Working Group on Physics, Modern IT and Artificial Intelligence
Arbeitskreis Physik, moderne Informationstechnologie und Künstliche Intelligenz (AKPIK)

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Overview of Sessions

Sessions

AKPIK 1.1–1.9	Tue	16:00–18:15	AKPIKa	**AKPIK I: Data Science & Analytics**
AKPIK 2.1–2.9	Wed	16:00–18:15	AKPIKa	**AKPIK II: Deep Learning**
AKPIK 3	Wed	18:30–19:30	AKPIKa	**Mitgliederversammlung (Annual Meeting)**
AKPIK 4.1–4.9	Thu	16:00–18:15	AKPIKa	**AKPIK III: Simulation & Application**

Annual General Meeting of the Working Group on Physics, Modern IT and Artificial Intelligence

Wed 19:00–20:00 AKPIKa

AKPIK 1: AKPIK I: Data Science & Analytics

Time: Tuesday 16:00–18:15 Location: AKPIKa

AKPIK 1.1 Tue 16:00 AKPIKa

The PUNCH4NFDI consortium with the "Nationale Forschungsdateninfrastruktur" (NFDI) — •Thomas Schörner-Sadenius — DESY, Hamburg, Germany

With the "Nationale Forschungsdateninfrastruktur" (NFDI, national research data infrastructure), a massive effort is undertaken in Germany to provide a coherent research data management and make research data useable according to the FAIR data principles.

PUNCH4NFDI is the consortium of particle, astro- and astroparticle, and hadron&nuclear physics within the NFDI. It aims for a FAIR future of the data management of its community and at harnessing its massive experience particularly in "big data" and "open data" for the benefit of "PUNCH" sciences (Particles, Universe, NuClei and Hadrons) as well as for the entire NFDI.

In this presentation, we will address the needs for FAIR and open data management and the plans of the PUNCH4NFDI consortium to address this needs.

AKPIK 1.2 Tue 16:15 AKPIKa

German-Russian Astroparticle Data Life Cycle Initiative: results and perspectives — •Victoria Tokareva, Andreas Haungs, Donghwa Kang, Frank Polgart, Doris Wochele, and Jürgen Wochele for the GRADLCI-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Germany

Distributed data processing in astroparticle physics experiments is mostly discussed in the context of large experiments (e.g. CTA, IceCube). On the other hand, small and medium-sized experiments often employ specialized historically developed data-processing methods and specific software. This may complicate effective usage of solutions, developed for handling large-scale homogeneous data, and impede collaborations between scientific groups in joint analysis, in particular in the highly relevant field of multimessenger astroparticle physics.

To address such challenges, the international project German-Russian Data Life Cycle Initiative (GRADLCI) was established with its main goal of supporting the processing of data from astroparticle physics experiments throughout the entire data processing cycle, from collection and storage to preparation of data analysis results for publication as well as data archiving and open access.

This talk will outline the results achieved in all major areas of the project, such as: extension of KASCADE Cosmic-ray Data Center (KCDC), development of distributed data aggregation platform and software for multimessenger analysis, publication of scientific data as well as outreach activities.

AKPIK 1.3 Tue 16:30 AKPIKa

Status of Beam-Based Feedback Development for Superconducting Electron Linear Accelerator ELBE — •Andrei Maalberg[1,2], Michael Kuntzsch[1], and Eduard Petlenkov[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [2]Department of Computer Systems, Tallinn University of Technology, 19086 Tallinn, Estonia

The superconducting electron linear accelerator ELBE at Helmholtz-Zentrum Dresden-Rossendorf represents a versatile light source operated in continuous wave mode. As new experiments and beam modes place a higher demand on the beam stability, it becomes critical to investigate new ways of improving the existing beam control schemes. Following this, the current control system is planned to be upgraded by a beam-based feedback, and in this contribution we summarize the work in progress.

