
CAROLINÆ
AD VTRVMQVE
1666

Final NM13/V7 General Assembly

Copenhagen 15th October 2015

Tomas Lundqvist

MAX IV LABORATORY – AN INTERNATIONAL NATIONAL FACILITY

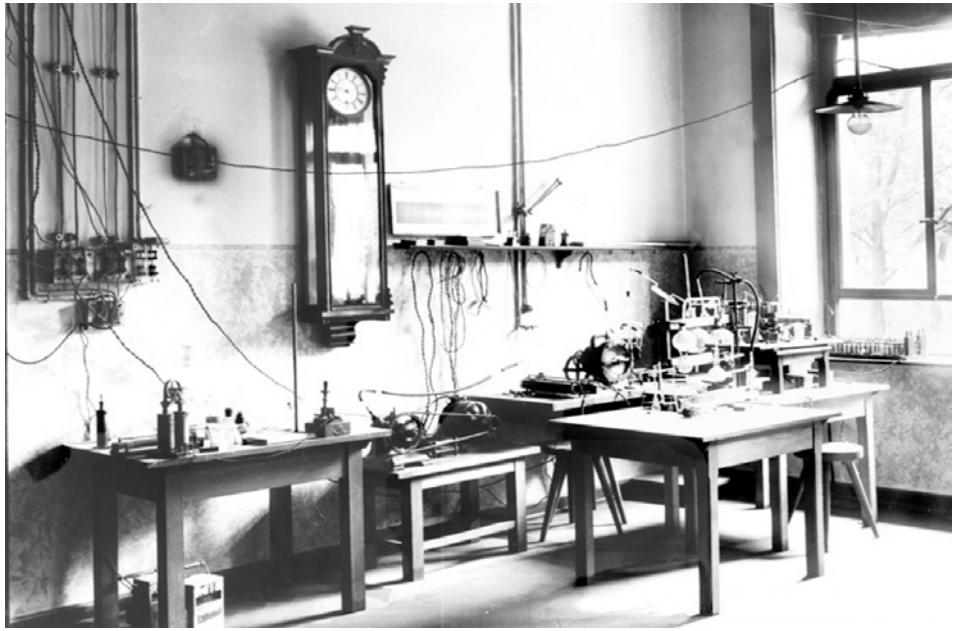
Content

- MAX-lab
- Short update on the MAX IV project
- Our (my) challenges …

MAX IV – X-rays has come a long way

W.C. Röntgen
1845-1923

A.B. Röntgen
1845-1923



Röntgen's lab 1895, Univ. Würzburg

Make things visible to the naked eye !

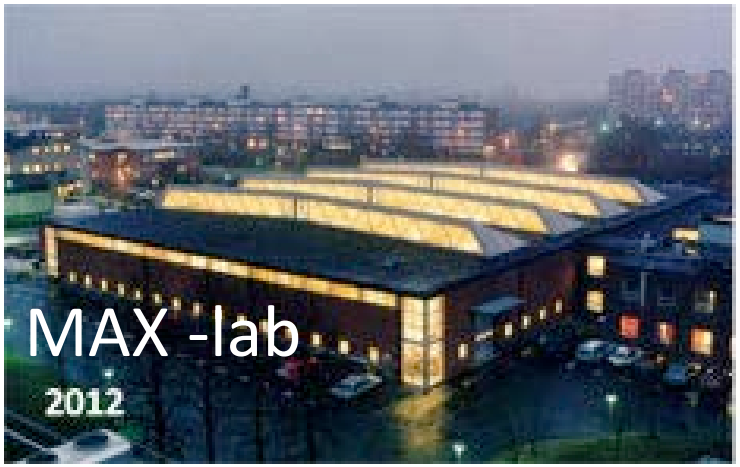
Twins but not identical

- **Light (X-rays)**
- Swedish funded
- MAX-lab since 25 years
  MAX IV opens 2016
- **… microscopy, fast measurements …**

- **Neutrons**
  (from atomic nucleus)
- 17 member states
  (SWE, DK, NOR, …)
- Building started Sep 2nd 2014
  Science starts ≈2023
- **… large & thick samples, water …**

MAX IV – currently two facilities

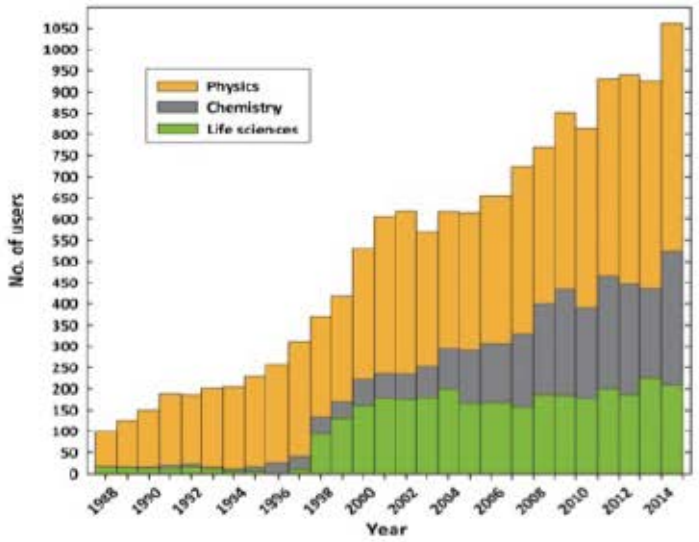
Turning off
and
turning on
the light



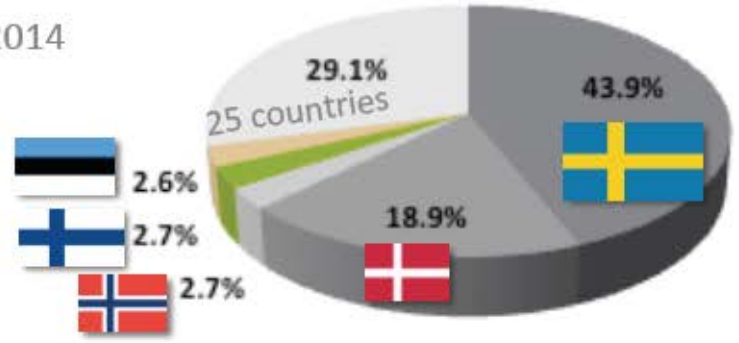
6 months of darkness in Lund

MAX IV a National User Laboratory

Academic
[Peer review]



