Proposal to measure the spin dependent structure functions $g_1(x)$ and $g_2(x)$ for proton and neutron at HERA

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21/9/89
DESY-PRC

HERMES - Collaboration

(Argonne NL, Caltech, MPI für Kernphysik HD
U.Illinois UC, Los Alamos NL, Madison,
Marburg, MIT, New Mexico State U., Münche
(~~Quebec~~), (~~Saclay~~), Stanford, Tarino,
TRIUMF/Alberta/Simon Fraser, (~~Uppsala~~),
W.+M. Williamsburgh)

14 institutes - 65 physicists

Status report

Final proposal will be submitted
~1 month from now.

Reminder: $g_1(x) = \frac{1}{2}\sum_f e_f^2 (q_f^+(x) - q_f^-(x$

EMC/SLAC measurement:

$$I_1^p = \int_0^1 dx\, g_1^p(x) = 0.126 \pm 0.010 \pm 0.015$$

Ellis-Jaffe S.R: $I_1^p = \underline{0.189} \pm 0.($

If Bjorken S.R correct:

$$I_1^n = -0.065 \pm 0.010 \pm 0.015$$

$$\langle S_z \rangle_{\text{all quarks}} = 0.060 \pm 0.047 \pm 0.069$$

$$\langle S_z \rangle_{s\bar{s}} = -0.095 \pm 0.016 \pm 0.023$$

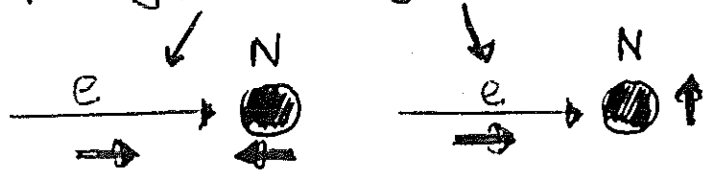
"Spin Crisis"

Explanations:
- large gluon polarization
- orbital angular momenti
  of quarks, gluons,
- Higher twist effect
- Violation of Biorken S.R

<u>However</u>: Speculations all based on just one number: I_1^p with large error bars.

To distinguish between models and to find true explanation

<u>need</u>: precise measurement of <u>x dependence</u> of $g_1(x)$, $g_2(x)$ for both proton and neutron



<u>Our proposal</u>

- Long. pol. e beam of HERA
- Polarized internal gas targets (storage cell
  - H, D: all nucleons polarizable $f = 1$
    ($f(NH_3) = \frac{3}{17}$, $f(C_4H_9OH) = \frac{1(}{7(}$
  - ^3He : polarized neutron target ($f \sim \frac{1}{}$

⇓

High precision in relatively short running times

Possible problems connected with storage cell

- Synchrotron radiation

  $O(10^{15})$ γ/s would hit walls of st. cell

  $O(10^{12})$ γ/s " be scattered into spectrometer

  ⇓

  Need: — modified beam line

  — movable collimators (± 7mm, ±2.3mm

  — clam shell st. cell (± 12.6mm, ±3.8m

  ➡ $O(10^{5})$ γ/s scattered into detector most of them from target gas

- Depolarisation by magnetic bunch field

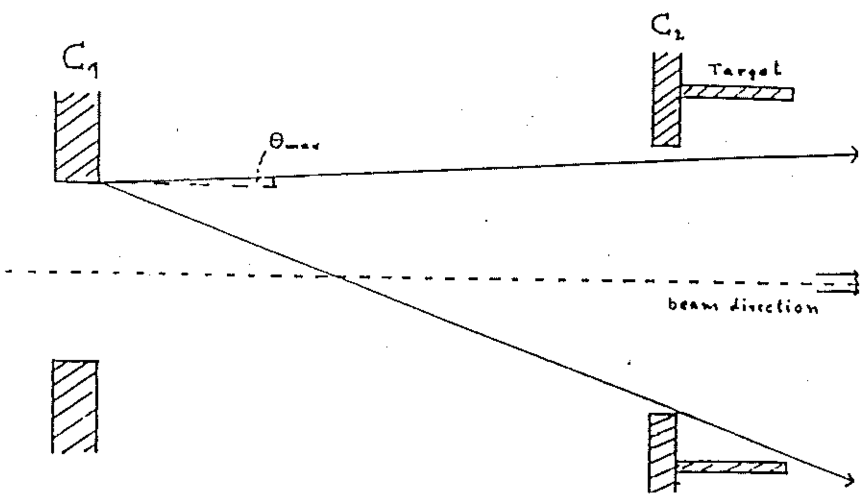
  Need: Holding field ($B \sim 0.33T$)

- Depolarisation by wall collisions

  Need: Coating (e.g. dryfilm)
  Holding field

Investigated in detail: o.K.

