



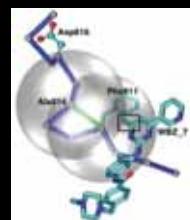


Sometimes you wonder  
why 100 GB and not 5 TB?



<http://www.gizmag.com/go/4547/>

Sometimes you wonder,  
why not just a pill?



<http://www.dagensmedicin.se/vetenskap/kvinnohalsa/cellprov-avslojade-aggstockscancer/>

<http://www.sciencedaily.com/releases/2007/05/070501115127.htm>

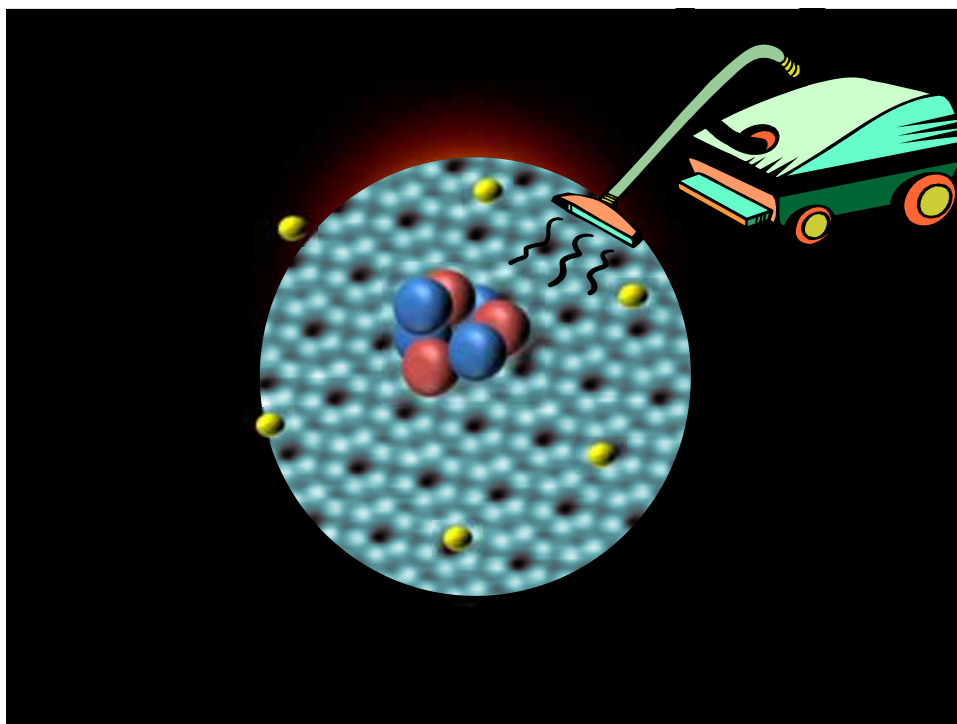
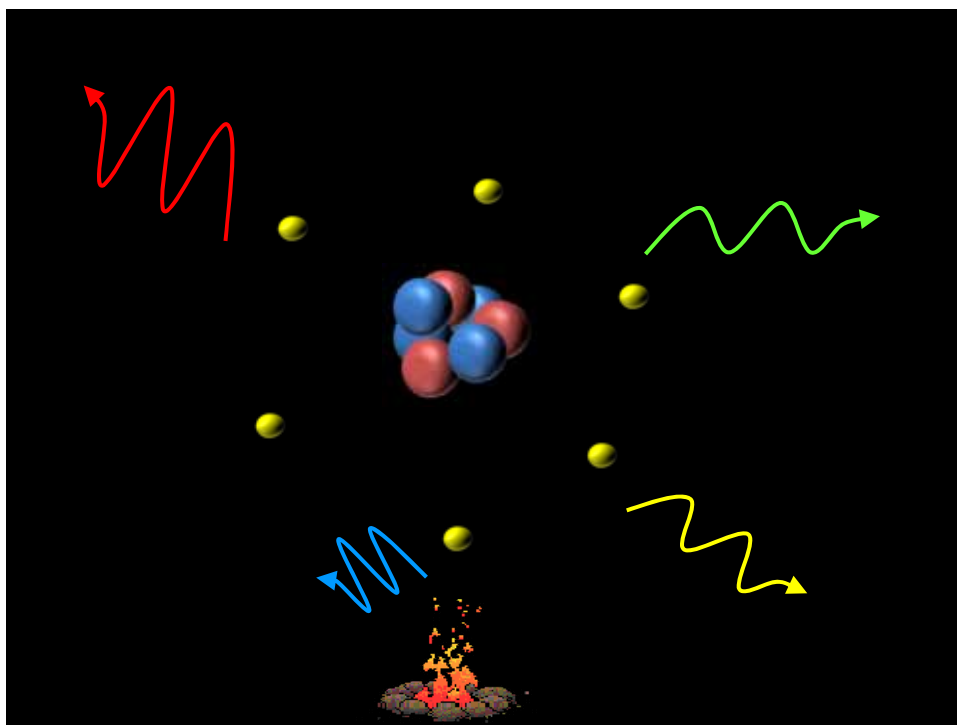
## Investigate and see!

