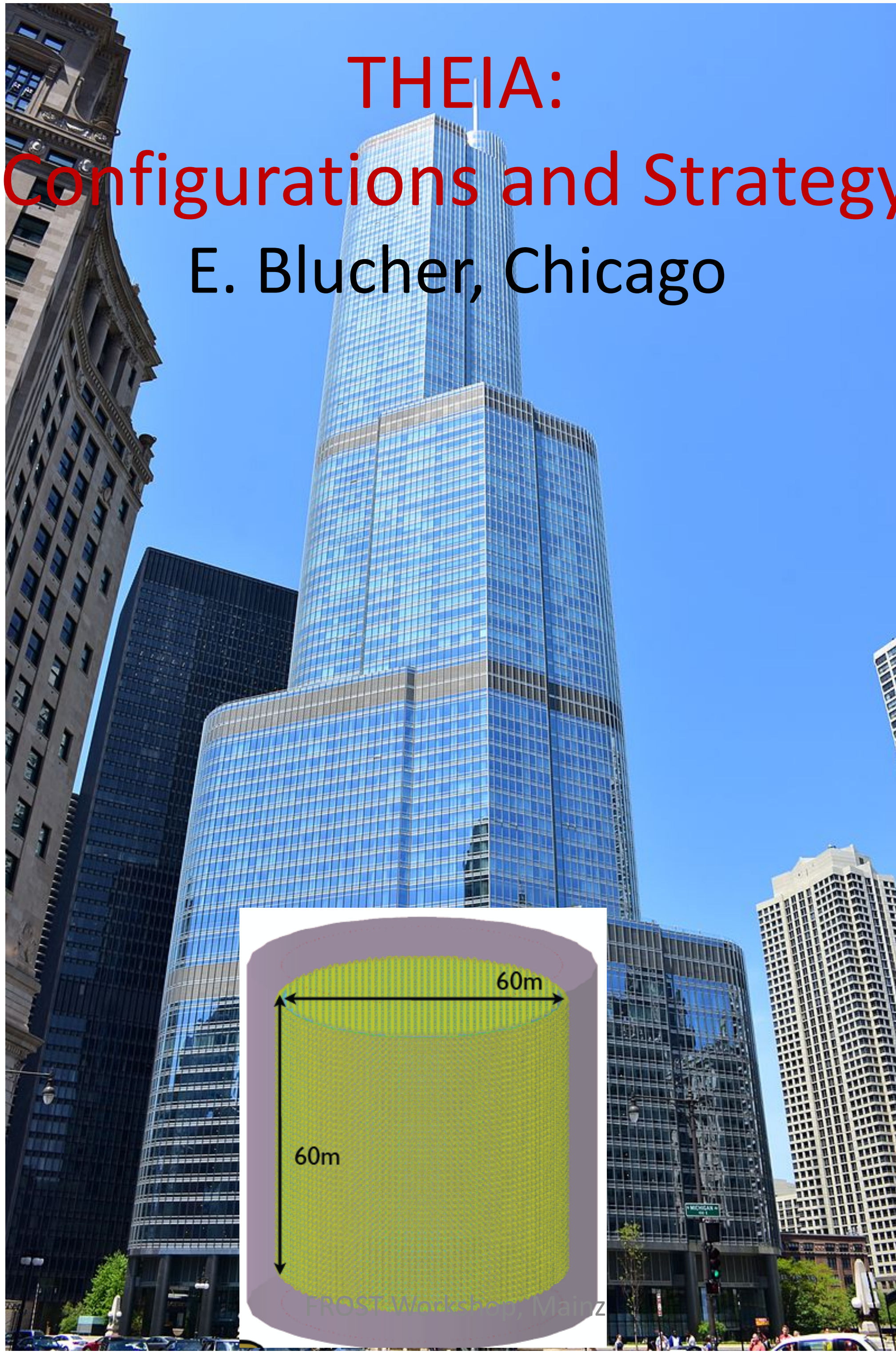
THEIA:
Configurations and Strategy

E. Blucher, Chicago



