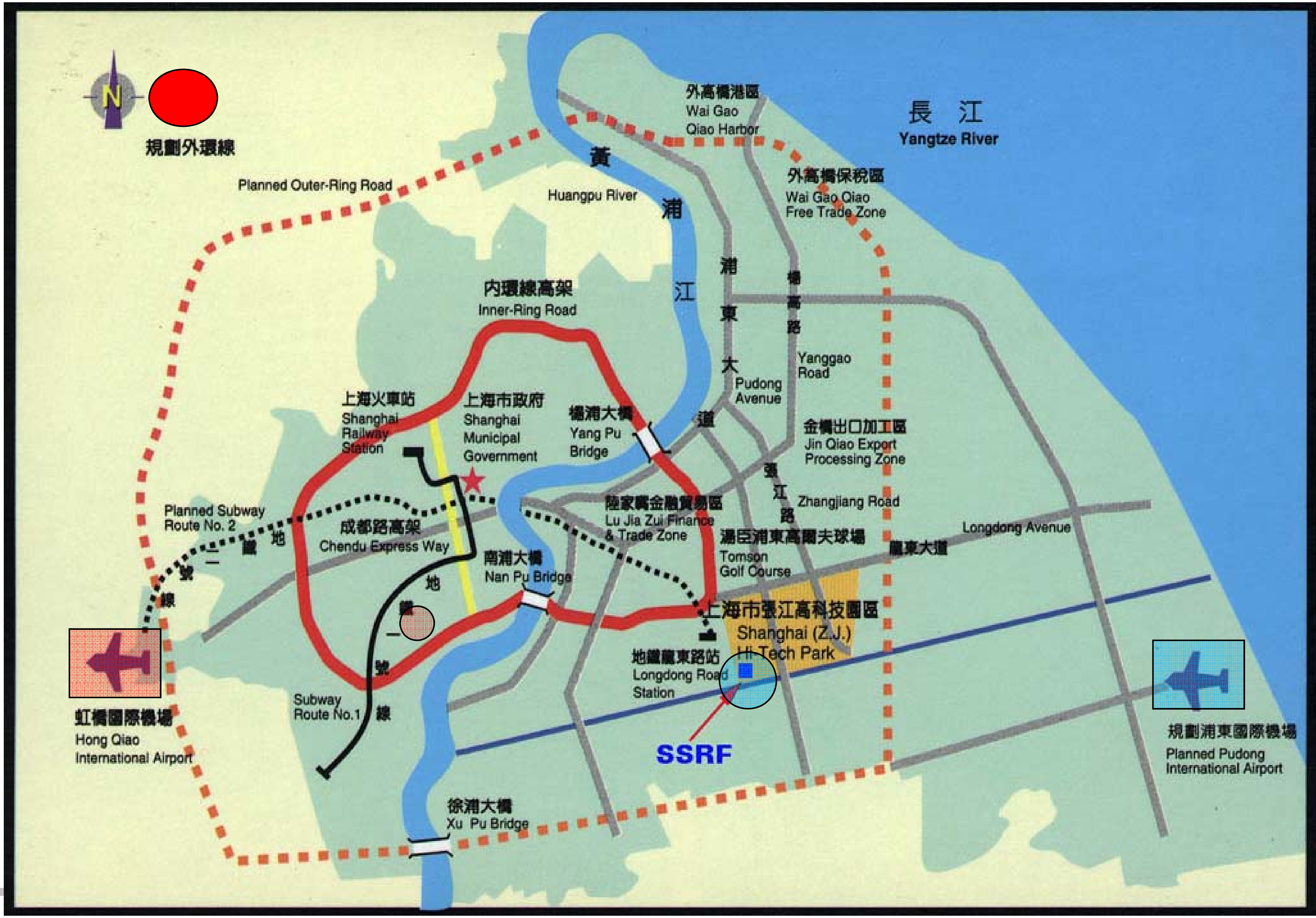
Shanghai Synchrotron Radiation Facility (SSRF) and SLEGS-prototype



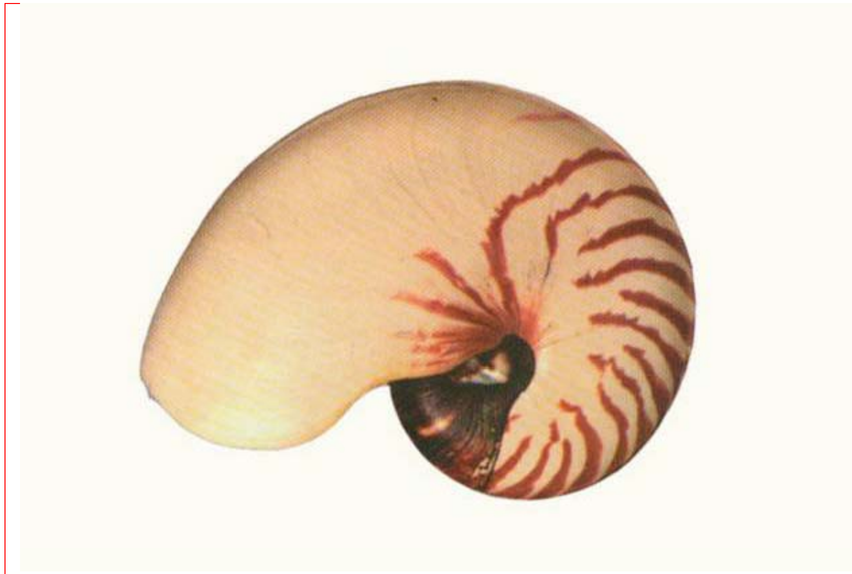
規劃外環線
Planned Outer-Ring Road
外高橋港區
Wai Gao Qiao Harbor
長 江
Yangtze River
黃浦江
Huangpu River
外高橋保稅區
Wai Gao Qiao Free Trade Zone
浦東大道
楊高路
內環線高架
Inner-Ring Road
Yanggao Road
Pudong Avenue
上海火車站
Shanghai Railway Station
上海市政府
Shanghai Municipal Government
楊浦大橋
Yang Pu Bridge
金橋出口加工區
Jin Qiao Export Processing Zone
張江路
Zhangjiang Road
Planned Subway Route No. 2
二號地鐵線
成都路高架
Chendu Express Way
陸家嘴金融貿易區
Lu Jia Zui Finance & Trade Zone
湯臣浦東高爾夫球場
Tomson Golf Course
龍東大道
Longdong Avenue
南浦大橋
Nan Pu Bridge
上海市張江高科技園區
Shanghai (Z.J.) Hi-Tech Park
地鐵龍東路站
Longdong Road Station
虹橋國際機場
Hong Qiao International Airport
Subway Route No.1
一號地鐵線
SSRF
規劃浦東國際機場
Planned Pudong International Airport
徐浦大橋
Xu Pu Bridge

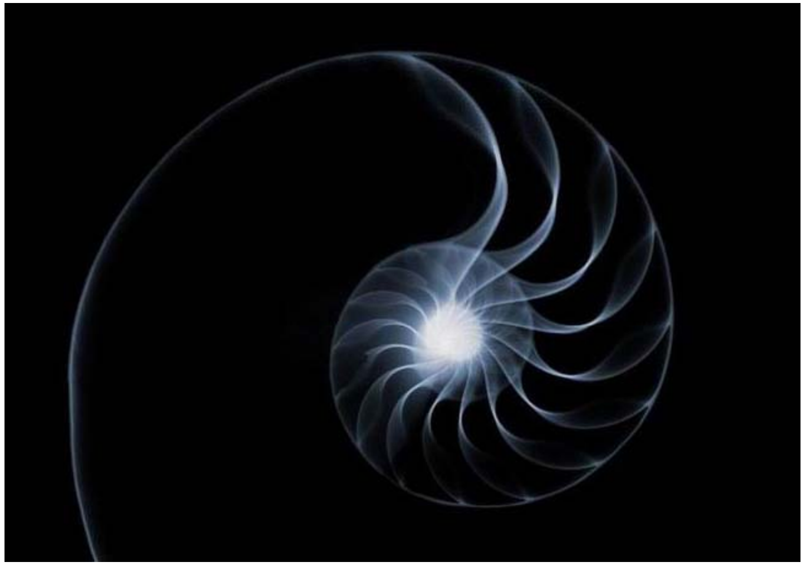
Overview

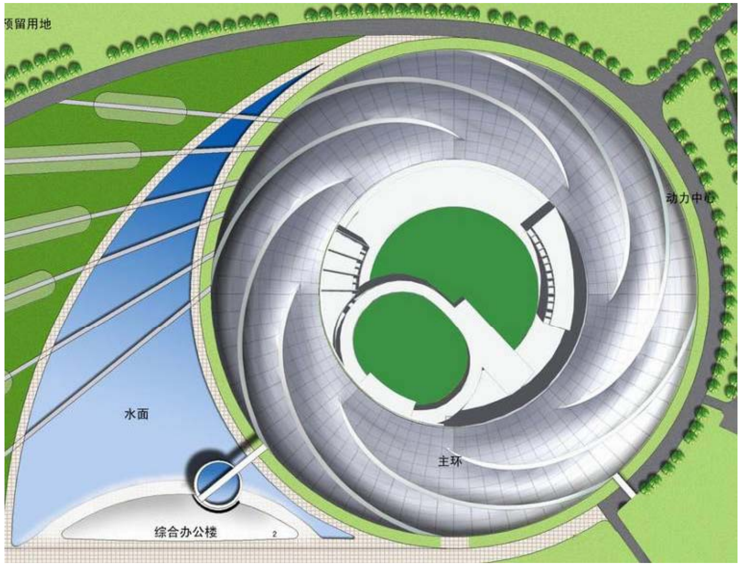
SSRF is a 3rd generation synchrotron radiation light source and aimed mainly at following research fields in present time：

- **Biological Sciences**
- **Physical and Materials Sciences**
- **Earth and Environmental Sciences**
- **BioMedical, Chemical and Industrial Applications**

Design of SSRF building—Nautilus shell





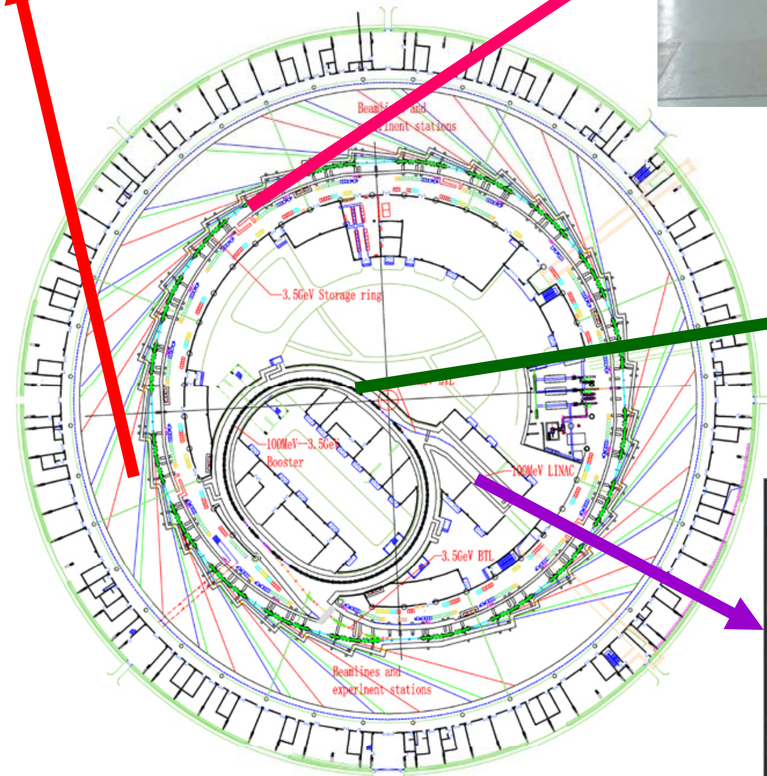


Designed plots of the SSRF Buildings

Birdview of SSRF

SSRF Layout

Beamlines



3.5GeV Storage Ring

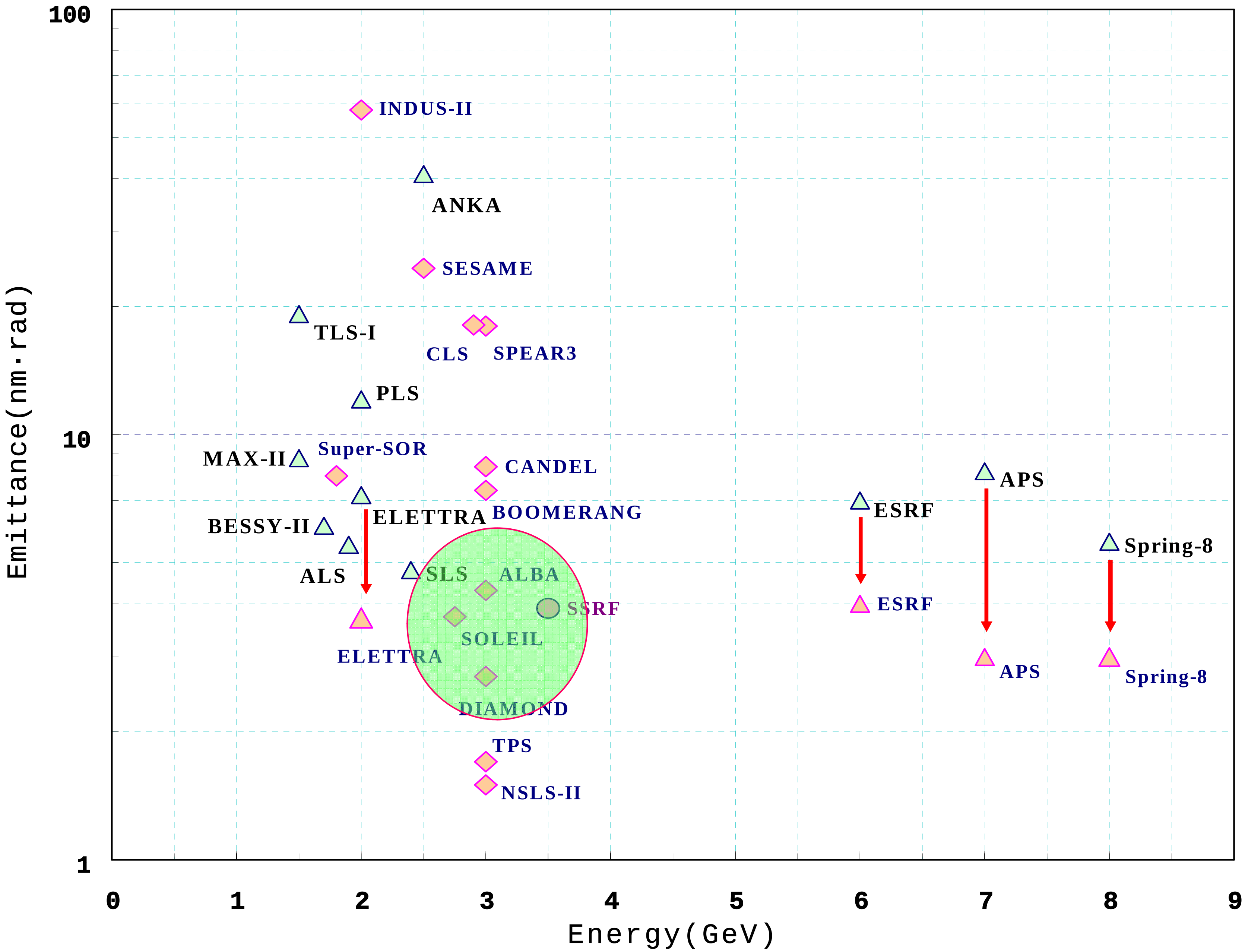
C=432m

3.5GeV Booster
C=180m

150MeV Linac

Main parameters of Storage Ring

Energy	3.5GeV
Circumference	432m
Lattice	Double Bend Achromat （Combined）
Number of Cells	20
Straight Sections	4×12m， 16×6.5m，
Current	200~300mA
Emittance	3.9 nm-rad
Life time	> 15hrs (top-up injection later)
Beam position stability	<10% beam size


