

Search for Axion-like particles in radiative muon decays

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Based on Collaboration with S.Knapen (LBNL) and D. Redigolo (INFN, Florence)
(To be appear soon)

Saga-Yonsei
Workshop
Jan 21, 2022

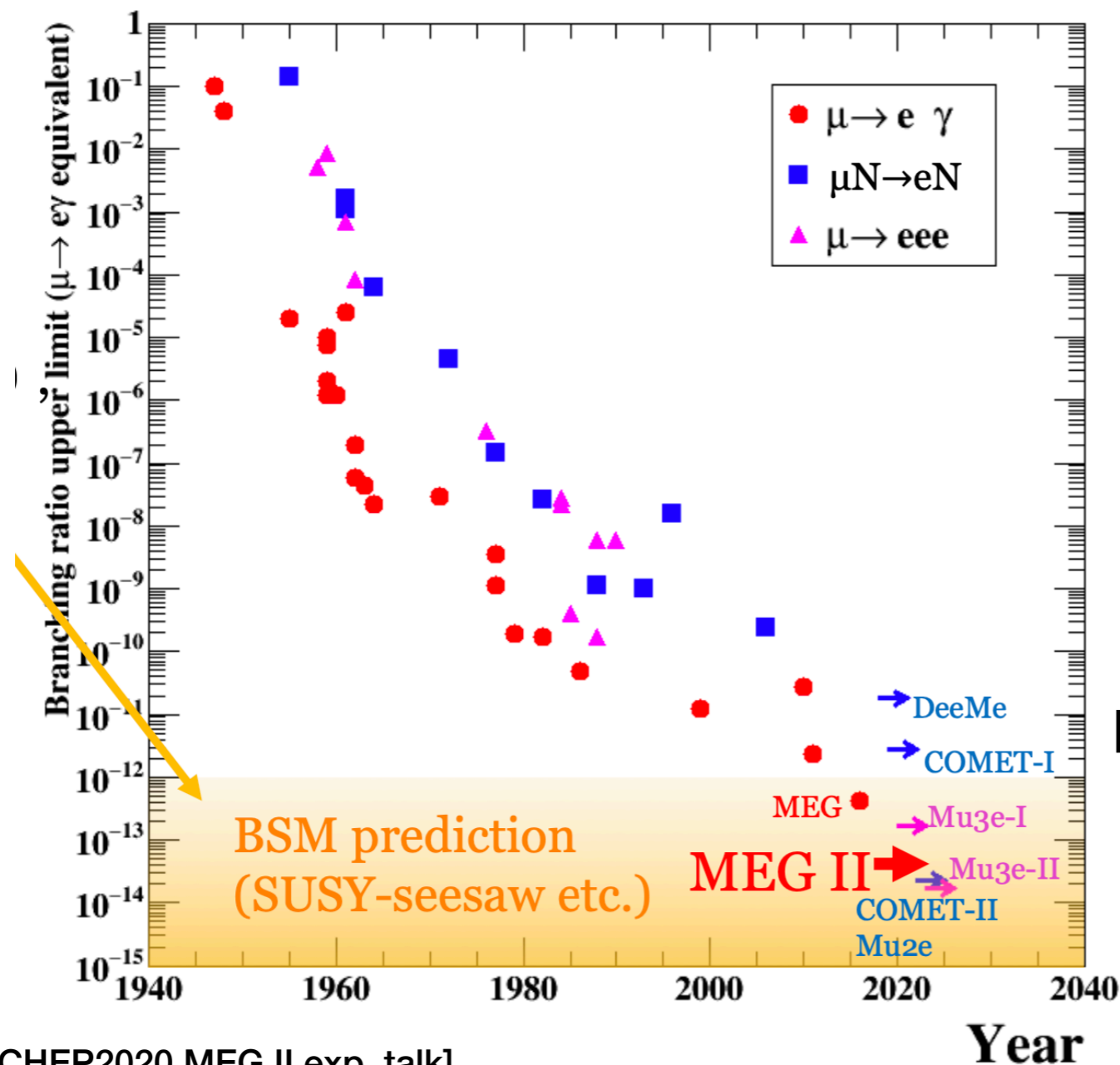
Outline

- Lepton-flavor violating ALP searches at upcoming muon exp. (MEG II) $\mu^+ \rightarrow e^+ \gamma$
- Flavor-violating ALP with the missing energy channel at MEG II exp. $\mu^+ \rightarrow e^+ \gamma a$
 $a \rightarrow \text{invisible}$
- New trigger proposal for missing energy channel.
- Conclusion

Lepton-flavor violating ALPs searches at upcoming muon experiments (MEG II)

MEG II experiment: (upcoming) Muon LFV search

Originally targeted $\mu^+ \rightarrow e^+ \gamma$



Best limit on
 $\text{Br}(\mu^+ \rightarrow e^+ \gamma)$

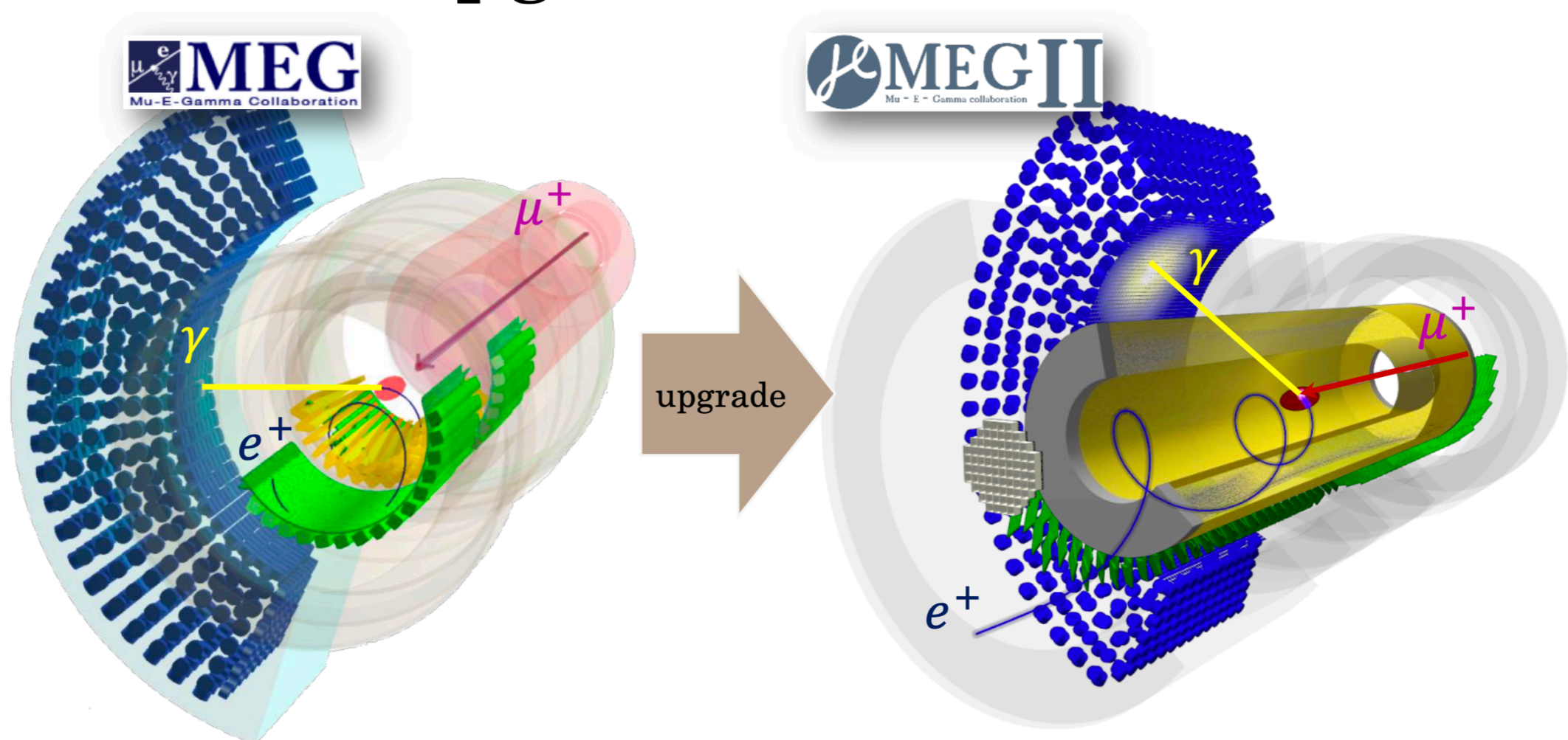
Lepton-flavor violating ALPs searches at upcoming muon experiments (MEG II)

