

Metode-testing

Modulation Transfer Function og endringer i røntgenrørfokus på eksponeringslaber

10.November 2025

Jarle Rambo Sølje, Ph.D.

Medisinsk fysiker

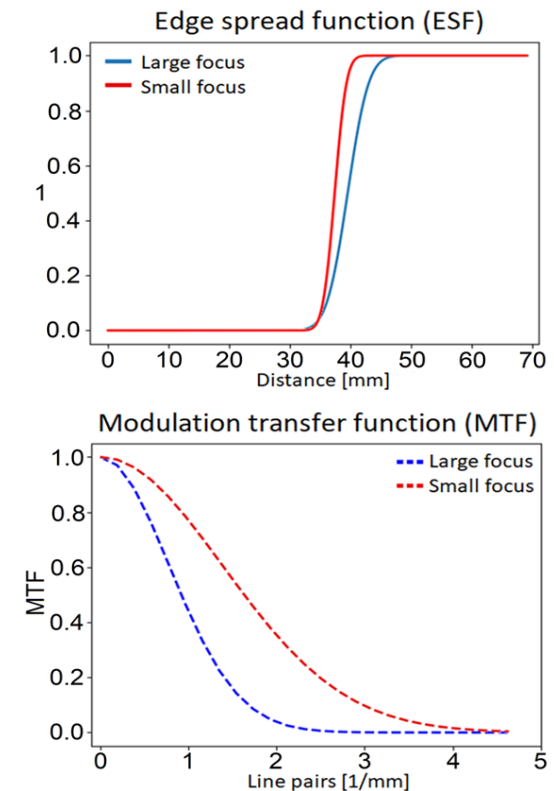
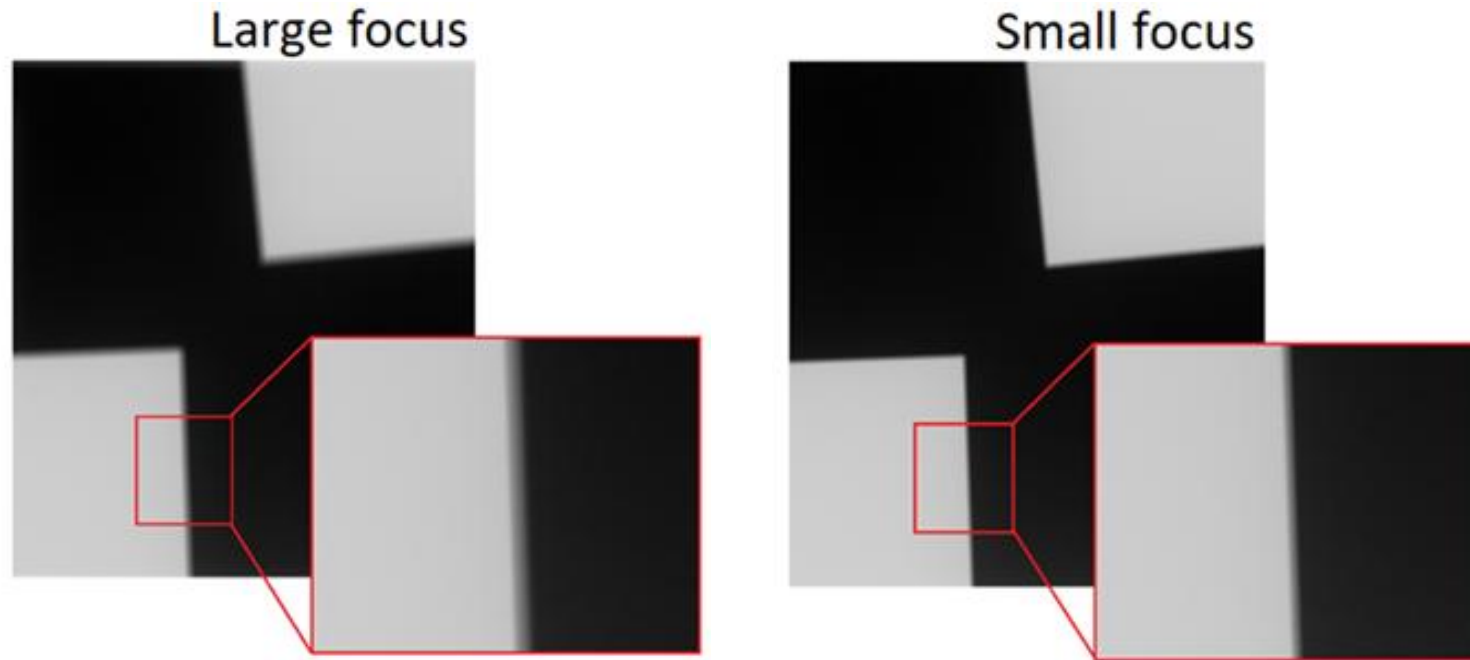
Avdeling for fysikk og bildeanalyse

Epost: jaraso@ous-hf.no

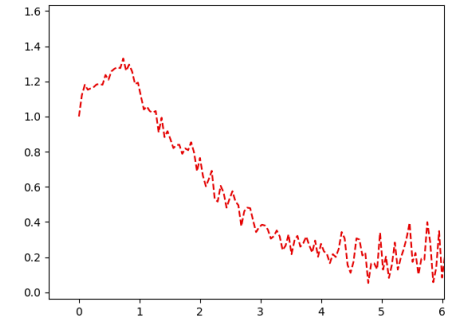
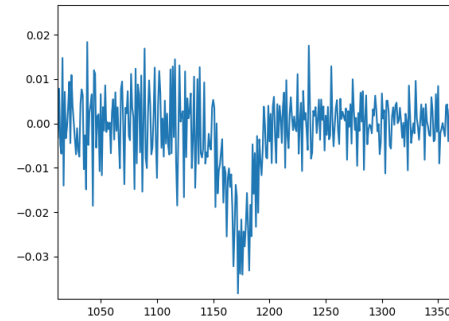
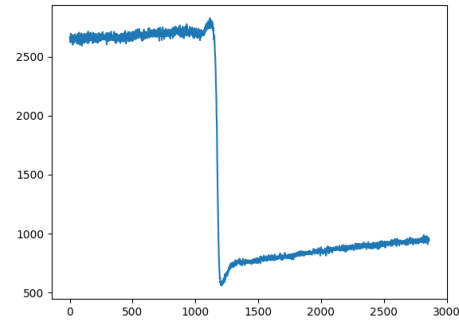
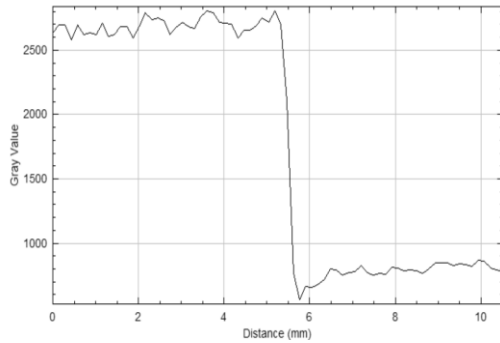
Endringer i fokus vil endre MTF

En av grunnene til at røntgenrør må byttes ut er fordi fokuset ryker

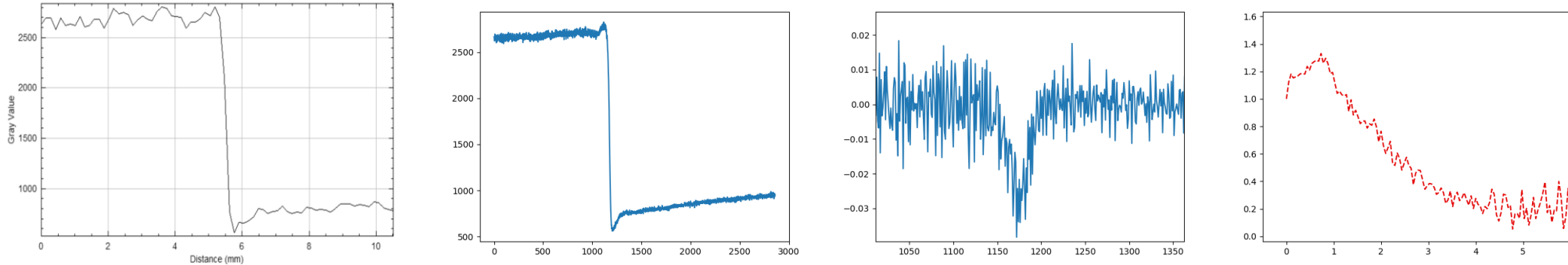
Kan MTF fortelle oss noe om helsen til røntgenrøret, eventuelt forutse når det er i ferd med å ryke?



Skrå kant -> Oversample ESF -> LSF -> MTF



Skrå kant -> Oversample ESF -> LSF -> MTF



Viktige punkter:

- Sampling i ESF vil påvirke MTF
 - Mengde og avstand mellom samplingspunkt
- Utfører kurve-tilpasning for å forhindre overestimering av MTF
 - Kan enten kurve-tilpasse ESF
 - Eller kurve-tilpasse LSF
 - Kurvetilpasningen vil påvirke MTF-kurven
- Kan også bruke en tynn vinklet wire i stedet for en vinklet skarp kant

Problemstillinger – Endringer i MTF

- Er det forskjell i hvordan oversamplingen utføres?
 - Sample gjennom å gruppere linjeprofiler - Buhr et.al, *Simple method for modulation transfer function determination of digital imaging detectors from edge images*, 2003
 - Sample basert på avstand fra piksel til en linje langs kanten - Ellen Wasbø et.al, [ImageQC](#)

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- Hvilken kurvetilpassning burde man bruke?
 - ESF: Error function, LOESS
 - (*LSF: Dobbel Gaussian, LOESS*)
 - (*Når burde man utføre kurvetilpasningen, på ESF eller LSF?*)

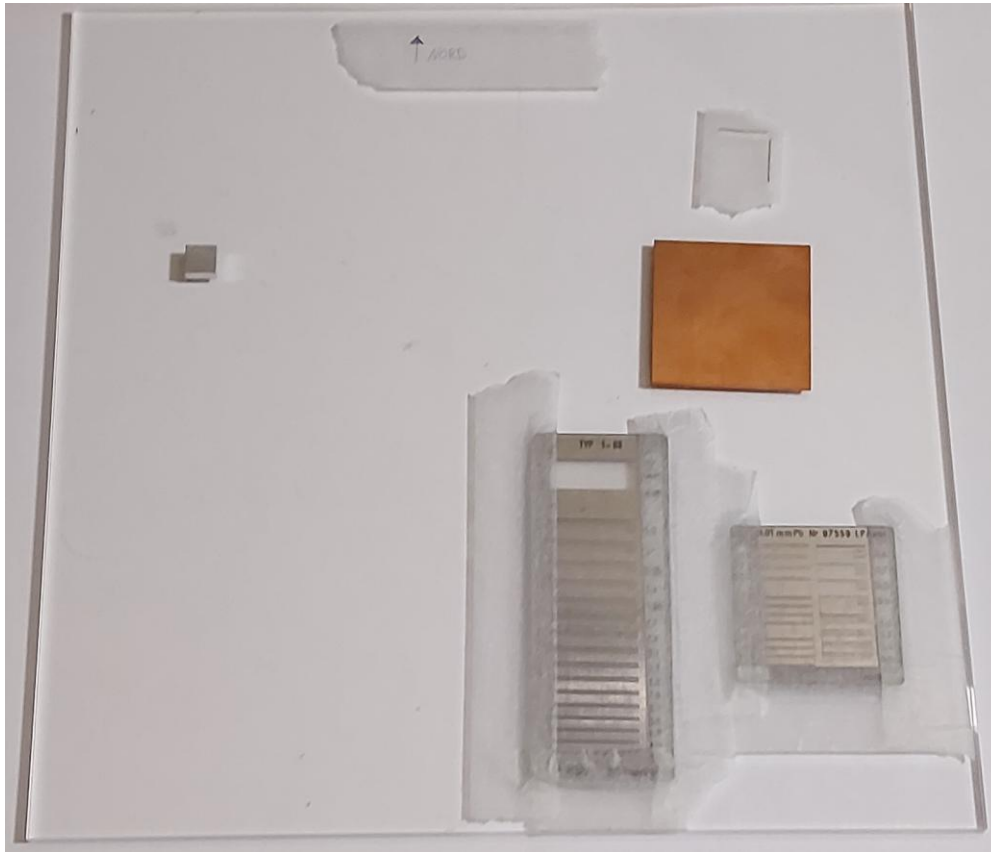
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 - (*Når burde man utføre kurvetilpasningen, på ESF eller LSF?*)
- Skrå-kant blir ofte ansett som det beste alternativet, men hva med wire?
 - Vil en være bedre på å fange opp endringer i lave/høye frekvenser enn en annen?
 - Hva med endringer i fokus?



