An Air Cherenkov Surface Veto Array

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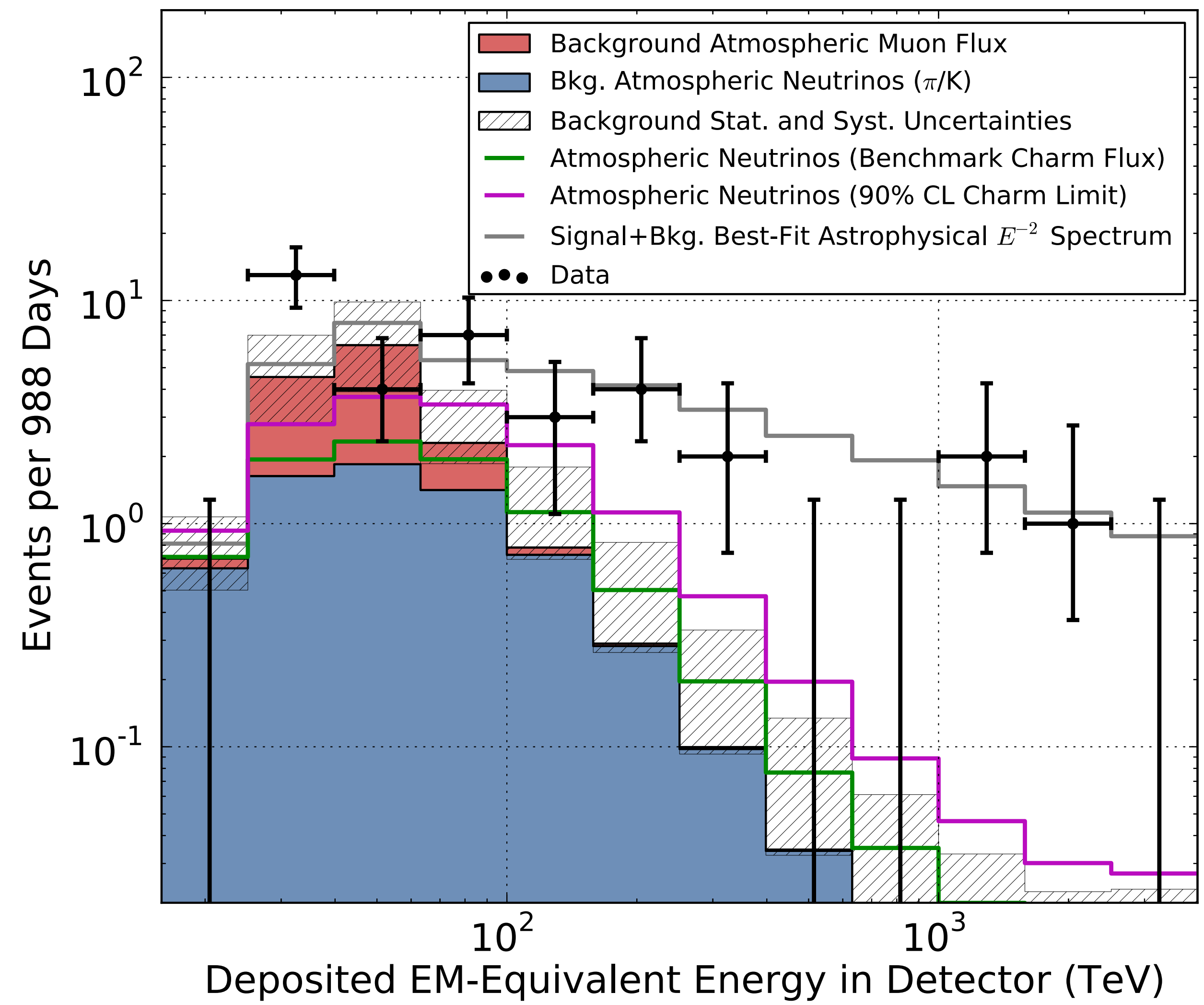
Reducing the Veto Energy Threshold

