Recent results from the MEG experiment

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(on the behalf of MEG collaboration)

Nufact 11
Geneva, 5 August 2011
Outlook

• The MEG experiment
  – The physics goal
  – Signal & background
  – Beam and detector layout

• The Run
  – Detector calibration & performance
  – Quality checks
  – Data summary

• Results
  – Analysis strategy
  – Review of results from Run 2009
  – Latest results from combined (2009+2010) data

• Perspectives for the future
  – Sensitivity plan

• Conclusions
The experiment

• Physics goal
• Signature & background
• Detector layout
LFV relation to EDM, g-2

- Contribution to EDM, MDM of leptons (hadrons) from diagonal elements of the slepton (squark) mass matrix
- LFV processes induced by off-diagonal terms (depend on how SUSY breaking is generated and what kinds of LFV interactions exist at the GUT scale)

\[ M_{\tilde{e}_L}^2 = \begin{pmatrix} m_{\tilde{e}\tilde{e}}^2 & \Delta m_{\tilde{e}\mu}^2 & \Delta m_{\tilde{e}\tau}^2 \\ \Delta m_{\tilde{e}\tilde{e}}^2 & m_{\tilde{\mu}\tilde{\mu}}^2 & \Delta m_{\tilde{\mu}\tilde{\tau}}^2 \\ \Delta m_{\tilde{e}\tilde{e}}^2 & \Delta m_{\tilde{\mu}\tilde{\mu}}^2 & m_{\tilde{\tau}\tilde{\tau}}^2 \end{pmatrix} \]

- SUSY effect on g-2 ⇒ deviations from SM predictions
- an experimental clue: E821 results

\[ \Delta a_\mu \neq 0 \text{ associated with SUSY} \]

\[ BR(\mu \rightarrow e\gamma) \geq 10^{-12} \]

G.Isidori et al.

⇒ strong physics case

LFV: an experimental review
Signal & background

$E_e = E_\gamma = 52.8 \text{ MeV}$

$\Theta_{e\gamma} = 180^\circ$

$B_{pro} \approx 0.1 \times B_{acc}$

$B_{acc} \propto R_{\mu} \Delta E_\gamma^2 \Delta E_e \Delta \Theta_{e\gamma}^2 \Delta t_{e\gamma}$

<table>
<thead>
<tr>
<th>Exp./Lab</th>
<th>Year</th>
<th>$\Delta E_e/E_e$ (%)</th>
<th>$\Delta E_\gamma/E_\gamma$ (%)</th>
<th>$\Delta t_{e\gamma}$ (ns)</th>
<th>$\Delta \theta_{e\gamma}$ (mrad)</th>
<th>Stop rate (s$^{-1}$)</th>
<th>Duty cyc. (%)</th>
<th>BR (90% CL)</th>
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<td>4.5</td>
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<td>MEG</td>
<td>2009</td>
<td>1</td>
<td>4.5</td>
<td>0.15</td>
<td>19</td>
<td>$3 \times 10^7$</td>
<td>100</td>
<td>$2 \times 10^{-13}$</td>
</tr>
</tbody>
</table>

Latest results ...
The layout

The beam

- The worldwide most intense DC beam (>10⁸m/s) of surface muons (28 MeV/c)
- Stopped on a thin (100 µm) target
- Currently $R_\mu = 3 \times 10^7$ s⁻¹ due to pile-up

The detector

- Liquid Xenon calorimeter for $\gamma$ detection (scintillation)
  - Fast ($\tau \sim 20\div40$ ns)
  - High light yield (70% NaI)
- Thin wall quasi-solenoidal spectrometer & drift chambers ($X_0=2 \times 10^{-3}$) for $e^+$ momentum
- Scintillation counters for $e^+$ timing

Latest results ...

