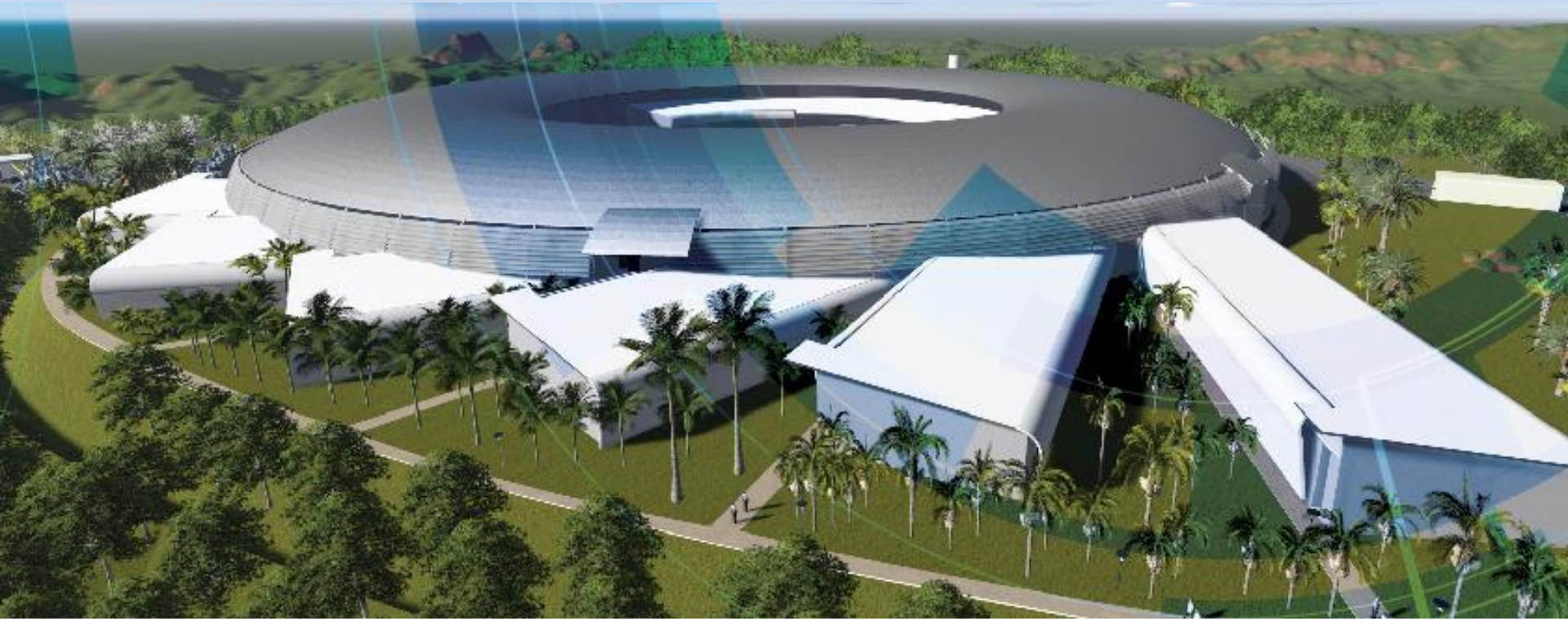
Sirius, the New Brazilian Synchrotron Light Source



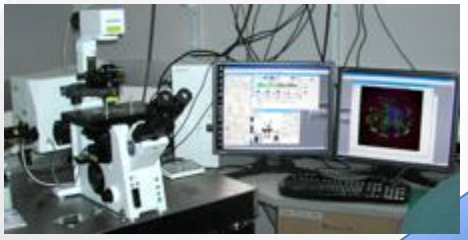
Antonio José Roque da Silva – jose.roque@lnls.br

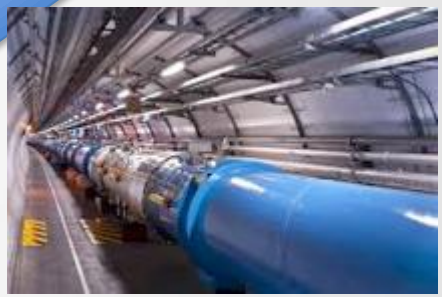
- Why and what is synchrotron radiation
- LNLS and CNPEM
- Sirius
- Conclusions

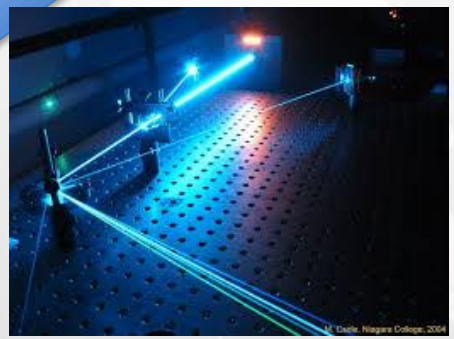
WHY SYNCHROTRONS?

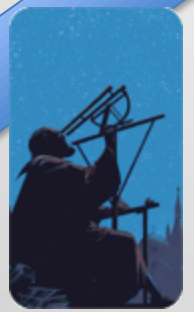
- 4ª Geração em Construção
- 3ª Geração em Operação
- 3ª Geração em Construção
- 2ª Geração em Operação

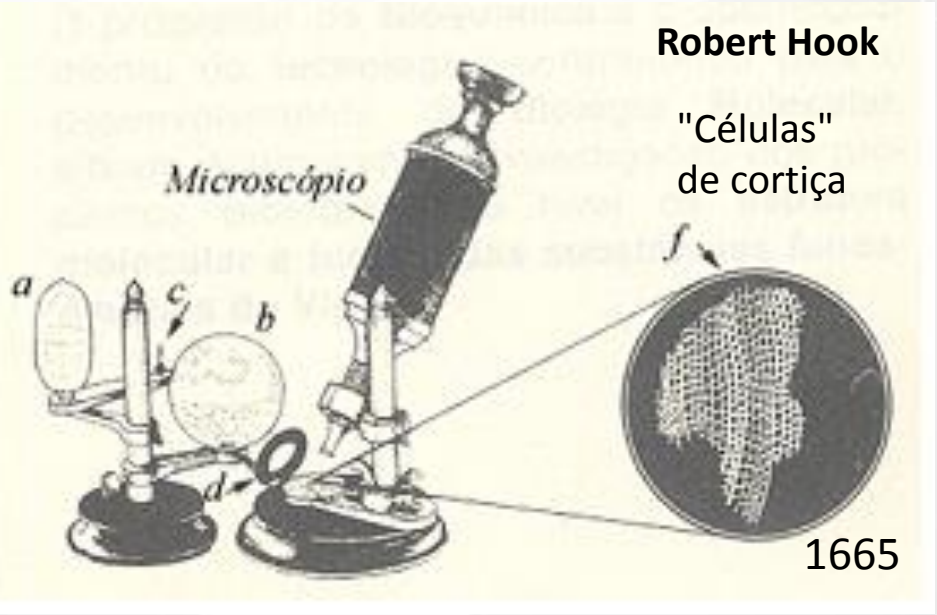
Evolution of instruments ⟷ **Evolution of knowledge**











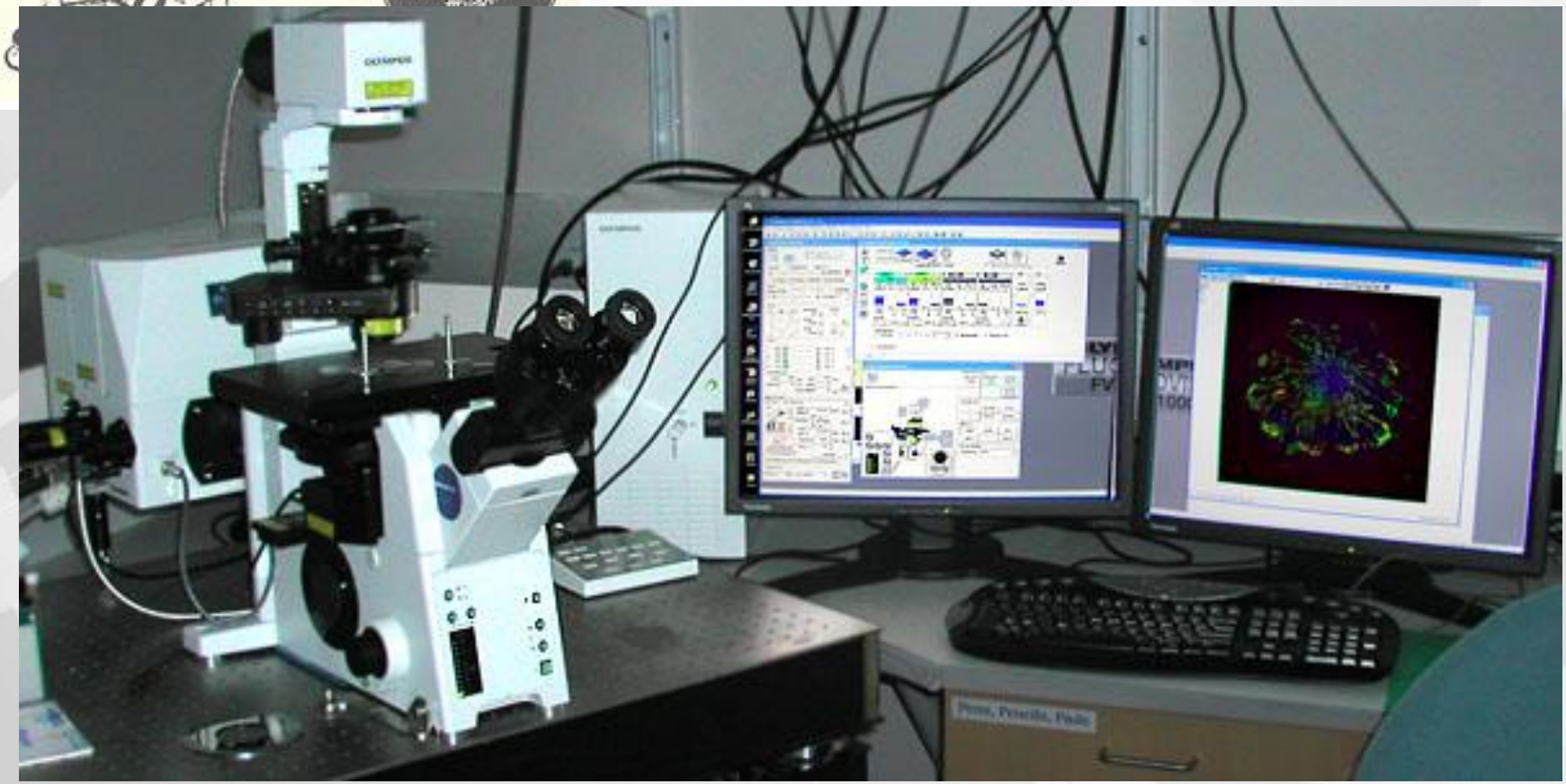
Robert Hook

"Células"
de cortiça

1665

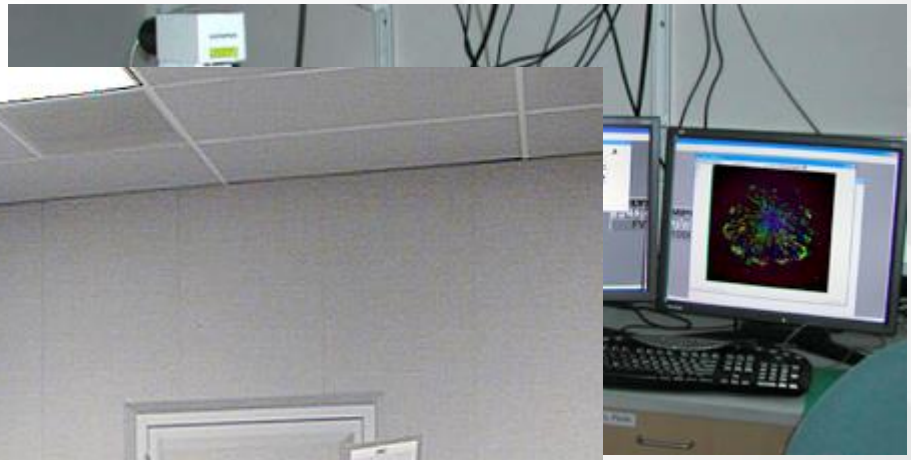
"...by the help of Microscopes, there is nothing so small, as to escape our inquiry; hence there is a new visible World discovered to the Understanding..."

Robert Hook
"Células"
de cortiça

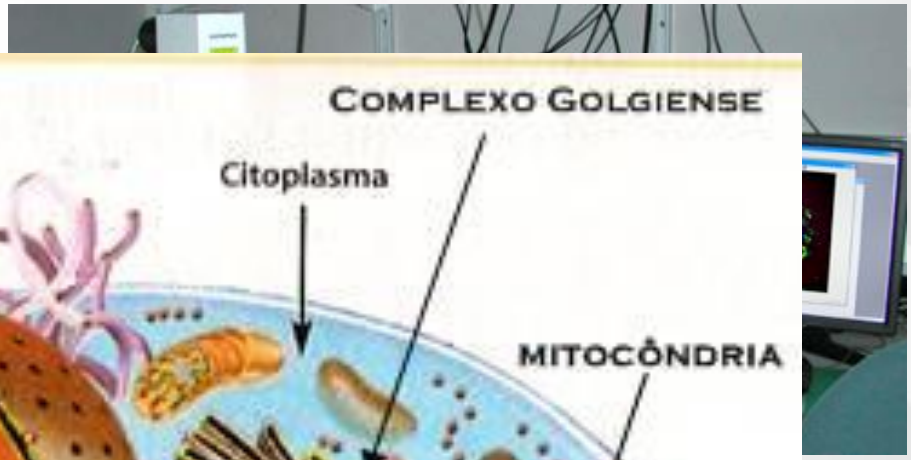


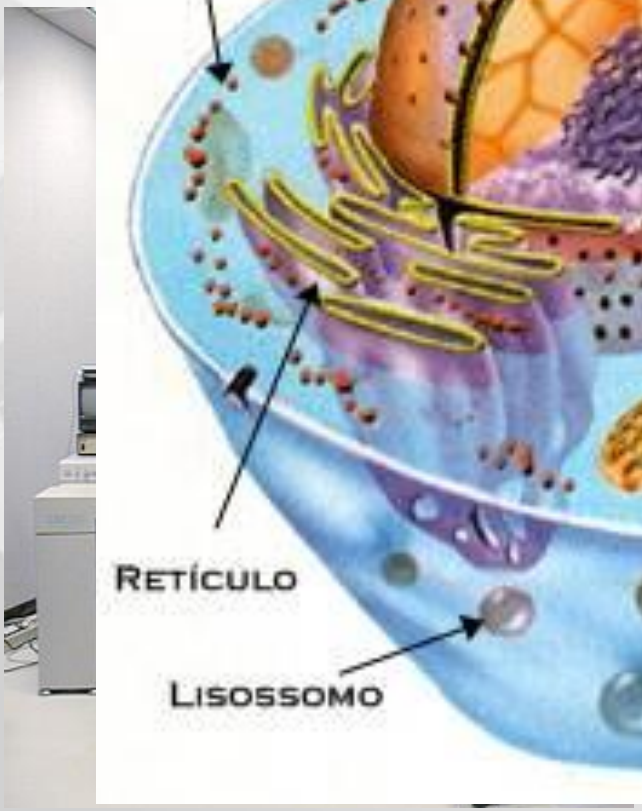
Robert Hook

"Células"



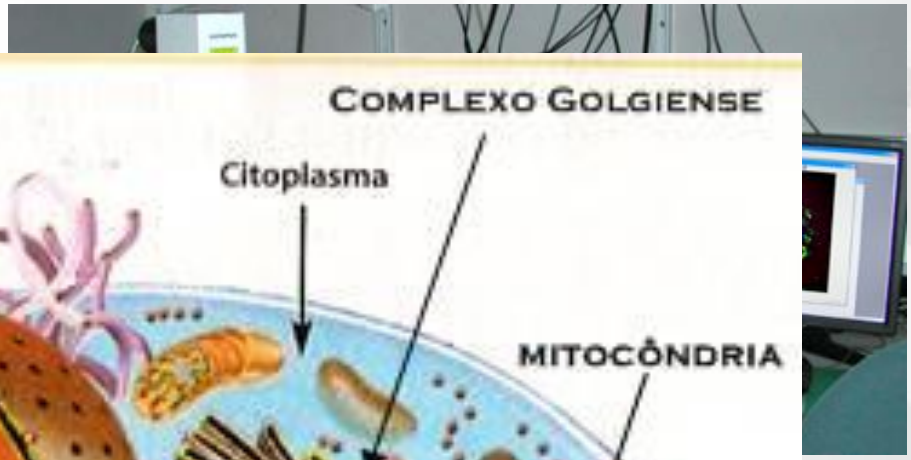
Robert Hook

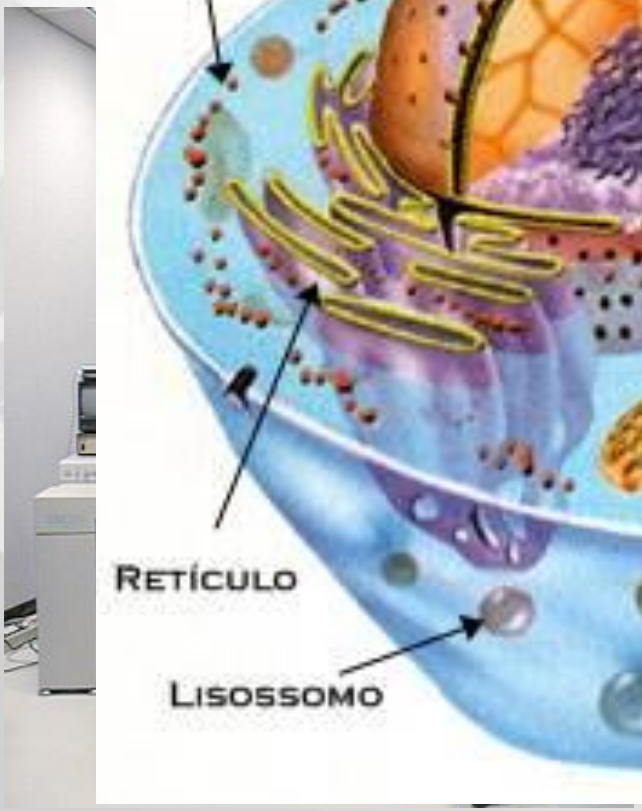




Núcleo
Membrana plasmática
Complexo Golgiense
Citoplasma
Ribossomo
Mitocôndria
Retículo
Lisossomo
Centríolo

Robert Hook





Membrana plasmática
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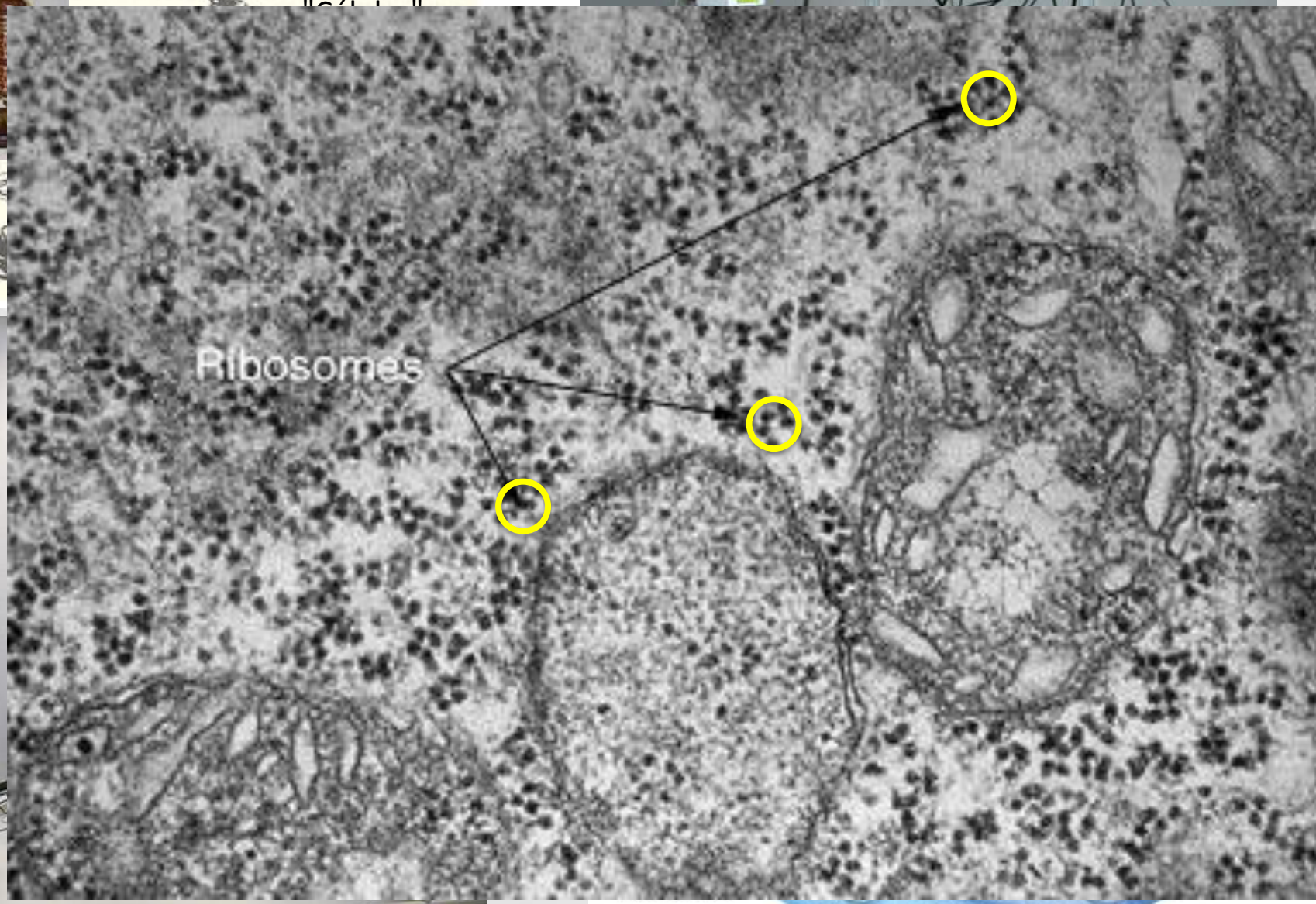
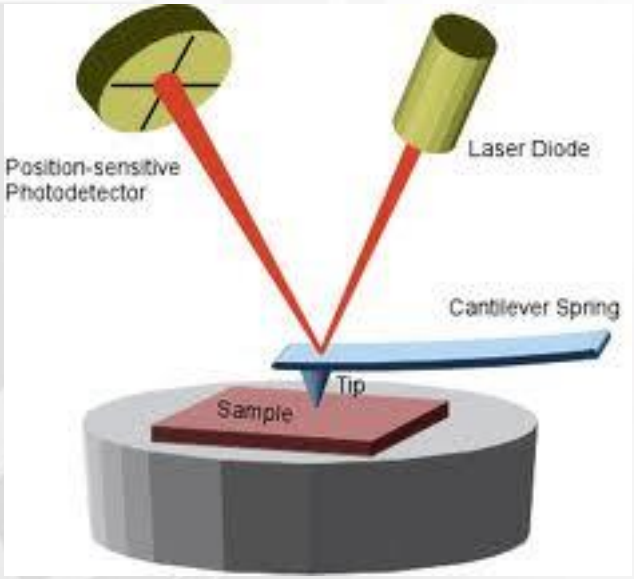
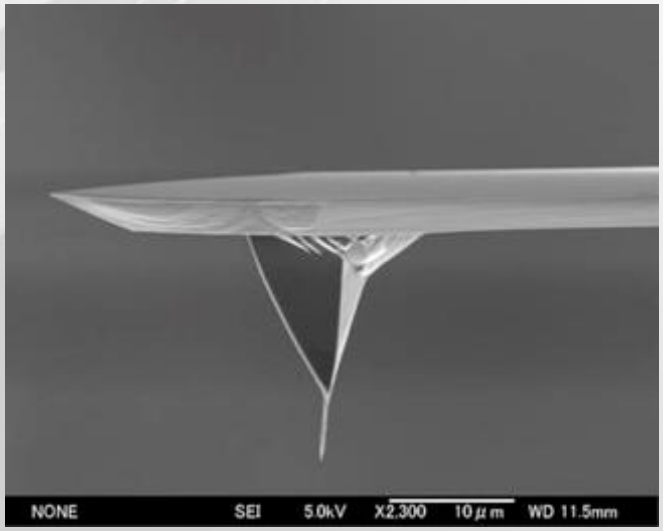
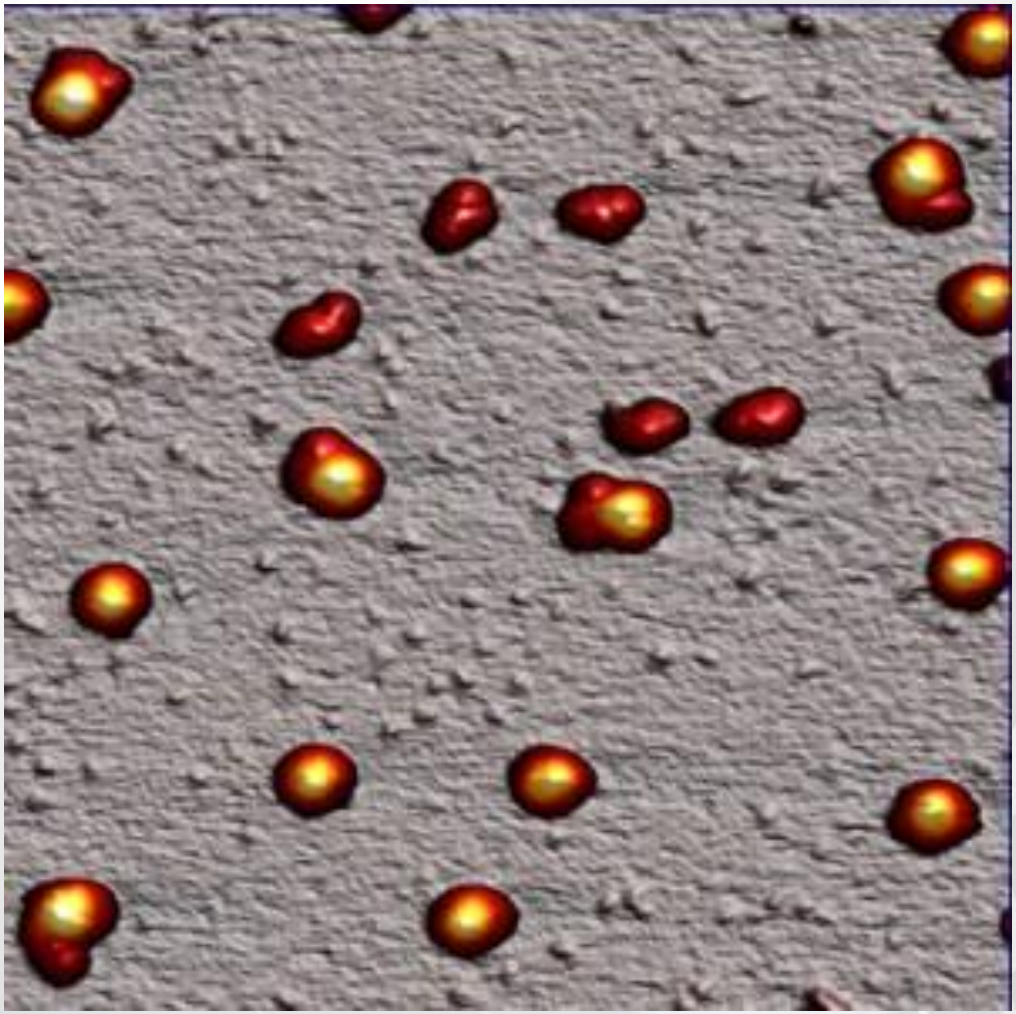


ATOMIC FORCE MICROSCOPY (AFM)

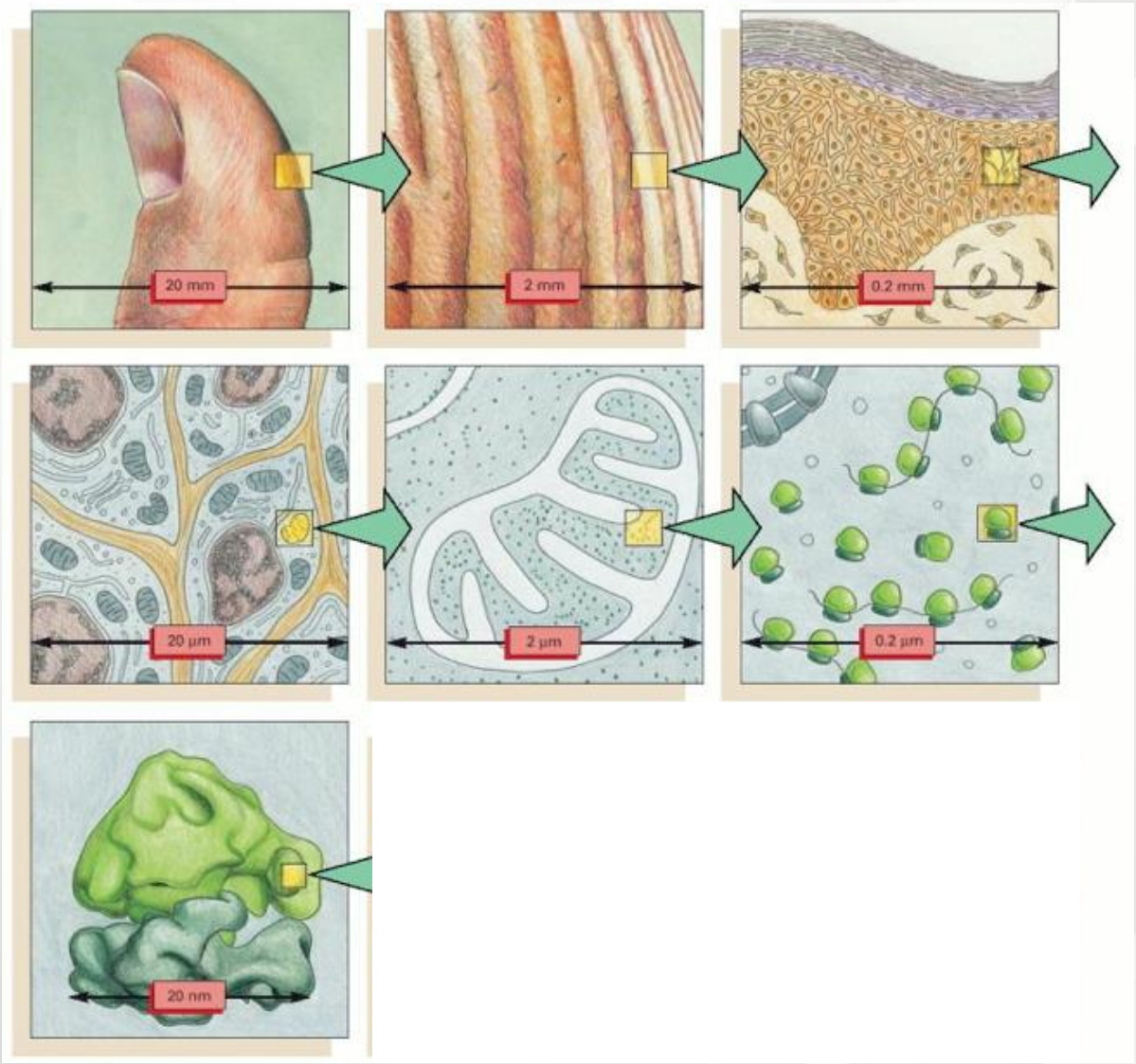




Ribossomo (0.36x0.36 µm^2)



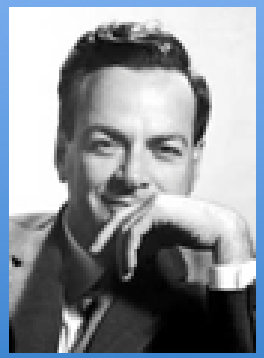
But how to really know how the ribosome works?



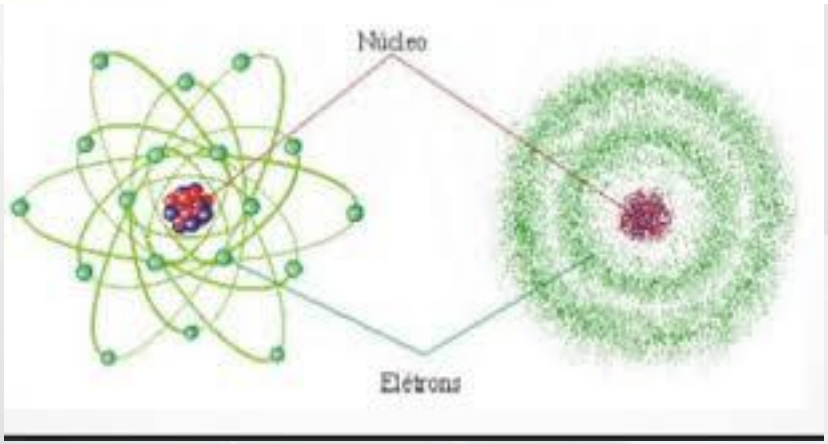
All things are made of atoms!

Richard Feynman

"If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis that ***all things are made of atoms***..."

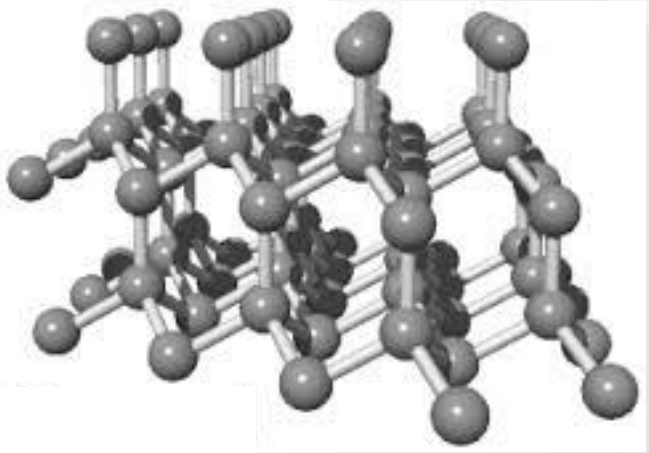


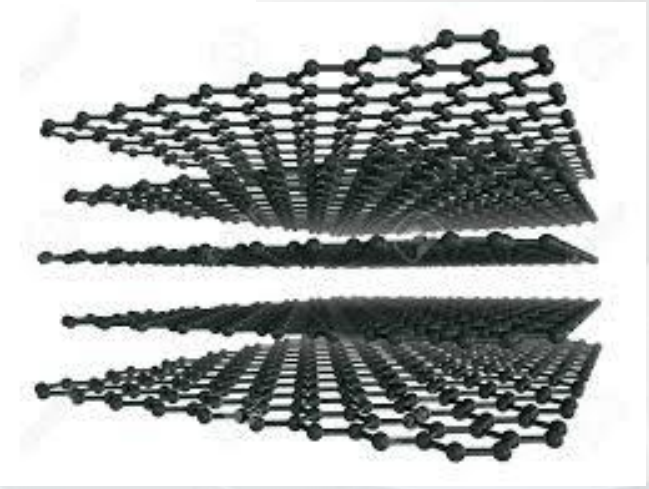
Richard P. Feynman



Which atoms and how they are organized in space determine the properties of materials ⇒ Atomic Structure

Diamond x Graphite ⇒ Only Carbon atoms!





