Megaton Ice Cherenkov Array

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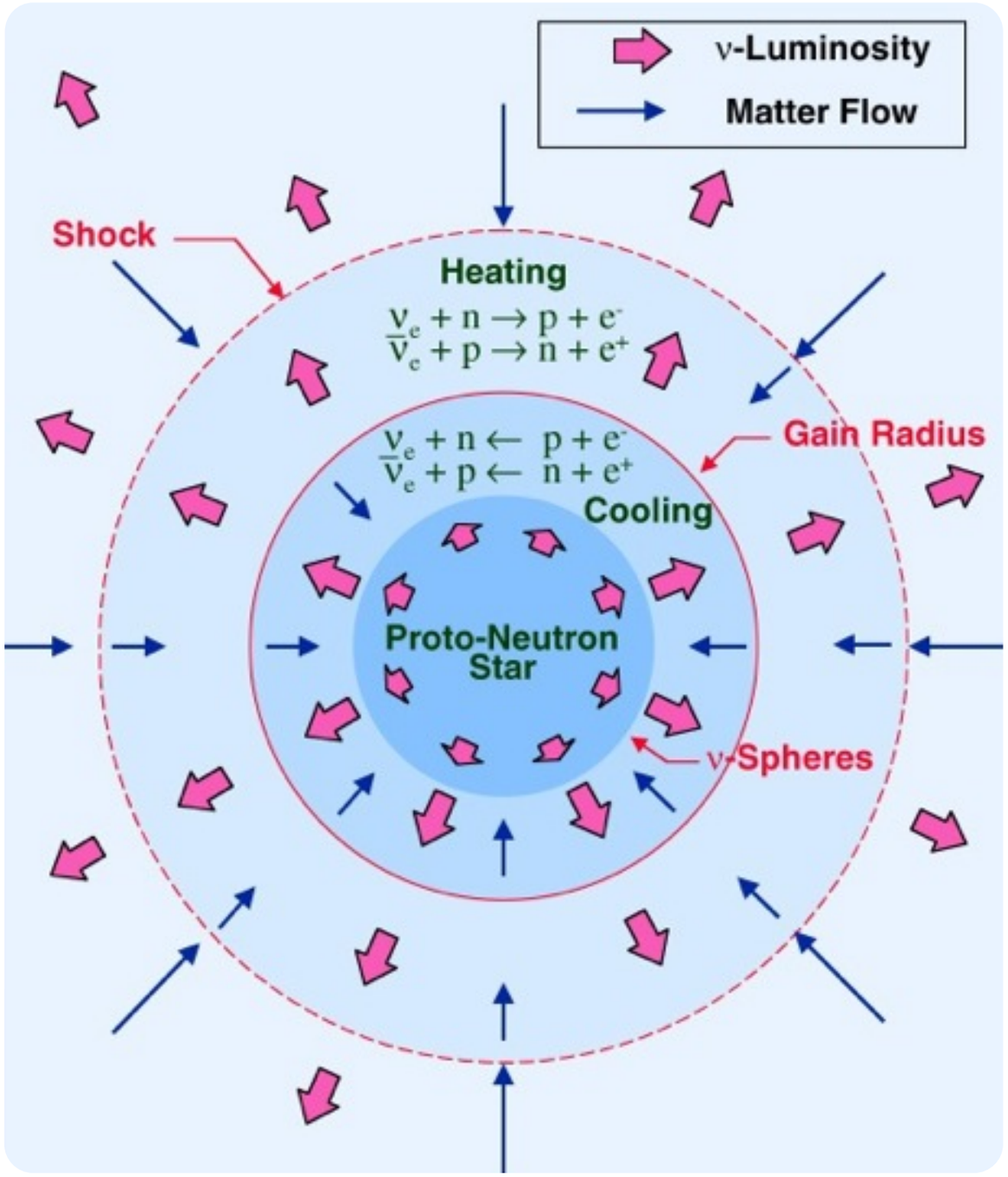
Outline

- Why is there a need for a megaton sized detector with sensitivity to neutrino signals at MeV energies?
- How can such a detector be produced?

