



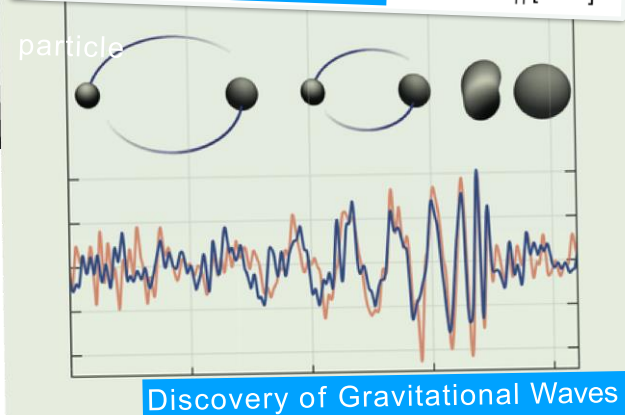
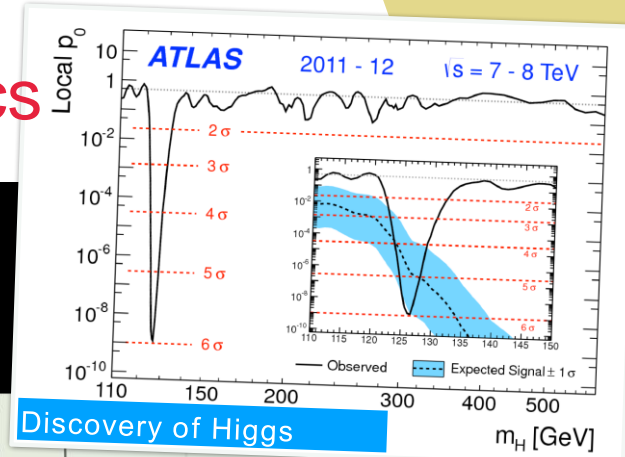
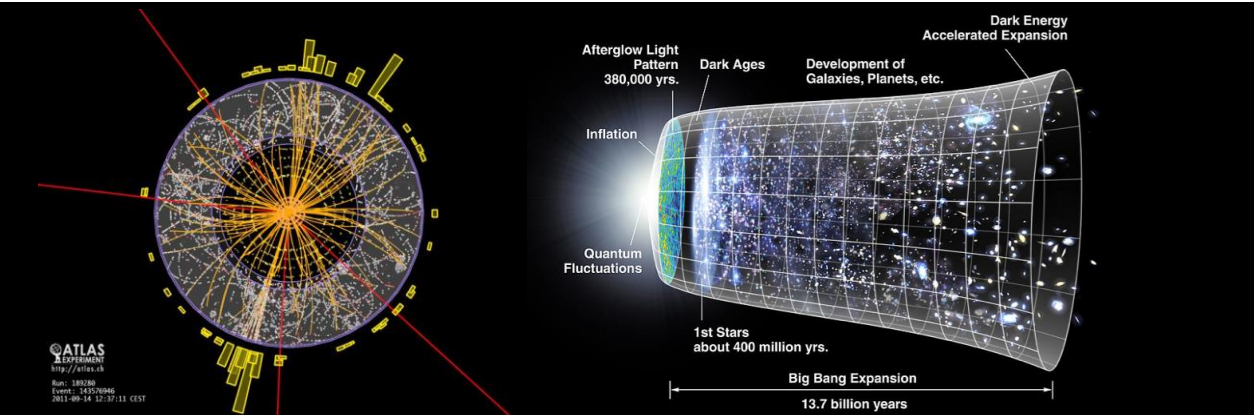
Maastricht University

Federated computing ecosystems for science

Nikhef, its science and ICT programme,
and the NikhefHousing data centre

David Groep
for the GEANT
SIG-RED workshop
November 19, 2024

Welcome to Nikhef the Dutch National Institute for Sub-atomic Physics



We probe our world, made of particles and fields,

- with collider physics, primarily at CERN
- astroparticle physics:
particles, radiation, and ripples coming from the universe

The Nikhef Partnership

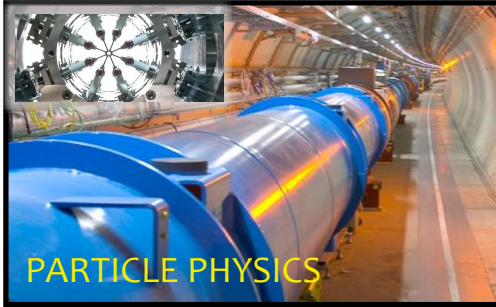
In itself a collaborative ecosystem

- university partners co-lead (most) research programmes
- aligned with a joint national strategy

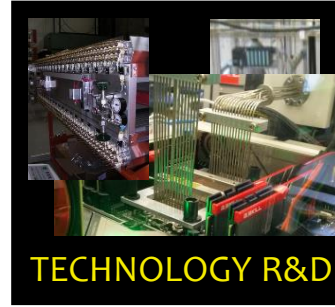
Permanent Staff	96
PhD candidates	125
Postdocs	43
Technical/engineer	88
Support	33



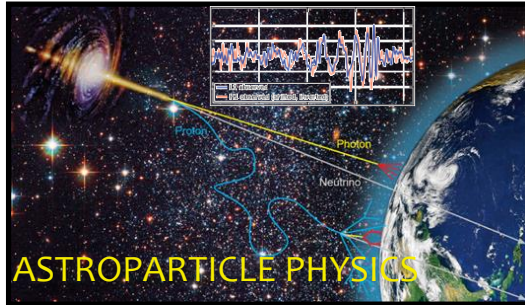
Nikhef Scientific Programmes



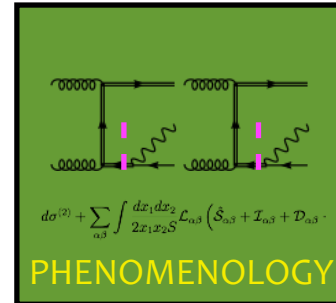
- Atlas
- LHCb
- Alice
- eEDM



- Detector R&D
- Physics Data Processing



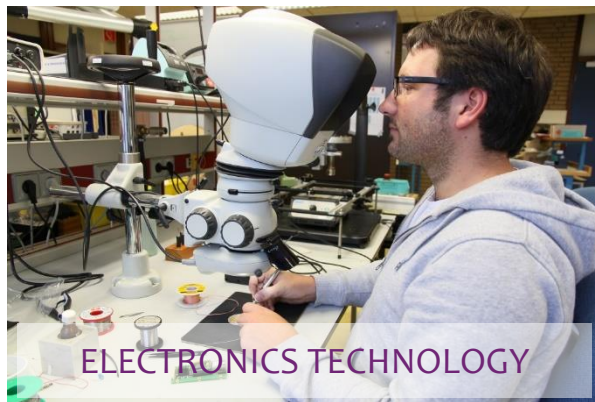
- Neutrinos
- Gravitational waves
- Cosmic Rays
- Dark Matter



- Theoretical Physics

Technical Engineering and technology transfer

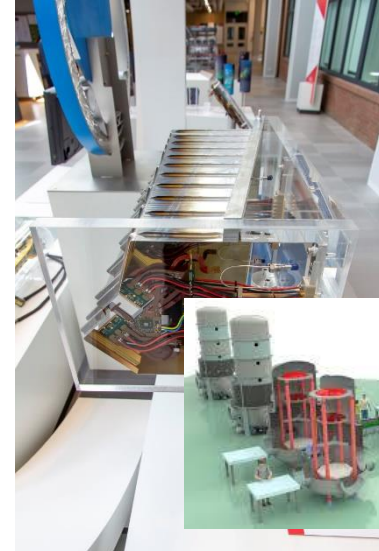
'The research at Nikhef relies on the development of innovative technologies. The knowledge and technology transfer to third parties, i.e., industry, civil society and general public, is an integral part of Nikhef's mission.'



pictures from Nikhef's 'Dimensions' magazine and Computing Office Hours; <https://www.nikhef.nl/en/nikhef-mission/>

