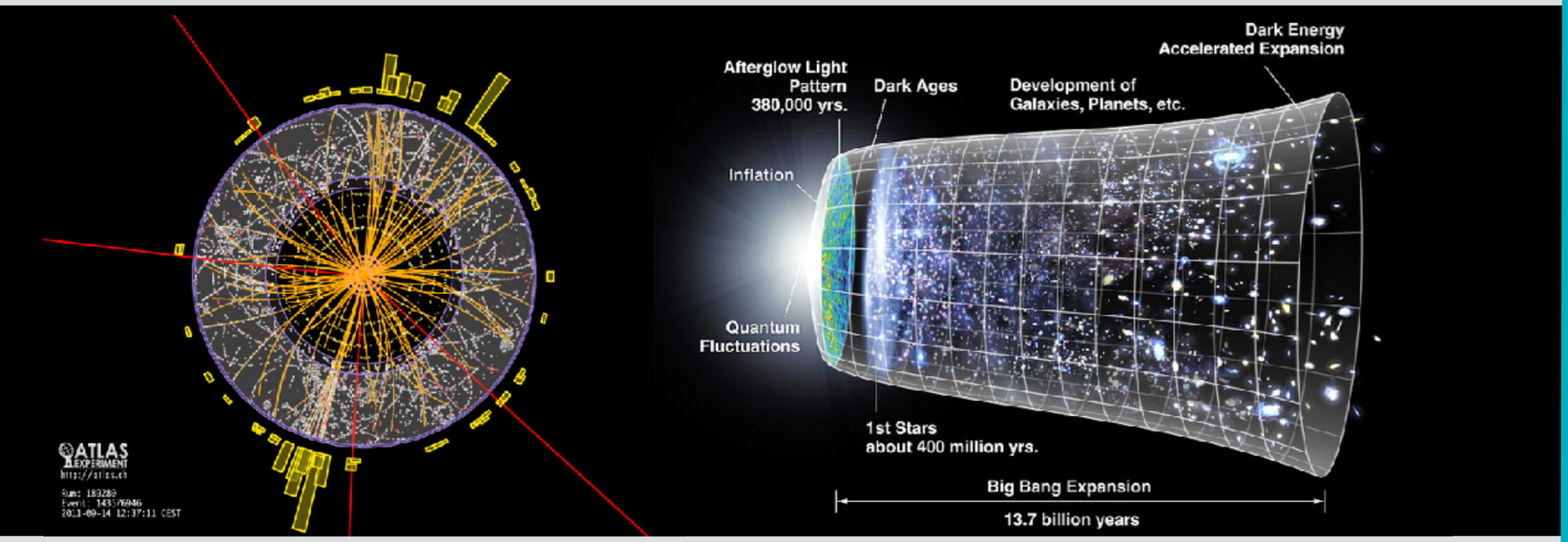
Nikhef

Introduction to Nikhef

Stan Bentvelsen

Nikhef mission

- Elementary particles and fields of our universum



  - Accelerator physics - CERN
  - Astroparticle physics
- Knowledge and technology transfer

NIKHEF MISSION

The mission of the National Institute for Subatomic Physics Nikhef is to study the interactions and structure of all elementary particles and fields at the smallest distance scale and the highest attainable energy. Two complementary approaches are followed:

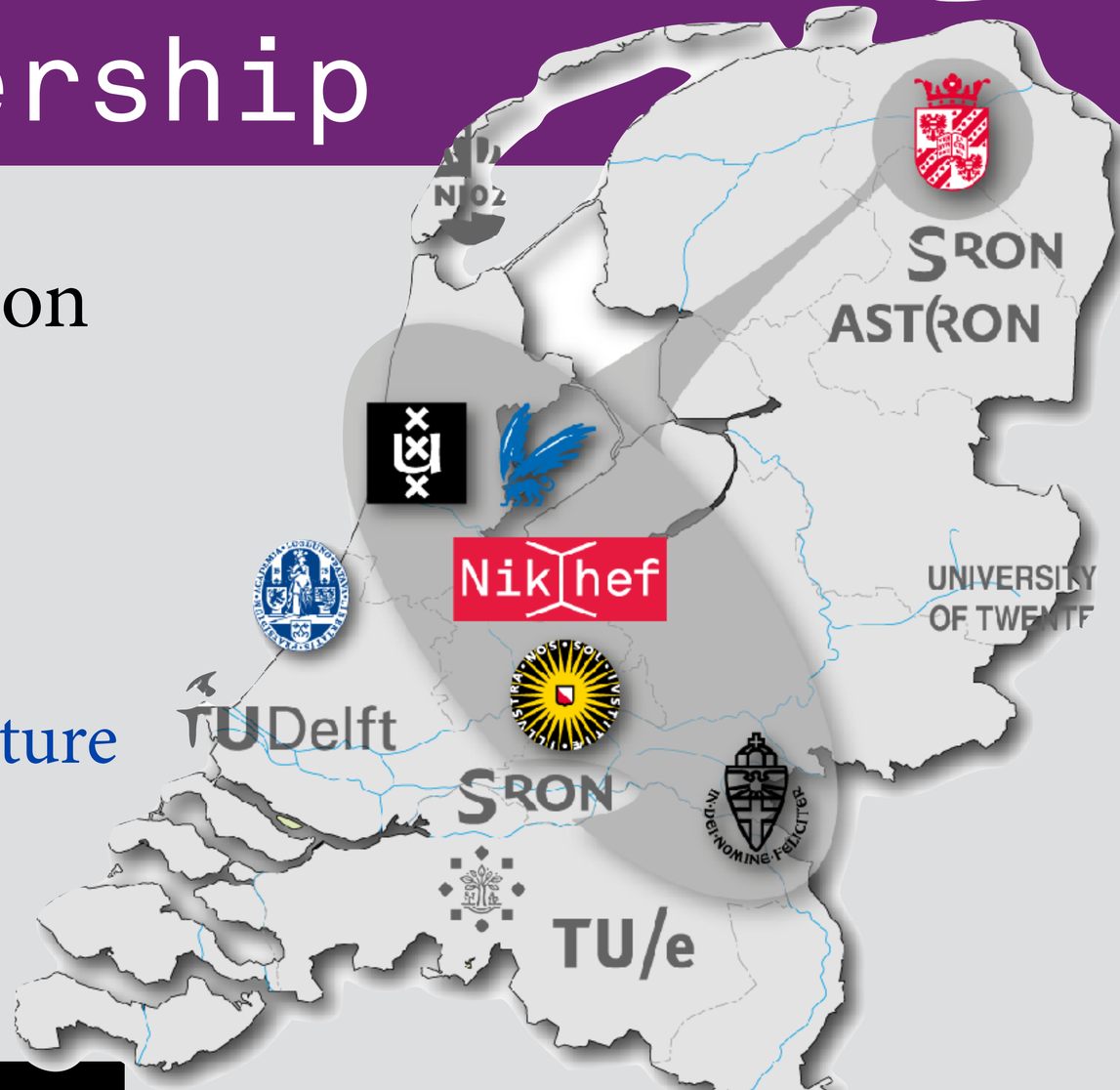
1. Accelerator-based particle physics – studying interactions in particle collision processes at particle accelerators, in particular at CERN;

2. Astroparticle physics – studying interactions of particles and radiation emanating from the universe.

Nikhef coordinates and leads the Dutch experimental activities in these fields. The research at Nikhef relies on the development of innovative technologies. The knowledge and technology transfer to third parties, i.e. industry, society and the general public, is an integral part of Nikhef's mission.

Nikhef partnership

- (Astro-) Particle Physics collaboration
  - Coordination of programme with 5 University partners
  - University partners take key positions
    - Leaders of the scientific programs
  - Added value Nikhef institute infrastructure
    - Technical support
    - Large computing infrastructure
    - Long term strategy & commitment



Permanent Staff	76
OIO+PD	129
Technical/engineer	71
Support	28

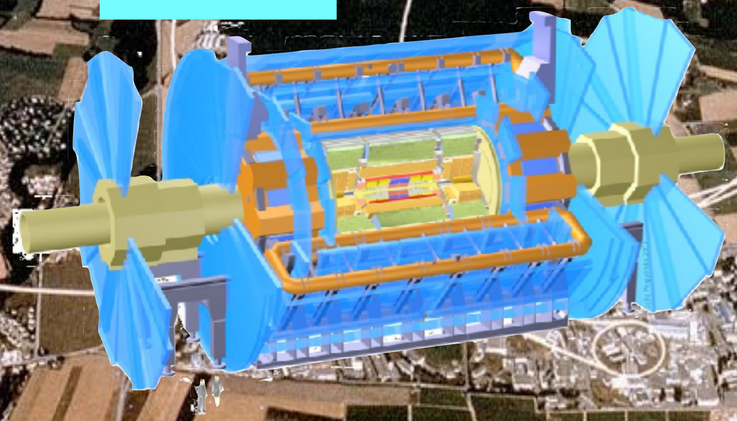
Core activity: LHC @ CERN

FOM LHC program until 2021 and roadmap funding:
Excellent scientific programme
Very visible role of the Netherlands at CERN

CMS

ALICE

ATLAS



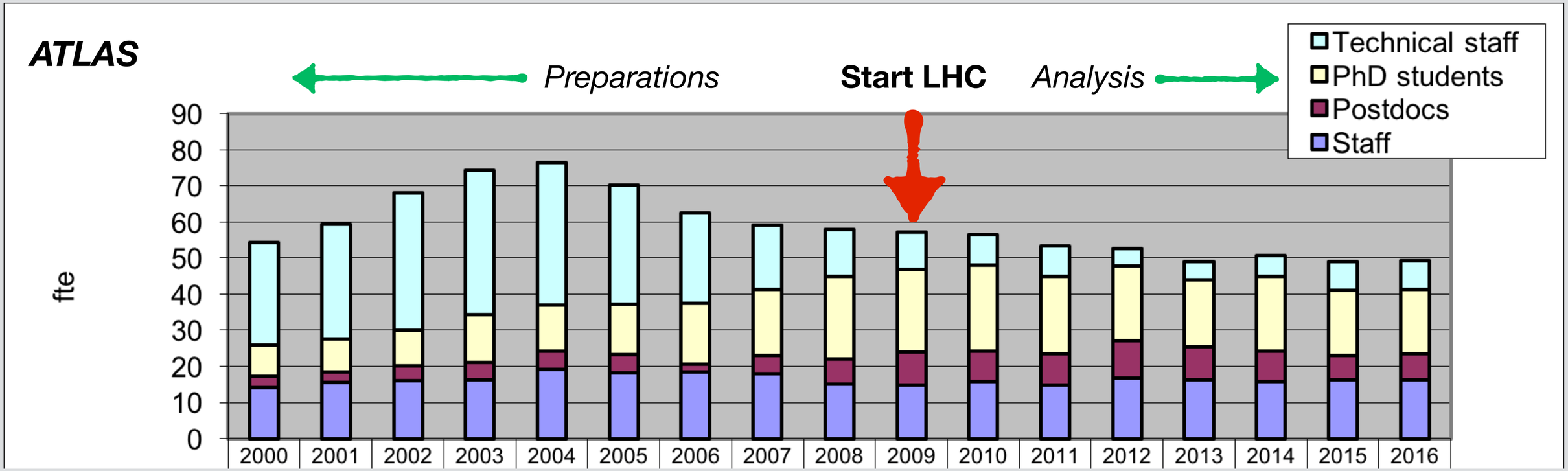
LHCb

protons

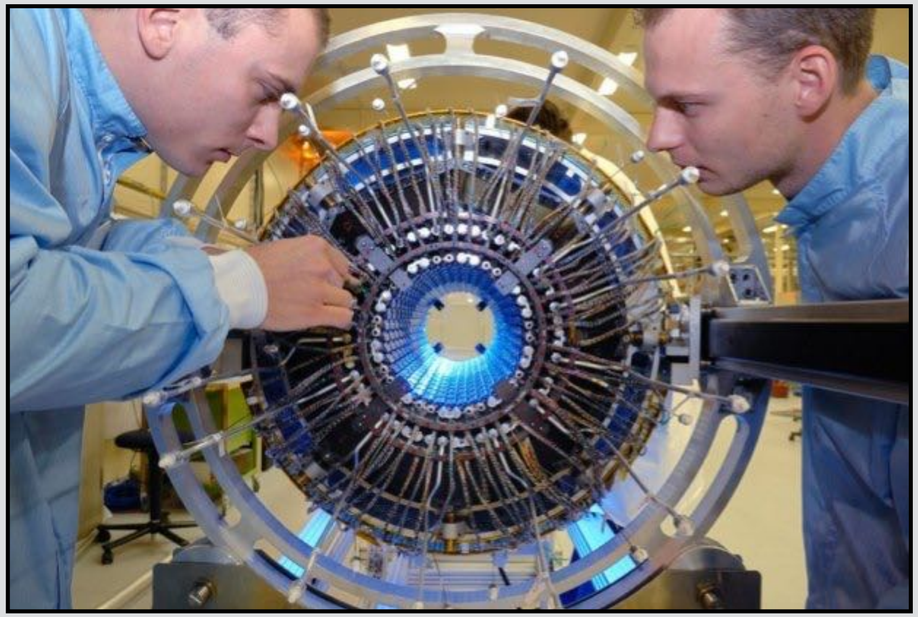
Dutch contribution to CERN (from OCW): 53 MCHF - 4.7%