100
10
1
Emittance(nm·rad)
0
1
2
3
4
5
6
7
8
9
Energy(GeV)
INDUS-II
ANKA
SESAME
TLS-I
CLS
SPEAR3
PLS
MAX-II
Super-SOR
CANDEL
ELETTRA
BOOMERANG
BESSY-II
ALS
SLS
ALBA
SSRF
SOLEIL
ELETTRA
DIAMOND
TPS
NSLS-II
ESRF
ESRF
APS
APS
Spring-8
Spring-8

Front-end region of beamline

Part of the 3.5GeV Booster

Storage Ring and IVU25B

SSRF Experimental Hall

SSRF Construction Schedule and Milestones

- Dce.25, 2004 Ground Breaking
- Dec. 2004 ~ May 2007: Building construction
- Jun. 2005 ~ Jun. 2008: Accelerator equipment and components manufacture and assembly
- Dec. 2005 ~Dec. 2008: Beamline construction and assembly
- May. 2007 ~ Jul. 2007: Linac commissioning
- Oct. 2007 ~ Dec. 2007: Booster commissioning
- Dec. 2007 ~ Dec. 2008: Storage ring commissioning
- Dec. 24, 2007, First SR Light Achieved
- May 2008 ~ Apr. 2009: Commissioning of beamlines
- May. 2009: The user operation began
- **Jan 19, 2010：National Closeout Review by the Central Government**

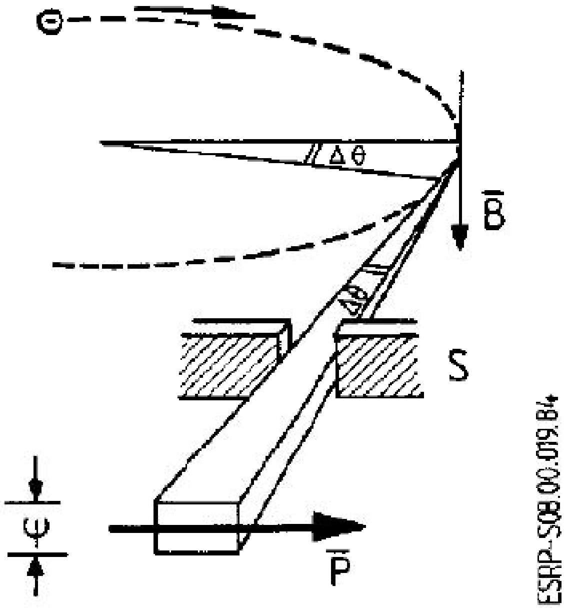
Design specifications of accelerators and beamlines have been achieved.

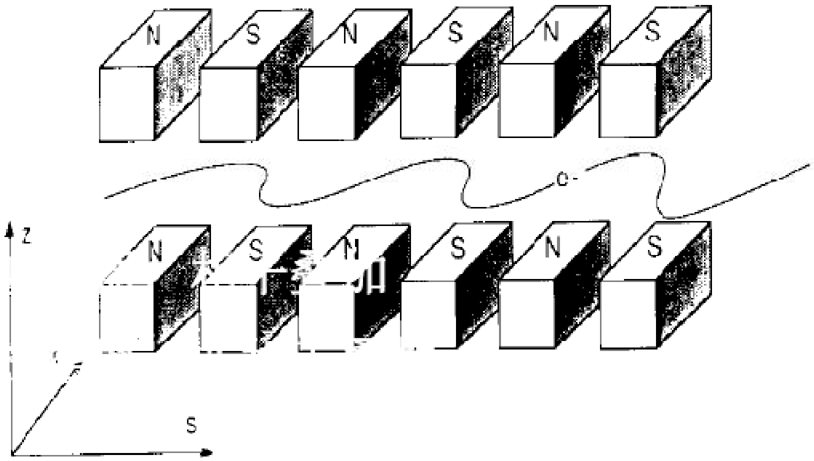
Jan 17, 2010: President Hu visited SINAP-SSRF

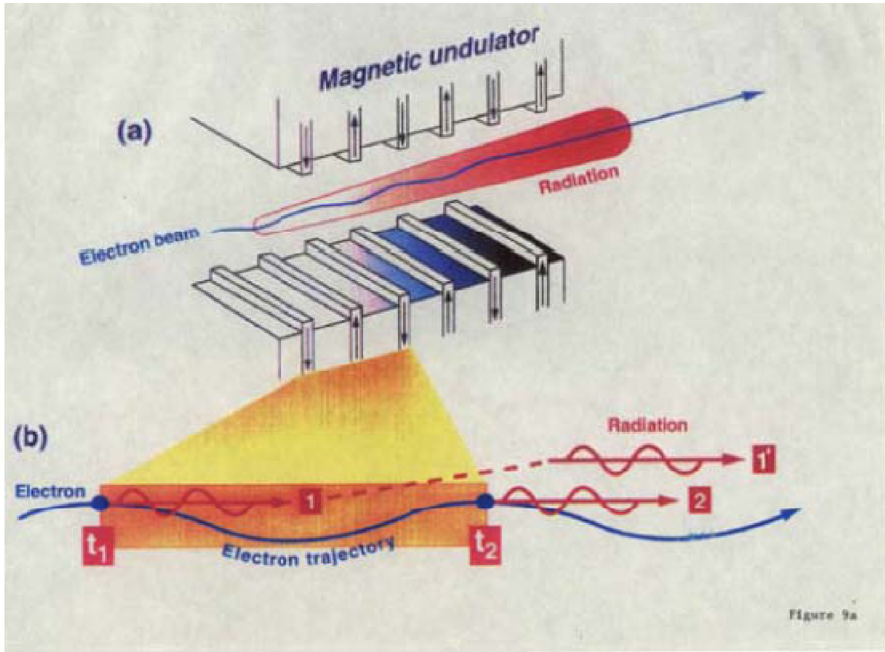
SSRF Phase I Beamlines

and User Operation

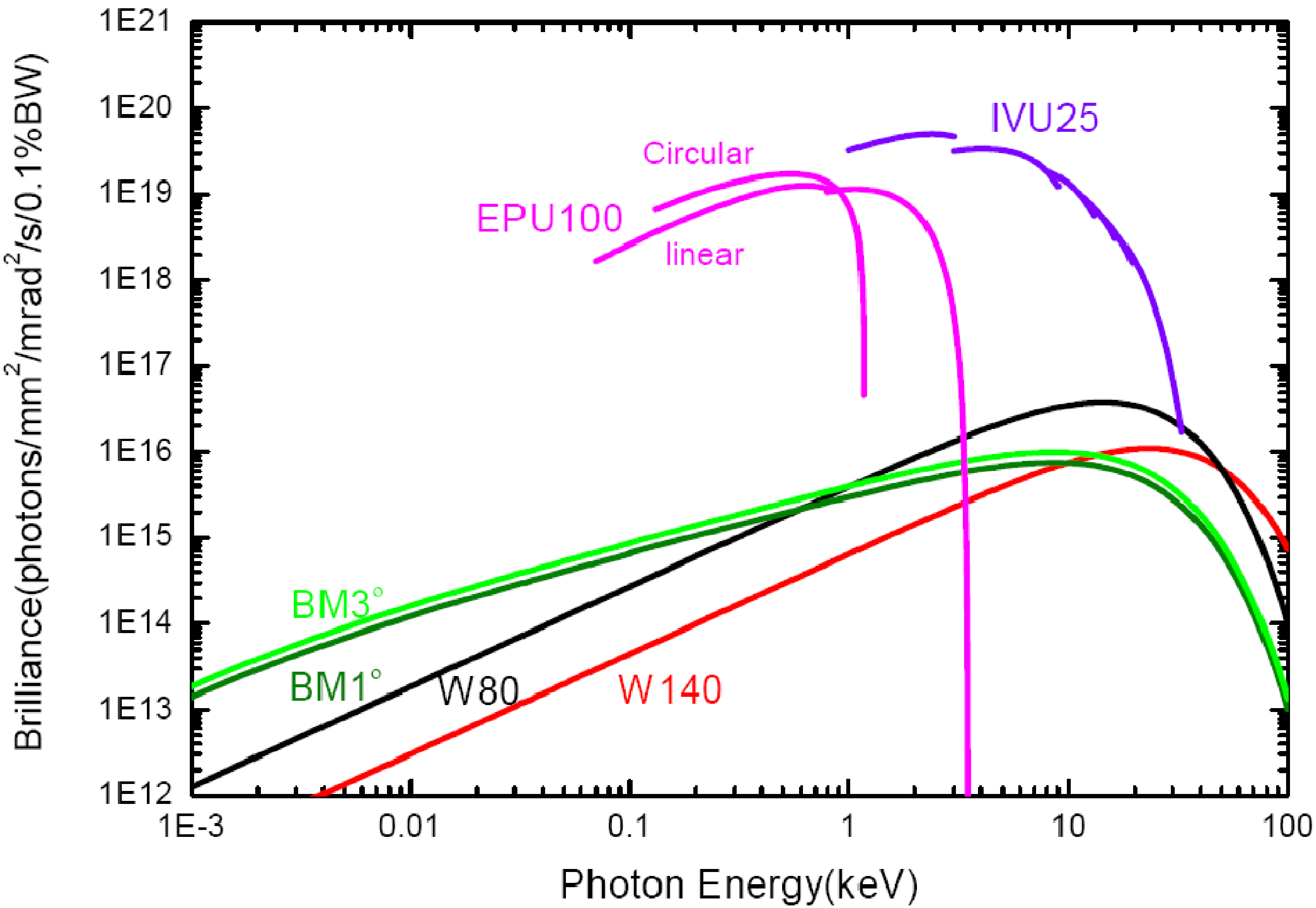
Three sources have been used for phase I beamlines:
Bending Magnet, Undulator and Wiggler





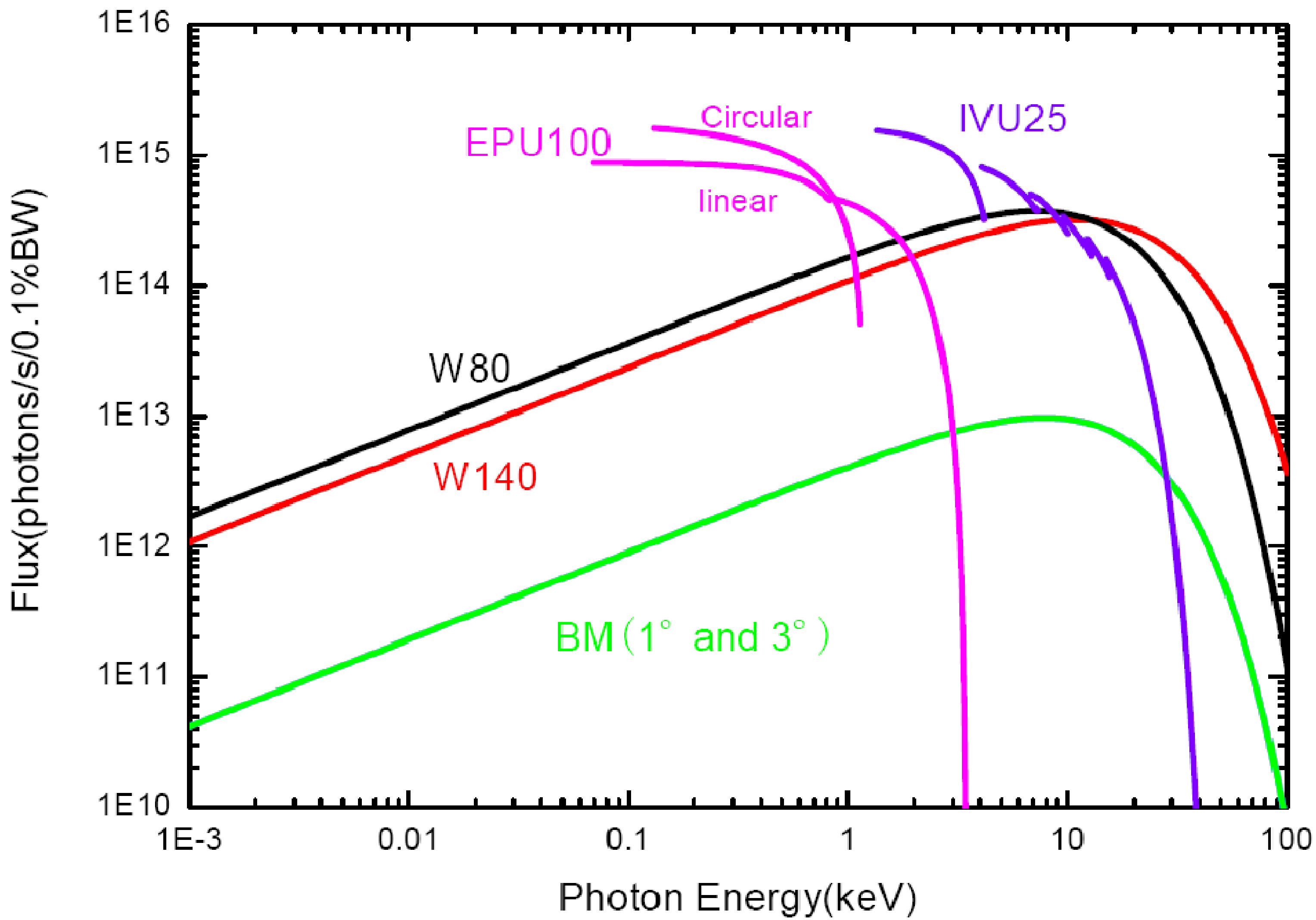


SSRF will provide very bright photon beams from 0.1-20keV



Typical spectral brilliance of SSRF @300mA

SSRF will provide high flux photon beams from 0.1-40keV



Typical spectral flux of SSRF @300mA

SSRF Phase I Beamlines

- **Macromolecular Crystallography Beamline (IVU)**
- **Diffraction Beamline (BM)**
- **XAFS Beamline (Wiggler)**
- **Hard X-ray Microfocusing Beamline (IVU)**
- **X-ray Imaging Beamline (Wiggler)**
- **Small Angle X-ray Scattering Beamline (BM)**
- **Soft X-ray Spectromicroscopy Beamline (EPU)**

