

WE BRING HIGH-TECH TO **LIFE**

CONTROL FOR THERMAL DEFORMATIONS IN THE EINSTEIN TELESCOPE

Aron Beekman

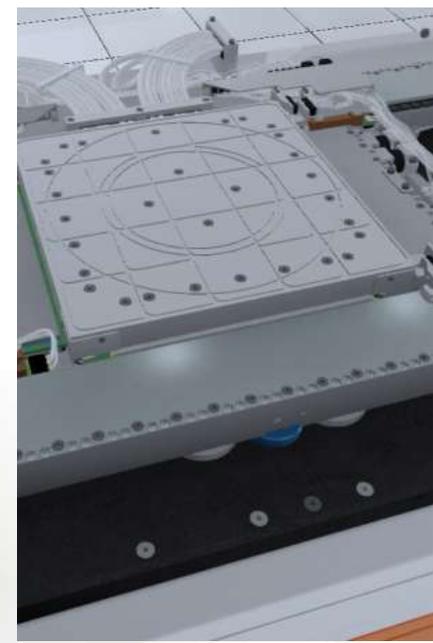
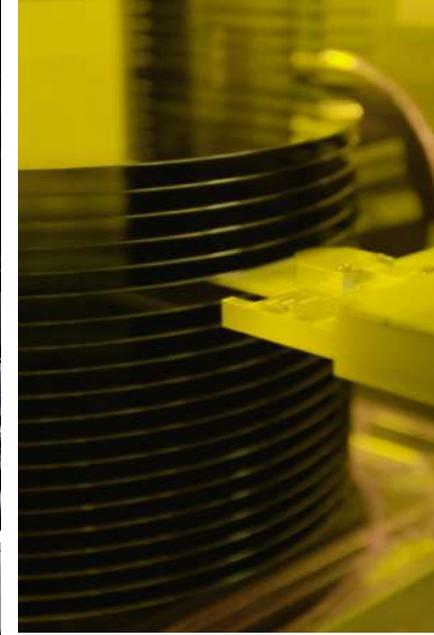
February 9th 2026





**YOUR GLOBAL
HIGH-TECH
SOLUTION
PARTNER THAT
ACCELERATES
INNOVATION**

**WE DEVELOP AND ASSEMBLE
HIGH-TECH SYSTEMS, UNIQUE
THROUGH SOFTWARE AND
APPLIED AI**



KEY SOLUTIONS



FLAWLESS SYSTEM CONTROL

SYSTEM CONTROL & APPS



NEXT-GEN SPEED & PRECISION

EXTREME POSITIONING



MAKE THE INVISIBLE VISIBLE

INSPECTION & ANALYSIS



BRING PRODUCT IDEAS TO LIFE

PROTOTYPING & SERIES PRODUCTION

MARKETS



ENGINEERING SERVICES

➤ SOFTWARE	➤ HIGH-TECH UX
➤ ELECTRONICS	➤ APPLIED AI & MATHEMATICS
➤ MECHANICS	➤ PHYSICS & OPTICS
➤ MECHATRONICS	➤ ASSEMBLY

EINSTEIN TELESCOPE IS A GRAVITATIONAL-WAVE OBSERVATORY PLANNED FOR 2035

Motion of heavy cosmological objects emits gravitational waves.

Unique cosmological probe into early universe.

