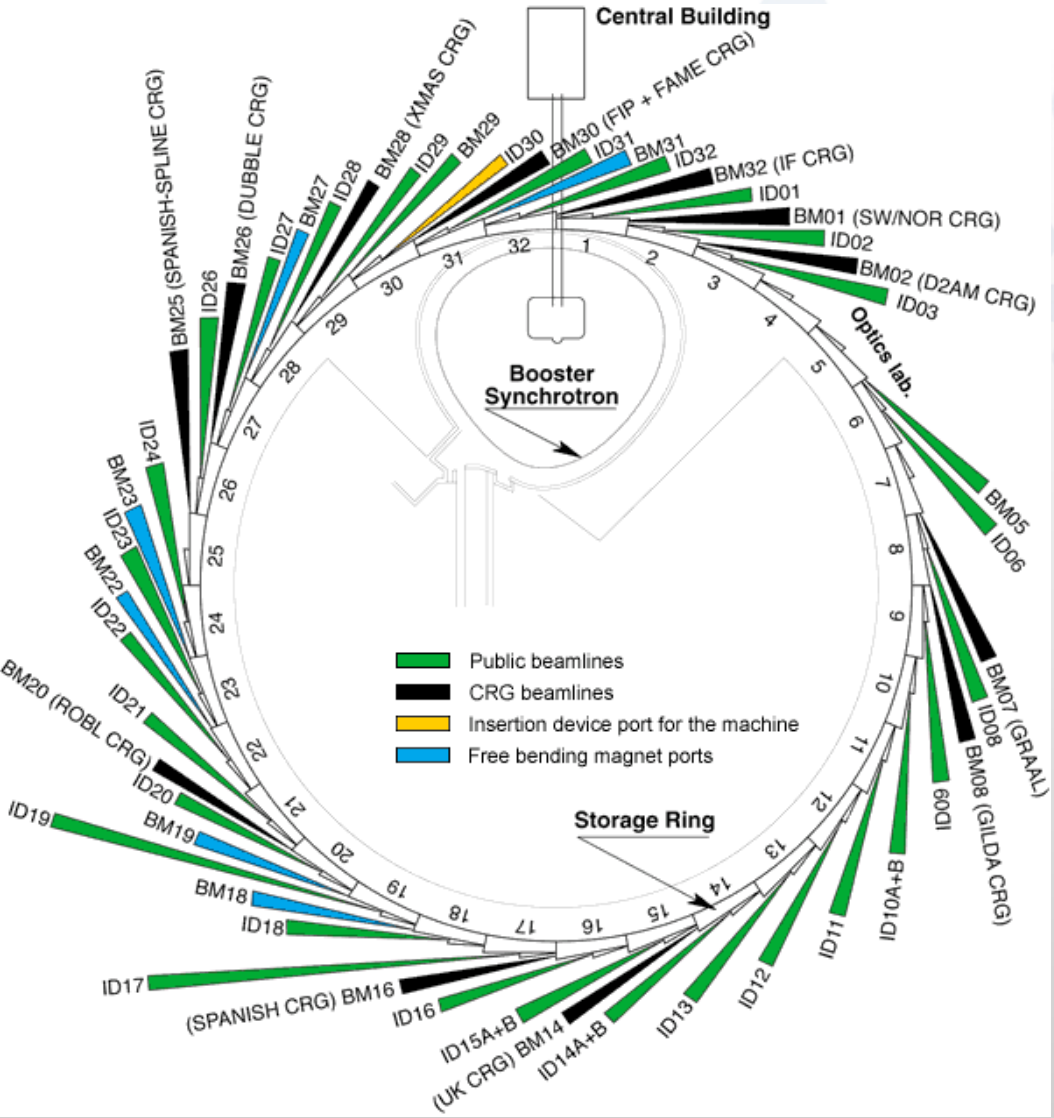
A Light for Science

Three way meeting APS 18 March 2008

The ESRF Beamlines and the Upgrade Programme

Outline

- Beamline developments to day
- Beamlines in the Upgrade Programme
- Preparing for the future



31 Public beamlines

29 ID and 2 BM

12 CRG beamlines

Beamline Groups

High Resolution and Resonance Scattering
ID16, ID26, ID18, ID28

Macromolecular Crystallography
ID14A, ID14B, ID29, ID23

Materials Science
ID09, ID11, ID15, ID27, ID31

Soft Condensed Matter
ID02, ID10A, ID10B, ID13

Surface and Interface Science
ID01, ID03, ID32

X-ray Absorption and Magnetic Scattering
ID08, ID12, ID24, BM29

X-ray Imaging and Optics
BM5, ID17, ID19, ID21, ID22

TBS: ID06

Five years Medium Term Scientific Plan - Beamlines

- ~8 beamlines (ESRF and CRG) are reviewed by international expert panels every year
- Recommendations from the panel are considered seriously by the management
- Ongoing major refurbishments for ~ 3 beamlines
- Instrumentation : Optics, Detectors, Sample Environment

ESRF Long Term Strategy – Upgrade Programme

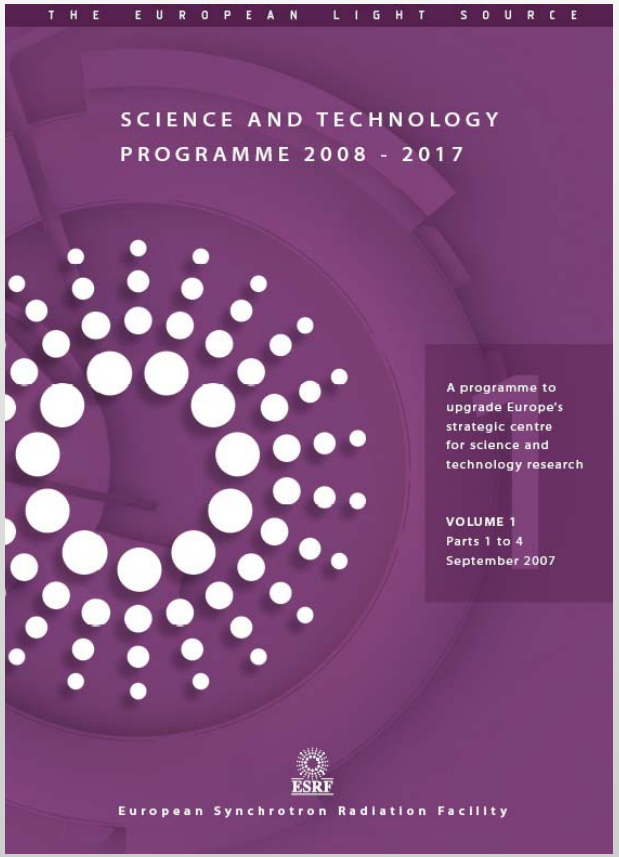
Important Council Decisions:

1.