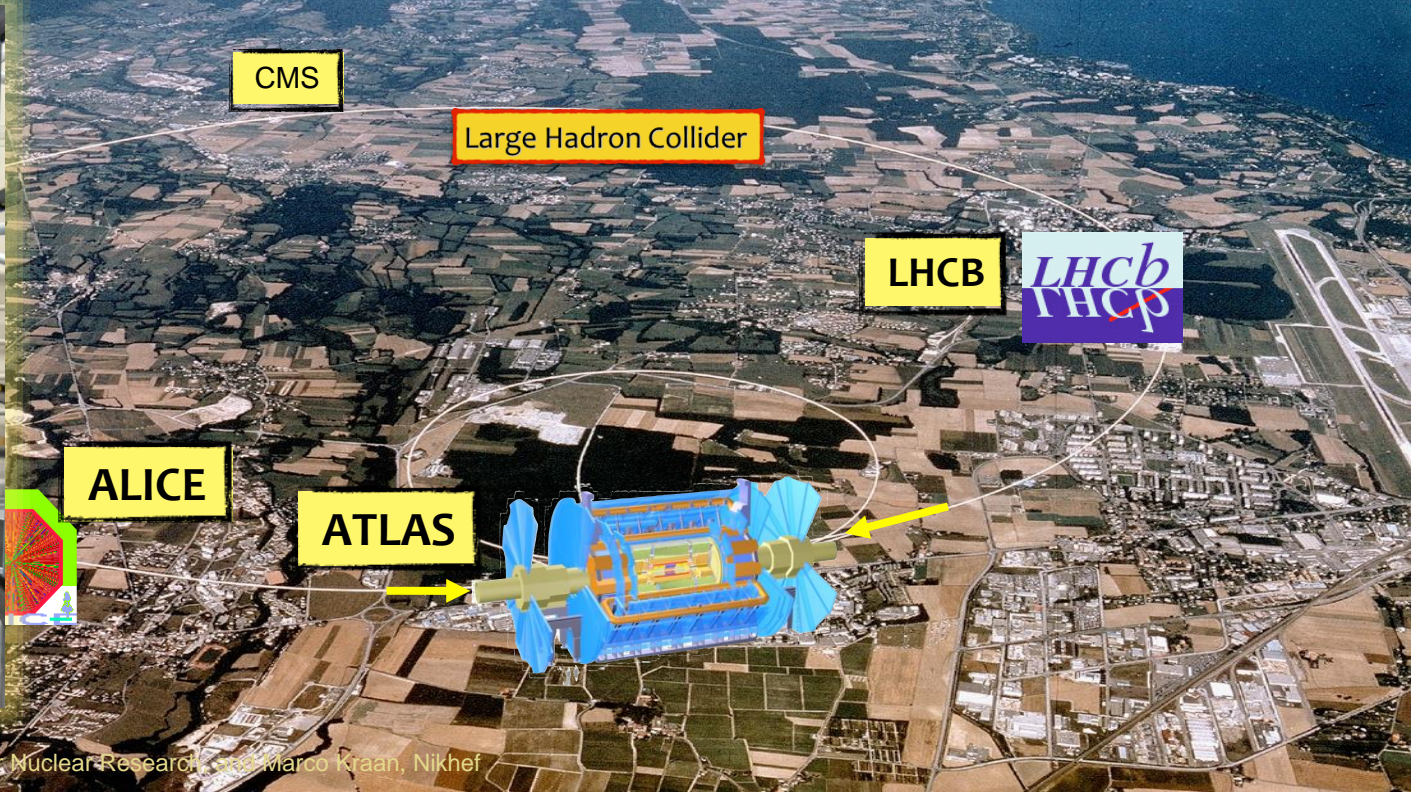
Infrastructure-intensive science

ATLAS AT CERN
~ 150 INSTITUTES
~1800 PHYSICISTS



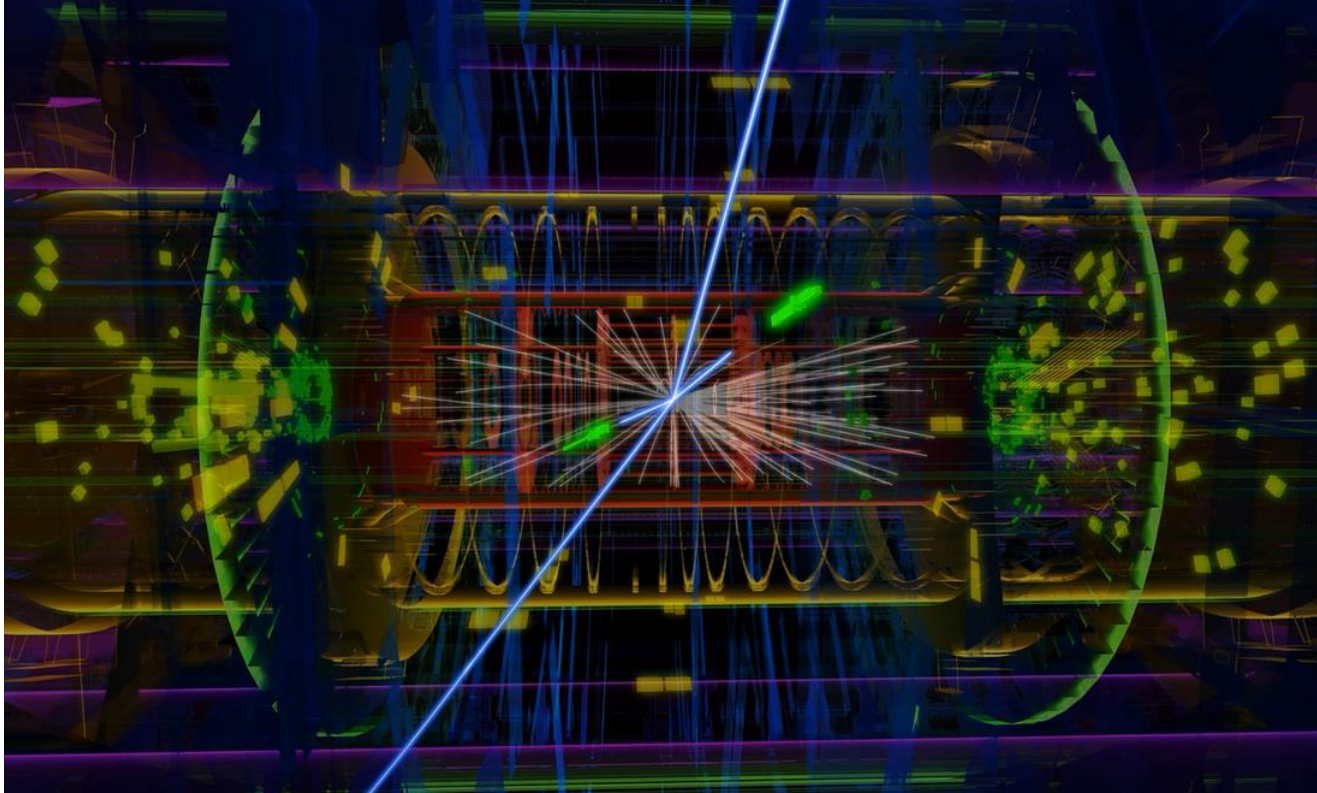
Slide materials from: Stan Bentvelsen, 2016, ATLAS collaboration, CERN; LHCb VELO and RF box at Nikhef and ET Pathfinder visualisation: Marco Kraan, Nikhef

Nikhef at CERN – LHCb, Atlas, Alice

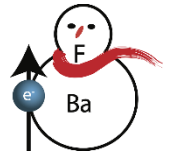
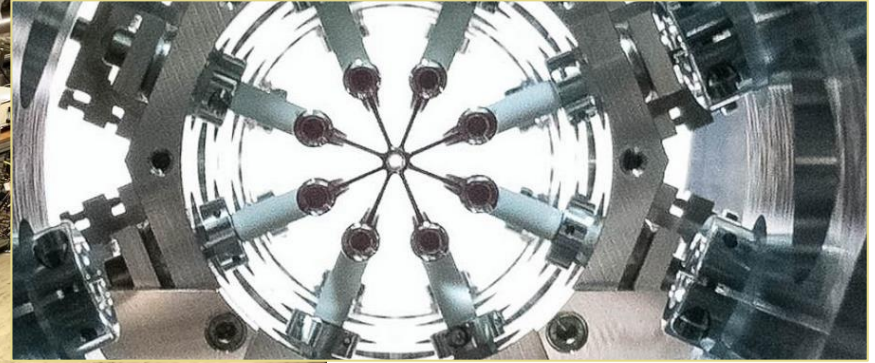
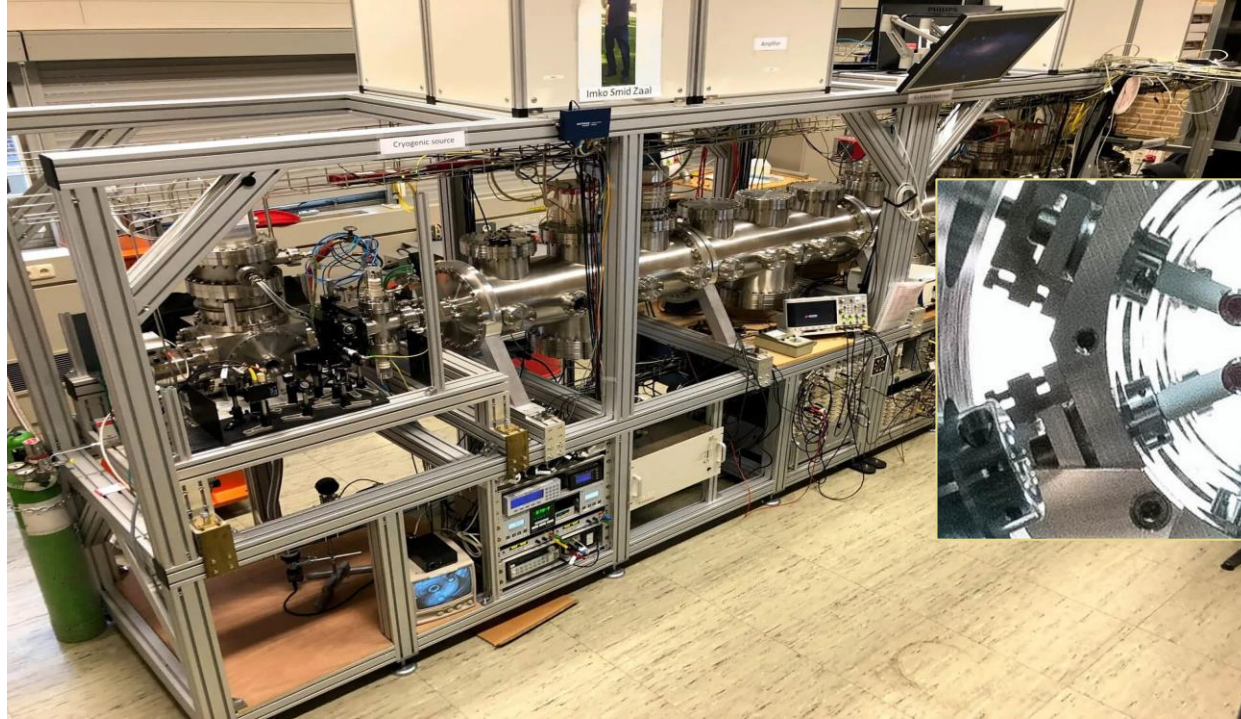


Imagery: CERN, European Organisation for Nuclear Research, and Marco Kraan, Nikhef

Atlas: up to 40 Tbyte/day of fresh raw data



And decelerate for ultra-high-precision measurements



<https://www.eedm.nl/> Nikhef and Rijksuniversiteit Groningen, images: Steven Hoekstra

Particles at Extreme Energies

Multi-Messenger

Propagation?
Mass composition!?

Interactions?
Mass composition!?

