

# Search for a dark matter photon in light mesons decays

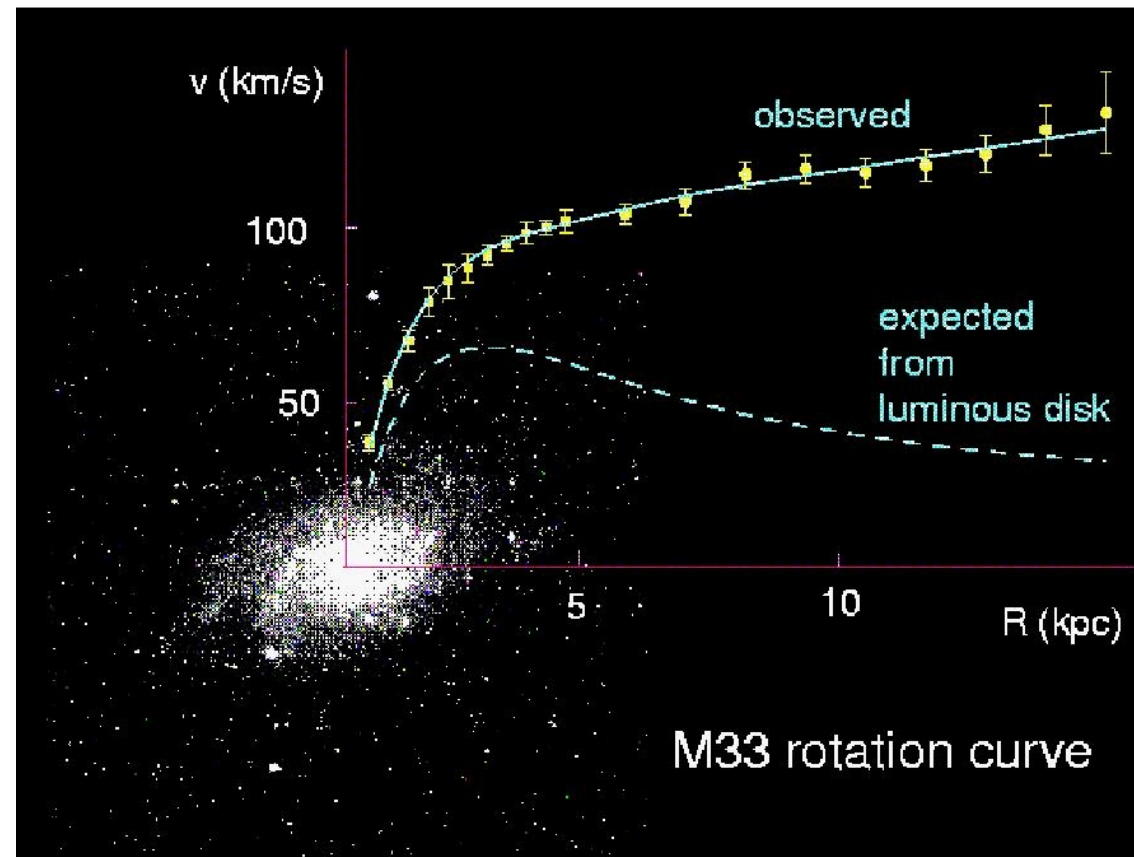
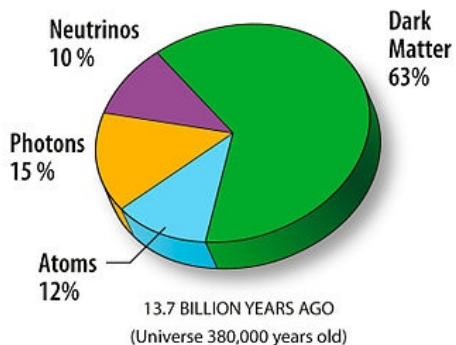
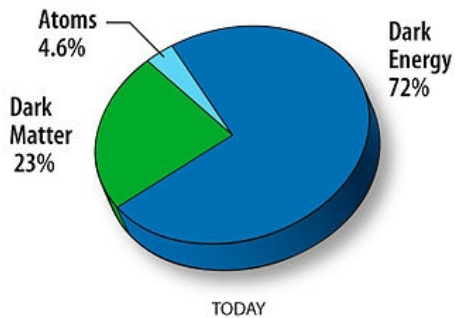
Andrzej Kupść  
Uppsala University

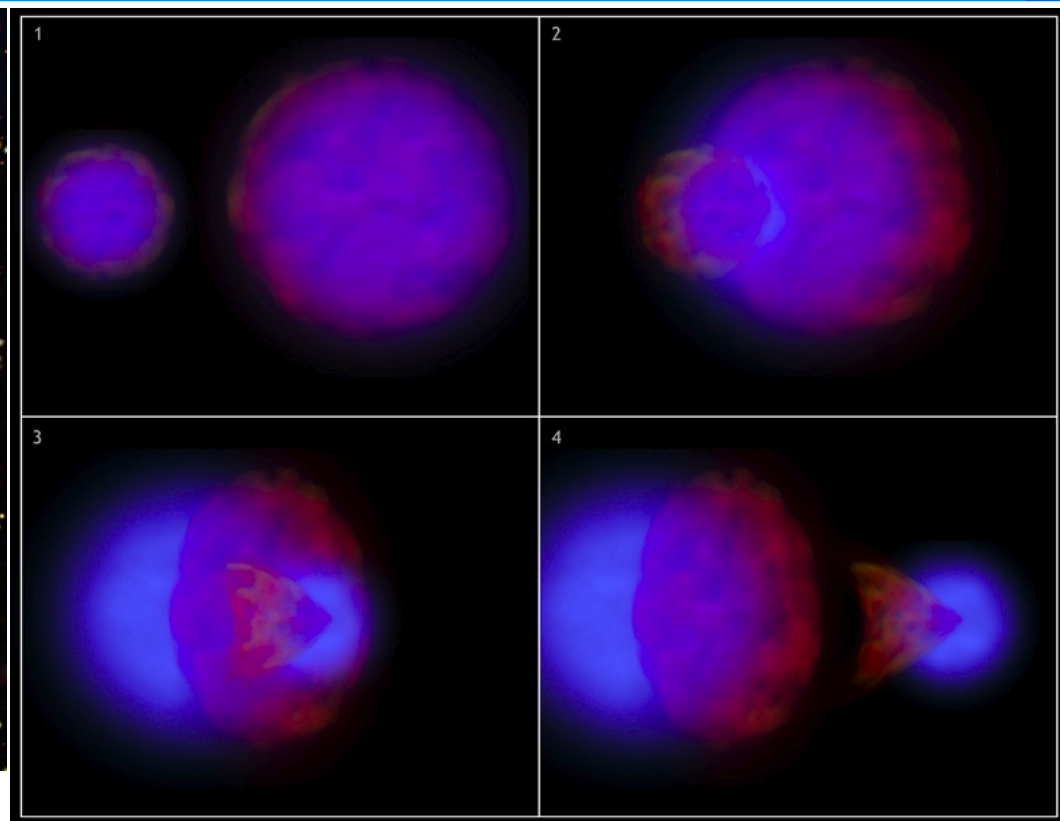


Kraków, June 4<sup>th</sup>, 2013

**Dark Matter:** Matter that emits or reflects minimal or no light but it has gravitational influence;  
Well established

