

# Report from BRN Neutrino Working Group

CPAD Instrumentation Frontier Workshop

Dec. 8<sup>th</sup>, 2019

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# BRN process

Feedback solicited from this list of experiments:

Instrumentation BRN: Midterm Report – Bonnie Fleming,  
Ian Shipsey

Here I will summarize the *Neutrino* section of the report  
as it stands and solicit feedback

Similar talk to be given Wed. in DC with feedback  
incorporated

Collaboration
DUNE
Daya Bay
JUNO
MINERVA
MicroBooNE
PROSPECT
T2K
Super-K
CERN Neutrino and Neutrino Pla
NOvA
ICARUS
SBND
ANNIE
COHERENT
ICECUBE
ANITA
ARA
ARIANNA
ANTARES
GRAND
KM3NET
MAJORANA/LEGEND
EXO
CUORE
NEXT
KamLAND-Zen
Old Snowmass mailing list

# Science Drivers: Big Picture

What is the origin of neutrino mass?

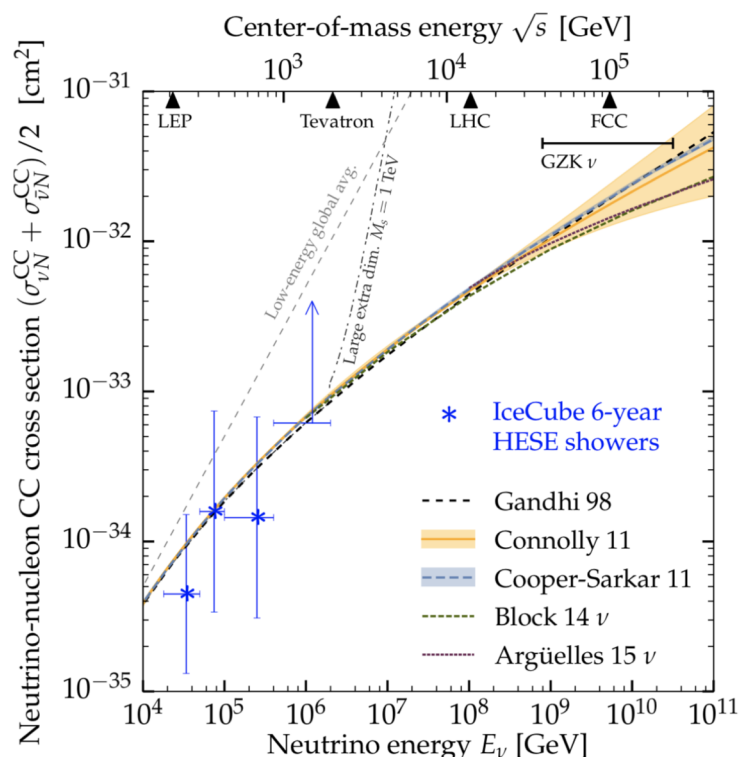
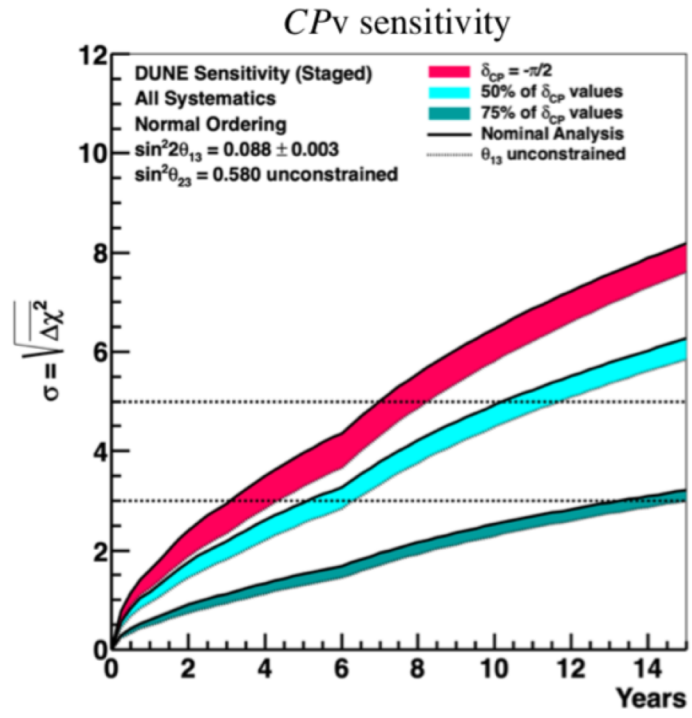
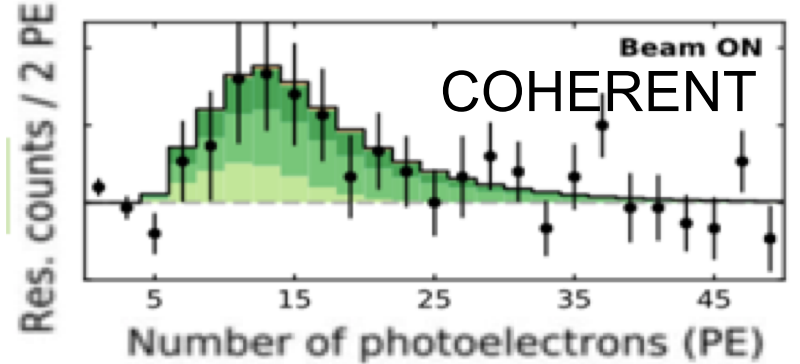
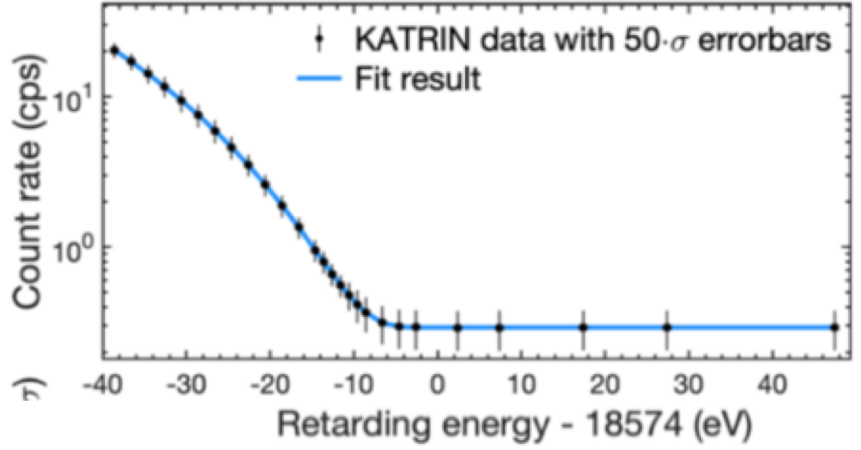
What is the neutrino mass hierarchy?

