

MEG実験 2009年データを用いた $\mu^+ \rightarrow e^+ \gamma$ 探索結果

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Outline

- Purpose and detector in MEG
- Physics analysis for $\mu^+ \rightarrow e^+ \gamma$ search on 2009 data
- Progress of analysis
- Prospect

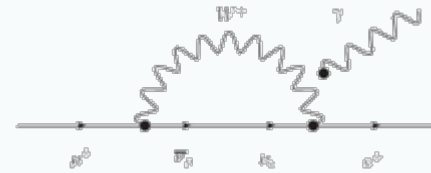
Current status and prospect are reported.

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

- $\text{BR}(\mu^+ \rightarrow e^+ \gamma) < 1.2 \times 10^{-11}$ (90% C.L.)
by MEGA experiment in 1999
- Simple decay with mixing charged lepton flavor
- BR in the Standard Model by neutrino oscillation is too small to be observed : $\text{BR} \sim 10^{-44} - 10^{-54}$

$$B(\mu \rightarrow e \gamma) = \frac{3\alpha}{32\pi} \sum_i \left| U_{\mu i}^* U_{ei} \frac{\Delta m_{21}^2}{M_W^2} \right|^2$$

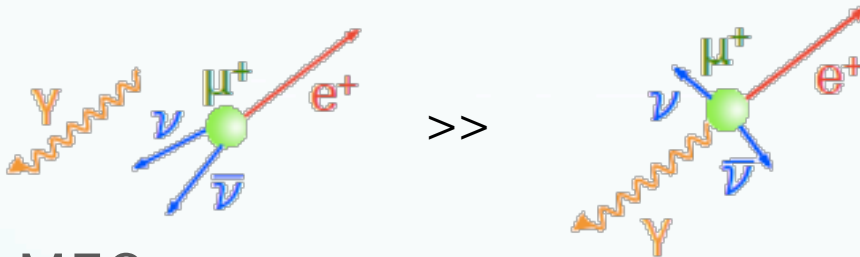
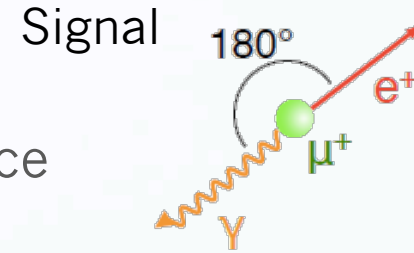
$$\approx \frac{\alpha}{128\pi} \sin^2 2\theta_{12} \left(\frac{\Delta m_{21}^2}{M_W^2} \right)^2 < 10^{-54}$$



- Many extensions of SM predict $\mu^+ \rightarrow e^+ \gamma$
near the current BR upper limit (1.2×10^{-11}).
 - SUSY GUT SU(5), SO(10), MSSM RN, etc.
 - $\mu^+ \rightarrow e^+ \gamma$ is clear evidence of new physics

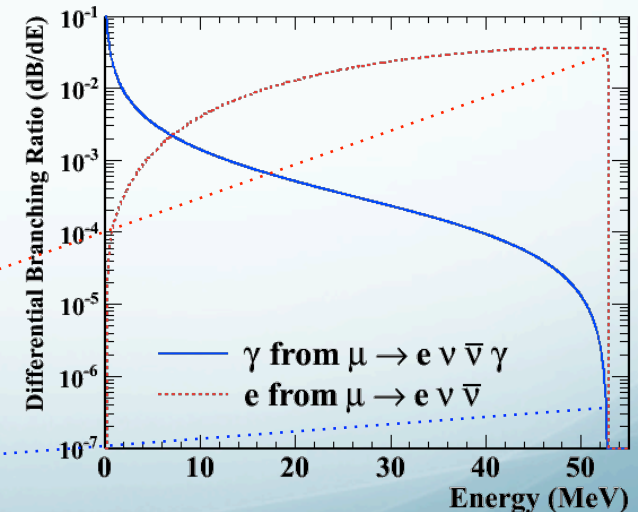
Background

- Signal
 - $E_e = E_\gamma = m_\mu/2 = 52.8 \text{ MeV}$
 - back-to-back decay with a time coincidence
- Two backgrounds of $\mu^+ \rightarrow e^+ \gamma$
 - Accidental BG and Prompt BG