Today, in an world ever more competitive scientifically and technologically, deep knowledge of materials properties is fundamental

Nanotechnology

Chemistry

Civil construction

Health

Biotechnology

Energy

Food

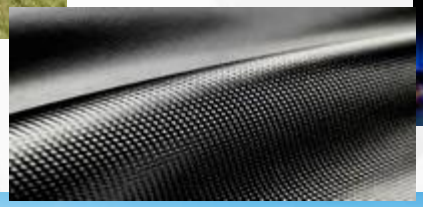
Agriculture

Environment

New Materials

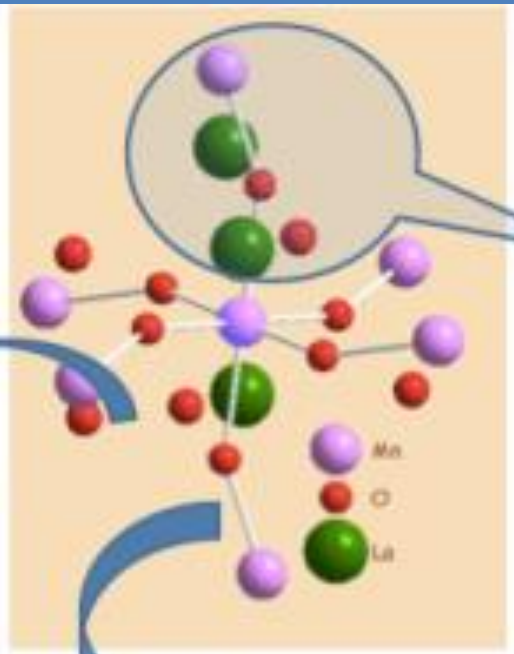
Aerospace and automobile industries

Textile



Today, in an world ever more competitive scientifically and technologically, deep knowledge of materials properties is fundamental

Nanotechnology

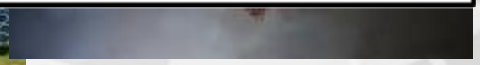


Kinds of atoms, chemical environment, local structural arrangement

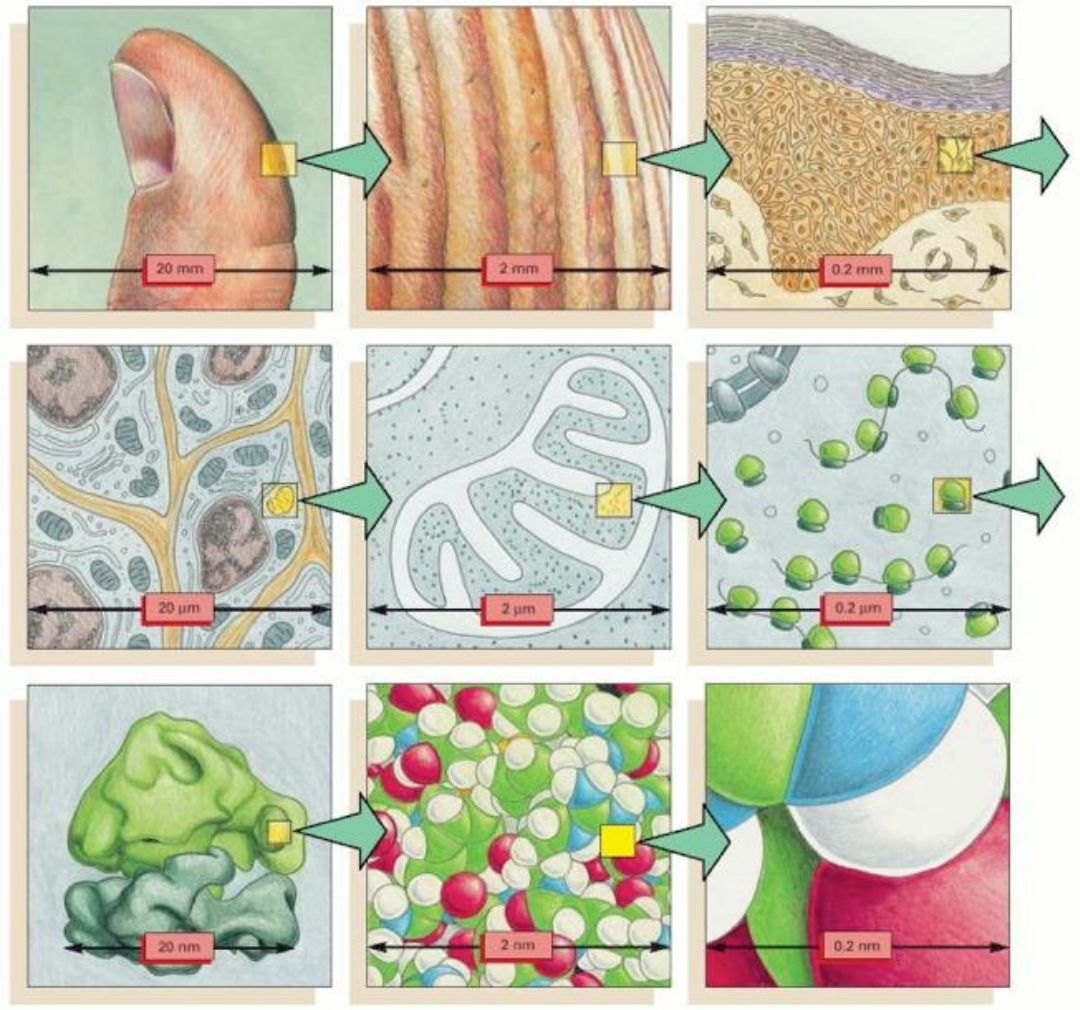
Distance between the atoms

Chemical bonds, electronic structure

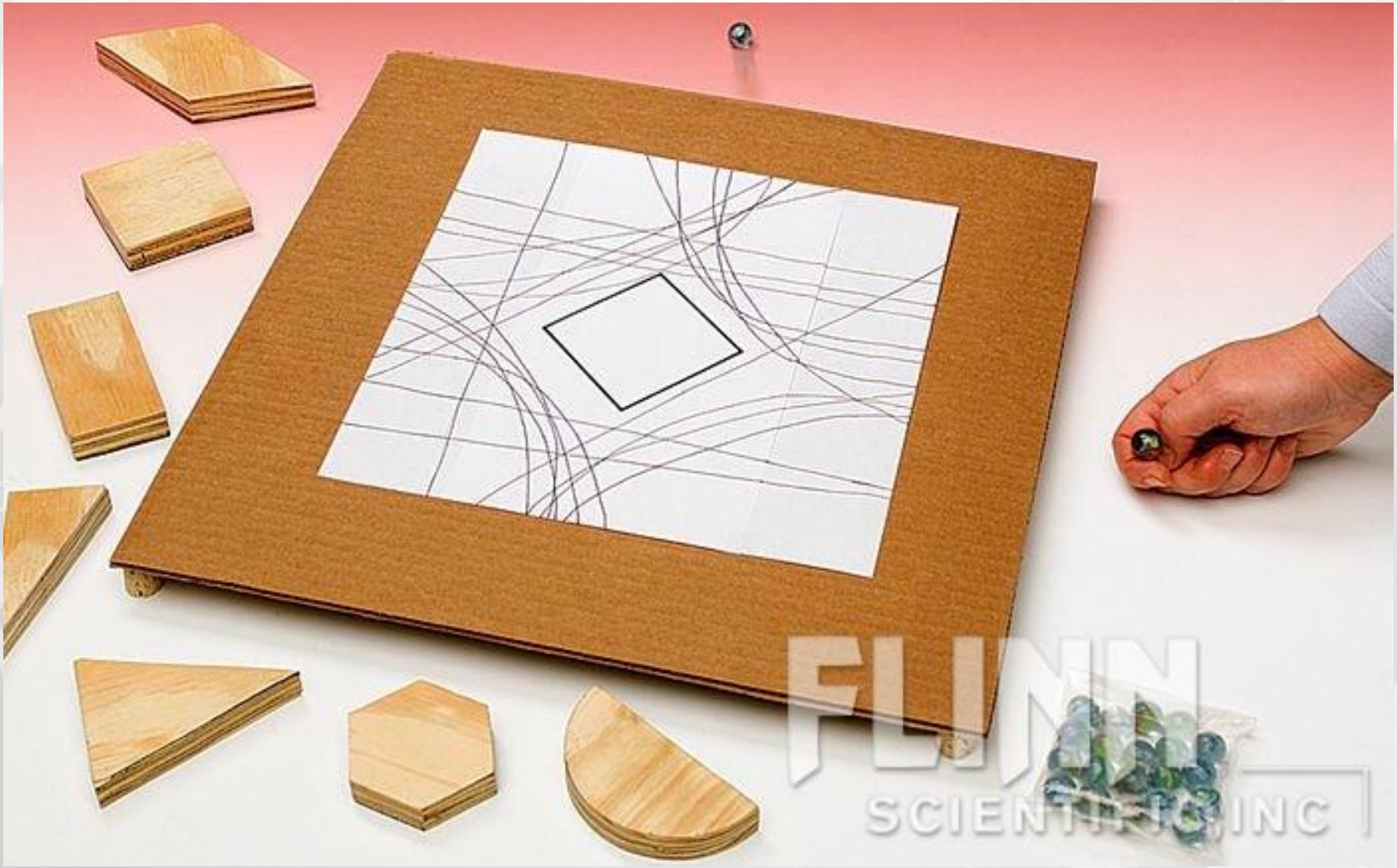
We need to obtain information about materials and processes at the atomic level, and in real conditions ⇨ special tools are needed



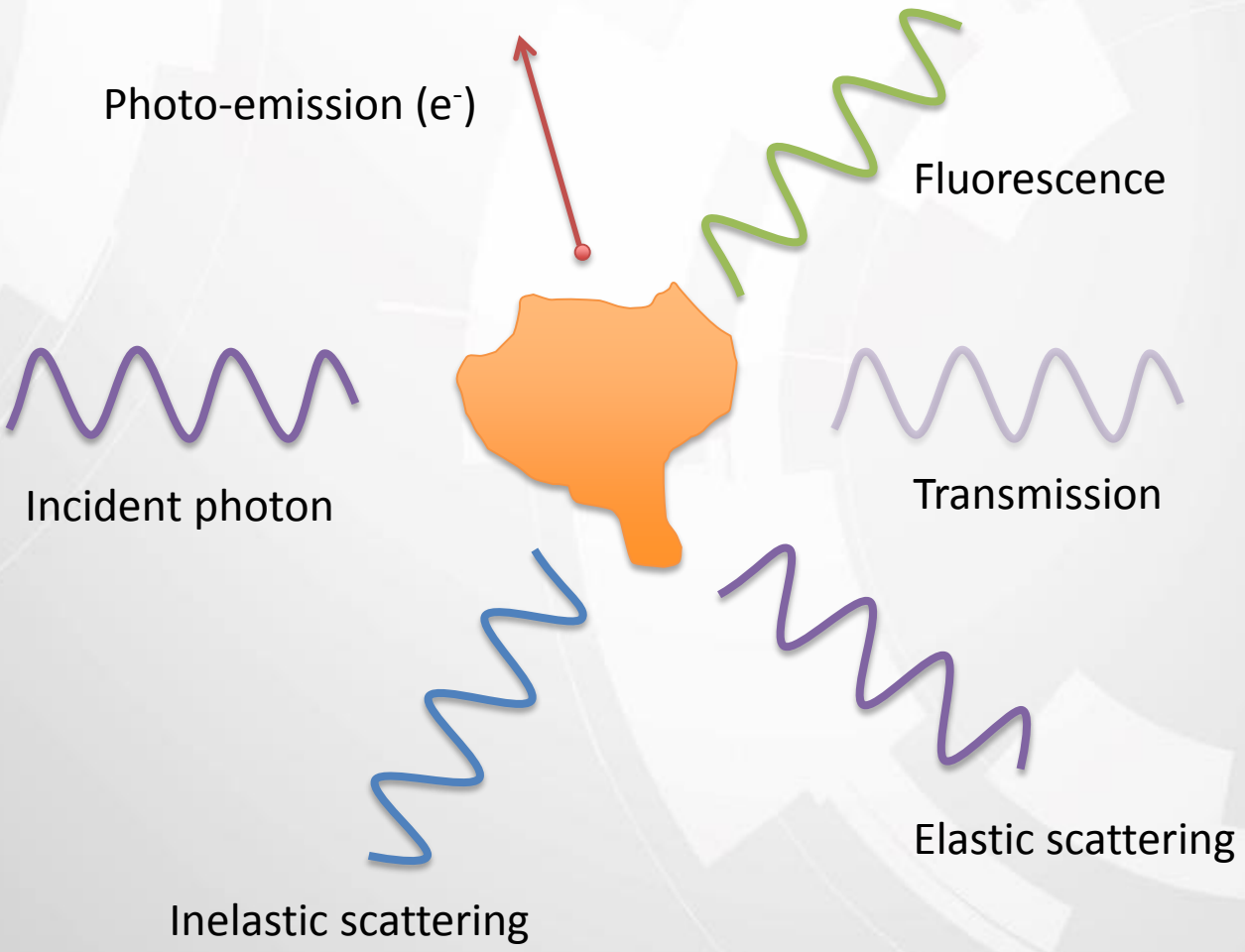
How to know the atomic structure of the ribosome?
Or of any other material, organic or inorganic?
How to ”see” at this scale?



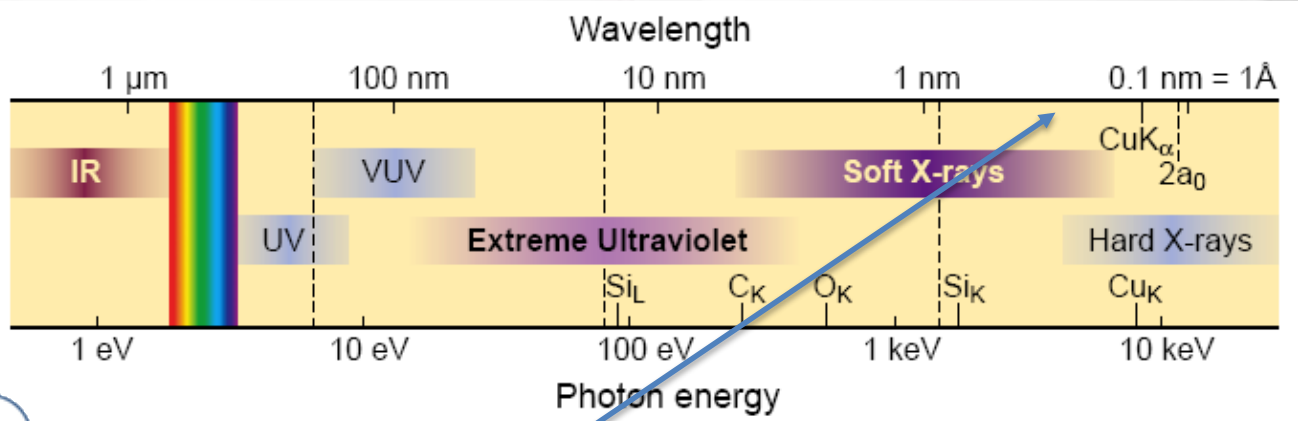
“Throw things” – electrons, neutrons, electromagnetic radiation (photons), etc. – at objects is on of the most common ways to learn about them.

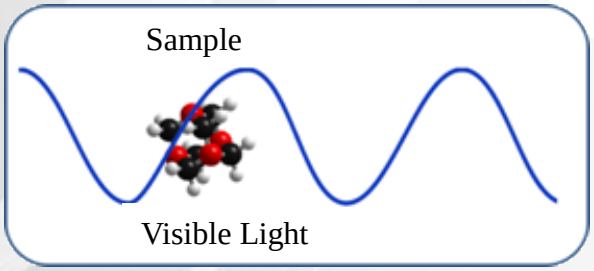


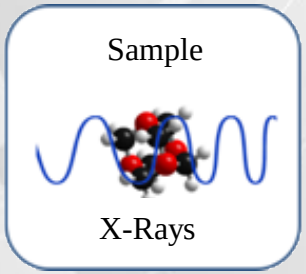
Electromagnetic Radiation
(one efficient way to investigate the structure of matter)

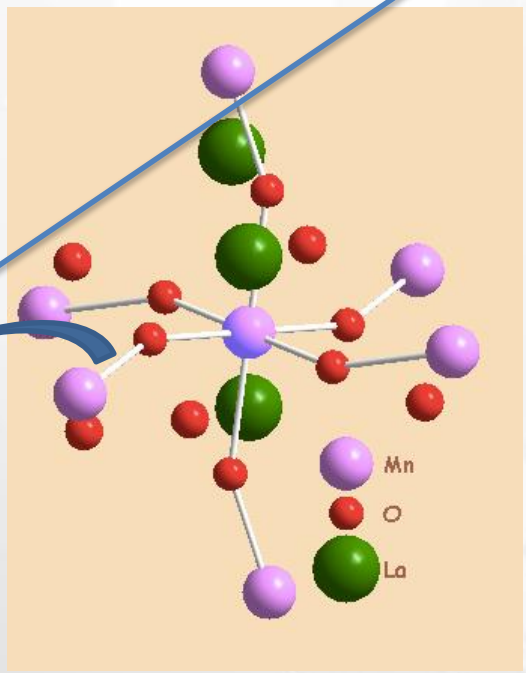


Which wavelength?



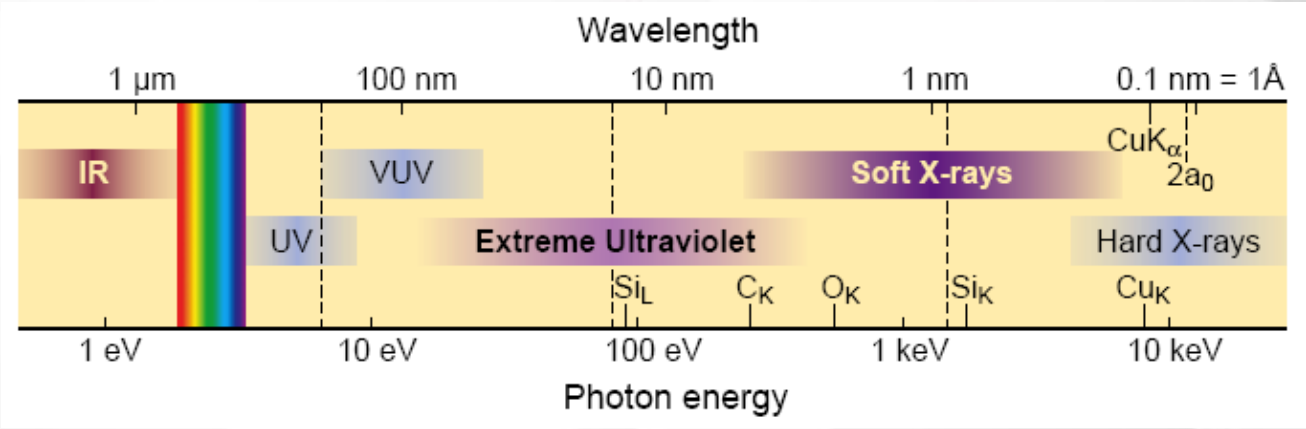


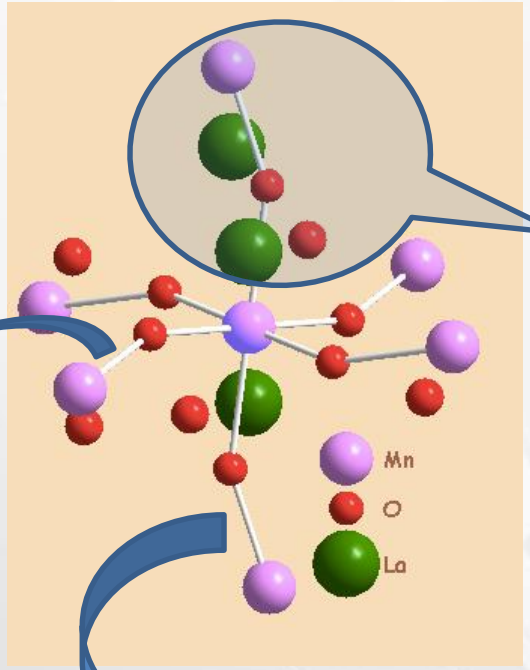




Distance between atoms
≈0.2-0.4 nm

Which wavelength?

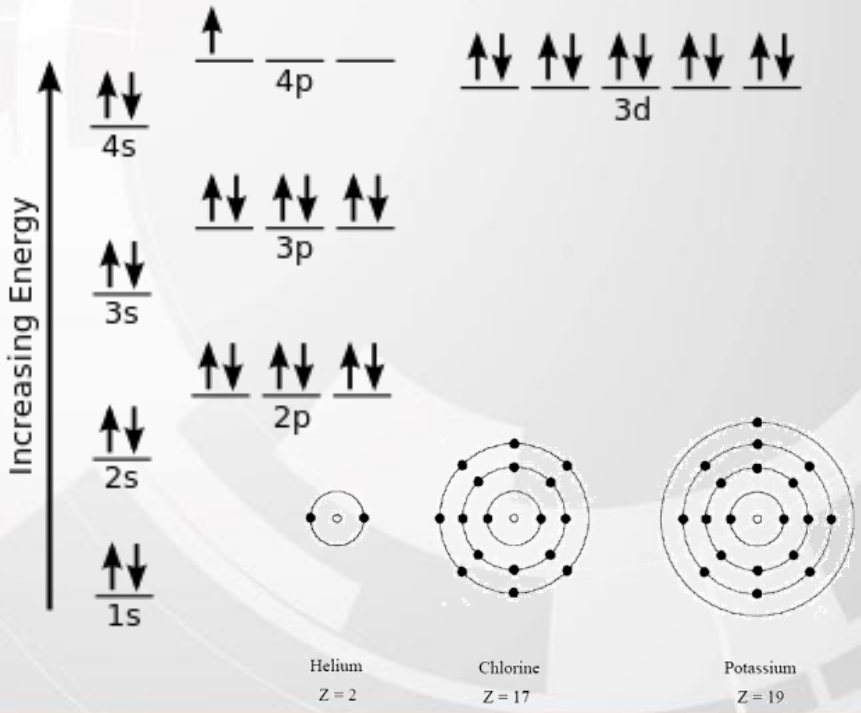




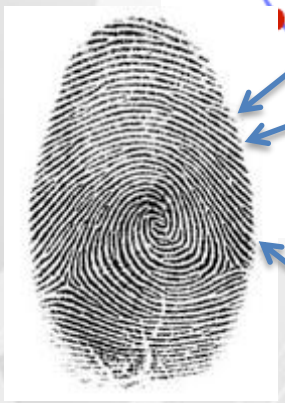
Types of atoms, chemical environment, local atomic structure

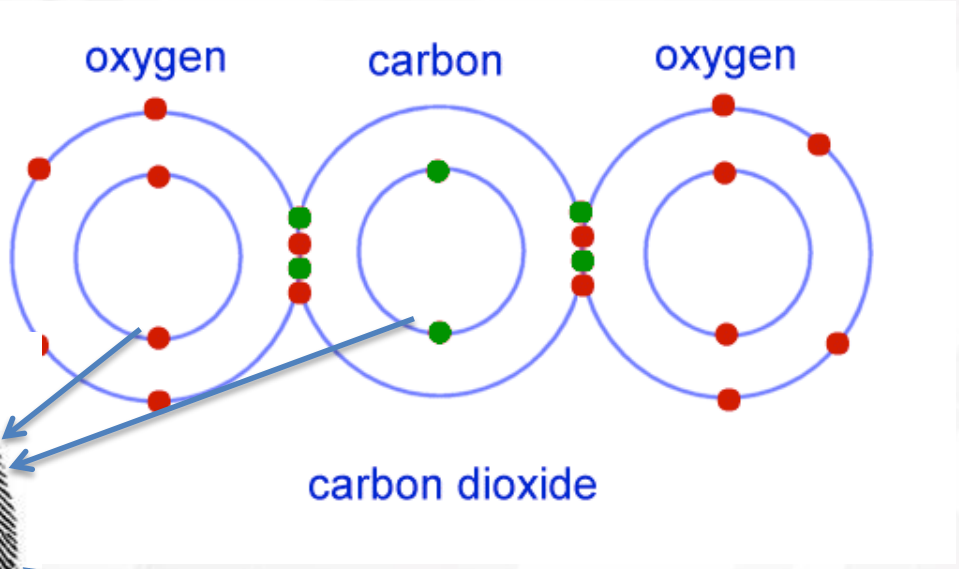
Distance between atoms
≈0.2-0.4 nm

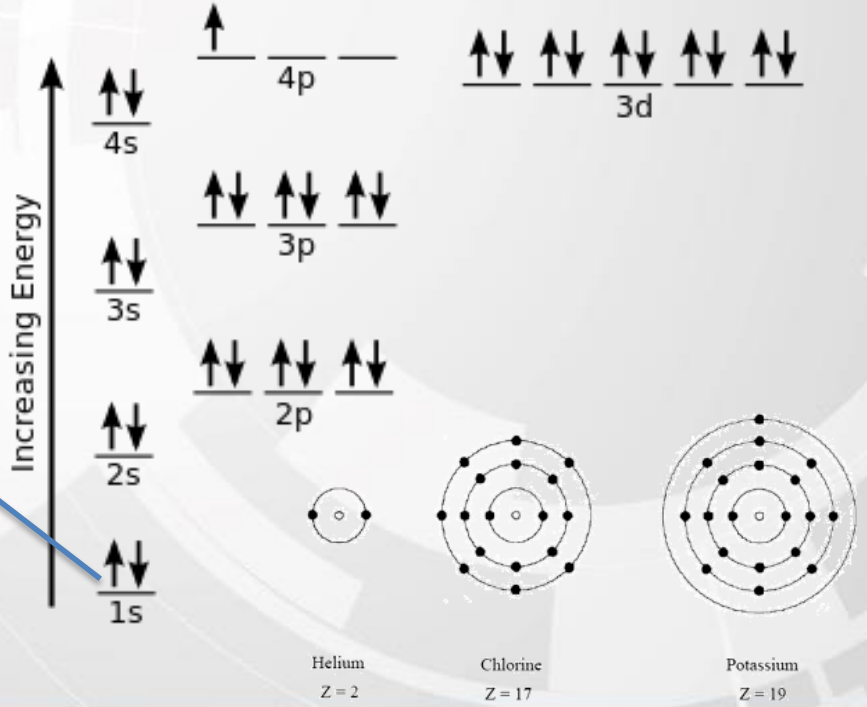
Chemical bonds, electronic structure


Increasing Energy
4s
4p
3d
3p
3s
2p
2s
1s
Helium
Z = 2
Chlorine
Z = 17
Potassium
Z = 19

X-Rays




oxygen
carbon
oxygen
carbon dioxide


Increasing Energy
1s
2s
3s
4s
2p
3p
4p
3d
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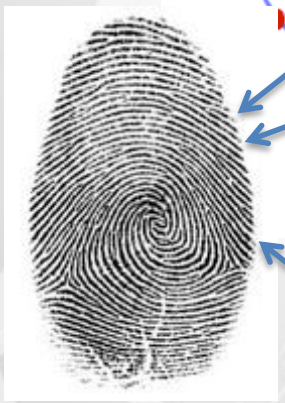
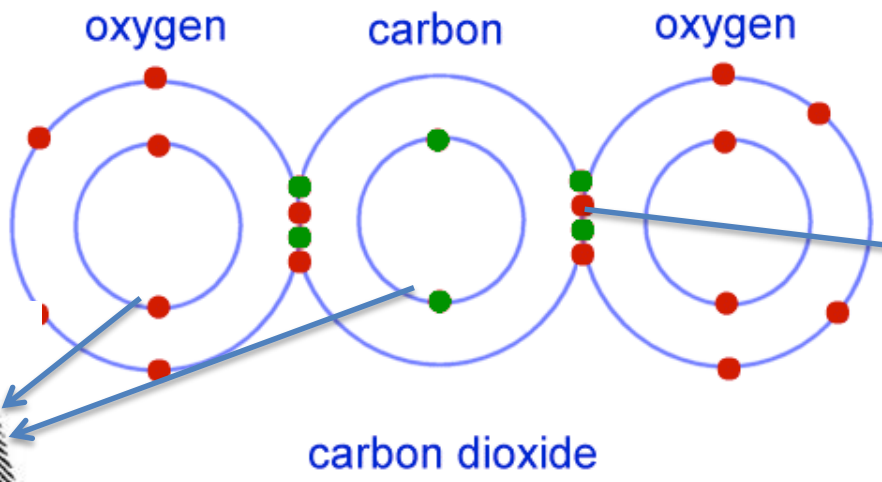
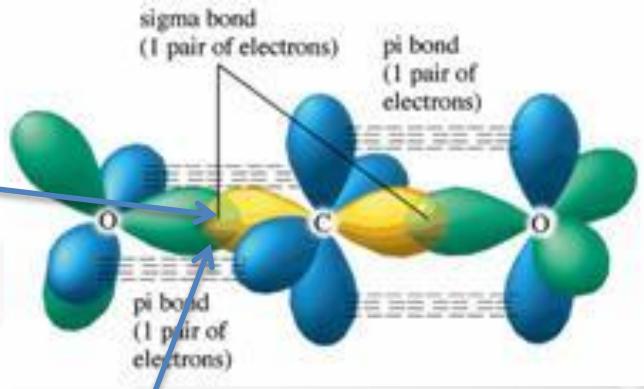
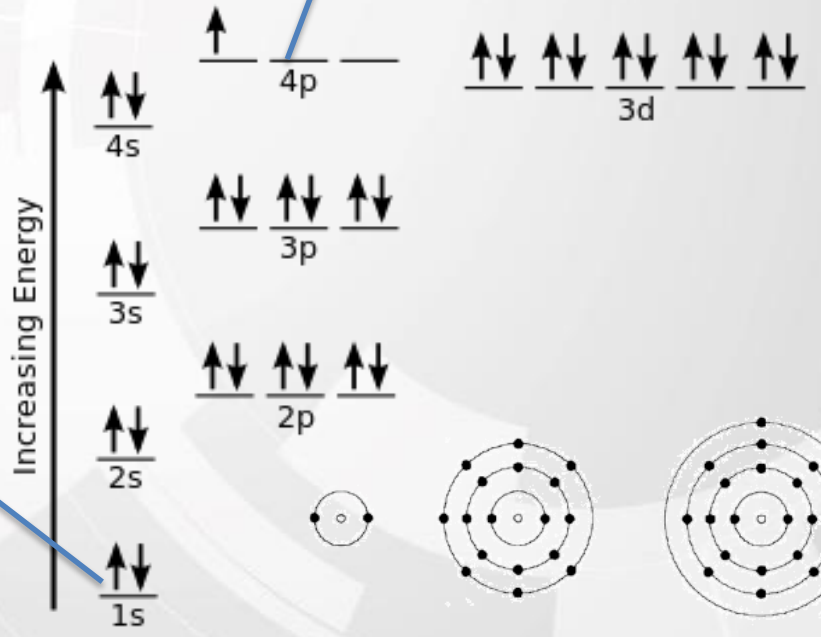


X-Rays


oxygen
carbon
oxygen
carbon dioxide


sigma bond
(1 pair of electrons)
pi bond
(1 pair of
electrons)
O
C
O
pi bond
(1 pair of
electrons)

