Center for the Advancement of Natural Discoveries using Light Emission

CANDLE Light Source Project in Armenia

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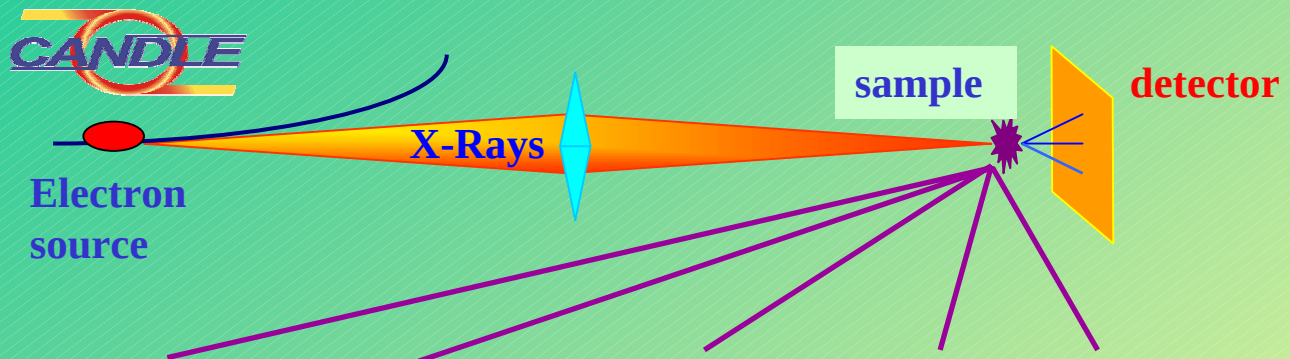
CANDLE-YSU, Armenia

1 June 2009

Contents

Why Synchrotron Light Source?

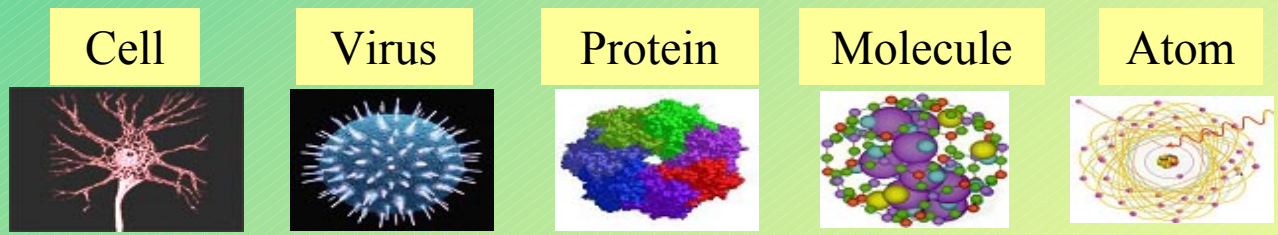


- High Brightness
- Continues Spectrum
- Tunability
- High Coherency

User Demands - 3-10 times

Spectrum

0.01 0.1 1 10 100 keV



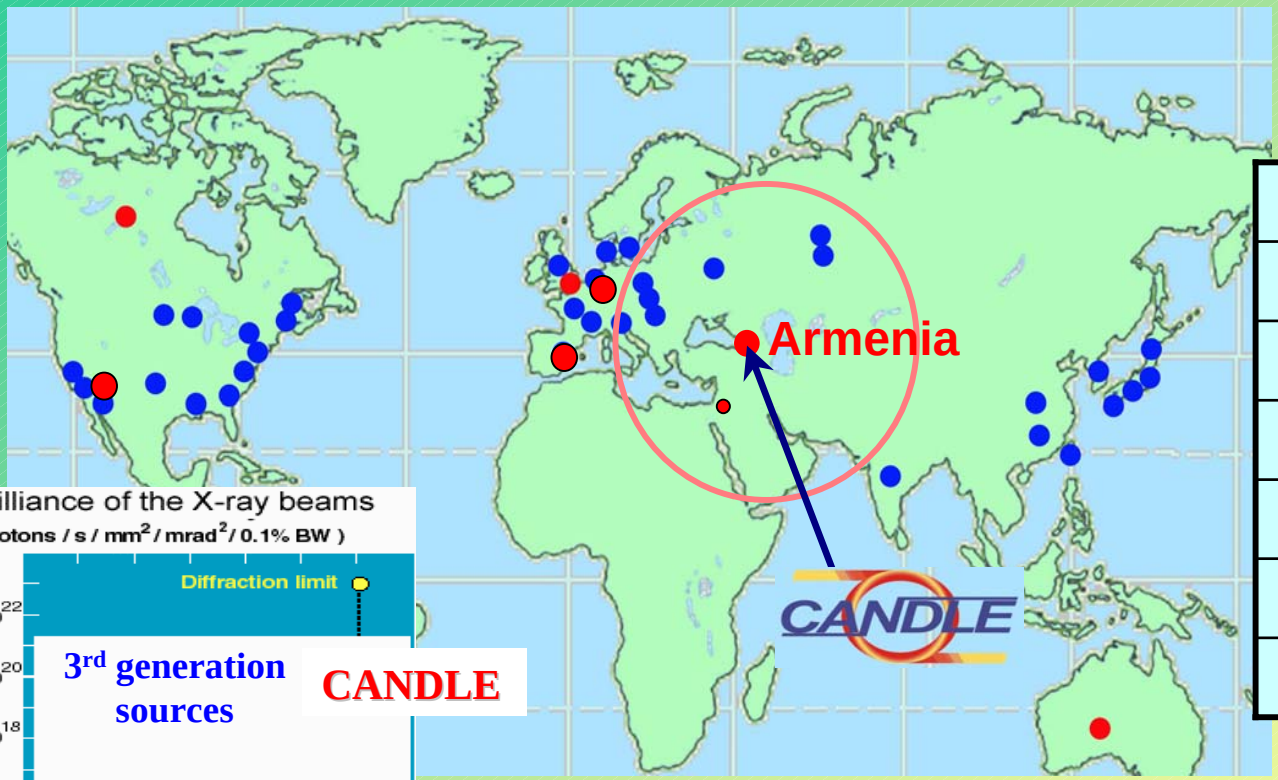
Science

- Biology
- Physics
- Material Science
- Medicine
- Chemistry
- Environments

Industry

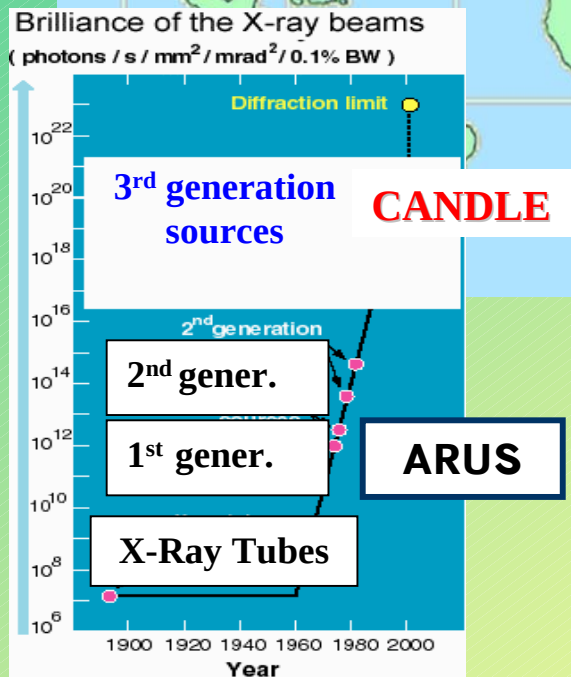
- Biotechnology
- Electronics
- New material
- Pharmacy
- Nanotechnology
- Microfabrication

Why Synchrotron Light Source?



XXI century

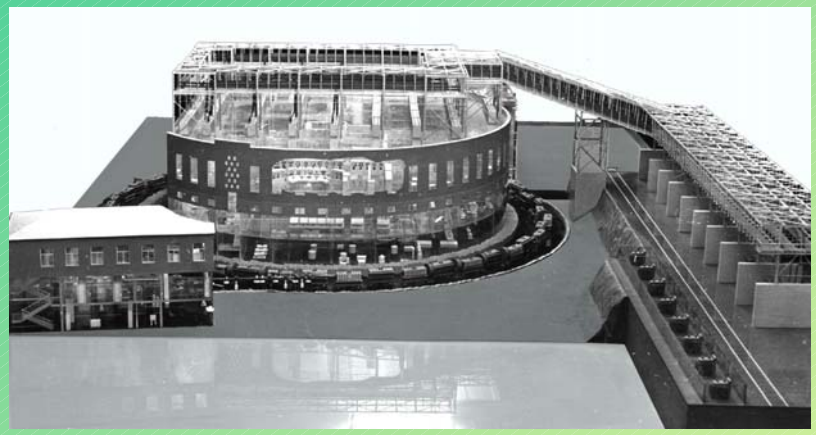
SPEAR3	USA
DIAMOND	England
SOLEIL	France
Boomerang	Australia
CLS	Canada
ALBA	Spain
CANDLE	Armenia



CANDLE will serve scientists of 2000 km radius region.

Why in Armenia ?

