MAX IV – How to get more for less

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EuCARD-2 meeting, Lund, April 2014

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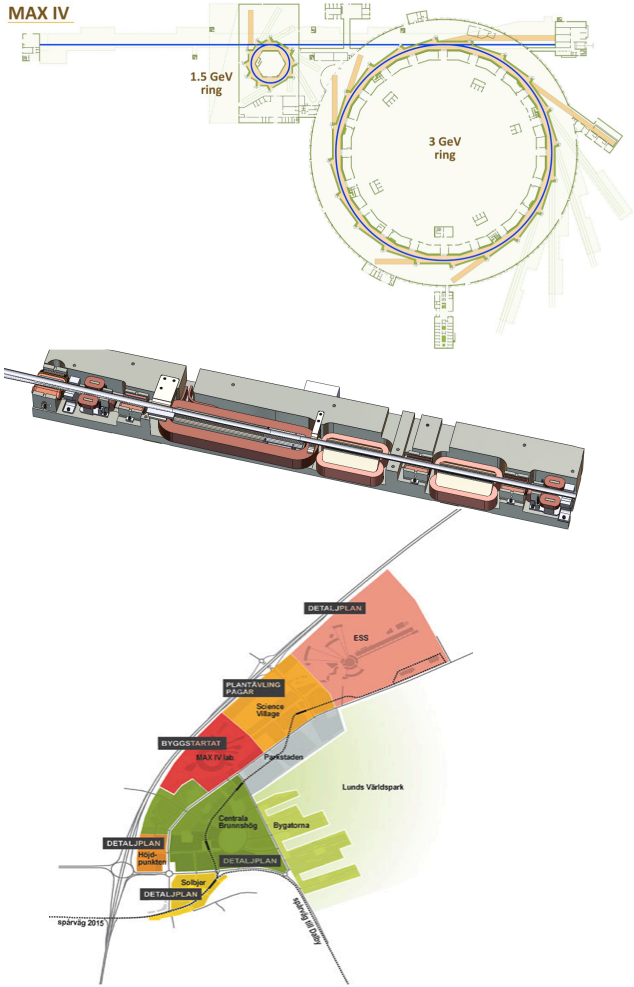


kraftringen

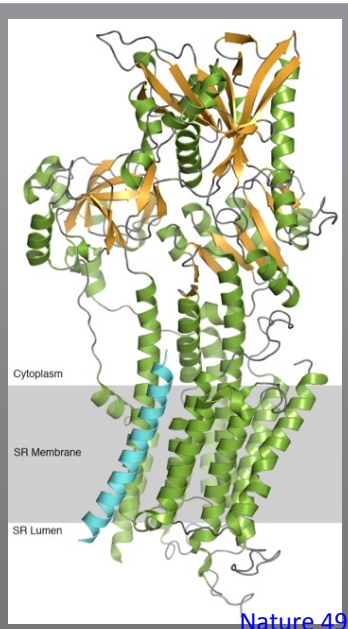
MAX IV

Design philosophy

- Sustainability
  - More than heat recycling!
  - Integrated concept
    - Design
      - Accelerator
      - Experiments
      - Data management system
      - …
    - Building
    - Operating
    - Using (transport, user housing, …)

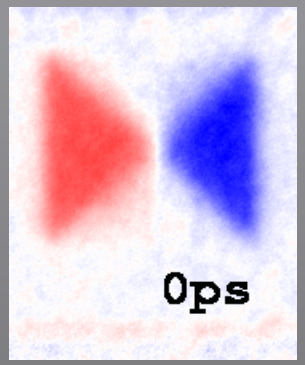
MAX IV – An X-Ray lamp!

Small – Atoms



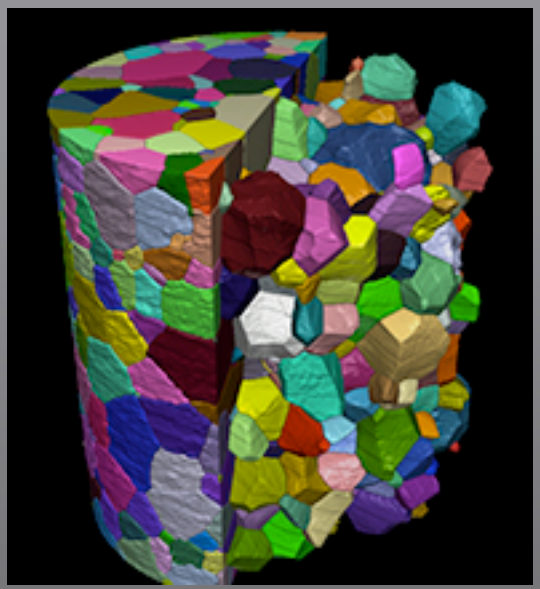
Nature 495, 265–269 (2013)

