Bosonic Super-WIMPs

In XENON100

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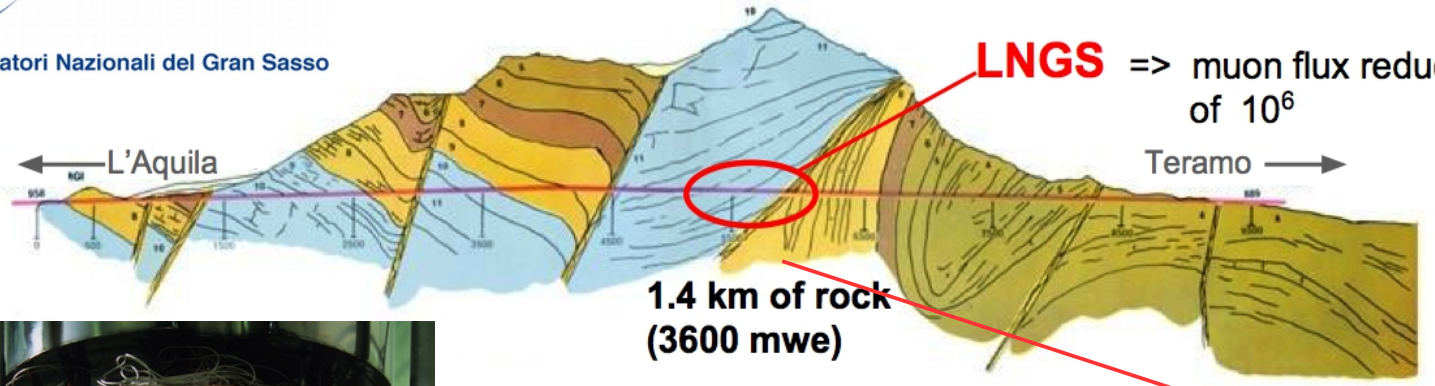
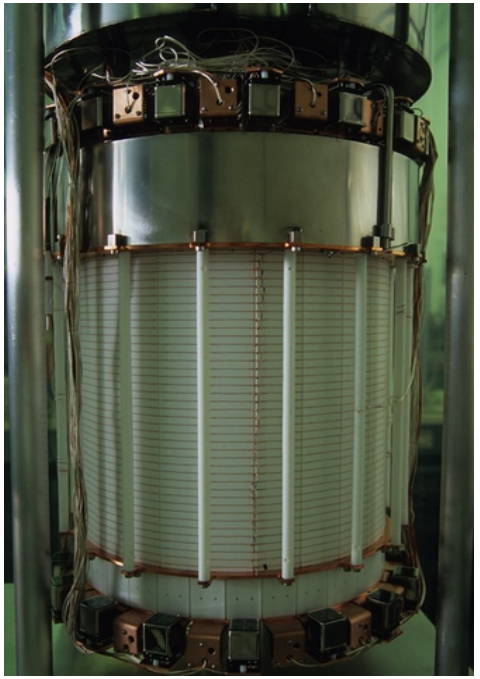
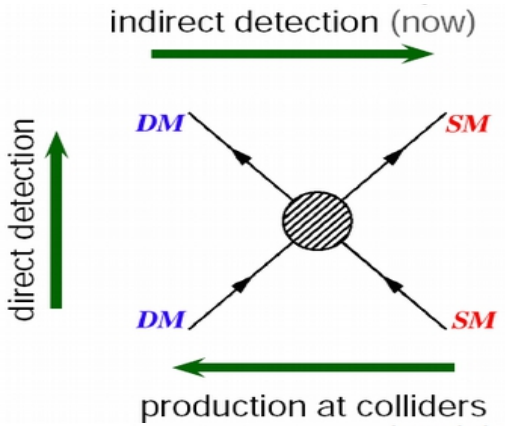
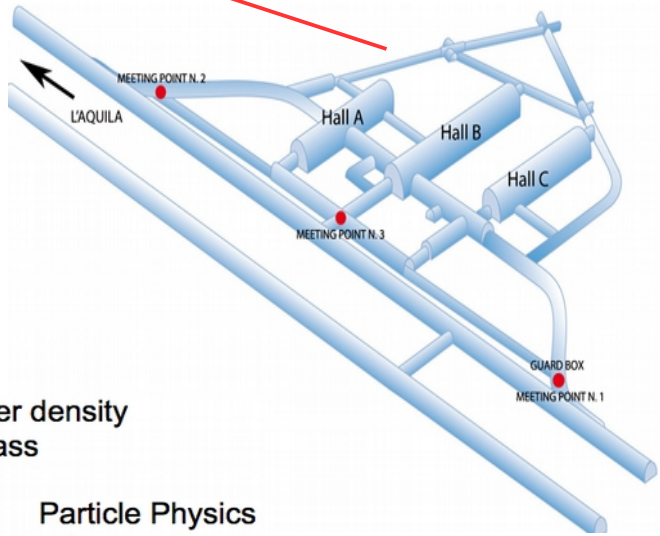
Searching for DM at LNGS

