BetaCage: A multi-wire proportional counter beta screening facility

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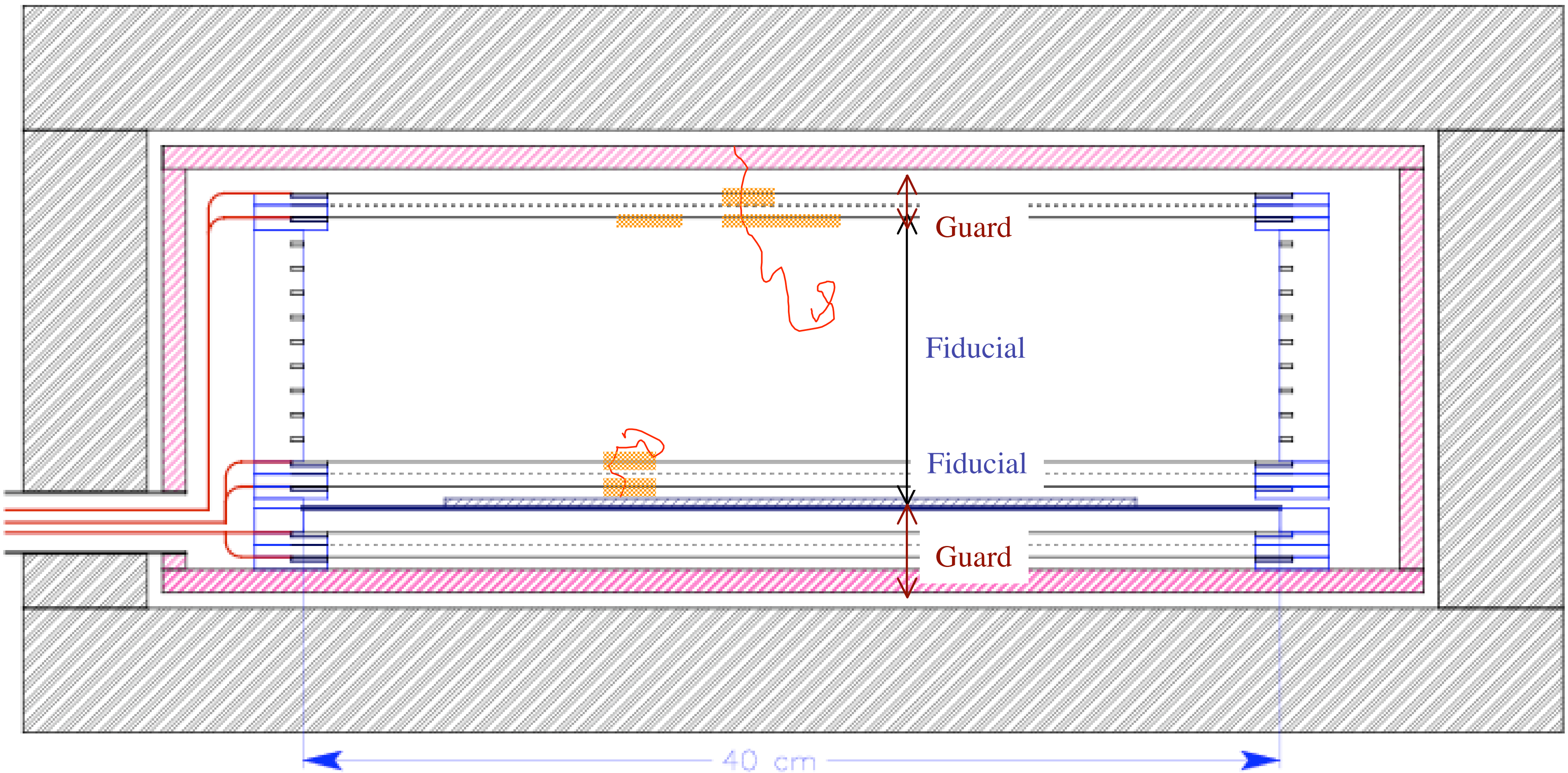
A new type of beta screening facility

