MEG : search for $\mu \rightarrow e\gamma$ with a $10^{-13}$ sensitivity

A. M. Baldini (INFN Pisa)

for the MEG collaboration
$\mu \rightarrow e \gamma$ search: experimental method
A “significant” result before any LHC discovery

Mirror Leptons can enhance LFV by 25-30 orders of magnitude
e.g. Br (\mu \rightarrow e\gamma)_{\text{LHT}} \sim 10^{-12\pm2}
could be tested by MEG(2007)

Full data taking in 2007

Start data taking in 2006
to fully test the whole experiment

Published in 2008

Presented last year

PSI: February 14th 2007
Detector Installation

Drift Chambers (8 out of 16)

Timing Counters (bars, not fibers)

No LXe

2006: run in December

Stopping Target

Gas Control System
(Cobra+DC)

N₂ Bag
Full MEG Beam Line
11 Main Components
All now Implemented
Commissioning Run Provisional Results

Data still under Analysis  PROVISIONAL

Rate at Entrance COBRA $1.15 \times 10^8 \mu^+ s^{-1}$ at 1.8mA, 4cm Tg
Rate at COBRA centre $> 6 \times 10^7 \mu^+ s^{-1}$ at 1.8mA, 4cm Tg (under investigation)
Beam Spot $\sigma \sim 10.8$ mm (as expected)

Collimator transmission $\varepsilon = 95\%$

SMH41 SMV41 Correction
at Centre of COBRA
~ 2 mm Horizontally
~ 7 mm Vertically
CORRECTION WORKS !!!

Separation Quality
High Intensity (slits open) $7.4 \sigma$
Low Intensity $8.1 \sigma$

Expected muon stopping rate in target = .62 of muons rate entering COBRA

Must correct for material in front of measuring device
Trigger, DAQ, Logging and Central MIDAS

**Trigger**
- 36 Type 1 boards
- 5 Type 2 boards
- 4 Ancillary boards
- all cabling
- Firmware version 0

**DAQ**
- DRS chips + cables for:
  - DC: 864 channels
  - TC: 60 channels
  - NaJ: 9 channels

**Logging and Central MIDAS**
- installed and operational (except for dc_trigger)
- data taking with all channels of installed sub-detector components

- 2 weeks of data taking at the end of december
- 285 runs taken at different beam intensities and HV settings
- in total ~600 GB recorded
MEG status report

TC: waveforms: 2 digitizers

Trigger@100 MHz

DRS @ 500 MHz or 2 GHz

PSI: February 14th 2007
Timing Counter: first results

Run 236 High Intensity (6 $10^7$ muons/s stopping in target)

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Data

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MC

**n. of hit bars/event**

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**Hit rate / bar**

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**Down stream**

**Up stream**

**Data**

**MC**

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**Entries** 678

**Mean** 1.639

**RMS** 1.053

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**Entries** 1937

**Mean** 15.89

**RMS** 7.184

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PSI: February 14th 2007
DRS charge vs Trigger WFM Charge
DCH: waveforms; DRS @ 500 MHz
Timing

Positrons spiralling in the chambers and hitting the TCs
MEG status report

DCH: first results; Hit rate / wire

DATA
RUN#156~#163
FS41=100 (~25% intensity)
primary proton : 1.4mA
DAQ pre-scale = 10
# of trigger ~ 10k

MC
RUNCONFIG = 1
(RUN2006)
event mode = 30 (muon)
# of generation = 1M

-> Very rough normalization
-> No efficiencies included

Run configuration

Rate of wire coincidences on chamber 11

Plane A
Plane B

Data
MC

PSI: February 14th 2007
MEG status report

DCH: Anode Asymmetry

MC: Use z-coordinate

Data: Use Anode asymmetry

\[ A = \frac{Q_u - Q_d}{Q_u + Q_d} \]

Rate map on chamber 11 (Monte Carlo)

Rate map on chamber 11

DS

US

PSI: February 14th 2007
Set to 100% the maximum intensity, scale the rest accordingly.

- Expected
- DCH Measured
- TICP Measured
LXe calorimeter construction status

PMT supporting structure → inside → Cold (LXe) vessel → inside → Warm vessel (vacuum)

PSI: February 14th 2007
Cryostat delay 1: cold vessel deformation (oct. 2006)

- Several mm gap
- LXe R.L.: 2.89 cm
- Support structure could not fit in ~6mm
Cold vessel re-machining

- The welded thin window was removed for this procedure
- Scrapped away the inner wall by 5mm at maximum
- PMT support successfully installed
- Checked with a gap gauge of 200 µm with the supporting structure installed on 22/Jan/2007
The 1st panel broke down in pressure test in June 2006

New (2nd) panel was designed
  - Honeycomb thickness 19mm → 26.5mm
  - High module prepreg 0.75mm → 1mm
  - Transition with fabric only → Taper Transition
  - Also this one broke on Aug. 21° 2006 in pressure tests
The 3rd Panel

