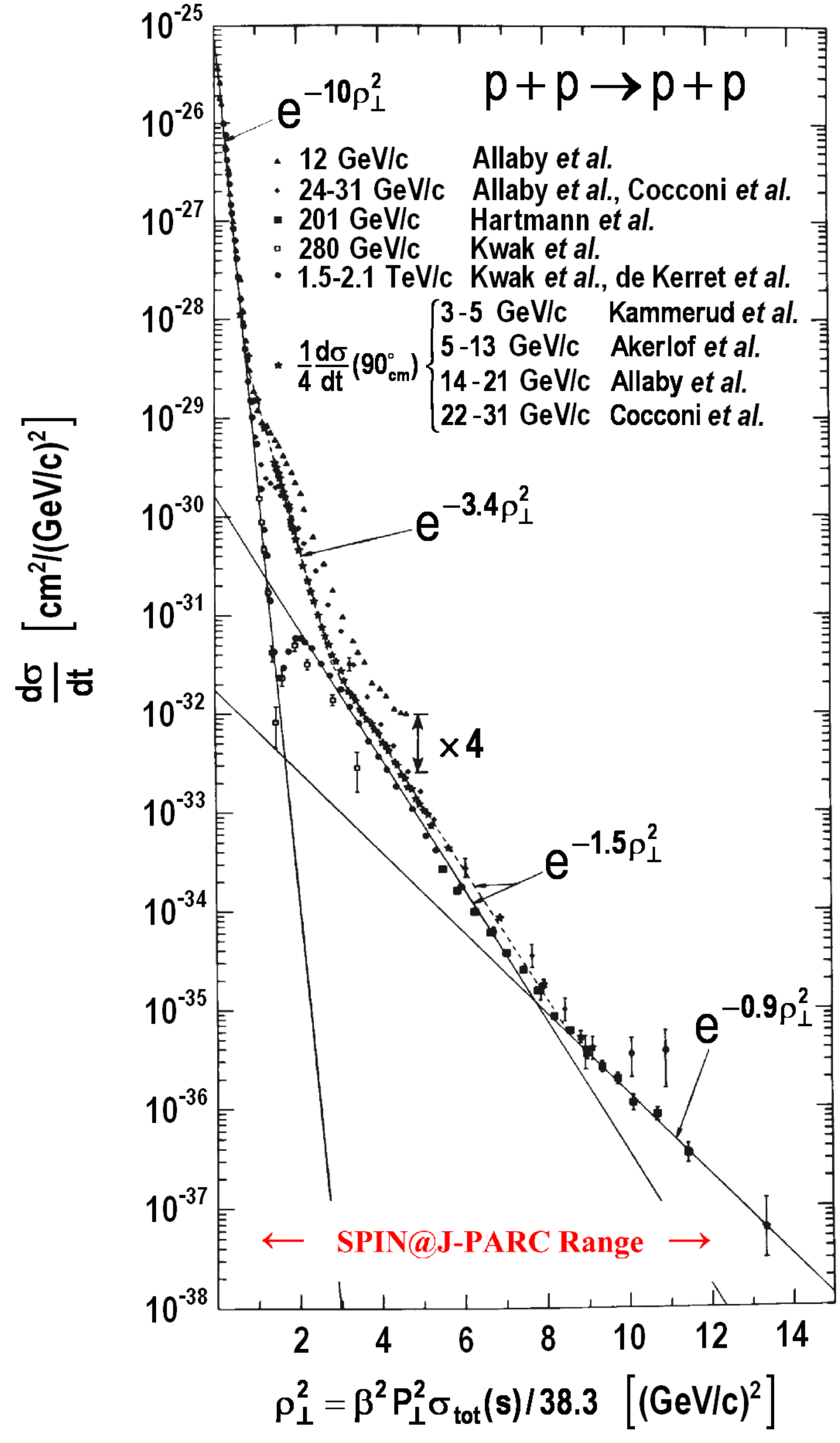
TIME-AVERAGED LUMINOSITY:

$L = I_B \cdot T \cong 2\ 10^{34}\ s^{-1}\ cm^{-2} \Rightarrow$

SPIN@J-PARC events/hour

$$= L\left(d\sigma/dt\right)\left(\frac{\Delta t \cdot \Delta\phi \cdot \varepsilon}{2\pi}\right) 3600\ s/hr$$

$$= 6\left(d\sigma/dt\ [nb]\right)\cdot\left(\Delta t\ [(GeV/c)^2] \cdot \Delta\phi\ [mr]\right)$$