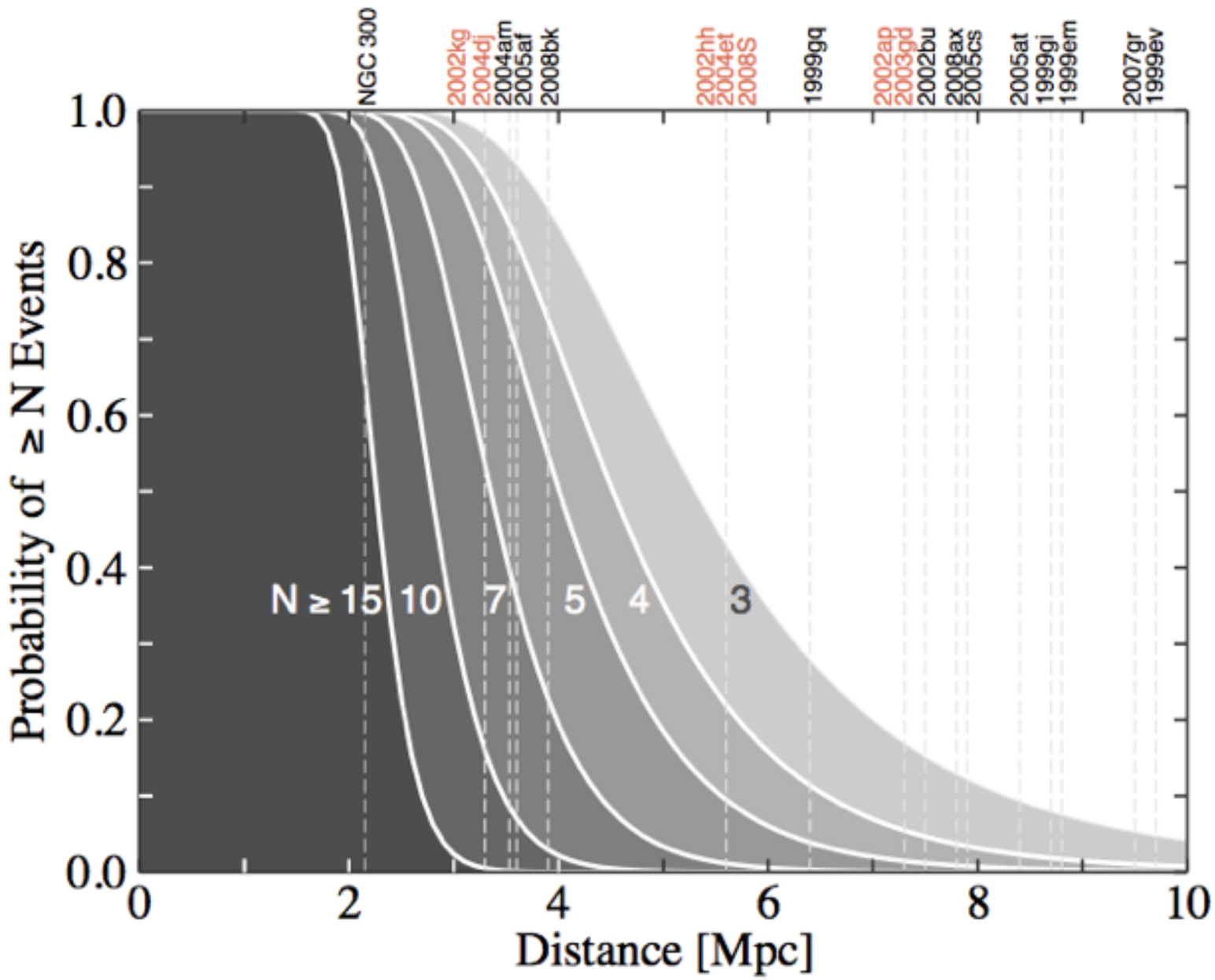
Supernova

- 99% of core-collapse supernovae energy escapes in the form of neutrinos
- The initial moments are opaque to everything but neutrinos
- ~3/century in the Milky Way



Supernova Detection

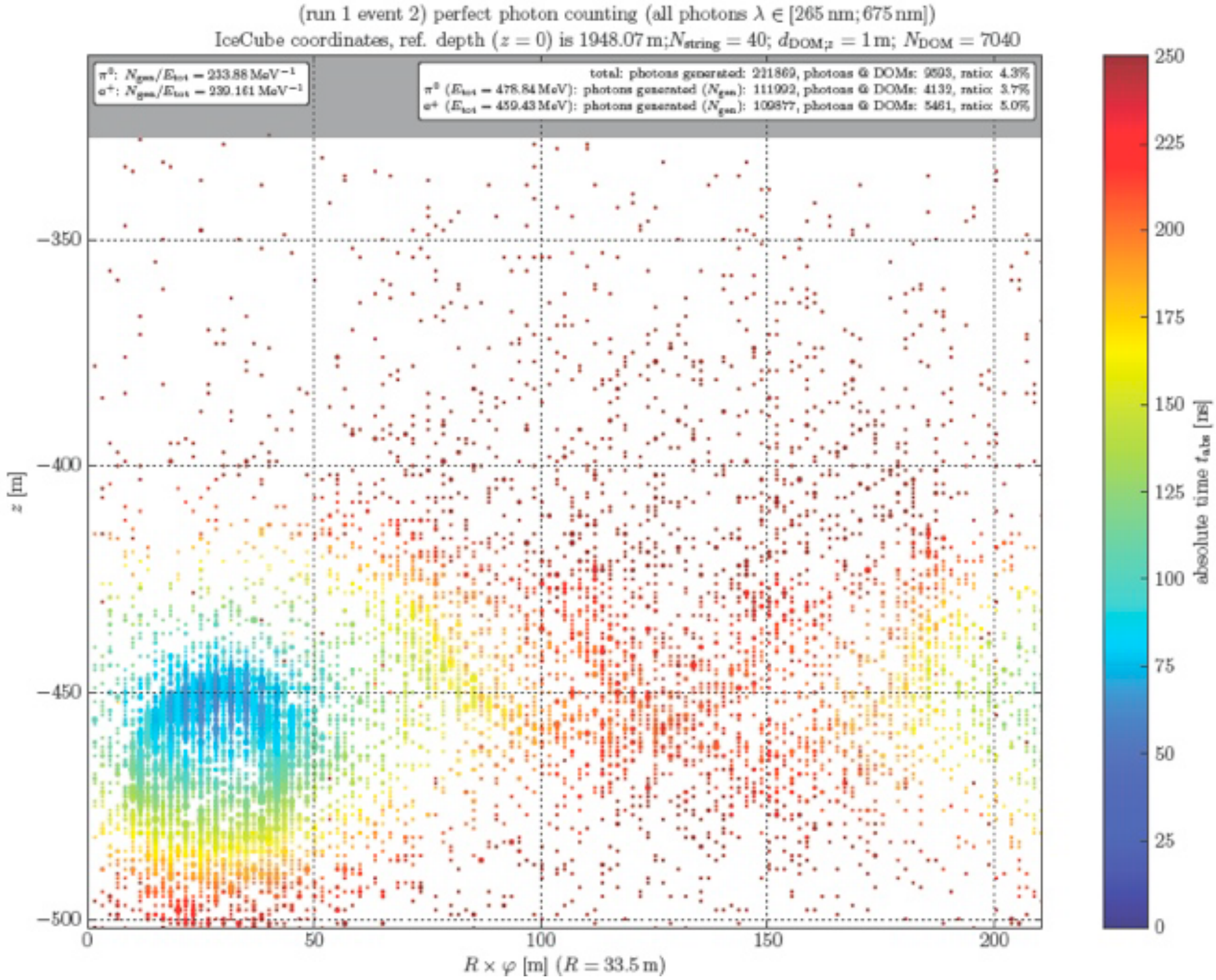
- A detector with a megaton(s) sensitive volume to bursts of MeV neutrinos could extend neutrino observation of SN to beyond our galaxy



Kistler et. al.
arXiv:0810.1959

Proton Decay Cherenkov Rings

- For an idealized detector, the rings from $p \rightarrow \pi^0 + e^+$ are visible by eye



