The SOLEIL Synchrotron Facility in France

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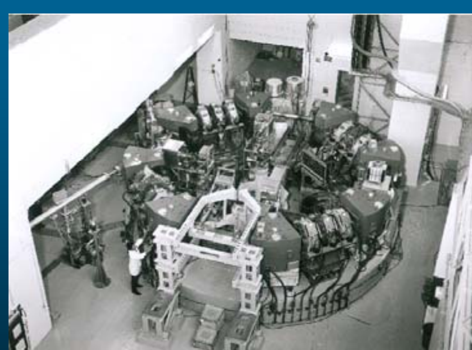
A brief history... from LURE to SOLEIL

1957 : construction of LAL
(Laboratoire Accelerateur Lineaire)

A brief history... from LURE to SOLEIL



1965 : construction of ACO
(Anneau de Collision d'Orsay),

A brief history... from LURE to SOLEIL

1972 : construction of DCI (Dispositif de Collision dans l'Igloo), 1.1 GeV – 1.85 GeV

A brief history... from LURE to SOLEIL

1982 : decision to build SUPER ACO (0.8 GeV)
Beginning of user operations in **1987**

A brief history... from LURE to SOLEIL

1985-1992: a step forward in France :

1990 : decision to build in Grenoble a third generation European synchrotron (beginning of operation 1992),

A brief history... from LURE to SOLEIL

Summer 1989, LURE users community think about a new synchrotron source to replace DCI and Super ACO.

November 91, LURE presents the first SOLEIL report

In 96 the project becomes directly activated by the Research minister which creates the first SOLEIL working group

The group works during three years and produces a report

Avril 99 : audit report of the SOLEIL APD

PANEL Members.

Albert HOFMAN CERN Geneva Switzerland

Jochen SCHNEIDER DESY-HASYLAB Hamburg Germany

Felix YNDURAIN CIEMAT Madrid Spain

Michel ANDEREGG ESA ESTEC Noordwijk The Netherlands.

The Scientific Case.

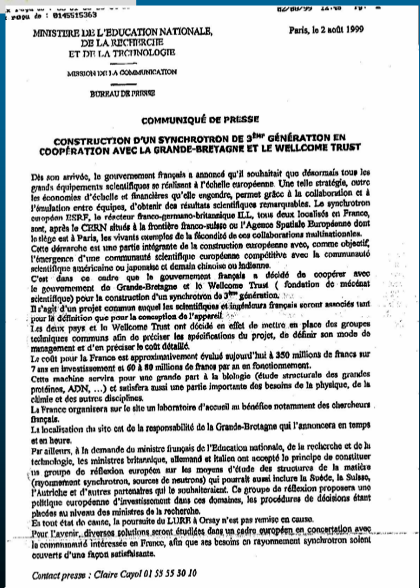
The high brilliance of SOLEIL allows for novel experiments on highly sophisticated instruments making use of very high energy and temporal resolution.....The teams involved in this research will provide the necessary expertise for building innovative beam lines and instrumentation. ...In the lower photon energy range SOLEIL is as brilliant as the ESRF for hard X-rays and provides the French scientists with an outstanding research tool in the areas where the community is very strong, which will attract also scientists from abroad.....The suggested beamlines meet the actual needs of the French community and are very attractive.....

The Machine.

The machine SOLEIL described in the report is a top quality storage ring incorporating the progress and developments achieved in the field till now. Its design is based on well-balanced priorities and well adapted to the user requirements. The physics and engineering basis leading to the adopted solutions are well documented in the Report.

Following this report.........

REJECTION and French participation to DIAMOND!!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Paris, le 2 août 1999

MINISTERE DE L'EDUCATION NATIONALE,
DE LA RECHERCHE
ET DE LA TECHNOLOGIE

MISSION DE LA COMMUNICATION

BUREAU DE PRESSE

COMMUNIQUÉ DE PRESSE

CONSTRUCTION D'UN SYNCHROTRON DE 3ème GÉNÉRATION EN COOPÉRATION AVEC LA GRANDE-BRETAGNE ET LE WELLCOME TRUST

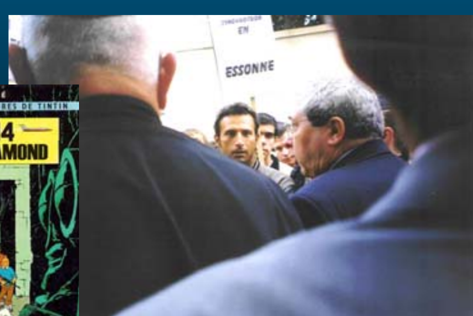
Dès son arrivée, le gouvernement français a annoncé qu'il souhaitait que désormais tous les grands équipements scientifiques se réalisent à l'échelle européenne. Une telle stratégie, outre les économies d'échelle et financières qu'elle engendre, permet grâce à la collaboration et à l'émulation entre équipes, d'obtenir des résultats scientifiques remarquables. Le synchrotron européen ESRF, le réacteur franco-germano-britannique ILL, tous deux localisés en France, sont, après le CERN situés à la frontière franco-suisse ou l'Agence Spatiale Européenne dont le siège est à Paris, les vivants exemples de la fécondité de ces collaborations multinationales.
Cette démarche est une partie intégrante de la construction européenne avec, comme objectif, l'émergence d'une communauté scientifique européenne compétitive avec la communauté scientifique américaine ou japonaise et demain chinoise ou indienne.
C'est dans ce cadre que le gouvernement français a décidé de coopérer avec le gouvernement de Grande-Bretagne et le Wellcome Trust (fondation de mécénat scientifique) pour la construction d'un synchrotron de 3ème génération.
Il s'agit d'un projet commun auquel les scientifiques et ingénieurs français seront associés tant pour la définition que pour la conception de l'appareil.
Les deux pays et le Wellcome Trust ont décidé en effet de mettre en place des groupes techniques communs afin de préciser les spécifications du projet, de définir son mode de management et d'en préciser le coût détaillé.
Le coût pour la France est approximativement évalué aujourd'hui à 350 millions de francs sur 7 ans en investissement et 60 à 80 millions de francs par an en fonctionnement.
Cette machine servira pour une grande part à la biologie (étude structurale des grandes protéines, ADN, ...) et satisfera aussi une partie importante des besoins de la physique, de la chimie et des autres disciplines.
La France organisera sur le site un laboratoire d'accueil au bénéfice notamment des chercheurs français.
La localisation du site est de la responsabilité de la Grande-Bretagne qui l'annoncera en temps et en heure.
Par ailleurs, à la demande du ministre français de l'Education nationale, de la recherche et de la technologie, les ministres britannique, allemand et italien ont accepté le principe de constituer un groupe de réflexion européen sur les moyens d'étude des structures de la matière (rayonnement synchrotron, sources de neutrons) qui pourrait aussi inclure la Suède, la Suisse, l'Autriche et d'autres partenaires qui le souhaiteraient. Ce groupe de réflexion proposera une politique européenne d'investissement dans ces domaines, les procédures de décisions étant placées au niveau des ministres de la recherche.
En tout état de cause, la poursuite du LURE à Orsay n'est pas remise en cause.
Pour l'avenir, diverses solutions seront étudiées dans un cadre européen en concertation avec la communauté intéressée en France, afin que ses besoins en rayonnement synchrotron soient couverts d'une façon satisfaisante.

Contact presse : Claire Cayol 01 55 55 30 10

Note: all labs also, are closed from july 31 st to end of August!


Regional Council
23 September 1999

President and other politicians of the regional council come to meet the LURE demonstrators in the street



Ministry of science, 21 October 1999,

27 march 2000, Roger Gérard Schwartzenberg : a new minister and happy end!

Construction d'un synchrotron de 3ème génération en France

Conférence de presse de Roger-Gérard Schwartzenberg

11-09-2000

Dès le 3 avril dernier, une semaine après ma nomination au ministère de la recherche, j'ai exprimé mon intention de rouvrir le dossier du synchrotron.
J'avais le sentiment, vérifié depuis par de nombreux rapports et consultations d'experts, que la décision de construire en France un synchrotron de 3ème génération était **scientifiquement nécessaire, financièrement possible et susceptible d'être arrêtée dans un délai de quelques mois**.
Le 18 juillet dernier, à un point de presse, j'ai pu déjà indiqué être "sûr à 95 %" qu'une décision positive serait prise.
Afin, d'une part, de terminer certaines concertations et consultations d'experts encore en cours, et, d'autre part, d'éviter toute annonce sur le synchrotron au mois d'août, qui avait été marquée l'an dernier par une décision contraire, cette annonce est donc faite au début de ce mois de septembre.
J'ai rencontré le 7 septembre M. Lionel Jospin sur ce dossier. J'ai proposé au Premier Ministre la construction d'un synchrotron de 3ème génération en France et le site de son implantation. Le Premier Ministre a retenu cette proposition.
Ainsi, cette décision sur un dossier complexe, aux nombreuses implications, a pu être arrêtée en 5 mois.