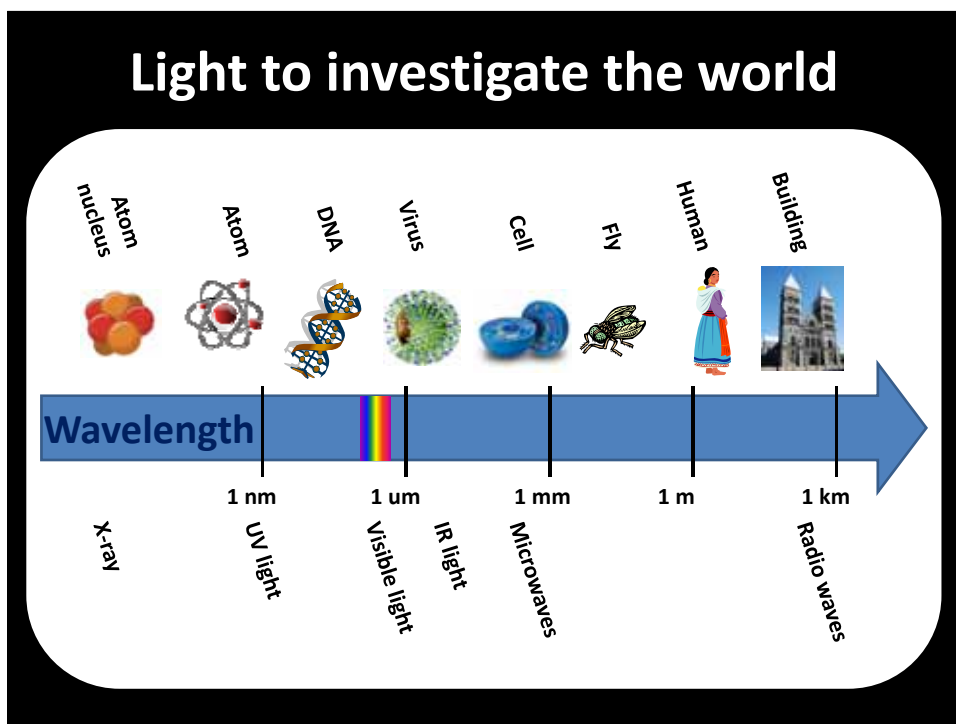
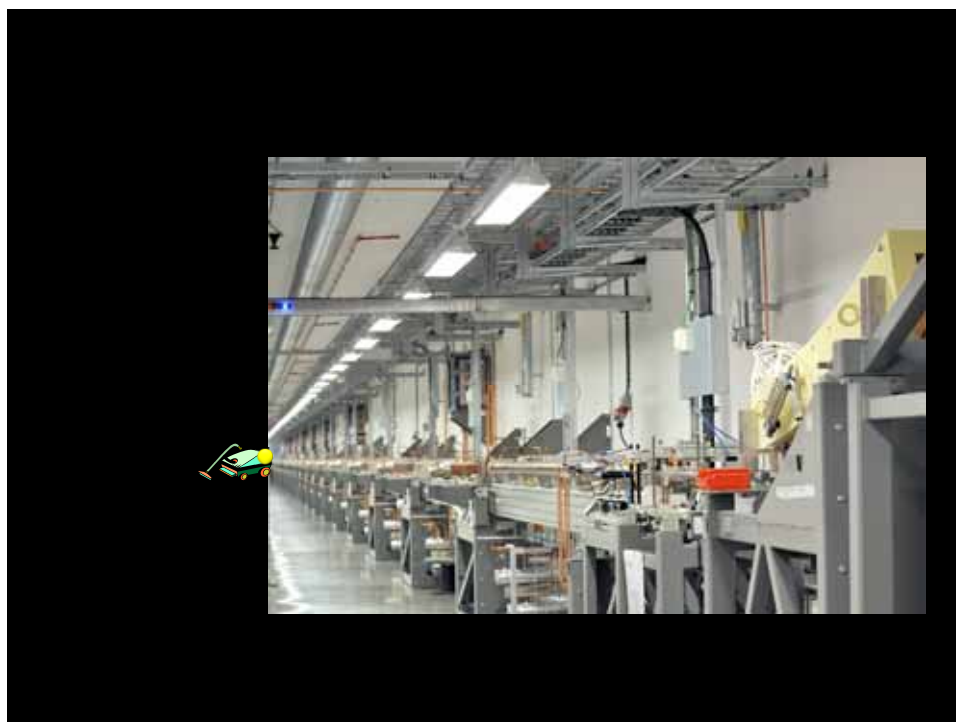


<http://gracespace.org.uk/wp-content/uploads/2010/05/nicole-katano-explore-child-in-the-rain.jpg>  
<http://www.petershamaog.org.au/index.php?id=53>

