# Evolving Antennas for Ultra-High Energy Neutrino Detection

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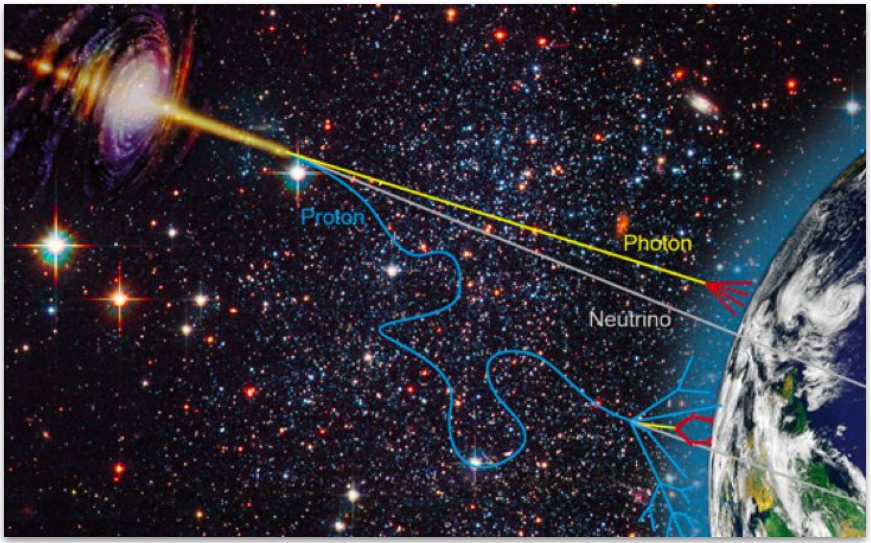
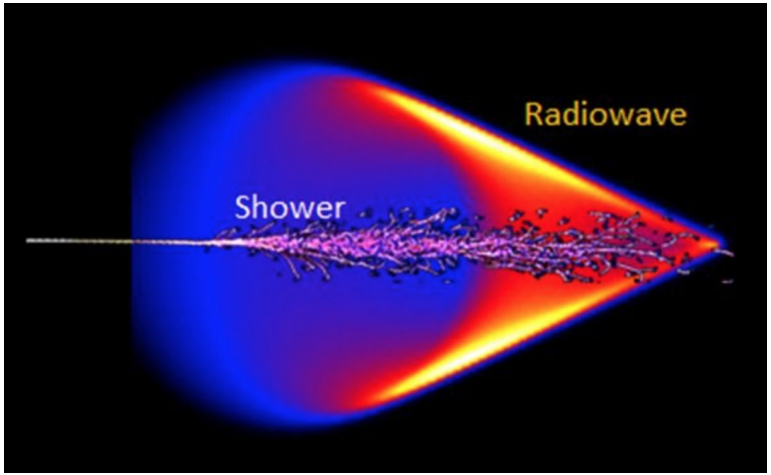
The GENETIS Project

# Ultra-High Energy Neutrino Astronomy

- Neutrinos are excellent **cosmic messengers**!
  - Point directly back to source



