

DTU DANCHIP

DTU Cen

TECHFORUM March 2018

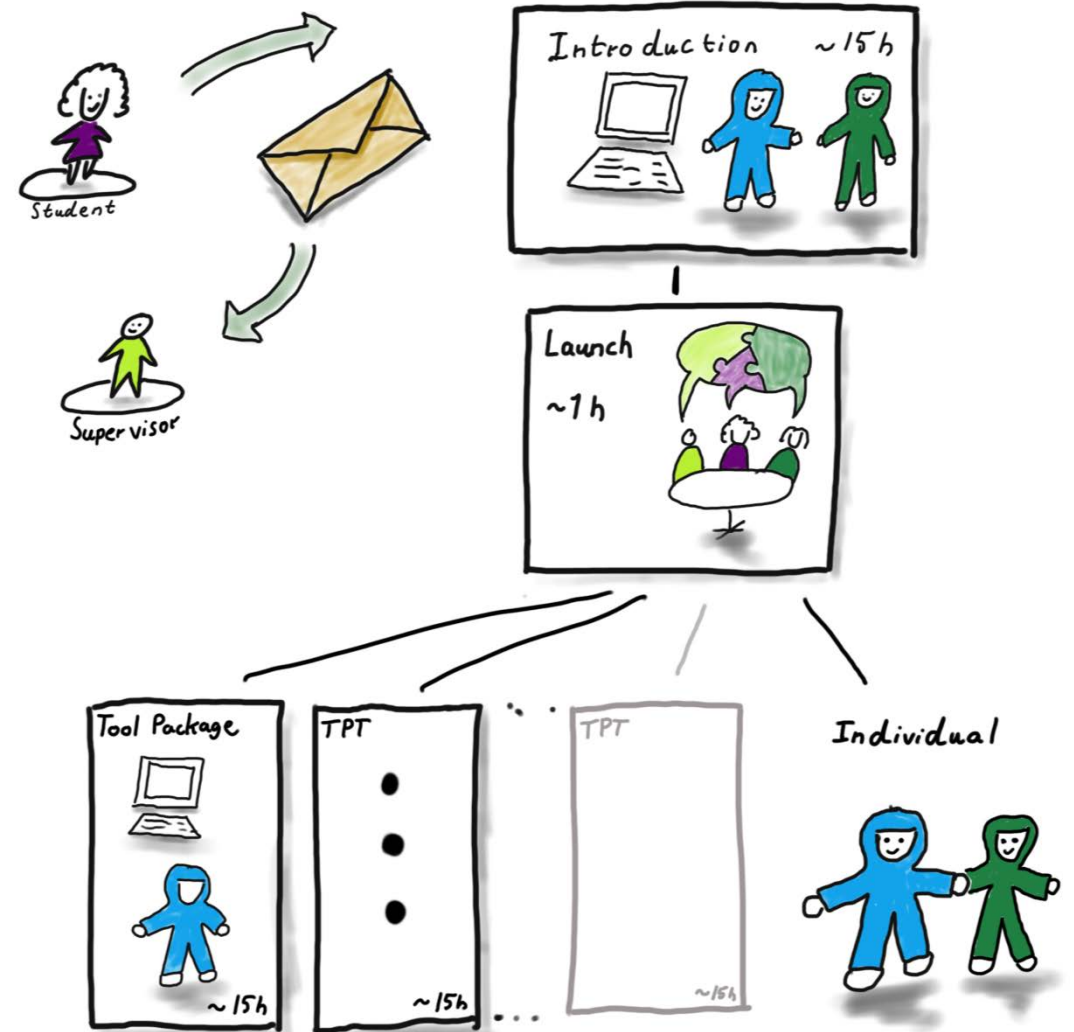


Agenda

- **Short news and updates**
- **Usage in 2017**
- **CEN development**
- **New cleanroom equipment**
- **Facility stuff**
- **Light rail**

TPT: Tool Package Training

- The way to get trained at Danchip
 - no more individual training on tools that are included in tool packages
- Danchip homepage for TPT is being revised
- Safety light = first part of standard introductory course
- Same safety course part one for all users, students, guests etc.





New DUV stepper

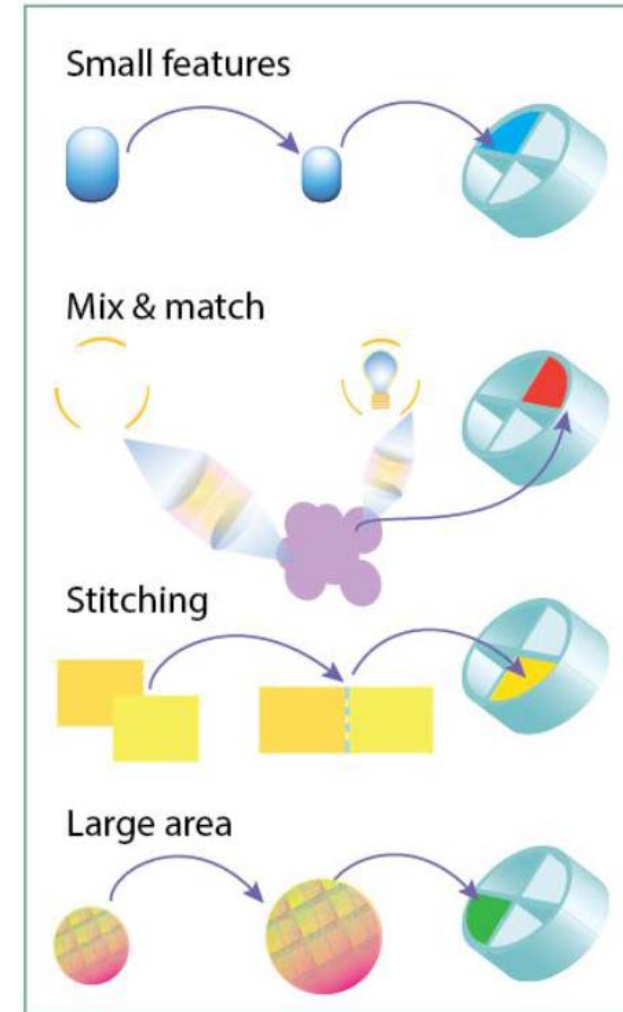
- Challenges
 - Present Canon FPA-3000-EX4 is 20 years old
 - Problem getting spare parts in the future
 - Size conversion (150/200 mm) is cumbersome
 - Would like better resolution (150 nm)
- Technical investigations ongoing
 - Nikon (visit to U of Southampton)
 - ASML (visit to Berkeley)
 - Canon (visit to Canon, Japan)
- New stepper will replace old



DUV Stepper II - Funding

- Enabling NAno PROduction - ENAPRO
- Application to Innofund
- 5 Partners
 - Ibsen
 - NIL Technology
 - SDU
 - AU
 - DTU

Focus areas



Pricebook 2018

Service from Danchip	Unit	Commercial activity	External project work, Danish academia ⁵	DTU Partner with budget in external projects	Internal DTU projects ¹
Cleanroom access (below cap) ^{2,3}	Kr/hour	800	380+44% OH	380	0
Category A tools	Kr/hour	370	120+44% OH	120	0
Category B tools	Kr/hour	630	240+44% OH	240	0
Category C tools	Kr/hour	3600	875+44% OH	875	0
Category D tools	Kr/hour	1200	180+44% OH	180	0
Category E tools	Kr/hour	1700	375+44% OH	375	0
Category F tools ⁴	Kr/hour	0	0	0	0
Danchip assistance	Kr/hour	1250	515+44% OH	515	0
Area rent	Kr/m ² /month	1600	NA	(200)	NA
Materials		At cost	At cost	At cost	At cost

Pricebook 2017

Service from Danchip	Unit	Commercial activity	External project work Danish academia	Internal DTU projects ¹	
Cleanroom access (below cap) ^{2,3}	Kr/hour	800	550	547	0
Category A tools	Kr/hour	370	170	173	0
Category B tools	Kr/hour	630	400	346	0
Category C tools	Kr/hour	3600	2100	1260	0
Category D tools	Kr/hour	1200	550	259	0
Category E tools	Kr/hour	1700	1300	540	0
Category F tools ⁴	Kr/hour	0	0		0
Danchip assistance	Kr/hour	1250	550	741	0
Area rent	Kr/m ² /month	1600	(200)		NA
Materials		At cost	At cost		At cost

Strikes and lockout

What we know

- The unions have only to a limited degree picked DTU for strike -> not expected to influence Danchip/Cen
- The "Moderniseringsstyrelse" has picked DTU and thus Danchip/Cen for lockout



<https://uaw.org/get-facts-lockout-honeywell-workers/>

What we don't know

- If there will be a lockout
- When it will come, if it comes (April 10th is the absolute earliest)
- Who will actually be affected?
 - Non-union members will not be locked out
 - "Yellow"-union members will not be locked out
 - Managers will not be locked out
 - Some key staff may also not be locked out

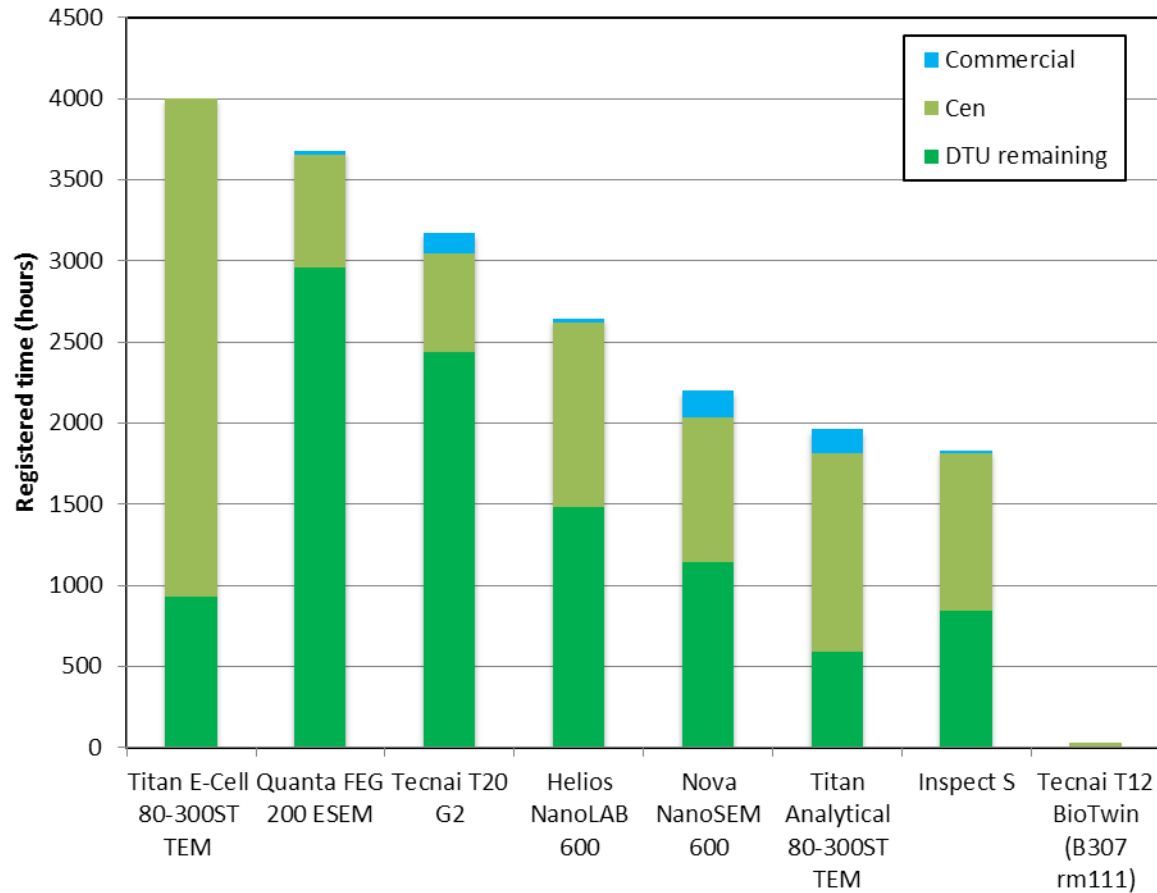
This is a too loose threat for us to act upon. We will continue with business as usual, and pay attention to the development.

