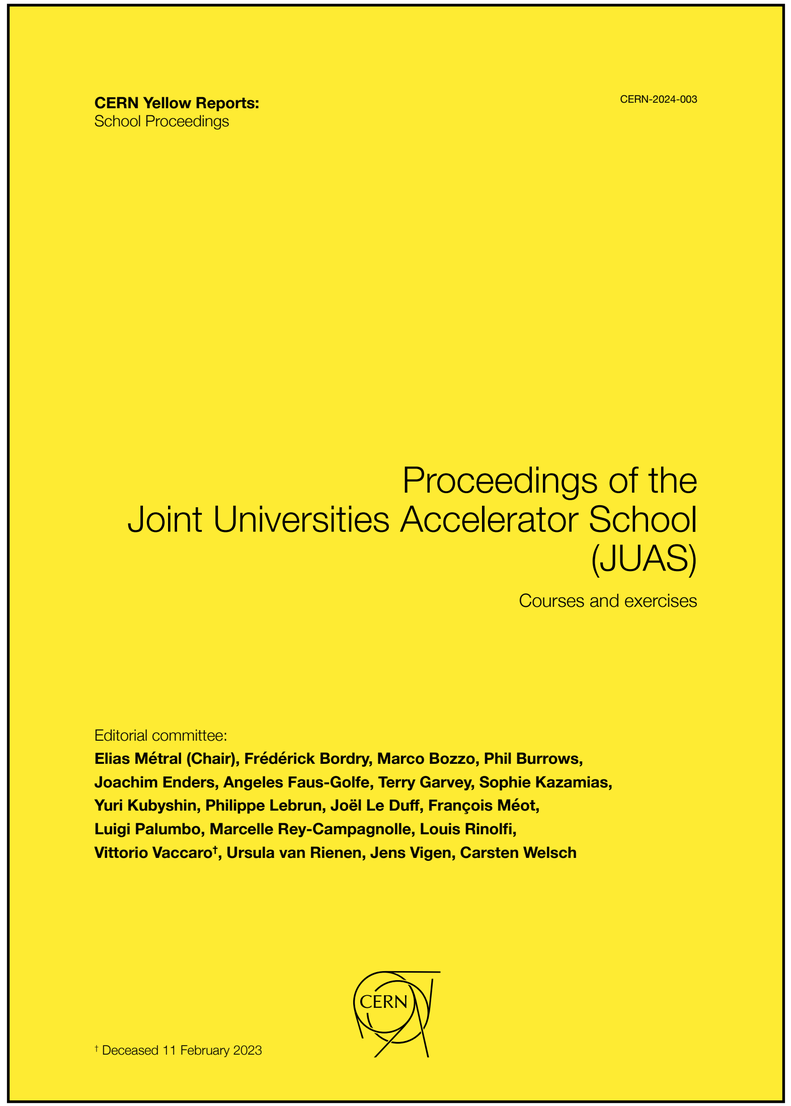
JUAS-2024 book: from conception to birth



=> Published last week (between 15/11/24 and 22/11/24):

https://doi.org/10.23730/CYRSP-2024-003

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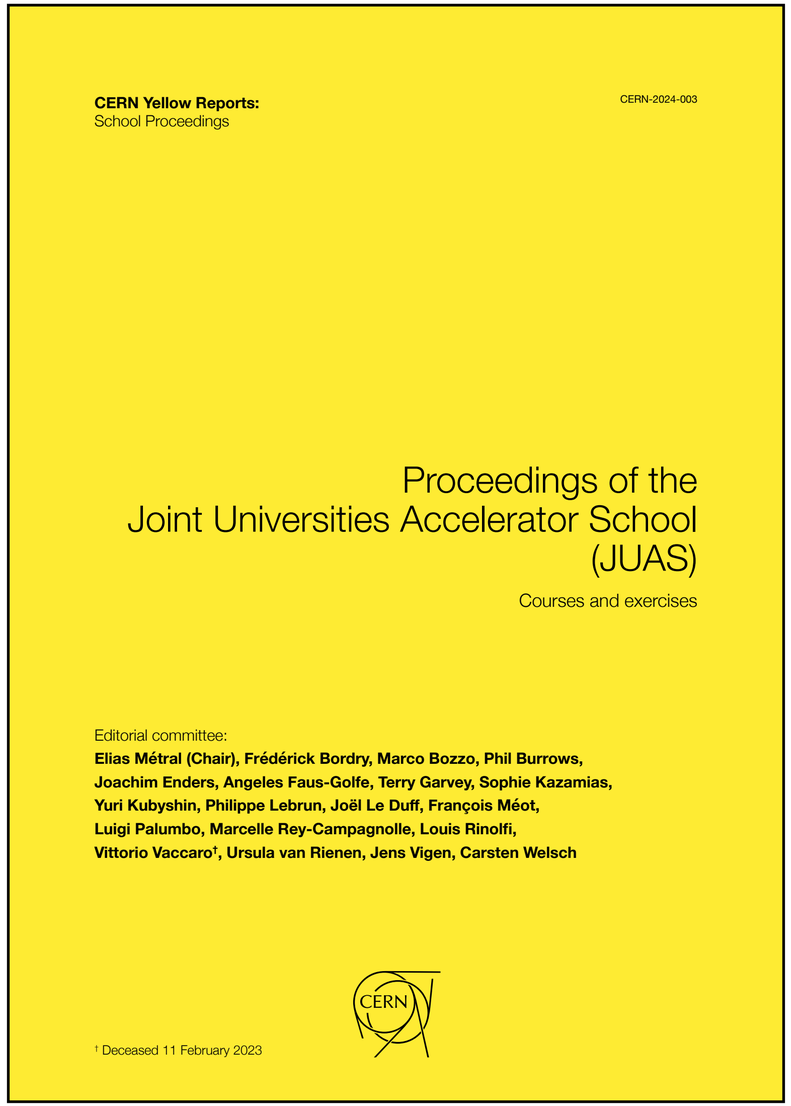

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We have (a lot of) time... but we cannot be late! => Why?

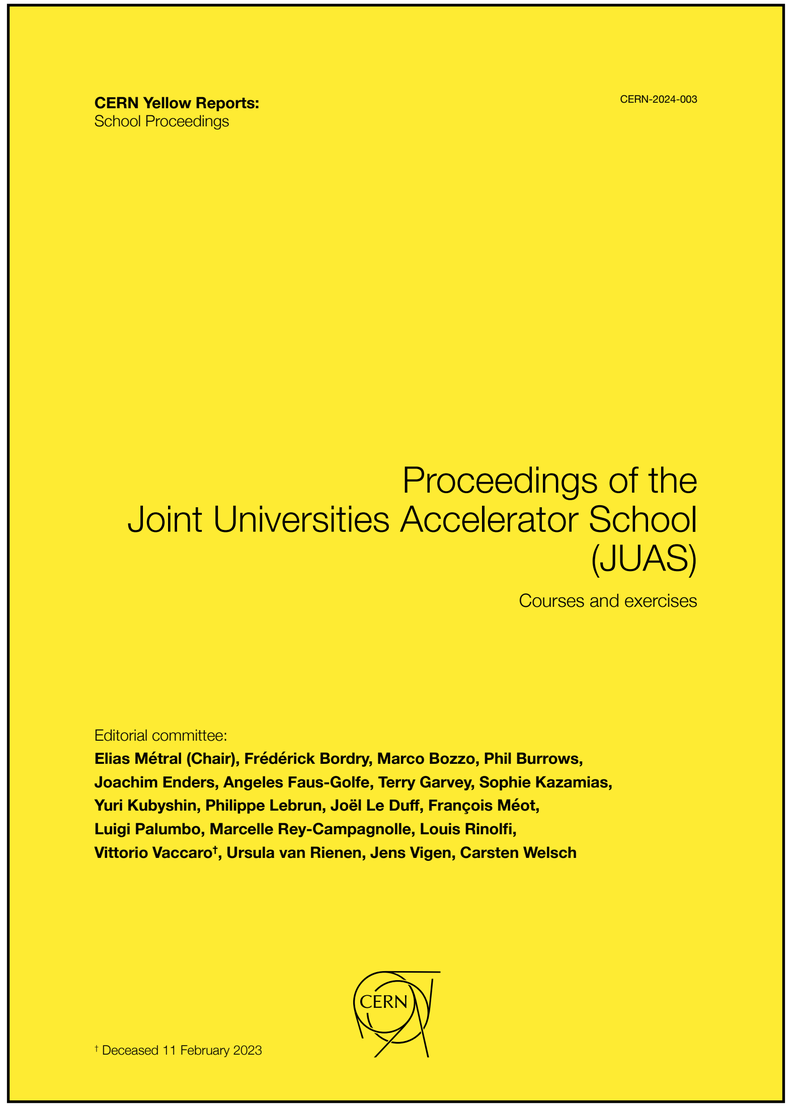
- JUAS started in 1994 and will be 30 years old in 2024
  - ✳ Celebration foreseen end November / beginning December

  - ✳ Need to publish the book before!

Kick-off meeting with Authors

E. Métral, 01/04/2022 3

JUAS-2024 book: from conception to birth



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What a journey!

