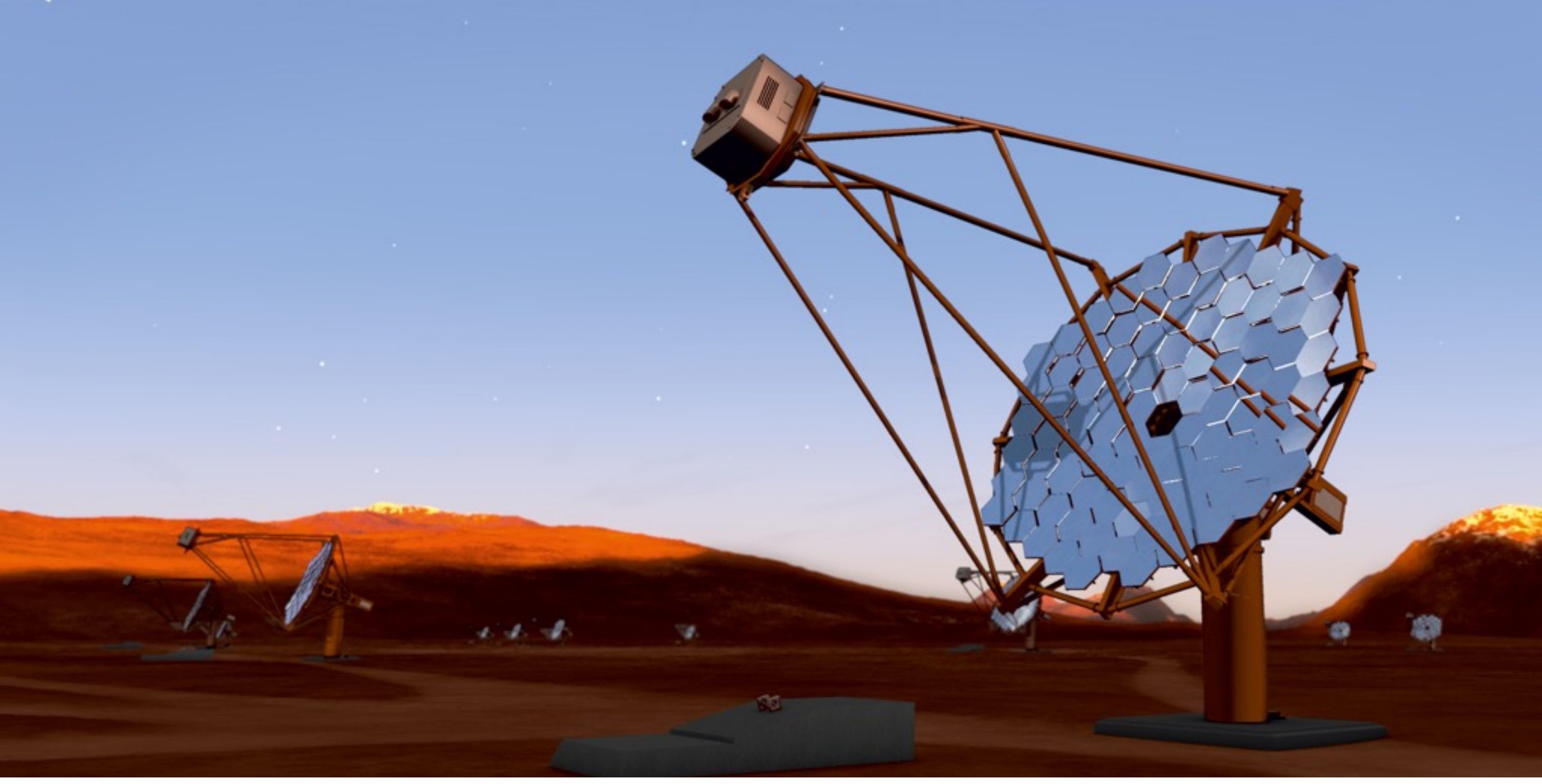
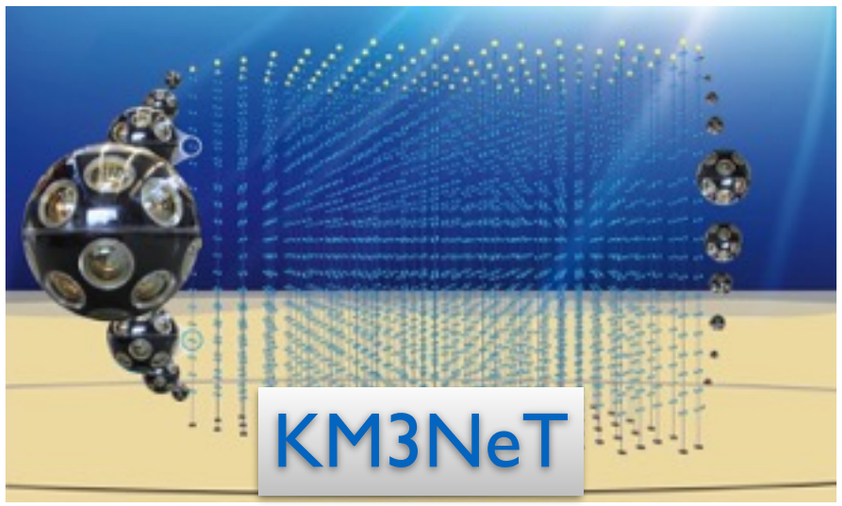