A big victory and huge celebration

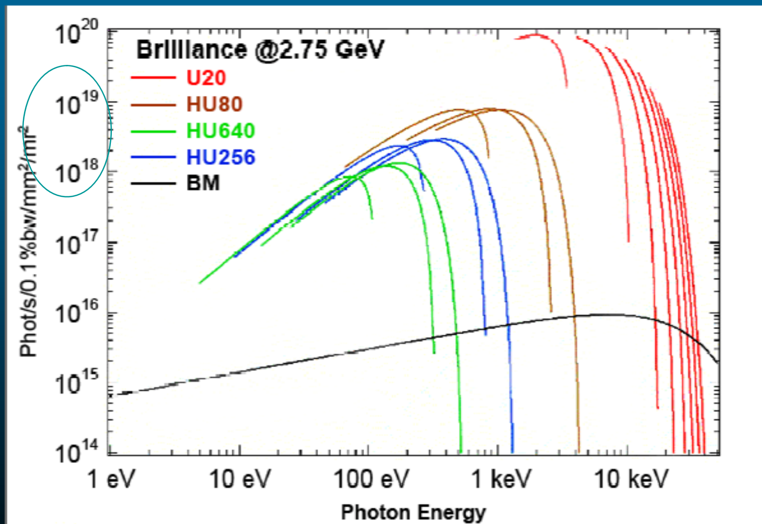
Design Criteria for SOLEIL

- High Brilliance and Coherence
- Long beam lifetime and injection rate (Top-Up)
- Extensive use of Insertion Devices such as Undulators and Wigglers
- Ratio of available straight sections to the circumference . Variable Polarisation.
- Stability: intensity (Beam Lifetime), position, size and energy
- Tunability: the right photon energy for the experiment
- Long straight sections
- Compactness (Budget)
- Upgrade potential

SOLEIL : main characteristics

Energy	2.75 GeV
Circumference	354 m
Number end lengths of straight sections	4 x 12 m 12 x 7 m 8 x 3.5 m
Emittance H	3.7 nm.rad
Emittance V	37 pm.rad
Current multibunch	500 mA
lifetime	16 h
8-bunch current	90 mA
lifetime	18 h

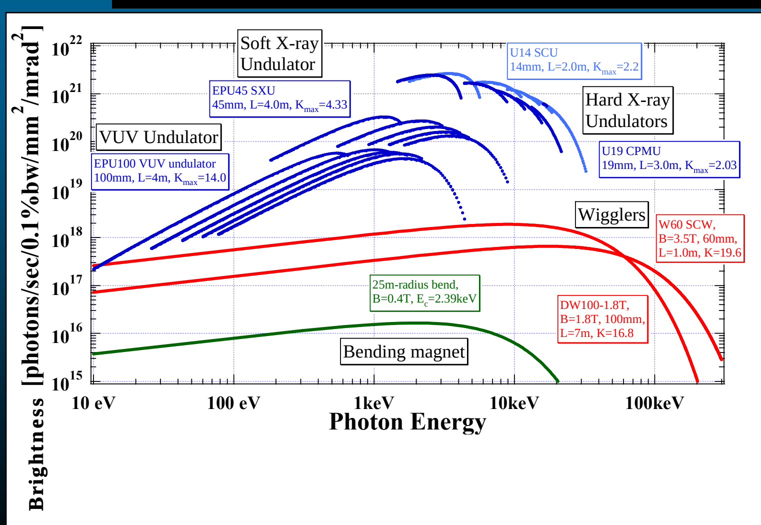
BRILLIANCE FOR SOLEIL



How does this compare with the most recent synchrotron facility: NSLS-II ?

Energy [GeV]	3
Circumference [m]	791.5
Number of DBA cells	30
Number of 8.6 m straights	15
Beta-functions in the center of the 8.6 m straights: β_x, β_y [m]	18, 3.1
Number of 6.6 m straights	15
Beta-functions in the center of the 6.6 m straights: β_x, β_y [m]	1.5, 0.8
Number of dipoles	60
Circulating current at 3 GeV, multi-bunch [mA]	500
Radio frequency [MHz]	499.68
Harmonic number	1320
Number of bunches at 80% fill	1056
Nominal bending field at 3 GeV [T]	0.4
Dipole critical energy at 3 GeV [keV]	2.4
Total Bending magnet radiation energy loss [keV]	286.4
Radiation energy loss per damping wiggler [keV]	129.3
Vertical emittance [nm-rad]	0.008
Horizontal emittance of bare lattice [nm-rad]	2.1
Horizontal emittance with three 7 m 1.8 T damping wigglers [nm-rad]	0.9
Horizontal emittance with eight 7 m 1.8 T damping wigglers [nm-rad]	0.55
Momentum compaction factor	3.7×10^{-4}
Bunch length, RMS, natural [mm, ps]	2.9, 10
Energy spread, RMS	0.05 –0.1%

How does this compare with the most recent synchrotron facility: NSLS-II



SOLEIL Location in France

SOLEIL Location in France

From Google Map

SOLEIL Location in France

From Google Earth

Location ,Budget, staffing

357 permanent staff

19 Hectares

Total budget for 2002 - 2009 period

454 M€

Investments	248 M€
Running	53 M€
Salaries	153 M€

Running budget per year starting in 2010: ~ 45 M€.

CEA and CNRS own 28% and 72% of the Synchrotron Soleil company respectively.

July 2001
1st day of « construction »

SOLEIL

March 2002

Archeological excavation

September 2003

Building Stability

15 m long pile

From Oct 2003 to January 2004, 595 piles were build

Jan 2004

Linac, Booster and Storage Ring , February 18 ,2004

June 2004

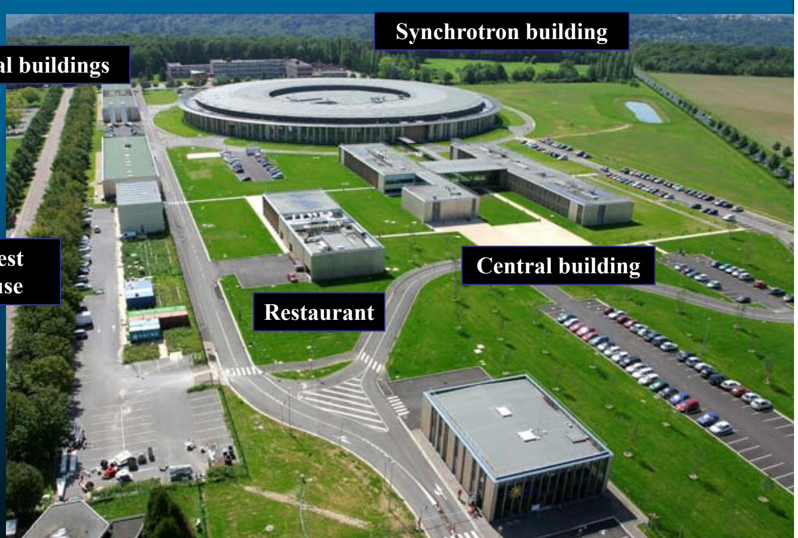
June 2004

The site in July 2004

Novembre 2004

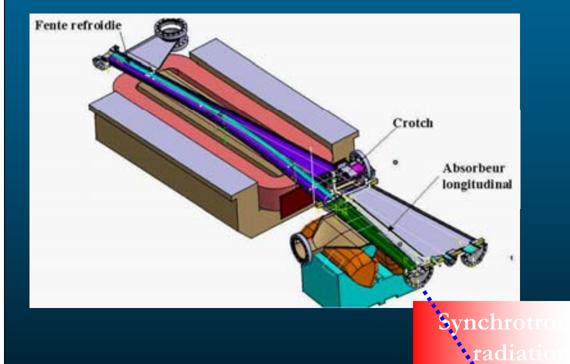
18 December 2006

TODAY



Technical features and innovations at SOLEIL storage ring

- Extended lifetime of thanks to



Quality of vacuum
- 10^{-10} mbar pressure ($2,5.10^{7}$ molecules per cm^{3})

NEG coated aluminium
- zirconium, vanadium and titanium alloy

Pumping system
- primary pumps
- 200 ionization pumps and 100 titanium sublimation pumps

