MEG実験 最終結果へ向けてのキャリブレーション及びデータ解析の現状

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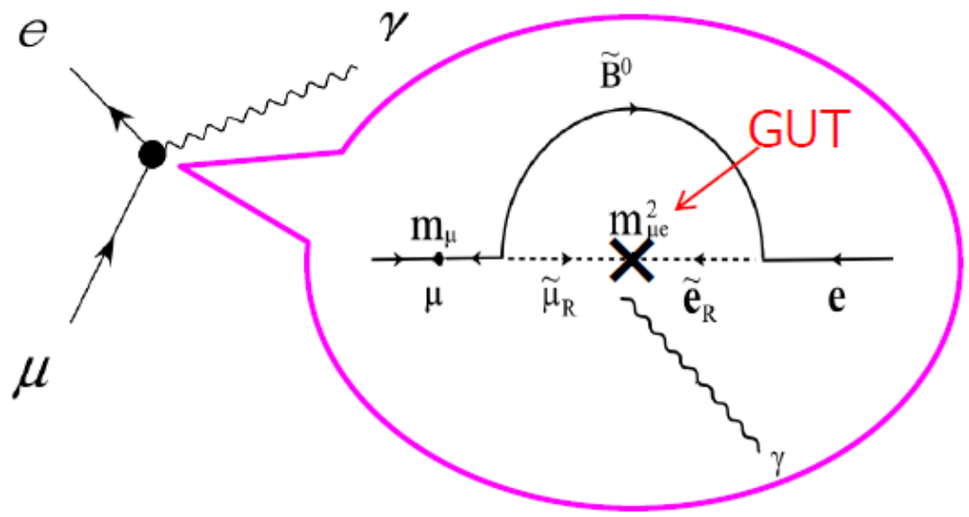
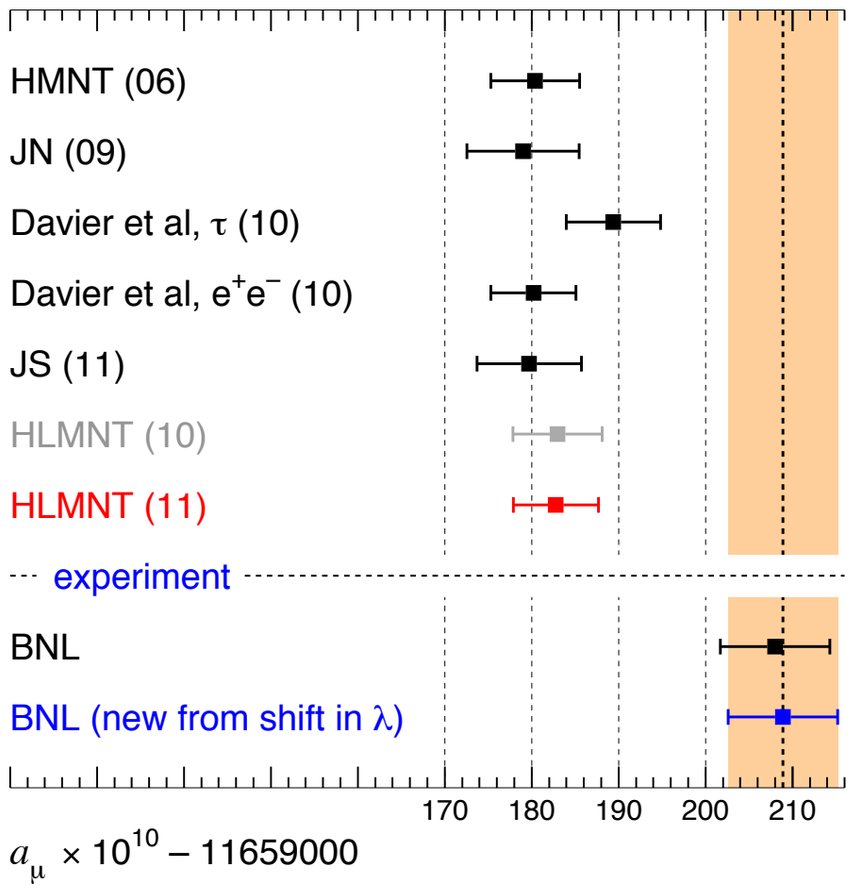
日本物理学会69回年次大会

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



- CLFV Forbidden in SM
  - Little SM background through ν oscillation : $Br(\mu^+ \rightarrow e^+\gamma) < 10^{-45}$
- So far, any CLFV signal has not been observed.
- Many new physics beyond SM (e.g. SUSY, Extra dimensions etc.) predict observable Br (10^{-14} - 10^{-11})
  - **Discovery will be an unambiguous evidence of new physics.**

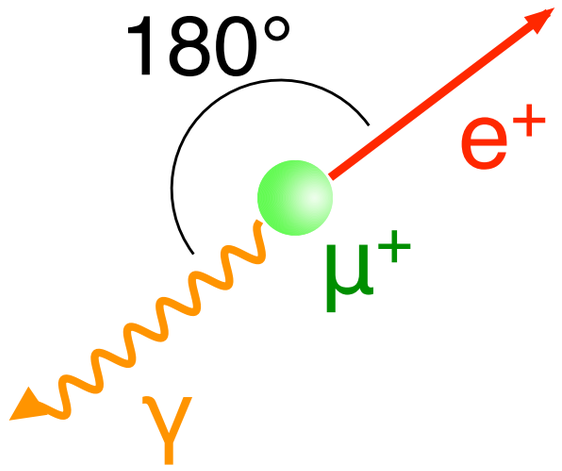
μ g-2



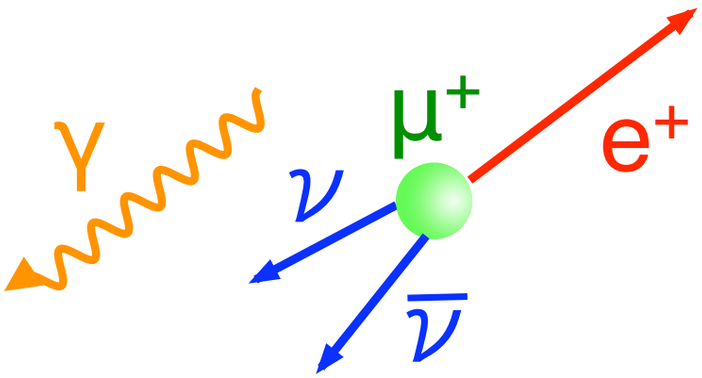
Hagiwara et al., arXiv:1105.3149 [hev-ph], 2011

Signal and background

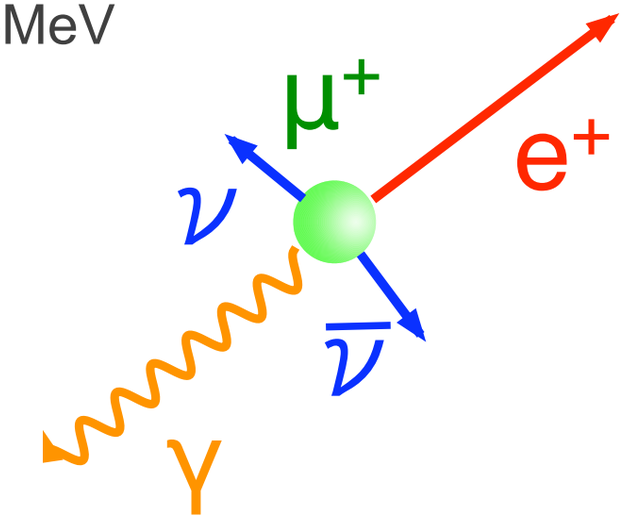
- Signal
  - μ^+ decay at rest
  - 52.8MeV (half of M_μ) (E_γ,E_e)
  - Back-to-back ($\theta_{e\gamma}$,$\varphi_{e\gamma}$)
  - Timing coincidence ($T_{e\gamma}$)



- Accidental background
  - Michel decay e^+ + random γ
  - Dominant background
  - Random timing, angle, E < 52.8MeV