What are the neutrino masses?

Do neutrinos and antineutrinos oscillate differently?

Are there additional neutrino types or interactions?

Are neutrinos their own antiparticles (Majorana or Dirac)?



# Classes of experiments targeted at science drivers

Oscillation experiments: Solar, atmospheric, reactor, accelerator neutrinos

Hierarchy, CP-violating phase(s), precision measurements

Beyond the SM physics (BSM) searches

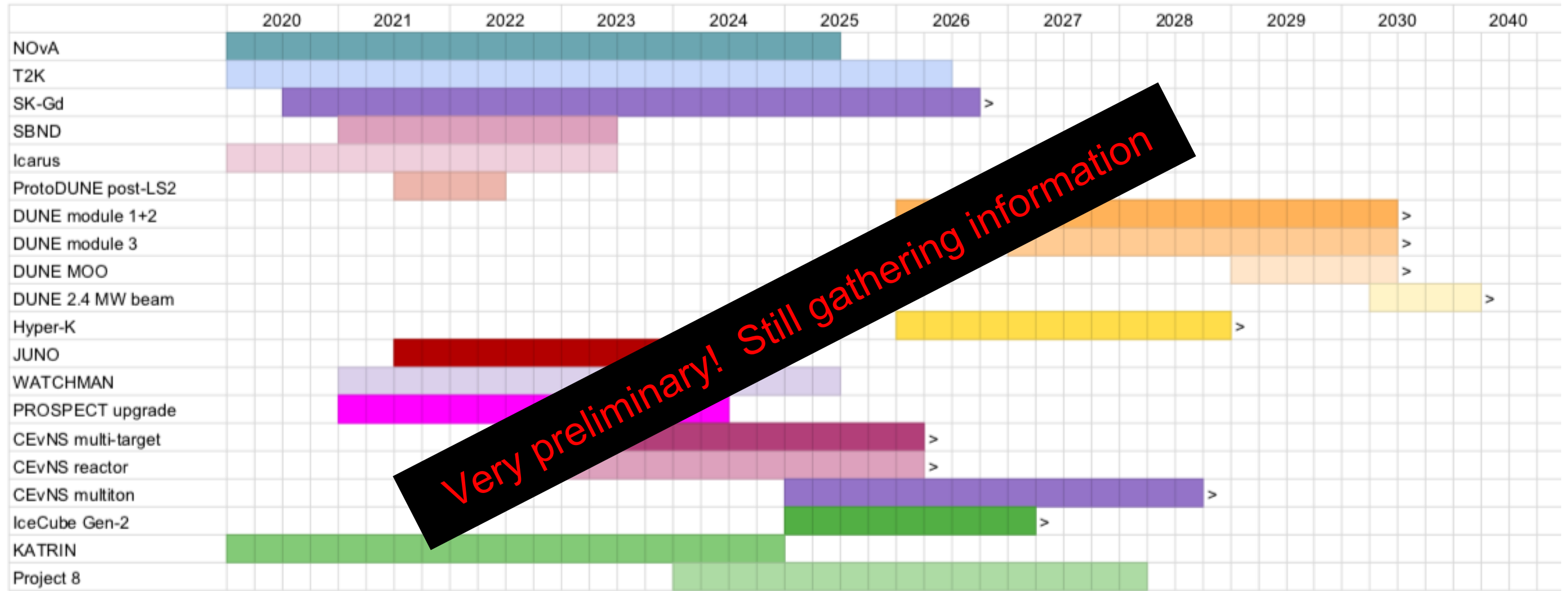
Astrophysical neutrinos: supernova, GRBs, AGNs, mergers (possible BSM)

Neutrino cross sections, CE $\nu$ NS (needed for interpretation of results, BSM)

Neutrinoless double-beta decay (Dirac or Majorana)

Kinematics of weak decays (Neutrino absolute mass scale - also with precision cosmology)