- motion of stars in galaxies
- gravitational lensing





## Origin:

- Massive compact halo objects *MACHO*
- Weakly interacting Massive particles



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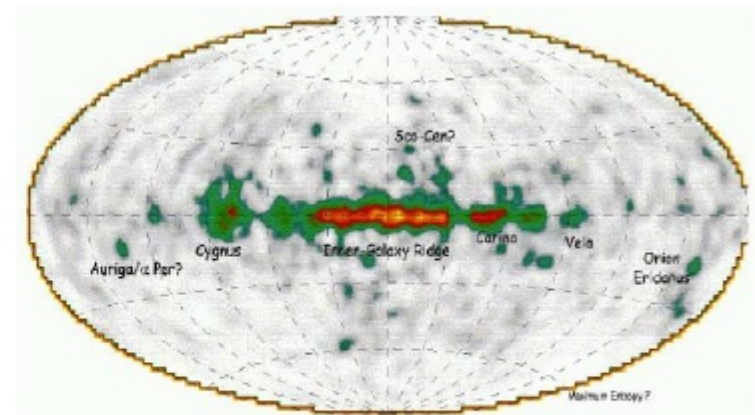
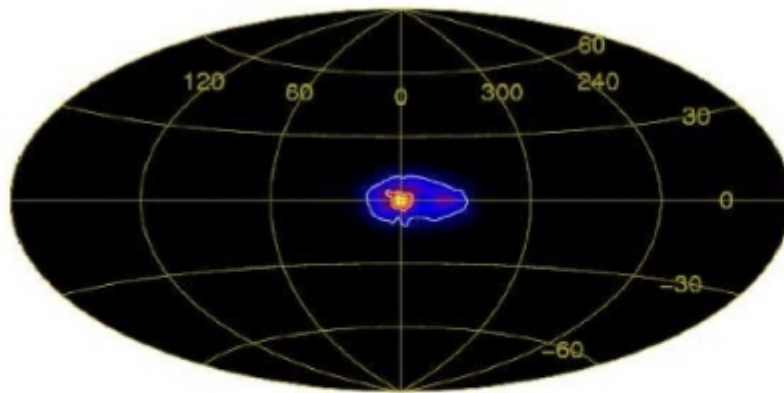
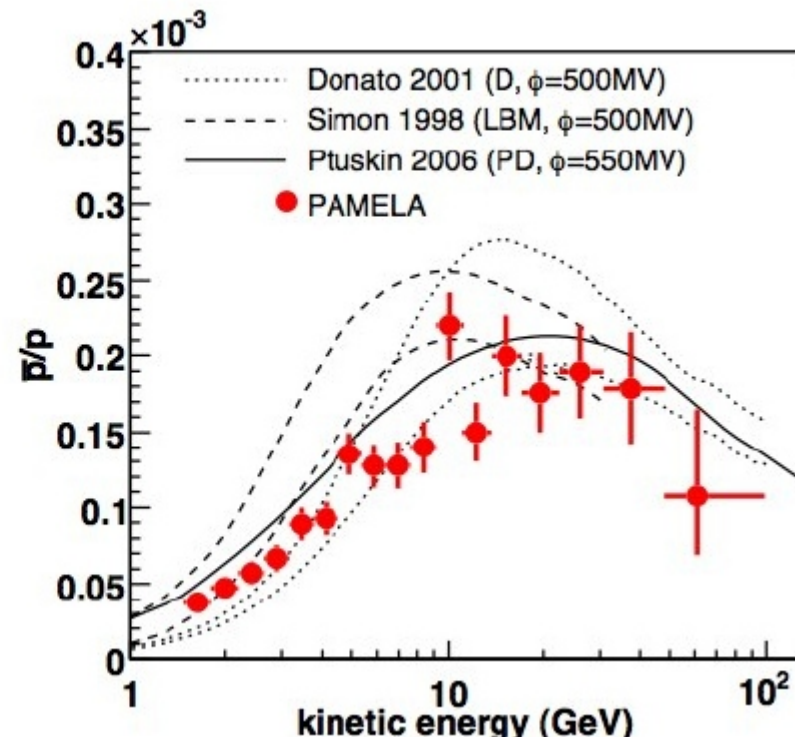
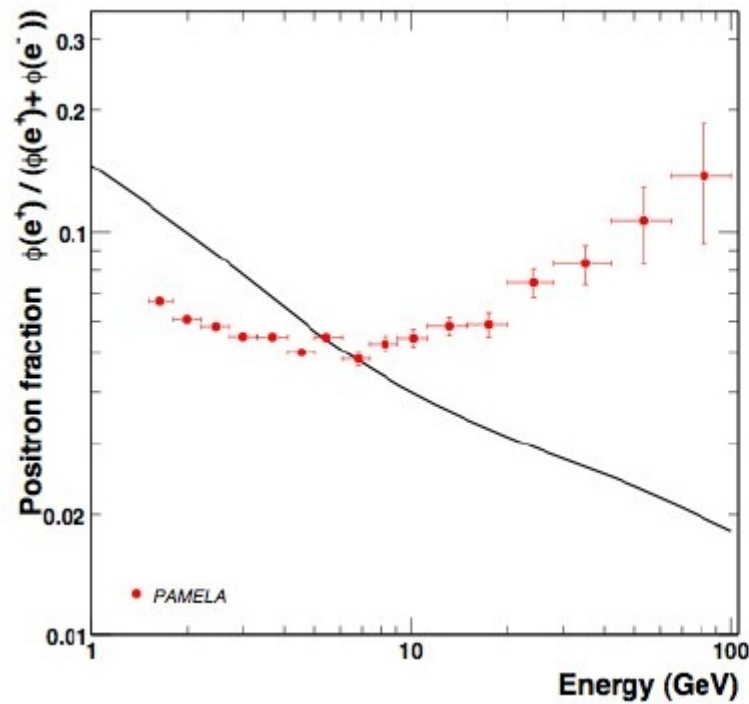
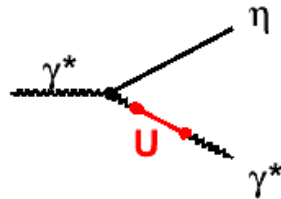
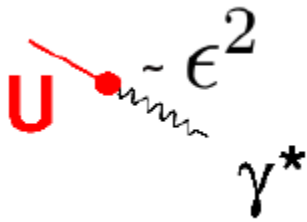


FIG. 4 511 keV line map derived from 5 years of INTEGRAL/SPI data (from Weidenspointner *et al.*, 2008a).

FIG. 7 Map of Galactic  $^{26}\text{Al}$   $\gamma$ -ray emission after 9-year observations with COMPTEL/CGRO (from Plüschke *et al.*, 2001).

