JLab @ Higher Energies

- Began with evolutionary upgrades of the CEBAF accelerator energy:
  - 4.0 GeV (spec) to 5.5 GeV (now)
  - on track for 6 GeV this year w/ January shutdown projects:
    - NL/SL cryomodule "shuffle"
    - 20th cryomodule added to SL
- Upgrade to 12 GeV, 100% DF (2001-07)
  - "Natural" extension, beautifully matched to the next generation of experiments
  - Excellent scientific justification (to be documented by the white paper developed following this workshop)

12 GeV Upgrade

Tripling CEBAF's design energy opens many new scientific opportunities *and* provides a broad, qualitative enhancement of the present program:

Key New Physics:

- Meson spectroscopy
  (defines E_{max} and requires the addition of "Hall D")
- Extend accessible Deep Inelastic Scattering regime to $x \rightarrow 1$ for a large range of Q^2
  (requires the SHMS in Hall C)
- Spin, Hadron, and Nuclear Microscopy
  (requires the CLAS upgrade, ancillary detectors in Hall A)

Higher energies $\Rightarrow$ better experiments addressing the current physics problems:

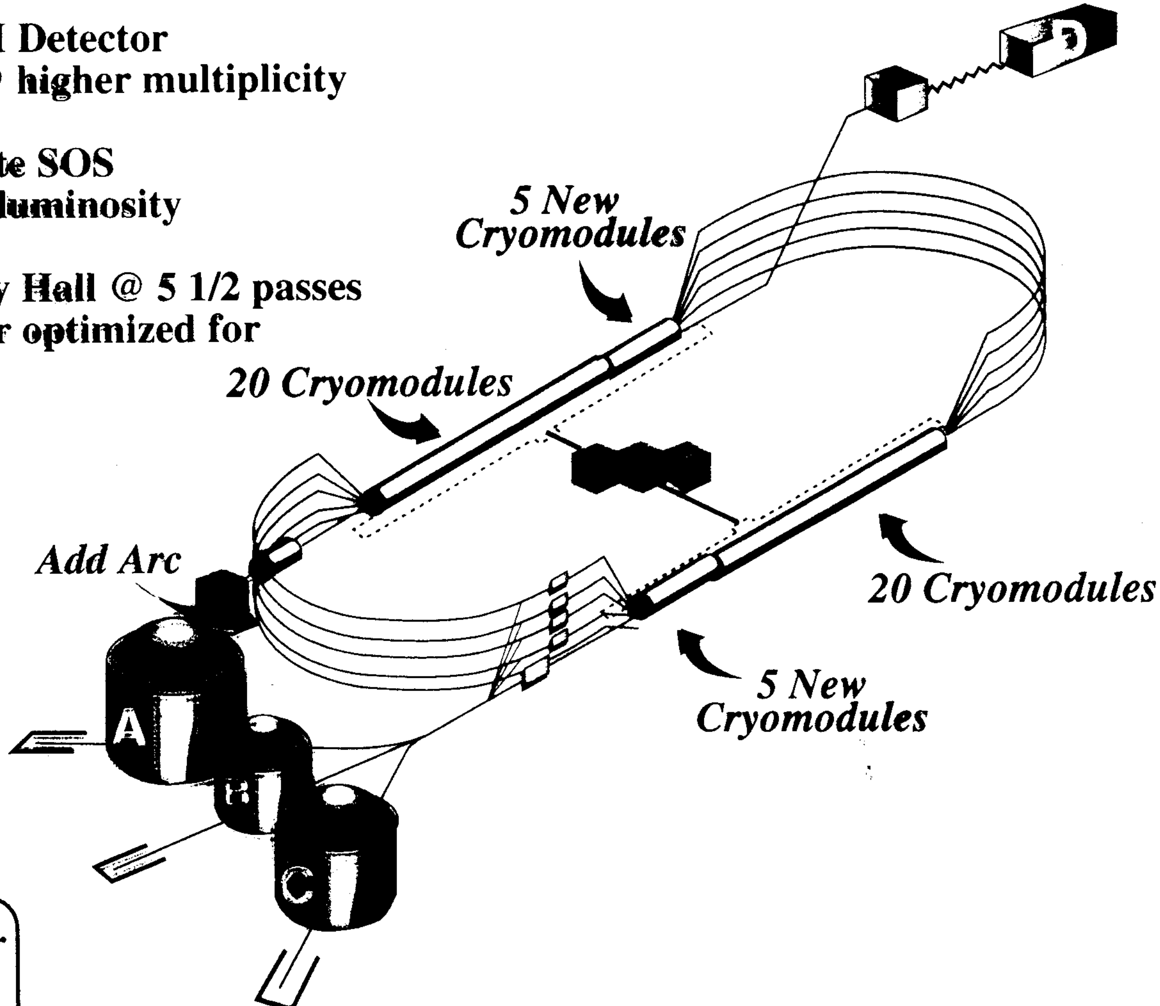
- Enhanced counting rates ($\sigma \sim E^2$)
- Dramatically improved experiment design flexibility & signal-to-noise ratio

Experimental Equipment for CEBAF @ 12 GeV

- Extensive effort with substantial JLab user community involvement to develop the plan:
  - Hall collaboration meetings & design studies
  - 2 Summer Workshops
  - "Hall D" collaboration activities
  - this workshop and the "white paper" activities to follow
- The broad outlines of the plan are clear
- Critical effort for this workshop and related activities:
  - Verify the match between the accelerator and research equipment characteristics and the requirements of key experiments motivating the facility
  - Document the key experiments for presentation to the broader community
- To be reviewed by the PAC following the model used for the "base equipment"

CEBAF @ 12 GeV, 5 1/2 Pass

- Hall A - Retain HRS pair
  Add Ancillary Detectors
- Hall B - Rebuild Region I Detector
  for improved coverage @ higher multiplicity
- Hall C - Add SHMS/delete SOS
  to support high Q^2, high luminosity
- Hall D - New photon-only Hall @ 5 1/2 passes
  New 4π hermetic detector optimized for
  Meson Spectroscopy



Accelerator down ~ 1 year
for Installation
and Commissioning

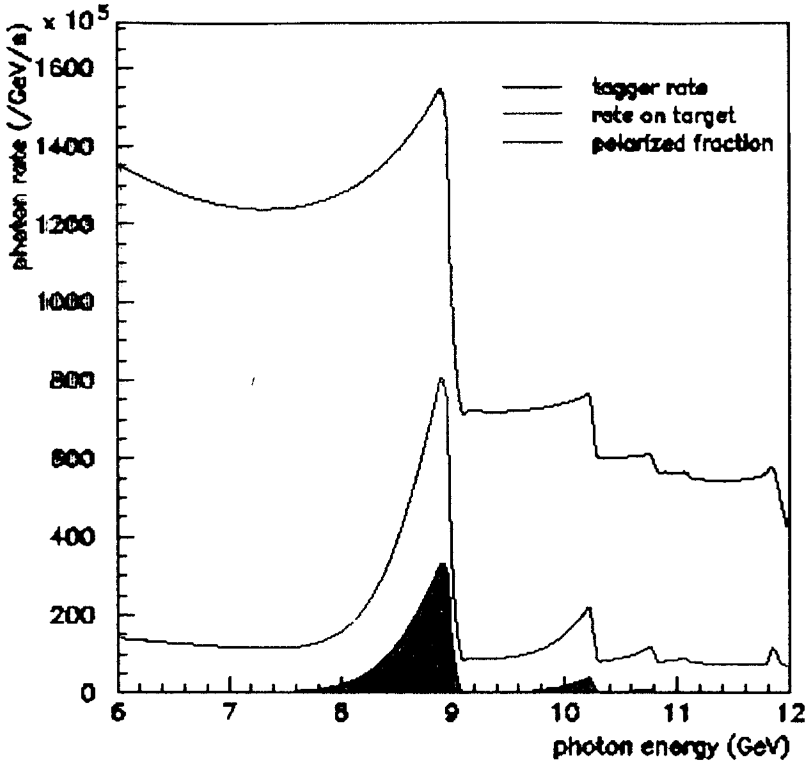
Meson Spectroscopy drives: $E_{max} \rightarrow$ 12 GeV and the need for Hall D

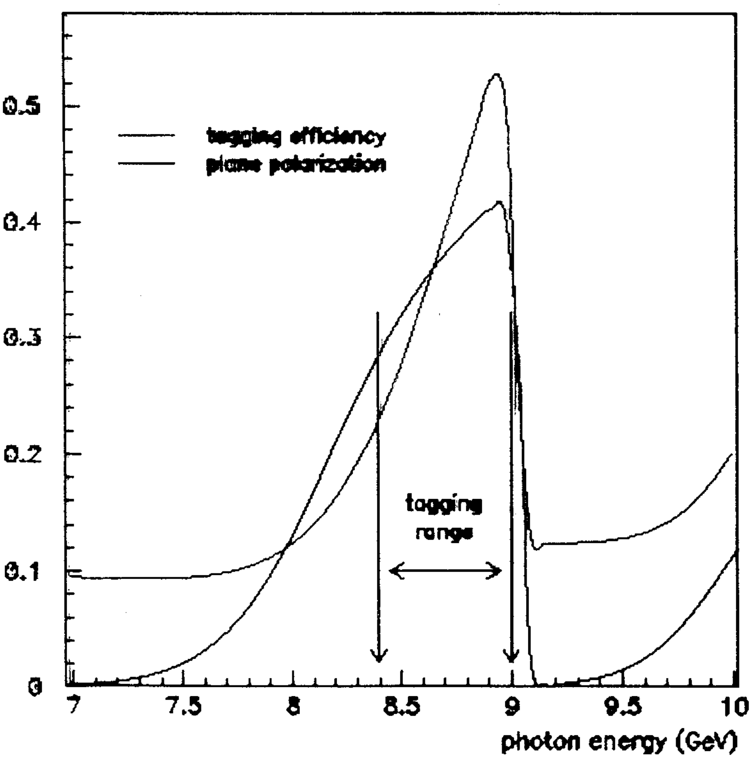
- Photoproduce and identify mesons with masses between 1 and 2.5 GeV
  - ⇒ need Eγ from 5 to ≥ 9 GeV
  - ⇒ polarization essential
- Tagged coherent bremsstrahlung the best approach at JLab energies and currents
- Optimization of coherent peak and polarization requires
  - tight collimation
  - $E\gamma \sim E_0/2$

