JAGIELLONIAN UNIVERSITY
IN KRAKOW

SOLARIS
NATIONAL SYNCHROTRON
RADIATION CENTRE

SOLARIS

New light for Polish science

Marek Stankiewicz

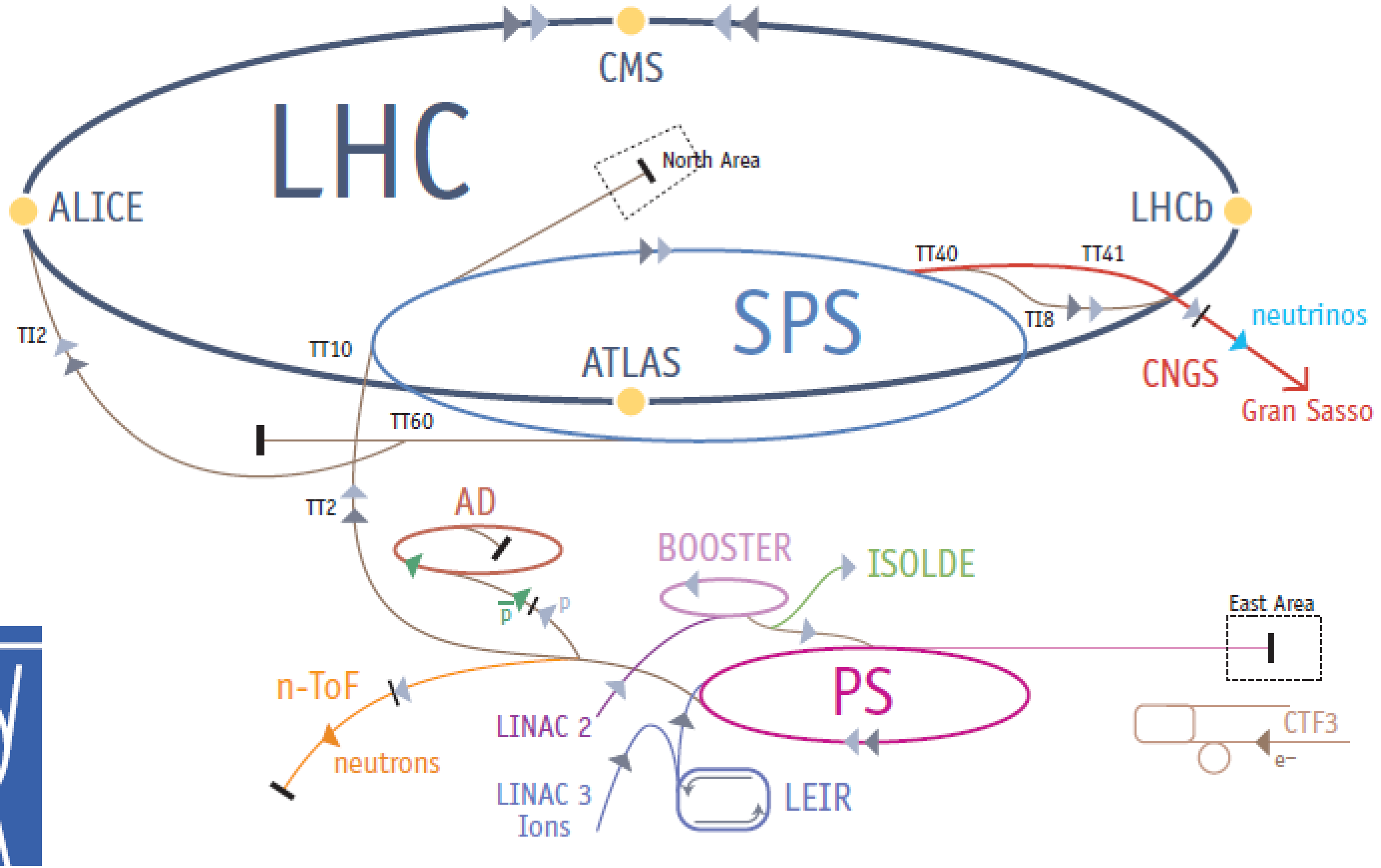
The CERN Accelerator School

INNOVATIVE
ECONOMY
NATIONAL COHESION STRATEGY

EUROPEAN UNION
EUROPEAN REGIONAL
DEVELOPMENT FUND

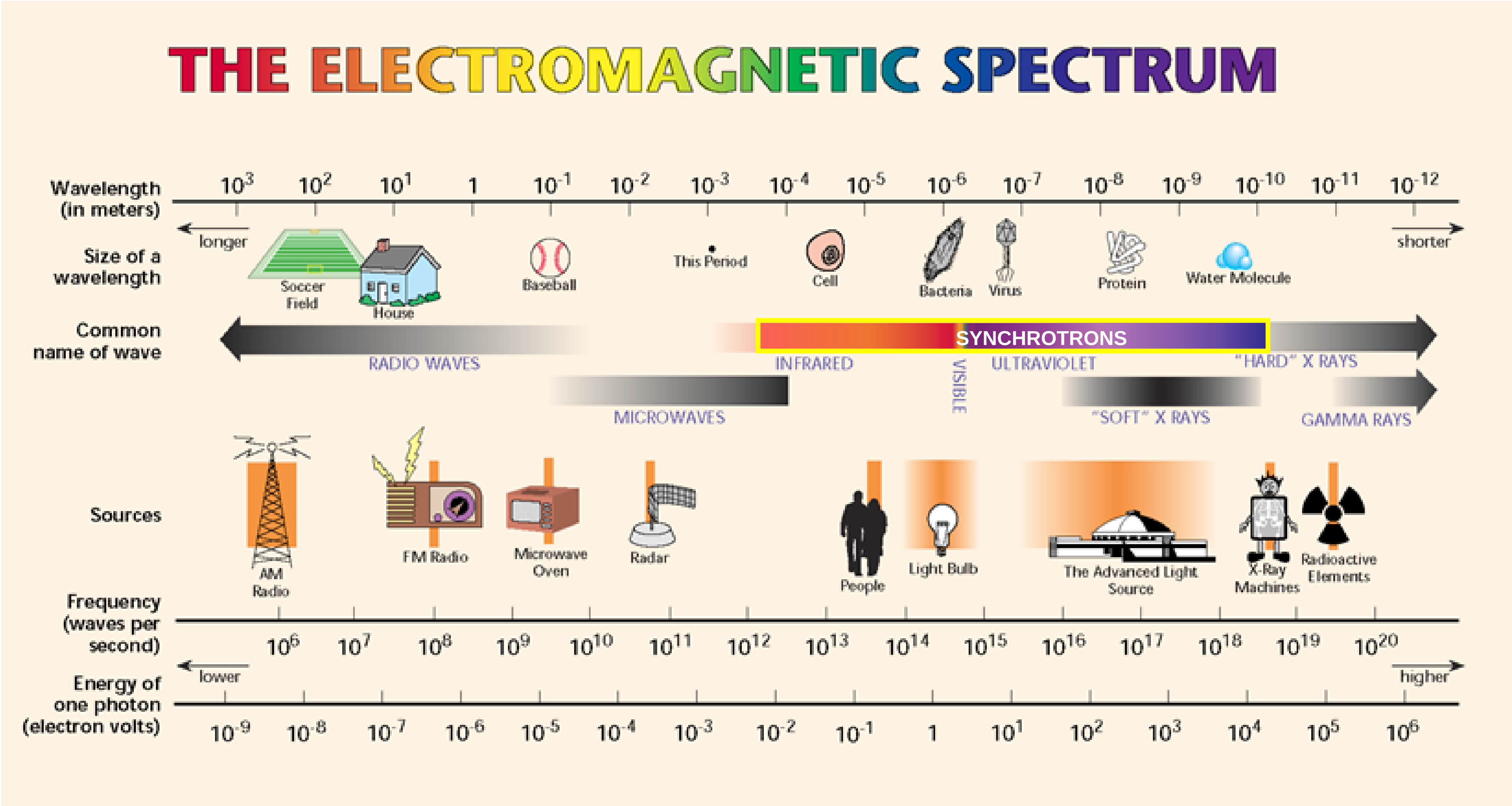
NCBJ, 5 October 2015

Accelerators @ CERN



Synchrotron – unique source of electromagnetic (EM) radiation

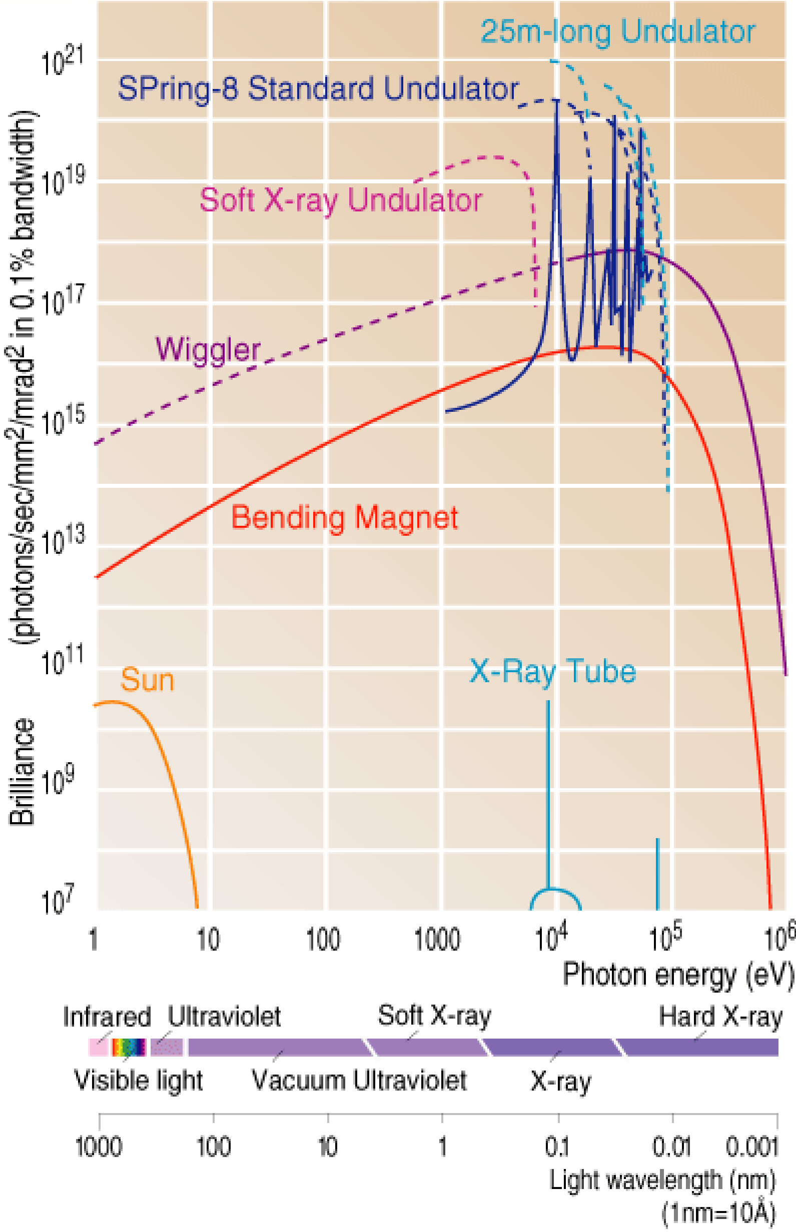
Change of electron trajectory => EM emission => magnets-the heart of synchrotron



Synchrotron: unique, man made source of EM radiation

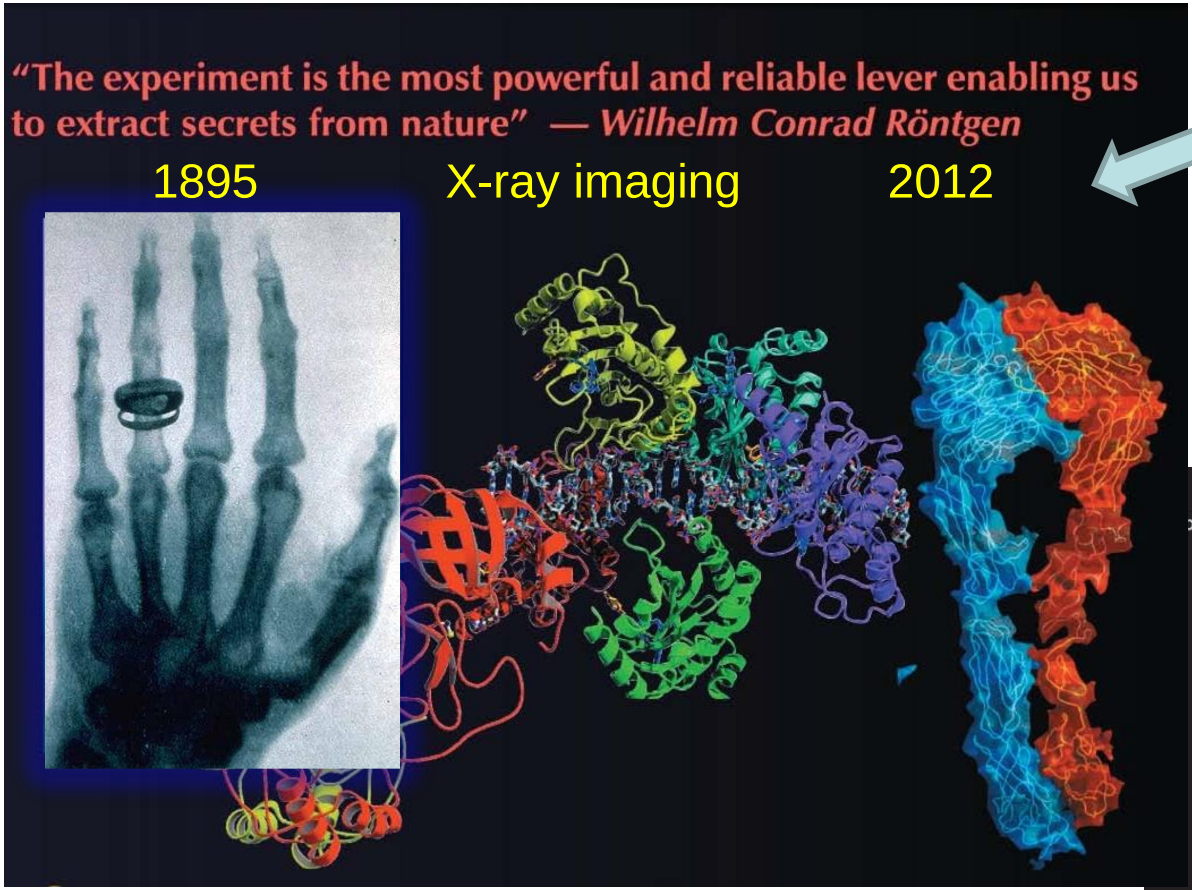
Properties:

- Broad spectral range: 10^{-1} - 10^{5} eV (10^{5} – 10^{-1} Å)
- Monochromaticity
- Intensity
- Collimation
- Small spot (nano meters)
- Polarization
- Adjustable (pulsed) time structure



Unique torch, manipulator and scalpel

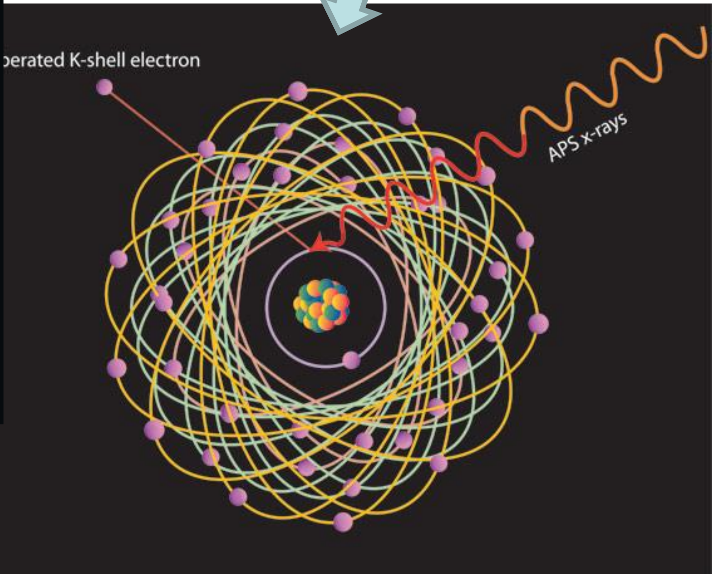
- ***Röntgen – first X-rays generation and application - 1895***
- ***Classical X-ray tubes development***
- ***Synchrotrons – generations I, II, II and IV (FELs)–ongoing dev since1960***



"The experiment is the most powerful and reliable lever enabling us to extract secrets from nature" — *Wilhelm Conrad Röntgen*

Materials' structure
macro → nano

Atomic & molecular
spectroscopy & manipulation

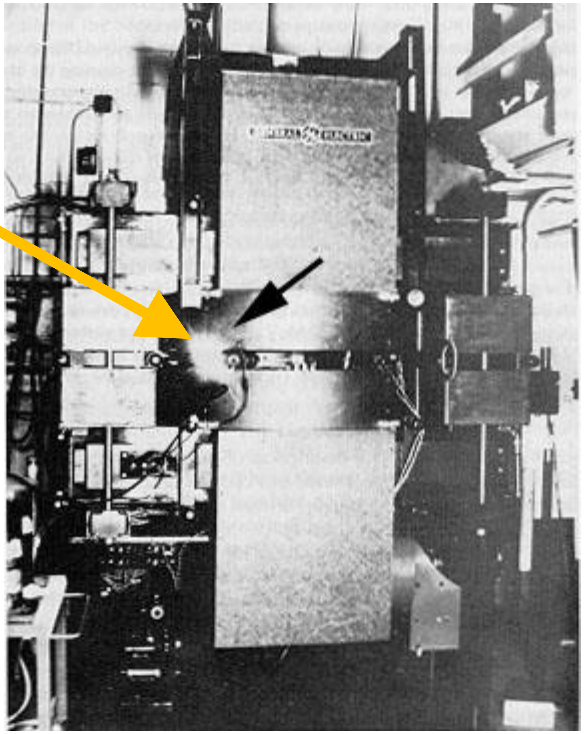


Numerous Nobel prizes awarded for X-ray related research

History of SR sources

- **1947** – **I generation**– parasite operation at 70 MeV *General Electric* electron synchrotron

Vacuum chamber of *General Electric* synchrotron 1947



- **1956** **first experiments** (Tomboulian i Hartman) **angular and spectral characteristics** of SR radiation in 80 Å to 300 Å range.
- **First spectroscopy measurements** - Be i Al foil transmission near K and L edges

I Generation – synchrotrons – parasite opearation

- **1961** – **first SR dedicated experimental beamline @** Synchrotron Ultraviolet Radiation Facility (SURF) in National Bureau of Standards (NBS);
  energy 180 MeV (photon critical energy 335 Å (40 eV) – Madden & Codling.