# Rough Timeline of Neutrino Experiments



# Summary of Neutrino Report

# Enhancement of LArTPCs

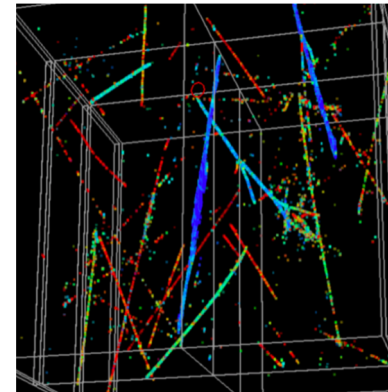
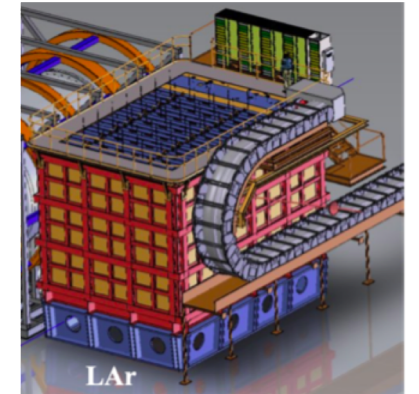
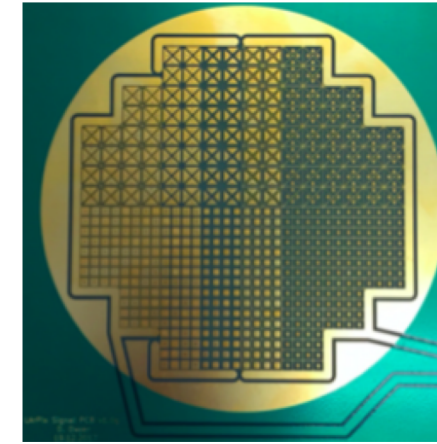
## Liquid Argon Time Projection Chambers

### “Incremental” improvements

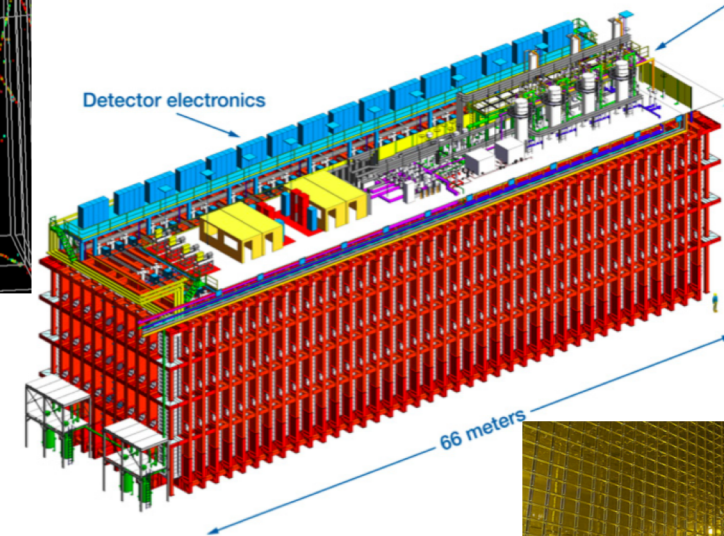
- HV delivery & stable operation
- Cold electronics
- Photons (see next PRD)
- Event reconstruction techniques

### Possibly transformative

- Novel charge readouts--  
pixelized readouts
- Underground argon
- Magnetized detectors

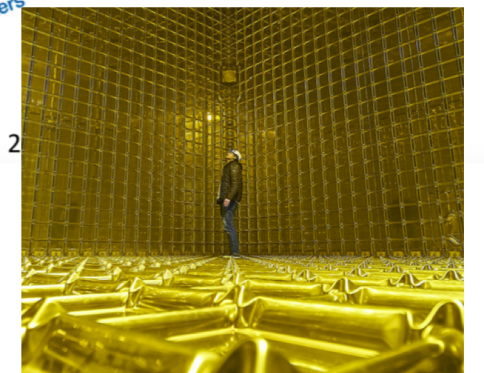
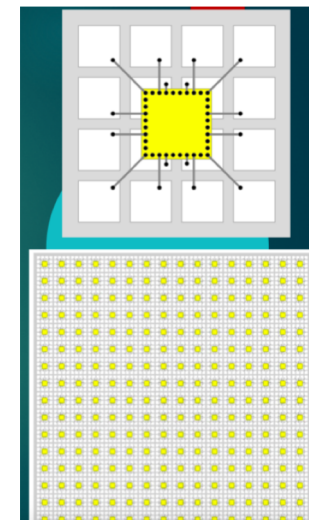


