DETECTOR LIMITATIONS, STAR*

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Presented at the Spin Meeting
Brookhaven National Laboratory, Upton, New York 11973

10 June 1998

Every detector has limitations in terms of solid angle, particular technologies chosen cracks due to mechanical structure, etc. If all of the presently planned parts of STAR were in place, these factors would not seriously limit our ability to exploit the spin physics possible in RHIC.

What is of greater concern at the moment is the construction schedule for components such as the Electromagnetic Calorimeters, and the limited funding for various levels of triggers.

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Figure II.2.2-2. Side view of a calorimeter module showing the projective nature of the towers and the location of the straps between the front and back plates. The 21st megatile layer is also shown.

-2-
What is good in STAR

(before I launch into a limitations talk)

Large solid angle

Good tracking with Momentum   -1 < eta < 1  -all phi
Some tracking with some Momentum info  1 < eta < 2  -all phi
Tracking  2.5 < eta < 4  -all phi
EMC  -1 < eta < 2  -all phi
SVT  -1 < eta < 1  -all phi

This is good for Gamma + Jet, Jet-Jet, e+ e-, etc

Kinematic coverage over a range in x for gluon (see S. Vigdor Talk)

Z0 statistics

W statistics

options for h1 x h1 other than h1 x h1 bar

TALKS YESTERDAY:

# DIRECT PHOTON AT STAR - STEVE VIGDOR
# JETS - STAR - STEVE HEPPelman
Figure 3: EMC energy response to electron in ADC counts at four energies: a) 0.5 GeV; b) 1 GeV; c) 2 GeV; d) 5 GeV.
Figure 1.2.4.1: Schematic drawing of STAR EMC showing the physical towers and the module boundaries (left) and the trigger tower boundaries (right). The vertical axis represents $\phi$ from 0 to $2\pi$ while the horizontal axis depicts $\eta$ from -1 to 1 for each frame.

The physical sizes of the channels and pads were chosen to augment the physics capabilities of the EMC. Specifically, the SMD allows more precise measurements of the angular position of jets, identification of $e^+e^-$ pairs, separation of $\pi^0\gamma$ and identification of direct photons. To do this, the SMD provides good electromagnetic shower position resolution, multi-shower separation and electron-hadron separation through measurement of the transverse shower profile.
<table>
<thead>
<tr>
<th>SMD Design Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber Position inside EMC</td>
</tr>
<tr>
<td>Rapidity Coverage (Single Module)</td>
</tr>
<tr>
<td>Azimuthal Coverage (Single Module)</td>
</tr>
<tr>
<td>Occupancy (p+p)</td>
</tr>
<tr>
<td>Occupancy (Au+Au)</td>
</tr>
<tr>
<td>Chamber Depth (Cathode to Cathode)</td>
</tr>
<tr>
<td>Anode Wire Diameter</td>
</tr>
<tr>
<td>Gas Mixture</td>
</tr>
<tr>
<td>Gas Amplification</td>
</tr>
<tr>
<td>Signal Length</td>
</tr>
<tr>
<td>Strip Width (Pitch) in $\eta$ for $</td>
</tr>
<tr>
<td>Strip Width (Pitch) in $\eta$ for $</td>
</tr>
<tr>
<td>Strip Width (Pitch) in $\phi$</td>
</tr>
<tr>
<td>Number of Strips per Module</td>
</tr>
<tr>
<td>Total Number of Modules</td>
</tr>
<tr>
<td>Total Number of Readout Channels</td>
</tr>
</tbody>
</table>

Table III.1.