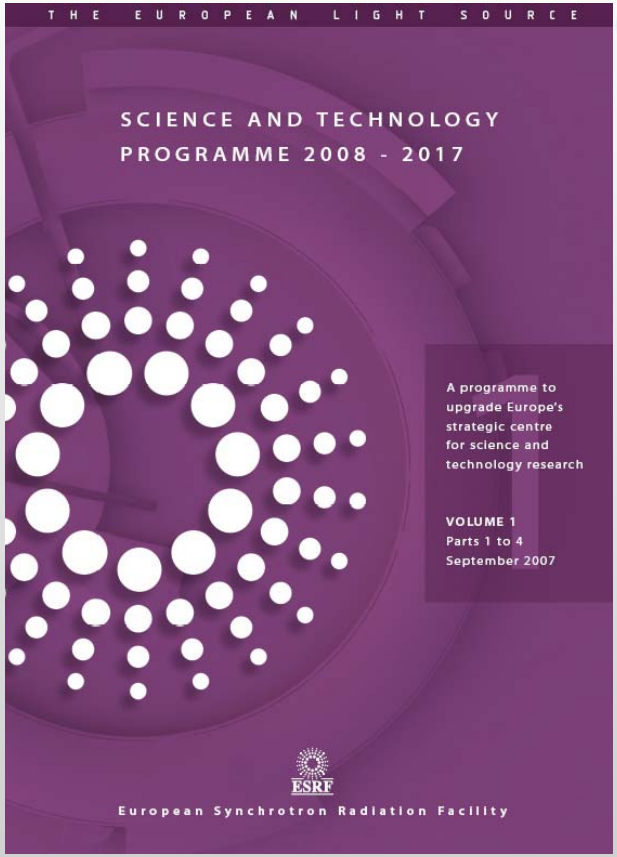
June 2006: Integrate the Medium Term Scientific Plans with the Long Term Strategy into a 10 years planning

2.

November 2007: Acceptance of the Scientific and Technology Programme described in the Purple Books



Science and Technology Programme 2008-2017



Volume 2: Annexes

Annex 1

Conceptual Design reports

Ed Mitchell and the Upgrade Team

Beamline Groups

High Resolution and Resonance Scattering — **5 CRD**
ID16, ID26, ID18, ID28

Macromolecular Crystallography — **4 CDR**
ID14A, ID14B, ID29, ID23

Materials Science — **6 CDR**
ID09, ID11, ID15, ID27, ID31

Soft Condensed Matter — **5 CRD**
ID02, ID10A, ID10B, ID13

Surface and Interface Science — **3 CDR**
ID01, ID03, ID32

X-ray Absorption and Magnetic Scattering — **7 CDR**
ID08, ID12, ID24, BM29

X-ray Imaging and Optics — **4 CDR**
BM5, ID17, ID19, ID21, ID22 — **TBS: ID06** — **3 CRD**

Five Scientific Highlight Areas

Nano-Science and Nano-Technology

Structural/functional Biology and Soft Matter

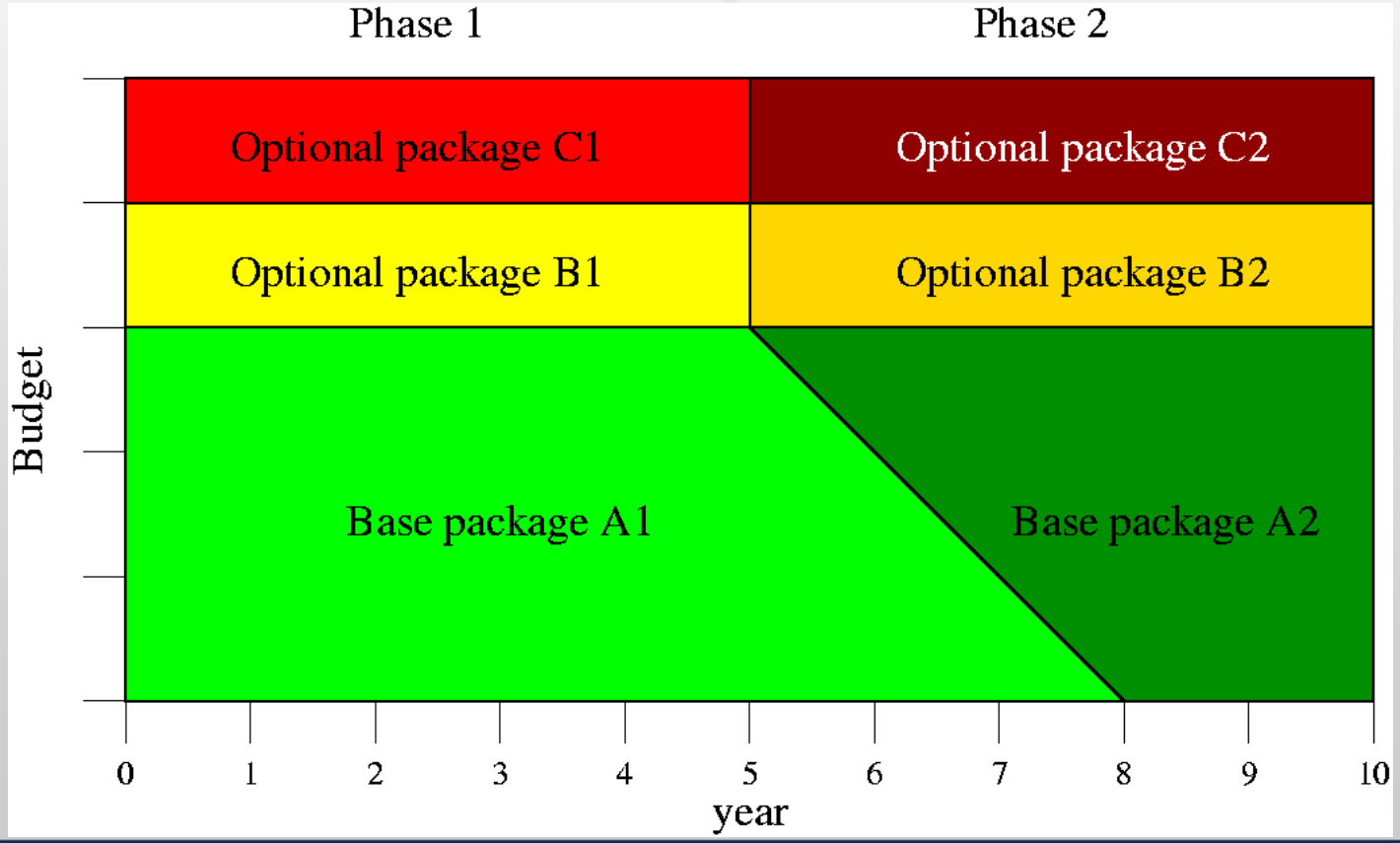
Pump-Probe Experiments Time Resolved Diffraction