modules in South Dakota



Cryogenic systems

Neutrinos from Fermilab in Illinois



1000 trucks with 2

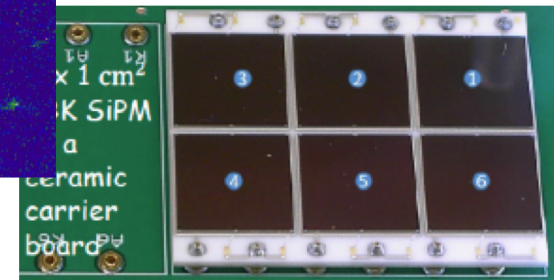
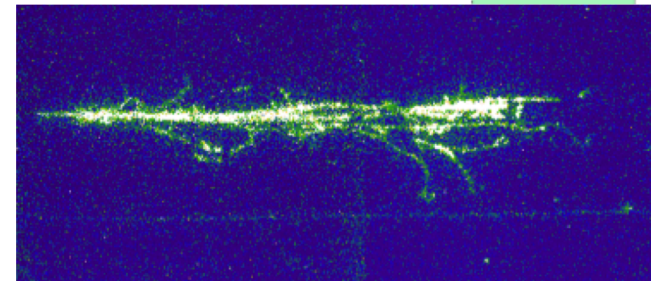
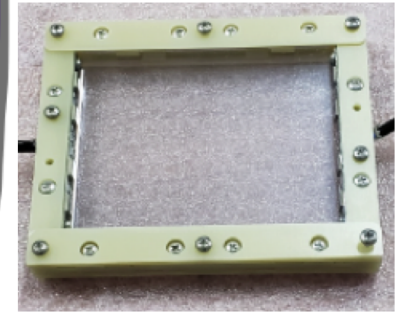
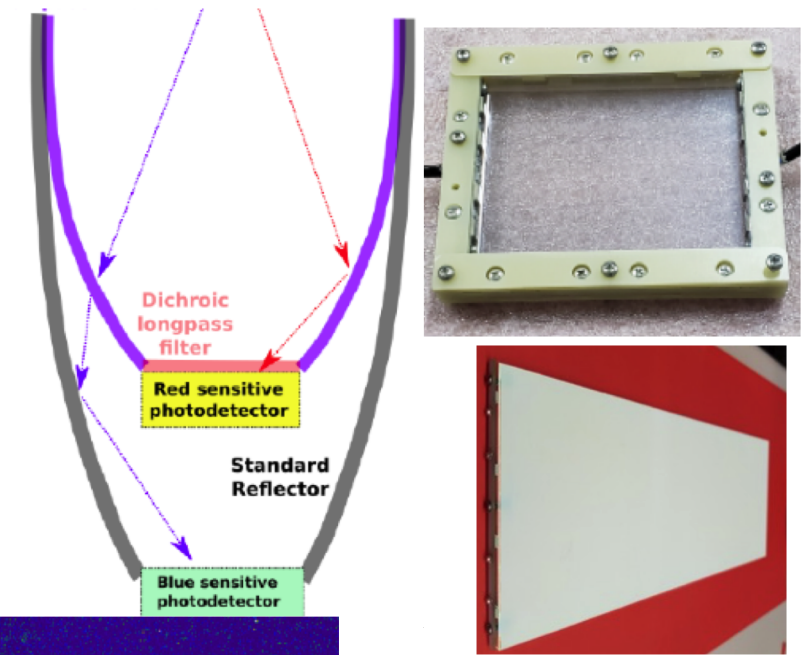
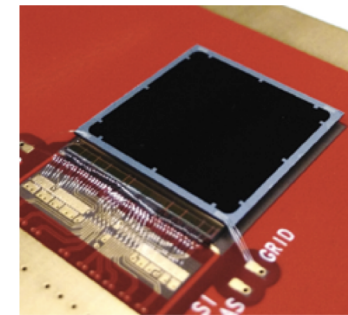
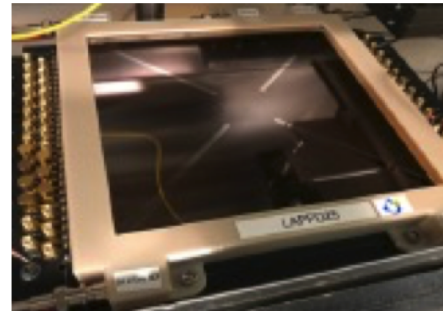
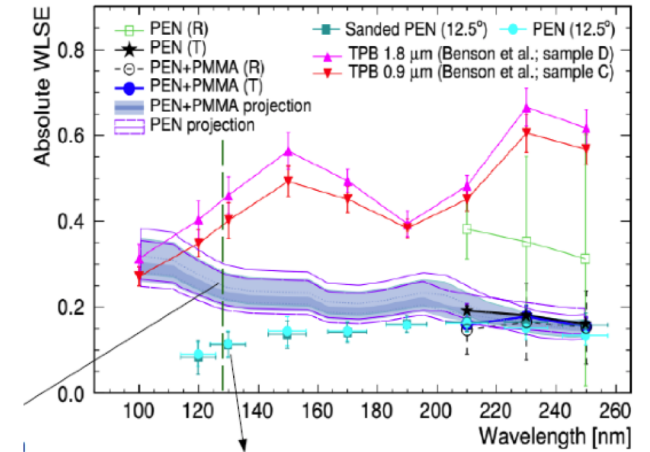
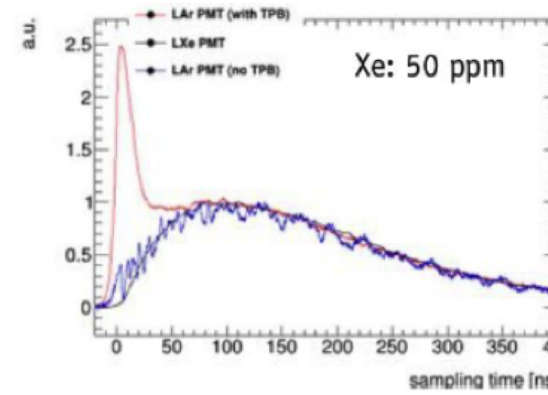
# Enhanced Photodetection

## Improvements in photon detection enabling $\nu$ physics

- Improved calorimetry and tracking
- Enhanced signal-to-background discrimination
- Reduced thresholds

## Active field of development:

- New reflectors and wavelength shifters
- Novel photosensors and light traps
- Cherenkov vs. scintillation discrimination
- Scalable (i.e. large-area) photodetection systems
- Ultrafast timing: Large Area Picosecond Photon Detectors (LAPPDs)

