FROM RESEARCH TO INDUSTRY

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Sonate

NEUTRONS FOR MATERIALS SCIENCE

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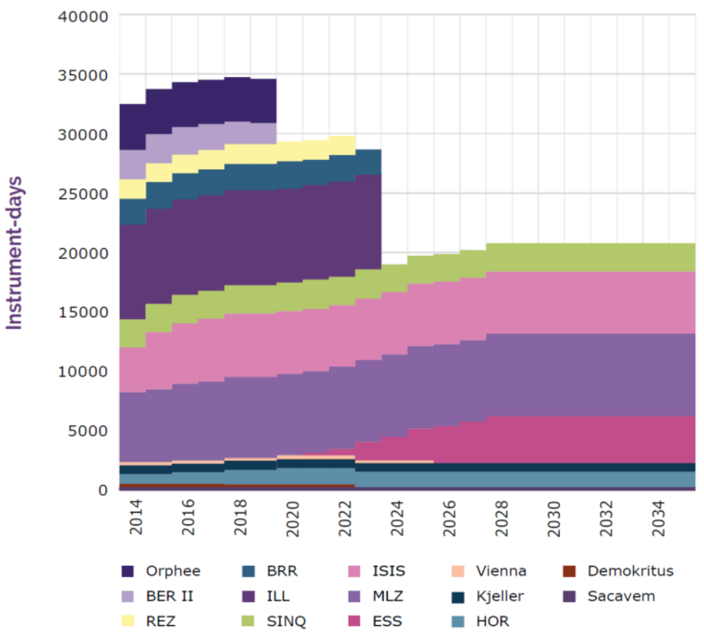
CONTEXTE

Years 2000: Golden Age in Europe

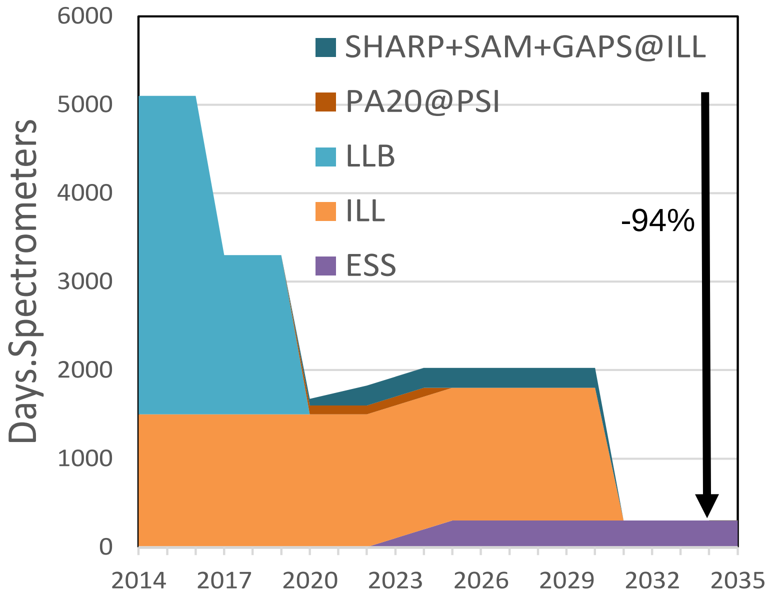
- >30000 Instrument.Days for a community of 6000-8000 users

Neutrons in Europe
(baseline ERFRI scenario)



ESFRI Report, *Neutron scattering facilities in Europe, Present status and future perspectives, 2017*

in France



The IPHI – Neutrons demonstrator

Objective:

→ Test the different key elements of a compact source

- Accelerator — I_{peak} > 60mA
- Target — Lifetime ~1000 – 2000 hours (at 50kW)
- Moderator — Produce thermal and cold neutrons
- Instruments

The SESAME "*IPHI – Neutrons*"

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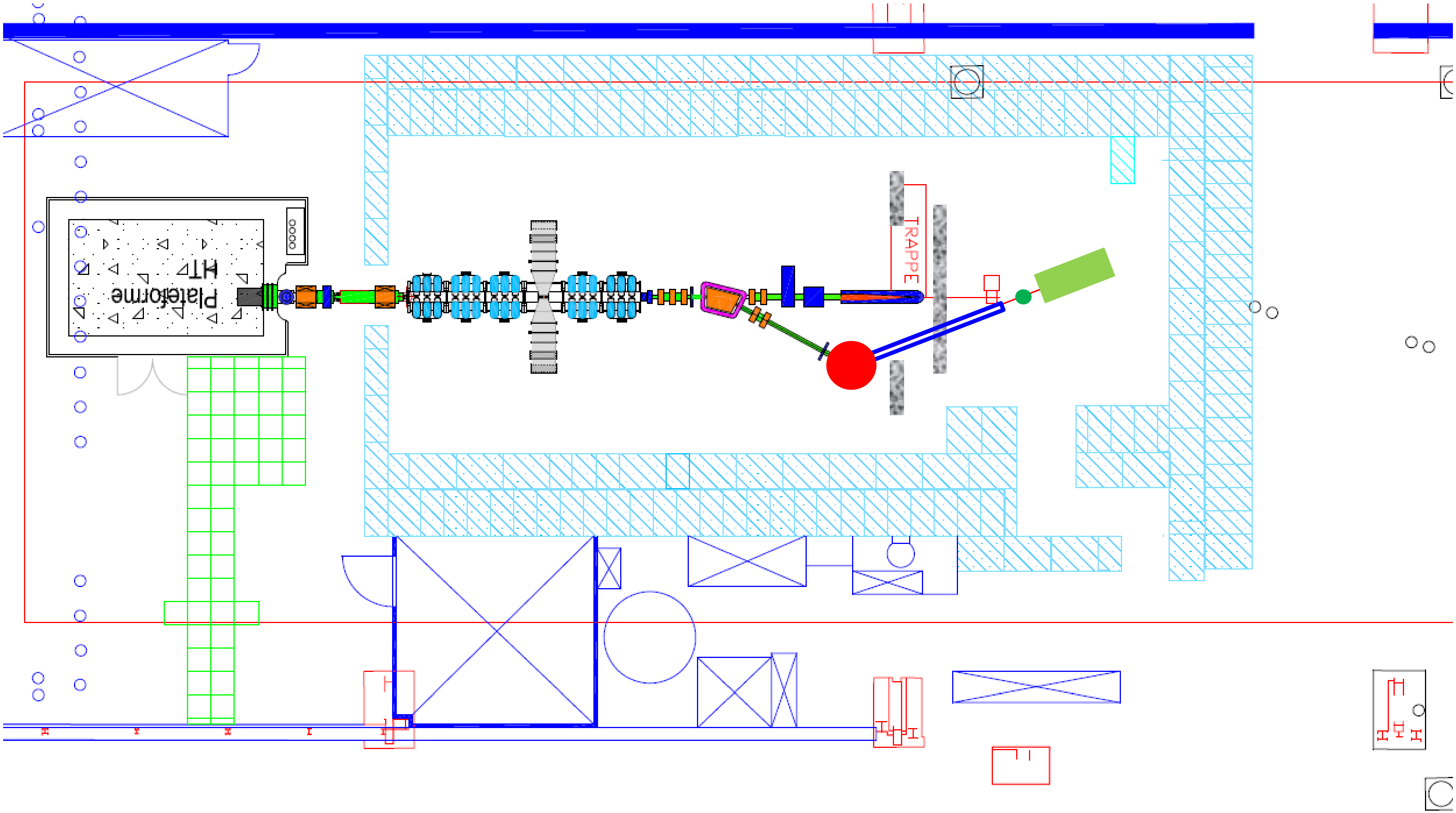
- 2018-2020
- Operation at 50kW (E_p = 3MeV) on a beryllium target
- A "generic" scattering instrument

