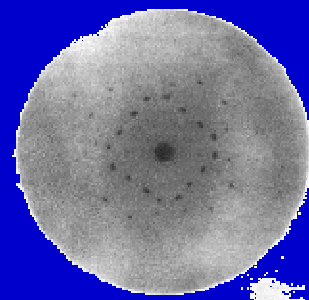
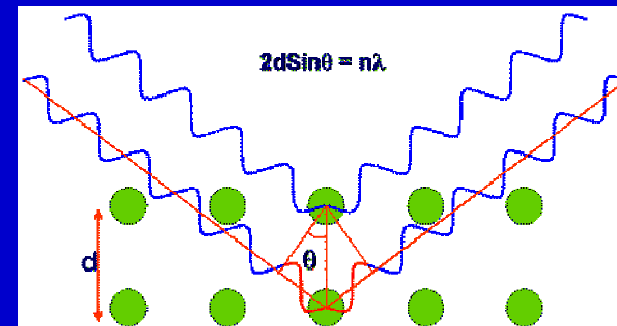
Synchrotrons, free-electron lasers and the activity of the Hungarian synchrotron radiation community

An introduction to the subject and
mutual introduction of the participants

XFEL Workshop on Possible In-Kind Contributions from Hungary
19 December 2006, Budapest

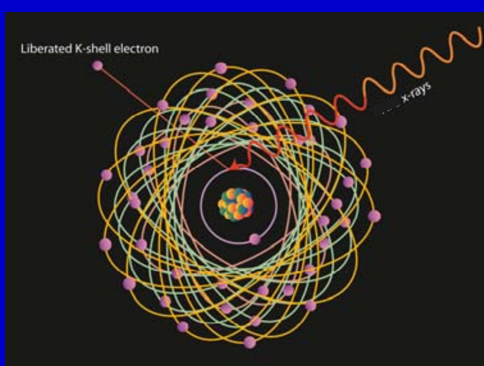
Early history of X-rays: the experimental methods

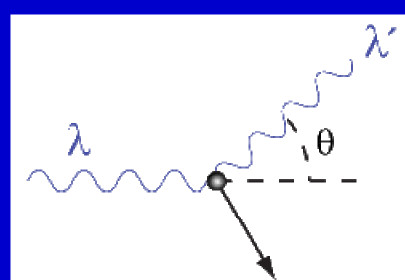




1895: W.C. Röntgen
plain radiography
(photoelectric effect)

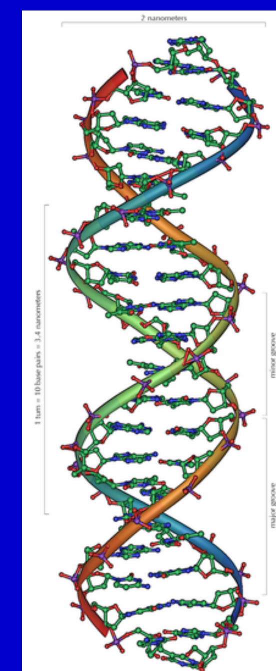
1912: M. v. Laue, P. Knipping:
diffraction of X-rays





