MEG Run 2008 陽電子スペクトロメータ

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日本物理学会秋季大会(2008/09/20-23), 於山形大学
The MEG Positron Spectrometer
Requirements for the Experiment

\[ \mu^+ \rightarrow e^+ \gamma \]

signature

physics background

accidental background
Requirements for the Experiment

- Use DC muon beam
- Operational in High Rate
- Good Pile-up Rejection
- Excellent Resolutions
- $\gamma$-ray Suppression

$\mu^+ \rightarrow e^+ \gamma$

signature physics background accidental background
The MEG Positron Spectrometer

- Lateral View -

- Cross-sectional View -

Target
COBRA Solenoid
Drift Chamber
Timing Counter

20-23 Sep. 2008, JPS Meeting, Yamagata University
The MEG Positron Spectrometer

- **Must Be**
  - Operational with High Rate (~30MHz Muon Decay)
    - Graded B-field Solenoid (COBRA magnet)
    - Small Cell Drift Chamber (4.5mm cell spacing)
  - Very Light Material (**0.002X₀** in Fiducial Tracking Volume)
    - Open-frame Structure of Segmented Drift Chambers
    - Filled with Helium and Helium-based DC Active Gas
    - Very Thin Foil as a Cathode Plane
    - No Vertex Detector / No Other Tracking Devices
  - Very Good Timing Resolution
    - Fast Timing Counter with Track Extrapolation from Tracker
  - Very Good Vertex/Angular Resolution
    - Done by Only Trace Back from Tracker
Calibrations & Commissioning
Calibrations

- We need several calibration methods for the $e^+$ spectrometer

  - For Drift Chamber
    - Wire Misalignment (By using Michel $e^+$ tracks)
    - Timing Pedestal (By fitting arrival-time distribution)
    - Time-to-Distance (By using Michel $e^+$ tracks)
    - Absolute Momentum (By fitting Michel Spectrum)
    - Target Position (By extrapolating track from DC)

  - For Timing Counter
    - Gain calibration in Magnetic field
    - Relative Timing Calibration with LXe photon detector
Calibrations - Cont. -

2008 Crosses downstream: Displacement x10

2008 Crosses downstream: Displacement x10

B = 1.1T
θ = 5°-45°

Michel Spectra

without correction
radiative correction

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Commissioning

- The # of hardware components of the spectrometer is strongly limited
  - in consequence, operation and readout are made challenging and difficult.
    - *eg.* (in 2007) Several chambers were not operational due to defective protection for pure helium. Many channels were not connected properly at the patch-panel system due to defective contacts.
- Such many N/A channels affect drastically on not only the chamber operation but also the analysis.
  - It was necessary to add air doping
  - Tracking resolution/efficiency were affected by small number of measured points
- **It is NECESSARY to have a careful commissioning run.**
- For the “MEG Run 2008”, we had a dedicated run period, called “Michel Run” in the *runup* to the Physics Run.

- **Michel Run = “commissioning”, “calibrations”, “performance estimation”, and “background estimation”**
Performances
Momentum Resolution

- Endpoint is fitted to the convolution of “response function” and “Gaussian”, with three free parameters; “$P_{\text{edge}}$”, “$\sigma_p$” and “Normalization”.
- We need “response function”, could be produced by MC
  - taking into account “DC real situation”, “Trigger Condition” and “Radiative correction to the Michel spectrum”.

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Efficiencies

- DC Intrinsic Efficiency (~100%)
- Track Find/Reconstruction Efficiency
  - Design: ~50% (for all event)
  - Design: ~98% (for acceptable event)
- Spectrometer Efficiency
  - Design: ~65%
  - due to DC elec.
Applications
Track Extrapolation (1)

- Towards Stopping Target
  - Vertex Reconstruction
  - No Vertex Detector
  - Angular Blind to LXe
  - Only Track Extrapolation can reconstruct
  - $e^+$ Emission Angle Reconstruction

- Both are Necessary to judge Signal
Track Extrapolation (1)

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- LXe calorimeter
- $\mu^+$
- Drift Chambers
- $e^+$ spectrometer

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Track Extrapolation (2)