Science at Extreme Conditions

X-ray Imaging

The Upgrade a phased scenario

- Base package A1 includes 8 beamlines
  Optional package B1 consists of 2 additional beamlines
- Identification 8+2 beamlines requiring the Upgrade



Candidate beamline projects Phase I

Restricted SAC Meeting and ESRF Management on 29-07-2007
8+2 Phase I beamlines distributed among the areas:

2+1: Nano-Science and Nano-Technology

2: Life Sciences and Soft Matter

2: X-ray Imaging

1+1: Extreme Conditions

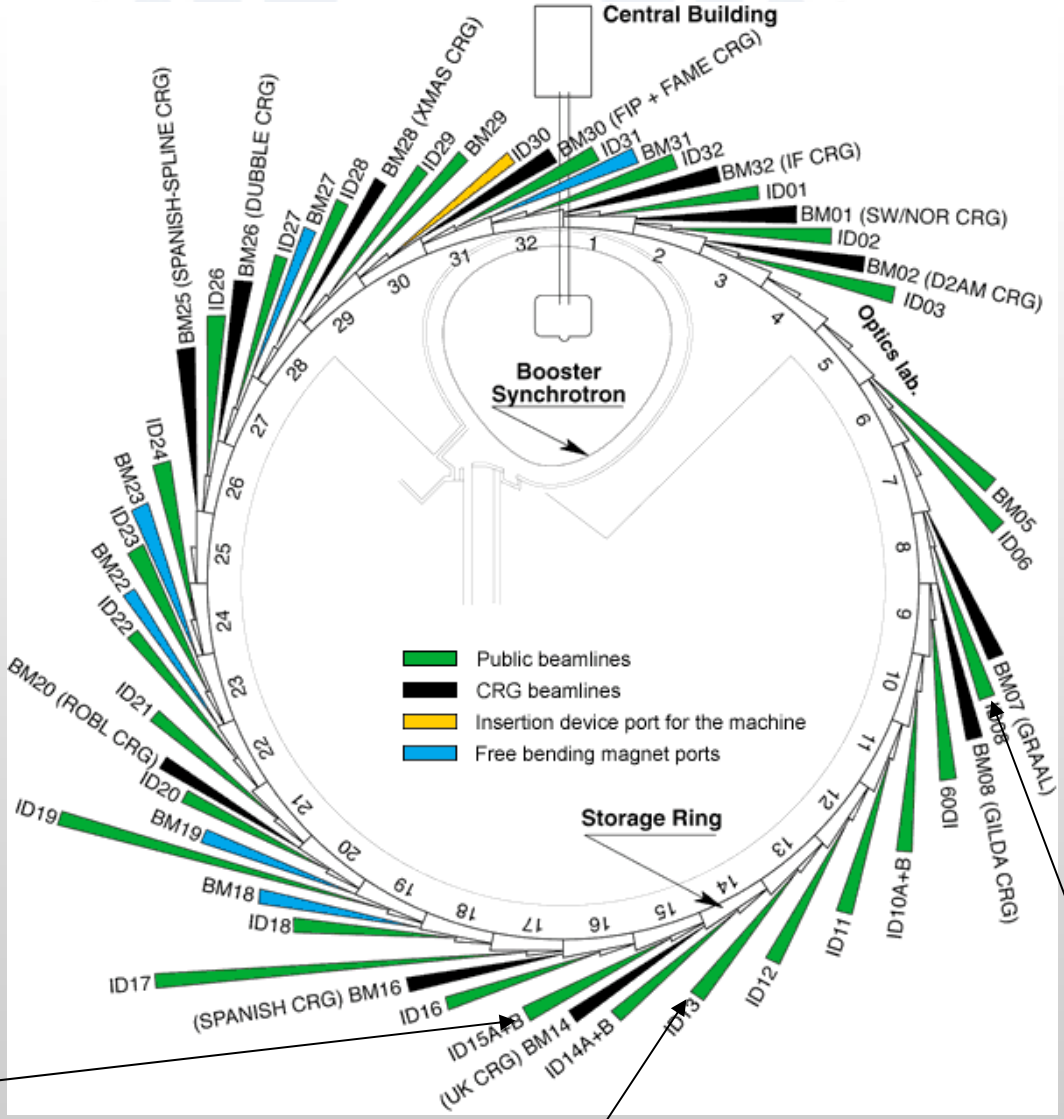
1: Pump and Probe and Time-resolved Science

Information meeting on the Upgrade Programme 24. October

Candidate beamlines Phase I – Presented to the SAC Nov 2007

- **UPBL1:** Local probe coherent diffraction imaging and nanobeam diffraction for characterisation of individual nanostructures
- **UPBL2:** High energy beamline for buried interface structure and materials processing
- **UPBL3:** Nuclear resonance beamline for the study of nanoscale materials: the interplay of growth, structure, electric and magnetic properties as well as dynamics
- **UPBL4:** Beamline for imaging, fluorescence and spectroscopy at the nanoscale
- **UPBL5:** Beamline for parallel and coherent beam imaging
- **UPBL6:** High energy resolution inelastic scattering in the hard X-ray range with micro- and nano-focus capabilities
- **UPBL7:** Soft X-rays for nano-magnetic and electronic spectroscopies
- **UPBL8:** Nano- and microbeam crystallography for structural and functional biology and soft matter
- **UPBL9(a):** Sub-microradian angular resolution small-angle scattering for probing the structure and nonequilibrium dynamics of self-assembled soft matter and biological systems

  UPBL9(b): Structural dynamics of molecular assemblies
- **UPBL10:** Large-scale automated screening, selection and data collection for macromolecular crystallography
- **UPBL11:** Pushing the limits of energy dispersive X-ray absorption spectroscopy towards the nano in spatial and temporal resolution.



V. Honkimaki
UPBL2

C. Riekel UPBL8

N. Brookes
UPBL7

UPBL1: COHERENT DIFFRACTION IMAGING

AIM OF "CDI":

- reveal the relation between structure and functionality of Nano-materials properties induced by quantum confinement

REQUIRED FOR:

- novel (opto-)electronic devices (laser, detectors, sensors, LEDs…..)
- quantum dot based quantum cryptography
- future quantum computing

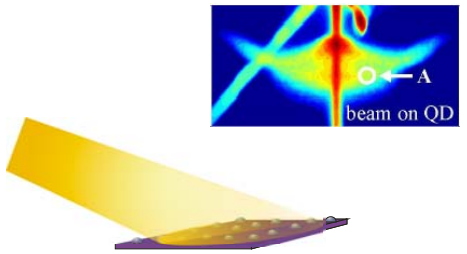
EXPERIMENTAL:

- quantum systems exhibit **exploitable quantum confinement effects**
- they depend on shape, strain and composition of single nanostructures
- Immediate need for novel characterisation techniques at the nanometre scale