Good experience with test experiment at VEPP3



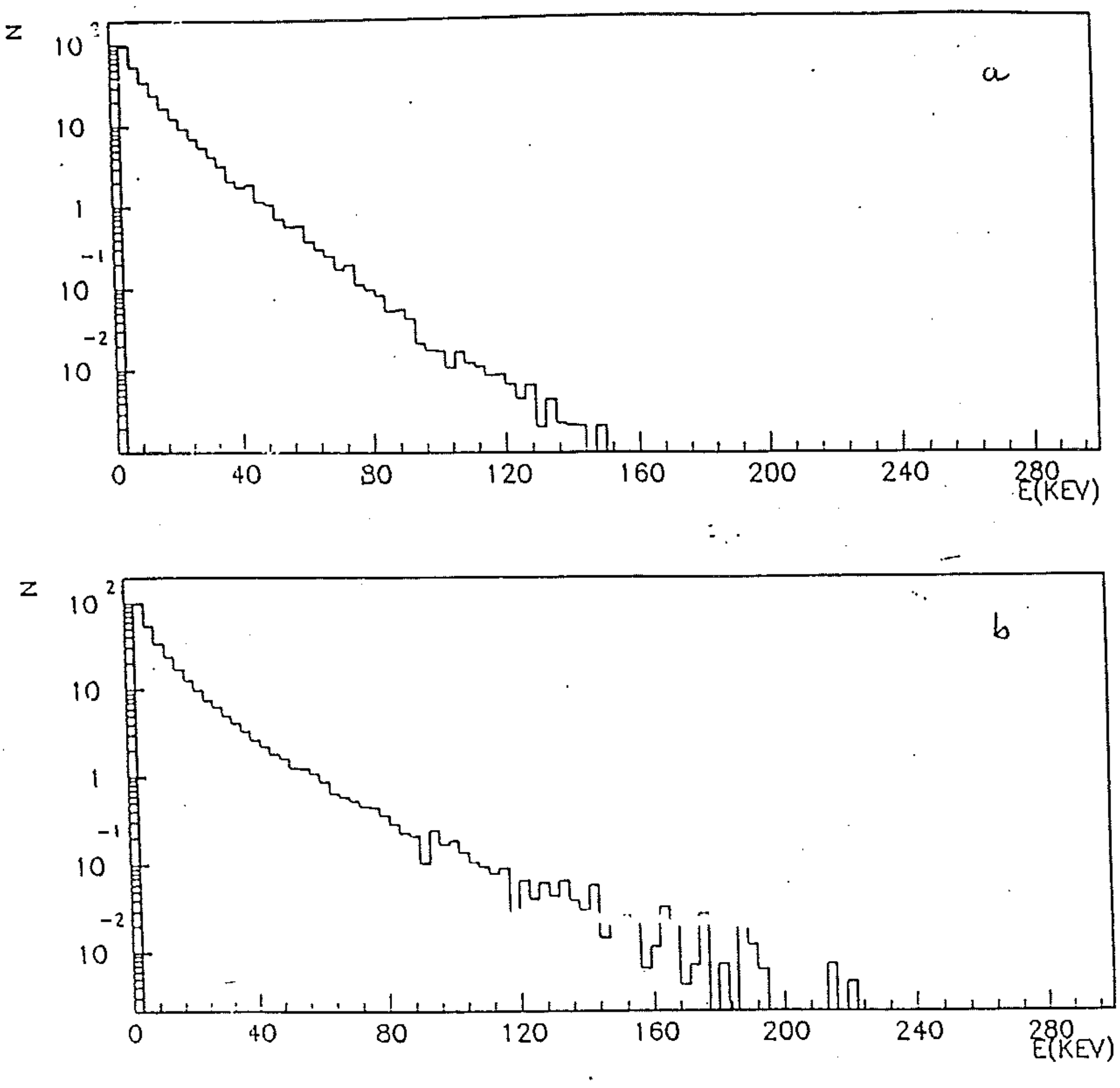
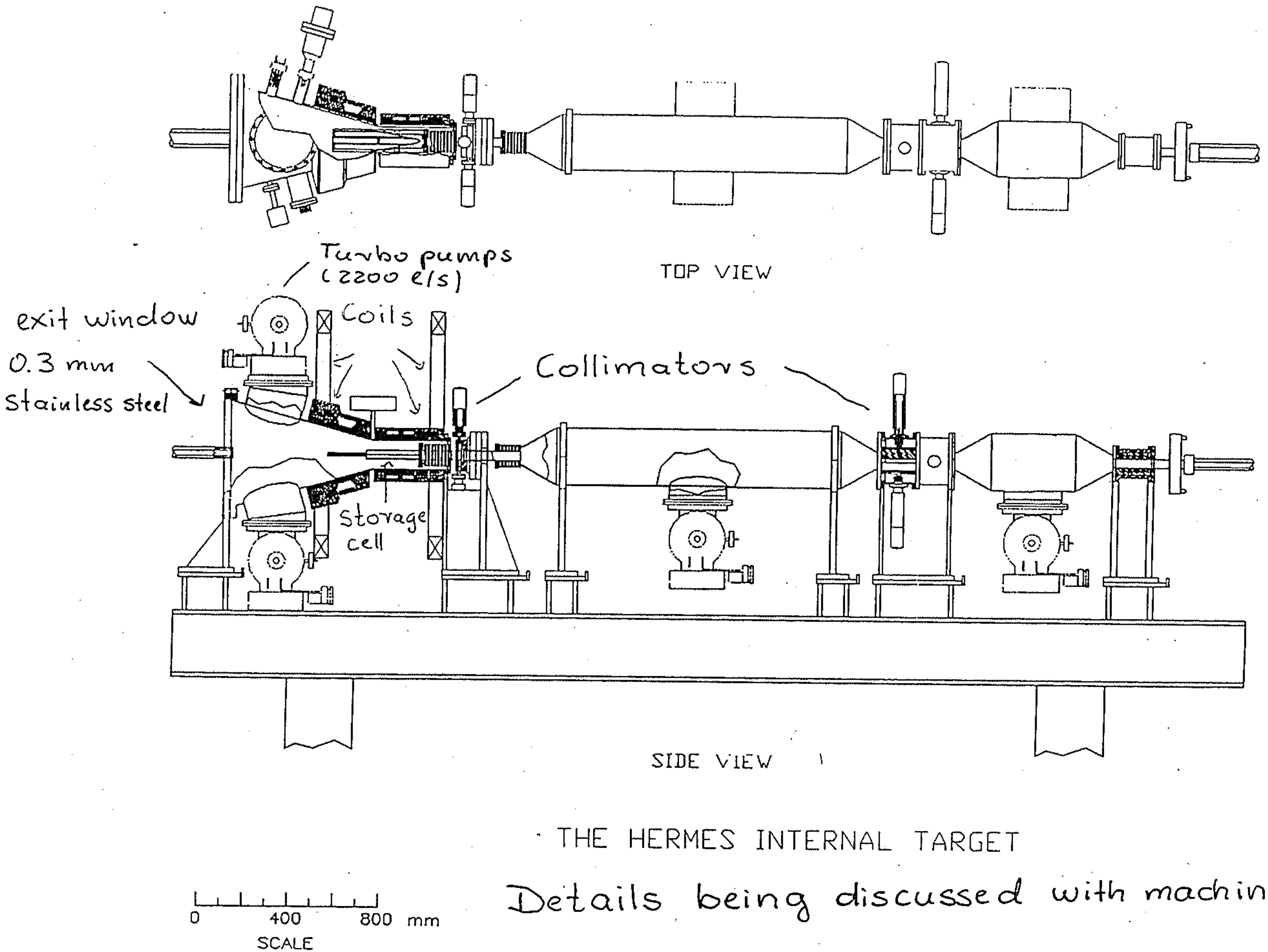


Fig. 2.4.4: The energy spectrum of the dipole (a) and quadrupole (b) radiation hitting C.



