Registration open until October 1st

KSETA Topical Courses, October 7 – 18, 2024

Searching for new physics with gravitational waves: let's build an extreme-mass ratio inspiral waveform generator! (deeper) **Particle and Astroparticle Physicists**	**Jens Boos (KIT)**	**07.10.2024** **08.10.2024** **10.10.2024**	**09:00 – 12:15** **09:00 – 12:15** **09:00 – 12:15**	**Bldg. 30.23, room 06/01 (CS)**

Gravitational waves are the emergent medium to probe our understanding of gravity, with increasing relevance in the age of gravitational wave astronomy. Current experiments (LIGO/Virgo/Kagra) are sensitive to gravitational waves stemming from the collision of stellar-mass black holes of roughly comparable masses. While an excellent probe for gravity in the strong-field regime, analytical treatments are extremely difficult to perform and in practice one resorts to numerical relativity. However, future experiments, like the Laser Interferometer Space Antenna (LISA), will be sensitive to the gravitational waves stemming from the collision of small, stellar mass black holes with giant, supermassive black holes. In such "extreme-mass ratio inspirals" (EMRI) it is possible to perform perturbative computations, since the large mass ratio allows one to approximate the small orbiting black hole as a point particle. The goal of this course is to understand how a fundamental model of gravity (say, general relativity) can be used to estimate the shape of the gravitational waves stemming from such an EMRI, using perturbative and largely analytical techniques. To that end, we will develop a simple Mathematica sheet that will generate such a gravitational wave pattern given (to zeroth order, with necessary simplifications in resolution and accuracy). In a second step, we will consider a modified version of gravity, and explore how this qualitatively changes the gravitational wave pattern. If time permits, we will briefly discuss how EMRI gravitational wave patterns will be analyzed in practice when LISA becomes operational in the currently envisioned mid-2030's.

Note: Graduate-level general relativity is helpful, but not required.

Comprehensive Guide to Modern Web Technologies and Personal Webpage Development (better) **all**	**Nicholas Tan Jerome (KIT)**	**08.10.2024** **09.10.2024**	**13:30 – 16:45** **13:30 – 16:45**	**Bldg. 30.23, room 06/01 (CS)**

This course offers an extensive exploration of contemporary web technologies and the development of personal web pages. Divided into two parts, the first section delves into fundamental web technologies, including HTML, JavaScript, and CSS, and progresses to more advanced topics such as building a simple web server using Python, enabling client-server data interaction through Ajax, and introducing popular frameworks like Angular. Hands-on examples and exercises, including deployments using AWS, and visualizations with d3.js and Three.js, are incorporated to solidify understanding. The second part provides a thorough overview of the current hosting landscape and guides readers through setting up personal webpages using platforms like WordPress with AWS Lightsail, Hugo with AWS S3, and Python frameworks with AWS EC2. Additionally, the process of purchasing a domain and connecting it to hosting services via AWS Route 53 is covered, equipping readers with the knowledge to establish and manage their online presence effectively.

Note: Participants are required to have their laptops to follow this course and **they must install Python on their laptops**.

Having an AWS free account is a plus, but not a must.

FPGA programming with hands on (broader) **all**	**Luis Ardila (KIT), Timo Muscheid (KIT) und Lukas Scheller (KIT)**	**09.10.2024** **11.10.2024**	**09:00 – 12:15** **13:30 – 16:45**	**Bldg. 30.10, room 216 (CS) ITIV** **Max. 16 people**

Field-Programmable Gate Arrays (FPGA) are powerful devices that combine the advantages of custom ASICs and the flexibility of microcontrollers. They are able to perform real-time, parallel signal processing and data analysis, while being reconfigurable by describing its functionality using hardware description languages (VHDL, Verilog etc.). One field of application of these devices is the readout of detectors in large scale physics experiment. In this course, we will give an introduction to FPGAs in this specific use-case by learning the underlying technologies and exploring the possibilities and limits of them. Additionally, we will dive into the programming of FPGAs by looking at several hands-on practical examples.

Lattice QCD (broader) **Theoretical Particle Physicists**	**Andreas Jüttner (CERN)**	**10.10.2024** **11.10.2024**	**13:30 – 16:45** **09:00 – 12:15**	**Bldg. 30.23, room 06/01 (CS)**

Lattice Quantum Chromodynamics is playing a central role in the phenomenology of the SM and beyond. By means of numerical simulations, the QCD path integral can be simulated and predictions be made with improving precision and control over systematic errors. Recent examples are the computation of the hadronic vacuum polarisation relevant for resolving the muon-(g-2) puzzle, hadronic matrix elements as input to flavour phenomenology, Standard Model parameters (quark masses and strong coupling constant), hadron spectroscopy and scattering, …

These lectures will start with a detailed discussion of the discretisation of scalar quantum field theory as an example, then proceed with gauge and fermion fields, followed by the discussion of the elements of a full simulation of QCD. The lectures will also cover how hadronic matrix elements are computed including data analysis and involved systematic effects, as well as challenges that need to be addressed next.

Rhetoric in Scientific Presentation (better) **all**	**Sara Rogalski (IMPETUS/Prioriset)**	**14.10.2024** **15.10.2024**	**09:00 – 17:00** **09:00 – 17:00**	**Bldg. 50.19, Seminar room 2 (CS, InformatiKOM)**

Max. 12 people

This workshop is tailored for PhD Students and researchers across disciplines who aim to enhance their ability to convey complex ideas with clarity, impact, and persuasion.