5 August 2011
The Run

- Detector monitoring & calibration
- Performances
- uality checks
- Data summary
Laser
(rough) relative timing calib.  
< 2~3 nsec

LED
PMT Gain  
Higher V with light att.
Can be repeated frequently

alpha
PMT QE & Att. L  
Cold GXe  
LXe

(p, γ) reactions  

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

(n,γ) on Ni  
Neutron pulsed generator to induce (n, γ)  

Latest results ...
LXe PMT monitoring

- $^{241}$Am sources on $\phi=100\mu m$ wires to
  - determine PMT QEs
  - monitor absorption length

$R_\alpha = 7$ mm

$R_\alpha = 40 \mu m$
\[ \pi^- p \rightarrow \pi^0 n \]
\[ \pi^0 \rightarrow \gamma \gamma \]

- $E_\gamma = 55 \ (83) \text{ MeV} \rightarrow \text{close to signal window}$
- liquid H-target
- beam polarity and settings to be changed as well
  \rightarrow to be used quite seldom (~ 1/year)
(p,γ) reactions

- Makes us of a Cockcroft-Walton accelerator to deliver tunable-energy protons to a Li$_2$B$_4$O$_7$ target
  - Li: high rate, higher energy photon
  - B: two (lower energy) time-coincident photons

<table>
<thead>
<tr>
<th>Reaction</th>
<th>$E_{res}$</th>
<th>$\sigma_{res}$</th>
<th>$\gamma$-lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li(p,γ)Be</td>
<td>440 keV</td>
<td>5 mb</td>
<td>(17.6, 14.6) MeV</td>
</tr>
<tr>
<td>B(p,γ)C</td>
<td>163 keV</td>
<td>$2 \times 10^{-1}$ mb</td>
<td>(4.4, 11.7, 16.1) MeV</td>
</tr>
</tbody>
</table>

$\Delta E/E = 8.5\%$ (FWHM)

Latest results ... 11 5 August 2011
B(p,γ)C reaction

- 2 simultaneous lines to exploit the (LXe-TC) coincidence

![Graph showing energy deposits in LXe and TC with 4.4 MeV and 11.6 MeV peaks.]

\[ \sigma = 478 \pm 12 \text{ ps} \]

\[ t_{\text{LXe}} - t_{\text{TC}} \]
Monitoring

- All methods operational during Run 2010
- Confirm stability of the energy scale within 0.3%
Scale linearity

![Graph showing scale linearity with data points and a straight line fit with a factor of 0.9992 ± 0.000264.]

Latest results ...
Tracker performance (1)

- No decay available to produce back-to-back particles at these energy (apart from $\mu \rightarrow e\gamma \ldots$ if any)
- positron momentum $\rightarrow$ fit of Michel edge
- muon decay vertex $\rightarrow$ fit to target holes
Tracker performance (2)

- direction $\Rightarrow$ fit of double-turn positrons
- track segments reconstructed as due to different particles
- angular resolution obtained from the difference of the two reconstructions at the turning point
New implementations

2010
- DC
  - calibrations with Mott-scattered positrons
    (dedicated beam+target, tunable momentum byte down to 1%)
  - cosmic rays data for relative DC alignment
  - newly reconstructed magnetic field
    (measurements on a lattice + symmetry + Maxwell equation constraints)
- XEC
  - \((n,\gamma)\) reactions induced by a pulsed neutron generator
- XEC-DC alignment
  - XEC “radiography” based on Pb-cubes in known positions w.r.t. DC

2011
- DAQ+ trigger
  - multiple-buffer read-out
    \(\Rightarrow\) trigger efficiency*livetime from 75% (2010) to 98% (2011)
- DC HV system (newly implemented, see later)
Run 2010 prematurely ended due to a serious quench of the transport solenoid.
Results

• The analysis strategy
• Review of results from Run 2009
• Combination of (2009+2010) data

(see J.Adam et al. Arxiv:1107.5547)
Analysis strategy

- likelihood analysis strategy
  - blinding observables: $E_\gamma$ and $\Delta t_{e\gamma}$

energy sideband       signal box       time sidebands

pdfs:
- signal: from detector response function
- accidental: from event distribution in data sidebands
- RD: from RD data distribution and trigger simulation (angular cut)
Likelihood fit

