Elettra and FERMI: two Accelerator-based Radiation Sources in Trieste

G. Paolucci
Sincrotrone Trieste

Elettra history and milestone

- *Early 80's*
  proposal by the European Science Foundation for two new synchrotron radiation laboratories one for hard x-rays and a complementary one for vuv/soft x-rays

- *1986*
  Decision to build the two infrastructure: ESRF (several European countries including Italy, 15% of the shares) and Elettra as a *national* facility

- *1991-1993*
  construction

- *October 1993*
  start of commissioning

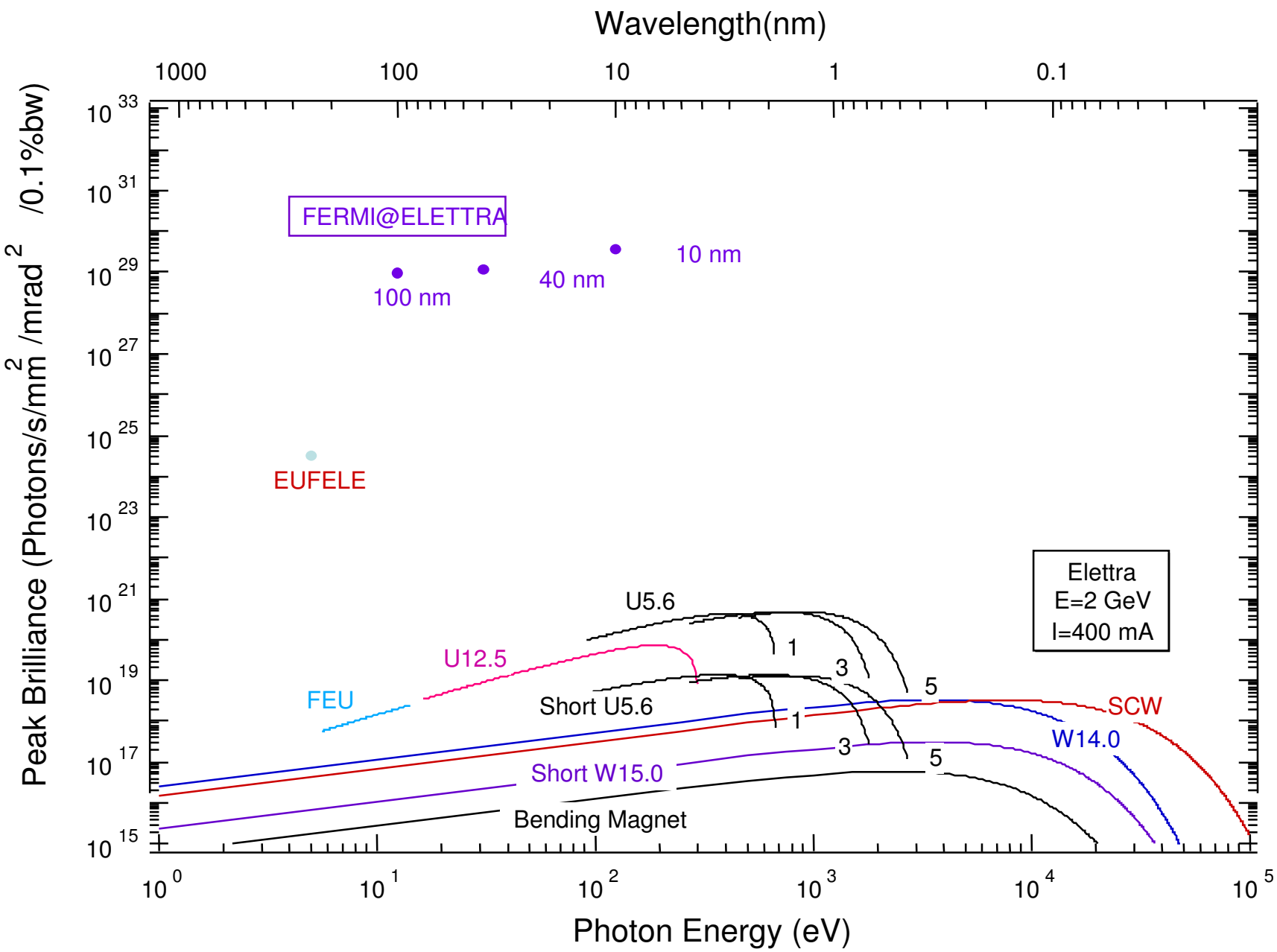
- *January 1995*
  first user groups

Aerial view of ELETTRA during the construction.

Picture was taken on May 14, 1992 by a USSR spy satellite.


Image © 2007 DigitalGlobe
©2007 Google™
Pointer 45°38'42.42" N 13°50'53.14" E
Streaming 100%
Eye alt 443 m

Photon sources at Elettra



ST’s mission

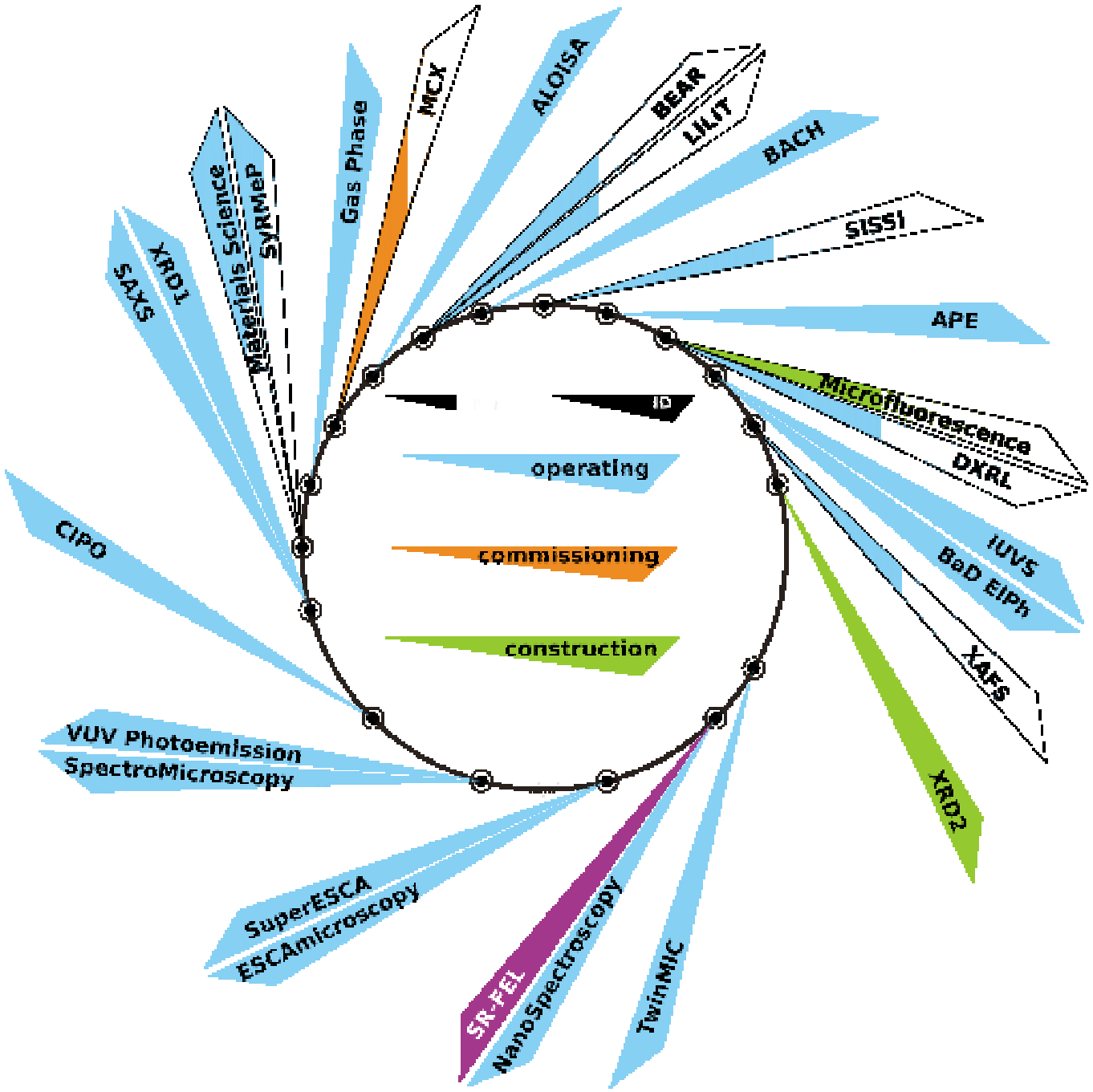
We are an international multidisciplinary laboratory of outstanding quality, specializing in synchrotron radiation and its use in the Science of Matter.
Our mission is to promote cultural, social and economic growth through:

- Basic and applied research in relevant fields;
- Technical and scientific training;
- Technology transfer.

We will lead by providing a platform for internationally recognized research and enhance the impact and relevance of science for society.

Elettra & SESAME

- Host laboratory for IAEA sponsored training
- Co-sponsoring with ICTP training fellowships
- Provide SESAME with Elettra RF cavities
- …..



