Status Report on the Jet Target

T. Wise, Univ. of Wisconsin
June 17, 2002

for
RHIC Spin Collaboration Meeting X
RIKEN BNL Research Center

JET TARGET STATUS JUNE17 02

Quick review of idea

Jet H target of known polarization $|Q| \approx 0.9$

P beam of unknown polarization $|P| \approx 0.5$?

Unknown Ay 0.03 ~~0.5~~ expected for p-p elastics)

Method relies on $A_{y_{beam}} = A_{y_{target}}$

WORKING GROUP EXISTS -not a formal collaboration

CURRENT MEMBERS on project in no particular order:

[Mail list is **much** longer]

WISCONSIN	T. WISE	
	W. HAEBERLI	
	M. CHAPMAN	tech support
IUCF	E. STEPHENSON	
BNL	A. BRAVAR	
	G. BUNCE	
	G. MAHLER	
	W. MENG	
	Y. MAKDISI	
	A. ZELINSKI	

To assist in near future:

Don Barton

D. Hseuh

STRATEGY

1) MEASURE JET POLARIZATION WITH BRP
(to ≈ 1% hopefully) also expect $Q\downarrow \neq Q\uparrow$

2) GENERATE θ YIELDS NEAR 90°
by rotating through $Q\downarrow,\uparrow$, $P\downarrow,\uparrow$

Example

$$Y_{L\uparrow\uparrow} = I_\uparrow t\, \varepsilon_L \sigma_0 \left[1 + P_\uparrow A_Y + Q_\uparrow A_Y + A_{YY} P_\uparrow Q_\uparrow\right]$$

6 unknowns: $\frac{I_\uparrow}{I_\downarrow}$, $\frac{\varepsilon_L}{\varepsilon_R}$, $P_\uparrow$, $P_\downarrow$, A_{YY}, A_Y ← we can measure

NOTE: $t\downarrow = t\uparrow = t$

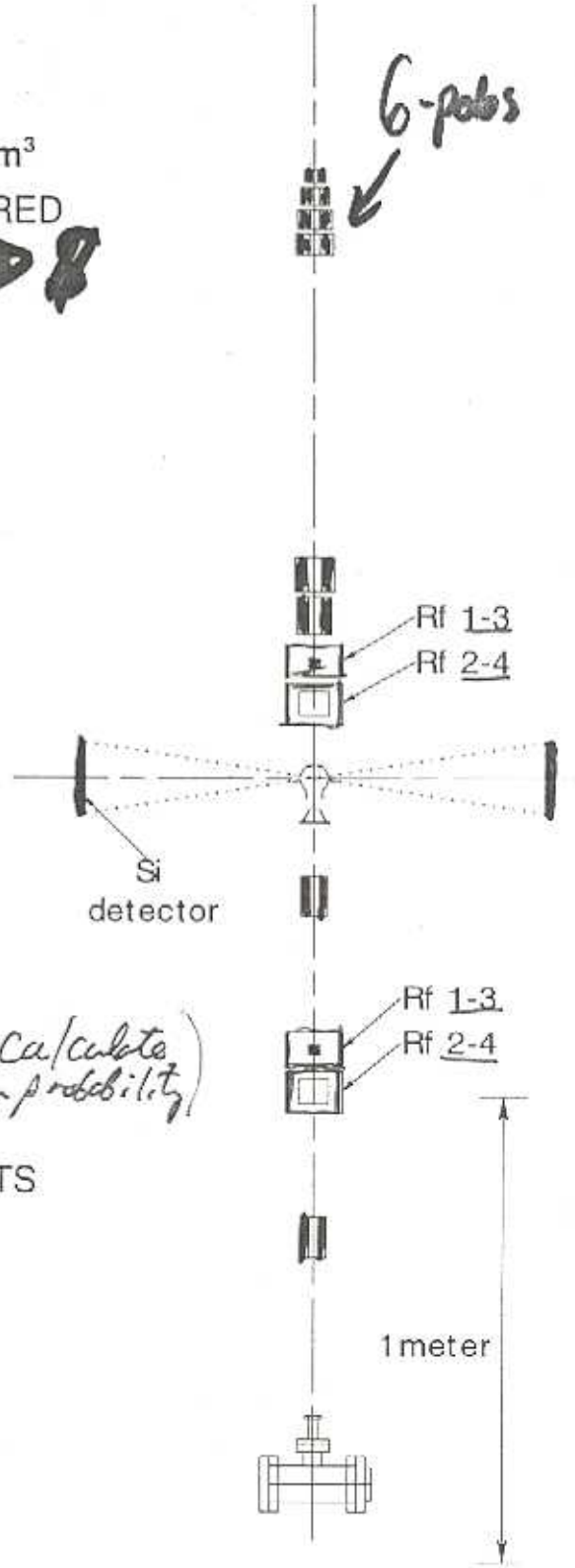
target constant to $<10^{-4}$ level

We expect $I\downarrow \neq I\uparrow$
and $P\downarrow \neq P\uparrow$

An independent measurement
of beam Luminosity is helpful
but not required.