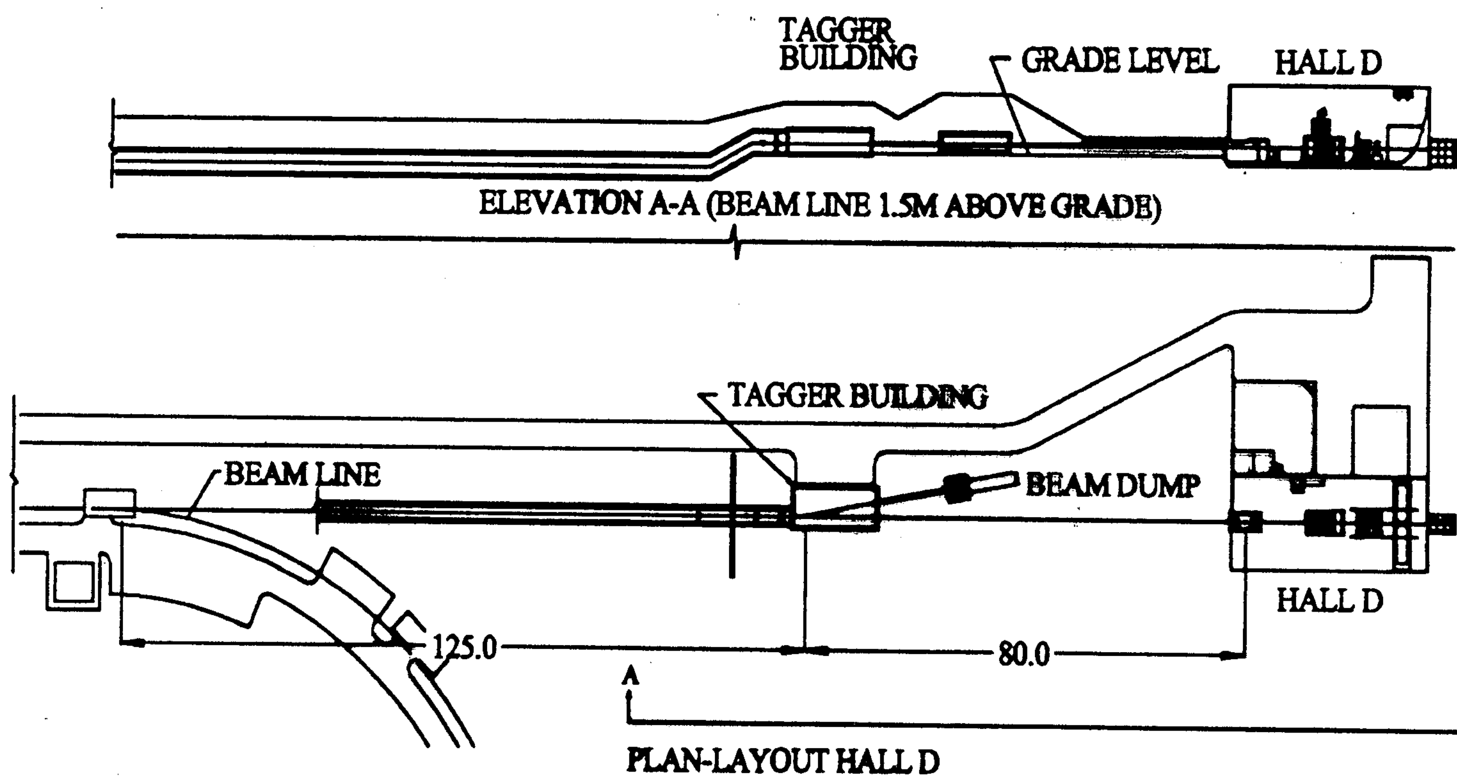
  acceptable tradeoffs up to $E\gamma \sim \frac{3}{4}E_0$

  ⇒ need 12 GeV electron beam
- Cost optimization and distance needed to match collimation w/ beam emittance
  - ⇒ 5½ passes, Hall D

