Response Characteristics of a Large-Area Ion Chamber with Various Radiotherapy Beams

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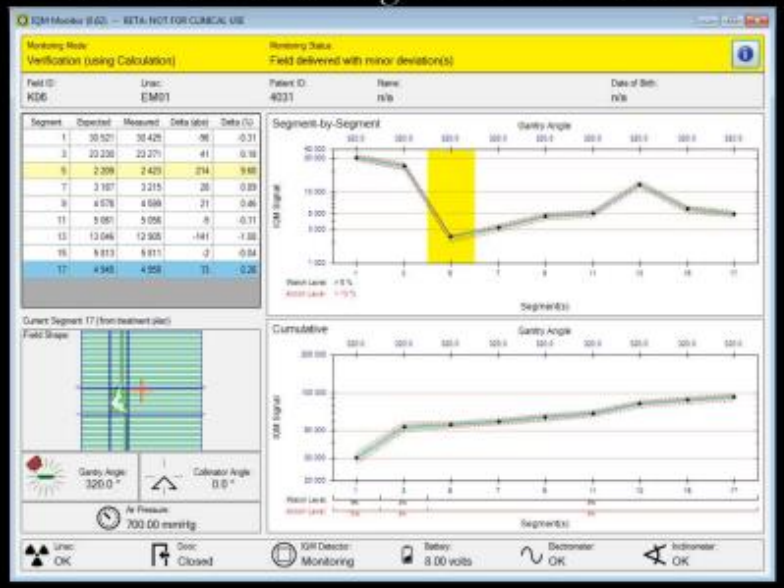
Med Phys. 2009 Dec;36(12):5420-8.

An integral quality monitoring system for real-time verification of intensity modulated radiation therapy.

Islam MK[1], Norrlinger BD, Smale JR, Heaton RK, Galbraith D, Fan C, Jaffray DA.

Real-time Monitoring of an IMRT Field



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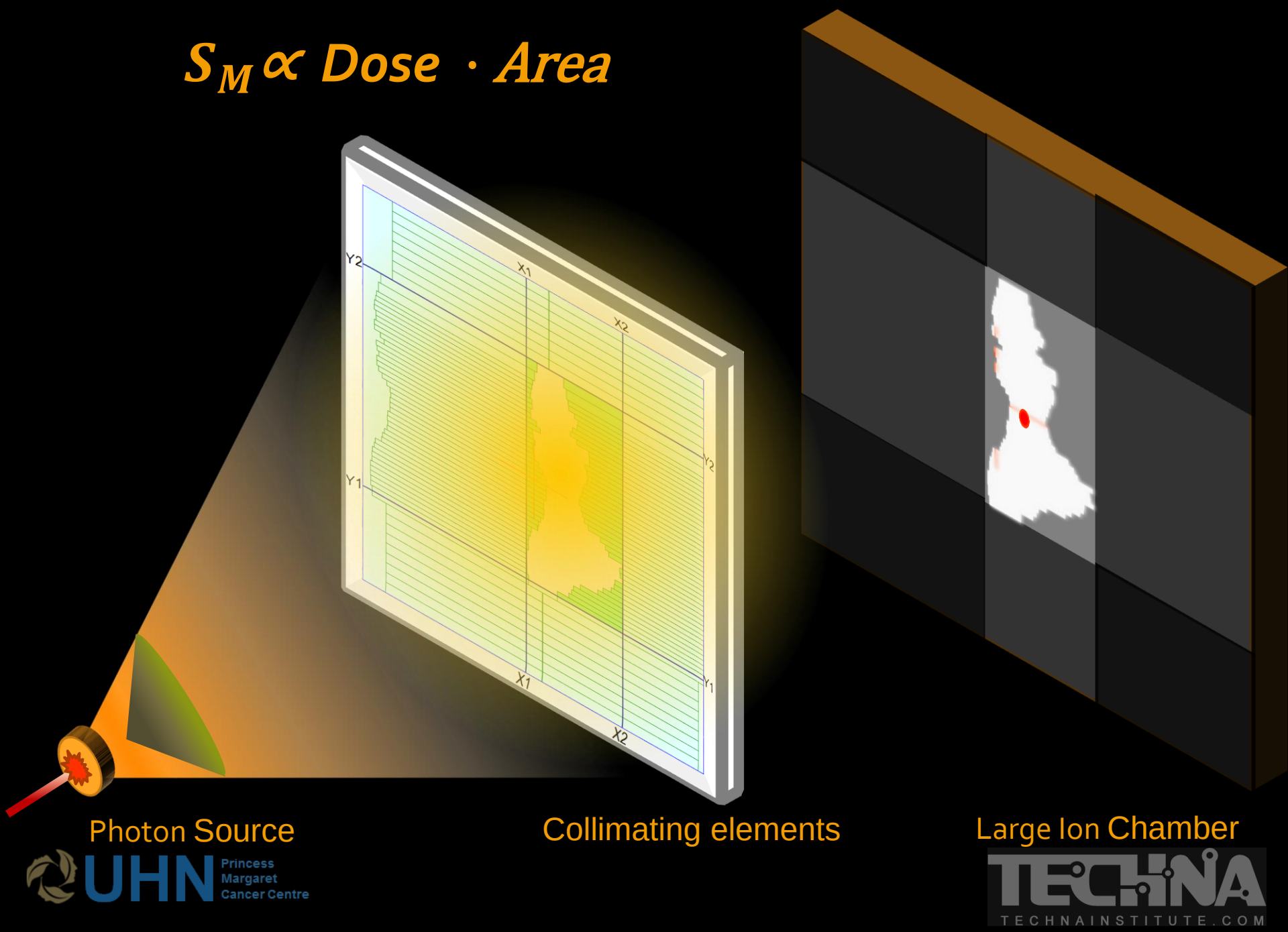
$S_M \propto Dose \cdot Area$



