Limits on Low-Mass WIMP with p-PCGe

TEXONO@KSNL New Results *[arXiv: 1303.0925]*

Limits on spin-independent couplings of WIMP dark matter with a p-type point-contact germanium detector

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(Dated: March 4, 2013)

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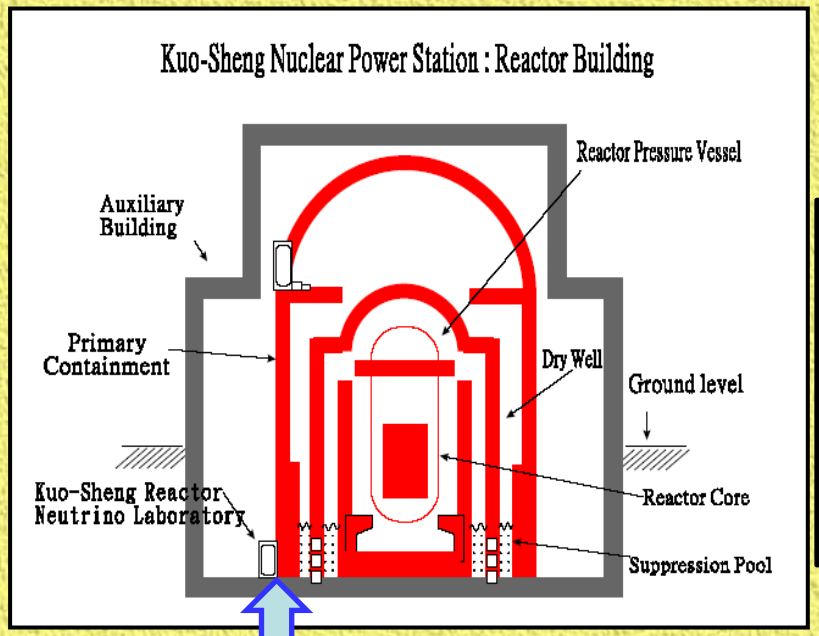
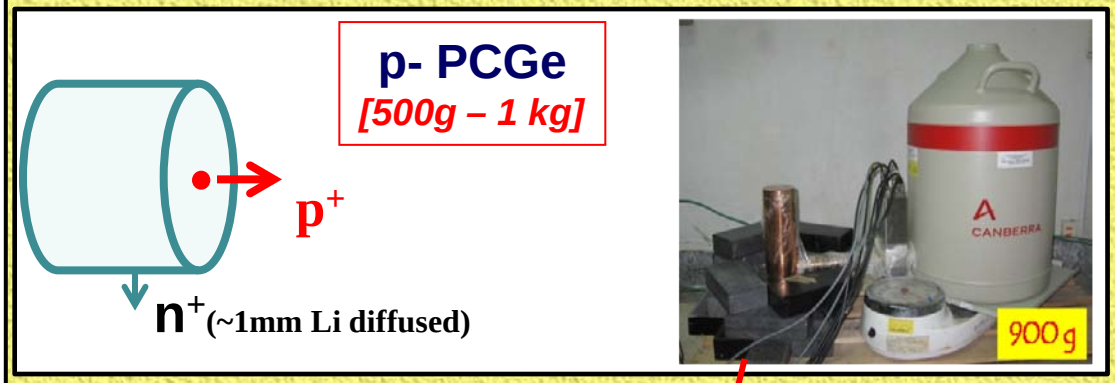
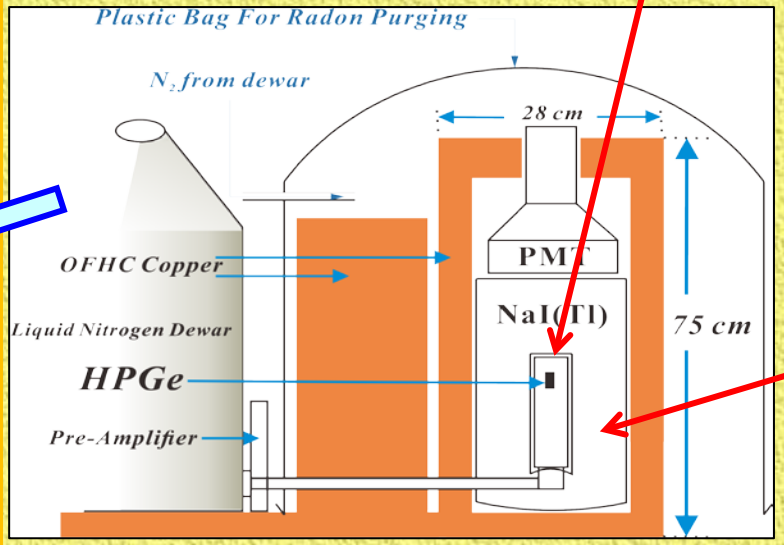
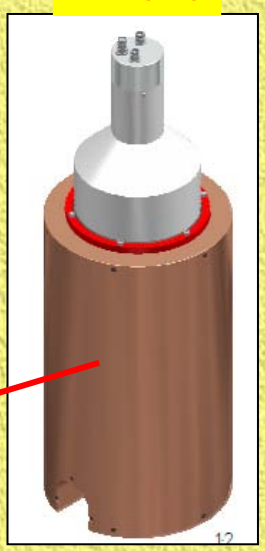