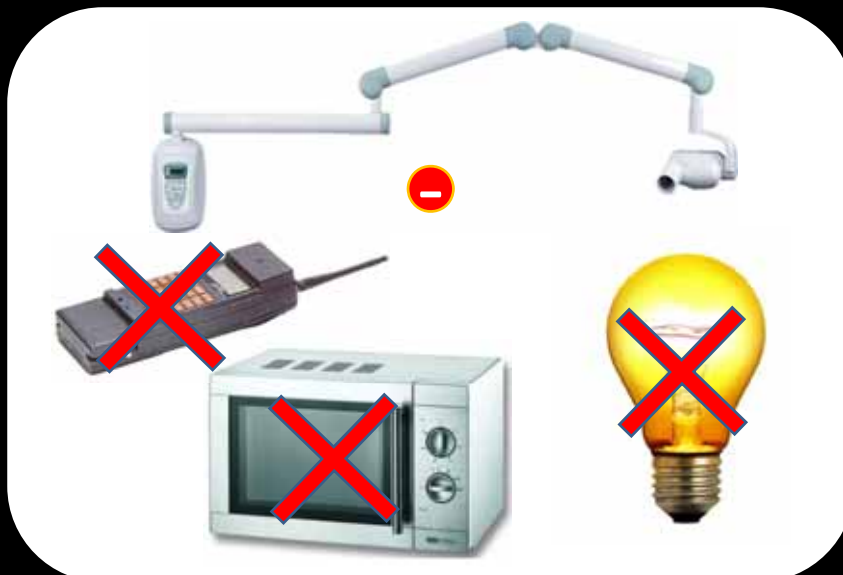


<http://idowns.net>

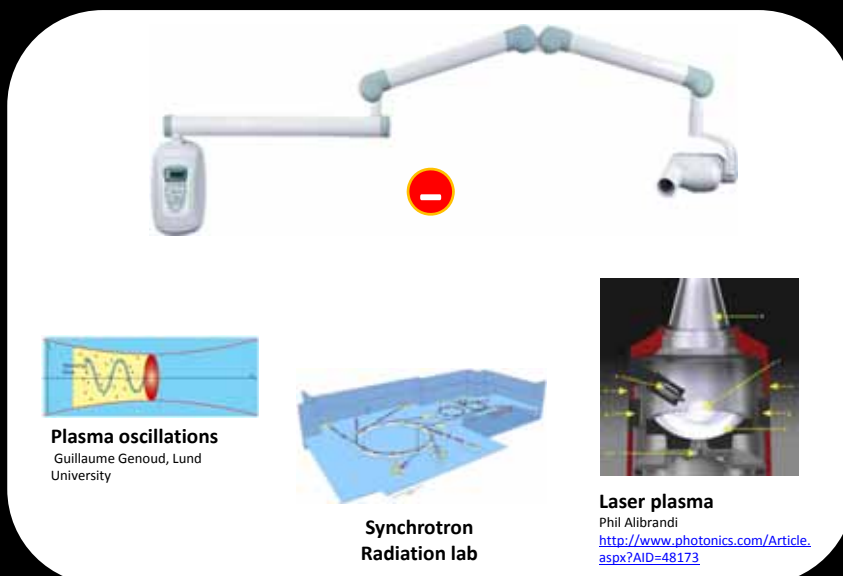




## Light sources around us

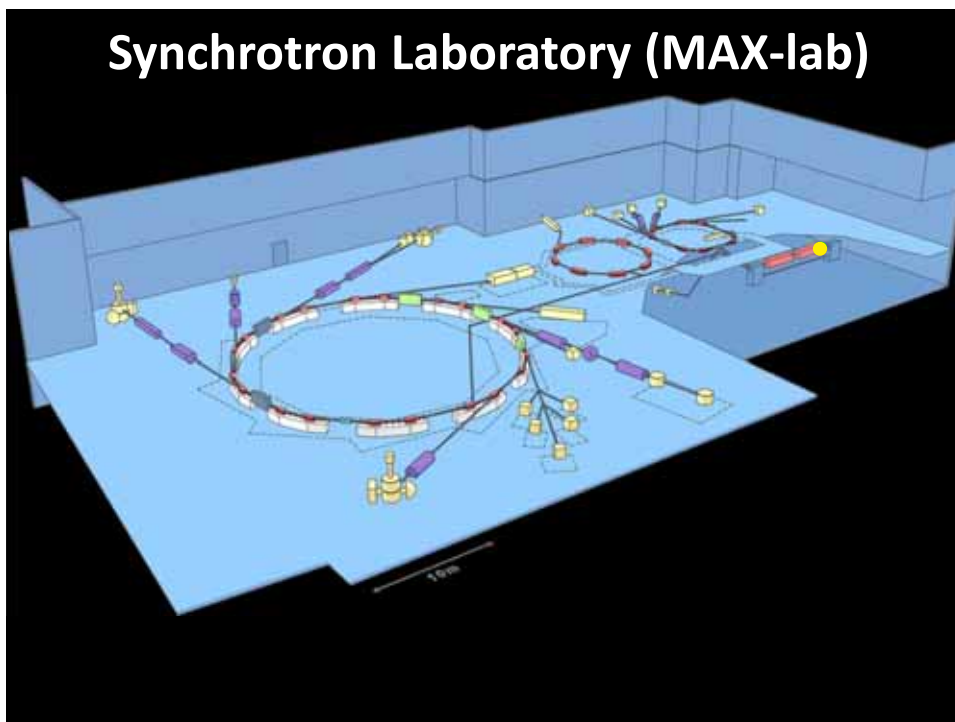


## Light sources around us





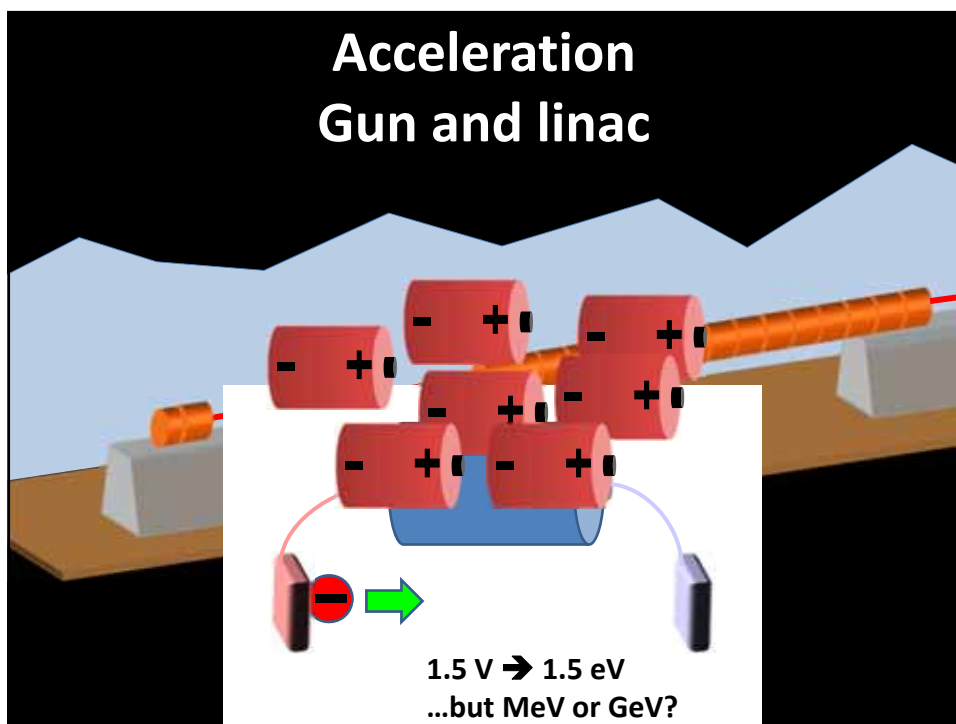
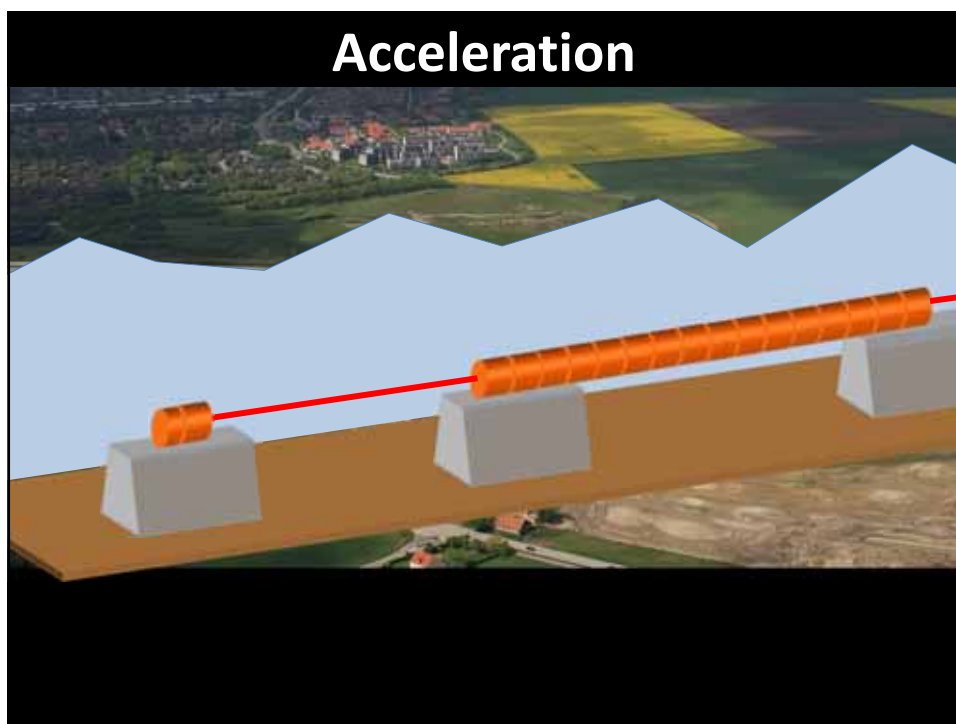
## Synchrotron Laboratory (MAX-lab)

