ThomX – Revue de projet - 21 novembre 2019

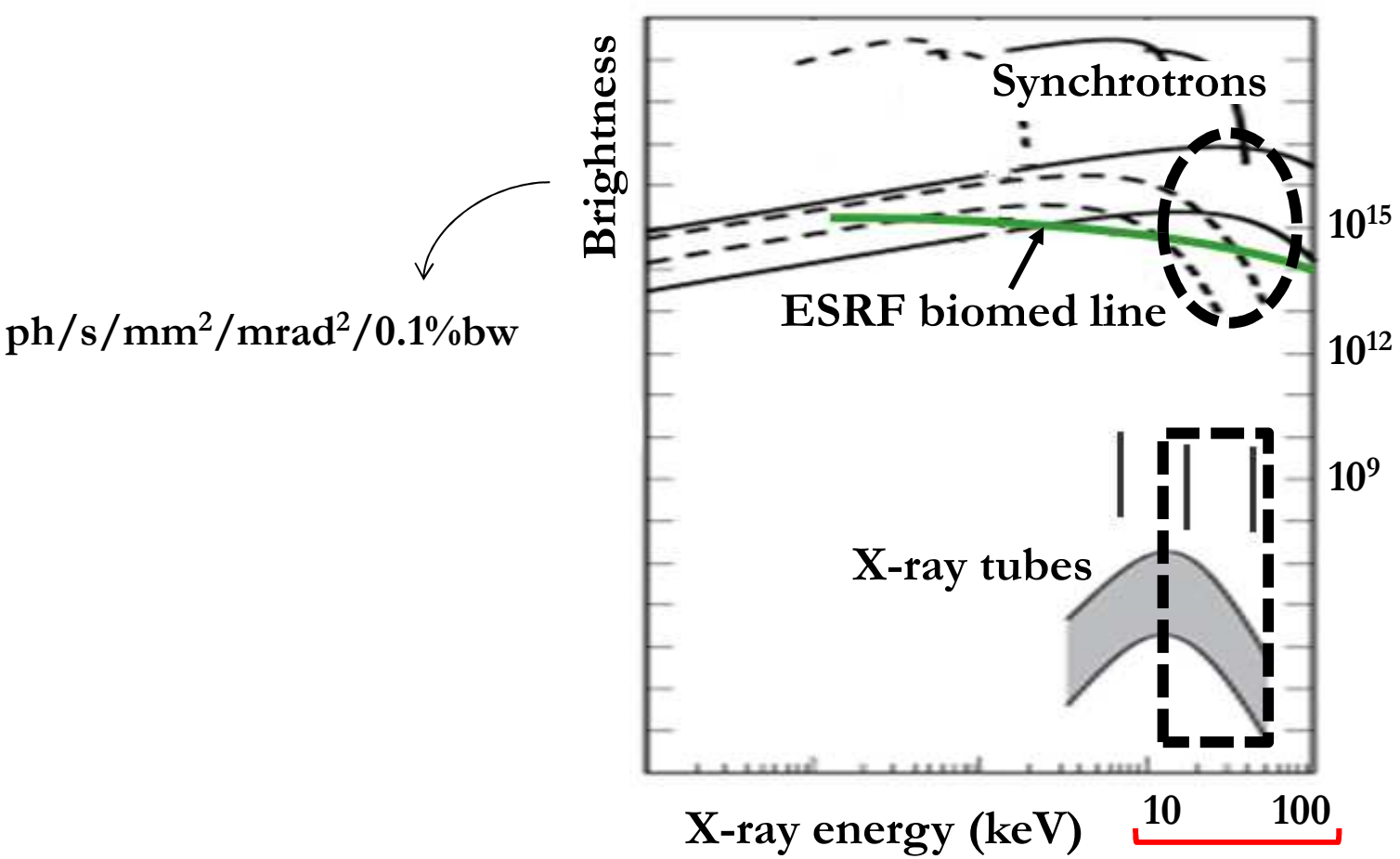
High flux Compton compact sources: state of the art