1923: Compton effect

1953: J. Watson,
F. Crick: the DNA
double helix



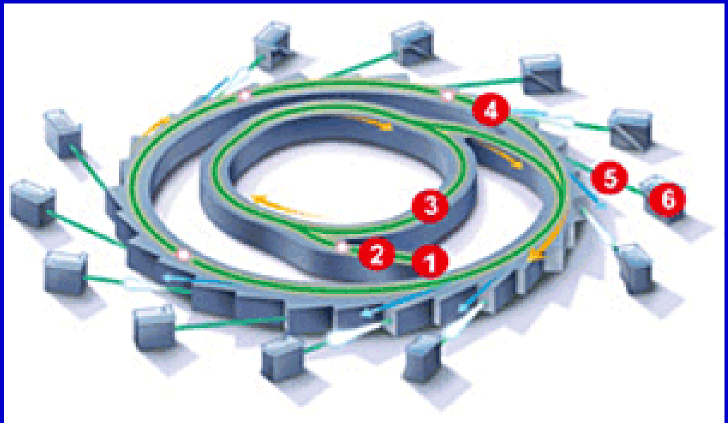
Development of X-ray sources

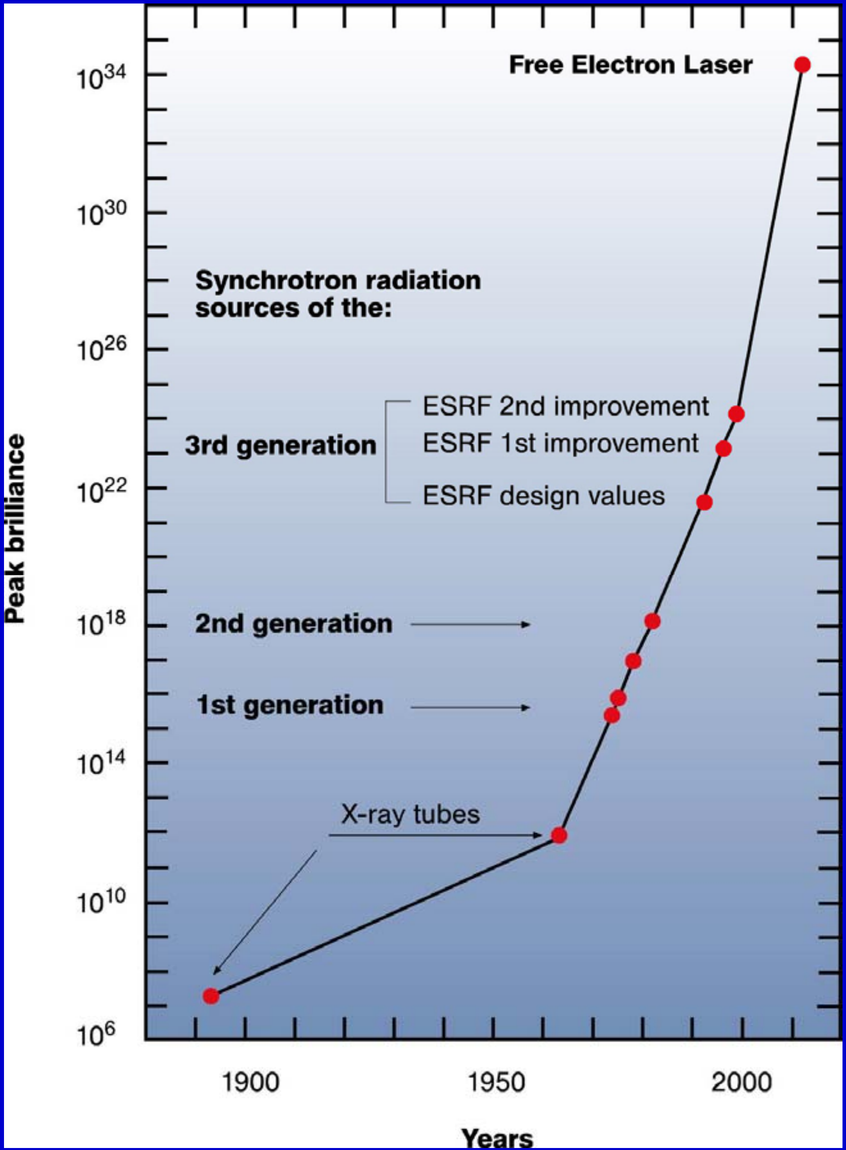
1895 – 1965: X-ray tubes

1965 – 1995: 1st and 2nd generation synchrotrons