- MEG
 - Enough μ^+ with less pile-up
 - PSI ring cyclotron, DC surface μ^+
 - High-rate e^+ counting
 - COBRA magnet, low-mass drift chamber
 - High-resolution γ measurement
 - Liquid xenon detector

BR fraction of μ decay (E_e/E_γ)

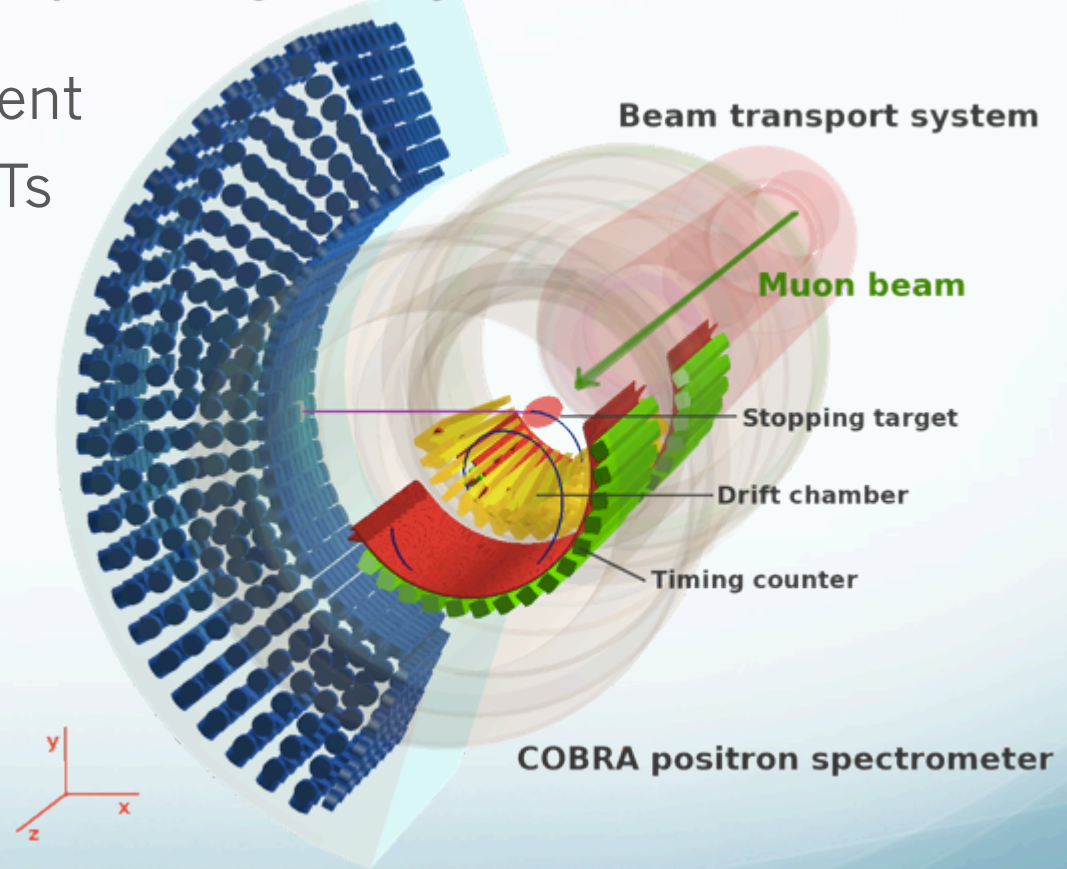


Detector

Energy, timing and position measurement of γ and e

- Liquid xenon detector
 - gamma-ray measurement
 - 900L LXe and 846 PMTs
- Drift chamber
 - e^+ tracking
 - Z and R measurement
- Timing counter
 - e^+ timing

