Start Counter

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this talk
Functionality

- element of LEVEL 1 Trigger
- start signal for tracking detectors
- identify beam pulse (using tracking information)
Performance Requirements

- time jitter $< \pm 3$ ns
- time resolution with tracking information: $\sigma \leq 0.5$ ns
- maximal solid angle coverage
- large segmentation (background reduction)
Start Counter Design

- array of 40 scintillators with bent ends
- light guides to low field region (< 2kG)
- read out by high field PMT
- similar to existing CLAS start counter
Start Counter 3d View

PMT

light guides

scintillators
Start Counter Side View

50cm - 150 cm depends on space

50 cm

light guides

detector

outside UPV
Start Counter Front View
Individual Scintillator:

- 8 cm
- 145°
- 50 cm
- thickness: 5 mm
R&D Studies with H6614

using cosmic rays

Eljen Technology EJ204 and EJ208 Scintillator bars: 70 x 3 x 0.5 cm
peak position as a function of position in detector
σ of time difference as a function of position

\[ \Rightarrow \sigma \leq 0.5 \text{ ns can be achieved} \]
Geometry of Detector

- use events with only 1 charged particle as benchmark
- require at least 1 hit in detector
- minimize length of detector
b_2 \rightarrow a_1 \pi \rightarrow \pi^+ \pi^0 + \pi^0 + \pi^0

detection efficiency as a function of vertex location along the beam direction

<table>
<thead>
<tr>
<th>color</th>
<th>l cm</th>
<th>z_d cm</th>
<th>o_c cm</th>
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</thead>
<tbody>
<tr>
<td>Blue</td>
<td>50</td>
<td>-6</td>
<td>10</td>
</tr>
<tr>
<td>Green</td>
<td>50</td>
<td>-6</td>
<td>6</td>
</tr>
<tr>
<td>Cyan</td>
<td>50</td>
<td>-6</td>
<td>4</td>
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<tr>
<td>Gray</td>
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<td>-6</td>
<td>3</td>
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<tr>
<td>Red</td>
<td>50</td>
<td>-6</td>
<td>2</td>
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</table>
Rate Studies

- electromagnetic background simulated with GEANT
- photon flux $10^8 \gamma/s$
- 5 mm collimator
- 30 cm LH$_2$ target
total charged rate: \(\approx 9\) MHz
per scintillator: 225 kHz

\[ \frac{e^+}{e^-} \text{rate in entire detector (Hz)} \times 10^3 \]

\(r_B\) distance from photon beam
Readout

- H6614-70 system (Hamamatsu):
  - gain $10^7$
  - photo cathode well matched to EJ200, 208 scintillator
  - according to data sheet, practically no gain loss up to 2kG

- single ended readout
- time jitter due to light propagation $\pm 2$ ns
## Cost Estimate

<table>
<thead>
<tr>
<th>Item</th>
<th>Channels</th>
<th>Total Units</th>
<th>Unit Price</th>
<th>Total Price</th>
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<tbody>
<tr>
<td>Number of detectors</td>
<td>40</td>
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<td></td>
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<tr>
<td>scintillator (EJ200)</td>
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<td>40</td>
<td>600</td>
<td>24000</td>
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<td>sides</td>
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<td>light guides (1mm)</td>
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<td>1680</td>
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<td>PMT</td>
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<td>2100</td>
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<td>HV</td>
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<tr>
<td>UV lamp</td>
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<td>7000</td>
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<tr>
<td>Glue &amp; Materials</td>
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<tr>
<td>Mech construction (support &amp; connectors)</td>
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<tr>
<td>Cables&amp;Connectors</td>
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<td><strong>TOTAL</strong></td>
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</table>
Future work to be performed

• further optimize geometry
• study performance of PMT in magnetic field
• design and prototype light guides & connectors
• study front end readout possible ?
• design support structure for scintillators
• alternative readout systems: SiPM (double sided)
• fast wavelength shifting fibers
Summary

• current design satisfies requirements
• can be completed within 2 years after funding
• new technologies (SiPM etc) can enhance detector performance