Astroparticle, cosmology and gravitation

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Based on the Giens workshop group 5 and 6 documents

"The proposal shall outline priorities following a thematic approach, with special emphasis on future large infrastructures/projects, including preparatory steps for a next project at CERN after LHC in a global context, and consider time scales and resources. It shall also consider possible future participation by CERN in experiments outside the Geneva Laboratory as part of the Strategy implementation." (European Strategy group mandate)

Astroparticle physics: particle physics implications

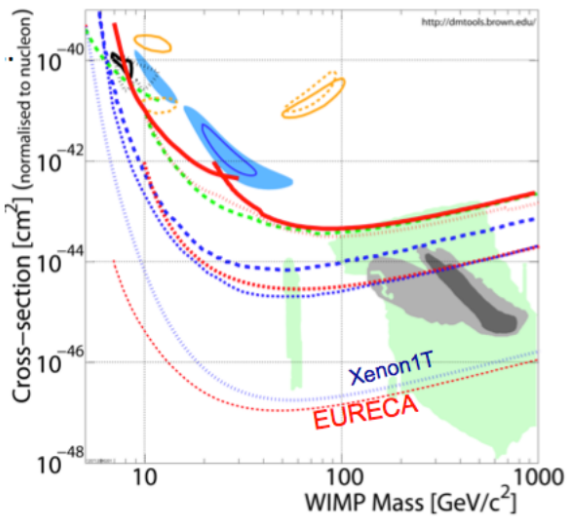
- dark matter: direct and indirect searches
- searches for new particles and phenomena (magnetic monopoles, PBHs..)
- tests of conservation laws (baryonic number, Lorentz invariance)

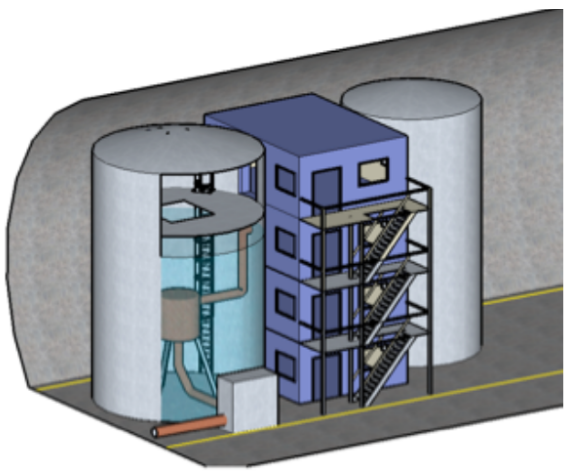
dark matter searches

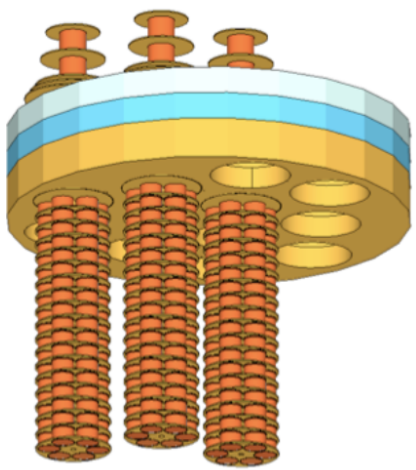
- complementary to LHC searches
- direct searches:
  - present: EdelweissIII, CRESST, Xenon100
  - future: Eureca, Darwin
- indirect searches:
  - γ HESS/MAGIC/VERITAS, Fermi (present), CTA (future)
  - ν IceCube, Antares (present), KM3Net? (future)
  - charged CR: AMS, with CERN involvement (present), GAPS? (future)

direct searches: Eureca

- Ge+scint., build on knowledge from EdelweissIII and CRESST
- 150 kg (2015), 1 ton (2018)
- hardware cost phase 1 (150 kg): 8.6 M€
- CERN past involvement in cryogenics
- large french involvement (IRFU, IN2P3, Neel, ...)
- technical cooperation with US S-CDMS teams
- possible location at LSM

