

TAIWAN PHOTON SOURCE

X-ray Nanoprobe Beamline for Nanoscale Solid State Physics Research

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2018/09/27

National Synchrotron
Radiation Research Center

X-ray and IR Image Group
Experiment Facility Division
NSRRC

www.nsrcc.org.tw

Outline

- Synchrotron Light Source
- Application of Synchrotron Light
- X-ray nano probe at TPS

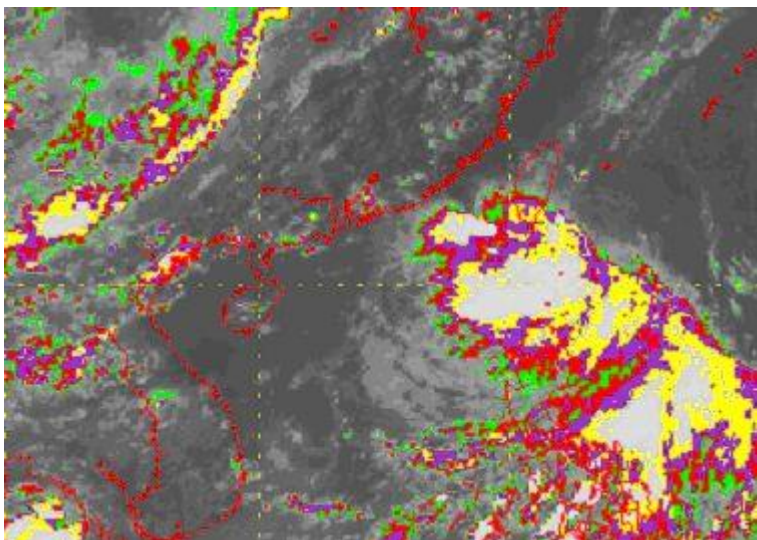


“Light” is indispensable to man’s exploration of nature.

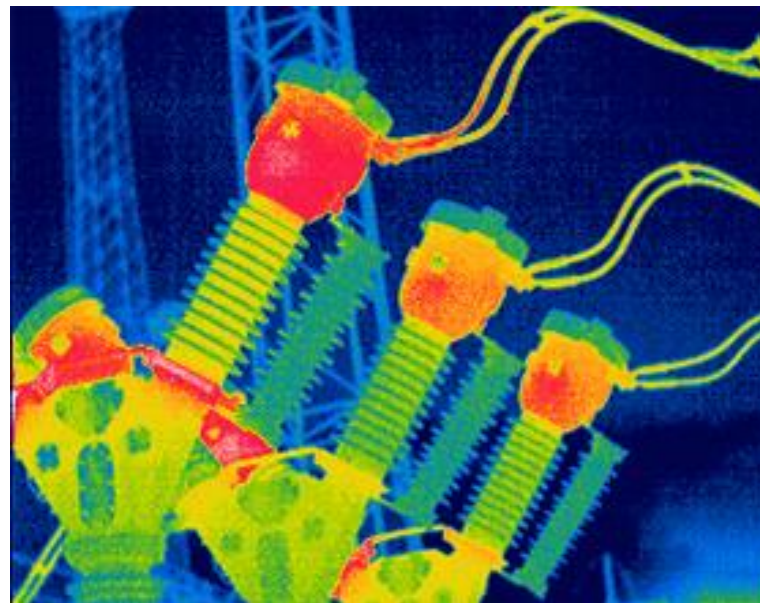


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Invisible light: IR and X-ray...



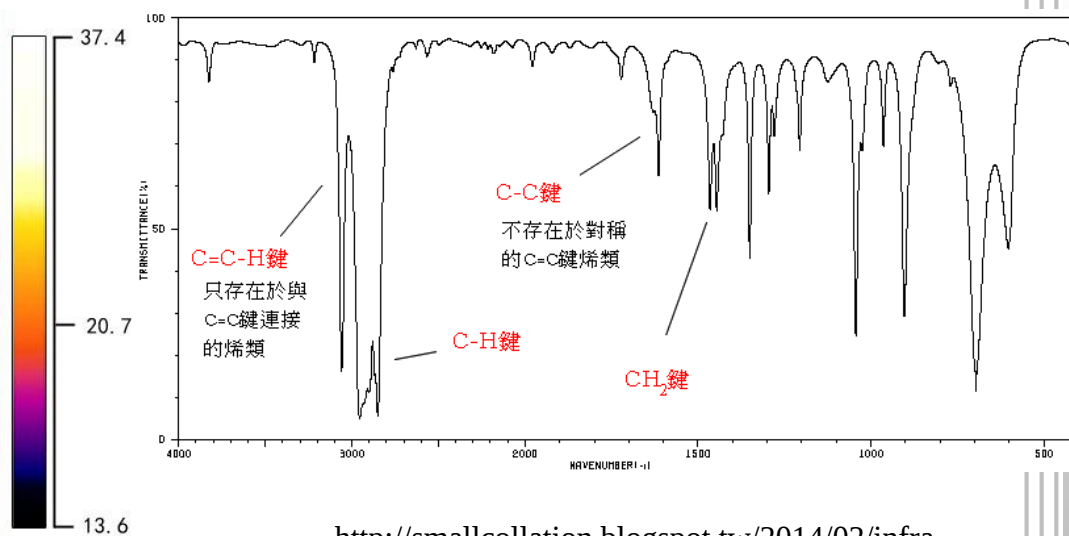
http://www.hko.gov.hk/prtver/html/docs/education/edu02rga/radiation/radiation_02-c.shtml



<http://www.yingfukeji.com/appl/grid.html>

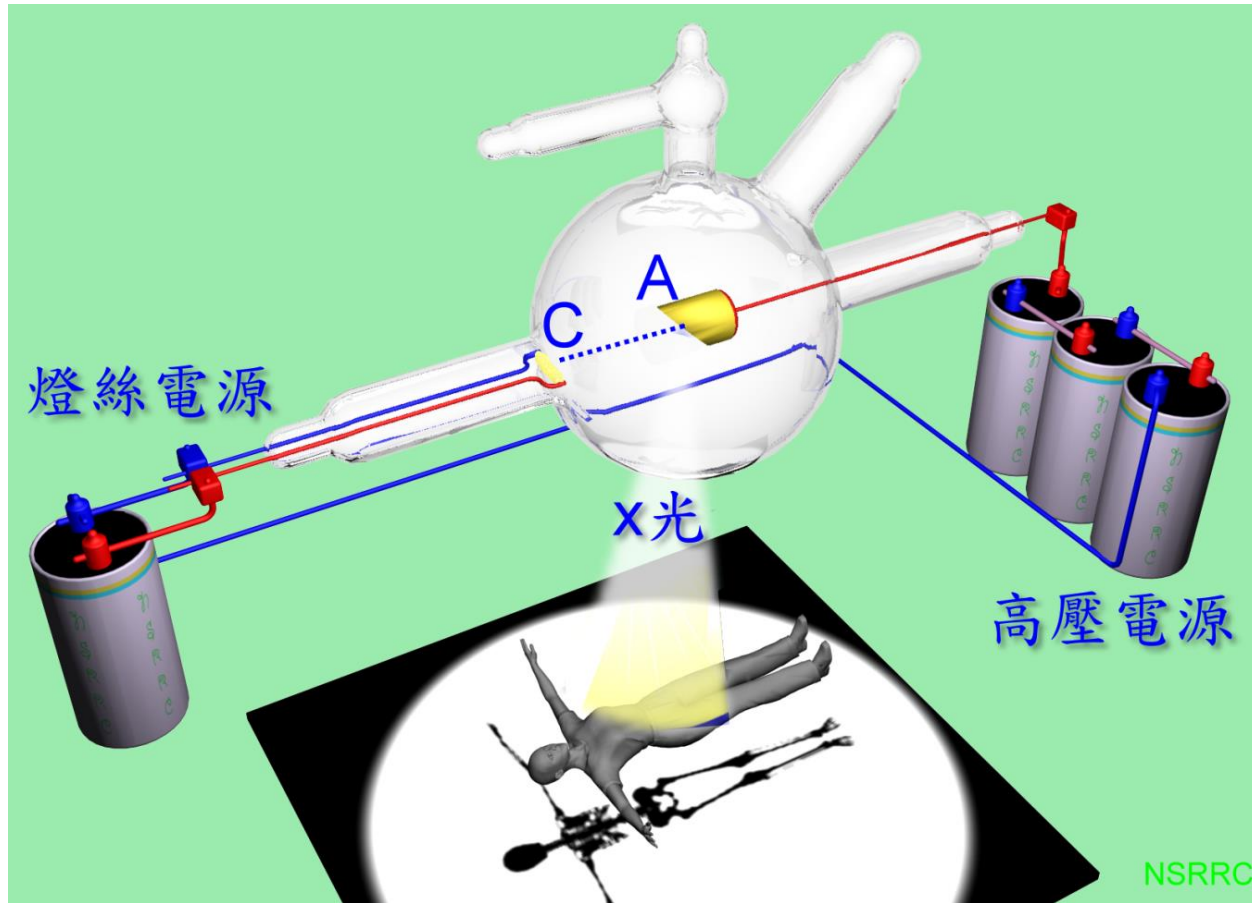


<http://www.uv-teck.com/Ttwjy>



<http://smallcollation.blogspot.tw/2014/02/infrared-spectroscopy-of-alkanes.html#gsc.tab=0>

Rontgen used a simple accelerator to discover X-rays



1895



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Hand mit Ringen (Hand with Rings): Wilhelm Röntgen's first "medical" X-ray, of his wife's hand, taken on 22 December 1895 and presented to Ludwig Zehnder of the Physik Institut, University of Freiburg, on 1 January 1896.

<http://en.wikipedia.org/wiki/X-ray>



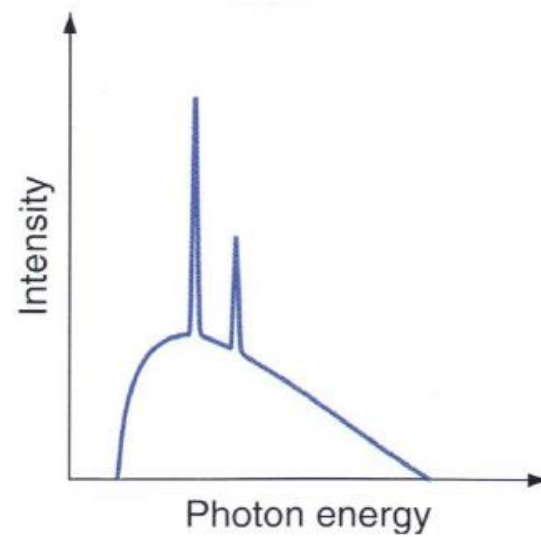
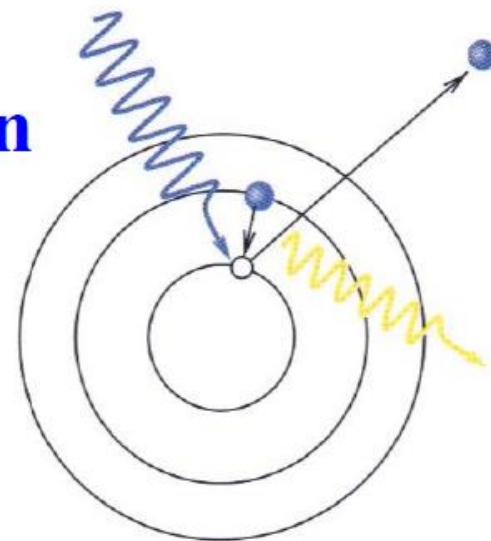
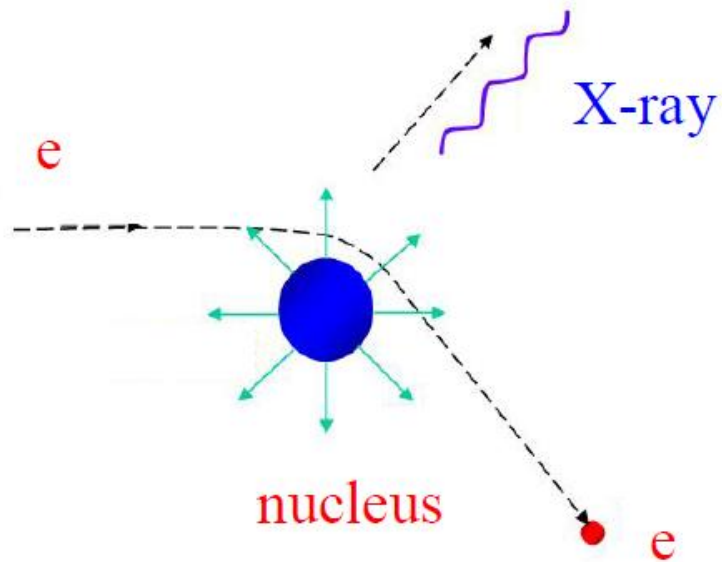


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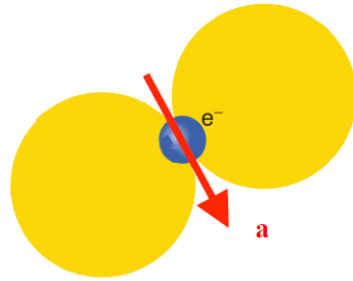


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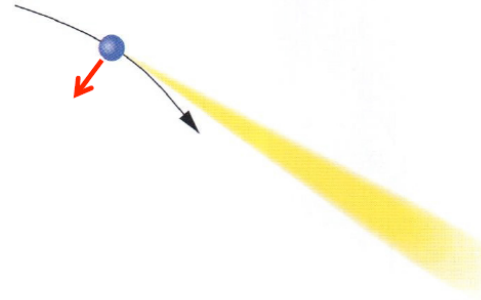
Characteristic X-ray emission



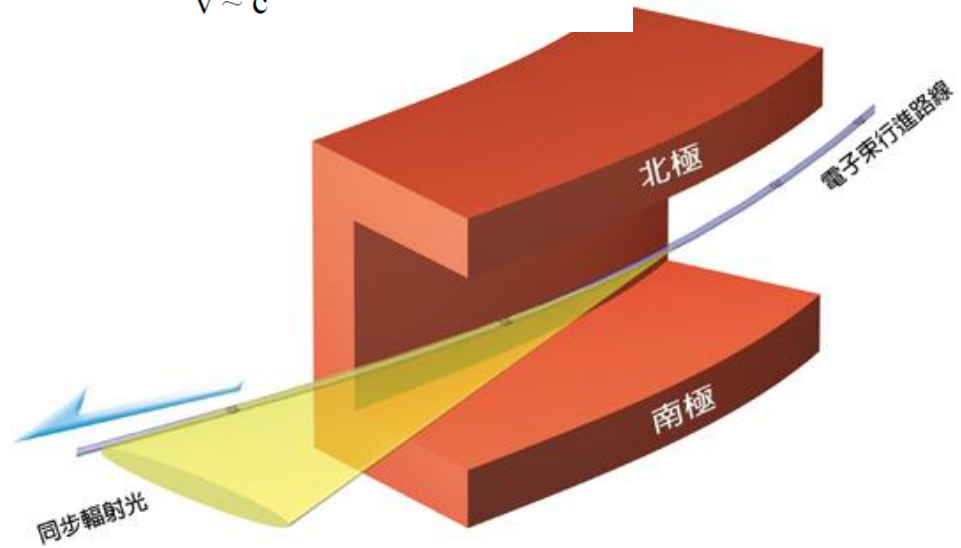
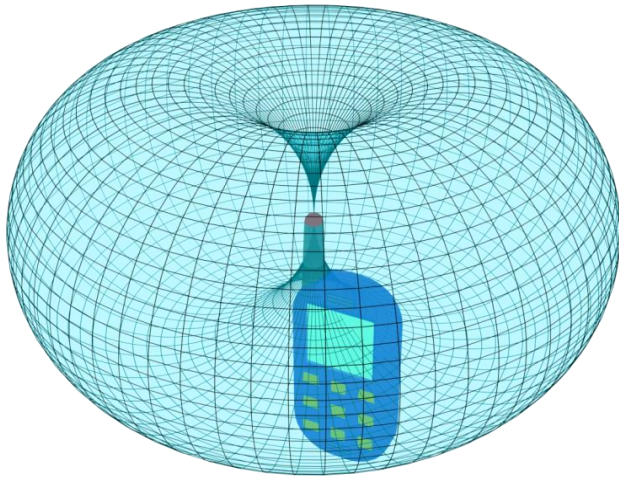
Electromagnetic wave from a moving charge



$v \ll c$



$v \sim c$



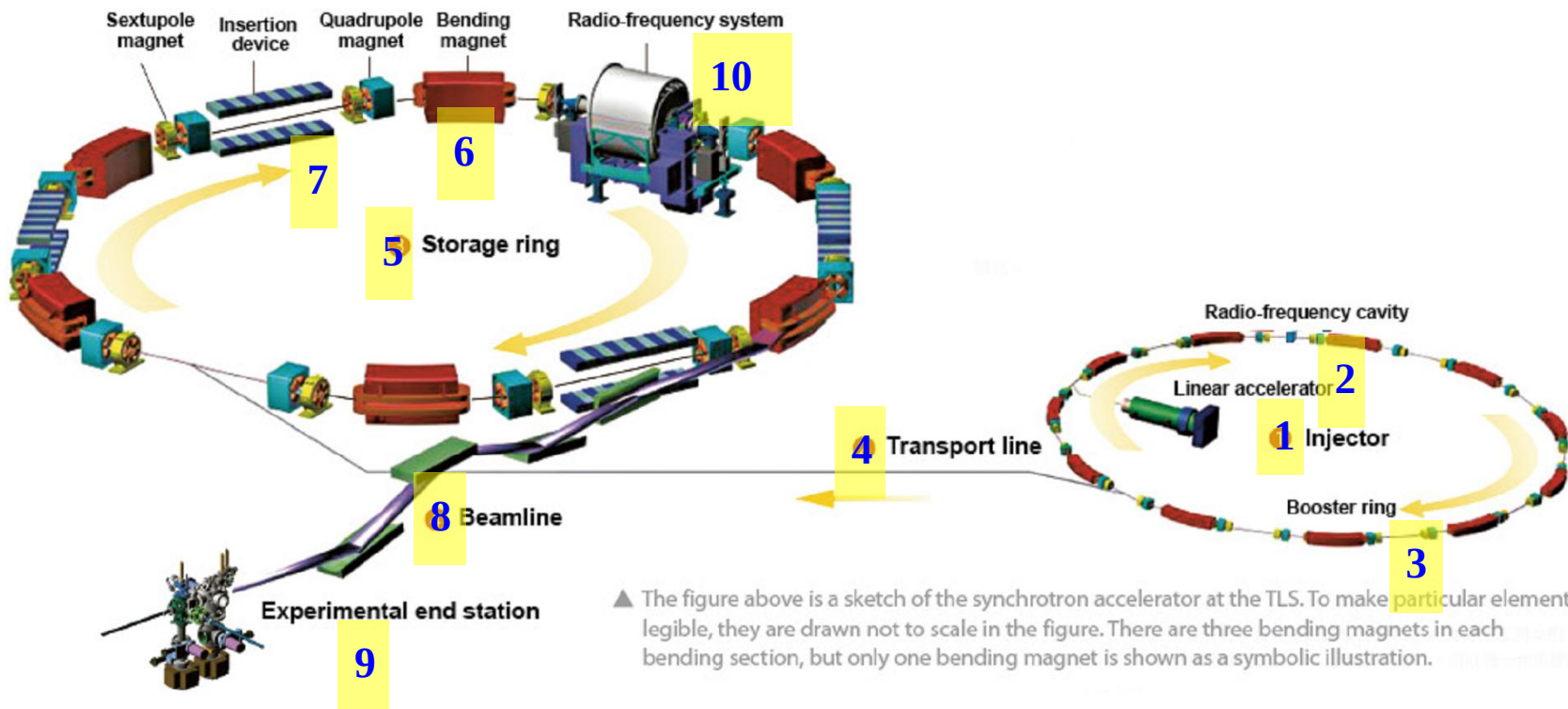
二極偏轉磁鐵



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同步加速器光源的原理

- 電子在電子槍(1)內產生，經過直線加速器(2)加速至能量為5,000萬電子伏特。
- 電子束進入增能環(3)後，繼續增加能量至15億電子伏特(1.5GeV)，速度非常接近光速(0.99999995倍)。
- 電子束經由傳輸線(4)進入儲存環(5)。
- 當儲存環累積足夠的電子束後，經由各個磁鐵的導引與聚焦，電子束在偏轉磁鐵(6)及插入磁鐵(7)發出同步加速器光源，經由光束線(8)將光源引導至實驗站(9)進行實驗。
- 電子束在發出同步加速器光源後，要靠高頻腔(10)來補充失去的能量。





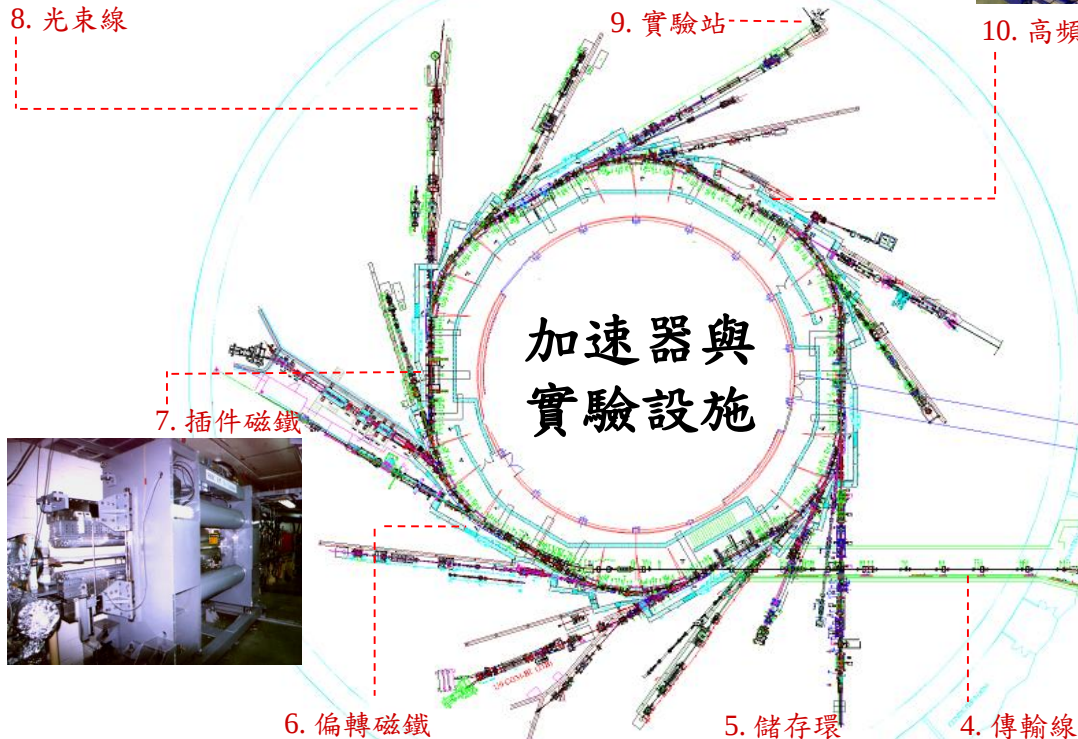
8. 光束線



9. 實驗站



10. 高頻系統



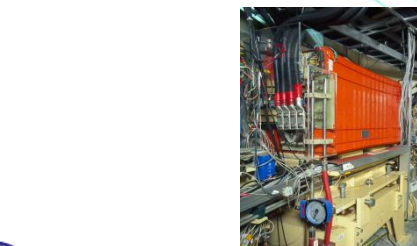
7. 插件磁鐵



1. 電子槍



2. 直線加速器



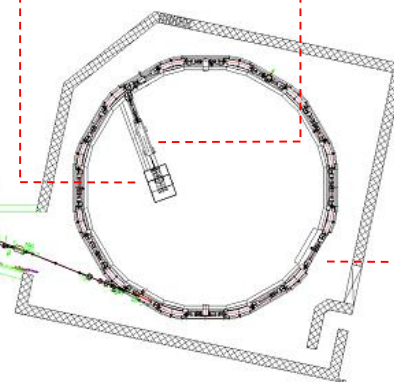
6. 偏轉磁鐵



5. 儲存環



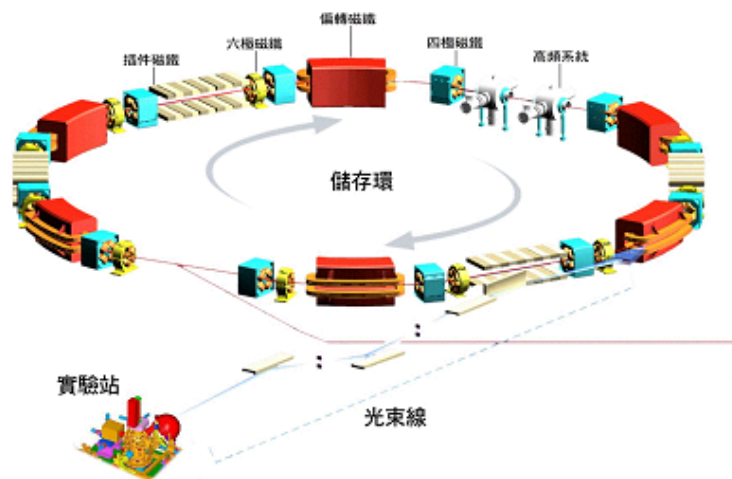
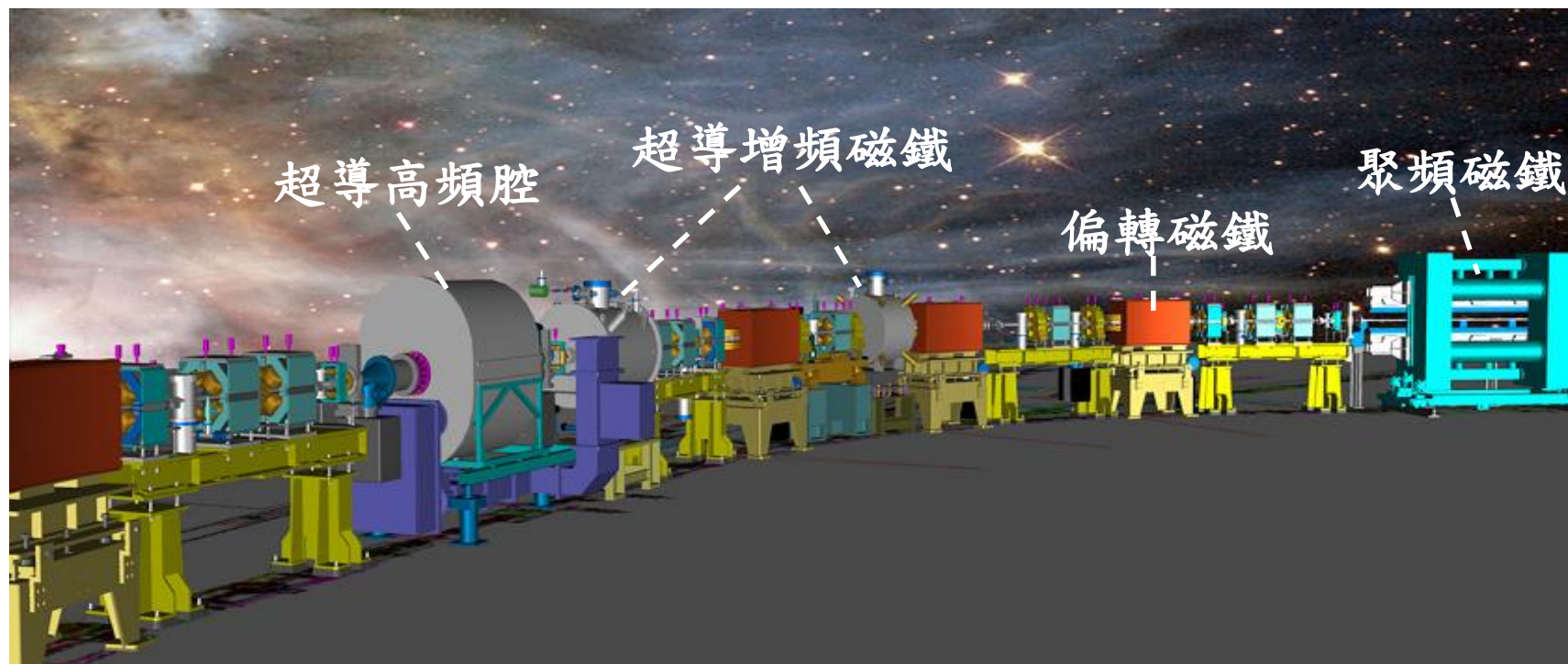
4. 傳輸線



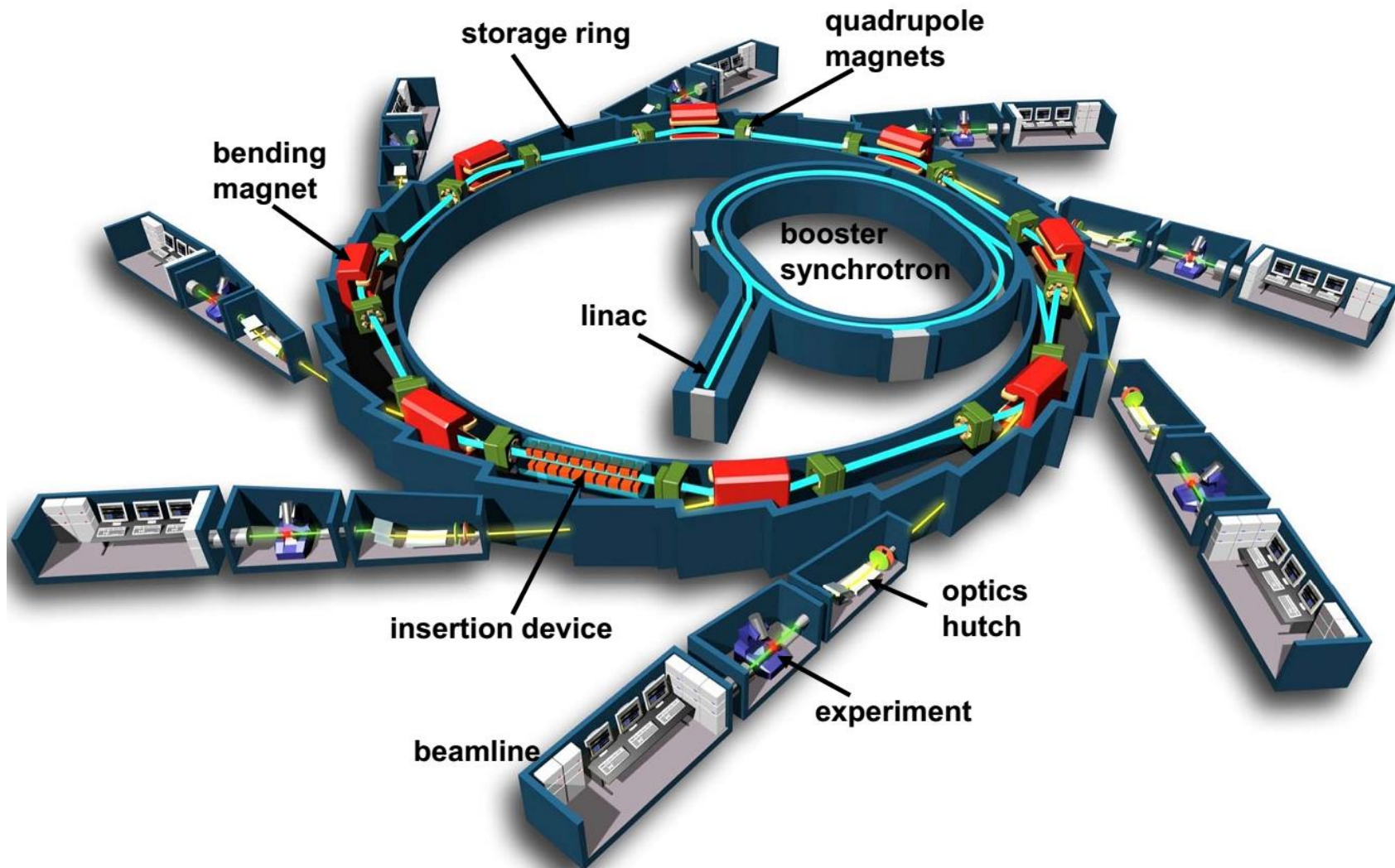
3. 增能環



儲存環 3D 圖

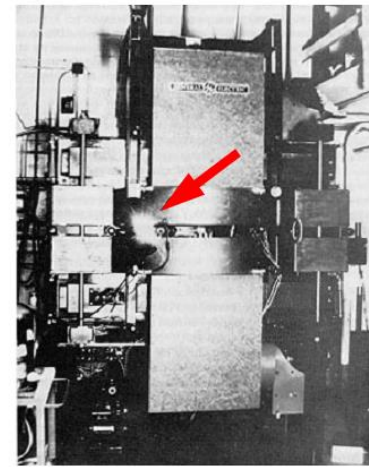


A Synchrotron Step by Step



A brief history

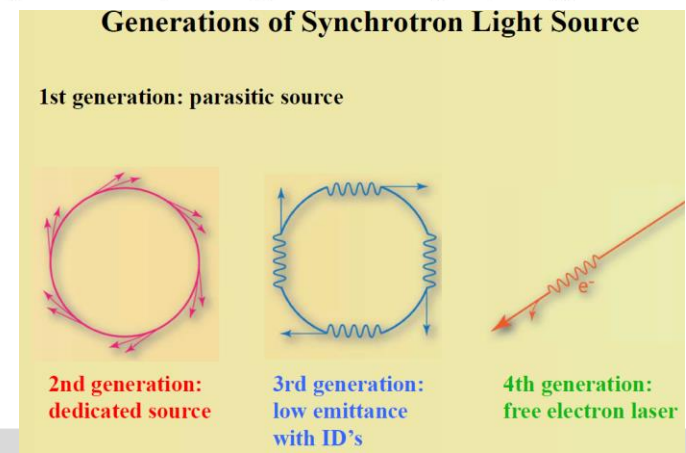
- First observed:
1947, General Electric, 70 MeV synchrotron
- First user experiments:
1956, Cornell, 320 MeV synchrotron
- First insertion Device:
1979, 7 pole wiggler, SSRL
- 1st generation light sources: high energy physics synchrotrons and storage rings used parasitically for synchrotron radiation – eg DESY (Germany), INS-SOR (Tokyo), SPEAR (USA), (1960's, 1970's)
- 2nd generation light sources: purpose built synchrotron light sources, eg Photon Factory, NSLS, Daresbury (1980s onwards)
- 3rd generation light sources: optimised for high brilliance with low emittance and Insertion Devices; SPRing-8, ESRF, APS, Diamond, ... (1990's onwards)
- Free Electron Laser sources: FLASH (Germany), LCLS (USA), SACLA (Japan), FERMI (Italy) ... (2000's)
- Next??