A.I. Alikhanian



A.I. Alikhanov

Construction of 6 GeV synchrotron (1967)

Burakan Observatory

Armenian Nuclear Plant

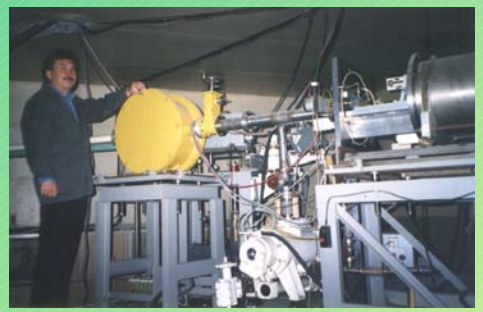
Why in Armenia ?

ARUS-6 GeV

The major achievements in HEP include

- The study of pion photoproduction, eta-meson generation.
- X-ray transition radiation and XTR detectors.
- Development of Quasi-Cherenkov radiation.
- Exper. observation of particle channeling radiation in crystals.
- Development of track spark chambers.

1971-1975 – Three Synchrotron Radiation Beamlines



Lab. of Radiation
Solid State Physics

Lab. of Radiation
Biophysics

Solid State Dept of
Yerevan State Univ.

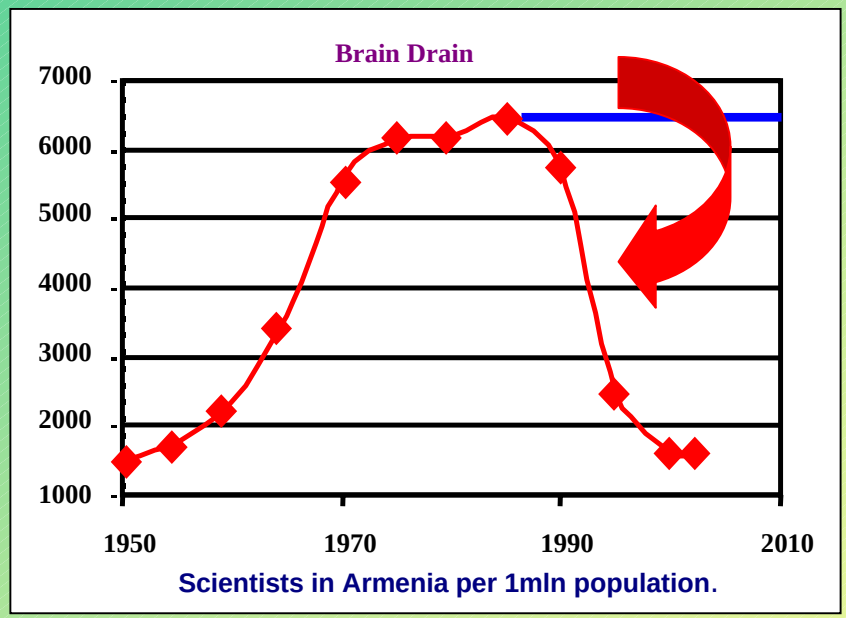
Scientific Potential

SLAC SPIRES

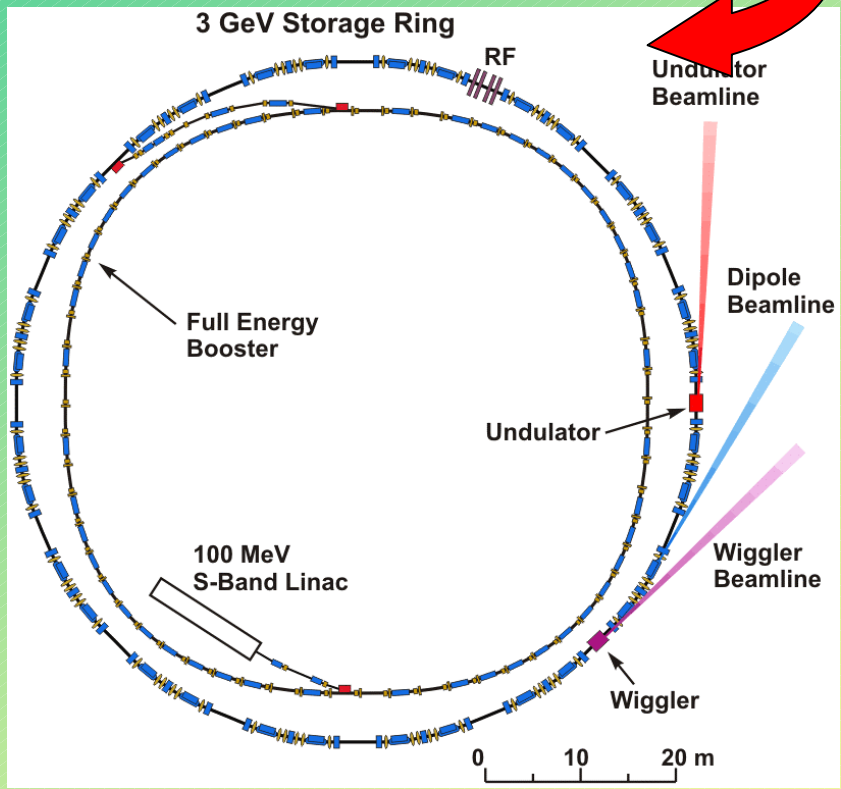
HEP Database-2000

	Total Papers	Population (mln)	Papers/ 1mln
USA	150 738	270.3	558
Germany	51 142	82.1	623
France	27 937	58.8	475
UK	27 664	59.1	468
Sweden	5 206	8.8	591
Italy	33 307	58	574
Japan	31 390	126	249
Finland	31 18	5.1	611
Switzerland	33 876	7.3	4 640
Israel	6 236	5.4	1 154
Armenia	2 929	3.5	813
Russia	48 577	146.8	331
Georgia	1 626	5.7	285
Estonia	180	1.6	112
Belarus	883	10.4	85
Ukraine	4 241	51.8	82
Kazakhstan	943	17.3	55
Azerbaijan	422	7.8	54
Uzbekistan	887	23	38
Tadzhikstan	99	6.1	16
Turkey	893	63.4	14
Iran	416	64	7

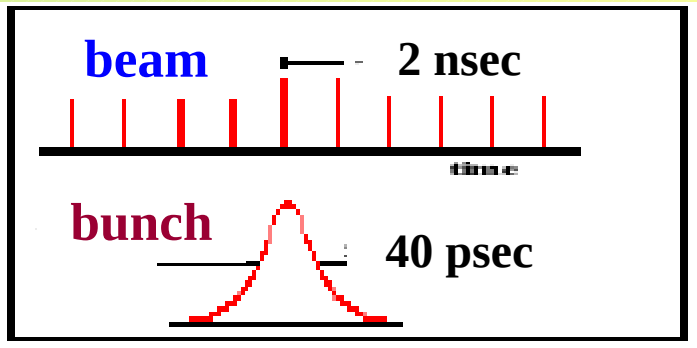
Brain Drain



3 GeV CANDLE Light Source



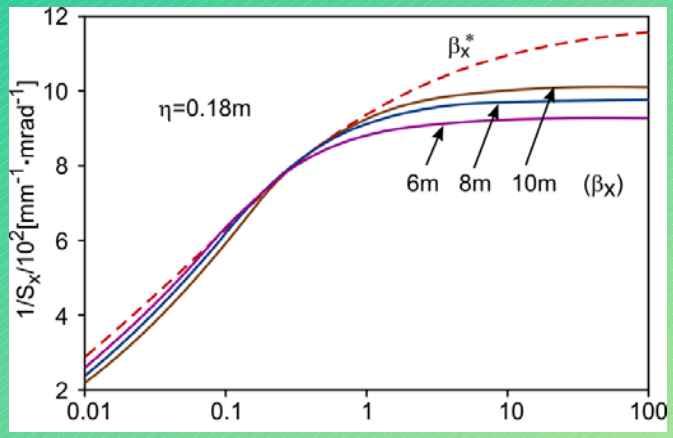
Energy	3 GeV
Current	350 mA
Circumference	216 m
Frequency	499.65 MHz
Harm. Number	360
Periods No	16
Straight section	4.8m
Lattice type	DBA
Emittance	*8.4 nm*
Beam lifetime	*18.4 hours*