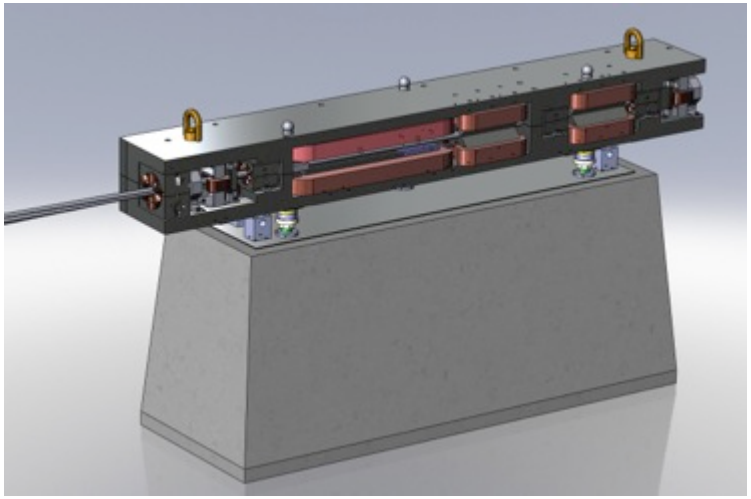
2014

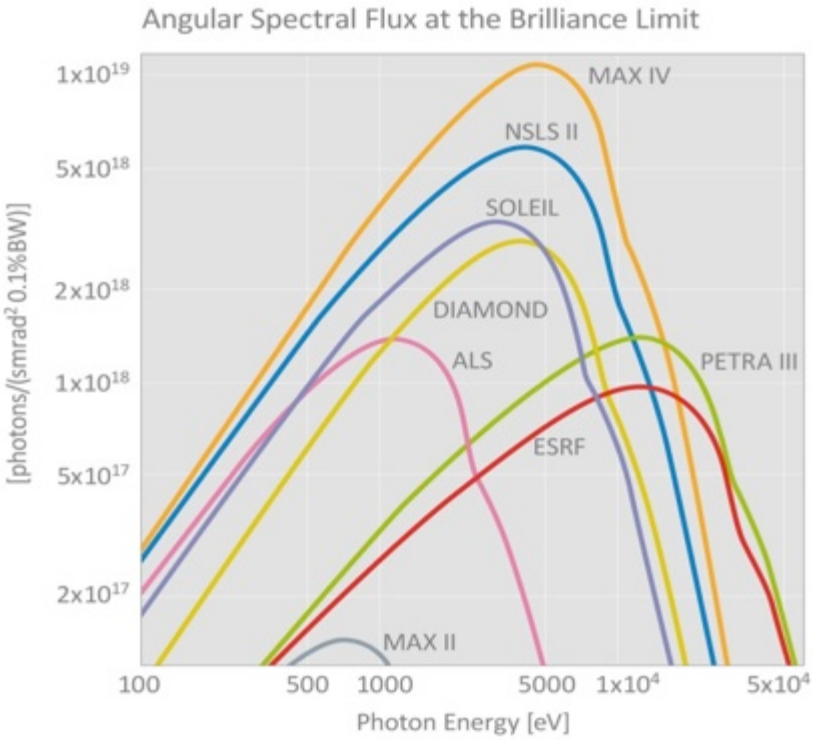


Commercial
[Paid, proprietary]

Imaging Resource
BONE SUPPORT
AkzoNobel
Tomorrow's Answers Today
SARomics
HALDOR TOPSØE
ADROIT SCIENCE
ABB
:CR:
novo nordisk®
AstraZeneca
Tetra Pak
PROTECTS WHAT'S GOOD™
LEO
Höganäs
sasol
novaled
MEDIVIR
SP
Sprint Biosclence
MAX IV

What is unique with MAX IV?





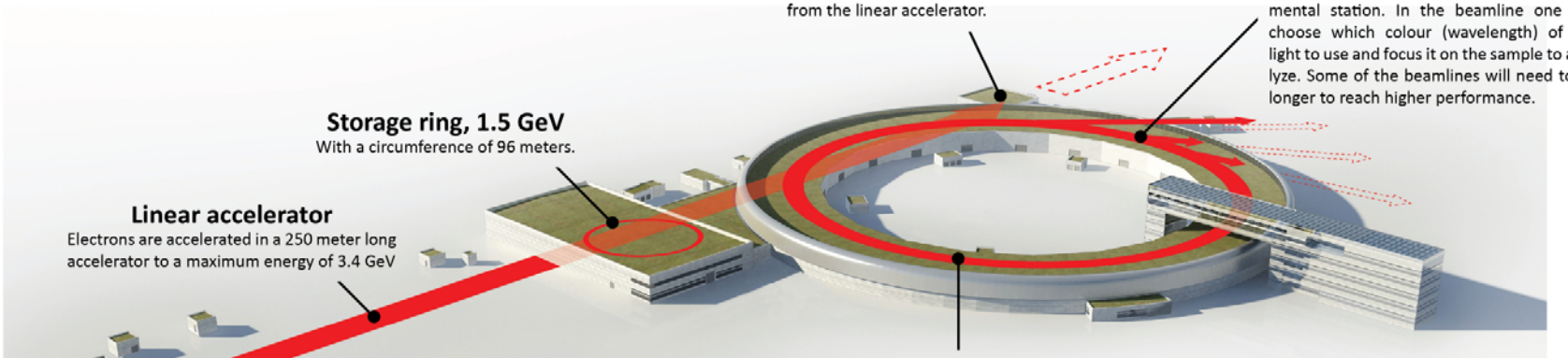
- Technological breakthrough
- Brightness (≈ x 100):
  Small spot & divergence
- High coherence

NSLS-II First Girder:
14-foot, 8-ton structure holding multiple magnets installed in the accelerator ring. June 15, 2010

MAX IV First MBA magnet:
dipole & multipol magnets installed @ mock-up.
May 6, 2014

MAX IV

Investment in accelerator ~1150 MSEK
13 beamlines ~900 MSEK
Operations ~350 MSEK/year (2016)
Secured until 2019 (VR + LU)



Short pulse facility
Extremely short light flashes can be produced here by using the electrons directly from the linear accelerator.

Beamline
The light that is produced by the electrons shines through the beamline to the experimental station. In the beamline one can choose which colour (wavelength) of the light to use and focus it on the sample to analyze. Some of the beamlines will need to be longer to reach higher performance.

Storage ring, 1.5 GeV
With a circumference of 96 meters.

Linear accelerator
Electrons are accelerated in a 250 meter long accelerator to a maximum energy of 3.4 GeV

Electron Gun
In the electron gun all electrons used in the facility are extracted from a piece of metal (copper or tungsten) with a similar technique to that used in a traditional thick-TV-set

Storage ring, 3.0 GeV
With a circumference of 528 meters. Stores electrons, which have been accelerated in the linear accelerator, in a vacuum tube. The electrons are bent around the storage ring by magnets. When the electrons turn in the magnets they emit light, similar to how the current in an antenna emits radio waves. Since the electrons travel with close to the speed of light, the light is called synchrotron radiation and has very special properties.

Experimental stations
At the end of the beamline sits the experimental station. Each station is specialised to a specific science area. Here the samples is mounted and one measures what happens when it is illuminated by synchrotron radiation.

Radiation
The electrons in the accelerator create a small amount of background radiation when the machine is operated. When the machine is switched off there is no remaining radiation as no radioactive material is produced. The accelerator itself is built into concrete and thus one can work freely in all other areas of the laboratory. If someone would enter the accelerator area the machine will stop automatically.

~26 beamlines in 2026 is the plan

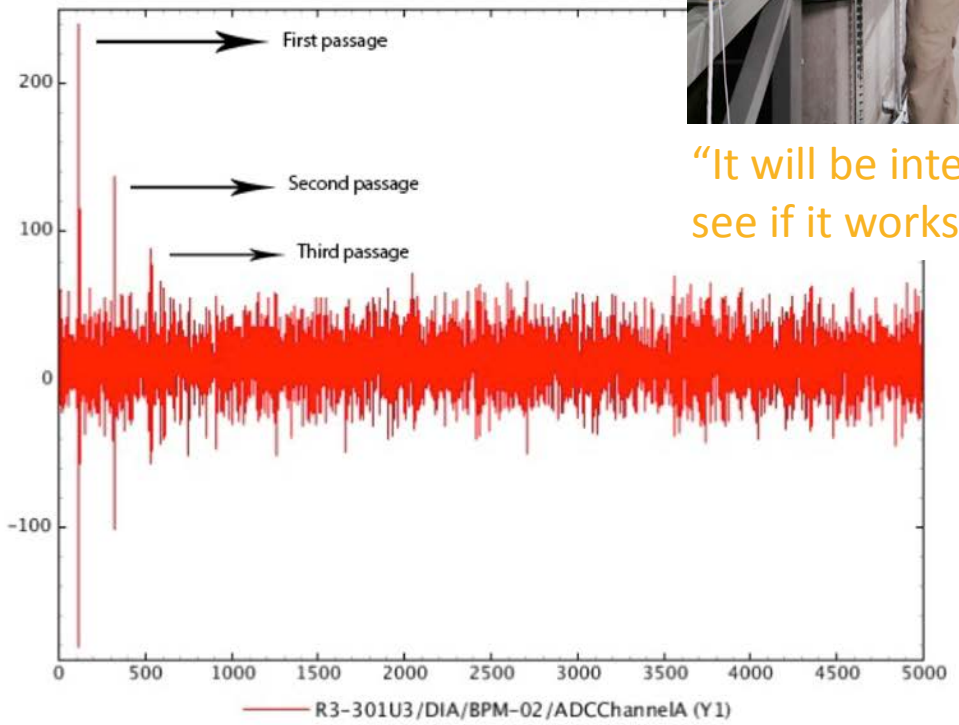
Building Project completed: 2015-06-01!

The MAX IV Laboratory - We make the invisible visible

Beam in the machine

BEAM IN THE MACHINE

2015-08-26



"It will be interesting to see if it works"

With 300 days to go until the inauguration the accelerator group at the MAX IV Laboratory now for the first time has been able to thread the electron beam all the way around the large 3 GeV ring.

nature | International weekly journal of science

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NATURE | NEWS

Next-generation X-ray source fires up

Swedish synchrotron promises to open up new avenues for researchers.