IUV-In-Vacuum Undulator

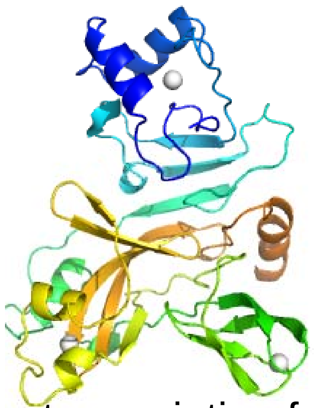
BM –Bending Magnet

EPU-Elliptically Polarized Undulator

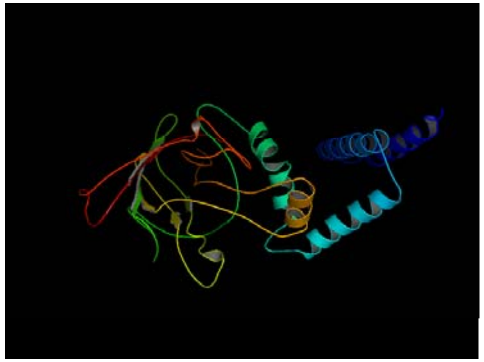
- **User operation started from May 6, 2009;**
- **Since then, about 1200 hours beamtime has been provided to users;**
- **~200 groups and 1000 users have come for experiments so far;**
- **~1600hrs user beamtime has been provided.**

New Structures: Data collected on SSRF BL17U1 (MX)

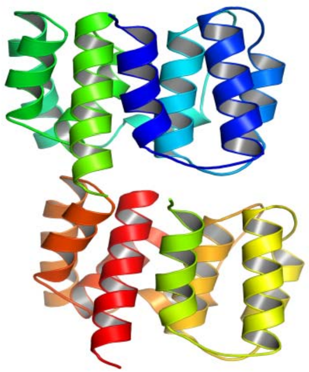
Arabidopsis thaliana deg5
2.0Å; (W.M. Gong)



One transcription factor of SARS virus; (Z.H. Rao)

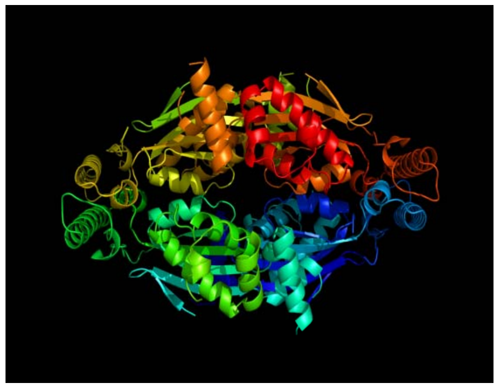


A bacteria oxidase
(Z.L.Cui)



M1 protein of Avian Influenza Virus 1.89Å (Y.G. Shi)

C-terminal domain of Sgf29
1.92Å（J.Y.Zang）

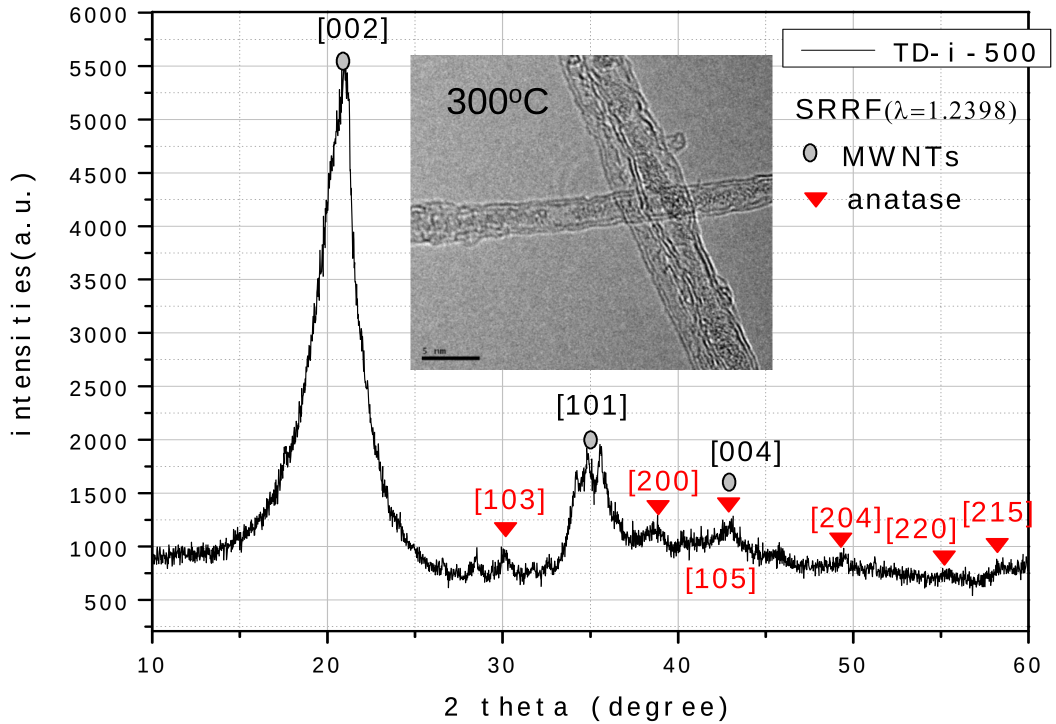


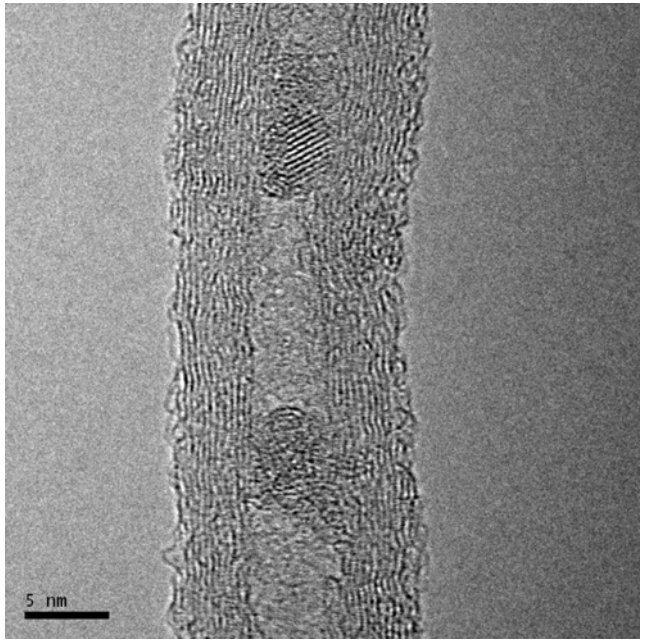
ePolB 2.6Å; J.H. Zhou

So far, more than 40 new structures have been solved.

XRD Beamline

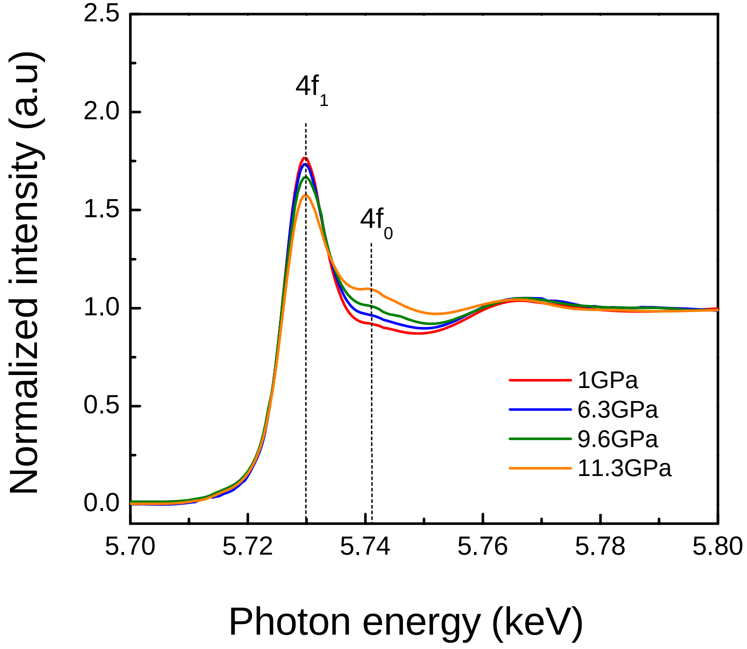
Diffraction of TiO_2 nano-particles embedded in Muti-wall Carbon Nanotube

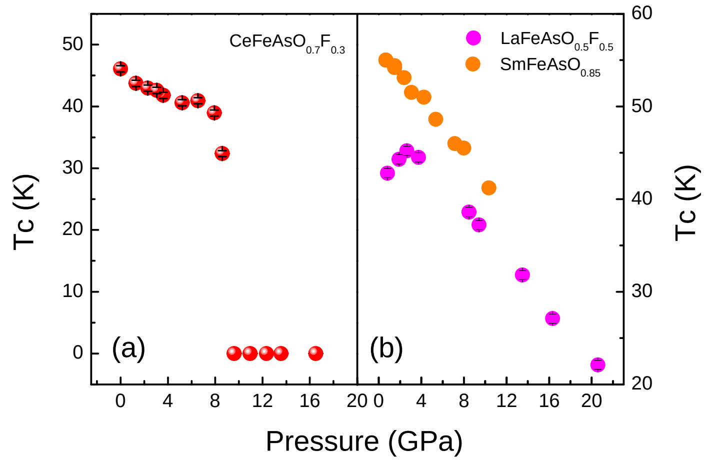




(X.L. Pan , DICP, CAS)

High pressure XAFS results: superconductor CeFeAsO1-xFx



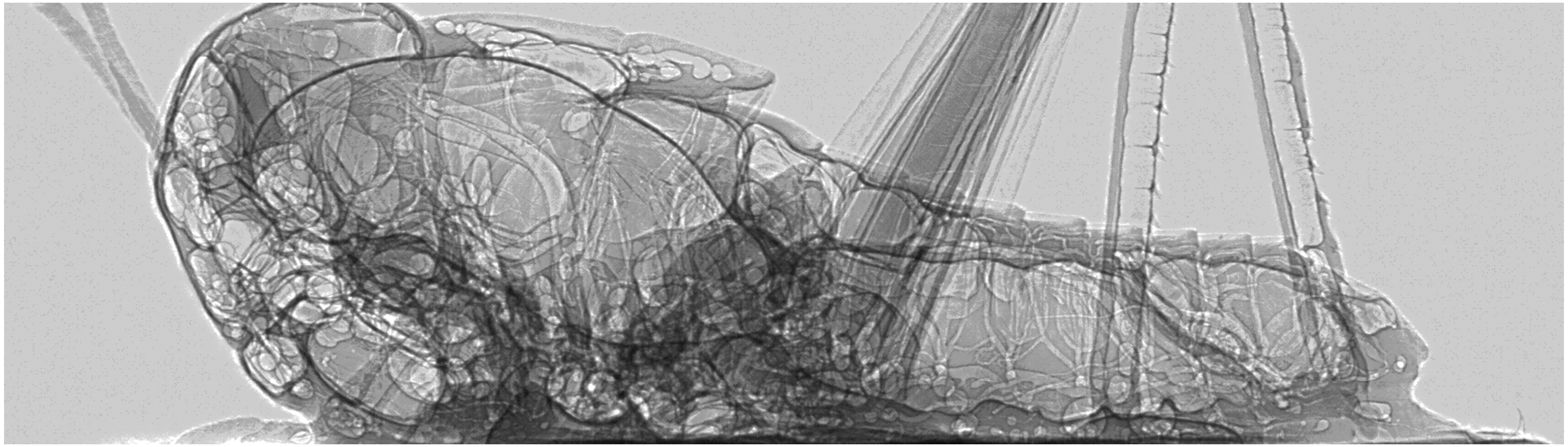


High-pressure XAFS experiments reveal that the variation of Ce valence is very little, the origin of superconducting-nonsuperconducting transition under applied pressure is mainly caused by Kondo screening of Ce 4f moment.

