



Analyse multi-messagers photon/neutrino avec le télescope ANTARES

Aurore MATHIEU

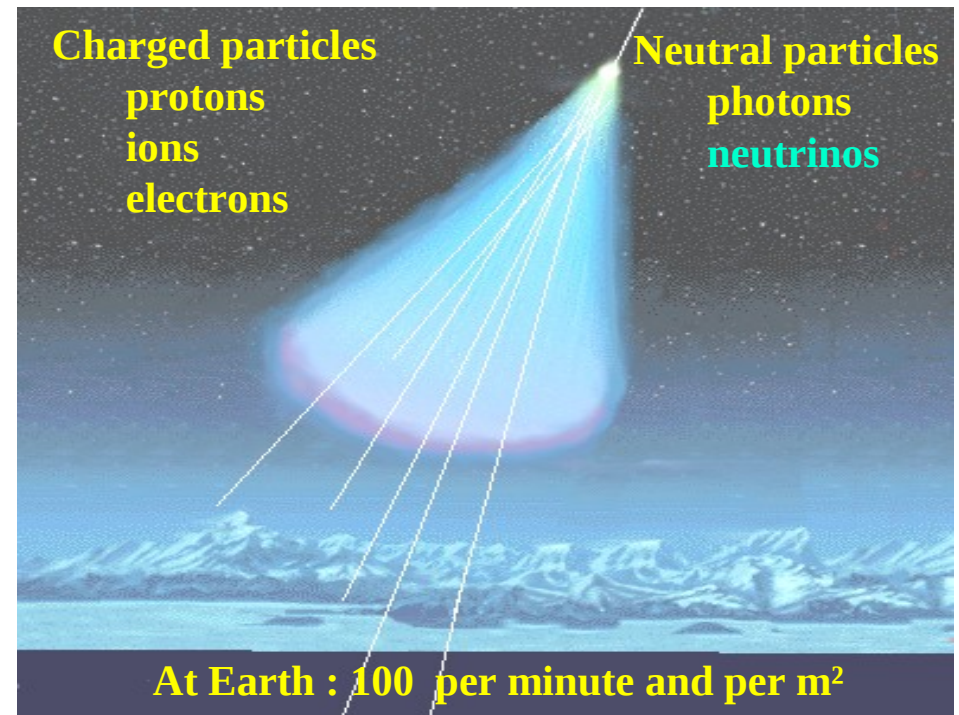
Visite L3
24 avril 2015

Cosmic rays



Cosmic rays were discovered a century ago by Victor Hess and we still do not know their origin ...

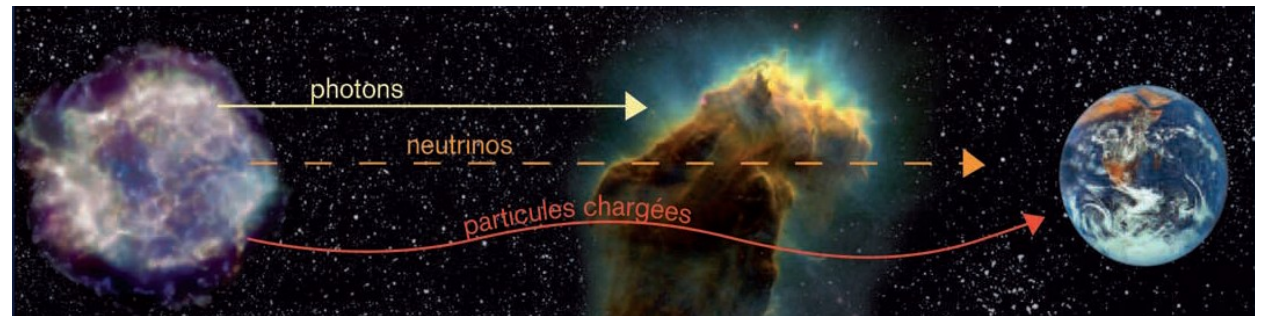
Cosmic rays interact with the upper atmosphere and produce large particle showers ...



Neutrino astronomy

Neutrinos are unique messengers to study the high energy Universe:

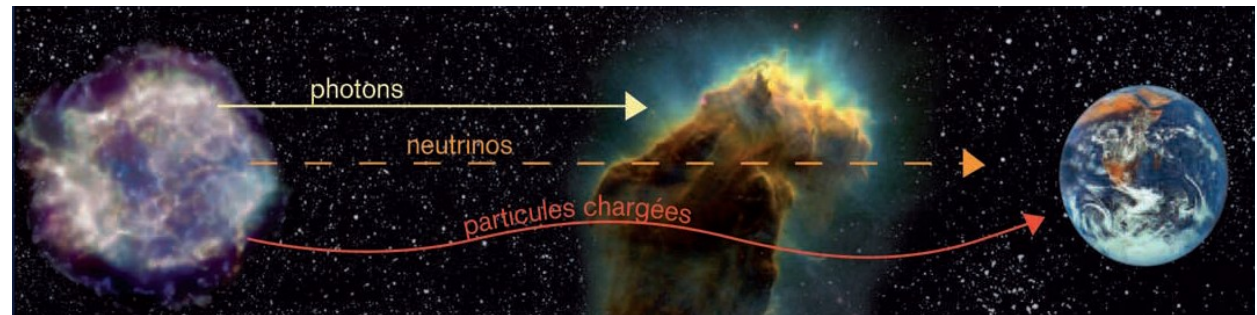
- Electrically neutral
- No absorption
- Weakly interacting



Neutrino astronomy

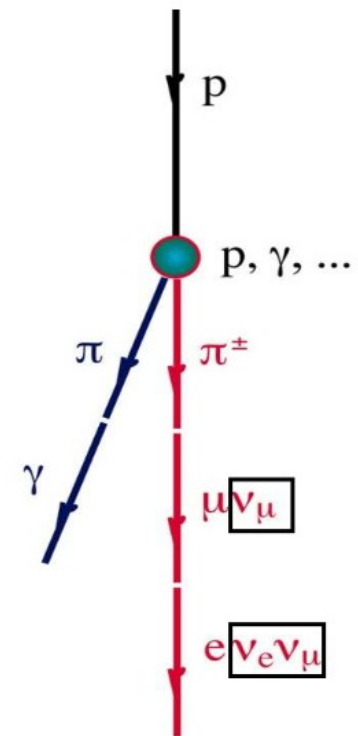
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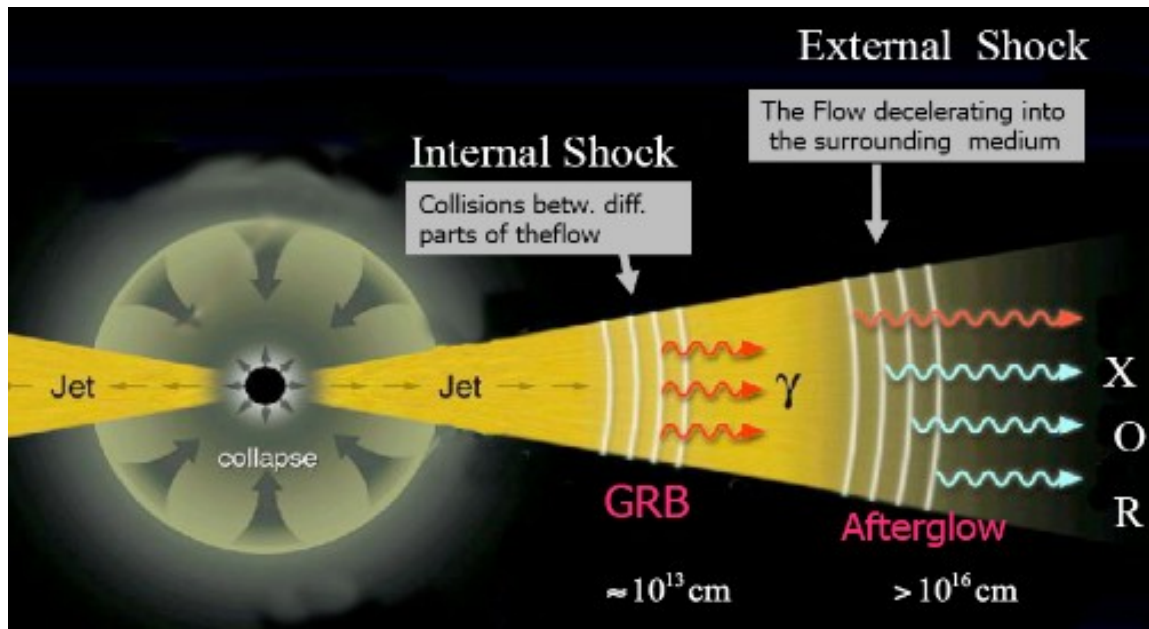
Cosmic neutrinos:

- Neutrinos possibly produced in interactions of high energy nucleons with matter or radiation
- If **hadronic mechanisms**:
 $\text{High energy nucleons} + \text{hadrons} \longrightarrow \text{mesons} + \text{hadrons}$
 $\longrightarrow \text{neutrinos and photons}$
- Simultaneous emitters of neutrinos and gamma-rays
- Detection from a cosmic source would be a direct evidence of hadronic scenario



Example of sources

- High energy neutrinos from gamma-ray bursts and core-collapse supernovae

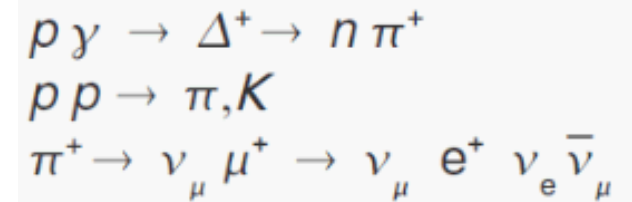


GRB neutrinos:

relativistic jets (Fireball model)