Fantom

- Utgangspunkt i IAEA fantom

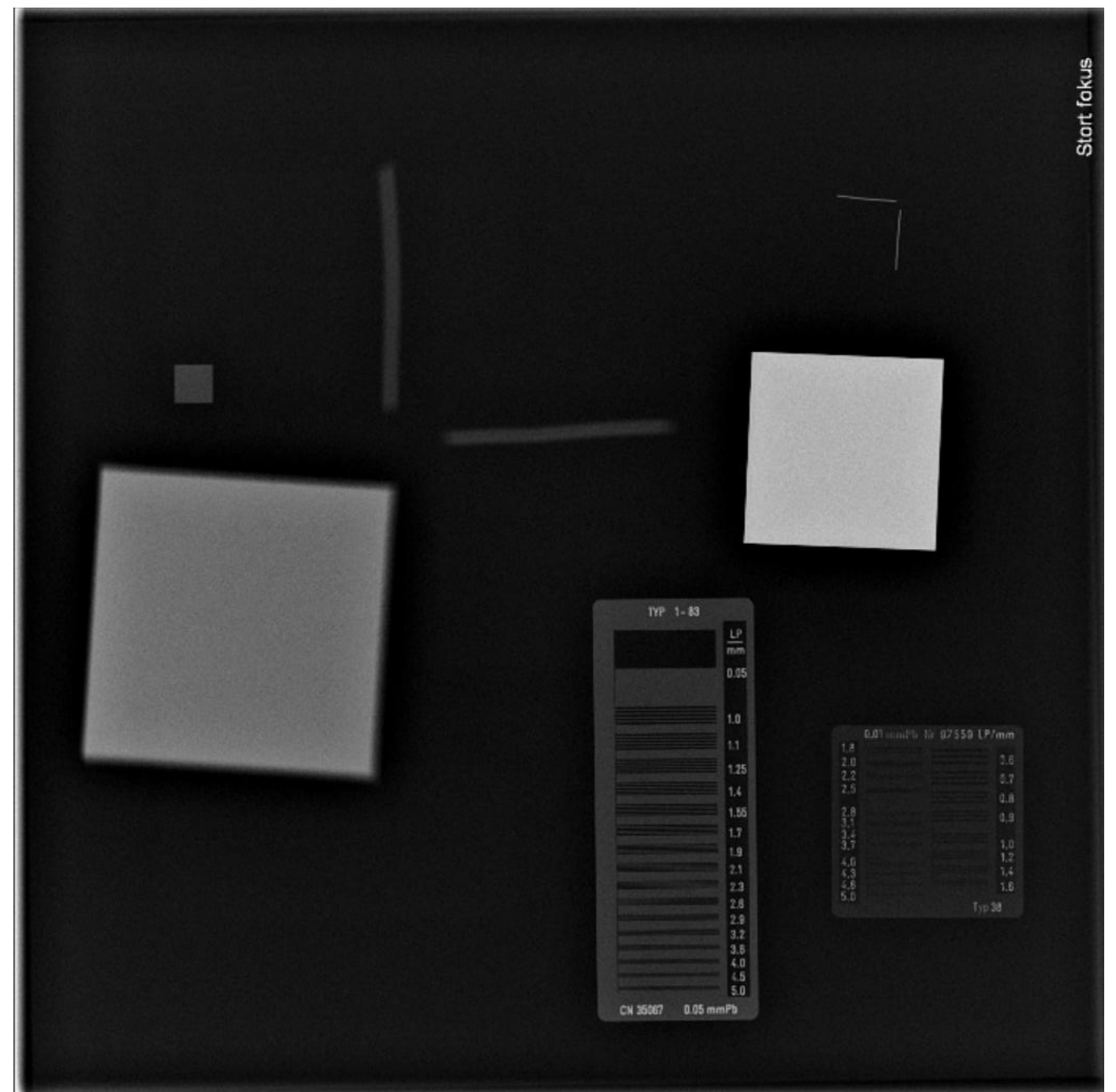
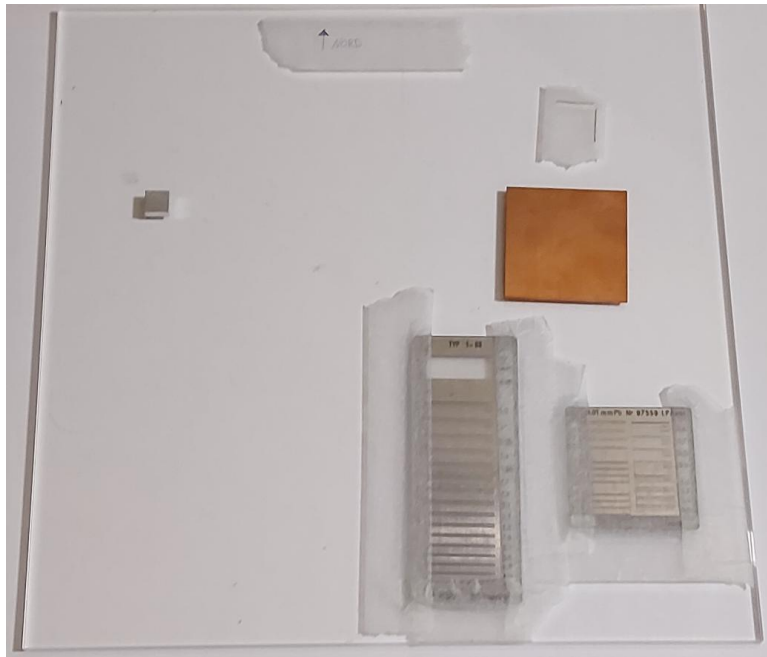


- 2 mm kobberplate



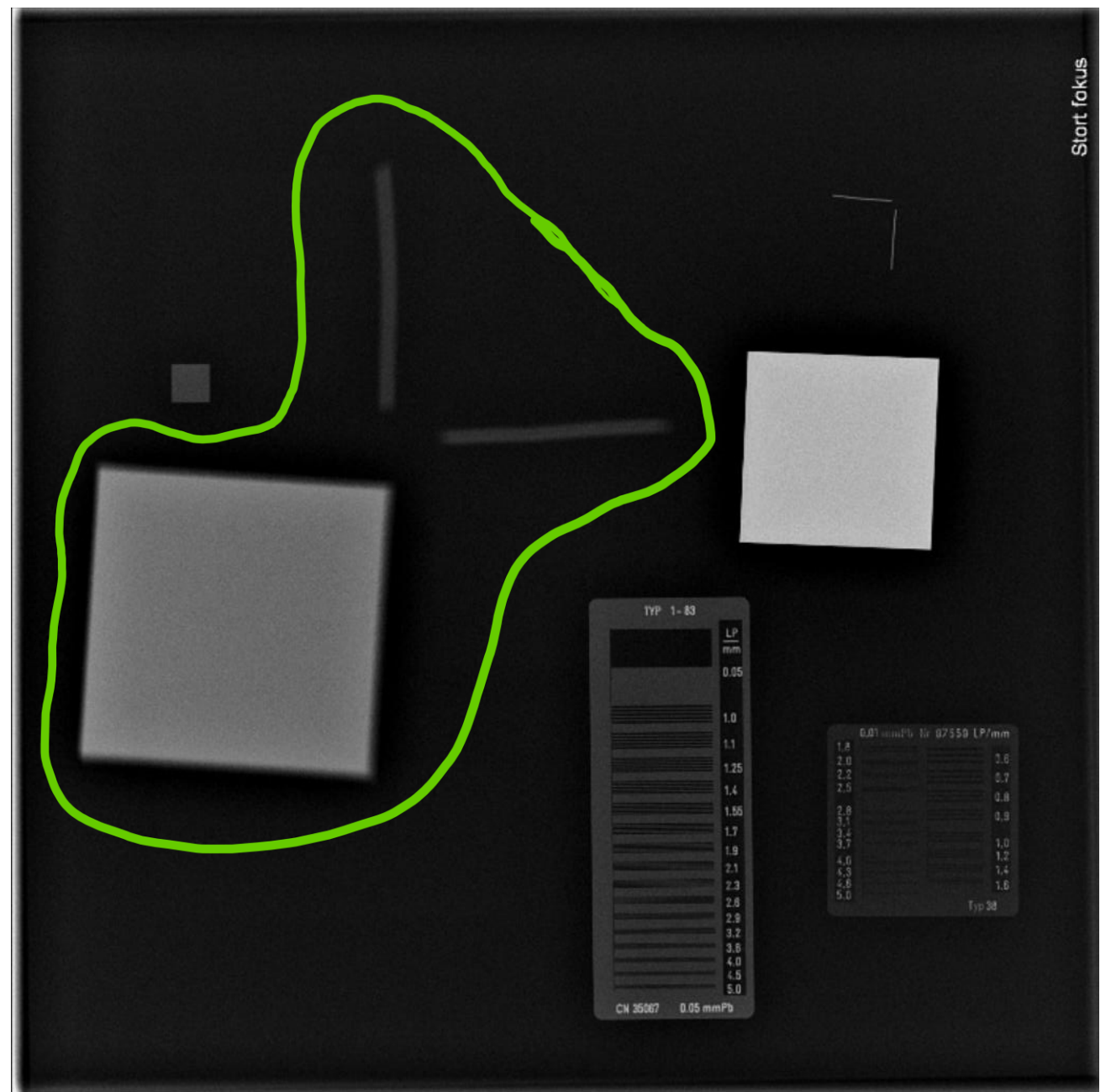
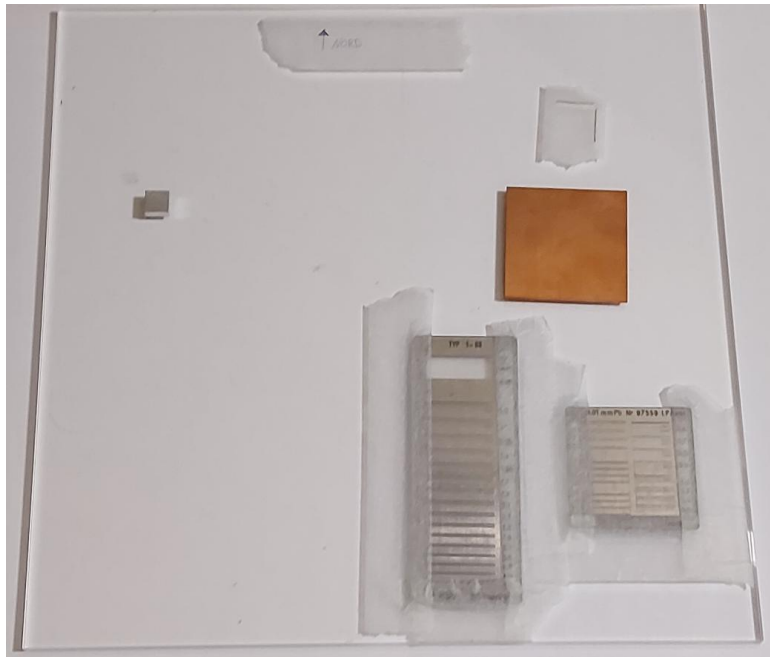
Fantom

- Røntgenbildet ser slik ut



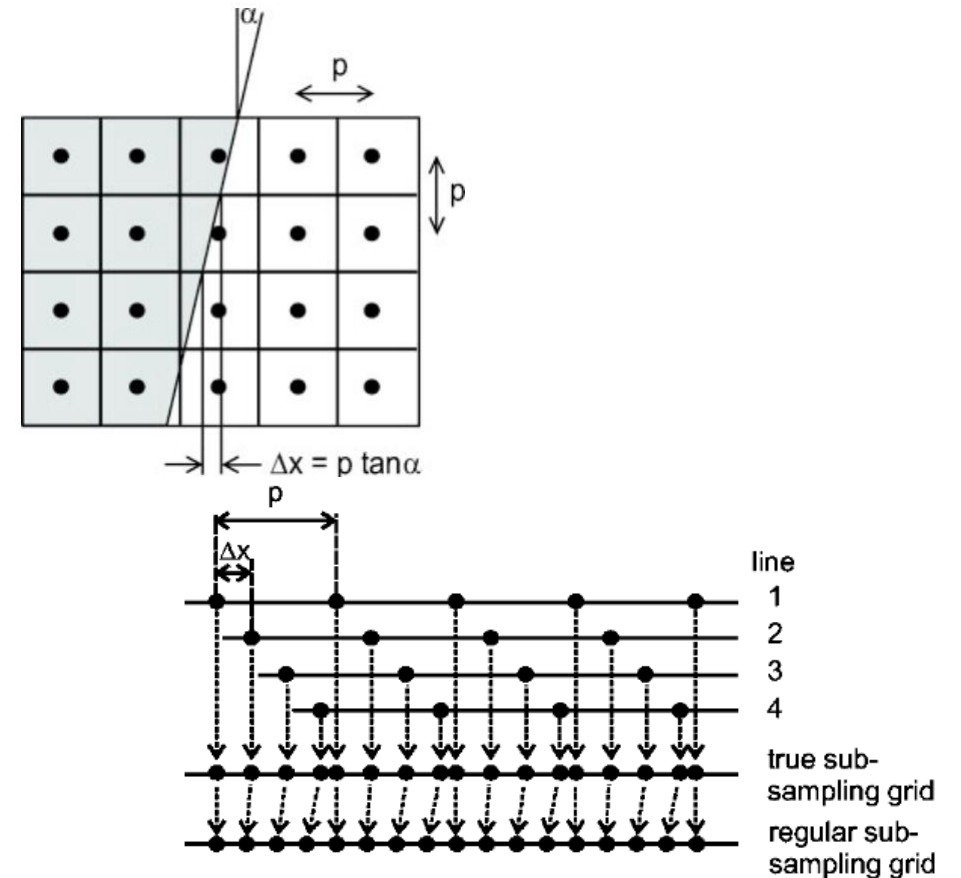
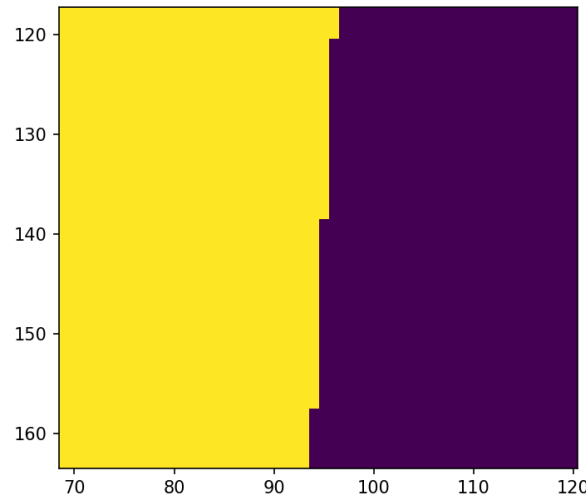
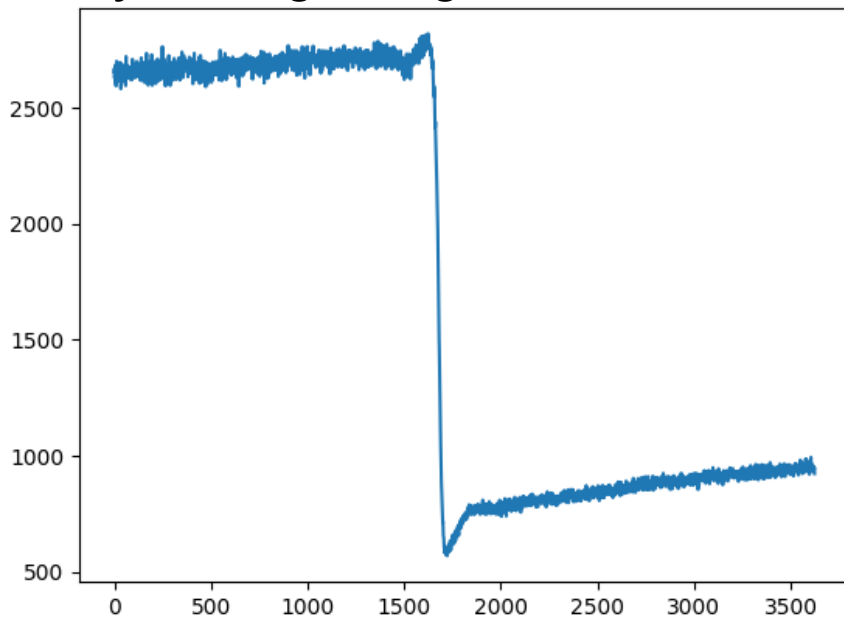
Fantom