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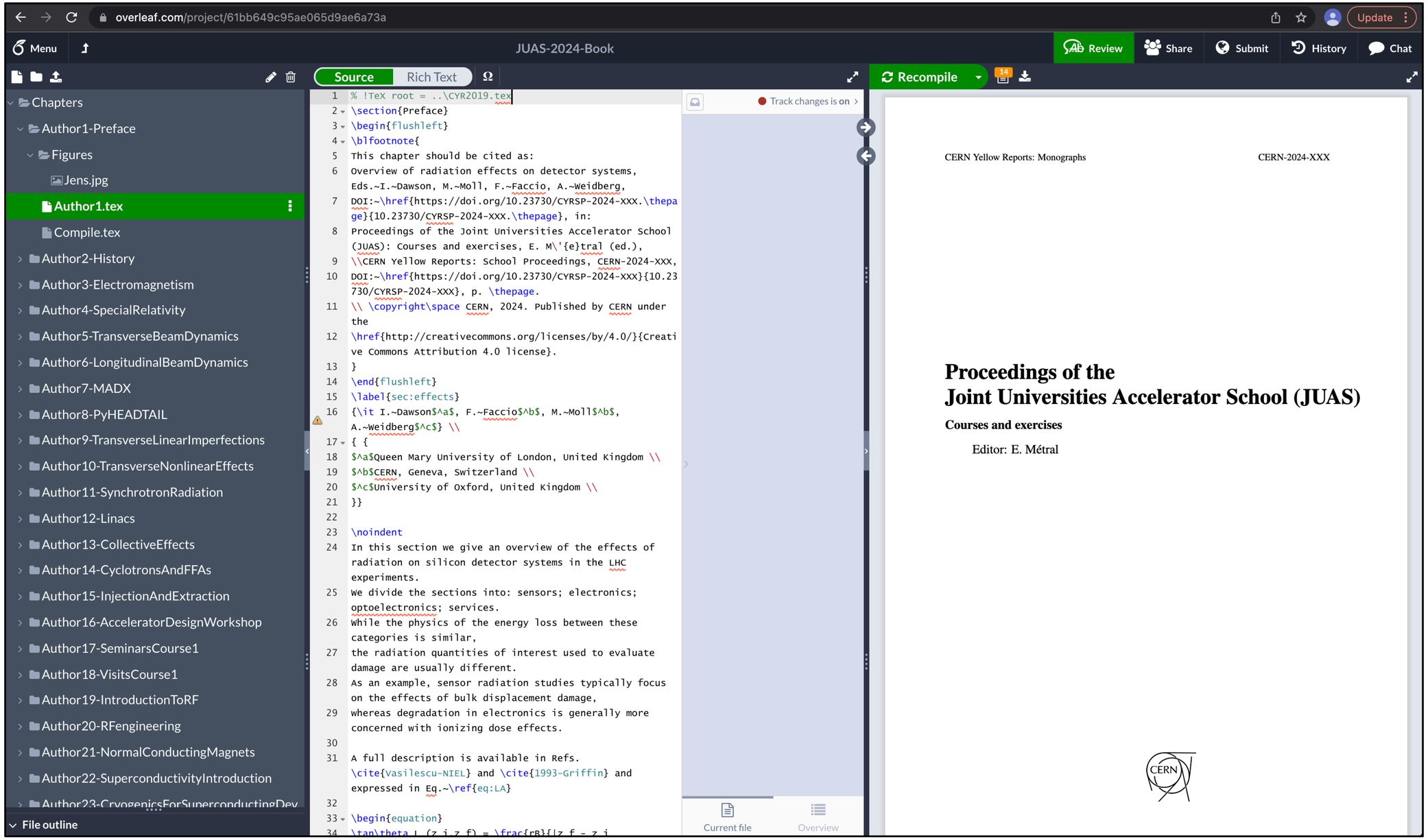
- **16/12/2021: Jens Vigen (CREB publisher)** sent me a first Overleaf template, on which we started to work…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Author5-TransverseBeamDynamics
Author6-LongitudinalBeamDynamics
Author7-MADX
Author8-PyHEADTAIL
Author9-TransverseLinearImperfections
Author10-TransverseNonlinearEffects
Author11-SynchrotronRadiation
Author12-Linacs
Author13-CollectiveEffects
Author14-CyclotronsAndFFAs
Author15-InjectionAndExtraction
Author16-AcceleratorDesignWorkshop
Author17-SeminarsCourse1
Author18-VisitsCourse1
Author19-IntroductionToRF
Author20-RFengineering
Author21-NormalConductingMagnets
Author22-SuperconductivityIntroduction
File outline
% !TeX root = ..\CYR2019.tex
\section{Preface}
\begin{flushleft}
\blfootnote{
This chapter should be cited as:
Overview of radiation effects on detector systems,
Eds.~I.~Dawson, M.~Moll, F.~Faccio, A.~Weidberg,
DOI:~\href{https://doi.org/10.23730/CYRSP-2024-XXX.\thepage}{10.23730/CYRSP-2024-XXX.\thepage}, in:
Proceedings of the Joint Universities Accelerator School (JUAS): Courses and exercises, E. M\'{e}tral (ed.),
\\CERN Yellow Reports: School Proceedings, CERN-2024-XXX,
DOI:~\href{https://doi.org/10.23730/CYRSP-2024-XXX}{10.23730/CYRSP-2024-XXX}, p. \thepage.
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\href{http://creativecommons.org/licenses/by/4.0/}{Creative Commons Attribution 4.0 license}.
}
\end{flushleft}
\label{sec:effects}
{\it I.~Dawson^a, F.~Faccio^b, M.~Moll^b, A.~Weidberg^c} \\
{ {
^{a}Queen Mary University of London, United Kingdom \\
^{b}CERN, Geneva, Switzerland \\
^{c}University of Oxford, United Kingdom \\
}}
\noindent
In this section we give an overview of the effects of radiation on silicon detector systems in the LHC experiments.
We divide the sections into: sensors; electronics; optoelectronics; services.
While the physics of the energy loss between these categories is similar,
the radiation quantities of interest used to evaluate damage are usually different.
As an example, sensor radiation studies typically focus on the effects of bulk displacement damage,
whereas degradation in electronics is generally more concerned with ionizing dose effects.
A full description is available in Refs. \cite{Vasilescu-NIEL} and \cite{1993-Griffin} and expressed in Eq.~\ref{eq:LA}
\begin{equation}
Track changes is on
Current file
Overview
CERN Yellow Reports: Monographs
CERN-2024-XXX
Proceedings of the
Joint Universities Accelerator School (JUAS)
Courses and exercises
Editor: E. Métral
CERN

- **07/02/2022:** kick-off meeting for the **Editorial Board** of the JUAS book
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CERN Yellow Reports: Conference Proceedings

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Vol. 9 (2020): Proceedings of the ICFA mini-Workshop on Mitigation of Coherent Beam Instabilities in Particle Accelerators, Zermatt, Switzerland, 23–27 September 2019

Vol. 9 (2020): Proceedings of the ICFA mini-Workshop on Mitigation of Coherent Beam Instabilities in Particle Accelerators, Zermatt, Switzerland, 23–27 September 2019

Editors: E. Métral, G. Rumolo, T. Pieloni

This ICFA Mini-Workshop on "Mitigation of Coherent Beam Instabilities in Particle Accelerators" (MCBI2019) focused on all the mitigation methods for all the coherent beam instabilities, reviewing in detail the theories (and underlying assumptions), simulations and measurements on one hand, but on the other hand trying to compare the different mitigation methods (e.g. with respect to other effects such as beam lifetime) to provide the simplest and more robust solutions for the day-to-day operation of the machines.

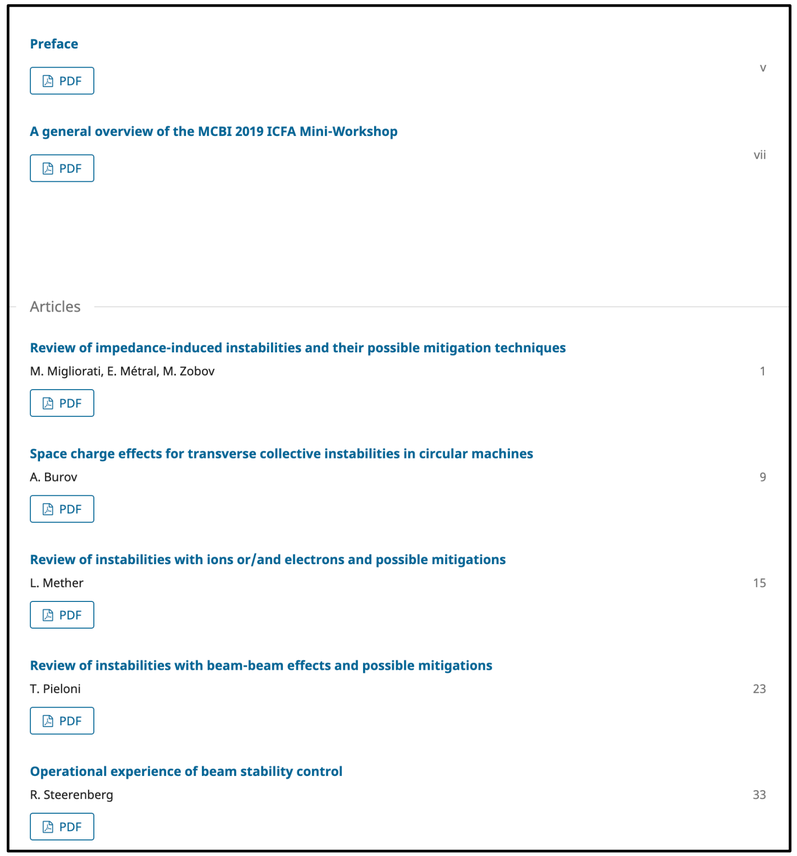
ISBN 978-92-9083-588-2 (paperback), ISBN 978-92-9083-589-9 (PDF)