II Generation – **storage rings** – source: bending magnets

- **1968** – Tantalus I – University of Wisconsin – **first storage ring** – synchrotron dedicated for SR generation – 240 MeV

III Generation – storage rings with **insertion devices**

1981 – **first permanent magnet undulator** - Lawrence Berkeley Laboratory

IV Generation – free electron lasers (FELs) – linear accelerator + undulator system

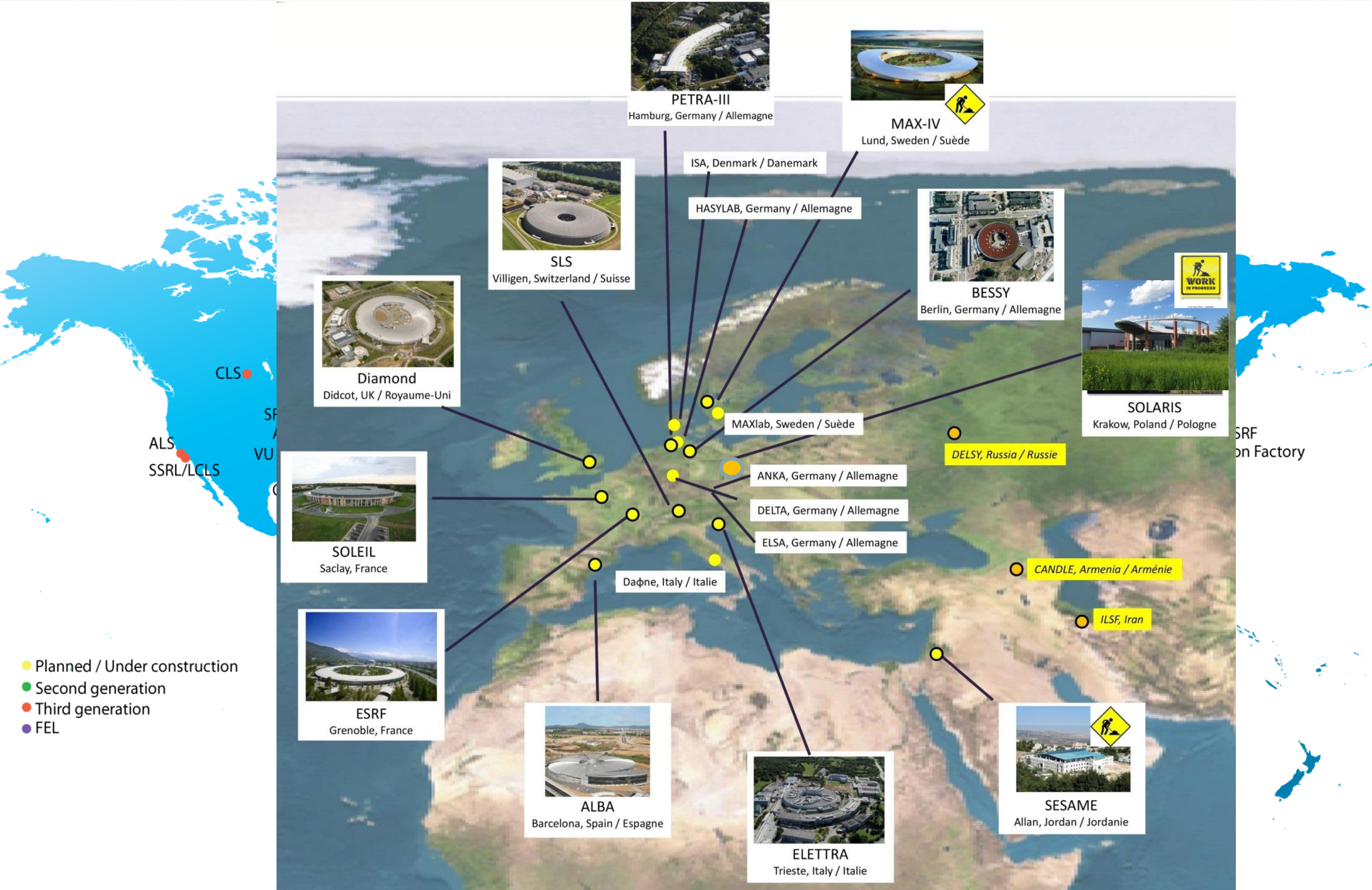
Applications of synchrotron radiation (light) source

Synchrotrons open new research frontiers in

- ✓ fundamental research
  - ✓ Physics
  - ✓ Chemistry
  - ✓ Cosmology
  - ✓ Biology
  - ✓ Geology
  - ✓ …….
- ✓ applied research
  - ✓ Material studies
  - ✓ Environmental science
  - ✓ Archeology and cultural heritage
  - ✓ Medicine
  - ✓ Semiconductor industry
  - ✓ Pharmaceutical industry
  - ✓ ……

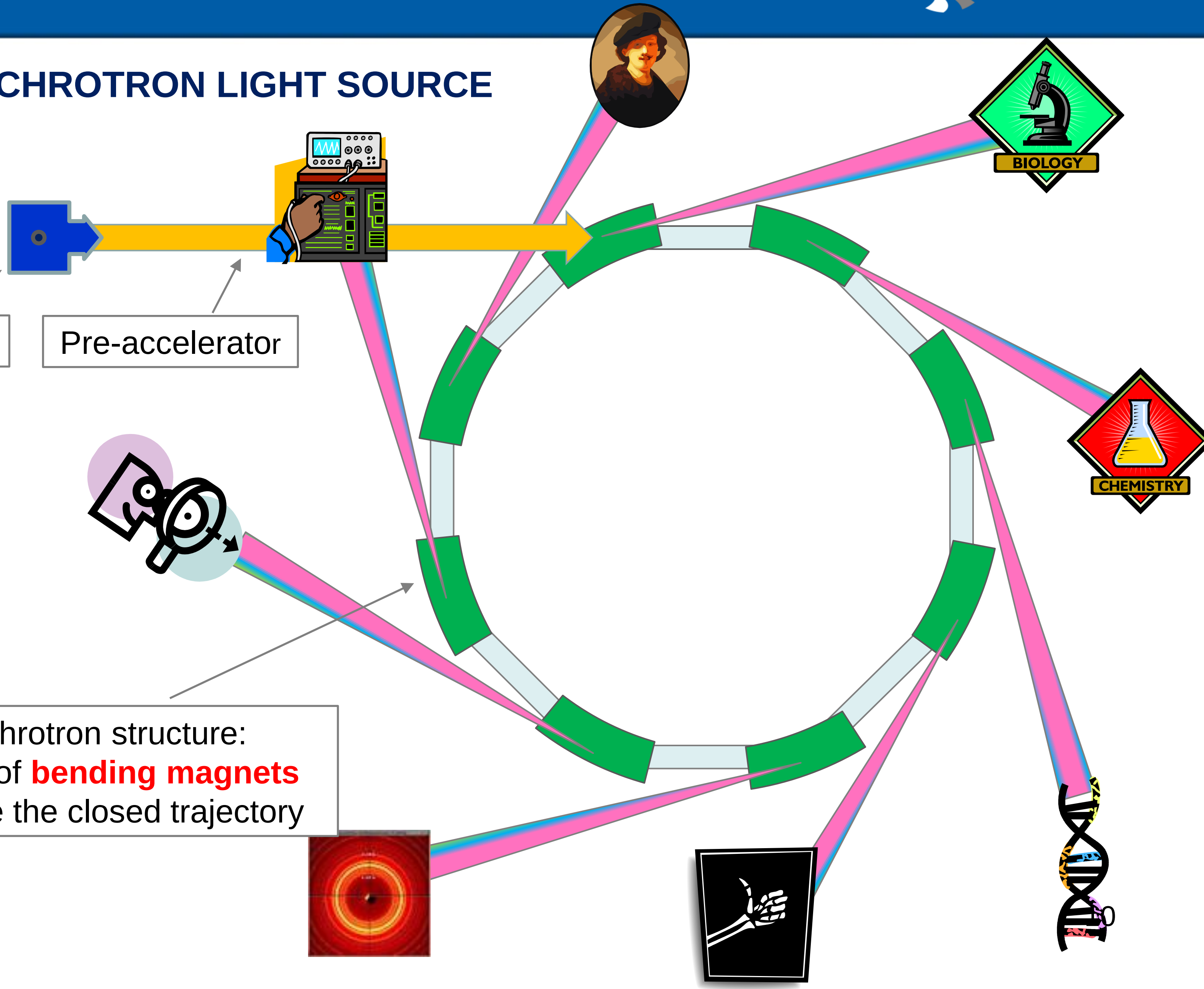
Multidisciplinary, multiuser research facilities

Map of SR facilities



- Planned / Under construction
- Second generation
- Third generation
- FEL

TYPICAL SYNCHROTRON LIGHT SOURCE LAYOUT



Electron source

Pre-accelerator

Synchrotron structure:
number of **bending magnets**
to assure the closed trajectory

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SOLARIS

Project settings and boundary conditions

SOLARIS NATIONAL SYNCHROTRON RADIATION CENTRE

The motivation

- Polish synchrotron radiation users community - >300
- Polish Synchrotron Radiation Users Society (PTPS)
- Polish Synchrotron Consortium – 36 members
- Long lasting initiative to built a SR source in PL
- **2009 – 40 M€ package assigned**

The goal

- **The best possible synchrotron radiation source for the money**
- **Upgreadable**

The context

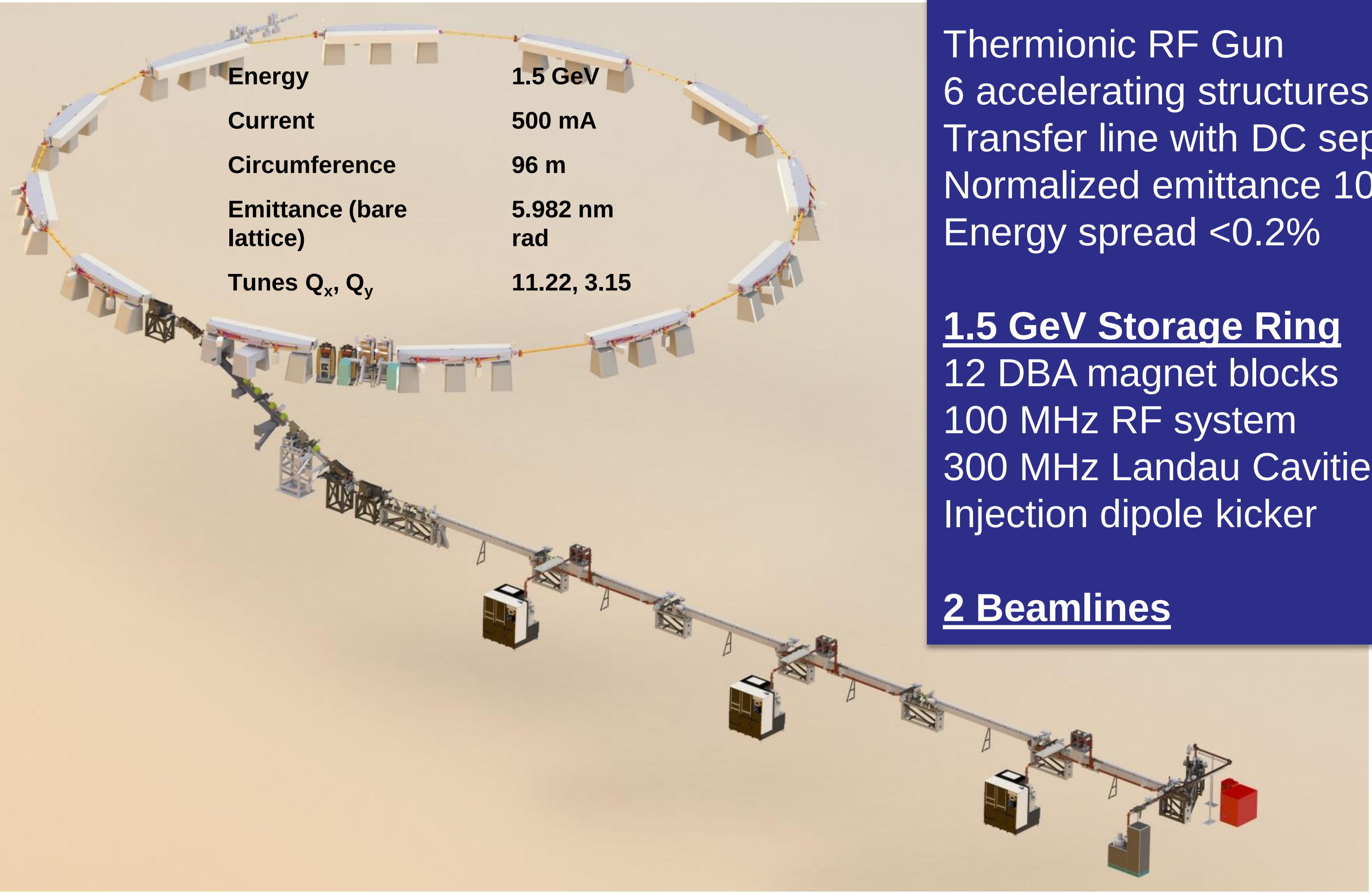
- New MAX-IV facility in Lund - 2 rings:
    - MAX IV ring: 3 GeV, 528m circumference
    - MAX II replacement: 1.5 GeV, 96m circumference ring
- SOLARIS - **replica** of the new 1.5 GeV MAX-lab ring
- New MAX-lab magnet technology - Integrated Double Bend Achromats

SOLARIS

Project settings and boundary conditions

- **National Project, executed by Jagiellonian University**
- **Timetable**
  - Conceptual design 2009
  - Project approved 2010
  - Deadline: December 2015
- **Budget**
  - 50 M€ - EU funds
- **Deliverables**
  - Building
  - Machine (linac + synchrotron)
  - 2 experimental beamlines

Machine



Energy	**1.5 GeV**
Current	**500 mA**
Circumference	**96 m**
Emittance (bare lattice)	**5.982 nm rad**
Tunes Q_x, Q_y	**11.22, 3.15**

600 MeV Injector:

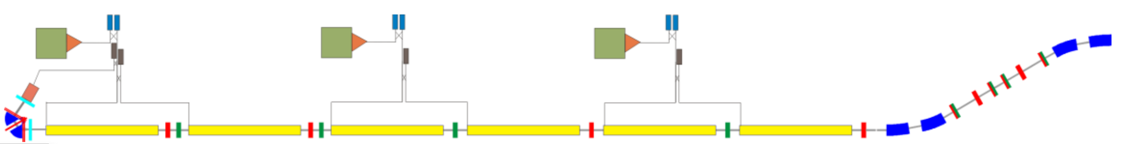
Thermionic RF Gun
6 accelerating structures
Transfer line with DC septum
Normalized emittance 10mm mrad
Energy spread <0.2%