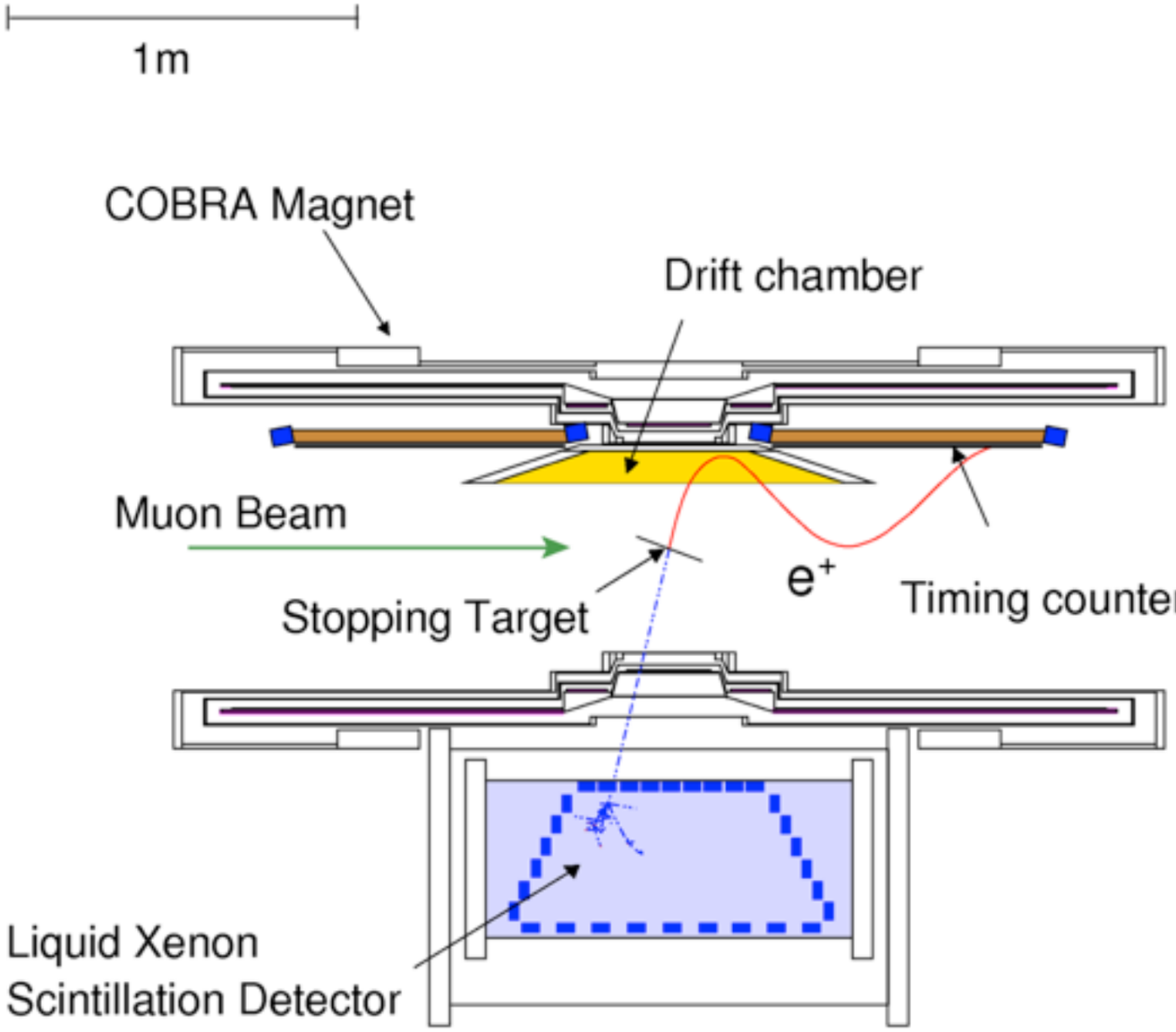


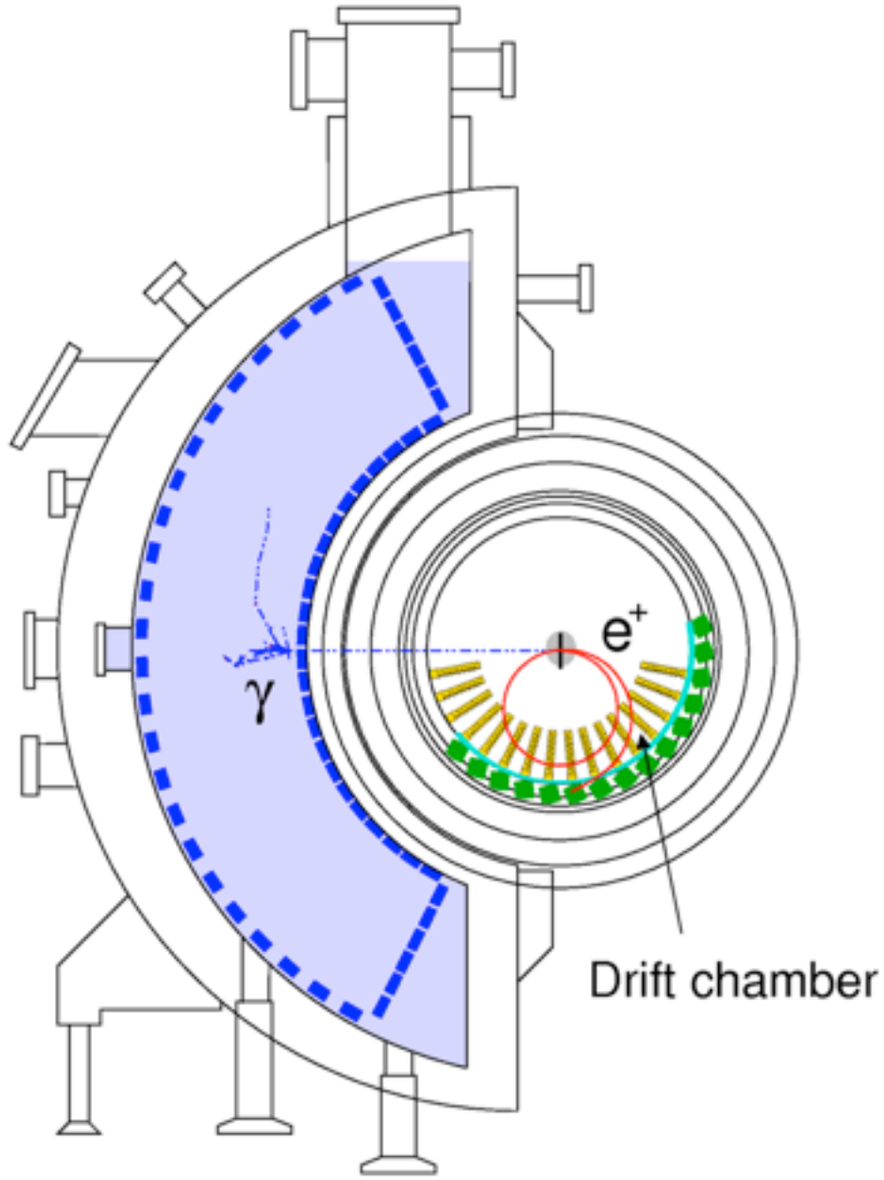
- Radiative muon decay
  - $\mu^+ \rightarrow e^+\nu\nu\gamma$
  - Timing coincident, not back-to back, E < 52.8MeV