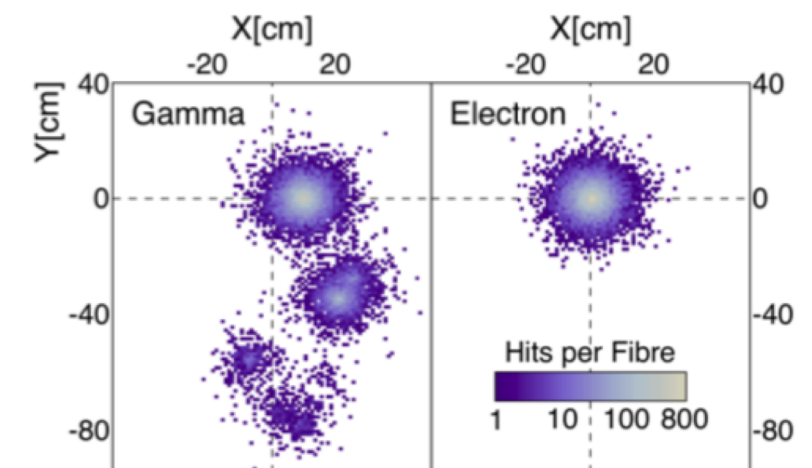
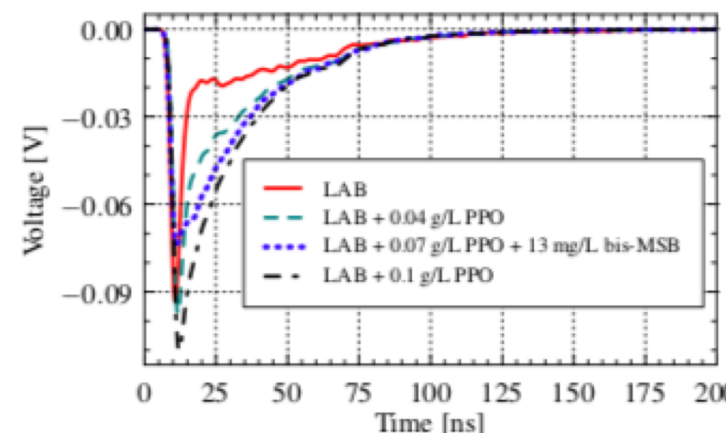
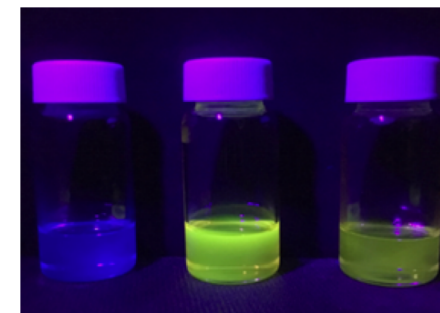
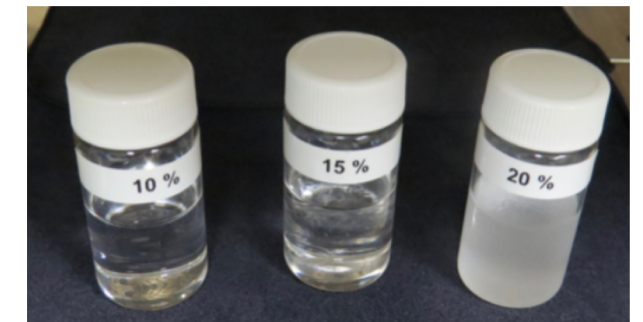
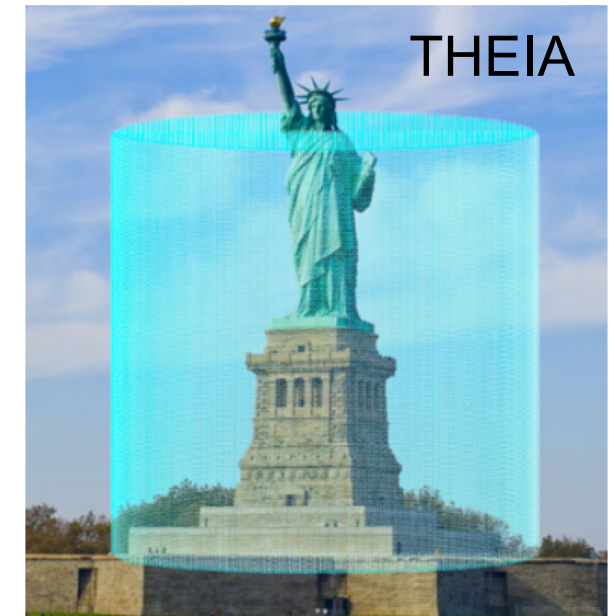




# New Scintillators

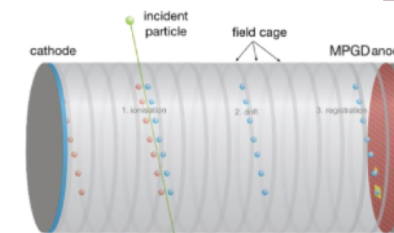
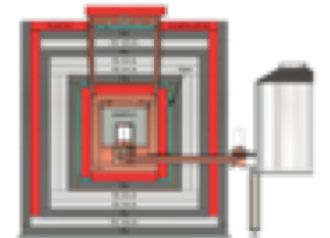
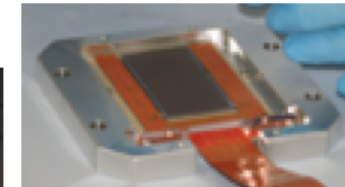
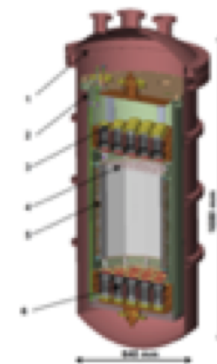
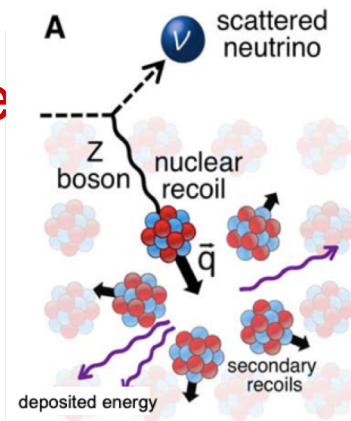
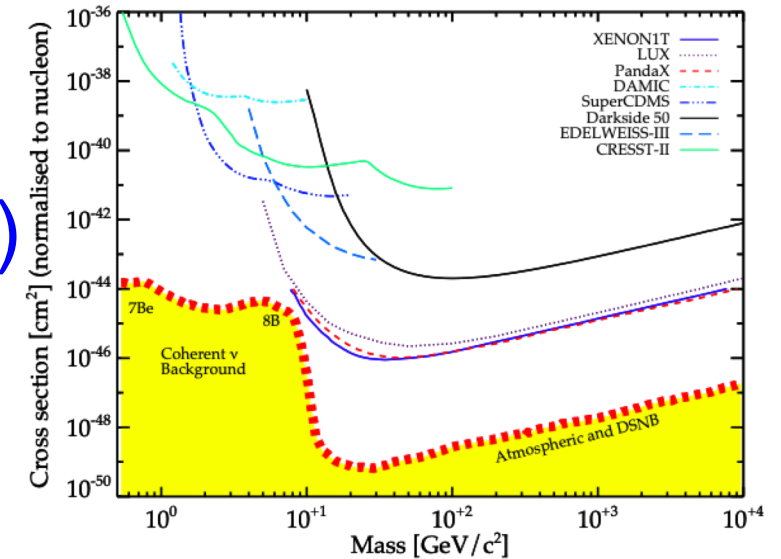
Developments in scintillator technology (connected to photosensor/wavelength-shifter technology)