IPHI - Neutrons

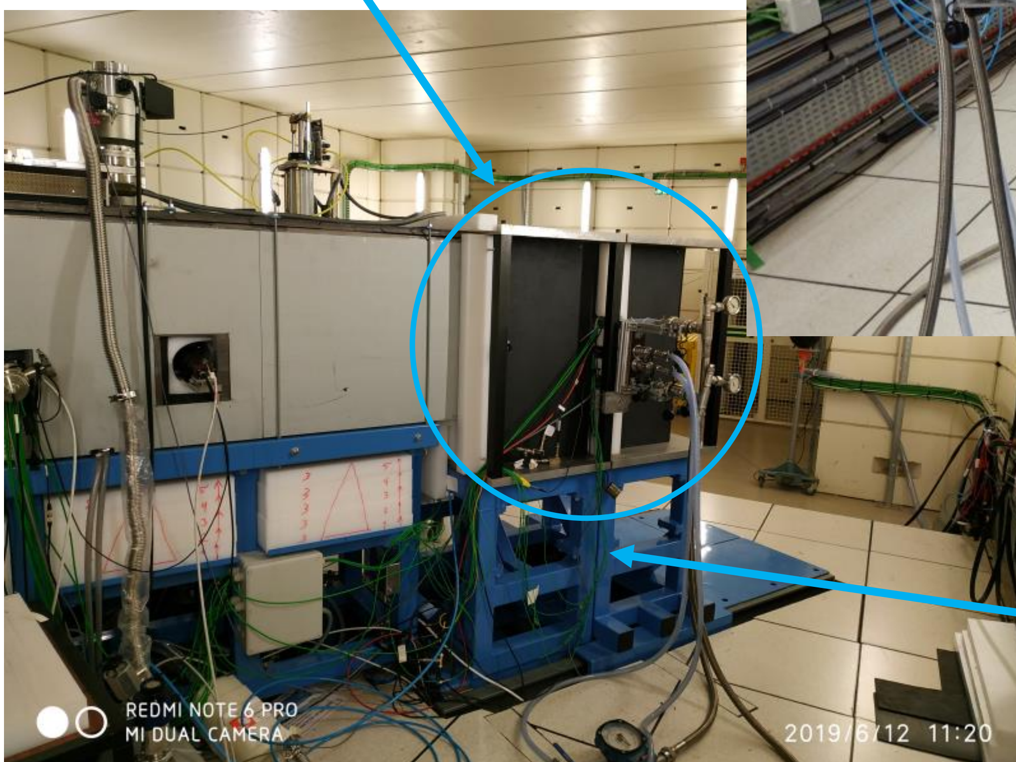


1 « generic » instrument : SANS, réflectomètre, imagerie, diffraction

Mesurements on samples – prrof of concept - performances

TARGET - MODERATOR – SHIELDING

Target – moderator – shielding box



Target

TMR mounted on 2 trolleys
for an « easy opening »