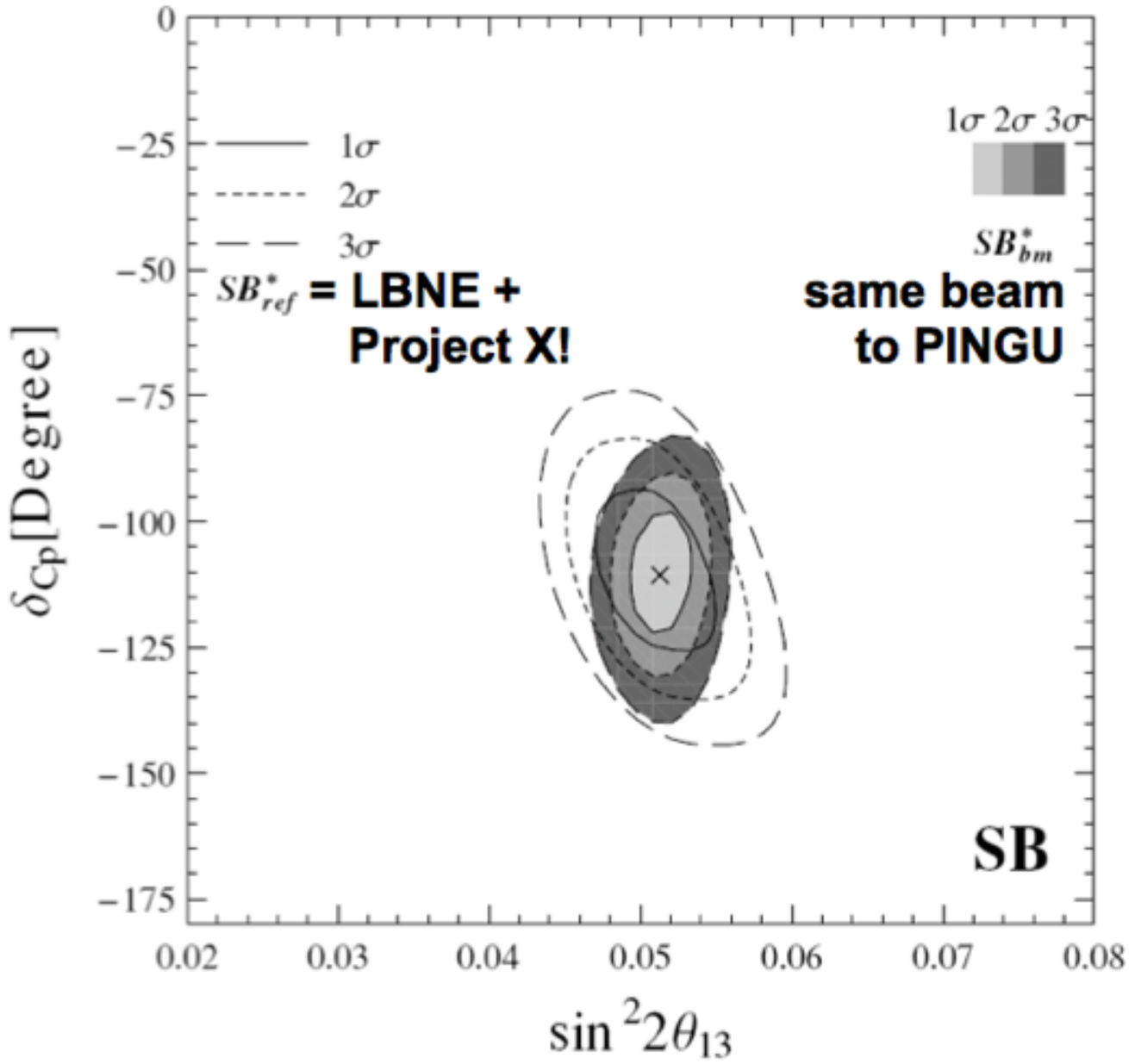
Beam?

"Superbeam FNAL-PINGU?", W. Winter

Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

Upgrade path towards δ_{CP}?

- Measurement of δ_{CP} in principle possible, but challenging
- Requires:
  - Electromagnetic shower ID (here: 1% mis-ID)
  - Energy resolution (here: 20% x E)
  - Maybe: volume upgrade (here: ~ factor two)
  - Project X
- Performance and optimization of PINGU, and possible upgrades (MICA, …) require further study



(Tang, Winter, JHEP 1202 (2012) 028)