Laboratori Nazionali del Gran Sasso









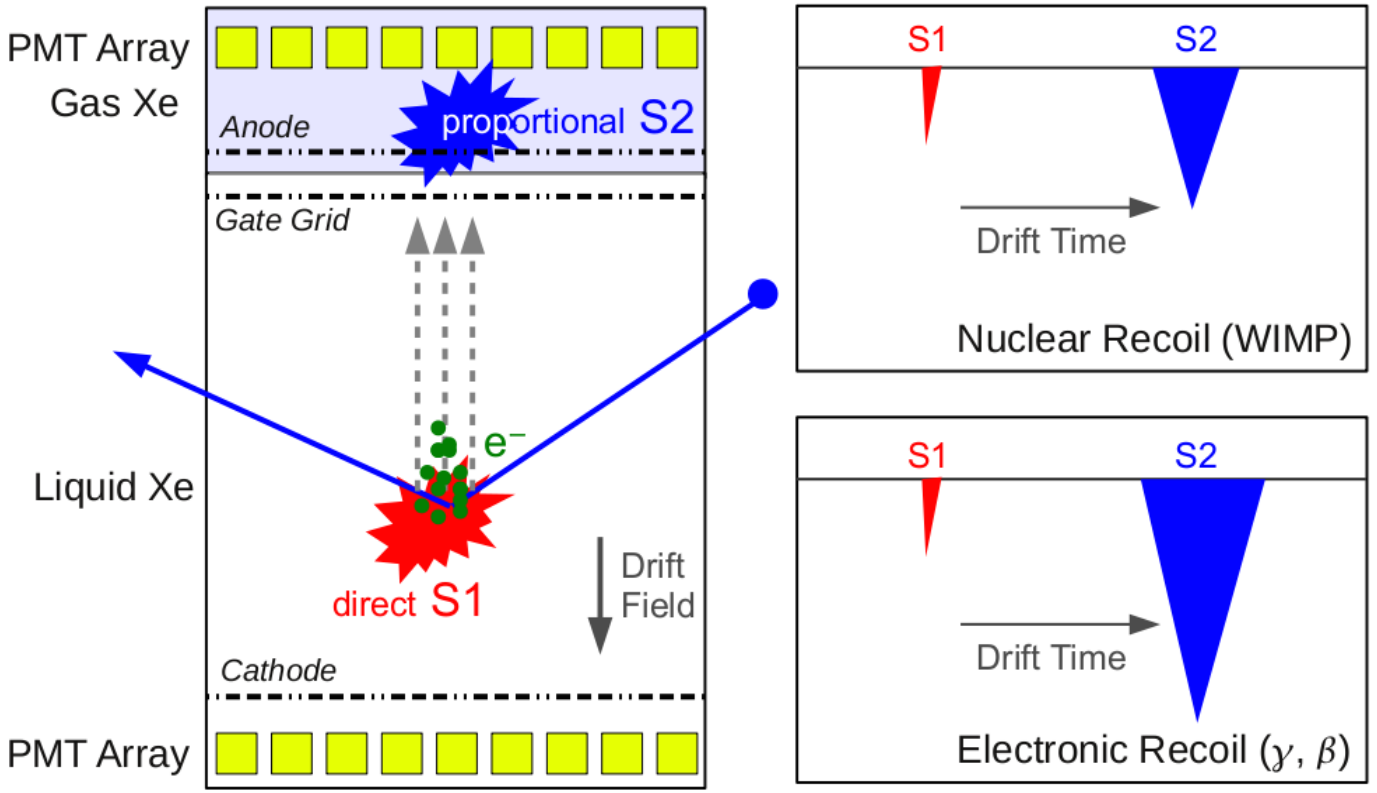
Local dark matter density
WIMP mass

Detector — Particle Physics

Event Rate: $R \propto N \frac{\rho_\chi}{m_\chi} \langle \sigma_{\chi-N} \rangle$