Nucleus

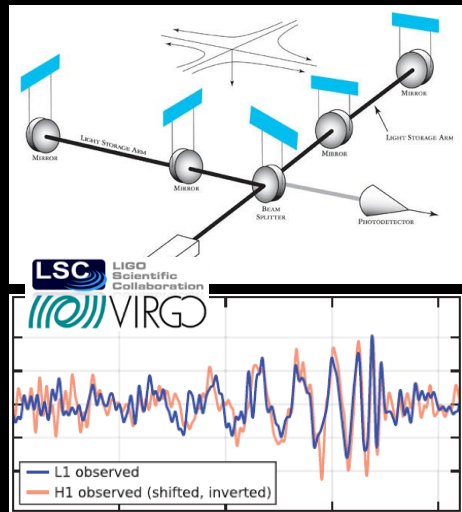
Proton

Photon

Neutrino

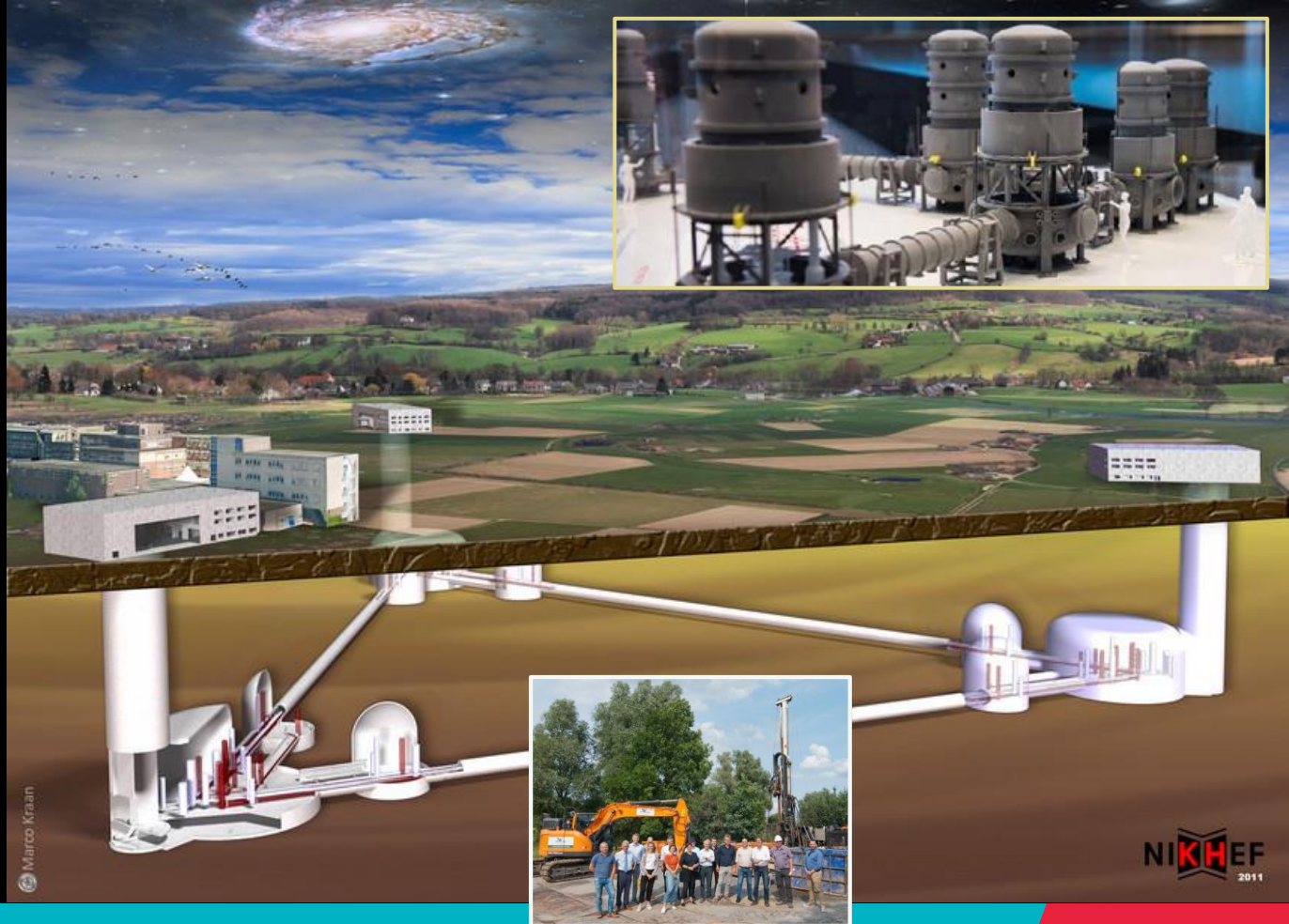
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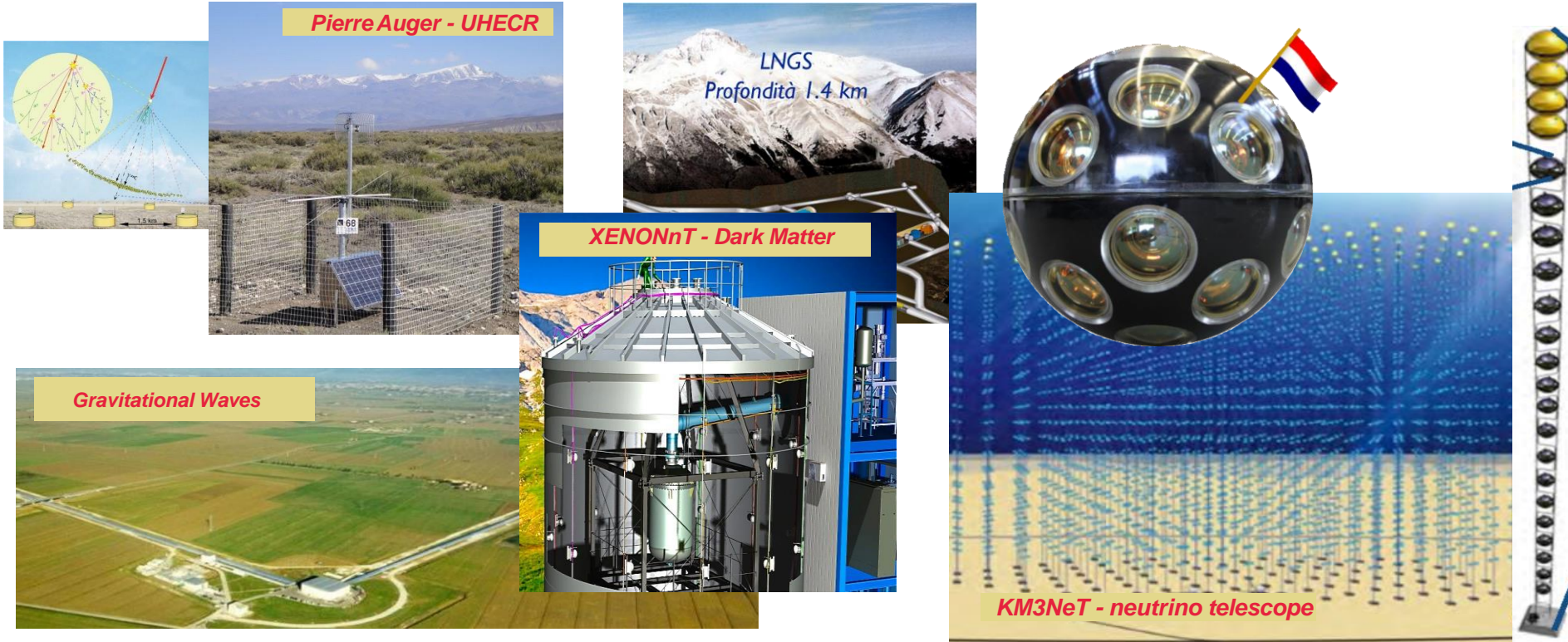


Einstein Telescope projected in the **Euregio Maas Rijn**, images: Marco Kraan; ET Pathfinder at UM, Maastricht, NL

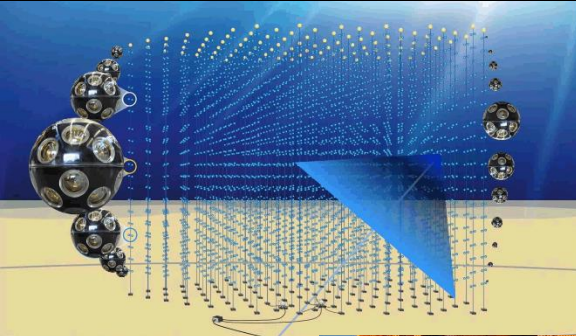
GW150914 event:
gw-astronomy collaborations, LIGO



The astro-particle physics programmes Nikhef



Slide: Stan Bentvelsen, Nikhef SEP 2023, KM3NeT collaboration, Virgo Collaboration, Xenon-nT collaboration, Pierre-Auger collaboration



Little white structures prevent the HV bases and cables to touch each other

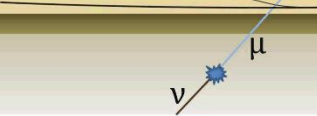


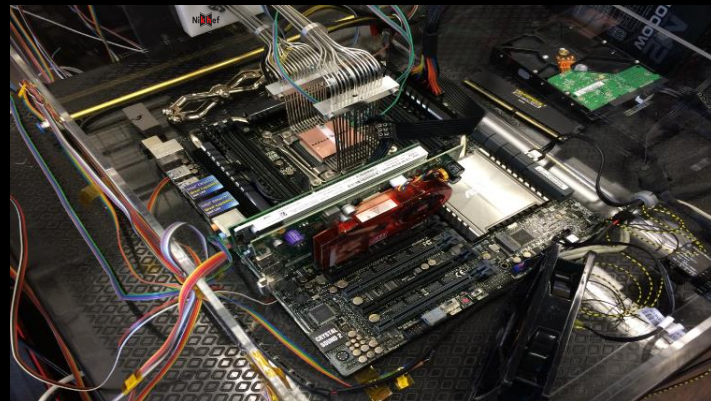
Image sources:
Nikhef, NIOZ,
KM3NET collaboration,
NRC Handelsblad

Enabling Research Programmes – next gen infrastructure



Detector R&D

Theoretical
Physics



Physics Data Processing

Infrastructure research for research infrastructures at Nikhef

Algorithmic design patterns and software

- scientific software (GPU) acceleration, new algorithms, high-performance processors
- software design patterns for workflow & data orchestration, and (energy) efficiency



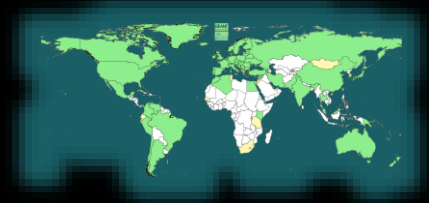
Infrastructure, network & systems co-design R&D

- building 'research IT facilities'
- co-design & development
- big data science innovation
- research *on* IT infrastructure



Infrastructure for trusted collaboration

- trust and identity for enabling communities
- managing complexity of collaboration mechanisms
- securing the infrastructure of our open science cloud



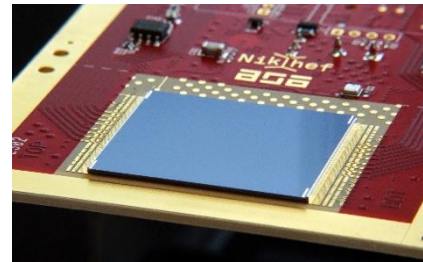
Algorithms and detectors go hand in hand