1.5 GeV Storage Ring

12 DBA magnet blocks
100 MHz RF system
300 MHz Landau Cavities
Injection dipole kicker

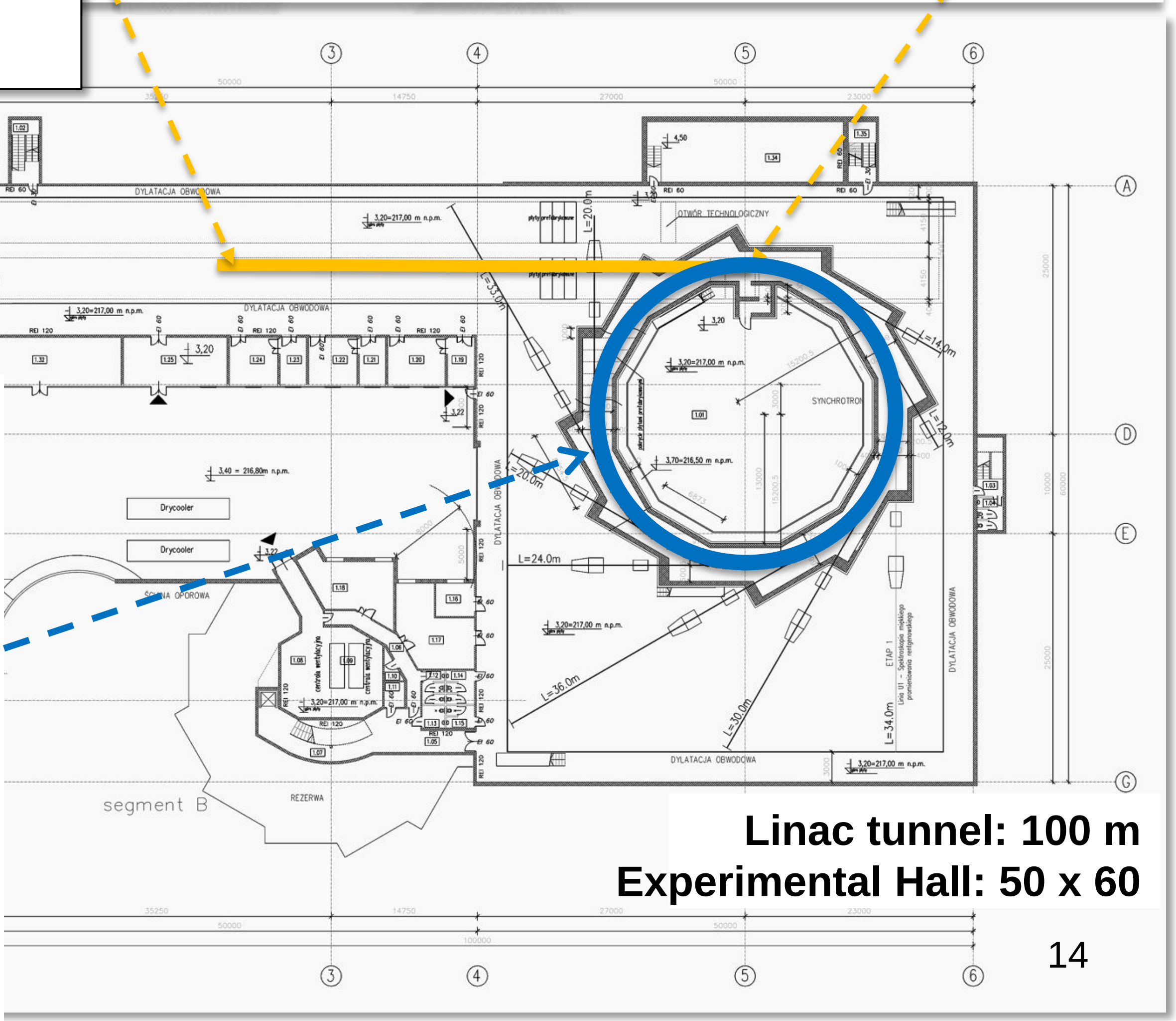
2 Beamlines

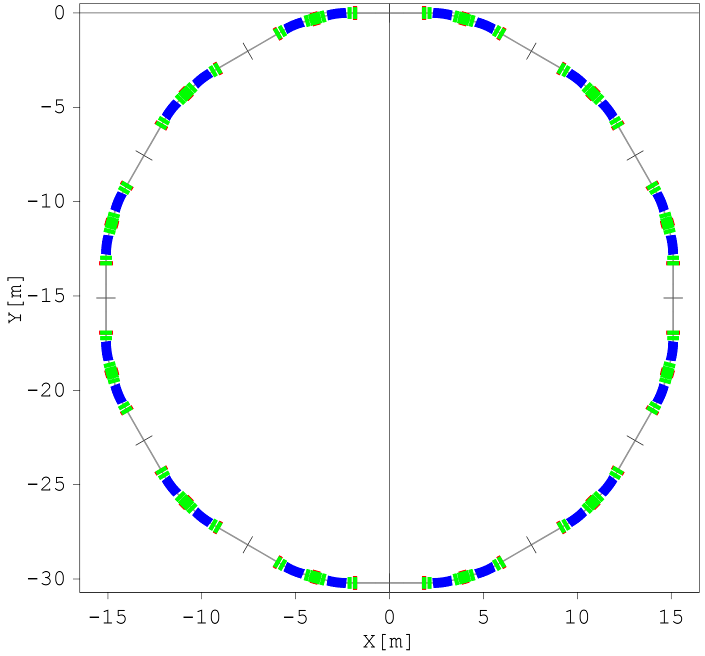
Solaris – layout- building



Thermionic RF gun, 3 GHz Linac. 550 MeV. ~50 m incl transfer line

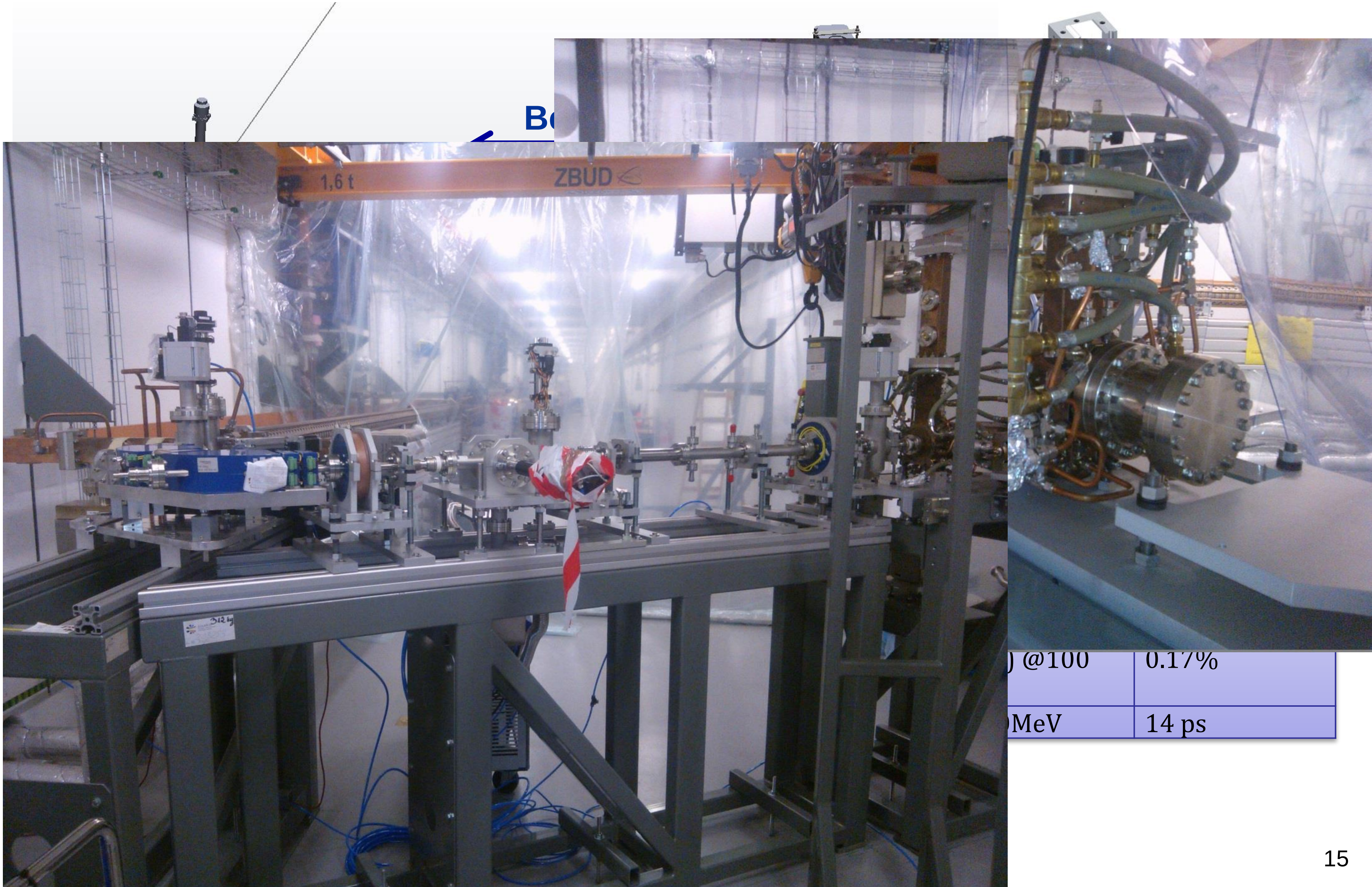
4 levels:
Linac: ~ -7m
Synchrotron & experimental hall: ~ -3m





Linac tunnel: 100 m
Experimental Hall: 50 x 60

Gun system

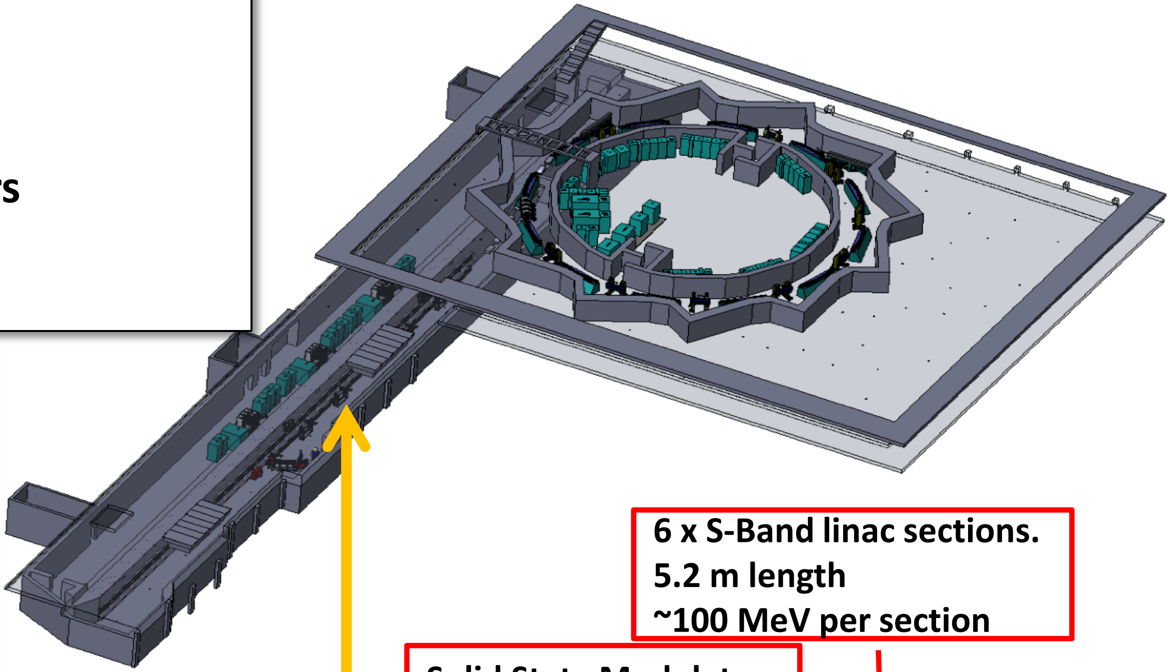


@100	0.17%
MeV	14 ps

Linac

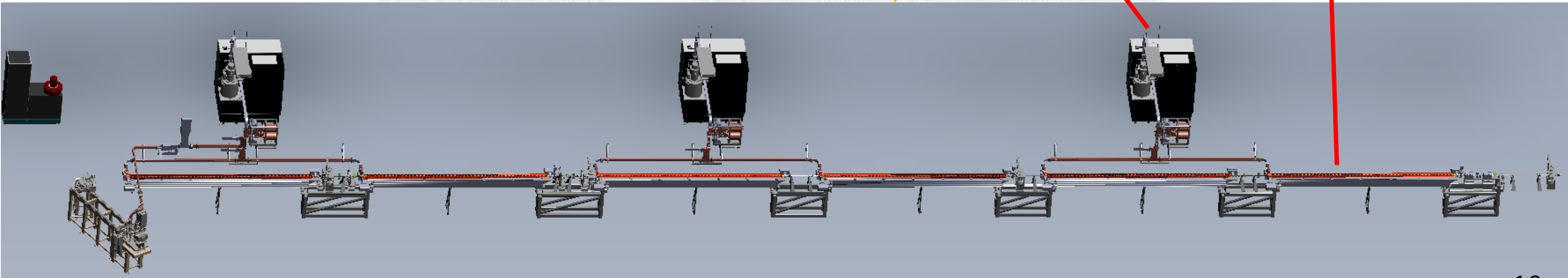
- **6 accelerating structures combined in 3 units**
    - **Accelerating gradient 20 MeV/m**
    - **S-band – 2998.5 MHz**
- **Power:**
- **3 RF Units :**
    - **ScandiNova K2 modulators**
    - **Toshiba klystrons**
    - **SLED cavities**

Bunch charge	0.1 nC
Emitance(geom, rms) x/y	3.1 / 2.0 nm rad
Energy max.	600 MeV
Energy spread(rms)	0.23%
Bunch length (rms)	3.68 ps
Injection rep. rate	2 Hz



6 x S-Band linac sections.
5.2 m length
~100 MeV per section

Solid State Modulators



Linac installation

Racks with equipments installed

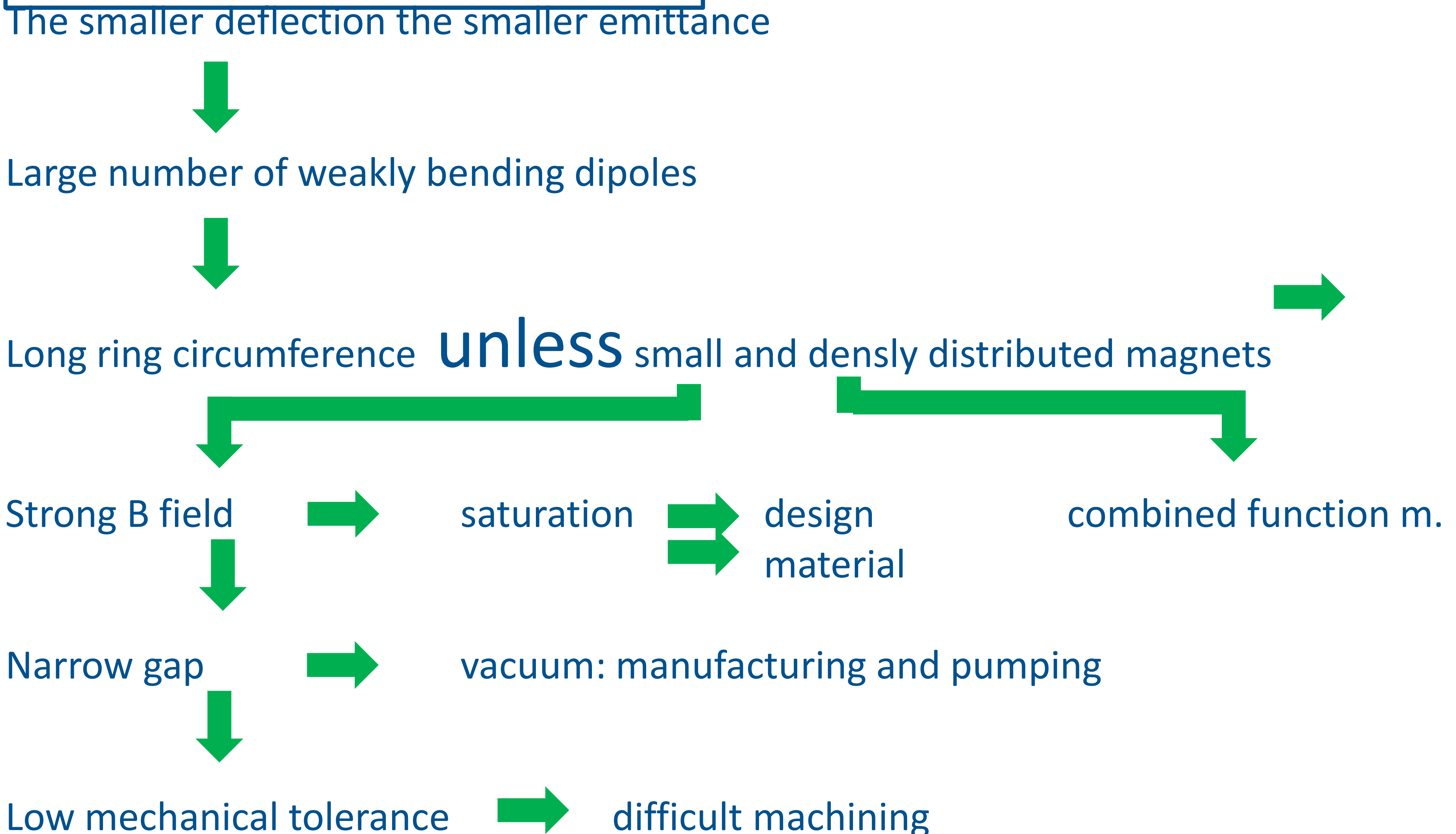
Modulators and SHG partially installed

Linac and waveguide system up to the transfer lineand installed under vacuum

Requirements imposed by low ε

$$\varepsilon_{x0} = C_q \gamma^2 \frac{I_5}{J_x I_2} \propto C_q \frac{\gamma^2}{N^3} \propto C_q \gamma^2 \theta^3$$

The lower energy the lower emittance



The smaller deflection the smaller emittance

Large number of weakly bending dipoles

Long ring circumference **unless** small and densly distributed magnets

Strong B field → saturation → design → material

combined function m.

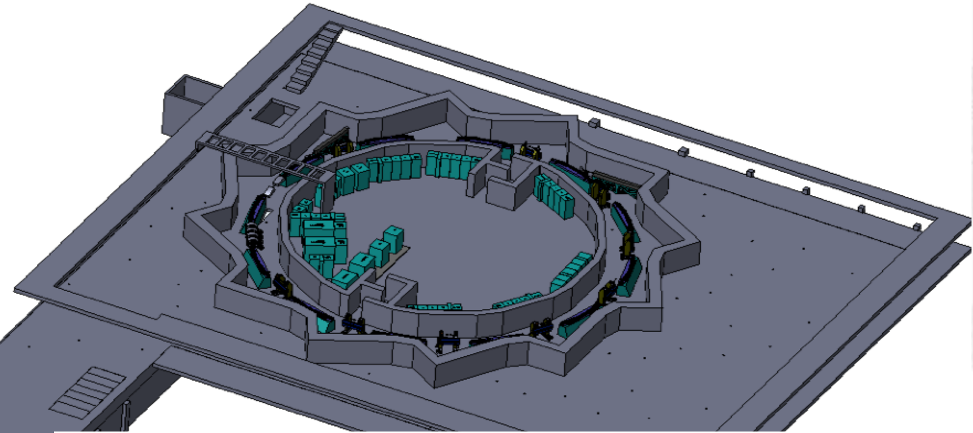
Narrow gap → vacuum: manufacturing and pumping

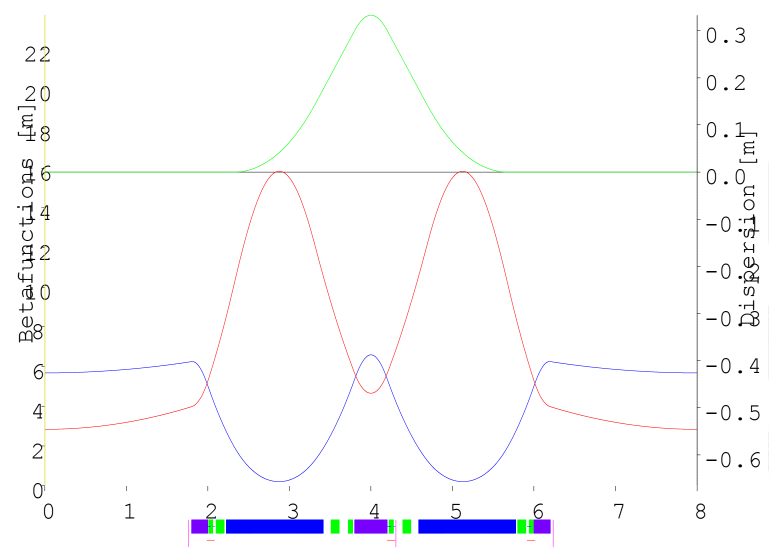
Low mechanical tolerance → difficult machining

SOLARIS – unique design of storage ring

mats)

Storage Ring





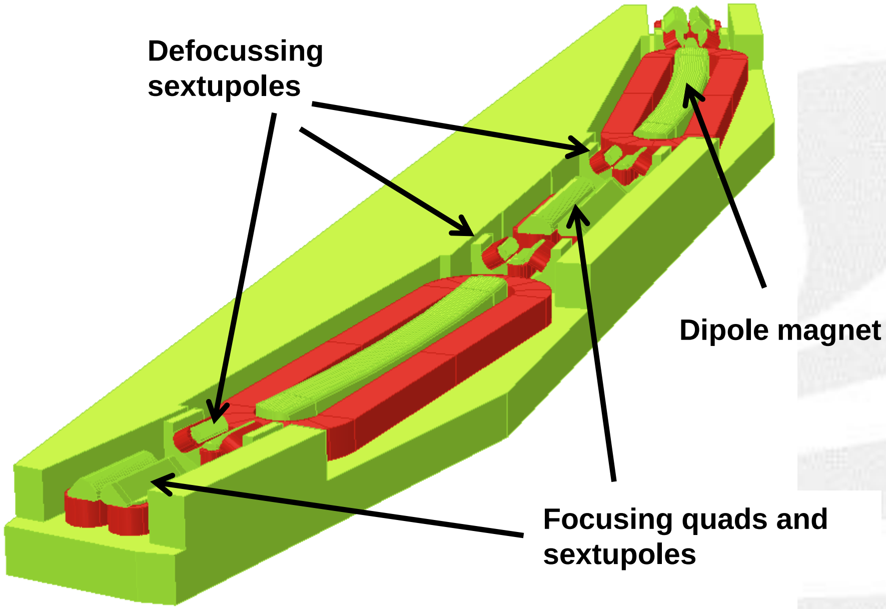
12 DBA Cells – 96 m circ.
Space for ID's ~ 3.5 m
10 straight sections for IDs
Combined- function magnets
  - Gradient dipoles
  - Quads with integrated sextupole