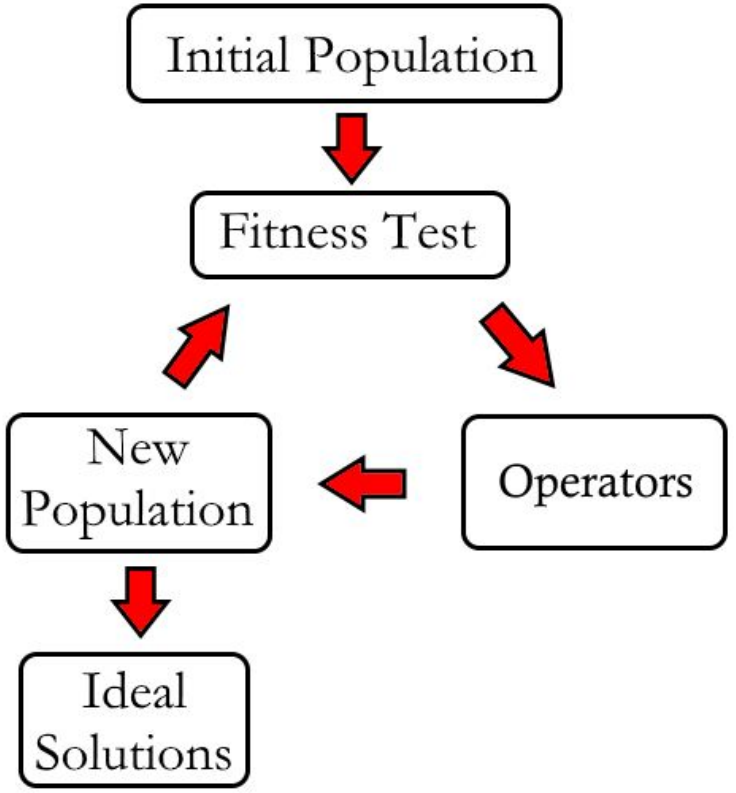

- Many UHE neutrino experiments utilize antennas to detect the Askaryan effect




[1] https://lecospa.ntu.edu.tw/zh/experiment-zh/experiment-i-ultra-high-energy-neutrinos

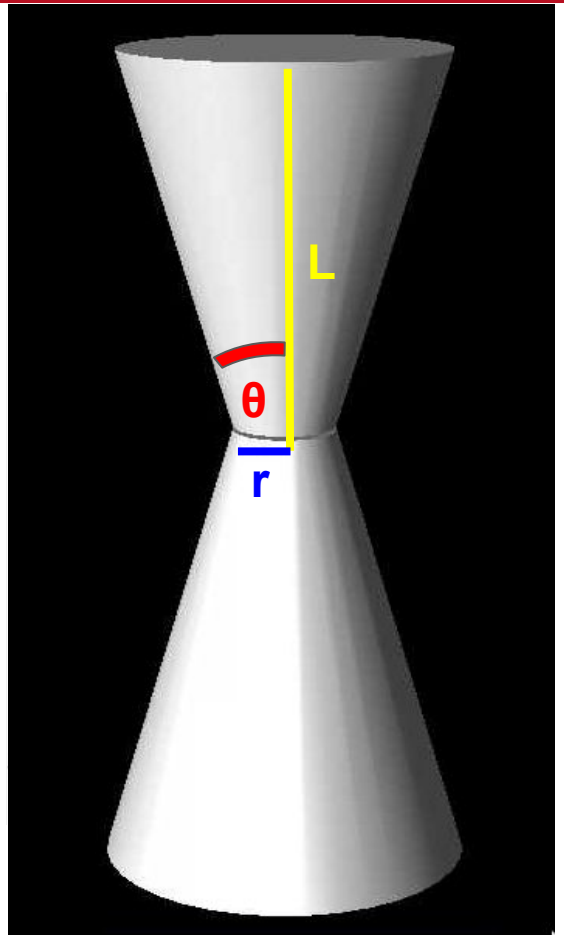
# Genetic Algorithms

- **Designed to mimic natural selection**
  - Generate initial population of possible solutions (individuals)
  - Determine fitness of each individual
  - Select individuals to form the next generation (tournament/roulette)
  - Form next generation (crossover/ mutation/reproduction)
  - Repeat!

