A Probabilistic Framework for Asteroid Risk Assessment

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The Stanford ERRG develops quantitative risk models for big problems.

- Cyber threats
- Seismic risk and infrastructure
- Medical problems (anesthesia)
- Strategic timing in games
- Space systems and satellites
- Nuclear weapons arsenals
- ***Asteroids: risk of NEO impacts and mitigation***

Risk analysis can play a key role in informing decision makers.

- Risk analysis is based on probability and systems analysis
- Probability is a measure of 'what we know' (and not only past frequencies and statistics)
- Data -> Model -> Insights for decision makers
- Data come from physical measurements, in situ or elsewhere, other models, expert opinion
- Many powerful examples
  - Shuttle, seismic risk, terrorism, offshore oil platforms, …

Risks posed by future asteroid impacts.

Historical data are important,
but do not tell the whole story:

- What is the probability of different numbers of annual deaths from asteroid impacts? The mean has little relevance (e.g., the population is changing).
- What is the probability that an asteroid of a particular size, angle, composition, will hit the Earth in a given time period?
- What if an asteroid of given characteristics (size, angle, etc.) hit a large city?

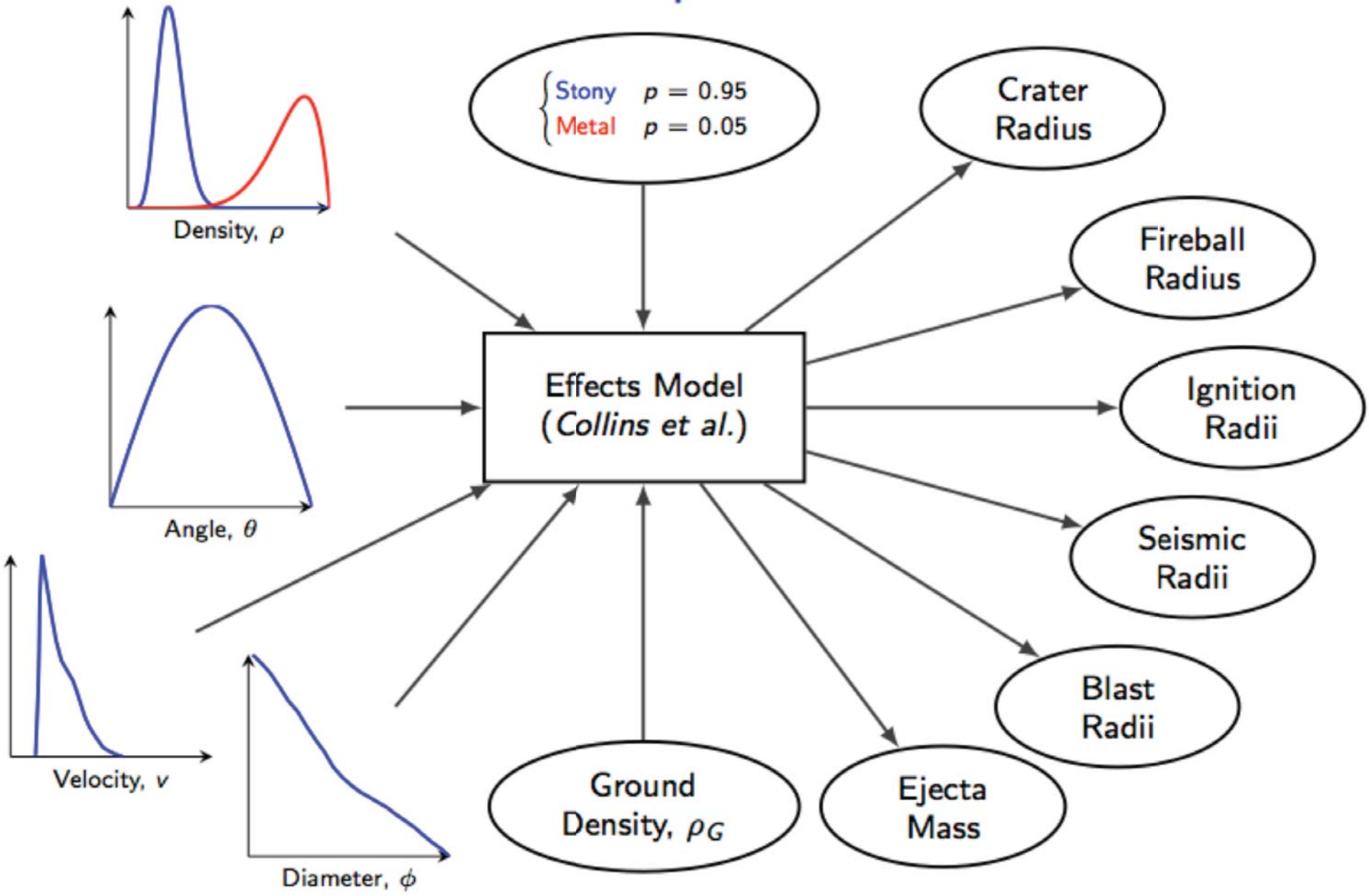
Our risk analysis approach

Our research focuses on improving our understanding of asteroid impact risks, and the prospects of mitigating it.

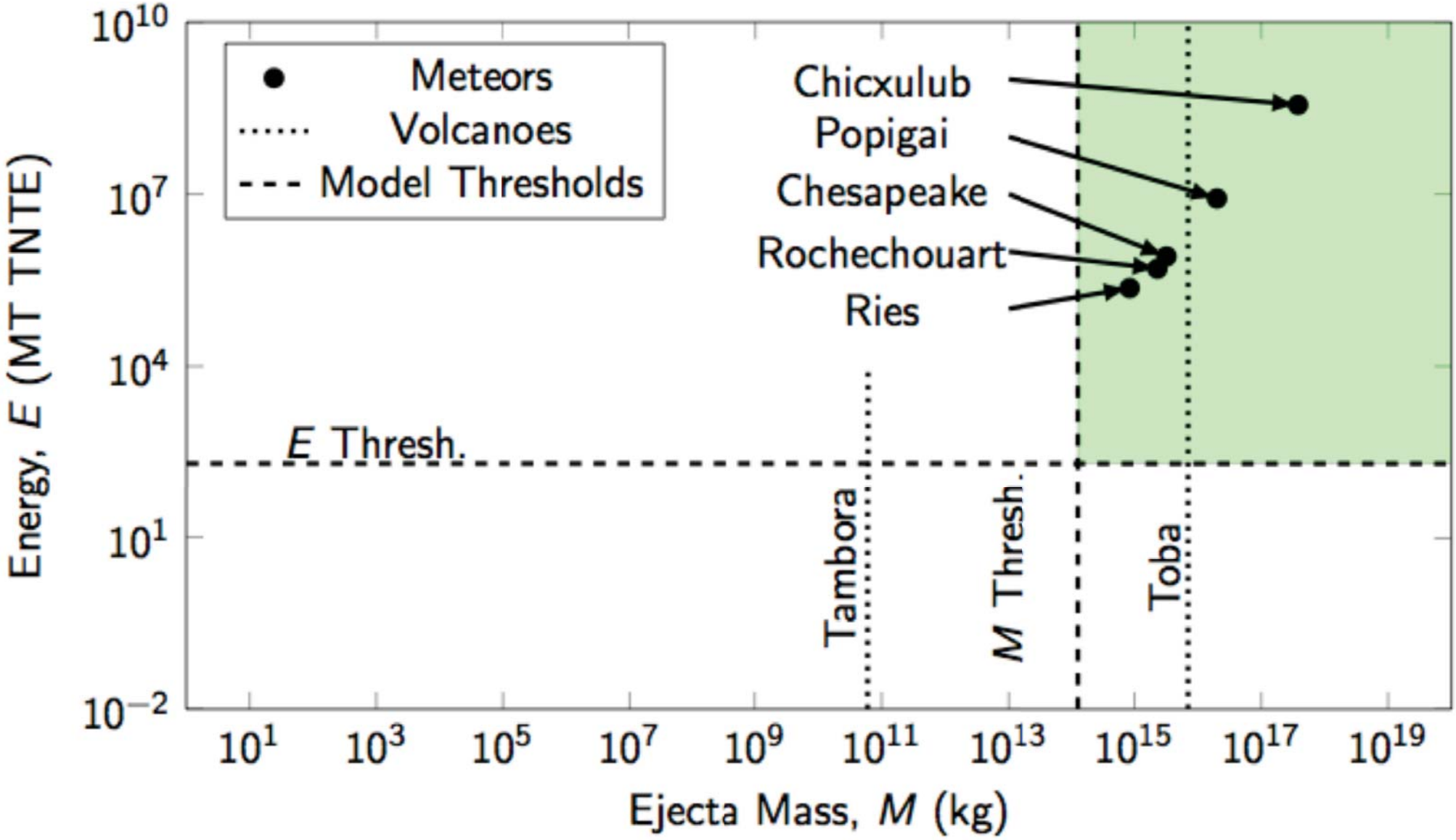
- What is the distribution of the total number of fatalities from *primary effects* of asteroid impacts in a given time period?
- What is the probability of a *globally significant event* in a given time period?
- How effective are proposed mitigation options (in terms of risk reduction)?

