

APPEC EUROPEAN ASTROPARTICLE PHYSICS STRATEGY 2017-2026

<http://www.appec.org/roadmap>

i. The Extreme Universe: a Multi-Messenger Approach

- High-energy cosmic rays
- High-energy gamma rays
- High-energy neutrinos
- Gravitational waves

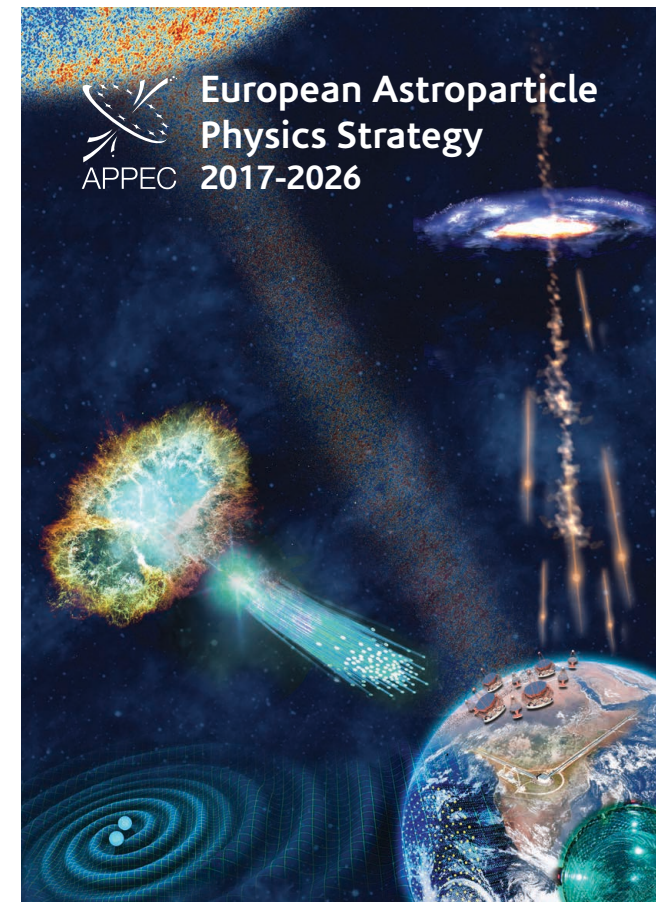
ii. Mysterious neutrinos → accelerator oriented

- Neutrino mass and neutrino nature
- Neutrino mixing, mass hierarchy and more

iii. The Early Universe → only CMB

iv. The Dark Universe

- Dark Matter
- Dark Energy



Overview of **General Relativity** projects

- **Laboratory experiments** (CERN) measuring **gravitational effect on antihydrogen** atoms using different techniques
 - **ALPA-g**: release H-bar from a vertical magnetic atom trap and record their positions when they annihilate on the walls of the experiment
 - **AEgIS** (Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy): vertical deviation of a pulsed horizontal beam of cold H-bar
 - **GBAR** (Gravitational Behaviour of Antihydrogen at Rest): free fall of ultra-slow H-bar
- **Gravitational-wave astronomy** based on interferometer
 - **AdV+** (Advanced-Virgo+, Italy, Pisa): **high-frequency** (50 – 500 Hz) upgraded advanced-Virgo (two arms of 3 km)
 - **ET** (Einstein Telescope, European Gravitational Observatory, location ?): **high-frequency** (10 – 2000 Hz) underground-interferometer with three arms of 10 km
 - **LISA** (Laser Interferometer Space Antenna, ESA, L1 position): **low-frequency** (2×10^{-5} – 0.1 Hz) space-interferometer with three arms of 2.5×10^6 km