DOI: https://doi.org/10.23732/CYRCP-2020-009

Published: 2020-12-16

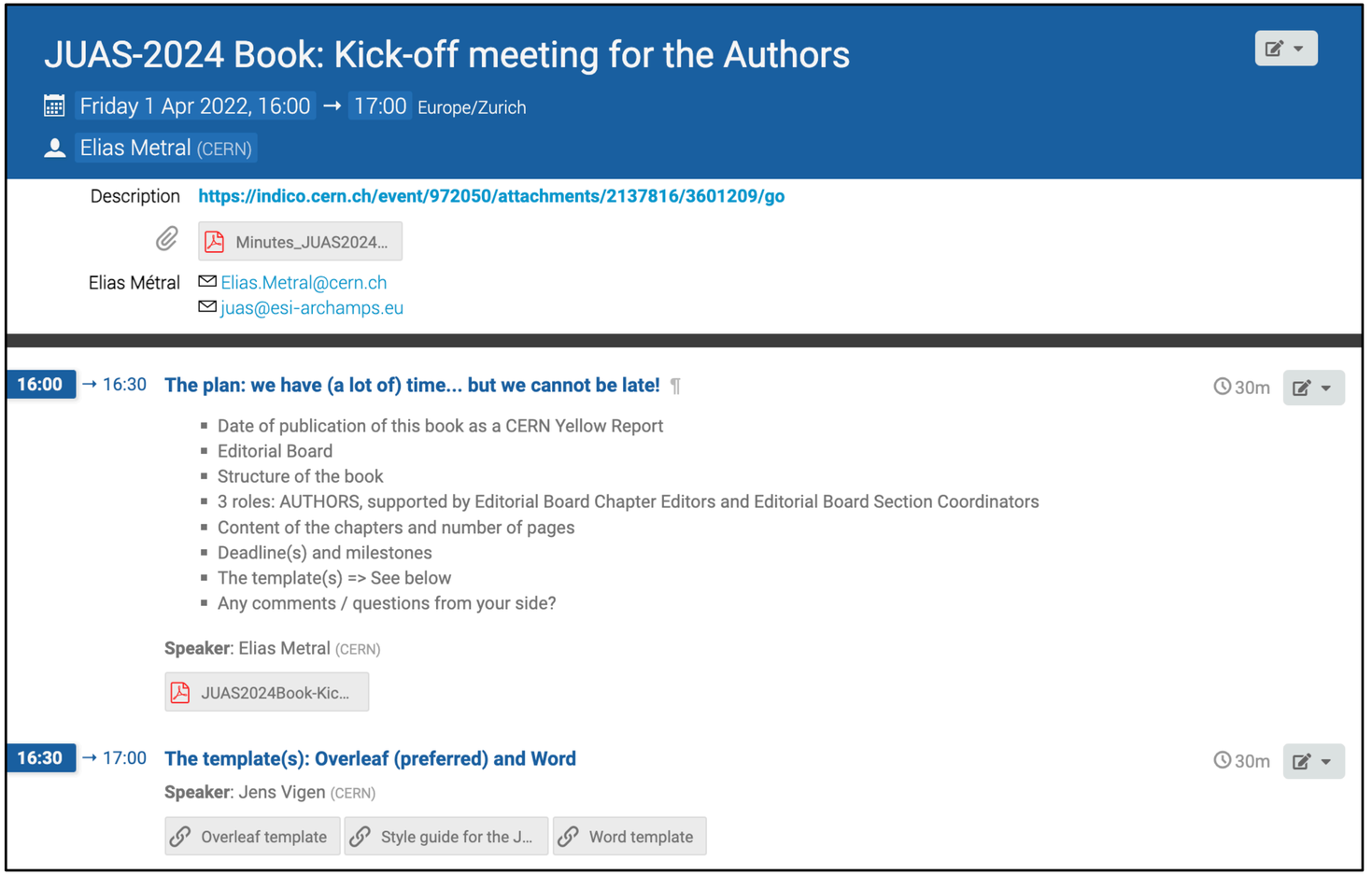
Full Issue

PDF



Articles

- **01/04/2022:** kick-off meeting for the **Authors** of the JUAS-2024 book



JUAS-2024 Book: Kick-off meeting for the Authors

Friday 1 Apr 2022, 16:00 → 17:00 Europe/Zurich

Elias Metral (CERN)

Description https://indico.cern.ch/event/972050/attachments/2137816/3601209/go

Minutes_JUAS2024...

Elias Métral Elias.Metral@cern.ch

juas@esi-archamps.eu

16:00 → 16:30 **The plan: we have (a lot of) time... but we cannot be late!** ¶ 30m

- Date of publication of this book as a CERN Yellow Report
- Editorial Board
- Structure of the book
- 3 roles: AUTHORS, supported by Editorial Board Chapter Editors and Editorial Board Section Coordinators
- Content of the chapters and number of pages
- Deadline(s) and milestones
- The template(s) => See below
- Any comments / questions from your side?

Speaker: Elias Metral (CERN)

JUAS2024Book-Kic...

16:30 → 17:00 **The template(s): Overleaf (preferred) and Word** 30m

Speaker: Jens Vigen (CERN)

Overleaf template | Style guide for the J... | Word template

We have (a lot of) time... but we cannot be late! => Why?

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Publication date
(by Jens Vigen from CERN Library)

15 November 2024

(i.e. in 31.5 months)

3 roles

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- **2nd role**: **Editorial Board Chapter Editor (EBCE)** => To help an AUTHOR of a Chapter
- **3rd role**: **Editorial Board Section Coordinator (EBSC)** => To help the Editorial Board Chapter Editors and AUTHORS of a Section and coordinate the work in a Section

19 members of Editorial Board

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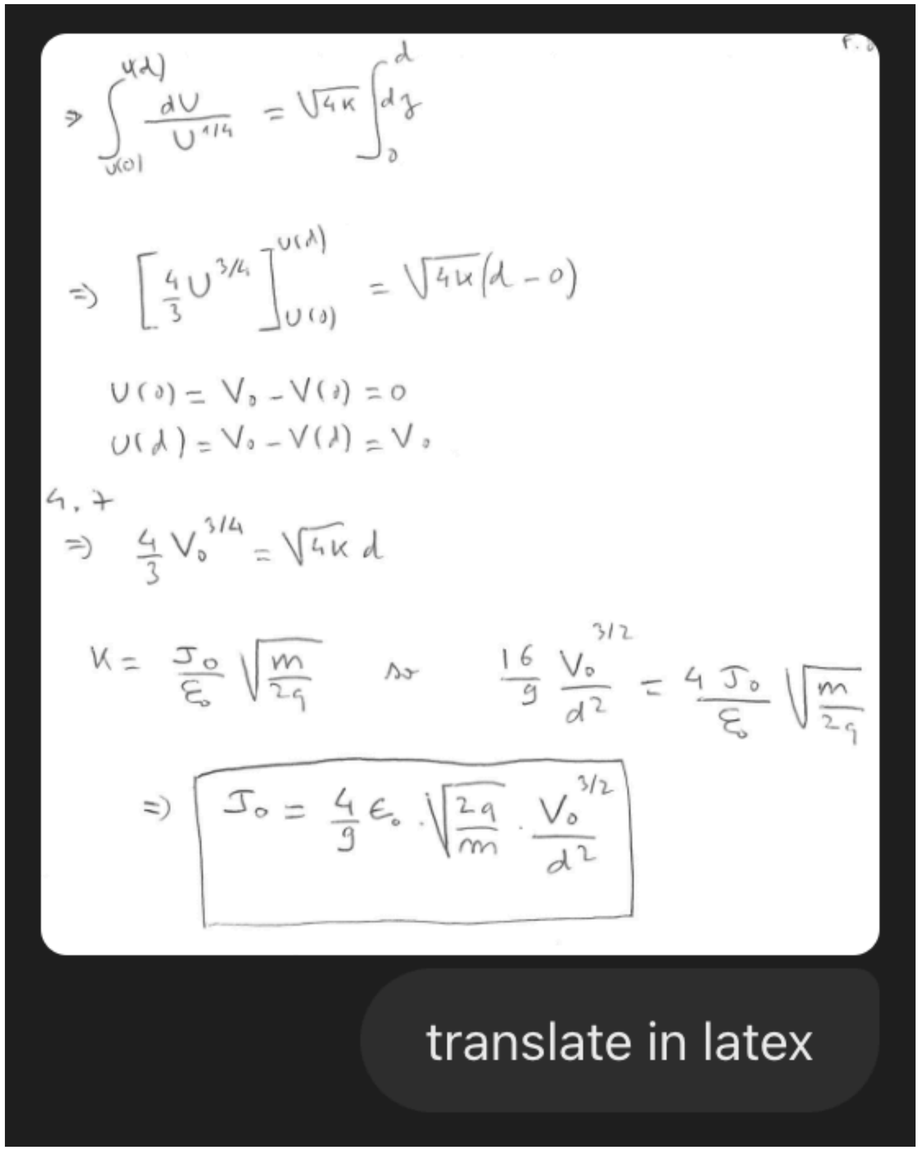
Many thanks for all his work to move several Word papers (with many equations) into Overleaf (without ChatGPT)