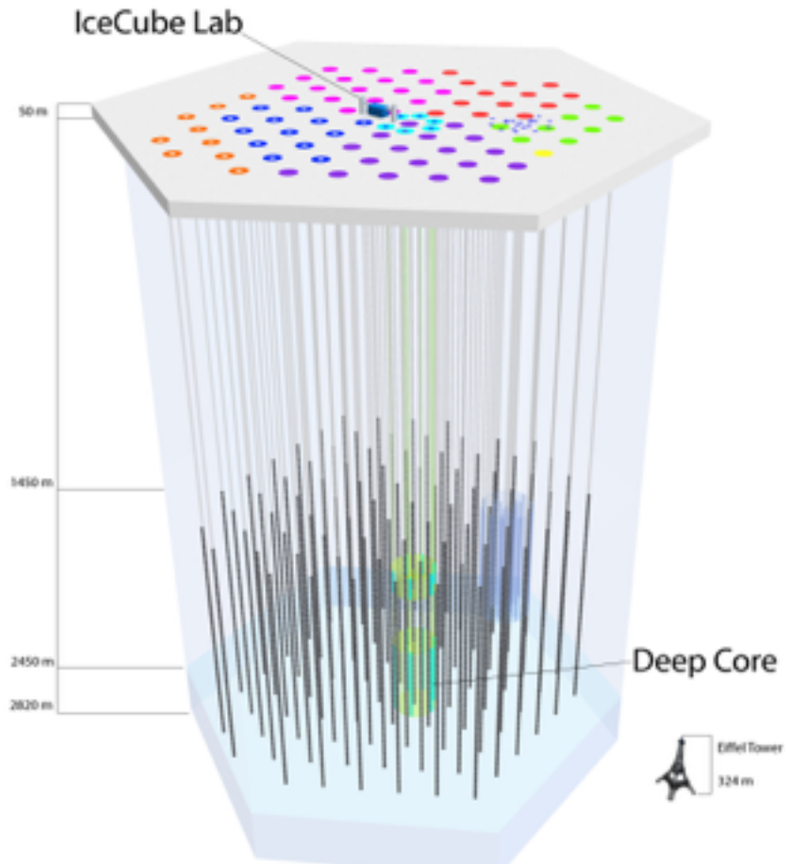
Observe a ToO following an alert from high-energy neutrino telescopes