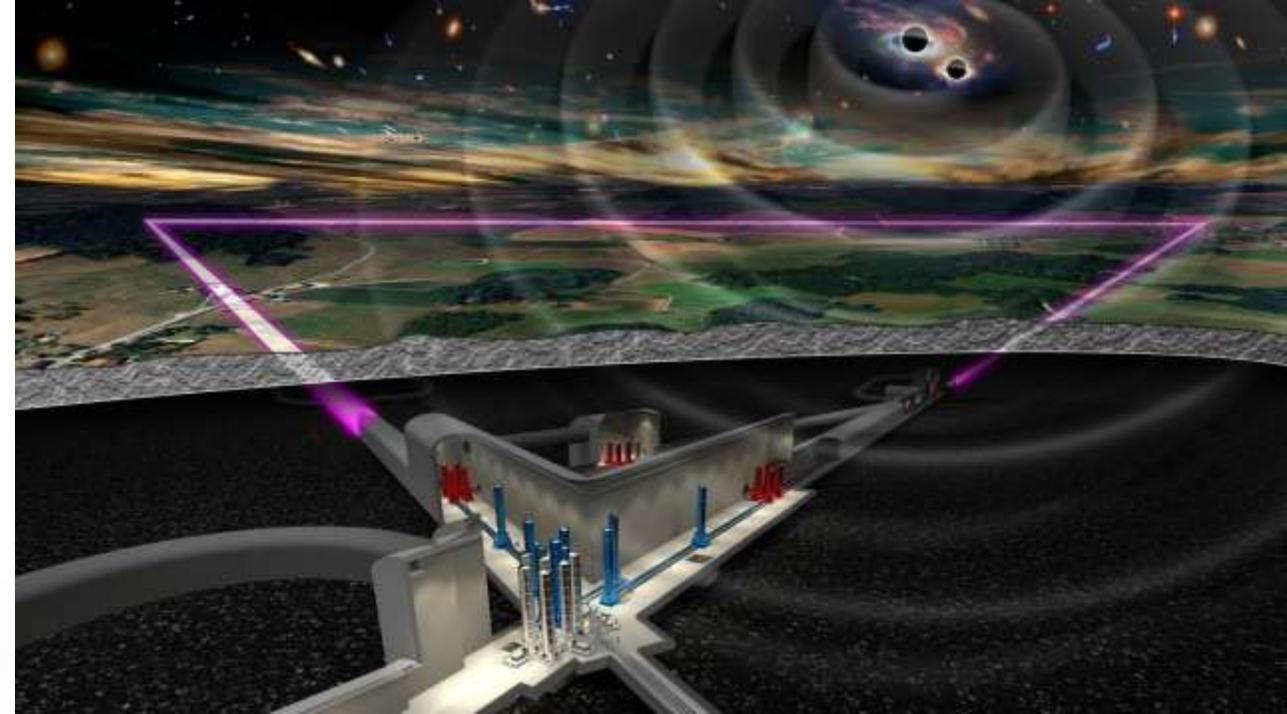
First gravitational wave observation by LIGO in 2015.



Nobel Prize
in Physics 2017

Next generation observatory: **Einstein Telescope**

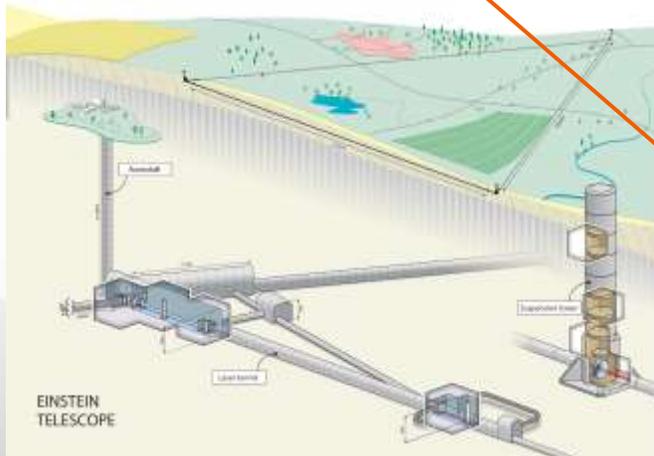
- larger – more accurate – more sensitive
- fully underground in vacuum tunnels
- mirrors cooled to 10K
- 3 interferometers in triangle geometry enables resolving direction
- location to be decided in 2027: Euregio Maas-Rijn?



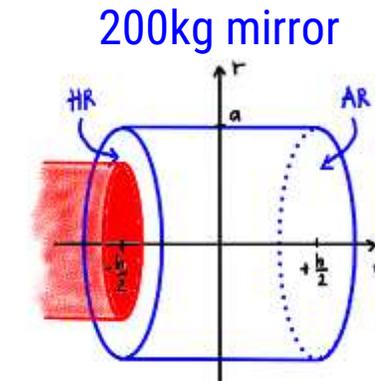
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R&D SCHEME TECHNOLOGY DOMAINS EINSTEIN TELESCOPE 2025–2027

- Part of the valorisation program ET (NGF)
- Public/private collaboration
- 5 technology domains
 1. Vibration-free cooling
 2. Vacuum technology
 3. Vibration damping
 4. Optics
 5. Thermal deformations