Recent use of ChatGPT



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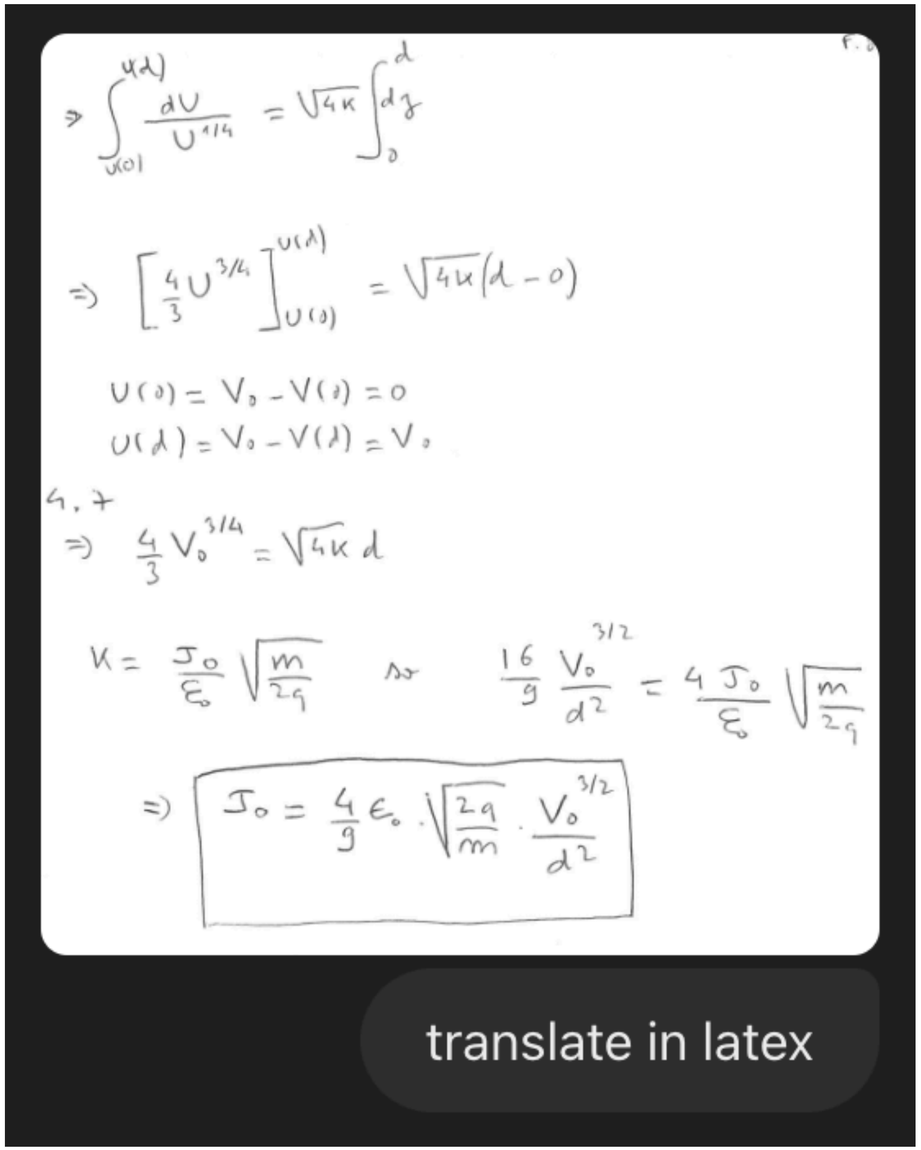


```
\int_{U(0)}^{U(d)} \frac{dU}{U^{1/4}} = \sqrt{4k} \int_{0}^{d} dz \\
\\
\implies \left[ \frac{4}{3} U^{3/4} \right]_{U(0)}^{U(d)} = \sqrt{4k} (d - 0) \\
\\
U(0) = V_0 - V(0) = 0 \\
U(d) = V_0 - V(d) = V_0 \\
\\
4.7 \quad \frac{4}{3} V_0^{3/4} = \sqrt{4k} d \\
\\
k = \frac{J_0}{\epsilon_0} \sqrt{\frac{m}{2q}} \quad \text{so} \quad \frac{16}{9} \frac{V_0^{3/2}}{d^2} = \frac{4 J_0}{\epsilon_0} \sqrt{\frac{m}{2q}} \\
\\
\implies J_0 = \frac{4}{9} \epsilon_0 \sqrt{\frac{2q}{m}} \cdot \frac{V_0^{3/2}}{d^2}
```

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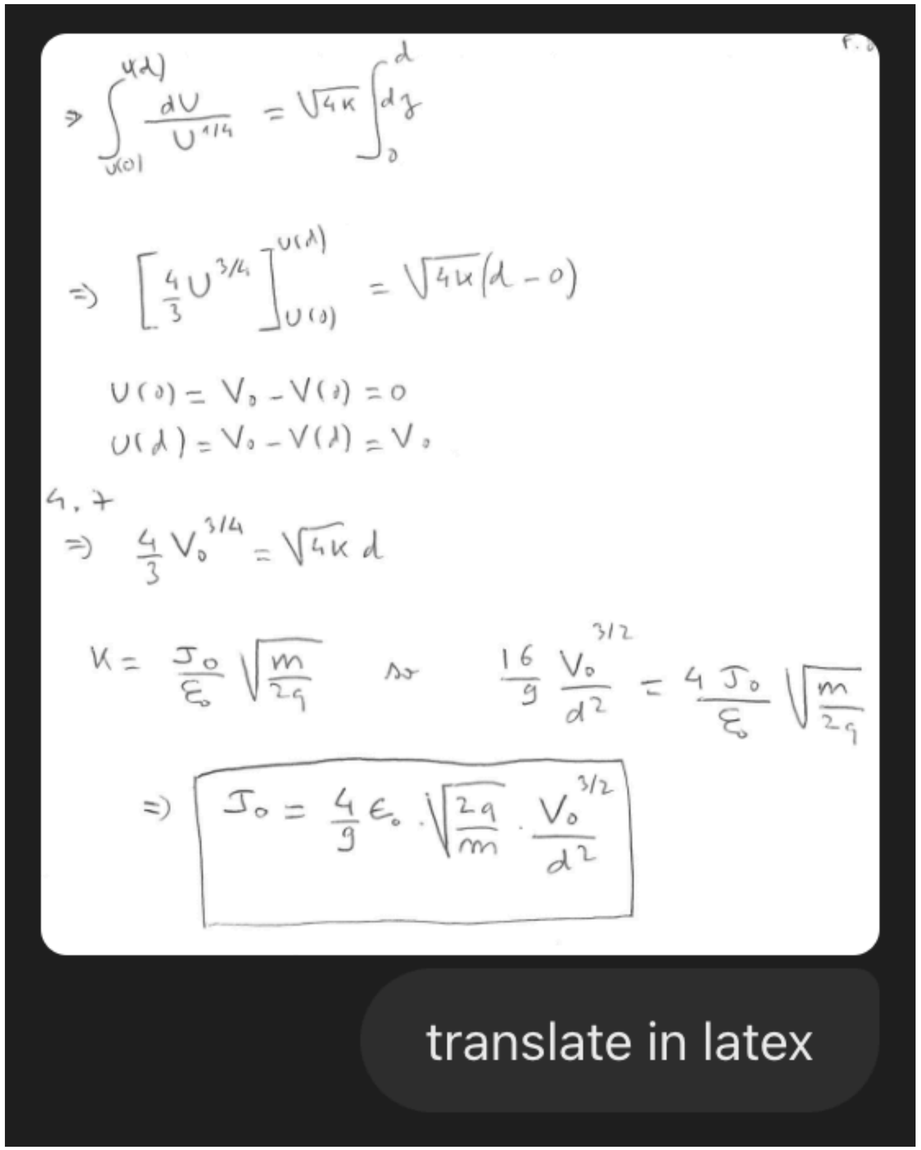

$$\int_{U(0)}^{U(d)} \frac{dU}{U^{1/4}} = \sqrt{4k} \int_0^d dz$$

$$\Longrightarrow \left[\frac{4}{3}U^{3/4}\right]_{U(0)}^{U(d)} = \sqrt{4k}(d-0)$$