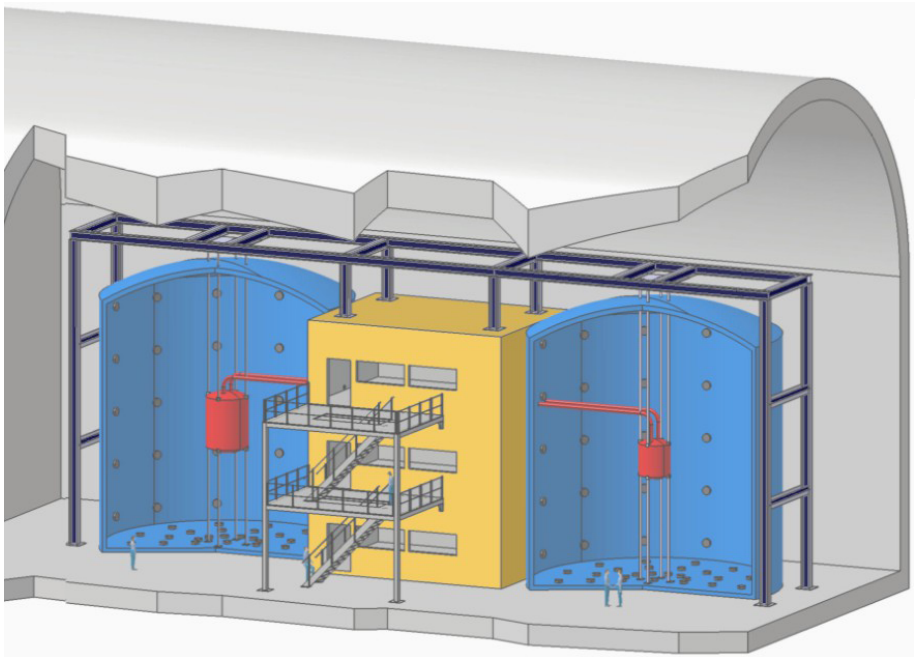


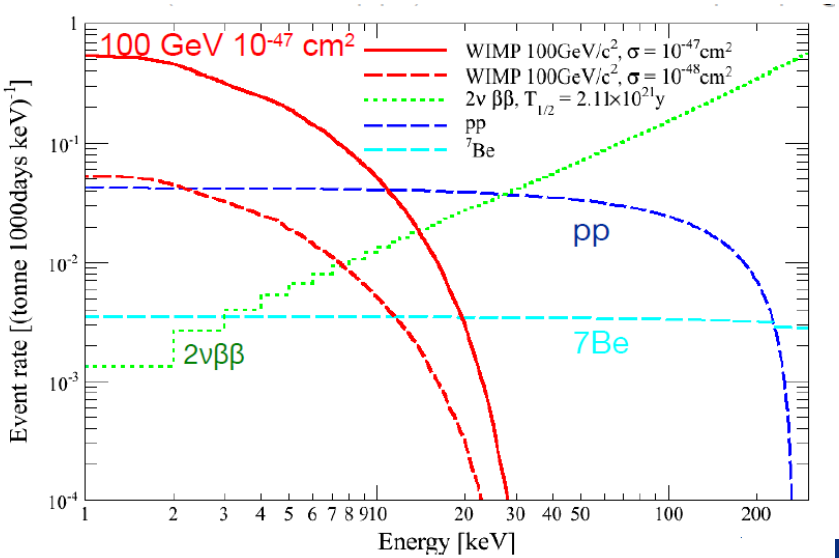




direct searches: Darwin

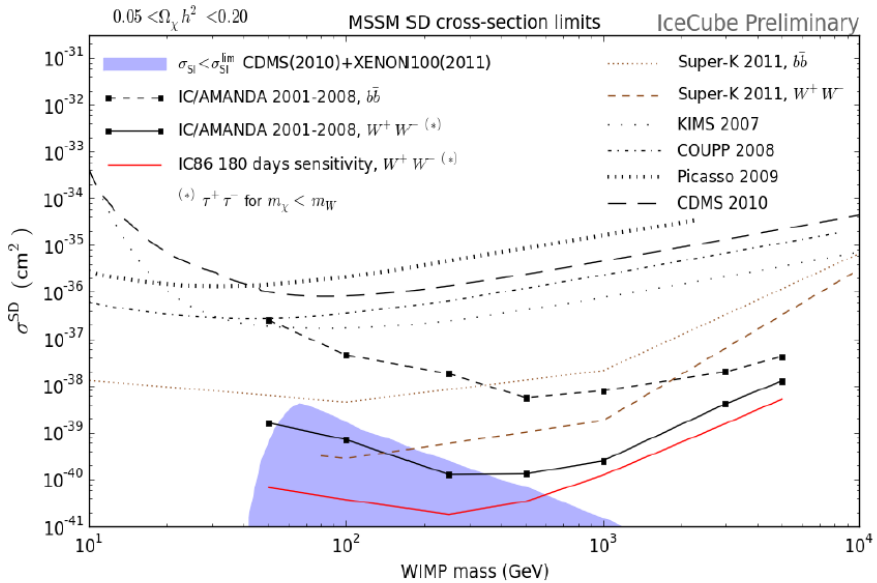
- liquid Xenon or Argon, build on Xe10, Xe100, Xe1t (2015)
- 20 tons, 10 tons fiducial
- only small french involvement (Subatech) in Xe100
- Xe1t at LNGS