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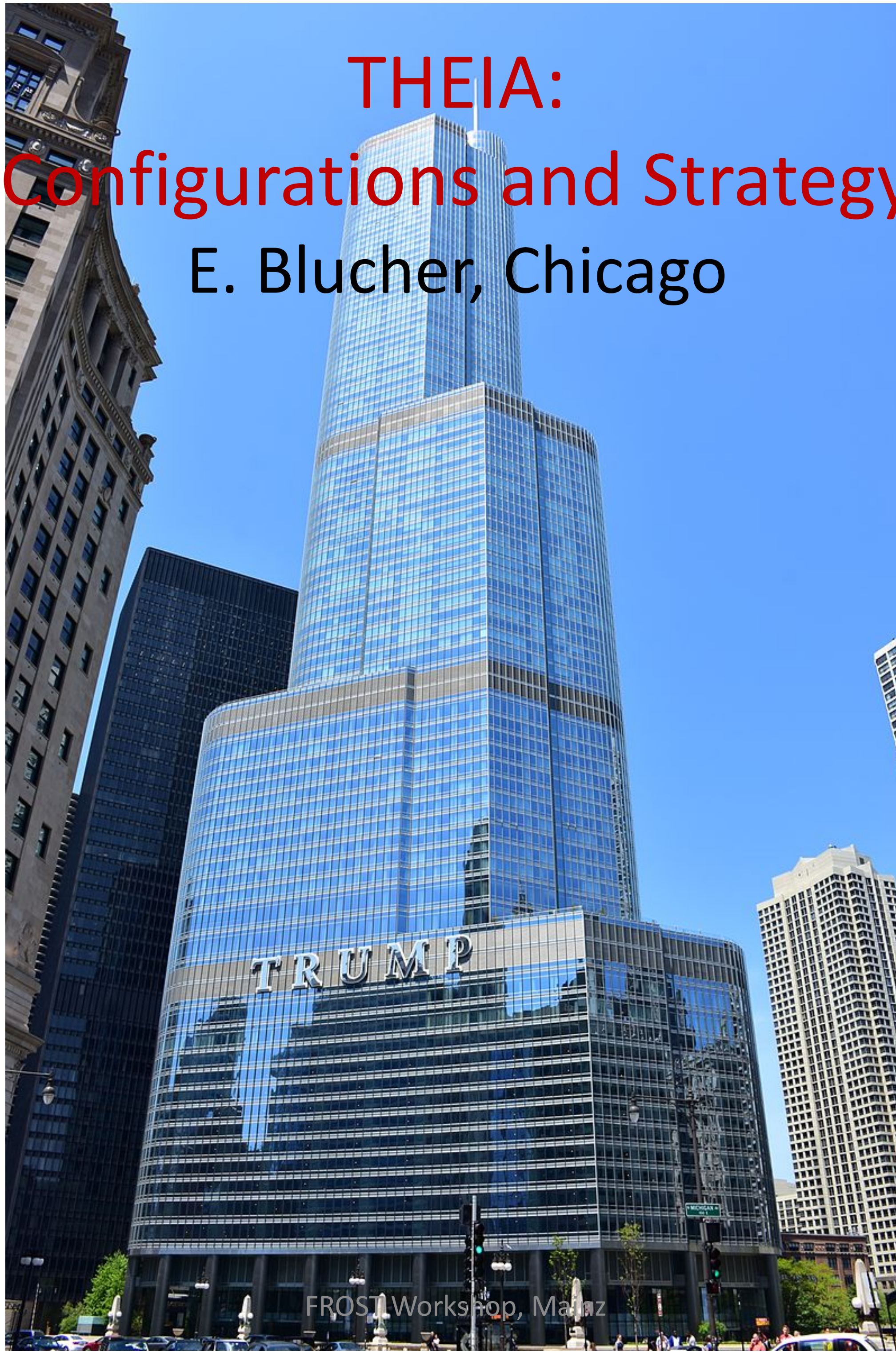