THE HERMES INTERNAL TARGET

Details being discussed with machine people

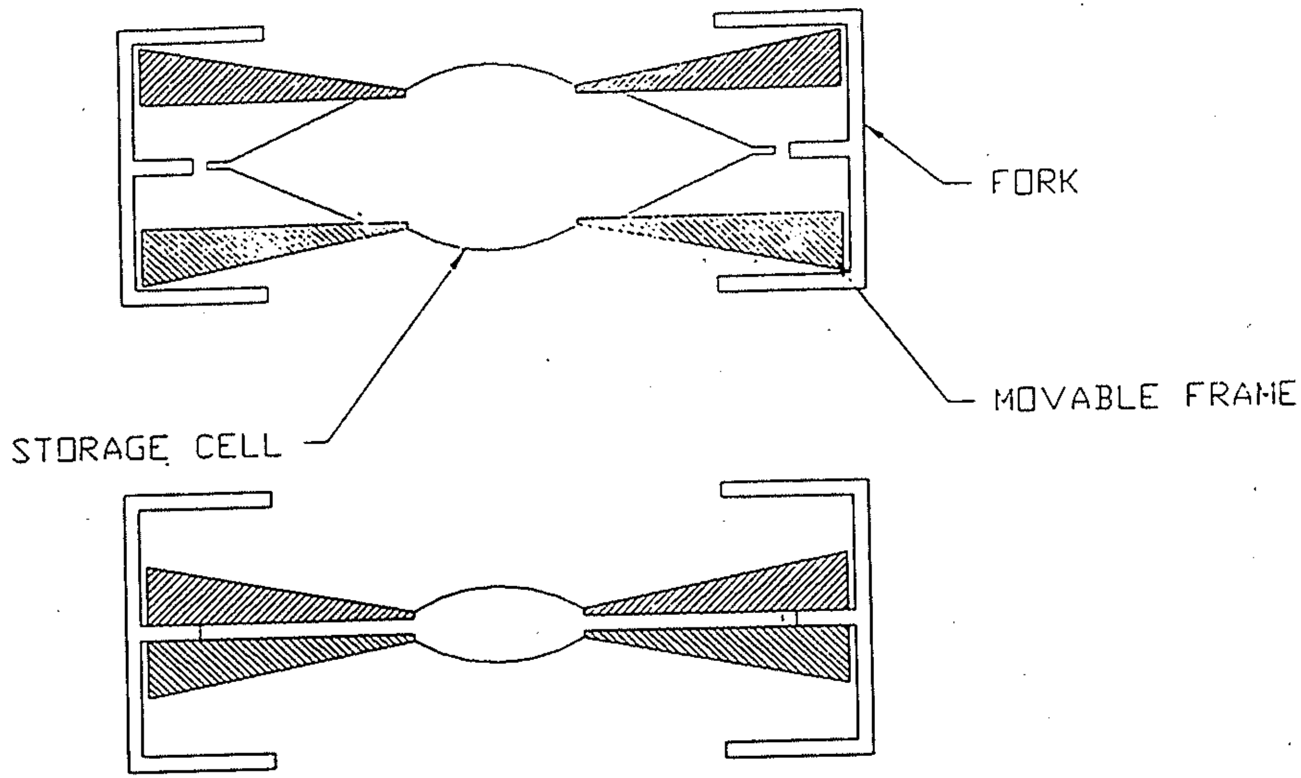


Fig. 2.2.18. THE PRINCIPLE OF HERMES TARGET CELL

Status H/D source

- Vacuum system, diagnostics, controll operational
- First version of dissociator operational
- Systematic studies of
  - degree of dissociation – flux density –
  - beam pressure – velocity distribution
    ↓
    optimize magnet configurati

- Get > 10^{20} H atoms/s at dissociator
- Estimate 6.5×10^{16} atoms/s in one HF stat into acceptance of st. cell
  (Factor of 2 higher than best source)
- Possible improvements: Optimization of dissociator, lower nozzle tem
  ⇒ 10^{17} s^{-1} realistic

— — — — —

- Sextupole magnets ordered, expected end of year
  ↓
  Pole tip field 1.5 T

— — — —

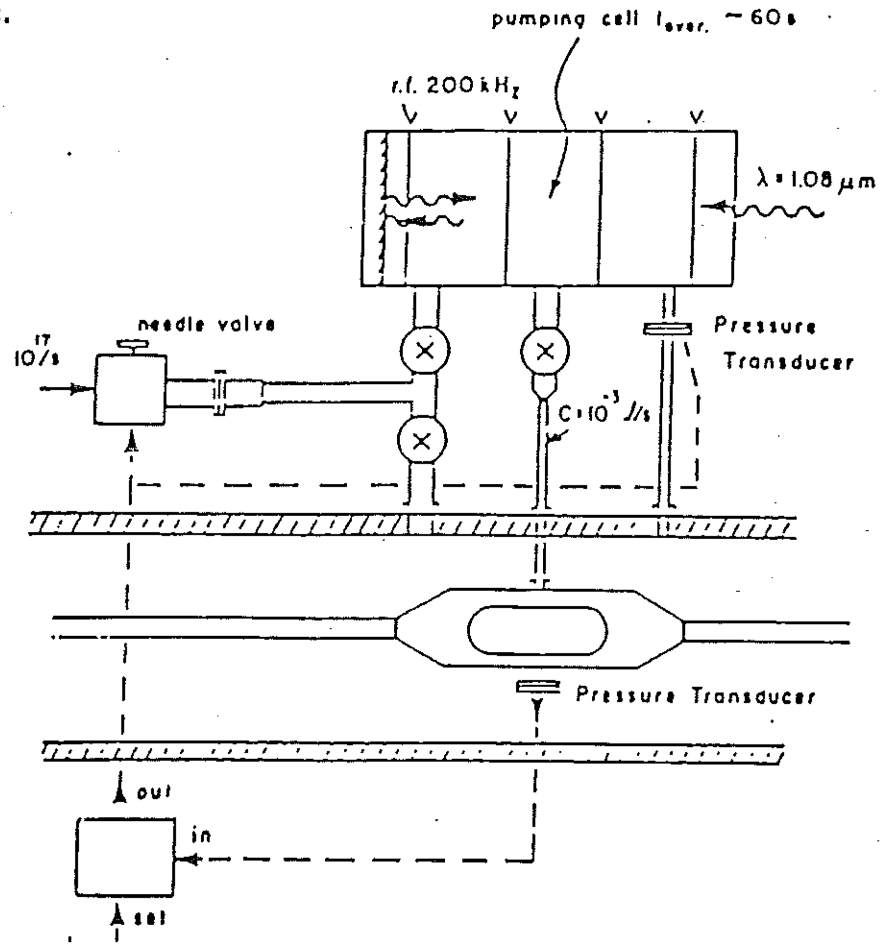
- First test experiment at Heidelberg TS'
  <u>Next spring.</u>

