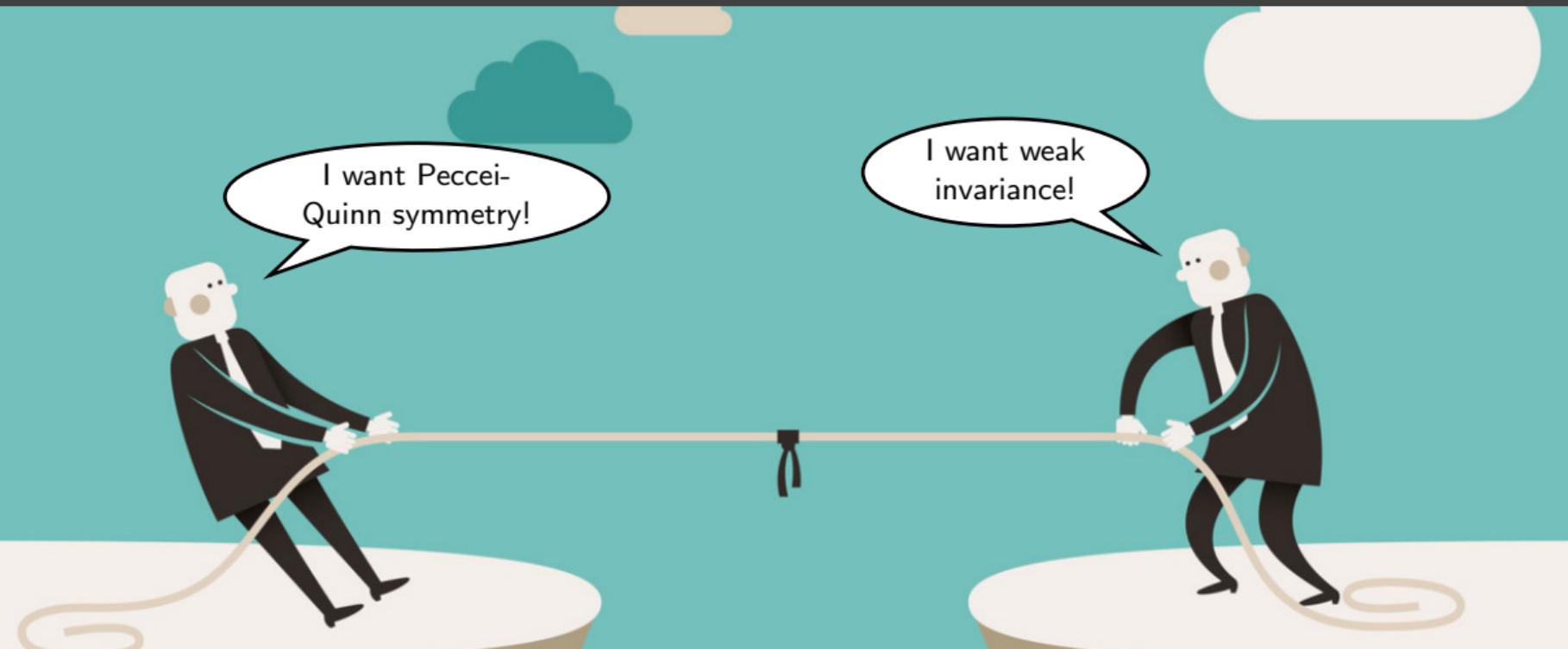


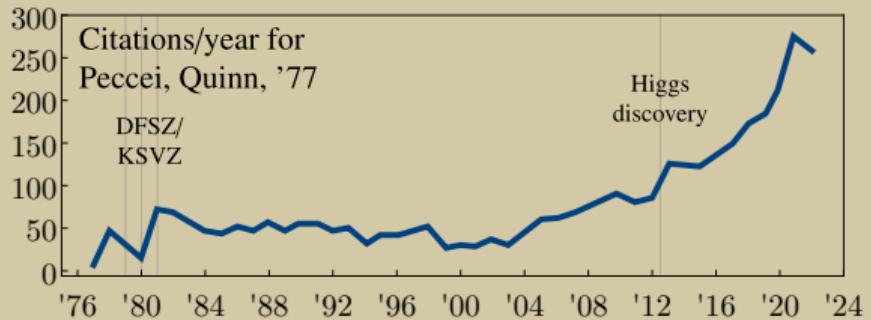
# New Insights Into Axion-Lepton Interactions

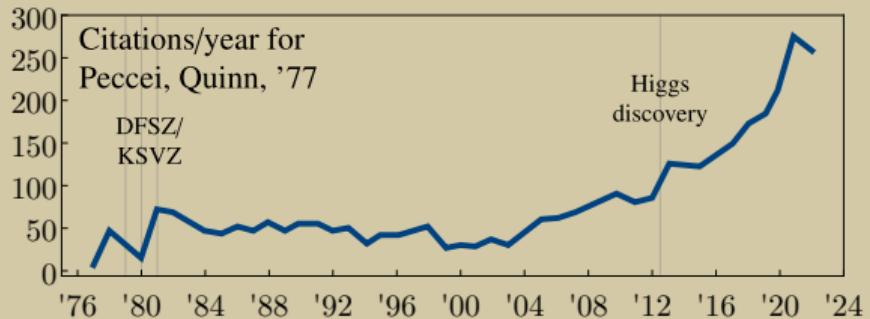
Aspen Center for  
Physics

Jeff Dror

[2209.00665]  
w/ Altmannshofer, Gori





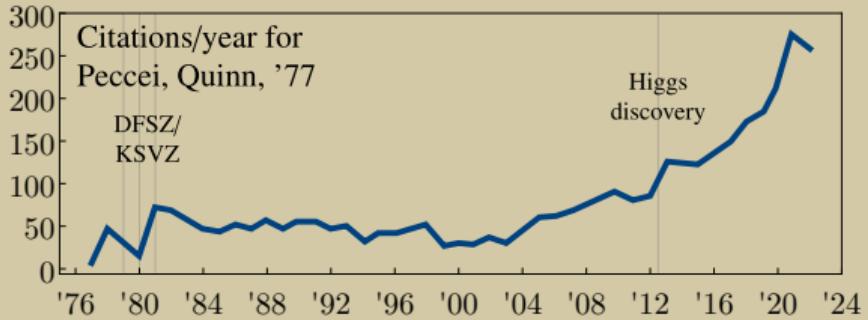


UF

Tokyo

The Axion

ADMX



# Lepton-Axion Effective Theory

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Is the vector coupling physical?

Is  $\partial_\mu a \bar{\ell} \gamma^\mu \gamma_5 \ell = -m_\ell a \bar{\ell} \gamma_5 \ell$ ?

Is the neutrino term  $\propto m_\nu$ ?

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$3 \rightarrow 2$  parameters

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RG flow

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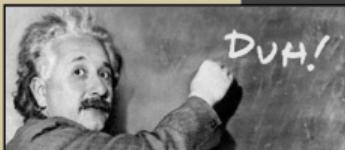
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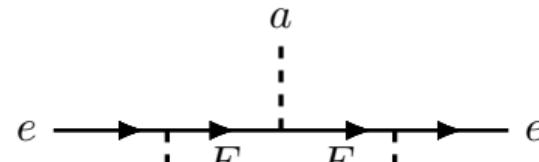


