

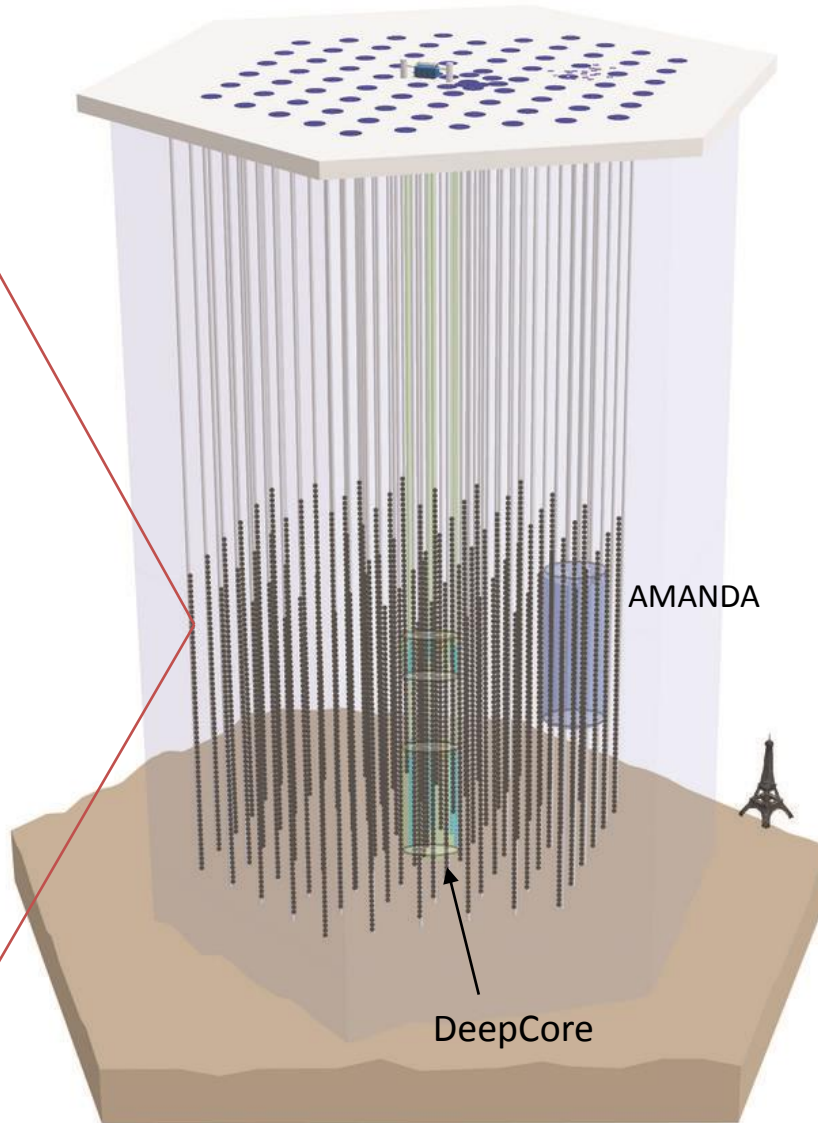
NEUTRINO ASTROPARTICLE PHYSICS

UPPSALA
2018 MARCH 13

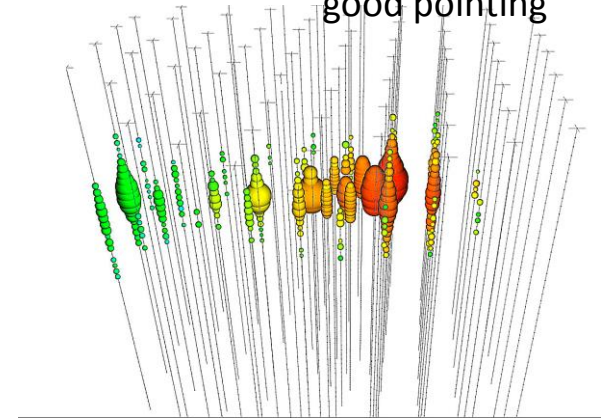
PHOTO: MARTIN WOLF

IceCube Neutrino Observatory

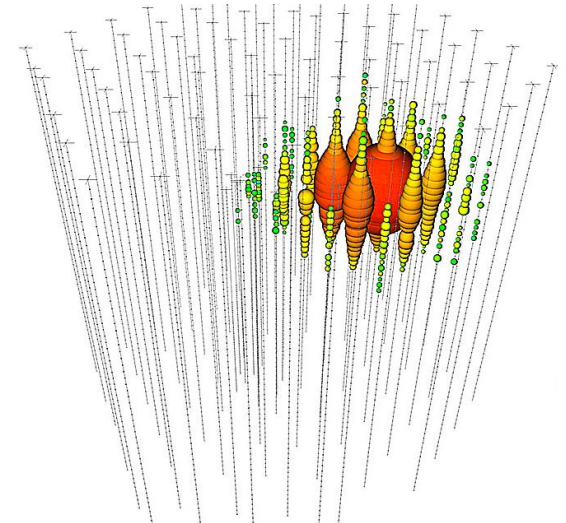
Digital Optical Module



track topology =
good pointing



High Energy Neutrino Events



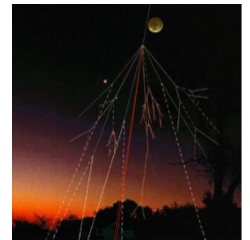
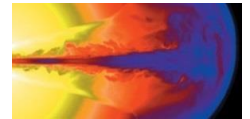
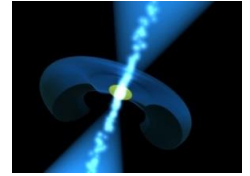
cascade topology =
good energy resolution

Astrophysics of the extreme Universe; **Multi-Messenger Astronomy**

Sources of cosmic rays \Leftrightarrow sources of neutrinos

Analyses: **Point-sources**, **Extended emissions**, **Transients**, bursts,
Diffuse flux (integrated emission over sky)

Targets: Supernovae remnants, Active Galactic Nuclei,
Gamma Ray Bursts, Starburst Galaxies, Microquasars, ...



Dark matter annihilation produces neutrinos

Analyses search for signal from: **Sun's core**, **Galactic Center**, **Galactic Halo**, Galaxy clusters and dwarf galaxies

Particle physics

Neutrino oscillations, neutrino mass ordering (*core activity of new NBI group*)

Charm production in cosmic ray interactions

Violation of Lorentz invariance, quantum decoherence

Exotic searches: **magnetic monopoles**, ...



Ultrahigh Energy Neutrinos from cosmic ray interactions with CMB

Cosmic ray physics

energy spectrum around "knee", composition, anisotropy

Supernova in our galaxy (if one occurs)