Technical features and innovations at SOLEIL storage ring

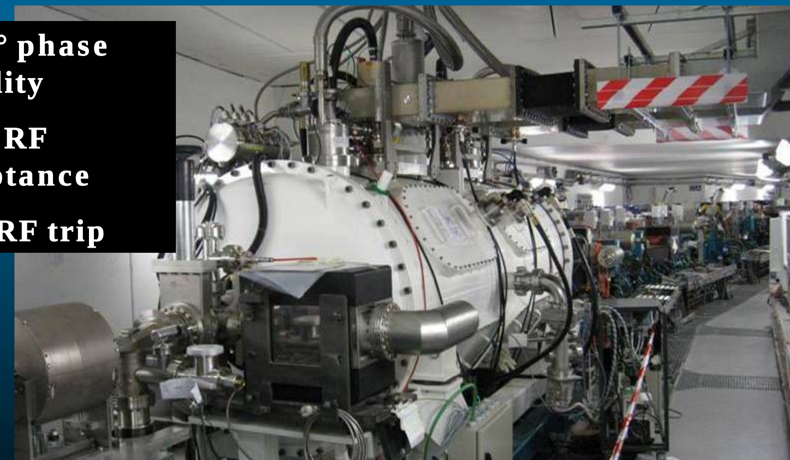
- Supraconducting radio frequency cavity

Supraconducting radio frequency cavity: made of Copper + Niobium

Two cavities soaking in liquid Helium(-269°C)

Superconducting cavities

- 0.1 ° phase stability
- 6 % RF acceptance
- No RF trip

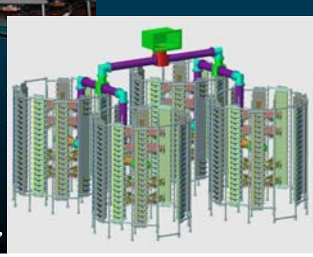


1st cryomodule enables alone operation up to 300 mA.
A 2nd cryomodule is operational since end of 2008 for operation at 500 mA

Technical features and innovations at SOLEIL storage ring

- SOLEIL original design of RF power supply(using transistors):Modular and reliable

400 kW per cryomodule

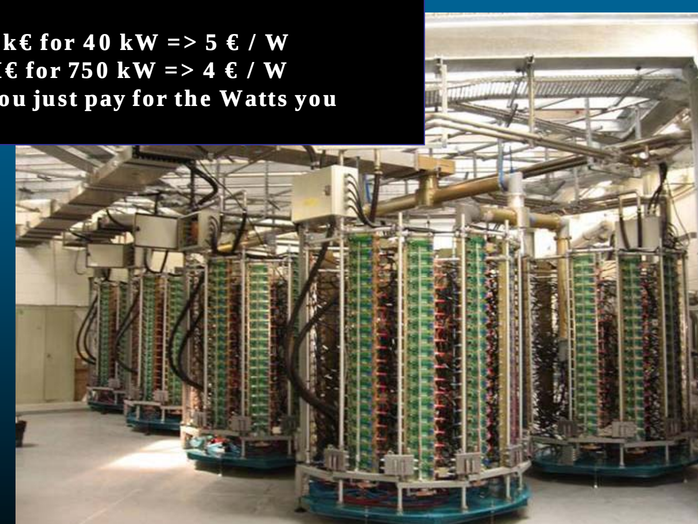


4 towers of amplified power 50 kW (each at 352 MHz)

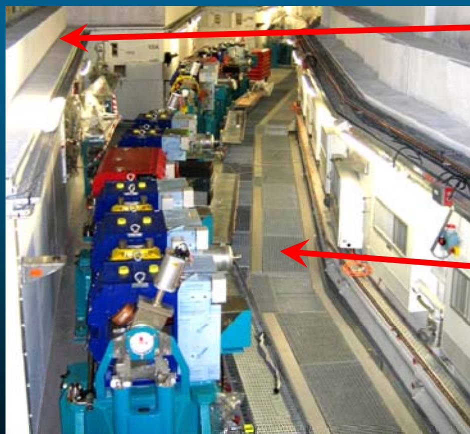
(2 Cavity , 8 towers per cryomodule.)

Storage Ring RF plant

Full Cost
Booster : 200 k€ for 40 kW => 5 € / W
Stor. Ring : 3 M€ for 750 kW => 4 € / W
Modularity = You just pay for the Watts you actually need



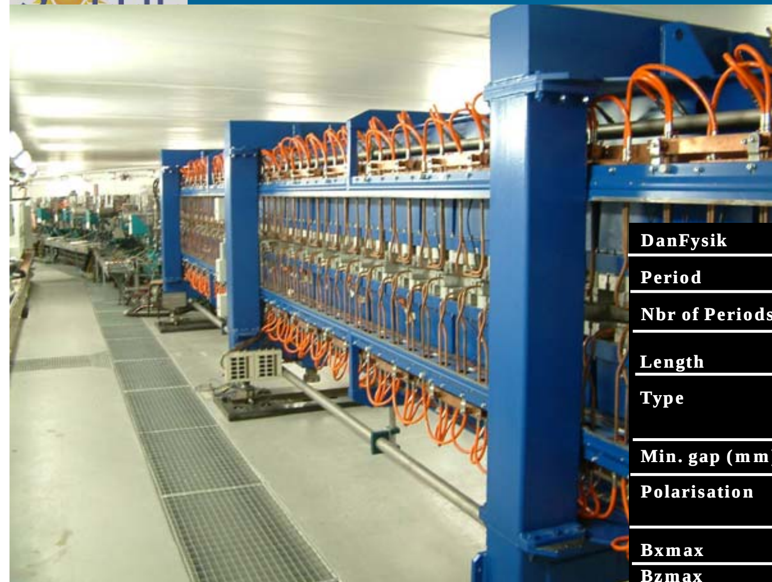
Technical features and innovations at SOLEIL storage ring



Shielding

Stability and precise temperature control
21 ± 0.1 °C inside tunnel
± 1 °C inside experimental hall

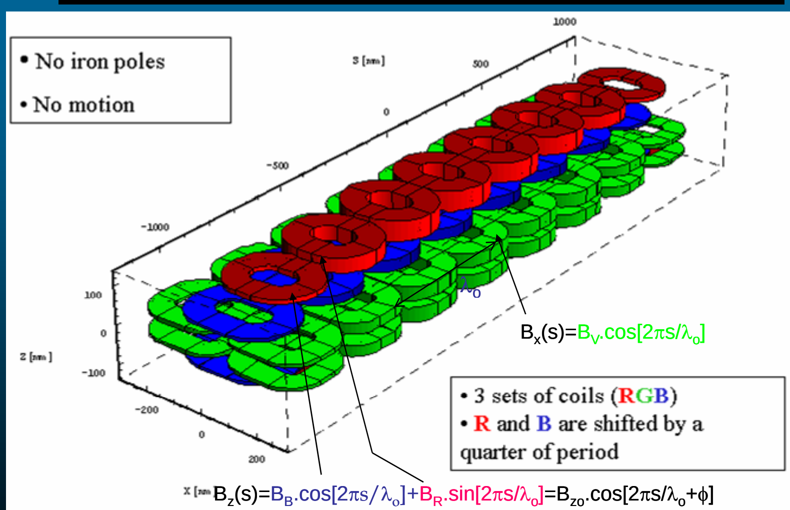
Electromagnet Helical Undulator HU640



DanFysik	HU640
Period	640 mm
Nbr of Periods	14
Length	10.0 m
Type	Electro-magnetic
Min. gap (mm)	19
Polarisation	Circ./Lin. adjustable
Bxmax	0.09 T
Bzmax	0.11 T
Photon Energy	5 – 40 eV