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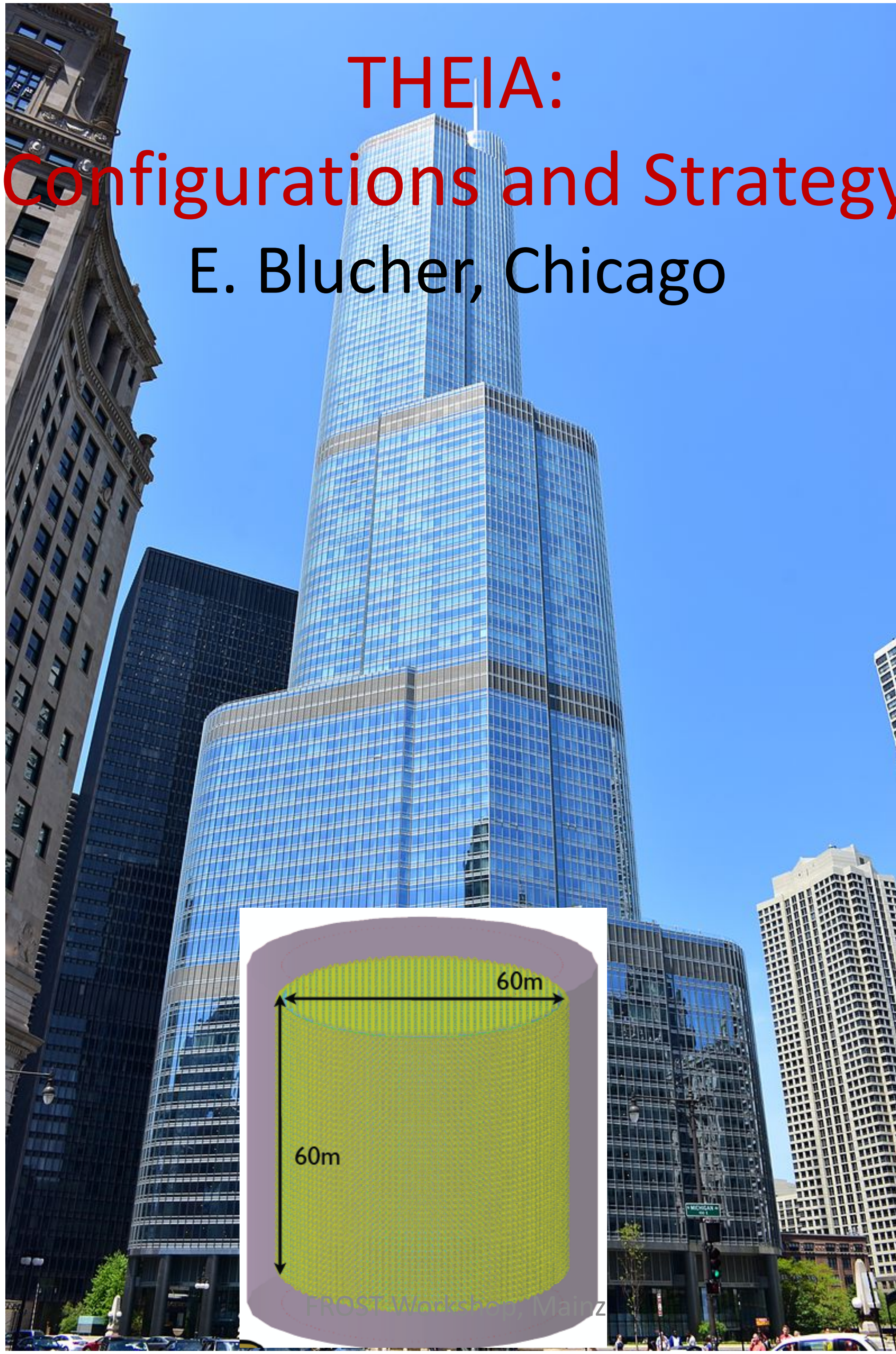


How to realize physics opportunities of THEIA

- Many exciting and challenging physics topics, each of which would likely lead to a different detector optimization.
- Wouldn't several distinct detectors be better than one multi-purpose detector?