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dramatic consequences

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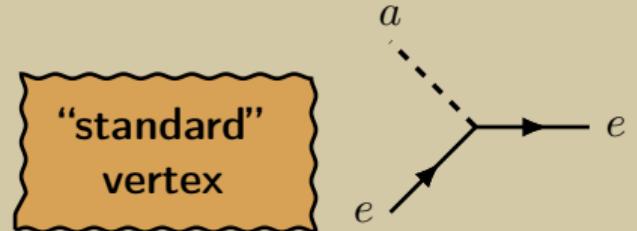
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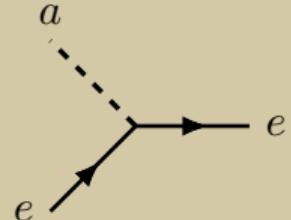
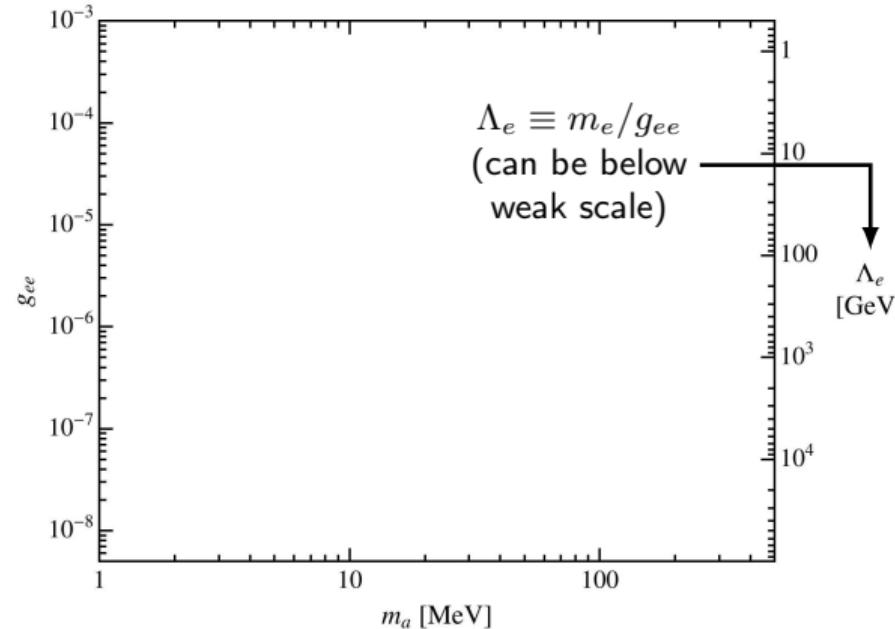
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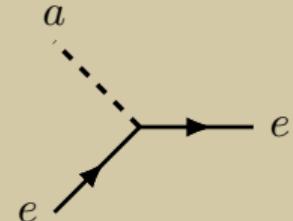
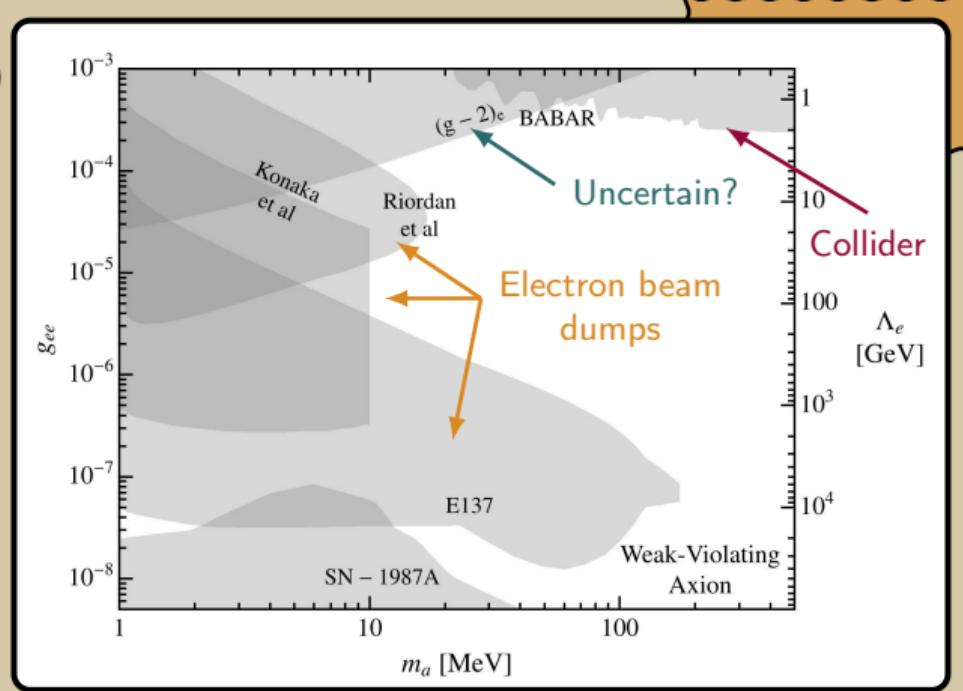
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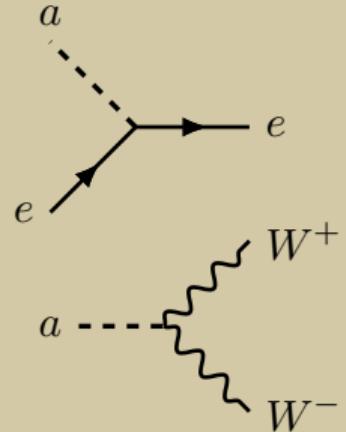
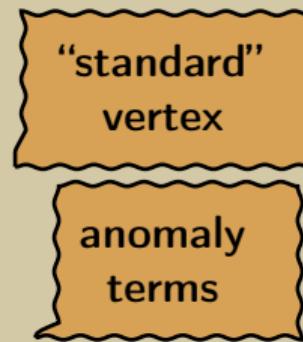


[BABAR - '14], [Riordan et al - '87], [Bjorken et al - '88], [Bross et al - '91]  
 [Morel et al - '20], [Lucente, Carenza - '21]

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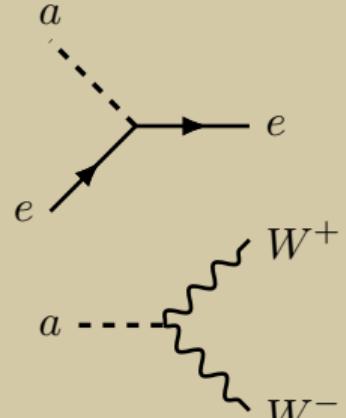
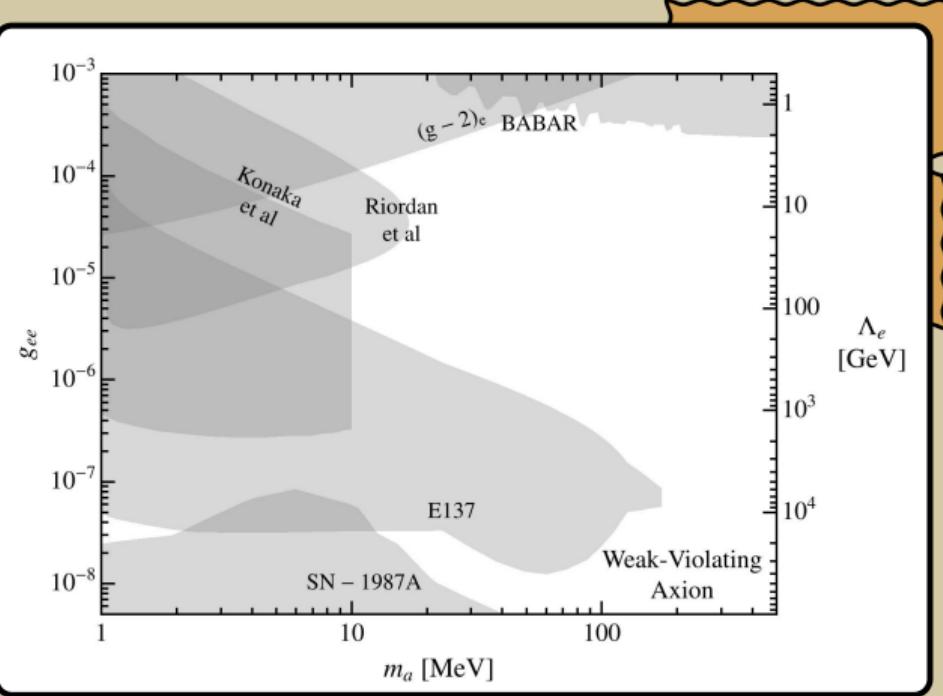
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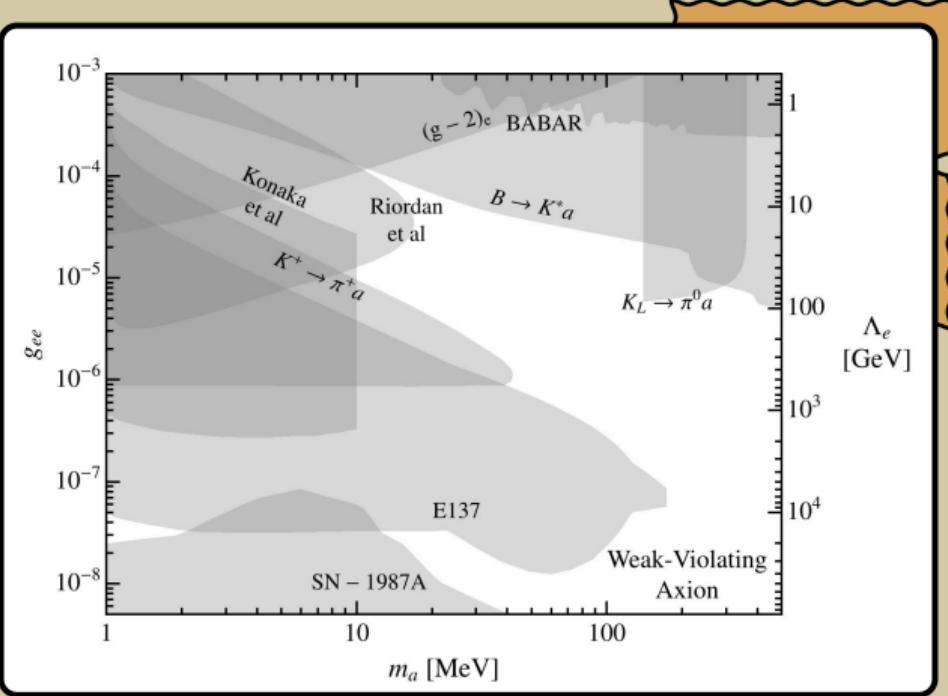
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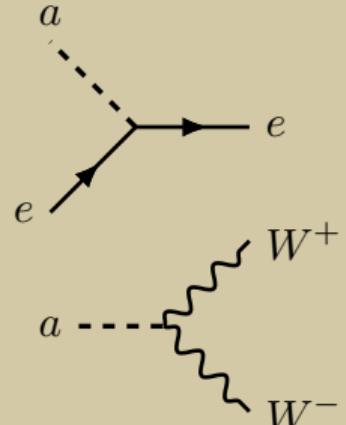
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[Bauer et al - '21]

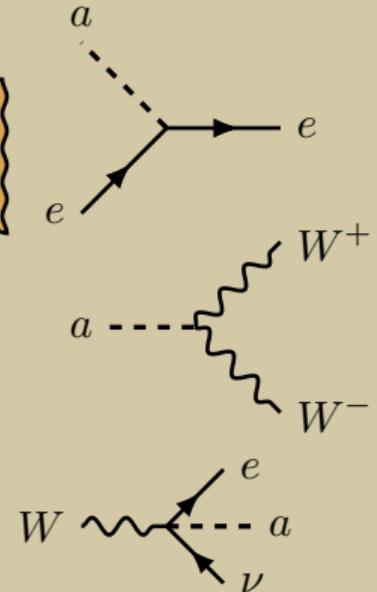
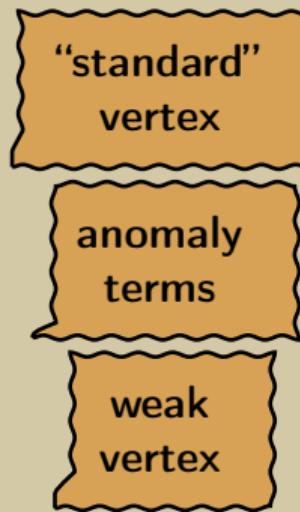


