

# Limit on the effective magnetic moment of solar neutrinos from Borexino Phase-II data

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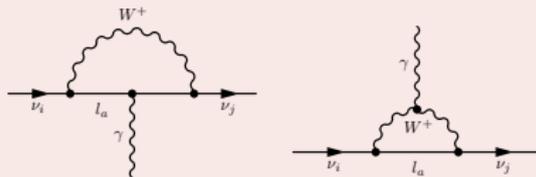
Joint Institute for Nuclear Research

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# Magnetic moment of solar neutrinos

## EM neutrino interaction

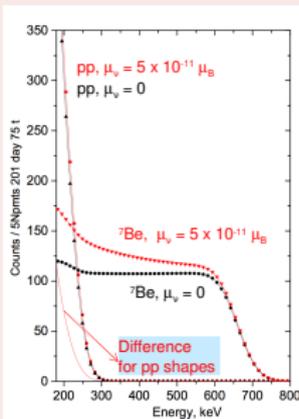
- occurs at one-loop level (for massive neutrinos only)
- changes neutrino helicity (and possibly flavor)



- $\mu_\nu$  can contribute to the  $\nu - e$  elastic scattering

$$\frac{d\sigma_{\text{EM}}}{dT_e} \propto \mu_{\text{eff}}^2 \left( \frac{1}{T_e} - \frac{1}{E_\nu} \right)$$

effective magnetic moment is  $\mu_\nu$  for a flavor mixture

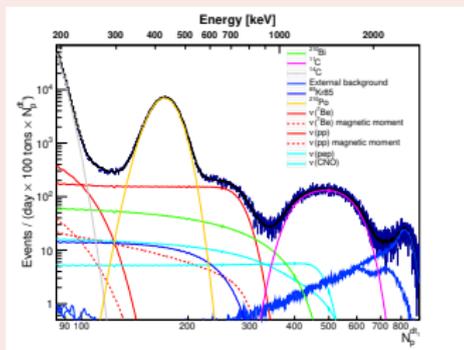


## Borexino experiment

- large mass (278 tons liquid scintillator)
- low threshold ( $\sim 200$  keV on recoil electrons)
- energy resolution ( $\sim 5\%$  @ 1 MeV)

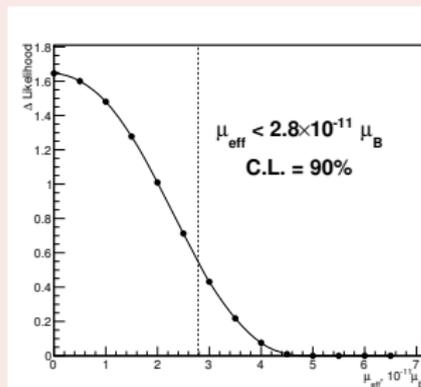
# Borexino results

## Electron recoil spectrum



1291.5 days livetime (Phase-II)  
spectral fit of solar neutrino data

## Effective magnetic moment of solar neutrinos



## Magnetic moments of mass and flavor eigenstates

Dirac neutrinos :  $|\mu_{11}^D| < 3.4$ ;  $|\mu_{22}^D| < 5.1$ ;  $|\mu_{33}^D| < 18.7$ ;

Majorana neutrinos :  $|\mu_{12}^M| < 2.8$ ;  $|\mu_{13}^M| < 3.4$ ;  $|\mu_{23}^M| < 5.0$ ;

Flavor eigenstates :  $|\mu_e| < 3.9$ ;  $|\mu_\mu| < 5.8$ ;  $|\mu_\tau| < 5.8$ .

in  $10^{-11} \mu_B$  (90% C.L.)