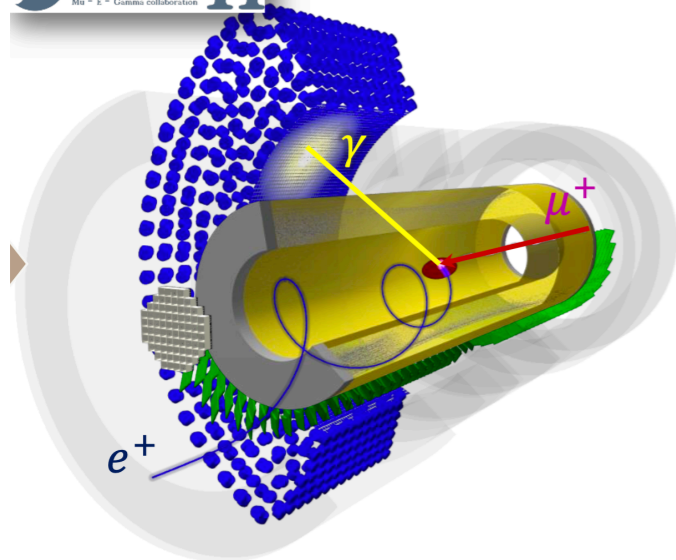
MEG II experiment: (upcoming) Muon LFV search

Originally targeted $\mu^+ \rightarrow e^+ \gamma$

& Usually optimized for Hard & back-to-back event search

Detector upgrades from MEG





$$N_{\mu^+} \sim 1.8 \times 10^{15}$$

$$\mathcal{R}_{\mu^+} \sim 7 \times 10^7 \mu^+ \text{'s/sec}$$

MEG II experiment has world leading luminosity of muons.

Suggesting New trigger & data-taking strategy for light LFV axion-like particle searches

by using the process $\mu^+ \rightarrow e^+ a \gamma$

($e^+ + \gamma + \text{missing E}$)

$$\mathcal{L}_{\text{eff}}^{\text{LFV}} = \frac{\partial_{\mu} a}{2f_a} \bar{\mu} \gamma^{\mu} (C_{\mu e}^V + C_{\mu e}^A \gamma_5) e$$

Main backgrounds:

