Status and prospects of charged Lepton Flavor Violation searches

Physics in Collision 2012

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Outline

Physics motivation for cLFV searches

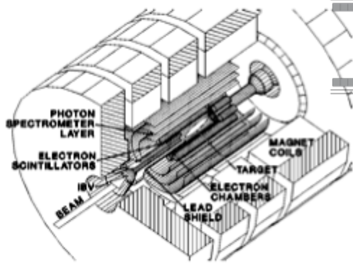
The muons

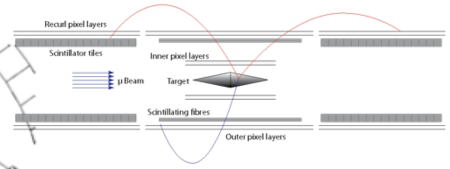
- $\mu \to e\gamma$ (MEG)
- $\mu \to e\ e\ e$ (SINDRUM, Mu3e)
- $\mu A \to eA$ (DeeMe, COMET, Mu2e, PRISM)

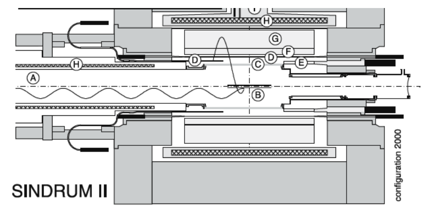
The taus

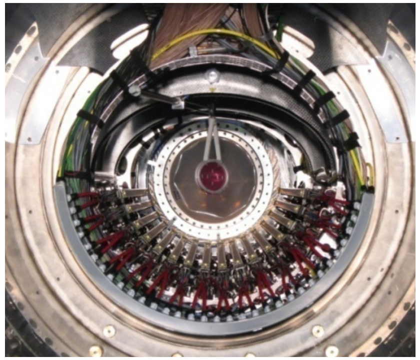
- $\tau \to \mu\gamma,\ e\gamma$ (BaBar, BELLE)
- $\tau \to lll$ (BaBar, BELLE)

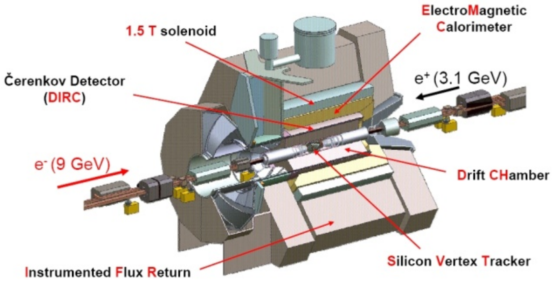
Conclusions

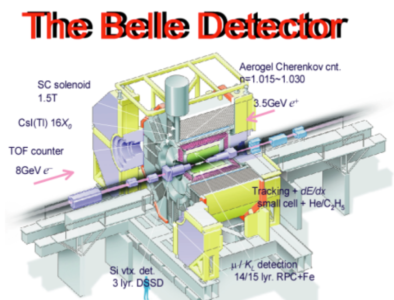


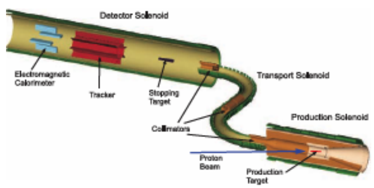


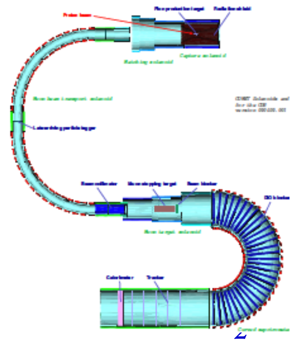












Physics motivations

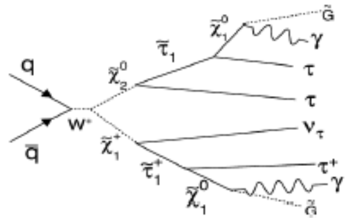
The Standard Model is believed to be a low-energy approximation a of a more fundamental theory

DM, number of parameters, unexplained symmetries, flavor structure, ...

All models beyond the SM contains new particles that could

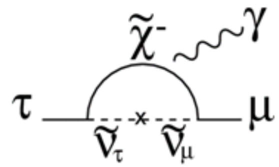
either be directly discovered

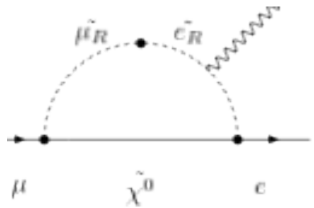
(high energy frontier)

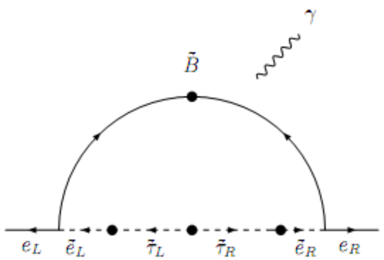


or seen through their contributions in loops

(high precision frontier)







Physics motivation

1) The cLFV decay is undetectably small in the extended Standard Model, which takes into account the neutrino masses and mixings
Example $\mu \to e\,\gamma$ decay

$$\Gamma(\mu \to e\gamma) \approx \underbrace{\frac{G_F^2 m_\mu^5}{192\pi^3}}_{\mu-\text{decay}} \underbrace{\left(\frac{\alpha}{2\pi}\right)}_{\gamma-\text{vertex}} \underbrace{\sin^2 2\theta \sin^2\left(\frac{1.27\Delta m^2}{M_W^2}\right)}_{\nu-\text{oscillation}}$$

$$\approx \frac{G_F^2 m_\mu^5}{192\pi^3}\left(\frac{\alpha}{2\pi}\right)\sin^2 2\theta_\odot \left(\frac{\Delta m^2}{M_W^2}\right)^2,$$

BR ~ 10^{-54}

2) New Physics scenarios "naturally" enhance the rate of cLFV decay by 30-40 orders of magnitude, through loops of new particles

- cLFV decays are clean, no SM contaminated, evidence of new physics
- The expected rates are close to the experimental upper bound and within the capabilities of present and near future experiments

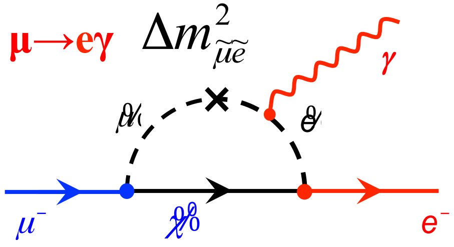
Physics connections

G.Isidori *et al*. Phys. Rev. D75 (2007) 115019

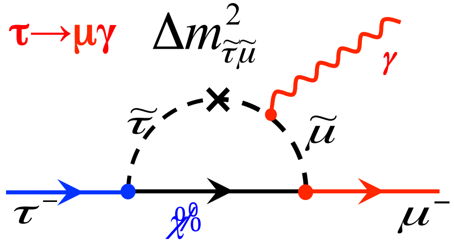
Example

In a specific model MSSM /GUT extension with large tanβ

μ→eγ $\Delta m^2_{\tilde{\mu}\tilde{e}}$

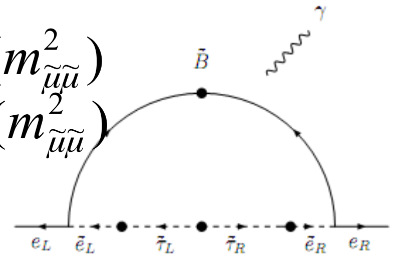


τ→μγ $\Delta m^2_{\tilde{\tau}\tilde{\mu}}$

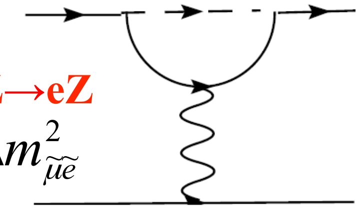


μEDM $\Im(m^2_{\tilde{\mu}\tilde{\mu}})$

g - 2 $\Re(m^2_{\tilde{\mu}\tilde{\mu}})$



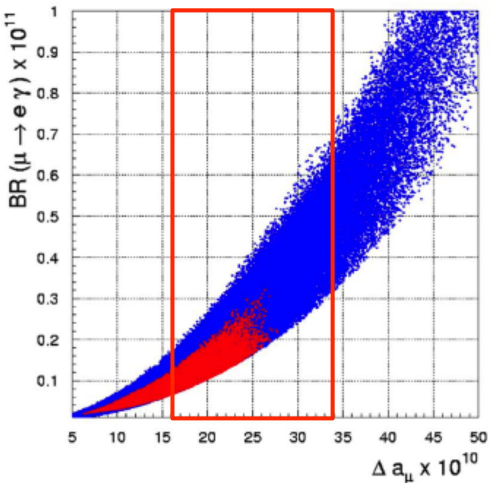
μZ→eZ $\Delta m^2_{\tilde{\mu}\tilde{e}}$

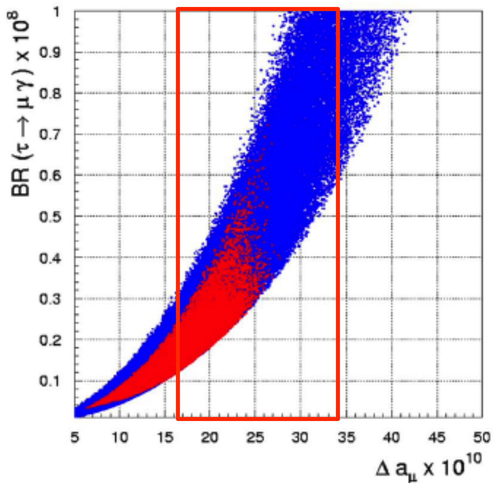


If the g-2 anomaly is real (2.9 σ)

$$\Delta a_\mu \equiv a_\mu^{\exp} - a_\mu^{SM} = (249 \pm 87) \times 10^{-11}$$

T.Aoyama et Al. ArXiv:1205.5370v2





It should be $BR(\mu \to e\gamma) \approx 10^{-12}$

$BR(\tau \to \mu\gamma) \approx 10^{-9}$

Physics connections: Θ_{13}

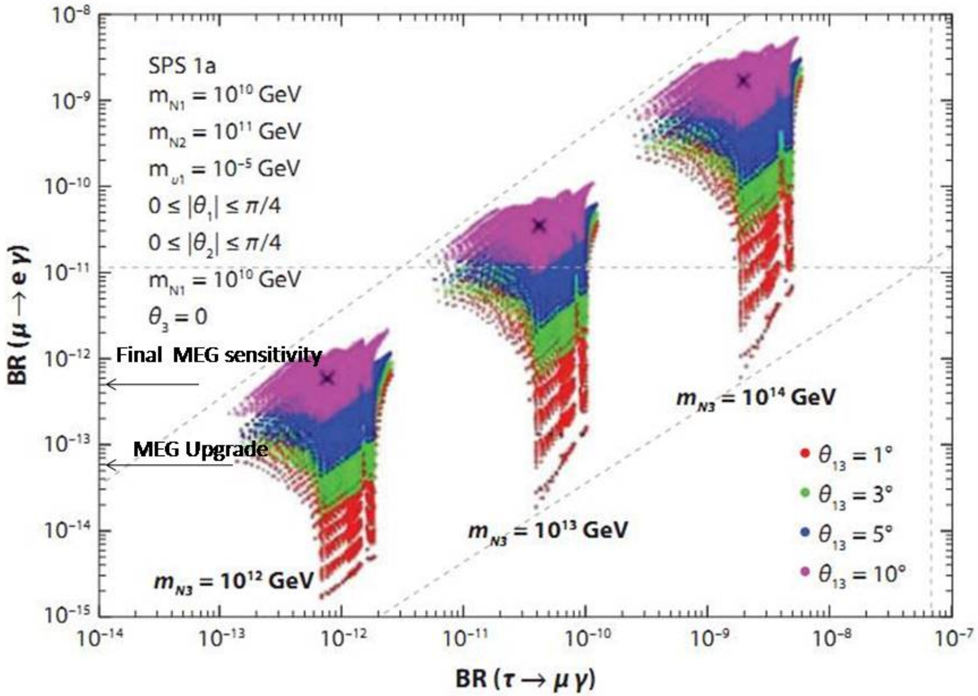
S.Antush et al, JHEP 11 (2006) 090

Non-GUT SUSY model with seesaw mechanism

- It depends on many parameters
- Recent result from DayaBay of Θ_{13} = 8.5° reduces the model predictions

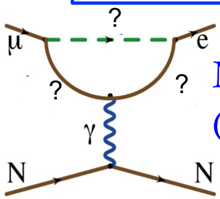
$$BR(\mu \rightarrow e\gamma) \approx 10^{-12} \div 10^{-13}$$

$$BR(\tau \rightarrow \mu\gamma) \approx 10^{-10} \div 10^{-12}$$

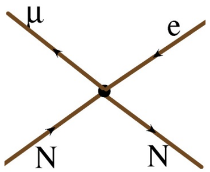


Effective lagrangian

$$L_{LFV} = \frac{m_\mu}{(\kappa+1)\Lambda^2}\,\overline{\mu_R}\sigma^{\mu\nu}e_L F_{\mu\nu} + \frac{\kappa}{(\kappa+1)\Lambda^2}\,(\overline{\mu_L}\gamma^\mu e_L)\,(\overline{e_L}\gamma_\mu e_L)$$



New coupling
(SUSY, heavy ν, ...)

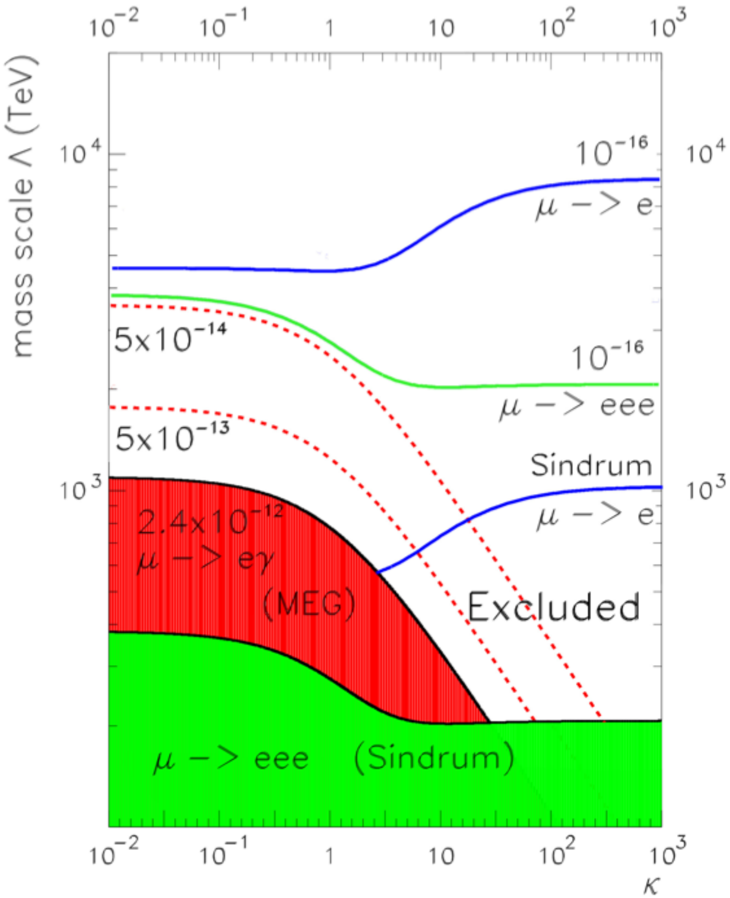


Contact terms
(leptoquatks, Z' ...)