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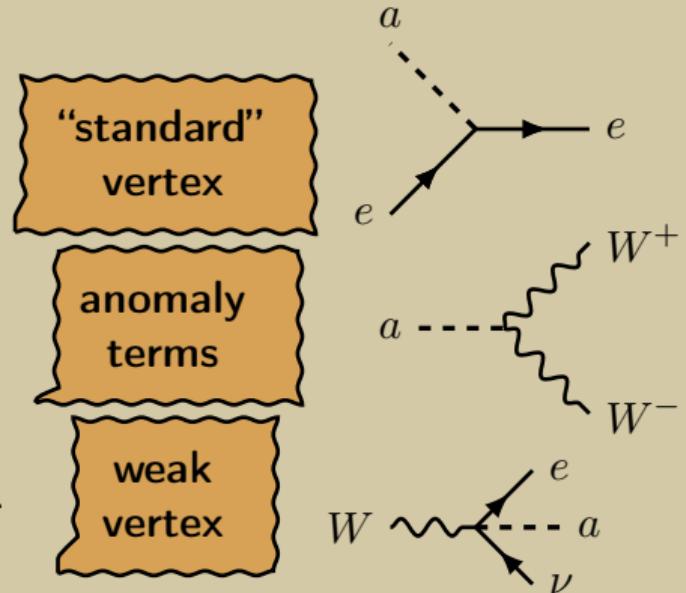


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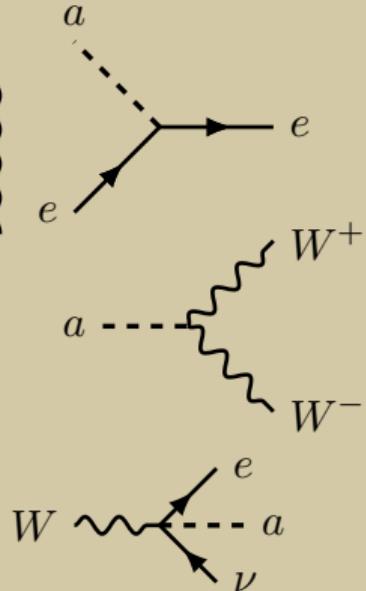
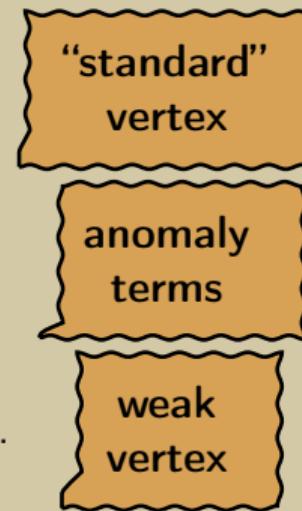
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charged  
meson  
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## ALPs from $\pi^+$ decay\*

↳ ALP removes helicity suppression

$$\nu \longleftrightarrow e^+$$

\*ALP- $\pi^0$  mixing and quark coupling

E.g., [Krauss, Wise - '86], [Bardeen et al - '87],  
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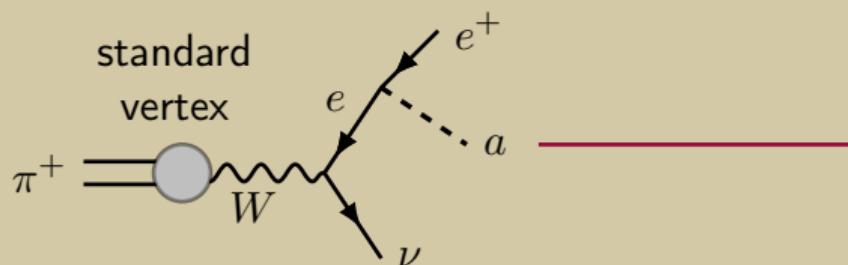
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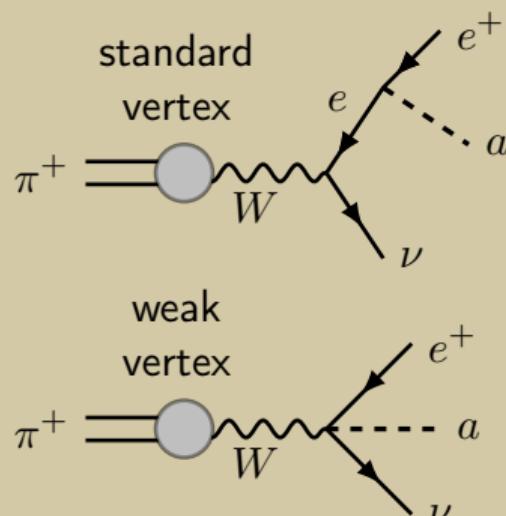
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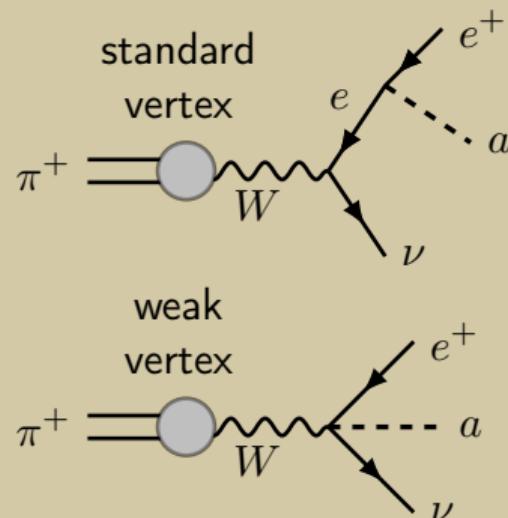
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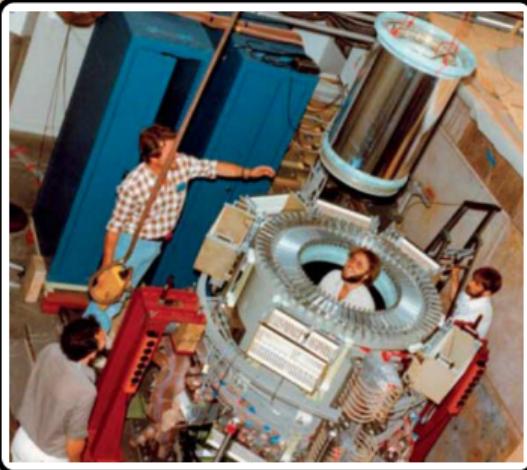
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## Experimental Capabilities

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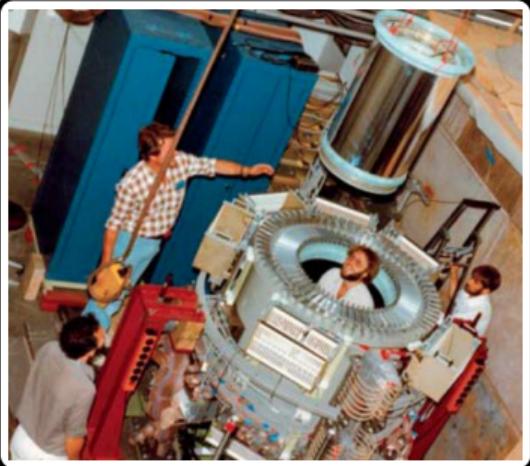
LIMITS FOR SHORT-LIVED NEUTRAL PARTICLES EMITTED IN  $\mu^+$  OR  $\pi^+$  DECAY  
SINDRUM Collaboration



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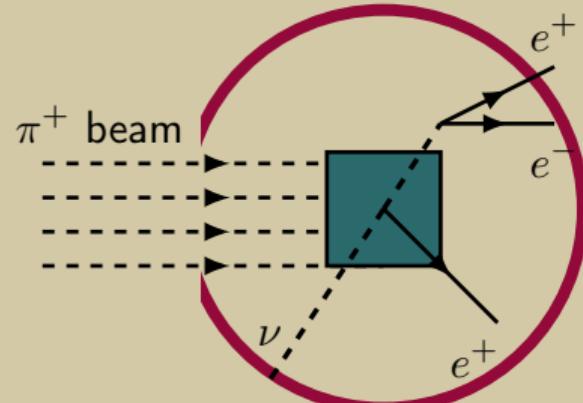


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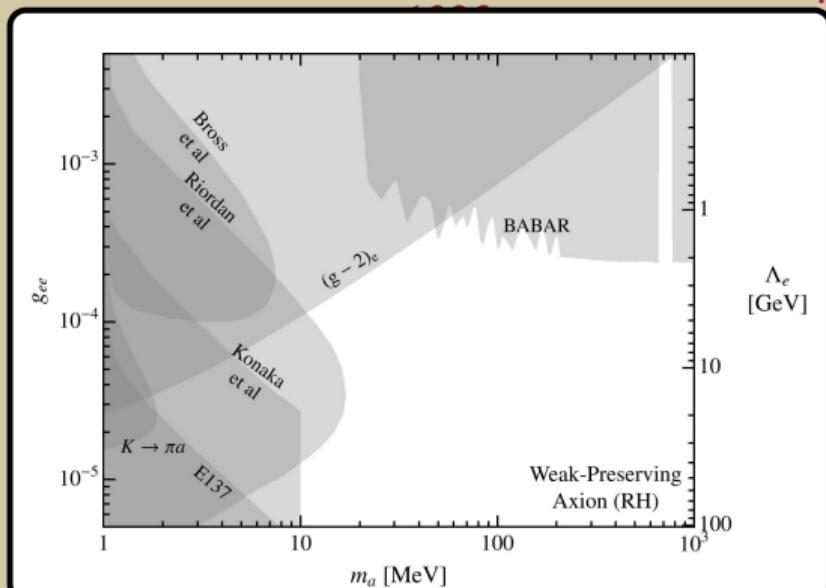