Fast – Switching



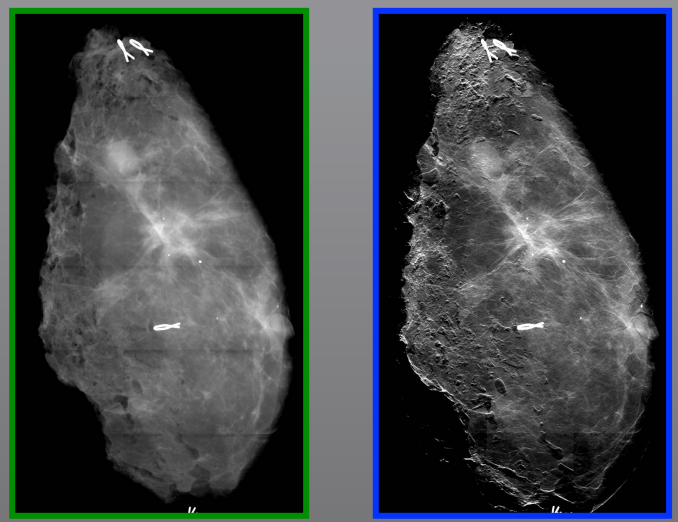
(PRL) 94, p. 217204

Complex – Materials



H. Friis Poulsen et al.
www.imaging.dtu.dk

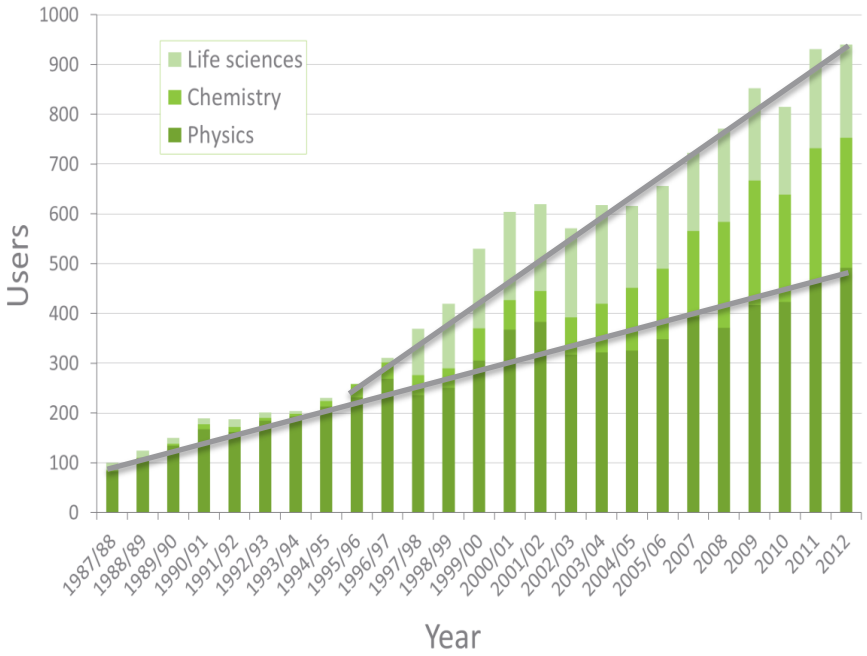
Relevant – Medicine

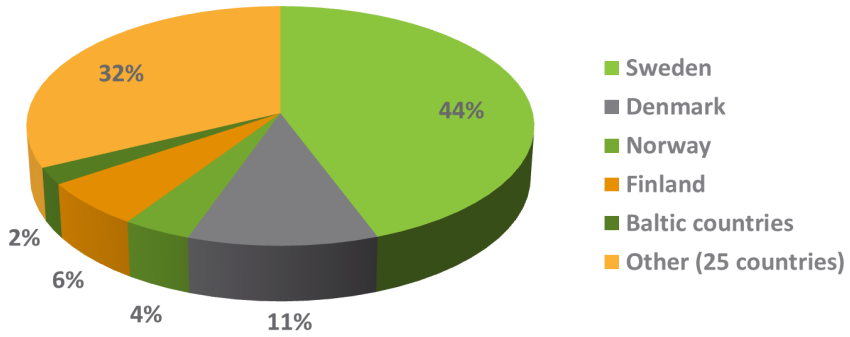


Invest. Rad. 2011;46:801-806

A National Laboratory

Academic