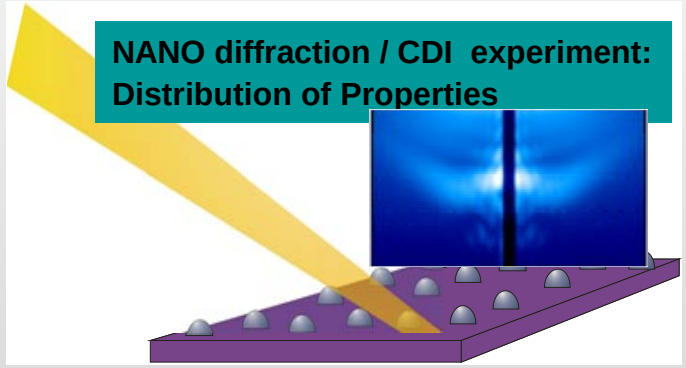
SOLUTION:

- **Nano diffraction on individual nanostructures**
  Distributions of properties rather than averages
- **Coherent Diffraction Imaging**
  nano-crystals and non-periodic objects
  no model assumptions needed due to phase retrieval

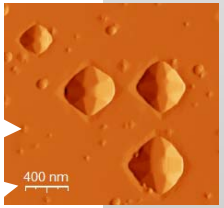
"Conventional" experiment : Average Properties

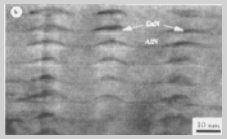


NANO diffraction / CDI experiment: Distribution of Properties

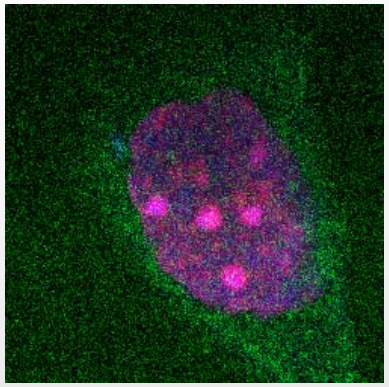


RESULTS:
Shape, strain, composition of single nano-objects





UPBL4: Nano-scale X-ray Imaging



D. Fioretto, Univ. Perugia

1 μm — ID19/ID22

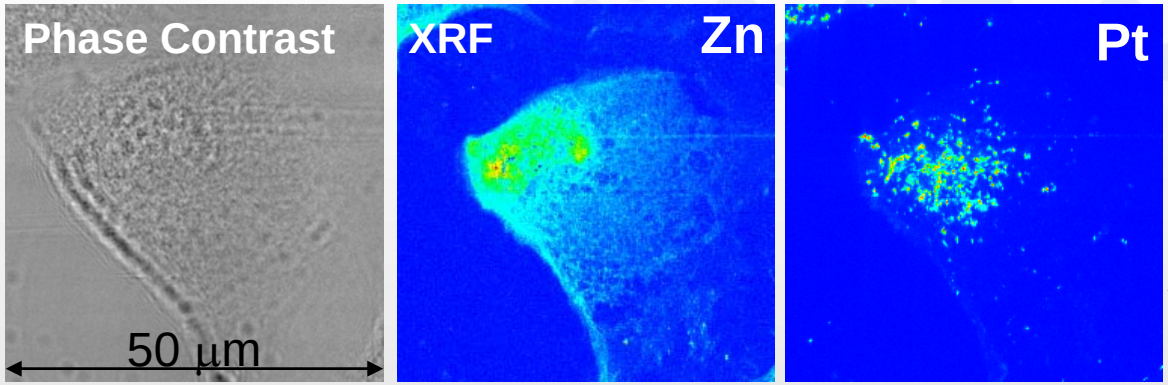
100 nm — ID22NI

10 nm — UPBL4

***S**canning **F**luorescence and **I**maging at the **N**anoscale using **X**-rays*

- An intense state-of-the-art *nano-probe* providing unique very high resolution capabilities for *3D imaging* and *fluorescence micro-analysis*
- To be implemented on a *new long beamline* at a *high-beta* straight section with a *dedicated microscope*

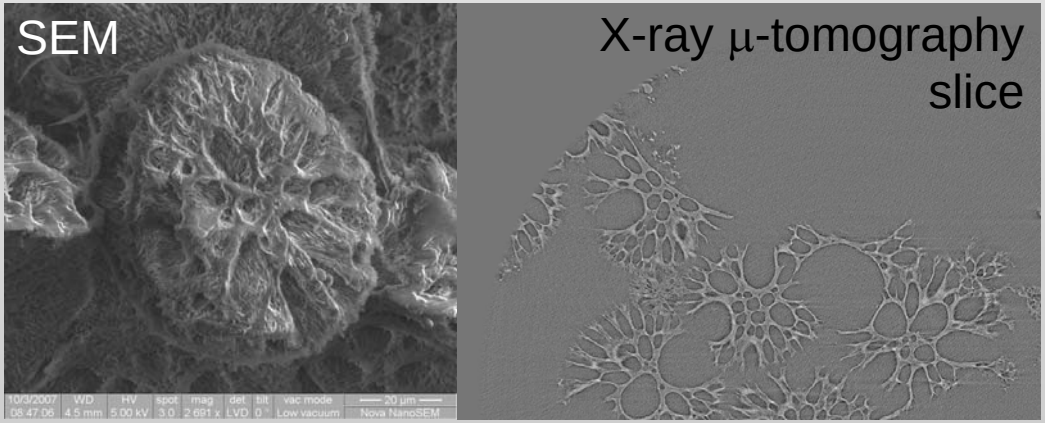
UPBL4: Nano-particle / cell / tissue interaction



ID22NI S Bohic, P Cloetens; B. Kysela, Univ. Birmingham

Pt nanoparticles
ϕ : 6 nm
target the nucleus

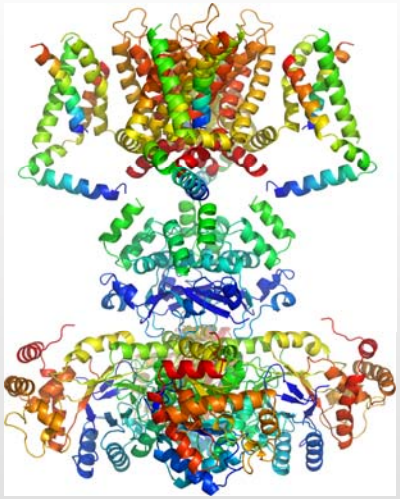
Towards imaging of individual nano-particles and their interaction with cells and tissues