Photon Source

Collimating elements

Large Ion Chamber

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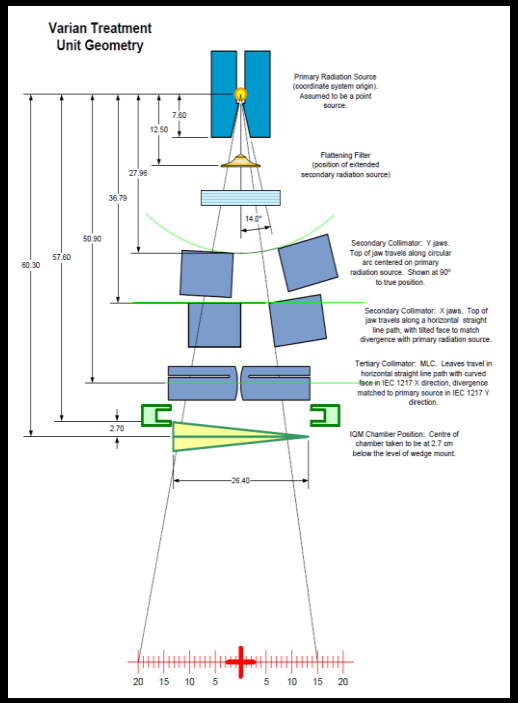
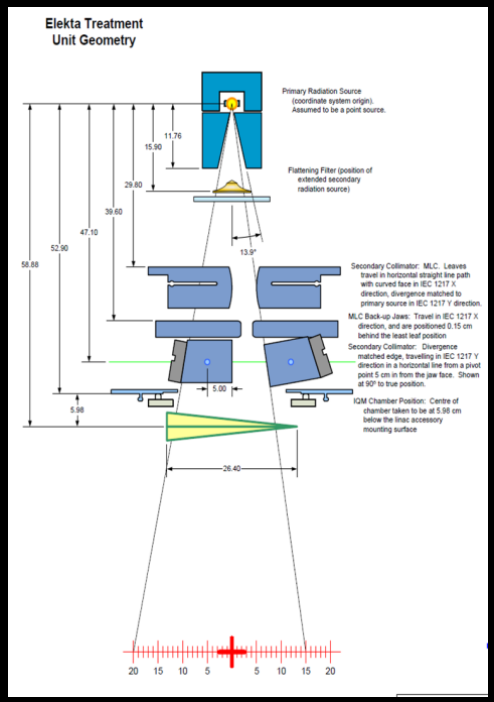
Factors that influence IQM signals