USAGE 2017

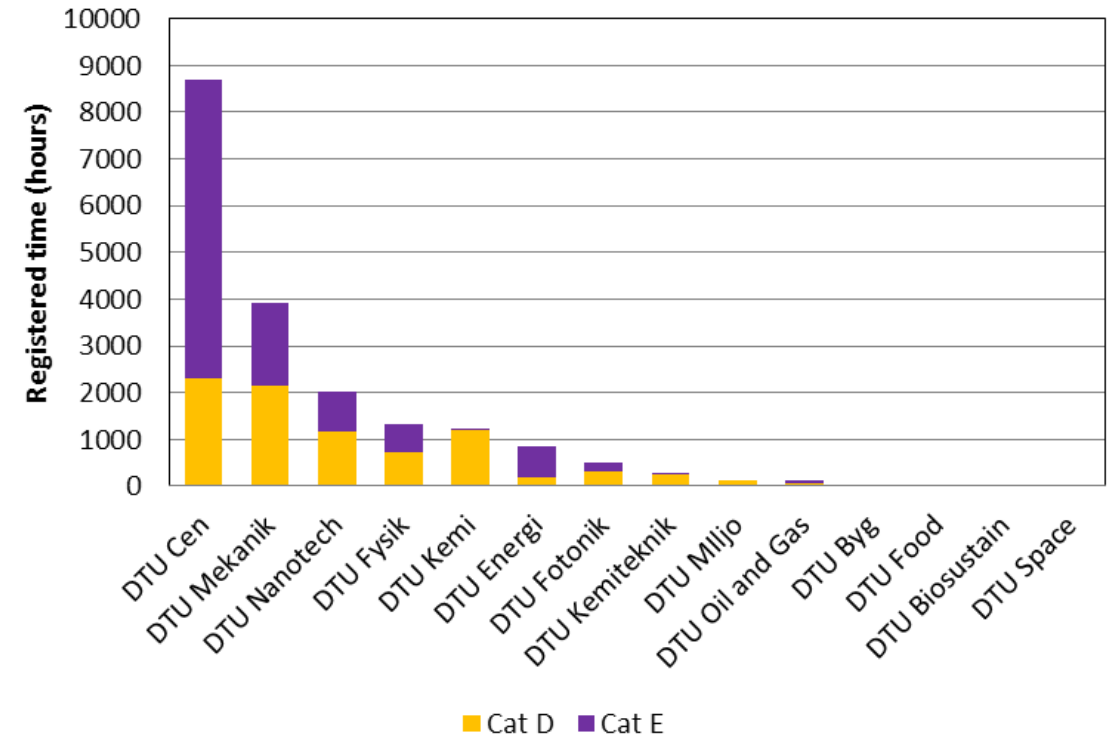
Facts and figures

Total usage CEN

Use of CEN microscopes in 2017



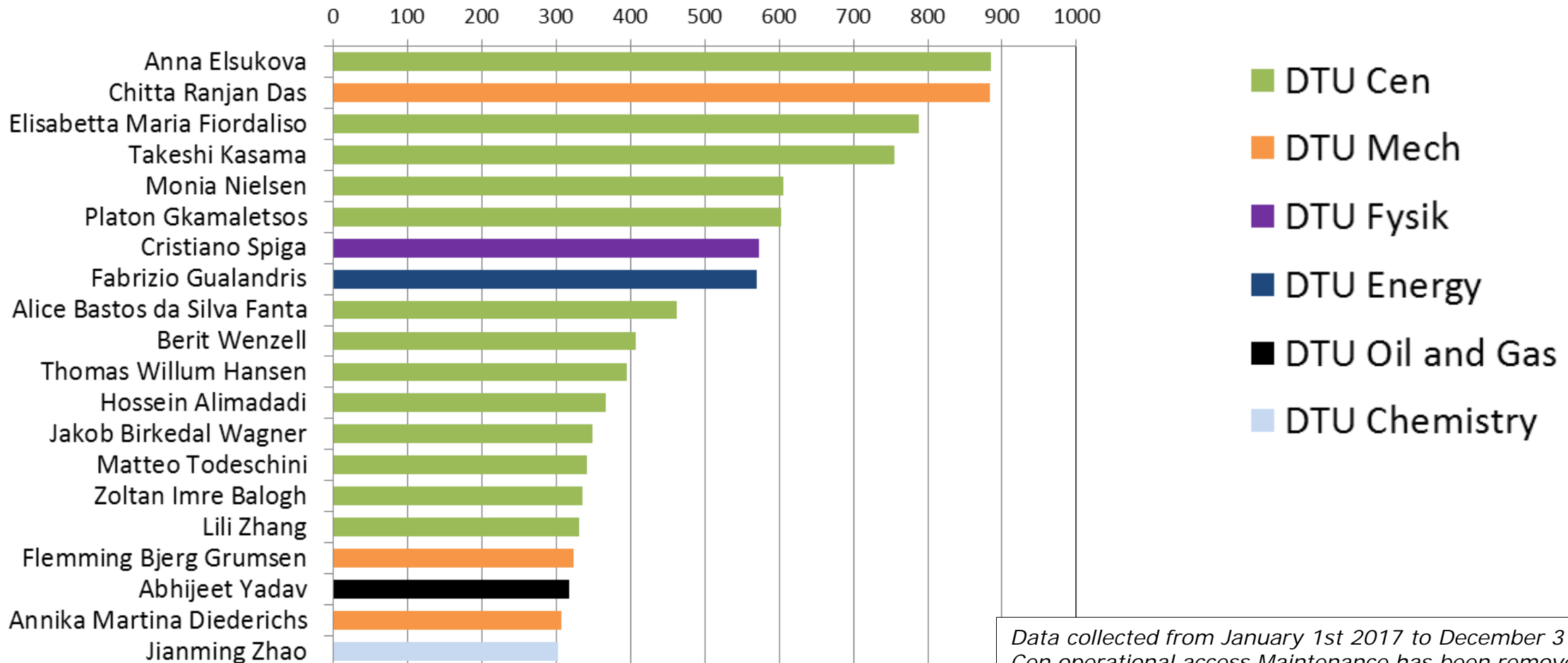
DTU use of Cen 2017



Data collected from January 1st 2017 to December 31st 2017.
 Cen operational access Maintenance has been removed from dataset.
 Total microscope usage in the period: 19591 hours

Who uses the microscopes

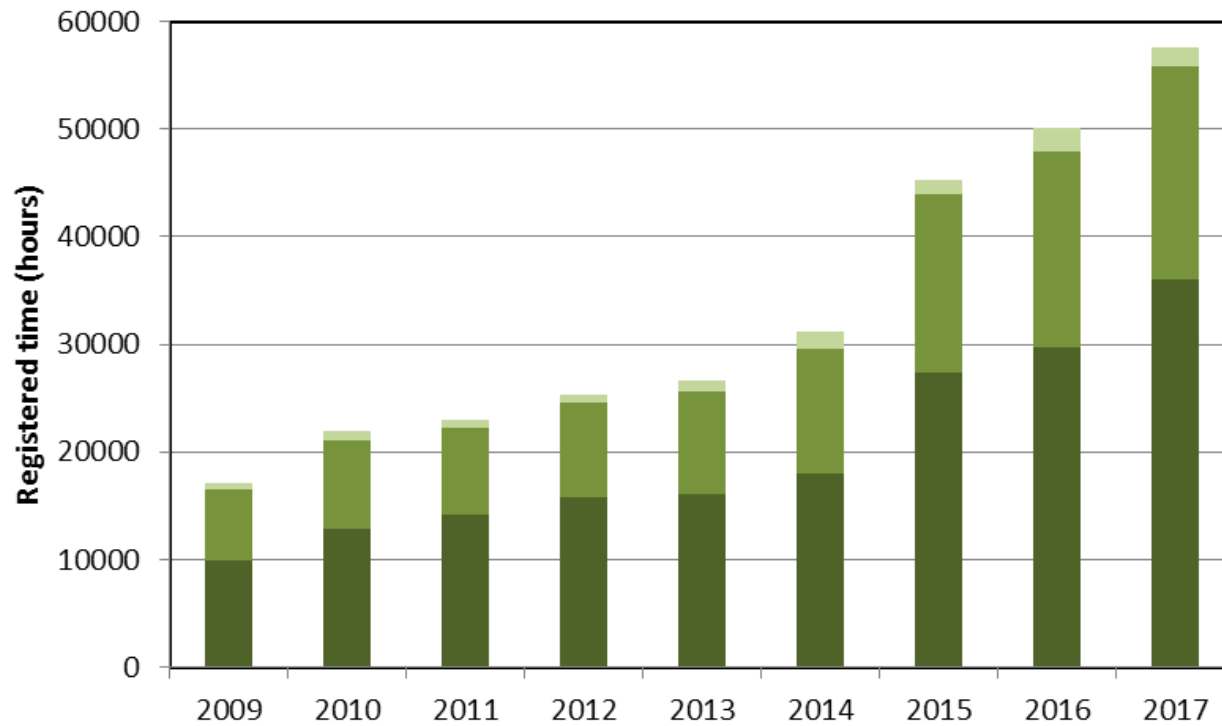
Top 20 Cen Microscope users 2017



Data collected from January 1st 2017 to December 31st 2017.
 Cen operational access Maintenance has been removed from dataset.
 Total microscope usage in the period: 19591 hours

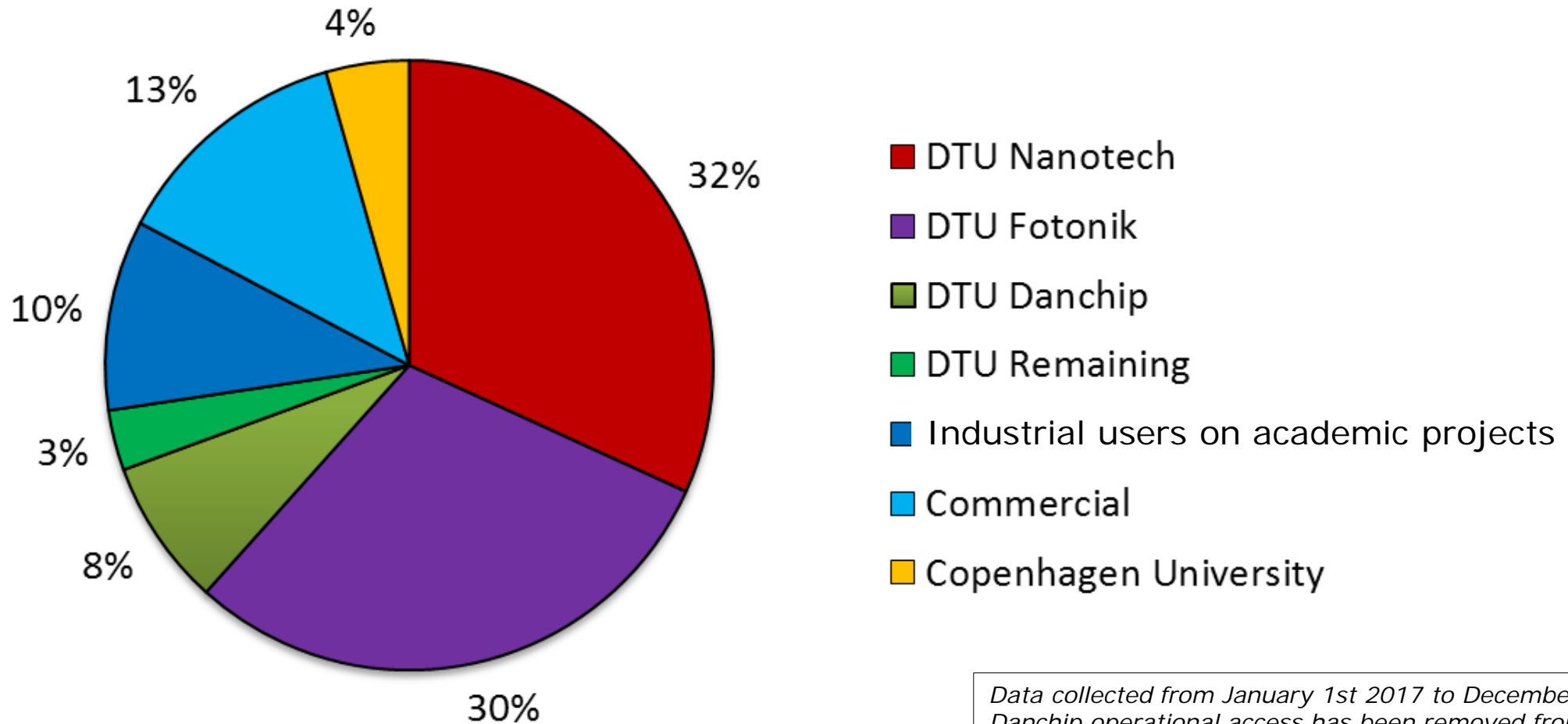
Total machine usage Danchip

Cleanroom tool usage 2009 to 2017



- 500 registered users
- 75 total staff, 15 research staff, 10 PhD stud.
- 60 peer reviewed publications (2017) with DCH/CEN staff directly involved (authored/co-authored); 2 + 5 publications in Nature Publishing Group
- Used by 15 departments and 4 Centers of Excellence (Grundforskningscentre)
- 20 companies
- 170 ext. financed research projects with budgeted activities in Danchip/Cen last 5 years