2015 Cheiron School



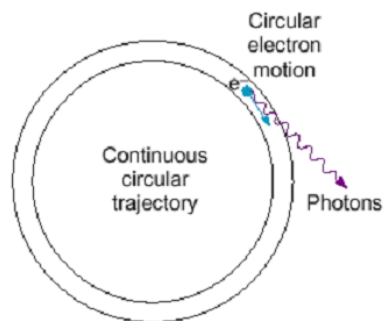
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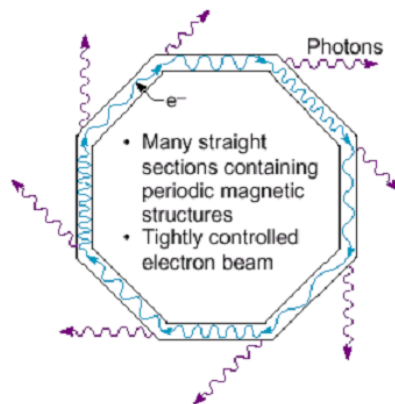
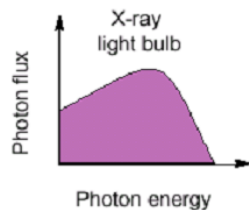
Third Generation Sources: Undulator Insertion Devices

1st, 2nd Generation

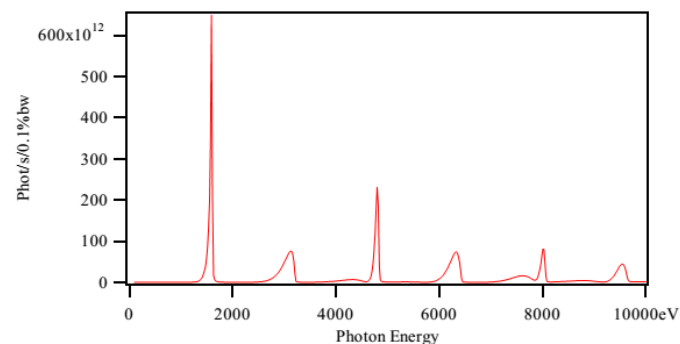
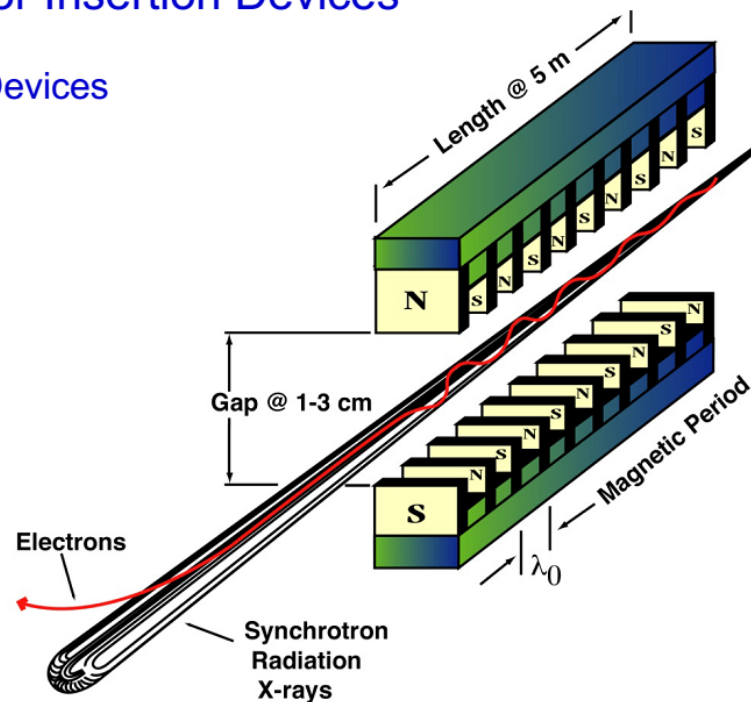
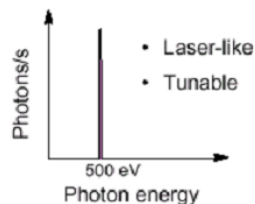
3rd Generation: Insertion Devices



Bend Magnet Radiation

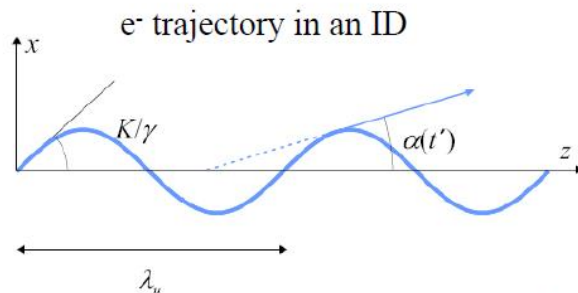
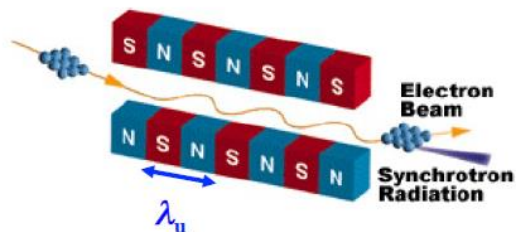


Undulator Radiation

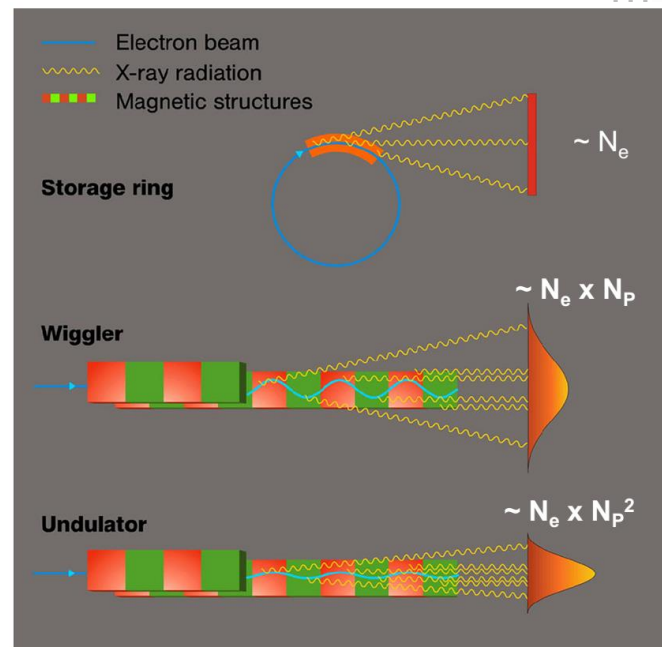
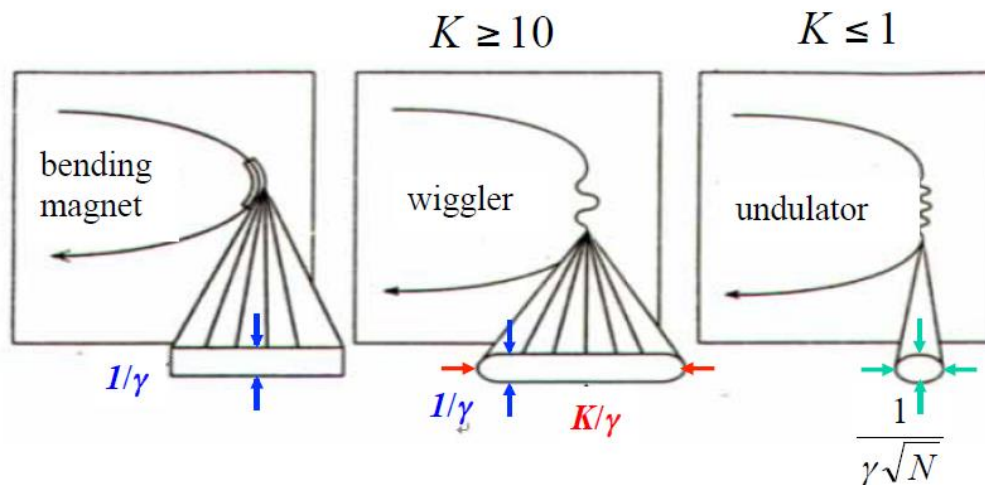


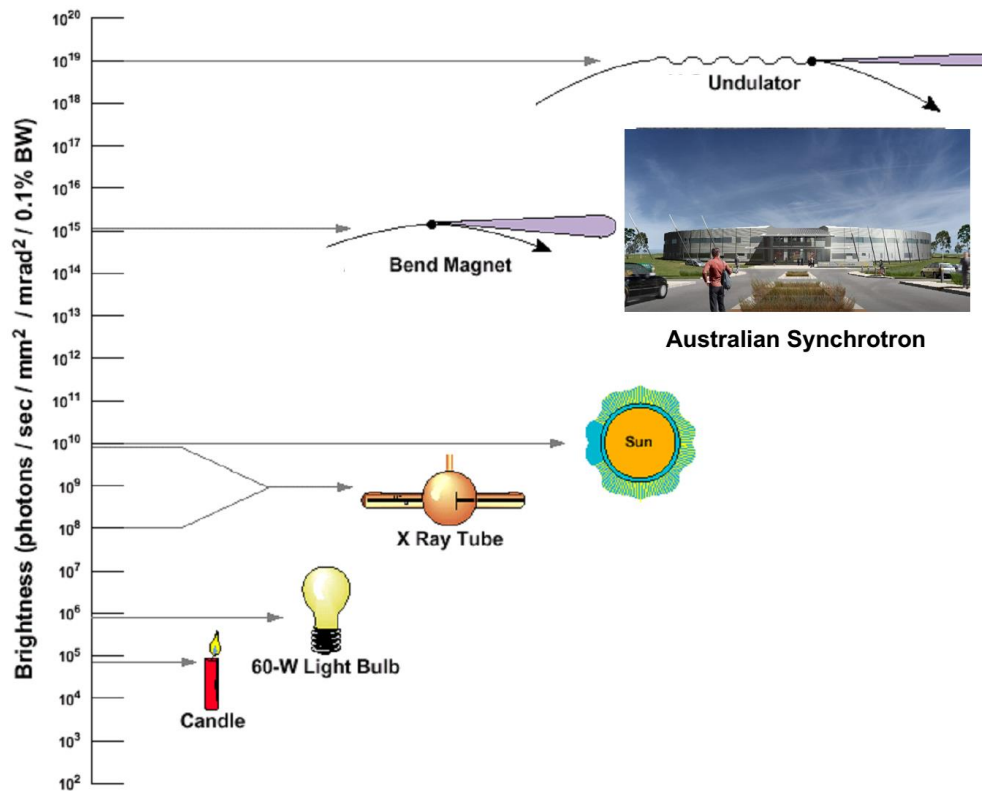
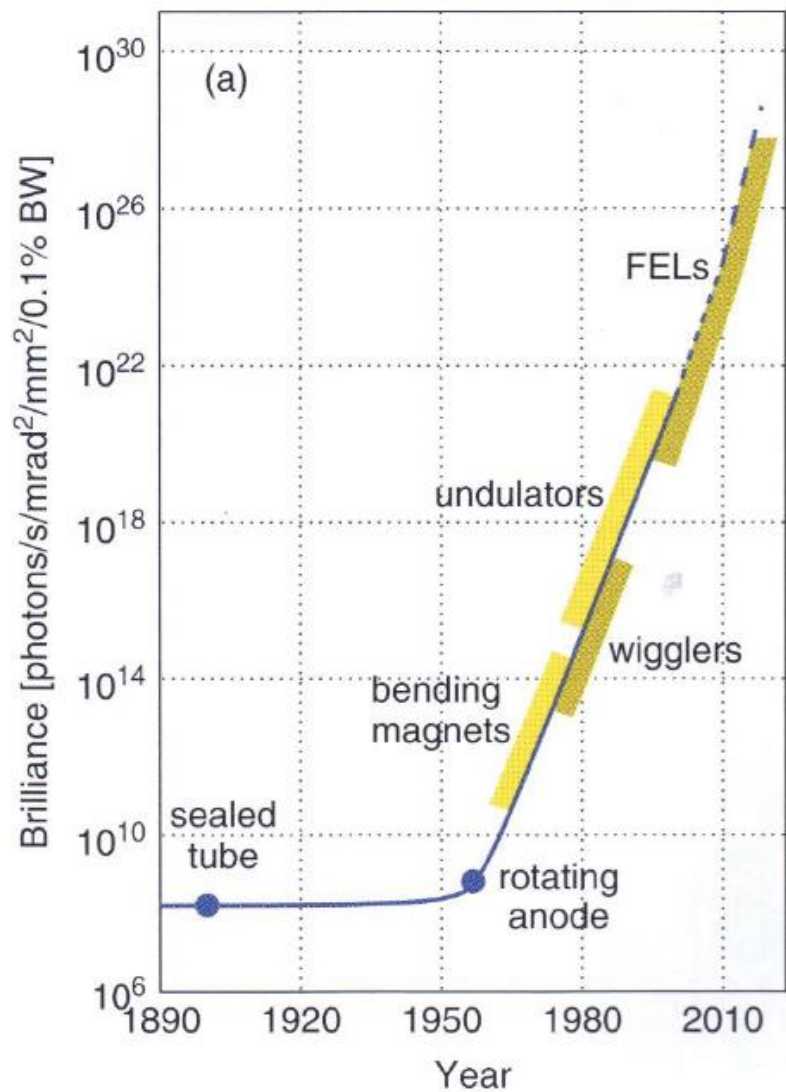
Angular distribution of synchrotron radiation emitted from various magnets

Wiggler or undulator



$$K = \alpha_{\max.} / \gamma^{-1}$$

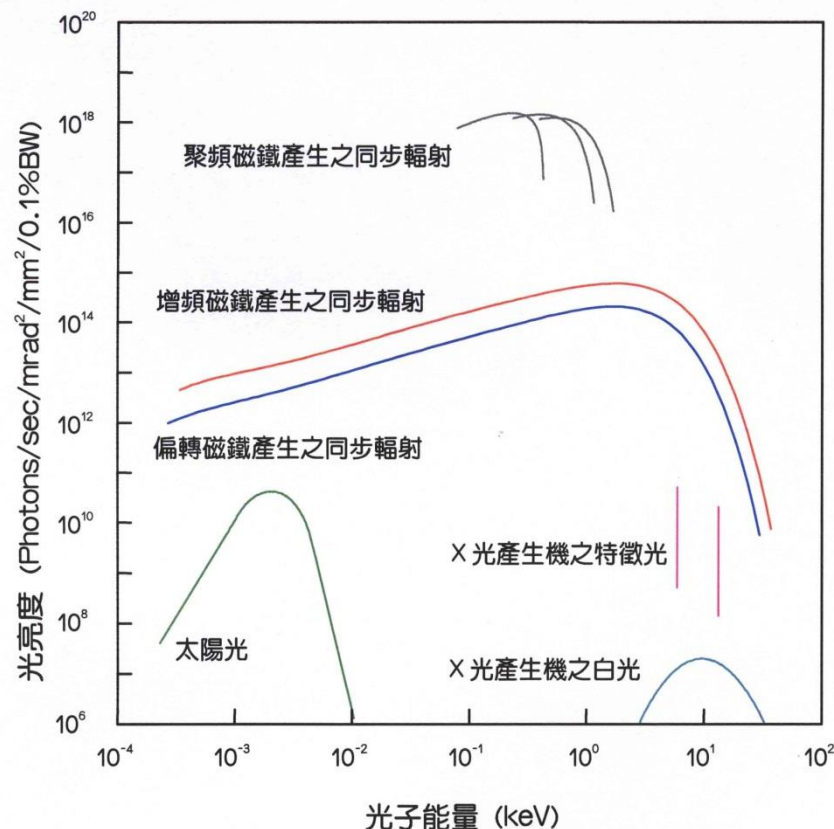




Unique Features of Synchrotron Light Source

- High intensity
- Continuous spectrum
- Excellent collimation
- High polarization
- Pulsed-time structure

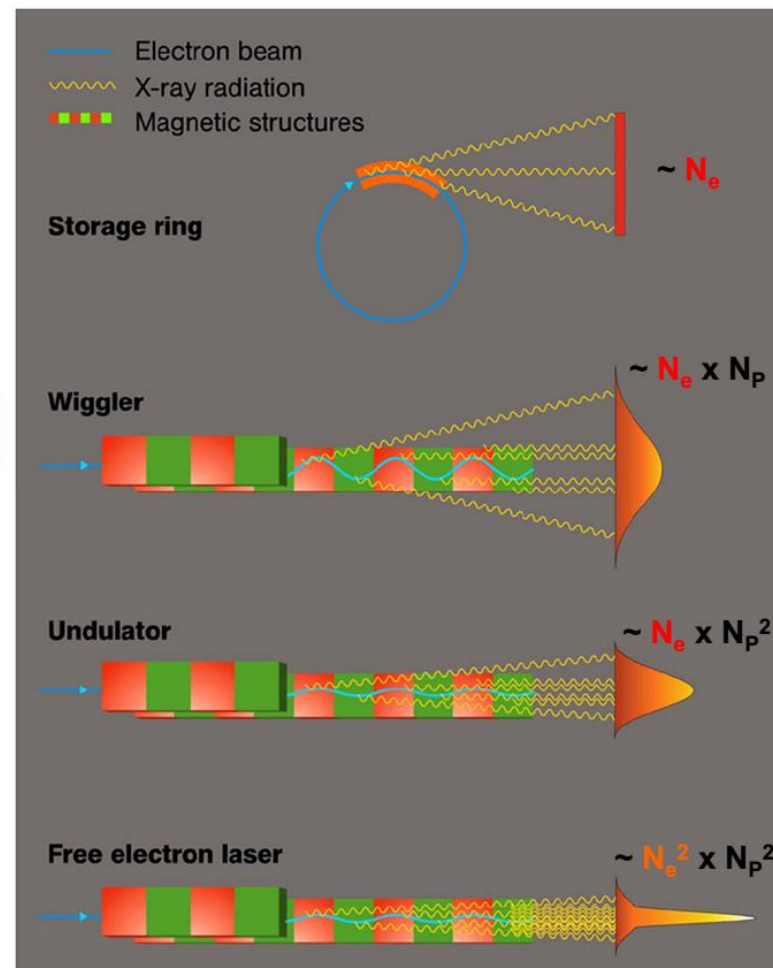
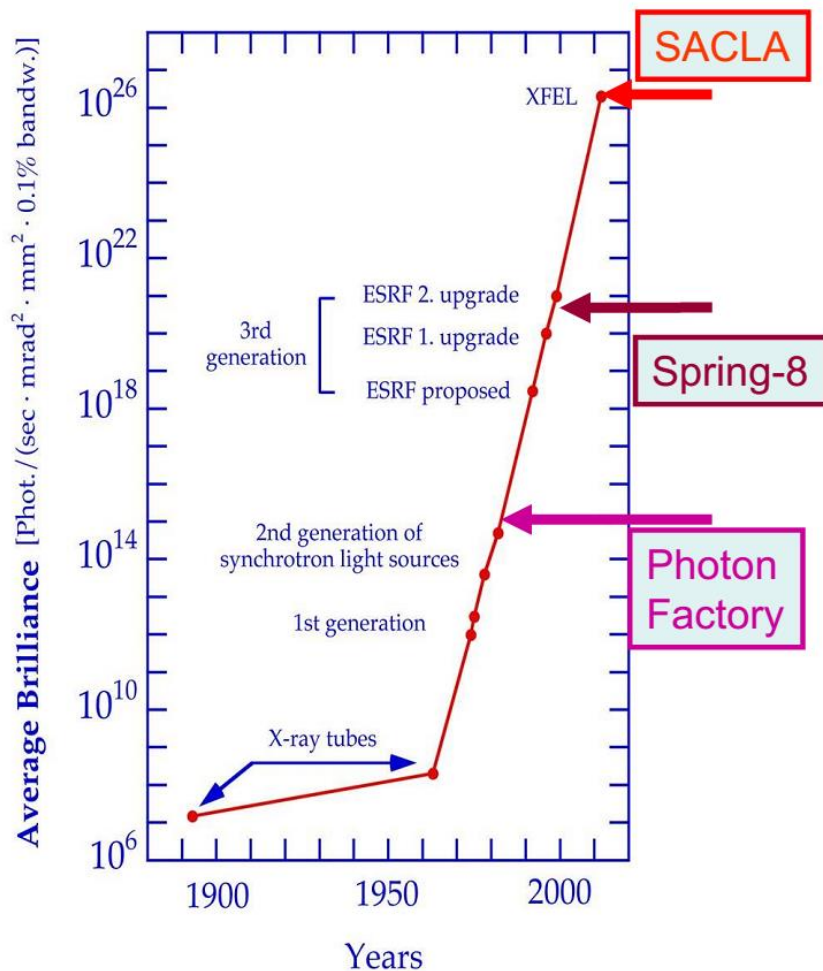
以X光為例，同步加速器光源在這個波段的亮度比傳統X光機還要強百萬倍以上！過去需要幾個月才能完成的實驗，現在只需幾分鐘便能得到結果。以往因實驗光源亮度不夠而無法探測的結構，現在藉由同步加速器光源，都可分析得一清二楚，也因此得以開發新的研究領域。



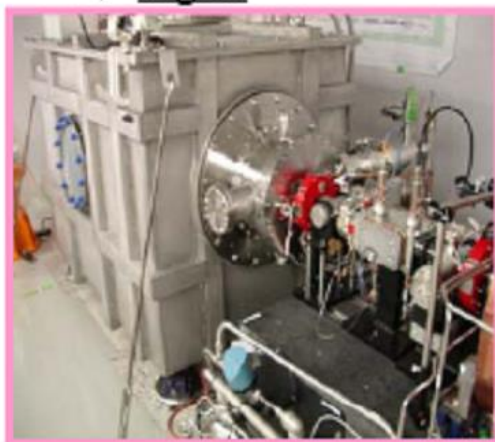
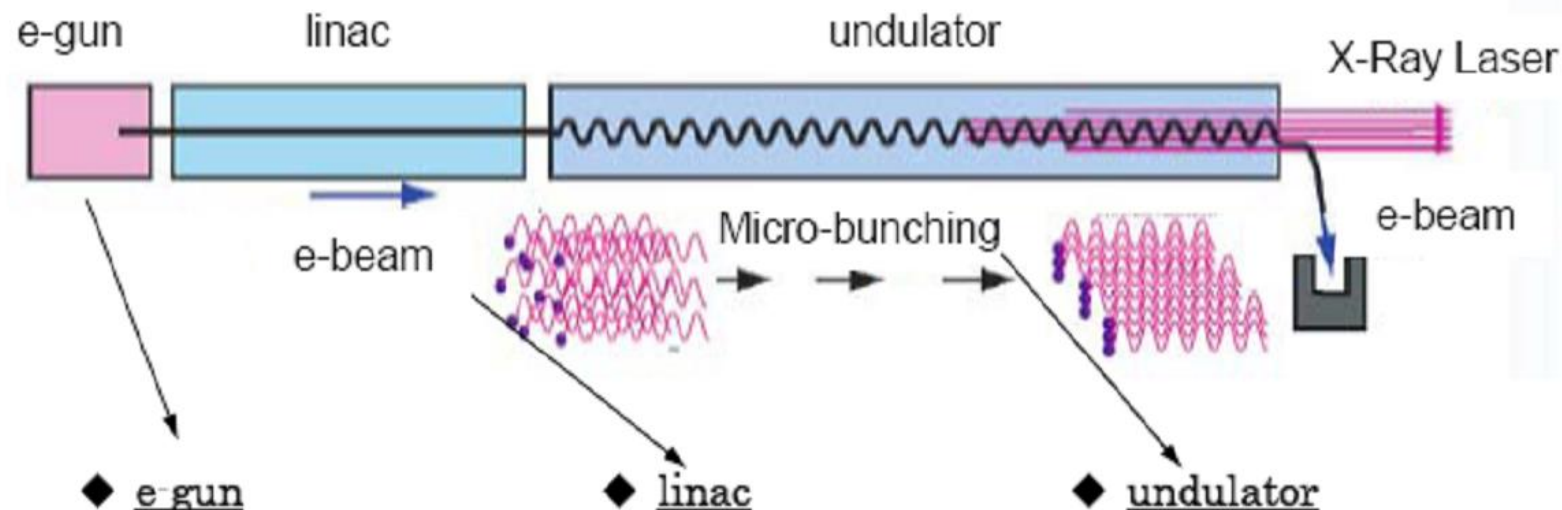
- 光子能量：一般單位為電子伏特(eV)，一電子伏特為電子在真空中通過一伏特電位差所獲得的能量。
- 光亮度：指單位時間內通過單位立體角的單位頻寬光子數。



Next Step - X-ray Lasers? Yes → FELs



Linac-Based Free Electron Laser Self-Amplified Spontaneous Emission (SASE)



SACLA 1st beamline: 90m Undulator



2012 Cheiron School Tour

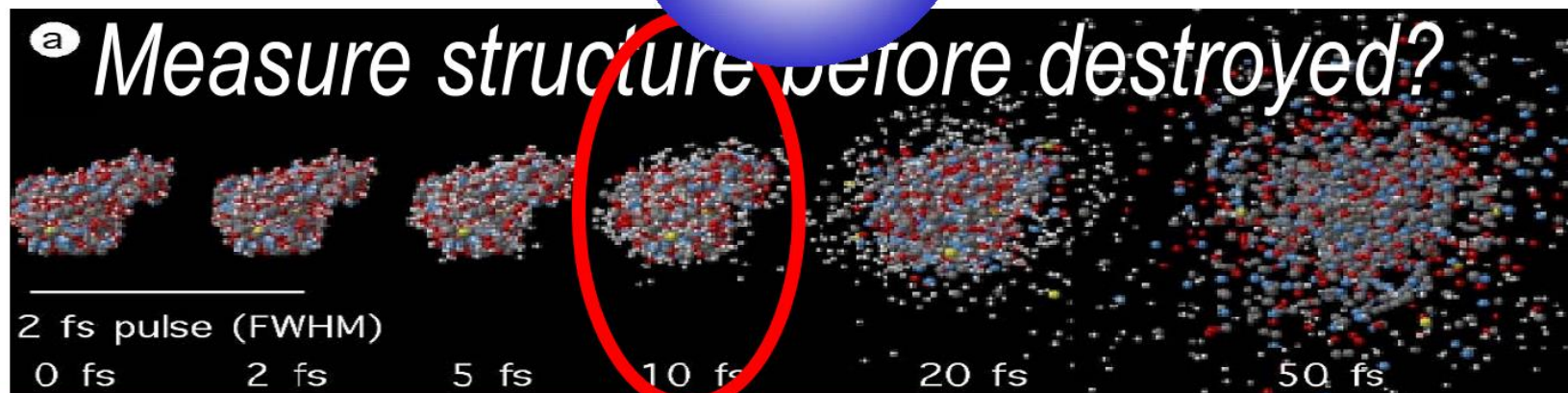
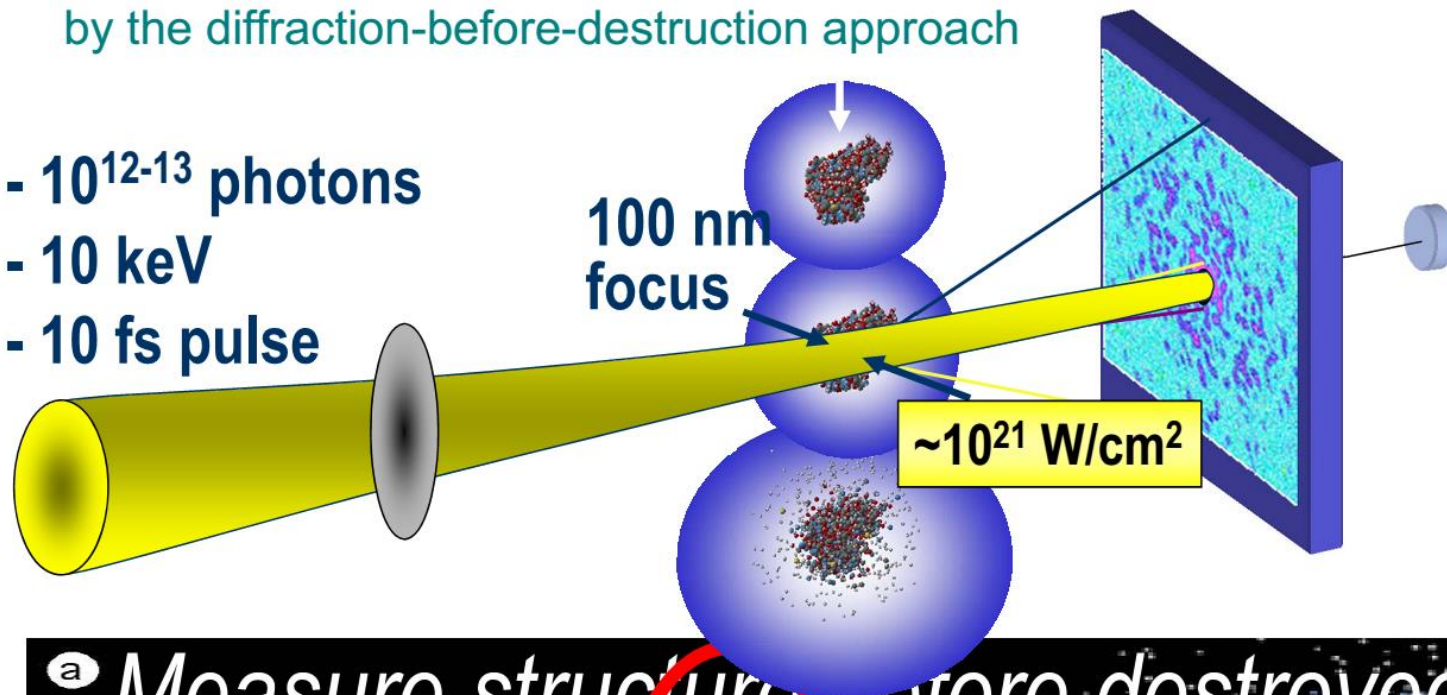


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Coherent diffractive imaging of single particles

by the diffraction-before-destruction approach

- 10^{12-13} photons
- 10 keV
- 10 fs pulse



Calculations. in vacuum Neutze et al., Nature 2000



$$E = h\nu = hc/\lambda,$$

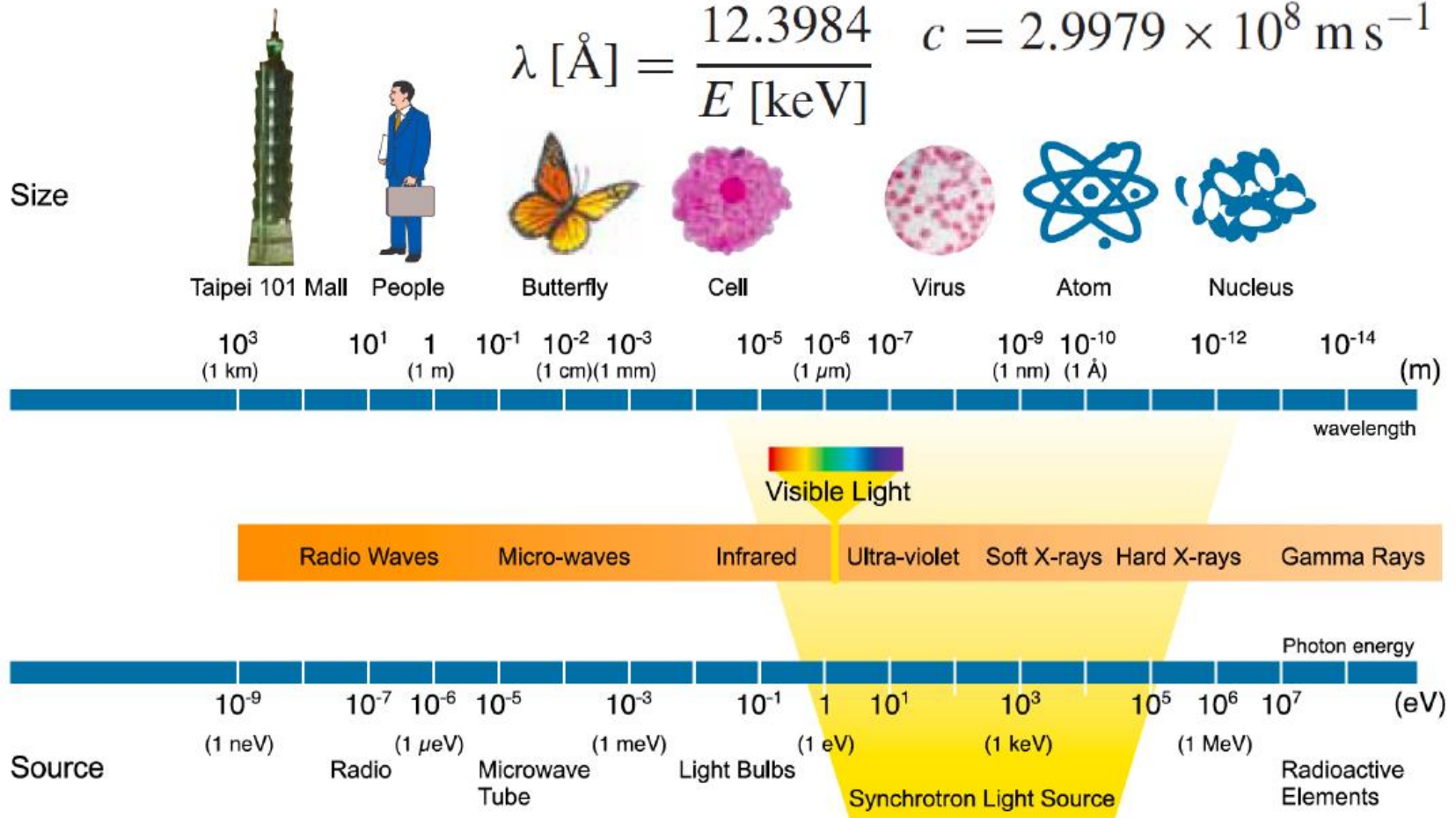
$$h = 6.626 \times 10^{-34} \text{ J s}$$

$$c = 2.9979 \times 10^8 \text{ m s}^{-1}$$

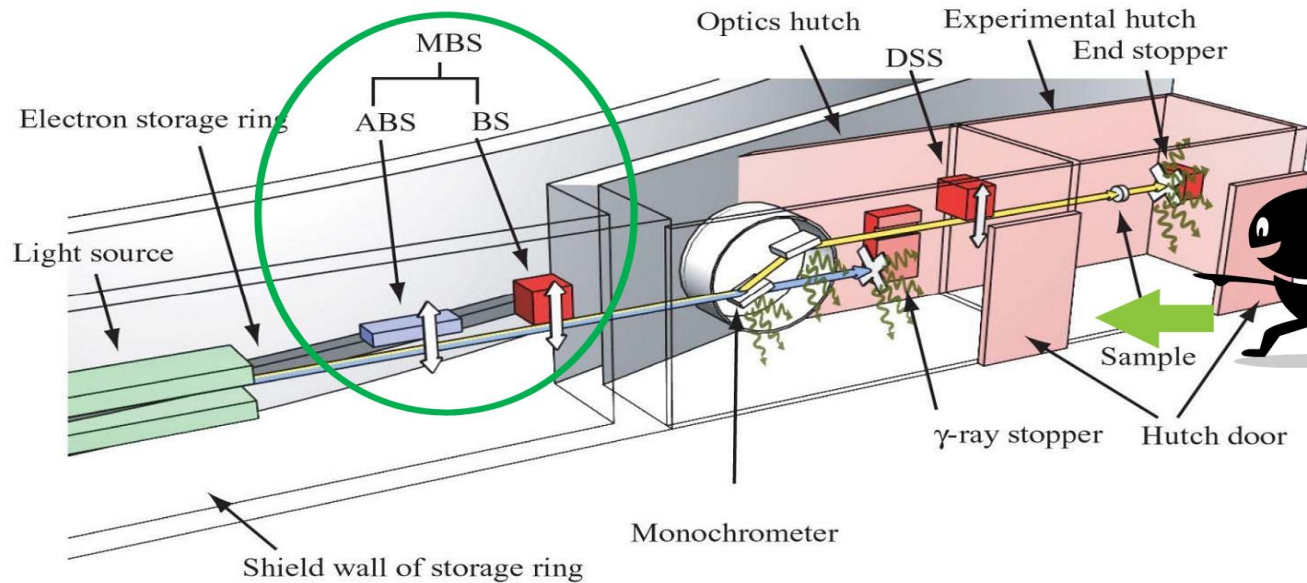
Electromagnetic Spectrum

$$\lambda [\text{\AA}] = \frac{12.3984}{E [\text{keV}]}$$

Size



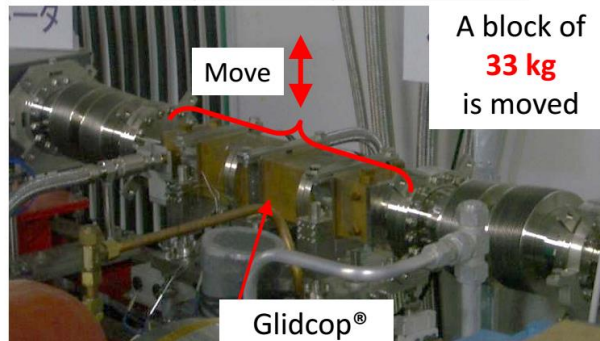
Beamline



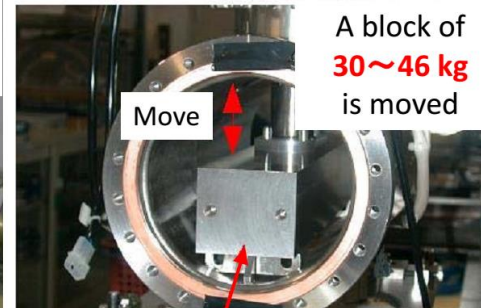
When we operate a main beam shutter (MBS), what happens ?

For safety

X-ray → **Absorber (Abs)** → **Beam shutter (BS)**
to protect BS from heat load to shield you against radiation



(copper that is dispersion-strengthened with ultra-fine particles of aluminum oxide)



the thermal conductivity not so high

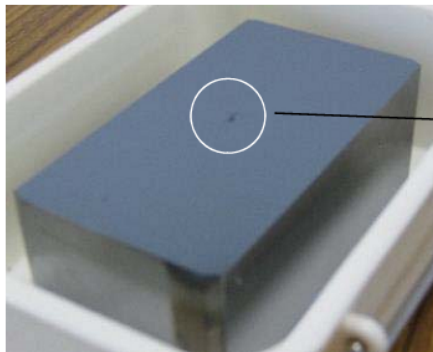


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National Synchrotron Radiation

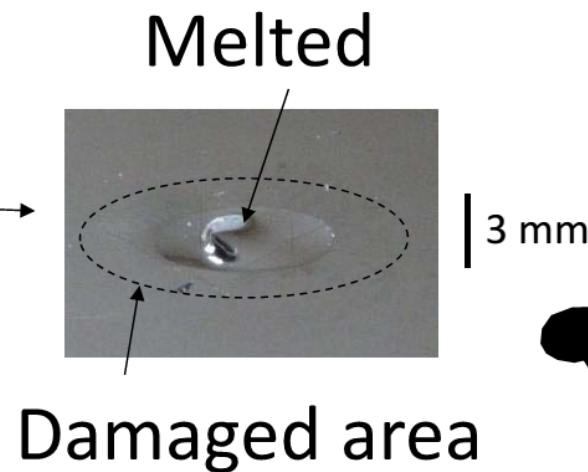
If an optical component is irradiated
by too much power

One user opened FE slit excessively.