DESIGN ISSUES

1) • JET NOT A POINT TARGET
   9mm long with density **7×10^{11} atom/cm^3**
2) LONG 50-80cm SILICON ARMS REQUIRED
   for bunch separation and resolution.
3) VERTICAL JET ORIENTATION
4) • TARGET GUIDE FIELD
   a) 0.1 T with **$\Delta B/B = 6 \times 10^{-3}$**
   b) 60mm free aperture
   c) no zero crossing along JET path
   d) low Bdl from JET to Si detectors
   e) low stray field at rf transitions
5) JET HAS H_2 DILUTION
   -need to measure
6) HIGH JET GAS LOAD
   a) 1.6×10^{-3} mbar-liter/s H_2
   b) must capture ≈ 99% of JET
   c) geometry makes pumping difficult
7) RESONANCES –special BRP mode
   to observe resonances (Theory Student? Calculate transition probability)
8) • 2:00 REGION IS CROWDED
9) • COMPATABILITY WITH EXPERIMENTS
   We want to run jet during heavy ions
   OR rapidly remove from ring
   (and install)



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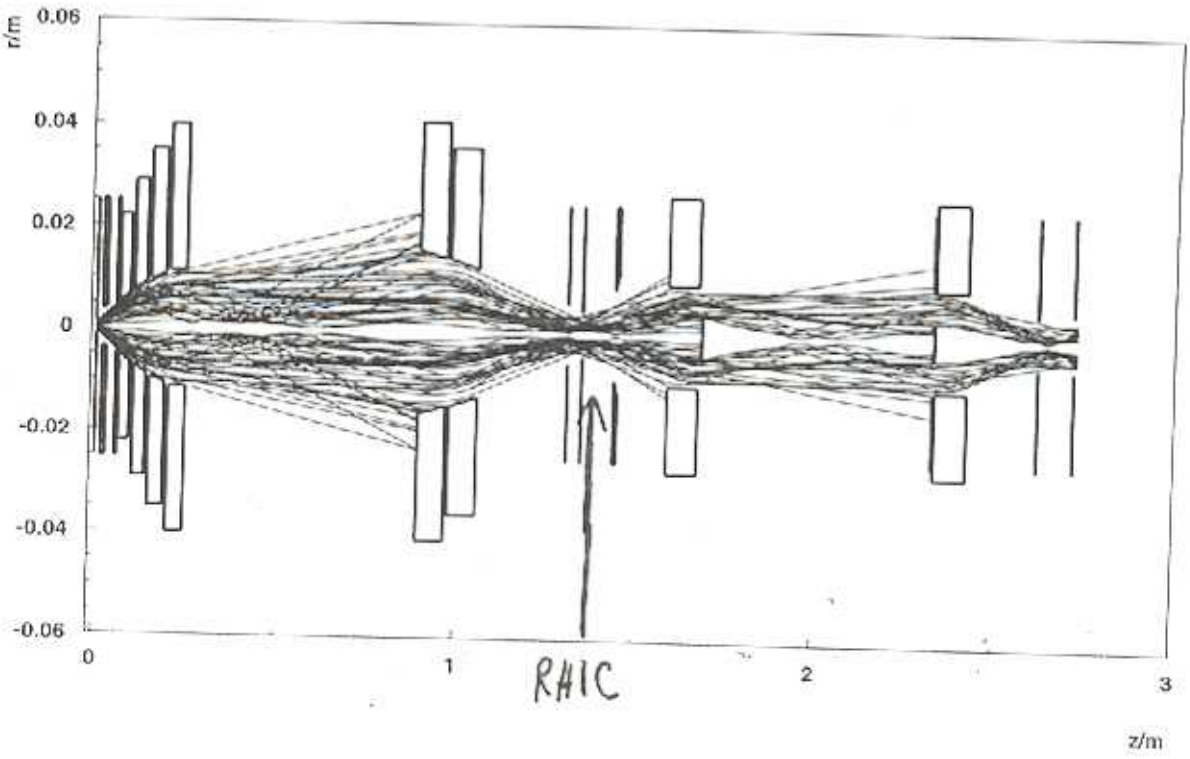


50 starting rays, step 1 entire path

file name: /home/wise/HKcode_outputs/plot_st1.ps

TARGET MAGNET

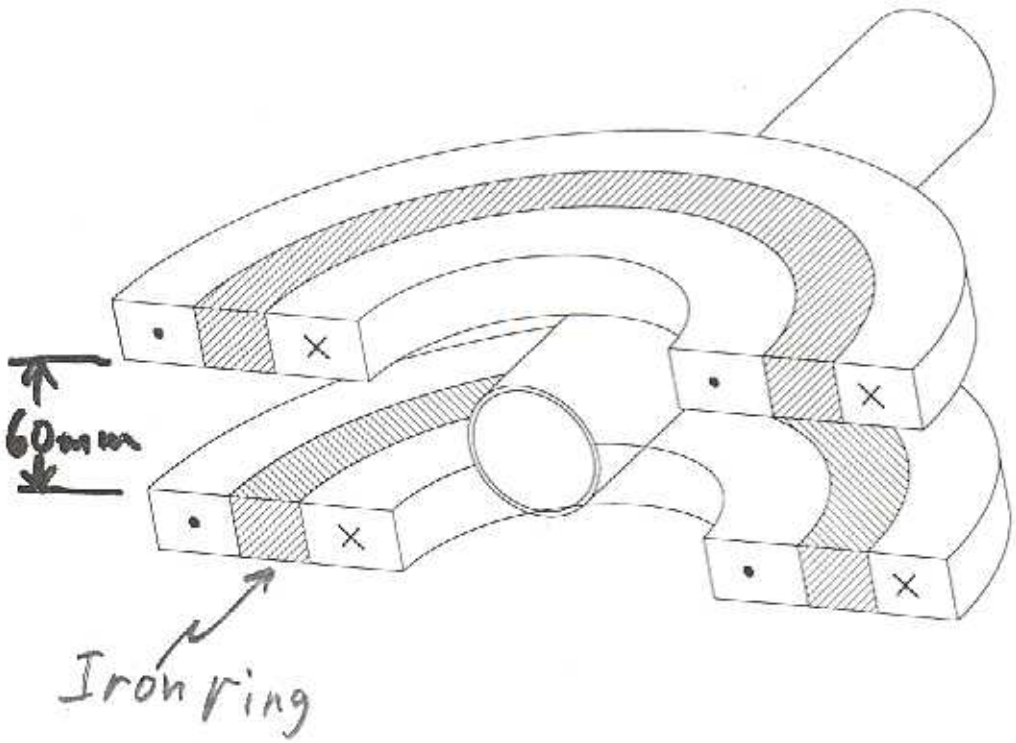
WHY 0.1T WITH UNIFORMITY $\Delta B/B = 6 \times 10^{-3}$?
MAXIMUM INTENSITY REQUIRES 2 HYPERFINE STATES