We have built and demonstrated a probabilistic risk analytic framework that can be used to examine these questions.

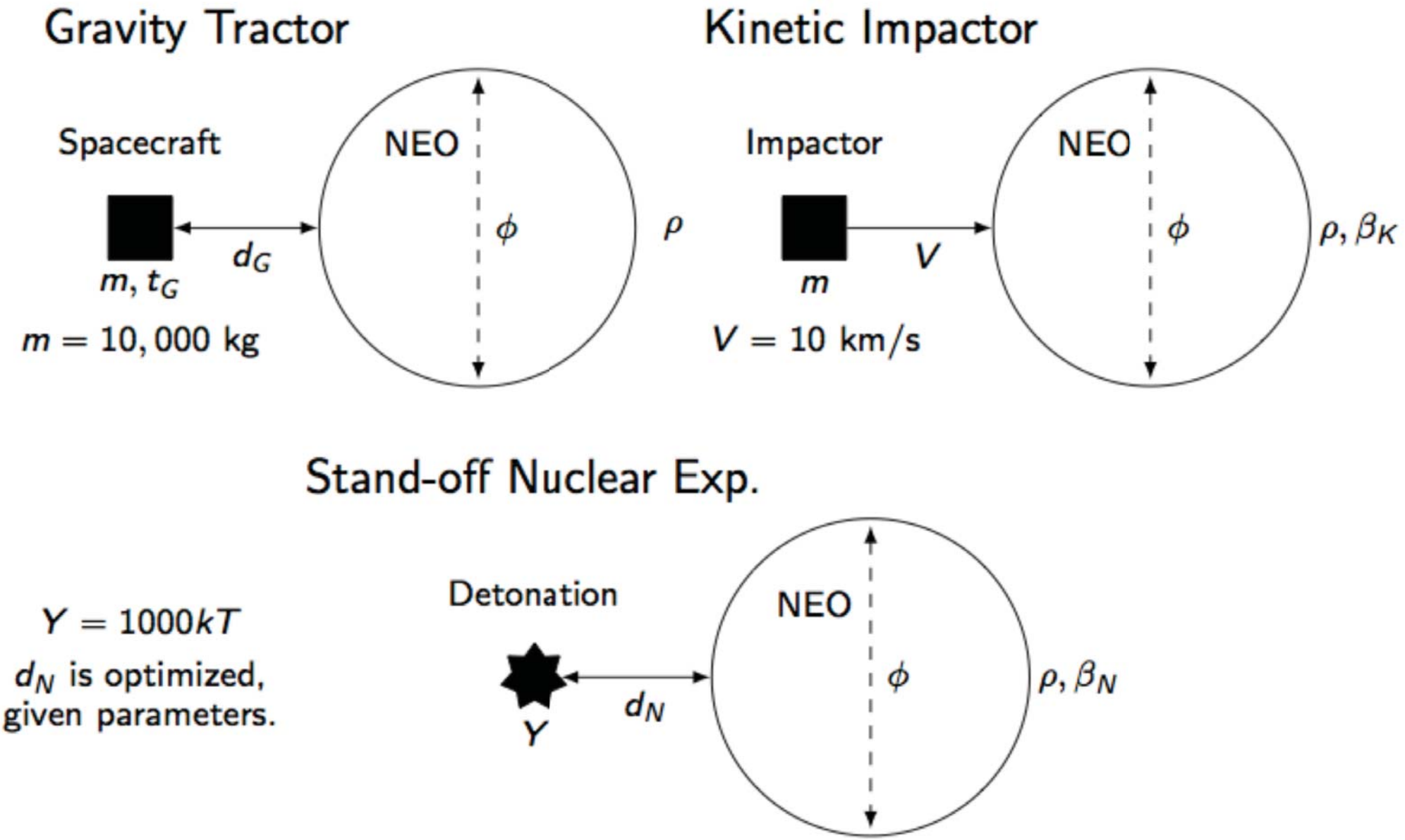
Our model uses probabilistic inputs for key characteristics of impacts.