- The extraterrestrial neutrino flux appears to have a power law spectrum of E^{-2} or a bit softer



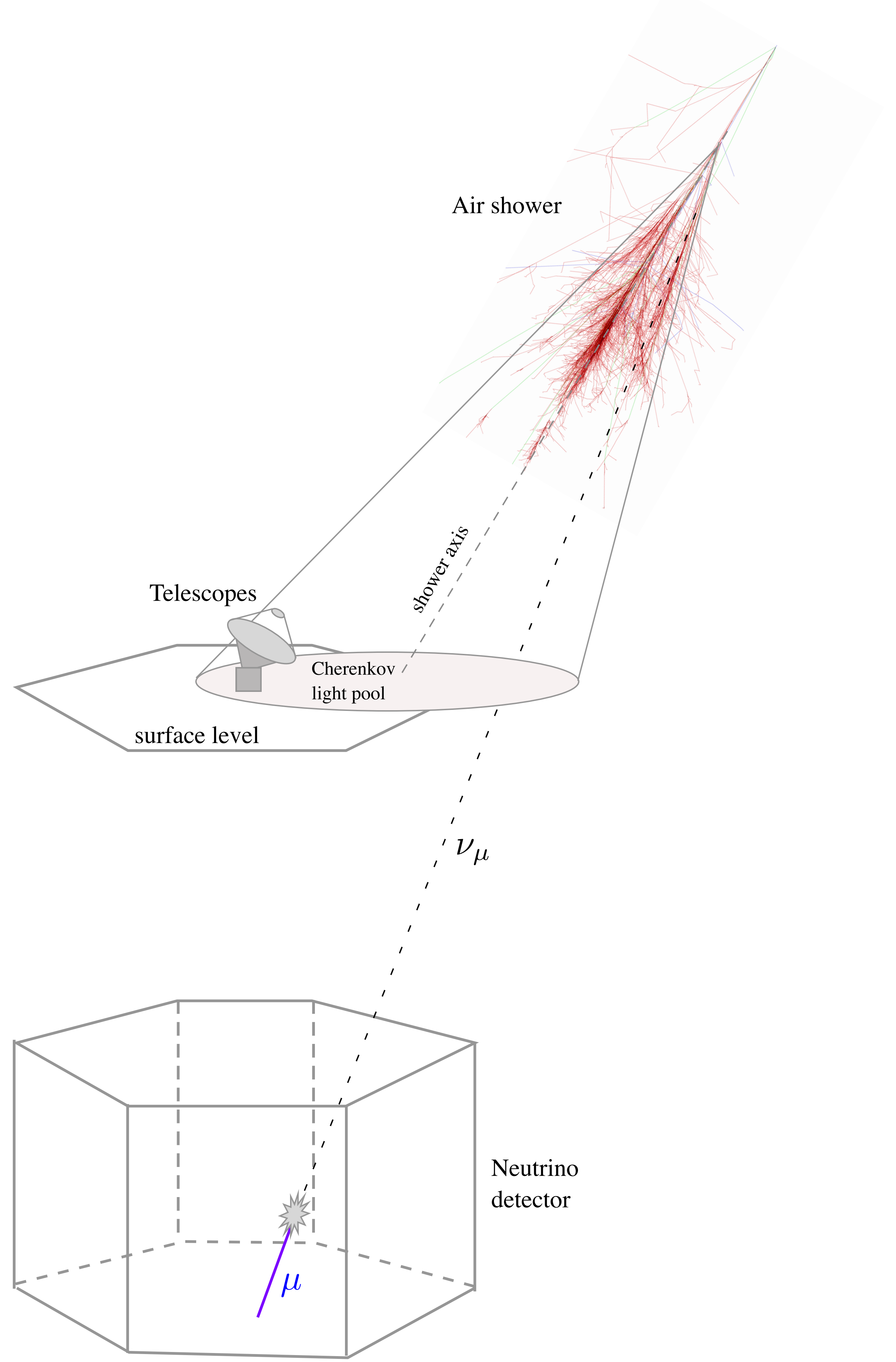
- The co-produced muon veto restricts us to neutrino energies above ~60 TeV
  - In this energy range we are seeing ~8 astrophysical neutrinos per year
- A surface veto with low energy threshold could increase rates for downgoing astrophysical neutrinos by
  - a factor of 1.5 – 3 due to lower energy threshold (depending on spectrum)
  - a further factor of maybe 2 – 5 due to increased fiducial volume (depending on flavor)
- Broader spectral range would also be useful for understanding source dynamics