UV


Increasing Energy
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3s
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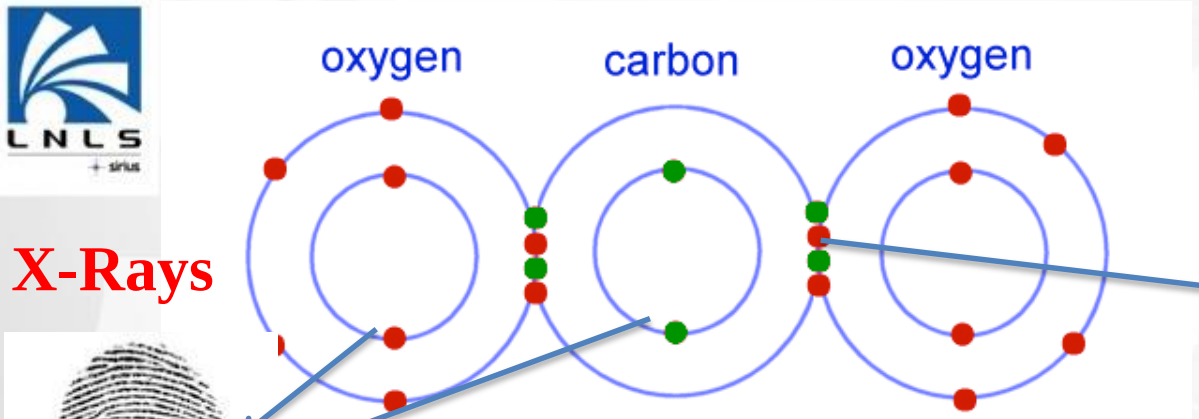
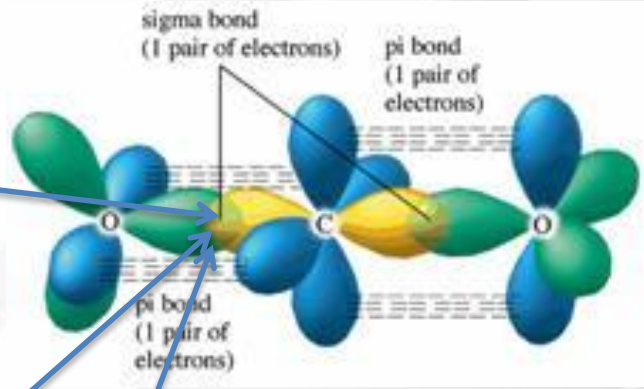
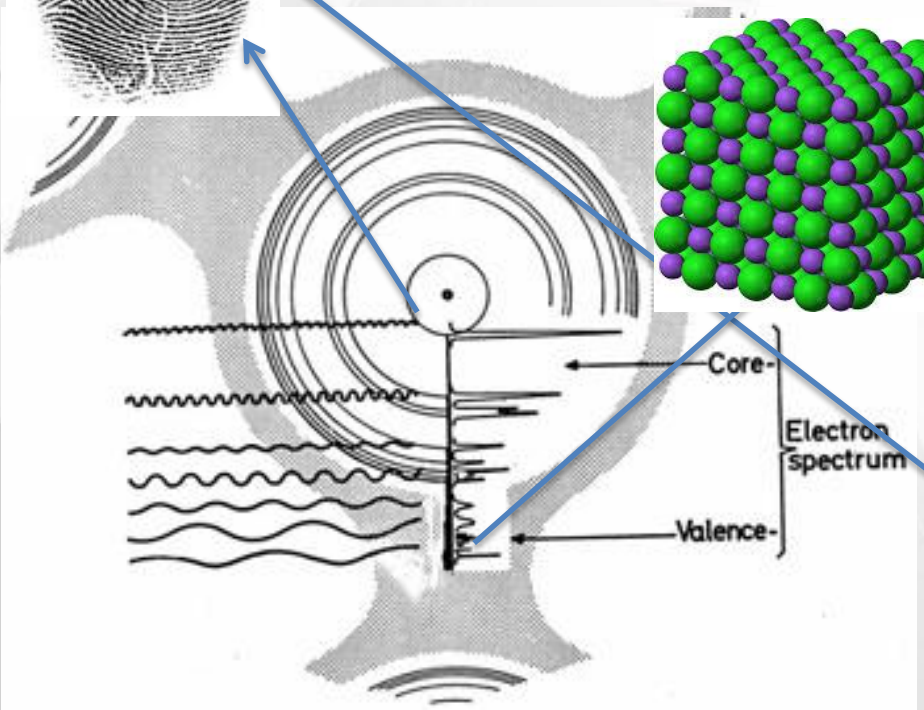
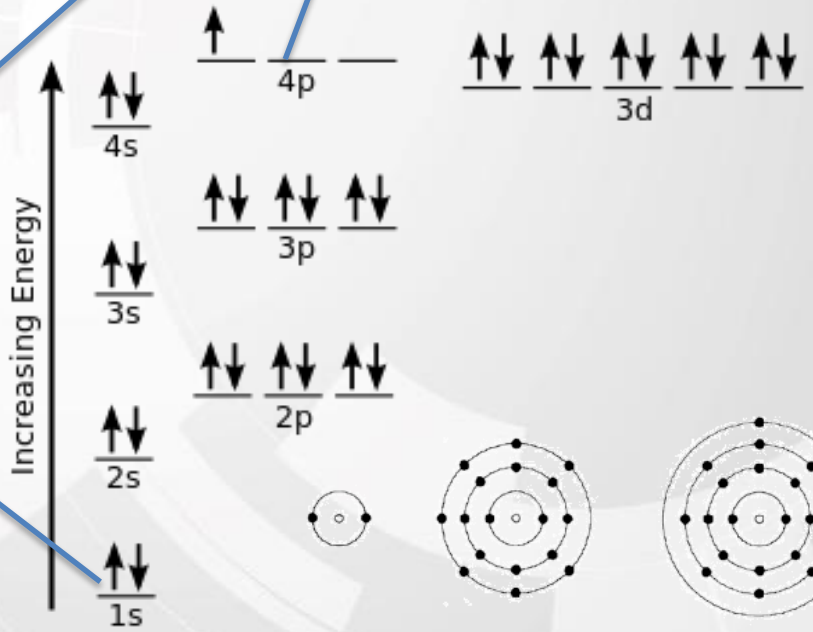

oxygen
carbon
oxygen
carbon dioxide

X-Rays


sigma bond
(1 pair of electrons)
pi bond
(1 pair of
electrons)
O
C
O
pi bond
(1 pair of
electrons)

UV


Core-
Electron
spectrum
Valence-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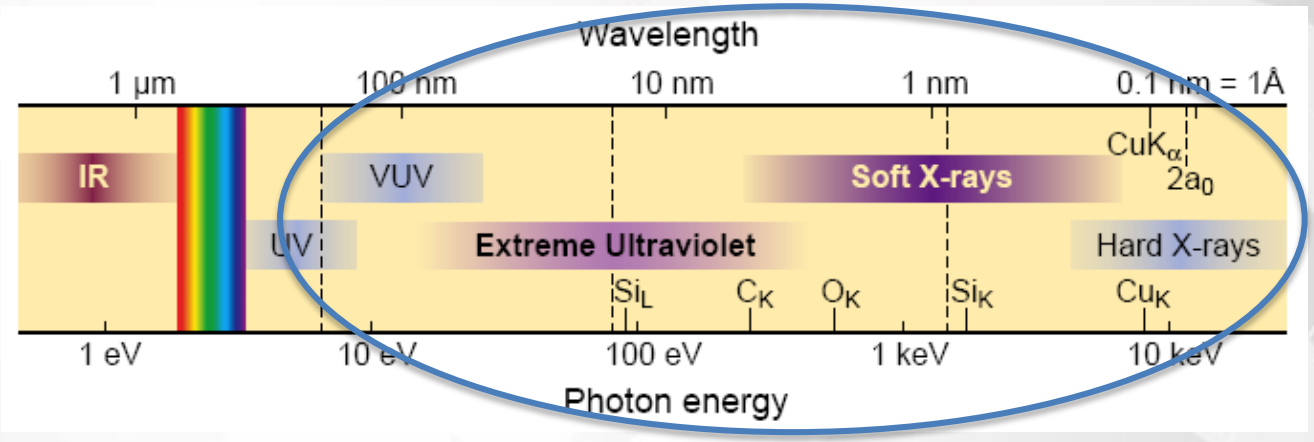
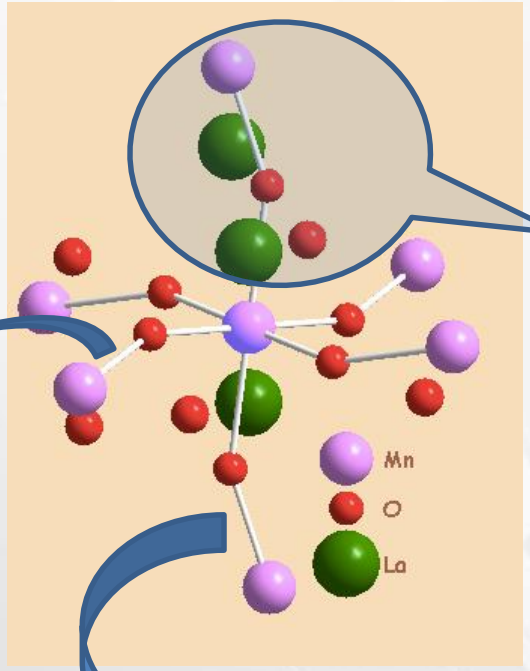


Which wavelength?

X-Rays and UV!

How to obtain them?



Types of atoms, chemical environment, local atomic structure

Distance between atoms
≈0.2-0.4 nm

Chemical bonds, electronic structure

Thus, it is important to have a good, tunable, source of UV and X-rays...

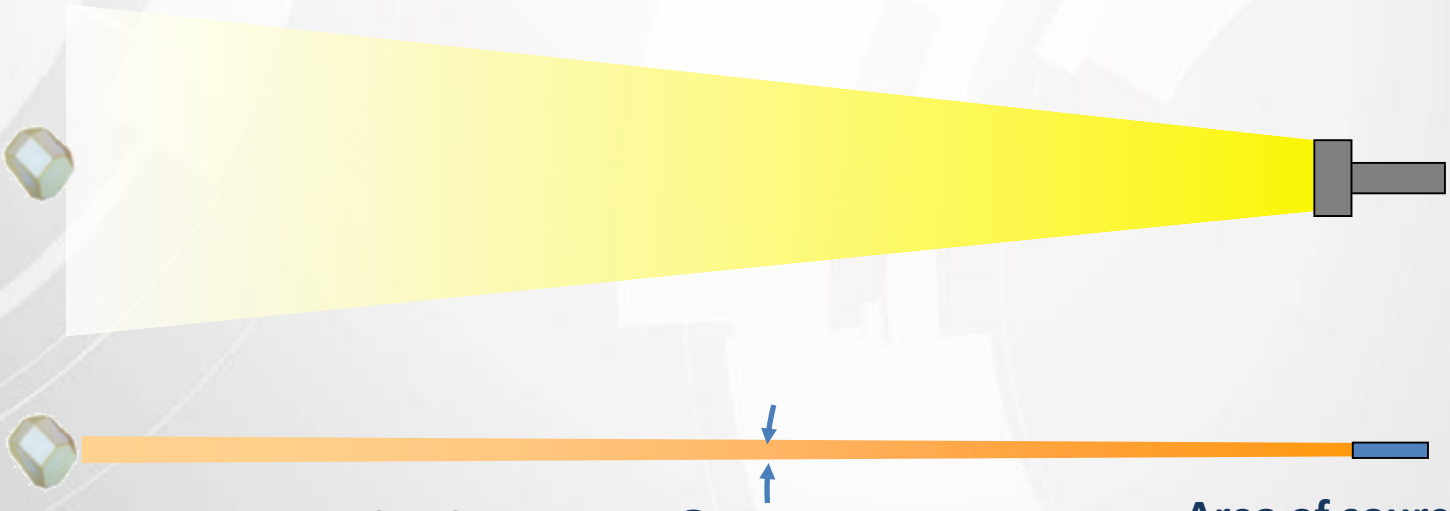
Another advantage of X-rays – low absorption
One can see ”inside the materials” (bulk)

Thus, it is important to have a good, tunable, source of UV and X-rays...

- **What is a ”good source”?**
- **How to build one?**

What makes a good light source?

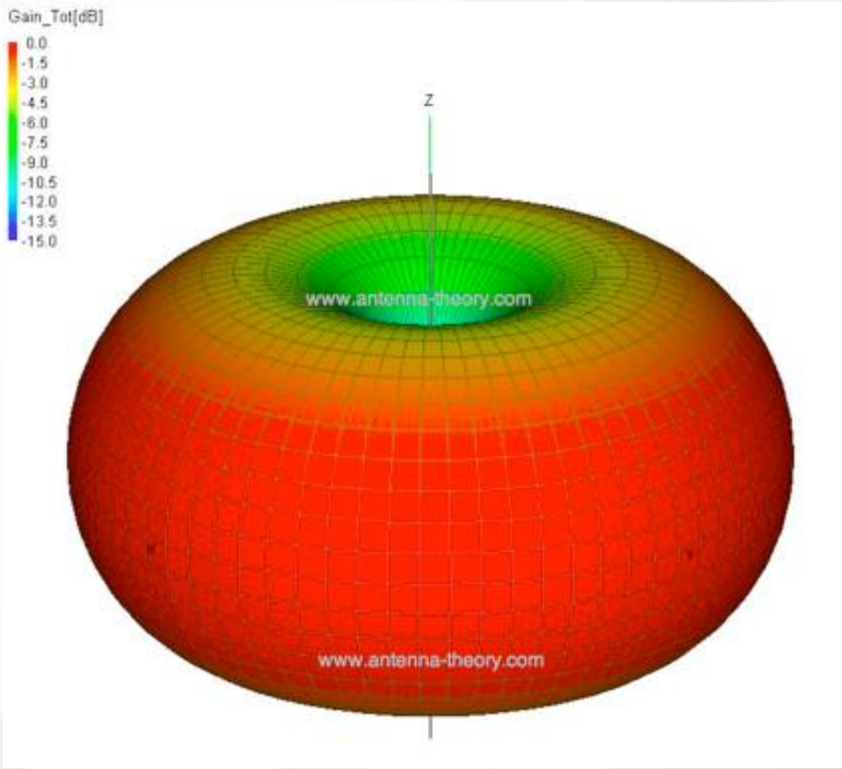
- Intense, high flux (photons/s).
- Small and collimated.



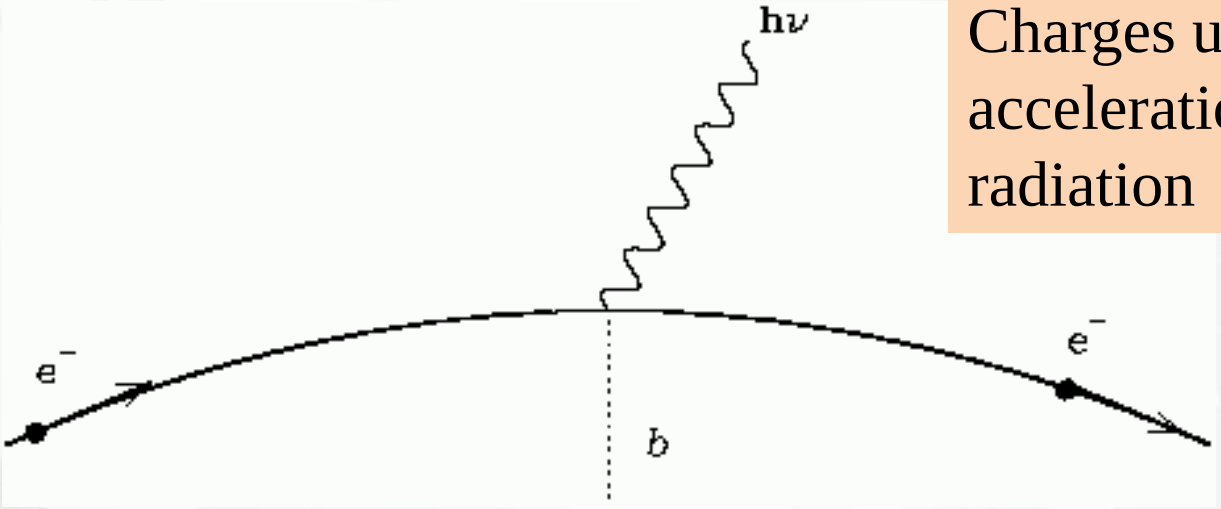
$$\text{Brightness} = \frac{\text{Flux}}{S \times \Omega}$$

Emittance

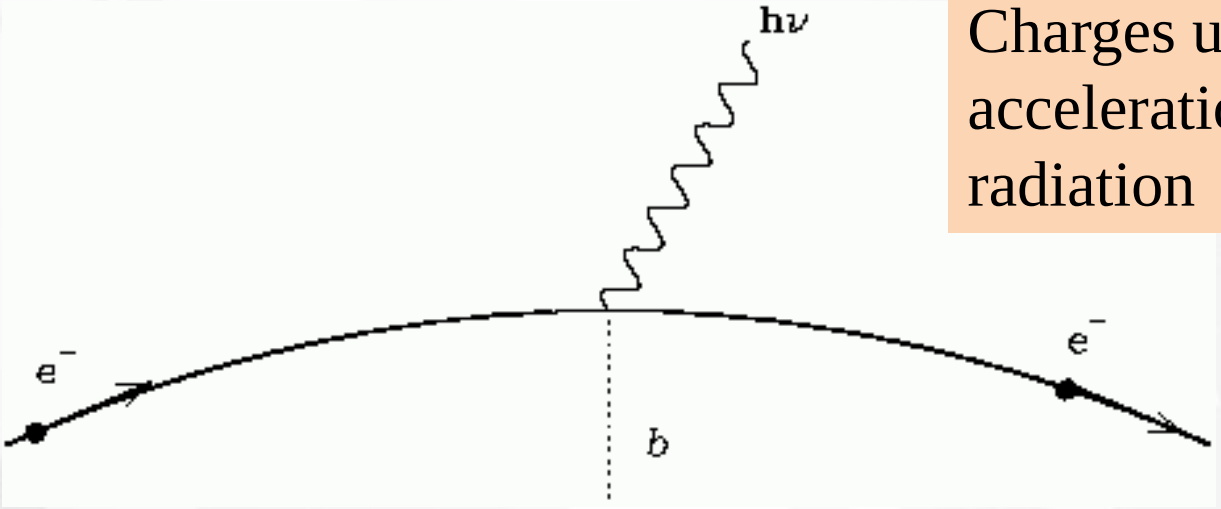
Accelerated charges emit radiation



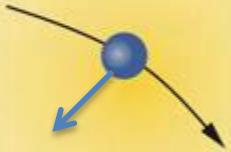
Charges under centripetal acceleration will also emit radiation



Charges under centripetal acceleration will also emit radiation



Classical case

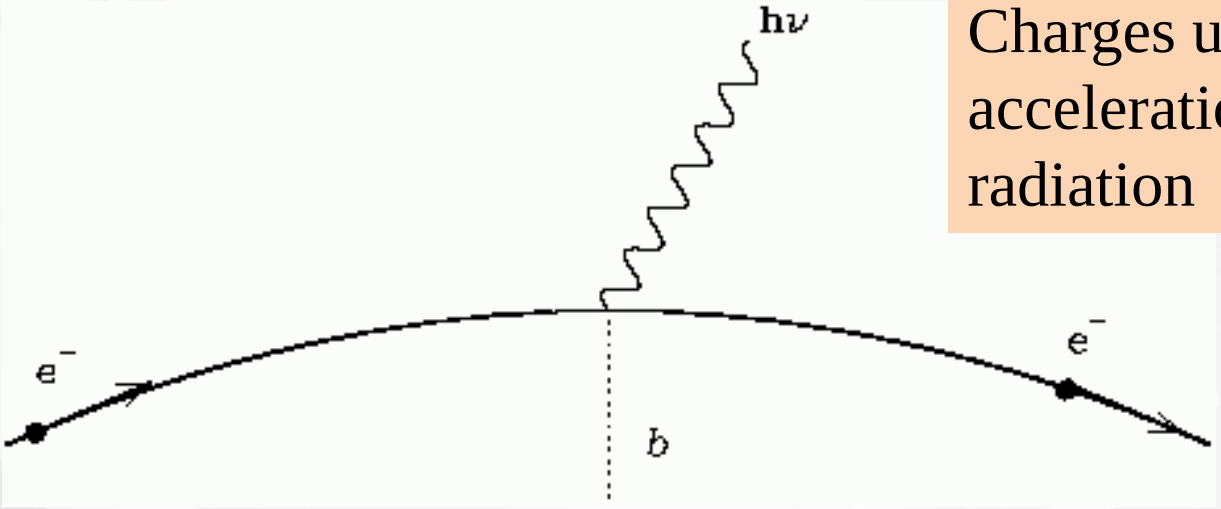


Centripetal acceleration

Isotropic emission

$v << c$

Charges under centripetal acceleration will also emit radiation



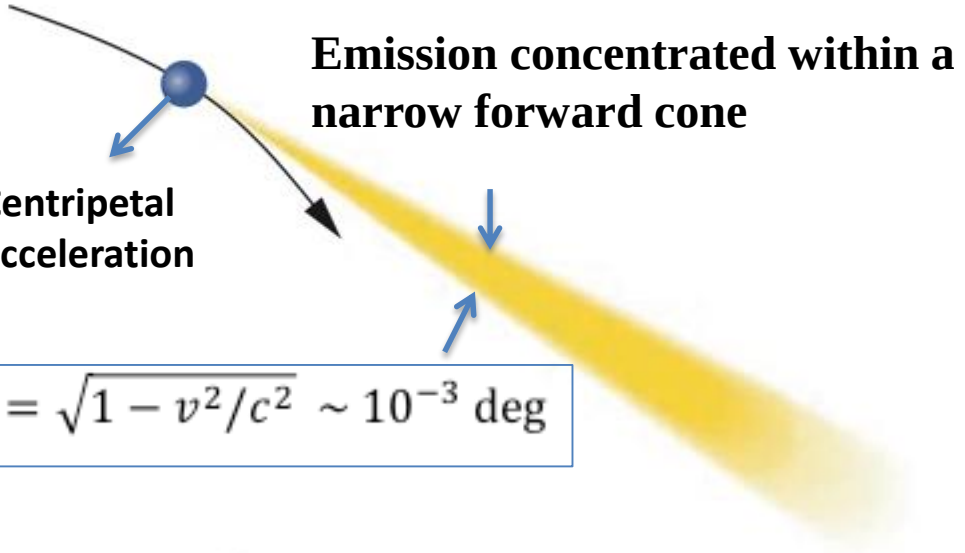
Classical case

Centripetal acceleration

Isotropic emission

v << c

Relativistic case



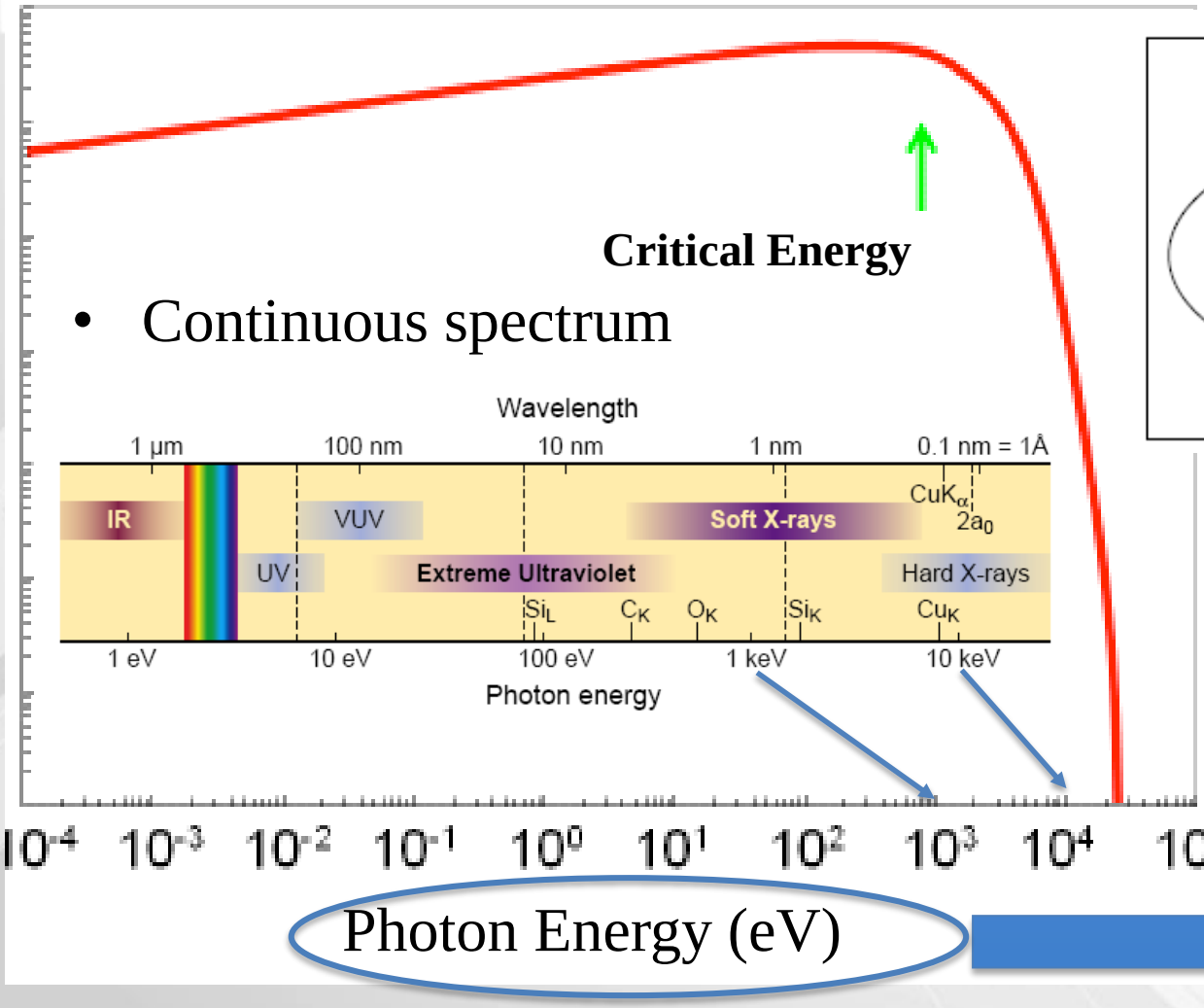
Emission concentrated within a narrow forward cone

Centripetal acceleration

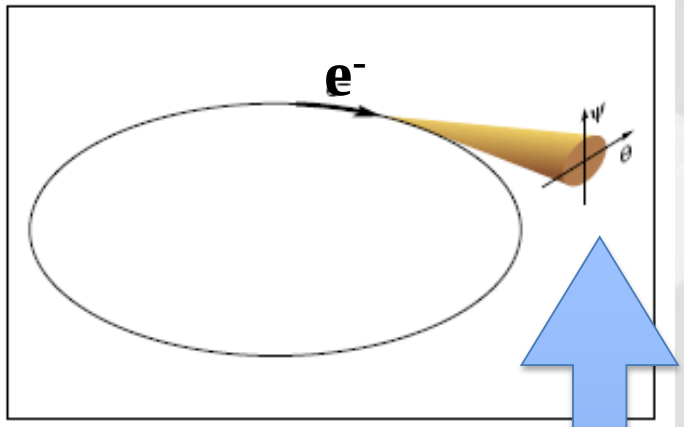
$$\frac{1}{\gamma} = \sqrt{1 - v^2/c^2} \sim 10^{-3}\ \text{deg}$$

v ~ c

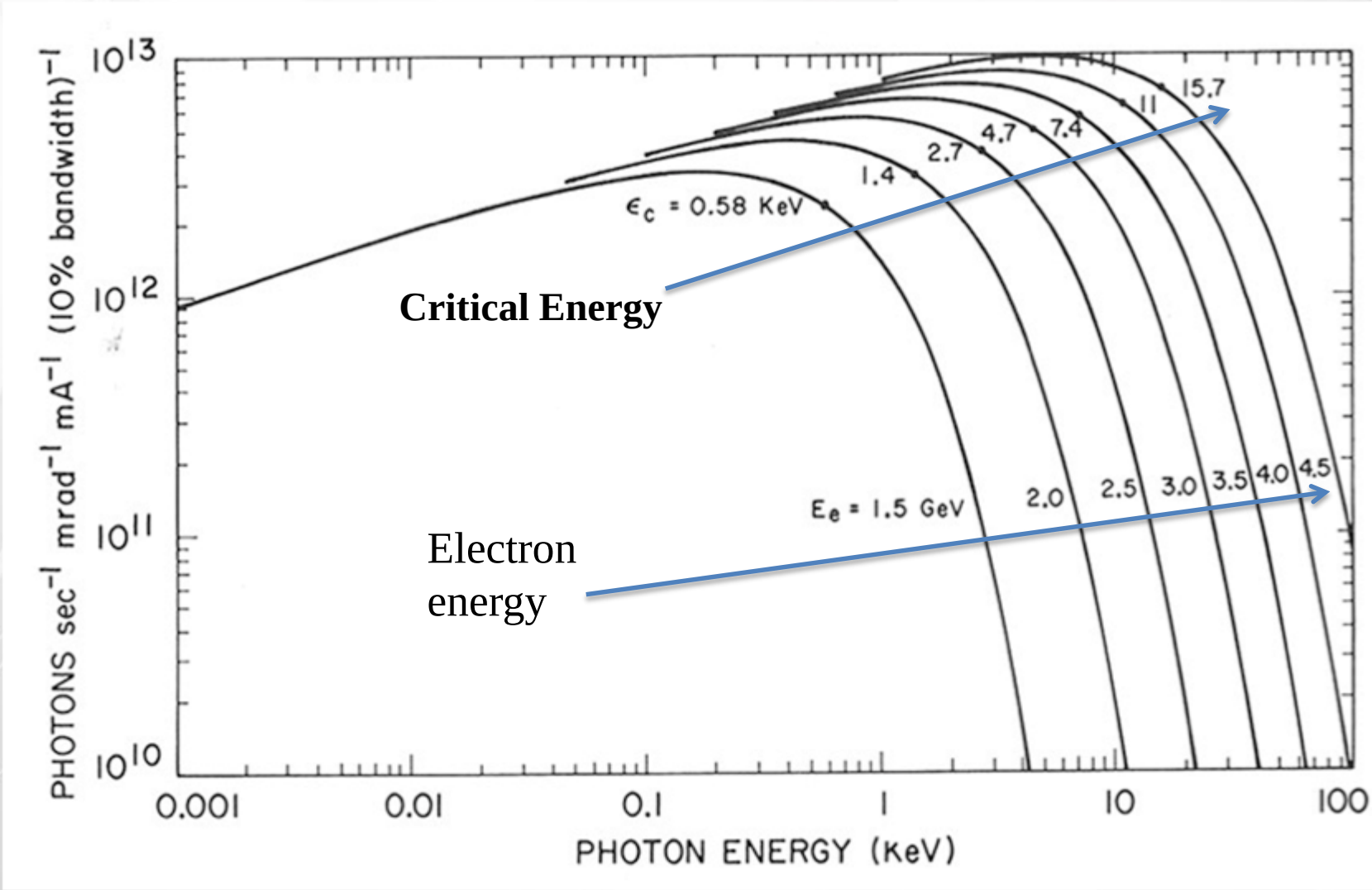
Typical spectrum of synchrotron emission



- Continuous spectrum



Photon Energy (eV)

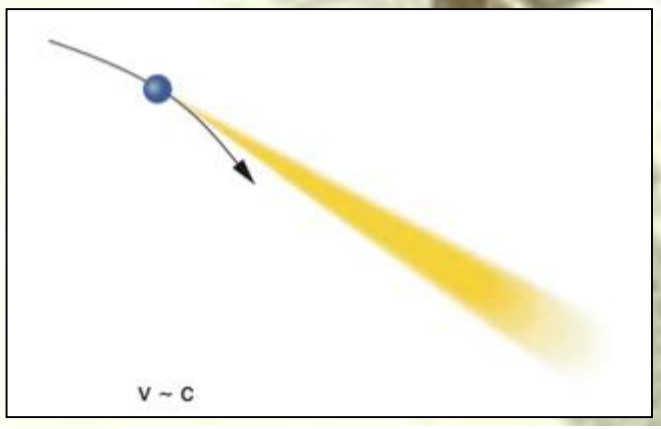


$$E_c(\mathrm{keV}) = 0.6650 E_e^2(\mathrm{GeV}) B(\mathrm{T})$$

Critical Energy

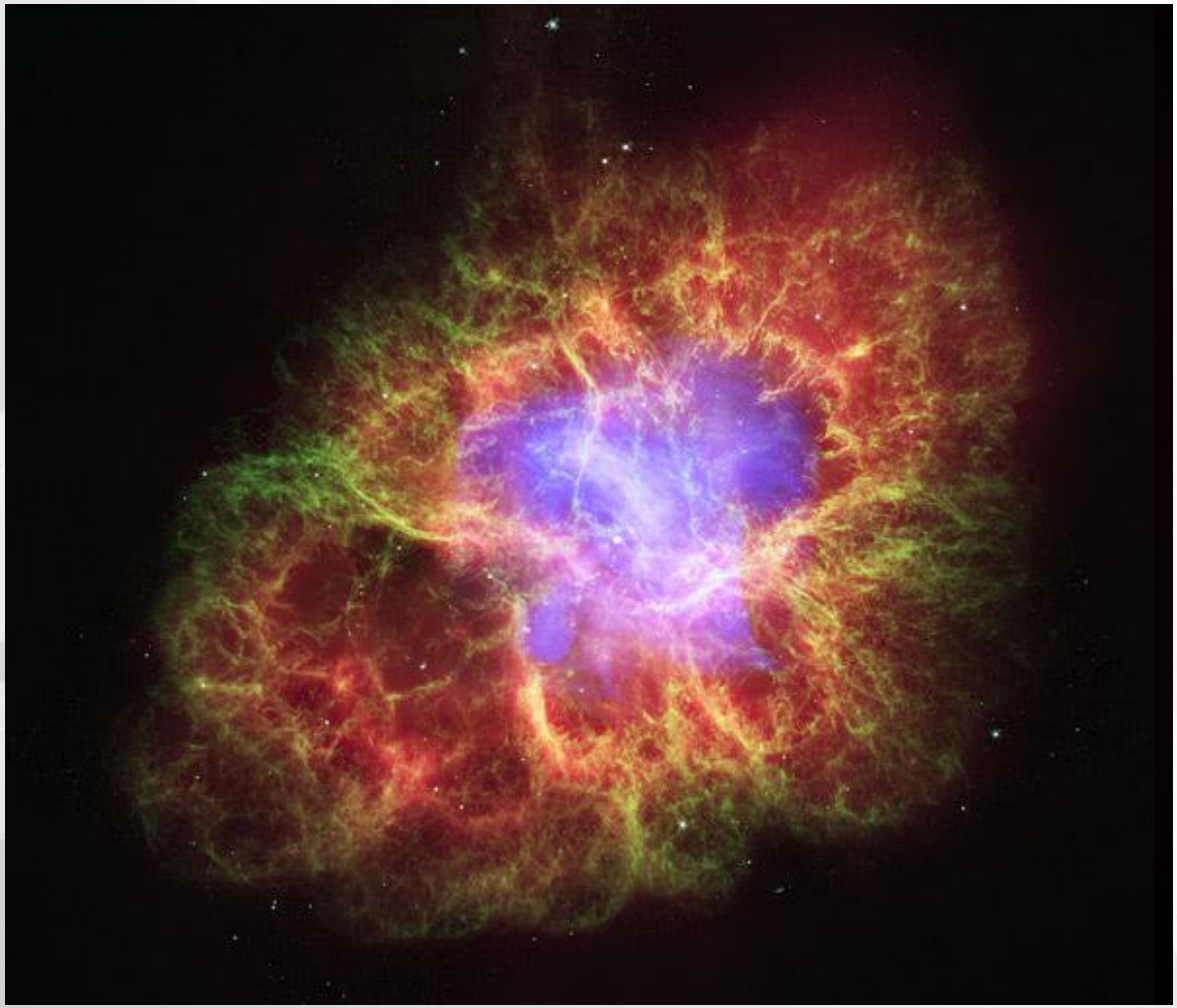
Synchrotron radiation

Electromagnetic radiation emitted by a charged particle travelling at a speed close to the light when its trajectory is ”curved” by a magnetic field



A relativistic electron beam is used to generate high brightness radiation from infra-red to X-rays.

