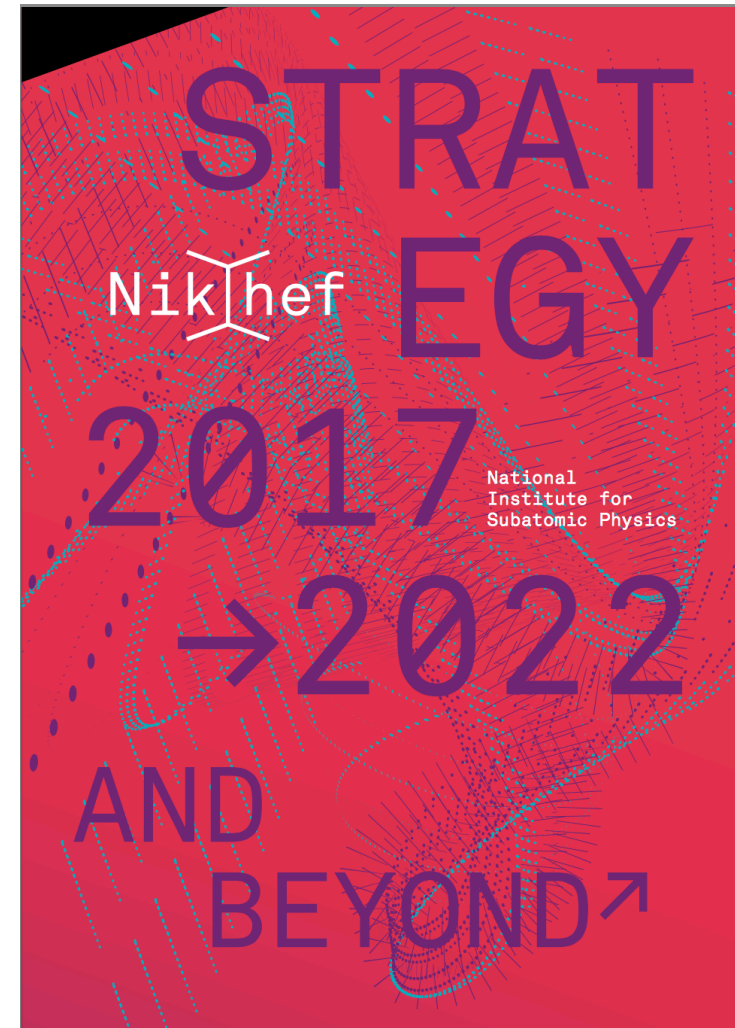


The logo for Nikhef, featuring the word "Nikhef" in a white, sans-serif font. The letter "i" has a dot, and the letter "k" has a vertical bar. The "h" is stylized with a vertical bar and a horizontal bar. The "e" has a horizontal bar. The "f" has a vertical bar and a horizontal bar. The logo is centered in the upper half of the slide.

Nikhef

Conclusions  
December 12, 2017

- Panel visit, September 18+19  
– Thanks to all of you!





- Nikhef is a world leading laboratory in particle physics,
  - with outstanding achievements in detector and electronics design, construction and commissioning, physics analysis and advanced computing techniques, supported by a strong theory group.
- The way the Nikhef laboratory is organized is enviable -
  - underpinning its past and undoubtedly its future success.
- Nikhef makes an outstanding contribution to the society.

- Scientific quality: world-class
- Relevance to society: world-class
- Viability: very good
  - We recommend mission budget be increased.
  - Renovate the Nikhef buildings.
- NWO next step:
  - Portfolio analysis of institutes collection (end 2018)
    - What is the institute's added value in the national context and its international position?
    - Are the institutes responsive and dynamic to account for the societal challenges?



- Core values for NWO
  - Groundbreaking
  - Committed
  - Reliable
  - Connecting



nationale  
wetenschaps  
agenda



*Building Blocks of Matter and  
Fundamentals of Space & Time*

- Coalition agreement recent government:
  - Additional funding for fundamental science -
    - Nationale Science Agenda in new NWO

Bouwstenen van materie en  
fundamenten van ruimte en  
tijd ▶



# Nikhef 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

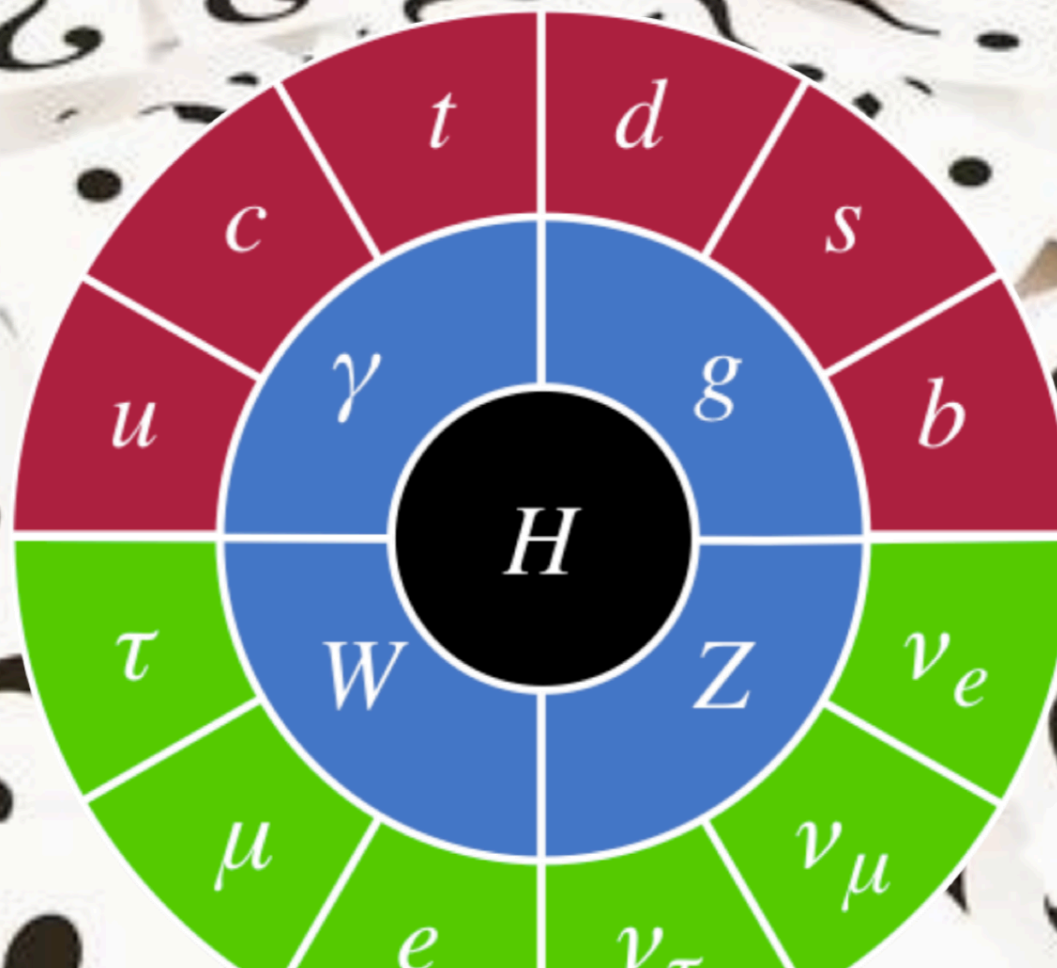
## 2. *New opportunities:*

- 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





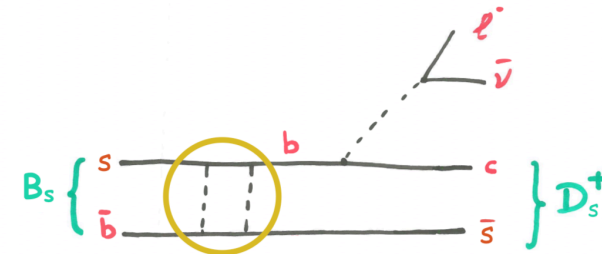
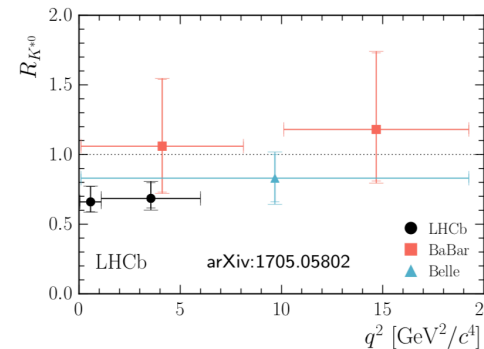
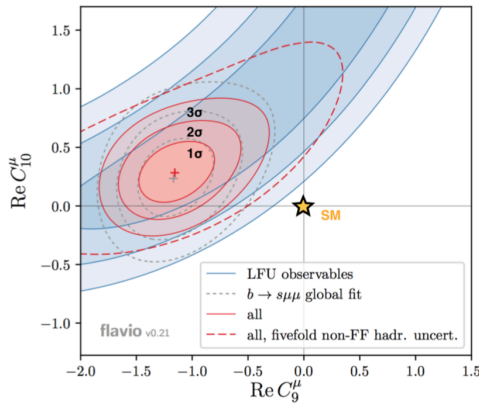
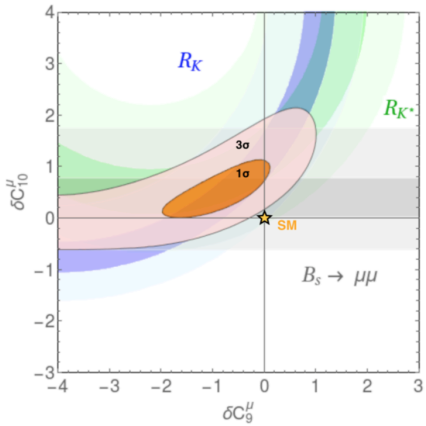
*After Higgs - fundamental & new challenges !*

# LHC data exciting

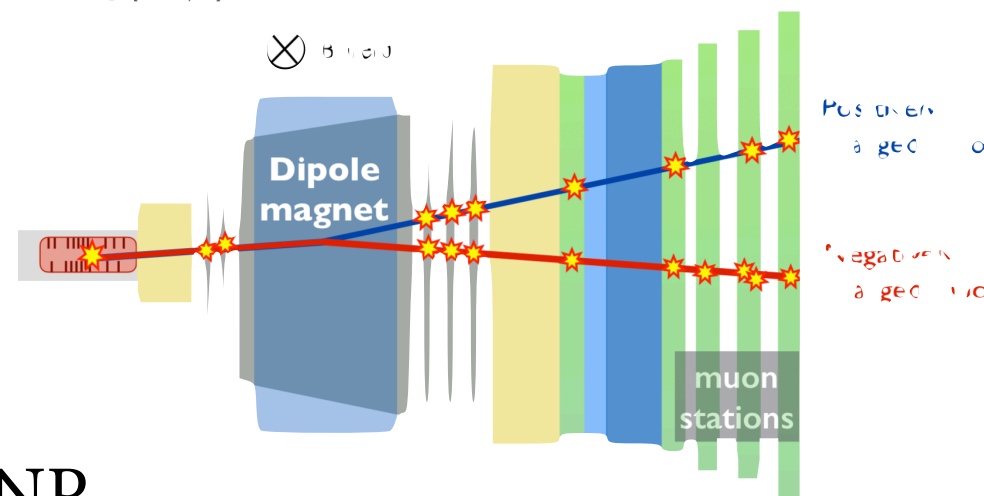
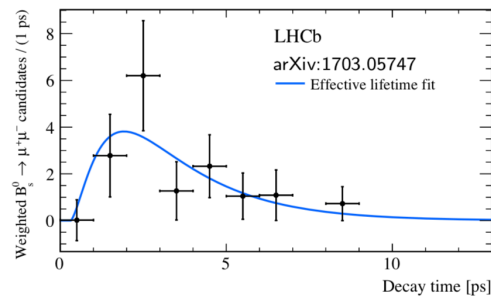
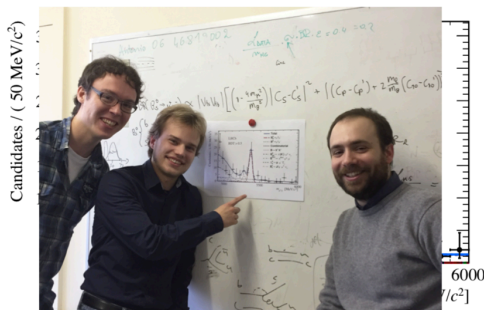
Clean observables (3.5-4 $\sigma$ )

All observables (4-6 $\sigma$ )

From April this year!  
(2 bins with 2.2, 2.5 $\sigma$  resp.)



Mick Mulder



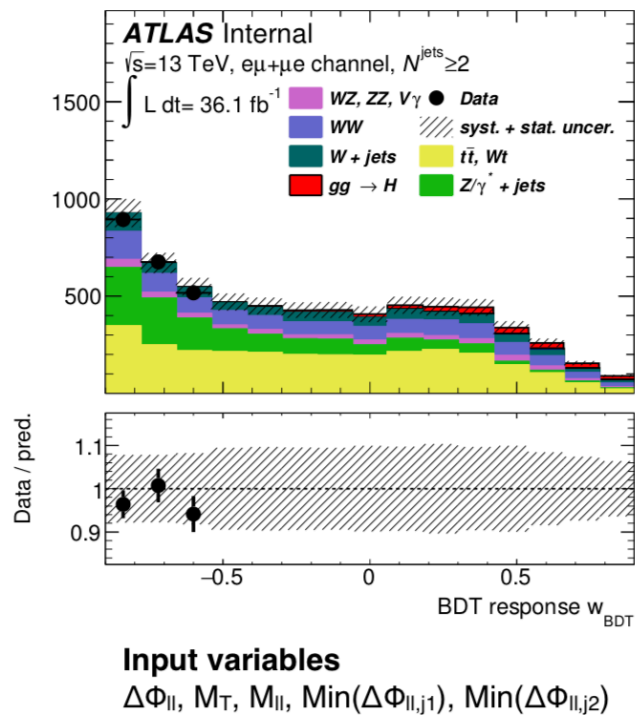
Laurant Dufour

- My (opportunistic) bet for the key to NP...