Reducing complexity is both in hardware and algorithms



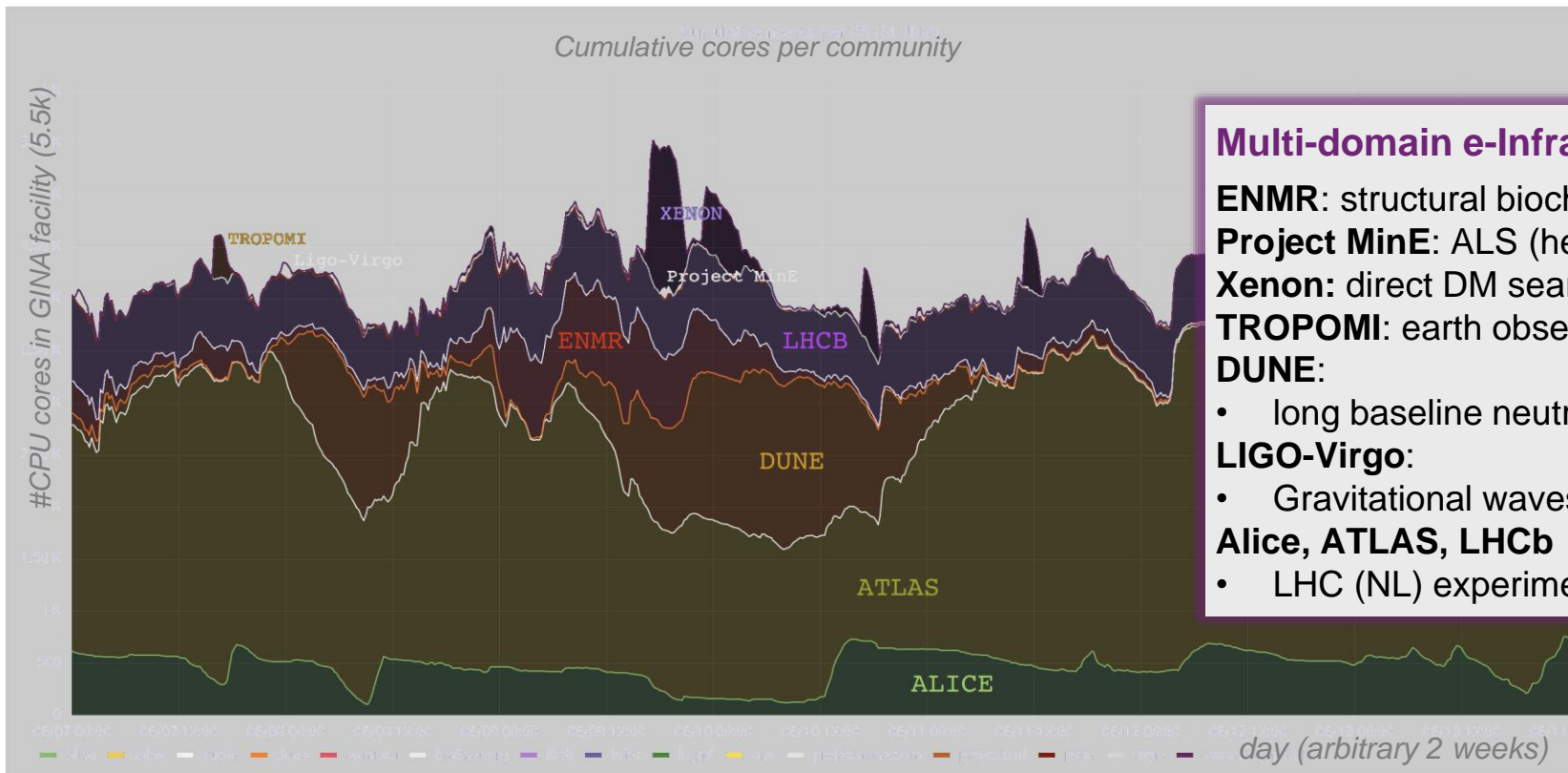
If we ‘do nothing’, the HL-LHC intensity will result in hundreds of overlapping ‘images’ that are impossible to disentangle:

- improve timing resolution to 10-50ps (more ‘frames’ per collision)
- accelerated algorithms and dedicated GPU kernels, also ‘off-line’



From: FASTER (LHCb images) and R.Geertsema LHCP2022; right: TimePIX4 (also used at e.g. M4i)

Data Processing infrastructure – the Dutch SURF example



Multi-domain e-Infrastructure

ENMR: structural biochemistry

Project MinE: ALS (health)

Xenon: direct DM searches

TROPOMI: earth observation

DUNE:

- long baseline neutrinos

LIGO-Virgo:

- Gravitational waves

Alice, ATLAS, LHCb

- LHC (NL) experiments

Sharing more than resources: data, software, research pipelines, expertise

*Thematic Digital Competence Centres -
beyond data stewards and 'dead' data for open science*

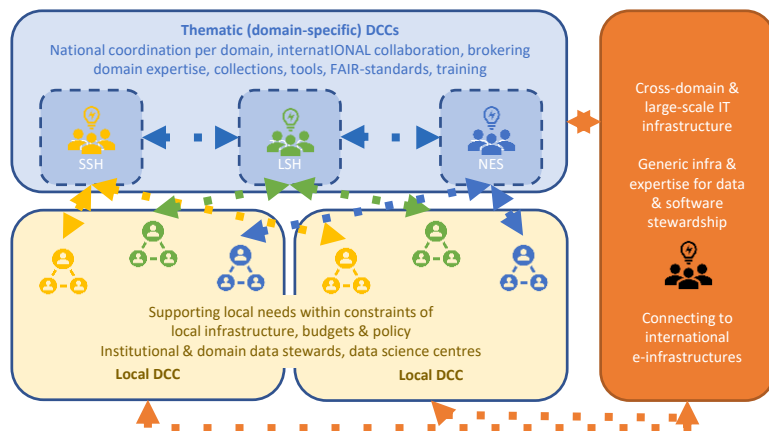


Image by: Ruben Kok, LSH TDCC and DTL

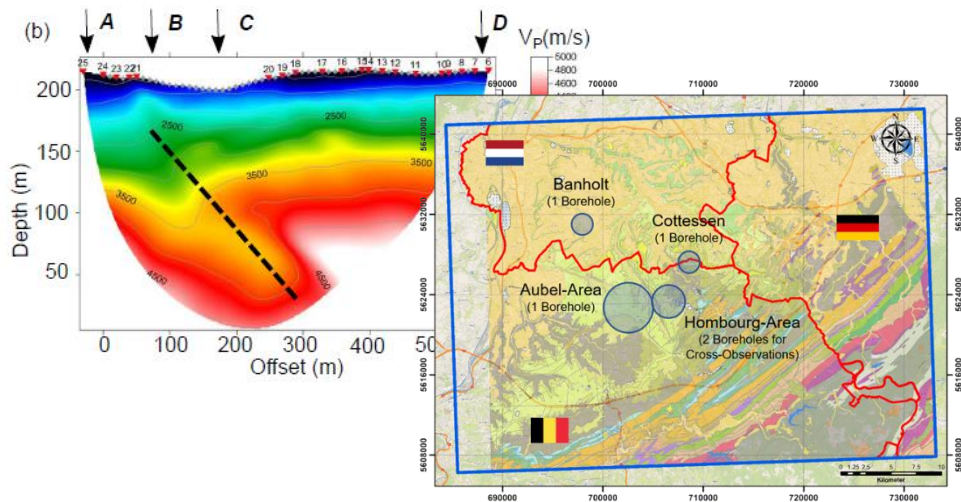
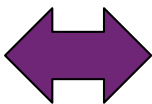
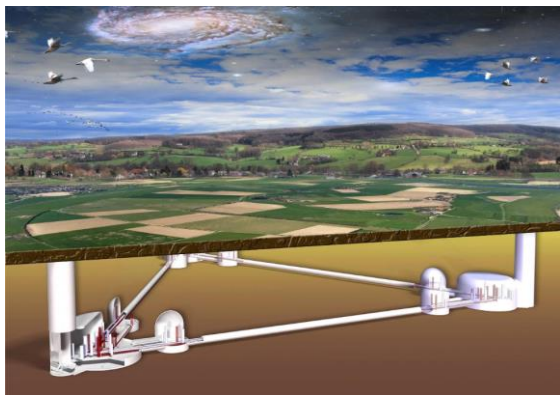
Software and infrastructure essential to bring 'dead' data to life!



Sharing expertise: thematic digital competence centres

an example from the Natural and Engineering Sciences domain

Case study: Einstein Telescope seismic studies in EUregion Meuse-Rhine in the *E-TEST* project



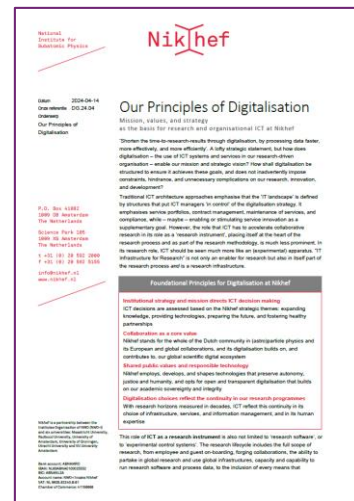
Data collected here is also useful for many other domains outside of the ET planning ...

ET impression: Marco Kraan (Nikhef) from "Terziet drilling campaign" <https://www.nikhef.nl/wp-content/uploads/2019/10/Terziet-Drilling-Campaign-Final-NoC.pdf>
Seismic data: S Koley (VU and Nikhef) *Sensor networks to measure environmental noise at gravitational wave detector sites*, ISBN 978-94028-2054-6; map image: etest-emr.eu project site

Looking at ICT as a research instrument, like our detectors

'ICT infrastructure for research – distinct from the office and enterprise service'

- research data today has joint challenges, and hence shared e-Infrastructure!
- and needs a different governance compared to enterprise IT



Riding the infrastructure innovation chain together

Computing Sciences Research



Future Computer Systems and Networking Research in the Netherlands: A Manifesto

ICT Research Platform Netherlands, SIG Future Computer and Network Systems
Editors: Alexandru Iosup (VU, A.iosup@vu.nl) and Fernando Kuipers (TU Delft, F.A.Kuipers@tudelft.nl)

Executive summary

Society's engine for responsible and sustainable future? Computer Systems Our modern society and competitive economy depend on a strong digital foundation and, in turn, on sustained computer systems research and innovation. Computer systems, ranging from small, embedded devices to large data centers and the networks that connect them, are a remarkable technology area that has been a major driver of economic growth and societal progress. Computer systems and related ICT infrastructure enable over 3.3 million jobs and over 60% of the GDP, and novel services and products, and where every CI invested in such systems generates CIS in added value. Sustained investments in capital networking infrastructure have made the Netherlands home to one of the world's most advanced digital infrastructures. The Netherlands has a long tradition of 65% for government and public education organizations. Our overarching goal with this document is to highlight the grand societal, technological, and scientific opportunities and challenges in future computer systems research and innovation (Computer Systems), and to outline how to maintain the leading position the Netherlands has in this area.