Infrastructure Plans for Neutrino Astroparticle Physics

UU and SU prioritized infrastructure proposal to RFI

The IceCube Upgrade

New Ice Drill

7 New Strings, new module designs

Upgrade detector calibration

-> astrophysical neutrinos

Lower energy threshold

-> neutrino oscillation measurements

*Chad Finley's talk
at Partikeldagarna*

The Radio Array

ARIANNA / ARA -type surface array

Detect ultrahigh energy neutrinos

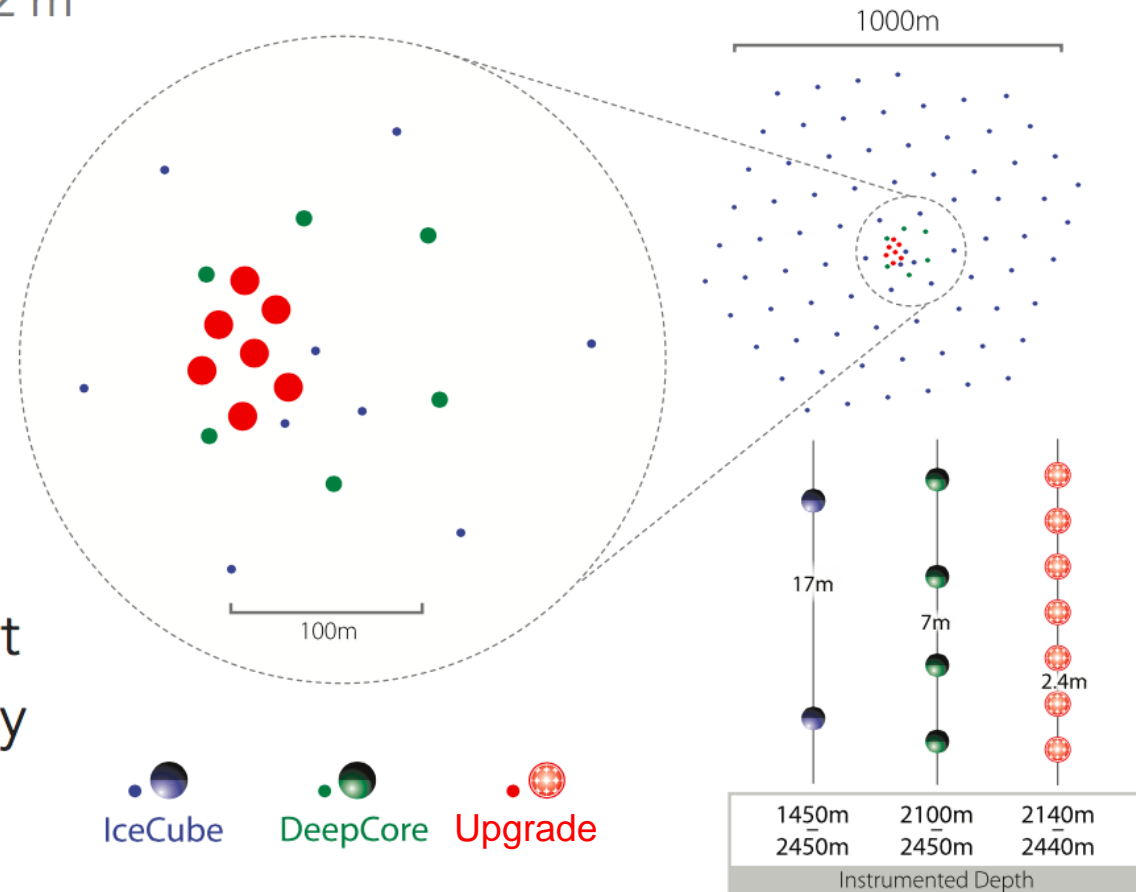
-> astrophysical flux at higher energy
than IceCube

-> cosmogenic neutrinos from GZK

*Allan Hallgren's talk
at Partikeldagarna*

The IceCube Upgrade

- Seven new strings of multi-PMT mDOMs in the DeepCore region
 - Inter-string spacing of ~ 22 m
- Suite of new calibration devices to boost IceCube calibration initiatives
- Improve scientific capabilities of IceCube at both high and low energy



The IceCube Upgrade

DOM (Digital Optical Module) – Upgrade Edition

IceCube DOM



5 160 currently operating in IC

(20% built in Sweden)