2kW



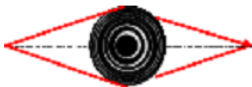
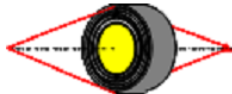
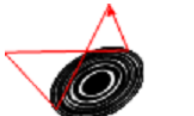
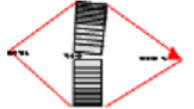
LN2-cooled
Si crystal



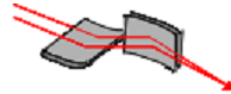
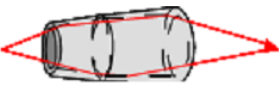
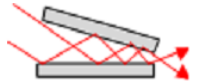
Slit : *"Too much is as bad as too little"*



Overview of x-ray focusing devices

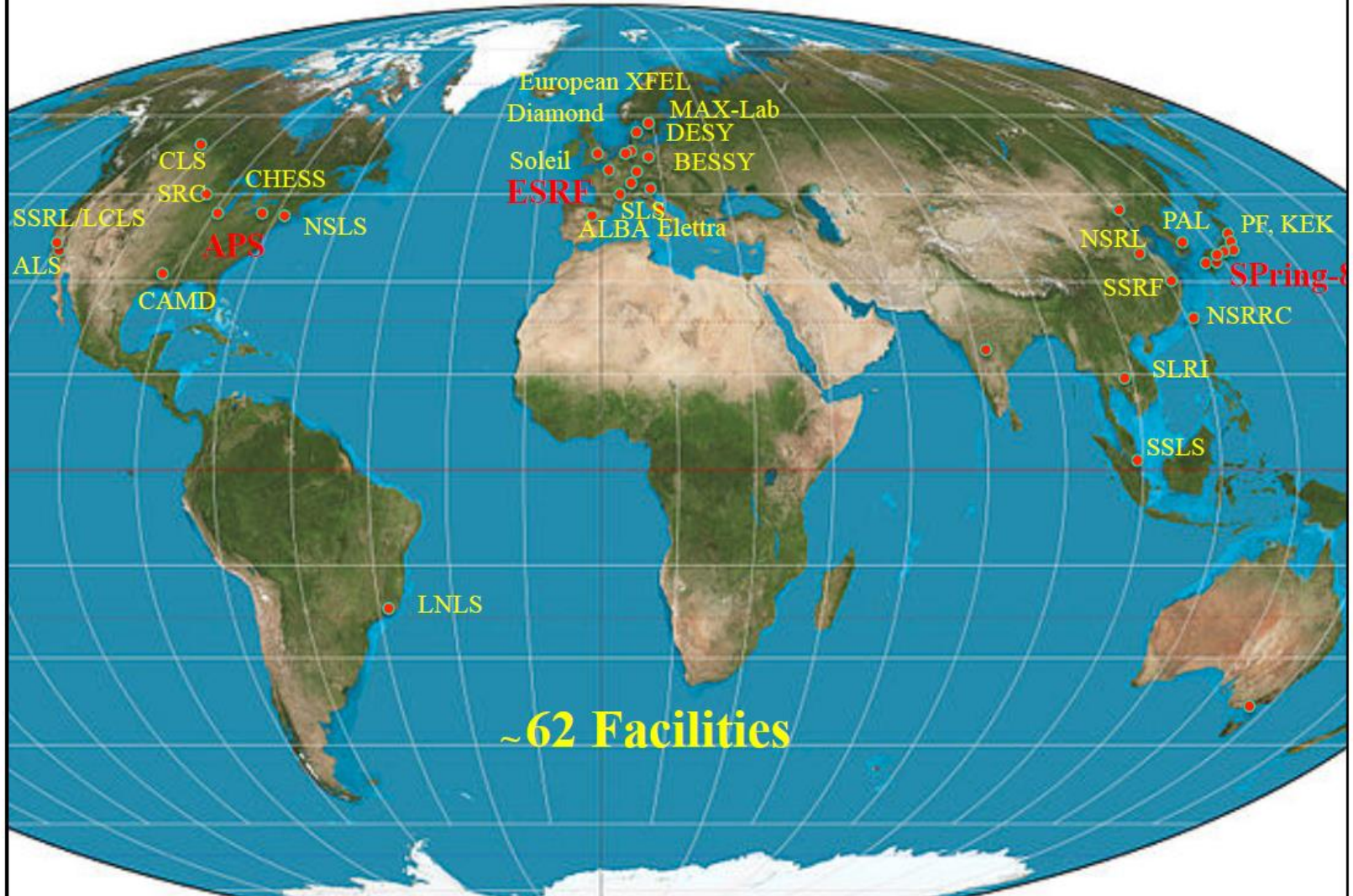
Diffraction	focus size, focal length [energy]	energy range	aberration -coma -chromatic -figure error
 Fresnel Zone Plate	12 nm, $f = 0.16$ mm [0.7 keV], 30 nm, $f = 8$ cm [8 keV]	soft x-ray hard x-ray	-coma small -chromatic exist -figure error small
 Sputter sliced FZP	0.3 μ m, $f = 22$ cm [12.4 keV], 0.5 μ m, $f = 90$ cm [100 keV]	8-100 keV	-coma small -chromatic exist -figure error large $\rightarrow$ small
 Bragg FZP	2.4 μ m, $f = 70$ cm [13.3 keV]	mainly hard x-ray	-coma small -chromatic exist -figure error small
 Multilayer Laue Lens	16 nm(1D), $f = 2.6$ mm [19.5 keV], 25nm $\times$ 40nm, $f = 2.6$ mm, 4.7mm [19.5 keV]	mainly hard x-ray	-coma large -chromatic exist -figure error small

Refraction	focus size, focal length [energy]	energy range	aberration -coma -chromatic -figure error
 Pressed Lens	1.5 μ m, $f = 80$ cm [18.4 keV], 1.6 μ m, $f = 1.3$ m [15 keV]	mainly hard x-ray	-coma small -chromatic exist -figure error large
 Etching Lens	47nm $\times$ 55nm, $f = 1$ cm, 2cm [21 keV]	mainly hard x-ray	-coma small -chromatic exist -figure error small

Reflection	focus size, focal length [energy]	energy range	aberration -coma -chromatic -figure error
 Kirkpatrick-Baez Mirror	7 nm $\times$ 8nm, $f = 7.5$ cm [20 keV]	soft x-ray hard x-ray	-coma large -chromatic not exist -figure error small
 Wolter Mirror	0.7 μ m, $f = 35$ cm [9 keV]	<10 keV	-coma small -chromatic not exist -figure error large
 X-ray Waveguide	95 nm, [10 keV]	soft x-ray hard x-ray	-coma large -chromatic not exist -figure error large



World Map of Synchrotron Facilities



Outline

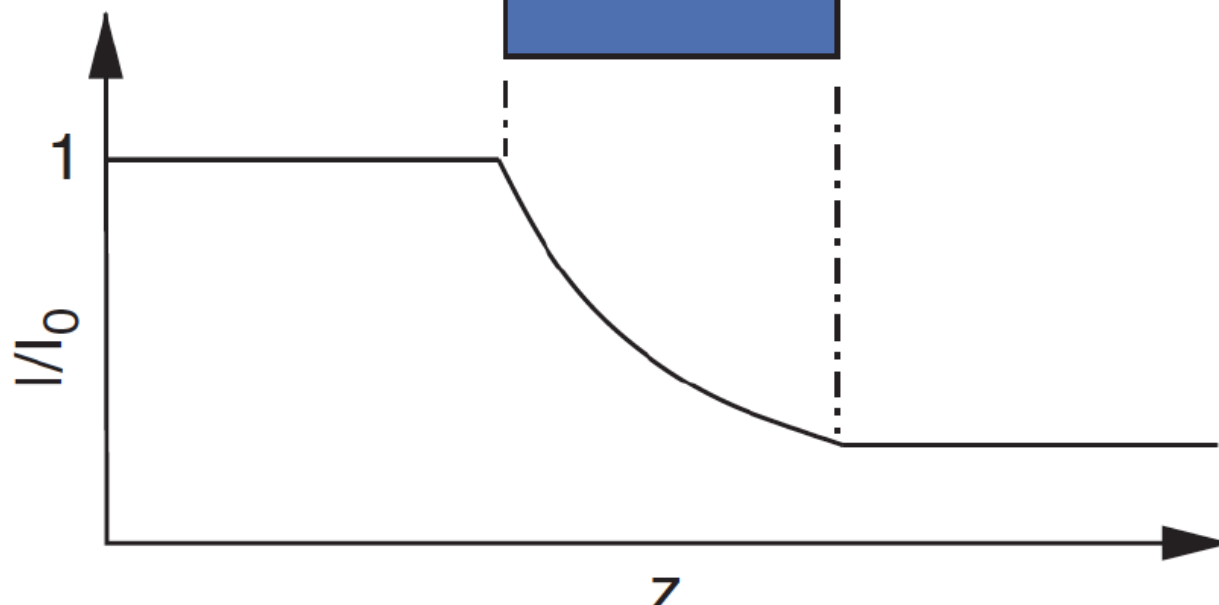
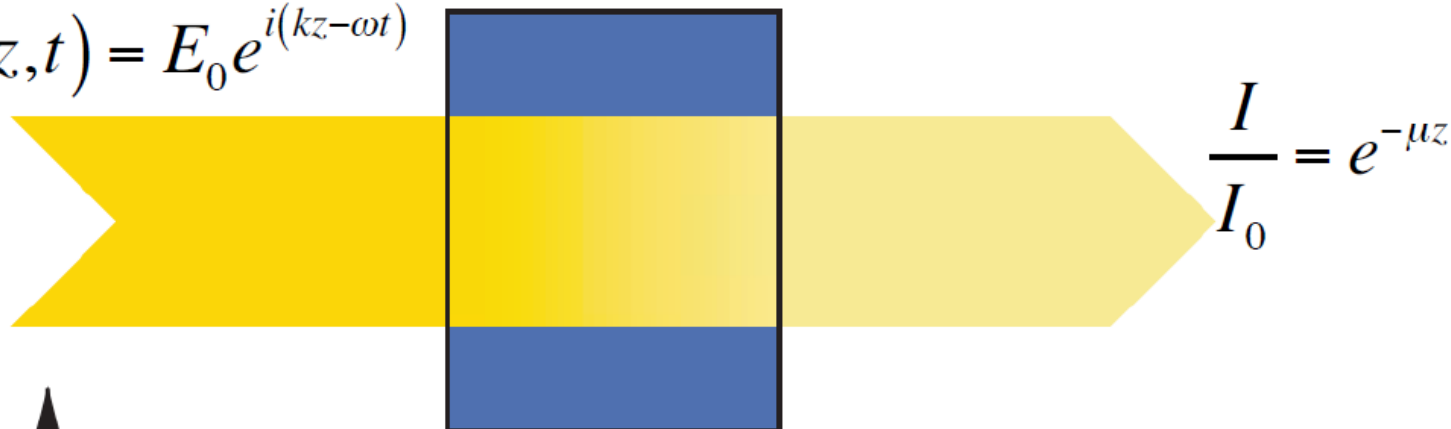
- Synchrotron Light Source
- Application of Synchrotron Light
- X-ray nano probe at TPS



Absorption

$$E(z, t) = E_0 e^{-n_I k z} e^{i(n_R k z - \omega t)}$$

$$E(z, t) = E_0 e^{i(kz - \omega t)}$$



absorption coefficient

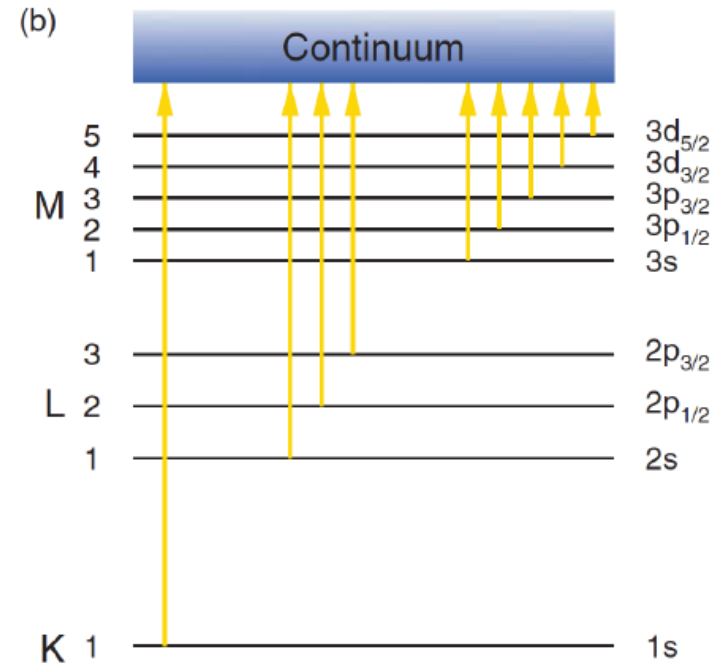
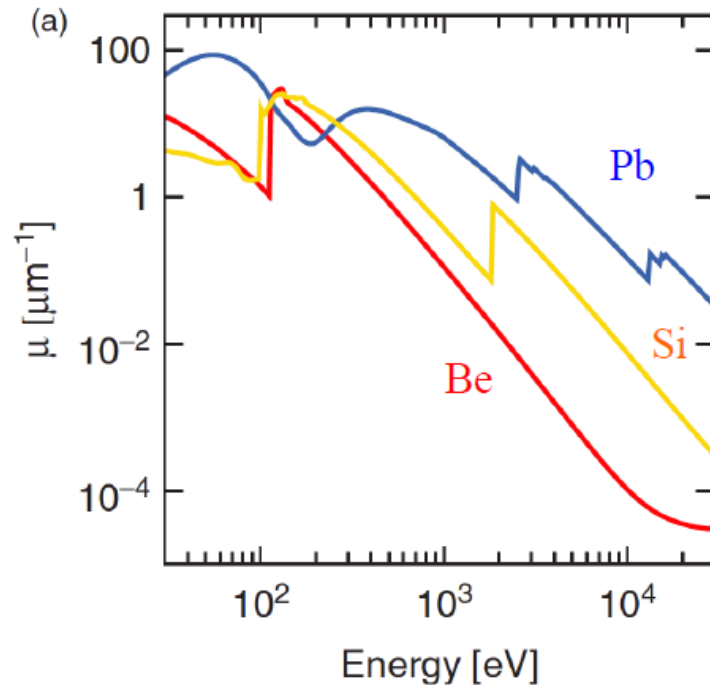
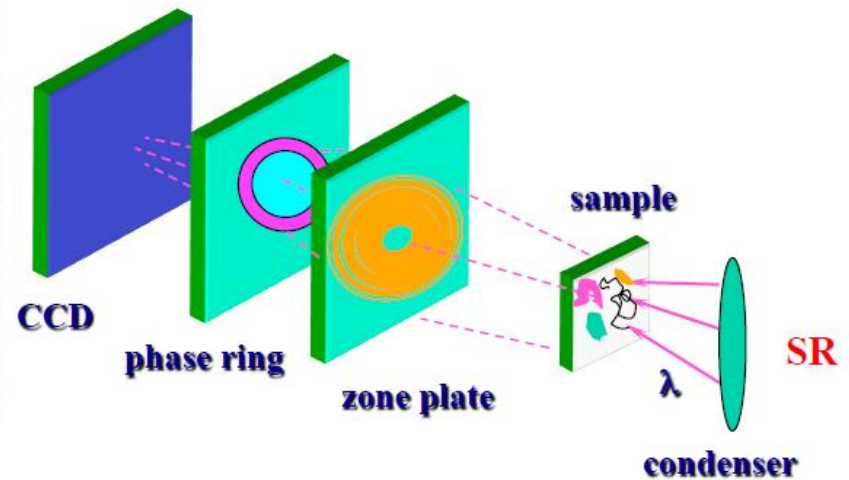


Figure 2.16 (a) The x-ray absorption coefficient μ for beryllium (red curve), silicon (yellow) and lead (blue) as a function of the photon energy. (b) Sharp increases in the absorption occur when the photon energy is just sufficient to eject the electron from the electronic orbital to the continuum. The x-ray absorption (left) and atomic orbital labellings (right) are shown.



Transmission X-ray Microscope (TXM)

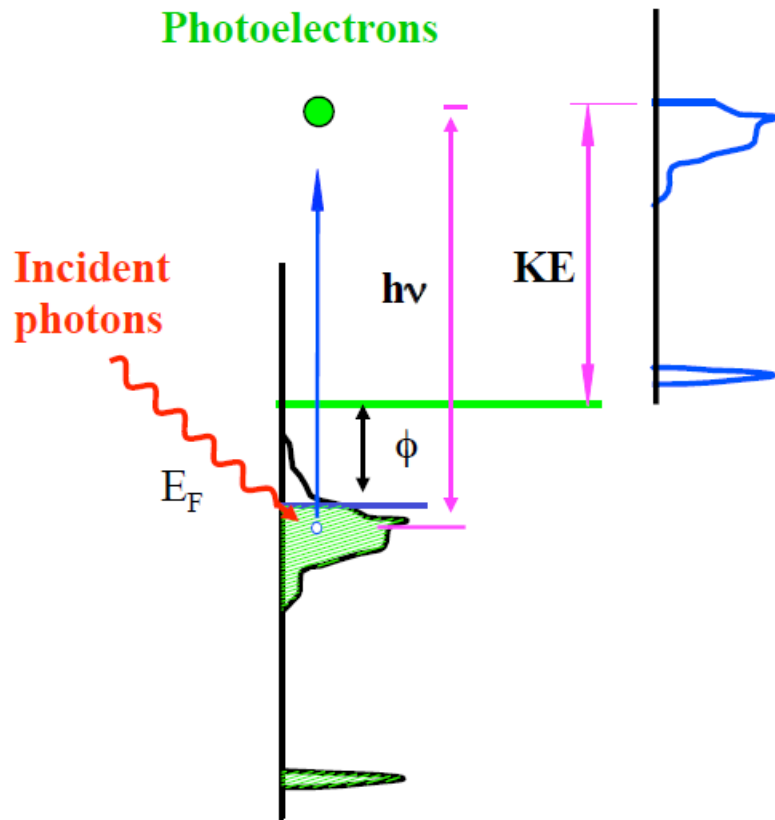


energy: 8 keV
3D tomography
spatial resolution = 60 nm



Photoemission Spectroscopy

Energy Distribution Curve (EDC)



$$KE = h\nu - BE - \phi$$

$$\frac{d\sigma}{d\Omega} \propto \sum \left| \langle \Psi_f | A \cdot P | \Psi_i \rangle \right|^2 \cdot \delta(E_f - E_i - h\nu)$$

Selection rule: $\Delta l = \pm 1$

$\Delta m_l = 0$ (linearly polarized)

$\Delta m_l = +1$ (L. circularly polarized)

$\Delta m_l = -1$ (R. circularly polarized)

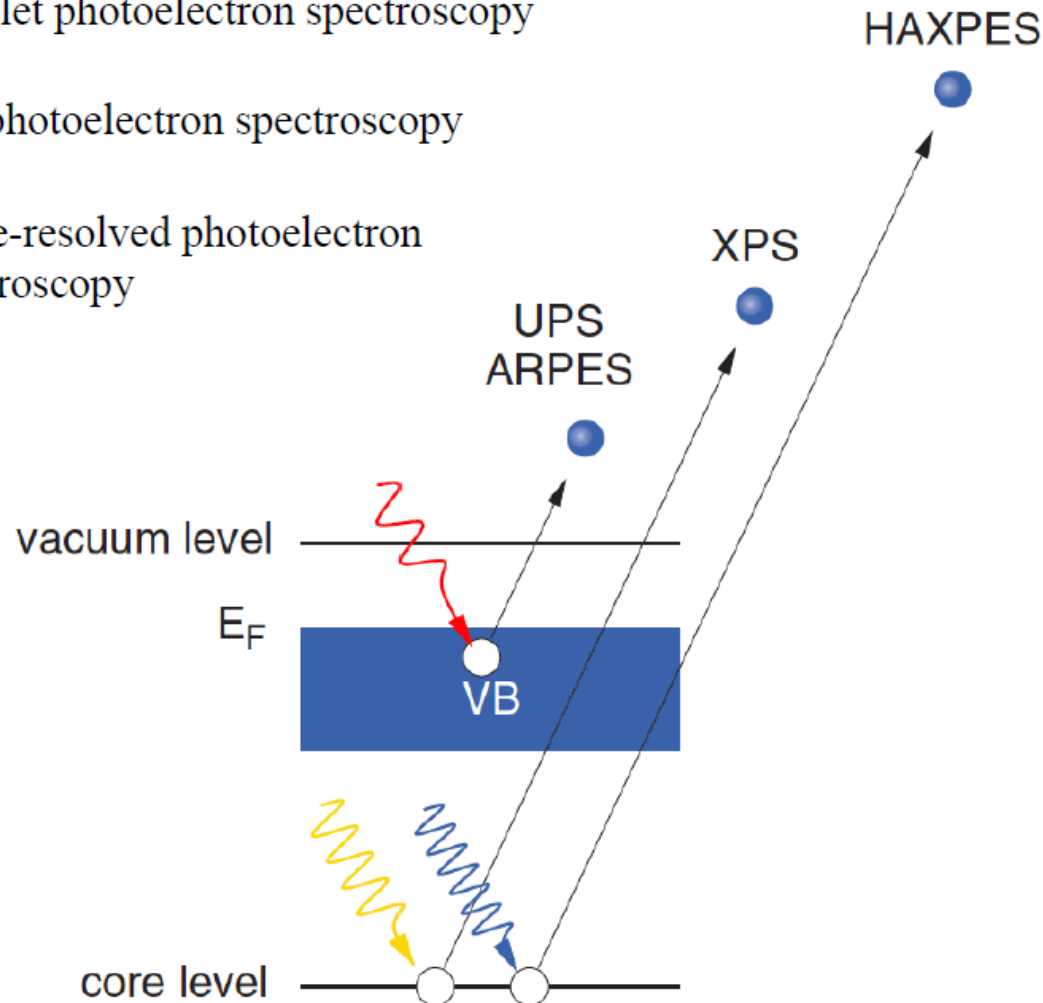


HAXPES = Hard X-ray photoelectron spectroscopy

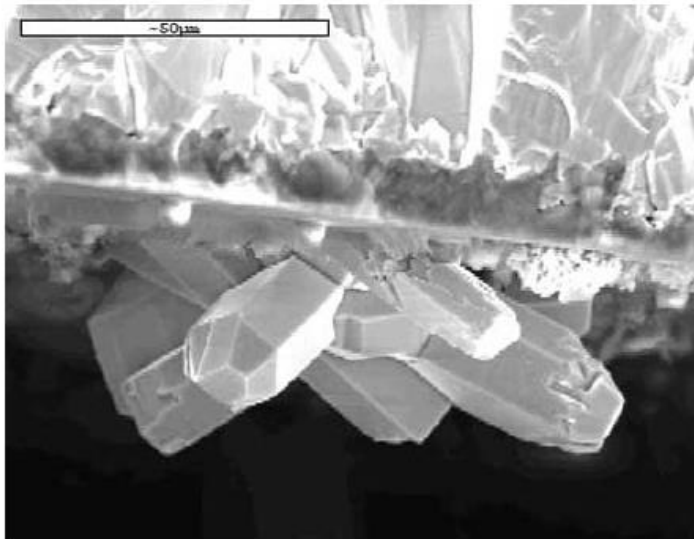
UPS = ultraviolet photoelectron spectroscopy

XPS = X-ray photoelectron spectroscopy

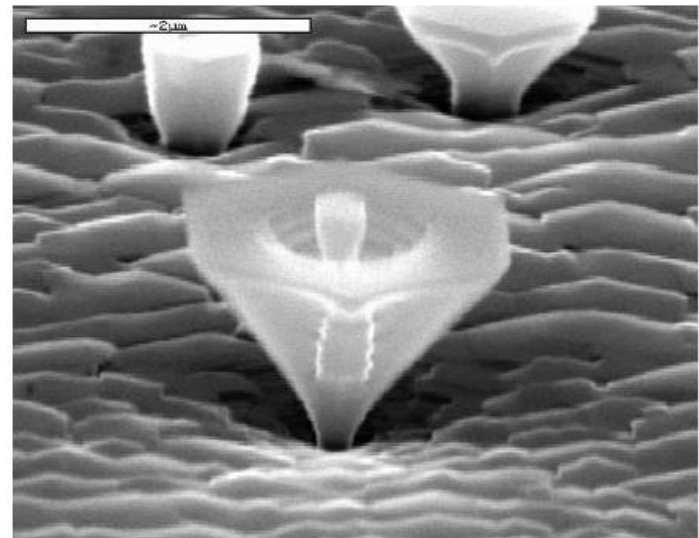
ARPES = angle-resolved photoelectron spectroscopy



“Crystals”

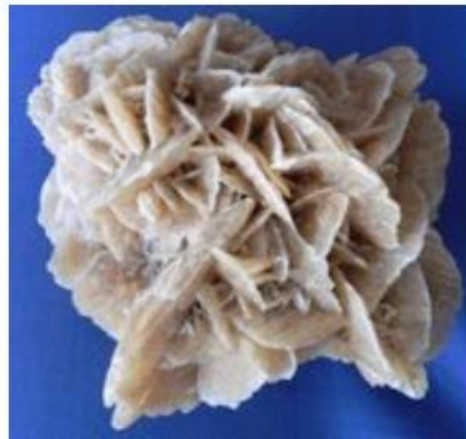


GaN (hexagonal) crystal cluster grown by hydride vapor phase epitaxy



AlN pyramids grown by MBE

Sand Rose of gypsum
(石膏) crystals



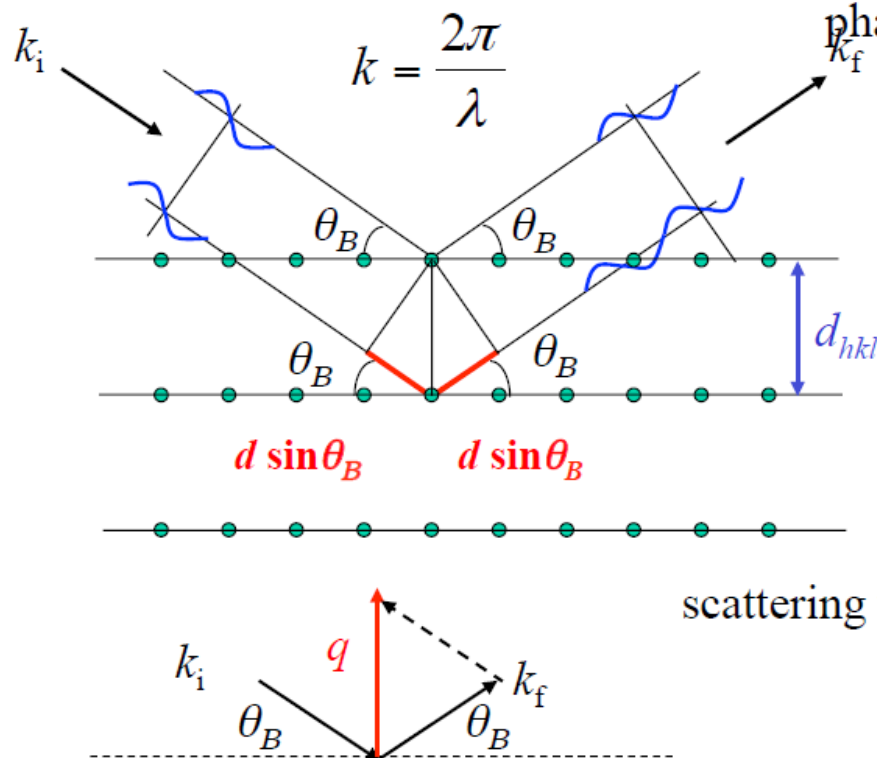
Bragg Law - X-ray reflected by the (hkl) planes

$$\vec{E} = E_0 e^{i(\vec{k} \cdot \vec{r} - \omega t)}$$

Path Difference $L = 2d_{hkl} \sin \theta_B$

Constructive interference: $L = n\lambda$

phase difference $\phi = k L$



Bragg Law: $2d_{hkl} \sin \theta_B = n\lambda$

$$2\pi \frac{2}{\lambda} \sin \theta_B = 2\pi \frac{1}{d_{hkl}} = G_{hkl}$$

scattering vector $\vec{q} = \vec{k}_f - \vec{k}_i$ $q = 2 \frac{2\pi}{\lambda} \sin \theta_B$

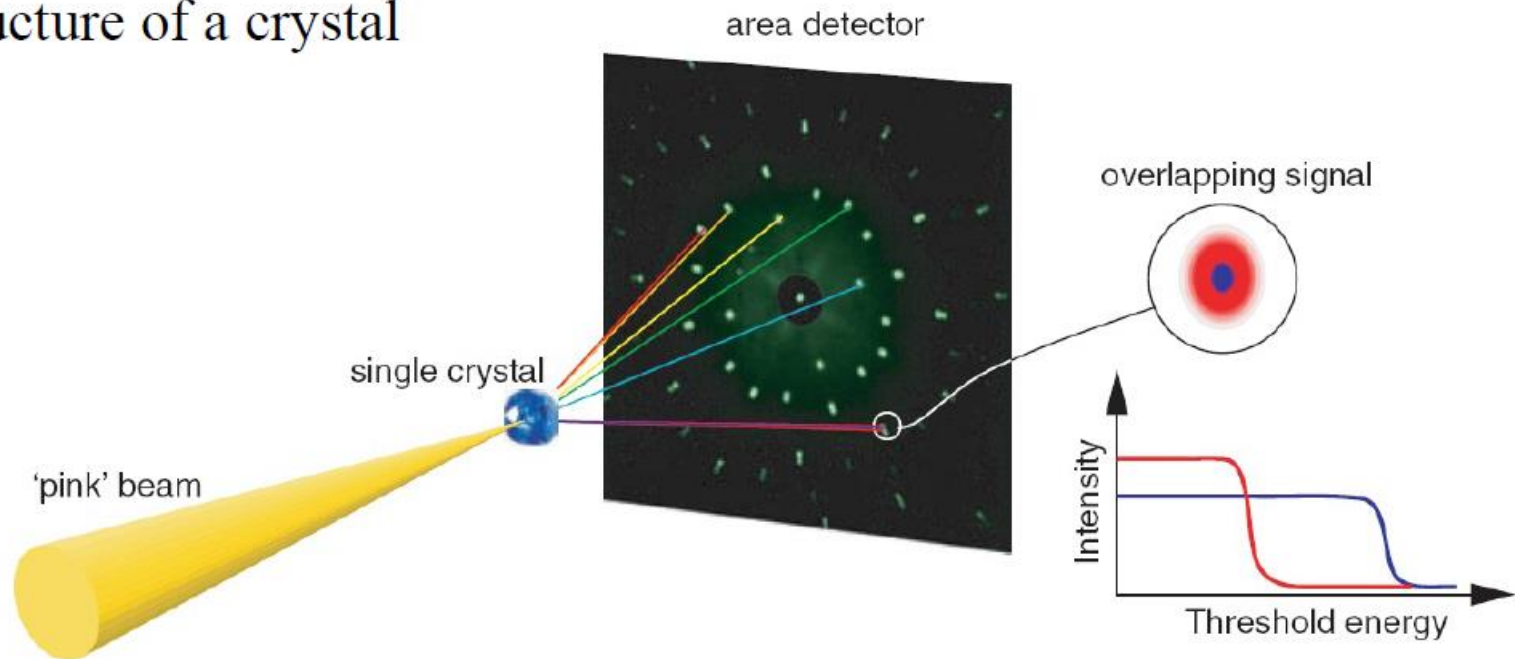
$q = G_{hkl}$

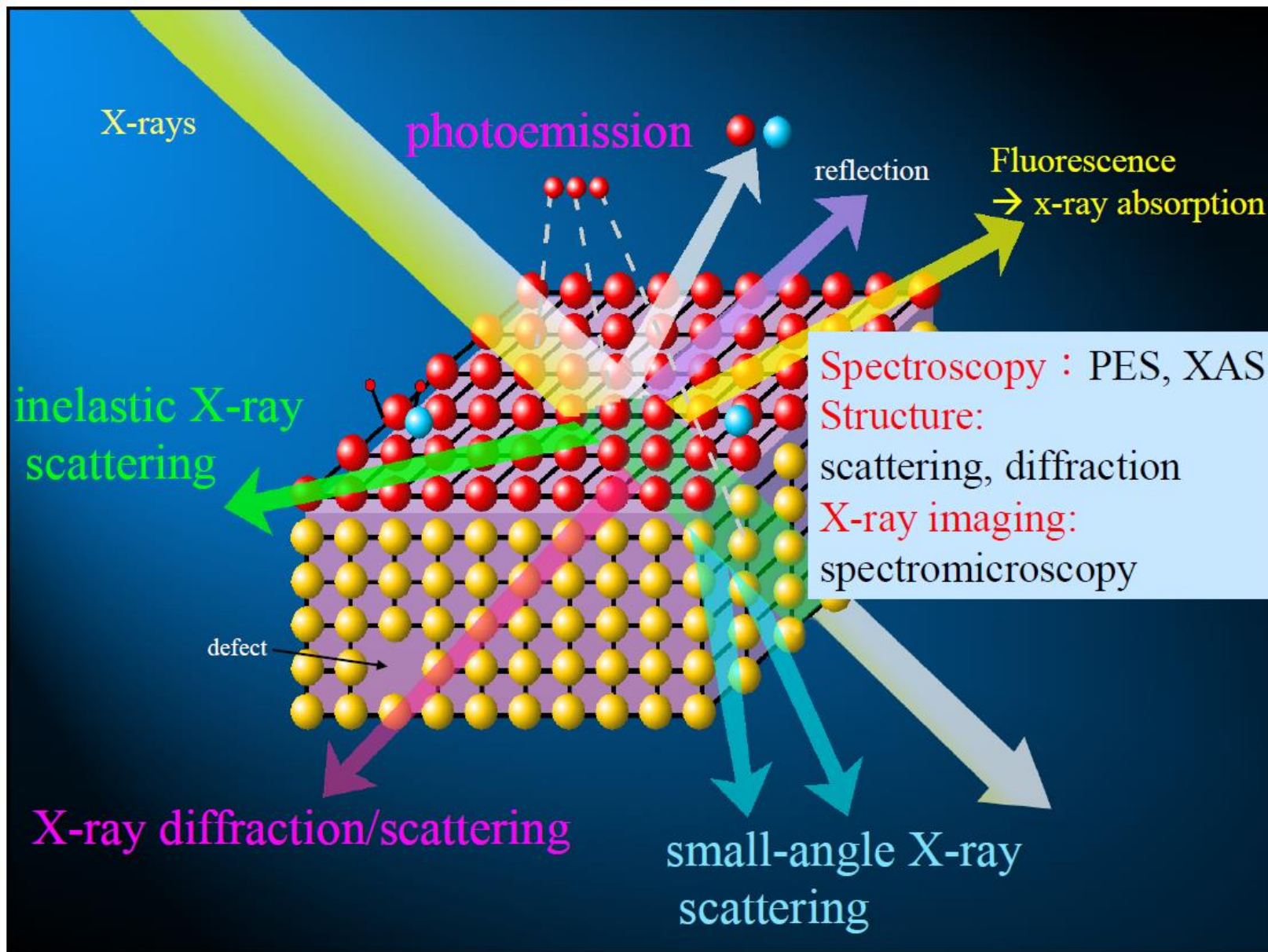
In terms of diffraction, two key characteristics of a set of crystal planes :
 $1/d$ and orientation

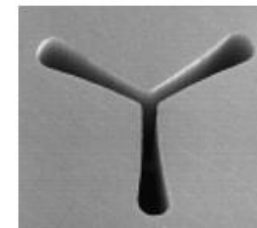
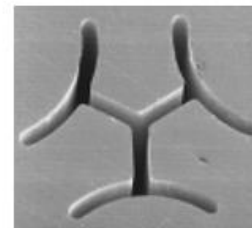
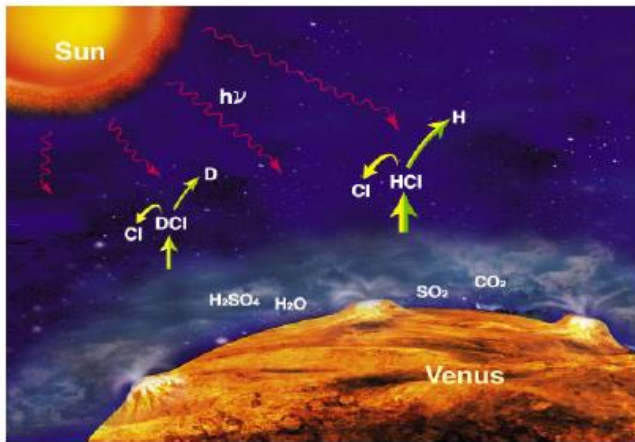
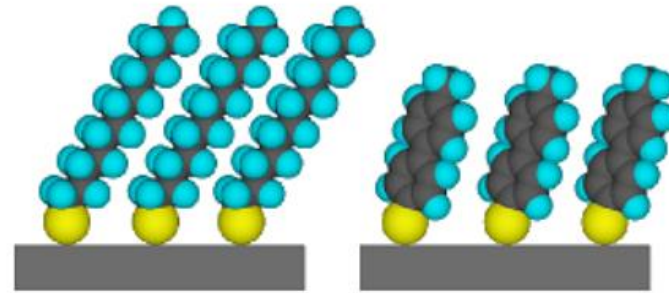
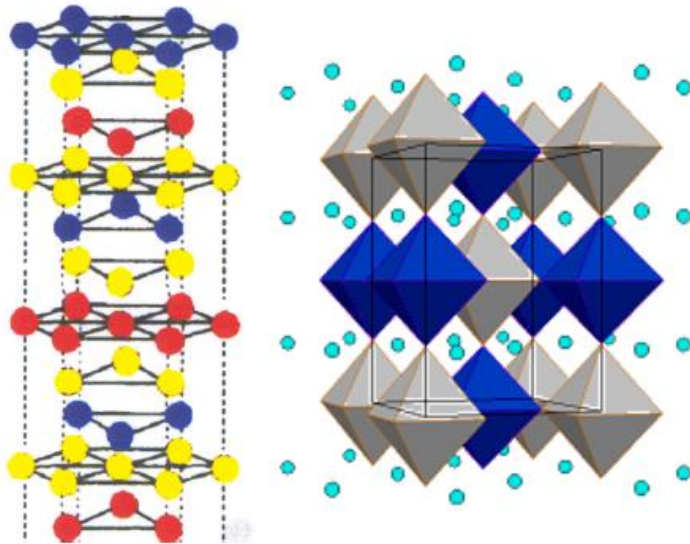


Single Crystal Diffraction - Laue Diffraction

- Method: stationary
- Light source: a polychromatic 'pink' beam (e.g. $\Delta E < 1$ keV @ 10 keV)
- Applications: orient single crystals, determine their crystal quality, dynamical studies of transient crystalline states (time-resolved study)
- Disadvantage: not well-suited for determining the full atomic structure of a crystal



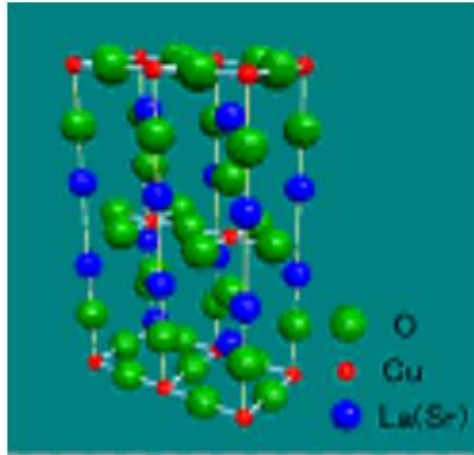




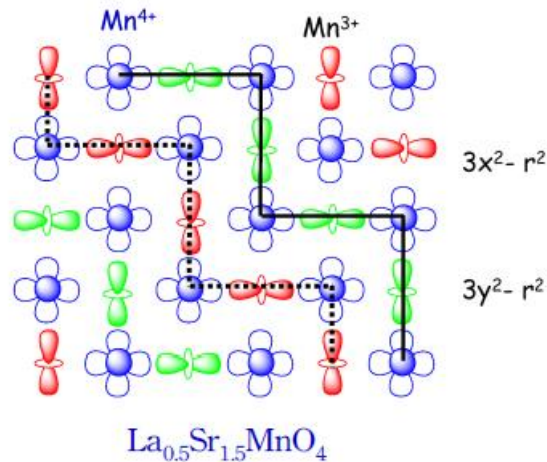
Synchrotron light source is a powerful tool for basic and applied studies in physics, chemistry, materials, biology and medicine, and their many subfields.