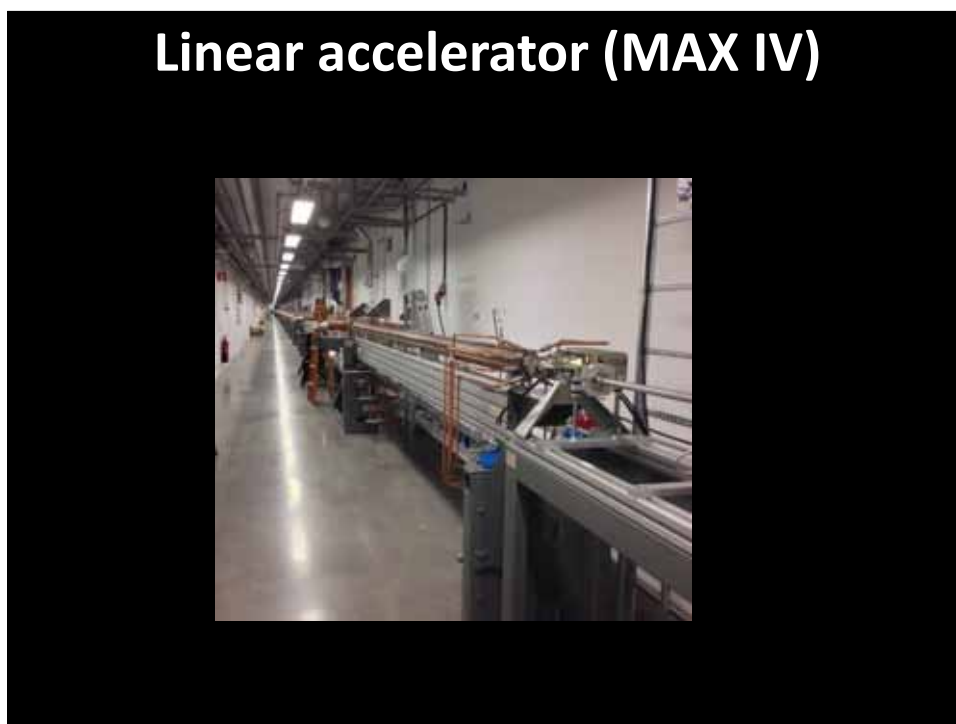
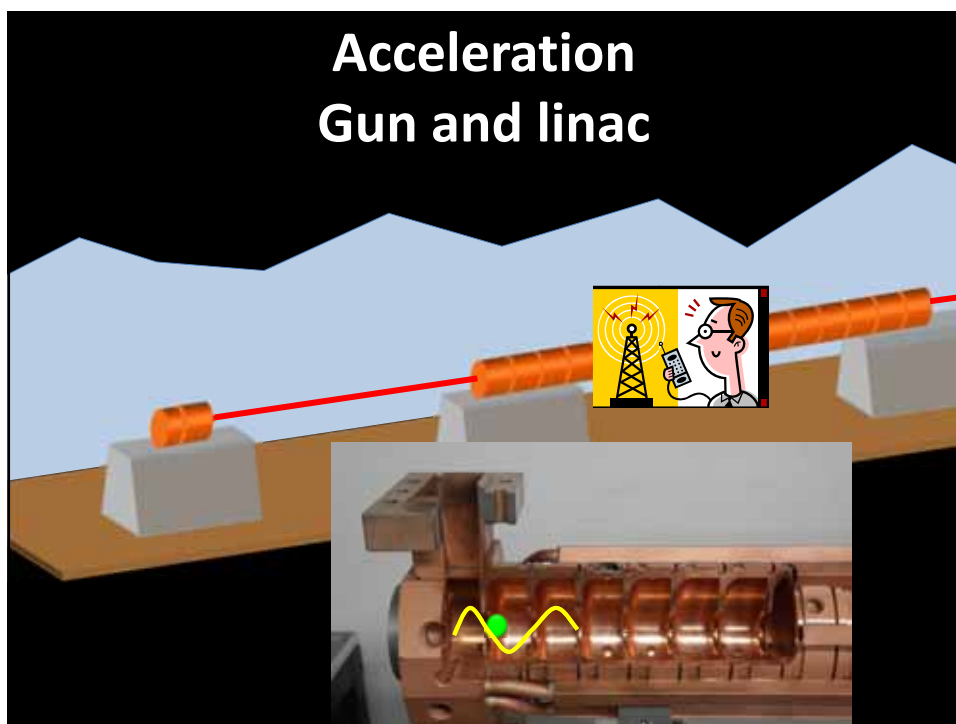