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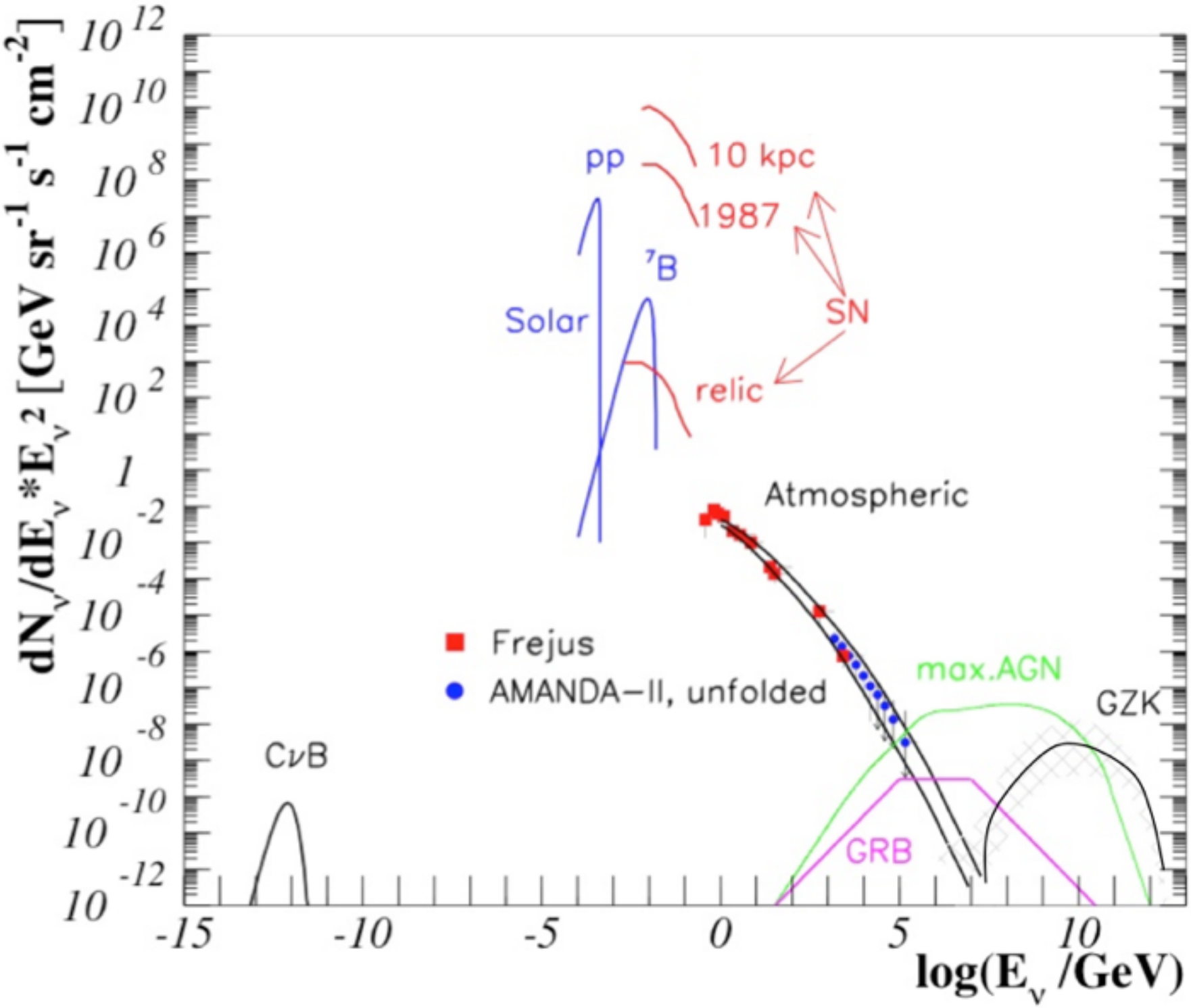
Detector

Neutrinos in Nature

- Physics
- Detector

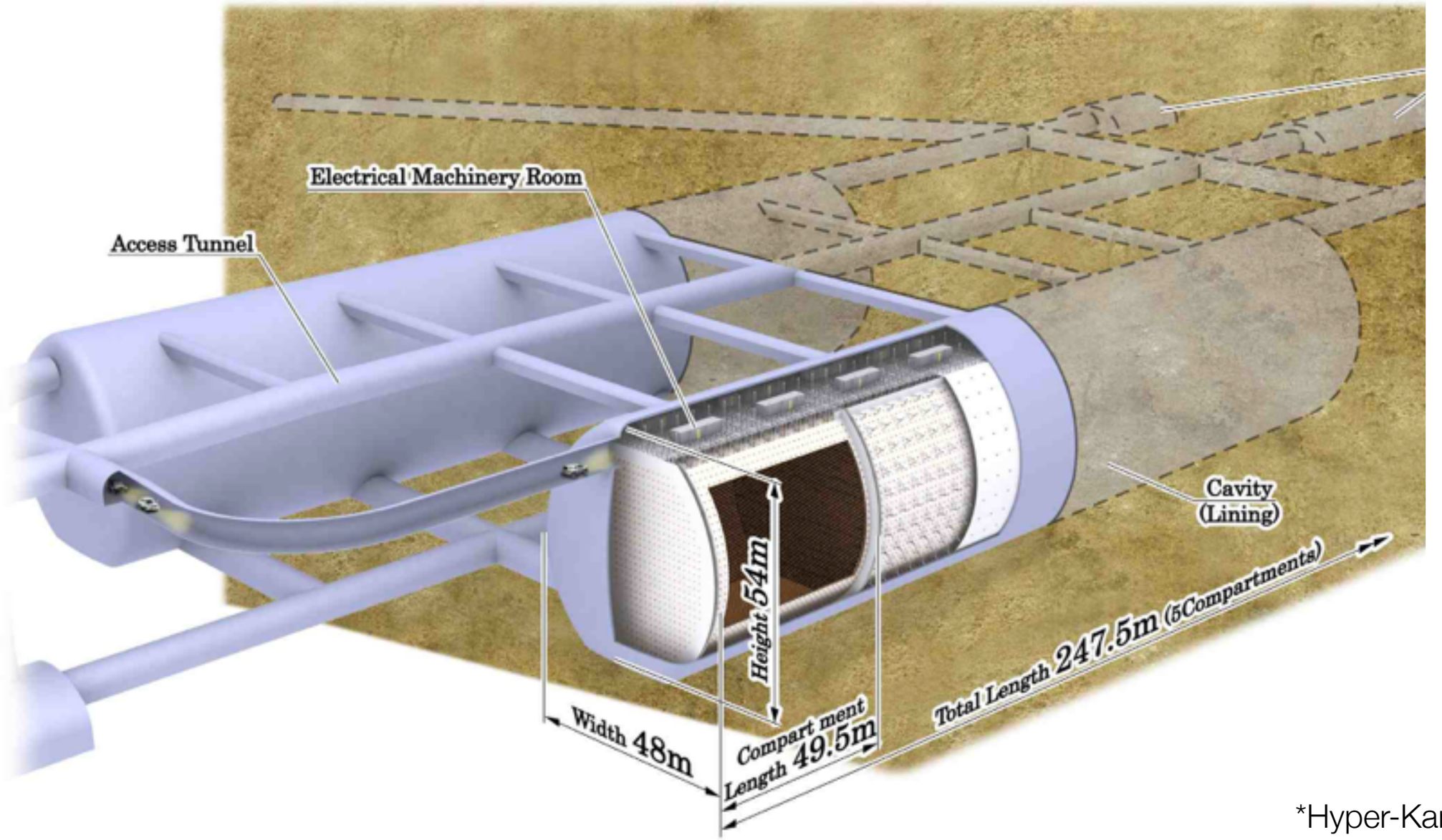


Requirements

- Go big - Increase the chance of seeing multiple neutrinos from the same O(10) second neutrino burst
- Go deep - the neutrino signal can be mimicked as a product of atmospheric muons
  - Direct interaction
  - Cosmogenic radiation activation