28 m from core#1 @ 2.9 GW
~30 mwe overburden





NaI(Tl)



TEXONO@KSNL New Results *[arXiv:1303.0925]*

Configurations:

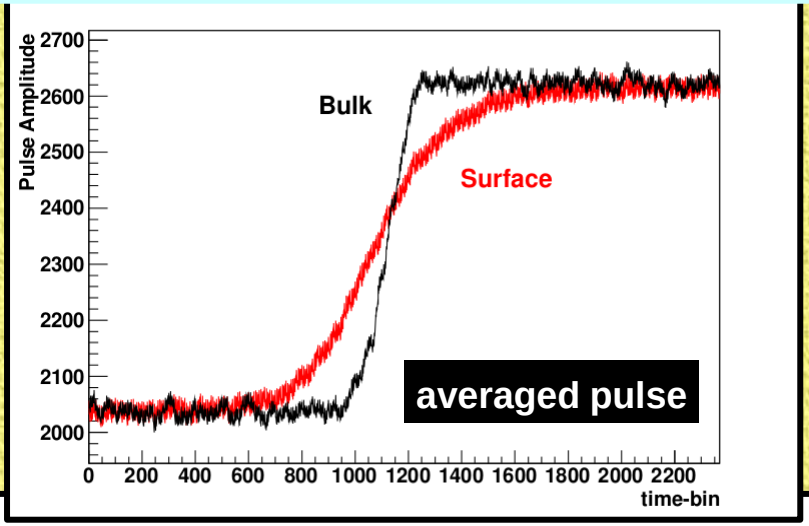
- 39.5 kg-days of data @ KSNL
- Baseline design with NaI(Tl) AC & active CR vetos
- PPCGe , 840 g fiducial mass
- Analysis above electronic noise edge of 500-eV

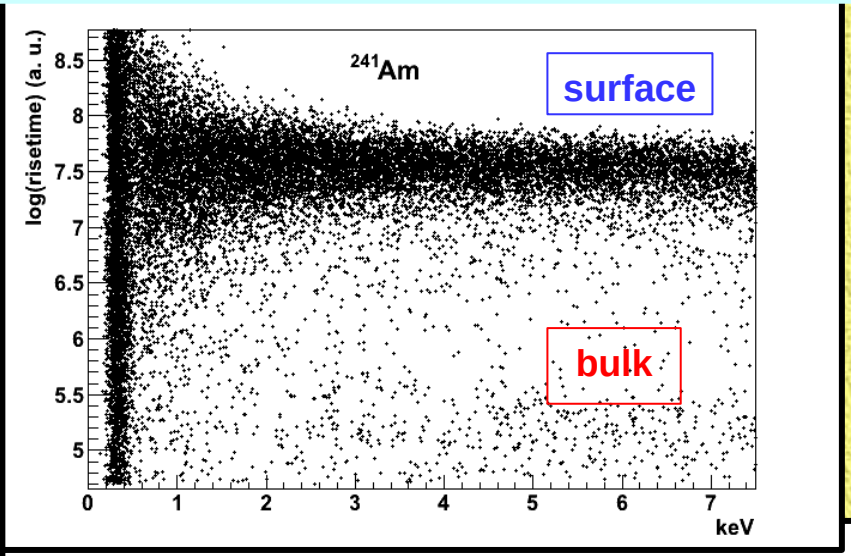
Basic (Previously Used) Selection Criteria:

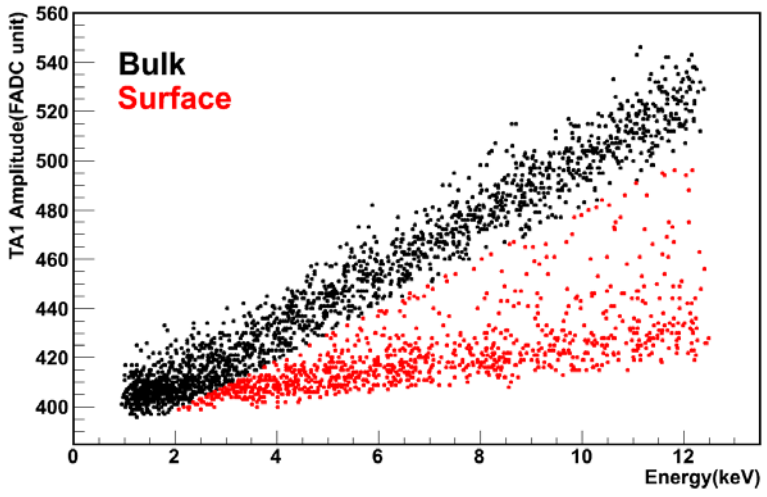
- ✂ Physics Vs Electronics Noise (PN) :
  - ➢ pedestal tails, microphonics, preamp-reset induced ……
  - ➢ Via pulse shape analysis & timing
  - ➢ WIMP-eff ~ survival of doubly-tagged ACT+CRT events
- ✂ Anti-Compton vetos (ACV) : NaI(Tl) anti-coincidence
  - ➢ WIMP-eff ~ survival of random trigger (RT) events
- ✂ Cosmic-Ray vetos (CRV) :
  - ➢ WIMP-eff ~ survival of RT
  - ➢ CR-rejection eff : survival of reference samples with NaI(Tl)>20 MeV

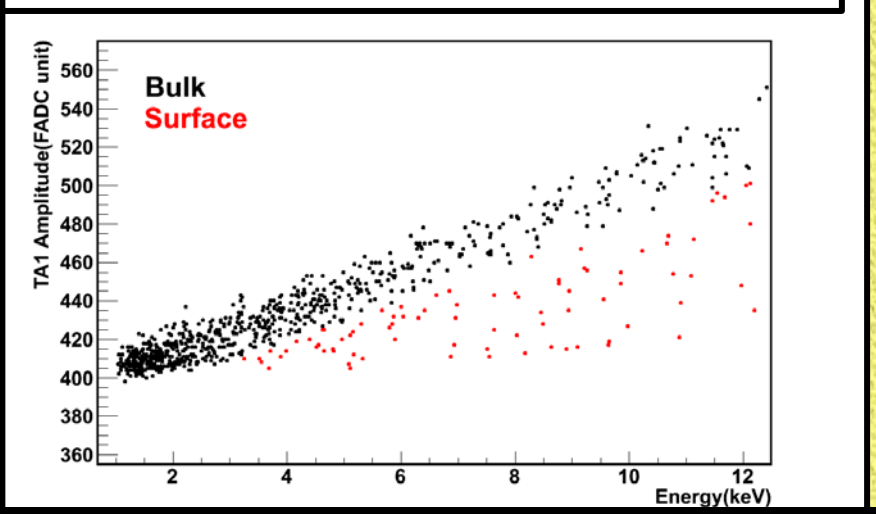
PSD for Surface Vs Bulk Events @ PCGe

- n+ "inactive layer" is not totally dead; signals finite but slower rise time
- ACV+CRT events (neutron rich) samples do not show surface band
- Understand/Measure Efficiencies and Suppression Factors ?