Parametrised with

- mass scale Λ
- balancing factor κ

Comparison of different channels



Physics connections

Within a given NP scenario different processes are linked together with a specific pattern

We could even have signal on one channel and nothing on others

$\mu \to e\gamma$, $\mu Z \to eZ$, $\tau \to e\gamma$, $\tau \to \mu\gamma$, $\tau \to lll$, $\tau \to \mu h$

g-2 , μEDM

or in other words

The structure and the couplings of NP beyond the SM could be constrained by multiple precision measurements

unfortunately

No clean and direct evidence of New Physics has been established so far

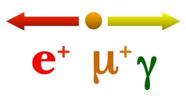
The muons

Muons are excellent probes for high precision measurements

- intense continuous and pulsed beams can be obtained;
- long lived;
- simple final states at low energy : small detectors;

$\mu \rightarrow e\gamma$

Signal

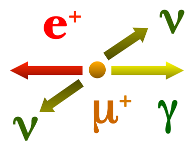


$\theta_{e\gamma} = 180°$

$E_e = E_\gamma = 52.8$ MeV

$T_e = T_\gamma$

Prompt

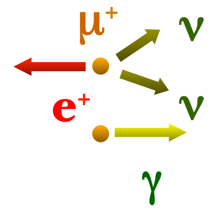


$$\mu \rightarrow e\bar{\nu}\nu\gamma$$

$$B_{\text{prompt}} \approx 0.1 \times B_{\text{acc}}$$

at 3x10^7 μ-stop/s

Accidental



$$e^+e^- \rightarrow \gamma\gamma$$
$$\mu \rightarrow e\bar{\nu}\nu\gamma$$
$$e\mathcal{N} \rightarrow e\mathcal{N}\gamma$$

$$\mu \rightarrow e\bar{\nu}\nu$$

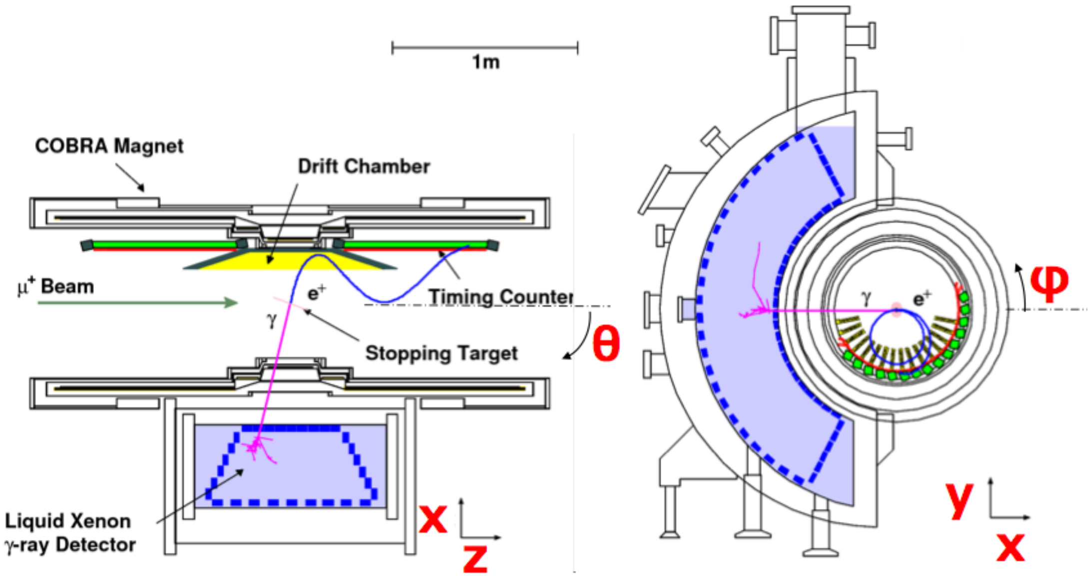
$$B_{\text{acc}} \approx R_\mu \Delta E_e \Delta E_\gamma^2 \Delta\theta^2 \Delta t$$

The accidental background is dominant and it is determined by the experimental resolutions

Exp./Lab	Year	ΔEe/Ee (%)	ΔEγ / Eγ (%)	Δteγ (ns)	Δθeγ (mrad)	Stop rate (s^{-1})	Duty cyc. (%)	BR (90% CL)
SIN	1977	8.7	9.3	1.4	-	5×10^5	100	3.6×10^{-9}
TRIUMF	1977	10	8.7	6.7	-	2×10^5	100	1×10^{-9}
LANL	1979	8.8	8	1.9	37	2.4×10^5	6.4	1.7×10^{-10}
Crystal Box	1986	8	8	1.3	87	4×10^5	(6..9)	4.9×10^{-11}
MEGA	1999	1.2	4.5	1.6	17	2.5×10^8	(6..7)	1.2×10^{-11}
MEG	2009 - 12	1	4.5	0.29	25	3×10^7	100	6×10^{-13}

μ→eγ

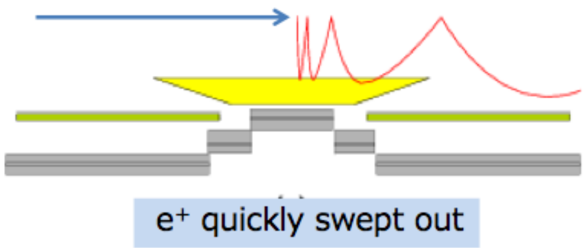
MEG in a nutshell

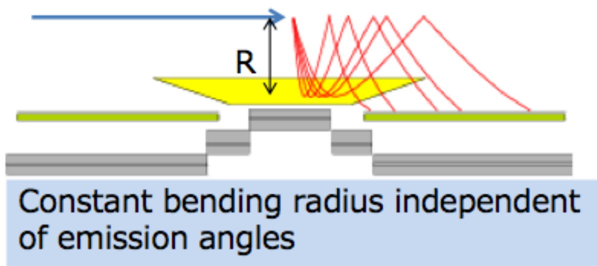


- Signal selection with μ^+ decay at rest
- Most intense DC muon beam of 3 x 10⁷ μ/s at PSI
- Quasi-solenoidal spectrometer & low mass drift chamber for e+ momentum
- Scintillator bars and fibers for e+ timing
- Liquid Xenon calorimeter for photon detection read by PMT
- ~10⁷ fully efficient trigger bkg suppression
- Waveform digitization for all channels

Gradient B field to

- Reduce pileup
- Facilitate pattern recognition
- Maintaining good momentum resolution

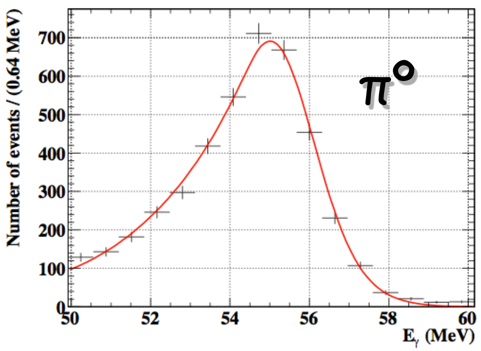


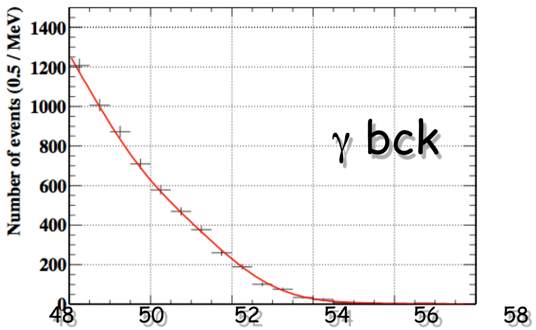


$\mu \rightarrow e\gamma$

MEG resolutions

$E\gamma$





Average upper tail for deep conversions

- σ_R = **(1.7 ±0.15) %**

Systematic uncertainty on energy scale **< 0.6 %**

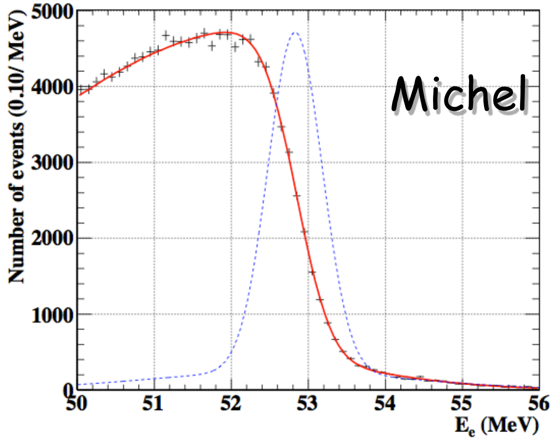
Ee^+

Double gaussian momentum resolution

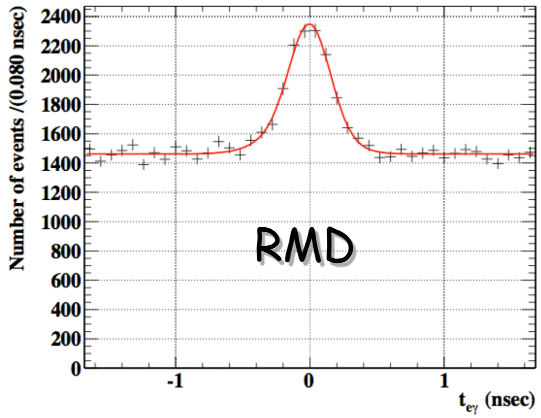
- σ(p) = **320KeV (0.86%)** (core)

Positron angle resolution measures using multi-loop tracks

- σ(φ) = **6.5mrad** (core)
- σ(θ) = **10.8mrad**



$Te\gamma$



40 MeV < Eg < 48 MeV

Resolution corrected for a small energy-dependence

- σ(t) = **(133± 15) ps**

Stability along the run

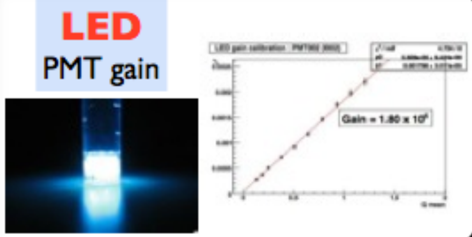
- **< 15 ps**

μ→eγ

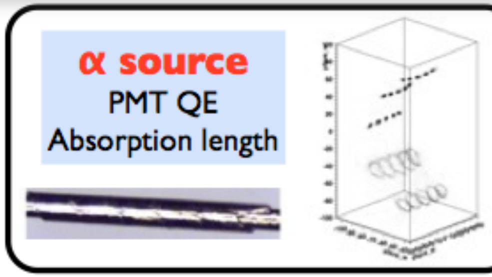
MEG: calibrations

XENON CALIBRATION

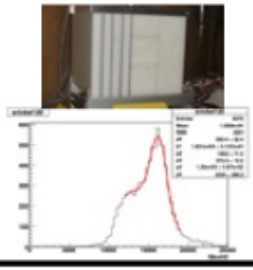
LED
PMT gain



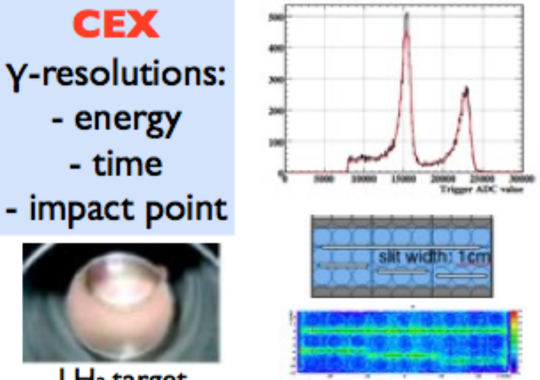
α source
PMT QE
Absorption length



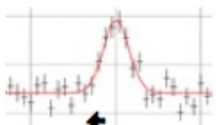
Ni γ generator
9 MeV γ-line
beam on/off calib.



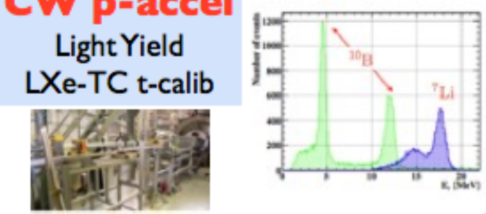
CEX
γ-resolutions:
- energy
- time
- impact point