Status of ^{3}He source (Caltech, MIT)

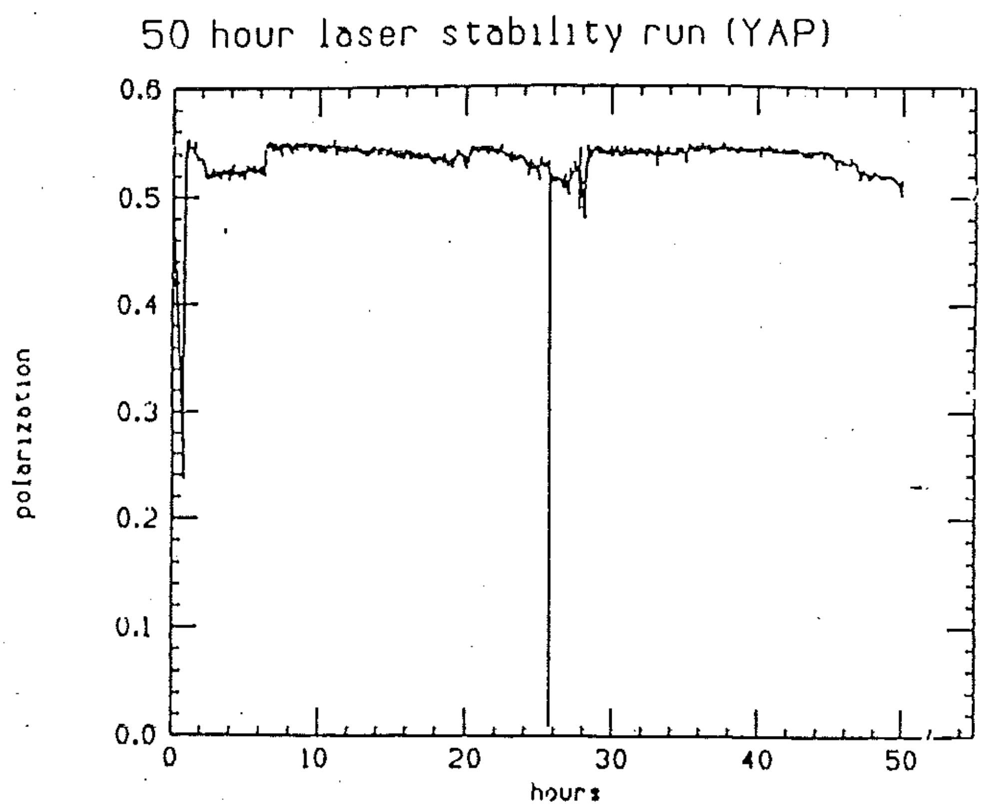
Principle: Metastability exchange optical pumping

- Polarization achieved at Caltech: ~55%
  Paris: ~70%
- Tested at Bates with 40 μA 250 MeV e^-
  No significant depolarization
- Prototype source under construction at MIT
- Polarimeter constructed and tested
- YAP laser assembled, tuned to He transition
- Flow through system tested at 1.3 mbar with 10^{17} atoms/s
- Helmholtz coil under construction
- Test of complete system: Fall 89

tube.



pumping cell t_aver. ~60 s
r.f. 200 kHz
λ = 1.08 μm
needle valve
10^17/s
Pressure Transducer
C = 10^-3 l/s
Pressure Transducer
out
in
set



50 hour laser stability run (YAP)
polarization
hours
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
10
20
30
40
50

Some details of spectrometer

Magnet: (LANL)

Modify existing magnet at LANL

(Vandalize two others)

$\int B dl \sim 1.5$ Tm

Field in bore of septumplate:

0.014 Tm e , 0.0045 Tm p

Calorimeter: (Caltech, Illinois, LANL)

Options: – Dense Pb-glass (SF57-DF6
(well understood)

$\frac{\sigma_E}{E} \sim 3.6\%/\sqrt{E} + C\%$ (C: 3?)

