# Free-running Sync correction for MV-imaging with aSi:H flat panels

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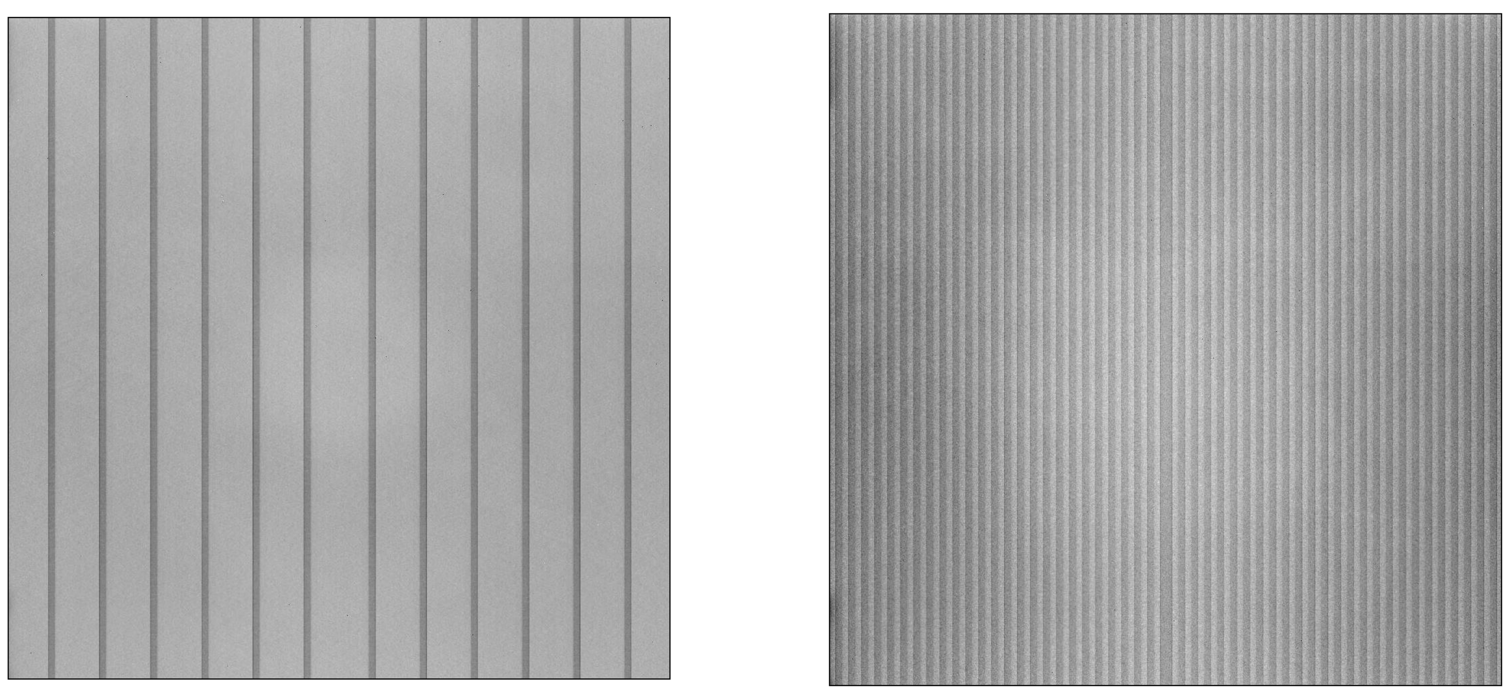
## Purpose

In radiotherapy **electronic portal imaging devices** (EPIDs) for MV-imaging are a major component in patient's treatment verification and machine's QA tasks. These applications show the need for a reliable tool to measure absolute and relative doses and provide image material of high quality.

When running an **amorphous silicon (aSi:H) flat panel** in **free-running mode**, frames are taken with a constant frame rate while the beam is on (Elekta platform). The main reason for this setting is associated with Multilevel Gain calibrations and corrections as applied in online imaging during radiation. However, this mode leads to challenging synchronization artefacts which are presented as **light and dark vertical stripes - the Sync stripes**. These artefacts are getting worse when irradiating with lower dose rates or displaying single frames.