- Linac Head Structure
- Beam Energy
- Beam Calibration





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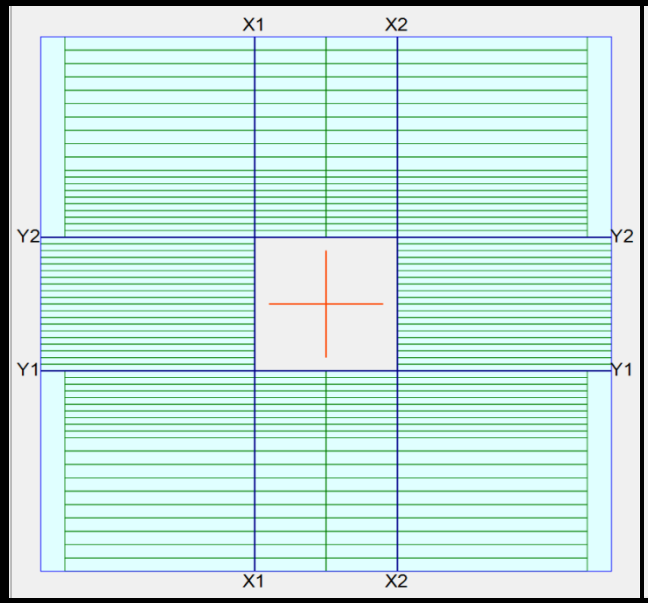
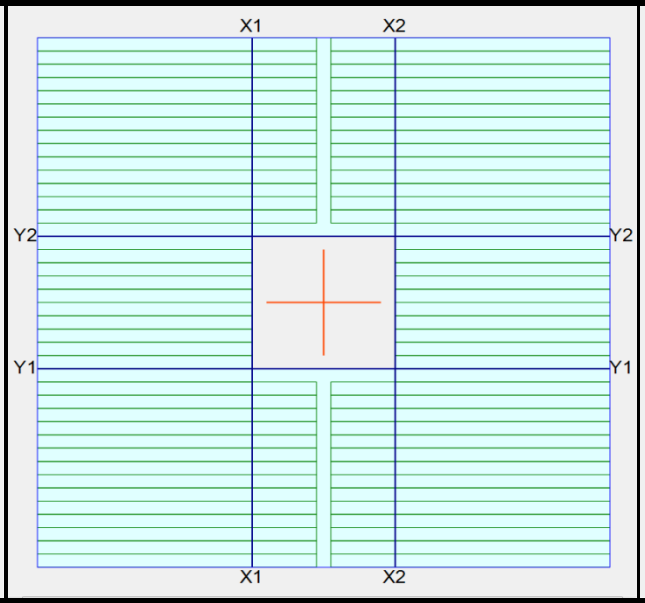
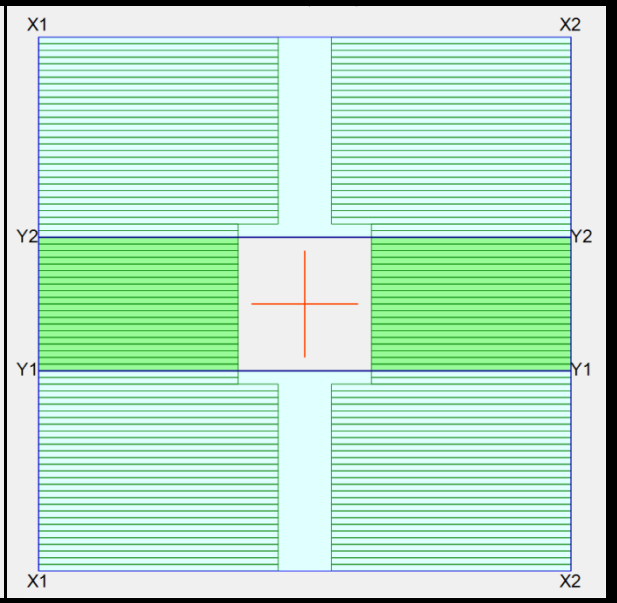
Varian Millennium Collimator