P+ (1+4) or P- (2+3)

$$|P| = \left(1 + \frac{\chi}{\sqrt{1+\chi^2}}\right)/2 \simeq 0.95 @ 0.1\,T \quad (\chi = 2)$$

DEPOLARIZING RESONANCES. We need uniformity to slip between closely spaced resonances

4-COIL DESIGN WITH IRON RING MINIMIZES $\int$ Bdl FOR ESCAPING RECOIL PROTONS



W. Meng design

$\int B \cdot dl =$ 18 G-cm

- Vorylon -

HERMES Resonances

also 1↔2 + 3↔4

H. Kolster. Thesis

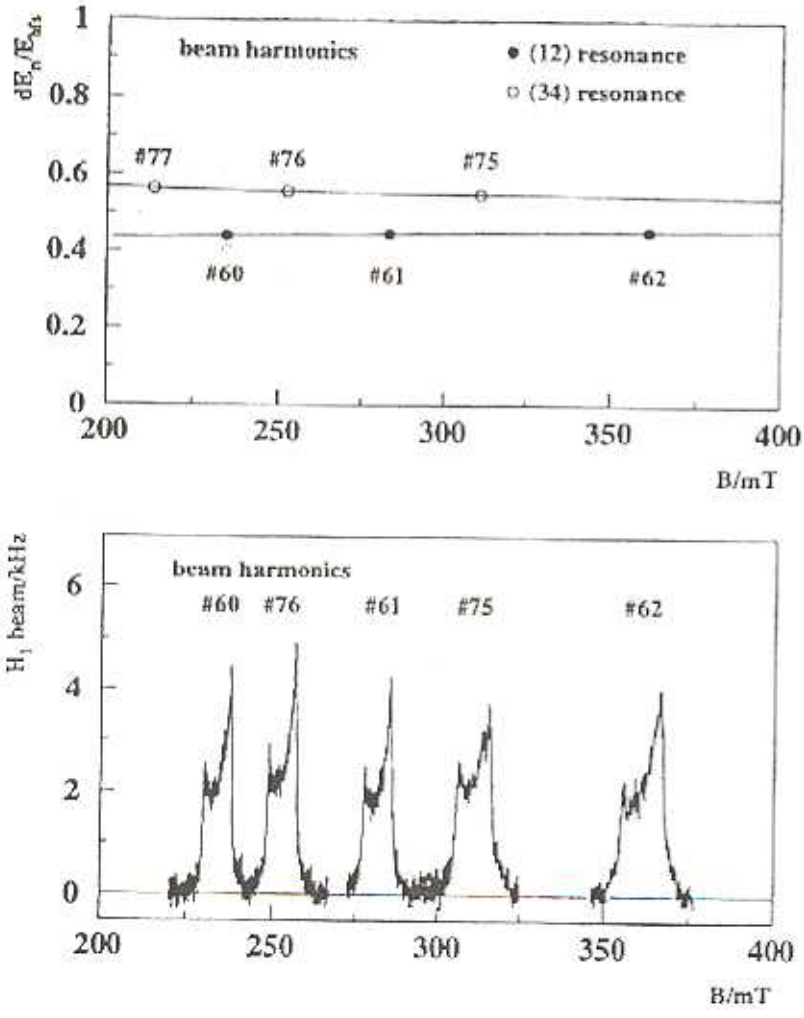
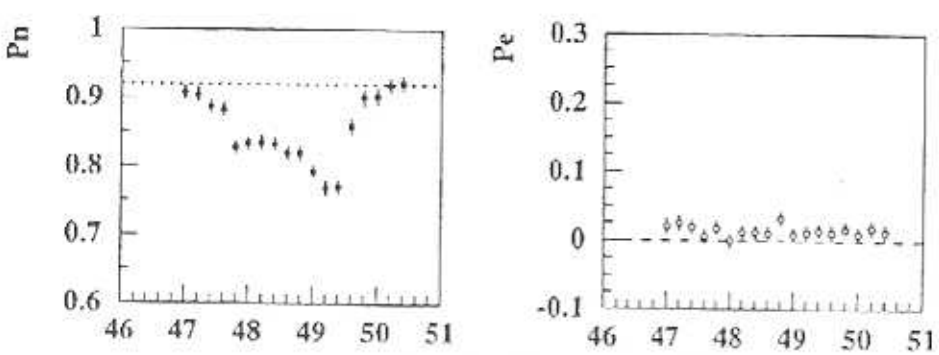
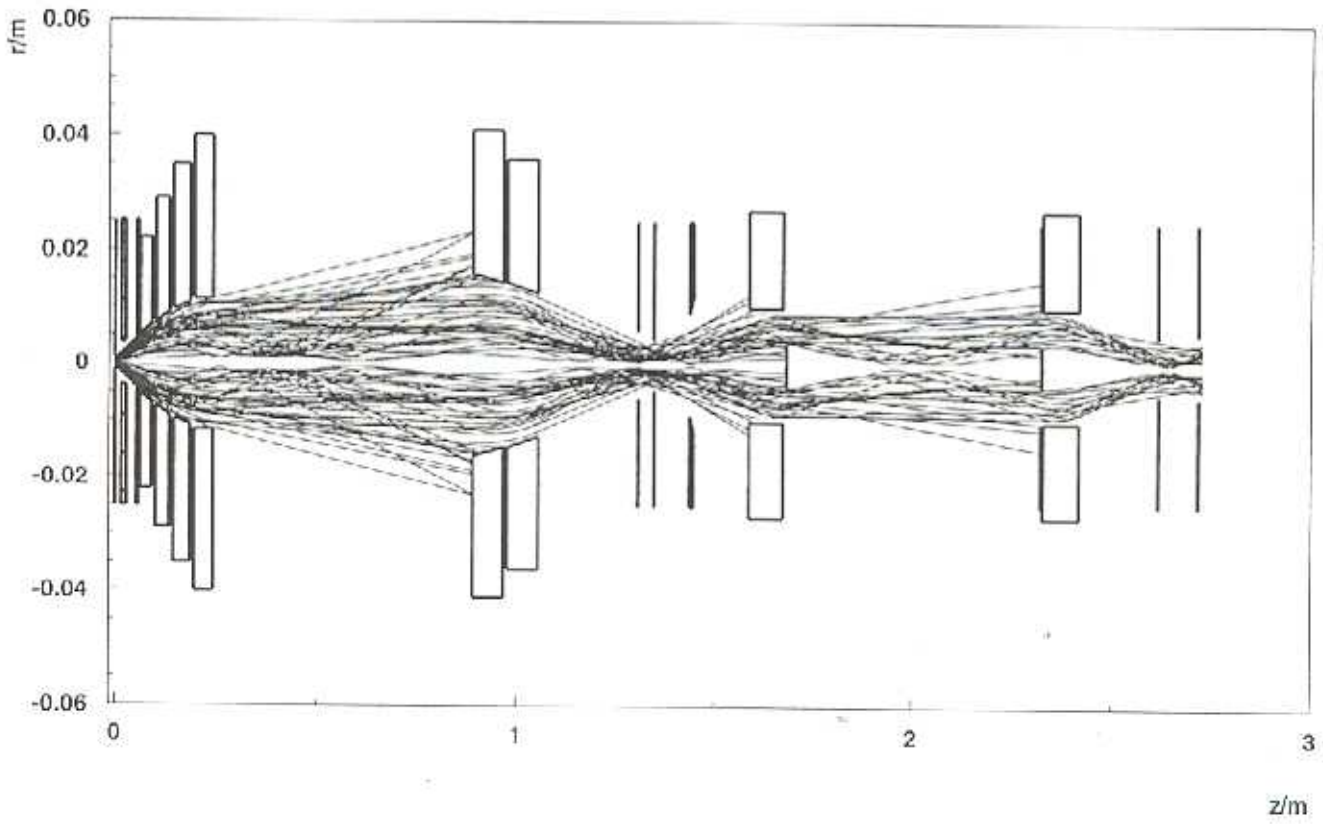