TARGET TESTS SPRING 2019

Operation at 3kW power on the target

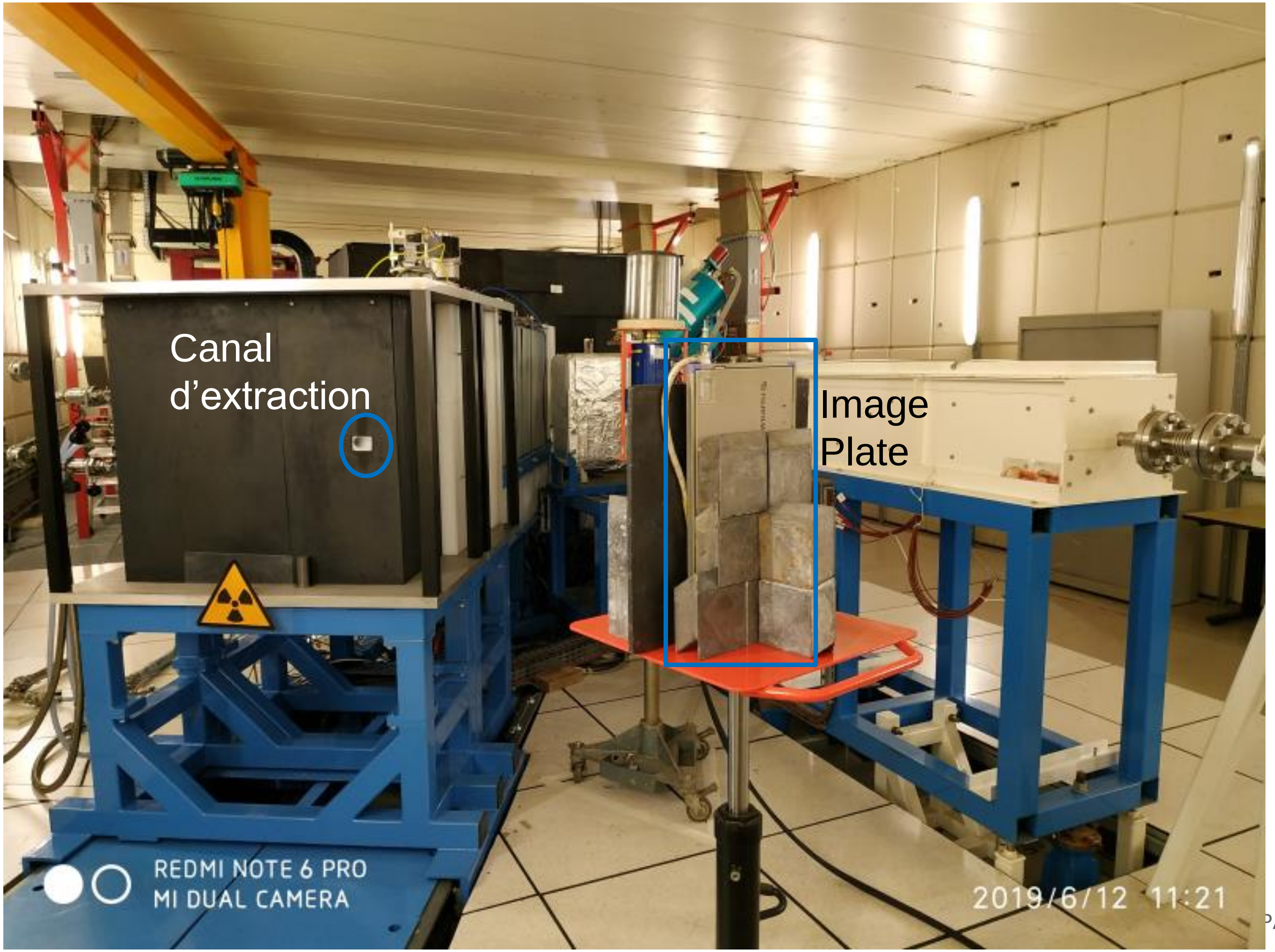
- E_p = 3MeV, peak current 20mA, pulse length 2850µs, frequency 17Hz
- Average power density on the target 650W/cm² (in the center of the target)
- Peak power in a pulse 60kW
- Operation at high temperature (500°C) to promote the diffusion of implanted protons

Mai – June 2019

→ Operation for more than 50 heures at 3kW (over ~2 weeks)

- Average proton current = 0.9mA
- Proton fluence on the target ~ 50mA.heures ~ 8×10^{20} protons/m²
- On-line optical control of the target state
  - No visible change of the surface roughness
- 8-9 hours operation per day