MEG Experiment

PSI in Switzerland

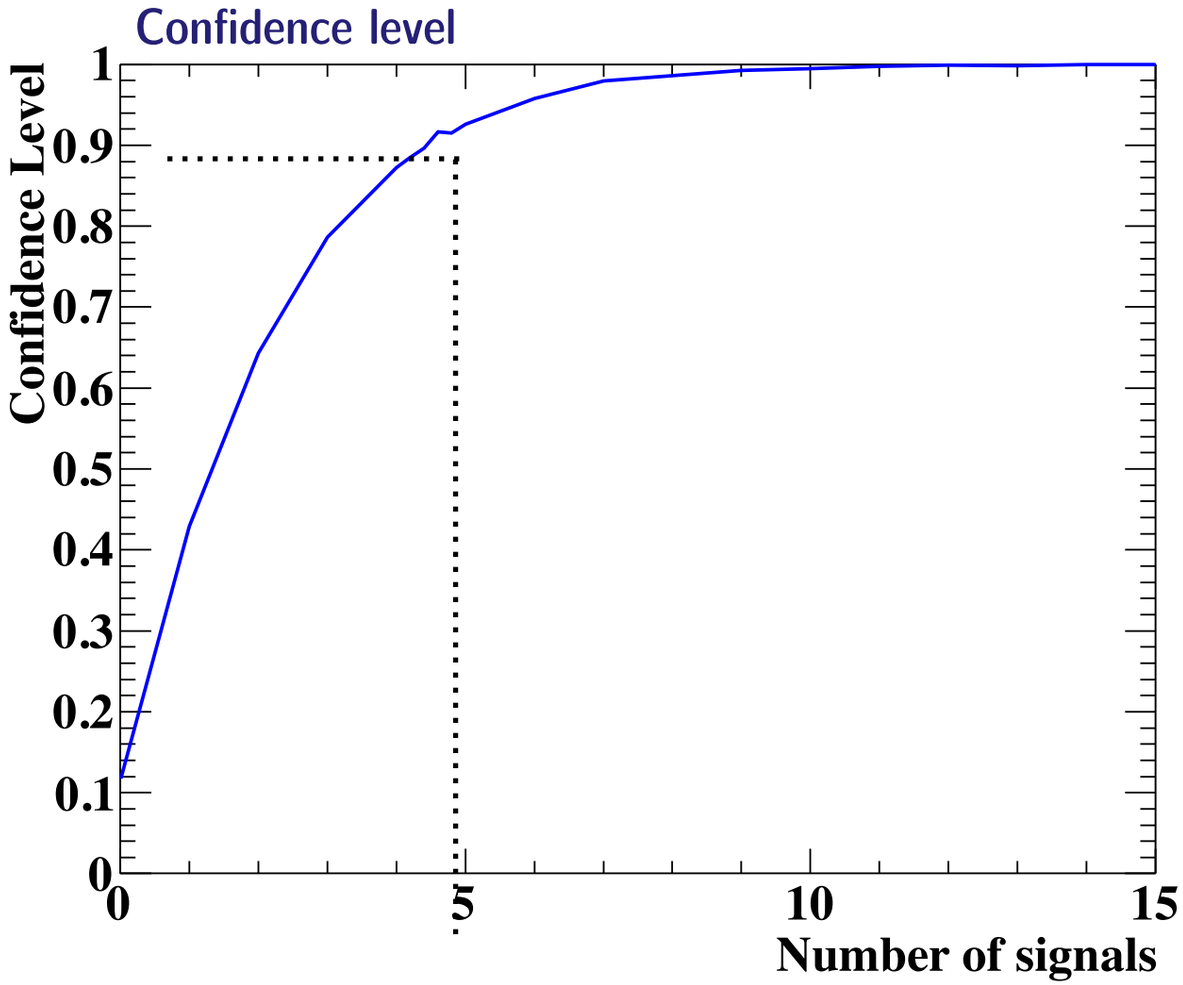




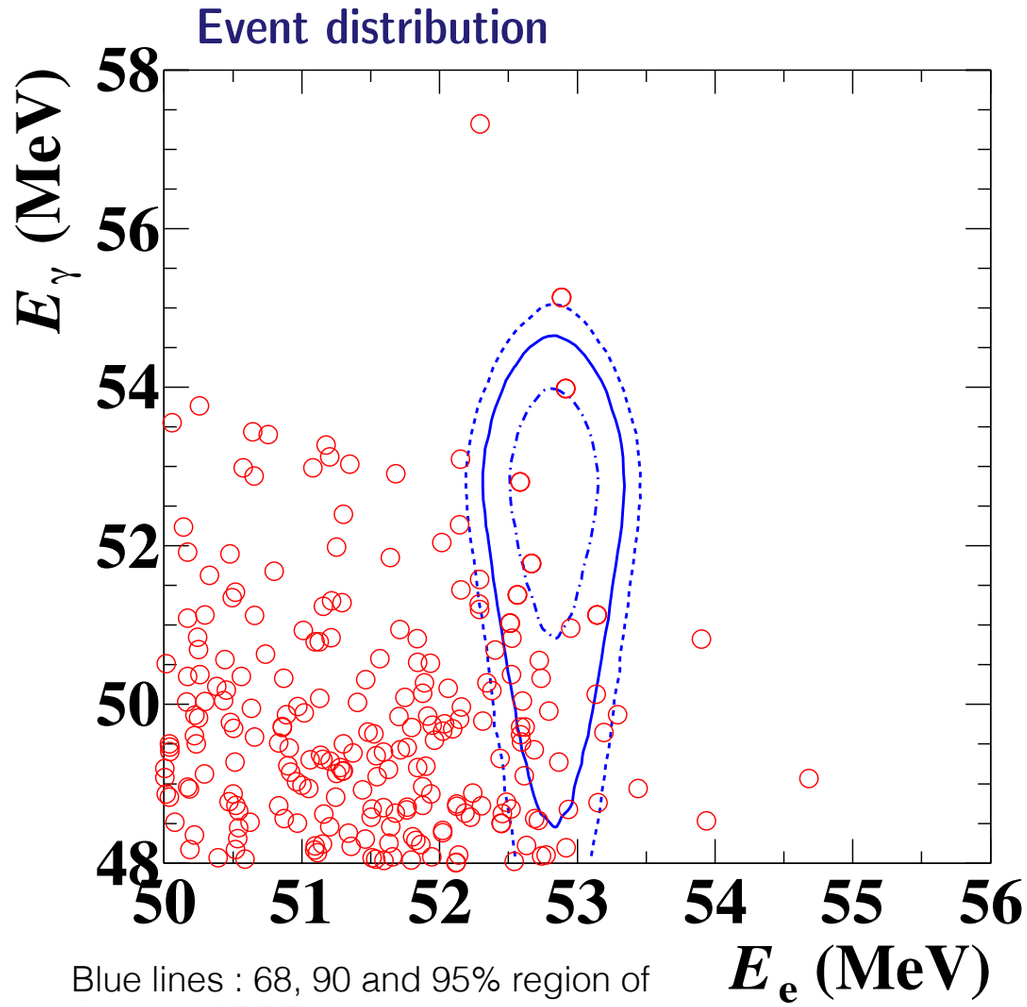
Physics data taken in 2009-2013

Eur. Phys. J. C, 73 (2013) 2365

Latest result



normalization : 7.77×10^{12}



Blue lines : 68, 90 and 95% region of the signal PDF

$Br(\mu^+ \to e^+ \gamma)$

Sensitivity	7.7×10^{-13}
Best fit	-0.6×10^{-13}
Uppler limit @ 90% C.L.	**5.7×10^{-13}**

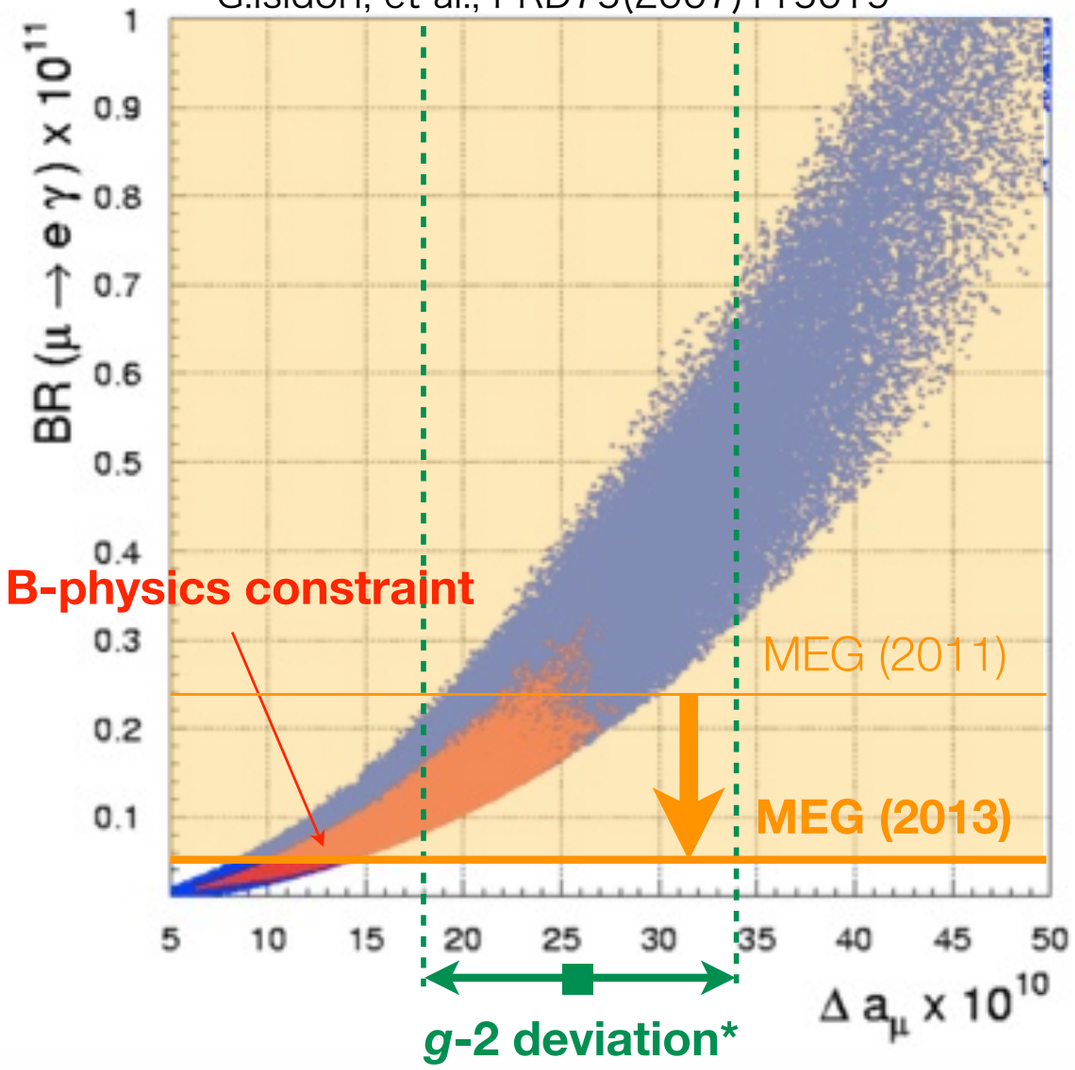
arXiv:1303.0754 [hep-ex]
Phys. Rev. Lett. 110, 201801 (2013)