ThomX: assets and prospects

Marie Jacquet, on behalf ThomX

High flux Compton compact sources in the world (flux > 10^{11} – 10^{13} ph/s)

Brightness of Synchrotron sources and X-ray tubes (hard X-rays)



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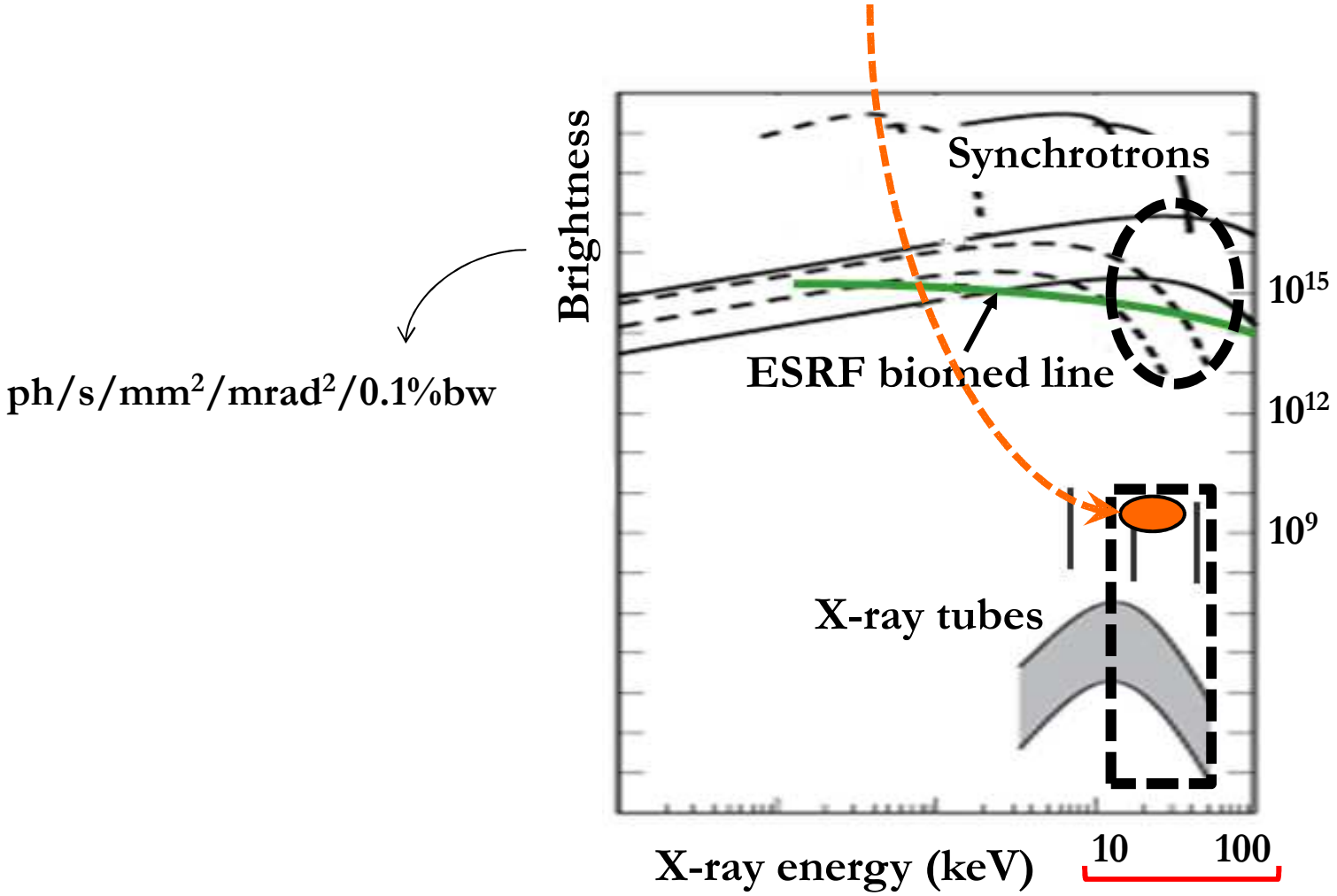
1 CCS Lync. Tech. : 15-35 keV ; 10^{11} ph/s

