OLYMPUS Experiment at DORIS

R. Beck, F. Brinker
for the
OLYMPUS- collaboration

MAC meeting, November 11th, 2010, Hamburg

- Motivation
- OLYMPUS Experiment
- Status and Timeline
- Requirements for DORIS
- Summary
Unpolarized Elastic e-N Scattering

- Measure (Rosenbluth) cross section
  - single photon exchange – Born approximation

\[
\left( \frac{d\sigma}{d\Omega} \right)_{\text{Rosenbluth}} = \left[ \frac{|G_E|^2 + \tau |G_M|^2}{1 + \tau} + 2\tau |G_M|^2 \tan^2 \frac{\theta}{2} \right] \left( \frac{d\sigma}{d\Omega} \right)_{\text{Mott}}
\]

\[\tau = \frac{Q^2}{4M_p^2} \quad \left( \frac{d\sigma}{d\Omega} \right)_{\text{Mott}} = \frac{\alpha^2 \cos^2 \frac{\theta}{2}}{4E^2 \sin^4 \frac{\theta}{2}} \frac{E'}{E}\]

- Extract \( G_E \) and \( G_M \)

\[
\sigma_{\text{red}} = \frac{\left( \frac{d\sigma}{d\Omega} \right)_{\text{Rosenbluth}}}{\left( \frac{d\sigma}{d\Omega} \right)_{\text{Mott}}} \epsilon (1 + \tau)
\]

\[= \epsilon |G_E|^2 + \tau |G_M|^2\]

\[\epsilon = \left[ 1 + 2(1 + \tau) \tan^2 \frac{\theta}{2} \right]^{-1}\]

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Rosenbluth and Recoil Polarization

- All Rosenbluth data from SLAC and Jlab in agreement.
- Dramatic discrepancy between Rosenbluth and recoil polarization technique.
- Discrepancy explained as effect of two photon exchange (TPE).

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Rosenbluth and Recoil Polarization

- Observed effect
  - mostly explicable by 2-photon exchange
  - experimental proof missing

Polarization transfer data

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Rosenbluth data with two-photon exchange correction


lepton
virtual photons
nucleon
Rosenbluth and Recoil Polarization

- Most sensitive variable for two-photon effects
  - Cross section ratio $e^+/e^-$
    - exactly unity in Born approximation
    - several percent effect at $Q^2 \sim 2$ GeV$^2$


Saturation at $Q^2 \sim 2$–3 (GeV/c)$^2$

Empirical extraction by M. Vanderhaeghen

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**Experimental Requirements**

- Requirements
  - electron and positron beams
    - $E \sim 2$ GeV
    - frequent switch
  - pure proton target
  - lepton-proton coincidence measurement
  - large theta coverage (epsilon range)
  - minimise systematic uncertainties
    - symmetric arrangement
    - precise relative luminosity

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DORIS at DESY

- $e^+$ and $e^-$ beams
  $E = 2.0 \ (4.5) \text{GeV}$
  $Q^2 = 0.6-2.4(4.1) \ (\text{GeV/c})^2$
- OLPMPUS experiment fits in former ARGUS location

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OLYMPUS Experiment

OLYMPUS @ DORIS

- Change toroidal coils polarity once a day
- Change between electrons and positrons once a day
- Left-right symmetry

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OLYMPUS Experiment

- DORIS beam
- target
- time-of-flight scintillators
- drift chambers
- GEM trackers
- magnet coils
- 12deg luminosity telescopes
- Moller/Bhabha luminosity calorimeters

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• Detector components
  – have arrived at DESY
  – are being refurbished
• Assembly in parking position
  – area has been cleared
  – platform, rails and frames mounted
  – toroidal coils installed and wired
  – magnet commissioning to start these days
Wire Chambers

- Shipped without wires
- Completely re-wired
- Currently
  - electronics assembly

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TOF Detectors

- Modified arrangement - new mounting
  - designed, in production
- Modules are at DESY
  - 9 joints re-glued
  - calibration in progress
- Development of new flasher system
• Target cell installed and aligned
• Cold-head installed
• Pumps and controllers connected
• Vacuum gauges connected
DESY integration:
Will be new vacuum segment.
Valves controlled by DESY vacuum group.

Pumps and internal valves will be controlled by OLYMPUS

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Experimental Requirements

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Experimental Requirements

- 2 symmetric luminosity monitors
  - 12deg telescopes: GEMs + MWPCs (coincident)
  - 2deg Moller/Bhabha calorimeters at
- Regular change of both
  - particle type: \( i = e^+ \) or \( e^- \)
  - magnet polarity: \( j = \) pos or neg
- Combination
  - efficiency and acceptance effects cancel to first order

\[
N_{ij} = L_{ij} \sigma_i \kappa_{ij}^p \kappa_{ij}^l
\]

lumi  proton, lepton efficiency

\[
\frac{\sigma_{e^+}}{\sigma_{e^-}} = \left[ \left( \frac{N_{e^+} + N_{e^-}}{N_{e^-} + N_{e^-}} / \frac{A_{e^+} + A_{e^-}}{A_{e^-} + A_{e^-}} \right) / \left( \frac{N_{fwd}^{e^+} + N_{fwd}^{e^-}}{N_{fwd}^{e^-} + N_{fwd}^{e^-}} / \frac{A_{fwd}^{e^+} + A_{fwd}^{e^-}}{A_{fwd}^{e^-} + A_{fwd}^{e^-}} \right) \right]^{\frac{1}{2}}
\]