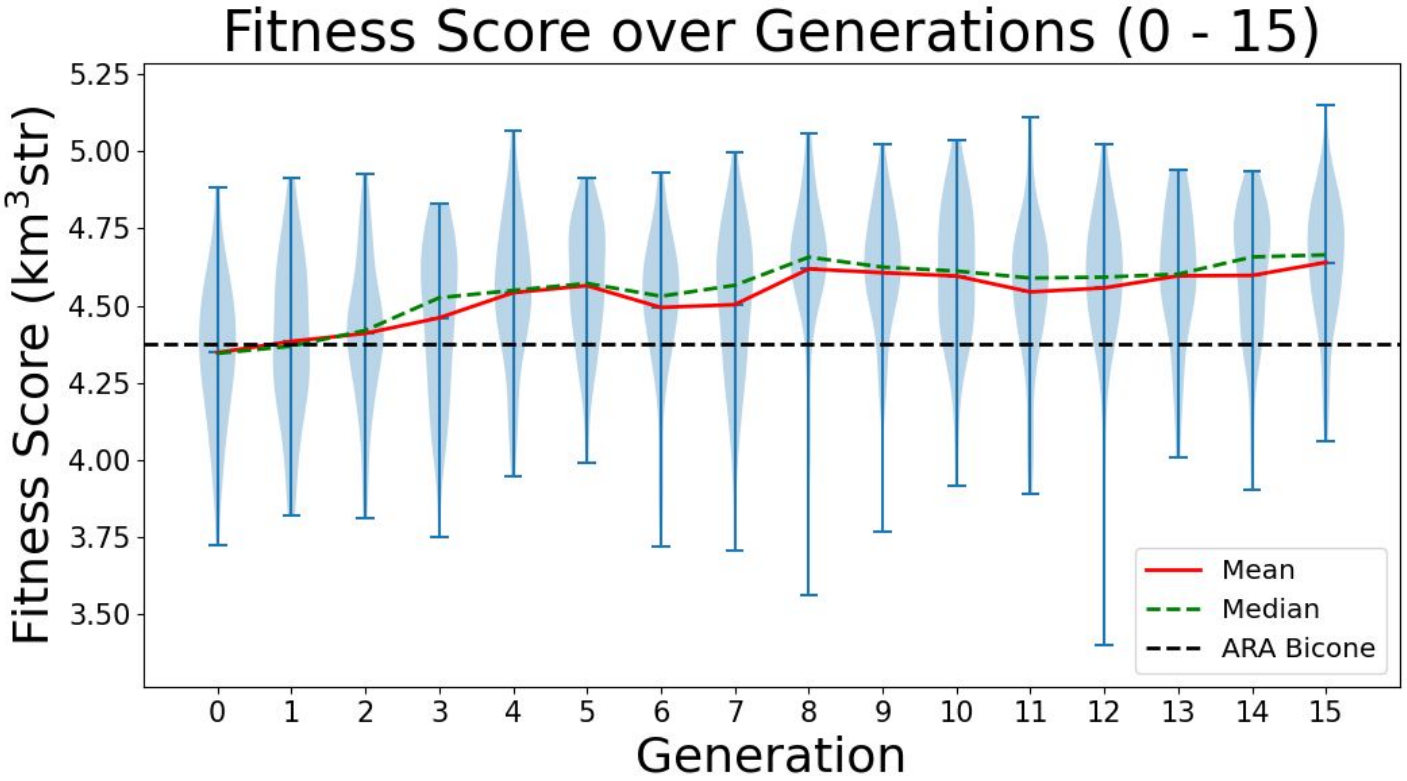


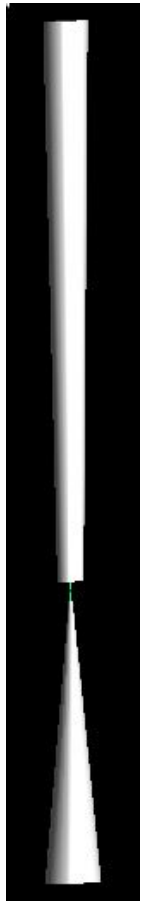
# First GENETIS Design

- First goal is to **generate an asymmetric bicone antenna**
  - Six genes for each individual: **length, inner radius, and opening angle** for each cone
- **Compare designs against VPol antennas in ARA**
  - ARA size constraints implemented
  - AraSim effective volume is the fitness score
- 50 individuals evolved over 15 generations