⇒ 10 TeV–10 PeV neutrino

Meszáros & Rees, Waxman

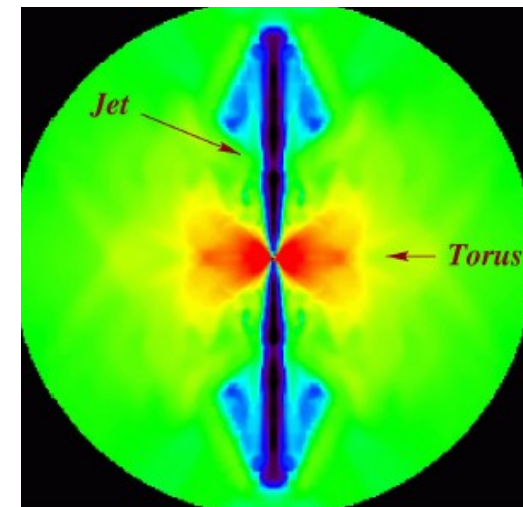


SN neutrinos:

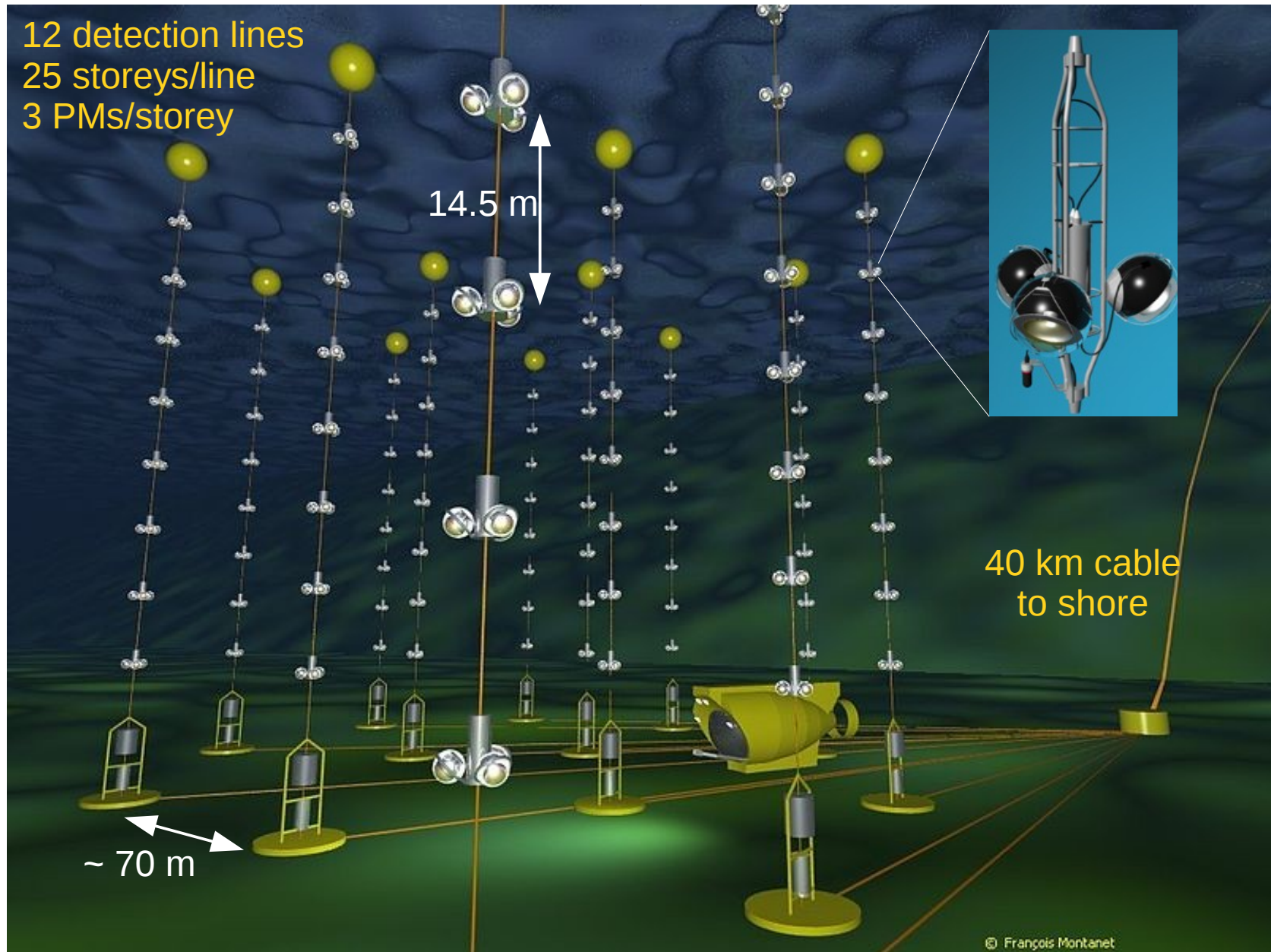
connection GRB-SN (choked jet, mildly relativistic)

⇒ 100 GeV–10 TeV neutrino

Razzaque & al., Ando & Beacom



The ANTARES telescope



The ANTARES telescope

12 detection lines
25 storeys/line
3 PMs/storey

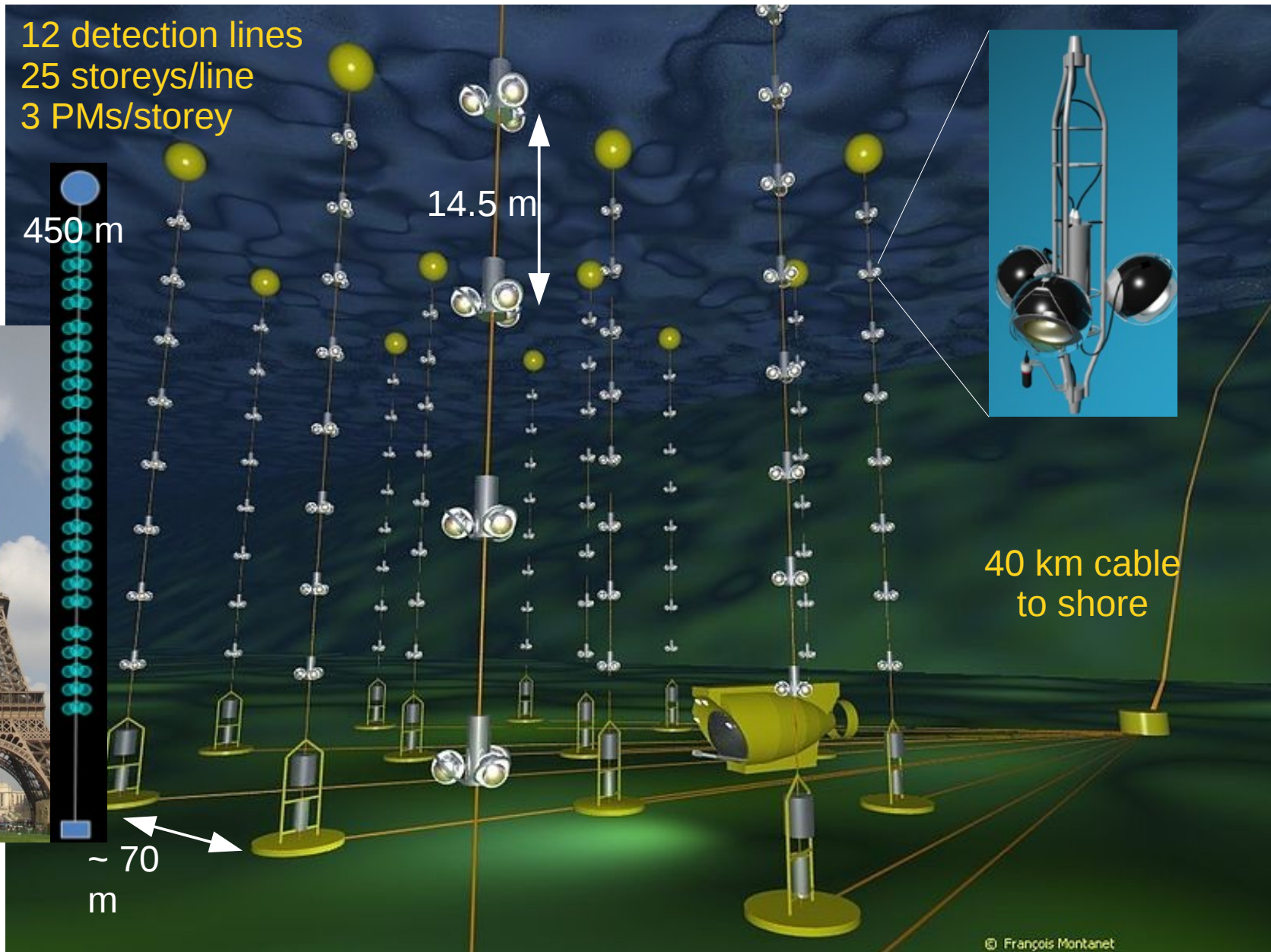
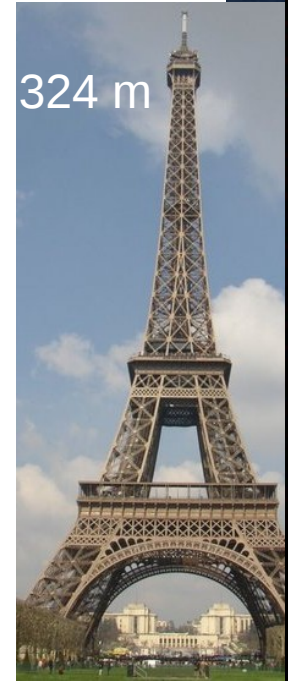
450 m