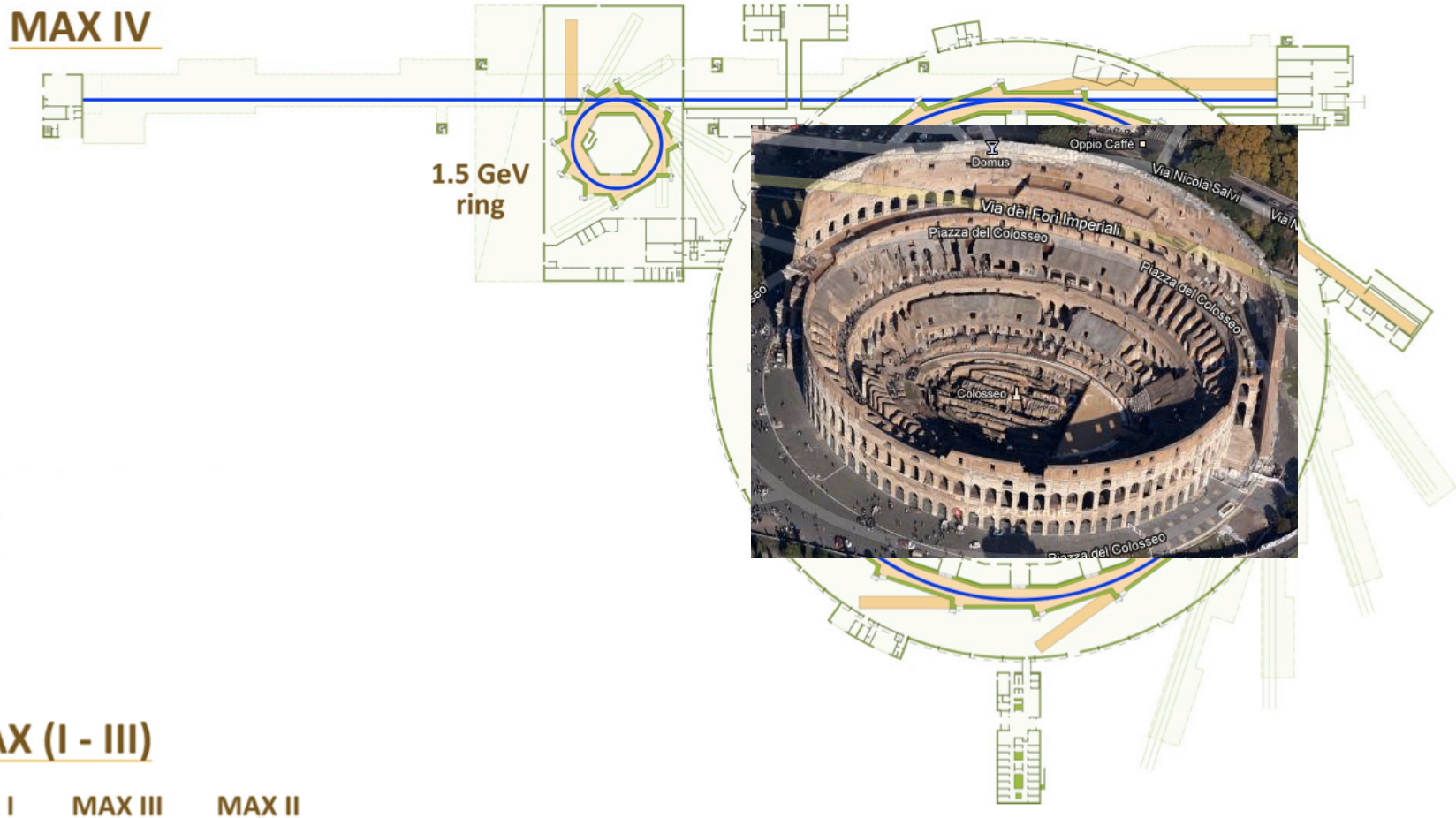


Commercial

~ 5% of total available beamtime

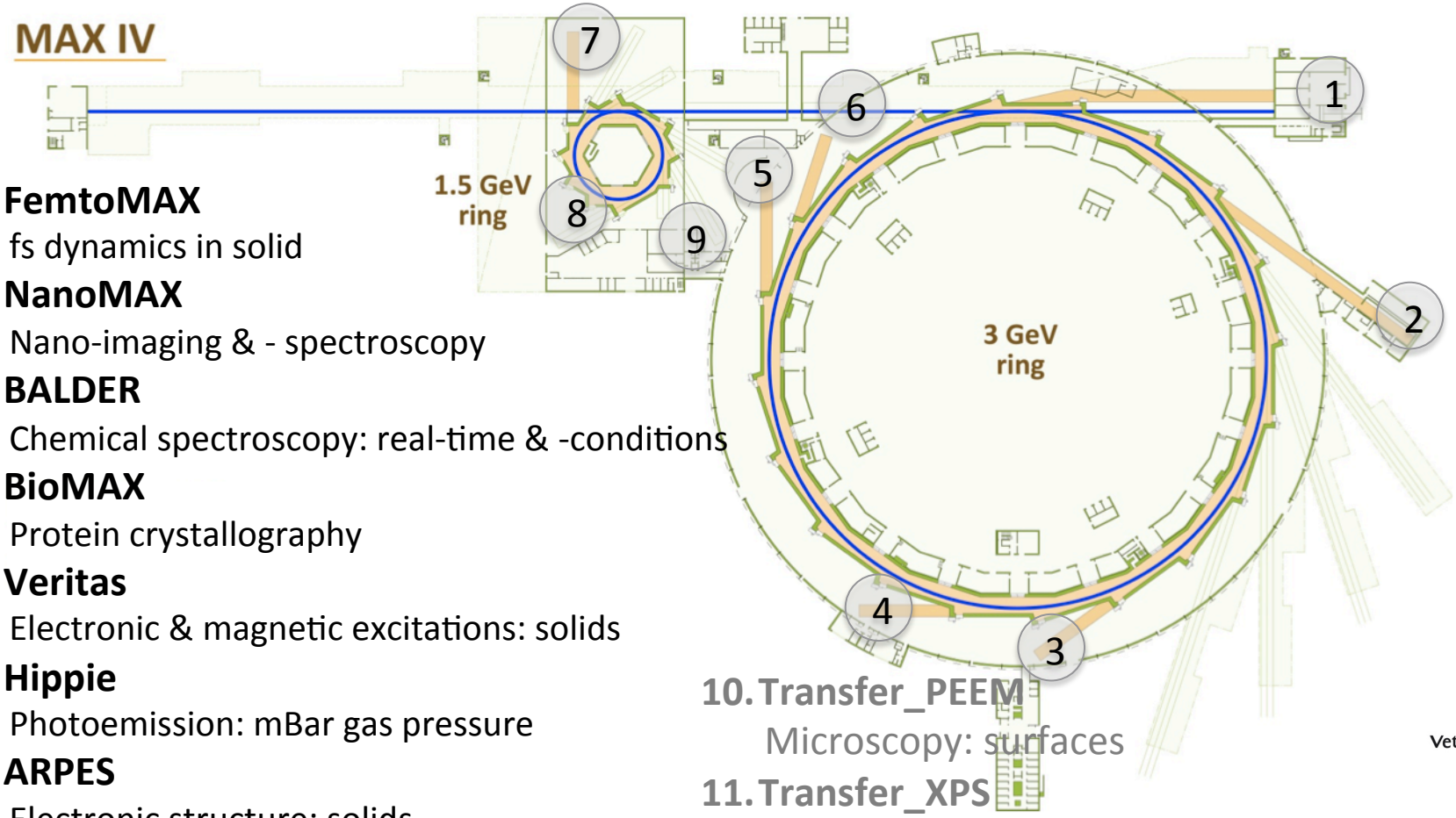
Imaging Resource
BONE SUPPORT
AkzoNobel
Tomorrow's Answers Today
HALDOR TOPSØE
SARomics
Colloidal Resource
novo nordisk®
AstraZeneca
Tetra Pak
PROTECTS WHAT'S GOOD™
L E O
Höganäs
sasol
novaled
MAX IV