Fig. 6.4:
Upper graph:
The expected position of the resonances derived from the Fourier spectrum of the beam. The number of the beam harmonics is plotted next to the data points.
Lower graph:
Measured positions of the resonances versus the average magnetic field in the target cell. The HERMES operating point of $B = 335\,\mathrm{mT}$ lies in between two resonances.



p3.28 b



50 starting rays, 5 to 6 entire path

file name: /home/wise/HKcode_outputs/plot_st1.ps

TARGET MAGNET

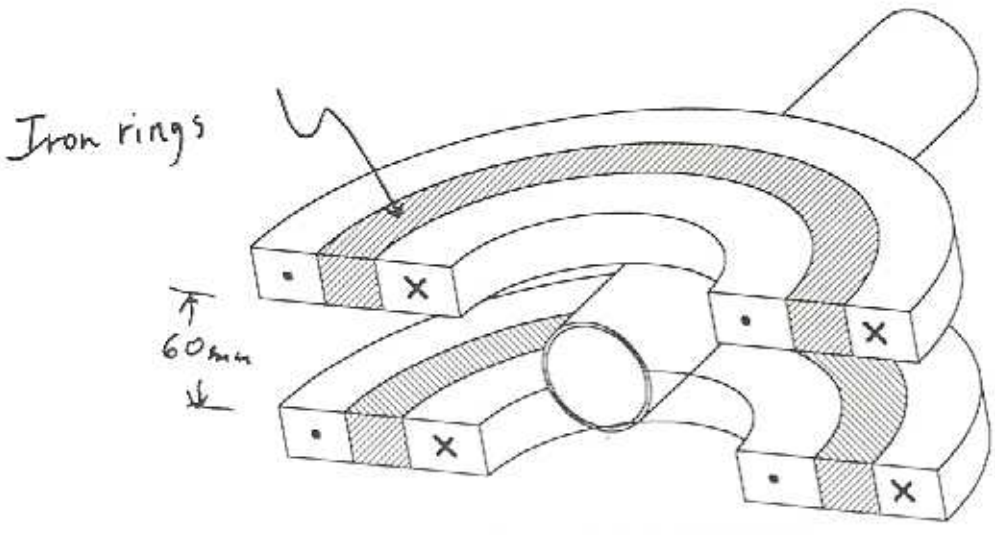
Why 0.1 T with $\frac{\Delta B}{B} \sim 5 \times 10^{-3}$?

a) Maximum JET intensity requires 2 hyperfine states: $p^+(1+4)$, $\bar{p}(2+3)$

$$|P| = \left(1 + \frac{\chi}{\sqrt{1+\chi^2}}\right)/2 \simeq 0.95 \text{ @ } 0.1\ T$$

b) depolarizing resonances
need uniformity to avoid 1-2 or 3-4 resonance.
at $B \gtrsim 0.1$ T all others are avoided at any uniformity.