Davide Castelvecchi

26 August 2015 | Corrected: 27 August 2015

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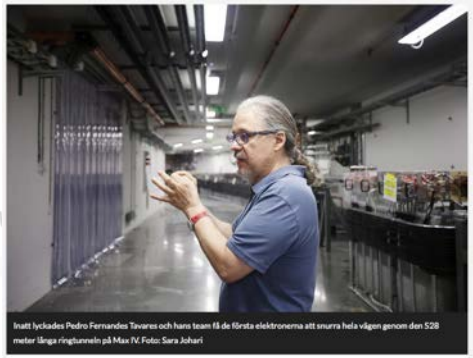
Sweden's MAX-IV laboratory will host the first two 'fourth-generation' light sources.



Inatt lyckades Pedro Fernandes Tavares och hans team få de första elektronerna att snurra hela vägen genom den 528 meter långa ringtunneln på Max IV. Foto: Sara Johari

Genombrott för Max IV

PUBLICERAD 26 AUGUSTI 2015, 15:39

LUND, SKÅNE

KAJSA-STINA KALIN

Följ @kskalin

829 Delningar | Facebook | Twitter | LinkedIn

I natt var ett historiskt ögonblick på forskningsanläggningen Max IV i Lund. För första gången lyckades personalen få elektronerna att susa hela vägen runt den största, 528 meter långa, lagringsringen.

– Det är såklart fantastiskt spännande och roligt, säger Pedro Fernandes Tavares, projektledare för lagringsringarna.

Helene Hellmark retweeted your Tweet.

View

MAX IV Laboratory @MAXIV...

MAX IV fires up

nature.com/news/next-gene...

AIP | American Institute of Physics

Programs and Resources | Publications | Career Resources | Member S

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Physics Today Daily Edition

URL: http://scitation.aip.org/content/aip/magazine/physicstoday/news?TRACK=RSS

Updated: 4 hours 56 min ago

Next-generation synchrotron fires up in Sweden

27 August 2015

Nature: A new synchrotron x-ray light source built at Sweden's MAX IV electron bunches were successfully beamed all the way around the syr trajectories cause them to emit x rays, are steered and focused by a se achieves stronger magnetic fields with the use of more compact magn resulting intense pulses of x rays could be used in any number of labo battery in real time or the structure of much smaller protein crystals th

Tisdag 1 sep | Sök | Kundserv

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Annons

Nu rör sig elektronerna i Max IV

I ett helt år har installationen pågått av den stora lagringsringen på Max IV-laboratoriet i Lund.

Nu har acceleratorgruppen för första gången lyckats leda elektronstrålen runt den nya stora lagringsringen, som formellt heter 3 GeV-ringen.

”Driftsättningen har gått smidigt, det är trots allt 140 magnetblock, med mer än 1 400 individuella magneter, som ska finjusteras så att elektronstrålen kan ledas runt ringen”, berättar Pedro Fernandes Tavares, projektledare för lagringsringarna, i ett pressmeddelande.

Installationen har krävt extrem exakthet.

Annons

SvD VIN&MA

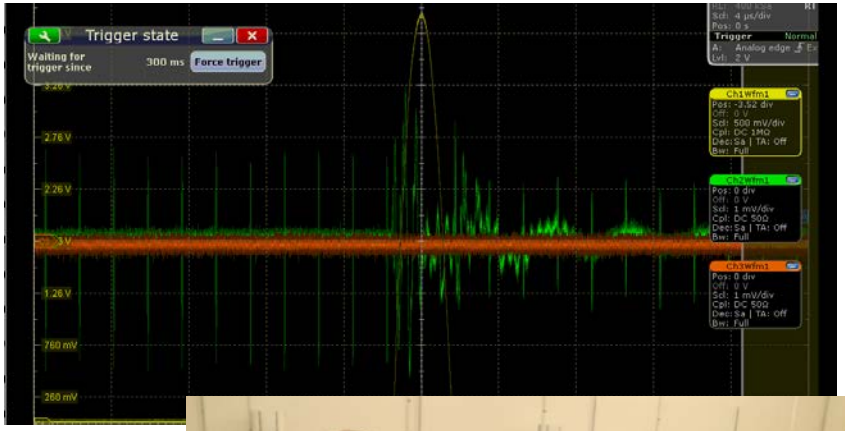
With 300 days to go until th

Laboratory now for the first time has been able to thread the electron beam all the way around the large 3 GeV ring.

MAX IV

Already old news …

Stored Beam !



Only a few days later …

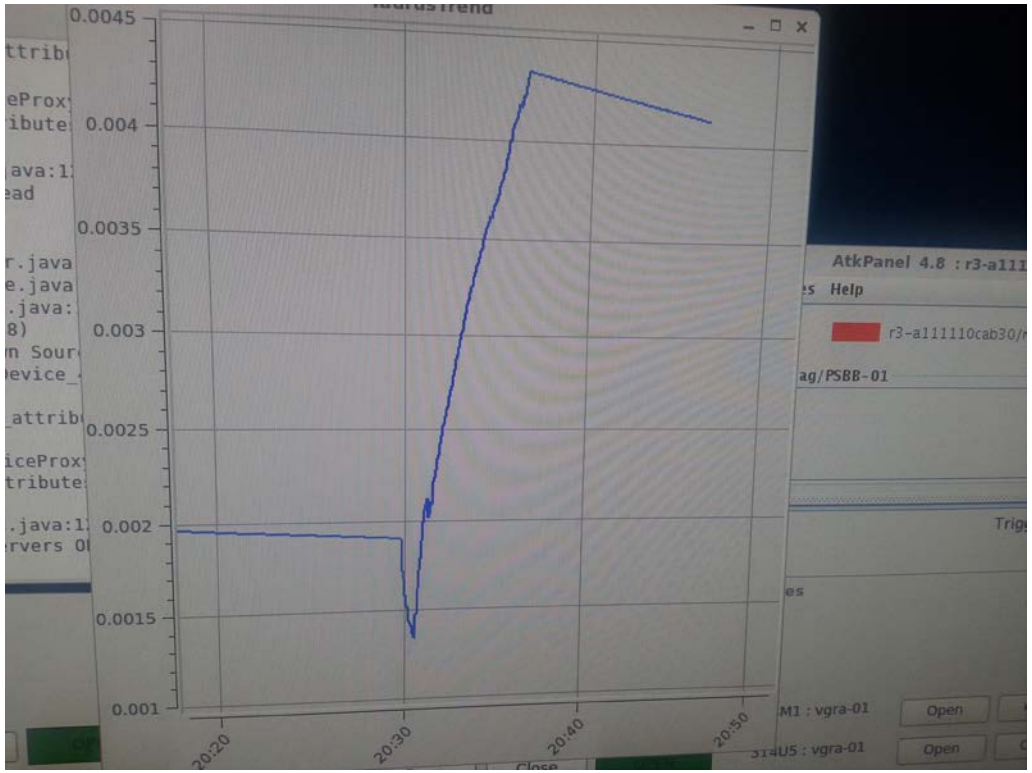
Hey Alla,

Another milestone of 3 GeV ring commissioning has just been reached – as we powered up two of the six RF cavities in the ring, we could capture the injected electron beam and keep it circulating in the machine until the next LINAC pulse, 2 seconds later. Here is a picture of the signal as seen on an oscilloscope and also of a very happy commissioning team getting ready to celebrate !

Cheers
Pedro

Already old news …

Ramping up!