The MAX IV Project



Linac	3 GeV
Length (m)	300
Bunch charge	100 pC @ 10 Hz
Pulse (FWHM)	30 fs – 5 ps
Full energy injector	1.5 / 3 GeV

Rings	3 GeV	1.5 GeV
Circumference (m)	528	96
Straight sections	20	12
Emittance (nm rad)	< 0.3	6
Beam (σ in μm) [H x V]	50 x 6	184 x 13



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. **Transfer_PEEM**
    Microscopy: surfaces
11. **Transfer_XPS**
    Electronic structure: surfaces & gases
12. **CoSAX**
    Geometric structure & correlation: (bio) liquids
13. **Soft*i*MAX**
    Microscopy & method development

Vetenskapsrådet

What is MAX IV Laboratory?

Brunnshög/Lund NE – Brief overview

- *" Worlds top leading research facilities, European model for sustainable cities & a meeting place for science, culture and recreation"*
- 3 - 4 000 homes and 40 000 jobs/workplaces in an area of 250 hectares by ~2030-2035
- Sustainability vision: 150% locally generated renewable energy, long term.
  Transport: 1/3 public transport, 1/3 by foot/bike & 1/3 by car

- Next generation synchrotron radiation facility in Sweden
- ~50 GWh power consumption, ~45 GWh waste heat
- Inauguration: 2016

- *" Worlds top leading research facility in terms of availability, sustainability & innovation"*
- ~250 GWh power consumption
- ~200 GWh waste heat
- Start of construction 2014, fully up & running 2025

Solbjer

- 9 blocks, 2-6 floor houses
  - Office: 42 000 sqm
  - Premises: 4000 sqm
  - Residential: 700 units, 70 000 sqm
- Start of construction: 2015

- *"Worlds best research & innovation environment and a showcase for Swedish sustainability planning"*
- Visitor center, Science center, Short-term housing for researchers, Branches of universities, Offices for research facilities and their partners
- Start of construction: 2015

