Possible Improvements of MEG Experiment

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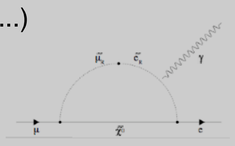
The MEG experiment is an upcoming experiment to seek evidence for the lepton flavor violating process, μ→eγ down to a 10^{-13} level in branching ratio. The experiment is powerful enough to explore new physics beyond the standard model. In order to fully exploit the maximum beam intensity and not be limited by background considerations, a future upgrade of the experiment is necessary. Possible upgrade strategies for the MEG experiment will be discussed here.

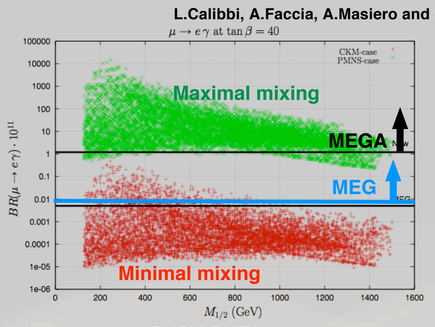
Introduction

MEG Experiment

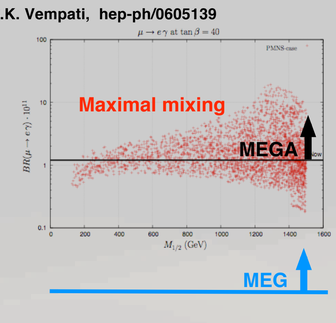
- An upcoming experiment at PSI to search for $\mu \to e\gamma$ down to $BR \sim 10^{-13}$
- Real chance to "discover" evidence for new physics beyond the standard model (SUSY-GUT, ν_R, ...)
- Complementary to LHC experiment
  - Even more sensitive in some cases.



L.Calibbi, A.Faccia, A.Masiero and S.K. Vempati, hep-ph/0605139



SUSY-GUT/seesaw
(within LHC sensitivity reach)



SUSY-GUT/seesaw
(outside LHC sensitivity reach)

Signal and Background

Signal kinematics

- Back-to-back
- Mono-energetic E_e=52.8MeV E_γ=52.8MeV
- Coincident in time

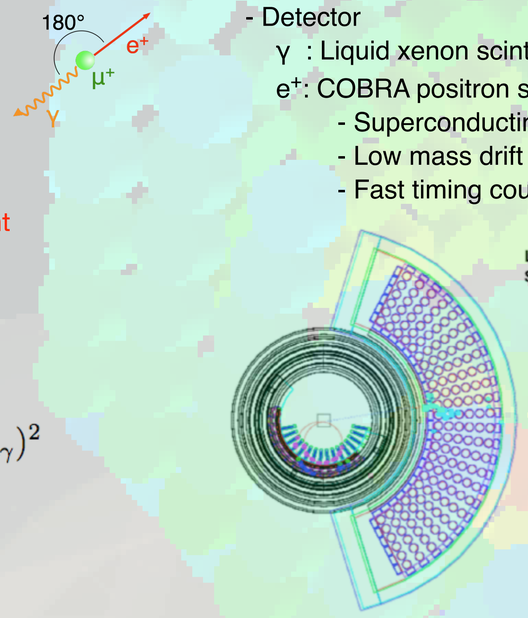
Background

- Prompt: μ→eγνν
- Accidental: μ→eνν + random γ ←Dominant

$$B_{acc} \propto \delta E_e \cdot \delta t_{e\gamma} \cdot (\delta E_\gamma)^2 \cdot (\delta \theta_{e\gamma})^2$$

Detector

- World's most intense DC μ^+ beam at PSI up to 10^8 μ^+/sec
- Detector
  - γ : Liquid xenon scintillation detector
  - e^+: COBRA positron spectrometer
    - Superconducting magnet with gradient field
    - Low mass drift chamber system
    - Fast timing counter



MEG

Sensitivity of MEG experiment

Assumptions
- Measured detector resolutions
- *BG* = 1 events
- Running time: $T = 4\times10^7$ sec (2 years beam time)
- $R(\mu) = 3\times10^7$ μ sec^{-1}

$BR(\mu\to e\gamma) < 1.5\times10^{-13}$ at 90% CL

Detector Performance (measured)