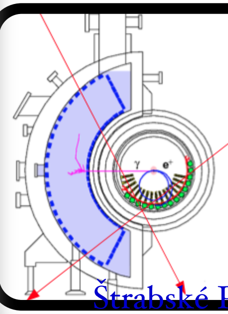
$\mu \to e\nu\bar{\nu}\gamma$



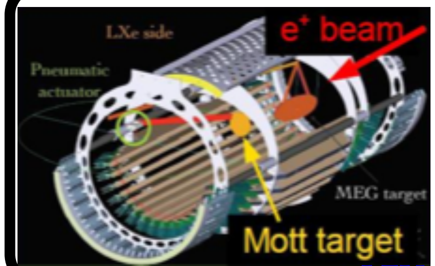
CW p-accel
Light Yield
LXe-TC t-calib



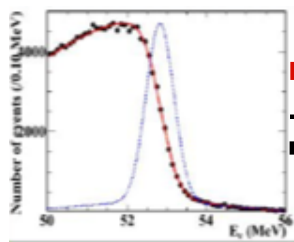
TRACKER CALIBRATION



Cosmic Ray
- DC alignment
- TC uniformity
- LXe monitoring



e⁺ Mott-scatter
- Monochromatic, tunable momentum bean



Michel decays
- $\mu \to e\ \nu\ \nu$ for momentum scale

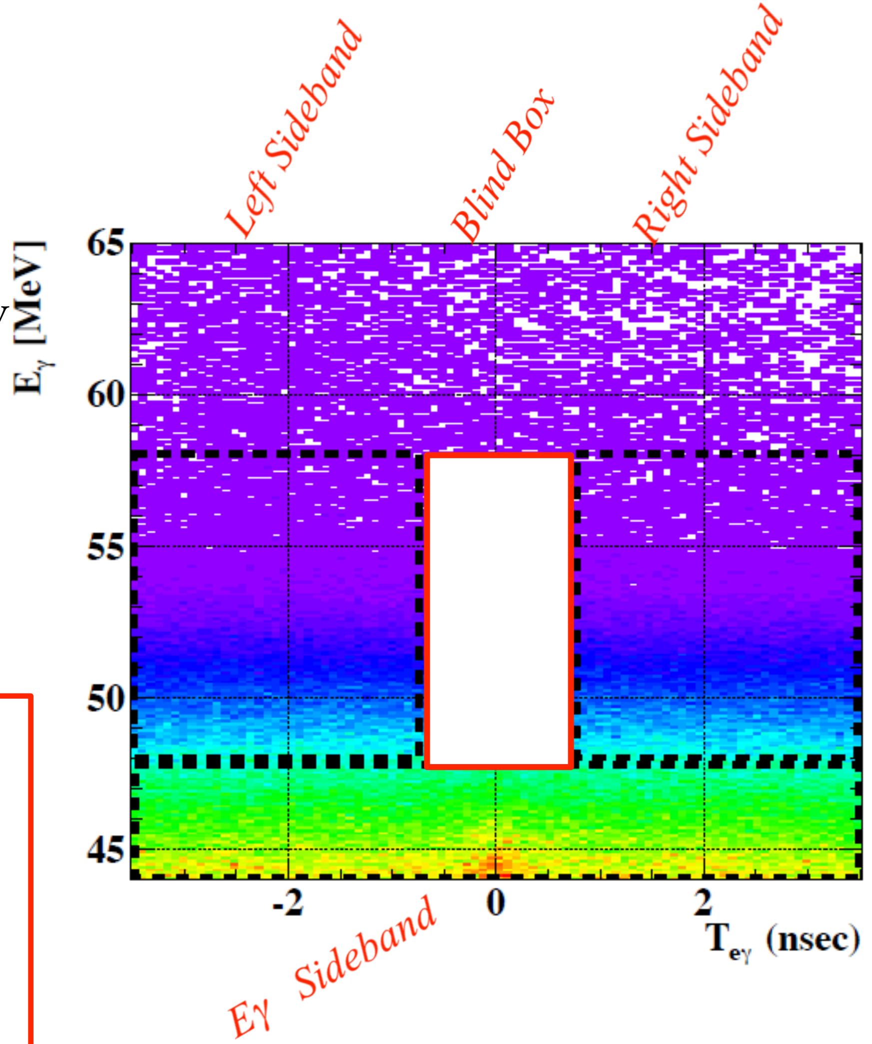
μ→eγ

MEG: Analysis principle

- A μ→eγ event is described by 5 kinematical variables $\vec{x}_i = \left(E_\gamma, E_e, t_{e\gamma}, \vartheta_{e\gamma}, \varphi_{e\gamma}\right)$

- Use of likelihood analysis on a wide blind box
- Likelihood function is built in terms of probability density function PDFs for
  - Signal,
  - radiative Michel decay RMD
  - accidental background BG,

- The PDF for RMD and BG are measured in the side bands
- The PDF for Signal are measured with calibration events



μ→eγ

Normalization

- The normalization factor is obtained from the number of observed μ decay positrons taken simultaneously (prescaled) with the μ→eγ trigger
- Independent from
  - Absolute e⁺ efficiency and detector variations
  - Instantaneous beam rate variations

O(1)

$$\frac{\mathcal{B}(\mu^+ \to e^+\gamma)}{\mathcal{B}(\mu^+ \to e^+\nu\bar{\nu})} = \frac{N_{\mathrm{sig}}}{N_{e\nu\bar{\nu}}} \times \frac{f^{e}_{e\nu\bar{\nu}}}{P \cdot \epsilon_{\mathrm{pu}}} \times \frac{\epsilon^{\mathrm{trig}}_{e\nu\bar{\nu}}}{\epsilon^{\mathrm{trig}}_{e\gamma}} \times \frac{\epsilon^{\mathrm{DC}}_{e\nu\bar{\nu}}}{\epsilon^{\mathrm{DC}}_{e\gamma}} \times \frac{1}{A^{\mathrm{geo}}_{e\gamma}} \times \frac{1}{\epsilon_{e\gamma}}$$

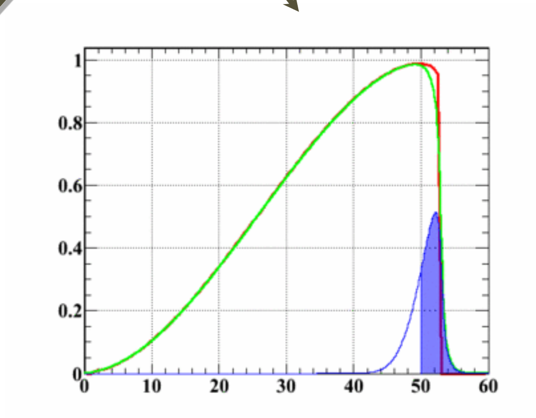
~40k

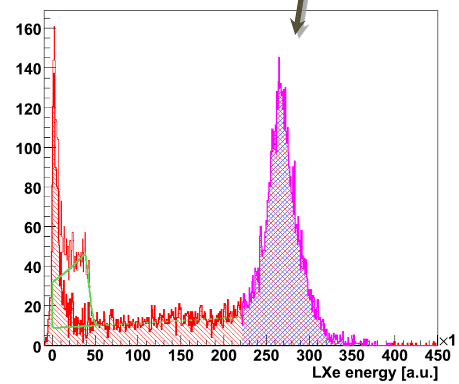
10^7

theory

resolution

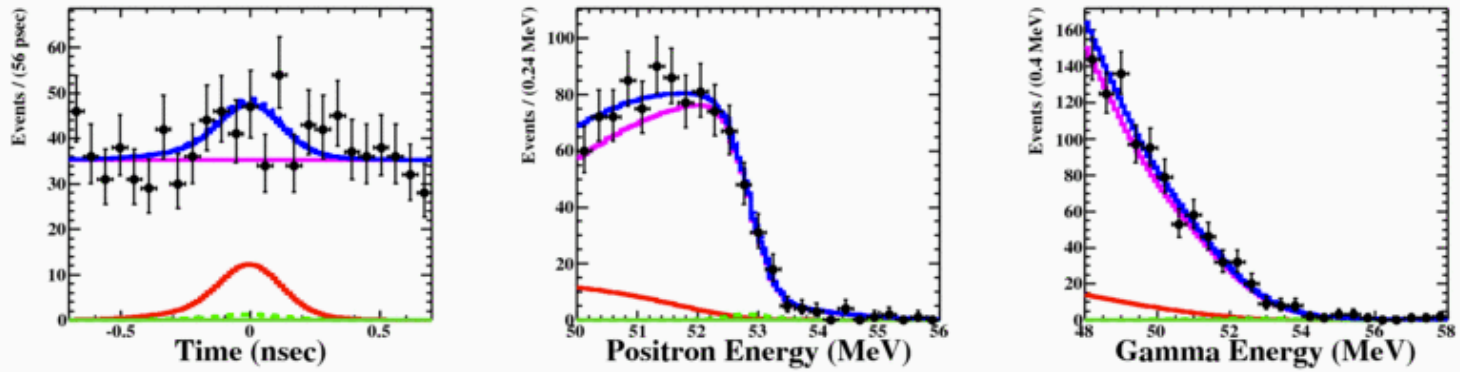
acceptance

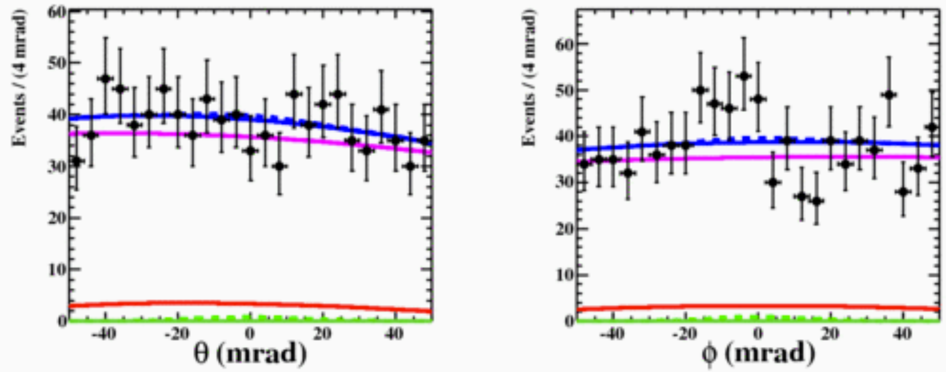




$\mu \to e\gamma$

MEG: 2009 – 2010 result





$N_{Sig} = -0.5^{+7.9}_{-4.7}$

$N_{RMD} = 765 \pm 12$

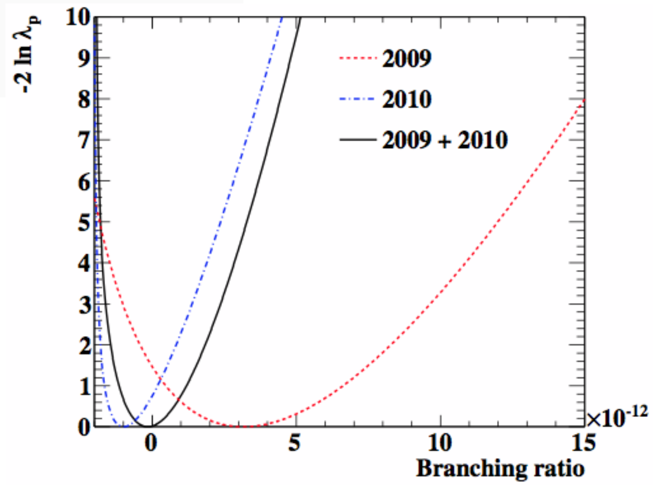
$N_{BG} = 88 \pm 12$

2009-2010 : $\sim 17 \times 10^{13}$ μstop on target

Espect. UL from S.B.: 1.6×10^{-12}

$BR(\mu \to e\gamma) < 2.4 \times 10^{-12}$ (at 90% C.L.)

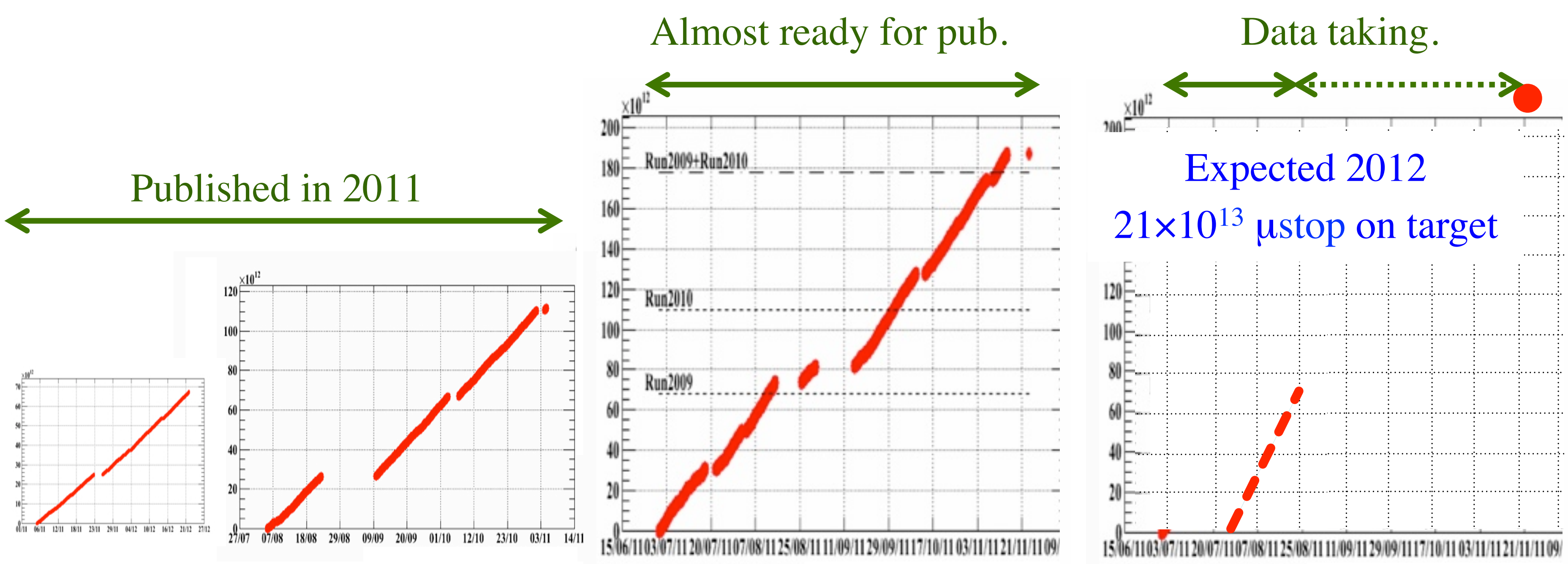
Phys. Rev. Lett. 107, 171801(2011)



μ→eγ

MEG: present

Accumulated number of μ stop on target (units: vertical 10^{12} , horiz. date)



2009
1.5 months

2010
3 months

2011
6 months

2012
6 months

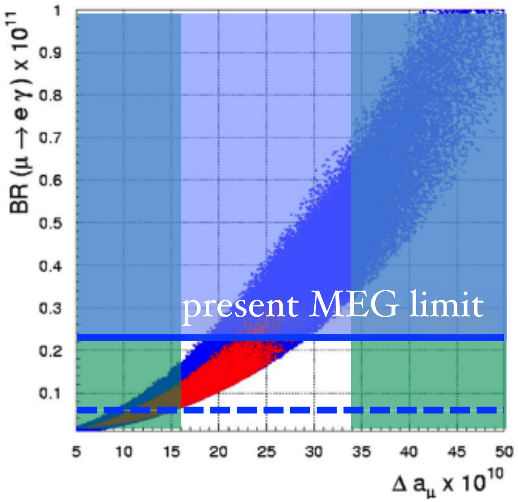
Expected sensitivity BR(μ→eγ) ~ 6×10^{-13}

$\mu \rightarrow e\gamma$

Implications

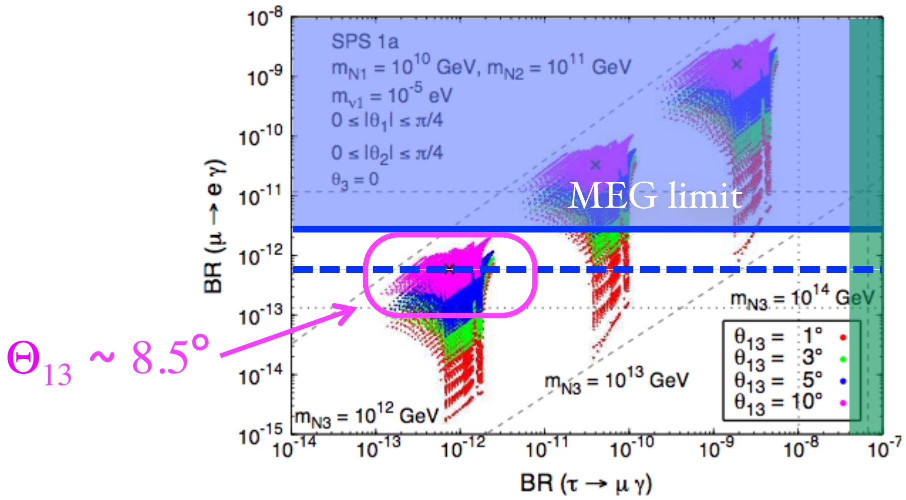
G.Isidori *et al*. Phys. Rev. D75 (2007) 115019