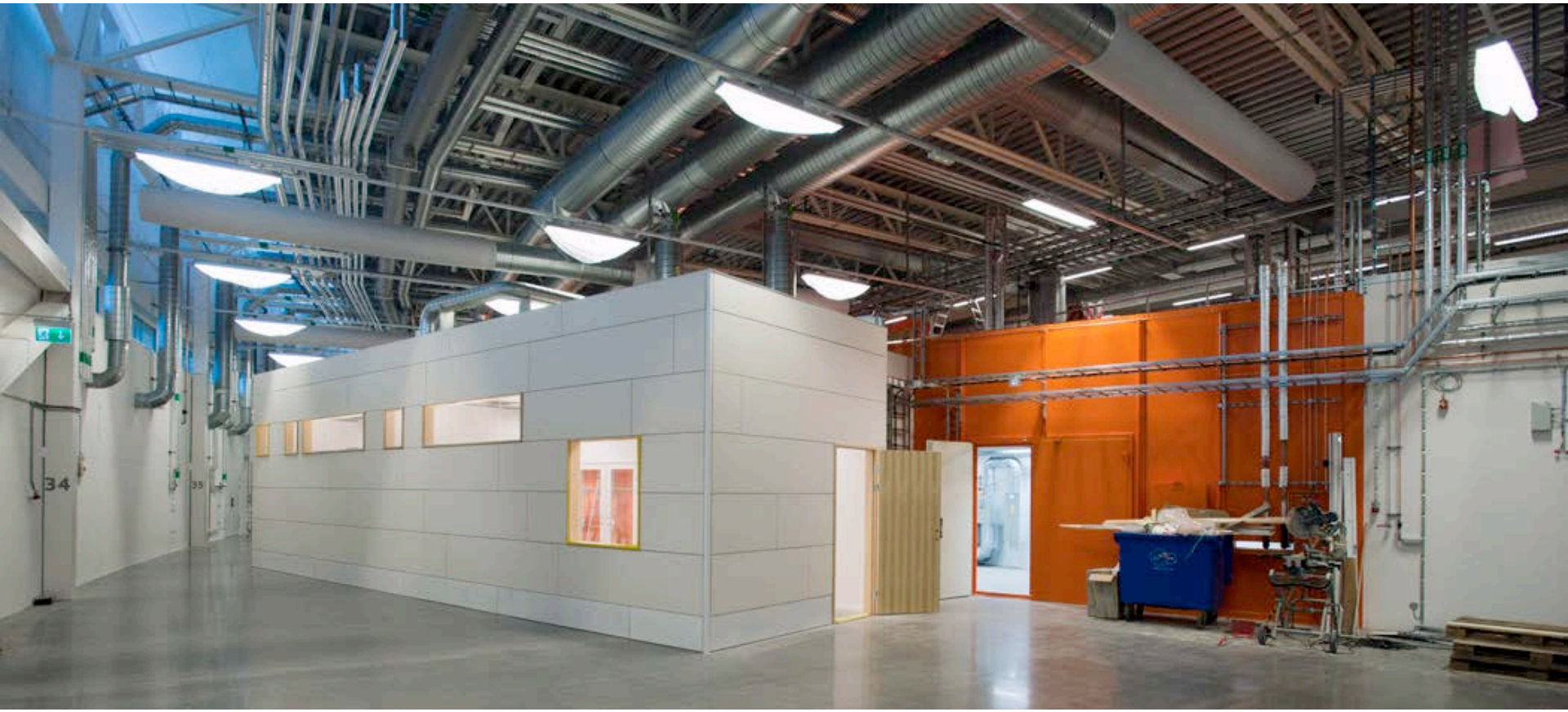


Yesterday

"Today we have demonstrated current stacking in the 3 GeV ring, reaching over 4 mA of stored beam current. That means that we are capable of adding electrons to the already circulating beam, which opens the way to reaching higher currents in the next stages of commissioning. The attached picture shows the process of charge accumulation."

Cheers
Pedro

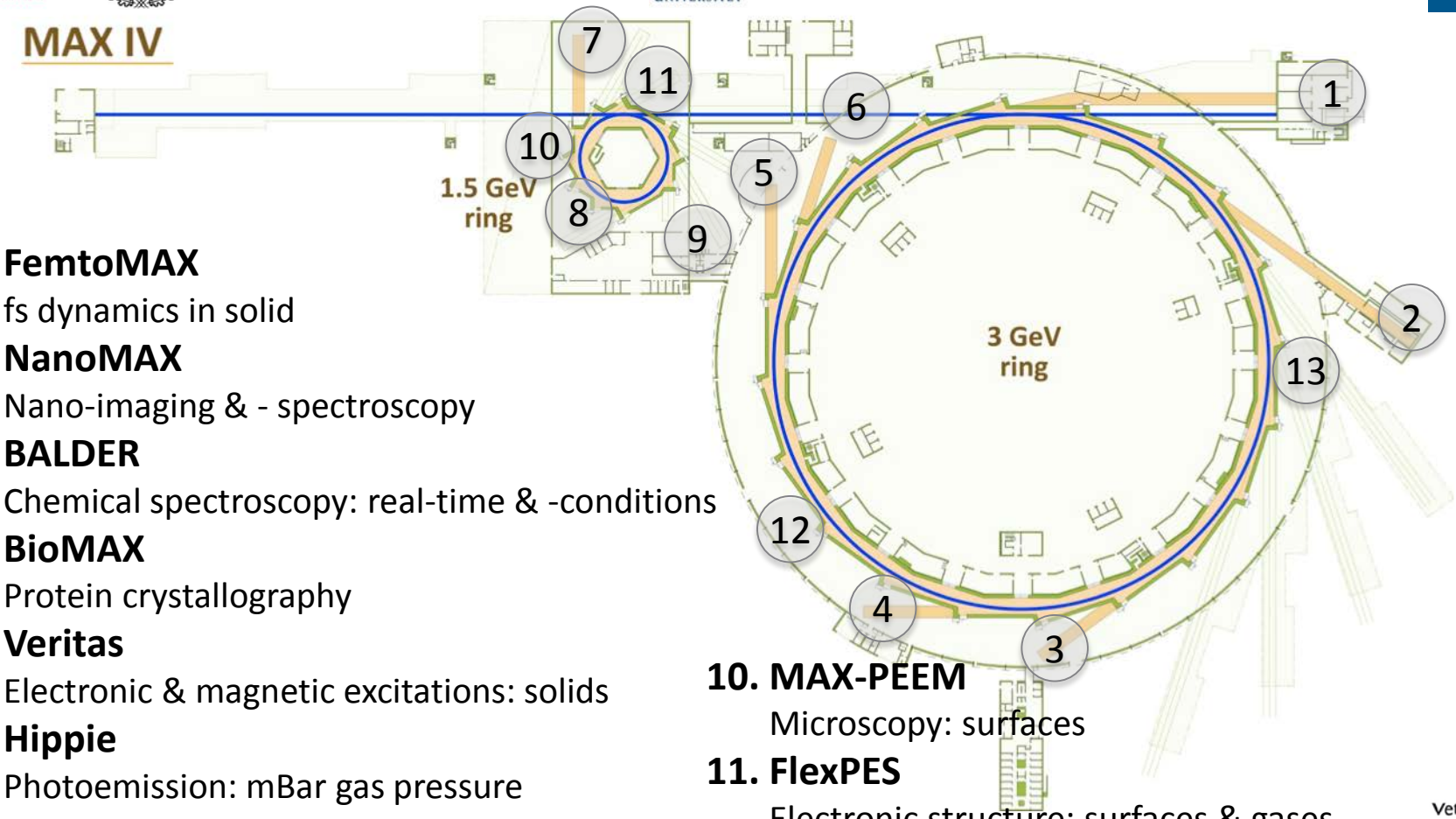
Example of an experimental station - BioMAX



Hutch for the BioMAX beamline completed and ready for installing the equipment.