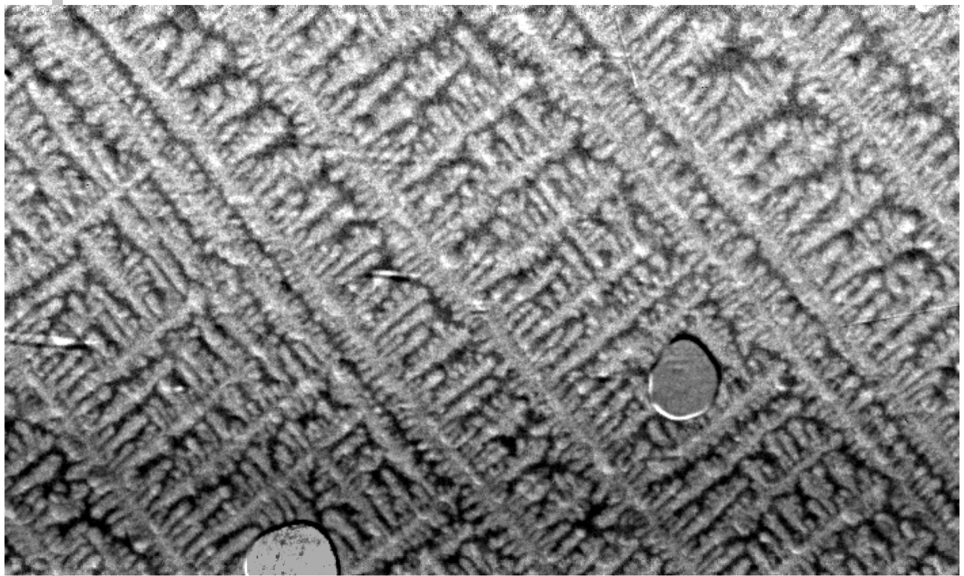
(Institute of Physics, Chinese Academy of Sciences LiLing Sun)

X-ray Imaging Beamline

中国科学院上海应用物理研究所
Shanghai Institute of Applied Physics, Chinese Academy of Sciences

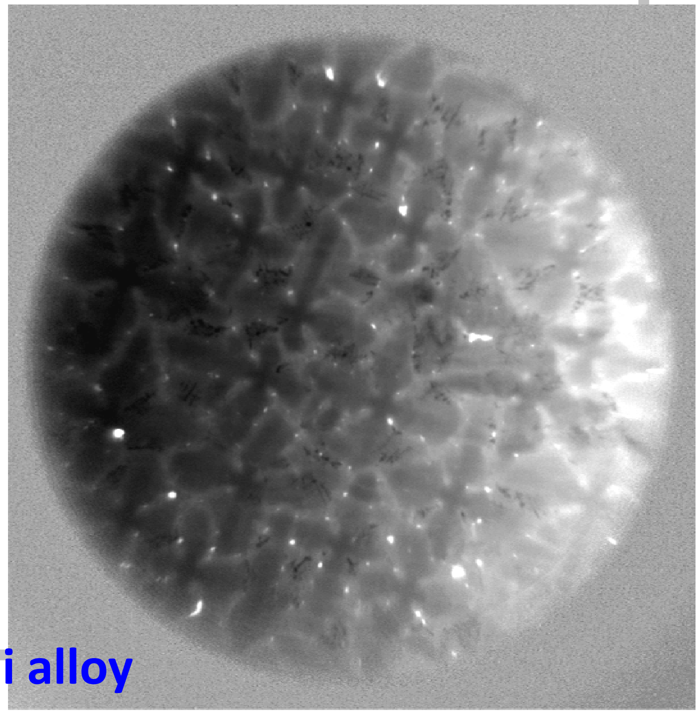


X-ray phase contrast imaging to a live grasshopper



Sn-Bi alloy with low melting point

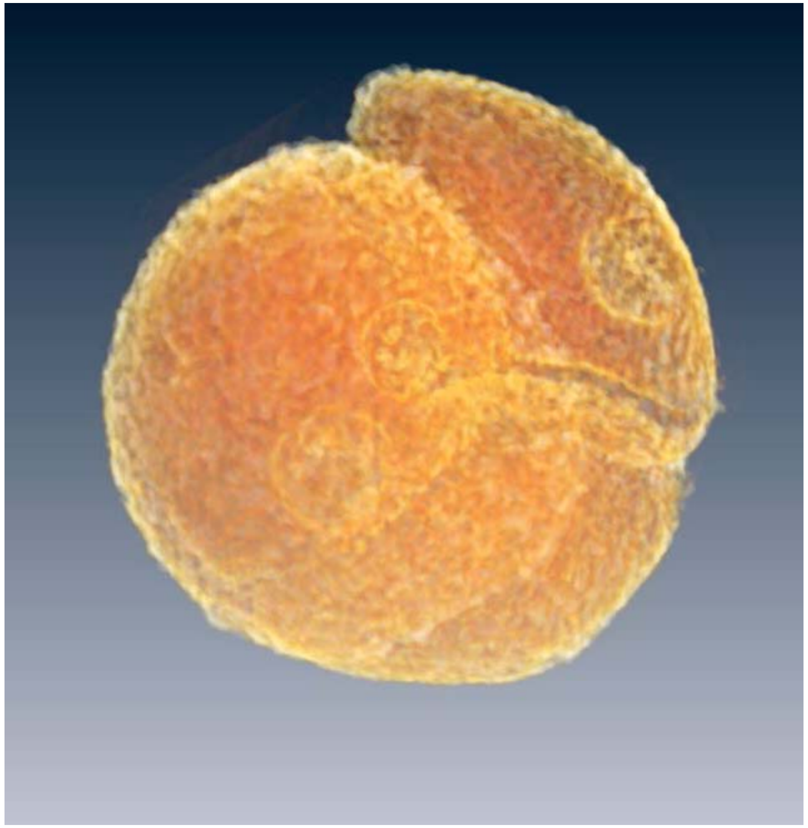
Dendrite in alloy



Ni alloy

Paleontology （古生物学）

3D CT of Cambrian paleontologic embryo fossil.



Left sample: Pixel size of CCD 2.25μm, Energy 20keV, Exposure time 2s.

Right sample: Pixel size of CCD 0.65μm, Energy 17keV, Exposure time 7s.

M.Y. Chu, NIP

Capacity of Beamline on SSRF

- 18 Straight sections for IDs
  - In vacuum undulators will be employed to produce brilliant x-ray beams and a standard straight section can accommodate two IV-undulators.
  - A long straight can accommodate two or more standard undulators
  - More than 26 ID beamlines have been scheduled
- 20 BMs

Two beamlines can be extracted from each BM at 1° and 3°,
Up to 38 BM ports (including 4 IR ports) available

SSRF has a capacity of accommodating more than 60 beamlines

Future Beamline programs

◆Beamlines for National Protein Science Facility
-----The project has been approved

- Three Protein crystallography beamlines
  - Large macromolecular complexes and assemblies
    Protein micro-crystals: membrane proteins etc.
  - High throughput crystal screening and structural determination
- Small angle X-ray scattering beamline(Bio-SAXS)
  - High performance(very small angle X-ray scattering) beamline for the studies of protein dynamics and interaction
- IR Beamline with two end-stations
  - Time-resolved spectroscopy for protein dynamics and interaction
  - Microspectroscopy and imaging for structural and functional studies of cell, tissue and organisms

◆ SSRF Phase II beamlines: A proposal to CAS

- 24 beamlines have been proposed as the preliminary program, by making full use of the brilliant beam and the partial coherence to achieve higher spatial resolution and energy resolution, faster time resolution;

- Detailed program is under discussion and is open for modification.

SLEGS-prototype and

the future plan

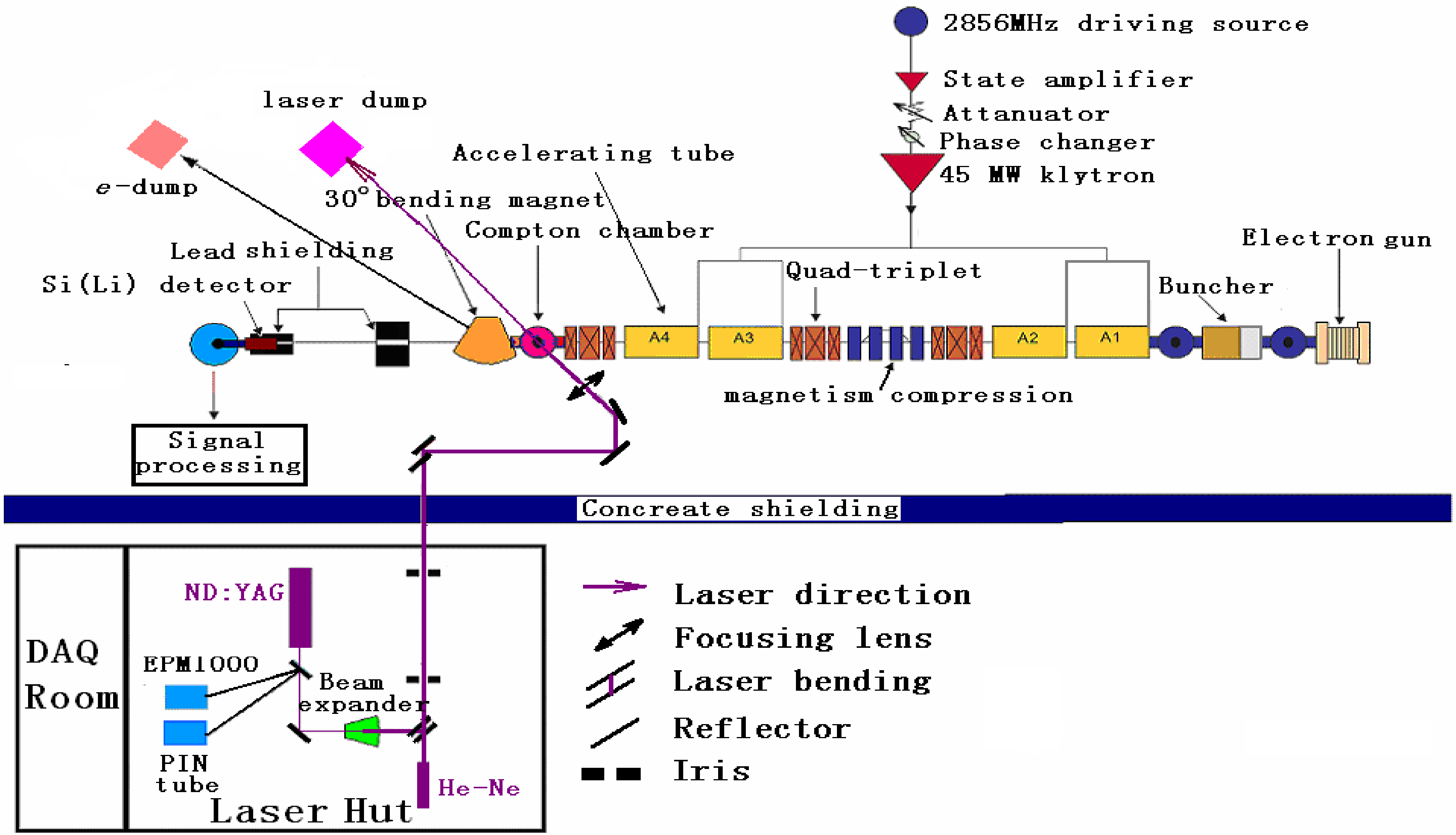
Bird View of SINAP in Jiading

Shanghai Laser Electron Gamma Source (SLEGS)-prototype experiments

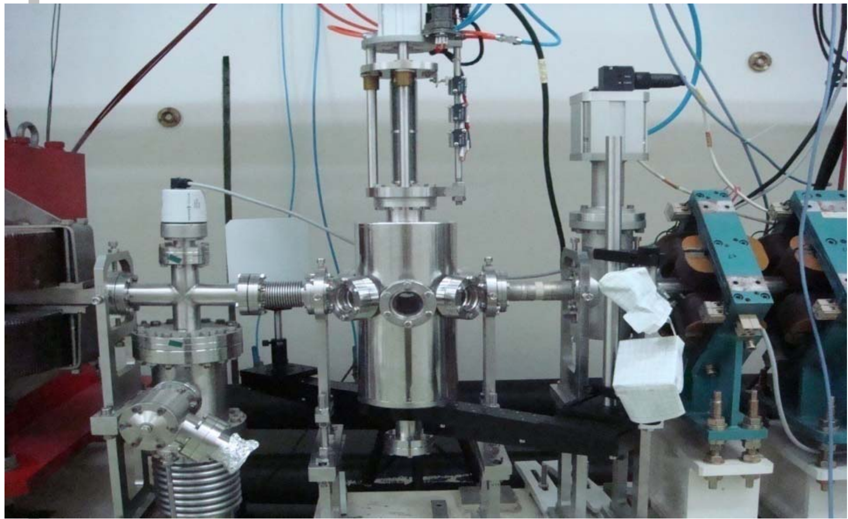
100MeV LINAC at SINAP

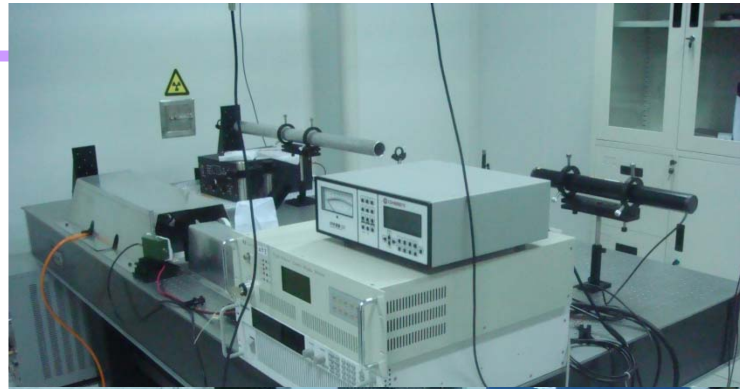
Shanghai Institute of Applied Physics, Chinese Academy of Sciences