4-Coil design with Iron minimizes $\int B \cdot dl$ for recoils

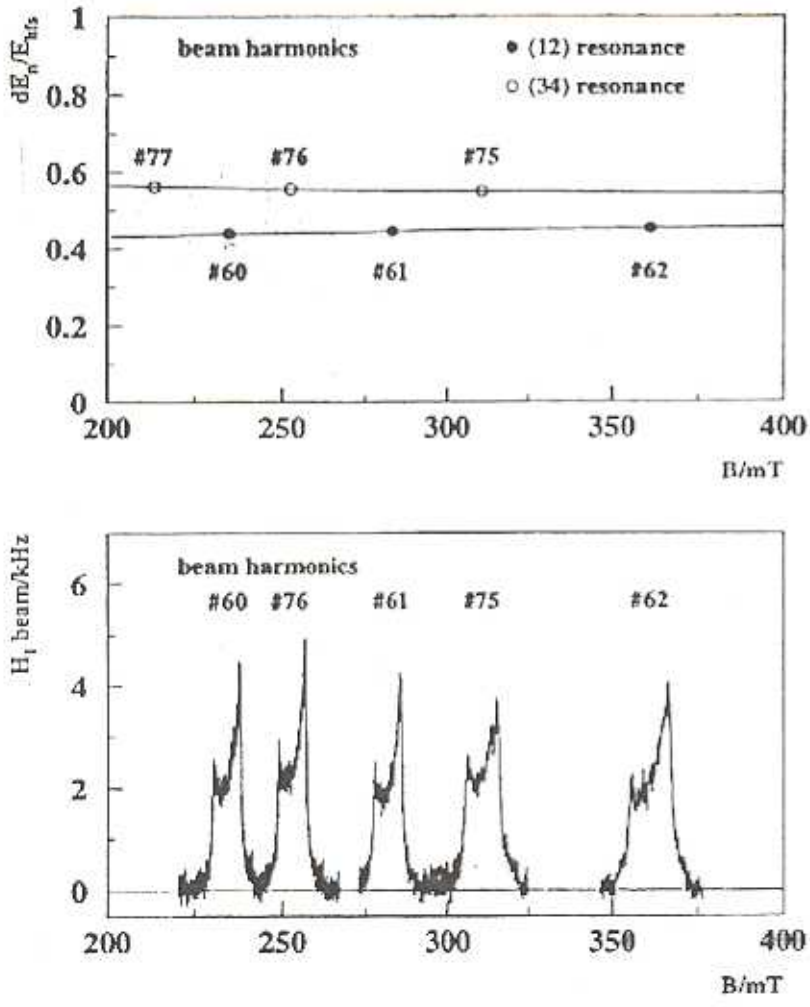


W. Mong design

$\int B \cdot dl = 18$ gauss-cm
- Very low -

HERMES Resonances
also 1↔2 + 3↔4

H. Kolster.
thesis



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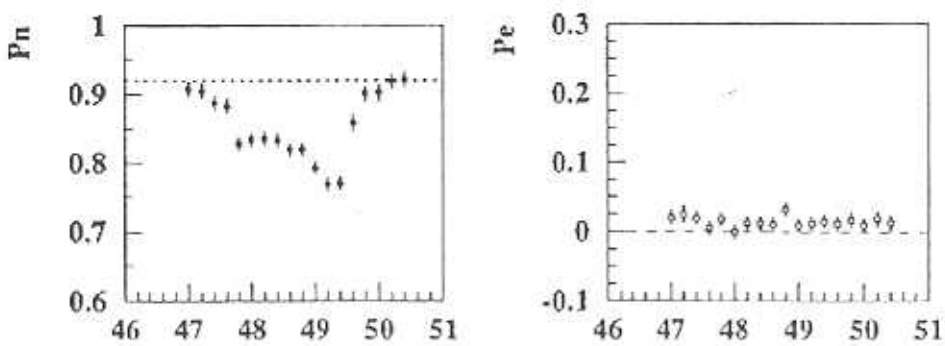
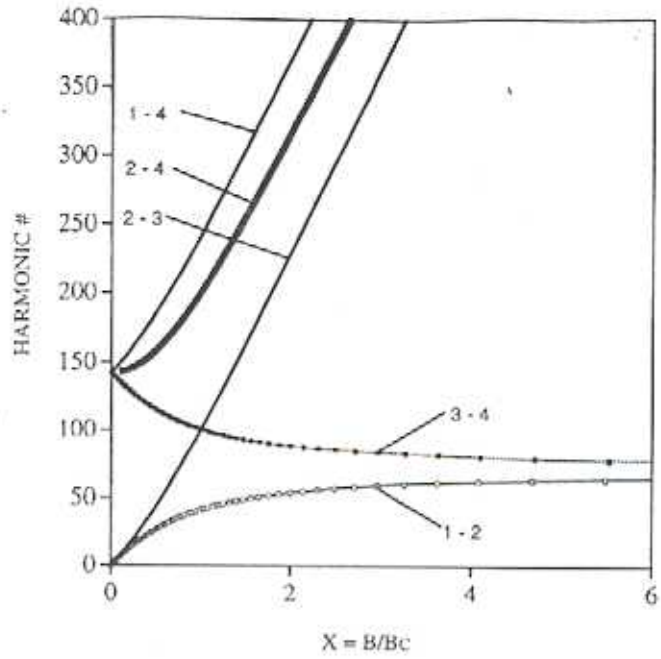