BioMAX – May 2015

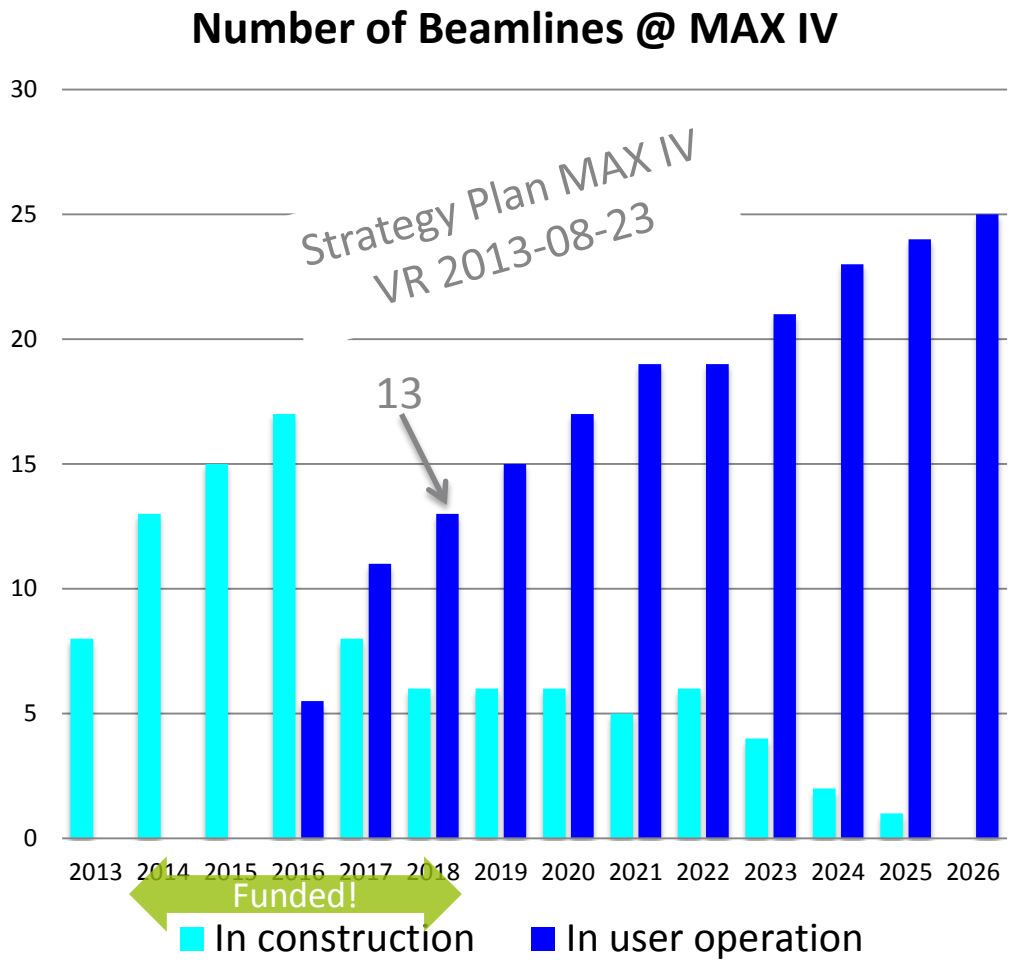
Experiments mid - 2016

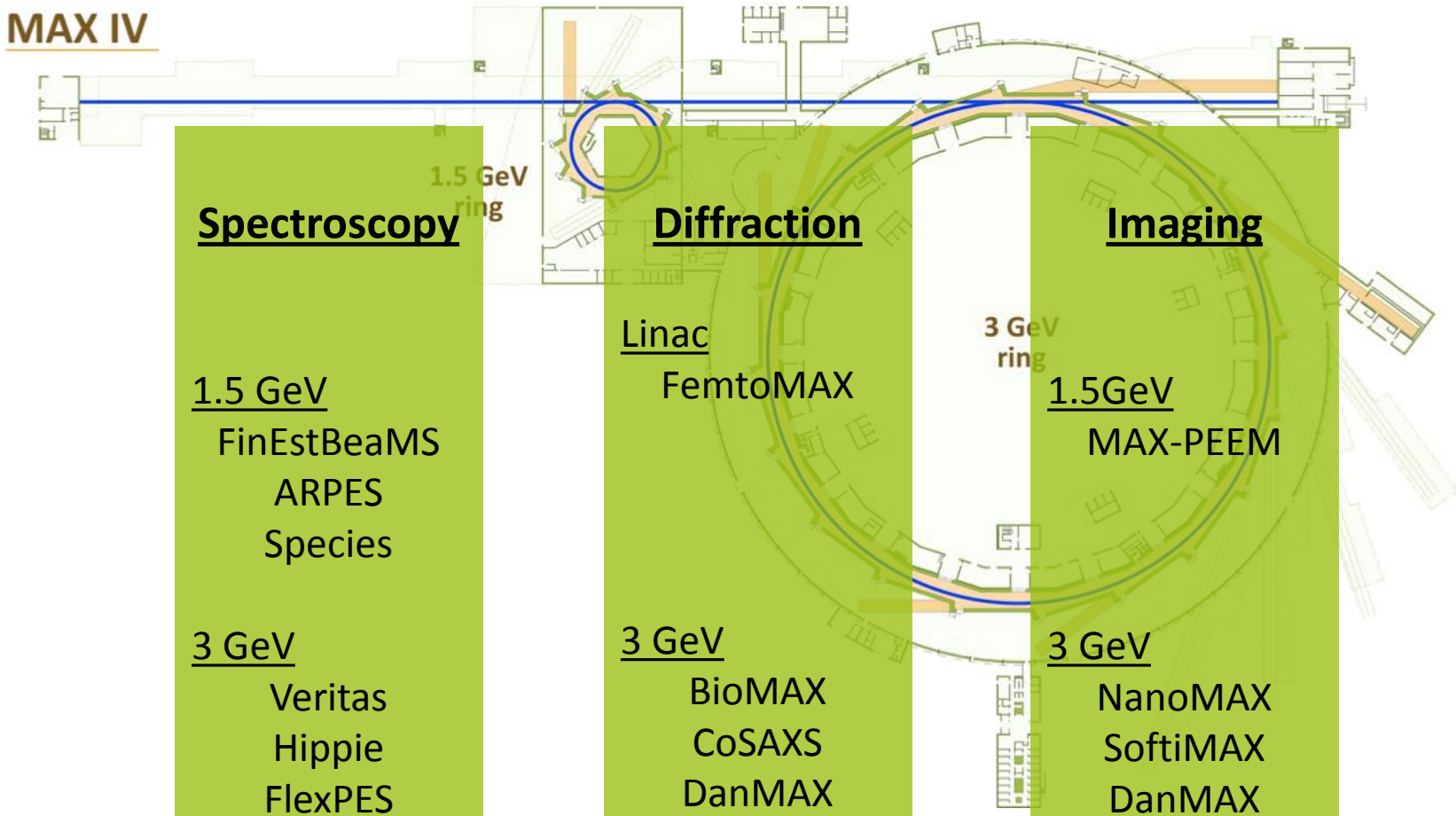


1. **FemtoMAX**
   fs dynamics in solid
2. **NanoMAX**
   Nano-imaging & - spectroscopy
3. **BALDER**
   Chemical spectroscopy: real-time & -conditions
4. **BioMAX**
   Protein crystallography
5. **Veritas**
   Electronic & magnetic excitations: solids
6. **Hippie**
   Photoemission: mBar gas pressure
7. **ARPES**
   Electronic structure: solids
8. **FinEstBeaMS**
   Electronic structure: gases, aerosols
9. **SPECIES**
   Electronic & magnetic excitations: surfaces
10. **MAX-PEEM**
    Microscopy: surfaces
11. **FlexPES**
    Electronic structure: surfaces & gases
12. **CoSAXS**
    Geometric structure & correlation: (bio) liquids
13. **Soft*i*MAX**
    Microscopy & method development
14. **DanMAX**
    Powder diffraction & imaging: materials science

BL Expansion Strategy

- 13 Funded BLs in opeation in 2018:
  1. FemtoMAX
  2. NanoMAX
  3. BALDER
  4. BioMAX
  5. Veritas
  6. Hippie
  7. ARPES
  8. FinEstBeaMS
  9. SPECIES
  10. Transfer_PEEM
  11. Transfer_XPS
  12. CoSAXS
  13. SoftiMAX
  - DanMAX
  - MicroMAX
  - MedMAX
  - ForMAX
  - DiffMAX
  - iMAX
- New application 2019 - 20XX.
  - Ramp-up to 20 BLs?!





Spectroscopy

1.5 GeV
- FinEstBeaMS
- ARPES
- Species

3 GeV
- Veritas
- Hippie
- FlexPES
- Balder

Diffraction

Linac
- FemtoMAX

3 GeV
- BioMAX
- CoSAXS
- DanMAX

MicroMAX?
ForMAX?

Imaging

1.5GeV
- MAX-PEEM

3 GeV
- NanoMAX
- SoftiMAX
- DanMAX

MedMAX?
ForMAX?

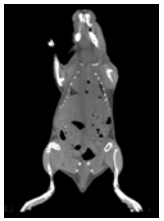
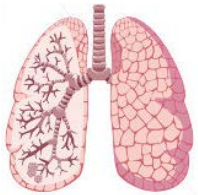
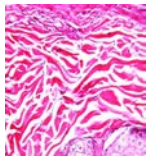
Challenge 1

HOW TO REACH OUT WITH WHAT WE CAN DO ?