Unique source currently in the world



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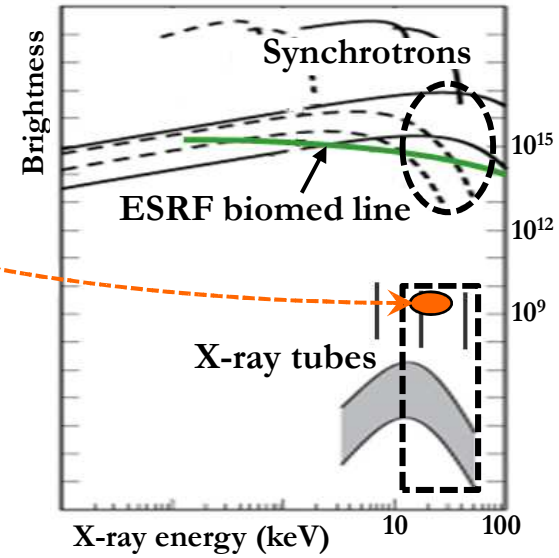

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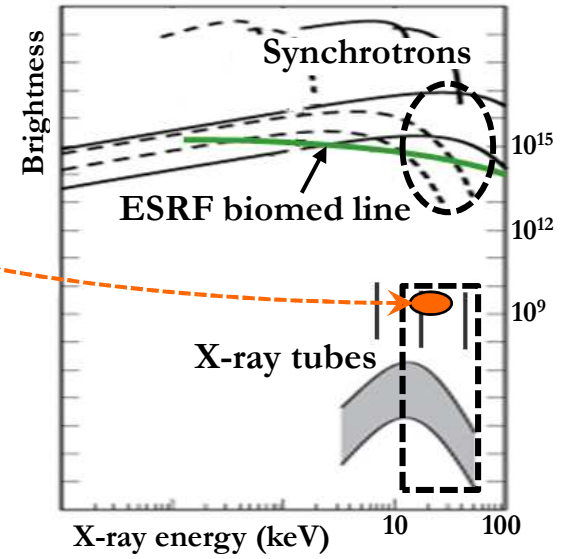

1998 **1st paper**

2006 **1st beam**

2006-2015 Development ctrl/comm, soft, automatization, feedbacks (Lyncean)

End 2015 Machine sold to Munich Univ.

2017 **Nominal parameters reached** **(~ 10^{11} ph/s)**

Today - Development devices and feedbacks for stability, reproducibility … (collab Lync./Munich)

- **1st scientific Munich results 2017-2018**

- Academic researchers only by a physicists-biomedical team, 10-15 people. **No external users**

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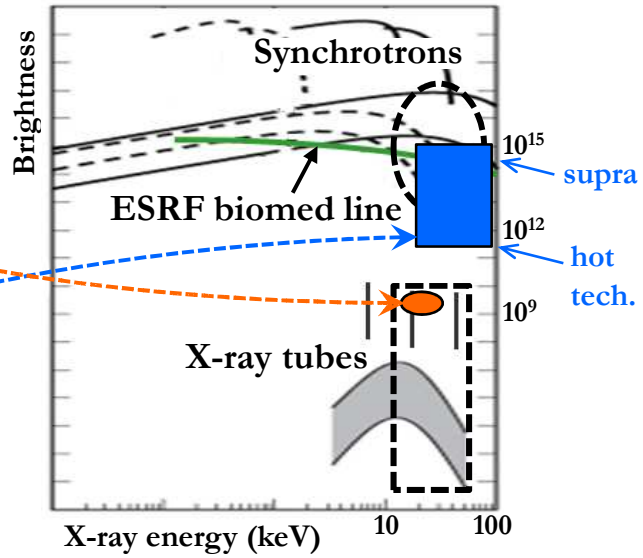