« RADIOGRAPHIE » SETUP

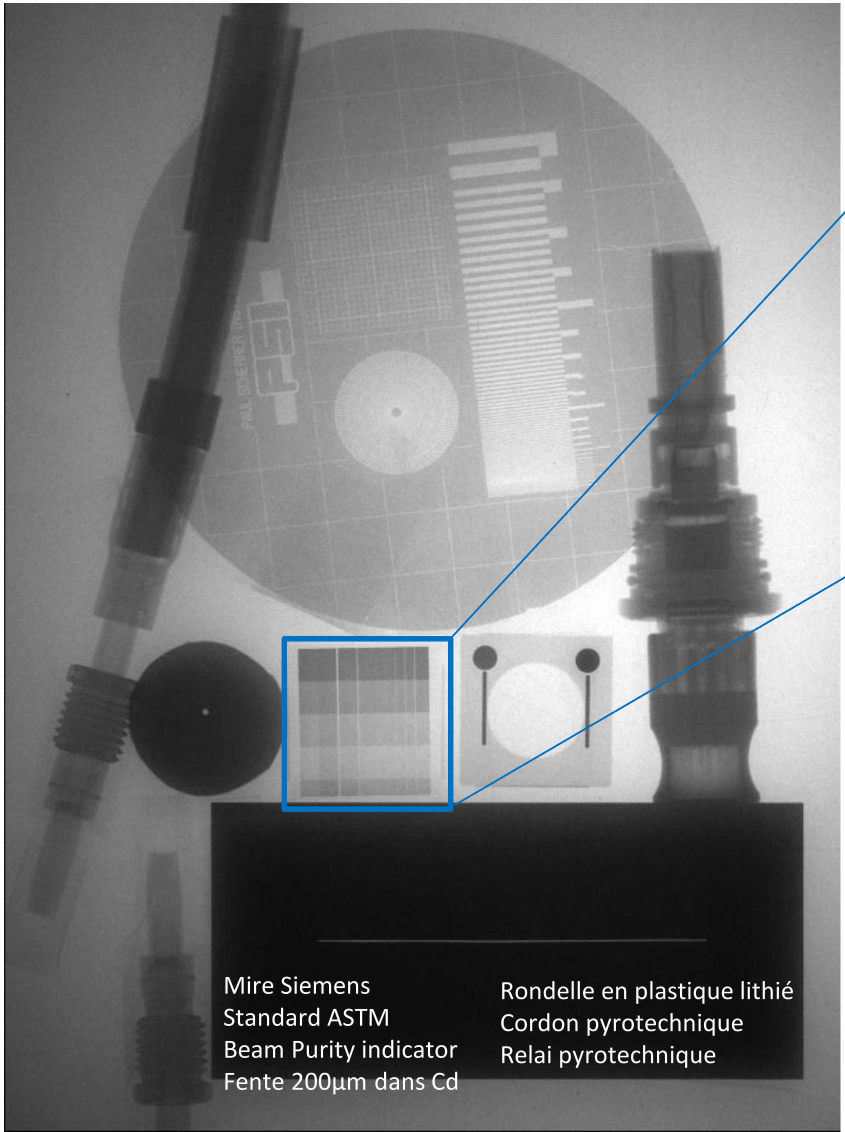


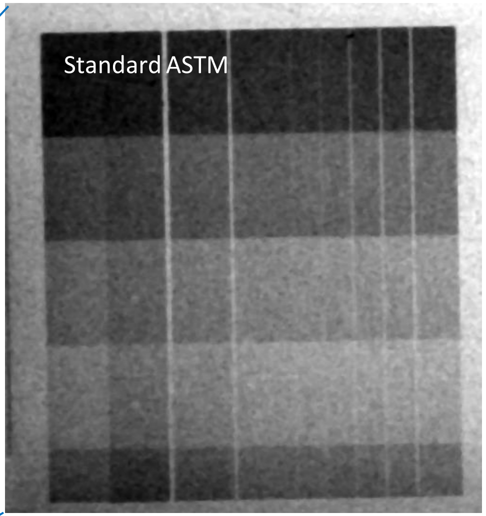
MONTAGE DE RADIOGRAPHIE

Image Plate montée derrière une plaque de plomb

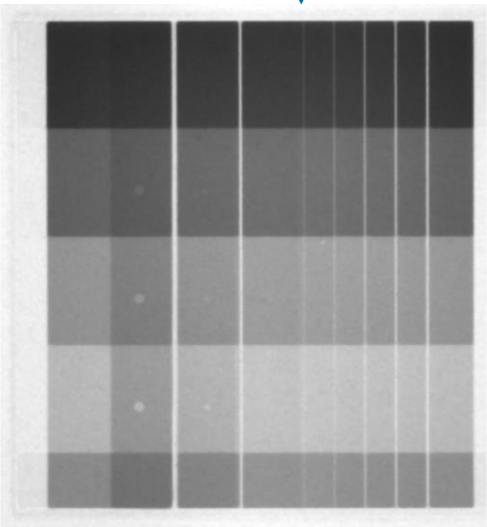
NEUTRON RADIOGRAPHY

IPHI 1hour à 3kW





Spacer 15µm



G45 « standard conditions » (P = 14MW)

DIFFRACTION SETUP

Crystal in 4 cercles craddle

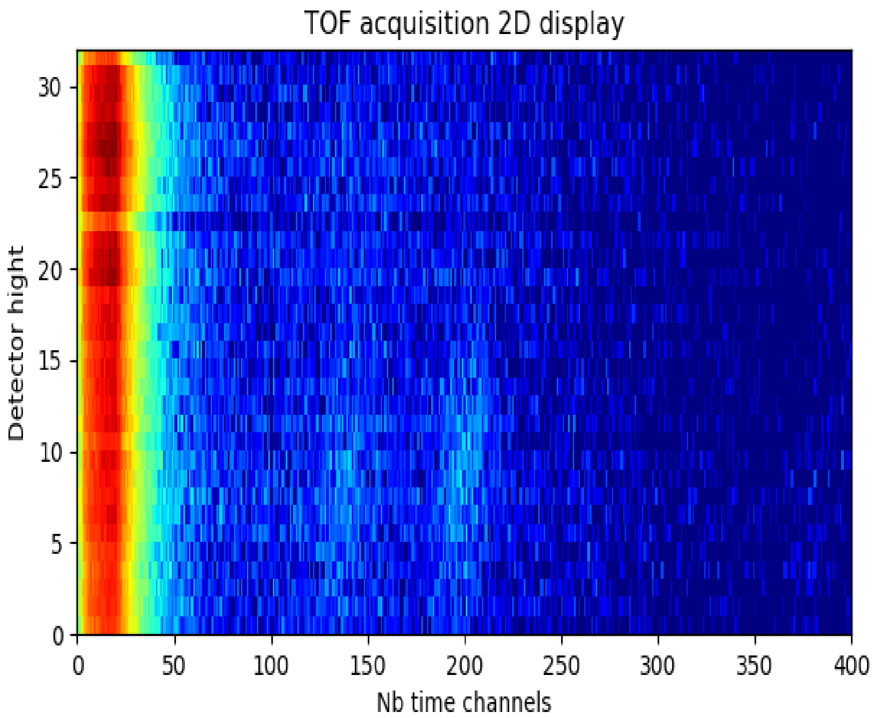
Source

Detector MT32
(30x30cm)