Condensed-Matter Physics



Electronic properties of novel materials can be revealed with X-ray scattering.

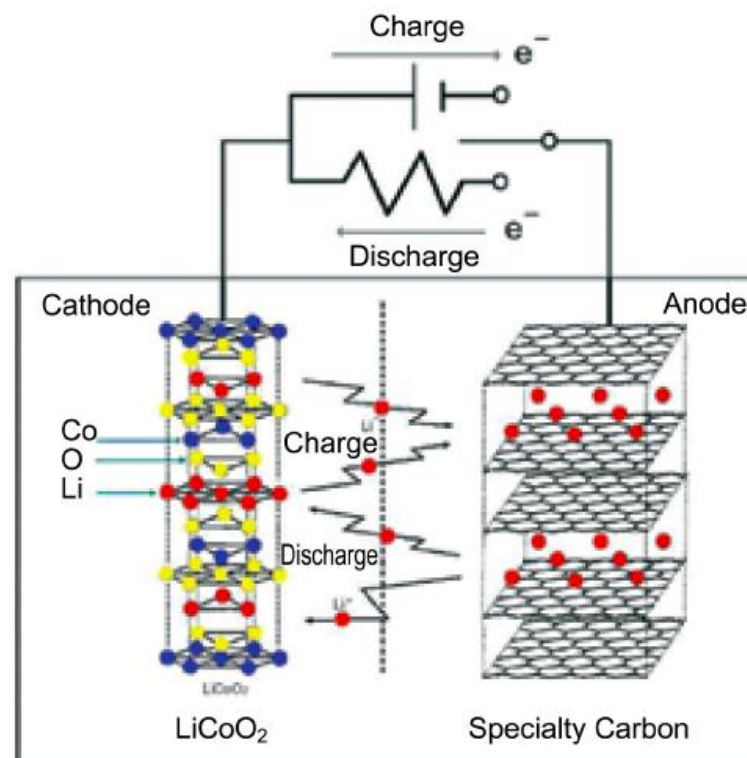
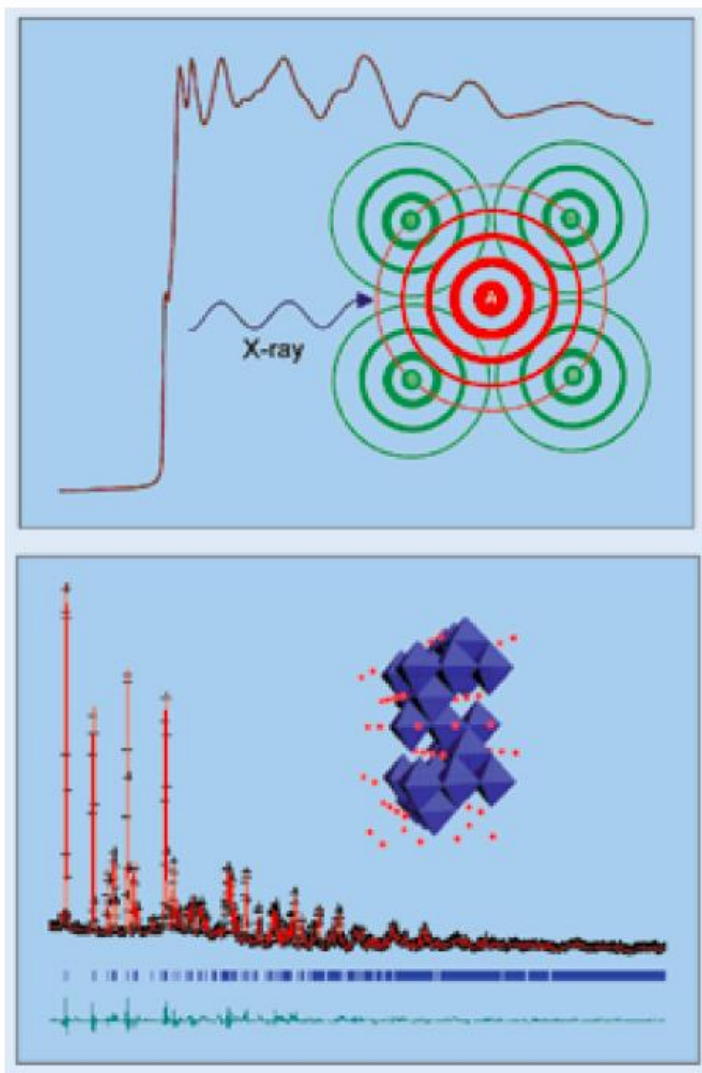


(Source: website of Railway Technical Research Institute, Japan)



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Energy Science



structure $\leftrightarrow$ electrochemical properties of electrode



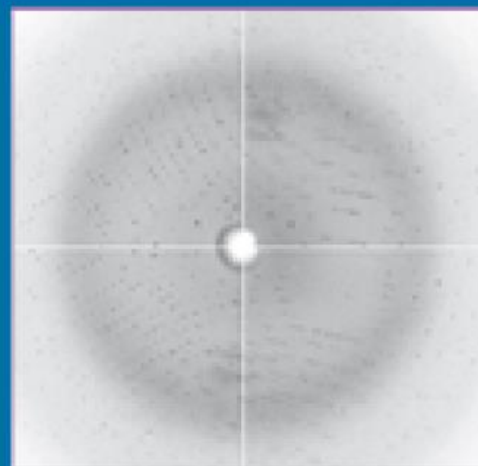
develop novel electrode materials.



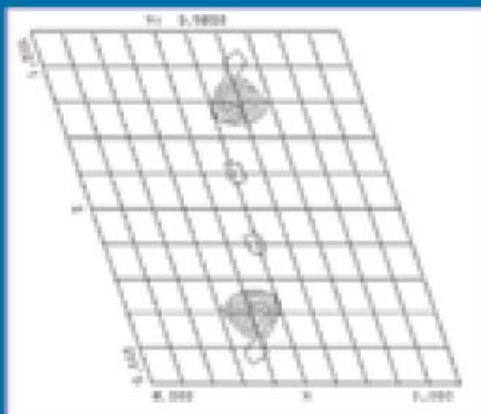
Biological structure: protein crystallography



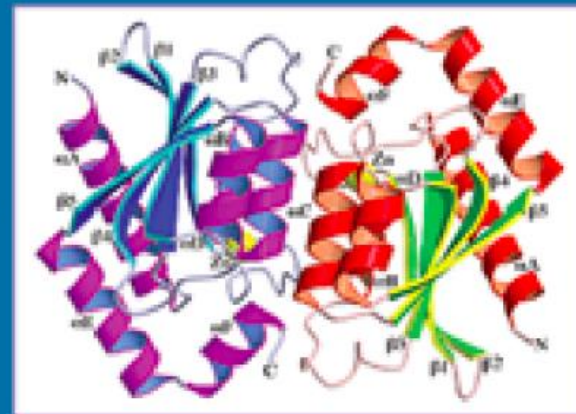
(1) crystallization



(2) data collection

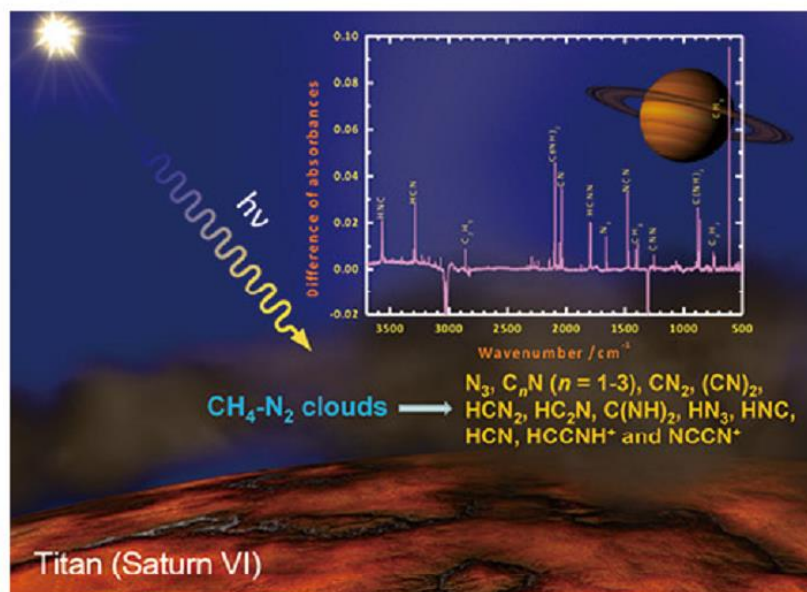
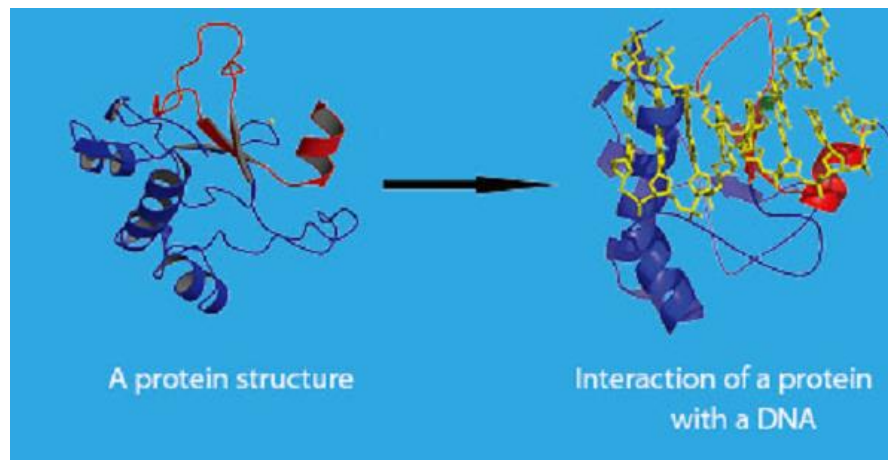


(3) determination of heavy atom position

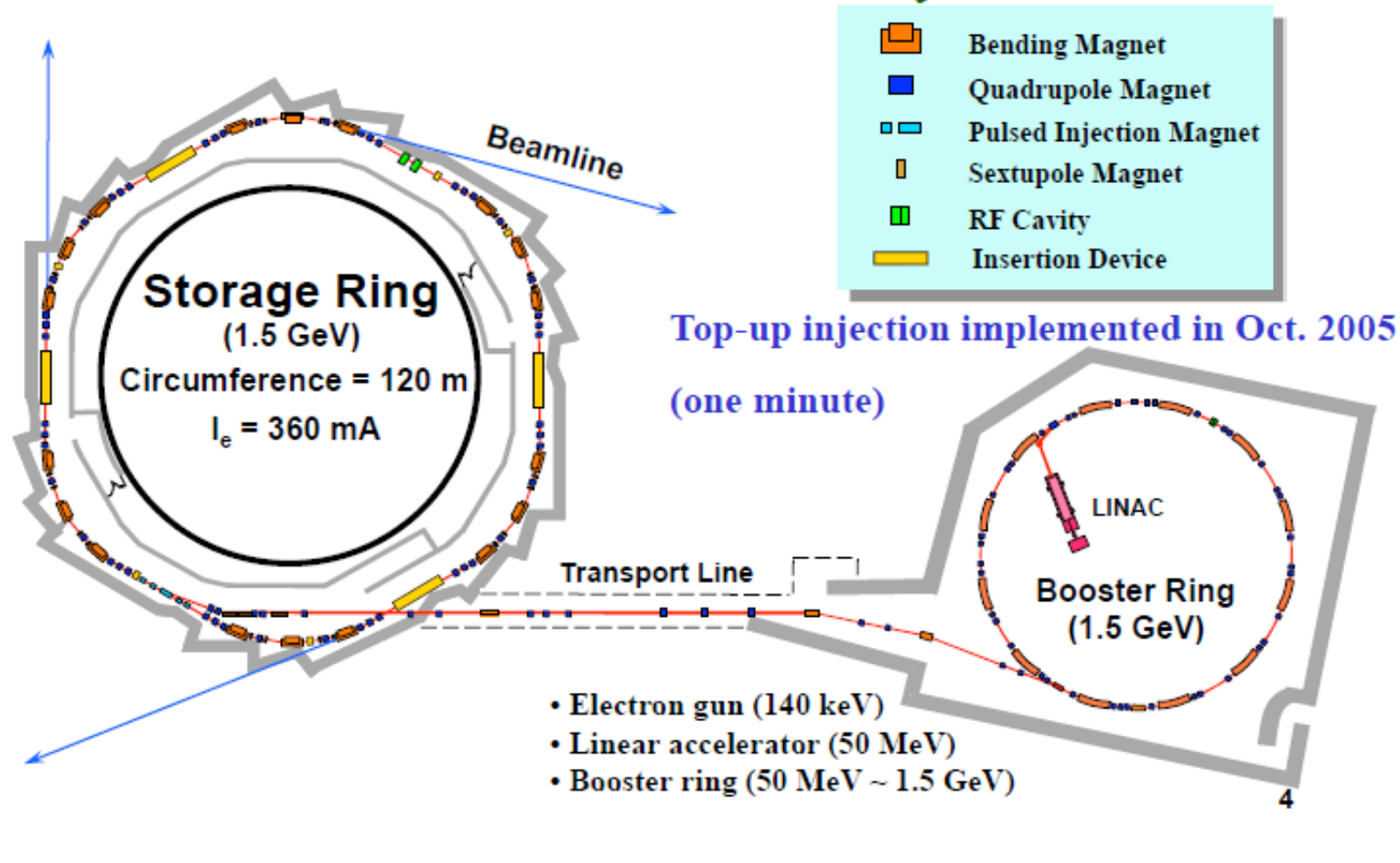


(4) determination of molecular structure





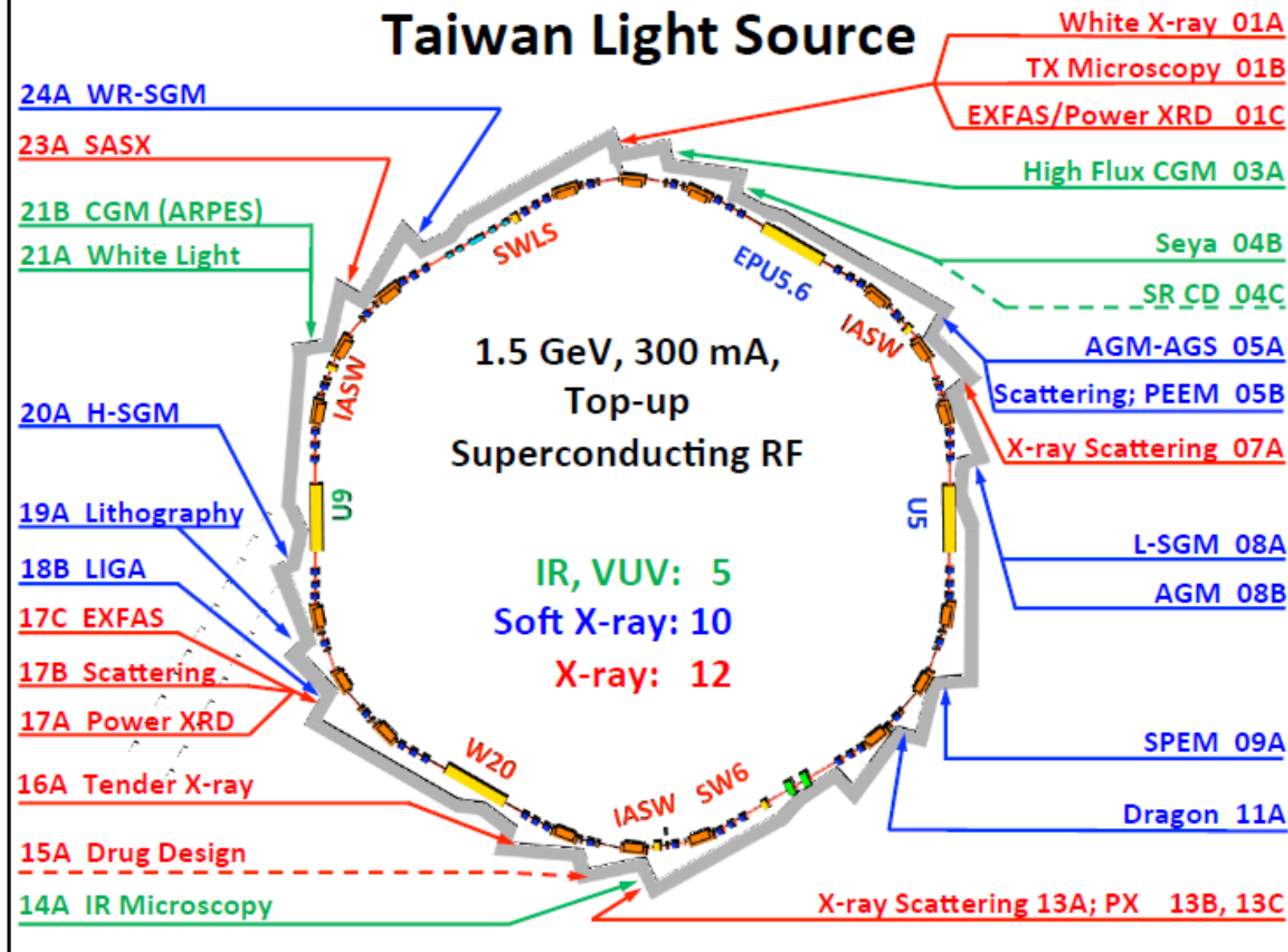
Taiwan Light Source (TLS) Accelerator Facility



TLS Experimental Hall



Taiwan Light Source



NSRRC is constructing a low-emittance synchrotron-based light source, Taiwan Photon Source (TPS)



3 GeV
518.4 m
500 mA
1.6 nm-rad

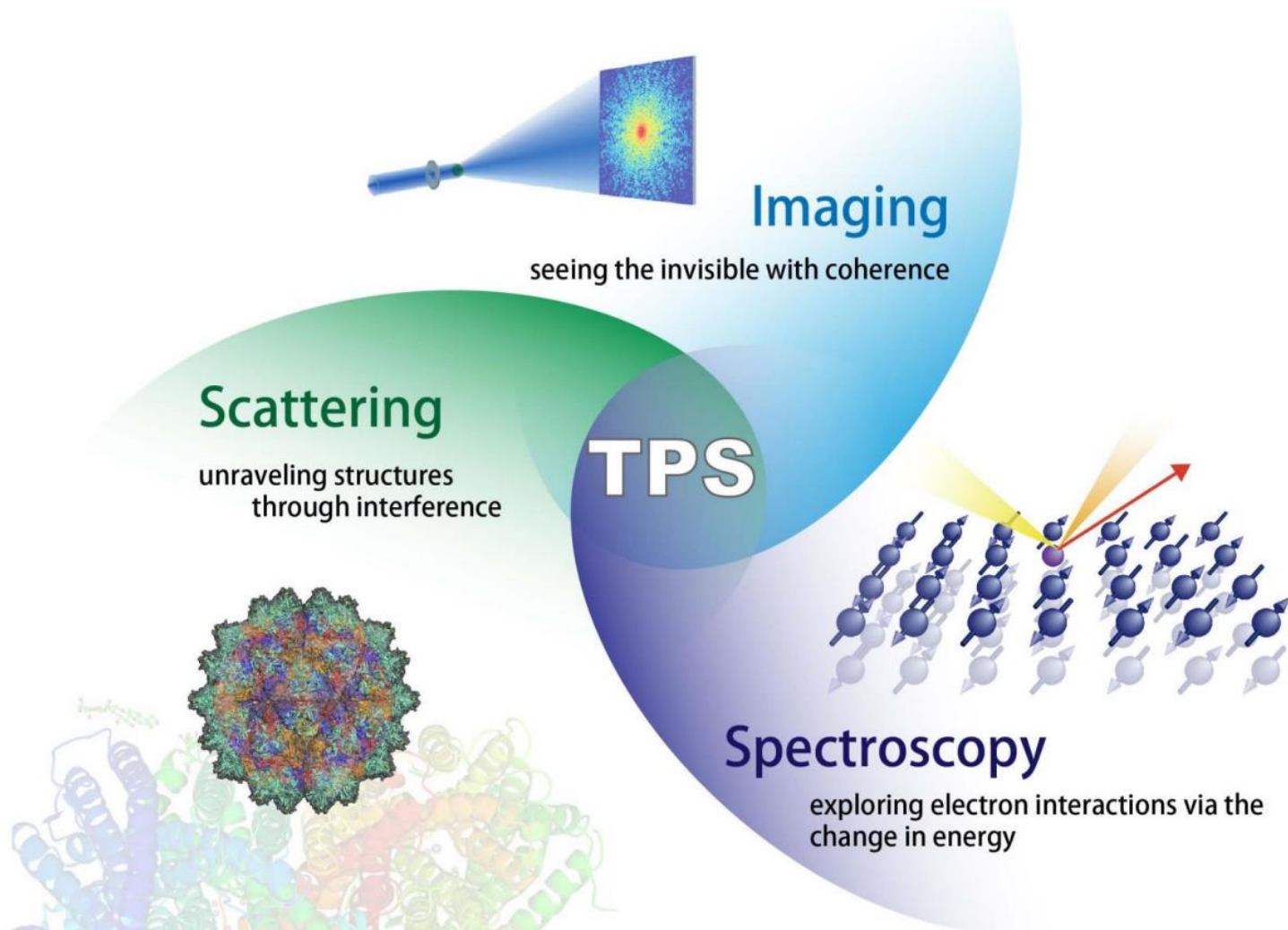
TPS

TLS



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National Synchrotron Radiation Research Center

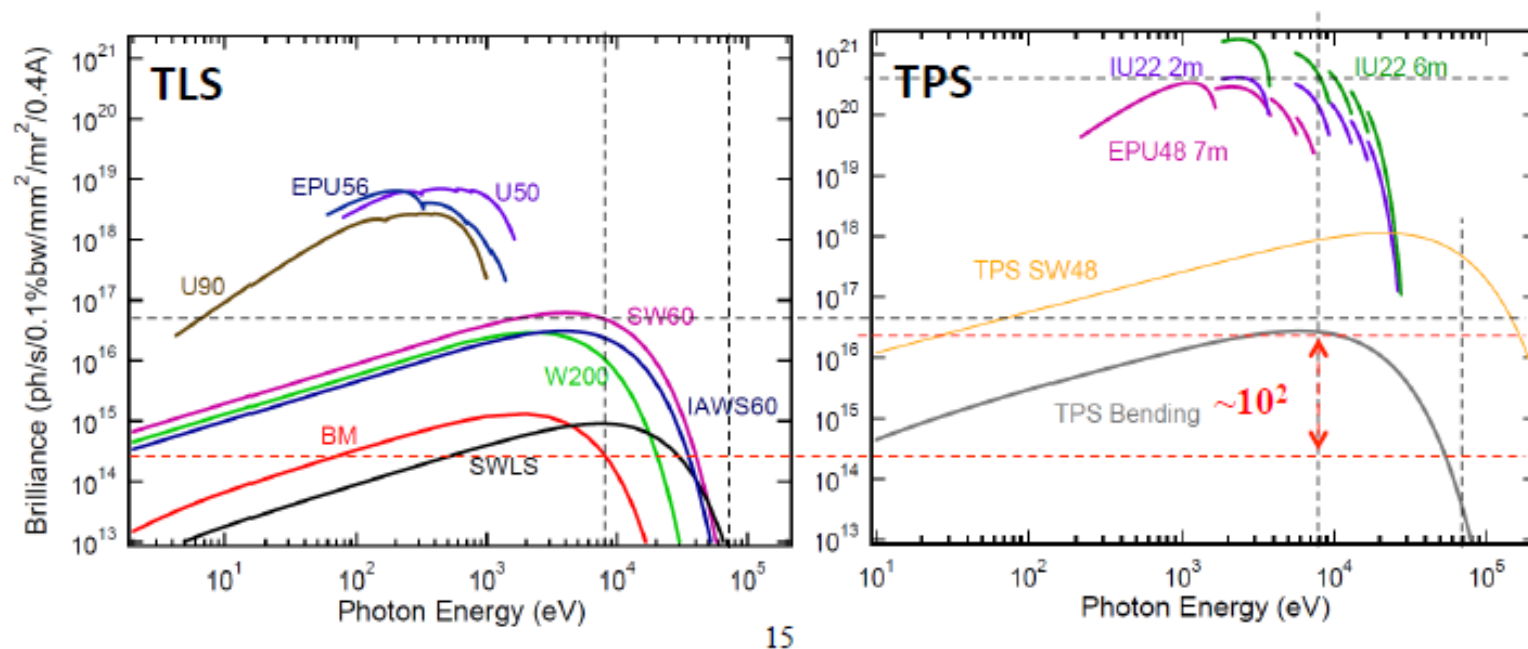
TPS provides opportunities for scientists to reveal electrons, spins, and lattices, covering a wide range of applications.



Comparison of Brilliance between TLS and TPS

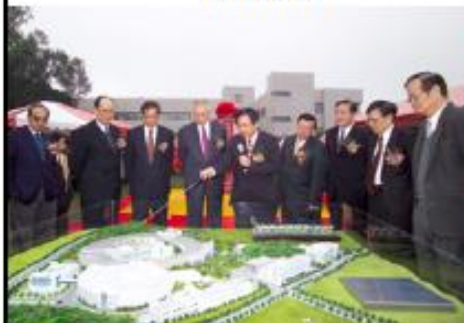
The X-ray spectrum (photon energy 8 keV - 70 keV):
the brightness of bending magnet $>10^2$.

the brightness of IDs: 4~6 orders of mag.



中心現址衛星圖 (太空中心提供)

Groundbreaking
2010-02-07



2010-02-10



2010-05-21



2010-08-04



2011-02-05



2011-09-27



2012-05-14



2013-01-16





Civil Construction of TPS



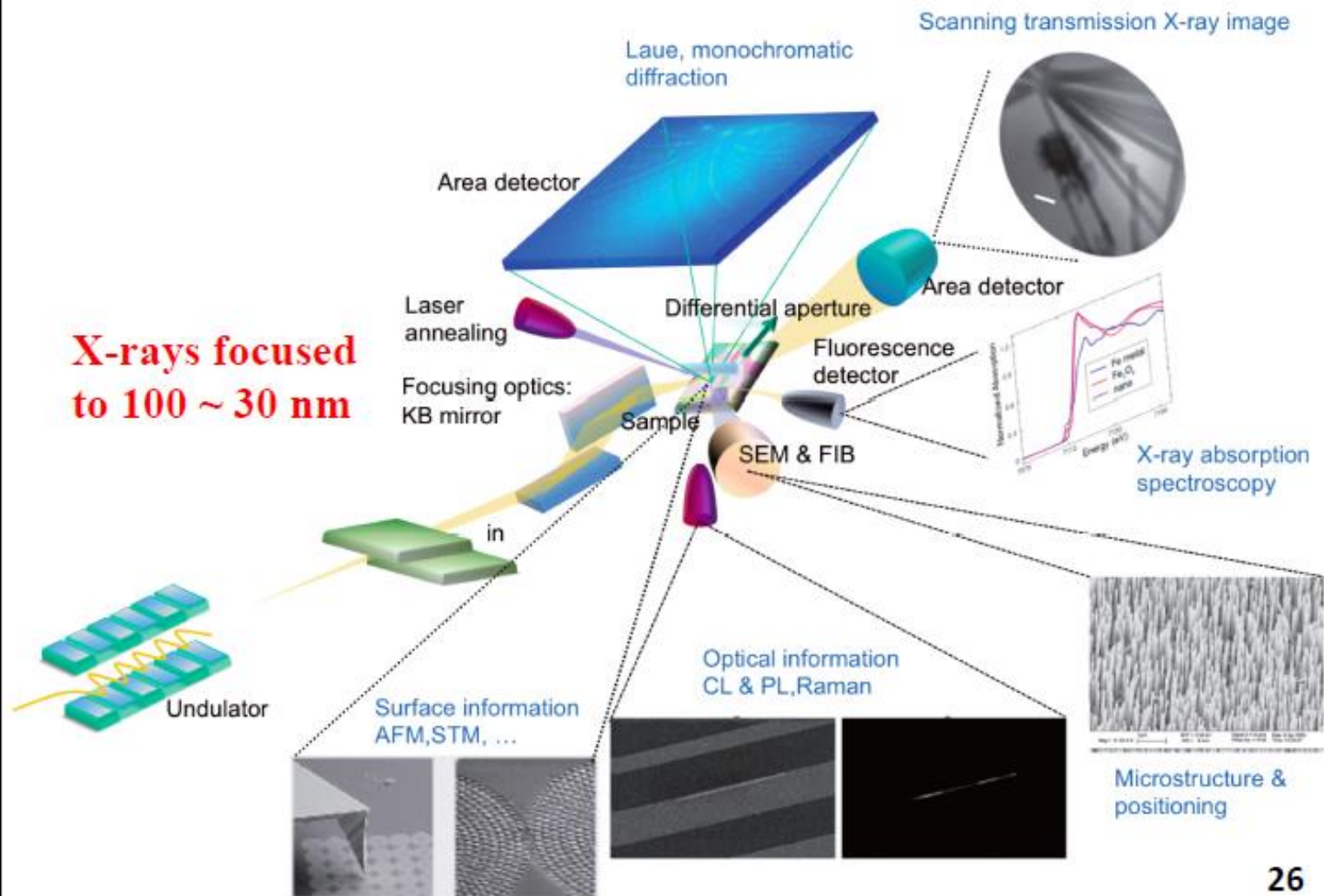
Taiwan Photon Source (TPS)

台灣光子源第一道光芒
2014. 12. 31



國家同步輻射研究中心
National Synchrotron Radiation Research Center

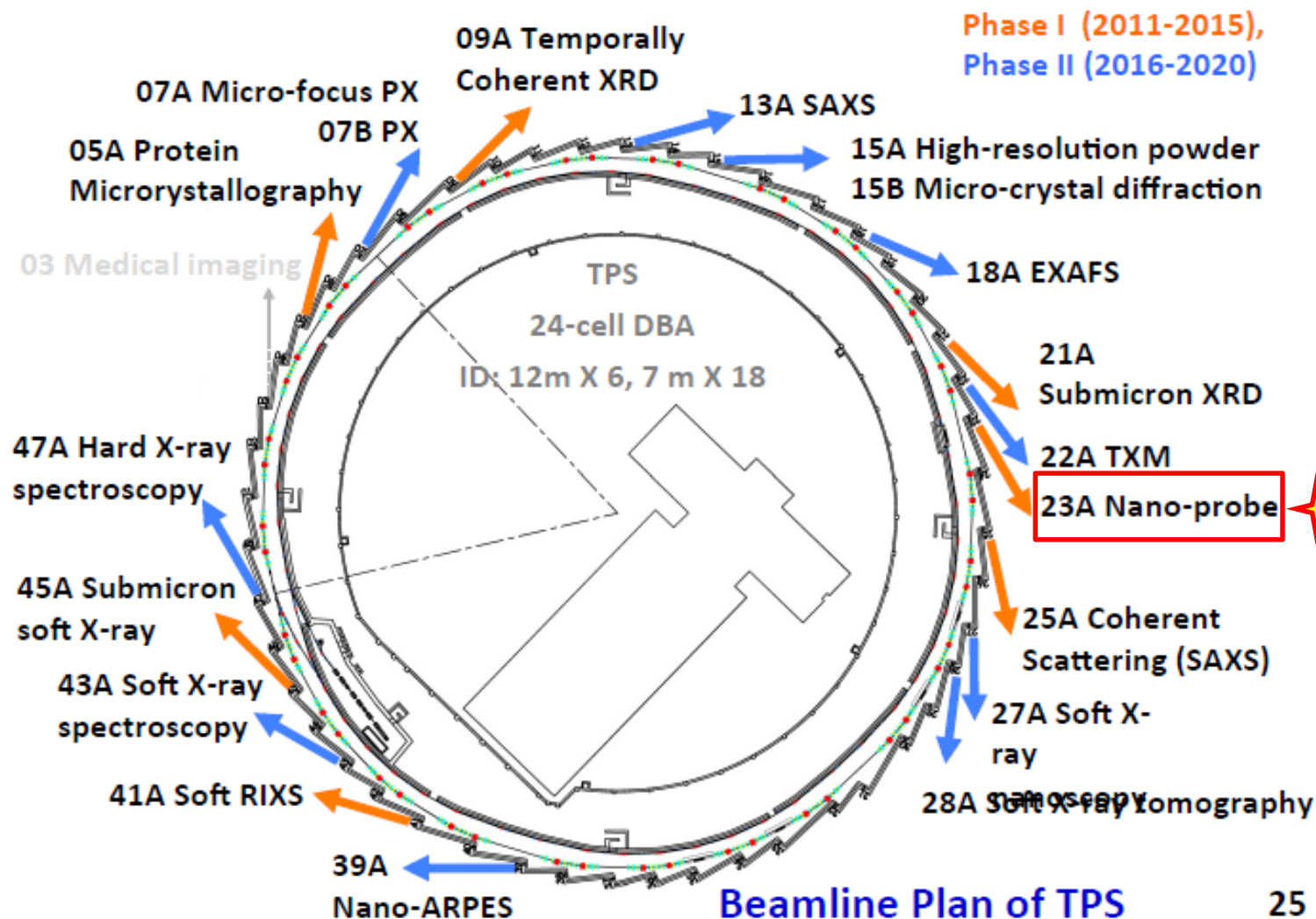
TPS will brighten the future of scientific discovery.



26



The user operation of the TPS will begin in 2015.