Combination of topics (and different physics communities) may allow far greater resources than any single-topic experiment could justify.

- The breadth of the THEIA physics program provides a broad intellectual foundation for the experiment. THEIA will not have the "one number experiment" problem of many neutrino experiments.

Sounds good, but does it work?

Challenge for THEIA

- Key challenge is to understand which topics can be addressed in similar configurations. Answer will depend on details of both scintillator and photodetectors.
- How many different configurations are needed to do the physics?
- These different configurations may suggest thinking of THEIA as a facility, which will be configured differently to perform different measurements. These different phases may provide a natural way to spread out costs, making the initial cost affordable.

Cost

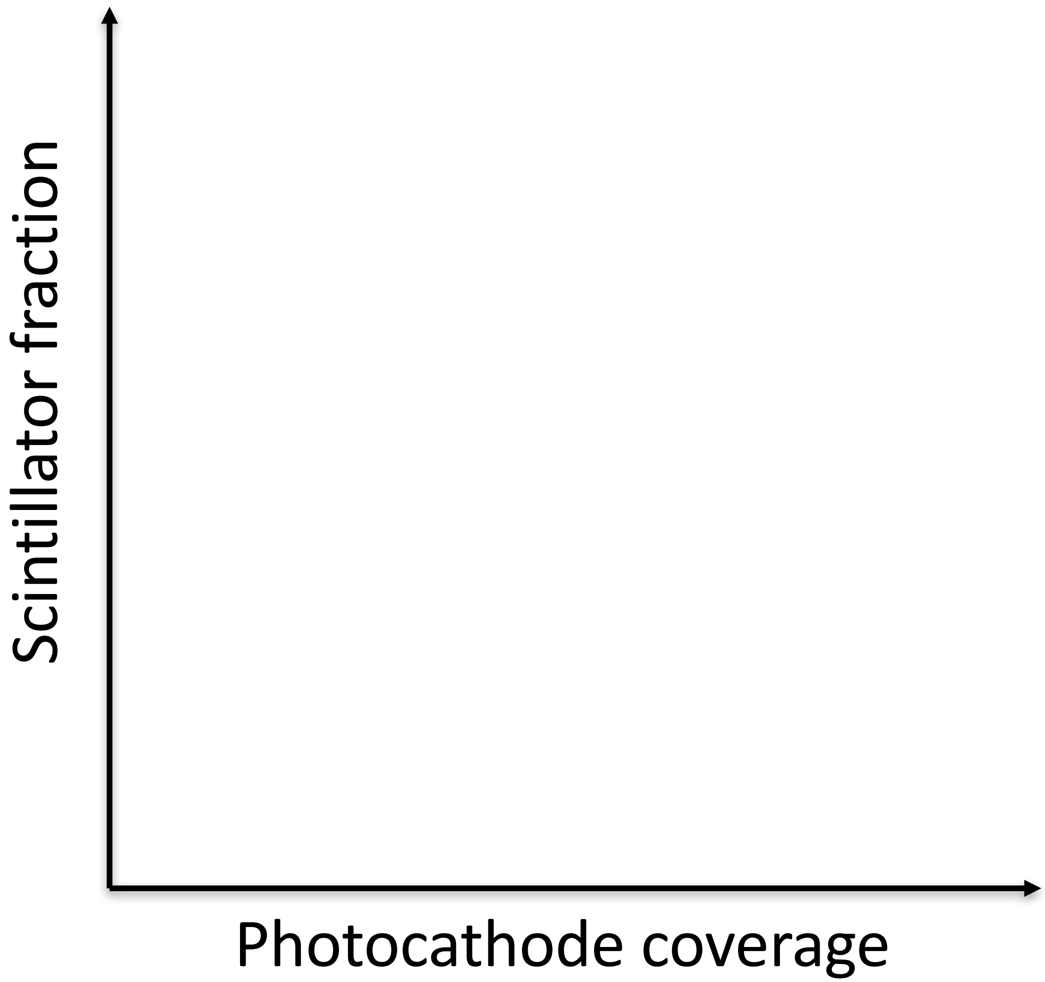
- Cost is clearly a critical part of optimizing detector configurations.
- Costs are driven by photon sensors, excavation, scintillator, isotope, and inner bag (for isotope containment).
- Lower energies require more light collection (richer scintillator fraction and/or higher photocathode coverage)