Fraction of access to cleanroom 2017

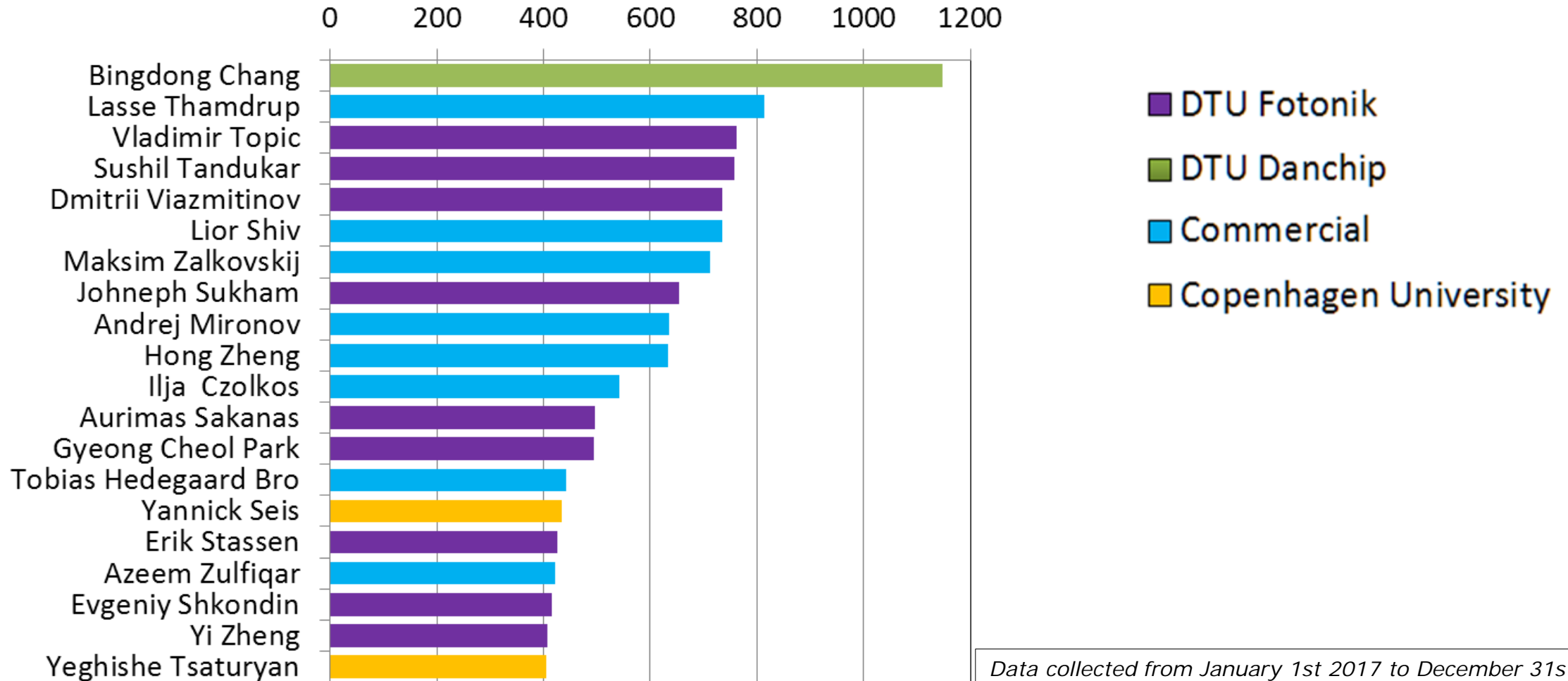


*Data collected from January 1st 2017 to December 31st 2017.
Danchip operational access has been removed from dataset.
Cap is not in effect.
Total access in the period: 32664 hours*

Facts and figures



Top 20 user cleanroom access 2017



Data collected from January 1st 2017 to December 31st 2017.
Danchip operational access has been removed from dataset.
Cap is not in effect.
Total access in the period: 32664 hours

CEN DEVELOPMENT

December

New (second hand) TEM (~~April 2017~~)

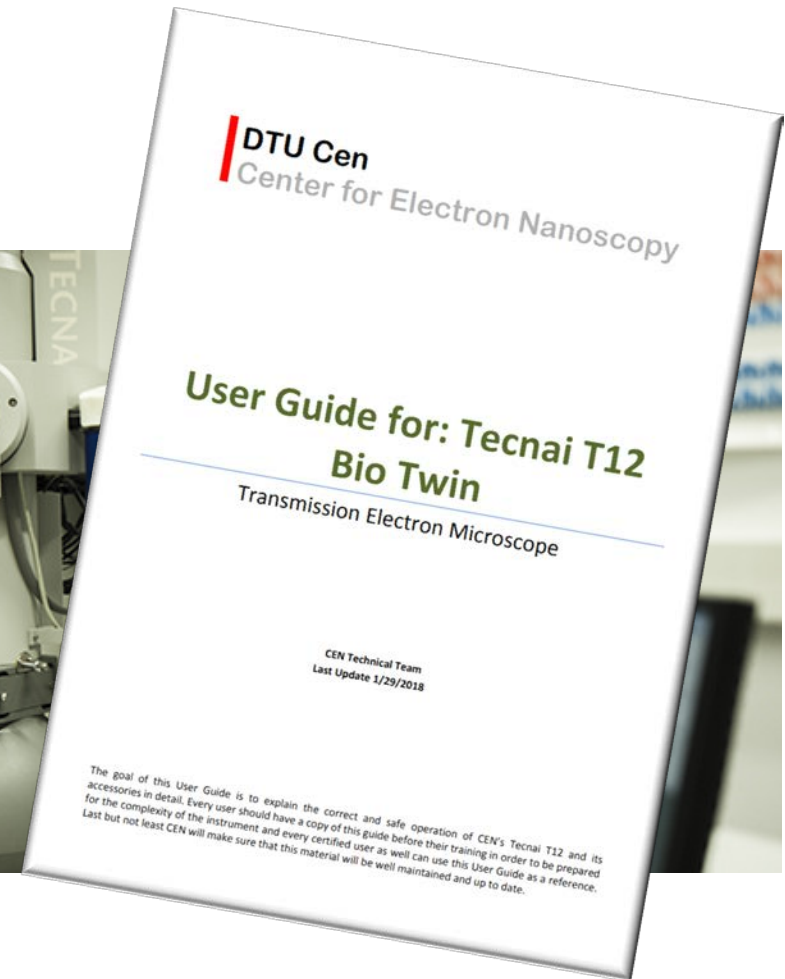
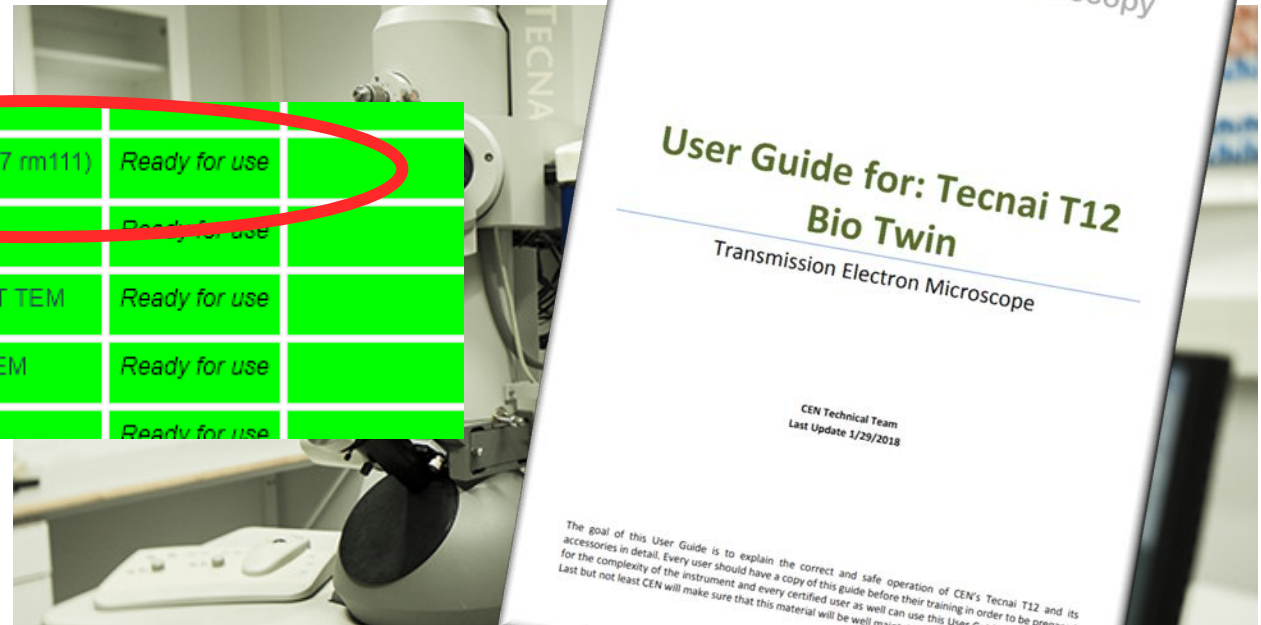
120 kV TEM (FEI Tecnai 12)

120 kV TEM especially for soft-matter analysis.

FEI Tecnai 12 Bio-Twin Information Card

Manufacturer	FEI
Model	Tecnai 12 Bio-Twin
Emitter	LaB ₆ (or W)
Resolution	0.49 nm (point)
Acceleration voltage	40 - 120 kV
Camera	Orius
Objective lens	C _s 6.3 mm C _c 5.0 mm

Tecnai T12 BioTwin (B307 rm111)	Ready for use
Tecnai T12 BioTwin	Ready for use
Titan Analytical 80-300ST TEM	Ready for use
Titan E-Cell 80-300ST TEM	Ready for use
Video Kit CEN	Ready for use



EDS Swap

- New windowless EDX detector for the ATEM
- 'Old' ATEM EDX detector -> ETEM
- 'Old' ETEM EDX detector -> Tecnai T12 Bio Twin

- All this is happening March 12-18

Ultramicrotome (April 2018)

Ultramicrotome for Perfect Sectioning at Room Temperature and Cryo Leica EM UC7

The **Ultramicrotome** Leica EM UC7 provides easy preparation of semi- and ultrathin sections as well as perfect, smooth surfaces of biological and industrial samples for TEM, SEM, AFM and LM examination.