Crab Nebula (6500 light-years)

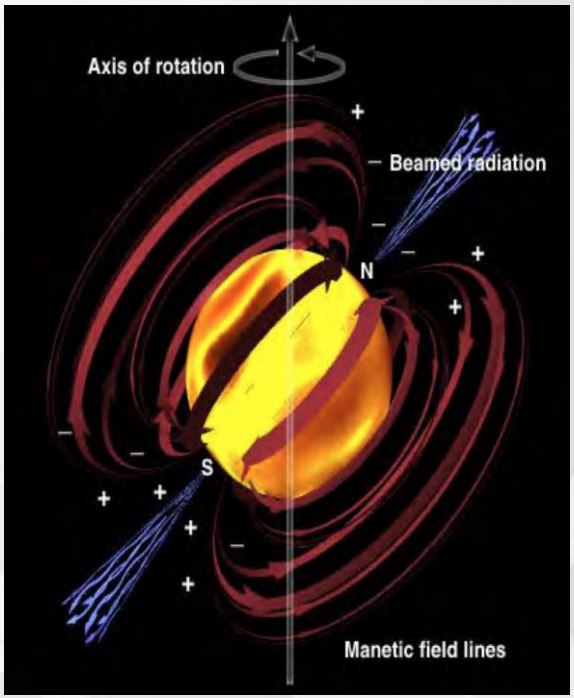


3 "color" composite of the Crab Nebula November 1999

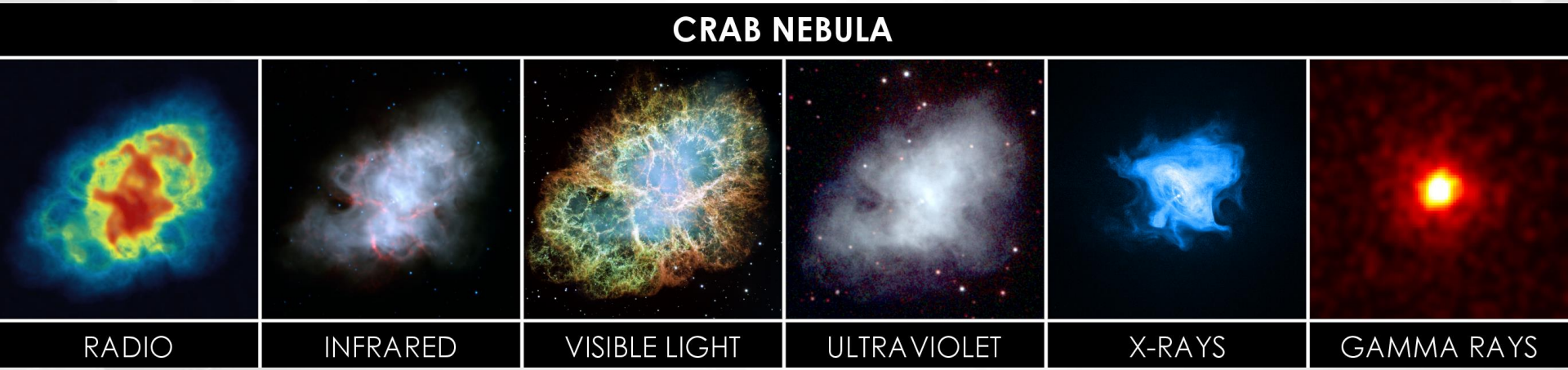
Credit: ESA, NASA, J. Hester & A. Loll, Arizona State University

Nebula
- ~11 light-year diameter
- Expanding at ~1500 km/s

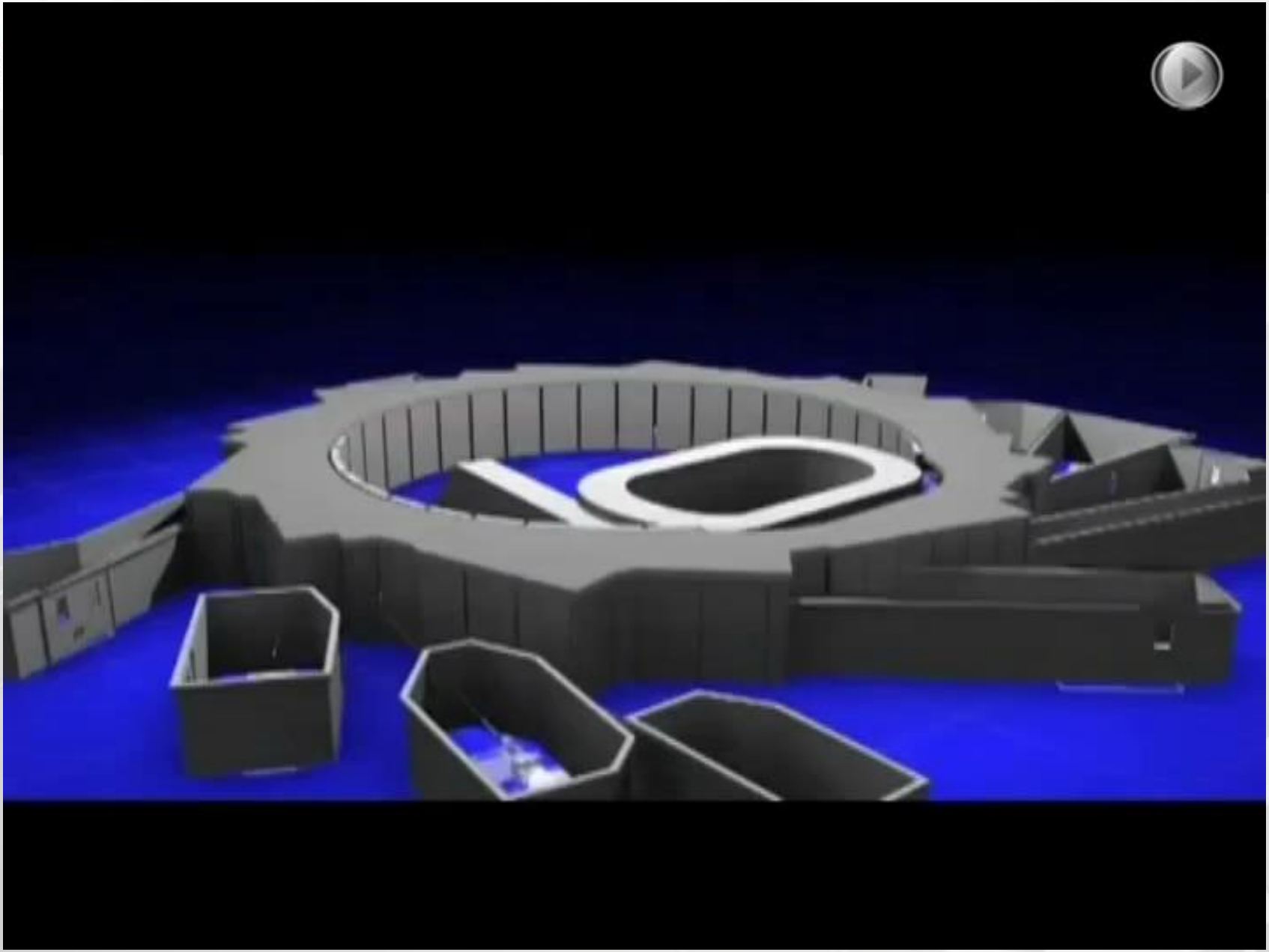
Neutron star
- ~30 km diameter
- ~30 Hz rotation
- ~10^8 T mag. field



Crab nebula from distinct frequencies (wavelengths)

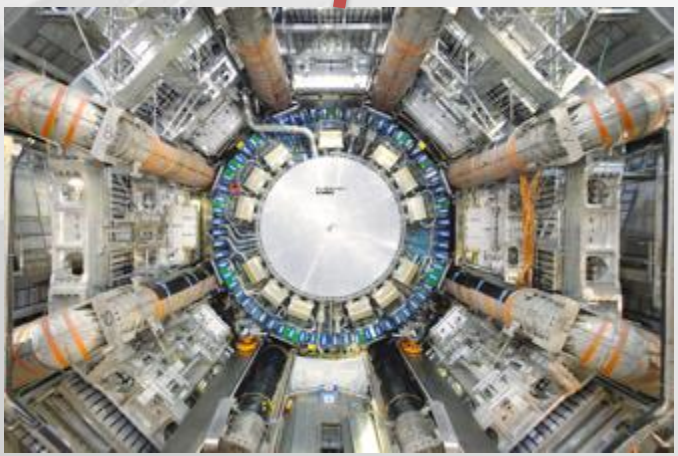


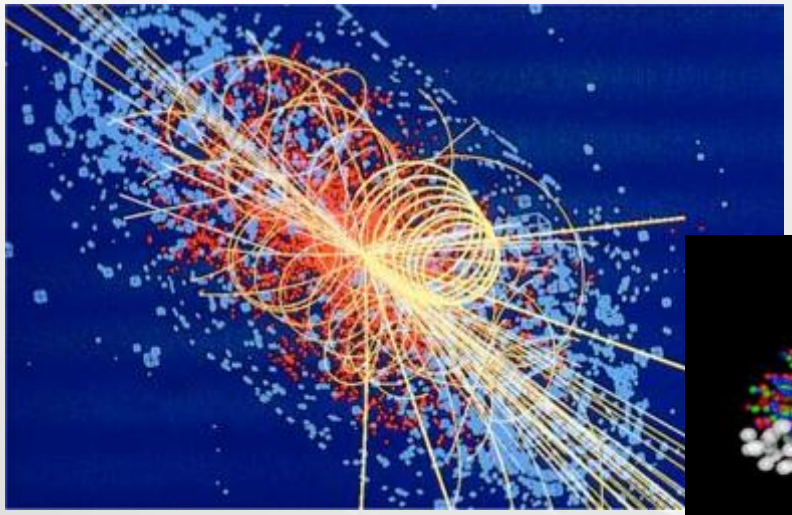
wikipedia

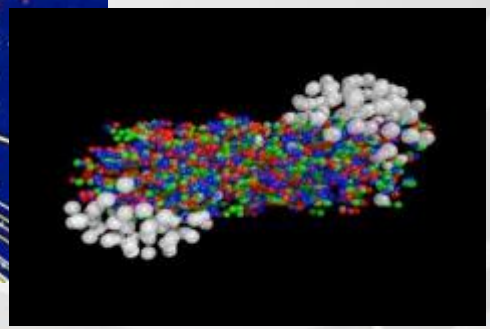


LHC - CERN

- Protons accelerator
- Collider







First particle accelerators **1930**

Particles with more and more energy

bigger and bigger machines

Particle physics

1947 First observation of synchrotron radiation

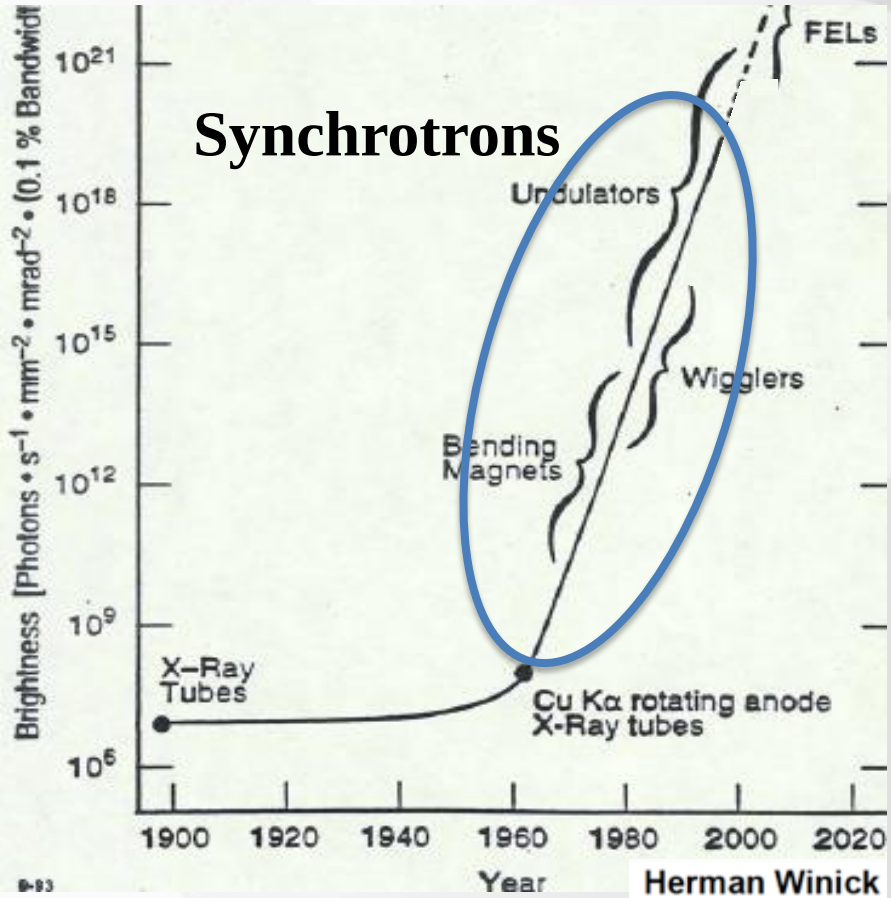
1980 Construction of the first "dedicated" machines

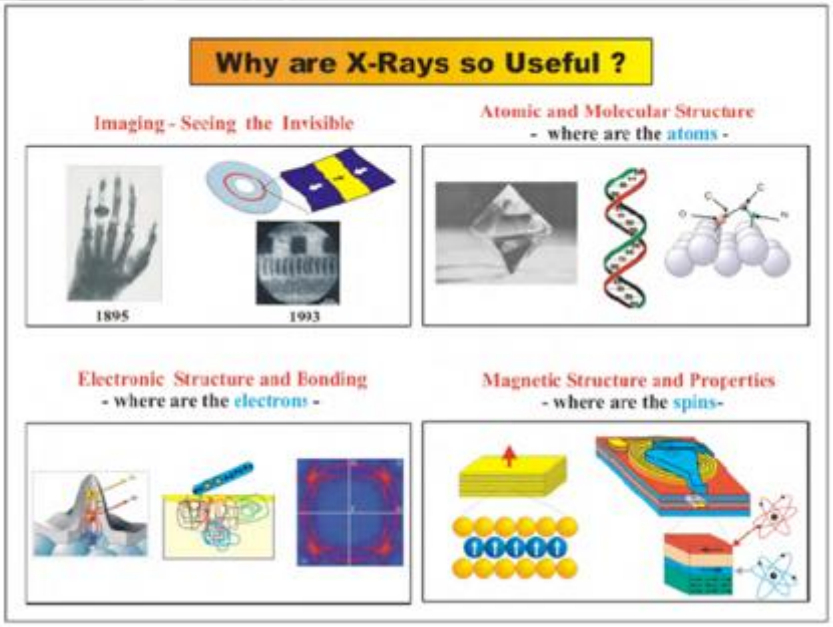
Synchrotron radiation

X-rays Brightness
×
Time

Synchrotron Light Sources

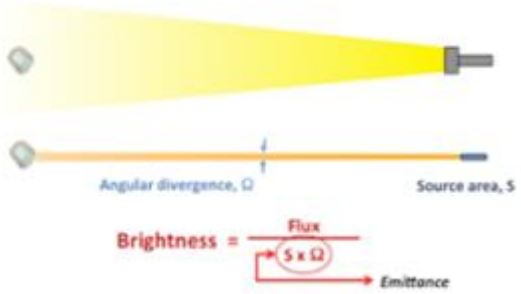
Changed the level/quality of materials research, organic and inorganic





A "good" source of light – High brightness

- Intense, high flux (fotons/s).
- Small and collimated source.

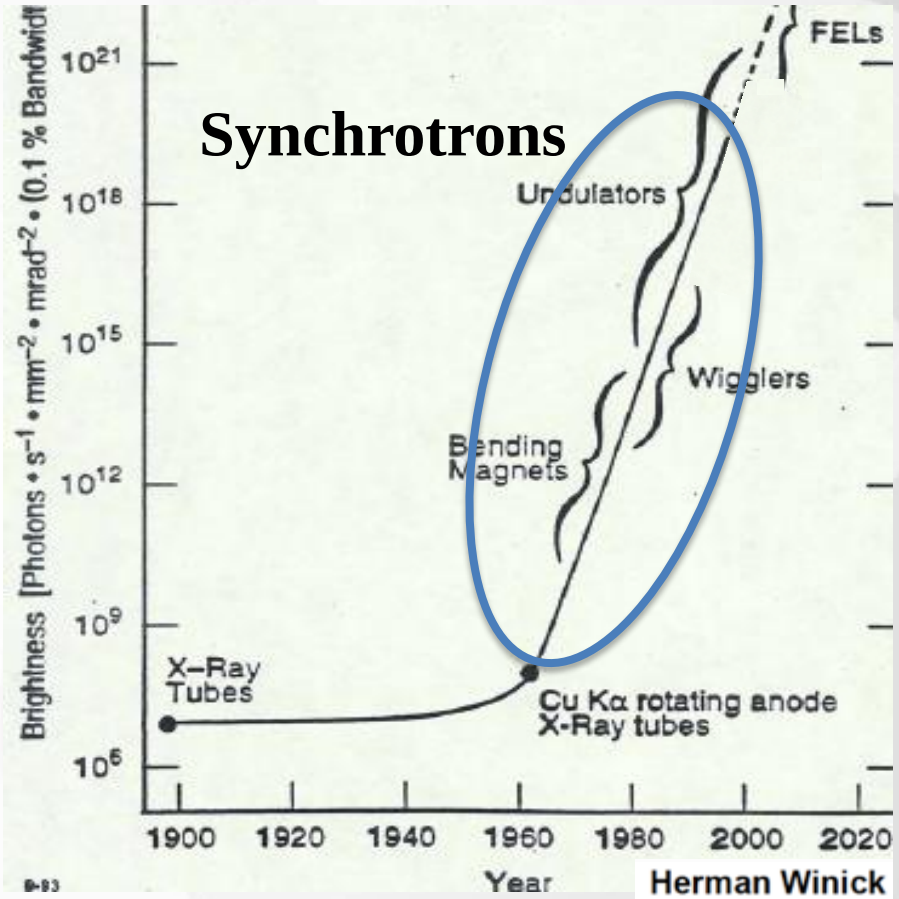


X-rays Brightness
×
Time

Synchrotron Light Sources

Changed the level/quality of materials research, organic and inorganic

THIS IS WHY SO MANY SYNCHROTRONS!



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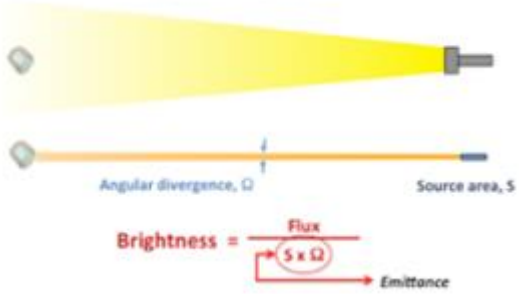
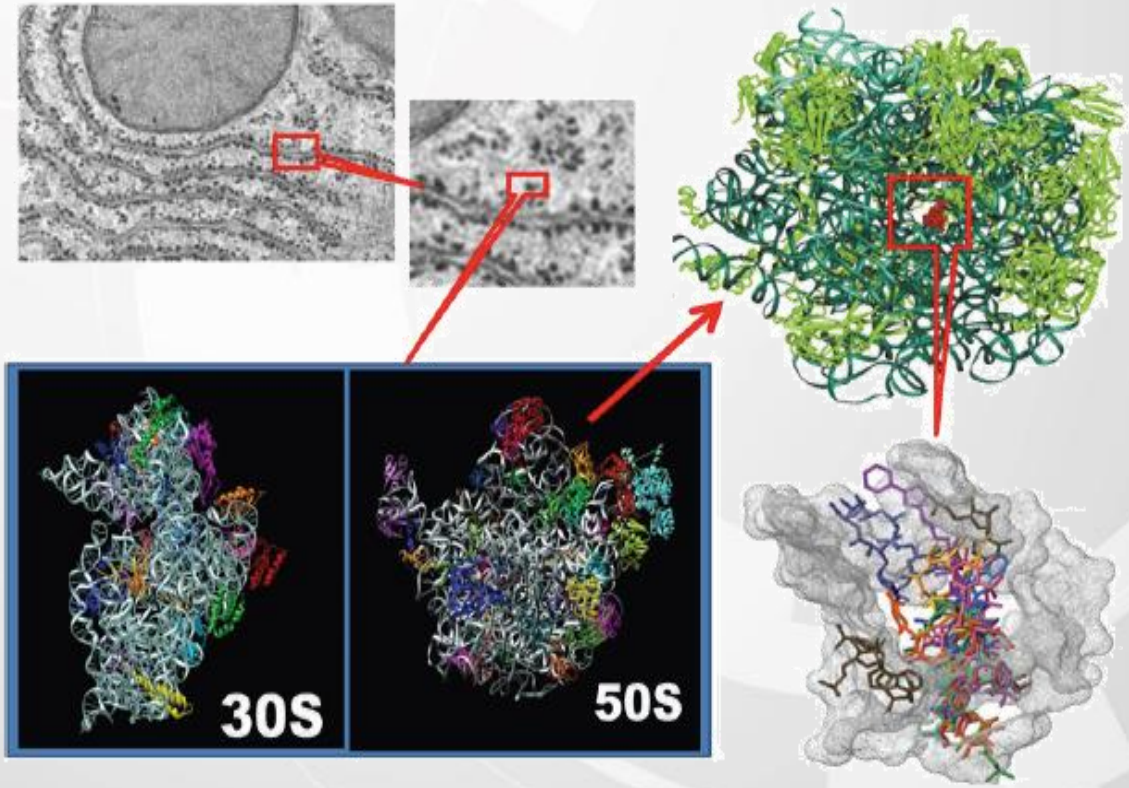


- Atomic Structure of Ribosome

- Besides the impact in fundamental knowledge, there is a huge impact for antibiotics development

V. Ramakrishnan; T. A. Steitz; Ada E. Yonath
Chemistry Nobel Prize – 2009

USE OF SYNCHROTRONS WAS FUNDAMENTAL!



LNLS – A pioneering lab in Brazil

First synchrotron light source in the southern hemisphere

Still the only one in Latin America

Built between 1987-1997

Around 85% built in house

Training of human resources

1993-1995

Magnets production

Luis Câmara


Luis Câmara


Nelson Chinaglia

Luis Câmara

1992

Brazilian Journal of Physics, vol. 23, no. 1, March, 1993 53

Design and Applications of a Toroidal Grating Beamline

A. Rubens B. de Castro[1] P. T. Fonseca[1] J. G. Pacheco
J. E. Verdugo, M. S. Z. Graeff[1], G. B. Fraguas[1]
Laboratório Nacional de Luz Síncrotron/CNPq, Caixa Postal 6192, 13081-970, Campinas, SP, Brasil
[1] *also at Instituto de Física "Gleb Wataghin", Universidade Estadual de Campinas Caixa Postal 6165, 13081-970, Campinas, SI:*

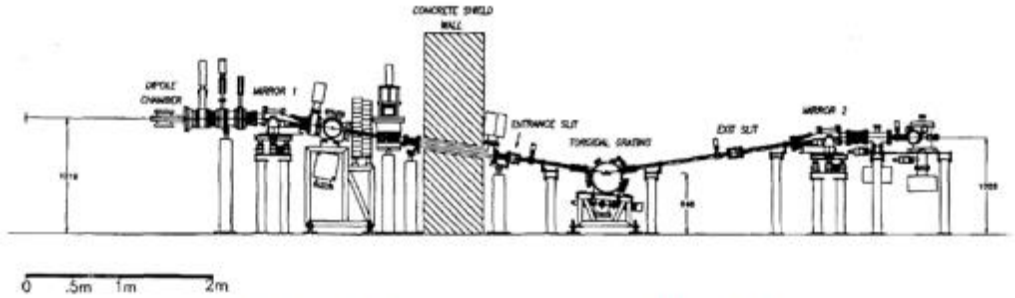
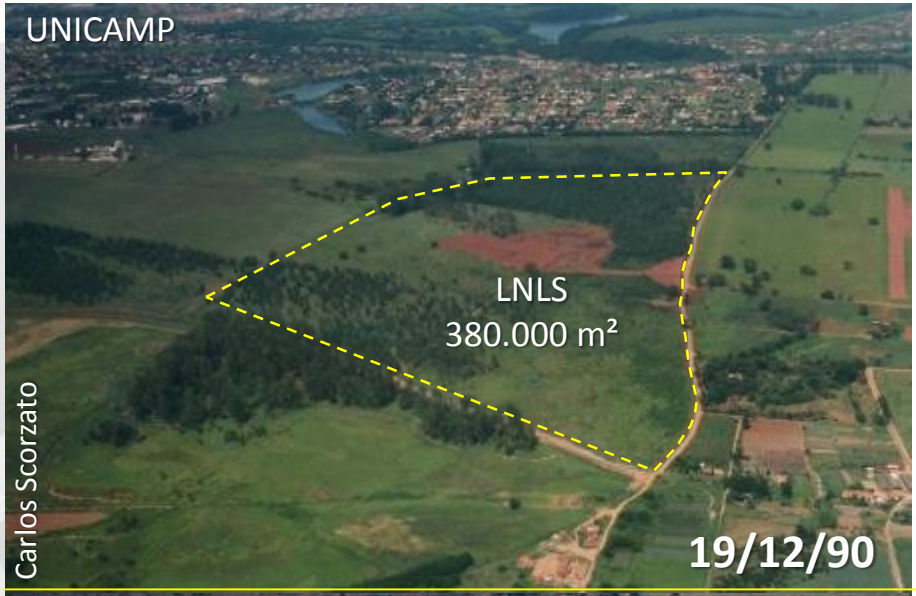


Figure 1: The LNLS TGM beamline, as installed at CAMD (Baton Rouge-USA)

First beamline projected and built by LNLS is installed for testing at the Center for Advanced Microstructures and Devices (CAMD) at Louisiana State University (USA)

1990 a 1996 – Constructions at LNLS Campus



May/1996 – assembly of ring concluded

Nelson Chinaglia

6/11/1996
Assembly of first beamlines

Nelson Chinaglia

22/11/1997 – Inauguration of LNLS by the President Fernando Henrique Cardoso

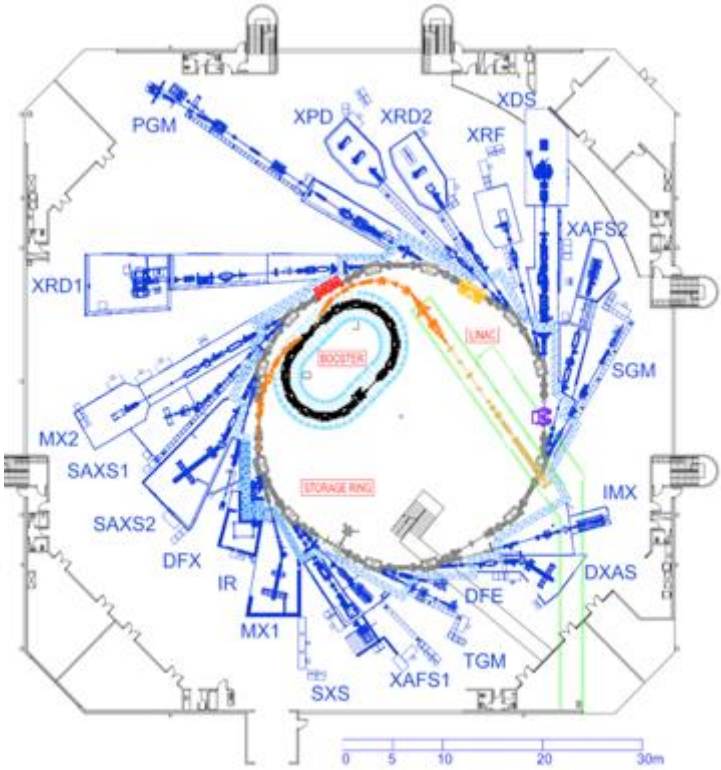
CORTESIA/CORREIO POPULAR

CNPEM
Centro Nacional de Pesquisa em Energia e Materiais

Brazilian Center for Research in Energy and Materials

LNLS

UVX



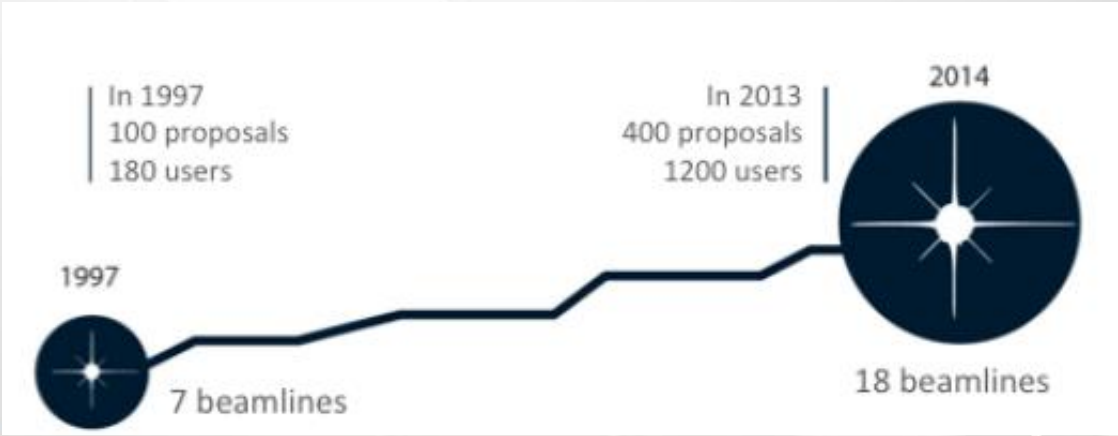
18 experimental stations

~40% SP
~40% OTHER STATES
~20% OTHER COUNTRIES

2014

1196 users
79% Br; 11% Ar
456 newcomers

379 proposals



CNPEM is a private nonprofit organization working under contract with the Brazilian Ministry of Science, Technology, and Innovation

Example: Chagas' Disease

Carlos Chagas
1909

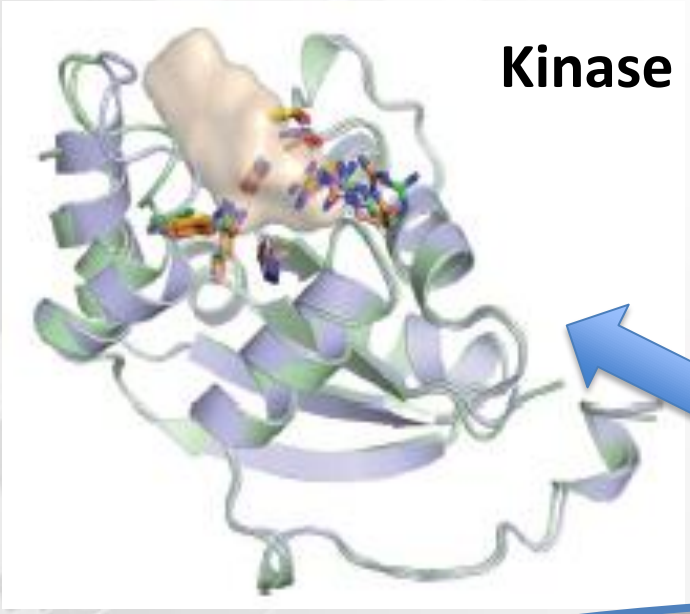
Barbeiro

Trypanosoma cruzi

Current treatments include drugs with low efficiency in the chronic phase and with severe, harmful side effects

- Affects from **8 to 10 million people** in Latin America.
- High social and economical cost

Researchers at LNBio-CNPEM and other centers in Brazil are seeking drugs that work about 10 times better than what is commercially available



Kinase

Goal – discover and elucidate the molecular mechanism of novel and more selective and efficient drugs (inhibitors)

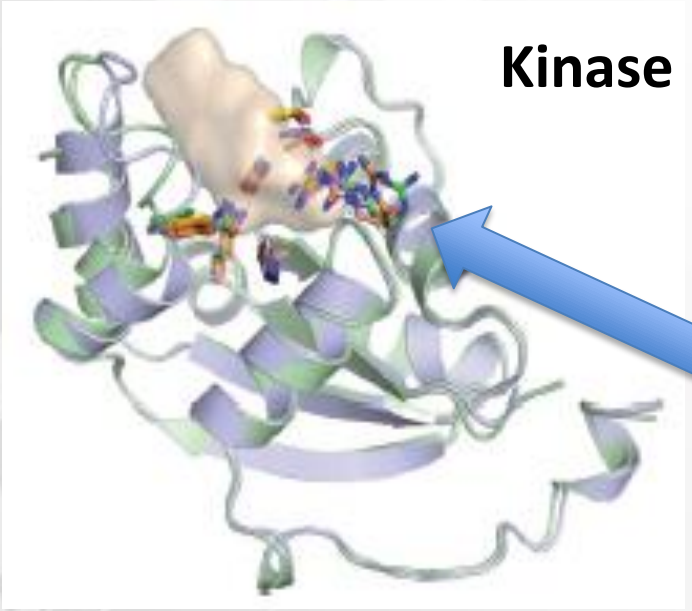
Target – Trypanosomatid Kinases

In order to efficiently find the inhibitors, one needs to know the **atomic structure** of the kinase

Crystal of kinase proteins

M. Murakami (LNBio) et al.

Researchers at LNBio-CNPEM and other centers in Brazil are seeking drugs that work about 10 times better than what is commercially available



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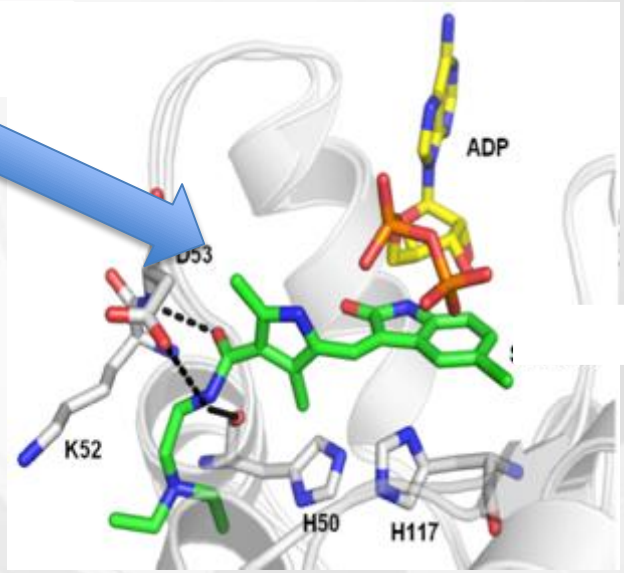


