TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Physik Institut für Kern- und Teilchenphysik

Laborpraktikum
Nuclear and Particle Physics

INSTITUT FÜR
KERN- UND
TEILCHENPHYSIK

Summer semester 2023

https://tu-dresden.de/mn/physik/iktp/studium/praktikum/laborpraktikum

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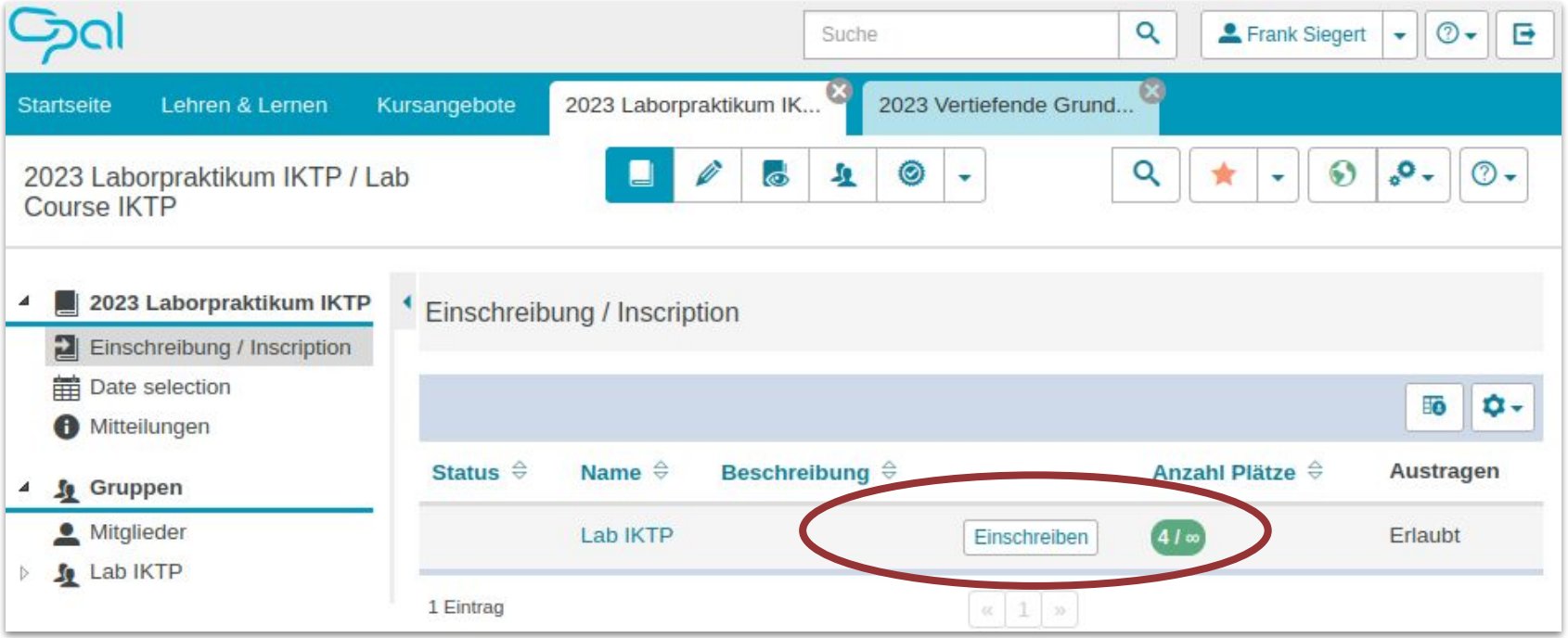
Organisation

- In the Master's degree in physics, the Laborpraktikum is a compulsory requirement in the specialisation area "Particle and Nuclear Physics → **HISQIS-Anmeldung (160005)**!
- Selection from:
  - 8 experimental tasks (typically 2 half days or 1 full day)
  - 4 QFT tasks (4 half days)

  Requirement: **4 full working days** in total
- Date: typically Thursdays, starting times from tutor
  - You need to contact the tutor **at least 1 week in advance**!
  - Submit your reports **2 weeks after the lab**!
- There will be a compulsory briefing on **radiation protection** at the end today.

