ML applications at Institute of Radiation Physics @ HZDR

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Amalea-Meeting, Dec. 1st, 2019, DESY

Outline

- Diamond search: status

- Laser accelerated protons

- Organisatorical things

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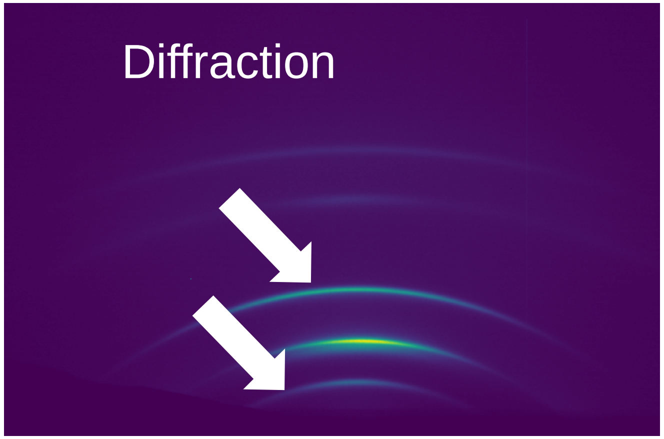
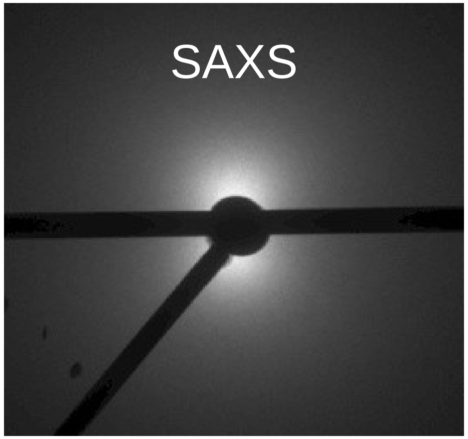
ML-based diamond feature extraction from scatter images

- Experiments modelling the environment of gas-filled planets
- Diamond formation under extreme conditions [1]
- Done by Dominik Kraus et al (FWKH, HZDR) at SACLA

[1] Kraus et al., Formation of diamonds on laser-compressed hydrocarbons at planetary interior conditions. Nature Astronomy 2017





Diffraction and SAXS are performed in parallel

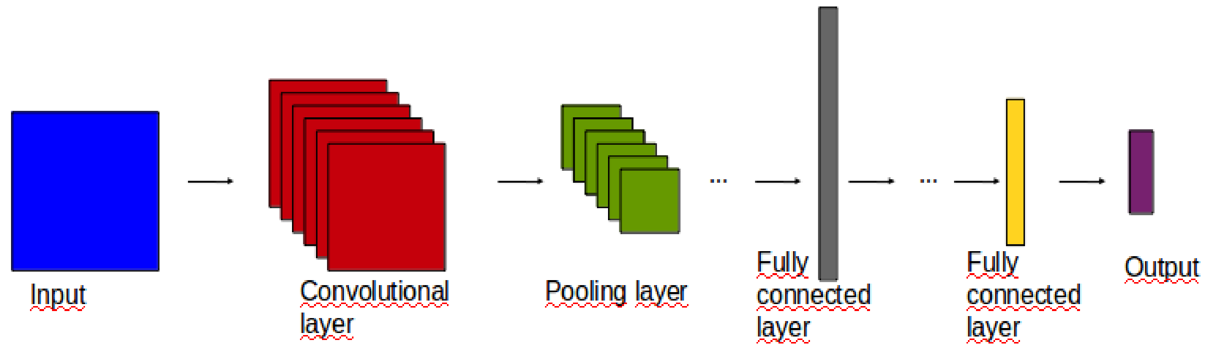
- Visualization of diamond features in diffraction images works
- Detection from SAXS images?
- CNNs for diamond feature detection also from SAXS images?
- Images labelled according to diffraction images

ML-based diamond feature extraction from scatter images

Aim: image classification and determine decisive parts of the image

Method:

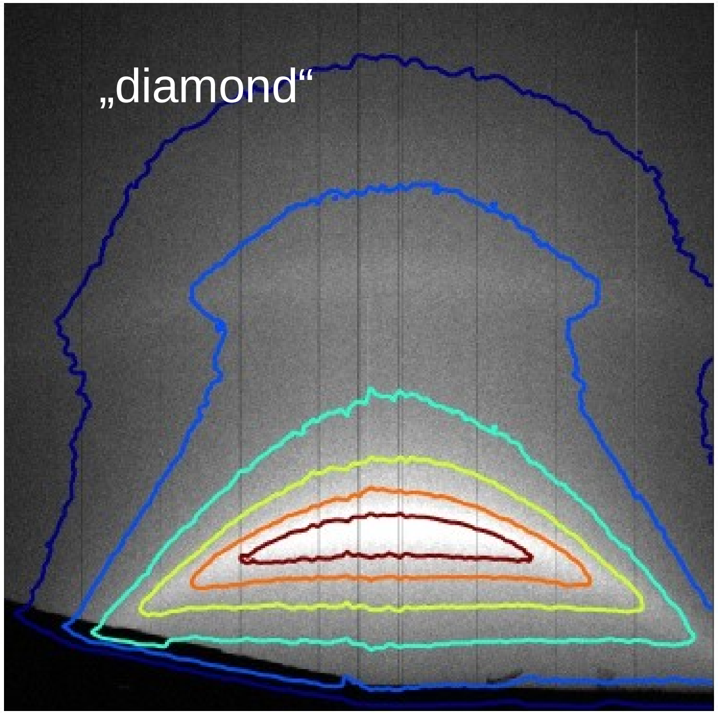
- 90 images with PET target
- Diamond (and main shot): 45, non-diamond (and preshot): 45
- test: 10 (5/5), training: 80, batch size 1-2, 10-20 epochs
- Pytorch: CNN with 3 convolutional layers plus max pooling and 3 fully connected layer, kernel size: 5
- class activation mapping [2]: identify the importance of the image regions by projecting back the weights of the output layer onto the convolutional feature activation map

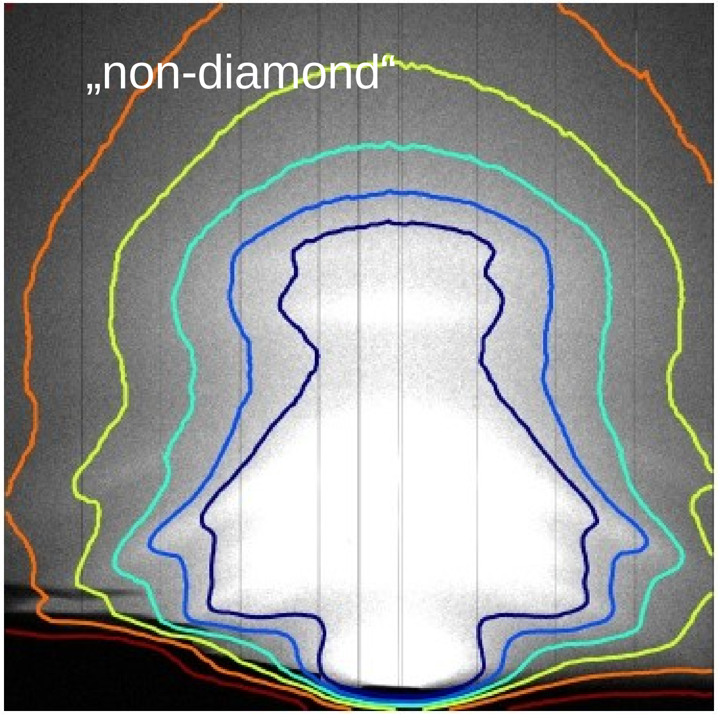


ML-based diamond feature extraction from scatter images

Results: Classification of diffraction images

- Diffraction images correctly classified (100 %)