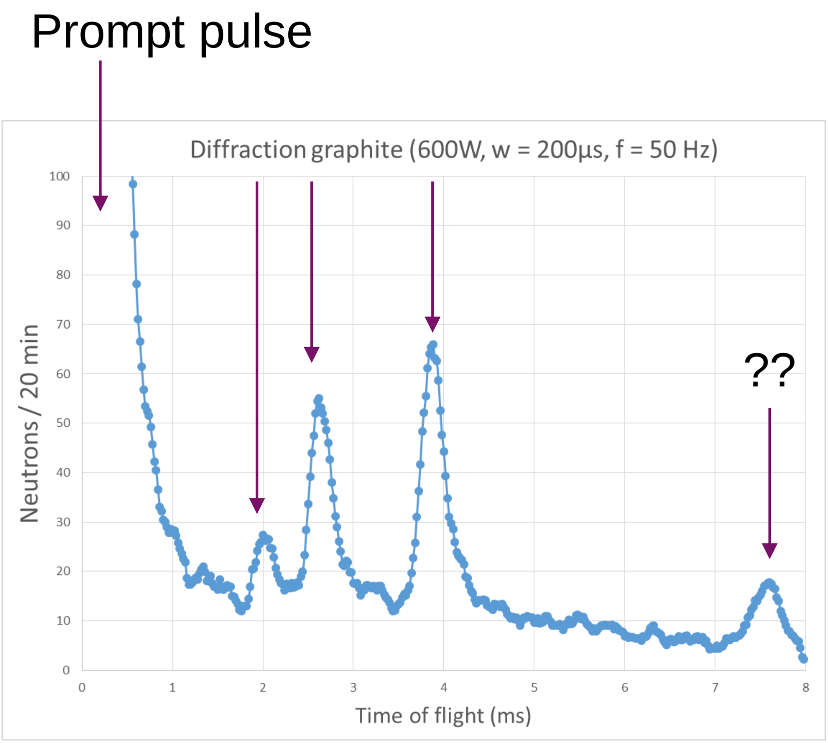
DIFFRACTION

Detector MT32 (32 tubes of 300mm) at 90° from the beam axis

- graphite crystal – no collimation
- 50Hz, 200µs, 600W, 20 min
- Poor efficiency of the MT32 detector for thermal neutrons

