ML for FEL background reduction

Using Robust Statistics and Machine Learning methods to help with data reduction in FEL data analysis pipeline

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Hamburg, 18.12.2019

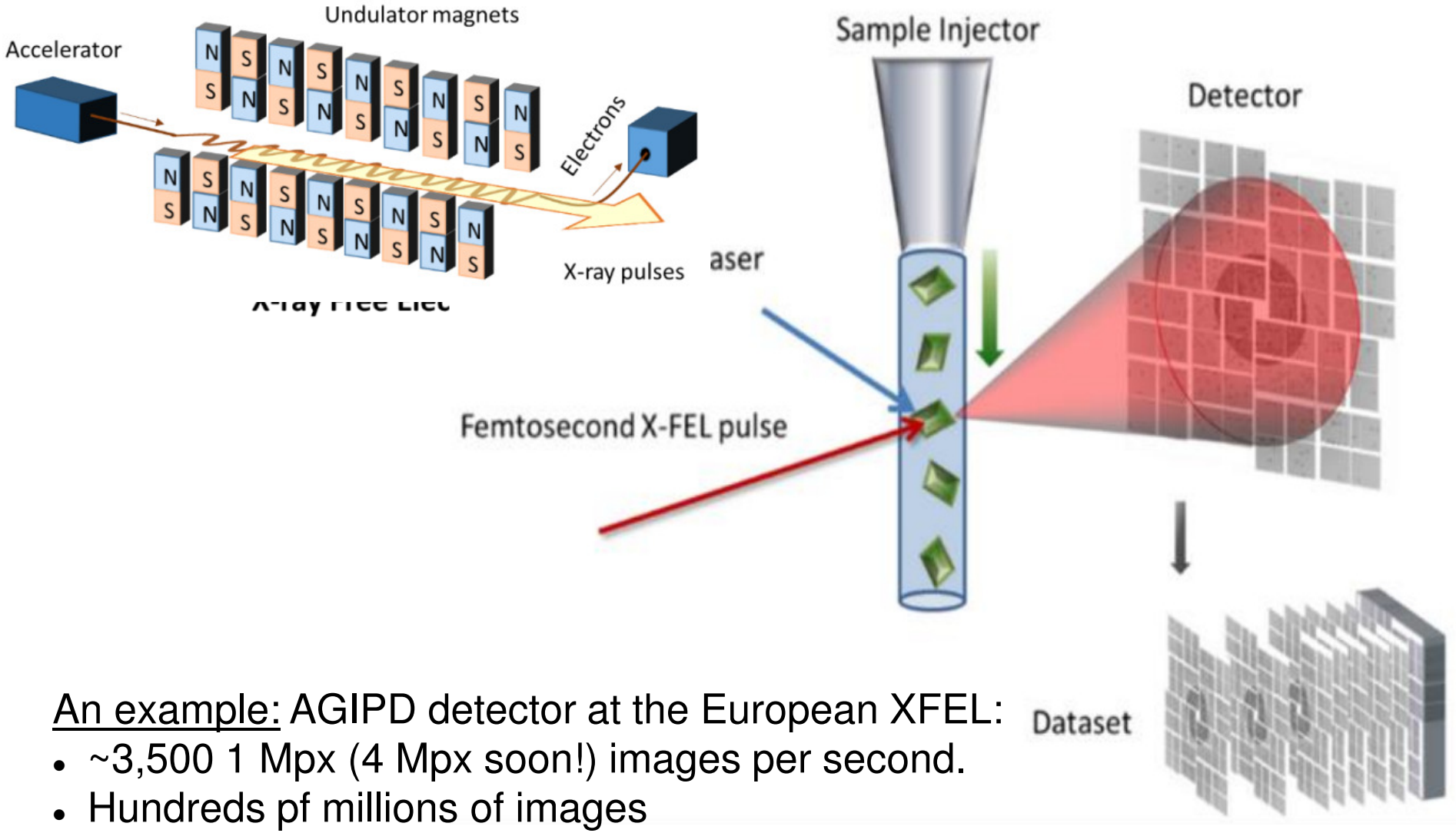
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

Agenda

- FEL experiments and data volume problem
- FEL hit and non-hit detection
- Detectors pixels performance
- Normal and Abnormal behavior
- Bad pixel masks
- Modelling the background
  - Statistical Models
  - Towards DL

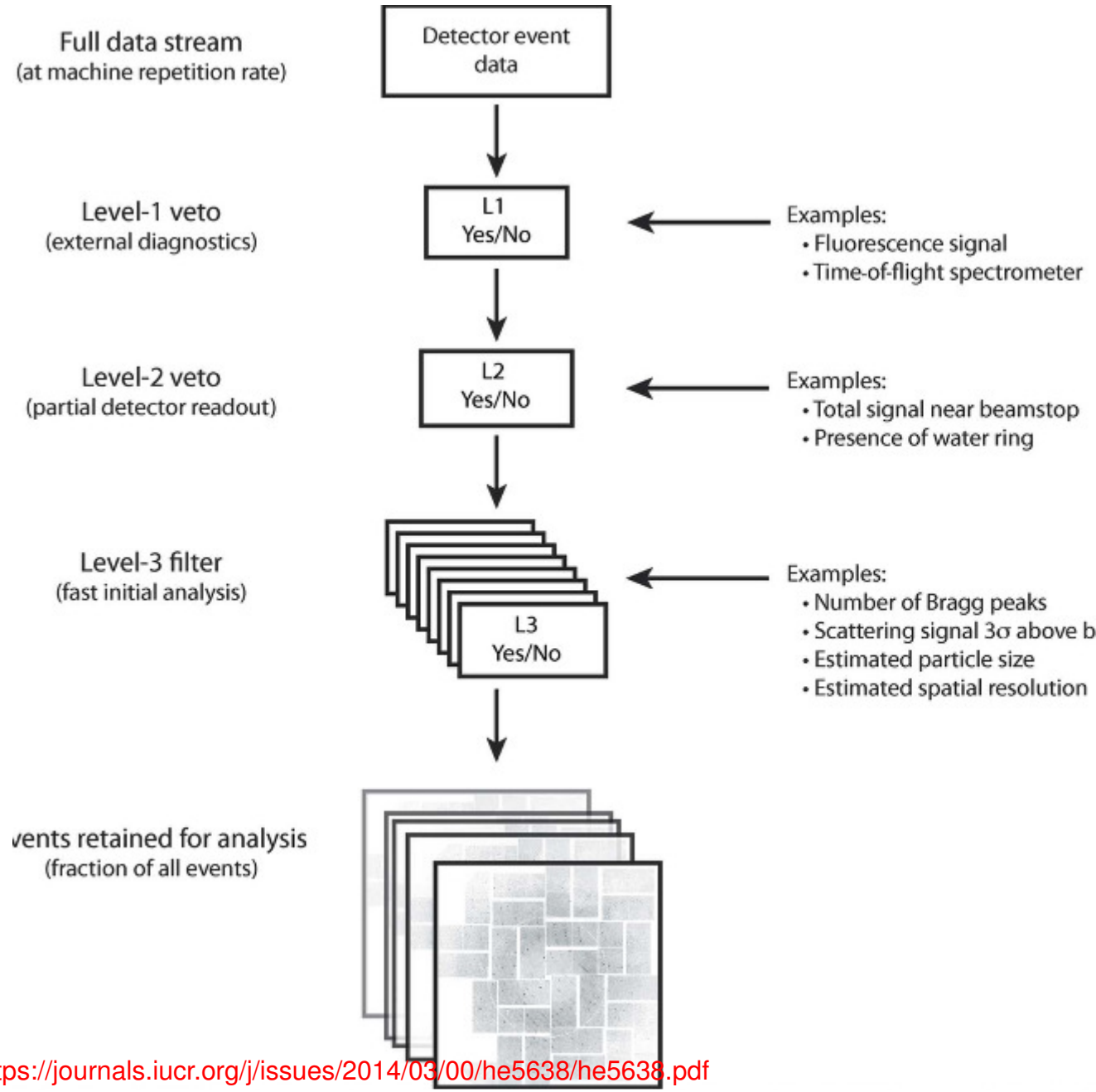
FEL Data volume challenge



An example: AGIPD detector at the European XFEL:

- ~3,500 1 Mpx (4 Mpx soon!) images per second.
- Hundreds pf millions of images
- We need maybe thousands of good images...