Tagging efficiency

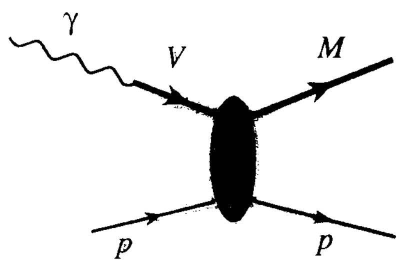


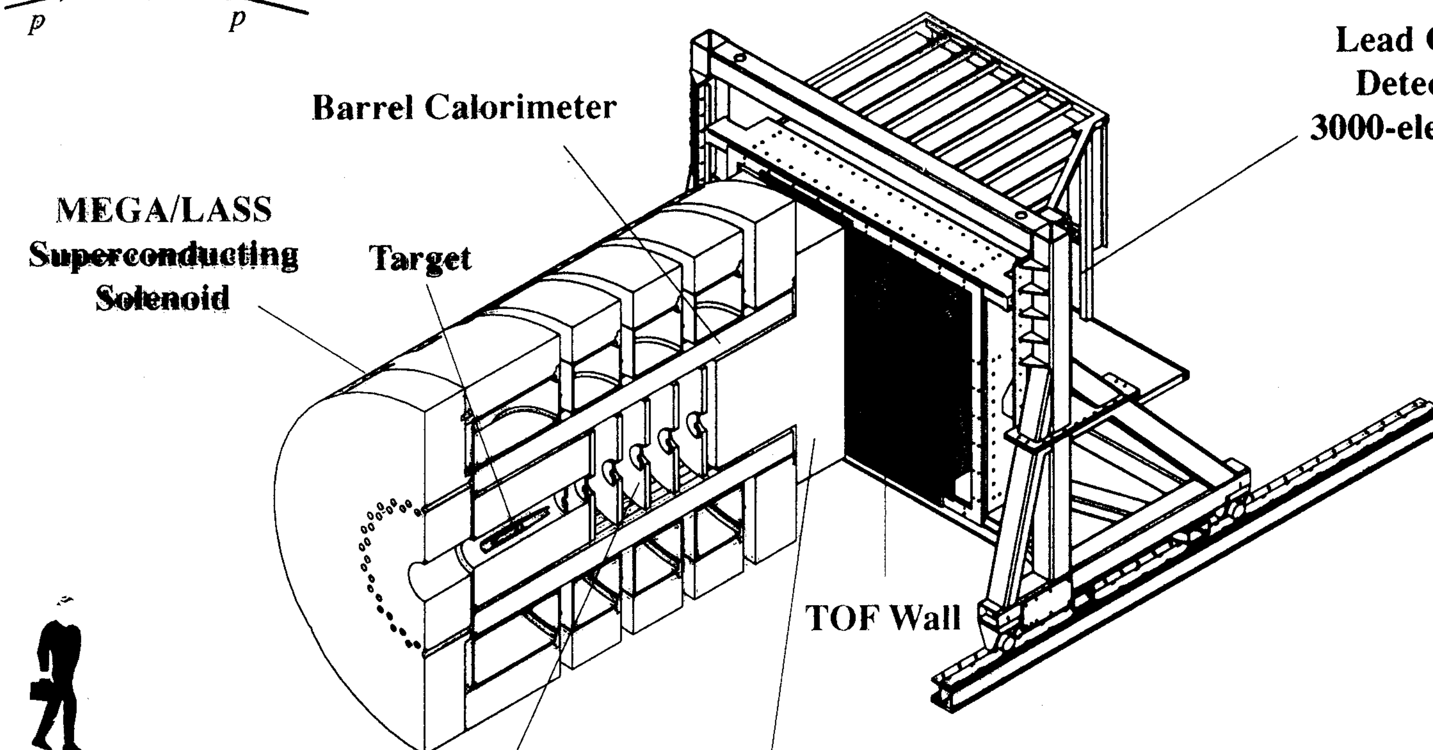


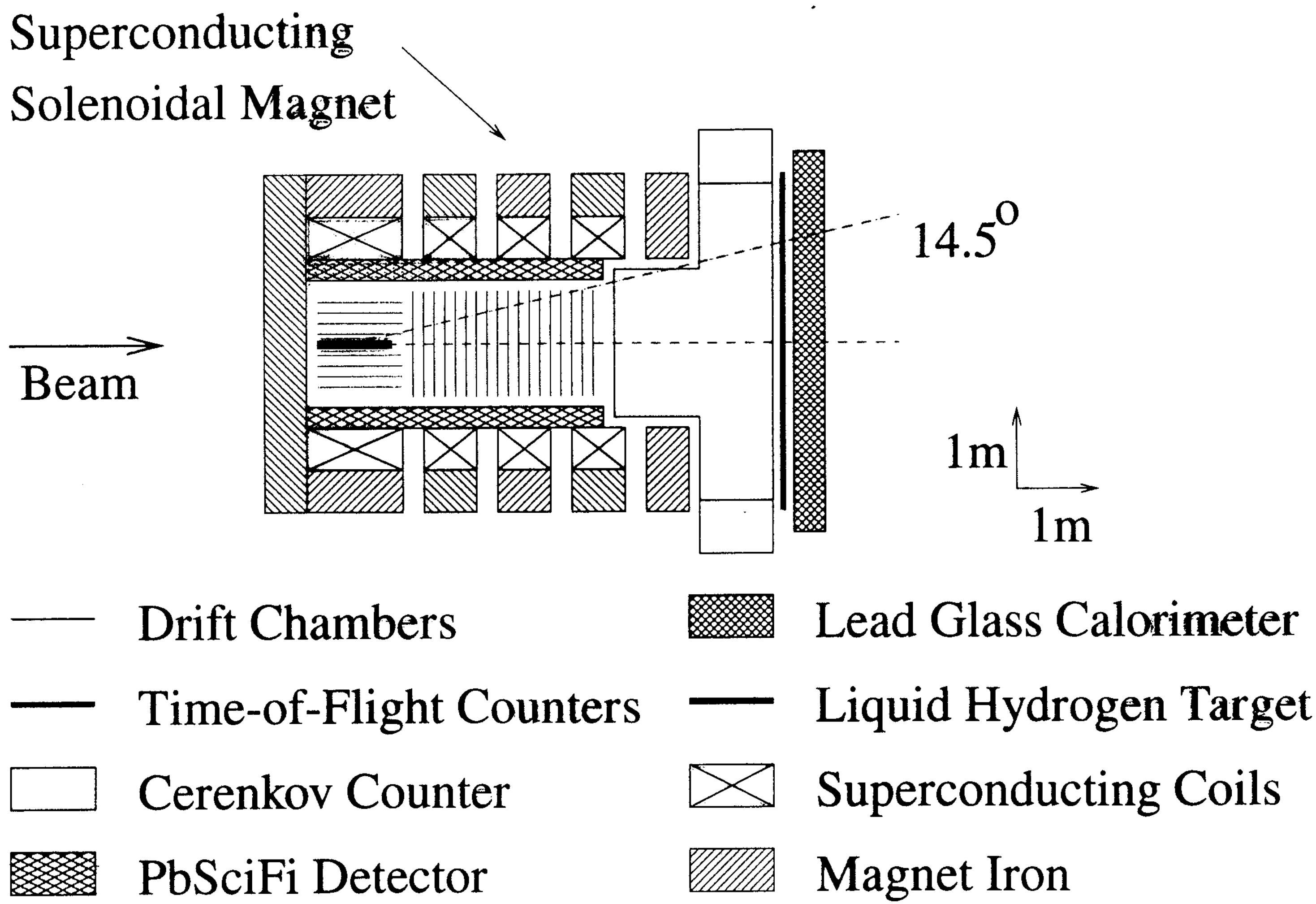


HALL D LAYOUT WITH 125 M BEAM CONDITIONING FROM TANGENT POINT

Photoproduction of Unusual Mesons
The Hall D Spectrometer

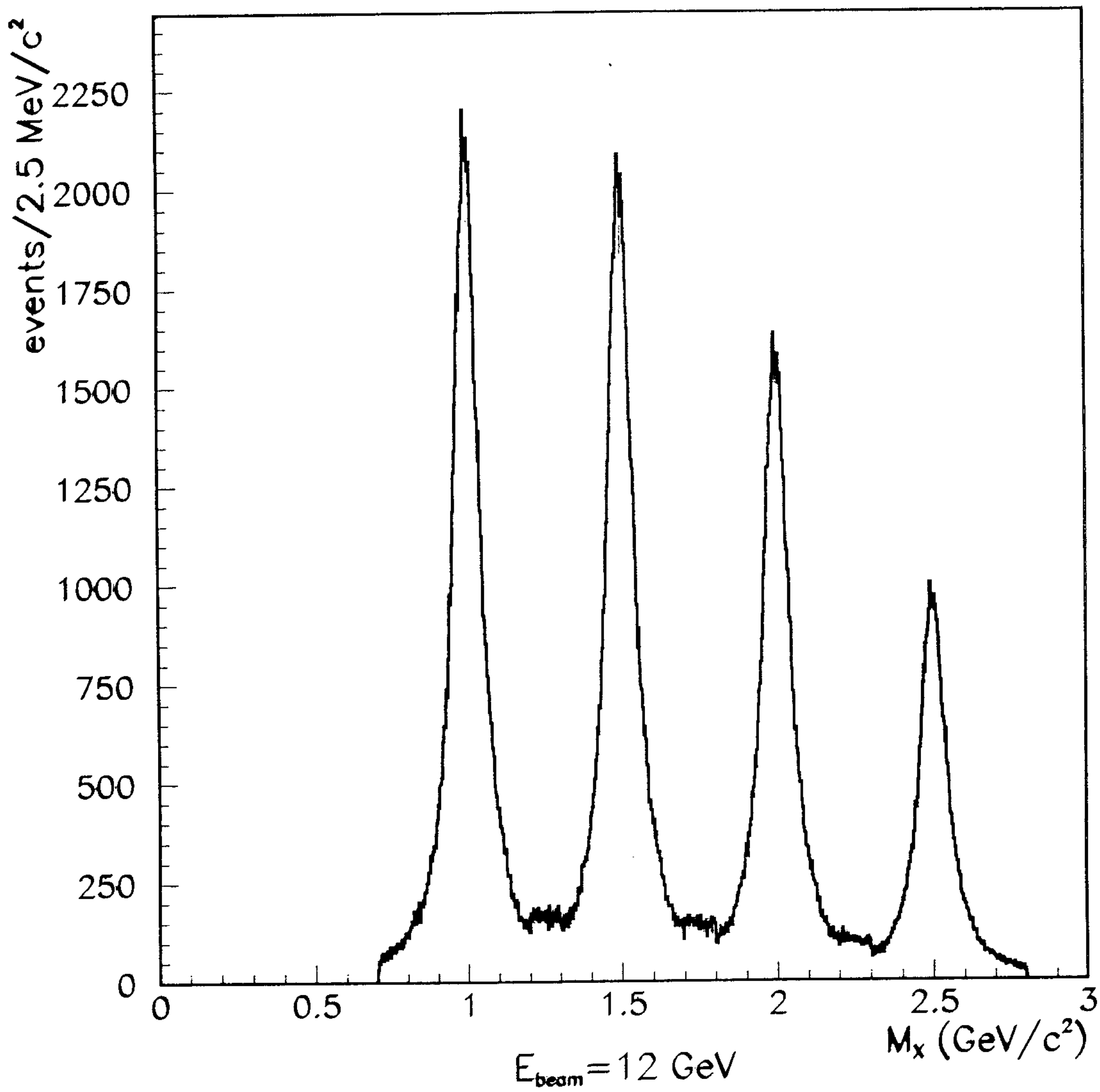






Superconducting
Solenoidal Magnet
Beam
14.5°
1m
1m
Drift Chambers
Time-of-Flight Counters
Cerenkov Counter
PbSciFi Detector
Lead Glass Calorimeter
Liquid Hydrogen Target
Superconducting Coils
Magnet Iron

Anticipated measured mass distribution of 4 produced resonances in the reaction
$\gamma p \rightarrow Xp$



1st year of operation at 10% of the ultimate luminosity should provide 10x the existing world's data set on meson spectroscopy

The Hall D Collaboration

- 80 Physicists from 25 institutions
  (A. Dzierbia, spokesman)
- 8 Workshops since 7/97 at 6 Institutions
- Letter of Intent presented to PAC15, 1/99
- Draft Design Report Completed
- Reviewed by an ad hoc PAC sub-committee 12/6-7/99. ; Formal report pending, but closeout noted:
  - the project is well suited for *definitive* searches for exotic states that are required according to our current understanding of QCD
  - JLab has *unique* capabilities for this physics
  - The basic approach of the collaboration is sound
  - R&D is needed

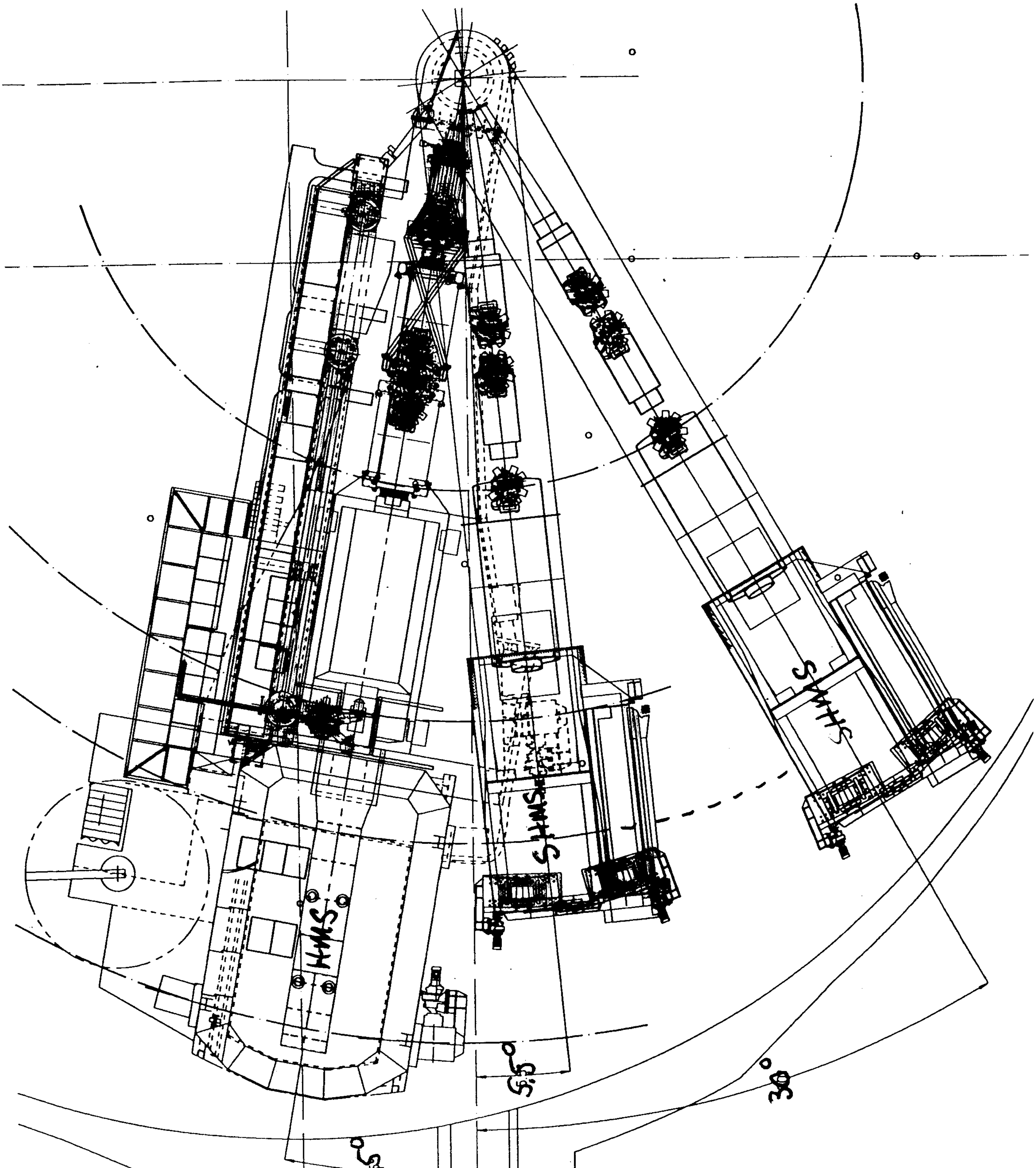
Hall C

- Focus remains high luminosity, high Q^2 physics

- Retain capability for "one of a kind" setup experiments
  (t_{20}, G^E_n, G0, ...)

- Build Super High Momentum Spectrometer (SHMS) matched to 11 GeV, high luminosity, moderate resolution (10^{-3}) experiments

- HMS becomes lower energy spectrometer of coincidence pair


HMS
SMHS
SMHS

SHMS Base Design

Characteristic	SHMS	SHMS "lite"*
Configuration	QQD	QQD
P_{max} (GeV/c)	12	6
Solid Angle (msr)	1.7-3.0	1.7-3.0
In-plane (mr)	13	13
Out-of-plane (mr)	42	42
Minimum Scattering Angle (deg)	5.5	5.5
Bend Angle (deg)	18.9	18.3
D (cm/%)	1.852	1.765
D/M (cm/%)	3.12	3.12
Acceptance (%)	±10	±10
Focal Plane Angle (deg)	4.69	5.07
Resolution:		
Momentum	10^{-3}	10^{-3}
In-plane angle (mr)	0.9	0.9
Out-of-plane angle (mr)	3.0	3.0
Dipole Power (MW)	0.03	0.7