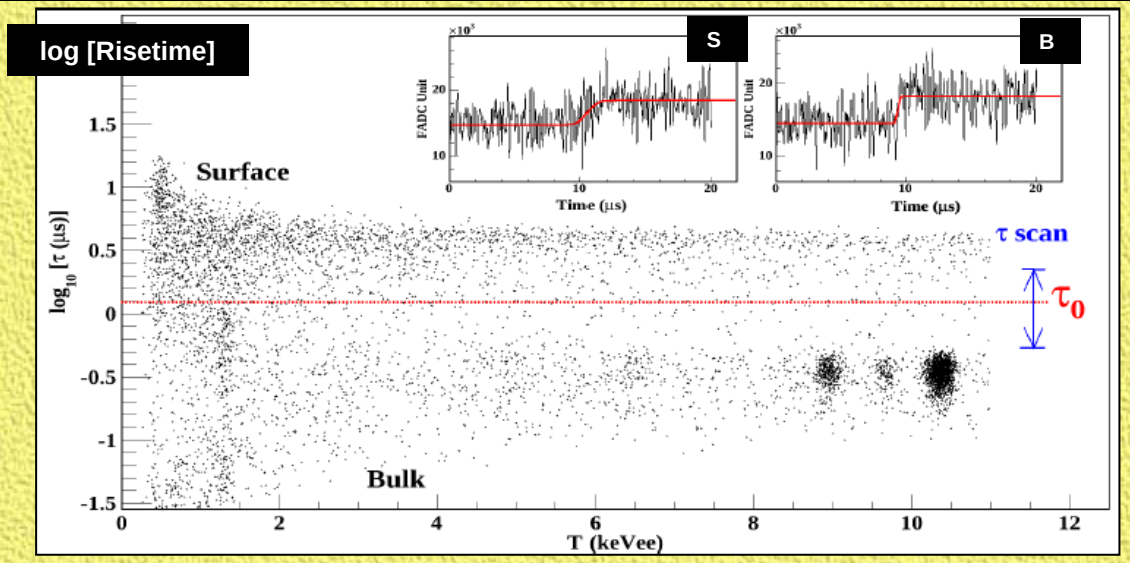




γ-rich background: cosmic veto & anti-Compton trigger

n-rich background: cosmic trigger & anti-Compton veto

Bulk Vs Surface (BS) Events Selection & Efficiencies



Valid scheme should produce physics rates insensitive to location

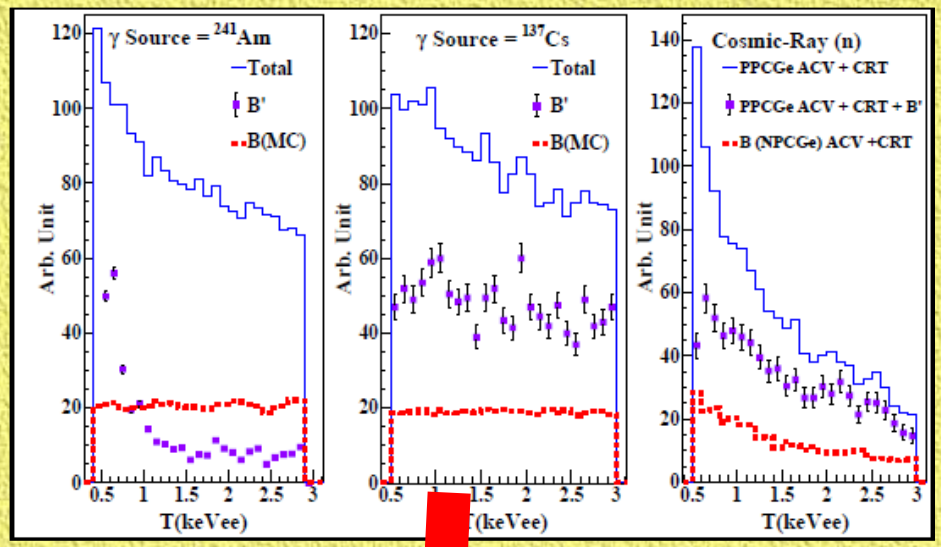
"Calibration" ≡ measure energy-dependent signal-retaining (ε_{BS}) & background-suppressing (λ_{BS}) efficiencies, such that [B,S=real ; B'S'=measured]