- 22 beamlines in operation and open to external users
- 1 beamline under commissioning
- 2 beamlines under construction
- 1 FEL test beamline

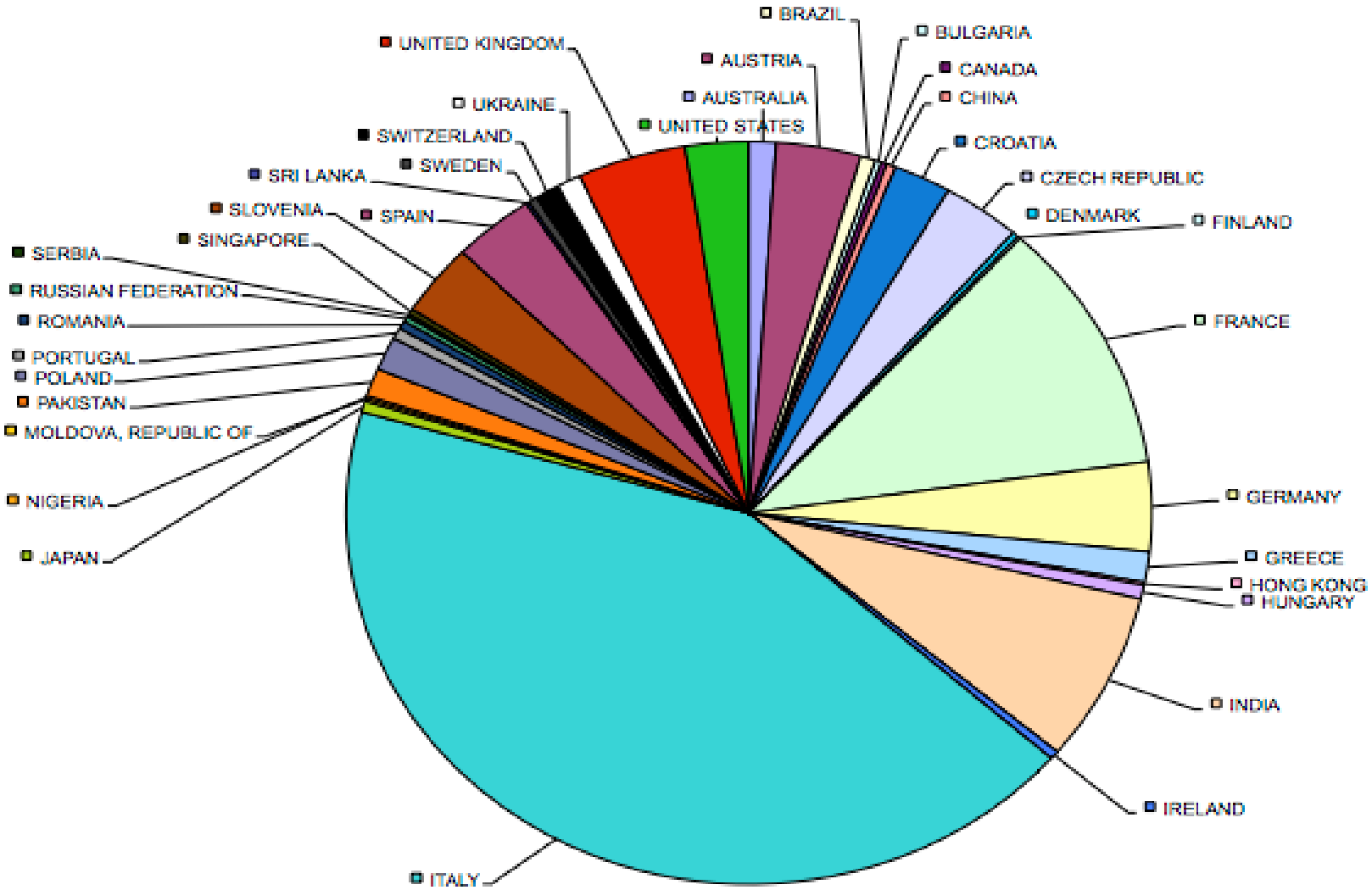
Break-up of the proposals submitted:

Term	II/08	I/08	II/07	I/07	II/06	I/06	II/05	I/05	II/04	I/04	II/03
Total	382	443	355	278	315	328	287	307	328	348	298
-S-	42	56	50	37	51	50	47	44	50	48	34
ILP	77	75	55	39	43	81	90	70	86	73	64
-T-	50	58	49	54	56	---	---	---	---	---	---
-H-	73	84	79	43	46	72	58	57	77	79	75
-A-	18	27	25	17	21	29	16	17	26	25	20
-C-	101	107	75	70	69	96	53	86	64	85	70
-M-	21	36	22	18	29	0	23	33	23	38	35

Steady increase in the number of proposals:

there is a scope for new sources!

PROPOSALS RECEIVED IN 2008



2008 proposals

Beamline	Submitted Proposals	Scheduled Proposals
ALOISA	29	16
APE	38	18
BACH	16	16
BAD_ELPH	16	8
BEAR	38	26
CIRCULARPOLARIZATION	22	18
DEEP LITHOGRAPHY	12	5
ESCAMICROSCOPY	34	11
GASPHASE	38	20
IUVS	42	8
LILIT	2	2
MATERIALS SCIENCE	37	20
NANOSPECTROSCOPY	66	21
SAXS	68	32
SISSI	48	20
SPECTROMICROSCOPY	5	2
SUPERESCA	31	10
SYRMEP	31	24
TWINMIC	37	17
VUV PHOTOEMISSION	34	11
X-RAY DIFFRACTION	106	51
XAFS	58	23
Total	**808**	**379**

The “standard” Elettra BT distribution model

- The beamline group (Elettra+partners) gets 30% for maintenance and in-house research
- 70% is given on the basis of the Review panel priority list with corrections for specific agreements with partners
- Proprietary research BT is taken from the 30% and given back to the BL group in the subsequent semester (together with part of the revenue)

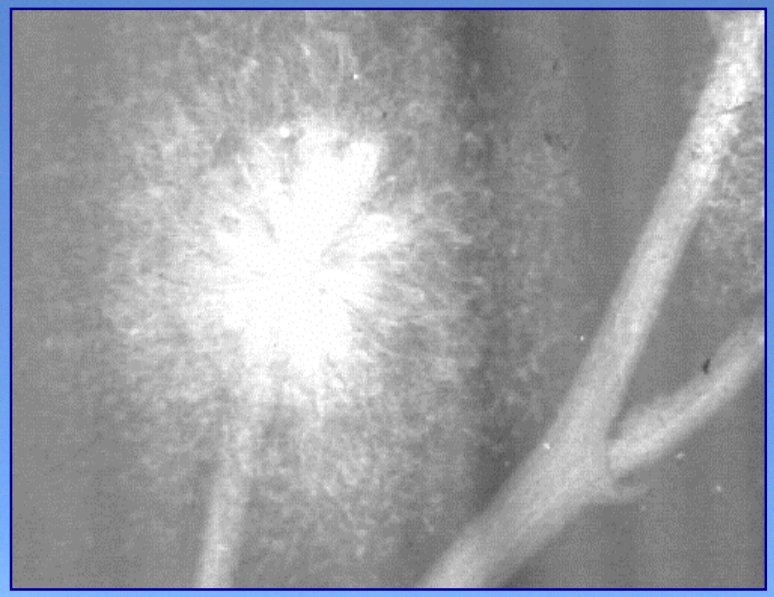
Users funding schemes

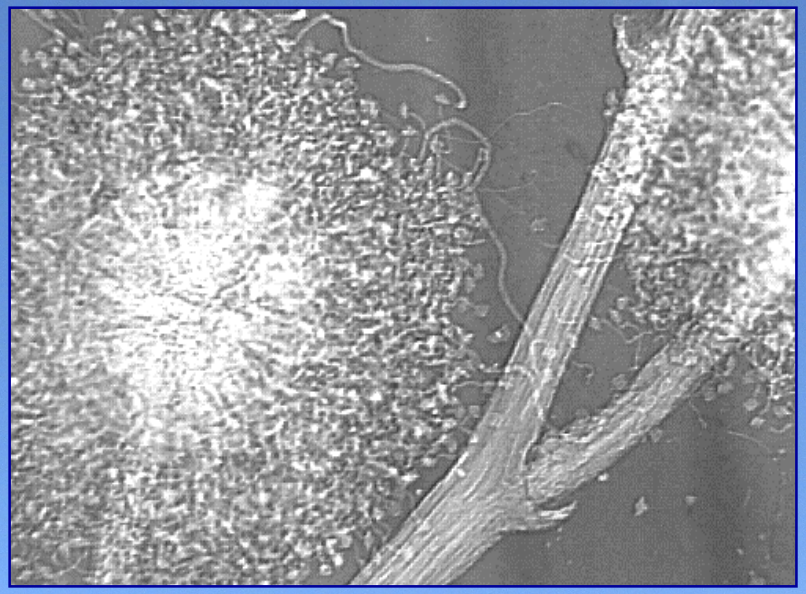
- EU users outside Italy are partially supported by the Integrated Infrastructure Initiative (I3)
- Italian users are partially supported by Elettra
- Indian users are supported through an agreement between between the Italian ministry for Foreign Affairs and the Indian Department for Science and Technology
- Users from Emerging Countries are supported through an agreement with the Abdus Salam ICTP