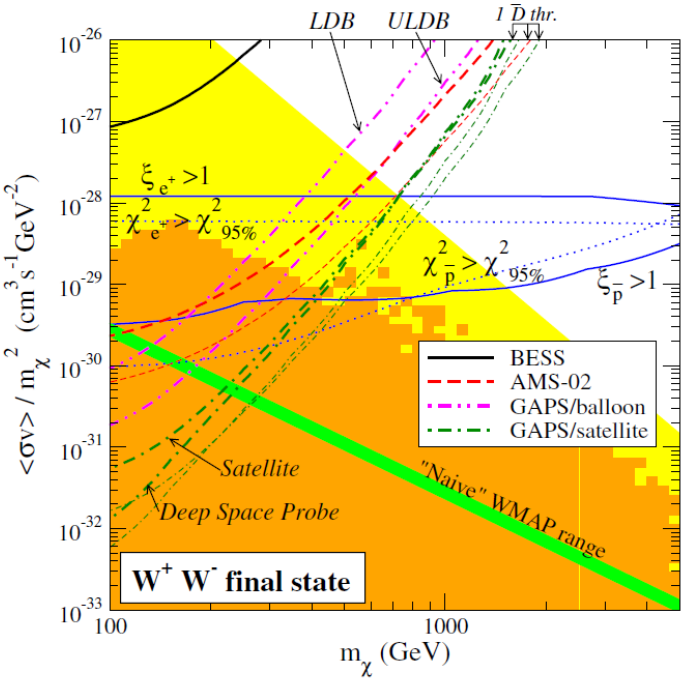




Indirect searches: neutrinos and charged CR

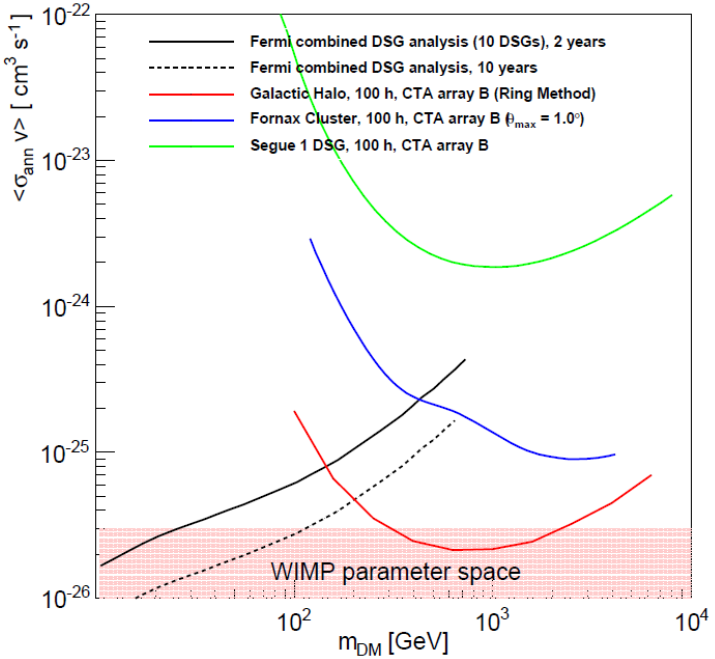
- ν Interesting limits from IceCube/SuperKamiokande (present) on SD scattering cross-sections
- Limit/discovery potential with AMS-02 (present) or GAPS (future?) and antideuterons.

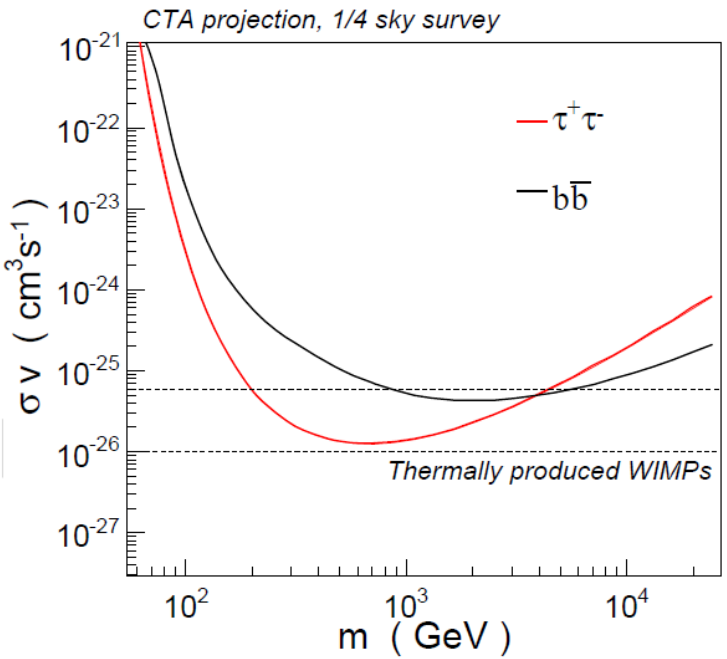




Indirect searches: CTA

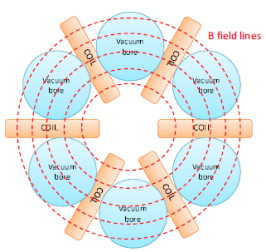
- VHE γ ray observatory.
- built on the experience of HESS/MAGIC/VERITAS
- $>$ 1000 members, 27 countries
- large french involvement (IRFU,IN2P3,INSU)
- Preconstruction phase (2014-2015), construction should start in 2016