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

Radiative Muon Decay (RMD) bkd
 $\propto \mathcal{R}_{\mu^+}$

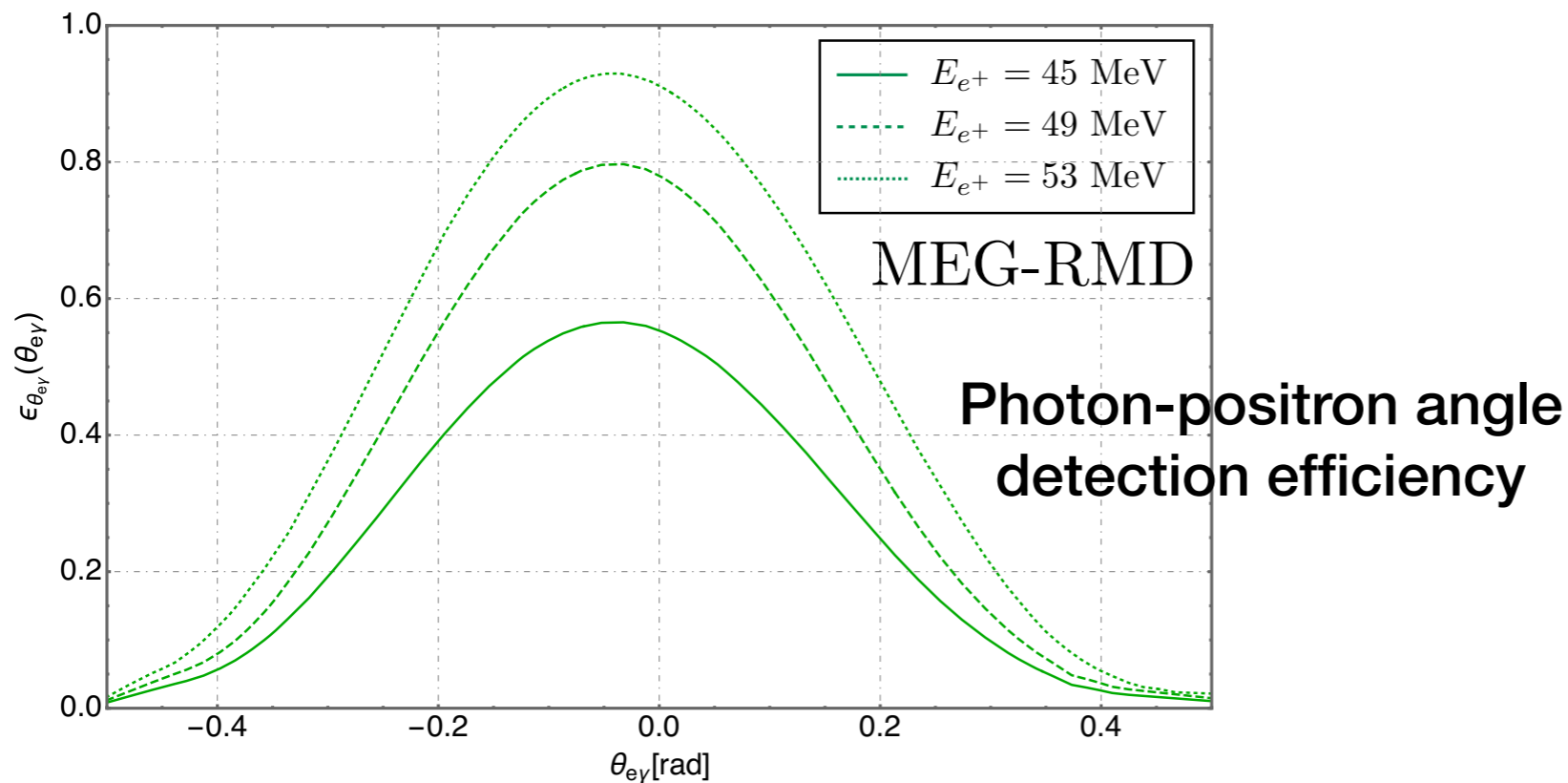
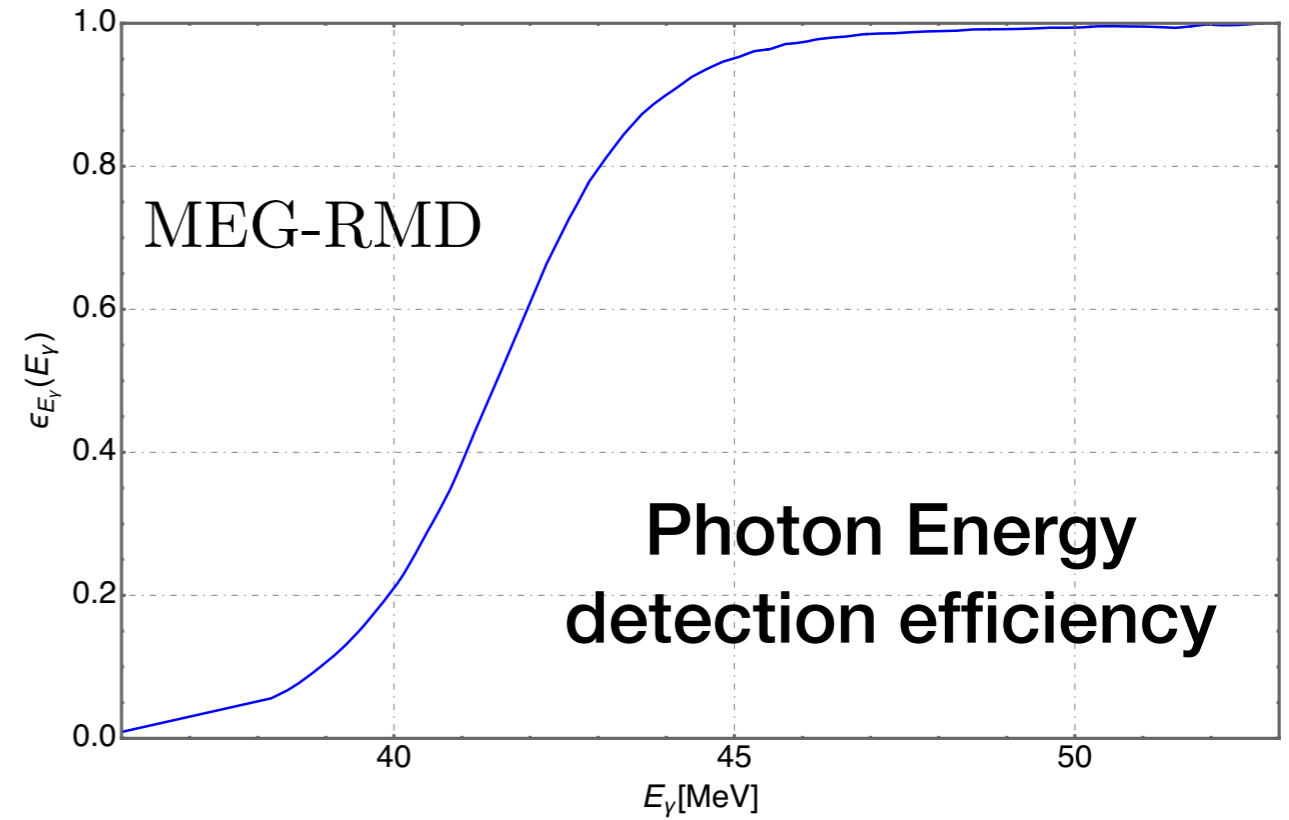
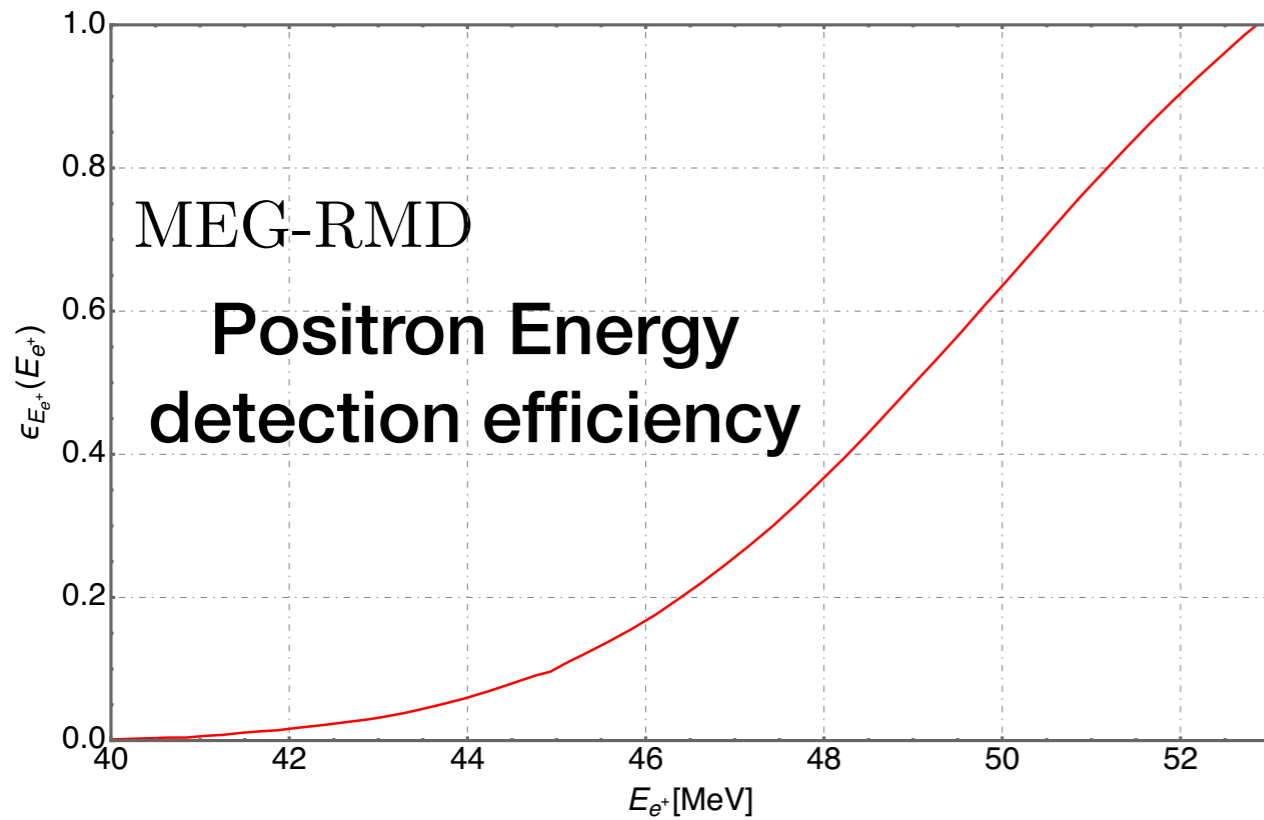
within a narrow time window

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

$$\mu^+ \rightarrow (e^+) \nu \bar{\nu} \gamma$$

Random Coincidence (RC) bkd
 $\propto \mathcal{R}_{\mu^+}^2$

“Conventional” Trigger selections at previous search (MEG exp.) (Optimized for $\mu^+ \rightarrow e^+ \gamma$ back-to-back Ev.)