- Røntgenbildet ser slik ut



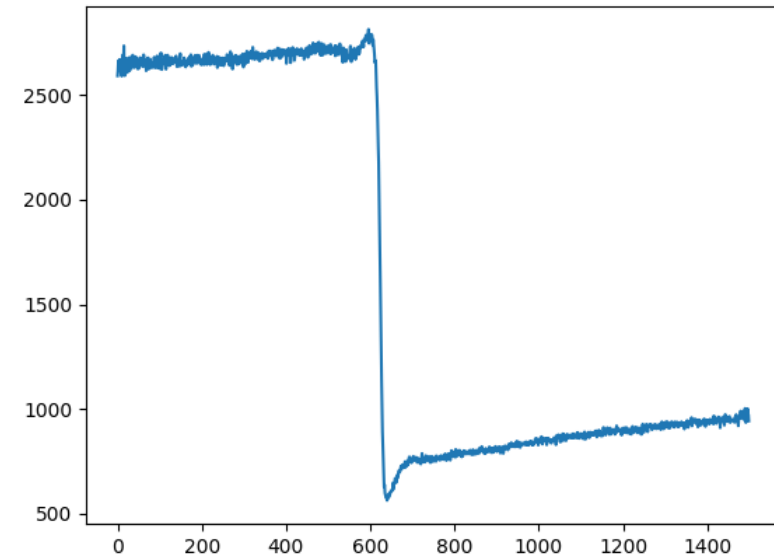
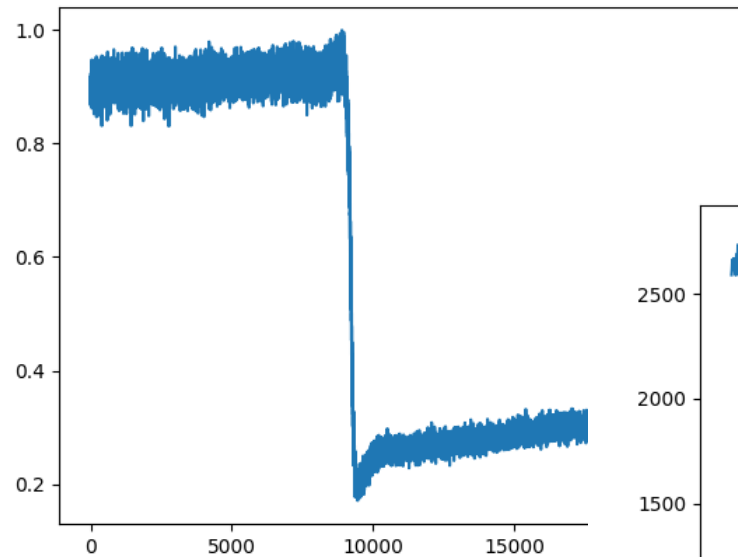
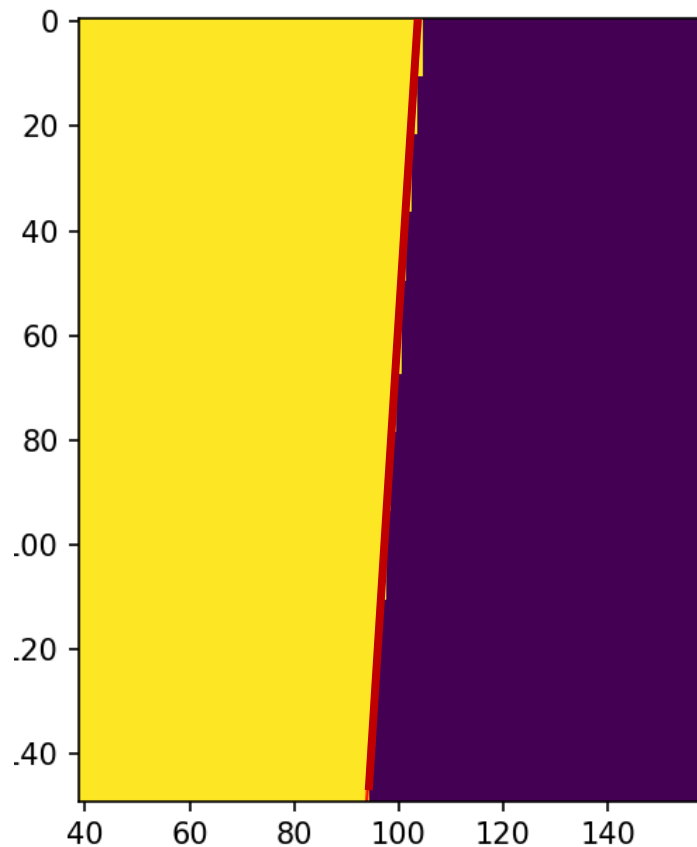
Hvordan utføre oversamplingen

Buhr et.al, *Simple method for modulation transfer function determination of digital imaging detectors from edge images*, 2003

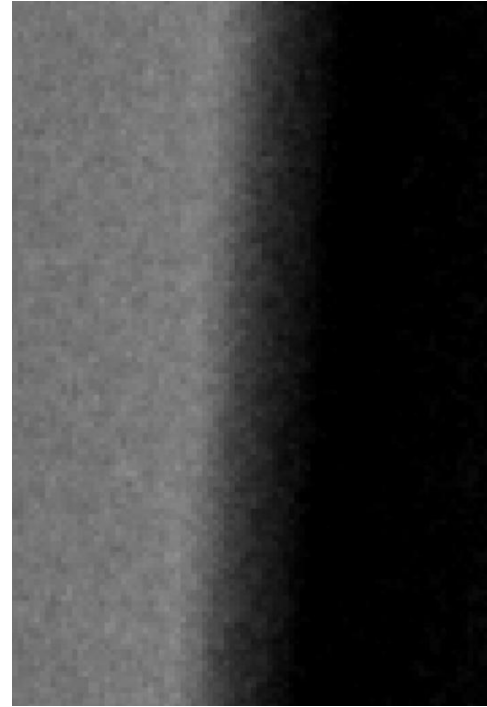
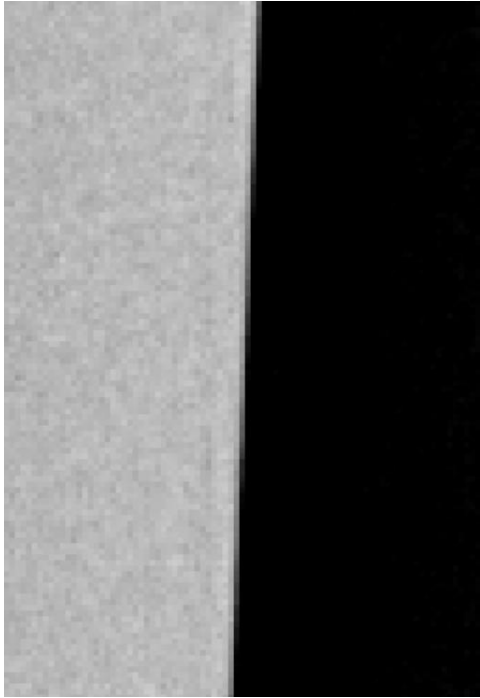


Hvordan utføre oversamplingen

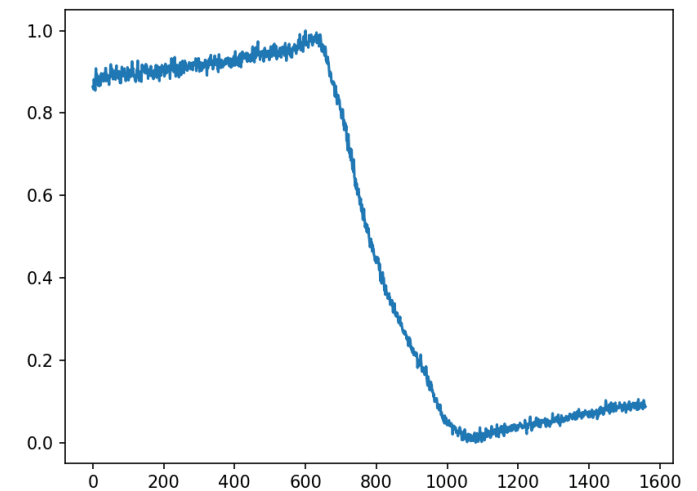
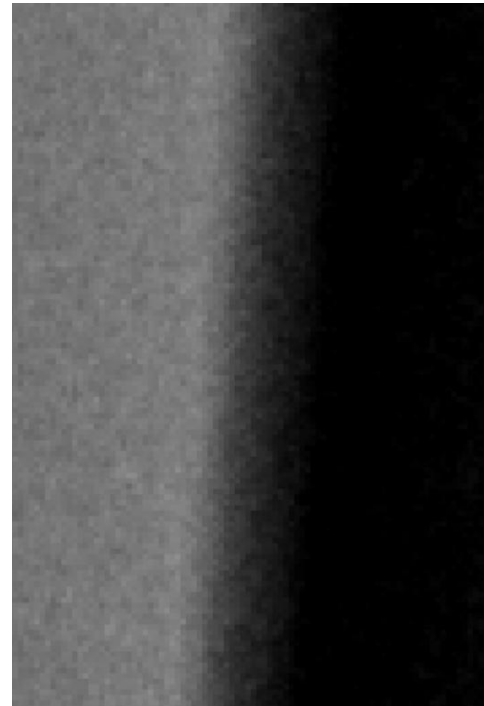
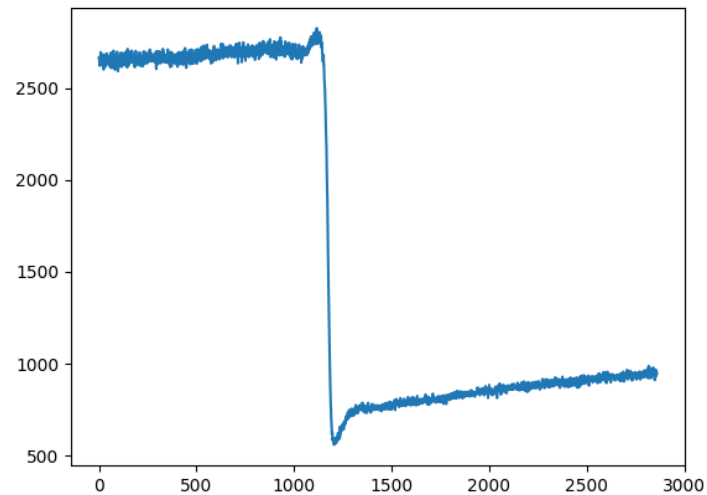
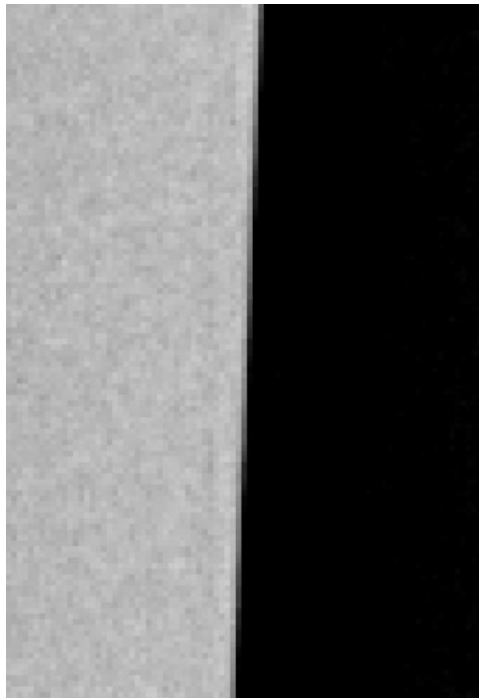
Wasbø et.al ([ImageQC](#))



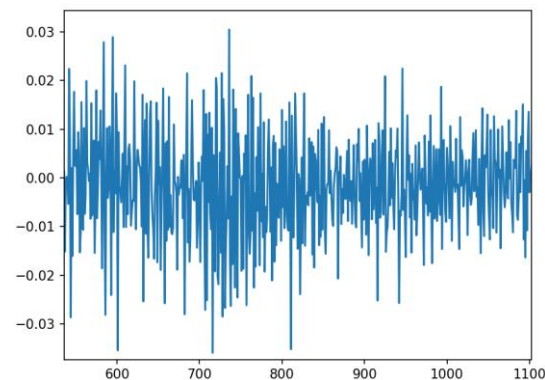
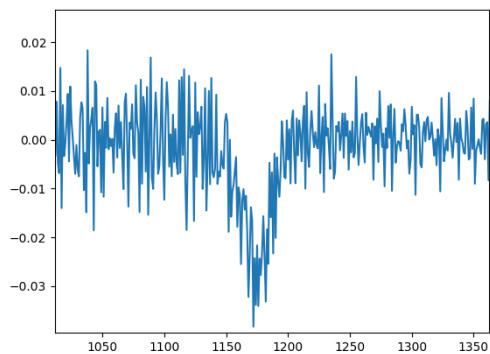
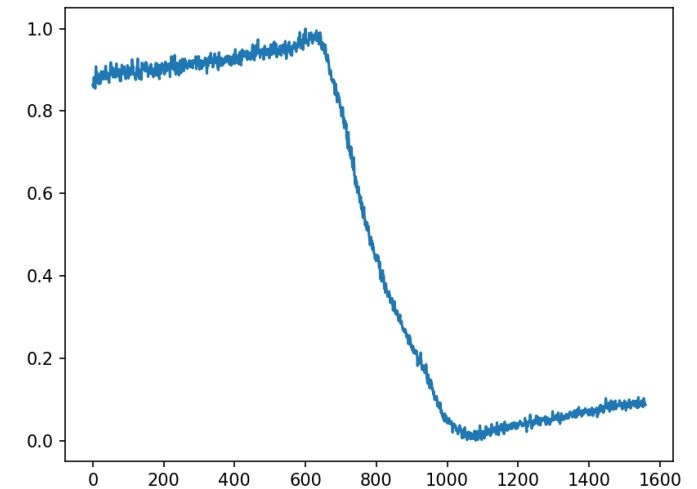
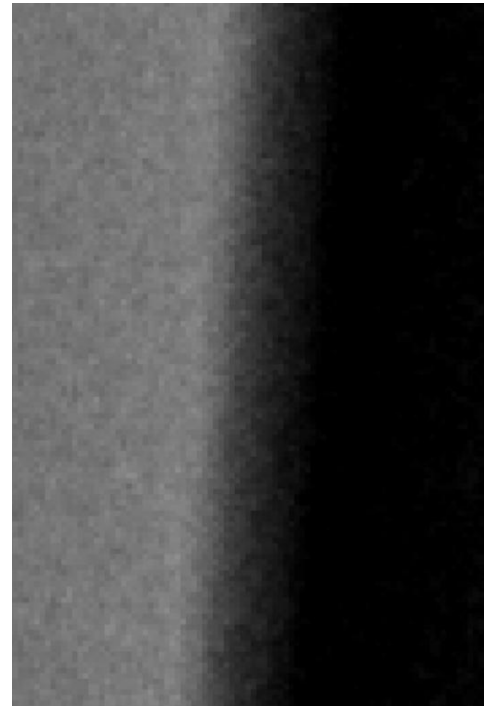
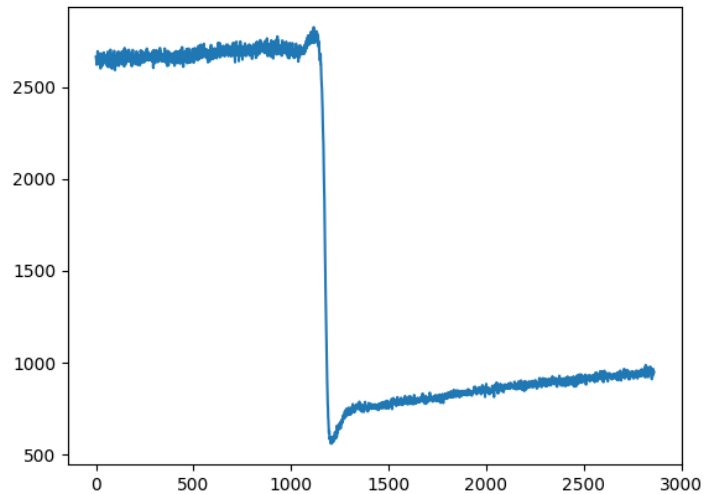
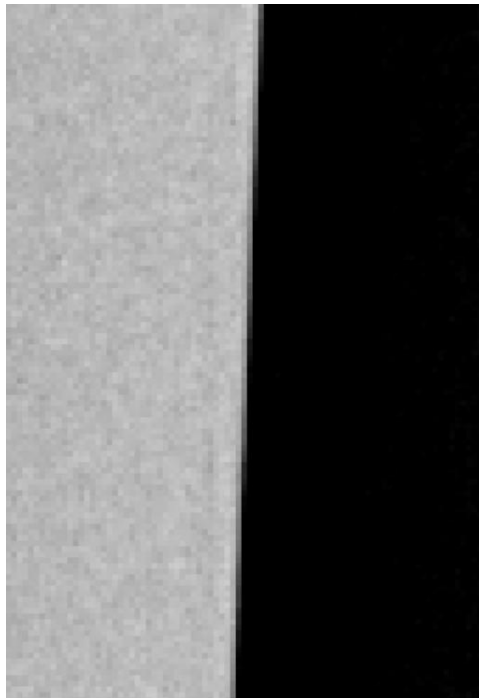
Får et problem med ESF...