# Large Asymmetric Run

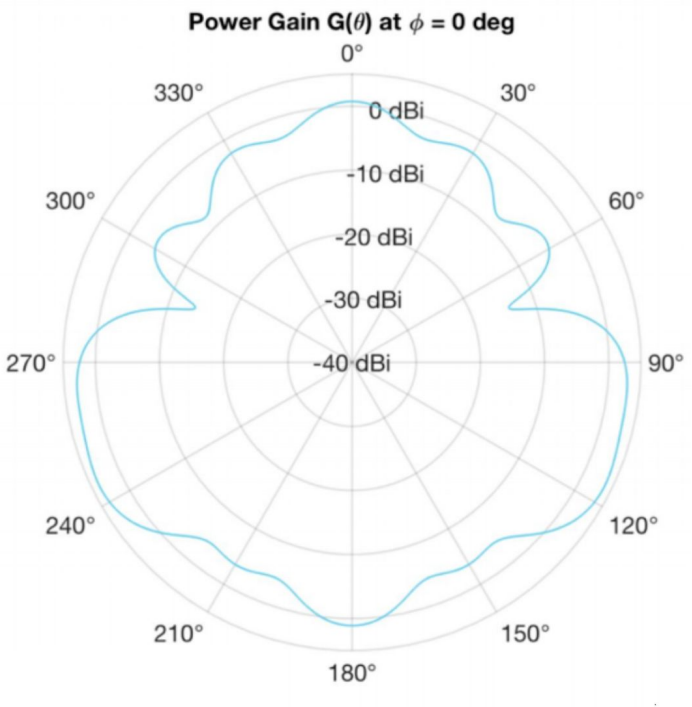


# Gain Pattern Evolution

- **Evolve gain patterns** for in-ice neutrino detection

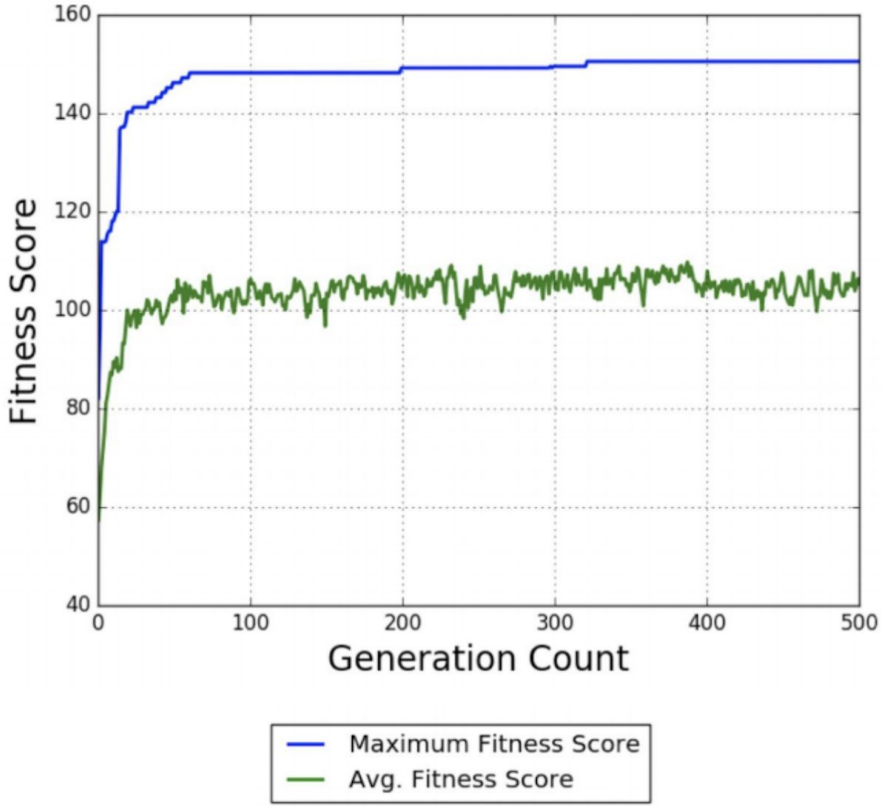
- Allows us to quantify the **maximum improvement** possible
  - Without being concerned with antenna constraints



# Gain Pattern Evolution

- Uses a sum of 13 azimuthally symmetric spherical harmonic functions to model the antenna response

- No need for XFdtd or antenna modeling



# Future Endeavors

- **Run time optimization**
  - Antenna database for asymmetric bicone
- Add nonlinear bicone to full loop
- Obtain results for gain pattern evolution with more complex simulation software
- Apply to different experiment aspects
  - Including new geometries, array design, and triggering systems