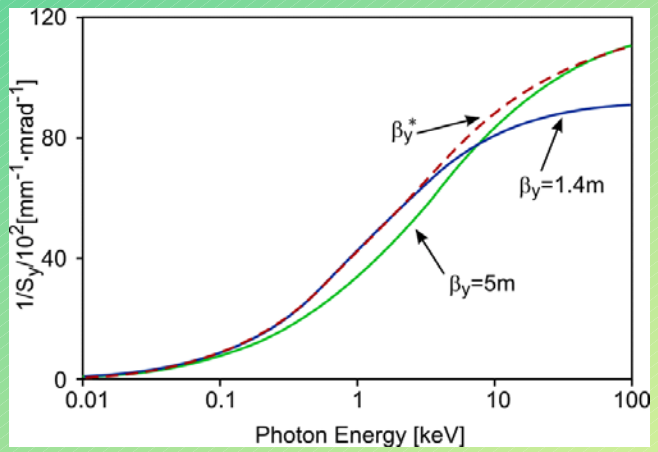


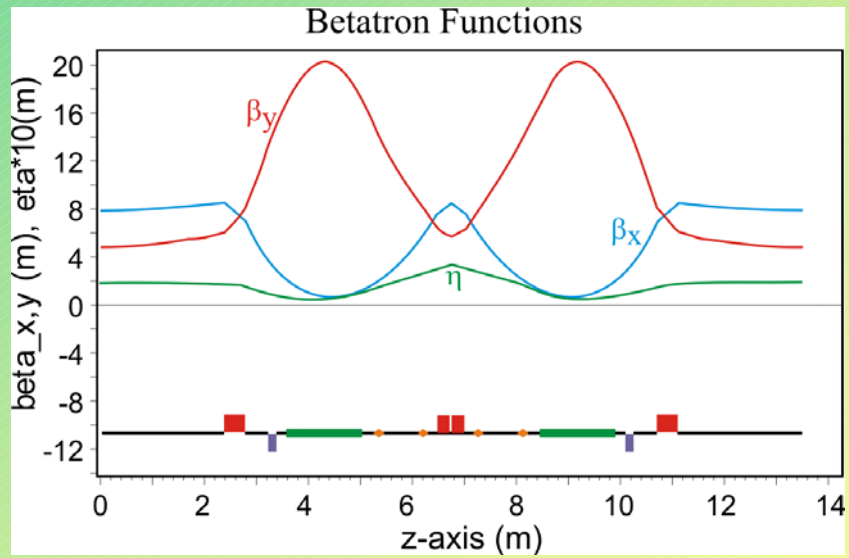
Time structure

Storage Ring – Figure of Merit

- High Brightness & Stable Beams

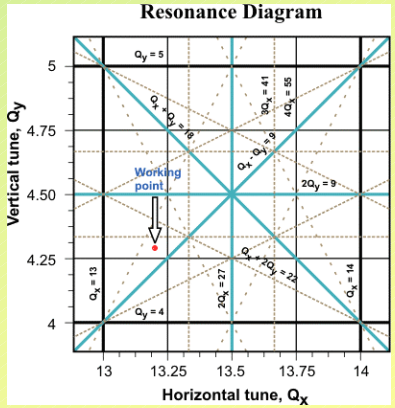






Tunes

$$Q_x = 13.22$$
$$Q_y = 4.26$$



$$\eta = 0.18\,m, \quad \beta_{x,y} = 7.9/4.8\,m$$

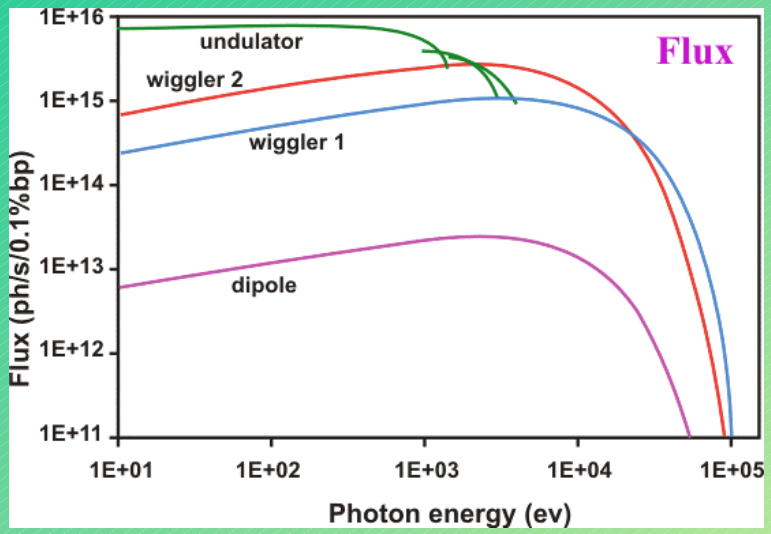
V. Tsakanov et al, Rev. Sci Instr., 2002

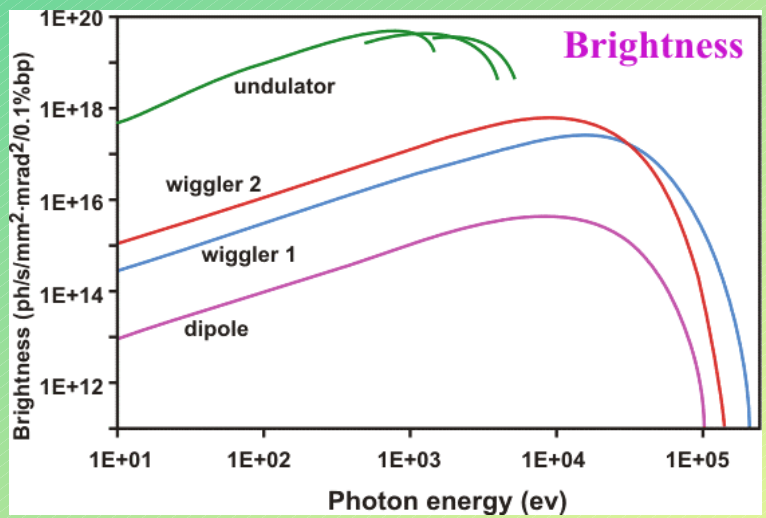
M. Ivanian et al, NIM (A) 2004

Emittance

$$\varepsilon_x = 8.4\ nm \cdot rad$$

Radiation Characteristics





Dipole beamline

Dipole field B (T)	1.354
Critical ph. energy (keV)	8.1

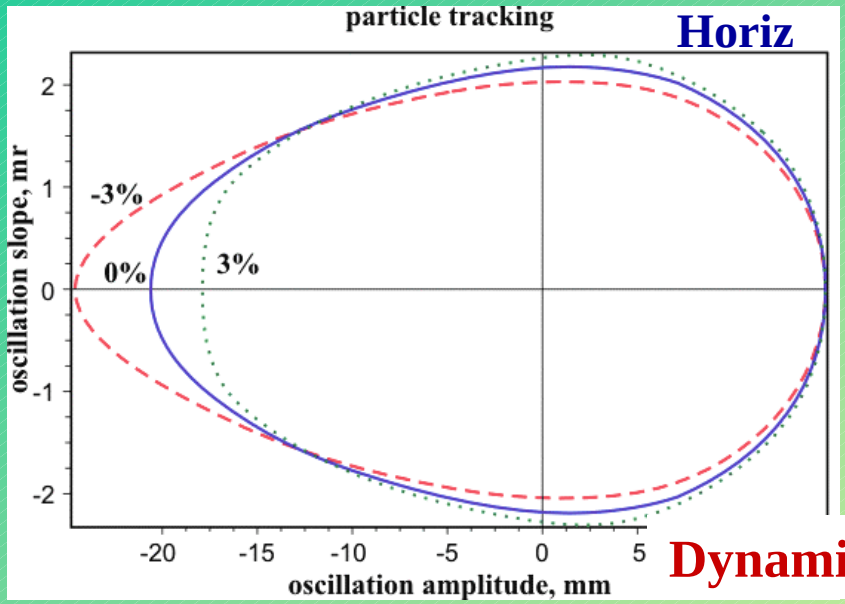
Wiggler type I

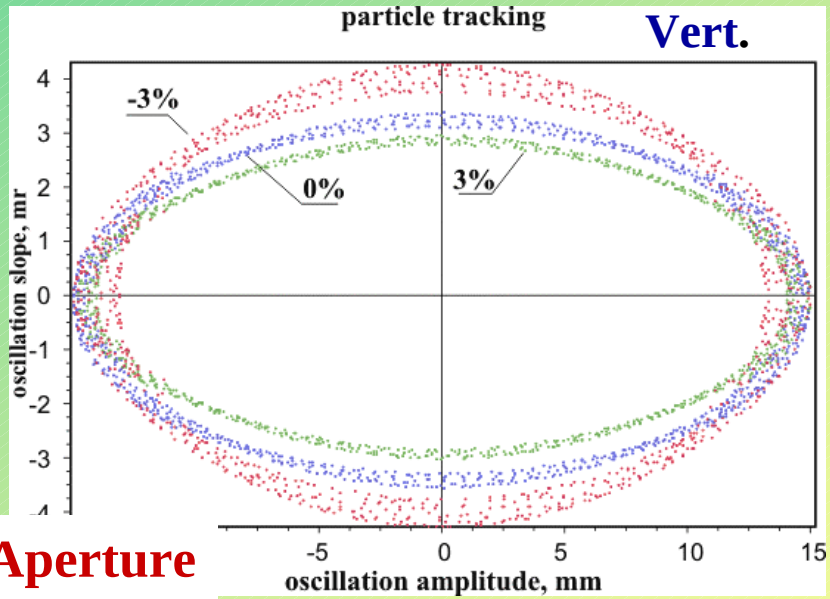
Magnetic field (T)	1.98
Period length (cm)	17
Critical ph. energy (keV)	11.97