Past example: manpower ATLAS

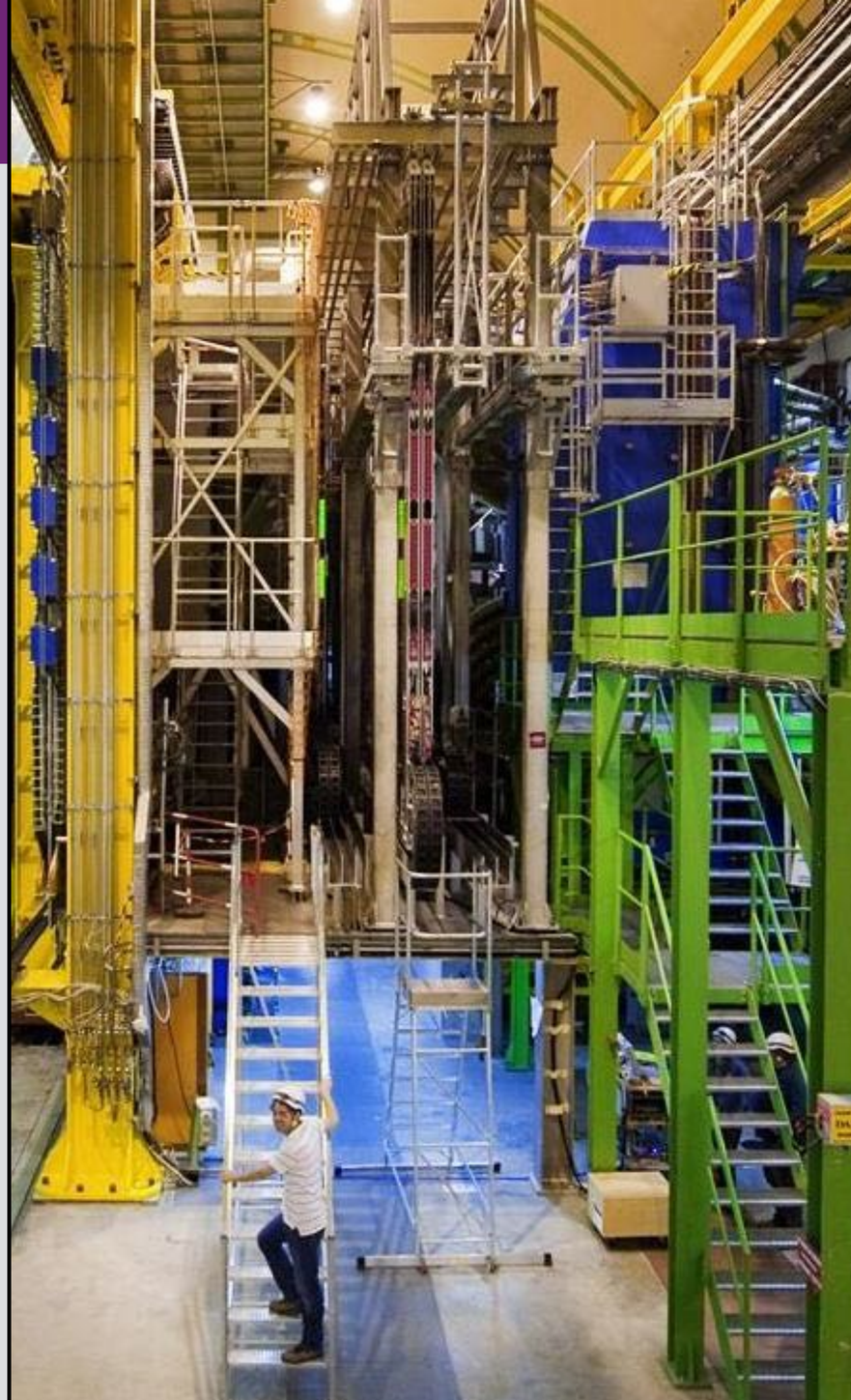
- Long term commitments - large infrastructure
  - Building phase: *R&D - hardware - instrumentatie*
  - Exploitation phase: *Computing - analyse - fenomenologie*



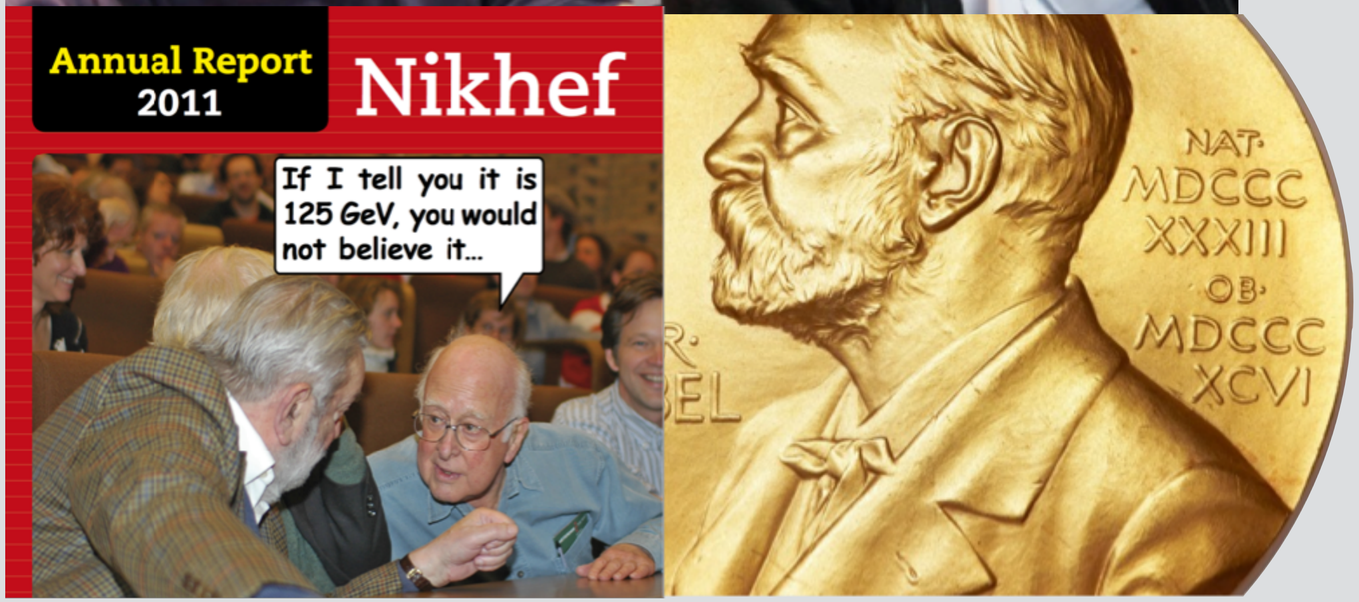
Construction@LHC



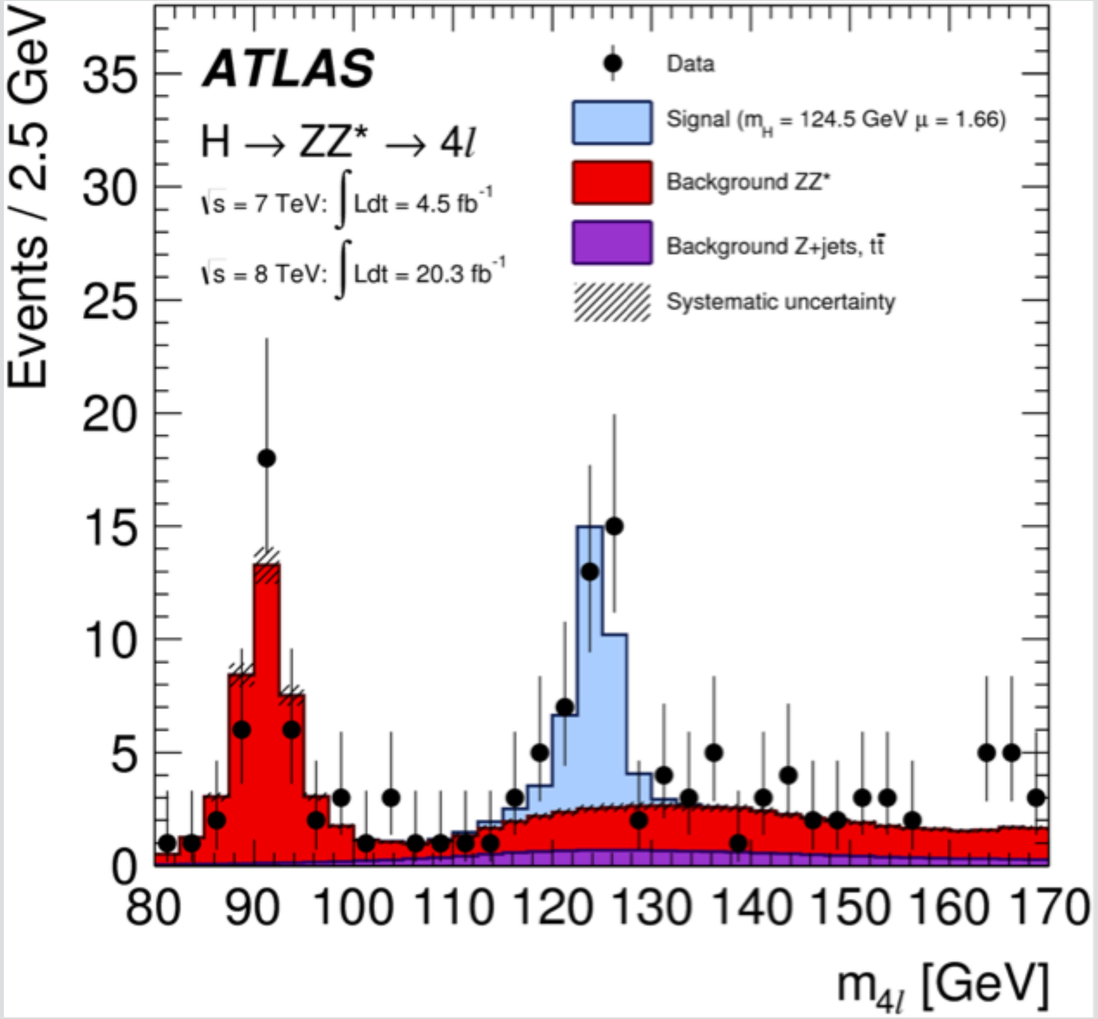
Challenging projects commitment via MoU



From dream to reality



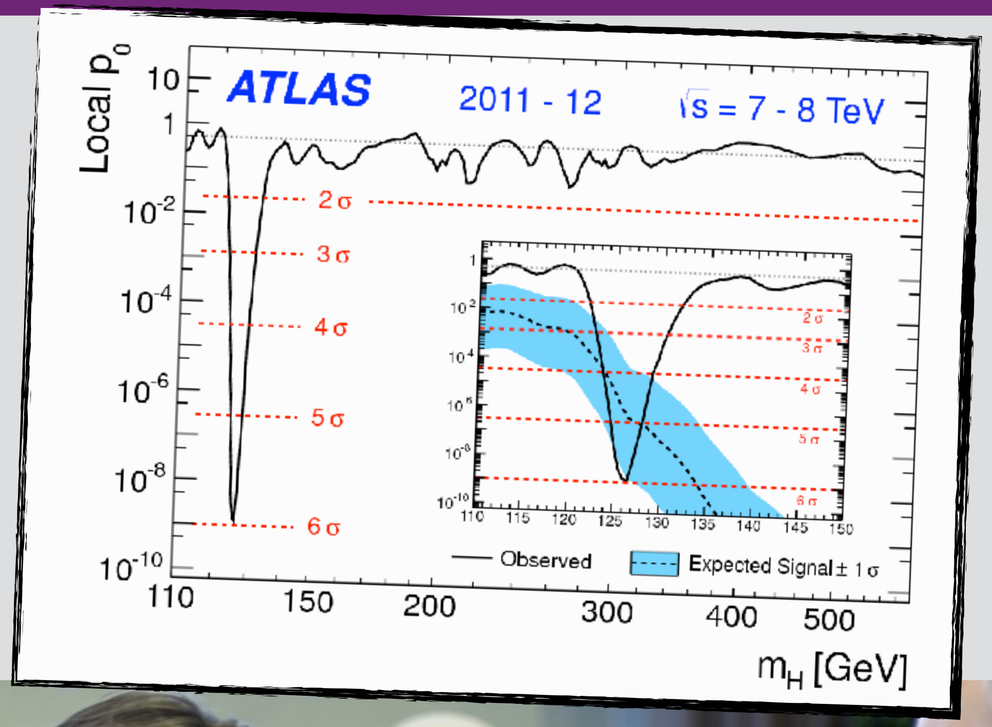
Discovery Higgs particle in 2012



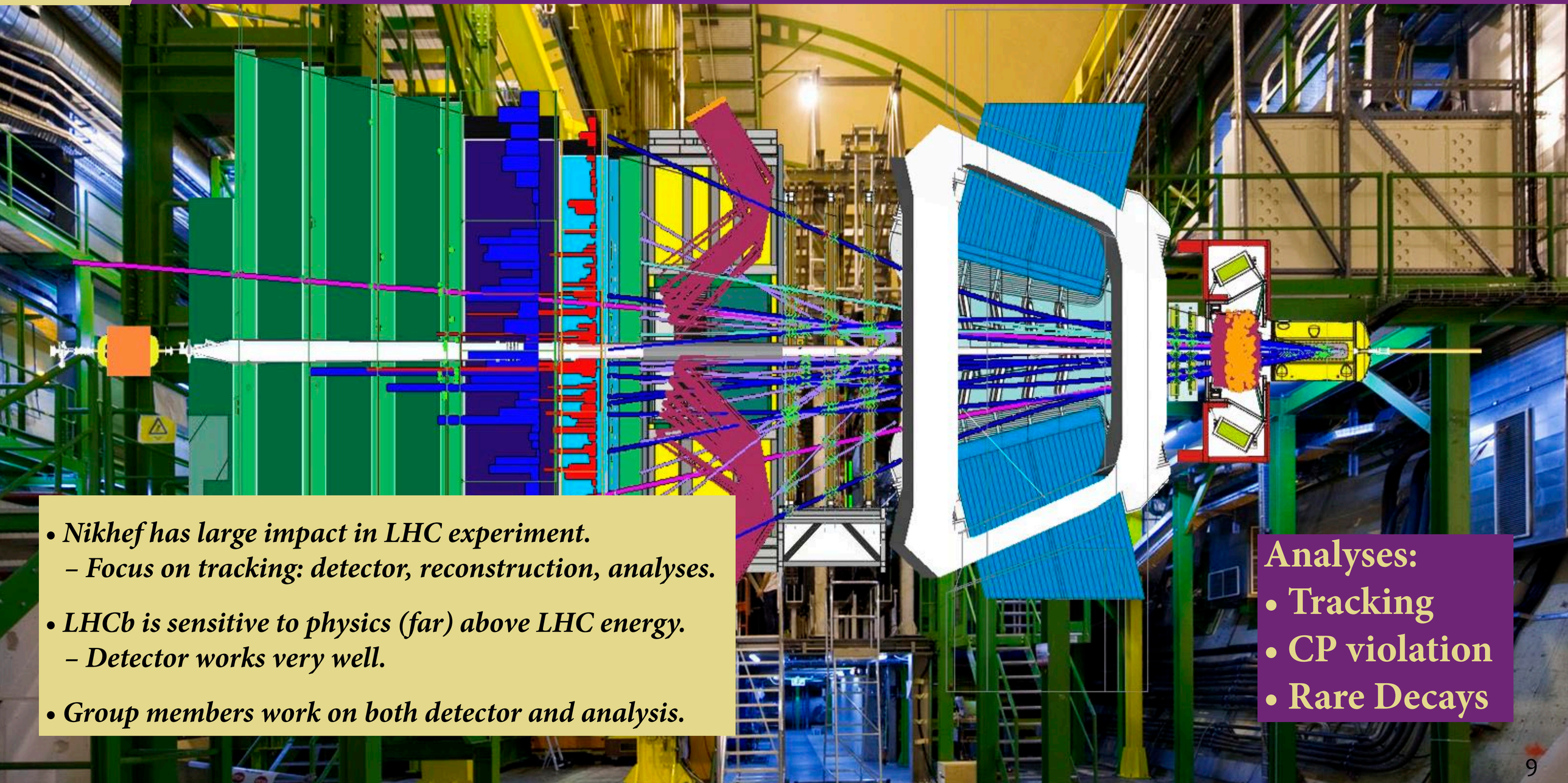
Discovery of the Higgs

"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"