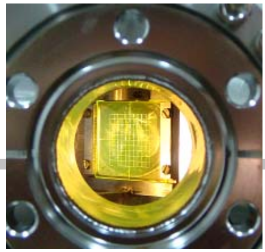
Experimental layout

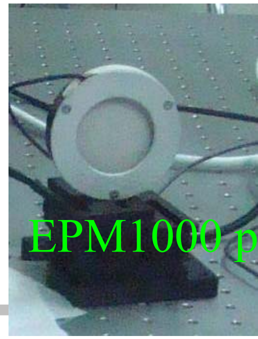


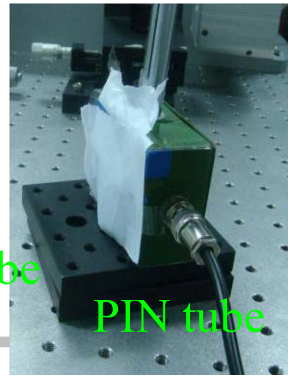
Experimental setup







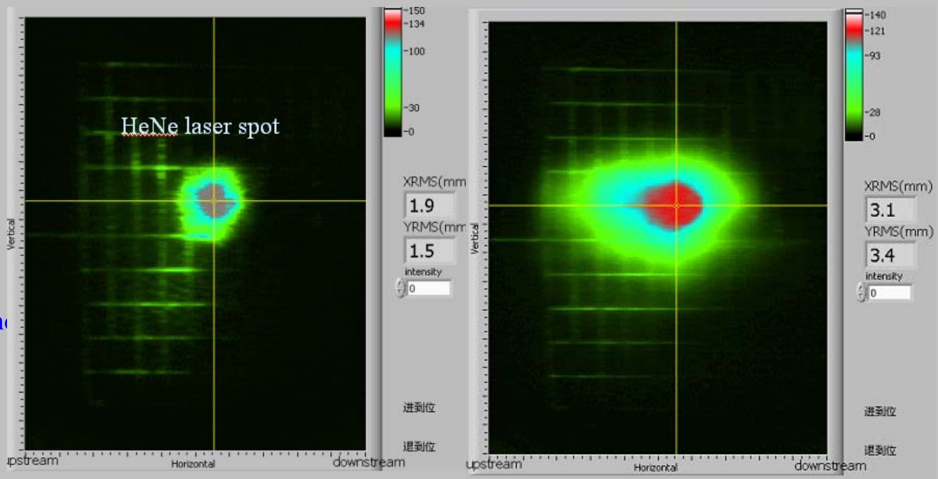




Electron and Laser Parameter	SINAP II	SINAP I
Electron Beam Energy	108.1MeV	108.1MeV
Beam Emittance	~50 πmm-mrad	~50 πmm-mrad
Electron Beam Spot size (rms)	$3.1\times3.4mm^2$	$2.5\times3.1mm^2$
Beam Charge	~30pC	~100pC
Bunch Length (rms)	0.85ns	0.95ns
Macrobunch repetition	5Hz	5Hz
Laser Beam size at IP (rms)	$0.3\times0.3mm^2$	$<0.5\times<0.5mm^2$
Nd:YAG laser wavelength	1064nm	1064nm
Nd:YAG laser power	200MW	15MW
Nd:YAG laser pulse length	7.8ns	15.3ns
Nd:YAG laser repetition	2.5Hz	2.5Hz

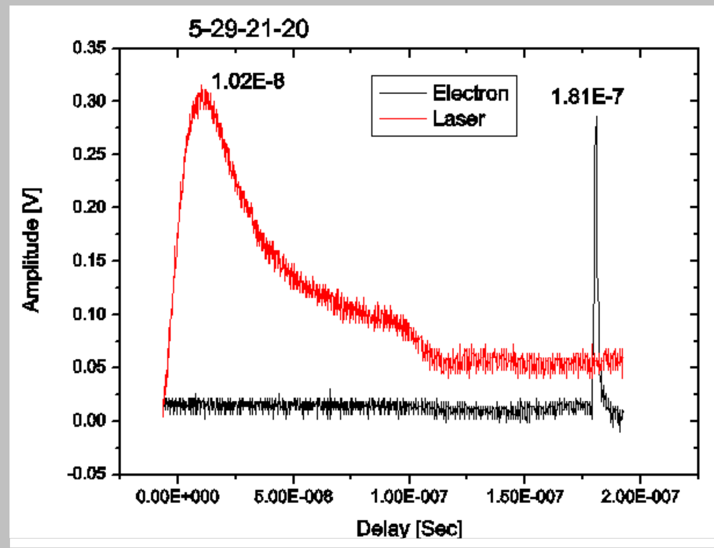
Experimental results

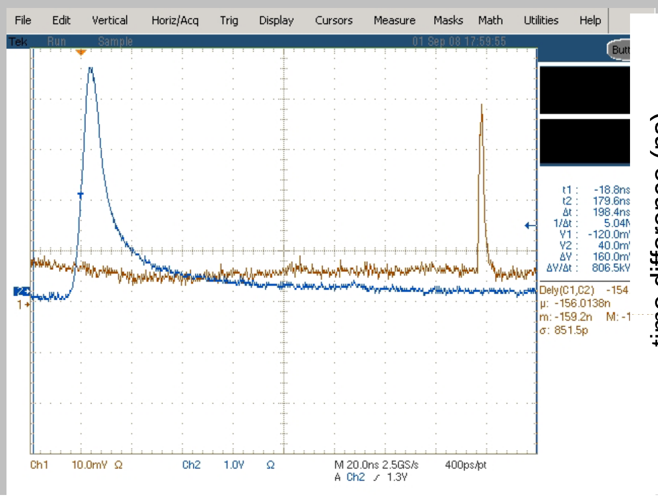
Space overlap

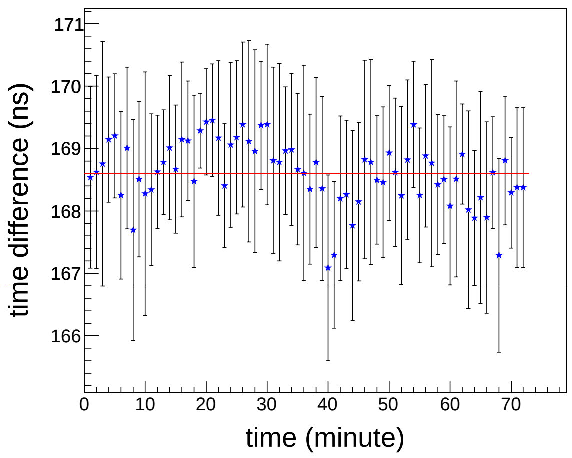


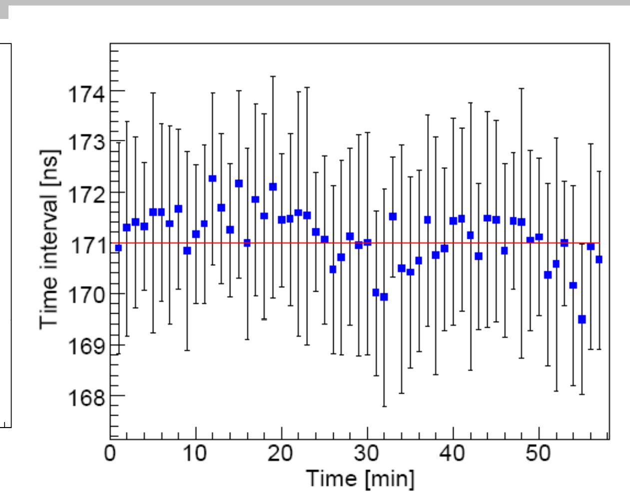
Syn

Synchronization









SINAP I: X-ray spectrum of calibrated ^{125}I radioactive source (top-left) and its calibration result (top-right); LCS X-ray spectrum after background subtraction (bottom-left)

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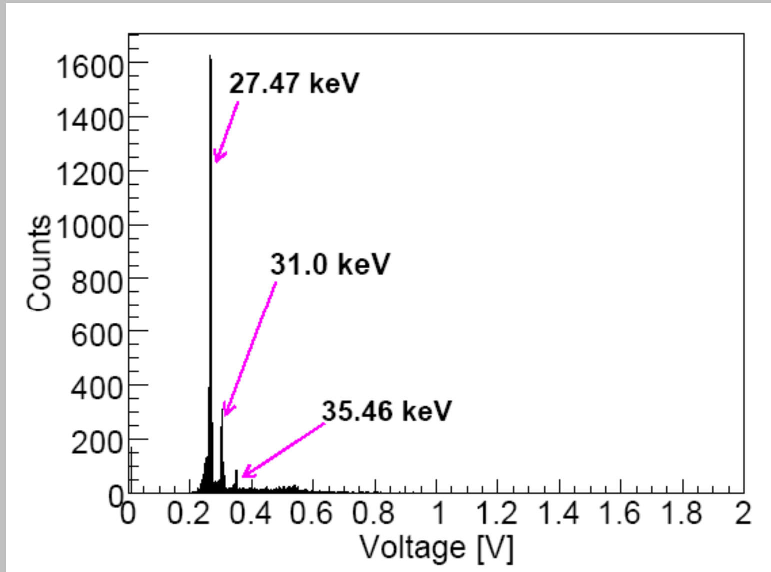
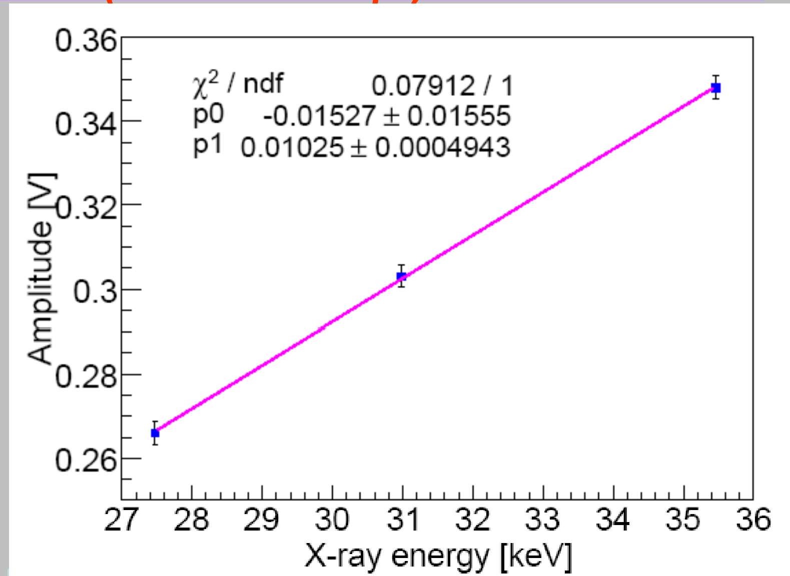
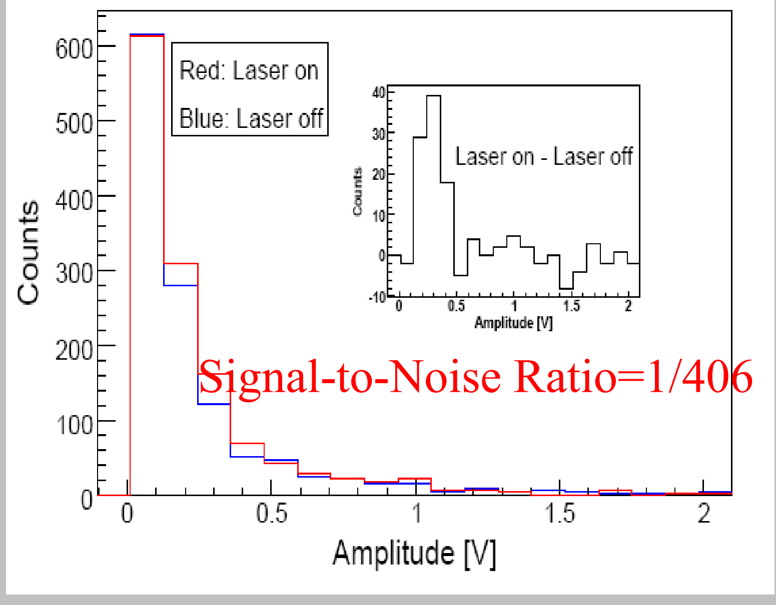
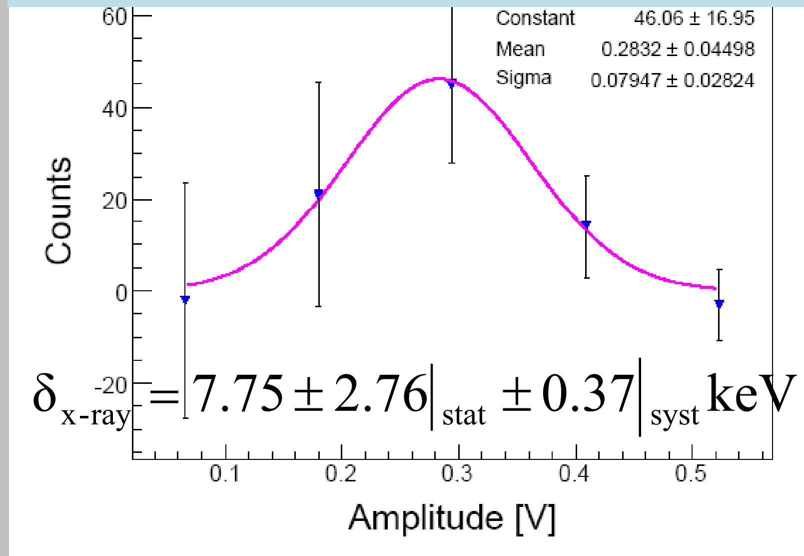




$$E_{\text{x-ray}} = 29.12 \pm 4.39\big|_{\text{stat}} \pm 2.06\big|_{\text{syst}}\ \text{keV}$$





$$\delta_{\text{x-ray}} = \big|7.75 \pm 2.76\big|_{\text{stat}} \pm 0.37\big|_{\text{syst}}\ \text{keV}$$