Undulator

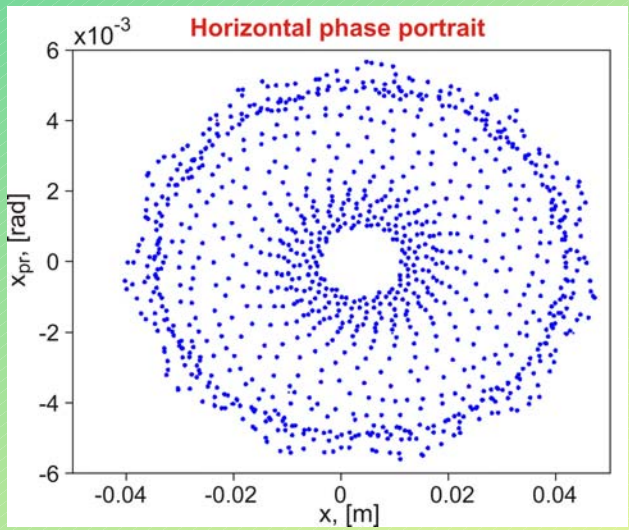
Magnetic field (T)	0.3
Period Length (cm)	5
Photon energy n=1,3,5 (keV)	0.85/ 2.6 /4.3

Storage Ring – Dynamics

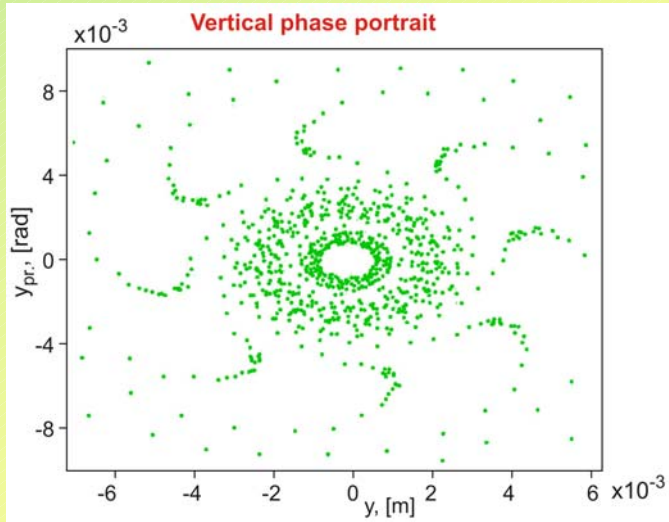




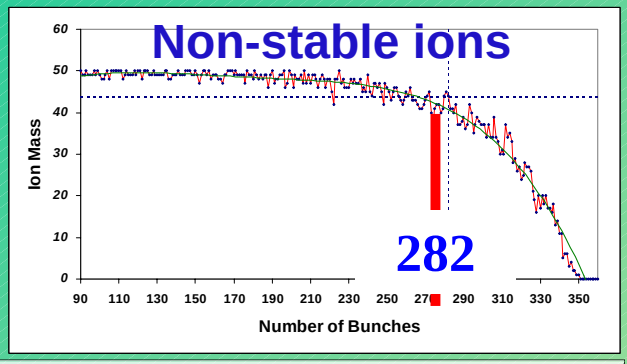
Dynamical Aperture

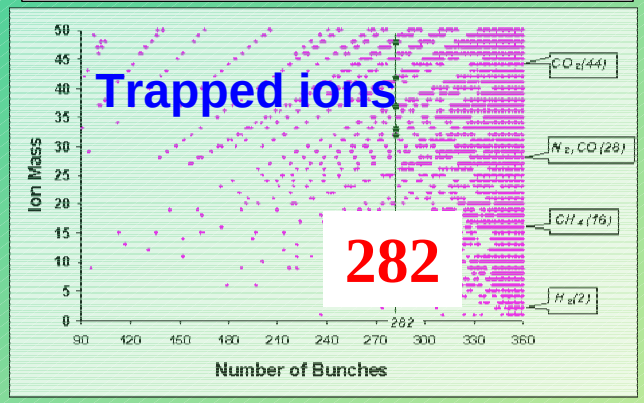


Large oscillations



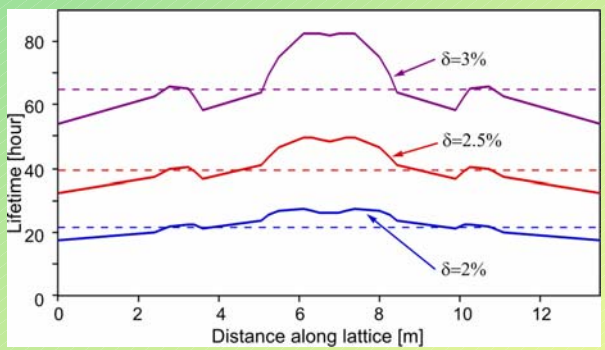
Ion Trapping & Beam Lifetime





Stable ion mass	Residual gas species
-	2, H_2
-	16, CH_4
17	-
-	28 , N_2 , CO
32	-
33	-
37	-
42	-
-	44, CO_2
48	-

Touschek Lifetime –39.4 hours

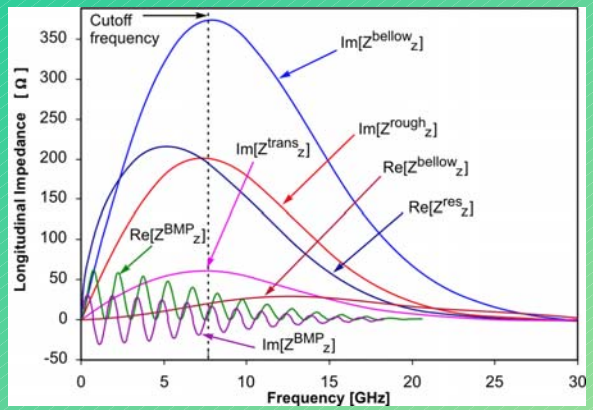


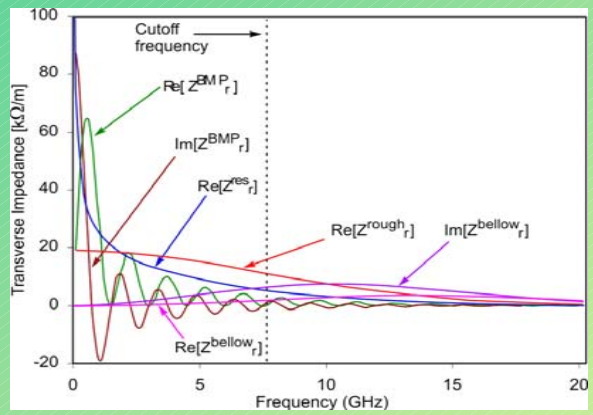
Coupling	1%
Gap Voltage	3.3 MV
Energy Accept.	2.4%
Vacuum	1 nTorr

