INSTYTUT FIZYKI JĄDROWEJ
IM. HENRYKA NIEWODNICZAŃSKIEGO
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Physics applications of the accelerator

Adam Maj
IFJ PAN Kraków

3rd Workshop on Research & Innovation in Poland: Research Programme for Linear Accelerator - Radioisotopes and Applications

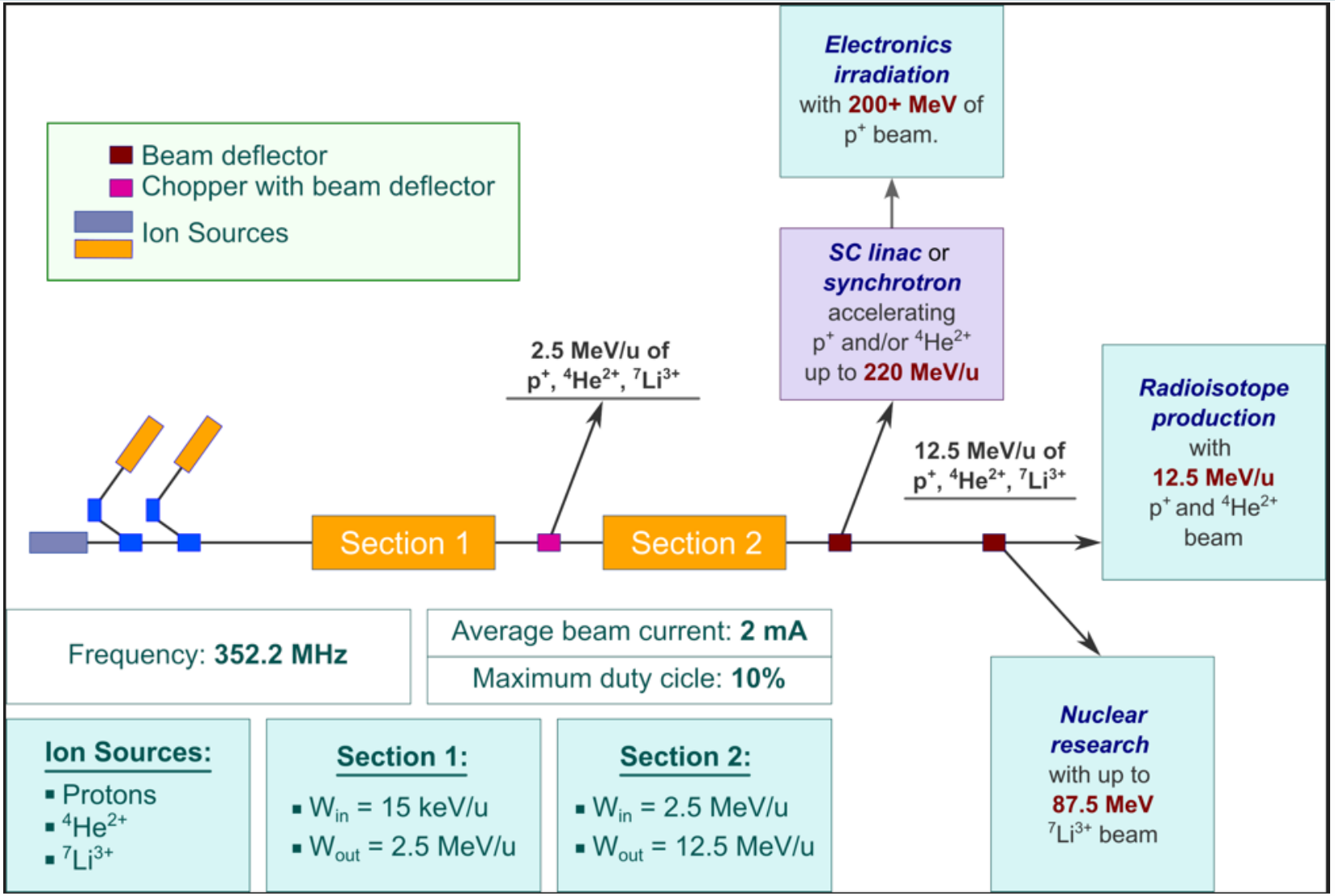
IFJ PAN Krakow, 22-23 Oct 2026

This presentation is an overview of the outcomes of the previous workshop (May 2026) dedicated to the possible physics cases to be done with a new linear accelerator.