Requirements for different physics topics

	Size (kt)	Loading	Resolution (light yield * coverage)	Direction / rings	Cleanliness	Depth	Bag
NLDBD	10 [Important]	*Te, Nd…* [Critical]	[Critical]	[Important]	[Critical]	[Critical]	[Important]
Solar	10 [Important]	*Li* [Important]	[Critical]	[Important]	[Important]	[Critical]	[Nice to have / not important]
Geo	100 [Critical]	*Gd* [Nice to have / not important]	[Important]	[Nice to have / not important]	[Important]	[Important]	[Nice to have / not important]
DSNB	50 [Important]	*Gd* [Nice to have / not important]	[Important]	[Important]	[Important]	[Critical]	[Nice to have / not important]
Supernova	50 [Important]	*Gd* [Nice to have / not important]	[Important]	[Important]	[Important]	[Important]	[Nice to have / not important]
Nucleon decay	100 [Critical]	[Nice to have / not important]	[Important]	[Important]	[Nice to have / not important]	[Important]	[Nice to have / not important]
Sterile	10 [Nice to have / not important]	[Nice to have / not important]	[Important]	[Nice to have / not important]	[Nice to have / not important]	[Important]	[Nice to have / not important]
Long baseline	50 [Important]	[Nice to have / not important]	[Nice to have / not important]	[Critical]	[Nice to have / not important]	[Important]	[Nice to have / not important]