- Large-scale hybrid water Cherenkov/scintillators
  - Improved particle ID and reconstruction for neutrino physics
- R&D directions
  - Water-based scintillators
  - Slow scintillators
  - Opaque scintillators
  - Alternative fluors

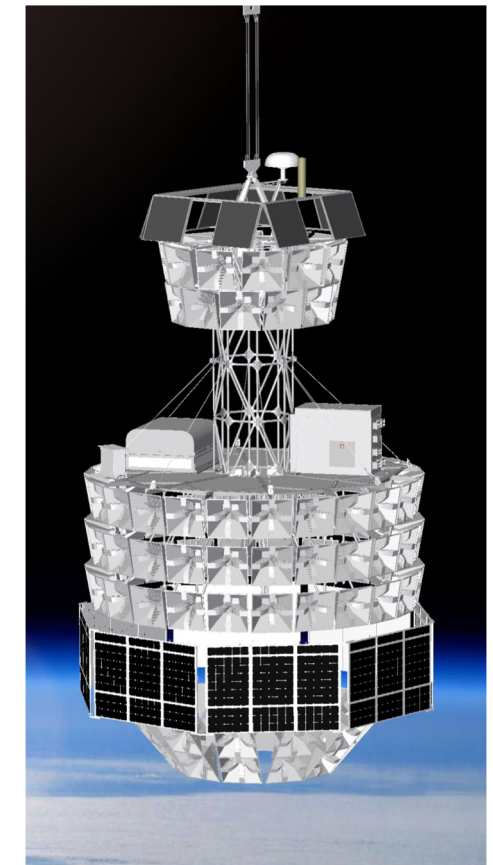
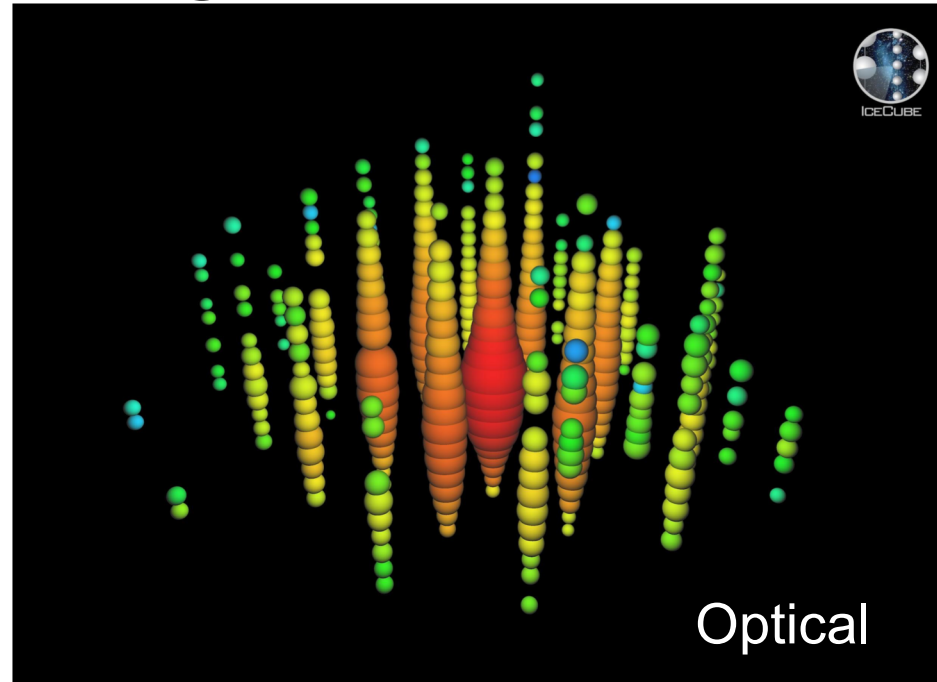
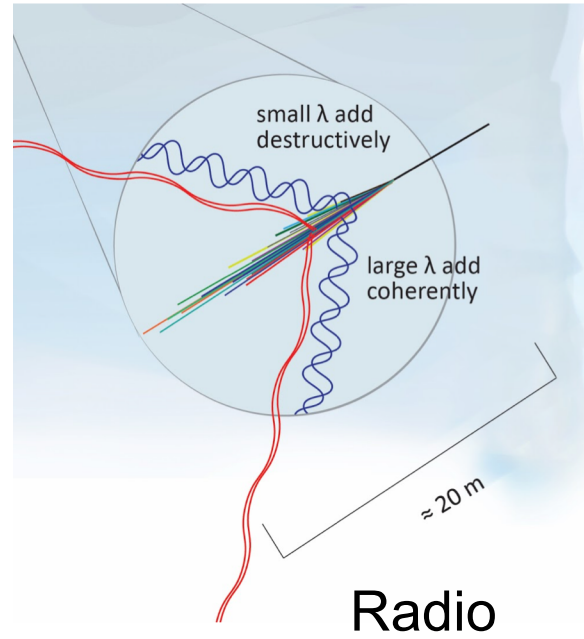


