Karlsruhe Institute of Technology

ETP Monday Meeting

18.03.2024

Markus KLUTE (markus.klute@kit.edu)
Institute of Experimental Particle Physics (ETP)

New Team Members

KSETA Workshop

- Mar. 13-15 in Wildberg

- https://indico.scc.kit.edu/event/3745/overview

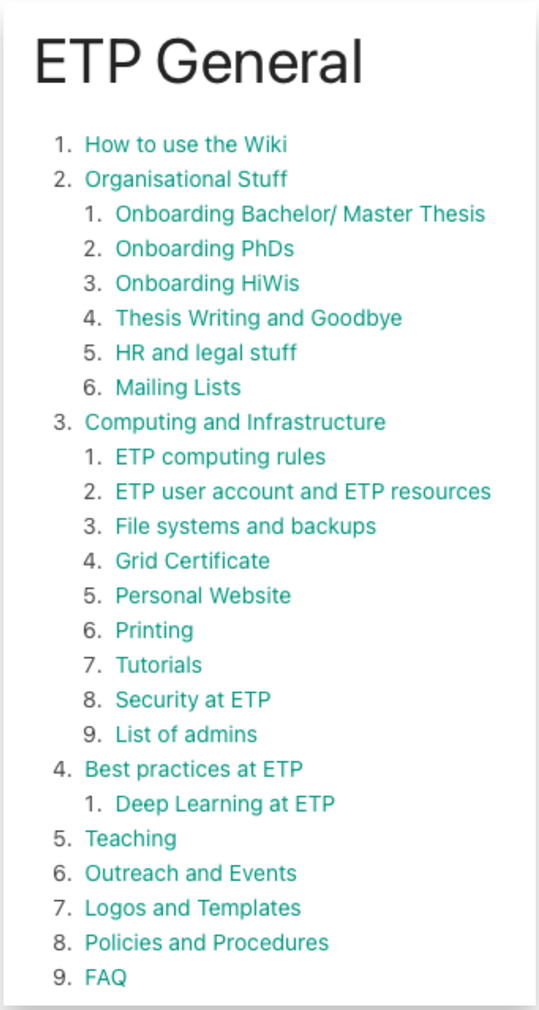
KSETA Workshop

New ETP Wiki

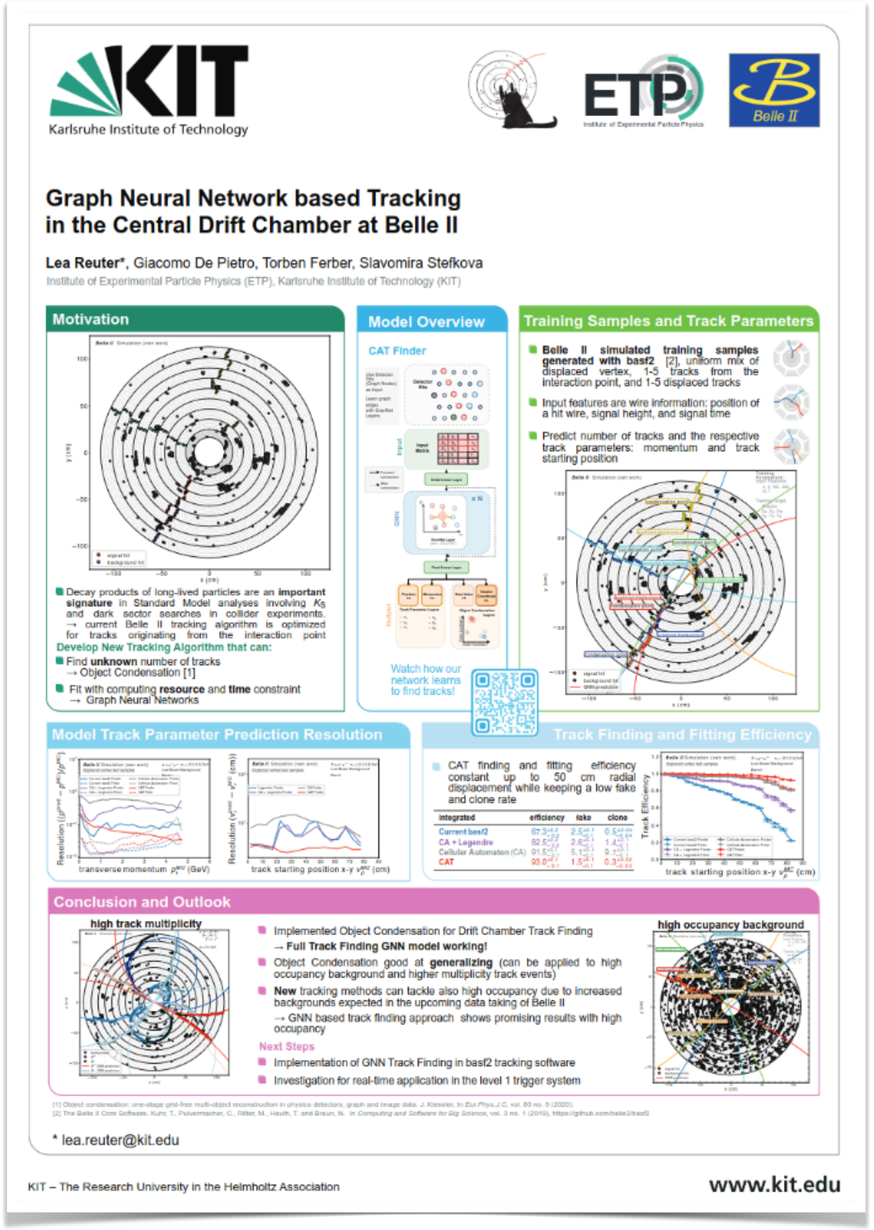
Wiki of the Institute of Experimental Particle Physics