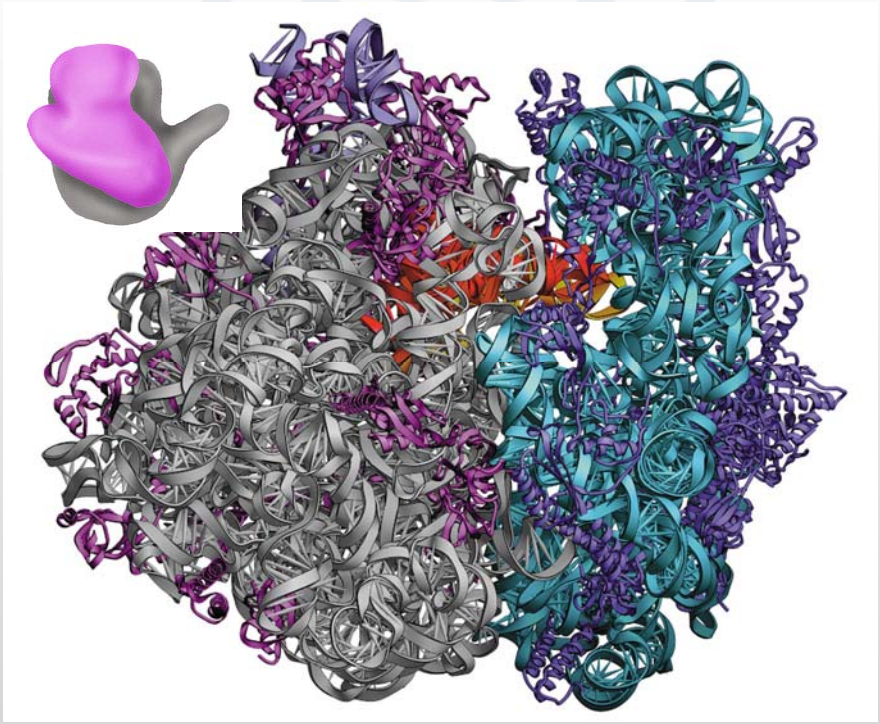
Polymer scaffold for stem cell cultivation

J Nygaard, M Foss, iNano, Aarhus University; P Cloetens

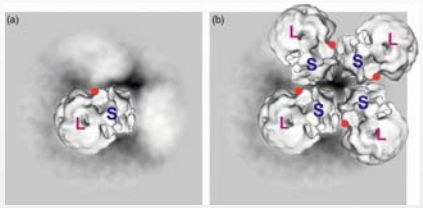
Progress In Structural Biology.



The resolution of the structure and the biophysical properties of the **Voltage dependant K+ channel** led to the Nobel Prize for Chemistry for ESRF user Rod McKinnon (in 2003. Mechanism remains elusive

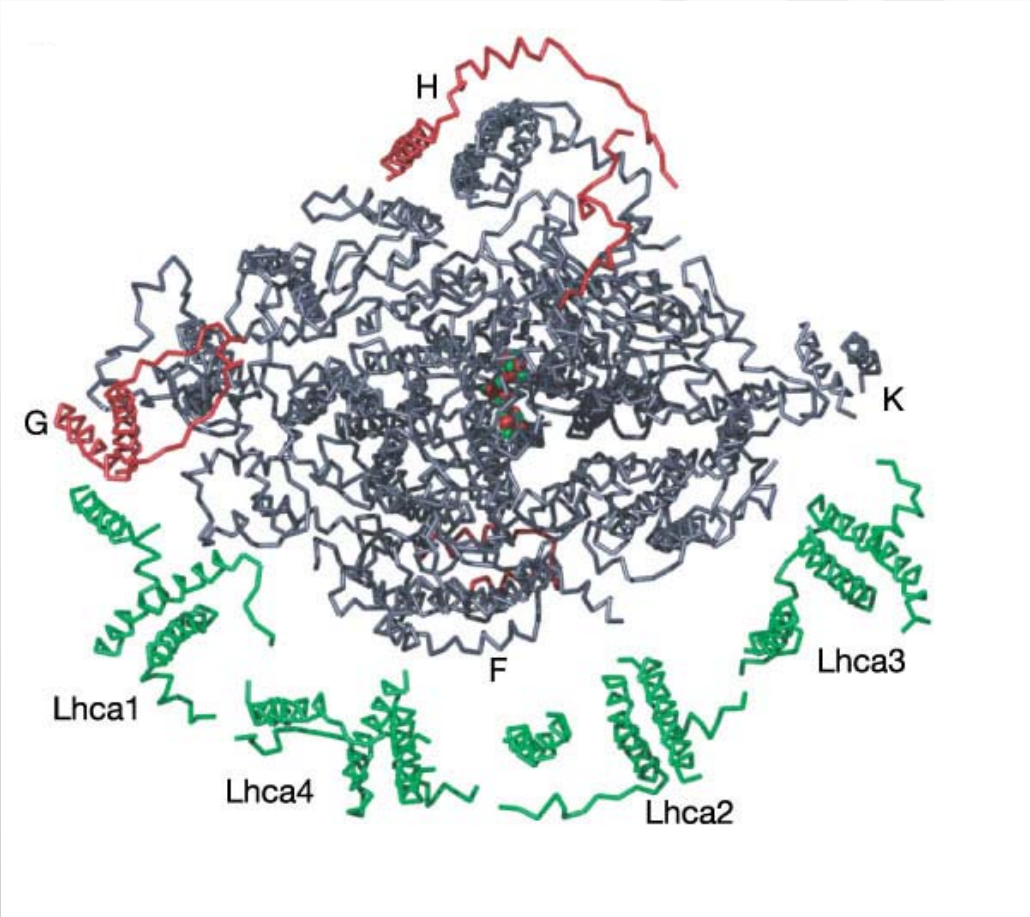


Ribosome Structural and Functional knowledge has improved from very low resolution/detail to atomic level **due almost entirely to SR. And screening thousands of samples !**



The spliceosome: the most complex macromolecular machine in the cell? Preparing Genes for translation by Ribosomes. Detailed Structural knowledge of the fundamental actions will be **entirely** dependent on SR.