Other blocks to be built

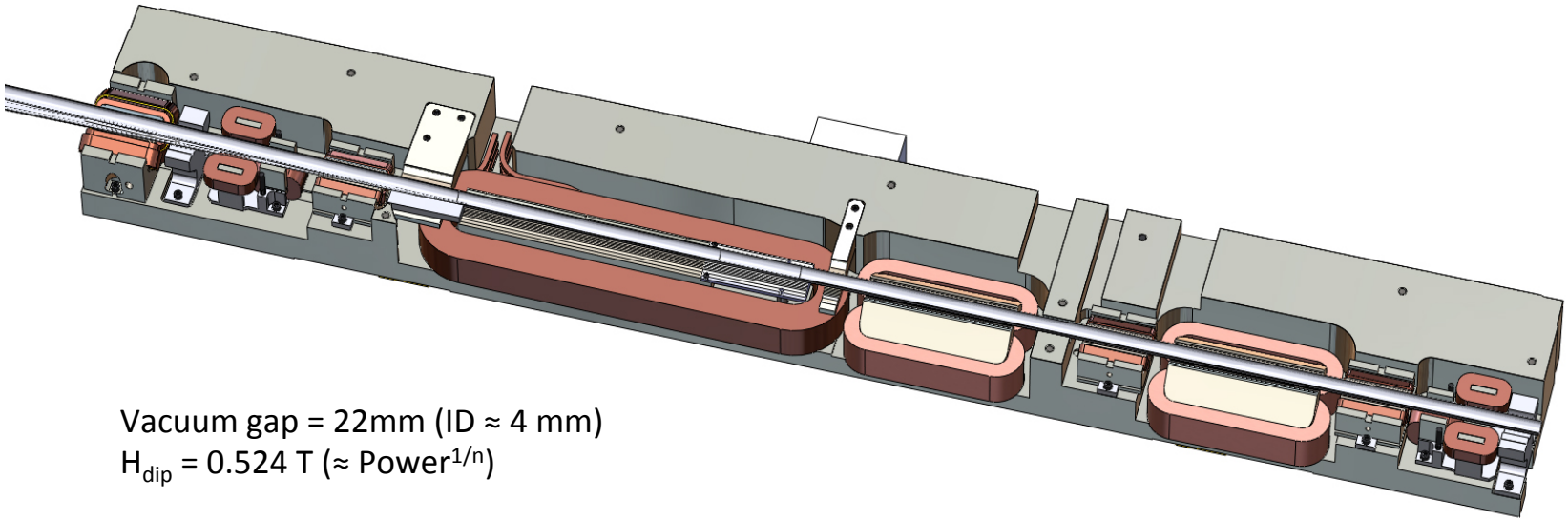

1.) REDUCE !
2.) Reuse
3.) Recycle

1.) REDUCE!

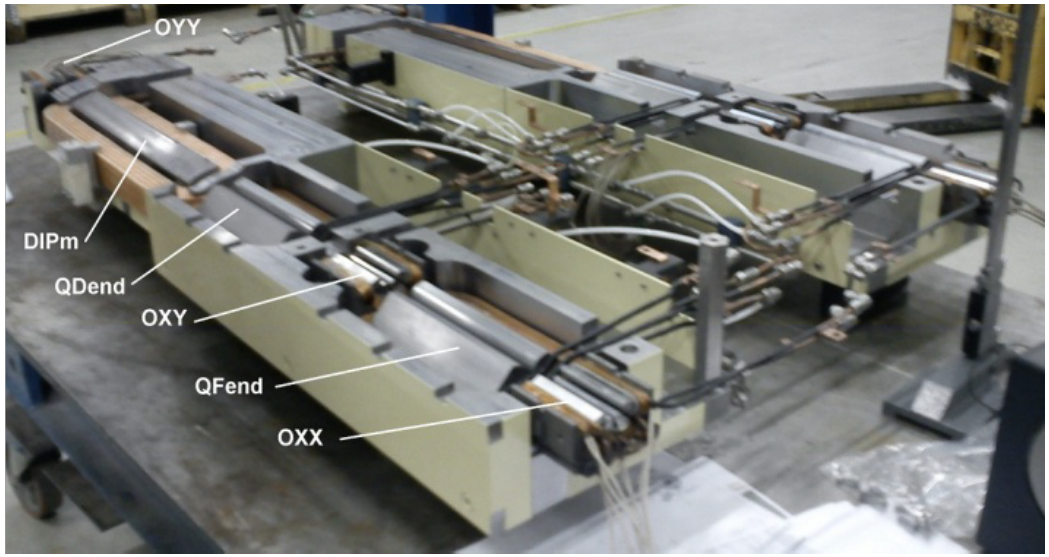
- MBA: Many weak dipole magnets
  - (7 * 20) magnets, 0.52 T each
  - Small vacuum gap
  - No damping wigglers!
  - Avoid SC technology!
- RF: 100 MHz Tetrodes
  - Efficiency ≈ 70%
  - Low RF voltage w/ high coupling cavities - transmission lines
    ≈ 60% of electric power to transmitters -> synchrotron radiation

- Total electric power (3 GeV ring @ 500 mA)
  - Magnets: 500kW
  - RF: 500 – 1000 kW (depending on IDs)
  - Power consumption in W/m = 1/10 of MAX II ring!
- LINAC
  - 1.4 MW @ 100 Hz (2, 10 Hz options)