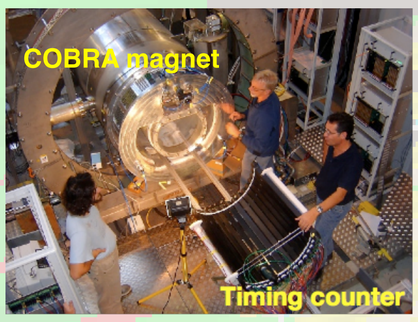
ΔEγ	5 %
ΔEe	0.9 %
$\delta t_{e\gamma}$	100 psec
$\delta\theta_{e\gamma}$	23 mrad

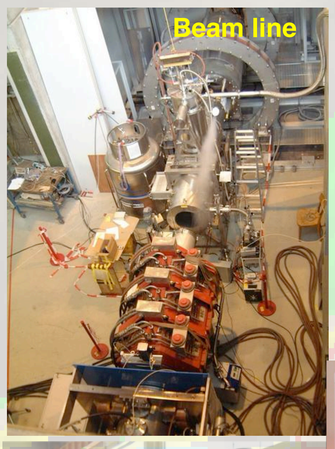
Cf.)

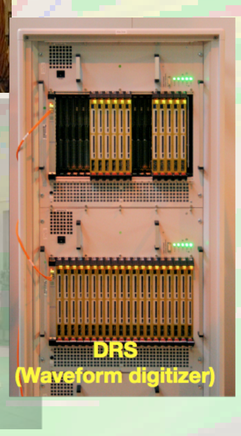
Single event sensitivity $\frac{1}{N_\mu \cdot T \cdot (\Omega/4\pi)} \times \frac{1}{\varepsilon_e \cdot \varepsilon_\gamma \cdot \varepsilon_{sel}}$

$BR(\mu\to e\gamma) = 1.1\times10^{-14}$

with full intensity beam ($R(\mu) = 1\times10^8$ μ sec^{-1})

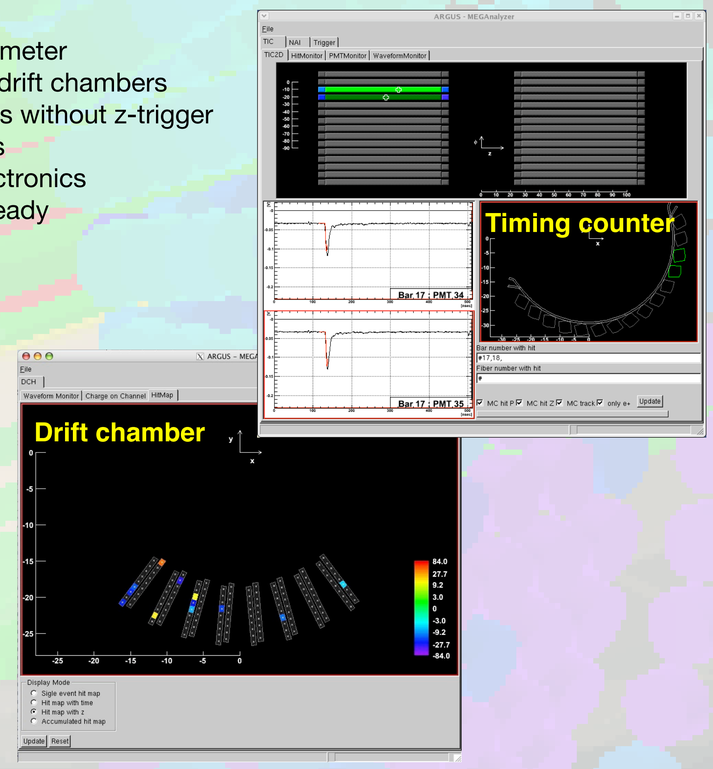






Run2006

- Commissioning run
  - Beam
  - COBRA spectrometer
    Half of the the drift chambers
    Timing counters without z-trigger
    fiber counters
  - DAQ/trigger electronics
- LXe detector not ready



Possible Improvements

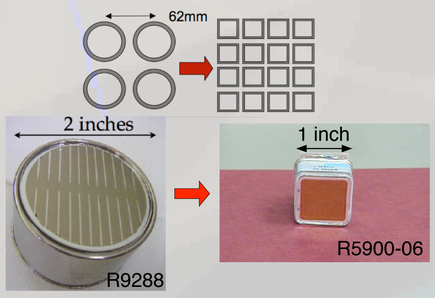
Ideas on Upgrade of Experiment

Present MEG is powerful enough, but we could do better...