The presented there cases, together with the results of this workshop, will constitute the main chapter of the planned White Book

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…
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Beam deflector
Chopper with beam deflector
Ion Sources
Electronics irradiation with 200+ MeV of p+ beam.
SC linac or synchrotron accelerating p+ and/or 4He2+ up to 220 MeV/u
2.5 MeV/u of p+, 4He2+, 7Li3+
12.5 MeV/u of p+, 4He2+, 7Li3+
Radioisotope production with 12.5 MeV/u p+ and 4He2+ beam
Section 1
Section 2
Frequency: 352.2 MHz
Average beam current: 2 mA
Maximum duty cicle: 10%
Nuclear research with up to 87.5 MeV 7Li3+ beam
Ion Sources:
Protons
4He2+
7Li3+
Section 1:
Win = 15 keV/u
Wout = 2.5 MeV/u
Section 2:
Win = 2.5 MeV/u
Wout = 12.5 MeV/u

Nuclear Physics topics

- **Study of Fission Processes Induced by Protons, Alpha Particles, and Heavy Ions** – M. Ciemała et al.
- **Gamma spectroscopy of the nuclei produced in fast-neutron-induced fission reaction** - Ł.W. Iskra et al.
- **Investigation of Nuclear Two-Photon (2γ) Decay in Even-Even Nuclei via Proton Excitation of 0_2^+ States**, M. Ciemała et al.
- **Half-life measurements of long-lived isotopes** - Ł.W. Iskra et al.,
- **Gamma decay of giant resonances (GDR, GQR) excited by proton or alpha beam** - M. Kmiecik, M . Ciemała, A. Maj et al.
- **Measurements of stretched resonances decays in light atomic nuclei** - N. Cieplicka-Oryńczak, B. Fornal, M. Ciemała
- **Discrete gamma-ray spectroscopy in light ion beam- induced reactions** - M. Matejska-Minda, P. Bednarczyk, I. Dedes, D. Duda
- **Nuclear dynamics in few nucleon systems** – A. Kozela et al.
- Implementation of beam energy and energy spread diagnostics, W. Parol, P. Kulessa, A. Kozela

Bio-Med-Materials topics

- **Radiobiological response to proton irradiation enhanced by metallic nanoparticles** – B. Kłębowski, J. Depciuch-Czarny
- **Development of High-Resolution Proton-Induced X-ray Emission Spectroscopy for Chemical Speciation Studies in the Tender X-ray Range** – J. Czapla-Masztafiak, W. Błachucki, R. Fanselow, A. Yakovliev
- **Production of Medical Radionuclides and Nuclear Data Measurements with future LINAC**, A.A. Ahmed, T.M. Mróz, J.W. Mietelski
- **Investigation of Radiation Hardening in Metastable Materials for Cryogenic Applications** – B. Skoczeń
- **Accelerating Discovery: AGH Perspectives on Materials Science and Biophysics at Poland's New Linear Accelerator** – M. Marciszko-Wiąckowska, K. Szaciłowski, P. Bała

Gamma spectroscopy of the nuclei produced in fast-neutron-induced fission reaction –

Ł. W. Iskra et al.