D-Egg



4π sensitivity

Compact diam. reduces drilling costs

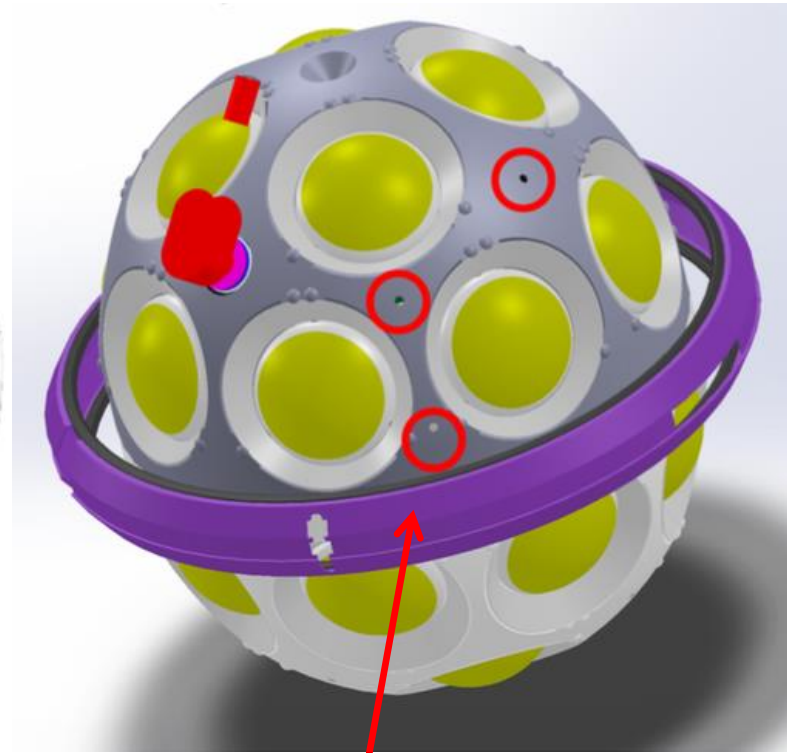
mDOM



4π sensitivity

Directionality

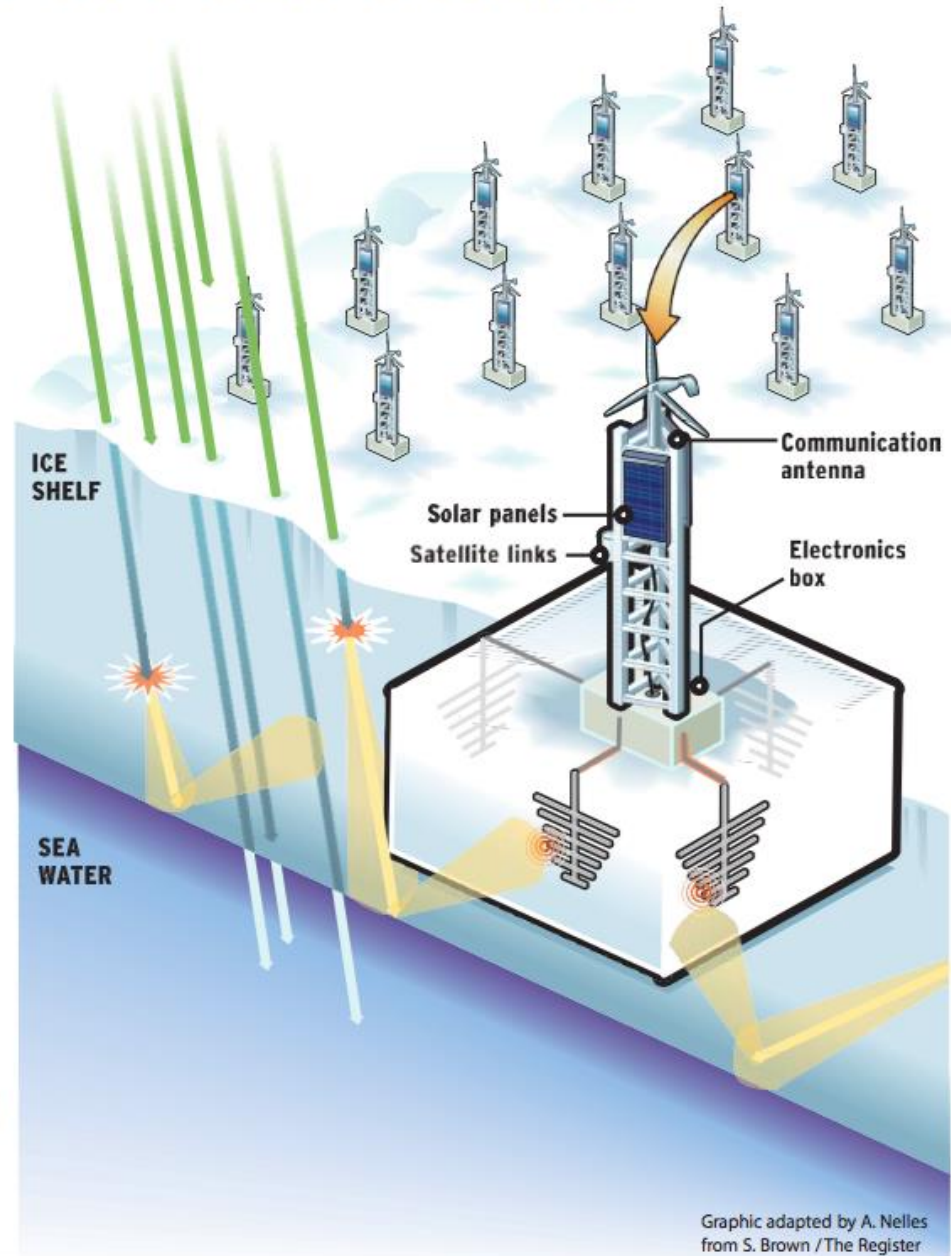
Low noise via coincidence req.



