Guiding novel flat panel detector designs with direct measurements of depth-dependent scintillator gain and blur

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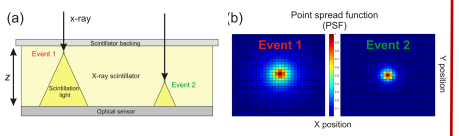
Single x-ray imaging (SXI) of depth-localized interactions in scintillators

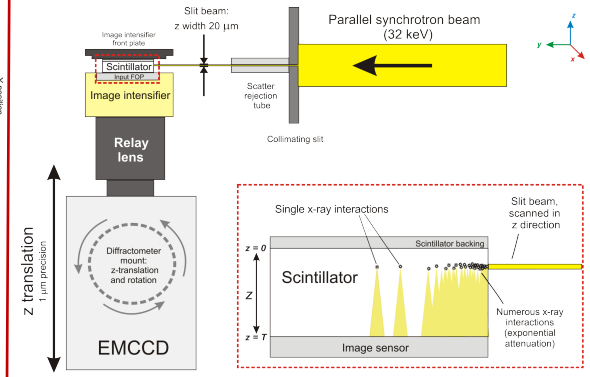
Background: Depth-dependence in scintillator gain, spatial blur degrades DQE(*f*) of indirect flat panel detectors



Motivation: Explore FPD designs to maximize scintillator thickness for dose-efficiency, and minimize loss in DQE(*f*) due to depth effects

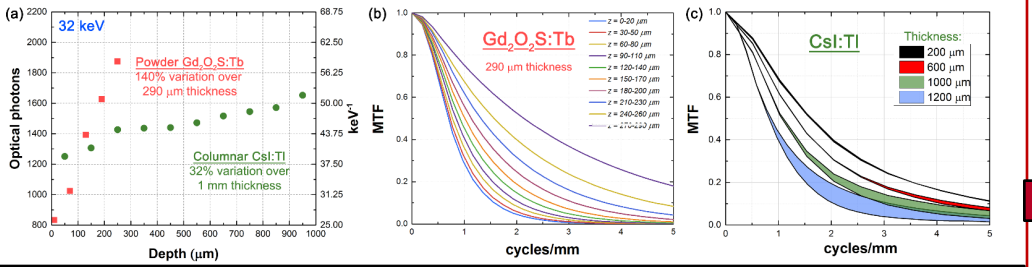
Approach: Image depth-localized single x-ray interactions in scintillators[1]

Parallel synchrotron beam (Δz = 20 μm, 32 keV) scanned in scintillator thickness (z) dimension



Direct measurements of depth-dependent scintillator gain and blur

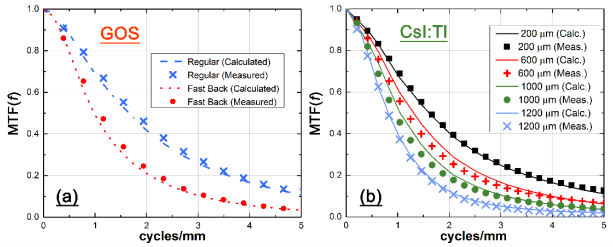
Depth-dependent gain and MTF measured in Gd_2O_2S:Tb (GOS) and CsI:Tl scintillators



Validation of depth-localized gain and blur measurements

SXI measurements used to calculate scintillator presampling MTF(*f*) in energy-integrating detector

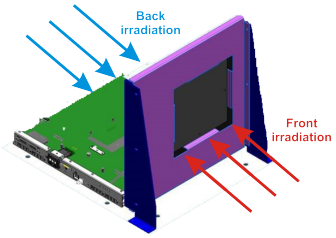
Excellent agreement with slanted-edge measurements made using CMOS image sensor (48 μm pixel)