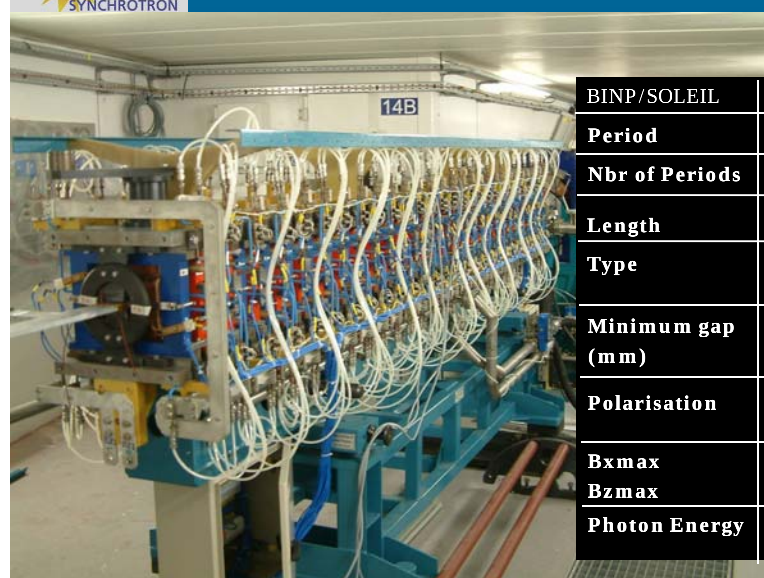
Helical Undulator HU640 principles

Electromagnetic undulator with variable polarization



Radia code: http://www.esrf.fr

Electromagnet Helical Undulator HU256



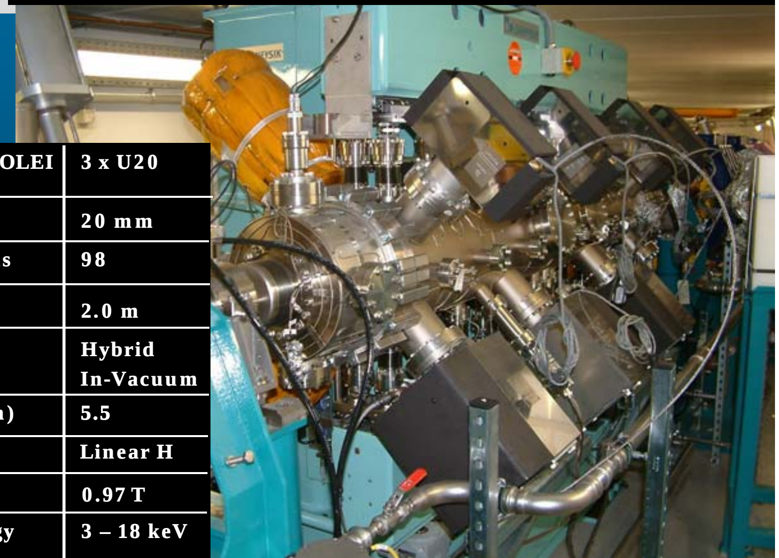
BINP/SOLEIL	3 x HU256
Period	256 mm
Nbr of Periods	12
Length	3.6 m
Type	Electro-magnetic
Minimum gap (mm)	15 (V) 50 (H)
Polarisation	Circ./Lin. H et V
Bxmax Bzmax	0.275 T 0.400 T
Photon Energy	10 – 1000 eV

Apple-II Type Helical Undulator HU80

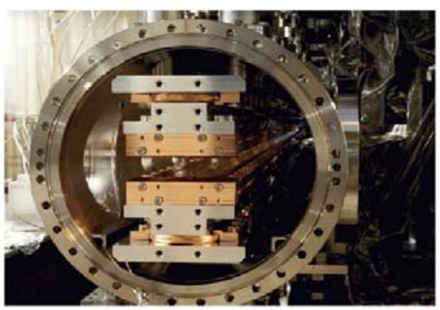
ELETTRA/SOLEIL	3 x HU80
Period	80 mm
Number of Periods	19
Length	1.65 m
Type	Apple-II
Minimum gap (mm)	15 to 250
Polarisation	Circ./Lin.
Bxmax Bzmax	0.76 T 0.85 [1.0] T
Photon Energy	80 [35] – 1500 eV

In-Vacuum undulator U20 inside SR tunnel

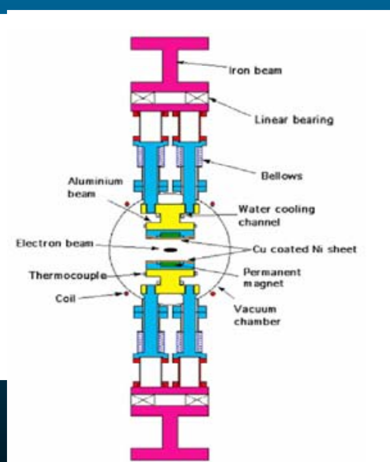
DANFYSIK/SOLEIL	3 x U20
Period	20 mm
Nbr of Periods	98
Length	2.0 m
Type	Hybrid In-Vacuum
Min. gap (mm)	5.5
Polarisation	Linear H
Bzmax	0.97 T
Photon Energy	3 – 18 keV



In-Vacuum Undulator

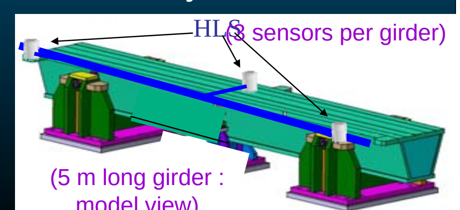


Magnetic blocks in the vacuum with an operating magnetic gap of 4 – 6 mm



Metrology and Survey

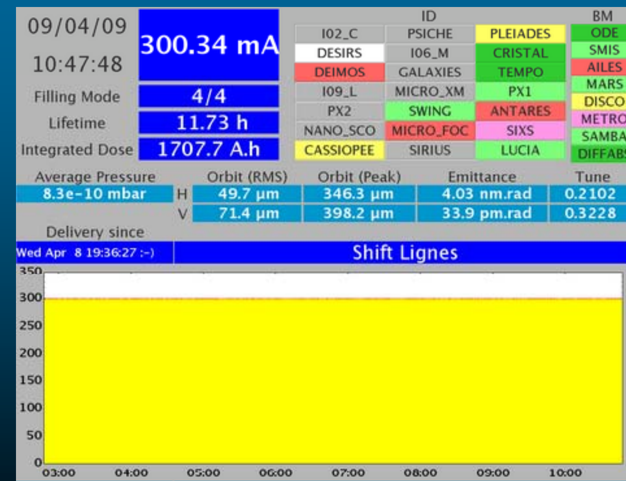
- Planimetric survey (s,x) by optical means :
  - ✓ theodolite (*long scale)*
  - ✓ wire ecartometer (*short scale*) designed especially for SOLEIL by a french company, *5 mm* rms measured accuracy ~ with a 15 m long Kevlar wire
- Altimetry survey (z) : HLS (*Hydrostatic Levelling System*) network used in an absolute way



Support Groups

- Opticals calibration
- Metrology
- Detectors
- UHV
- Biochemistry
- Chemistry
- Magnetism

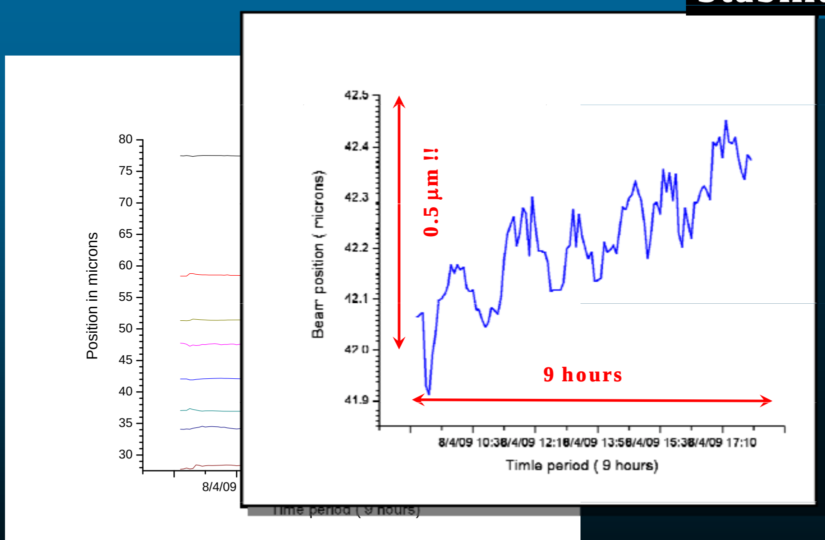
Today’s operation



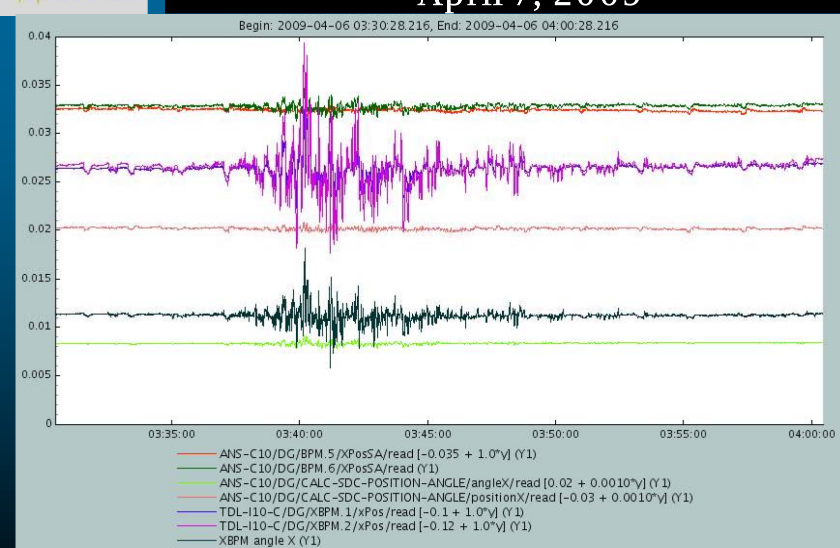
Top-Up-300mA

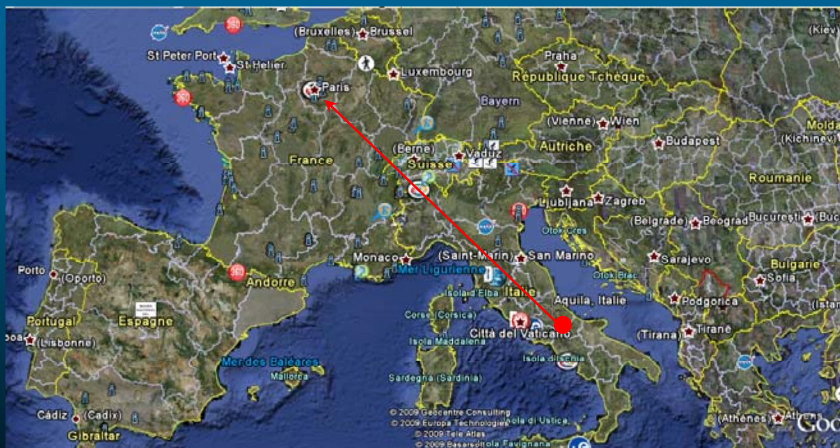
Today’s operation

Stability!



