# Measuring the Milky Way with Dark Matter

Craig J Copi

Case Western Reserve University

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# WIMP Scattering Rate (Spin Independent)

$$\frac{dR}{dQ} = \frac{(m_n + m_\chi)^2}{2m_n^2 m_\chi{}^3} A_N{}^2 \sigma_p F^2(Q) \rho_0 \int \frac{f(\boldsymbol{v})}{v} d^3 v.$$

Variables affecting rate:

1. Experimental Choice
2. Particle Physics
3. Astrophysics

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# Astrophysics from Dark Matter

Measure rate **and** modulation. The modulation amplitude is small $\mathcal{O}[(2v_\oplus/v_{\rm halo})^2] \sim 0.05$.

- Modulation signal contains information about the isotropy of the halo.

  Isotropic Halo: Phase determined by the Earth's motion around the Sun (152.5 days).

  Anisotropic Halo: Phase determined by the alignment of the anisotropy, the Earth's motion, and the WIMP mass.

  DAMA modulation signal consistent with isotropic halo.

- Ratio of rate to modulation amplitude provides information about velocity distribution, $f(\boldsymbol{v})$.

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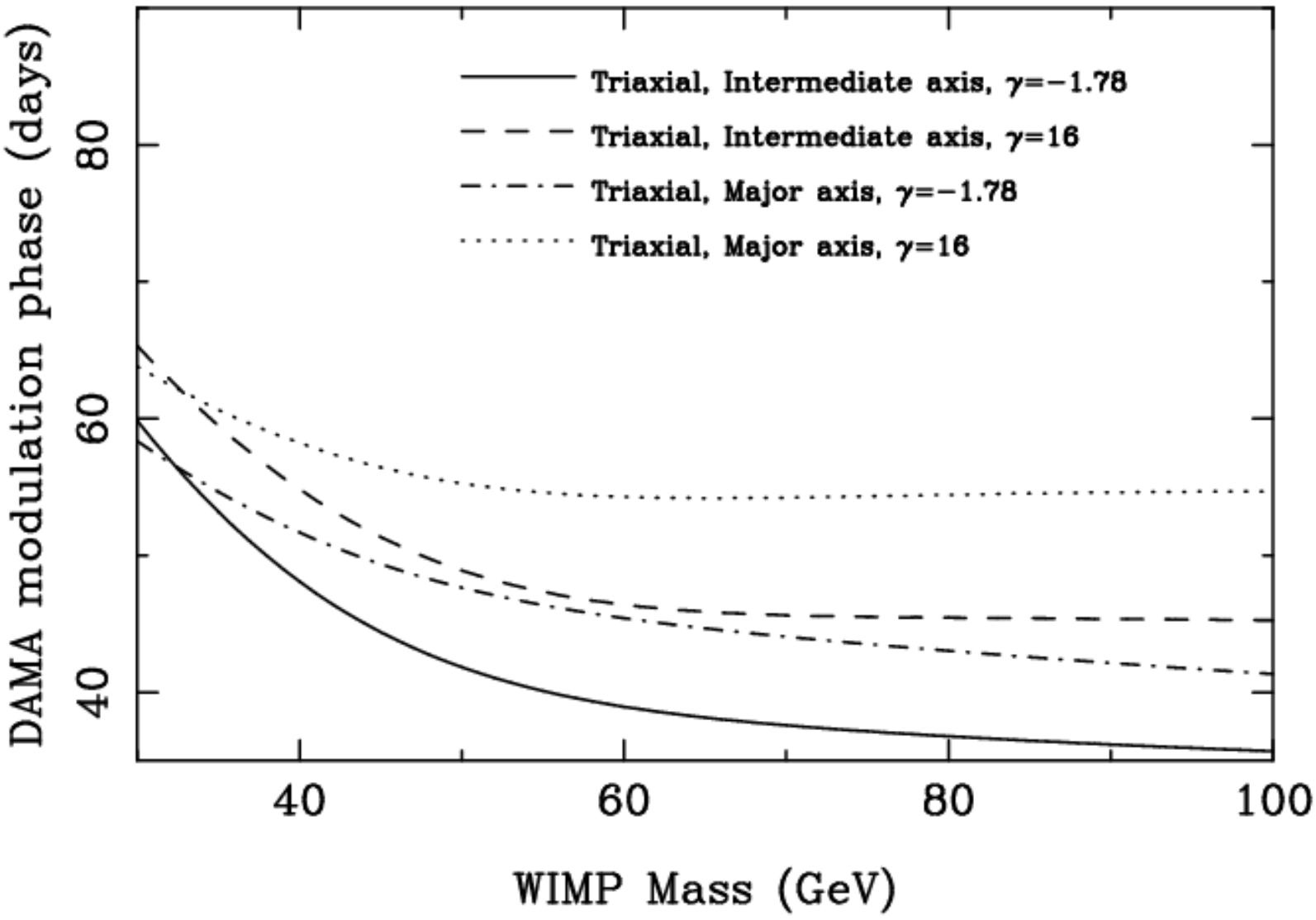