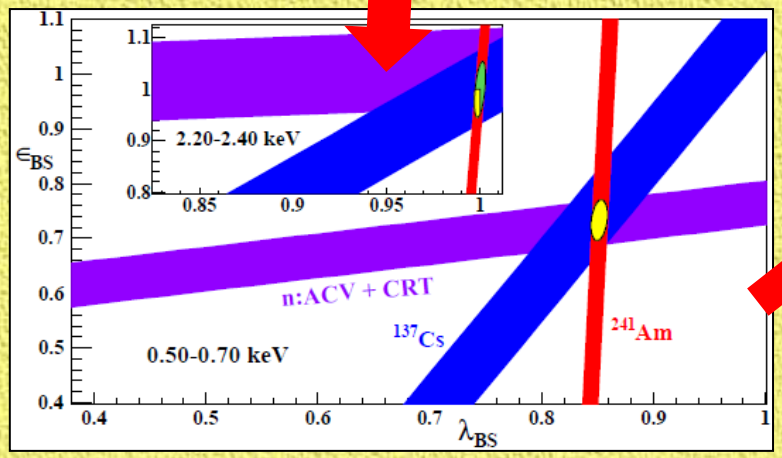
$$B' = \epsilon_{BS} \cdot B + (1 - \lambda_{BS}) \cdot S$$
$$S' = (1 - \epsilon_{BS}) \cdot B + \lambda_{BS} \cdot S$$

Approach: Identify *at least* two calibration data where (B,S) are known & (B',S') measured ⊕ solve coupled equation for (ε_{BS}, λ_{BS}) ⇨ correct physics (B'S') to get (B,S)

Three complementary *[different depth distributions]* calibration data:

- ☑ Very Surface-rich **low-energy γ** (^{241}Am, 60 keV) ; B=simulation
- ☑ Surface-rich **high-energy γ** (^{137}Cs, 660 keV) ; B=simulation
- ☑ Bulk-rich cosmic-induced **high energy neutrons** by ACV+CRT tagging ; B=same tag from NPCGe