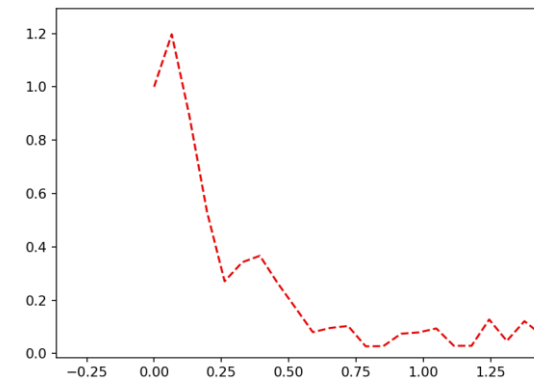
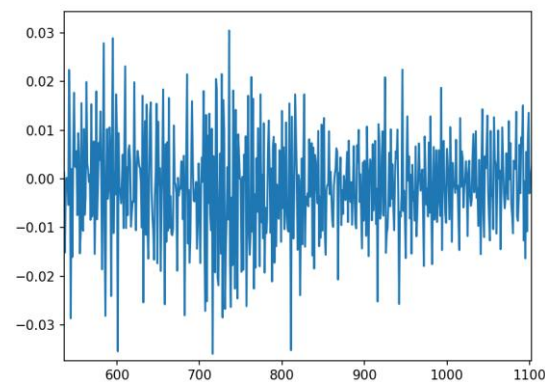
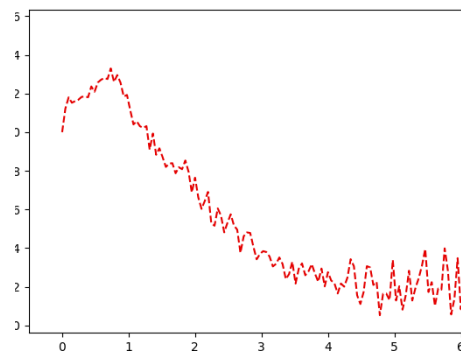
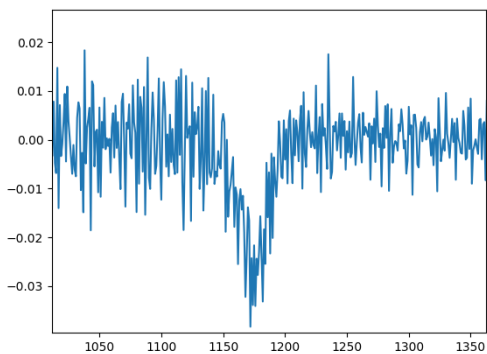
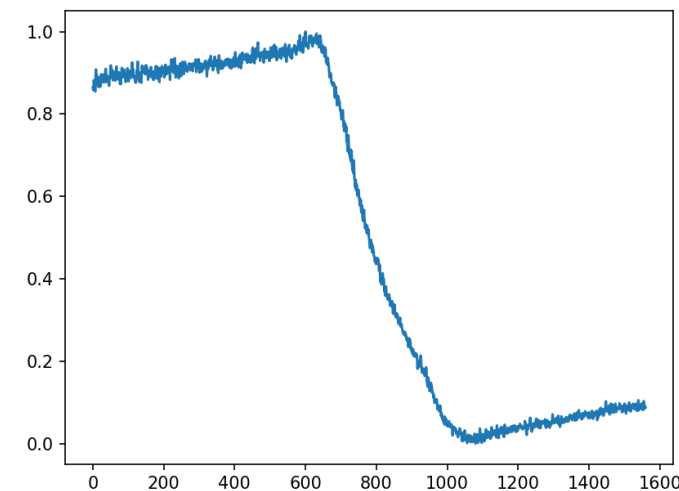
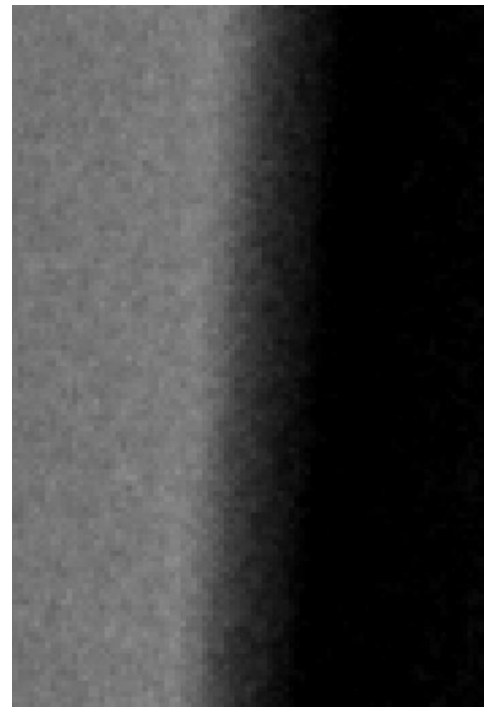
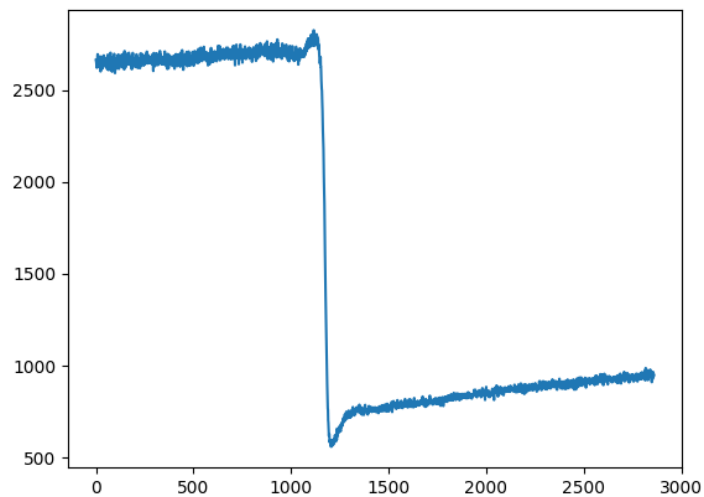
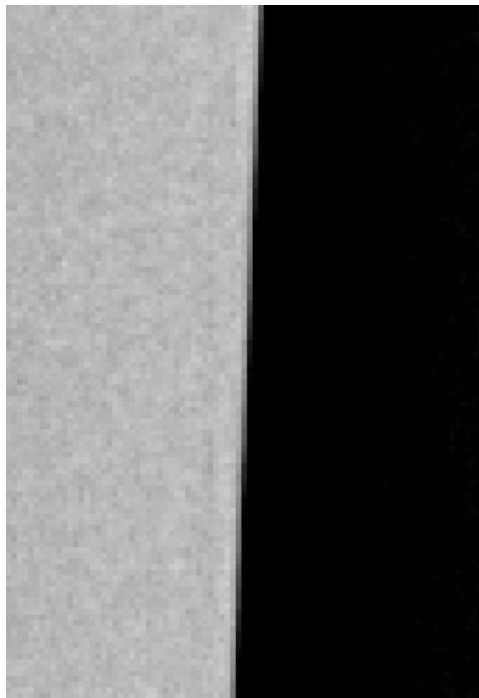
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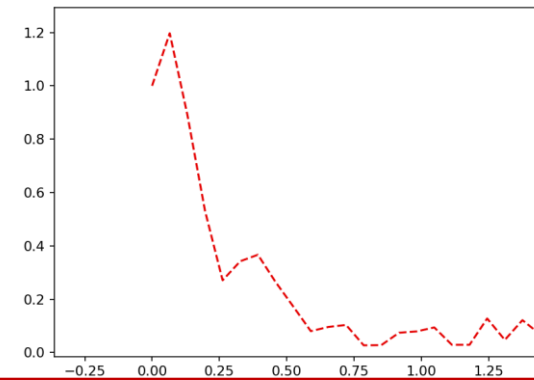
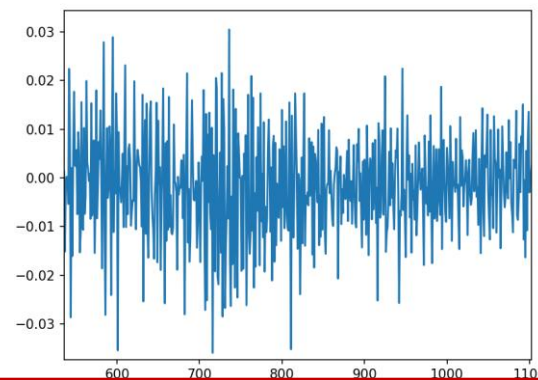
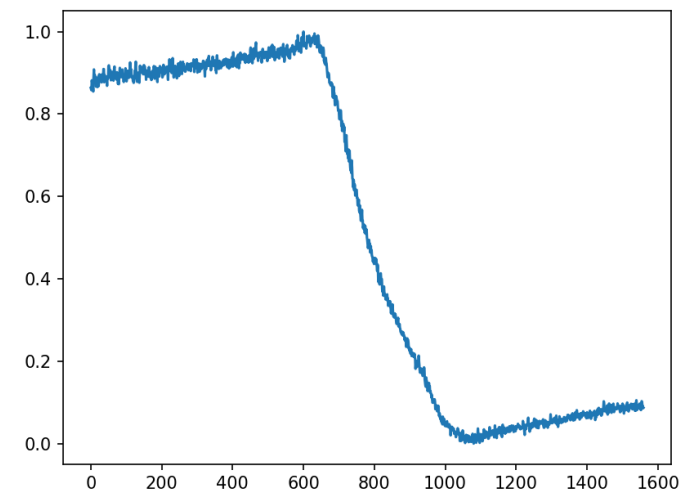
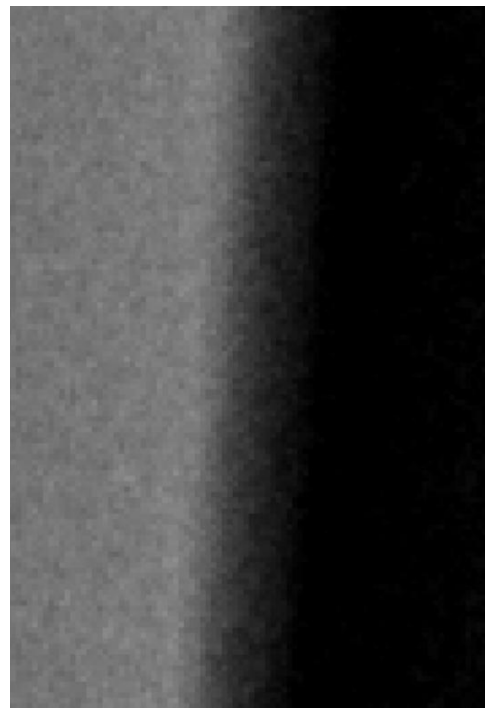
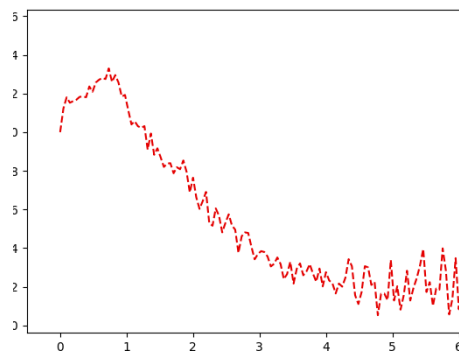
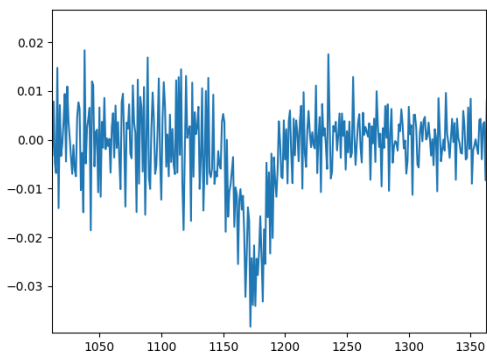
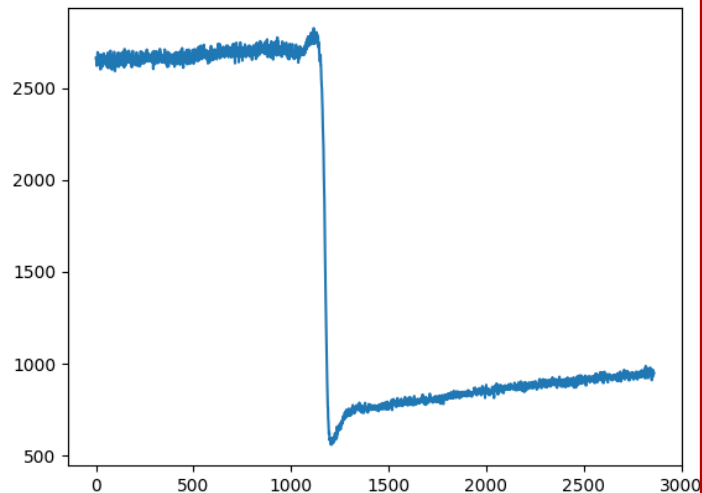
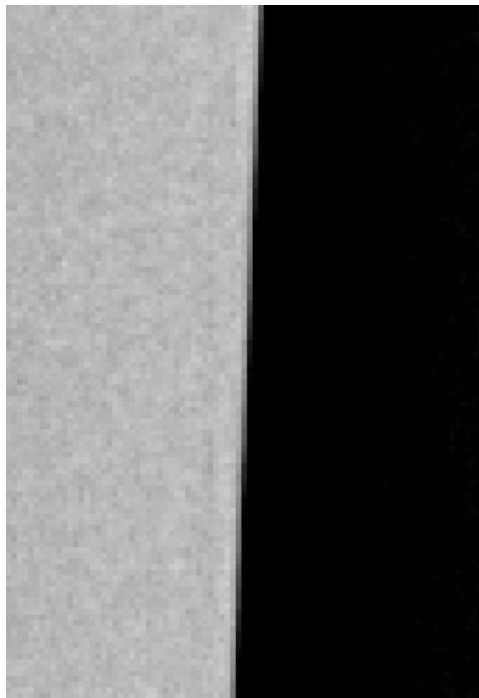
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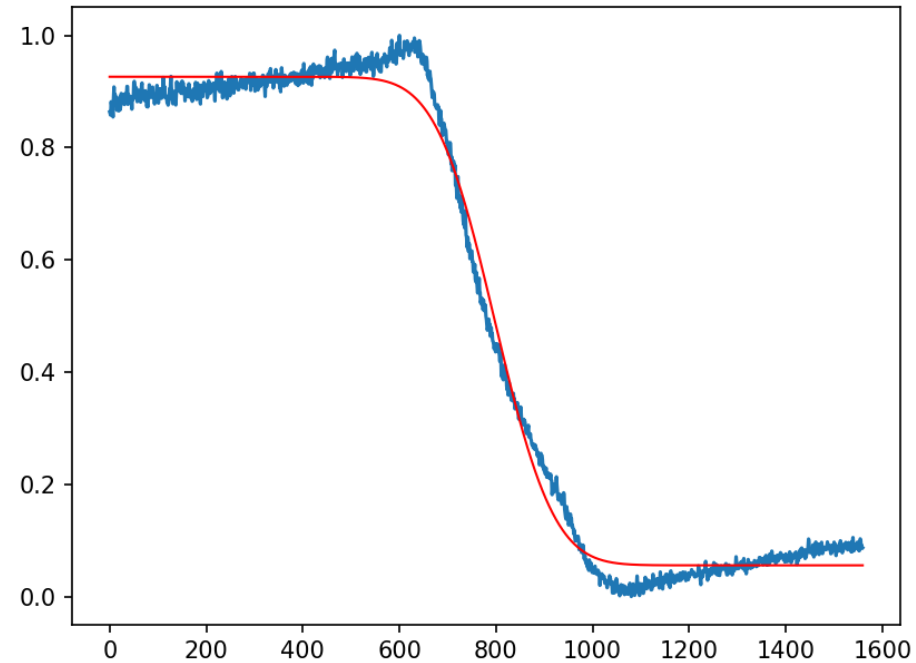