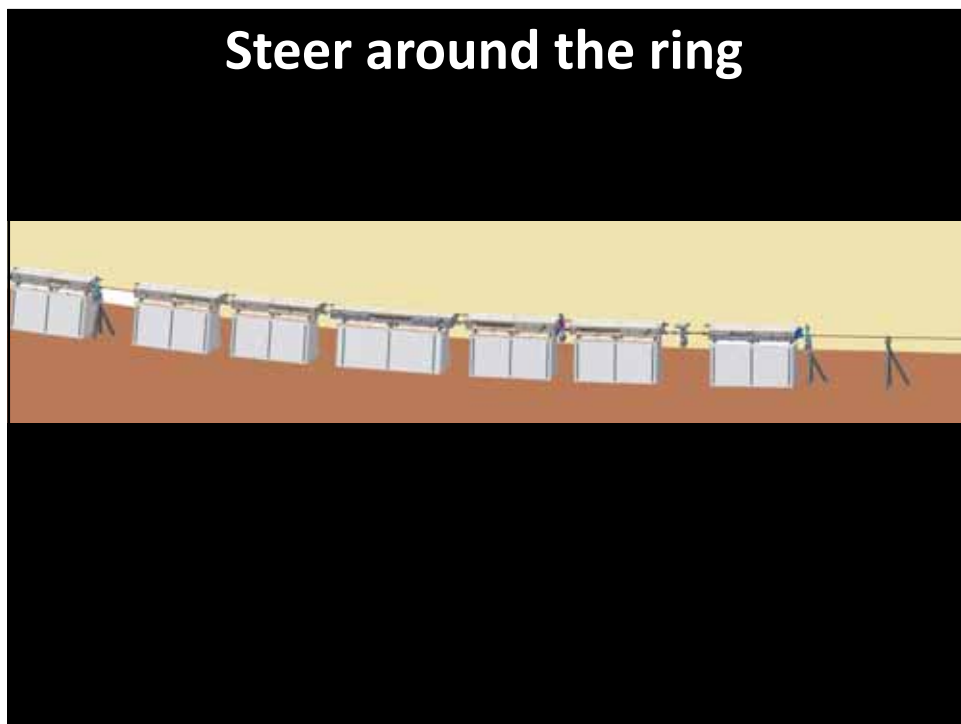
## The pieces of MAX IV

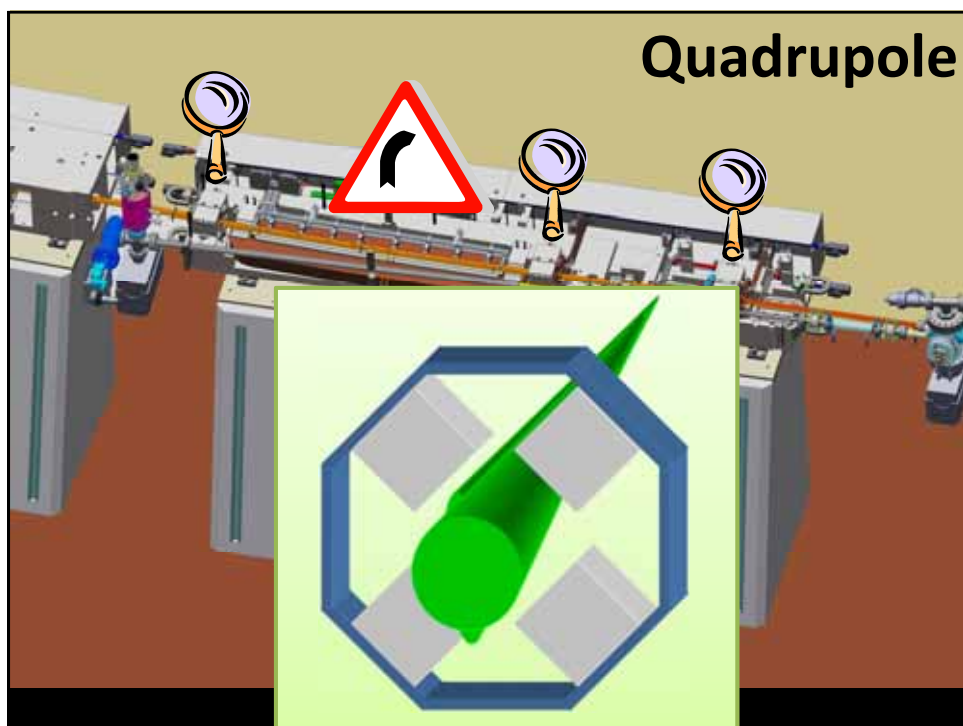
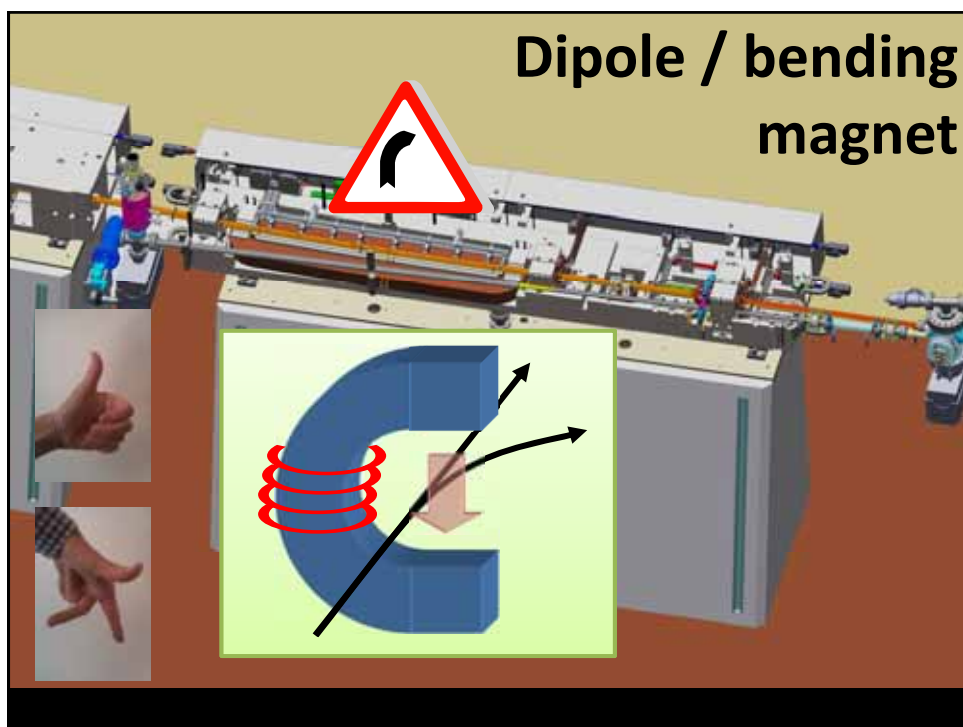