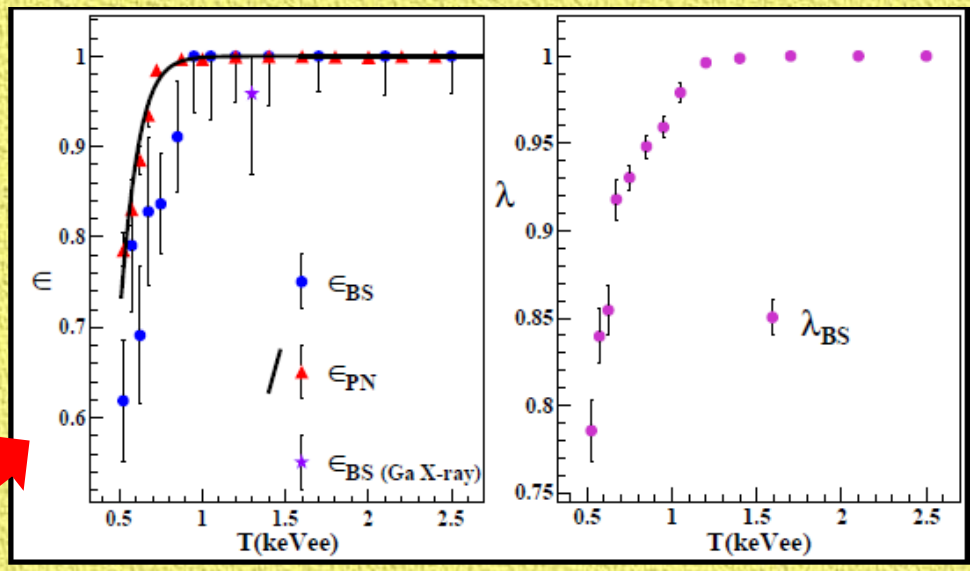
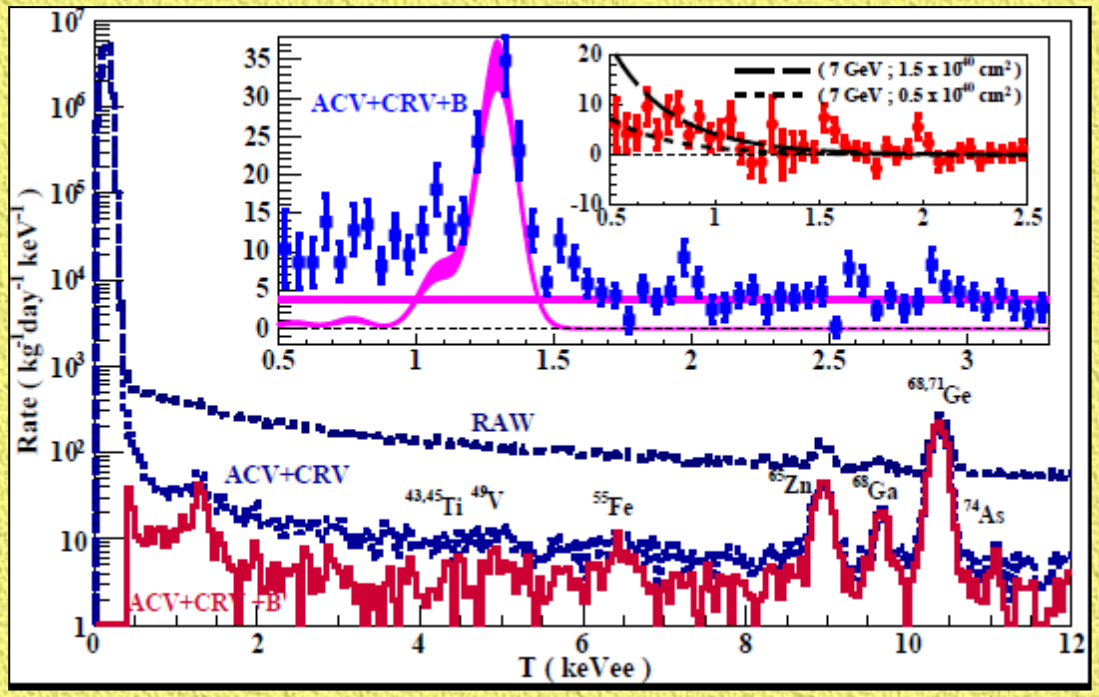


