#### **Annual meeting 2015**



- Remarkable year -
  - -KM3NeT: first line deployed with first light
  - -XENON1T: first light detected
  - -Auger: Hints for common sources IceCube
  - Virgo-LIGO: data + being commissioned
  - -ILC: new initiative @ Nikhef
  - -LHCb: lots of hints for new physics
  - -ALICE: detailed understanding HI physics
  - -ATLAS: exciting hints!
  - -Theory: N<sup>3</sup>LO Higgs production
- Groningen will join Nikhef!



### 11 Staff Members @ VSI

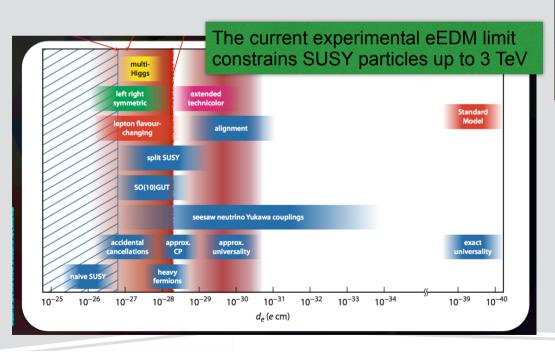




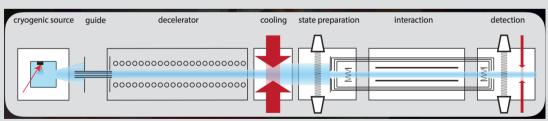
#### eEDM Groningen

Steven Hoekstra

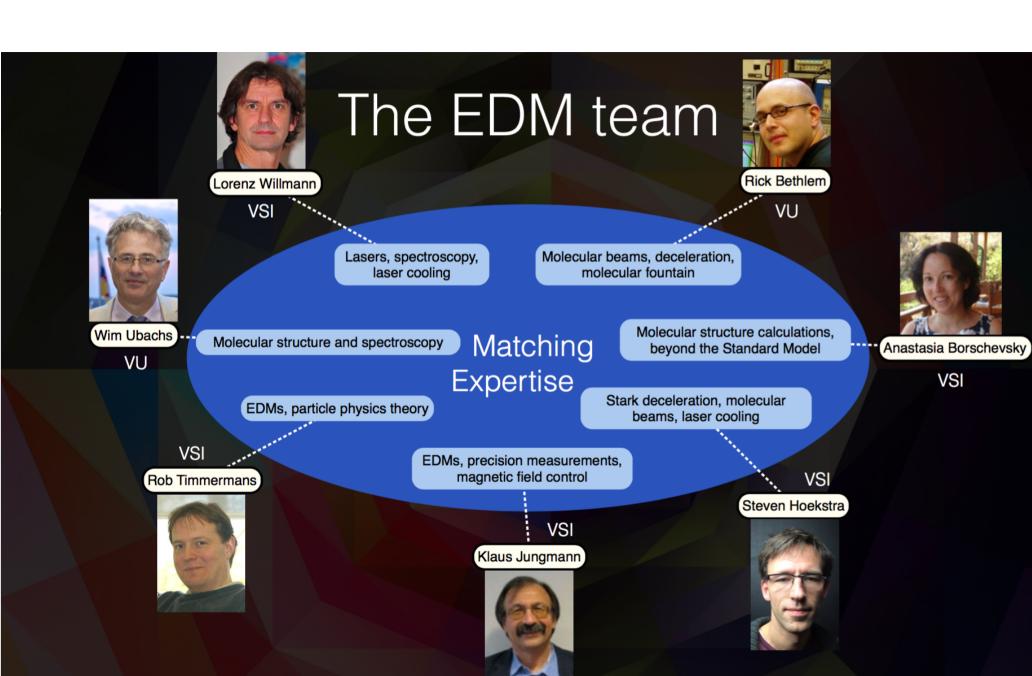
- Is the electron round?
  - -Most exciting low-energy particle physics experiment
  - -Ambitious and realistic plan
  - -Excellent team with expertise







Decellerator with intense beams of molecules, raise interaction time



# WELCOME TO NIKHEF FOR GRONINGEN THEORY!



Elisabetta, Daniel, Eric, Diederik, Rob, Kyriakos

and all their postdocs, PhD's,...





### **Advanced Virgo**

Chris van den Broeck

Virgo+LIGO

LIGO-Virgo Collaboration observations resumed with Advanced LIGO instruments in Sept. 2015

First joint Advanced LIGO-Virgo run in 2016

#### Scientific promise

- Direct detection of gravitational waves
- Test strong-field dynamics of GR
- Cosmography
- Signals from the early Universe

#### Advanced LIGO

- First observing run started in September, will end in mid-January
- Current range for binary neutron stars: 60-80 Mpc
  - Final design sensitivity: ~200 Mpc
- Commissioning to continue in 2016
- Advanced Virgo
  - Installation in progress
  - 2016-17: 6-month science run joint with Advanced LIGO



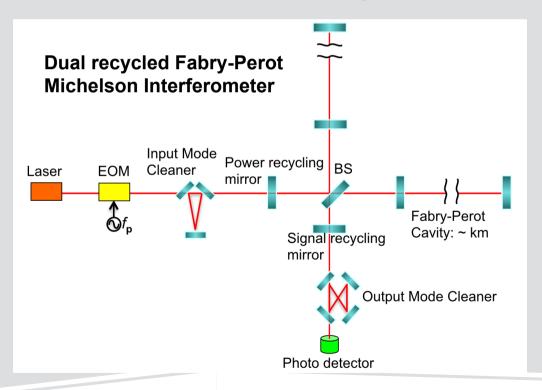




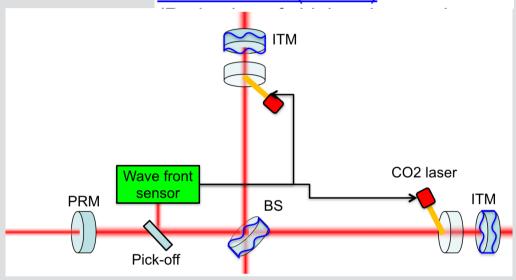
#### Virgo



 Phase Camera for Advanced Virgo



Problem: Degeneration of higher order modes (HOMs)



Solution: Thermal Compensation System (TCS)

\*Sensor: Phase camera

\*Actuator: CO2 laser with compensation plates

#### Installation in Advanced Virgo

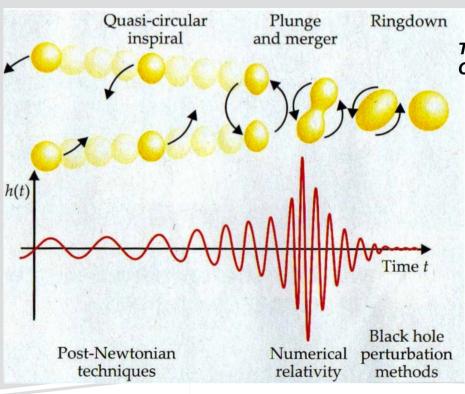
Three phase cameras will be installed



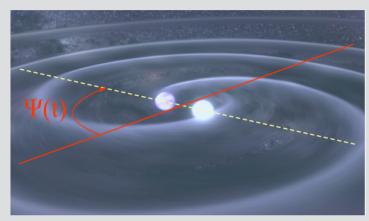
#### **Virgo**



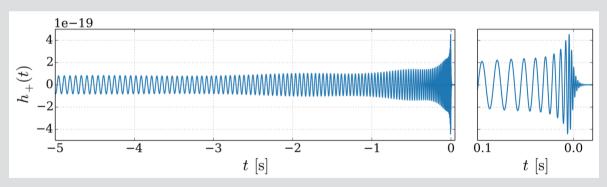
- Testing strong-field dynamics ART
  - -General relativity at its 100th birthday