# Large, Low-Threshold, Low-Background Nuclear Recoil Detectors

- Relevant for both dark matter and  $\nu$  physics (CE $\nu$ NS)
- Desirables: large mass (ton+ scale), low threshold, low background, energy resolution, directionality
- Technologies:
  - Noble liquid, single and dual phase
  - Cryogenic bolometers
  - Inorganic scintillators
  - CCDs
  - Gas TPCs
  - ...
- Challenges: radiopurity, noise, energy deposition sensing, electronics, signal processing, detector response

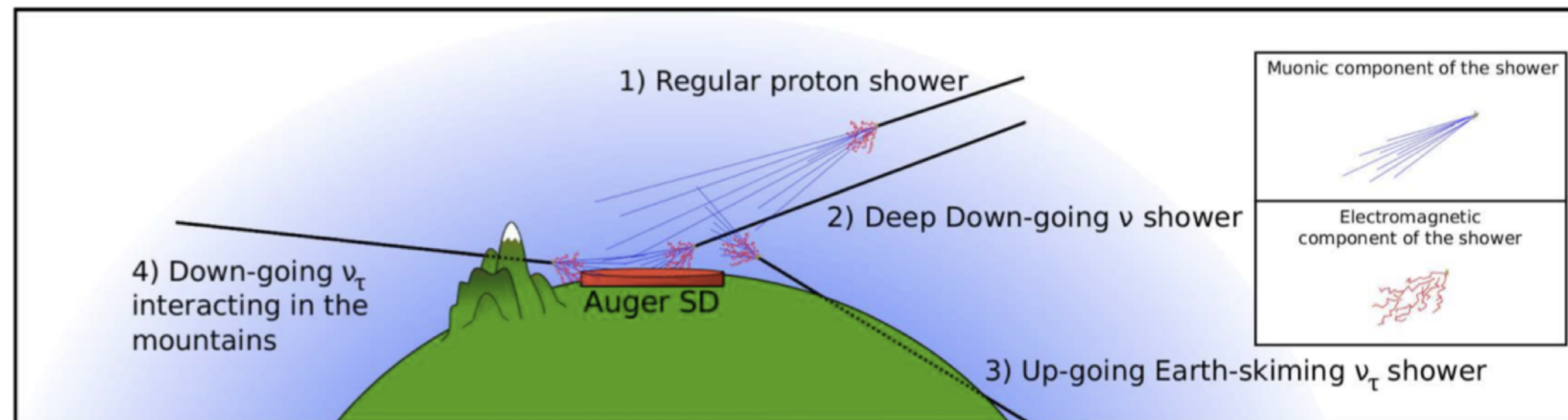


# Astrophysical Neutrino Detection through lower thresholds, larger volumes

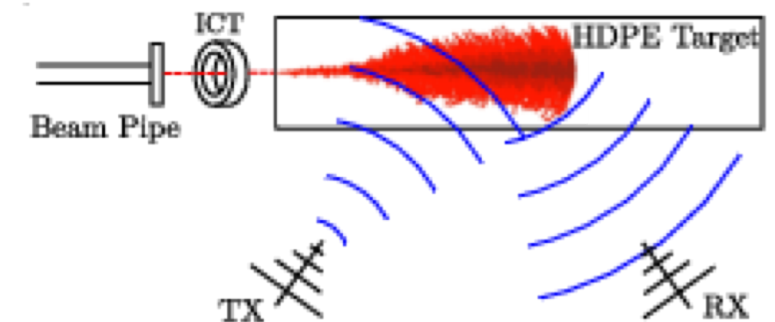


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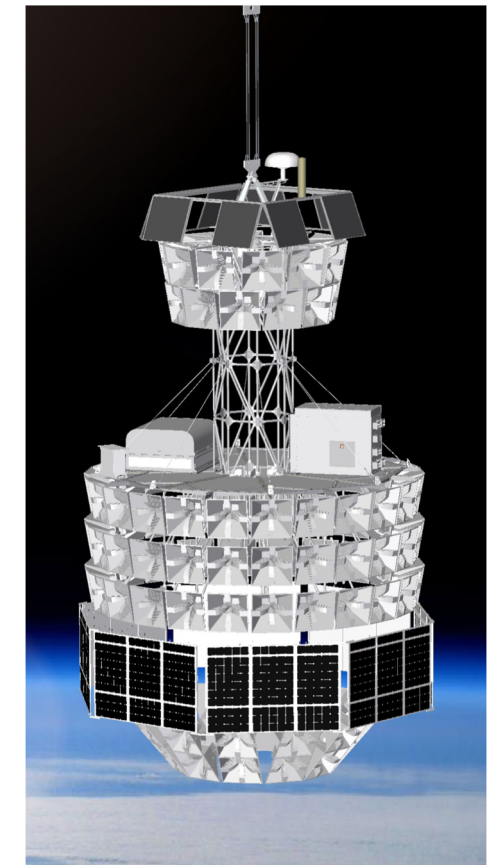
## Tau neutrinos via air showers: Auger, GRAND, BEACON