• Frequentist approach based on Feldman-Cousins prescriptions with profile likelihood ratio ordering

\[
\mathcal{L}(N_{\text{sig}}, N_{\text{RMD}}, N_{\text{BG}}) = \frac{e^{-N_{\text{obs}}}}{N!} e^{-\frac{1}{2} \frac{(N_{\text{BG}} - \langle N_{\text{BG}} \rangle)^2}{\sigma_{\text{BG}}^2}} e^{-\frac{1}{2} \frac{(N_{\text{RMD}} - \langle N_{\text{RMD}} \rangle)^2}{\sigma_{\text{RMD}}^2}} \prod_{i=1}^{N_{\text{obs}}} \left( N_{\text{sig}} S(\vec{x}_i) + N_{\text{RMD}} R(\vec{x}_i) + N_{\text{BG}} B(\vec{x}_i) \right),
\]

\[
LR_p(N_{\text{sig}}) = \frac{\max_{N_{\text{BG}}, N_{\text{RMD}}} \mathcal{L}(N_{\text{sig}}, N_{\text{BG}}, N_{\text{RMD}})}{\max_{N_{\text{sig}}, N_{\text{BG}}, N_{\text{RMD}}} \mathcal{L}(N_{\text{sig}}, N_{\text{BG}}, N_{\text{RMD}})}.\]

• Observables
  – kinematics (\vec{x})
  – event counts in the sidebands

• Parameters
  – number of signal and background events

Latest results ... 27 5 August 2011
### Performance summary

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
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<tbody>
<tr>
<td>Gamma E (\sigma_{2\text{cm}}) - 63%</td>
<td>1.9%</td>
<td>1.9%</td>
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<tr>
<td>Relative timing (T_{\text{ev}}) (RMD)</td>
<td>150ps</td>
<td>130ps</td>
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<tr>
<td>Positron E [Michel edge]</td>
<td>330 keV (82% core)</td>
<td>330 keV (79% core)</td>
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<tr>
<td>Positron (\theta)</td>
<td>9.4 mrad</td>
<td>11.0 mrad</td>
</tr>
<tr>
<td>Positron (\phi) [at zero]</td>
<td>6.7 mrad</td>
<td>7.2 mrad</td>
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<tr>
<td>Positron (Z/Y)</td>
<td>1.5/1.1(core) mm</td>
<td>2.0/1.1(core) mm</td>
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<tr>
<td>Gamma position</td>
<td>5(u,v)6(w) mm</td>
<td>5(u,v)6(w) mm</td>
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<tr>
<td>Trigger efficiency</td>
<td>91%</td>
<td>92%</td>
</tr>
<tr>
<td>Gamma efficiency</td>
<td>58%</td>
<td>59%</td>
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<tr>
<td>Positron efficiency</td>
<td>40%</td>
<td>34%</td>
</tr>
<tr>
<td>Muon stopping rate</td>
<td>(2.9 \times 10^7) s(^{-1})</td>
<td>(2.9 \times 10^7) s(^{-1})</td>
</tr>
<tr>
<td>DAQtime/real time</td>
<td>35/43 days</td>
<td>56/67 days</td>
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<tr>
<td>SES [analysis region]</td>
<td>(0.92 \times 10^{-12})</td>
<td>(0.44 \times 10^{-12})</td>
</tr>
</tbody>
</table>
Update of 2009 analysis

Selection: $|T_{e\gamma}| < 0.278\text{ns}$; $\cos\Theta_{e\gamma} < 0.9996$

$51 < E_{\gamma} < 55\text{ MeV}$; $52.34 < E_e < 55\text{ MeV}$

Rank of variables
In each sample

$1, 1.64, 2\sigma$ contours
Likelihood 2009

$0.17 \times 10^{-12} < BR < 9.6 \times 10^{-12}$

90% C.L.

Sensitivity $= 3.3 \times 10^{-12}$

$BR = 0$ probability $= 8\%$

updated 2009 data

Nsig best value $= 3.4$
Data 2010, time sidebands

Latest results ...
Data 2010, signal region
Fit 2010

Confidence Level

BR < 1.7 \times 10^{-12}

90\% C.L.