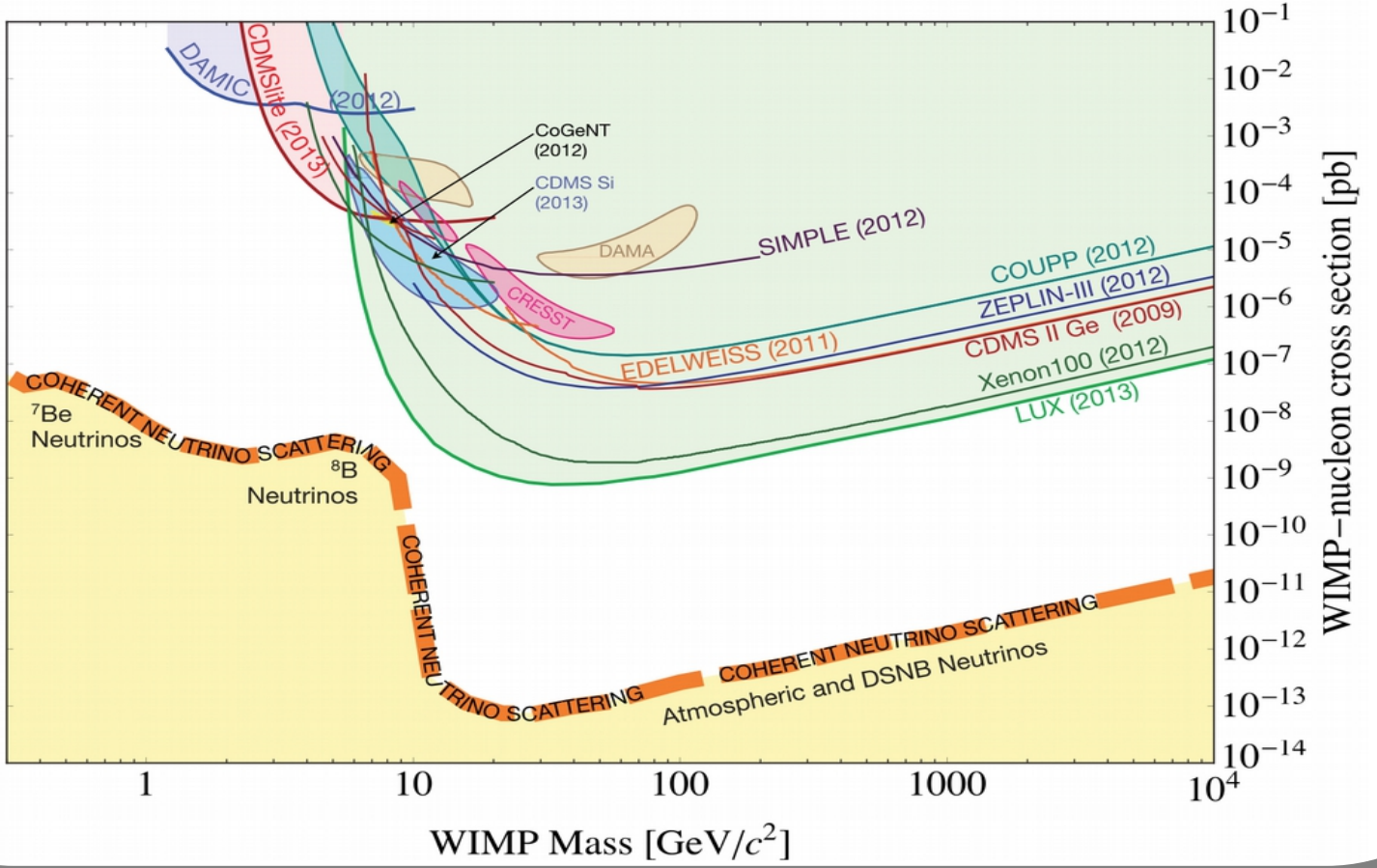
2-phase TPC Concept

- Purpose is to extract electrons produced by initial interaction (S1) in the liquid to then produce proportional scintillation (S2).
- Time difference between S1 and S2 enables for Z-position.
- fiducial volume of the TPC and background reduction.



Status for WIMPs

- Several claimed observations, none have been confirmed as dark matter.
- New experiments such as LUX and XENON1T to probe new parameter space for WIMPs
- Becomes important to use the current generation of dark matter detectors to look for alternative dark matter models.

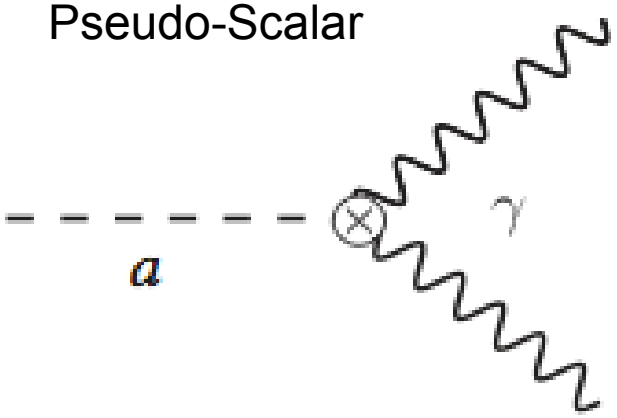


Bosonic Super-WIMPs

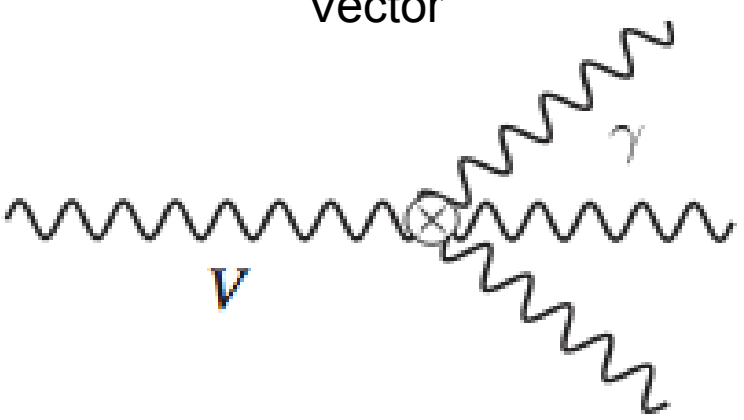
- Pseudo-scalar model formed through same process as axions.
- Additional Vector particle formed similarly.
- Vector and Pseudo-scalar couple to the standard model via the axion electric effect.
- Decays into photons allowed via this model

$$\mathcal{L}_{\text{int}} = \frac{C_\gamma a}{f_a} F_{\mu\nu}\tilde{F}^{\mu\nu} - \frac{\partial_\mu a}{f_a}\bar{\psi}\gamma^\mu\gamma^5\psi + \cdots \qquad \mathcal{L} = -\tfrac{1}{4}V_{\mu\nu}^2 + \tfrac{1}{2}m_V^2 V_\mu^2 + e\kappa V_\nu \psi \gamma_\mu \psi + \cdots$$