New Standard in Ultramicrotomy

Combining ergonomic design and innovative technology the Ultramicrotome Leica EM UC7 sets new standards in Ultramicrotomy. It offers a range of outstanding features and benefits of use for the ultramicrotommist, whether highly skilled or absolute beginners.

For research use only

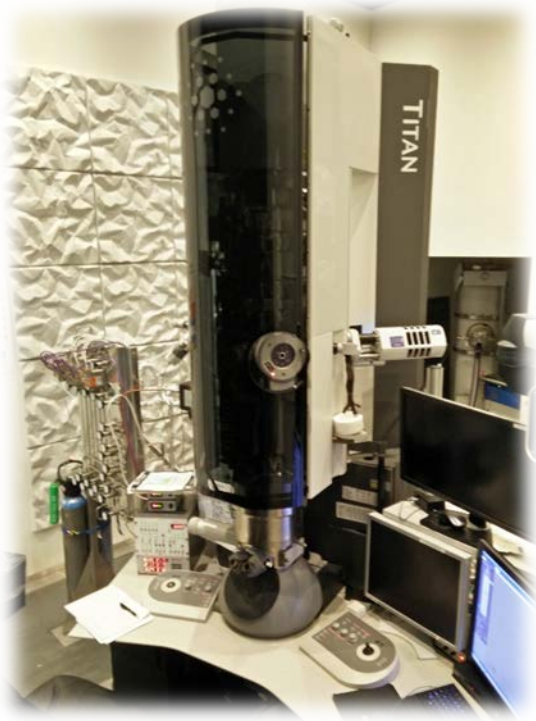


High-Pressure Freezer

- We are aiming at purchasing a high-pressure freezer this year
- More will follow...

High Pressure Holder

- Treatment of Fe oxide in hydrogen
- 800°C
- 600 mbar H₂



+



=

NEW EQUIPMENT

Pegasus 2: DRIE of silicon



- Background:
 - Bottleneck situation on Pegasus 1
 - Backup system & research
- 6" set-up (TDESC) – permanent
- Present status (interrim period – waiting for Twin-Pegasus)
 - Backup tool for Pegasus 1
 - 6" processing: Transfer from ASE

Coming up – 2018

X-Ray Diffractometer (Rigaku SmartLab)

Material properties (crystalline/ poly/nano-crystalline):

- crystal orientation
- grain size
- electron density
- film thickness

Released to superusers

General release in 18Q2



Diamond thin film (used system, Seki SDS 5250S)

- Microwave Plasma CVD (2nd hand system)
- Generator: 5 kW @ 2.45 GHz
- Substrate: 4" max (2" standard)
- Gases: N_2 , H_2 , CH_4 , O_2
- Currently: Only operated by Kristian Hagsted Rasmussen



In the pipeline

- **Renewal** of our old (15-25 years) **Plasma etching tools**

- Conventional RIE – various materials

replacement found 

- AOE (STS) for etching dielectrics (oxides/nitrides)

replacement found 

- Deep Si-etch of 6" + substrates

replacement found 

- **Renewal** of our old (10-25 years) **PVD tools** - looking for:

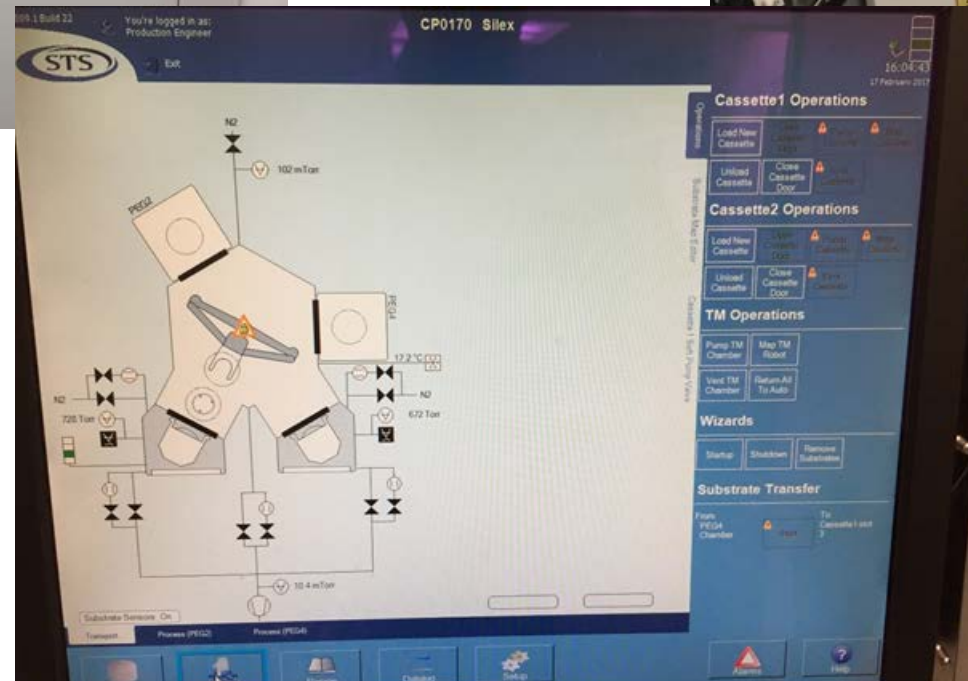
- New workhorse on E-beam evaporation

replacement found 

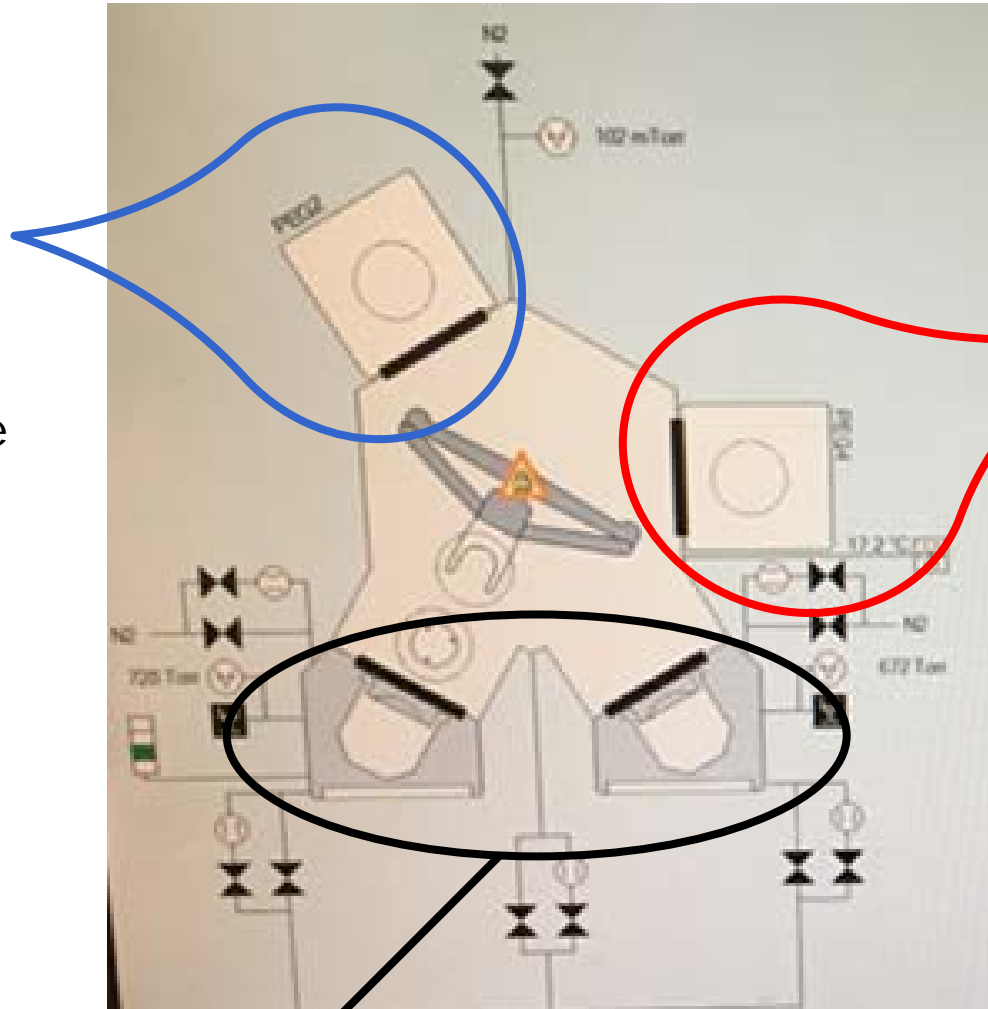
- PVD multi-chamber tool: Dielectric sputter /
DC sputter / central dealer

not decided 

Coming up: Twin-Pegasus (version 2010)



Twin-Pegasus: The Plan



Pegasus 3

DRIE (Si) – 6"
High-throughput
Cassette-Cassette
"Workhorse"

Pegasus 4

DRIE (Dielectrics) – 6"
Reconfigure (Dielectrics)
High-throughput
Cassette-Cassette
"Workhorse"

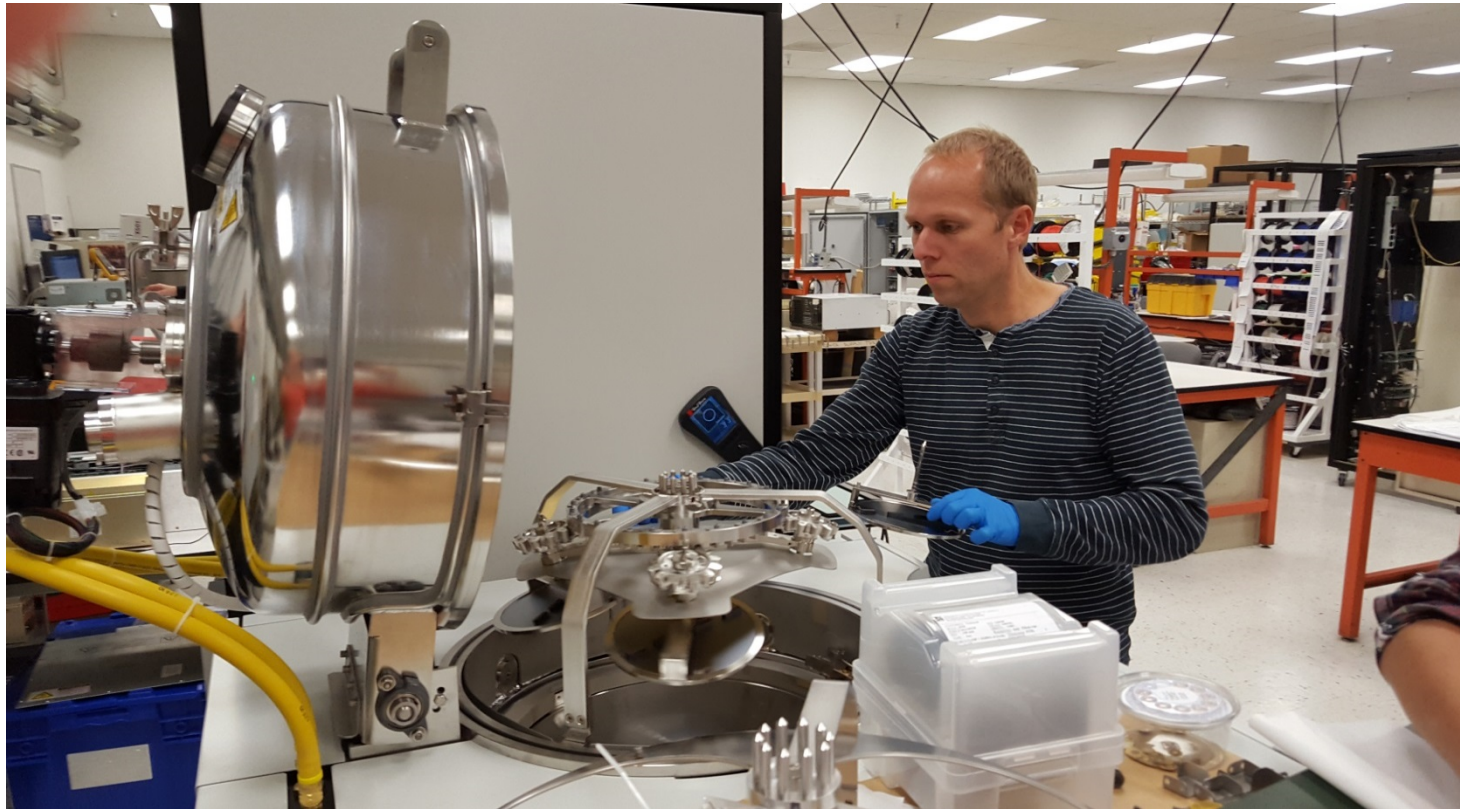
CPX Platform

twin vacuum cassette cluster
(Brooks handler)