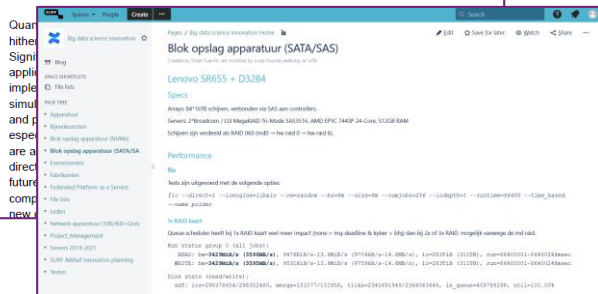
Future-proof digitalization requires ICT research and development (R&D), now. The Dutch Government and societal stakeholders have identified an urgent need to expand economic and social participation by businesses and citizens. R&D in ICT innovation, innovation, and growth will

**Operational Research
(near-term, NextGen storage,
800G+ network, QC & simulators)**

From Quark to Quantum ... with LHCb

Jacco de Vries: Maastricht University/Nikhef jdevries@nikhef.nl
Daniel Campora: Maastricht University/CERN dcampora@cern.ch
Kareljan Schoutens: UvA/QuSoft c.j.m.schoutens@uva.nl
David Groep: Nikhef davidg@nikhef.nl
Ariana Torres: SURF ariana.torres@surf.nl

Introduction



**Operational innovation
(procurement, systems
vendor co-engineering)**



involving non-CS research domains

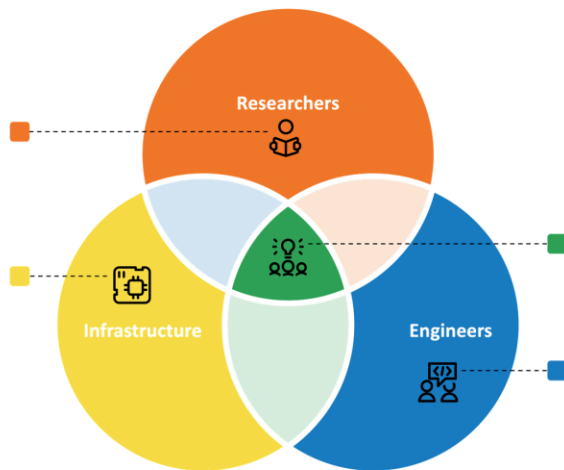
25

Images: SLICES-RI, CompSysNL, UM & SURF QC, SURF SOIL BDRI, Nikhef, its Science Programme, and the Dutch National e-Infrastructure regionaleSpeeltoern.nl @Nikhef



Nikhef

SURF Experimental Technologies Platform



SURF-ETP
Open and collaborative environment to foster the assessment of cutting-edge technologies and methodologies.

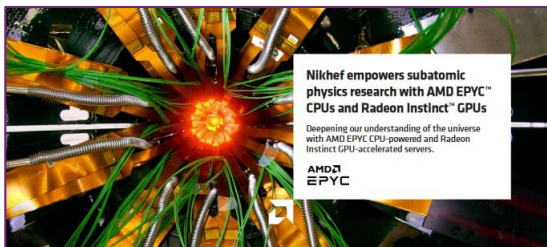
Engineers
Leverage their technical skills and motivation to surf the state-of-the-art.

SURF

The screenshot shows the SURF Experimental Technologies Platform website. The header includes the SURF logo, a 'Spaces' dropdown, a search bar, and a 'Log in' link. The left sidebar contains a navigation menu with links to iRODS, JupyterHub for education, Object Store, ODISEI Secure Supercomputer, Persistent Identifiers (PIDs), Research Drive, Service Desk, Snellius, LUMI, NLSRC, and Experimental Technologies Platform. The main content area is titled 'Overview' and is divided into three sections: 'Compute', 'Network', and 'Storage'. Each section displays a grid of featured hardware products with their logos and brief descriptions. The 'Compute' section includes AMD Instinct MI210, NVIDIA Grace Hopper Superchip, Intel GPU Max 1100, Xilinx ALVEO U250, NextSilicon Maverick, Xilinx VCK5000 Versal, and Cerebras WSE-2. The 'Network' section includes Cornelia Omni-Path Express and Nokia 7750 SR-1x-48D. The 'Storage' section includes Fungible FS1600.

<https://servicedesk.surf.nl/wiki/display/WIKI/Experimental+Technologies+Platform> and <https://www.surf.nl/en/etp> - contact Raymond Oonk at SURF for more info

And since speed does matter ..



Nikhef empowers subatomic physics research with AMD EPYC™ CPUs and Radeon Instinct™ GPUs

Deepening our understanding of the universe with AMD EPYC CPU powered and Radeon Instinct GPU-accelerated servers.

AMD EPYC

CUSTOMER
Nikhef

INDUSTRY
Subatomic Physics

CHALLENGES
Increasing data throughput with higher I/O and memory bandwidth

SOLUTION
Densys AMD EPYC™ X800 and T800 CPUs, and AMD Radeon Instinct™ M50 GPUs

RESULTS
Faster processing and the ability to harness GPU-accelerated machine learning to cope with rapidly expanding experimental data volume

AMD TECHNOLOGY AT A GLANCE
AMD EPYC™ X800 processors with 32 cores
AMD EPYC™ T800 processors with 64 cores
AMD Radeon Instinct M50 GPUs

TECHNOLOGY PARTNER
Lenovo

AMD + NIKHEF CASE STUDY

Many of the latest scientific discoveries are as much about the computing power used to analyze experimental data as they are about the theories behind them. At the forefront of advancing the processing capabilities for subatomic physics research is Nikhef, the Dutch National Institute for Subatomic Physics. Nikhef has provided computing that has helped with the discovery of gravitational waves in 2016, the Higgs boson, and the fundamental physics in between, including confirmation that many of the heavy elements in the universe are produced in neutron star mergers.

"The institute performs blue-sky research to learn more about the nature of the universe and the building blocks of matter," explains Roel Aaij, Scientific Staff Member at Nikhef. "The fundamental goal of this institute is to find the big universal box of building blocks everything is made from," adds Tristan Smeets, IT Architect at Nikhef. "The more computing power that the institute can have at its disposal, the more that can be discovered. This led the team to AMD EPYC™ processors and Radeon Instinct™ GPUs, which delivered the performance Nikhef's workloads required and the solution price that aligned with their budget."

Data-hungry science
Nikhef is involved in many different experiments, but all of them require a considerable level of computing power. "About 100 scientific staff work at Nikhef," explains Aaij. "These staff usually work on one (or sometimes more than one) of the experiments Nikhef is involved in."

Three of these experiments are at CERN, the ATLAS, LHCb, and ALICE experiments. There are several astroparticle physics experiments. One is the Pierre Auger experiment, covering several thousand square kilometers of Pampa in Argentina. The area is equipped with detectors to search for air showers caused by extremely high energy particles that arrive from the universe. Then there is the neutrino physics experiment KM3NeT, and dark matter research with the XENON experiment. Finally, there is a large gravitational waves physics group that is a member of the LIGO-Virgo experiment collaboration.

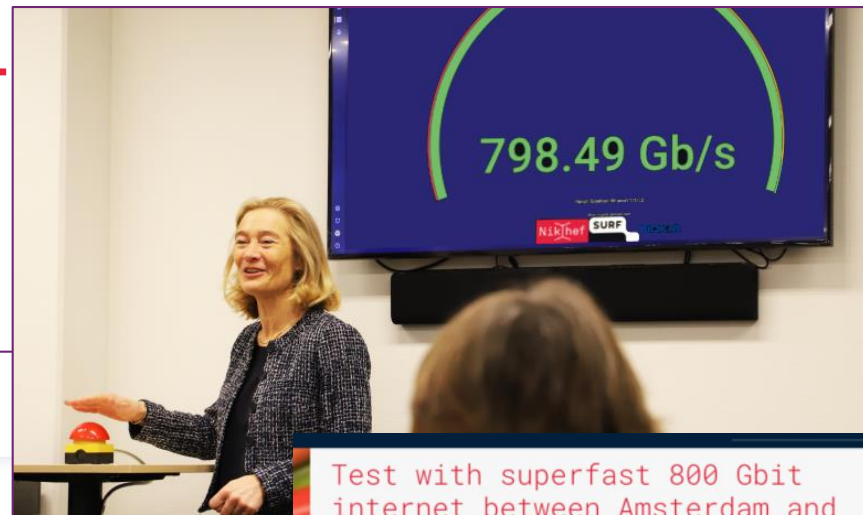
If there's one thing all these experiments have in common, it's the increasing amounts of data that the experiments produce. "The scientists always want more data," says Smeets. "I think there are few experimental physics papers that do not end with 'we need more data.' And in the field of physics, to get more data you build a more sensitive experiment." In the case of the Large Hadron Collider (LHC) at CERN, the big idea produced will be particularly huge.

"In about five years the LHC will increase the number of collisions detected by about a factor of 10," says Aaij. "This means that the experiments will start producing a similarly increasing amount of data. If we look at the growth of storage space and compute capacity over time, then we do not expect to open up close to a factor 10 in increase of performance for a fair budget. We need to deal with that because we need to process the data. Otherwise, we can't do science with it." This is where AMD EPYC™ processors and GPU acceleration have offered the best solutions to satiate the hunger for growing data processing ability.



NIKHEF, SURF AND FUNGIBLE SET NEW BENCHMARK FOR THE WORLD'S FASTEST STORAGE PERFORMANCE

Companies Double Current Performance Record, Set the New Bar at 6.55 Million Read IOPS



Test with superfast 800 Gbit internet between Amsterdam and CERN successful

15 April 2024

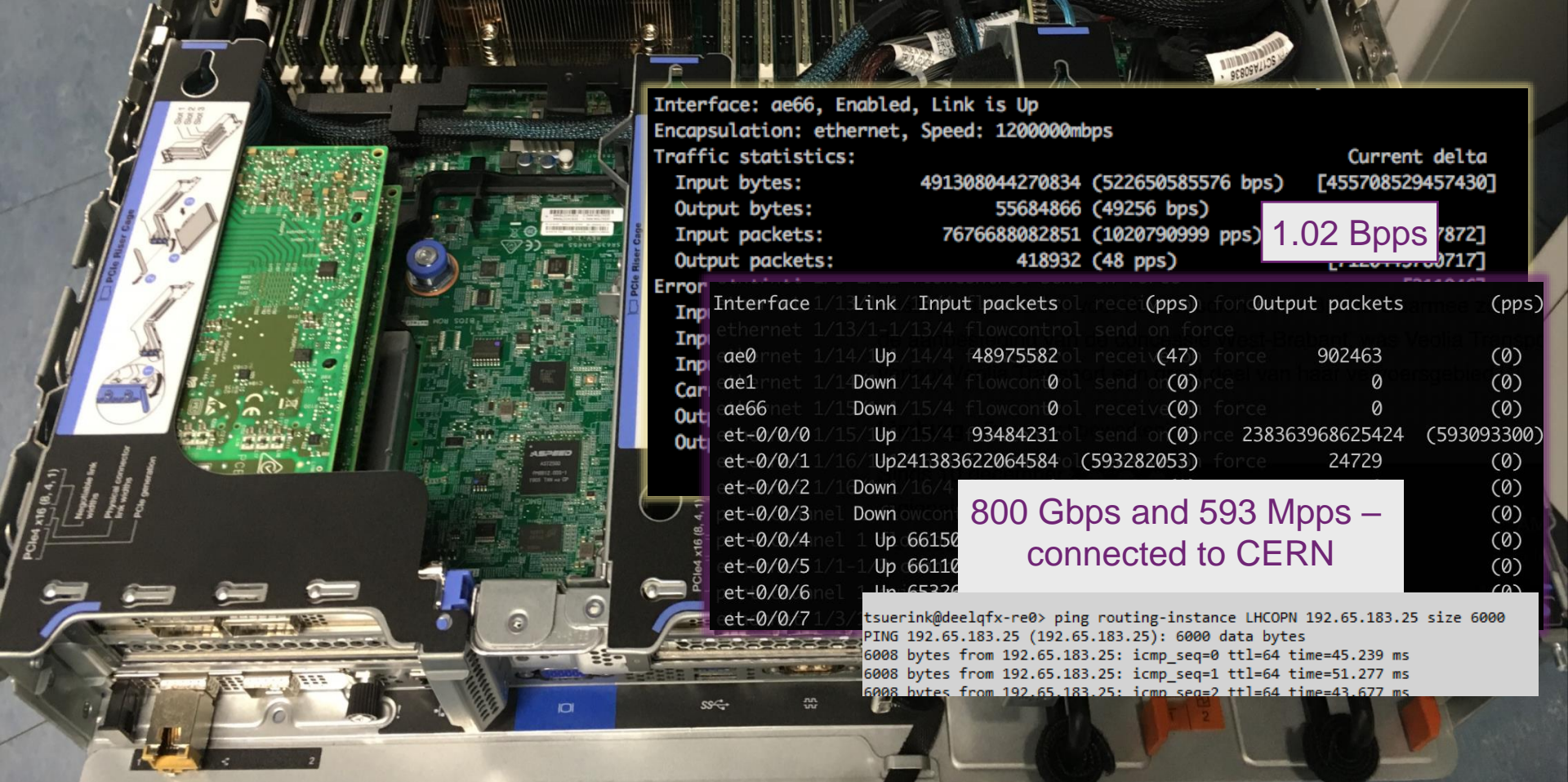
Nokia and SURF have successfully tested an 800 Gbit/s data connection between Nikhef in Amsterdam and CERN in Geneva. Such a connection is needed to transmit data from the upcoming high-luminosity LHC accelerator.