- wiki.etp.kit.edu
- wiki admin: Greta Heine
- to see contents: log in via ETP Gitlab account
- structure
  - **ETP General** (wiki How To, organisational stuff, computing & infrastructure, etc)
  - **Belle II, CMS, DELight** specific pages
  - Admin area

Everyone is responsible for maintenance of the wiki!



KSETA Workshop Poster - Congrats to Lea!



Graph Neural Network based Tracking in the Central Drift Chamber at Belle II

Lea Reuter*, Giacomo De Pietro, Torben Ferber, Slavomira Stefkova
Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Motivation

- Decay products of long-lived particles are an **important signature** in Standard Model analyses involving K_S and dark sector searches in collider experiments.
  → current Belle II tracking algorithm is optimized for tracks originating from the interaction point

Develop New Tracking Algorithm that can:

- Find **unknown** number of tracks
  → Object Condensation [1]
- Fit with computing **resource** and **time** constraint
  → Graph Neural Networks

Model Overview

CAT Finder

Watch how our network learns to find tracks!

Training Samples and Track Parameters

- **Belle II simulated training samples generated with basf2** [2], uniform mix of displaced vertex, 1-5 tracks from the interaction point, and 1-5 displaced tracks
- Input features are wire information: position of a hit wire, signal height, and signal time
- Predict number of tracks and the respective track parameters: momentum and track starting position

Model Track Parameter Prediction Resolution

Track Finding and Fitting Efficiency

- CAT finding and fitting efficiency constant up to 50 cm radial displacement while keeping a low fake and clone rate

integrated	efficiency	fake	clone
Current basf2	87.3	2.5	0.5
CA + Legendre	82.6	2.4	1.4
Cellular Automaton (CA)	91.5	5.1	9.2
CAT	93.0	1.5	0.3

Conclusion and Outlook

high track multiplicity

high occupancy background

- Implemented Object Condensation for Drift Chamber Track Finding
  → **Full Track Finding GNN model working!**
- Object Condensation good at **generalizing** (can be applied to high occupancy background and higher multiplicity track events)
- **New** tracking methods can tackle also high occupancy due to increased backgrounds expected in the upcoming data taking of Belle II
  → GNN based track finding approach shows promising results with high occupancy

Next Steps

- Implementation of GNN Track Finding in basf2 tracking software
- Investigation for real-time application in the level 1 trigger system

[1] Object condensation: one-stage grid-free multi-object reconstruction in physics detectors, graph and image data. J. Kieseler, In Eur.Phys.J.C, vol. 80 no. 9 (2020).
[2] The Belle II Core Software. Kuhr, T., Pulvermacher, C., Ritter, M., Hauth, T. and Braun, N. In Computing and Software for Big Science, vol. 3 no. 1 (2019), https://github.com/belle2/basf2