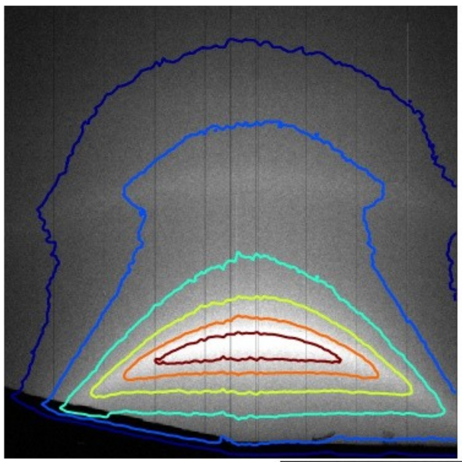
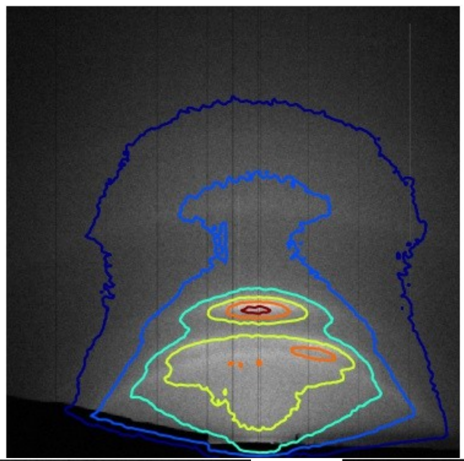
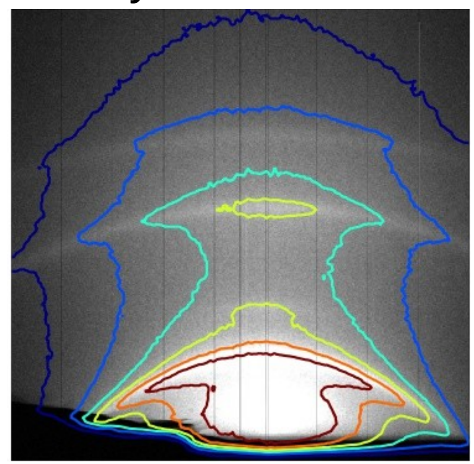
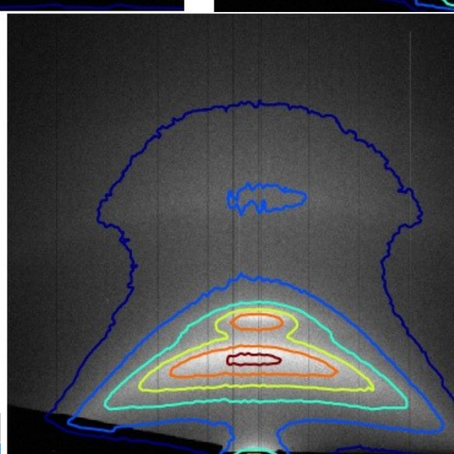
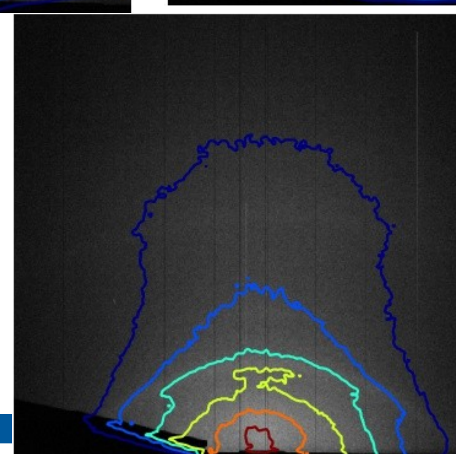