# Dark matter photon

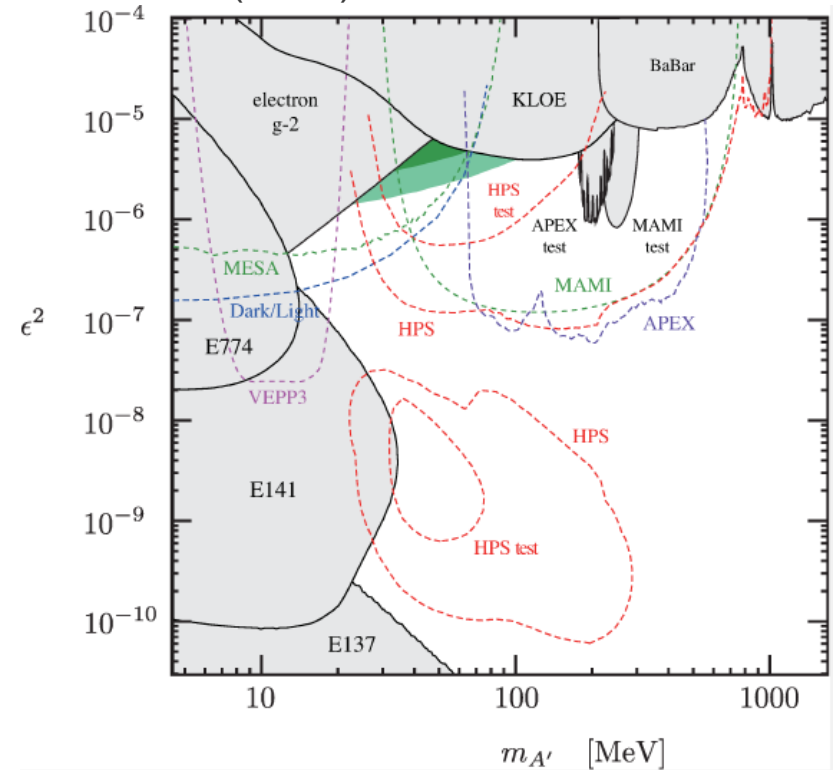
Hypothesis: Dark matter particles interact via:  
Vector boson with mass 1 MeV - 1 GeV:  
- can mix with photon ( parameter  $\epsilon$  )



It could explain:

- astrophysics anomalies
- muon magnetic moment anomaly

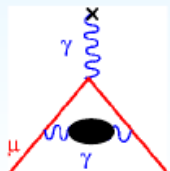
Arkani-Hamed PRD79  
(2009)015014



World wide efforts:  
dark/hidden photon, U boson,  $A'$

# Muon magnetic moment anomaly

$$a_{\mu}(\text{Expt.}) = 116592089(63) \pm 10^{-11} \quad (0.54 \text{ ppm})$$

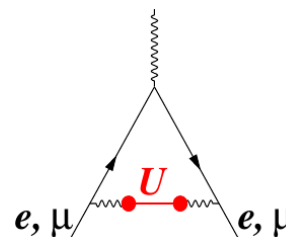
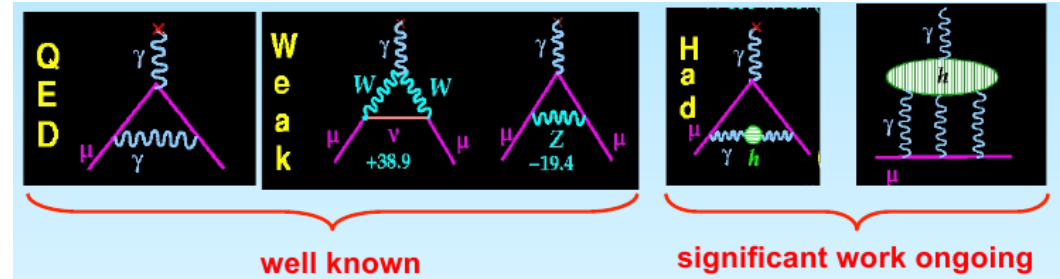
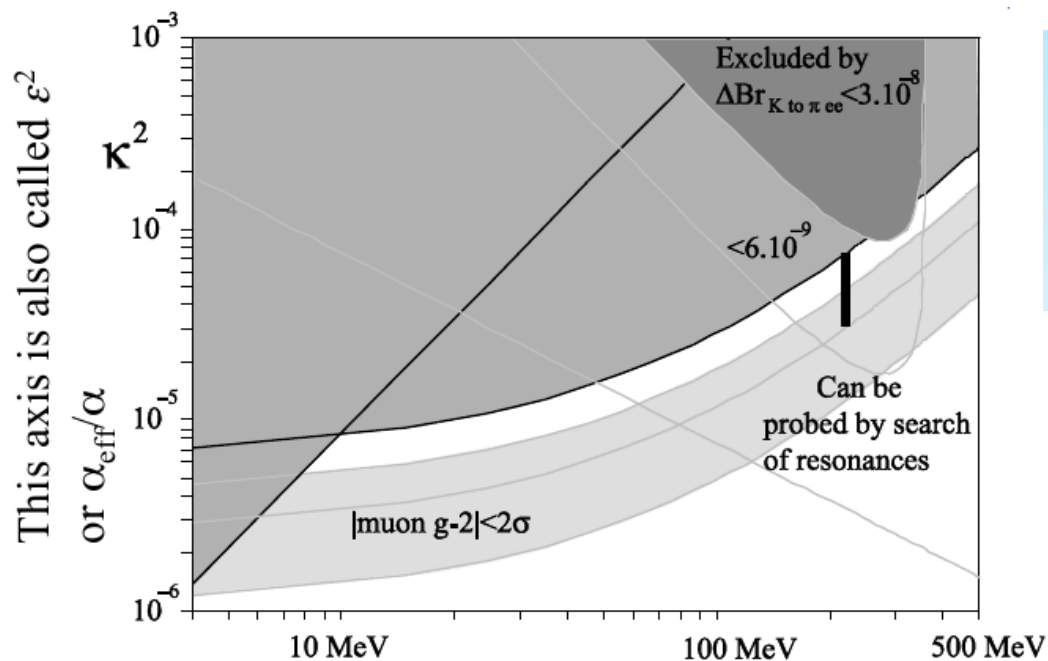
$$\vec{\mu} = g \left( \frac{Qe}{2m} \right) \vec{s} \quad g = 2(1 + a); \quad a = \frac{(g - 2)}{2}$$


$a$  is the muon anomaly, due to VP effects ( $g=2$ , according to Dirac eq.)

$$a_{\mu}^{SM} = 116\,591\,802 \pm 49 \times 10^{-11} \quad \text{M. Davier et al. 2011}$$

$$a_{\mu}^{E821} - a_{\mu}^{SM} = (287 \pm 80) \times 10^{-11} \quad (3.6 \sigma)$$

Hint of new physics?