MSSM – GUT with large tan β



S.Antush et al, JHEP 11 (2006) 090

non-GUT SUSY SSM with seesaw



g - 2

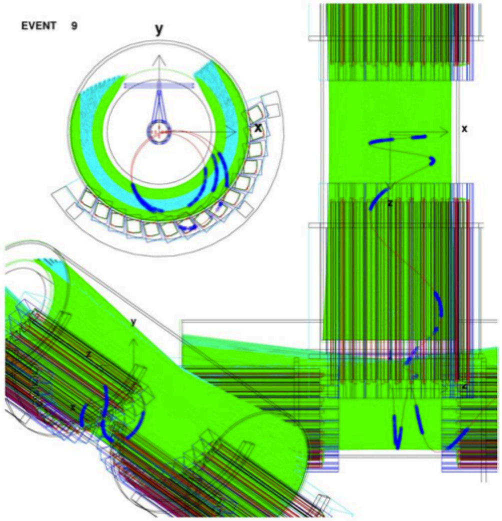
B-factory

—— Published MEG limit on 2009-2010 data

- - - - Expected sensitivity with the full data set

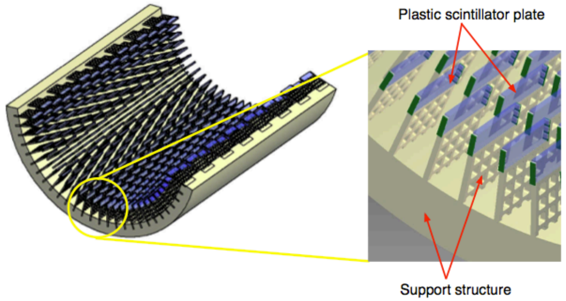
$\mu \to e\gamma$

MEG: upgrade



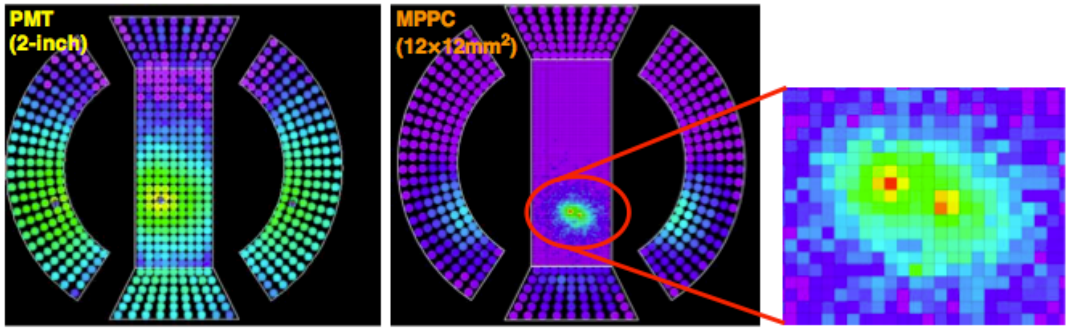
Unique volume tracker

- 3 times more hits
- tracking up to TC
- lower MS



Segmented TC with scintillator bricks and SiPM

- reduced pile up
- multiple hit information



SiPM instead of PMT in inner face

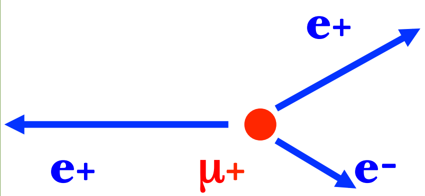
- increased sensitive area
- Better pileup rejection
- Improved photon reconstruction

Goal: sensitivity to BR($\mu \to e\gamma$) ~ 5×10^{-14} after 3 years of data starting in 2015

$\mu^+ \to e^+ e^+ e^-$

signal

$\mu \to eee$

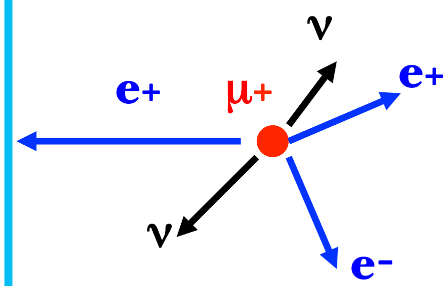


- **Coplanarity**
- **Vertexing**
- $\Sigma E_e = m_\mu$
- $T_{e+} = T_{e+} = T_{e-}$

background

correlated

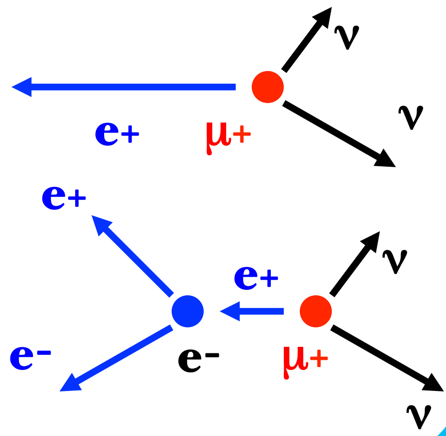
$\mu \to e\, e\, e\, \nu\, \nu$



accidental

$\mu \to e\, \nu\, \nu$

$\left\{ \begin{array}{l} \mu \to e\, \nu\, \nu \\ e^+ e^- \to e^+ e^- \end{array} \right.$



Present limit from SINDRUM : $B(\mu \to 3e) < 1 \times 10^{-12}$

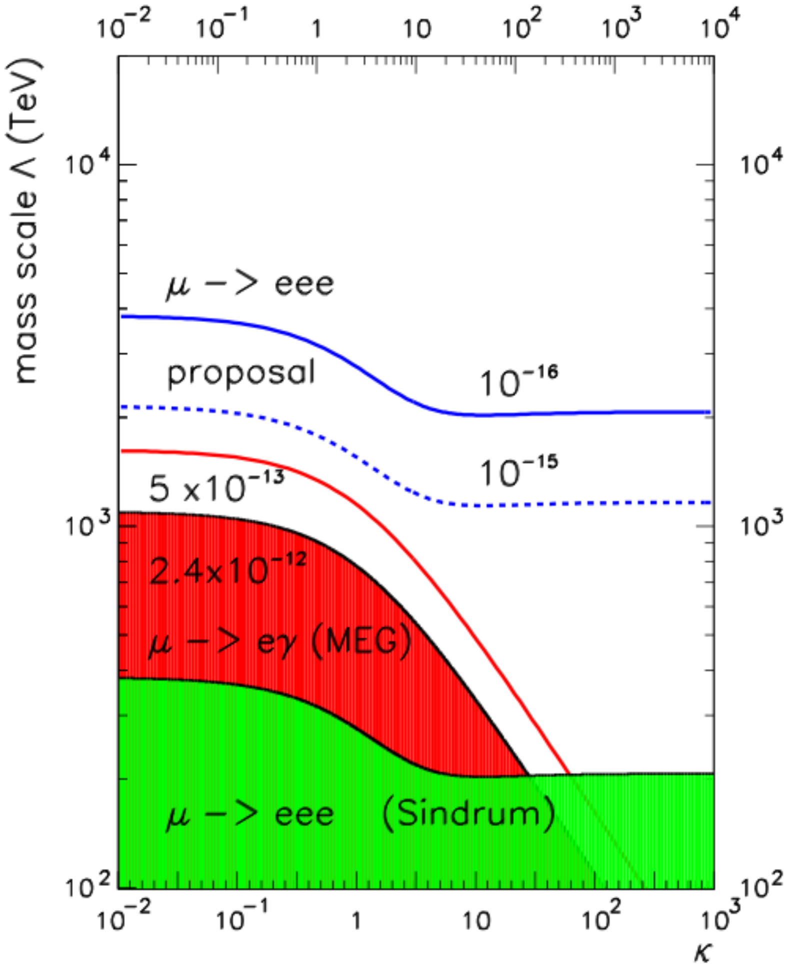
U.Bellgardt et al. Nucl.Phys. B299(1988)1 μ→3e

Mu3e LoI at PSI

- Letter of Intent presented at PSI in 2011
- Sensitivity goals
  - Phase I (2014 – 2017) : 10^{-15}
  - Phase II (> 2017) : 10^{-16}

	PHASE I	PHASE II
Year	2014-2017	> 2017
Muon Rate/s	$2 \cdot 10^8$	$2 \cdot 10^9$
Total Running Time	350 days	350 days
Stopped-Muon Decays	$3 \cdot 10^{15}$	$3 \cdot 10^{16}$
Exp. Background	0	0
Detector Acceptance	0.7	0.7
Detector Efficiency	0.7	0.7
Sensitivity (90% CL)	10^{-15}	10^{-16}

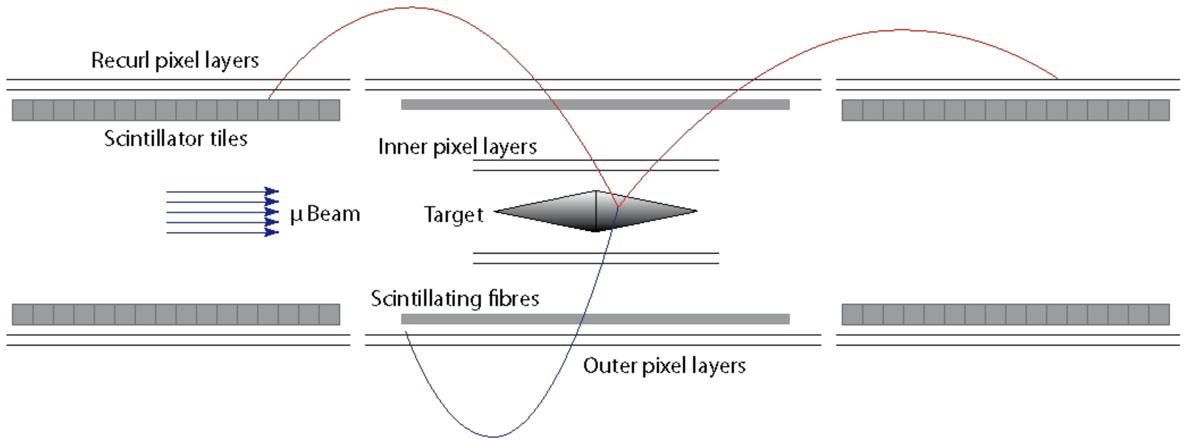
- Background rejection
  - Null total momentum
  - Invariant muon mass
  - Equal emission time



D.Wiedner at NuFact 2012
Mu3e LoI

μ→3e

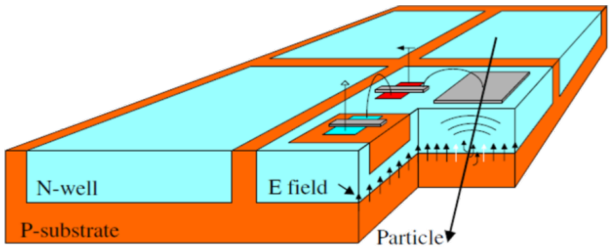
Mu3e detector challenges



Aggressive schedule:
start data taking in 2014

Needs momentum and timing with excellent resolutions

- Tracker with HV-MAPS (275 million of channels)
  - fast 100 ns timing
  - Low X0 (thinned to 50 μm)
  - No cooling (low power constraint)
  - Light support structure
- Timing measurement with scintillating fibers and high resolution hodoscope
  - Fibers for track selection (1 ns resolution)
  - Scintillating tiles (100 ps on on each particle)



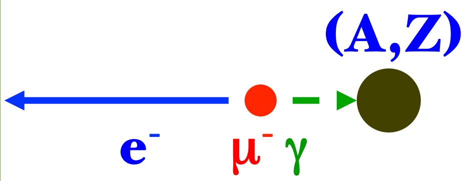
HV Monolithic Active Pixel Sensors

$\mu^- \rightarrow e^-$ conversion

Signal

coherent LFV decay

$\mu\,(A,Z) \rightarrow e\,(A,Z)$

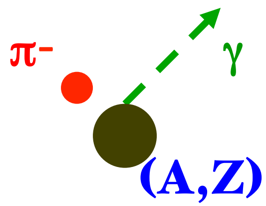


$E_e = m_\mu - E_B - E_R$

Background

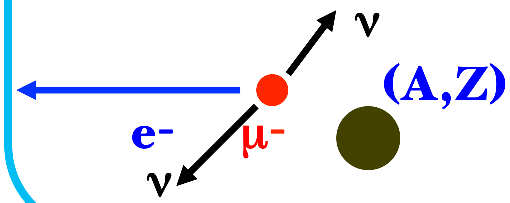
RPC (radiative pion capture)

$\pi\,(A,Z) \rightarrow \gamma\,(A,Z\text{-}1)$



MIO (muon decay in orbit)

$\mu\,(A,Z) \rightarrow e\,\nu\,\nu\,(A,Z)$



Present limit from SINDRUM II : $B(\mu \rightarrow e{:}Au) < 7\times10^{-13}$

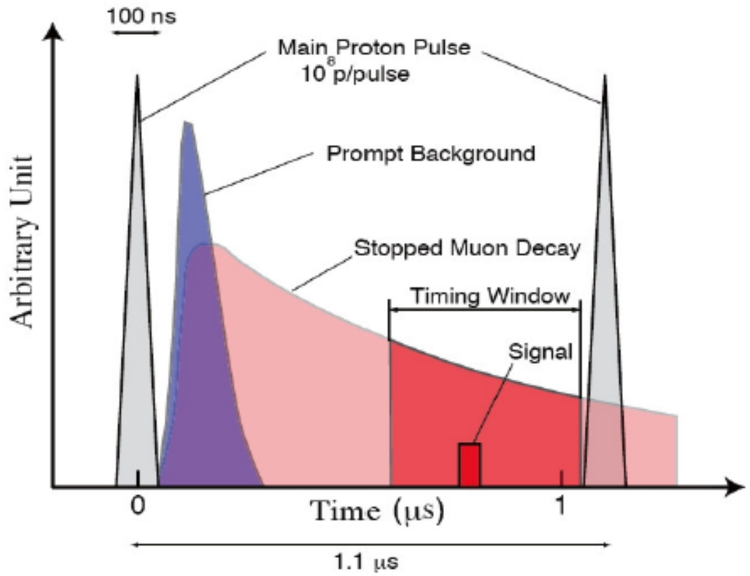
E. Bertl et al. Eur.phys.J. C47 (2006) 337

$\mu^- \to e^-$: common aspects

Only 1 particle in the final state: no accidental Background
chance to explore very low BR