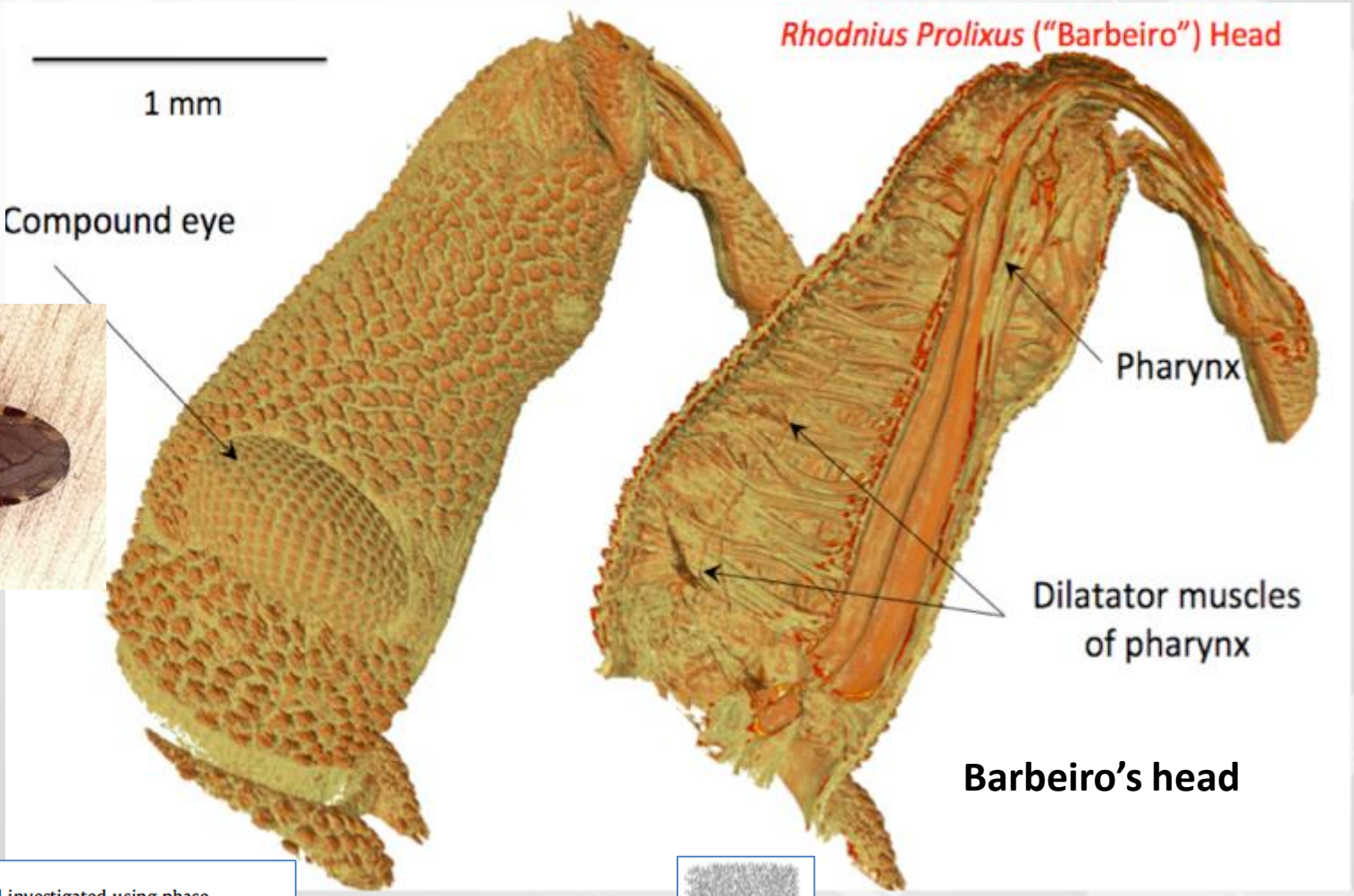
Search for inhibitors

Atomic Structure

M. Murakami (LNBio) et al.

To study the Chagas' disease one could also study the "barbeiro" itself

- x-ray tomography with resolution under 1 μm



Barbeiro's head

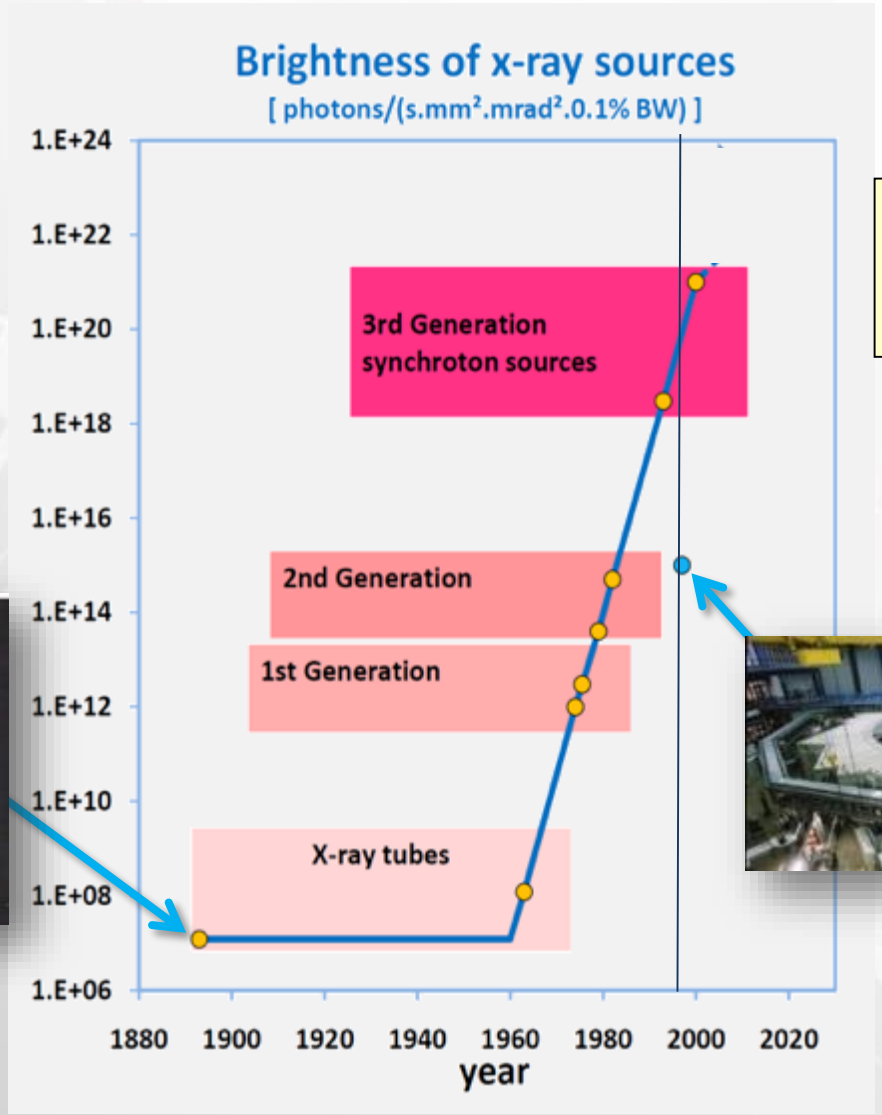
Review paper

Ecdysis period of *Rhodnius prolixus* head investigated using phase contrast synchrotron microtomography

G. Sena [a], L.P. Nogueira [b,*], D. Braz [a], A.P. Almeida [c], M.S. Gonzalez [d], P. Azambuja [e], M.V. Colaço [b], R.C. Barroso [c]

Physica Medica (2016)

Brightness evolution of X-ray sources



2ª Generation Machine

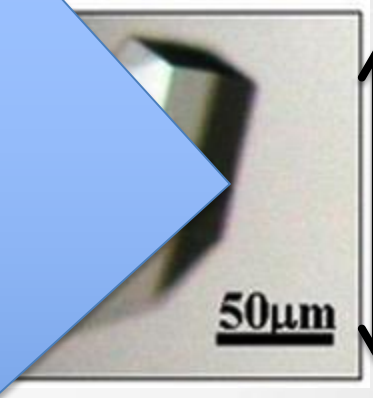
High emittance – Low brightness

Low energy (1.37 GeV)

UVX

Coming back to the crystals and atomic structure

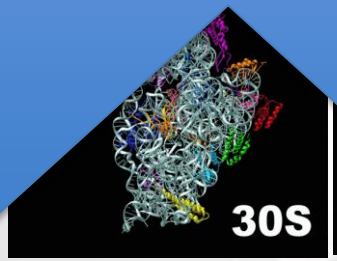
Crystal sizes that we can study today in Brazil: > 50 µm



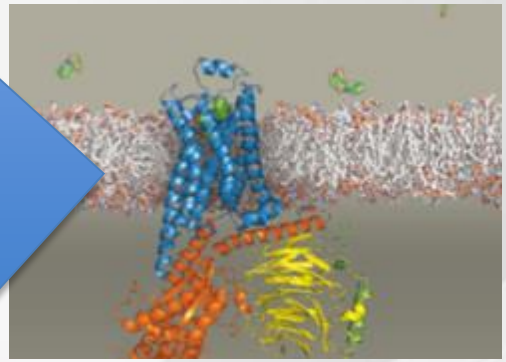
Typical sizes of crystals today at LNLS: 100-300 µm

HOY
Molecular cr
today

Brazil today is out of this game!



Molecular superstructures (Ribosome – 2009 Chemistry Nobel Prize)



Membrane proteins (G-protein-coupled receptors - 2012 Chemistry Nobel Prize)

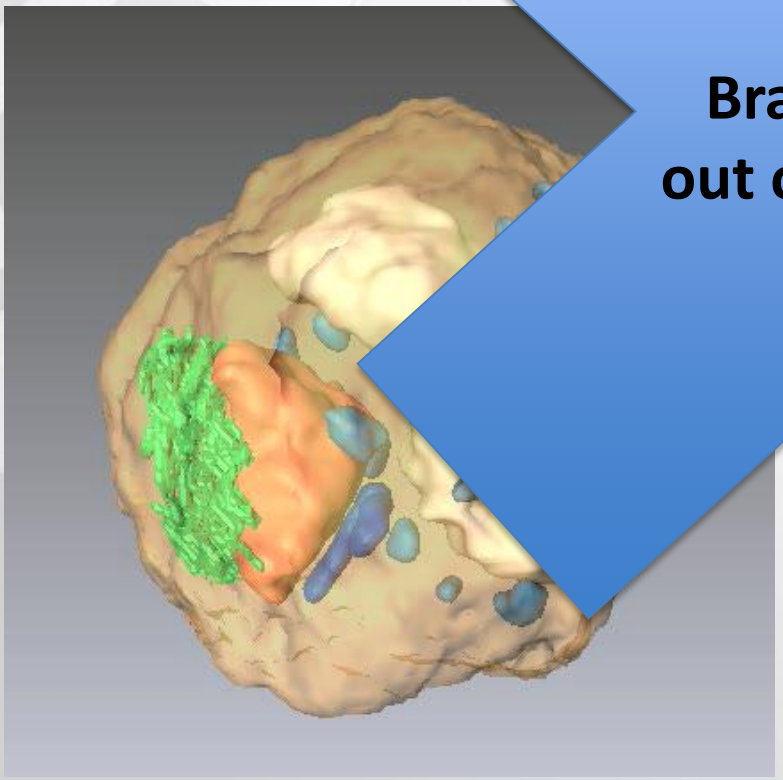
Quantitative 3D imaging of whole, unstained cells by using X-ray diffraction microscopy

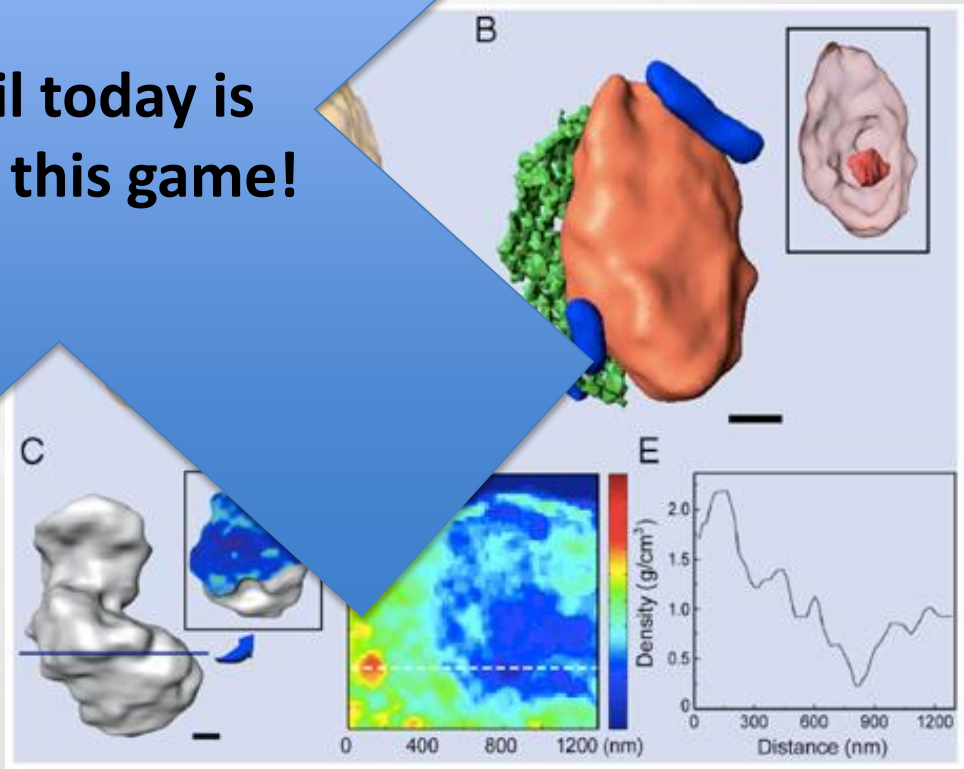
PNAS 2010

Huaidong Jiang[a,2], Changyong Song[b] ... Chen[a], Rui Xu[a], Kevin S. Rain... in P. Fahimian[a], Chien-Hung Lu[c], Ting-Kuo Lee[c], Akio Nakashima[d], J... Ishikawa[b], Fuyuhiko T... wei Miao[a,1]

...on

Brazil today is out of this game!



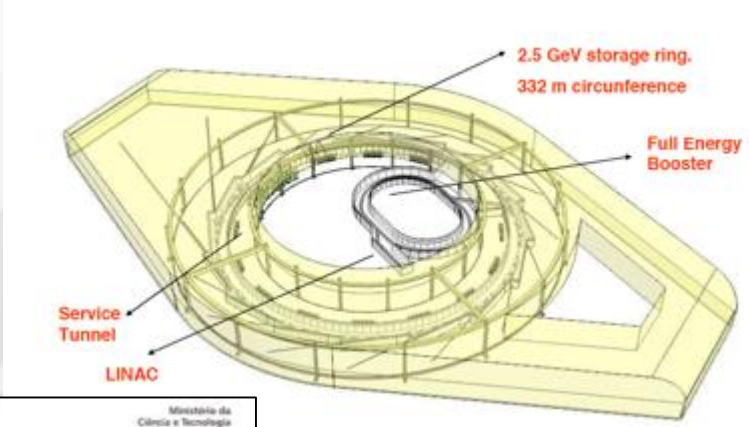


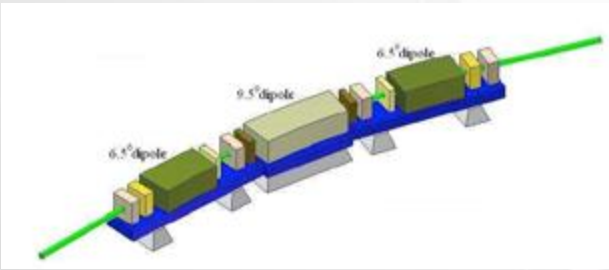
The new Brazilian Synchrotron Light Source

2003 – In the 13th User Meeting, the users discussed the need to start studying the possibility of a new, more competitive, light source

2006 – Recommendation, in the 2006-2009 Strategic Plan of ABTLuS, that a task force should be created in LNLS to study a new, low emittance light source

2008 – Proposal to prepare a conceptual design of a new light source is presented to MCTI
- TBA; 2.5 GeV; 2.62 nm.rad; 332 m; damping wigglers; permanent magnets





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2009-2012 – Prepared CDR and Scientific Case; prototypes built; investment in infra-structure; building; basic project; MAC assembled

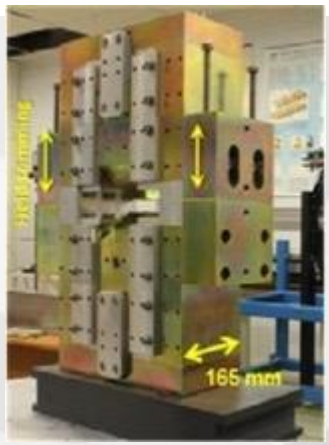
3-Bend Achromat proposal

2T permanent magnet superbend

Beam energy	3.0	GeV
Circumference	479.7	m
Beam emittance without IDs, horizontal	1.7 – 2.8	nm.rad

permanent magnets lattice

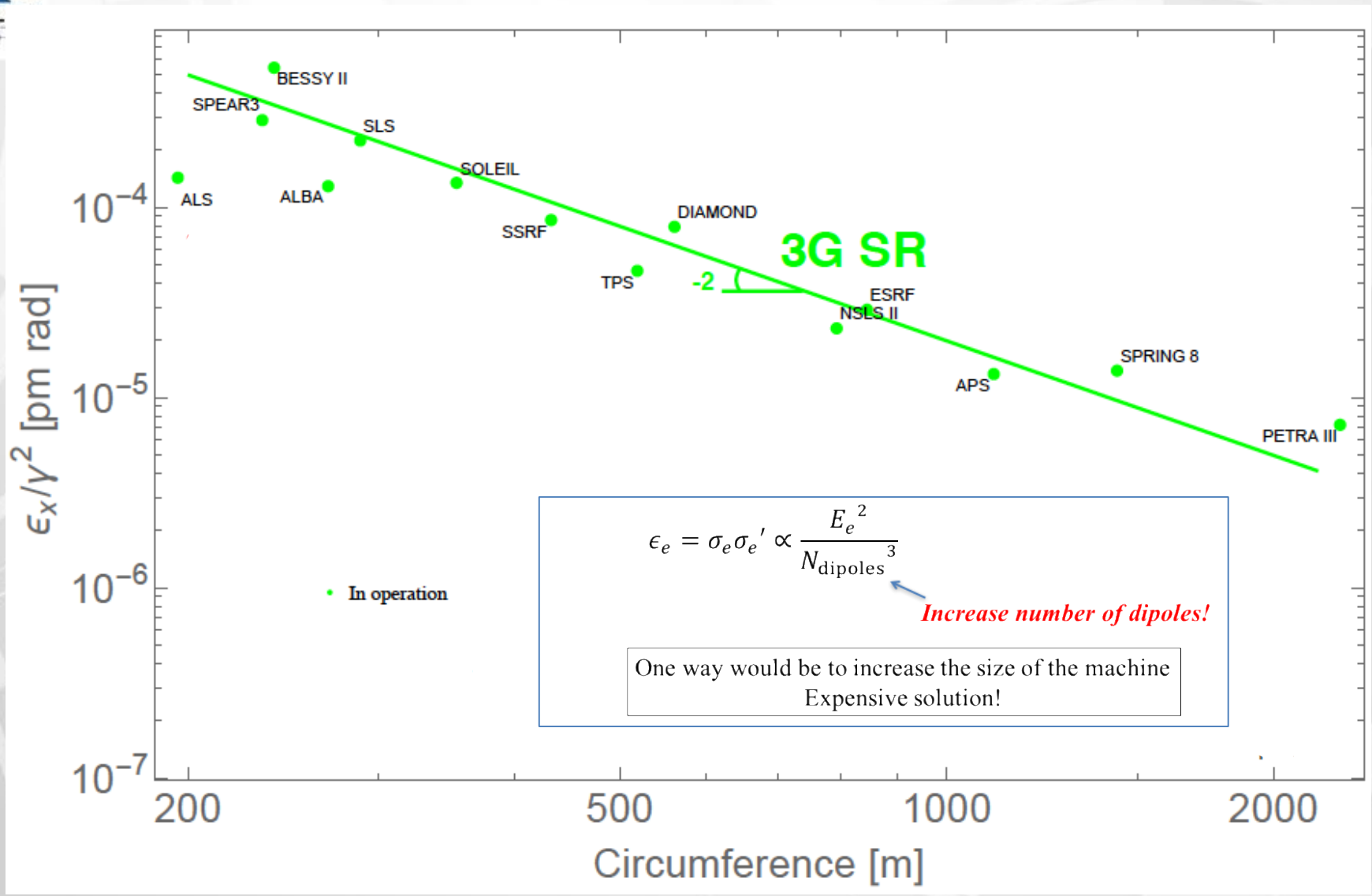
Did not have final land yet!



Most important MAC (18 to 20 of June 2012) recommendation

The present lattice design is excellent by today's standards, but the committee urges LNLS to **push for tomorrow's brightness standard (e.g. <1 nm emittance)**.

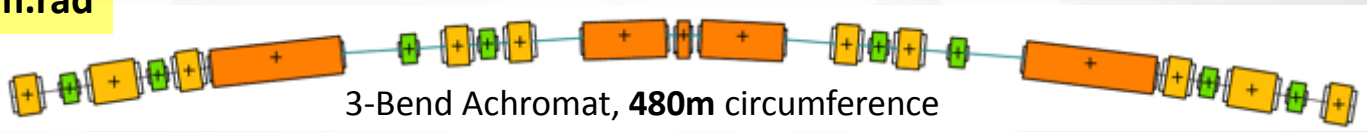
Natural emittance of some Light Sources



A radical turn

- **Sirius presented to the Machine Advisory Committee meeting in June 2012:**

Emittance: **1.7 nm.rad**



3-Bend Achromat, **480m** circumference

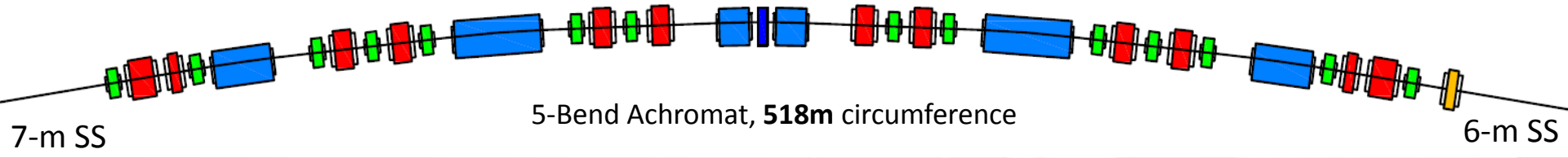
- **MAC recommendation:**

Go for a sub-nanometer.radian emittance

- **Sirius four months after 2012 MAC recommendation**

Emittance: **0.28 nm.rad**

MBA Design



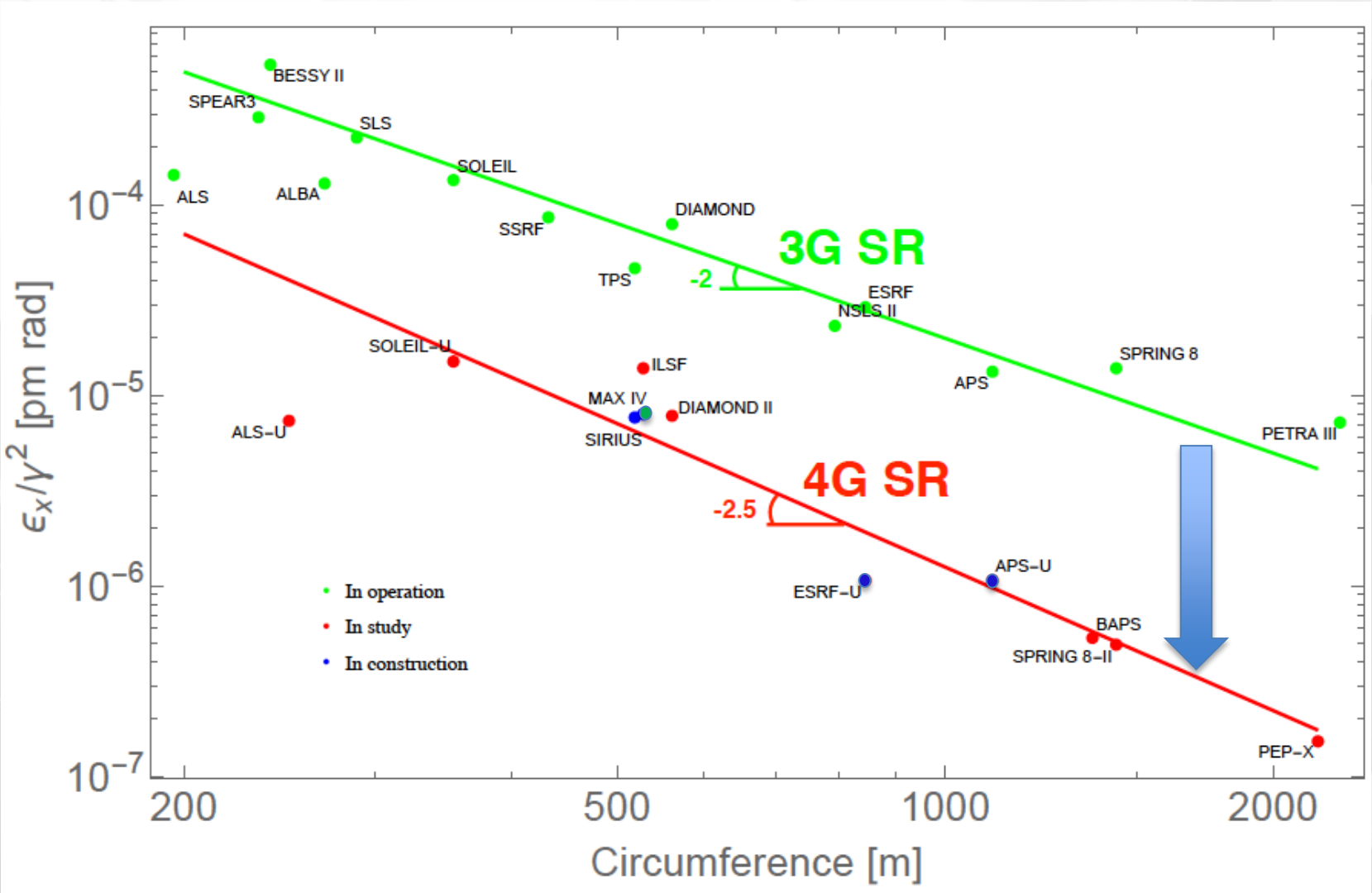
7-m SS

5-Bend Achromat, **518m** circumference

6-m SS

Emittance of UVX = 100 nm.rad

Natural emittance of some Light Sources



4th Generation Storage Rings

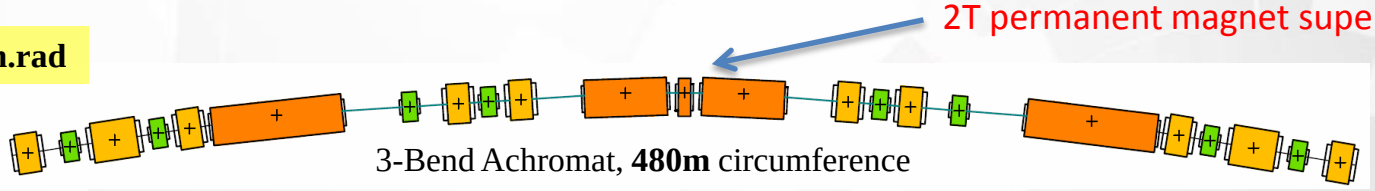
Harry Westfahl

First MBA synchrotron to start operation

Evolution of Sirius lattice design

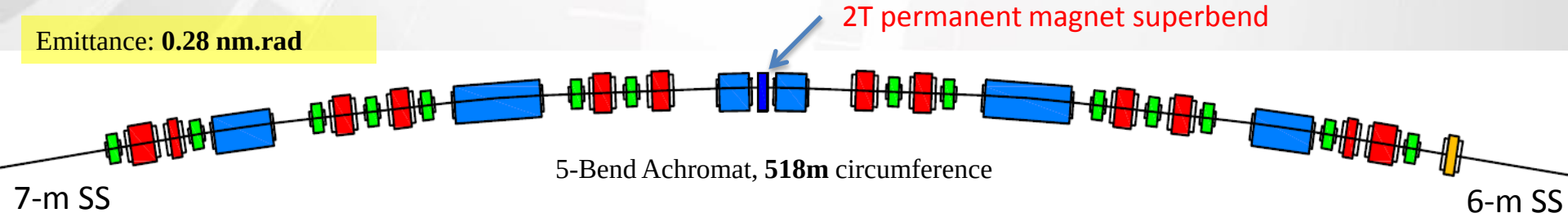
- 2012 - Sirius before Machine Advisory Committee (3rd Generation)

Emittance: **1.7 nm.rad**



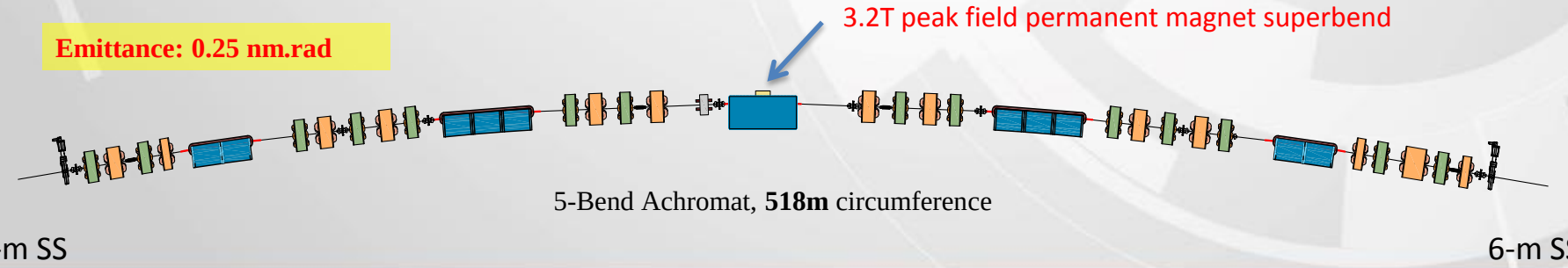
- 2012 - Sirius after MAC recommendation (4th generation)

Emittance: **0.28 nm.rad**

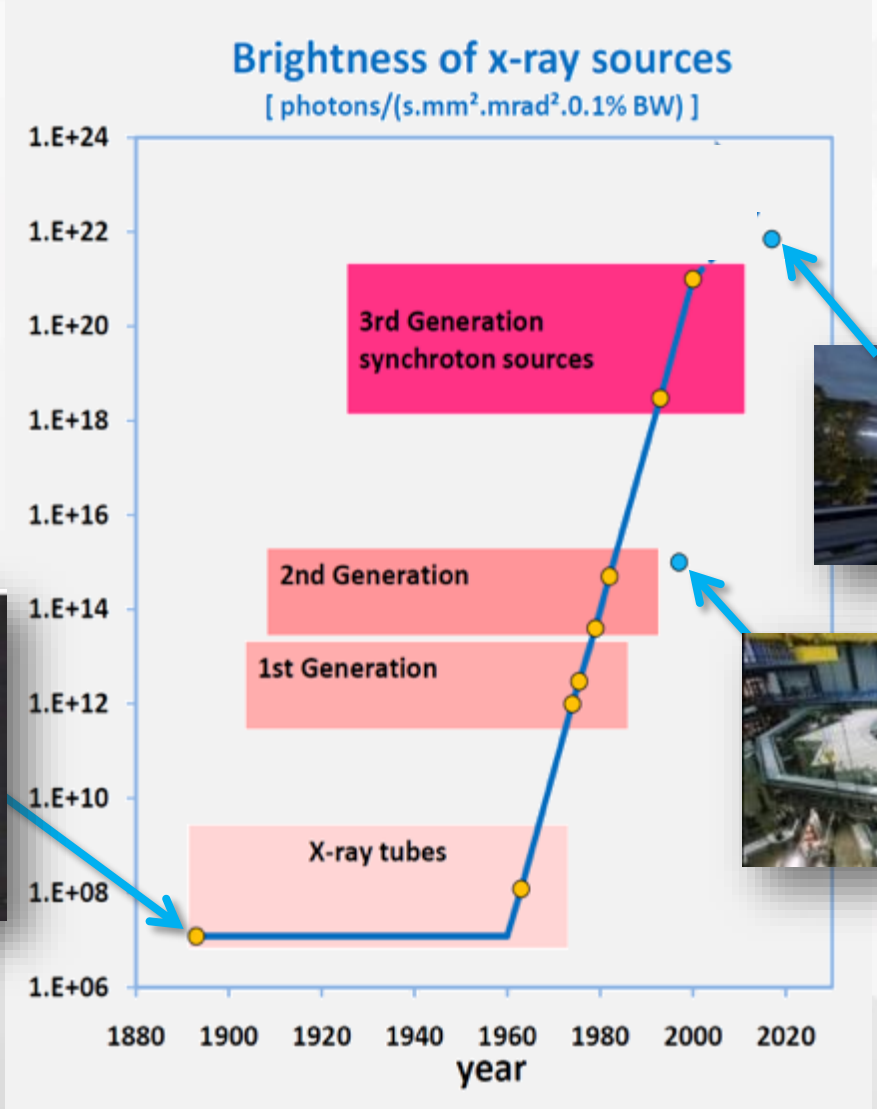


- 2016 - Sirius today (version SI.V17.01-S05.01)