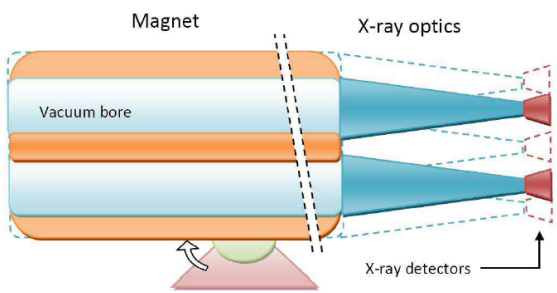


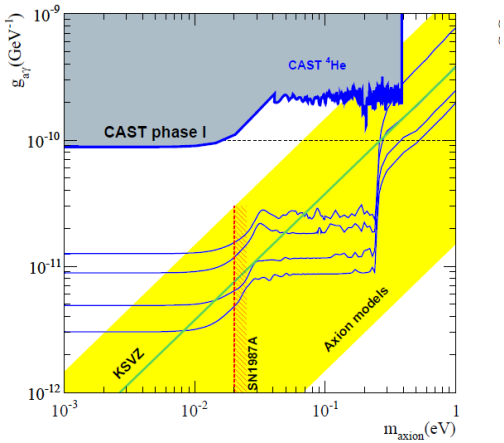


New particles: axion searches

- axion particle is the most natural solution to the strong CP problem
- may be dark matter if mass M in range 10^{-5} – 10^{-3} eV.
- indirect searches with Cherenkov telescopes
- microwave experiments (ADMX) if axion is DM
- solar experiments: CAST (present), IAXO (future), does not assume axion is DM.
- CERN involved in IAXO (also IRFU involved)







Dark energy and universe acceleration

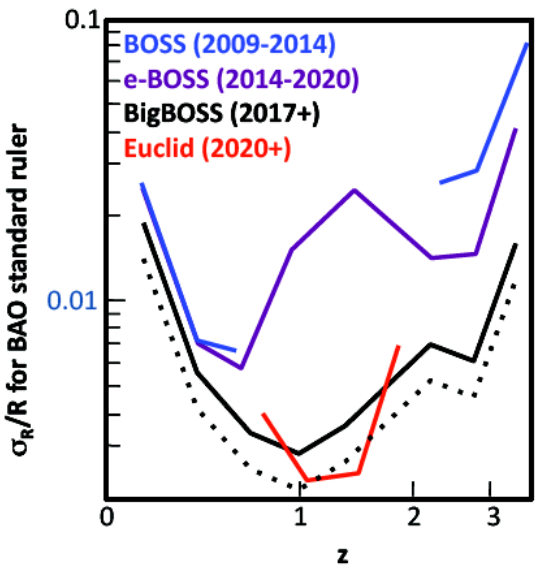
- Look for deviations from ΛCDM (e.g evolution of $w = \frac{p}{u}$ with time).
- Compare ΛCDM with theory of growth of cosmic strutures

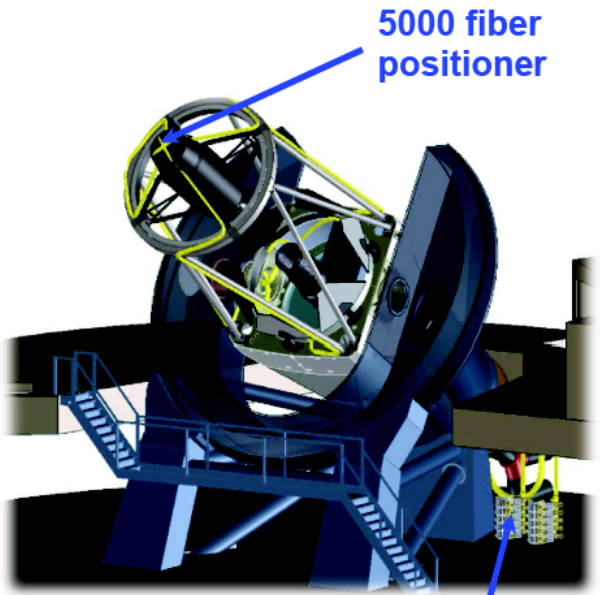
Several experimental techniques:

- Growth of structure
  - Weak lensing
  - Galaxy clustering
- ΛCDM
  - BAO
  - Supernovæ

BAO: BigBOSS

- construction: 2014-2017
- first light: $\sim$ 2018
- 5 year survey (14000 deg^2)
- science: Dark Energy (BAO)
- construction cost 60 M$, running cost 30 M$
- $\sim$ 100 participants: Europe (France: IRFU,INSU, IN2P3), USA, China, Brazil

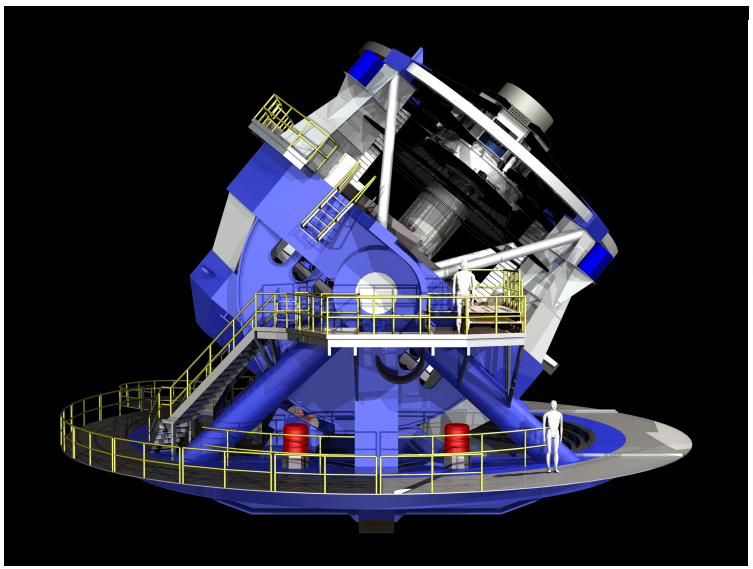


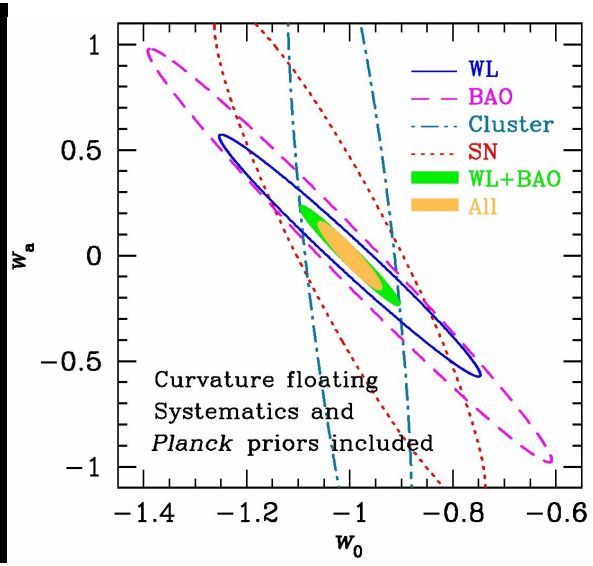


Mayall 4m telescope at Kitt Peak

Future ground based project: LSST

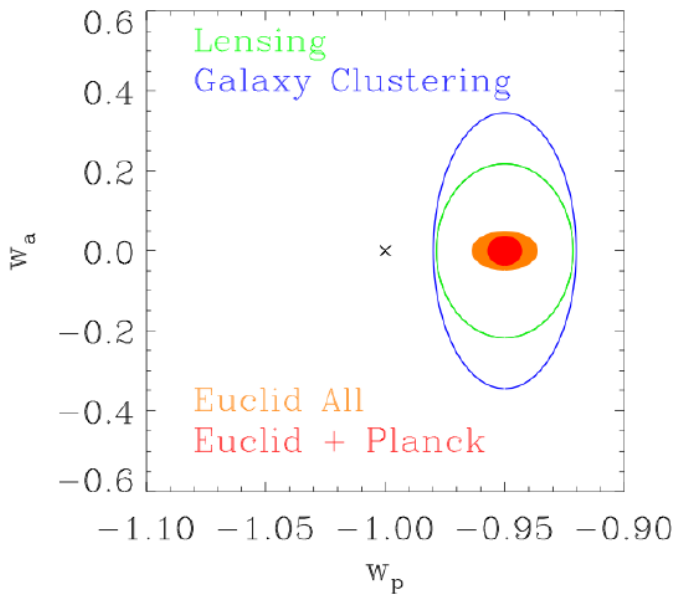
- Construction 2012-2017.
- Estimated construction cost: 617 M$
- French contribution 7 M€, from IN2P3 and TGIR