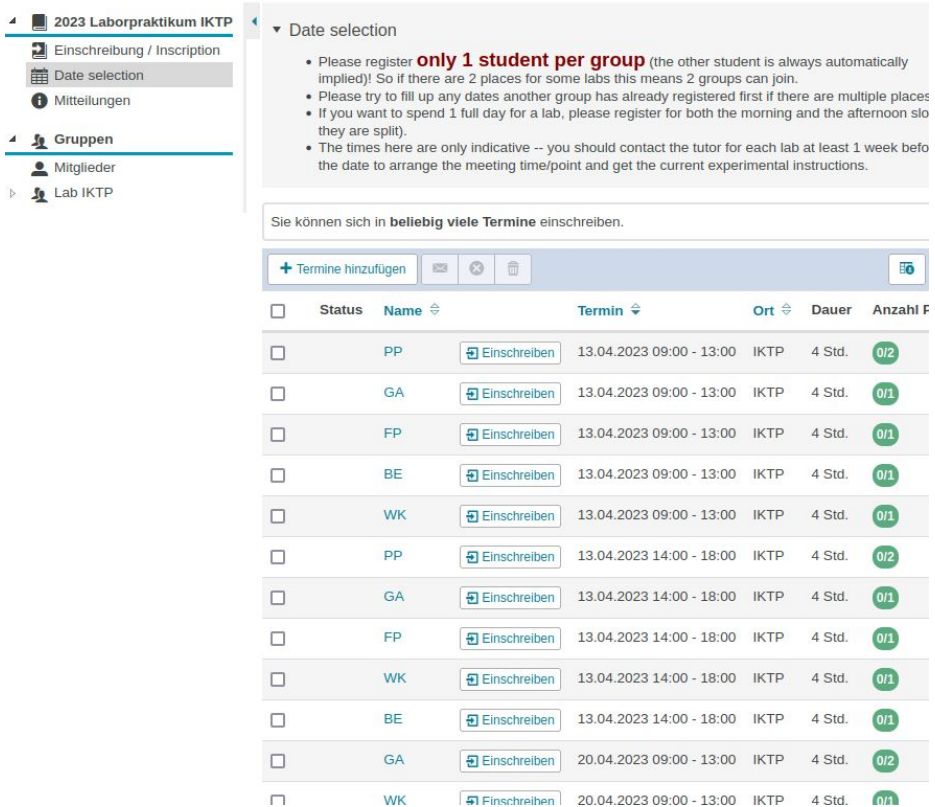
Organisation

- Subscribe in OPAL
  - Later → Date selection



Organisation

Max Stange	ASB E20	Tel. 34129	max_vincent.stange@tu-dresden.de	ML
Manuel Gutsche	ASB 429	Tel. 42369	manuel.gutsche@mailbox.tu-dresden.de	PP
Johann Voigt	ASB K09	Tel. 37666	johann_christoph.voigt@mailbox.tu-dresden.de	FP
Yingjie Chu	ASB E10	Tel. 33905	yingjie.chu@tu-dresden.de	GA
Dirk Döhler	ASB 410	Tel. 32487	dieter_dirk.doehler@mailbox.tu-dresden.de	WK
Dirk Döhler	ASB 410	Tel. 32487	dieter_dirk.doehler@mailbox.tu-dresden.de	PE
Katja Roemer	HZDR	Tel. ?	k.roemer@hzdr.de	SD
Georg Rugel, Janis Wolf	HZDR	Tel. *0351 260 -3296 bzw. -2282*	g.rugel@hzdr.de, j.wolf@hzdr.de	BM
Dominik Stöckinger	ASB E13	Tel. 42248	Dominik.Stoeckinger{at}tu-dresden.de	QFT