Data volume



Data correction by calibration constants

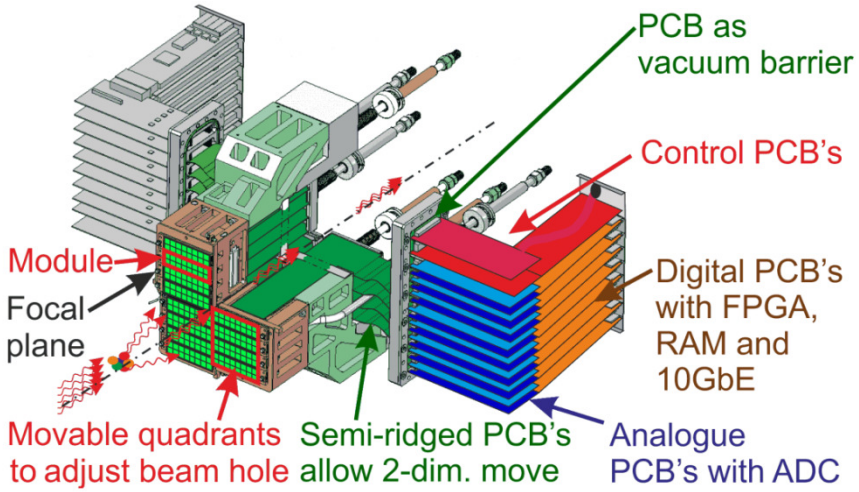
- ✓ Bad pixel mask
- ✓ Pedestal correction
- ✓ Gain correction

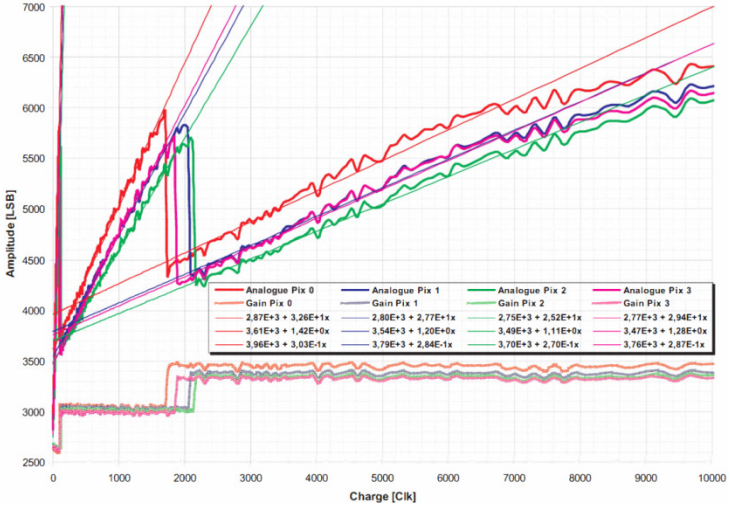
Runtime pre-processing

- ✓ Artefacts detection and segmentation
- ✓ Common mode removal

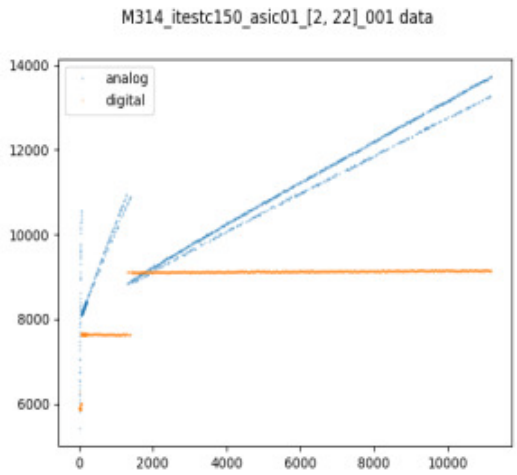
https://journals.iucr.org/j/issues/2014/03/00/he5638/he5638.pdf