Applications

Images of a Mimosa flower

10 keV

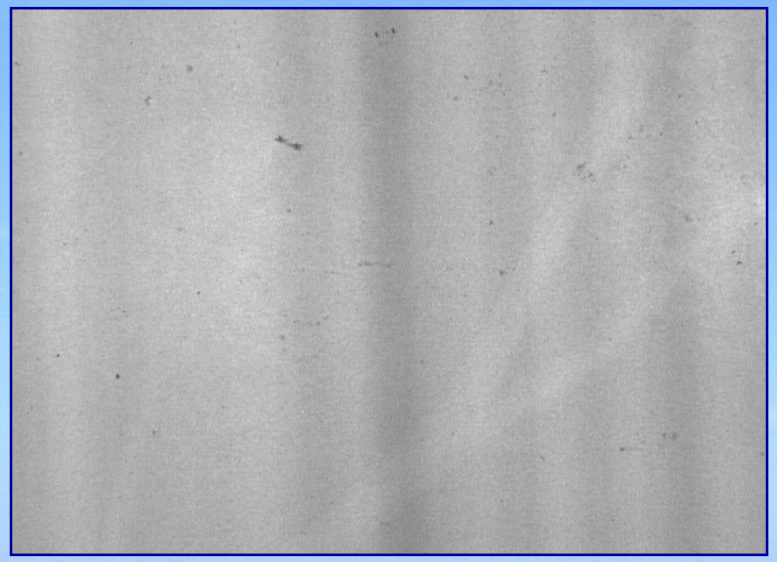


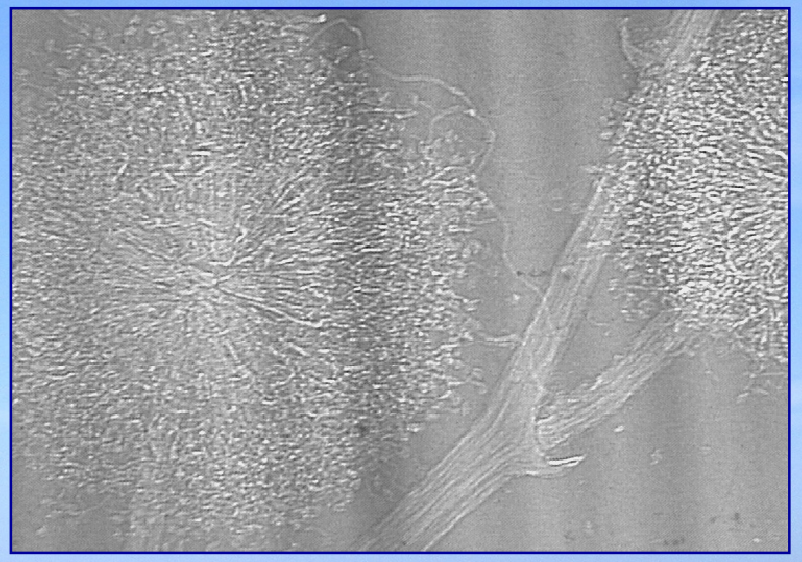


Absorption

Phase-contrast

25 keV





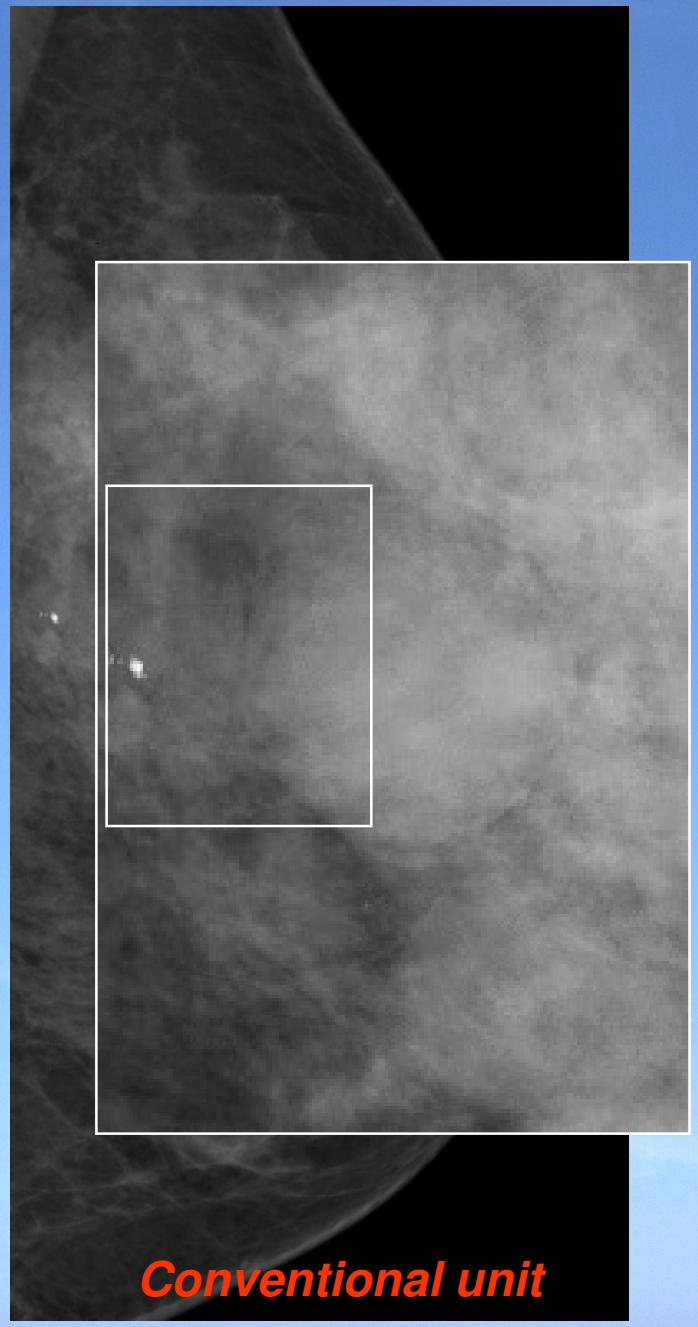
Mouse

slope + 5%

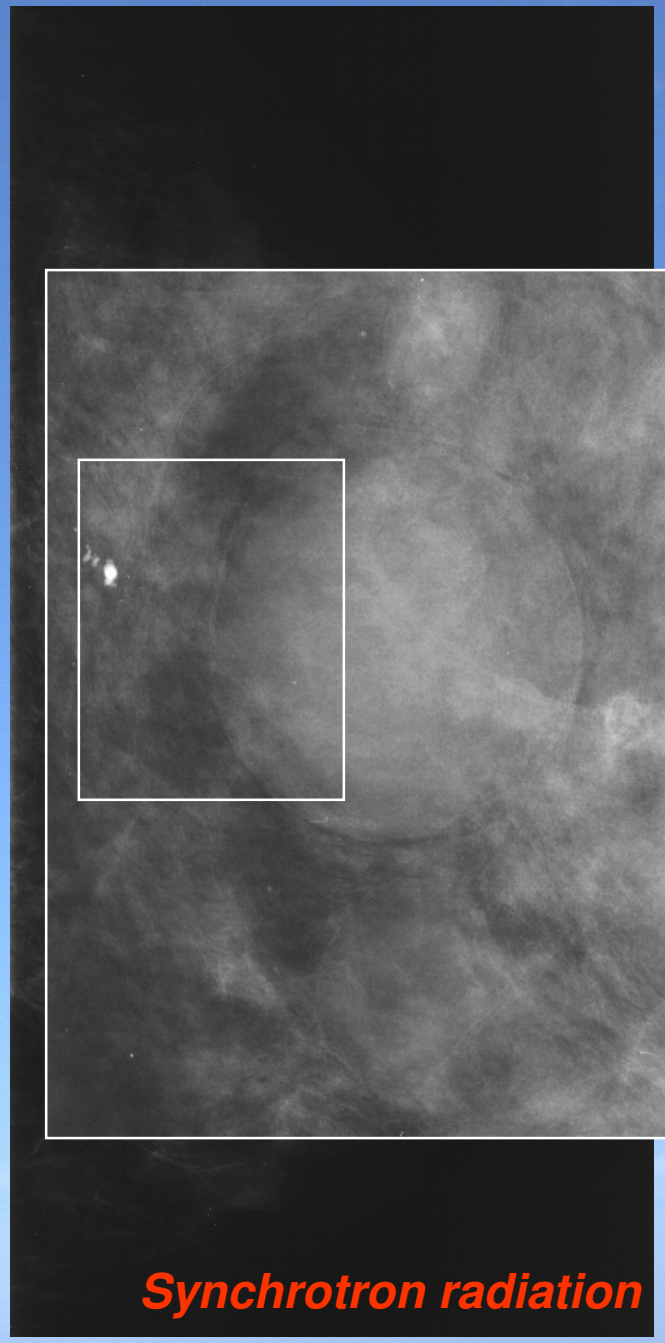
top

Patient support

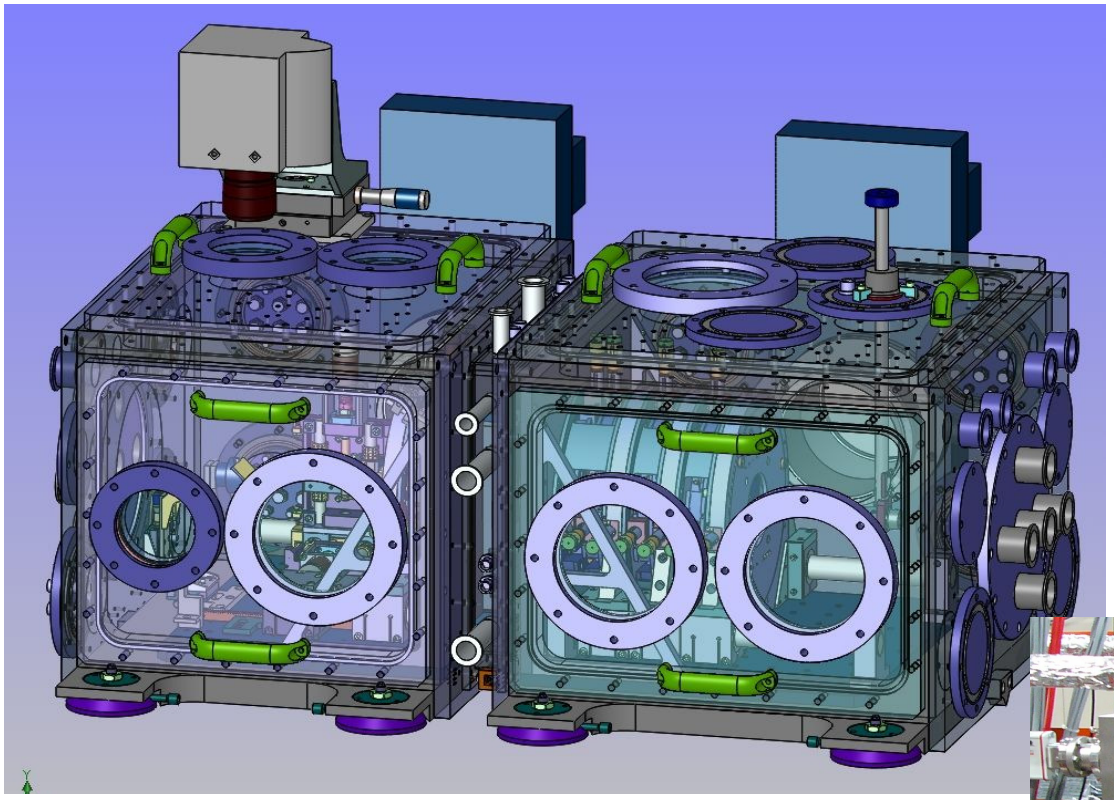