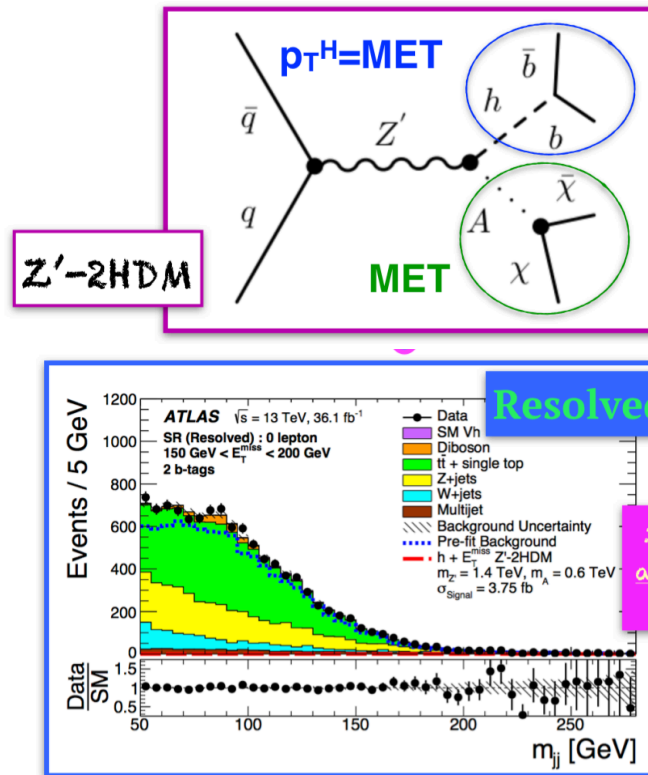
# LHC data - in full swing!

- Higgs properties
  - CP of Higgs



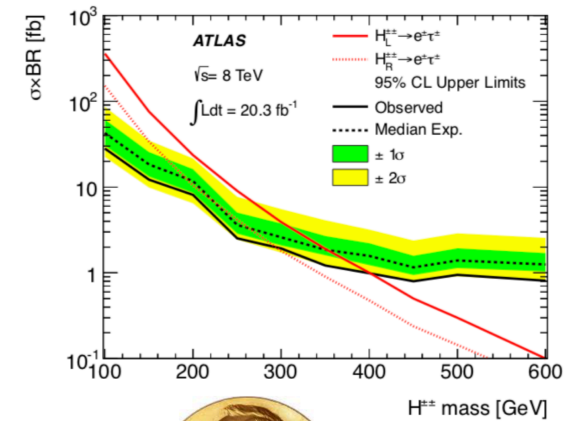
Remco Casteleijn

## Mono-jets



Veronica Fabiani

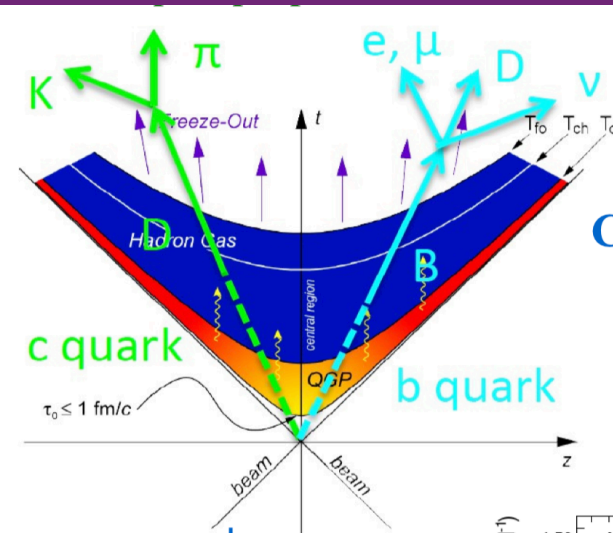
## LFV



Marcus Morgenstern

- Collective Flow
  - already strong constraints on shear viscosity, open questions initial state, hadronization, ...
- Hard and EM Probes
  - jet structure measurements can be used to constrain interference in the jets, medium properties, thermalisation, degrees of freedom, ...
- Heavy flavour
  - special role as it is a well calibrated probe and contributes to better understanding of collective flow and jet-medium interactions
- Correlations
  - Understanding the magnetic field in these collisions and the strong cp violation

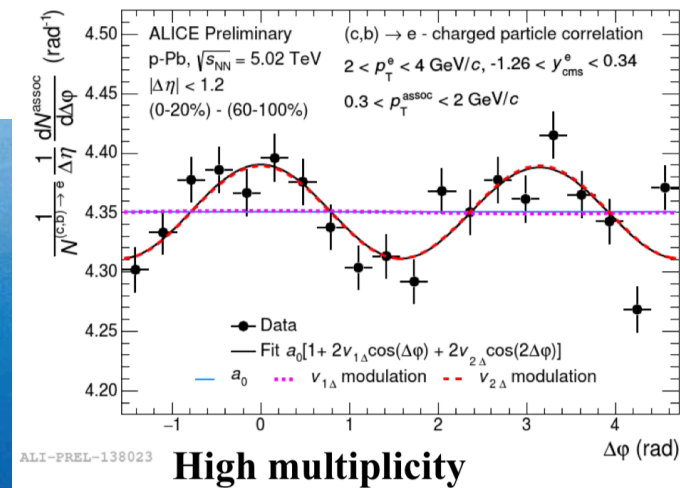
*Raymond Snelling*



*Cristina Bedda*

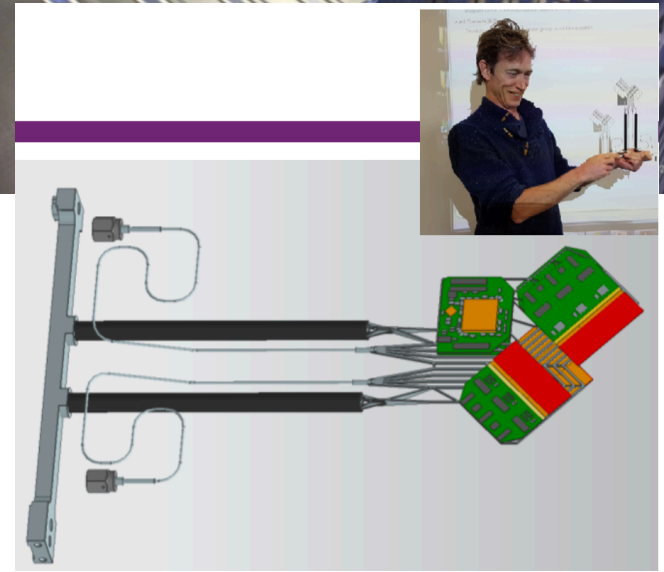
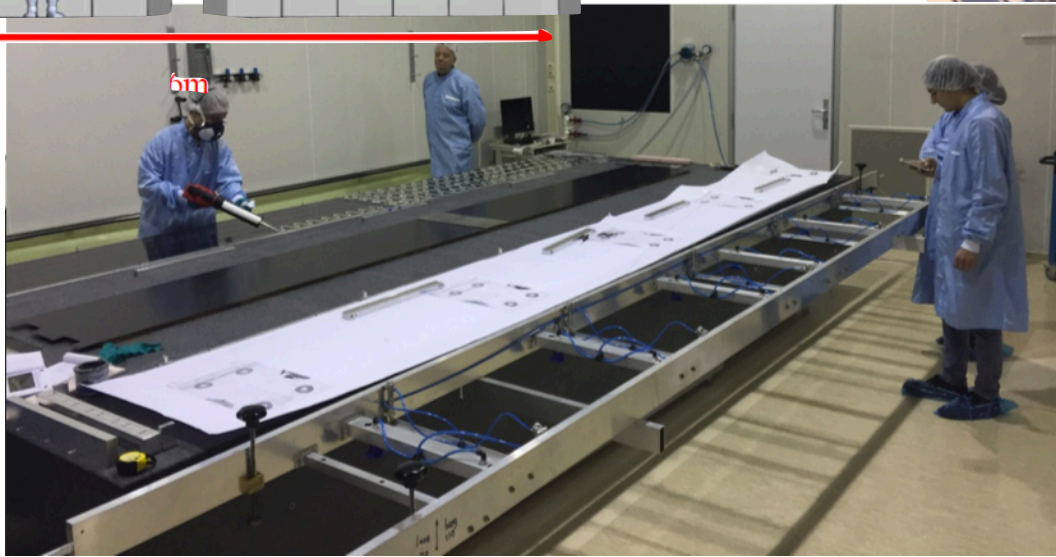
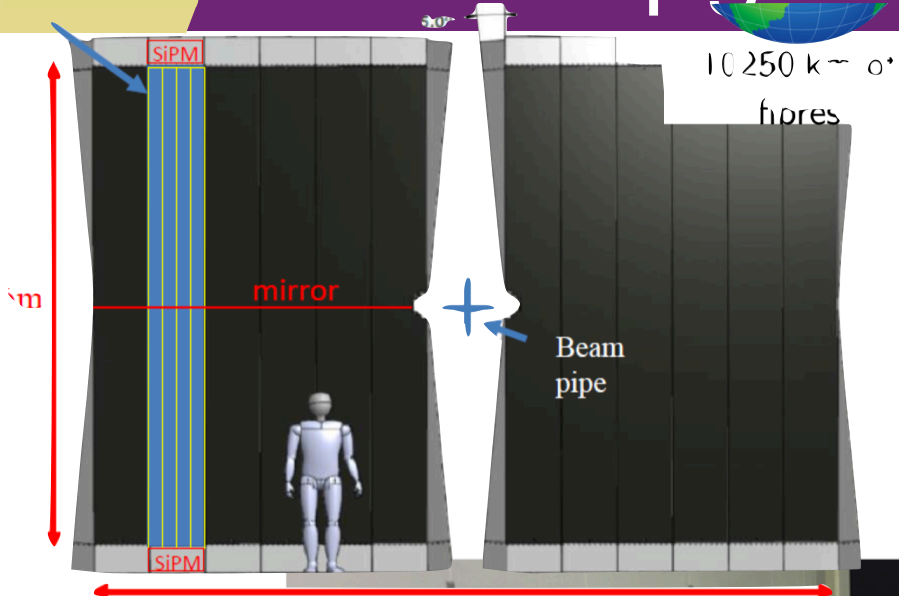


*New emerging collective degrees of freedom?*



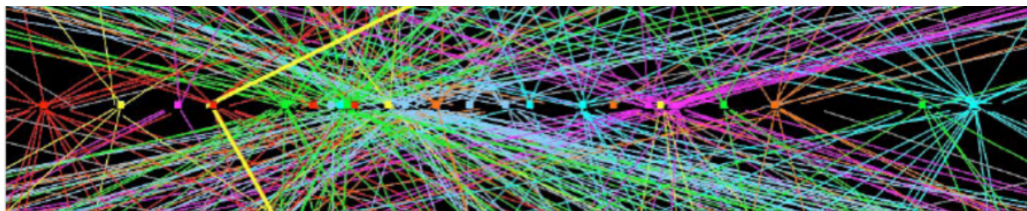


# LHCb upgrade

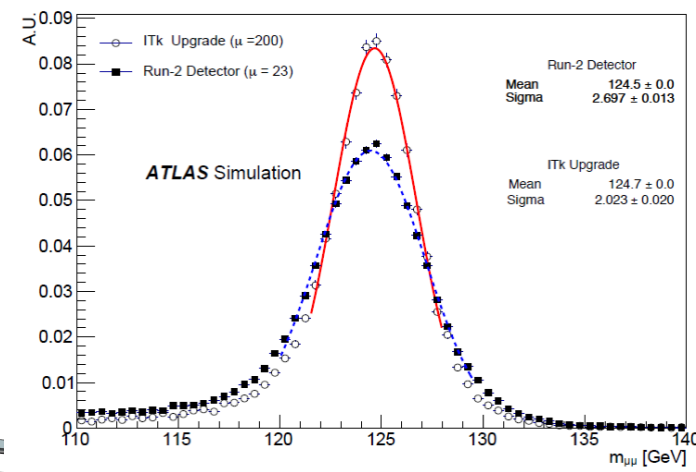
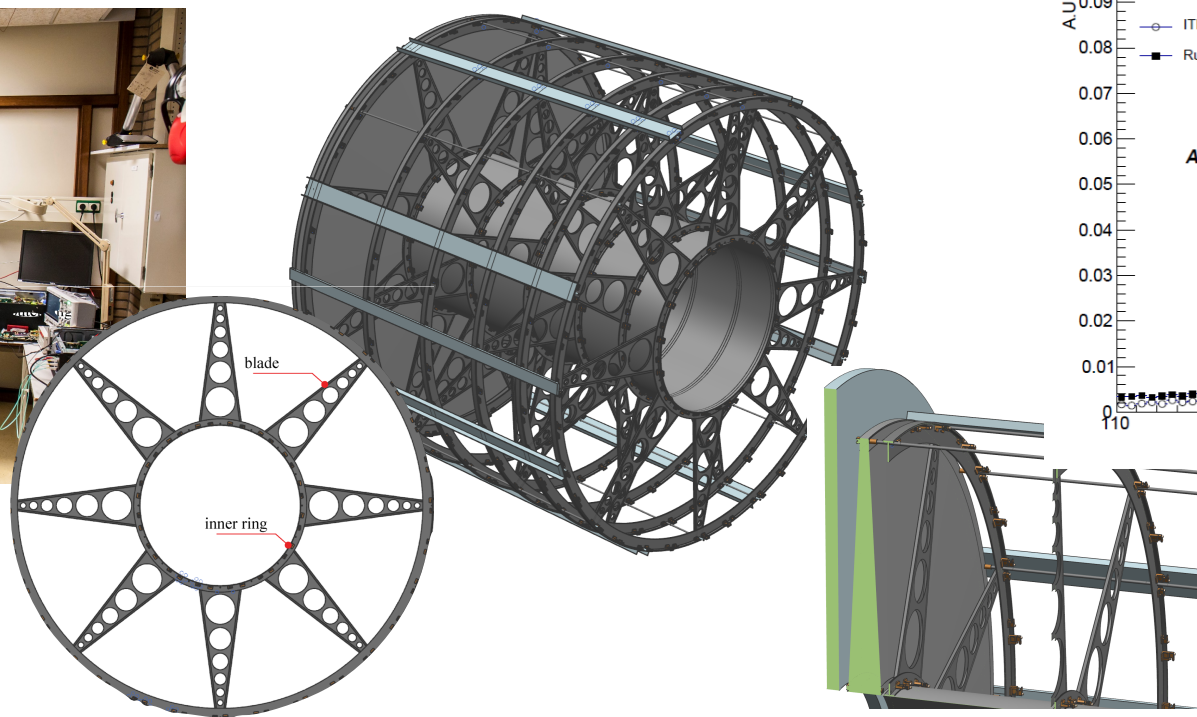
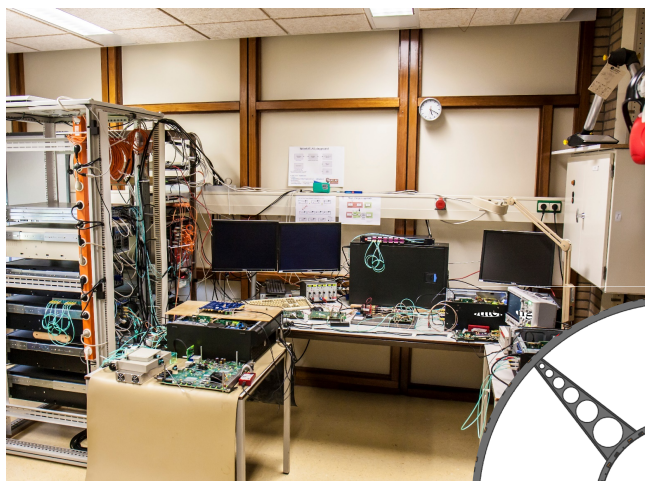