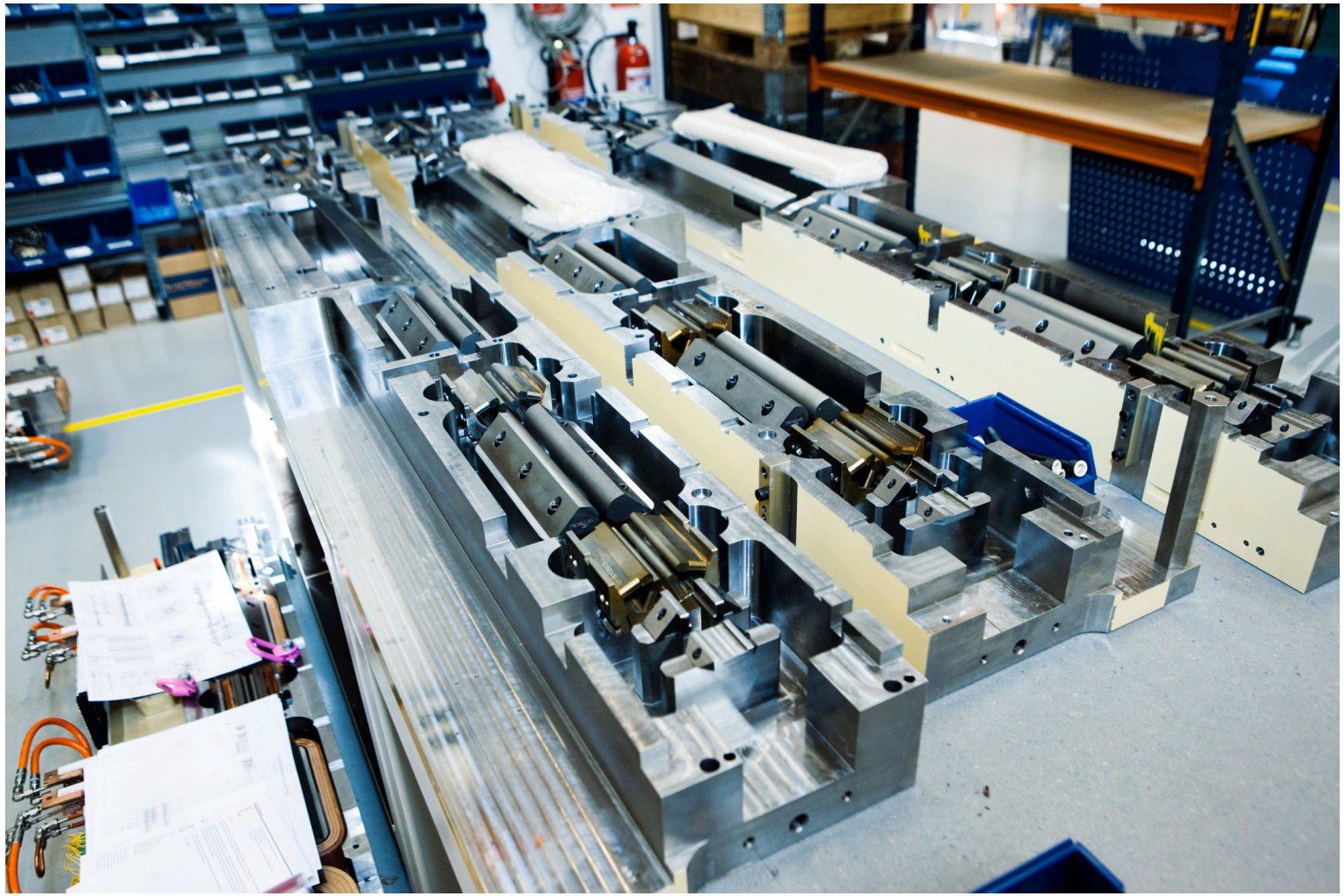
1.) REDUCE! Multi-bend Achromat



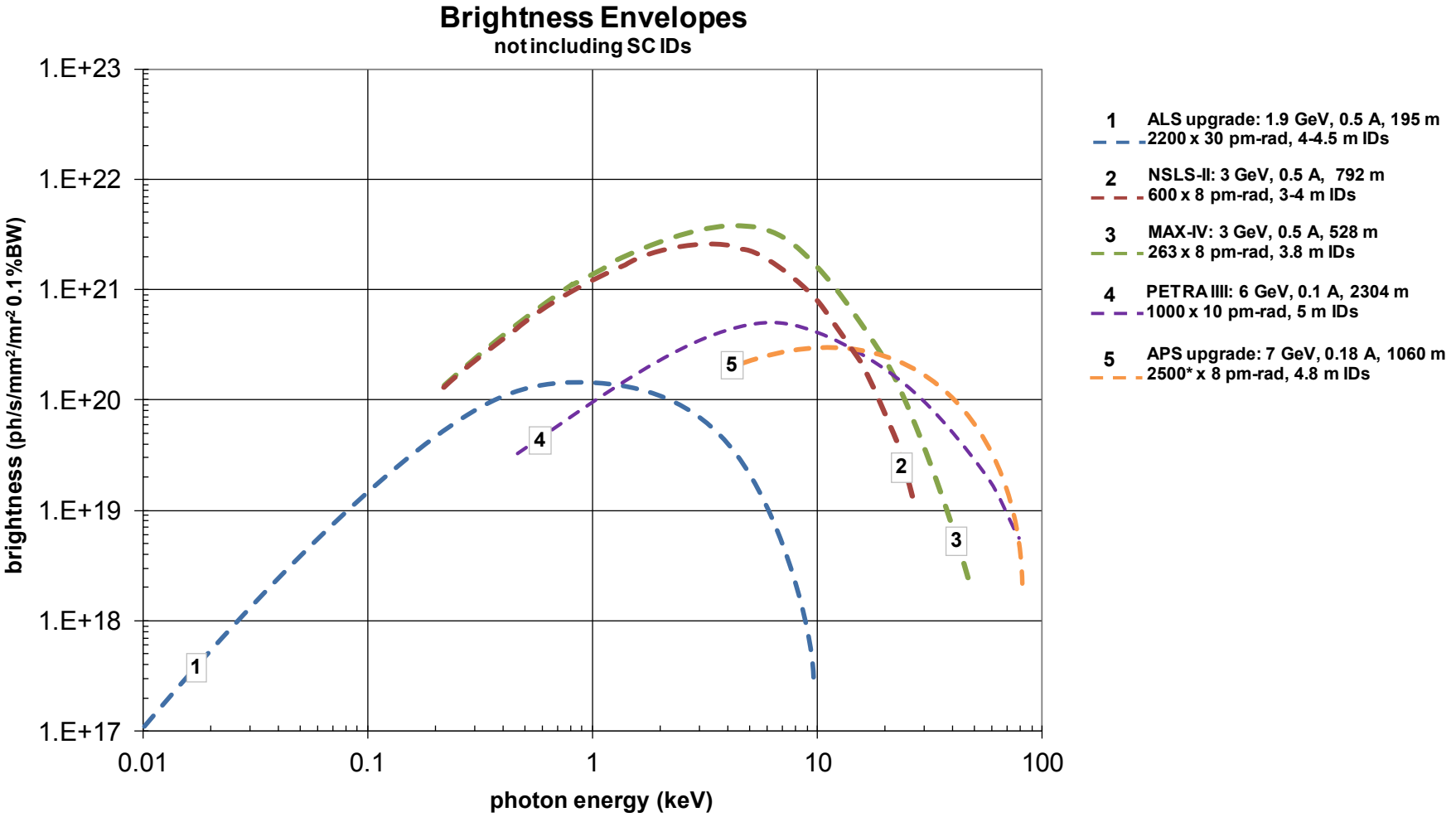
Vacuum gap = 22mm (ID ≈ 4 mm)
H_{dip} = 0.524 T (≈ Power$^{1/n}$)