Pat. 8 - 164839 – GA – CC RIGHT s



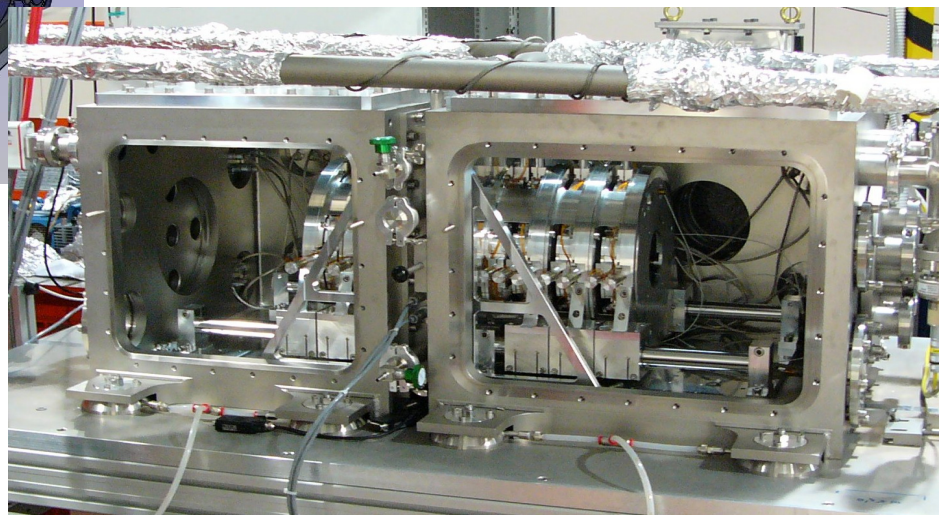
Conventional unit



Synchrotron radiation

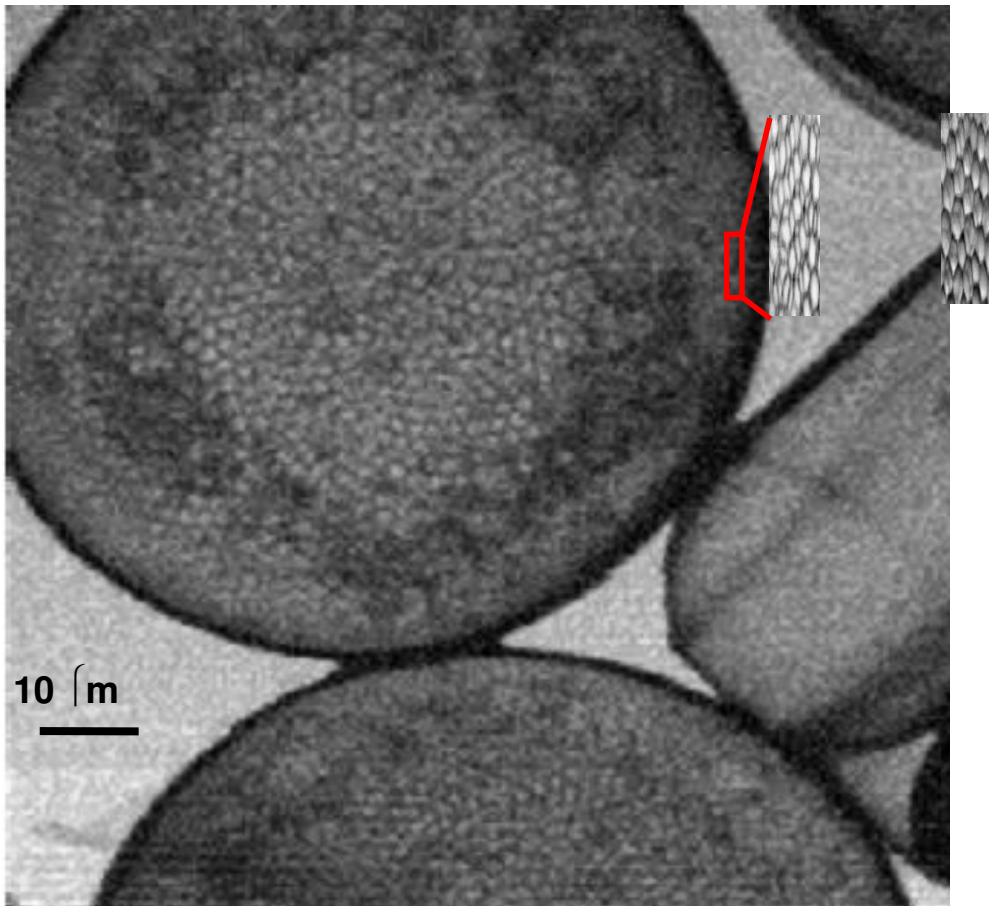


TwinMic station

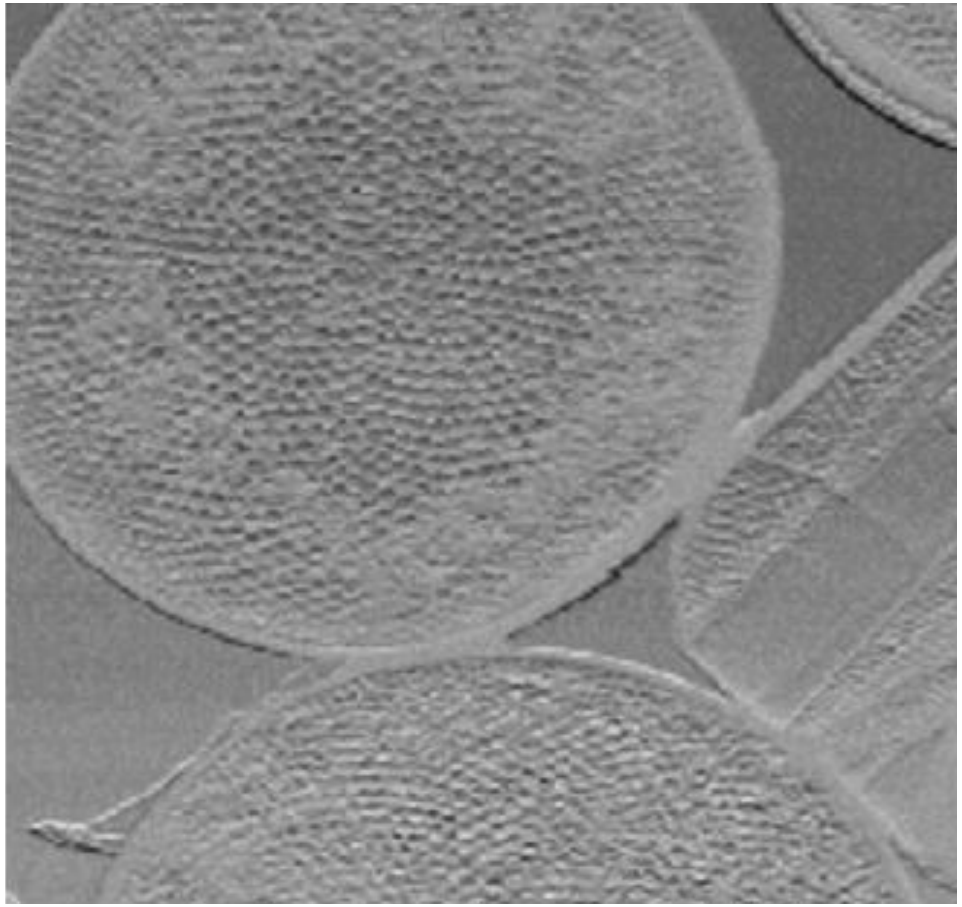


B. Kaulich, D. Bacescu, G. Rostaing et al.

Simultaneous acquisition of images with different contrast using the fast read-out EMCCD camera:



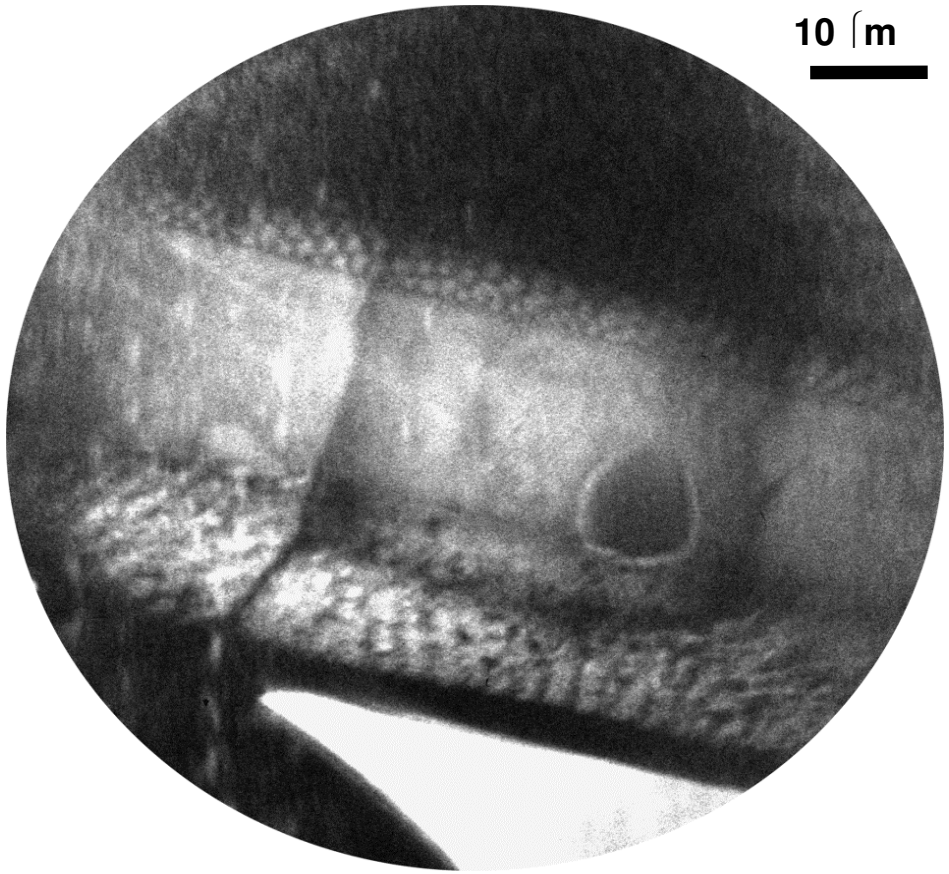
Bright field image



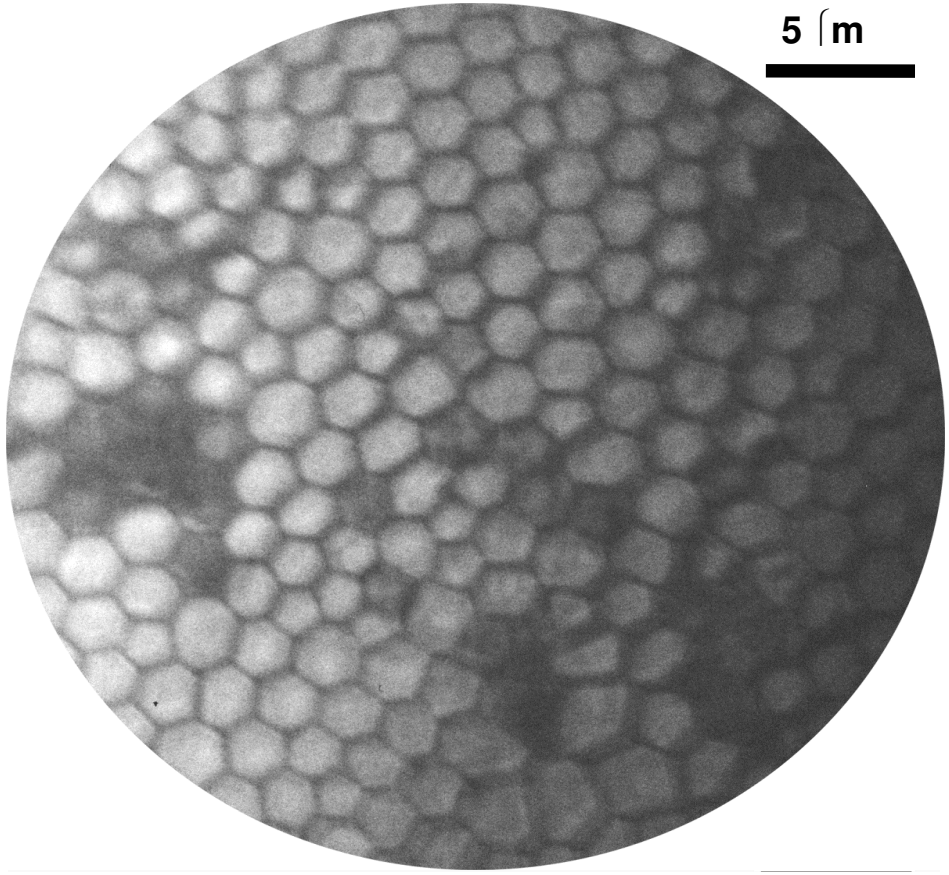
DPC mode – X-moment

Images acquired in STXM mode with FRCCD camera; E=1320 eV, 200x190 px, 50ms dwell/px

Planktonic diatom "Coscinodiscus sp." in full-field imaging mode:



342x magnification, 30s exposure

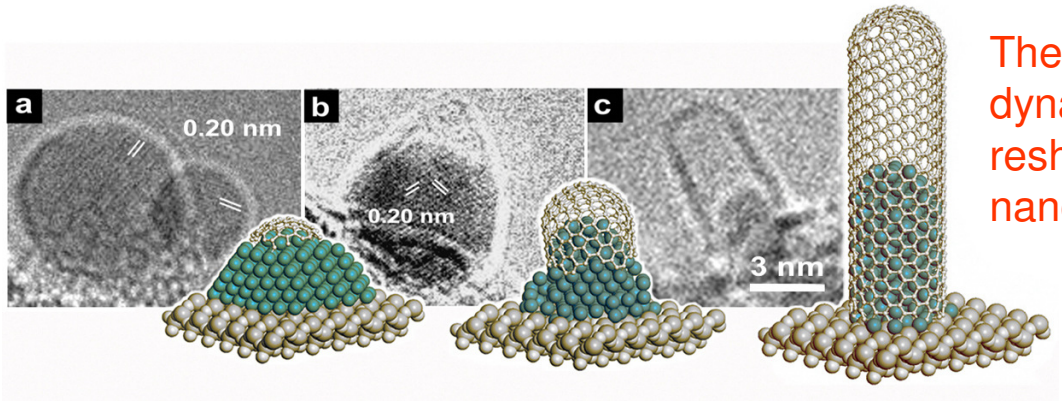


820x magnification, 60s exposure

Photon energy: 518 eV, condenser concept: T. Wilhein, U. Vogt, P. Charalambous, data not flat- and background corrected (Specimen from A. Beran, LBM Trieste, I)

Catalyst dynamics during surface-bound carbon nanotube nucleation

S. Hofmann, M. Cantoro, S. Pisana, A. Parvez, A.C. Ferrari, F. Cervantes-Sodi, J. Robertson, R. Sharma, G. Du, C. Ducati, C. Mattevi, C. Cepek, R. Dunin-Borkowski, S. Lizzit, L. Petaccia, A. Goldoni, NanoLetters 7 (2007)

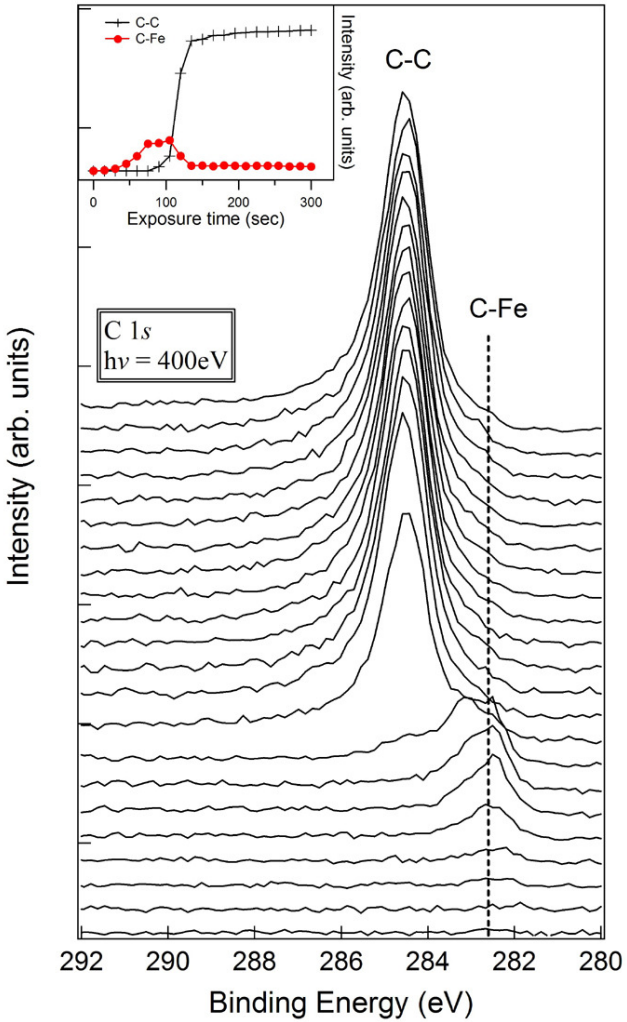


The formation of graphitic carbon leads to the dynamic reshaping of the catalyst particle. This reshaping defines the morphology of the carbon nanotube.

For SWNT we observe crystalline phase contrast from the transition metal catalyst nano-particles. The 0.20 nm reflection observed is expected for metallic fcc Ni(111), but also for Ni_2O_3(200) and Ni_3C(113).

We have highlighted some of the progress made towards an atomistic CNT growth model by combining in-situ TEM and XPS. Selective acetylene chemisorption and the formation of a carbon-rich surface layer were observed on otherwise crystalline transition metal nano-particles. Structural selectivity is determined by the dynamic interplay between carbon network formation and catalyst particle deformation.

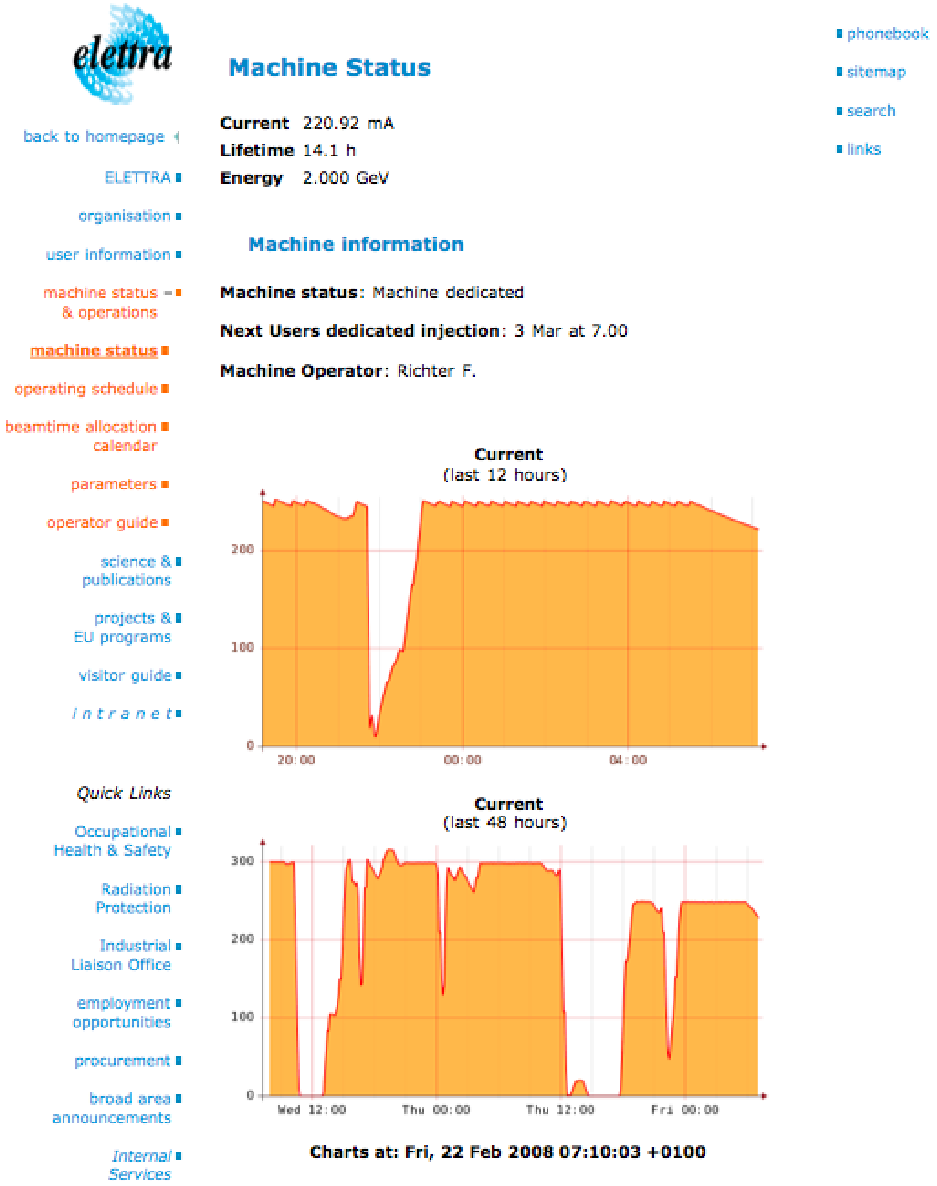
The catalyst is active in its metallic state; Fe and Ni films that were deliberately oxidised before annealing showed a lower/no nanotube yield on C_2H_2 exposure.



Developments

New injector!