In essence, the work status can be outlined as follows. First, a plant model has been developed that demonstrated how RF noise translates into electron beam instabilities. Based on this modelling, an optimal H2 controller has then been designed to reduce the impact of RF noise on electron beam properties. As a last step, the designed controller is currently being transferred into VHDL code to be executed on fast FPGA hardware. The resulting beam-based feedback system will be evaluated at ELBE in dedicated machine development shifts.

AKPIK 1.4 Tue 16:45 AKPIKa

Imaging in space, time and frequency: M87* as movie — Philipp Arras[1,2], Philipp Frank[1], •Jakob Knollmüller[2,1], Reimar Leike[1], Philipp Haim[1], Martin Reinecke[1], and Torsten Ensslin[1] — [1]Max-Planck Institute for Astrophysics — [2]Technical University Munich

The recent observations of the black hole shadow of M87* with Very Long Baseline Interferometry (VLBI) by the Event Horizon Telescope (EHT) open the possibility to investigate the dynamical processes right at the edge of black holes. In this regime, traditional radio-astronomical imaging algorithms are brought to their limits. Compared to regular radio interferometers, VLBI networks have fewer antennas. The resulting sparser sampling of the Fourier sky can only be partly compensated by co-adding observations from different days, as the source changes. Here, we present an imaging algorithm that copes with the data scarcity and the source's temporal evolution, while simultaneously providing uncertainty quantification on all results. Our algorithm views the imaging task as a Bayesian inference problem of a time-varying flux density, exploits the correlation structure between time frames, and reconstructs a whole, 2+1+1 dimensional time-variable and spectral-resolved image at once. (https://arxiv.org/abs/2002.05218)

AKPIK 1.5 Tue 17:00 AKPIKa

Adaptive predictor as trigger mechanism for cosmic rays radio signals corrupted by noise — •Clara Watanabe[1,2,3], Paulo Diniz[2], Joao de Mello Neto[1], and Tim Huege[3,4] — [1]Physics Institute, Federal University of Rio de Janeiro (UFRJ) — [2]Multimedia and Telecommunications Laboratory (SMT), The Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (COPPE), Federal University of Rio de Janeiro (UFRJ) — [3]Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT) — [4]Astrophysical Institute, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium

Adaptive filtering belongs to the realm of learning algorithms, so widely used in our daily life when we hear about machine learning, artificial intelligence, pattern recognition, etc. It is formally defined as a self-designing device with time-varying parameters that are adjusted recursively in accordance with the input data.

The trigger mechanism is known to be a central task in radio detection experiments as it selects among all the voltages traces events that reach the antennas, a cosmic ray induced signal.

In this work, it is presented the efficiency of a trigger mechanism developed using the adaptive predictor filter technique, since its capability is well known in the usage for time series prediction. It is also independent from an external detector, considering only the online temporal series that arrives in the antennas in a simulated data set and noise.

AKPIK 1.6 Tue 17:15 AKPIKa

Classification of respiratory-related RNA virus sequences using Machine Learning — Louis Oberer, •Angel Diaz Carral, and Maria Fyta — Institute for Computational Physics, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

A very simple and efficient approach to analyze and identify respiratory related virus sequences based on Machine Learning is proposed. The method is based on RNA sequence comparison and the open reading frame (ORF). Data from the respiratory related corona viruses are collected and features are extracted based on reoccurring nucleobase tuples in the RNA. These are further used for classification purposes. Well separated clusters for the respiratory related corona viruses were found in the feature space. The relevant features are the natural nucleobase triplets used in protein biosynthesis. Accordingly, our methodology is simply based on counting nucleobase triplets, normalizing the count to the length of the sequence and applying PCA techniques. Our very simple and very efficient approach was also validated by including more RNA sequences from the herpes virus family. We discuss the relevance of this scheme in identifying differences in similar viruses and its impact in bioanalysis.