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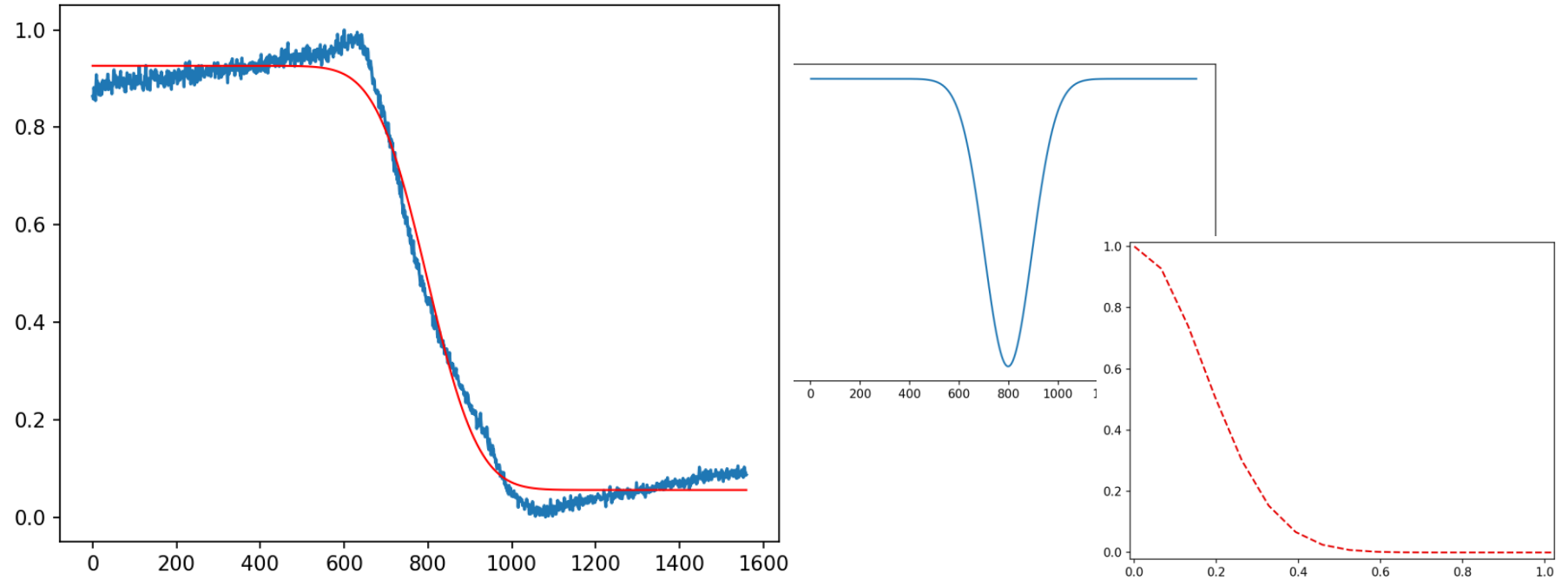
Kurvetilpasning på ESF – To alternativer

- Error function



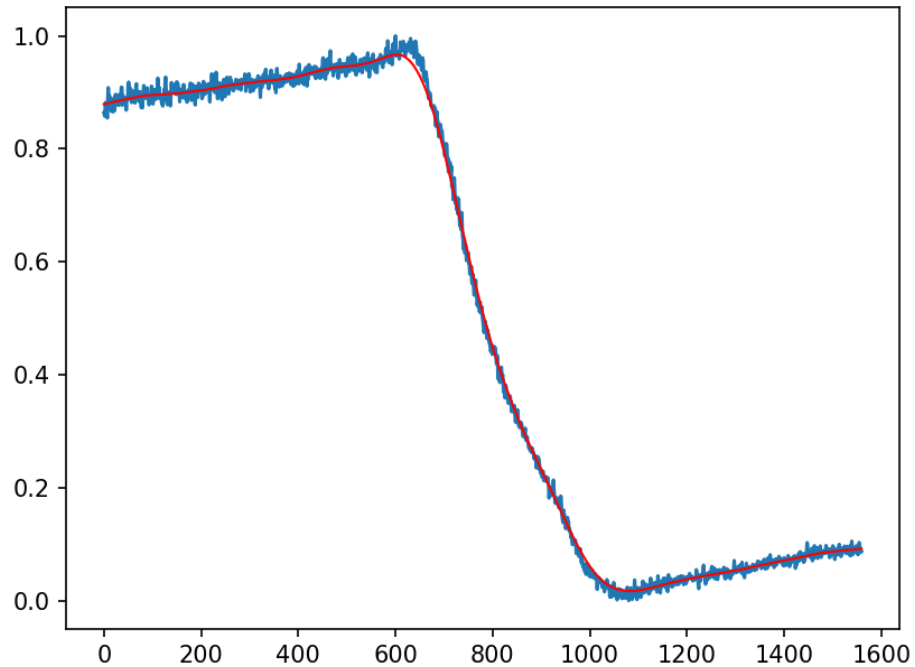
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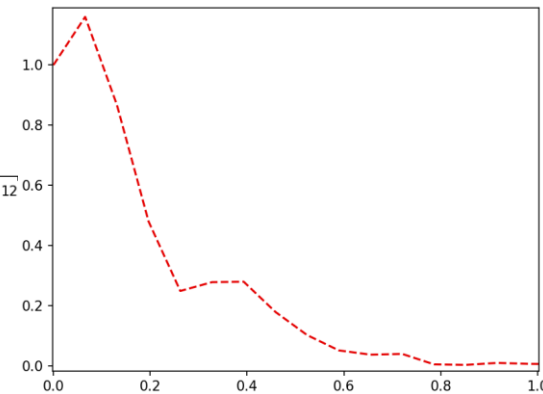
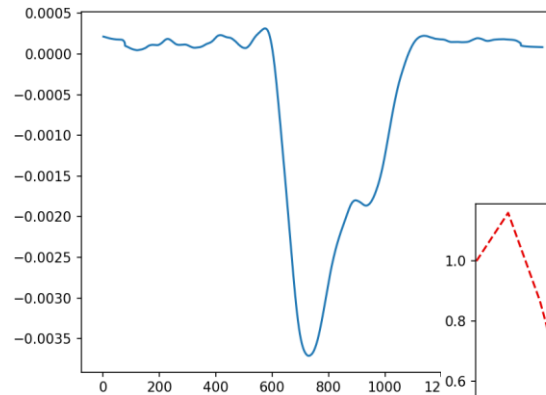
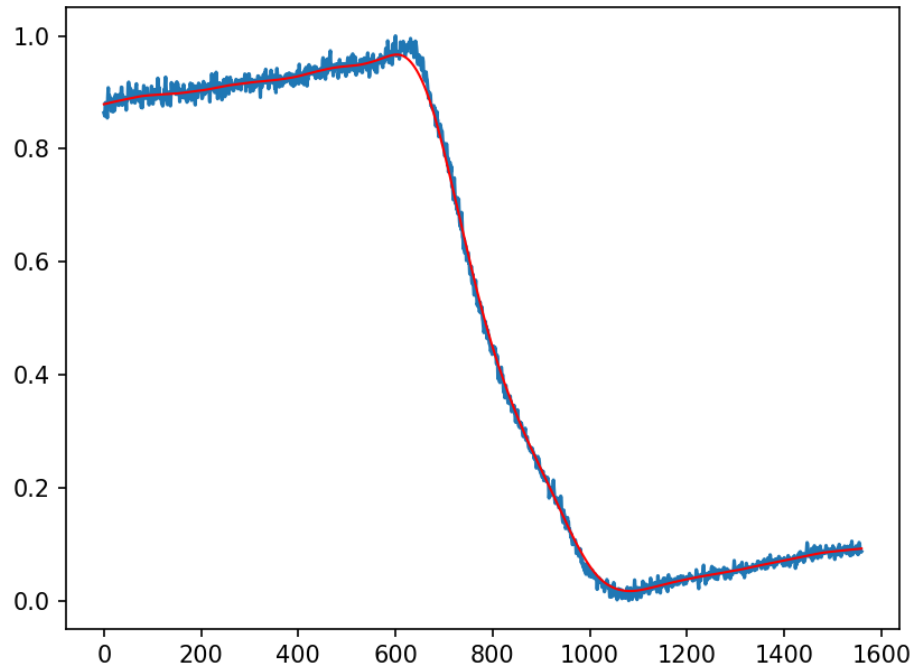
Kurvetilpasning på ESF – To alternativer

- Error function
- LOESS - *locally weighted running line smoother*

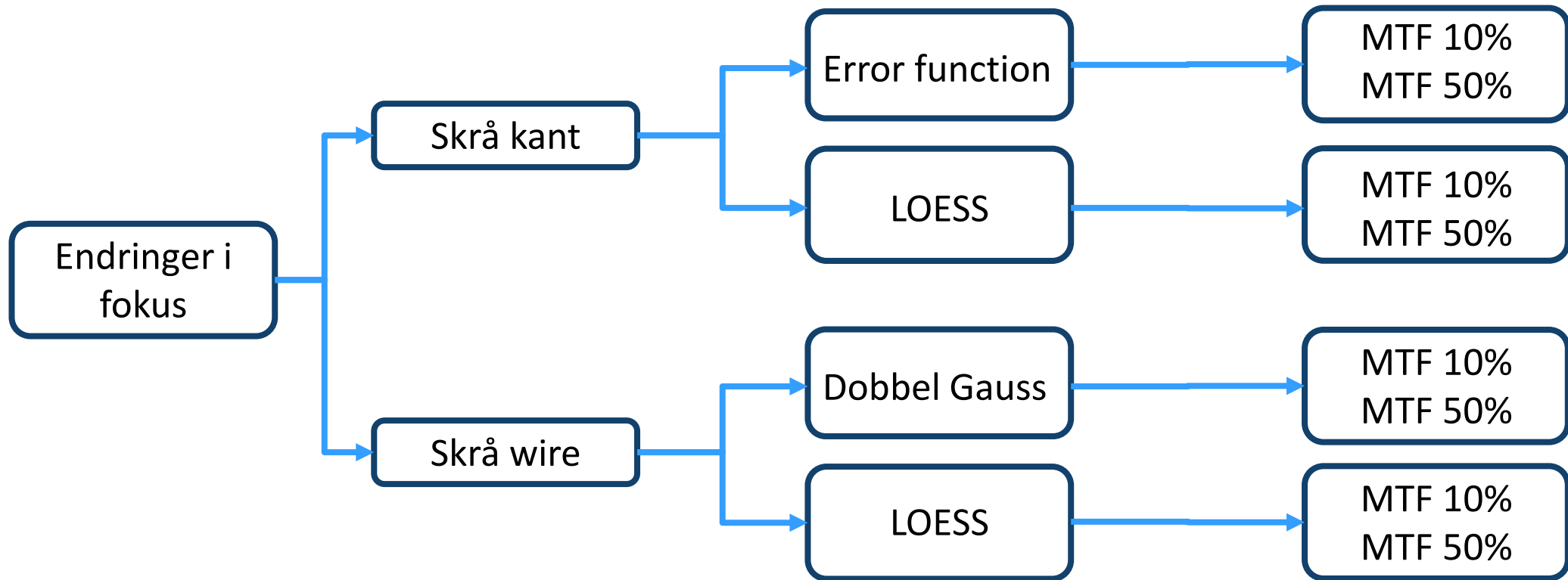


Kurvetilpasning på ESF – To alternativer

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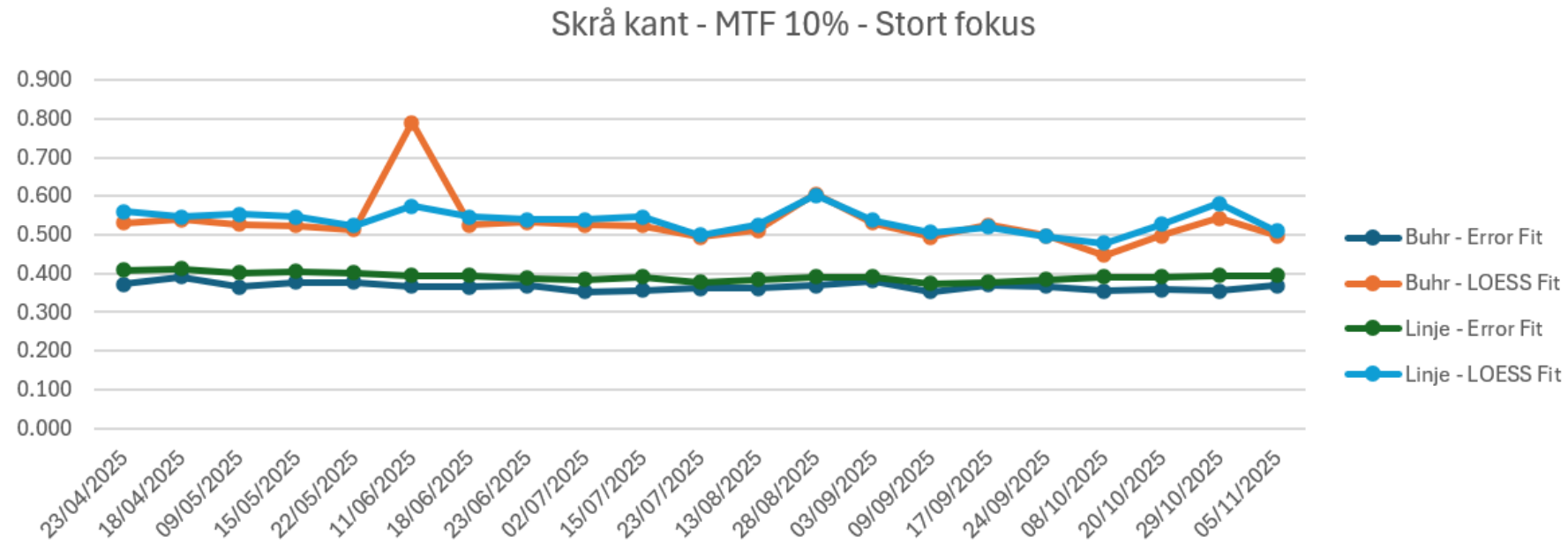