Patrick Koppenberg

# Upgrades



- Number of vertices increases from  $\sim 25$  -  $\sim 200$   $\rightarrow$  requires higher granularity and higher trigger bandwidth



Marcel Vreeswijk

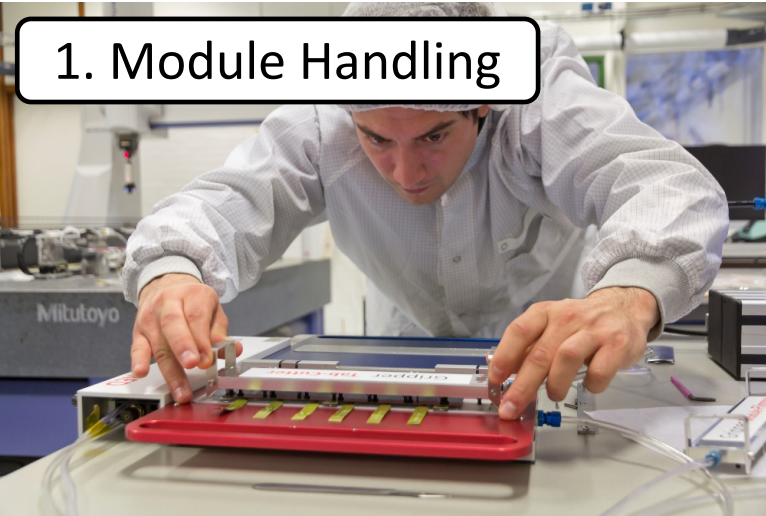


# FIRST HALF STAVE READY

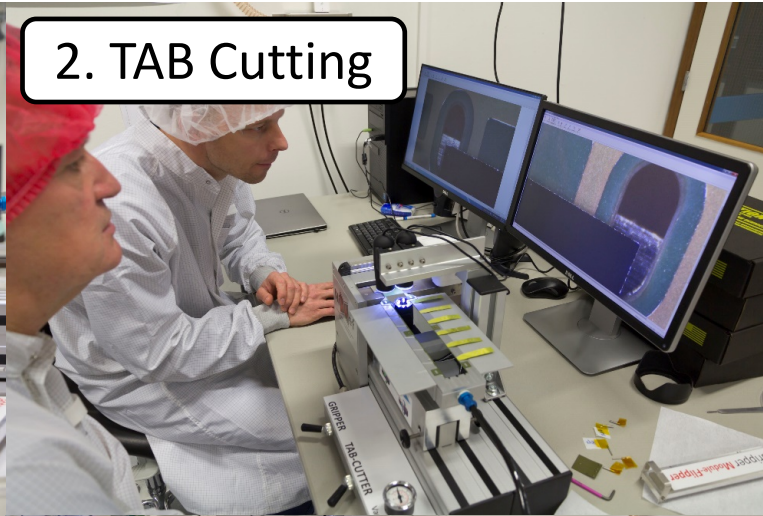
Goran Simatovic

ALICE Inner Tracker System

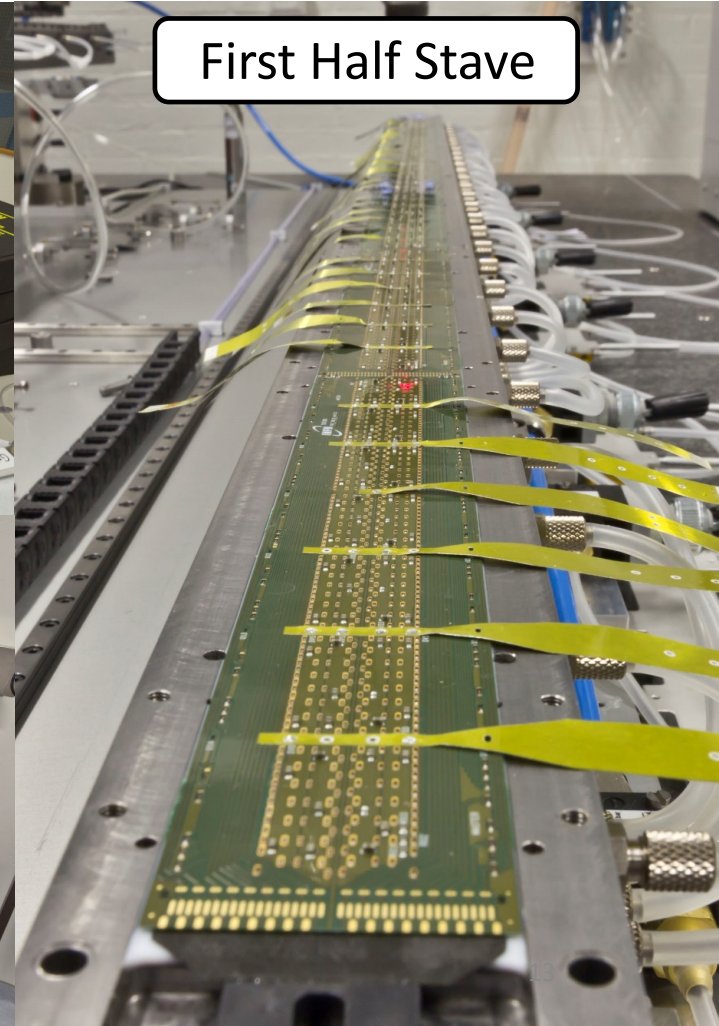
1. Module Handling



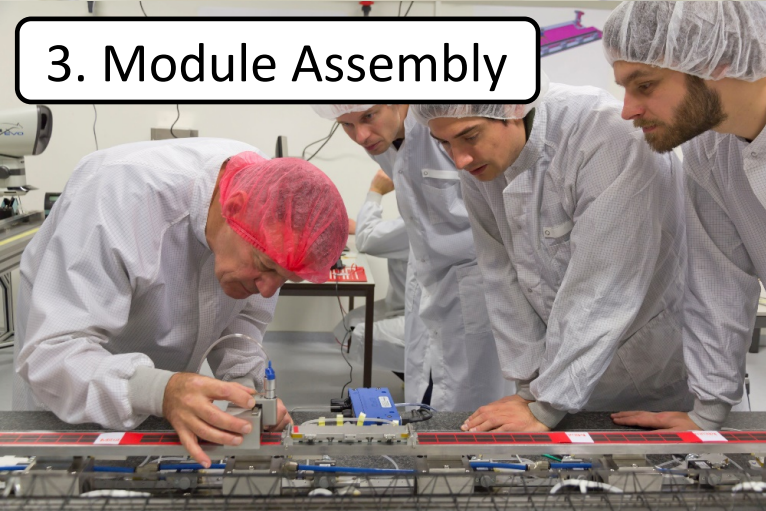
2. TAB Cutting



First Half Stave



3. Module Assembly



4. Soldering





# KM3NeT preparations

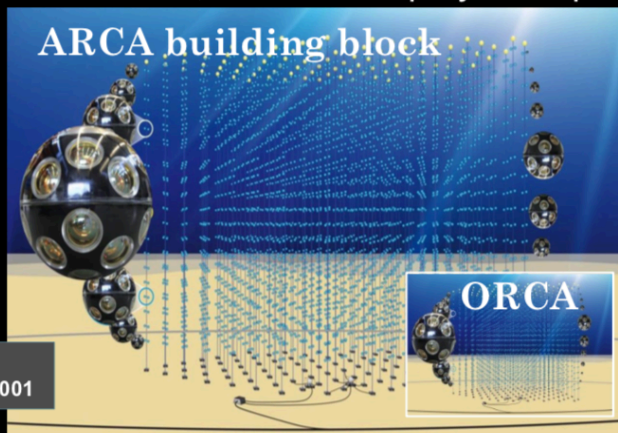
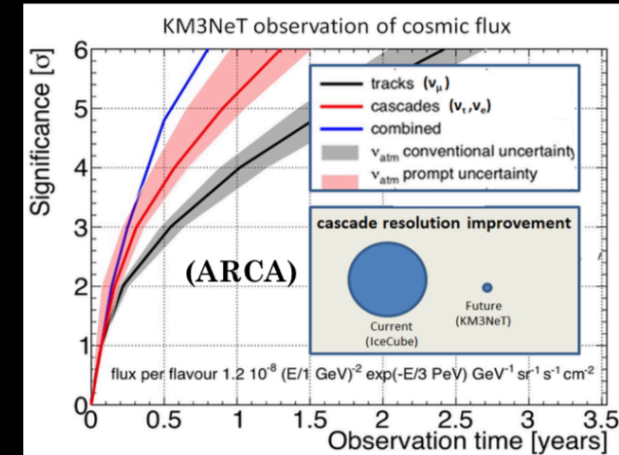
## KM3NeT, neutrino observatory in the Mediterranean – deployment has started

### ARCA: Astrophysical Research with Cosmic in the Abyss

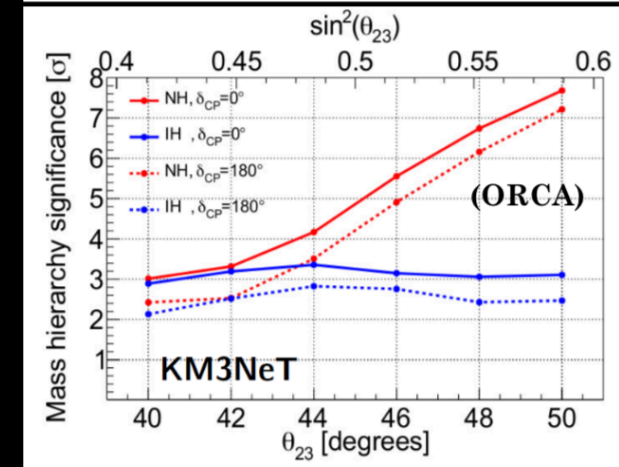
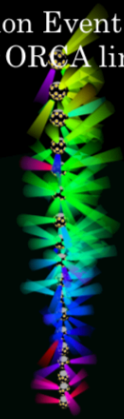
- 2 'building blocks' of 115 lines in Italy
- Find the sources of PeV cosmic (IceCube) neutrinos: excellent angular resolution for each neutrino flavour
- First lines deployed, planned completion 2022

### ORCA: Oscillations Research with Cosmics in the Abyss

- Densely instrumented block of 115 lines in France
- Atmospheric neutrinos between 1 and 100 GeV
- Mass hierarchy:  $3\sigma$  in 4 years for all  $\theta_{23}$  +  $\nu_\tau$  appearance + new physics +  $\theta_{23}$  + Dark Matter
- Planned completion: 2020, First line deployed Sept. 22; all sensors working

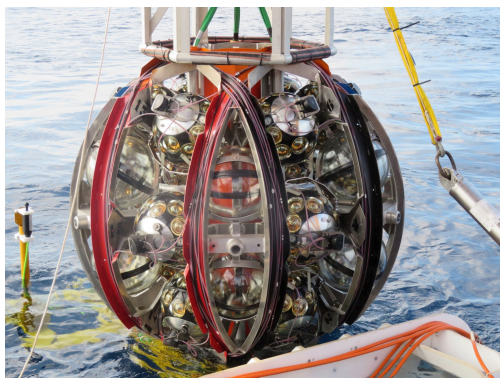


Muon Event in 1<sup>st</sup> ORCA line

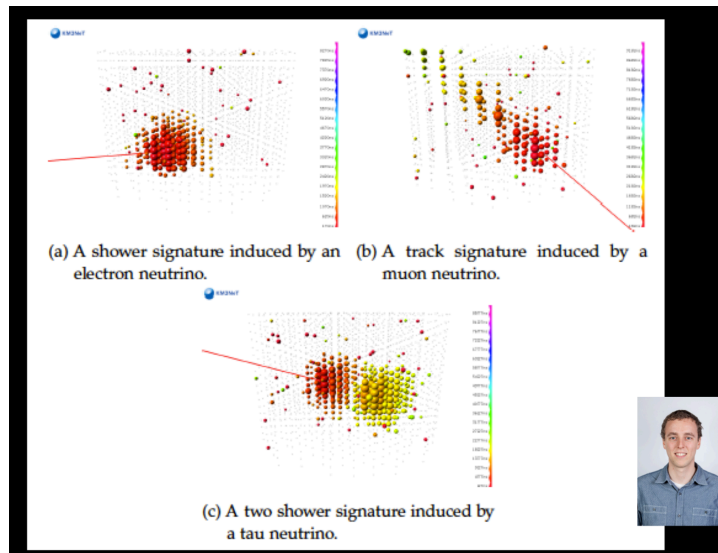
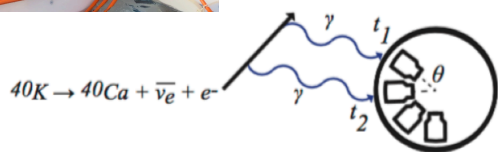