Liquid xenon gamma-ray detector

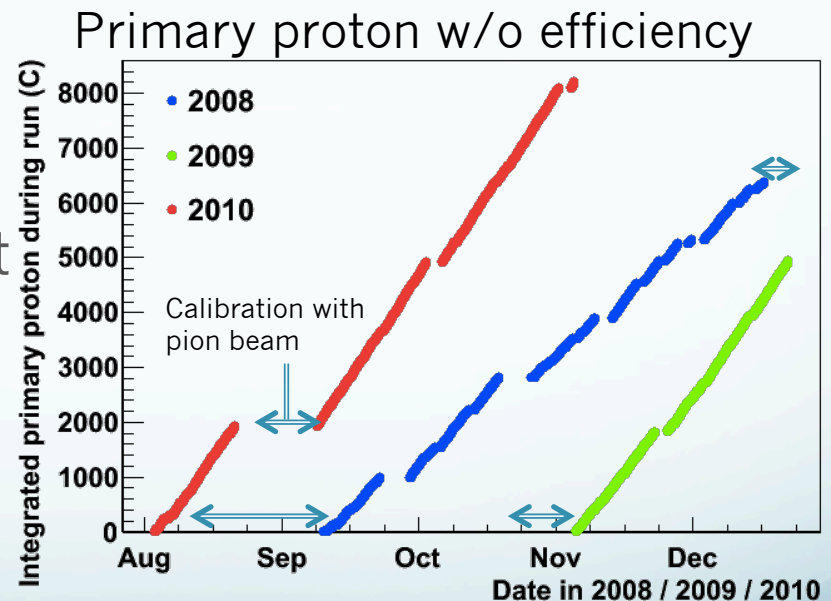


History of MEG

Proposed in 1999, development and installation until 2007

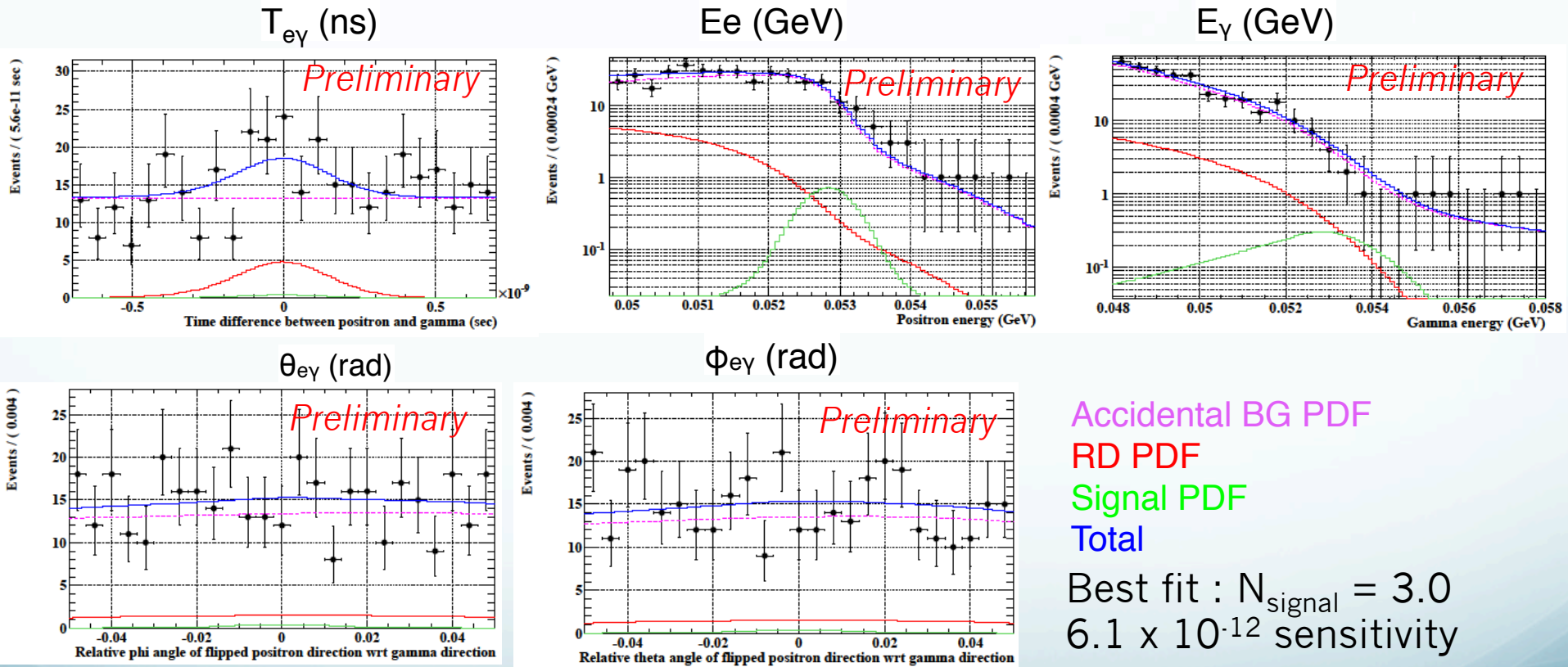
Physics run and observed μ

- 2008 first physics run
 - $N_{\mu} = 0.5 \times 10^{12}$ for three months
 - Low DC efficiency
 - Low LXe light yield
- 2009 : used for preliminary result
 - $N_{\mu} = 1 \times 10^{12}$ for two months
- 2010
 - $N_{\mu} = 2 \times 10^{12}$ for three months
- 2011 ~
 - Continue for a few years toward to $O(10^{-13})$



2009 preliminary result

- Likelihood analysis and toy-MC for BR estimation on 2009 data
 - Reported in the last JPS meeting



$\text{Br}(\mu^+ \rightarrow e^+ \gamma) < 1.5 \times 10^{-11}$ at 90% C.L.