Photosystem I from Plant (*Pisum sativum*)



Monomeric

12 core subunits

4 light harvesting membrane proteins

45 transmembrane helices

167 chlorophylls

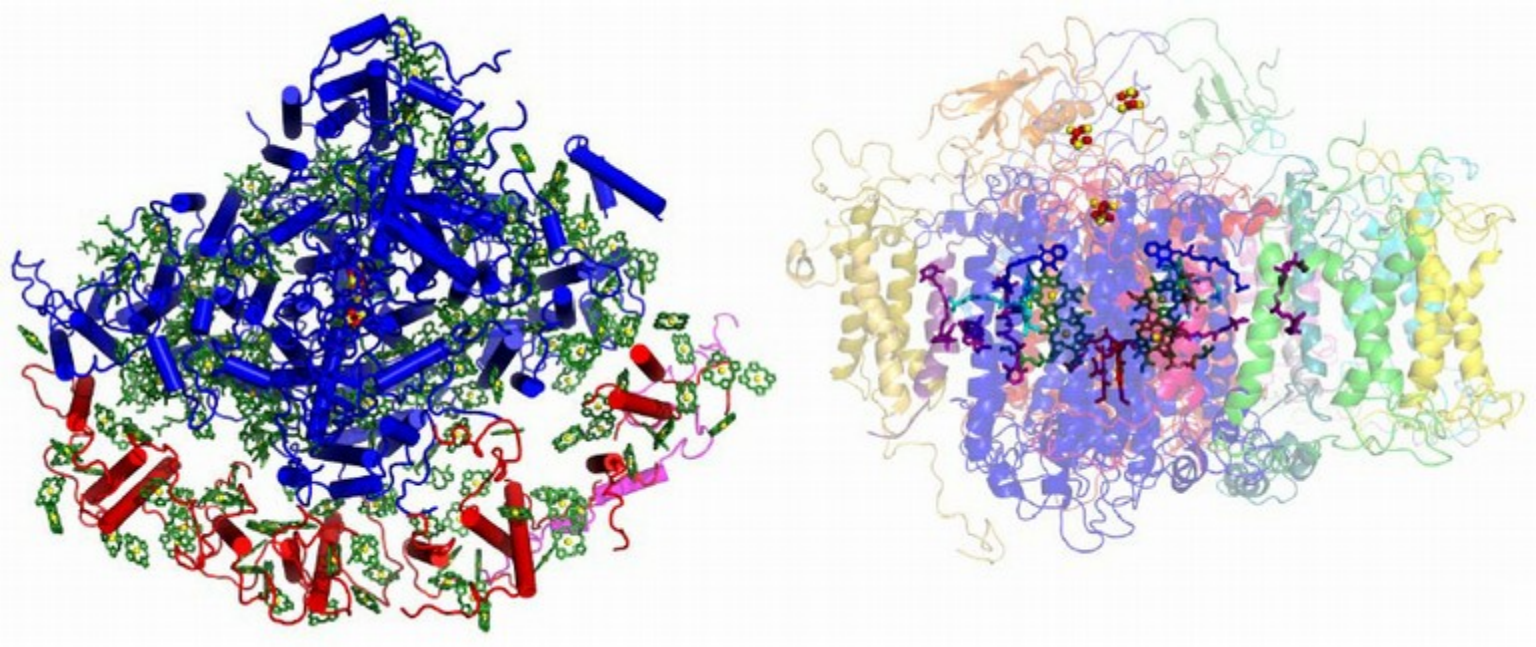
3 Fe-S clusters

2 phylloquinones

Resolution 4.4 Å

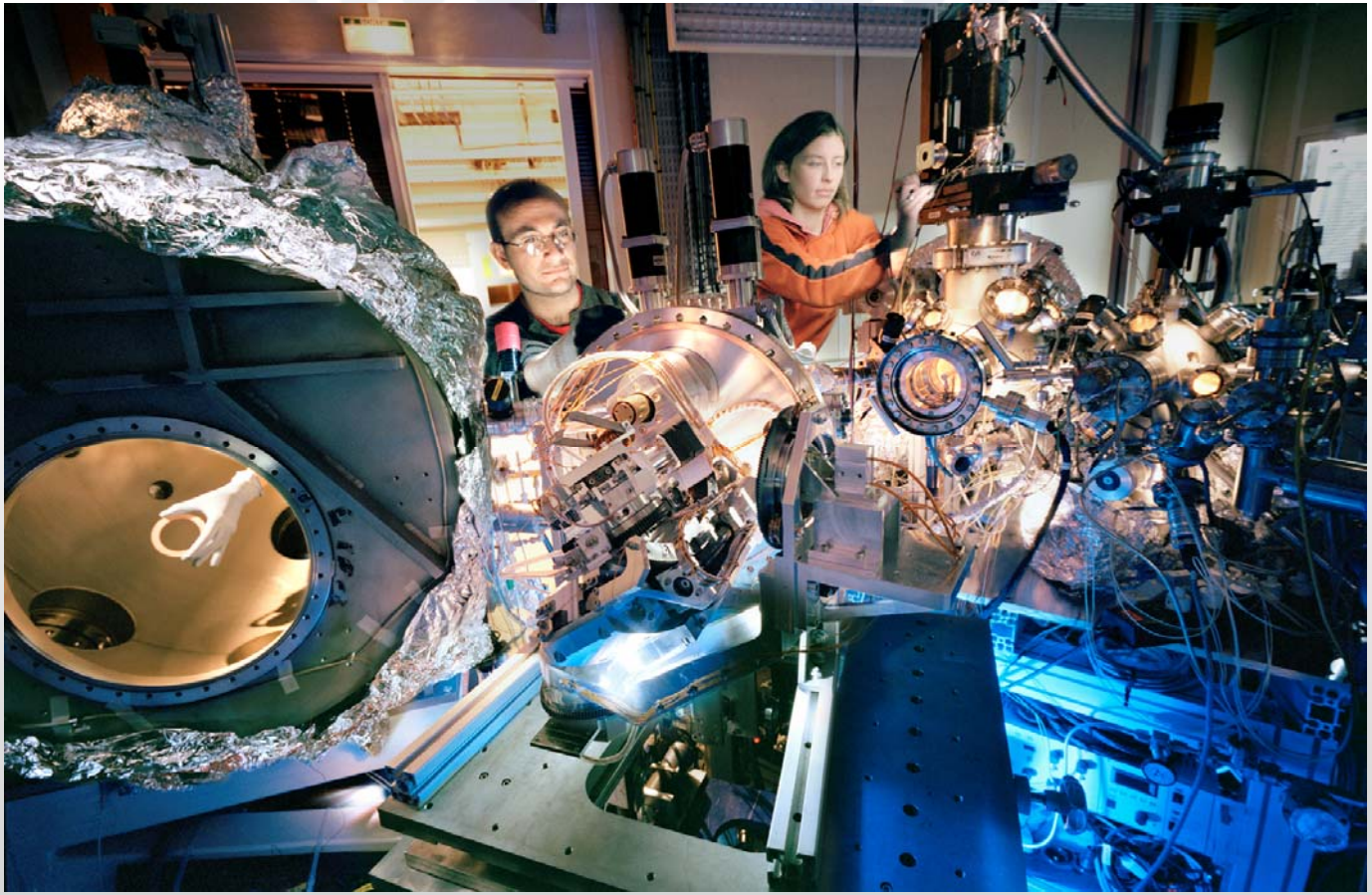
Ben-Sham, Frolow, Nelson, Nature 426 (2003) 630

ID23-2: Better resolution data from larger, radiation sensitive crystals



A. Amunts, O. Drory & N. Nelson, The structure of a plant Photosystem I supercomplex at 3.4 Å resolution. (2007) *Nature*, 447, 58-63.

Microbeams and screening facilities



What is next?