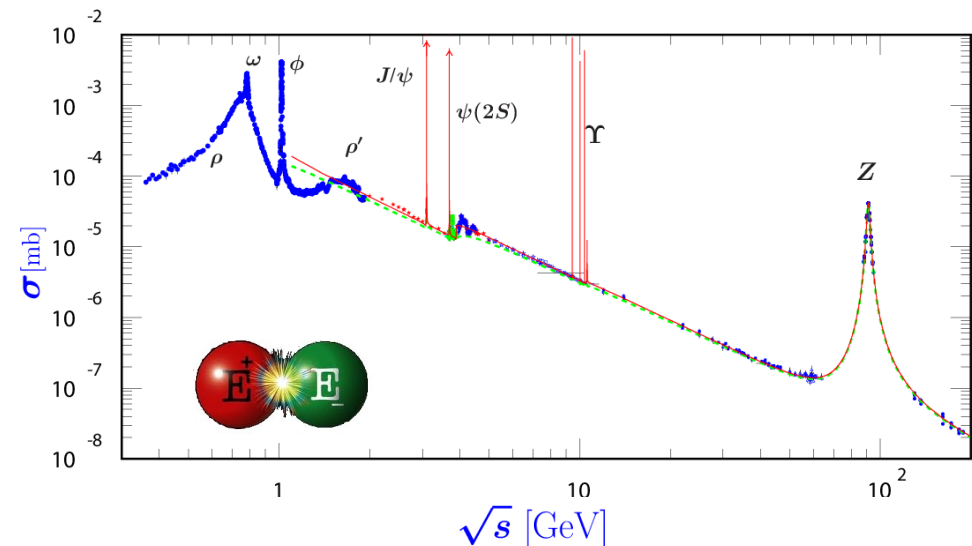
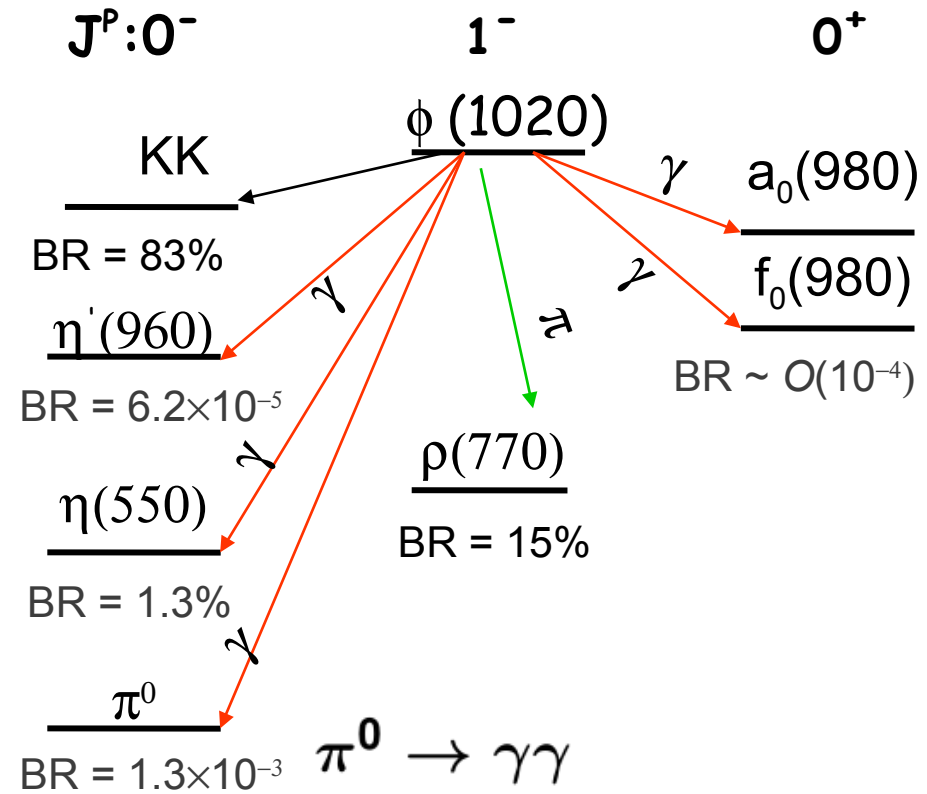


(Krasnikov, Gninenko; Fayet; Pospelov)

# Light neutral mesons

- $u\bar{u}$ ,  $d\bar{d}$ ,  $s\bar{s}$  systems
- quantum mixing

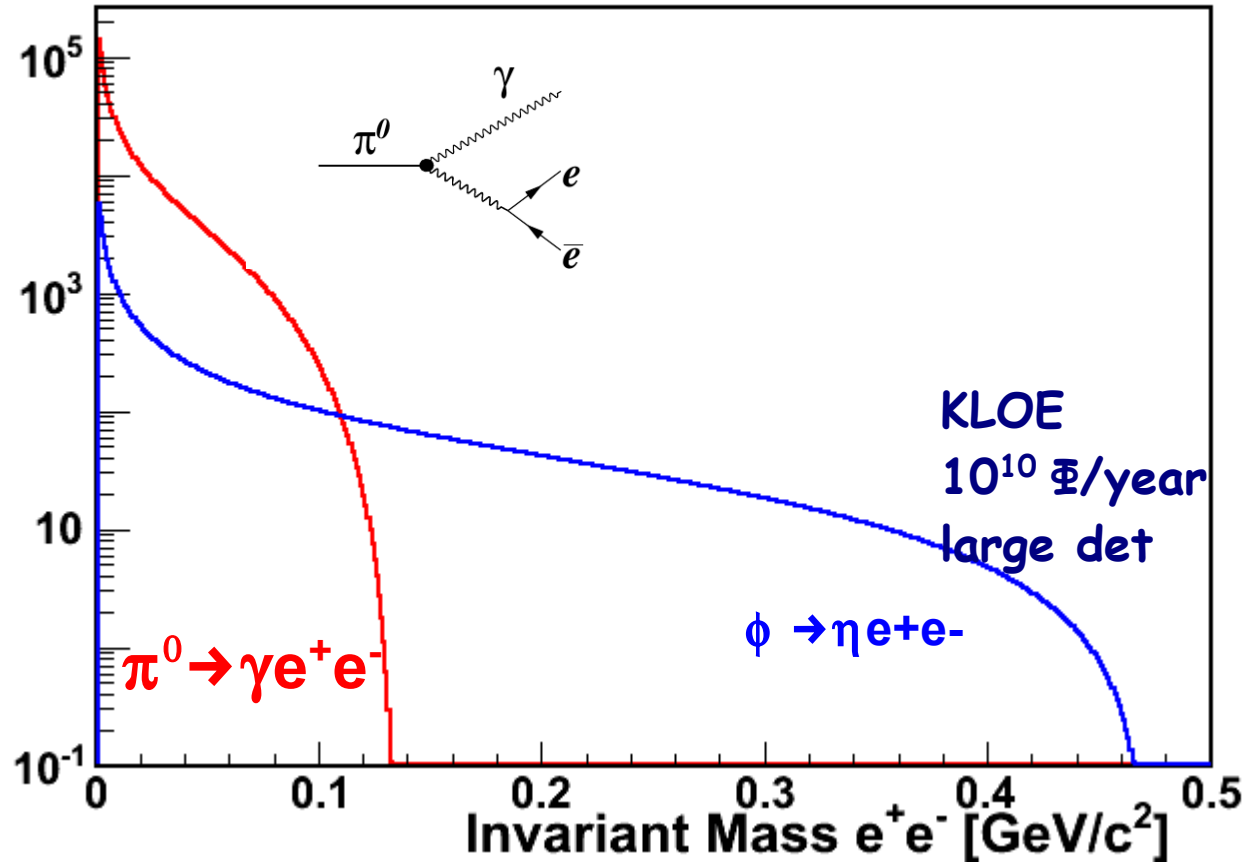
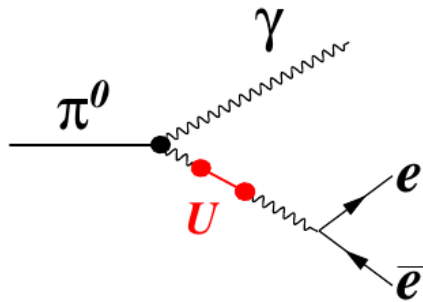
para Ps  $2\gamma$  annihilation  $^1S_0 \rightarrow \pi^0, \eta$   
 ortho Ps  $3\gamma$  annihilation  $^3S_1 \rightarrow \Phi$