* Uses SLAC B203 dipole

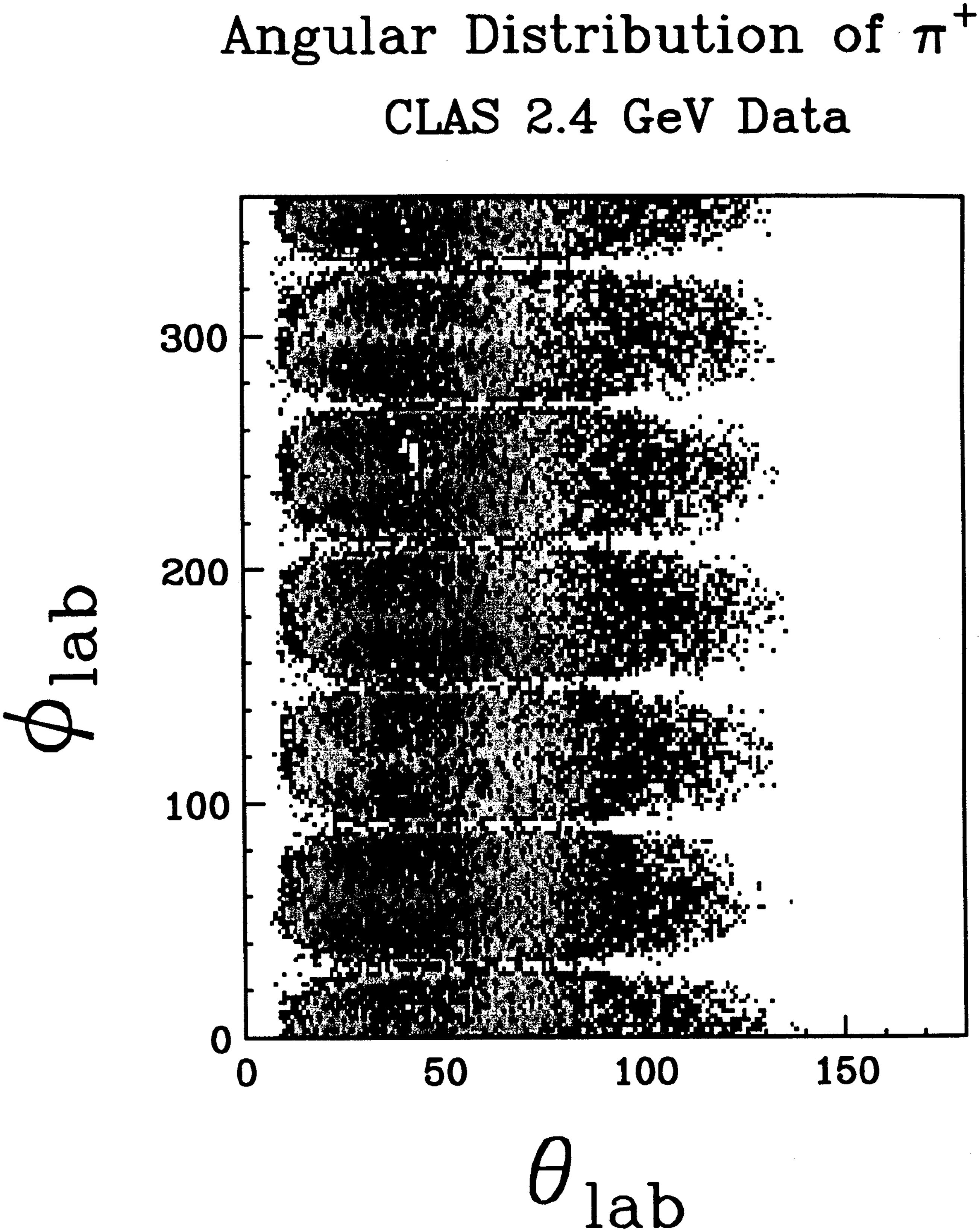
Hall B

- Improve CLAS instrumentation to realize the full potential of the toroidal SC coil/geometry

- Extend ability to identify exclusive final states in e and γ - induced reactions to higher energies

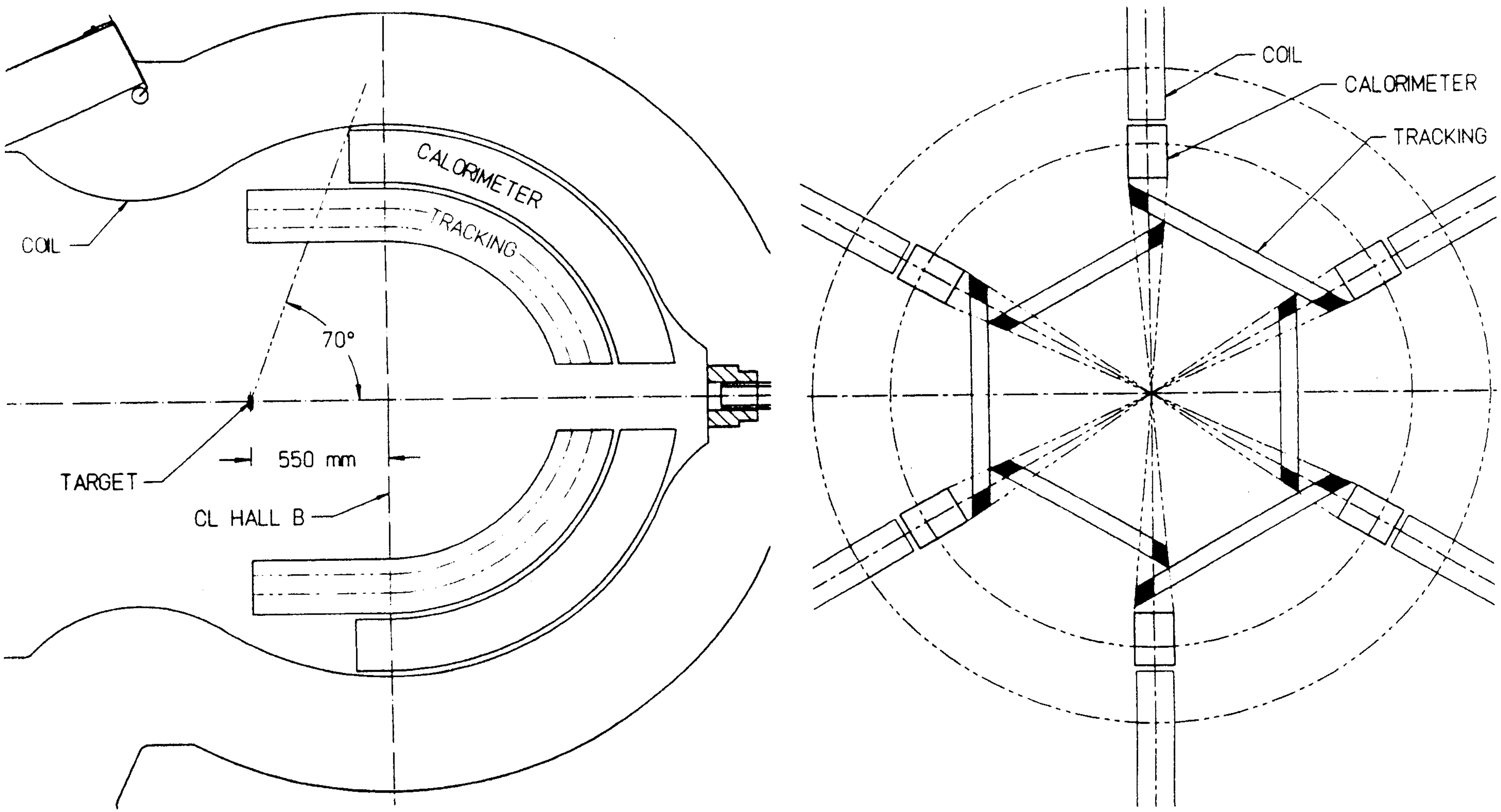
- Requires a strategy change:
  full detection of final hadronic state
  instead of missing mass technique

- Rebuild inner detector package:
  - full coverage tracking and PID
  - complement outer calorimeters by calorimeter strips in front of the coils
  - develop new magnetic shield



Angular Distribution of π^+
CLAS 2.4 GeV Data
300
200
100
0
50
100
150
ϕ_{lab}
θ_{lab}

POTENTIAL LAYOUT OF CLAS INNER DETECTOR



Hall B Detector Development

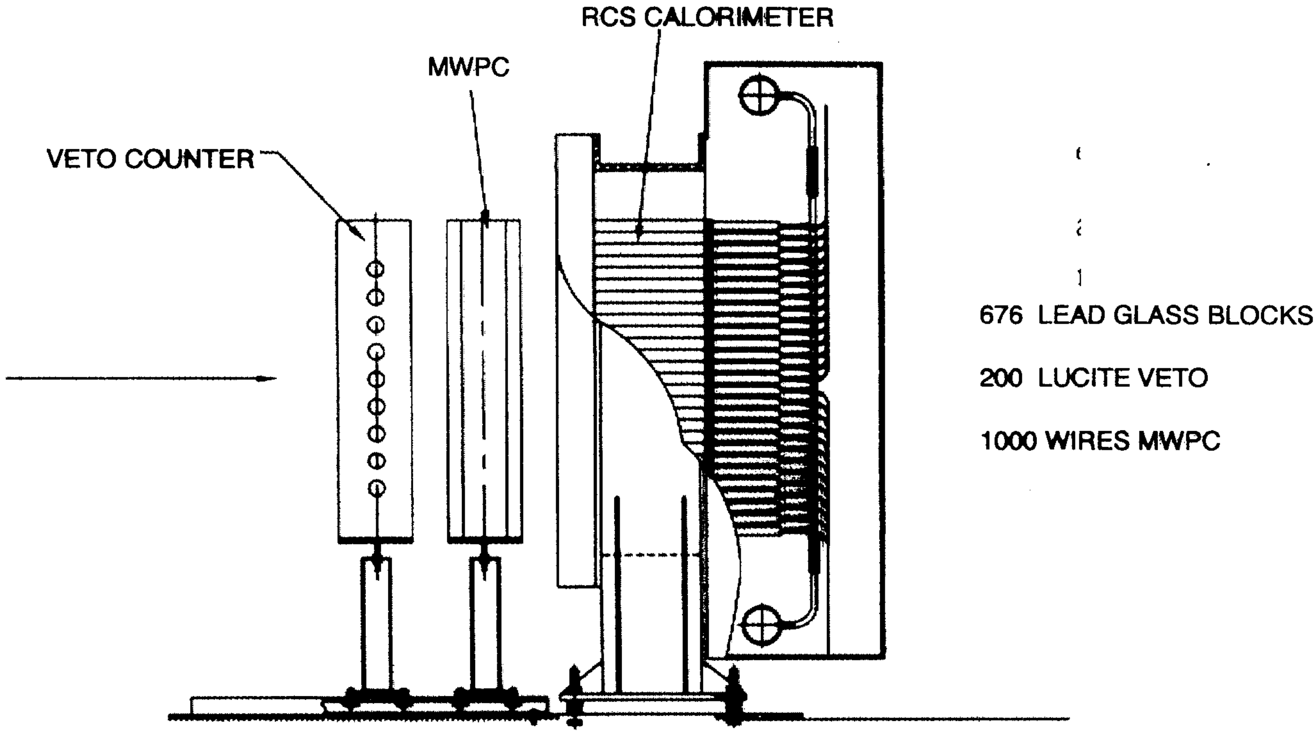
- Ring Imaging Cerenkov
  - prototyping at RPI using multi-anode PMTs
- Inner Calorimeter
  - NSU evaluating a 5x5 lead-tungstate array on loan from Giessen; beam tests 11/99, results under study
  - 3 prototypes under development at ITEP (2 vendors of lead tungstate, one Pb-scintillator sandwich)
- Work needed on inner tracking and magnetic shielding

Hall A

- Retain HRS pair to take advantage of their excellent momentum and angular resolution capabilities
- Enhance research capability of the hall with experiment-driven equipment additions:
  - septa for forward angle capability
  - a photon calorimeter for real and virtual Compton scattering
    - •
    - •
    - •