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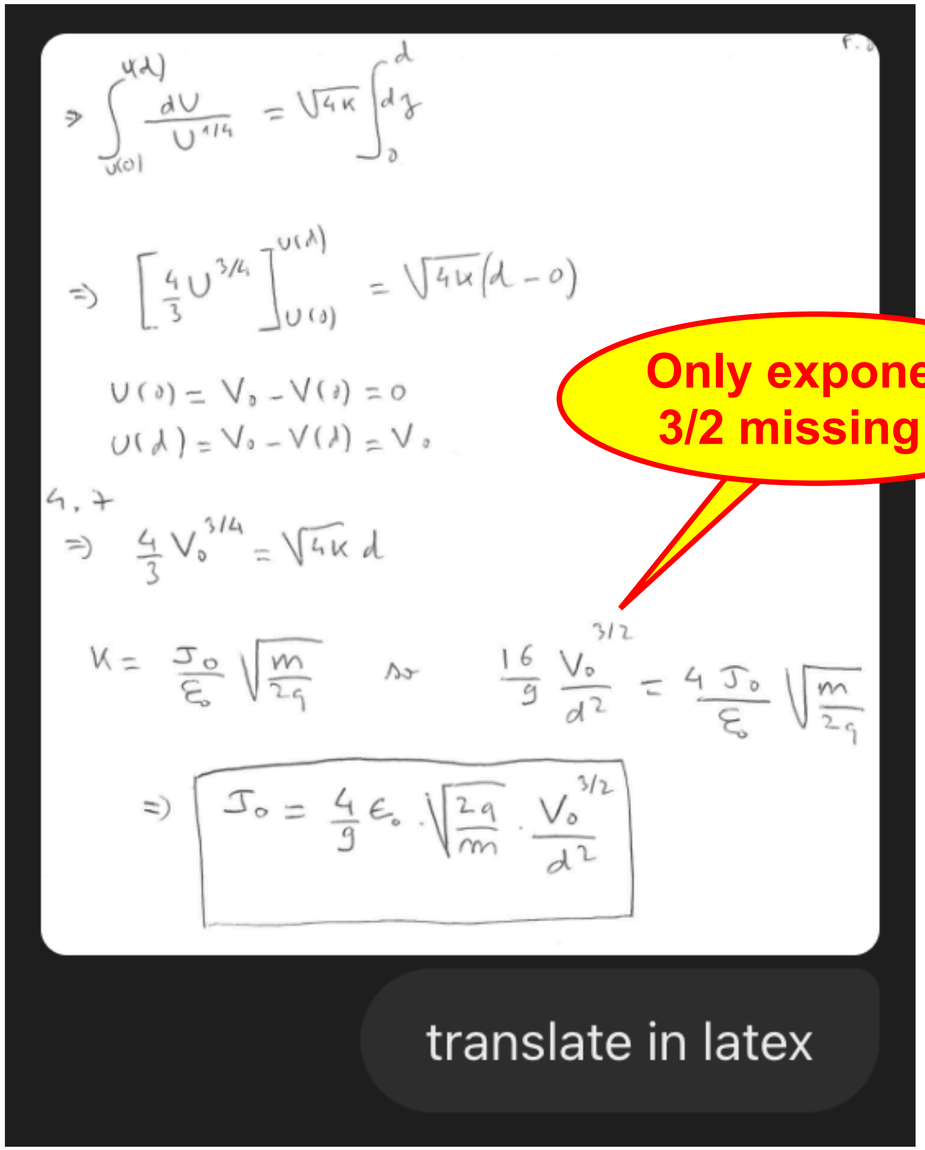

Only exponent 3/2 missing…

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62 authors

- 1) Reyes Alemany Fernández
- 2) David Alesini
- 3) Claire Antoine
- 4) Michaela Arnold
- 5) Vincent Baglin
- 6) Hannes Bartosik
- 7) Nicolò Biancacci
- 8) Luca Bottura
- 9) Frédéric Bouly
- 10) Oliver Brüning
- 11) Sergio Calatroni
- 12) Nicola Carmignani
- 13) Fritz Caspers
- 14) André Durham
- 15) Mamad Eshraqi
- 16) Paolo Ferracin
- 17) Peter Forck
- 18) Nuria Fuster Martínez
- 19) Davide Gamba
- 20) Jean-Christophe Gayde
- 21) Alexander Gerbershagen
- 22) Massimo Giovannozzi
- 23) Edda Gschwendtner
- 24) Bastian Härer
- 25) Heino Henke
- 26) Benedikt Hermann
- 27) Bernhard Holzer
- 28) Rasmus Ischebeck
- 29) Bertrand Jacquot
- 30) John Jowett
- 31) Roberto Kersevan
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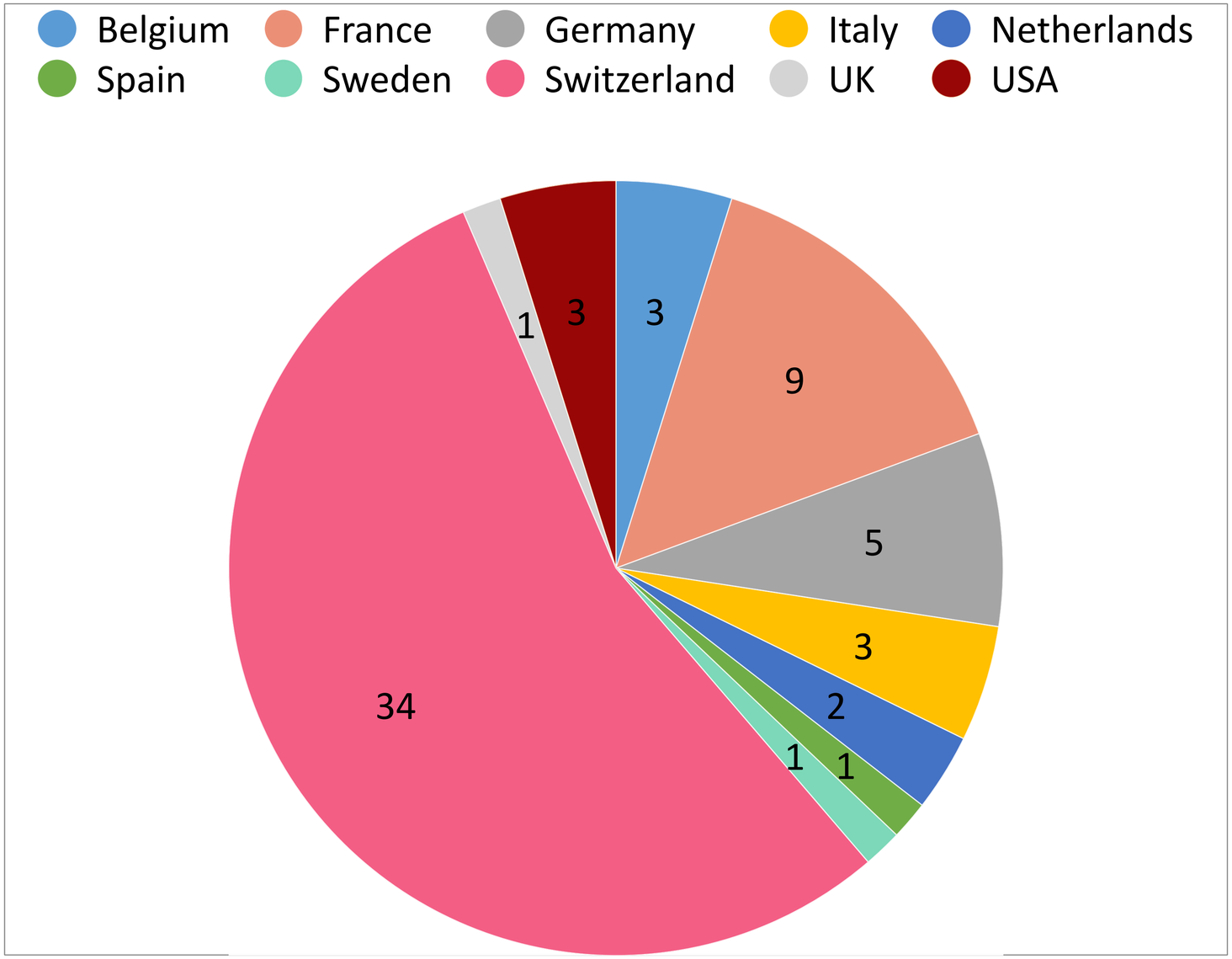
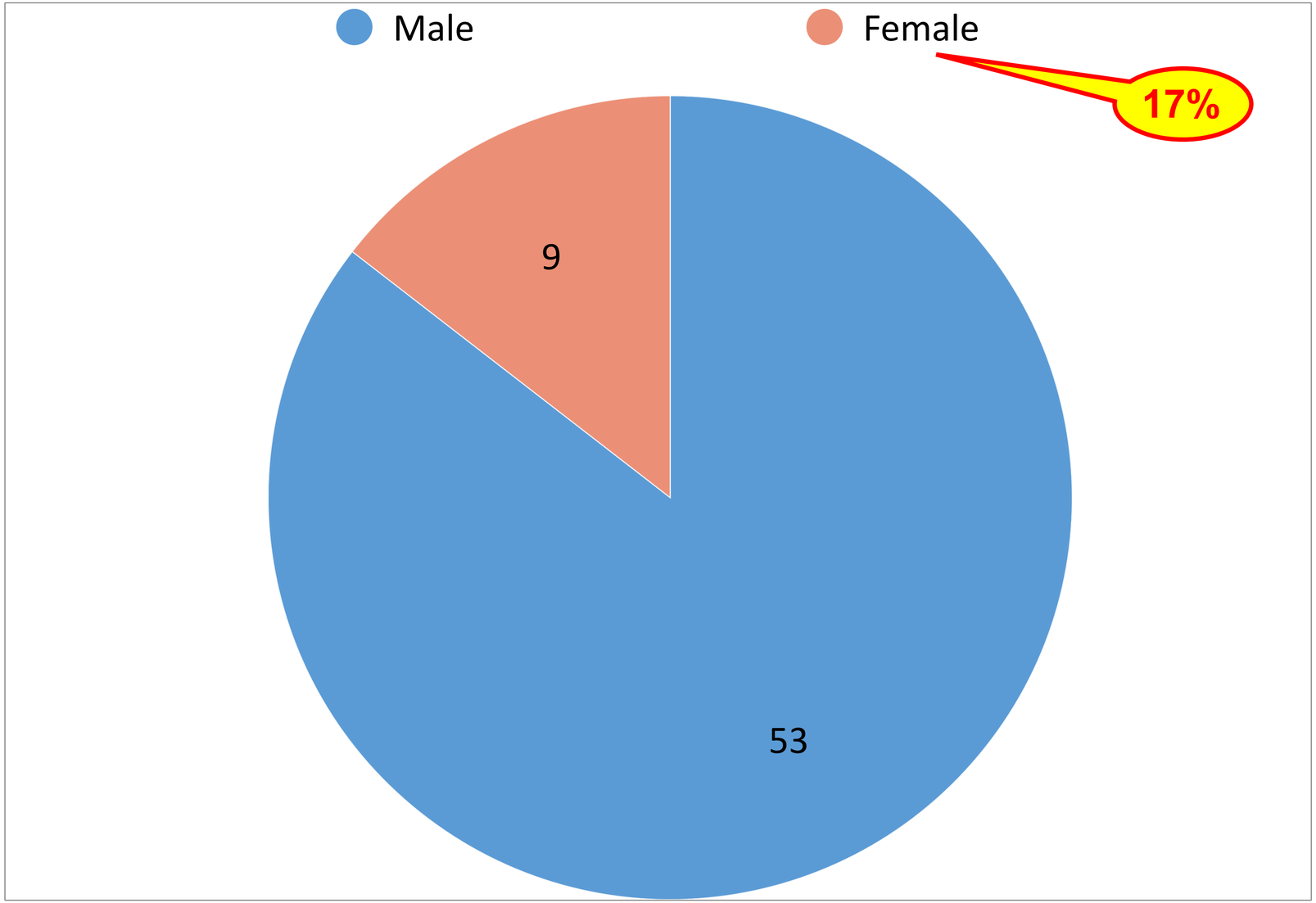
- 50) Benoit Salvant
- 51) Todd Satogata
- 52) Jacobus Maarten Schippers
- 53) Daniel Schulte
- 54) Jochem Snuverink
- 55) Thomas Thuillier
- 56) Erik Van Der Kraaij
- 57) Christine Vollinger
- 58) Maurizio Vretenar
- 59) Manfred Wendt
- 60) Thomas Zickler
- 61) Frank Zimmermann
- 62) Elke Zimoch