BK: Analyse von Blasenkammeraufnahmen

- Auswertung historischer Blasenkammeraufnahmen
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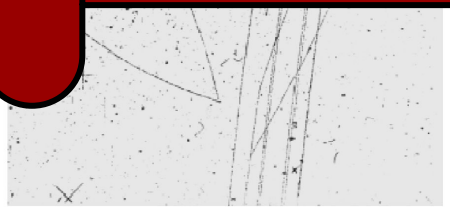
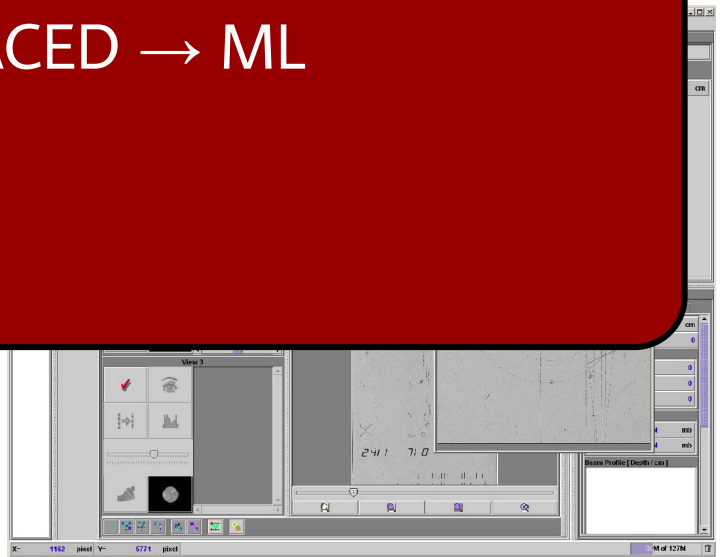
REPLACED → ML