AKPIK 1.7 Tue 17:30 AKPIKa

FlashCam 2.0 Prototype: New DAQ system with Xilinx Zynq-Devices — •Mario Schütt — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

FlashCam, a FlashADC system, has been developed and built at Max-Planck-Institut für Kernphysik in Heidelberg (MPIK). FlashCam is used in a variety of experimental setups based on different detectors like photo multipliers (PMTs) and germanium ionization detectors. For the germanium detector readout in the LEGEND 1000 experiment, the MPIK wants to develop a new Flash ADC system which is called FlashCam 2.0. The system needs a flexible design because it has to handle different pulses on different times scales like PMT pulses (ns time range) and Ge-detector pulses (mus time range). The latter also requires high precision, i.e. a 16bit resolution. Modern experiments like LEGEND are often based on single or multiple detector arrays. Thus, effective DAQ systems have to be scalable. Ease of usage and cost per channel are further crucial factors.

The talk starts with a recap of the FlashCam characteristics. The second part is a summary of the FlashCam 2.0 Prototype setup and its technical innovations. In the conclusion first application results are shown.

AKPIK 1.8 Tue 17:45 AKPIKa

Interessante digitale Wissenschaftskommunikationsformate (Outreach) — •Marcus Mikorski für die Netzwerk Teilchenwelt-Kollaboration — Institut für Kernphsyik, Frankfurt am Main, Deutschland

Mit Lego das ALICE Experiment virtuell konstruieren, eine Echt oder Fake Wissenschaftsshow als virtuelles Meeting, eine Masterclass digital durchführen... . Solche Formate hätte es wohl ohne die Pandemiesituation so nicht gegeben.

Outreach Methoden sind bisher zum Großteil auf Events, Podien, Zuschauende, die mitmachen oder zumindest mitklatschen und ähnliches angewiesen gewesen. Die Pandemie zwingt zum Umdenken.

Berichte aus der Praxis zu einzelnen Formaten sollen in diesem Vortrag als Anreiz dienen, die eigene Kommunikationsstrategie in der Pandemie, aber eben auch darüber hinaus anzureichern. Die Beispiele stammen aus dem ALICE Forschungsschwerpunkt und der Tätigkeit des Vereins BesserWissen e.V. .

AKPIK 1.9 Tue 18:00 AKPIKa

Minianalyse zum Test des 97.1% Klima-Konsens-Claim — •Philipp Lengsfeld, Adedamola Adedokun, Andreas Glassl und Margarita Grabert — re:look climate gGmbH Berlin

Im Geist der Methodik der Technikfolgenabschätzung haben wir den sogenannten 97.1% Klimaforschungskonsens einer Prüfung unterzogen. Wir postulieren, dass die von Cook et al. (2013) [1] durchgeführte Abstraktanalyse von über 11.000 wissenschaftlichen Publikationen als crowd based science analysis auf Grund falscher Klassifizierung zu nicht belastbaren und irreführenden Ergebnissen geführt hat. Wir schlagen eine neue Klassifzierung der untersuchten Arbeiten vor: Nicht Einteilung basierend auf der Positionierung bezüglich der AGW (anthropogenic global warming)-Hypothese durch die Autoren im Abstrakt, sondern Einteilung der zu Grunde liegenden Daten und Untersuchungen: Für AGW relevant oder nicht, wenn relevant: Wird AGW-Hypothese gestützt, geschwächt oder sind die Ergebnisse uneindeutig.

Diese Hypothese unterziehen wir einem Test ('Minianalyse') durch Analyse zweier Publikationsmonate (2019, 2009) unter Nutzung der von Cook et al. genutzen search strings (EBSCO Datenbank) (ca. 2000 Arbeiten 2019, 800 Arbeiten 2009). Dabei wird klar belegt, dass die Missqualifikationen in beiden Jahrzehnten erheblich sind. Statt über 90% Unterstützung des AGW ist der Anteil der AGW-stützenden relevaten Untersuchungen deutlich unter 10%.