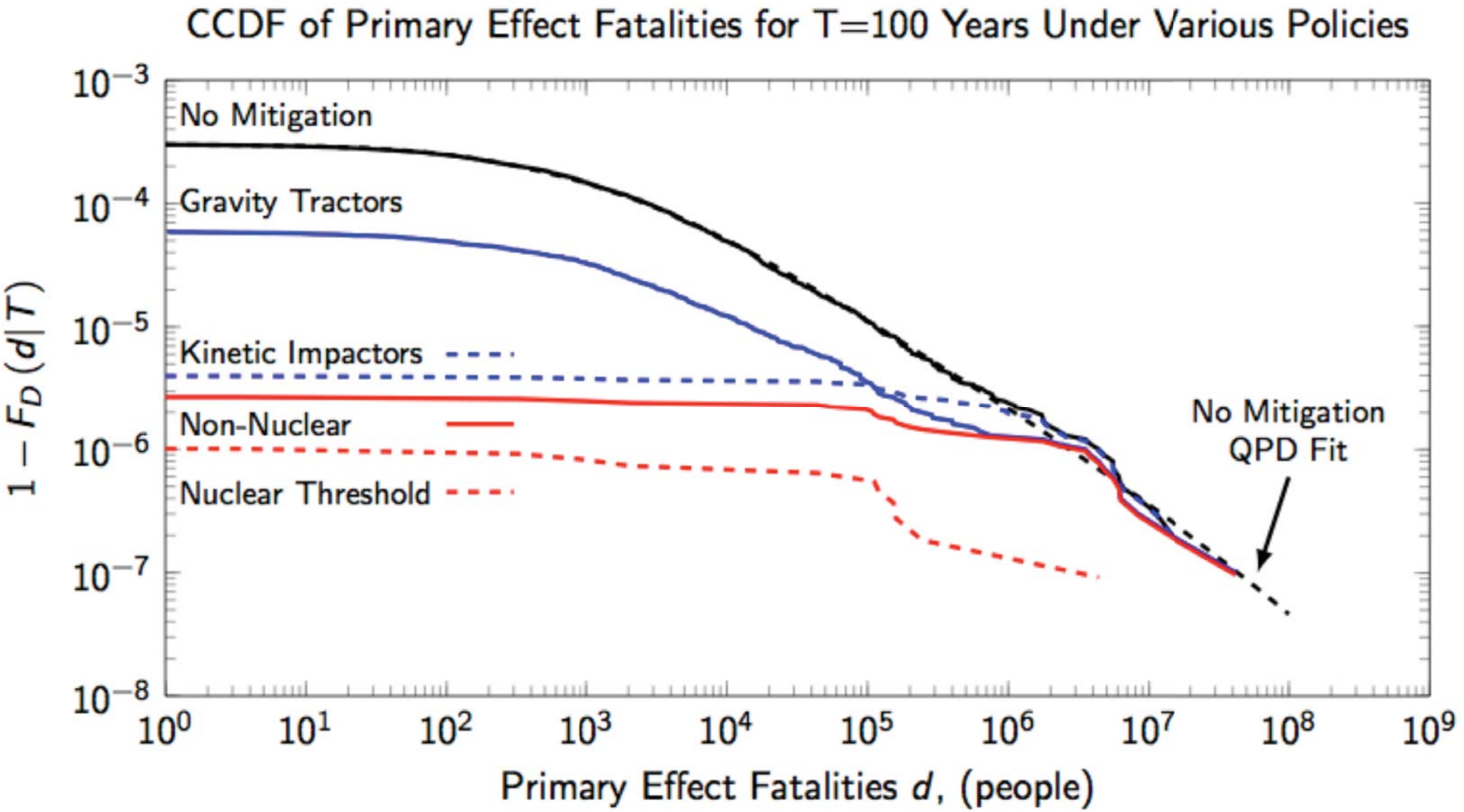
We distinguish primary (localized) effects from global effects.