Surface Veto Techniques

- Current veto threshold fundamentally limited by absorption in ice overburden
- Could extend the surface air shower array – IceTop/IceVeto
  - Pro: straightforward technology, already proven at Pole
  - Pro: 100% duty cycle
  - Con: energy threshold determined largely by altitude (& detector spacing)
  - Con: need many detectors over a large area to cover desired solid angle
- In gamma-ray astronomy, air Cherenkov instruments provide a lower energy threshold than extensive air shower arrays (even very dense ones)
  - Worth considering whether this approach could be useful for a veto

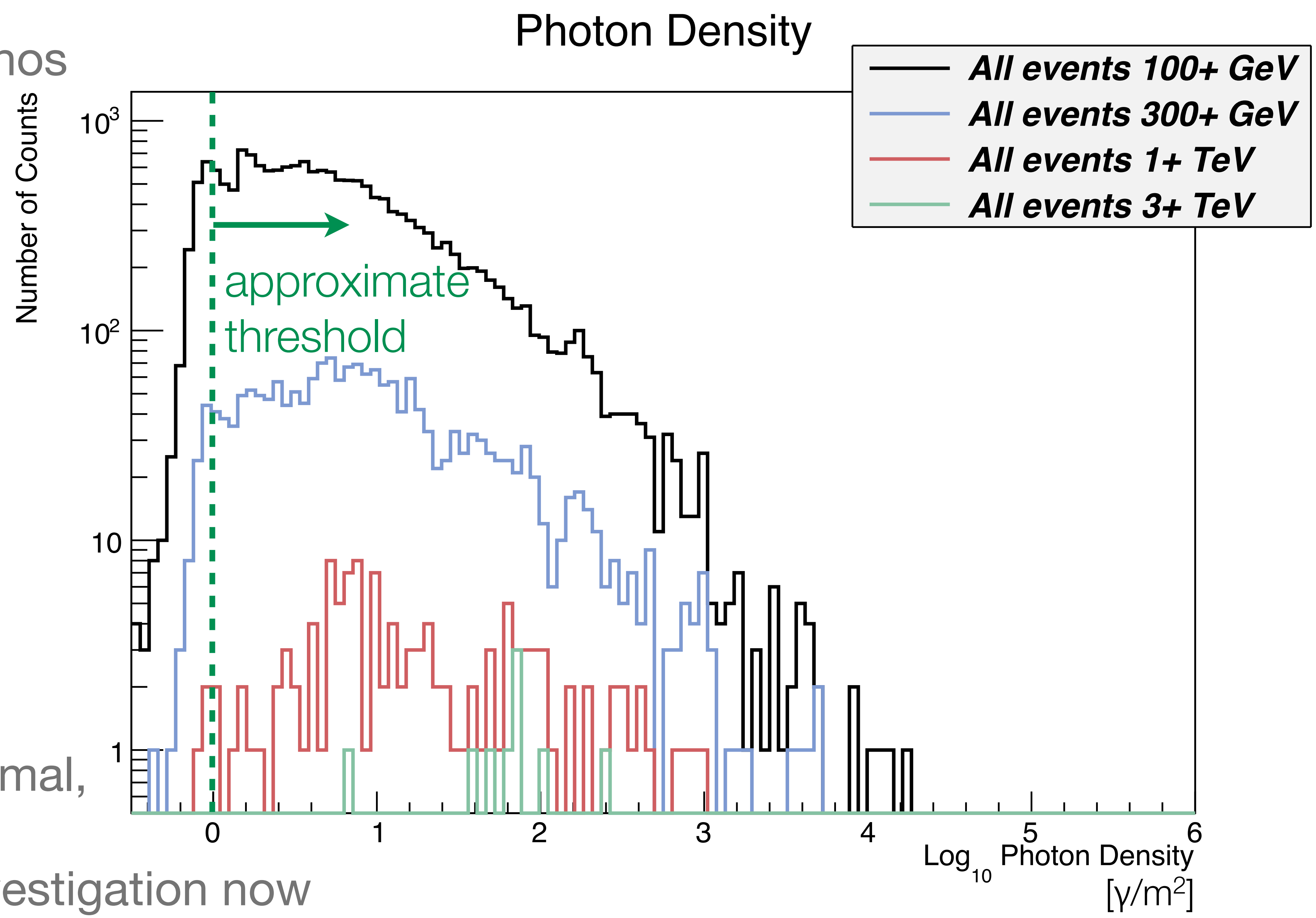
Air Cherenkov Veto

- Goal: the cheapest, crudest ACTs possible
  - γ/hadron separation irrelevant
  - Angular resolution important only insofar as it affects light concentration efficiency
  - Energy threshold relatively high
- Use an array of small telescopes to compensate for restricted field of view
  - Duty cycle would probably be limited to 20-30% (sun, moon, aurorae, weather)



Air Shower Detection

- For a veto energy threshold E_{veto}, need to reliably detect showers with energy $E_p > 3E_{veto}$
  - High energy neutrinos are well aligned with shower axis
- Sensitivity to ~1 Cherenkov photon per square meter should be possible with a 4-5 meter diameter mirror
  - NB: telescope placement suboptimal, some showers are missed – under investigation now



(Guesstimated) Specifications and Cost

- Aim for wide field of view, don't worry about performance
- Thinking about a 4-5 meter single mirror telescope
    - Simple mount; altitude-azimuth is just fine…
- 10° diameter field of view?