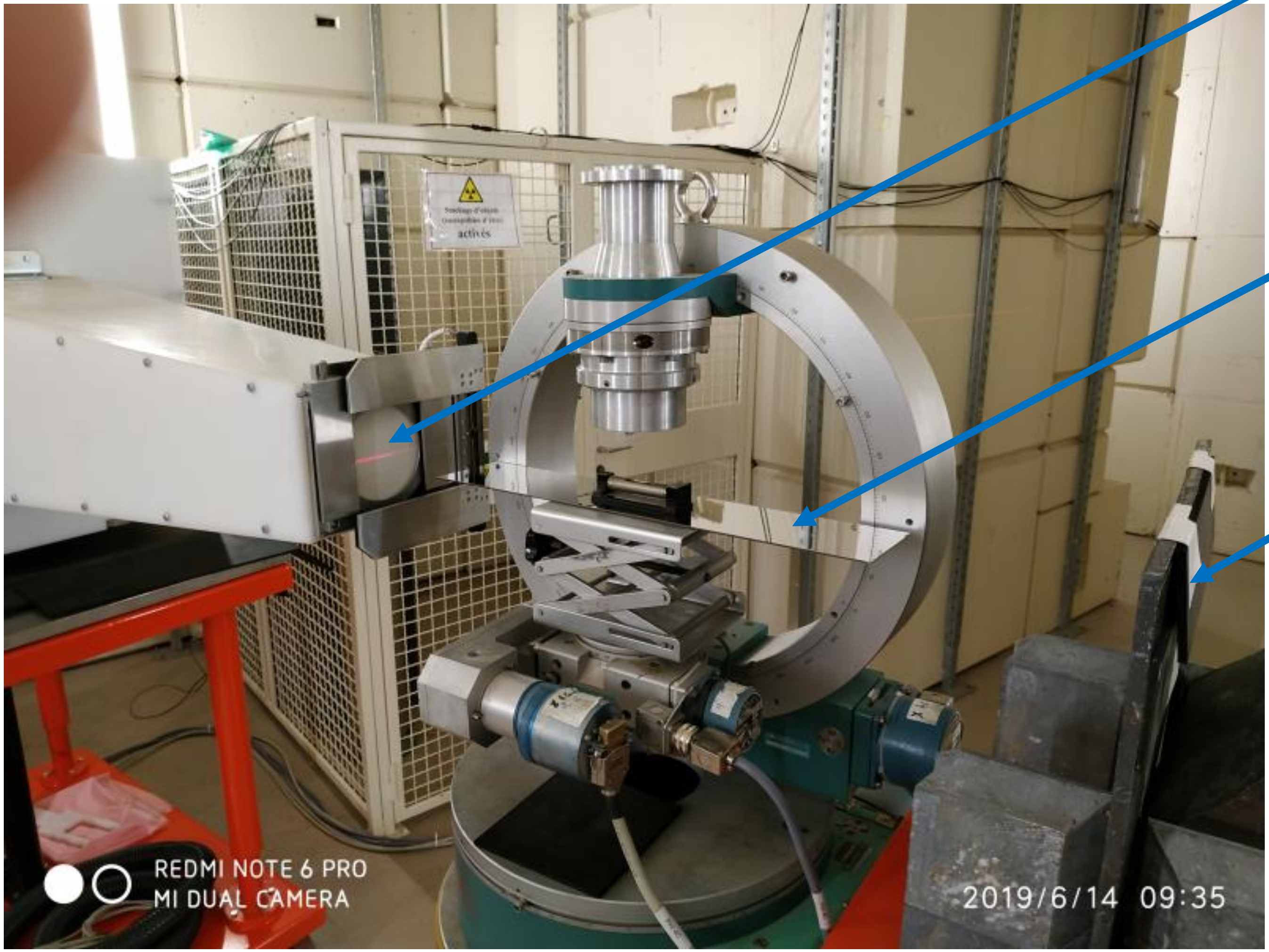


Raw data



After integration

REFLECTIVITY SETUP



Detector collimator entrance

Neutron mirror

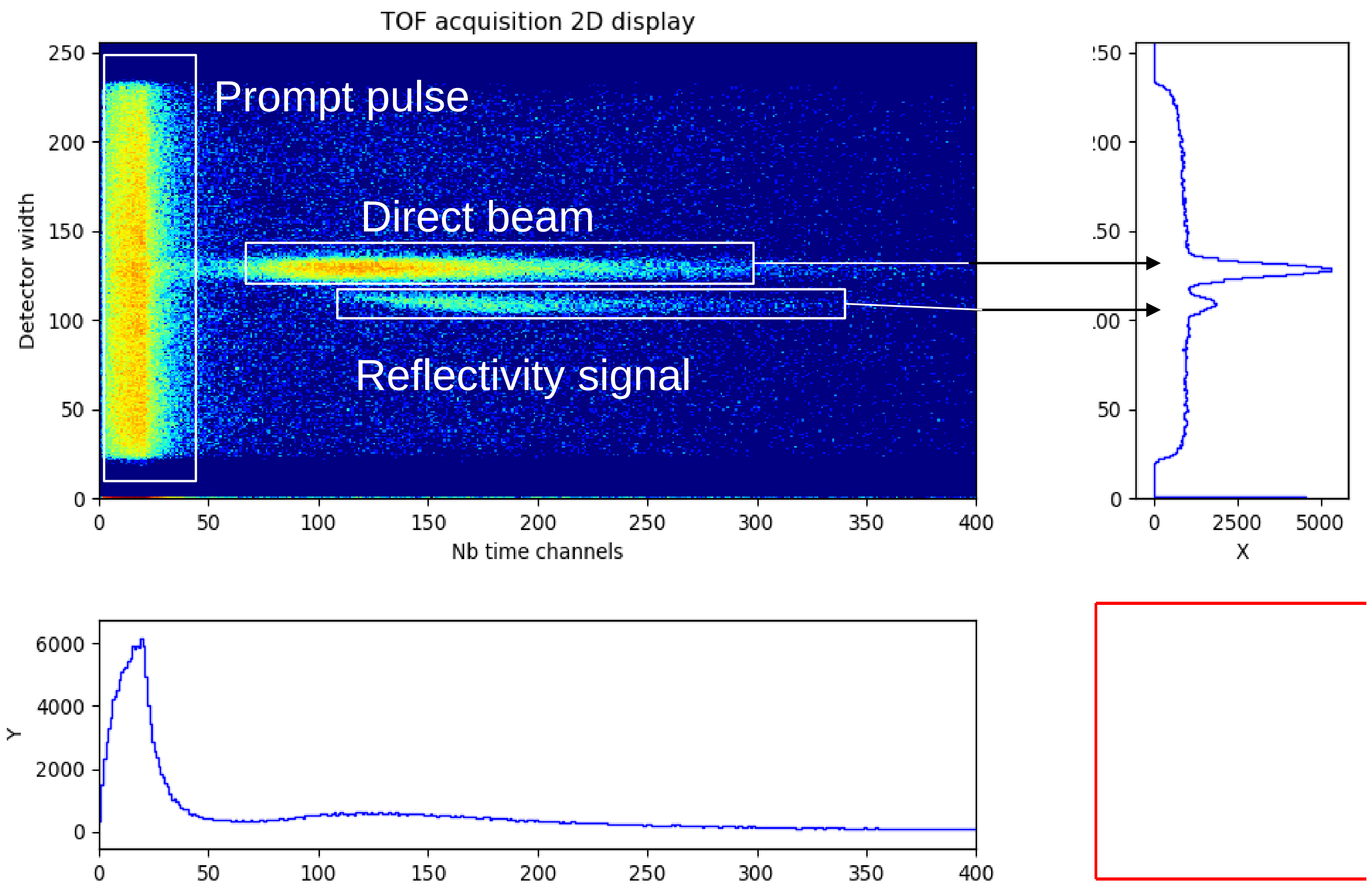
Collimation slit 7mm

Source

REFLECTIVITY

Neutron super-miror

- Operation à 50Hz, 400µs, 1.2kW, 10 min

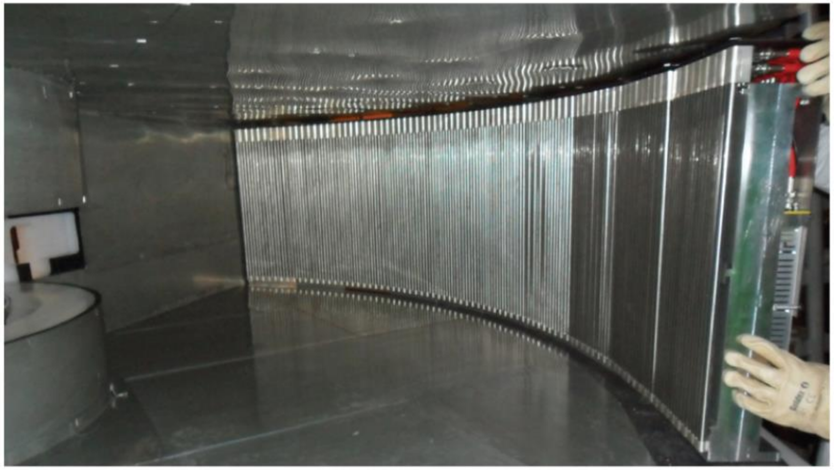


WORKPLAN 2019 - 2020

Fall 2019

- Ramping of the accelerator to 50 kW
- Design of the 50kW target (scaling of the 3kW target design + beam sweeping)
- New thermal PSD detector
- SANS & powder diffraction
- Other tests on ESS devices (monitors, détectors)

Winter 2020



- Shielding improvements
- Scattering spectromeer improvements
  - Neutron guide
  - Collimation slits
- Tests target 50 kW
- Tests cold moderator (para – H_2)