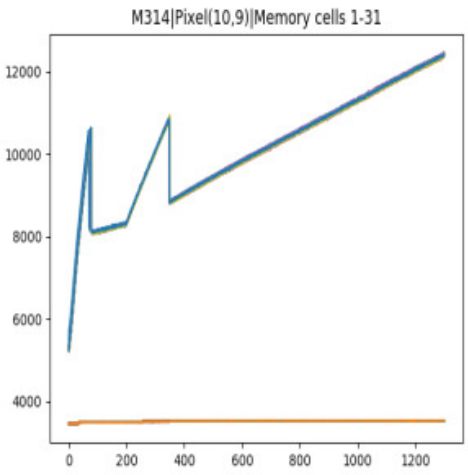
A detector's pixel: AGIPD

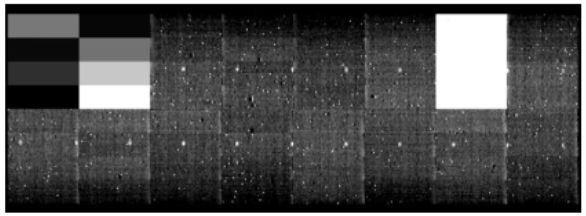




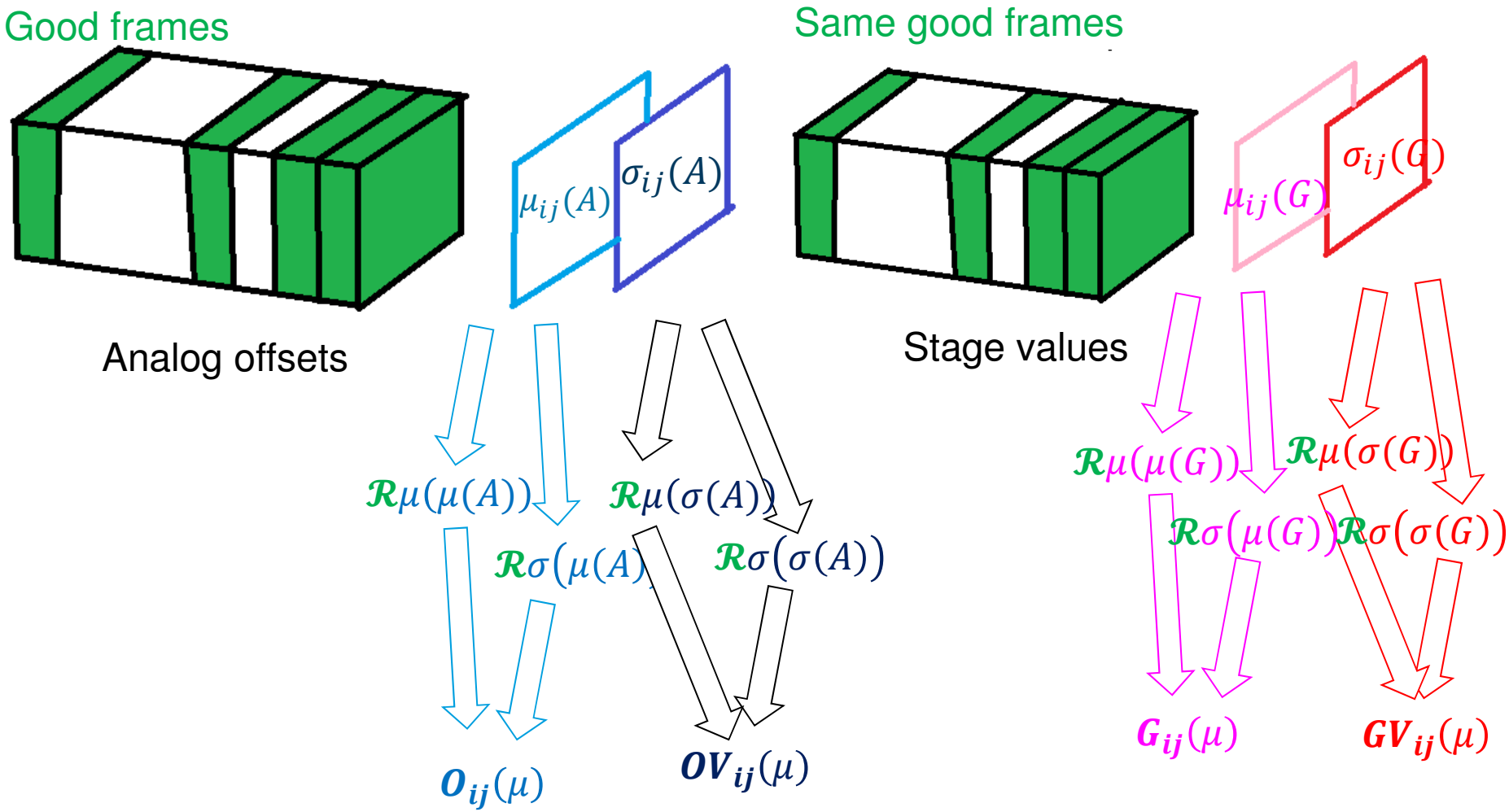
Abnormalities in pixels







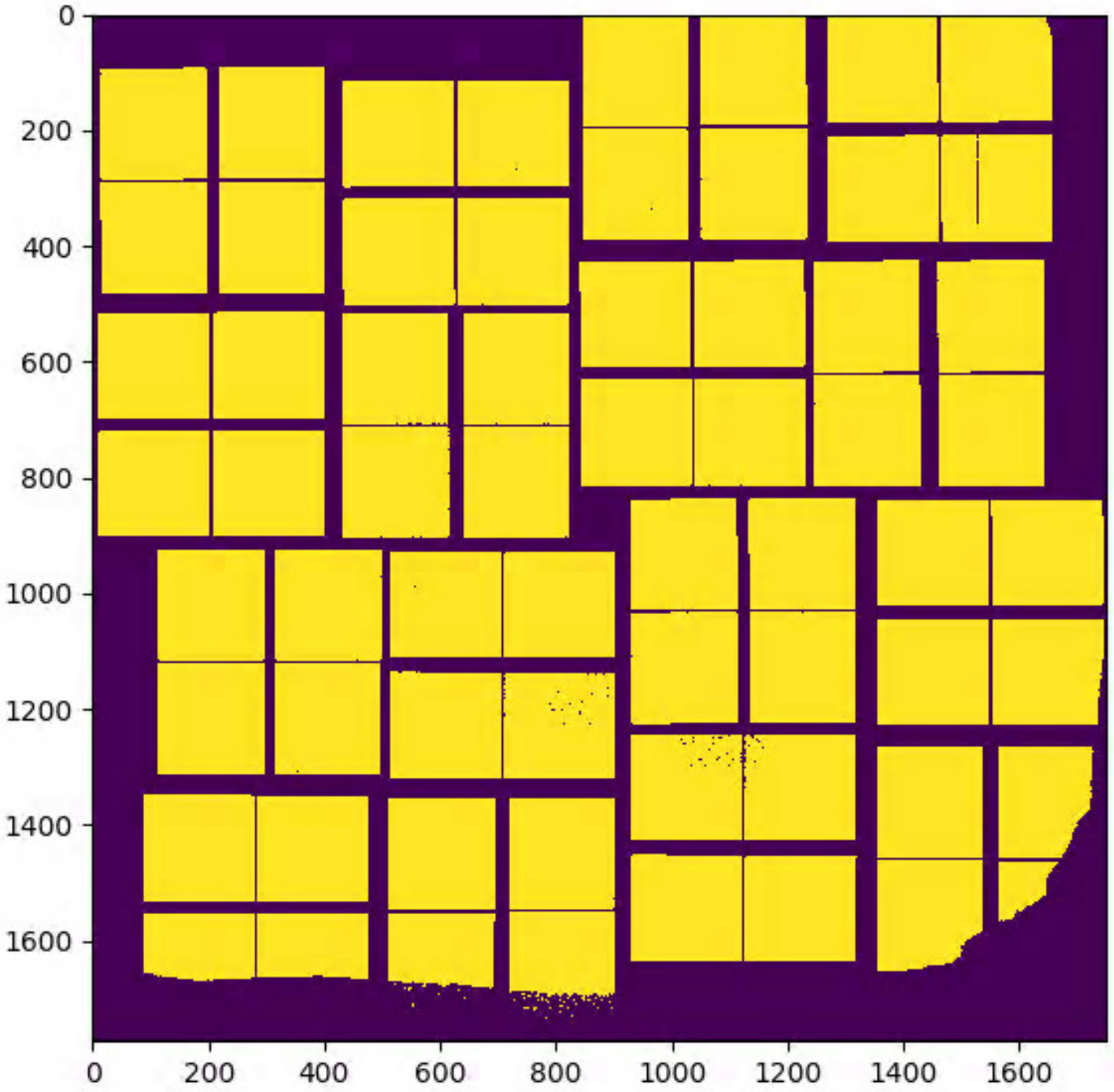
Abnormality maps



$\mathcal{R}$ means a robust function that trusts only normal pixels

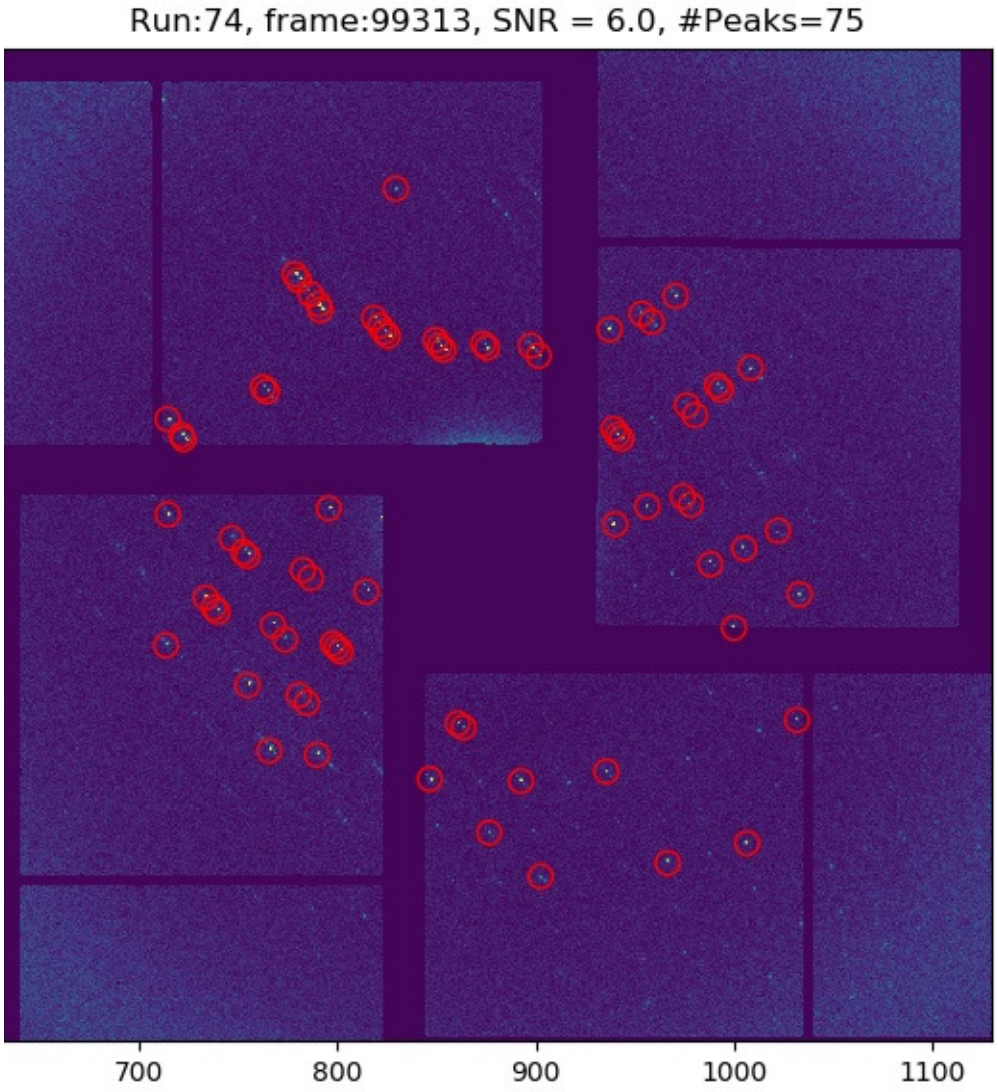
Bad pixel mask

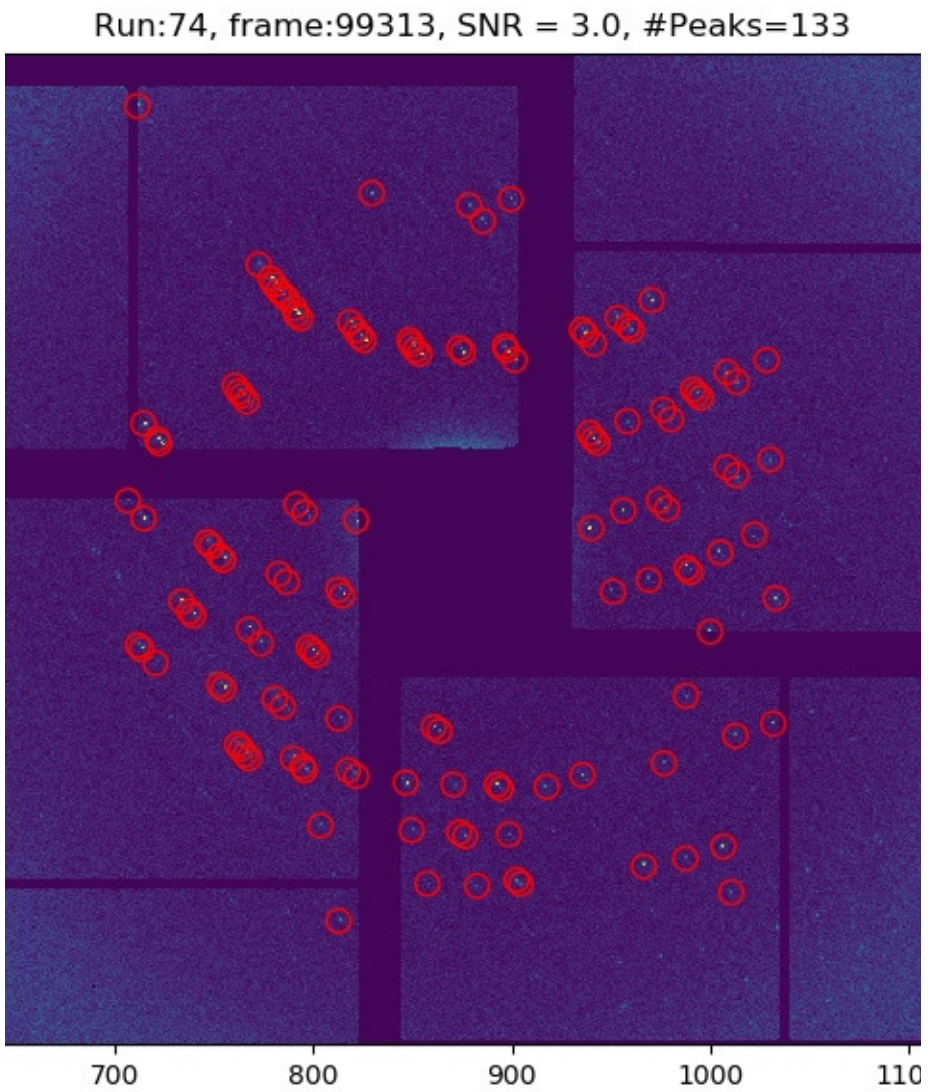
The tool is complete and tested for AGIPD (EuXEFL) and CSPAD (Old LCLS)