Sensitivity = 2.2 \times 10^{-12}

2010 data

Number of signals

Latest results ... 33 5 August 2011
### Combined fit

<table>
<thead>
<tr>
<th>Data set</th>
<th>$B_{\text{fit}}$</th>
<th>LL</th>
<th>UL</th>
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<tbody>
<tr>
<td>2009</td>
<td>$3.2 \times 10^{-12}$</td>
<td>$1.7 \times 10^{-13}$</td>
<td>$.96 \times 10^{-11}$</td>
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<tr>
<td>2010</td>
<td>$-9.9 \times 10^{-13}$</td>
<td>$-$</td>
<td>$1.7 \times 10^{-12}$</td>
</tr>
<tr>
<td>2009 + 2010</td>
<td>$-1.5 \times 10^{-13}$</td>
<td>$-$</td>
<td>$2.4 \times 10^{-12}$</td>
</tr>
</tbody>
</table>

Sensitivity = $1.6 \times 10^{-12}$

**Systematic errors included** (2% effect on UL)
Larger contributions from relative angle offset, correlation in positron kinematical variables, normalization
Conclusions

• Past
  – Data taken agree with no LFV hypothesis
  – MEGA limit improved by a factor 5

• Future
  – Sensitivity expected to achieve $5 \times 10^{-13}$ with 2011 and 2012 data
  – Detector
    – other major improvements
      • new 2Gs digitizer (DRS4), linear in its dynamic range
      • possibility to reduce both DAQ and calibration deadtime
  • need to run in stable condition until 2011 to reach the goal
Backup slides
Pile-up rejection

- reconstruction of the main cluster
- replacement of Npe for pile-up cluster with expected values
TC status

- New fast electronics for the shaping of fiber-coupled APDs
  - Stereo reconstruction of TC hit point
  - Useful at both trigger and off-line stage
- Implementation of a Nd-laser
  - Precise tool for LXe-TC timing

Latest results ...
QE measurement

Obtained by comparison of measured vs. expected number of photoelectrons from each α-source
Scintillation mechanism

Xe + radiation

excitation

Xe* + Xe

ionization

Xe2+ + e-

recombination

Xe + Xe**

Xe** → Xe*

excimer

2Xe + hv

λ=175nm, 14 nm FWHM

excitation probability

∝ dE/dx
Features

- **Compact**
  - $Z=54$, $\rho=2.95 \text{g/cm}^3$ ($X_0=2.7 \text{cm}$), $R_M=4.1 \text{cm}$ @ $T=165 \text{K}$

- **High light yield**
  - $LY=42000 \text{phe/MeV} \approx 0.7 LY(\text{NaI})$ for m.i.p.’s

- **Fast**
  - $\tau_1=4\text{ns}$, $\tau_3=22\text{ns}$, $\tau_{\text{rec}}=45\text{ns}$

- **Particle ID**
  - $\tau_\gamma \approx 2 \tau_\alpha$
  - $LY_\alpha = 1.2 \times LY_{\text{mip}}$

- **$n = 1.65$ ($\approx n_{\text{quartz}}$)**
  - good optical coupling with PMTs

- **No self-absorption** ($\lambda_{\text{Abs}}=\infty$)
  - position-independent energy response
  - homogeneous calorimeter
Light absorption

• Due to the presence of contaminants (mainly oxygen and water moisture in the VUV region)
• Measurements of optical properties available in the literature often contradictory

Absorption coefficients ($\lambda^{-1}$) @ 1 ppm in LXe

Latest results ...
Additional quenching factors

• Ionization quenching
e-capture by electro-negative impurities (namely O₂)
  (WARP collaboration, submitted to NIM A, and references therein)

• Non-radiative collitional reactions
  \[ \text{Xe}_2^* + \text{N}_2 \rightarrow 2 \text{Xe} + \text{N}_2 \]
  \[ \frac{1}{t'} = \frac{1}{\tau} + k[N_2] \]  (shorter decay-time)
  \[ A' = A_j / (1 + \tau k[N_2]) \]  (lower light intensity)

used in LAr to shorten the long decay-time component
(WARP collaboration, arXiv:0804.1217v1 [nucl-ex])

In both cases, quenching of scintillation light is expected,
More significant in the case of lightly ionizing particles
DC operation in Run 2008

- operated in He+ethane 50%/50% mixture and immersed in He-atm
- at turn-on (July 08) the system was fine 30/32 planes OK (@1850 V)
- HV deterioration observed during the Run; at the end
  - 11/32 planes OK (@1850 V)
  - 7/32 planes off-nominal voltage (1700÷1800 V)
- body of evidence for He-diffusion inside the HV distribution frame

Latest results ...