To be updated

Analysis improvement and Prospect

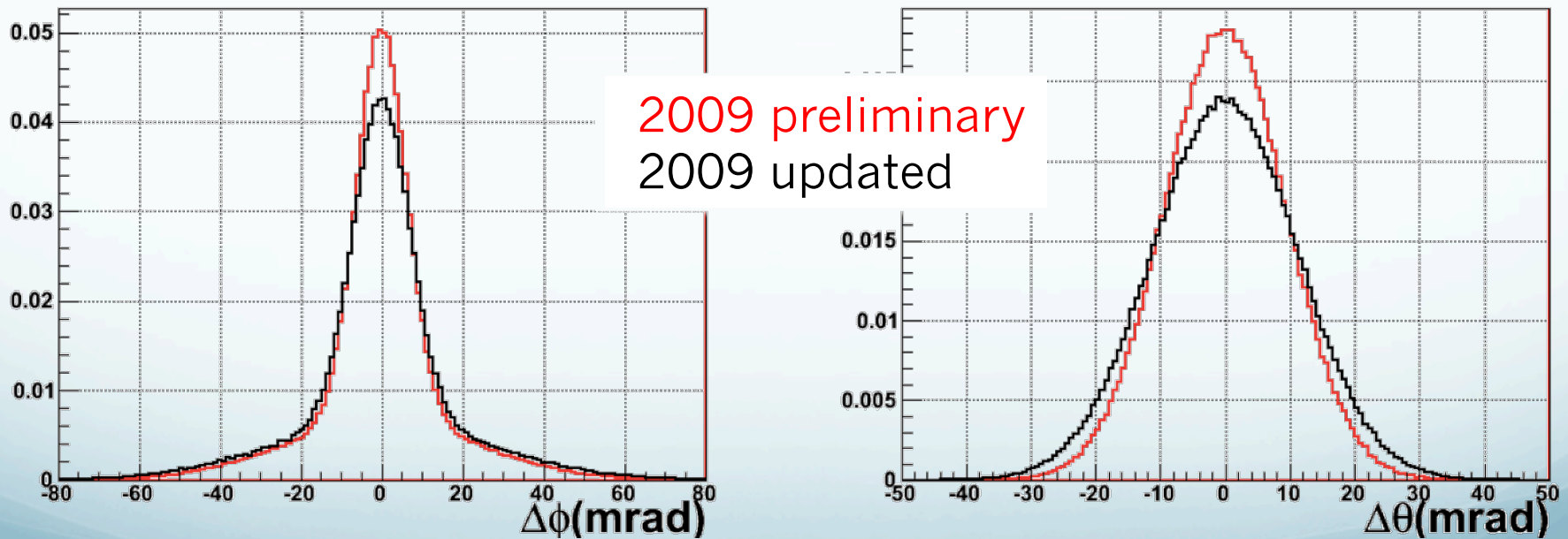
Update on analysis

- Improvement of analysis for both 2009 and 2010 data
 - Improved e^+ tracking code
 - Apply more suitable B field for e^+ tracking
 - Found misalignment when measuring B
 - Better understanding of reconstruction bias in the positron spectrometer with MC study
 - Alignment of detectors
 - Better treatment of E_γ higher tail
 - Physics analysis uses background information of sideband data in profile likelihood

Improvement of e^+ analysis

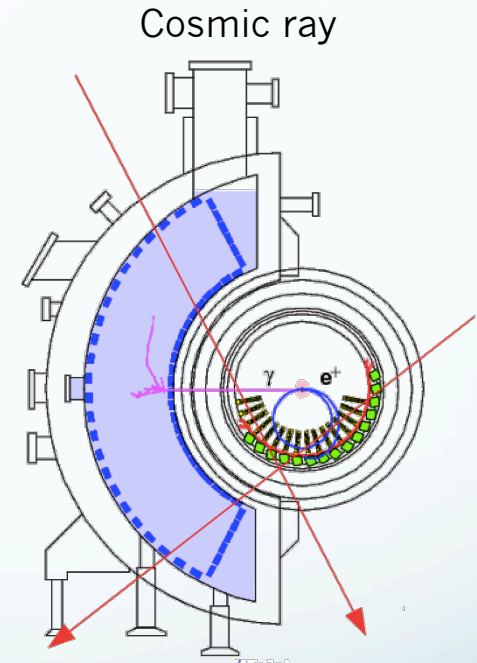
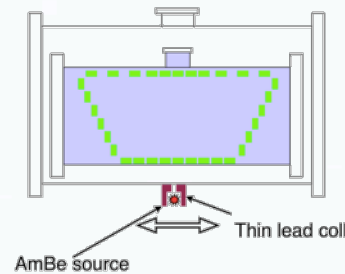