Letter of Intent:  
J.Phys. G43 (2016) no.8, 084001

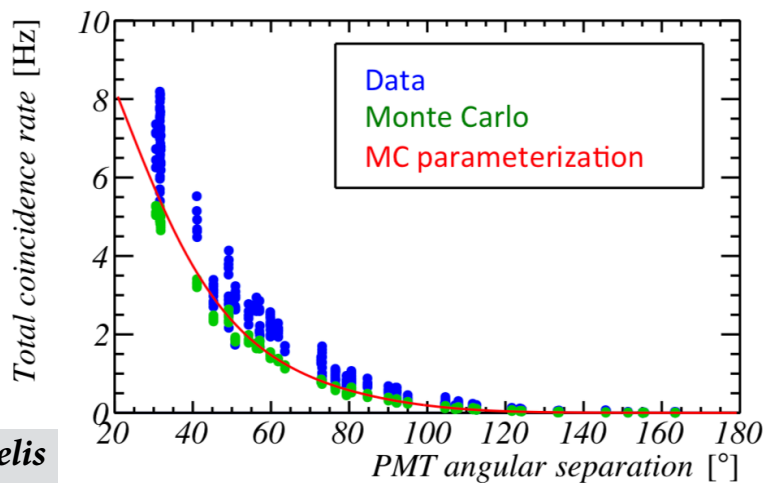
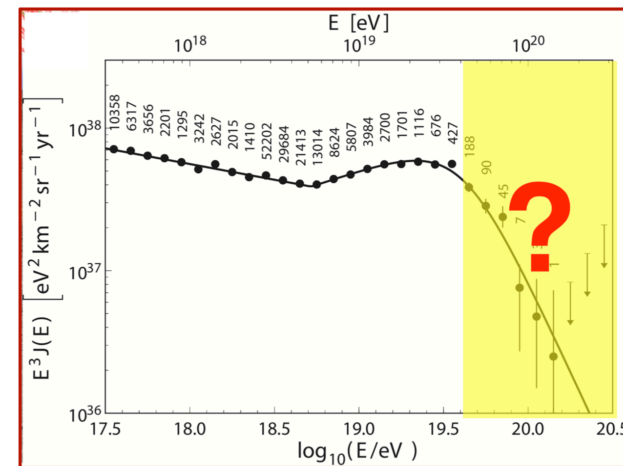
# Data coming - APP experiments



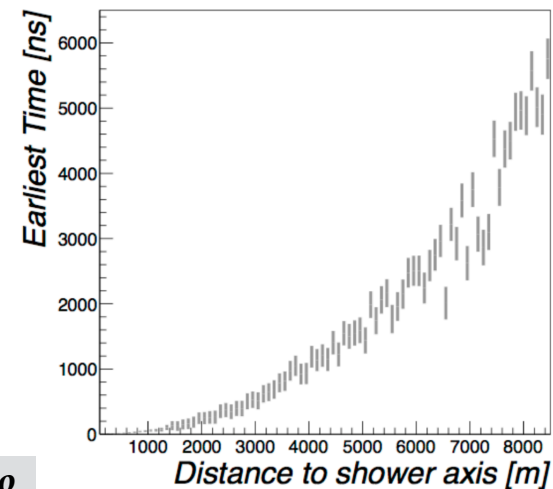
Auger



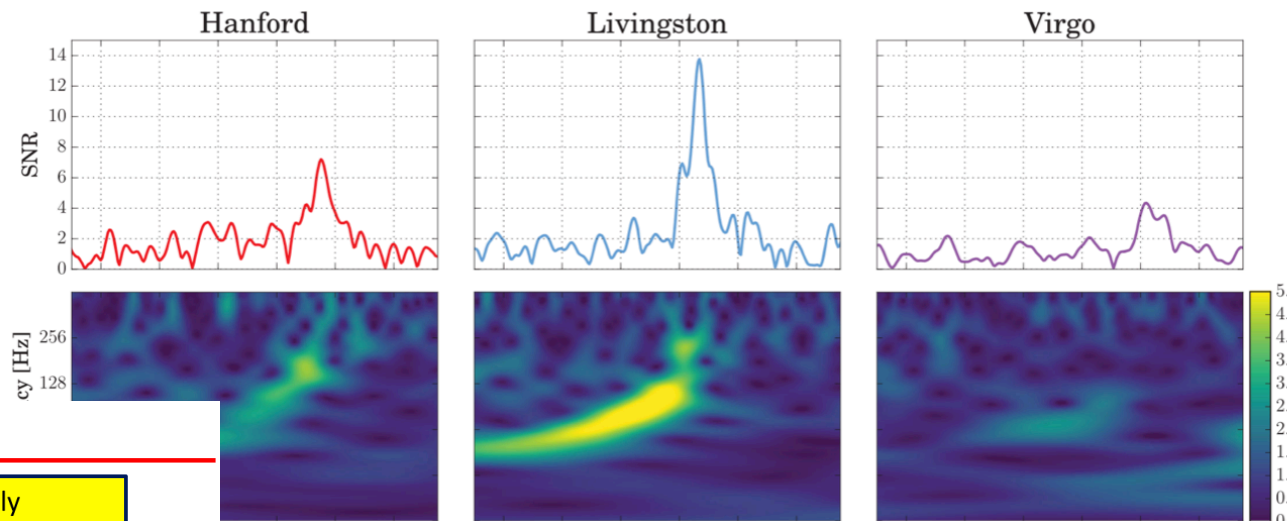
Robert Bormuth



Karel Melis



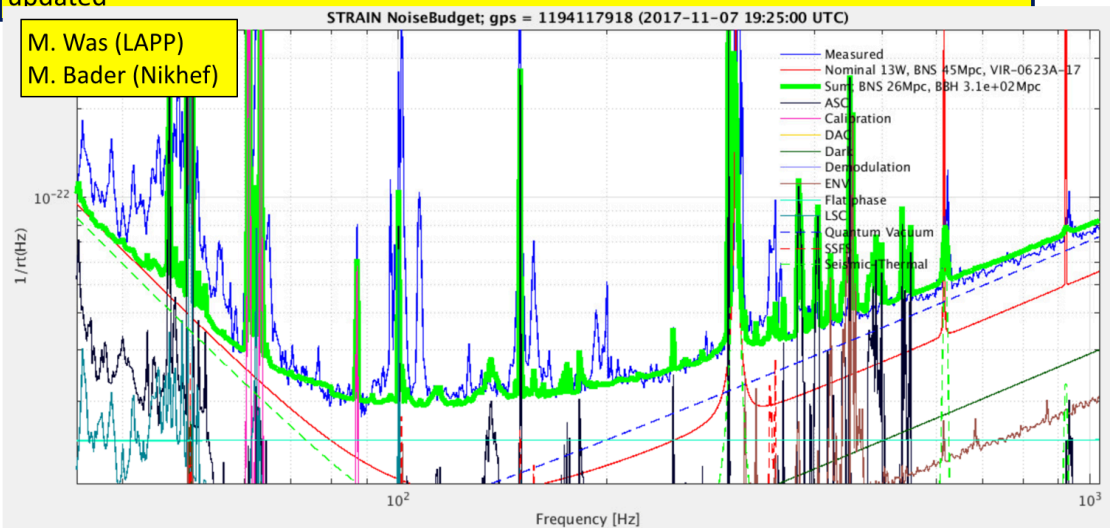
Giuseppe De Mauro



## Virgo commissioning

**Noise budget** ⇔ measured vs modeled breakdown of the noise curve daily updated

M. Was (LAPP)  
M. Bader (Nikhef)



Alessandro Bertolini

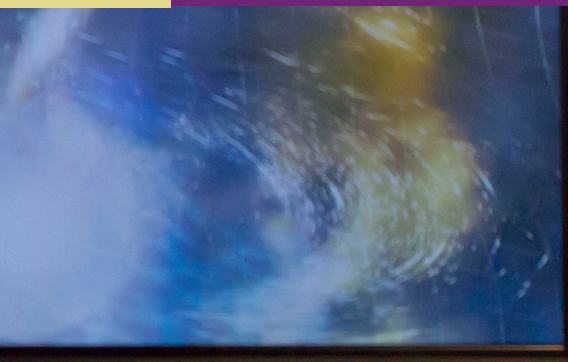


# Nobel prize banquet



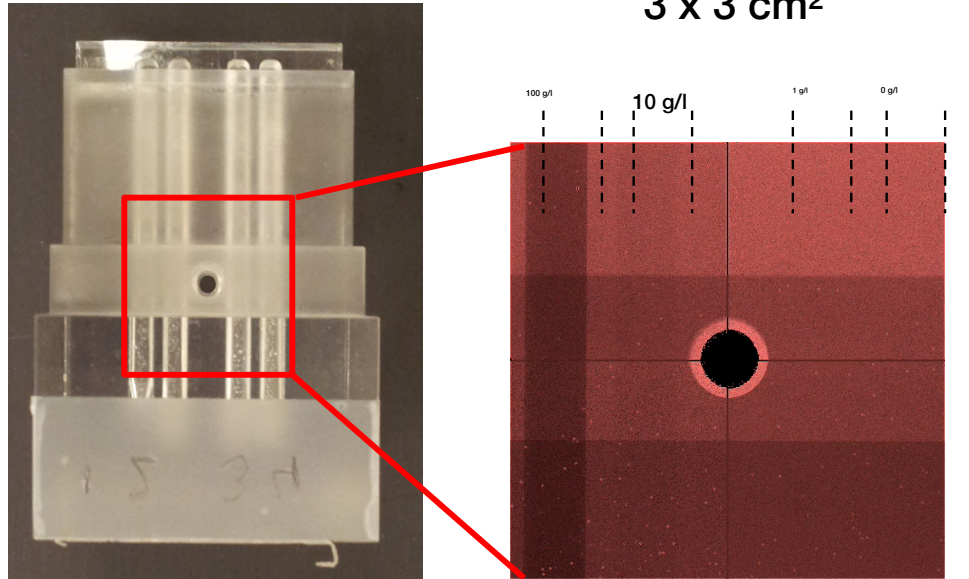


# NS coalescence

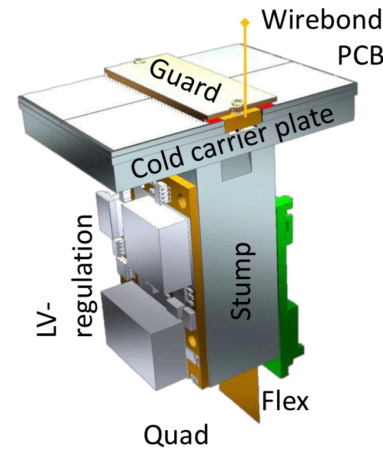
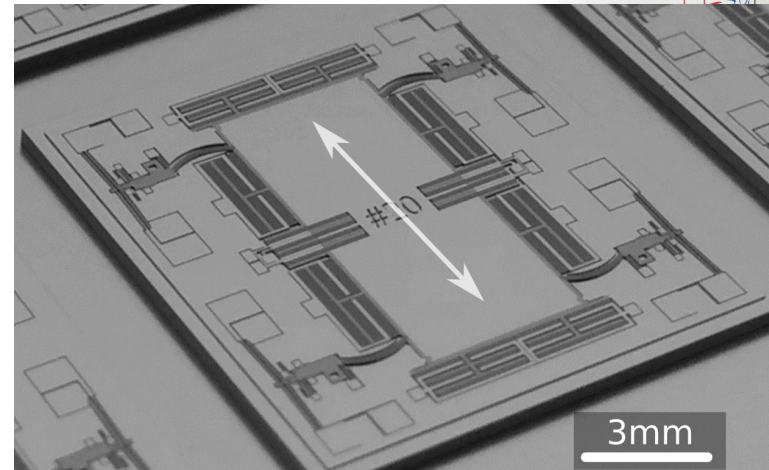
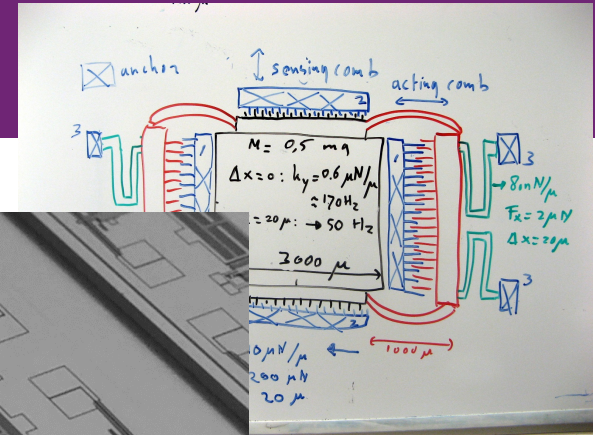




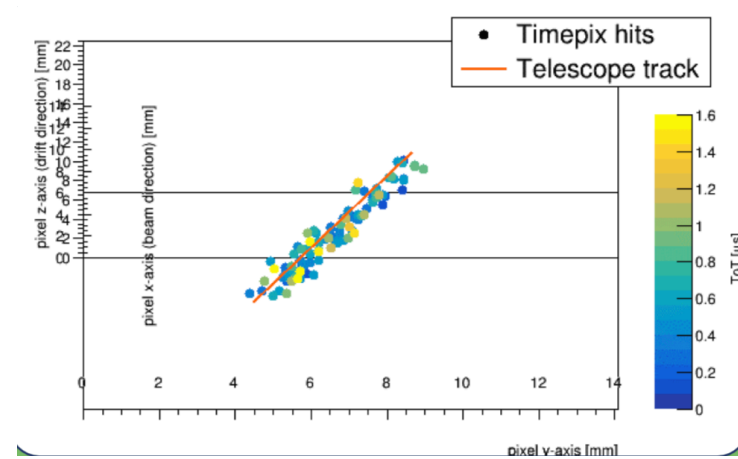
**Martin van Beusekom**  
3 x 3 cm<sup>2</sup>