In this workshop, participants will delve into the art of rhetoric, discovering proven techniques to craft compelling narratives and deliver presentations that leave a lasting impression.

The workshop aims to equip participants with advanced rhetorical strategies to enhance the clarity, impact, and persuasive impact of their scientific presentations. Participants will learn to craft compelling narratives, optimize visual and verbal communication, and confidently engage with audiences, fostering effective science communication.

Content:

- Preparing a talk and discussion in English
- Practicing and perfecting public speaking
- Concisely and professionally introducing and promoting oneself
- Involving the audience in one's talk
- Improving body language and non-verbal communication

The participant will learn:

- Necessary skills to successfully and appealingly present scientific papers at conferences, and to be able to confidently defend research results during discussions.

- Exercises to improve; non-verbal communications such as appropriate and fluid body language; the ability to listen and react generously; and to integrate focusing techniques which magnify the power of the speaker.

Novel strategies for high-granularity and radiation hardness LGAD sensors and front-end electronics (broader) **all**	**Michele Caselle (KIT)**	**16.10.2024** **17.10.2024**	**09:00 – 12:15** **09:00 – 12:15**	**Bldg. 11.40, Seminar room 221 (CS, Tulla)**

Low-Gain Avalanche Diodes (LGADs) are emerging as a highly effective solution for 4D-tracking, thanks to their exceptional time resolution and strong resistance to high radiation fluence. These sensors are crucial in applications demanding high temporal precision, such as high-energy physics experiments at CERN's Large Hadron Collider, medical imaging, and advanced scientific instrumentation. A key advantage of LGADs is their ability to produce strong signals while maintaining rapid response times, typically within tens of picoseconds. The primary goal of this lecture is to provide a comprehensive overview of the principles, design, and applications of ultrafast LGAD sensors. The course is structured into three sections:

1. Design of Ultrafast LGAD Sensors

This section delves into the key parameters and strategies for designing ultrafast silicon sensors. Emphasis will be placed on the specialized gain layer that enables high signal amplification and the importance of minimizing material budget, which is critical in applications where space and weight are constraints.

2. Front-End Electronics and Readout Strategies

This section covers the strategies for managing high-speed, low-noise signals while maintaining minimal power consumption, ensuring that the temporal resolution provided by LGAD sensors is preserved. Key components include Charge-Sensitive Amplifiers (CSA), transimpedance amplifiers, and shaper circuits that optimize the signal-to-noise ratio (SNR) and prepare signals for digitization. Additionally, Time-to-Digital Converters (TDCs), which measure the precise time of signal arrival and the time-over-threshold with picosecond accuracy, will be discussed. TDCs are integral to the readout chain, leveraging LGADs' temporal precision, making them essential for applications like particle tracking in collider experiments.

3. Applications and Future Directions

This final section provides an overview of the current applications of LGAD sensors and their associated front-end electronics in high-energy physics and medical imaging. It will also explore future challenges and potential advancements, such as the use of novel semiconductor materials like silicon carbide (SiC) to enhance radiation hardness and overall performance.

Conclusion

Ultrafast LGAD sensors, paired with advanced front-end electronics, represent a significant leap forward in high-speed detection systems, offering unprecedented temporal resolution. These qualities make LGADs indispensable in a wide range of cutting-edge applications. Ongoing research and innovation are expected to further enhance the performance, scalability and cost-effectiveness of LGAD technology and its electronics, broadening their applicability across various fields.

How to Create Better Data Visualizations	**Eamonn Maguire**	**17.10.2024**	**13:30 – 16:45**	**Bldg. 11.40, Seminar room 221**
(better)	**(Oxford University)**	**18.10.2024**	**09:00 – 12:15**	**(CS, Tulla)**
all				

This course aims to equip participants with the skills needed to create effective, informative data visualizations. With a focus on visual storytelling and clear communication, we'll cover techniques for choosing appropriate chart types, designing glyphs, selecting colors, and optimizing layouts. Through hands-on exercises, students will learn how to create visualizations using Python's visualization libraries. We'll also explore best practices for creating effective visual presentations of data for different audiences.

Software Engineering for Physicists	**Pranav Sampathkumar**	**16.10.2024**	**13:30 – 16:45**	**Bldg. 11.40, Seminar room 221**
(better)	**(KIT)**	**18.10.2024**	**13:30 – 16:45**	**(CS, Tulla)**
All				**Max. 20 people**

Knowledge transfer of existing codebases and scripts is essential to scientific endeavours. As scientists create more and more open codebases to share and collaboratively develop, it becomes imperative we learn software engineering fundamentals. It helps our development paradigm align with industry standards, which allows for more maintainable and transferable code. It also reduces onboarding and offboarding time from projects and speeds up scientific development.

In this course, we will present strategies to use well-known tools in a "clean" manner, that are based on current industry standards which can allow for creation of codebases which live well beyond the work times of individual contributors. The topics we cover include:

• Git: How to structure a repository, How to create good commits and have a useful history, How to organize a project on GitHub and other integration with other collaboration tools.

• Strategies in Software Development Life Cycle (SDLC) E.g.: Waterfall model, Continuous Integration, Agile development

• Programming paradigms and styles: Test/Behaviour driven development, Signs to look out for in bad code (code "smells") and how to fix them, rules of thumb for neat code.

• Tools to help have a better programming structure (Formatters, Linters etc.)

• Hands-on Session in some of these principles.

Pre-requisites: Most of this course will be taught with Python as examples so a working knowledge of Python is expected. Basics of Git is also recommended as the course deals only with meta-level strategies and not the basics.