1995 – 2005: 3nd generation synchrotrons

2005 – free-electron lasers

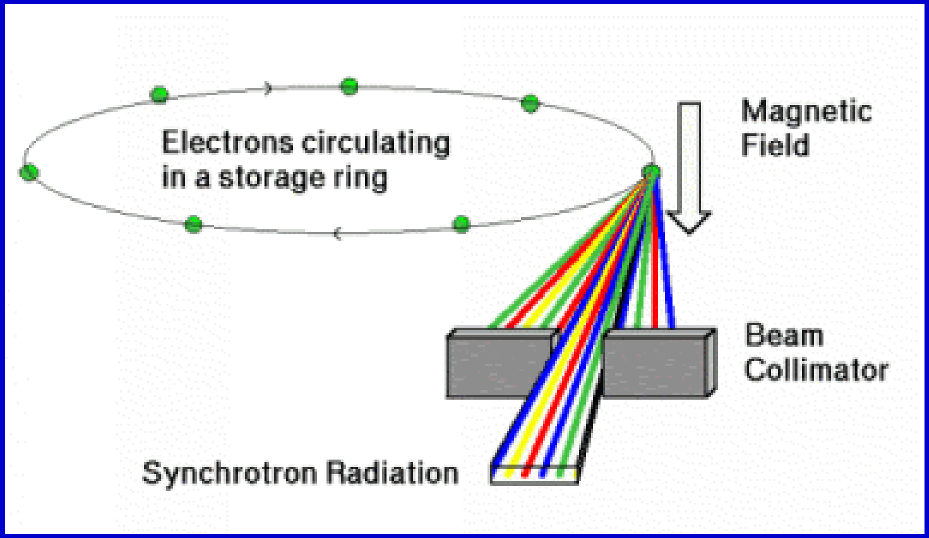




Synchrotron radiation

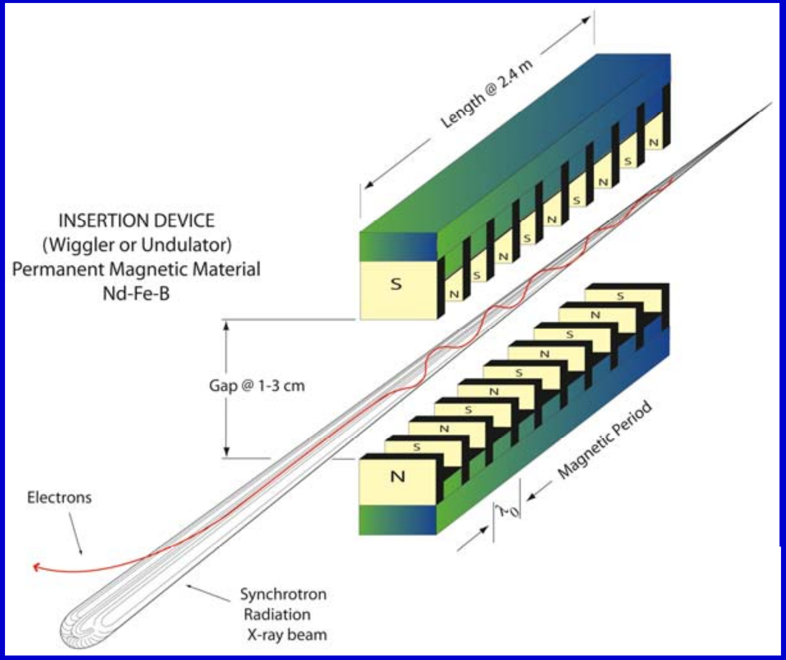
1st and 2nd generation synchrotrons:

radiation from bending magnets

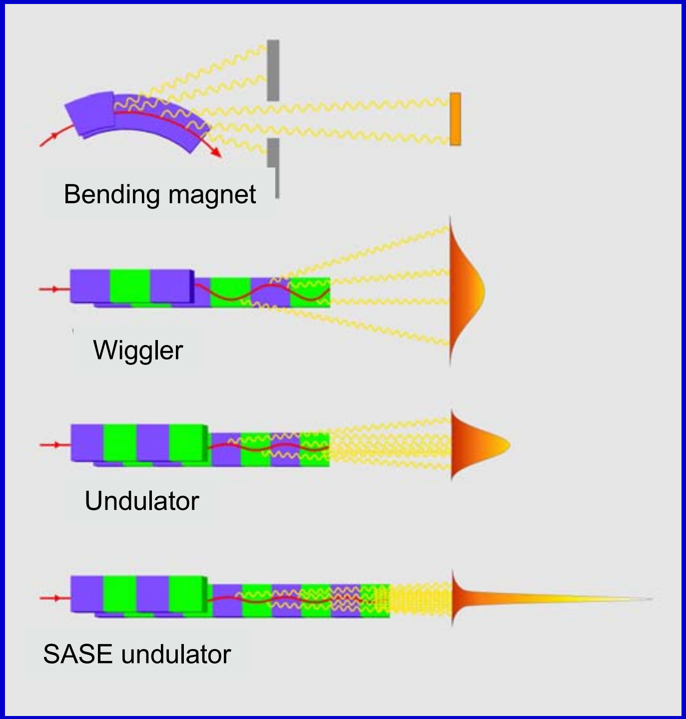


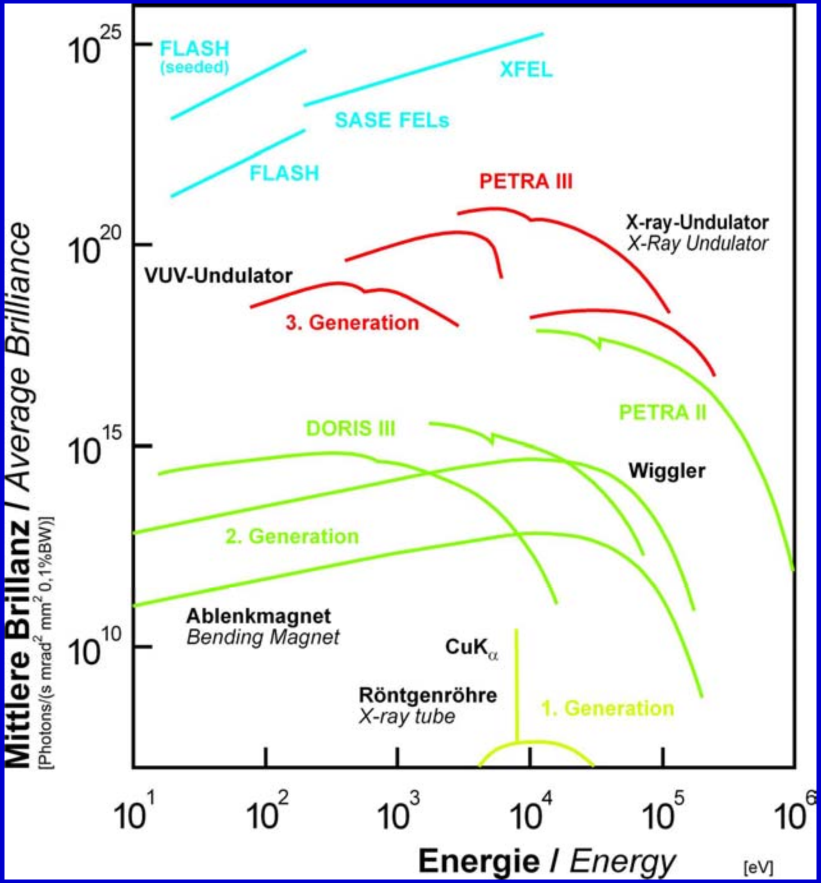
3rd generation synchrotrons:

radiation from insertion devices



Synchrotron and FEL radiation sources





Spatial distribution and coherence properties

Energy distribution (brilliance)

Properties of synchrotron radiation

- Tunable energy
  - Versatility
- High degree of polarisation
  - Sensitivity to magnetisation direction
- High brilliance
- Small beam size
- Small beam divergence
  - Small objects, special sample environment
- Pulsed time structure
  - Fast processes can be followed
  - New methods become available

Novel properties of XFEL radiation

- Peak brilliance: a gain of 10^9 as compared to synchrotron undulators
- Average brilliance: a gain of 10^4 as compared to synchrotron undulators
- Beam divergence: 10 – 10^2 times smaller than that of a synchrotron undulator
- Pulse duration: 10^3 times shorter as compared to synchrotrons
- Completely new fields of research and development will be opened
- Unprecedented challenge for designers of the machine and experimental instruments

The Hungarian synchrotron radiation community

About 60 scientists directly and another 150 indirectly involved

- *Budapest University of Technology and Economics*

  ESRF, DESY (SAXS: liquid crystals, lipid molecules, environmental applications, microporous systems)

- *Eötvös Loránd University, Budapest (3 departments)*

  ESRF, DESY, ELETTRA (XRD: plastic deformation in metals, metallic glasses; microtomography: impurities in alloys, composites; protein crsytallography; inelastic scattering, resonant X-ray emission spectroscopy: spin-crossover, geological applications)

The Hungarian synchrotron radiation community

- *HAS Biological Research Center, Szeged*
  ELETTRA (SAXS: lipid membranes)
- *HAS Chemical Research Center, Budapest*
  SRS (ESCA: semiconductors)
- *HAS Institute of Nuclear Research, Debrecen*
  DESY, MAX (resonant electron spectroscopy, angle-resolved photoelectron spectroscopy)
- *HAS KFKI Atomic Energy Research Institute, Budapest*
  BESSY, DESY, LNLS, PAL (XRF, micro-XRD: environmental applications)

