Installation and Performance of Jungfrau Detectors at Diamond Light Source

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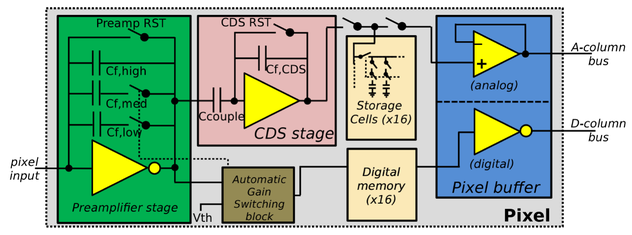
Jungfrau

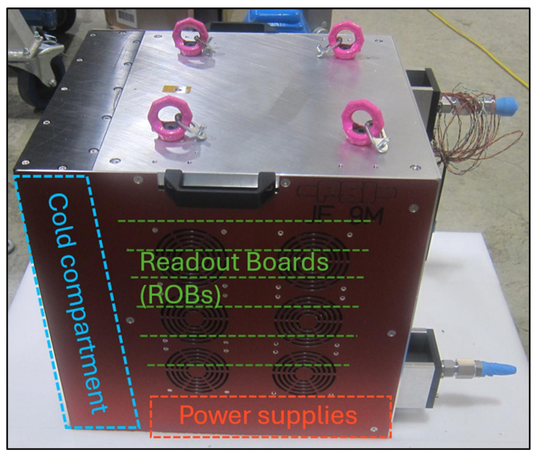


Jungfrau pixel architecture

Jungfrau is a modular detector family, based on tiling 0.5 Mpixel modules. A module uses 4x2 ASICs, bump bonded to a single sensor. Pixel size is 75µm square. Sensors are 320µm Si. Very large dynamic range, from single photon to 10^4 photons/frame, is enabled by integrating the input charge, with adaptive gain provided by switching feedback capacitors. Continuous Frame rates up to 2.2kHz are available and pixel output is encoded by a 16 bit number, giving data rates near 20Gb/s per module. Power consumption is near 40W per module. The integrating approach requires cooling the sensors to below -10ºC.

Services for 9M

- Standard European 3-phase ac mains
- Chiller 1 (sensors): Lauda VC5000, -15ºC flow, 1.3kW capacity, 3.2 bar pump
- Chiller 2 (power supplies): SMC HEC006A5B, 20ºC
- Readout boards (ROBs) are fan cooled
- Dry air purge for cold compartment
- Copper network for slow control
- Fibre network for data, 850nm MM, 9 x 40Gb/s



Jungfrau-9M

Interlocks for 9M

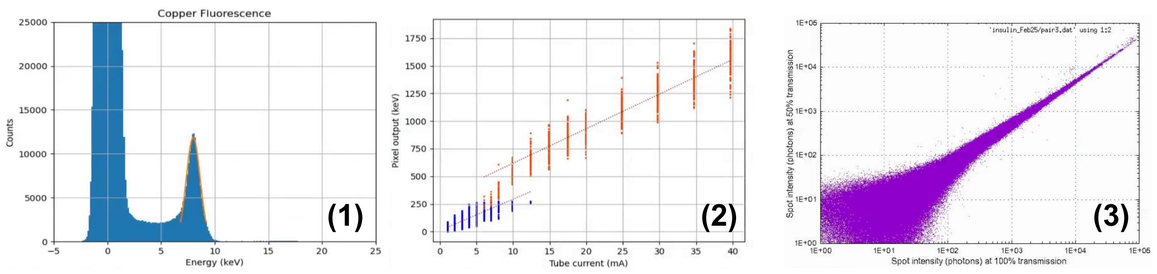
Potential failure modes
- Cooling failure - overheating of front ends
- Dry air failure - condensation on front ends
- Condensation on ROBs, if cooled but unpowered

Sensors for Interlocks
Installed as standard by PSI:
- Sensirion SHT-35 sensor for temperature & RH

Added in DLS installation:
- K-type thermocouple
- Honeywell HIH-4000-003 sensor for RH
- Belimo 22PF-1UC flow meter on cold flow

Jungfrau 1M at DLS

Jungfrau-1M evaluated in Lab and on Diamond Beamline I24. Examples:
- Darks behaviour
- Single photons using X-ray tube (Cu-Kα, 6keV) **(1)**
- Direct beam from X-ray tube → gain switching **(2)**
- Diffraction from known samples (e.g. insulin) → linearity, dynamic range **(3)**

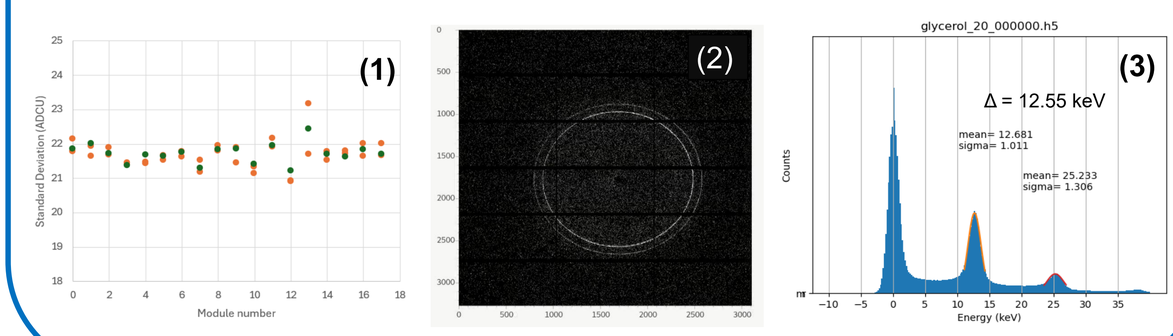


Although a switching discontinuity exists in raw pixel data, it is small under sparse illumination and doesn't affect integrated diffraction spots significantly.