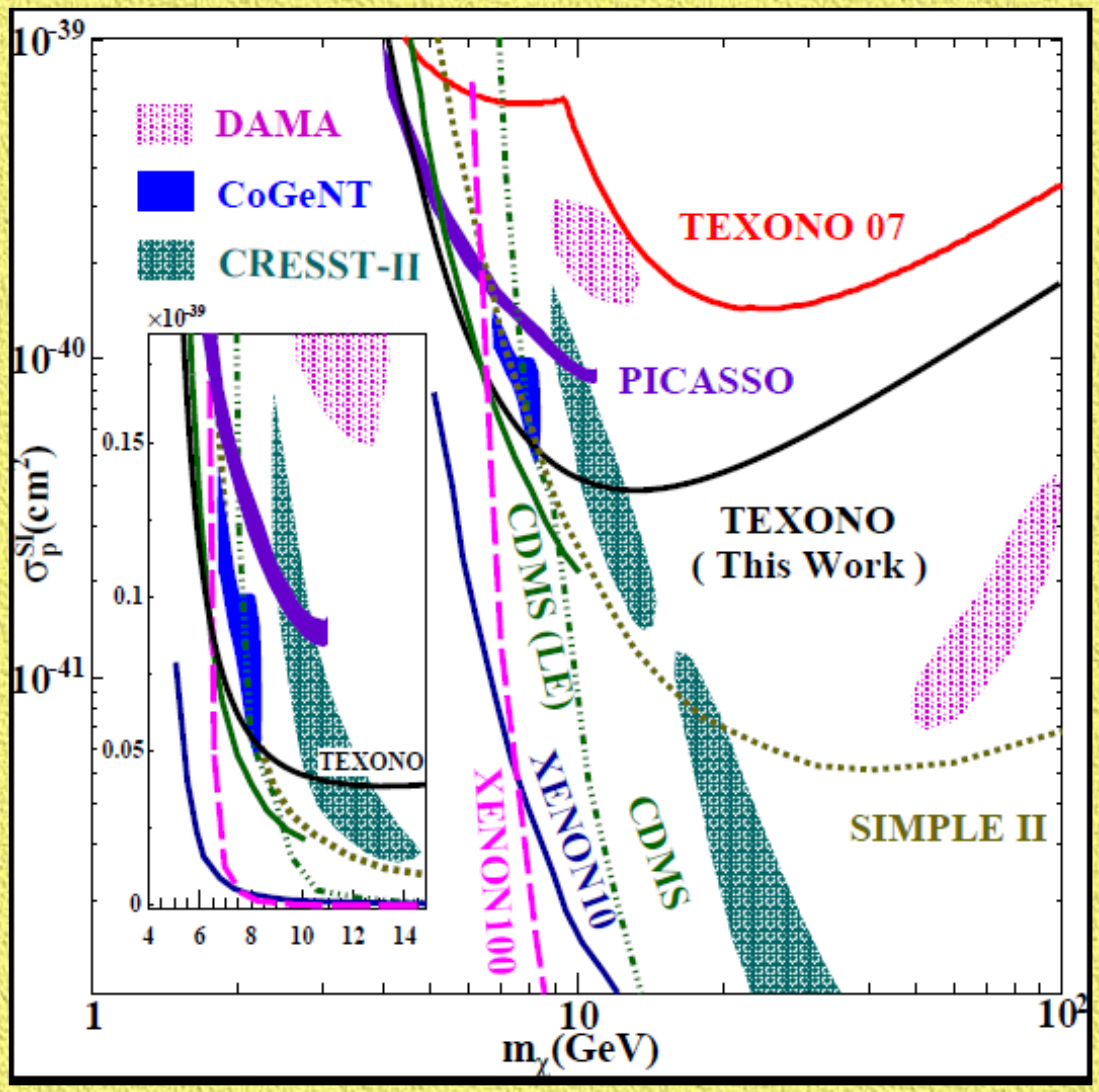
TABLE I: The p-values for the stability hypothesis on the key parameters following a τ-scan of Figure 1. The ACV+CRV+B rates are insensitive of the choice of τ_0.

Energy Range (keVee)	0.5-0.7	1.5-1.9
ϵ_{BS}	$< 10^{-5}$	$< 10^{-5}$
λ_{BS}	$< 10^{-5}$	$< 10^{-5}$
ACV+CRV+B'	0.24	0.16
ACV+CRV+S'	0.17	0.21
ACV+CRV+B	0.57	0.65

"Candidate Events" = ACV+CRV+B

- ACV+CRV+B' + (ε_{BS}, λ_{BS}) correction
- insensitive to exact BS-cut location
- Subtract flat γ background & L-X-ray
  - residual spectrum for placing WIMP constraints
  - $\exists$ not-yet-accounted-for sub-keV events





New limits probed and excluded some of the low-mass WIMP allowed regions implied by other experiments.

Summary & Prospects

- Competitive and relevant results on low-mass WIMPs with sub-keV Ge detector, *even at* a surface location
- Presence of cosmic-ray crucial for this B/S calibration scheme
- Same design at underground laboratory (CDEX-1 @ CJPL) can only be better
- Extra experimental handles for background understanding/suppression
  - CR- and AC-tagged events for calibration & normalization
  - Compare NPCGe & PPCGe responses
  - Compare surface & deep sites