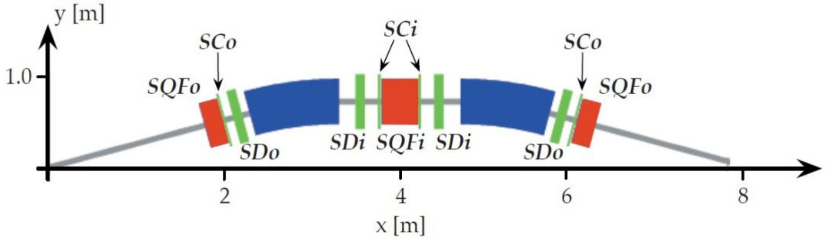
Storage Ring Parameters	Value
Energy	1.5 GeV
Current	500 mA
Circumference	96 m
Horizontal emittance (bare lattice)	5.982 nm rad
Coupling	1%
Tunes Q_x, Q_y	11.22, 3.15
Natural chromaticities ξ_x, ξ_y	-22.96, -17.14
Momentum compaction	3.055×10^{-3}
Momentum acceptance	4%
Overall Lifetime	13 hrs

Optics design by S.C. Leemann - MAXIV

MAXIV Facility, DDR, § 3, http://www.maxlab.lu.se/maxlab/max4/DDR_public

Storage ring magnets





Achromat made of one block of iron incorporating youkes and poles for all magnets:

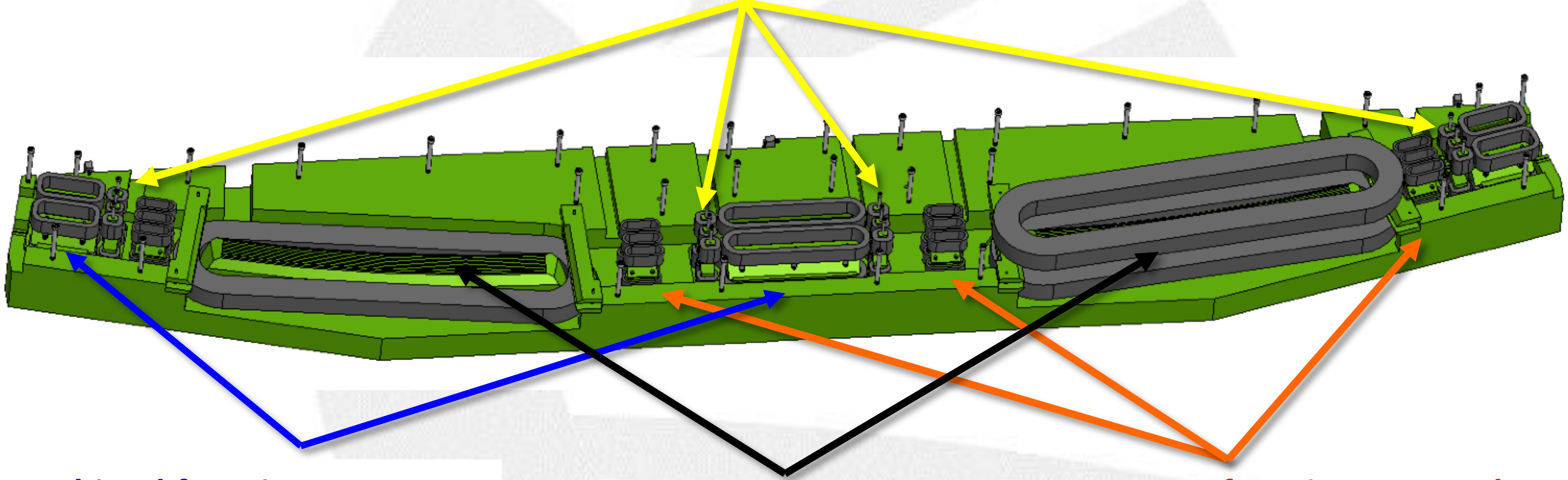
SQFo – quadrupol/sextupol
SCo/SCi – thin correcting sextupole with x & y coils
SDo – sextupoles
DIP – gradient dipoles
SDi – sextupoles
SQFi – integrated quadrupol/sextupol

	K [m^{-1}]	K [m^{-2}]	K [m^{-3}]	B[T]	B[Tm^{-1}]	B[T m^{-2}]
SQFo		5.736667	36.67683		-28.713	-183.57
SCo1						
SDo			-91.9217			460.08
DIP	15	-1.34		1.31	6.74	
SDi			-73.225			366.51
SCi1						
SQFi		4.99849	4.99849		-25.018	-140.35

Magnets

Storage Ring – Magnets (mirror symmetric)

Machined from solid iron, 2 half slabs, ~4.5 m, ~4 Tons each slab



Multi-coil correction magnets (COD, Skew quads, aux. sextupoles)

Combined focusing quadrupole-sextupole magnets

Gradient bending magnet with pole-face strips

Defocusing sextupole magnets

Magnets designed by M. Johansson - MAXIV

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DOE Decision (2013)

APS: -> stop current upgrade, change to MBA a la MAX IV!

12 SEPTEMBER 2013 | VOL 501 | NATURE | 149

PHYSICS

Ultimate upgrade for US synchrotron

Argonne lab banks on beam-bending magnets in bid for world's most focused X-ray light source.

BY EUGENIE SAMUEL REICH

Every day, in dozens of synchrotrons around the globe, electrons are whipped around in circular storage rings to provoke them into emitting X-rays, useful for imaging materials, identifying chemical-reaction products and determining crystal structures.

But photon scientists do not want just any old storage ring. For more than a decade, they have dreamt of 'ultimate' storage rings — ones that use specialized magnets to produce X-ray beams that are as tightly focused as theory allows.

Now, researchers at the largest US synchrotron, the Advanced Photon Source (APS) at the Argonne National Laboratory in Illinois, are taking steps to develop this technology. In the process, they hope to leapfrog several international facilities that have a head start.

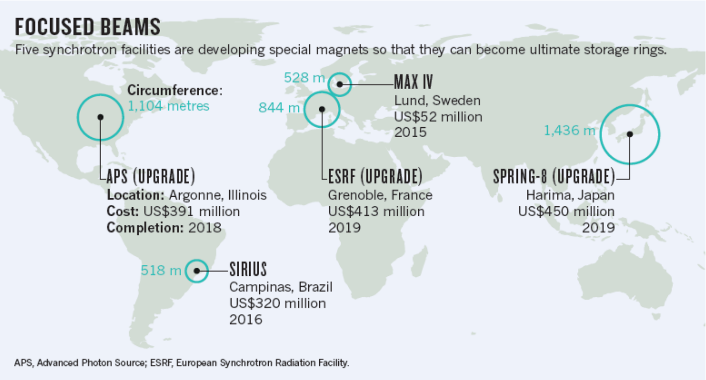
In Sweden, ultimate-storage-ring technology is being pioneered at MAX IV, a 528 circumference synchrotron in Lu there first sought to increase the brightness of the synchrotron's X 2006 by focusing electron beams The design relied on groups of seve known as multi-bend achromats, th used in as many as 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".

Eriksson now has believers. In a report posted online on 29 August, researchers at the Argonne lab describe how they are hoping to upgrade the 1.1-kilometre-circumference APS with multi-

Magnets for the Swedish MAX IV synchrotron.

bend achromats (se "Th agnets would unstable by bending it too much and introducing too many fluctuations. But the work at MAX IV showed that very compact magnets enable bending paths that are short enough to stop fluctuations from building up.

The US Department of Energy, which funds the APS, still needs to approve the plan. In July, one of the department's advisory committees suggested that US labs were being left behind while other countries push towards ultimate storage rings. The committee had also recommended pursuing a next-generation X-ray



FOCUSED BEAMS

Five synchrotron facilities are developing special magnets so that they can become ultimate storage rings.

APS, Advanced Photon Source; ESRF, European Synchrotron Radiation Facility.

SOURCE: US DEPARTMENT OF ENERGY/BESAC; MAX IV

laser, useful for making 'molecular movies' of chemical reactions, among other things (see *Nature* **500**, 13–14; 2013). But such a laser would have limitations: its strongly peaked light pulses would destroy delicate materials. Ultimate storage rings, by contrast, satisfy a need for more gradually peaked pulses of light.

Researchers say that these storage rings could revolutionize X-ray imaging by making it possible to map evolving chemical processes. Current X-ray sources are not bright enough to track changes in materials with nanometre and nanosecond resolution, because there are not enough coordinated photons in the beams. Ultimate storage rings would change that. "A whole class of new problems opens up," says Paul Evans, a materials scientist at the University of Wisconsin–Madison. For example, he says that the rings could be used to investigate what happens chemically and electrically at the interface between mat inside a battery as it ru

The A raising the uch above US$391 million. MAX IV is implementing the technology for only 340 million Swedish kronor ($52 million), but that ring is smaller and the price tag would not include the overhead costs that are charged at US energy-department labs.

After its upgrade, the APS could surpass MAX IV by approaching the theoretical limit for the most focused beam possible. The Swedish synchrotron will contain 20 multi-bend achromats, whereas the APS upgrade calls for around 40. In 2012, physicists at SLAC National Accelerator Laboratory in Menlo Park, California, showed that the number of multi-bend achromats around a larger ring could be pushed even higher without fundamentally destabilizing the electron beam. "The key is to make the bending gentle," says Yunhai Cai, head of beam physics at SLAC.

Alongside APS, the European Synchrotron Radiation Facility (ESRF) in Grenoble, France, has also opted for a multi-bend-achromat upgrade, after a working group concluded last October that the technology was affordable. ESRF director-general Francesco Sette says that accelerator physicists there showed that multi-bend achromats could work with the facility's existing injector, a part of the machine that supplies extra electrons to the main ring a few times each day. He had previously thought that a new injector would be needed. "We are today in full swing to launch as soon as possible," he says.

Storage rings in Brazil and Japan will also be upgraded with multi-bend achromats, giving MAX IV a window of only one year from its projected completion date of 2015 before it faces competition (see 'Focused beams').

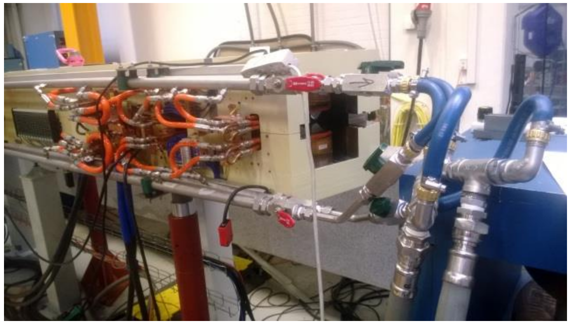
Some have suggested that particle-physics tunnels ld eventually be turned into th multi-bend achromats. .2-kilometre-circumference lly housed a particle acceler- re the decay rates of matter d a 6.3-kilometre tunnel closed Tevatron particle accelerator at Fermilab near Batavia, Illinois, is another candidate for conversion. Eriksson says that building ultimate storage rings of that size would not be realistic for Sweden, given the relative size of its science budget.

He knows that Sweden's time in the vanguard will be short-lived, and has mixed feelings about seeing other countries adopting the technology that he and his colleagues pioneered so enthusiastically. "We are both happy and a little sorry," he says. ■

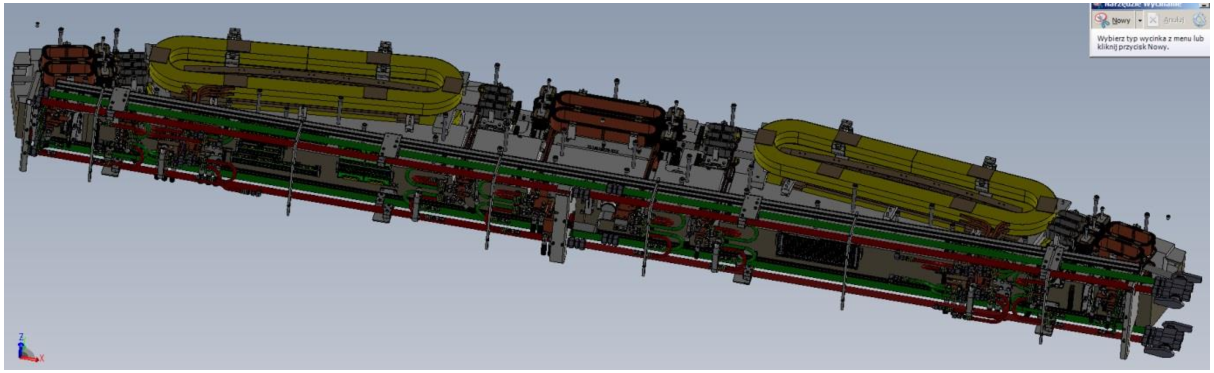
CORRECTION

The News story 'NASA ponders Kepler's future' (*Nature* **501**, 16–17; 2013) inflated the size of asteroids that the probe could watch for — they would be several hundred metres in diameter rather than several hundred kilometres.

Pictures



Prototype magnet at Danfysik (Copenhagen)



Wybierz typ wycinka z menu lub kliknij przycisk Nowy.

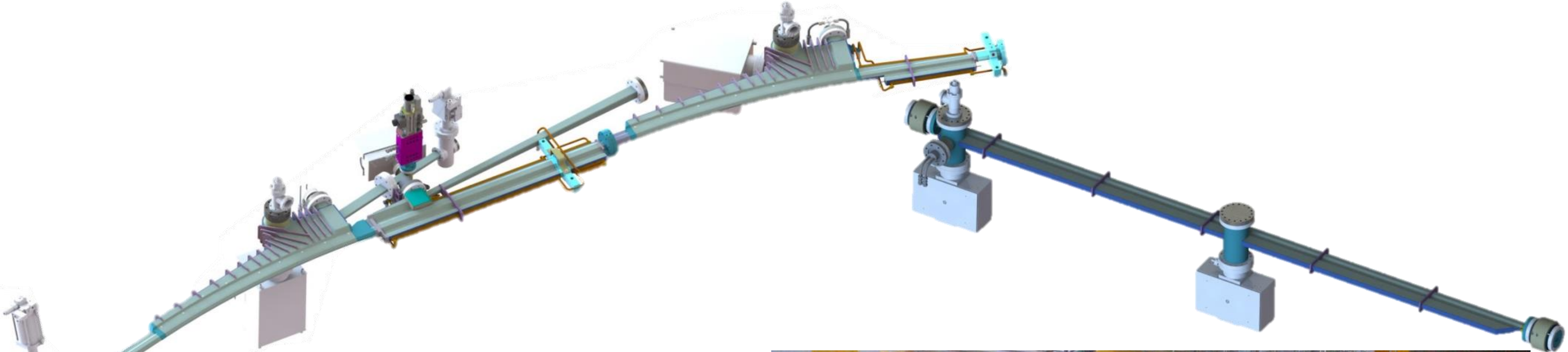
Magnets installation

- First magnet delivery - 2nd of September

- Second magnet delivery – week 37, 2014
- Last magnet delivery –week 45, November 2014)

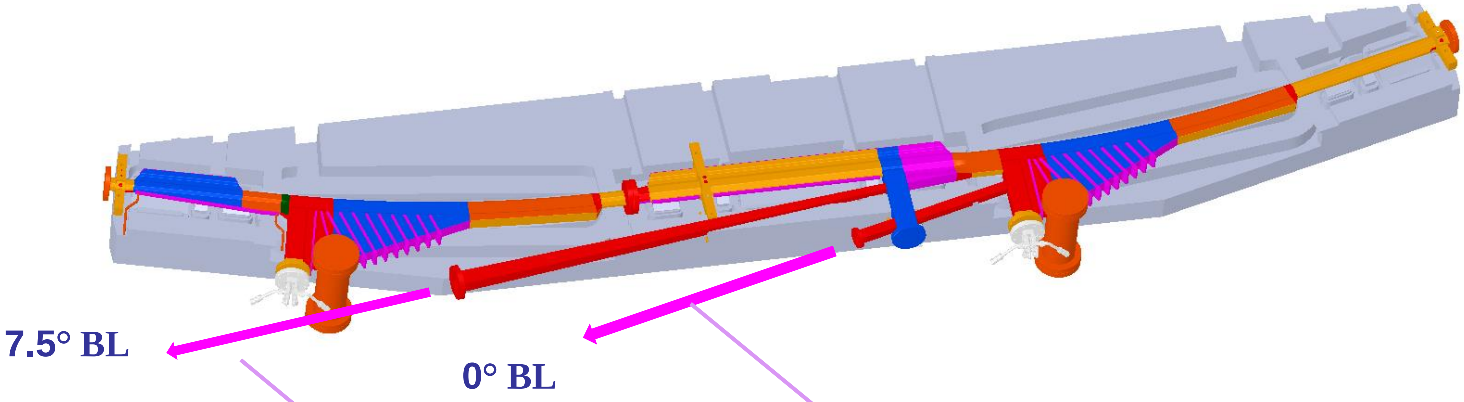
Storage Ring Vacuum Chambers

- Storage ring vacuum chambers manufactured by FMB Berlin



Photon output

Model 3D magnet vacuum chamber



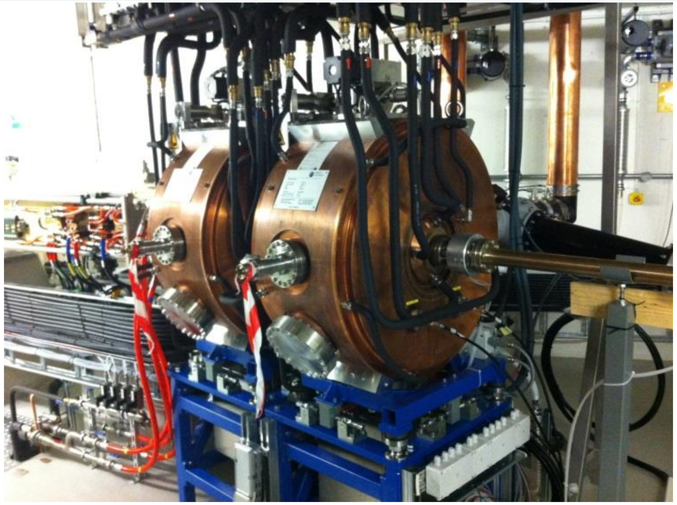
BM photons
± 10/7.5 mrad H/V
Power 113 W

ID photons
± 5/2 mrad H/V
Power : ~600 W

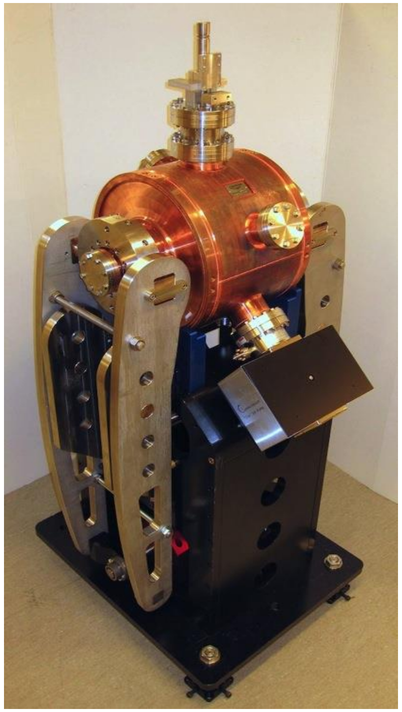
Vacuum Chambers Installation
NCBJ Świerk