EarthQuake Terramotto d'Aquila April 7, 2009





24 beamlines

24 Beamlines approved by the Council + 1 beamline to be founded

18 on insertion devices and 7 on bending magnets

Spectral range equally shared :

50% below 1.3 keV and 50% above

Phase 1: 11 beamlines in operation =>opened to external Users since 2008

6 on insertion devices and 3 on bending magnets + 2 IR

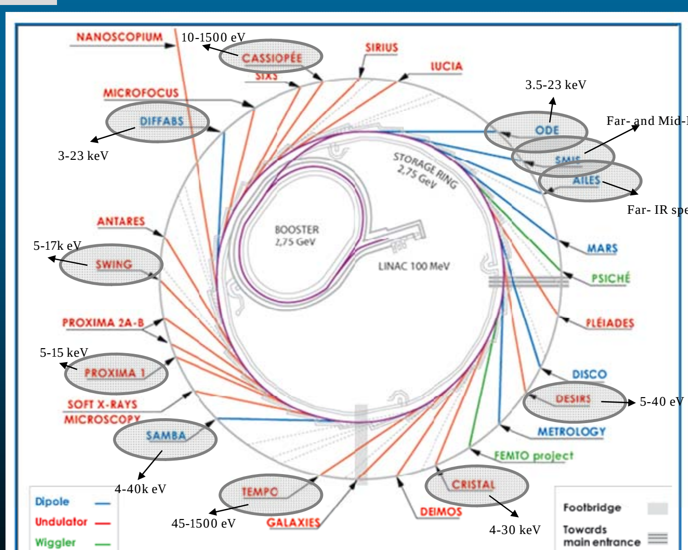
Phase 2: 7 beamlines to open in 2009

5 on insertion devices and 2 on bending magnets

+ 7 beamlines on ID to open in 2010

3 Straight sections still free + 14 bending magnet beamports!

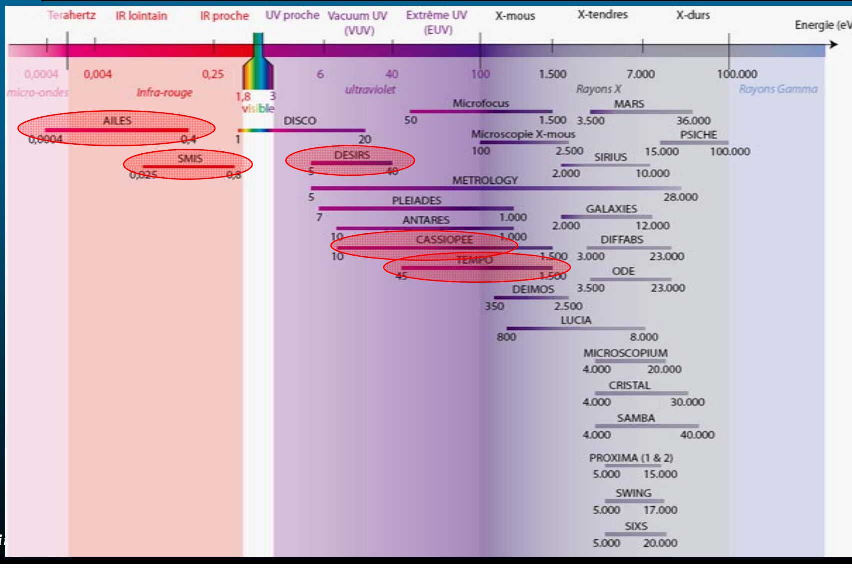
Beamlines Portfolio Phase I



Beamlines per photon energy range

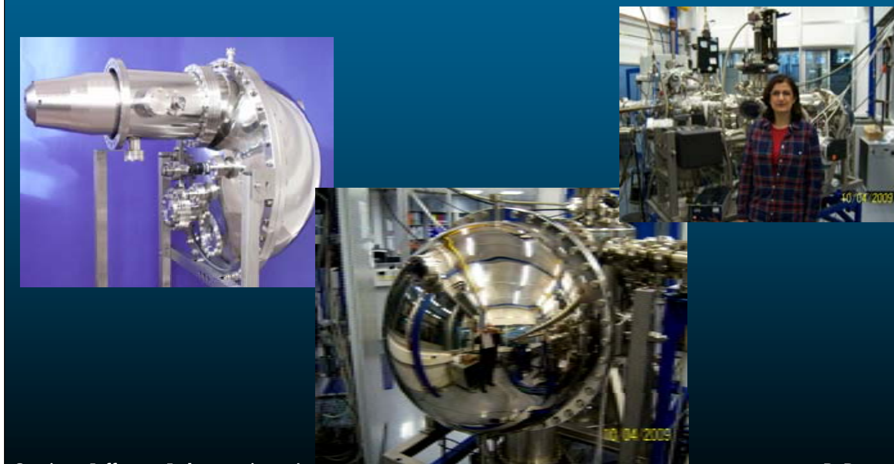
Energy range	List of Beamlines
Infrared	AILES, SMIS
VUV / UV / Visible	ANTARES, DESIRS, DISCO, METROLOGY, PLEIADES
Soft X-rays <1.5KeV	ANTARES, CASSIOPÉE, PLEIADES, TEMPO, DEIMOS, METROLOGY, Microfoc
Tender X- rays 1 à 10KeV	LUCIA, SIRIUS, GALAXIES, DEIMOS, SIRIUS
Hard X-rays >8KeV	CRISTAL, DIFFABS, ODE, MARS, SAMBA, PSICHÉ, SIXS, PROXIMA 1, PROXIMA 2, METROLOGY, NANOSCOPIUM, SWING, GALAXIES, SIRIUS

Jefferson Labs FEL ~ 250nm in the UV to far-IR (ThZ).



Photoemission / Photodiffraction beamlines

Surface Science CASSIOPEE and TEMPO



CASSIOPEE: Fermi Surfaces

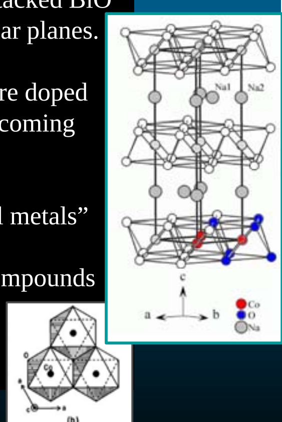
A.Nicolaou, V. Brouet (LPS, Orsay) & CASSIOPEE team.

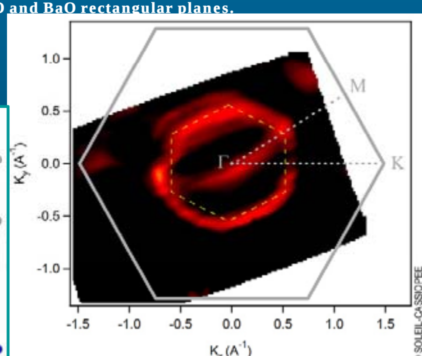
The studied sample is a [Bi2Ba2O2][CoO2] compound, made of cobalt oxide (CoO2) triangular planes separated by stacked BiO and BaO rectangular planes.

Cobaltates electronic structure
$[Bi_2Ba_2O_2][CoO_2]$
(CoO_2) planes by stacked BiO And BaO rectangular planes.

The CoO2 planes are doped with electrons coming from the stacked planes ➔ “bidimensional metals”

superconducting compounds up to -170°C.



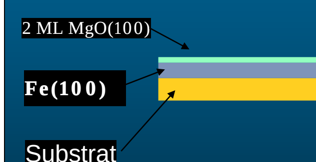


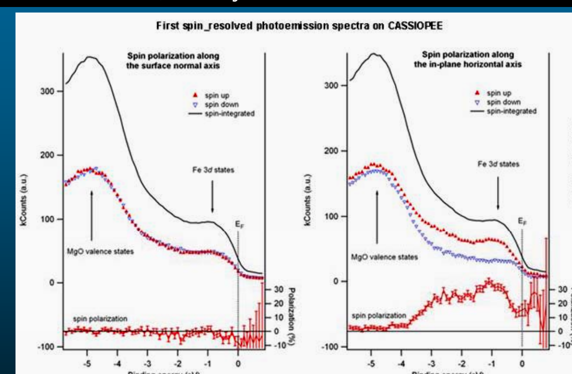
Fermi surface
➔ hexagonal symmetry of CoO_2 planes
Main origin of conducting property rather than rectangular BiO BaO ones.