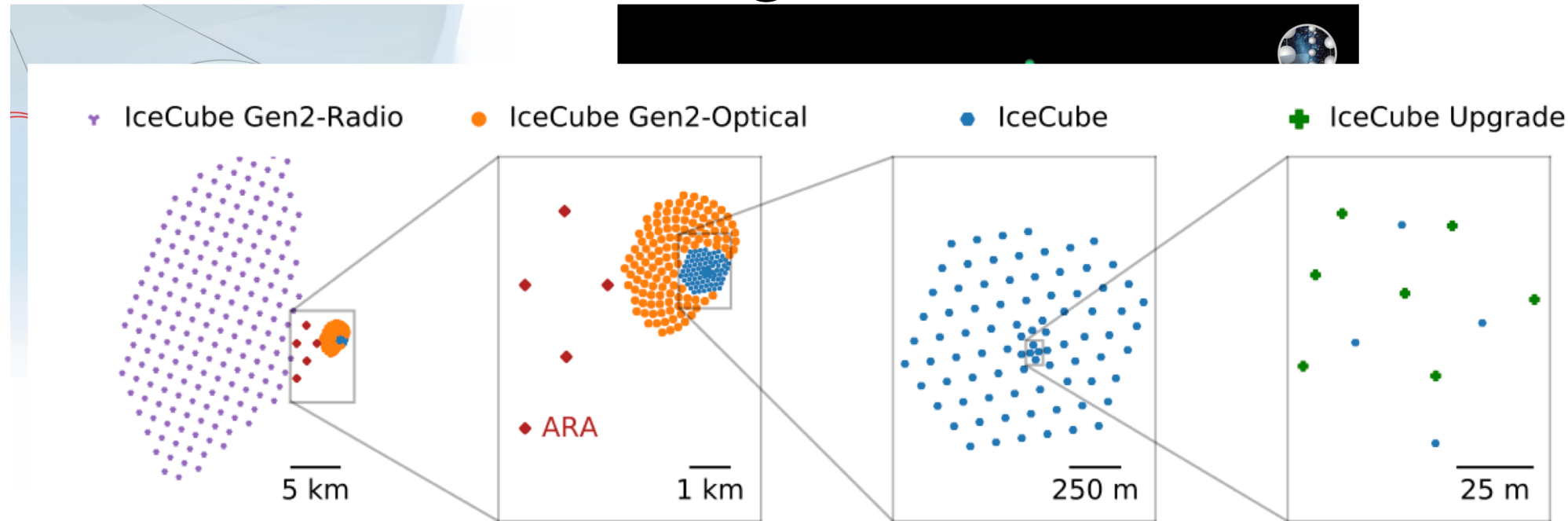
## New! radar technique RET



# Astrophysical Neutrino Detection through lower thresholds, larger volumes

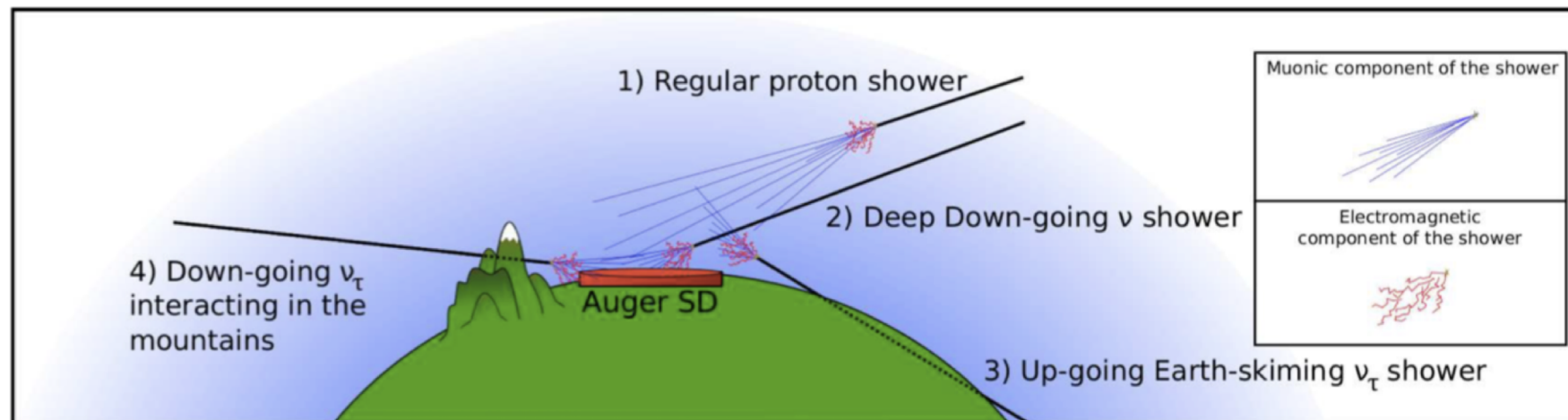


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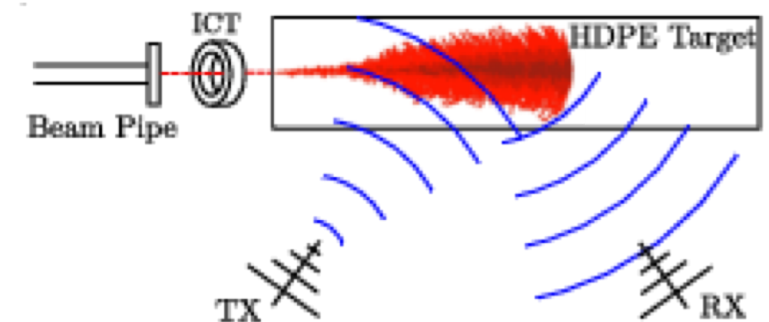


Need fast (>GHz) digitization at low power (~1 W/antenna), power, communication over 100s km<sup>2</sup> array

Tau neutrinos via air showers: Auger, GRAND, BEACON



New! radar technique RET



# Next steps

Looking for more input

Many of us will meet again in DC Dec. 11th-14th