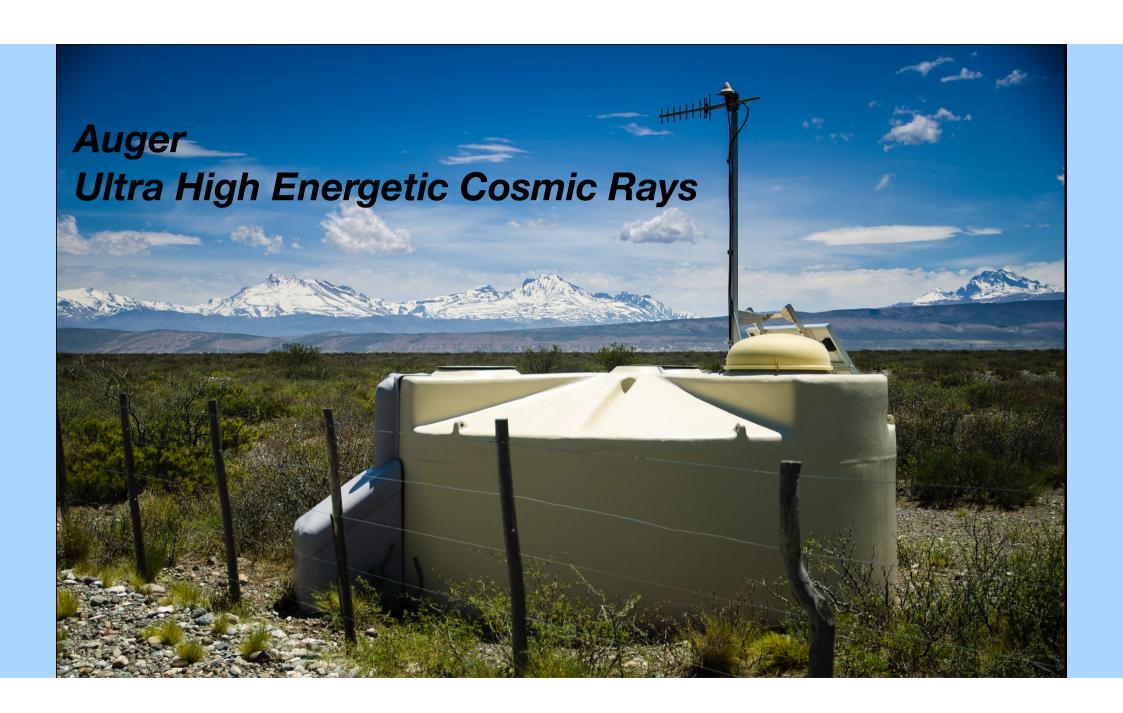
T-shirt Open Day October 3rd 2015



Parameter test of ART



Ringdown also within band: First direct evidence for existence of black holes

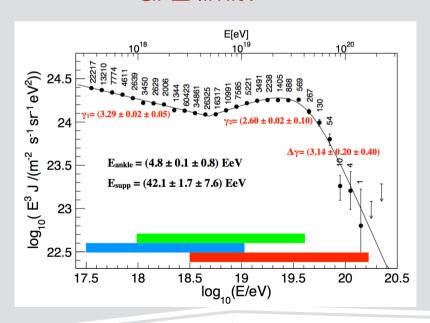




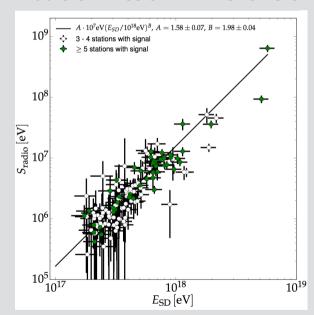


Auger

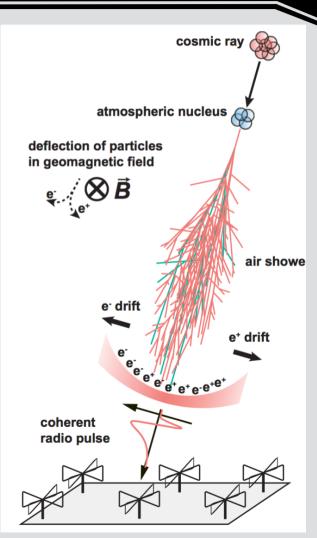
- UHECR:
  - -Point sources?
  - Maximum energy
    - acceleration limit?
    - GKZ limit?



#### Radio emmission in Air Showers



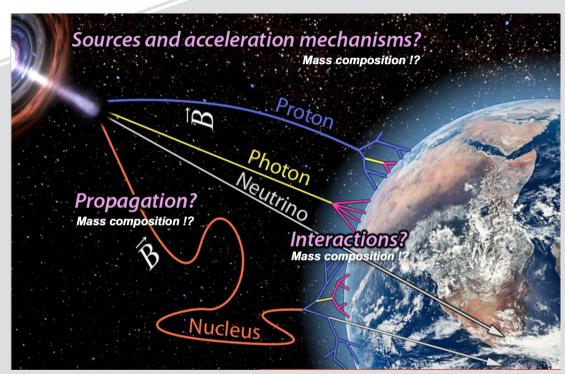
24-29% energy resolution calibrated radio with SSD





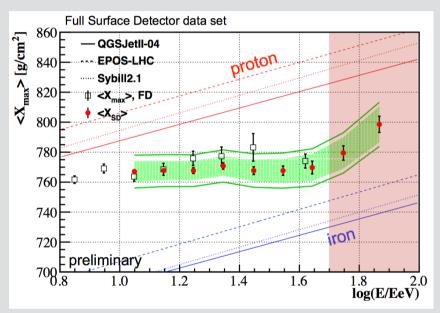
#### Auger





Mass composition?

Get mass composition measurement in the GZK region



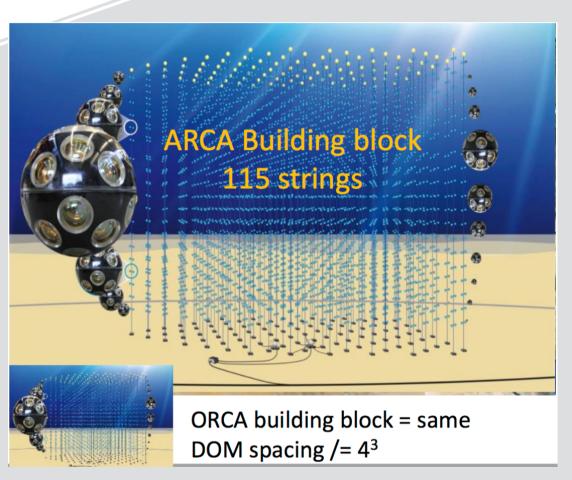


Water-Cherenkov detector and Scintillator have different response to electrons and muon





#### **KM3NeT**



- Phase 1:
  - 31 strings, ~10% ARCA, ~5% ORCA
  - Funded! Construction begun
  - 2017 completion
- KM3NeT 2.0:
  - 100% ARCA and ORCA
  - Completion 2020
- Excellent period!
  - -First real string deployed
  - -ESFRI status