More Conventional Method

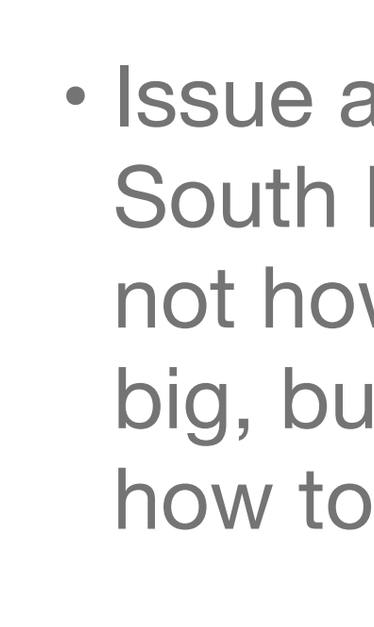
- Take existing water Cherenkov methods and scale them up
- Underground excavation is a considerable cost



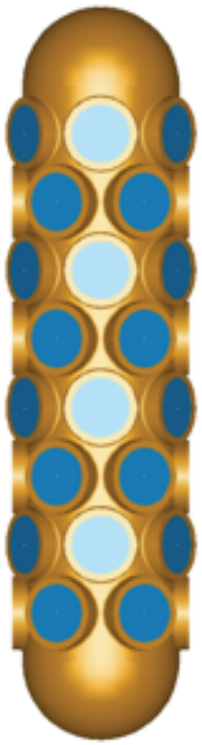
*Hyper-Kamiokande LoI

Possibilities

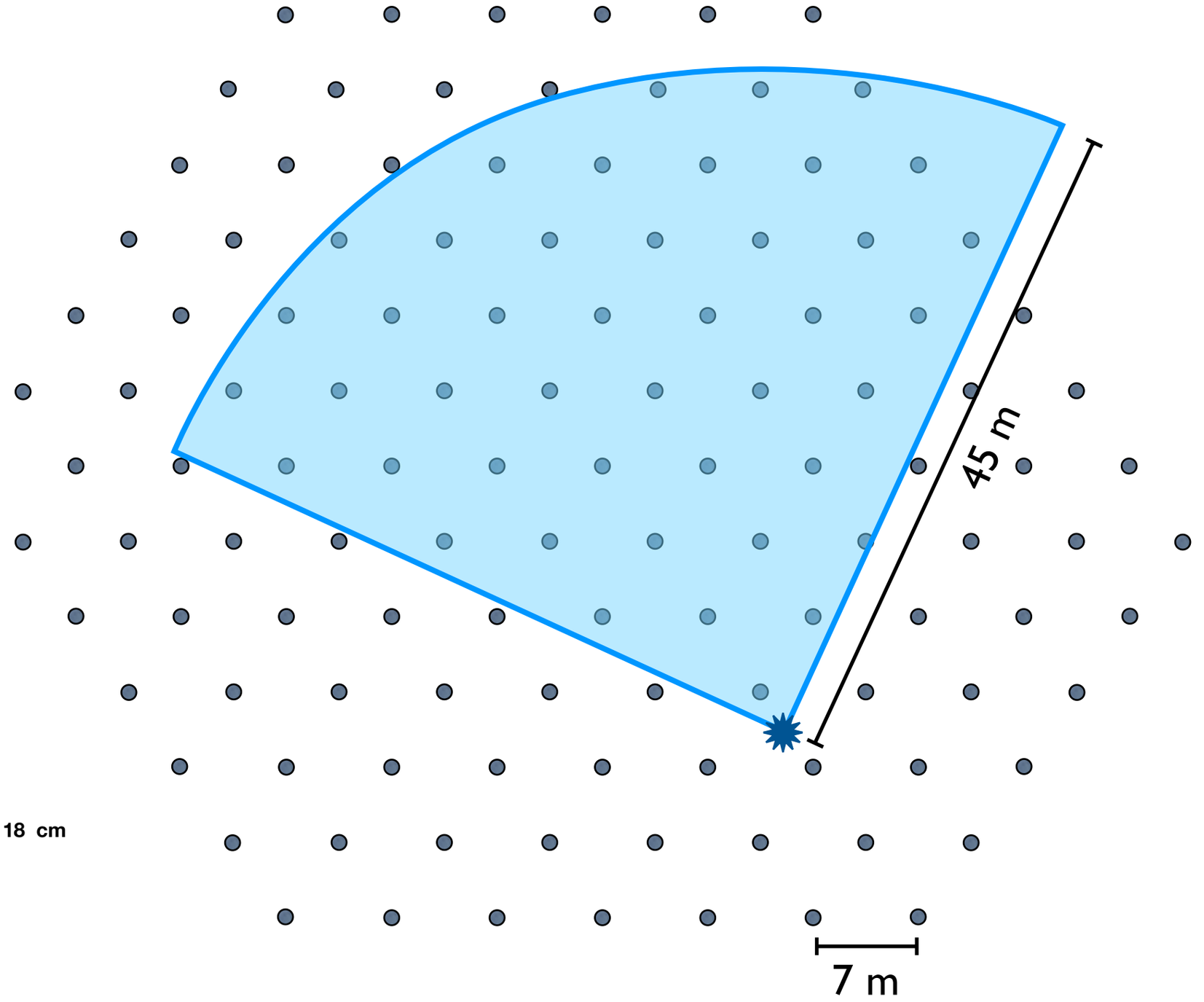
- Issue at the South Pole is not how to go big, but instead how to go small