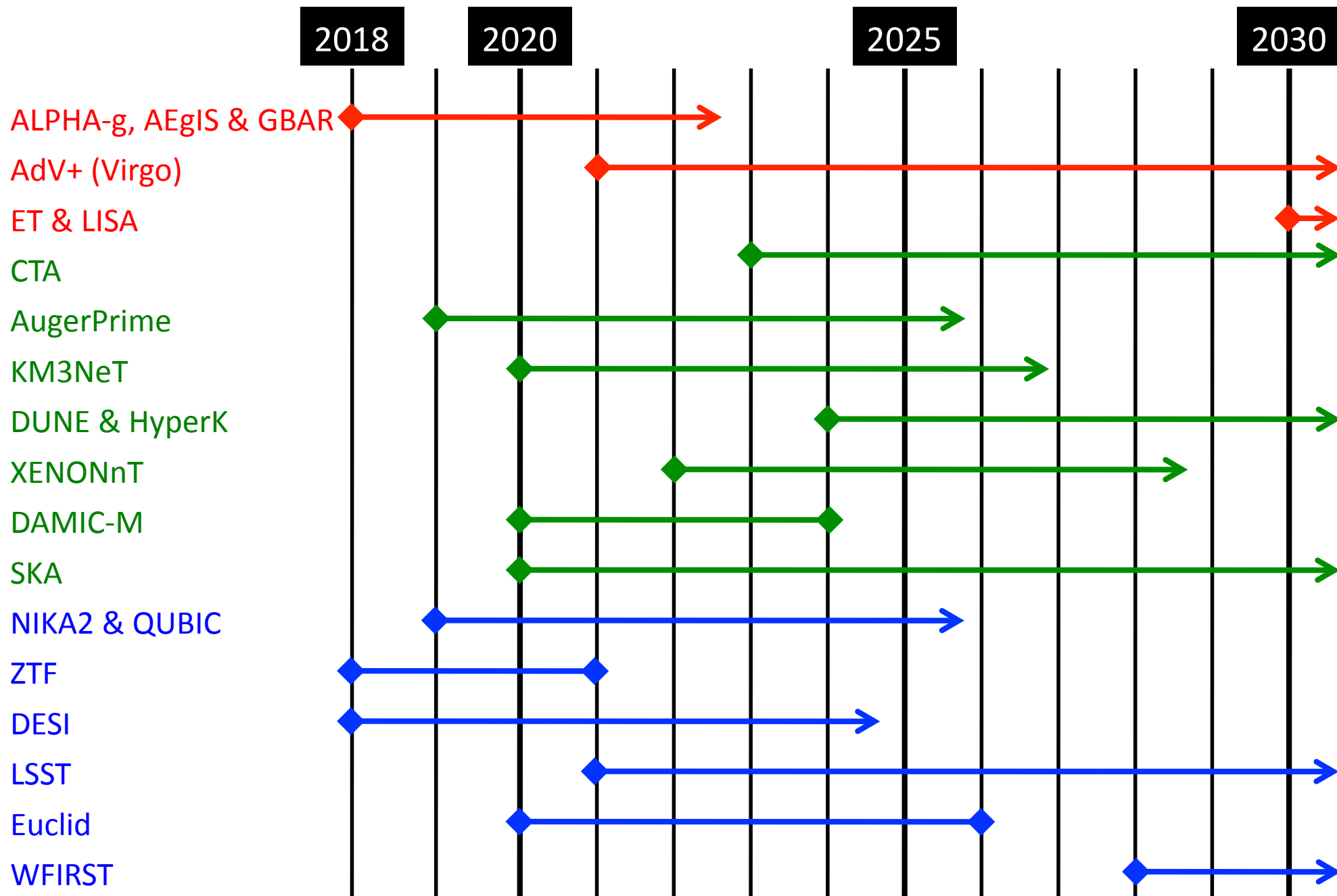
Overview of **Astroparticles** projects

- **CTA** (Cherenkov Telescope Array, Chile and Spain): **high-energy γ -ray** (20 GeV – 300 TeV) to probe WIMPS from annihilation processes at TeV masses
- **AugerPrime** (Argentina): upgrade of Auger with additional detector to measure air shower content (e & μ) to determine the nature of primary **ultra-high-energy cosmic ray** (proton or nuclei)
- **KM3NeT** (Mediterranean Sea): **ν -telescope** with two instruments
 - ARCA (Greece) for high-energy (PeV scale) astrophysics neutrino
 - ORCA (Toulon) for low-energy (GeV scale) to determine mass hierarchy
- **DUNE** (US, FermiLab) & **HyperK** (Japan): ν long-baseline accelerator experiment with giant detector useful for **astrophysics ν 's** with complementary technologies (40 k-ton liq-Ar for DUNE and 1 M-ton water for HyperK)
- **XENONnT** (8 ton of Xe, Gran Sasso, Italy), **EURECA** (European Underground Rare Event Calorimeter Array, 1 ton cryogenic EDELWEISS-like, Modane) and **DAMIC-M** (Dark Matter in CCDs with 1 kg, SNOLAB, Canada): search for **dark matter (WIMPS) detection** via scattering by nuclei giving light-flashes, ionization and/or heat signal
- **SKA** (Square Kilometre Array, South-Africa & Australia): radio telescope (0.1 – 25 GHz) of thousands of antenna covering the size of a continent

Overview of **Cosmology** projects

- **QUBIC** (Q&U Bolometric Interferometer for Cosmology, Argentina) and **NIKA2** (New Iram Kid Array-2, Spain): measurement of **B-mode in CMB** with high-angular resolution ground-based telescopes (150 – 260 GHz) giving access to **gravitational waves produced during inflation period**; but require subtraction of B-mode due to E-mode lensing by wide-frequency range space telescopes (or balloon flights)
- **ZTF** (Zwicky Transient Facility, US, Mont Palomar): Supernovae Ia (SNe Ia) low-redshift ($z < 0.05$) survey to measure local expansion rate, i.e. **Hubble constant**, prerequisite for cosmic scale studies