PSI Ring Cyclotron Proposal R-22-01.1  
PIONEER: Studies of Rare Pion Decays

W. Altmannshofer 1 H. Rinne 2 E. Blucher 3 D. Brusman 4,5 I. Cominada 6

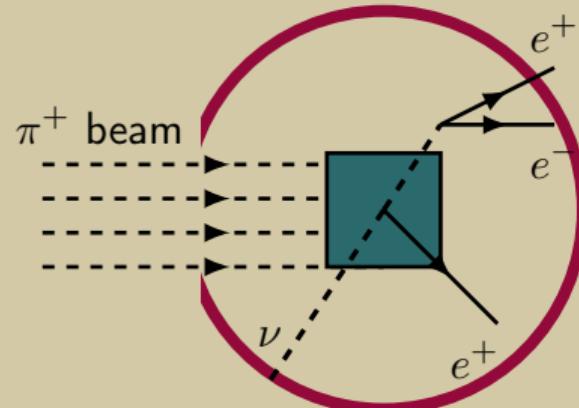


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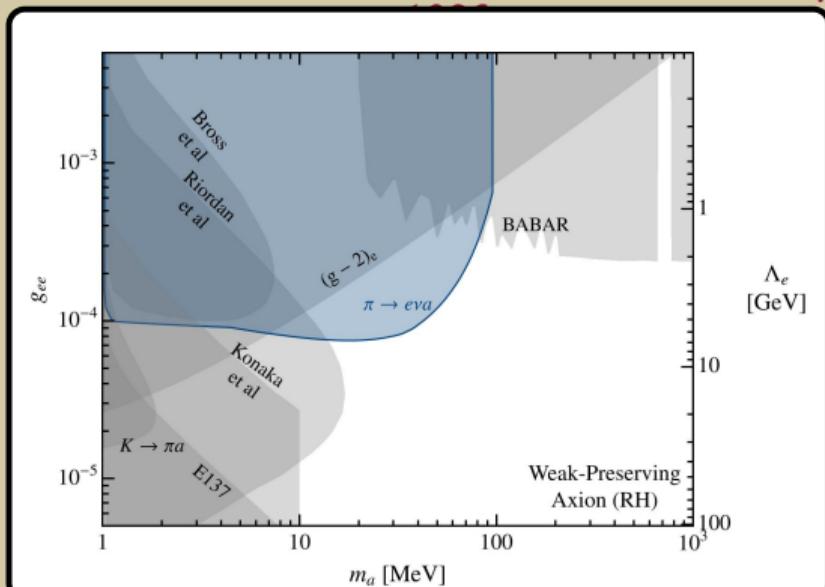


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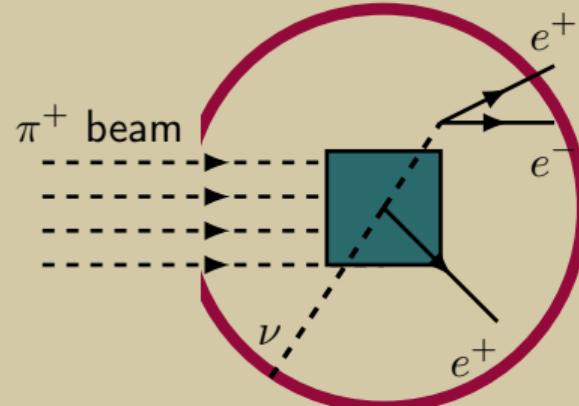


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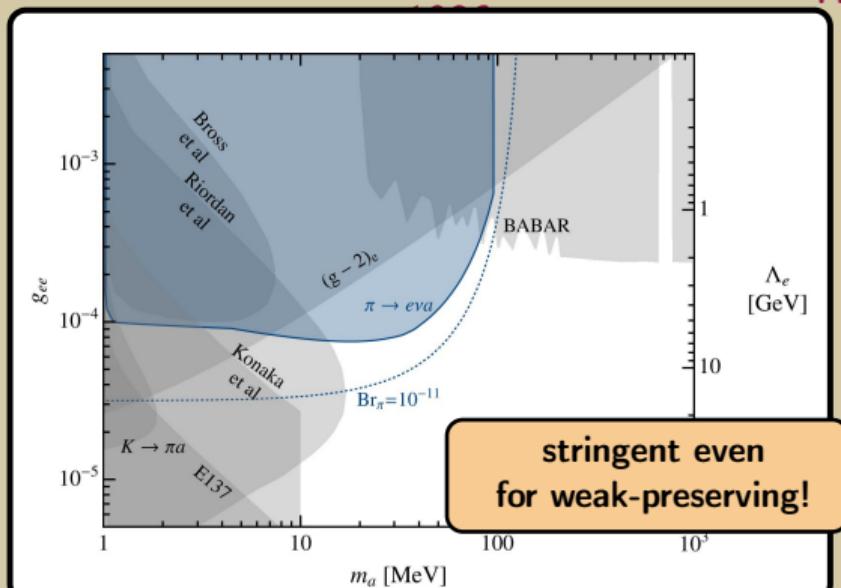


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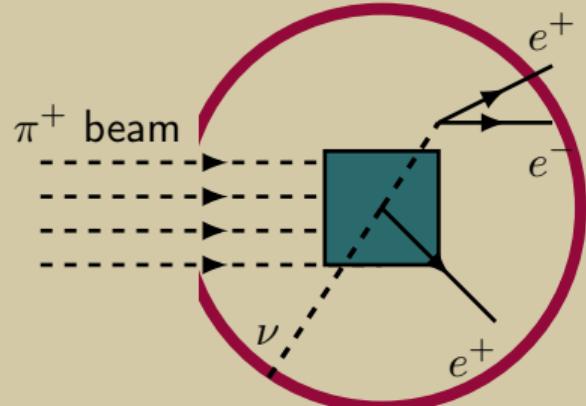


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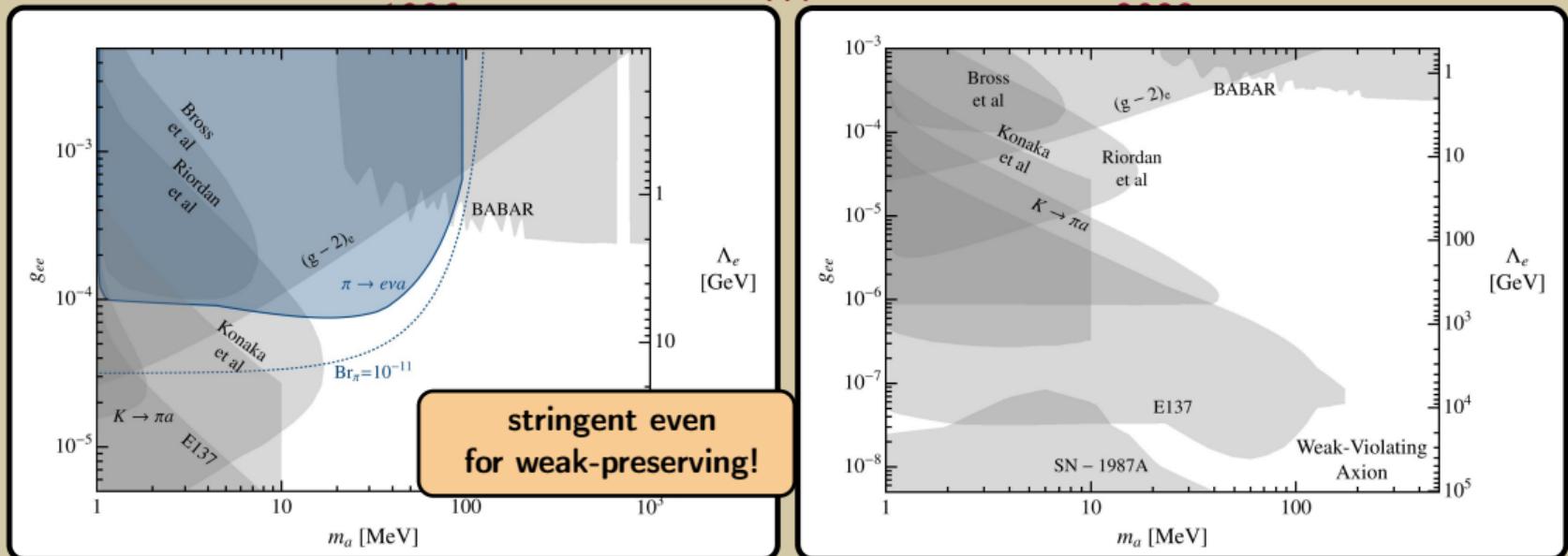
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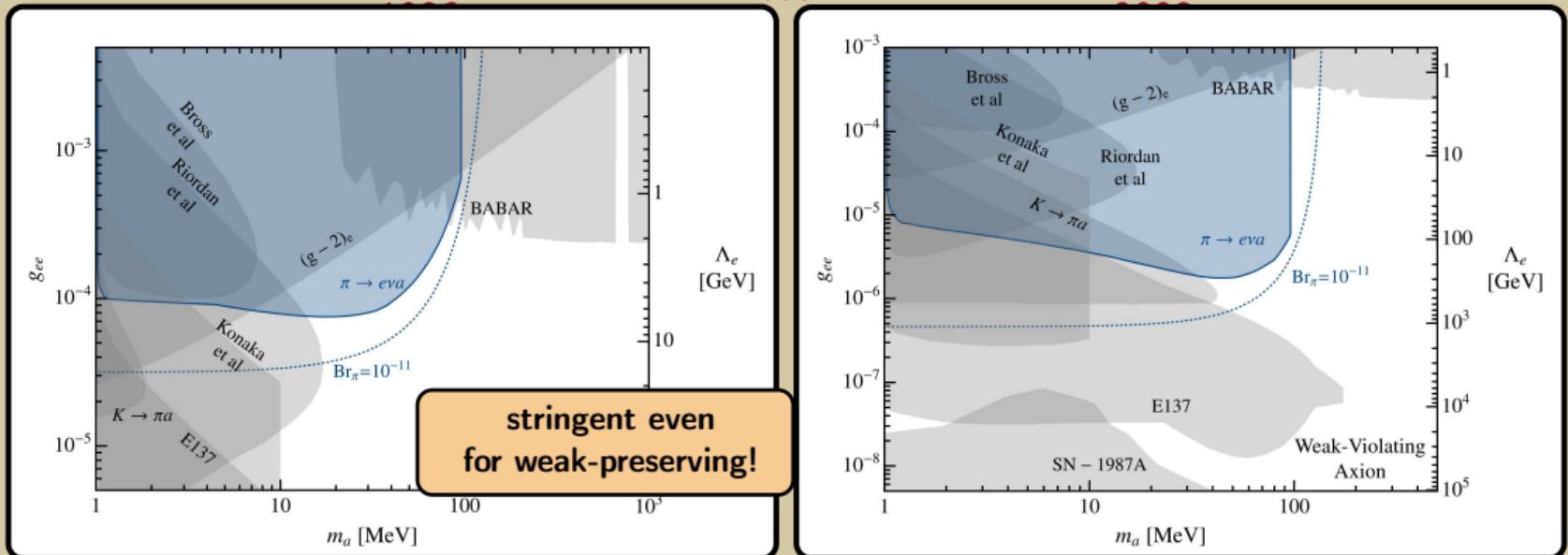
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time