Systematic uncertainties (in total 1% in UL)
- relative angle offsets
- correlations in e^+ observables

New Physics constraints

SUSY-GUT

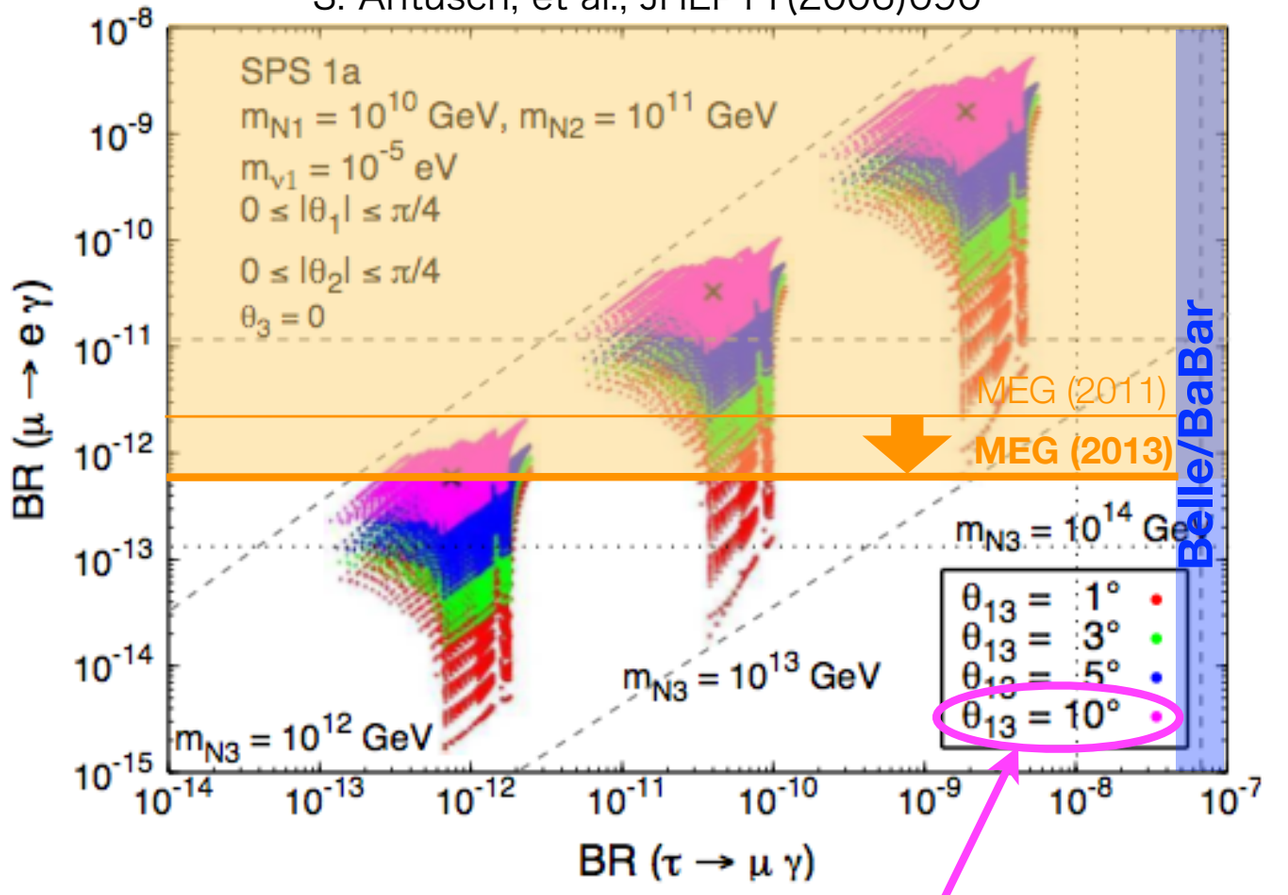
G.Isidori, et al., PRD75(2007)115019



* a_μ(EXP):PRD73(2006)072,
a_μ(SM):Hagiwara et al., JPG38(2011)085003

SUSY-Seesaw

S. Antusch, et al., JHEP11(2006)090



Large θ_{13} measured (~9°)!