14.5 m

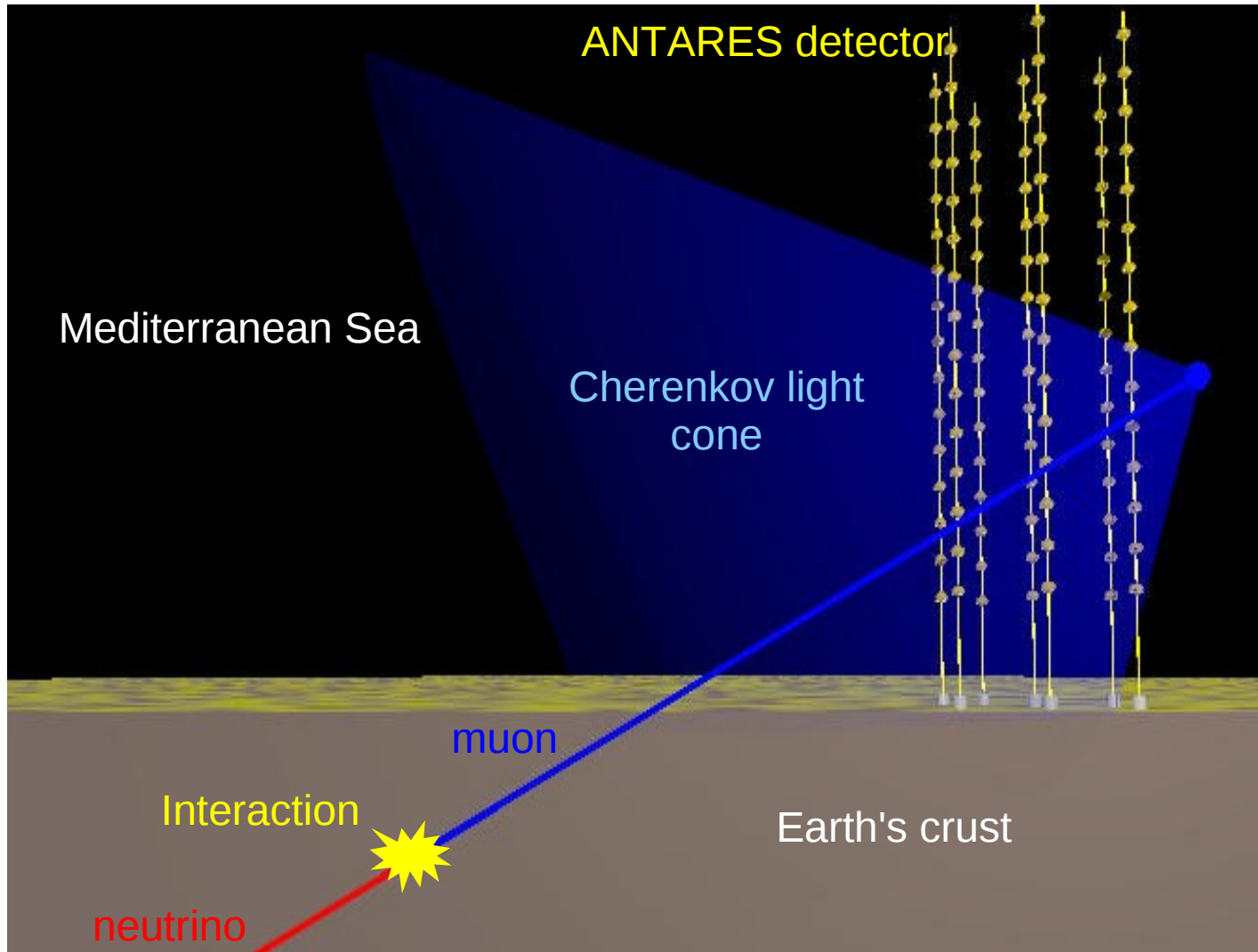
40 km cable
to shore

~ 70
m

© François Montanet



Detection principle

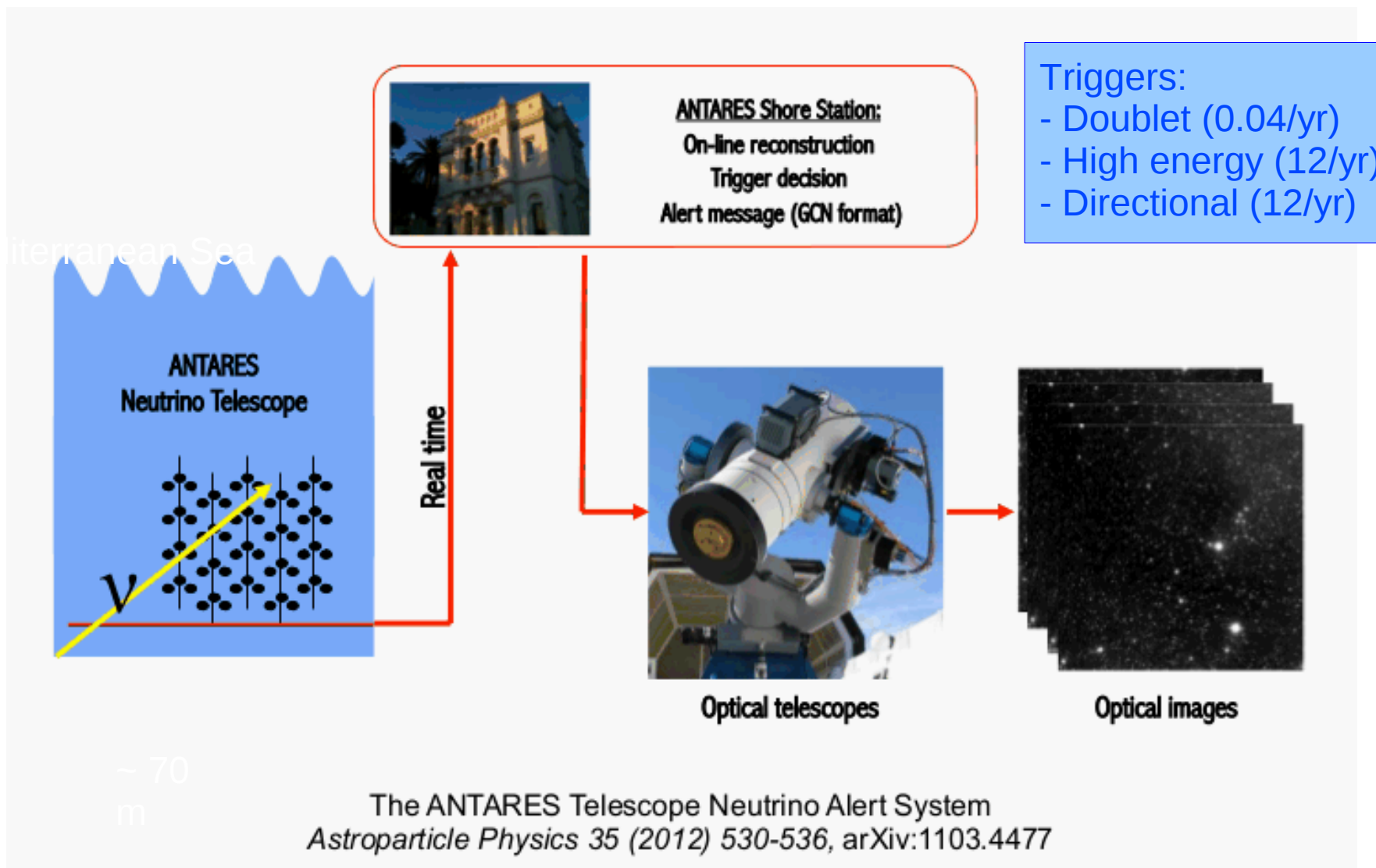


The ANTARES neutrino telescope detects Cherenkov light created by a muon coming from the interaction of a neutrino with the Earth