Photon Calorimeter

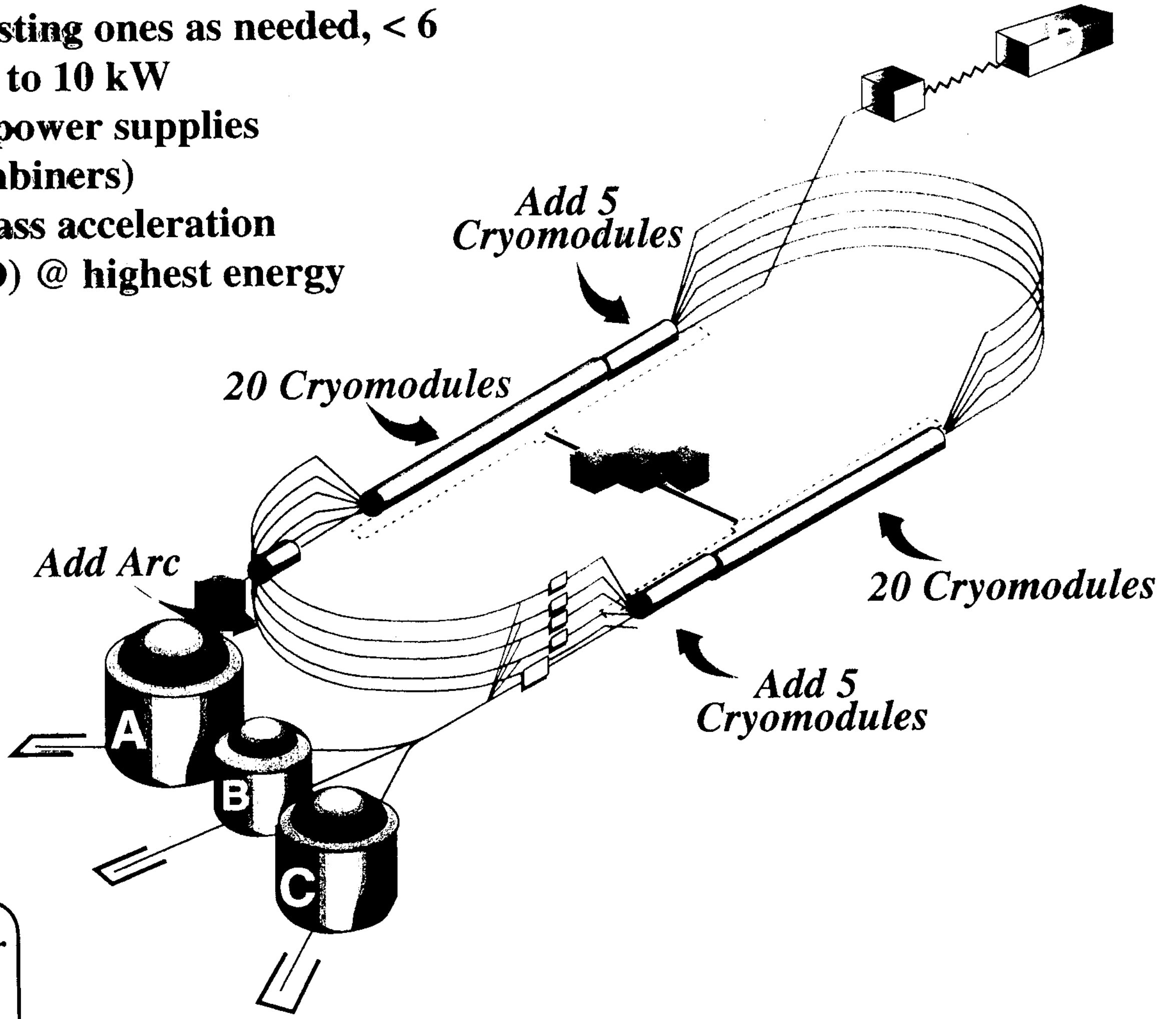
- Stage I: 1 x 1 m^2 lead glass (under assembly) for real Compton scattering experiments



- Stage II: 2 x 2 m^2 "$PbWO_4$" for DVCS, electron detection, ...

CEBAF @ 12 GEV, 5 1/2 PASS

- 65+ MV, high Q cryomodules
  - Install 10 in empty slots
  - Replace/rework existing ones as needed, < 6
- Increase cryo capacity to 10 kW
- Upgrade arcs (mostly power supplies and spreader/recombiners)
- Add 10th arc for 5.5 pass acceleration
- Add a new hall (Hall D) @ highest energy (photons only)



Accelerator down ~ 1 year for Installation and Commissioning

Drawings/leemann/CEBAF@12Gev 5.5

Beam Characteristics

- 100% Duty Factor
- Excellent Beam Characteristics:
  - ~5 nm emittance
  - 1-2 x 10^{-4} $\delta E/E$
- 1 MW total beam power
  $\Rightarrow \geq$ 75-90μA *total* available @ 11 GeV
- Multiple Beam Capability:
  - Hall D must get highest energy available (generally 5½ pass)
  - Halls A, B, and C each get *unique* energies from 1-5 pass
  - So, for example, if the linacs were operated at 1.1 GeV each, then

    Hall D = 5 ½ x 2.2 = 12.1 GeV

    Halls A, B, C choose from among 2.2, 4.4, 6.6, 8.8, and 11.0 GeV

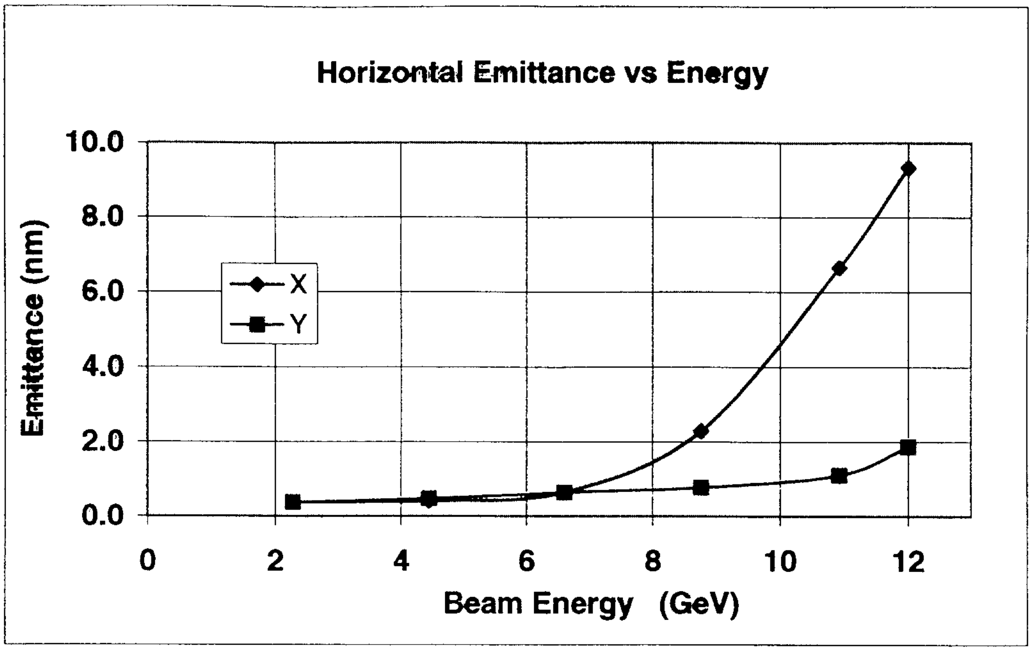
12 GeV Upgrade Beam Parameters

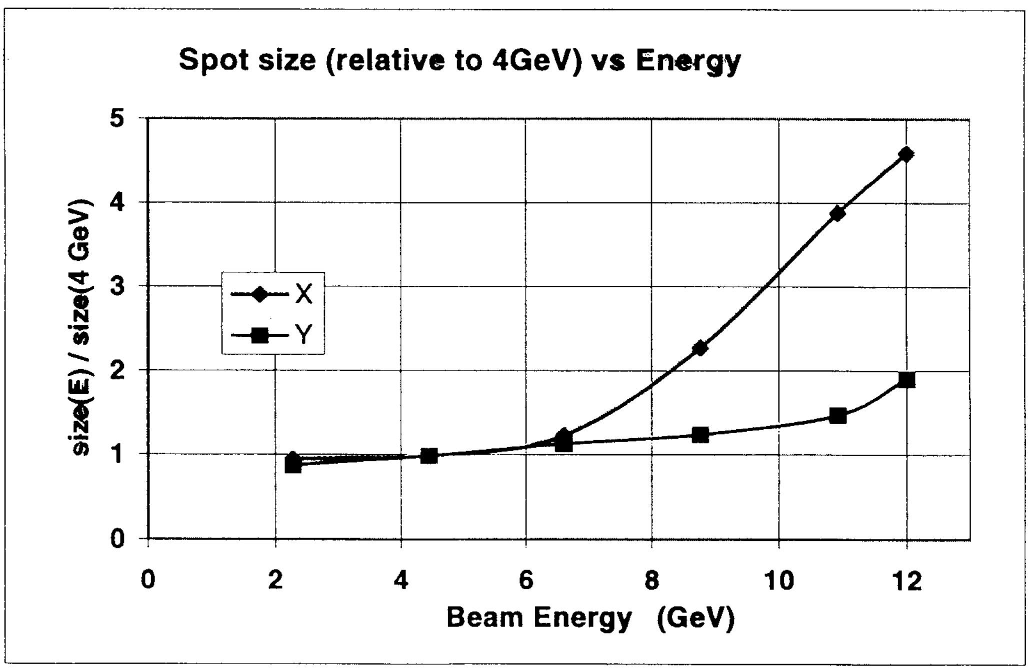
	CEBAF @ 4 GeV	CEBAF @ 12 GeV
5-pass (Halls A, B, &C)		
Energy (GeV)	4.0	11.0
Energy spread (%)	0.01	0.023
x-emittance (m)	$< 1\times10^{-9}$	7×10^{-9}
y-emittance (m)	$< 1\times10^{-9}$	1×10^{-9}
5½ - pass (Hall D only)		
Energy (GeV)	n/a	12.1
Energy spread (%)	n/a	0.026
x-emittance (m)	n/a	10×10^{-9}
y-emittance (m)	n/a	2×10^{-9}