EVENT RATES & ERRORS in A_n

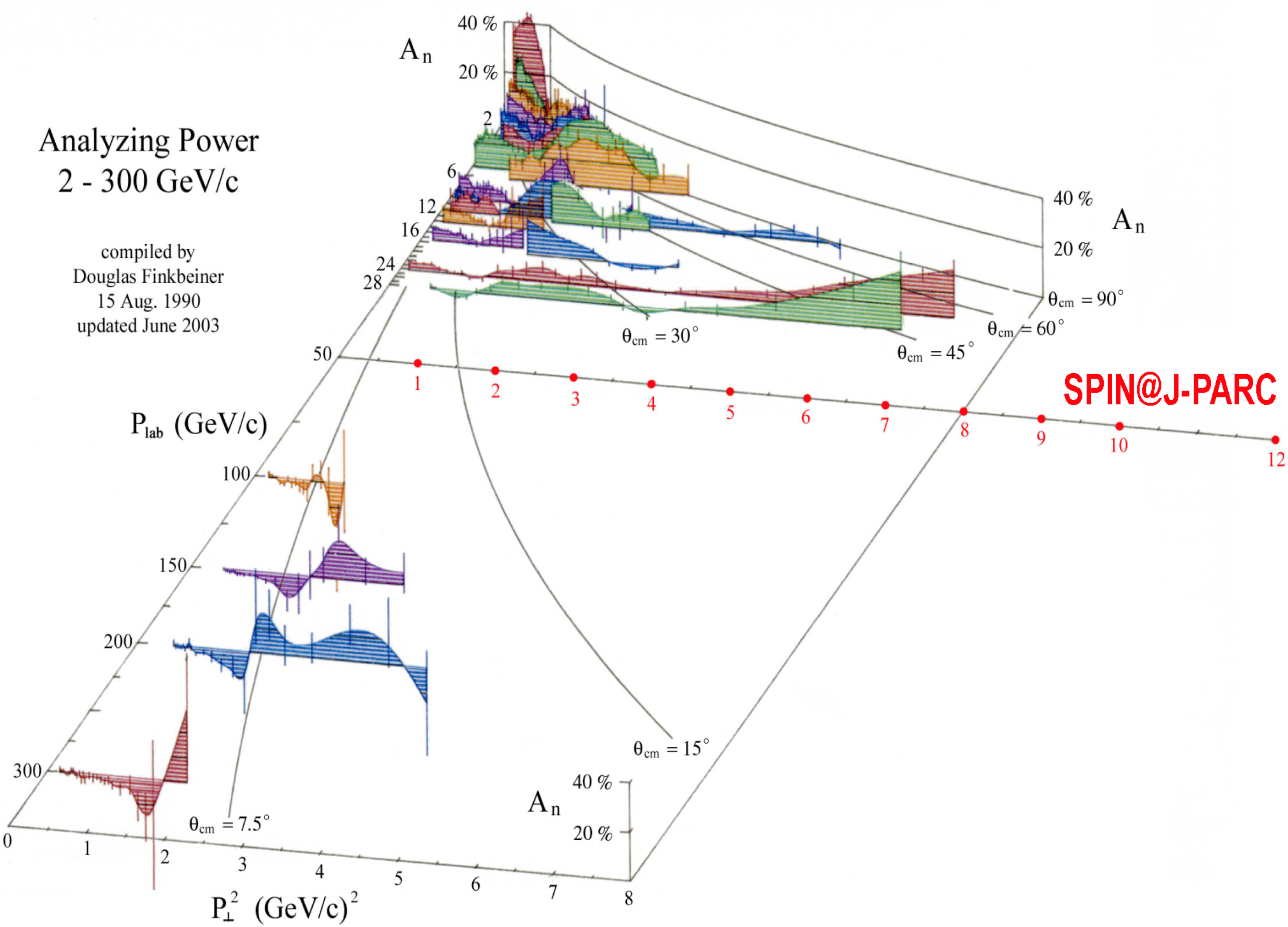
$P_\perp^2$ $(GeV/c)^2$	Δt $(GeV/c)^2$	$\Delta\phi$ mr	$d\sigma/dt$ $nb/(GeV/c)^2$	EVENTS per hour	HOURS	EVENTS	$\Delta A_n = [.85\sqrt{N}]^{-1}$ (%)	
1.0	0.06	159	4000	230000	100	$2.3\cdot10^7$	0.03	
2.0	0.09	177	90	8600	100	$8.6\cdot10^5$	0.1	
3.0	0.25	194	19	5500	100	$5.5\cdot10^5$	0.2	
4.0	0.35	210	4.0	1800	100	$1.8\cdot10^5$	0.3	
5.0	0.45	225	0.9	550	100	$5.5\cdot10^4$	0.5	
6.0	0.56	240	0.22	180	200	$3.6\cdot10^4$	0.6	
7.0	0.67	254	0.055	56	200	$1.1\cdot10^4$	1.1	Super Q_1
8.0	0.79	268	0.016	20	300	$6.0\cdot10^3$	1.5	"
9.0	0.92	282	0.0047	7.3	400	$2.9\cdot10^3$	2.2	"
10.0	1.06	296	0.0017	3.2	600	$1.9\cdot10^3$	2.7	"
12.0	1.25	324	0.0003	0.73	800	$4.4\cdot10^2$	4.9	"

TOTAL HOURS: 3000 + 500 (TUNE-UP)
WITH 10^{11} PROTONS/sec

NOTE: WITH POLARIZED BEAM (P_B) and POLARIZED TARGET (P_T)

$\Delta A_{nB} = (P_B\sqrt{N})^{-1}$; $\Delta A_{nT} = (P_T\sqrt{N})^{-1}$; $\Delta A_{nn} = (P_B P_T \sqrt{N})^{-1}$ and $\Delta d\sigma/dt = (\sqrt{N})^{-1}$

ANALYZING POWER for PROTON-PROTON ELASTIC SCATTERING



Ratio Spin-Parallel : Spin-Antiparallel Proton-Proton Elastic Cross-Sections