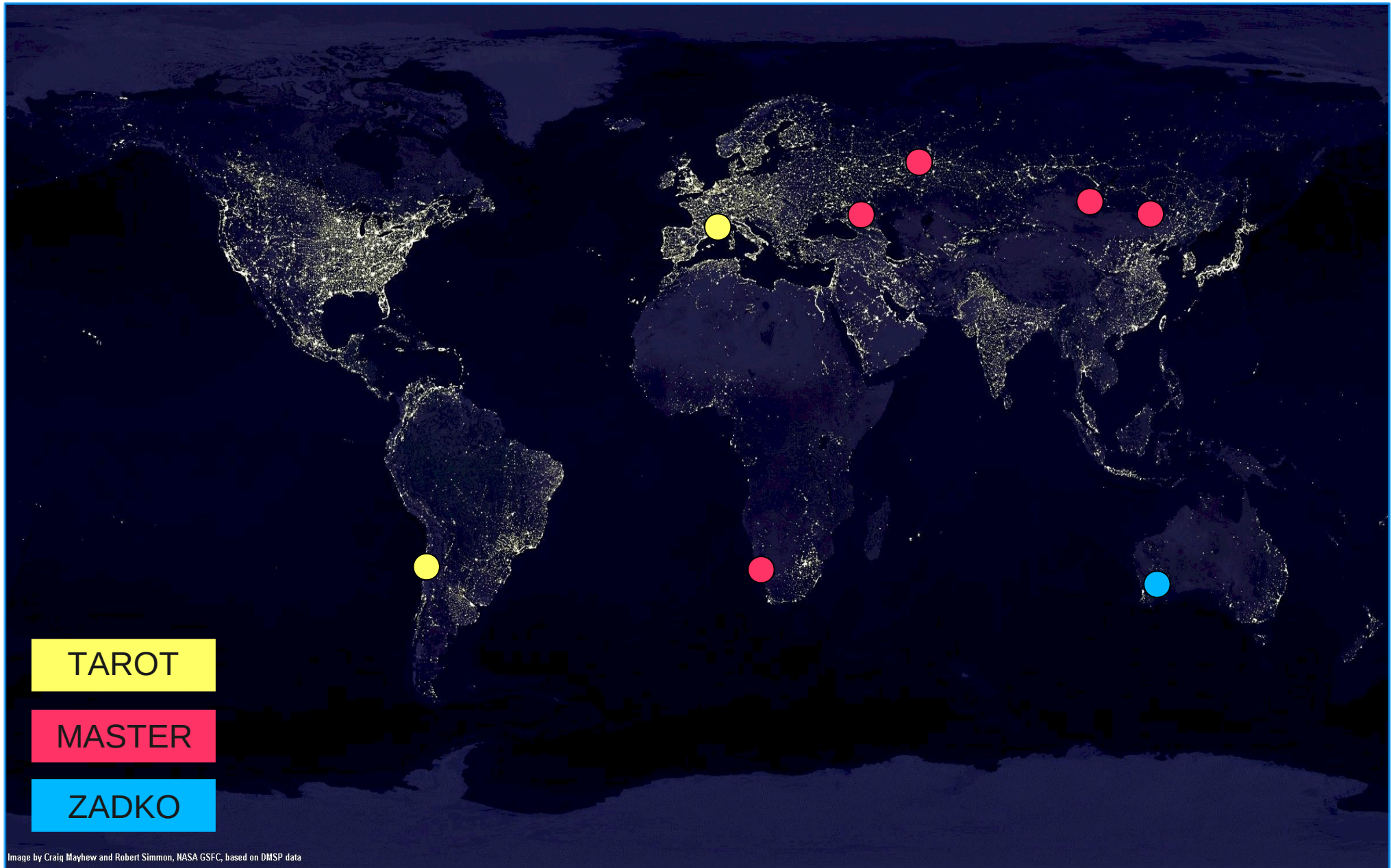
We are looking for upgoing events !

TAToO

- Optical follow-up: search for an optical counterpart
- Transient sources: GRBs, SNe



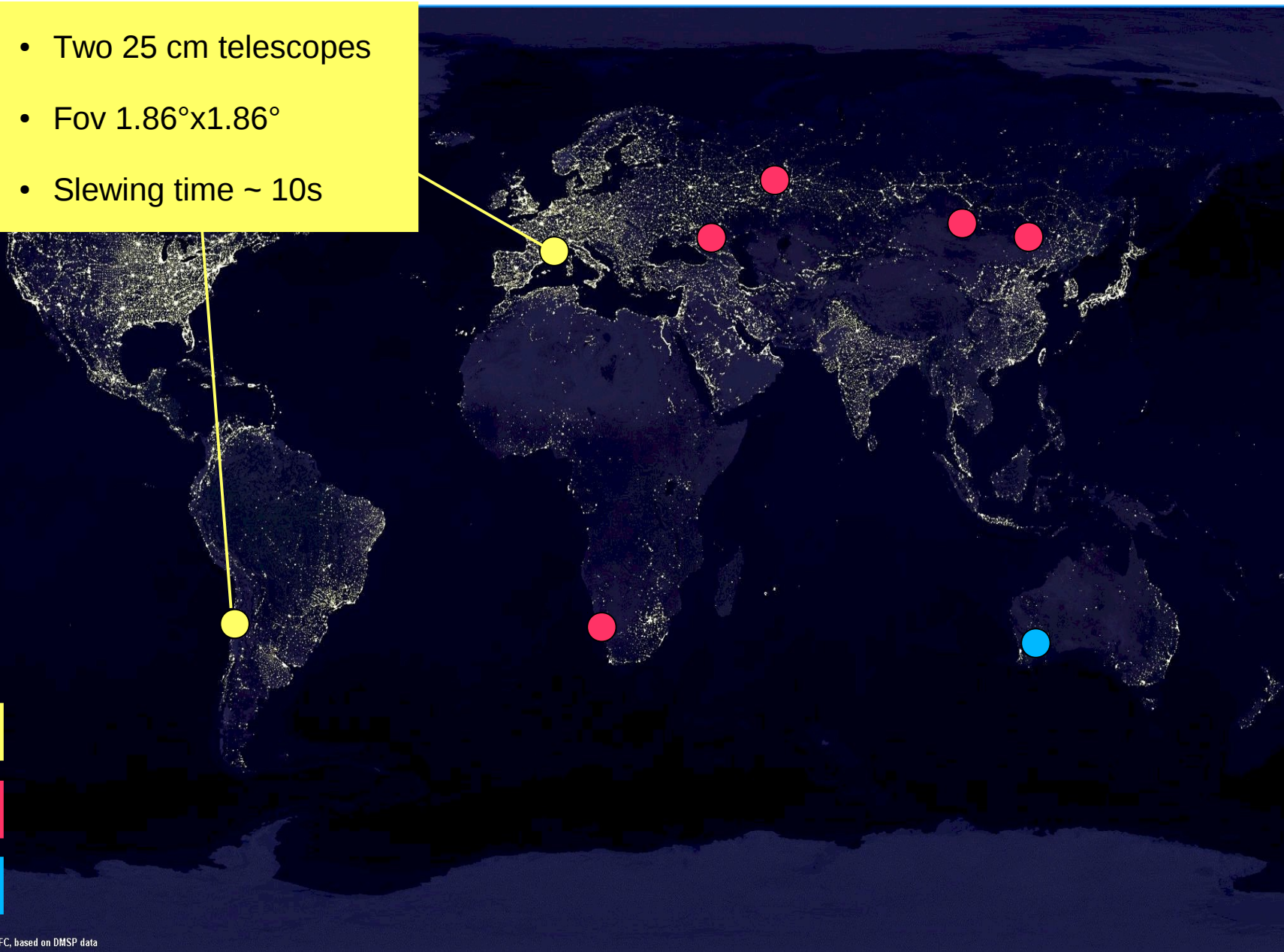
Follow-up with telescopes



Follow-up with telescopes

TAROT Calern

- Two 25 cm telescopes
- Fov $1.86^\circ \times 1.86^\circ$
- Slewing time $\sim 10s$