Emittance: 0.25 nm.rad



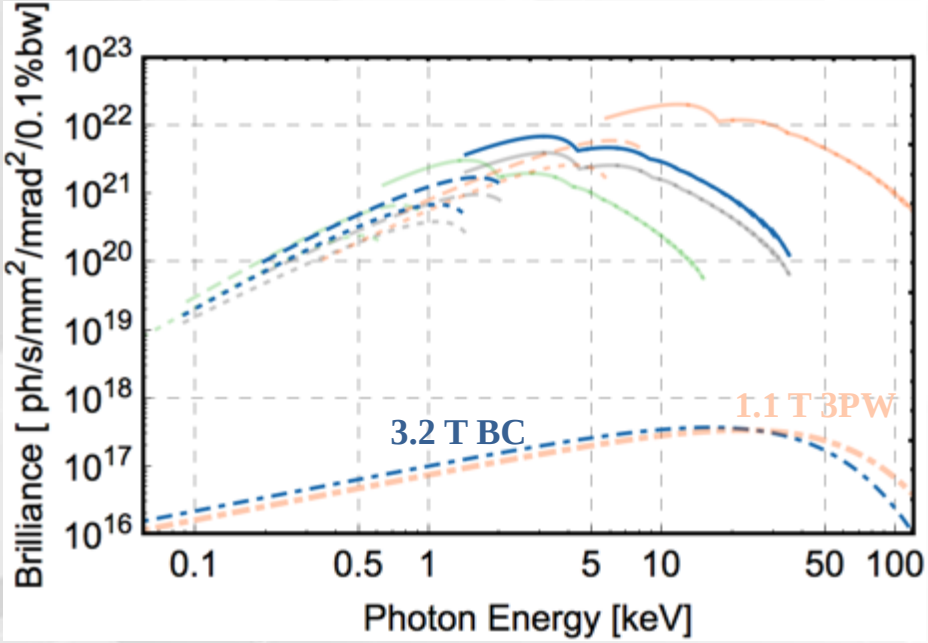
Brightness evolution of X-ray sources

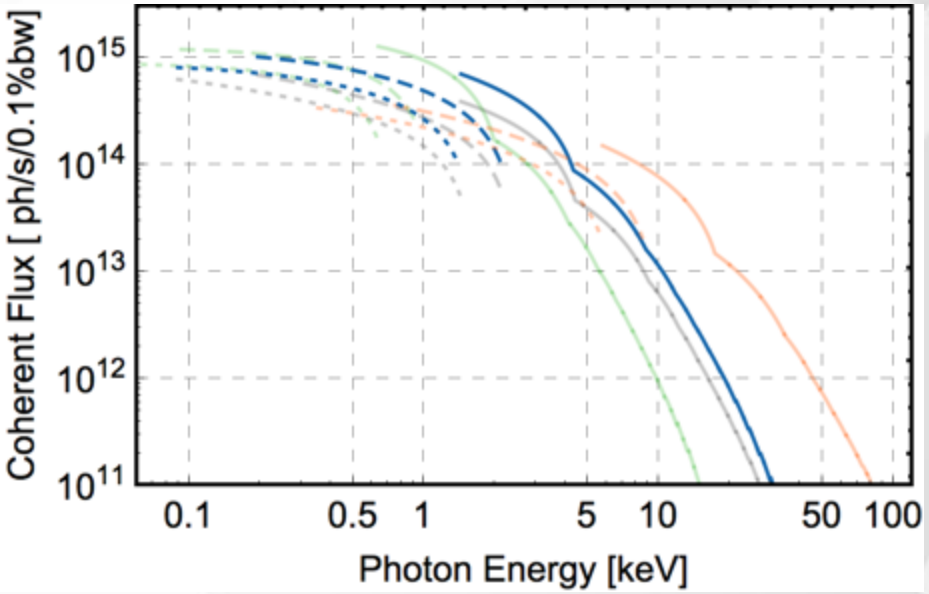


Sirius

UVX

Brilliance Comparison





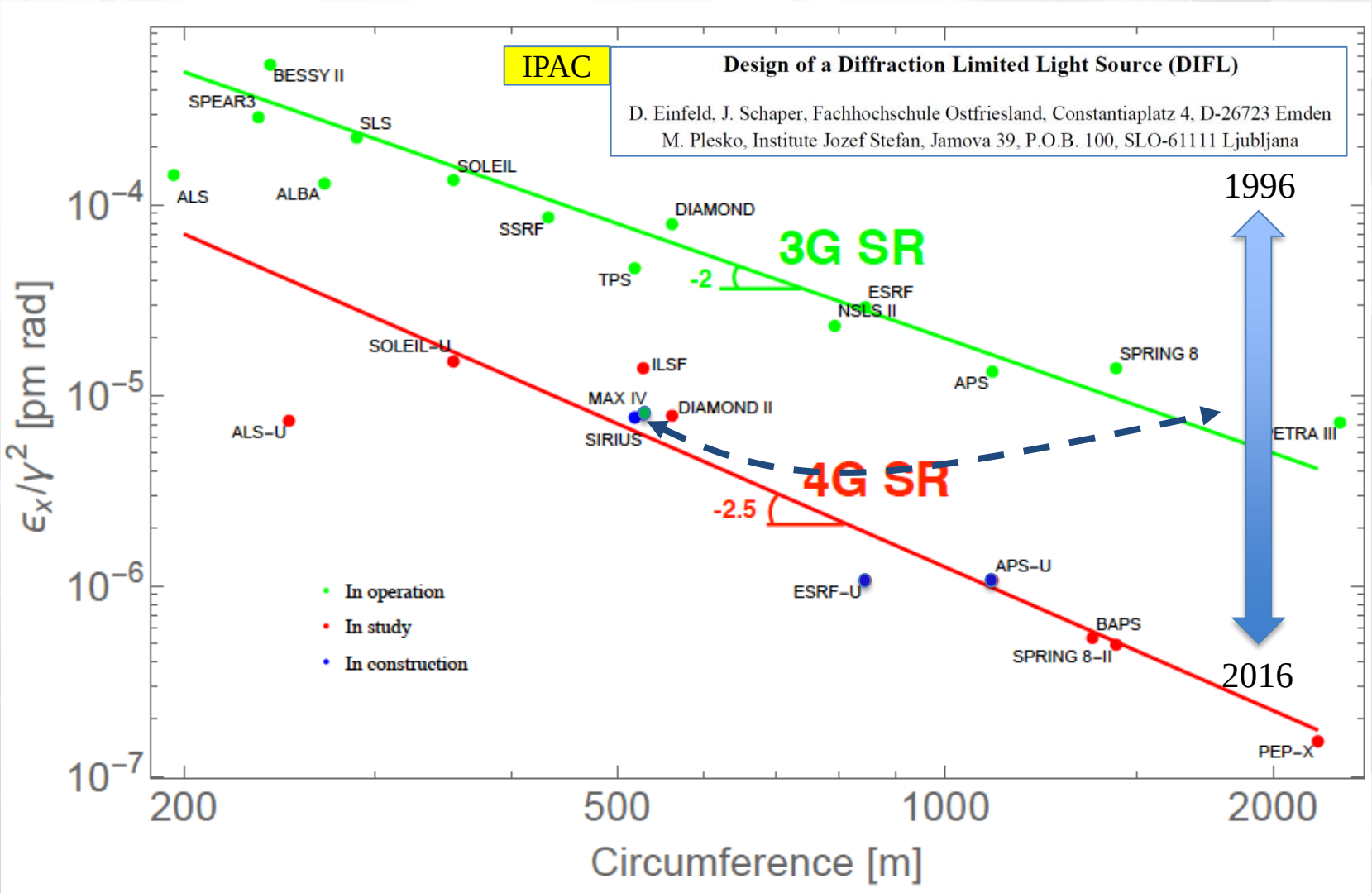
- λ_u = 17 mm, K_{max} = 2.2, L_u = 4 m
- λ_u = 34 mm, K_{max} = 5.0, L_u = 4 m
- λ_u = 51 mm, K_{max} = 6.0, L_u = 4 m
- BM (3.2T @ Sirius, 1.1T @ ESRF-U)

	E [GeV]	σ_E [%]	ε_x x ε_y [pm rad x pm rad]	β_x x β_y [m x m]	I [mA]
Sirius	3	0.09	245 x 2.5	1.4 x 1.7	350
MAX IV	3	0.08	328 x 4	9 x 2	350
ALS-U	2	0.08	50 x 50	3 x 3	350
ESRF-U	6	0.09	147 x 5	5.2 x 2.4	200

nature

SOURCE: US DEPARTMENT OF ENERGY/BESAC; MAX IV

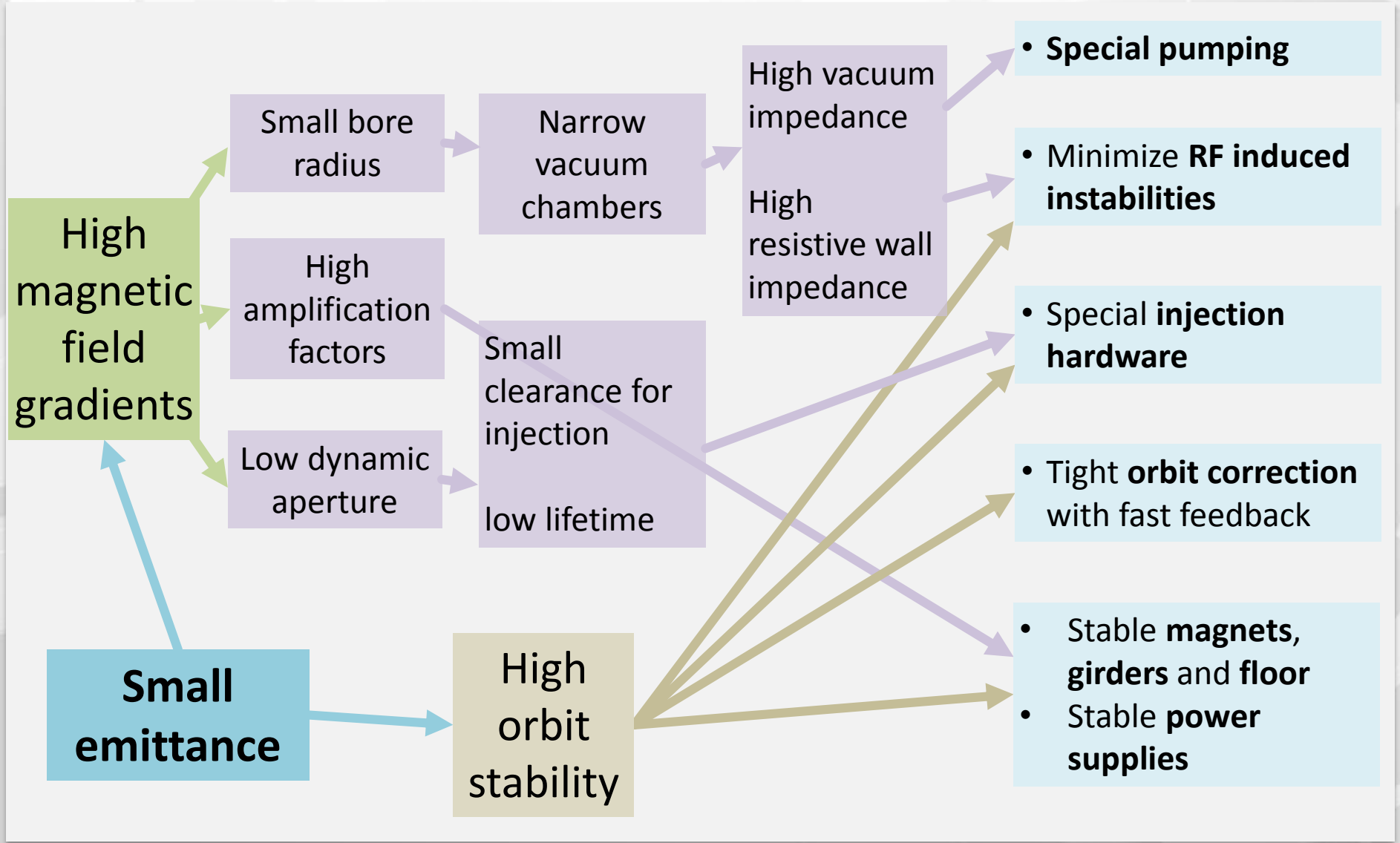
Natural emittance of some Light Sources



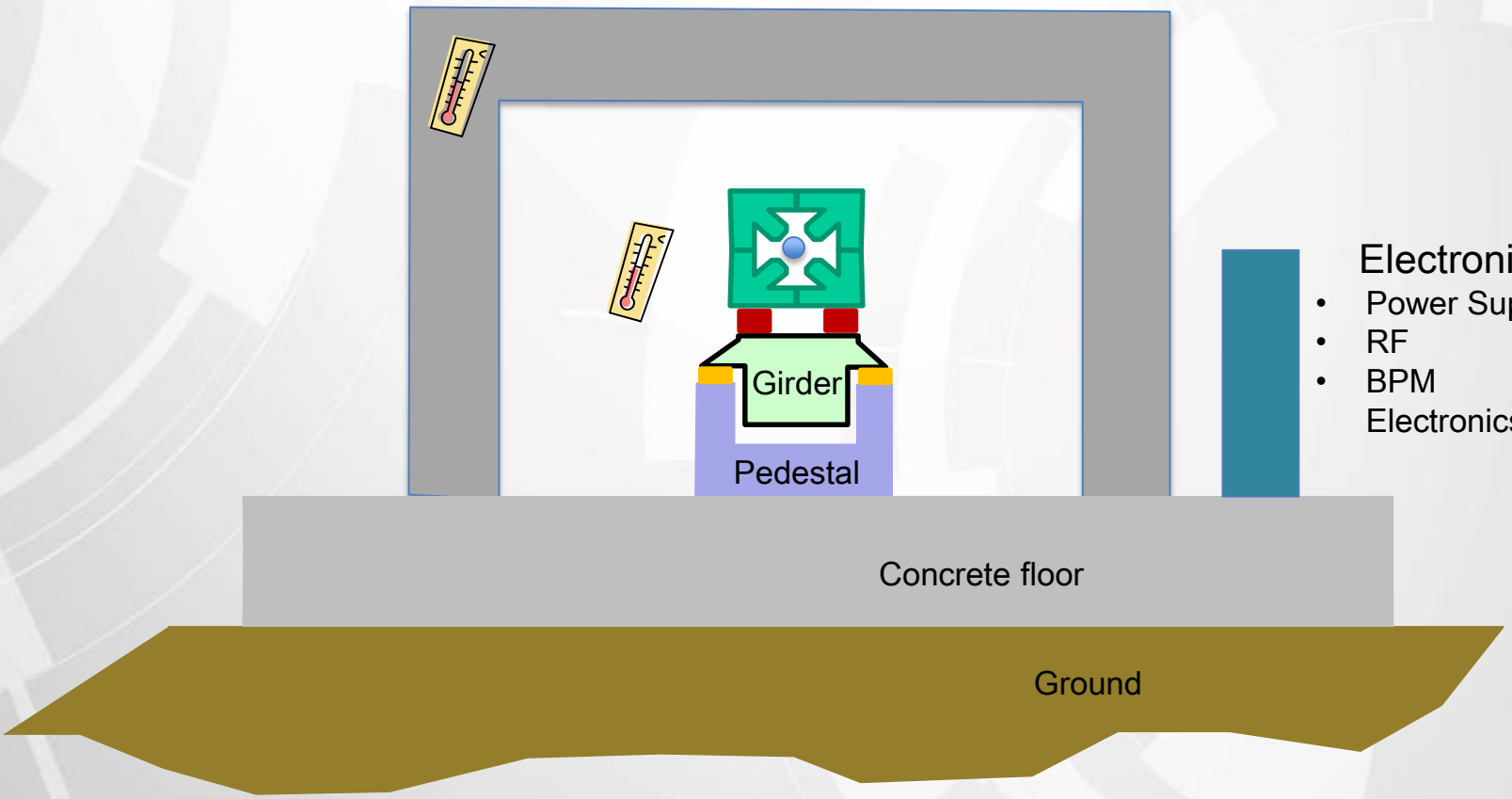
4th Generation Storage Rings

Harry Westfahl

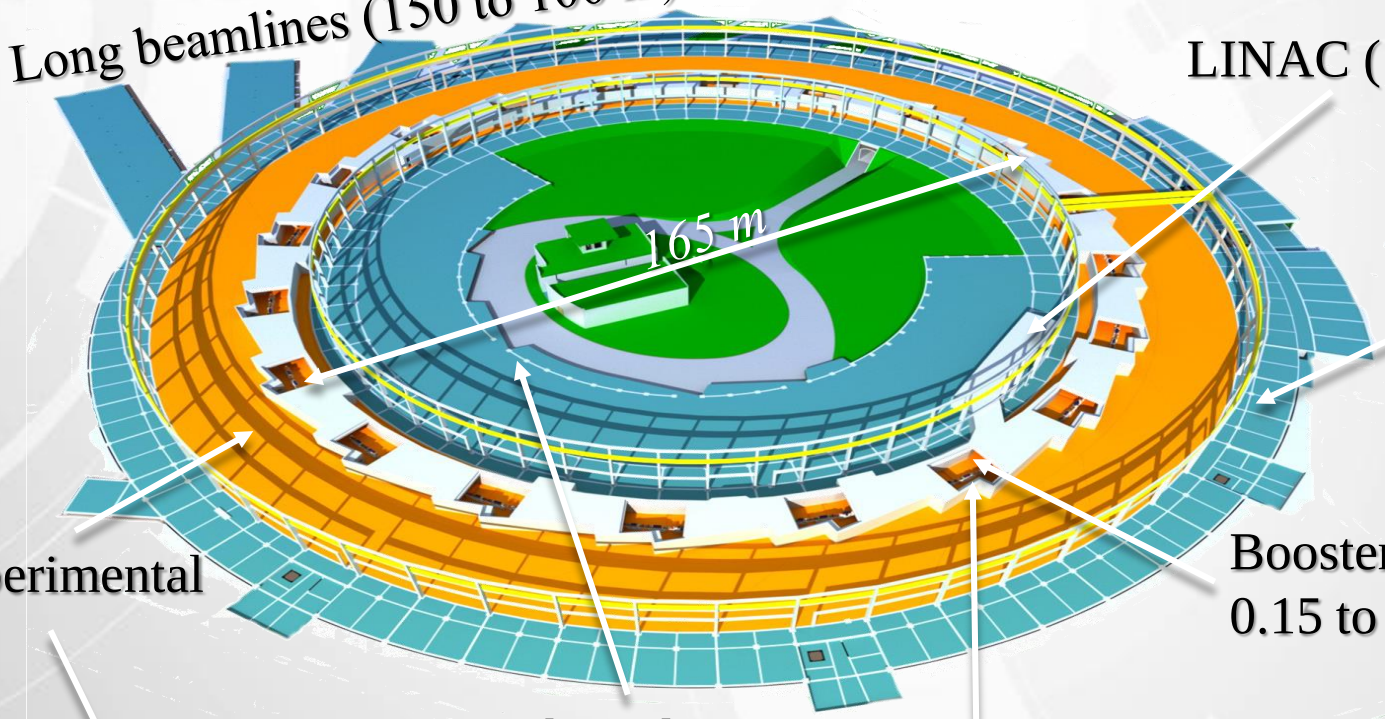
Challenging Engineering

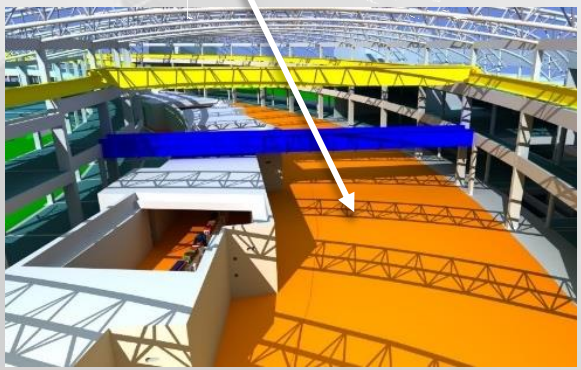


It's all about stability !

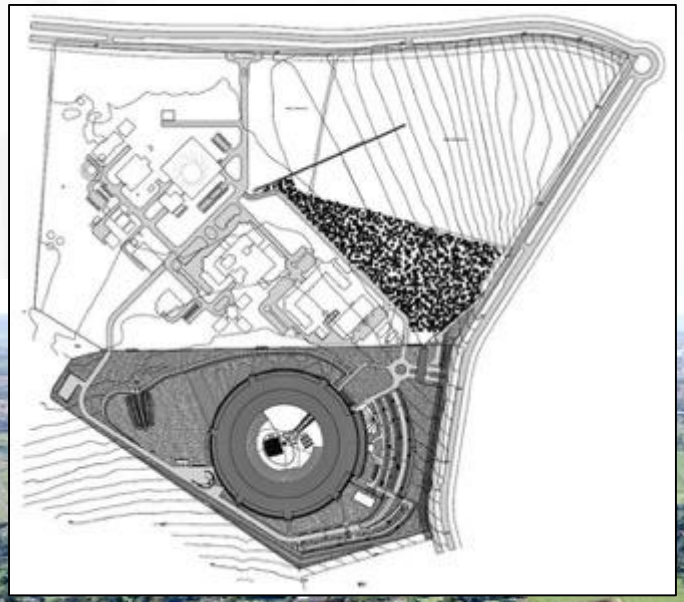


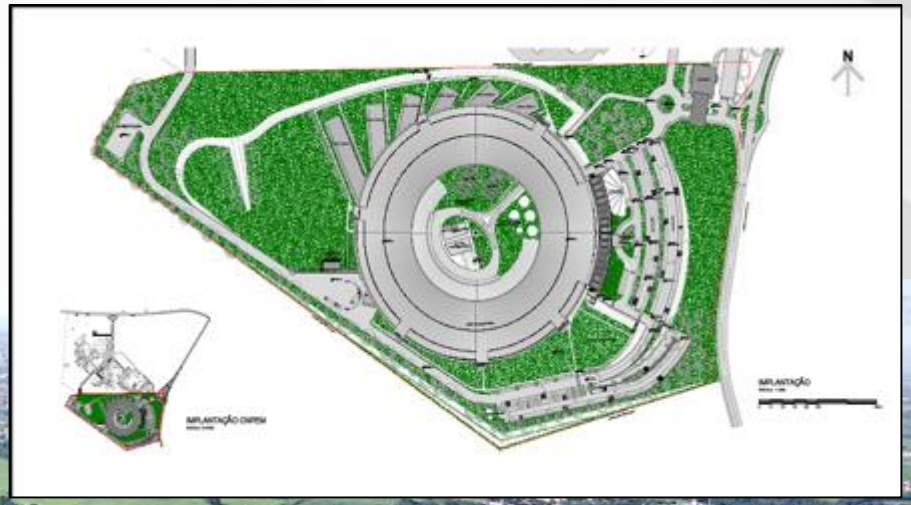
The Sirius building





SIRIUS @ CNPEM



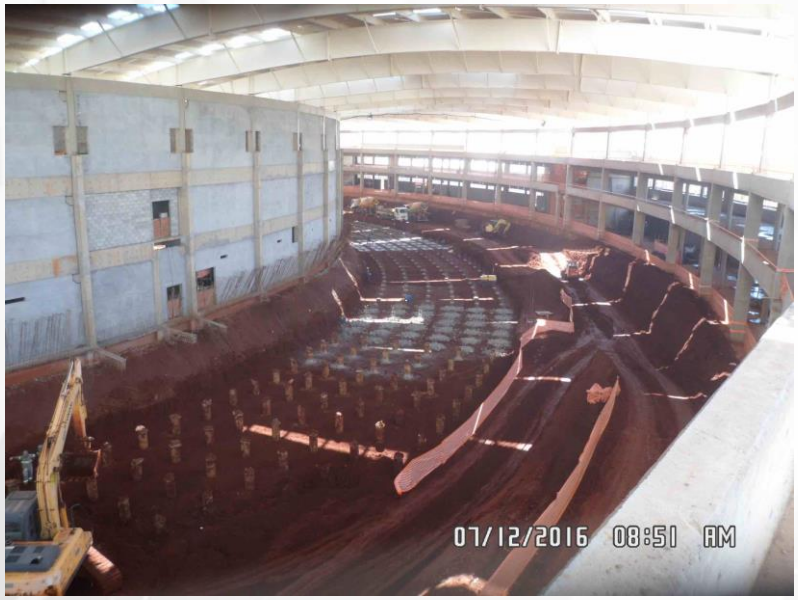

N
IMPLANTAÇÃO

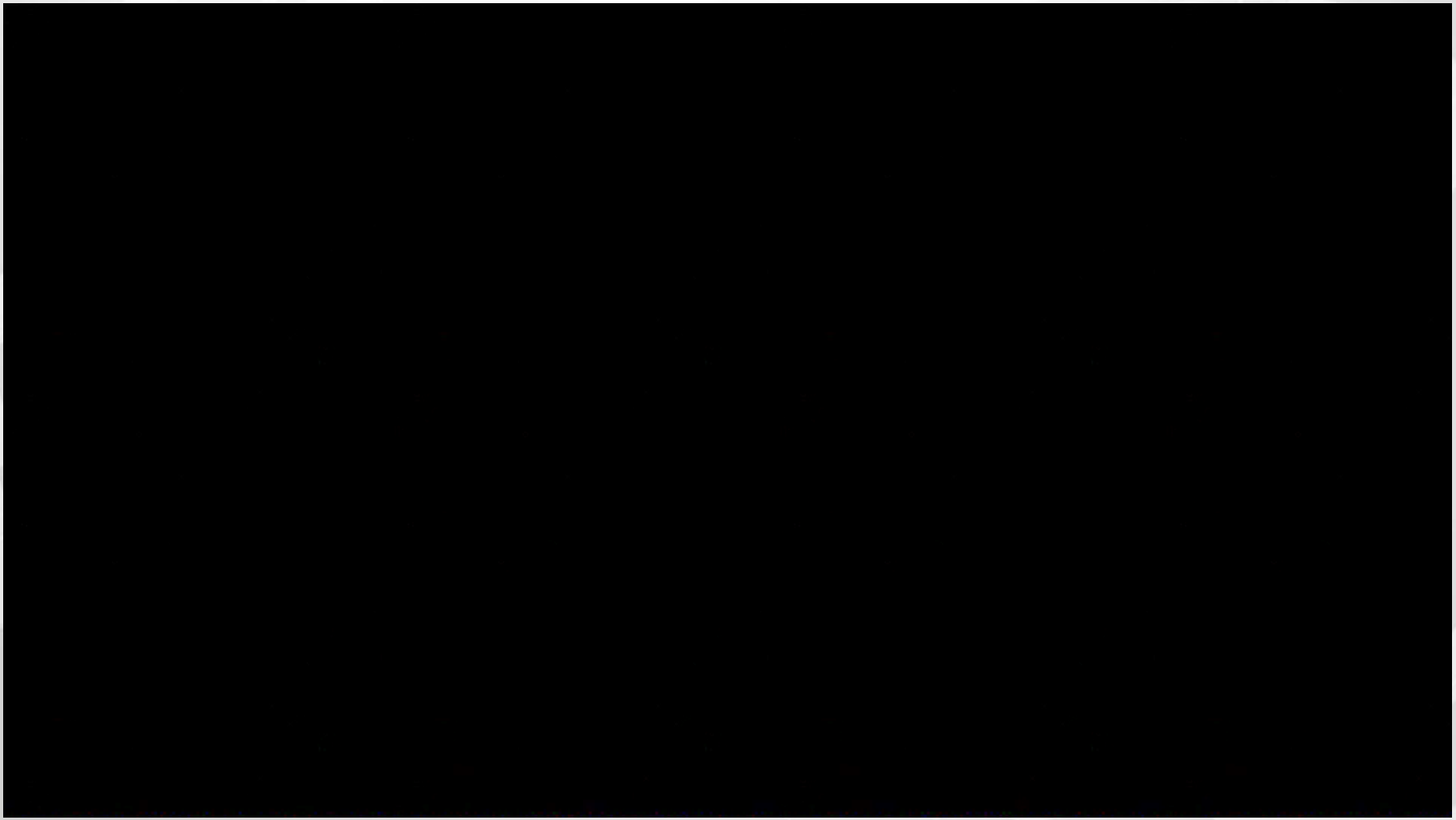
Building design and construction

- Executive project concluded – 2012-2014 Engineering A Hill International Company
- Total area - 68.000 m^2
- Special floor to minimize effects of vibration on the accelerator and beamlines

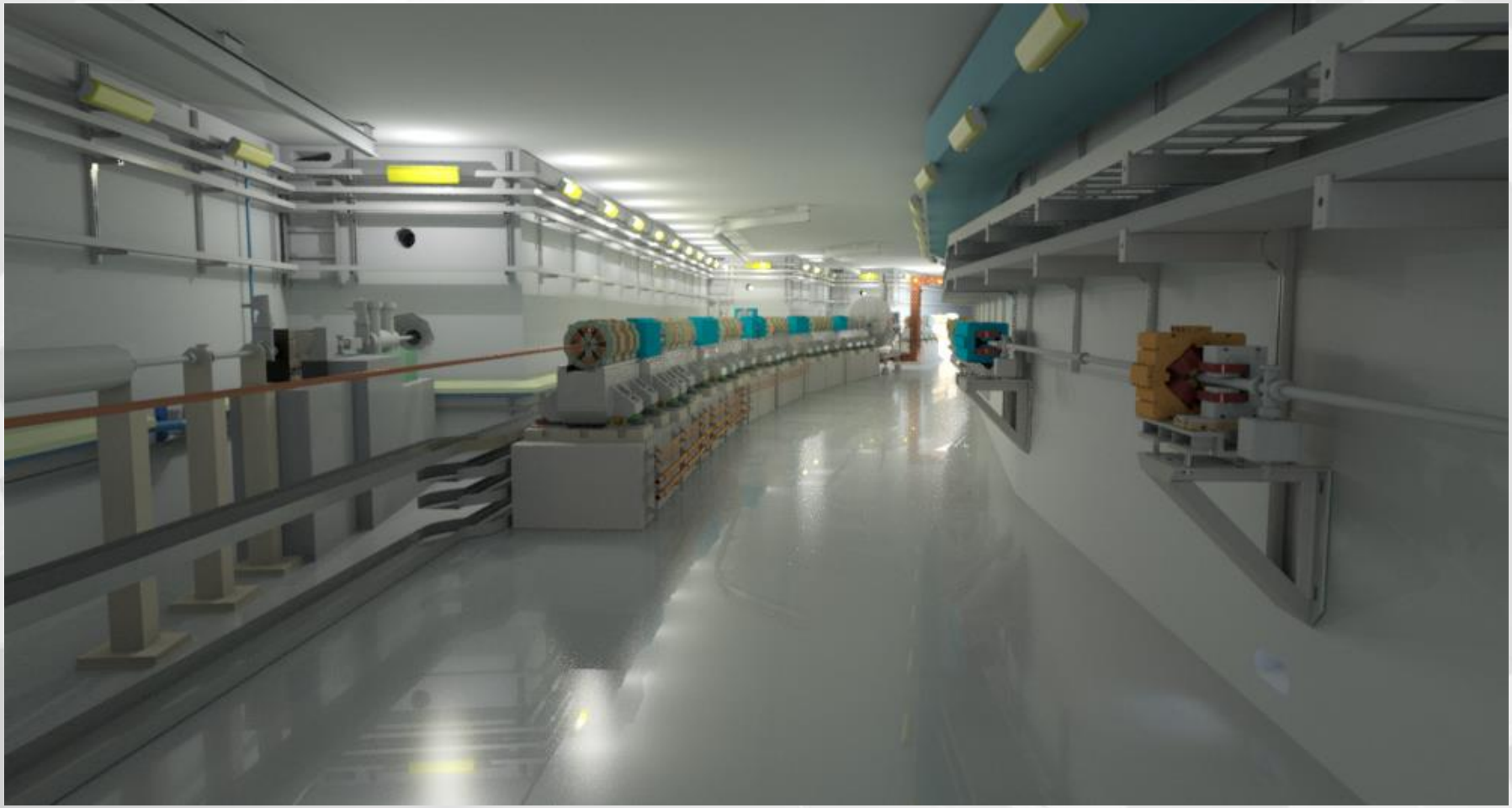
~41% CONCLUDED

Estacas e Capitéis do Piso Especial





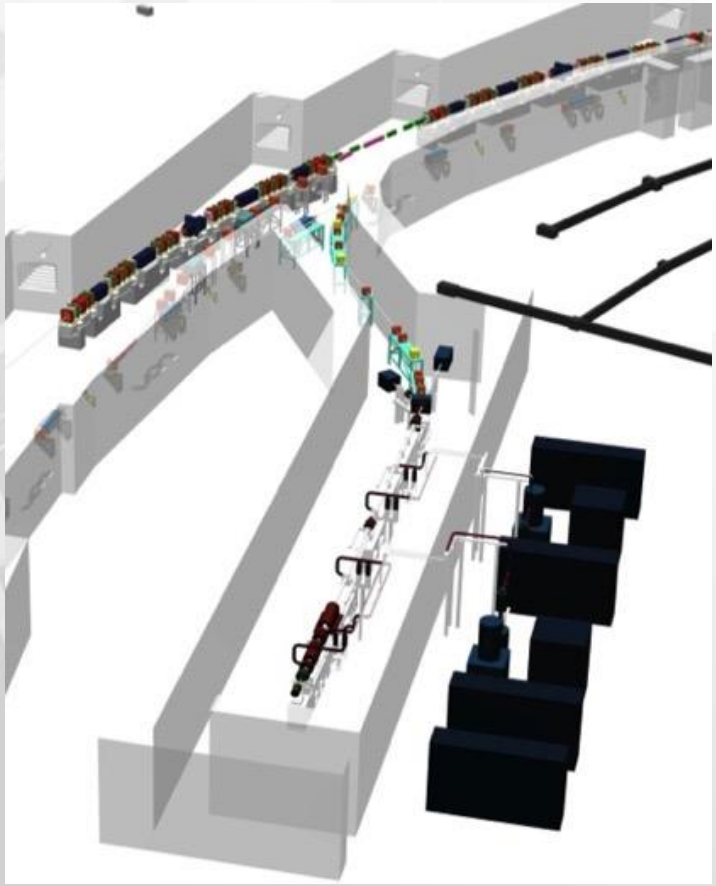
Inside the accelerators tunnel



LINAC (SSRF- Shanghai)

- The LINAC is ready and passed the acceptance tests in Jan. 2016
- 1st semester 2016: injector commissioning, BPM and waveguide acceptance tests and user manuals.