Flux ~ 100 * F_{Lync} → ~ 10^{13} ph/s

Br ~ 10^{2} - 10^{6} * Br_{Lync} → ~ 10^{11} - 10^{15} ph/s/mm²/mrad²/0.1%bw

NESTOR	Ukraine	2005	← 1st paper about the project
LEXG	Russian	2008	
TTX	China	2008	
QB	KEK	2008	
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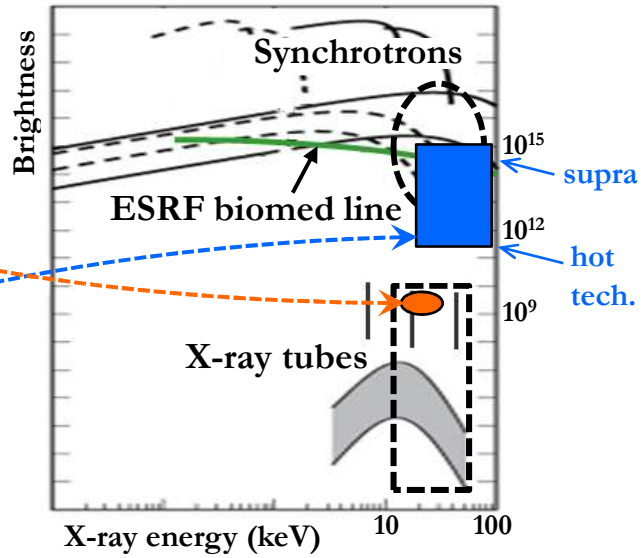

As of today,
none of these projects has yet succeeded
in producing 10^{12} - 10^{13} ph/s

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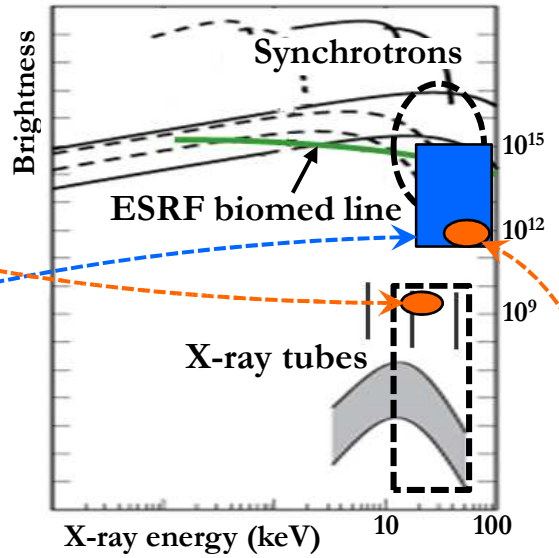

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Currently the most advanced one

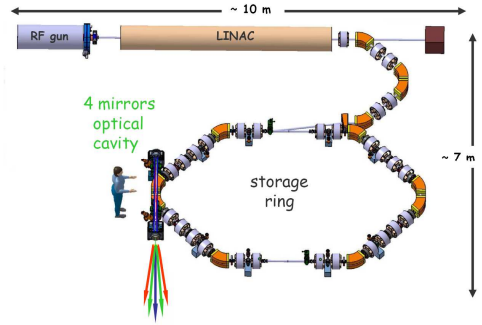
Just an example, with orders of magnitude, to illustrate the potentialities of a Compton source "à la ThomX" (= delivering F ~ 10^{13} ph/s , Br ~ 10^{11})

Medical imaging and therapy applications

Clinical CT scanner
Radiotherapy unit

0.3 mm
imaging resolution

Standard Radiotherapy
(MeV)



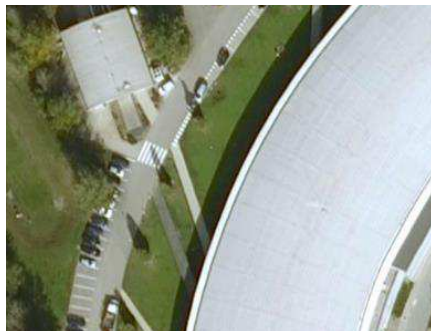
Compton sources (ThomX)

~ 0.05 mm expected at ThomX

New therapies (80 keV)