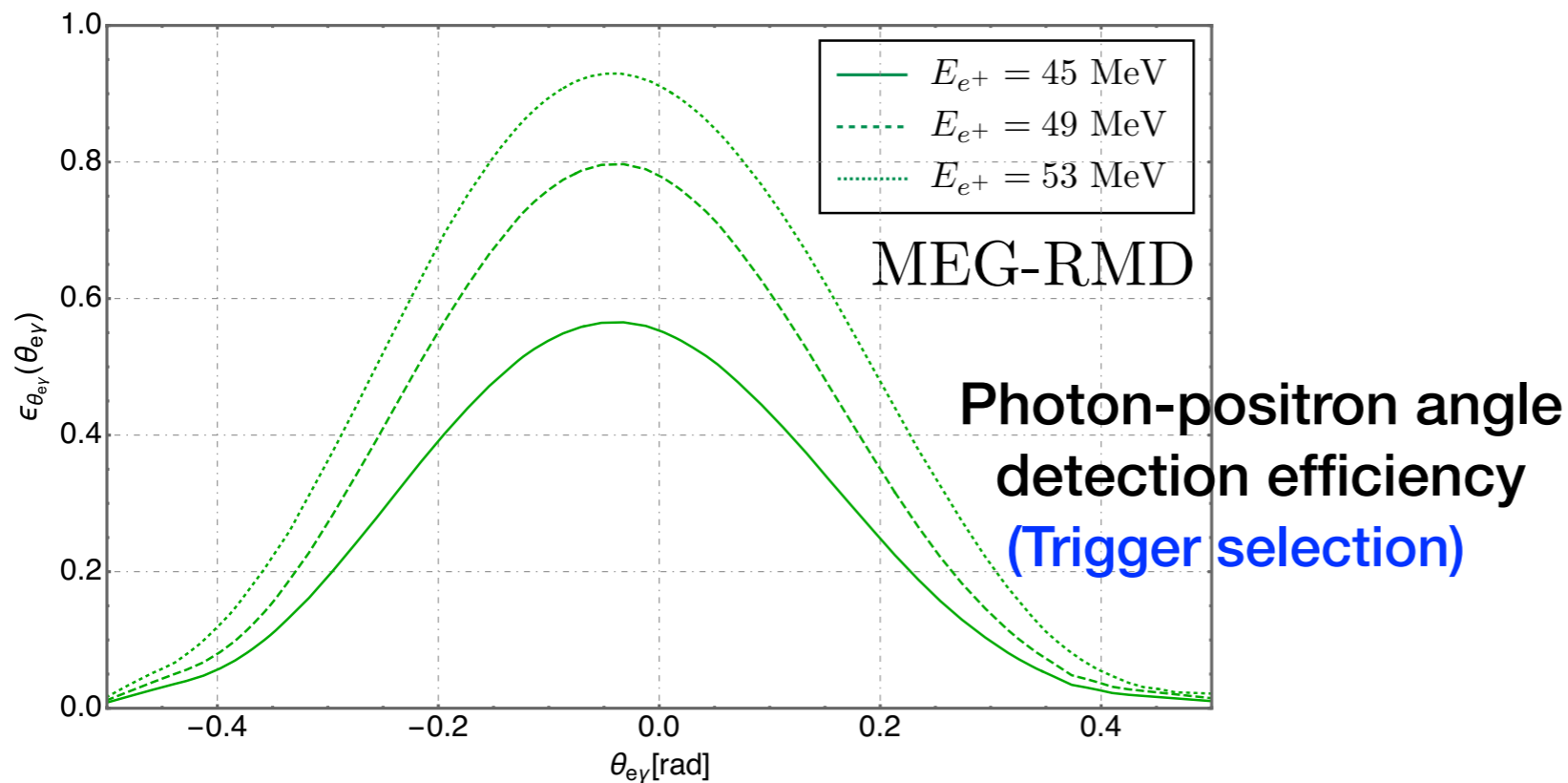
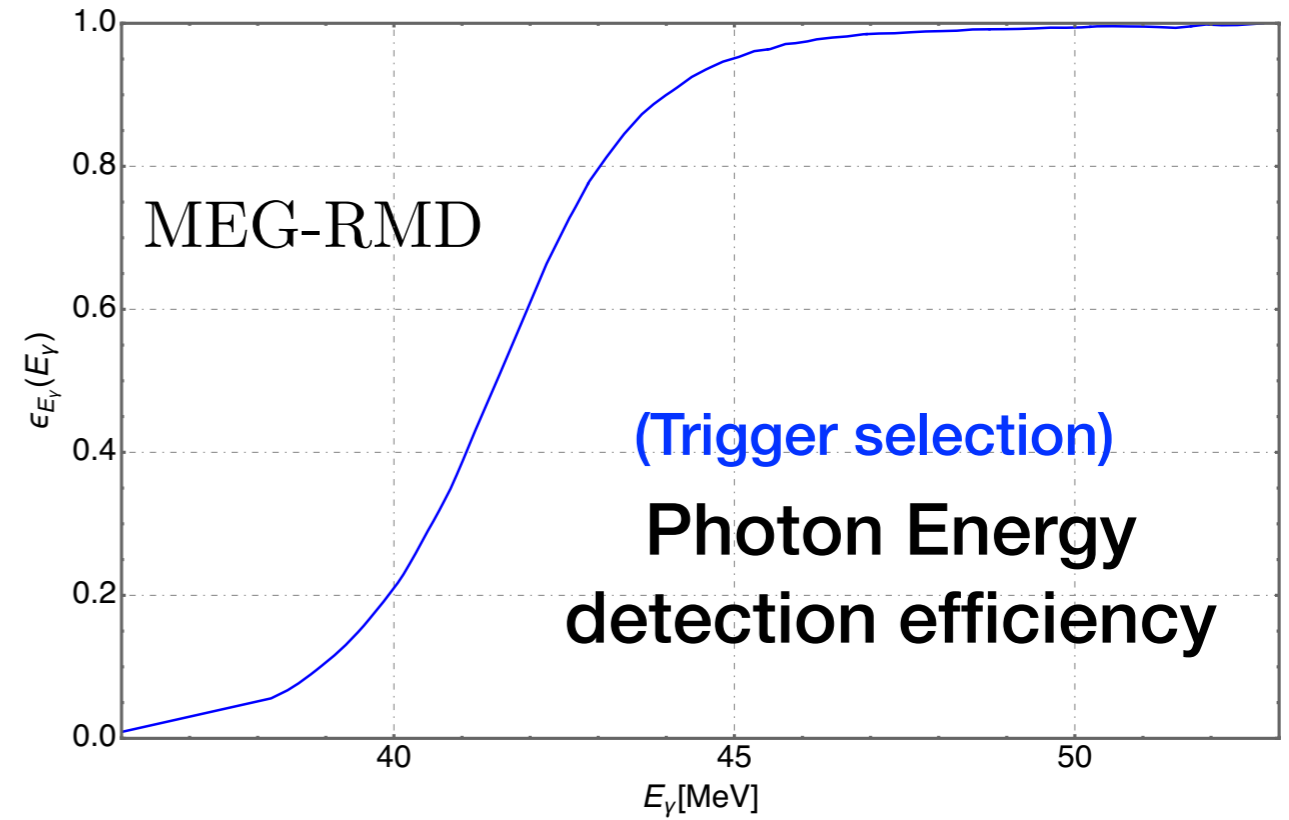
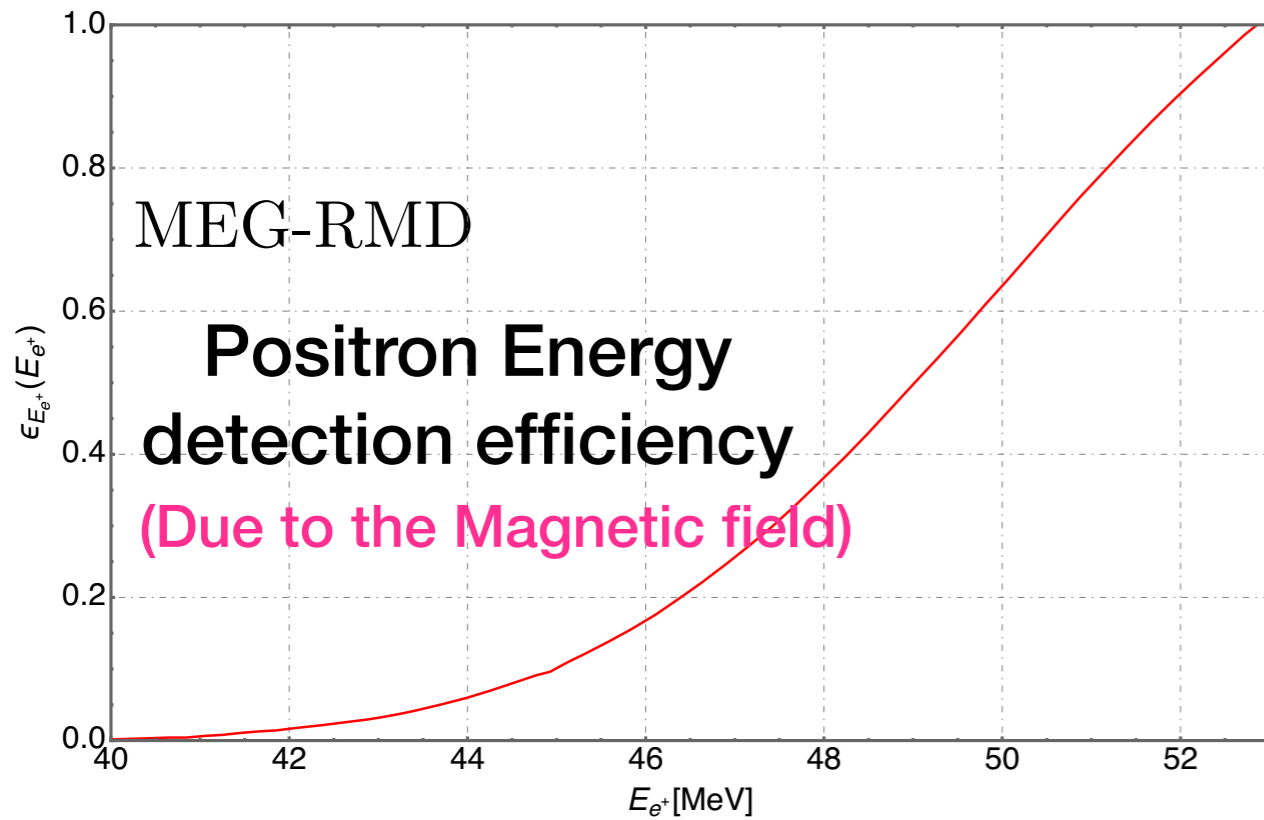


$$\theta_{e\gamma} = \pi - \theta_e - \theta_\gamma$$

$$\phi_{e\gamma} = \pi + \phi_e - \phi_\gamma$$

$\theta_{e\gamma} = 0$ & $\phi_{e\gamma} = 0$
correspond to exactly
back-to-back Event.