62 authors: country distribution



62 authors: gender distribution



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- 1) The manuscript should explain in some detail **WHAT IS TAUGHT AT THE JUAS AND NOT MORE**: in particular, it should not be the occasion to write a book for each Chapter and provide hundreds of references. Ideally, it should be done with a university style, i.e. selecting the most important items and trying to explain them in detail (providing the most relevant references) **=> Main message: less subjects but with more details**

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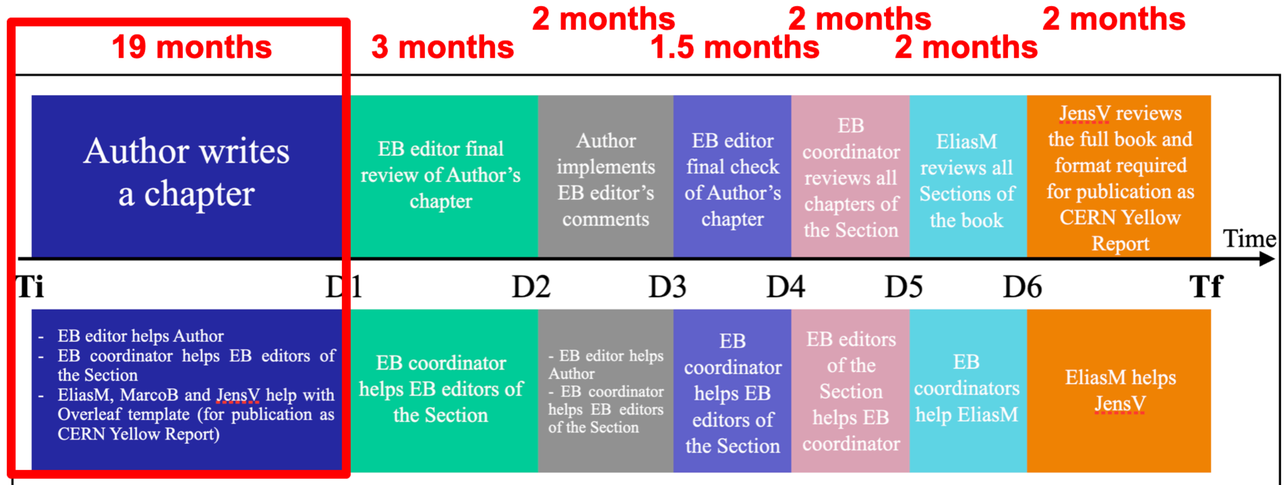
- 5) The Chapter summary (at the beginning of each Chapter) should be ~ half a page (or at least less than 1 page for the longest lectures)

Deadline(s) and milestones



Ti (Tinitial) = March 2022: Invitations sent by EliasM to all authors of chapters — Done

D1: Deadline for Author to finish the chapter and send it (officially) to EB editor — 31/10/2023

D2: Deadline for EB editor for final review of chapter and to send comments to Author — 31/01/2024

D3: Deadline for Author to implement all comments from EB editor — 31/03/2024

D4: Deadline for EB editor for final check and to send chapter to EB coordinator — 15/05/2024

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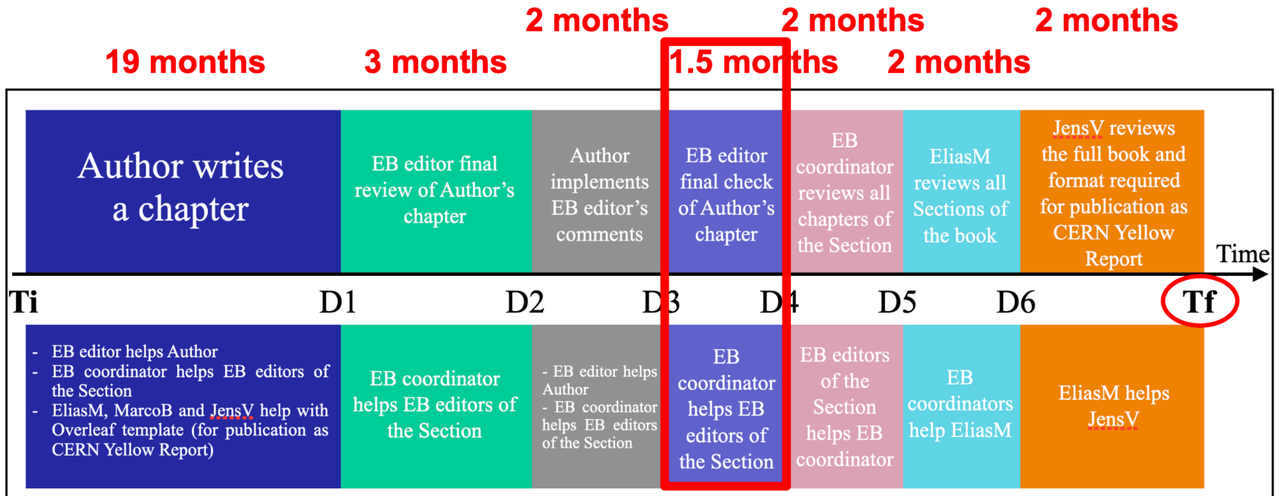
D6: Deadline for EliasM to send all the Sections of the book to JensV — 15/09/2024

Tf (Tfinal) = 15 November 2024: Deadline for JensV to publish the book

=> We started the 1st and most important Phase 1 of 19 months (until 31/10/2023):

Some MILESTONES will be proposed in each Section by the EBSC

Deadlines and milestones



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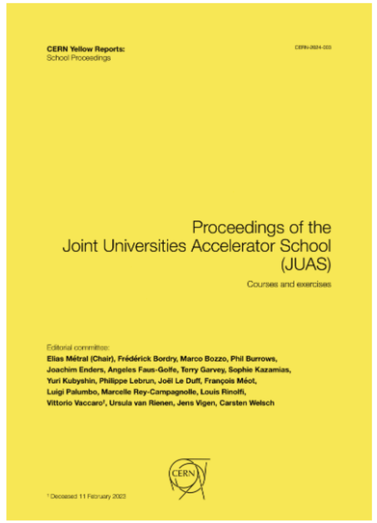
+ Celebration of the 30th anniversary of JUAS and presentation of the JUAS book on 27/11/2024 at the CERN Science Gateway (see **https://indico.cern.ch/event/1372615/**)

Vol. 3 No. I–IV (2024): Proceedings of the Joint Universities Accelerator School (JUAS)—Courses and exercises