Normal Hierarchy  $m_2$   $m_3$   $m_1$   $m_2$   $m_1$   $m_2$   $m_2$   $m_3$   $m_4$ 

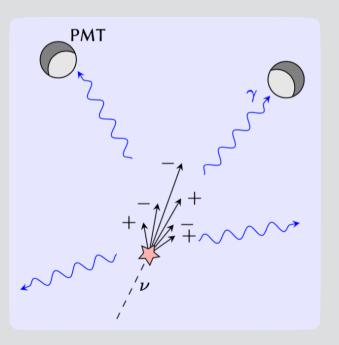
Mass hierarchy: 3σ in 3 years of data taking

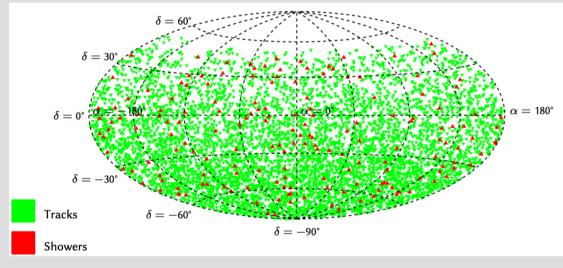


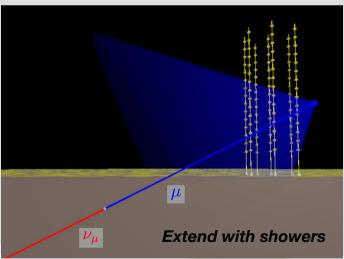
#### **Antares**



- Neutrino reconstruction
  - muon track cherenkov light







#### Searching for point sources

Various approaches used:

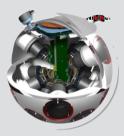
- Full Sky search
- Fixed Point search
- IceCube HESE candidates
- Galactic Centre Region
- Extended Source at Galactic Centre

Not found - but constraints on flux



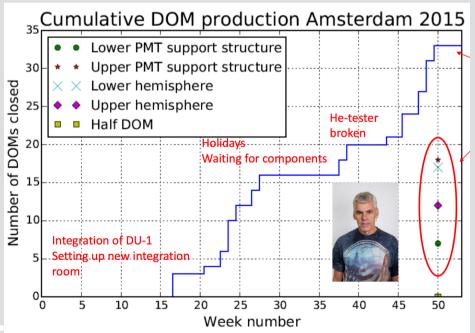
Ronald Bruijn

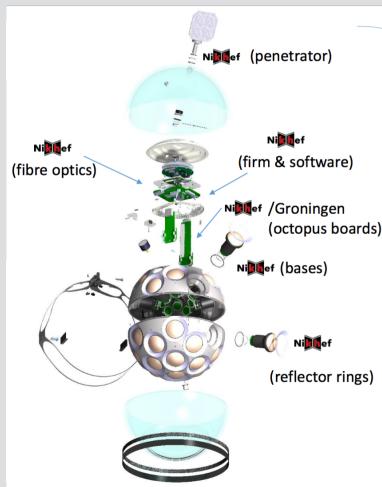
- How to build DOMs?
  - Detector units 1&2







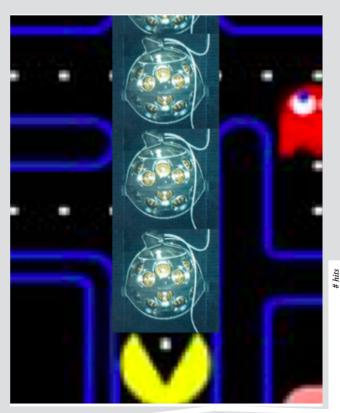


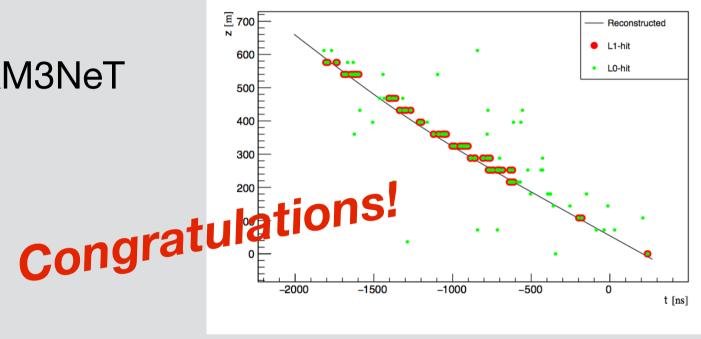




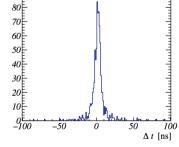
### **KM3NeT**

First data of KM3NeT





One day after power-on, one hour after first data!



Nearly sub-ns timing calibration



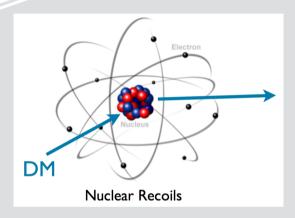
## The XENON experiment

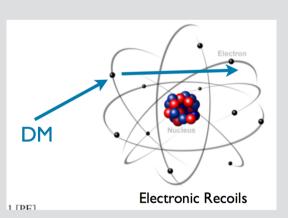




## XENON100 & XENON1T

Patrick Decowski

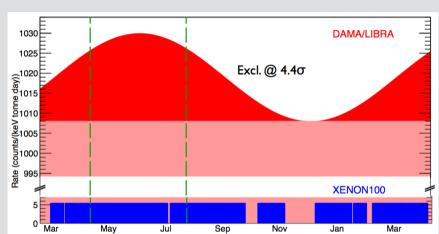




- XENON100
  - -physics analyses -
    - Annual modulation
       DAMA excluded
    - low mass WIMPS
- XENON1T
  - preparations
  - finalizing to go!



Nikhef is best connected institute outside LNGS!





### XENON1T

Chris Tunnell

- DAQ to analysis
- First light detected!

# 

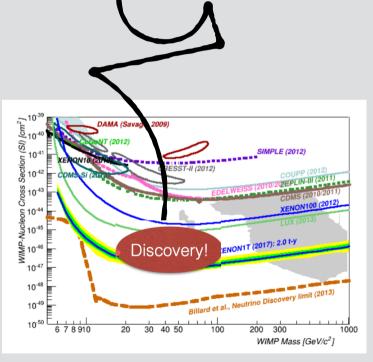
 Thanks PDP!