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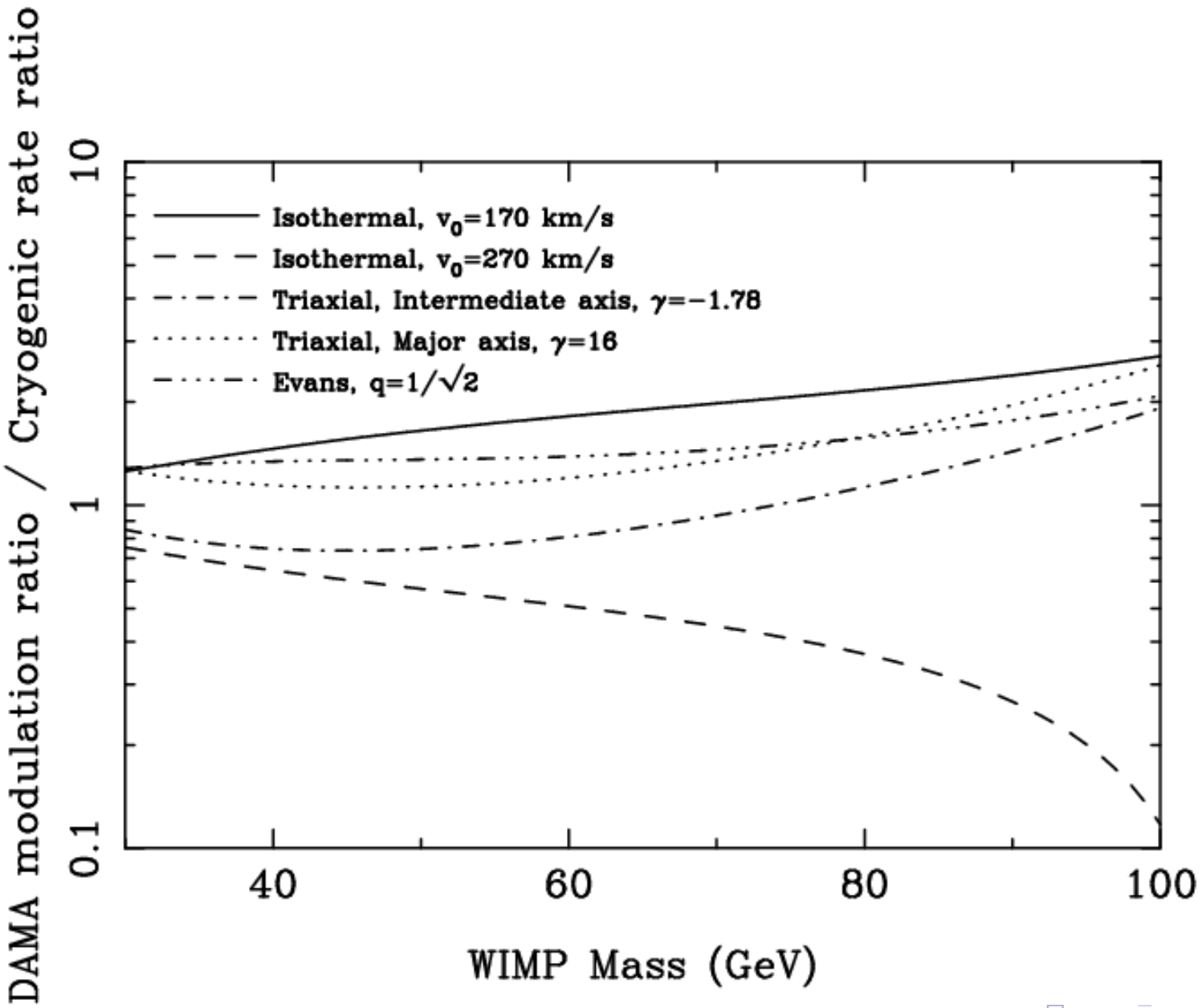


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# Summary I

- Isotropy of the halo distribution can be gained just from the modulation phase.
- Information about the shape of the distribution can be gained from comparison of rate and modulation amplitude.
- Distribution $f(v)$ may be reconstructed from hundreds to thousands of events.
- Work done to allow consistency between DAMA and CDMS/EDELWEIS/XENON/... also shows the range of model uncertainties.