    - Angular resolution will be poor at the edge of the FOV, but we only care about keeping the focus tight enough to discriminate from night sky BG
- 80 cm diameter camera: around 300 PMTs, 4 cm diameter
- Cost perhaps \$150k – \$200k per telescope
    - Dominated by PMTs in the camera
    - Reductions possible? Do we even need an imaging telescope?

Veto Telescope Array

- With 10º FOV, a small array of 10-15 telescopes could cover much of the Galactic plane with a margin to accommodate angular resolution
    - Hardware costs might be \$2M – \$3M, based on these estimates
- To tile the sky down to 45º from zenith (6200 sq. deg.) would require about 80 telescopes: around \$12M – \$15M
- Specifications and cost estimates are very rough estimates – simulations of actual design would be required to guarantee requirements would be met
    - Cost estimate might go up or down – non-imaging array would be half that
    - Typical trigger rate O(kHz) – false veto rate for 100 ns window O(1%) or lower
    - New technical challenges (reliability, snow accumulation, etc.) to think about

Outlook

- An air Cherenkov veto array with coverage of the Galactic plane appears feasible, although more study is clearly needed
  - A small array would likely cost a few million (plus R&D)
- Early estimates suggest that reduction in veto threshold of one to two decades in energy might be possible
  - Even with limited duty cycle, could increase statistics for sources in the Southern sky by a factor of several, depending on the spectrum
  - Optimization of telescope placement may improve veto threshold
- Probably offers lowest possible veto energy threshold, but with limited duty cycle and some new complexity
- Synergy with atmospheric neutrino physics?