2015年是台灣光子源值得紀念的一年



The first synchrotron light
from TPS (December 31, 2014)



104年第一季:
儲存電流達到 100 毫安培
(室溫RF共振腔 (Petra))



104年第二季及第三季:
安裝2台超導RF共振腔
(KEKB) & 10台插件磁鐵



104年第四季:
TPS & 第一期7條光束線
試車

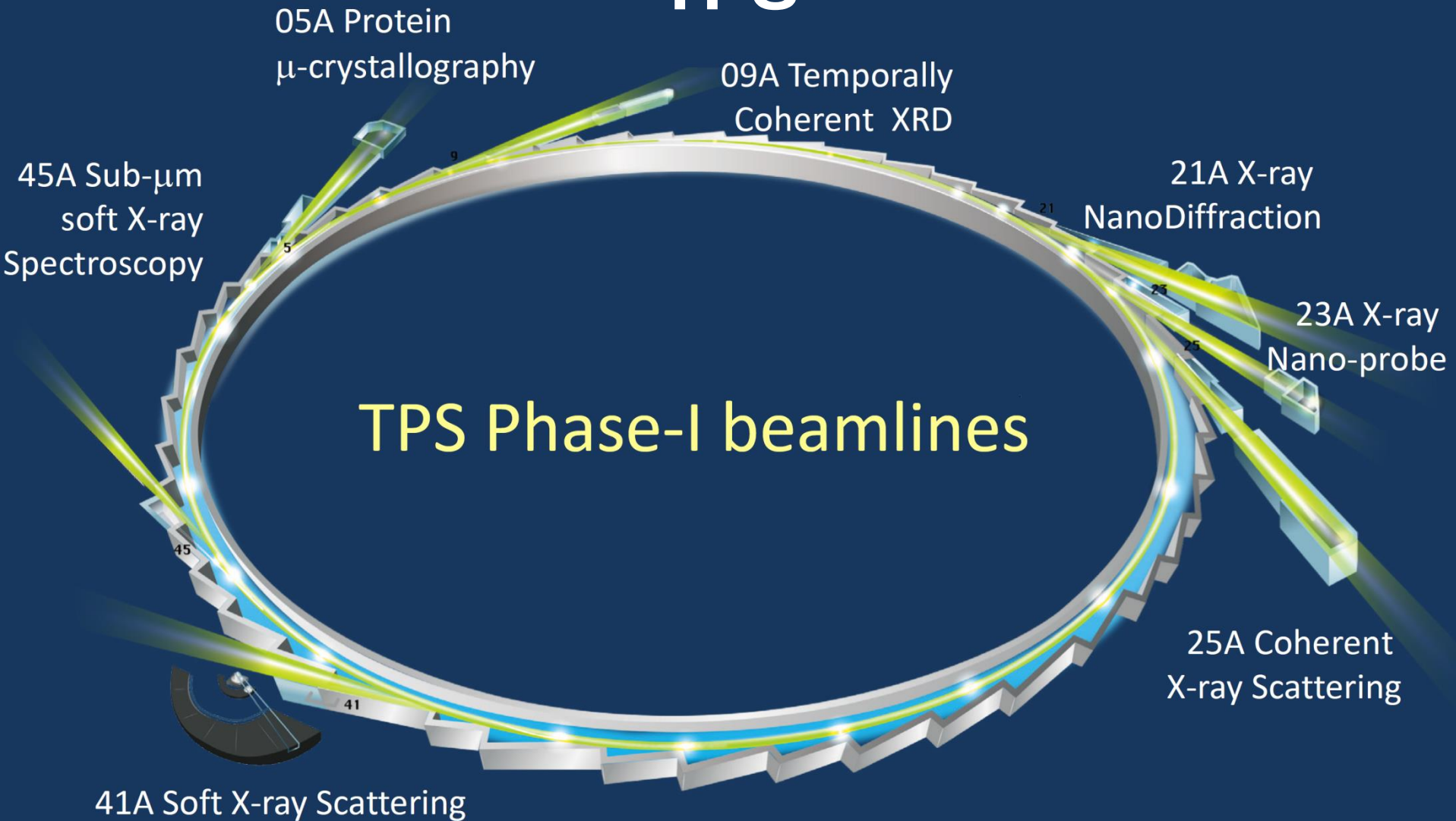


Outline

- Synchrotron Light Source
- Application of Synchrotron Light
- X-ray nano probe at TPS



Nanoprobe project is in the first phase at TPS



- nano-XRF (x-ray fluorescence)
 - Element-specific nanoimaging
- nano-XAFS (x-ray absorption fine structures)
 - Local electronic structure
 - Local chemical environments
 - Element-specific, averaged over nano-size area
- nano-XEOL (x-ray excited optical luminescence)
 - X-ray-to-visible down-conversion efficiency in nano phosphor
- nano-PXM (projection x-ray microscopy)
 - Absorption and phase contrast x-ray images

Beyond sub-ten-nm resolution (coherent)

- nano-CXDI (coherent x-ray diffraction imaging)
- Bragg-ptychography
 - strain dynamics in nano-devices

Other than X-rays

- SEM (SE, EDS, CL with high spatial resolution)
- Fly scanning
- Nanomotors (optional)
- Sample environment -heat, electric, L-He (optional)

Beamline specification

- Energy range : 4 - 15 keV
- Photon flux :
 $10^{10} \sim 10^{11}$ photons/sec
- Energy resolution :
< 2×10^{-4} with Si(111) crystals
- Beam size :
~ 40 nm at 10 keV (H × V, FWHM)
- High-order harmonic contamination :
 $\leq 1 \times 10^{-4}$
- Energy scanning capabilities.



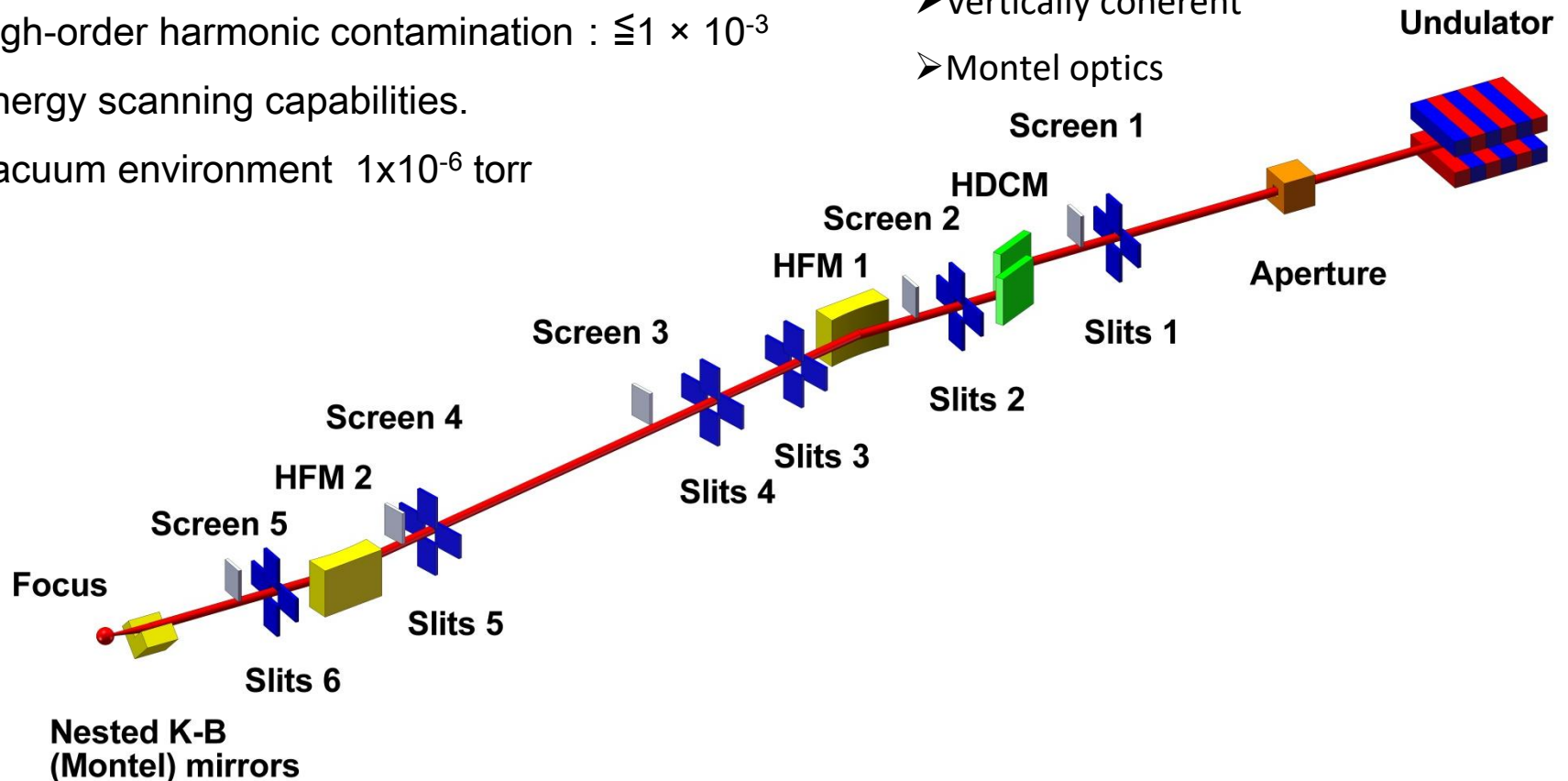
Optical Layout

Expected Beamline performance

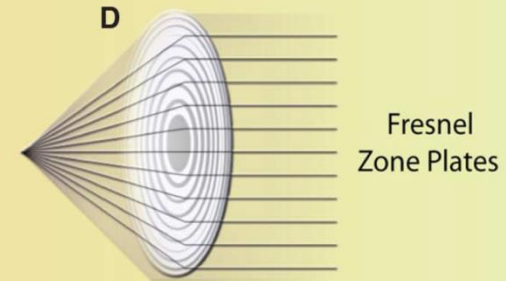
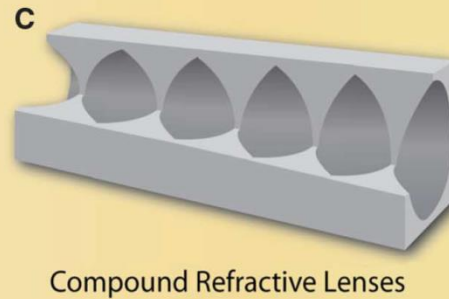
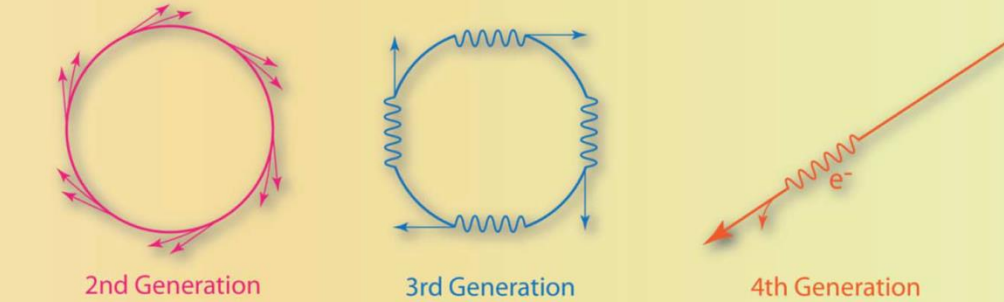
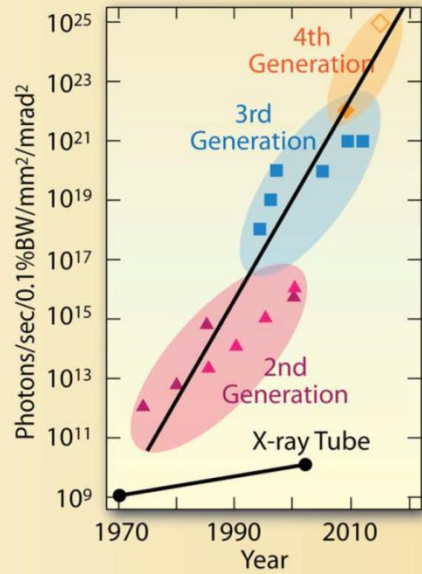
Features

- Energy range : 4 - 15 keV
- Photon flux : $10^{10} \sim 10^{11}$ photons/sec
- Energy resolution : $< 2 \times 10^{-4}$ with Si(111) crystals
- Beam size : ~ 40 nm at 10 keV (H $\times$ V, FWHM)
- High-order harmonic contamination : $\leq 1 \times 10^{-3}$
- Energy scanning capabilities.
- Vacuum environment 1×10^{-6} torr

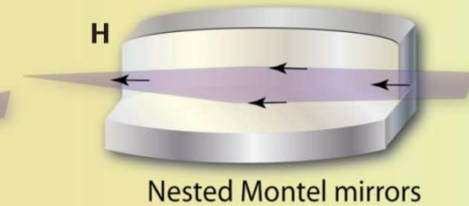
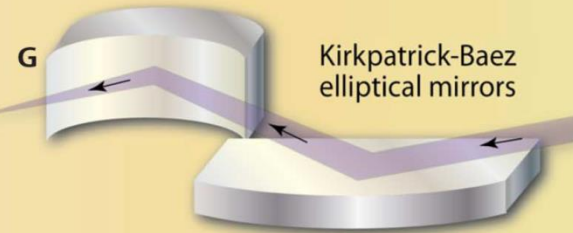
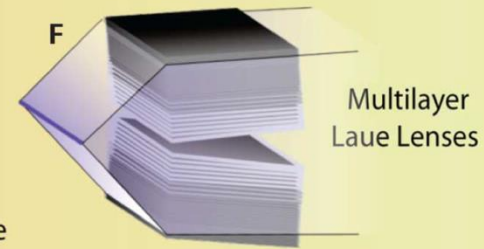
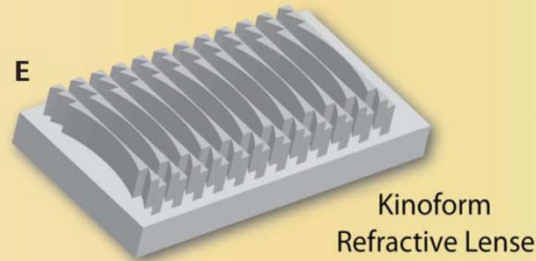
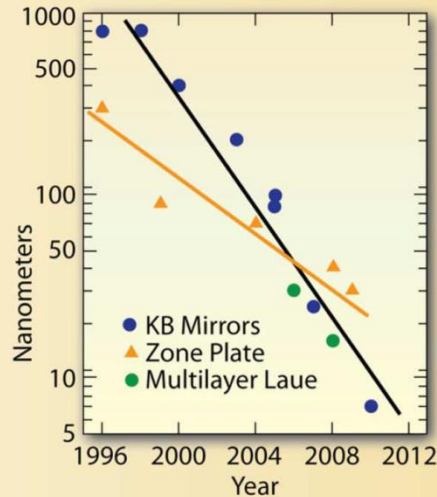
- 2-stage Horizontal focusing
- Horizontal DCM
- Short in length (< 70 m)
- Windowless
- Vertically coherent
- Montel optics



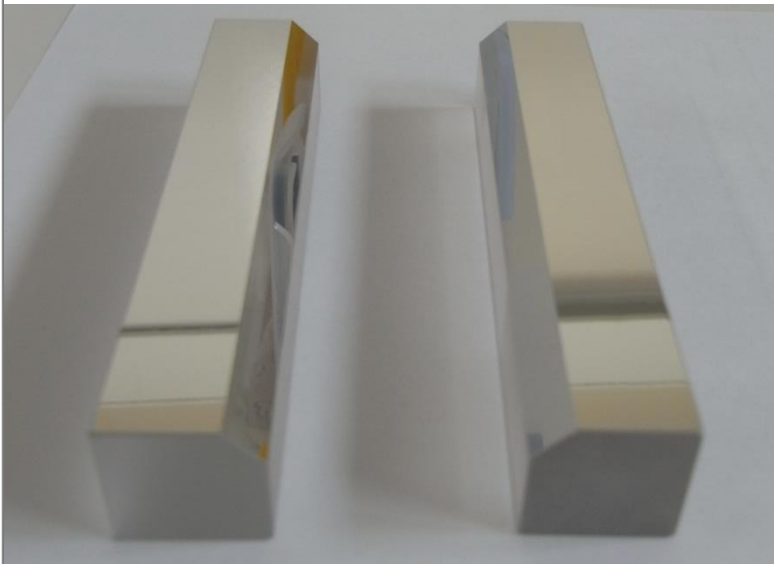
A Time-average 10 keV X-ray Brilliance



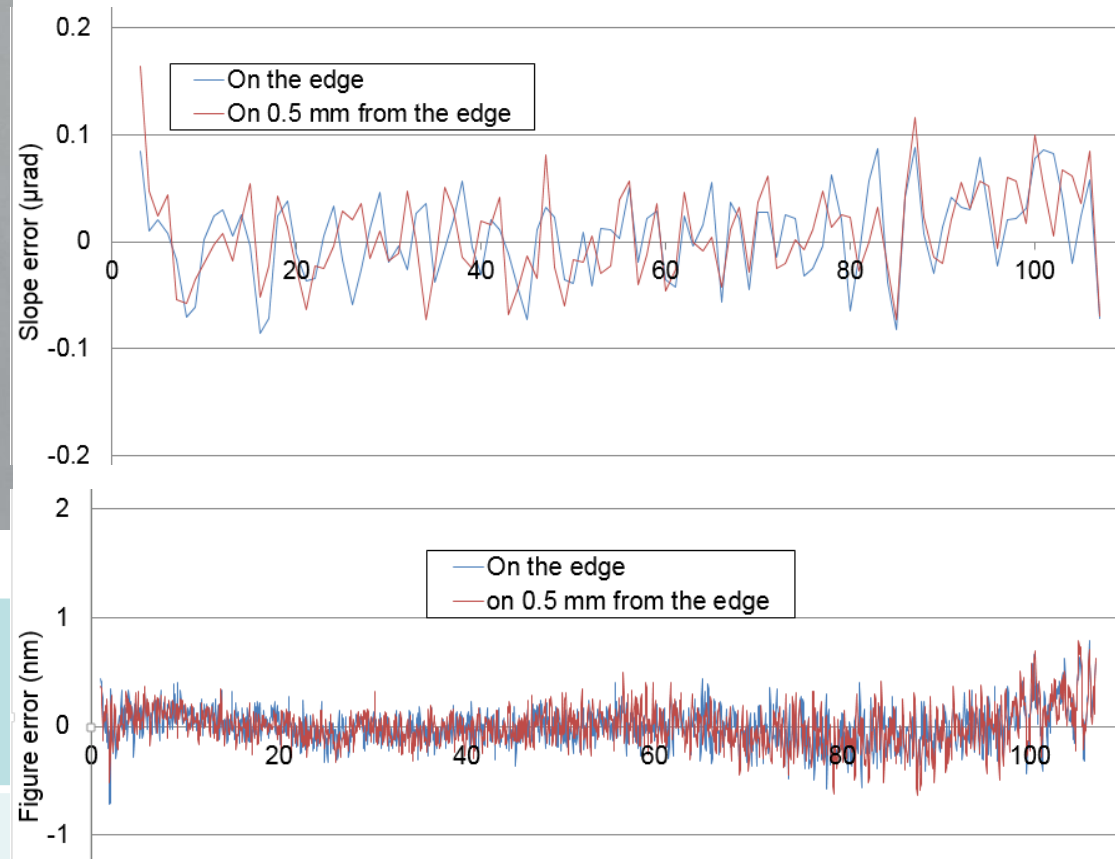
B 10 keV Spot Size



1. nano-optics: Montel mirrors



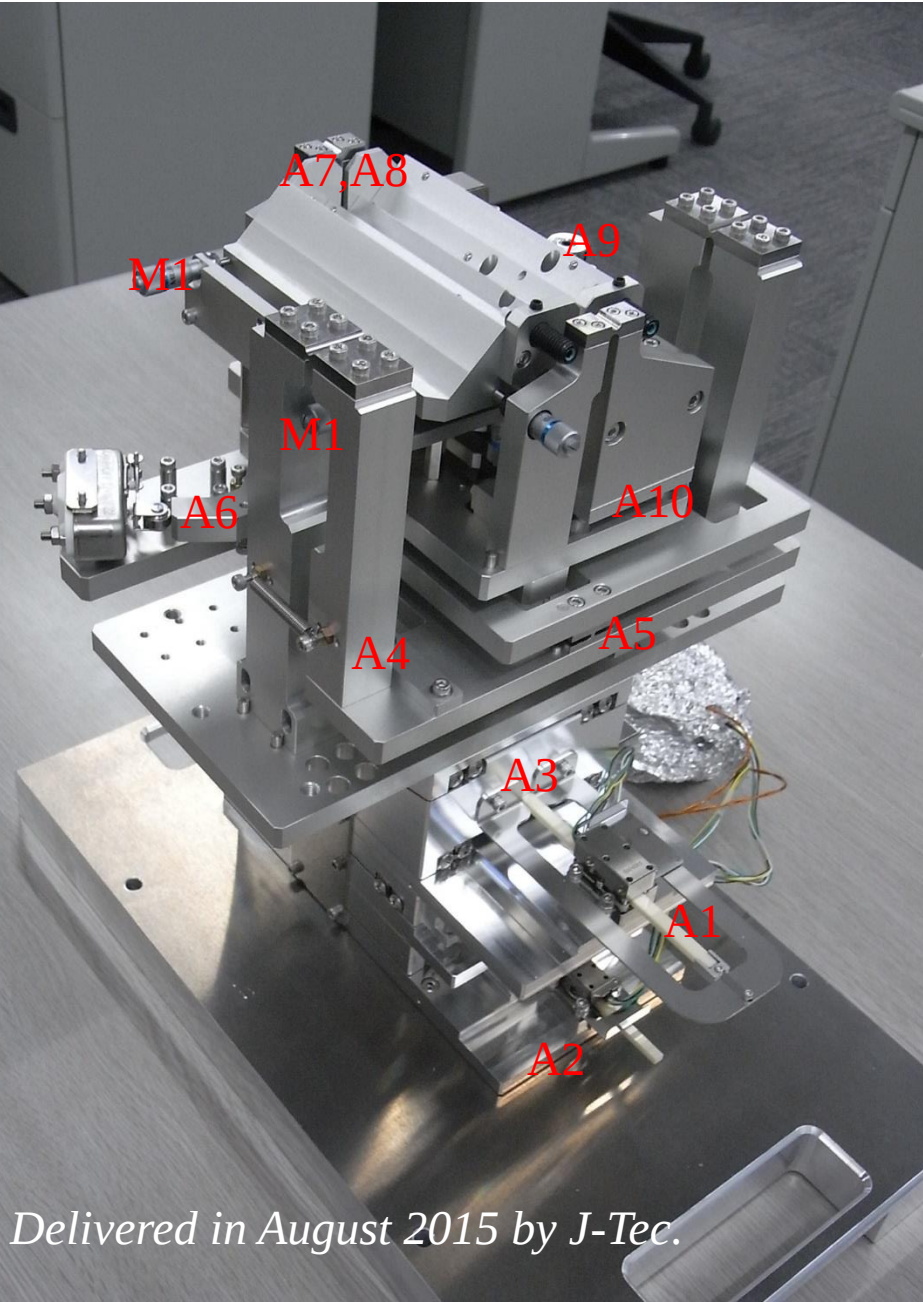
	Slope error RMS	Roughness (nm) RMS
Mirror 1	0.042 (μrad)	0.135 (nm)
Mirror 2	0.039 (μrad)	0.142 (nm)



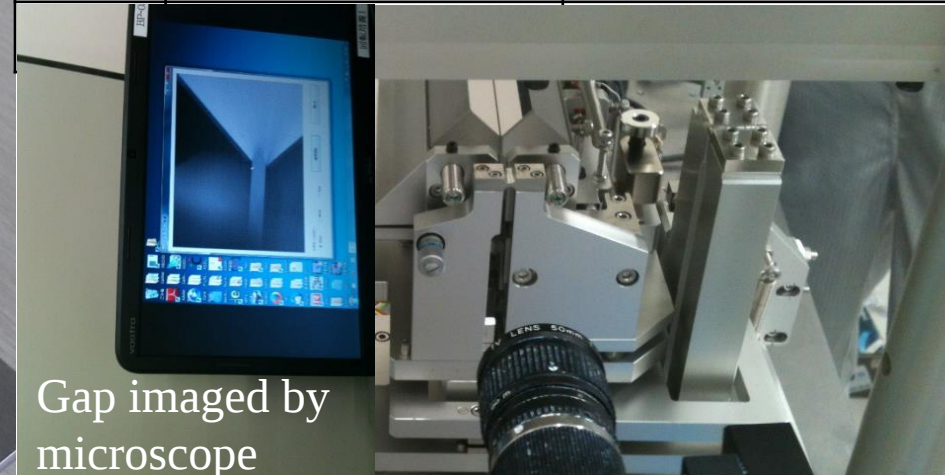
No crack at edge is observed by
Optical microscope



Mirror holders



A1	X	Optical encoder
A2	Y	Optical encoder
A3	Z	Optical encoder
A4	Pitch	Laser interferometer
A5	Roll	Laser interferometer
A6	Yaw	Laser interferometer
A7	Top-Y	Pre-aligned
A8	Top-Z	Pre-aligned
A9	Top-Pitch (X)	Pre-aligned
A10	Top-Roll (Y)	Pre-aligned



Delivered in August 2015 by J-Tec.

Montel Mirrors in the holder

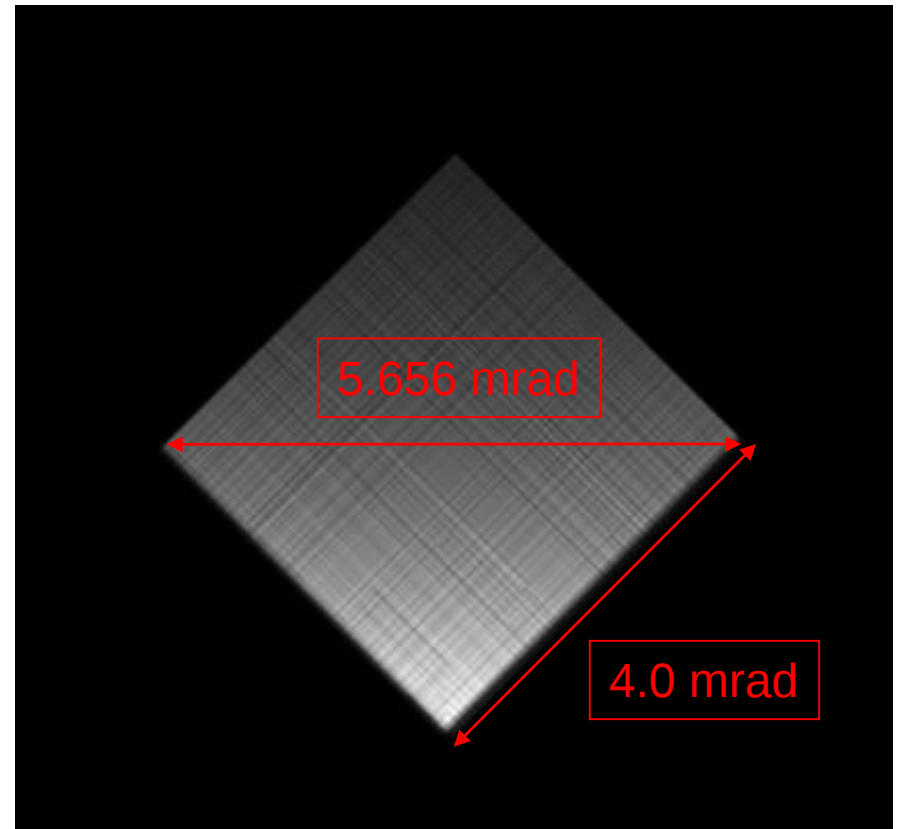
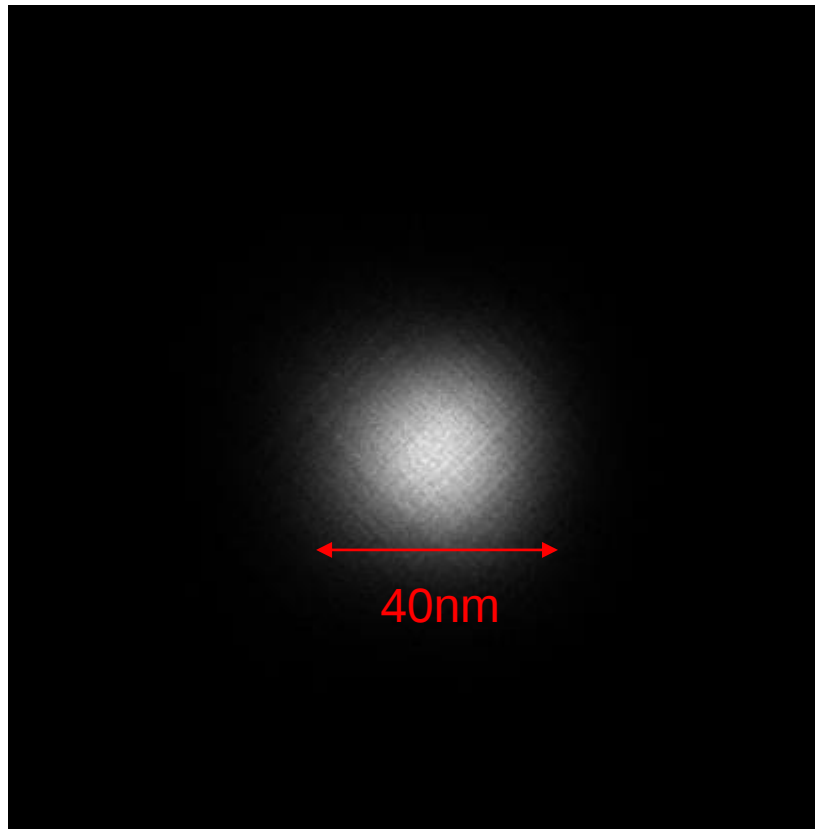
Simulation of Focus Spot

Simulation at 10 keV, average reflection=0.802, by ray tracing

Source size 12.5 μm x 12.5 μm

Source divergence 6 μrad x 6 μrad

FHWM 25nm x 25nm,



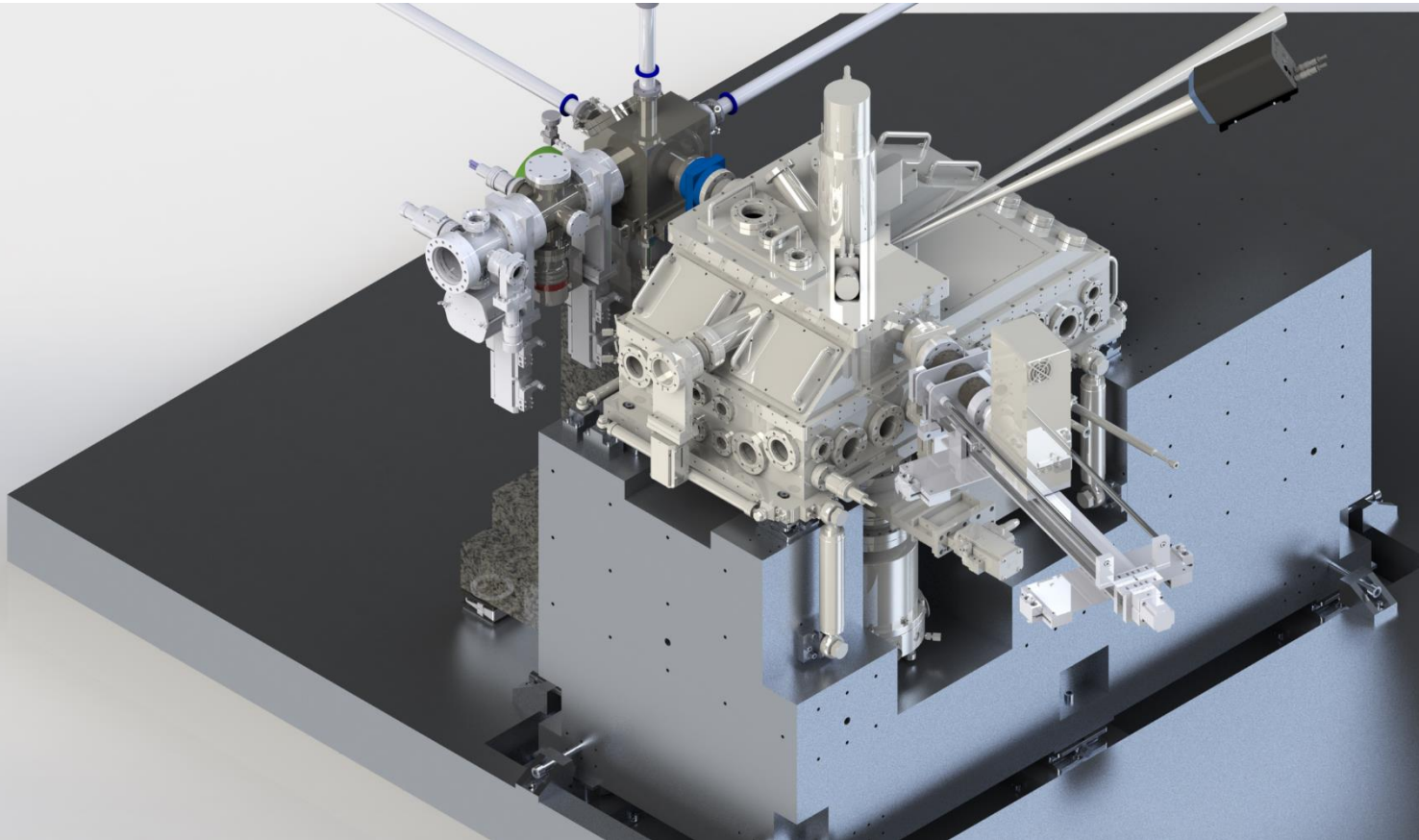
國家同步輻射研究中心
National Synchrotron Radiation Research Center

Simulated
Focus spot size

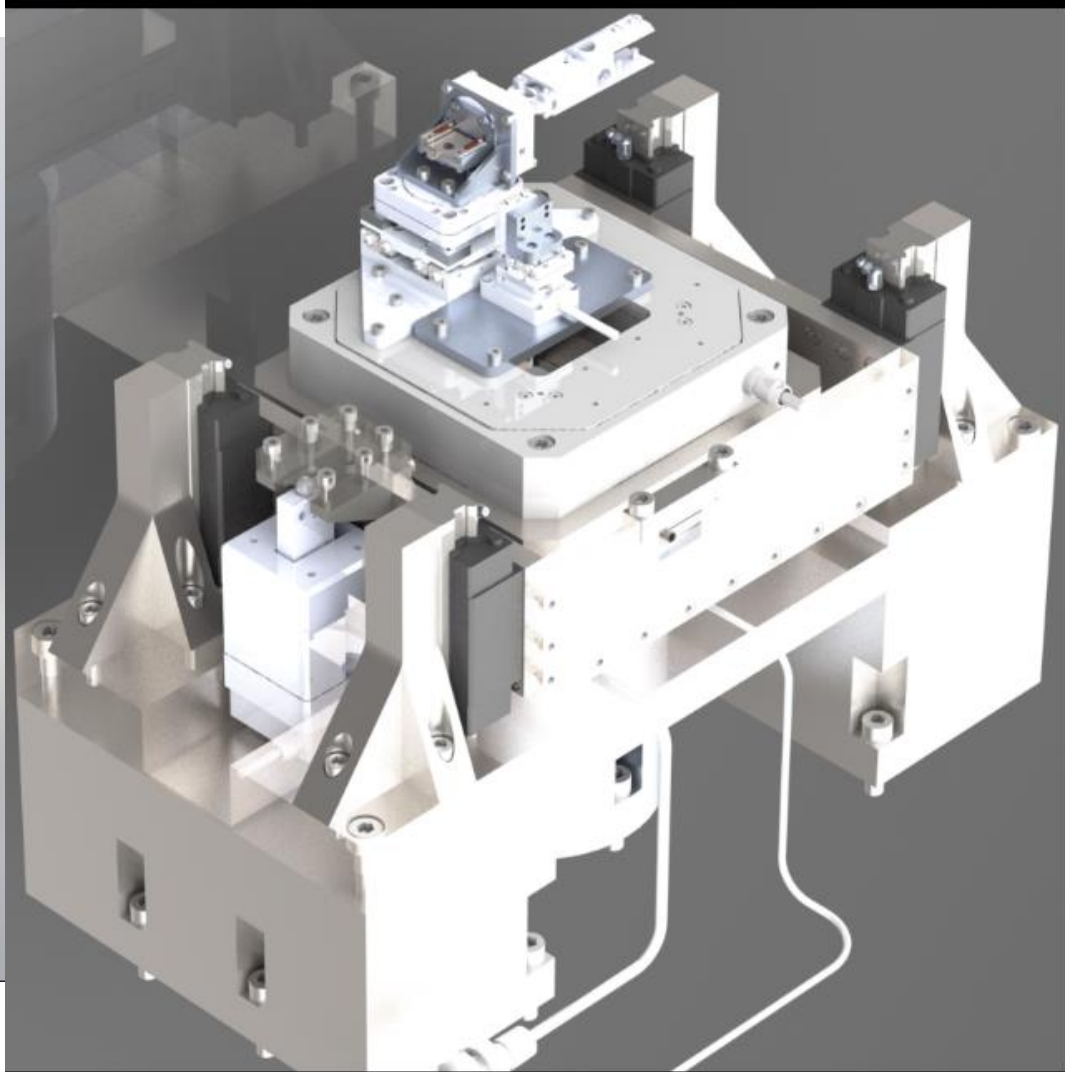
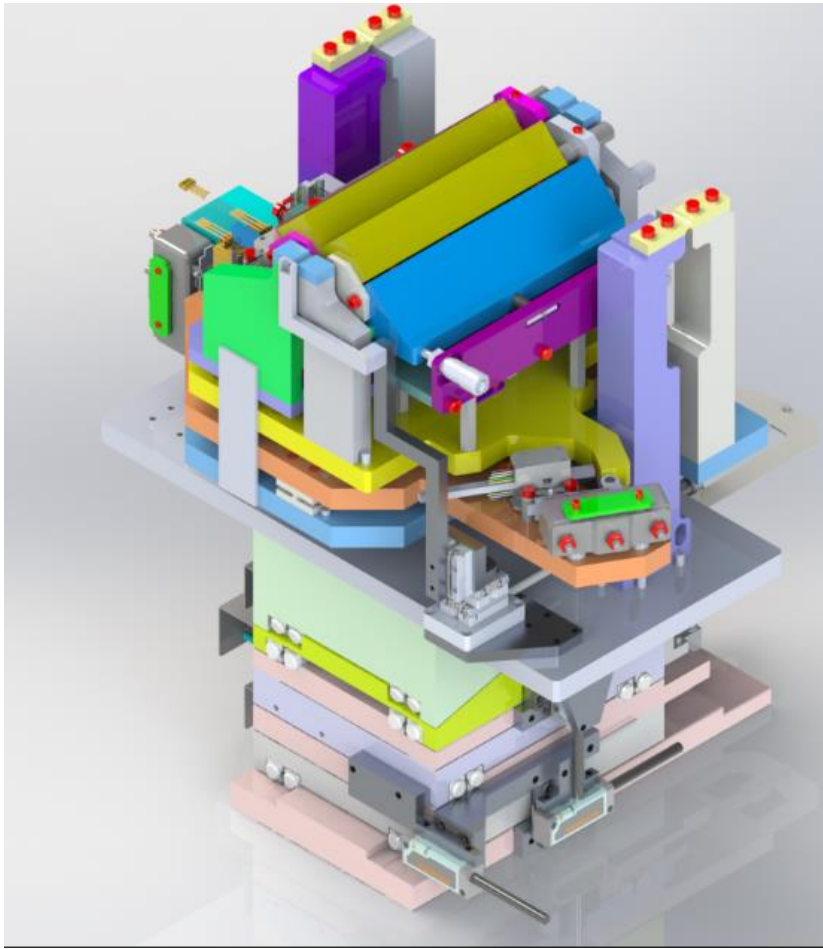
Simulated
Divergence