3MW laser power



Laura van der Schaaf PhD thesis 2020

Few Watts of laser power absorbed by mirror

→ small mirror deformation

→ loss of accuracy

Actuators (ring heaters, CO₂ lasers) compensate thermal deformations

R&D scheme purpose: Better actuators
Better sensors
Better control

Merope Consortium

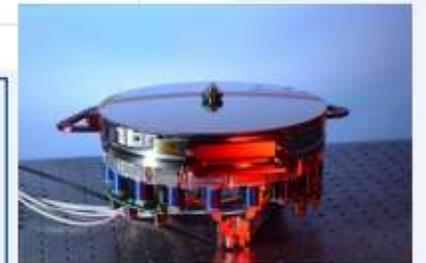
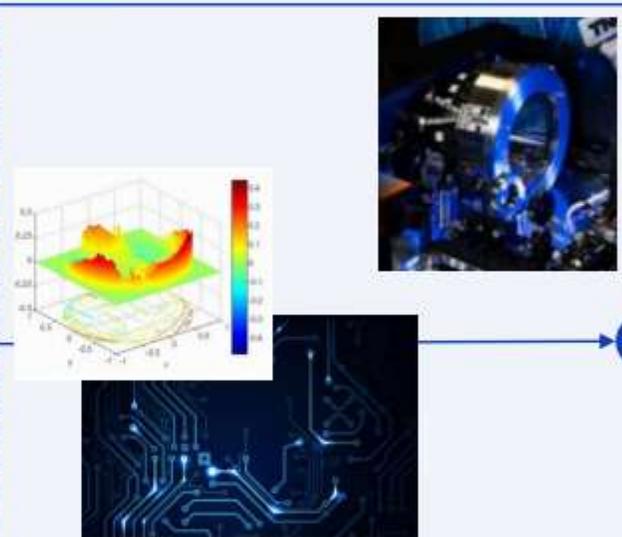
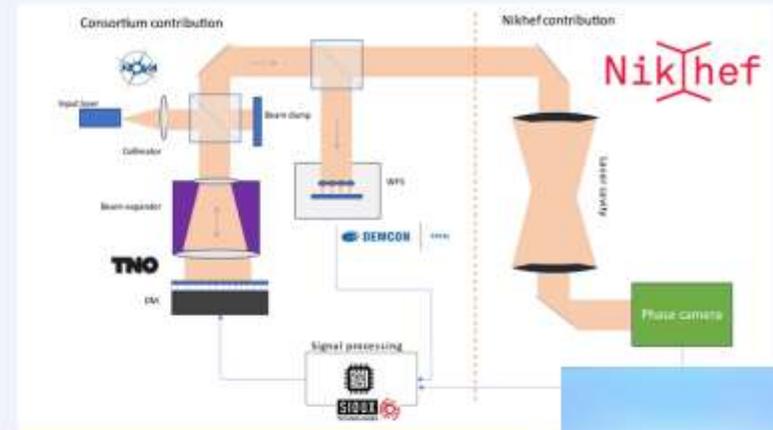
Actuators