CASSIOPEE :

First spin resolved measurements on magnetic tunnel junction

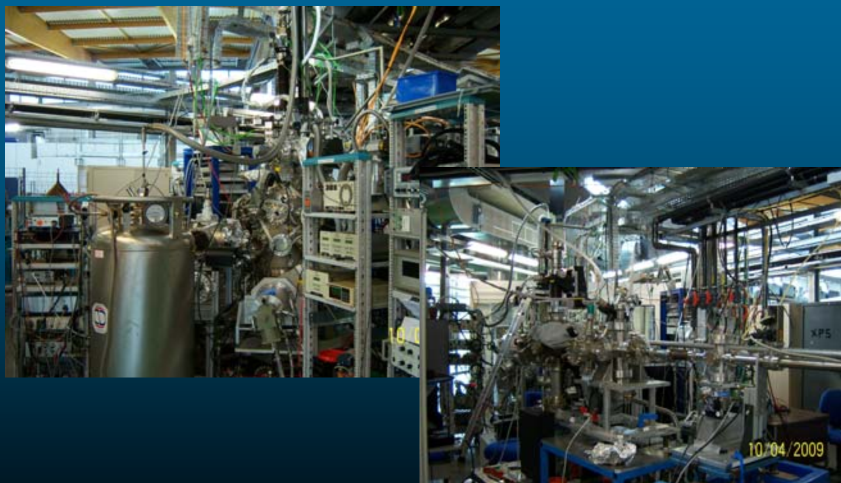
S.Andrieu et al , Nancy & CASSIOPEE team



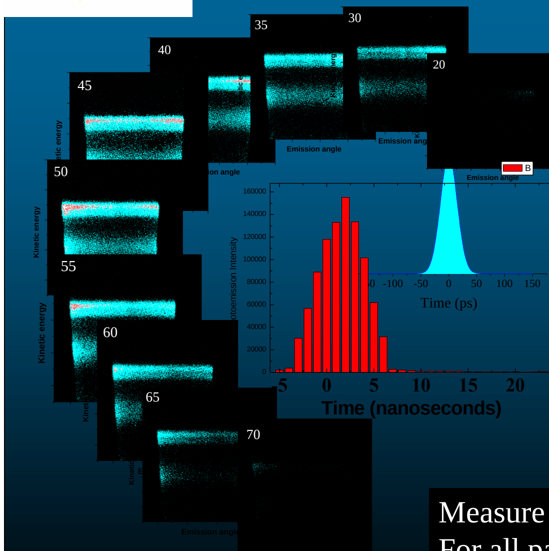


Fe/MgO bilayer
remanent magnetization along the horizontal axis in the surface plane.
spin polarisations measured simultaneously ⊥ to surface and along the horizontal axis of the surface
➔ no spin polarisation along the normal to the surface, while the Fe 3d states show 45% polarisation along the magnetisation axis

TEMPO :Time Resolved Photoemission



TEMPO :Time Resolved Photoemission



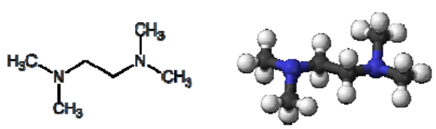
Experiments uses the 30 ps
Time width of the Soleil pulse

2D detection at 5ns step

Measure of electrons time of flight
For all pass energies and K.E.

Surface reaction kinetics

Time dependent study of the adsorption modes
for the
N,N,N',N' Tetra methyl ethylenediamine on Si(001)-2×1



2 possible adsorption configurations on Si

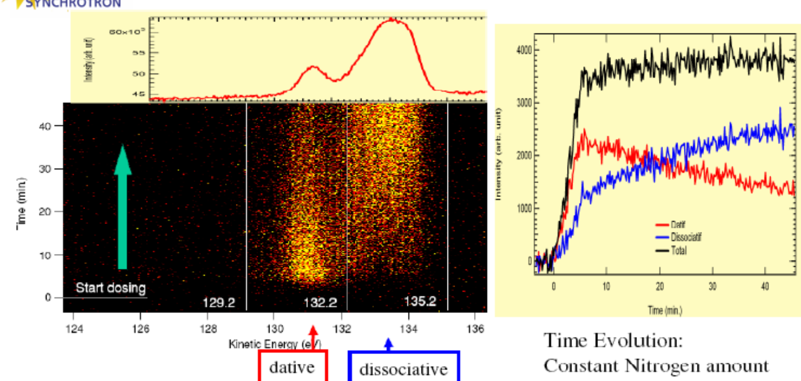
F.Sirotti et al

C.Mathieu, J.-J. Gallet,
F. Bournel, G. Dufour, F. Rochet

LCPMR

TEMPO Beamline March 2008

Surface reaction kinetics



N - 1s Photoemission spectra
Integration time 0.5 s
Binding energy variation: 2 eV

Time Evolution:
Constant Nitrogen amount
Transformation :
Dative → dissociative
During exposure

LCPMR

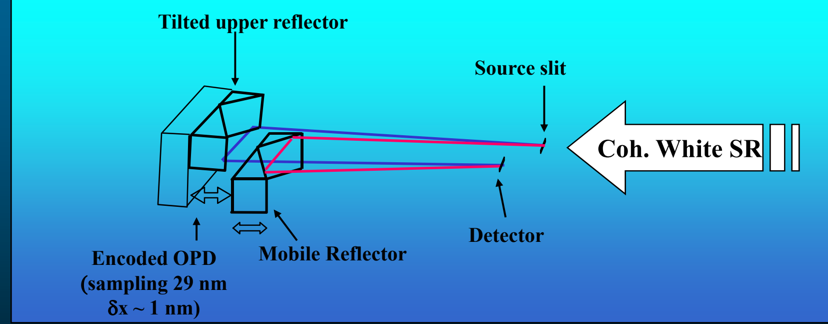
DESIRS (5-40 eV)

A VUV high resolution variable polarization beamline @ SOLEIL for dichroism and spectroscopy

1. **High resolution spectroscopy**
2. **Molecular dynamics and reactivity**
   - Mass spectrometry on biomolecules
   - Radicals
3. **Photoionization dynamics**
4. **Alignement, dichroism and chirality**
   - Gas phase ionization of chiral species (PECD)
   - Condensed phase photochemistry on amino-acids (homochirality of life)
5. **Excitation and relaxation in the condensed phase**

The Fourier-Transform spectrometer in the VUV

- The beamsplitter problem for VUV interferometer :
  - ➡ Wave-front division instead of amplitude division

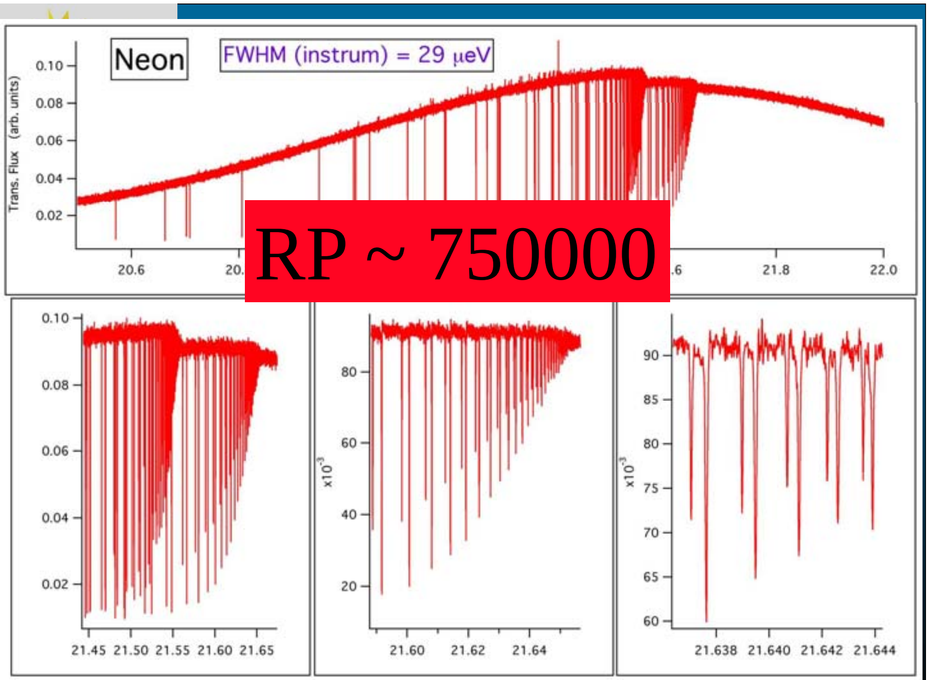


- Multiplex detection over a wide band
- RP max ~ 1 x 10^6 @ 20 eV (RP = 2 OPD / λ)
- quite unsensitive to thermal fluctuations
- absolute calibration down to 10^{-7}