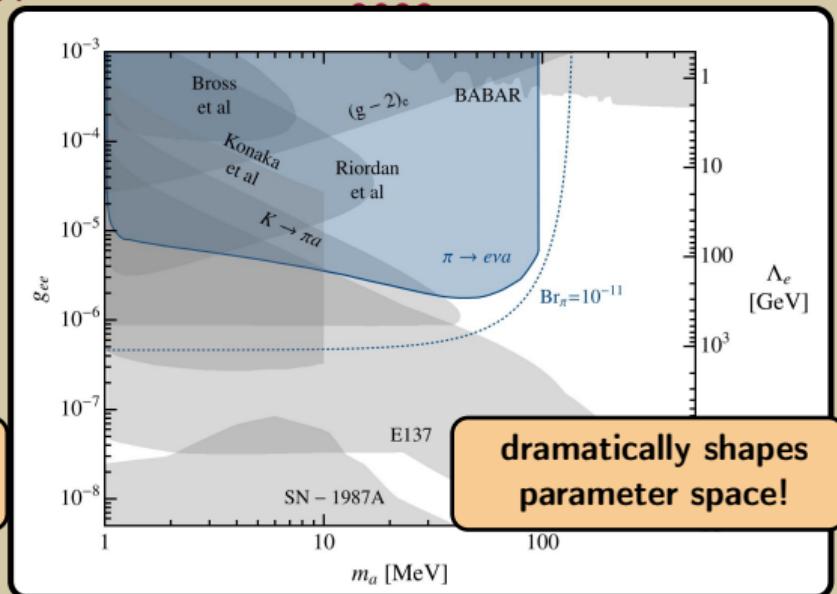
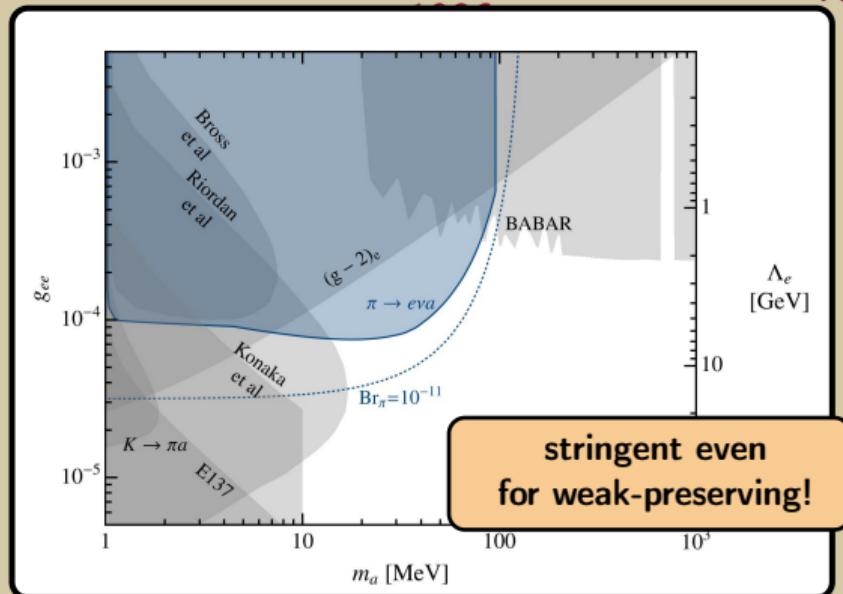
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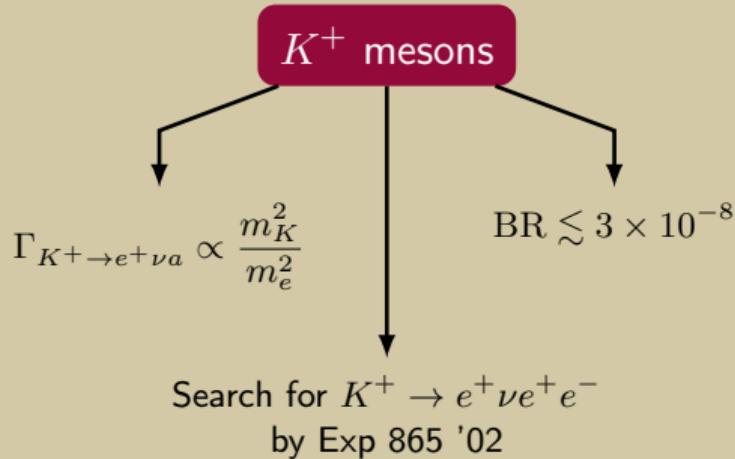


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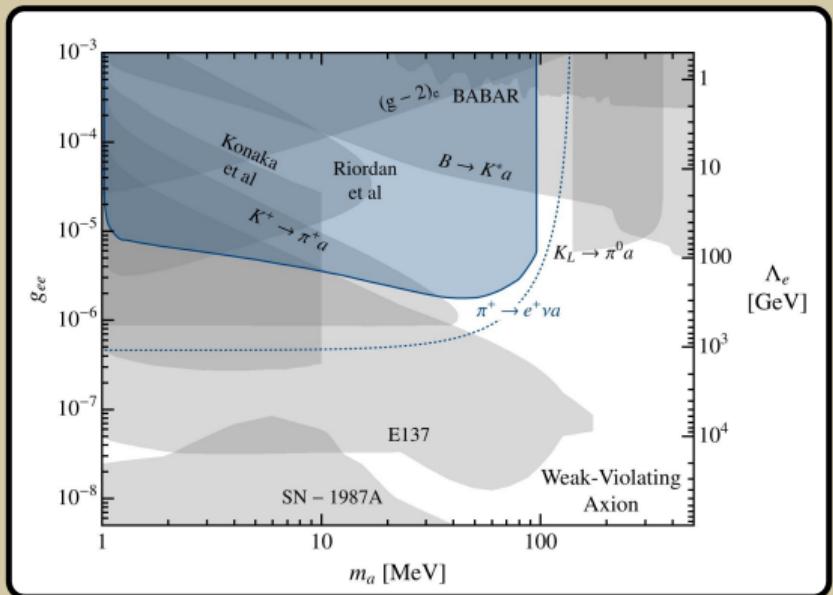
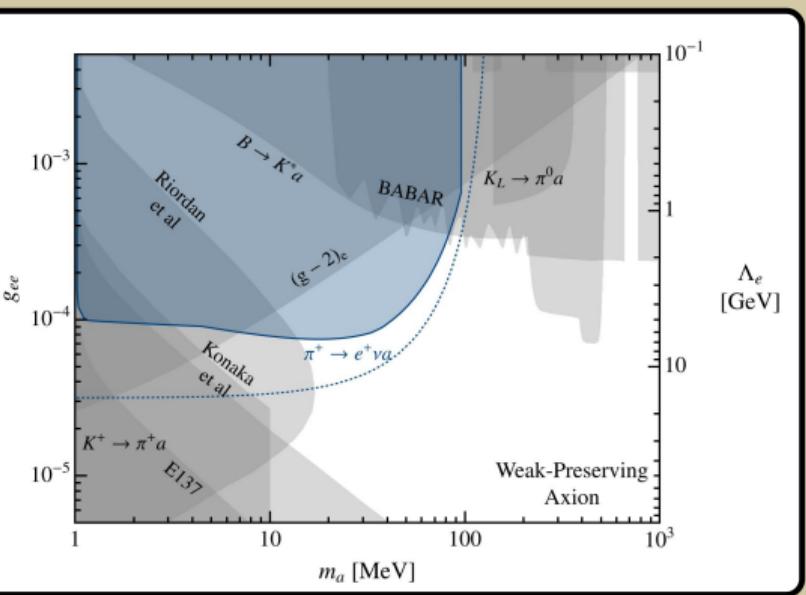