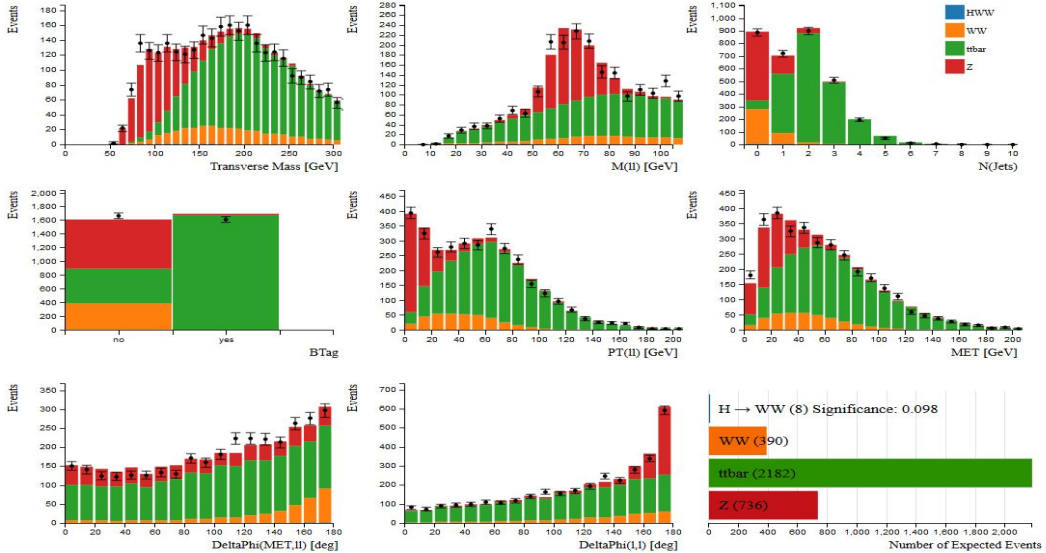


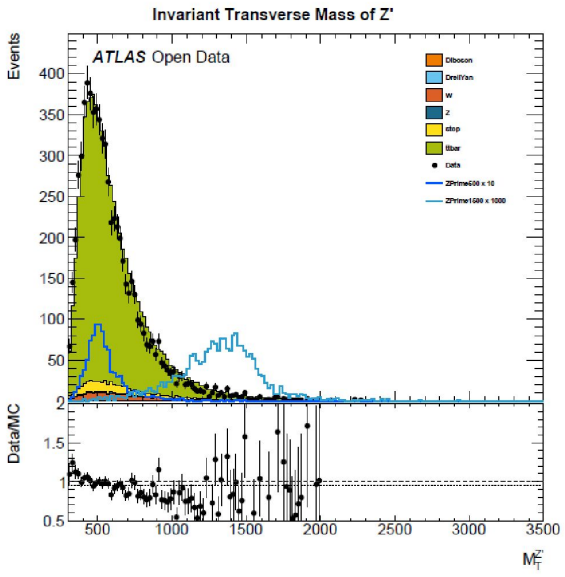


PP: Analysis of ATLAS pp-Daten

- Classical data analysis: 1 fb^{-1} ATLAS data and Monte Carlo simulation (Open Data)
- Graphically analysis of event displays
- Selection of Higgs events using histograms of observables
- Data analysis: Search for Higgs bosons and heavy Z' bosons using statistical data analysis

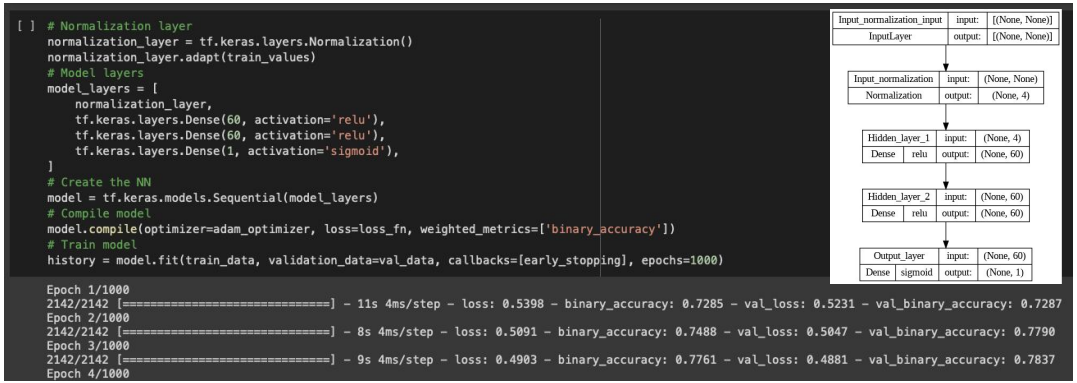
(1 full day or 2 half days)





ML: Neural Networks hunting for Higgs boson

- Simulated data from the ATLAS experiment at CERN analysed using Neural Networks (NN)
- Train a NN to find Higgs boson events



```
[ ]  # Normalization layer
     normalization_layer = tf.keras.layers.Normalization()
     normalization_layer.adapt(train_values)
     # Model layers
     model_layers = [
         normalization_layer,
         tf.keras.layers.Dense(60, activation='relu'),
         tf.keras.layers.Dense(60, activation='relu'),
         tf.keras.layers.Dense(1, activation='sigmoid'),
     ]
     # Create the NN
     model = tf.keras.models.Sequential(model_layers)
     # Compile model
     model.compile(optimizer=adam_optimizer, loss=loss_fn, weighted_metrics=['binary_accuracy'])
     # Train model
     history = model.fit(train_data, validation_data=val_data, callbacks=[early_stopping], epochs=1000)

     Epoch 1/1000
     2142/2142 [==============================] - 11s 4ms/step - loss: 0.5398 - binary_accuracy: 0.7285 - val_loss: 0.5231 - val_binary_accuracy: 0.7287
     Epoch 2/1000
     2142/2142 [==============================] - 8s 4ms/step - loss: 0.5091 - binary_accuracy: 0.7488 - val_loss: 0.5047 - val_binary_accuracy: 0.7790
     Epoch 3/1000
     2142/2142 [==============================] - 9s 4ms/step - loss: 0.4903 - binary_accuracy: 0.7761 - val_loss: 0.4881 - val_binary_accuracy: 0.7837
     Epoch 4/1000
```