70 MeV e-
is required
for ThomX

ThomX	9 mGy/s
ESRF	6 mGy/s



Synchrotron line

0.001 mm
imaging resolution

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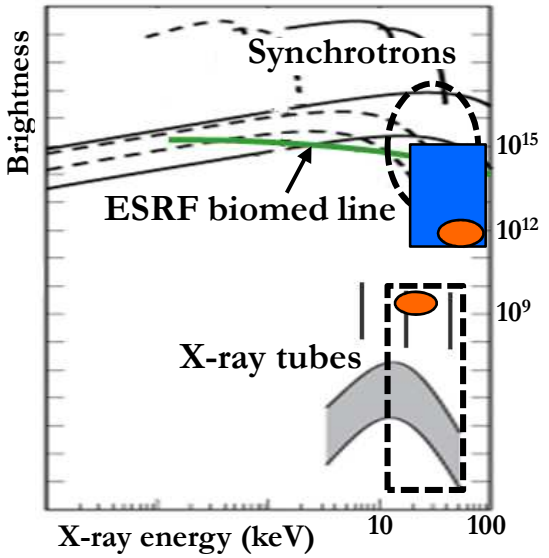

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Outline

- **ThomX or any other Compton source project delivering a flux > 10^{12} ph/s**

  → **big challenge**

- **Thomx must**

  - Obtain its first beam (2020)

  - Stabilize this beam (in intensity and in position)

  - Reach the beam nominal values

  - Demonstrate its potentialities and probe its limitations for each analysis technique

  - Automate the machine operation as much as possible

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  Several years of academic studies and researches (collaborations, thesis …)

- And, after all this, ThomX could become a platform for "paying users" and/or a new prototype could be constructed/industrialized for a particular usage (medical, material science, industry …)

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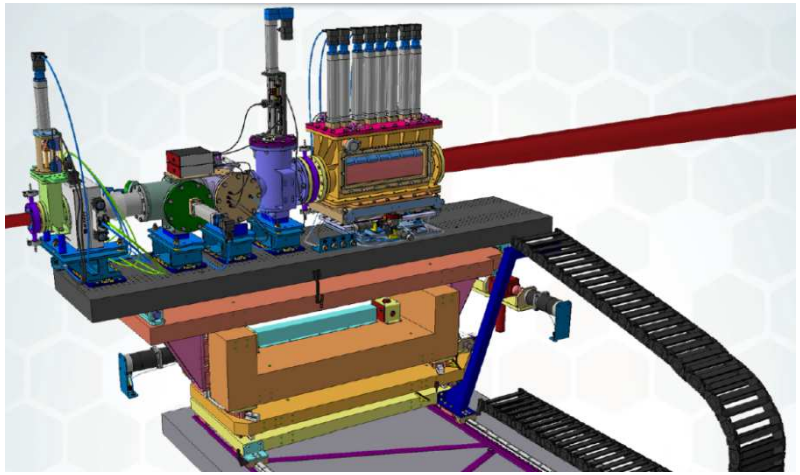
All equipment items
for users' experiments
will be already available