# Directional Detectors

Measure $\frac{dR}{d\Omega}$ or even $\frac{dR}{dQ\,d\Omega}$.

**Benefits:**

- Forward-backward asymmetry is "large", $\mathcal{O}(v_\odot/v_{\rm halo}) \sim 1$.
- Clear signature.
- Not likely to be reproduced by backgrounds.

**Drawbacks:** Experimentally very difficult!

- Track resolution.
- Track direction measurable?
- Instrumentation: 2-D versus 3-D?

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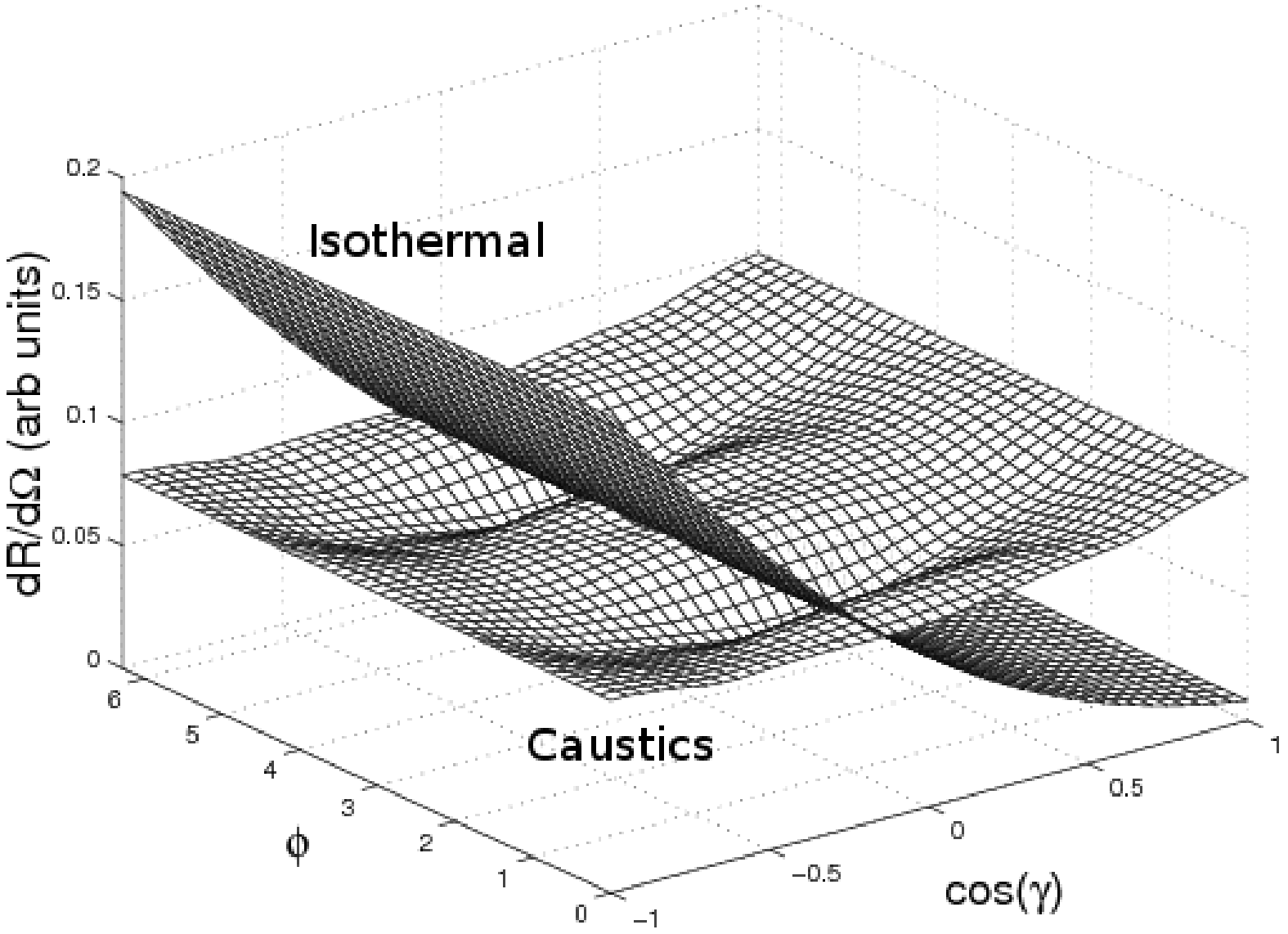


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# Summary II

- "Properly aligned" 2-D detector with forward-backward symmetry alone is sufficient for identifying a WIMP signal even with S/N=1.
- Full (perfect) $dR/d\Omega$ determination lowers event requirements by approximately a factor of 2.
- Limits for a 3-D detector without forward-backward track direction information are very model dependent ($f(\boldsymbol{v})$ and ($m_\chi$).
- A 2-D detector without forward-backward track direction information is "useless".