New workhorse on E-Beam Evaporation:



Direct award: FC2000 from FerroTec-Temescal



- High throughput (15 min)
- High flexibility (special holders)
- High uniformity (HULA substrate holder)

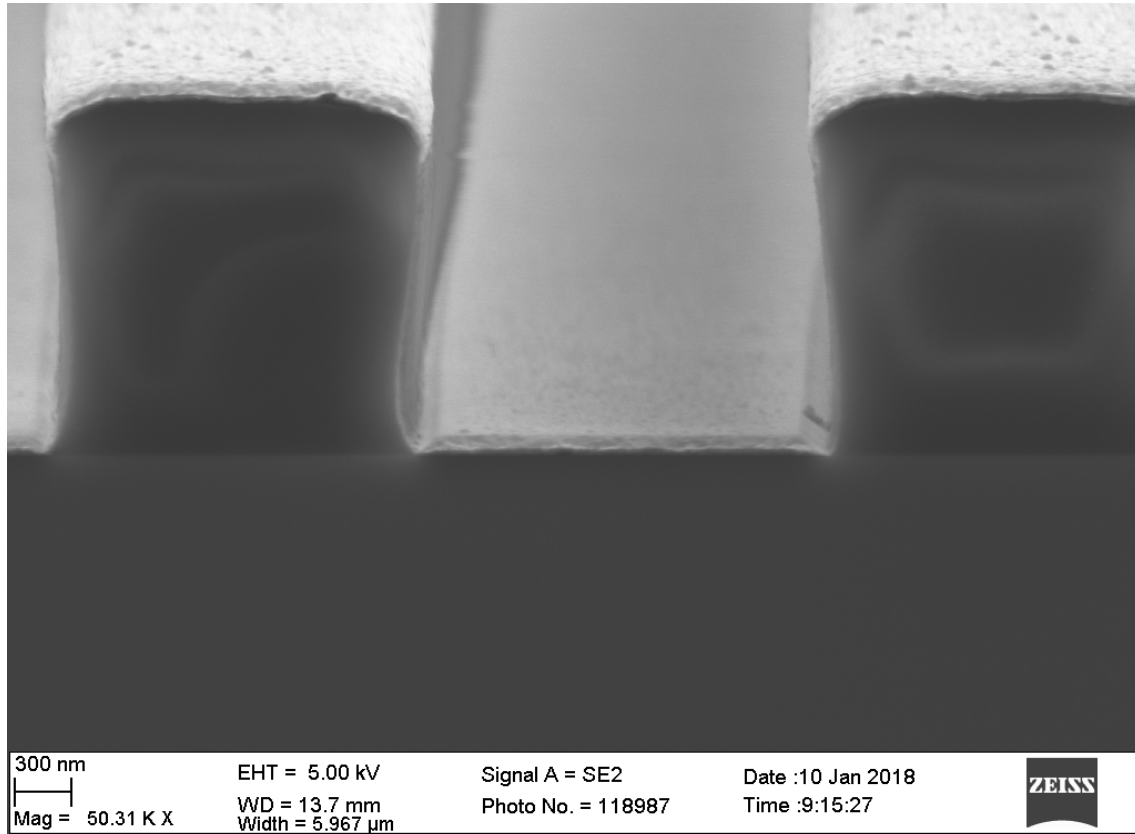


FAT in Livermore, CA, went very well

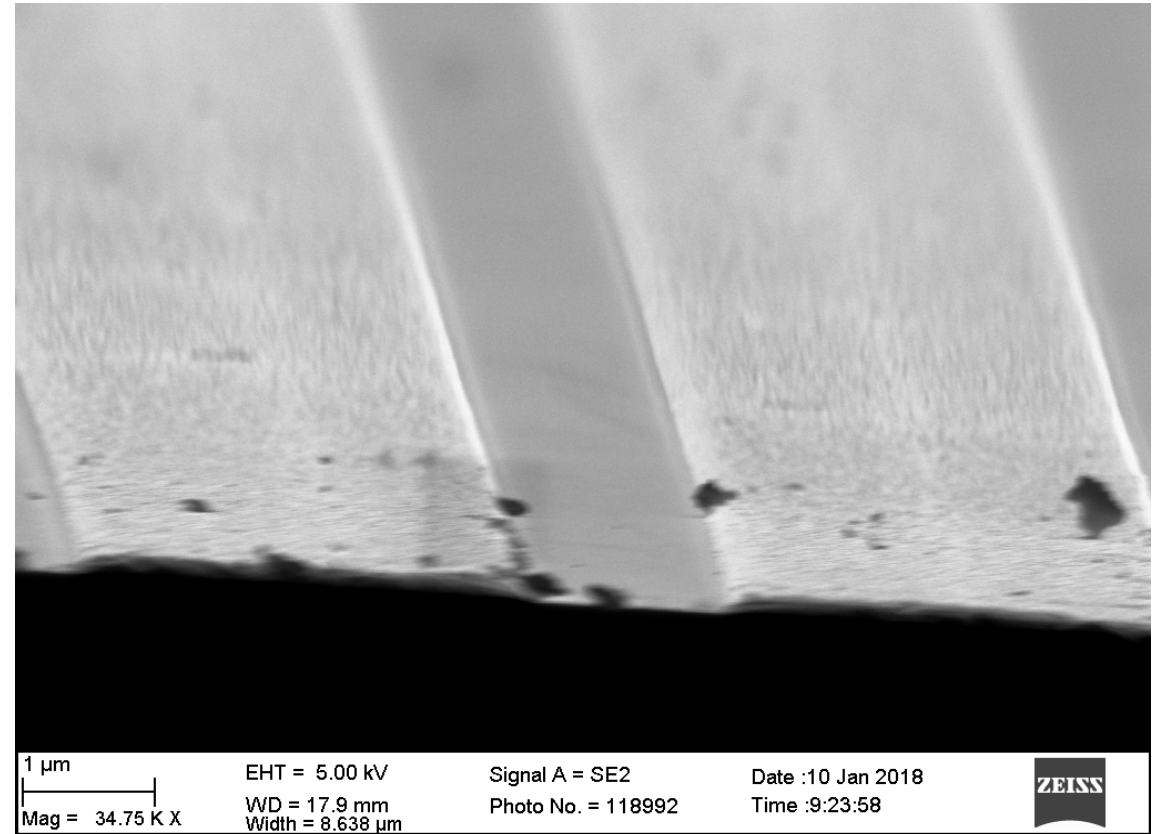
- high throughput confirmed
- high uniformity confirmed ($< 2\%$)

SAT mid-March (this week)

FC2000 from FerroTec-Temescal

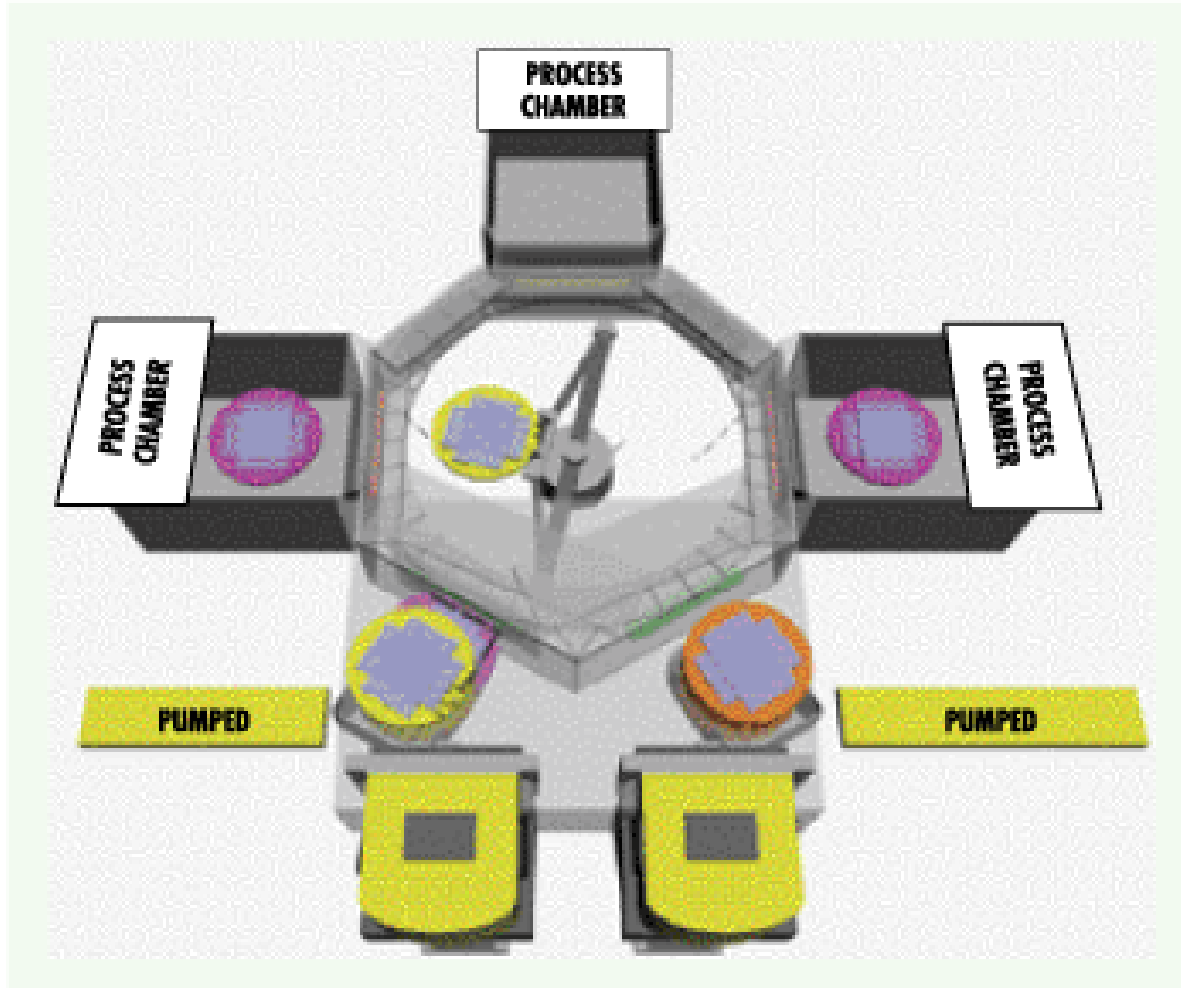


Au/Ti on negative resist



Au/Ti lines after lift-off

Dual-Sputter system: New functionalities



PVD **multi-chamber** tool:

- Dielectric sputter
- DC sputter
- Separate nitrides/oxides
- Central dealer

PVD multi-chamber tool: Candidate from Lesker



OCTOS robotic cluster tool:

- 2 x PVD75 sputter systems
- Distribution chamber (Genmark robot)
- Cassette station (10 wafer cassette)

Planning test (next month):