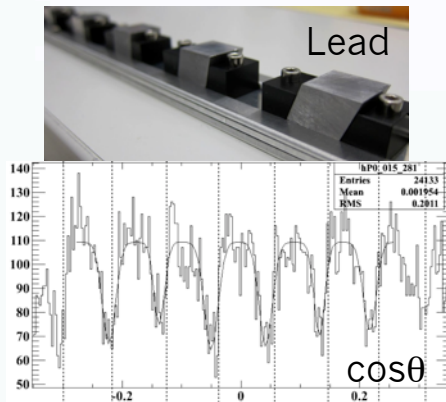
- Resolutions improved
 - σ_{Ee}^* : 0.74 % \rightarrow 0.61 %
 - σ_{ϕ}^* : 7.4 mrad \rightarrow 6.1 mrad
 - σ_{θ} : 11.2 mrad \rightarrow 9.4 mrad

* core component of double Gaussian



Study for position uncertainty

- Alignment check for Liquid xenon detector
 - Lead brick with 18 MeV γ ray
 - Scan with radioactive source along detection face



- Alignment check for Drift chamber
 - Reconsidered optical survey, B field, cosmic ray
- Alignment between detectors with cosmic ray

Systematics of position had brought the largest impact on the result

- Reduced uncertainty from 7.5/7.5 mrad to 3.2/3.1 mrad (ϕ_{ey}/θ_{ey})