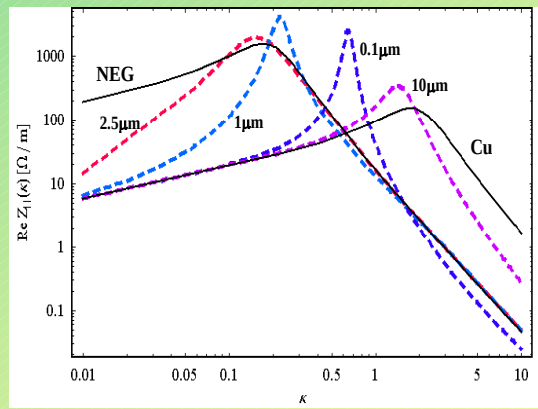
Beam lifetime - 18.4 hours

Ring impedance & Instabilities

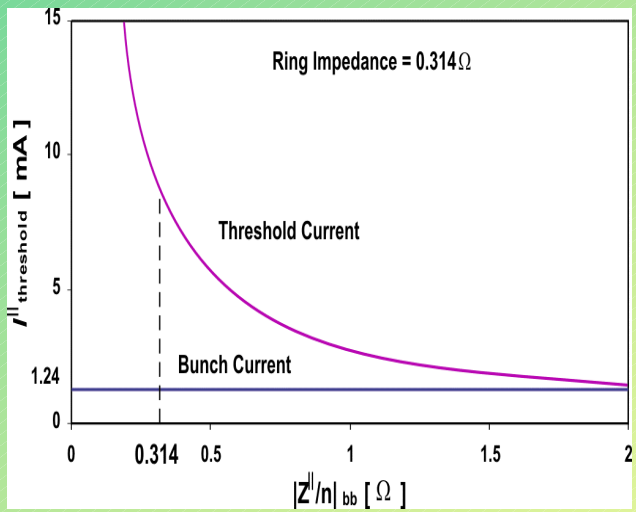
M. Ivanian et al, Phys. Rev STAB-2004

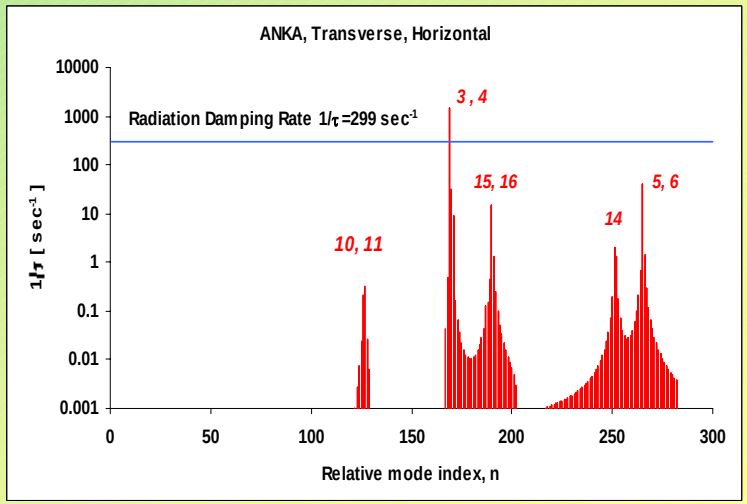






Longit. Imped. - 0.3 Ω **Trans. Imped. - 12.5 kΩ/m** **Undulator Imped.**



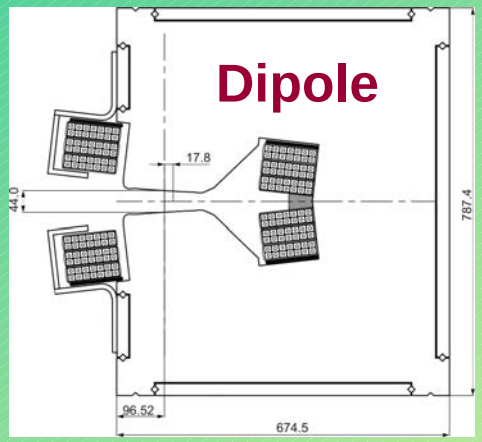


Single bunch Instability

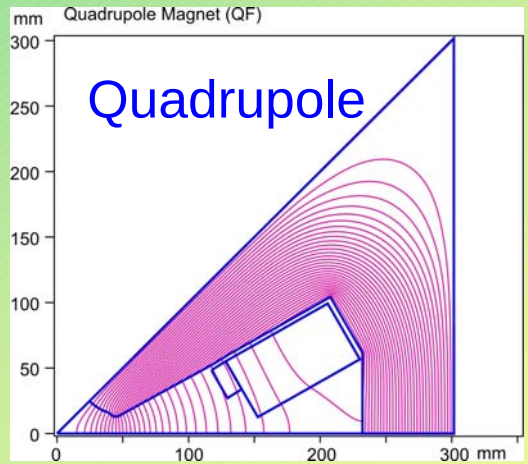
Multi-bunch Instability

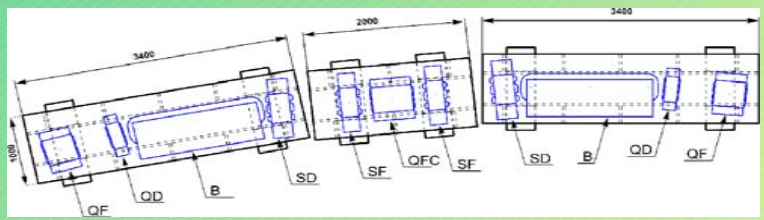
Storage Ring – Magnets

B=1.354 T, G=3.3T/m
aperture=44mm

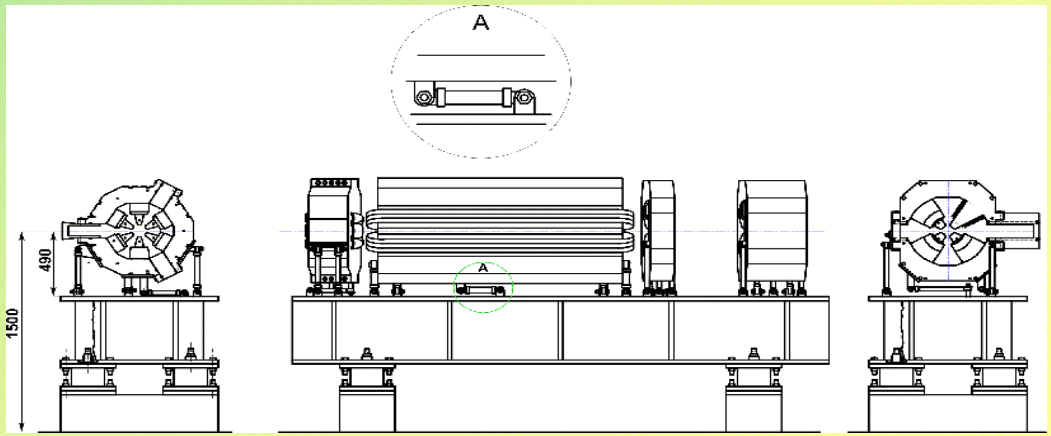


G=20 T/m
aperture=50mm





Magnet supports



Storage ring – Vacuum system

Mater. – Stainless Steel

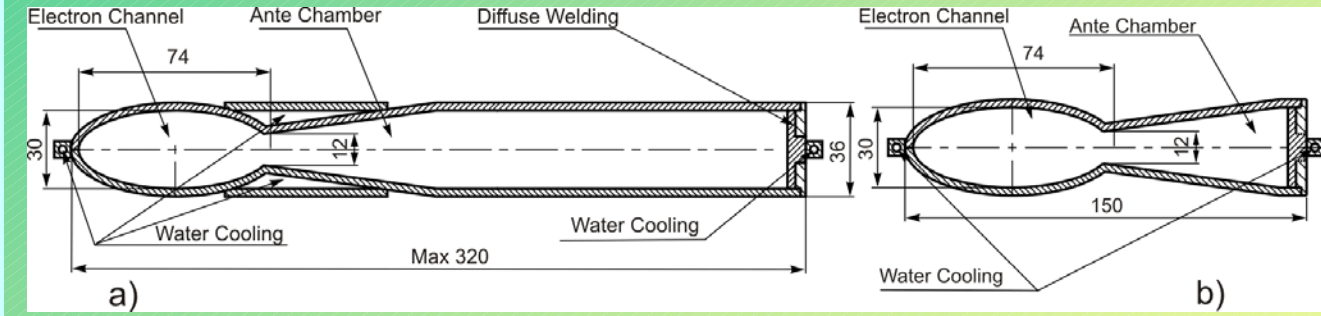
Vacuum – 1 nTorr

Fore-vacuum - 2

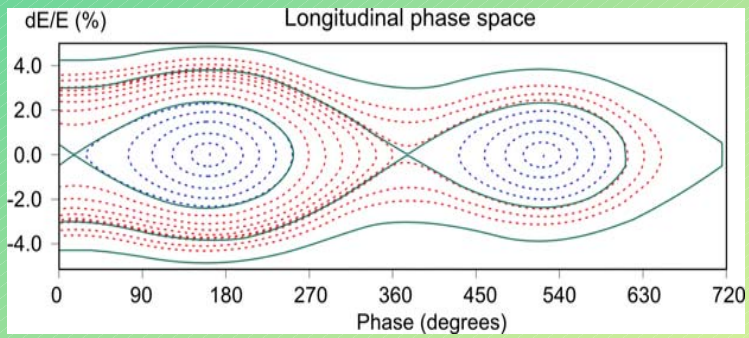
Turbo-molecular – 16

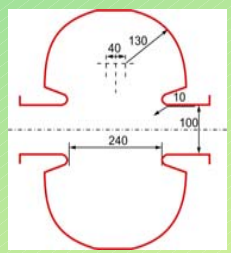
Titan-sublimation – 80

Ion pumps - 64



Storage Ring – RF

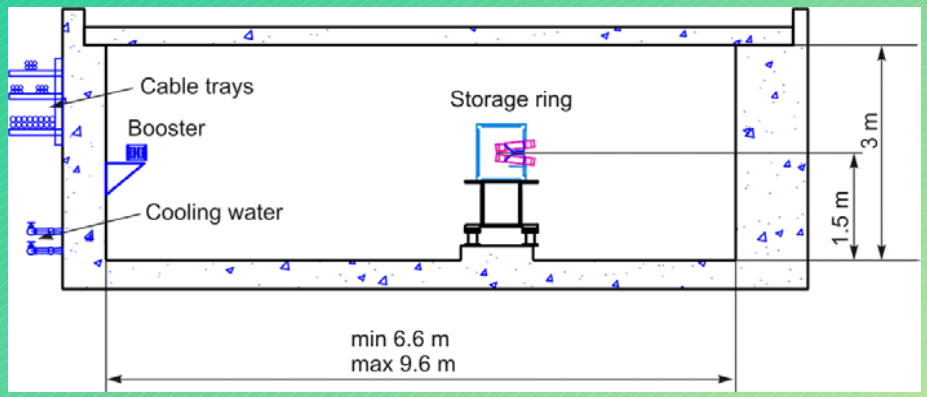




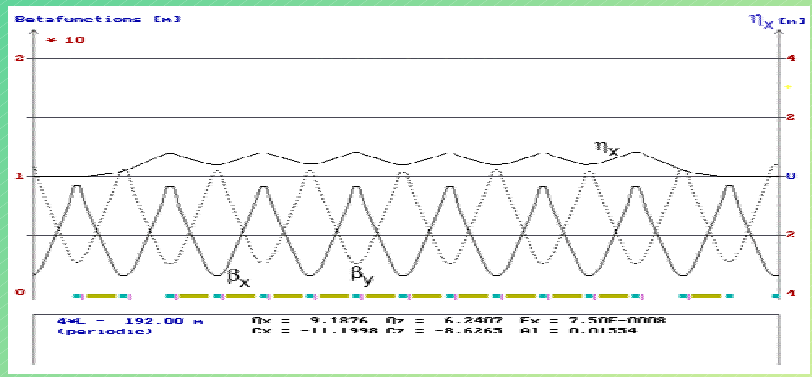
ELETTRA type cavity

Energy loss/turn	0.97 MeV	1.39 MeV
Shunt Impedance	6x3.4 MΩ	
Total RF power	660 kW	830 kW
Gap Voltage	3.3 MV	3.3 MV
Energy acceptance	2.4%	2%
Energy Spread	0.1%	0.1%