Elekta MLCi2



Elekta Agility



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IQM Response Characteristics With Different Radiotherapy Beam

- IQM Intrinsic and effective spatial sensitivity
- Response as a function of field size
- Response as a function of beam energy
- IQM response as a function of dose rates

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Studied Linac Models

- TrueBeam (Varian Medical Systems, Palo Alto, CA)

  . Millennium MLC
  . 6 MV, 10 MV, 6 FFF, 10 FFF

- Clinac iX (Varian Medical Systems, Palo Alto, CA)

  . Millennium MLC
  . 6 MV, 18 MV

- Infinity (Elekta AB, Stockholm, Sweden)

  . Agility Collimator
  . 6MV, 18 MV

- Infinity (Elekta AB, Stockholm, Sweden)

  . MLCi2 Collimator
  . 6 MV, 18 MV

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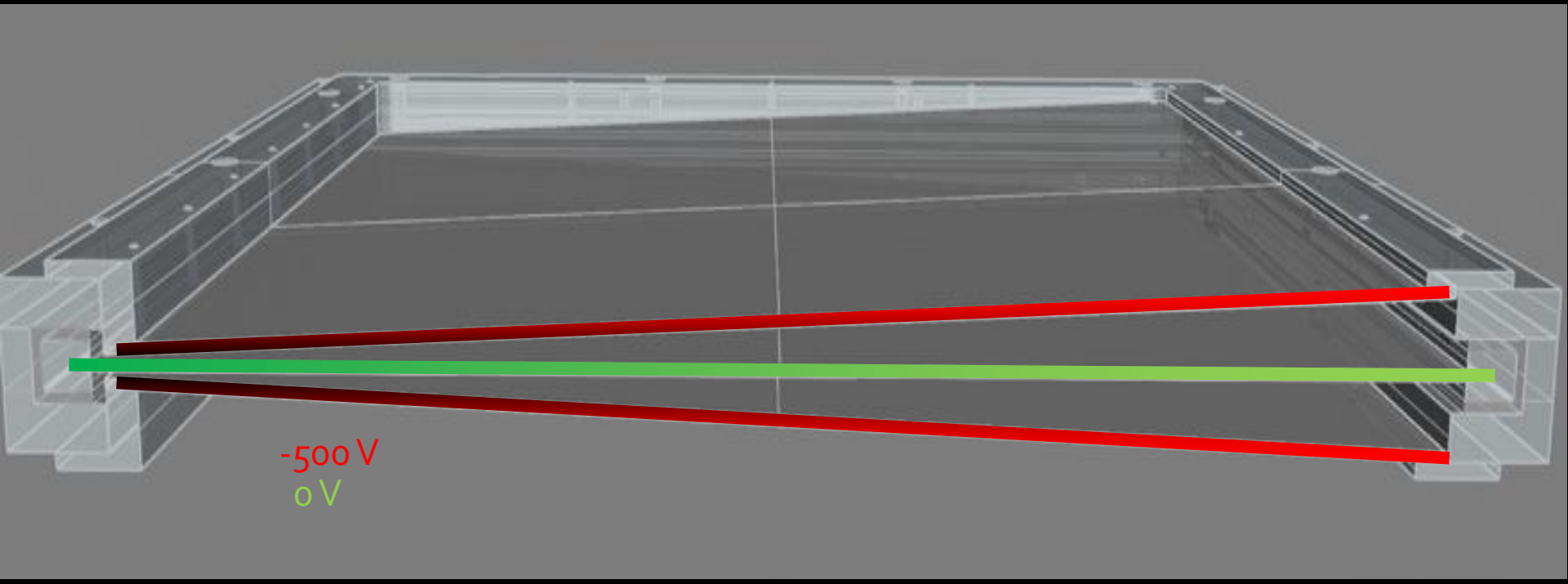
Objectives