Pseudo-Scalar



Vector



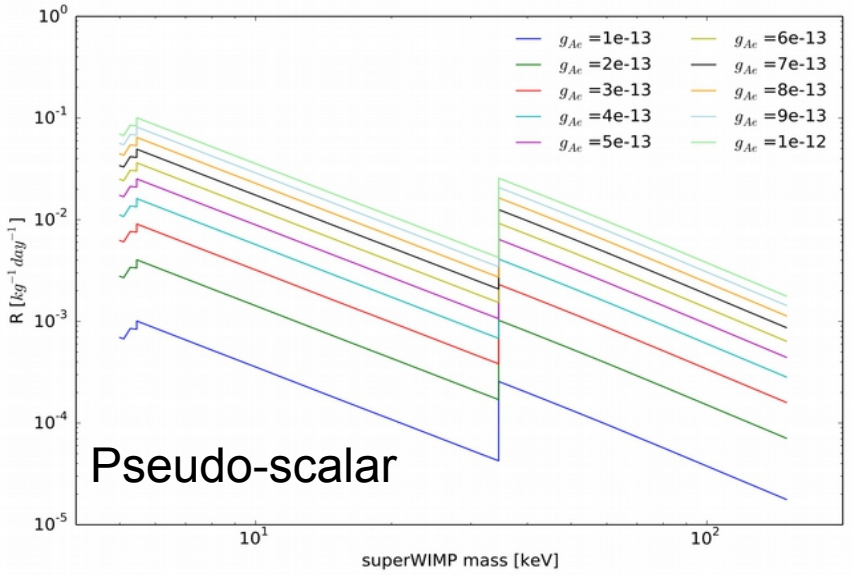
Pospelov et. al. Phys. Rev. D 78, 115012

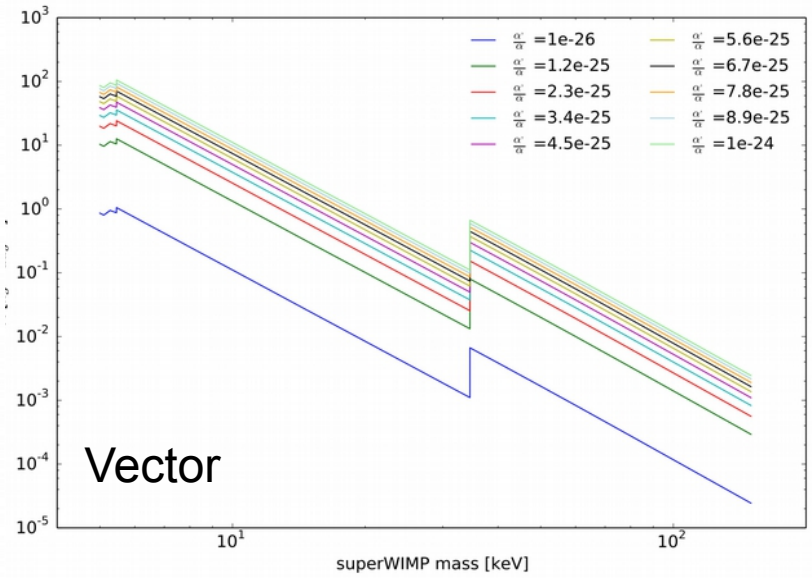
Bosonic Super-WIMPs

- Absorbed completely into a xenon atom via the axio-electric effect .
- Enables XENON100 to detect a new type of dark matter in the keV scale.
- Vector and Pseudo-scalar super-WIMP models are probed.
- XMASS currently has placed lowest limits on these coupling constants

$$R = \frac{1.29 \times 10^{19}}{A} g_{Ae}^2 m_A \sigma_{pe} \left[\frac{1}{kg}\frac{1}{day}\right]$$

$$R = \frac{4 \times 10^{23}}{A} \frac{\alpha'}{\alpha} \frac{1}{m_A} \sigma_{pe} \left[\frac{1}{kg}\frac{1}{day}\right]$$





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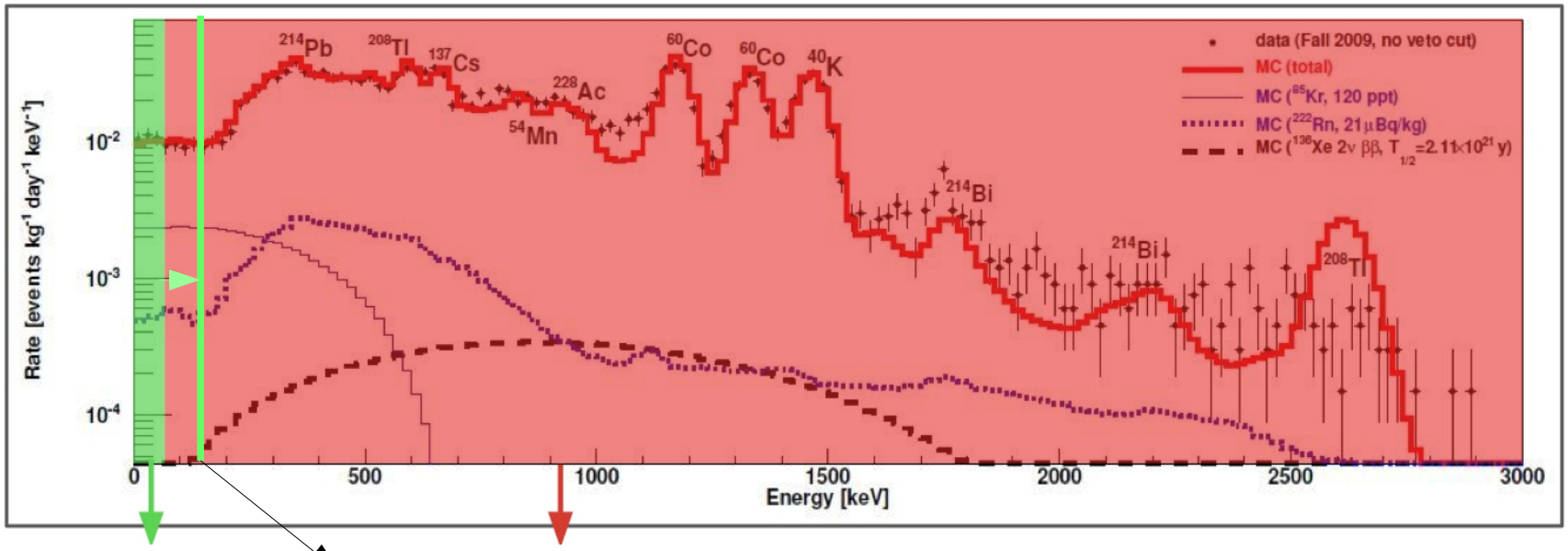
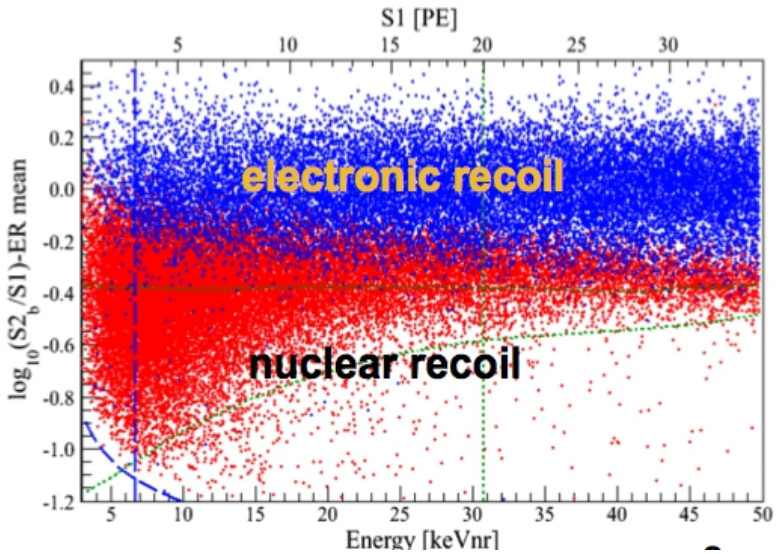
Detection in XENON100