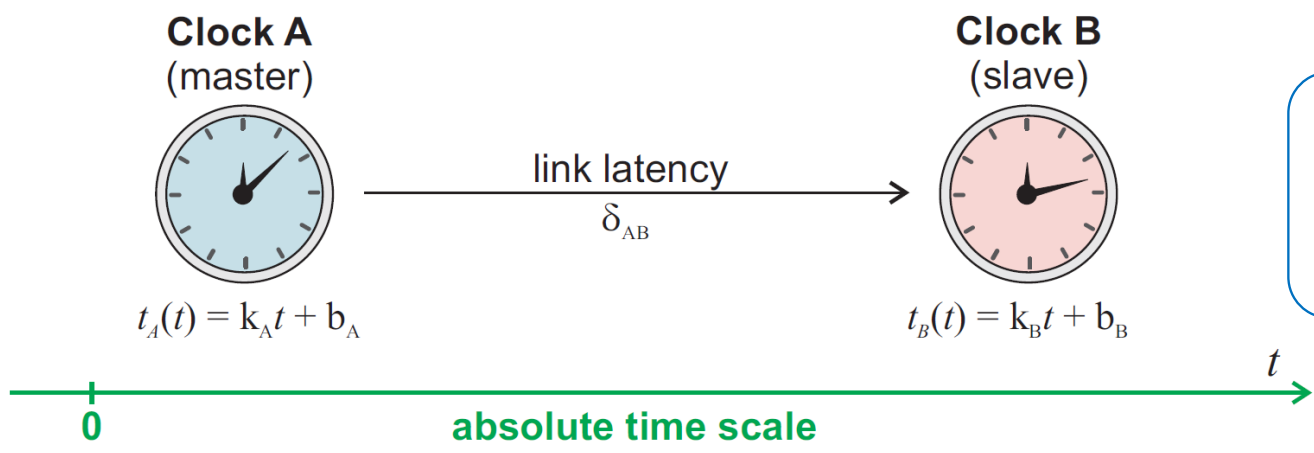
**Boris Boom**



**Kees Ligtenberg**

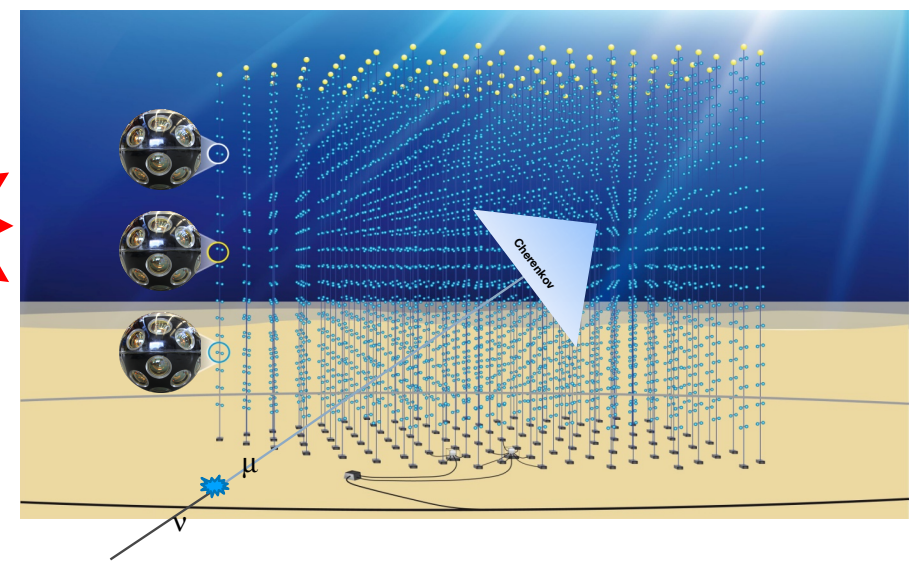
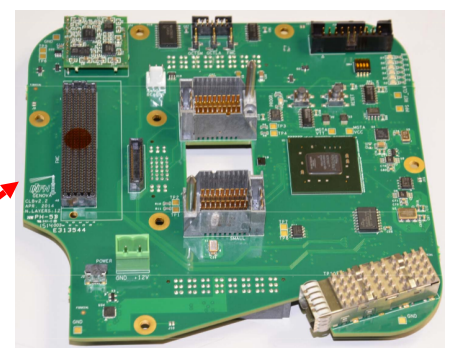
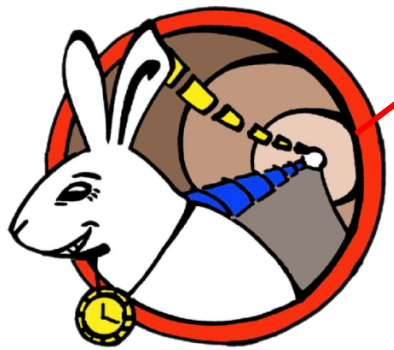


# White Rabbit



INRIM/Italy (Coordination)		RISE/Sweden		NIKHEF/NL	
NPL/UK		VSL/NL		OPNT/NL	
OBSPARIS/France		7SOL/Spain		TED/France	
VTT/Finland		LEONARDO/Italy		SUPPORT FROM: CERN, Nokia, NIST, Fair-GSI, INAF, Sunet, Chalmers, Netnod, Schneider Electric, Sverige Radop	

Peter Jansweijer



Jacopo Fumagalli

I CAN FEEL THE FORCE...

What a privilege to have such a theory group at Nikhef-  
quote Niels Tuning

IT IS STRONG INSIDE THIS ONE.

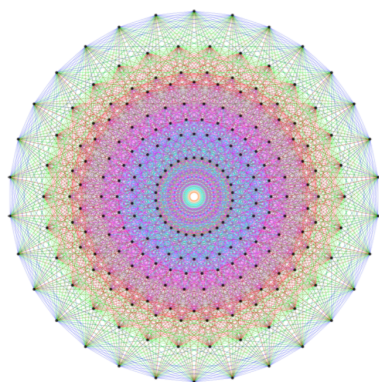
Franz Herzog

$$\beta(Q) = Q^2 \frac{d\alpha_s(Q)}{dQ^2} = -\beta_0 \alpha_s^2 - \beta_1 \alpha_s^3 - \beta_2 \alpha_s^4 - \beta_3 \alpha_s^5 - \beta_4 \alpha_s^6 - \dots$$

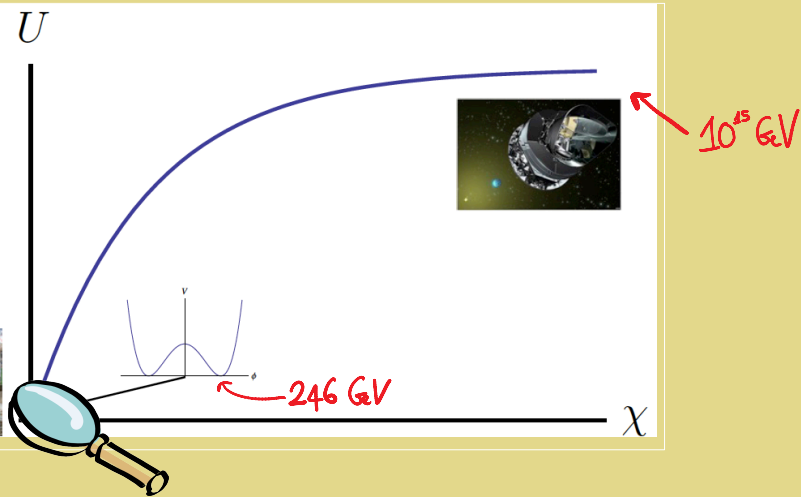
### Old Results

$$\begin{aligned} \beta_0 &= \frac{11}{3} C_A - \frac{4}{3} T_F n_f, \\ \beta_1 &= \frac{34}{3} C_A^2 - \frac{20}{3} C_A T_F n_f - 4 C_F T_F n_f, \\ \beta_2 &= \frac{2857}{54} C_A^3 - \frac{1415}{27} C_A^2 T_F n_f - \frac{205}{9} C_F C_A T_F n_f + 2 C_F^2 T_F n_f \\ &\quad + \frac{44}{9} C_F T_F^2 n_f^2 + \frac{158}{27} C_A T_F^2 n_f^2, \\ \beta_3 &= C_A^4 \left( \frac{150653}{486} - \frac{44}{9} \zeta_3 \right) + \frac{d^{abcd} d^{abcd}}{N_A} \left( -\frac{80}{9} + \frac{704}{3} \zeta_3 \right) \\ &\quad + C_A^3 T_F n_f \left( -\frac{39143}{81} + \frac{136}{3} \zeta_3 \right) + C_A^2 C_F T_F n_f \left( \frac{7073}{243} - \frac{656}{9} \zeta_3 \right) \\ &\quad + C_A C_F^2 T_F n_f \left( -\frac{4204}{27} + \frac{352}{9} \zeta_3 \right) + \frac{d^{abcd} d^{abcd}}{N_A} n_f \left( \frac{512}{9} - \frac{1664}{3} \zeta_3 \right) \\ &\quad + 46 C_F^3 T_F n_f + C_A^2 T_F^2 n_f^2 \left( \frac{7930}{81} + \frac{224}{9} \zeta_3 \right) + C_F^2 T_F^2 n_f^2 \left( \frac{1352}{27} - \frac{704}{9} \zeta_3 \right) \\ &\quad + C_A C_F T_F^2 n_f^2 \left( \frac{17152}{243} + \frac{448}{9} \zeta_3 \right) + \frac{d^{abcd} d^{abcd}}{N_A} n_f^2 \left( -\frac{704}{9} + \frac{512}{3} \zeta_3 \right) \\ &\quad + \frac{424}{243} C_A T_F^3 n_f^3 + \frac{1232}{243} C_F T_F^3 n_f^3, \end{aligned}$$

1.



A projection of the 8 dimensional  $4_{21}$  polytope invariant under the the  $E_8$  Lie group 20



### New Result

$$\begin{aligned} \beta_4 &= C_A^5 \left( \frac{8296235}{3888} - \frac{1630}{81} \zeta_3 + \frac{121}{6} \zeta_4 - \frac{1045}{9} \zeta_5 \right) \\ &\quad + \frac{d^{abcd} d^{abcd}}{N_A} C_A \left( \frac{514}{3} + \frac{18716}{3} \zeta_3 - 968 \zeta_4 - \frac{15400}{3} \zeta_5 \right) \\ &\quad + C_A^4 T_F n_f \left( -\frac{5048959}{972} + \frac{10505}{81} \zeta_3 - \frac{583}{3} \zeta_4 + 1230 \zeta_5 \right) \\ &\quad + C_A^3 C_F T_F n_f \left( \frac{8141995}{1944} + 146 \zeta_3 + \frac{902}{3} \zeta_4 - \frac{8720}{3} \zeta_5 \right) \\ &\quad + C_A^2 C_F^2 T_F n_f \left( -\frac{548732}{81} - \frac{50581}{27} \zeta_3 - \frac{484}{3} \zeta_4 + \frac{12820}{3} \zeta_5 \right) \\ &\quad + C_A C_F^3 T_F n_f \left( 3717 + \frac{5696}{3} \zeta_3 - \frac{7480}{3} \zeta_4 \right) - C_F^4 T_F n_f \left( \frac{4157}{6} + 128 \zeta_3 \right) \\ &\quad + \frac{d^{abcd} d^{abcd}}{N_A} T_F n_f \left( \frac{904}{9} - \frac{20752}{9} \zeta_3 + 352 \zeta_4 + \frac{4000}{9} \zeta_5 \right) \\ &\quad + \frac{d^{abcd} d^{abcd}}{N_A} C_A n_f \left( \frac{11312}{9} - \frac{127736}{9} \zeta_3 + 2288 \zeta_4 + \frac{67520}{9} \zeta_5 \right) \\ &\quad + \frac{d^{abcd} d^{abcd}}{N_A} C_F n_f \left( -320 + \frac{1280}{3} \zeta_3 + \frac{6400}{3} \zeta_5 \right) \\ &\quad + C_A^3 T_F^2 n_f^2 \left( \frac{843067}{486} + \frac{18446}{27} \zeta_3 - \frac{104}{3} \zeta_4 - \frac{2200}{3} \zeta_5 \right) \\ &\quad + C_A^2 C_F T_F^2 n_f^2 \left( \frac{5701}{162} + \frac{26452}{27} \zeta_3 - \frac{944}{3} \zeta_4 + \frac{1600}{3} \zeta_5 \right) \\ &\quad + C_F^2 C_A T_F^2 n_f^2 \left( \frac{31583}{18} - \frac{28628}{27} \zeta_3 + \frac{1144}{3} \zeta_4 - \frac{4400}{3} \zeta_5 \right) \\ &\quad + C_F^3 T_F^2 n_f^2 \left( -\frac{5018}{9} - \frac{2144}{3} \zeta_3 + \frac{4640}{3} \zeta_5 \right) \\ &\quad + \frac{d^{abcd} d^{abcd}}{N_A} T_F n_f^2 \left( -\frac{3680}{9} + \frac{40160}{9} \zeta_3 - 832 \zeta_4 - \frac{1280}{9} \zeta_5 \right) \\ &\quad + \frac{d^{abcd} d^{abcd}}{N_A} C_A n_f^2 \left( -\frac{7184}{3} + \frac{40336}{9} \zeta_3 - 704 \zeta_4 + \frac{2240}{9} \zeta_5 \right) \\ &\quad + \frac{d^{abcd} d^{abcd}}{N_A} C_F n_f^2 \left( \frac{4160}{3} + \frac{5120}{3} \zeta_3 - \frac{12800}{3} \zeta_5 \right) \\ &\quad + C_A^2 T_F^3 n_f^3 \left( -\frac{2077}{27} - \frac{9736}{81} \zeta_3 + \frac{112}{3} \zeta_4 + \frac{320}{9} \zeta_5 \right) \\ &\quad + C_A C_F T_F^3 n_f^3 \left( -\frac{736}{81} - \frac{5680}{27} \zeta_3 + \frac{224}{3} \zeta_4 \right) \\ &\quad + C_F^2 T_F^3 n_f^3 \left( -\frac{9922}{81} + \frac{7616}{27} \zeta_3 - \frac{352}{3} \zeta_4 \right) \\ &\quad + \frac{d^{abcd} d^{abcd}}{N_A} T_F n_f^3 \left( \frac{3520}{9} - \frac{2624}{3} \zeta_3 + 256 \zeta_4 + \frac{1280}{3} \zeta_5 \right) \\ &\quad + C_A T_F^4 n_f^4 \left( \frac{916}{243} - \frac{640}{81} \zeta_3 \right) - C_F T_F^4 n_f^4 \left( \frac{856}{243} + \frac{128}{27} \zeta_3 \right) \end{aligned}$$