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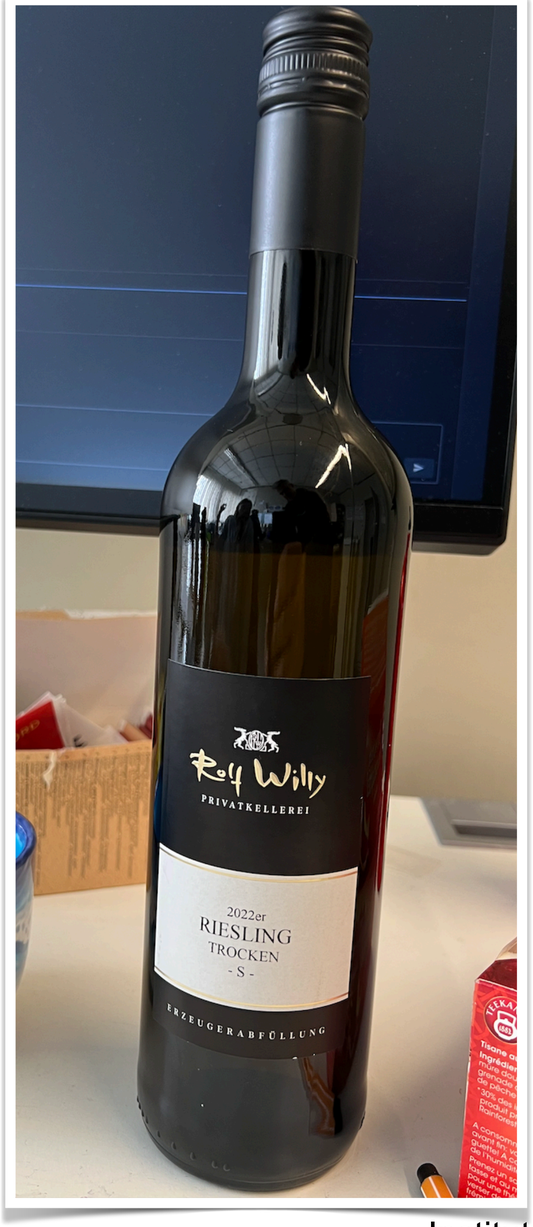


ETP Events in 2024

- Most difficult step in planning events is finding the date.
- Here are (updated) proposals for 2024
  - Summer Party - 04.07.24 (Higgs turns 12!)
  - Summer Hike - week of July 29, 2024
  - Schloss Lichtspiele - 09.08.24
  - Christmas Party - 06.12.24 (Lily turns 12!)