Peter Higgs & Francois Englert



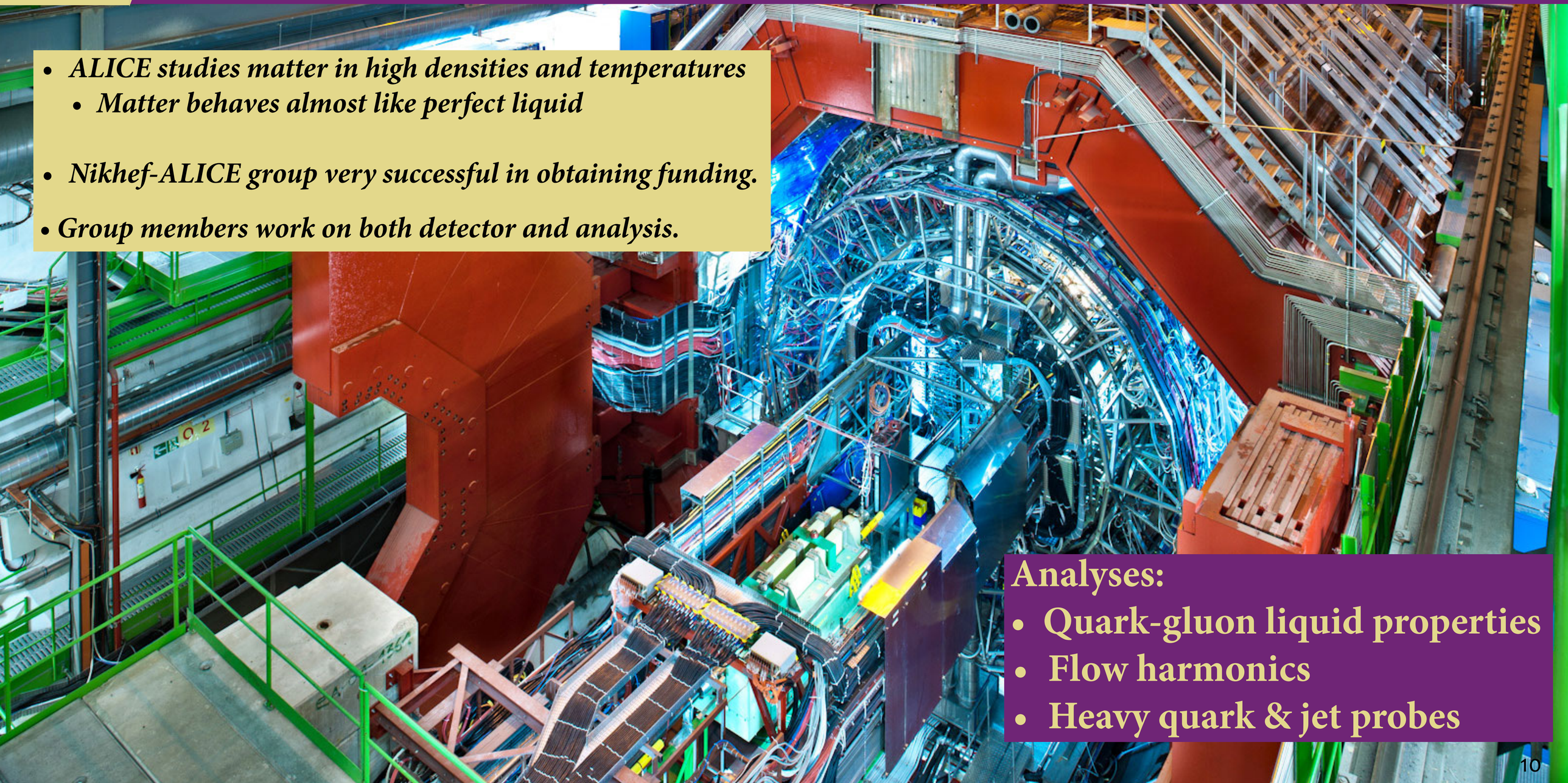
LHCb activities



- *Nikhef has large impact in LHC experiment.*
  - *Focus on tracking: detector, reconstruction, analyses.*
- *LHCb is sensitive to physics (far) above LHC energy.*
  - *Detector works very well.*
- *Group members work on both detector and analysis.*

Analyses:
- **Tracking**
- **CP violation**
- **Rare Decays**

ALICE



- *ALICE studies matter in high densities and temperatures*
  - *Matter behaves almost like perfect liquid*
- *Nikhef-ALICE group very successful in obtaining funding.*
- *Group members work on both detector and analysis.*

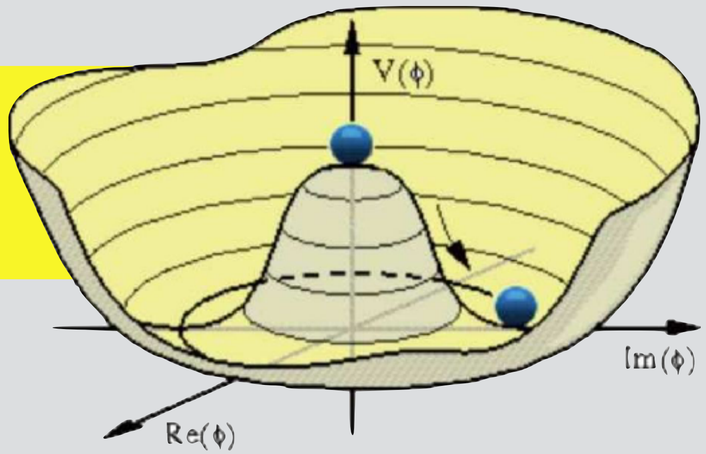
Analyses:

- **Quark-gluon liquid properties**
- **Flow harmonics**
- **Heavy quark & jet probes**

Beyond the standard model

Higgs discovered? Fundamental new challenges !

$$V_{Higgs} = V_0 - \mu^2 \phi^\dagger \phi + \lambda \left(\phi^\dagger \phi\right)^2 + \left[\bar{\psi} Y \psi \phi + h.c.\right]$$



Large energy in vacuum:
Cosmological constant?

Large quantum corrections
Origin of Dark Matter?

Higgs self coupling:
Is our universum stable?

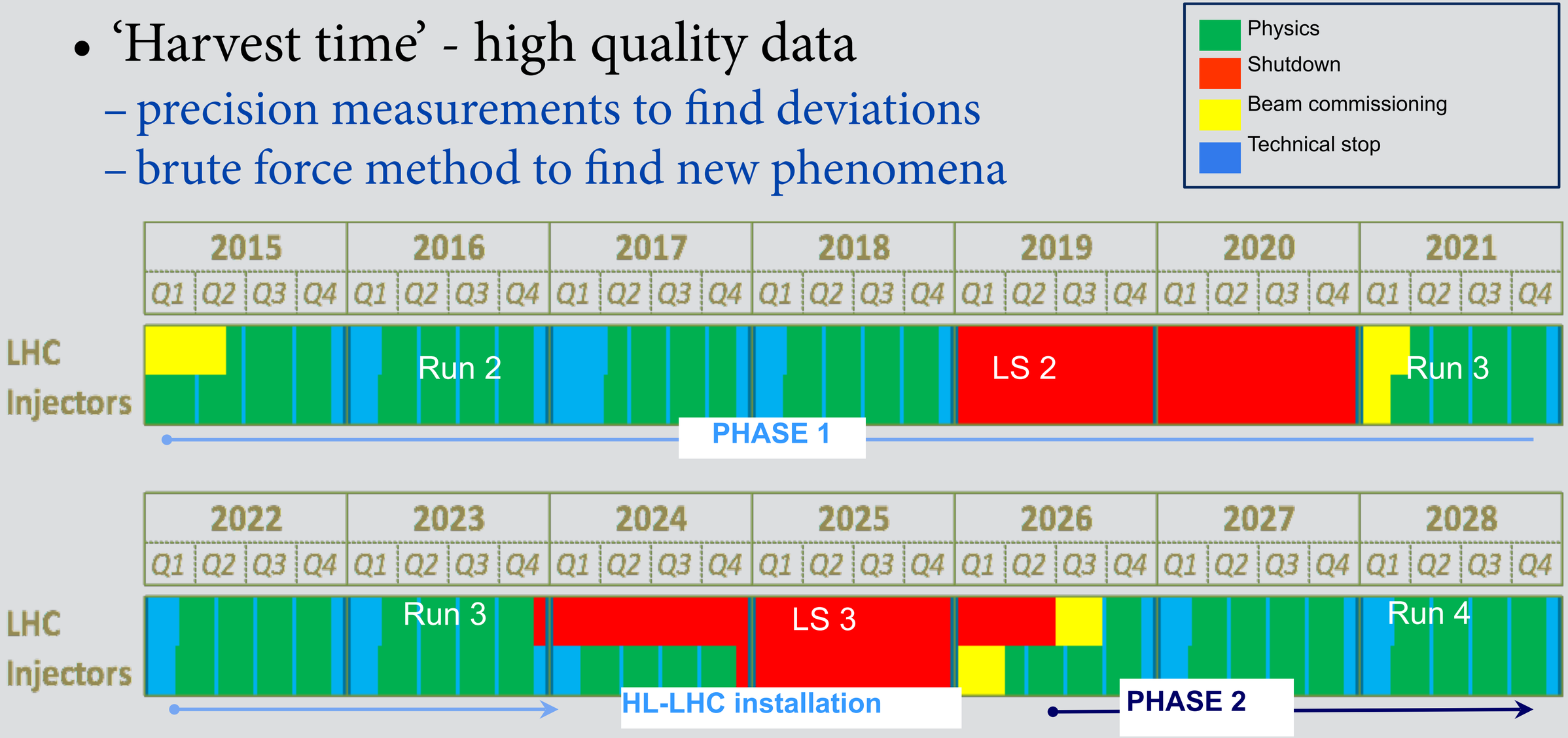
Higgs mass for particles:
Difference matter-anti-matter?
Mass of neutrino's?

Strategy Nikhef

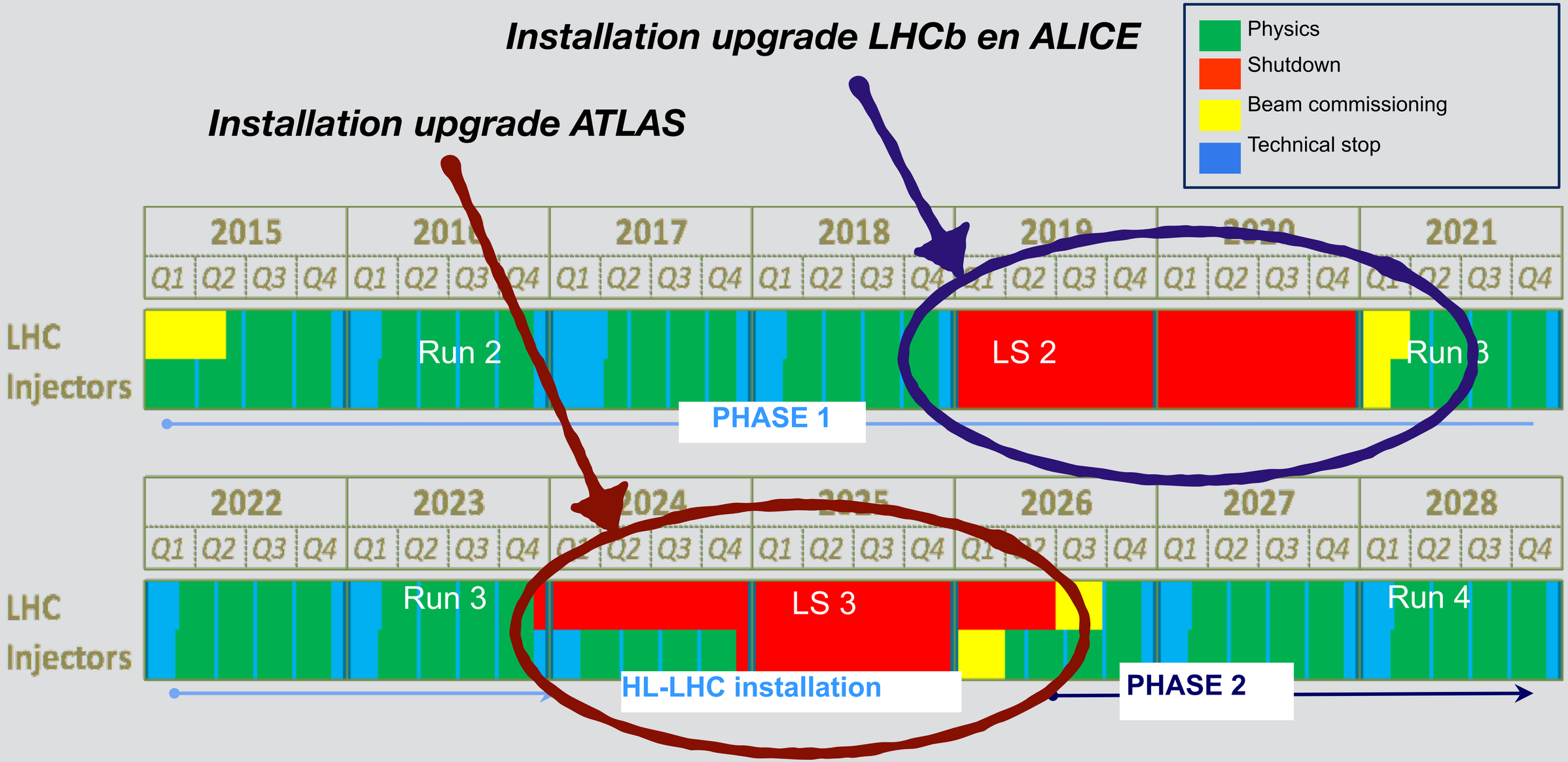
1. High precision measurements - signal deviations Standard Model
2. Higher energies - produce new heavier particles
3. Astroparticle physics - observe (new) particles from universe