Detector requirement: excellent momentum resolution
Target: aluminium
Fundamental element: the beam line

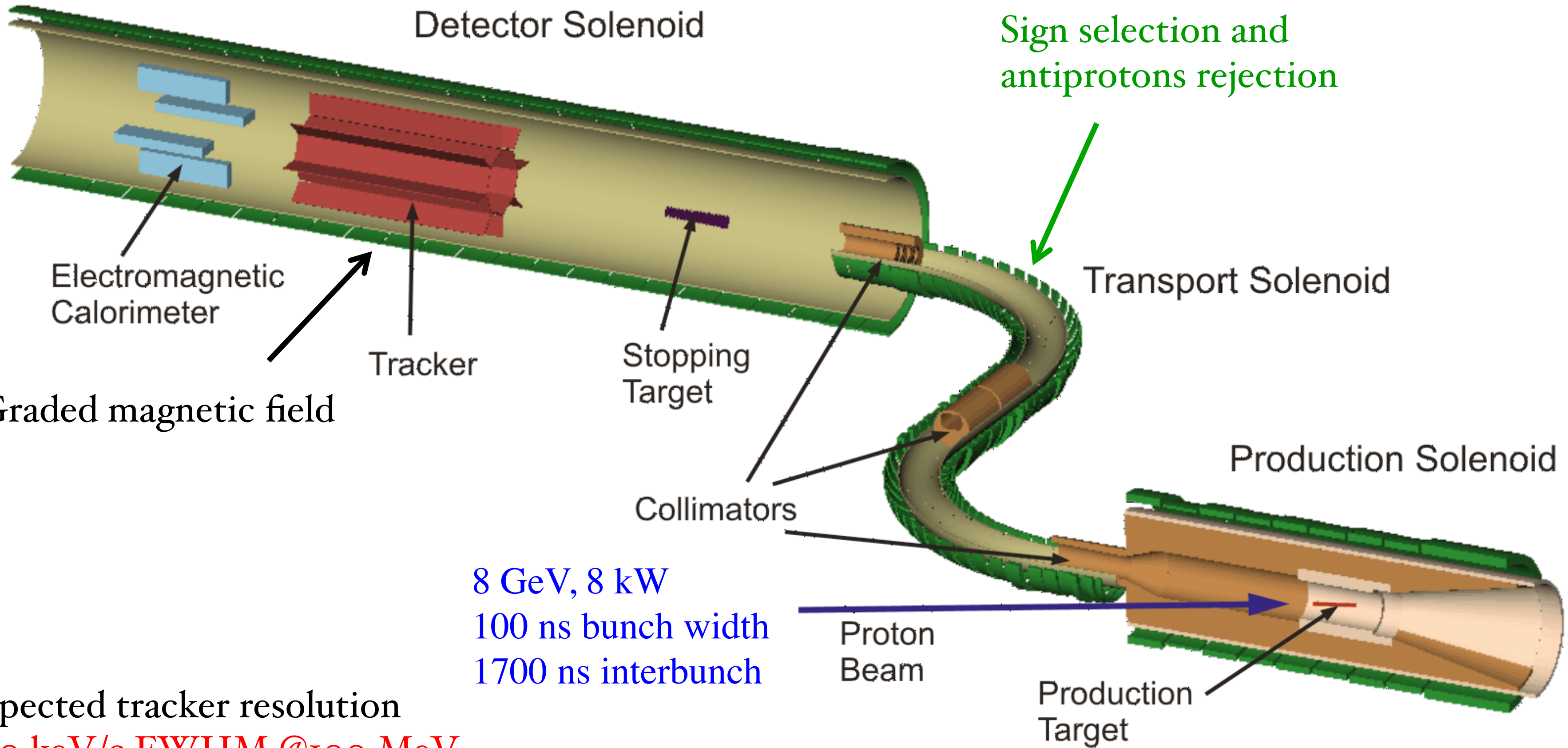
- Ultra high intensity μ beam ~ 10^{11} μ/s
- Pulsed P beam
  - Short beam-on (dt ~ 10ns)
  - Long beam-off (Δt ~ 1 μs)
- Huge p extinction factor (10^{-10} or FFAG)
- Low momentum μ (~ 68 MeV/c)
- Narrow momentum spread (<2 %)



80-90% of the cost is the beam line

μ⁻→e⁻

Mu2e at Fermilab



Sign selection and antiprotons rejection

Graded magnetic field

8 GeV, 8 kW
100 ns bunch width
1700 ns interbunch

Expected tracker resolution
900 keV/c FWHM @100 MeV

Goal: UL at 6×10^{-17} in 3 years

Background : 0.41 +/- 0.08 events with p-extinction of 10^{-10}

Data taking : 2019

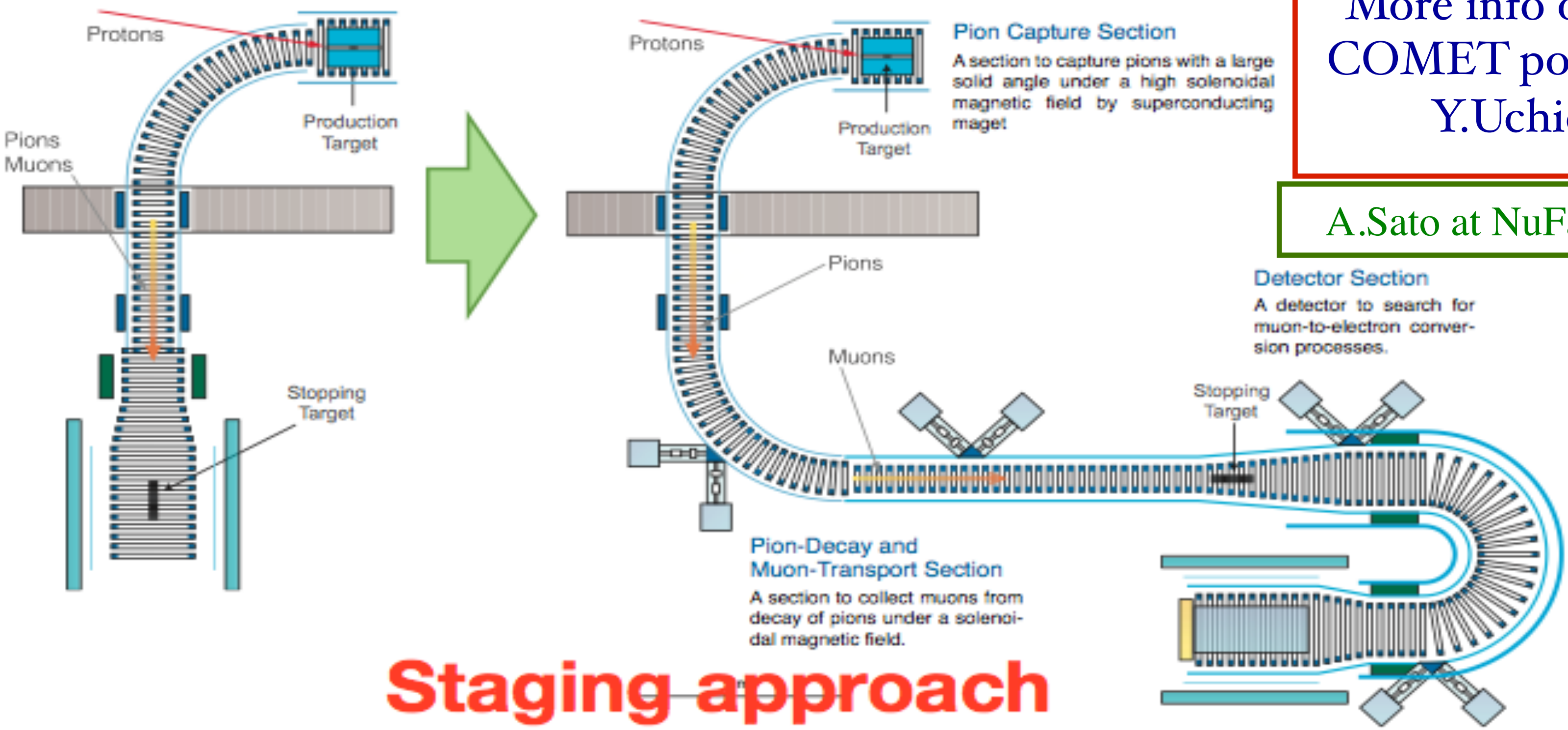
E.Hungerford at NuFact 2012
Mu2e CDR for CD1

$\mu^- \rightarrow e^-$

COMET at J-PARC

More info on the COMET poster by Y.Uchida

A.Sato at NuFact 2012



Staging approach

COMET Phase-I :

physics run 2017-

BR(μ+Al→e+Al)<7x10^{-15} @ 90%CL

- *8GeV-3.2kW proton beam, 12 days
  - *90deg. bend solenoid, cylindrical detector
  - *Background study for the phase2

COMET Phase-II :

physics run 2019-

BR(μ+Al→e+Al)<6x10^{-17} @ 90%CL

- *8GeV-56kW proton beam, 2 years
- *180deg. bend solenoid, bend spectrometer, transverse tracker+calorimeter

$\mu^- \rightarrow e^-$

Mu2e and COMET summary

Mu2e

Site: FermiLab

Goal: UL at $6x10^{-17}$ in 3 years

Background : 0.41 +/- 0.08 events

Beam : p-extinction of 10^{-10}

Data taking : 2019

Tracker: 900 keV/c at 100 MeV

Upgrade: Project-X for 10^{-18}

COMET phase II

Site: J-PARC

Goal: UL at $6x10^{-17}$ in 2 years

Background : 0.34 +/- 0.08 events

Beam : p-extinction of 10^{-10}

Data taking : 2019

Tracker: 400 keV/c at 100 MeV

Upgrade: PRISM for 10^{-18}

COMET phase I

Goal: UL at $7x10^{-15}$ in 12 days

Background : 0.34 +/- 0.08 events

Beam : background study

Data taking : 2017

Tracker: detector development

$\mu^- \rightarrow e^-$

DeeMe

Idea: μ-e conversion electrons may come directly from the proton target

Motivation : moderate sensitivity but timely achieved and at low cost

Background: < 0.6 evts for $8x10^7$ s of run

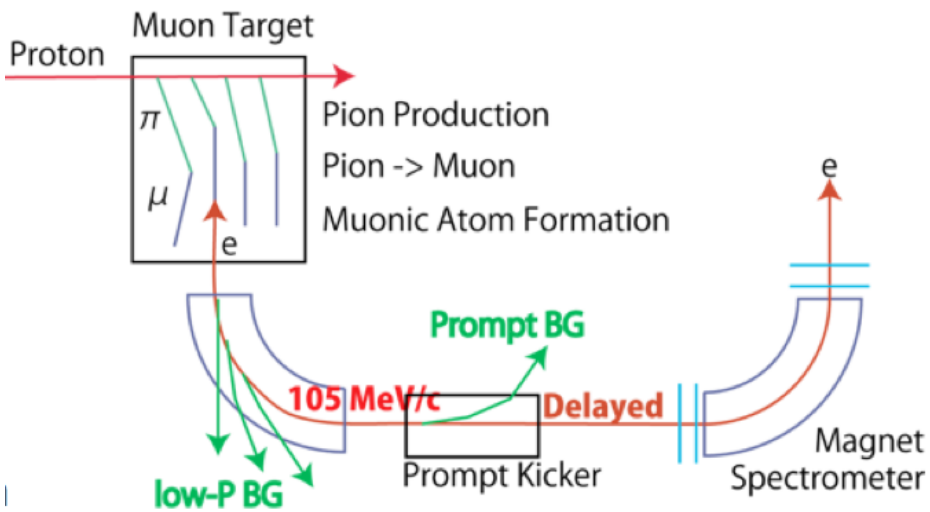
Sensitivity: S.E.S $2x10^{-14}$ for $2x10^7$ s of run

or S.E.S $0.5x10^{-14}$ for $8x10^7$ s of run

Time : first results in 2015

Beam Line: H-line in Material and Life science Facility at J-PARC

Status: Stage 1 approval in 2011



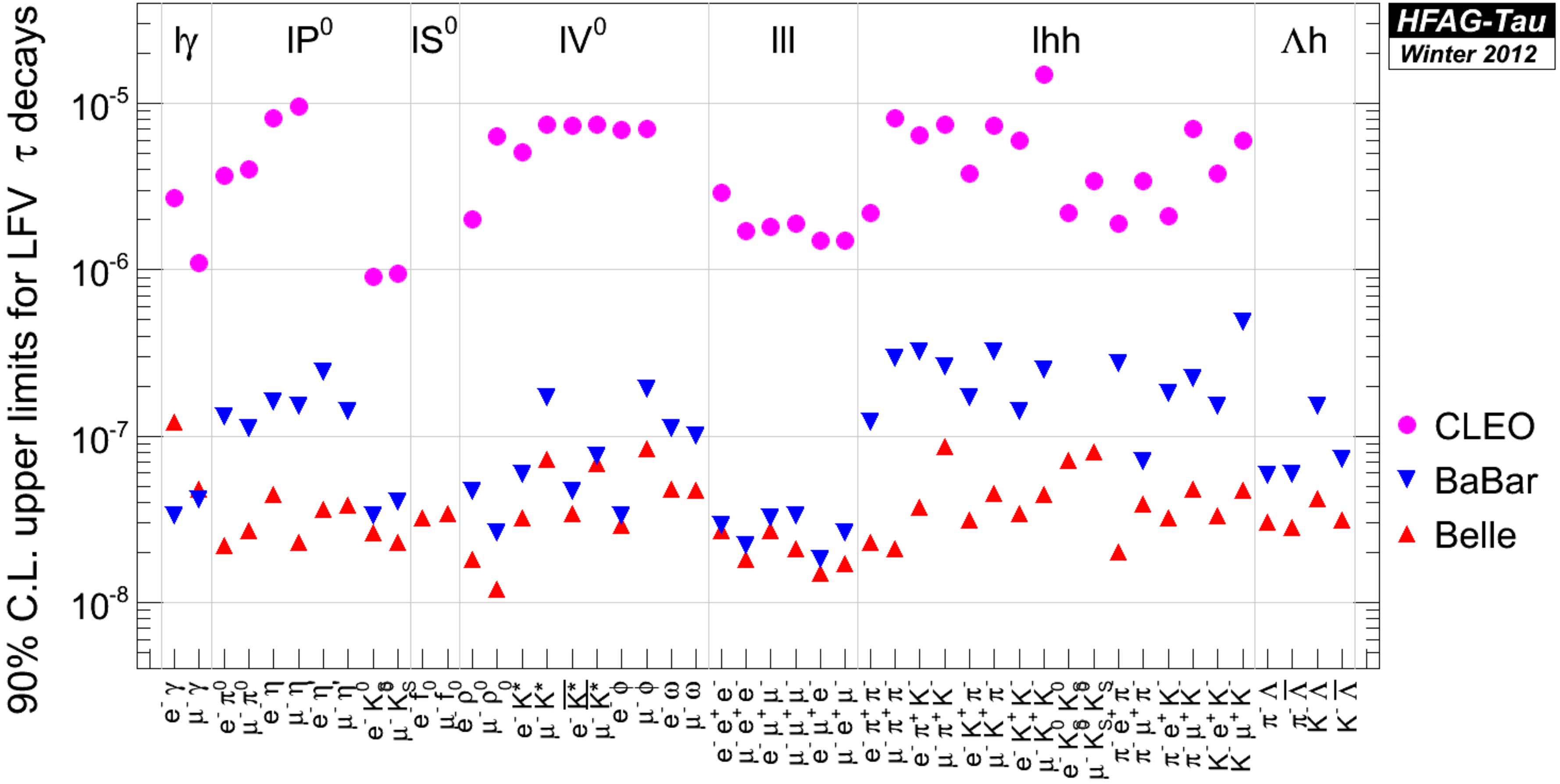
M.Aoki at NuFact 2012
DeeMe proposal R28 at J-PARC