RF System

- 2x 100 MHz Main cavities
- Power source –Rhode Schwartz – solid state units 2x60 kW
- 2xLandau Cavities to be installed during winter shut down



100 MHz main cavities



300 MHz Landau cavity

Operation Phase	Final LC
Total LC voltage	487 kV
LC Rsh (=V2/P)	5 MΩ
Total LC Cu losses	16 kW

σ_s=14.2mm →60mm

Operation Phase	Final MC
Energy loss	130 keV
Current	500 mA
Total SR power	65 kW
Total RF voltage	560 kV
Cavity voltage	280 kV
Cavity Rsh (=V^2/P)	3.2 MΩ
Total Cu losses	49 kW
Coupling	2.3
Min. RF station power	57 kW

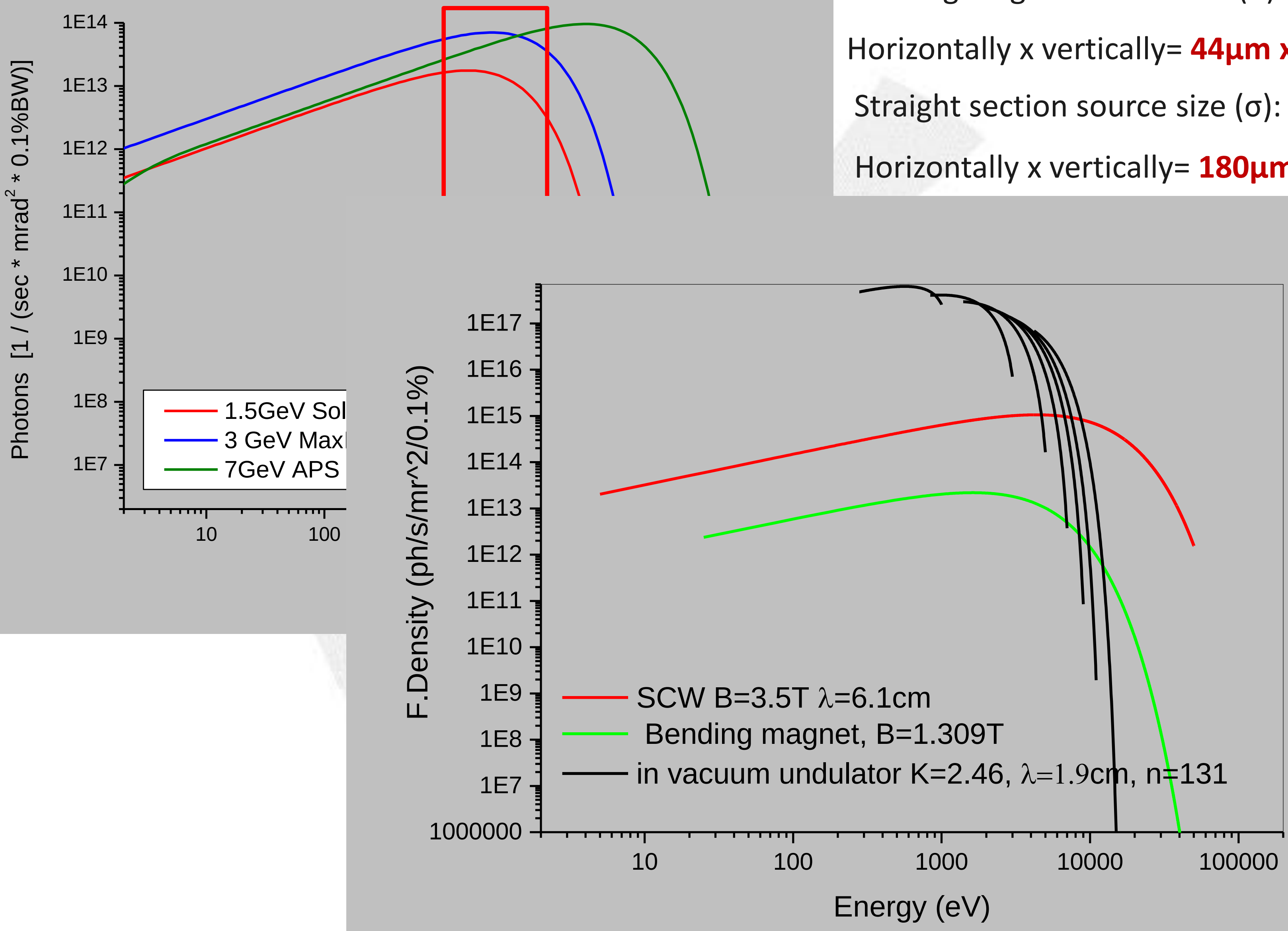
Photon flux

Bending magnet source size (σ):

Horizontally x vertically= **44µm x 30µm**

Straight section source size (σ):

Horizontally x vertically= **180µm x 10µm**



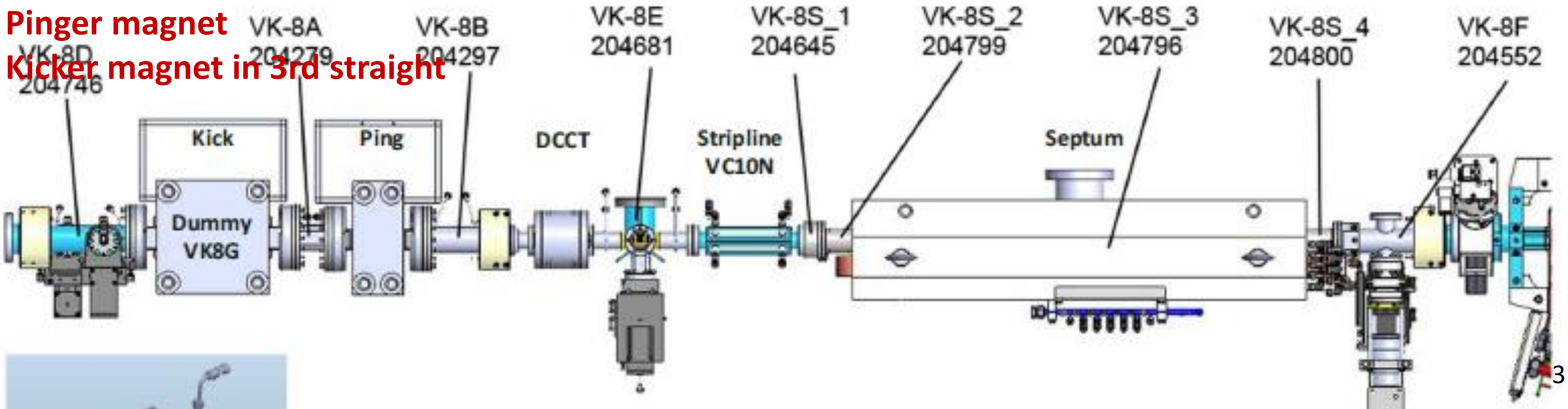
Beam Instrumentation

Injector

- YAG screens with Basler cameras and Tokina lenses – (10+2)
- Stripline BPMs with Libera Single Pass – (8)
- Current transformers with RTO oscilloscopes – (4)
- Faraday Cup connected to oscilloscopes – (2+1)
- Stripline chopper with 500 MHz signal generator

Storage ring

36 button BPMs (3 per cell) with Libera Brilliance+ (SOFB at 10Hz, with future upgrade to 10kHz FOFB)
Vertical and Horizontal scrapers
NPCT current transformer probe
Electrostatic Stripline for tune measurement
YAG screen with CCD Basler camera
Pinger magnet
Kicker magnet in 3rd straight



SOLARIS – comparison

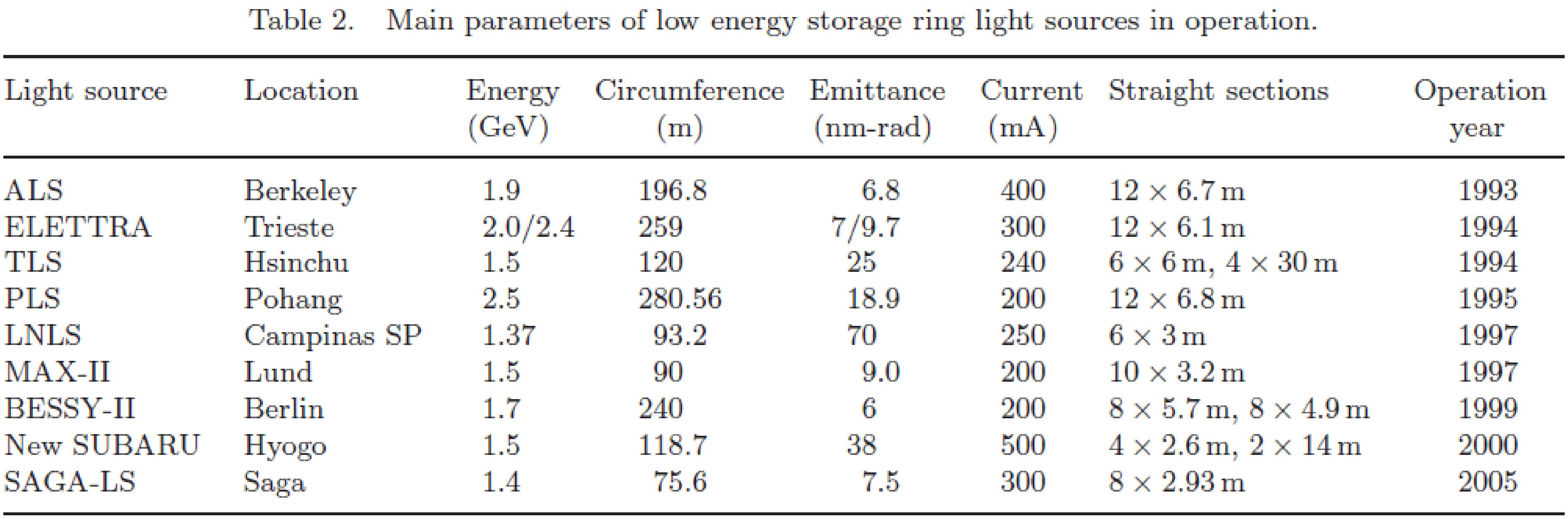
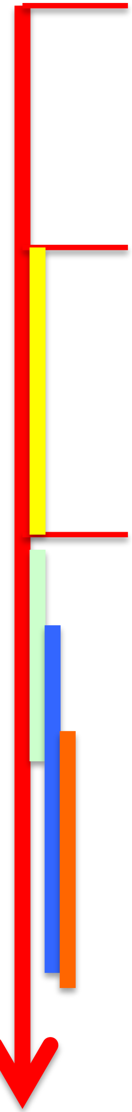


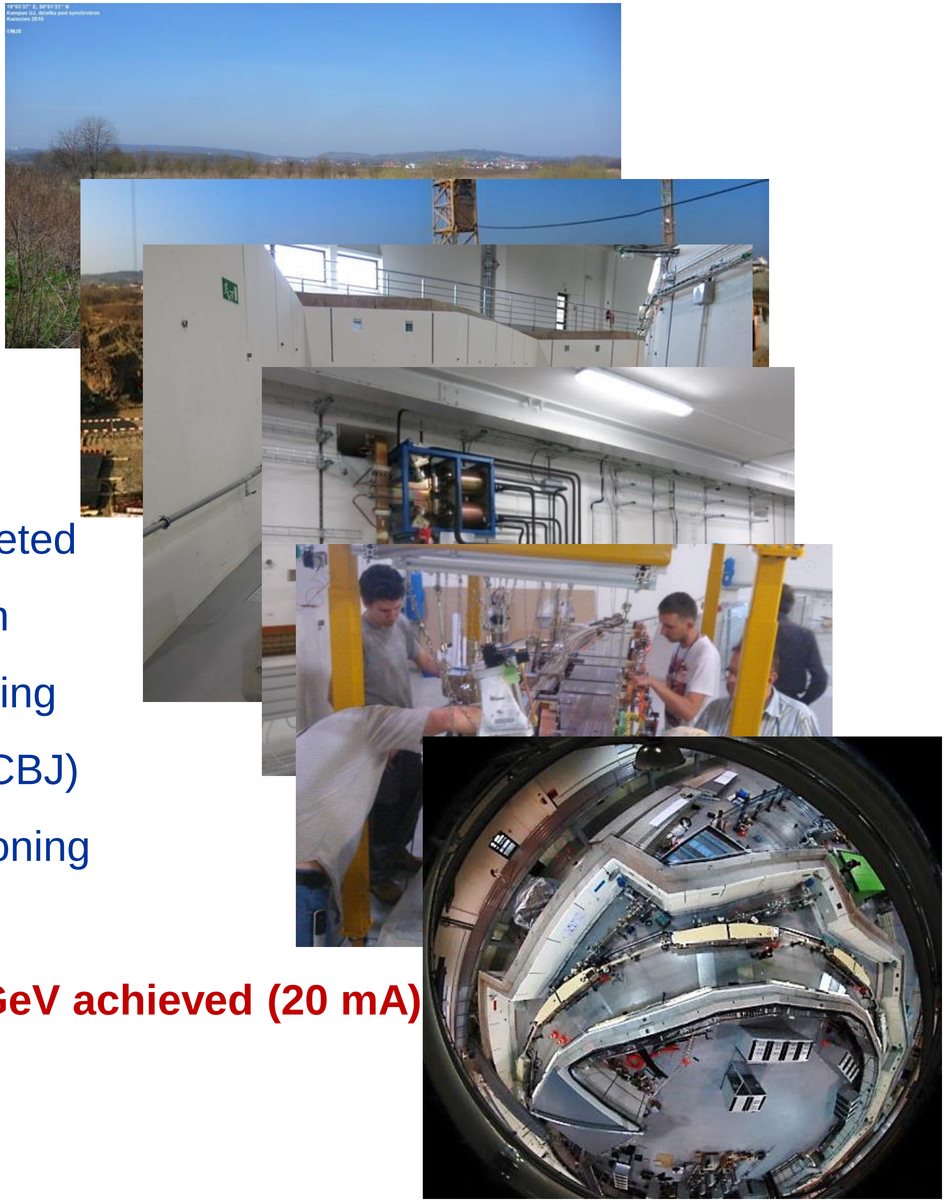
Table 2. Main parameters of low energy storage ring light sources in operation.

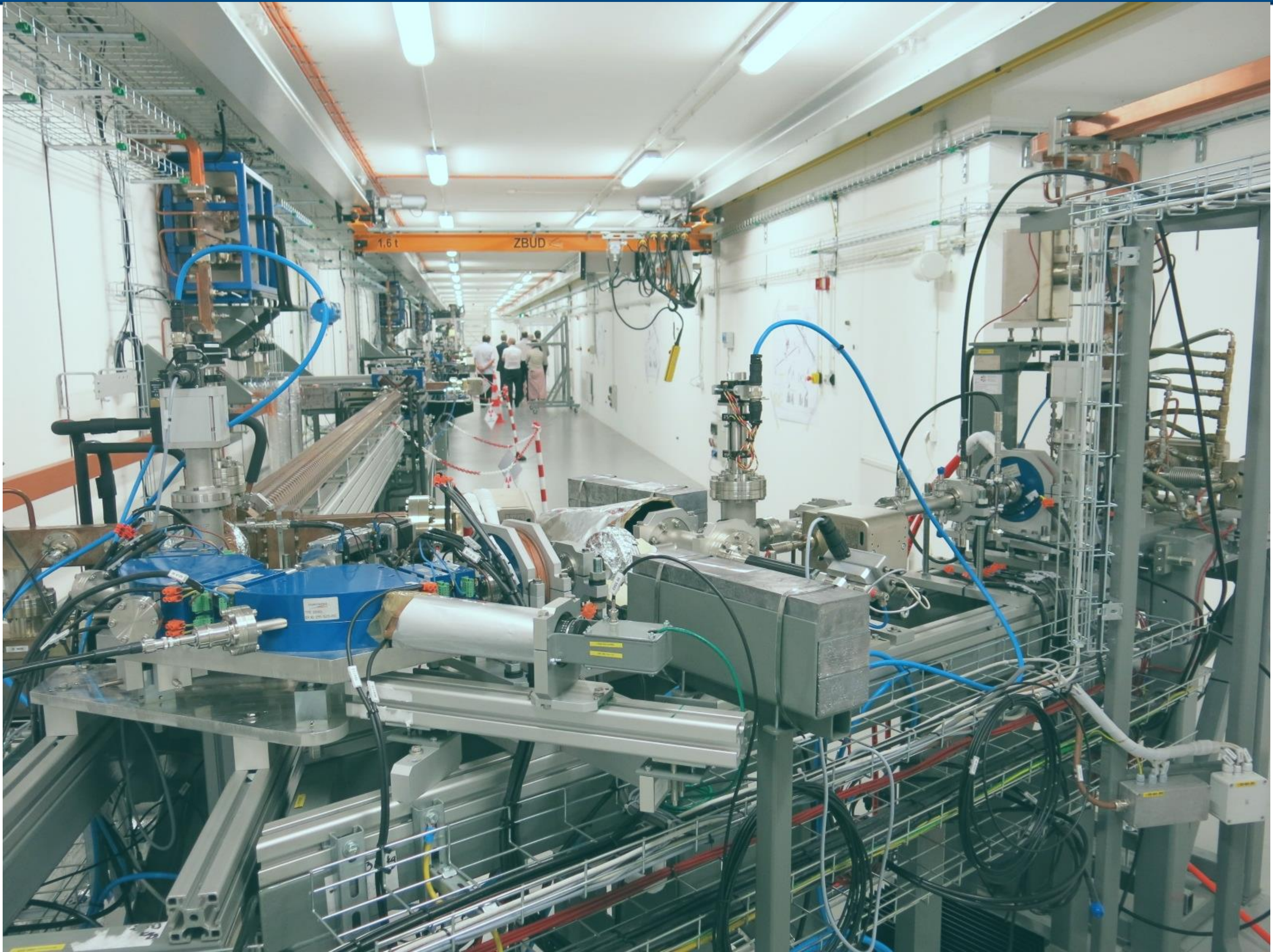
Light source	Location	Energy (GeV)	Circumference (m)	Emittance (nm-rad)	Current (mA)	Straight sections	Operation year
ALS	Berkeley	1.9	196.8	6.8	400	12 × 6.7 m	1993
ELETTRA	Trieste	2.0/2.4	259	7/9.7	300	12 × 6.1 m	1994
TLS	Hsinchu	1.5	120	25	240	6 × 6 m, 4 × 30 m	1994
PLS	Pohang	2.5	280.56	18.9	200	12 × 6.8 m	1995
LNLS	Campinas SP	1.37	93.2	70	250	6 × 3 m	1997
MAX-II	Lund	1.5	90	9.0	200	10 × 3.2 m	1997
BESSY-II	Berlin	1.7	240	6	200	8 × 5.7 m, 8 × 4.9 m	1999
New SUBARU	Hyogo	1.5	118.7	38	500	4 × 2.6 m, 2 × 14 m	2000
SAGA-LS	Saga	1.4	75.6	7.5	300	8 × 2.93 m	2005
SOLARIS	**Kraków**	**1.5**	**96**	**5.6**	**500**	**12 x 3.5 m**	**2015**