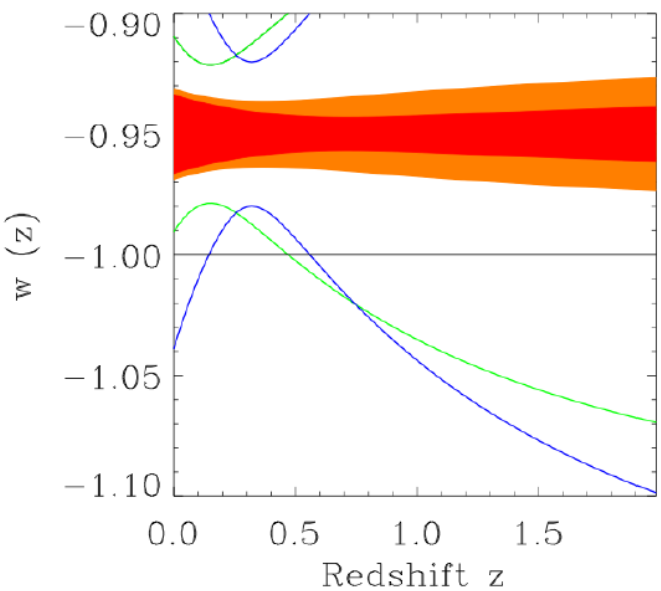




Future space based project: Euclid

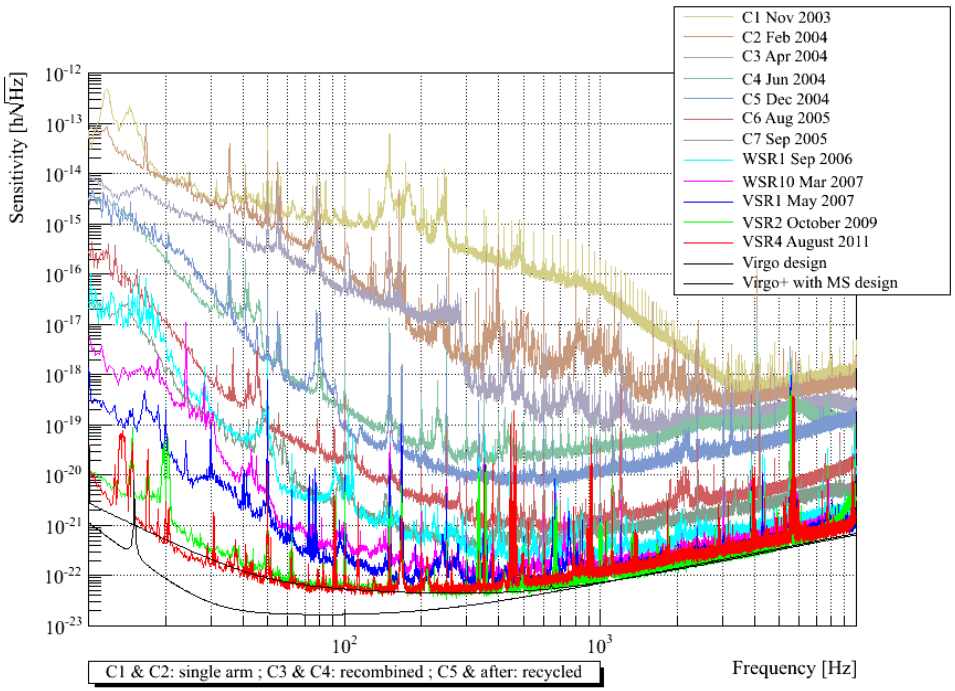
- Selected by ESA, October 2011
- Now in Phase B, to be launched in 2019
- Heavy involvement of IRFU/INSU/IN2P3
- Cost 800 M€, french part 8M€