[1] Cook et al. Quantifying the consensus on anthropogenic global warming in the scientific literature, 2013 Environ. Res. Lett. 8 024024

AKPIK 2: AKPIK II: Deep Learning

Time: Wednesday 16:00–18:15 Location: AKPIKa

AKPIK 2.1 Wed 16:00 AKPIKa

Demonstrating learned tree reconstruction with graph neural networks — James Kahn[2], Oskar Taubert[2], •Ilias Tsaklidis[1], Markus Götz[2], Giulio Dujany[3], Tobias Boeckh[1], Florian Bernlochner[1], Pablo Goldenzweig[2], Isabelle Ripp-Baudot[3], Lea Reuter[2], and Arthur Thaller[3] for the Belle II-Collaboration — [1]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn — [2]Karlsruher Institut für Technologie (KIT) — [3]Hubert Curien Multi-disciplinary Institute, Strasbourg (IPHC)

Hierarchical tree data structures are commonly used in a variety of domains to express chronological interactions. Within particle physics, decay trees need to be reconstructed using only information from the final state particles (FSPs) that reach the detector. The FSPs are represented as leaf nodes in a decay tree graph and they are used to reconstruct the intermediate nodes up to the level of the root. Established methods that retrieve the structural information of the tree, often require domain-specific knowledge to narrow down the combinatorial phasespace, mainly due to the combinatorial explosion in scenarios with many FSPs. In this work, inspired by the usage of a tagging algorithm for full event reconstruction in Belle II, we propose a method of encoding the whole tree structure into leaf-node relations, using a Lowest Common Ancestor based matrix representation. We demonstrate this method using an attention-based transformer network as baseline and a Neural Relational Inference graph network.

AKPIK 2.2 Wed 16:15 AKPIKa

Deep Learning Based Analysis Approaches in Radio Interferometry — •Kevin Schmidt, Felix Geyer, Stefan Fröse, and Paul-Simon Blomenkamp — TU Dortmund, Dortmund, Germany

Radio interferometry enables studying our universe at the highest resolutions. The used telescope arrays collect information about the observed sky in Fourier space. Analyzing the measured sample allows the reconstruction of the source images. As the amount of available antennas in a radio interferometer array is limited, the measured Fourier space always remains incomplete. By directly applying the inverse Fourier transformation to the measured data sample, noisy artifacts dominate the reconstructed image.

The `radionets` project aims to reconstruct the incomplete data samples with Deep Learning based analysis approaches. To train Deep Learning models, suitable Monte Carlo data sets with known ground truths are essential. Therefore, a procedure to simulate observations of radio galaxies with radio interferometers is implemented. This talk gives an overview of the developed simulation chain and the general reconstruction idea.

AKPIK 2.3 Wed 16:30 AKPIKa

Deep Learning based Likelihood Reconstruction of IACT Events — •Noah Biederbeck — TU Dortmund

The Cherenkov Telescope Array (CTA) is the next-generation gammaray observatory, currently under construction. Once finished, it will comprise over 100 imaging air Cherenkov telescopes (IACTs) at two sites with the goal of improving over the sensitivity of the current generation by at least an order of magnitude. First prototypes for all telescope variants have achieved first light and are observing.

In this talk a novel approach to event reconstruction for IACT data, based on deep learning, is presented. A generative neural net predicts full camera images from a set of physical event parameters. These predicted images are compared to data using a Poissonian likelihood loss in order to reconstruct the event properties.

First results on single-telescope events will be presented and possible extensions to joint predictions of array events will be outlined.

AKPIK 2.4 Wed 16:45 AKPIKa

Boosting neural network performance through symmetry considerations using surface detector data from the Pierre Auger Observatory — Darko Veberic[1], David Schmidt[1], Markus Roth[1], •Steffen Hahn[1], Ralph Engel[1], and Brian Wundheiler[2] for the Pierre Auger-Collaboration — [1]Karlsruhe Institute of Technology (KIT), IAP, Germany — [2]Universidad Nacional de San Martin (UNSAM), ITEDA, Argentina

man-made accelerators ($\sim 10^{19}$ eV) is the detection and understanding of cosmic rays arriving at Earth. To probe them we rely solely on indirect detection of air showers. The hugest detector in this field of research is the Pierre Auger Observatory. On part of its detection strategy is to gauge the footprint of arriving particles at ground level with an triangular grid of multi-detector stations.