Beam HARMONIC # ↑

Calculated field values for resonances 1−2, 3−4

∴ ~~2−3~~, ~~2−4~~, ~~1−4~~ } gone at 0.1T

Relative Strength B/B_{max}

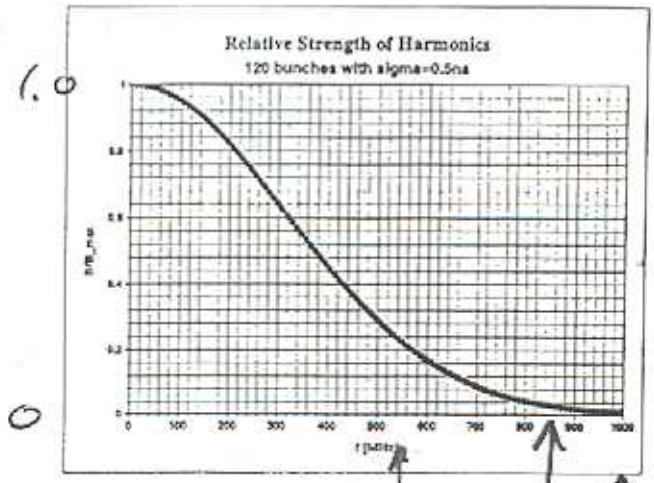


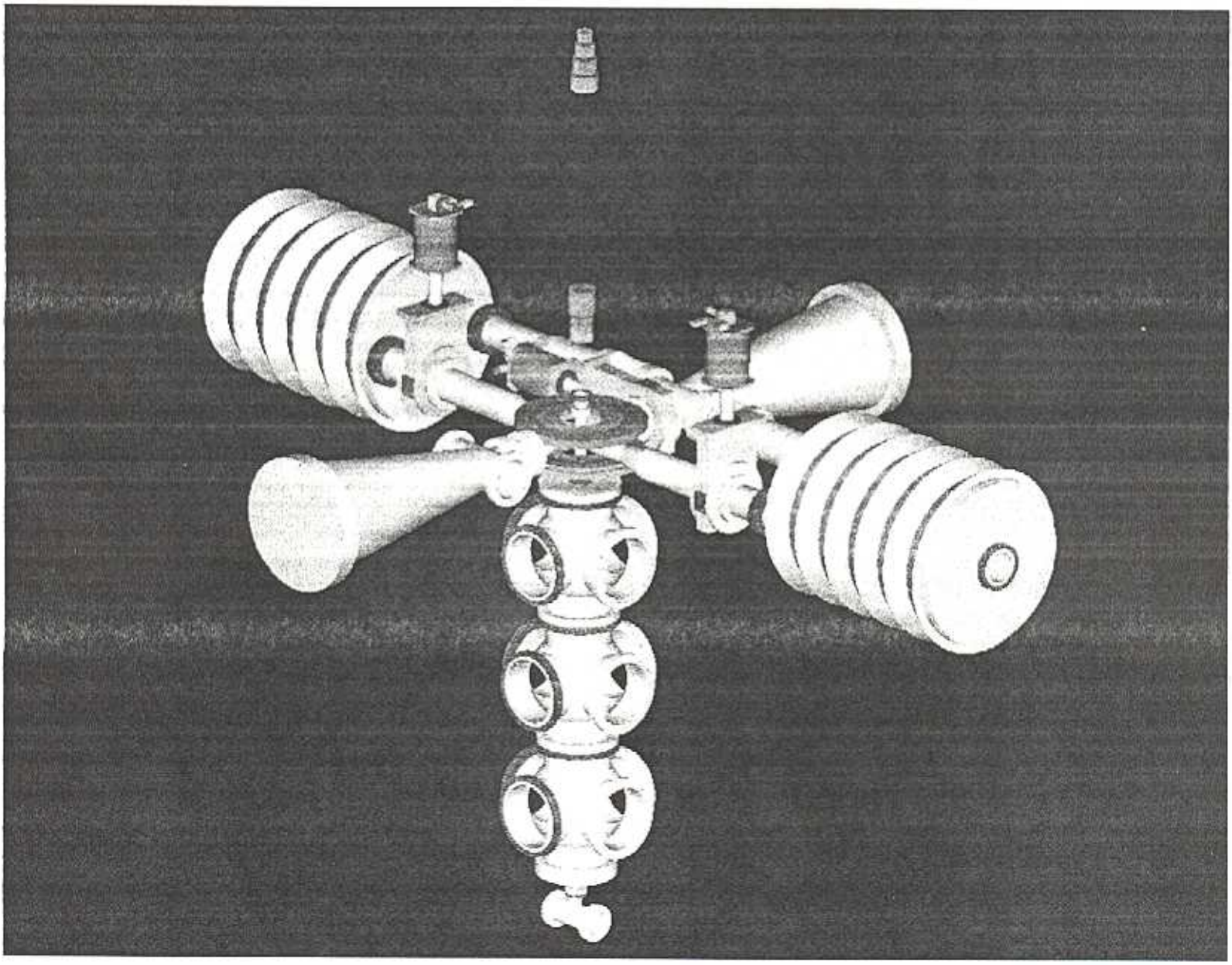
Figure 12. Relative power spectrum for the RHIC proton bunch field.