Inverse kinematics with ^{7}Li beam

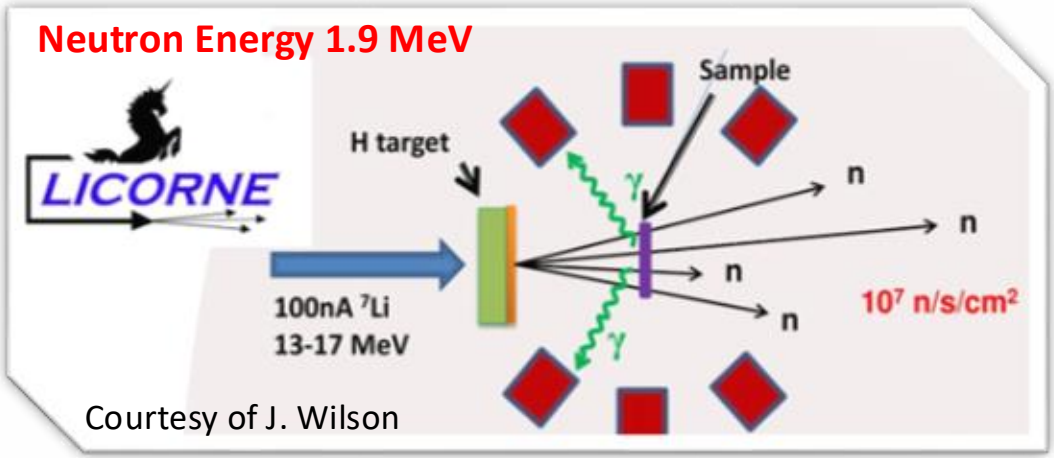
$p(^{7}Li,n)^{7}Be$

directional beam

fast neutrons

high intense beam

LICORNE (**L**ithium **I**nverse **C**inematiques **OR**say **NE**utron source)