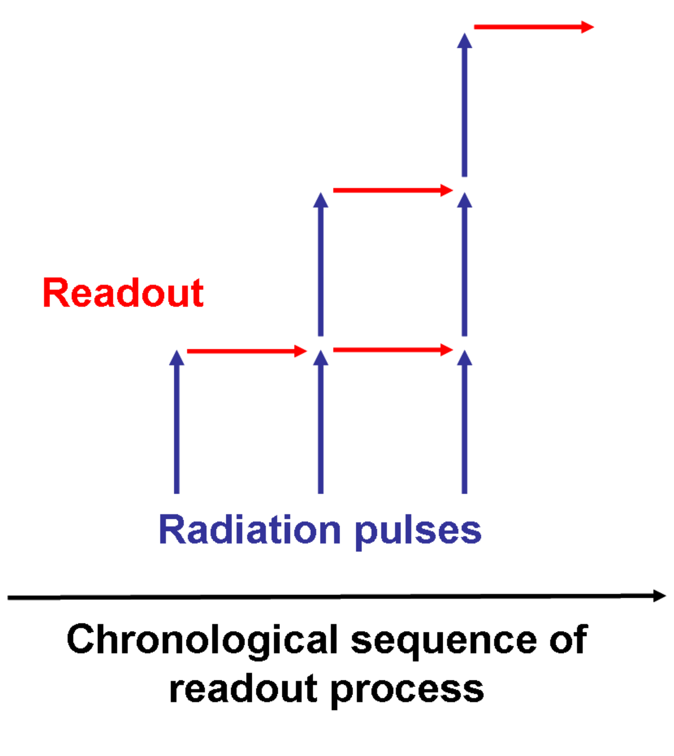
Former observations have shown that the pulse repetition frequency (PRF) correlates with the number and width of stripes due to the number of charge pulses accumulated per frame. This implies a **multiplicative correction**. By analysis of the specific properties of Sync stripes a theoretical model was deducted to describe and correct the artefacts.



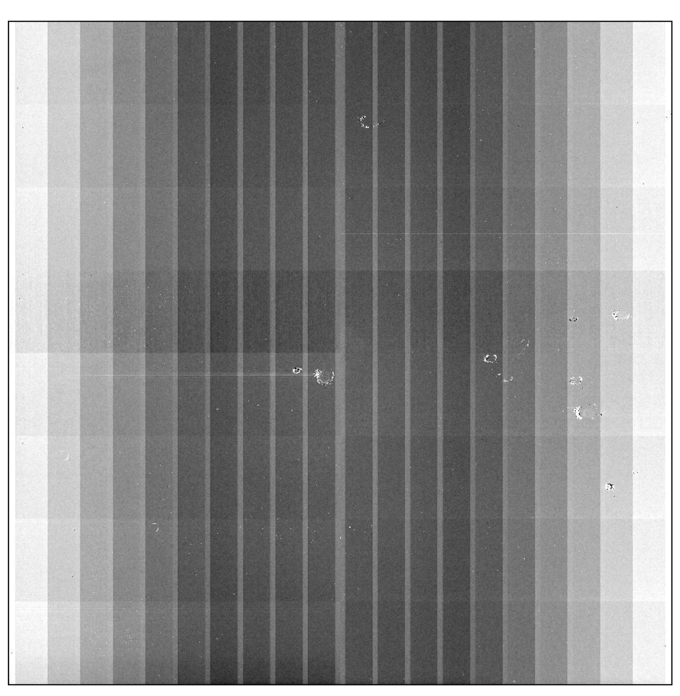
*Multilevel corrected images with Sync stripes at PRF 25 and PRF 100*

## Methods

The aSi:H flat panel by Perkin Elmer (type RID 1680 AL5) comprises 2 x 8 subpanels, each 512 x 128 pixel with separate readout electronics, and has a total size of 1024 x 1024 pixel. The **readout** is performed sequentially **column wise from the outside** of the active area **to the centre** of the detector. This is done simultaneously for the left and right panel side. Subsequently, column readouts are correlated with an increasing time stamp chronologically. The readout of one frame comprises 512 image columns and 16 pre- and postamble columns and takes 433 ms, i.e. 796 µs/column. While the beam is on, radiation pulses are emitted and induce a signal detected at the panel. Depending on the PRF a certain number of pulses is accumulated during the readout of one frame. The **interference of radiation pulses with column readout** presents itself by the expressive Sync stripes. Especially when looking on a startup frame the effect of the simultaneous pulsing and readout is seen. It leads to increasing steps towards the panel centre with a dose of 1/64 MU per step (on Elekta Synergy platform).