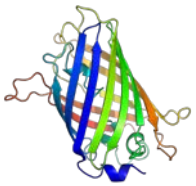
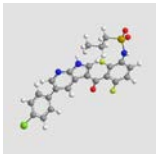
Biology at different length scales

MedMAX II | MedMAX I | NanoMAX SoftiMAX | coSAXS | BioMAX | MicroMAX | FemtoMAX Balder

10^{-6} m — 10^{-9} m — 10^{-10} m



Animals | Organs | Tissues | Cells | Micro-structures | Molecular complexes | Biomolecules | Atoms

Disease models | Histopathology | Cellbiology | Molecular Medicine/Chemical Biology

Challenge 2

HOW TO BECOME WORLD LEADING?

How to become world leading?

- The unique qualities of the beam will attract people who are interested in technical and methods development
- Cutting edge and easy to use methods will attract the leading science
- Already happening for bio-imaging:

Martin Bech, Lund University
Spoke person MedMAX

Rajmund Mokso, PSI
Project leader MedMAX

Chris Jacobsen APS
Consultant MAX IV

MAX IV

Challenge 3

HOW TO HANDLE THE DATA?

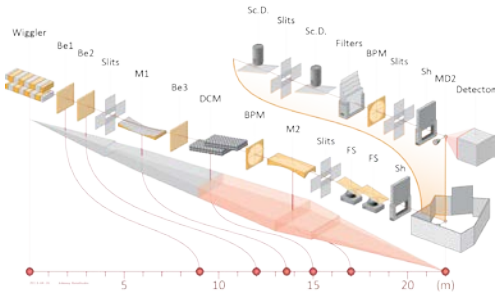
1M Features

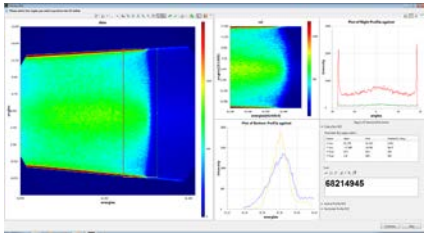
Not only brighter beams but also bigger and faster detectors

Number of Modules	2
Number of Ethernet links	4 x 10 Gbit
Frame rate	3 kHz (12 bit)
Dead time	3 μs
Expected compressed data rate to disk	600 - 800 MByte
Cooling	Water (Modules & Boards)
Dimensions	234 mm x 114 mm x 130 mm
Weight	~ 3.9 kg

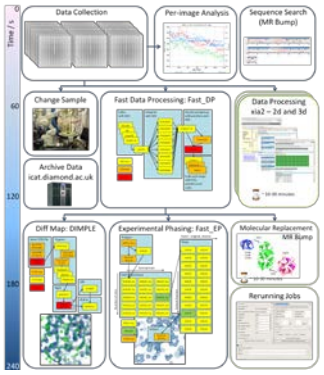
EIGER X 1M: 6.5 GB/s raw data rate, 180,000 images/minute

Keeping track of experiments and data: Data Catalogues



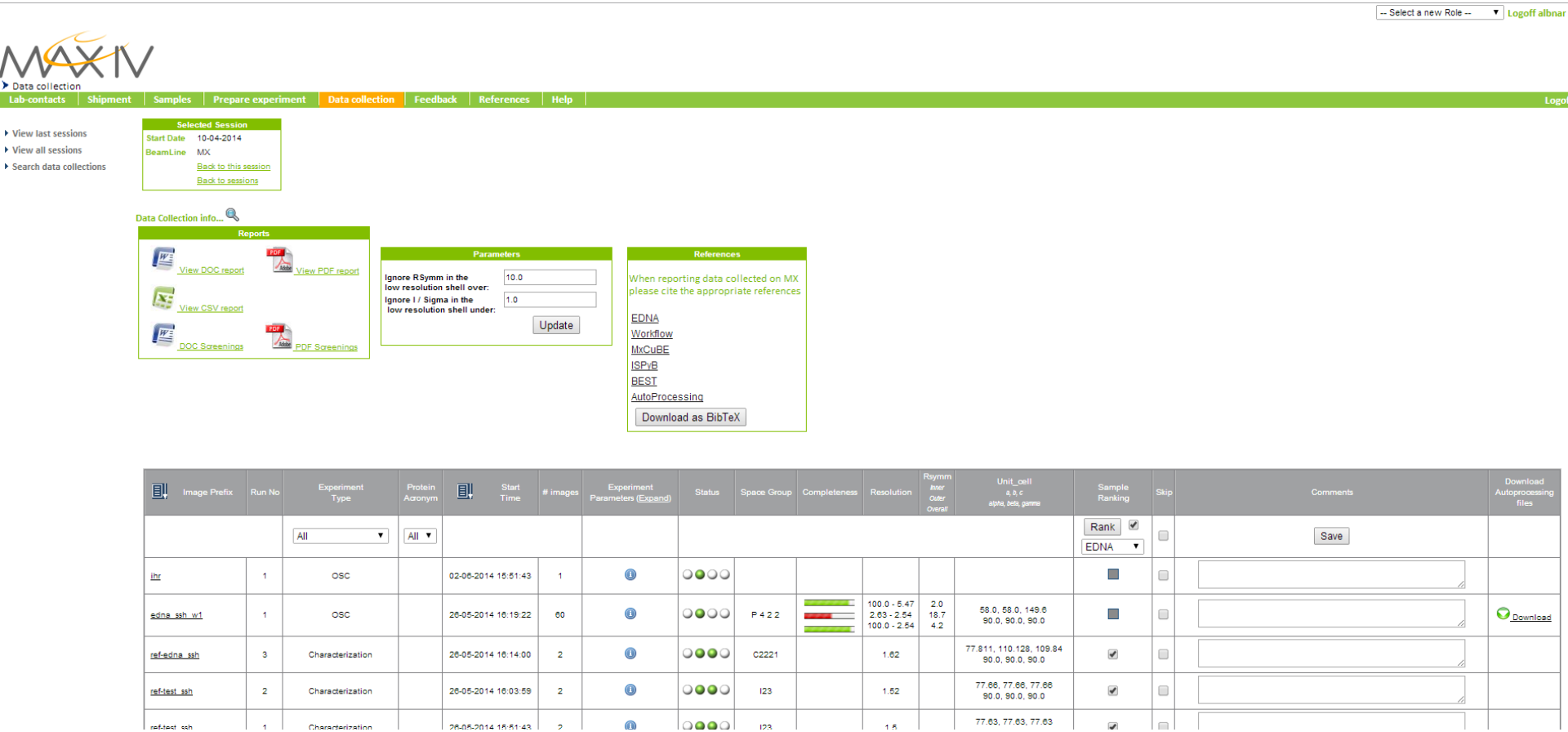


- Raw data
- Pre processed data
- Meta data
- Workflows
- (Analysis results)



(file system)
Databases
Web portals

Future: automation and remote access Laboratory Information Management System (LIMS)