- Towards Timing Counter
  - Flight-Length correction
  - Triggering Time given by TC
  - Muon Decay Time is unknown

- Impact Position Reconstruction
  - DC-TC Matching is required

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Track Extrapolation (2)

- **Towards Timing Counter**
  - Flight-Length correction
  - Triggering Time given by TC
  - Muon Decay Time is unknown

- Impact Position Reconstruction
- DC-TC Matching is required
- Both are Necessary to judge Signal

- LXe calorimeter
- Drift Chambers
- e+ spectrometer
- Timing Counter hit
Run2008 (Commissioning Run)
pre- Run 2008 (Commissioning Run)

16-18/July 2008, we took “Michel Run” for calibration/commissioning
- 534 runs in total, ~3M events were acquired
- Two settings of muon-beam intensity were prepared same as 2007
  - normal: $3 \times 10^7$ muon/sec (346 runs, ~1.6M events)
  - low: $1 \times 10^6$ muon/sec (188 runs, ~1.3M events)
- DC conditions were very stable (much better than 2007)
  - most of planes were applied by 1840v w/o any trips
  - it was necessary to add an air contamination to avoid unwanted discharge

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Run 2008 (Performances/Resolution)

- Reconstructed Michel Spectrum and Estimated Momentum Resolution

- PRELIMINARY -
(MICHEL - RUN 2008)
Reconstructed Michel Spectrum and Estimated Momentum Resolution

$E_{\text{edge}} = 52.88 \pm 0.29 \text{ MeV/c}$

$\sigma_p = 551 \pm 79 \text{ keV/c}$
Run 2008 (Extrapolation/Resolution)

- **Vertex Resolution**
  - $\sigma_{x,y} = 1.8$ mm

- **Angular Resolution**
  - $\sigma_{\phi} = 0.6-7$ deg.
  - $\sigma_{\theta} = 0.3-4$ deg.
Run 2008 (Performances/Efficiencies)

- Efficiency Staging:

- Denominator Definition:
  - $e^+$ which contains more than 6 hits is counted as denominator
  - $e^+$ which achieves radius larger than 6-th cell is counted as denominator

- Summary of preliminary reconstruction efficiencies with 2 beam rate

<table>
<thead>
<tr>
<th></th>
<th>Track Finder</th>
<th>Track Fitting</th>
<th>after $\chi^2$ cut</th>
<th>(after $xy/\theta\phi$ cut)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michel 2008</td>
<td>98/97%</td>
<td>72/70%</td>
<td>65/60%</td>
<td>(45/32%)</td>
</tr>
</tbody>
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Run2008 (Physics Run)
Run 2008 (Physics Run)

- MEG Physics Run Started on September 12th (last week !)
- We will continue 12 weeks of beam time till Christmas shutdown.
- Now we are trying:
  - trigger optimization
  - offline process starting
    - pre-selection study
    - PDF refining for MLH
  - background estimation
  - (detector studies)
Run 2008 (Physics Run)

- Spectrometer Prospects in Run 2008 (12 weeks beam-time).

<table>
<thead>
<tr>
<th>resolution</th>
<th>condition</th>
<th>condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy resolution</td>
<td>2.2%</td>
<td>Acceptance</td>
</tr>
<tr>
<td>Angular resolution</td>
<td>14.5%</td>
<td>Muon Rate</td>
</tr>
<tr>
<td>Timing resolution</td>
<td>127ps</td>
<td>Efficiency</td>
</tr>
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- According to the easy estimation, better sensitivity than current experimental upper limit can be expected.

- Consideration based on the background estimation will be presented in the next talk (「MEG Run2008 バックグラウンド」内山雄祐)
Conclusion

- MEG Starts the First Physics Run in this year !!!
- We had a dedicated run period, called “Michel Run” in the runup to the Physics Run.
  - Detector Calibration (Drift Chamber, Timing Counter)
  - Spectrometer Calibration (Momentum, Timing)
  - Performance Estimation (Resolution, Efficiency)
  - Background Estimation
- Even this year’s (not perfect, very short) condition can achieve better sensitivity than the current experimental upper limit.
- now, physics data-taking is running !!
backup slides