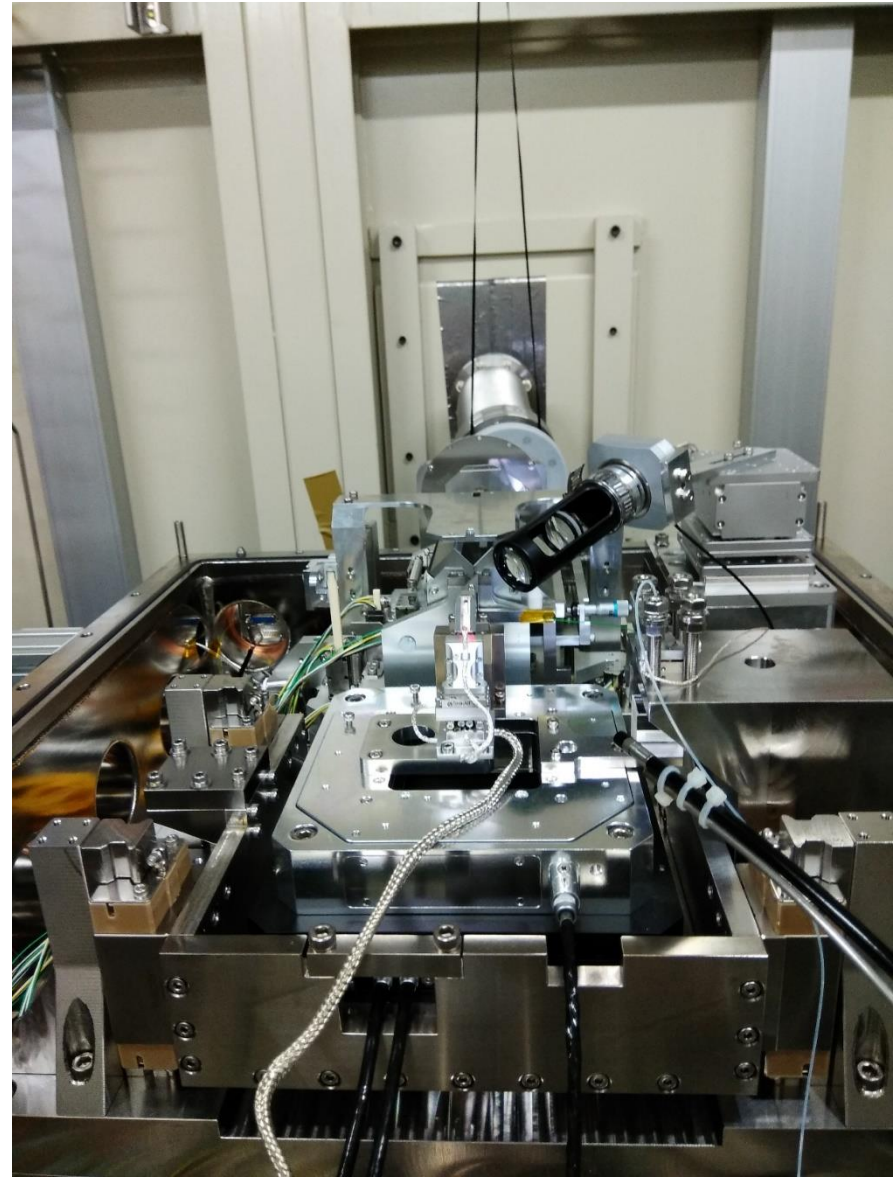
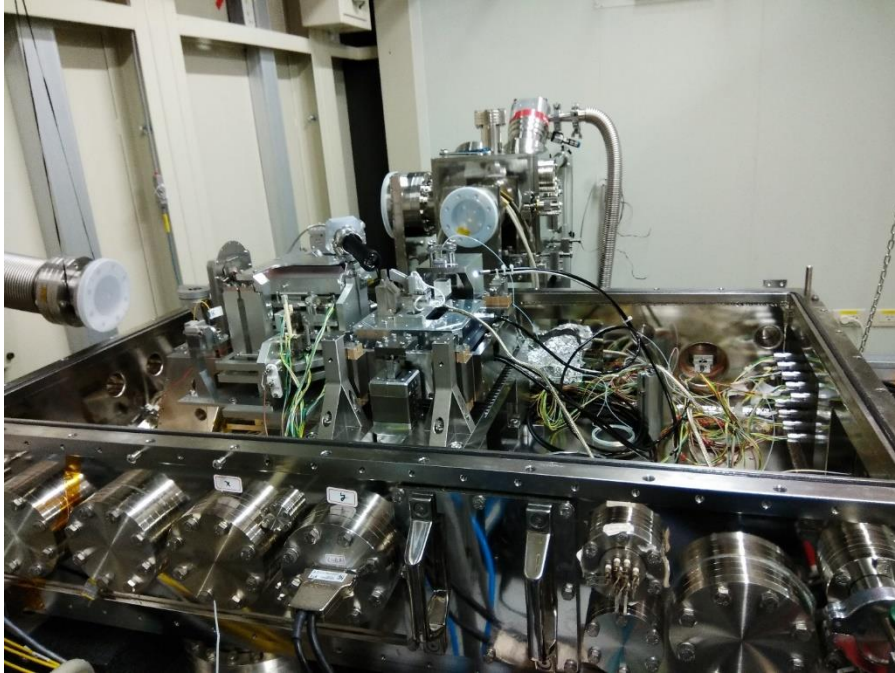
By Gung-Chian Yin

Experimental Station



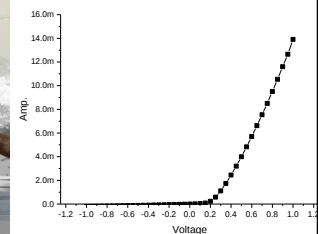
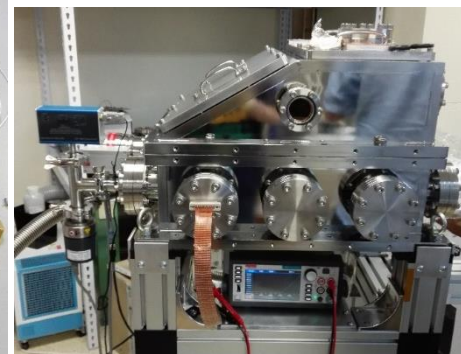
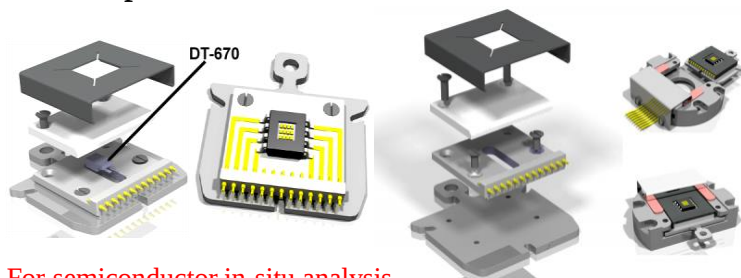
Experimental Station





Sample environment and Preparation Chamber

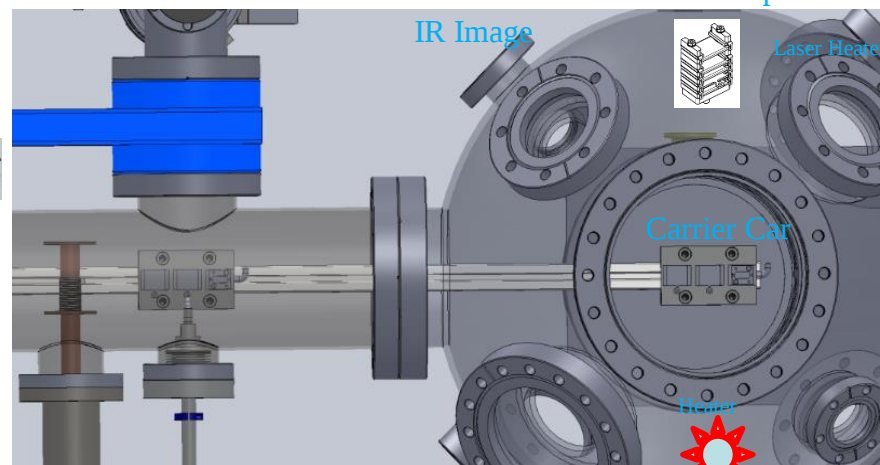
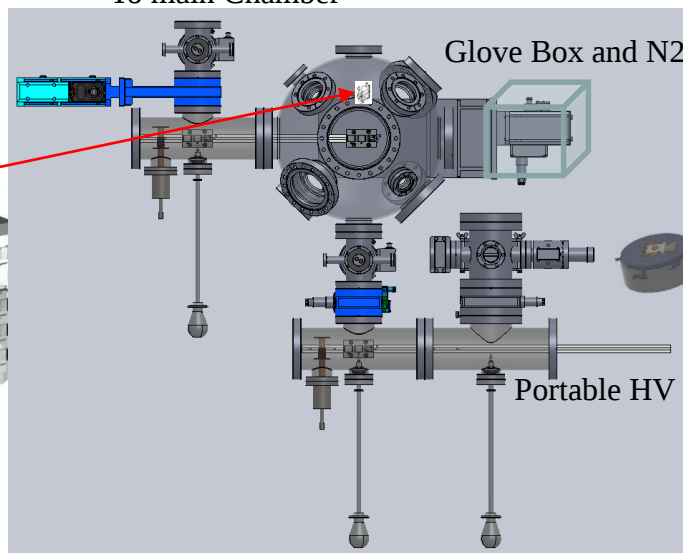
Sample Holder with 13 electrical contacts



To main Chamber

Glove Box and N₂ Purge

5*4=20
Pieces



Stack of Receptacles

IR Image

Laser Heater

Carrier Car



Ion Gun and
O₂ Plasma

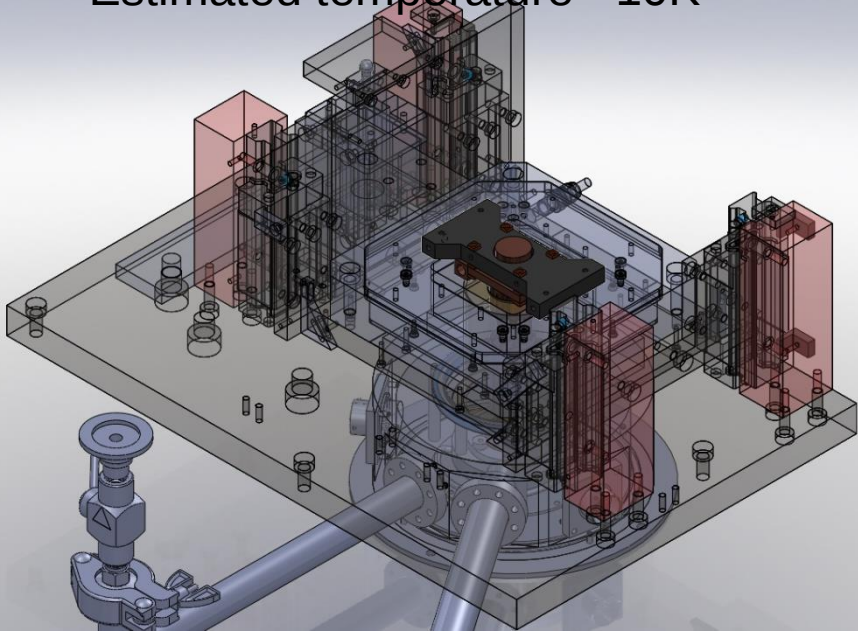
Conduit of
Reaction Gas
+ MFC (O₂, H₂ ...)



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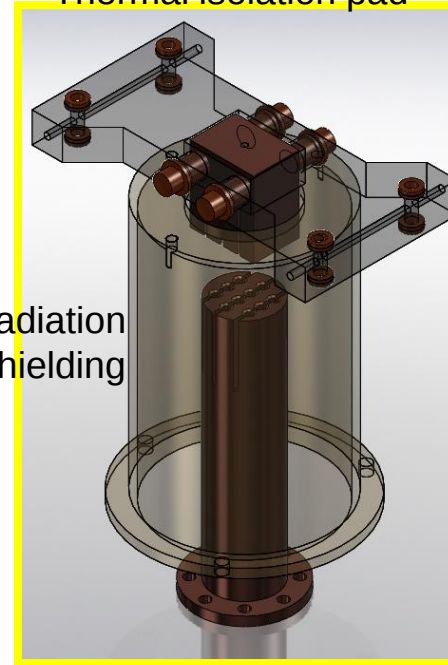
The Design of the L-He Cooling System

- JANIS ST-500 He cryo-stage
- Estimated temperature~ 10K

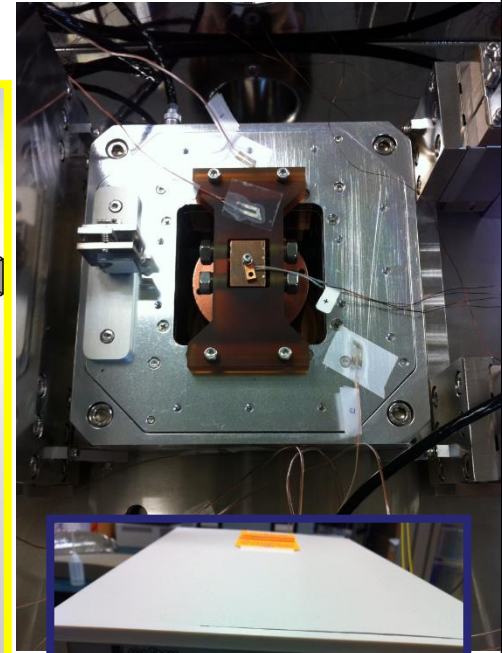


Thermal isolation pad

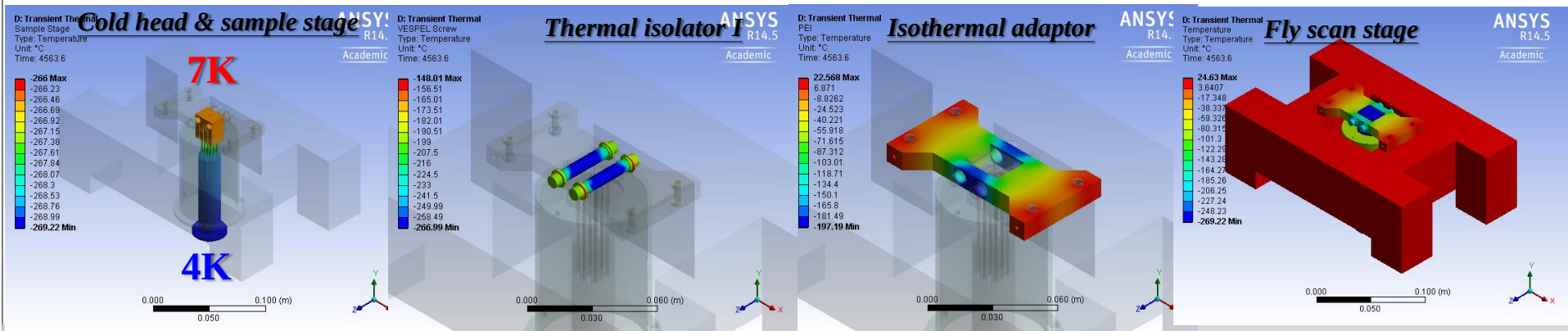
Radiation shielding



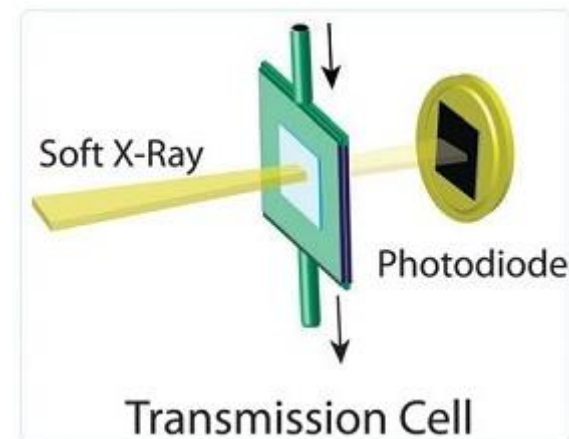
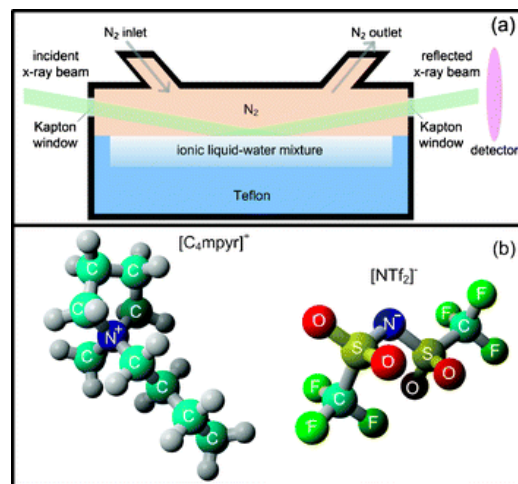
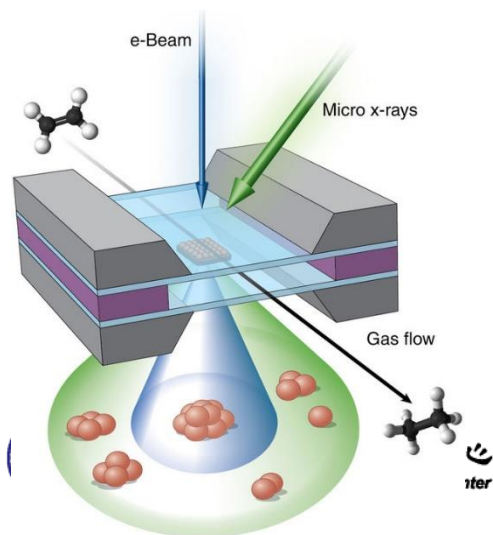
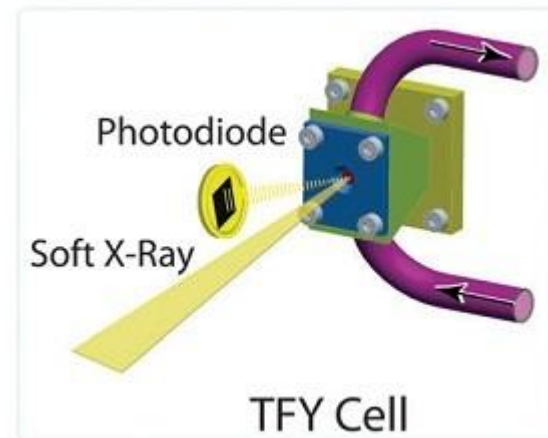
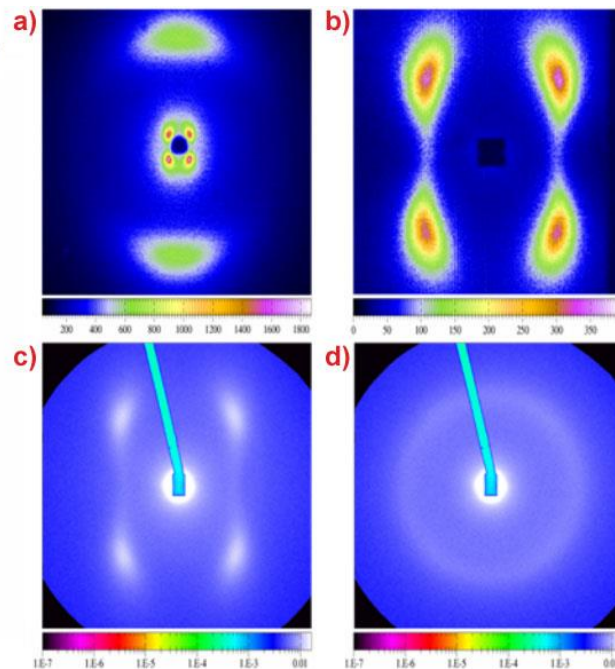
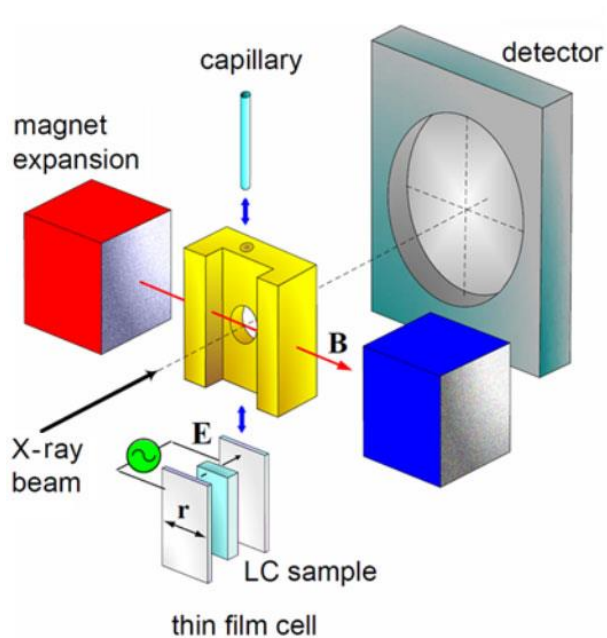
Cooling head

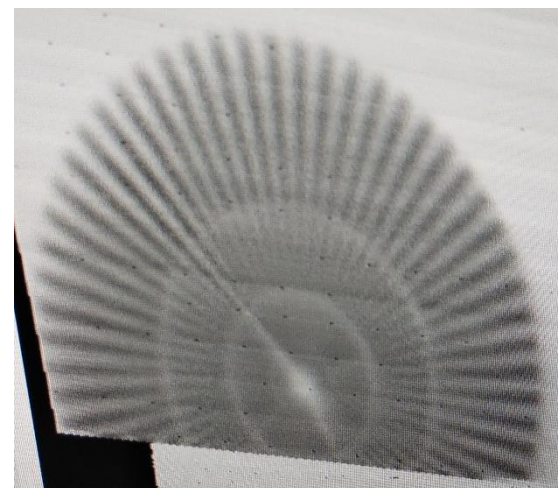
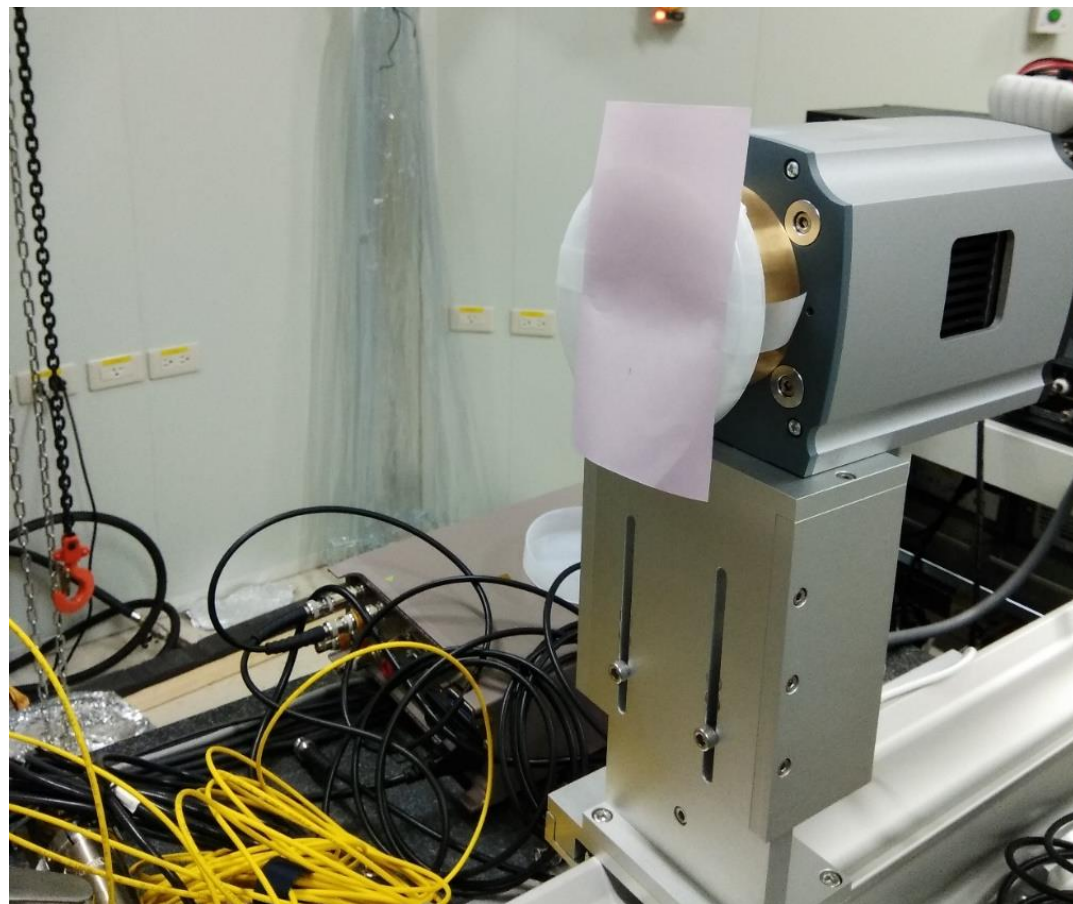
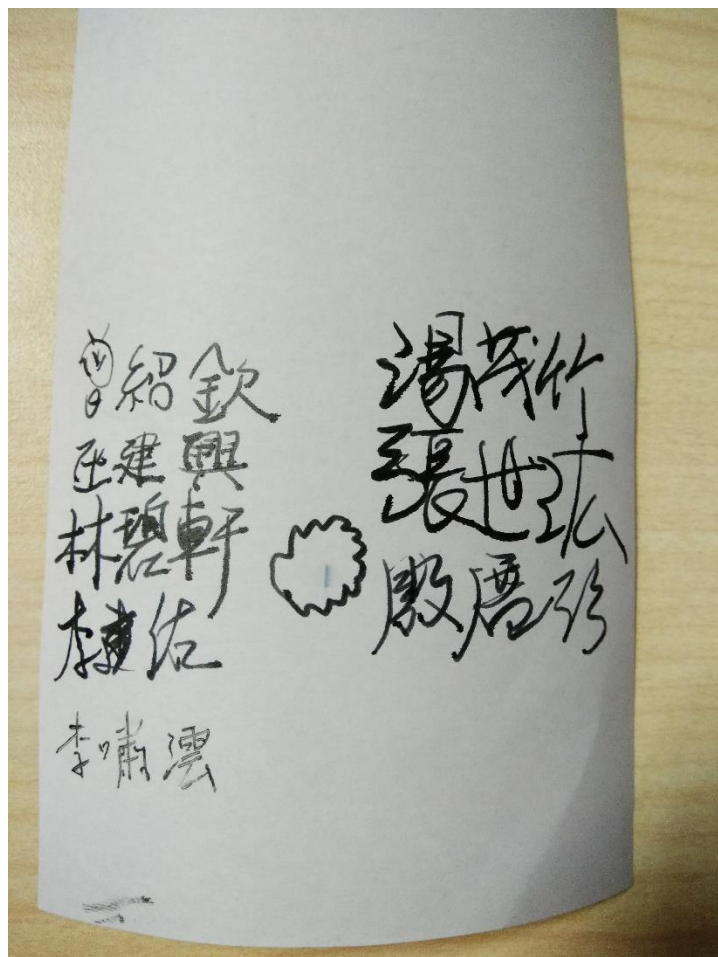


→ FEM simulation results



In-Situ Gas and Liquid Cell





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National Synchrotron Radiation Research Center

nano-XRF (x-ray fluorescence)

Element-specific nano-imaging

Doping of ZnO NWs by transition metal Co.

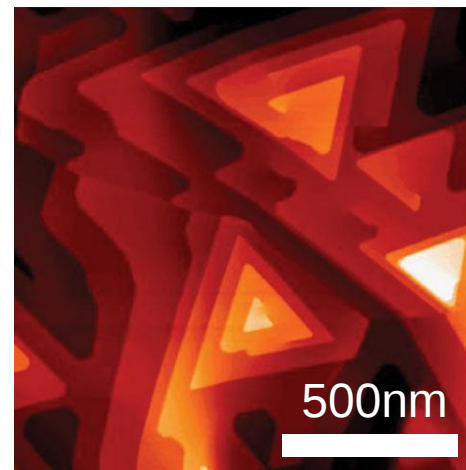
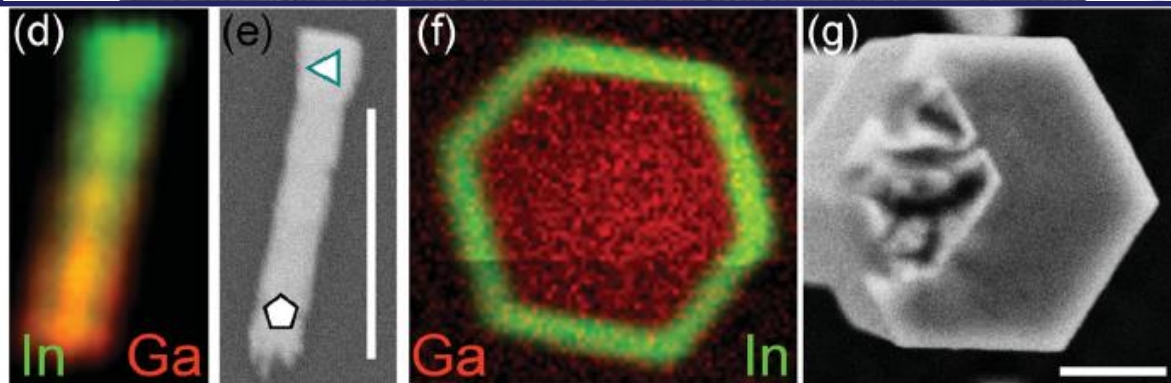
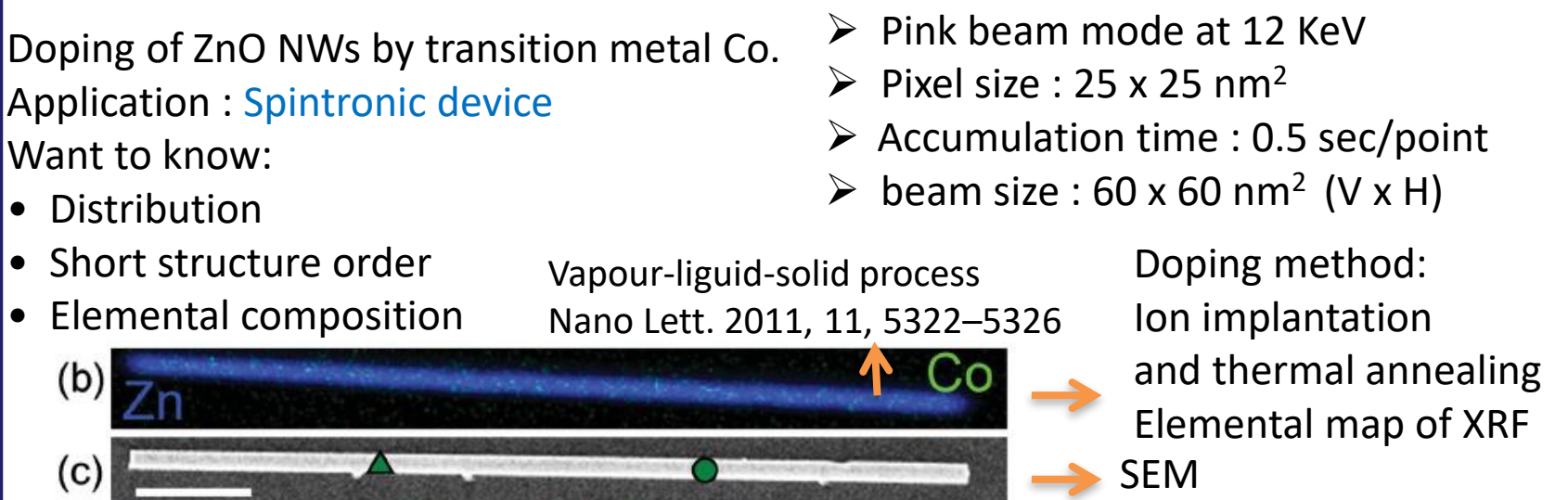
Application : [Spintronic device](#)

Want to know:

- Distribution
- Short structure order
- Elemental composition

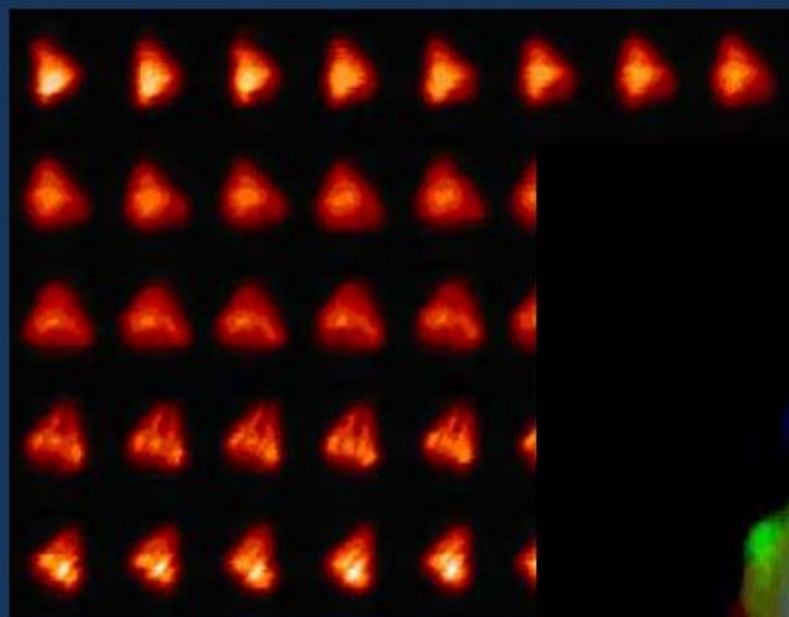
Vapour-liquid-solid process
Nano Lett. 2011, 11, 5322–5326

Doping method:
Ion implantation
and thermal annealing
Elemental map of XRF
SEM

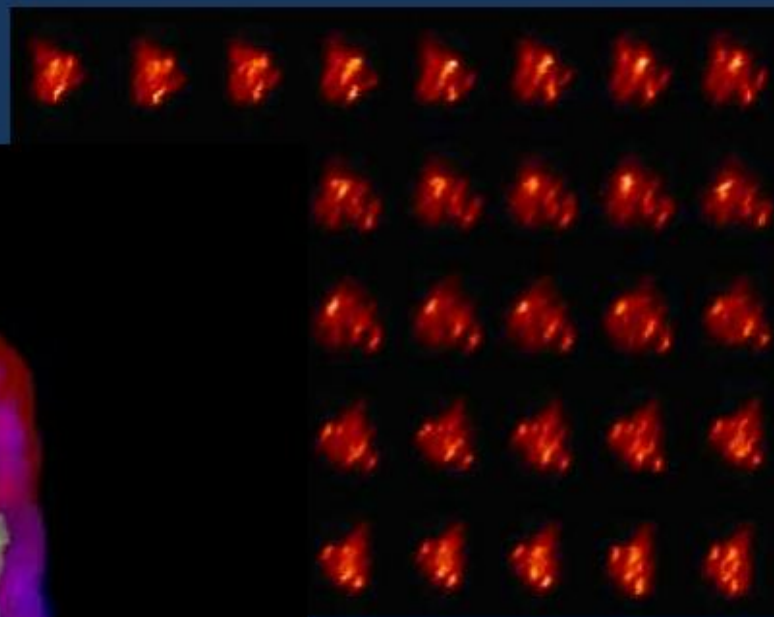


High resolution XRF tomography

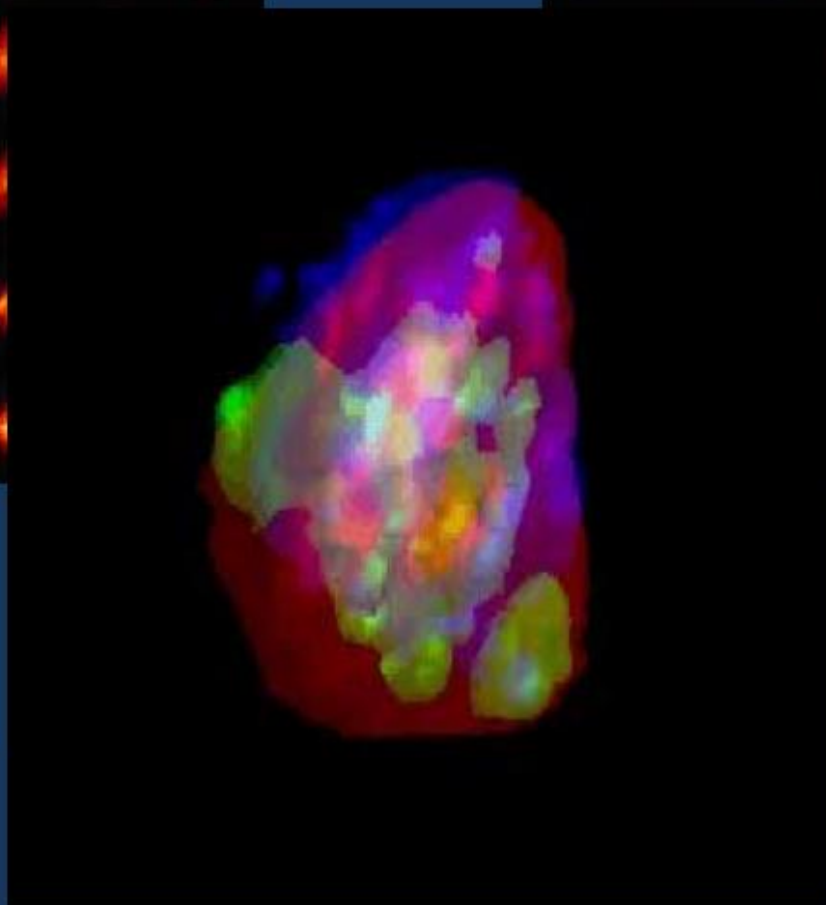
Pixel size: 100 nm, sample rotation 0-180° (4.5° / image)