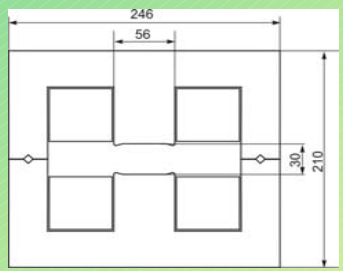
Booster synchrotron

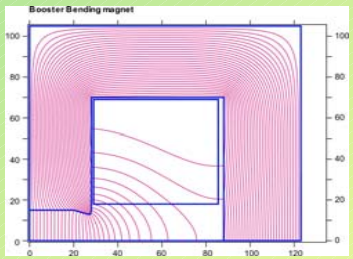


Energy	3 GeV
Pulse current	10 mA
Repetition	2Hz
Circumference	192 m
Emittance	75 nm-rad

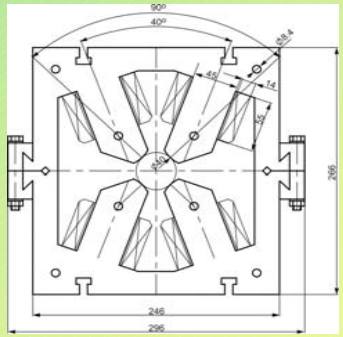


Lattice with missing dipole

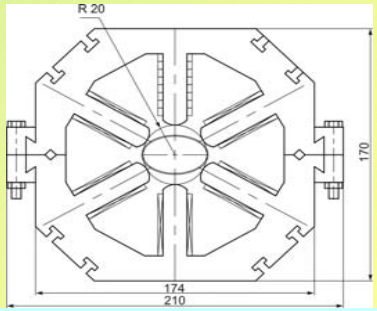




Dipole B=0.024 - 0.72T

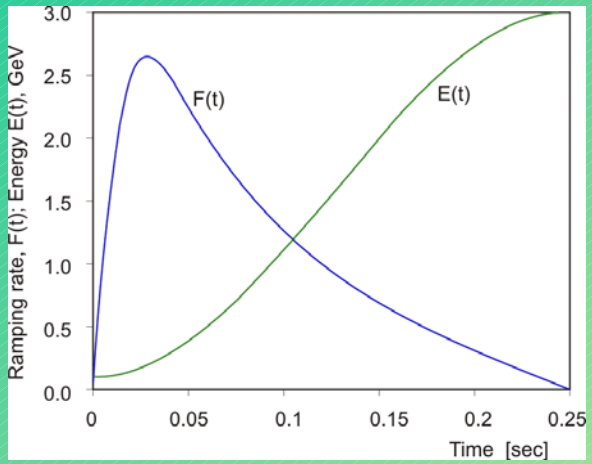


Quadrupole G=10-13 T/m

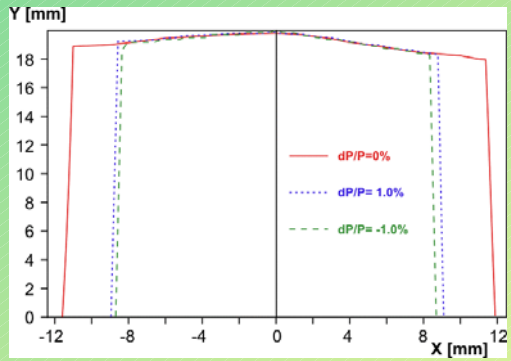


Sextupole S=90/110 T/m2

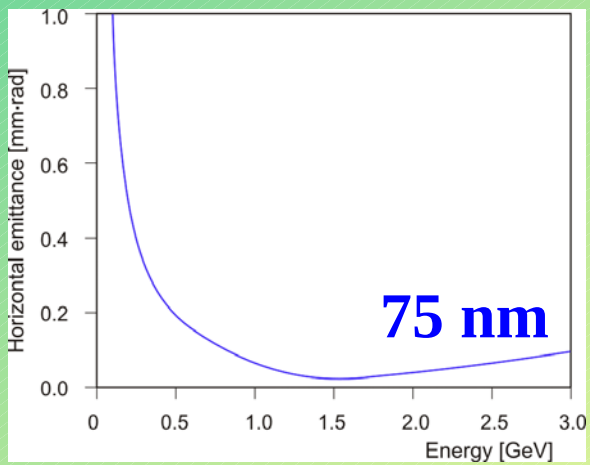
Energy ramp and Injection



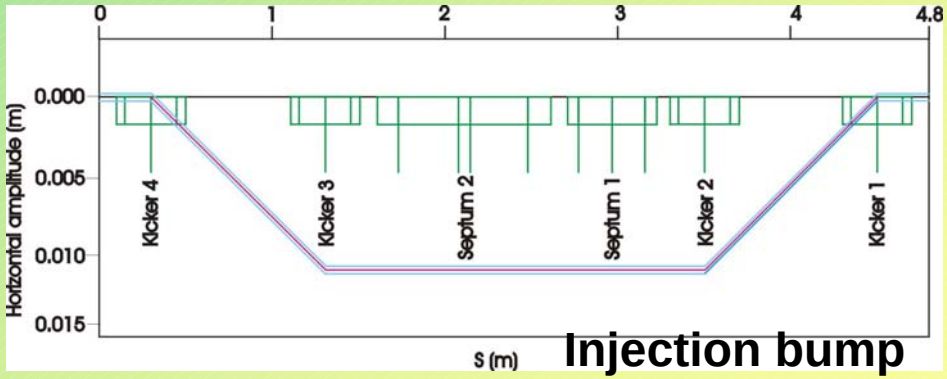
Dipole ramping rate and energy gain



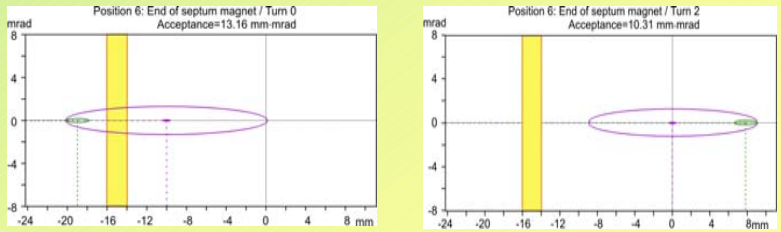
Dynamic aperture



Emittance vs energy

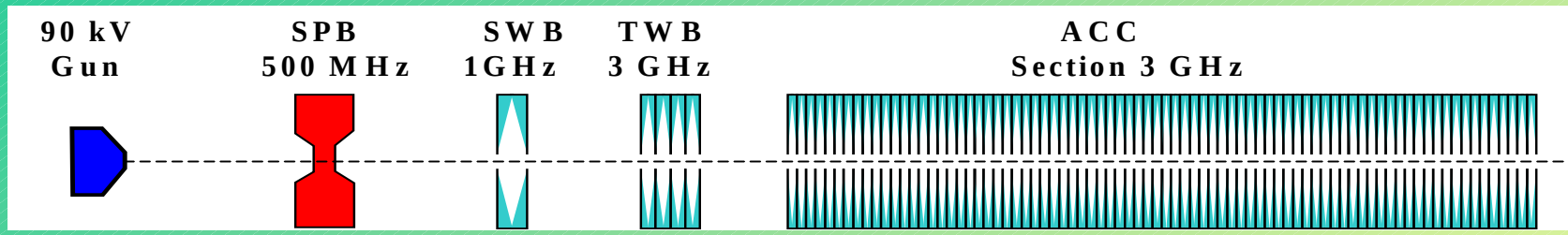


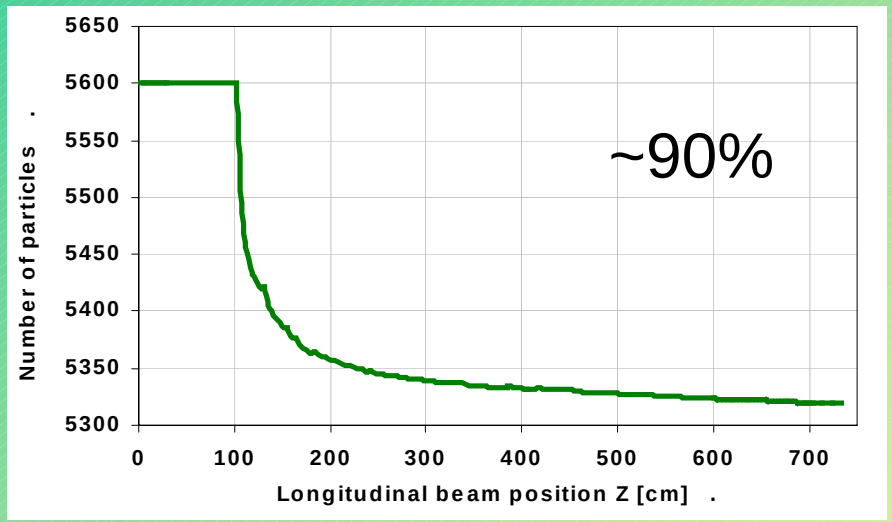
Injection bump

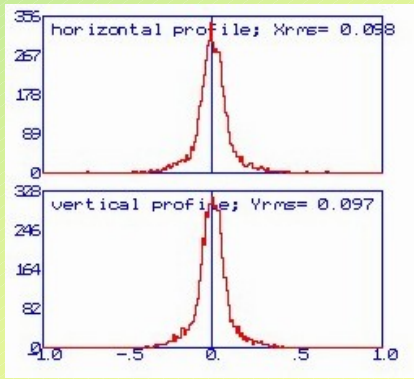


Injected beam: 1 and 3 turns

Linac







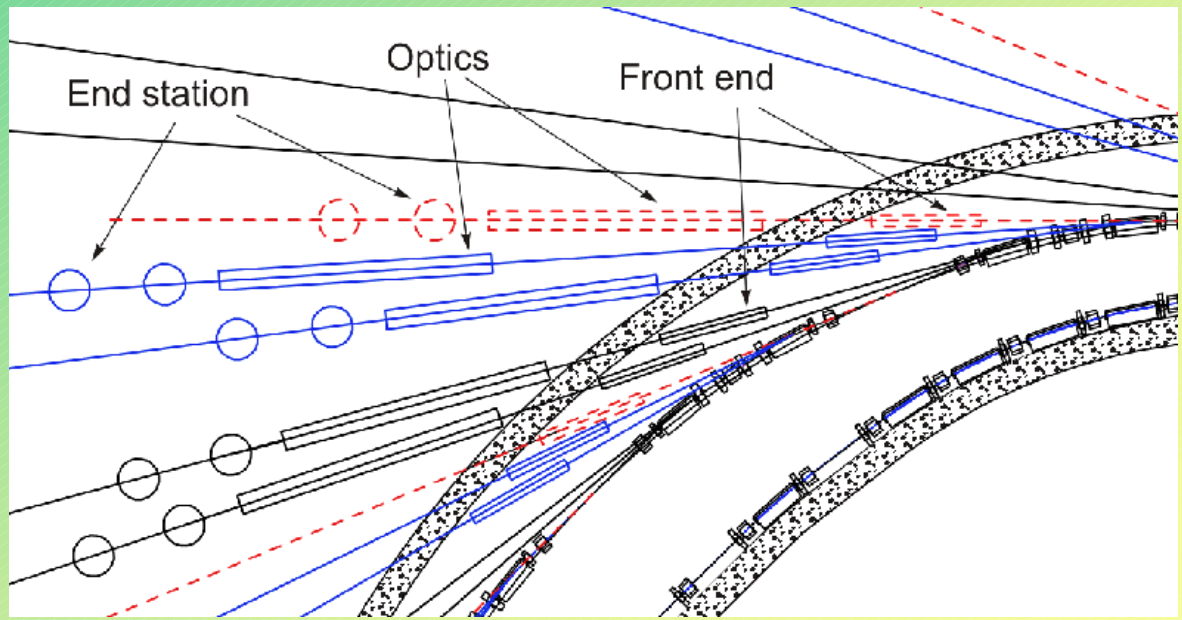
Energy 100 MeV
Current 1- 20 mA
Pulse length 2-600 nsec
Frequency 3 GHz
Energy Spread < 1%
Emittance < 1 mm-mrad

Beamlines

Dipoles – 32
Wigglers – 8
Undulators-4
Exp. Stations ~40

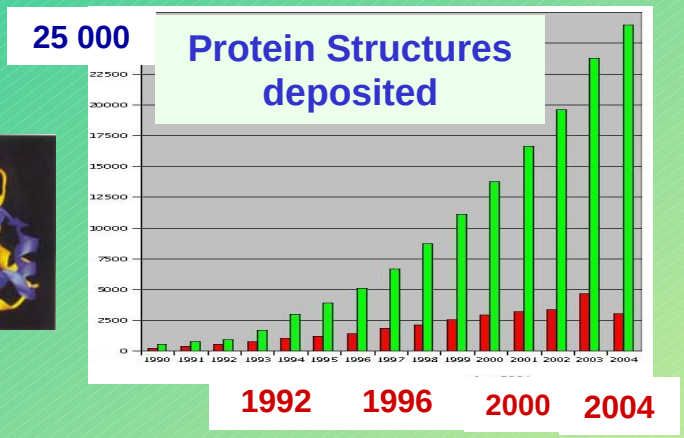
1st Stage

1. Diffraction&scattering (dipole)
2. XAS Beamline (dipole)
3. LIGA (dipole)
4. Imaging Beamline (wiggler)
5. SAXS Beamline (wiggler)
6. Soft X-ray microscopy and spectroscopy (undulator)