SiO₂, ITO, TaO₂, TiO_x, NiV, AlN

2" TORUS magnetron: 4" and 6" substrates



Logitech Orbis CMP sytem

- Purchased in co-operation with DTU Fotonik
- Polishing of 2, 4 and 6 inch wafers
- Polishing of 20x20mm Pieces
- Highly smooth initial surfaces, no lapping
- SF1 polish fluid and Chemcloth
- No acids or bases
- Si + SiO₂ polishing only with SF1
- SAT in April
- Expected release end of May





Nano-Master SWC-4000

- For cleaning of polished wafers
- Cleaning of 2, 4 and 6 inch wafers
- Cleaning of 20x20mm Pieces
- Megasonic (water) and brush cleaning
- No acids and bases
- Ionizer
- FAT in April
- Expected release mid June



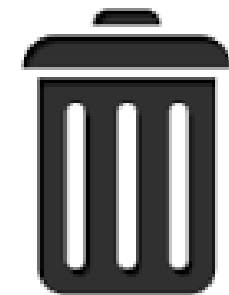
Booking rules on e-beam writer

- Too many bookings are cancelled less than 24 hours before
- Some bookings are even forgotten!
- E-beam files are often not ready
- This creates unnecessary bottle necks
- How can we improve this situation?
- We are imposing stricter booking rules



Tools leaving the cleanroom

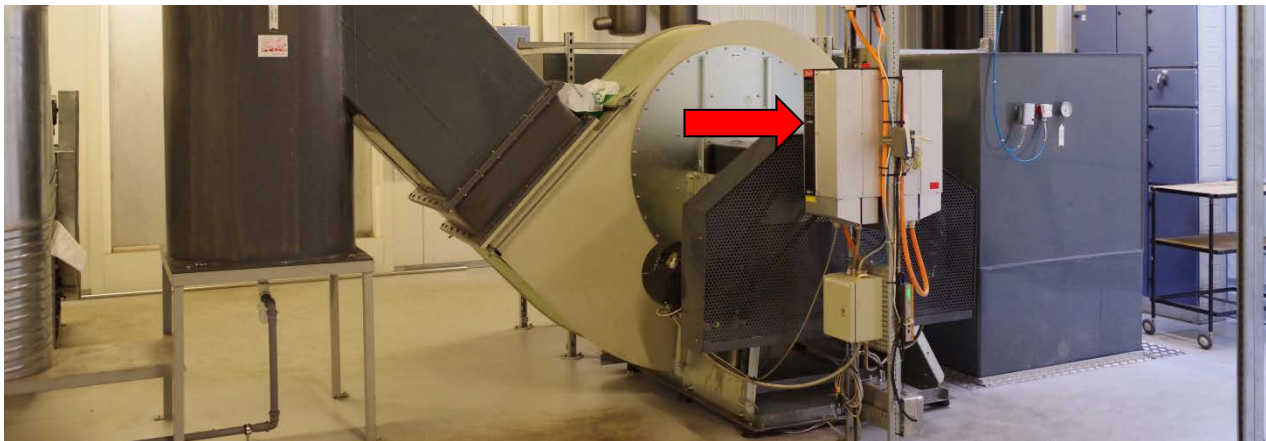
- PECVD 2 (replaced by PECVD 4)
- RIE 2
- Alcatel



FACILITY ISSUES

Mild evacuations

- Many mild evacuations during 2017 and 2018
- Cooperation with CAS to find root cause
- Problem located to exhaust fan in new part of the cleanroom.
- The fan has battery backup
- Power spikes \Rightarrow Control module resets
- Found "dirty" electronics inside module
- Module changed
- Wednesday 7 March 12:02:
 - A power spike shut down DUV stepper & PECVD4
 - But no evacuation alarm
 - Maybe we found the root cause ☺
- We will keep observing (and praying)



Lots of upcoming disturbances

- Week 16 (16- 22 April. Not confirmed):
 - Installation of residual-current circuit breakers
 - Cleanroom closed
 - Tools will be shut down end week 15
 - Tools may not be running start week 17
- Week 29-30 (16-29 June. Confirmed):
 - No heat on campus \Rightarrow No humidity control.
 - We are trying to obtain a contingency heating module.
- Decommissioning of CVD2+RIE2. Gas shutdown:
 - B_2H_6 , PH_3 , SiH_4 , NH_3 , N_2O , CF_4 , Ar , O_2
 - Maybe in week 16, if possible

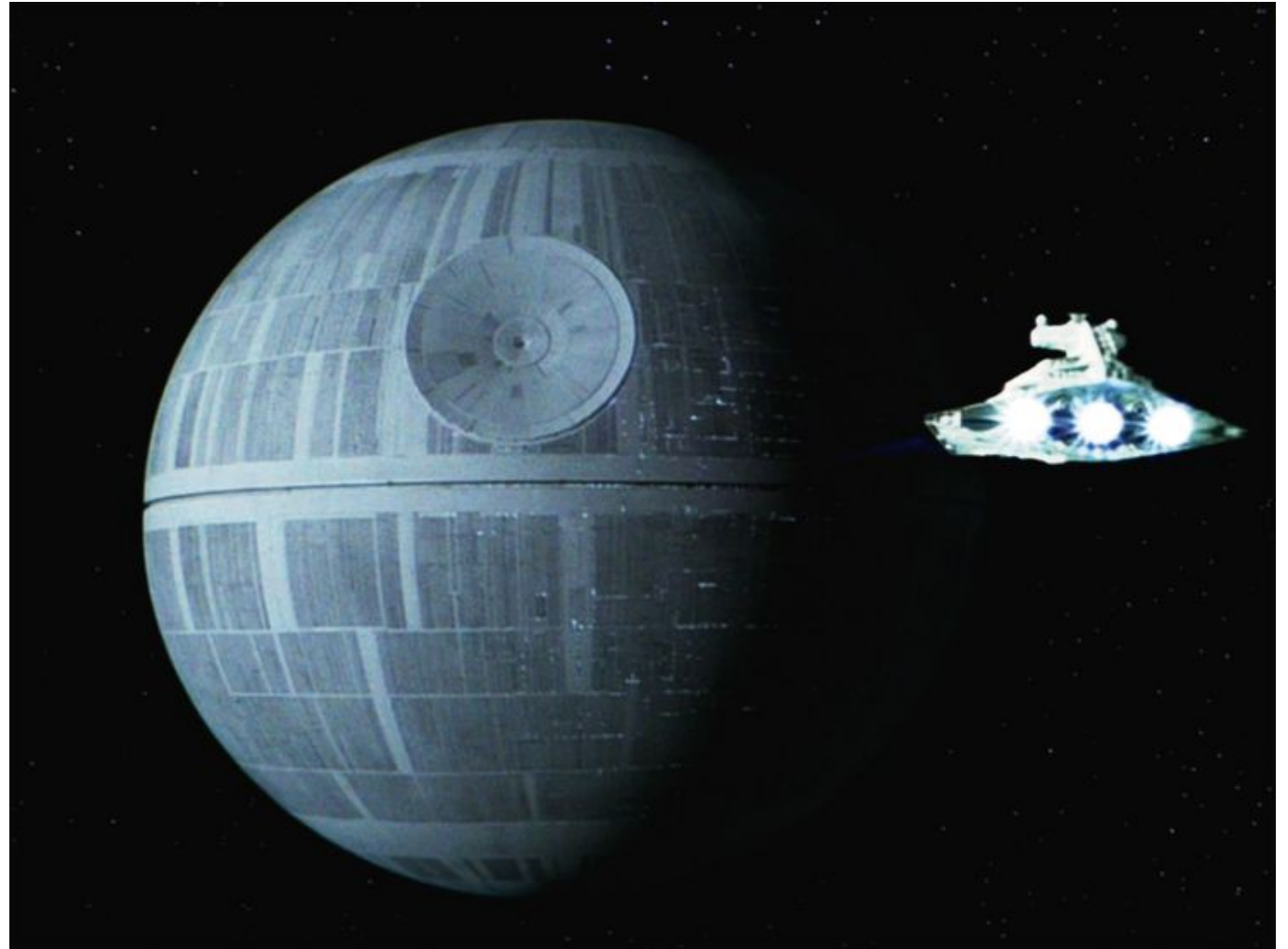


Gas breakdowns

- One tiny hole in a 6 mm HBr steel pipe caused:
 - CH₄ down 4.5 months
 - HBr down 5.5 months
 - BCl₃ still not back (waiting for new bottle)
- NH₃ down since 9 March due to leaking regulator
- Corrosive gases most problematic
- Extremely long lead time on gas parts and bottles
- Difficult to obtain good gas welders
- How to avoid this from happening again:
 - Stock more spare parts
 - Find alternative spare part suppliers
 - Separate problematic (corrosive) gases
 - Always have a backup gas welder