Status of 2010 run

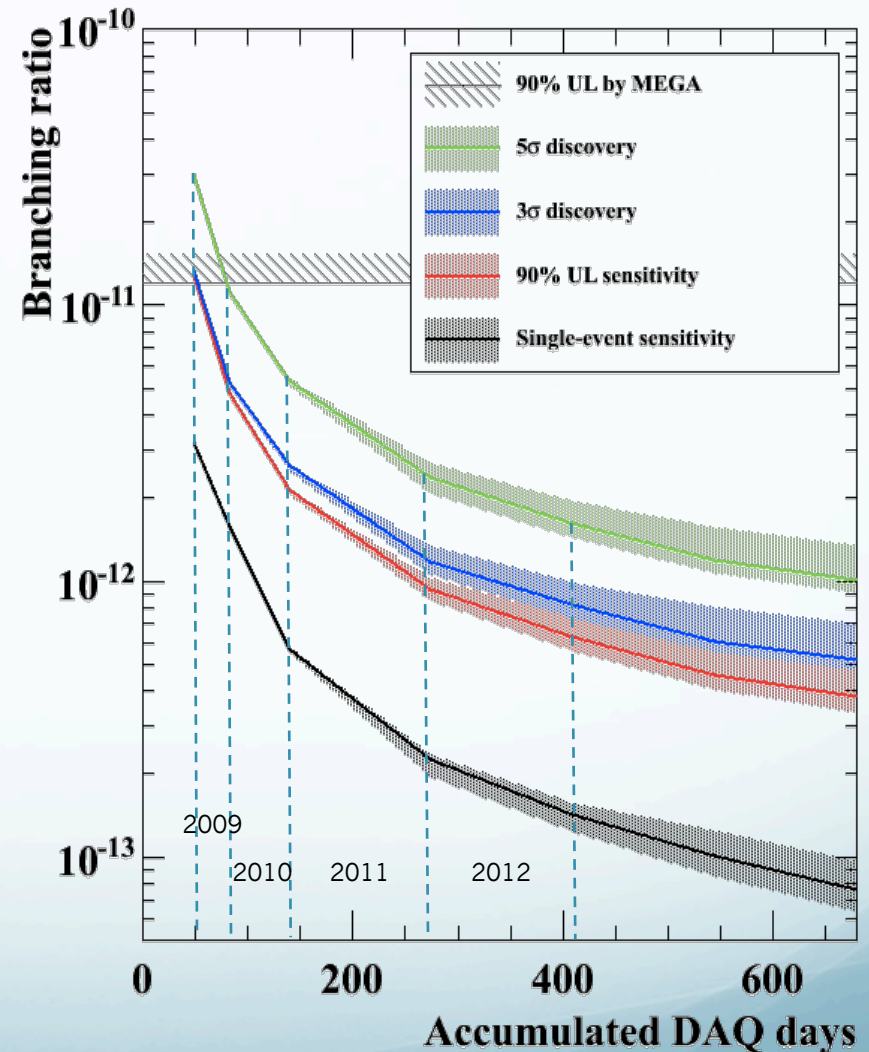
- Optimization of muon momentum
 - Various degrader set were tested with changing thickness
- Many calibration events using $\pi^0 \rightarrow 2 \gamma$ for the liquid xenon detector
 - Fine calibration and performance evaluation
- New calibration apparatus
 - 9 MeV - neutron generator for a gamma-ray calibration
 - Target for Mott scattering to calibrate the positron spectrometer
 - Test BGO instead of NaI for $\pi^0 \rightarrow 2 \gamma$ calibration
- Z-tagging fiber detector for a positron
 - Efficient e- γ direction match will be considered in the trigger logic
- Better trigger / DAQ performance
 - 92 % direction match, less inter-board jitter, etc.
- Premature end by the beam transport solenoid on 6 November
- Double statistics from 2009 data

Plan for physics analysis

- Combined 2010 data with 2009 for a next update on result
 - Calibration and analysis of 2010 data will be ready soon.
 - Difference of detector performance between years can be taken into account.
- Next update will be shown in this summer.
 - 3 x 2009 statistics (= 2009 + 2010 data)
 - With many improvements
- Analysis becomes more sensitive by using profile likelihood.

Prospect

- Run 2011 will start soon.
 - 99% live time / 99 % direction match with fiber / reduced chamber noise
 - Long and stable run is expected
- Sensitivity of BR
 - Cut analysis based on a S/N likelihood just for a prospect
 - Band indicates conservative/reasonable/optimistic improvement of detector performance



Summary

- Analysis improved.
 - e^+ resolution, less systematic uncertainty, etc.
- Preliminary result will be updated in this summer.
 - Use combined data in 2009 and 2010
- Next run will be taken for a long time.