2. Reconstruct data

3. Analyze data







## Theory









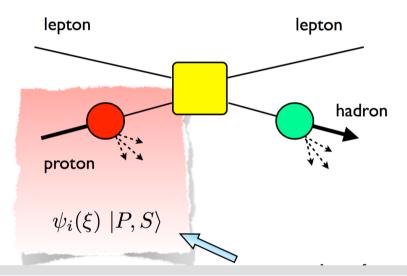




Theory

Andrea Signori - Piet Mulders

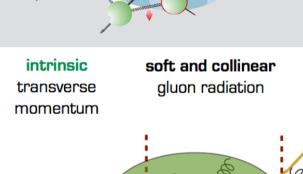
**POLARIZED ONES ???** 



unpolarized longitudinal transverse

 $\{ f_1(x), g_1(x), h_1(x) \}$ 

very good getting better basic





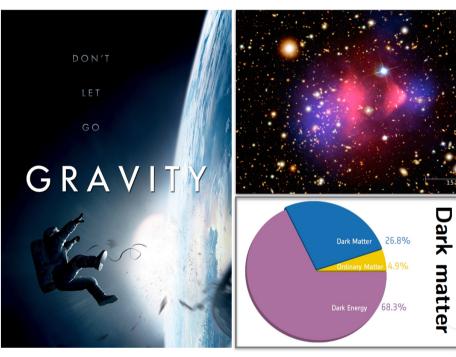
AT THE LHC ONLY UNPOLARIZED GLUONS

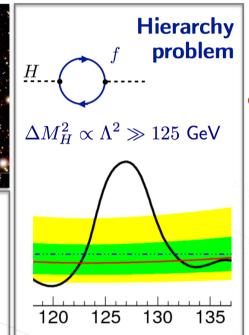
ARE IMPORT...

3) Questions? Interested? Come to the 3rd floor!

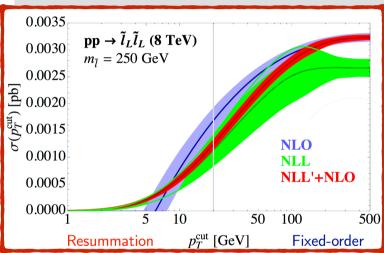
#### Lisa Zeune

# New physics Beyond the Standard Model must exist





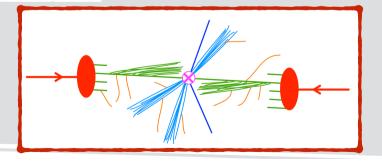
Precise cross sections including jet veto resummation important to fully exploit the LHC data



Test your favorite Susy model:

FastLim

Papucci, Sakurai, Weiler, LZ





#### Theory

Small Manifold of extra dimensions

Large Dimension



 Strings in real world with extra dimensions and with particles

-the problem = finding

branes + fluxes + geometries + ... = parameters

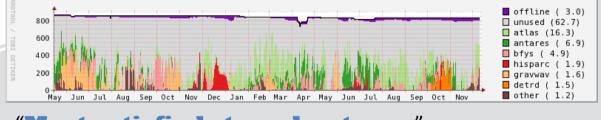
... but where is de Sitter within the string landscape?

3) Questions? Interested? Come to the 3rd floor!





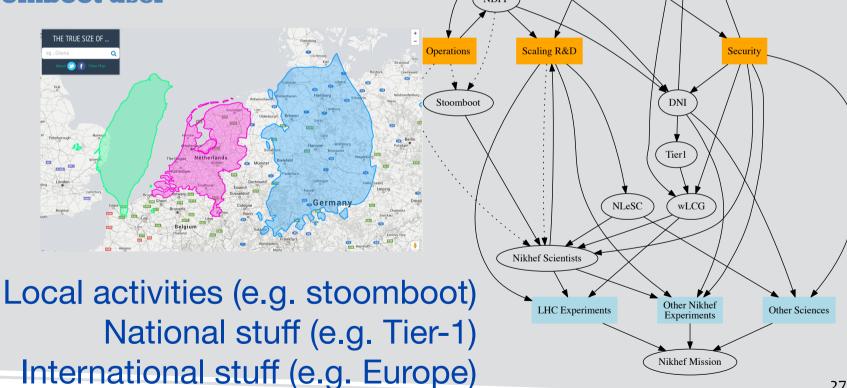
27



"Most satisfied stoomboot user"

#### One of the fine tools available at Nikhef





NWO Roadman

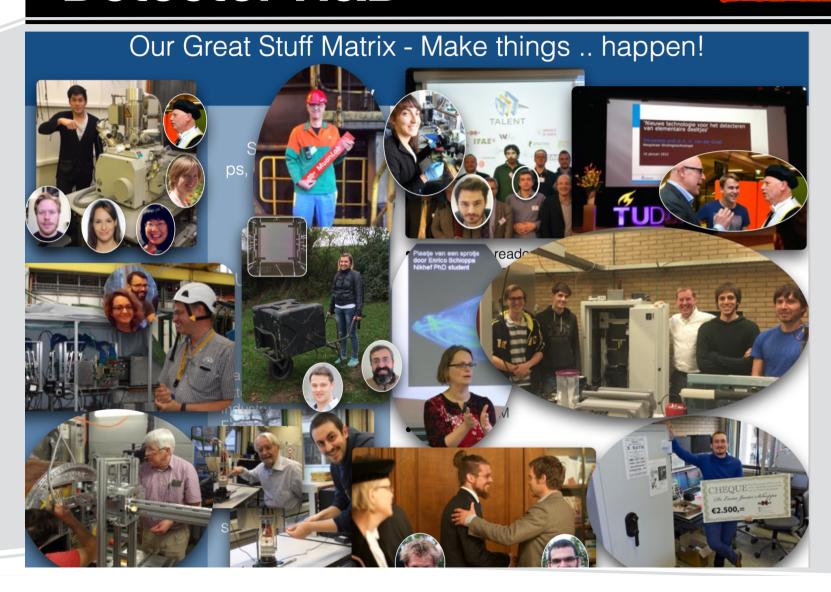
Computing Hardware

PDP Manpower



#### **Detector R&D**

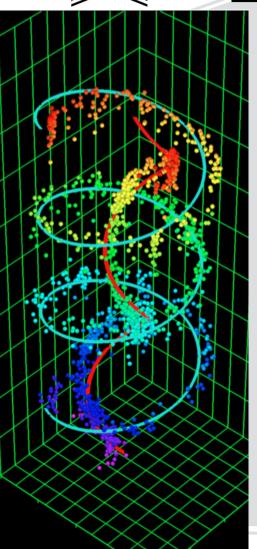
Niels van Bakel

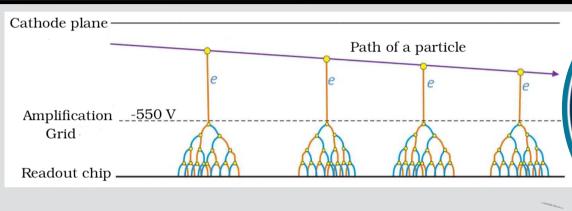




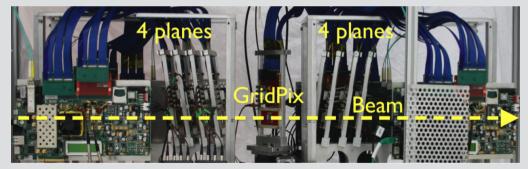
#### **Detector R&D**

Stergios Tsigaridas

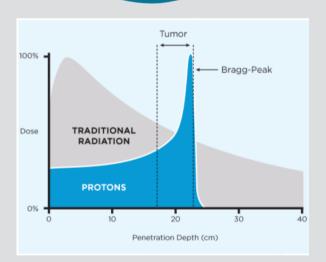




#### GridPix



Testbeam work - improve on Time Walk and further improving of spark-proofing GridPix