Top-up tests under way
Routine top-up operation foreseen in 2010



The “new” Elettra:

Undulator and beamline upgrade priorities

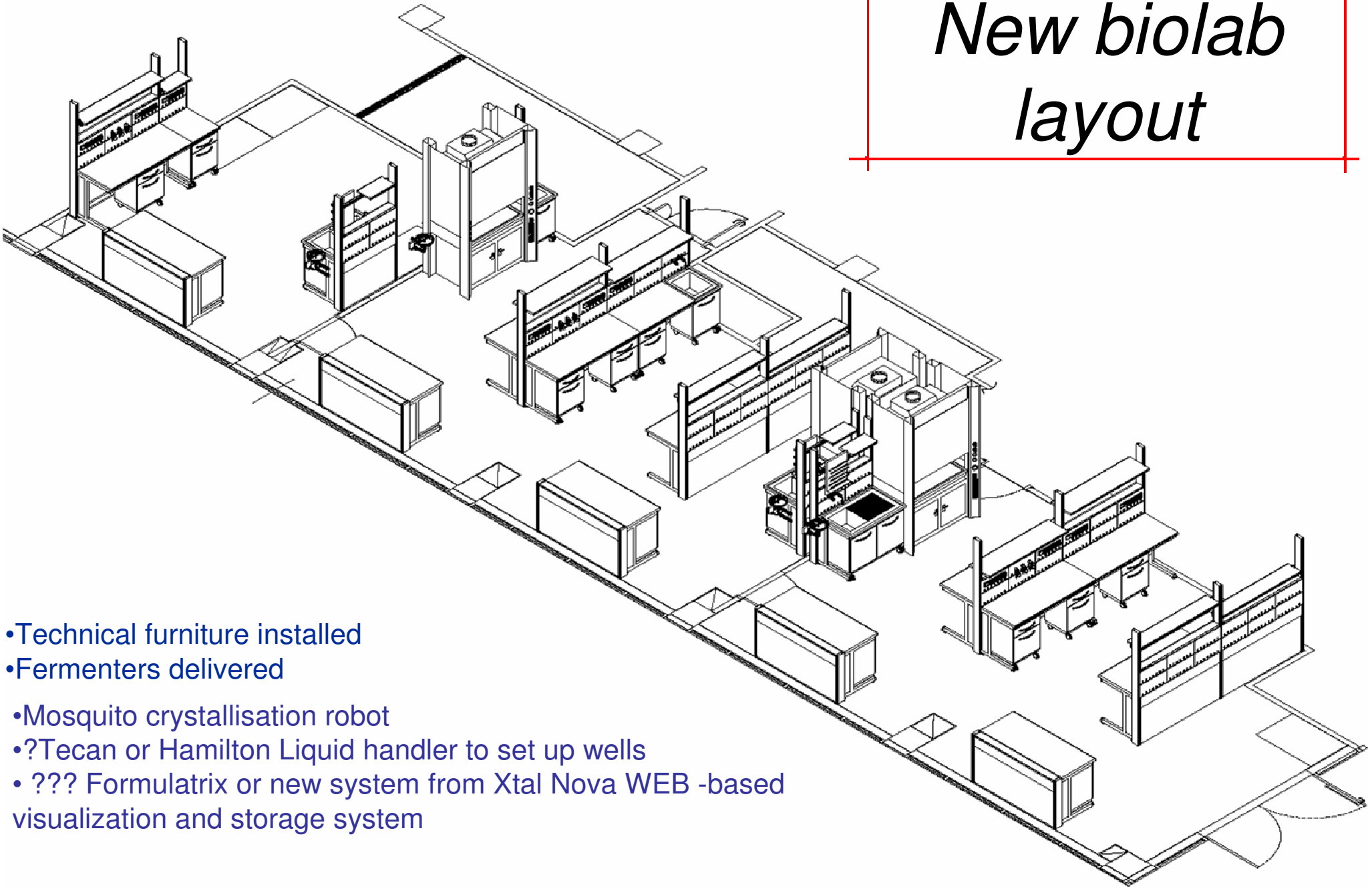
- Replacement of the SuperESCA/ESCAmicroscopy undulator
- Construction of a new high energy inelastic scattering beamline
- Replacement of storage ring FEL undulators
- Upgrade of the Nanospectroscopy beamline
- Replacement of the Gas phase beamline undulator

Protein Crystallography at Elettra

- Upgrade the existing diffraction beamline
- Set-up a new structural biology wet lab
- Build a MAD and two fix wavelength dedicated beamlines
- Hire scientists and a number of postdocs

elettra

New biolab layout



- Technical furniture installed
- Fermenters delivered

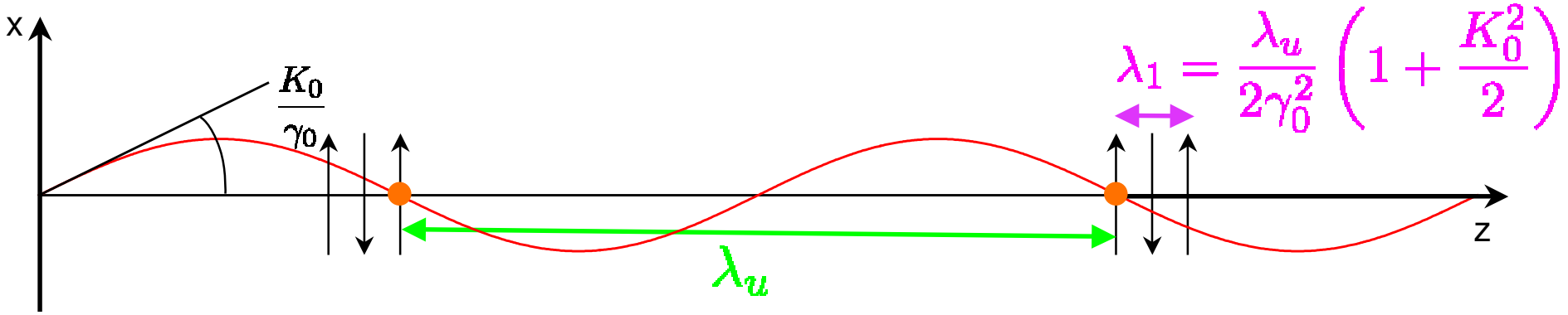
- Mosquito crystallisation robot
- ?Tecan or Hamilton Liquid handler to set up wells
- ??? Formulatrix or new system from Xtal Nova WEB -based visualization and storage system

FERMI@elettra - Project Update

User Requirements

- **User Requirements**
  - **100 - 10 nm range (and less) - fully tuneable & polarised coherent radiation**
  - **100's MW to GW's of peak power**
  - **10^{13} to 10^{14} photons/pulse**
  - **0.05 to > 1ps photon pulse lengths**
  - **good pointing stability**
  - **reasonable pulse to pulse timing jitter**
  - **good pulse reproducibility ~10% ⊗I/I**