- IQM Intrinsic and effective spatial sensitivity

Response as a function of field size

Response as a function of beam energy

IQM response as a function of dose rates



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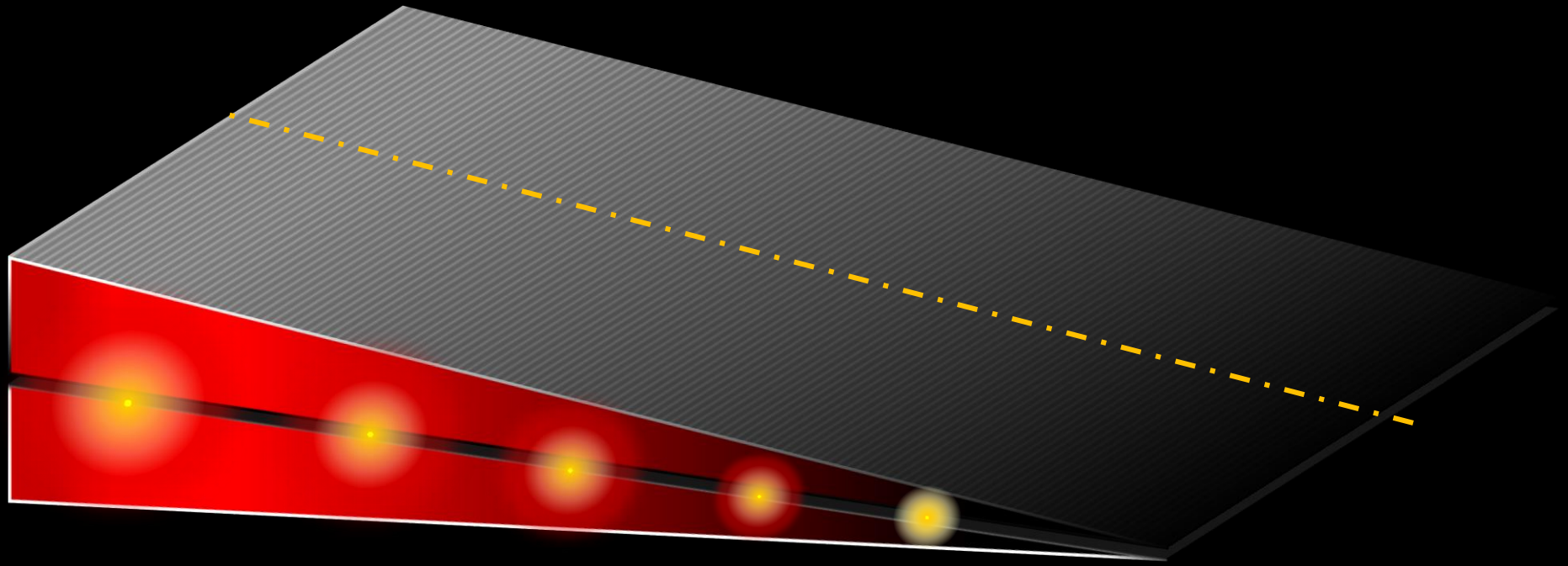