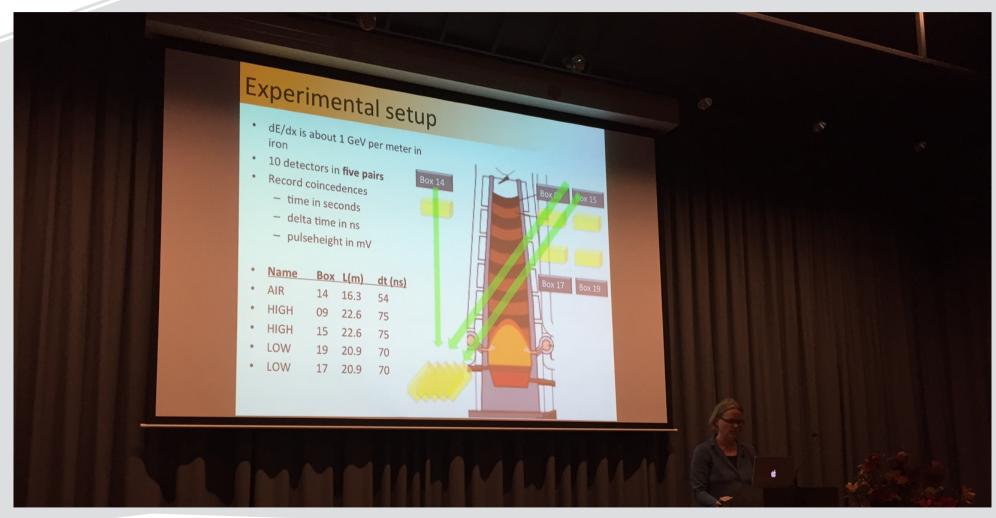


e.g. Medical Applications



### **Detector R&D**

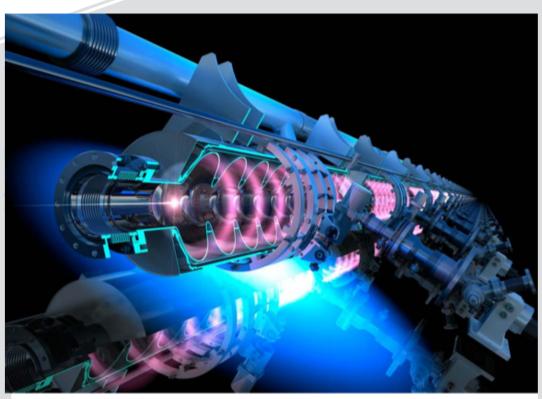






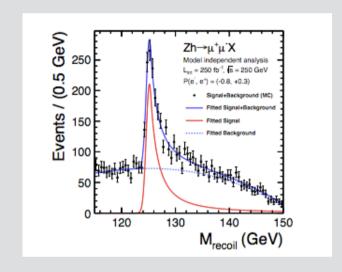
### **ILC** initiative







Asian Linear Collider Workshop 20-24 April '15 KEK Tsukuba, Japan

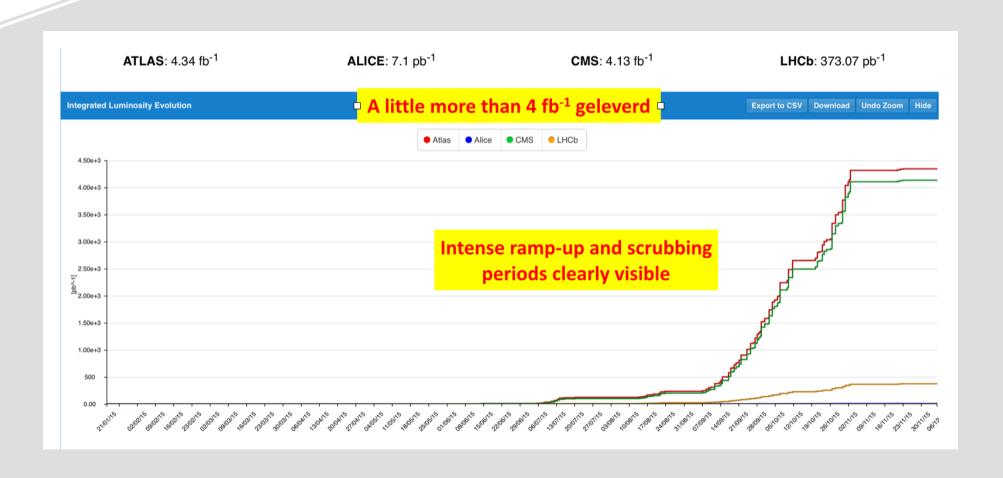


- Nikhef visibly active in ILC
- The WAR gave a very positive advice
  - The director has given follow up to this
  - In december prepared/submitted a NWO investment plan for the ILC in order to be part of the NWO roadmap





## Ni ef A slow startup of LHC





### LHC program



• LS2: Start juli 2018 LS3: Start 2023



- Large group with successful external funding
  - -15 PhD students in total with 7 staff
- ITS upgrade for installation in 2018-2019
  - -Excellent expertise from e.g. Nikhef's ET

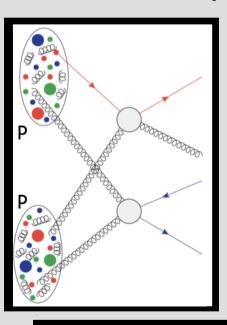


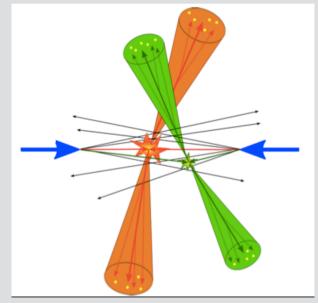


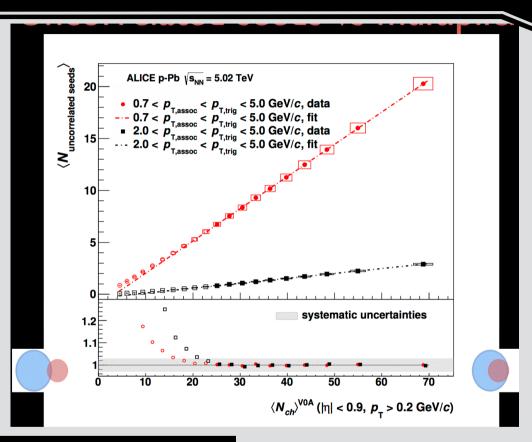
### ALICE

Emilia Leogrande

Multi-particle interactions







- \* high multiplicity: MPI increase linearly with multiplicity
  - \* dominate the particle production mechanism at high multiplicity
- ★ low multiplicity: change in dynamics