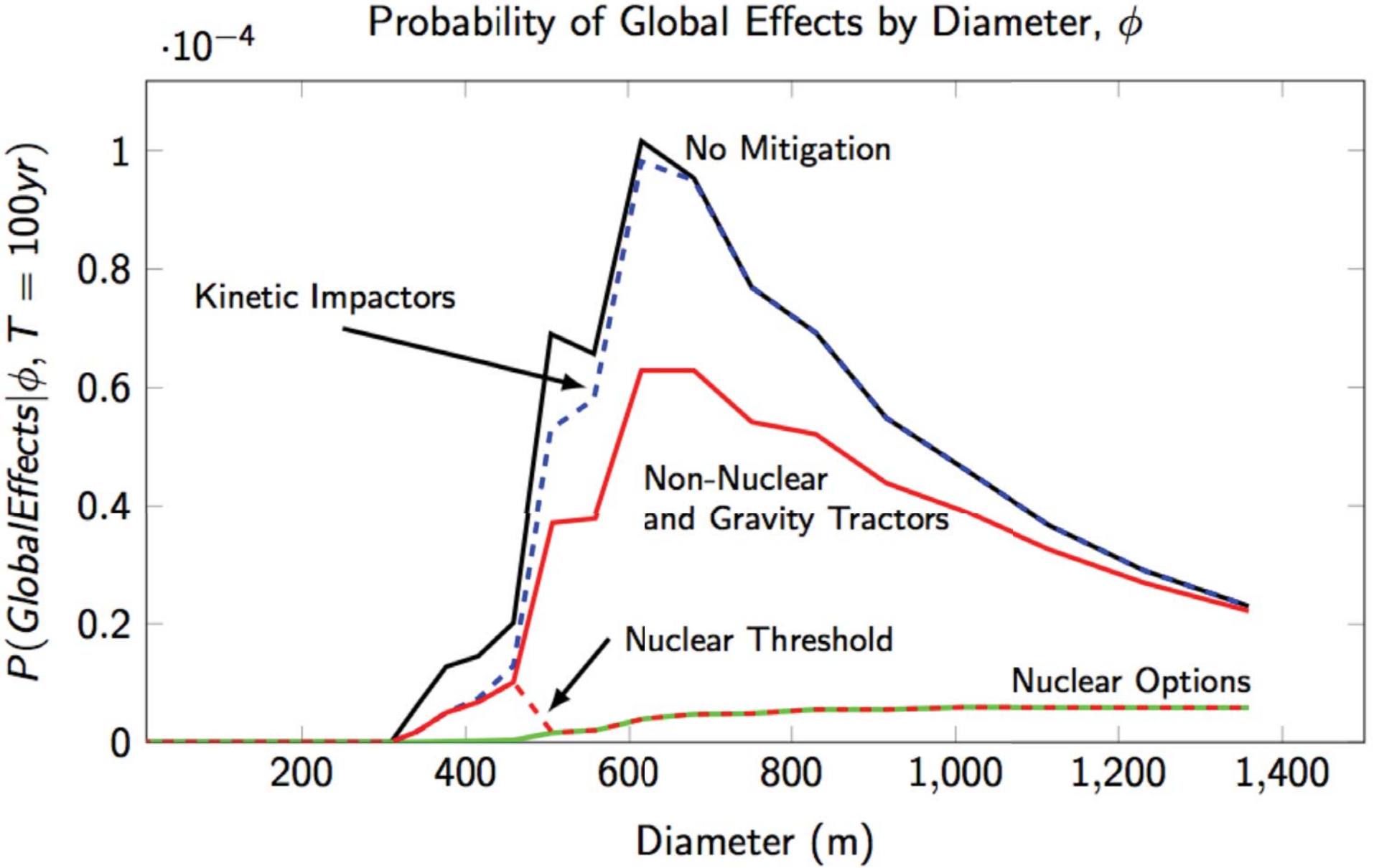
We assess the effectiveness of proposed mitigation methods by comparing risks



Mitigation options can be effective, and significantly reduce overall risks.



Mitigation options can also be effective considering asteroid size.



Preliminary Conclusions

- We have developed and demonstrated a probabilistic risk analytic framework for asteroid impact risks worldwide.

- Improved probabilistic risk analytic techniques can enhance our understanding of:
  - The risks posed by asteroid impacts
  - The trade-offs involved in assessing mitigation options (costs and risk reduction benefits)

Initial analyses suggests that

- Loss distributions for asteroid impacts have a long tail, with a non-negligible probability of large scale events
- Means do not provide sufficient information; we must understand the distribution over losses and how mitigation options change those loss distributions
- Mitigation options using existing technologies are likely to be effective, assuming one can see them coming
- Observation remains a key issue. Improvements will help reduce the risk, provided that the information is received in time to permit effective response.

Additional work is needed to

- Improve input parameter distributions
  - Observed vs. Unobserved, Densities, etc.
- Improve mitigation option physics
- Improve modeling of (changing) human population
- Include (changing) economic effects
- Enhance simulation software

Planetary Defense is an important part of securing our collective future. The Stanford ERRG is excited to work with its scientists and experts to improve this analytic tool and use it to help inform policy and decision making.

Back up slide:
publications and references

Publications and Selected References

- Our papers
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