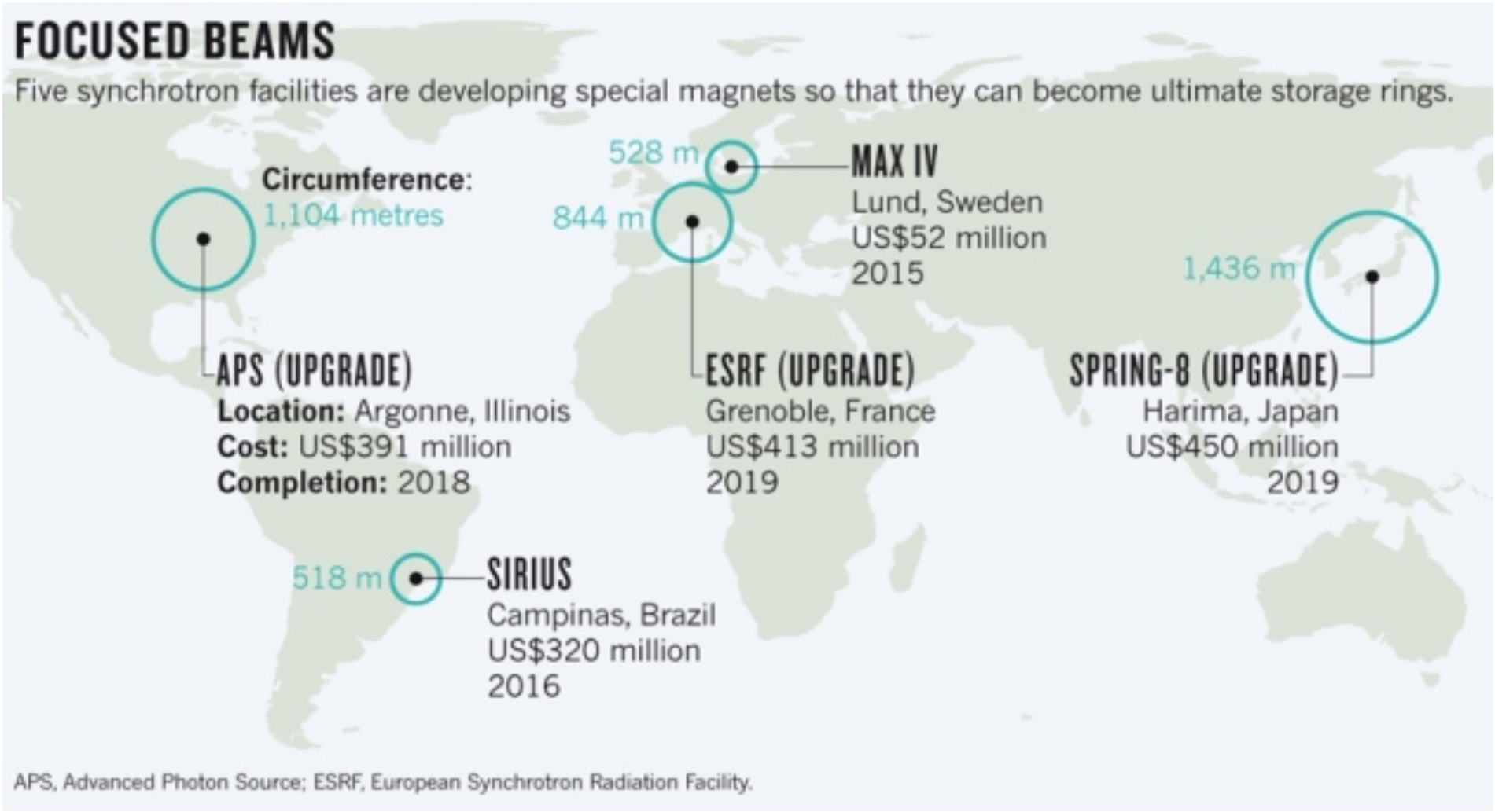
MBA Magnet



MAX IV & other DLSR's



SCIENTIFIC AMERICAN™

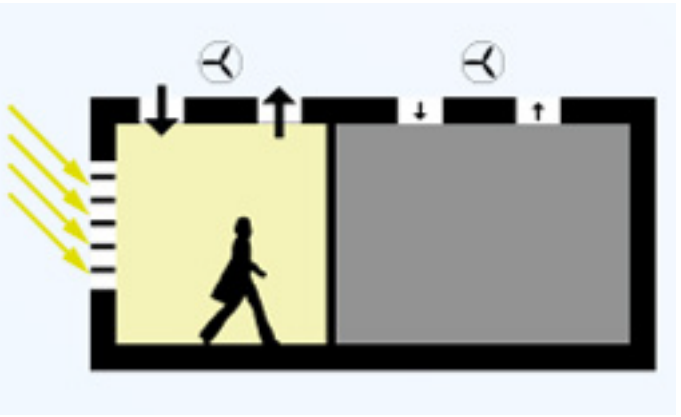


By Eugenie Samuel Reich and Nature magazine | Tuesday, September 10, 2013

MAX IV

1.) Reduce! Building

- Daylight / LED lightning
- Ventilation on demand
- Passive T-stabilization for Linac tunnel
- Green roof
- Building materials
  - Carpet from recycled fish nets



SWEDEN GREEN BUILDING COUNCIL

BREEAM SE

GREENBUILDING

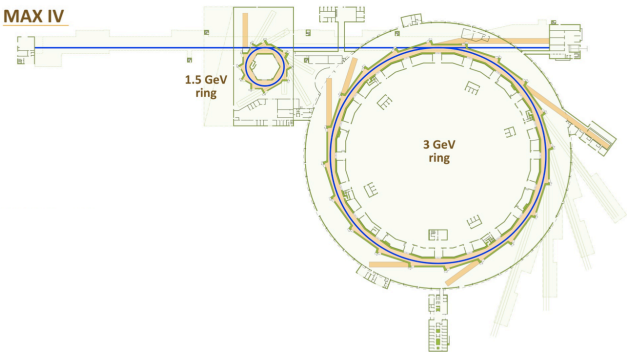
MILJÖ BYGGNAD

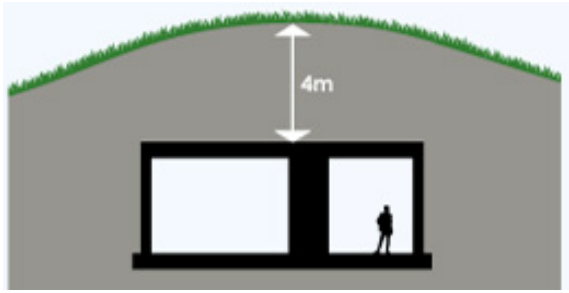
MAX IV

2.) Reuse

- LINAC
  - Injector
  - SPF / FEL

- Excavation
  - Damping
  - Radiation safety



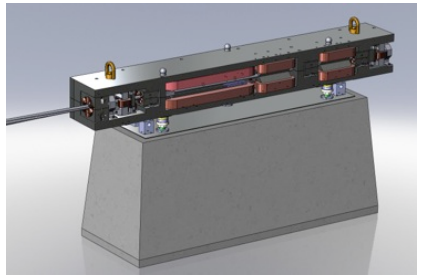


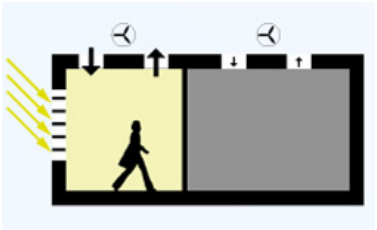
3.) Recycle

- 15 year contract (signed Sep 2012)
- Local district heating < 1800 houses in Lund, Lomma, Eslöv
- Ramping up with MAX IV operation
  - 2015 ≈ 5,6 GWh/year
  - 2018 ≈ 31,5 GWh/year.
- Cooling systems
  - technical equipment
    - 25°C
    - **55°C (heat pumps boost to 75°C)**
  - Buildings
    - 7-12°C degrees

MAX IV – Getting more for less!

- **Reducing is more important than recycling**
- Small magnet gaps provide higher (multipole) fields @ lower power.
  BUT more difficult vacuum.
- Integrated view
  - Magnets & vacuum & RF
  - Accelerator & building
  - MAX IV & ESS & SVS
- **Lower power bill ->**
  - **Good conscience & political good will**
  - **Lower operations cost**
  - **More money for science**
  - ☺






MAX IV Inauguration
Tuesday, June 21st 2016, noon (CEST 13:08:55)