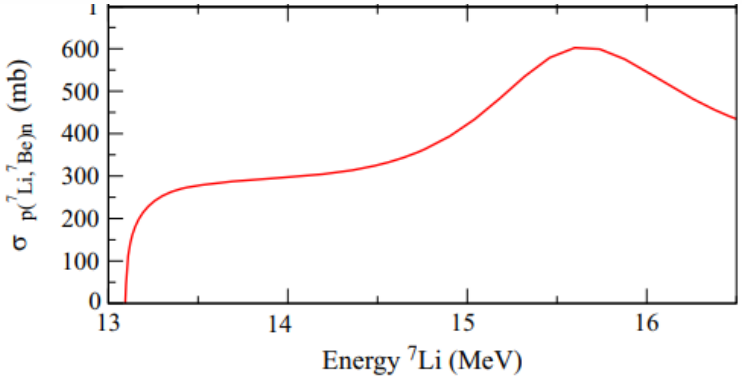


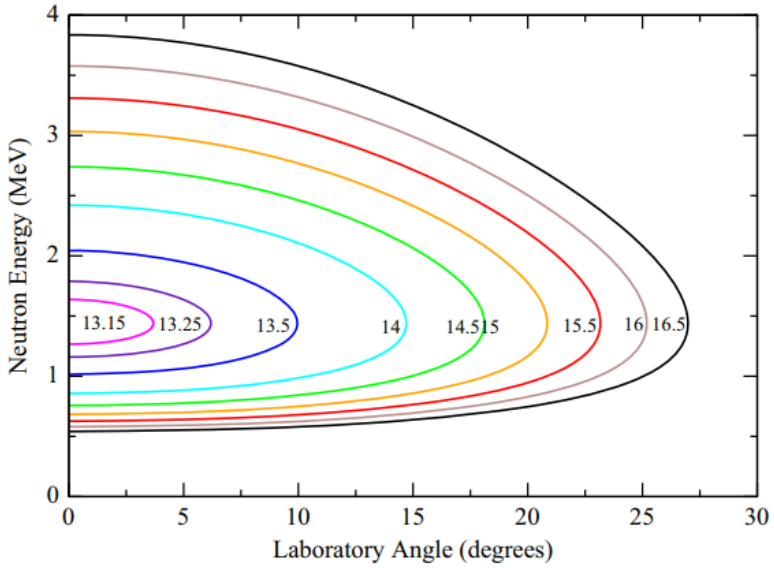
LISKRA (LIthium neutron Soure in KRAkow

Production of fast neutrons using a LINAC

Beam energy

Type of exit channel	Q-value (MeV)	Threshold energy (MeV)	Primary 0° neutron energy
$n_0 + {}^{7}_{4}Be$	−1.644	13.098	1.44
$n_1 + {}^{7}_{4}Be^{*}(0.429\ MeV)$	−2.073	16.513	3.84
$n_2 + {}^{3}_{2}He + {}^{4}_{2}He$	−3.230	25.726	8.18
$n_3 + {}^{7}_{4}Be^{*}(4.57\ MeV)$	−6.214	49.489	18.79





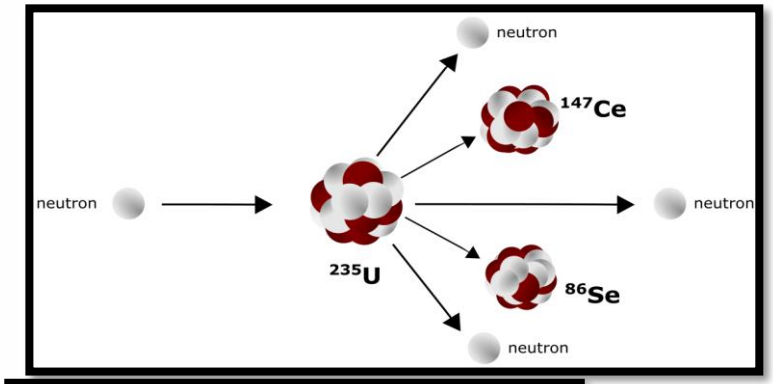
collimated beams and high neutron fluxes at short distances