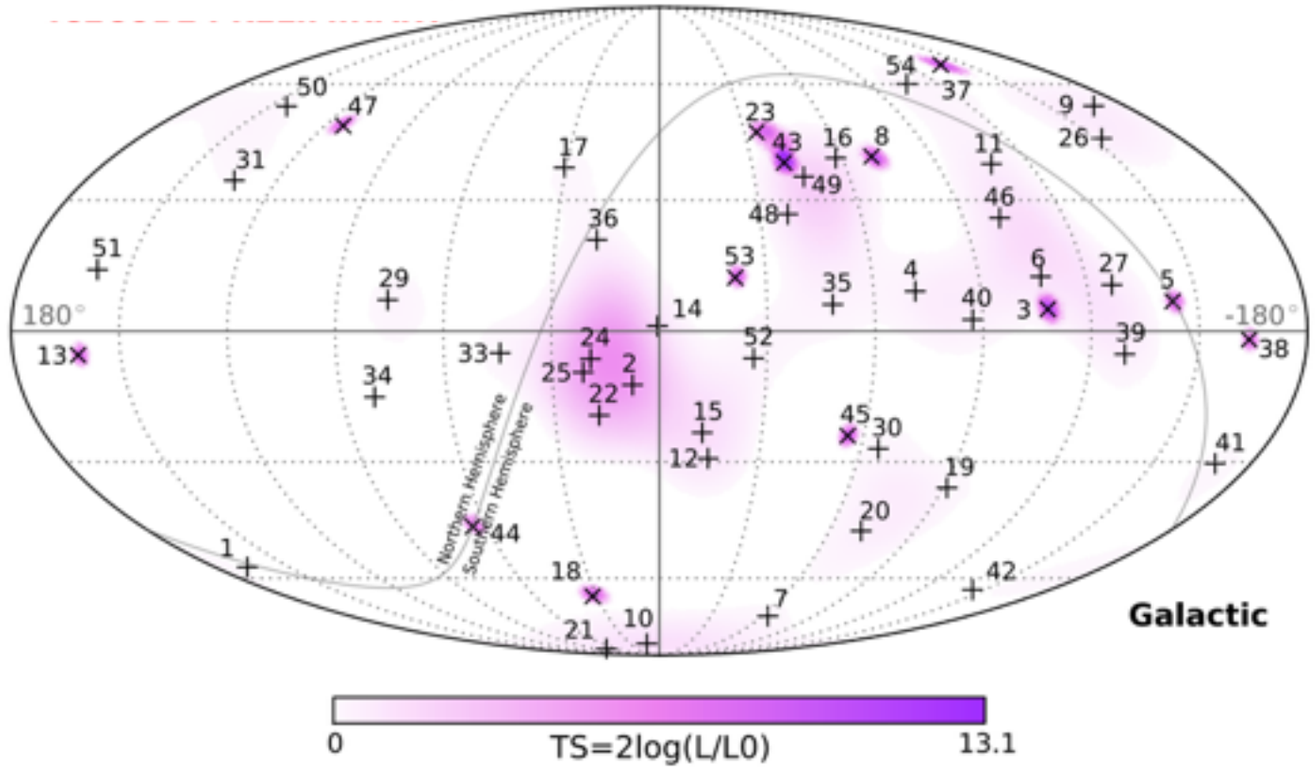
Fabian Schüssler (IRFU/CEA-Saclay) on behalf of the WG
2nd Top Level Use Case meeting, Bologna, 2016-06-22

Overview + Introduction

- Working group
  - Angelo Antonelli
  - Andrea Bulgarelli
  - Alessandro Carosi
  - Stefano Covino
  - Diego Götz
  - Antonio Stamerra
  - Fabian Schüssler
  - Paul O'Brien
  - Susanna Vergani
- Use Case template:
  - Link: Neutrino ToOs
- Modifications marked in red







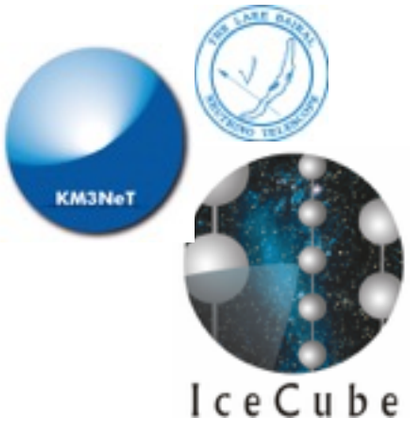
High-energy neutrinos: Introduction

"Transient KSP"

→ v5

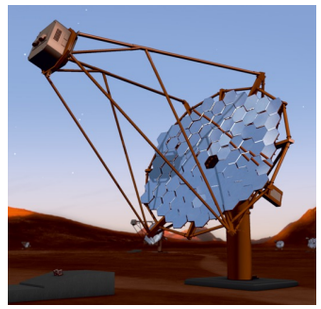
- alerts from IceCube (+ KM3NeT/GVD/…)
- state-of-the-art of neutrino alerts
  - pre-define a list of potential sources + search for neutrino rate increases
    - resolution: extragal. point-source
    - timescale: hours - weeks
  - neutrino doublet/triplets within a few degrees
    - resolution: a few degrees
    - timescale: minutes - hours
  - single, high-energy contained events (HESE)
    - resolution: 0.3 - 15deg
    - timescale: seconds - minutes
- searching for transient gamma-ray source within the neutrino error region
  - causally connected emission process => hadronic acceleration
  - currently no a-priori on source scenario (low vs high energy, short vs long, etc.)