Endringer i fokus og MTF



Resultater

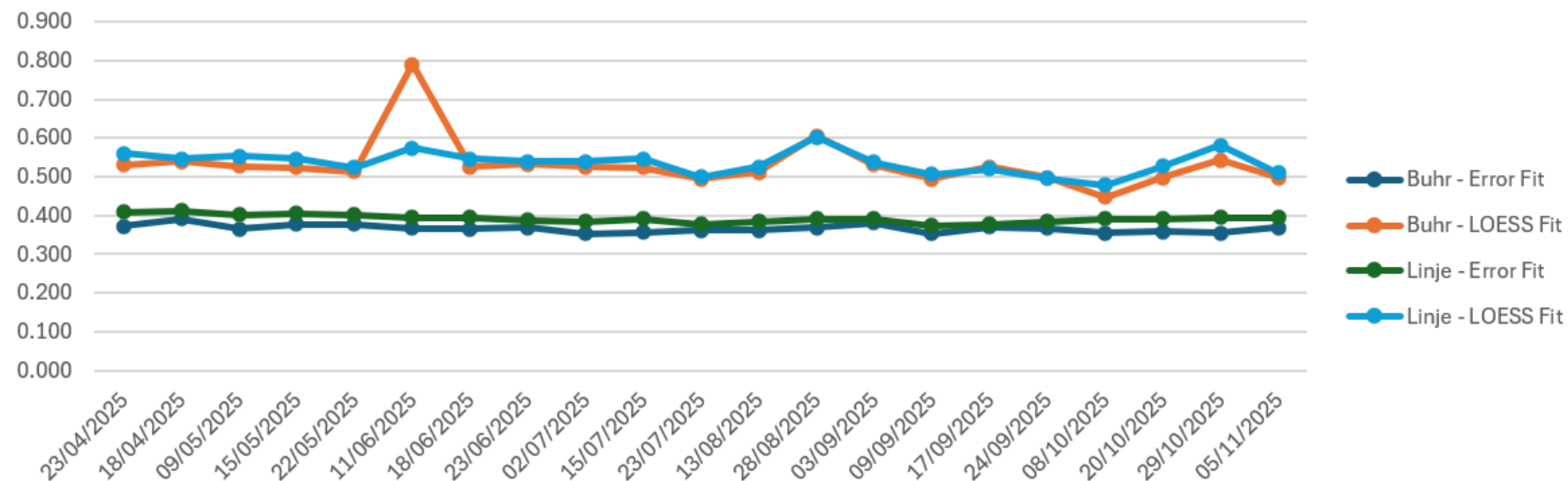
- Skrå kant
– MTF 10 %



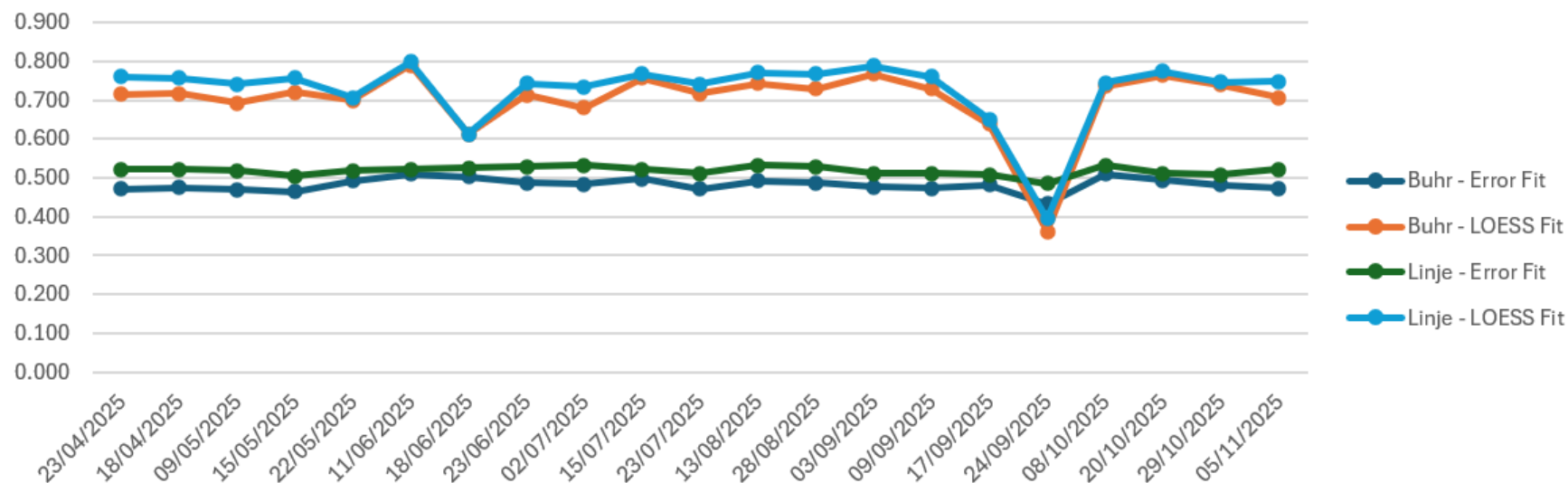
Resultater

- Skrå kant
– MTF 10 %

Skrå kant - MTF 10% - Stort fokus

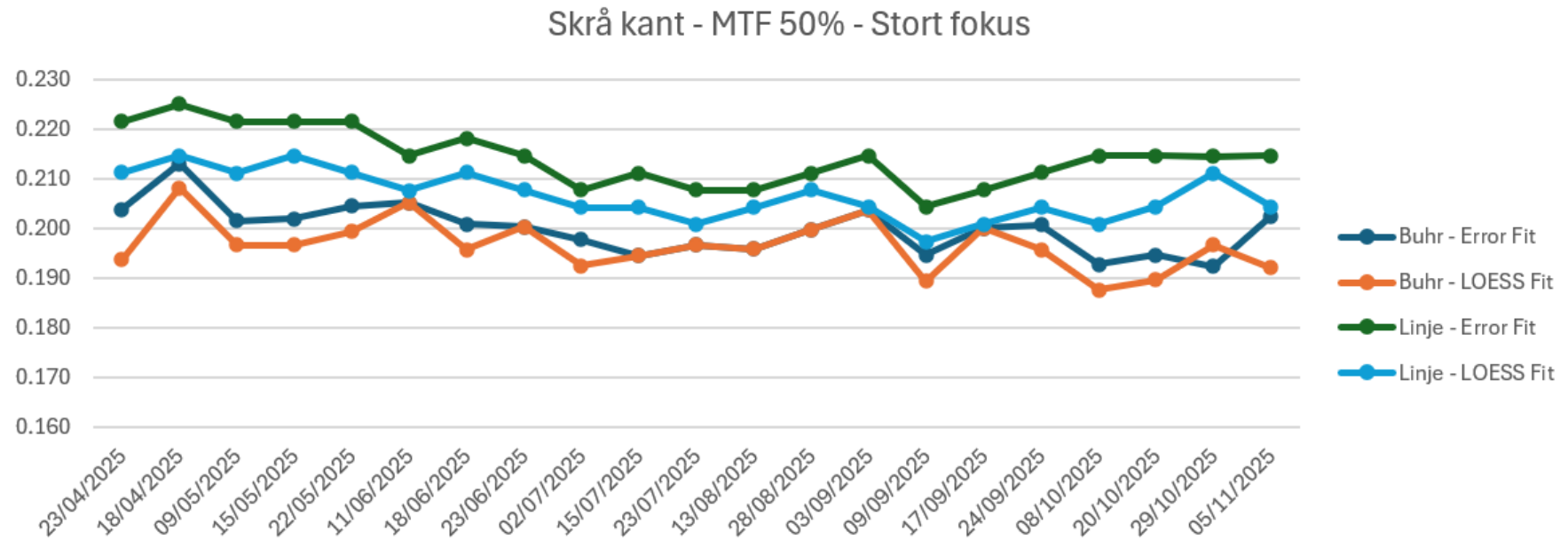


Skrå kant - MTF 10% - Lite fokus



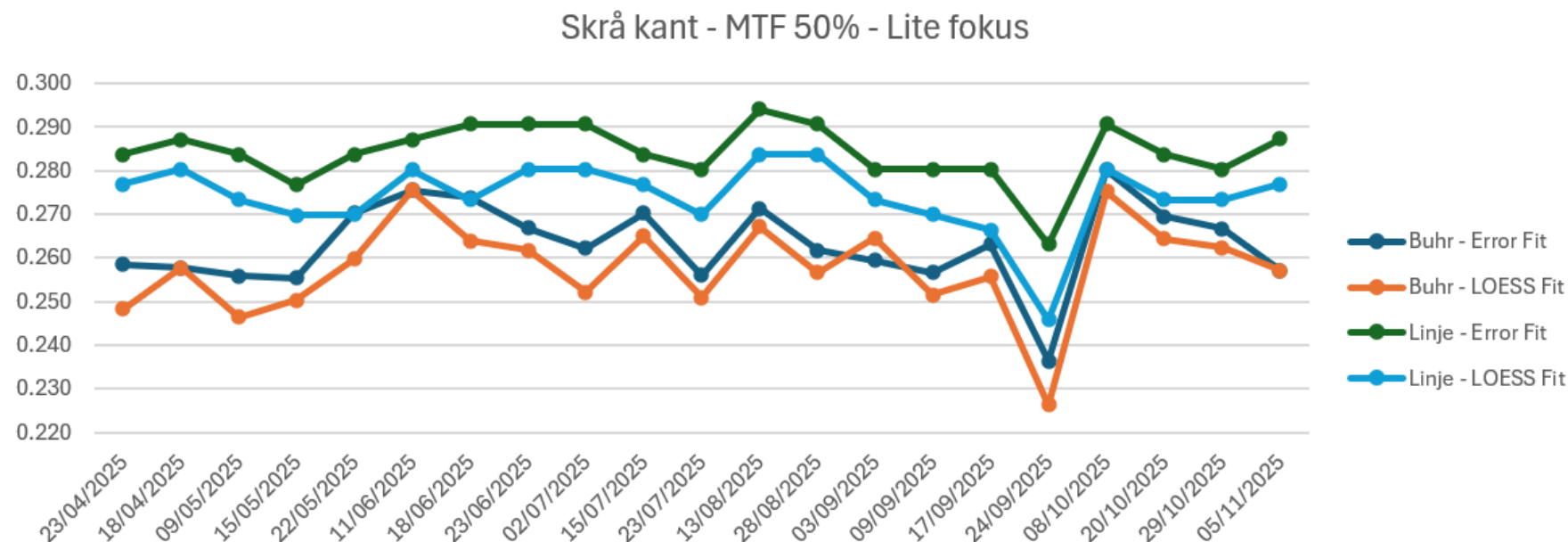
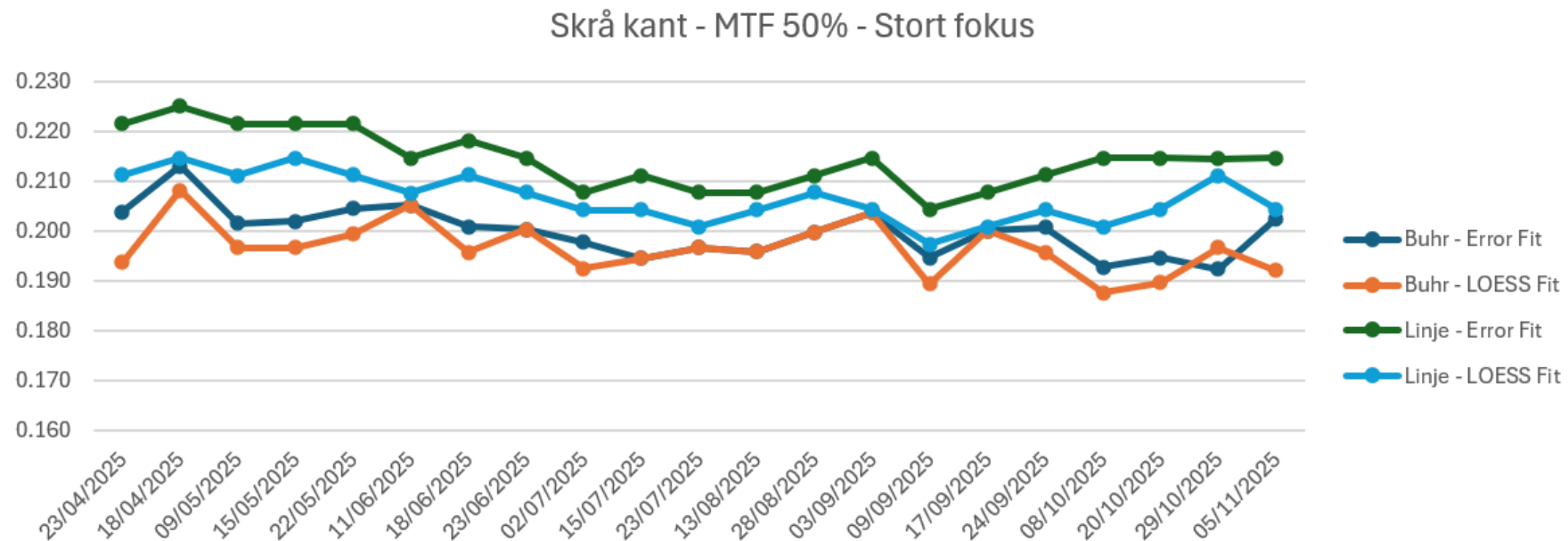
Resultater

- Skrå kant
– MTF 50 %



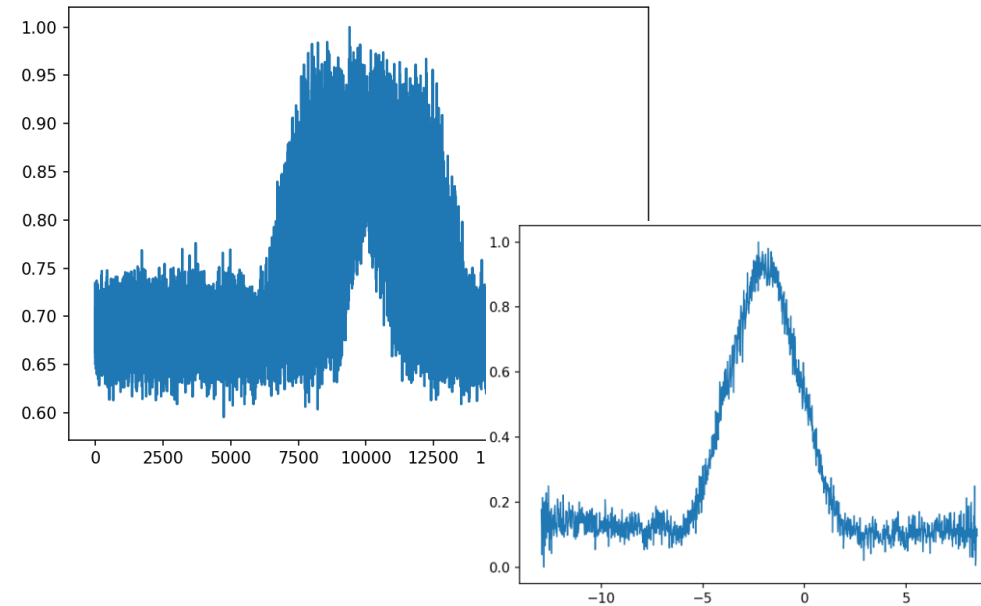
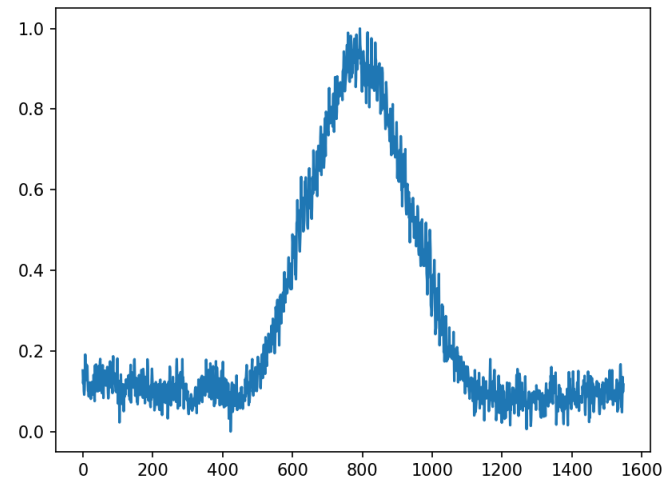
Resultater