The taus

Taus are excellent probes for high precision measurement
with differences with respect to muons

- Massive initial state, many channels
- Massive initial state, effects enhanced by 3÷5 orders of mag
- Intensity could be an issue 10^{+10} τ/year vs 10^{+8} μ/s
- Short lived
- Complex detectors

LFV in τ decays



In NP models limits are linked: $\mu \to e\gamma$ at $\approx 10^{-12}$ implies $\tau \to \mu\gamma$ at $>10^{-9}$

τ –LFV Detection strategy

b - factories are also excellent τ - factories

$$\sigma\left(e^+e^- \to \tau^+\tau^-\right) \approx 0.9 \times \sigma\left(e^+e^- \to b\bar{b}\right) \approx 0.92\text{nb} \qquad \sqrt{s} = 10.54\text{GeV}$$

Search strategy

- Identify ττ couples with a τ – tags in 1 prong sample
- Search LFV on the other side
- Likelihood analysis and blind box

Variables

- Invariant mass $m_{BC} = \sqrt{E_{beam}^2 - p_{sig}^2}$ it should be m_τ
- Missing energy $\Delta E = E_{sig} - E_{beam}$ it should be = 0

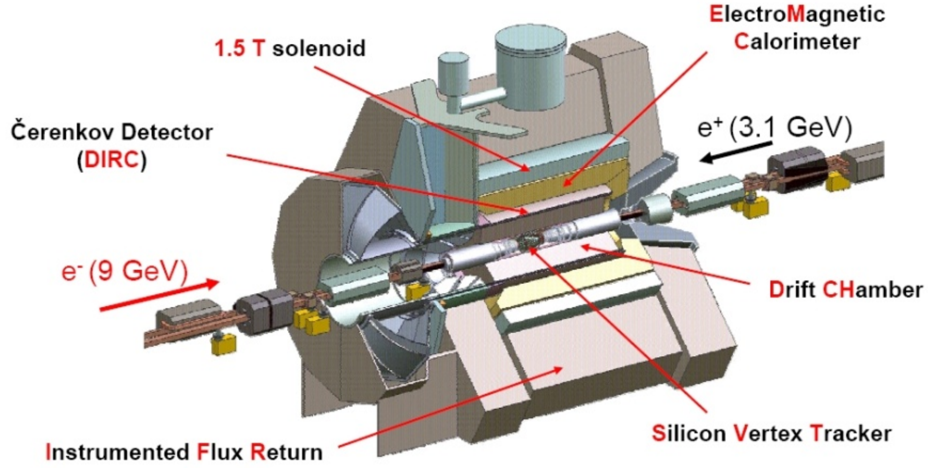
Background

- Generally small, clean environment
- Tails of the ττ distributions, μμ, uds, Bhabha, cc

τ→eγ/μγ

BaBar

Machine: PEP-II at SLAC
Energy: mainly at Υ(4s)
Lorentz boost: $\beta\gamma \sim 0.55$

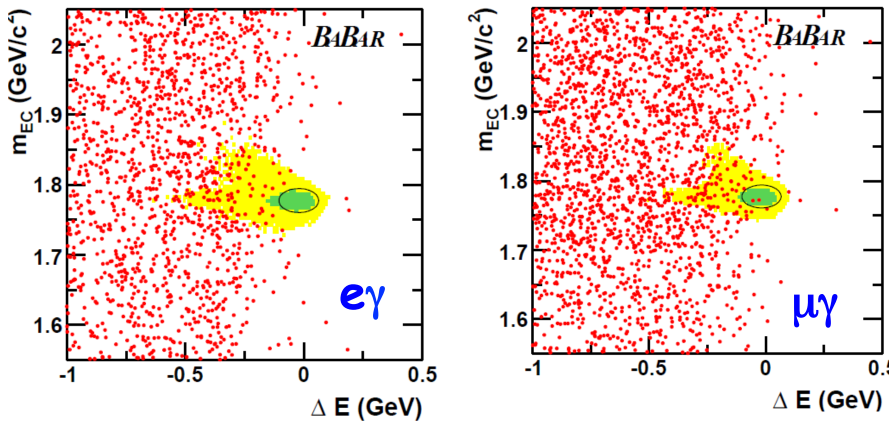


Data sample:

468 fb^{-1} @Υ(4S)

90 fb^{-1} @Υ(nS)

$(963 \pm 7) \times 10^6$ τ decays



Upper Limit @ 90% C.L.:

$BR(\tau \to \mu\gamma) < 4.4 \times 10^{-8}$

$BR(\tau \to e\gamma) < 3.3 \times 10^{-8}$

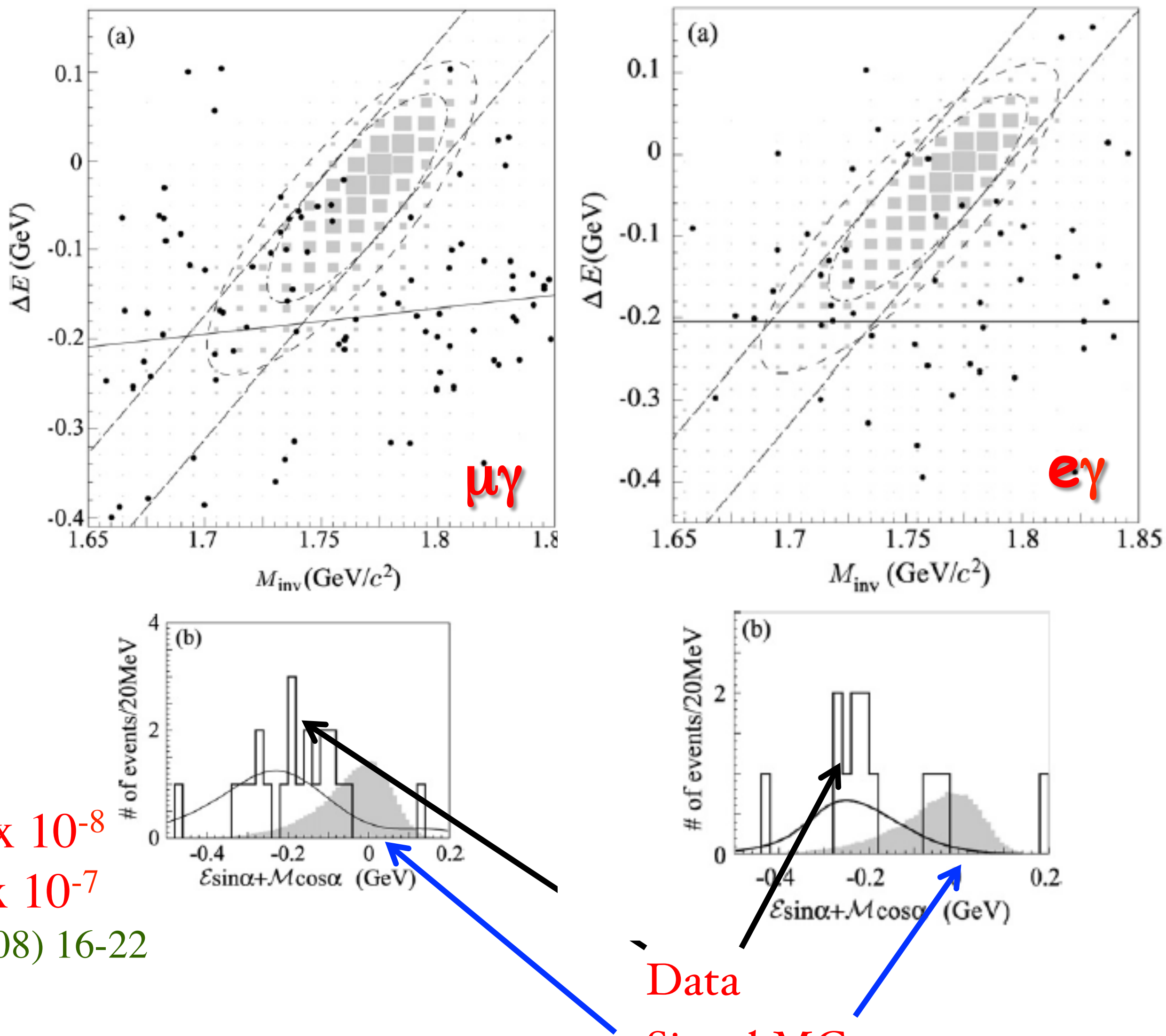
BABAR Collaboration PRL 104 (2010) 021802 τ→eγ/μγ

BELLE

Data sample:

535 fb^{-1} @Υ(4S)

~5 x 10^8 τ decays



Upper Limit @ 90% C.L.:

BR(τ → μγ) < 4.5 x 10^{-8}

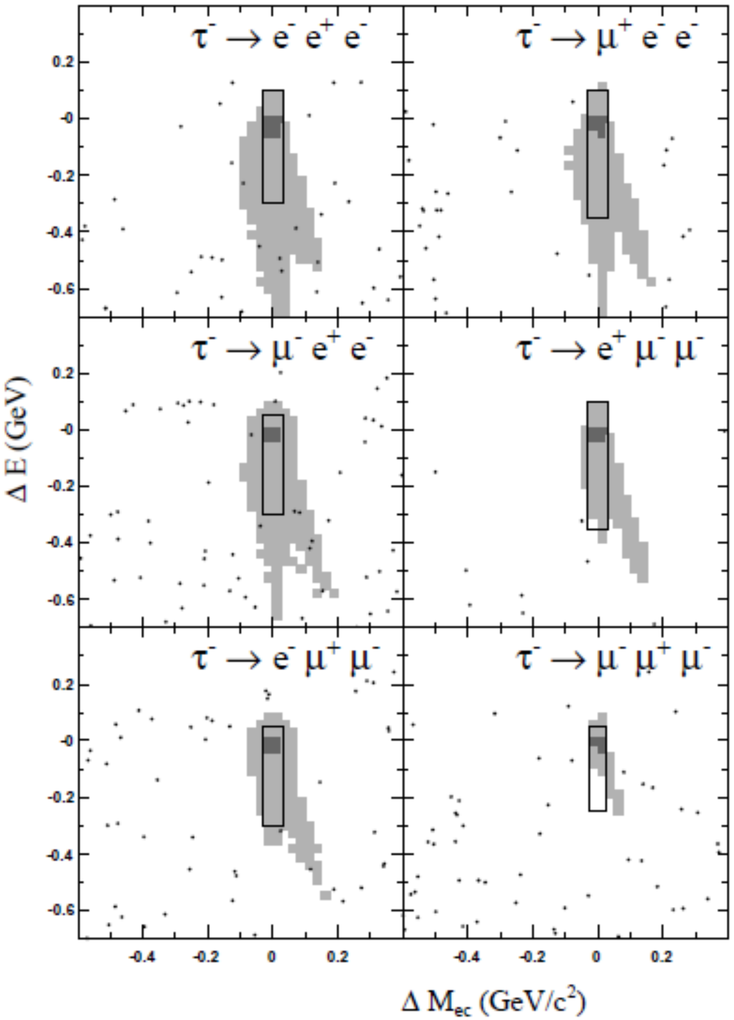
BR(τ → eγ) < 1.2 x 10^{-7}

BELLE Collaboration, PL B666 (2008) 16-22

$\tau \to lll$

BaBar

BABAR Coll. PhysRevD81, 111101 (2010)



- Standard 1-prong tag
- Three tracks of opposite tot charge on the signal
- Data sample 468 fb^{-1}

- Search based on invariant mass and ΔE
- Very low background on these channels
- no excess observed

Mode	Eff. [%]	N_{bgd}	UL_{90}^{exp}	N_{obs}	UL_{90}^{obs}
$e^-e^+e^-$	8.6 ± 0.2	0.12 ± 0.02	3.4	0	2.9
$\mu^-e^+e^-$	8.8 ± 0.5	0.64 ± 0.19	3.7	0	2.2
$\mu^+e^-e^-$	12.7 ± 0.7	0.34 ± 0.12	2.2	0	1.8
$e^+\mu^-\mu^-$	10.2 ± 0.6	0.03 ± 0.02	2.8	0	2.6
$e^-\mu^+\mu^-$	6.4 ± 0.4	0.54 ± 0.14	4.6	0	3.2
$\mu^-\mu^+\mu^-$	6.6 ± 0.6	0.44 ± 0.17	4.0	0	3.3

U.L. Range: $(1.8 \div 3.3) \times 10^{-8}$ (90% C.L.)

$\tau \to lll$

BELLE

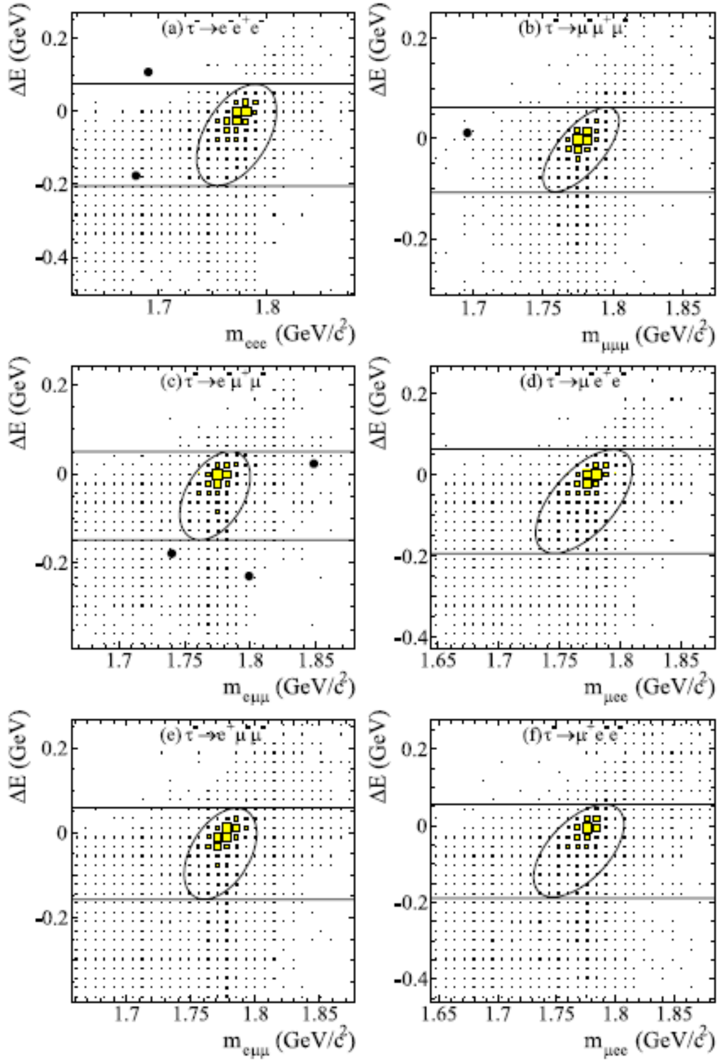
BELLE Coll. PL B687 (2010) 139-143

Data sample 782 fb^{-1}

Very low background channel.