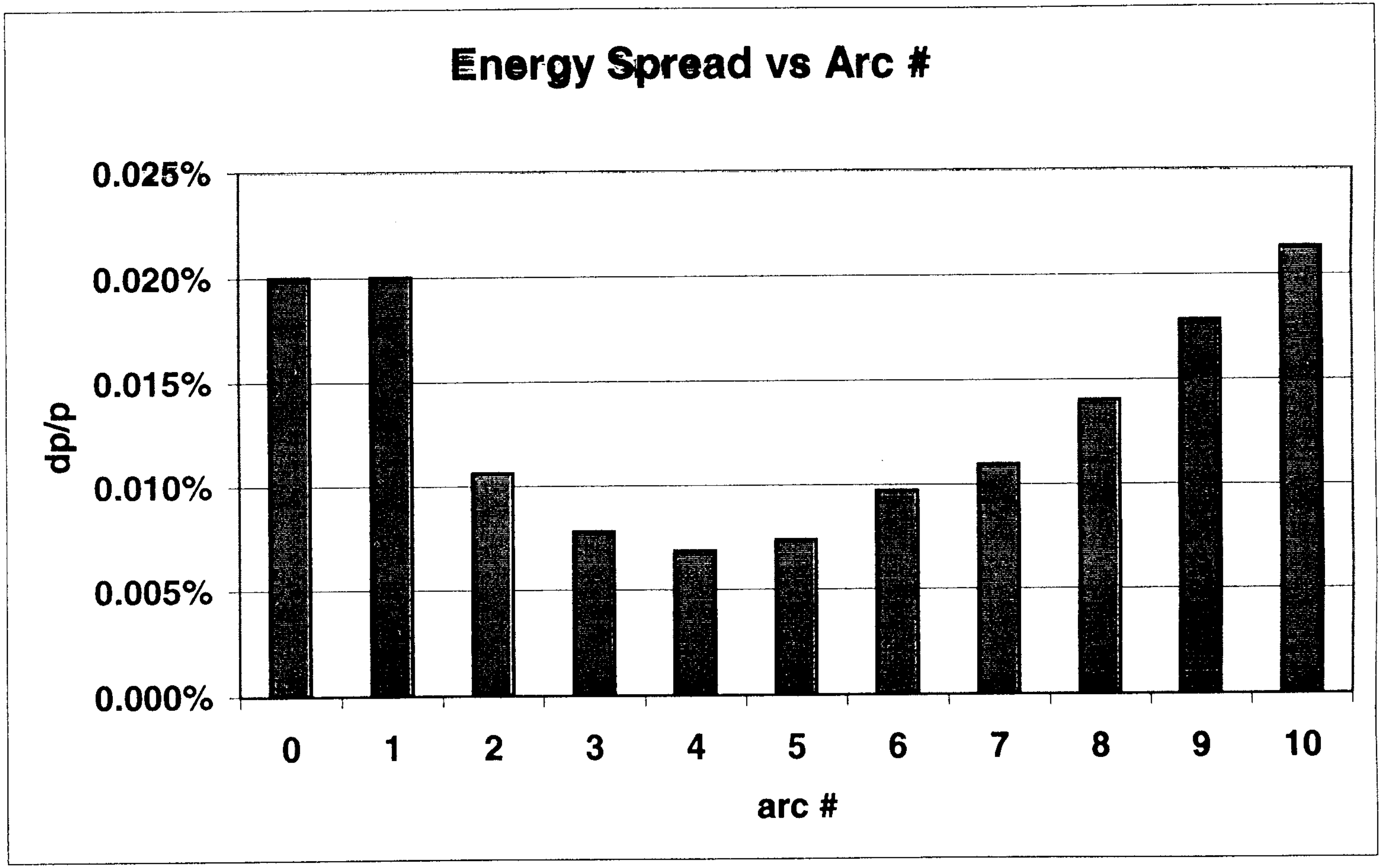
Key questions for this workshop and related activities:

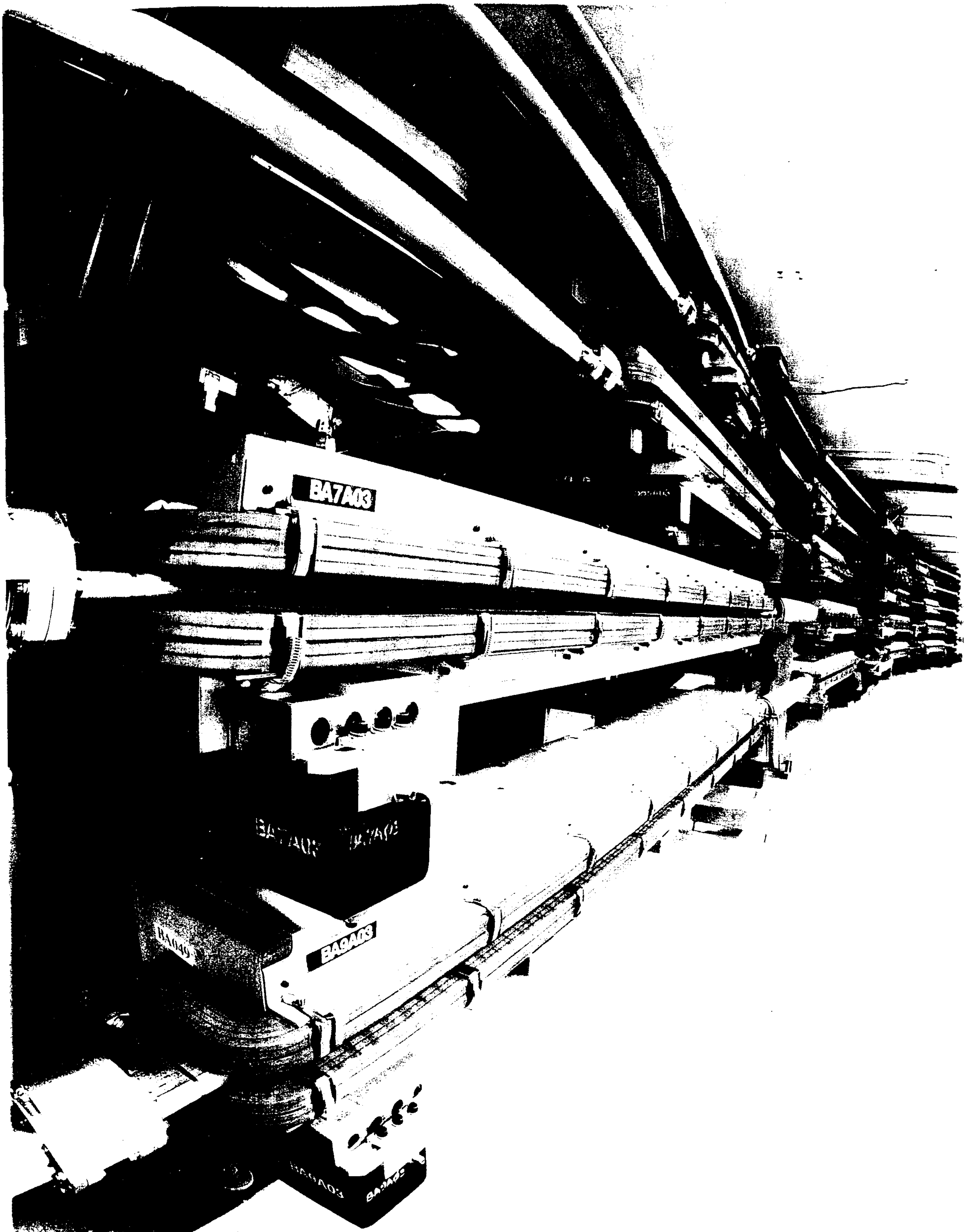
- Do these values meet the needs of the experimental program?
- Can we live with a worse energy spread? (5×10^{-4} ?; 10^{-3} ?)

Baseline 12 GeV optics



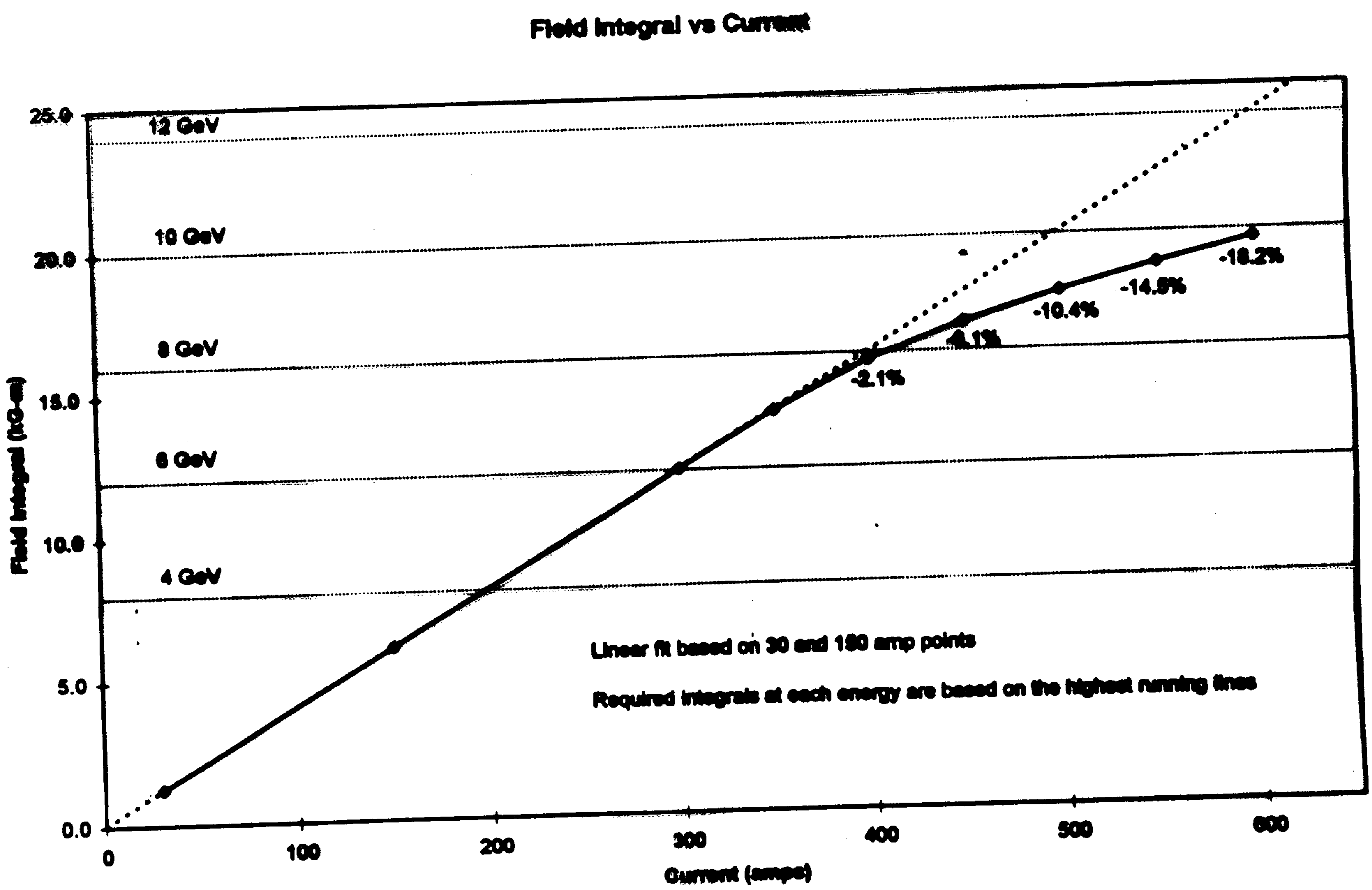



Energy Spread vs Arc #
0.025%
0.020%
0.015%
0.010%
0.005%
0.000%
dp/p
0
1
2
3
4
5
6
7
8
9
10
arc #