The Hungarian synchrotron radiation community

- *HAS KFKI Research Institute for Particle and Nuclear Physics, Budapest*

  ESRF, DESY, Spring-8 (nuclear resonant scattering: magnetic thin films)

- *HAS Research Institute for Solid State Physics and Optics, Budapest*

  ESRF, DESY, APS (XRD, holography, nuclear resonant scattering: fullerenes, quasicrystals, novel isotopes)

The Hungarian synchrotron radiation community

- *University of Debrecen*

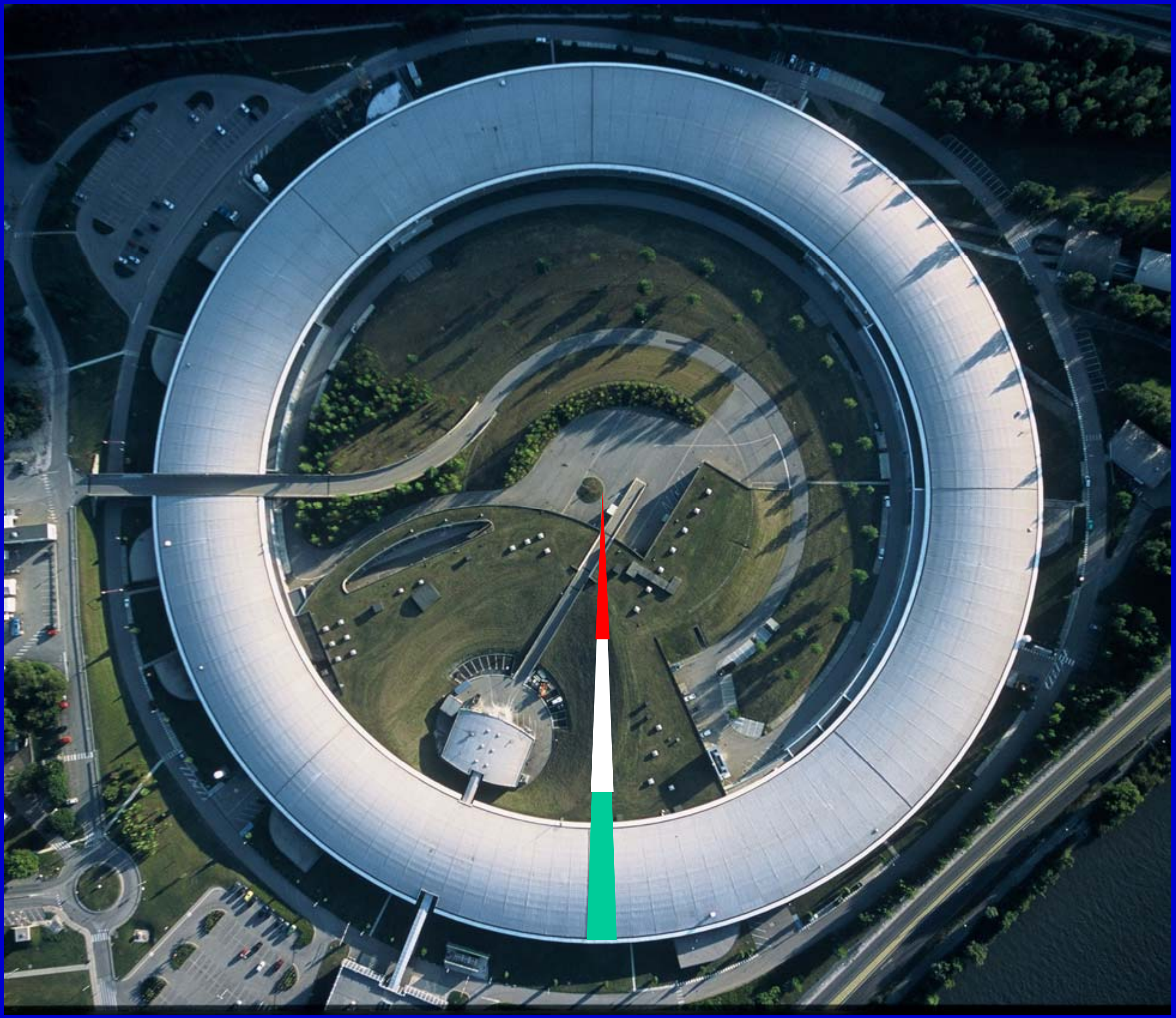
  ESRF (XRD: anomalous diffusion)