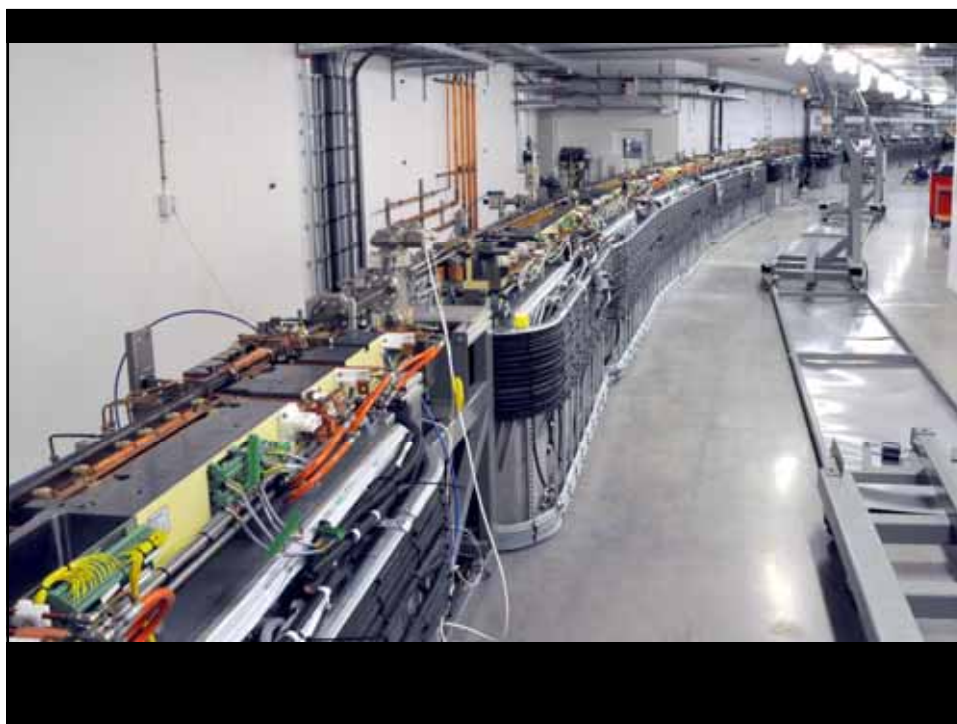
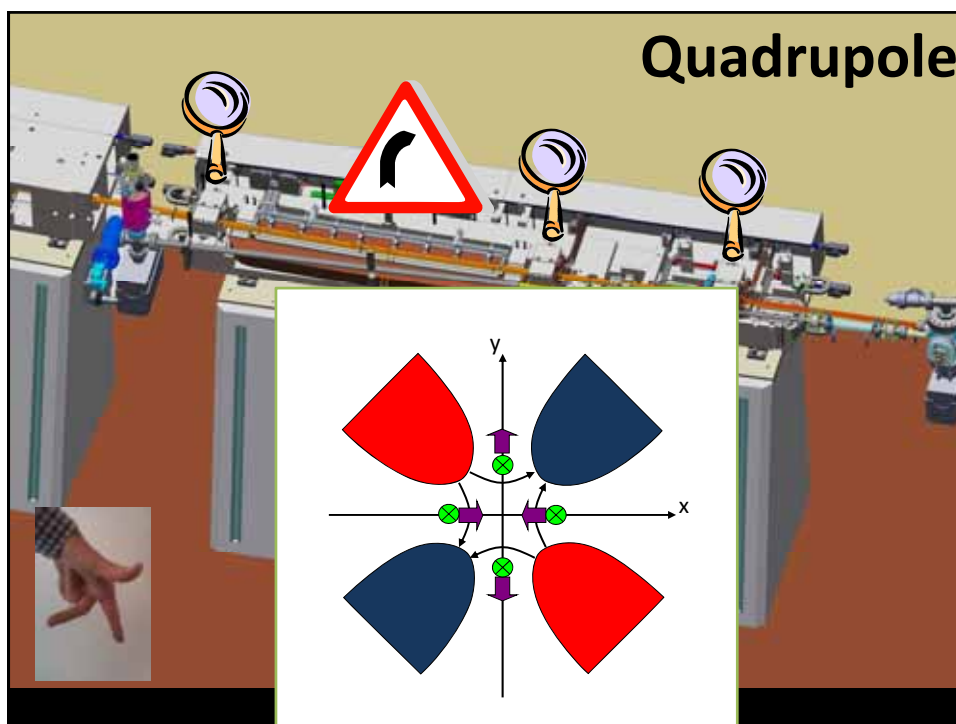