“Conventional” Trigger selections at previous search (MEG exp.) (Optimized for $\mu^+ \rightarrow e^+ \gamma$ back-to-back Ev.)



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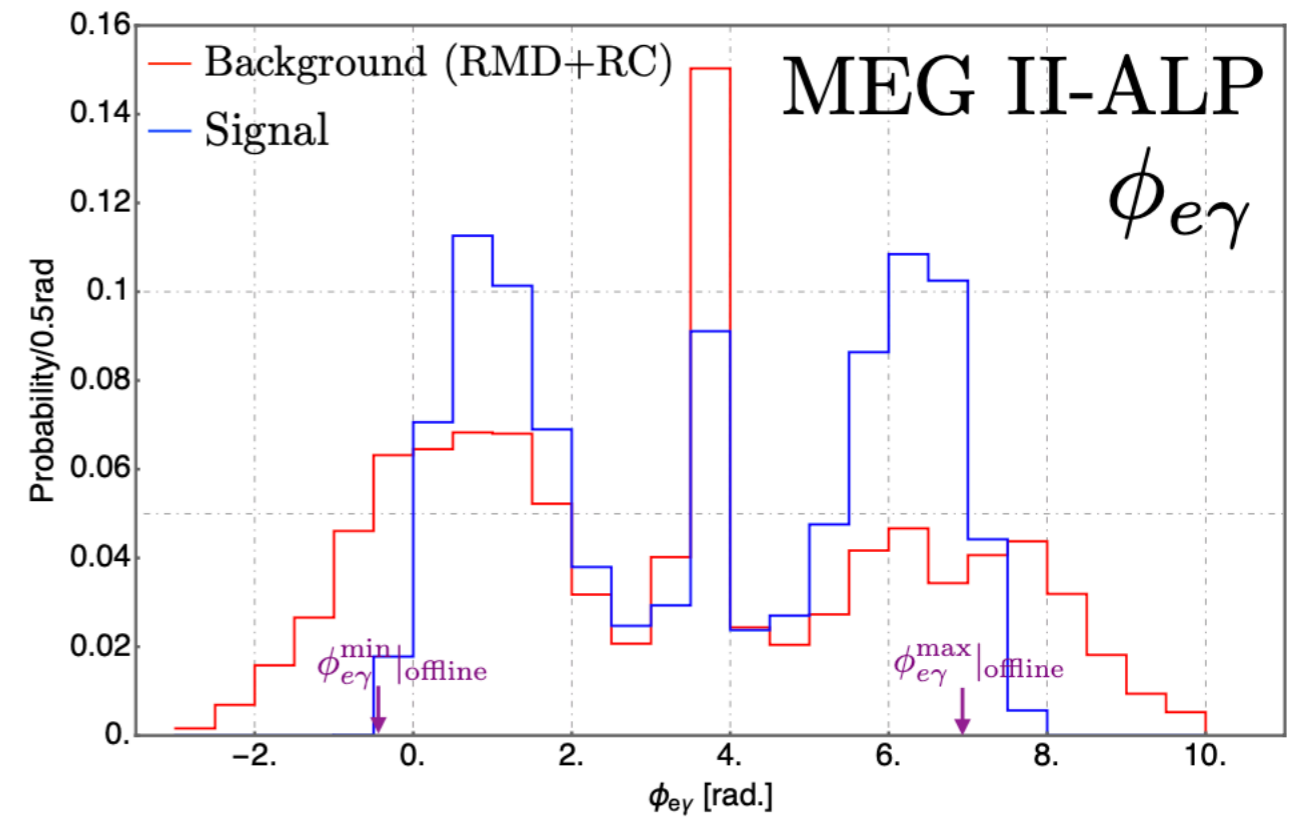