# 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
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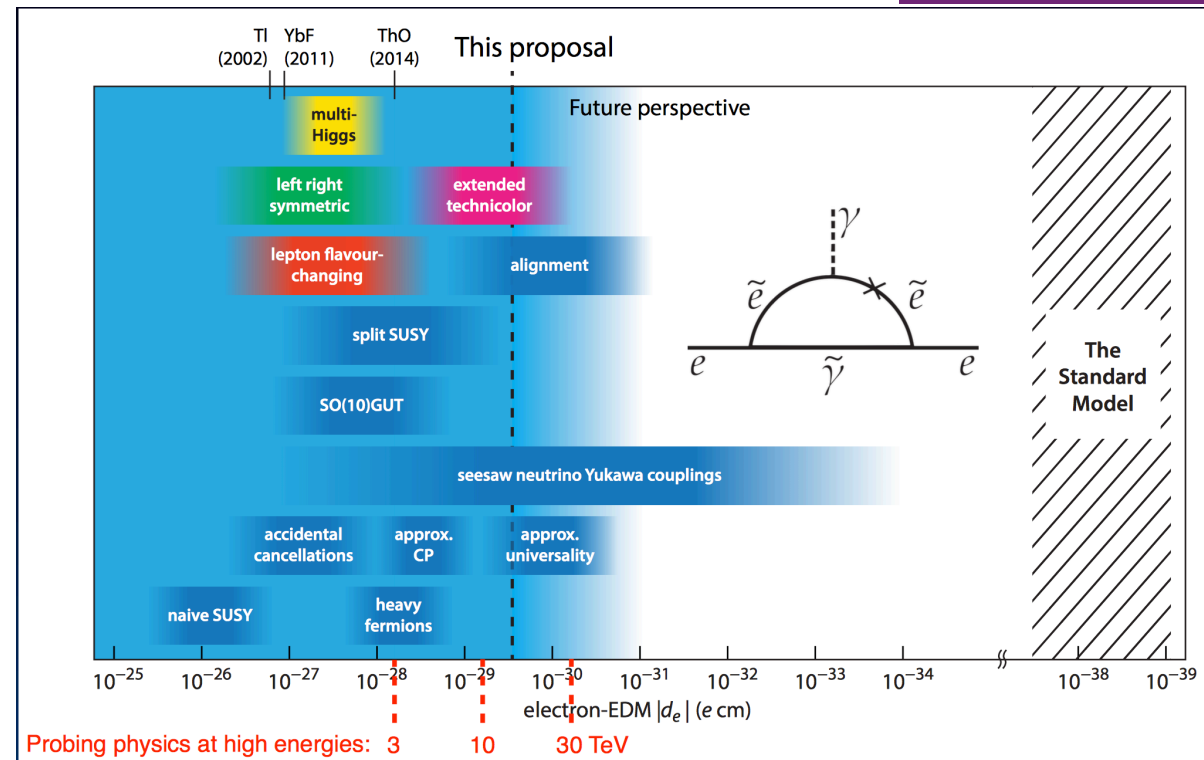
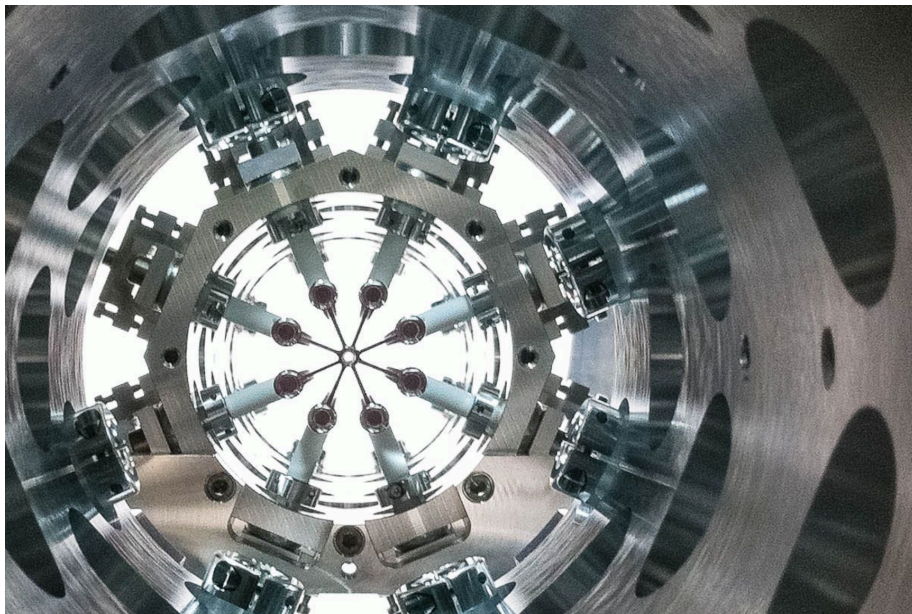
## 3. *Beyond scientific' goals:*

- 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

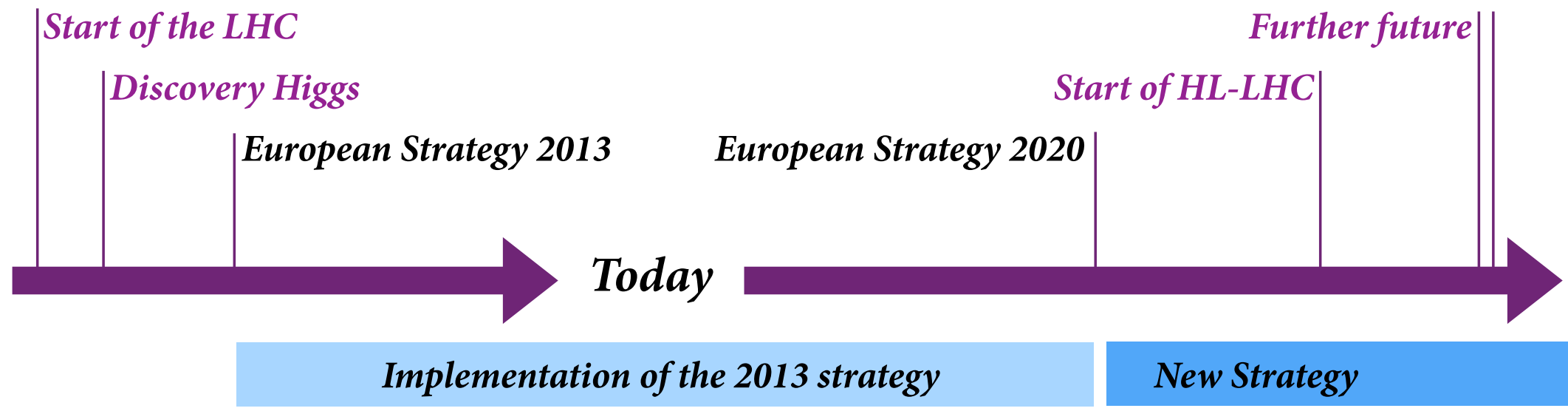
# High precision electron EDM

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

New - 2017



# 2013 European Strategy



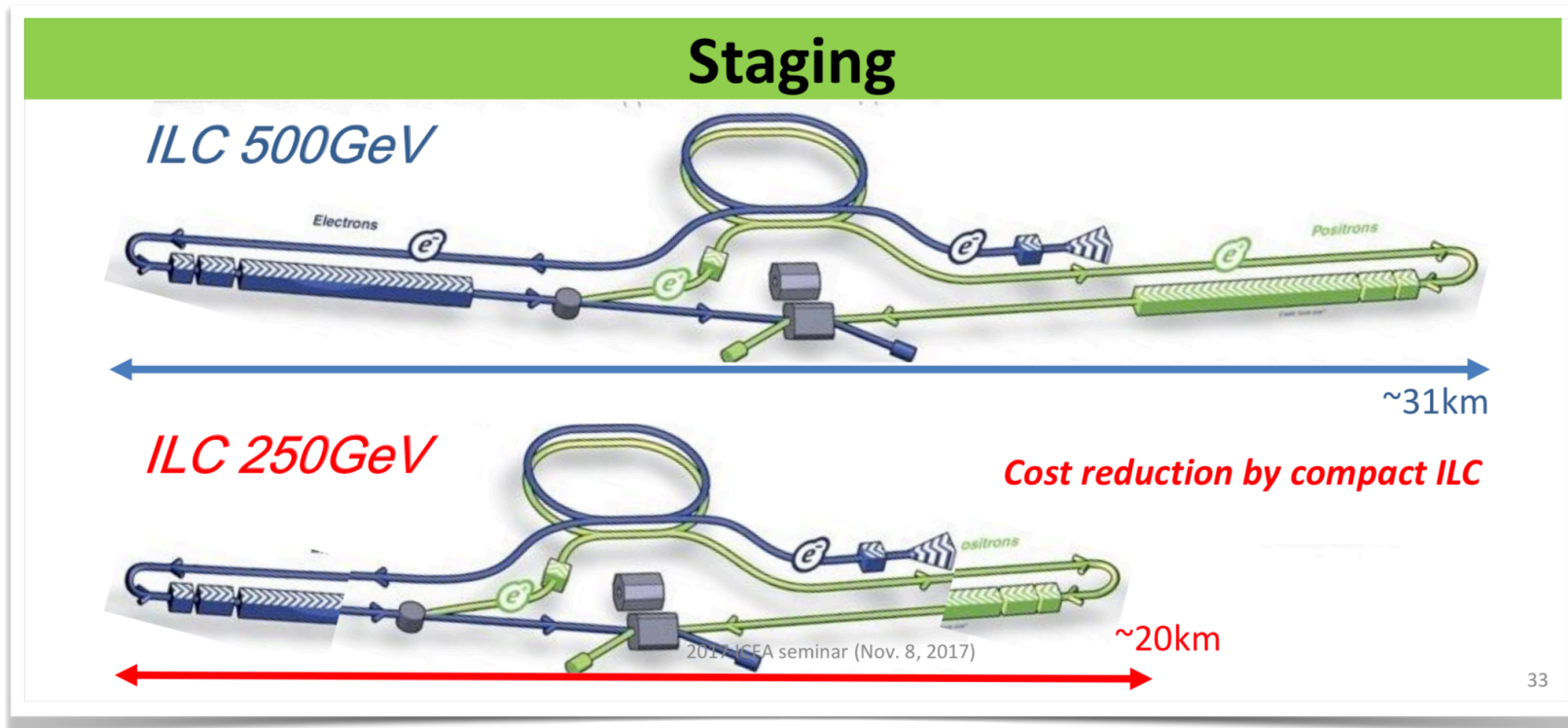
*Europe's top priority should be the **exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors** with a view to collecting ten times more data than in the initial design, by around 2030. This upgrade programme will also provide further exciting opportunities for the study of flavour physics and the quark-gluon plasma.*

- Nikhef involvement  
– check!



# Future ILC

*There is a strong scientific case for an **electron-positron collider**, ... Europe looks forward to a proposal from Japan to discuss a possible participation.*

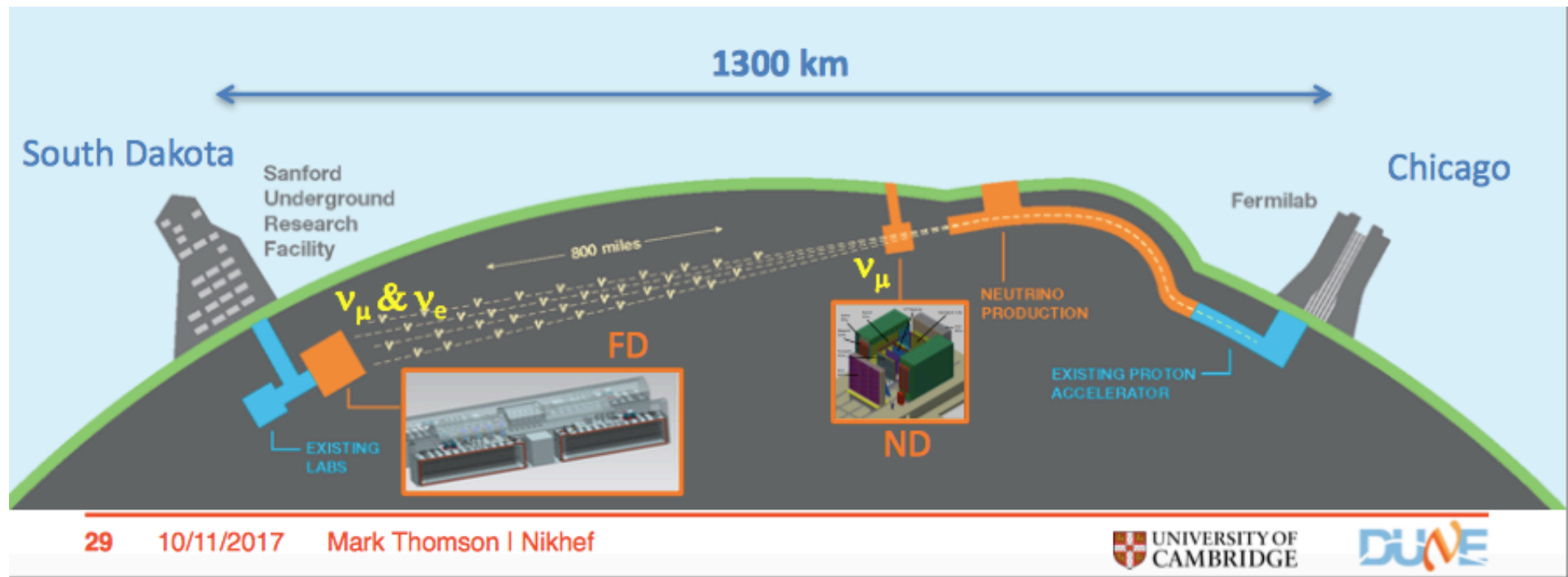


# ILC developments

- ILC will start running at 250 GeV as a Higgs factory
  - Significant cost savings on the machine (40% to 5 B\$)
  - All reports (Physics, TDR, Site, Human R) for the Ministry MEXT are finalized
  - DIET members (150) OK; now ready to go to Japanese government
- Waiting for a statement from the Japanese Government for their willingness to host ILC before end of 2018
- Mondial consortium
  - In US bilateral contacts have been established
  - In Germany and France there is large political support (also industrial)
  - At CERN a European action plan is made (Council) with contributions of CERN
  - Netherlands contribution to ILC only via CERN