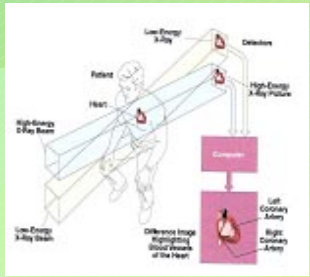


Structural Biology

- *Protein Structure*
- *Drug design*



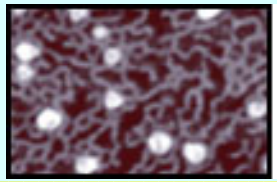
Medicine



- *Angiography*
- *Bronchography*
- *Mammography*
- *Computed Tomography*
- *Photon Activ. Therapy*
- *Microbeam Rad. Therapy*

Physics

- *Macro-molecular physics*
- *High-Temp superconductivity*
- *Physics of nano-particles*
- *Surface physics*



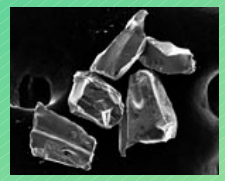
Chemistry

- *Chemical Dynamics*
- *Polymers*
- *Nanoscale chemistry*
- *Biochemistry*
- *Catalytic Interfaces*

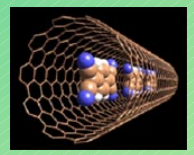
Material Science

3D structure of new material

Crystal growth
New Crystals

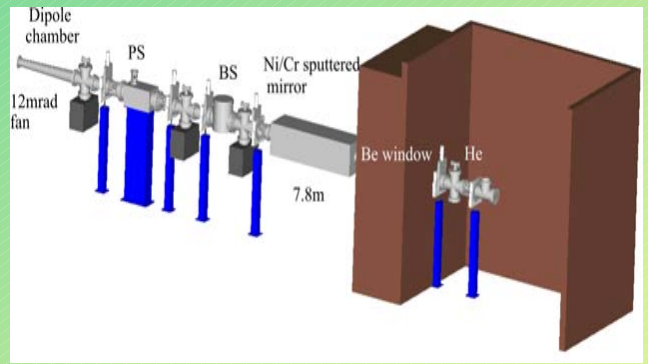


- *Nano-structures*
- *Nano-tubes*

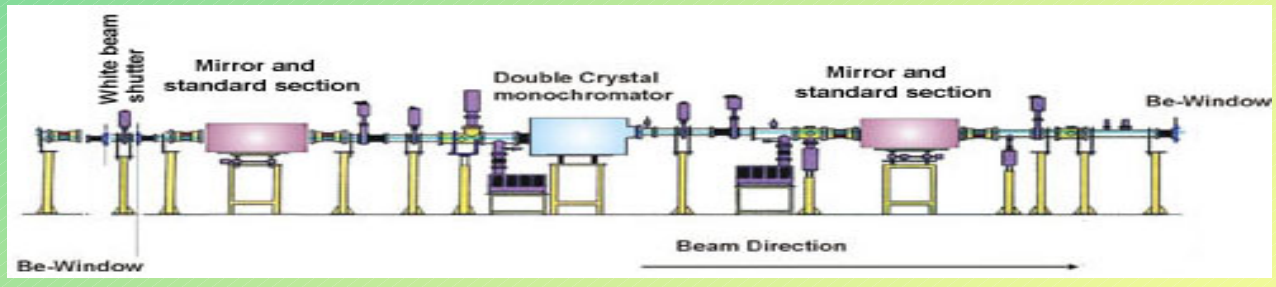


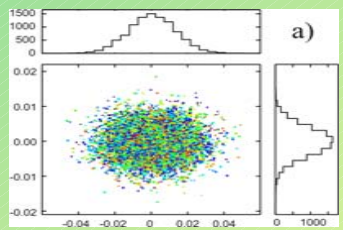
Micro-fabrication

X-Ray Lithography - LIGA

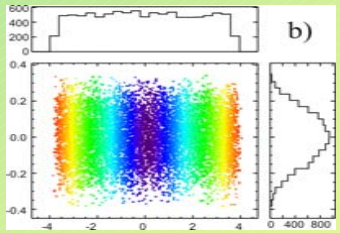


Diffraction & Scattering Beamline

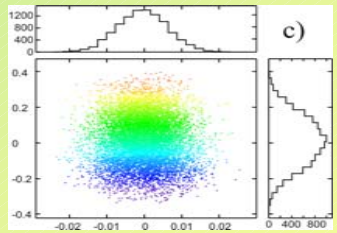




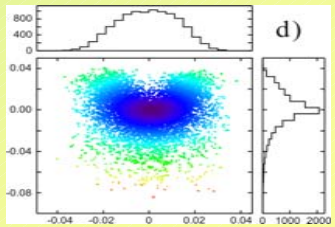
Initial beam



After mirror M1



After DCM



Focused Beam

CANDLE Activity

Review Panel

08 December 2001

01 February 2002

01 July 2002

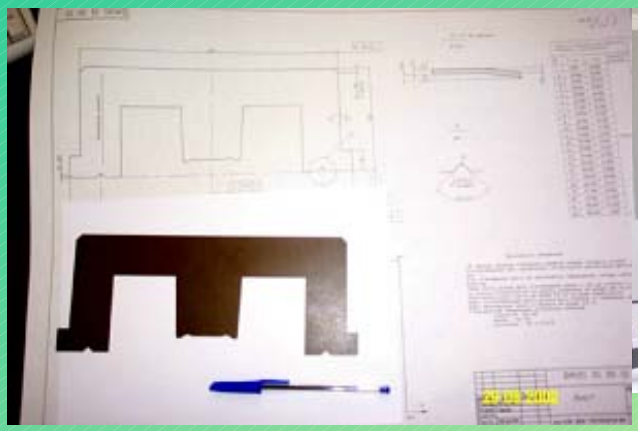
"CANDLE is a world-class project enabling frontier research in a whole spectrum of basic and applied sciences.