Fe



Cr

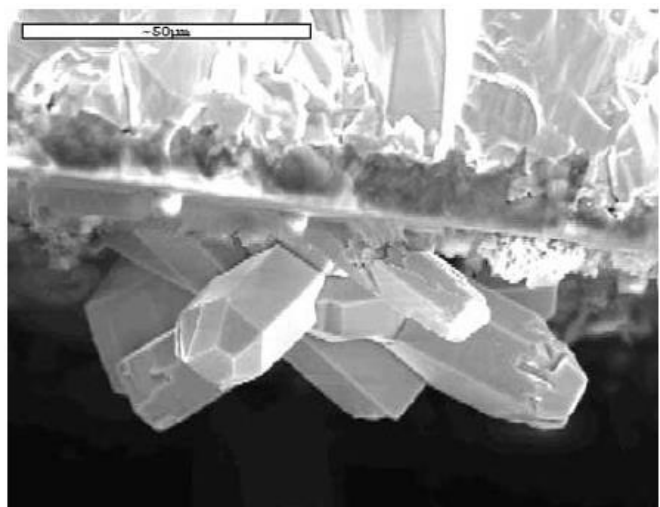


Composite
Fe-Cr-Se

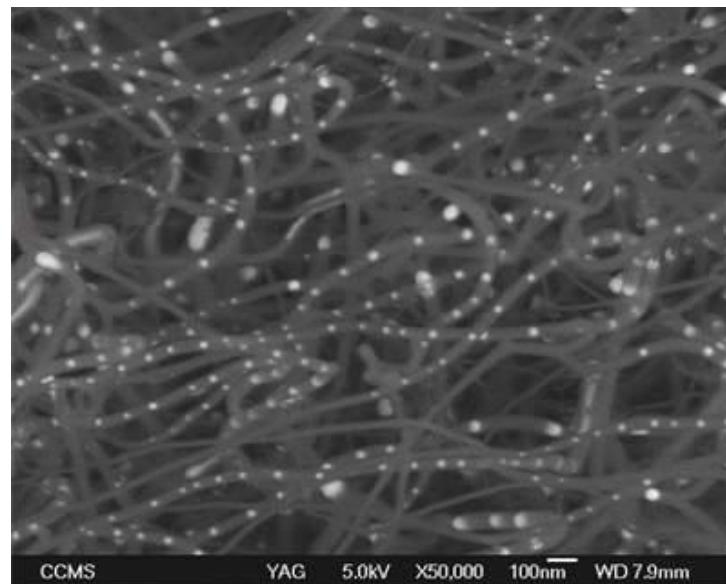
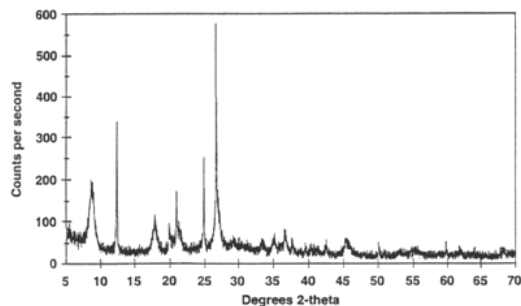
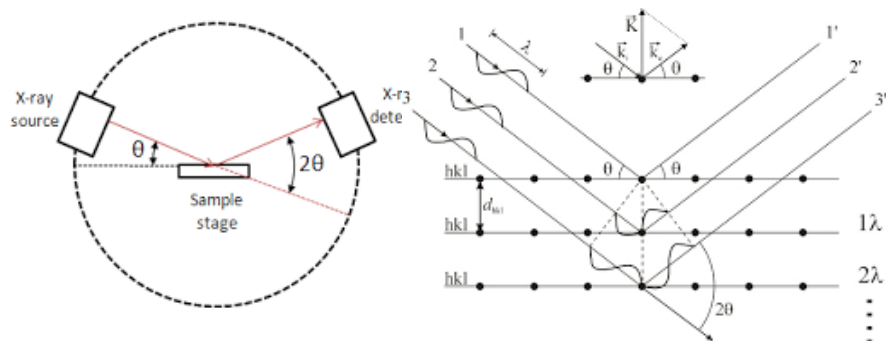
Silversmit *et al.*, *Anal. Chem.* 81 (2009)

nano-XRD (x-ray Diffraction)

nano-Crystalline

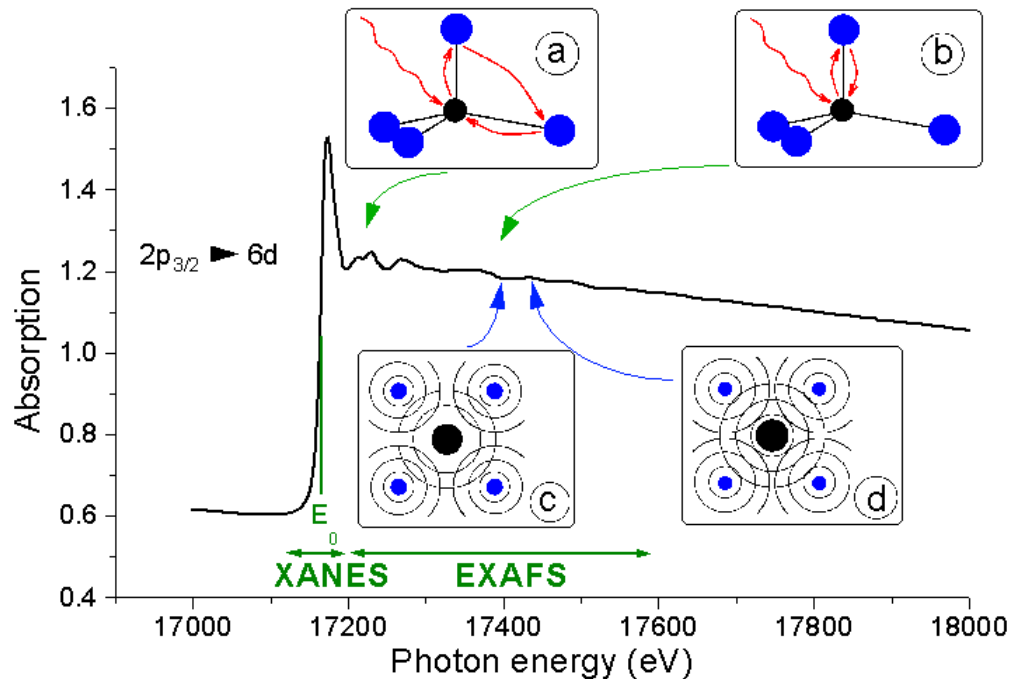
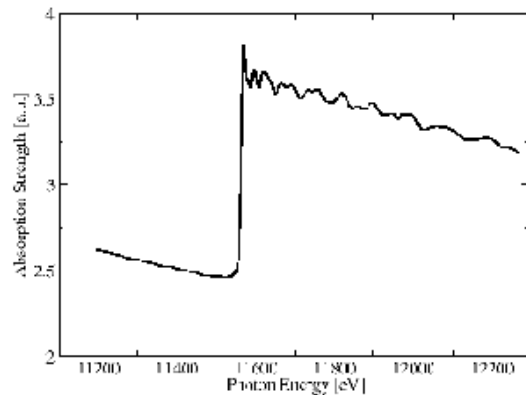
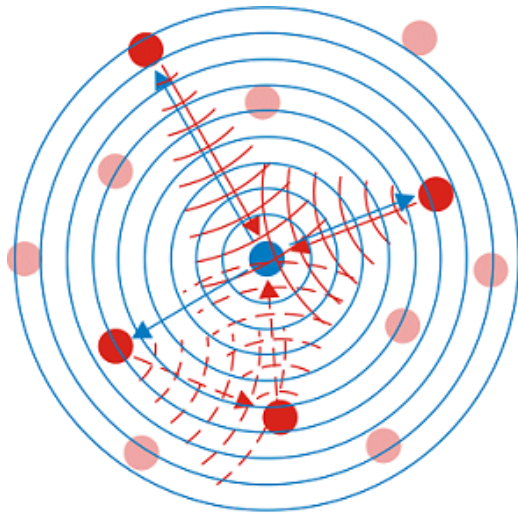


Carbon

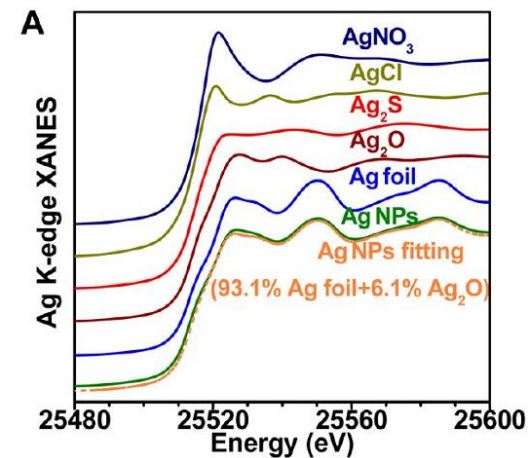
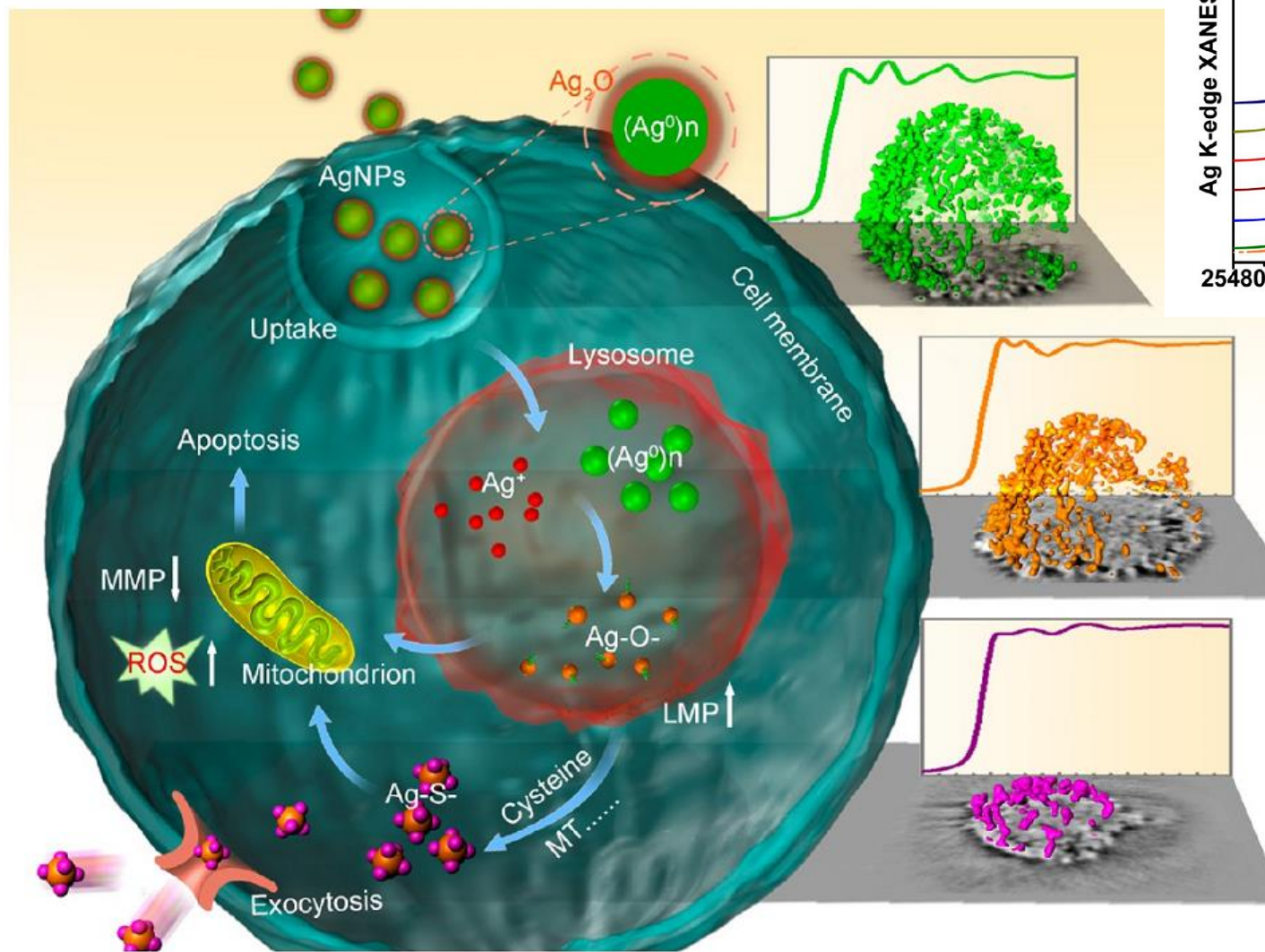


nano-XAFS (x-ray absorption fine structures)

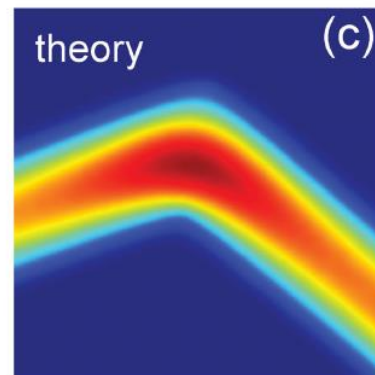
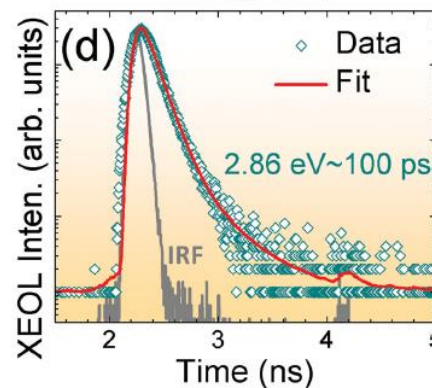
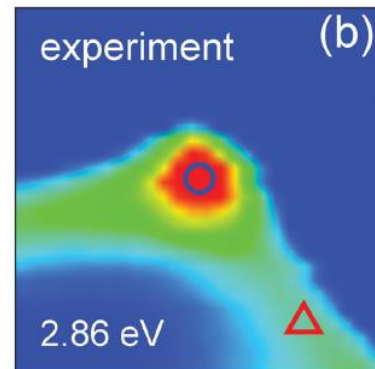
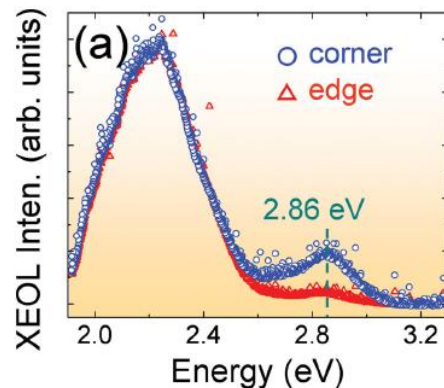
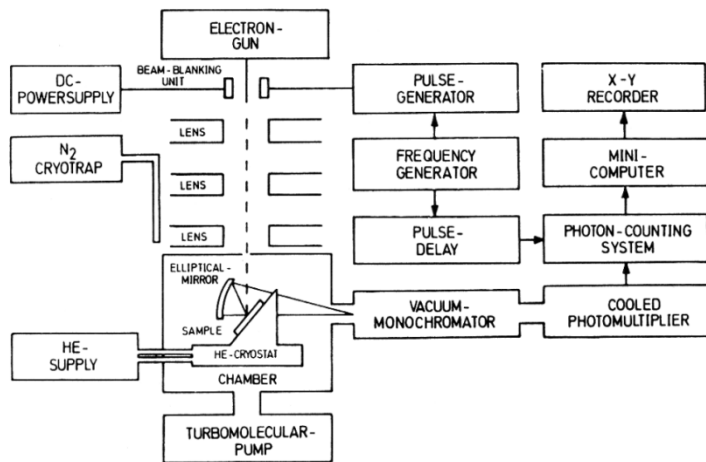
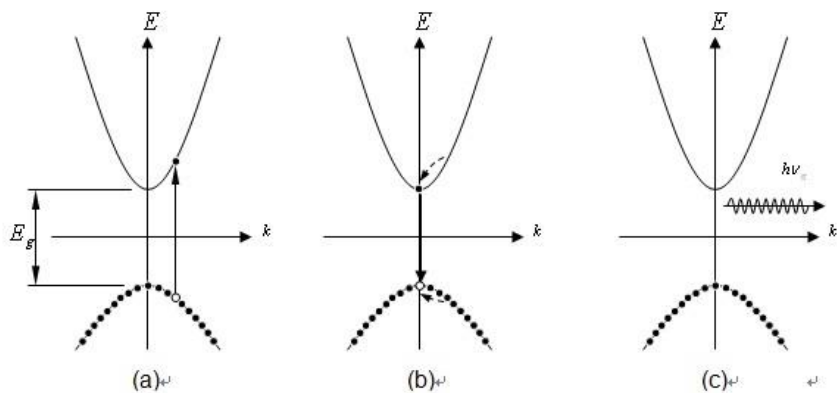
- Local electronic structure
- Local chemical environments
- Element-specific, averaged over nano-area



nano-XAFS



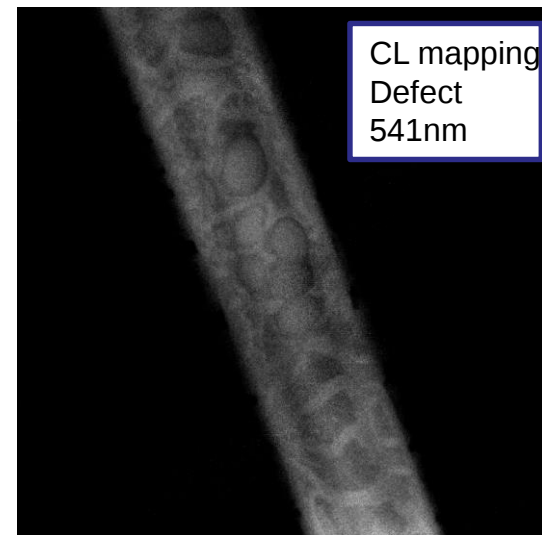
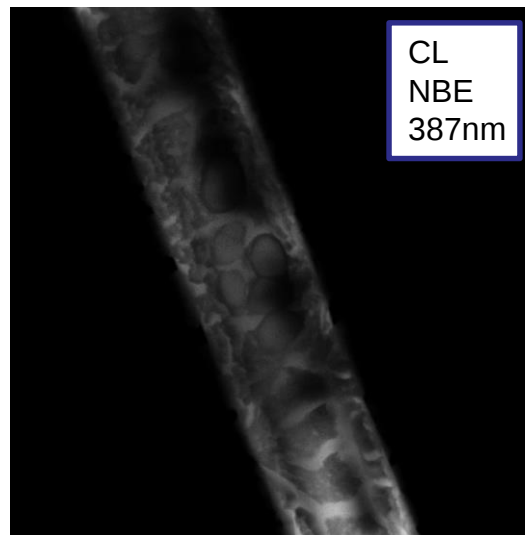
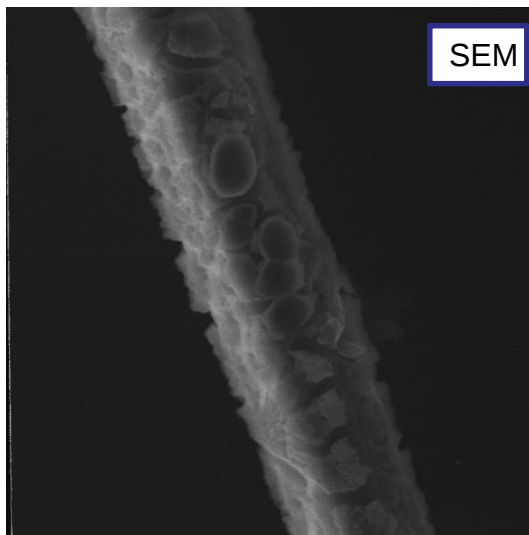
nano-XEOL (x-ray excited optical luminescence) & CL (cathodoluminescence)



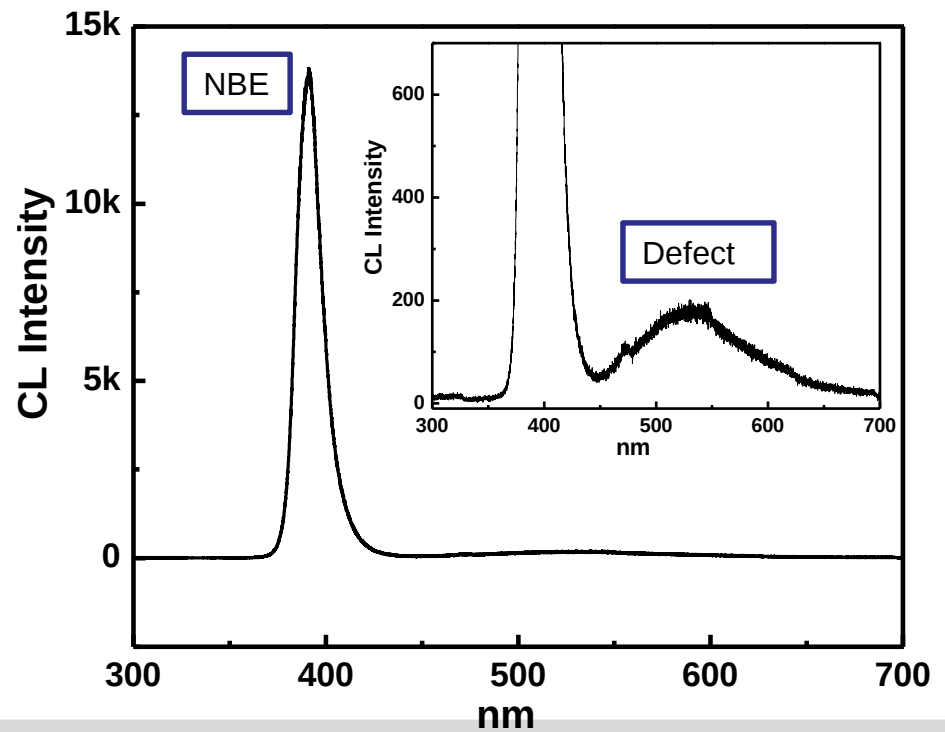
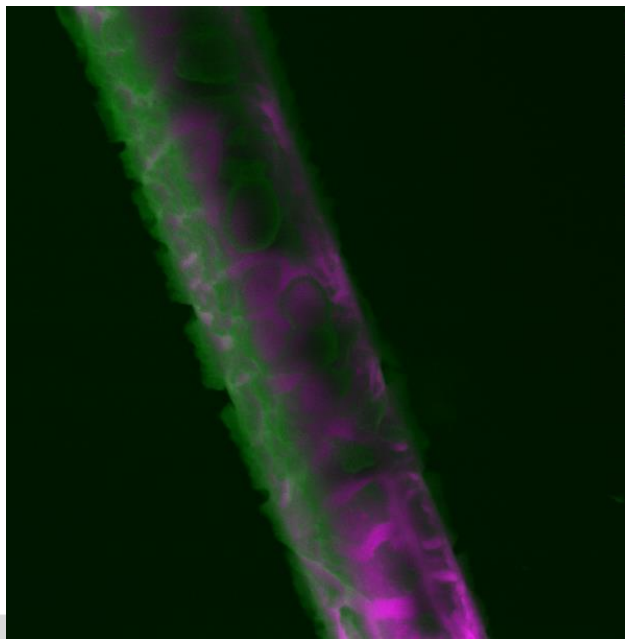
XEOL: 1.nano-area
2.multi-layer, buried layer

Doping species, Band gap, Defect band,
Charge transport

ZnO microwire
SEM and CL mapping

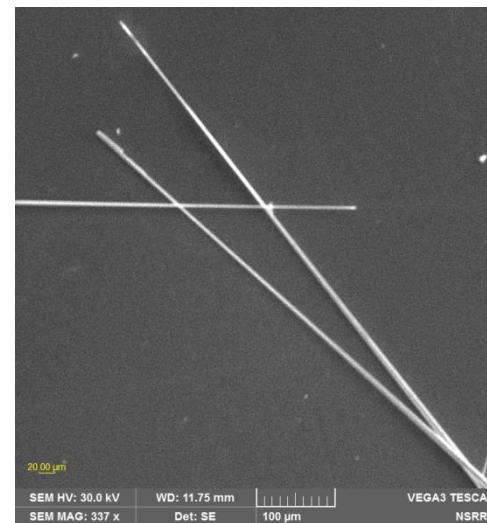
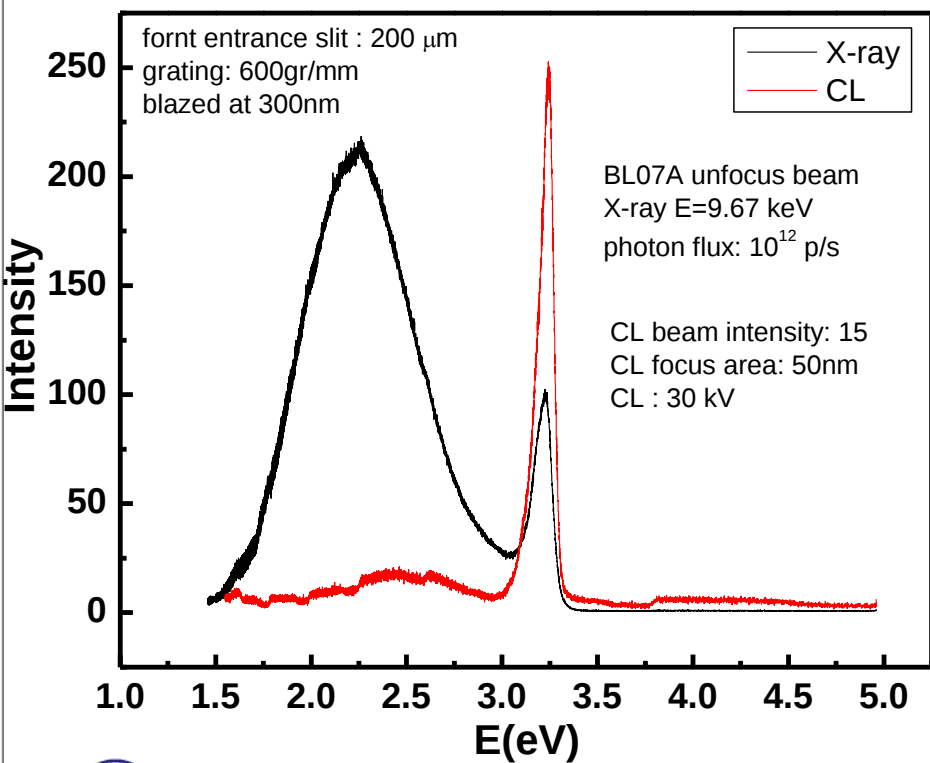


40 μm x 40 μm

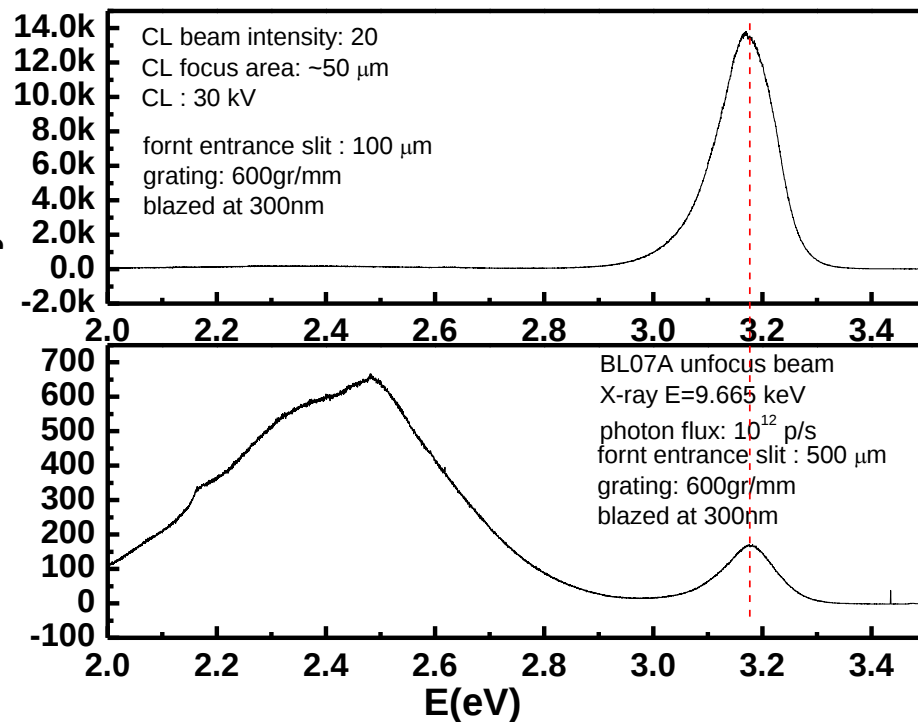




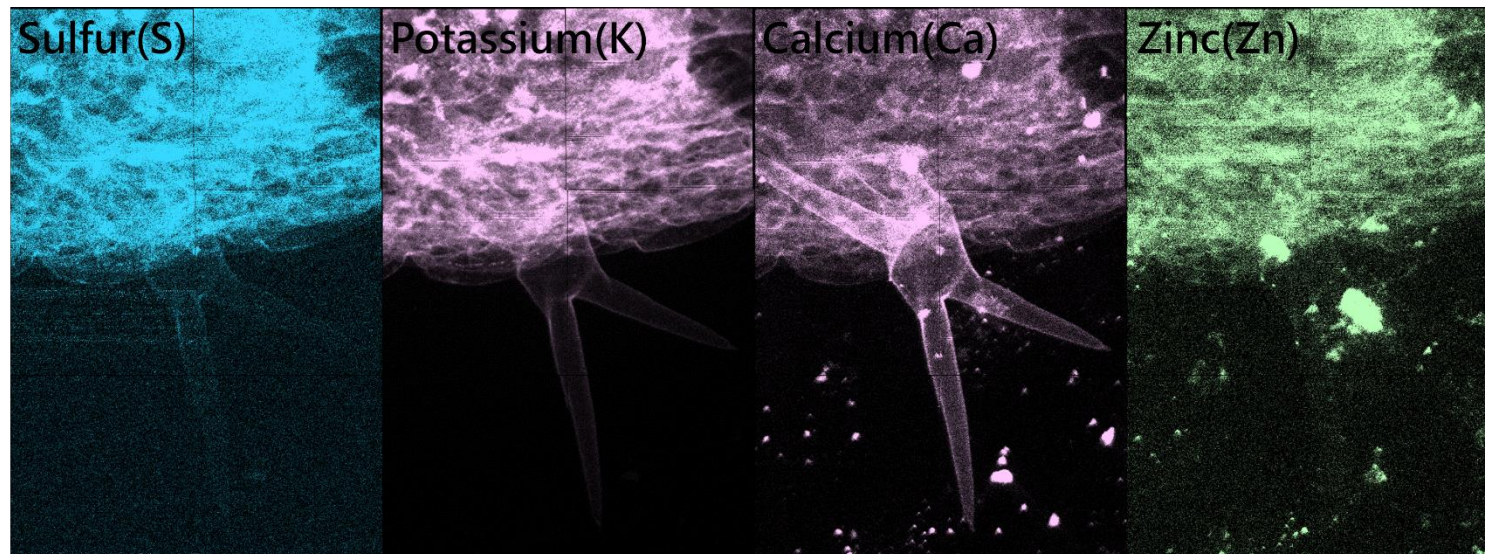
O-polar ZnO wafer



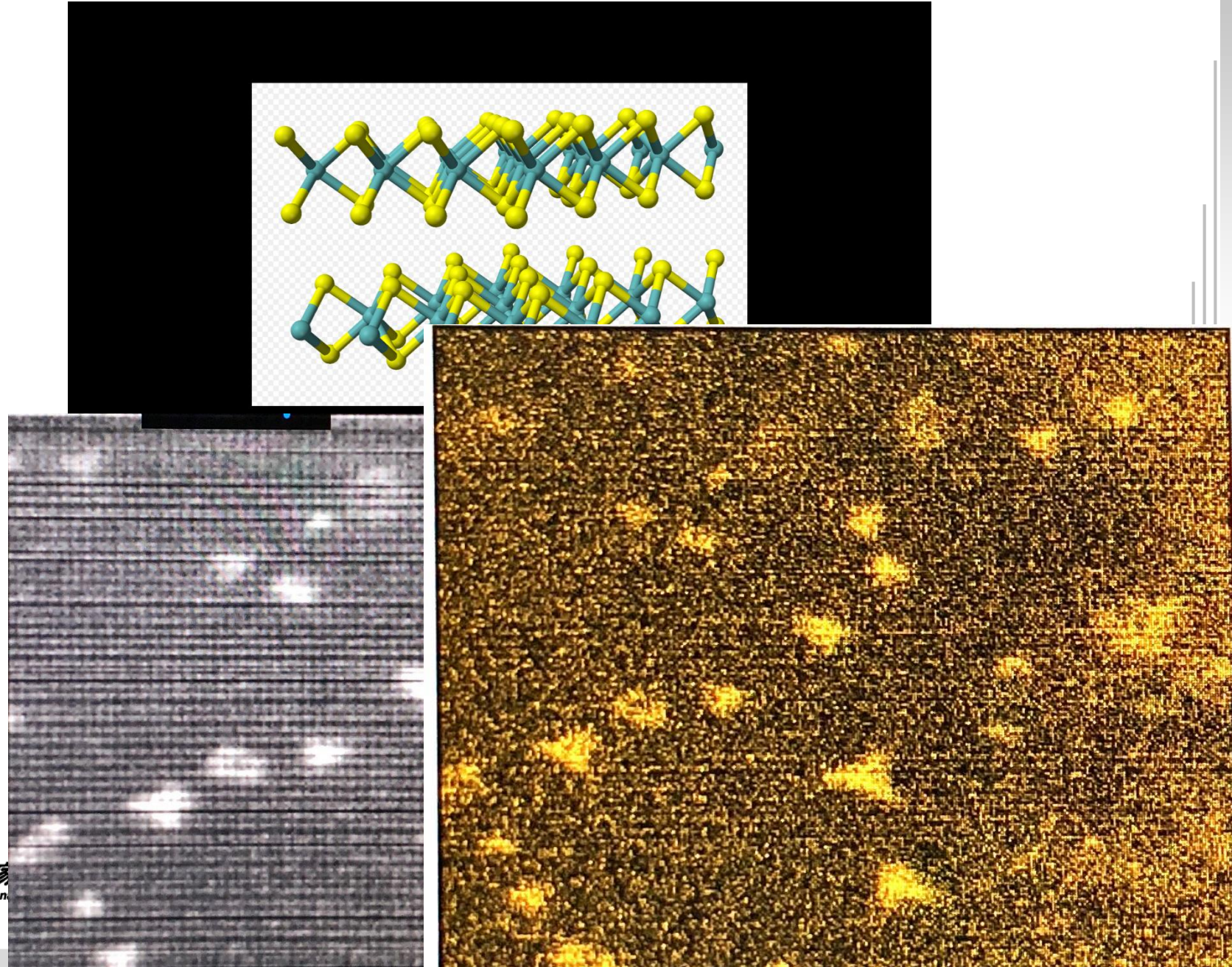
ZnO single microwire



nano-XRF testing

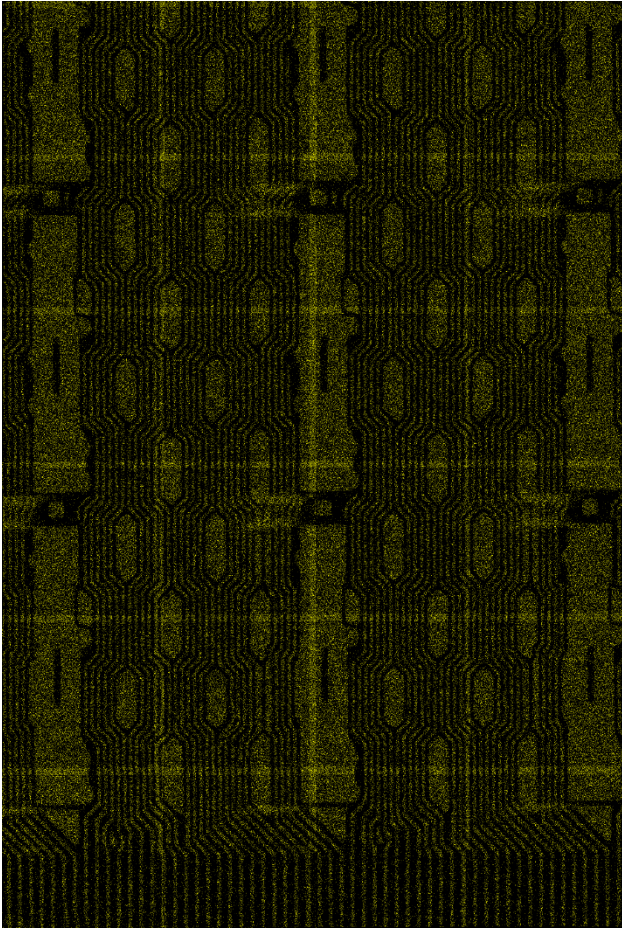


nano-XRF testing

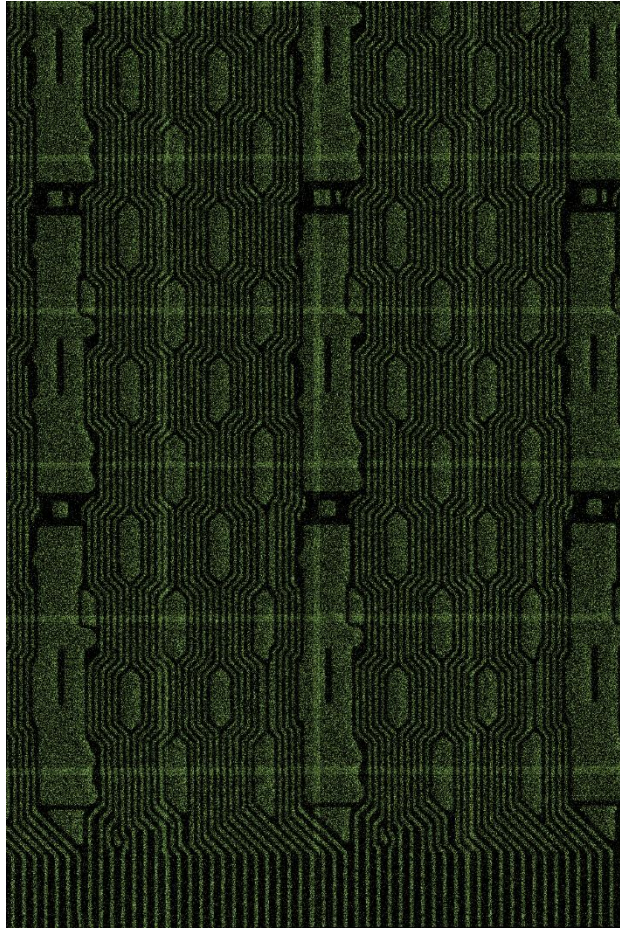


nano-XRF testing

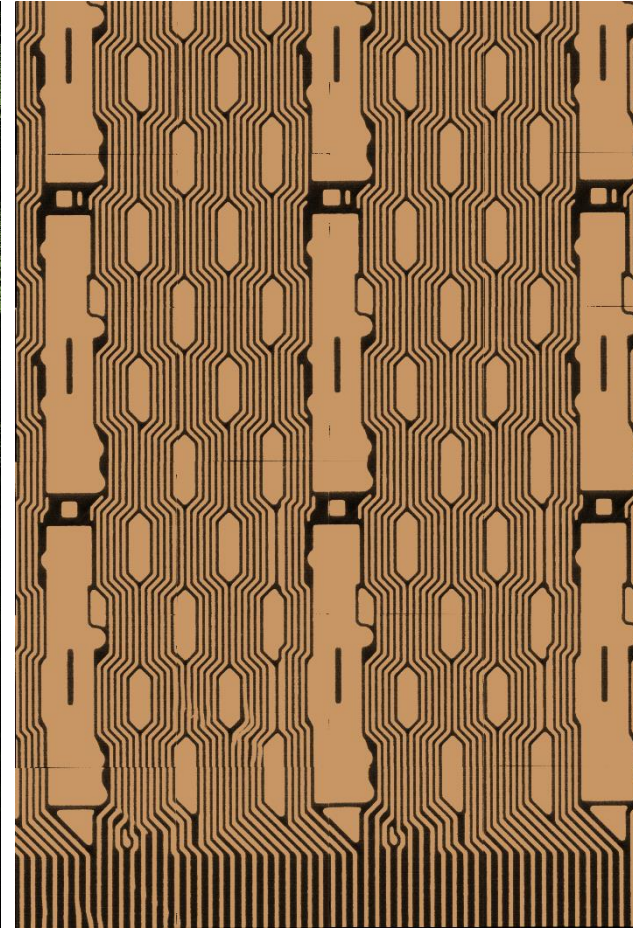
1780eV_Silicon(Si)