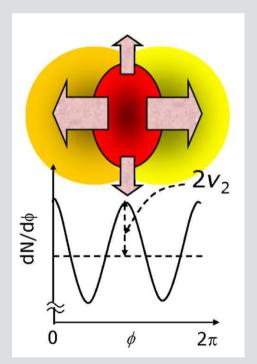
p-HI collions

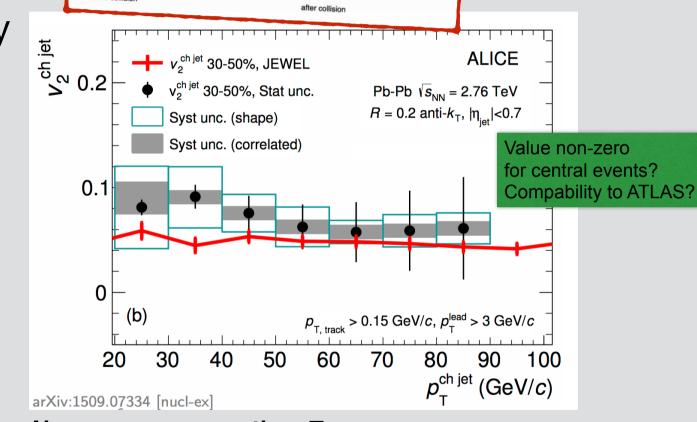


### **ALICE**

Redmer Bertens

- Azimuthal anisotropy
  - -angle v<sub>2</sub>





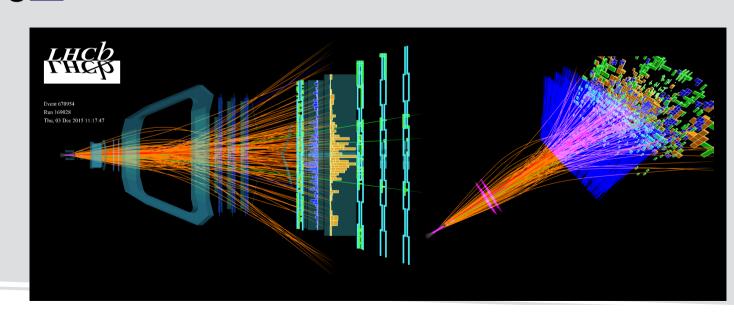
Non-zero v<sub>2</sub> over entire pT range Confirmation of jet energy loss in the collision medium

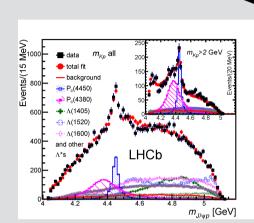


### **LHCb**



- Detector works xxtremely well
  - -20th birthday of LHCb
  - -Thanks to all engineers & technicians @ Nikhef!
- Many new puzzling sults
  - -Very rich program
- Physics program
  - -CP violation
  - -Very rare B decays



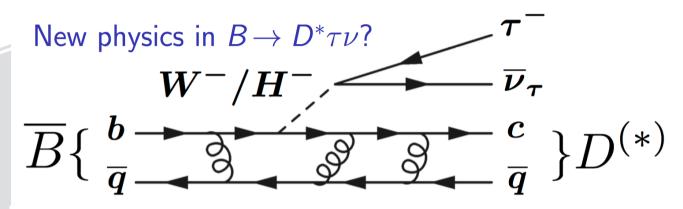






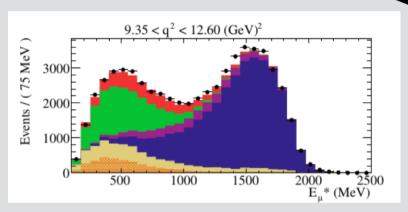
### **LHCb**

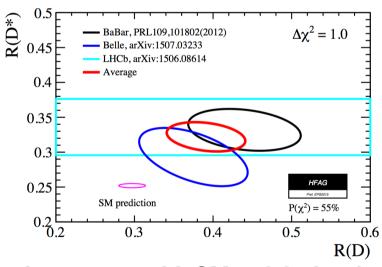




$$\mathsf{R}(D^{(*)}) = \mathcal{B}(B \to D^{(*)} au 
u) \ / \ \mathcal{B}(B \to D^{(*)} \mu 
u)$$

- Challenges:
  - -neutrino in final state
  - -combinatorics
- MVA and fits to extract yields

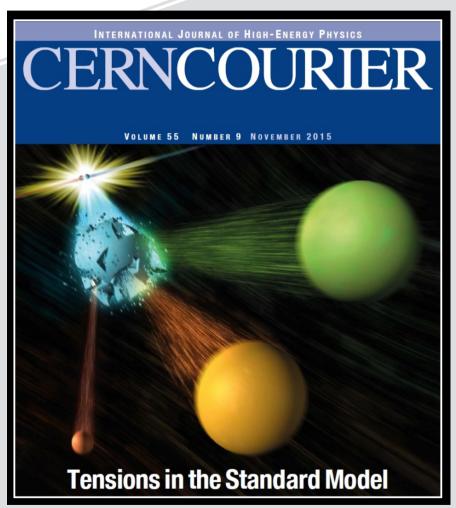




Agreement with SM at 3.9σ level



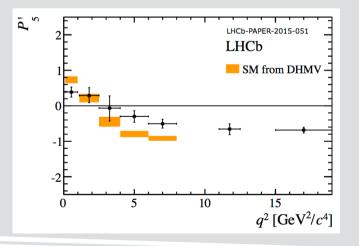




$$R_K = \frac{\Gamma(B^+ \to K^+ \mu^+ \mu^-)}{\Gamma(B^+ \to K^+ e^+ e^-)}$$

$$R(D*)$$

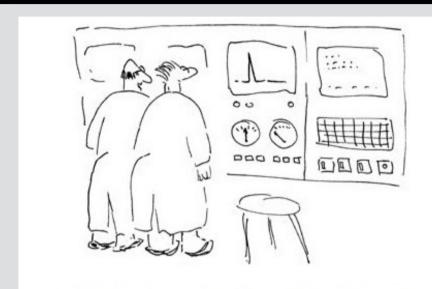
$$\left| \mathcal{R}(D^*) \right| \equiv \mathcal{B}(\overline{B}{}^0 \rightarrow D^{*+} \tau^- \overline{\nu}_{ au}) / \mathcal{B}(\overline{B}{}^0 \rightarrow D^{*+} \mu^- \overline{\nu}_{\mu})$$



- -Lepton nonuniversality
- -FCNC's
- -more...



- Model building
  - -1) Model independent fits
  - -2) Leptoquarks
  - -3) heavy Z'



WELL, EITHER WE'VE FOUND THE Z' BOSON, OR MARCEL'S JUST PUT THE KETTLE ON

- Many tantalyzing hints
- This time, they seem to point in the same direction...
- One parameter needs adjustment (C<sub>9</sub>)



### LHCb

### Run-2 challenge

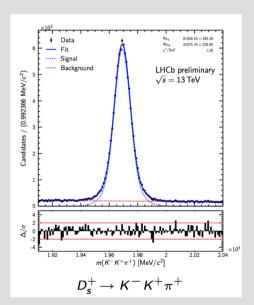
Can we maintain improve performance under more challenging conditions?



### Offline → Online!

- Do "Online" what used to be done "Offline"
  - Calibrate in "Real Time"
  - Run offline reconstruction online
  - Skip offline reconstruction / skimming
  - Don't store events / information that you won't really use...

### **Turbo Charm**



"The problem is not the problem.

The problem is your attitude about the problem"

Software improvement:

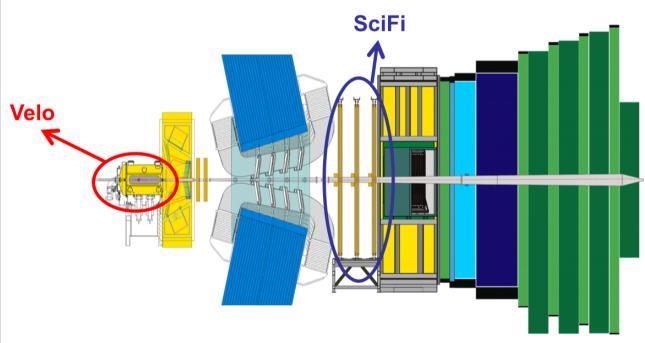
Equivalent to 'a few MCHF' of hardware
Unified online and offline reconstruction!