LHC roadmap until ~>2030

- ‘Harvest time’ - high quality data
  - precision measurements to find deviations
  - brute force method to find new phenomena

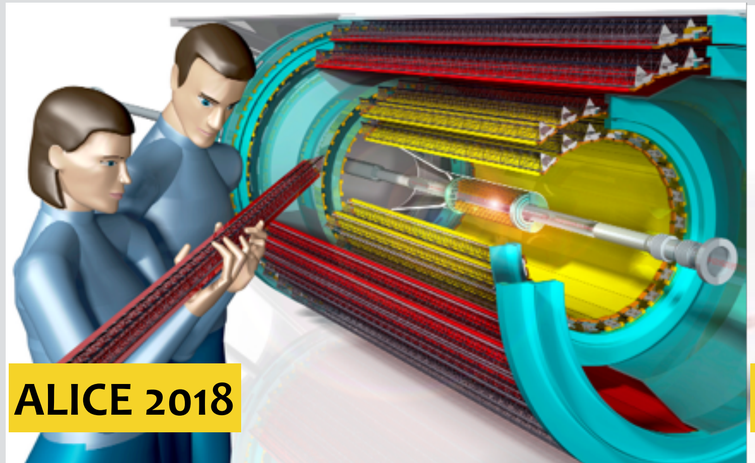


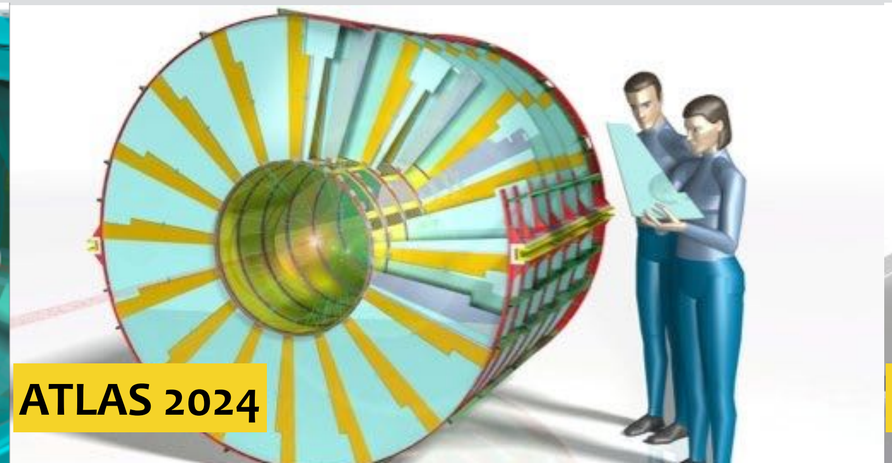
LHC roadmap

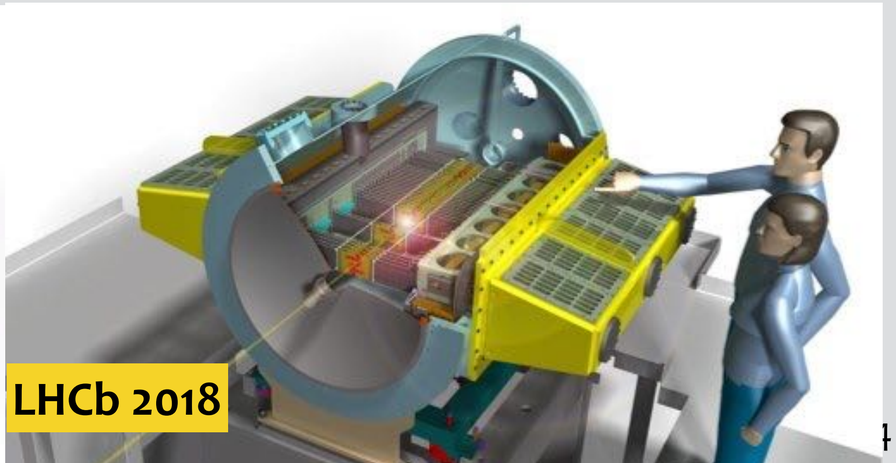

Installation upgrade LHCb en ALICE
Installation upgrade ATLAS
Physics
Shutdown
Beam commissioning
Technical stop
2015
2016
2017
2018
2019
2020
2021
Q1 Q2 Q3 Q4
LHC Injectors
Run 2
LS 2
Run 3
PHASE 1
2022
2023
2024
2025
2026
2027
2028
LHC Injectors
Run 3
LS 3
Run 4
HL-LHC installation
PHASE 2

Nikhef - LHC (2017-2025)

- Installation upgrades ATLAS, LHCb en ALICE
  - Top priority for LHC - connection to R&D
    - Build complete parts of detector for ALICE, ATLAS & LHCb
    - Tracking detectors, very radiation hard
- Computing infrastructure
    - Extension of Tier-1 infrastructure - increase efficiency algorithms
- Physics exploitation - exciting and very relevant!
  - After 2022 new funding program via ENW







Strategy 2017-2022

1. *Proven approaches*
- Construct the upgrades and exploit the physics of the LHC experiments ATLAS, LHCb and ALICE
- Build KM3NeT phase 2.0 and exploit neutrino (astro)physics
- Exploit the astroparticle experiments Advanced Virgo, XENON1T/NT and the Auger Observatory
- Full utilisation of the theory, detector R&D and computing activities

2. *New opportunities:*
- Determine the electron EDM with world-class precision
- Prepare for a post-LHC high-energy accelerator period
- Strengthen and exploit the thematic connections between individual scientific programmes
- Prepare a bid to locate the Einstein Telescope in the Netherlands

3. *Beyond scientific' goals:*
- Establish further links with industry in terms of transfer of knowledge generated at Nikhef
- Attract and train a new generation of scientists and engineers
- Modernise the Nikhef branding and building
- Inspire and nurture scientifically aware general audiences

APP portfolio

The choice of these experiments, which can be seen as the elite of particle- and astroparticle physics experiments, is excellent.

European Strategy for Astroparticle Physics

APPEC–Astroparticle Physics European Consortium

Pierre Auger - cosmic rays

Xenon1T - Dark Matter

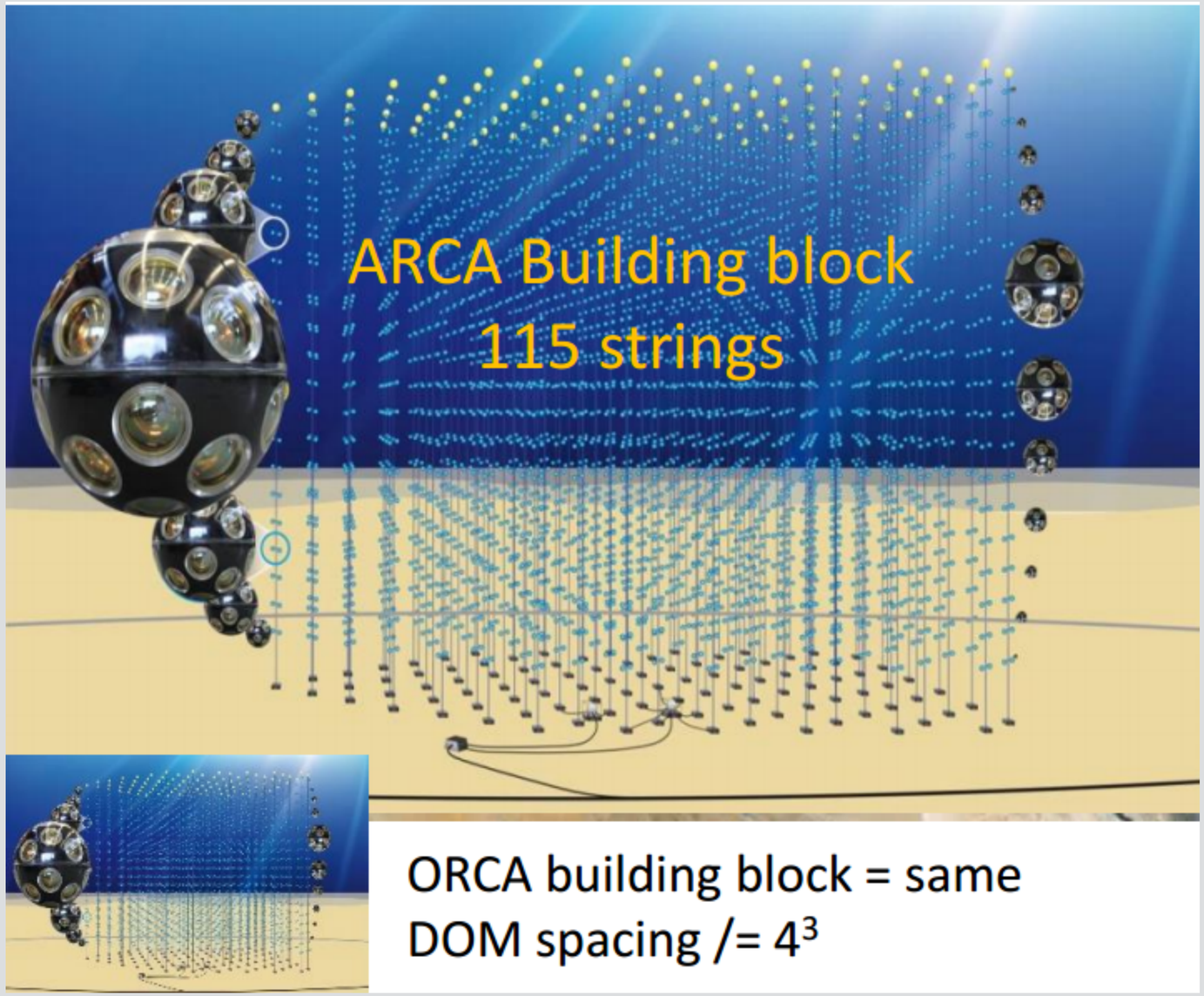
KM3NeT - neutrino detection

Adv VIRGO - Gravitational Waves

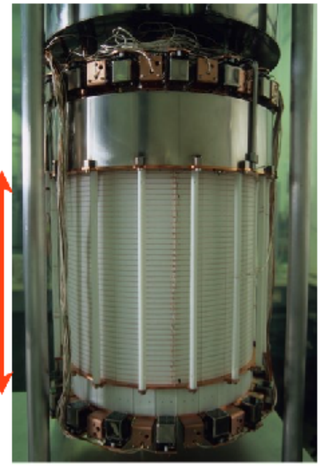
KM3NeT2.0 - ARCA and ORCA

- KM3NeT 2.0 project
  - ESFRI project - France, Italy, Greece and NL
- ARCA:
  - Astrophysical Research with Cosmic in the Abyss
    - 2 building blocks
- ORCA:
  - Oscillations Research with Cosmics in the Abyss
    - 1 building block