Knowledge of track direction is **essential**!

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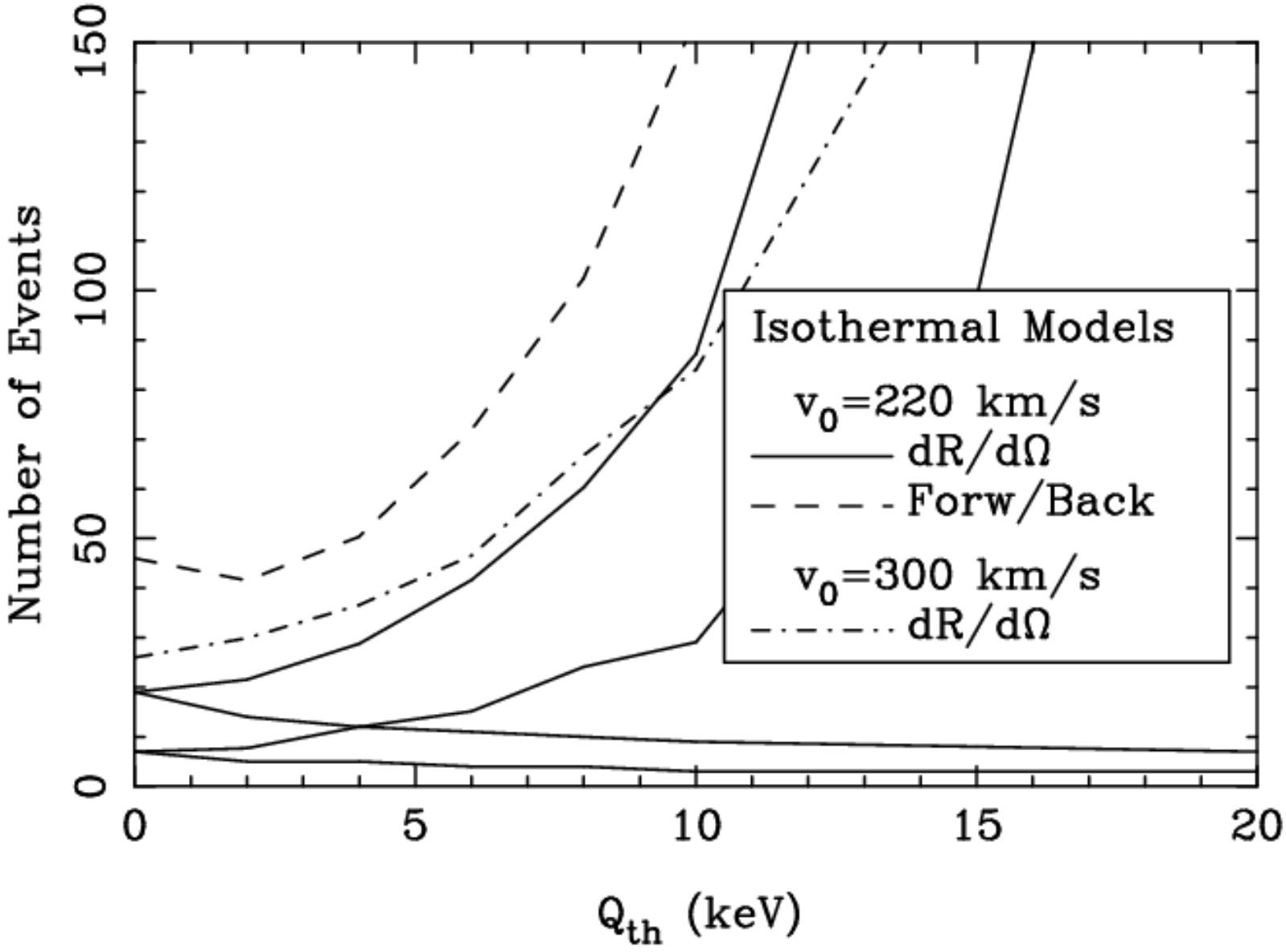


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