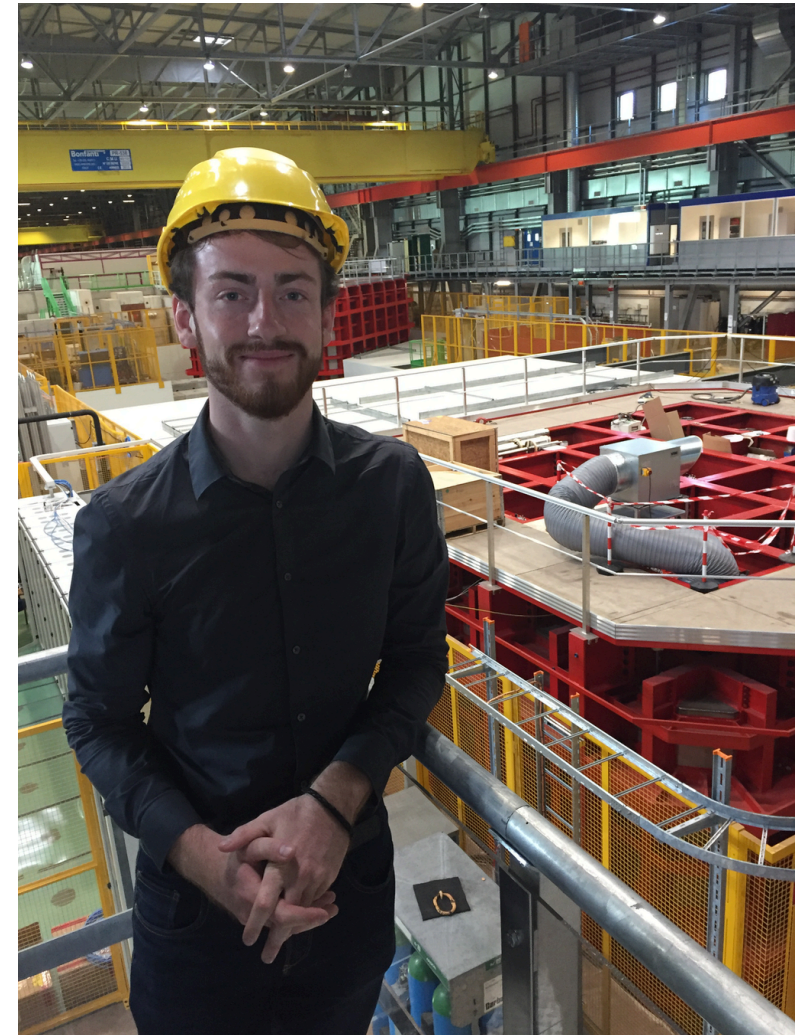
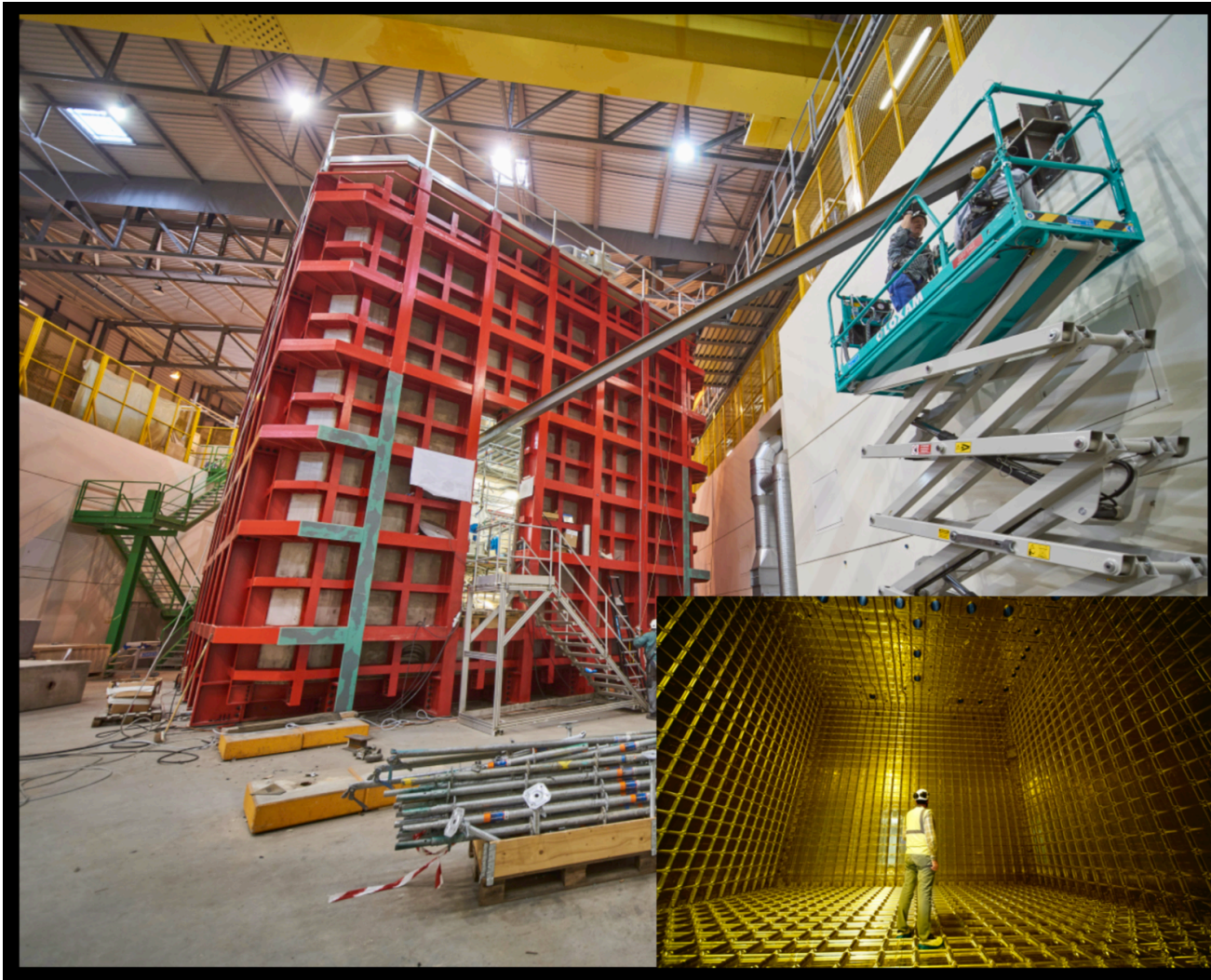
# Neutrino programme

*CERN should develop a **neutrino programme** to pave the way for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.*





# protoDUNE at CERN





European Astroparticle  
Physics Strategy  
2017-2026

- Launch of the new APPEC roadmap  
– Brussels, January 9th, 2018

*APPEC strongly supports the Auger collaboration's installation of AugerPrime by 2019.*

*It also strongly supports Europe's next-generation ground-based interferometer, the Einstein Telescope (ET) project, in developing the required technology and acquiring ESFRI status. In the field of space-based interferometry, APPEC strongly supports the European LISA proposal.*

*GVD), APPEC strongly endorses the KM3NeT collaboration's ambitions to realise, by 2020: (i) a large-volume telescope with optimal angular resolution for high-energy neutrino astronomy; and (ii) a dedicated detector optimised for low-energy neutrinos, primarily aiming to resolve the neutrino mass hierarchy.*

*In the coming years, CERN should seek a **closer collaboration with ApPEC on detector R&D** with a view to maintaining the community's capability for unique projects in this field.*

# ECFA panel - instrumentation

- Help to create a coherence of the global R&D effort by encouraging synergy between different activities and advising funding agencies.

Our ambition “make R&D shine”

## – Chair Els Koffeman

- Doris Eckstein (DESY) - scientific secretary
- Arno Straessner (Dresden)
- Phill Alport (Birmingham)
- Laurent Serin (Orsay)
- Sylvia dalla Torre (INFN)
- Lucy Linssen (CERN)

### **REWARD YOUNG TALENT**

- **Continue to act as review panel**
- **Connect with existing review boards**
- **Explore new roles**
  - **Review R&D for Astroparticle Physics Experiments**
  - **National/regional R&D activity in Europe**
- **Initiate R&D discussion for EU strategy on particle physics**



# 2013 European Strategy



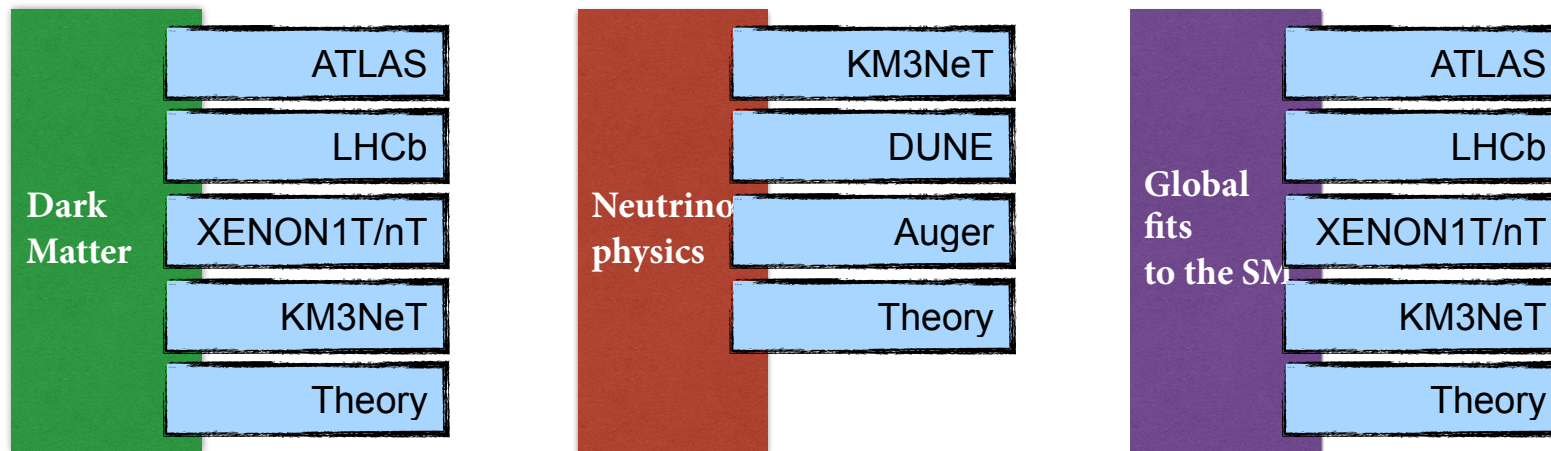
- Approval of process (council - now)
- Official launch of Strategy Update (September 2018)
- Collect input (end 2018)
- Open meeting (april-may 2019)
- Closure meeting (EPS 2019)
- Drafting Strategy Document Update (early 2020)
- Conclusion of the process (May 2020)

**European Particle Physics Strategy Update**  
**H. Abramowicz (chair), K. Ellis (SPC),**  
**J. d'Hondt (ECFA), L. Rivkin (Lab directors)**

**Collect input from Nikhef in 2018**

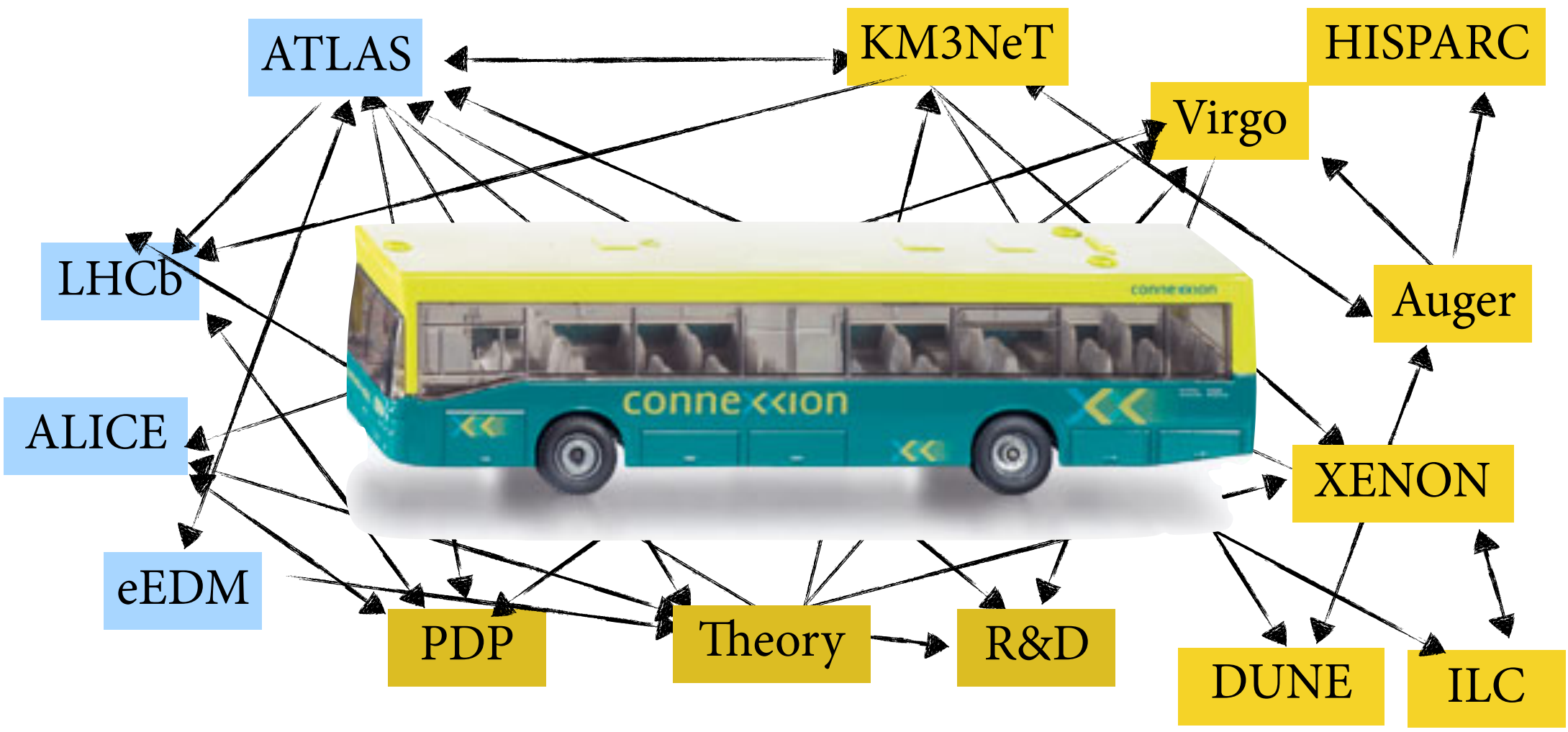
# Thematic connections

- Fully exploit overlap science programs @ Nikhef
  - Thematic cross connection & optimization of science portfolio