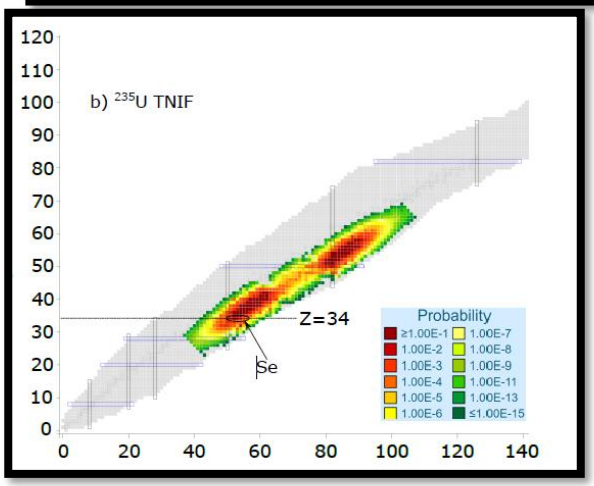
$^{7}Li^{3+}$ 16 - 50 MeV

2 - 19 MeV neutrons

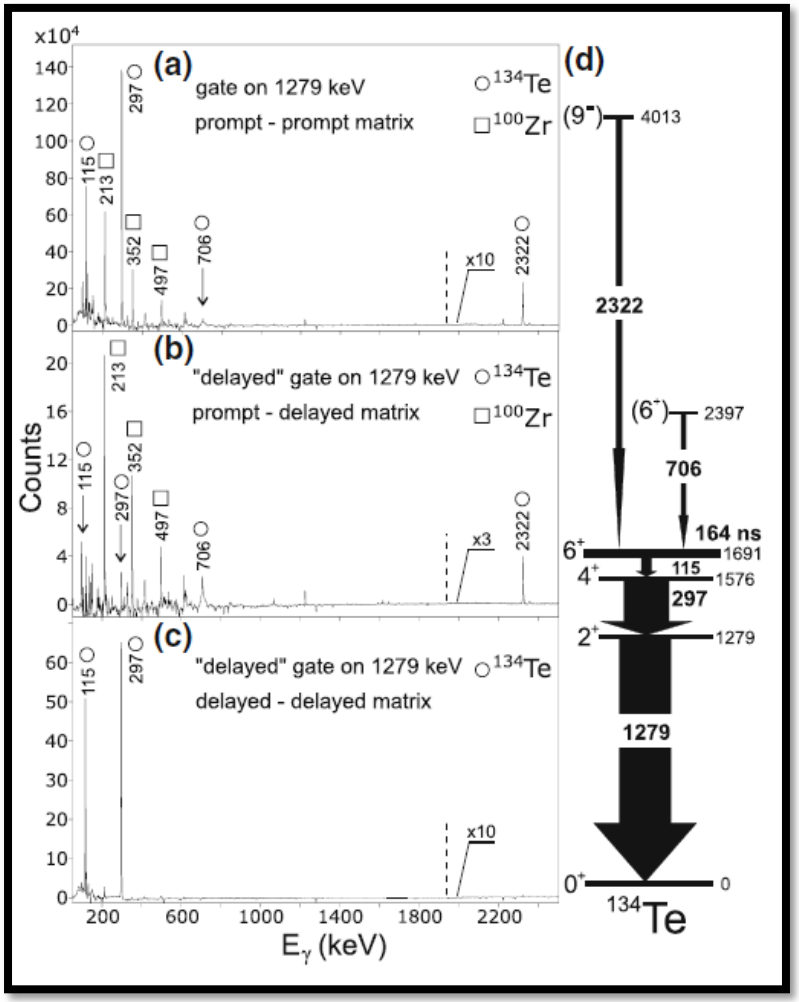
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Gamma spectroscopy of the nuclei produced in fast-neutron-induced fission reaction





Hundreds of different nuclei produced in one experiment



- **High statistic data**
  - **long duration of the experiment**
  - **pawerfull detection system**
- **Pulsed beam – fission tag**

The proposed infrastructure will make possible the experimental program in which generated fast neutrons are used to induce fission of actinide targets. The resulting fission fragments will populate exotic regions of the nuclear chart.