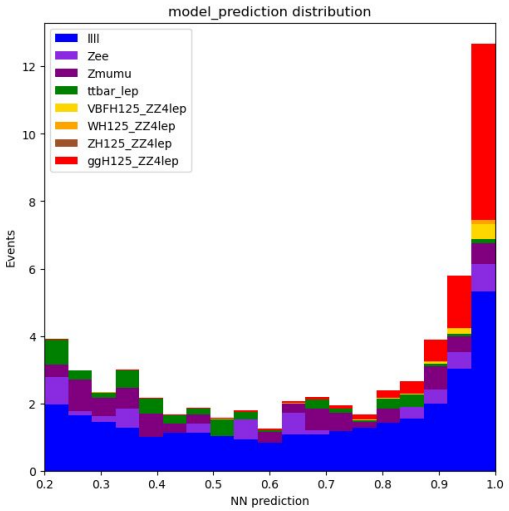
Input_normalization_input	input:	[(None, None)]
InputLayer	output:	[(None, None)]

Input_normalization	input:	(None, None)
Normalization	output:	(None, 4)

Hidden_layer_1		input:	(None, 4)
Dense	relu	output:	(None, 60)

Hidden_layer_2		input:	(None, 60)
Dense	relu	output:	(None, 60)

Output_layer		input:	(None, 60)
Dense	sigmoid	output:	(None, 1)

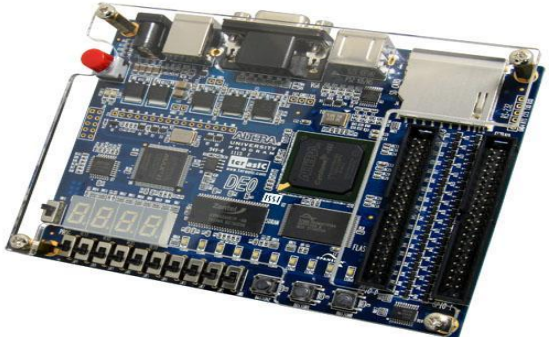


- Choose suitable training setup
- Design your own NN
  → Show us that you can beat the given NN!
- Report: please submit a well-documented Jupyter notebook

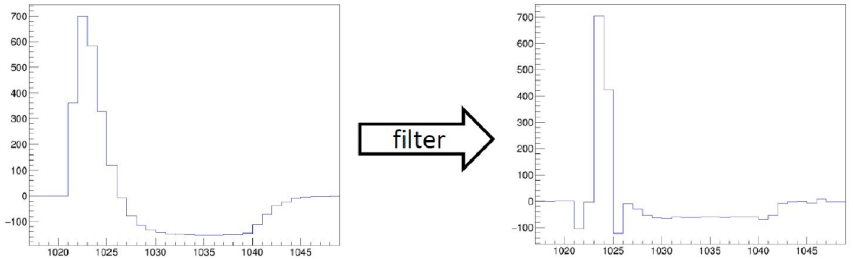
(1 full day or 2 half days)

FP: Electronical data processing and FPGA

- Program a “Field Programmable Gate Array” (programmable circuit)
- Use examples to learn the development environment for FPGAs
- Logic gate
- Steer electronical componentes (LED, 7 segment display)
- Design a digital filter for signal processing with an FPGA
- Learn basic tools for firmware development



Wiener Filter



GA: Gamma spectrometry

- Record gamma spectra with NaI scintillation detectors and a high-resolution High-Purity Ge detector