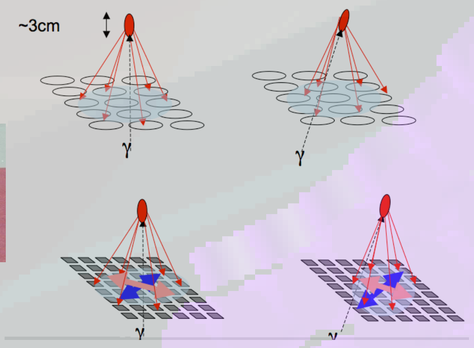
Detector upgrade
- LXe detector
  - Higher QE PMT (recent development by Hamamatsu)
    → Photoelectron statistics
  - Finer granularity with smaller PMT
    → Position reconstruction
    → Incident angle reconstruction
    → Shallow event reconstruction
    → Pile-up rejection
  - Other photon sensor with higher QE? (APD, SiPM)
- Drift chamber
  - Reduce material
    → Resolutions and backgrounds
- Double the acceptance
    → Better *S/B* with lower beam rate

Using polarized beam
→ See "*μ→eγ Measurement with Polarized Muon Beam*", H. Nishiguchi

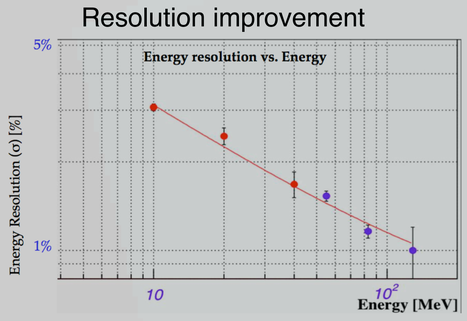
Finer granularity



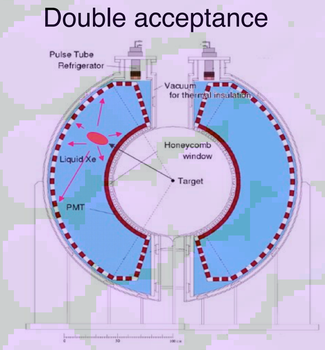
Incident angle reconstruction



Resolution improvement



Double acceptance



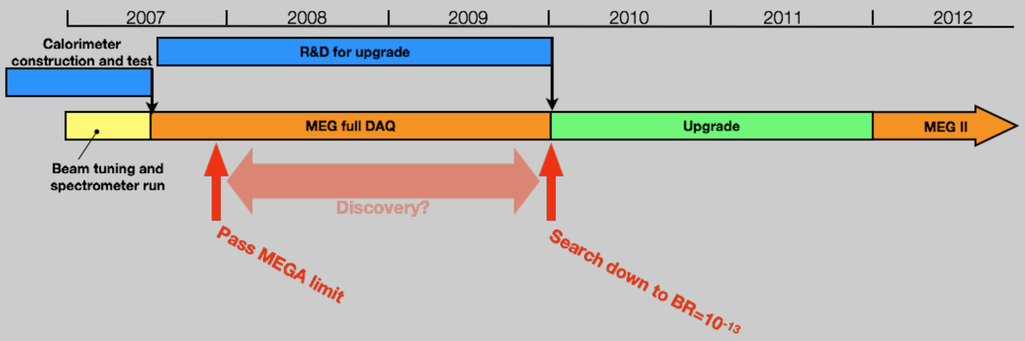
Quick Look at Effect of Upgrades

Improvement	
LXe detector	
Higher QE PMT + coverage	δE_γ x 0.65, $\delta t_{e\gamma}$ x 0.77
Finer granularity with smaller PMT	$\delta\theta_{e\gamma}$ x 0.72, B_{acc} x 0.6
Drift chamber	
Reduce material	δE_e x 0.8
General	
Double acceptance	B_{acc} x 0.5

→ x10 better sensitivity could be possible

cf.) $B_{acc} \propto \delta E_e \cdot \delta t_{e\gamma} \cdot (\delta E_\gamma)^2 \cdot (\delta\theta_{e\gamma})^2$

Time Line (My Personal View)



Conclusion

- The MEG experiment is preparing to start soon.
- The present MEG is powerful enough, but a sensitivity improvement might be possible with a detector upgrade and full intensity beam.
- Quick look at the effect of the detector upgrade shows that a sensitivity improvement of a factor of ten might be possible.