# Dalitz decays

$$\pi^0 \rightarrow \gamma e^+ e^-$$

$$2m_e < m_U < m_\pi$$



**WASA-at-COSY**

$pp \rightarrow pp\pi^0$

$10^4 \pi^0/s$

**small detector**

C-O Gullstrom UU  
 M. Berlowski NCBJ  
 M. Hodana JU  
 J. Zdebik JU  
 I Sarra, Roma ...



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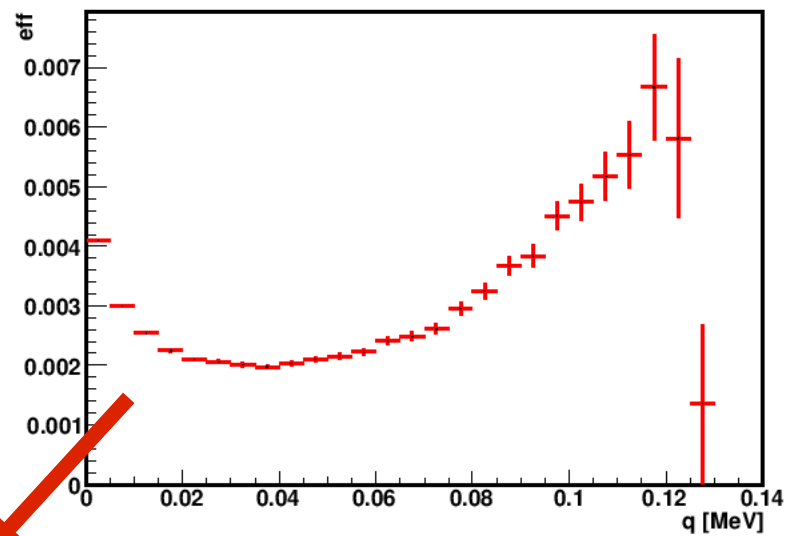
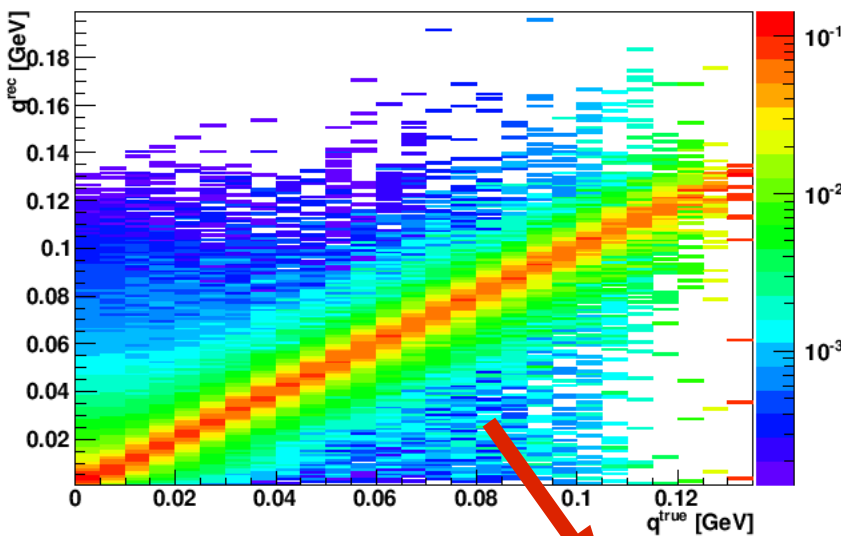
# Search for: $\pi^0 \rightarrow \gamma U \rightarrow \gamma e^+ e^-$



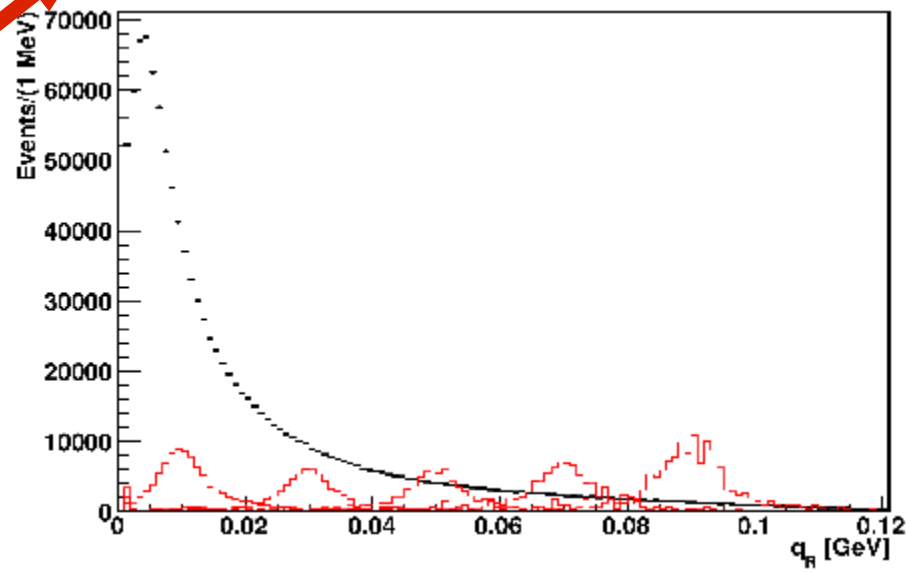
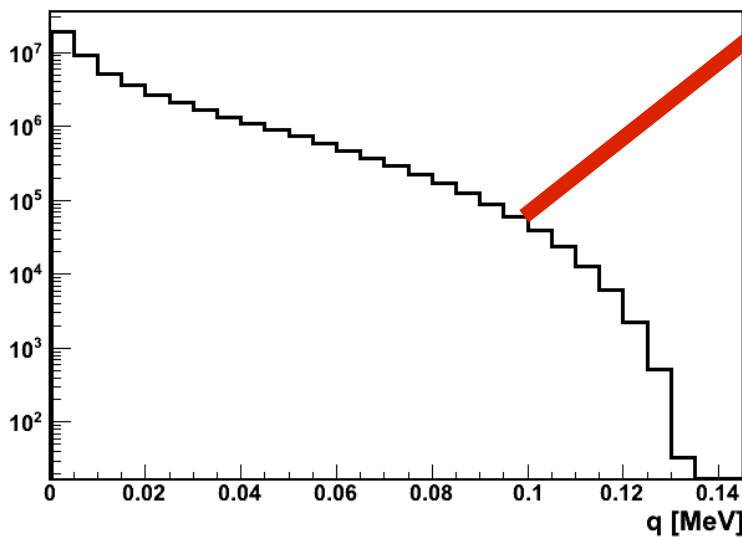
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Smearing matrix