- Skrå kant
– MTF 50 %



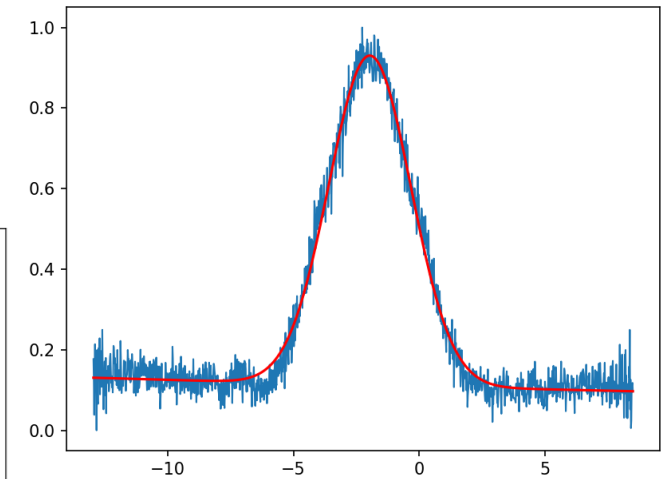
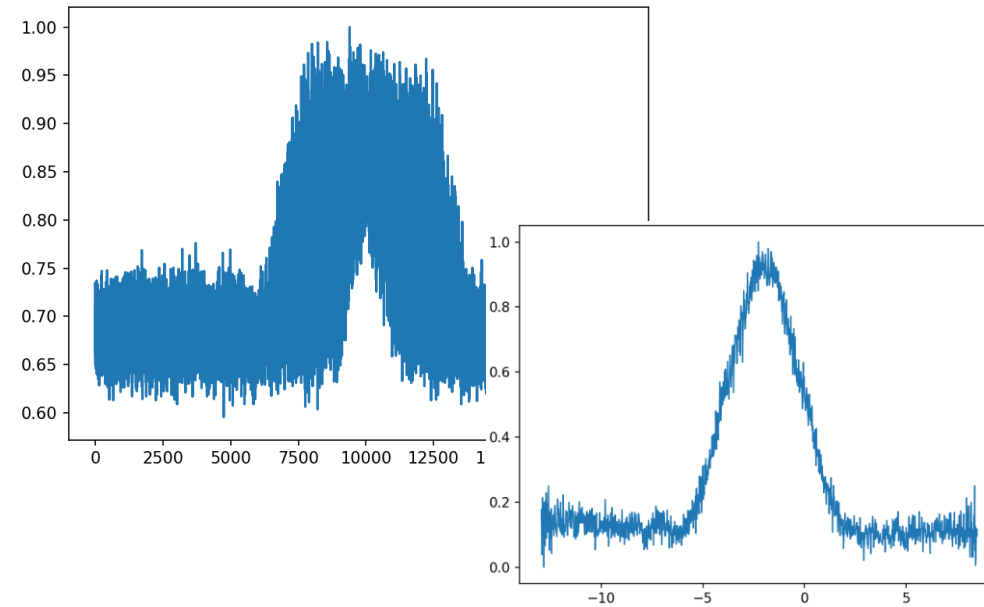
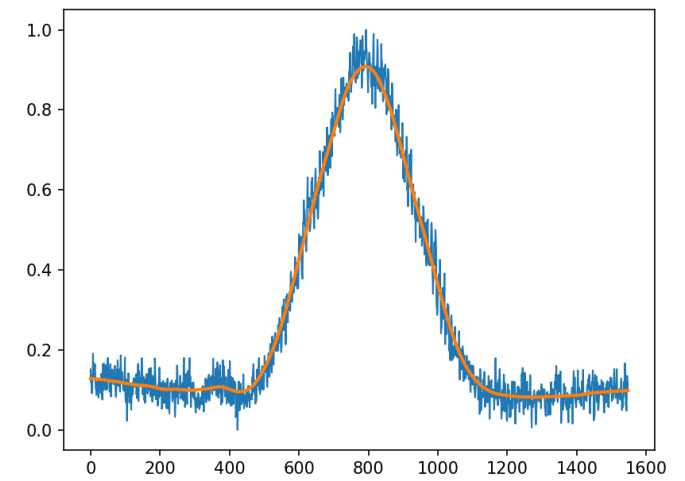
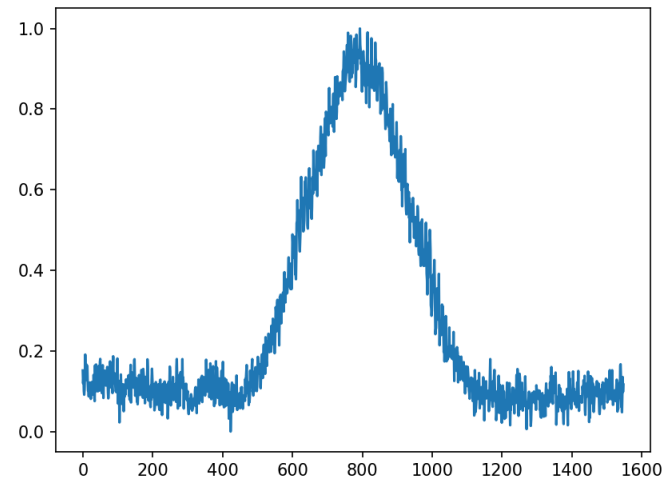
Wire

- Oversampling
 - Buhr
 - Linjeavstand



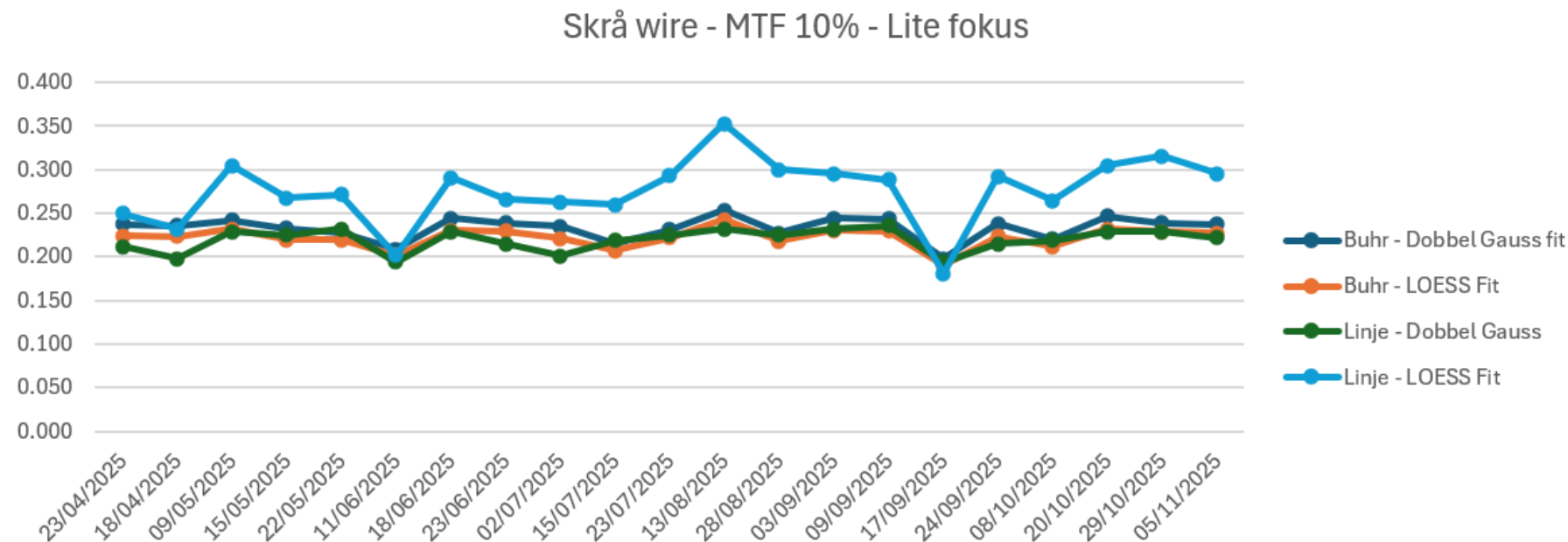
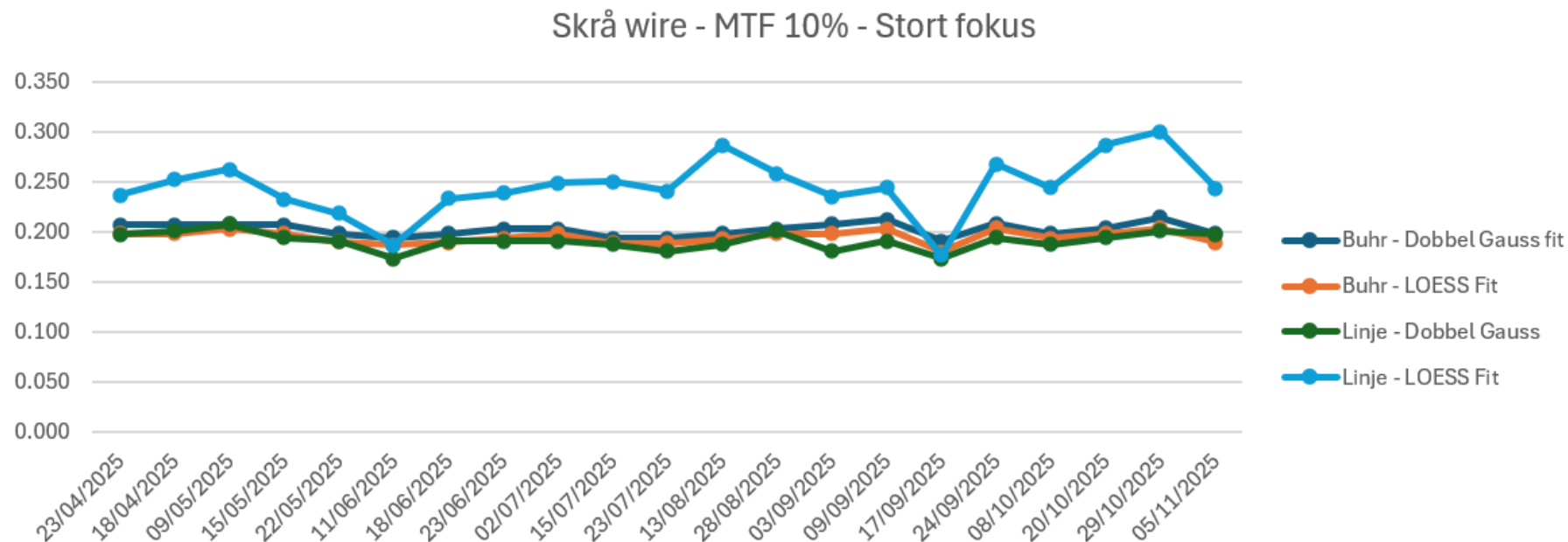
Wire

- Oversampling
 - Buhr
 - Linjeavstand
- Kurvetilpasning
 - Dobbel Gauss
 - LOESS



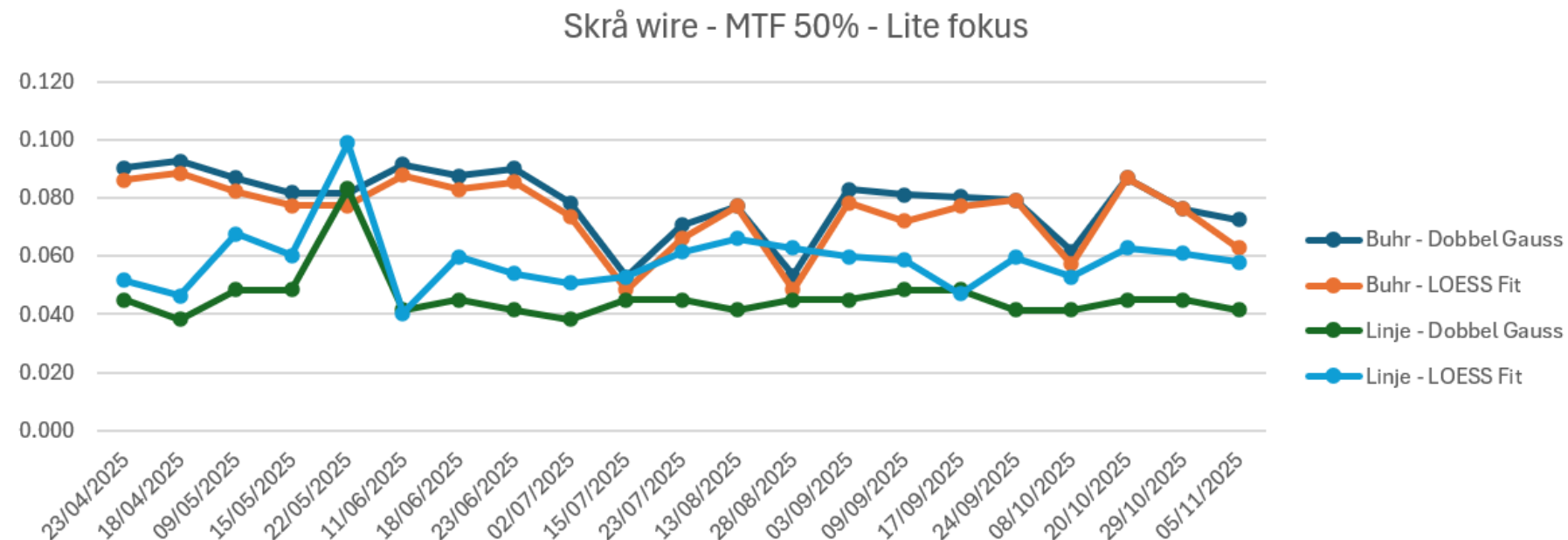
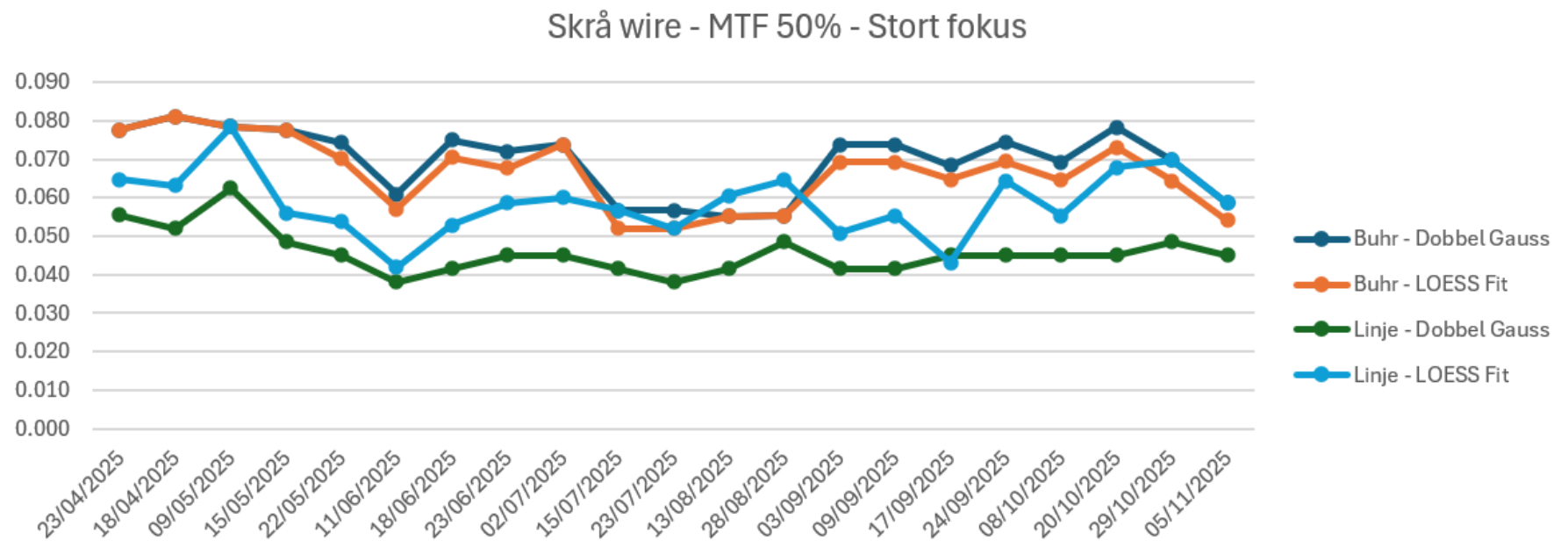
Resultater