Diffraction pattern of a hit

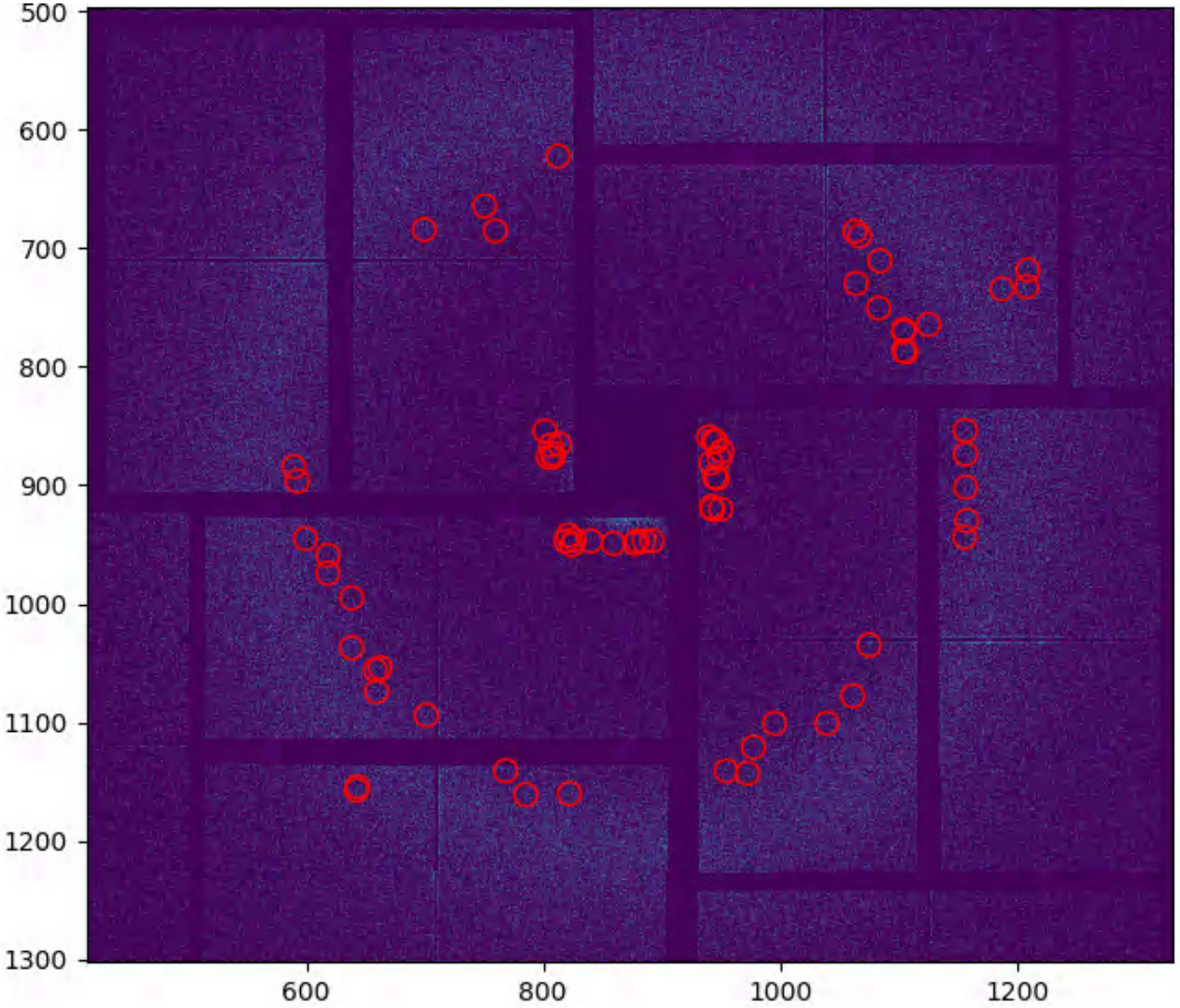
Data from CXI-DB32 – LCLS 2015 – CSPAD detector