Other events

- FCC community event May 22-24 in Bonn

Other events

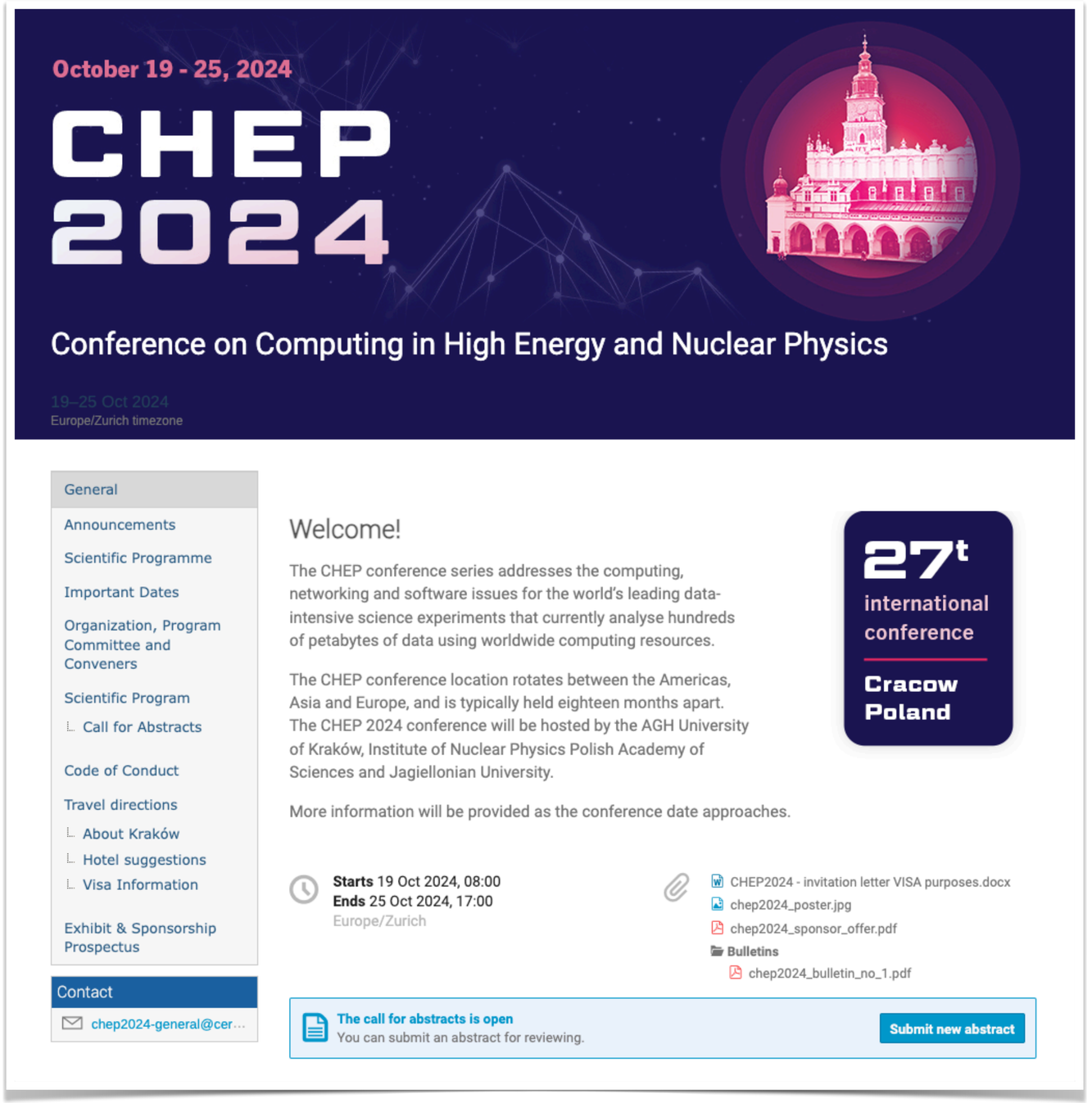
55. Herbstschule of High-Energy Physics 2024 (formerly Maria Laach)

		Mon	Tue	Wed	Thu	Fri	Sat	Sun
				4/9	5/9	6/9		
Week 1	7h30	Breakfast						
	09h00-09h55			SM - Melnikov	LHC - Kado	DM - Kahlhöfer	LHC - Kado	
	10h10-11h05			DM - Kahlhöfer	SM - Melnikov	LHC - Kado	SM - Melnikov	
	11h20-12h15			LHC - Kado	DM - Kahlhöfer	SM - Melnikov	Excerise	
	12h30	Lunch						
	14h30-16h00		Arrival	Excerise	Excerise	Excerise	Excursion	Hike
	16h30-18h00			Excerise	Groups	Groups		
	18h30	Dinner						
	20h00		Welcome - Lecture		Lecture			

		Mon	Tue	Wed	Thu	Fri	Sat	Sun
		9/9	10/9	11/9	12/9	13/9		
Week 2	7h30	Breakfast						
	09h00-09h55	Quantum - Funcke	BSM - McCollough	Quantum - Funcke	QCD - Uwer	Quantum - Funcke		
	10h10-11h05	BSM - McCollough	QCD - Uwer	BSM - McCollough	BSM - McCollough	Flavour - Gersabeck		
	11h20-12h15	QCD - Uwer	Flavour - Gersabeck	QCD - Uwer	Flavour - Gersabeck	Closeout		
	12h30	Lunch						
	14h30-16h00	Excerise	Free	Excerise	Groups	Departure		
	16h30-18h00	Groups		Groups	Groups			
	18h30	Dinner						
	20h00	Lecture			Lecture			

Other events

- CHEP 2024
  - Abstracts by May 10
  - In CMS, April 2



ArXiv - Recent

- Lars Sowa