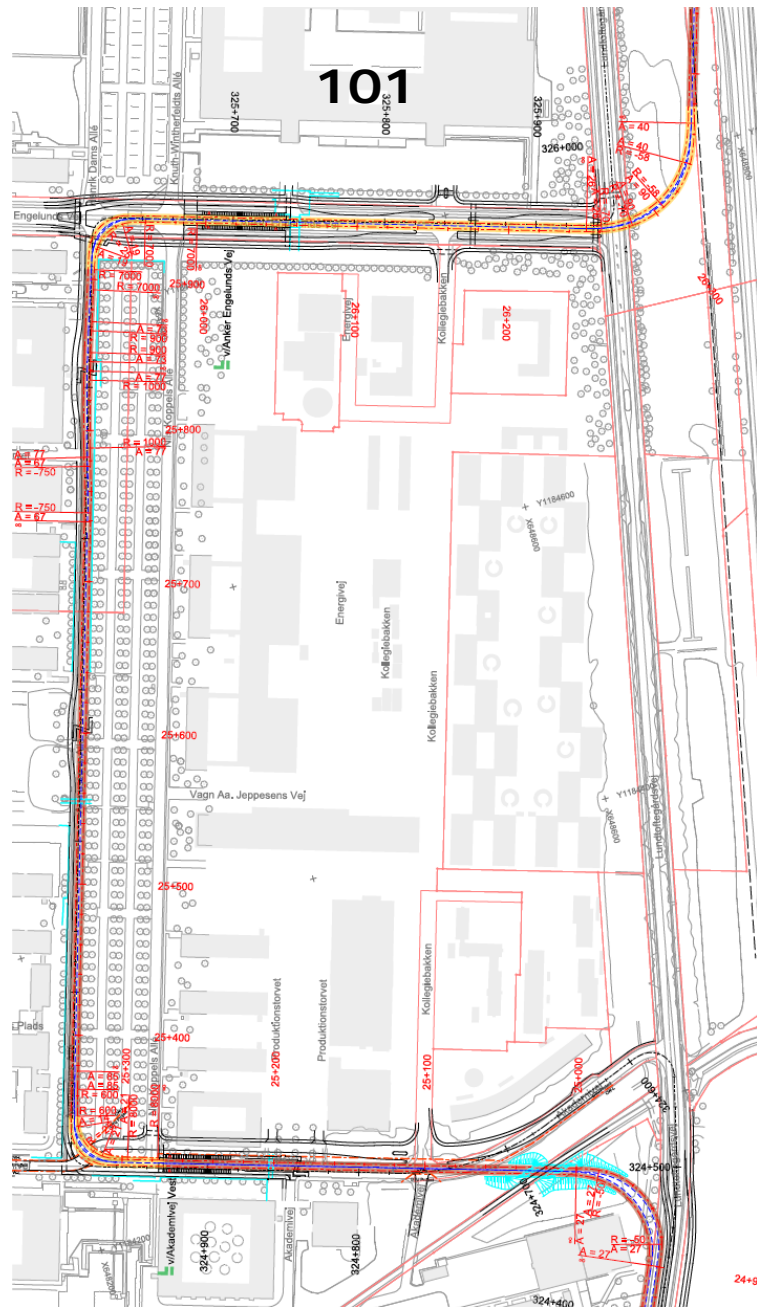


The Light Rail is coming



Light rail alignment on DTU Lyngby campus

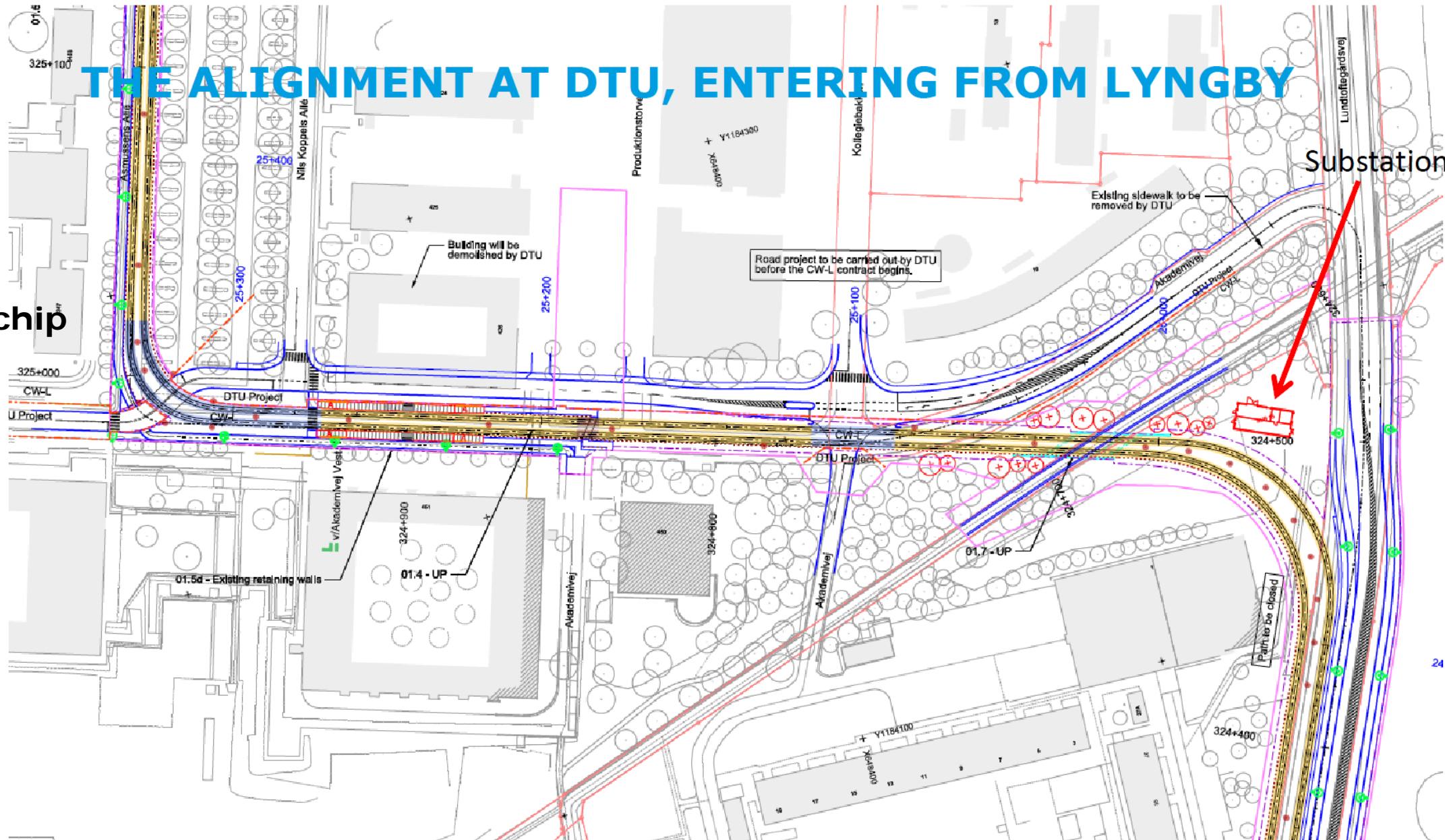
- Expected operational in 2024
- Tender on tracks, trams completed
- Political decision made
- Boundary conditions
 - Alignment fixed
 - Tram type fixed
 - Wires might be locally modified (segmentation)
 - Tracks might be locally modified (damping)



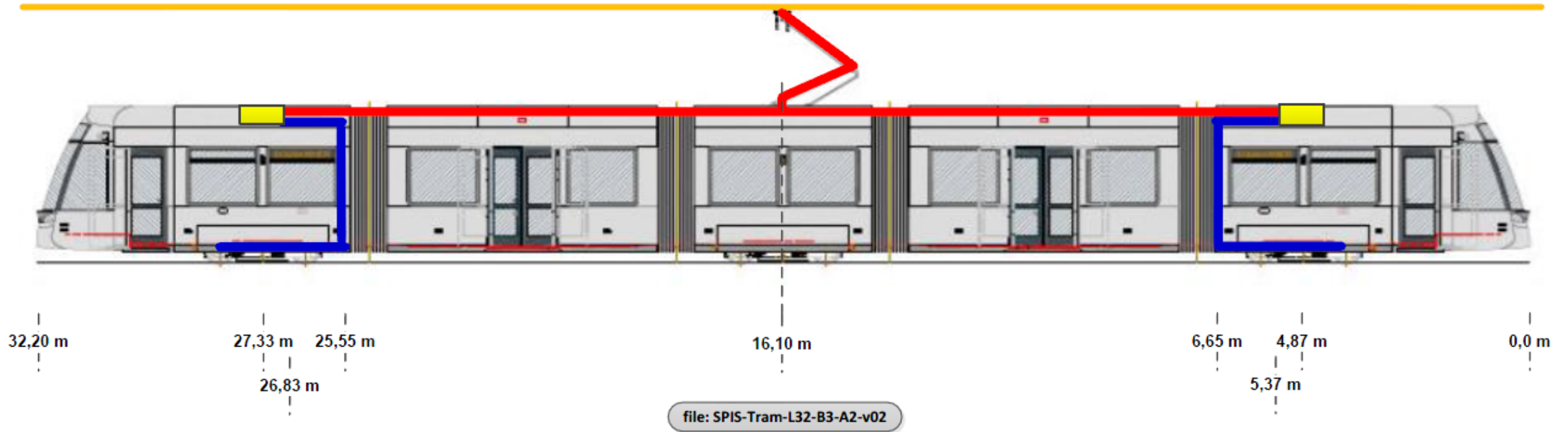
Fotonik
Nanotech
Danchip

THE ALIGNMENT AT DTU, ENTERING FROM LYNGBY

Danchip



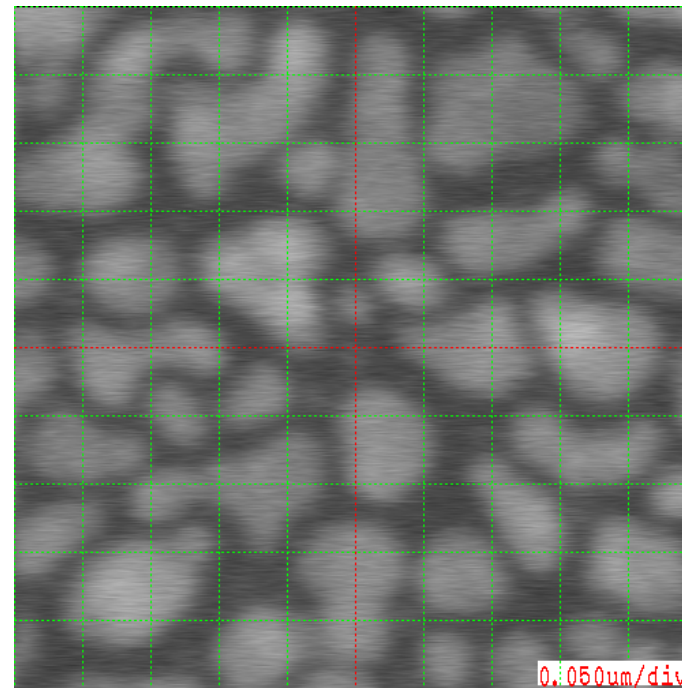
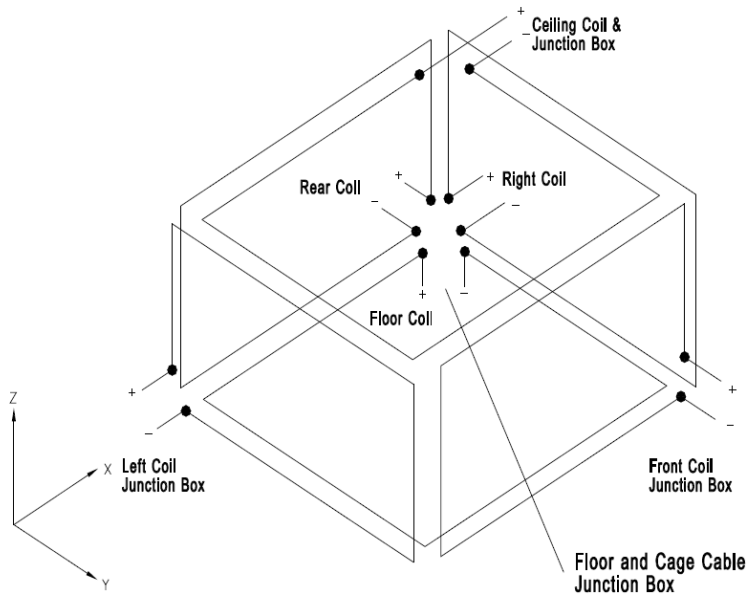
Tram model



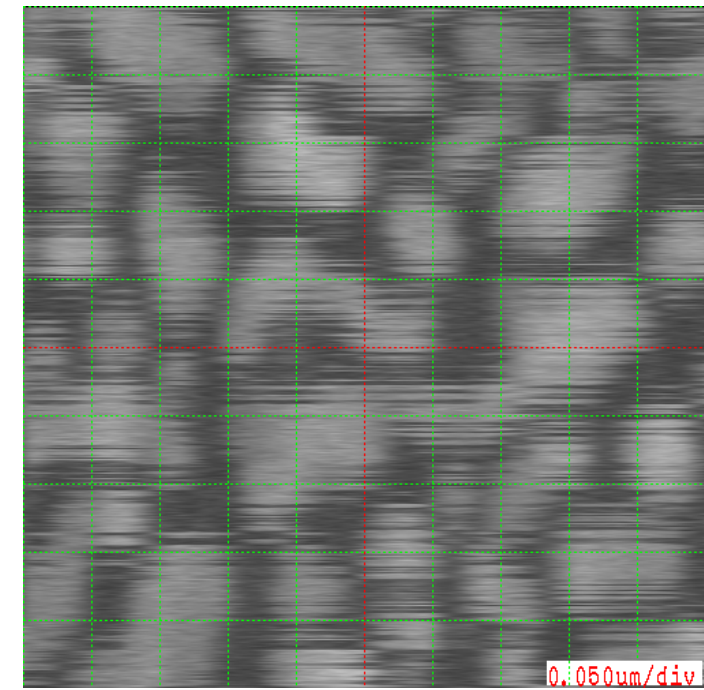
- max. current: 1200 A per tram
- speed at point of field weakening: 27 km/h
- bogies: 3 (powered, trailing, powered)
- return currents: 2 powered bogies
- roof height: 3,10 m

Electromagnetic testing of e-beam

- Using the EMI cancellation systems' Helmholtz coils in test mode
- Applying electromagnetic white noise
- > 50 nT: Large disturbances observed
- **Tram level: 600-800 nT (!)**
- If unshielded/uncompensated, the tram will have massive impact
- Mitigation possible at the tram line and at the e-beam – maybe a combination is needed