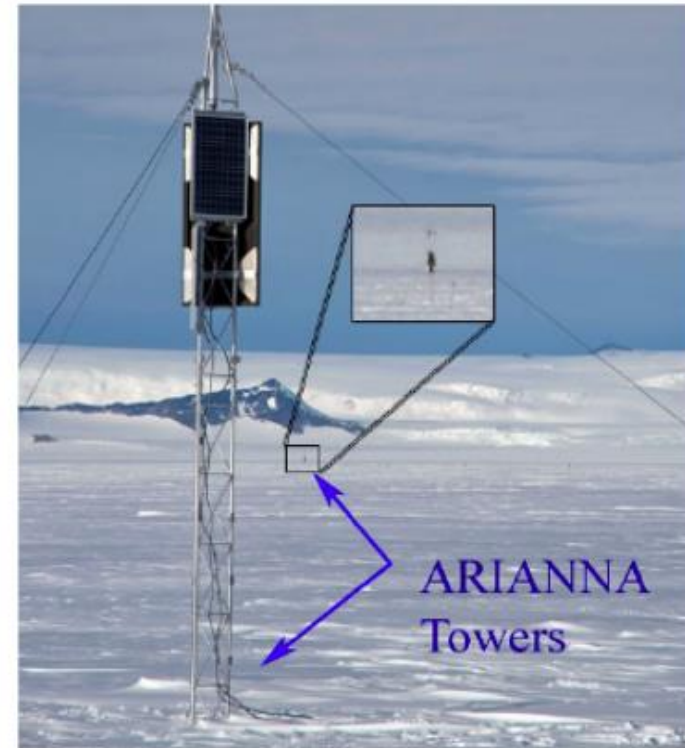
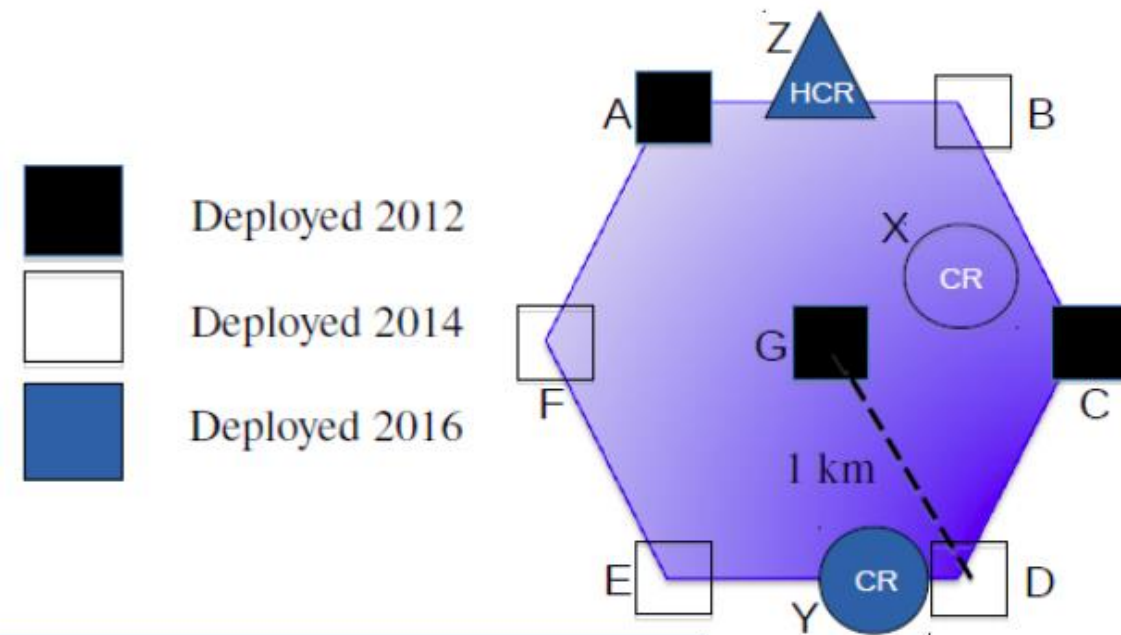
LED flashers in all directions for precision calibration

