

# Search for the dark scalar $S$ in $\eta(') \rightarrow S\pi^0$ at GlueX/JEF

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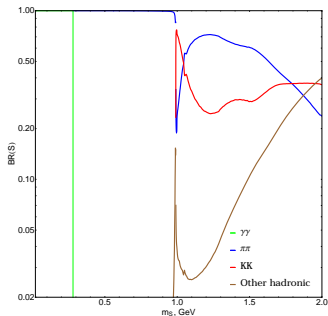
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# Introduction

Search for a MeV-GeV dark Higgs boson,  $S$ , that couples to quarks and gluons. Initially proposed by B. Batell et al. ([arxiv:1812.05103](https://arxiv.org/abs/1812.05103)) and refreshed by L. Gan et al. ([arxiv:2007.00664](https://arxiv.org/abs/2007.00664))

- B. Batell et al.:
  - ▶ For,  $m_S < 2m_\pi$ ,  $S \rightarrow \gamma\gamma$
  - ▶ For,  $m_S \geq 2m_\pi$ ,  $S \rightarrow$ hadrons and in particular  $\pi\pi$
- L. Gan et al.:
  - ▶ For,  $m_S < 2m_\pi$ 
    - ★  $S \rightarrow \gamma\gamma$
    - ★ If  $m_S \geq 2m_e$ ,  $S \rightarrow e^+e^-$
    - ★ If  $m_S \geq 2m_\mu$ ,  $S \rightarrow \mu^+\mu^-$
  - ▶ For,  $m_S \geq 2m_\pi$ ,  $S \rightarrow$ hadrons and in particular  $\pi\pi$



# Numbers of expected events and UL on observed events

Relation between number of expected events,  $N_{\text{th}}^S$ , and of UL on observed events,  $N_{\text{obs}}^{\text{UL}}$

- $N_{\text{th}}^S = N_{\eta} \cdot \mathcal{B}(\eta \rightarrow S\pi^0)$ 
  - ▶  $N_{\eta}$ : number of  $\eta$ ;  $N_{\eta} = \sigma \cdot \mathcal{L}$ 
    - ★  $\sigma$ : cross-section
    - ★  $\mathcal{L}$ : integrated luminosity
  - ▶  $\mathcal{B}$ : branching ratio
- $N_{\text{obs}}^{\text{UL}} = N_{\text{th}}^S \cdot \epsilon$ 
  - ▶  $\epsilon$ : detection efficiency

Then,

- $\mathcal{B}(\eta \rightarrow S\pi^0) = \frac{N_{\text{obs}}^{\text{UL}}}{\epsilon \cdot N_{\eta}}$

So, for  $S \rightarrow \gamma\gamma$

- $\mathcal{B}(\eta \rightarrow S\pi^0) = \frac{N_{\text{obs}}^{\text{UL}}}{\epsilon \cdot \mathcal{B}(\eta \rightarrow \gamma\gamma) \cdot N_{\eta}}$
- $\mathcal{B}(\eta \rightarrow S\pi^0) \simeq 0.056 \left( \frac{g_u}{7 \times 10^{-4}} \right)^2$
- $\alpha_S = g_u^2 / (4\pi)$
- $\alpha_S^{\text{UL}} = \frac{1}{4\pi} \frac{(7 \times 10^{-4})^2}{0.056} \frac{N_{\text{obs}}^{\text{UL}}}{\epsilon \cdot \mathcal{B}(\eta \rightarrow \gamma\gamma) \cdot N_{\eta}}$

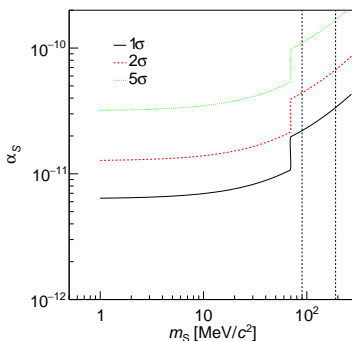
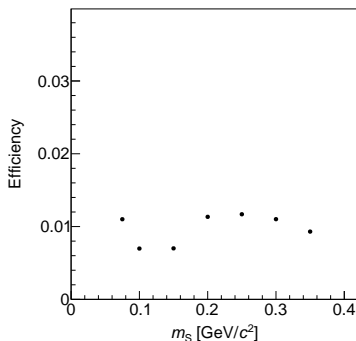
# Sensitivity

Is defined as  $N_{\text{sig}} = x\sqrt{N_{\text{bkg}}}$  where:

- $N_{\text{sig}}$ , number of signal for a given  $m_S$  and window corresponding to  $\Delta m_S = 3\sigma$  ( $\sigma$  is the signal resolution)
- $N_{\text{bkg}}$ , number of background for the same  $m_S$  and window
- $x$  is the significance in “sigma” unit

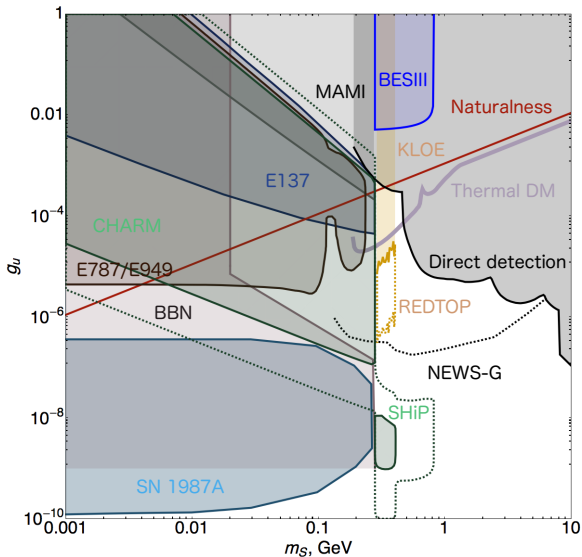
Then by replacing  $N_{\text{obs}}^{\text{UL}}$  by  $N_{\text{sig}}$

- $\alpha_s^{\text{Sensitivity}} = \frac{1}{4\pi} \frac{(7 \times 10^{-4})^2}{0.056} \frac{x\sqrt{N_{\text{bkg}}}}{\epsilon \cdot \mathcal{B}(\eta \rightarrow \gamma\gamma) \cdot N_\eta}$
- $N_\eta = 5 \times 10^7 \eta$



# Comparison to existing bound and future experiments

For 100 days,  $g_u \sim 7 \times 10^{-5}$



# Conclusion

To be continued