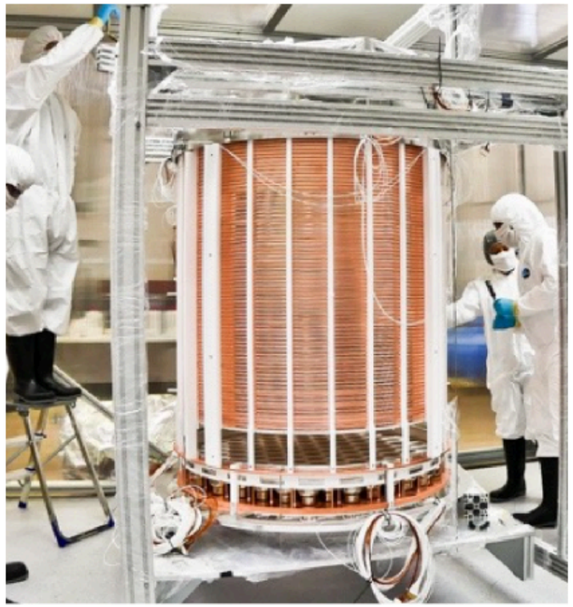
Largest activity of Nikhef workshops



Dark Matter: Gran Sasso

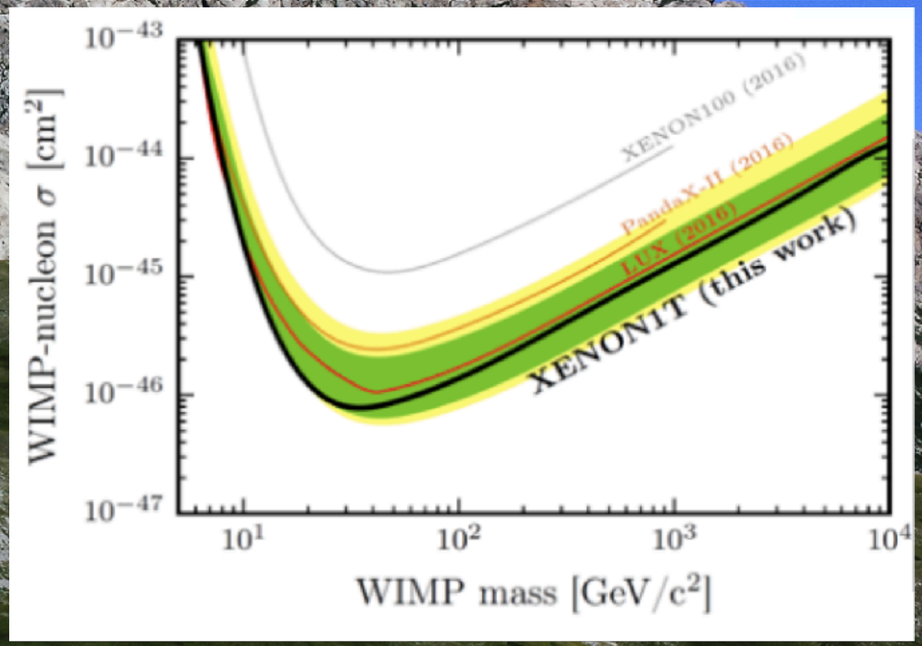


XENON100
(160kg Xe):
Analysis



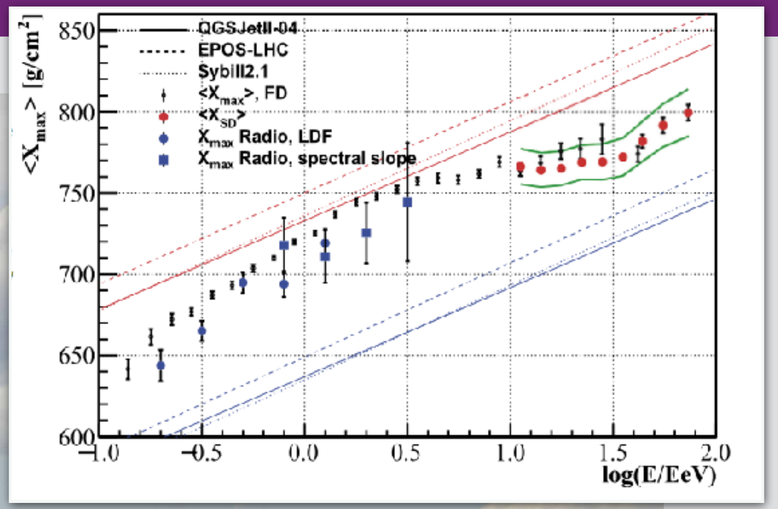
XENON1T
(3500kg Xe),
XENONnT
(7500kg Xe)
Cryostat & Support
DAQ / Trigger
Dataprocessor

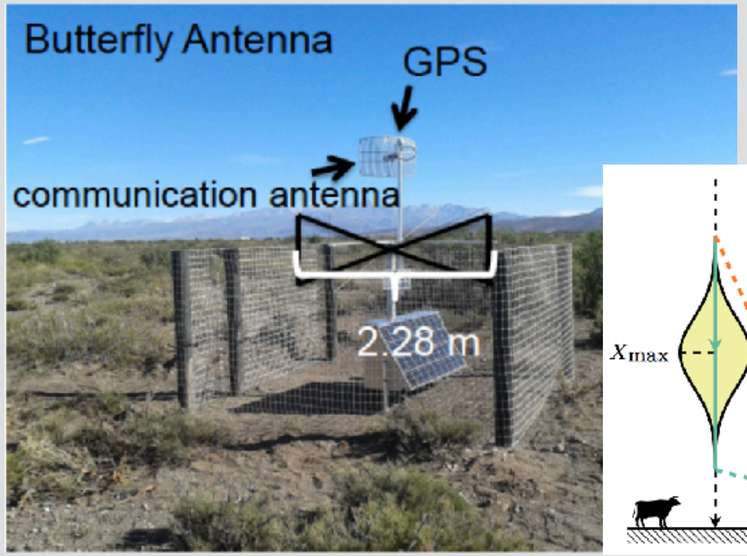
Very successful start of XENON1T
- taking over the world best limit
preparing for XENONnT
- a bright future towards DARWIN

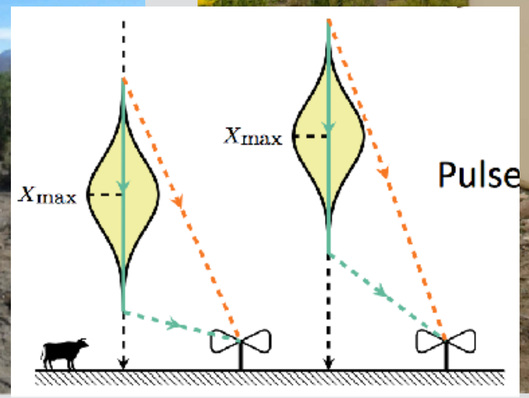


Pierre Auger UHECR

- Mass composition
  - Detection CR with radio (AERA)
    - NWO-G proposal
  - Surface Detection of cosmic rays

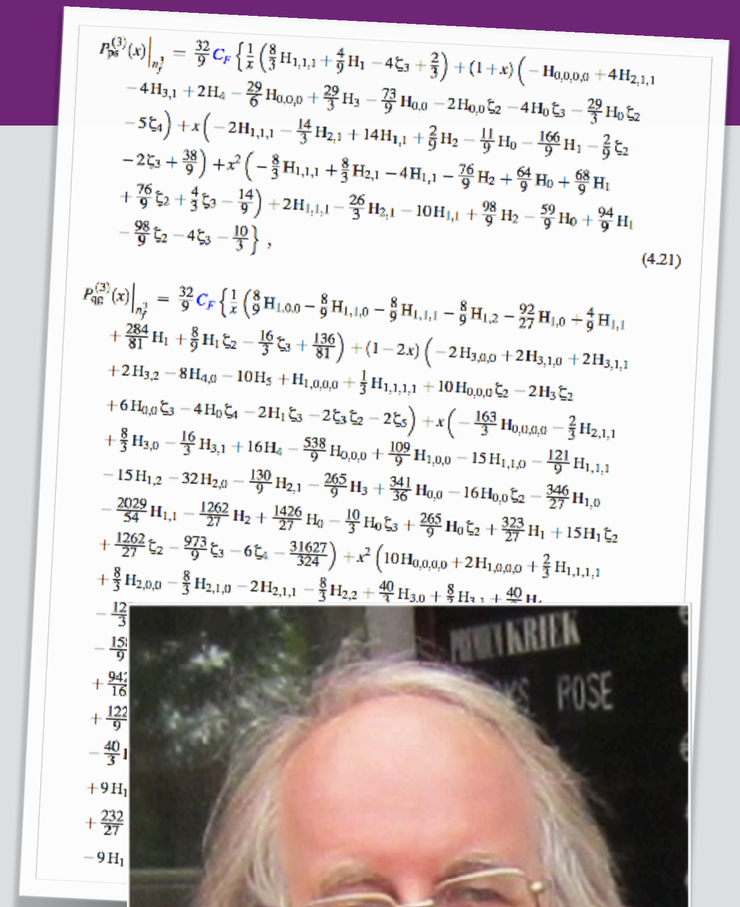


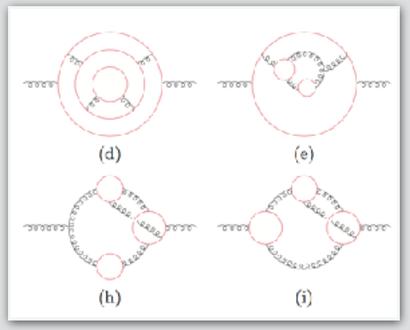


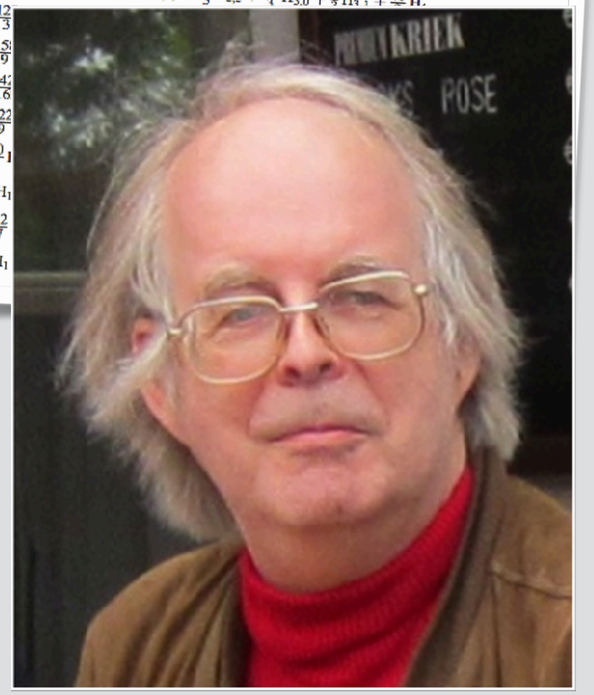


Theory - centre

- National centre in particle phenomenology
  - *Higgs as probe and portal*
  - *Observing the Big Bang*
- Very active and lively group
  - Interactions with experimental groups
- Highlights:
  - FORM algebraic manipulation
    - Calculations 4 loop splitting functions
    - 5 loop beta calculations
  - NNNLO Higgs production
  - Rare B decays
  - QCD resummation , …..