III.1.3 Detector Assembly and Quality Control

Schematic diagrams of the SMD detector are given in Figures III.2 and III.3. The detector consists of a two-sided aluminum extrusion. Anode wires are strung in each channel and the cells of the extrusion are sealed by copper-clad PC boards on top and bottom. The strips come on a 2.5 mm thick copper-backed PC board. The back of this board is a continuous ground. These PC boards are glued onto the aluminum profile through three layers of epoxy with a total thickness of about 100 $\mu$m. These layers provide the electrical insulation of the strips from the aluminum profile and form a sealed gas chamber volume. A 90$\%$ Ar-10$\%$ CO$_2$ gas mixture is flowed continuously through the chamber.
Figure 14: The measured in the SMD transverse shower’s profiles for electrons at the energies: a) 0.5 GeV; b) 1 GeV; c) 2 GeV; d) 5 GeV.
Figure 19: a) the single-sided cuts applied for the front and back SMD planes to identify 5 GeV electrons with 90% efficiency; b) the amplitude spectra in the EMC for the entire data sample and surviving events (hatched) after applying cuts in the SMD; c) the distribution of the ratio of the sum of the strip logarithmic weights over energy deposition in the EMC for the front vs back planes of the SMD for the events surviving after the first cuts, and applied cut to identify electrons with 80% efficiency; d) the amplitude spectra in the EMC for the events surviving after the all applied cuts (hatched) as well as for the entire data sample.
Limitations

No Hadron Calorimeter > jet trigger is not sharp
Must set EM threshold low to be efficient,
and then take lots of low energy stuff

EM Calorimeter coming on Late in Program > Partial Detector for
Early Spin Physics

<table>
<thead>
<tr>
<th>Year</th>
<th>Fraction of Barrel coverage</th>
<th>End Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-1999/2000</td>
<td>10%</td>
<td>?</td>
</tr>
<tr>
<td>End 2001/2002</td>
<td>50%</td>
<td>?</td>
</tr>
<tr>
<td>End 2003/2004</td>
<td>100%</td>
<td>?</td>
</tr>
</tbody>
</table>

Much of Trigger is Unfunded > Low level trigger rate is limited to
DAQ and Tape rate

so energy thresholds are driven up
in order to get rate down

( miss low x physics until funded)
( low statistics until funded)

Vertex Pos. Det. Unfunded > More processing to find correct vertex
out of 800 in TPC
Other:

TPC used for Tracking > Need other detectors to support it in high Lum. pp
to make track finding faster
find vertex
seed for tracks
provide vertex for momentum resolution

SVT coverage not all there in early running
Don't need it for much of the Spin Program
(but it will do B physics for spin measurements)

Only 1 End Cap
Still have physics coverage, just less rate

Momentum Resolution
only 12% at 40 GeV, but this is ok for W, Z with calorimeter
SOFT THRESHOLD FOR JET TRIGGER
(DUE TO FRAGMENTATION + EM ETC)

Threshold on E_{transverse} (GeV) 0.8x0.8 high patch
High-\(P_t\) momentum resolution in STAR

\[\frac{\Delta P_t}{P_t}, \%\]

- TPC only
- TPC + Vertex
- TPC + SVT

TPC resolution:
\[\sigma_p = 500 \mu m\]
\[\sigma_s = 700 \mu m\]

SVT resolution:
\[\sigma_p = 25 \mu m\]
\[\sigma_s = 25 \mu m\]
Trigger

The basic idea is that with all the STAR trigger present we could have 1000 HZ at level 0 (summed over all triggers), and certain thresholds.

However, since most of STAR trigger is deferred, the Level 0 rate can't be more than 60 Hz with < 50% deadtime (and maybe the rate is lower)

This drives some of the thresholds up about a factor of 4 to get the rate down.

Particularly:
- jets I (large EMC patch trigger)

less so:
- electrons 1
- gammas 1 (single EMC tower trigger)
- di-electrons 1

Trigger that will be there: **Early**

**Level 0**
- towers 0.2 x 0.2 for jet trigger
- highest .05 x .05 tower for gamma/e trigger
- Global Et for jet-jet
- maybe simple 2-hits
- charge multiplicity (CTB, MWC)
Unfunded Trigger:

Level 0
VPD to select 20 out of 800 vertices stored in TPC
SMD to get a factor of 3-5 on single tower trig rate

Level 2  Spatial Information using:
Calorimeter
Shower Max. Detector
Charged Multiplicity Counters
Silicon Vertex

A factor ~ 5 in trigger rate

Shower width for e to pi
Size of Jet in EM
Charged multiplicity(CTB + MWC) + neutral energy (EMC)
to define jet
refined jet-jet, gamma-jet, e+ e-
possible isolation cut for gamma using energy ratios
finding correct interaction point for tracking using SVT