New data

Data taking finished in summer 2013

Since 2012, 15% higher beam rate is used

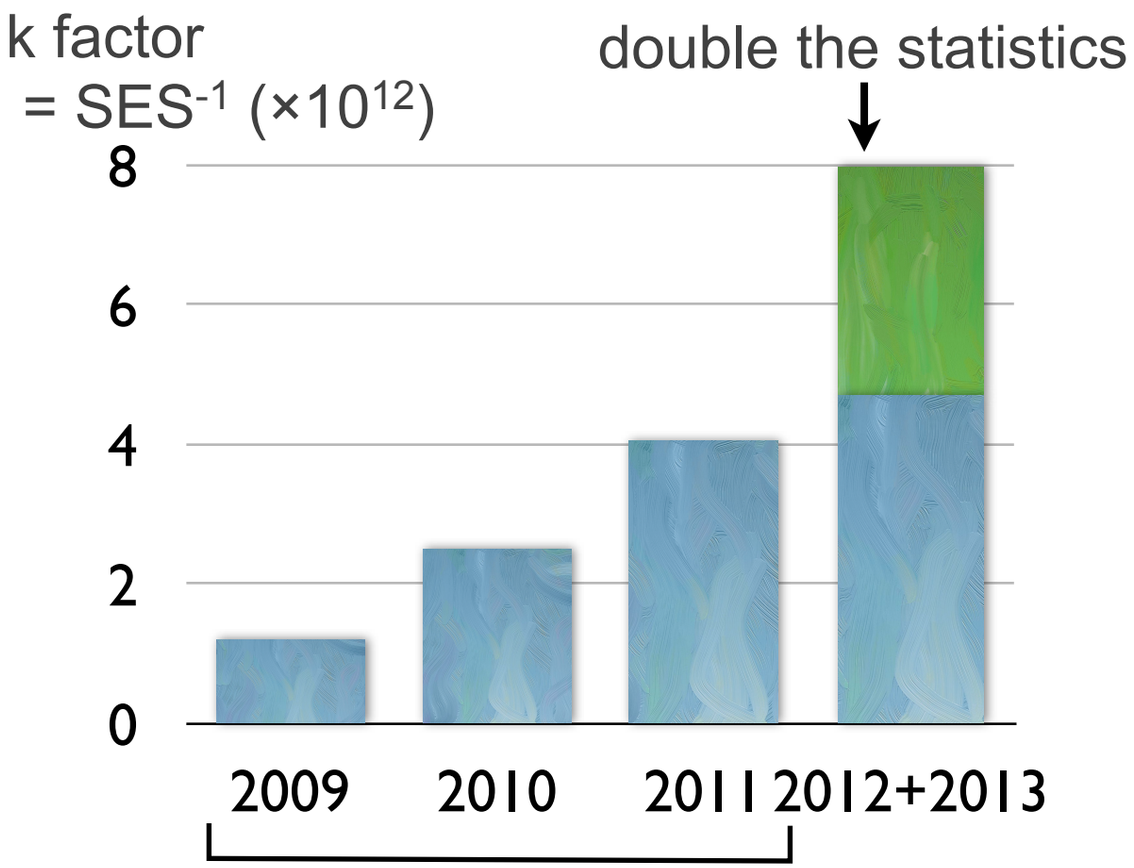
2009-2011 sensitivity

7.7×10^{-13}

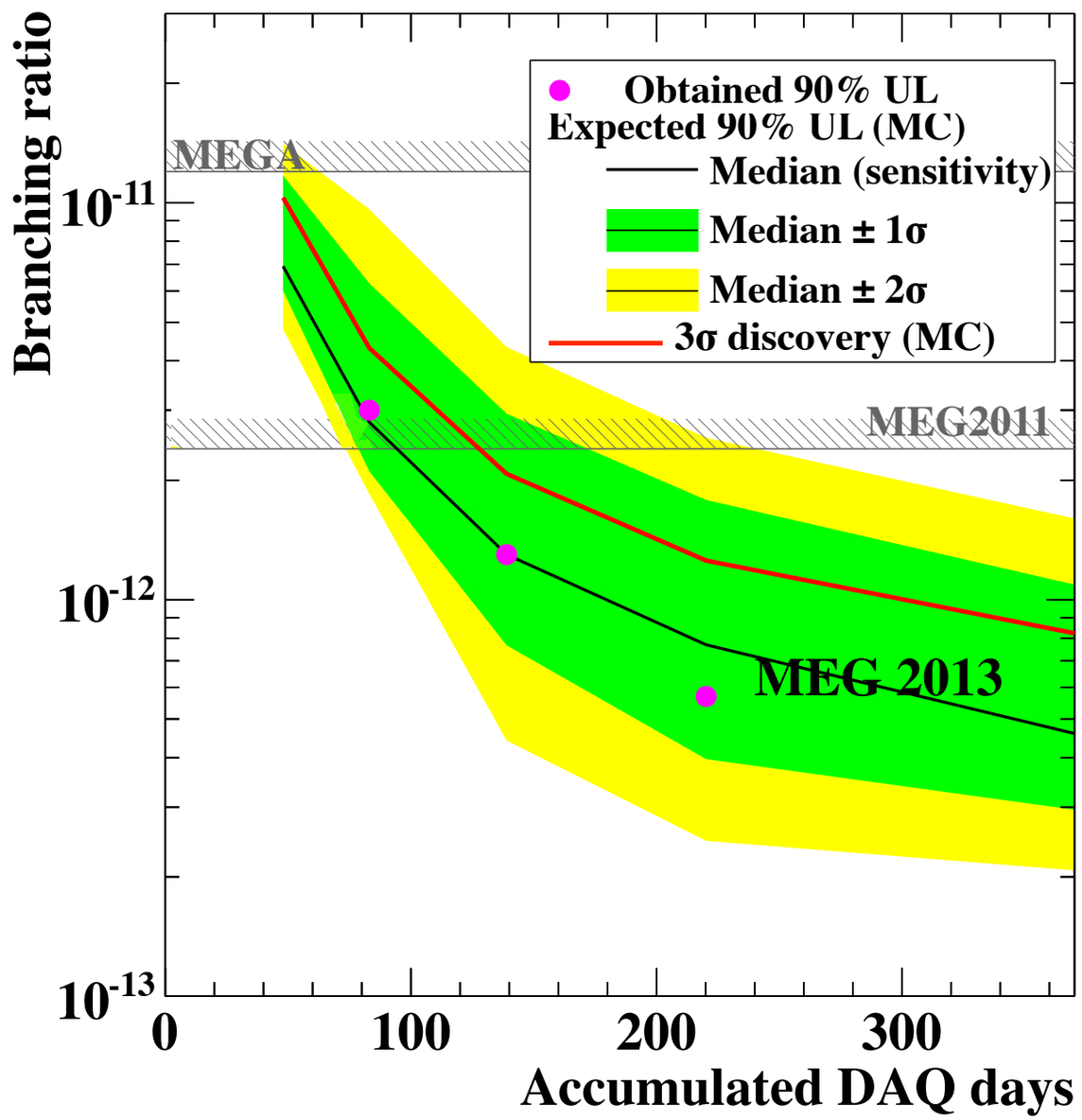
Expected 2009-2013 sensitivity

$\sim5\times10^{-13}$

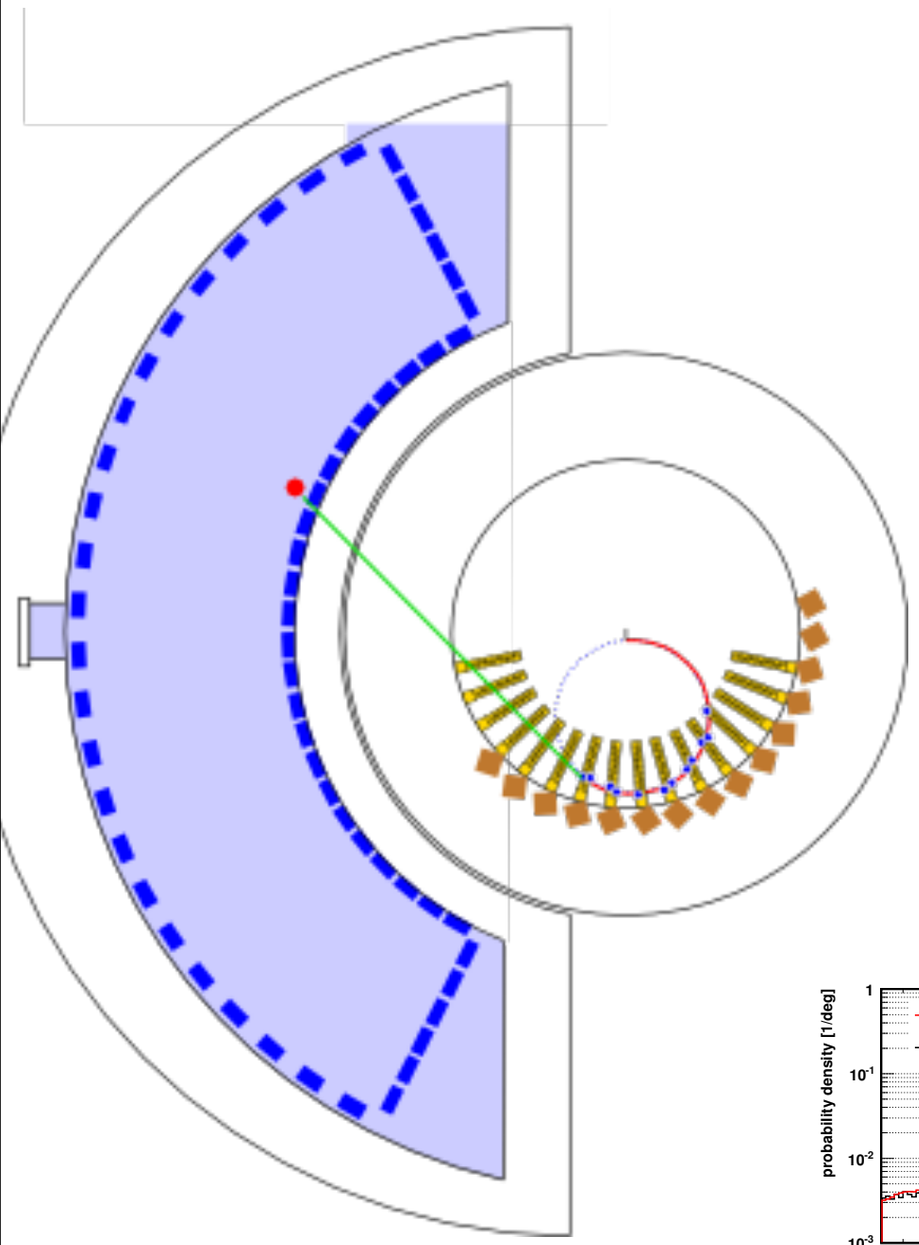
Further improvement is expected (next slides)



Observed limits and sensitivity

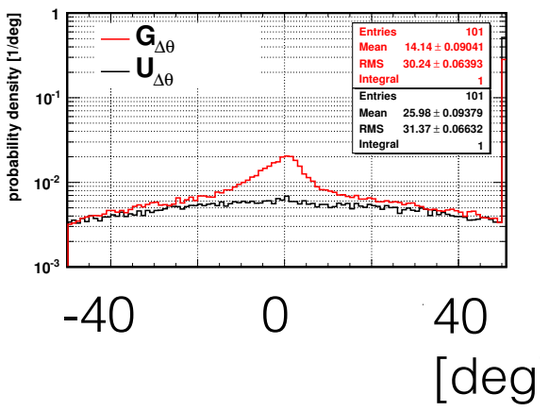


AIF Analysis

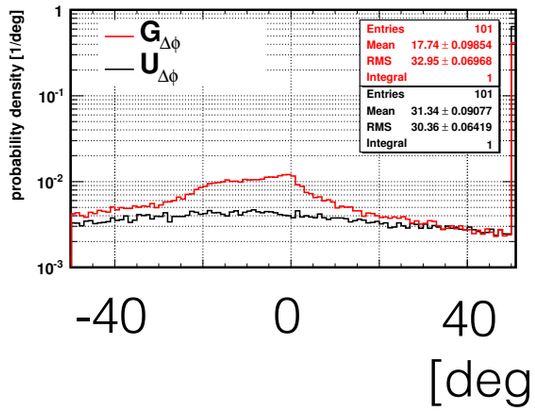


- Annihilation in flight (AIF) is one of the main BG γ source.
  - Mainly come from the target and drift-chamber.
- New analysis was developed to match a vanished positron and a hit in LXe detector
- The matching variable will be used in the physics analysis as PDFs