The test used existing fiber-optic connections through Belgium and France toward Geneva in Switzerland over a total distance of 1,648 kilometers. An 800 Gbit/s connection is about a thousand times faster than the Internet connection in an average household.

Nokia's latest photonic technology, the sixth-generation super-coherent Photonic Service Engine (SPE-6s), was deployed in the tests, along with 16QAM-shaped modulation. The results of the tests will be announced in more detail next week at a Nokia expert conference in Athens.

Data hub

Image: Minister of Economic Affairs M. Adriaansens launched the Innovation Hub with Nikhef, SURF, Nokia and NL-ix, January 2023. Composite image from <https://www.surf.nl/nieuws/minister-adriaansens-lanceert-testomgeving-voor-supersnelle-netwerktechnologie>



Interface: ae66, Enabled, Link is Up
Encapsulation: ethernet, Speed: 1200000mbps
Traffic statistics:

		Current delta
Input bytes:	491308044270834 (522650585576 bps)	[455708529457430]
Output bytes:	55684866 (49256 bps)	
Input packets:	7676688082851 (1020790999 pps)	1.02 Bpps [7872]
Output packets:	418932 (48 pps)	[1207900717]

Error

Interface	1/1	Link	Input packets	ol	recei	(pps)	for	Output packets	(pps)
ethernet	1/13/1-1/13/4	flowcontrol	send on	force					
ae0	rnet 1/14/Up	/14/4	48975582	ol	recei	(47)	force	902463	(0)
ae1	rnet 1/14/Down	/14/4	flowcontrol	send on	(0)	rece		0	(0)
ae66	rnet 1/15/Down	/15/4	flowcontrol	receive	(0)	force		0	(0)
et-0/0/0	1/15/Up	/15/4	93484231	ol	send on	(0)	rece	238363968625424	(593093300)
et-0/0/1	1/16/Up	24138362	2064584	ol	(593282053)	force		24729	(0)
et-0/0/2	1/16/Down	/16/4							(0)
et-0/0/3	nel	Down	owcon						(0)
et-0/0/4	nel	1	Up	66150					(0)
et-0/0/5	1/1-1	Up	66110						(0)
et-0/0/6	nel	1	Up	65320					(0)
et-0/0/7	1/3/								(0)

800 Gbps and 593 Mpps –
connected to CERN

```
tsuerink@deelnqfx-re0> ping routing-instance LHCOPN 192.65.183.25 size 6000
PING 192.65.183.25 (192.65.183.25): 6000 data bytes
6008 bytes from 192.65.183.25: icmp_seq=0 ttl=64 time=45.239 ms
6008 bytes from 192.65.183.25: icmp_seq=1 ttl=64 time=51.277 ms
6008 bytes from 192.65.183.25: icmp_seq=2 ttl=64 time=43.677 ms
```


Our science data flows are somebody else's DDoS attack



Belastingdienst

Home Menu Zoeken

Home > Actueel > ICT en informatievoorziening > De systemen testen dankzij een unieke samenwerking

Lees voor

De systemen testen dankzij een unieke samenwerking

Dinsdag 14 maart 2023 | Het laatste nieuws het eerst op NU.nl



Forse ddos-aanvallen en nerdgrapjes tijdens nachtelijke oefening overheid

Door Rutger Otto

12 feb 2023 om 05:02
Update: een maand geleden

202 reacties

Het begon in 2018. Een bijzondere samenwerking tussen overheden, internetproviders- en exchanges, academische instanties, non-profitorganisaties en banken. Nadat duidelijk was dat de aanval was uitgevoerd worden de systemen getest. Het begon met een simpele DDoS aanval, maar werd steeds meer uitgebreid. Het werd een wapen tegen de criminaliteit. Onlangs...

Op de...
Een goe...
Examen...
Wat gebeurde er die nacht...
Vragen over dit artikel?
Terug naar boven ↑



Betastingsdienst

Home

Home > Aanslagen > Ik heb een DDoS aanslag ontvangen - wat nu?

Ik heb een DDoS aanslag op mijn netwerk ontvangen - wat nu?

U ontvangt een DDoS aanslag op uw netwerk, bijvoorbeeld omdat u vergeten bent werkende tegenmaatregelen te nemen. Er staat dan een geschat aantal pakketten per seconde op uw monitoring.



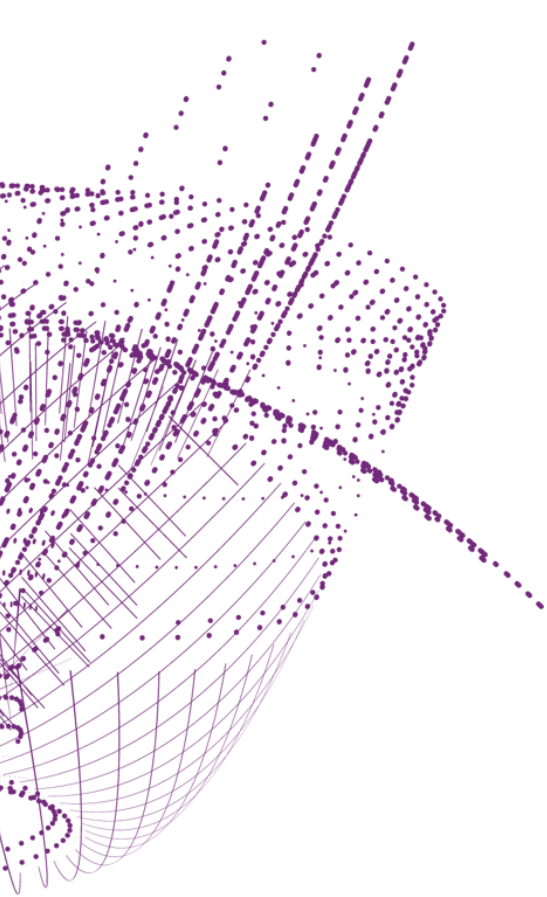
Bandbreedte

Pakketjes

Tb/s

Gp/s

Image sources: belastingdienst.nl, rws.nl, nu.nl, werkentegennederland.nl



A collaborating 'ecosystem'
for science and innovation

How did we get here?

The Nikhef data centre – at the end of the 1980s



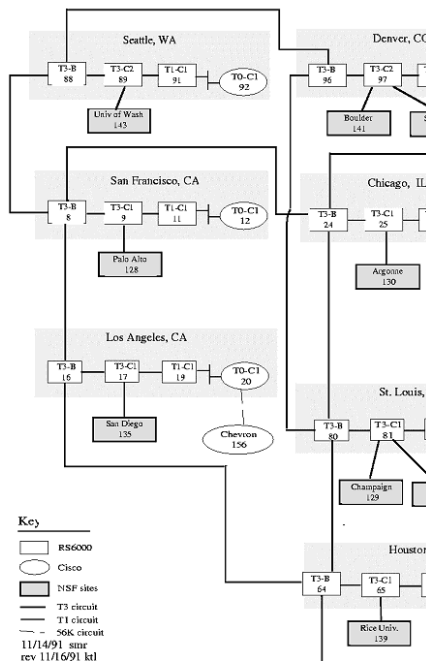
Gould, Sun, and DEC systems, taking several racks each

- 500 m² floor area
- Raised floor: +60cm
- walls are 'movable' to accommodate expansion

Nikhef room H1.37 – terminal stations on the raised data floor of the computer room (H1.40, behind the glass-panel walls)

Collaborative Research Infrastructures: all about networking!

ANSNET/NSFNET T3 Topology as of 11/18/91



From: Stephen Wolff
Sent: Thursday, November 17, 1988 8:28 AM
To: HOSTMASTER@NSI-NIC.ARPA; P100001@CIS.GOV
Subject: RE: [HOSTMASTER@NSI-NIC.ARPA: Re: mcvax internet connection]

> Thanks for the additional information re: CWI-ETHN, net
> #152.35.164.
> This is to let you know that we have changed the status of this
> network to connected.

See - Thanks!