Background spectrum from XENON100



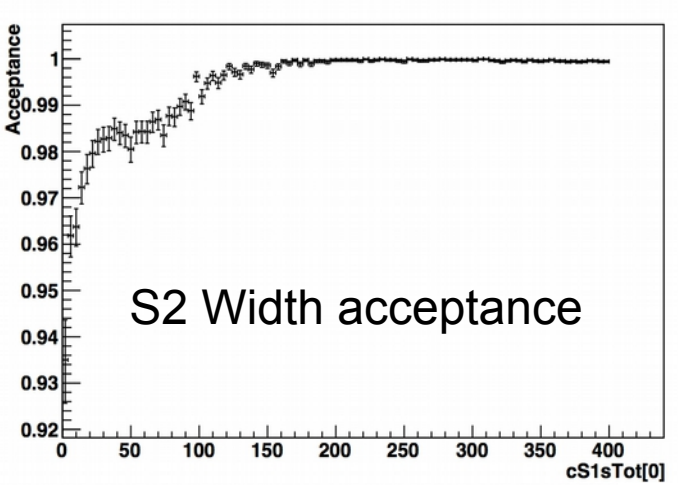
WIMP search energy range	Bosonic Super-WIMP search	Out of RoI

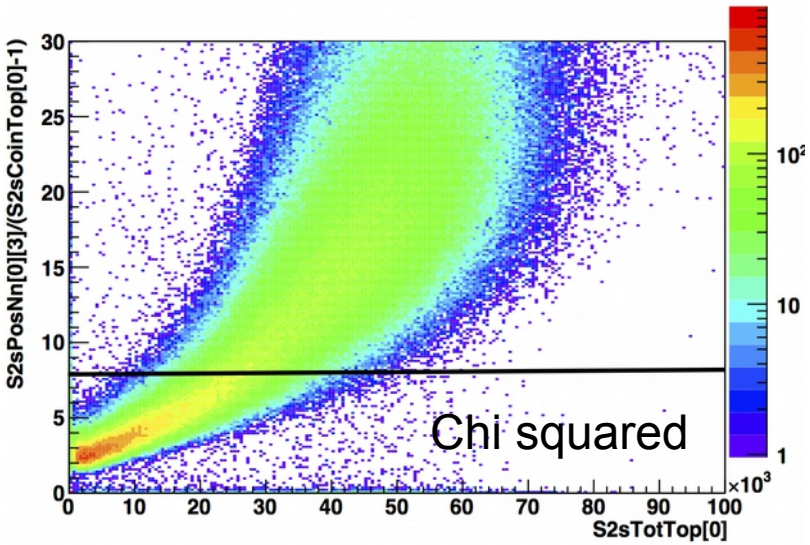
- Bosonic superWIMPs can be found in range up to ~150 keV in XENON100.
- Higher Energies more difficult due to higher background.