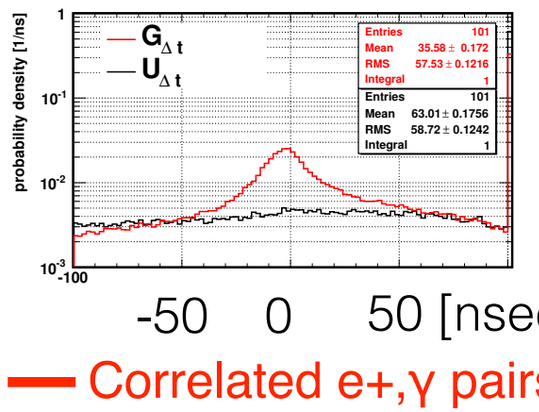
Δθ PDF



Δϕ PDF



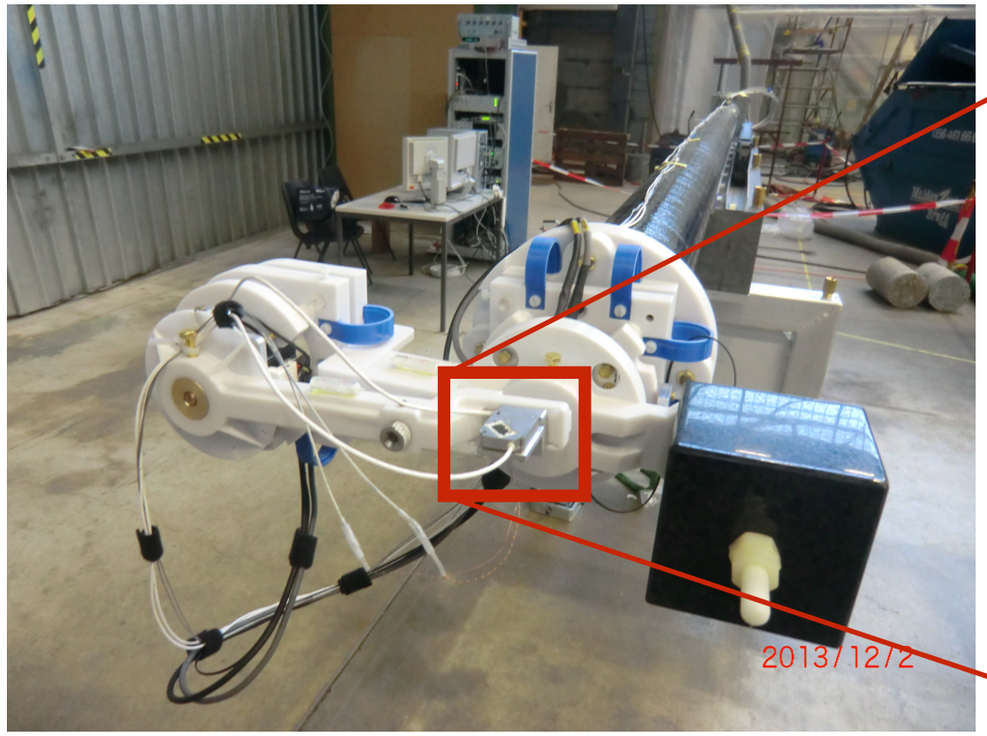
Δt PDF

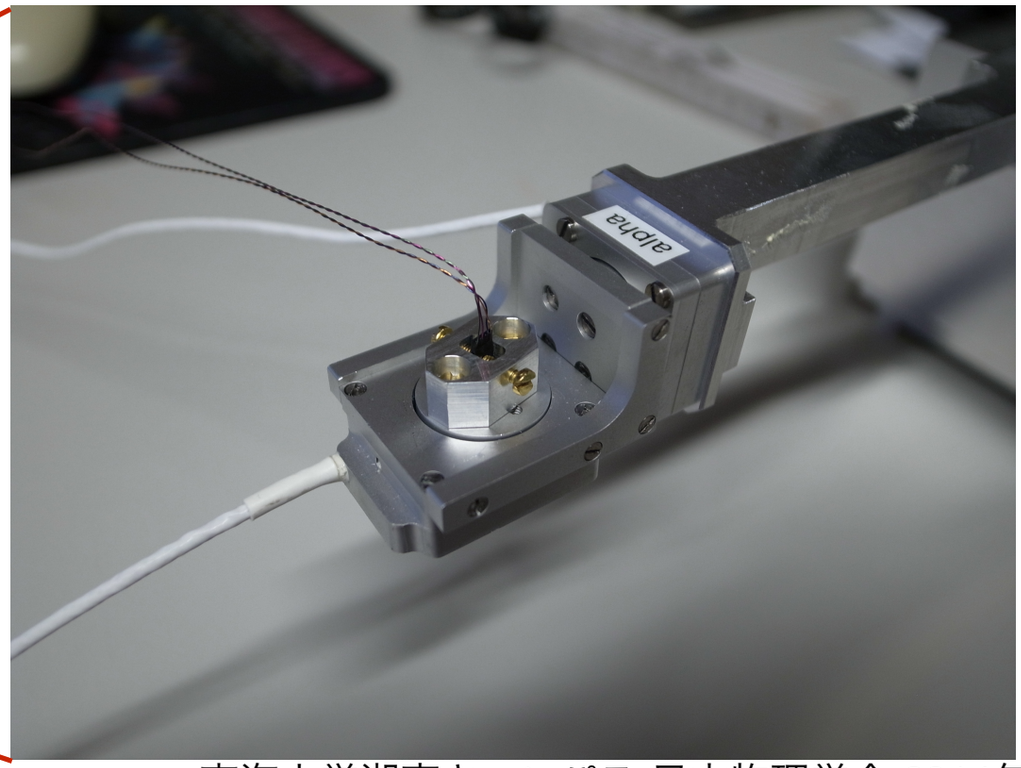


16% improvement of the sensitivity is expected.

B-field measurement

- Previous measurement done in 2006
  - Precision : 0.2%
  - Possible mis-alignment of sensors
  - It was done before installing materials around the magnet (e.g. LXe detector)
- New measurement
  - ~100k points 3D mapping inside the COBRA magnet
  - Rotation of the sensor head to measure 3 axis field and to cancel systematic errors.
  - Goal : 0.1% (300μm position precision is needed)





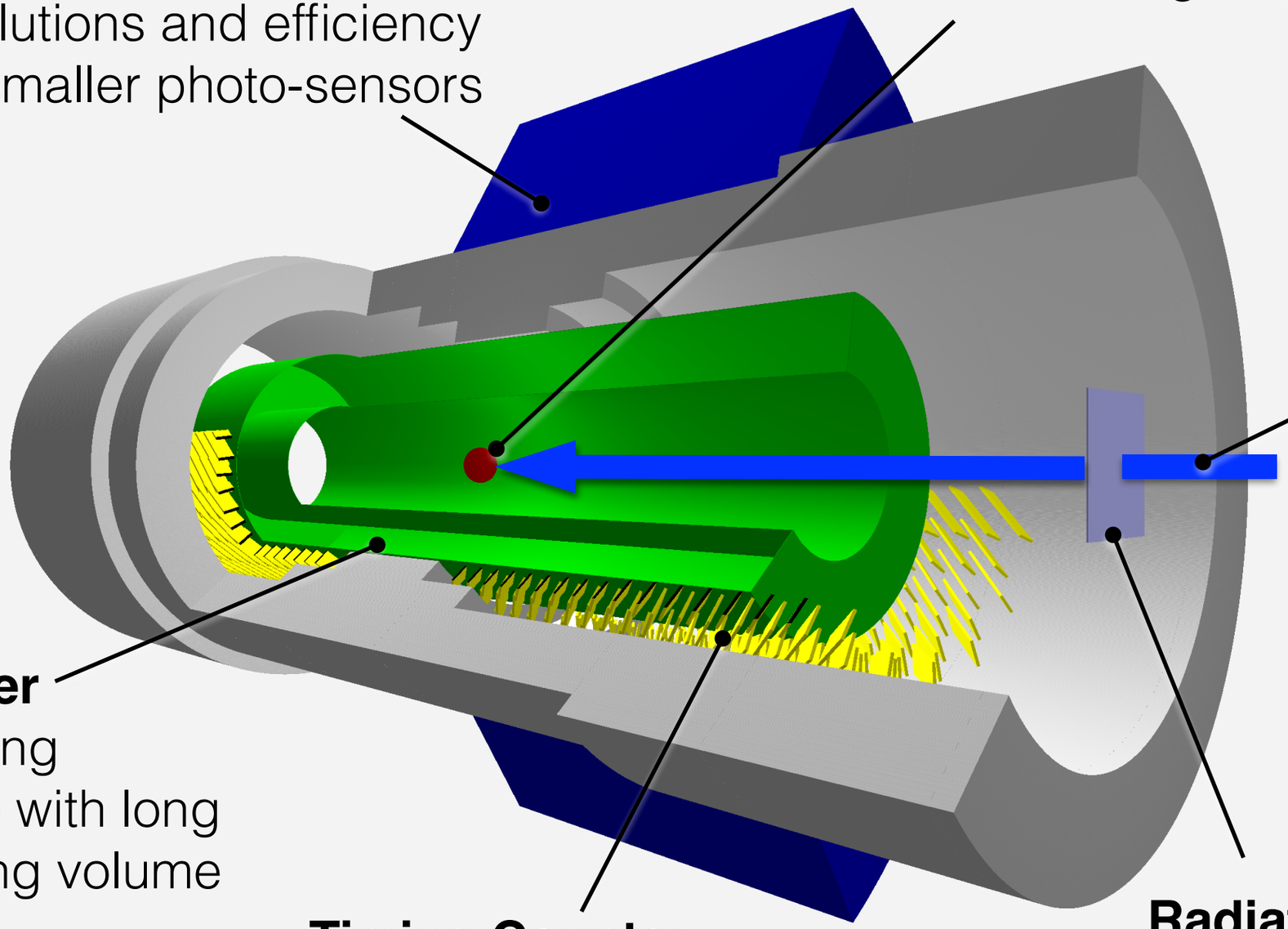
Status and future

- Data process status
  - Calibration of new data (2012, 2013) is almost finished.
  - Data reprocess will be finished in a couple of months.
- Preliminary results including the new data will be presented in this summer.