Sensors



Control

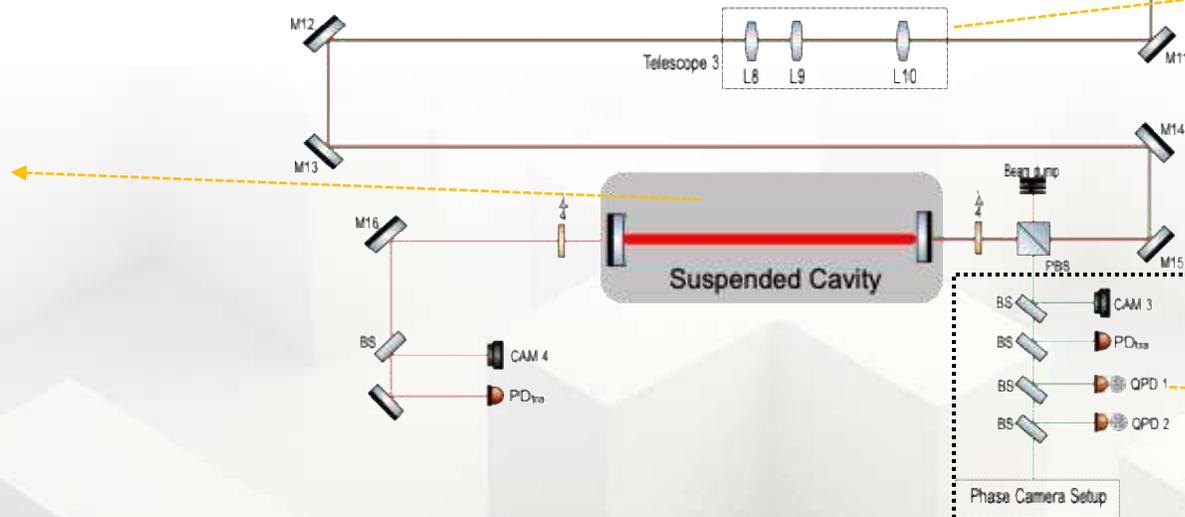
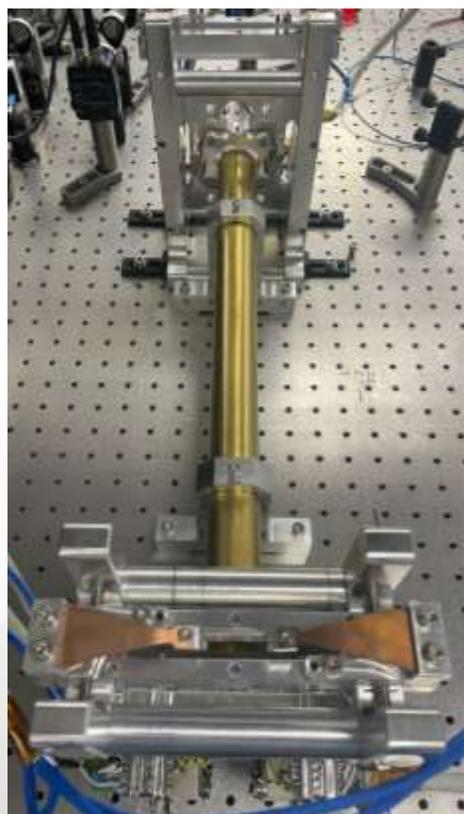
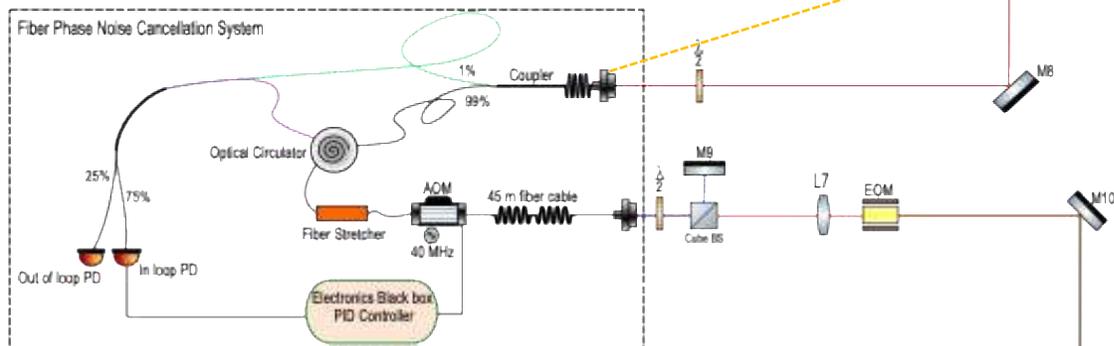
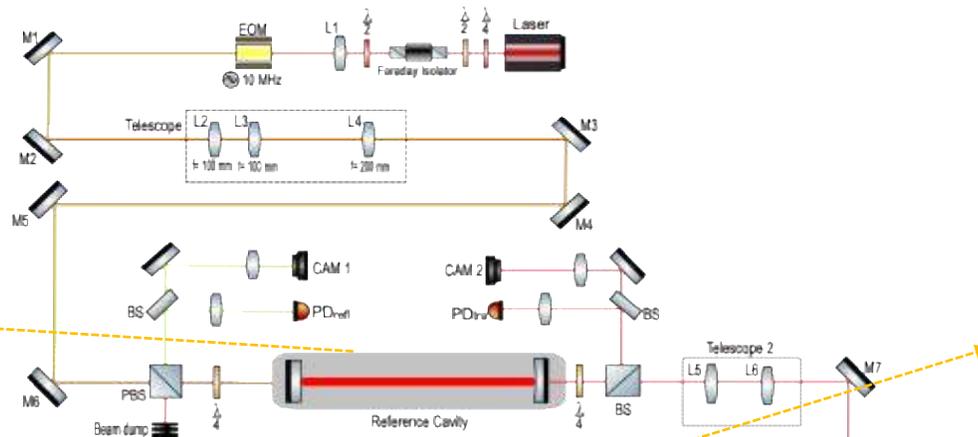