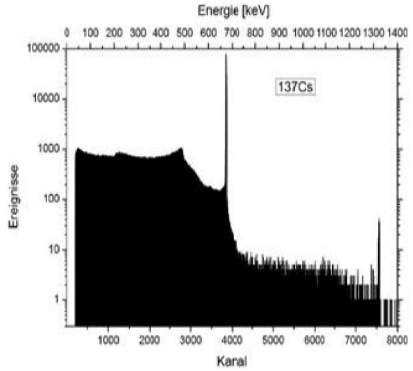
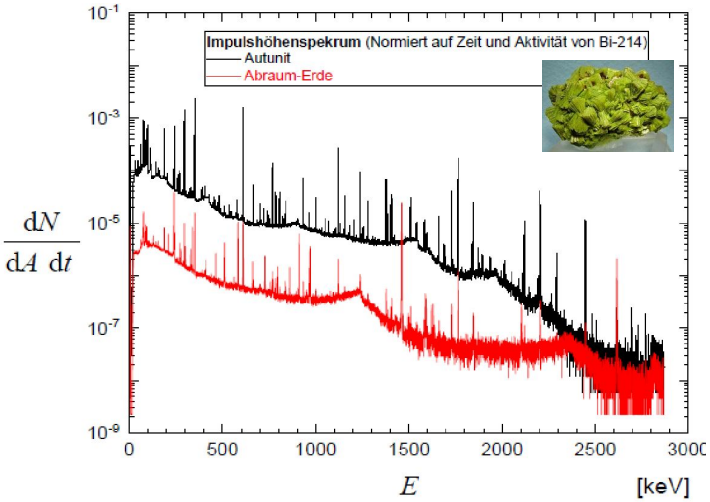


Tabelle 1: Daten der Eichpräparate.

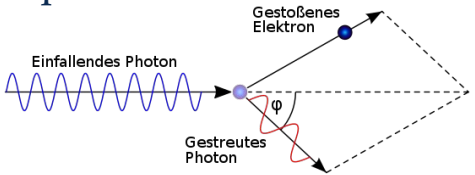
Isotop	Aktivität (kBq)	Datum	Halbwertszeit (a)
^{137}Cs	44.2	18.10.93	30.17
^{60}Co	44.6	19.10.93	5.272
^{152}Eu	42.3	18.10.93	12.4
^{207}Bi	37.2	18.10.93	38
^{133}Ba	46.6	19.10.93	
^{241}Am	4.21	19.10.93	
^{226}Ra	4.33	9.11.93	1600
^{22}Na	41.5	18.10.93	2.602

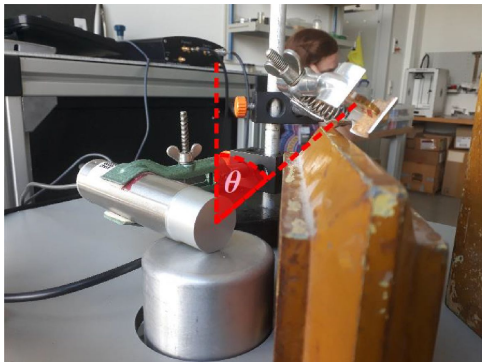
- If you already took this course during the Bachelor studies you will get advanced tasks here
  → Contact the tutor in that case



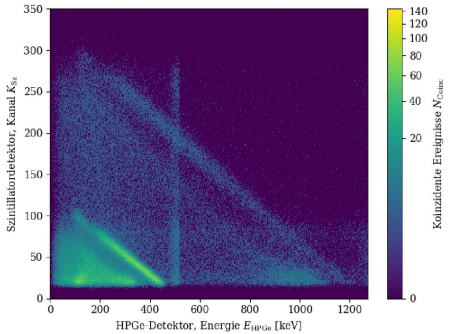
WK: Wide-angle Compton coincidence method