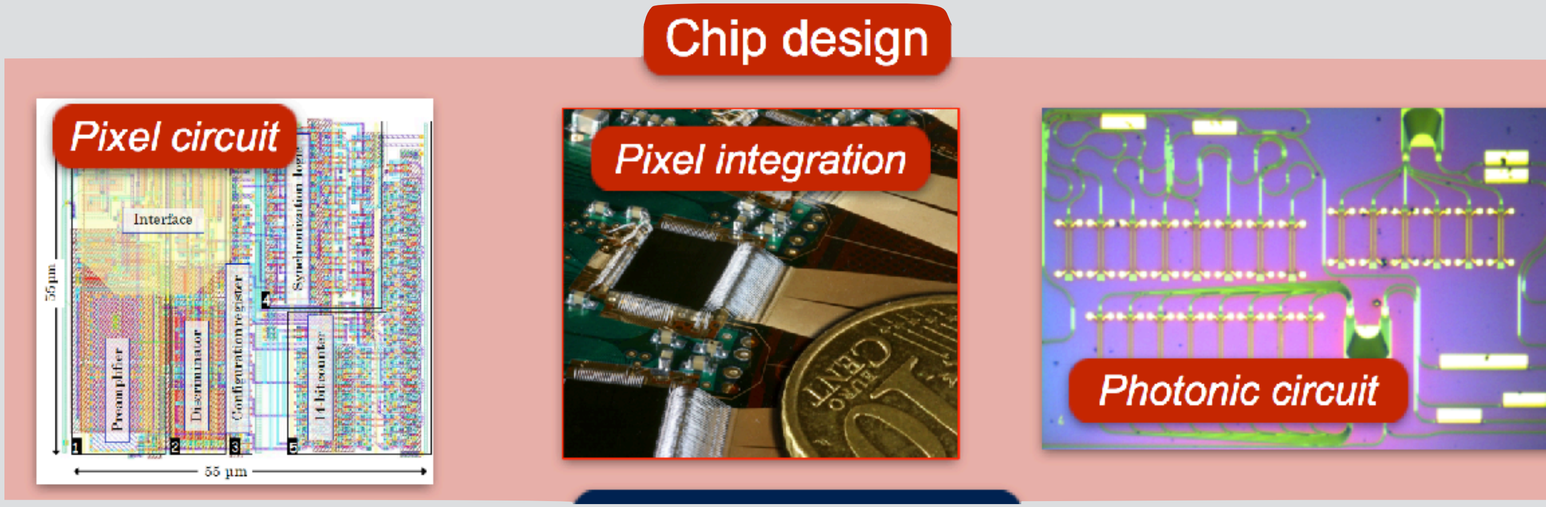


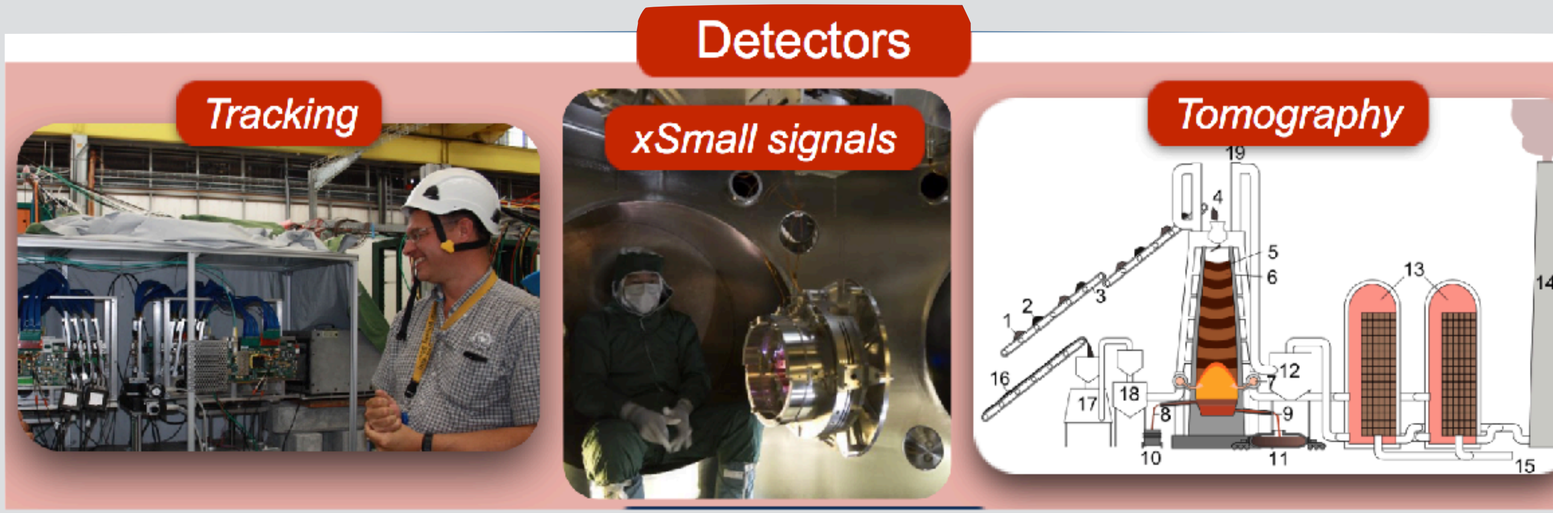


Theory group includes Groningen, Nijmegen, Amsterdam

Detector R&D, spin-off

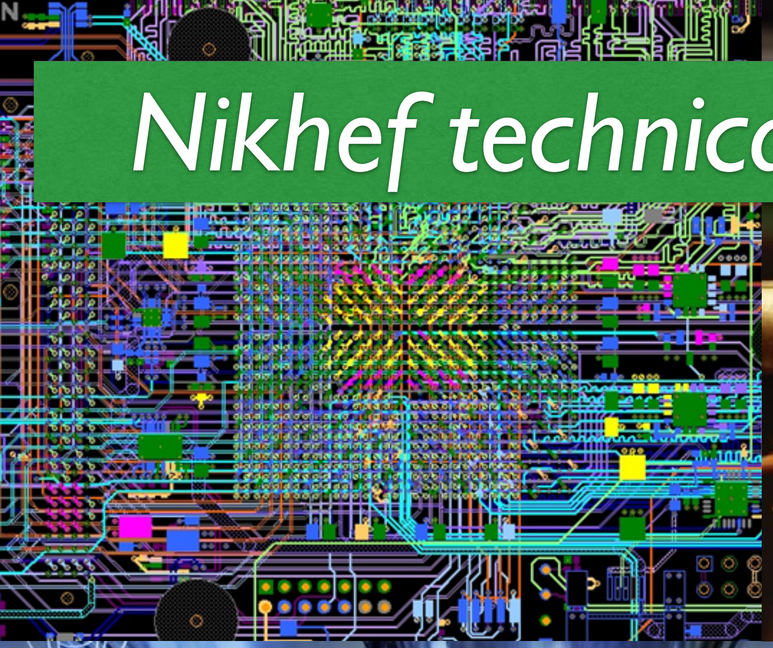
- Activities
  - new technologies
    - microchip - timepix family
    - instrumentation GW
  - knowledge transfer
- Spin-off examples
  - Medipix applications
  - Innoseis

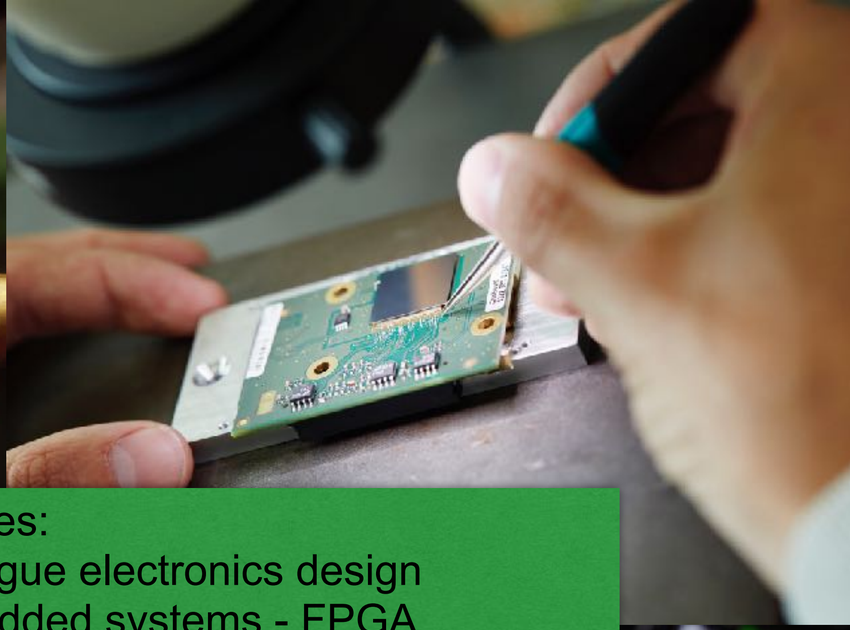




Recently two tenure track positions were offered

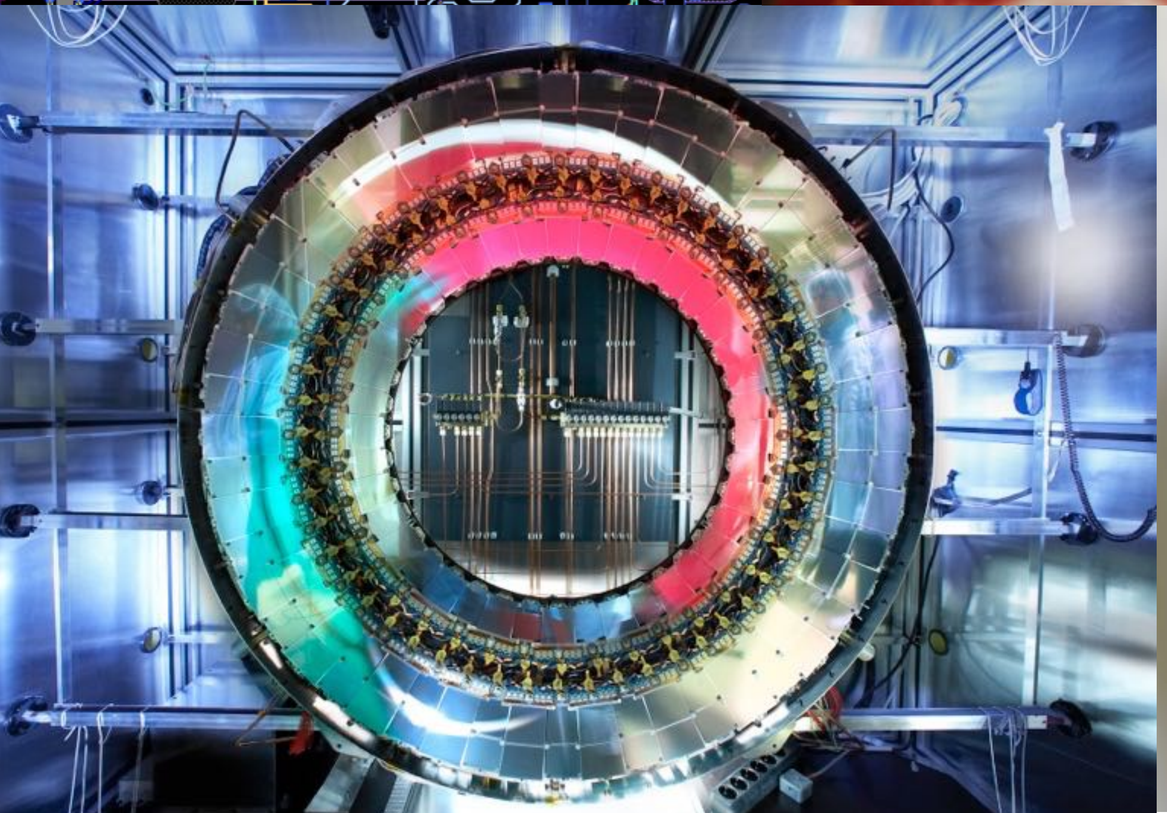
Nikhef technical groups

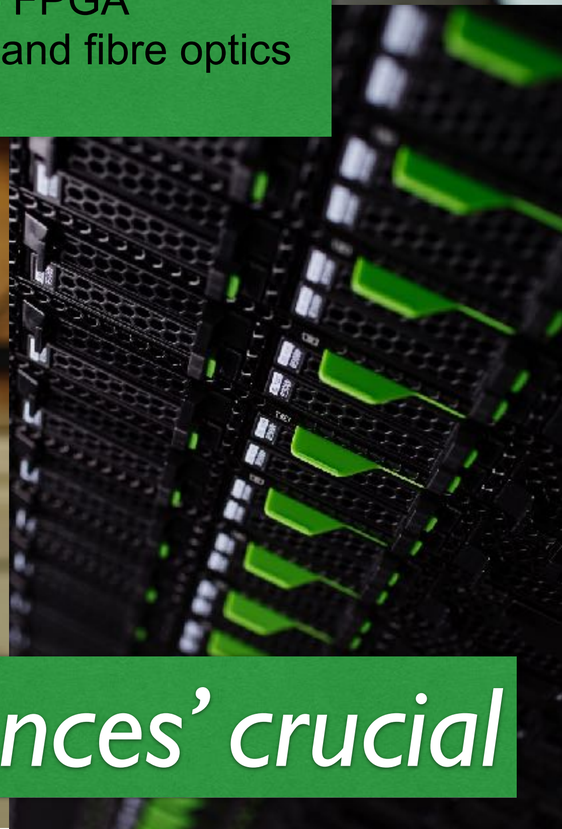




Examples:

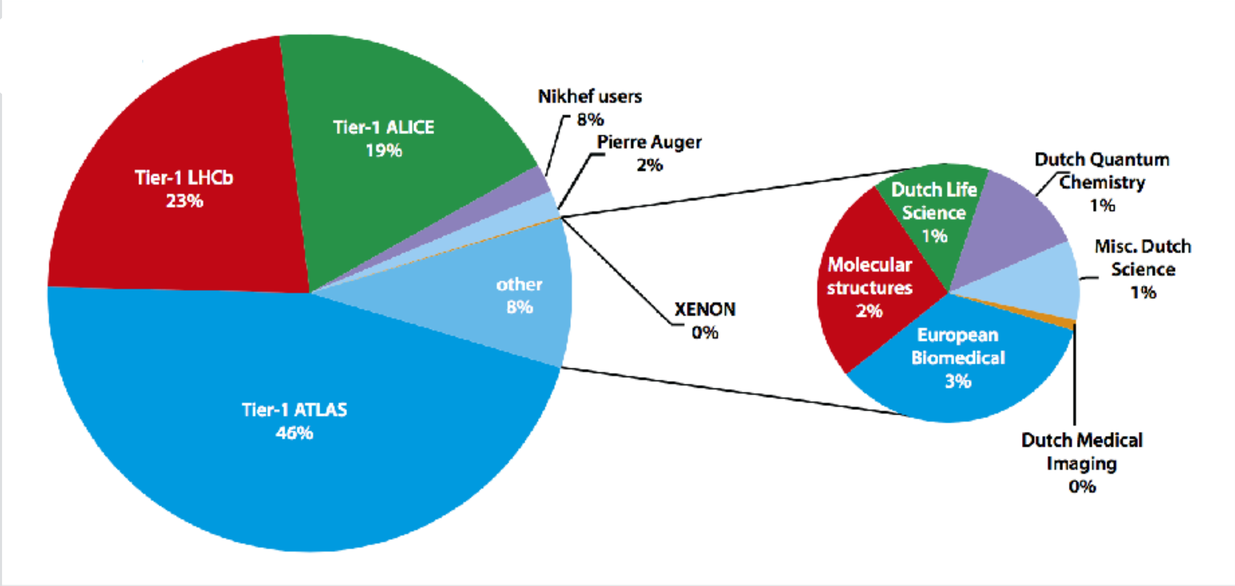
- Analogue electronics design
- Embedded systems - FPGA
- Data communication and fibre optics
- IC design



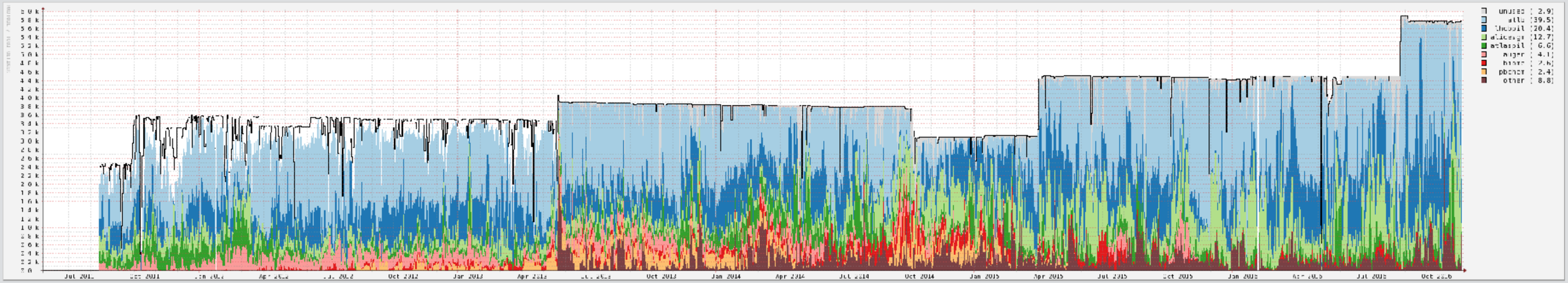


‘Core competences’ crucial

Computing - Big Grid



- Tier1 centre - Steadily growing GRID infrastructure -
  - reaching to almost 6000 cores
  - state-of-the-art networking reaching terabits/s bandwidth
- Available to non-HEP clients (~8%)