## Other Charged Mesons

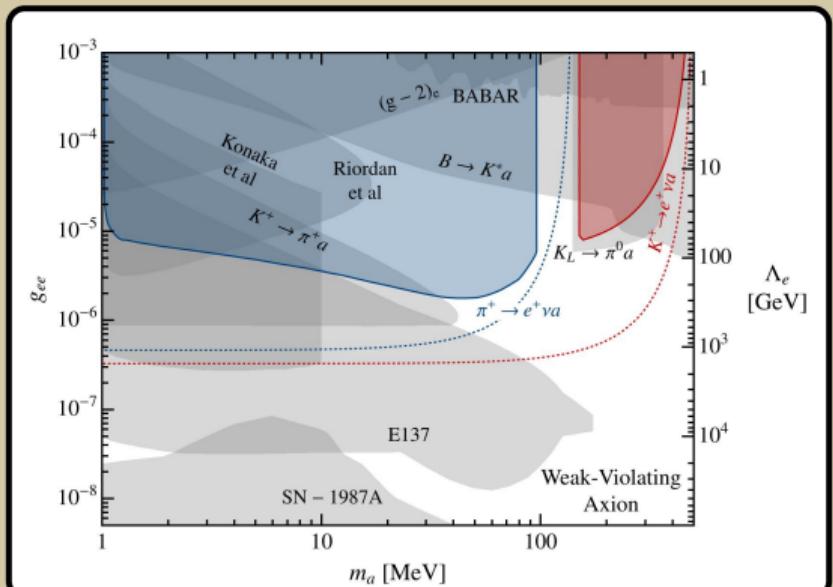
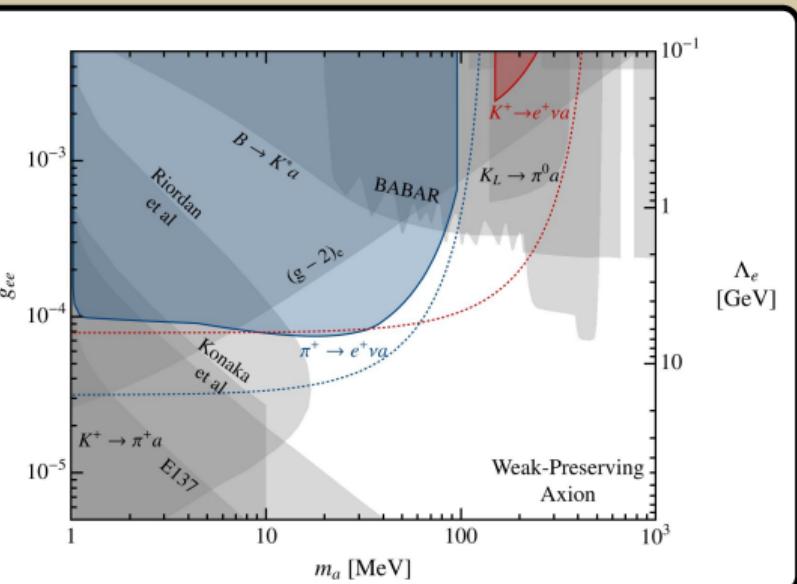


\*Improve with Kaon factories\*

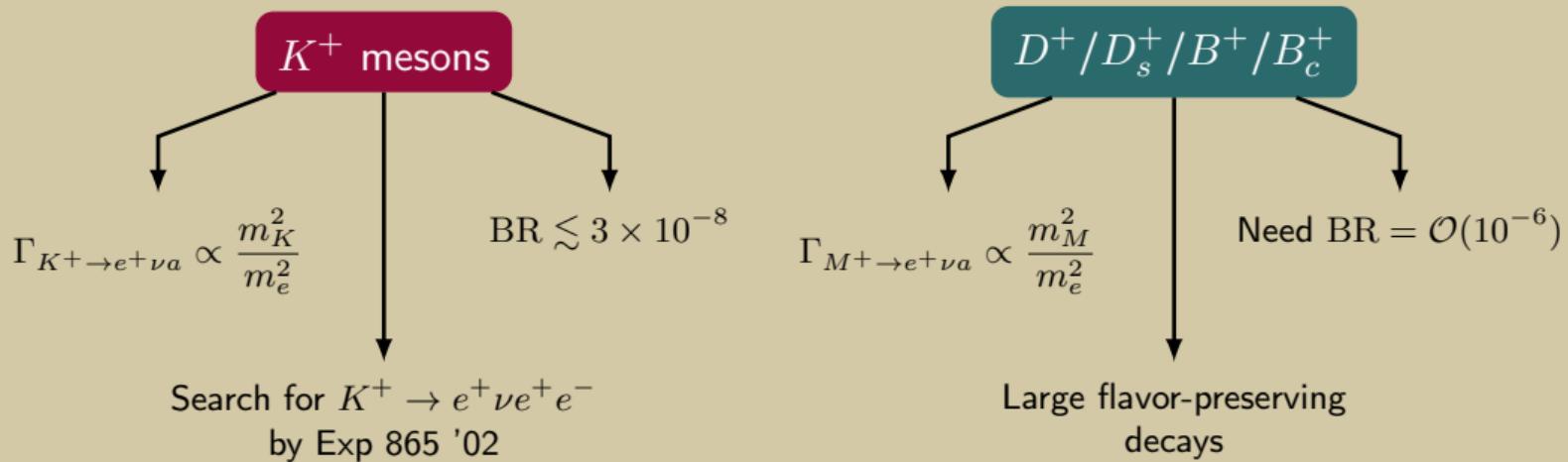
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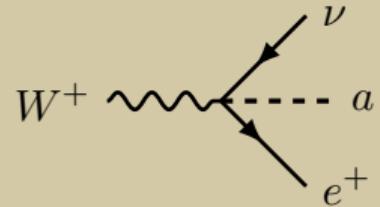
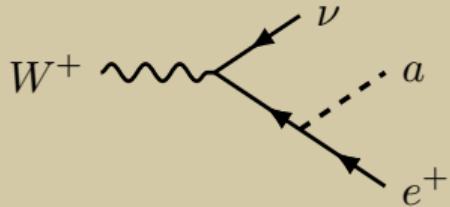


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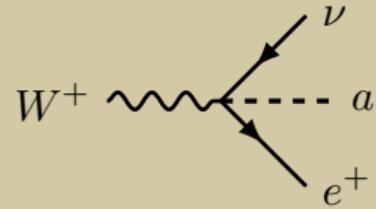
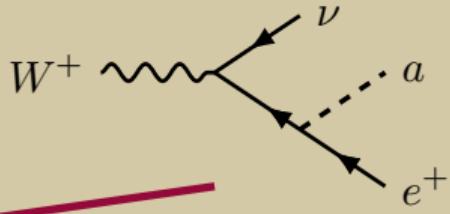


\*Improve with Kaon factories\*

## $W^+$ boson decay

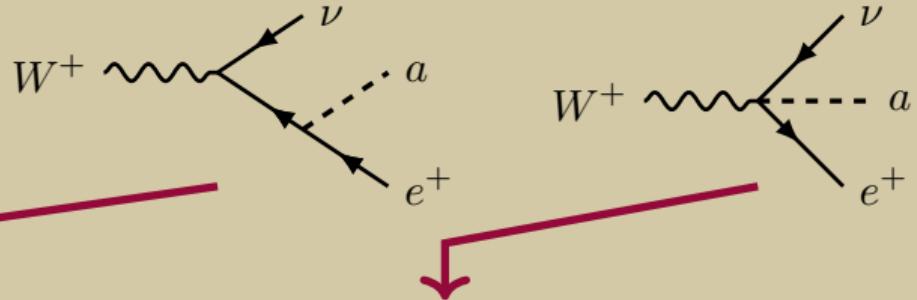


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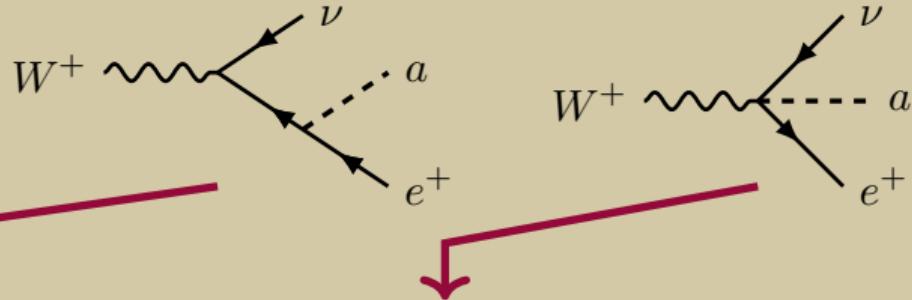