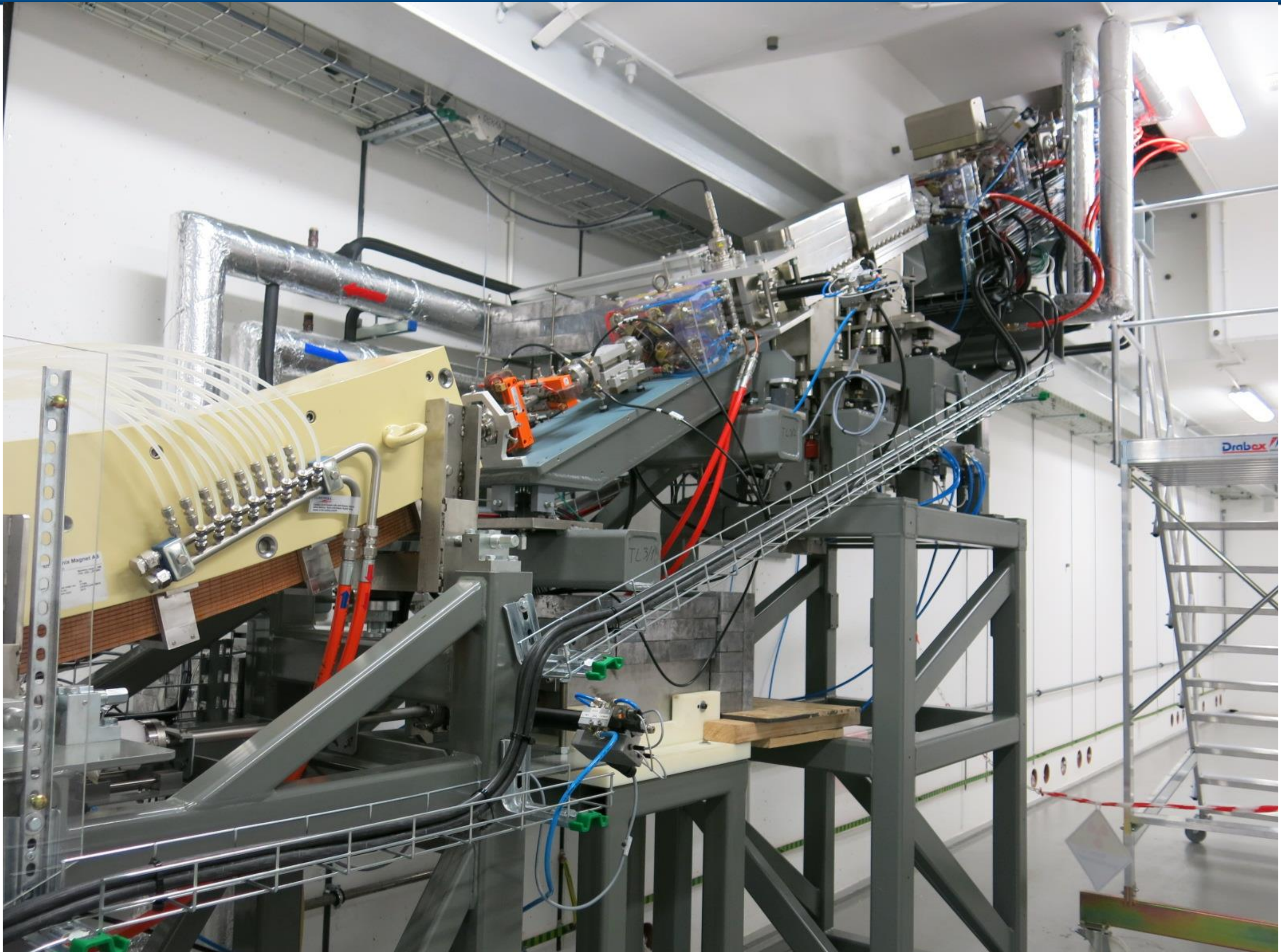
Timetable

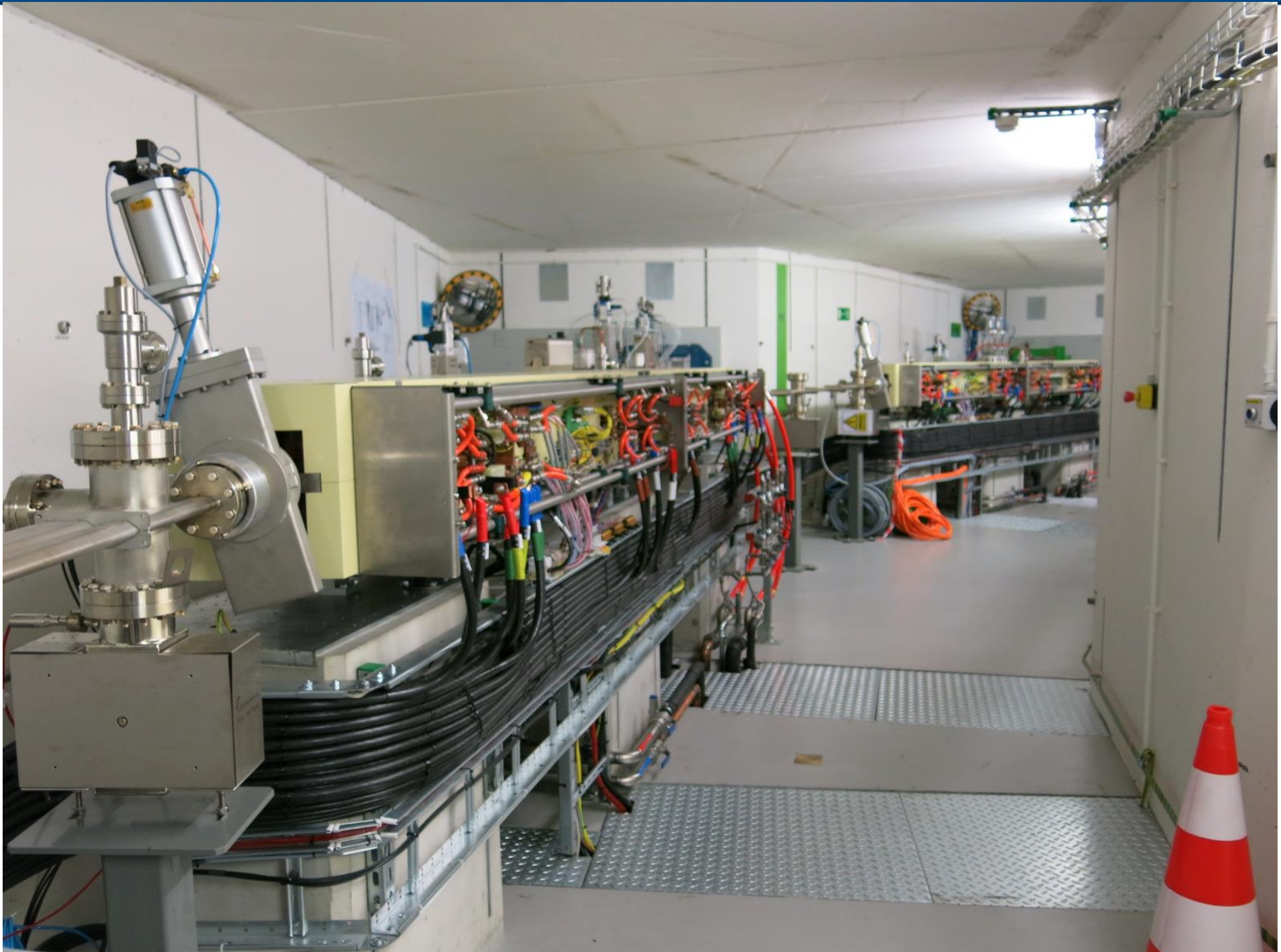


- April 2010 – contract signed JU-MNiSW
- December 2012 – ground breaking
- May 2014 – building construction completed
- June 2014 – start of machine installation
- November 2014 - start of linac conditioning
- April 2015 – storage ring assembled (NCBJ)
- May 2015 - start of storage ring conditioning
- **19th of June 2015 – first light**
- **1st of October 2015 – full energy 1.5 GeV achieved (20 mA)**
- December 2015 – end of the project