MEG II (upgrade)

LXe Calorimeter
Higher resolutions and efficiency with using smaller photo-sensors

Target
Thinner target
Active target option



Muon Beam
More than twice intense beam

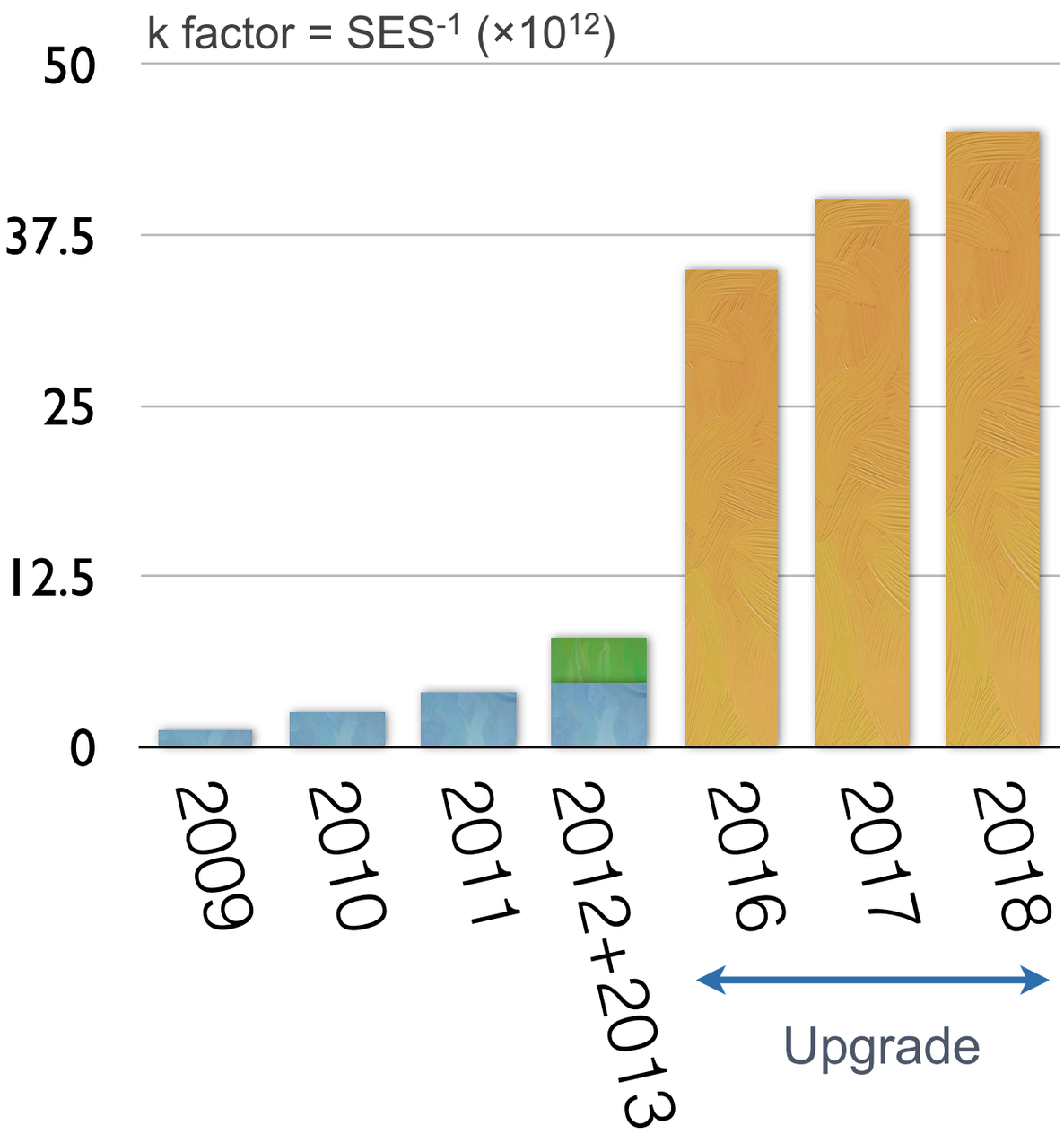
Drift chamber
Higher tracking performance with long single tracking volume

Timing Counter
Higher time resolution with highly segmented detector

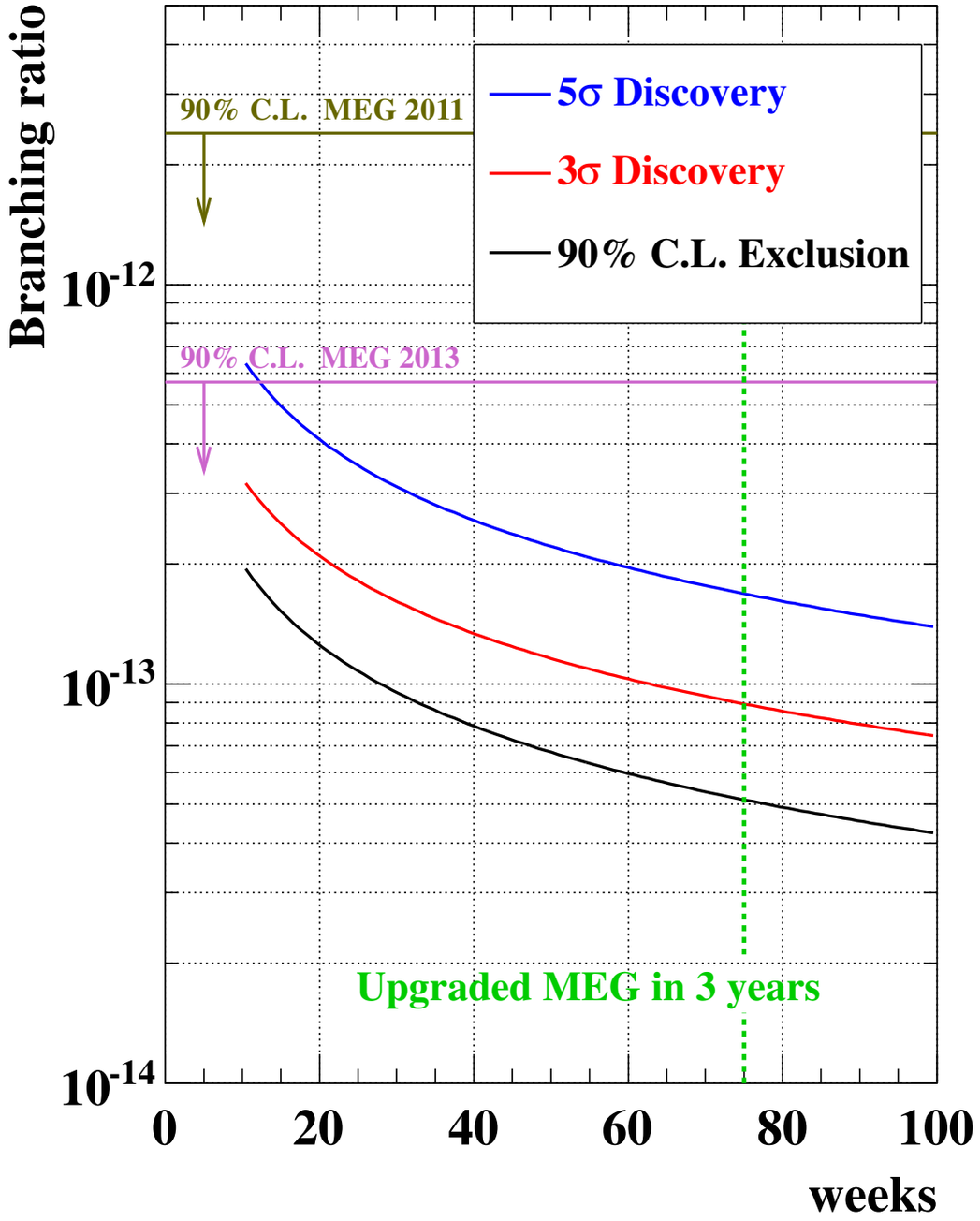
Radiative Decay Counter
Identify gammas from muon radiative-decays