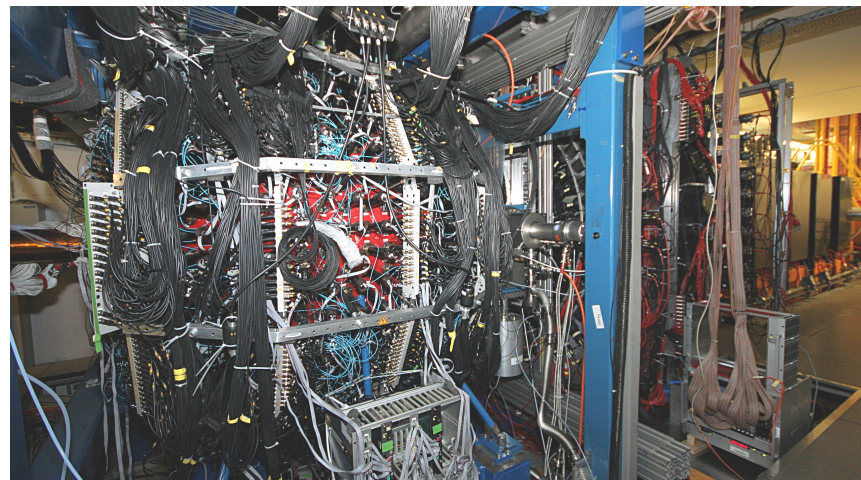
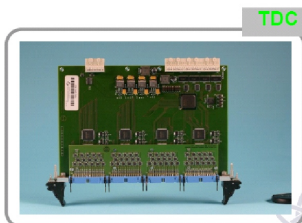
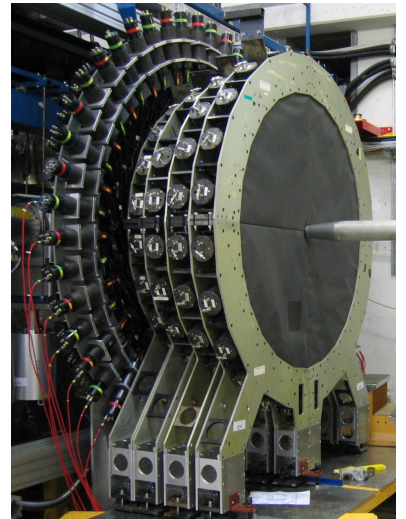
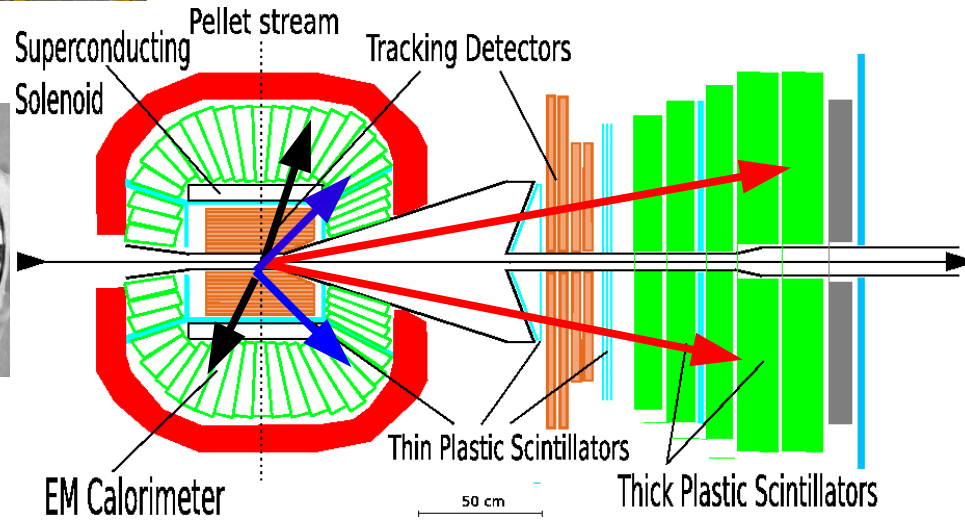
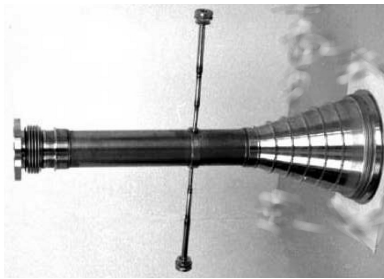
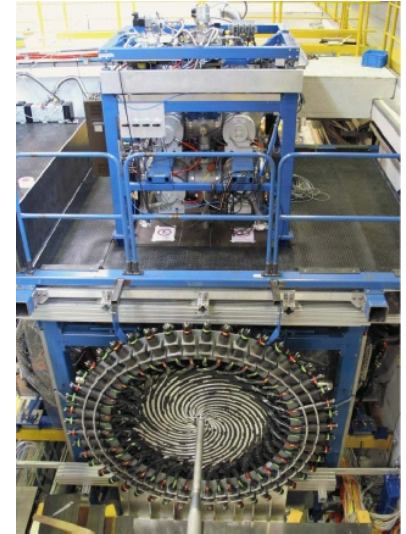
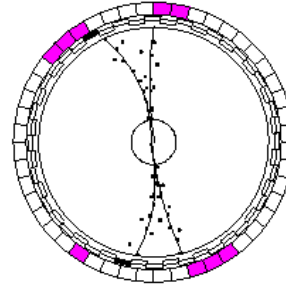
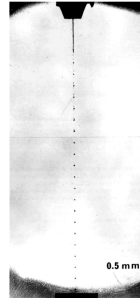
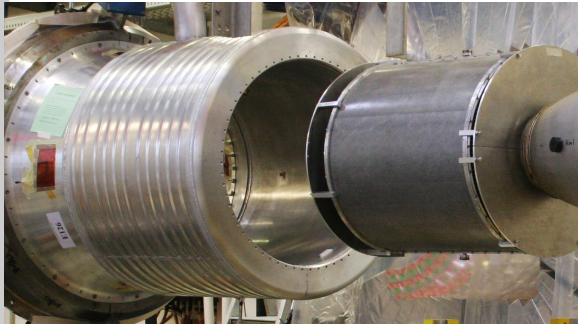
$$N_i^d / N_{Tot} = \sum_j S_{ij} \epsilon_j \nu_j (\pi^0 \rightarrow e^+ e^- \gamma) + S_{ik} \epsilon_k \beta_k$$