- Idea driven by low energy beta contamination limiting CDMS, EDELWEISS
- Ge detectors insensitive to low energy betas
  - Metal cans, dead layer.
- Complement to chemical measurements
  - Short lived isotopes can't be detected chemically
- Major drawback:
  - Poor spectral information. But perhaps not so bad for betas.
- Beta background goals:
  - CDMSII: 10^{-4} cnts/keV/cm^2/day
  - 1 ton: 10^{-6} cnts/keV/cm^2/day

MWPC screening facility

- Deploy minimum material needed to stop β in question.
  - 150 keV e^- $\approx$ 10 cm Ne (1 atm)
  - Gas is best method to achieve this low mass
    - Semiconductor - capacitance to high - noise to high.
    - Scintillator. Dead layer on surface, ^{14}C
- Minimum surface detector
  - Only achievable with gas detector.
  - 20 μm Ø, 1/2 cm spacing - 0.4% coverage

Design concept



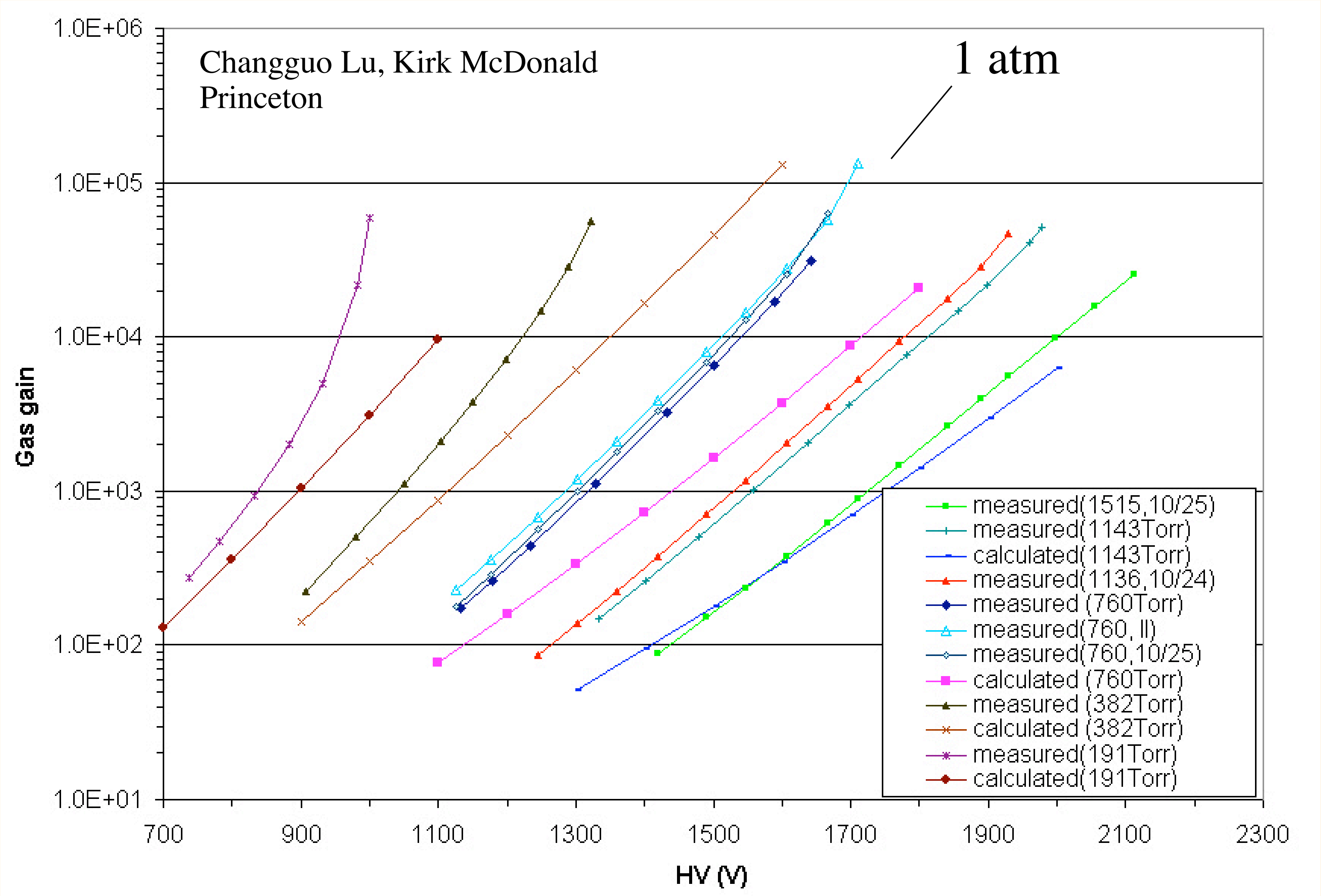
Design

- 1 atm Ne
  - Or Xe, possibly higher pressure.
- Alternating, crossed sense and anode wires.
  - Fiducial length - ≈ 4 cm
  - z - guard region - ≈ 4 cm
  - xy readout.
    - Extent of guard region to be determined.
    - Benefit of small scale x-y readout resolution?
- 20 μm Ø wires, Voltages ≈ 2 k V
  - Drift field depends on wire and grid separation (few hundred V/cm)

Gas choice

- Xe, Ne, He - radiopure gasses
  - Ne:
    - Best for low energy betas: 10 cm contains 150 keV
    - Inexpensive - allows flushing, atm pressure operation
  - Xe:
    - Good for high energies, alphas.
    - May require outer chamber to be evacuated
- Quench gas: ^{14}C problem
  - Not a problem if maintain $< 10^{-16}$ g/g. (CTFI: 2×10^{-18} also see T. Litherland talk)
  - Could possibly use non-organic quench gas, e.g., SF_6.