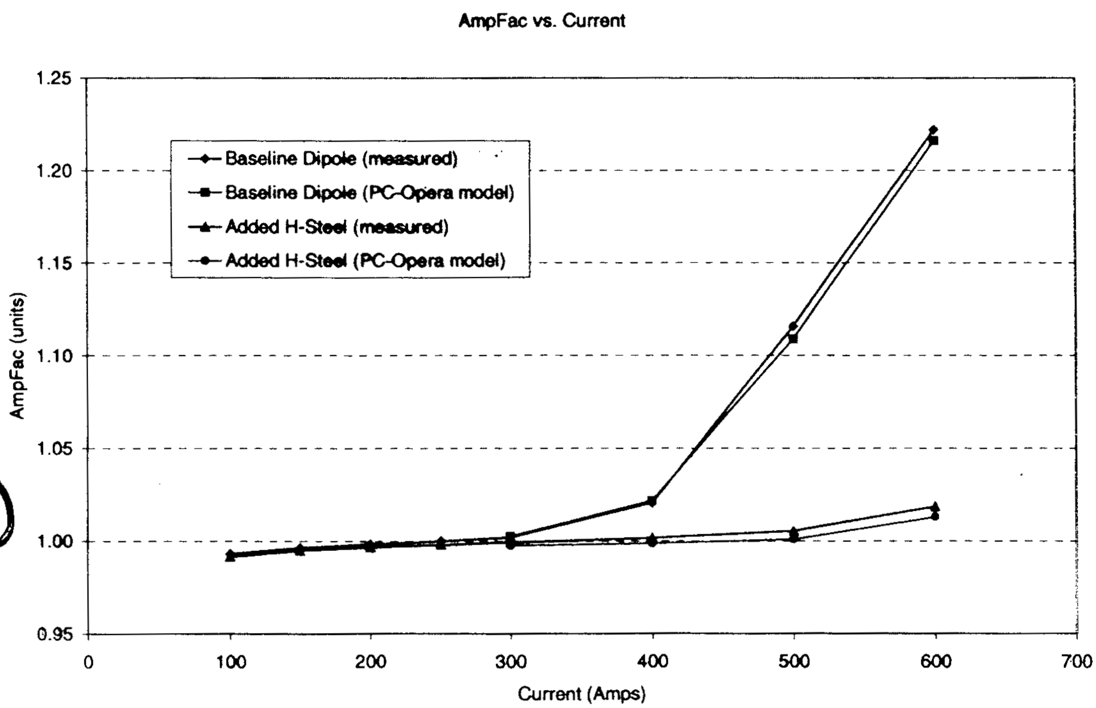
CEBAF EAST ARC MAGNETS

BB110 Measurement on Pickup Coil Stand



Prototype BB with added H-Steel.

Saturation versus Current



$\left(\frac{B}{I}\right)^{-1}$ (arb. units)

10-Sep-99

15:56

ARC 5.5 PASS 12 GeV UPGRADE PLAN

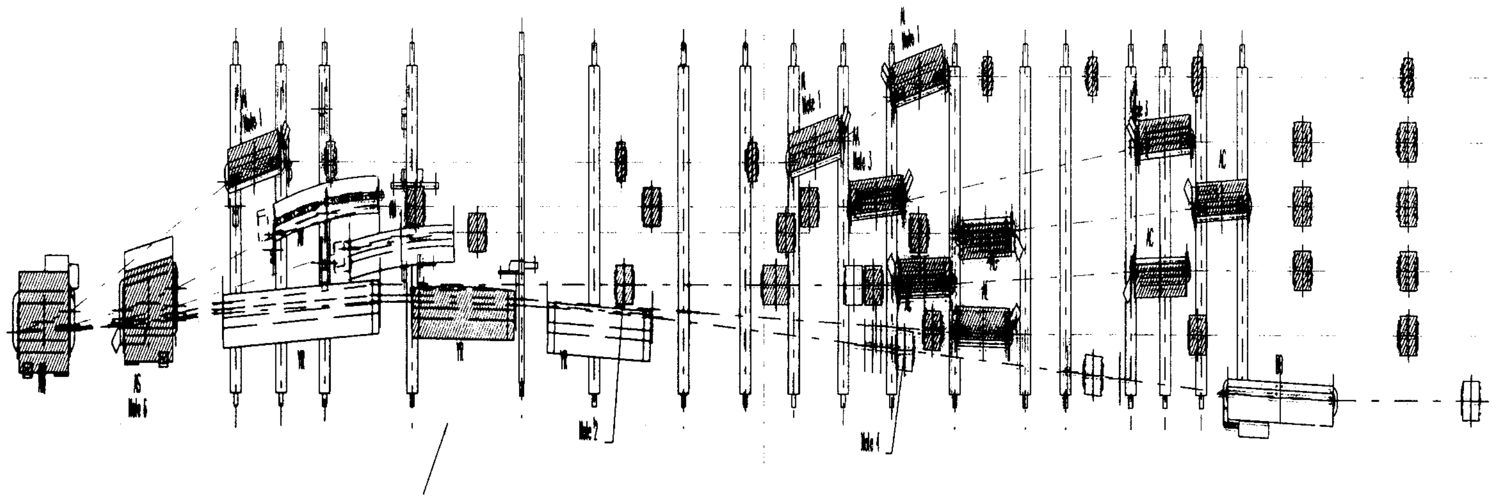
BASELINE

	CURRENT					H - MAGNET PLAN						
				6 GeV					12 GeV		SAT.	TOTAL
ARC #	MAG	Lm	ENERGY	TESLA	AMPS	MAG	Lm	ENERGY	TESLA	AMPS	%	AMPS
1	1-BE	1	0.668	0.44	222							
2	2-BR	2	1.268	0.41	206							
3	2-BE	2	1.868	0.61	297	2-[illegible]H	2	[illegible]	1.11	[illegible]	1%	[illegible]
4	2-BB	4	2.468	0.40	200							
5	2-BB	4	3.068	0.50	249	2-[illegible]H	4	[illegible]	[illegible]	452	0%	[illegible]
6	2-BB	4	3.668	0.60	299	2-[illegible]H	4	[illegible]	[illegible]	[illegible]	1%	[illegible]
7	2-BA	6	4.268	0.47	231							
8	2-BA	6	4.868	0.53	264	2-BA	6	[illegible]	[illegible]	[illegible]	0%	[illegible]
9	2-BA	6	5.468	0.60	299	2-BAH	6	[illegible]	1.[illegible]	[illegible]	1%	[illegible]
10						2-HSS	8	11.023	0.90	452	0%	452
A	1-BA	3	6.068	0.50	252							
B	1-BE	1	6.068	0.63	305	1-BEH	1	11.023	1.14	554	1%	560
C	1-BA	3	6.068	0.50	252							

NO CHANGE

BASE LINE CHANGE

East Spreader



No Change in position from present installation

Change in 'Y' only from present installation

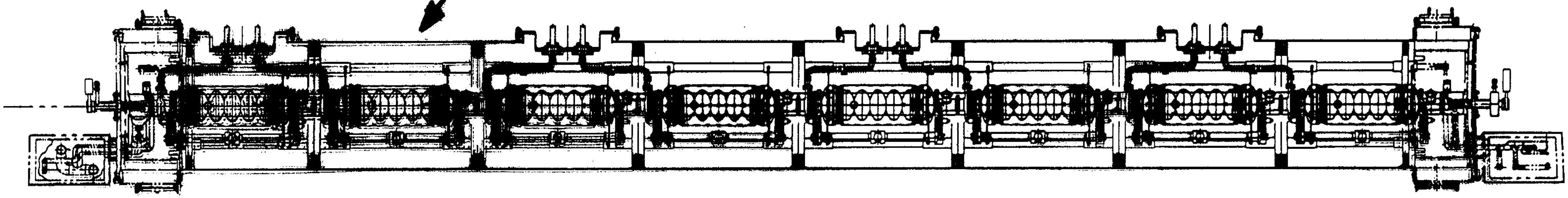
Change in 'Z' and 'Y' from present installation

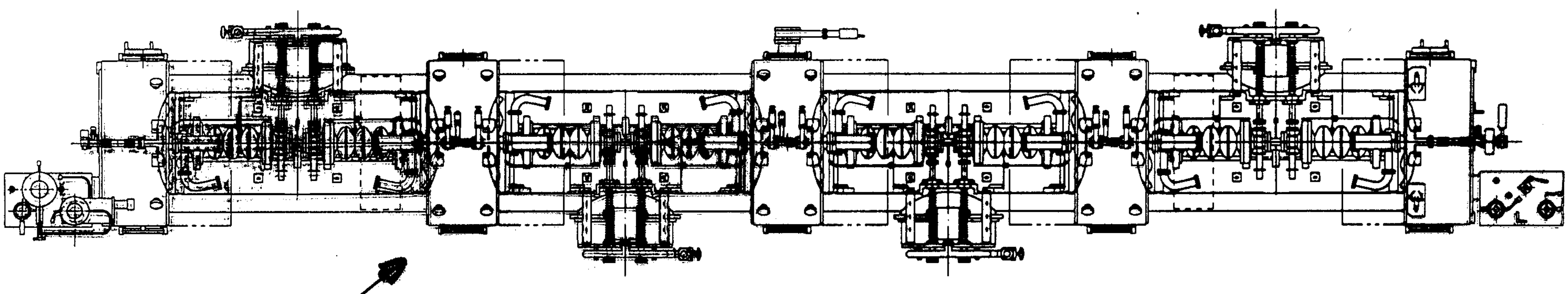
Change in 'Z' only from present installation

NEW magnets.