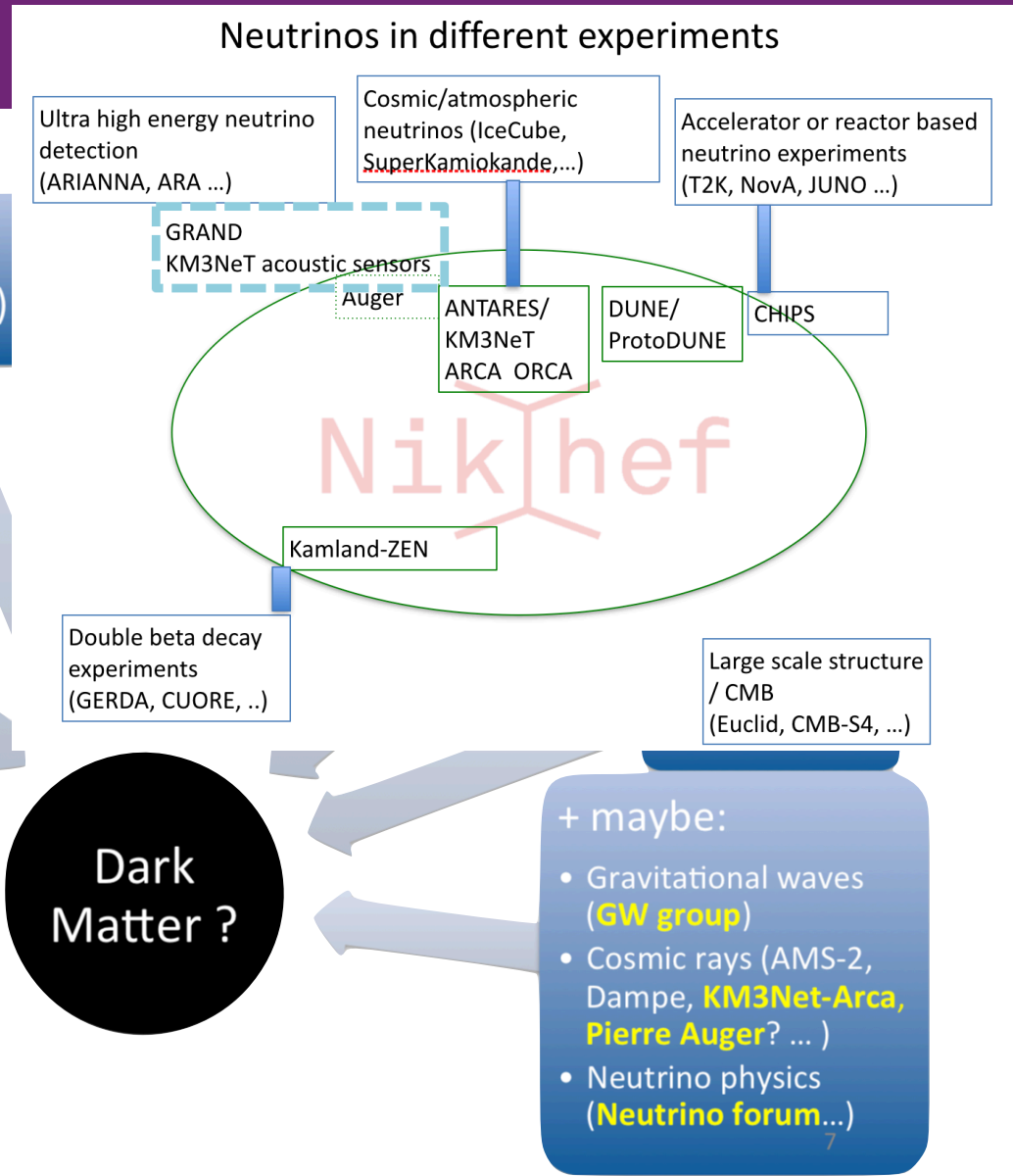


- Connection between Astroparticle physics and Astronomy
  - Committee for Astroparticle Physics Netherlands - CAN
    - Gravitation Astroparticle Physics Amsterdam - GRAPPA
    - Institute for Mathematics, Astronomy and Particle Physics RU - IMAPP
    - Quantum Universe - Particle Physics and Astronomy RUG

# Synergies between Nikhef programs





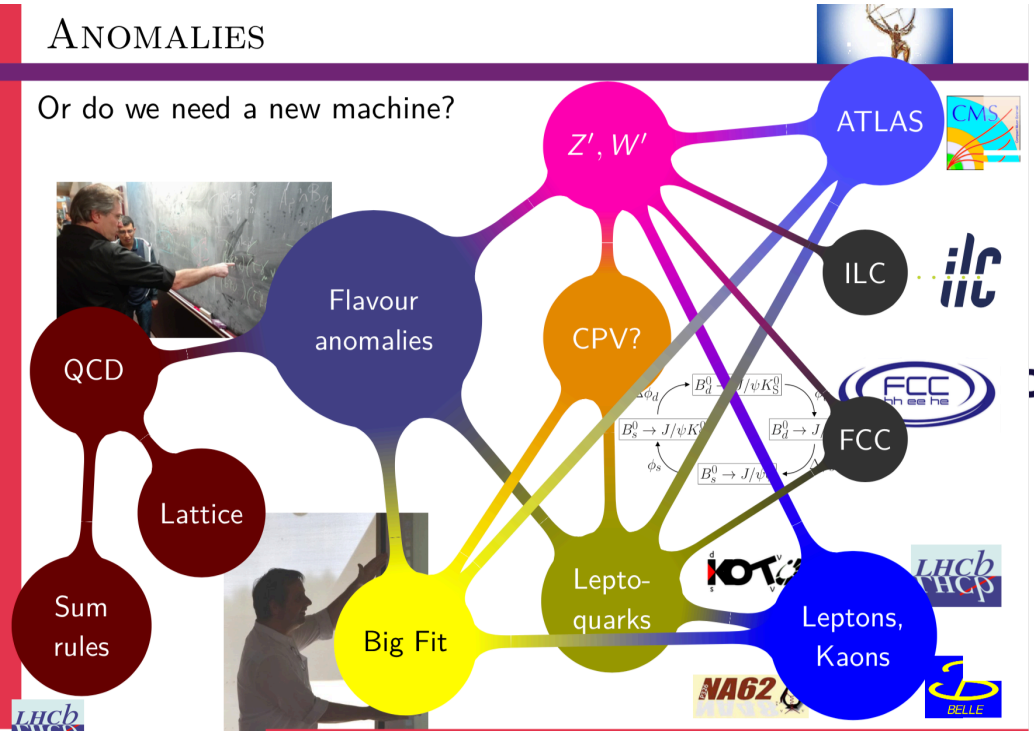


Colliders  
(**ATLAS**, et al)

## R&D Connects

### ANOMALIES

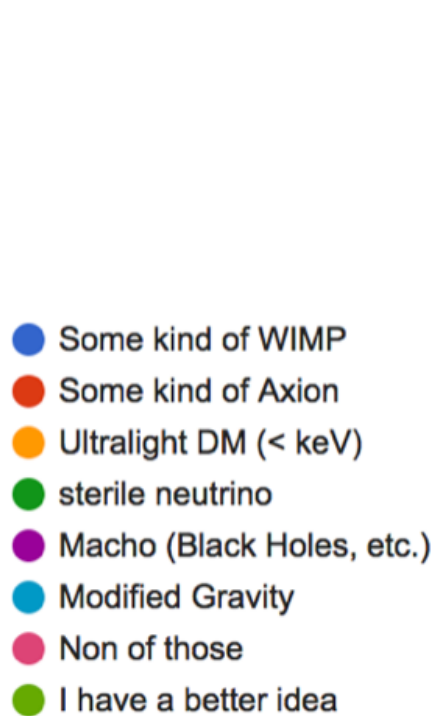
Or do we need a new machine?



# Your favorite DM candidate

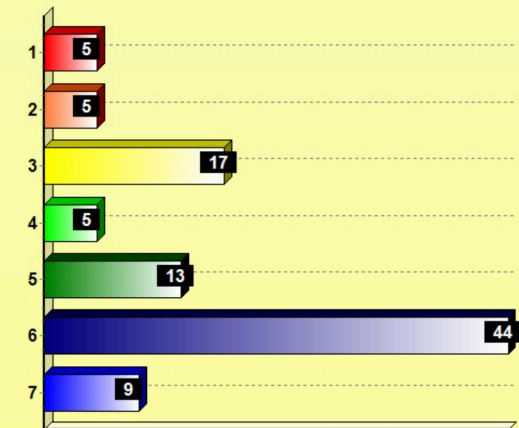
A survey : What is your favourite / best motivated Dark Matter candidate ?

14 Antworten

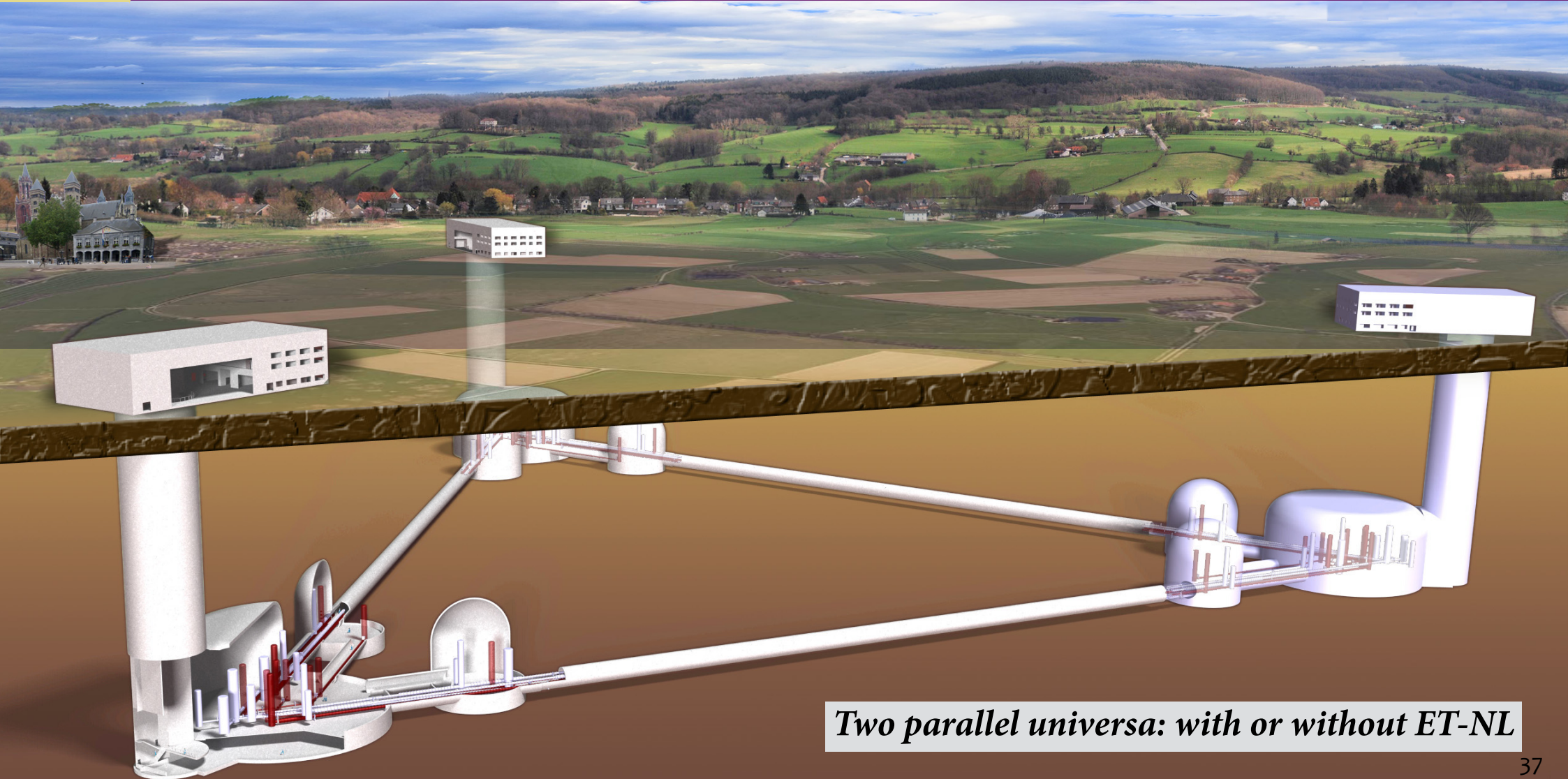


## 6. What is the nature of Dark Matter ?

- 1) normal neutrino
- 2) sterile neutrino
- 3) neutralino (LSP)
- 4) black holes and brown dwarfs
- 5) hot air
- 6) something else
- 7) dark matter doesn't exist



# ETNL - prepare bid ~2021



*Two parallel universa: with or without ET-NL*



# Strategy 2017-2022

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# Opening new (tenure) staff positions

- Advertisements out soon!
- Physics Data Processing group
  - Getting the most physics out of modern computer processors
- ATLAS
  - All-round experimental physicist
- LHCb
  - All-round experimental physicist with emphasis on detector development

- Welcome to Sarah Caudill
  - Zwaartekrachtgolven
  - University of Wisconsin-Milwaukee







- Matteo Tacca
  - R&D groep
  - Instrumentation gravitational waves (optics)







# New colleagues



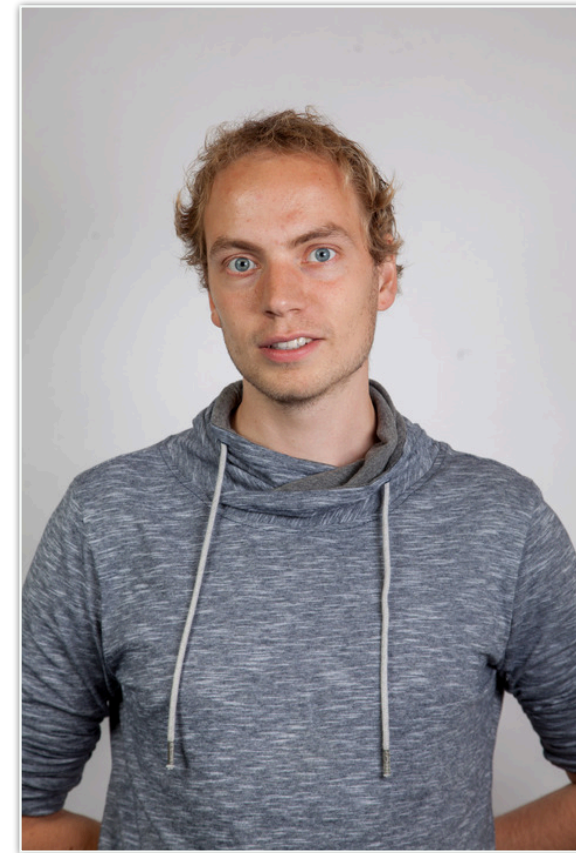
- Bas Swinkels
  - Gravitation group
  - Virgo commissioning





- 'Science faculty' University of Maastricht

- Gideon Koekoek
- Jacco de Vries





# Research Data Management

*Jeff Templon*

- Policy in draft form
- Implements NWO Institute DM policy framework
- Our focus: find balance between intended result and minimal work

Nikhef Research Data Management Policy v03

**Nikhef Research Data Management Policy**

The Dutch National Institute for Sub-atomic Physics Nikhef, via its mission and through the programmes, projects, and collaborations that it operates and subscribes to, is a significant producer of scientific research data, and transfer of this knowledge to third parties, i.e., industry, civil society and general public, is an integral part of Nikhef's mission. Nikhef is committed to ensuring careful management and optimal exploitation of the research data, both in the short term and the long term, in alignment with the principles on data management of NWO, and in accordance with this Policy<sup>1</sup>.

**Scope**

This Policy applies to all research data that are relevant for re-use and produced as a result of Nikhef *Research Activities*, i.e.,

- all approved granted research programmes and granted research projects, and
- research projects so designated and approved by the Nikhef director, and
- any activity that results in *Published* data as per the General Principles.





*Dark Matter in the LHC*  
*dr Wouter Hulsbergen*

*Search for (anti) matter differences*  
*dr Niels Tuning*

*Where do cosmic neutrinos come from?*  
*dr Aart Heijboer*





*ISOTDAQ workshop at Nikhef*

# Have a good trip home!



*To all the speakers of this Nikhef jamboree:  
Thank you so much for your truly excellent presentations!*