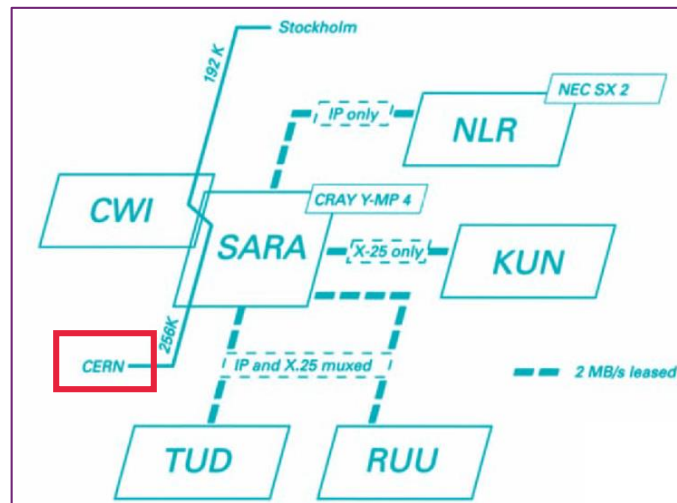
Rich - dal

-B

*Eerste e-mail over de eerste niet-militaire
druisatlanthische internet-verbinding!*

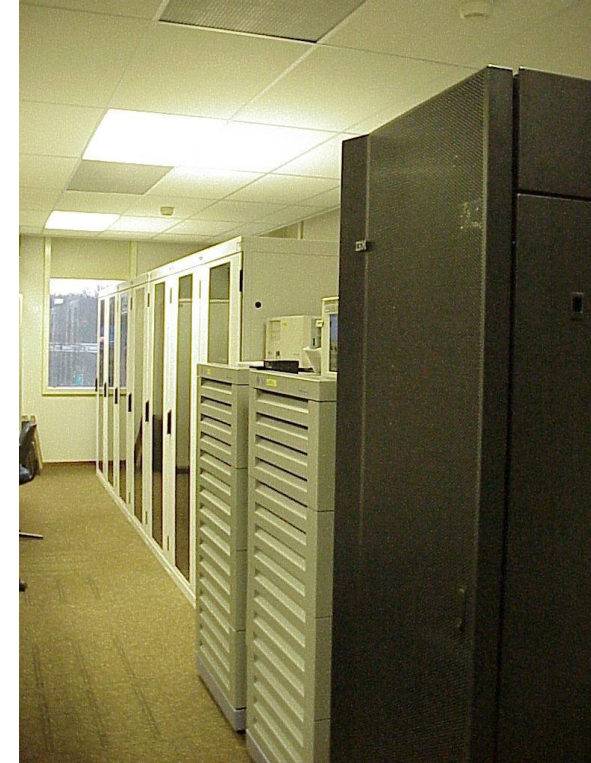
Piet

be it human or computer networks ...



See <https://personalpages.manchester.ac.uk/staff/m.dodge/cybergeography/atlas/historical.html> for more historic maps ; right-hand image: SURFnet2, 1990
first email to MCVAX at CWI from <https://www.cwi.nl/en/news/cwi-celebrates-25-years-of-open-internet-in-europe-in-november/> (Piet Beertema, CWI, 1988)

'IBR-LAN' at Nikhef – connecting local and global networks



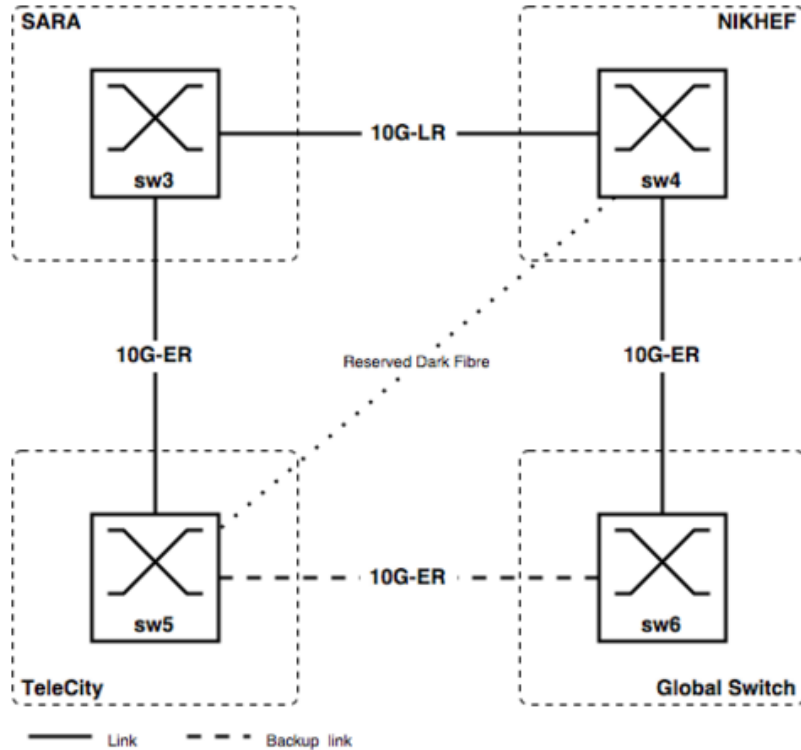
International Backbone Router Local Area Network "IBR-LAN" at Nikhef, room H1.40 as seen in 1996. Right: H1.39 with nikhef.nikhef.nl racks and early DAS-2 system

What happens if you welcome two networks onto your floor

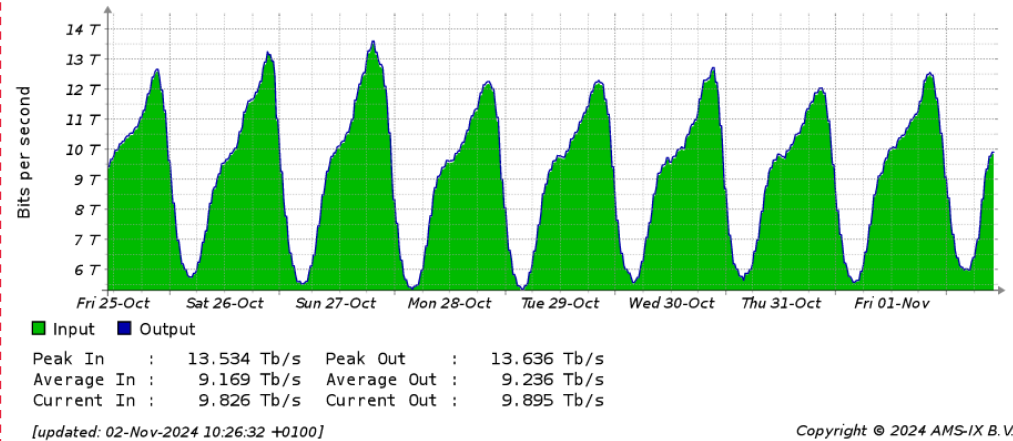


Image: AmsIX at Nikhef H140 in 2007 – foto Beeldbank Amsterdam <https://archief.amsterdam/beeldbank/detail/a95bc475-8fcc-d0d1-37f9-b077ba3729db/media/>

A growing internet!



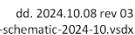
AMS-IX topology, 2002



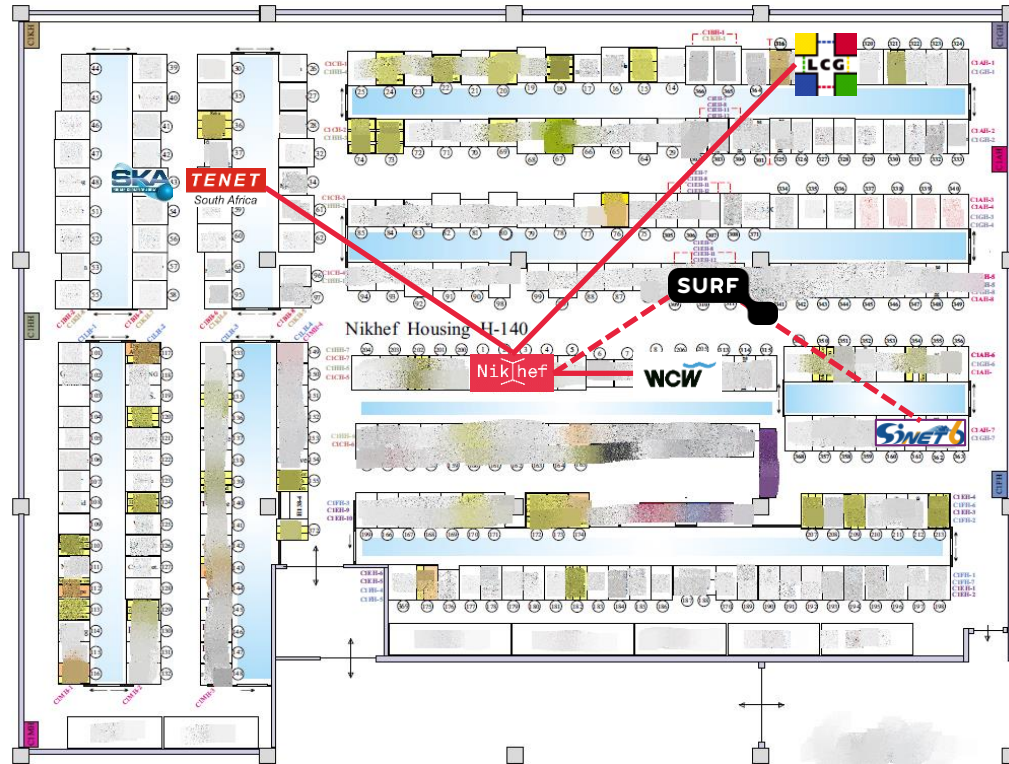
Copyright © 2024 AMS-IX B.V.

AMS-IX traffic Nov 2, 2024; <https://stats.ams-ix.net/> <https://www.ams-ix.net/ams/colocations>

AS1104



Connect each other ... and scientific data and instruments



dashed lines: traffic is routed via ancillary facilities of SURF and GEANT first (currently: AMS9 at WCU) SKA Meerkat traffic via TENET

What happens inside a data centre ...



‘Connectivity’ housing and ‘hosting’ are different things:

- NikhefHousing (H140) has connectivity parties only, and does not host any content
- what you see on the 1st floor tour is *network* equipment: shipping data, but not keeping anything

2nd floor has our science data centre

And no single connectivity data centre is a single point of failure:
Internet protocols are engineered to re-route traffic

Today's data centre at Nikhef

'NikhefHousing' data centre

- from the first 2 racks in a corner
- to now > ~400 racks
- many different connectivity parties
- **376** networks present in PeeringDB
- connectivity-focus, not hosting



Nikhef 'science' data centre H234b

- 47 racks and ~350 kW
- hosts Nikhef, CERN, gravitational waves, and SURF *research* data
- strengthens connectivity at, and uses NikhefHousing

Data centre installation management, ever growing

- active/free cooling chillers installed on the roof in 2009
- data floor: ~400 racks
- evolving hot-isle/cold-isle configuration
- electricity generator sets 2003, 2009, 2021
- aquifer thermal energy storage (ATES) system installed 2010