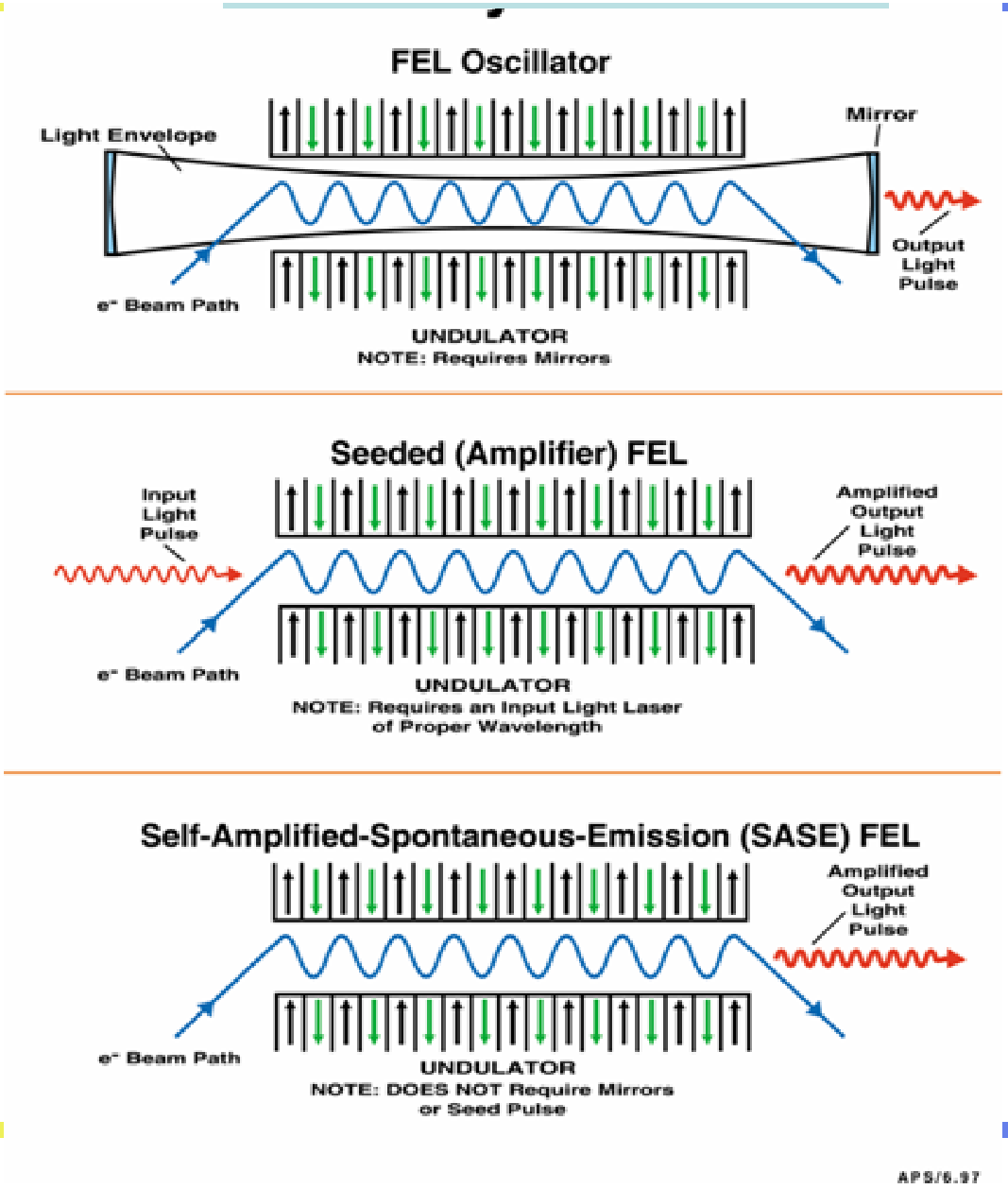
The FEL basic phenomenon



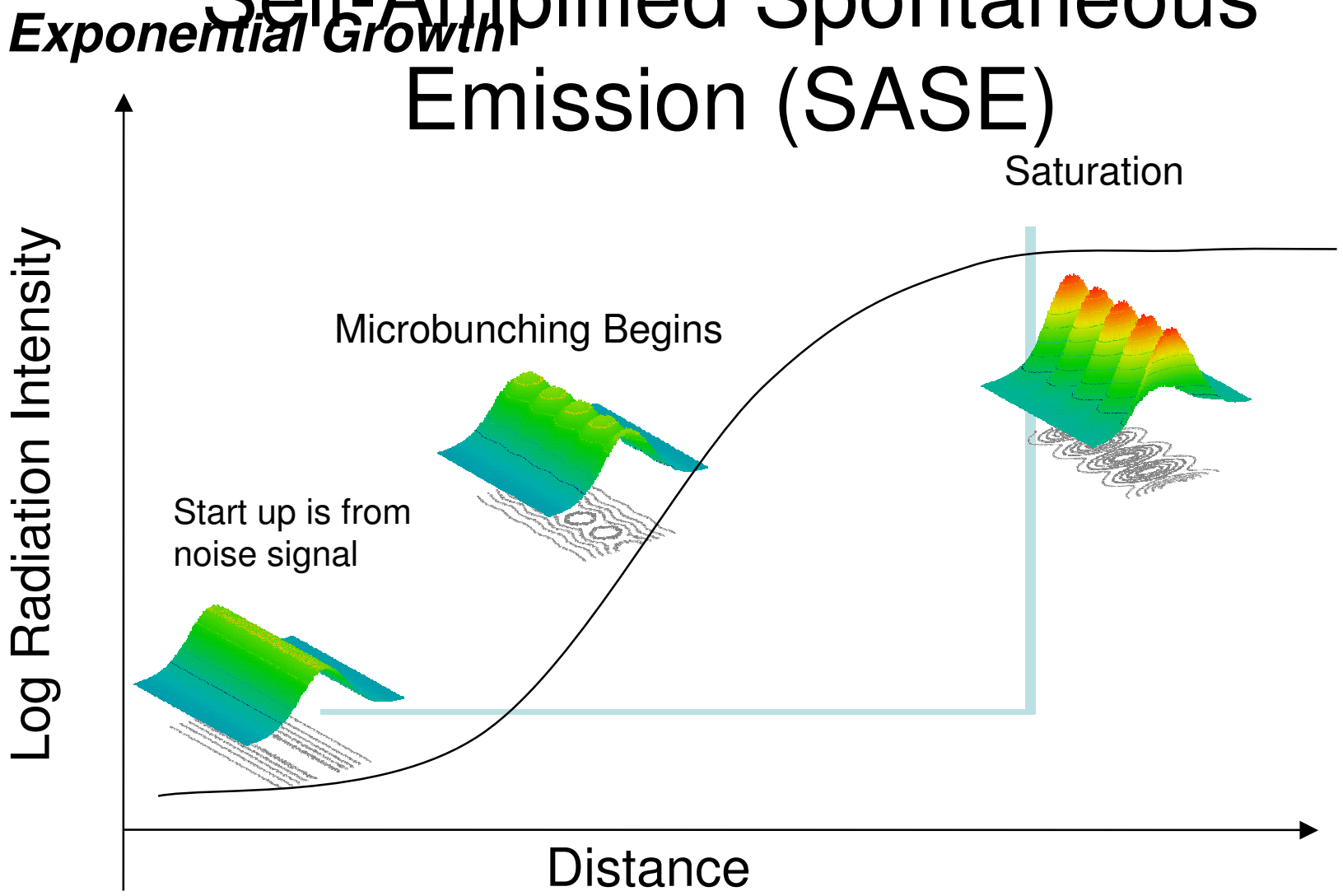
After an electron travels one undulator period λ_u of the sinusoidal trajectory, a plane wave (represented by alternating vertical arrows) overtakes the electron by one resonant wavelength λ_1. Thus, the undulator radiation carrying this resonant wavelength can *exchange energy* with the electron over many undulator periods.

Depending on the phase between the electrons and the plane wave, some electrons **gain** energy from the radiation, while other **lose** energy to the radiation. Slower electrons are accelerated while faster ones are slowed down leading to "**microbunching**"

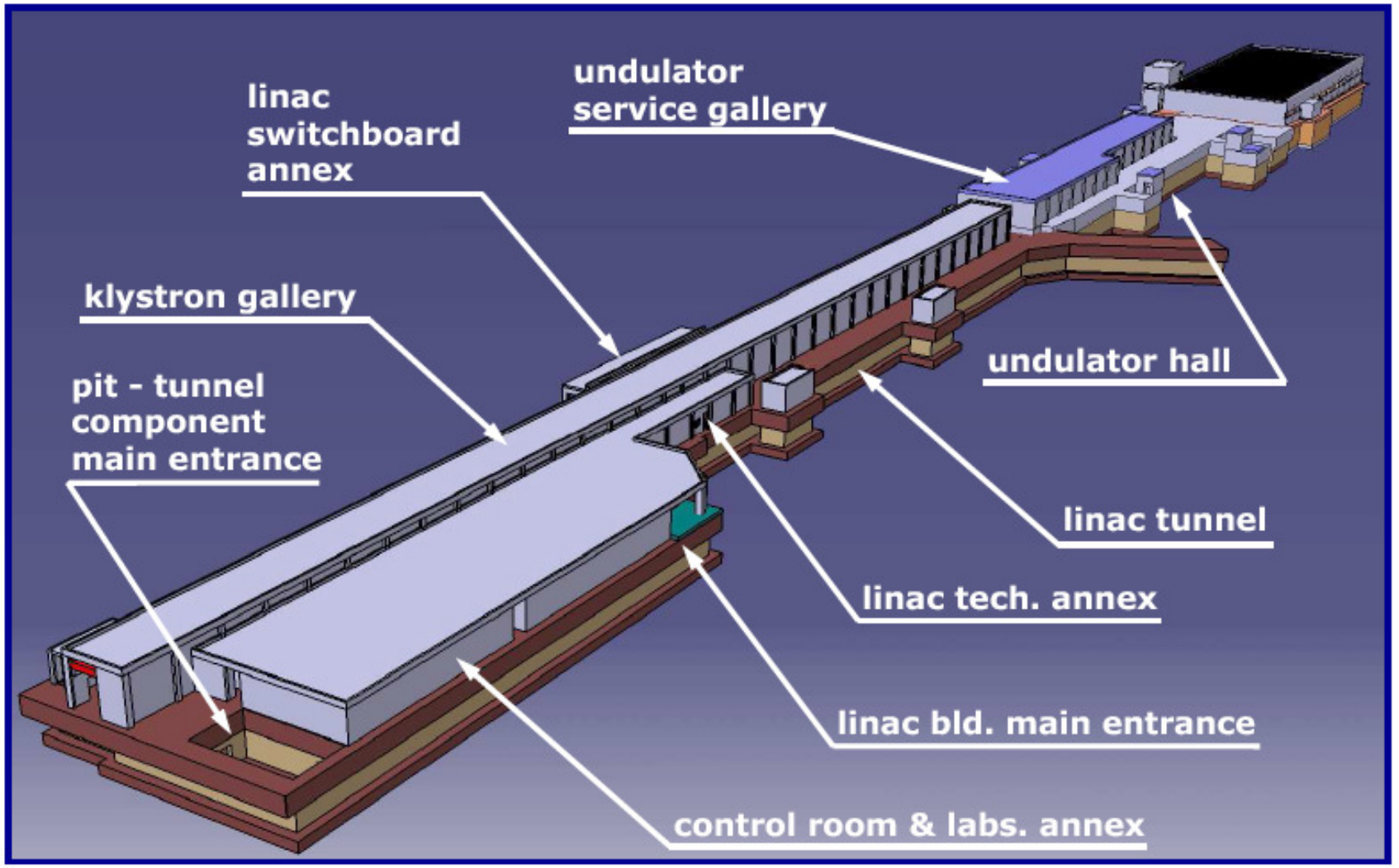
FEL Types: Oscillator, Seeded FEL, SASE



Self-Amplified Spontaneous Emission (SASE)



