

Search for dark photons using CRESST-II data

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Prospects in Low Mass Dark Matter
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Dark Photons as dark matter candidate

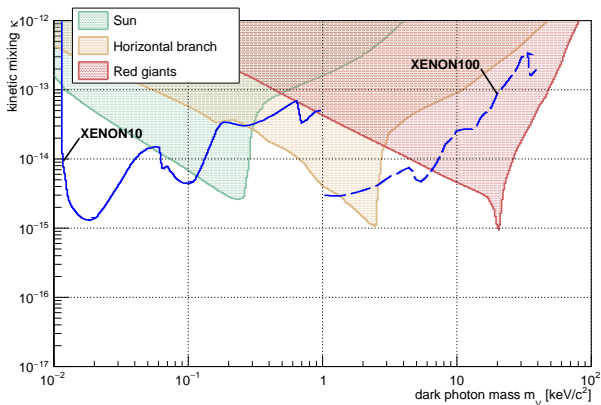
- Long-lived vector states
- Masses of $\mathcal{O}(\text{eV})$ to $\mathcal{O}(100 \text{ keV})$
- Small mixing κ with Standard Model photons
- Constrains from astrophysics weaker than for axion-like particles
- Signal: peak at dark photon mass m_V

→ Peak search in electron-recoil band

Further details:

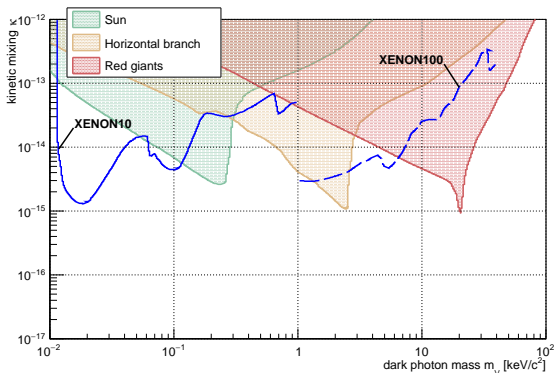
- M. Pospelov, et al., Phys. Rev. D **78**, 115012 (2008)
- H. An, et al., Phys. Rev. Lett. **111**, 041302 (2013)
- H. An, et al., Phys. Lett. B **747**, 331 (2015)

Current limits on kinetic mixing



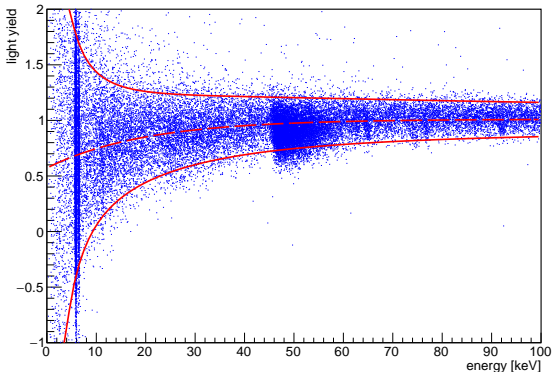
- Astrophysics: Anomalous energy losses in the sun, horizontal branch stars, and red giant stars
- Direct dark matter searches: XENON10 and XENON100

Region of interest for CRESST-II



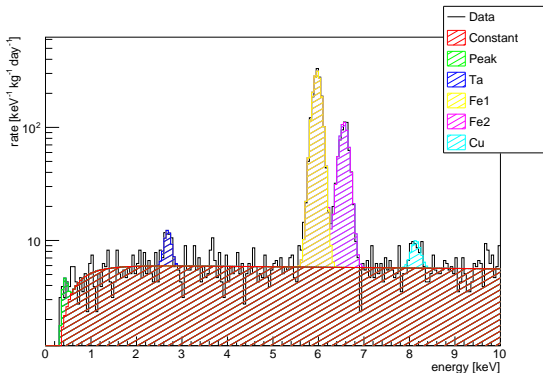
- Rate-only analysis for XENON10, Spectral fit for XENON100
 - Gap in astrophysical constraints between 200 eV and 1 keV
- CRESST-II: Detector with best energy threshold of ~ 300 eV
(→G. Angloher, et al., arXiv:1509.01515, submitted to EPJ C)

Data selection



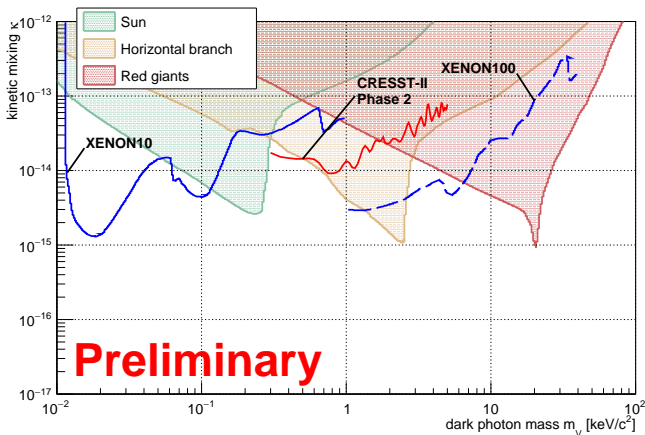
- Dark photons interact with electrons
 - Signal in electron-recoil band expected
- Only data in central 90% band (solid red lines)