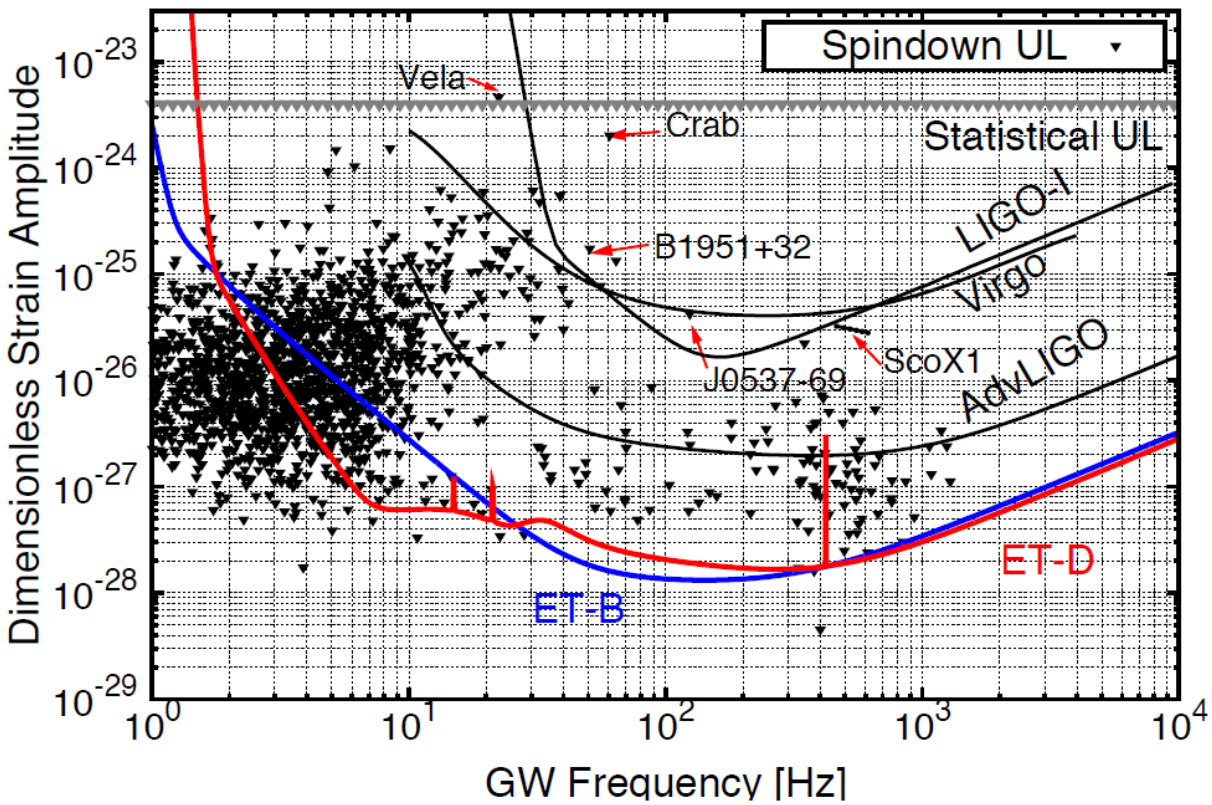
GW: state of the art

- Present goal: detection of gravitational waves
- Once detected, useful in astrophysics (binary mergers) or cosmology (diffuse GW background).
- VIRGO (with IN2P3 participation) reached the design sensitivity.