5 August 2011
The rate of events with a reconstructed track decreases with the Run going on → absolute $e^+$-$e^-$-efficiency getting lower and lower.
e\textsuperscript{+}-momentum resolution

obtained from a fit of the edge of Michel spectrum (with a slight dependence on the emission angle)

\[ \chi^2/d.o.f = 126 / 95 \]

\[ f_{\text{core}} = 0.845 \pm 0.005 \]
\[ \mu_{\text{core}} = 0 \text{ (fixed)} \]
\[ \sigma_{\text{core}} = 0.431 \pm 0.007 \text{ MeV} \]
\[ \mu_{\text{tail}} = -0.51 \pm 0.05 \text{ MeV} \]
\[ \sigma_{\text{tail}} = 1.89 \pm 0.06 \text{ MeV} \]

twice worse than expected
• Relative efficiency (i.e. fraction of signal/Michel events) is almost constant during the run (in spite of DC deterioration)
• average ratio agrees with the expected fraction of $e^+$ with $p>50$ MeV

$\frac{\varepsilon_S}{\varepsilon_M} = 9.87 \pm 0.45$

→ it is possible to normalize the signal pdf by counting the number of Michel
Summary of Run 2010

- Aug-Oct, 2009 (DAQ time: 56 days)
- μ-stop rate: 2.9 × 10^7 s^-1
- Total μ-stop in target: 1.1 × 10^{14}
- Optimized μ-stop distribution in target
- Improved electronics timing accuracy (DRS4)
- Smooth and efficient DAQ had to be stopped on Nov. 5th due to the problem of the BTS.
- Resultant data statistics: \( \times 1.9 \) higher w.r.t. run 2009
- Normalization factor: \( k = 2.1 \times 10^{12} \) (preliminary)
- Calibration and optimization of the analysis are still in progress.

Delayed start: DCHs construction, MEG target accidentally broken
Premature end: BTS solenoid magnet problem on beginning of November
Polarizzazione dei muoni

- Fascio costituito da “surface muons” \( \Rightarrow P = 1 \)
- Possibili effetti di depolarizzazione
  - contaminazione da “cloud muons” (i.e. muoni da decadimenti di pioni non a riposo) \( \Rightarrow \Delta P = 4\% \)
  - rotazione di spin \( \Rightarrow \Delta P < 0.7\% \)
  - multiplo scattering nel bersaglio \( \Rightarrow \Delta P < 0.3\% \)
  - divergenza del fascio \( \Rightarrow \Delta P = 4\% \)
\[ \langle P_z \rangle = 0.92 \pm 0.03 \]

- Misura della polarizzazione
  - distribuzione angolare dei decadimenti di Michel
    (tanto più asimmetrica all’end-point)

Esperimento MEG ...

\( P = 1 \)
Esperimento MEG ...

Blue: US

Red: DS

\[ \mathcal{G}_1 = 20 \]
\[ \mathcal{G}_2 = 30 \]

\[ \mathcal{G}_1 = 10 \]
\[ \mathcal{G}_2 = 20 \]

\[ \mathcal{G}_1 = 0 \]
\[ \mathcal{G}_2 = 10 \]

\(< P > = 0.89 \pm 0.04 \) (only statistical error)
Radiative decays

- The number of observed events is compatible with estimated efficiencies.
- Also the angular distribution agrees with expectations.
- Also seen in normal data (with kinematical cuts applied).

\[ \sigma(\Delta t_{e\gamma}) = (159 \pm 9) \text{ ps} \]
(extrapolated to 143 ps @52.8 MeV)

- Contribution from tracking
- \(e^+\) time-of-flight uncertainty

Latest results ...