Level 3
- Using momentum in trigger (as opposed to just writing to tape)
- Using Momentum + EMC to sharpen jet trigger threshold
- Tracking using EMC hits as seeds
  (fast way to find 30 tracks out of 2400 )
- Optimizing tracking so that at least some raw data can go to tape
  from a few tracks to improve momentum resolution offline
With full trigger capability a possible plan might be:

**Level 0 output**

*Must be < 1000 Hz*

*eg Split among*

*jet patch,*

*high tower,*

*Et,*

*charge mult*

*each with multiple thresholds, with prescaling at low thresholds*

*maybe 12 triggers*

**Level 1 output**

*< 1000 Hz*

*use Shower max amplitude (no spatial info)*

*very crude correlation of energy and multiplicity*

**Level 2 input**

*eg 300 Hz*

**output to DAQ**

*must be < 60 Hz*

**to Tape**

*must be < 60 Hz*

*(maybe much less...if not enough LVL 3 processing see below)*
A toy trigger table:

(Note that Thresholds are not sharp, so thresholds do not correspond to real physics thresholds)

<table>
<thead>
<tr>
<th>Level 0</th>
<th>Jet Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$&gt;20 \text{ GeV}$ no prescale</td>
</tr>
<tr>
<td></td>
<td>$&gt;12 \text{ GeV} \times 7$ prescale</td>
</tr>
<tr>
<td></td>
<td>$&gt;7 \text{ GeV} \times 50$ prescale</td>
</tr>
</tbody>
</table>

High (.05) tower) $>7 \text{ GeV}$ no prescale
- $>5 \text{ GeV} \times 5$ prescale if weak lvl 2, lvl 3

Two High (.05) $>6 \text{ GeV}$ no prescale
- $>3 \text{ GeV}$ depends on lvl 2, lvl 3
STAR barrel, PP jets, $\sqrt{s}=200$GeV

- Efficiency of jet finding, %
- RMS $P_T$ resolution, %

$P_T$ jet, GeV/c
With $P_T^e$ cut $\geq 25$ GeV/c

Efficiency for $W^+$ - 80%, Background - 5%

Efficiency for $W^-$ - 85%, Background - 20%
This is my first order pass at a STAR b scalar (800 pb⁻¹ C5000)

-2  -1.5  -1  -0.5  0  0.5  1  1.5  2

Transverse Flight Distance

10⁴  10³  10²  10

▲ = positive flight distance
▼ = negative flight distance

Lxy (transverse plane)
<table>
<thead>
<tr>
<th>Signal</th>
<th>$\sqrt{s}$ (GeV)</th>
<th>Events</th>
<th>$x$ Range</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W^+$</td>
<td>500</td>
<td>72,000</td>
<td>0.05-0.3</td>
<td>$\Delta u(x)/u(x) \sim 0.01 - 0.02$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$\Delta d(x)/d(x) \sim 0.01 - 0.02$</td>
</tr>
<tr>
<td>$W^-$</td>
<td>500</td>
<td>21,000</td>
<td>0.05-0.3</td>
<td>$\Delta d(x)/d(x) \sim 0.02 - 0.04$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$\Delta \bar{u}(x)/\bar{u}(x) \sim 0.02 - 0.04$</td>
</tr>
<tr>
<td>$Z^0$</td>
<td>500</td>
<td>3,200</td>
<td>0.05-0.3</td>
<td>$\Delta h_1/q \sim 0.2$</td>
</tr>
<tr>
<td>$\gamma + \text{jet}$</td>
<td>500</td>
<td>$3 \times 10^6$</td>
<td>0.02-.3</td>
<td>$\Delta G(x)/G(x) \sim 0.03$</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>$3 \times 10^5$</td>
<td>0.05-.3</td>
<td>$\Delta G(x)/G(x) \sim 0.04$</td>
</tr>
<tr>
<td>Dijets</td>
<td>500</td>
<td>$5 \times 10^7$</td>
<td>0.03-.4</td>
<td>$\Delta G(x)/G(x) \sim 0.03$</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>$2 \times 10^7$</td>
<td>0.08-.4</td>
<td>$\Delta G(x)/G(x) \sim 0.05$</td>
</tr>
</tbody>
</table>