NEW DESIGN CONCEPT : 8 x 7CELL CAVITY ASSEMBLY

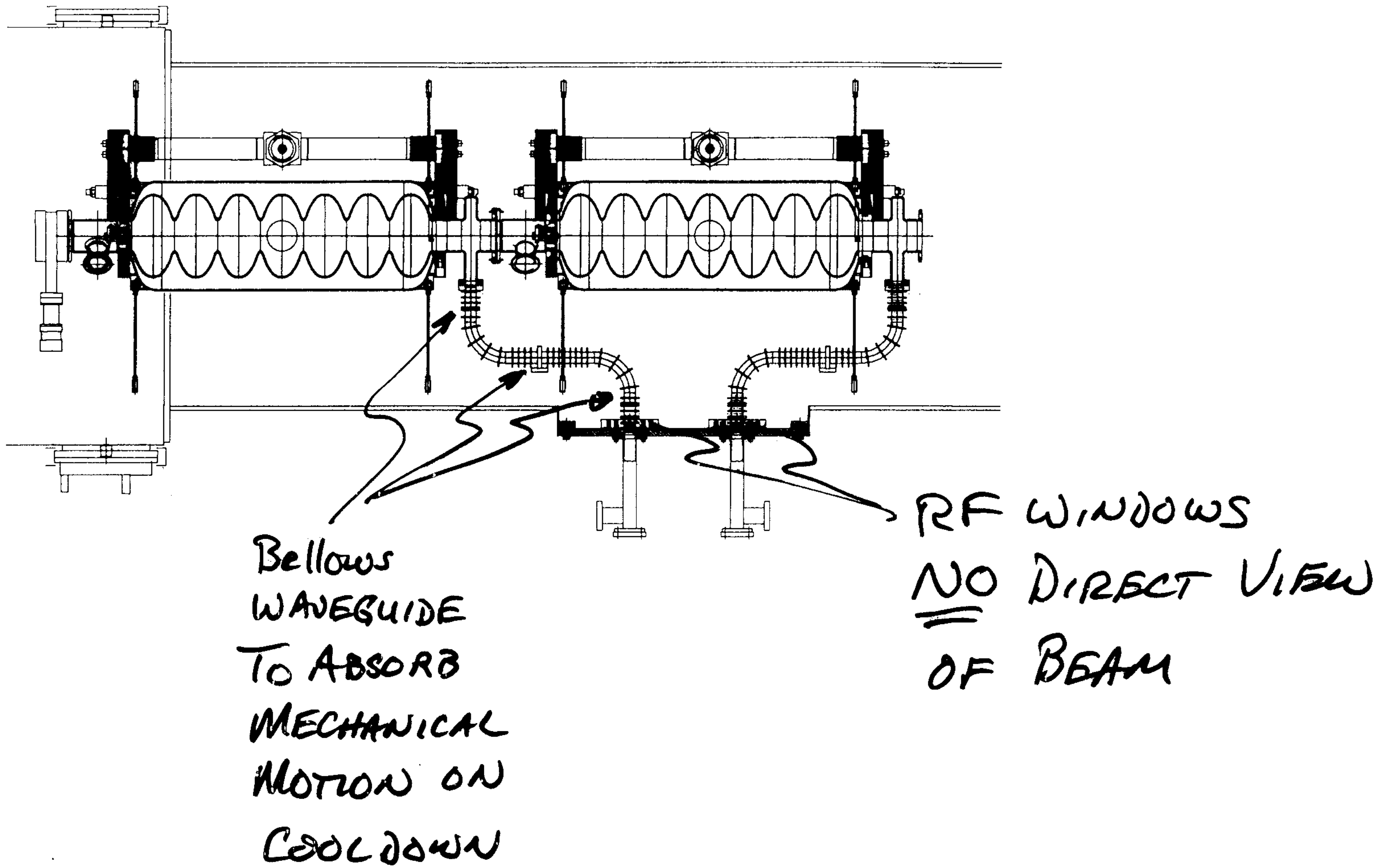
56 cavities/cryomodule



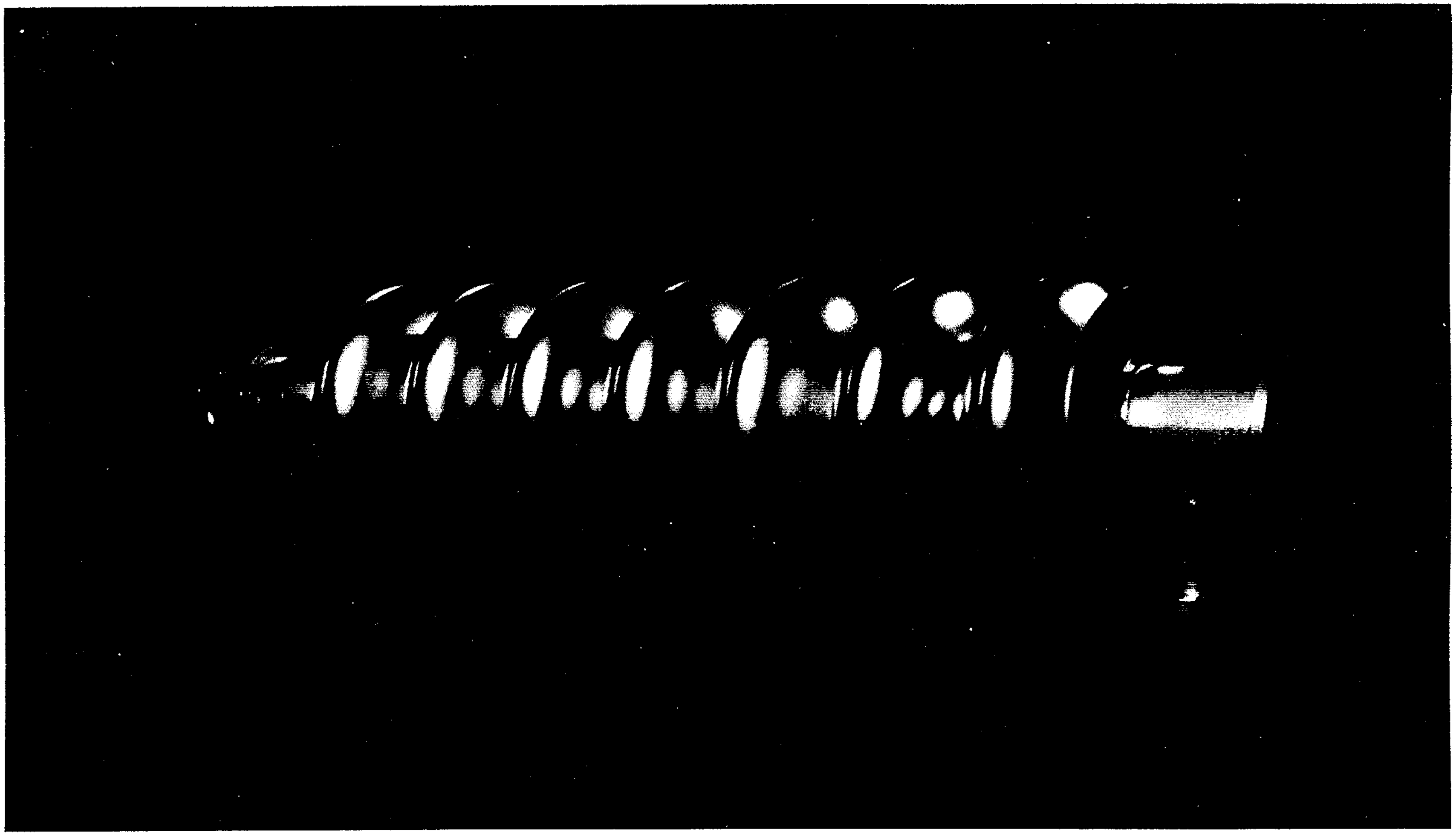


∃ CRYOMODULE : 4 x (2 x 5CELL CAVITY)

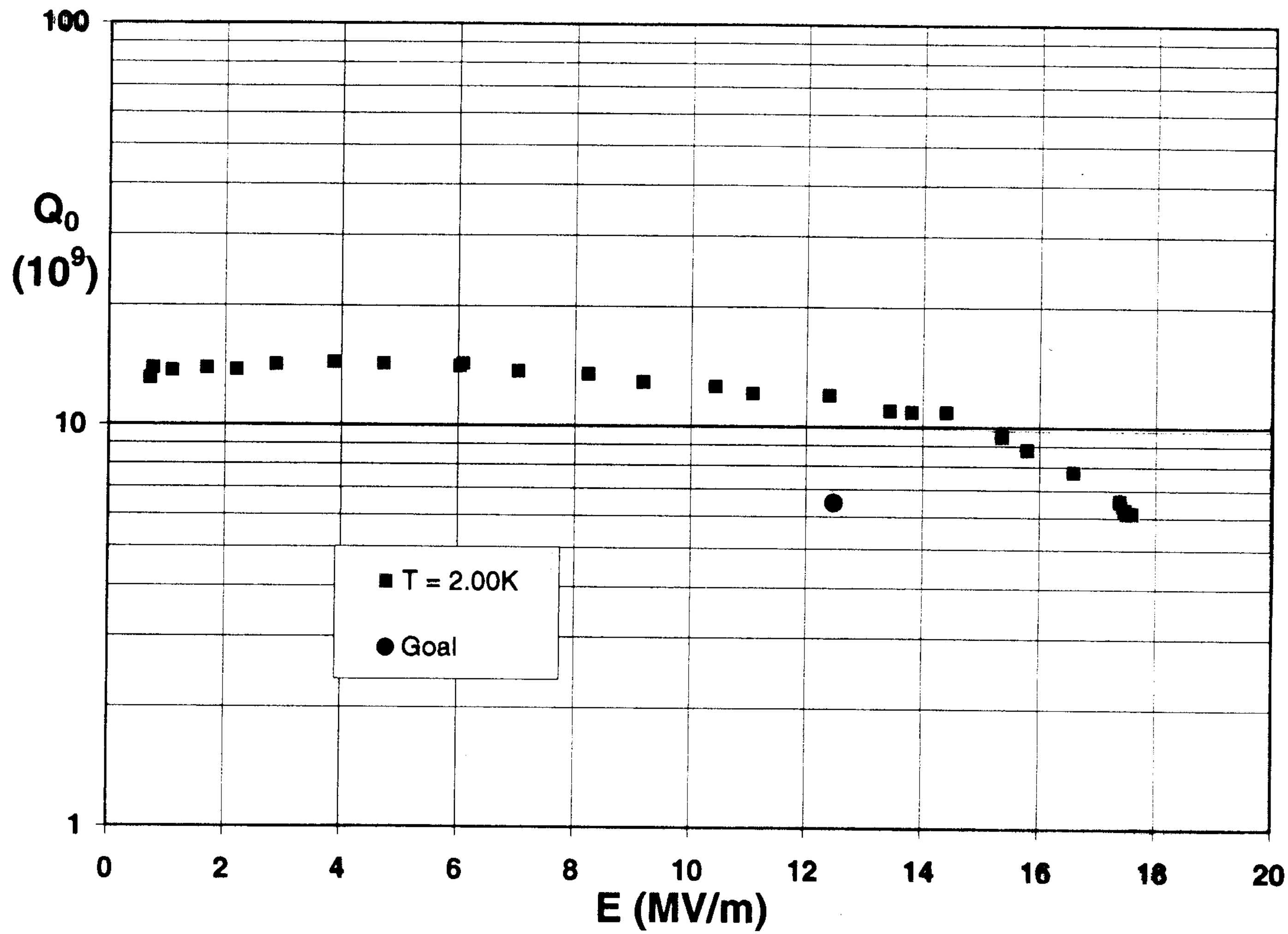
40 cavities/cryomodule


Bellows
WAVEGUIDE
TO ABSORB
MECHANICAL
MOTION ON
COOLDOWN
RF WINDOWS
NO DIRECT VIEW
OF BEAM

Prototype Seven-Cell Cavity.



Results of the Test of the First Seven-Cell Prototype.



Summary

- CEBAF@12 GeV opens exciting new physics opportunities
- Substantial work has been done to define and refine the accelerator upgrade:
  - it is straightforward
  - SRF cryomodule R&D essential to minimize cost is progressing well
- The experimental equipment required must be defined to a similar level soon
- The compelling physics case we see for the upgrade must be documented and sold to our colleagues prior to the next NSAC long range plan
  - Detailed studies, 3-star experiments, and the white paper are essential!
- Go to it!!!!