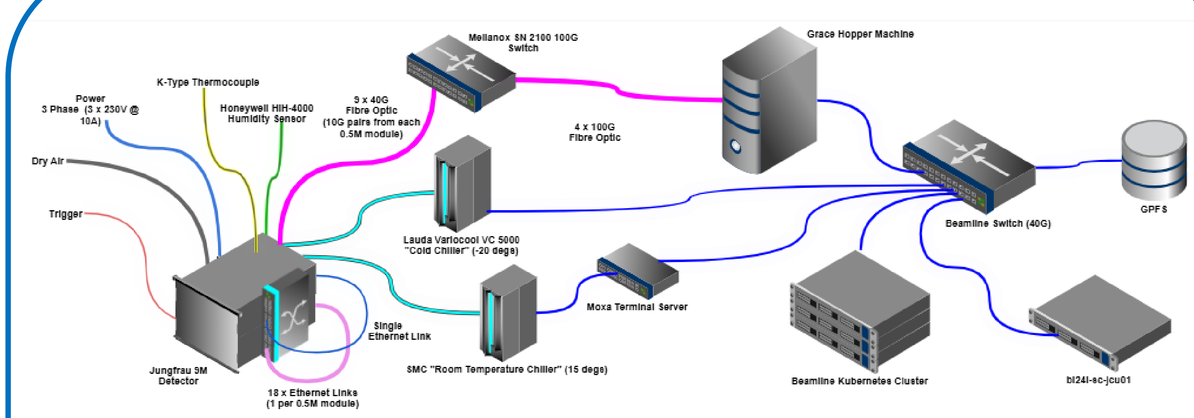
For more details: J.Matheson et al., Journal of Synchrotron Radiation: Volume 33, Issue 2 Pages: 331-343 (20th February 2026)

Acceptance tests for 9M

Jungfrau-9M tested on Diamond Beamline I24
- Power supply currents
- Compare noise maps before/after shipping **(1)**
- Check reconstruction of data streams using LaB6 rings **(2)**
- Single photons calibration check on Beamline I24 (12.4 keV) with glycerol as an amorphous scatterer **(3)**

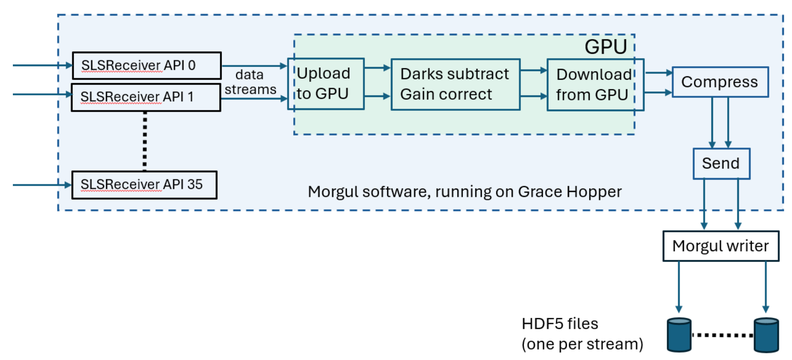


Hardware Layout for 9M



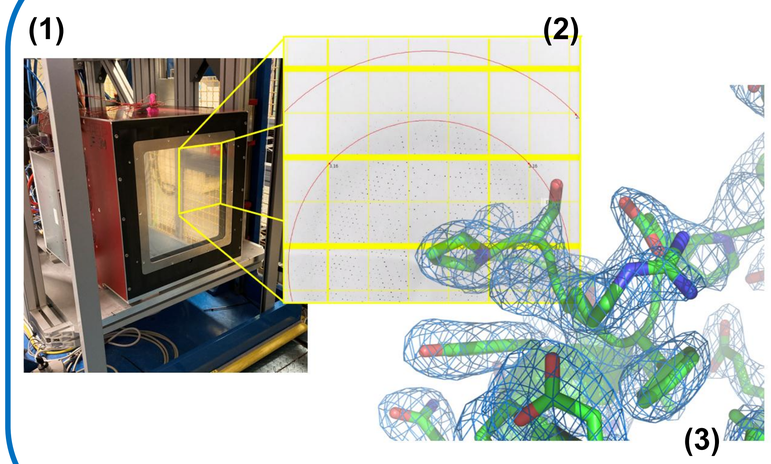
- "Grace Hopper" - QuantaGrid S74G-2U server
  - Hyperscale Products | QCT- Quanta Cloud Technology
  - https://www.nvidia.com/en-gb/data-center/grace-hopper-superchip/
- Trigger from beamline motion using Quantum Detectors PandaBox

DAQ Software for 9M



- Single Grace Hopper Uses 57% of GPU capacity at 1kHz frame rate
  - Measured using the NVIDIA-SMI utility
- Software optimisation expected to allow 2kHz running
- Bottleneck is memory access for darks subtraction / gain correction

9M in use



Jungfrau-9M detector on Beamline I24 **(1)**

Section of a diffraction image from human deacetylase (1kHz) **(2)**

Resulting electron density obtained from a single crystal at 100 K **(3)**

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