Installation starts September 2017

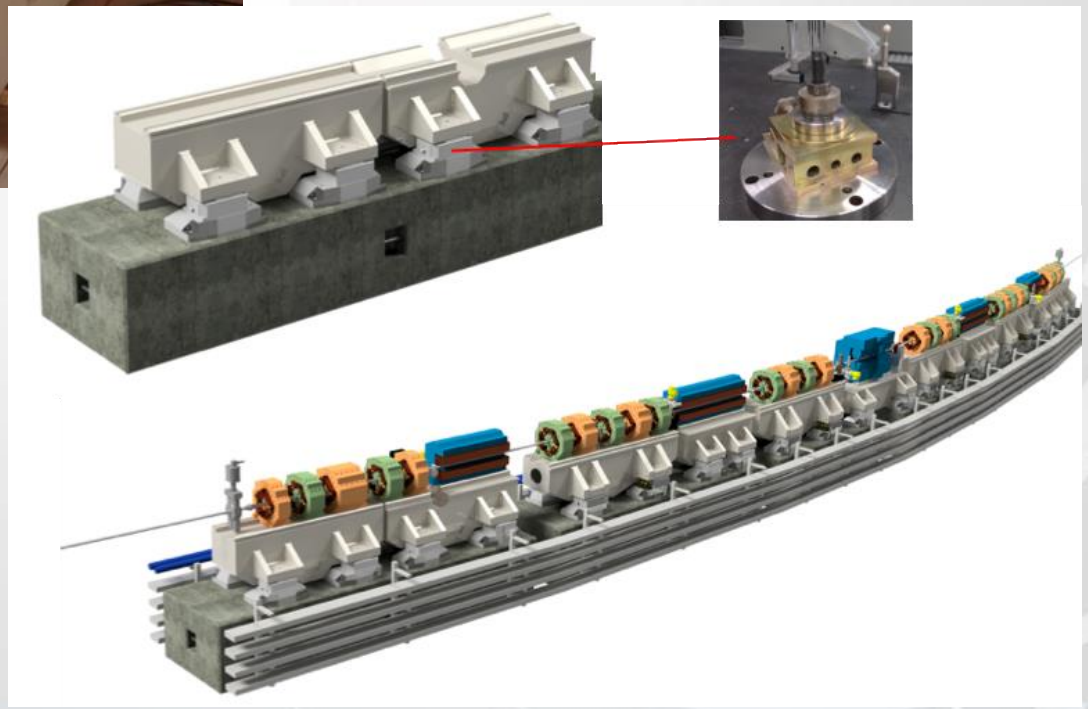


Girders and Pedestals

All supplied by Brazilian companies

JPHE
CALDEIRARIA E MAQUINAS

TOYO MATIC

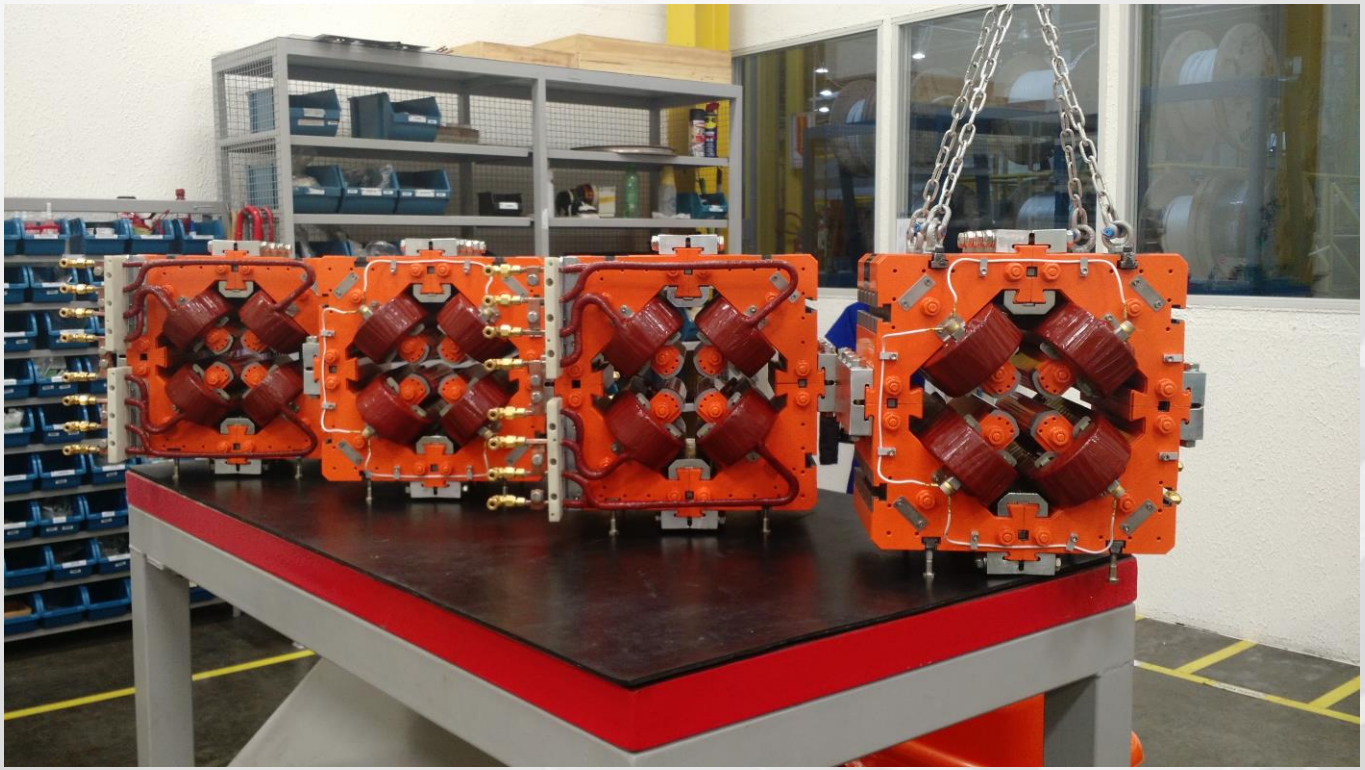


Booster Magnets

- Horizontal and vertical correctors (same design)
- Booster and Storage Ring

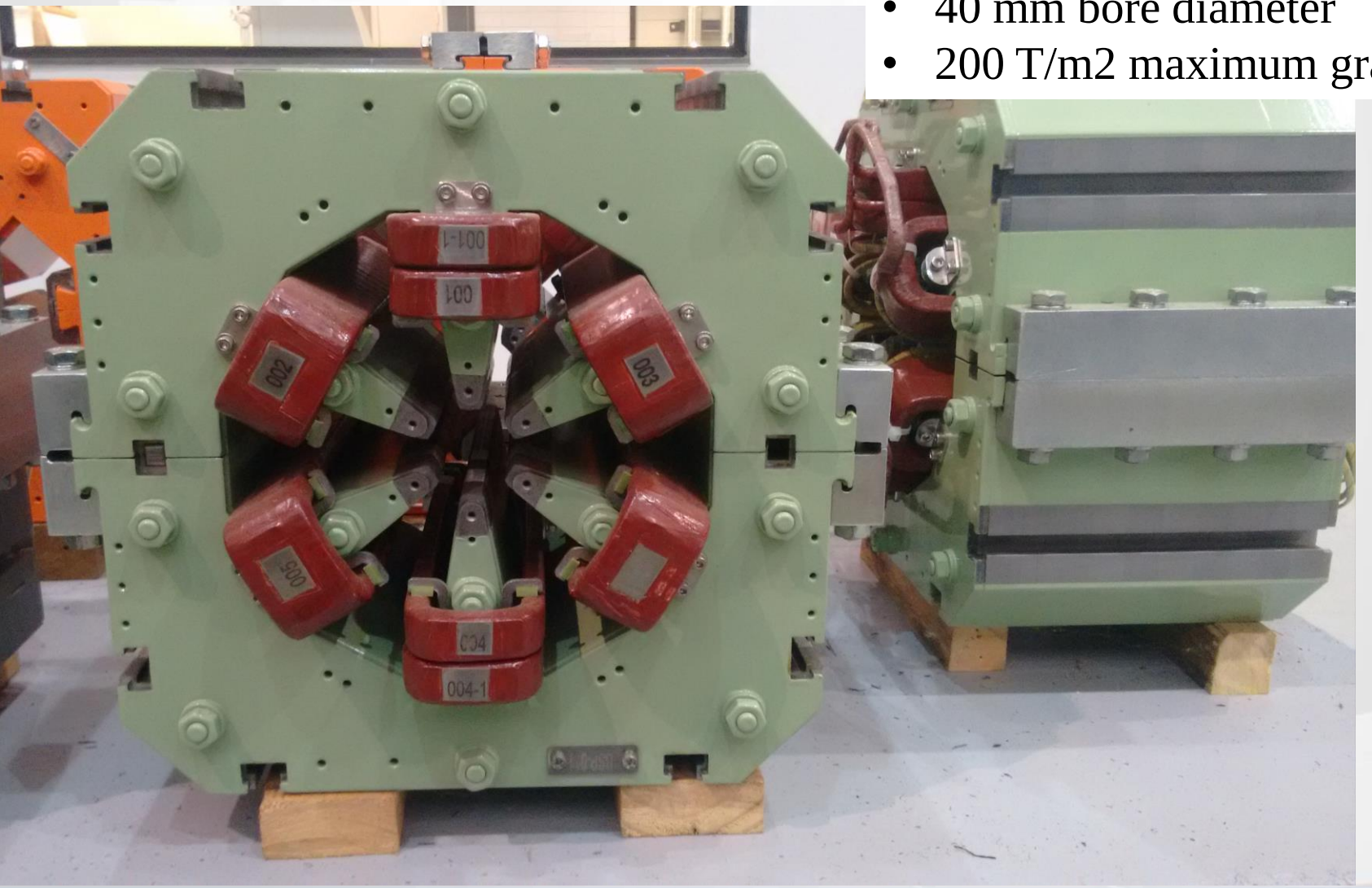
Booster Magnets

- Booster quadrupoles
- Booster and Linac-to-Booster transport line
- 40 mm bore diameter
- 19 T/m maximum field gradient



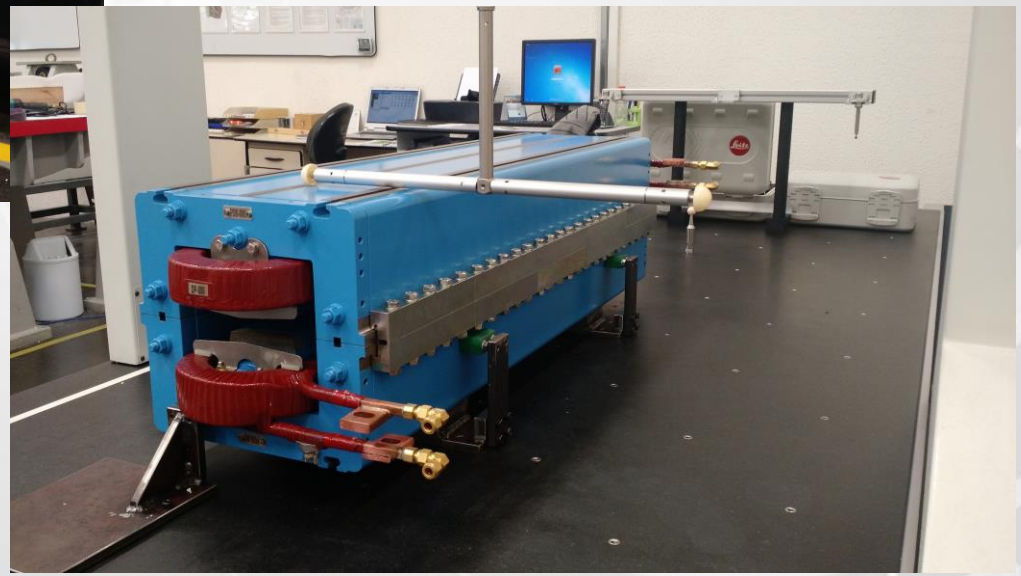
Booster Magnets

- Booster sextupole
- 40 mm bore diameter
- 200 T/m2 maximum gradient



Booster Magnets

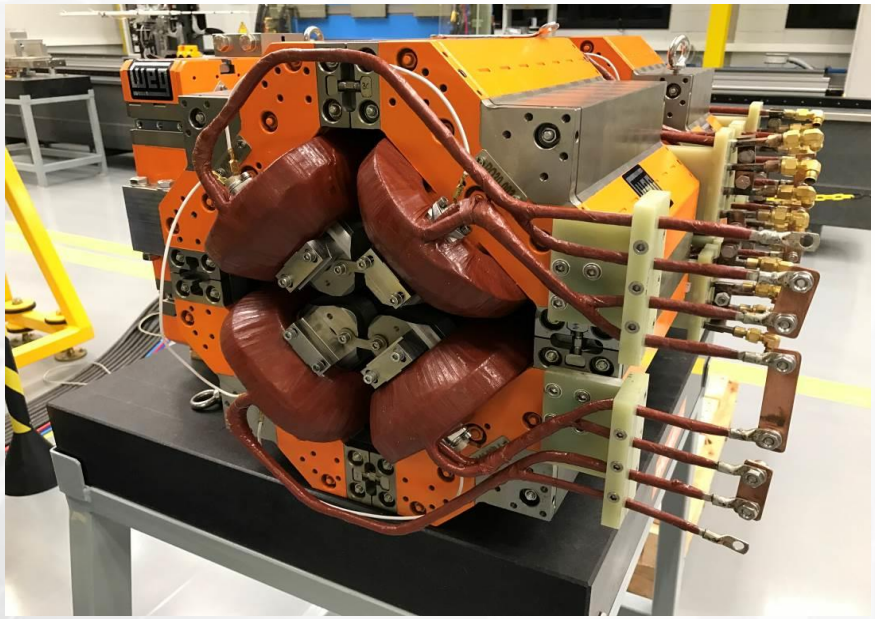
- Booster dipole (with quadrupole and sextupole components)
- 28 mm gap and 1200 mm length
- Dipole field: 1.09 T

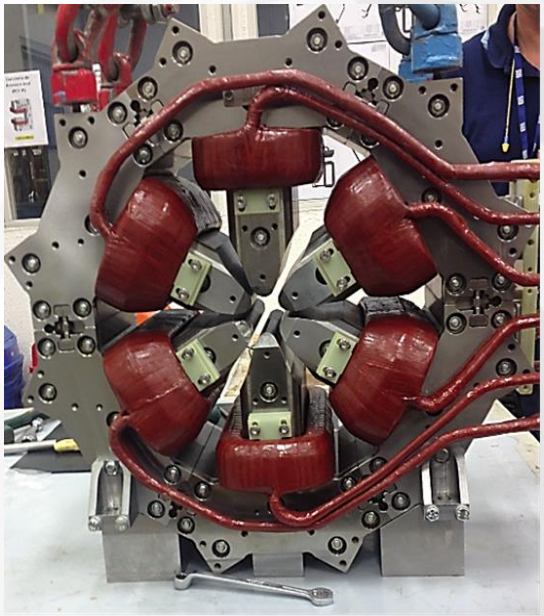


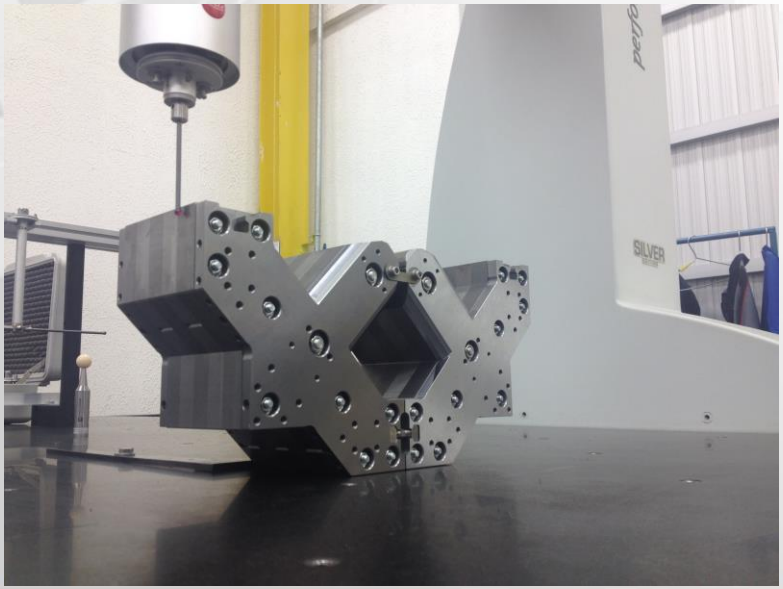
Booster Magnets

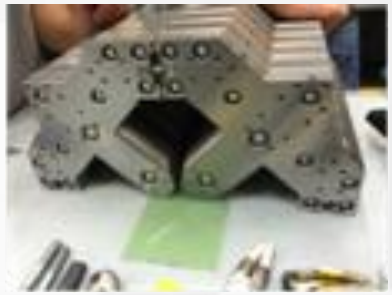
Booster correctors:	100%
Booster quadrupoles:	100%
Booster sextupoles:	100%
Booster dipoles:	March 2017

Storage Ring Magnets







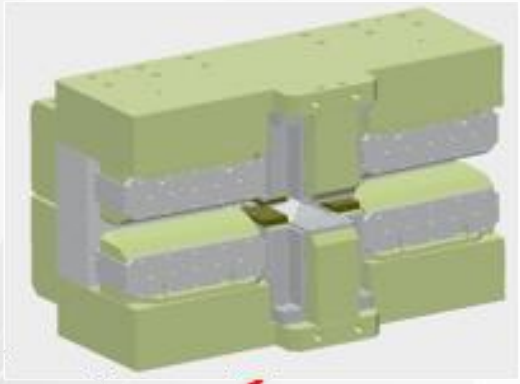


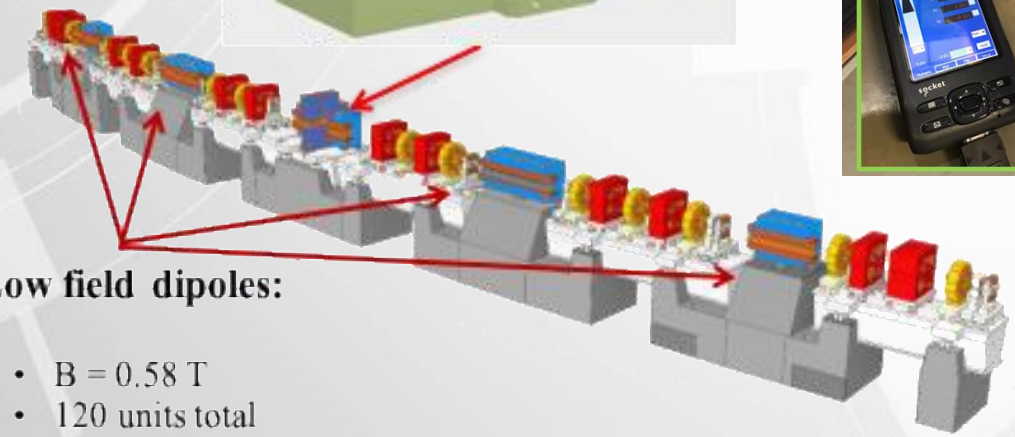
Magnets characterization room

Central Dipole – permanent magnet

NdFeB Superbend:

- B = 3.2 T
- 20 units total



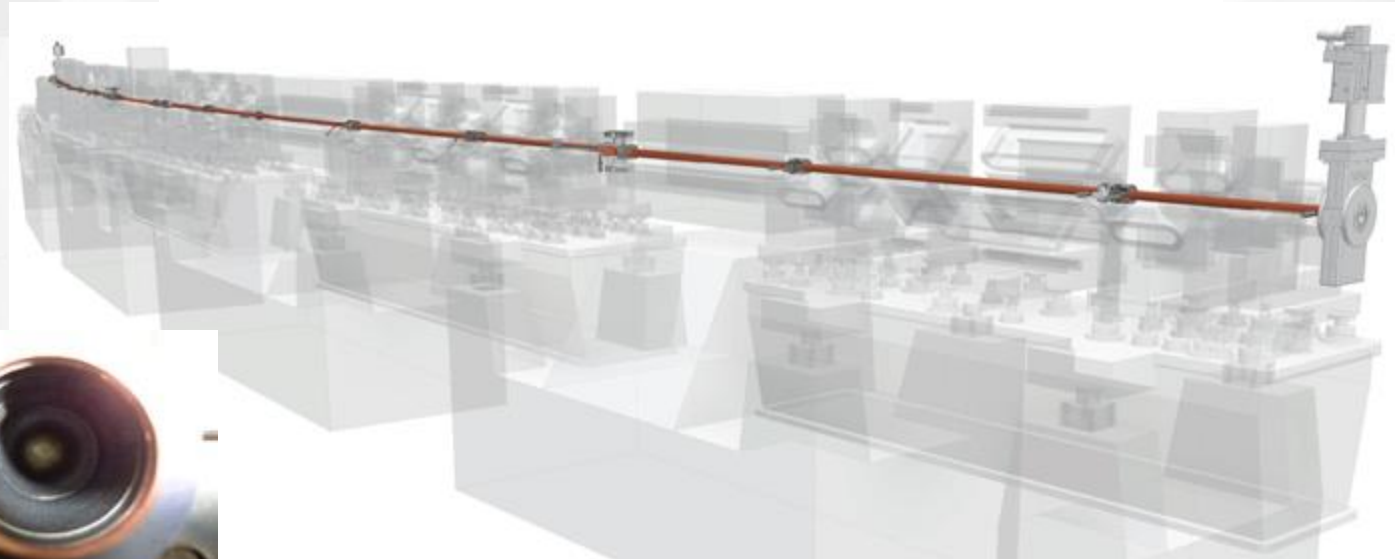


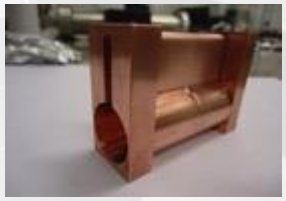
Low field dipoles:

- B = 0.58 T
- 120 units total

In house manufacturing

Vacuum Chambers (NEG Coating)

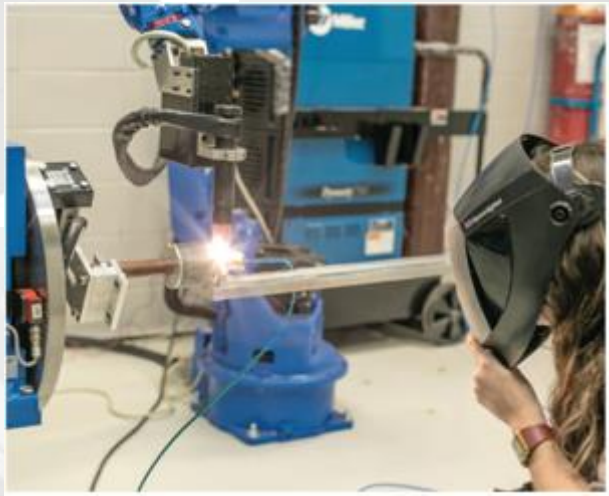




NEG Coating

Termomecanica

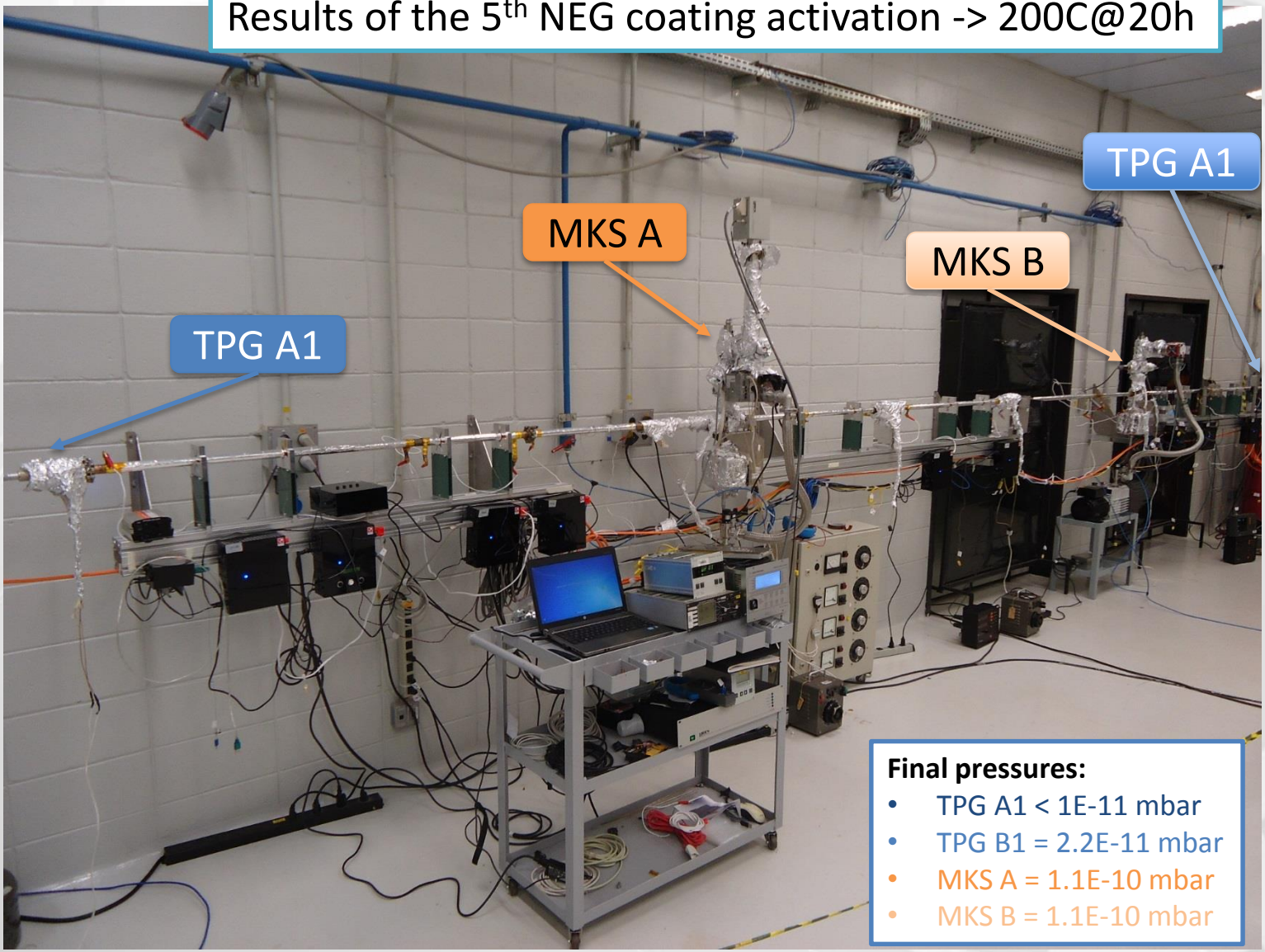
Cu/Ag alloy chamber



Cu welding

Vacuum system – half-arc mock-up test

Results of the 5th NEG coating activation -> 200C@20h

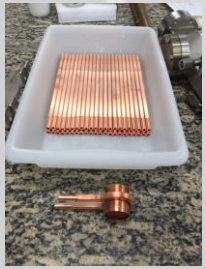


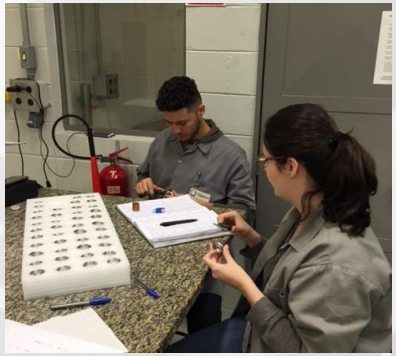
Final pressures:

- TPG A1 < 1E-11 mbar
- TPG B1 = 2.2E-11 mbar
- MKS A = 1.1E-10 mbar
- MKS B = 1.1E-10 mbar

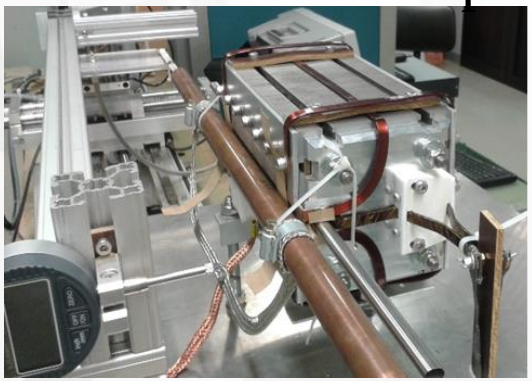
Booster (first chambers received)

Storage ring – In house production started

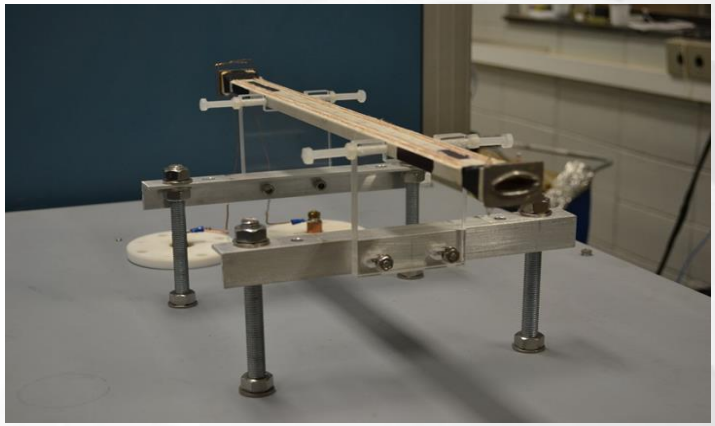




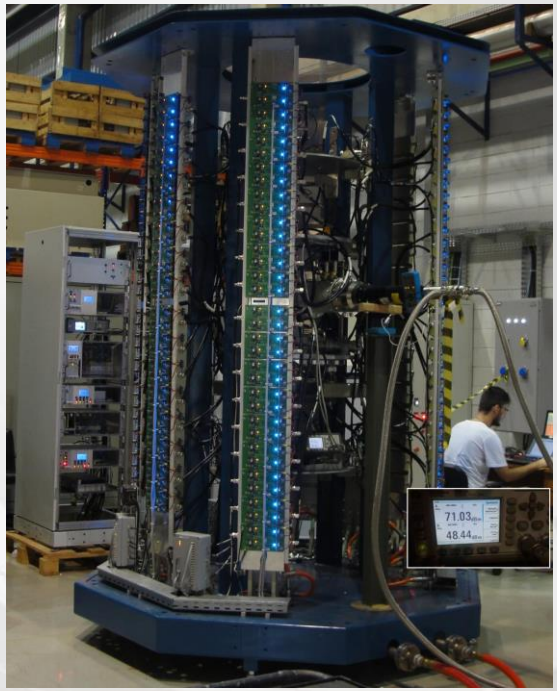
Septum



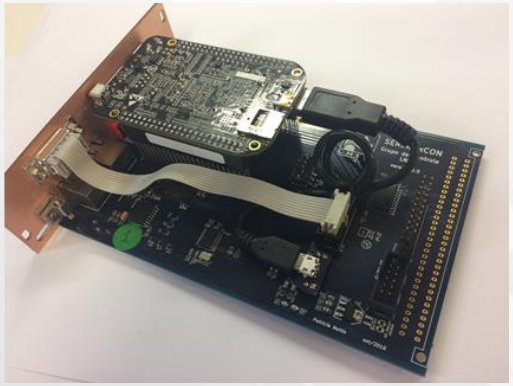
Non-linear Kicker



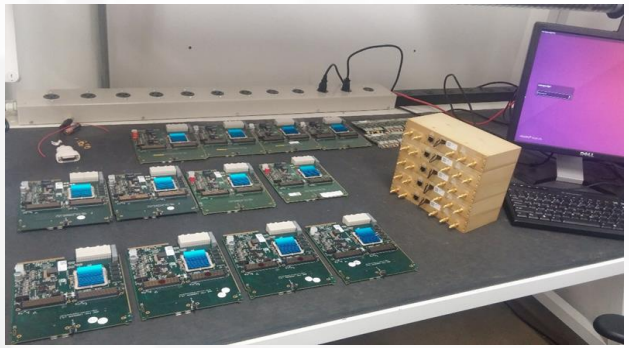
RF Amplifier

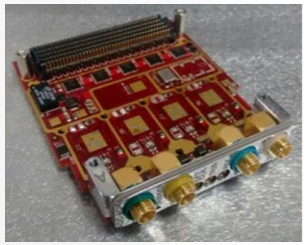
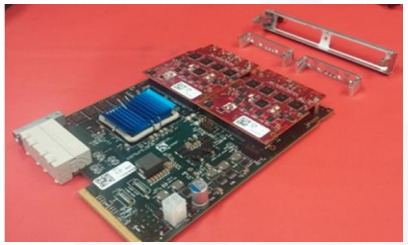


Control system

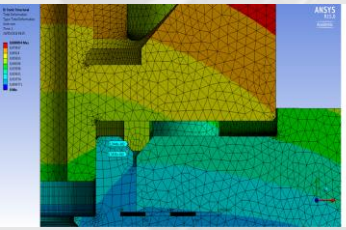
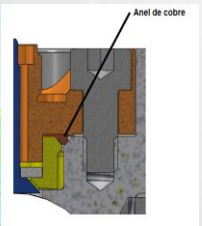


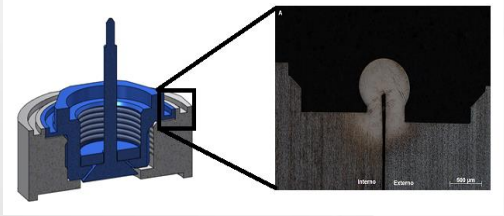
Diagnostic (BPM electronics)

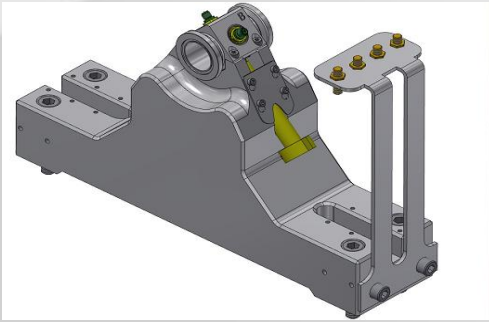
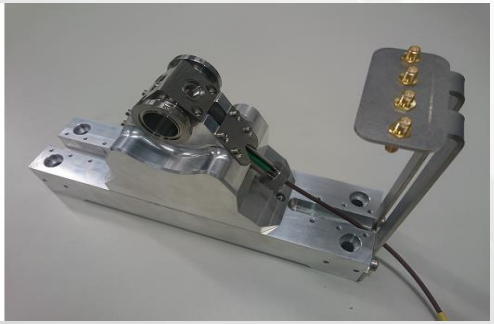
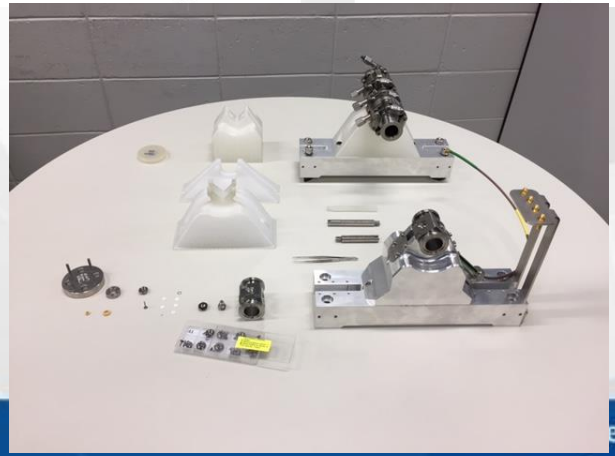