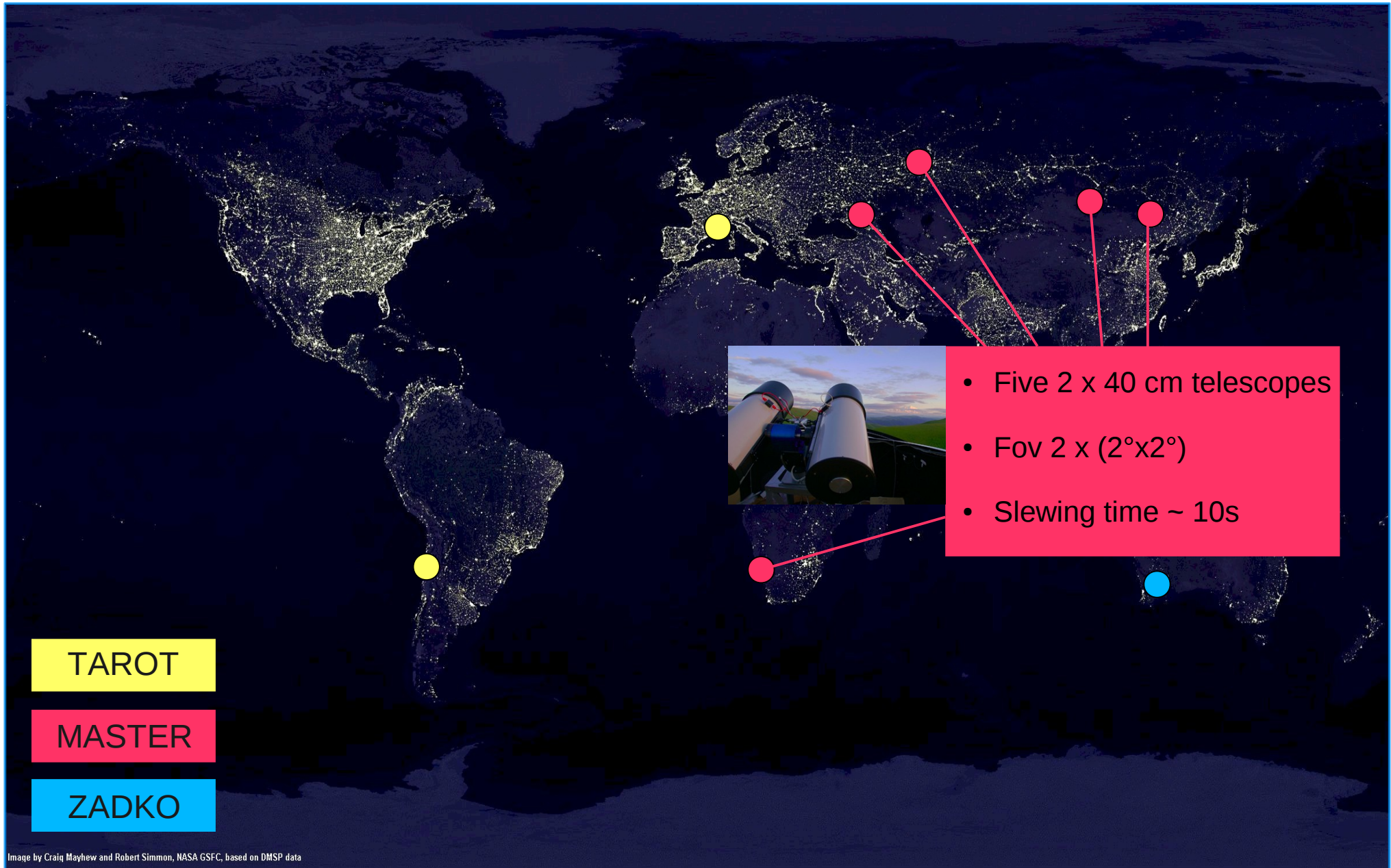
TAROT

MASTER

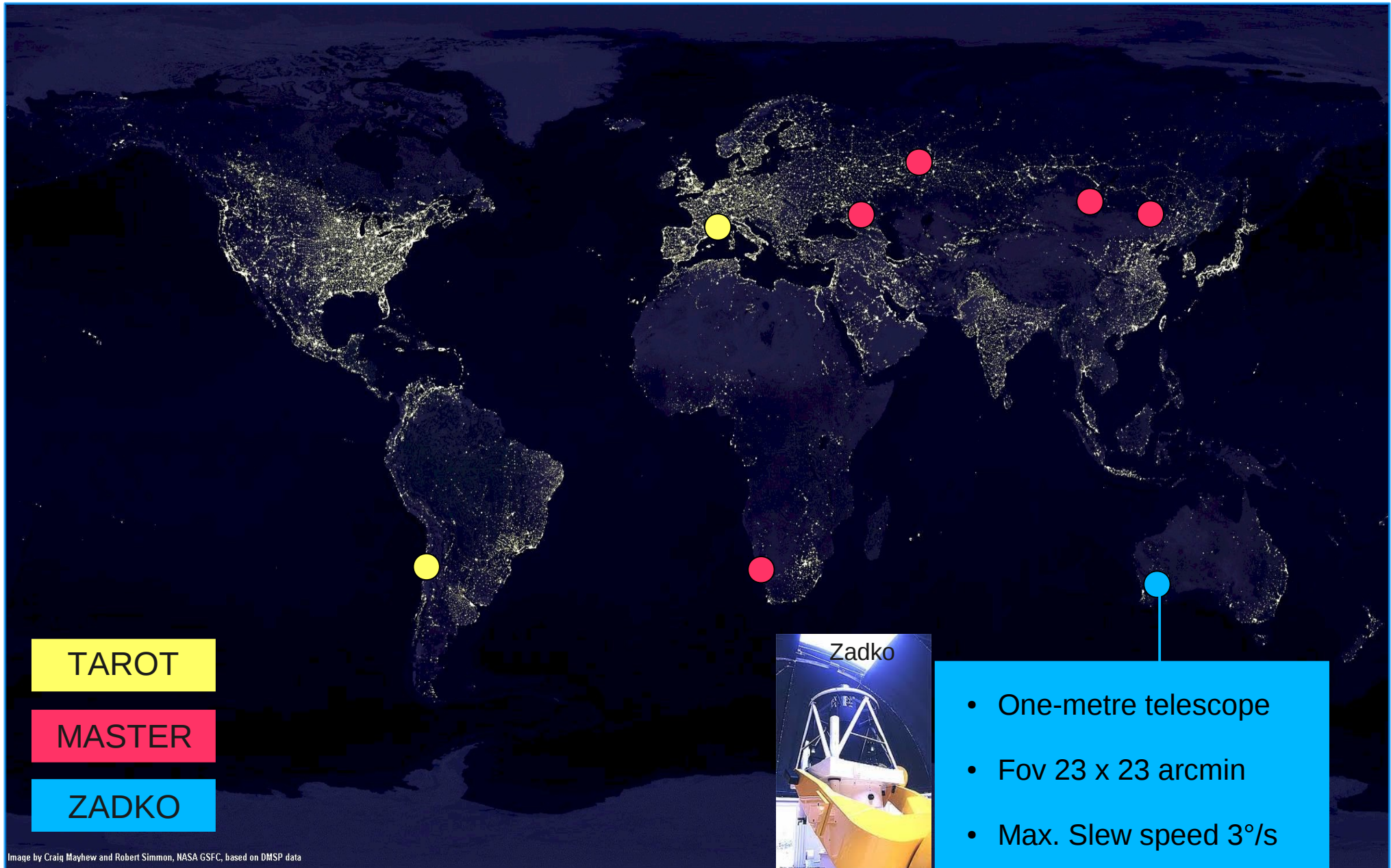
ZADKO

Image by Craig Mayhew and Robert Simmon, NASA GSFC, based on DMSP data

Follow-up with telescopes

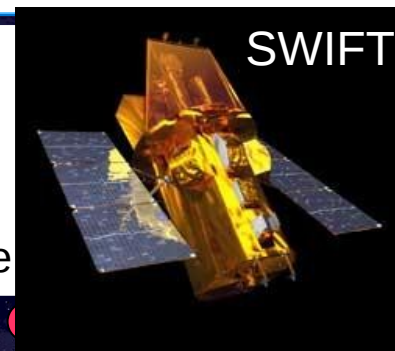


Follow-up with telescopes



Follow-up with telescopes

- X-ray follow-up
- Fov 23.6 x 23.6 arcmin
- 0.3-10 keV energy range



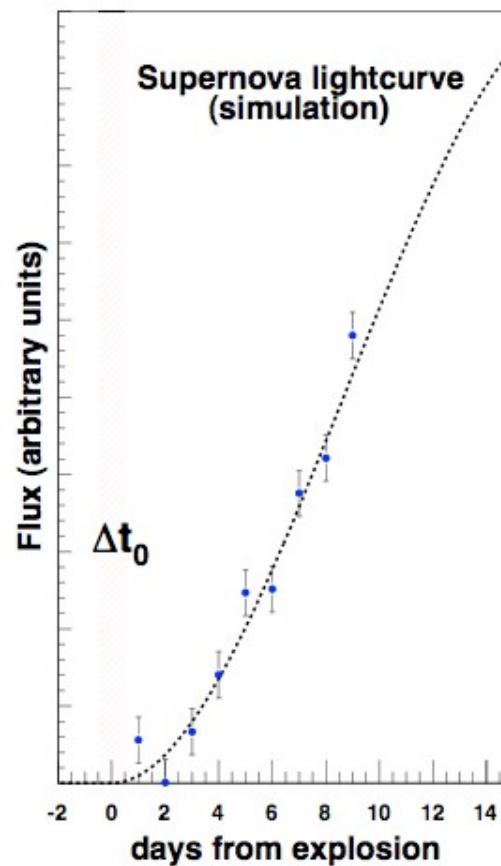
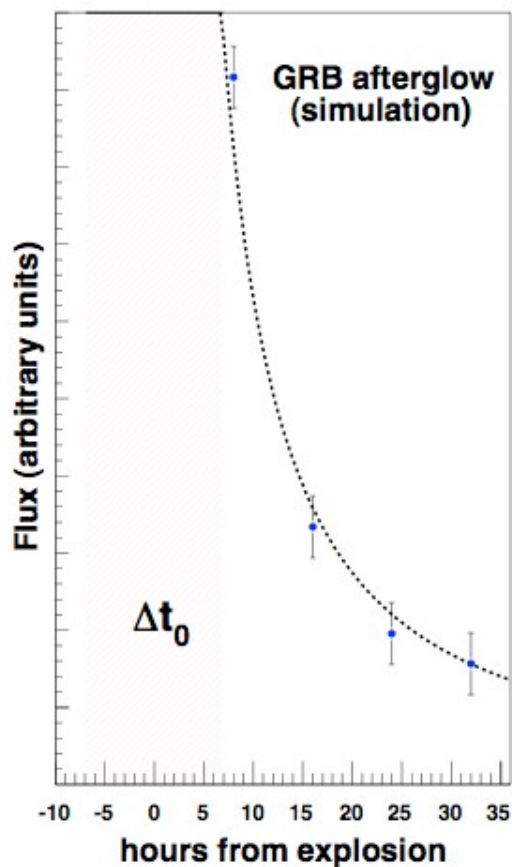
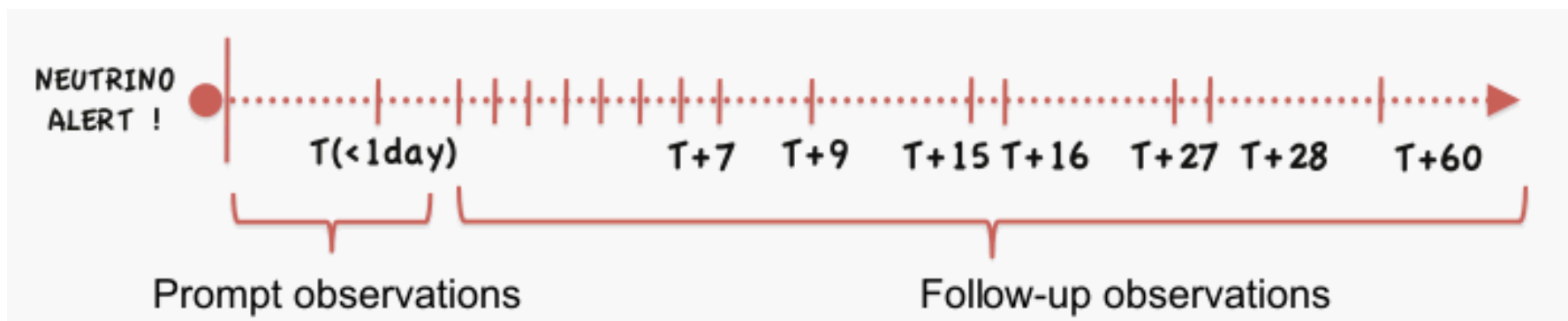
TAROT