- **DESI** (Dark Energy Spectroscopic Instrument, US, Kitt Peak National Observatory): measurement of Baryon Acoustic Oscillations (BAO) to map the **expansion rate of the Universe** over large redshift range $0.5 < z < 3$
- **LSST** (Large Synoptic Survey Telescope, Chile) and **Euclid** (ESA): **multi-probe surveys** to map the Universe expansion (SN Ia and BAO) and structure growth rate (weak lensing and cluster counting and weighting) to constrain **dark energy** and measure dark matter over a large redshift interval $z < 3$
- **WFIRST** (Wide Field Infrared Survey Telescope, NASA): like Euclid, but with a mirror of 2.4 m (instead of 1.2 m) and more dedicated to infrared domain

Overall approximate timeline



RÉSUMÉ DES DISCUSSIONS DU 6 AVRIL 2018

Présents : Ziad, Eric, Philippe C., Julien, Valentin et Philippe R.

1. Valentin a présenté le projet GRAND (Giant Radio Array for Neutrino Detection)
 - Environ 50 physiciens dont une petite dizaine de permanents français (3 LPNHE, 1 LPC, 1 Subatech et 3 IAP), mais pas d'engagement officiel de l'IN2P3
 - Physics case: radio-astronomie (50 – 200 MHz) et étude des rayons cosmiques (signal radio), en particulier les neutrinos de ultra haute énergie (UHE $\sim 10^{18}$ eV) avec interaction de ν_τ dans la roche environnante (trajectoire quasi horizontale) $\nu_\tau \rightarrow \tau \rightarrow$ gerbe atmosphérique avec une résolution angulaire sur le $\nu_\tau \sim 0.1^\circ$
 - Planning envisagé
 - 2018 (en cours): GRANDProto35 = upgrade de TREND (160 k€, Chine)
 - 2020: GRANDProto300 = 300 antennes Horizon (design final) sur 300 km² (topologie finale de 1 antenne par km²) mais avec une DAQ intermédiaire
 - 2025: GRAND10k = 1^{er} élément du détecteur final avec 10,000 antennes
 - 203X: GRAND200k = détecteur final avec un taux de cosmiques de UHE 20 fois mieux que Auger
 - White-paper en rédaction (attendu pour l'automne)
2. Tour d'horizon rapide d'une sélection de projets phares dans le domaine dans lesquels l'IN2P3 est impliqué ou intéressé, et présentation d'un planning synthétique (slides précédents)
3. La date de la prochaine réunion se fera en concertation avec Pascal Gay et Emmanuel Gangler pour présenter respectivement KM3Net/ORCA et LSST@LPC