These surface detectors measure complex time signals giving us spatial and time information of the incoming secondary particles. This provides us with an huge amount of interpretable data which might contain hidden and convoluted knowledge not found by physical insights. Hence, exploiting deep neural networks for a data-driven analysis is a adequate way to explore this data even further.

Using symmetry considerations and modifying our input data accordingly, we are able to boost the performance of these networks without changing the networks'architectures or training process giving us basically a free improvement of prediction quality. Additionally, this standardization procedure also maximizes the information density in inputs allowing us to work memory-efficient.

AKPIK 2.5 Wed 17:00 AKPIKa

Belle II pixeldetector cluster analyses using neural network algorithms — •Stephanie Käs, Jens Sören Lange, Katharina Dort, Marvin Peter, Irina Heinz, Johannes Bilk, Peter Lehnhardt, and Johannes Budak — Justus-Liebigig-University

The Belle II DEPFET pixeldetector is operating since 2019, presently with 4 M pixels and trigger rates up to 5 kHz. The pixeldetector has the unique ability to detect exotic highly ionizing particles such as antideuterons or stable tetraquarks which due to their high energy loss do not reach the outer sub-detectors, and thus generate no reconstructable track. In order to identify these highly ionizing particles, multivariate analyses of pixeldetector clusters is performed. The multidimensional input space consists of variables such as single pixel signals, cluster observables, or Zernicke moments.

We present results for cluster classification using different neural network algorithms: multilayer perceptrons, Convolutional networks, Kohonen-type networks (often denoted as self-organizing maps) and Hopfield-type networks (often denoted as associate memories). Data preprocessing by Principal Components analysis and possible implementation on an FPGA for online reconstruction are discussed as well.

AKPIK 2.6 Wed 17:15 AKPIKa

Event reconstruction in JUNO-TAO using Deep Learning — •Vidhya Thara Hariharan — Institute for Experimental Physics, University of Hamburg

The primary goal of JUNO is to resolve the neutrino mass hierarchy using precision spectral measurements of reactor antineutrino oscillations. To achieve this goal a precise knowledge of the unoscillated reactor spectrum is required in order to constrain its fine structure. To account for this, TAO (Taishan Antineutrino Observatory), a ton-level, high energy resolution liquid scintillator detector with a baseline of about 30 m, is set up as a reference detector to JUNO. The 20% increase in the coverage of photosensors, the installation of Silicon Photomultipliers (SiPMs) instead of PMTs, the smaller dimension and the low temperature at -51°C, would enable TAO to achieve a photoelectron yield of 4500 p.e./MeV as compared to 1200 p.e./MeV in JUNO. This would in turn help TAO to achieve an energy resolution of 1.5/E(MeV). The measurement of the reactor antineutrino spectrum with this energy resolution will provide a model-independent reference spectrum for JUNO.

The reconstruction can be performed using several approaches. However previous studies have proved Deep Learning yields competitive reconstruction results. Hence this work aims at demonstrating the general applicability of Graph neural networks (GNNs) to reconstruct vertex and energy and later at studying the directionality.

AKPIK 2.7 Wed 17:30 AKPIKa

Kinematic Analysis of Radio Jets with Deep Learning — •Paul-Simon Blomenkamp and Kevin Schmidt — TU Dortmund, Dortmund, Deutschland

Active galactic nuclei (AGN) are some of the most intensely studied objects in the night sky. Some of these AGNs can accelerate matter in their core to relativistic speeds. These jets are prominent sources in radio astronomy. Analysing the kinematic properties of radio jets can give insight on many physical properties of the host galaxy. Previously this analysis was mostly done by manually tracking Gaussian components of the jets, which by its nature involves some degree of arbitrariness.

This work aims at the automated detection of Gaussian components in radio jets with Deep Learning. This is expected to accelerate and improve on the manual methods. Ideally, the model will be able to independently identify the components and their position in order to perform a kinematic analysis. To achieve these aims a Deep Learning model using Convolutional Neural Networks is to be developed. The current results have been achieved by using object detection models. The used dataset is composed of simulated Gaussian jet components in 640×640 images and is labelled. At the current state, the model is able to confidently identify and locate all the Gaussian components within the image.