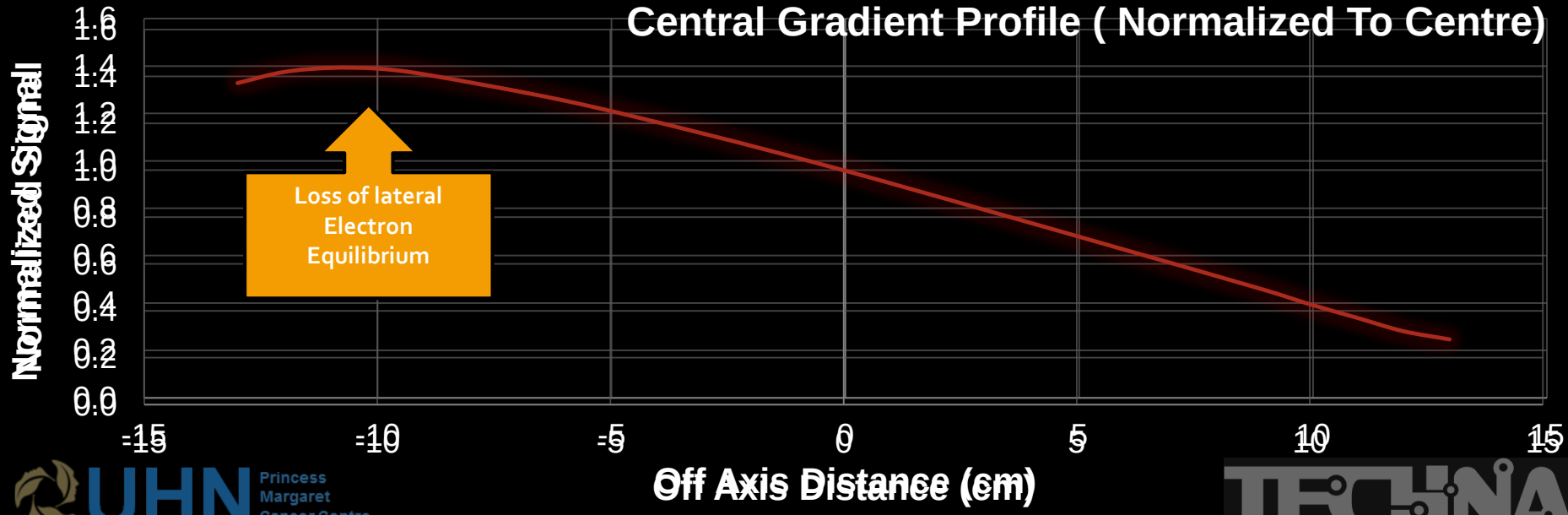

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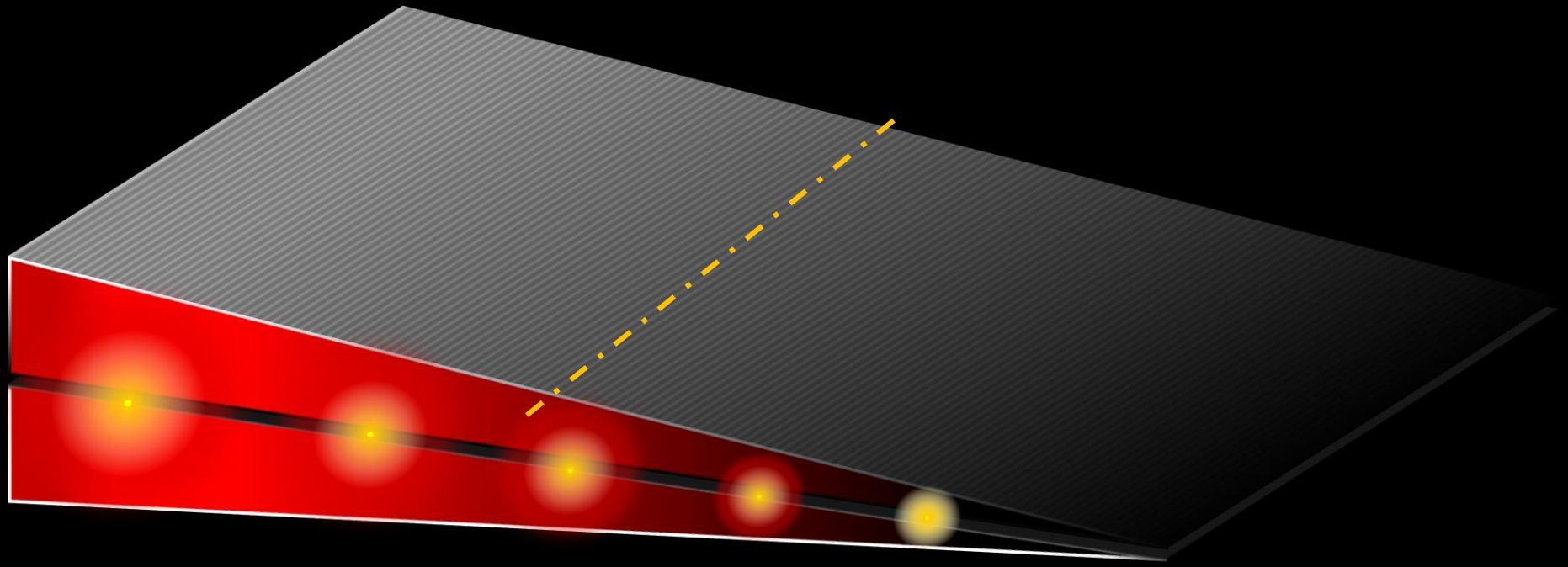