ML-based diamond feature extraction from scatter images

Results: Classification of diffraction images

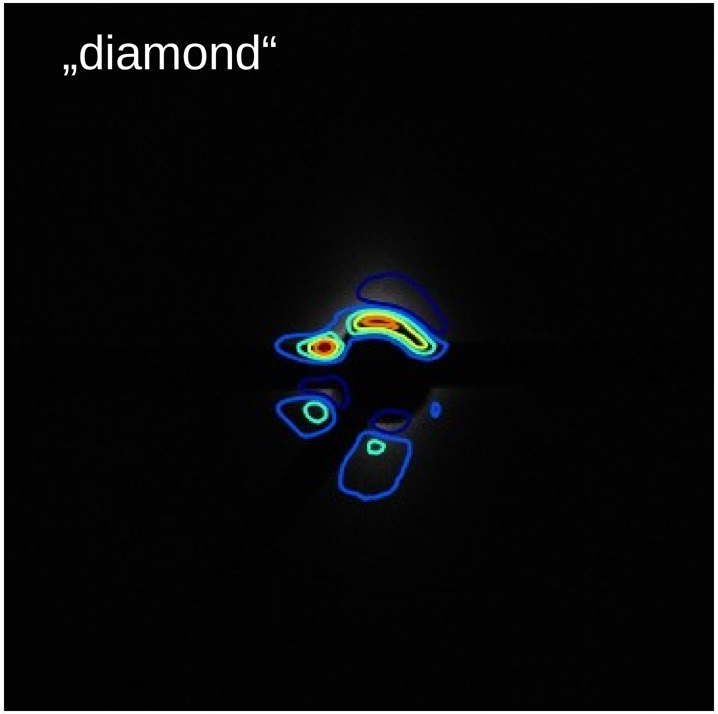
- Diffraction images correctly classified (100 %)
- Discriminative parts of the image are not always „diamond curves“

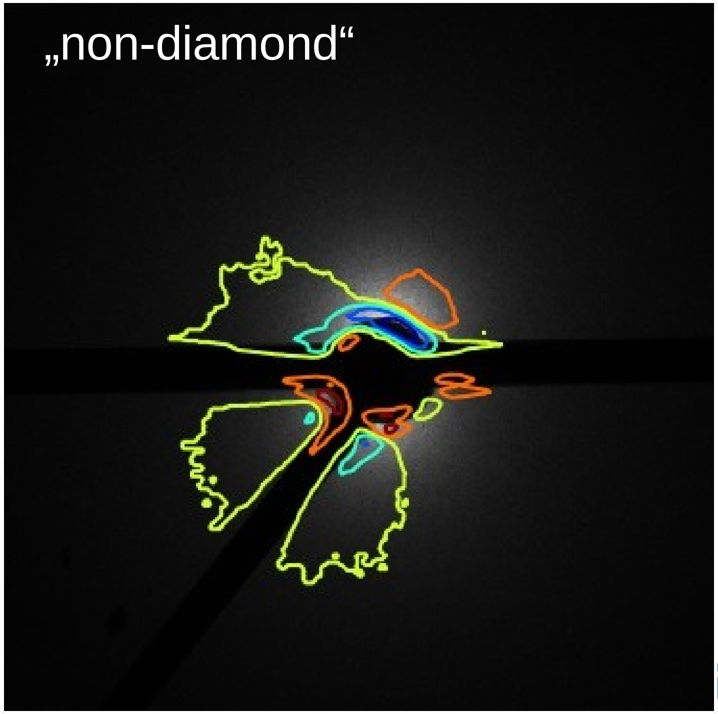






ML-based diamond feature extraction from scatter images

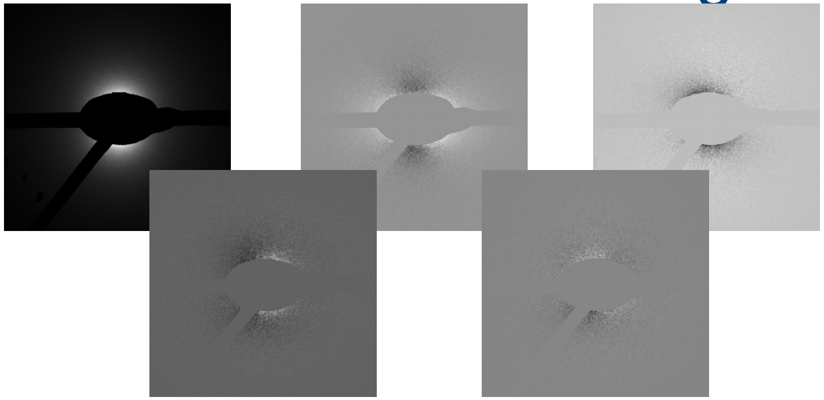
Results: Classification of SAXS images

- SAXS images mainly correctly classified (80-90 %)
- Highest intensity regions seem most relevant
- Analysis of discriminative features not straightforward
- Comparison with results of PCA analysis