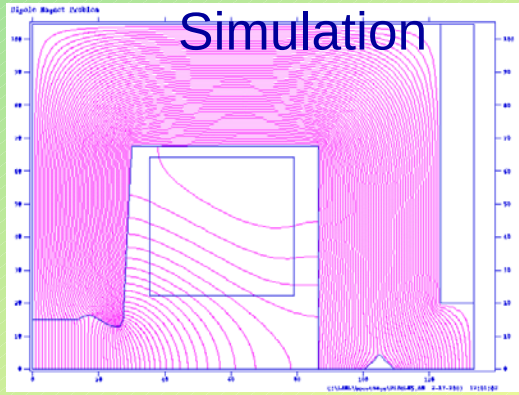
excellent investment from scientific-technical point of view."

From Panel Report

First Magnet

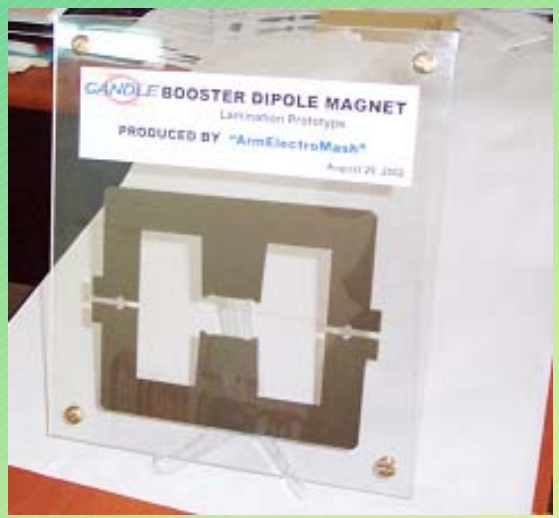
From Design





To Fabrication

ArmElectroMash



May 27 , 2003

MADE IN ARMENIA

Proposals

- Total number of proposals – 82
- Number of Scientists - 284
- Number of Institutes - 41
- Countries - 7

Armenia, England, Germany, Georgia, France, Russia, USA

Fields :

Physics, Biology, Medicine, Chemistry, Environment, Material science,

"From a review of the 69 experimental proposals , it is clear that strong Armenian user community will emerge as the facility is readied"

From Panel review

International Collaboration

Armenia, Germany, France, Italy, USA, Russia, Bulgaria, Greece, Georgia

European Round Table for SR and FEL

International Atomic Energy Agency

- *Letter of Supports*
- *Memor. of Understanding*
- *Collaboration Agreements*

CANDLE Review

- *CANDLE is a place where investment might lead to a major improvement in S&T infrastructure in Armenia.*

US Commission on S&T in Armenia, Nov 2004

"An Involvement of the Union in the Armenian CANDLE project would be a sign of encouragement to this project which concerned chiefly the European scientific teams "

European Union

***Amendment 102,* European Parliament, 26 Feb 2004**

International Committee of Future Accelerators
Future Light Sources Sub-Panel of the Beam Dynamics Panel

May 18, 2006
Statement of Support on CANDLE project

18 May 2006

Sub Panel recommends to international and local organizations

- *to include CANDLE in the priority list of projects conducted in Armenia*
- *start the pre-construction stage*

DESY Contribution

RF Components for 100 MeV Linac

Jan –Mar

2007

150 MW S-Band Klystron

7 MW Klystrons

Establishment of RF laboratory and RF Test Stand

University of Region de Provence

France

UNIVERSITE DE PROVENCE
(AIX-MARSEILLE I)
SECRETARIAT GENERAL - DIVISION DE LA RECHERCHE
CONSEIL SCIENTIFIQUE
Séance du 13 décembre 2002

IT DU REGISTRE DES DELIBERATIONS

Centre pour l'Avancement des Découvertes Naturelles en
LE) » en ARMENIE

e le projet : il rappelle que la lumière synchrotron permet de
ntifiques, médicaux et technologiques. Le projet est porté par
utenu par l'UNESCO, et consiste à construire à EREVAN, une
États unis soutiennent financièrement le projet. M. LE LAY,
tallation d'un synchrotron sur le plateau de l'Arbois, a pris
ctivités territoriales et de la forte communauté arménienne de la
er. Une aide sera également demandée à la Communauté
versités est un soutien scientifique. Les liens entre l'Université
tive du Président de l'Université, M. KAFTANDJIAN se sont
son avec l'université d'EREVAN en 1994.

mité son intérêt pour le projet CANDLE et lui apporte son

Pour extrait certifié conforme,
Marseille, le 23 MAI 2003
ar le Président et par délégation
ecrétaire Général de l'Université
Gérard BARBERAN

MEMORANDUM OF UNDERSTANDING

on the establishment of the international collaboration between the
Universities of Region Provence (France)
and the
Center for the Advancement of Natural Discoveries using Light Emission (Armenia).

On the occasion of the visit of Prof. Jean Marc Layet, Prof. Guy le Lay, Dr. Georges Terzian (Université de Provence in Marseille) and Prof. Patrick Soukiassian (Université de Paris-Sud/Orsay) to CANDLE laboratory in Armenia, 3-11 April 2003, discussions taken place during the meetings, the following memorandum of understanding is considered to be an important stage for the establishment of international cooperation on the creation and usage of the CANDLE facility.

CANDLE is a world-class 3 GeV intermediate energy 3rd generation synchrotron radiation facility that will provide high brightness photon beams ranging from the UV to hard X-Rays. The facility will be capable of providing the frontier research in such diverse fields of science and technology as structural biology, bio-informatics, physics, medicine, chemistry, material and environmental sciences, microfabrication and nanotechnology. The facility is considered to serve an international center with the large involvement of scientific groups from all over the world.

The creation of such facility in the region opens an excellent opportunity for the cooperative research programs between scientific institutions and high-technology related organizations of both parties to perform frontier researches leading to advance scientific and technological achievements. The collaboration will include:

- An establishment of joint research groups on Laboratories and Universities level;
- Organization of joint seminars and workshops on synchrotron radiation usage;
- Development of the beamline instrumentation and end stations for CANDLE;
- Development of the research programs to be conducted on CANDLE.
- Exchange of specialists and training of young scientists.

The success of the collaboration, especially at the initial stage of the project, needs a wide promotion among the scientific community with the aim to establish a corresponding infrastructure of the CANDLE oriented user community according to world-class standards developed in other similar laboratories in Europe and the USA.

We are excited with the outlooks that CANDLE opens for the broadband scientific research and are confident that a strong user community will be developed for this new state-of-the-art synchrotron radiation facility.

Professor Jean-Marc Layet
Dean of the Department "Scienc
Université de Provence in Marsei
France

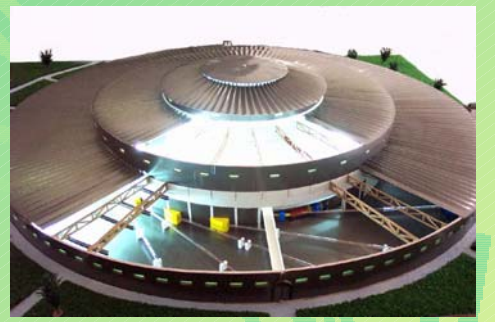
Support to the CANDLE project and express of interest in

- ***Biotechnology***
- ***Nanotechnology***

A natural byproduct of CANDLE

- **Renewal of the scientific standards to its past world-class level**
- **Employment of young and mature scientists**
- **Reverse of the brain drain**
- **World standard education**
- **High technology development**
- **Regional and world-wide cooperation**

Welcome to CANDLE



- International Laboratory
- User Friendly Environment
- World Class Research

I strongly support the CANDLE Project.

Just today the French Synchrotron SOLEIL has officially started to operate for the use of Scientific Discovery for which CANDLE would be a valuable tool.

BRUNO ZOTTER,
***CERN,* GENEVA, SWITZERLAND**