Mode	ε (%)	N_{BG}	σ_{syst} (%)	N_{obs}	$\mathcal{B}$ ($\times 10^{-8}$)
$\tau^- \to e^- e^+ e^-$	6.0	0.21 ± 0.15	9.8	0	< 2.7
$\tau^- \to \mu^- \mu^+ \mu^-$	7.6	0.13 ± 0.06	7.4	0	< 2.1
$\tau^- \to e^- \mu^+ \mu^-$	6.1	0.10 ± 0.04	9.5	0	< 2.7
$\tau^- \to \mu^- e^+ e^-$	9.3	0.04 ± 0.04	7.8	0	< 1.8
$\tau^- \to e^+ \mu^- \mu^-$	10.1	0.02 ± 0.02	7.6	0	< 1.7
$\tau^- \to \mu^+ e^- e^-$	11.5	0.01 ± 0.01	7.7	0	< 1.5

U.L. Range: (1.5 ÷ 2.7) x 10^{-8} (90% C.L.)



$\tau \to 3l$ search as no irreducible background
(no photons no problems with initial state radiation)
Limited by statistics

Future: high luminosity B factories

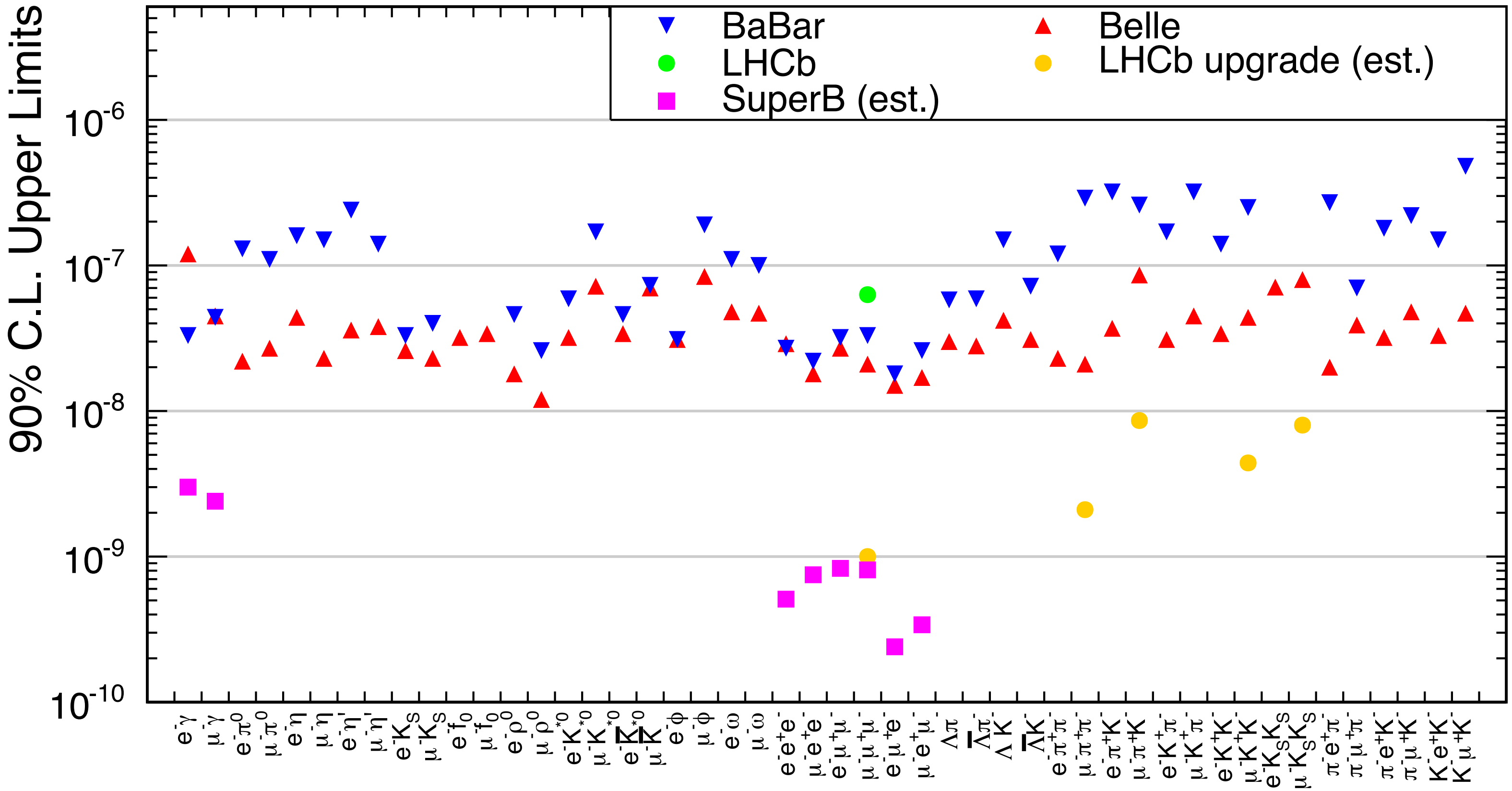
Projects of Super-B factories in
Japan (BELLE II at SuperKEKB) approved & funded start 2014
Italy (SuperB at CabibboLab) approved & part. funded start 2018

Expected luminosities:
10^{35} cm^{-2} s^{-1} (SuperKEKB), 10^{36} cm^{-2} s^{-1} (SuperB)

- Both projects would reach an integrated luminosity $L = 50$ ab^{-1}
- SuperB could exploit the beam polarization to reduce the background on $\tau \to l\gamma$
- Detector upgrades are foreseen
- Expected sensitivities
  - BR($\tau \to l\gamma$) < 2 x 10^{-9}
  - BR($\tau \to 3l$) < 2 x 10^{-10}
  - BR($\tau \to lh$ or lhh) < (2 ÷ 6) x 10^{-10}

More info on the SuperB given by A.Perez

Prospects on τ LFV



τ→*lll*

LHCb

Data sample: 80 mb^{-1} at 7 TeV

7.9 x 10^{10} τ produced

Production channel: $D_s \rightarrow \tau\nu$

Analysis strategy:

likelihood analysis on

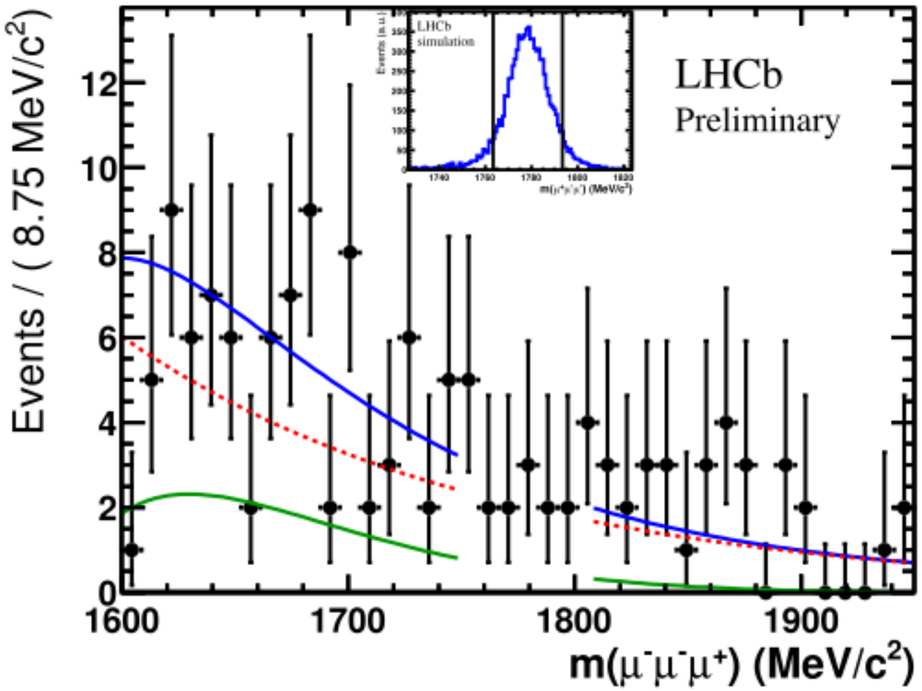
- Invariant mass
- Decay topology
- Particle id

Efficiency on signal: 11%

Result: BR < 6.3 x 10^{-8} (90% C.L.)

Competitive with future B factories !!

Paul Seyfert at NuFact 2012



Background

Red combinatorial

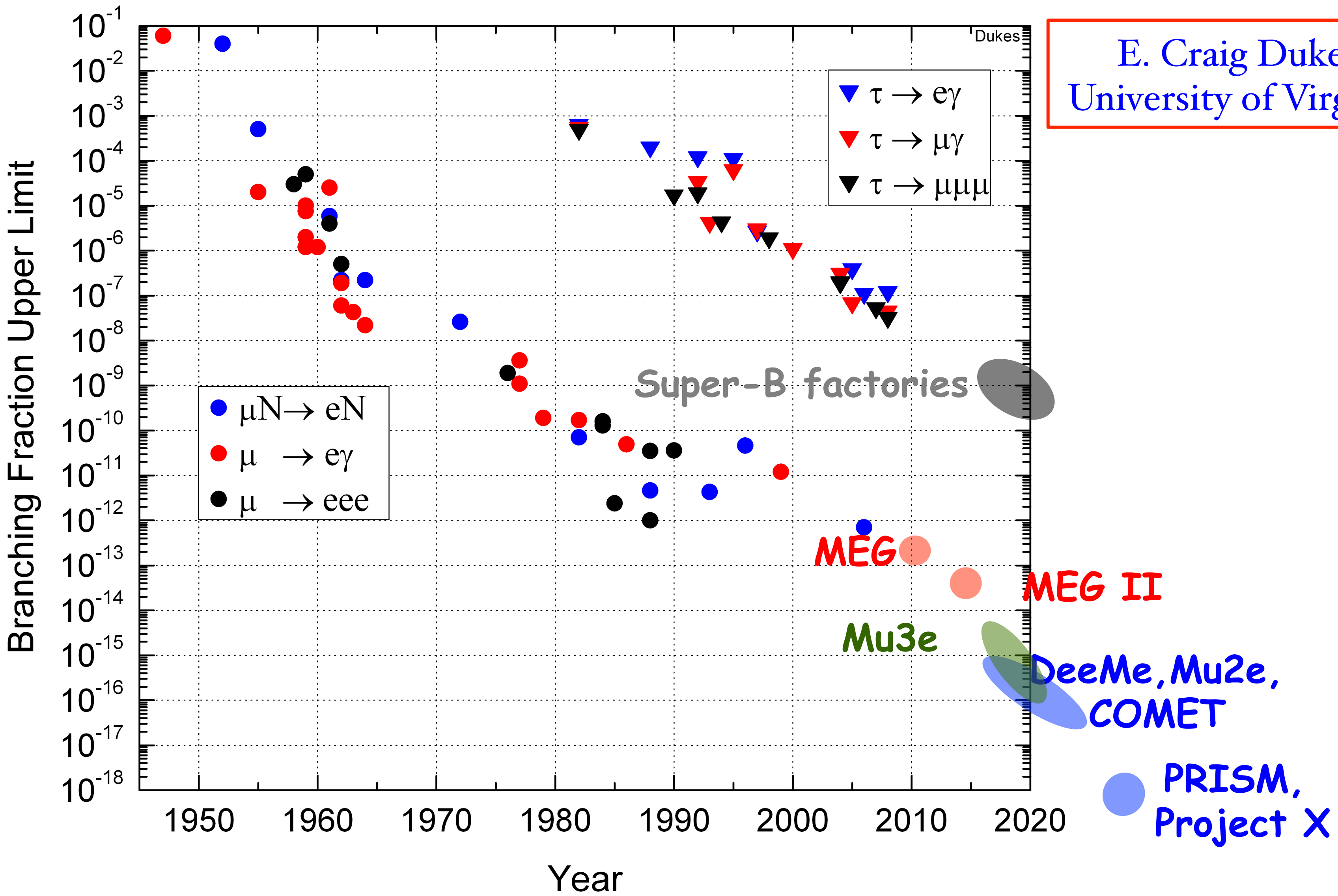
Green $D_s^+ \rightarrow \eta(\mu^-\mu^+\gamma)\mu^+\nu_\mu$

Blue total

Conclusions

- General arguments suggest that New Physics could be close to the experimental reach, both in particle searches and effects through loops
- The structure and the couplings of NP could be constrained by multiple precision measurements of cLFV
- MEG is close to publish new data and it will be upgraded to explore an interesting region down to ~5 x 10^{-14}
- Challenging $\mu \rightarrow e$ conversion searches are expected to start in 2015
- A search for $\mu \rightarrow 3e$ has been recently proposed
- Data on τ LFV decays are not yet fully analyzed, and new powerful machines are under construction or planned

Graphically



E. Craig Dukes
University of Virginia

Keep searching !