Main buildings 3D view 1/10



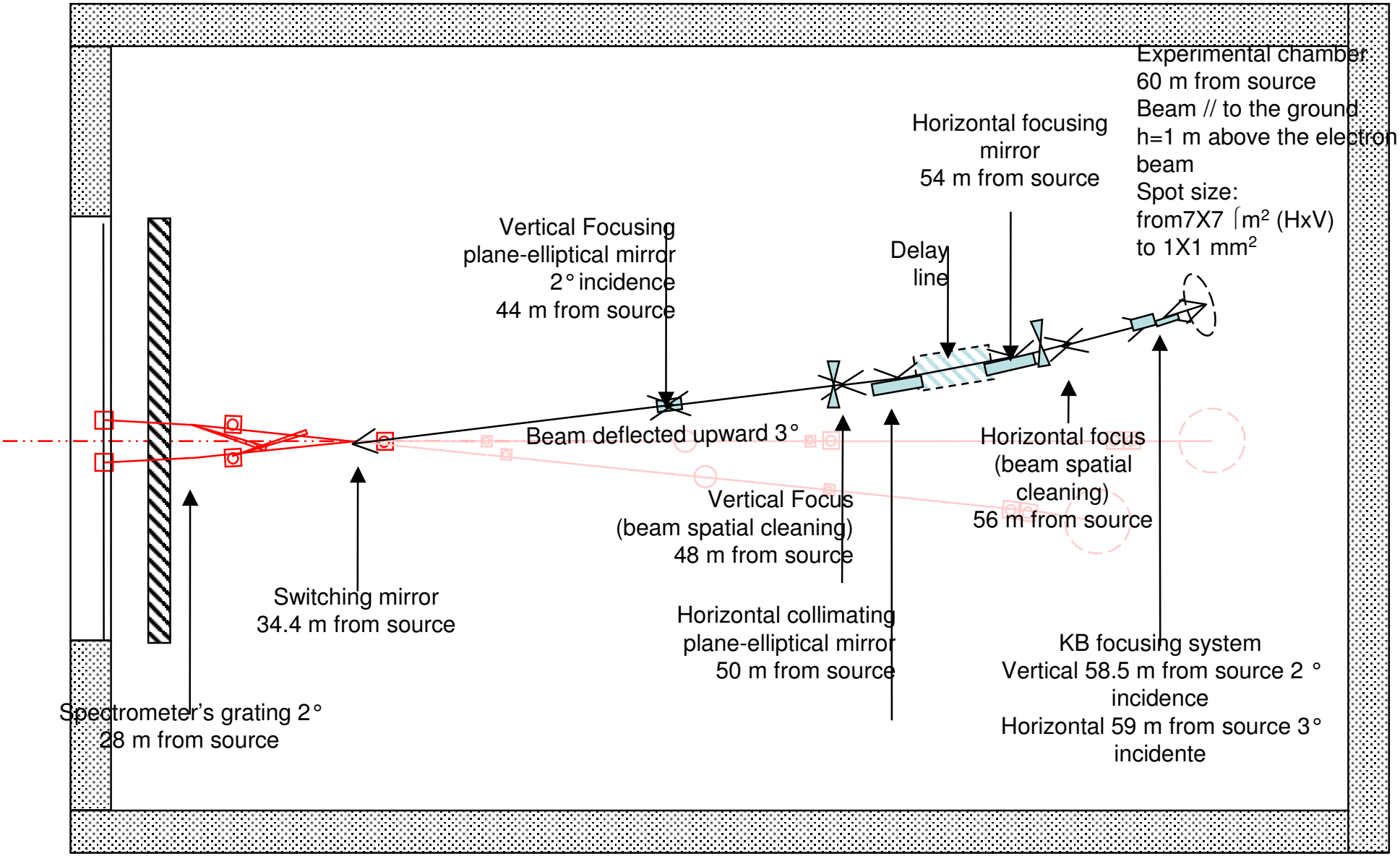
APPLE II Undulator Prototype

- APPLE II Undulator
  - Full variable polarization capability
- Prototype to be built in house
  - Design complete
  - Parts ordered and arriving
  - Assembly to begin in June
  - To Test
    - Mechanics
    - Motion Control
    - Quality

Undulator Industrialization

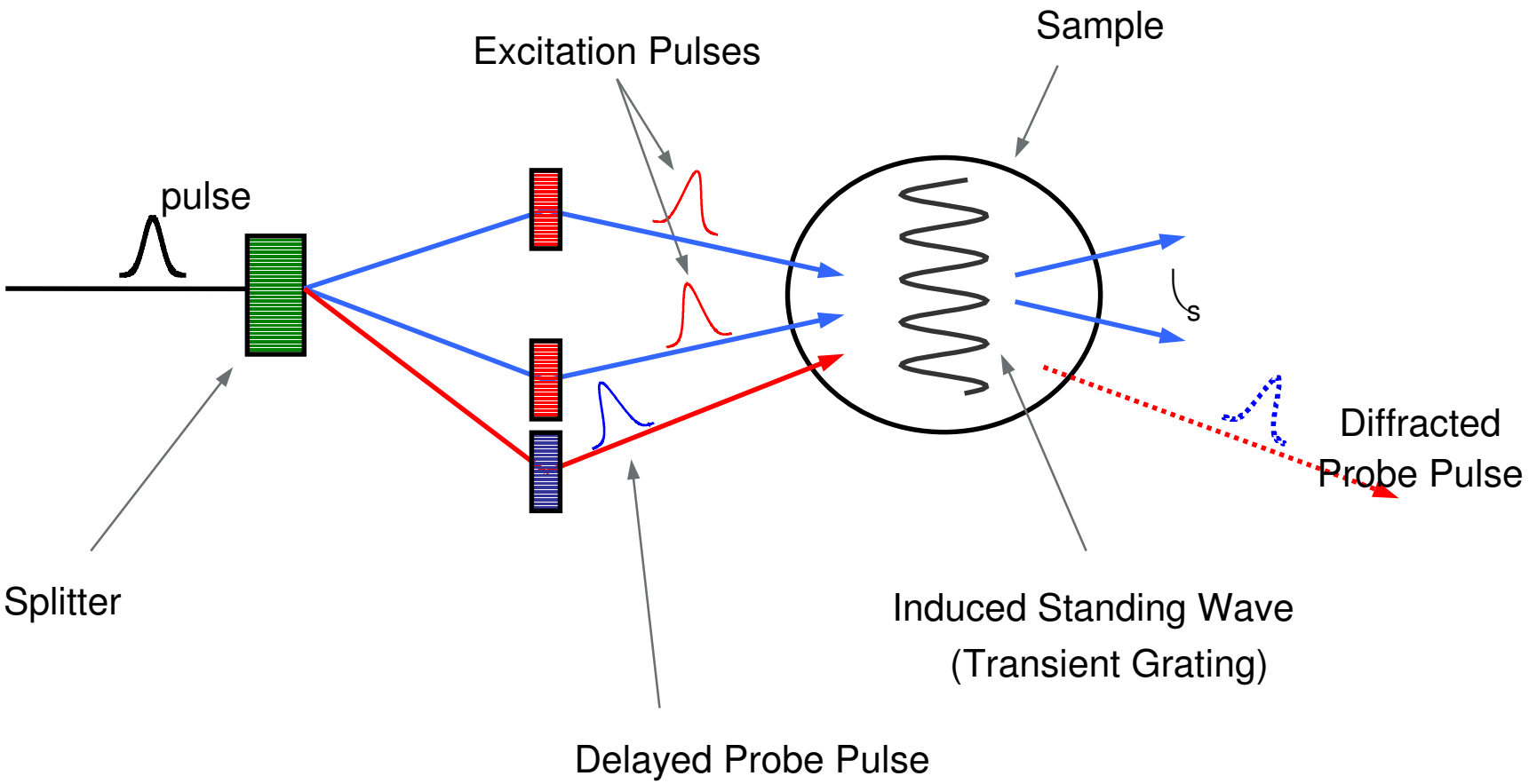
- Create a spin off company (KYMA) to build the undulators
  - 51% Sincrotrone Trieste
  - 49% Euromisure s.r.l. (Cremona) + Cosylab d.d.o. (Ljubljana)
  - Business in the process of formation, i.e. detailed business plan being finalized
- KYMA Responsibilities
  - Construction of Undulators
  - Tuning of Undulators
- Sincrotrone Trieste to provide expertise
  - I.e. the laser heater undulator

Microscopy beamline



D. Cocco -ST-

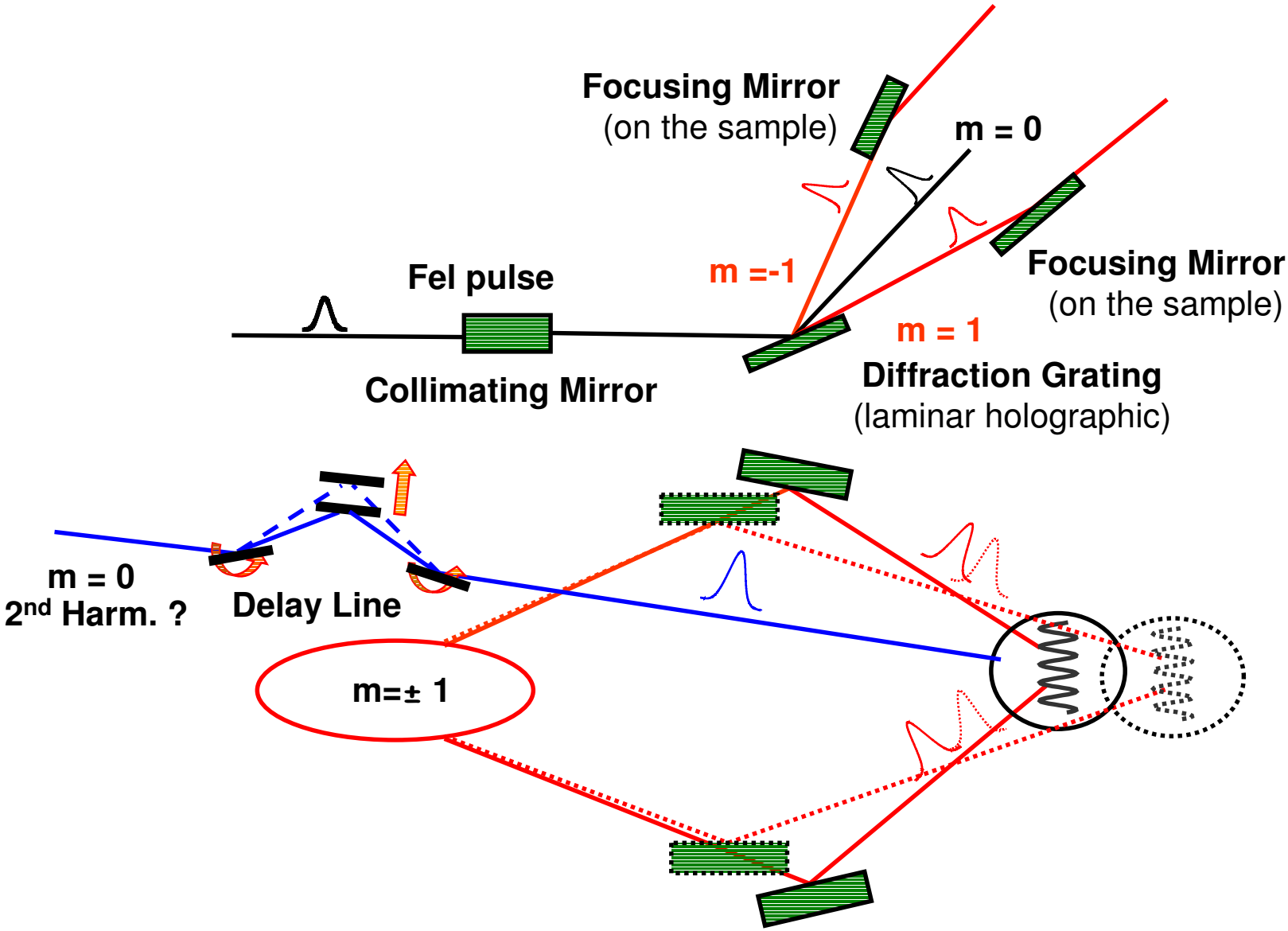
Transient Grating Spectroscopy



Standing Wave Periodicity $\Rightarrow$ $\Lambda = 2\pi/Q$ $\quad Q = 2k_o \sin \lambda_s/2$

Density Modulation Amplitude Monitored in Time by the Probe Pulse $\Rightarrow$ $F(Q, t)$

The FEL Beamline Layout



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