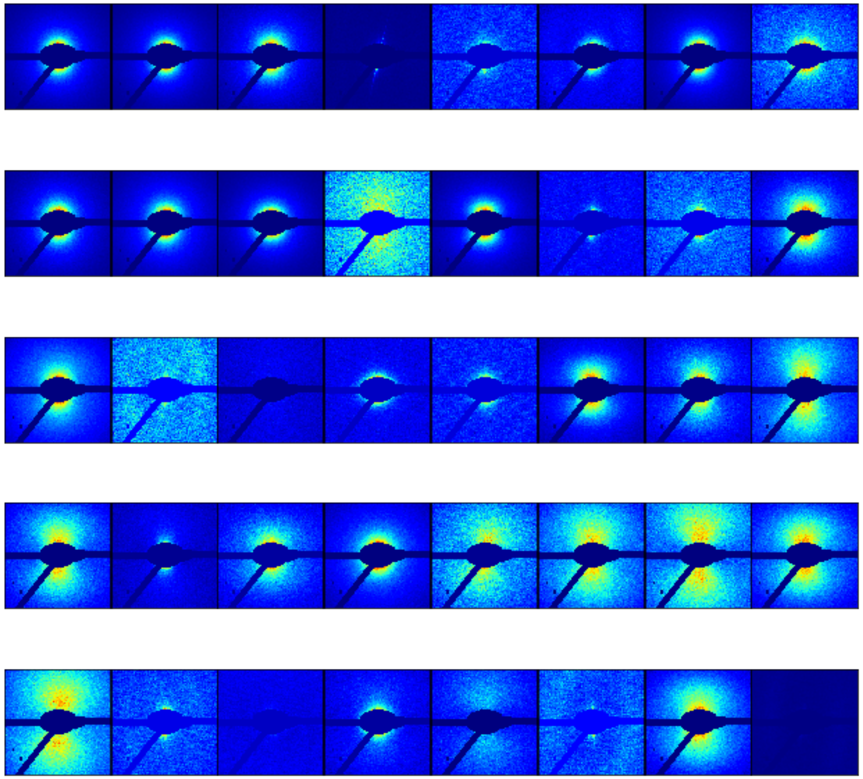


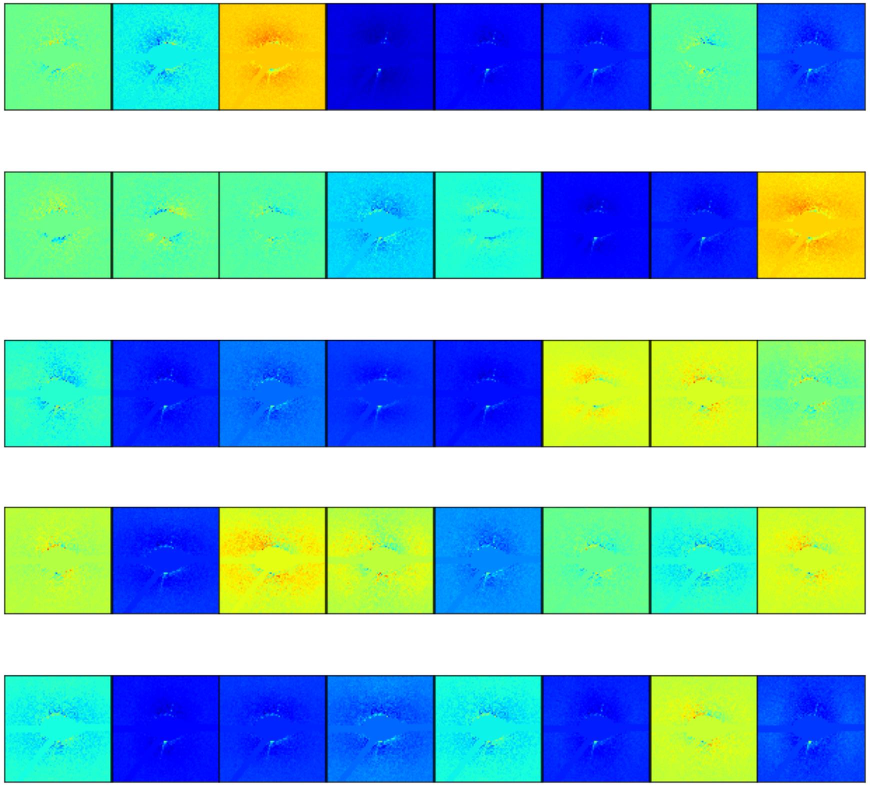
ML-based diamond feature extraction from scatter images