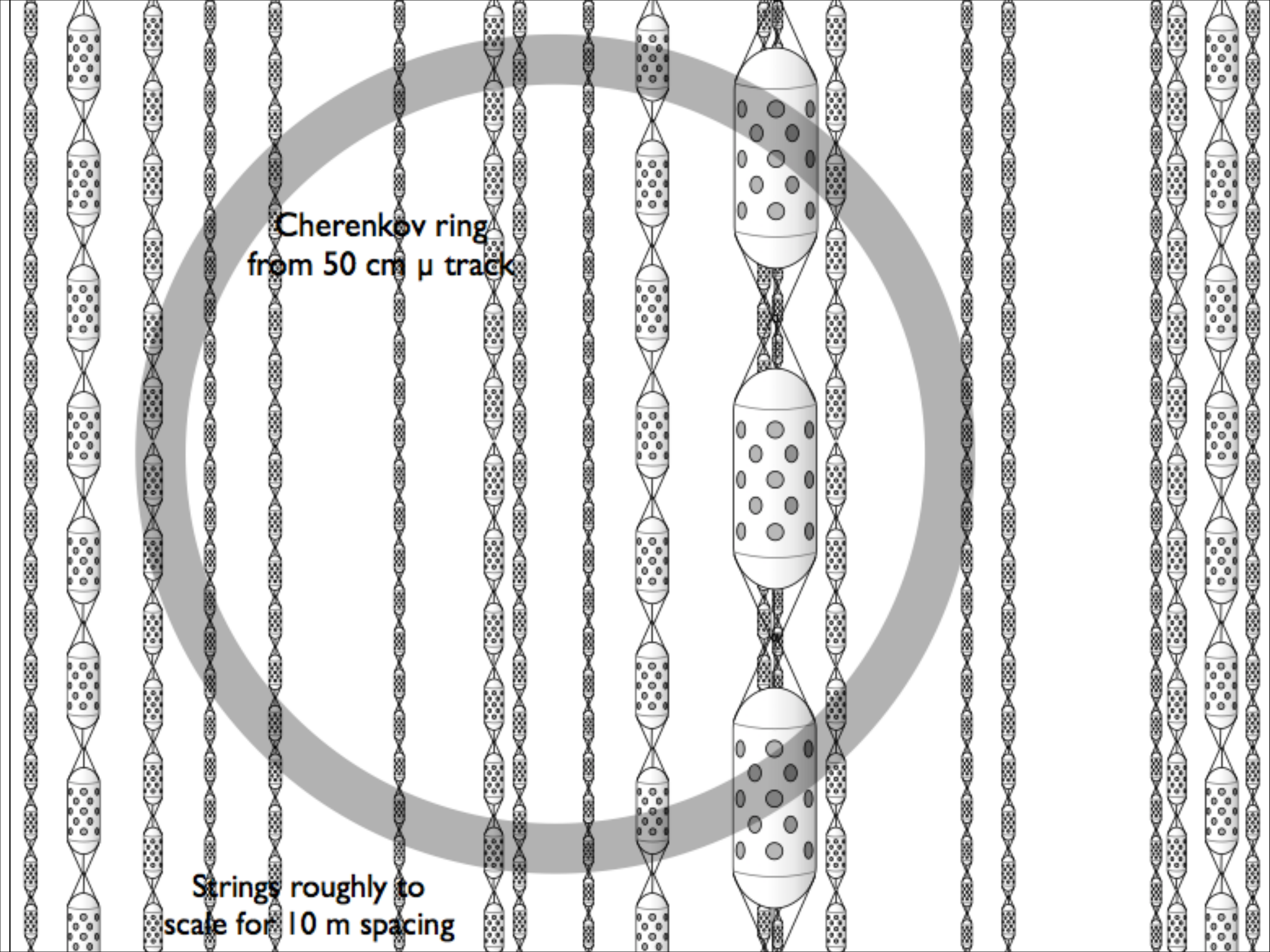


Courtesy P. Kooijman

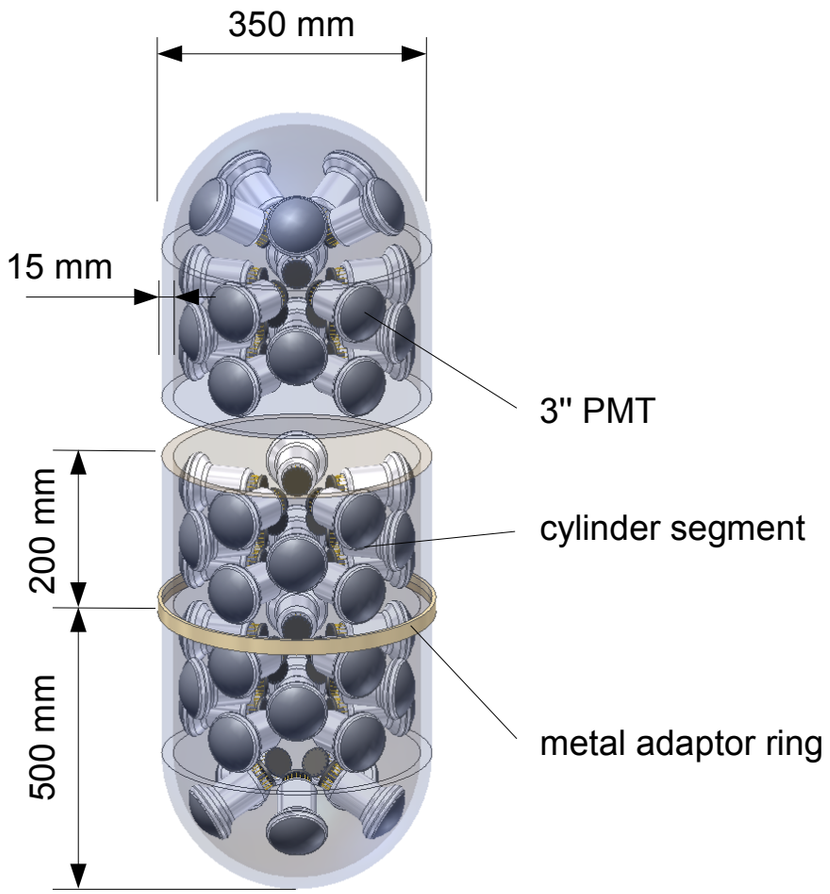


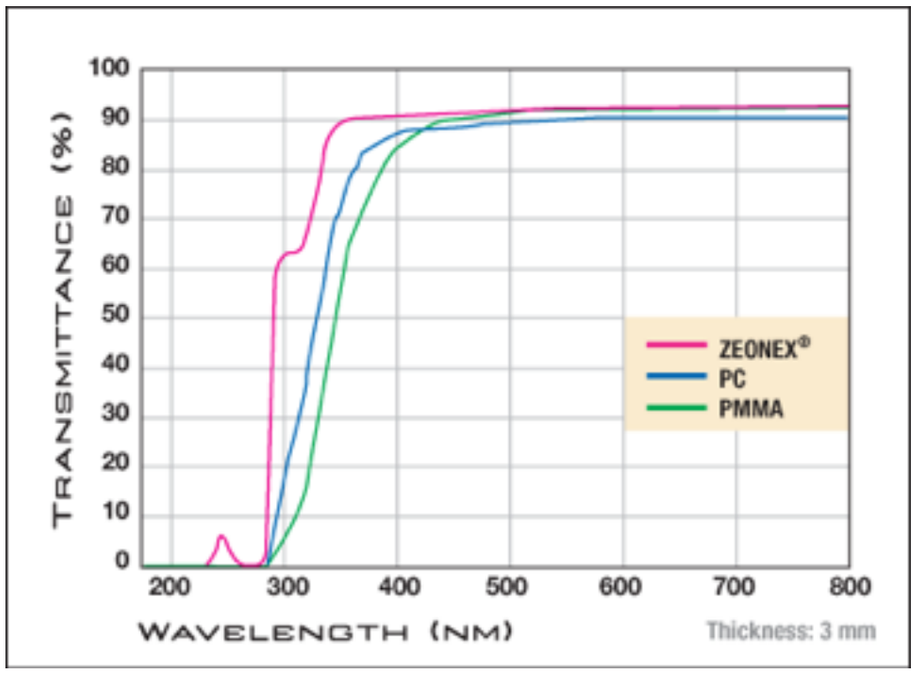
Courtesy P.O. Hulth




Cherenkov ring
from 50 cm μ track
Strings roughly to
scale for 10 m spacing