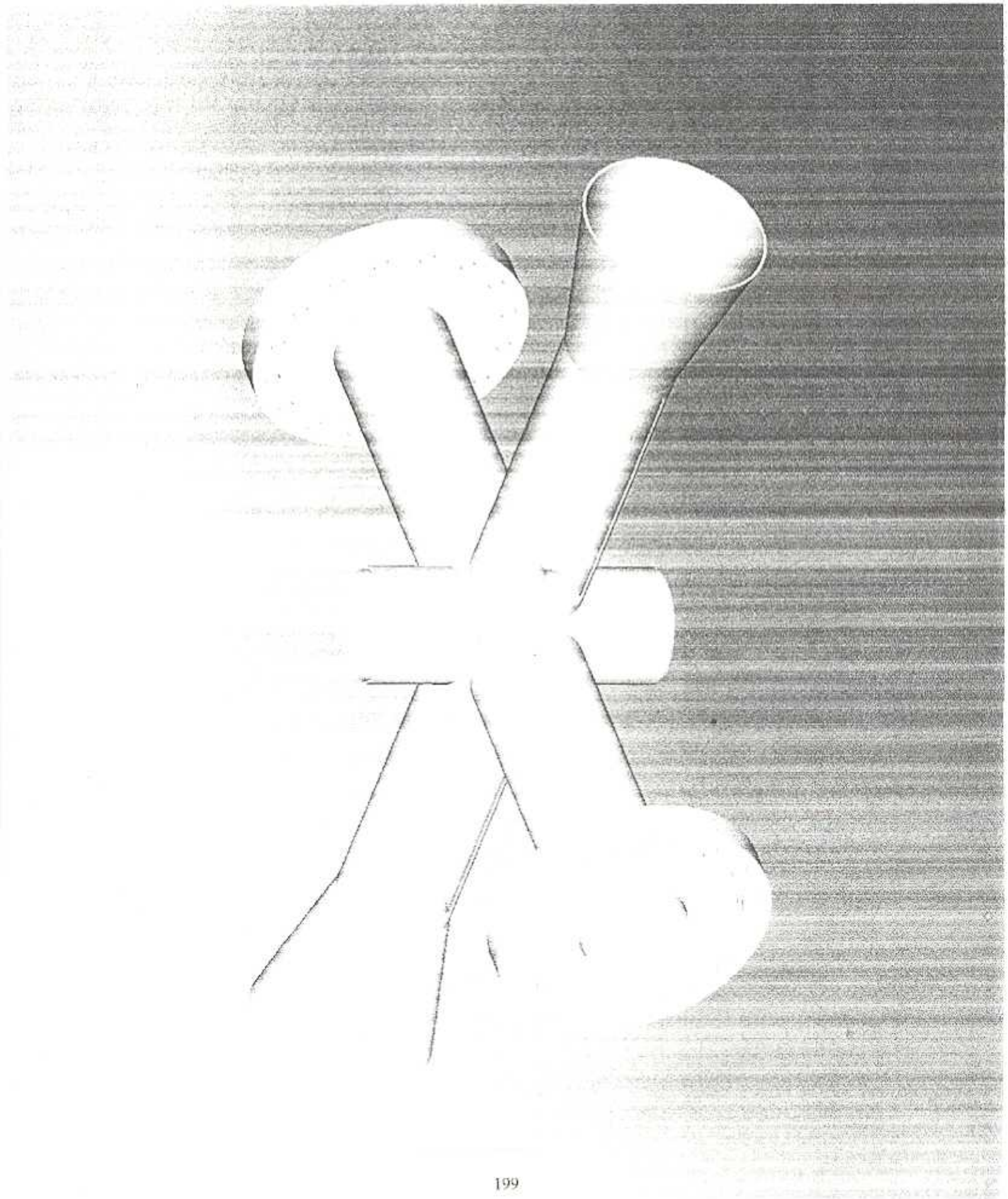
← from T. Roser + W. Mackay

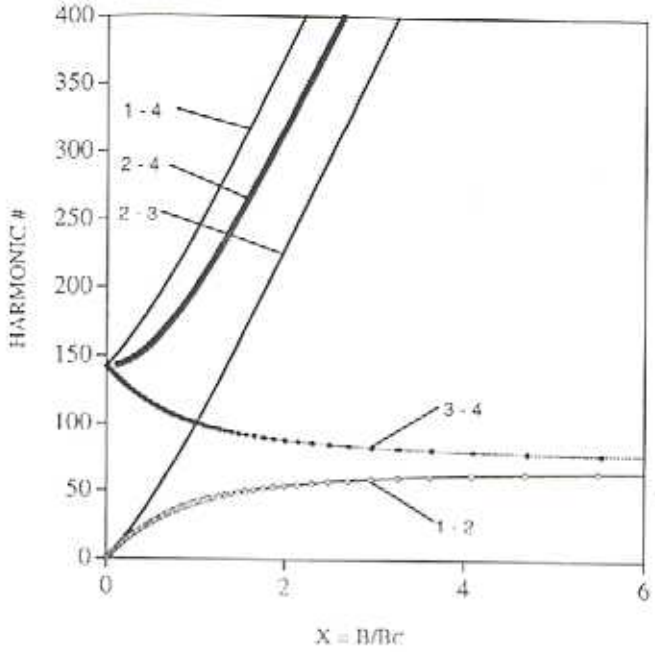
1−2 3−4

Harmonic # → n = 100

RHIC Bunch field depolarization Calculations

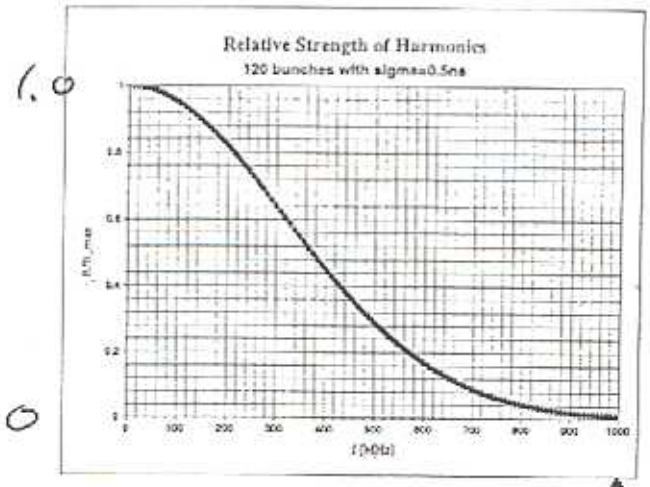






Beam HARMONIC # ↑

Calculated field values for resonances 1 − 2
+ 3 − 4
2 3
2 4
1 4



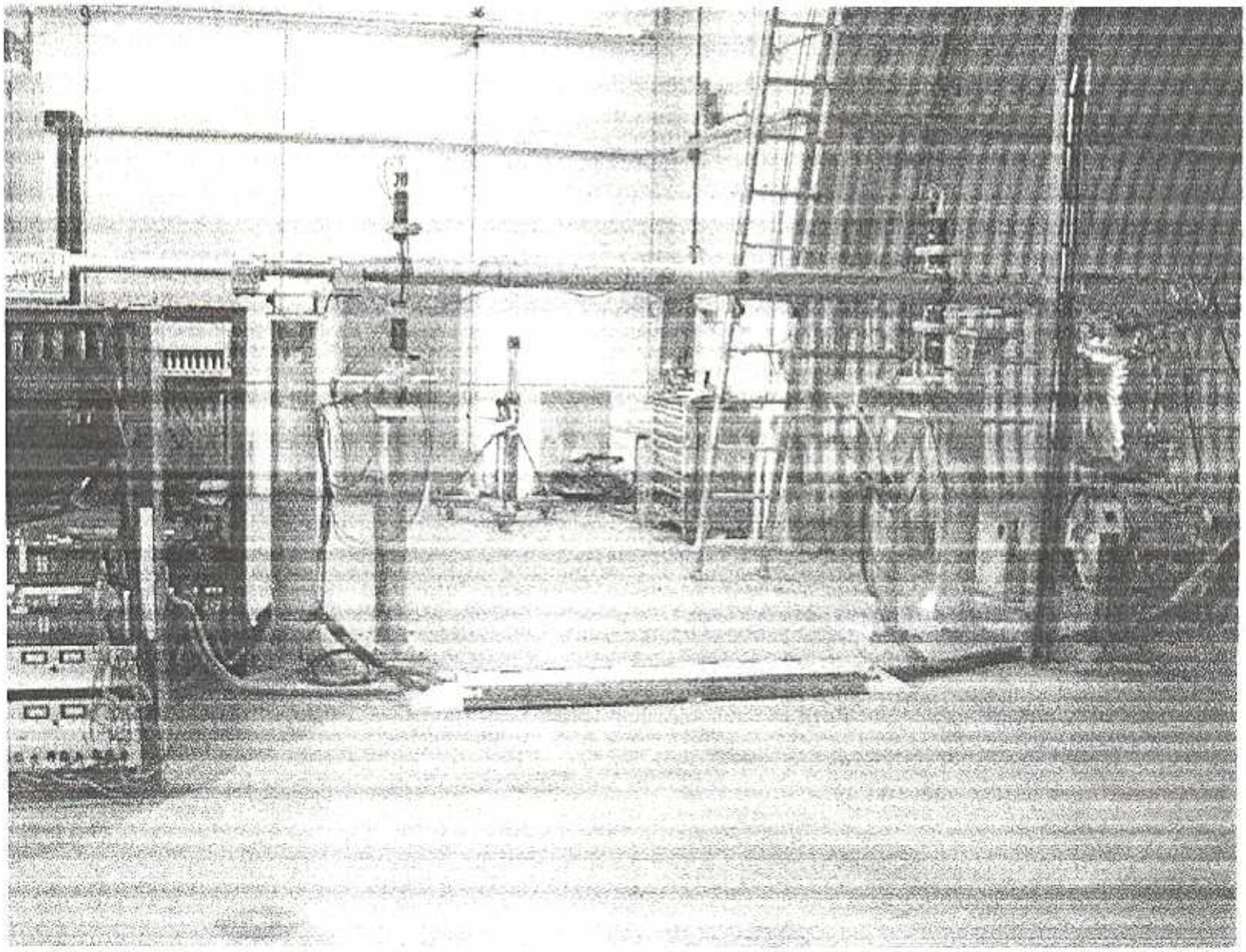
Relative Strength B/B_{MAX}

← from T. Rosen + W. Mackay

Figure 12. Relative power spectrum for the RHIC proton bunch field.

Harmonic # ⟶ n = 100

RHIC Bunch field depolarization Calculations



REMAINING DESIGN ISSUES

1) MAGNETIC SHIELDING OF Rf TRANSITIONS
   3-D calculations by W. Meng
   correction coils could possibly be needed
2) MEASUREMENT OF H_2 DILUTION OF JET
3) DETECTION LIMIT OF BRP
   Test bench under construction at Wisconsin
4) CAREFUL ESTIMATE OF Si BACKGROUNDS --next talk
5) FINAL DECISION ON JET LOCATION on agenda of JET collaboration meeting June 25
6) BEAM-LINE PUMPING a proposal is under development with BNL vacuum group
7) MECHANICAL MOUNTING AND ALIGNMENT and WIRING/PLUMBING -- how to make compatible with rapid move from staging area to ring?

*** WE ARE NOT YET READY FOR DETAIL ***
DRAWINGS TO BE MADE

OTHER TASKS

- COUNTING HOUSE -need cost +arrange for construction

- UTILITIES AND CABLING
  - not yet detailed
  - 40 meter cables

- ANALYSIS SOFTWARE
  - algorithms are known
  - BRP software in progress
  - Si data use existing waveform digitizers from Carbon target

- CONTROLS
  - just beginning
  - preliminary list exists
  - need to time coordinate Si and BRP data