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# WASA detector



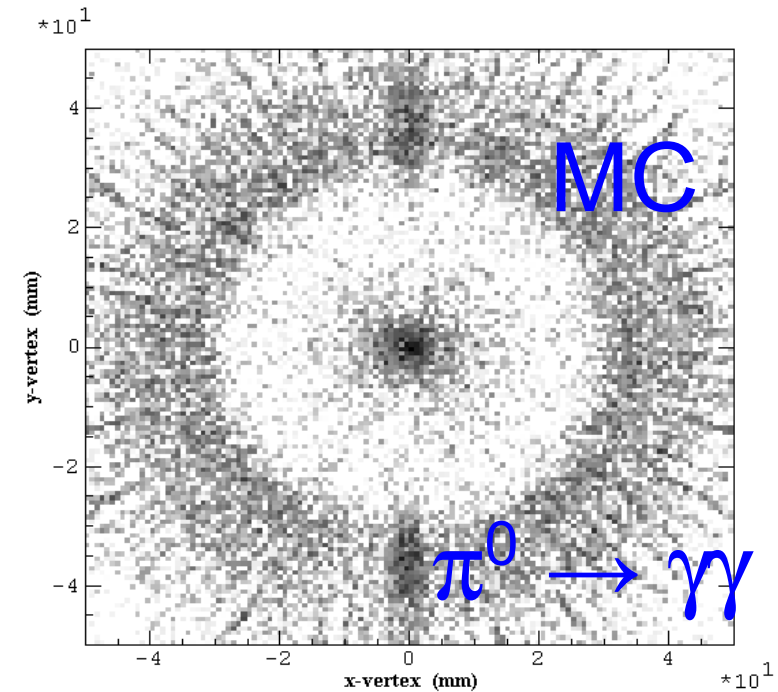
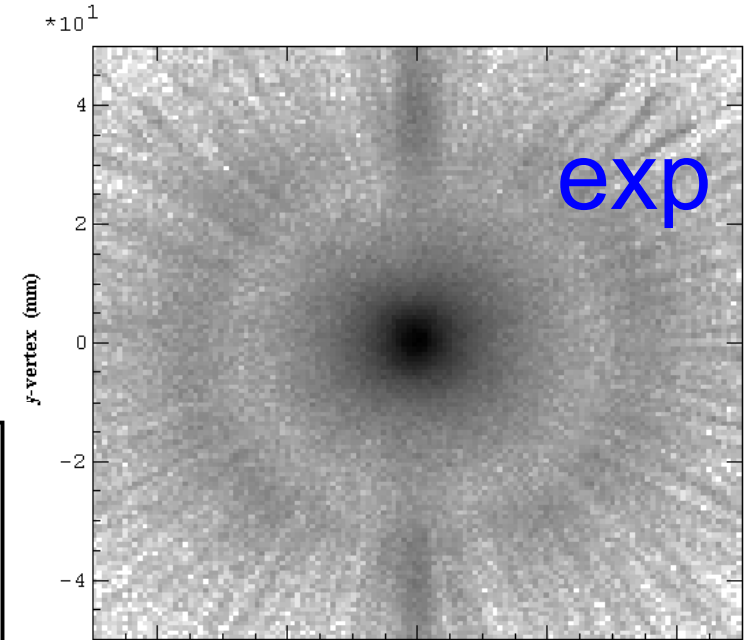
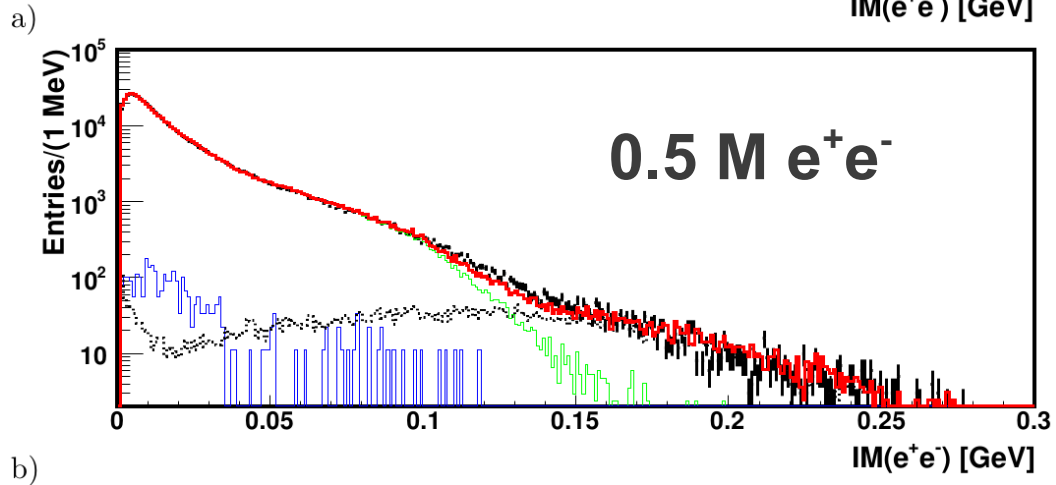
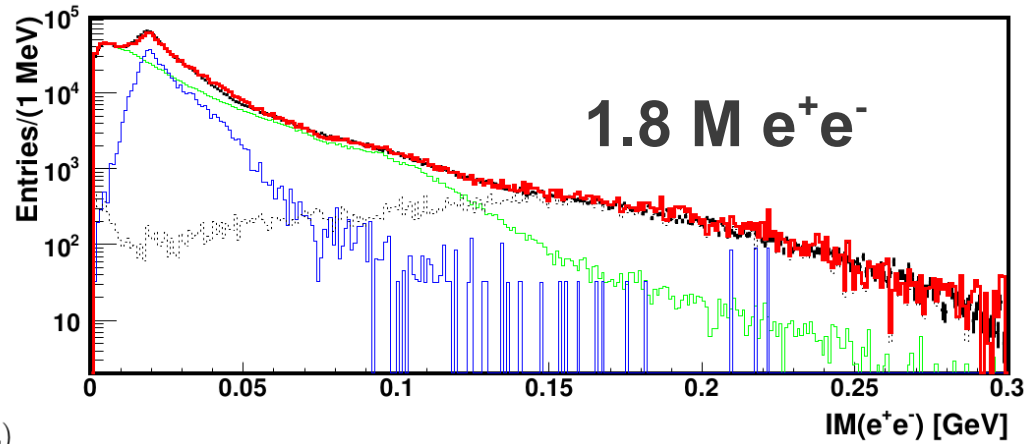
NIM A594,339