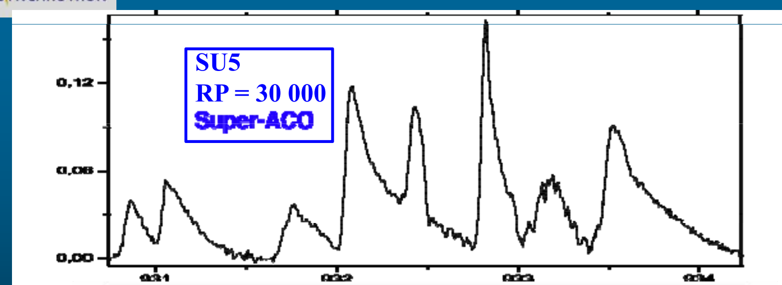
F. Polack, D. Joyeux, Ann Phys 22,151 (1997)

N. De Oliveira et al., Surf. Rev. Lett 9, 65 (2002)

N. De Oliveira et al., Rev. Sci. Instrum (2009).

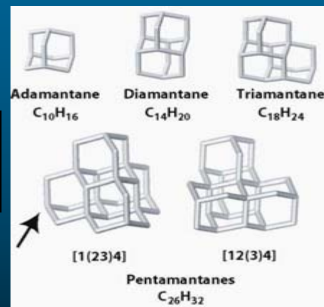


$^{12}C^{16}O$ 930-934 nm region (5 mixed bands)



Spectroscopy of gas phase diamondoids molecules

O. Pirali (AILES) (also at PPM), M. Vervloet, G. Garcia (DESIRS)
S. Boyé-Peronne, S. Douin, T. Pino
J. Oomens, H. Alvaro-Galue

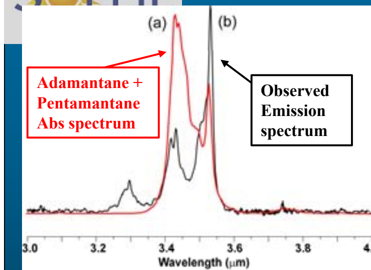


New class of molecular Carbon Structure
- diamond-like carbon cages : basic diamond unit cell
- sp^3 hybridised -terminated with H-atoms

High astrophysical relevance

- **Diamond nanocrystals (~ 2 nm) extracted from meteorites** [Lewis, Nature 18, 550, (1987)]
- **IR Emission features of HD 97048 (CS enveloppe) assigned to diamonds nanocrystals (≥ 50 nm)** [Guillois et al, ApJ, 521, L133 (1999)] **: CH band @ ~ 3.5 µm**

Diamondoids molecules : previous studies in the IR

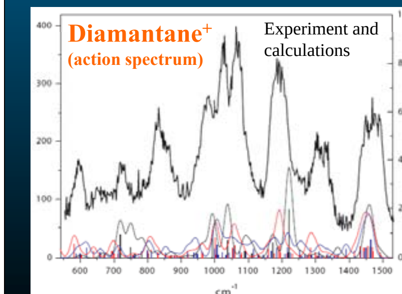


Possible participation of highly symmetric molecular diamondoids to the astrophysical emission spectra

O. Pirali, M. Vervloet, J. Dahl, R. Carlson, A. Tielens and J. Oomens, ApJ 661, 919 (2007)

IR emission → Abs in UV/VUV
But σ_{abs}(UV) neutral weak → role of the ions

IR spectroscopy of molecular diamondoids CATIONS @ FELIX (IR FEL)



**IRMPD of trapped ions (6-18 µm) :
How many IR photons are absorbed ?**

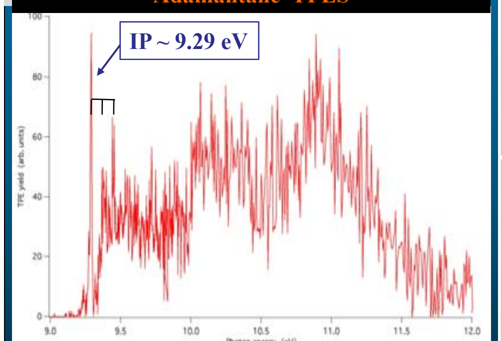
Need of data on Ionization Processes :
- **IP**
- **Fragmentation dynamics on the ion**

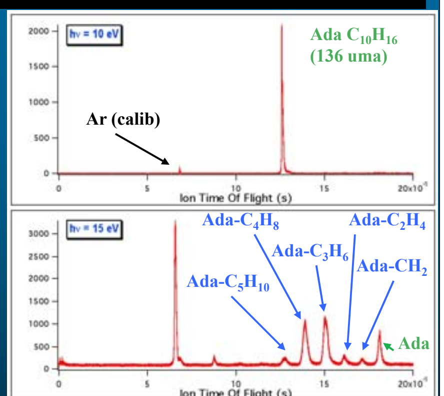
→ **DESIRS**

Pirali et al, JPCA, in preparation

Diamondoids molecules : first results

Adamantane TPES



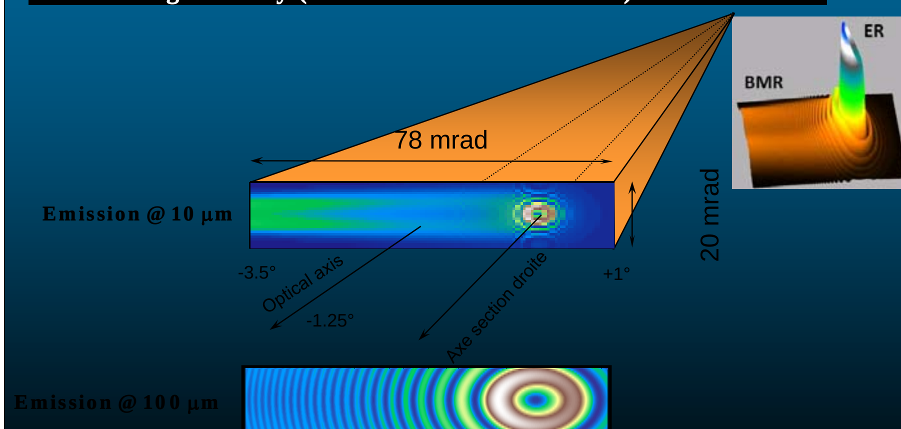


Results obtained for the first time on adamantane and diamantane :
- **Accurate experimental IP**
- **Appearance energies and fragmentation dynamics (analysis in progress)**

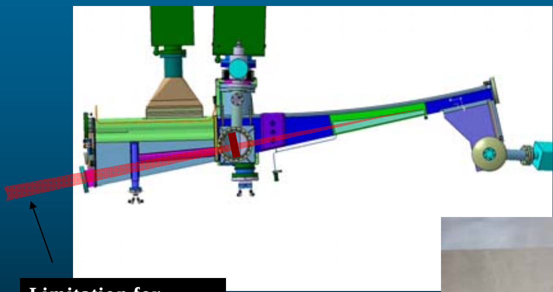
To be done :
- **Comparison of the spectra with IRMPD spectra of cations (using FELIX)**
- **Absorption of the neutral (in jet)**
- **New data to be included in astrophysical processes modelling**
- **Larger diamondoid (n = 3 -5)**

Infrared Beamlines

SOLEIL has two infrared beamlines, with an identical collection geometry (20 mrad V x 78 mrad H)



Infrared Beamlines



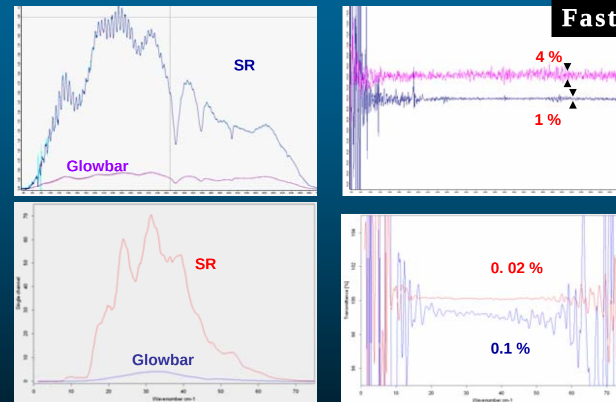
SMIS front end

Limitation for horizontal collection

Far-IR beamline AILES: stability improvments

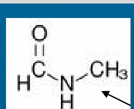
Mirror stabilization

Fast orbit feedback

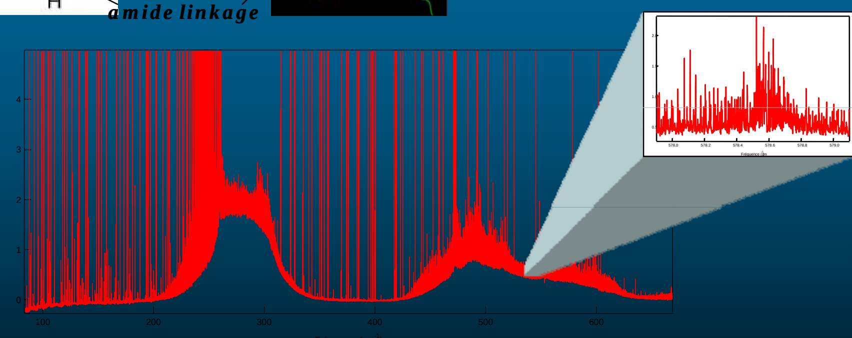


High intensity and improved signal to noise ratio
Extension to the THz
Ultimate resolution (0.001 cm^{-1}) without entrance iris