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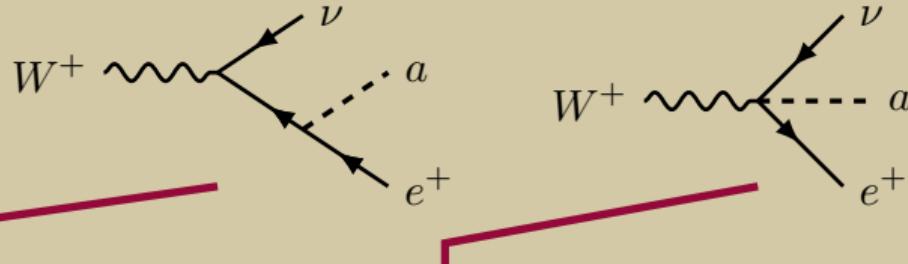
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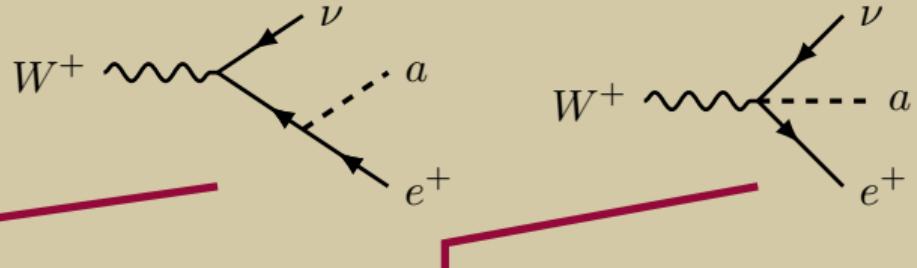
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$\pi^+ \gamma$	$< 7 \times 10^{-6}$	95%	40189
$D_s^+ \gamma$	$< 1.3 \times 10^{-3}$	95%	40165
$c\bar{X}$	$(33.3 \pm 2.6) \%$	—	
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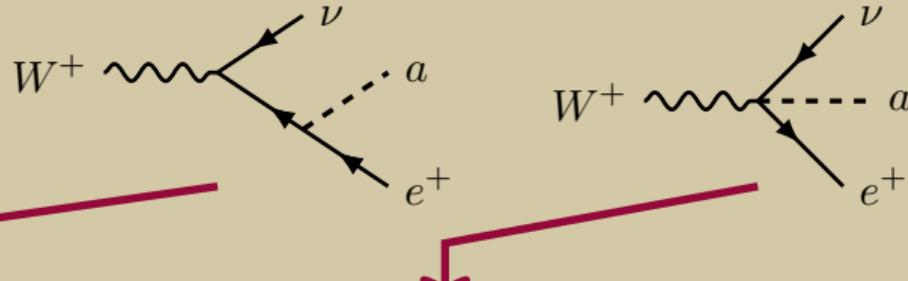
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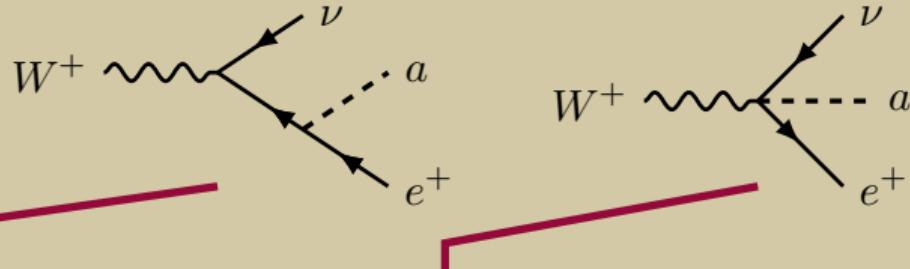
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contribute to  
total width  
 $2.085 \pm 0.04$  GeV

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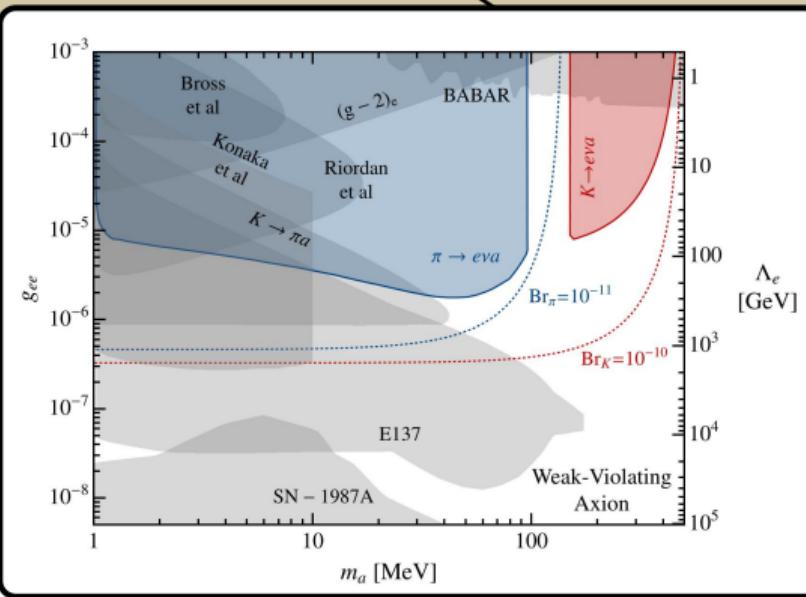
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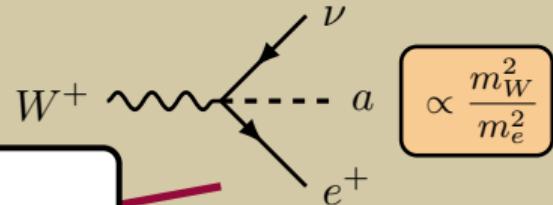
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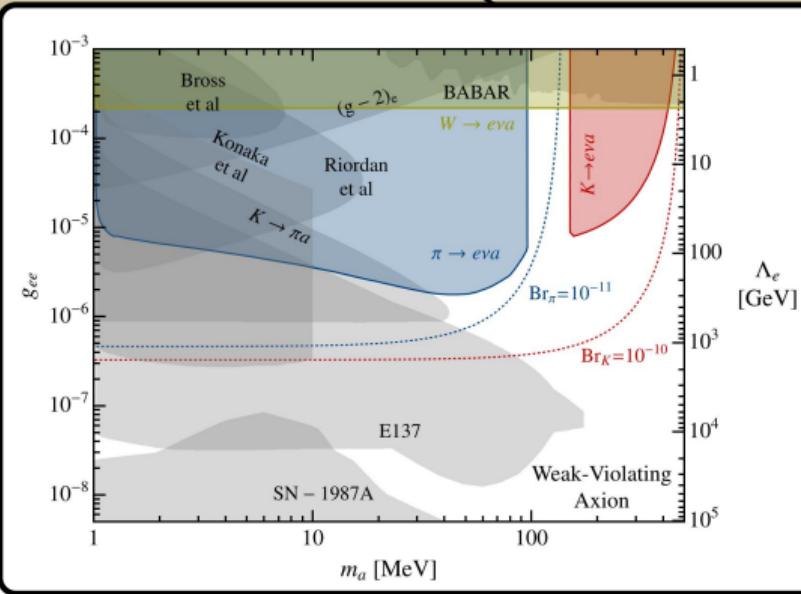


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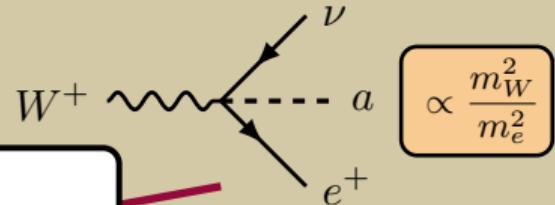
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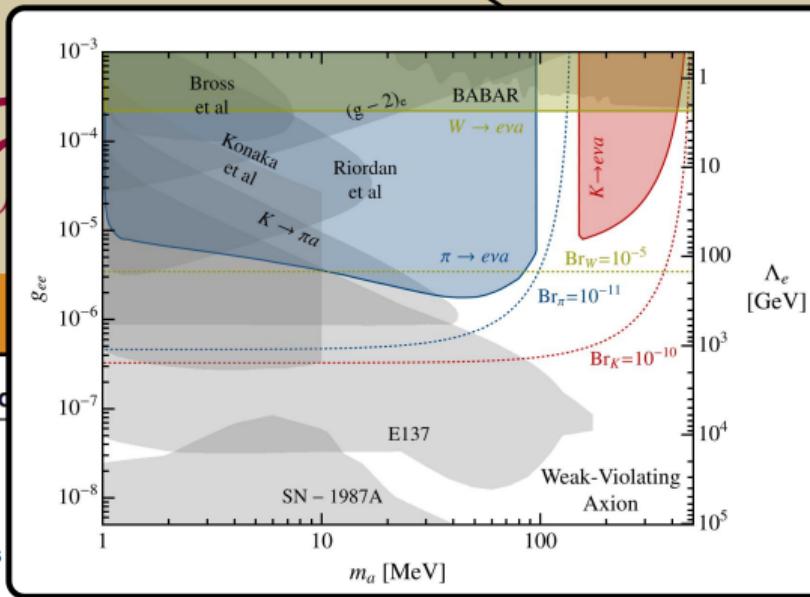
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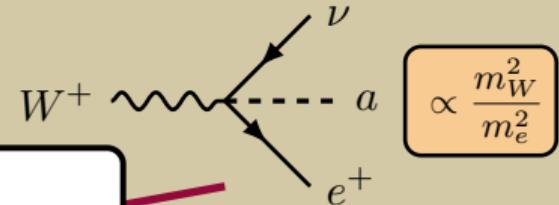
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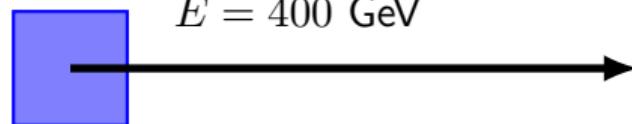
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# Proton Beam Dump Experiments