Demonstrator

TABLETOP EXPERIMENT @NIKHEF



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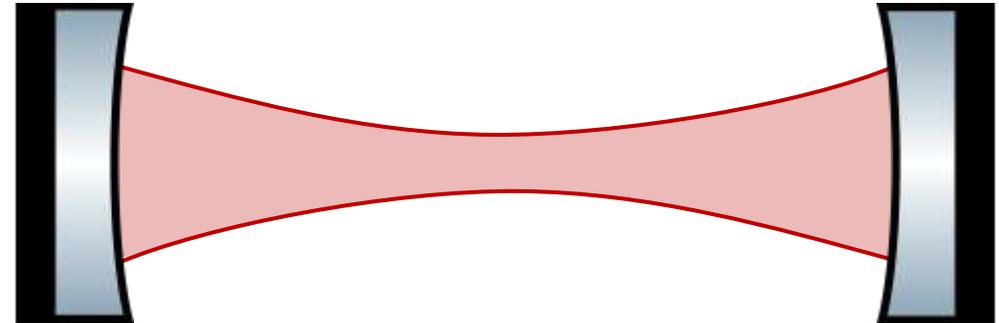
In preparation



INFER CURRENT STATE FROM PERTURBED MEASURED SIGNALS

Optimal

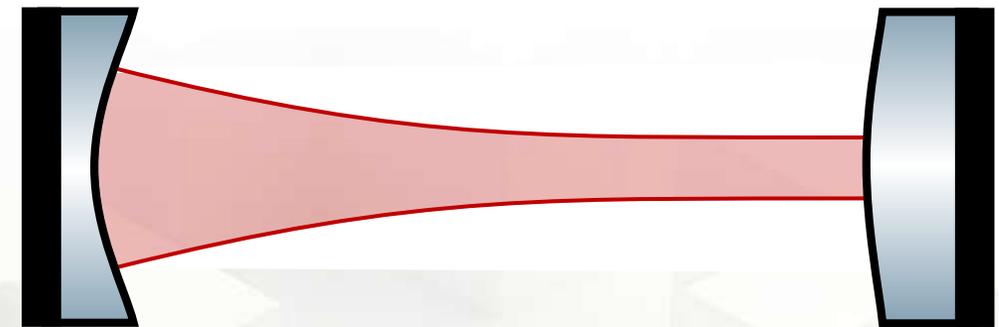
sensor data



Deformed

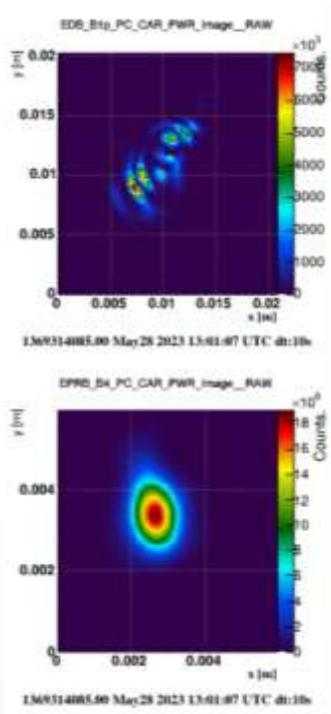


inference

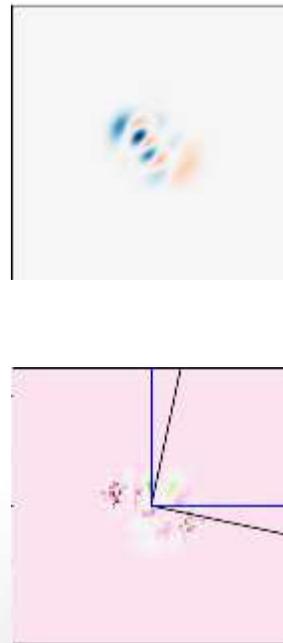


SIoux MATHWARE USES PHYSICS MODELLING AND OPTIMIZATION METHODS FOR INFERENCE

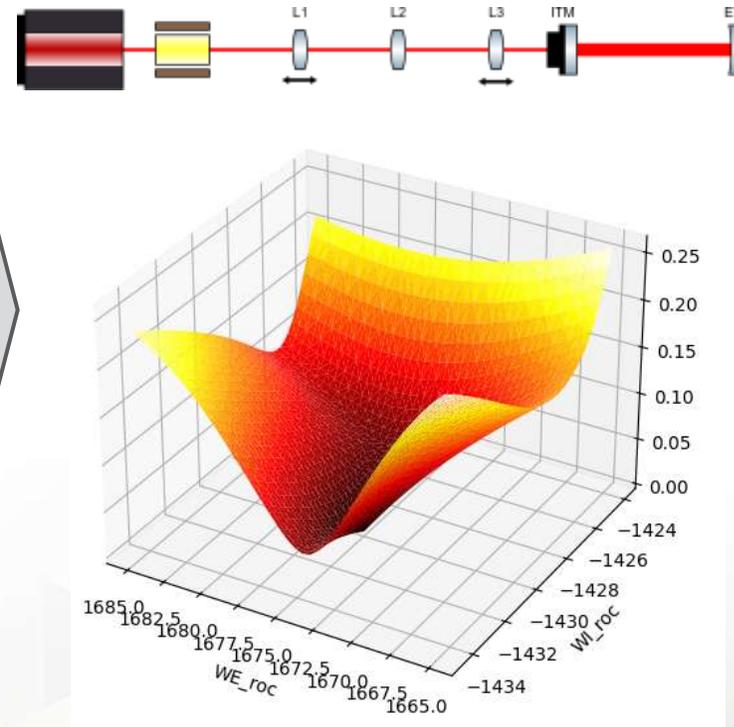
Raw signal



Signal analysis



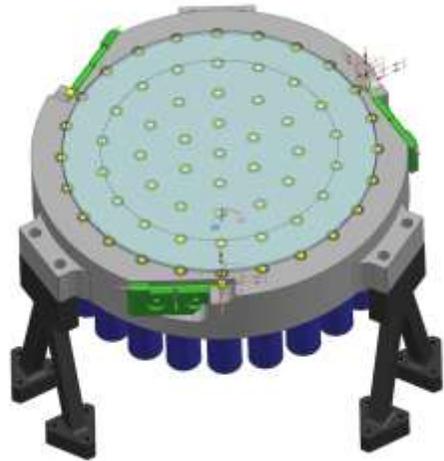
Model-in-the-loop optimization



Inferred state



NEXT STEPS INVOLVE INTEGRATION OF DEFORMABLE MIRROR WITH SUSPENDED CAVITY



design of deformable mirror

THEME FEATURE - MEASURING AND RECTIFYING OPTICAL PHASE ERRORS

TACKLING ET'S THERMAL DEFORMATION CHALLENGE

The ET Merope project addresses the challenge of improving the performance of the Einstein Telescope (ET), by measuring and correcting the optical phase errors that are induced by thermal loads. By developing advanced deformable mirrors, wavefront sensors, and automated inference algorithms, the project consortium aims to demonstrate several of the key building blocks required to actively correct such phase errors in the ET interferometer cavity. The project unites research institutes and industry partners to deliver innovative solutions, not only for enhancing sensitivity and stability in gravitational-wave detection but also enabling broader applications in astronomy, satellite communications, and other high-tech industries.