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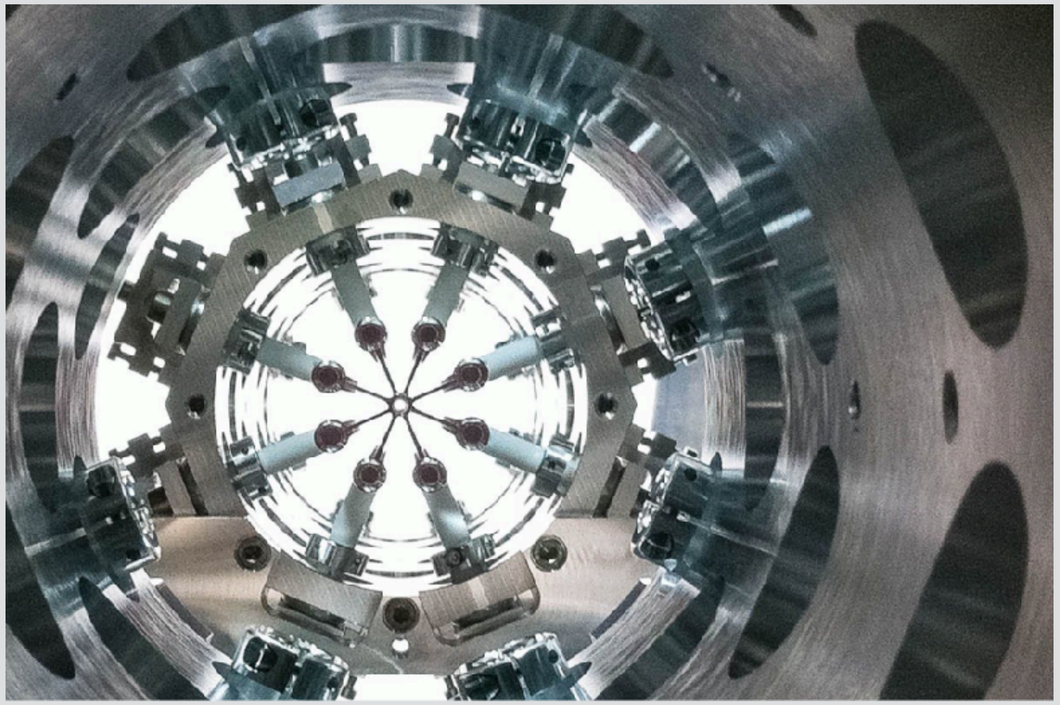
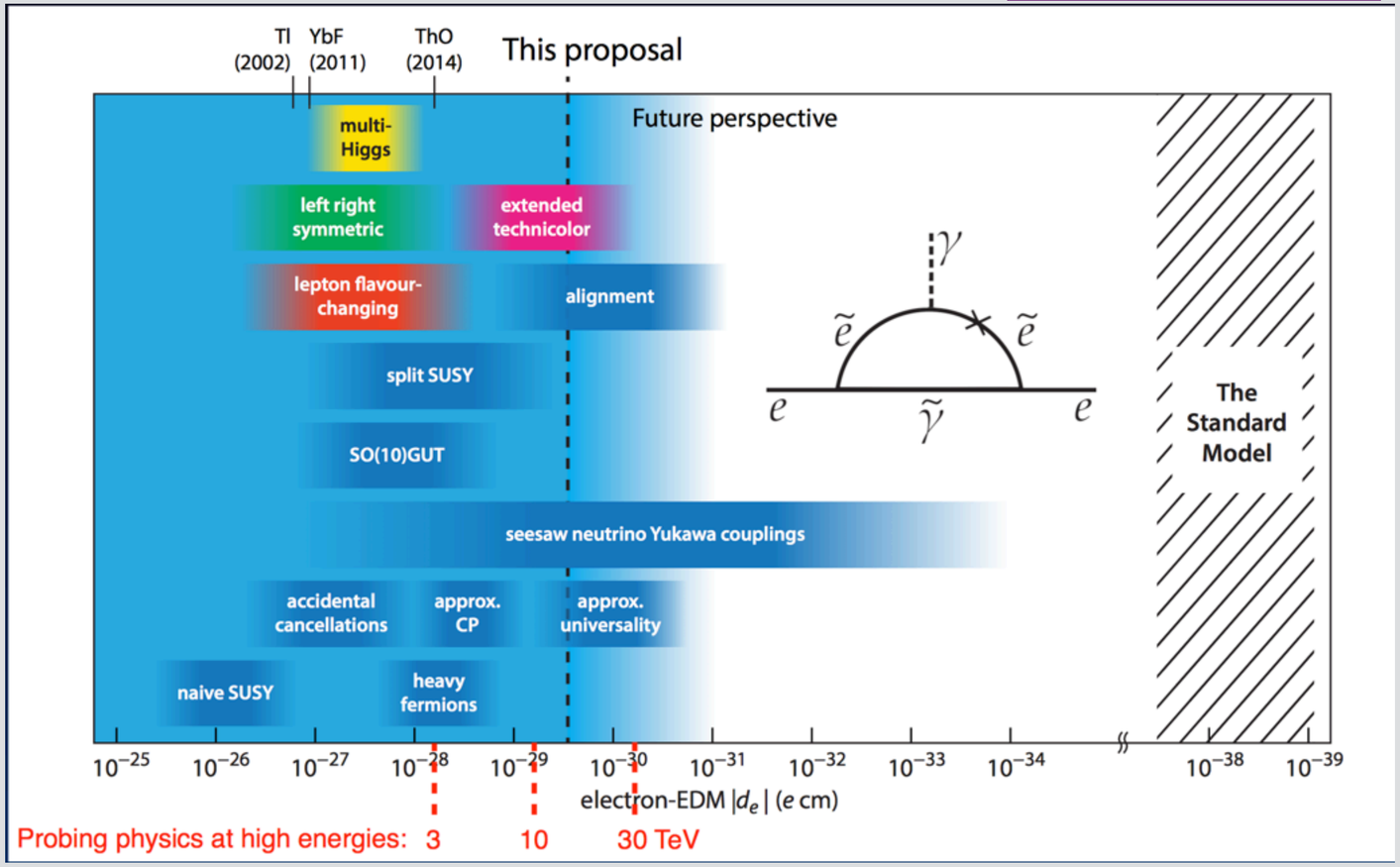
High precision electron EDM

- Measurement of electron Electric Dipole Moment in BaF
  - Use internal electric field in cold polar molecules to enhance by ~10^9
  - Decelerator in Groningen developed
  - Reach sensitivity in 2022

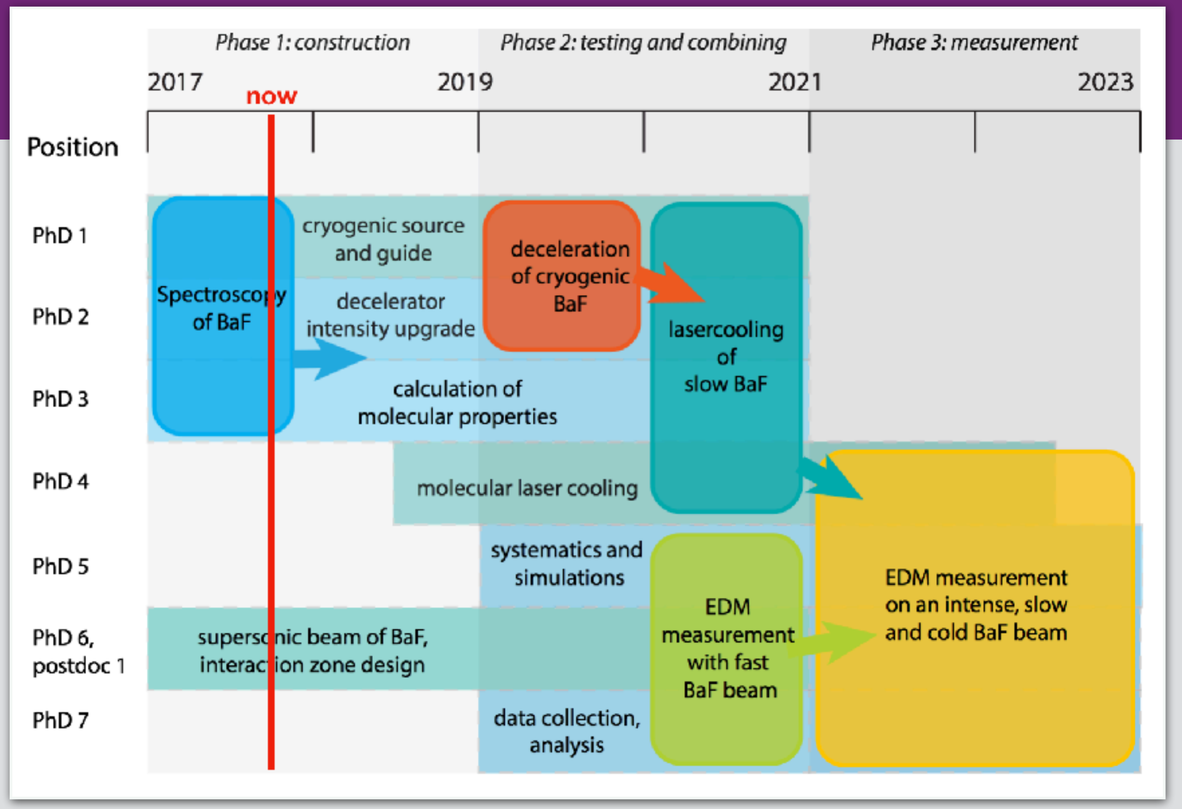
New - 2017



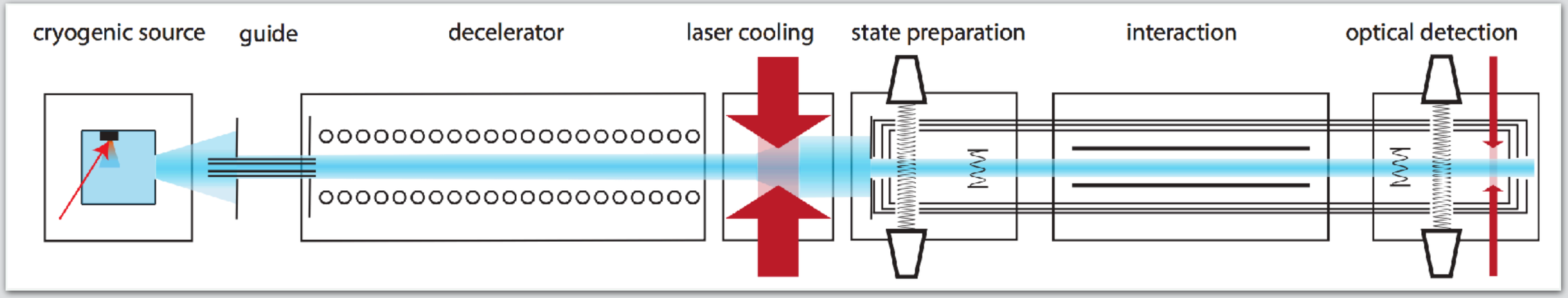


2. 'In house' eEDM

4 m long decelerator of molecules in Groningen



Project base collaboration with VU university on molecular physics



Gravitational Waves

- Virgo online in 2017 - join LIGO
- Ultimate sensitivity ~>2020
- Development roadmap R&D after 2022
  - vd Brand spokesperson Virgo - mei 2017

- 27 research papers
- 38 invited talks at conferences and workshops
- 36 outreach talks
- 5 articles by Nikhef staff in Dutch popular science magazines, and many more by journalists

NU.nl > Overig > Wetenschap

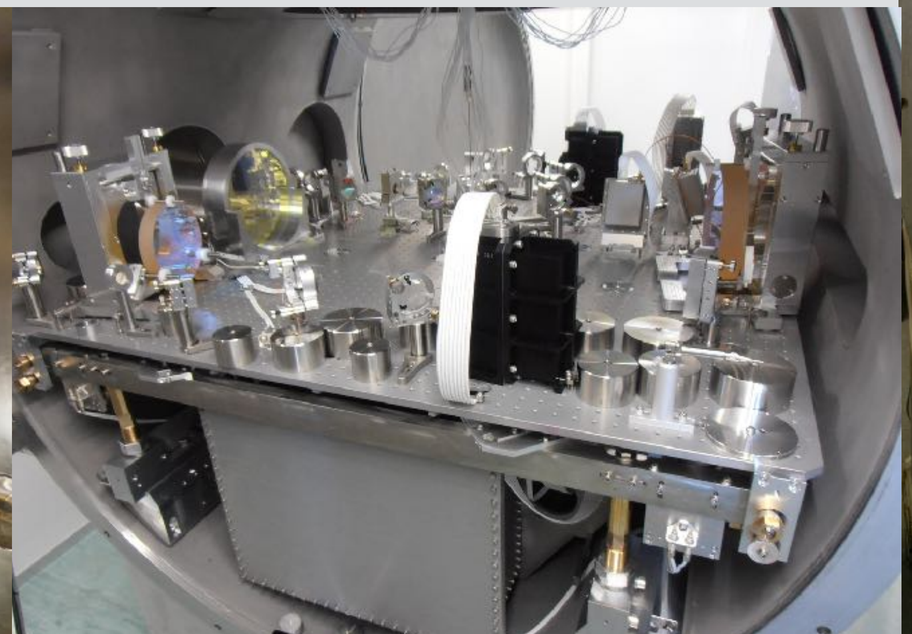
Opnieuw zwaartekrachtgolf van twee zwarte gaten gemeten