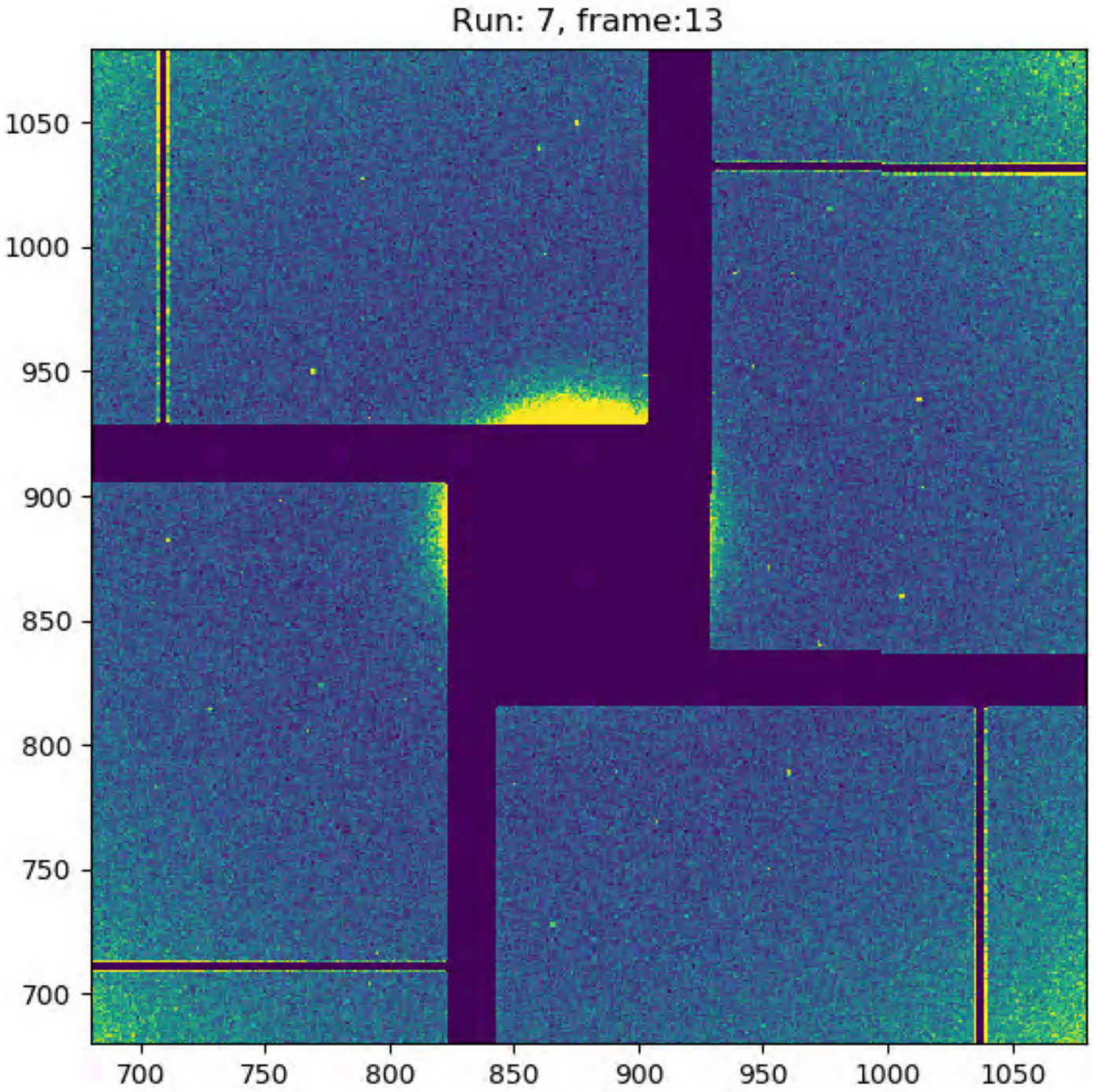


A non-hit with a too sensitive peakfinder

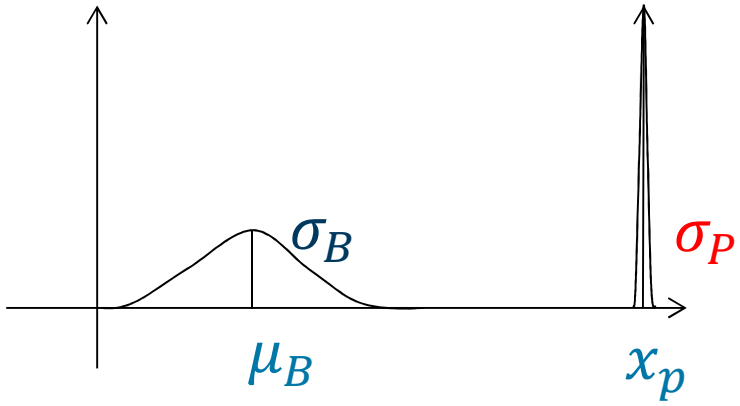
No data reduction this way



A weak pattern



A weak pattern

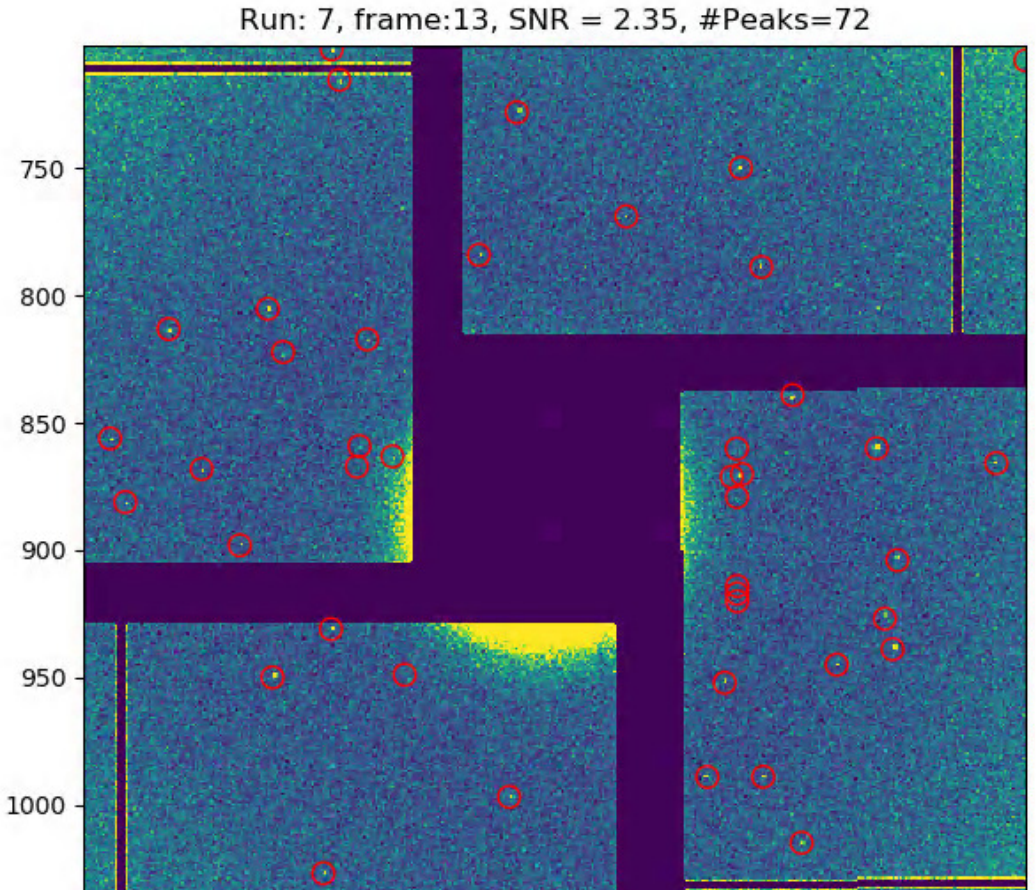


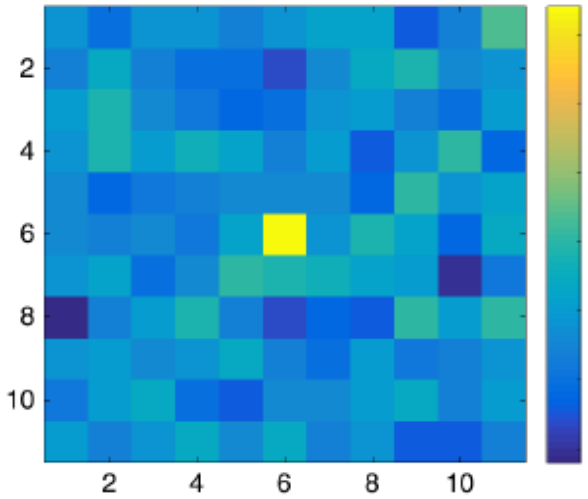
$$SNR = \frac{\mu_P - \mu_B}{\sigma_P + \sigma_B}$$