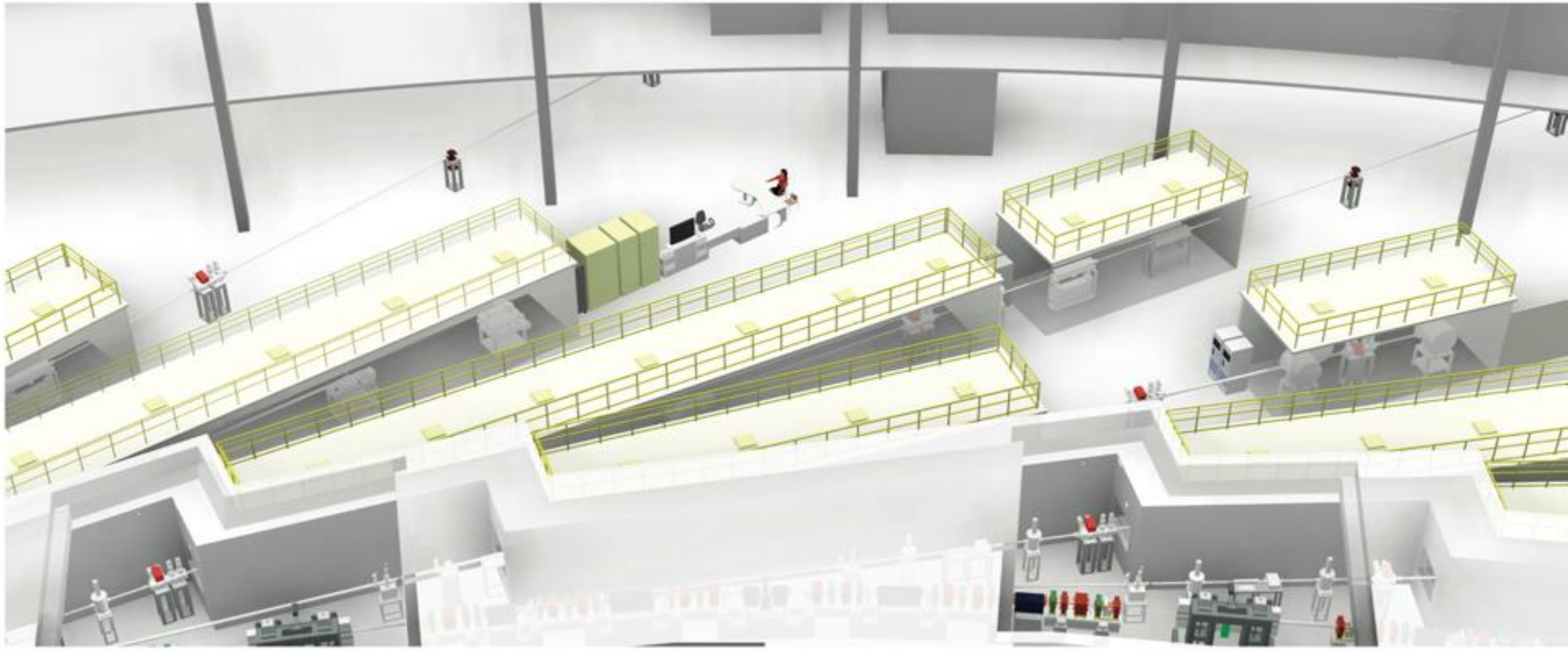
BPMs



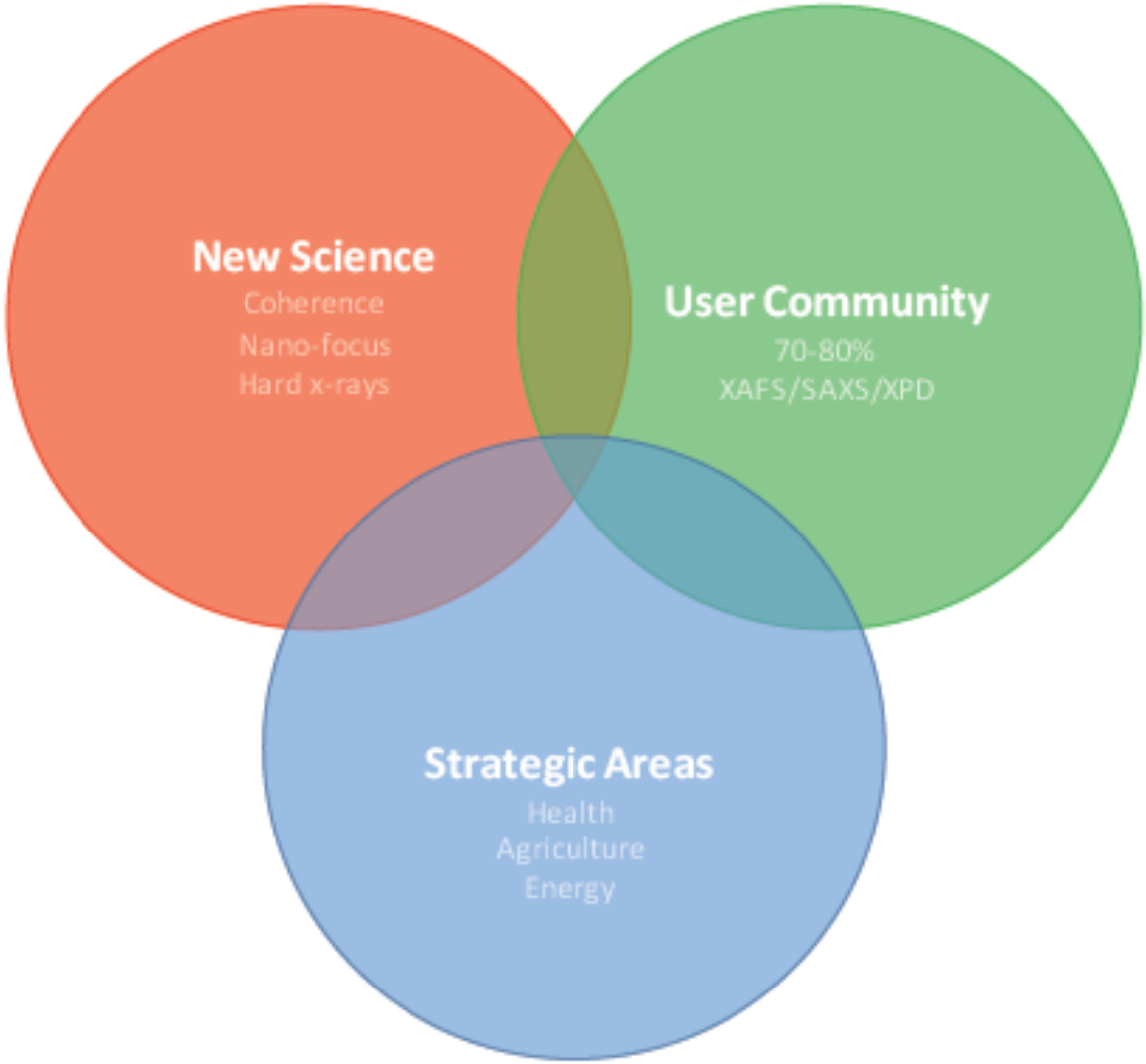





Beamlines



- Sirius will be able to have ~ 40 beamlines
- First phase – 13 beamlines

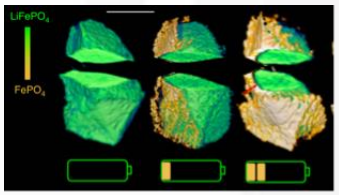
The choice of the first beamlines



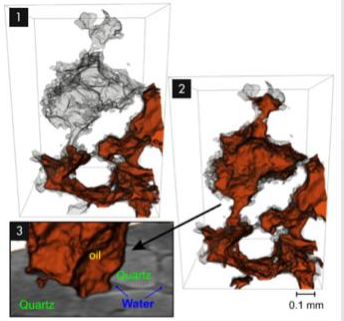
Most interesting/challenging materials are Inhomogeneous / Hierarchic / Composite - systems

”For many phenomena, we know ***how*** they happen, but don’t know ***why*** they happen.”

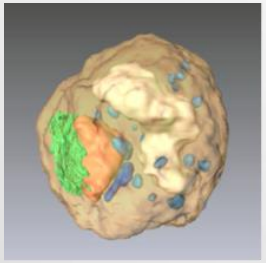
- In-situ/operando 3D imaging of virtually any material with nanometer resolution and several contrast mechanisms, such as
  - Chemical elements concentration
  - Chemical environment
  - Oxidation states
  - Chemical bonds
  - Crystalline structures
  - Grain orientation
  - Electronic densities
  - Magnetic moments
  - …



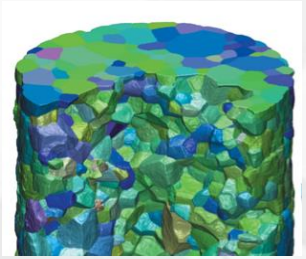
Dynamics in battery electrode nano grains *in operando*
Wang et al. Nature Comm. (2016)



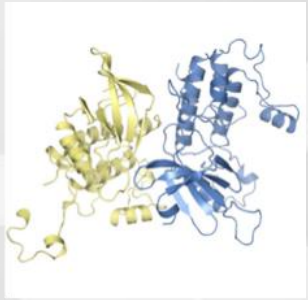
Real time oil flow in porous rocks
Berg et al. PNAS (2014)



Cell tomography
Miao et al. PNAS (2013)

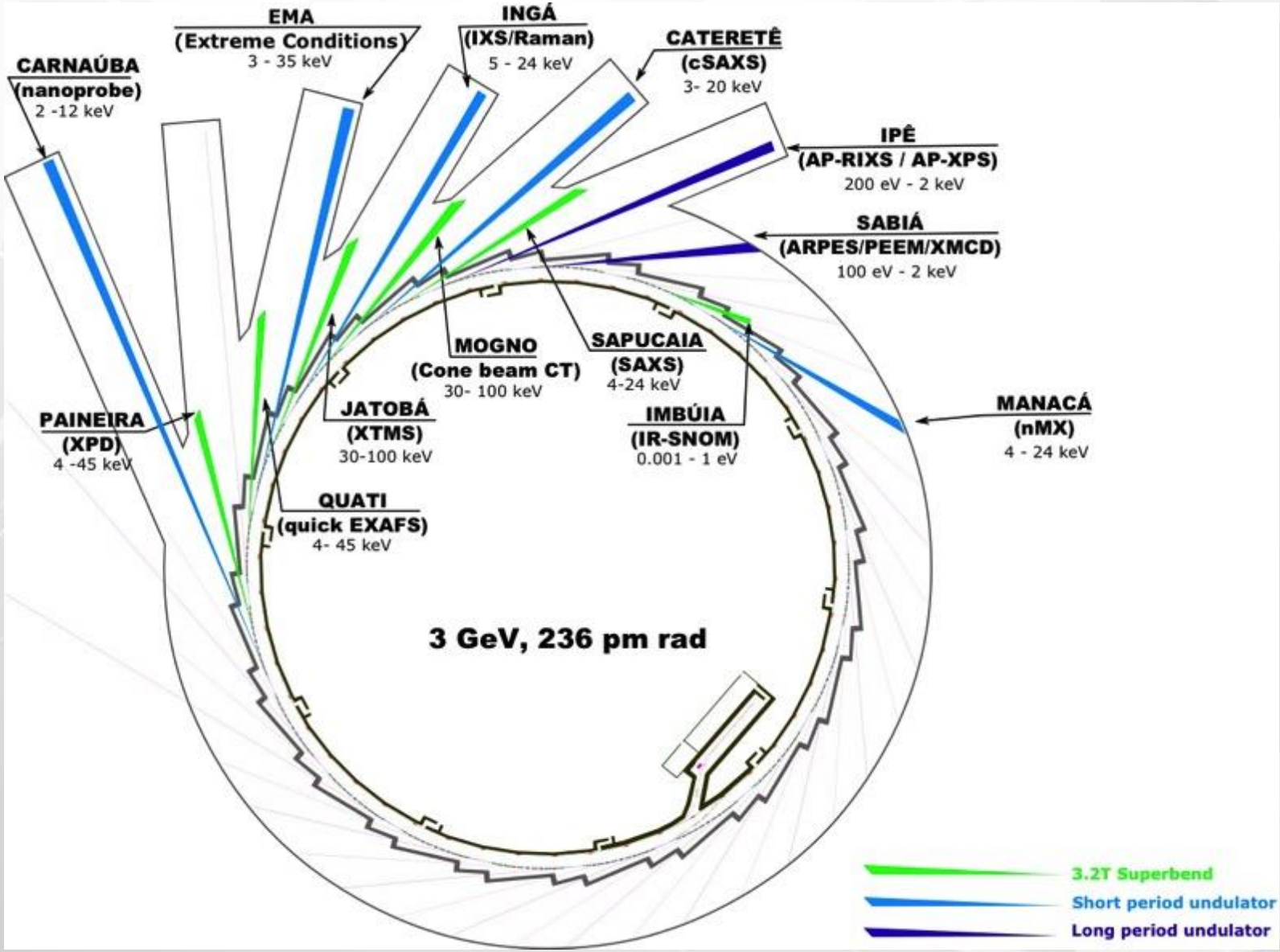


Crystalline grain mapping of alloys under stress
Nervo et al (2015)



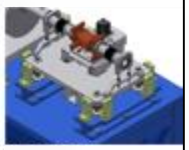
Membrane protein 3D structure

Initial phase beamlines



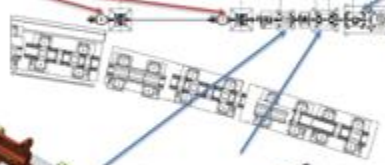
Beamlines Instrumentation

Front-end



Photon Shutter

XBPM (with Soleil)

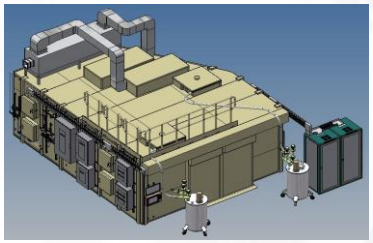


Fixed Mask (150μrad)

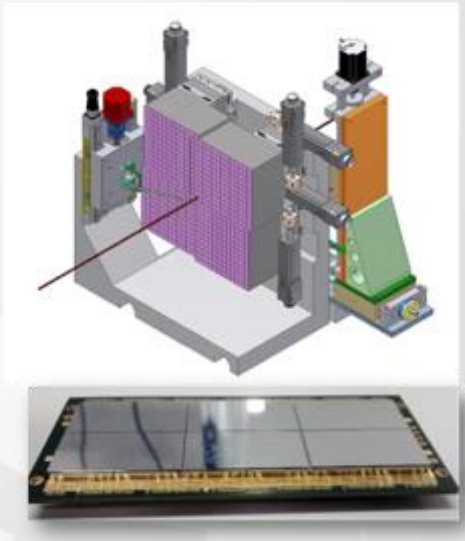
Slits (Max 60x60μrad)

Gamma Shutter
Collimator function (Lead)

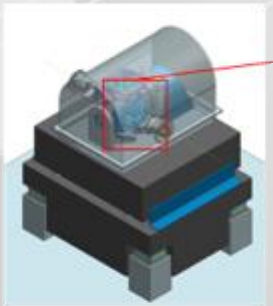
Optical Hutch

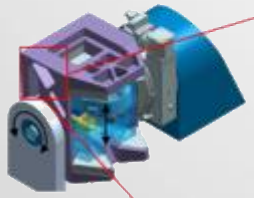


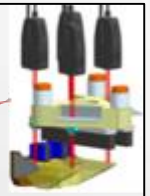
Large Area Detectors



Double Crystal Monochromator



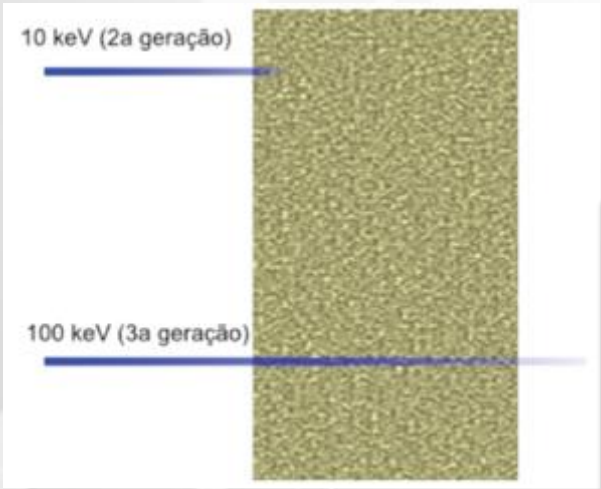




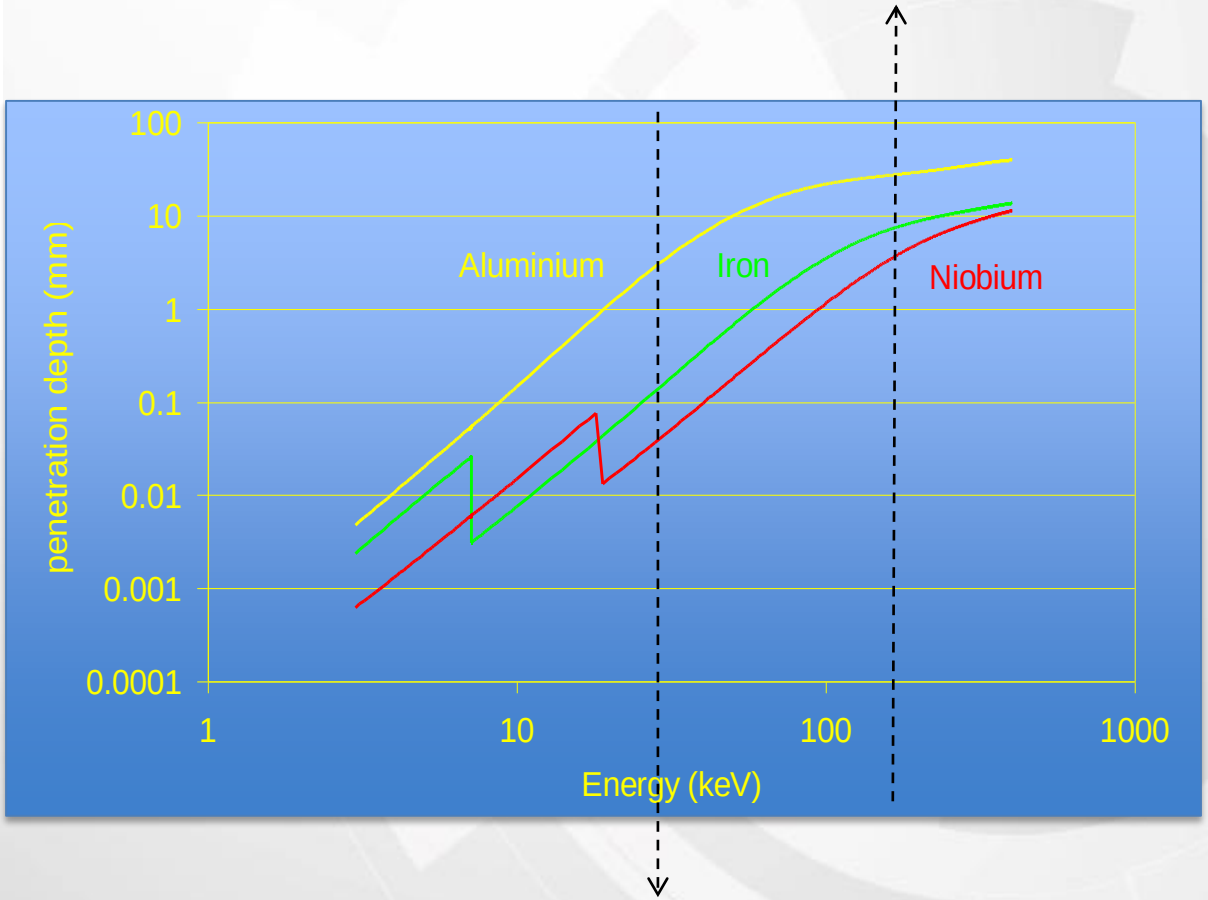
Double Channel Cut Monochromator

Optical metrology laboratory

Penetration of x-rays



High energy beamlines on Sirius



Maximum energy at the XDS beamline on UVX

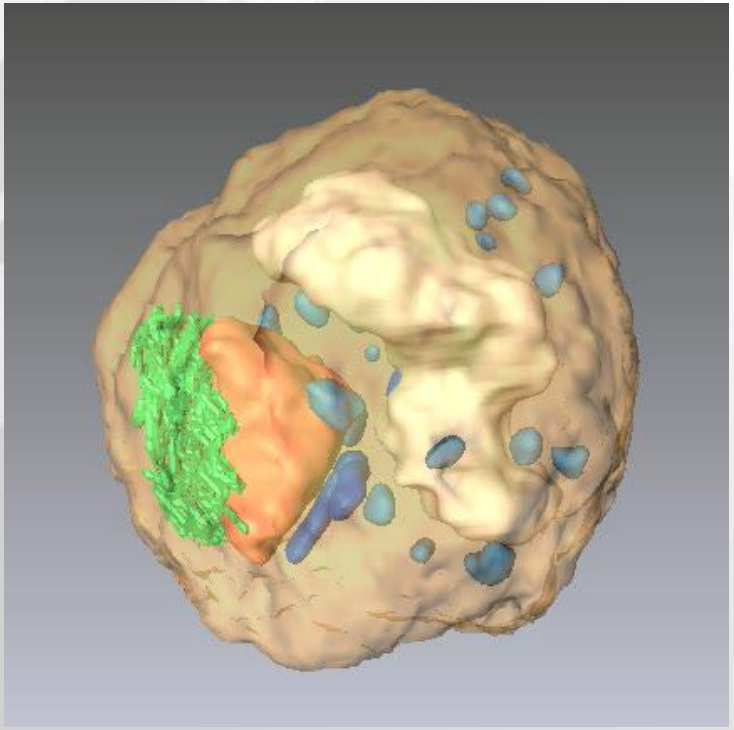
Sirius - High Degree of Coherence (Mammals Cells)

Sirius – Very Small Beam Nanofocus

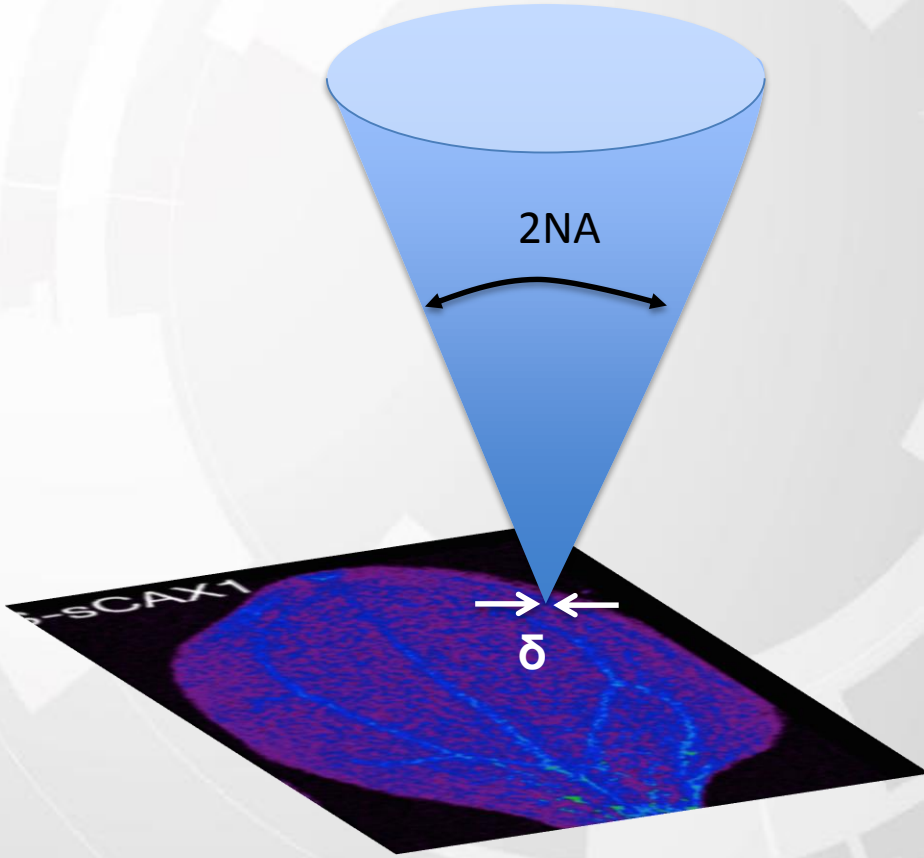
PNAS 2010

Quantitative 3D imaging of whole, unstained cells by using X-ray diffraction microscopy

Huaidong Jiang[a,2], Changyong Song[b], Chien-Chun Chen[a], Rui Xu[a], Kevin S. Raines[a], Benjamin P. Fahimian[a], Chien-Hung Lu[c], Ting-Kuo Lee[c], Akio Nakashima[d], Jun Urano[d], Tetsuya Ishikawa[b], Fuyuhiko Tamanoi[d], and Jianwei Miao[a,1]



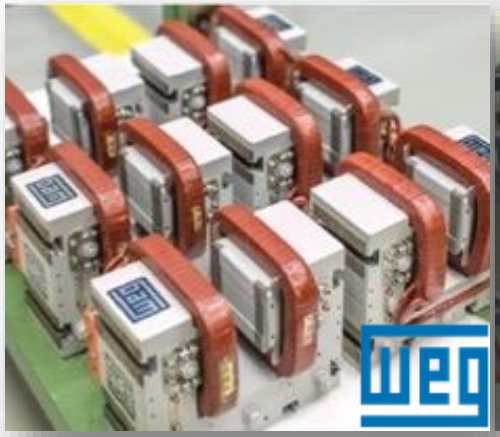
20 µm at UVX ➡ ***30 nm*** at Sirius

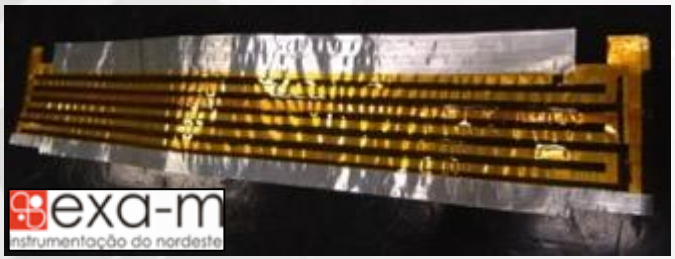


Brazilian Suppliers

- Continuous interaction with many Brazilian companies in order to find developers as well as suppliers for production (~ 200)

- WEG – magnets (Jaraguá do Sul, SC);
- EXA-M – vacuum baking tapes (Salvador, BA);
- Termomecânica – Cu/Ag alloy for vacuum (São Bernardo do Campo, SP) ;
- Engecer – special ceramics chambers (São Carlos, SP)
- FCA Brasil – vacuum chambers (Campinas, SP)
- BrPHOTONICS – Detectors (Campinas, SP)





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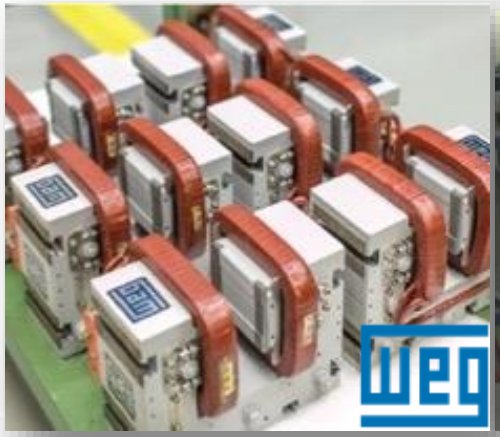
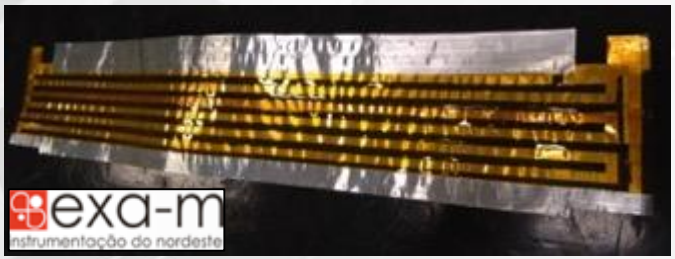
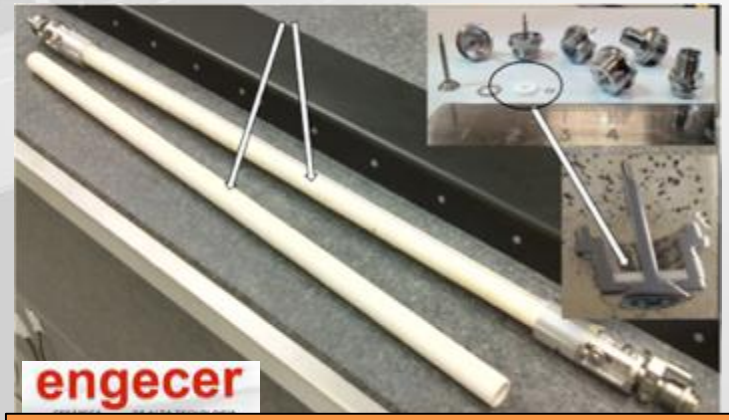
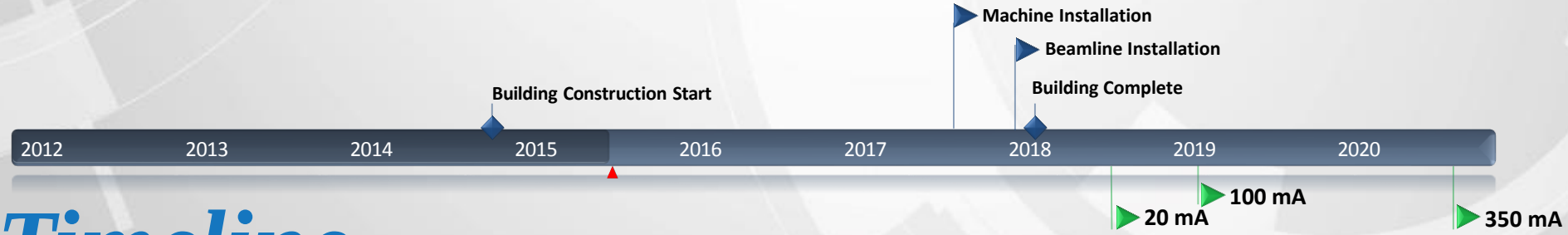






FAPESP/FINEP have launched two calls for companies from State of São Paulo to make developments for sub-projects for Sirius


Machine Installation
Beamline Installation
Building Construction Start
Building Complete
2012
2013
2014
2015
2016
2017
2018
2019
2020
100 mA
20 mA
350 mA

Timeline

Conclusion

- Synchrotron Science in Brazil (Latin America) has been built from ground up and reached a mature level to jump into a more competitive scenario

- Sirius is planned to be one of the best machines in the world

One of the most successful science projects in Brazil
In 30 years, evolved from scratch to a world class, state-of-the-art lab

National open lab

High Impact Science

Innovation

High Technology

High qualified human resources

Synchrotron/LNLS Structural Project

”Big Science”

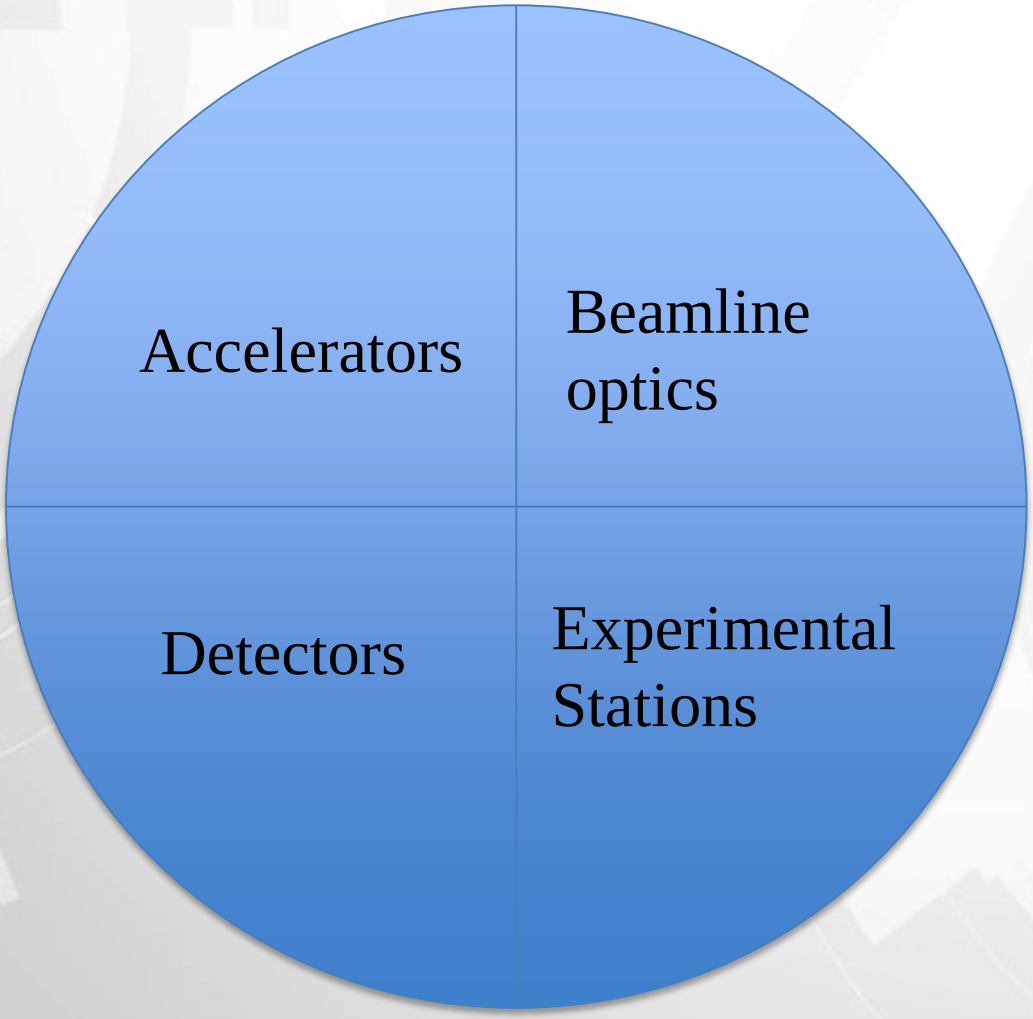
Instrumentation

Internationalization

New Laboratories

Management Model

A system is as good as its weakest link



HUMAN RESOURCES!

USERS

Conclusion

- Synchrotron Science in Brazil (Latin America) has been built from ground up and reached a mature level to jump into a more competitive scenario
- Sirius is planned to be one of the best machines in the world
- The science done by the users will determine its success

Thank you