Medium Term Scientific Plan 2008 – 2012
Beamline Activities

- Brainstorm meetings and workshops throughout 2008 to develop the UPBL Technical Design Reports (TDR)
- Accelerator and Source developments e.g.Insertion Devices and Beamline Front-Ends
- Instrumentation developments (Optics, Detectors, Sample Environment)
- Development of Partnerships (Soft Condensed Matter)
- Nanofocusing pilot projects (ID11, ID13, ID22NI)
- ID06 Beamline for tests of optics, detectors, etc

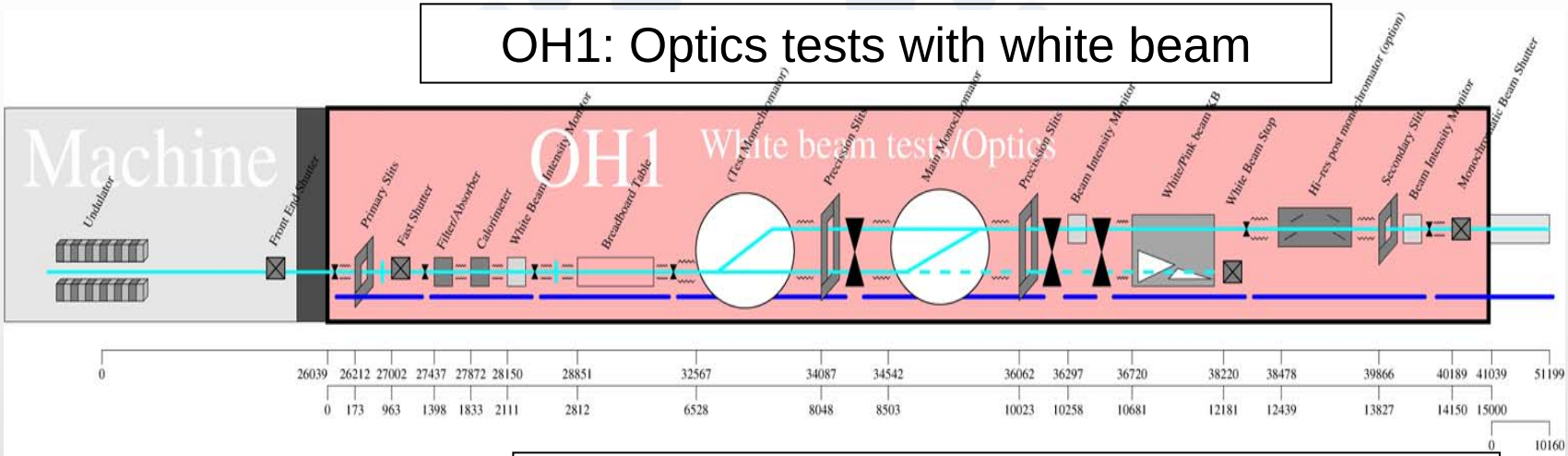
P. Fajardo

ID06: Instrumentation development

- Multi-purpose instrument development beamline
- Optics, detectors, monochromators, white beam profile monitors … for high energy/high brilliance applications (partnership with DESY)
- Development of high pressure science (geophysics, planetary physics)
- Development of very high magnetic field capabilities (> 30Tesla)