MEG II sensitivity

Statistics



Sensitivity

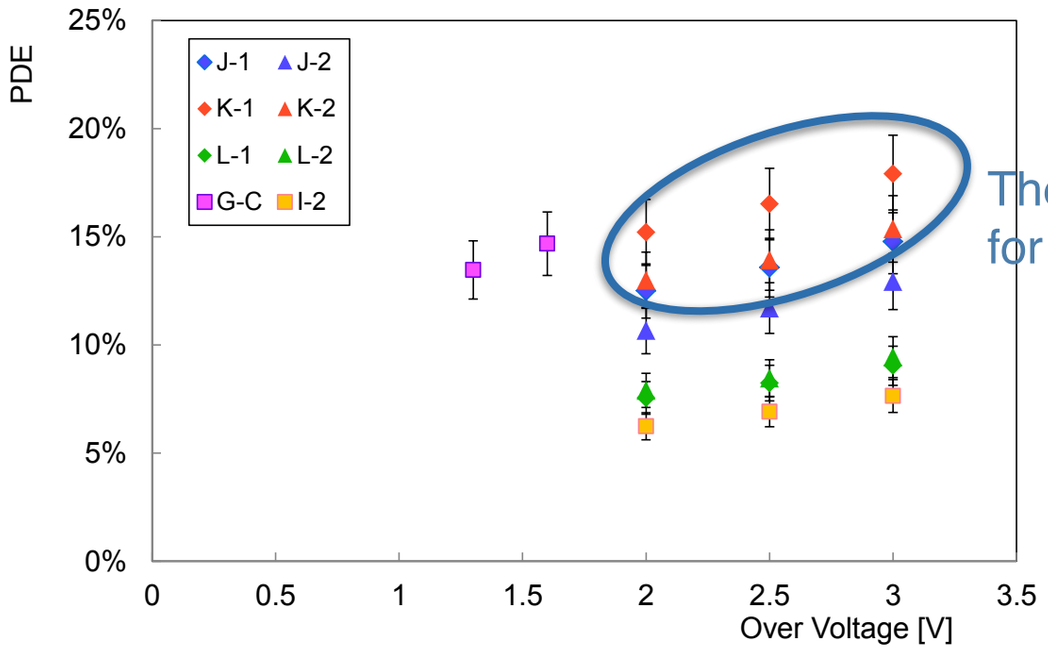


Upgrade R&D

- **Drift chamber**
  - Geometrical parameters of 2π cylindrical chamber have been fixed.
  - Prototype R&D on-going (Aging, resolution).

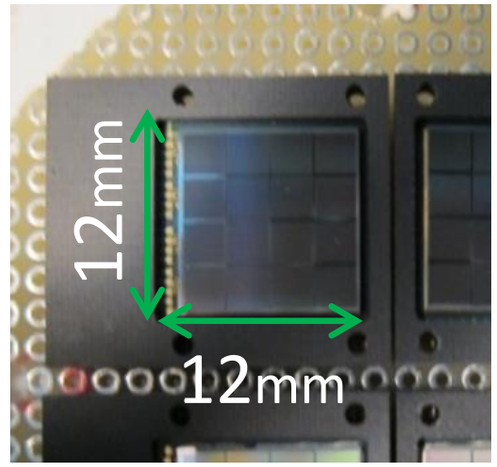
- **Xenon calorimeter**
  - Development of LXe MPPC is finished. Production of 600 MPPCs for a prototype is done.

- Mass test of MPPCs and the performance study of the calorimeter will be done with a prototype detector.



The highest PDE type for the mass production

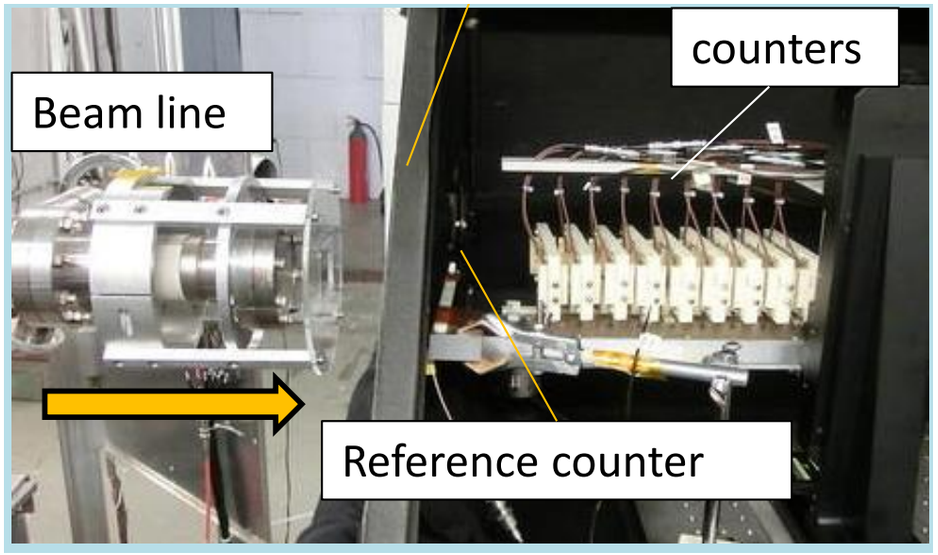
LXe MPPC prototype

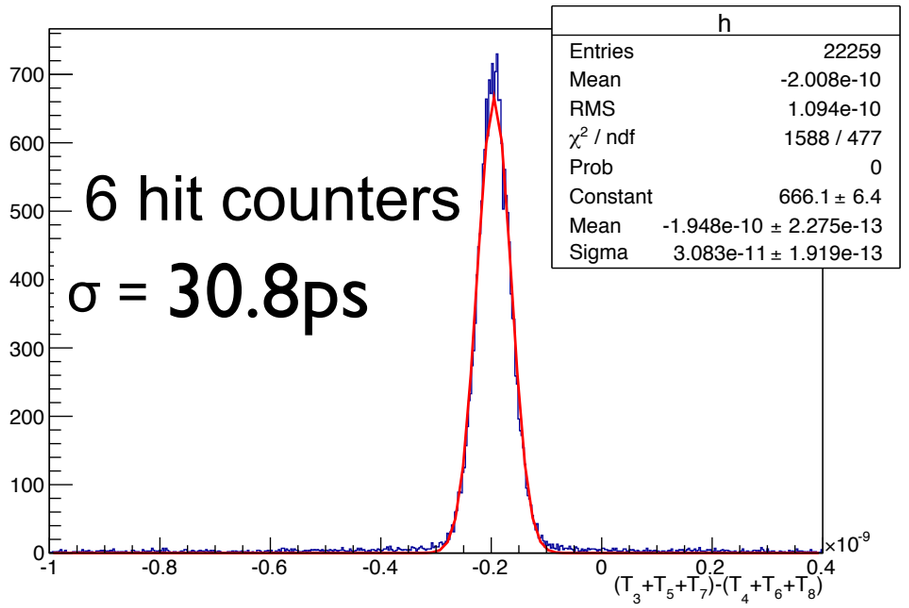


Upgrade R&D

- **Timing counter**
  - Excellent performance (time resolution : ~30ps) was confirmed with a beam test
  - Studies for the final detector design and calibration is on-going.

Timing counter beam test





- **Optional detectors**
  - Beam test of the active target will be done in this year.
  - We succeeded in identifying gamma ryas from μ^+ radiative-decays by using a newly developed Radiative Decay Counter in a beam test.

Summary

- For the final result, **MEG will double the data statistics** compared the previous analysis.
  - Calibration for new data is done
  - Currently data are processed
  - Improvements
    - New AIF analysis to improve the sensitivity further (16%)
    - New B-field measurement to reduce the systematic uncertainty.
  - **Preliminary result will be presented in this summer**

Br ($\mu^+ \to e^+ \gamma$) sensitivity $\times 10^{13}$

MEG I	Latest result	7.7
	Expectation	5
	Further improvement	>16% improvement
MEG II	Expectation	0.5
	with optional detector	>10-15% improvement

- **R&D and development of the upgrade detector** are being done in parallel to start the data taking from 2016

Backup

MEG II performance

Resolution (Gaussian σ) and efficiencies for MEG upgrade

PDF parameters	Present MEG	Upgrade scenario
$\sigma_{E_{e^+}}$ (keV)	380	110
e^+ σ_θ (mrad)	9	5
e^+ σ_ϕ (mrad)	11	5
e^+ σ_Z / σ_Y(core) (mm)	2.0/1.0	1.2/0.7
$\frac{\sigma_{E\gamma}}{E_\gamma}$ (%) w>2 cm	1.6	1.0
γ position at LXe $\sigma_{(u,v)}$-σ_w (mm)	4	2
γ-e^+ timing (ps)	120	80
Efficiency (%)		
trigger	$\approx$ 99	$\approx$ 99
γ reconstruction	60	60
e^+ reconstruction	40	95
event selection	80	85