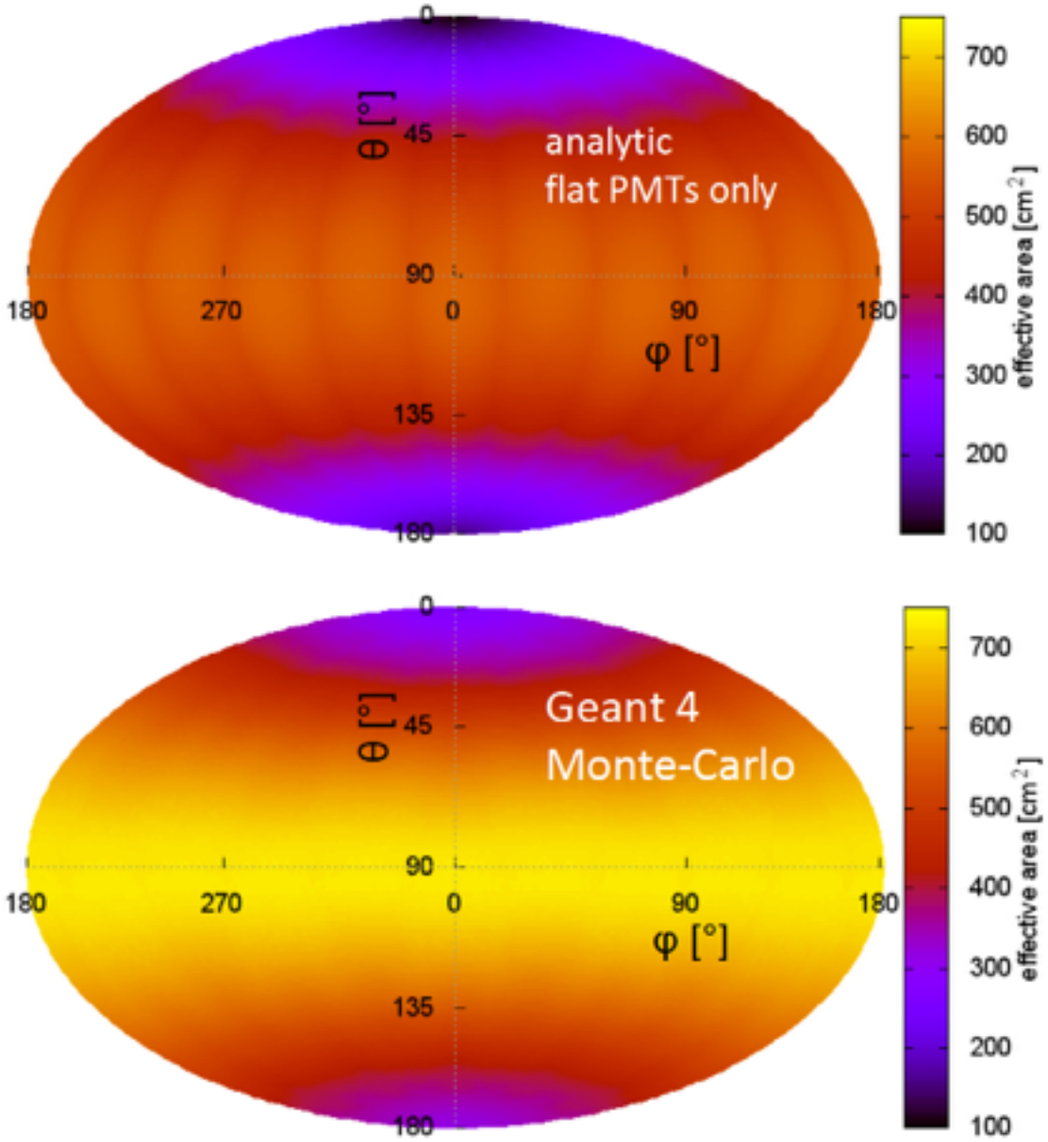
- Use multiple small PMTs, based on KM3Net design
- Replace glass sphere with quartz in order to allow transmission of shorter wavelength photons
- Cherenkov light intensity rises at lower wavelengths