Energy spectrum and fits results



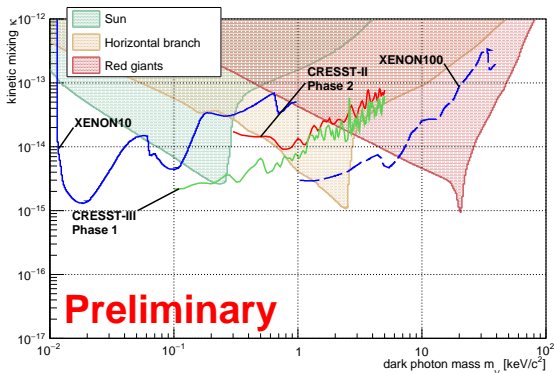
- Semi-empirical background model
 - Linear function + known peaks (^{55}Fe , ^{179}Ta , Cu fluorescence)
- Efficiencies taken into account
 - Room for Gaussian at low energies (→ conservative limit)

Limit on kinetic mixing κ



- Preliminary (conservative) limit for CRESST-II Phase 2
- New limit for $300 \text{ eV} \lesssim m_V \lesssim 500 \text{ eV}$

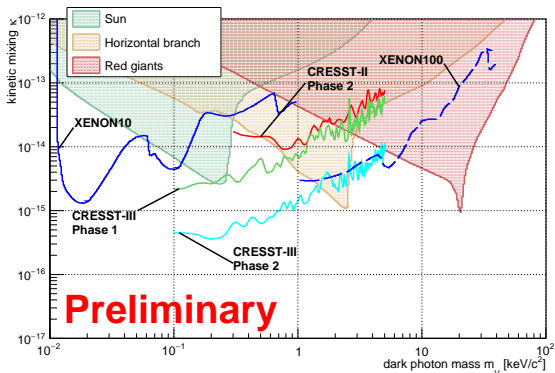
CRESST-III Phase 1



Assumptions for projected limit:

- Background as detector with lowest background (TUM40)
- Energy threshold: 100 eV, resolution: $\sigma = 20$ eV
- Exposure 50 kg-days

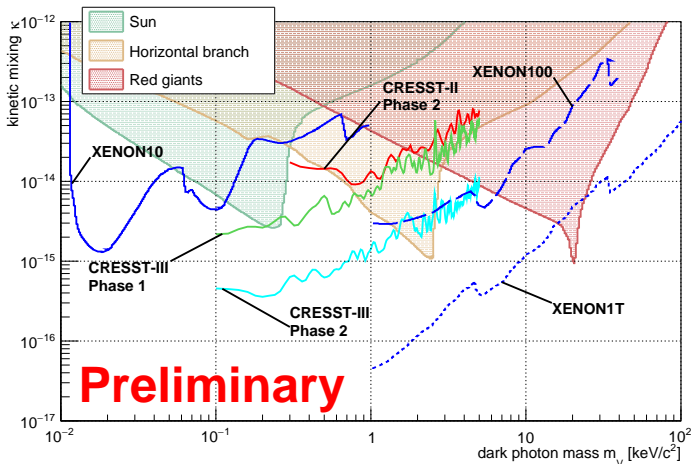
CRESST-III Phase 2



Assumptions for projected limit:

- Factor 100 less background than TUM40
- Energy threshold: 100 eV, resolution: $\sigma = 20$ eV
- Exposure 1000 kg-days

XENON1T



→ H. An, et al., PoS(EPS-HEP2015)397, arXiv:1510.04530

Conclusions and outlook

Conclusions

- CRESST detectors are optimized for nuclear recoils
- Good sensitivity also for dark photons (\rightarrow electron recoils) at energies corresponding to masses $m_V \lesssim 1$ keV
- New constraint for masses $300 \text{ eV} \lesssim m_V \lesssim 500 \text{ eV}$

Outlook

- Detailed background study might lead to better limit for CRESST-II data
 - High potential of CRESST-III to further constrain kinetic mixing κ for masses down to ~ 100 eV
- \rightarrow New results end 2016/ early 2017

Backup slides

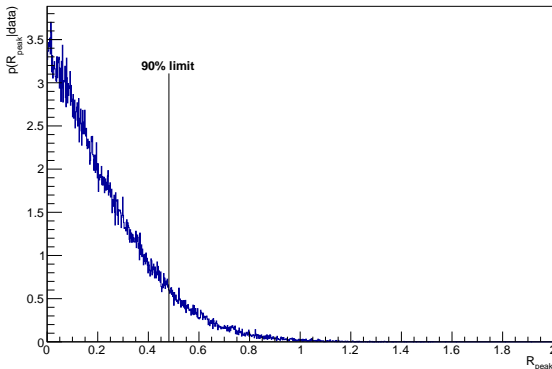
XENON10 - Rate-only analysis

- Ionization threshold ~ 12 eV
- 300 eV dark photon induces ~ 25 electrons
- Uncertainties in ionization yield, energy calibration and backgrounds
- ⇒ Conservative rate-only analysis of ionization events
- 246 events with up to 80 ionization electrons ($\lesssim 1$ keV)
- Rate for dark-photon absorption $\lesssim 19.3$ per kg-day (90% CL)
- Strongest limit for kinetic mixing κ for $12 \text{ eV} \lesssim m_V \lesssim 200 \text{ eV}$

Further details:

- H. An, et al., Phys. Rev. Lett. **111**, 041302 (2013)
- H. An, et al., Phys. Lett. B **747**, 331 (2015)

Spectral fits - XENON100, XENON1T, CRESST



- Fit of background model and Gaussian for dark photon signal to measured/ simulated spectrum.
 - Limit on rate of Gaussian obtained by the fit.
- Limit on kinetic mixing κ