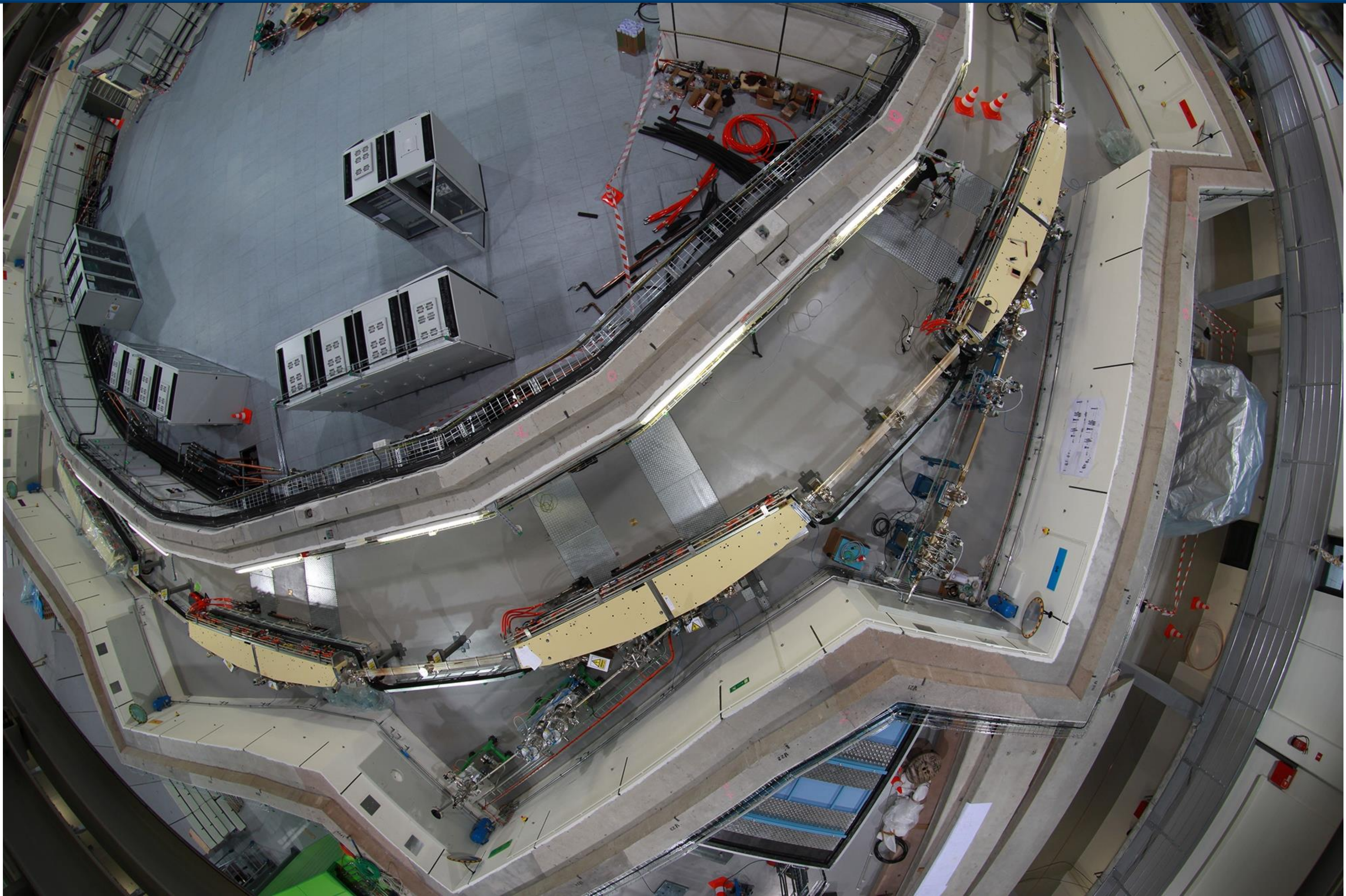



1,6 t
ZBUD

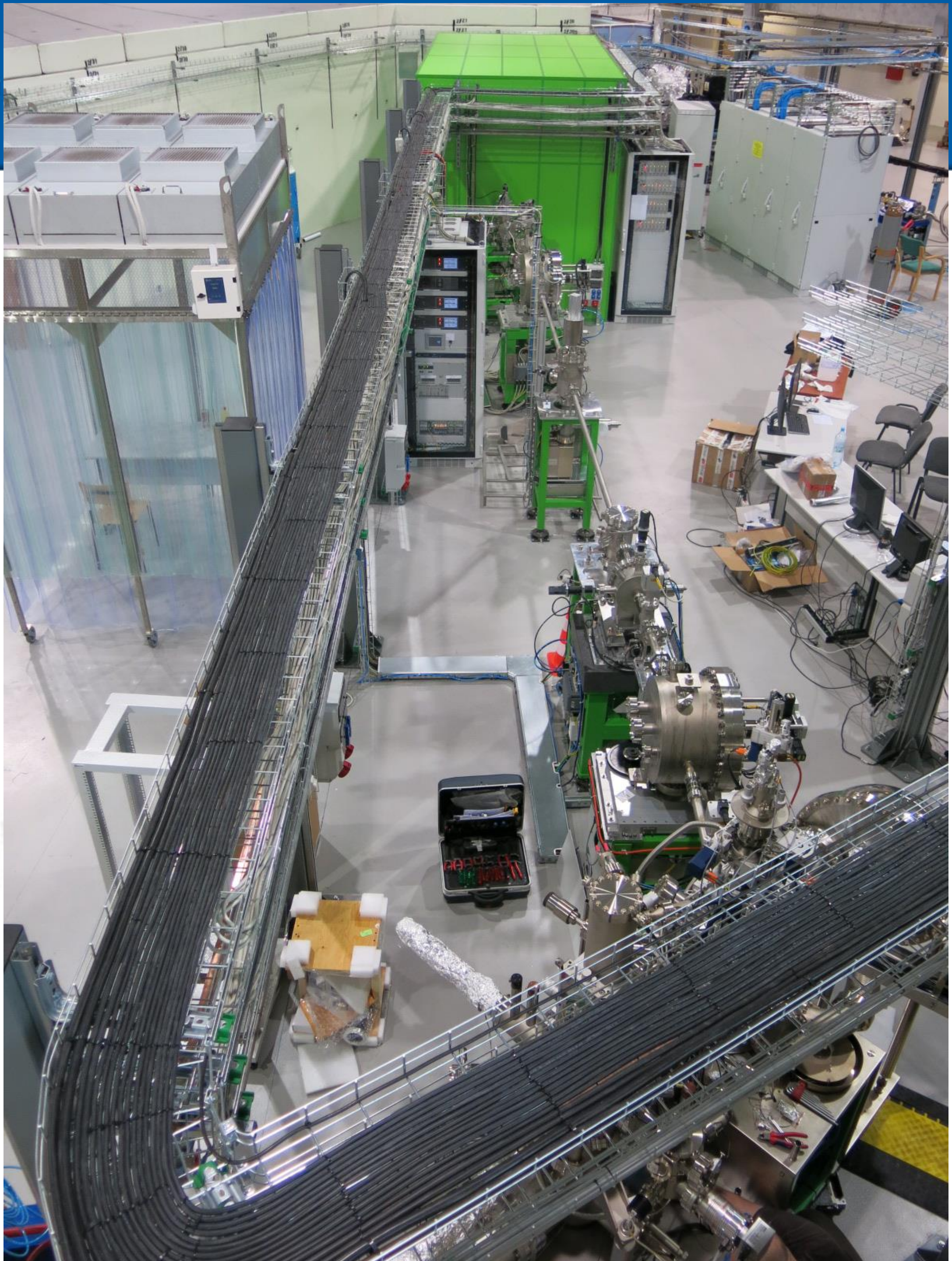

Drabex

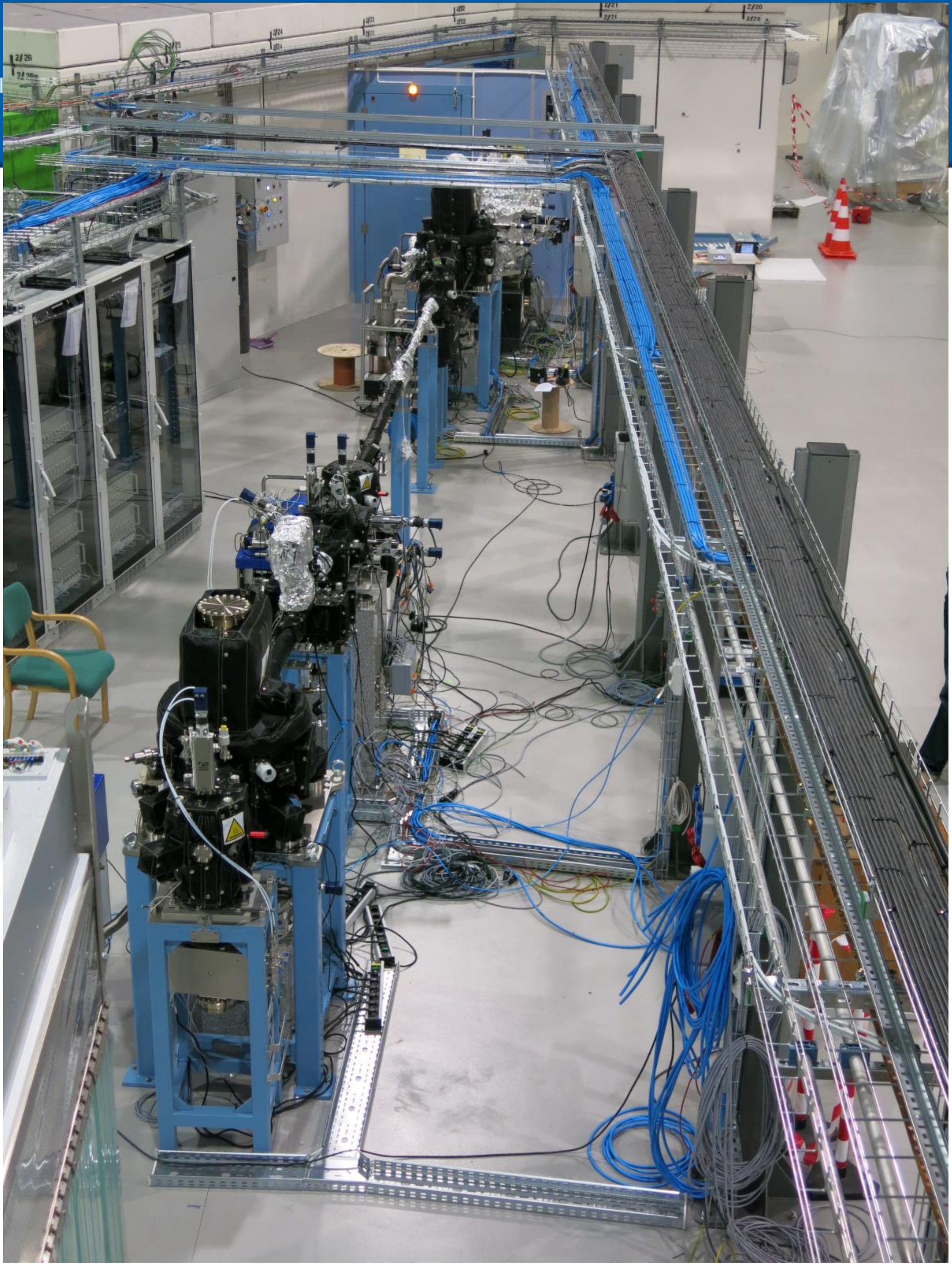


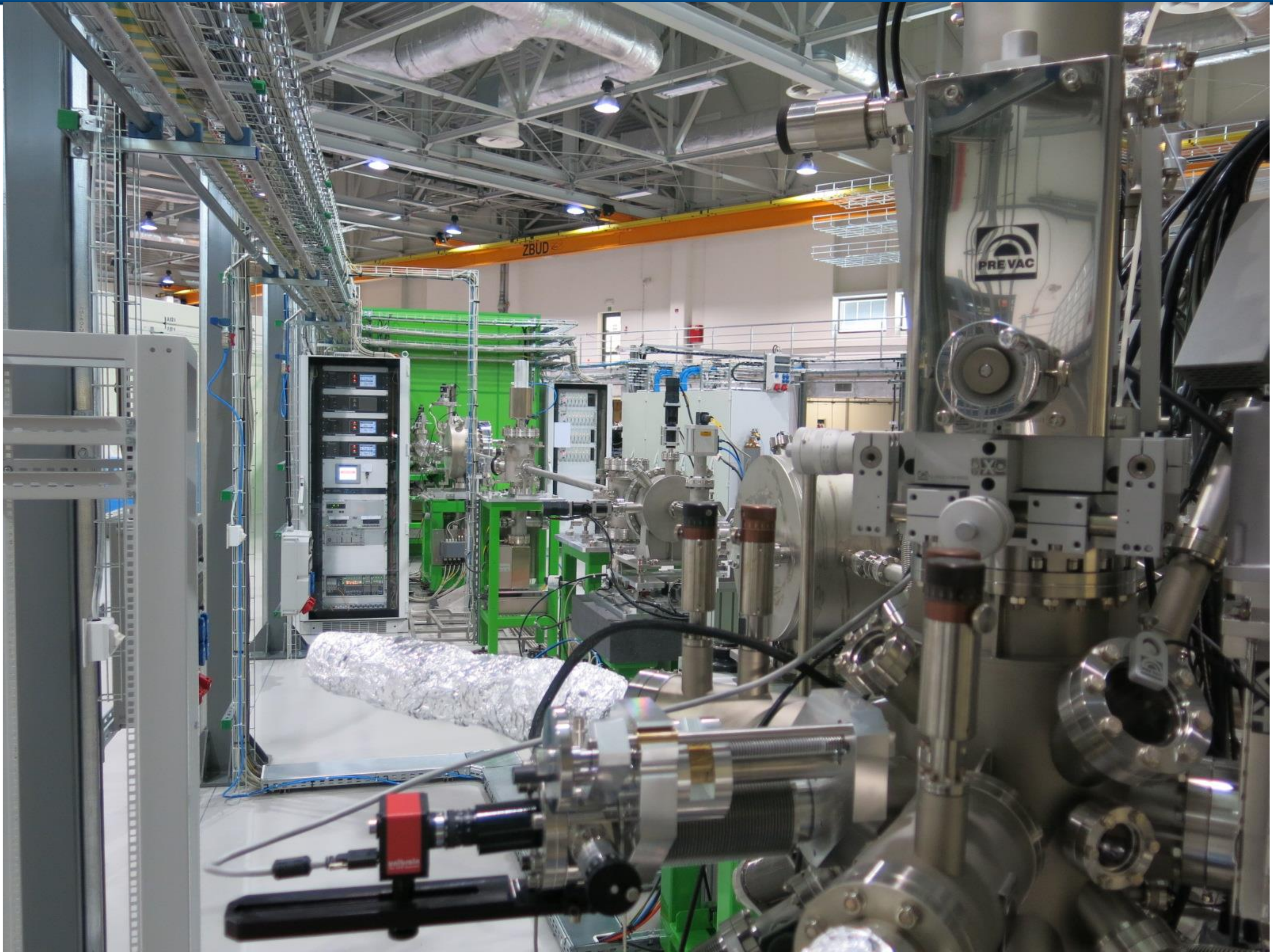

06
Uwaga !
wysokie napięcie
Attention !
High Voltage




2/19
2/19






ZBUD
PREVAC

PEEM/ XAS beamline parameters and layout

- Accesible energy range **200-2000 eV**

- Resolving power **E/dE = 4000** or better

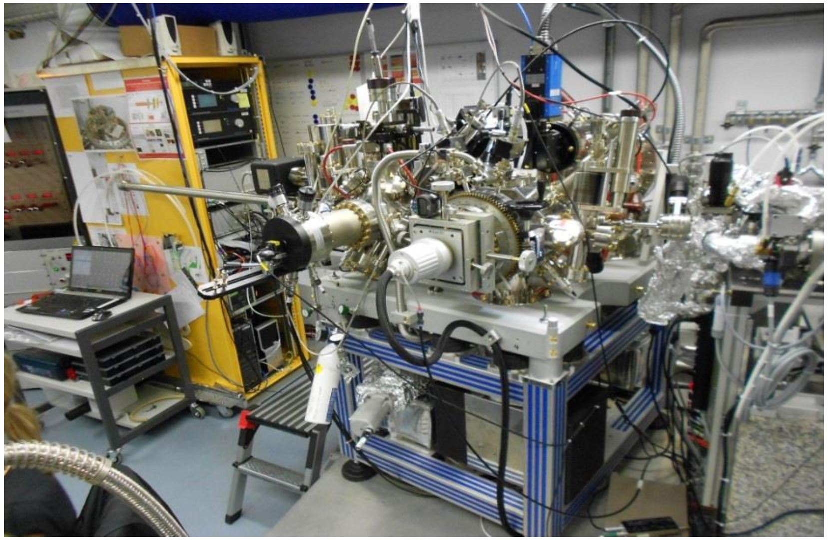
- Beam size in the sample position **100 x 50 µm^2 for PEEM** and **2 x 4 mm^2 for X-ray absorption spectroscopy (XAS)**

- PGM works in the collimated light

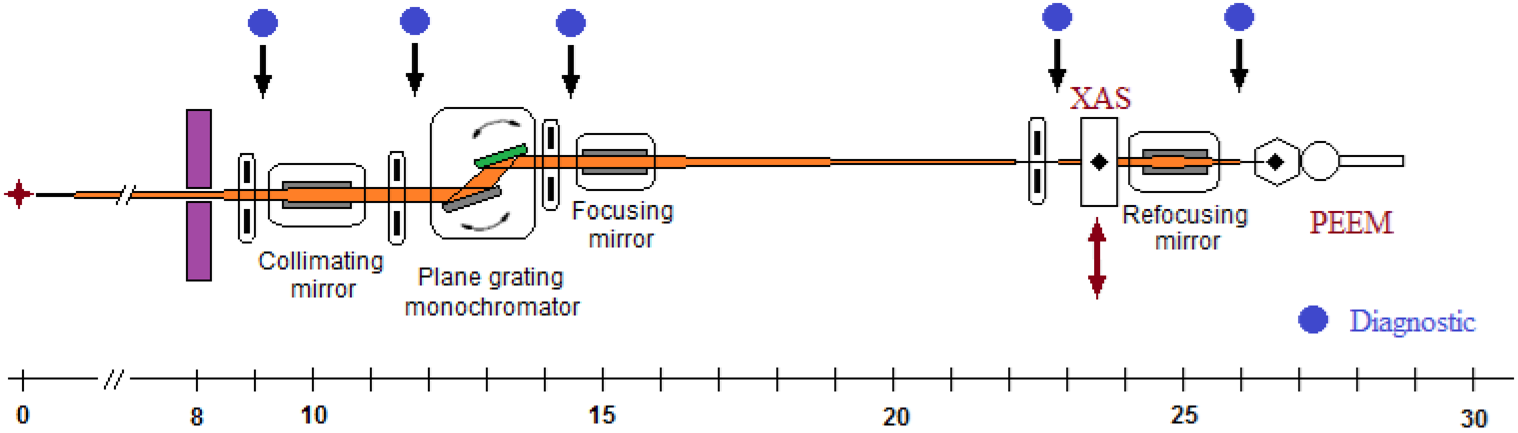
- Fixed exit slits

- Access to linear and circular (elliptical) polarization light

- Two end stations (PEEM and XAS chamber with TEY at pressure up to 10mbar)



March 2012: PEEM at Swiss Light Source
Nowadays: Krakow, Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences



UARPES beamline parameters and layout

Quaziperiodic undulator parameters

- Magnetic periods: **120mm**
- Electron Energy: **1.5 GeV**
- No of periods **N= 21**
- Gap min: **18 mm**
- Gap max: **220 mm**
- Total power: **600 W**

Monochromator

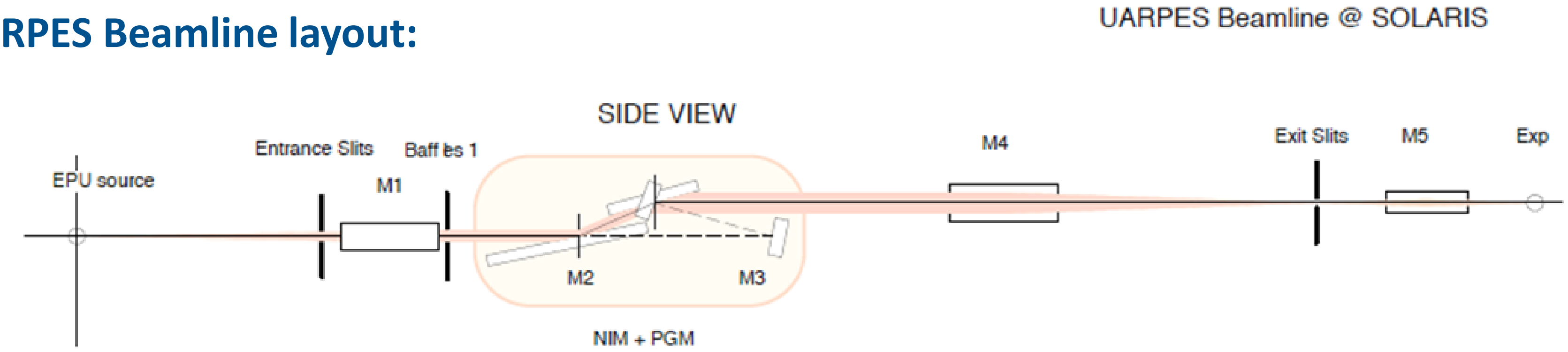
Two configurations:

- Normal Incidence (NIM) to operate in **8-30 eV**
- Planar Grating (PGM) to operate in **16-100 eV**

Other parameters

- Resolving power **≥ 20 000** over the full energy range
- photon flux on the sample **≥ 5x10^{11} photons/s** @20000 RP,
- available polarizations: linear: vertical, horizontal, inclined; circular; elliptical,
- higher harmonics at the sample position reduced below 1%,
- excited spot size on the sample **< 200 x 200 µm**

UARPES Beamline layout:



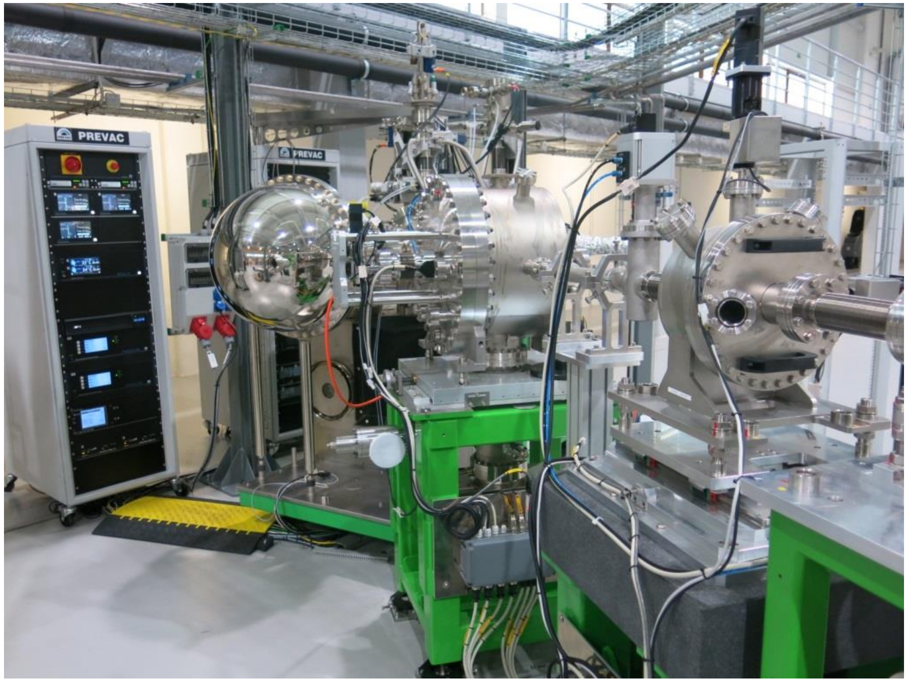
UARPES beamline parameters and layout

UARPES endstation parameters:

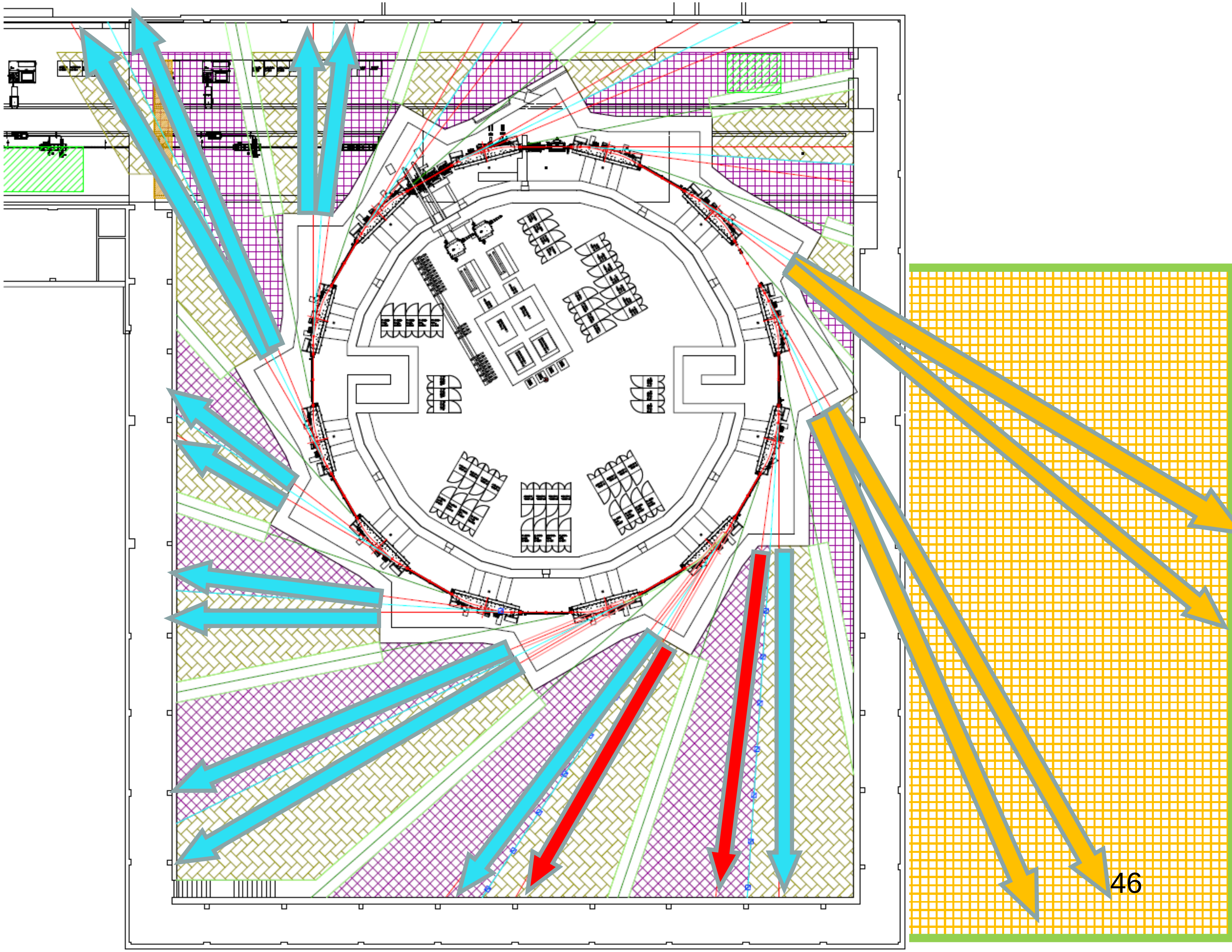
Scienta DA30-L XPS/UPS/ARPES analyzer

(this version allows for the combination of a 40 mm MCP and Scienta spin (Mott or VLEED)

Lens acceptance angle:	38º full cone
Angular resolved range:	± 15º full cone
Angular resolution:	0.1º for 0.1 mm emission spot
	0.4º for 1 mm emission spot
Analyzer radius :	>180 mm
Energy resolving power:	1750 (4000 - under optimal experimental conditions)
Energy resolution:	1.8 meV
Pass Energy:	2 - 200 eV
Kinetic energy range:	
Transmission mode:	0.5 - 1500 eV
Angular mode:	3 - 1500 eV
Deflection mode:	3 - 200 eV



SOLARIS - layout



Differences between MAX IV and Solaris 1.5 GeV

- **Linac and injection energy** – Solaris will us a reduced number of accelerating sections and injection will not be at full energy
- **Transfer line** – layout and support systems (beam heights and transfer line lengths) will be different although the same magnets will be used as for MAX IV.
- **Injection** with dipole kicker - MAX IV 1.5 GeV will use a pulsed kicker to the first vertical deflection magnet, this option will not be used for Solaris.
- **Ramping -** Power supplies for magnets will have to be ramped and the control system adjusted for this. Tune and optics feedback may have to be implemented.
- **Front ends** – differences in terms of components and distances between machine and the inner side of the shielding wall, the thickness (and type of concrete) and continuation into the experimental hall.
- **Beamlines** – the bending magnet beamline will be unique to Solaris and will require it own components, control system and electronics.
- **Future insertion devices** – SCW (placement, installation, beam dynamics)
- **Building and Services** – Buildings, shielding, general services, access areas, transportation on the site and logistics are different
- **Installation**

Project challenges

- First large scale facility project in PL
- EU money - strict regulations – tendering procedures, deadlines
- Uniqueness of the project
    - Special – unique equipment (design and manufacturing)
    - Very demanding infrastructure
    - Installation know how
    - Integration know how
    - Shortage of experts
- New challenges for administration at all levels