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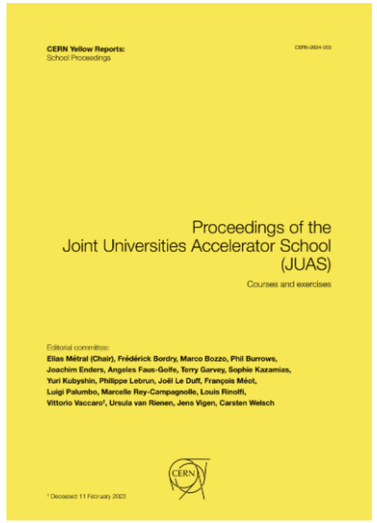

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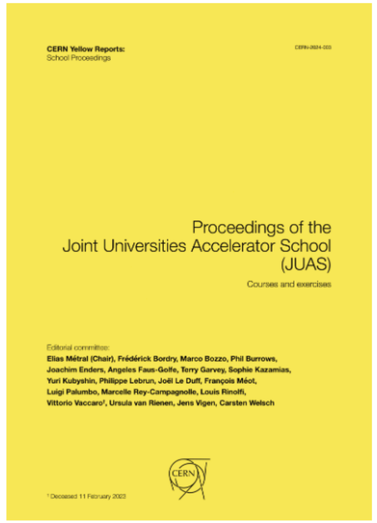

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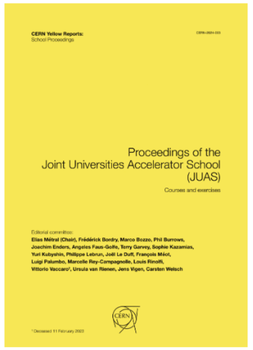

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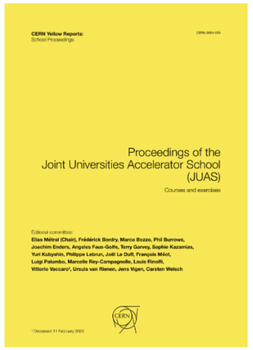

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Preface

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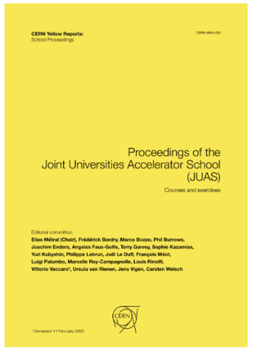

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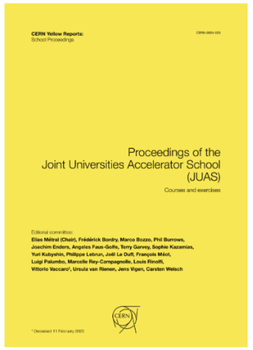

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European Scientific Institute (ESI), Archamps, France
ISN and CNRS, Grenoble, France (retired)

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Readers might study the full book, concentrate on special topics, or just have a glance. In any case, I wish you the same great feeling I got, realising the tremendous development in the field of particle accelerators over the last three decades and its expansion to become a dynamic interdisciplinary research area. I have been dumbfounded when faced with the level of complexity that some of the equipment has reached. I hope its future development finds a path in our new era of energy saving and preservation of the planet. Below, I will give only a short overview of the content of the full volume; the present state of basic knowledge on accelerators is to be found mostly in Parts I and II.

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Part I, covering JUAS Course 1, is dedicated to the science of particle accelerators, i.e. the basic theoretical foundations. As in the subsequent part, many exercises are provided, along with their solutions, to give students a comprehensive understanding of each step. Two chapters outline the fundamentals of electromagnetism and special relativity that are required to understand how these machines work.

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Part IV is an **appendix** to these proceedings, dedicated to the origin and history of this unique school. It shows how its present status results from successive improvements in the syllabus, pedagogy, and organisation due to the ongoing efforts of the JUAS Directors and boards. They follow the ongoing

Part I: 14 chapters (730 p.)

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Part editors: Elias Métral and Joël Le Duff 1

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Each chapter has its own DOI (Digital Object Identifier)

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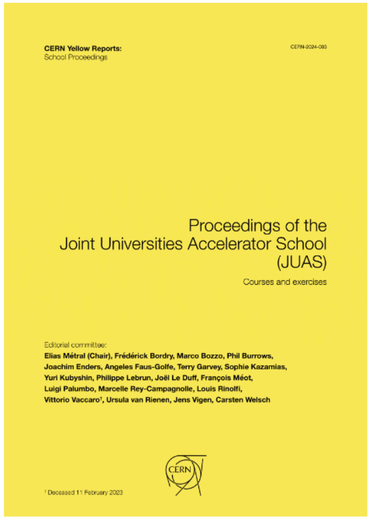
I.1 — Electromagnetism

Heino Henke

DOI: https://doi.org/10.23730/CYRSP-2024-003.3

Abstract

Electromagnetic fields are at the heart of accelerators. They accelerate, focus and guide charged particles and they are responsible for the stability as well as the instability of particle beams. Their range goes from constant fields up to very fast changing fields with frequencies of many GHz. Since electromagnetism is part of the university curriculum, we restrict ourselves to a review of some basics which are important to deal with problems in particle accelerators.



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Part I: 14 chapters (730 p.)

Chapter I.1

Electromagnetism

Example of the first chapter

Heino Henke
Technical University Berlin, Germany

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I.1.1 Introduction

Long ago, electricity and magnetism were well known separate phenomena. The birth of electromagnetism began with the discovery of Oestedt (1820) that an electric current is always associated with a magnetic field. Later on, Faraday (1831) discovered the electromagnetic induction, the creation of electric fields by a changing magnetic field. Electromagnetism was born. Maxwell (1864) extended and completed this work with the four equations, which relate the electric field $\boldsymbol{E}$ and magnetic field $\boldsymbol{H}$, together with the electromagnetic Lorentz force. The four equations are

$$\begin{aligned}
\oint \boldsymbol{H}(\boldsymbol{r},t)\cdot d\boldsymbol{s} &= \iint \boldsymbol{J}(\boldsymbol{r},t)\cdot d\boldsymbol{A} + \frac{d}{dt}\iint \boldsymbol{D}(\boldsymbol{r},t)\cdot d\boldsymbol{A} \quad , \\
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$\boldsymbol{E}, \boldsymbol{H}$ the electric and magnetic fields,

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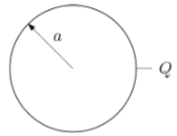
I.1.10 Exercises

I.1.10.1 Exercise 1: Given is a conducting hollow sphere carrying a charge Q. What is the field in- and outside and what is the stored energy? If the sphere were a model for an electron ($E_{0e} = 511$ keV) what is then the classical electron radius $r_e = a$?



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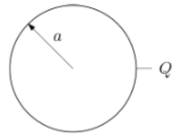

I.1.11.1 Solution to exercise 1

From Eq. (I.1.1) and due to spherical symmetry

$$\oiint_A \boldsymbol{D}\cdot d\boldsymbol{A} = \iiint_V \rho dV = 4\pi\varepsilon_0 r^2 E_r \begin{cases} 0 & r < a \\ Q & r \geq a \end{cases}.$$

Inside the sphere there is no field and no stored energy. Outside the sphere the energy stored in the field is

$$W_e = \frac{1}{2}\iiint_V \boldsymbol{E}\cdot\boldsymbol{D}dV = \frac{1}{2}\left(\frac{Q}{4\pi\varepsilon_0}\right)^2 4\pi\varepsilon_0 \int_a^\infty \frac{dr}{r^2} = \frac{Q^2}{8\pi\varepsilon_0 a}.$$

To find the classical electron radius the stored energy must be equal the electron rest energy

$$\frac{e^2}{8\pi\varepsilon_0 a} = m_{0e}c^2 \rightarrow a = \frac{e^2}{8\pi\varepsilon_0 m_{0e}c^2}.$$

Since there exist several models for an electron with slightly different factors the radius is defined as

$$r_e = \frac{e^2}{4\pi\varepsilon_0 m_{0e}c^2} = 2.81\times10^{-15}\,\text{m}.$$

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Part editors: Elias Métral and Joël Le Duff 1

I.4 — Longitudinal beam dynamics

Alexandre Lasheen

– Can we use the beam in another way than colliding with a target, what is the principle behind light sources?
→ Chapter I.10 on **synchrotron radiation**

– Do charged particles interact with each other, can we accelerate an infinite amount of particles?
→ Chapter I.12 on **collective effects**

– What systems do we use to provide the beam with an electric field, how are they designed?
→ Chapters II.2 on **RF engineering** and II.5 on **superconducting RF cavities**

– How do we measure a bunch profile, specifically in the longitudinal plane?
→ Chapter II.9 on **beam instrumentation**

Moreover, this course is devoted to describing the fundamentals of longitudinal beam dynamics with specifics linked to the design of **synchrotrons**. Dedicated chapters on **linacs** and **cyclotrons** can be found elsewhere in these proceedings (see Chapters I.11 and I.13). Similar concepts are covered in the other courses but possibly with different definitions, conventions, and assumptions to derive formulas.

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Examples of cross-references we implemented with JensV

CERN Yellow Reports: Monographs, CERN-2024-003

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Moreover, this course is devoted to describing the fundamentals of longitudinal beam dynamics with specifics linked to the design of **synchrotrons**. Dedicated chapters on **linacs** and **cyclotrons** can be found elsewhere in these proceedings (see Chapters I.11 and I.13). Similar concepts are covered in the other courses but possibly with different definitions, conventions, and assumptions to derive formulas.