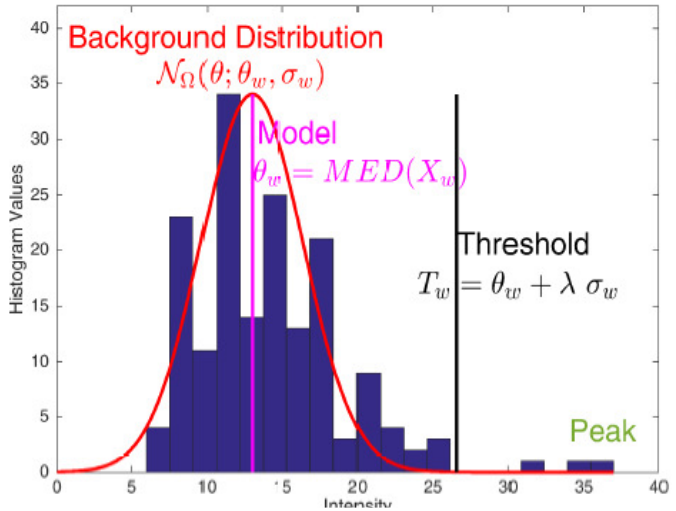
σ_P: pixel‘s uncertainty

⇑

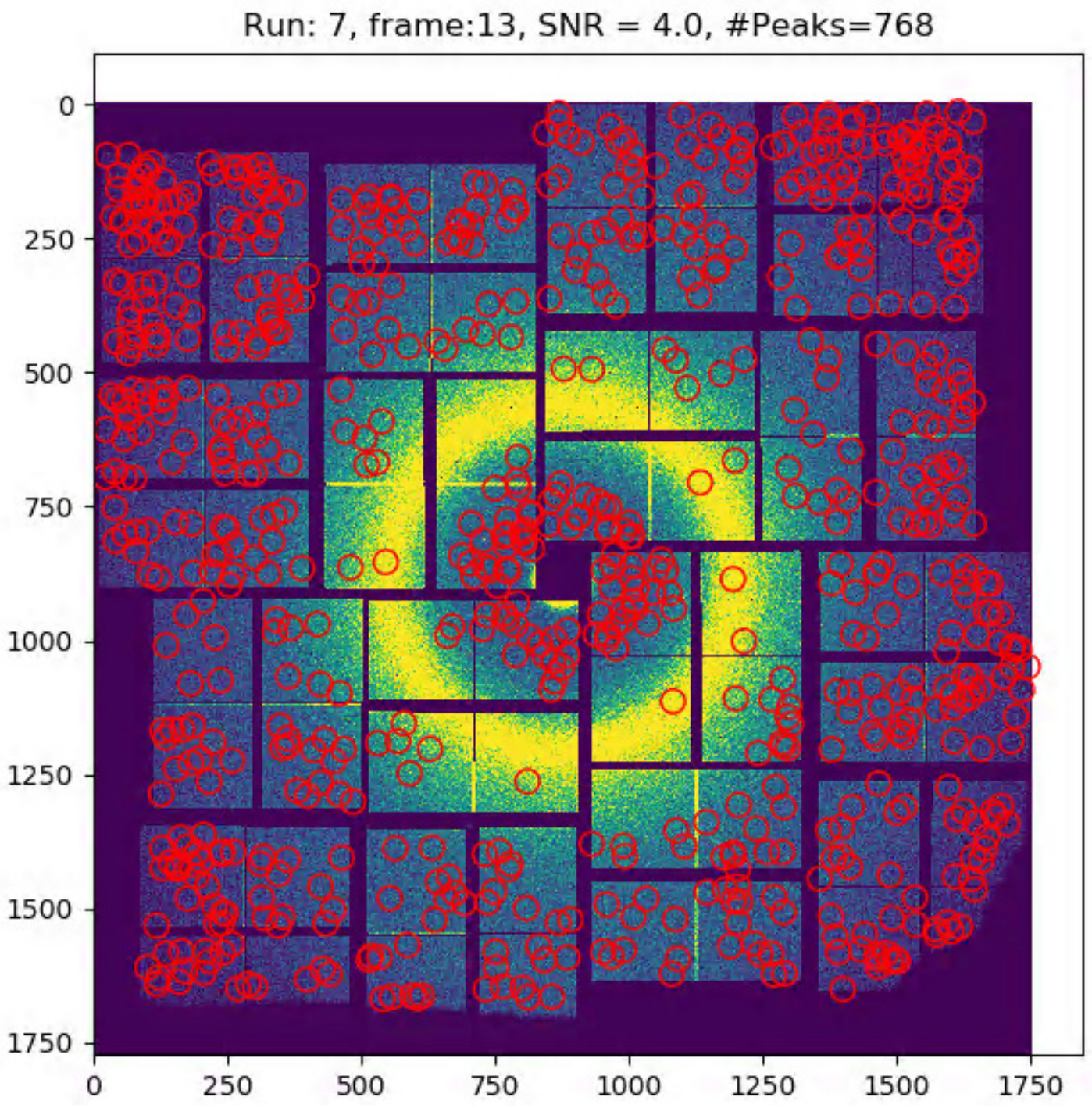
Can be learned



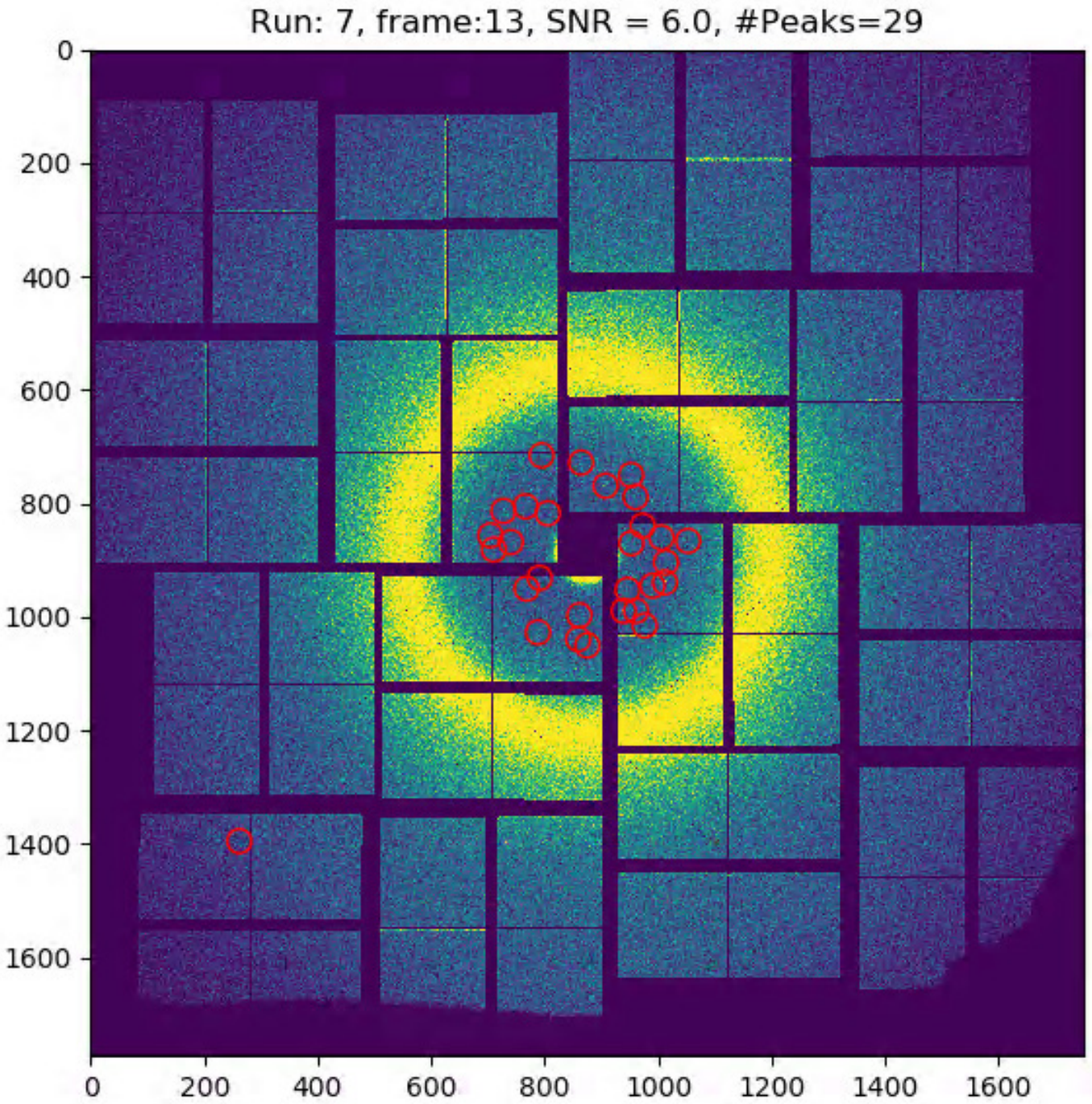




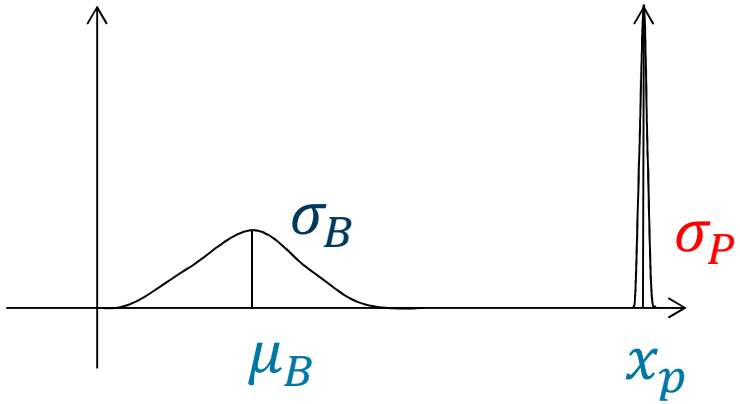
Low SNR and no σ_P uncertainty modelling



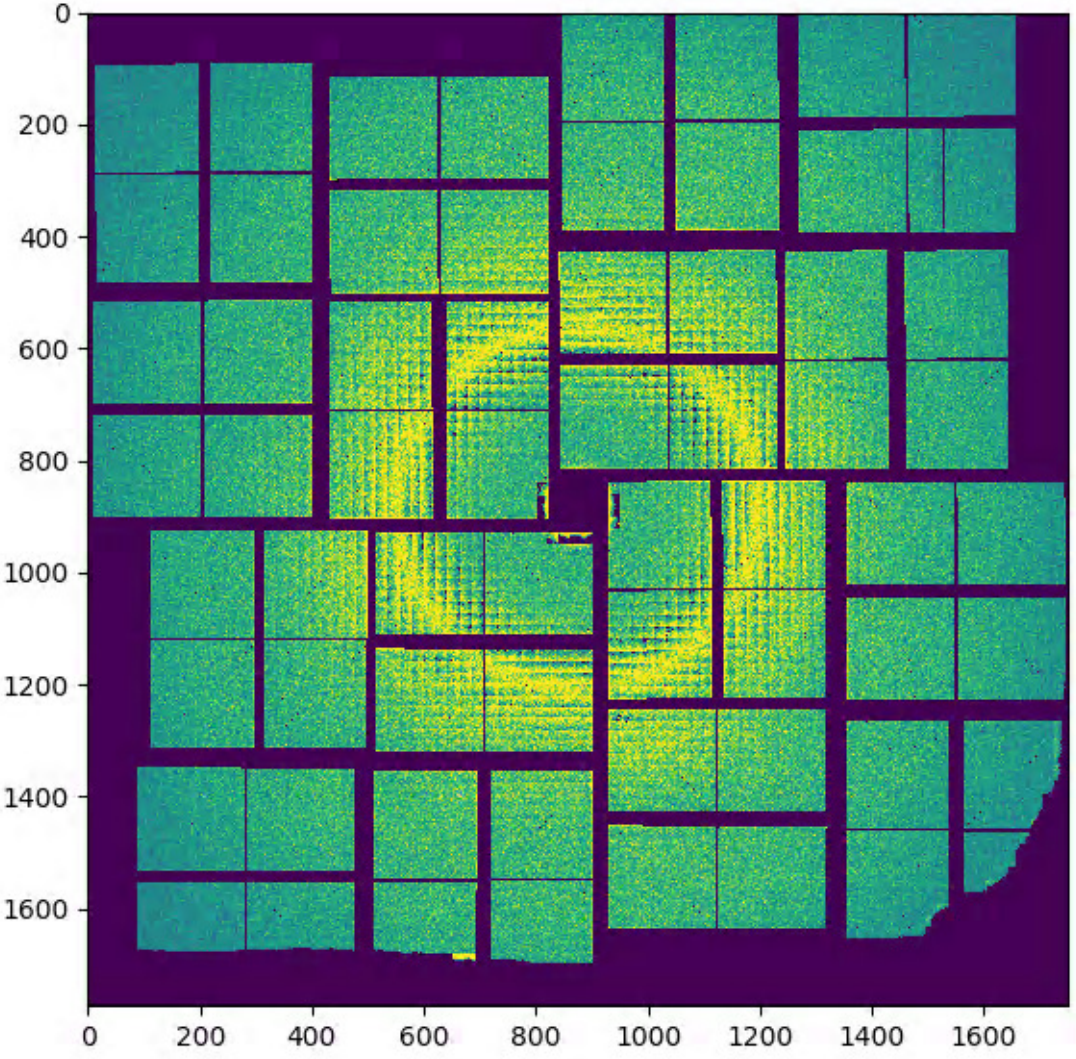
High SNR and no σ_P uncertainty modelling