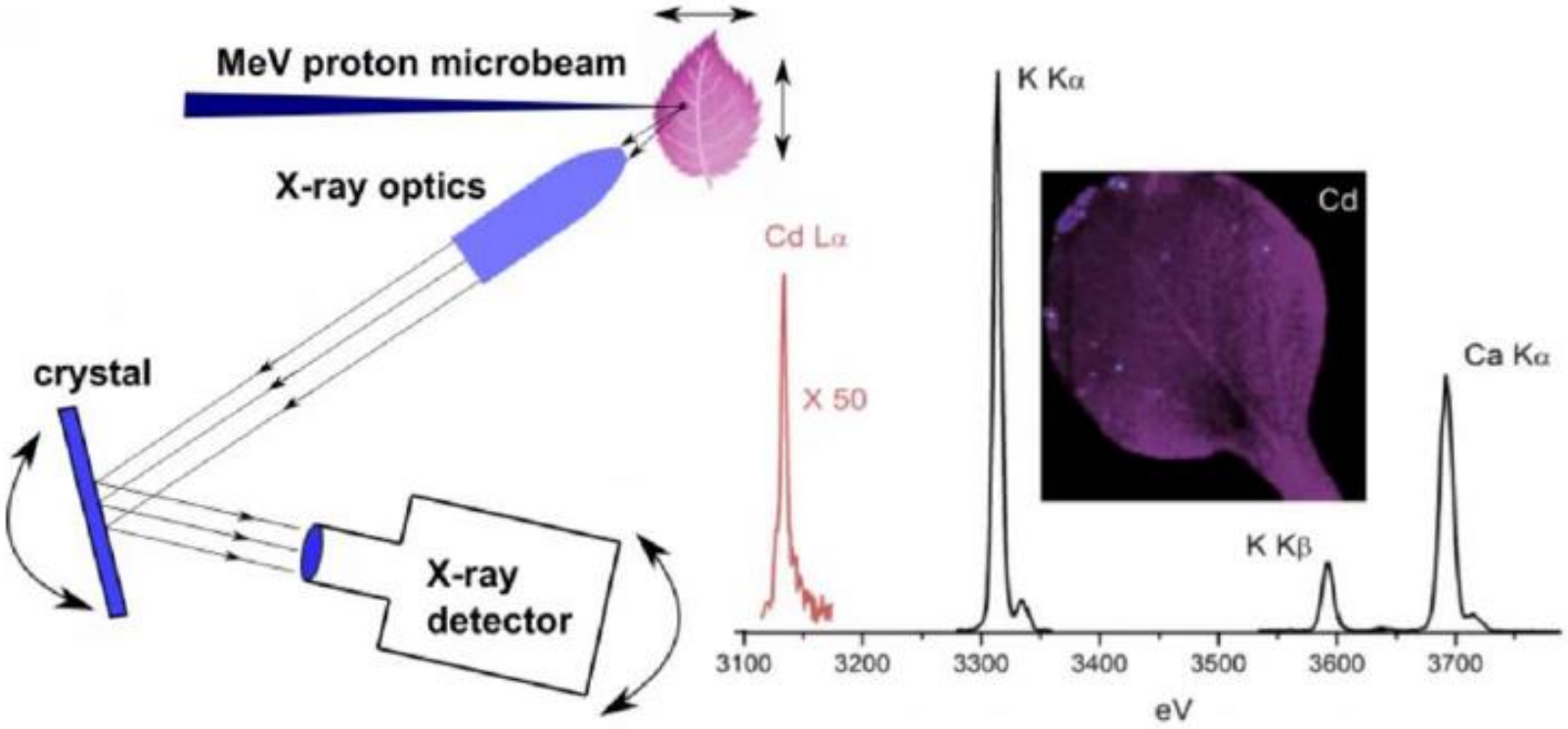
Investigations of nuclear structure will be carried out through γ-coincidence measurements, enabling searches for previously unobserved phenomena. In addition, the acquired data will provide valuable input for models de-scribing astrophysical nucleosynthesis processes as well as fission process itself.

Requirments

Section 2: 7Li with variable energy within 17 to 50 MeV range,
Required pulsation – around 400 ns repetition time and few ns pulse width
Beam on target around 10 μA

Development of High-Resolution Proton-Induced X-ray Emission Spectroscopy for Chemical Speciation Studies in the Tender X-ray Range

J. Czapla-Masztafiak, W. Błachucki, R. Fanselow, A. Yakovliev



The proposed infrastructure will enable the extension of high-resolution particle-induced X-ray emission (HR-PIXE) measurements into the proton-excited tender (2-5 keV) X-ray regime, which is crucial for analyzing biologically relevant elements such as phosphorus (P), sulfur (S), and chlorine (Cl).

Potential applications span a wide range of fields, including biological tissue imaging, sulfur/iron speciation, catalysis, nanoparticles, and functional materials.

Requirments

Section1: Protons with energy within 2 –3 MeV range
Beam current from tens to hundreds of nA, depending on sample type
Possibility of focused microbeam operation

White Book organization:

Chapter 1: Idea and initial assumptions
Chapter 2: Physics cases
Chapter 3: Cases for Radioisotopes and Applications
Chapter 4: Conclusions and Recommendations

Chapter 4 will be prepared by the Programme Committe (Editorial Board), coordinated by Marek Lewitowicz and Maurizio Vretenar

Plan to have the White Book ready - beginning of 2027

There is a possibility to publish the White Book (or parts of it) in

European Physical Journal – Research Infrastructures