- Skrå wire
 - MTF 10%



Resultater

- Skrå wire
– MTF 50%



Observasjoner

- Skrå kant virker å være mer innholdsrik enn wire
- Oversampling/ESF og kurvetilpasning påvirker MTF, men endringer i MTF fanges tilsynelatende opp av samtlige metoder
- Kant og wire fantom på røntgenrøret mister MTF raskt og har dårlig kontrast, MTF 50 % virker mer følsom enn MTF 10% med tanke på endringer

Svakheter

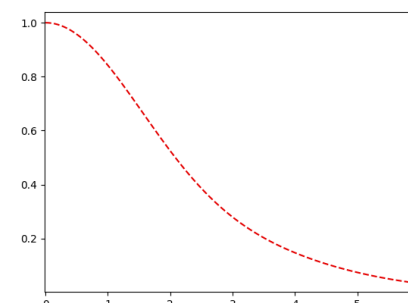
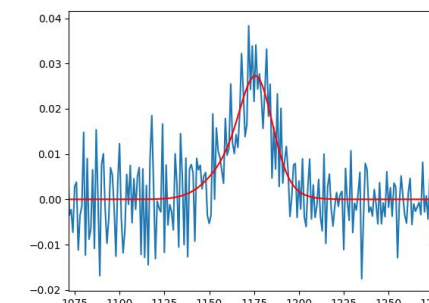
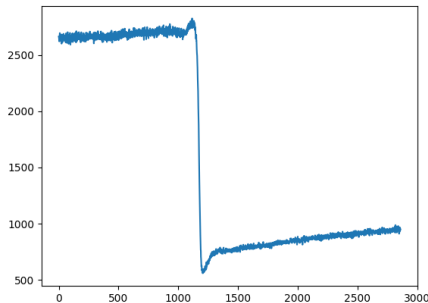
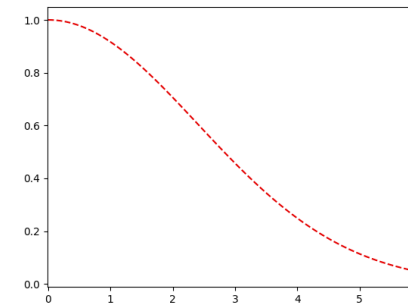
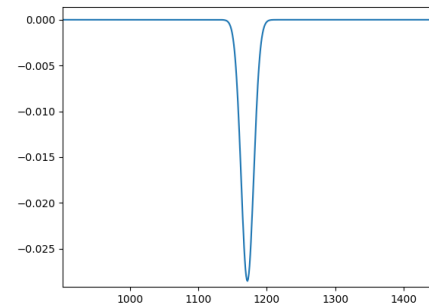
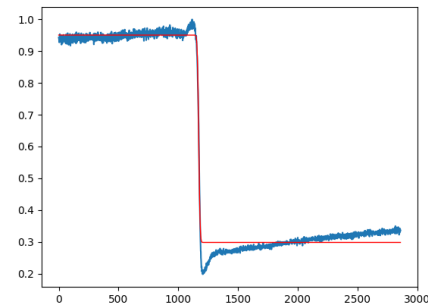
- Data fra kun en lab
- Har brukt AEK og abdomen protokoll på bildene
 - Mye støy over kanten, mulig at høyere dose vil hjelpe..?
 - Noe prosessering i bildet
 - Rådata bilder ville vært mer ideelt (men heel-effekt kan ødelegge avhengig av retning...)
- Ingen korreksjon for vaier tykkelse
 - Vrient å korrigere på grunn av utsmøringen... Vil endringer i fokus endre forstørrelse/tykkelse på vaier?

Veien videre

- Samle inn mer ukentlig data (6 måneder så langt)

Veien videre

- Samle inn mer ukentlig data (6 måneder så langt)
- Kan følge med på MTF på detektor
 - Kan gjøre kruve-tilpasning på enten ESF eller LSF



Takk for oppmerksomheten!

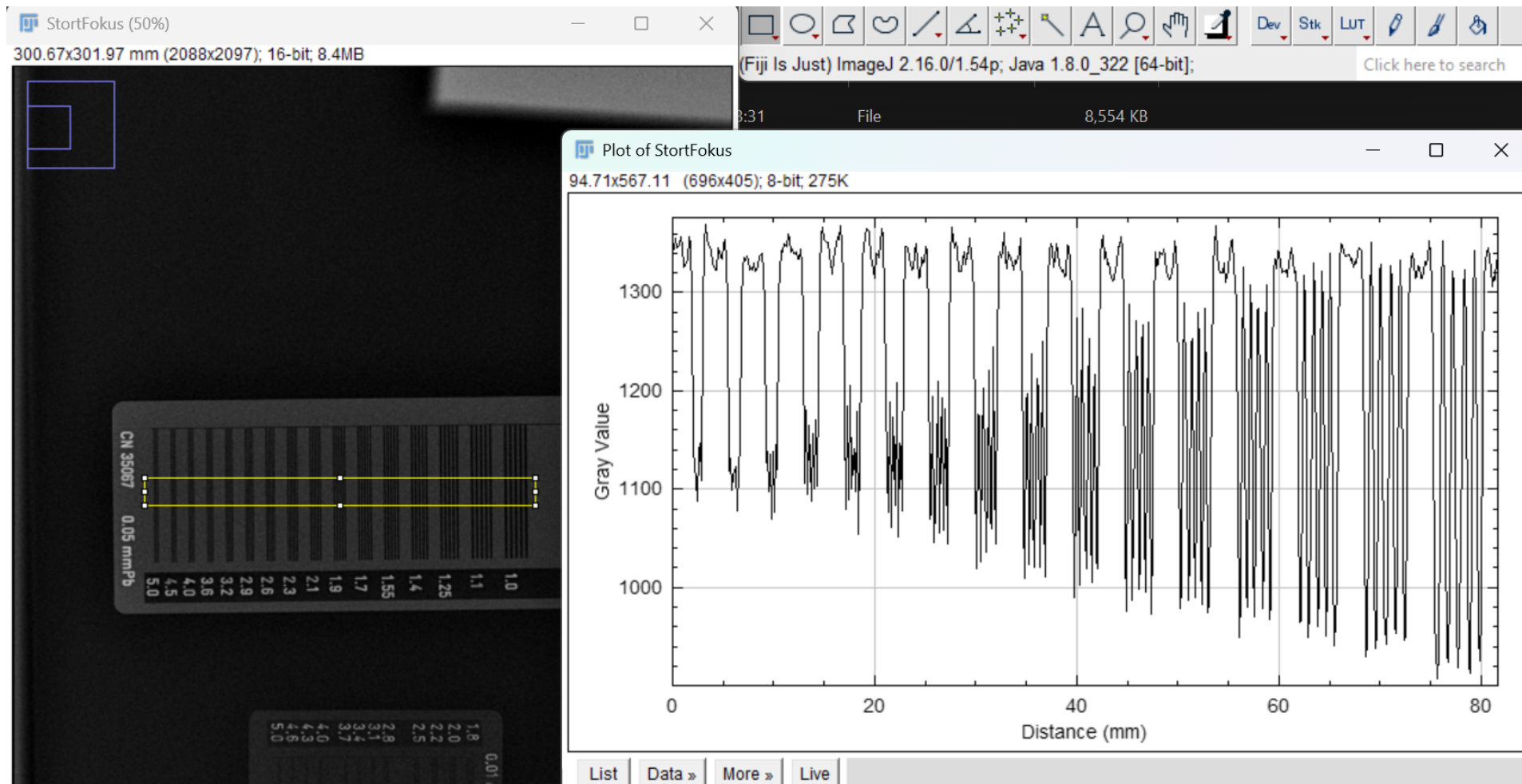
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Medisinsk fysiker

Avdeling for fysikk og bildeanalyse

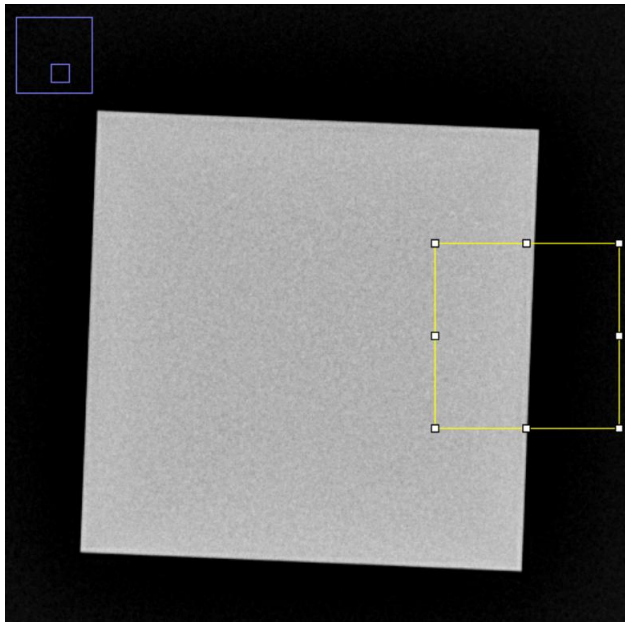
Epost: jaraso@ous-hf.no

Linjeparlinjal



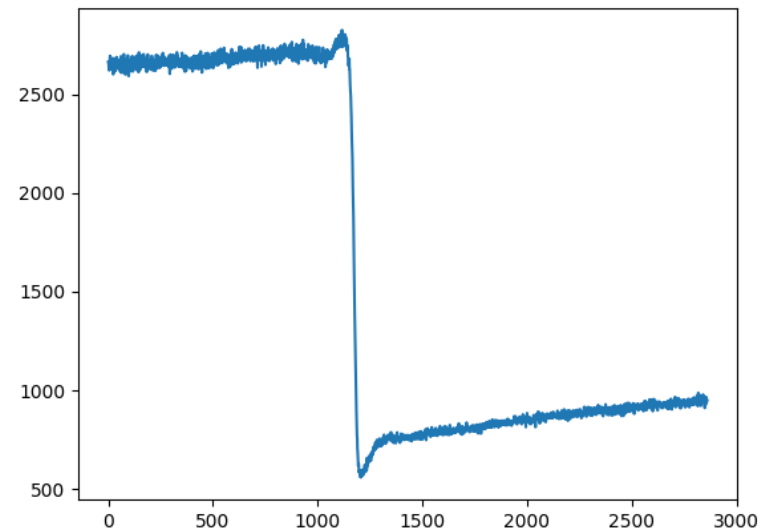
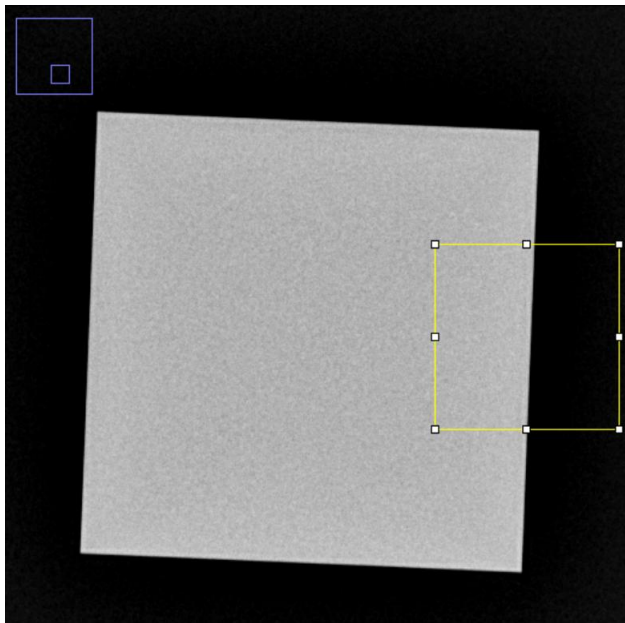
Kort om MTF

- Slanted edge – Oversampling (finere enn piksel pitch)



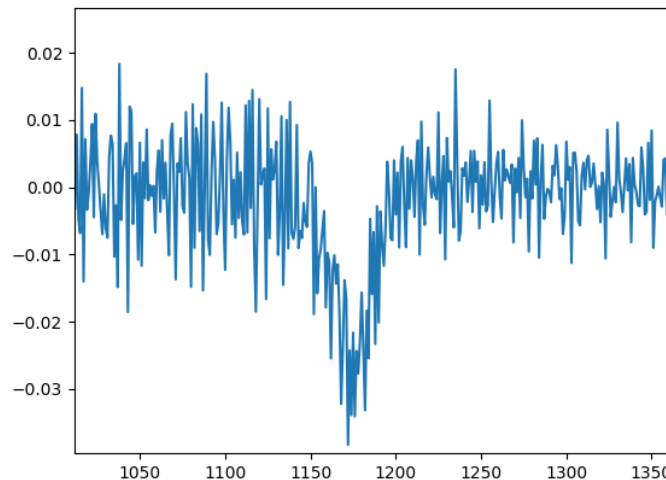
Kort om MTF

- Slanted edge – Oversampling (finere enn piksel pitch)
- Edge Spread Function (ESF) – Kumulativ ut-smøring/uklarhet av en ellers skarp kant (kanten ser ut som en S-kurve i bildet)



Kort om MTF

- Slanted edge – Oversampling (finere enn piksel pitch)
- Edge Spread Function (ESF) – Kumulativ ut-smøring/uklarhet av en ellers skarp kant (kanten ser ut som en S-kurve i bildet)
- Line Spread Function (LSF) – Deriverer ESF for å få mer informasjon om hvor mye ut-smøring som finner sted over kanten (ser ut som en Gauss-kurve)



Kort om MTF

- Slanted edge – Oversampling (finere enn piksel pitch)
- Edge Spread Function (ESF) – Kumulativ ut-smøring/uklarhet av en ellers skarp kant (kanten ser ut som en S-kurve i bildet)
- Line Spread Function (LSF) – Deriverer ESF for å få mer informasjon om hvor mye ut-smøring som finner sted over kanten (ser ut som en Gauss-kurve)
- Modulation Transfer Function (MTF) viser hvor mye ut-smøring det er for forskjellige kontraster (linjepar per mm)