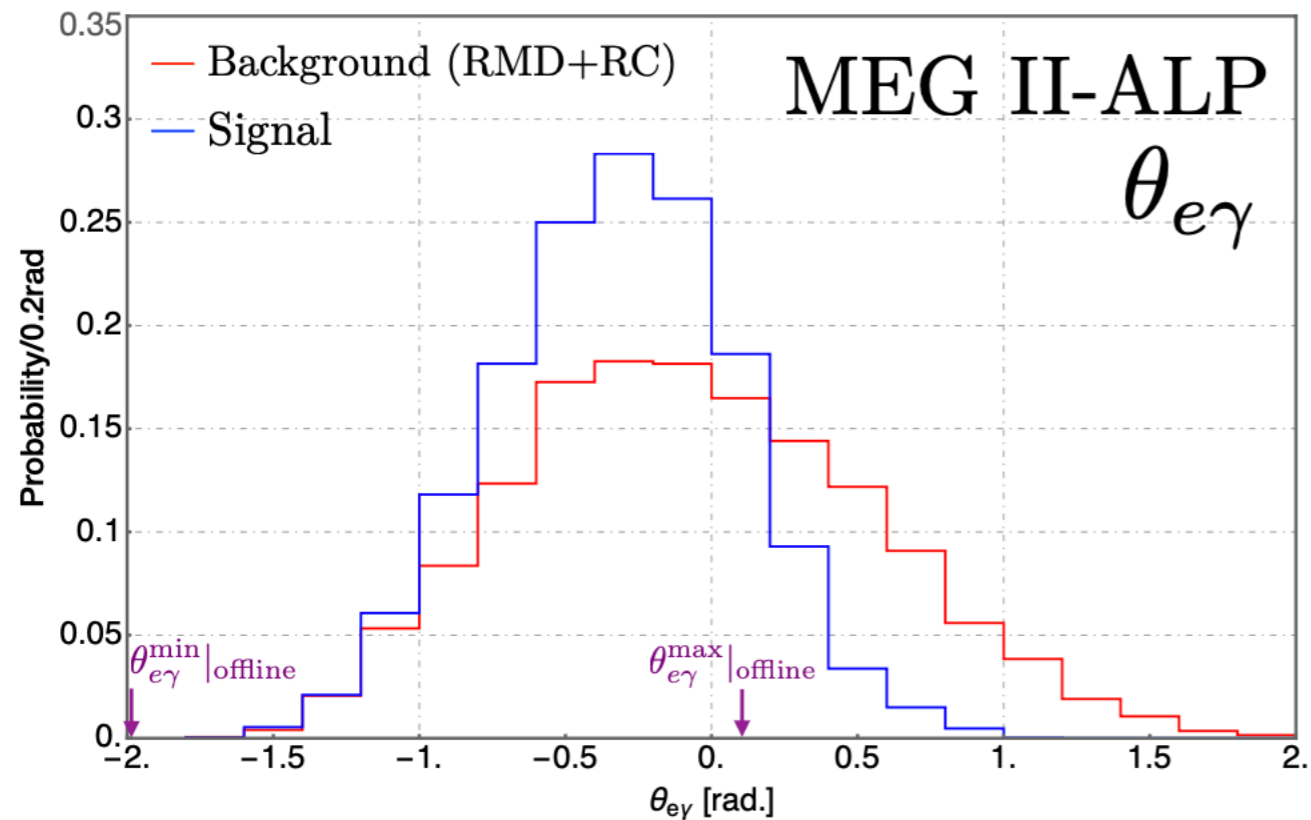
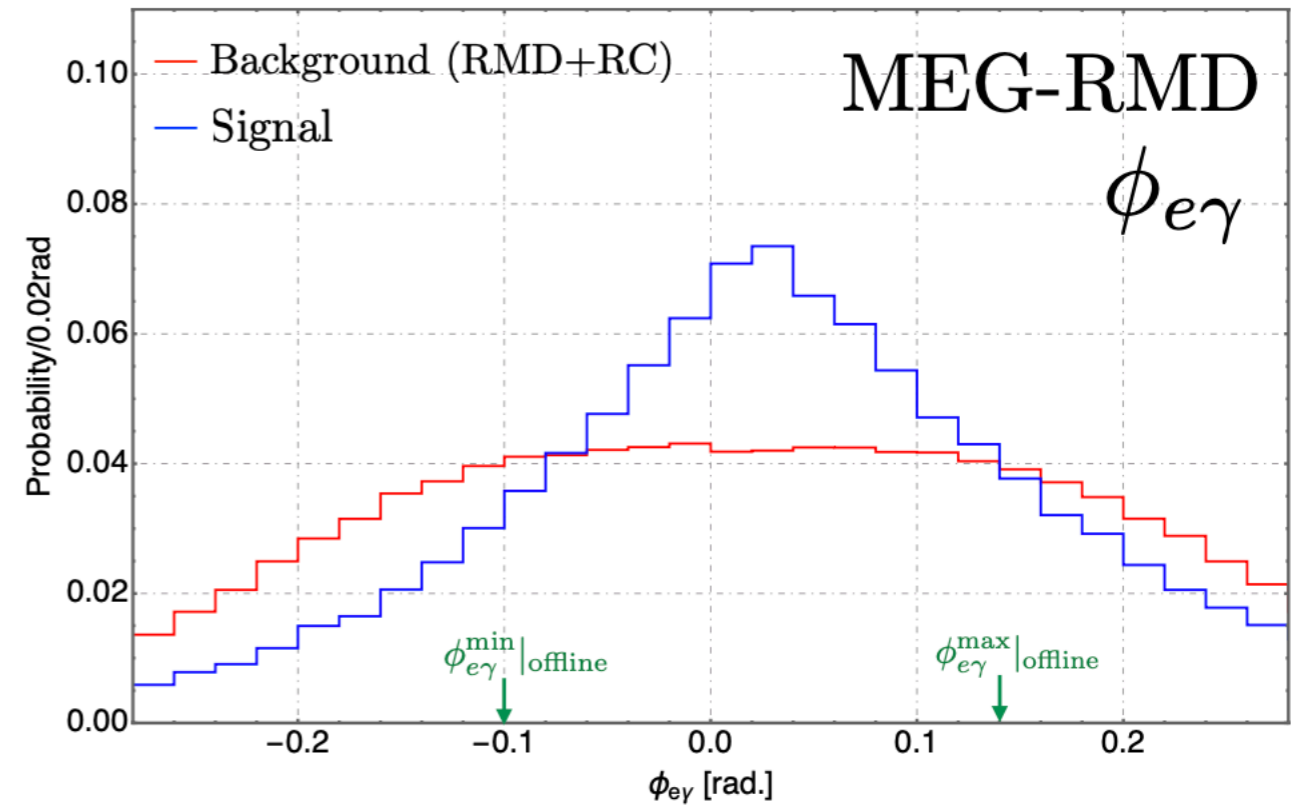
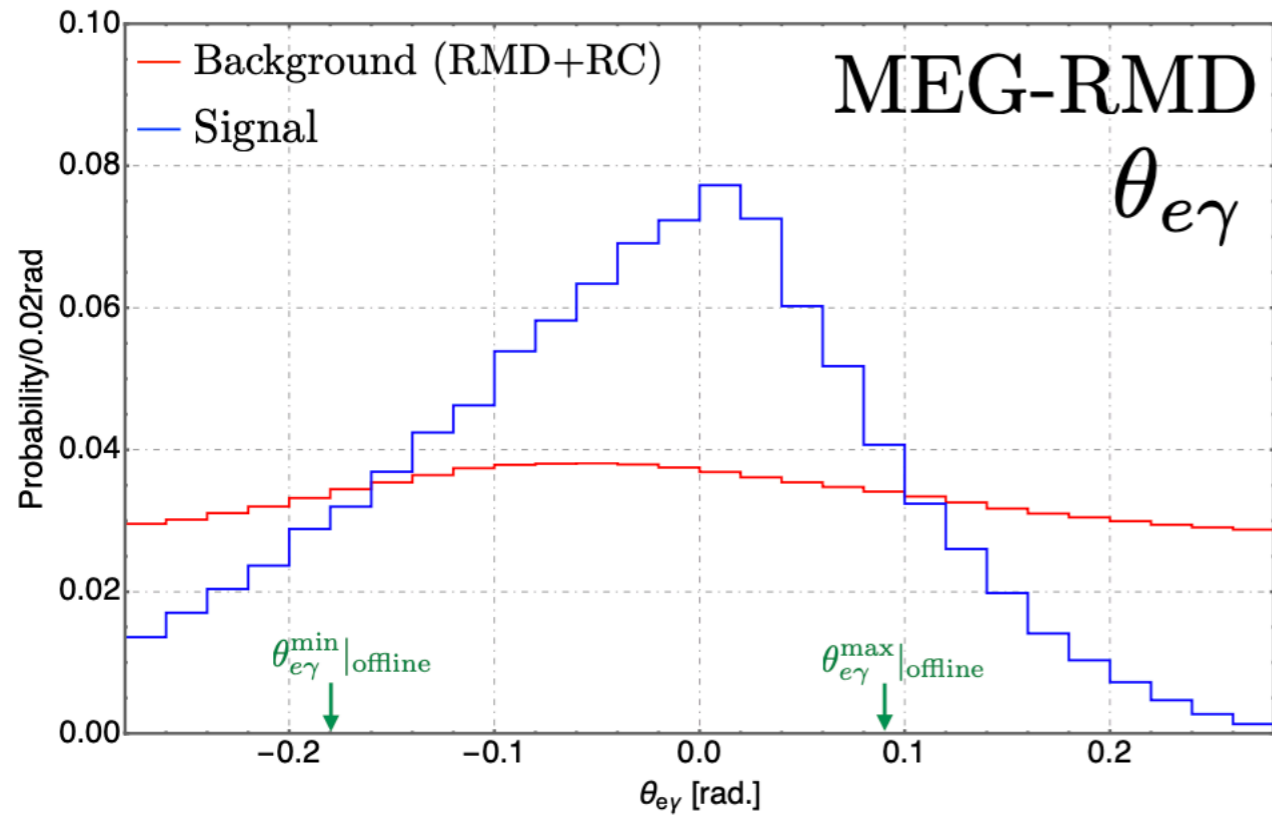
$\theta_{e\gamma} = 0$ & $\phi_{e\gamma} = 0$
correspond to exactly
back-to-back Event.