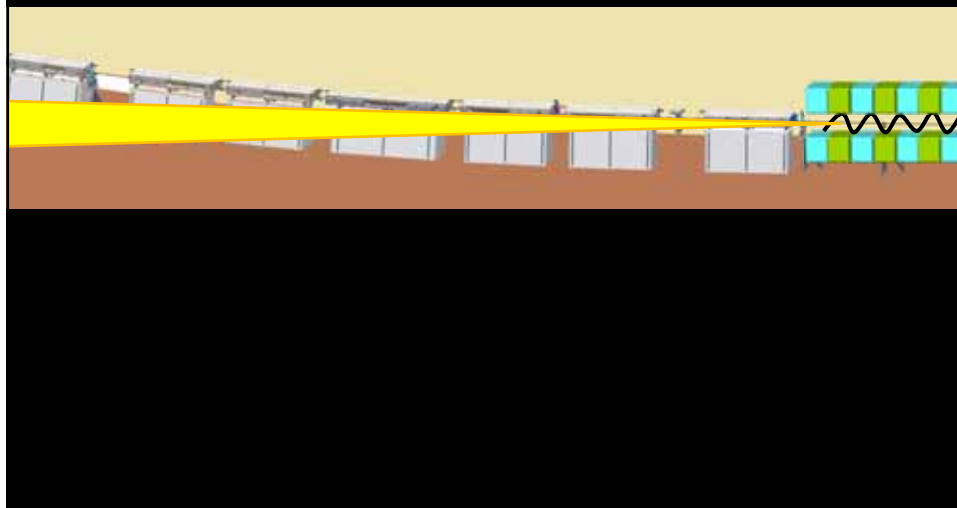






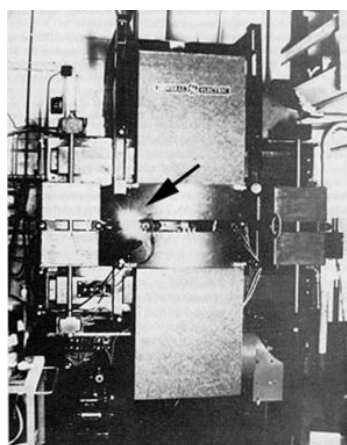


## Light and undulators



## First discovery of SR 1947

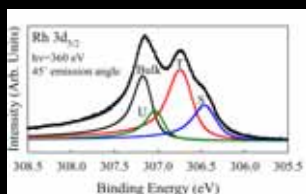
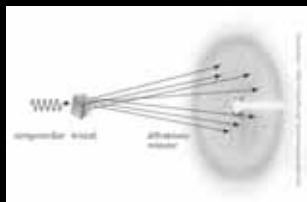
"On April 24, Langmuir and I were running the machine ... we asked the technician to observe with a mirror around the protective concrete wall. "  
(Herb Pollock)



General Electric Research Laboratory,  
Schenectady, NY, US

## Techniques at a beam line

Scattering

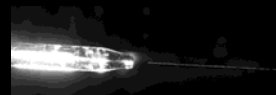
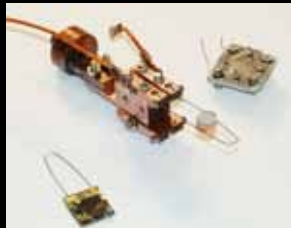


Spectroscopy

Imaging



## Samples



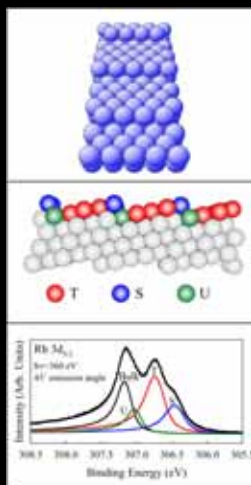


# Catalyser (rhodium)

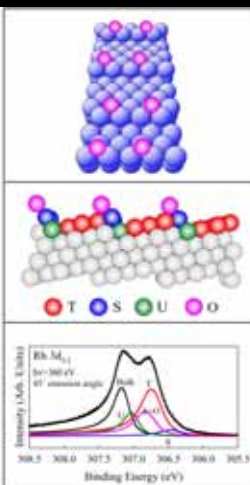
Geometry and chemical bonds with the help of photo electron spectroscopy



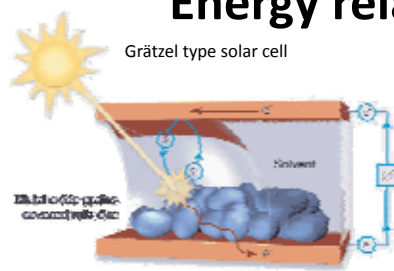
Clean rhodium-crystal surface



Some oxygen added

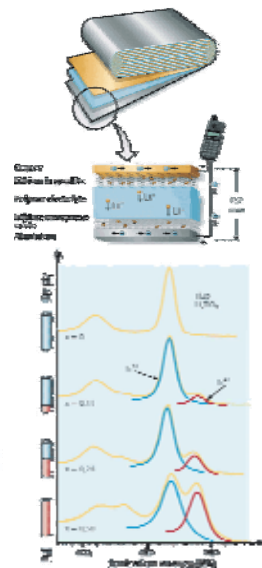


## Energy related research

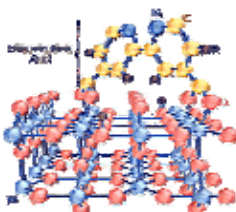


Grätzel type solar cell

Rechargeable Li batteries

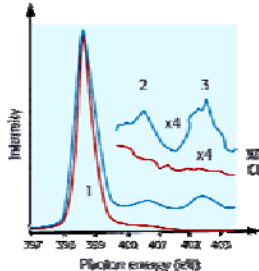


Bonding of dye molecules



J. Schnadt et al.

Probing charge transfer times < 2.5 fs



# What happens with the wood in the Vasa ship?



Photo: Hans Hammar skiöld, the Vasa Museum

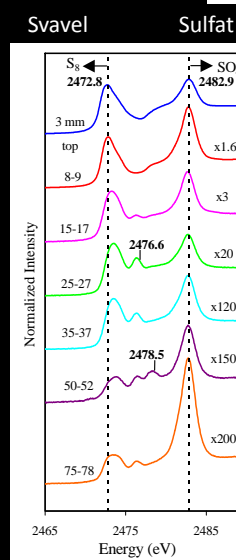
# What happens with the wood in the Vasa ship?



Svavel XANES spektra från Vasa



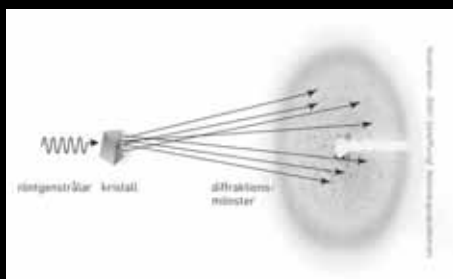
*Nature* **2002**, 415, 893-897  
M. Sandström *et al.*



## Drugs (ribosome in a bacteria)



2009 Nobel price in Chemistry  
Venkatraman Ramakrishnan, Thomas A. Steitz and Ada E. Yonath

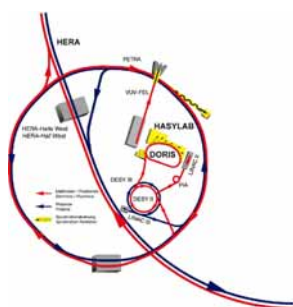


## 0th and 1st generation light sources

Parasitic machines, built to do something else.

DESY 7.4 GeV electron synchrotron  
1964 electron positron collider  
1967 SR production as a side effect

ACO in Orsay, Paris  
Electron-positron collider  
500 MeV



Where is DESY? (Erased from history?)



<http://www.sciencesaco.fr/>

## 2nd generation light sources

Built to produce Synchrotron Radiation from bending magnets.