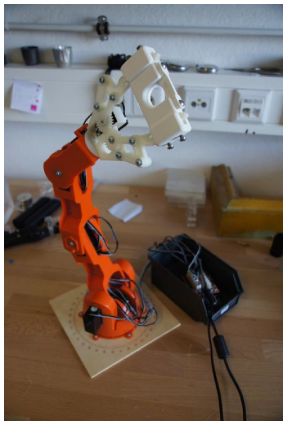
- Calibrate a scintillation detector with small Z by Compton coincidence measurements





- Use the angular and energy correlation of the electron and the scattered photon

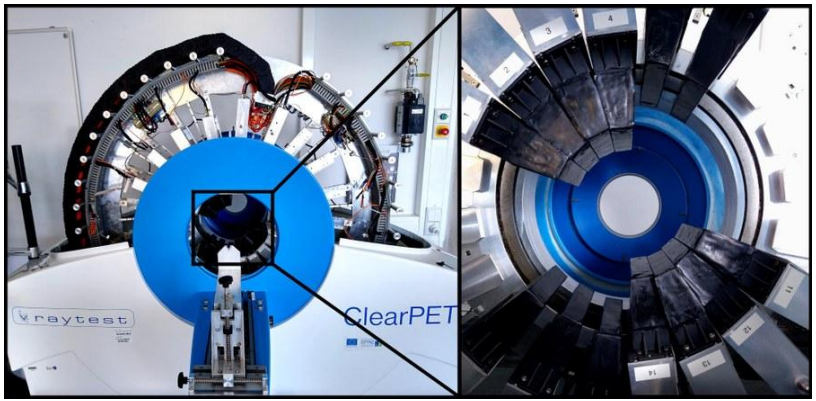


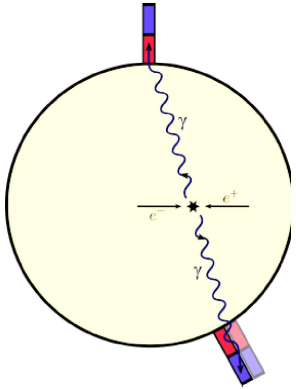


- Precision spectrum with a HPGe detector
- Robot steering and automatic signal recording

PE: Positron emission tomography

- New PET scanner:



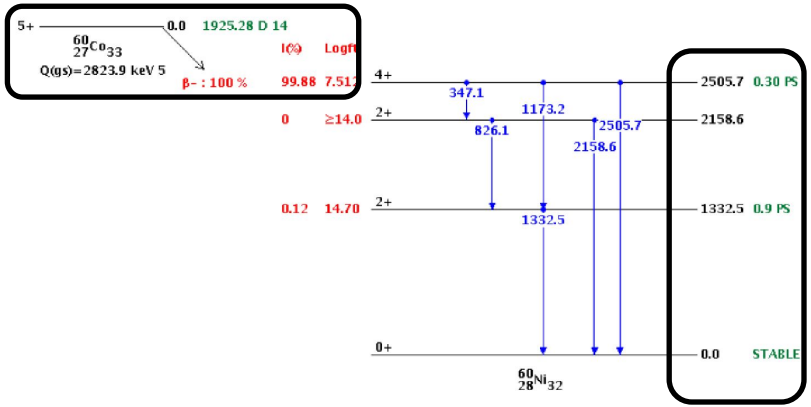


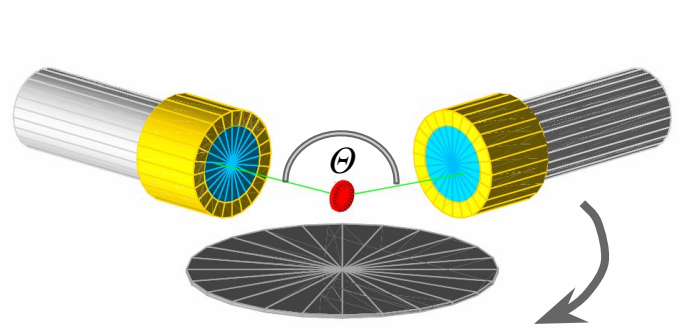
- Measure a point source
- Simple and filtered back projection
- Measure activity ratios
- Sinograms
- OSMAPOSL reconstruction algorithm