MASTER

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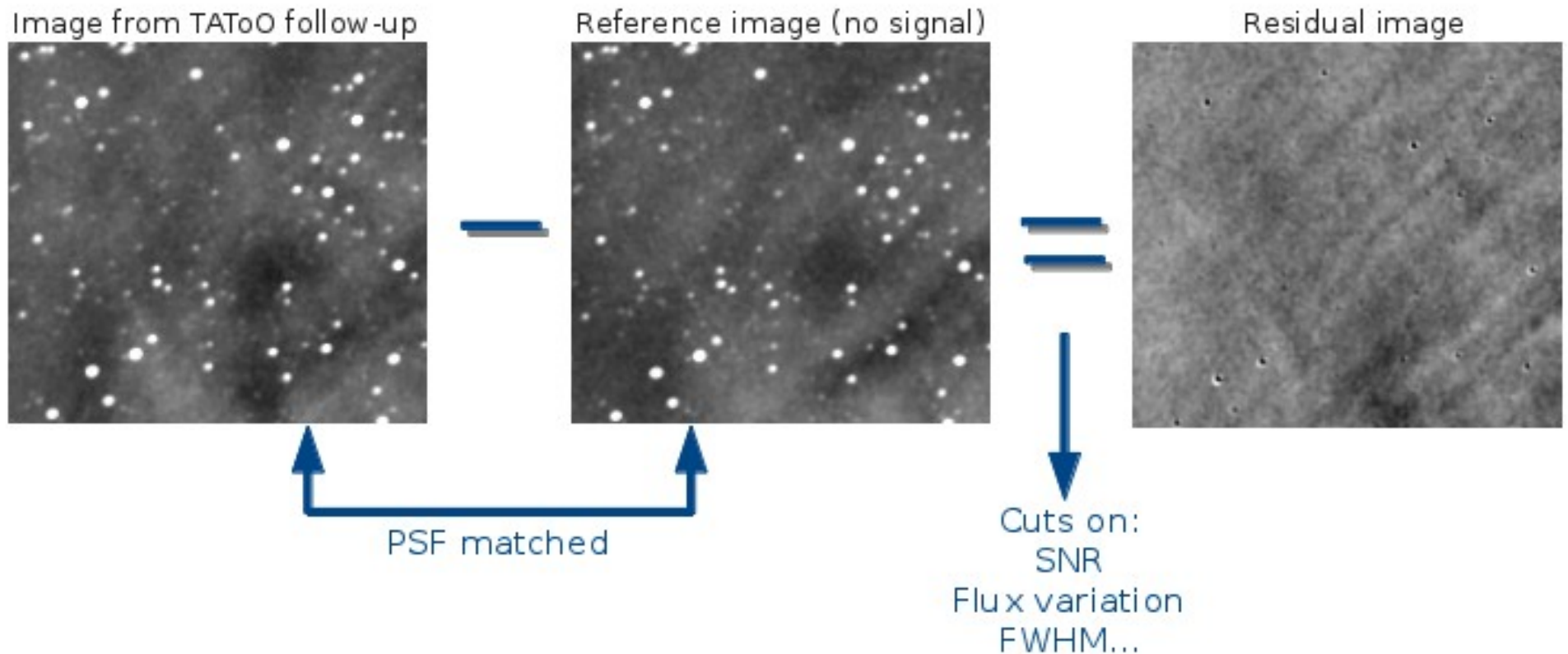
Image by Craig Mayhew and Robert Simmon, NASA GSFC, based on DMSP data

Optical follow-up strategy



Optical counterpart search

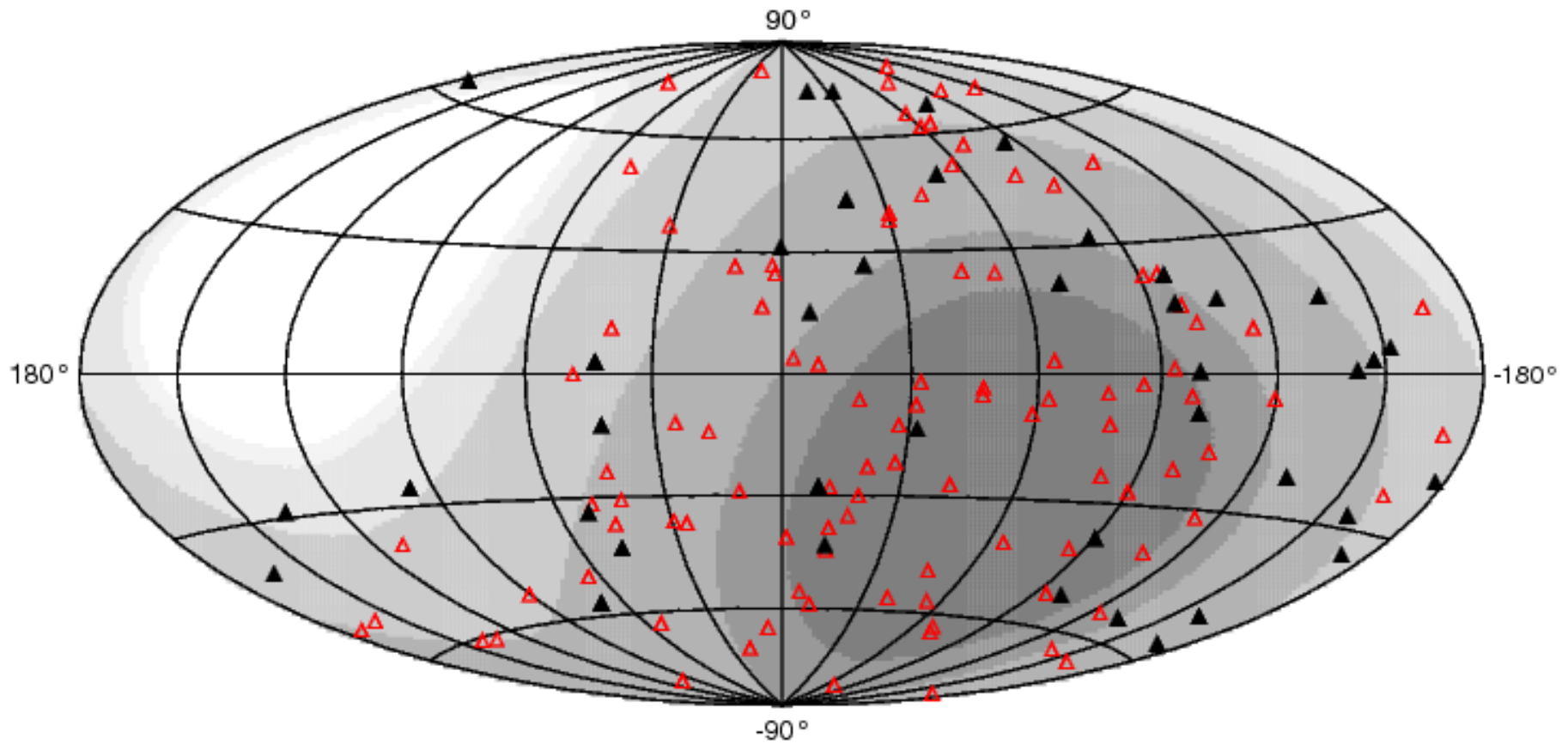
- Analysis based on the image subtraction:



- Development of a new pipeline for image analysis

Alerts

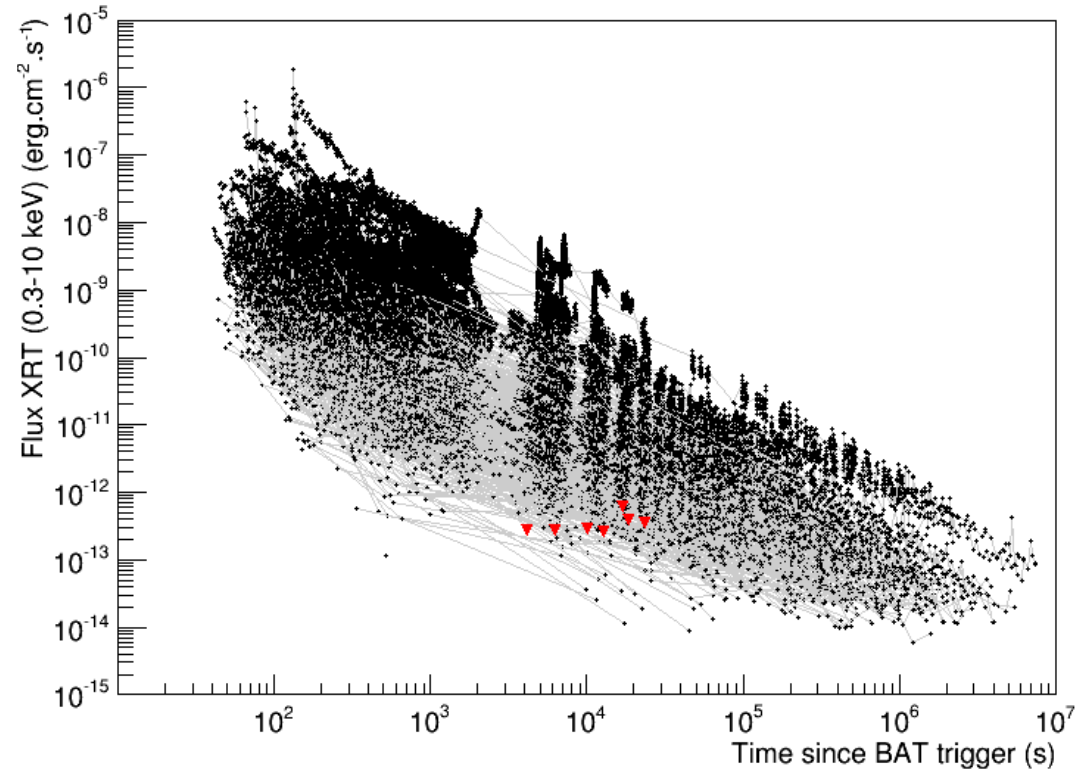
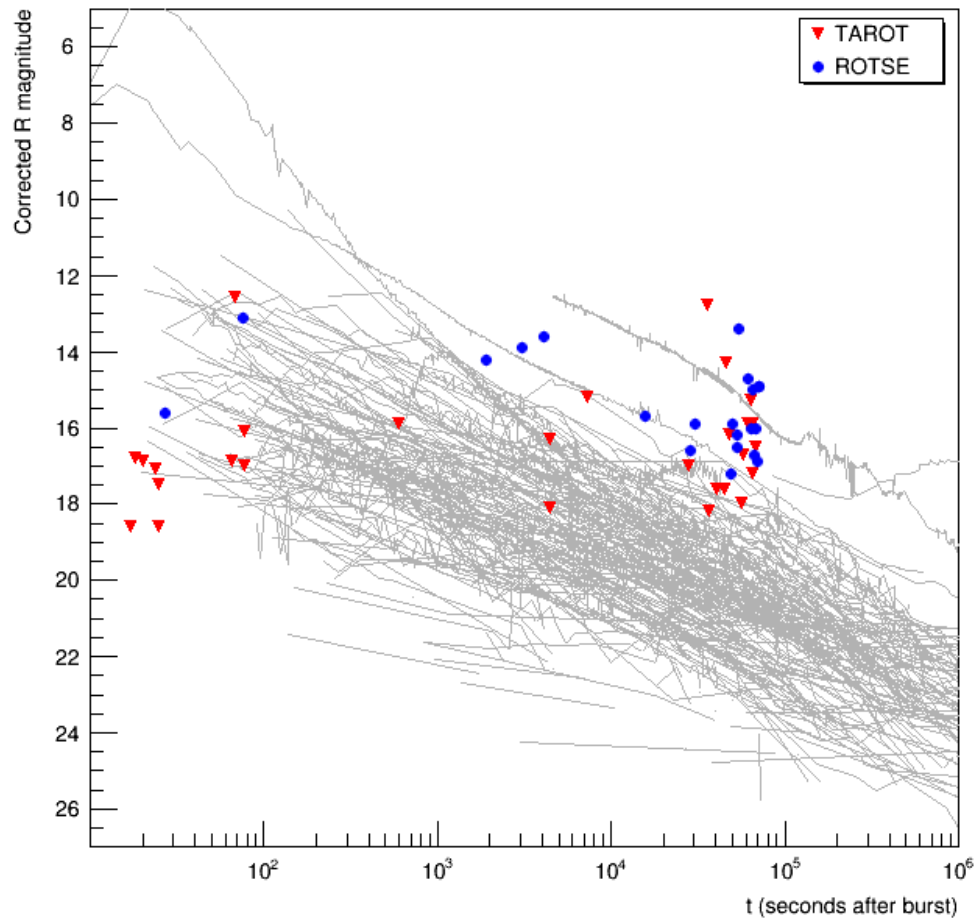
- Since 2009, ~150 alerts:



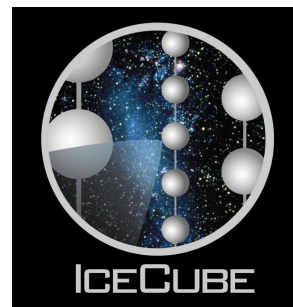
Prompt analysis

42 alerts with optical images & 7 alerts with X-ray data

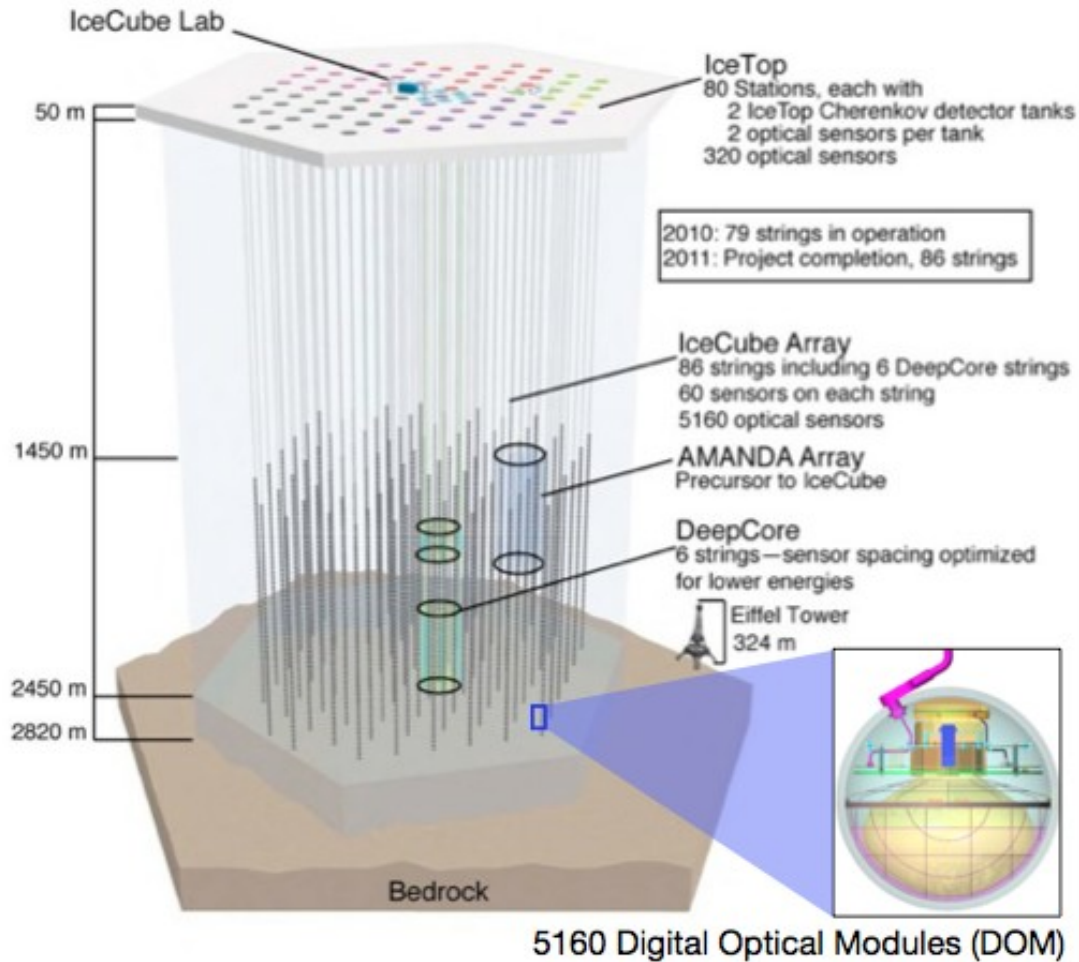
- ➔ No transient optical counterpart associated with a neutrino detection
- ➔ Upper limits on transient sources magnitude