Part I: 14 chapters (730 p.)

Part I — The science of particle accelerators—JUAS Course 1

Part editors: Elias Métral and Joël Le Duff 1

I.4 — Longitudinal beam dynamics

Alexandre Lasheen

Examples of cross-references we implemented with JensV

– Can we use the beam in another way than colliding with a target, what is the principle behind light sources?
→ Chapter I.10 on **synchrotron radiation**

– Do charged particles interact with each other, can we accelerate an infinite amount of particles?
→ Chapter I.12 on **collective effects**

– What systems do we use to provide the beam with an electric field, how are they designed?
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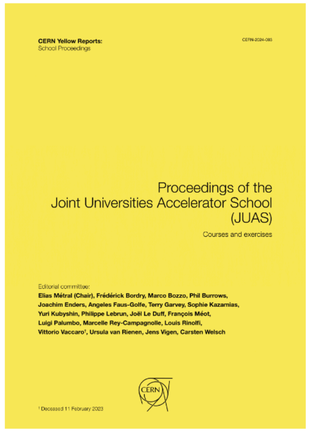
I.10 — Synchrotron radiation

Rasmus Ischebeck

DOI: https://doi.org/10.23730/CYRSP-2024-003.433

Abstract

Electrons circulating in a storage ring emit synchrotron radiation. The spectrum of this powerful radiation spans from the far infrared to the X-rays. Synchrotron radiation has evolved from being a mere byproduct of particle acceleration to a powerful tool leveraged in diverse scientific and engineering fields. Indeed, synchrotrons are the most brilliant X-ray sources on Earth, and they find use in a wide range of fields in research. In this chapter, we will look at the generation of radiation of charged particles in an accelerator, at the influence of this on the beam dynamics, and on the physics behind applications of synchrotron radiation for research.



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Part IV—Appendix: Origin and history of JUAS

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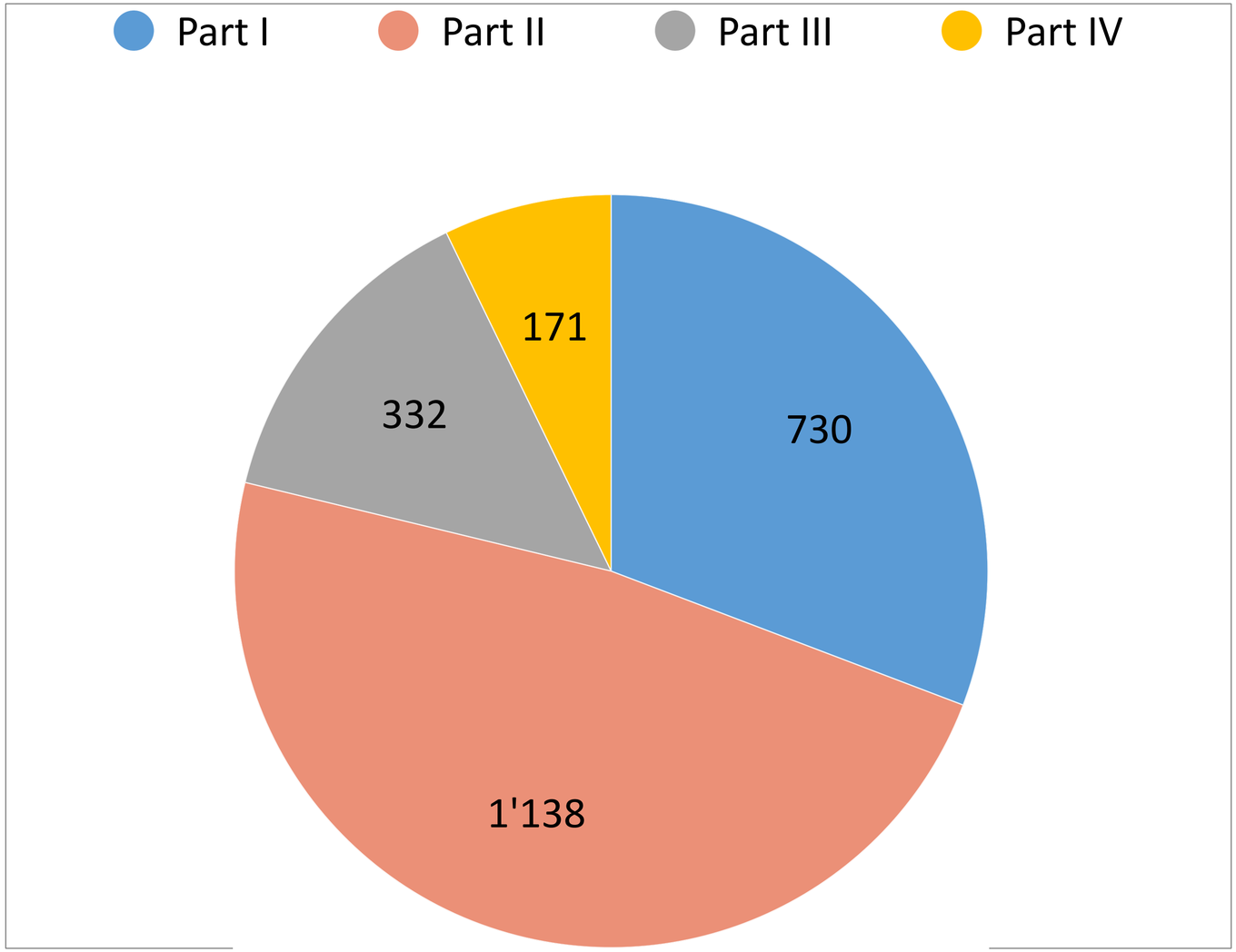

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Subject category	Accelerators and Storage Rings

BUNCHED BEAM COHERENT INSTABILITIES

J.L. Laclare
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ABSTRACT

In this chapter, we will deal with coherent longitudinal and transverse instabilities. It is a collective phenomenon which prevents one from increasing the current circulating in an accelerating device without losing the beam or spoiling its characteristics.

1. INTRODUCTION

The origin of the mechanism is the electromagnetic field created by the beam itself. This self-field is proportional to the beam intensity. Furthermore, like any solution of Maxwell's equations, because of boundary conditions, it depends strongly on the geometry and the electromagnetic properties of the environment. When the intensity gets large enough, it becomes sizeable in the sense that it cannot be neglected anymore when compared to the external guide field.

Dealing with coherent instabilities consists in solving the equation of motion of a population of particles while adding the self-field effect. Obviously, the self field perturbs the single particle motion, but this is not the remarkable effect. The important point is that under certain conditions the beam as a whole is unstable.

In literature, there is a countless list of contributions to the subject. The first to come have been written in the fifties. Nowadays, the subject is still in fashion. Many reports per year are being produced. This shows how difficult and important the subject is.

During these two chapters, I will review the fundamentals of coherent instabilities. In this respect, F. Sacherer's work is certainly the basic source. The main material for this chapter is drawn from the numerous reports he wrote about ten years ago. Numerous developments are derived from B. Zotter and G. Besnier's contributions.

In the following, we will only study bunched beams in circular machines; first longitudinal and then transverse motion.

2. LONGITUDINAL INSTABILITIES

2.1 Single particle longitudinal motion

With respect to the synchronous particle that circulates at the angular revolution frequency

$$\omega_0 = \frac{\beta c}{R} \qquad (1)$$

and crosses the Radio Frequency gap when the RF phase is φ_s, we describe the single particle motion with a pair of conjugate coordinates

$$\tau \quad \text{and} \quad \dot{\tau} = \frac{d\tau}{dt} . \qquad (2)$$

For a fixed observer located at azimuthal position θ around the machine, τ expressed in seconds represents the time interval between the reference particle passing and the test particle passing. The second coordinate

$$\dot{\tau} = \eta \frac{dp}{p_0} = -\frac{d\omega}{\omega_0} \qquad (3)$$

measures the instantaneous momentum deviation of the test particle. The parameter η is negative below the transition energy.

$$\eta = \frac{1}{\gamma_t^2} - \frac{1}{\gamma^2} . \qquad (4)$$

In smooth machines γ_t is of the order of Q_x (horizontal wave number).

We assume a purely linear synchrotron oscillation around the synchronous particle at frequency ω_{s_0}.

=> We hope these JUAS proceedings will also be very useful for the next generation (and all people interested)!

You can now all contribute to this global effort by **sending suggestions for corrections by e-mail** to the address: Elias.Metral@cern.ch => I will collect all of them and we will implement them with JensV either in this book in the coming days or in a 2nd Edition in the future…

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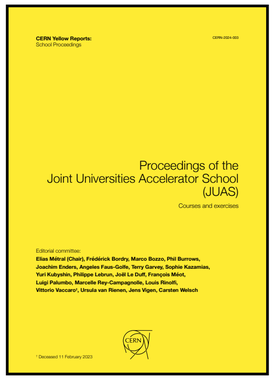

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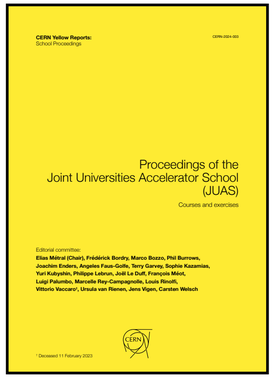

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