PAOLA BOLLAS AND WALTER JENNER

[DSPE Mikroniek November 2025](#)

www.einsteintelelescopeforbusiness.nl

DSPE MIKRONIEK
2025 (VOL. 46) ISSUE 5 PROFESSIONAL JOURNAL ON PRECISION ENGINEERING

■ **THEME: EINSTEIN TELESCOPE**
■ ET RESEARCH AND DEVELOPMENT FOR A NEW WINDOW ON THE UNIVERSE
■ SYSTEMS ENGINEERING FOR BIG SCIENCE - PLD RESEARCH CLUSTER
■ CHALLENGING APPLICATIONS OF VSL'S PICODRIFT INTERFEROMETER
■ PRECISION FAIR 2025 PREVIEW

MIKRONIEK IS A PUBLICATION OF THE DUTCH SOCIETY FOR PRECISION ENGINEERING WWW.DSPE.NL

MUTUALLY BENEFICIAL COLLABORATION BETWEEN INDUSTRY AND SCIENCE

Sioux is interested in Big Science

- Forefront of technology
 - Help to push the boundaries of knowledge
 - Translate back for our high-tech customers
- Keep our curiosity satisfied
- Long time scales → time for in-depth developments

Sioux is interesting to Big Science

- We speak the same language (> 60% PhD)
- Quick prototypes to standards compliant implementations of series
- Full-spectrum R&D partner for low volume, high mix & high complexity systems: from design to production

Sioux Technologies in Big Science

- Space
 - 25 years, 500 flight bio experiments in space
 - Jules Verne & Hayabusa return mission observation and analysis
- Radioastronomy
 - Reusable building blocks for energy efficient reconstruction using tensor cores
- Einstein Telescope



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