5 August 2011
Absorption ⇒ $R(E)$ position-dependent

Energy resolution dominated by shower-fluctuations

$E_\gamma = 52.8$ MeV

$\sigma_E$ vs $\lambda_{\text{abs}}$

$\text{MC}$

FWHM 2.15 MeV

Fractional FWHM 4.07 %

$\Rightarrow$ need to verify optical properties on a large-size prototype
The “Large Prototype”
Design

• 40 x 40 x 50 cm³, 100 l LXe
  
  (same depth, 1/10 of the final volume)

the world-wide largest at that time

• Equipped with 240 PMTs
  
  (HAMAMATSU R6041+R9288TB)
  - K-Cs-Sb photocathode
  - Quartz window (suited for VUV)

• Gas purification system
  
  (getter+Oxysorb) to keep impurity content < 1 ppb
Absorption measurement

- Use of $\alpha$-sources
  $N_{\text{phe}}$ vs distance
- Increase of both light yield and absorption length observed during the purification cycle
  $\Rightarrow$ removal of water

$\lambda_{\text{abs}} > 125 \text{ cm (68\% CL)} \quad \& \quad \lambda_{\text{abs}} > 95 \text{ cm (95 \% CL)}$
\[ \pi^- p \rightarrow \pi^0 n, \]

\[ \pi^0 \rightarrow \gamma \gamma \]

54.9 MeV < \( E(\gamma) \) < 82.9 MeV

\[ \theta > 170^\circ \text{ FWHM} = 1.3 \text{ MeV} \]

\[ \theta > 175^\circ \text{ FWHM} = 0.3 \text{ MeV} \]
Performances

FWHM 2.7 ± 0.1 MeV

FWHM (4.8 ± 0.2 %)

$\sigma_R = (1.23 \pm 0.09)\%$

$\sigma(E_\gamma)/E_\gamma = 4.8\%$

$\sigma(T_\gamma) = 125$ ps

unprecedented at these energies!
The final detector
• 4π, single-vessel detector consisting in

  • 800 l LXe
  • viewed by 848 PMTs
  • C-shaped, Ω/4π = 9%
  • located out of the spectrometer field (B < 100 G)
  • 19 X₀ depth (containment > 99%)
  • 0.4 X₀ front material

(see R.Valle’s talk for further details on the overall detector)
Setting the detector up

- **Detector instrumentation**
  - completed in Aug 2007
  - all PMTs mounted
  - sources
    - $\alpha$-wires
    - LEDs
    - Laser fibers
  - sensors
    - PT100 temperature sensors
    - Surface level meter
- **LXe transfer**
  - completed by 20 September
  - 15 days needed (10 l/h speed)
- **Purification system**
  - Liquid-phase circulation
  - dedicated pump, 70 l/h
  - molecular sieves (>25 g water absorption)
Absorption Length

- Data/MC ratio vs distance fitted with an exponential curve
- Slope compatible with no absorption
- Obtained on 25 Nov (after 180h purification)

\[ \lambda > 3 \text{ m @95\% C.L.} \]
Li(p,γ)Be reaction

- 1-morning data taking twice a week with a LiF target
- Clear 17.6 MeV peak on the 14.8 MeV broad resonance
- Improvement of light yield
- Consistent with absorption length measurement with α-sources
Troubles in 2007 run

• Light yield
  – smaller than expected ($\sim \frac{1}{2}$) in the case of $\gamma$-events
  – in agreement with expectations in the case of $\alpha$-events

• Scintillation decay time
  – shorter in the case of $\gamma$-events
  – OK in the case of $\alpha$-events

$\tau_\gamma = 34$ ns
$\tau_\alpha = 21$ ns

$\Rightarrow$ possible contamination from $O_2$ and/or $N_2$ impurity
Performances in 2007 Run