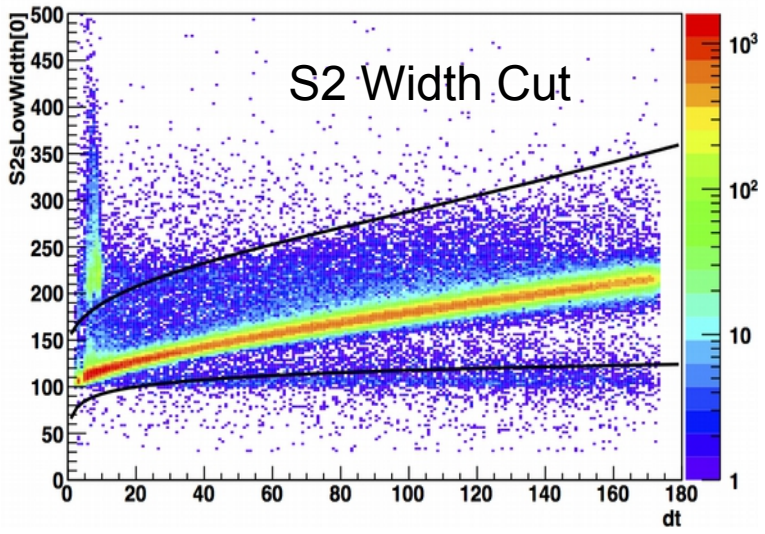


Selecting Events

- Must select the appropriate cuts for the analysis.
- Using collaboration vetted cuts, we can customise cuts for our analysis
- We cut events based on on:
  - Multi-site events
  - Gas events
  - S1/S2 signal widths
  - Noise
  - Events seen by less than 2 PMTs
  - Asymmetry between top and bottom PMTs
  - Profile likelihood of event distribution

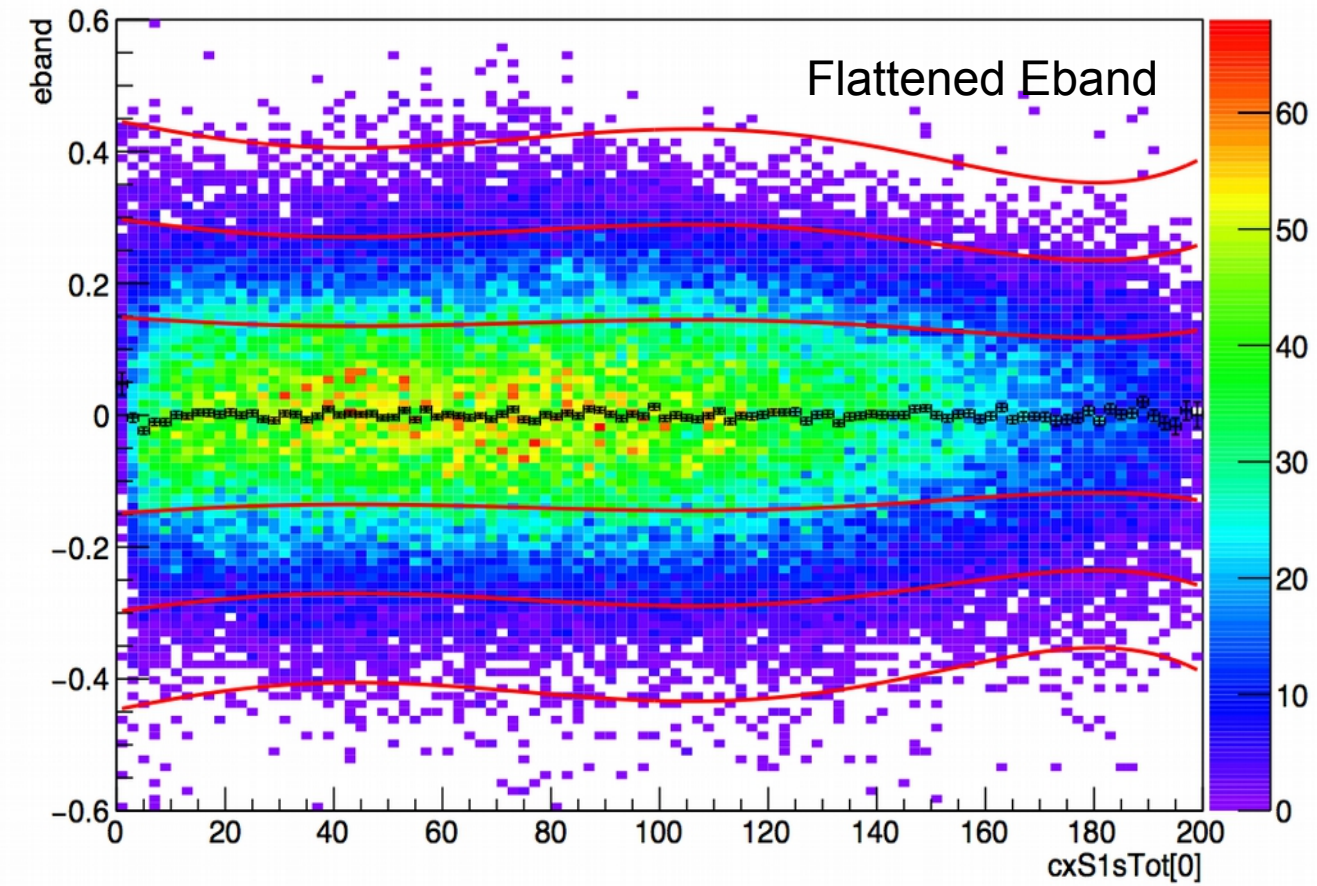






Selecting Events

- Must look in electronic recoil band for excess of events over BG
- Expected signal will be a delta function spread due to the energy resolution of the detector (2.5% at 1 MeV for XENON100).
- Preliminary limit can be set by counting events in energy range.