High-energy neutrinos: Observation Strategy I



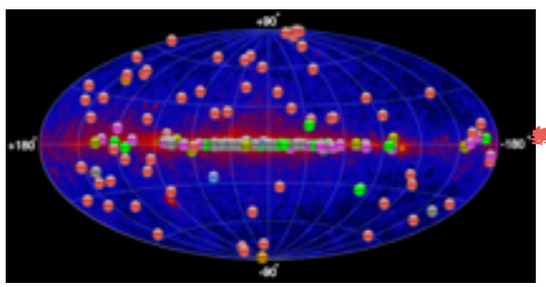
cta cherenkov telescope array

Neutrino-Scheduler pointings, priorities, etc.



Observation Mode #1

- input to RTA: catalog of known sources
- improved search for variability



- **FULL ARRAY** for 2h: **Observation mode #1**
- ToDO: divergent mode if large error region?
- Real-Time Analysis
  - searching for new sources
  - variability of known sources

End of Neutrino follow-up

cta cherenkov telescope array

High-energy neutrinos: Observation Strategy II

Observation Mode #1

Real-time analysis
- source detection
- variability from know source

- at least 2h of additional follow-up with the full array (confirm source detection and/or variability)
  - start follow-up right away (**#2**)
- RTA searching for variability of source(s)

End of Neutrino follow-up

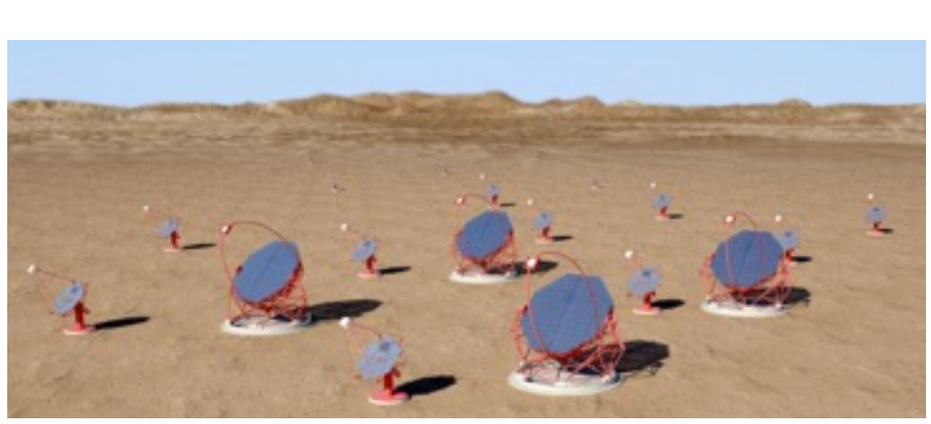
Outgoing alerts depending on privacy of incoming alerts

High-energy neutrinos: Observation Strategy III

Outside Neutrino follow-up

Level B analysis
- source detection
- variability of known source

- Discussion within the CTA-Neutrino team
  - might trigger follow-up with full array for 2h
    - Observation modes **#3**
- RTA searching for variability of source(s)



End of Neutrino follow-up

Observation parameters (GW + neutrinos)

- General assumptions: discovery observations, follow-up as many triggers as possible => as little constrains as possible
- N + S arrays
- parallel pointing
- coordinates: nominal pointing for most neutrino alerts (tiling for large uncertainties)
- minimum telescopes: 2 MSTs or 1 LST
- marginal sky quality + 1/2 moon light
- zenith < 70deg
- no precision pointing
- ToO time delays
  - hours - days for neutrinos (depending on alert properties)
- prioritization to be done (false alarm rate, time delay, error box, etc.)

Data products

- RTA/Level A analysis: for all gamma-ray sources within the ROI
  - position
  - light-curve with RTA integration time binnings
  - flux estimate
  - correlation with known sources/objects
- Level B/C analysis: for all gamma-ray sources within the ROI
  - position
  - light-curve (finer binning than Level A)
  - energy spectrum
  - correlation with known sources/objects
- Level B/C: flux upper limits might be requested for particular regions/sources (e.g. for known sources within the neutrino ROI)