Trigger & offline selections

- **Conventional selections**
 - **Very Hard Positron Energy cut (from physical limitations)**
 - **Very Hard Photon Energy cut (from trigger selection for back-to-back 2-body event)**
 - **A restrict angular selection (optimized for back-to-back Ev.)**

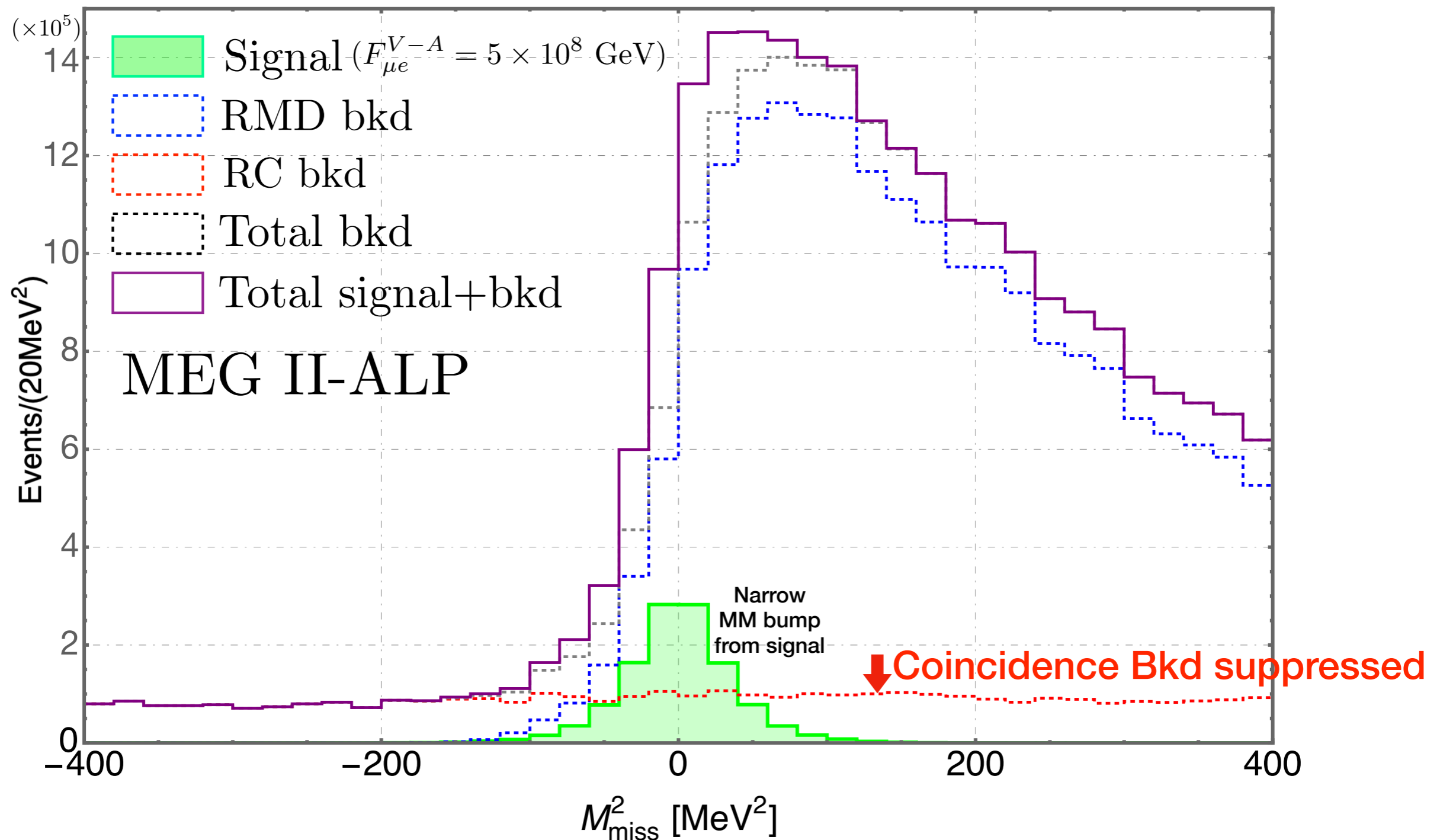
- **A new proposal of selections**
 - **Very Hard Positron Energy cut (from physical limitations)**
 - **A loose Photon Energy cut (for a large missing energy event)**
 - **An optimized angular selection (optimized for large miss E event)**

Angular selections



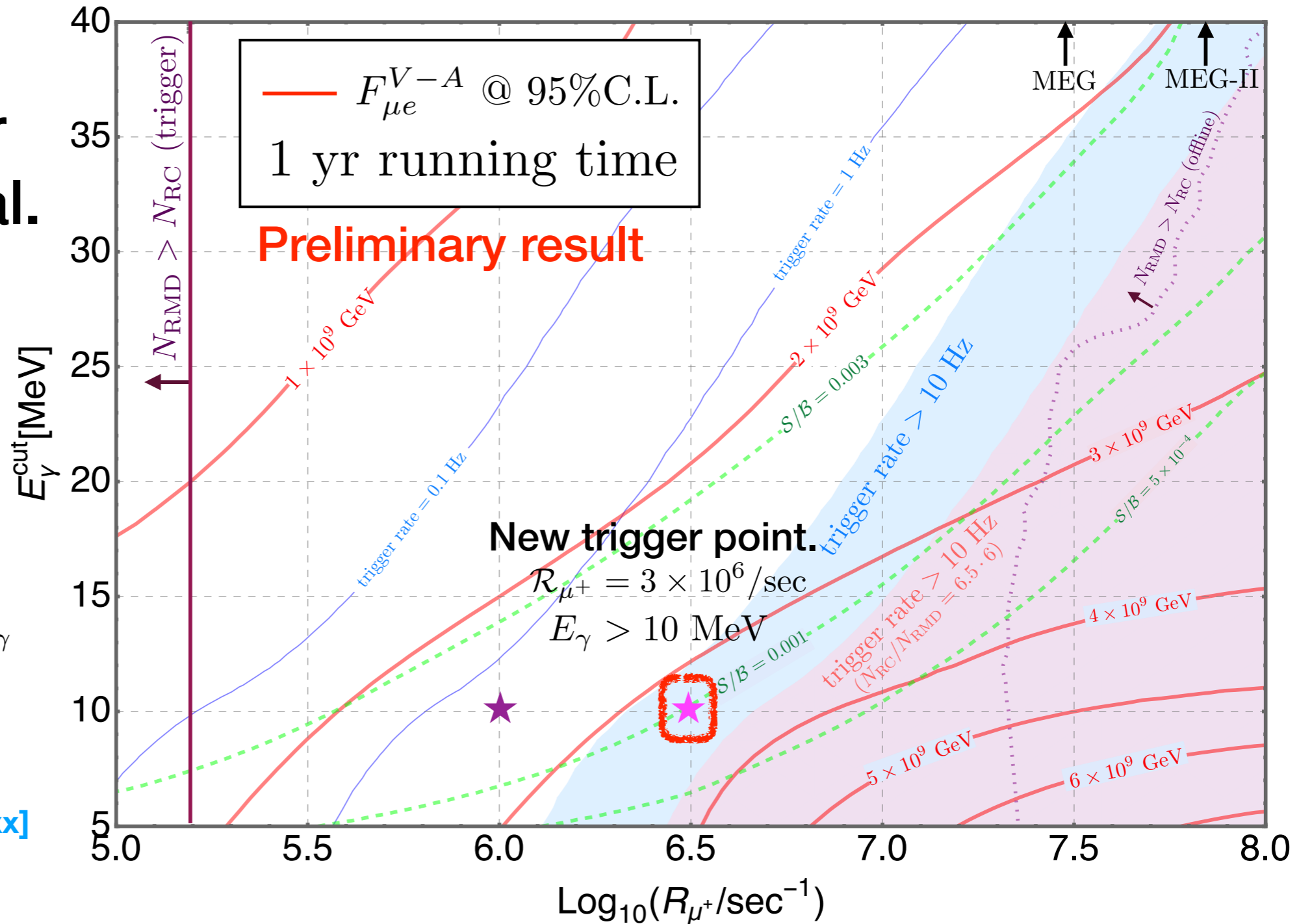
ALP search at MEG II exp.

- **Missing Mass distribution**



New and feasible trigger & data-taking strategy for **light** LFV axion-like particle searches

A new Trigger proposal.