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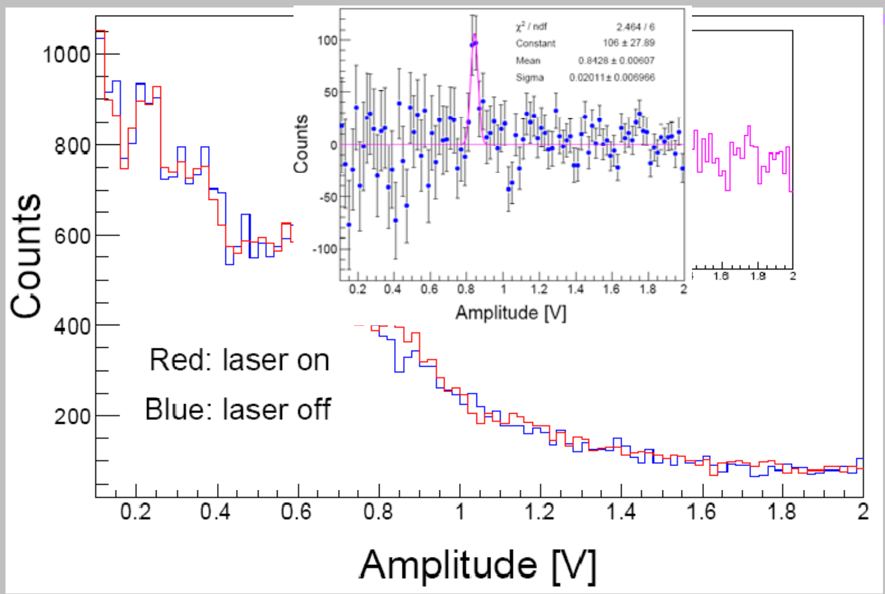
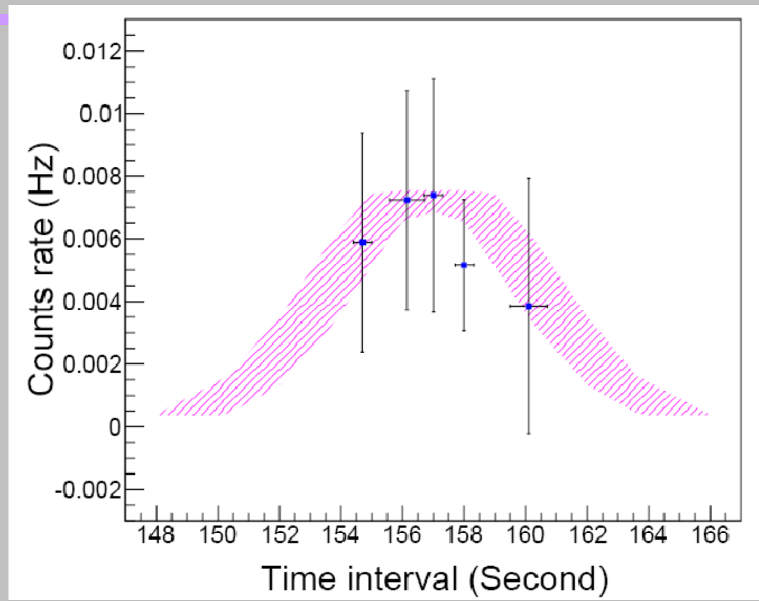
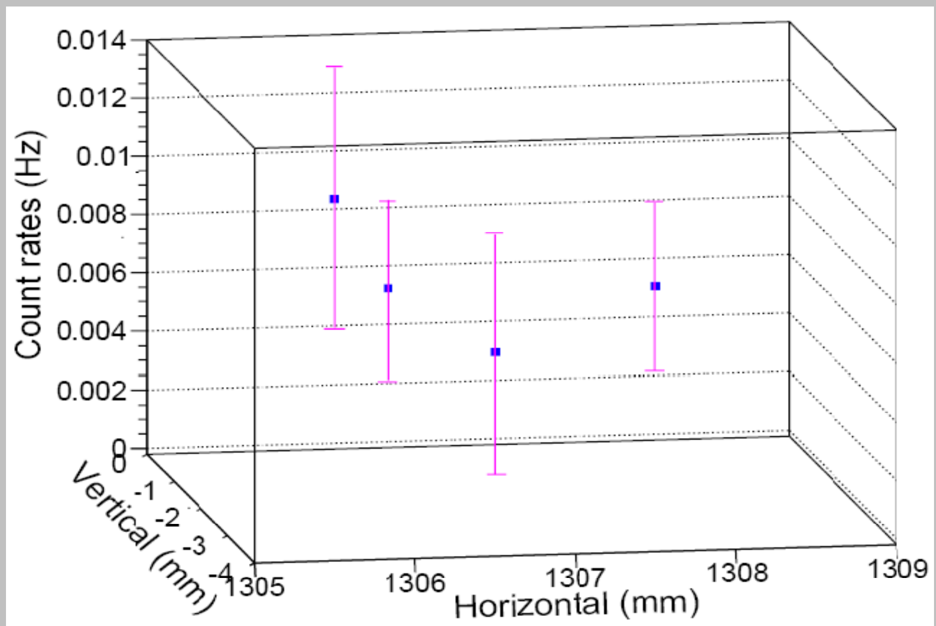
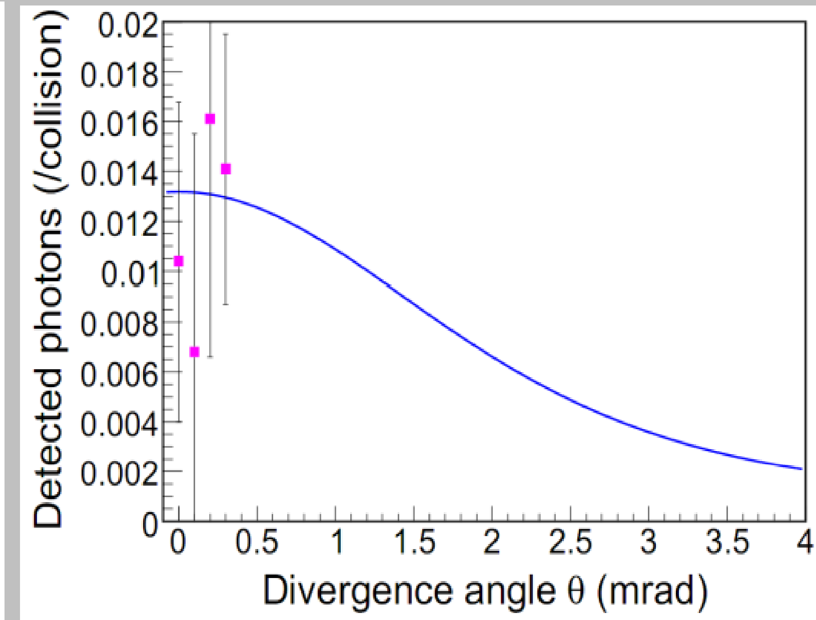
SINAP II: experimental results









Parameter	SINAP I	SINAP II
Energy (keV)	$31.73 \pm 0.12_{stat} \pm 1.64_{syst}$	$29.12 \pm 4.39\|_{stat} \pm 2.06\|_{syst}$
FWHM (keV)	$1.74 \pm 0.61_{stat} \pm 0.07_{syst}$	$18.25 \pm 6.50\|_{stat} \pm 0.87\|_{syst}$
Net counts	278±44	81±32
S/N	1/780	1/420
Count rate(cps)	0.0078±0.0026	0.0125±0.0050

Electron beam intensity of 100 MeV Linac ~ 1.0 nC/pulse，
frequency of laser and electron ~ 20Hz，
and we got the intensity of LCS X-ray:
$(5.2 \pm 2.0) \times 10^2$ photons/s (SINAP-I)，
$(1.7 \pm 0.3) \times 10^3$ photons/s (SINAP-II)

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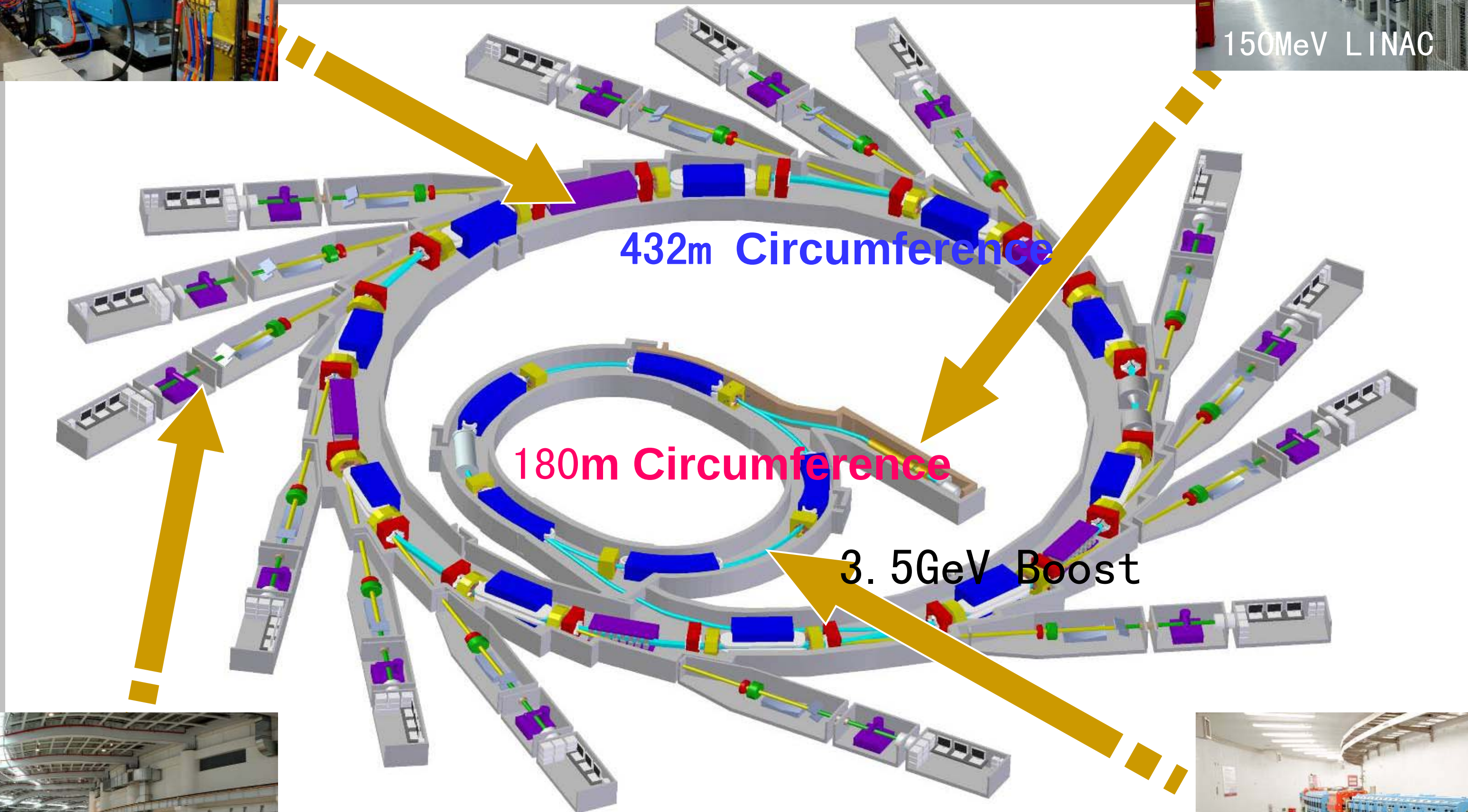
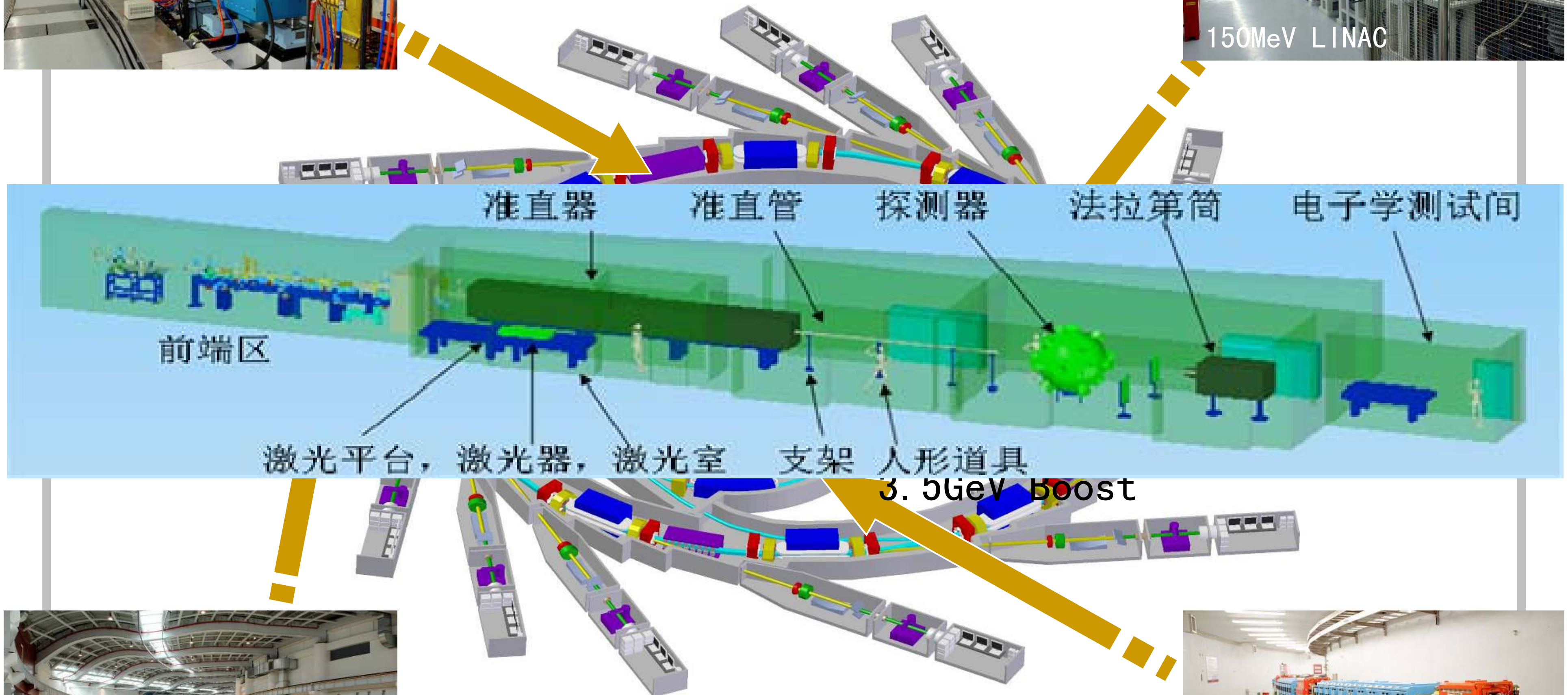
(4) Shanghai Laser Electron Source (SLEGS) at SSRF