Critical   Important   Nice to have / not important

Key Parameters



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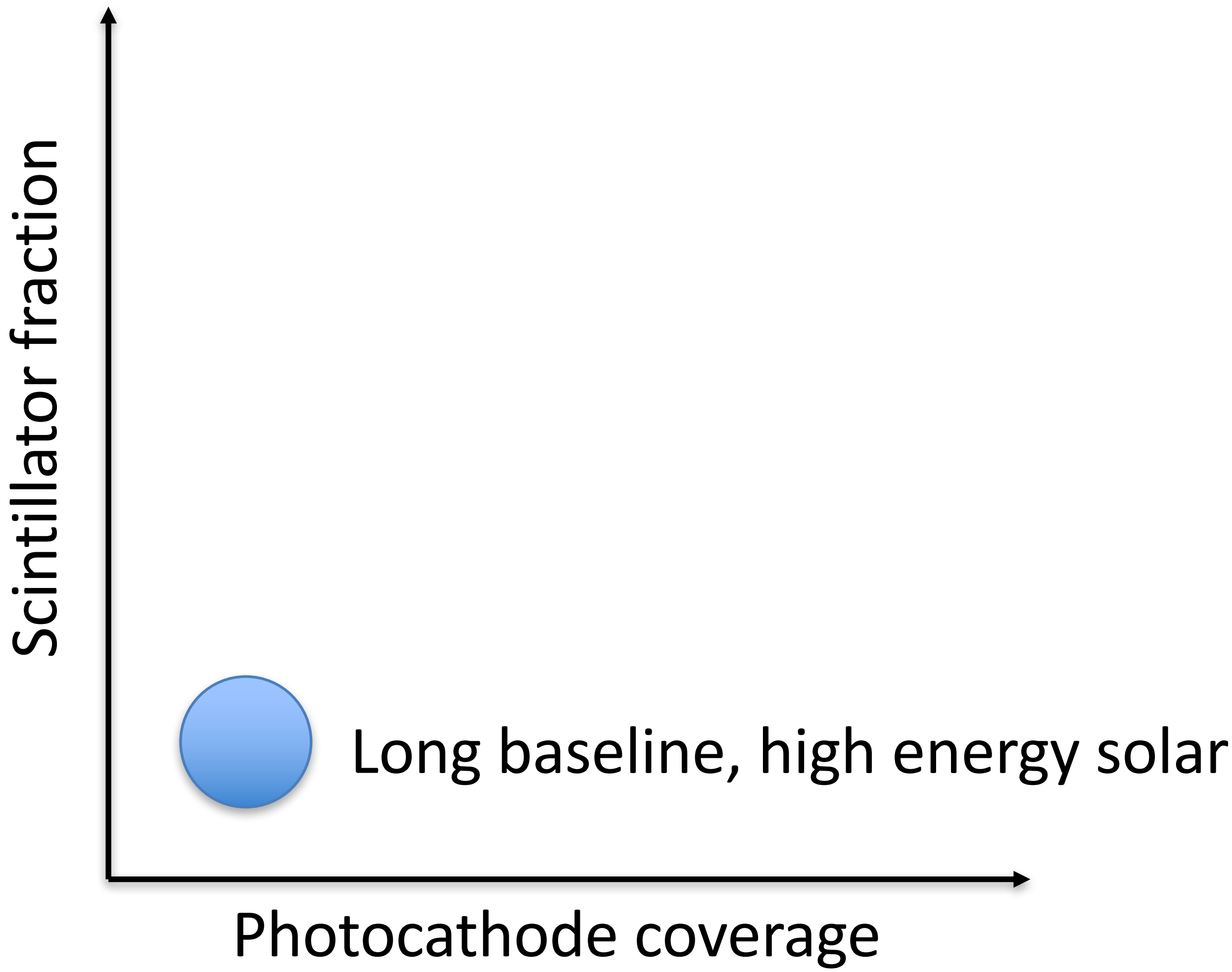