Concept of ARIANNA

- **Independent antenna stations** can be installed at low costs on the surface
- **High gain antennas (50 - 1000 MHz)** can be used to instrument a large volume
- **Ross ice-shelf** (Size of France), Moore's bay, 110 km from McMurdo
- Ice-water boundary **almost perfect reflector** for radio emission
- **Solar** (and wind ?) **power**
- **Real-time data** transfer via satellite, SBD
- Array of about 1300 stations needed, **36km * 36km**, grid with 1 km spacing
- ~ 30 Million USD



Current State of ARIANNA: The HRA



From C. Persichilli @ TeVPA 2017

European Strategy for Particle Physics (2006)

Addressed under “non-accelerator based particle physics”

“A range of very important non-accelerator experiments take place at the overlap between particle and astroparticle physics exploring otherwise inaccessible phenomena;

Council will seek to work with ApPEC to develop a coordinated strategy in these areas of mutual interest.”

From the update (2013):

“A range of important non-accelerator experiments take place at the overlap of particle and astroparticle physics, such as searches for proton decay, neutrinoless double beta decay and dark matter, and the study of high-energy cosmic-rays. These experiments address fundamental questions beyond the Standard Model of particle physics. The exchange of information between CERN and ApPEC has progressed since 2006.

In the coming years, CERN should seek a closer collaboration with ApPEC on detector R&D with a view to maintaining the community’s capability for unique projects in this field.”

APPEC Roadmap

From “European Astroparticle Physics Strategy 2017-2026”

As a relatively new field, European astroparticle physics does not benefit from a natural and strong inter-governmental organisation that has a remit to drive it, in the same way as CERN, ESO and ESA help to drive their areas of specialism. This is why, in 2001, European scientific agencies founded APPEC (the Astroparticle Physics European Consortium). Since 2012, APPEC became a consortium operated on the basis of a Memorandum of Understanding with the overarching aim of strengthening European astroparticle physics and the community engaged in this field.

Astroparticle physics risks “falling between the chairs”

APPEC Roadmap

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