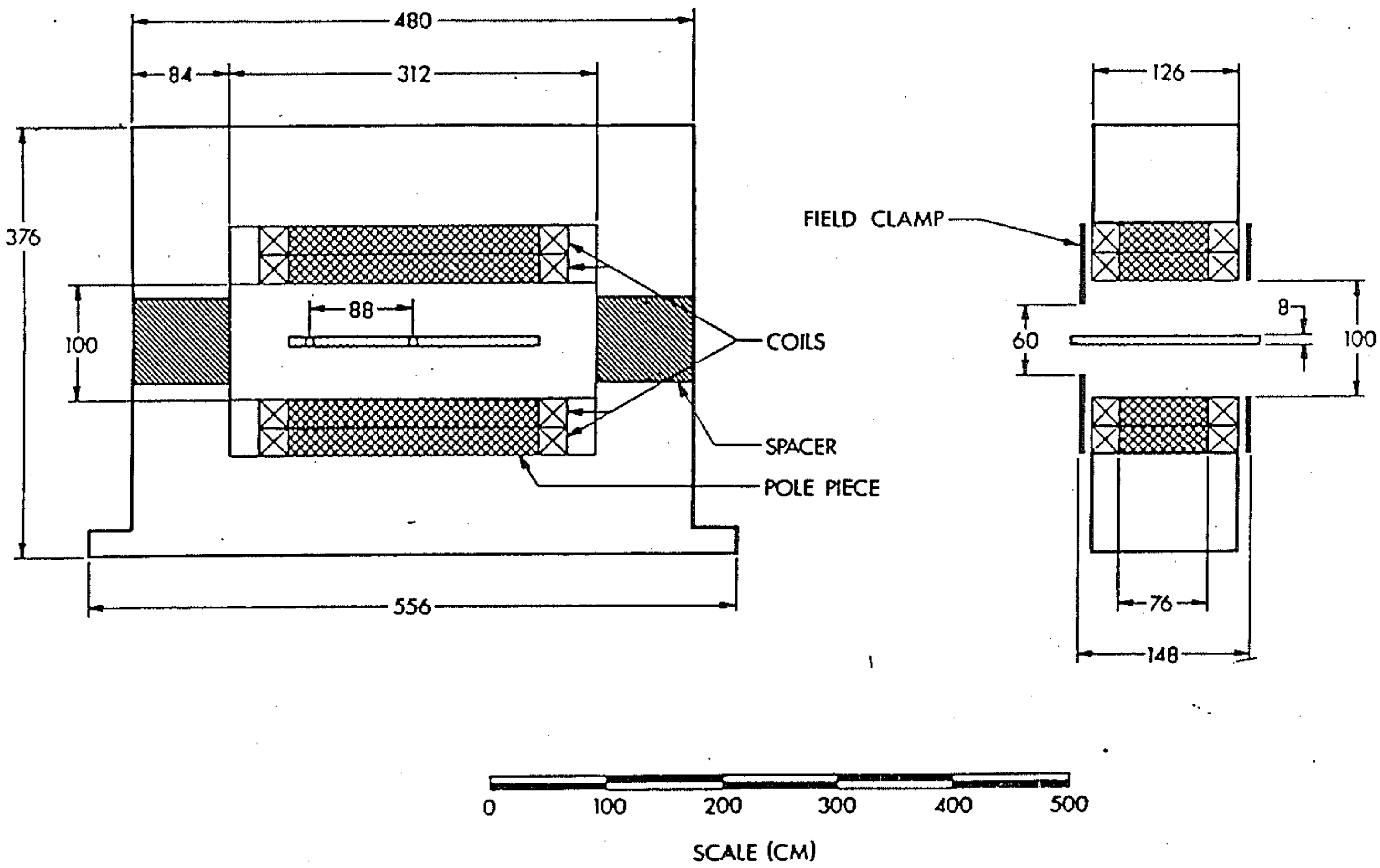
– Pb-Scint. fibers
(high radiation resistance-Mra
new device - further studies needed

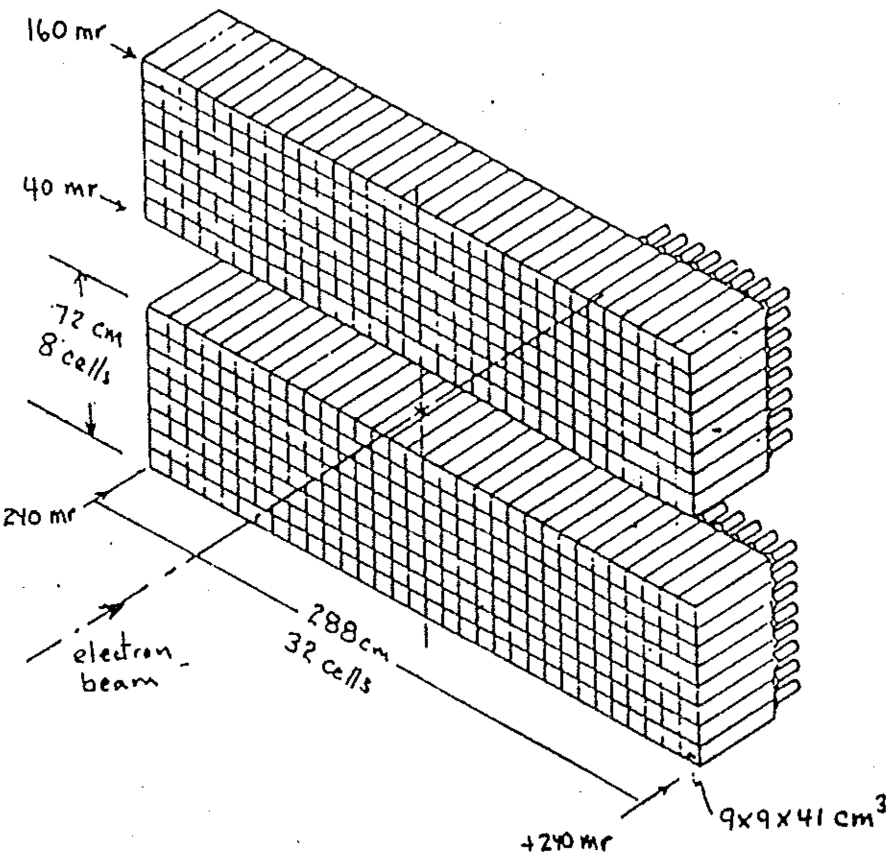
$\frac{\sigma_E}{E} \sim 6\%/\sqrt{E}$

Size: 288×72 cm^2; 32×8 elements, $9 \times 9 \times 41$ cm

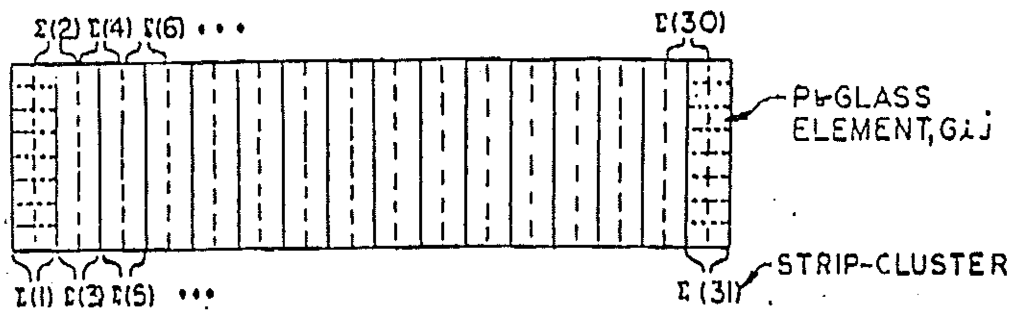
Pion rejection ($E > 4\text{-}5$ GeV): On-line ~30
off-line ~300