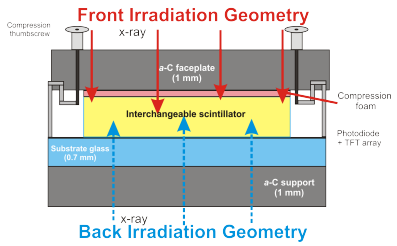


Improving detector performance with "back-irradiation"

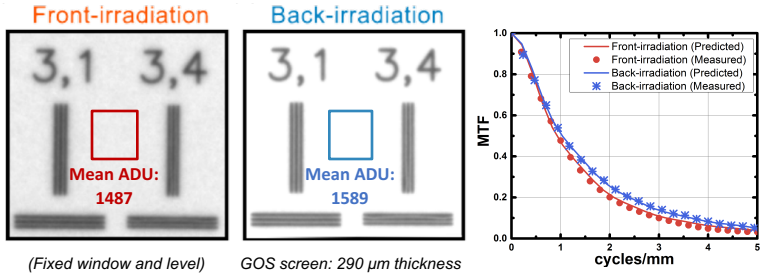
We have constructed a prototype flat panel detector allowing both "front-irradiation" (FI) and "back-irradiation" (BI) of an interchangeable scintillator

BI (first proposed by Fuji)[2] can be leveraged to push scintillator design limits





Spatial resolution and x-ray sensitivity of FI and BI are predicted using results from SXI, and confirmed by direct measurements with prototype FPD

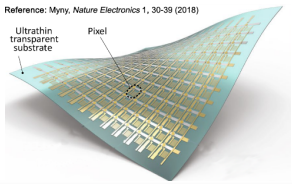


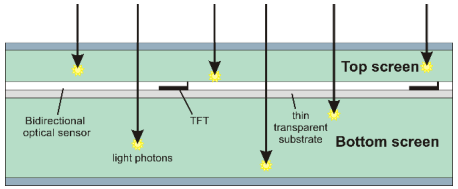
(Fixed window and level) *GOS screen: 290 μm thickness*

Dual-screen indirect flat panel detector

Recent advances in ultra-thin (<30 μm), flexible TFT technology are enabling novel, multilayer FPD structures, for example:

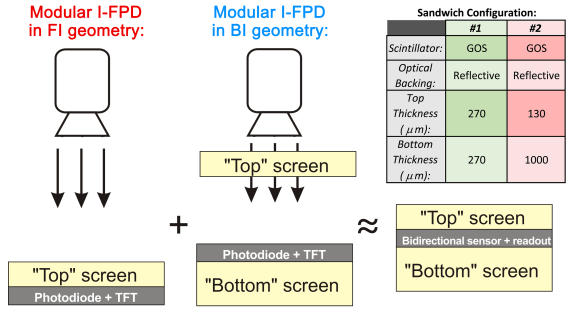
Dual-screen "sandwich" detector comprising a FI "top" screen and BI "bottom" screen in contact with a bidirectional-sensing photodiode/TFT array[3]





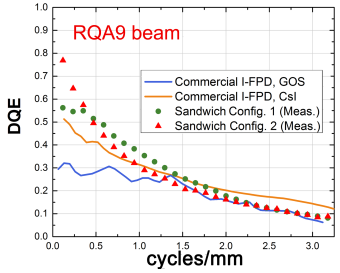
Dual-screen I-FPD performance estimation

Predict dual-screen I-FPD by linear combination of FI "top" screen image and filtered BI "bottom" screen image



Superior DQE at low spatial frequencies and comparable DQE at higher frequencies, compared to current detectors

Particularly advantageous at higher x-ray energies (e.g. RQA9, cone-beam CT)



Conclusions

Direct knowledge of $g(z)$ and MTF(z,f) informs potential I-FPD improvements through BI and dual-screen design concepts, which can be explored using a modular, bi-directional FPD.

References

[1] A. Howansky, et al., Proc. SPIE, 10132, (2017).
[2] A. Takasu, et al.," Proc. SPIE, 6510, (2007).
[3] A. R. Lubinsky, et al., Proc. SPIE 10573, (2018).

Acknowledgements

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