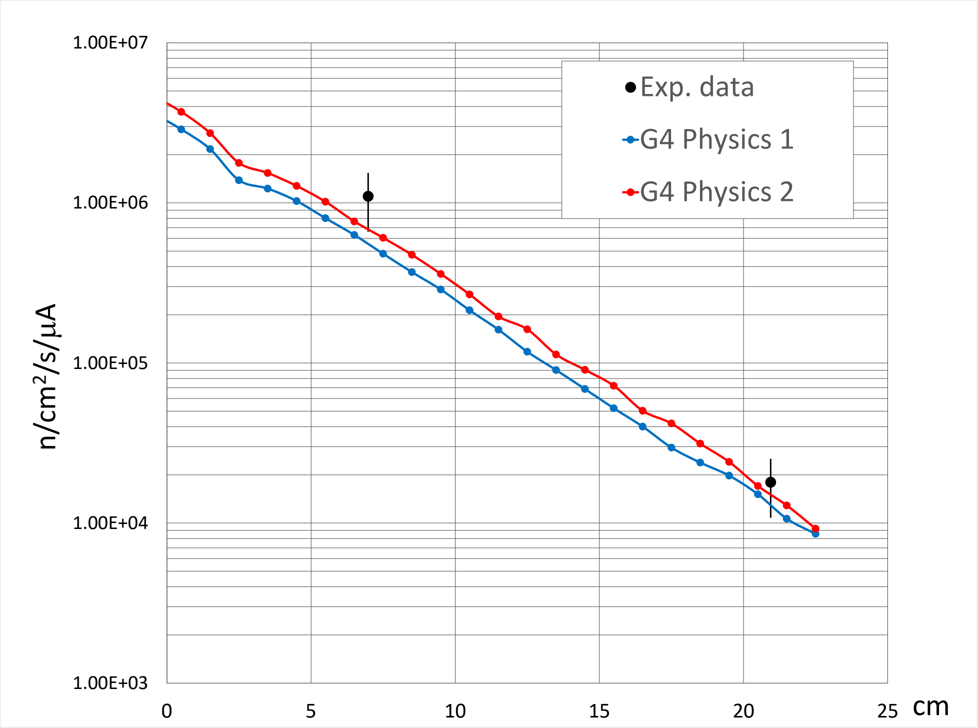
Spring 2020

- Operation [Radiography – Reflectometry – Diffraction – SANS]
- Améliorations rapports signal / bruit
- Qualification performances CANS → extrapolation pour SONATE (E_p = 20MeV, flux × 200)