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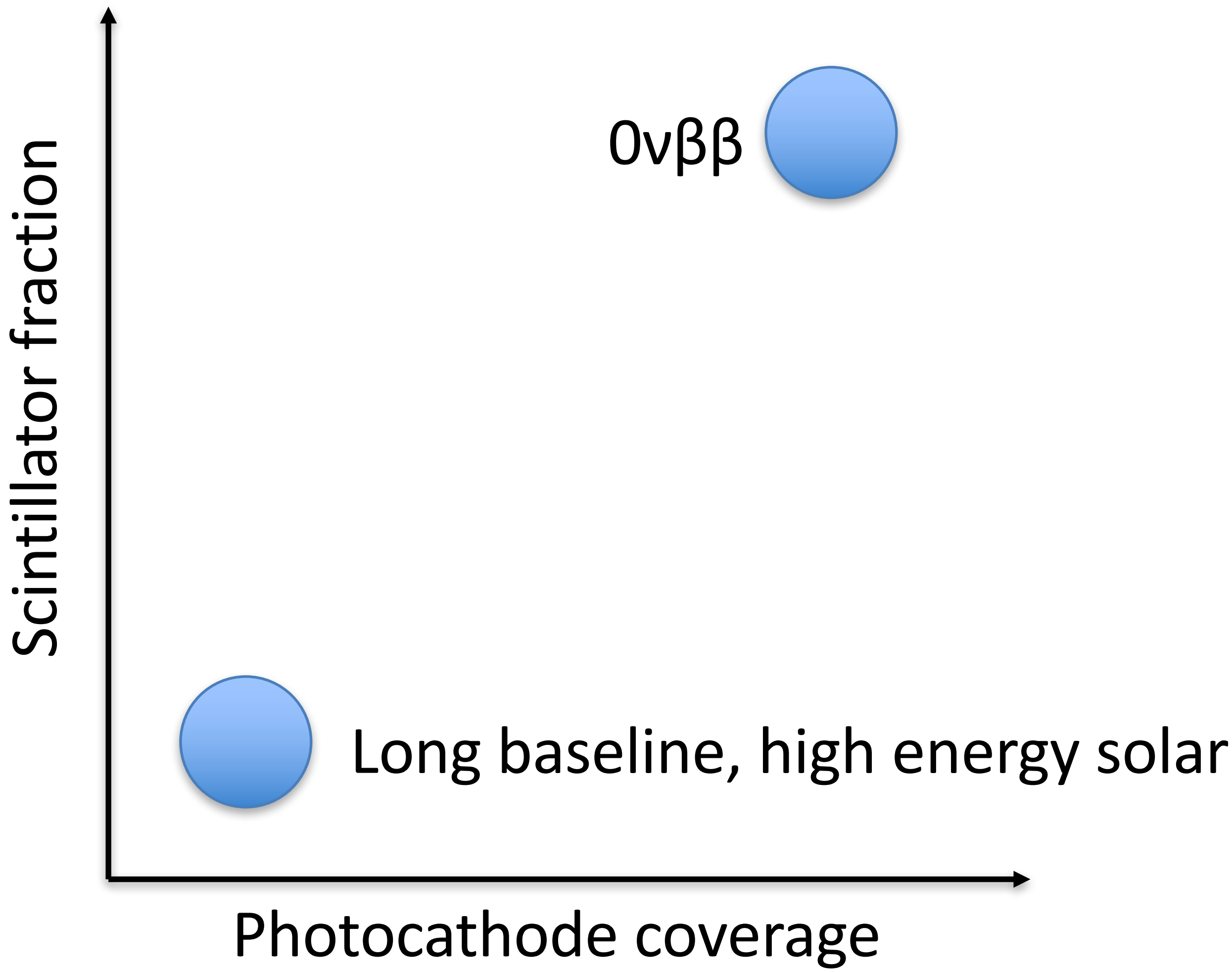