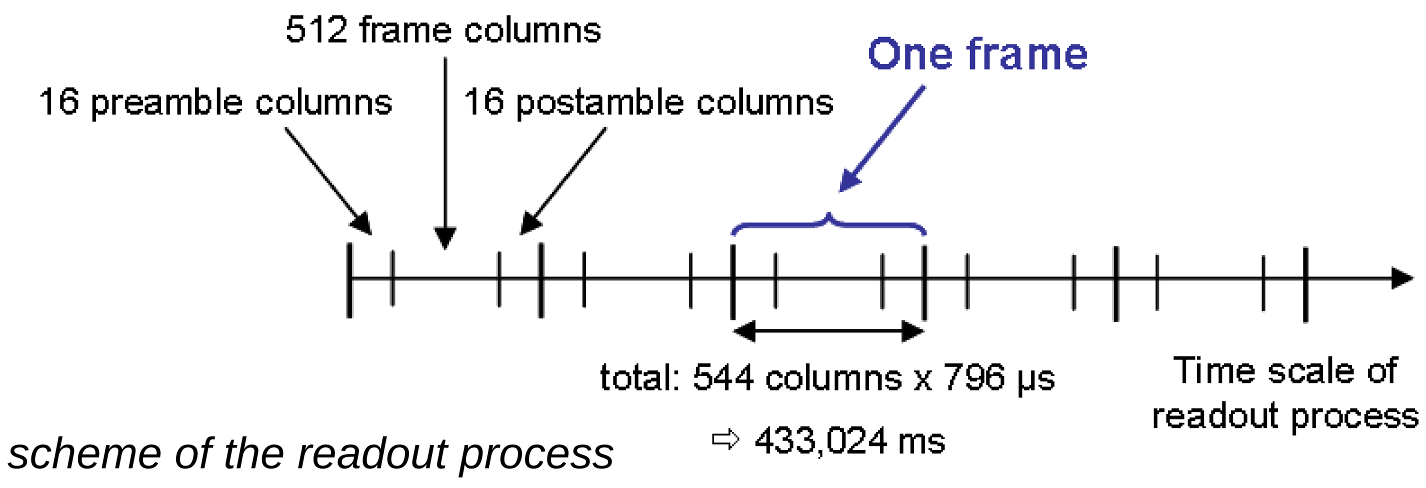



*Pulsing-Readout superposition*



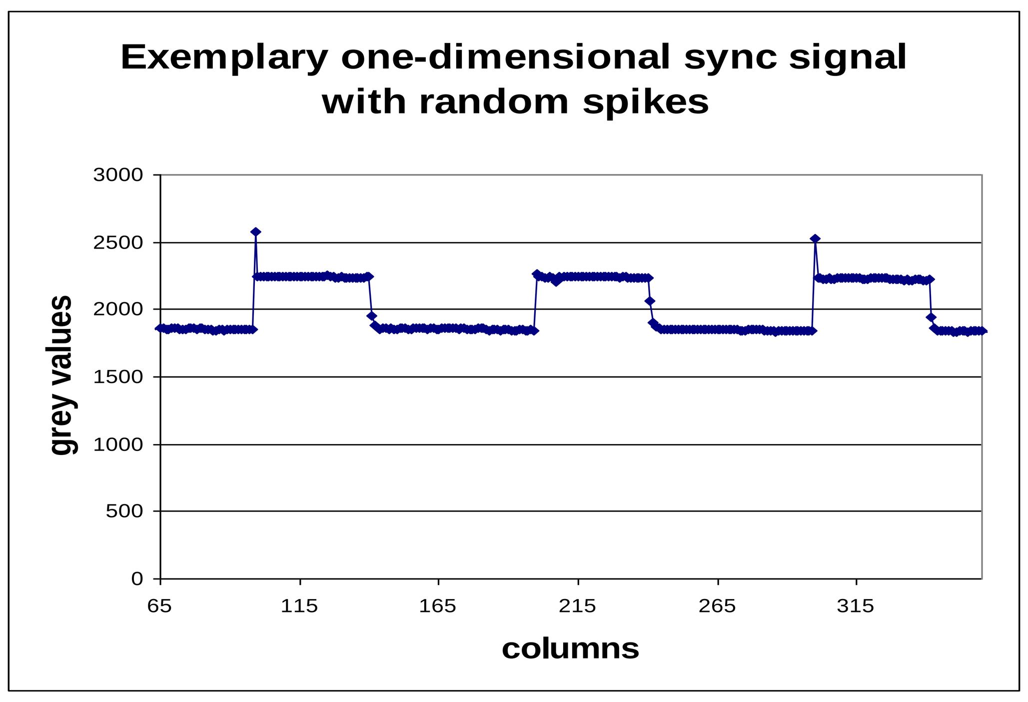
*Startup frame with stepped pattern*

A **theoretical model** was introduced which describes the interferences of the panel's readout procedure with the linac's PRF. For each PRF the amplitude of the periodic Sync signal as well as its period width can be calculated analytically. It has to be considered that this period is of floating point precision, so Sync stripes do not map directly to a pixel.




*Graphical scheme of the readout process*

The correction is done on a **per frame** basis by finding the remaining phase shift of the Sync pattern (self-triggered!) and applying the pre-defined correction factors. In an additional **post-processing** step, randomly appearing spikes as well as inaccuracies because of the floating-point period can be corrected separately.