Challenge 4

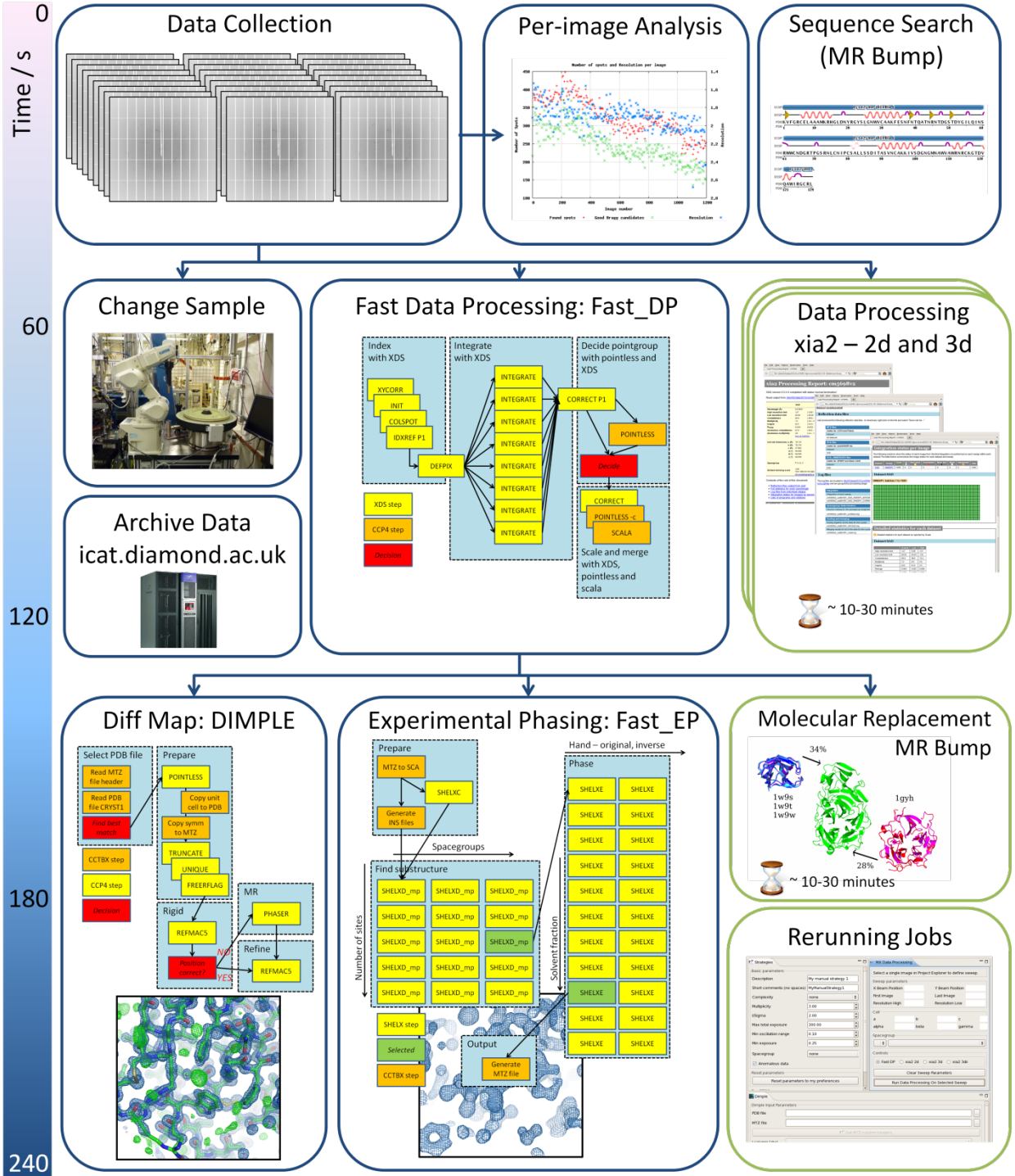
HOW TO ANALYSE THE DATA?

On-line Analysis

Data collection and experiment monitoring

Automated data reduction

Automated structure solution



Courtesy of Alun Ashton, Diamond Light Source

Provide analysis as a Service – on line and remotely

Set up national/international portals that provides storage, software and compute

- Provide pre installed analysis tools
  - Computing + high performance file system
  - Remote access
- Setup has to be done by experts
  - Application experts
  - Scientists

Needs to be resolved:

- Pan-DaaS – agreeing on meta data to be stored including format
  - H2020 application failed – work continues
  - Most European Photon and Neutron facilities
- Federated Identity Management
  - Umbrella
  - Edugain, Eduroam

Challenge 5

HOW TO INVOLVE INDUSTRY?

Industrial use of MAX IV - the emerging picture

New industrial users

Industry/Academic collaborations
Industry centers @ universities
Industry portals @ universities

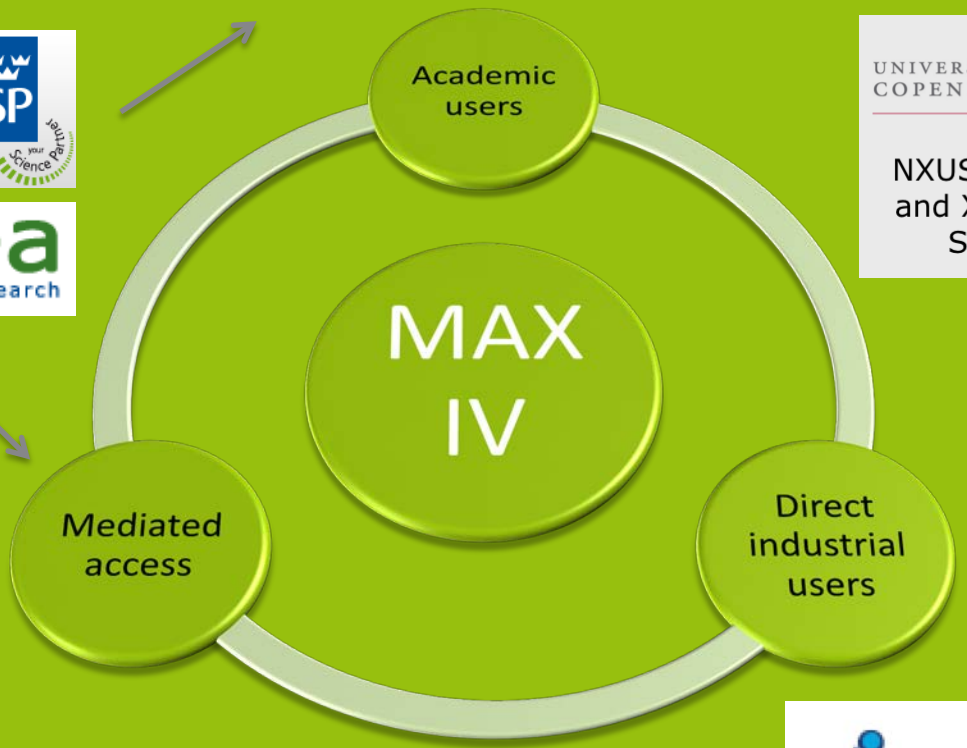
Universities

Danmarks Tekniske Universitet DTU
Imaging Industry Portal

UNIVERSITY OF COPENHAGEN
NXUS: Neutron and X-ray User Support

RI. SE
INNVENTIA
SP Science Partner
swerea swedish research

Institutes



Advanced users

ADROIT SCIENCE
:CR:
SARomics
Imaging Resource

Mediator companies

novo nordisk
AstraZeneca
HALDOR TOPSOE
MAX IV

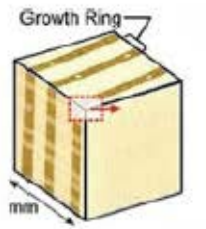
Partnering with Institutes

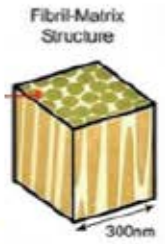
- First concrete examples of working with institutes

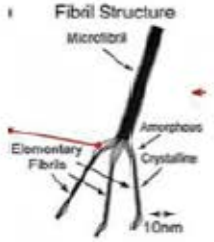
Wood at all length scales

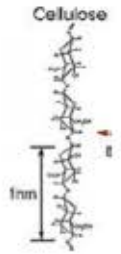
DanMAX SoftiMAX NanoMAX coSAXS Balder

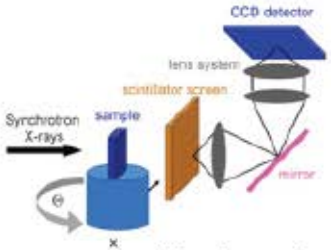
10^{-3} m 10^{-6} m 10^{-10} m



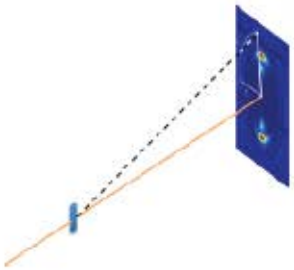




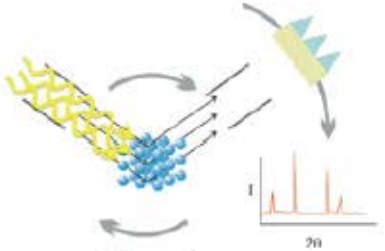




Tomographic imaging



Small angle x-ray scattering
SAXS



Diffraction

MAX IV

ForMAX

Knut och Alice Wallenbergs Stiftelse 25% ✓

Specific discussions ongoing:

Tetra Pak

KTH VETENSKAP OCH KONST

BILLERUDKORSNÄS

CHALMERS

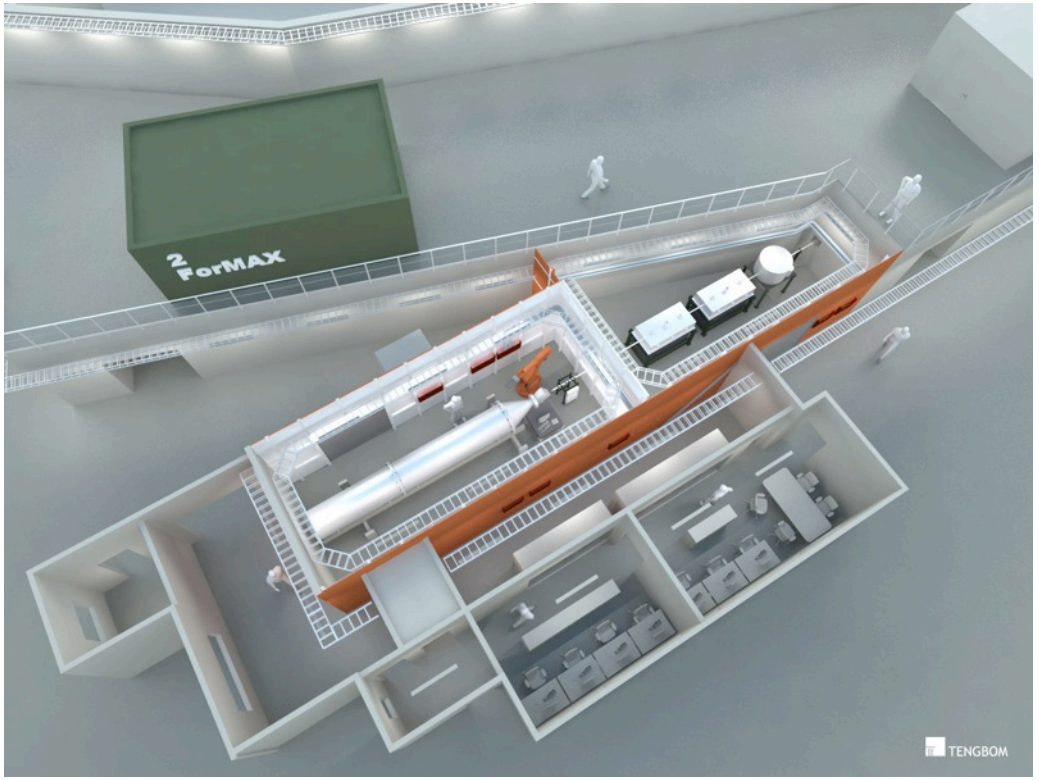
WWSC WALLENBERG WOOD SCIENCE CENTER

INNVENTIA

Cost of ownership (salaries + investment)
4 year building + 10 years operation:

- ForMAX beamline: 202 MSEK
- Education & training: 2 MSEK
- Additional endstation 20 MSEK

SUMM ≈220 MDKK



MAX IV

1st ForMAX Partners

CHALMERS

CHALMERS
President & CEO

28 May 2015

Letter of Intent

Chalmers University of Technology intends to take an active role in the build up of the MAX IV facility, the development of the long-term strategy for research, education and innovation as well as the use of the facility and support laboratories. The aim is to both contribute to realising MAX IV as a world leading facility for synchrotron x-ray based science but also to build up competence at Chalmers to take advantage of the unique possibilities that will be offered at MAX IV.

Until today we have contributed to the development of the facility by contributing to the science cases of several of the instruments currently under construction or in the planning stage as well as co-founded construction of the first beam lines together with the Knut and Alice Wallenberg Foundation and other Swedish universities. With this letter of intent we wish to express our ambition to take a further step in our engagement in the long term development of the MAX IV facility by a focused collaborative program around development of new instrumentation and experimental capabilities, education of the next generation of scientists, and innovation. Our ambition is to contribute both to hardware for instrumentation and to manpower for design, construction, commissioning and running of instruments at MAX IV.

Chalmers interest in instrumentation at the MAX IV facility covers a broad range of techniques including small angle scattering, spectroscopy, diffraction, imaging and techniques utilising the unique coherence. With the new program we aim to contribute both to the early commissioning of instruments already now in the construction stage but also to the realisation of such instrumentation currently not yet fully funded. For the latter we have a strong interest in seeing the realisation of a diffraction beamline with imaging capabilities as well as SAXS/WAXS beamline directed towards studies of complex soft materials such as what has been outlined in the early plans for the ForMAX beamline.

The initiative described above is a long-term effort to build up competence in advanced x-ray techniques and to create a platform for our researchers. We foresee a mutual exchange of staff by the secondment of Chalmers scientists to MAX IV and MAX IV scientists having adjunct positions as Chalmers. This program will be closely be coupled to our Areas of Advance in Materials Science, Nanoscience and Nanotechnology, Energy, Life Science Engineering, Transport, ICT, and Built Environment. The Areas of Advance Chalmers integrate research, education and innovation to tackle global challenges in close collaboration with partners in academia, research institutes, industry and society. In particular we see a large potential to act as a portal and competence resource for our strategic industrial partners to use MAX IV. We also intend to create synergies between MAX IV and our own infrastructures, such as the Chalmers Materials Analysis Laboratory, the Nanofabrication laboratory (part of the national infrastructure MyFAB) and C3SE (part of the national infrastructure SNIC), as well as with our educational programs on bachelor, masters and PhD levels.

Karin Markides
President & CEO

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Chalmers går in aktivt i MAX IV och ESS

Chalmers tar nu en aktiv roll i den vetenskapliga uppbyggnaden av MAX IV-laboratoriet och ESS i Lund. Chalmers satsar 50 miljoner kronor över sex år, som en investering i och drift av nya strålrör på MAX IV och utbildning av nästa generations materialforskare.

Satsningarna i Lund på röntgenkällan MAX IV och den sameuropeiska neutronkällan European Spallation Source (ESS) är den största svenska investeringen i forskningsinfrastruktur någonsin. De två anläggningarna kommer att bli världsledande inom respektive område och kan göra Sverige till ett centrum för design av nya material utifrån ny förståelse om deras mikroskopiska uppbyggnad.

Chalmers inleder nu ett formellt samarbete med ESS och MAX IV, som innebär permanent närvaro av chalmersforskare i Lund och ett starkt, formaliserat engagemang i den vetenskapliga utvecklingen av anläggningarna. Konkret handlar det just nu om utveckling och drift av nya strålrör på MAX IV, men också utbildning av nästa generations forskare i avancerade metoder för materialvetenskap och nanoteknologi.

– Vår satsning förstärker och breddar Chalmers och Sveriges kompetens inom avancerad forskning med hjälp av synkrotronljus och neutroner. Genom våra styrkeområden skapar vi en direkt länk mellan vår avancerade forskning, utbildning och innovation och anläggningarna i Lund, säger Lars Börjesson, vicerektor för Chalmers styrkeområden, som för övrigt är initiativtagare till ESS i Skandinavien.

Chalmers är idag ledande i Sverige inom forskning, utbildning och innovation inom materialvetenskap, nanoteknologi, energi, transport och produktion. I och med detta initiativ blir Chalmers en stark akademisk partner till MAX IV, som invigs nästa sommar, och ESS, som beräknas vara färdigbyggd 2019.

Samarbetet är ett viktigt steg i utvecklingen av hållbar energiteknik, supersnabb elektronik, framtidens läkemedel och lätta, starka material för marktransport och flyg, men det kommer också att stödja genombrott inom bland annat miljövetenskap och klimatforskning.

MAX IV

MAX IV Inauguration

Tuesday, June 21st 2016, noon (local time)

Vetenskapsrådet

Lunds Universitet

VINNOVA

Region Skåne

MAX IV

Inauguration – Midsummer 2016

June 18 &19

General public

- Open house
- BL's & accelerator, site, ...

June 20

All users, scientists

- Key-note
- Quick reports: accelerator, building, workshop, IT & controls, BL,…… Open BLs
- Dinner

June 21

Close collaborators, Funders, VIP, Staff, Board, committees, …

- Inauguration ceremony

Praise to the MAX IV Staff !!!