Selecting Events

- Must look in electronic recoil band for excess of events over BG
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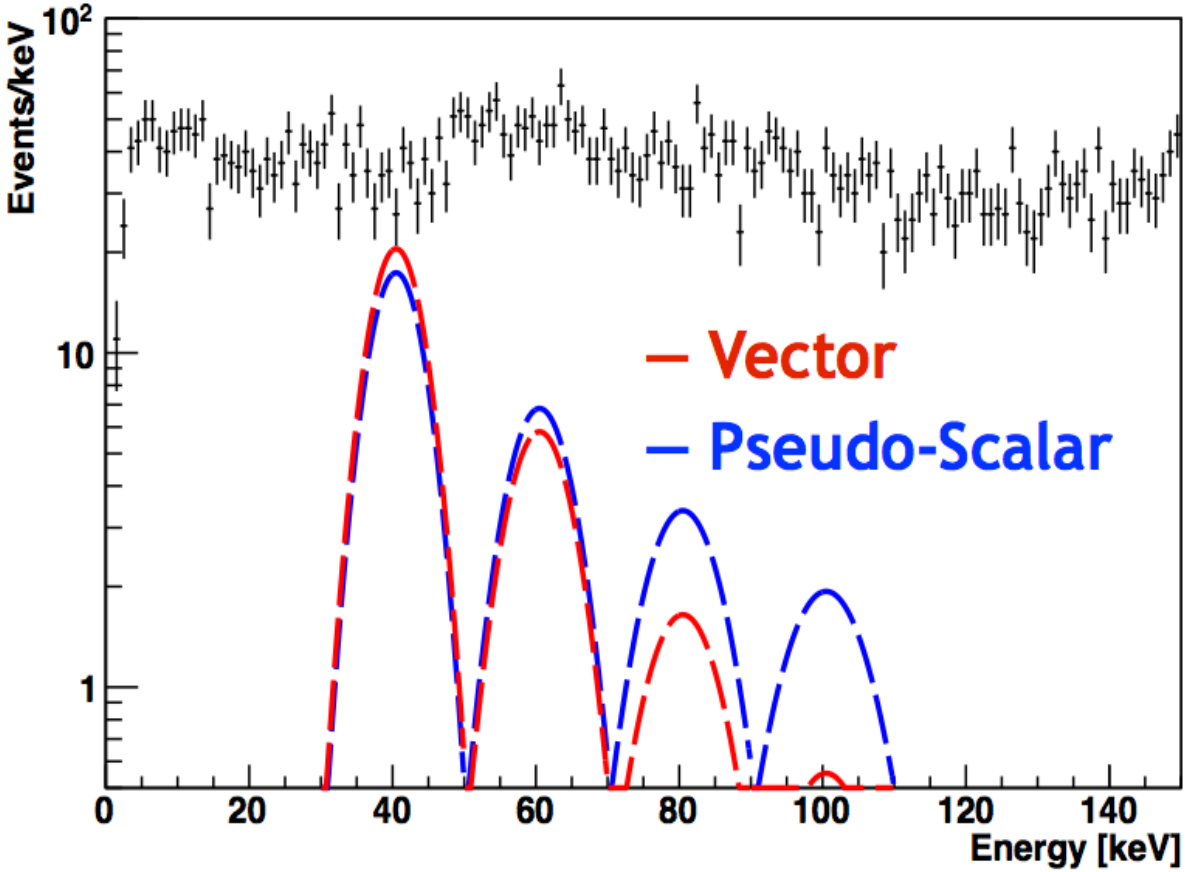
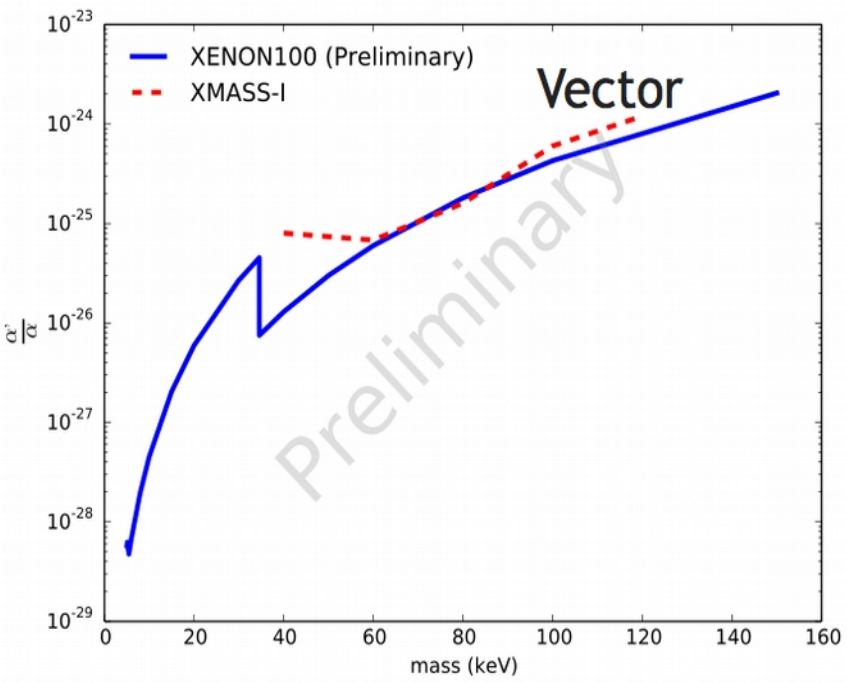
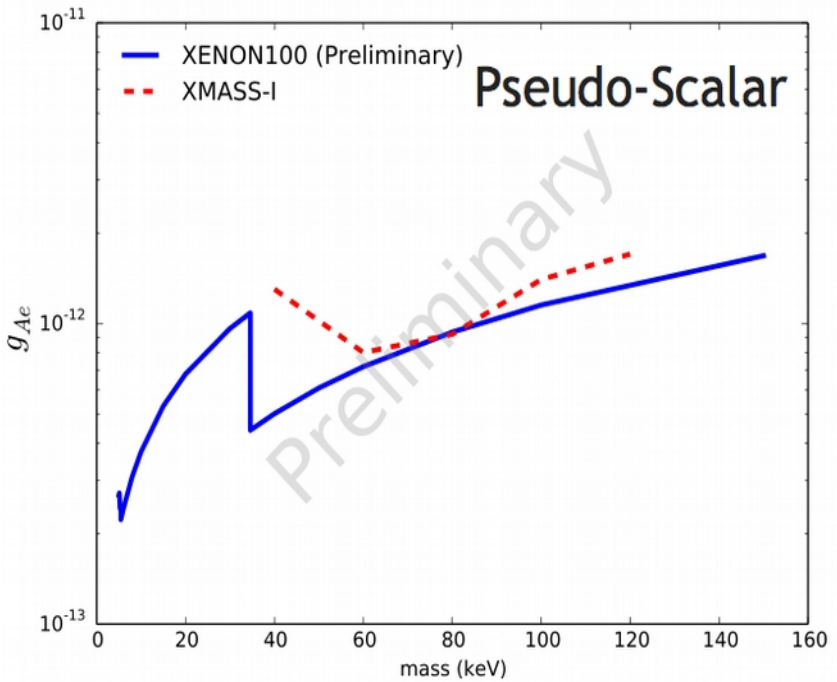
- Preliminary limit can be set by counting events in energy range, assuming flat ba