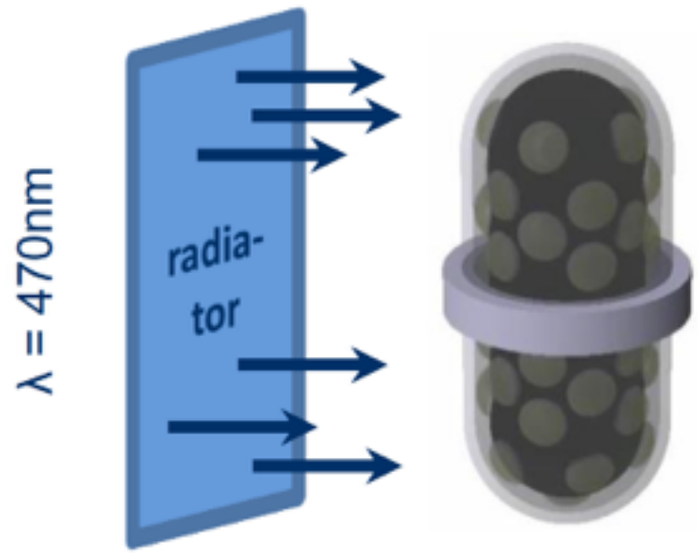




mDOM Coverage

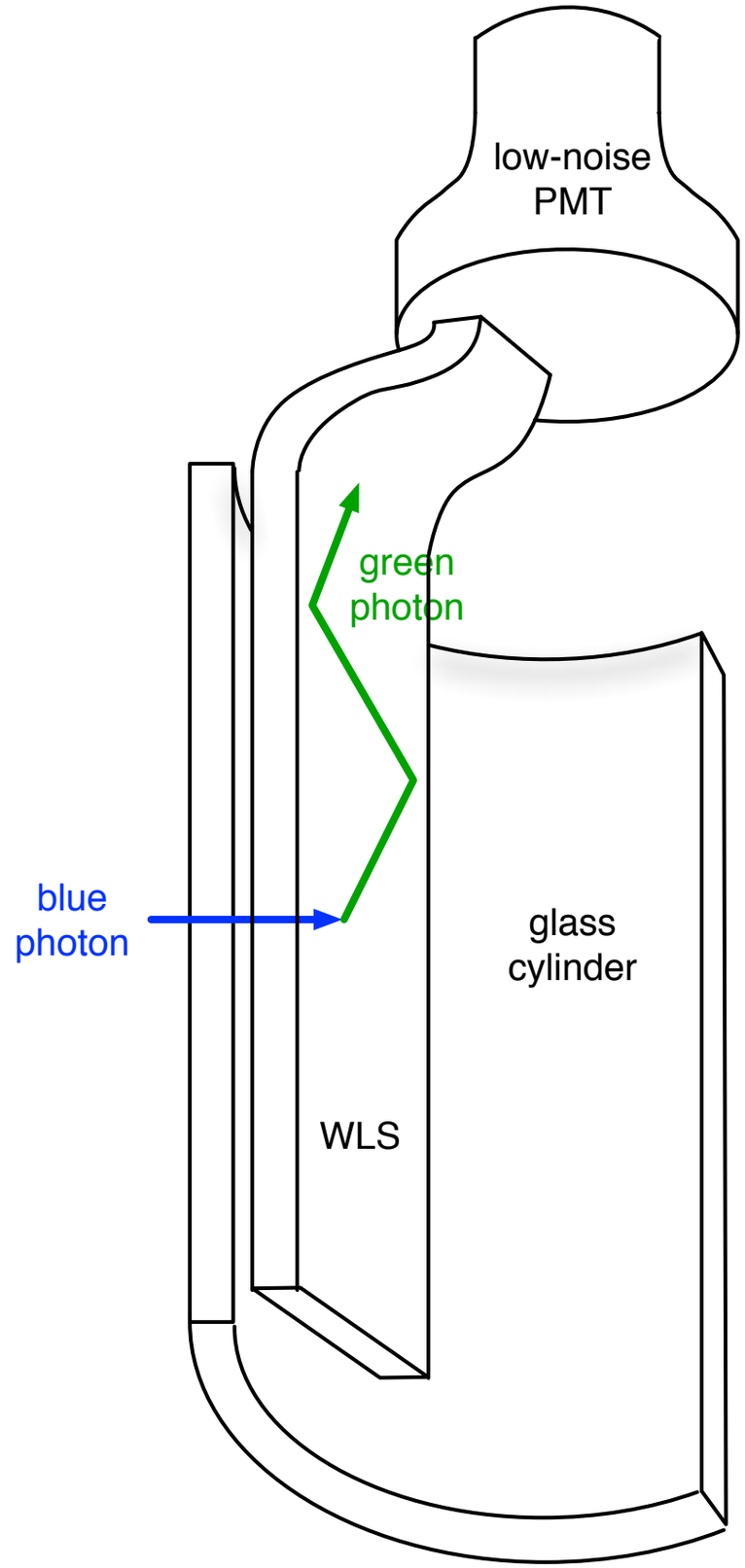
- Increased collection area
- Increased angular acceptance
- Directional sensitivity





Wavelength Shifters (WLS)

- Lower efficiency photon collection than PMTs
- Much, much cheaper than PMTs
- Cherenkov light intensity increases at wavelengths below the optimum sensitivity for PMTs



MICA Status

- If PINGU is approved, R&D modules can go into the ice
- Drilling and deployment are standard procedures
  - Reliable estimates on cost and time
- Unlike underground experiments, cost is ~linear with size, e.g. number of strings

Conclusion

- Extra galactic supernova
- Proton Decay
- Detector for Neutrino Factory, Beta beam or Super Beam
  - Mass Hierarchy, Lepton CP Violation
  - Option for PINGU as well depending on beam characteristics
- New photodetectors are required
  - Using PMTs in mDOMs, ~60% of detector cost is related to photo-detector
  - Lots of options (Micro-Channel Plates see talk by C. Christensen)