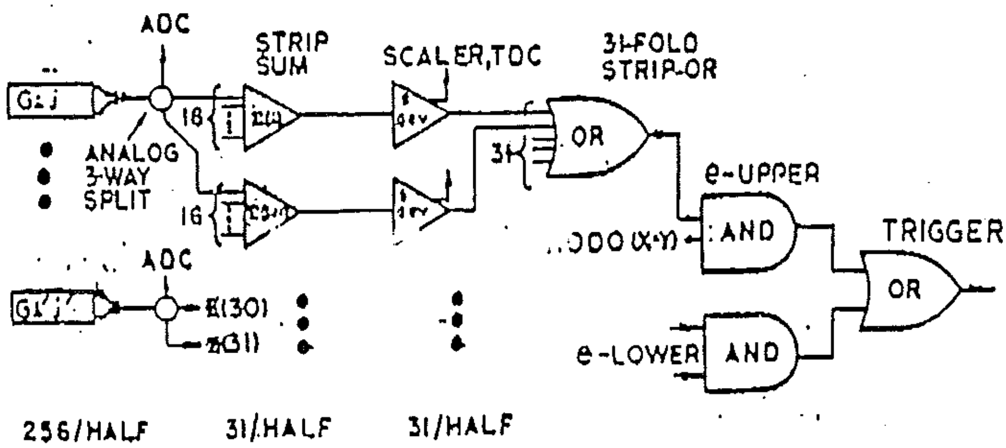
HERA EXPERIMENT SCM 105 MAGNET SCHEMATIC