SOLARIS future – stage II

- New beamlines
  - Room for another 12-14 beamlines and endstations, subject of funding. Conceptual designs of some of them are already emerging.
- Linac extension - full energy injection (1.5 GeV)
  - => top-up mode; 24 hrs operation
- Experimental hall extension – more beamlines

SOLARIS context

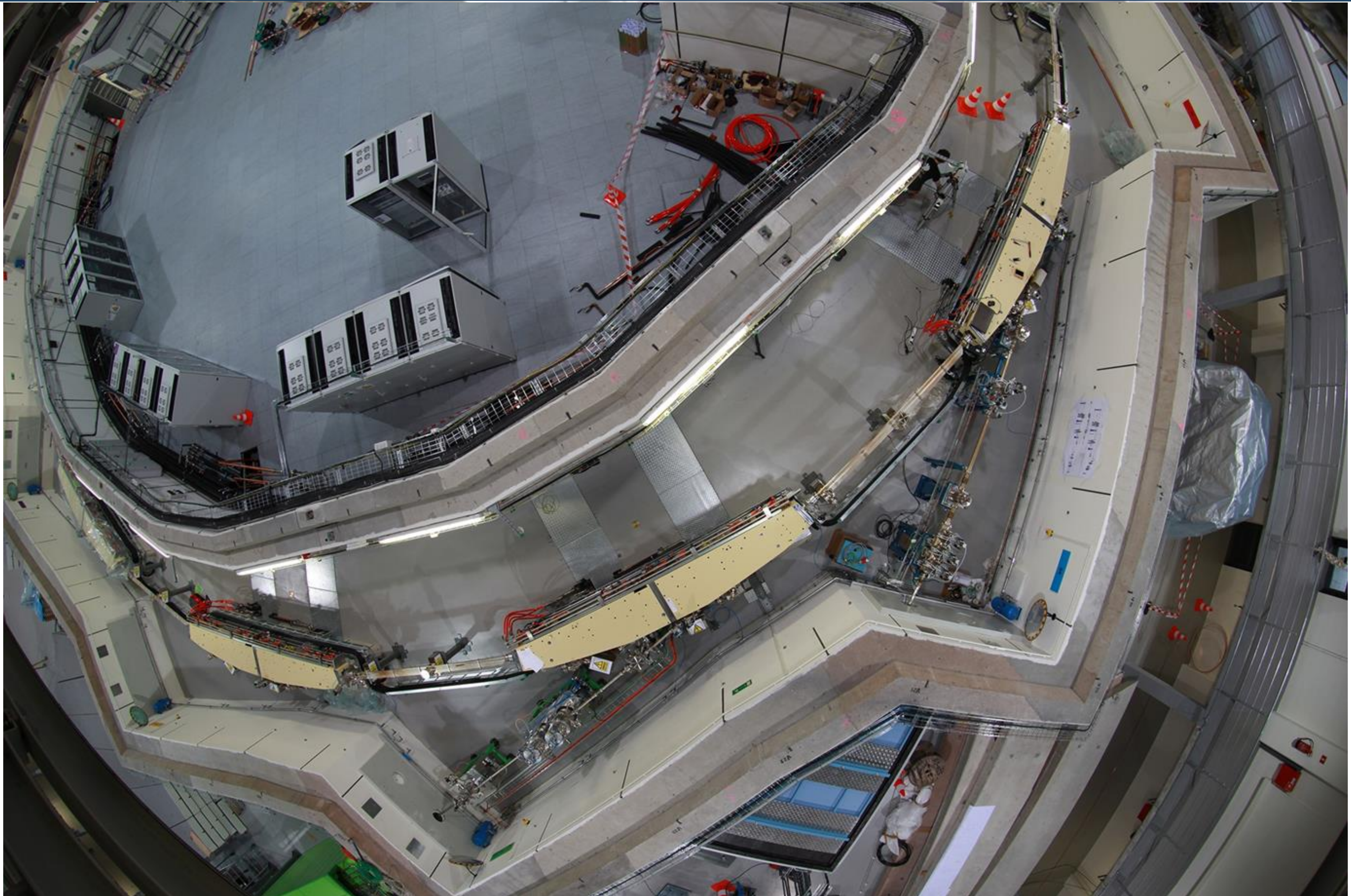
- The Polish synchrotron is going to be the first **research infrastructure of such substantial size and potential constructed in this part of Europe**

- The synchrotron, being a **large-scale, multi-user and multidisciplinary facility** represents a very **efficient investment in research infrastructure** by providing state-of-the-art research opportunities for many research groups

- The expected **benefits** are **not limited only to the scientific community**

- The availability of such a technologically advanced facility also **contributes to developments in** such areas like enhancing **education and training**, stimulating **hi-tech companies** and services, providing new options for the **research oriented industry, creation of new jobs**

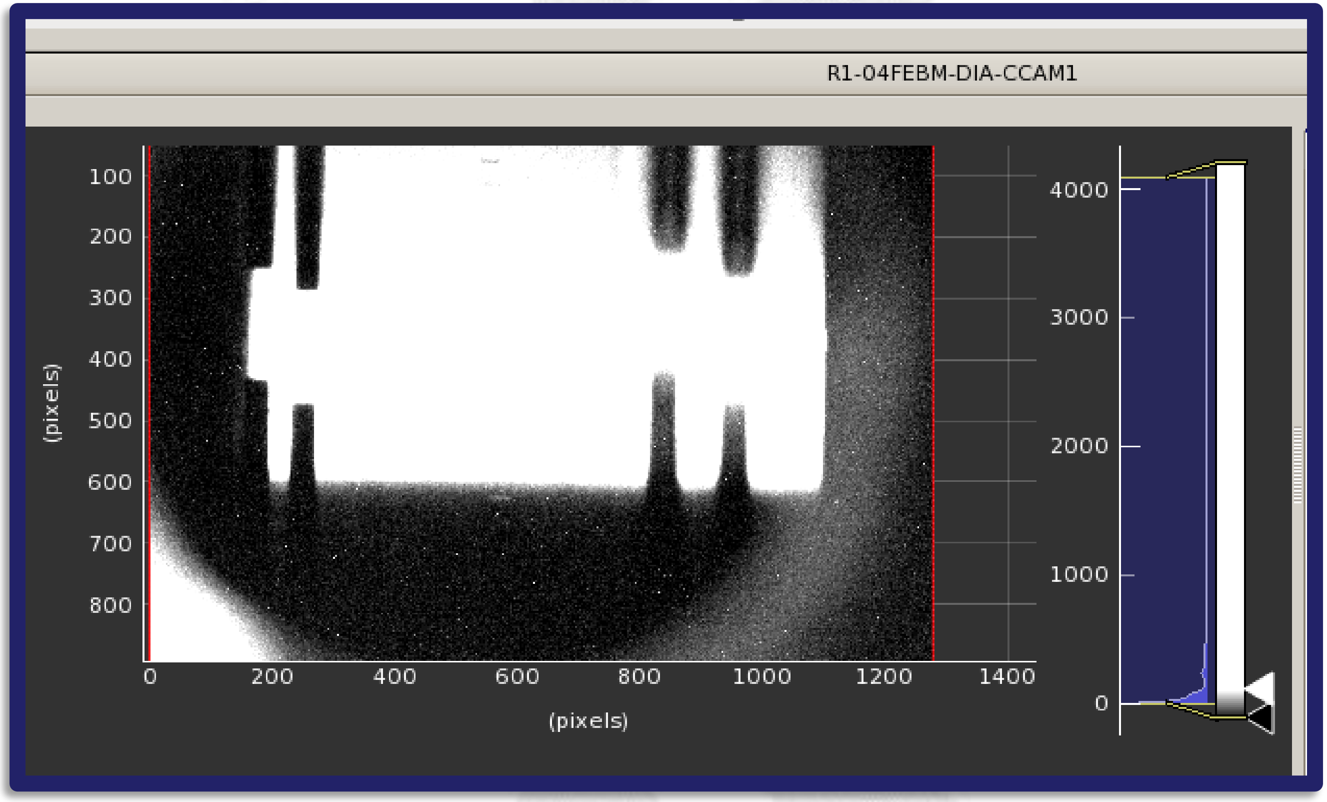
- **Solaris – Polish Research Infrastructure Roadmap Facility**



Solaris first light!!!

Injection Energy: **490 MeV**

Stored current: **5.2mA**



Photon beam at PEEM beamline front-end recorded on YAG screen monitor

Large research infrastucture mission

Huge spectrum of interaction

Access to the unique, state of the art infrastructure

Region development

New, unique research option, break-through experiments

Consolidation of resources and man power

User’s comfort

Very effective usage of resources and potential

Information, ideas exchange, research stimulation

Benefits for partners, consortia members (in-kind contributions, technology transfer)

Consolidation of know-how

Large infrastructure cost

1 km autostrady – **10 MEUR**

JAGIELLONIAN UNIVERSITY
IN KRAKOW

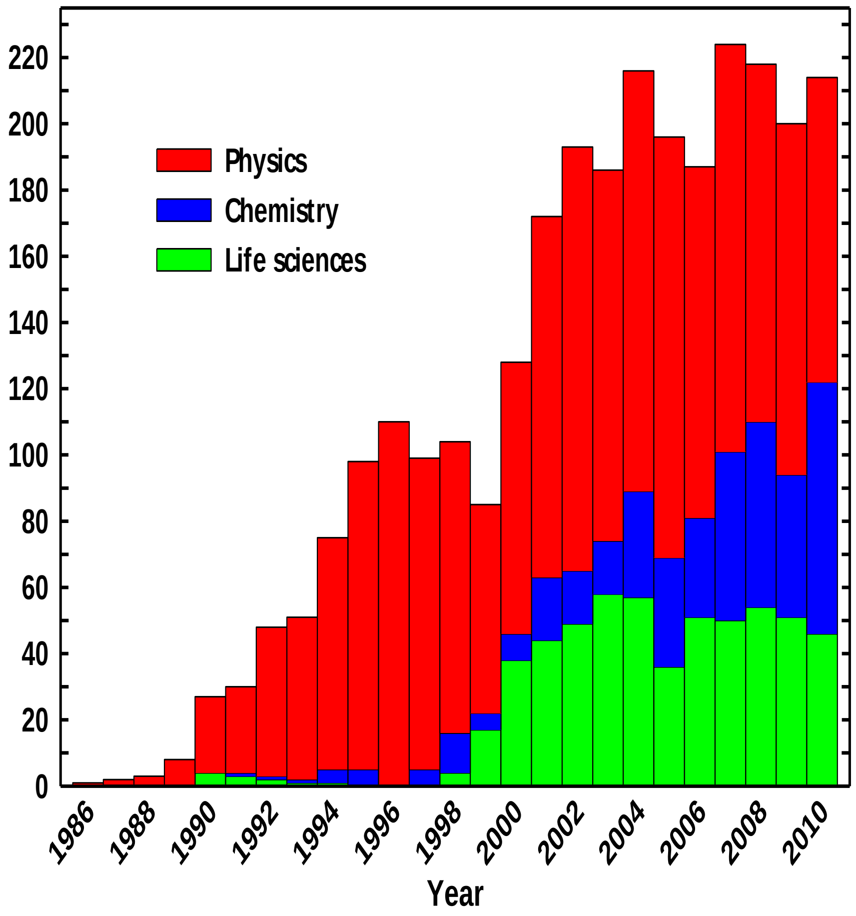
Large infrastructure cost

SOLARIS
NATIONAL SYNCHROTRON
RADIATION CENTRE

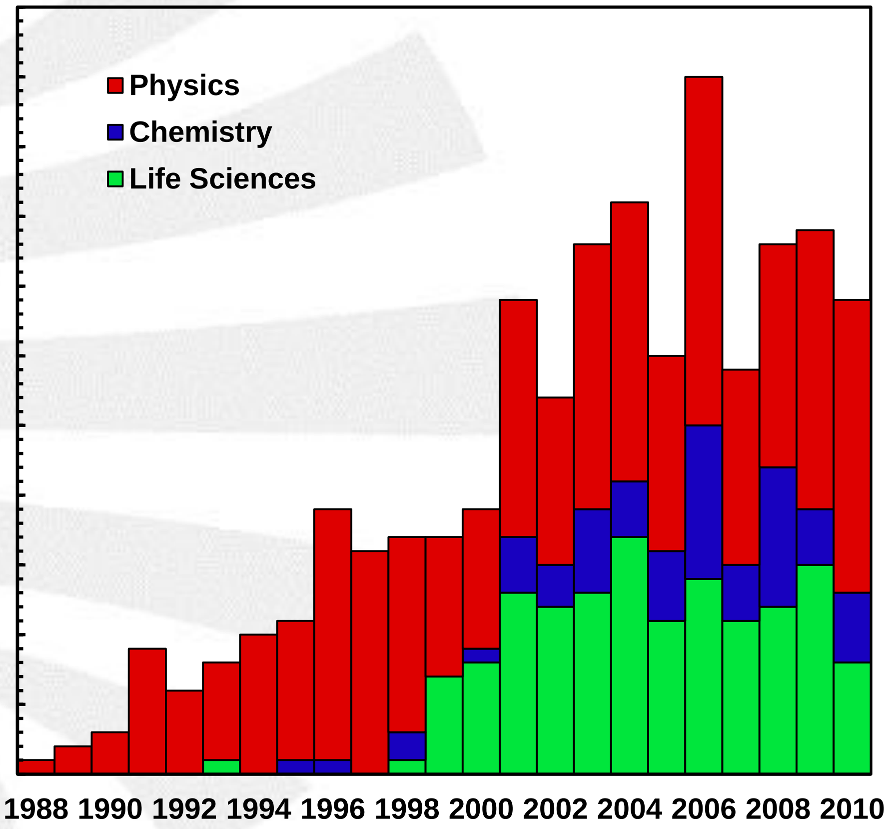
Synchrotron SOLARIS – **50 MEUR**

MAX I-III in Lund: more than 2 decades of activities – success story

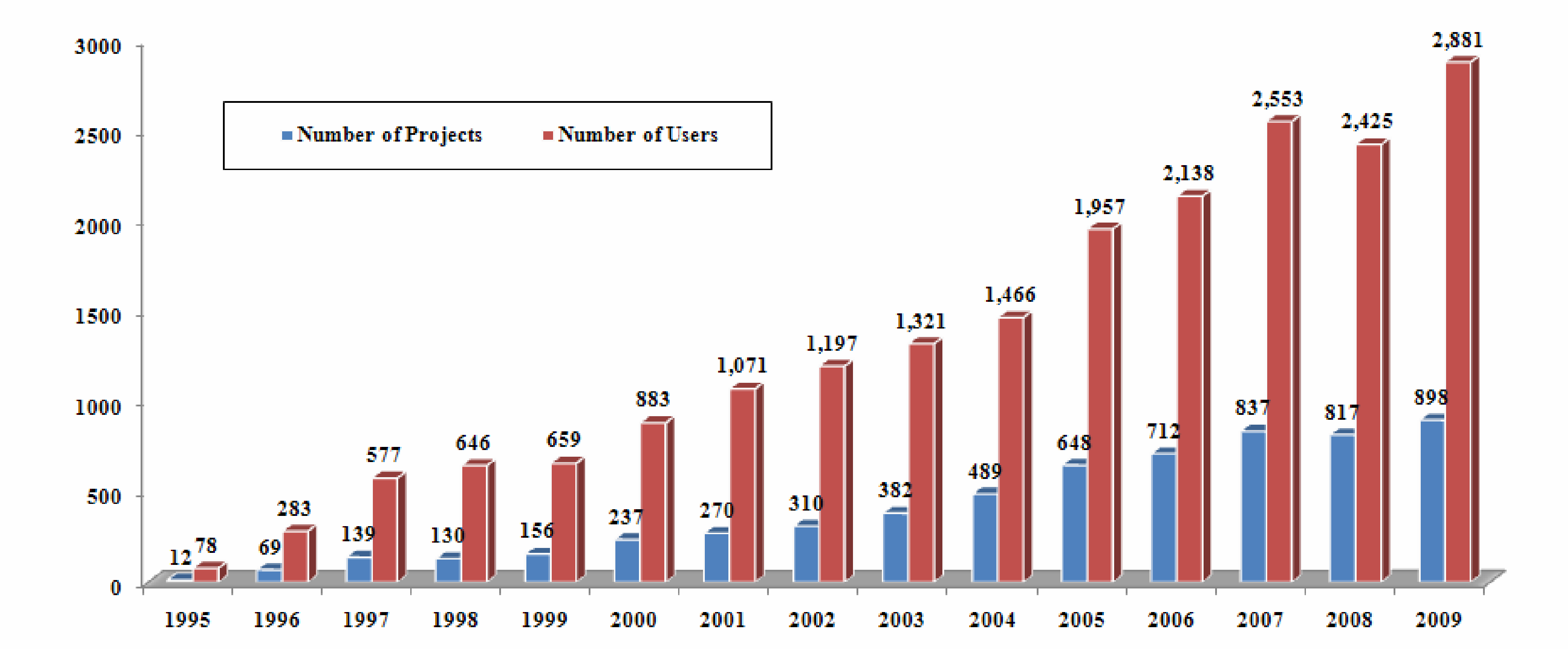
Publications 1/day



PhD thesis 1/week



Number of users and projects @ Pohang Light Source (South Korea)



SOLARIS @ Jagiellonian University new Campus:
ul. Czerwone Maki 98, Kraków 50^{o}01’21” N:19^{o}53’37” E

Collaboration

- **Project success relied on exemplary transnational collaborations**
- **FOREMOST - The freely given design of the MAX IV 1.5 GeV ring and its injector technology by MAX-lab**
- **MAX IV – Solaris Collaboration:**

  Training and exchange of personnel

  Exchange of ideas and requirements

  Collaboration in procurements and contract specifications: Procurements for Solaris were as options in MAX IV tenders

  Provision of state-of-the-art components: Gun System, Landau cavities, modifications to vacuum chambers and magnets

  Technical support with industrial follow-up and FATs

  Maximised return for cash by allowing industry to plan for double purchase orders

Collaboration

Elettra-Sincrotrone Trieste - Expert advice, contracts for PSS, design of transfer line, vacuum chamber components, beamline and front-end, EPU insertion device

Swiss Light Source - Bake-out oven and control, expert advice, training

Diamond - Expert advice

Soleil - Expert advice, commissioning software

ALBA - Expert advice, commissioing software, training

ESRF - IcePAP motion controllers, Expert Advice

Machine Advisory Committee – Expert advice of 5 world class experts from Diamond, Soleil, PSI

National Centre for Nuclear Research, Świerk - Vacuum system installation inclusive of linac, storage ring and RF cavities.

Polish Synchrotron Consortium (36 universities and institutes)

Polish Synchrotron Radiation Society

Polish Physical Society

PL-Grid

Institute of Catalysis and Surface Chemistry PAS – PEEM End Station

Cracow University of Technology

Acknowledgements

SR international community

MAX-lab Team

Machine Advisory Committee:

Albin Wrulich

Richard Walker

Amor Nadji

Jim Kay

+ Dieter Eifeld

Carlo Bocchetta for joinig Solaris Team

Thank you for your attention!

http://www.synchrotron.uj.edu.pl/
http://www.lightsources.org