- Upgrade plans
  - -and realisation



- Solution:
  - Read out detector at 40 MHz.
  - Replace front-end electronics and tracking system.
- Nikhef involvement: Velo, SciFi, trigger.







### PhD defenses @ 2015

- Rosemarie Aben
  - "Spinning de Higgs Spin en pariteitsmeting van het ontdekte higgsachtige boson in het H—>WW—>lvlv verval"
- Francesco Zappon
  - It is about time. Design and test of a per-pixel high-resolution TDC
- Erwin Visser
  - Neutrino's uit de Melkweg
- Roel Aaij
  - Triggering on CP Violation. Real-Time Selection and Reconstruction of Bs -> J/ψφ Decays
- Veerle Heijne
  - Zoektocht naar langlevende exotische deeltjes in LHCb
- Geert-Jan Besjes
  - Pushing SUSY's boundaries Searches and prospects for strongly-produced supersymmetry at the LHC with the ATLAS detector
- Stef Janssens
  - Trilling isolatie en precisie richten van vierpolige magneten in de Compact Linear Collider (CLIC)
- Wilco Koppert
  - GridPix: Ontwikkeling en Karakterisatie van een Gasvormige Traceer Detector





### ...in total 20 counted

- Stefan Gadatsch
  - -The Higgs boson
- Rolf Schön
  - -XAMS Development of liquid xenon detector technology for dark matter searches
- Carlos Perez Lara
  - -Azimuthal anisotropy of strange and charm hadrons measured in Pb-Pb collisions
- Rogier van der Geer
  - -Searches for new physics through single top
- Maarten Buffing
  - -Color and TMD universality in hadronic interactions
- · Antonio Castelli
  - -Measuring the Higgs boson mass using event-by-event uncertainties
- Kristof de Bruyn
  - -Searching for Penguin footprints: Towards high precision CP violation measurements
- Rose Koopman
  - -Ageing of the LHCb Outer Tracker & b-hadron production and decay at (sqrt)s = 7 TeV
- Nika Valencic
  - -Fusing the Vector Bosons Higgs production through VBF and WW scattering at the current and future LHC
- Alis Rodriguez Manso
  - -Balance functions: Multiplicity and transverse momentum dependence of the charge dependent correlations in ALICE
- Daniel Geerts
  - -Search for single top events at ATLAS
- Matthieu Blom
  - -Virgo seismic attenuation systems





## Nikhef personalia





- eScience grant, VENI, VIDI, VICI, projectruimte
- Professorship

















## Nikhef news

### Protons set to collide at 13 TeV to prepare for physics

Theoretisch natuurkundigen Eric Laenen, Kasper Larsen en Robbert Rietkerk hebben onlangs een methode ontwikkeld om relevante informatie over deelties botsingen op efficiënte wijze te berekenen. Hun nieuwe aanpak is gepubliceerd in een artikel in Physical Review Letters, dat de voorkant van het tijdschrift haalde.

Natuurkundigen ontwikkelen efficiënte berekeningsmethode

Botsingen tussen elementaire deelties, zoals geproduceerd bij de Large Hadron Collider in Geneve, zijn behoorlijk gecompliceerd. Het voorspellen van de uitkomst van zulke botsingen vereist dan ook zeer ingewikkelde berekeningen.

Om die taak eenvoudiger te maken, maken natuurkundigen gebruik van eikonale Feynman diagrammen. Zulke diagrammen geven een versimpelde weergave van een botsing, maar bevatten toch de essentiële informatie.

De wetenschappers van Nikhef, de Universiteit van Amsterdam en de ETH Zurich richtten zich op het imaginaire met het beautig deel van zulke diagrammen. Dat is van belang voor fase-verschillen bij LHC botsingen en eveneens voor een aantal theoretische vraagstukken.

Het artikel introduceert een nieuwe methode om het imaginaire deel van eikonale Feynman collaboratie nieuwe diagrammen te berekenen. Daarbij worden de diagrammen op verschillende manieren 'gesneden' in eenvoudigere stukken. Bijzonder is ook de systematische aanpak van deze beauty en strange q methode, waardoor het toegepast kan worden op een grote verscheidenheid aan eikonale strange en beauty q diagrammen.

alledaagse materie maar wer geproguceeru worden in botsingen in versnellers.

Fen hint van N

De nieuwe resultaten laten een verschil zien tussen de waarnemingen en de voorspellingen van het standaardmodel, met ten minste 3.7 standaarddeviaties significantie. Dit zou erop kunnen duiden dat er nieuwe fundamentele deelties of krachten in het spel zijn die het

zogenaamde Z' boson, een deeltje dat voorspeld wordt in verschillende nieuwe modellen en dat vaak geassocieerd wordt met het bestaan van een nieuwe fundamentele kracht.

onstarten voor de nieuwe LHC-run. Dan zullen nieuwe gegevens worden verzameld om het huidige, opwindende resultaat verder te ontrafelen: is het slechts een statistische fluctuatie of betreft het daadwerkelijk een eerste scheurtie in het standaardmodel?

Voor meer informatie kunt u contact opnemen met de afdeling Wetenschanscommunicatie: email - 020 592 5075 / 592 2075 of met: Prof. dr. Marcel Merk, Nikhef-programmaleider voor I HCh: e-mail - 020 5925107



the next 24 hours, beams of protons should in the Large Hadron Collider (LHC) at the 1-breaking energy of 13 teraelectronyolts for the first time. This is one of the many required to prepare the machine before the second physics run can begin. The LHC tions team plans to declare "stable beams" coming weeks - the signal for the LHC iments to start taking physics data at this nergy frontier.

nonth proton beams were back in the erator for the first time after two years of

e maintenance and consolidation. The first beam at the record energy of 6.5 TeV circulated

### liceert gecombineerde Higgs-metingen ATLAS en

17-05-2015

PHYSICAL

REVIEW

LETTERS

### uwsbericht

verscheen in het tijdschrift Physical Review eerste gecombineerde publicatie van de ATLASberimenten bij de Large Hadron Collider (LHC),

met uaarın een combinatie van de metingen van de massa van het higgsdeeltje door beide collaboraties. Het resultaat, verkregen door het samenvoegen van de analyses van de H -> ZZ en H -> gamma gamma kanalen, is:

Dit houdt een nauwkeurigheid in van 0.2%. Tevens toont de publicatie aan dat de higgsmassa-metingen in beide experimenten consistent met elkaar zijn, en dat ook de ZZ en gamma gamma kanalen hetzelfde resultaat geven. De meting is gelimiteerd door de beperkte grootte van de dataset, en zal in Run 2 van de LHC nog veel preciezer worden.

De higgsmassa is een belangrijke parameter binnen het Standaardmodel van de subatomaire fysica. Door een nauwkeurige meting van de higgsmassa en van andere observabelen kan de consistentie van het standaardmodel getest worden. Nieuwe fysica kan daarbij aanleiding geven tot quantumcorrecties die tot afwijkingen leiden. Daarnaast is de gemeten waarde van de higgsmassa een hele bijzondere: met deze waarde bevindt ons heelal zich in een metastabiele vacuümtoestand dicht bij een faseovergang.