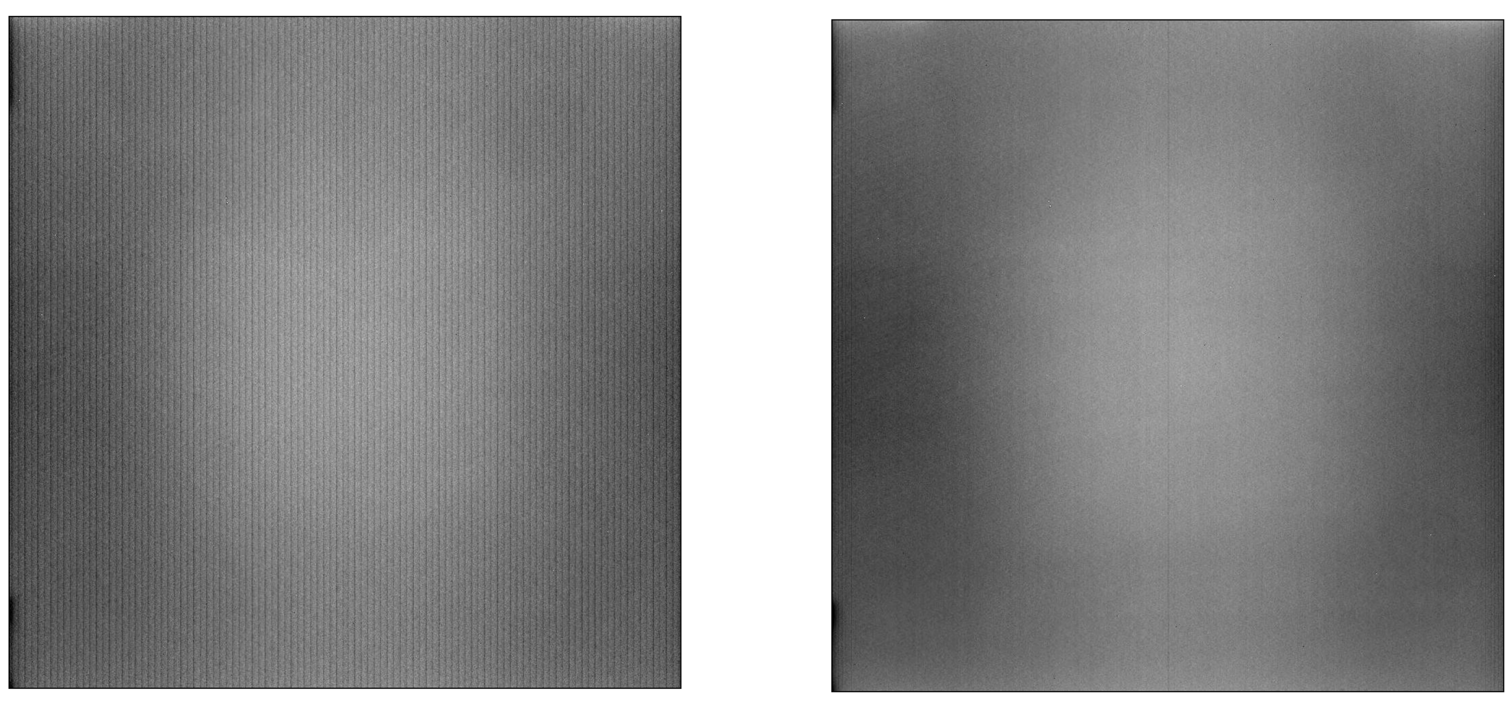



*Plot of an exemplary one-dimensional sync pattern*

During an evaluation phase, single frames were taken at different PRFs (Elekta Synergy platform 6.25, 12.5, 25, 50, 100, 200, 400 pps) and further the effect of the correction method was analysed.

## Results

The **Sync correction of single frames** at various PRFs is **successful** – the stripe artefacts are eliminated. Additionally, the phenomenological post-processing improves the result in numerous cases: Especially for the lower dose rates, the spikes can be eliminated while for the higher dose rates the inaccuracies at the edges can be minimized.



*Single frames taken at PRF 200 – Left: without sync correction, Right: after applying the free-running Sync correction*

## Conclusion

In contrast to a former phenomenological approach no additional calibration is necessary and the determined correction factors are far more exact. Considering clinical practice, the correction method **improves absolute dosimetry measurements** as well as new **real-time applications in IGRT**. During **online imaging**, even single frames can be displayed in high quality and for low-MU imaging at least **one frame is sufficient** for a clinically appropriate image. In near future verification tasks of VMAT treatments with varying dose rate will become feasible.