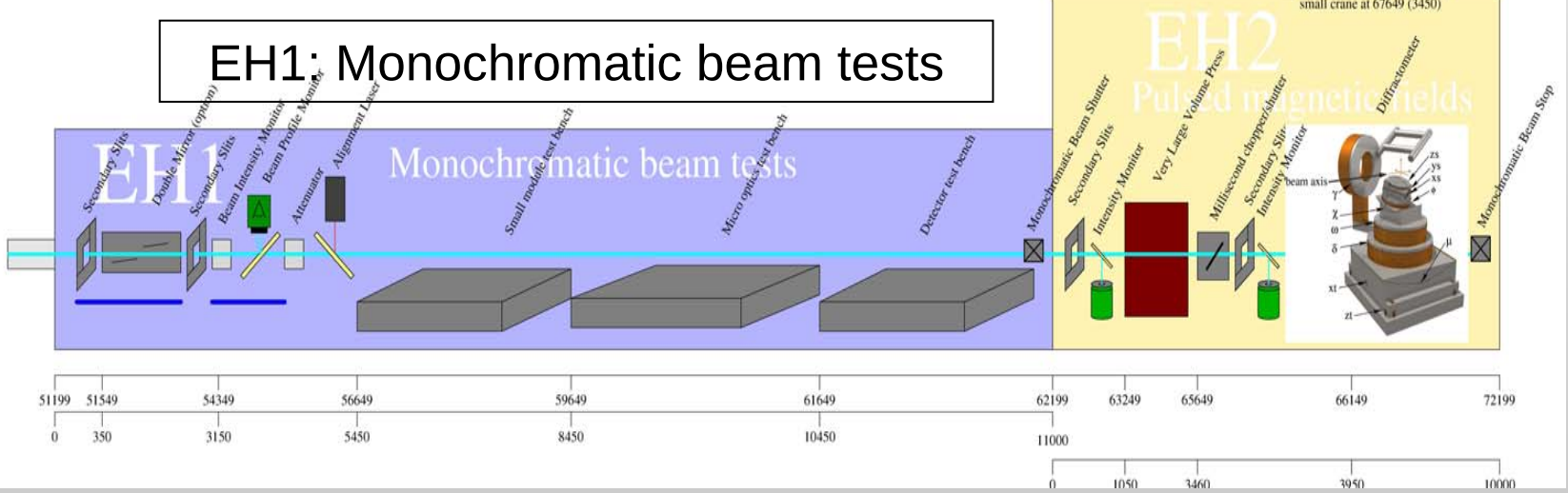
ID06: Instrumentation development

OH1: Optics tests with white beam

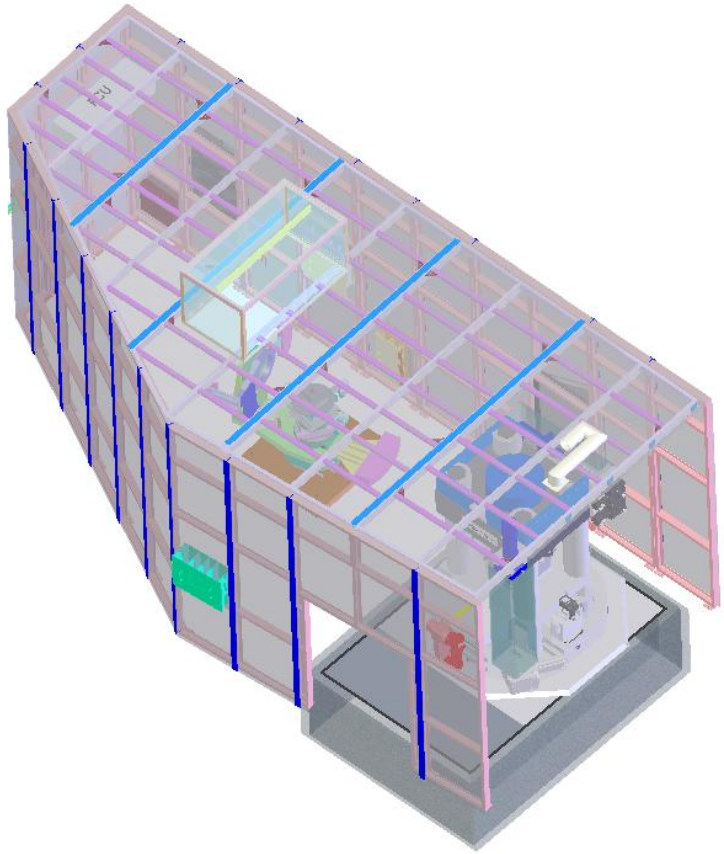


EH2: Large Volume Press, diffractometer

EH1: Monochromatic beam tests



ID06 Large Volume Press



EH2 with LVP and HMF

15 keV -> >80 keV

2 x Cryo Si (111)

In vac. undulators

(spring shutdown)

IP or large flat panel

pixelated detectors

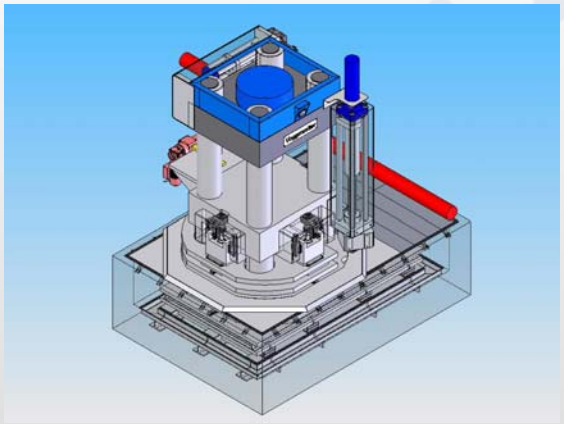
Radial collimation

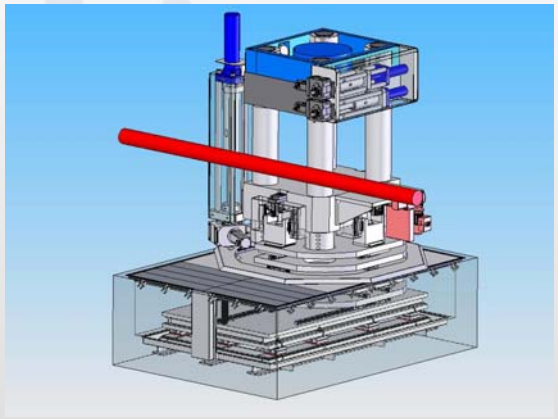
Spiral collimation

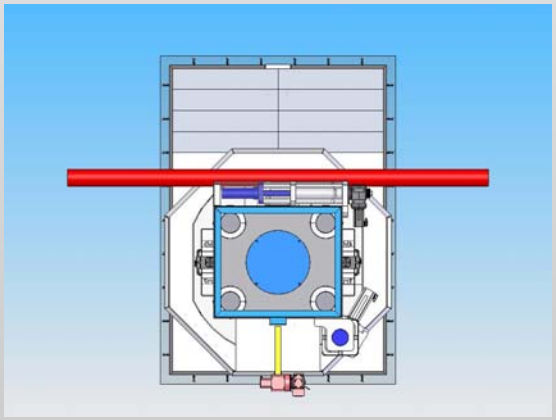
ID06: Instrumentation development

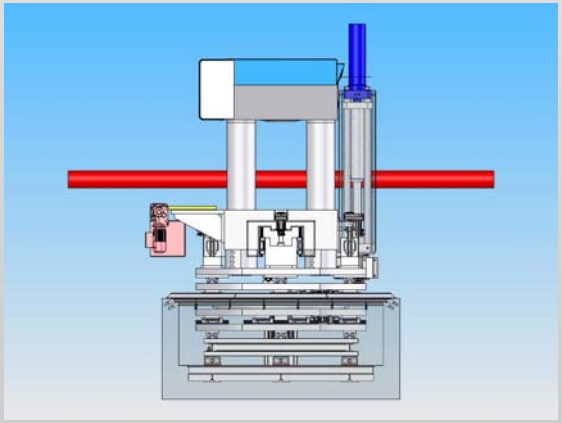
3D design models of the **Large Volume Press**

2 x 2 x 4 m^3, ~35 ton







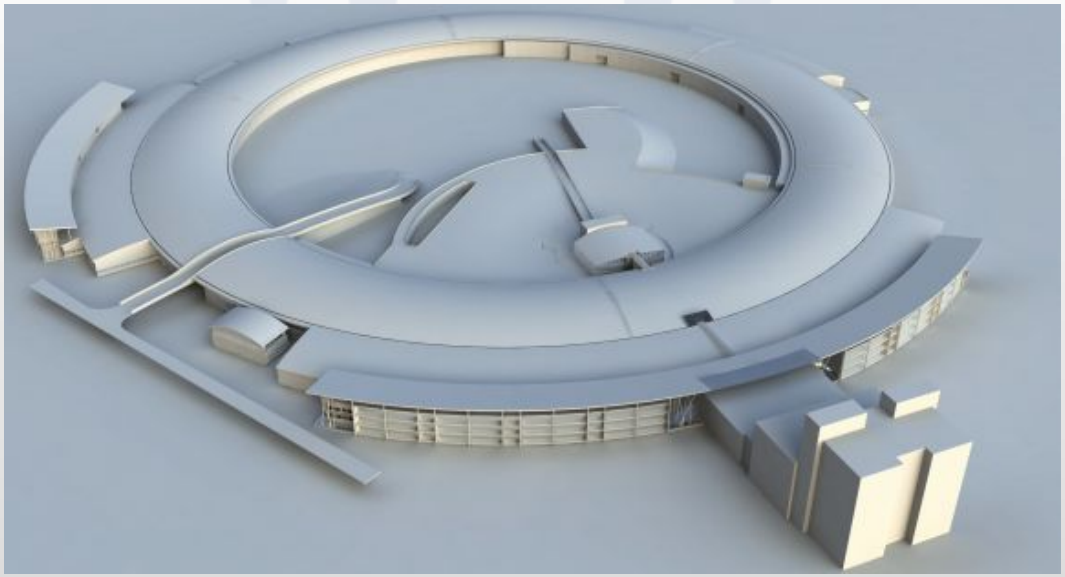


Large Volume Press

Removal of material from hutch for the concrete support at a depth of 1.4 m

Concrete put in in two stages

Steel support frame



We are preparing for the Upgrade

Thanks for your attention