Tantalus, 240 MeV, Wisconsin (Ed Rowe) (1968-87)



The injector in Jordan as SESAME (2014)



MAX I, 550 MeV, Lund, Sweden (1985-2015)



BESSY I, Berlin, 800 MeV (1982-99)

## 3rd generation Synchrotron sources nearby

built to use undulators

Diamond, Oxford



Soleil, Paris



BESSY II, Berlin



MAX II, Lund





## What comes next?



**SCIENTIFIC  
AMERICAN™**

**nature**  
international weekly journal of science

### Ultimate Upgrade for Synchrotron Particle Accelerator at National Lab

Argonne National Laboratory is banking on beam-bending magnets in its bid for the world's most focused X-ray light source

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

In Sweden, ultimate-storage-ring technology is being pioneered at MAX IV, a 528-meter-circumference synchrotron in Lund. Scientists there first sought to increase the intensity and brightness of the synchrotron's X-ray light in 2006 by focusing electron beams more tightly. The design relied on groups of seven magnets, known as multi-bend achromats, that could be used in as many as 20 places around the ring to nudge the paths of electrons back and forth until they lined up more-or-less perfectly. Machine director Mikael Eriksson recalls that when he toured US light sources to describe the project, "few believed it".

## "Ultimate" generation light sources

Free Electron Laser (FEL), Increasing coherence

<https://lcls.slac.stanford.edu>

**LCLS** Stanford



Hamburg

**European  
XFEL**



<https://media.xfel.eu>

**SACLA/XFEL** Japan



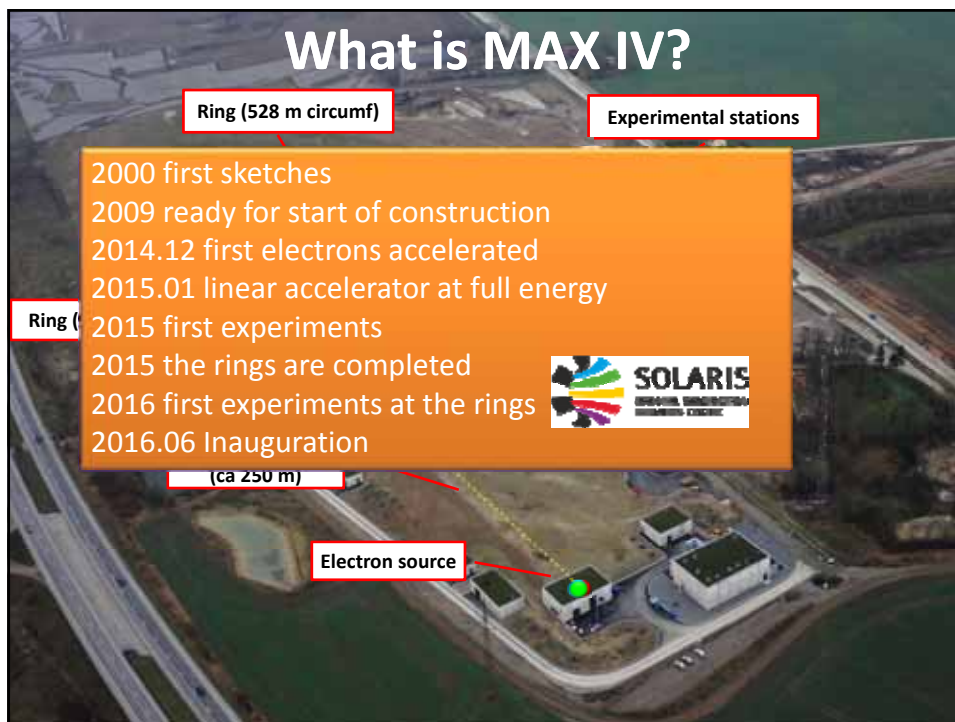
<http://xfel.riken.jp>

**SwissFEL** Switzerland



<https://www.psi.ch>

# What is MAX IV?



**Ring (528 m circumf)**

**Experimental stations**

2000 first sketches  
 2009 ready for start of construction  
 2014.12 first electrons accelerated  
 2015.01 linear accelerator at full energy  
 2015 first experiments  
 2015 the rings are completed  
 2016 first experiments at the rings  
 2016.06 Inauguration

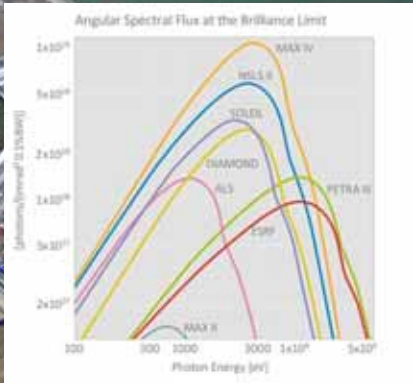
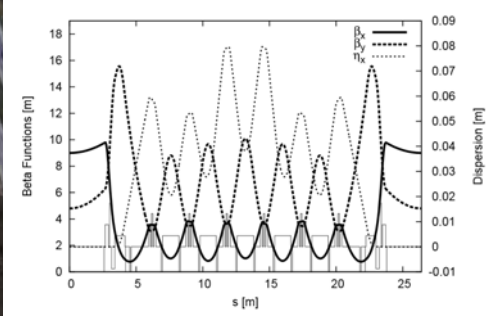
**Ring (ca 250 m)**

**Electron source**

**SOLARIS**  
 SYNCHROTRON LIGHT SOURCE  
 FOR SCIENTIFIC RESEARCH

# What is MAX IV?

Circumference (m)	528
Nr of straight sections	20
Injection	full energy, top-up
Stored current (mA)	500
Horizontal emittance (nm rad)	0.2 - 0.3
Vertical emittance (nm rad)	< 0.008
Horizontal beam size ( $\sigma$ $\mu$ m)	42 - 52
Vertical beam size ( $\sigma$ $\mu$ m)	< 6

**Angular Spectral Flux at the Bragg Limit**

Y-axis:  $\frac{d^2N}{ds d\Omega dE} \left[ \frac{1}{m^2 sr eV} \right]$

X-axis: Photon Energy [eV]

Curves shown: MAX IV, MAX II, SOLEIL, DIAMOND, ALS, ESRF, PETRA III.

**Beta Functions and Dispersion**

Y-axis: Beta Functions [ $\mu$ m] (left), Dispersion [ $\mu$ m] (right)

X-axis:  $s$  [m]