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12 deg Luminosity Monitor

- 3 GEMs + 3 MWPCs
- Designed and procured
- Assembly and testing
- Commission in DORIS: 2011
Moller/Bhabha Luminosity Monitor

- Existing radiation hard PbF$_2$ crystals
- Assembly and testing
**Expected Results**

- Beam $E = 2$ GeV
  - $Q^2 = 0.6 - 2.2 \text{ (GeV/c)}^2$

$$\varepsilon = 0.37 - 0.9$$
Well on track
- assembly ongoing
- in construction
  - GEM trackers
  - 12deg lumi: GEM + MWPC
  - Moller/Bhabha lumi calo
Commissioning in parking position
- February 2011
Move complete detector into DORIS
- August 2011
Commission in beam
- Fall 2011
Data taking
- 2 blocks in 2012

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• Clear correlation
• Fit $f(l) = a \cdot l + b \cdot l^2$
  – $a = 0 +/- 0.1$ (synch. rad.)
  – $b = 0.3 +/- 0.001$ (rest gas)
  – Verification with shielded scintillator planned

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• **No** higher count rates during injections
• No need to decrease HV during injection

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Background Studies

$\theta_p = 70^\circ$

$\Delta(t_p - t_e) = 400\, ps$

$\Delta(\phi_p + \phi_e) = 1-2^\circ$

$\theta_e = 20^\circ$

TOF paddle, electron

$\theta_e = 80^\circ$

TOF paddle, proton
Test Beam Time in Spring 2011

- TOF bars (spares from OLYMPUS)
- 3 Lumi GEM detectors
- 2 MWPCs
- 16 lead glass detectors (Bonn)
DORIS Requirements

• Experiment requires frequently switching from $e^+$ beam to $e^-$ beam.

• Measure ratio of positron-proton to electron-proton unpolarized elastic scattering to 1% stat.+sys.

• Control of systematic uncertainties essential.

• DORIS Parameter (1% effect on $R$)
  - beam offset $< 1$mm
  - beam direction $< 0.03$ deg
  - change in beam energy $< 0.5$ %

-> factor 10 better would be ideal only 0.1% systematic effect!

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Hier sollte Frank Brinker weiter machen
**Gas System**

Status of hardware:
- Main part of system operational
- Buffer system in progress

Status of slow control:
- Original software solution ported to new OS, operational
- Rewrite of backend and GUI started
- VME Drivers working
- Write new drivers for vacuum gauges (added functionality)

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Status of OLYMPUS -Project

• OLYMPUS-Proposal conditionally approved by PRC October 2008:

  1.) details of the OLYMPUS installation and running have to be worked out
  2.) necessary funding becomes available

Status on 1.)

Detail plan for OLYMPUS installation and running has been worked out, presented and approved at the OLYMPUS- collaboration meeting April, 2009

Responsibilities:

<table>
<thead>
<tr>
<th>Component</th>
<th>Collaborators</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLAST-detector</td>
<td>MIT, University of Colorado, Arizona State University</td>
</tr>
<tr>
<td>Target</td>
<td>MIT, INFN Ferrara, Universität Erlangen-Nürnberg</td>
</tr>
<tr>
<td>New Intersection point</td>
<td>DESY, MIT, St. Petersburg NPI</td>
</tr>
<tr>
<td>New Luminosity Monitor</td>
<td>Hampton University, INFN Bari, INFN Rome</td>
</tr>
<tr>
<td>Trigger, DAQ</td>
<td>Universität Bonn, Universität Mainz</td>
</tr>
<tr>
<td>Electronics</td>
<td>Universität Bonn, MIT, Universität Mainz</td>
</tr>
<tr>
<td>Tracking detectors</td>
<td>MIT, INFN Rome, Universität Mainz</td>
</tr>
<tr>
<td>Particle Identification</td>
<td>University of Glasgow, Arizona State University</td>
</tr>
<tr>
<td>Timing Scintillators</td>
<td>University of New Hampshire</td>
</tr>
</tbody>
</table>

DESY PRC MAY 5, 2009
Schedule

OLYMPUS detector
- detector and spectrometer transferred to DESY as scheduled
- drift chambers completely rewired
- TOFs refurbished and calibration system implemented
- toroid assembled, to be powered in November
  - DAQ system operational
  - lumi monitor system in final production phase

Testing of OLYMPUS target at MIT-Bates
- target chamber, target cell, cryohead assembled
- gas feed system operational
- complete system being tested at Bates
- ship via air to DESY in November 2010
- assemble and test in three pieces in December 2010
- install in December-February shutdown

Install test experiment in December 2010-February 2011
Install complete experiment in August 2011
Commission in fall 2011
Take data in two running blocks in 2012

Detailed schedule with critical milestones available
Other Experiments

• **JLab**

• **Novosibirsk**
  Similar experiment to DESY experiment has been considered. Positron currents are about an order of magnitude lower. No momentum measurement.

• **Parity violating electron scattering**
  Experiments at JLab and Mainz which measure transverse spin asymmetries are sensitive to two photon effects but not directly to the contribution which enters in $G_E^p/G_M^p$. 