Setting a Limit

- Will be able to improve our sensitivity via PL analysis and data from the most recent run.
- Potential to improve sensitivity by factor of 4 at low energies, and probe higher energies not attainable by XMASS.
- Preliminary results may be improved via optimisation of the electronic recoil band definition.

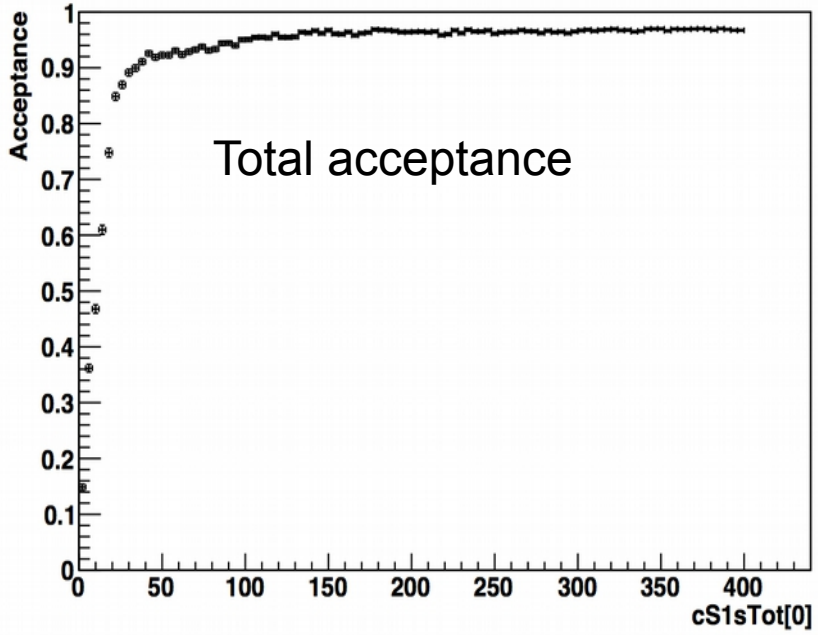


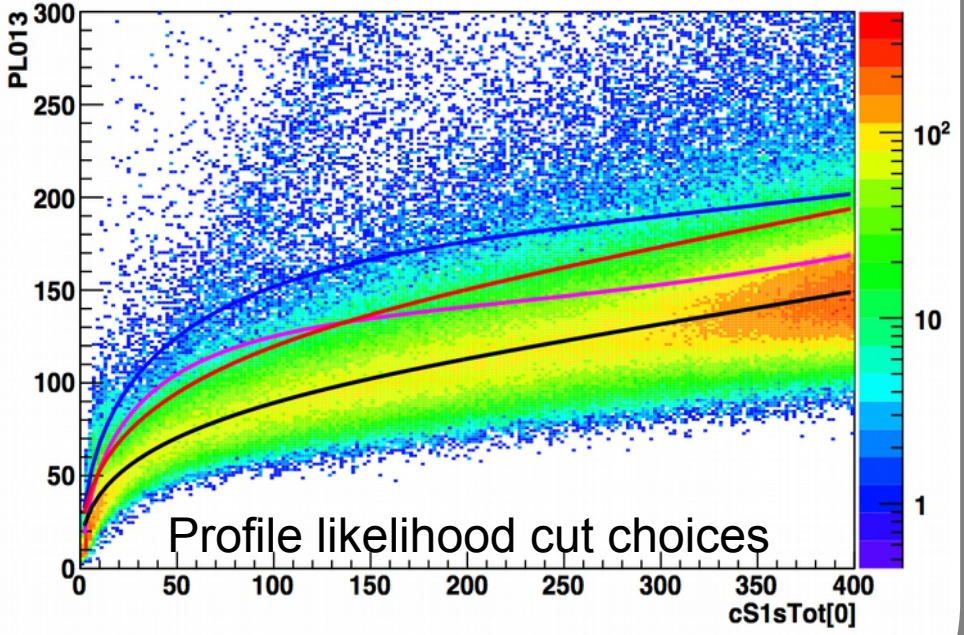


XMASS Limit: Phys. Rev. Lett. 113, 121301

Future

- Determine optimal set of cuts for the analysis
- Calculate acceptances
- Re-determine electronic recoil band
- Profile likelihood limit





Thank You!