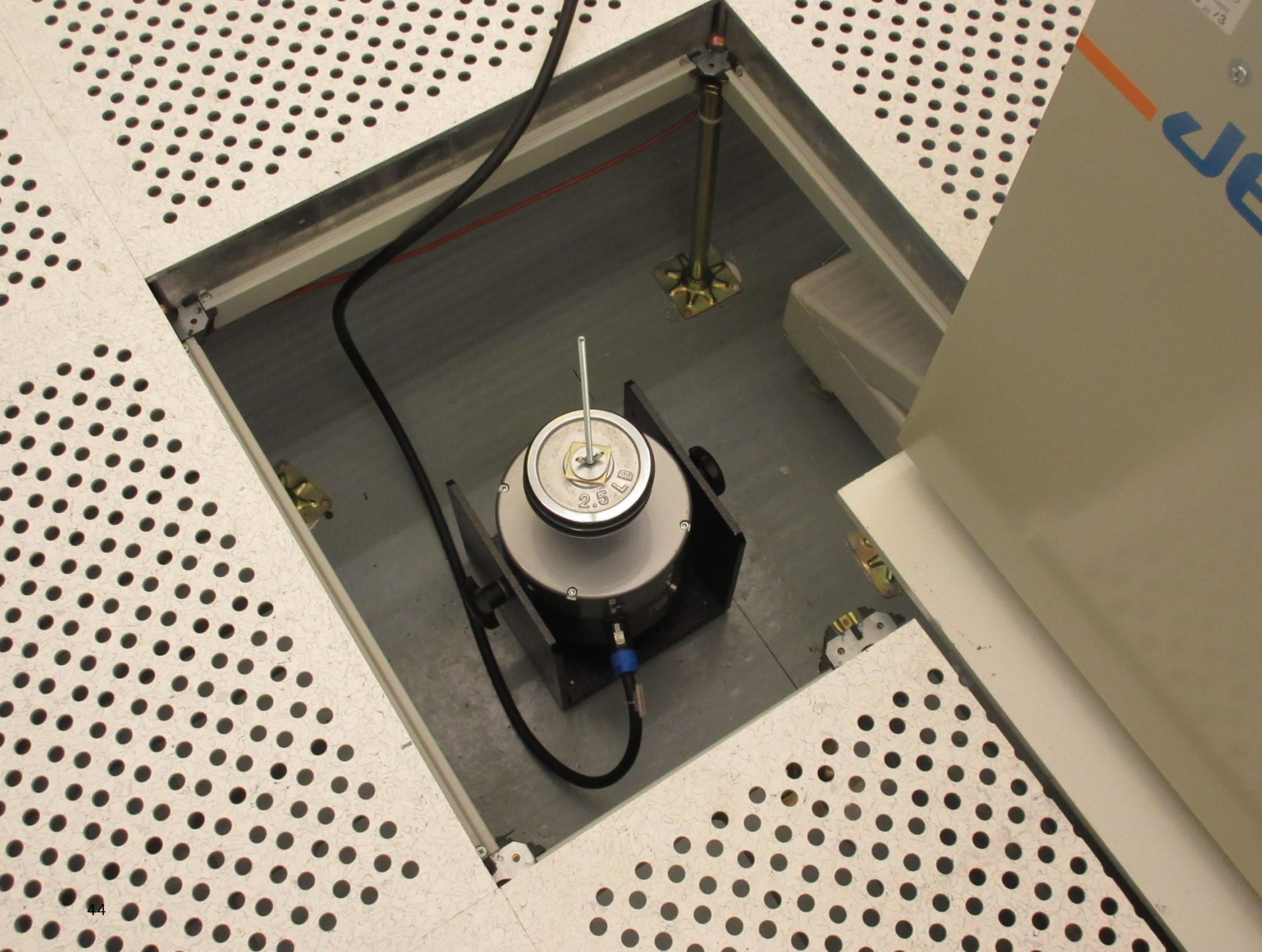
No applied field



150 nT perpendicular to tram line

Vibration testing

Mini shaker on e-beam floor



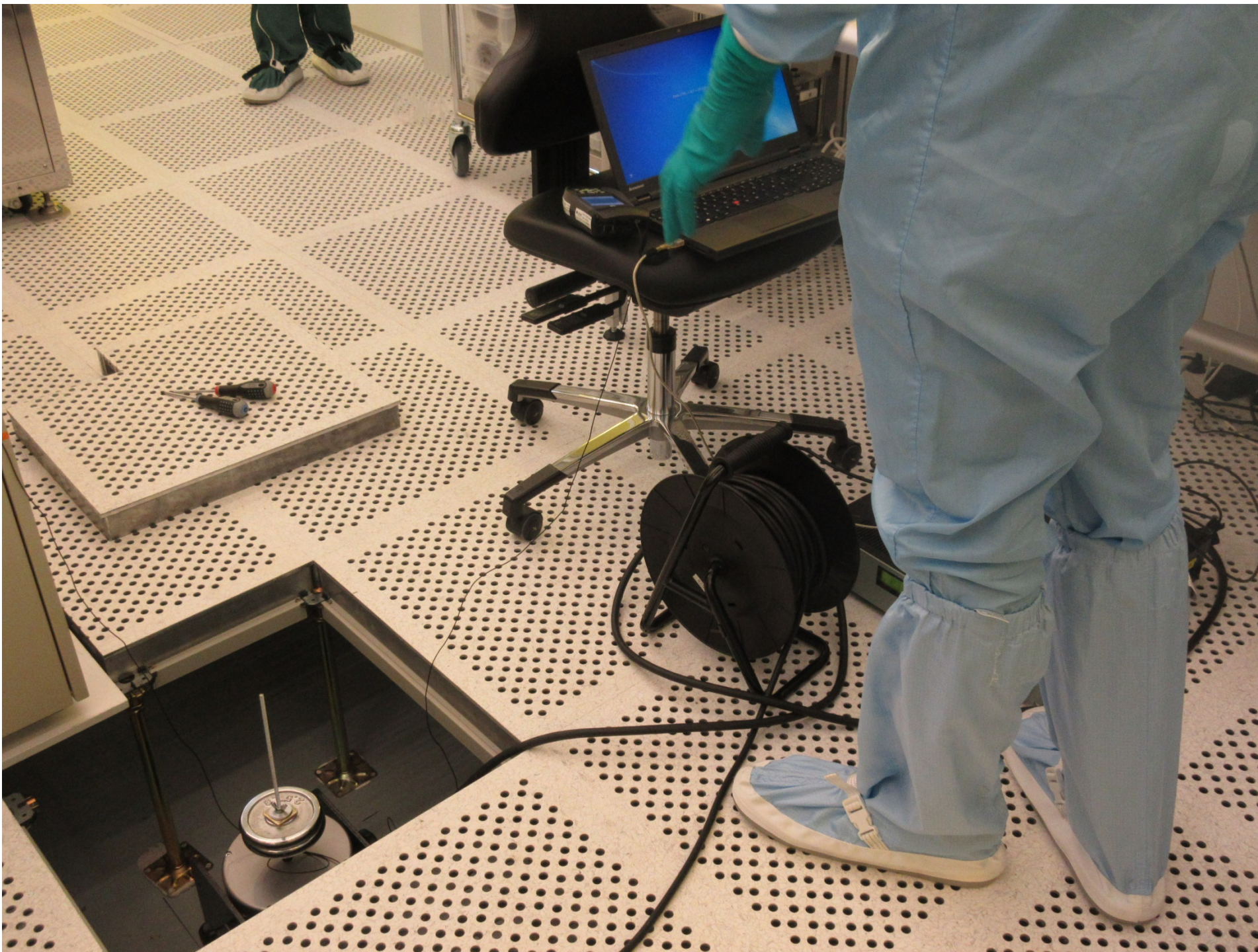
Vibration testing

Accelerometer on e-beam writer



Vibration testing

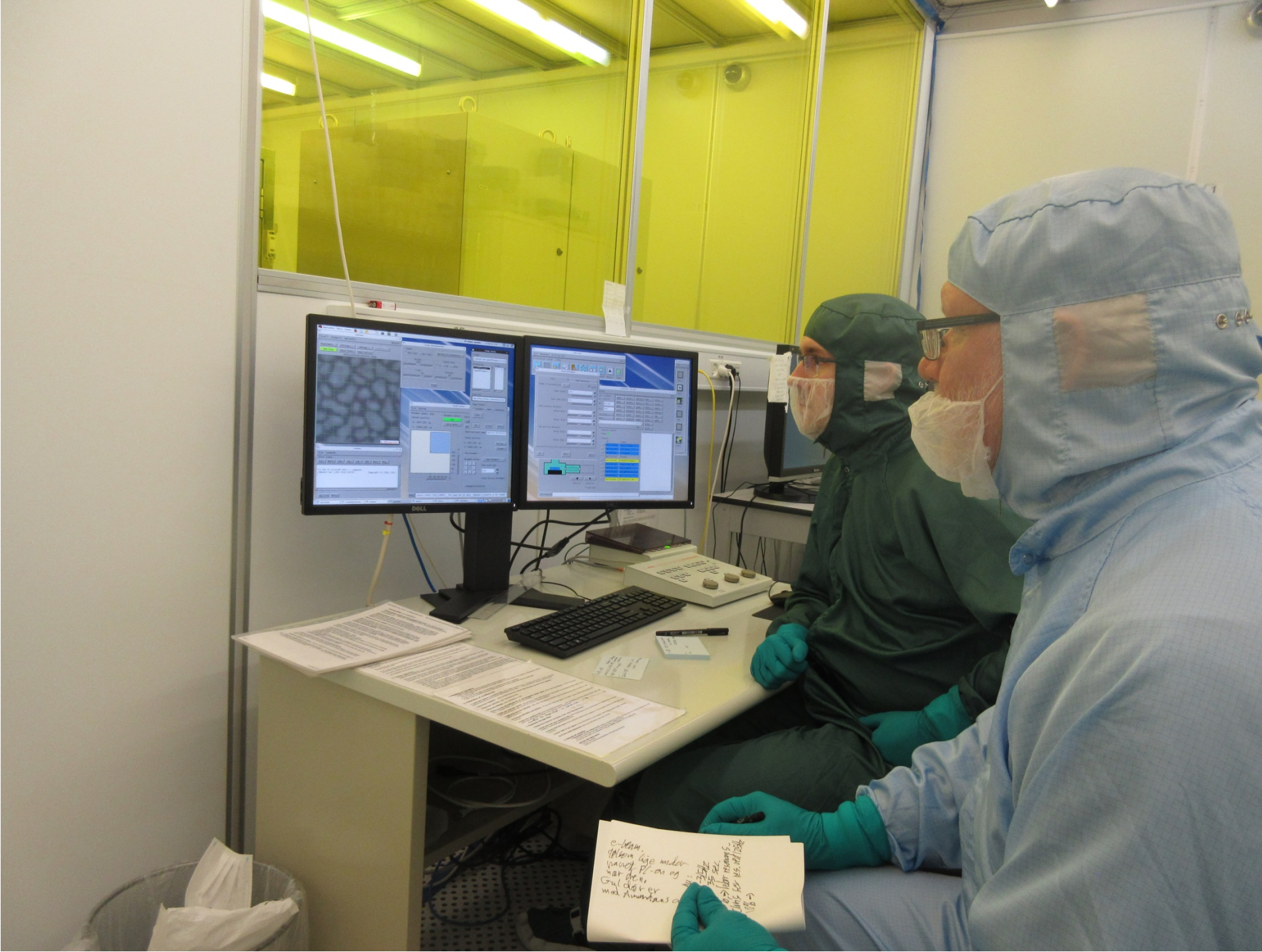
Analysis of vibrations



Vibration testing

Observation of e-beam in SEM mode

>2% shaker full scale: E-beam disturbance detected



Vibration testing – maxi shaker on future rail



Vibration testing – maxi shaker head



- Accelerometers on
 - Ground
 - Building
 - Damped floor
 - Equipment
- Data processing ongoing (Rambøll)
- Need to establish transfer functions
 - Tram line to Building
 - Building to damped floor
 - Floor to equipment

Outlook

- Busy spring – shutdowns and major replacements
- Paying extra attention to:
 - Lock out and strikes
 - Changes in user profiles
 - Gas installations
 - Light rail