Beamline and exp. station

SSRF capbility: 60 beam lines
and ~100 exp. stations

(4) Shanghai Laser Electron Source (SLEGS) at SSRF



Beamline and exp. station

SSRF capbility: 60 beam lines
and ~100 exp. stations

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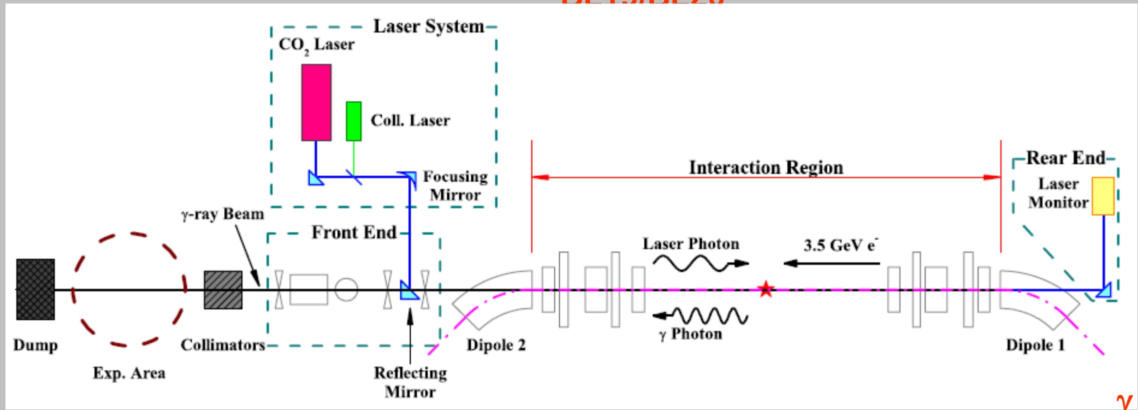
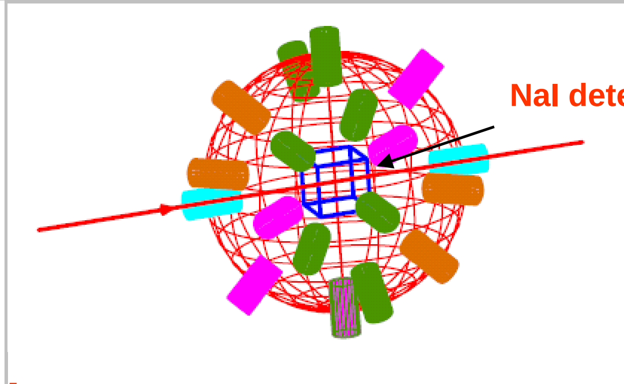
SLEGS Design

BL19/BL20

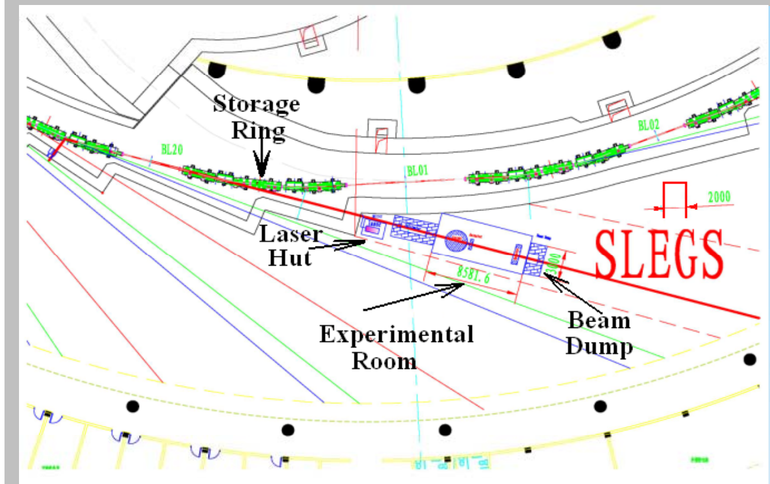


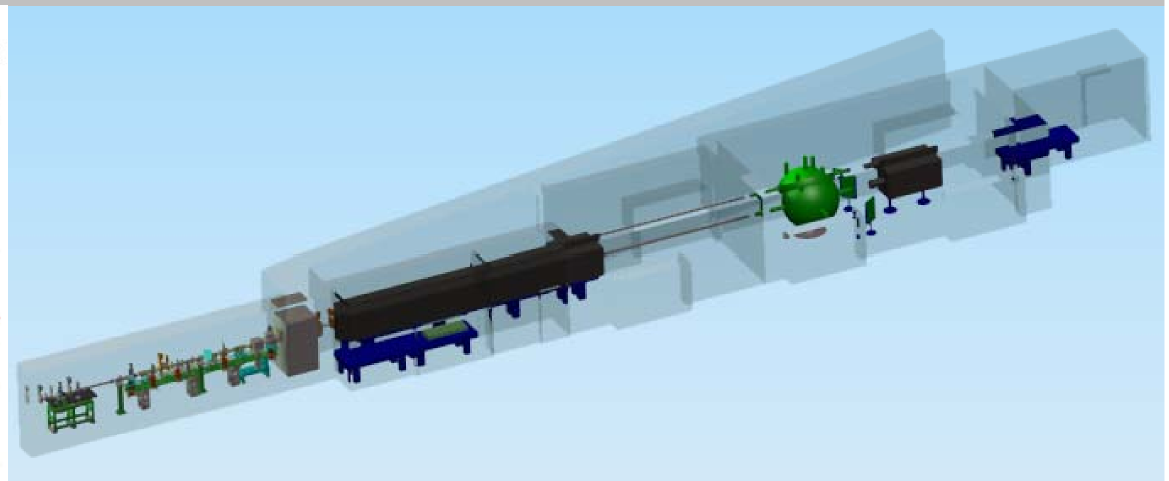


NaI detector

γ beam

Time-Projector-Counter

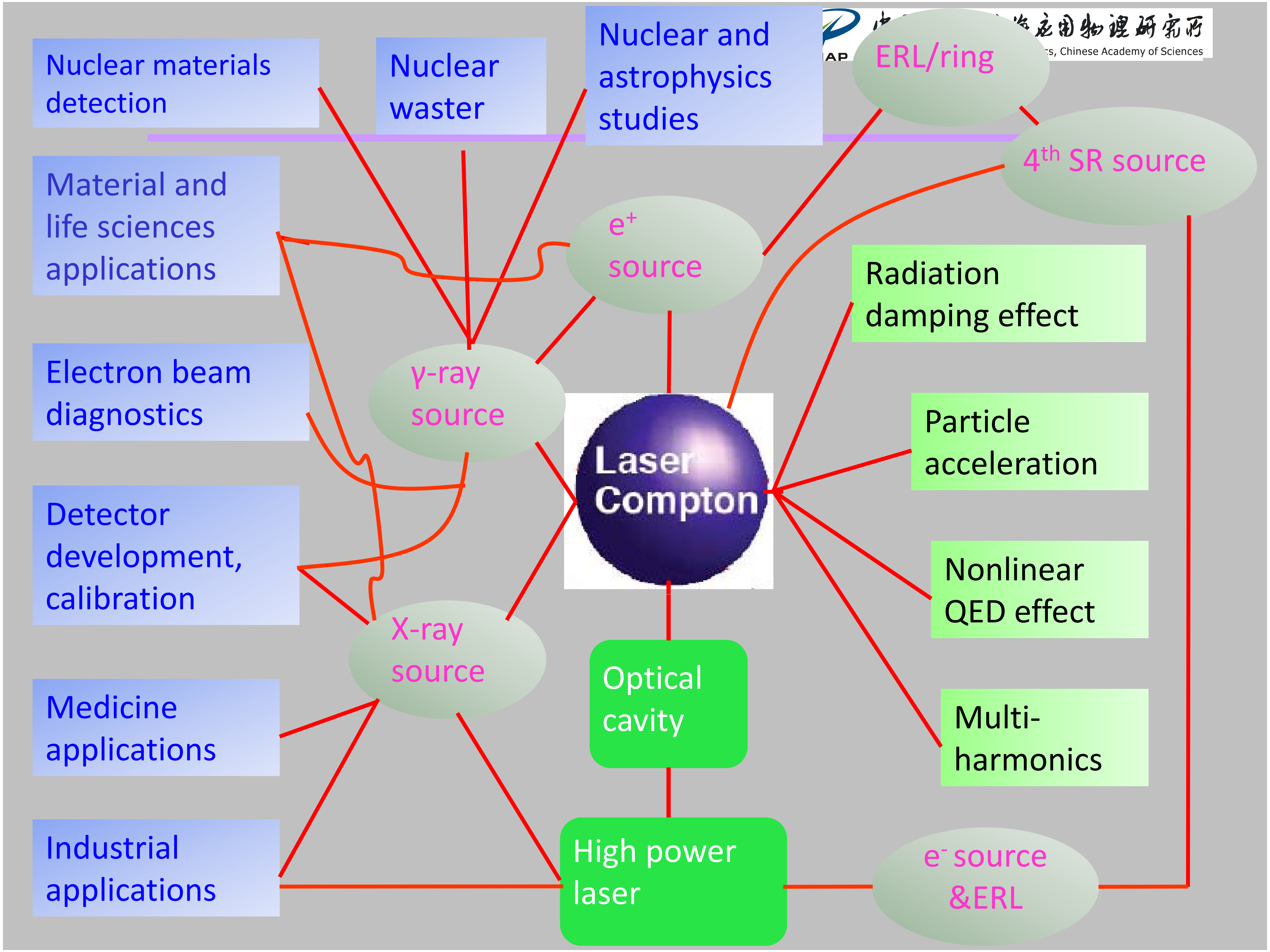




Physics Goals

- Astro-nuclear physics (e.g. 3α process)
- Spin-physics
- Hadron & Nuclear physics
  - Photo-disintegration
  - (γ ,n) reactions
- Nuclear Fluorescence
- Application for material science
- New photon sources with quantum technologies

……



Nuclear materials detection
Nuclear waster
Nuclear and astrophysics studies
ERL/ring
4th SR source
Material and life sciences applications
e+ source
Radiation damping effect
Electron beam diagnostics
γ-ray source
Laser Compton
Particle acceleration
Detector development, calibration
Nonlinear QED effect
X-ray source
Optical cavity
Multi-harmonics
Medicine applications
Industrial applications
High power laser
e- source &ERL

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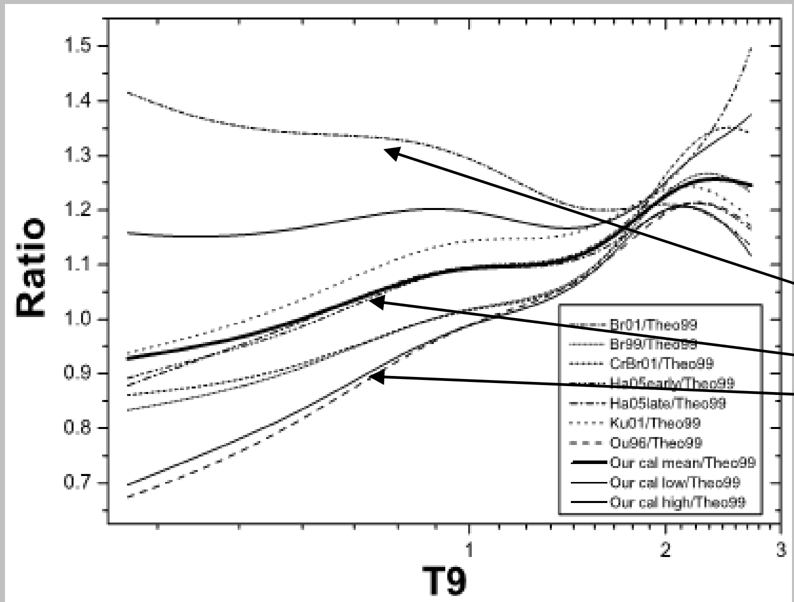
$^{12}C(\alpha,\gamma)^{16}O$ reaction rate

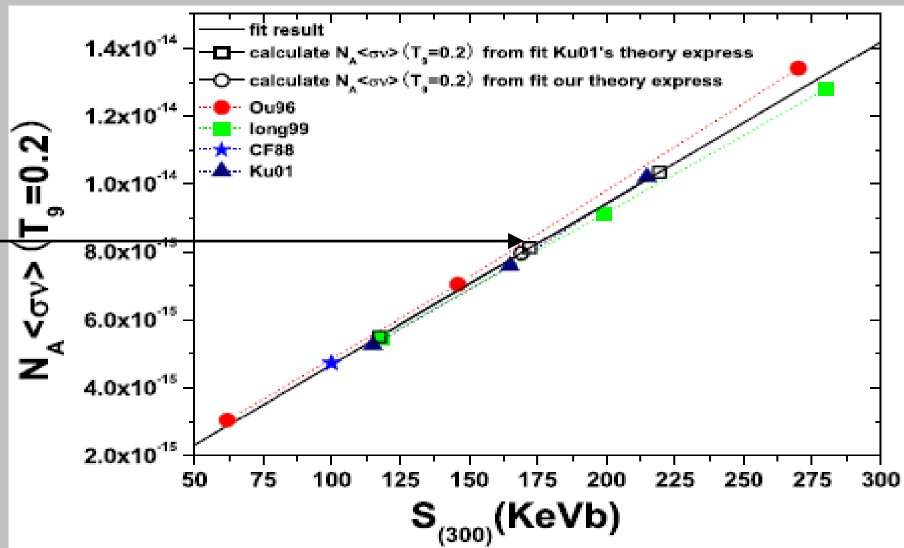


Our calculation reaction rate base on seven primary experiment data. We use NACRE's theory reaction rate to normalize the all rate.

We give the adopt rate and its high and low limit.