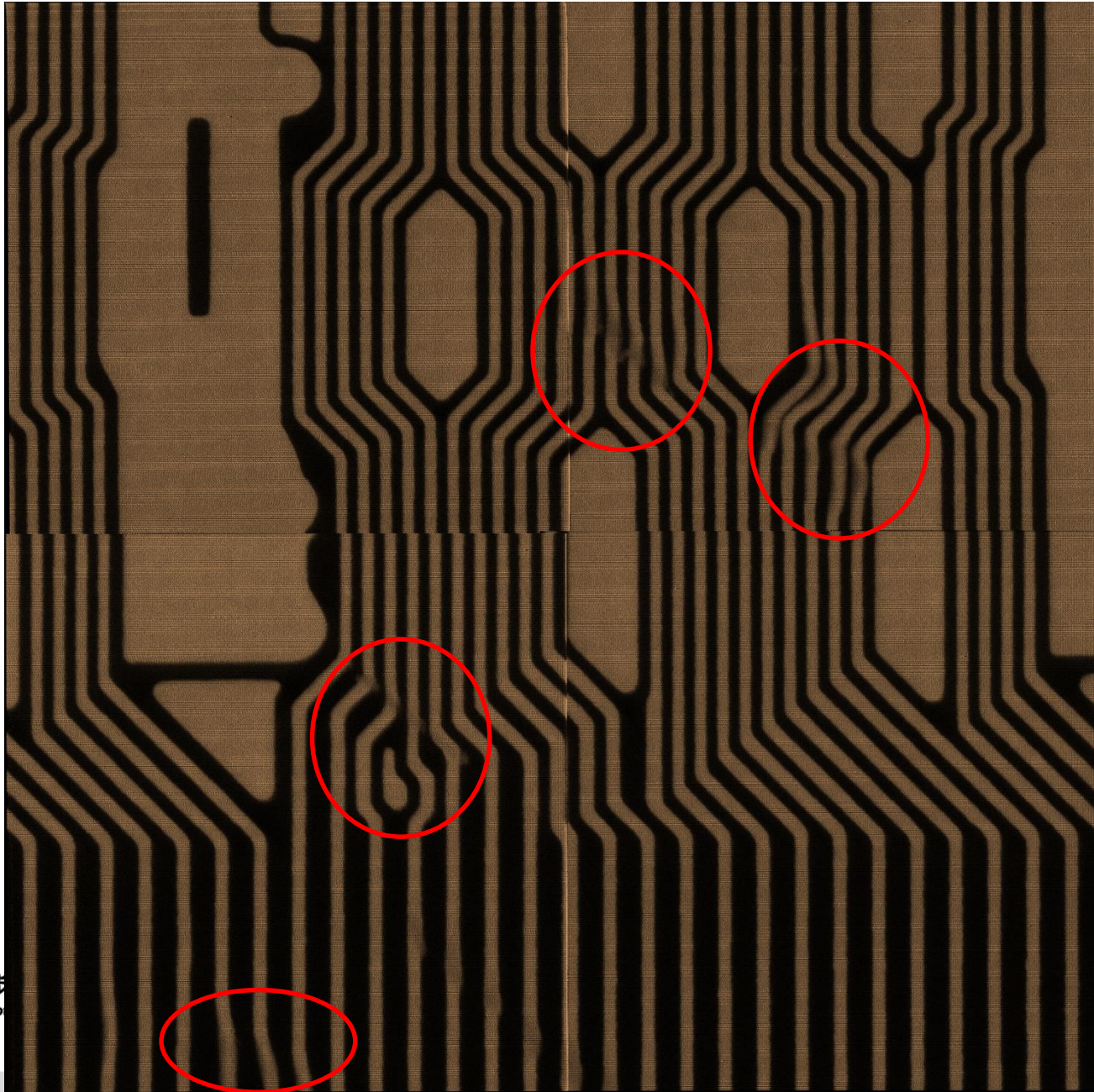
4510eV_Titanium (Ti)



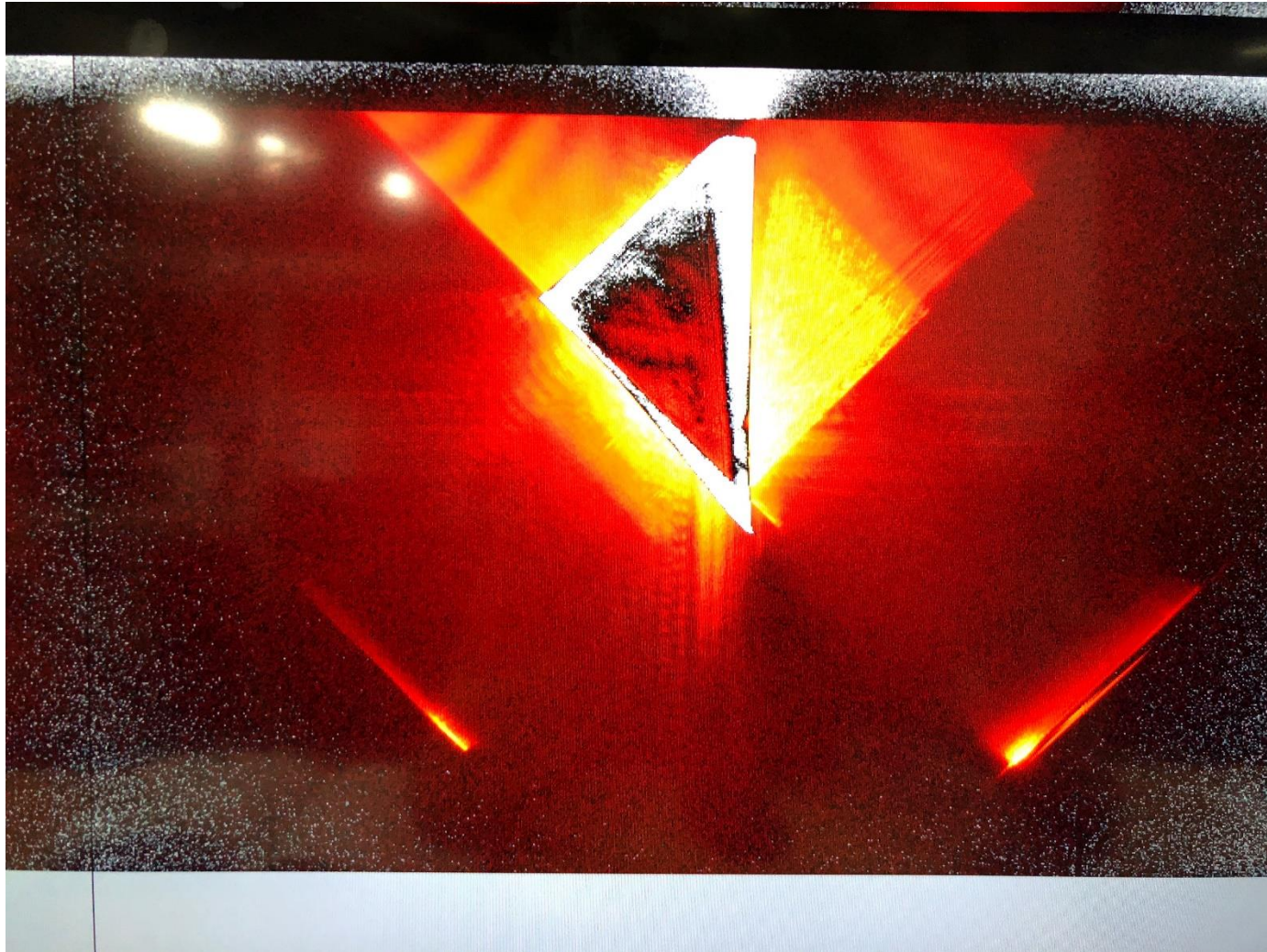
8040eV_Copper (Cu)



Defect (Cu)



Ptychography Testing For strain measurement



Time-Resolved X-ray Excited Optical Luminescence (TR-XEOL)

Photoexcitation dynamics in solution-processed formamidinium lead iodide perovskite thin films for solar cell applications

Hong-Hua Fang¹, Feng Wang², Sampson Adjokatse¹, Ni Zhao², Jacky Even³ and Maria Antonietta Loi¹

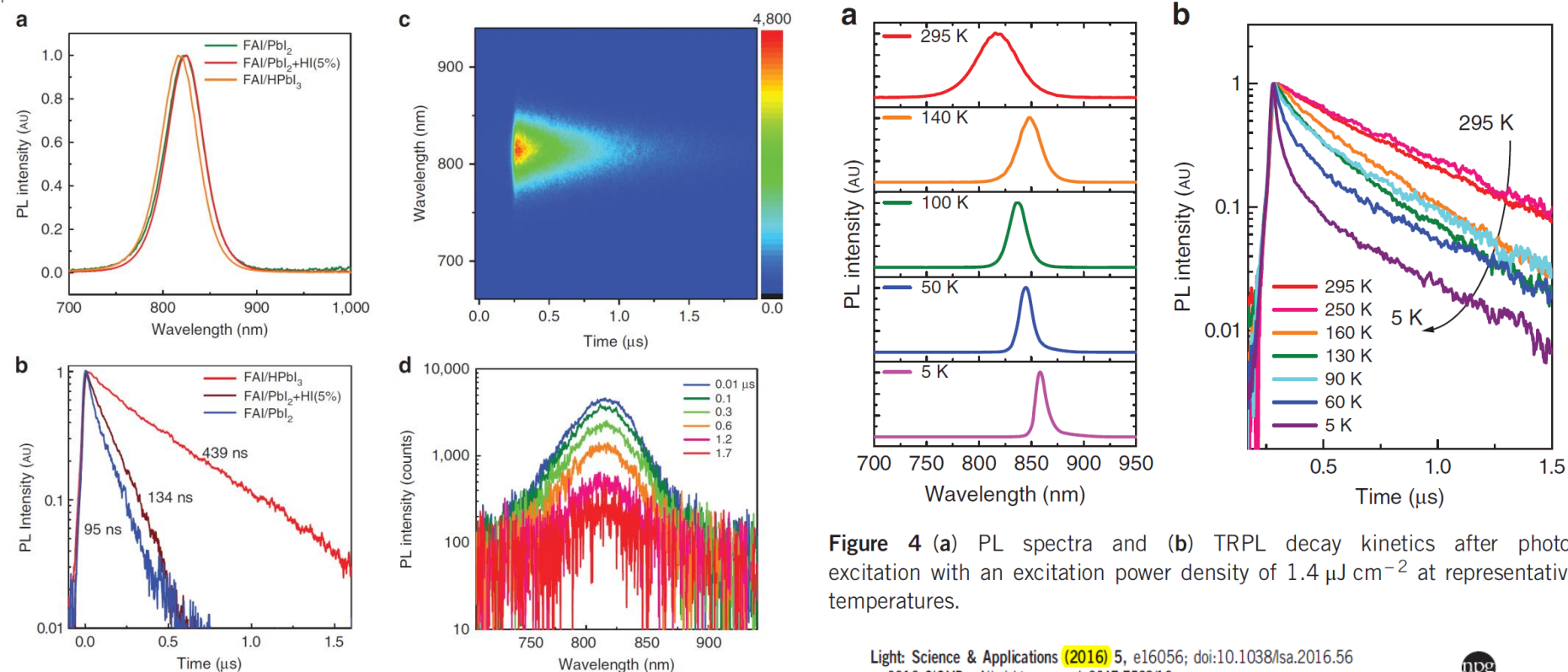
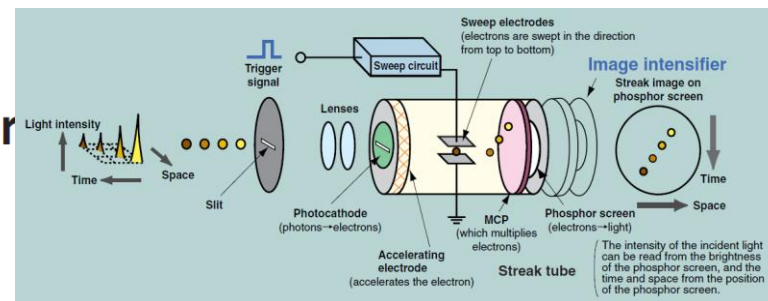
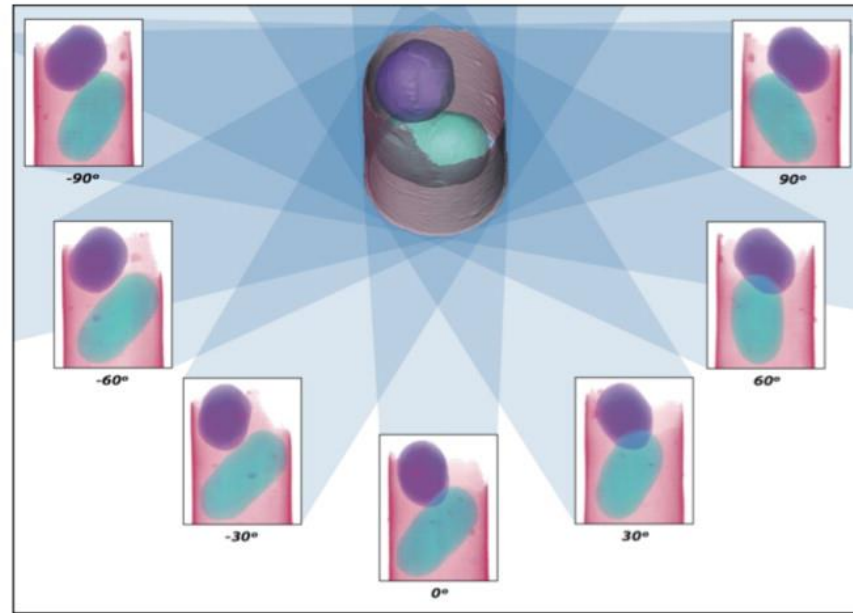
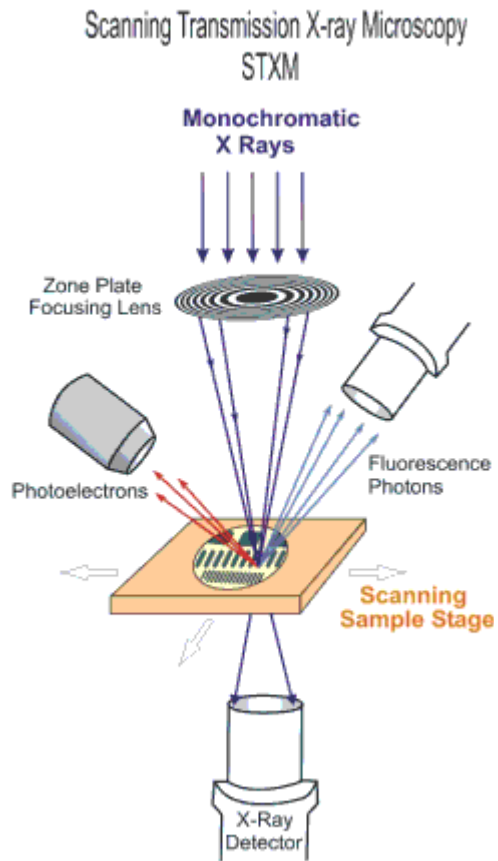


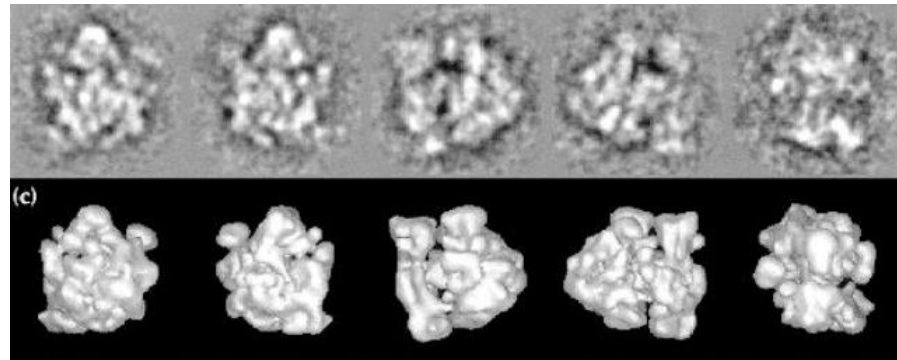
Figure 4 (a) PL spectra and (b) TRPL decay kinetics after photoexcitation with an excitation power density of $1.4 \mu\text{J cm}^{-2}$ at representative temperatures.

nano-PXM (projection x-ray microscopy)

– Absorption and phase contrast x-ray images



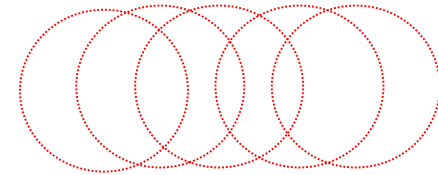
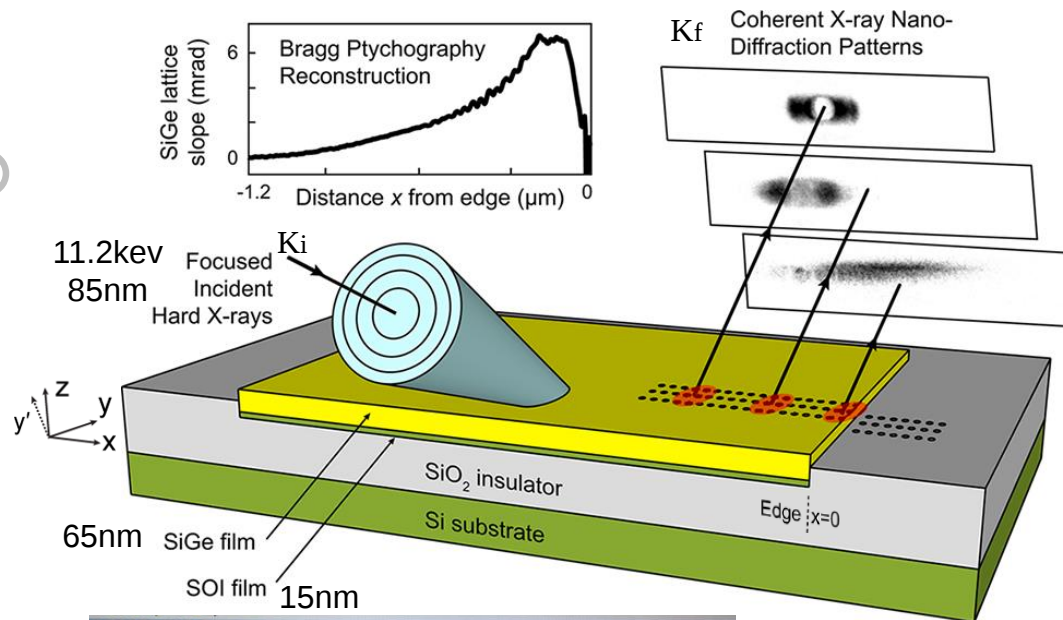
TRENDS in Cell Biology



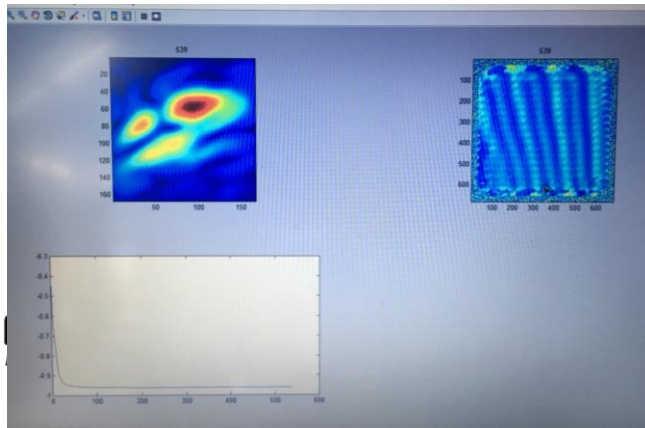
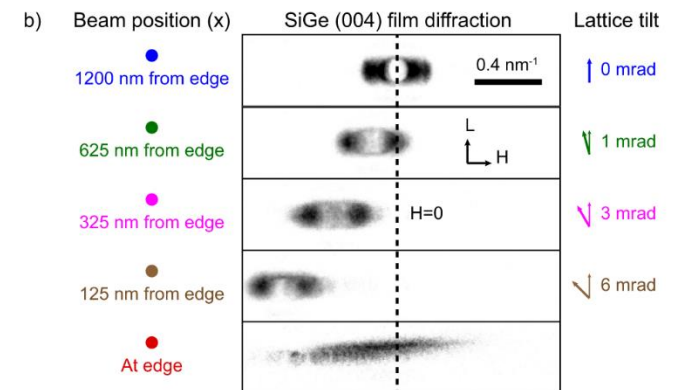
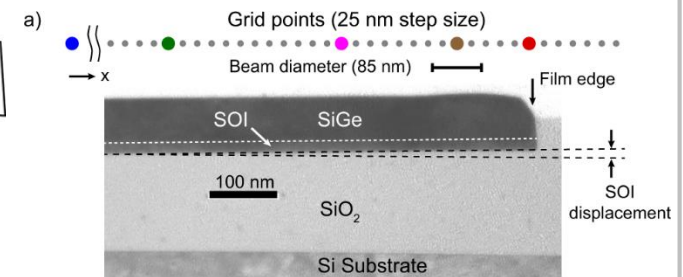
國家同步輻射研究中心
National Synchrotron Radiation Research Center

Adv. Mater. 2014,
DOI: 10.1002/adma.201304345

X-ray Bragg projection ptychography from thin film heterostructures



70% spatial overlap

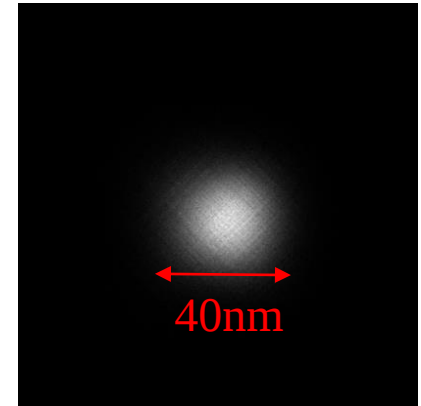


M. V. Holt *et al*, Phys. Rev. Lett. 112, 165502 (2014)

Summary

X-ray methods at 23A of TPS

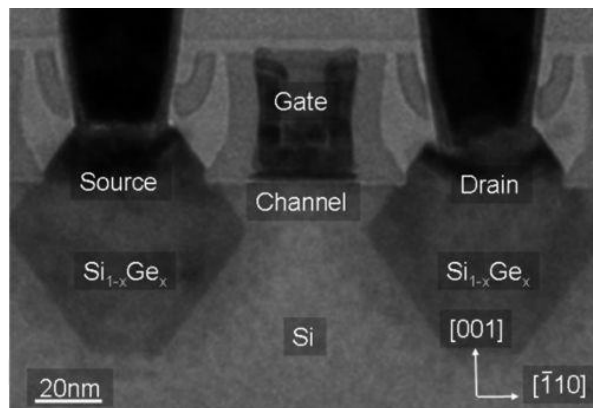
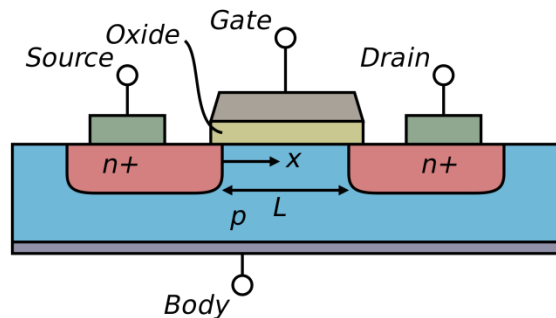
- nano-XRF (x-ray fluorescence)
 - Element-specific nanoimaging
- nano-XRD (x-ray diffraction)
 - Nano-Crystalline
- nano-XAFS (x-ray absorption fine structures)
 - Local electronic structure
 - Local chemical environments
 - Element-specific, averaged over nano-size area
- nano-XEOL (x-ray excited optical luminescence)
 - X-ray-to-visible down-conversion efficiency in nano phosphor
- nano-PXM (projection x-ray microscopy)
 - Absorption and phase contrast x-ray images
- nano-CXDI (coherent x-ray diffraction imaging)
- Bragg-ptychography
 - strain dynamics in nano-devices



Applications

Solid state physics

- Strongly correlated electron systems
YbAl₃, YbInCu₄, YbCu₂Si₂
La_{1-x}Sr_xMnO₃ (LSMO)
- Spintronics
LaVO₃, LaAlO₃, Fe_{3-x}M_xO₄ (M=Mn, Zn)
- Compound semiconductors
InGaZnO, GaCrN, InN, ZnMgO



M. Chu, et al., Annu. Rev. Mater. Res.
39 (2009) 203-229

High-k gate stacks

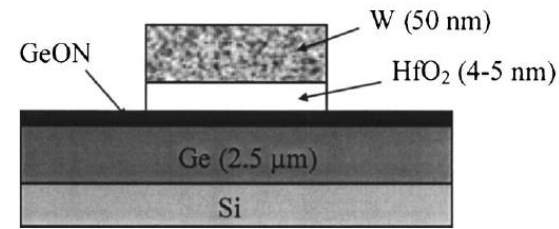
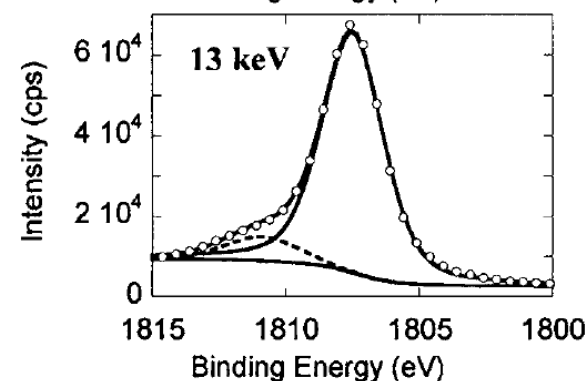
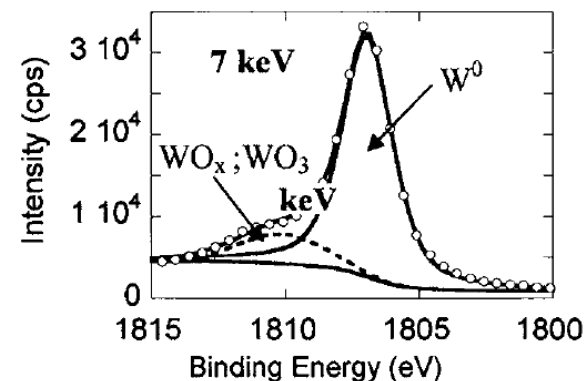


FIG. 1. Diagram of the W/HfO₂/GeON/Ge stack.





帳號 密碼 [忘記密碼](#) [註冊](#) [安全教育訓練](#) [實驗流程圖](#)

最新消息

- ☐ (NSRRC用戶函) 請於2/6 (五) 前建議2015年用戶年會研討會議題及邀請講員 (2015-01-06)
- ☐ 2015-2期NSRRC光東線使用申請至2015年1月31日 (六) 24時截止, 請如期繳交。 (2014-12-12)
- ☐ NSRRC公告 --- 明日10/16(四)本中心餐廳開賣囉! (2014-10-15)
- ☐ 2015年第一期 NSRRC 中子實驗計畫(包含SIKA), 申請至2015年1月5日 24:00截止。 (2014-12-08)
- ☐ To Users of SPring-8: Change in locations of check-in procedures and safety training sessions (2014-08-18)
- ☐ Announcement of Soft X-ray Chemistry Beamline, BL05B1, at NSRRC (2014-04-24)

實驗

- 查詢
- 光源
- 光束線
- 實安繳交
- 計畫排程
- 論文
- 研究生畢論清單
- 專利

委員會

- [用戶執行委員會]
- * 設置要點
- * 2015年用戶函
- 計畫評審委員會
- 研究群

連絡人

- 用戶設施
- * 科學研究組
- * 實驗設備組

位置圖表

- 中心配置
- 行政/研光圖
- [儲存環]
- 科學園區
- 新竹市
- 園區巡迴公車
- 清大-中心-國衛院區間車

服務資訊

- 新用戶申請
- 用戶卡申請
- 計畫申請
- 行政規章
- 歷屆用戶年會資訊
- 用戶行政與推廣辦公室
- 委託研究
- 光源產業應用小組
- 安全訓練

網路資源

[中子計畫](#)

[研究成果繳交](#)

[實安表填寫](#)

[國內補助](#)

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[NSRRC
演講公告](#)

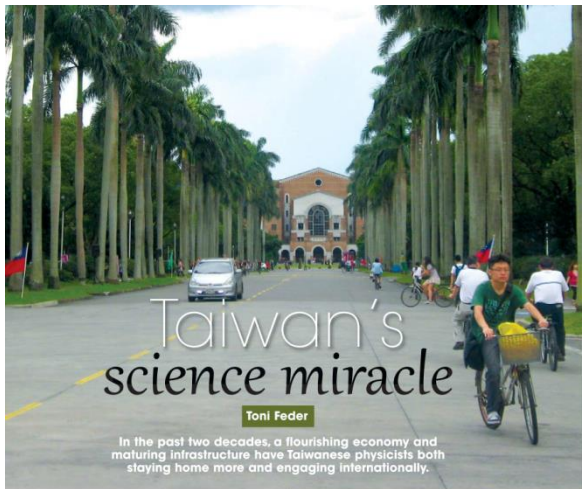
[申請參觀
NSRRC](#)

房價

每間單人住宿價為NT\$700/天, 雙人住宿價為NT\$1,000/天; 四人房價為NT\$1,500/天。

房型	實景	間數	房間坪數	收費	備註
二張單人床		30	6	1,000元/晚	單人住宿一律 NT \$700 元
四張單人床		1	12	1,500元/晚	
交誼廳		4	10		一至四樓
餐廳		2	7		三至四樓





March 2014 Physics Today

NEWS OF PHYSICS

A \$100 million medical research center is set to open in the near future. The center will be the largest medical research center in the world, and it will be the first of its kind in the United States. The center will be located in the heart of the city, and it will be the first of its kind in the United States. The center will be the largest medical research center in the world, and it will be the first of its kind in the United States. The center will be located in the heart of the city, and it will be the first of its kind in the United States.

Bill to revamp medical treatment

WASHINGTON, D.C. — A bill of Representative Paul Ryan (R-Ind.) would reshape the regulation of medical devices that have attracted much attention since the passage of the Affordable Care Act.

Asia's newest synchrotron sees first light

TAIPEI — Scientists at the new Taiwan Photon Source (TPS) have seen the first light from the world's newest synchrotron radiation facility. The facility, which is the first of its kind in the world, will be the first of its kind in the world. The facility, which is the first of its kind in the world, will be the first of its kind in the world.

columns & views

Taiwan unveils new synchrotron

Competitive activities around the globe to develop the world's brightest synchrotron light source have accelerated in recent years. Taiwanese scientists now aspire to be at the top of the list with the recently constructed Taiwan Photon Source.

NEWSMAKERS

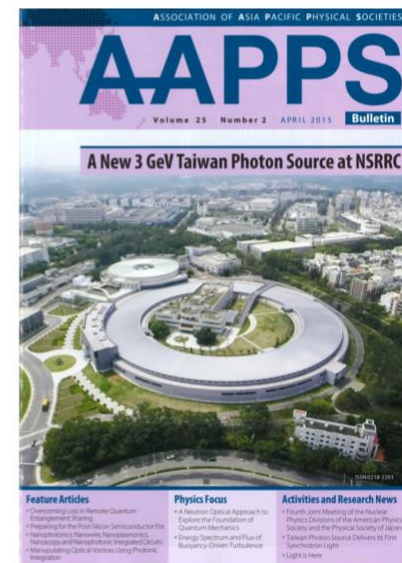
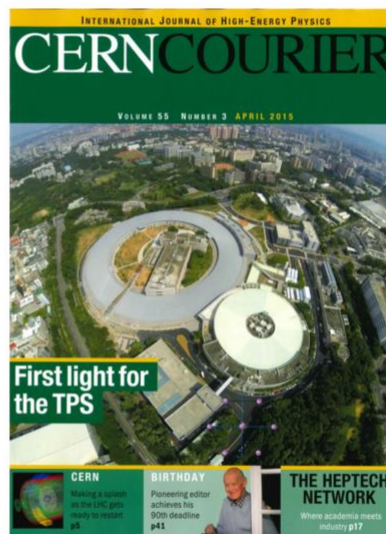
Corruption case snags scientist

A research career snarled by a corruption case in a high-profile university in New York City. Robert H. Rind, a senior professor at the Columbia University Mailman School of Public Health, has been accused of a corruption case. The case involves a research project that was funded by the National Institutes of Health. The case involves a research project that was funded by the National Institutes of Health.

Columns & Views

First light for the TPS

The Taiwan Photon Source (TPS) has seen the first light from the world's newest synchrotron radiation facility. The facility, which is the first of its kind in the world, will be the first of its kind in the world. The facility, which is the first of its kind in the world, will be the first of its kind in the world.



「科學」期刊(104年1月30日)

「自然光子學」期刊(104年5月專文)

「CERN科學通訊」期刊(104年4月號封面)

「亞太物理學會聯合會刊」期刊(104年4月號封面)

X-ray Nanoprobe Construction Team

Project Leader: Prof. J. Raynien Kwo (NTHU)

Construction Team

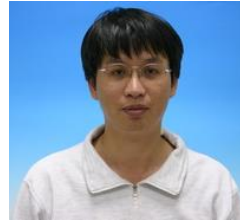
Leader

Mau-Tsu Tang



Beamline-

Shih-Hung Chang and Beamline Group



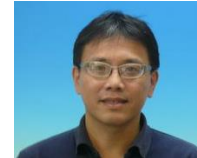
Endstation-

Gung-Chian Yin, optical design and overall system integration.

Bo-Yi Chen, Mechanical engineer.



Chien-Yu Lee, Electronic engineer.



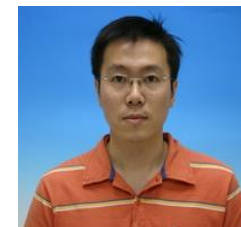
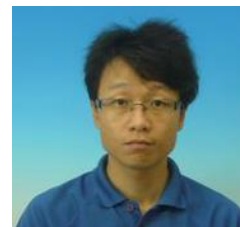
Huang-Yeh Chen, Mechanical design and experiment assistant.

Jian-Xing Wu, Software programmer, GUI and control panel design.

Beamline Scientist and Manager-

Shao-Chin Tseng, Sample preparation, experiment design

Bi-Hsuan Lin, Experiment design, XEOL, XRD.



國家同步輻射研究中心
National Synchrotron Radiation Research Center



Thanks for your attentions