AKPIK 2.8 Wed 17:45 AKPIKa

A Neural Network Architecture for Radio Imaging — •Stefan Fröse and Kevin Schmidt — TU Dortmund, Dortmund, Deutschland

In radio astronomy, an array of correlated antennas, called a radio interferometer, is used to produce high resolution images of the sky. The measurements take place in the complex Fourier space due to the pairwise correlation of antennas. Therefore, the amount of information to receive from such an array is restricted by the number of antennas. The missing information in the uv-plane will be reconstructed using a Neural Network. The architecture of this network is similar to the architecture used for the task of superresolution. Superresolution is an approach for upscaling images from a low resolution to a high resolution. This method is transferred to the task of measuring a source in the Fourier space and filling in the missing information. The core of this architecture is a residual approach to the network. This can be written as $y = \mathcal{F}(x) + x$ with the set of measurements x, the set of complete information y and the mapping function $\mathcal{F}(x)$. The task of the network is to learn the underlying mapping function. The neural network is able to learn the correct mapping for simulated radio images and also shows convergence for more complex images with large- and small-scale structures.

AKPIK 2.9 Wed 18:00 AKPIKa

Evaluation of Interferometric Data Reconstructed by Neural Networks — •Felix Geyer and Kevin Schmidt — TU Dortmund, Dortmund, Deutschland

Radio interferometry is used to monitor and observe distant astronomical sources and objects with high resolution. Especially Very Long Baseline Interferometry allows achieving the highest resolutions by combining the data of multiple telescopes. This results in an effective diameter corresponding to the greatest distance between two telescopes. The taken data consists of visibilities, which depend on the baselines between the telescopes. Because the distribution of these baselines is sparse, the sample of visibilities is incomplete. After transforming this sample to spatial space, this so-called "dirty image" is inadequate for physical inference and analyses. Thus, the image undergoes an elongated and mostly manually performed cleaning process in order to remove background artifacts and to restore the original source distribution.

A new and fast approach to reconstruct missing data reasonably is using Neural Networks. In this talk, the results and evaluation methods obtained using the simulations created in the `radionets` framework are presented and discussed. Especially the performance of clean versus noisy input data is examined.

AKPIK 3: Mitgliederversammlung (Annual Meeting)

Time: Wednesday 18:30–19:30 Location: AKPIKa

Mitgliederversammlung (Annual Meeting)

AKPIK 4: AKPIK III: Simulation & Application

Time: Thursday 16:00–18:15 Location: AKPIKa

AKPIK 4.1 Thu 16:00 AKPIKa

Deep Learning for Accelerating High Energy Physics Simulations — •Florian Rehm[1,2], Sofia Vallecorsa[1], Kerstin Borras[2,3], and Dirk Krücker[3] — [1]CERN (Switzerland) — [2]RWTH Aachen University (Germany) — [3]DESY (Germany)

In particle physics the simulation of particles transport through detectors require an enormous amount of computational resources. This motivated the investigation of different, faster approaches, to replace the standard Monte Carlo. We use Generative Adversarial Networks to simulate electromagnetic calorimeter responses and decrease the simulation time by orders of magnitudes while keeping the necessary level of accuracy. The standard approach for generating 3D images uses 3D convolutional layers, however, 3D convolutional networks are demanding in terms of computational resources and memory. We present a novel architecture using 2D convolutional layers for representing the 3D images which reaches a higher accuracy and reduces the computational time by a factor of 3. We further reduce the inference time by quantizing the neural network parameters to a lower precision using the novel Intel low precision optimization tool (iLoT). Performance benchmarks on Intel Xeon processors yield a 1.73x speed-up. Particle simulations follow the rules of quantum field theory. Therefore, it is reasonable to explore the potential of quantum computers for these simulations. However, today's quantum computers are by far not capable to solve such complicated tasks. Hence, the further planned initial investigations employ simplified models to study the performance of quantum computers.