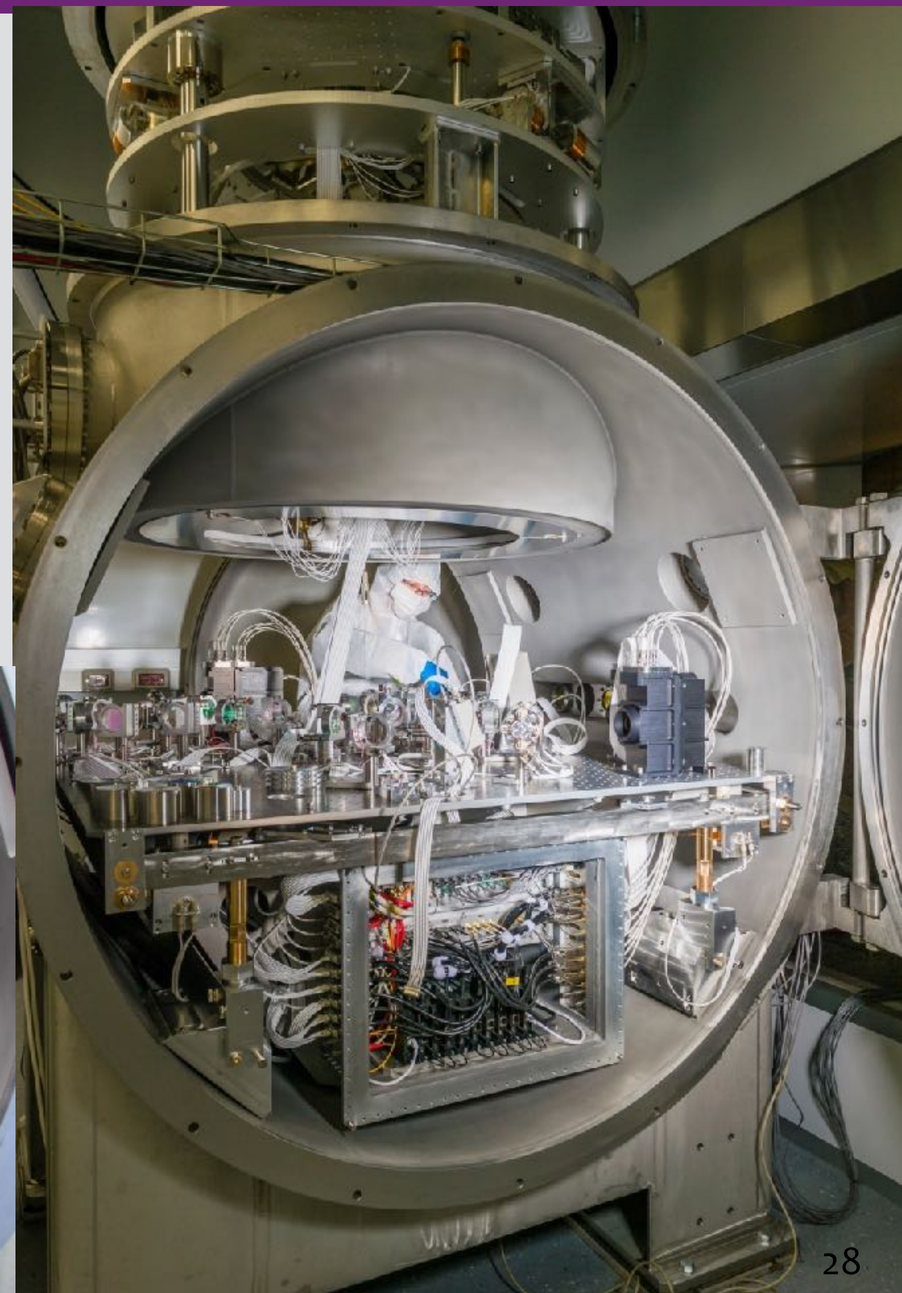
Gepubliceerd: 01 juni 2017 17:22
Laatste update: 01 juni 2017 17:55

Wetenschappers hebben voor de derde keer een zogeheten zwaartekrachtgolf gemeten. Deze golf is afkomstig van twee zwarte gaten op ongeveer drie miljard lichtjaar afstand en bereikte onlangs pas ons deel van het universum.

Nikhef in AdvVirgo

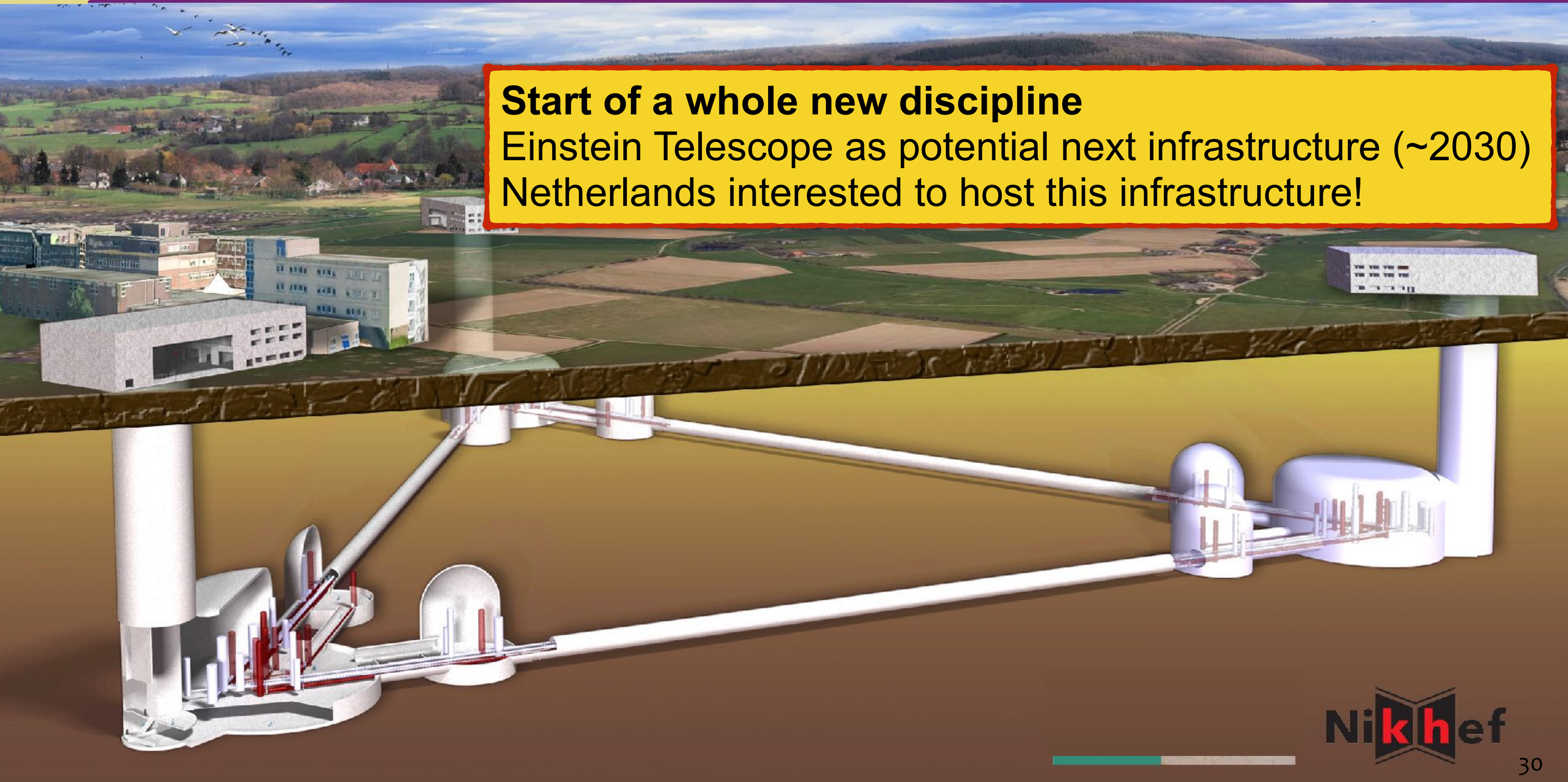
- Hardware responsibilities
  - MultiSAS, cryolinks, linear alignment, phase camera. Commissioning work …
- Data analysis
  - Binary coalescence





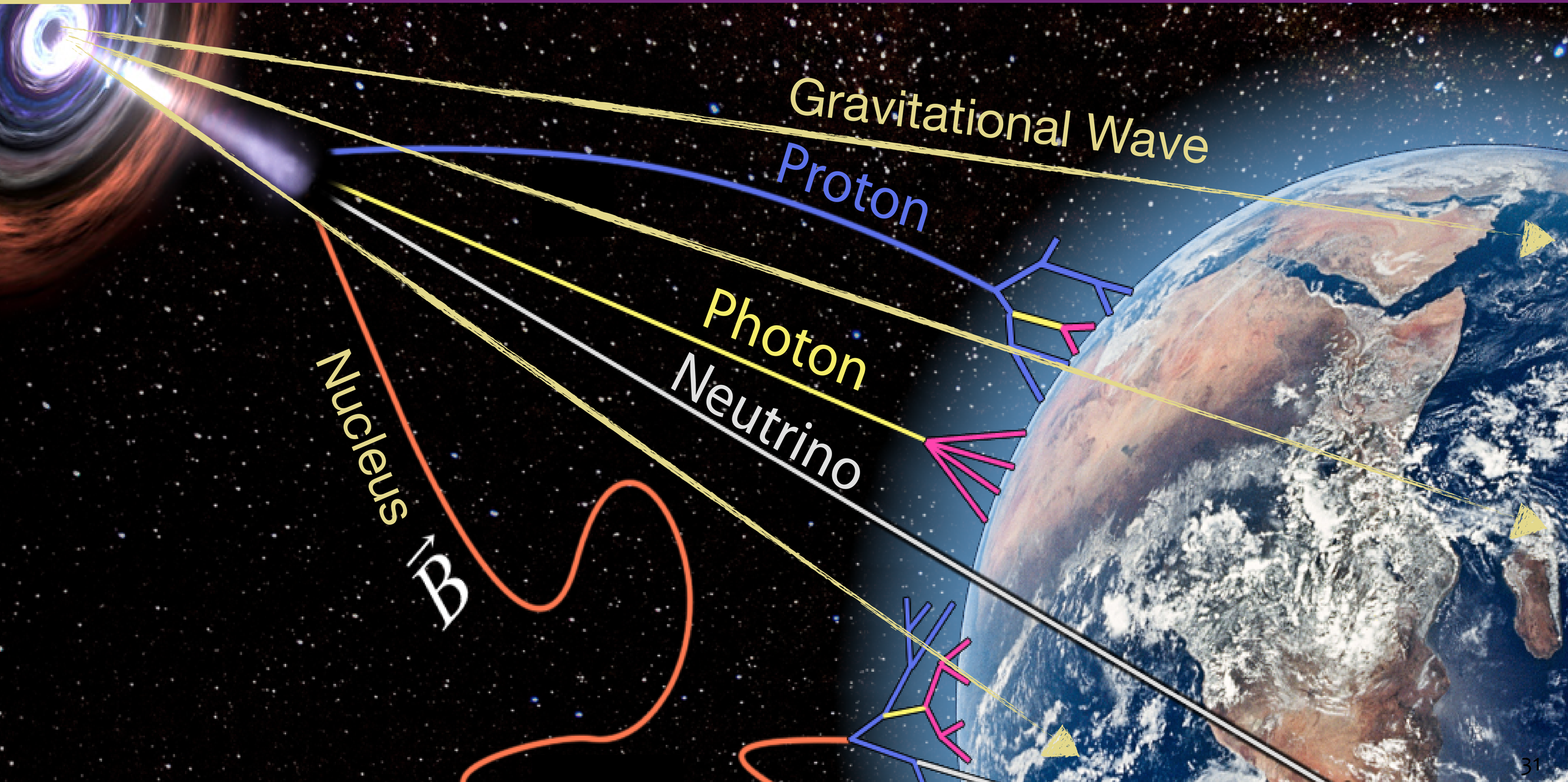
Binary Neutron Star

3rd generation - Einstein



Start of a whole new discipline
Einstein Telescope as potential next infrastructure (~2030)
Netherlands interested to host this infrastructure!

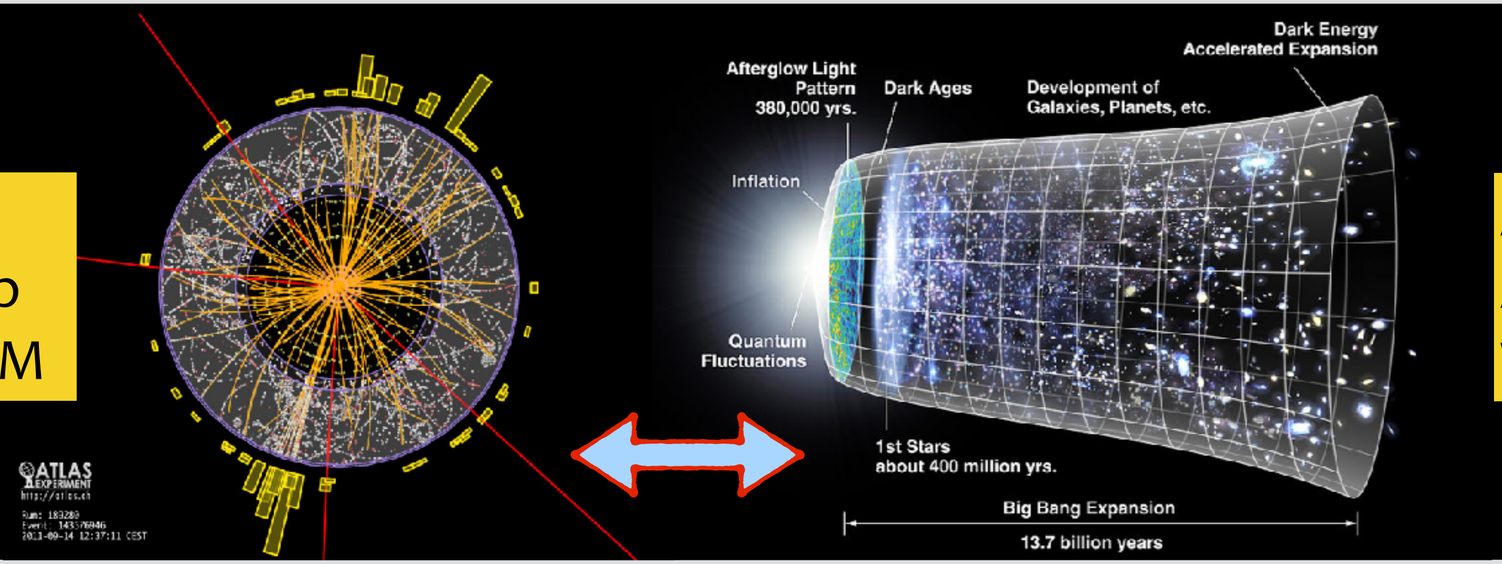
Multimessenger APP



Particle physics

LHC experiments form ‘backbone’ of Nikhef
Astroparticle physics is a central activity

LHC
ALICE, ATLAS, LHCb
High-precision eEDM



Astroparticles
Auger, KM3NeT, Virgo, XENON

- Enablers
  - Detector R&D
  - Theory phenomenology
  - Physics Data Processing
- Technical support
  - Mechanical technology
  - Electronics
  - Computing