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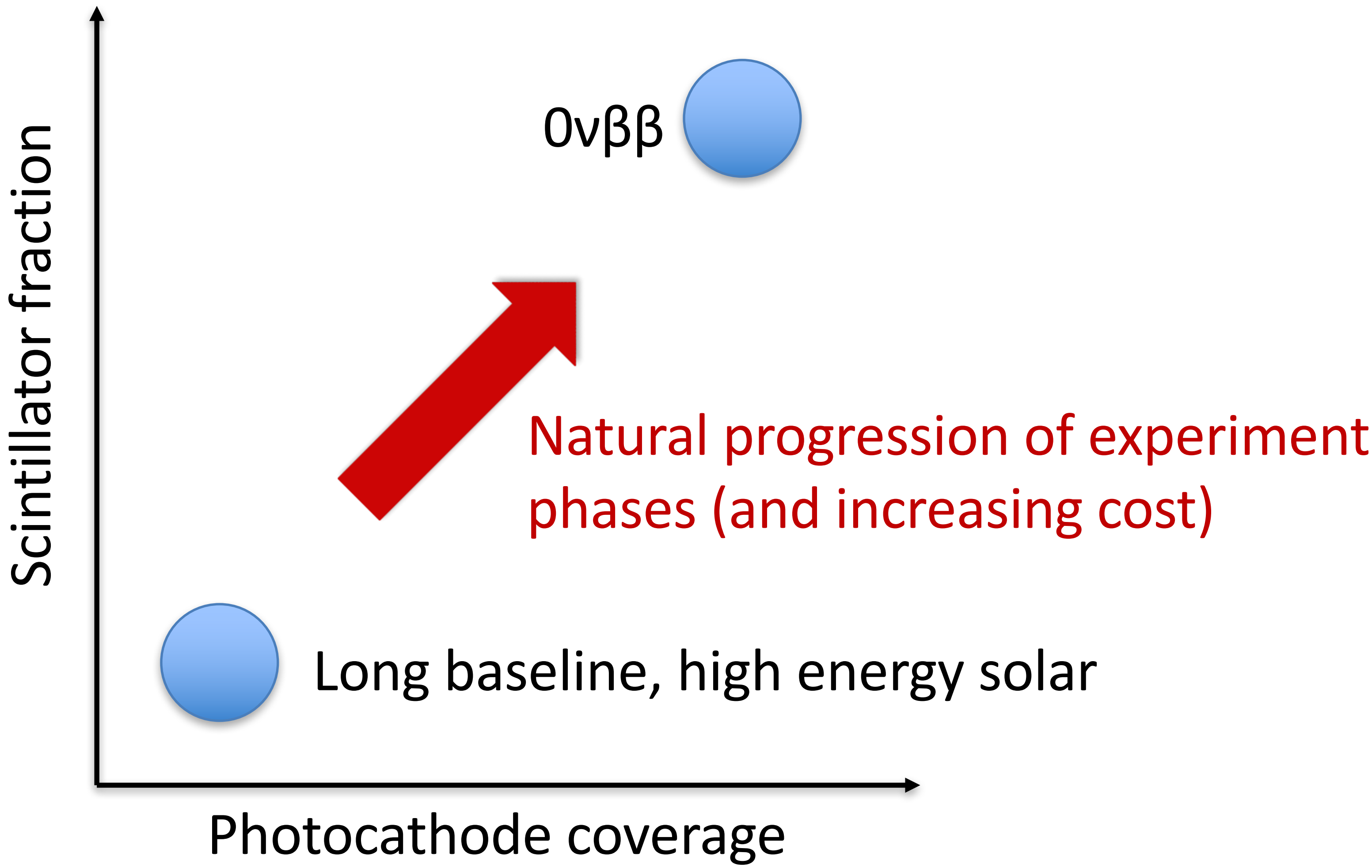

Phases of experiment

Phasing would move naturally from topics requiring less coverage and leaner scintillator mixture (e.g., beam physics) to high coverage and rich scintillator (e.g., double beta decay). For example:

Phase 1 (30% coverage, high water fraction)
Phase 2 (60% coverage, richer scintillator)
Phase 3 (90% coverage, ultra-rich scintillator, bag)

Phase 1 must be an exciting and compelling experiment.

Can detector be engineered to make reconfigurations efficient?

Location

- The site will define the scope of the physics program. SURF at Homestake is appealing because of depth and LBNF beam. (Note that Fermilab has been very supportive of THEIA idea. Following first FROST workshop, we were asked to present plans and physics program for THEIA at the June 2016 FNAL PAC meeting.) Other sites will offer different tradeoffs. For non-beam physics, it will be important to understand depth requirements for different topics.
- For different sites, optimal detector shape may be different.

Questions

- What are the properties (and cost) of WbLS?
  light yield, attenuation, scattering, quenching, timing
- What is the best cocktail to maximize physics output?
- What photodetector coverage is needed for different topics?
- What photodetector timing and position resolution is needed/achievable at reasonable cost? How good must timing be to separate Cherenkov and scintillation light efficiently?
- What richness of scintillator is required for different topics? With excellent timing, how rich a scintillator mixture will preserve Cherenkov information for beam physics?
- How good is reconstruction and particle ID?

THEIA - Telescope for Habitable Exoplanets and Interstellar/Intergalactic Astronomy