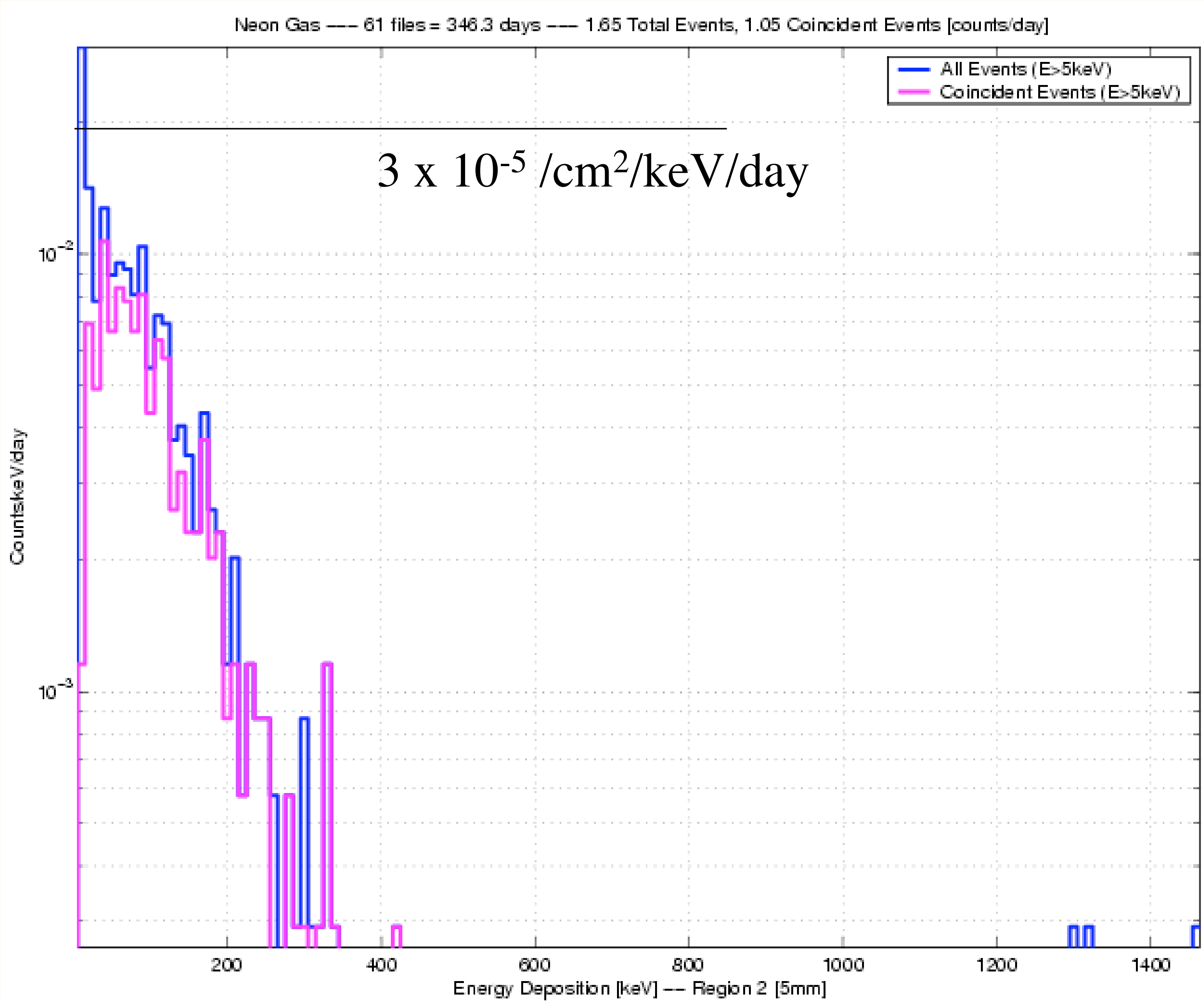
Gain in pure Xe, 20 μm Ø wires



Backgrounds

- Dominant: gammas
  - Assume 1 cnt/kg/keV/day with good shield
  - 5 mm trigger region.
  - Rate: $3x10^{-5}$ cnts/kg/keV/day at low energy.
- Other:
  - ^{14}C in quench gas
    - 5% methane, $2x10^{-18}$ g/g C14/C12
    - $1x10^{-7}$ /cm^2/keV/day
  - ^{85}Kr (in Xe)
    - Best commercial Xe ~ 5 ppb Kr (≈ 0.5 dru)
    - $1x10^{-6}$ /cm^2/keV/day
  - Wires.
    - Bulk: negligible - 10^{-8} /cm^2/keV/day
    - Surface: at 20 μm Ø, 0.5 cm spacing -> 250 smaller than sample
      - May have to clean wires
  - Rate from gammas in sample.
    - Need MC calc. Thin sample best .
      - Equal mass to gas ≈ 100 μm in Ge