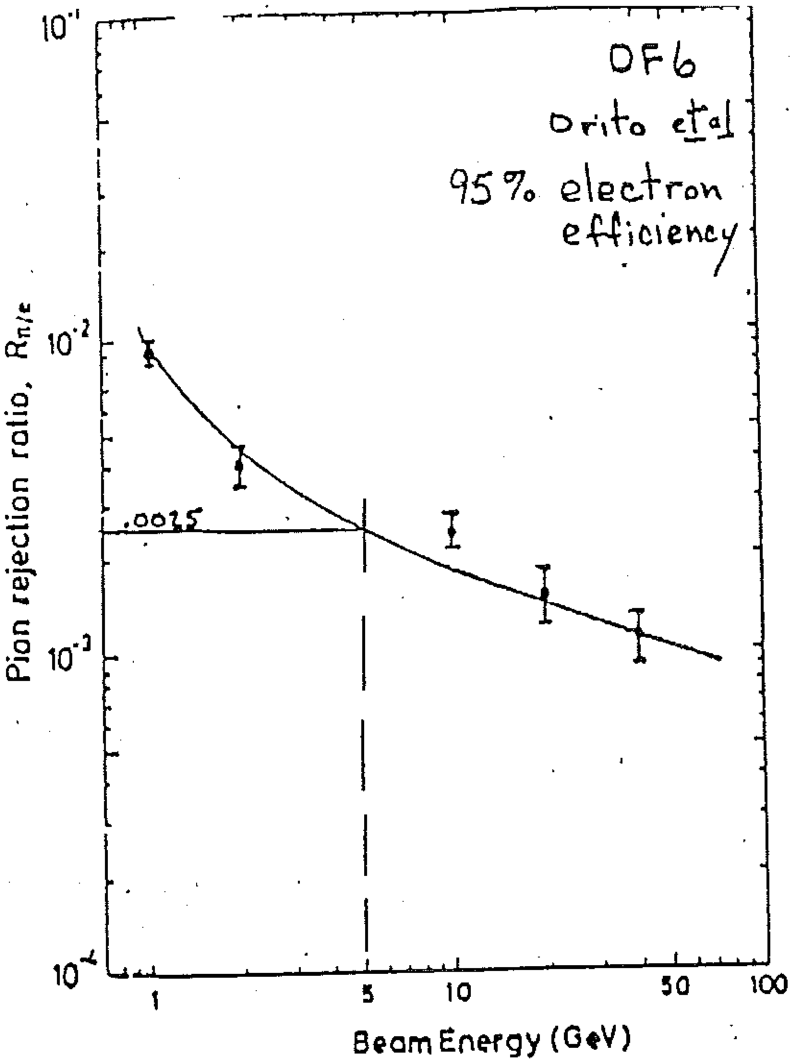




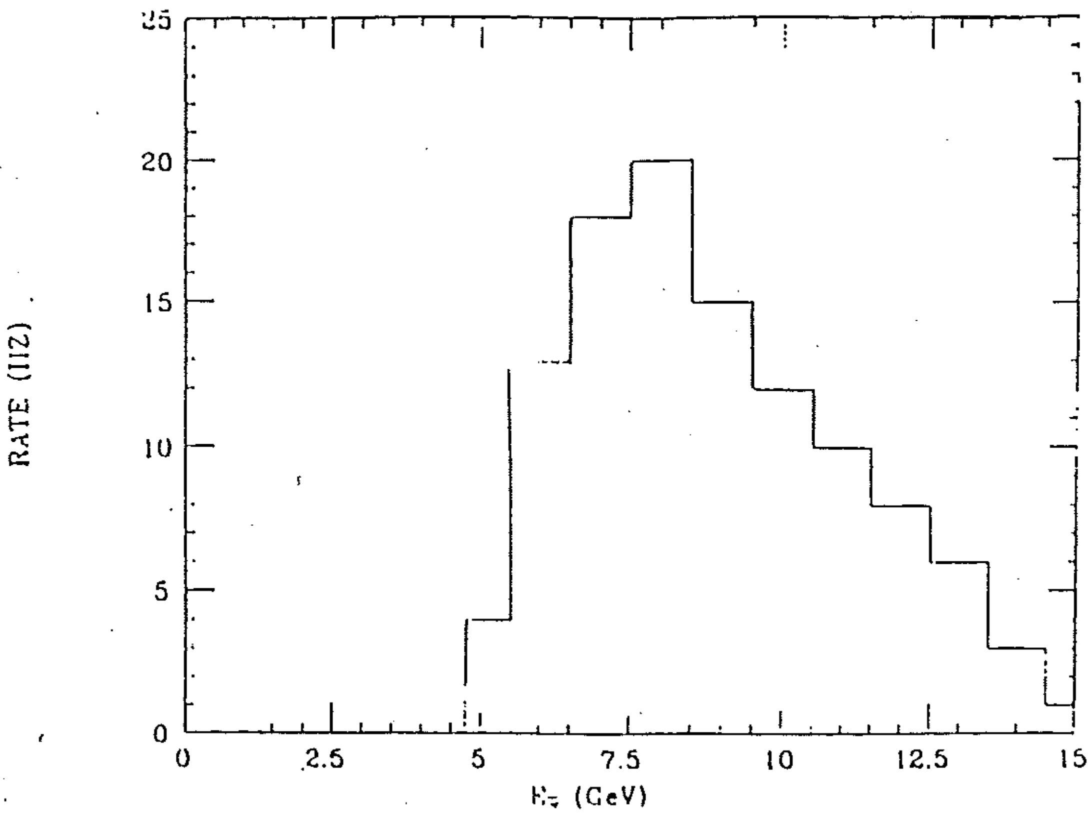
CALORIMETER STPIP-CLUSTER TPIGGER LOGIC

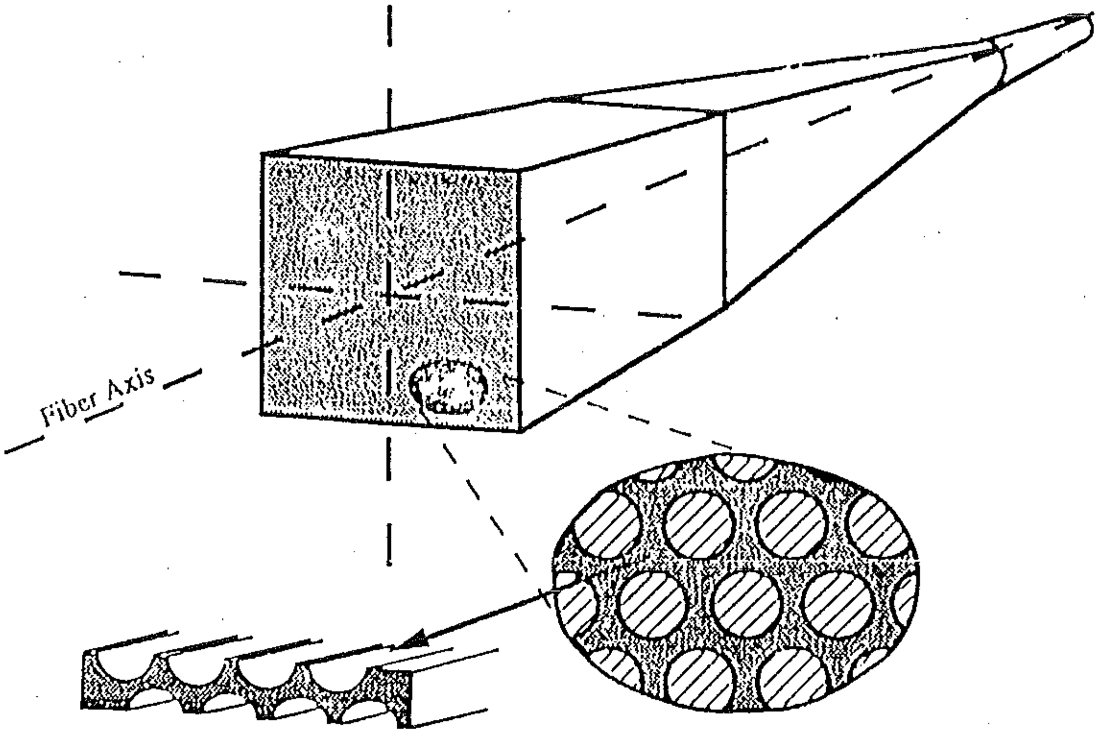






π TRIGGER RATE E > 4.5 GEV





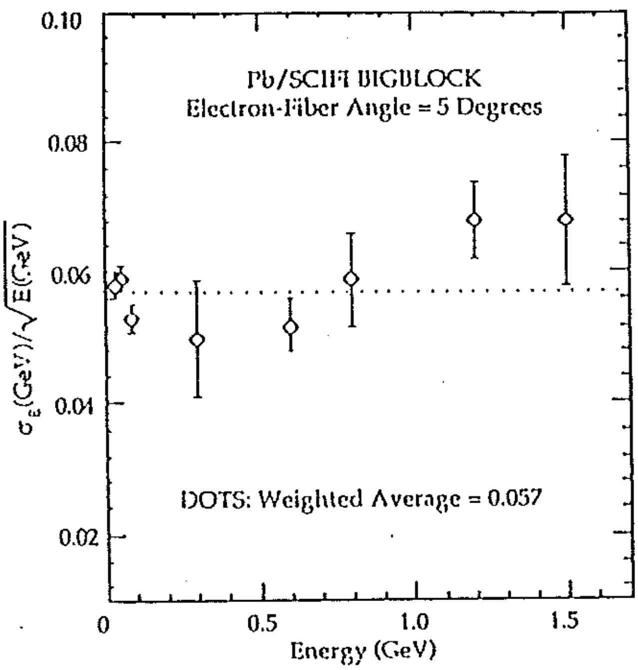


Figure 2. Resolution for a 10 x 10 x 22 cm^3 module (BIG BLOCK) at all energies plotted vs $\sigma\sqrt{E}$, with E in GeV. Note that the highest energy points will be remeasured as the detector-electronics chain exhibited a degree of non-linearity.