High resolution spectrum of N-Methylformamide
A model compound for understanding protein folding



amide linkage



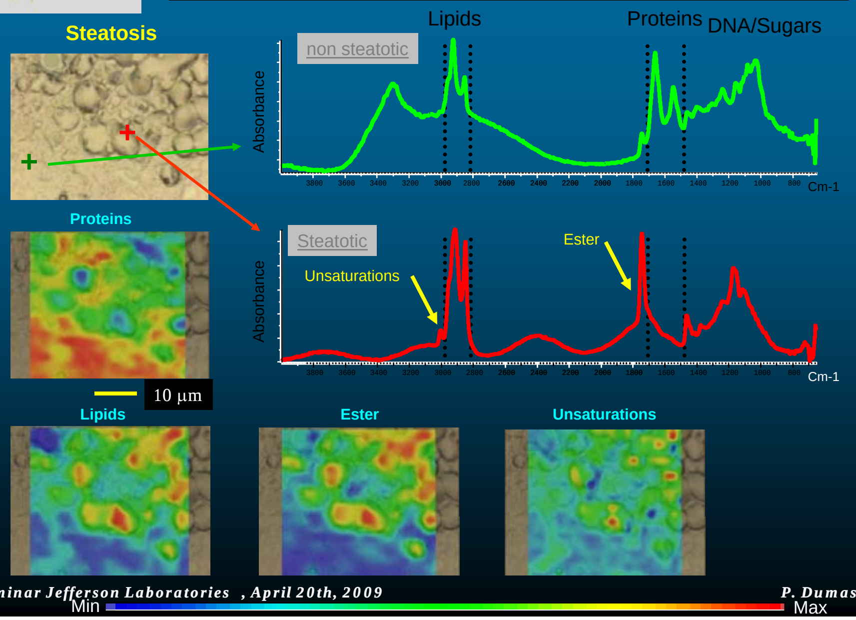
The absorption spectrum is fully resolved thanks to the combination of the high resolution interferometer with a 200 m path cell at low pressure.

(measurements : D. Mac Noughton and the AILES team)

Infrared spectro-micrscopy SMIS

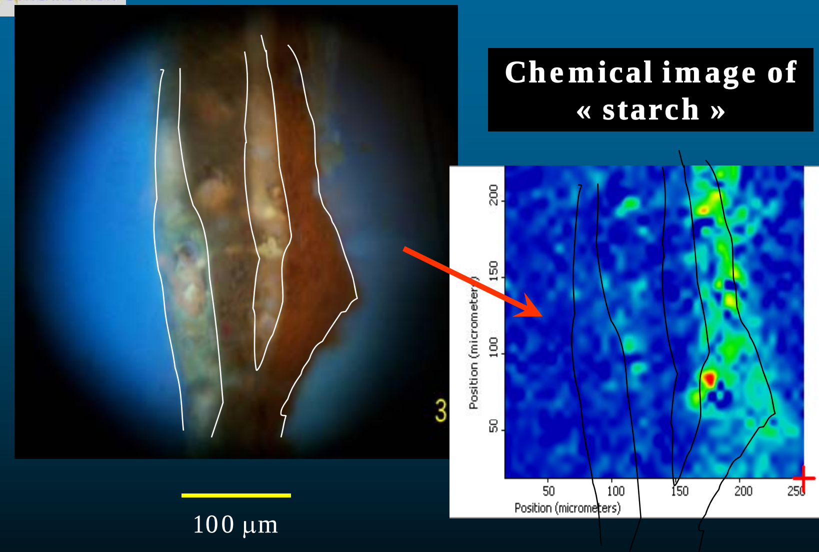
Two microscopes operating simultaneously

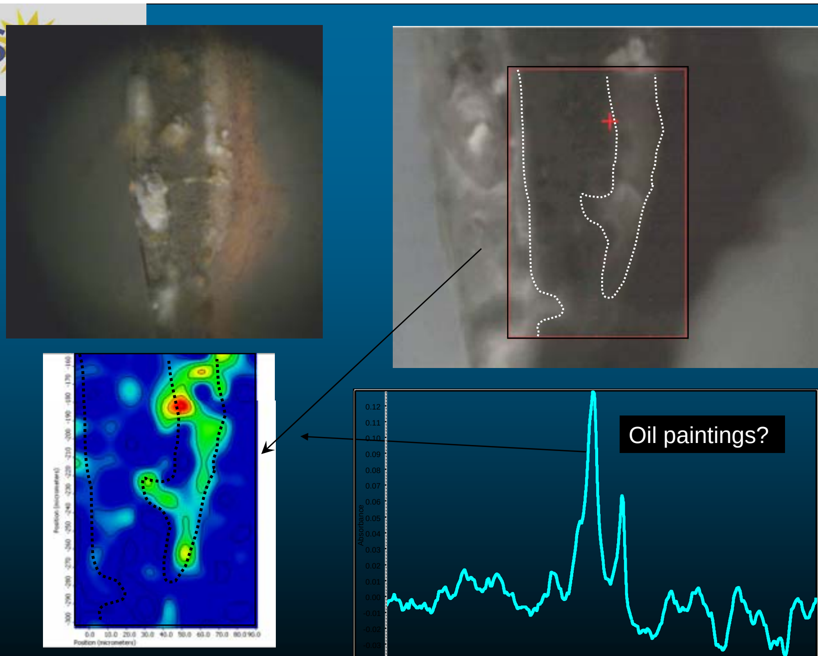
IR spectroscopy on steatosis



Fragment of REMBRANDT paintings

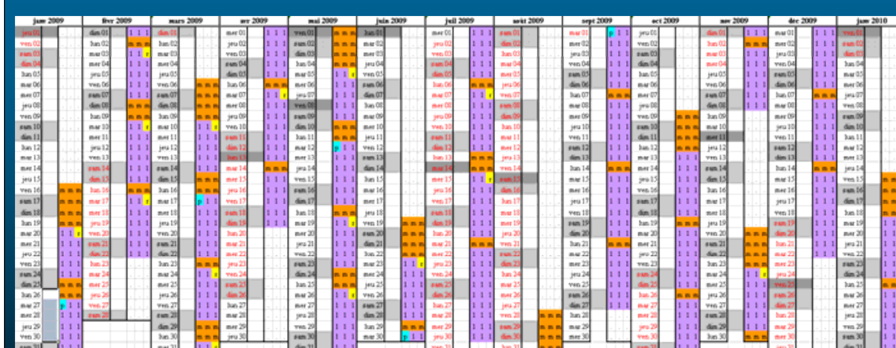
Chemical image of « starch »





Jana Sanyovaj and Koen Janssens

Operation schedule for 2009



191 Days	4424 hours	Beamline
60 Days	1440 hours	Machine Time
114 Days	2736 hours	Shutdown

SUMMARY

SOLEIL is up and runing: Phase I beamlines are all operational and Phase II are accepting expert users at the moment

Imaging is emphasized through
- long beamline for hard X-ray microscopy, and coherent imaging
- Soft X-ray microscopy (water window)
- Microdiffraction and micro-tomography

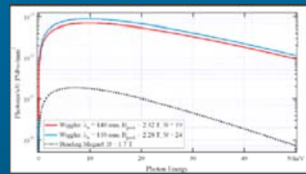
Biological and biomedical activities are boosted by the Executive Director Michel Van Der Rest, and one Life Science director Jean Pierre Samama, in additional to Science Director for Material Science (Paul Morin)

Special hello from…

Hello to friends and colleagues from Jean Claude Denard

Some perspective views

Sharing a wiggler source
W140 19 periods
for culturage heritage science



IPANEMA needs:
corpus approach
- X ray µ-imaging
  - 5-23 keV 3x3 µm²
  - trace elements analysis, corrosion
  - past environments
- X ray µ-tomography
  - 20-60 keV - phase contrast cm f.of view
  - teeth, bony material, fossils in sed.
  - material for heritage conservation