Ordered Subset Maximum A Posteriori One-Step Late

SD: Simulation based digital data processing

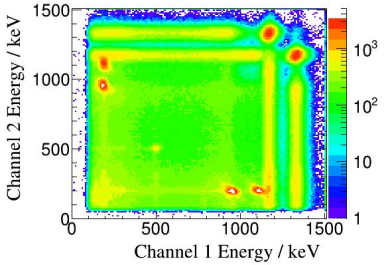
- Determination of angular correlation of the emitted γs of a ^{60}Co source

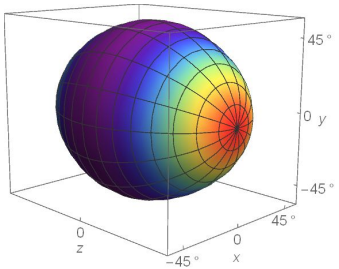




- Analog and digitized data recording
- Analysis with Geant4 simulation
- Jupyter based analysis + report

- <u>Optionally:</u> additional day at HZDR to discuss results and prepare report (notebook)





$$W(\theta) = 1 + \frac{1}{8}\cos^2\theta + \frac{1}{24}\cos^4\theta,$$

BM: Datierung mit einem Ionenbeschleuniger

Kurzbeschreibung

Am Praktikumstag wird die Technik und Anwendung der Beschleuniger-Massenspektrometrie (Accelerator Mass Spectrometry; AMS) am Beispiel einer Datierung am DREsden AMS (DREAMS) vermittelt. Das Experiment findet am 6MV-Beschleuniger des Helmholtz-Zentrums Dresden-Rossendorf statt. Die Studierenden sammeln dabei an einem wissenschaftlichen Großgerät direkte Erfahrung mit ultrasensitiver Massenspektrometrie. Das Experiment beginnt mit der Inbetriebnahme einer Sputter-Ionenquelle und der Erzeugung eines negativen Ionenstrahls. Anschließend wird der Strahltransport eines Isotopenpaares (z.B. $^{14}C/^{12}C$, $^{10}Be/^{9}Be$ oder $^{26}Al/^{27}Al$) durch den Beschleuniger durchgeführt. Nach der Aufnahme von Messwerten der Isotopenverhältnisse werden die Ergebnisse zur Datierung ausgewertet.

Der Versuch wird an einem Tag durchgeführt.

Versuchsziele:

- Grundlagen von Datierung mittels langlebiger Radionuklide
- Betrieb eines Massenspektrometers
- Bildung negativer Ionen in einer Sputter-Ionenquelle
- Verständnis für Ablenkung von Ionen in elektischen & magnetischen Feldern
- Ionenbeschleunigung am Tandem-Beschleuniger
- Nachweis einzelner Atome im Gasionisationsdetektor

QFT tasks

- [QFT 0: Muon decay and Feynman rules (4 half days)]
- QFT 1: Loop corrections to muon decay in the Standard Model (4 half days)
- QFT 2: Asymptotic freedom in QCD (4 half days)
- QFT 3: Calculation of the Higgs mass in the MSSM (4 half days)

Date: Thursday
Place: ASB E19
Time: 7:30 to 12:40 (half day) or individual arrangement

By arrangement, QFT tasks other than those listed here may be performed. If three QFT tasks are chosen, they can also be counted towards the laboratory practical course "Theoretical Physics". The QFT tasks typically require previous knowledge from the QFT lecture.

Now: Find yourself a lab partner

Now: Date selection

- Questions?