### Artikel Nikhef-onderzoeker besproken in Nature en Scientific

Recentelijk is een preprint article uitgekomen van Luc Hendriks, Sascha Caron, Abraham Achterberg, Christoph Weniger en collega's. De auteurs beschrijven hun bevindingen dat een fotonsignaal vanuit het centrum van onze Melkweg voor de Large Hadron Collider (LHC) een aanwijzing zou kunnen zijn voor (supersymmetrische) Donkere Materie. De preprint wordt in recente edities van Nature en Scientific American besproken onder 'nieuws':

http://www.nature.com/news/mysterious-galactic-signal-points-lhc-to-dark-matter-1.17485

Sascha Caron is Nikhef-onderzoeker en verbonden aan de Radboud Universiteit Niimegen. Luc Hendriks en Abraham Achterberg zijn verbonden aan de Radboud Universiteit Nijmegen. Christoph Weniger is verbonden aan de Universiteit van Amsterdam.

### CERN-onderzoekers ontdekken zeldzaam deeltjesverval

### FOM/Nikhef persbericht

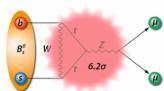
Een gezamenlijke speurtocht van de CMS- en LHCb-experimenten van CERN heeft geleid tot de ontdekking van een van de meest zeldzame deeltjesvervallen in de natuur: het verval van een B.0-meson naar twee muonen. Het artikel waarin de CERN-onderzoekers hun werk beschrijven, verschijnt vandaag in Nature.

Het B<sub>c</sub>0-meson is een instablel deeltje dat bestaat uit een zogenaamd beauty-antiquark en een strange-guark. Deze deeltjes heffen elkaar op in het verval en produceren daarbij twee muondeeltjes.

Naast dit verval hebben de fysici ook een hint gevonden van het vergelijkbare, maar nog zeldzamere verval van het B<sub>d</sub>0-meson naar twee muonen. Het B<sub>d</sub>0-meson lijkt op B<sub>s</sub>0deeltje, maar bevat een beauty-antiquark en een down-quark.

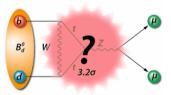
### Ouantummechanica

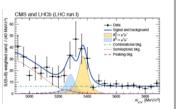
Vanwege hun zeldzaamheid bieden deze processen ons een diepe blik in de virtuele wereld van de quantummechanica. Hierin kunnen nieuwe, onbekende, deeltjes spontaan kortstondig verschijnen. Tijdens dit korte virtuele bestaan kunnen ze B-mesonen echter subtiel beïnvloeden. Daardoor kunnen juist de gemeten, zeldzame vervallen mogelijkerwijs vaker of minder vaak plaatsvinden dan natuurkundigen verwachten uit herekeningen met het Standaardmodel - de standaardtheorie waarmee fysici deeltjes en krachten beschrijven.



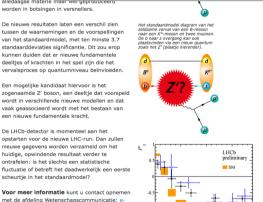
13-05-2015

Schematische weergaven (hierboven en hieronder) van de betreffende  $B_s^0$  – en  $B_d^0$  -vervalsprocessen volgens het Standaardmodel. Het getal geeft de stalistiches einbilieratie van de stalistiches einbilieratie van de stalistiches einbilieratie.





Het waargenomen signaal van LHCb en CMS. De zwarte punten zijn de waarnemingen, de gele en blauwe pieken geven de bijdragen van de B<sub>s</sub>0- en B<sub>d</sub>0-vervallen weer.





 Sijbrand de Jong president of the CERN council starting 1.1.2016





### Prize Jo van den Brand

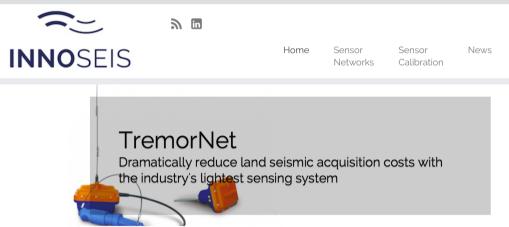
- FOM valorization prize
  - -"for his his commitment to the enhancement of the very basic knowledge and skills derived from his research in subatomic physics"
    - handed out during
       FOM Veldhoven in januari 2016





### Innoseis







Start-up prize - handed out by Neelie Smit



## Outreach and communication





### KM3NeT ESFRI status

### ESFRI roadmap

sneak peak of the report

### RECOMMENDED STATUS

candidate

KM3NeT 2.0 was the only project re-applying (as a project re-orientation) after ten years on the ESFRI roadmap. Its scientific case is evaluated 'very high' and its maturity 'high'. Both the SWG PSE and the IG are thus convinced that KM3NeT 2.0 has a very strong scientific case, with a better specification of the two-site option and the novel proven technology that was developed during the phase I, e.g. the previous status of ESFRI project since the 2006 Roadmap. With the own novel detector engineering and the updated budget plan, adjusted to the lower cost of the underwater infrastructure Km3NET 2.0 is considered very likely to move quickly towards implementation. ESFRI fully supports the Km3NET 2.0 and thus proposes it for inclusion in the 2016 ESFRI Roadmnap.



### Ongoing and future infra

Large infrastructure roadmap - Nikhef involvement Submitted to Large scale infrastructure yesterday

- LHC update
  - -Upgrade phase-1 and phase-2 ATLAS, LHCb, ALICE
- KM3NeT
  - -Roadmap funding request for KM3NeT 2.0
- International Linear Collider
  - -Future infrastructure we do not want to miss!
- Einstein telescope
  - -Proposal for Dutch site for this huge infrastructure



### National Science Agenda

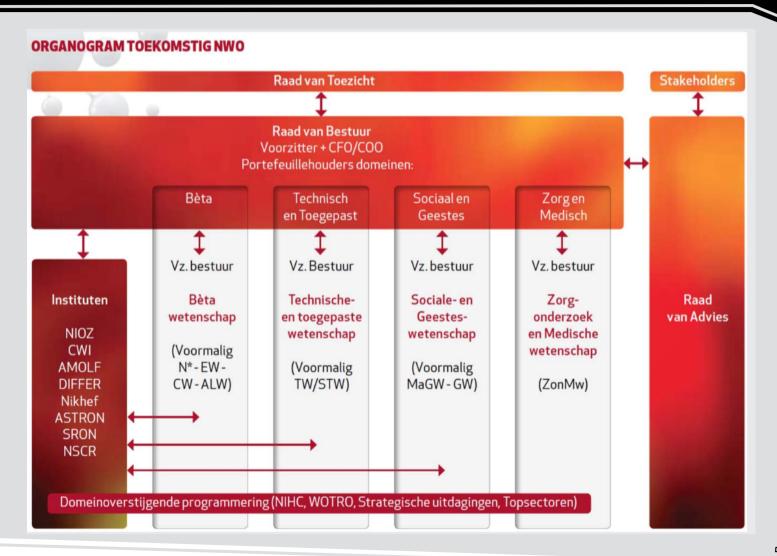
- 11500 questions formulated by general audience
  - -collected nationally in early 2015
- 140 key questions are identified
  - -NW128 "Kennen we alle elementaire bouwstenen van materie?"
  - -NW130 "Wat is donkere materie en wat is donkere energie?"
- 16 'sample' routes are defined
  - "Bouwstenen van materie en fundamenten van ruimte en tijd"
  - -Big Data

Connecting to these routes may become important in future funding



### **NWO** transition

- Grand Depart
  - -1.1.2017
  - Regular updatescommunication
    - Beerenschot:
       biggest
       organizational
       change we've
       ever seen





# Nikhef directorate team