Pixels uncertainties



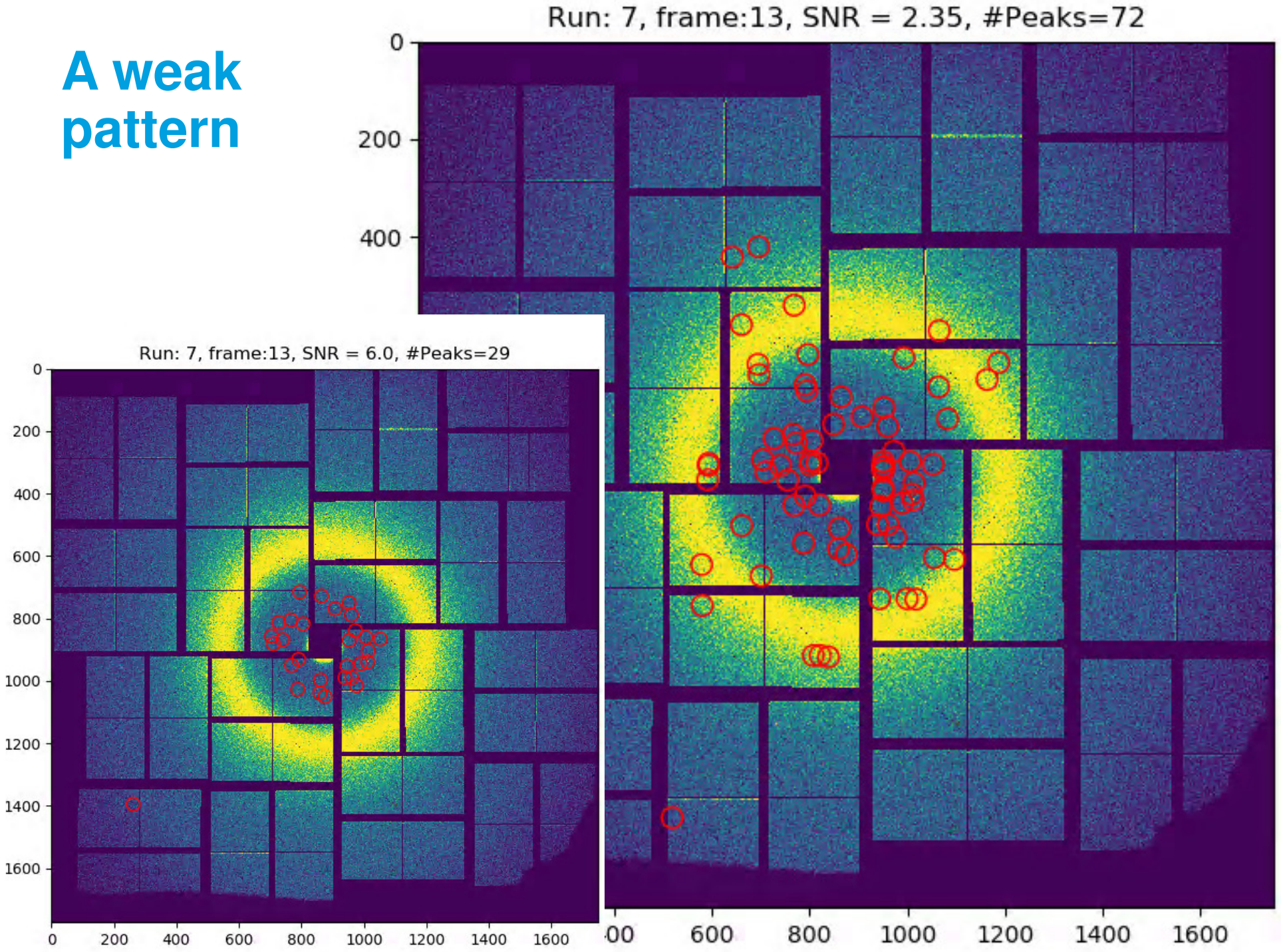
$$SNR = \frac{\mu_P - \mu_B}{\sigma_P + \sigma_B}$$



Prior σ_P:

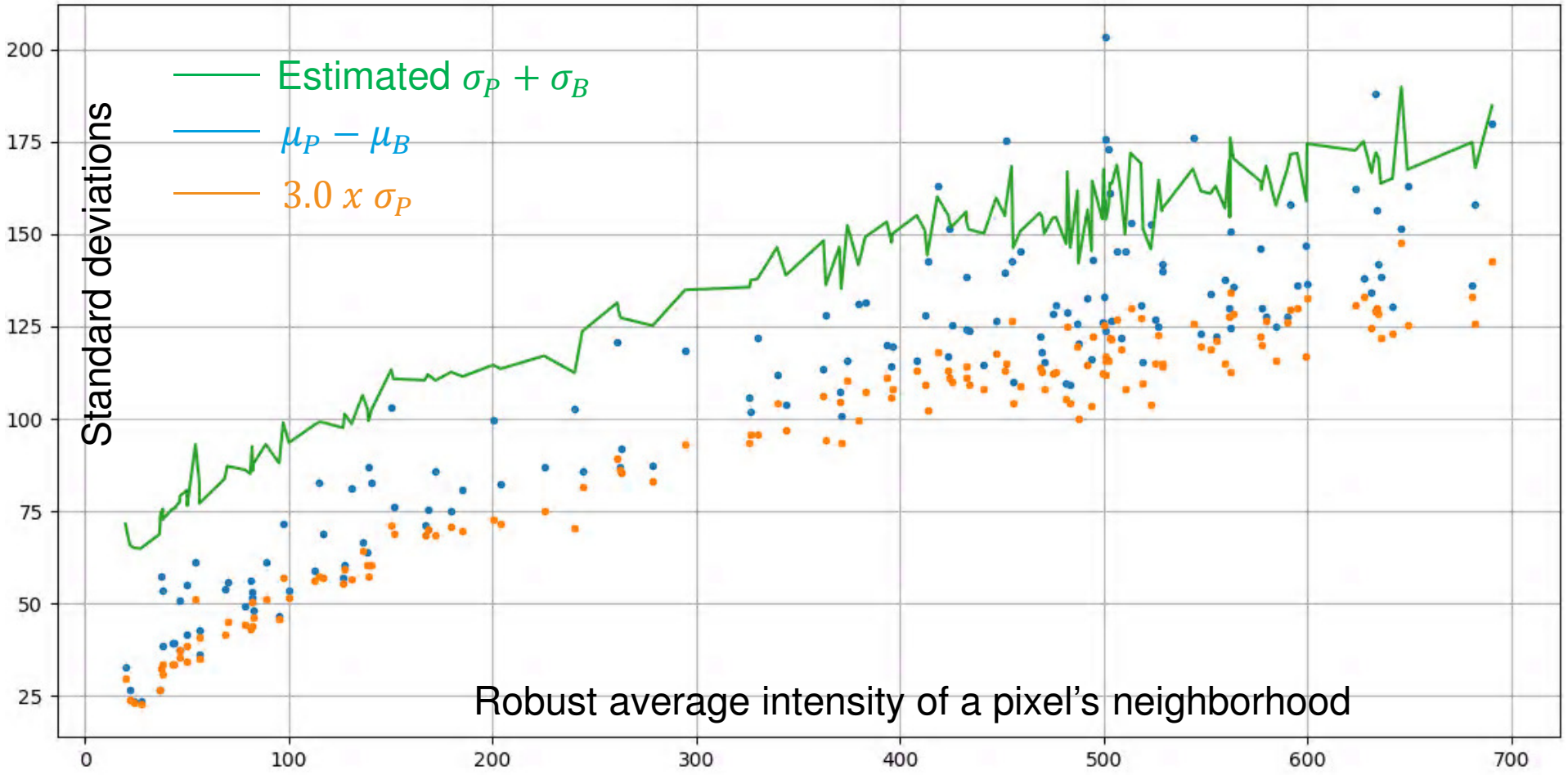
- Statistical
- How to use deep learning?