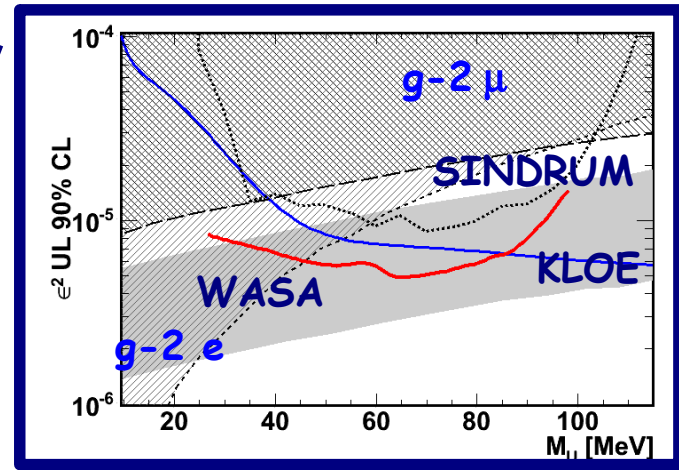
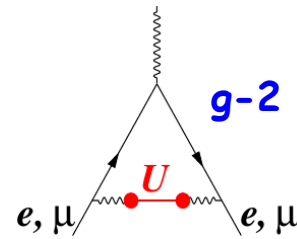
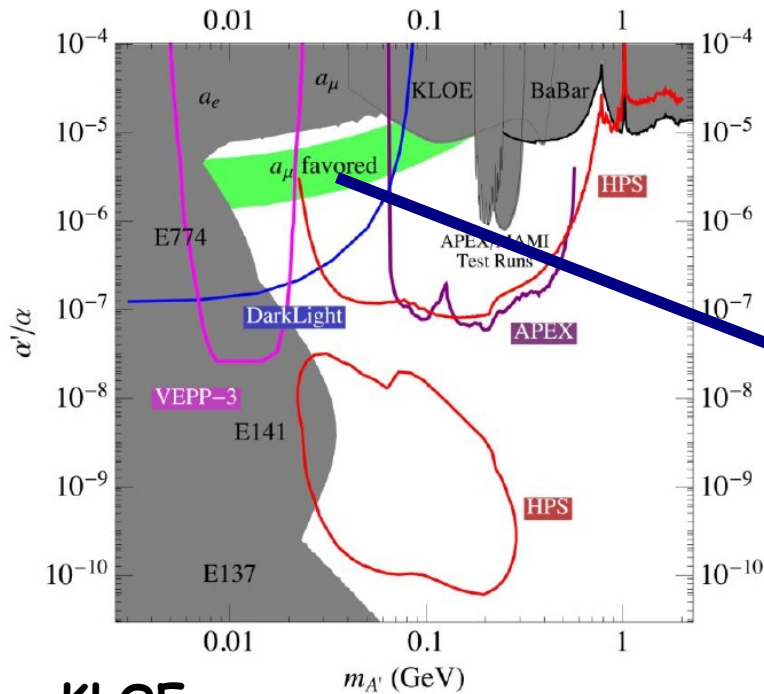


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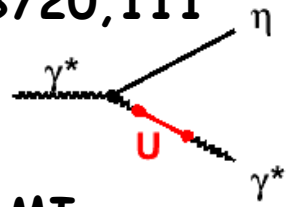


# Data analysis: $\pi^0 \rightarrow \gamma e^+ e^-$



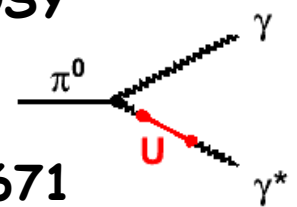


**KLOE**  
 $\phi \rightarrow \eta e^+ e^-$   
 PLB706,251  
 PLB720,111



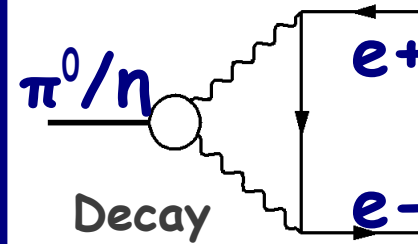
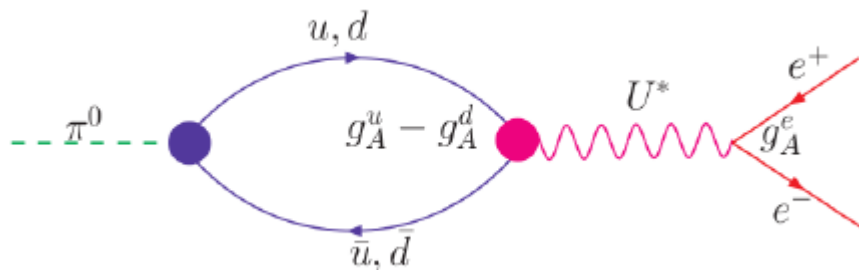
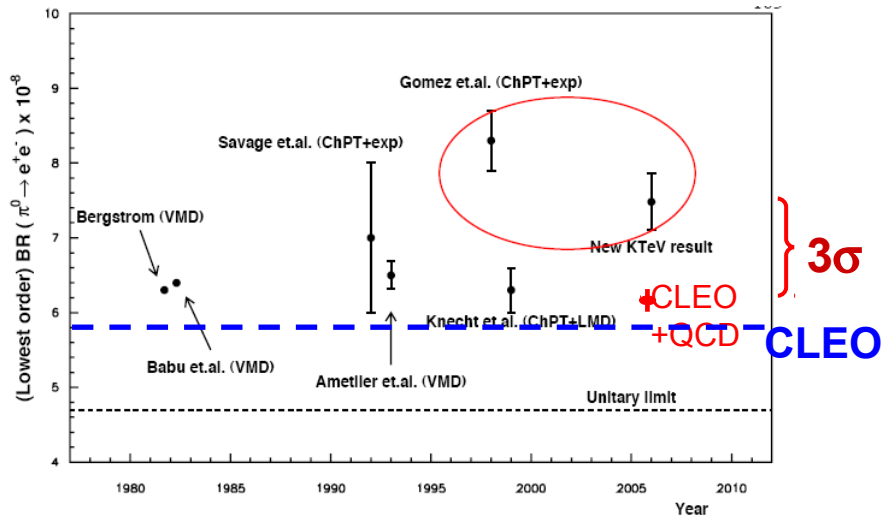
**MAMI**  
**NA48**  
**BESIII**

**WASA-at-COSY**  
 $\pi^0 \rightarrow \gamma e^+ e^-$   
 arXiv:1304.0671



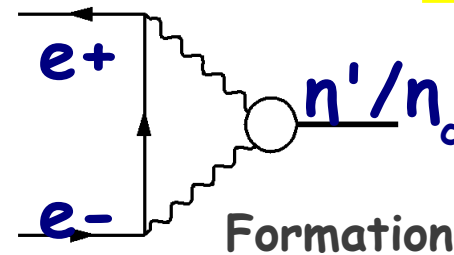
**g-2 preferred region will  
 covered soon (this year?)**

# $\pi^0, \eta \rightarrow e^+e^-$



HADES  
WASA  
CBall

	UB	SM <b>3σ diff</b>	EXP
$\mathcal{B}(\pi^0 \rightarrow e^+e^-) \times 10^8$	$\geq 4.69$	$6.23 \pm 0.12$	$7.49 \pm 0.38$ KTeV2007
$\mathcal{B}(\eta \rightarrow e^+e^-) \times 10^9$	$\geq 1.78$	$5.2 \pm 0.3$	$\leq 5.6 \cdot 10^3$ HADES2012
$\mathcal{B}(\eta' \rightarrow e^+e^-) \times 10^{10}$	$\geq 0.36$	$1.9 \pm 0.3$	$\leq 2.1 \cdot 10^3$ ND1988
$\mathcal{B}(\eta_c \rightarrow e^+e^-) \times 10^{14}$	$\geq 4.2$	<b>Dorokhov, PLB667,145</b>	



Nsk  $L=0.5\text{pb}^{-1}$

VEPP2000  
BESIII  
DAΦNE?

