A New Detector for Physics at HERA - III

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CIPANP
New York
May 2003
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• Silicon Tracker
• Calorimetry

• Acceptance
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• $e/\pi$ Separation

• Physics Reach

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Detector Concept

• Extend the **rapidity range** compared to existing detectors.

• Use a **dipole field** to pull scattered positrons into the acceptance.

Measure $F_2$ and $F_L$ for $0.1 < Q^2 < 10 \text{ GeV}^2$

• Make it symmetric

Vector Mesons
Forward Jets
Detector Concept

• **Silicon Tracker**
  - high resolution tracking
  - radiation resistant

• **Silicon Tungsten Calorimetry**
  - good energy resolution
  - good spatial resolution
  - good $e/\pi$ separation

• **Compact Tube**
  - fit into dipole magnet
  - plus endwalls

- EM

$R<60\text{cm}$
$L=10\text{m}$
Interaction Region

-5.8m

1 dipole field

too large synchrotron radiation fan.

Use existing HERA I and II magnets

50 pb⁻¹/year
Silicon Tracking

forward geometry

14 planes on each side

Each plane is

\( \approx 40 \times 40 \text{ cm}^2 \)

Baseline:

2 double-sided silicon detectors plus support

0.1\% \( X_0 \) per plane
Silicon Tracking

The beampipe opens up to allow for the deflected electron beam.

Detectors start at 3cm distance to the beam.

Symmetric beampipe is not needed. However, one side will be used to integrate pumps.
Calorimetry

Positron Hemisphere
EM calorimeter endwall at -5.0m
[might come from HERA-B]
25 x 1 $X_0$

EM barrel calorimeter
covering $z=\pm 70$cm
50 x $\frac{1}{2} X_0$

EM catcher calorimeters
at $z=-170$cm
and $z=-90$cm
25 x 1 $X_0$

EM catcher calorimeters
at $z=+90$cm
and $z=+170$cm
25 x 1 $X_0$

Proton Hemisphere EM
and hadron calorimeter endwall
at +4.8m [might come from ZEUS]

25 x 1 $X_0$

Baseline is silicon tungsten.
The center is a bit packed.

No tracking for eta < 1!
But good calorimetry!
Far Out Components

• **Proton Remnant Tagger**
  hadron calorimeter plus silicon strip detectors at \( \approx +20\text{m} \)
  diffractive and exclusive processes

• **Photon Calorimeter**
  electromagnetic calorimeter at \( \approx -100\text{m} \)
  luminosity from \( ep\gamma \) tagging of ISR

• **Spectator Calorimeter**
  hadron calorimeters above and below beamline at \( \approx +100\text{m} \)
  identify spectator nucleon in \( e\,d \) scattering

Details after design of beamline
Acceptance depends on:

• Energy
• Rapidity
• Azimuth angle
Acceptance

- for 3 hits per track

- focus on low $Q^2$

- for 4 hits per track

- central region

- forward region
Momentum Resolution

Full GEANT3 simulation [atlsim]

The system is not limited by the intrinsic resolution of the silicon strip detectors.
Bremsstrahlung

with beam-pipe

without beam-pipe

GeV positrons
eta = -3
on endwall

x(cm)
A creative beampipe can help with the tails.

And one can use Bremsstrahlungs-Recovery

Pretty hard to build silicon stations with less material.
Momentum Resolution

Improvements

- through software
- better plane - placement
- material reduction
The catchers and the endwalls should be similar to the end of the barrel.
Electrons and Pions

5 GeV Pions

5 GeV Positrons
Energy Response

Less of the hadronic energy is seen
e/π Separation

efficiency

rejection

easy above 5 GeV
energy/momentum > 0.9
e/π Separation

longitudinal energy profile cut

$E_e = 2 GeV$

$E_e = 3.5 GeV$

$E_e = 5 GeV$


**e/π Separation**

*Longitudinal and transverse cut*

- **$E_e = 2\text{GeV}$**
- **$E_e = 3.5\text{GeV}$**
- **$E_e = 5\text{GeV}$**

**Efficiency vs. Rejection Power**

- **$\eta = 0$**
- **$\eta = 1$**

Parameter values shown in the graphs.
Kinematic Range

for $F_2$

$Q^2$ (GeV$^2$)

- electron
- + jet ($E_p=460$ GeV)
- + jet ($E_p=920$ GeV)
High x Range

Range for structure function measurements

Ep=920GeV  Ep=460GeV

pb
Range for 10% R Measurement

solid - MRST99    dashed - SAT MODEL

$E_p=920.690\text{GeV}$   $E_p=920.460\text{GeV}$

$F_L/F_2$

$Q^2 = 1.5, 2.0, 2.5, 3.5, 5.0, 6.5, 8.5, 12, 15, 20, 25, 35, 45, 60, 90, 120$

$E_p=920.690\text{GeV}$   $E_p=920.460\text{GeV}$
Forward Jets

Large extension of jet coverage
Status

- Physics Program
- Conceptual Detector Design
- GEANT 3 Simulation
- Letter of Intent
  wwwwhera-b.mppmu.mpg.de/hera-3/index.html

There is a lot left to be done
Conclusions

A detector especially designed to extend the currently probed kinematic range in $e \, p$ scattering can facilitate an exciting physics program.

This can happen at a modified HERA machine or elsewhere.

Let’s hope it doesn’t get worse.