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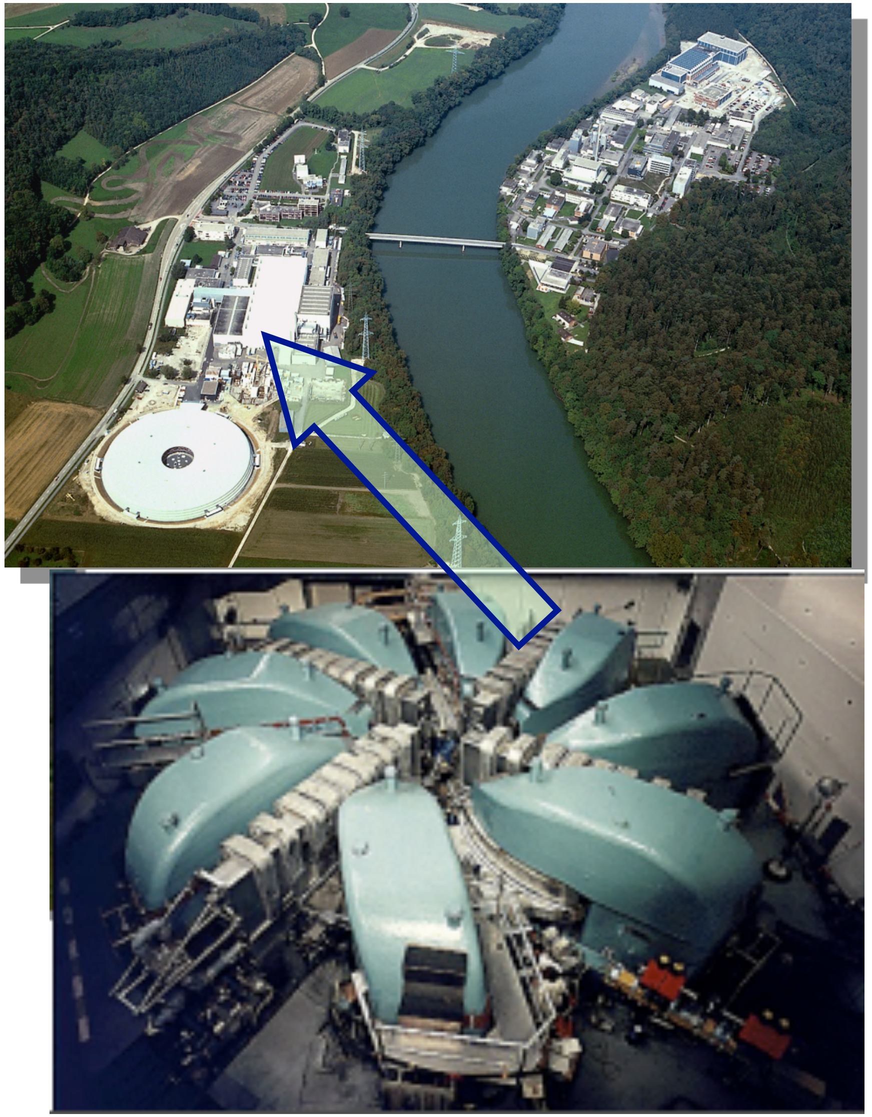
T.Aoyama *et al*. ArXiv:1205.5370v2
S.Antush *et al*, JHEP 11 (2006) 090

Spare

The Paul Sherrer Institute (PSI)



- The most powerful continuous machine (proton cyclotron) in the world;
- Proton energy 590 MeV;
- Power 1.2 MW;
- Nominal operational current 2.2 mA.

MEG: Systematic uncertainties

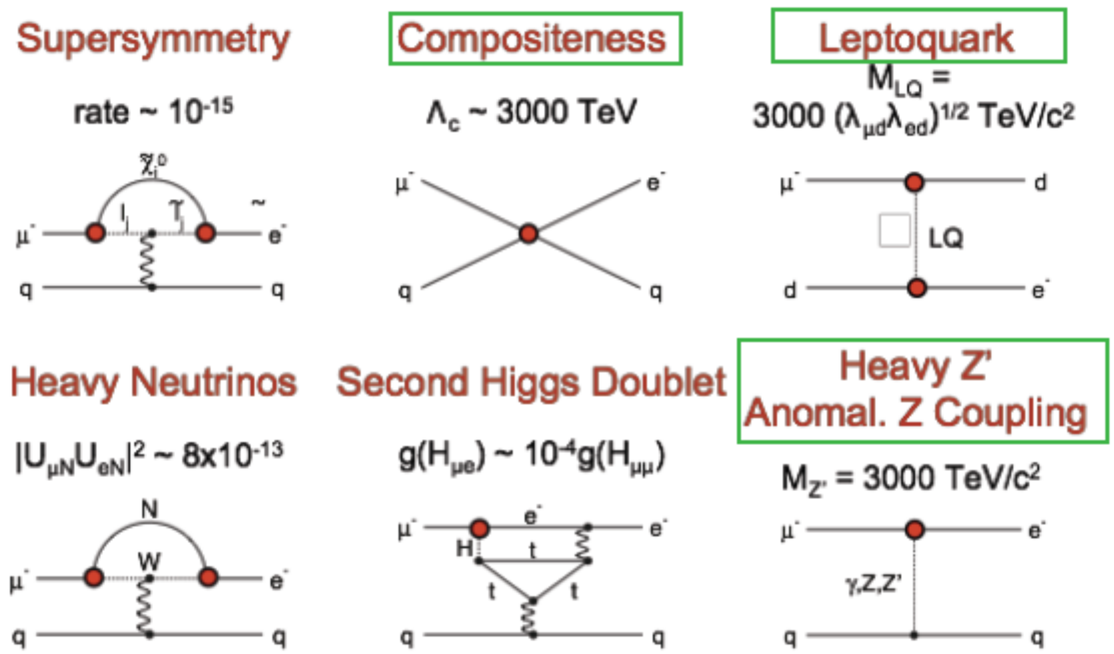
- The effect of systematics is taken into account in the calculation of the confidence region by fluctuating the *pdfs* according to the uncertainty values

	Uncertainty	
Normalization	8%	P_{e+} ε_γ ε_{TRG}
E_γ scale	0.4%	Light yield stability, gain shift
E_γ resolution	7%	
E_e scale	50 keV	from Michel edge
E_e resolution	15%	
$t_{e\gamma}$ center	15 ps	
$t_{e\gamma}$ resolution	10%	RMD peak
Angle	7.5 mrad	Tracking + LXe position
Angular resolution	10%	
E_e–φ_e correlation	50%	MC evaluation

- overall effect of systematics: $\Delta N_{sig} \sim 1$

$\mu^- \rightarrow e^-$ physics

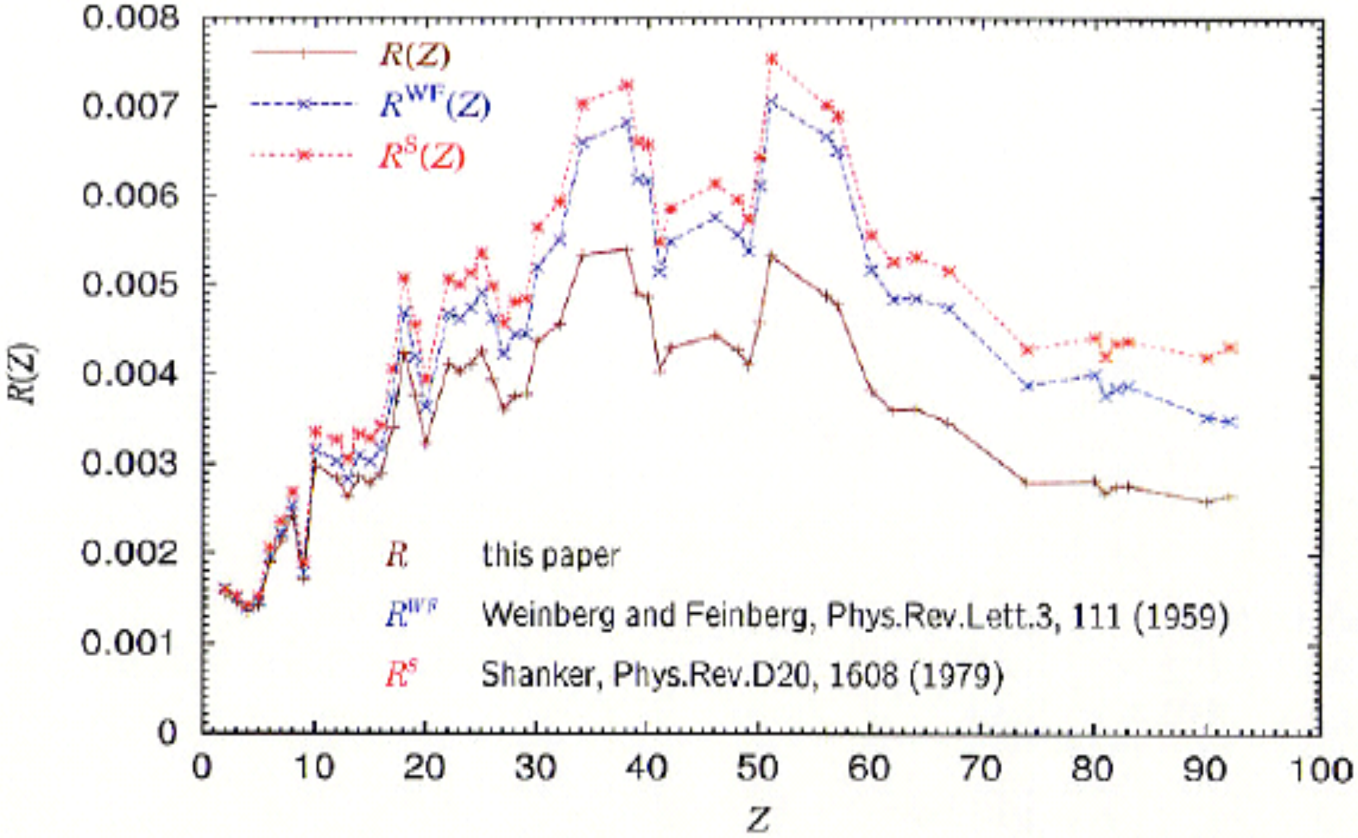
- Effects from almost all NP scenarios
- These do not contribute to $\mu \rightarrow e\gamma$



$\mu^- \to e^-$: sensitivity

R.Kitano et al Phys.Rev.D66(2002)096002

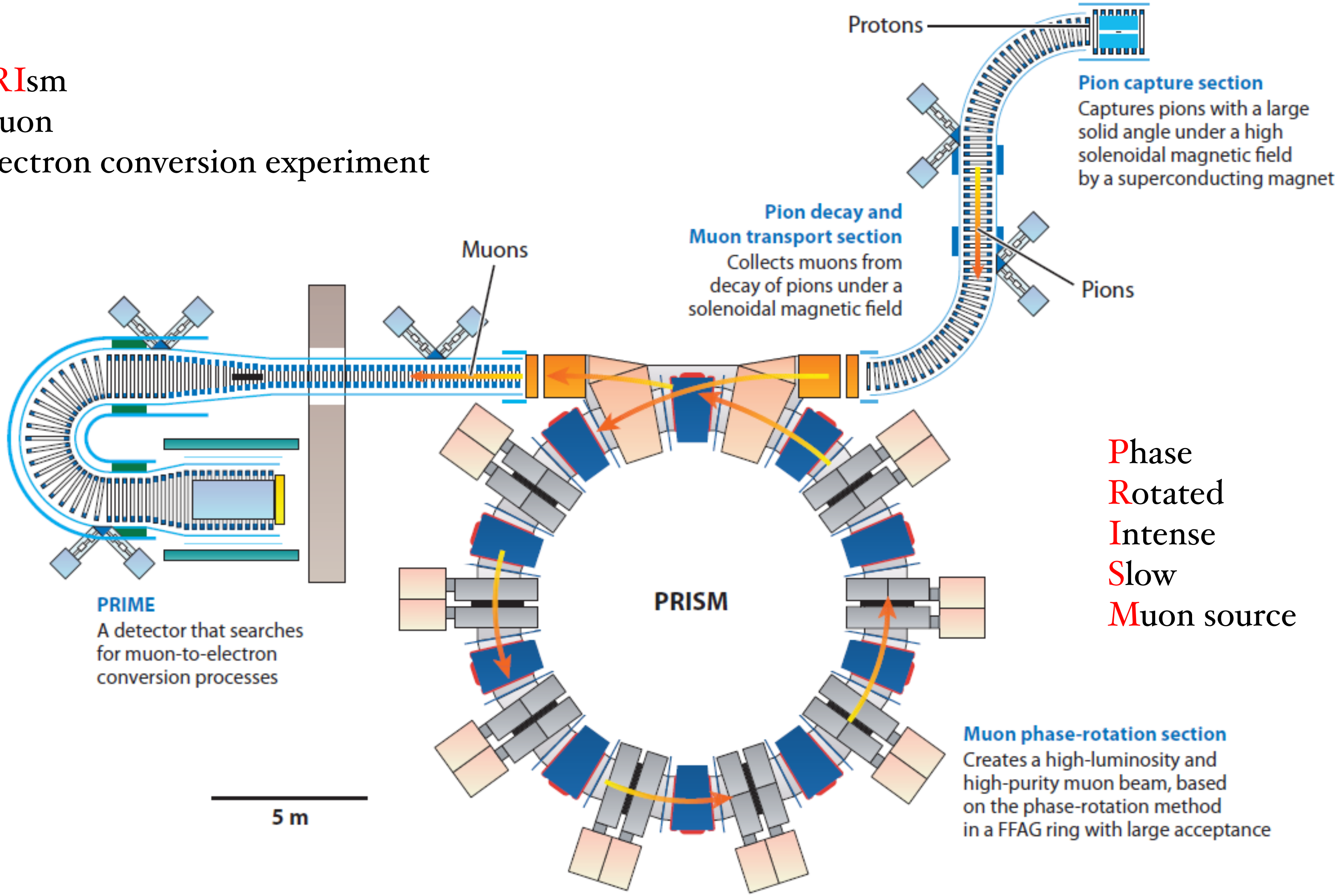
$R \equiv B_{\mu e}/B_{\mu\to e\gamma}$



These results are valid for a photonic dipole operator as found in many SUSY models.

PRISM/PRIME

PRIsm
Muon
Electron conversion experiment

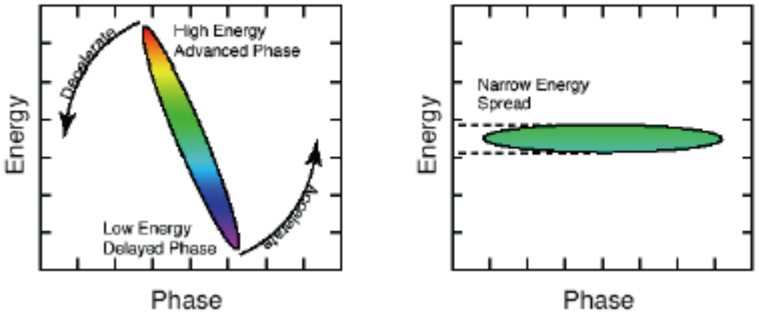


Phase
Rotated
Intense
Slow
Muon source

A. Sato, NP08

PRISM: motivation

Phase rotation



- Energy spread of μ reduced to 3 % FWHM

  by means of RF in the FFAG ring

- Well defined μ momentum 68 MeV/c
- Large aperture, high intensity ≈ $10^{11÷12}$ μ/s
- Long μ flight length 10^{-23} π suppression
- Kickers in the FFAG : p extinction not crucial

Small energy spread allows very thin targets

Momentum resolution ≤ 350 keV (FWHM) could be possible

Background reduced at 0.1 events

Experiment sensitive down to BR ≈ 10^{-18}

Experimental demonstration of phase rotation in FFAG in progress at Osaka

Far in the future ...