Ex: CHARM experiment

proton  
source

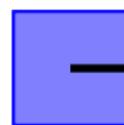


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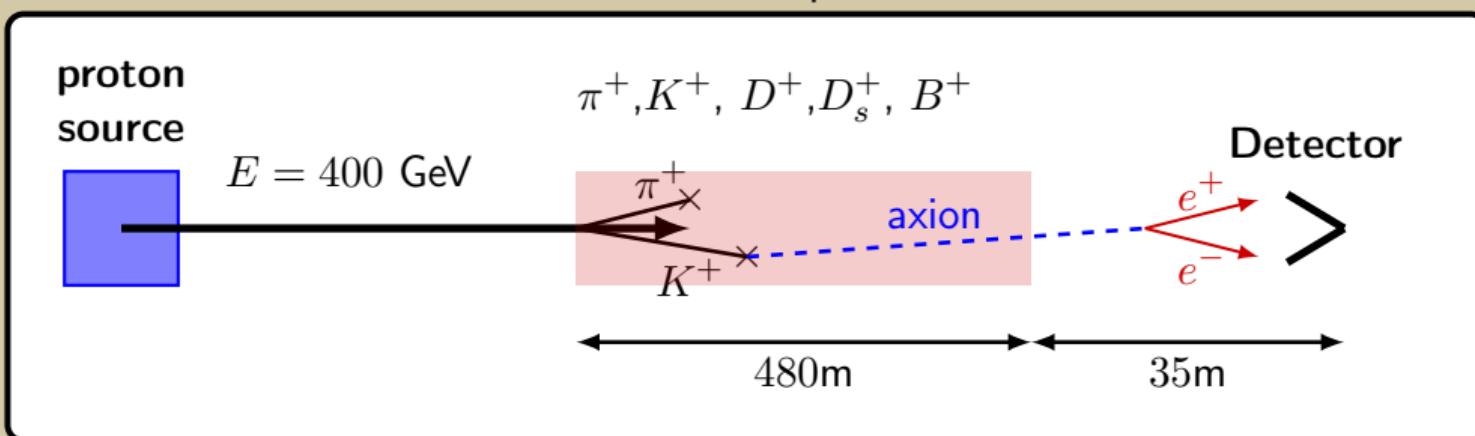
$\pi^+, K^+, D^+, D_s^+, B^+$



← →  
480m

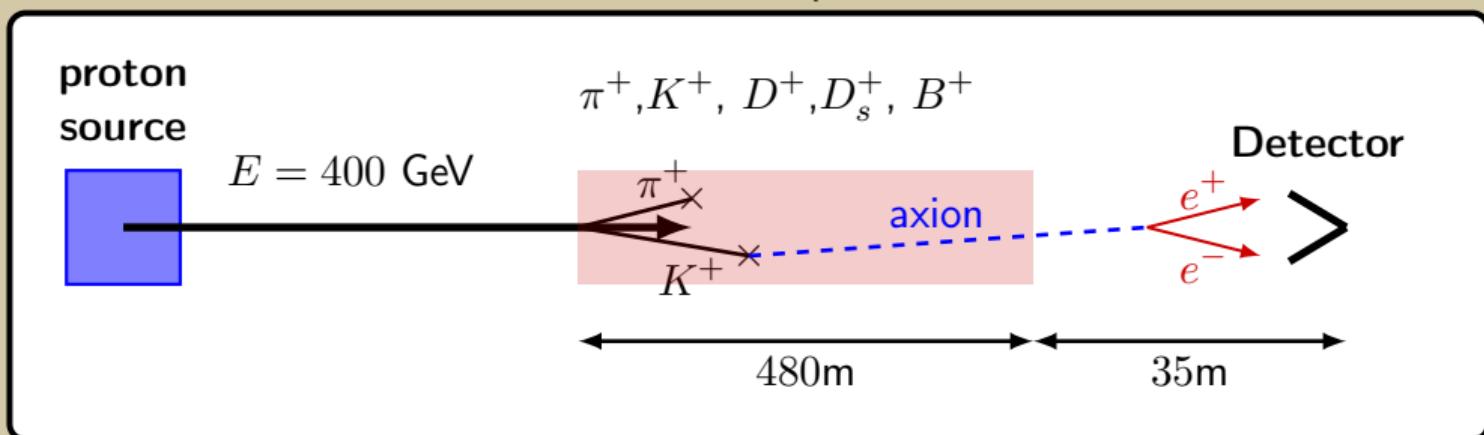
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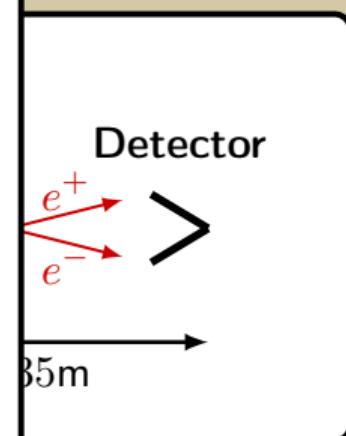
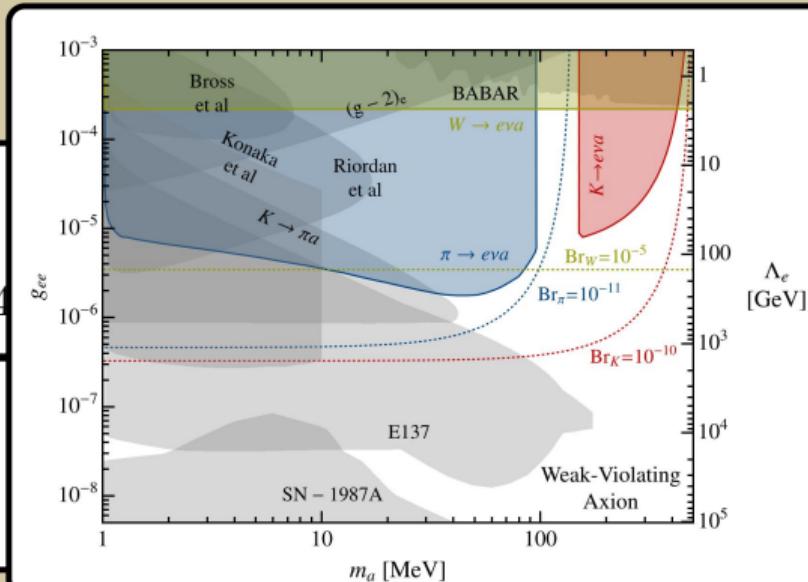
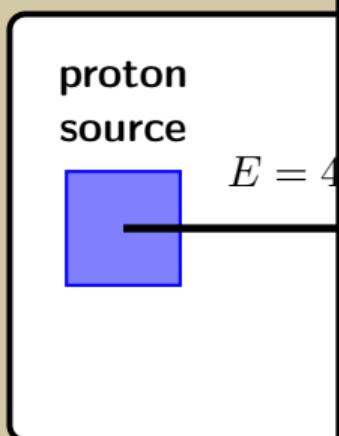
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observed zero  
events [CHARM - 1985]

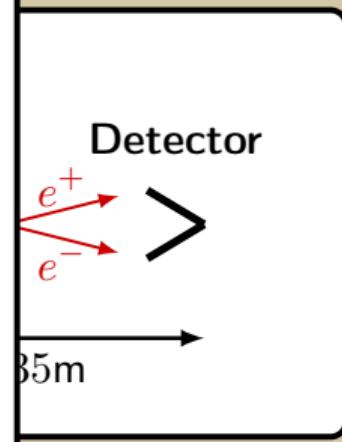
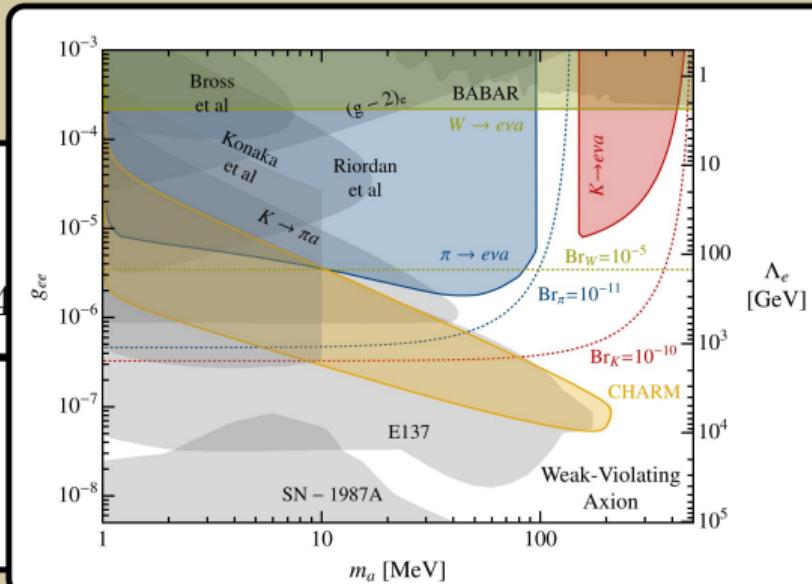
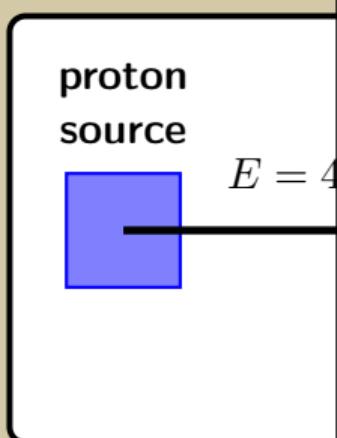
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revisited theory of axion-lepton interactions

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**weak-violating**

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Final  
Musings

weak-violating ALPs  
drive new  
phenomenology

every model has  
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Implications?