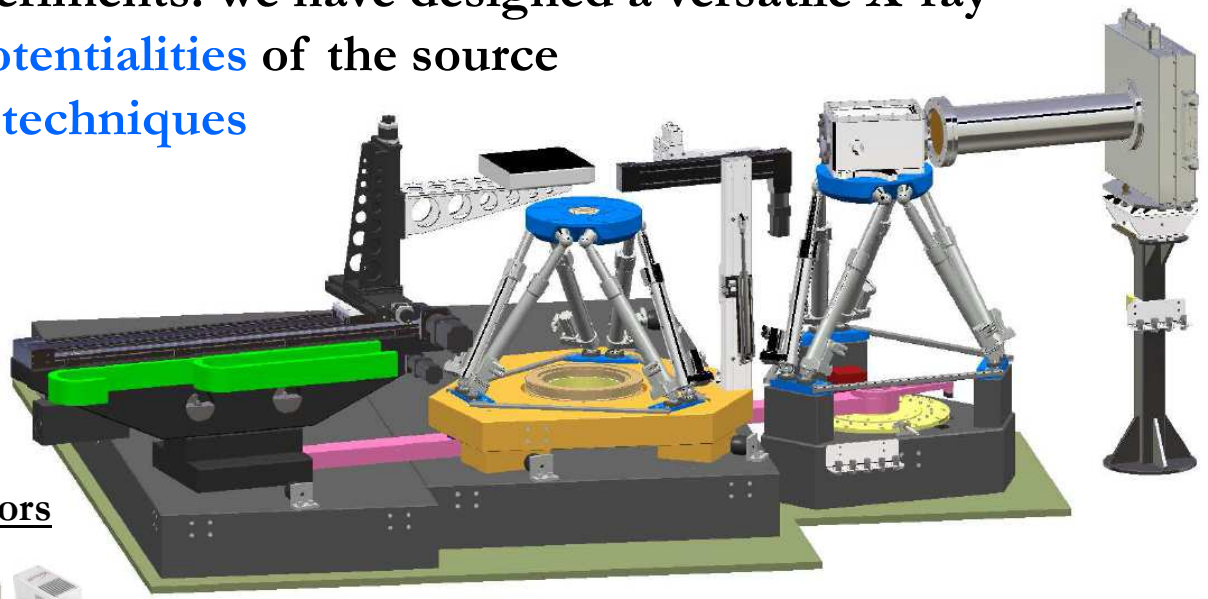
Equipment for

- beam monitoring
- beam focusing

(already installed)

Equipment for users' experiments: we have designed a versatile X-ray line to demonstrate the potentialities of the source in all the current analysis techniques

- Imaging
- Tomography
- Fluorescence
- Diffraction



+ detectors

(installed in next December)

Current serious collaborations, contact, thesis projects with users' communities

i.e. a precise experiment foreseen and quantified (in term of necessary flux and equipment items)

- Thesis proposed, descripted, planned

Hélène Elleaume (Inserm, Grenoble) - Alberto Bravin (Biomed. line ID17, ESRF) - David Sarrut (Tomographic Imaging and Radiation Therapy team, CREATIS center, Lyon)

They propose to use the special properties of **so-called scintillating nanoparticles to locally improve the efficiency of radiotherapy**. Monte Carlo simulations with the **Geant4 / GATE computation code** in order to extract variable compositions, sizes, and concentrations of nanoparticles, the maximum efficiency that can be achieved. Two X-ray sources will be compared to **validate these simulations**: the polychromatic radiation produced by the **ThomX** source and the monochromatic irradiation produced by the **ESRF synchrotron**.

Philippe Walter (Laboratoire d'Archéologie Moléculaire et Structurale, Jussieu) - Catherine Dejoie (High resolution powder diffraction ID22, ESRF) - Pauline Martinetto (Matériaux, Rayonnements, Structure, institut Néel)

L'objectif du projet de thèse est d'identifier toutes les phases cristallographiques trouvées dans des **pigments à base de carbone datant de l'époque romaine**. Pour cela il s'agit de développer une **méthodologie pertinente** afin de démêler un diagramme de diffraction des rayons X multi-phase et d'affiner un modèle structurel pour toutes les phases en présence (amorphe, en poudre, en monocristal). **La nouveauté de ce type d'approche** consiste d'une part à utiliser la contribution monocristalline (approche par cristallographie en série) pouvant apparaître sur le diagramme de diffraction 2D d'un échantillon hétérogène et d'autre part à associer **la diffraction des rayons X sur poudre (ID22, ESRF) à la diffraction monocristalline non monochromatique (ThomX, LAL).**

- Collaborations (national or international)

European COST/SYRA3 project (2013-2017) → Conferences - Working groups - Joint publications

The SYRA3 collaboration included **many participants and multidisciplinary European institutes** (hospitals, research centers, universities, a veterinary clinic, **two compact Compton sources**, an industry). This project consisted to **develop innovative methods in radiotherapy** and radiosurgery with X-ray and aimed to coordinate European works around techniques using synchrotron radiation or Compton photons **to treat cancer and certain diseases of the brain**.

European Innovative Training Network ITN project (will be submitted soon) → 3 partners
Dominik Schaniel (porteur) CRM^2 univ. Nancy - Institut Galien u-psud - LAL

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