PCA analysis (Deniza Chekrygina)

- Relate principle components to physics
- Subtract first three principle components from SAXS images
- Remaining features?





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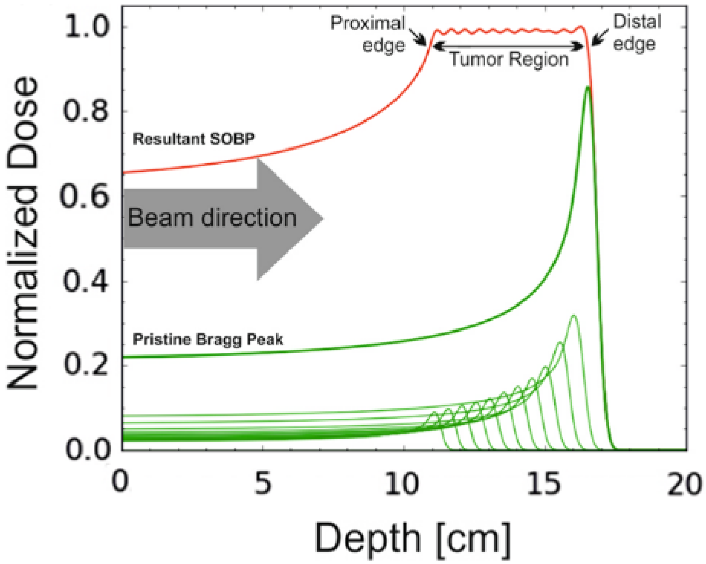
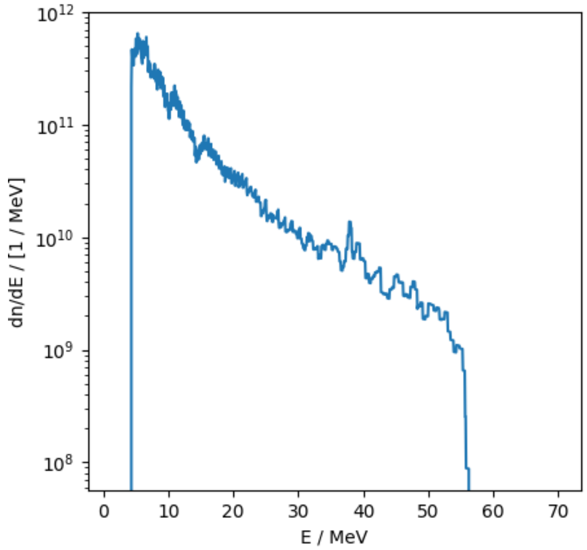
Laser accelerated protons

Background: protons following laser plasma acceleration need characterization



Masood et al
Appl. Physics
2013



- Measurement methods: spectrometer, radiochromic films, scintilator

- Idea: Learn angular-dependent energy spectrum of laser accelerated protons from Incomplete and noisy measurements of the energy deposition

$d^2n/(dEd\Omega) \Leftrightarrow d^2E/(dxdy)$

- dE/dx from Bethe-Bloch Equation, generation of training data using Geant4

HZDR

Organisatorical things

- Call for Hemholtz AI projects (up to 200k in 3 years), deadline January 17th, 2020

- Annual Workshop of the Machine Learning Community Dresden
  on May 18th/19th, 2020