- Internal reinforcement at the edges.
- Fiber with lower module but with a better Elongation (T300, used in aerospace applications with over 20 year service history).
  - 1.5mm prepreg thickness with 8 piles (1mm in the 2nd panel)
- Space-approved Resin epoxy (Hysol EA9361)
Construction Status of the 3rd Panel

- Project + Construction = 6 months
- Delivery to Pisa in this week
- Pressure and low temperature test next week: crucial test
Updated Construction Schedule

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Pre</th>
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<td>8 days</td>
<td>Thu 06/12/14</td>
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<td>Inbluaggio e trasporto</td>
<td>2 days</td>
<td>Wed 07/04/11</td>
<td>Thu 07/04/12</td>
<td>30</td>
</tr>
</tbody>
</table>

Now: superinsulation installation
Assembling the cold chamber inside the warm one + cleaning (5 weeks)

Final Cryogenic Test (2 weeks)

Shipping to PSI
Xenon Storage

- ~900L in liquid, largest amount of LXe ever liquefied in the world
- Very stable
  - Pressure raise 0.003MPa/h w/o cooling
  - 0.111 MPa → 0.2 MPa in 44 hours
**Proton Acc**

- **Li(p,γ)Be**
  - LiF target at COBRA center
  - 17.6MeV γ
  - ~daily calib.
  - Can be used also for initial setup

**Nickel γ Generator**

- **K**
- **Bi**
- **Tl**
- **F**

**Xenon Calibration**

- Laser
  - (rough) relative timing calib.
  - < 2~3 nsec
- LED
  - PMT Gain
  - Higher V with light att.
  - Can be repeated frequently
- **π^0 \rightarrow γγ**
  - \( π^0 \rightarrow γγ \) (55MeV, 83MeV)
  - \( π^0 \rightarrow γ + n \) (129MeV)
  - 10 days to scan all volume precisely
  - (faster scan possible with less points)
  - LH\(_2\) target

**μ radiative decay**

- Lower beam intensity < 10\(^7\)
  - Is necessary to reduce pile-ups
  - Better \( σ_μ \) makes it possible to take data with higher beam intensity
  - A few days ~ 1 week to get enough statistics

**α**

- PMT QE & Att. L
  - Cold GXe
  - LXe

**NaI**

- 3 cm 20 cm
- Source (Cf) transferred by comp air \( \rightarrow \) on/off
- 9 MeV Nickel γ-line
- 0.25 cm Nickel plate

**µ radiative decay**

\[ \mu \rightarrow e + γ + ν_μ \]

\[ π^- + p \rightarrow π^0 + n \]

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Machine Status

• original Completion Date:  
  ~ mid-May 2007

• NEW Completion Date:  
  ~ end-February & expected Ready for testing mid-April ~ 2007
Cockcroft-Walton Area

Constraints
- Safety System + Electrical Infrastructure unaltered
- Permanent Access from outside

πE5 Zone

πE5 Shielding Wall needs modifying

πM3 Shielding Must be MODIFIED

Approx. form C-W Area
Tasks & Problems

- **DC**
  - gas leakage
  - build / rebuild the chambers
  - track reconstruction code still missing

- **TC**
  - fiber detectors (APD electronics) & laser system
  - redesign & build N2 bags
  - further tests/calibration at Frascatti
  - matching with DC tracks

- **LXe**
  - honeycomb window ready this week - pressure test
  - C-W will arrive earlier! - testing mid-April

- **Trigger/DAQ**
  - data rate limited at 5Hz (full detector) - toward 100Hz?
  - DRS3 probably not for 2007

- **Computing**
  - data size reduction (9MB/event)

**Ready in mid-June**
(Ready in mid-May: N2 bag by April)
Cryostat delivery in mid-April
MEG status report

Other (possible) users at the earliest possible time...

PSI: February 14th 2007
Conclusions

First result: very good agreement of rates predicted by MC $\Rightarrow$ no significant unwanted backgrounds !!

Publish in 2008 the “significant” result

Hopeful for full data taking in 2007

Started “data taking” in 2006 without LXe detector

Background and Sensitivity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measured</th>
<th>Simulation</th>
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<tr>
<td>Gamma Energy (%)</td>
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<tr>
<td>Gamma Timing</td>
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<tr>
<td>Gamma Position (mm)</td>
<td>4.5-9.0</td>
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<td>Gamma Efficiency (%)</td>
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<td>e+ Angle (mrad)</td>
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<td>e+ Efficiency (%)</td>
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<td>Muon Decay Point (mm)</td>
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<td>Muon Rate ($10^8$/sec)</td>
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<td>Running Time ($10^7$sec)</td>
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<tr>
<td>90% CL Limit ($10^{-13}$)</td>
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</table>

Updated number should be available after Physics Meeting in Tokyo, March 29-30