- From $\pi^0$-decay events

$\sigma_{\text{up}} = 2.4\%$
FWHM $= 6.5\%$

Intrinsic resolution on a 12-PMT sample

$\sigma_t = 115\text{ps}$
Solutions for 2008 run

- **Impurity removal**
  - use of a $\text{O}_2$-getter cartridge
  - developed for LAr use at CERN
  - mounted at the outlet of the liquid-phase purifier with by-pass valves
  - (in parallel) restoring of gas-phase circulation through a Zr-getter

- **Avoid to use inner Nitrogen cooling pipe**
## Perspectives for 2008 run

<table>
<thead>
<tr>
<th></th>
<th>“Goal” Measured</th>
<th>Simulation</th>
<th>2007 Measured</th>
<th>2008 Prospects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma Energy (%)</td>
<td>4.5-5.0</td>
<td></td>
<td>6.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Gamma Timing (nsec)</td>
<td>0.15</td>
<td></td>
<td>0.27*</td>
<td>0.15*</td>
</tr>
<tr>
<td>Gamma Position (mm)</td>
<td>4.5-9.0</td>
<td></td>
<td>15.</td>
<td>9.0</td>
</tr>
<tr>
<td>Gamma Efficiency (%)</td>
<td>&gt;40</td>
<td></td>
<td>&gt;40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>e+ Timing (nsec)</td>
<td>0.1</td>
<td></td>
<td>0.12*</td>
<td>0.12*</td>
</tr>
<tr>
<td>e+ Momentum (%)</td>
<td>0.8</td>
<td></td>
<td>2.1</td>
<td>1.1</td>
</tr>
<tr>
<td>e+ Angle (mrad)</td>
<td>10.5</td>
<td></td>
<td>[17.]</td>
<td>[17.]*</td>
</tr>
<tr>
<td>e+ Efficiency (%)</td>
<td>65</td>
<td></td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Muon Decay Point (mm)</td>
<td>2.1</td>
<td></td>
<td>3.</td>
<td>3.*</td>
</tr>
<tr>
<td>Muon Rate (10^8/sec)</td>
<td>0.3</td>
<td></td>
<td>0.3***</td>
<td>0.3***</td>
</tr>
<tr>
<td>Running Time (week*)</td>
<td>100</td>
<td></td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Single Event Sens (10^{-13})</td>
<td>0.5</td>
<td></td>
<td>6.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Accidental Rate (10^{-13})</td>
<td>0.1-0.3</td>
<td></td>
<td>6.0*</td>
<td>1.0*</td>
</tr>
<tr>
<td># Accidental Events</td>
<td>0.2-0.5</td>
<td></td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td>90% CL Limit (10^{-13})</td>
<td>1.7</td>
<td></td>
<td>23.</td>
<td>6.9</td>
</tr>
</tbody>
</table>
Conclusions

• LXe scintillation is an established technique for e.m. calorimetry with unprecedented performances @ 50 MeV

• Validation by test on a 100l prototype

• Main concerns on the final detector experienced on 2007 Run are related to $O_2$, $N_2$ contamination

• Standard solutions adopted to fix that problem

• We are confident to reach goal resolutions by 2008 Run
Event selection of environmental radioactivity (non-dedicated trigger) → topological cuts to exclude α-induced events

- Identified lines
  - $^{208}$Tl (2.59±0.06) MeV
  - $^{40}$K (1.42 ± 0.06) MeV
- Low energy calibration

looks like a NaI ...

Latest results ...
Background suppression \(\Rightarrow\) improvements of detector performances

(in particular for \(E_\gamma\))

\[
BR_{acc} = \frac{N_{acc}}{N_\mu} = R_\mu \cdot \left(2 \frac{\delta E_e}{E_e}\right) \cdot \left[\frac{\alpha}{2\pi} \left(\frac{\delta E_\gamma}{E_\gamma}\right)^2 \left(\ln \left(\frac{\delta E_\gamma}{E_\gamma}\right) + 7.33\right)\right] \cdot \left(\frac{\delta \theta_{e\gamma}}{4}\right)^2 \cdot (2\delta t)
\]

\(\mu\)-rate \(e^+\)-energy  \(\gamma\)-energy  back-to-back timing

Latest results ...

71  

5 August 2011
α-sources, a closer view

$^{241}$Am-source