AKPIK 4.2 Thu 16:15 AKPIKa

Fast simulation and validation of the Time of Propagation detector at Belle II — •Isabel Haide[1], James Kahn[1], Alex Hagen[2], Jan Strube[2], Shane Jackson[2], Connor Hainje[2], and Pablo Goldenzweig[1] — [1]Karlsruher Institut für Technologie — [2]Pacific Northwest National Laboratory

The Geant4 based simulation of Cherenkov photons in the time-of-propagation (TOP) detector at the Belle II experiment is currently the largest contributor to the total event simulation time. Replacing conventional simulations with neural network solutions, also called generative models, for a reduced simulation time is being actively researched in most fields of particle physics.

This work investigates the replacement of the current Geant4 based TOP simulation with a generative model. Such generative models have to be validated against the system in place in order to verify when a solution is ready for production use. The goal of this work is to design an evaluation framework that determines the agreement between a neural network and the conventionally simulated output with a target towards generalization for other detectors.

This talk shows the current status of this evaluation framework for generative models for the TOP detector at Belle II. In the context of this framework, a new high dimensional Kolmogorov-Smirnov metric for probability distributions is presented.

AKPIK 4.3 Thu 16:30 AKPIKa

GPU Accelerated IACT/Fluorescence Simulation in Atmosphere — •Dominik Baack for the CORSIKA 8-Collaboration — TU Dortmund, Dortmund, Germany

As several new or upgraded cosmic ray experiments are starting in the very near future, the need for high-quality simulation will increase equally. In addition, the CORSIKA 7 Fortran codebase is being completely rewritten to a "state of the art" C++ simulation framework, this will allow the use of new techniques and modifications that were not possible in previous versions.

One of the biggest runtime consumers in the classic simulation, over 80 percent, is the propagation of optical photons, chernekov and fluorescence, through the atmosphere. With the wider availability of GPUs and other parallel accelerators in computing clusters, the runtime of this specific workload can be reduced significantly. With the application of early cuts optimized by machine learning and specific hardware tailored for parallel execution, such as GPUs, the runtime can be greatly reduced.

AKPIK 4.4 Thu 16:45 AKPIKa

The Julia programming language in Particle Physics — •Tamas Gal for the KM3NeT-Collaboration — University of Erlangen-Nuremberg, Erlangen, Germany — Erlangen Centre for Astroparticle Physics, Erlangen, Germany

There has been a shift of programming languages in the scientific context over the past two decades: Fortran and C/C++ being less and less popular while high-level languages like Python, R and Matlab gaining great attraction. However, they all suffer under the two-language problem, meaning that performance critical code – especially in Python – needs to be implemented in low level languages. Julia is a modern, scientific programming language which provides Python-like syntax and C performance and is designed for parallelism and distributed computation. This talk is a short introduction to the language, shows how Julia is utilised in the KM3NeT detector monitoring and live event reconstruction and features a few packages related to particle physics and scientific workflows in general.

AKPIK 4.5 Thu 17:00 AKPIKa

How normalizing flows generalize the Gaussian distribution — •Thorsten Glüsenkamp — FAU Nürnberg, Erlangen, Germany

Normalizing-flows, flexible continuous probability distributions, are emerging in many machine-learning applications. We discuss how they can be described as generalizations of Multivariate Normal distributions and how this might guide us for the choice of which flow to use.

AKPIK 4.6 Thu 17:15 AKPIKa

Error Mitigation Methods in Quantum Computing — •Tom Weber[1], Matthias Riebisch[1], Kerstin Borras[2], Karl Jansen[2], and Dirk Krücker[2] — [1]University of Hamburg (Germany) — [2]DESY (Germany)

There is a variety of problems or applications in which we expect quantum computers to outperform their classical counterparts in the future. However, as of today quantum devices are prone to high error rates and we therefore need to be able to deal with noise. Due to the relatively small qubit numbers presently available we cannot use full correction procedures, but instead are rather left with minimising the effects of errors on computational results with other techniques, known as quantum error mitigation.