NUMERICAL SIMULATION QUALIFICATIONS

Numerical simulations of the neutron production on a CANS

- MCNP and GEANT4

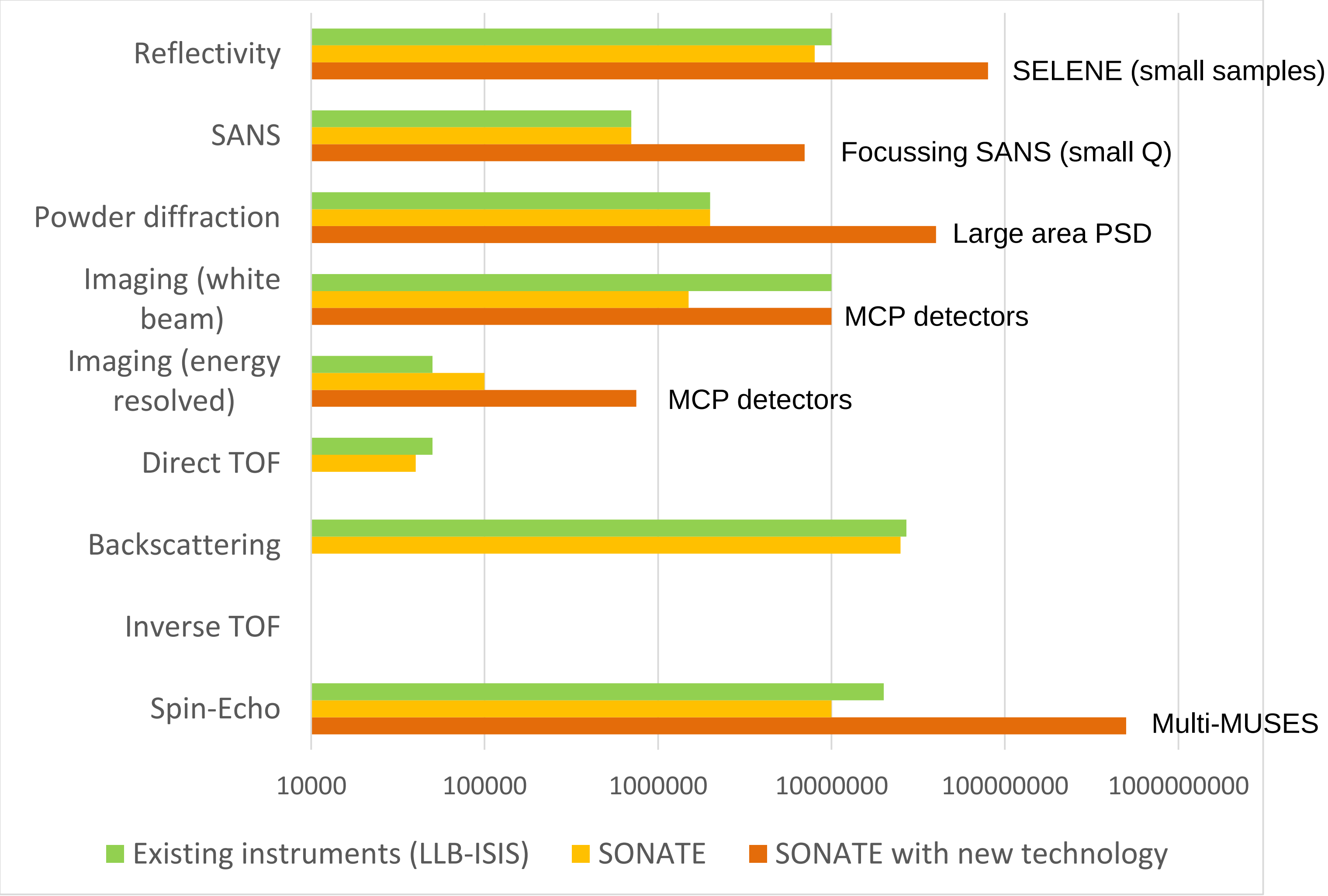


Definition of a reference design → SONATE

- E_p = 20 MeV, I_{peak} = 100 mA, duty cycle = 4%, P = 80 kW

Reference design SONATE

- E_p = 20 MeV, I_{peak} = 100 mA, duty cycle = 4%, P = 80 kW



2030: 10 INSTRUMENTS AROUND 2 TARGETS

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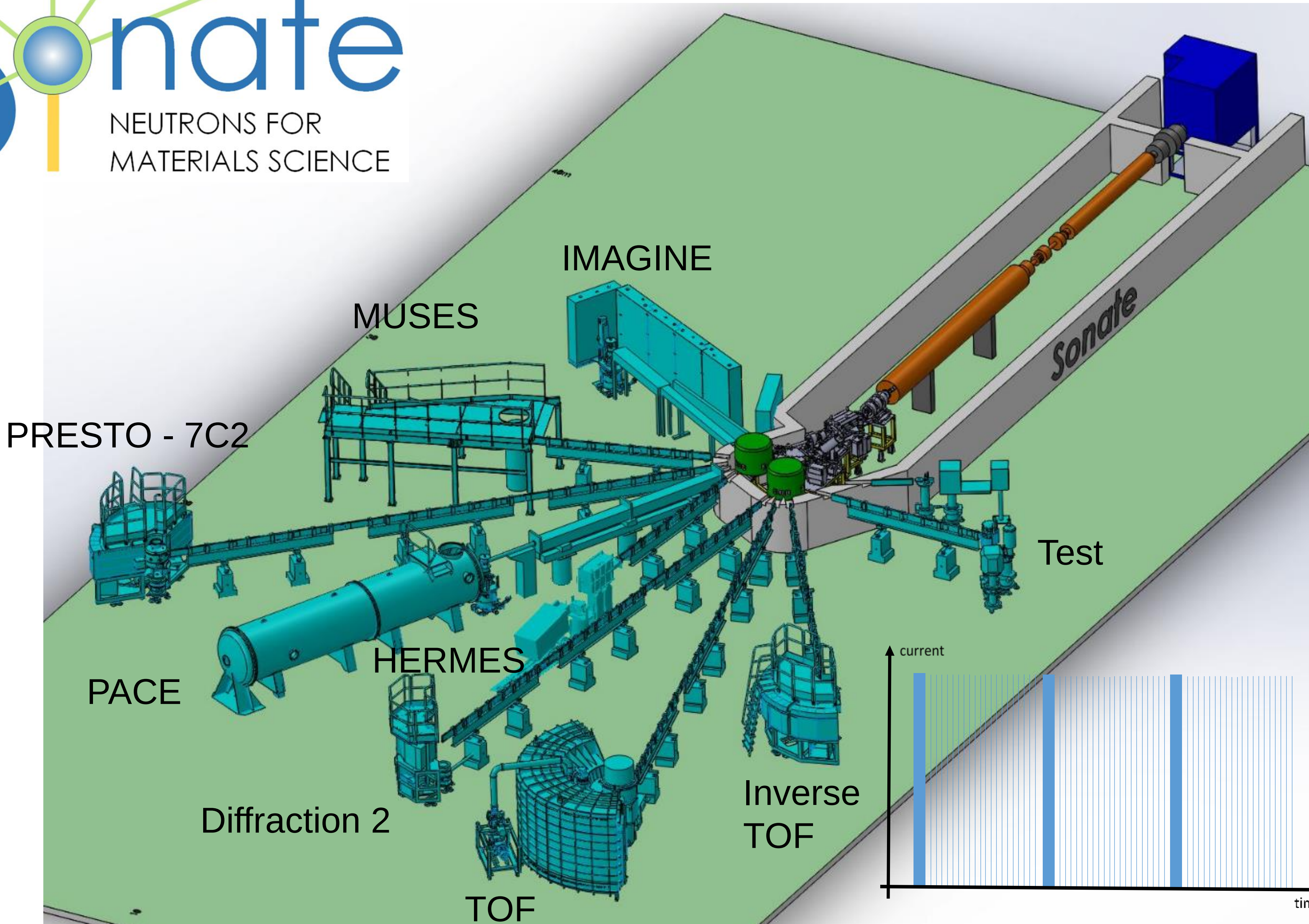

CONCLUSIONS

The performances of a compact source are potentially equivalent to a medium scale research reactor or spallation source

- Reduced cost compared to a reactor

Technologically

- Accelerator OK
- Cible → tests under way (+ other solutions under dev.)
- Moderator OK / can be updated over the time
- Instruments OK

Possibility to benefit from the French ecosystem

- Scientific and technical expertise at Saclay and Grenoble
- Wide user base
- Possibility to reuse the efforts injected into ESS
  - Accelerator construction
  - Instruments designs
  - Detector developments
  - Reduction et data processing
- Existing instrumentation / available

A CANS for a materials science plateform

NEUTRONS FOR MATERIALS SCIENCE

IPHI – NEUTRONS & SONATE CONTRIBUTORS

Monte-Carlo simulations

- H.N. Tran (IRFU/SPhN) (post-doc)
- L. Thulliez (IRFU/SPhN)
- A. Marchix (IRFU/SPhN)
- A. Letourneau (IRFU/SPhN)
- J. Darpentigny (IRAMIS/LLB)
- G. Gigante CEA/SPR (shielding / activation)

IPHI

- J. Schwindling (IRFU/SACM)
- N. Chauvin (IRFU/SACM)
- F. Sénée
- B. Pottin, G. Perreu
- A. Dubois
- D. Chirpaz, Y. Sauce
- O. Kuster, C. Deberles

Instruments simulations

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- A. Menelle (IRAMIS/LLB)
- F. Ott (IRAMIS/LLB)
- F. Porcher (IRAMIS/LLB)

Target - moderator

- N. Sellami (IRFU/SIS)
- B. Annighöfer (IRAMIS/LLB)
- P. Permingeat (IRAMIS/LLB)

Neutron measurements

- J. Darpentigny (IRAMIS/LLB)
- F. Ott (IRAMIS/LLB)
- A. Menelle (IRAMIS/LLB)

Technical support

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- B. Homatter (IRAMIS/LLB)
- P. Lavie (IRAMIS/LLB)
- J.-L. Meuriot (IRAMIS/LLB)
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Strategic support

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- A. Leservot (DRF/DCEPI)