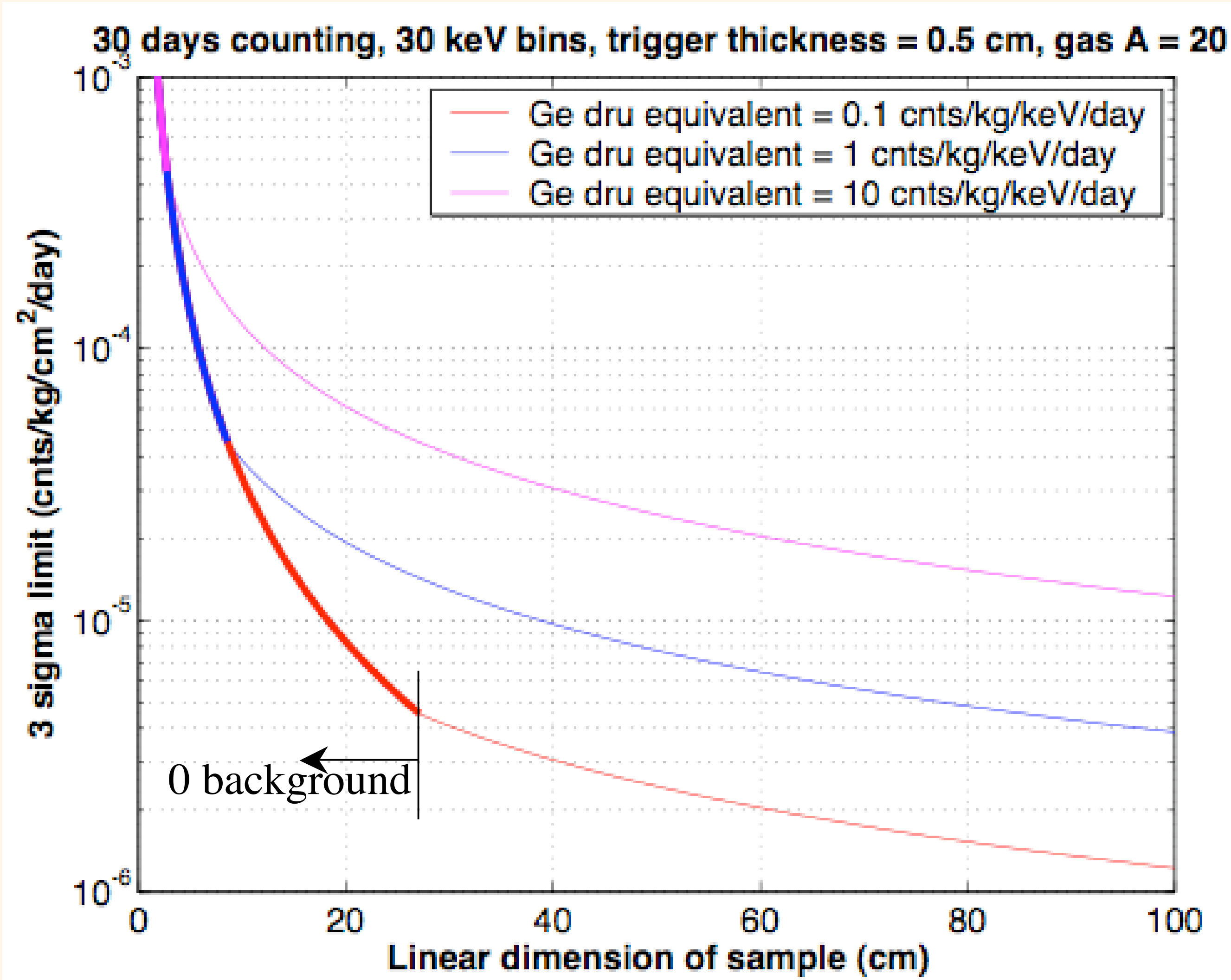
Gamma background



Backgrounds summary

Source	Rate (cnts/keV/cm^2/day)
Photon, nominal 1 dru (in Ge) environment	$3x10^{-5}$
Kr rate in full volume. Assume 20 ppb.	$4x10^{-6}$
5% methane quench gas (assume $2x10^{-18}$ C^{14}/C^{12}). Rate in full volume.	$1x10^{-7}$
Wires: Internal beta rate < 100 keV. U, Th contamination is typical for dirty metals, e.g. SS.	$\approx 10^{-8}$
Wires: Rate from gammas in full volume.	$\approx 10^{-13}$
30 resistors: Rate from gammas in full volume. Assume ≈ ppm U, Th, typical of ceramics	$\approx 10^{-6}$

Sensitivity (assuming background subtraction)



Other uses

- Alpha counting.
  - Probably very low background, but has not been studied
- ^{85}Kr: 20 ppb at 4×10^{-6} /cm^2/keV/day
- ^{14}C: Can fill counter with CO_2.
  - 10^{-16} or lower seems possible
  - Need ~ 10^1 g samples, week-month counting times.
  - Q: how competitive is this?