A weak pattern



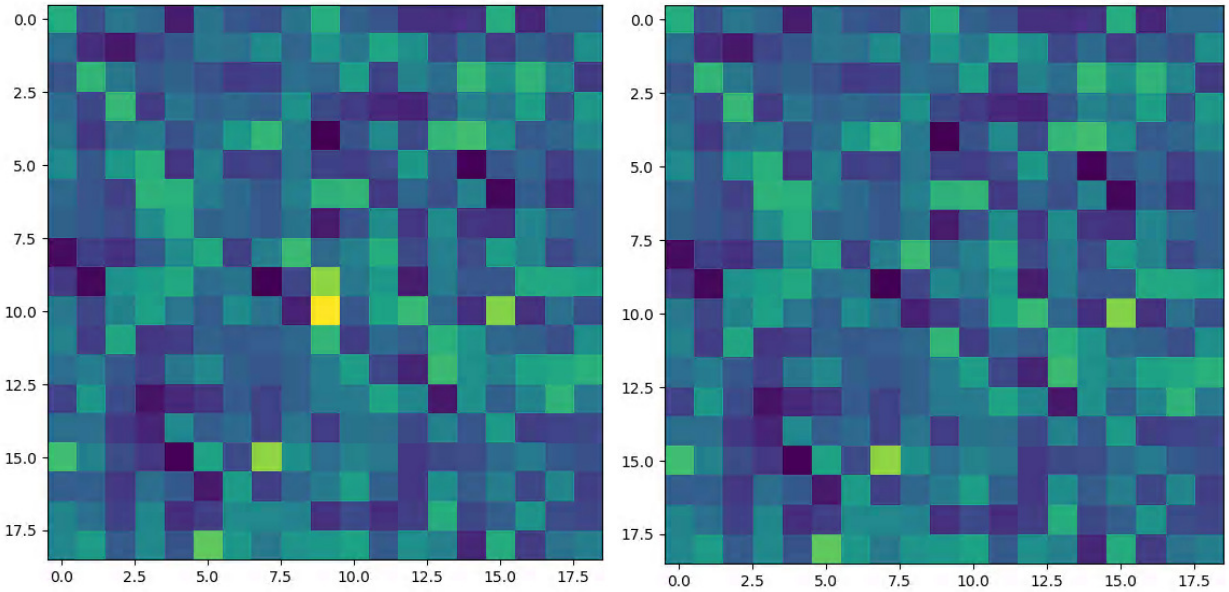
Pixels uncertainties statistical modeling: σ_P

- Image is for one pixel. Each data point is for an image. (25000 of them)
- Data: CXIDB32-LCLS-Nov-2014-CSPAD..
- Only frames where SNR of the pixel is above 3 are shown.

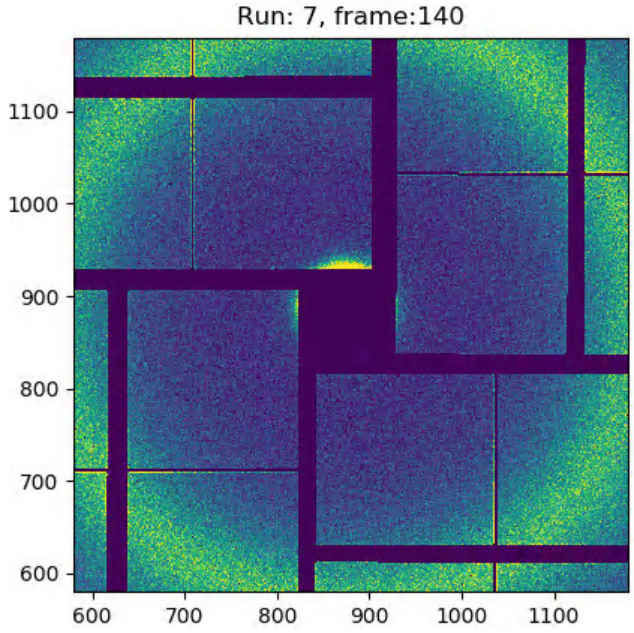


How to use deep learning?

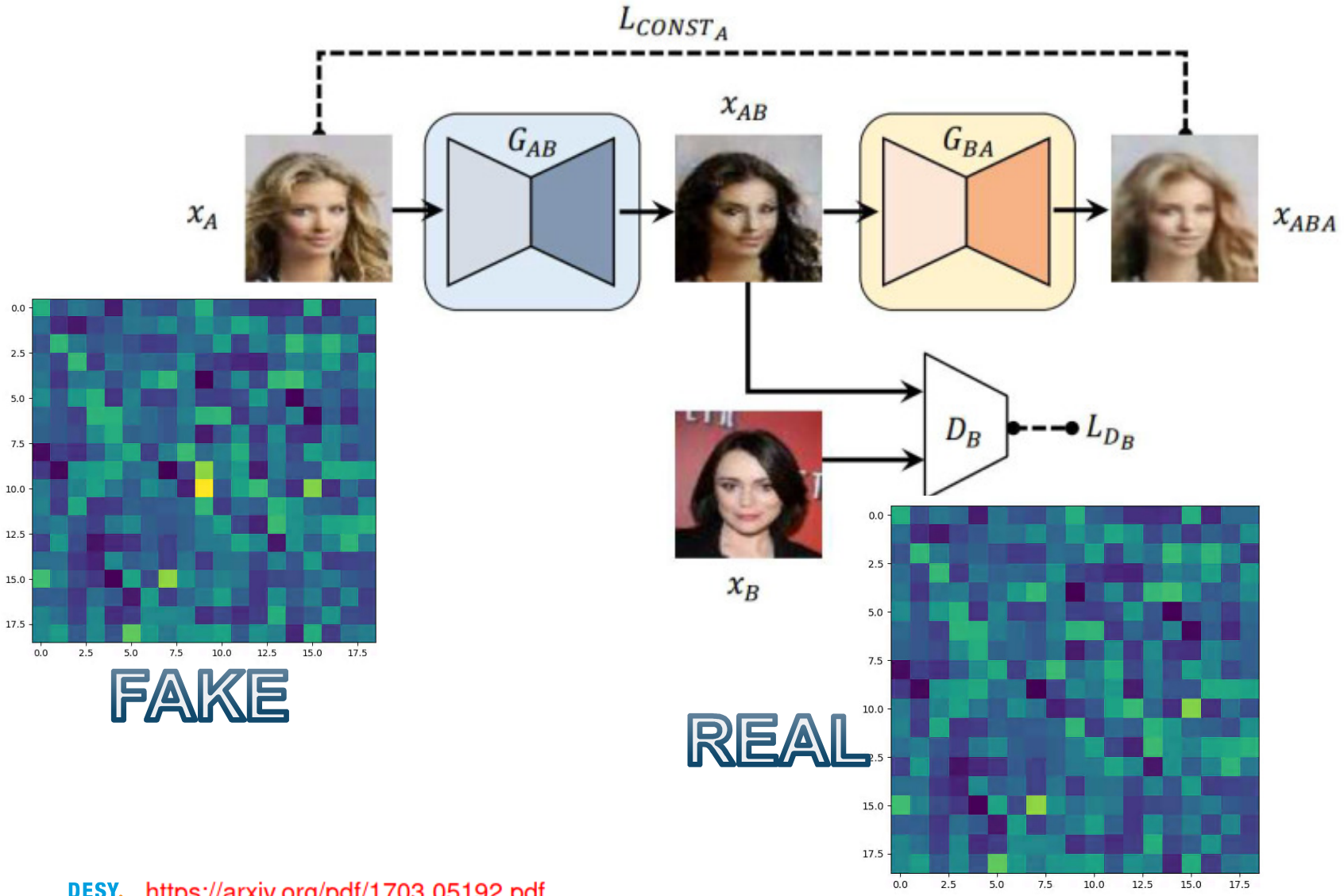
- Adversarial training



- I am trying pix2pix currently
- Questions:
  - How to divide image into parts ?
  - How many neural networks?
    - Make transfer learning possible?
  - How many Bragg peaks?
    - How large the training dataset?
- Anomaly detection using non-hits



Adversarial training by pix2pix



Thank you

Contact

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