During the execution of a quantum circuit on a quantum device, noise can occur at every stage. The preparation of the initial state, its further manipulation as well as the final measurement are all affected by errors. We present possible ideas to model different types of noise and explain ways to mitigate them. Moreover, we test those ideas in the context of variational quantum eigensolvers, which form a typical algorithm for quantum computers. The different approaches differ in effectiveness, flexibility and computational effort. To make quantum computing usable in the near future, we are working to develop mitigation methods which combine all these benefits.

AKPIK 4.7 Thu 17:30 AKPIKa

Classification of spin qubit detection events with neural networks — •Tom Struck[1], Javed Lindner[1], Arne Hollmann[1], Lars R. Schreiber[1], Floyd Schauer[2], Andreas Schmidbauer[2], and Dominique Bougeard[2] — [1]JARA-Fit Institute for Quantum Information, Forschungszentrum Jülich GmbH and RWTH Aachen University, Aachen, Germany — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg Germany

Fast and accurate detection of a qubit state is essential for quantum information processing, in particular for quantum error correction. Here, we detect the state of a single electron spin, localized in a Si/SiGe quantum dot, in a single shot measurement using a single-electron transistor [1]. We investigate the capability of a neural network to classify the experimental signal traces into spin-up and -down events [2] and compare the network performance to a state-of-the-art Bayesian inference filter, which is theoretically optimal for signals with Gaussian noise. We find that the neural network can outperform the Bayesian filter on experimentally recorded data. The network can be made robust to setup-variations by training with proper synthetic traces.

[1] T. Struck et al., npj Quantum Inf. 6, 40 (2020).
[2] T. Struck et al., arXiv:2012.04686 (2020).

AKPIK 4.8 Thu 17:45 AKPIKa

Deep Continuum Suppression with Predictive Uncertainties

— •Lars Sowa, James Kahn, and Pablo Goldenzeig — Karlsruhe Institute of Technology (KIT)

The Belle II collaboration works on precision measurements using data collected from the SuperKEKB collider. This requires a high purity of signal candidates, therefore it is necessary to suppress $e^+e^- \to \bar{q}q$ $(q = u, d, c, s)$ continuum events effectively. To do so, the Belle II analysis framework uses traditional machine learning methods. In recent years, deep learning techniques have shown to be very powerful, outperforming these traditional methods in many fields of research. While deep learning techniques are promising for continuum suppression, an ongoing problem is that they traditionally don*t provide meaningful uncertainties to their predictions, a key requirement for physics analyses.

Recent work has shown that deep ensemble methods solve this problem by providing a measure of prediction uncertainty making them a promising candidate for use in continuum suppression. This talk presents the current status of a study into deep ensemble continuum suppression with predictive uncertainty estimation for the Belle II experiment. Additionally, a decorrelation mechanism to prevent biasing features of interest is presented.

AKPIK 4.9 Thu 18:00 AKPIKa

Identification of exotic highly ionising particles at the Belle II pixel detector using unsupervised autoencoders — Jens Sören Lange, Stephanie Käs, and •Katharina Dort — Justus Liebig University Giessen, Giessen, Germany

The Belle II experiment at the high luminosity SuperKEKB e+e- collider has started operation in 2018. The present setup features a 1-layer DEPFET pixel detector with 4 M pixels and trigger rates up to 5 kHz, installed in close proximity to the interaction region. It offers the unique opportunity of detecting highly ionising particles such as antideuterons, pions with small transverse momentum < 100 MeV or exotic particle species like magnetic monopoles with a very short track length. Multivariate techniques are attractive tools to cope with the identification of these particles against the high beam background rates. In this contribution, we evaluate the performance of unsupervised autoencoders, in order to discriminate signal from beam background. In particular, we investigate the possibility of performing the training directly on background data, an unbiased approach to (a) avoid theoretical assumptions about the nature of signal and (b) avoid supervised training with Monte-Carlo data.