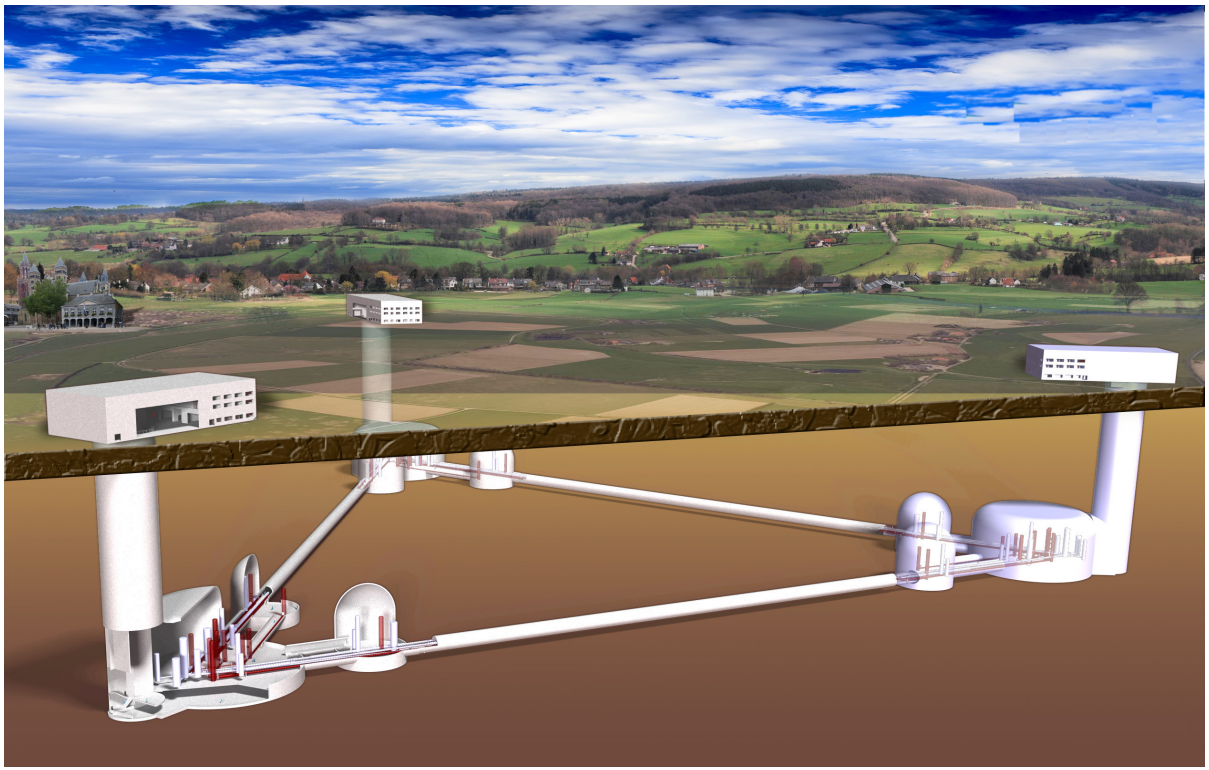
Near future: Advanced VIRGO

- Improvements with known state of the art technology.
- Investment period 2011-2014.
- IN2P3 25.5 physicists, investment 7 M€(total 21 M€)



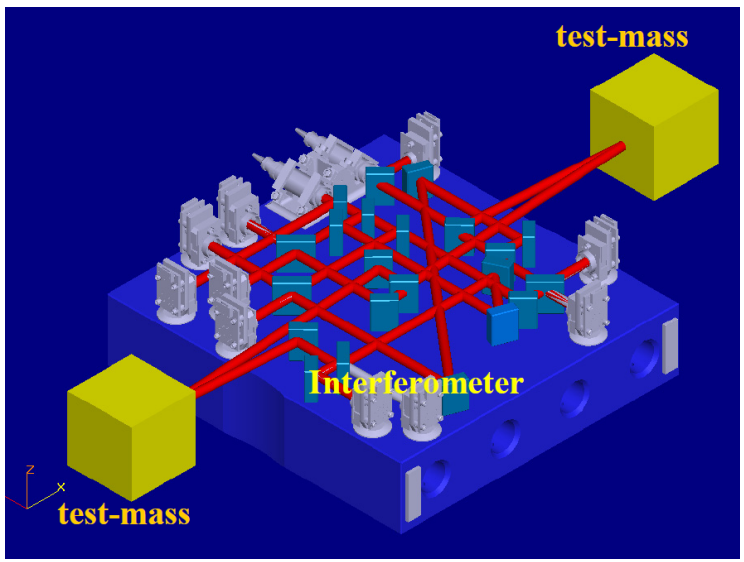
Future ground based antenna: Einstein telescope

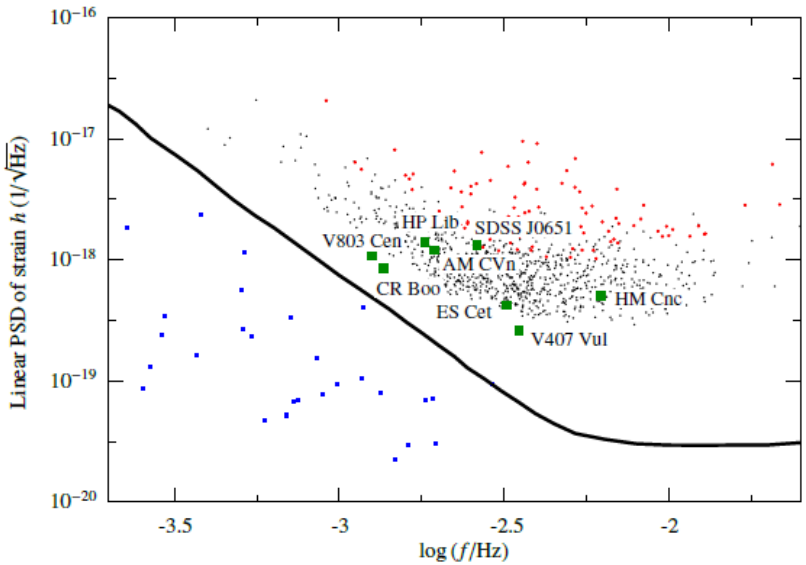
- Currently FP7 design study
- Investments after 2020
- Estimated cost $>$ 800 M€



Future space based antenna

- Near future: LISA pathfinder (2014)
- Future: eLISA/NGO, decision 2015, launch 2022?
- heavy involvement of ESA





What can CERN do for astroparticle, cosmology and gravitation?

A few simple thoughts

- ESO rather than CERN should be involved in CTA observatory.
- ESA (or NASA) rather than CERN should be involved in spatial missions (Euclid, LISA)

Experience from the past:

- Beams to underground facilities (MINOS,OPERA..)
- Nucleon decay experiments (NUSEX)
- Astronomical surveys (Sloan Digital Sky Survey)

CERN already involved in IAXO R& D.
What remains?: **Einstein Telescope, Eureca/Darwin**. Also possible is **LSST** (data analysis).