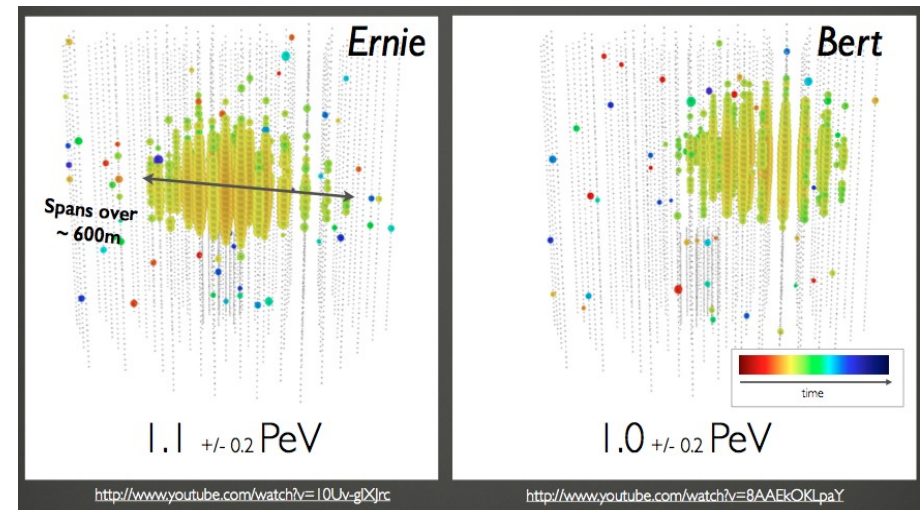
Neutrino telescopes in the world



IceCube



28 events:
2 with energy > 1 PeV



KM3NeT

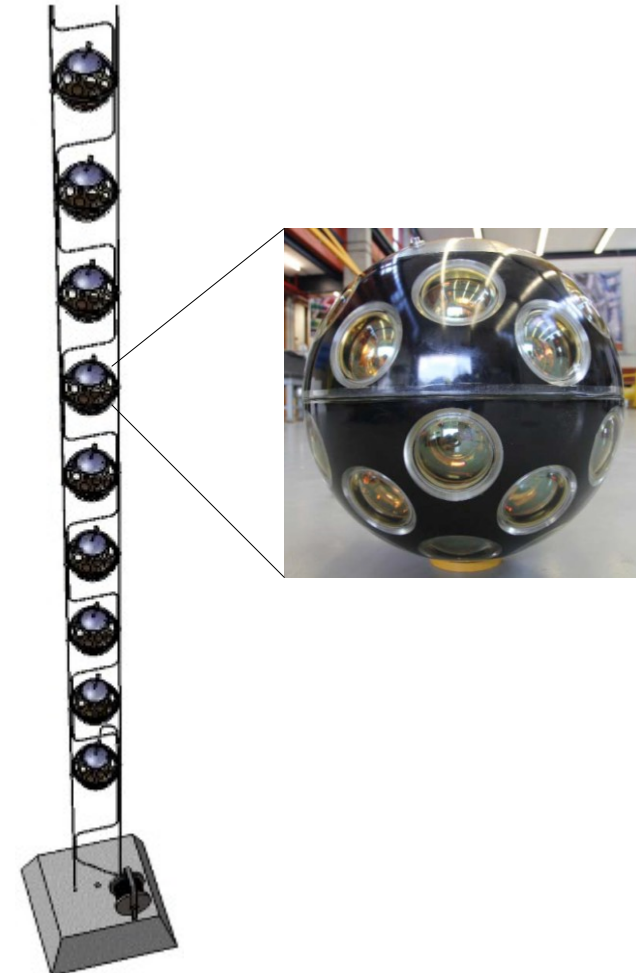
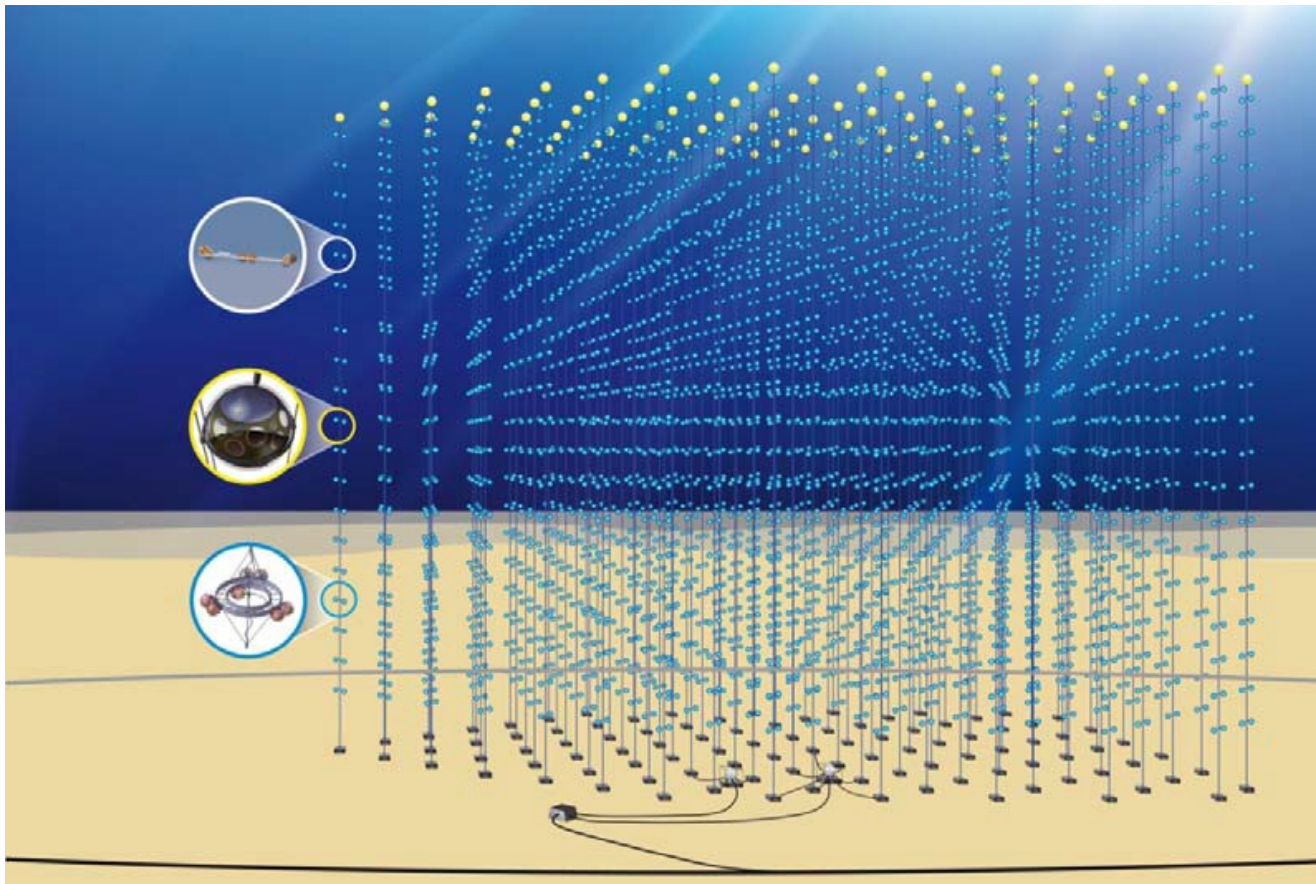
3 sites:

- KM3NeT-Fr
- KM3NeT-It
- KM3NeT-Gr

6 building blocks:

- ~ one hundred detection units
- 18 digital optical modules for each DU

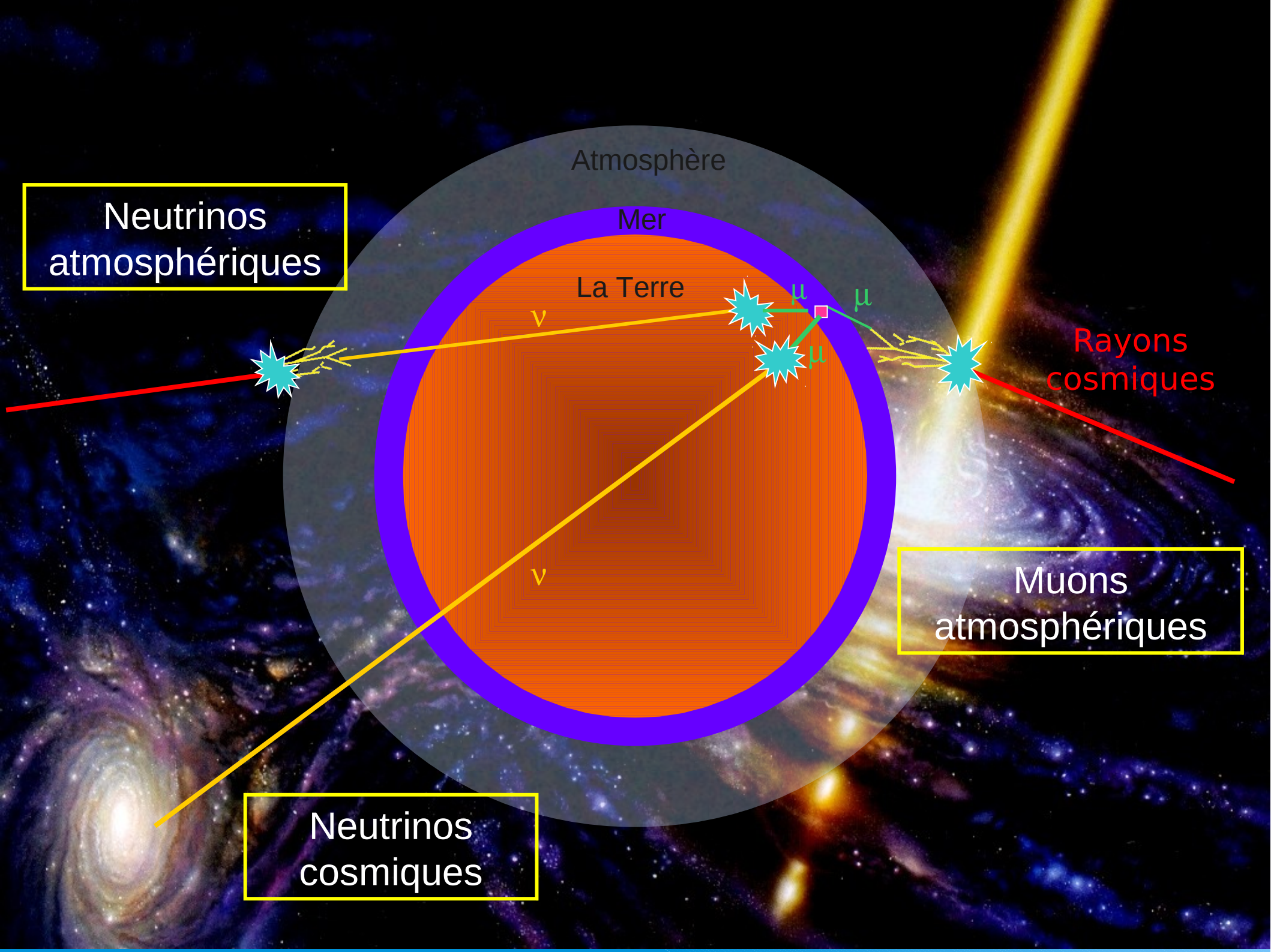
Sensitivity : x 50



Parcours

- **Licence** “physique et sciences pour l'ingénieur”, parcours physique, Université de Strasbourg
 - Stage L2 : “Étude des distributions de rayons cosmiques détectés par le télescope ANTARES”, IPHC. (T. Pradier)
- **Master** recherche “Physique”, parcours astrophysique & physique des corpuscules, Université Bordeaux 1
 - Stage M1 : “Étude des distances des pulsars”, CENBG, équipe astroparticules. (D. Smith & D. Dumora)
 - Stage M2 : “Analyse d'observations Herschel de proto-étoiles massives”, LAB. (J. Braine)
- **Doctorat** en astroparticules (3ème année) :
“Analyse multi-messagers photon/neutrino avec le télescope ANTARES”

Back up



Neutrinos atmosphériques

Neutrinos cosmiques

Muons atmosphériques

Atmosphère

Mer

La Terre

Rayons cosmiques

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