TRD (TRIUMF/Alberta/Simon Frazer

6 modules – total length 60 cm

Radiator (6.5 cm): polypropylene fiber

Chambers (2.5 cm): cell size – 2.7 cm

gas – Xe + 10% quenc

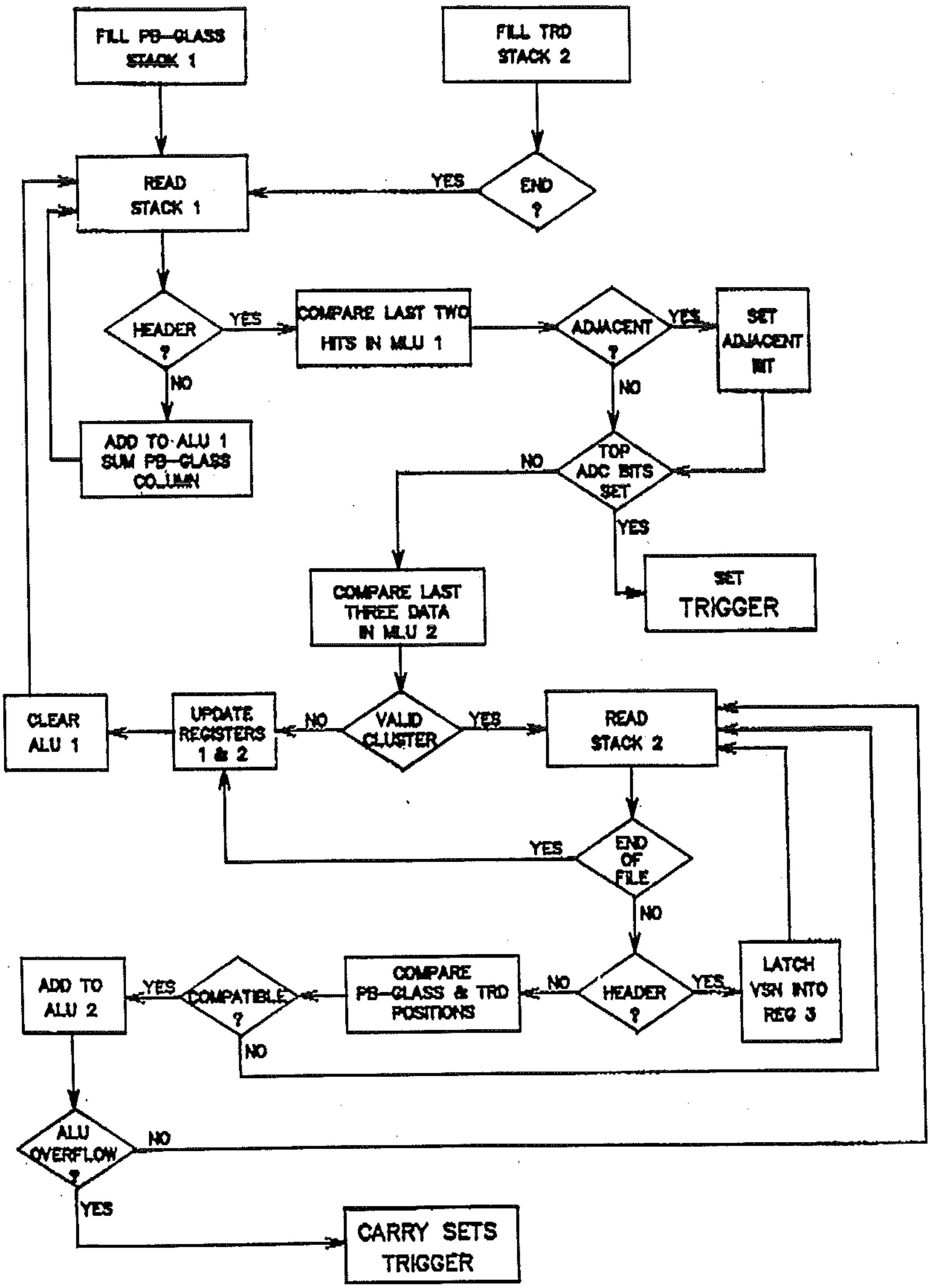
Second level trigger:

Combine information from TRD
+ Calorimeter
(vertical rows)

Additional π rejection: on-line ~ 10
off-line > 100

Total π rejection: ~ 30000

Prototyping started


FILL PB—GLASS STACK 1
FILL TRD STACK 2
READ STACK 1
YES
END ?
HEADER ?
YES
COMPARE LAST TWO HITS IN MLU 1
ADJACENT ?
YES
SET ADJACENT BIT
NO
NO
ADD TO ALU 1 SUM PB—GLASS COLUMN
NO
TOP ADC BITS SET
YES
SET TRIGGER
COMPARE LAST THREE DATA IN MLU 2
CLEAR ALU 1
UPDATE REGISTERS 1 & 2
NO
VALID CLUSTER
YES
READ STACK 2
YES
END OF FILE
NO
ADD TO ALU 2
YES
COMPATIBLE ?
COMPARE PB—GLASS & TRD POSITIONS
NO
HEADER ?
YES
LATCH VSN INTO REG 3
NO
ALU OVERFLOW ?
NO
YES
CARRY SETS TRIGGER

Tracking

Si-strips (.115 mm pitch)
(Torino)

Front chambers (3.5 mm drift, <0.2 mm res.)
(MIT)

Magnet chambers (1 mm res.)
(ANL)

Back chambers (5 mm drift, <0.2 mm res.)
(MPI)

Resolution dominated by multiple scatteri
and straggling.

$\frac{\Delta E}{E} \sim 0.7 - 1.7\%$

$\frac{\Delta Q^2}{Q^2} < 1.5\%$

$\frac{\Delta x}{x} \sim 1 - 8\%$

$\sigma_z \sim 0.5$ cm
$\sigma_r < 0.03$ cm } vertex resolution

Other projects

- **SMC - CERN** ; 100 GeV muons

  C_4H_9OH, C_4D_9OD target

  $f = \frac{10}{74}$ $\quad$ $f = \frac{10}{42}$

  $\mathcal{L} \sim 1.4 \times 10^{32}\ cm^{-2}s^{-1}$

  approved: scheduled for end 91 - early 92
  ↑ target construction.

  2 years data taking, > 2 years analysis;
  results for $g_1^n(x)$ earliest late 95 | Too large errors!

- **HELP - LEP** ; 50-100 GeV electrons
  H/D- Jet target

  $\mathcal{L} = 2-20 \cdot 10^{29}\ cm^{-2}s^{-1}$

  polarisation physics in 95? | rejected!

- **SLAC** 25 - 50 GeV electrons

  High pressure ^3He-target

  $\mathcal{L} \sim O(10^{35})\ cm^{-2}s^{-1}$

  Problems : High current on glass cell
  Same rate from cell walls as from ^3He
  " " " N_2 quench " "

  Restricted kinematic range

  Data taking 2 years from now? | Only g_1^n!

Our proposal is

still unique!