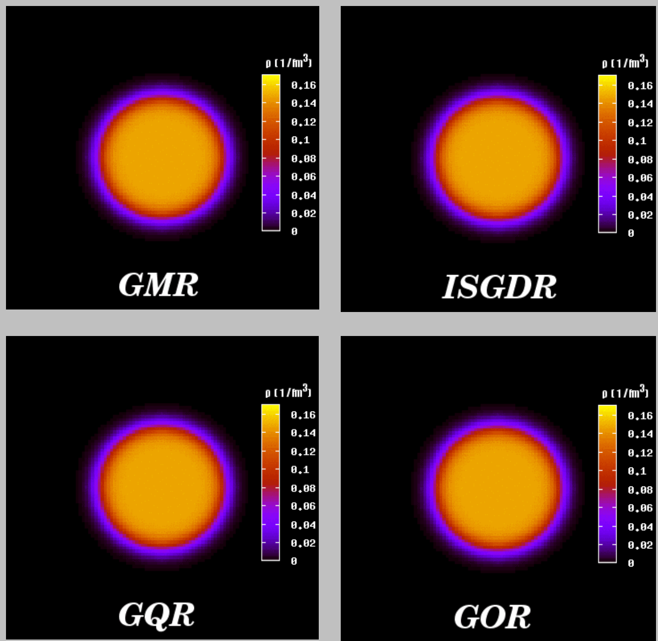
Almost it is linear, so measurement the S(300) value in lab is important!

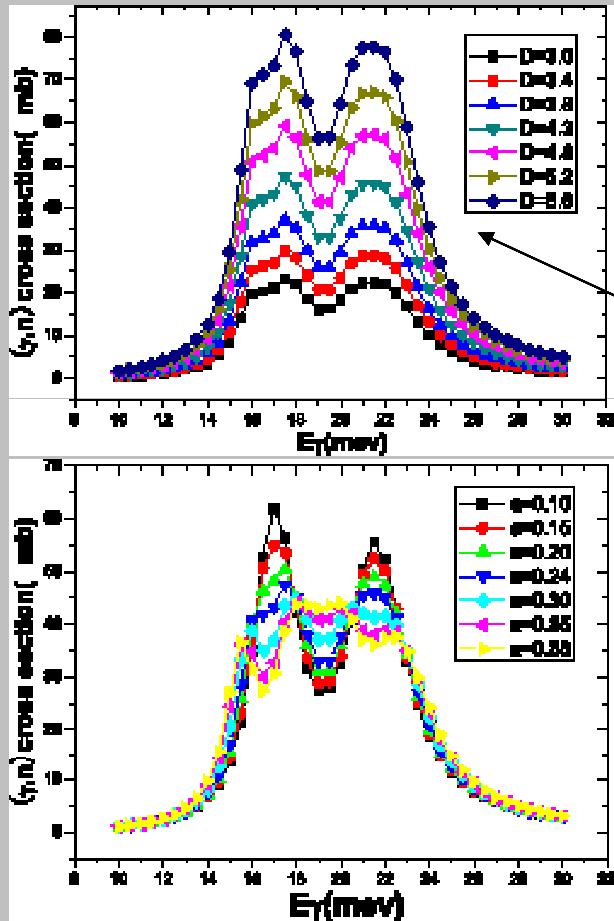
This is a scale of S(300) value vs. reaction rate at T9=0.2.



Samples of Nuclear Giant Resonances

Giant Monopole Resonance(L=0):
Iso-Scalar Giant Dipole Resonance(L=1):
Giant Quadrupole Resonance(L=2):
Giant Octupole Resonance(L=3):





Based on Interacting-boson model for (g,n) cross section of triaxial nuclei ^{48}Ti

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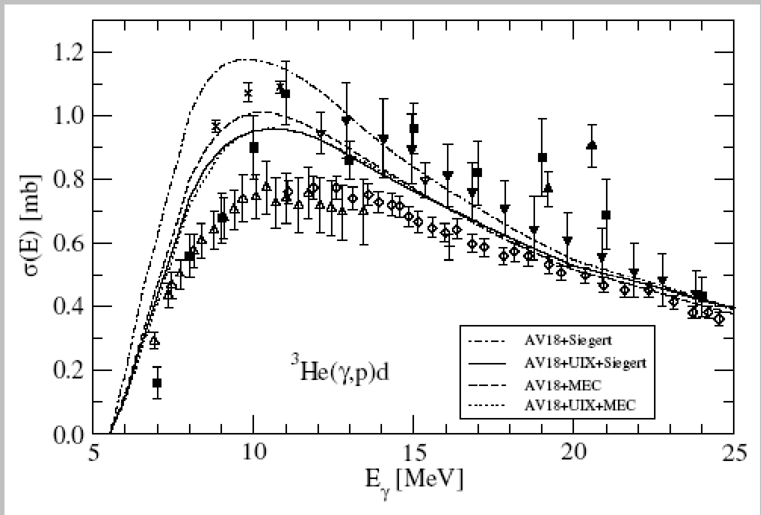
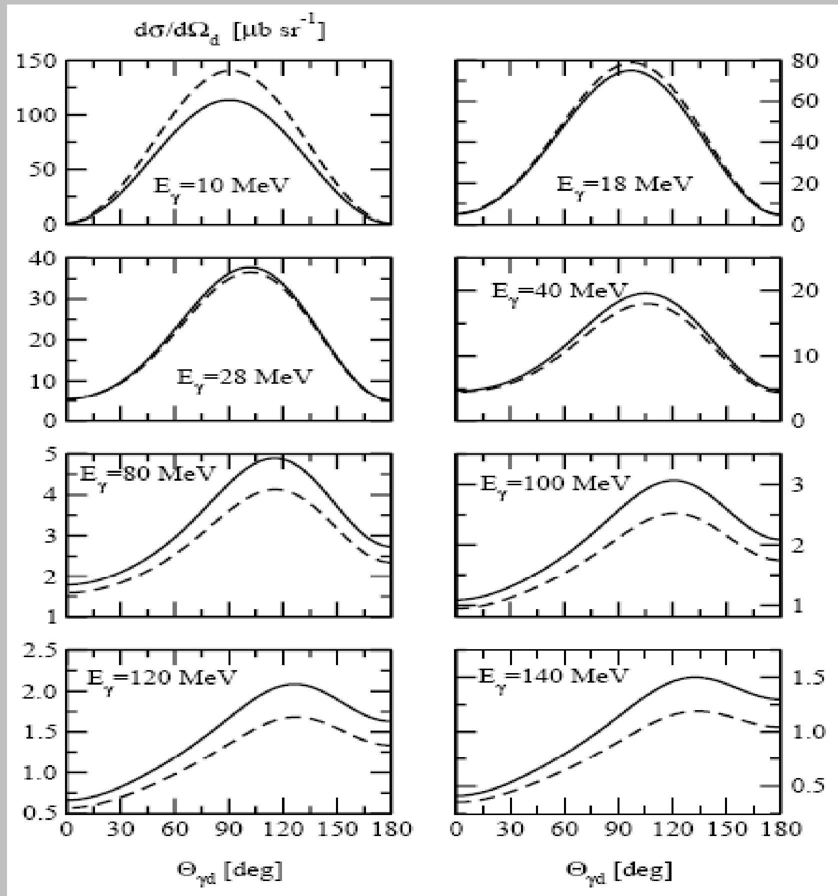
Study Three Body force



^{3}He(γ,d)p at different photon energies E_γ. Curves show results of calculations with the AV18 *NN* and Urbana IX 3NF forces (solid) and with the AV18 *NN* force alone (dashed). The current is treated in the Siegert approach.



Nuclear Instruments and Methods in Physics Research A 599 (2009) 118–123

A potential photo-transmutation of fission products triggered by Compton backscattering photons

J.G. Chen [a,*], W. Xu [a], H.W. Wang [a], W. Guo [a], Y.G. Ma [a], X.Z. Cai [a], G.C. Lu [a], Y. Xu [a,b], Q.Y. Pan [a], G.T. Fan [a,b], W.Q. Shen [a]

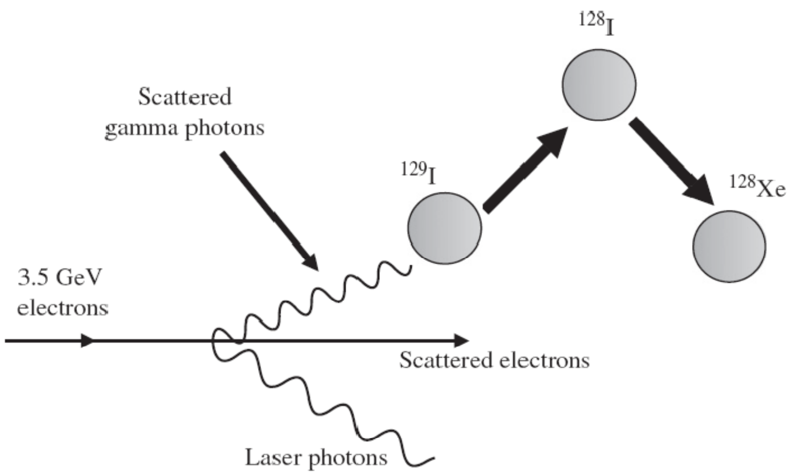
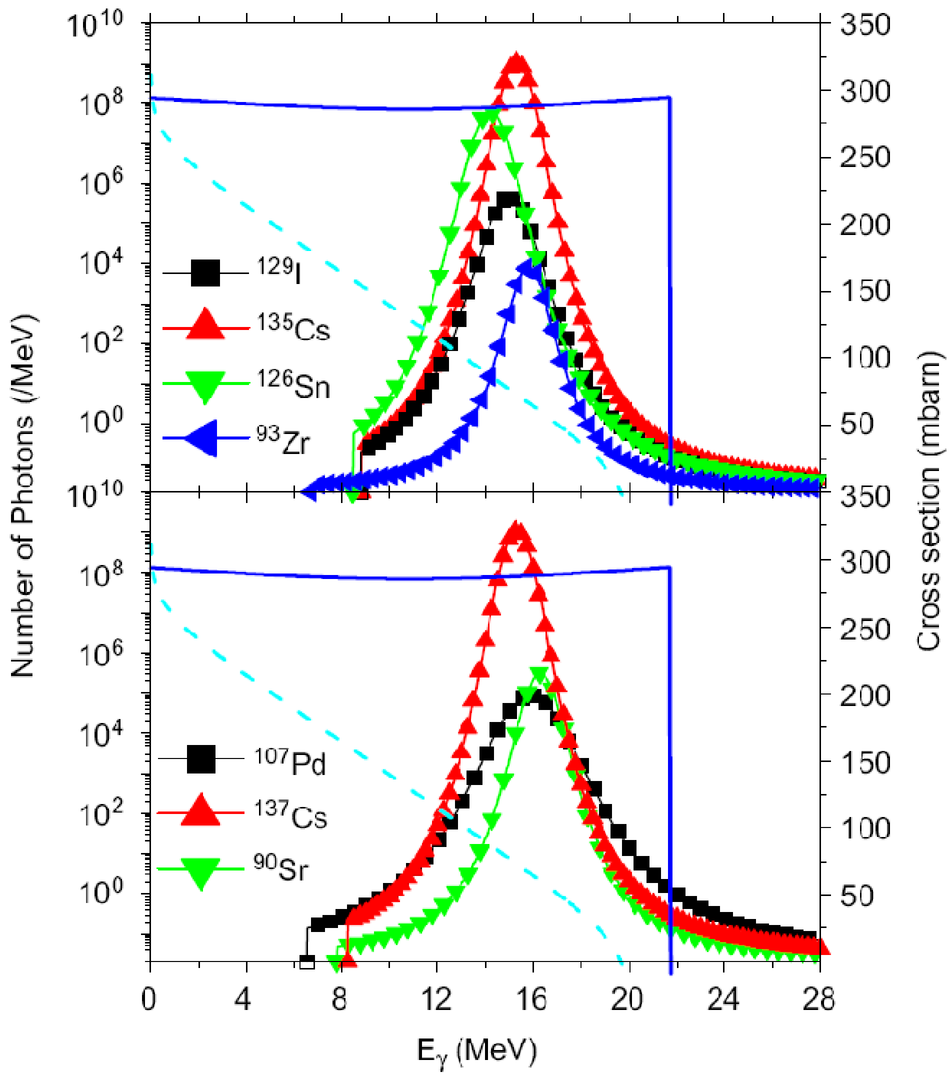


Fig. 1. The Compton scattering process between a laser photon and a relativistic electron as well as the transmutation of ^{129}I via the (γ, n) reaction.



By the SLEGS photons, it is possible to the transmutation of some long-lived fission product nuclides 129I, 135Cs, 126Sn, 93Zr, 107Pd, 137Cs and 90Sr.

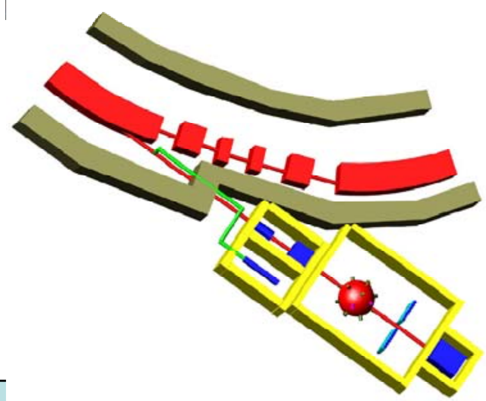
Research Activities of Nuclear Physics in SINAP

- **Radioactive beam physics and HIC (around ~100MeV/u; HIRF-CSR, RIKEN, TAMU etc)**
  - total cross section & momentum distribution
  - nucleon-nucleon momentum correlation
  - isospin physics: EOS & symmetric energy
  - multifrgamentation and liquid gas phase transition
  - collective flow

- **RHIC Physics @ STAR, BNL (~200GeV/c Au+Au)**
  - STAR barrel Time-of-Flight Project Project
  - Strange hadron and quark dynamics
  - jet-medium interaction
  - anti-matter hyperon

- **Shanghai Laser Electron Gamma Source (with <20MeV Photons) based on SSRF**
  - future physics: nuclear astrophysics with photons

- **Neutrinoless Double Beta Program and Dark Matter Program**
  - [CUORE Collaboration (Gran Sasso Nat Lab, Italy)]
  - [Xenon, JinPin Mountain, China]



- **Advanced Nuclear Energy Program (MSR based on Th-U loop)**

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Shanghai Institute of Applied Physics, Chinese Academy of Sciences

Profs. Hongjie Xu, Zhentang Zhao (Directors of SSRF)

Prof. Jianhua He et al. (Beamlines)

Profs. Wang Xu, Xiangzhou Cai et al. (SLEGS prototype)

SINAP-ZhangJiang Campus

Thanks for your attentions!

SINAP-JiaDing Campus