- *University of Szeged*

  ESRF (resonant X-ray emission spectroscopy: structure of solutions; biomedical imaging: drug and environmental applications)

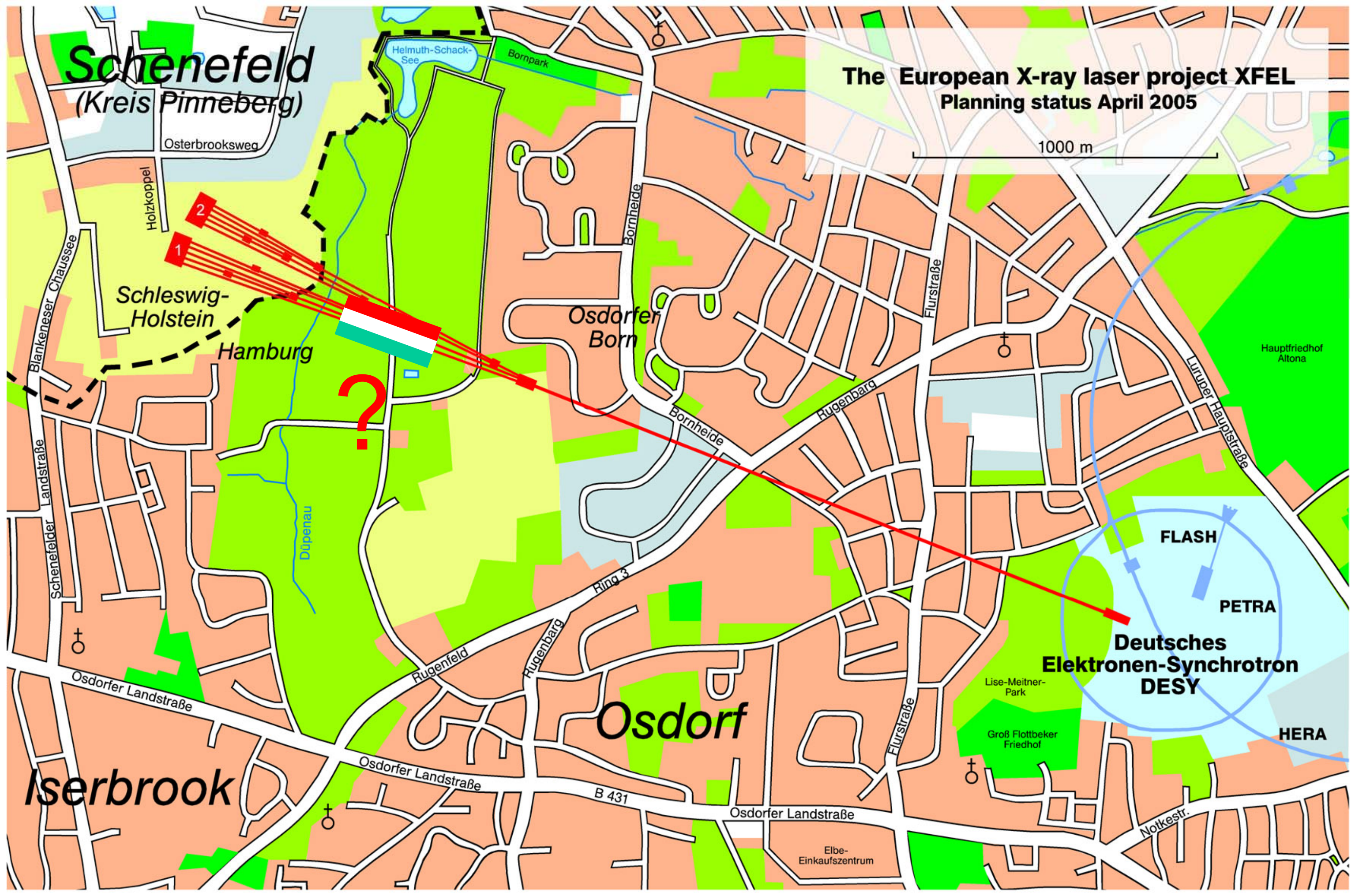
ESRF: a European facility

How long is the Hungarian part of ESRF?



1.7 m of 845 m

XFEL: a new European facility



How long part of XFEL will be built by Hungarian companies and institutions?