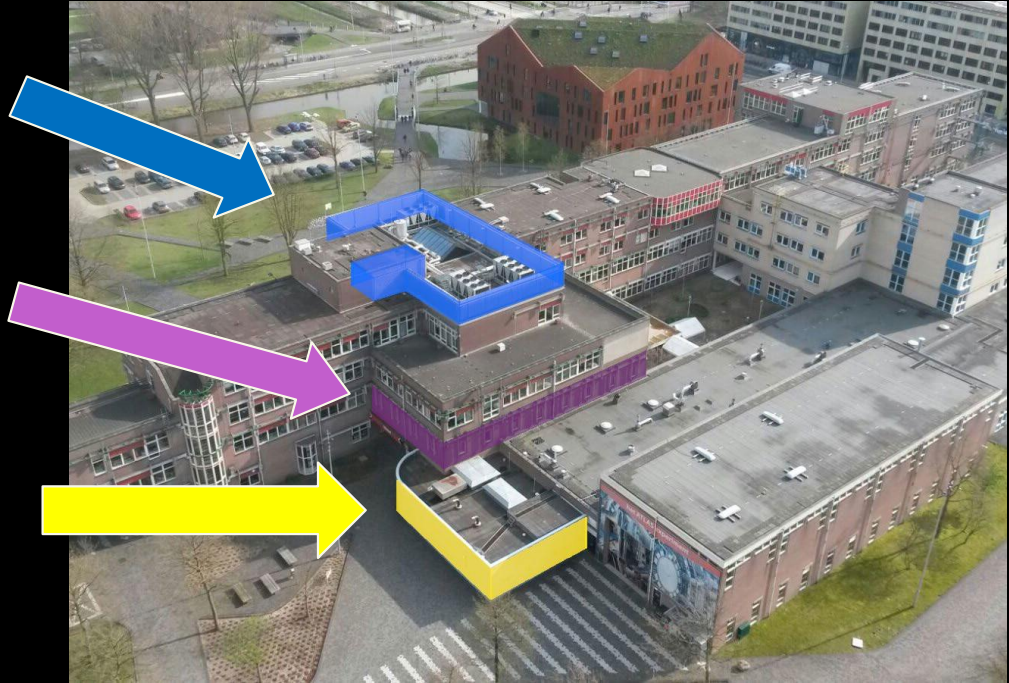
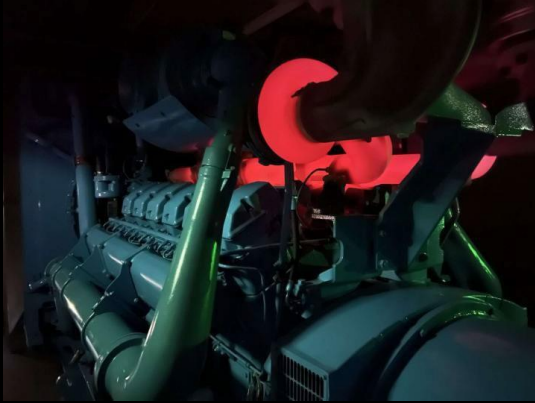


Image: Floris Bieshaar, Nikhef

Power in ... and power out ...



Three generators

- A-Feed 1250 kVA (pictured under load while testing)
- B-Feed 1700 kVA
- C-Feed 1250 KVA added with the current expansion

Separate redundant UPS for each



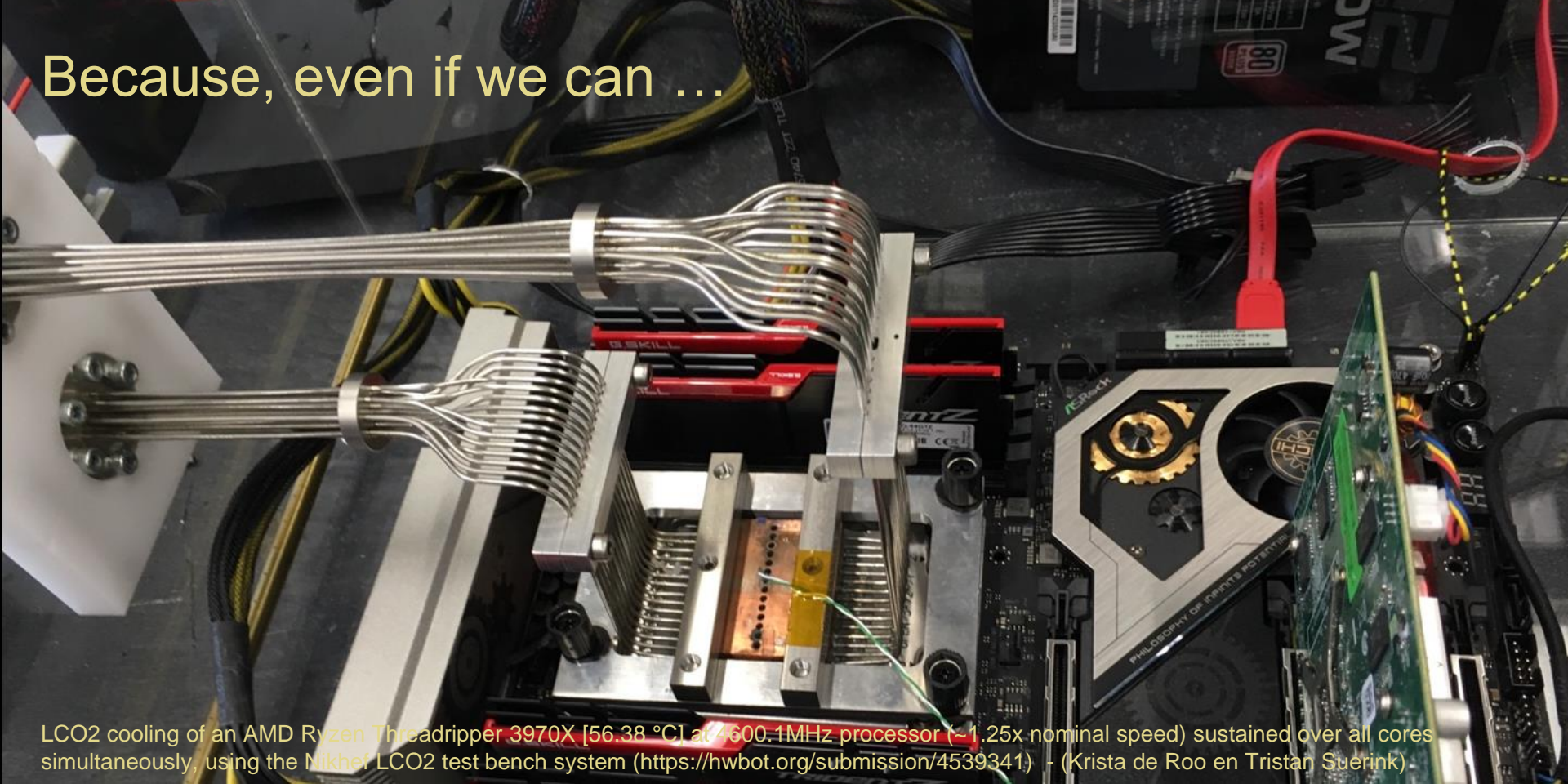
Heat re-use: aquifer thermal energy storage

*re-use heat to warm our building (pretty warm)
AND feed more heat to student housing opposite
nominal 'PUE' ~ 1.21*



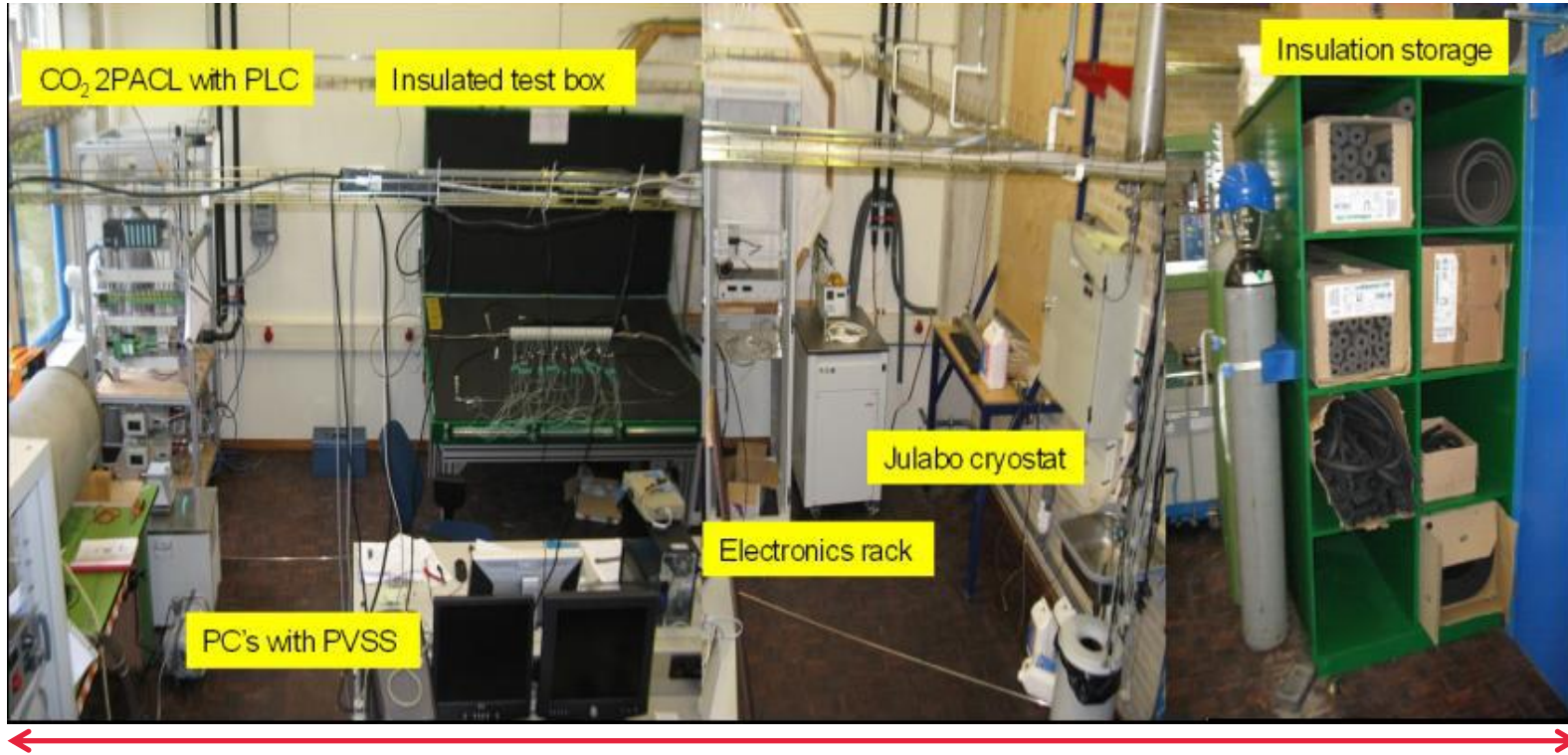
Generator image source: Floris Bieshaar. MacGilleevrylaan sketch: Science Park Amsterdam

Because, even if we can ...



LCO2 cooling of an AMD Ryzen Threadripper 3970X [56.38 °C] at 4600.1MHz processor (~1.25x nominal speed) sustained over all cores simultaneously, using the Nikhef LCO2 test bench system (<https://hwbot.org/submission/4539341>) - (Krista de Roo en Tristan Suerink)

... it is not always the most scalable solution!



Nikhef 2PA LCO₂ cooling setup. Image from Bart Verlaat, Auke-Pieter Colijn *CO₂ Cooling Developments for HEP Detectors* <https://doi.org/10.22323/1.095.0031>

Thanks, and enjoy Nikhef



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Tours

1. immediately: NikhefHousing ‘the backside of the internet’ with Anton Mors & me
2. After lunch: DarkMatter labs with Tina Pollmann, and the KM3NeT BOL Assembly in pimu (short walk) with Dorothea Samtleben