New offline selection

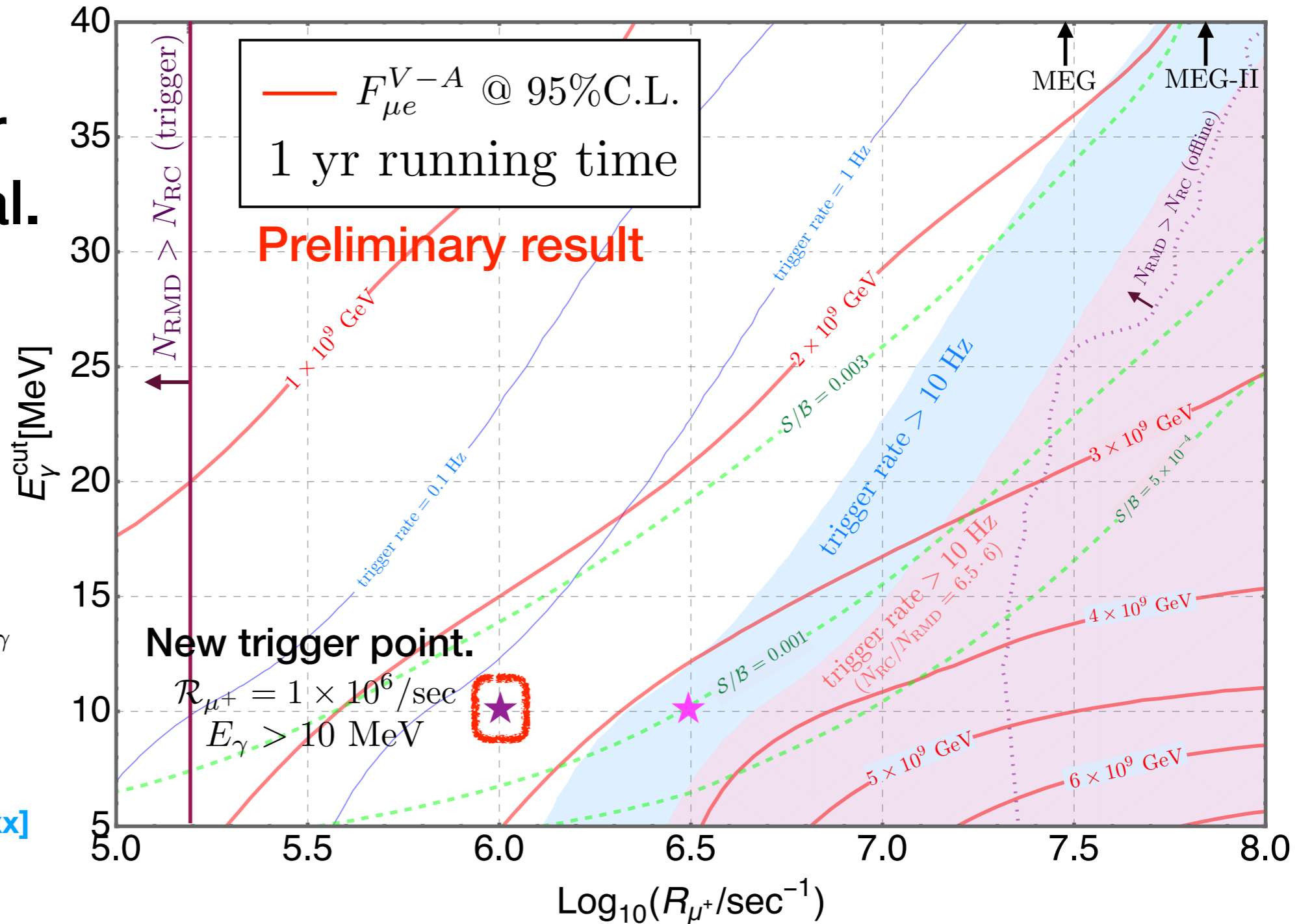
optimized $m_{\text{miss}}^2 + \theta_{e\gamma} + \phi_{e\gamma}$

YJ, S. Knapen,
D. Redigolo
[arXiv:22xx.xxxxx]

Relaxing photon energy cut and reducing the beam intensity will dramatically change the discovery potential.

New and feasible trigger & data-taking strategy for **light** LFV axion-like particle searches

A new Trigger proposal.

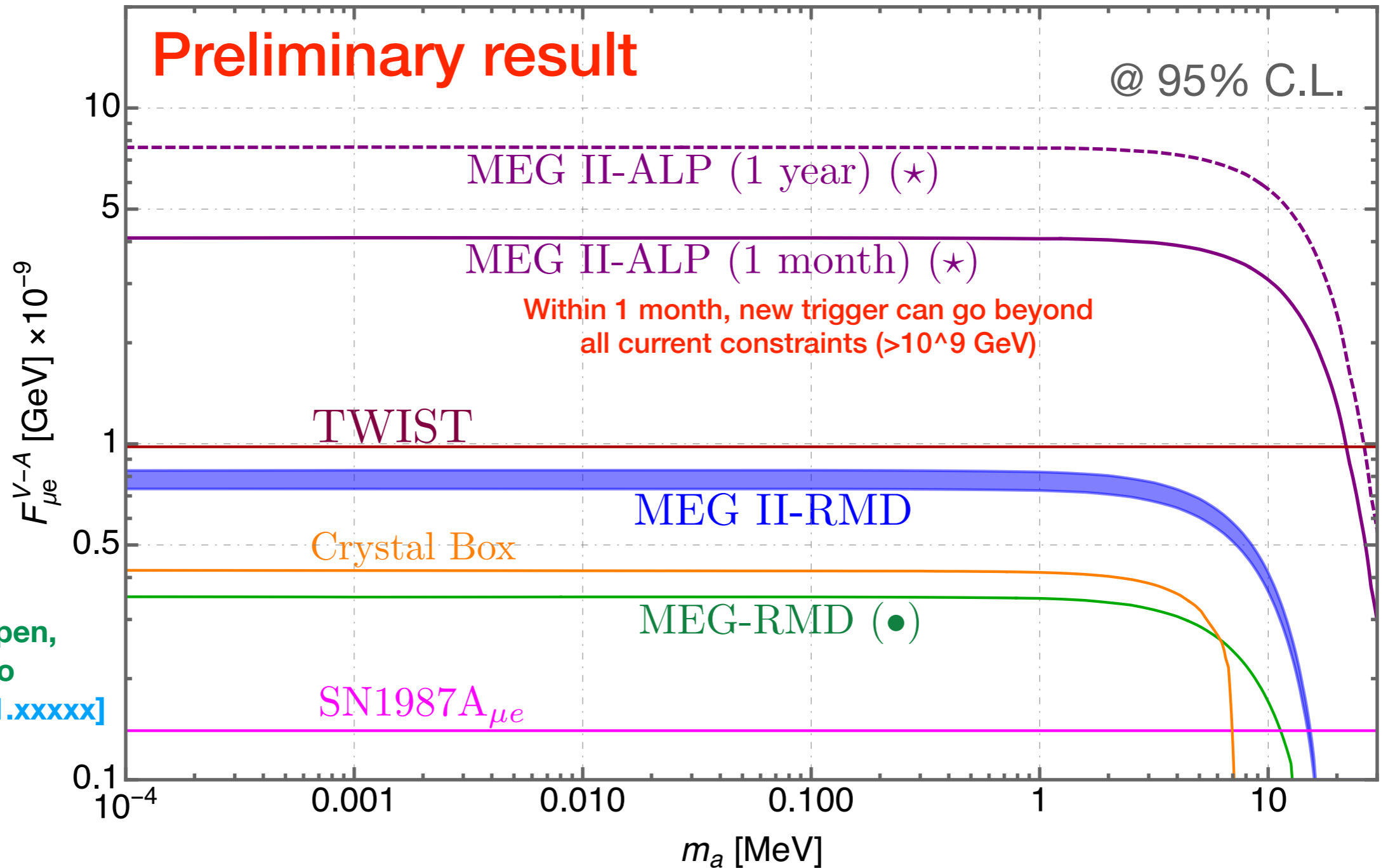


New offline selection
 optimized $m_{\text{miss}}^2 + \theta_{e\gamma} + \phi_{e\gamma}$

YJ, S. Knapen,
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Relaxing photon energy cut and reducing the beam intensity will dramatically change the discovery potential.

Suggesting **New and feasible trigger & data-taking strategy** for **light LFV axion-like particle searches**



YJ, S. Knapen,
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[arXiv:2201.xxxxx]

Relaxing photon energy cut and reducing the beam intensity will dramatically change the discovery potential.

Conclusion

- MEG II experiment is an ongoing experiment searching for $\mu^+ \rightarrow e^+ \gamma$ with world's best luminosity of muons.
- A new kinematic selection $\mu^+ \rightarrow e^+ a \gamma$ is required to have an optimized sensitivity at MEG II experiment.
- By lowering instantaneous luminosity & relaxing photon energy cuts, MEG II exp. can have an excellent projection for Missing energy search with axion-like particles.

Backup slides