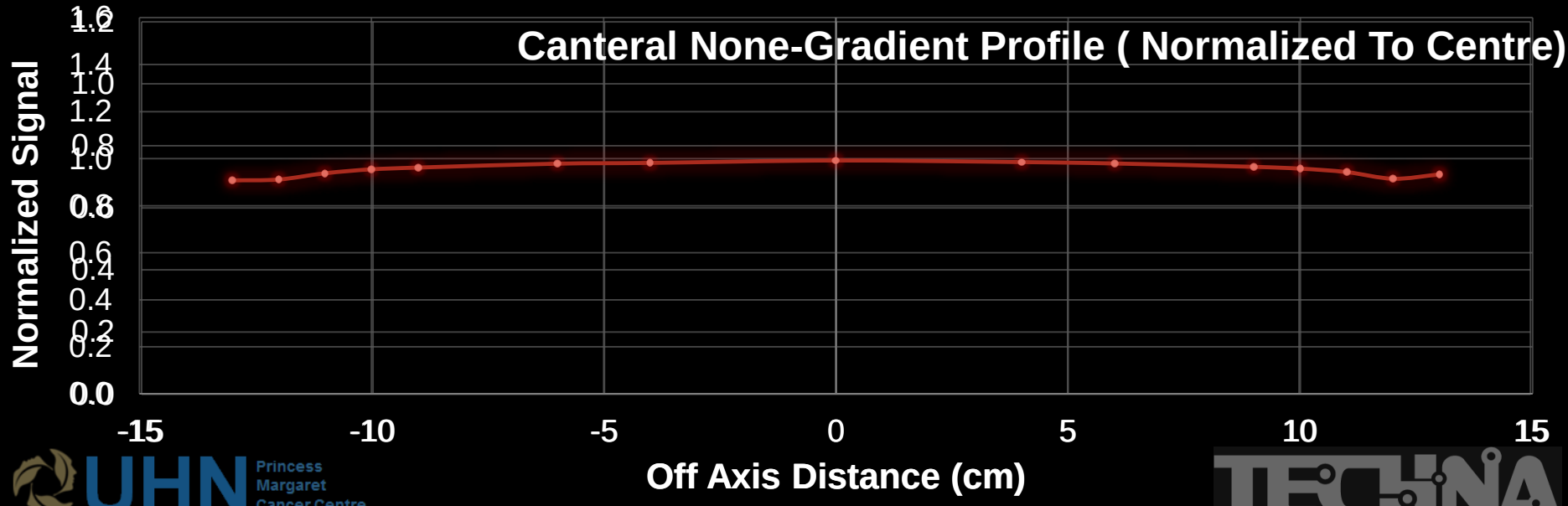

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IQM Intrinsic Response (Gradient Direction)

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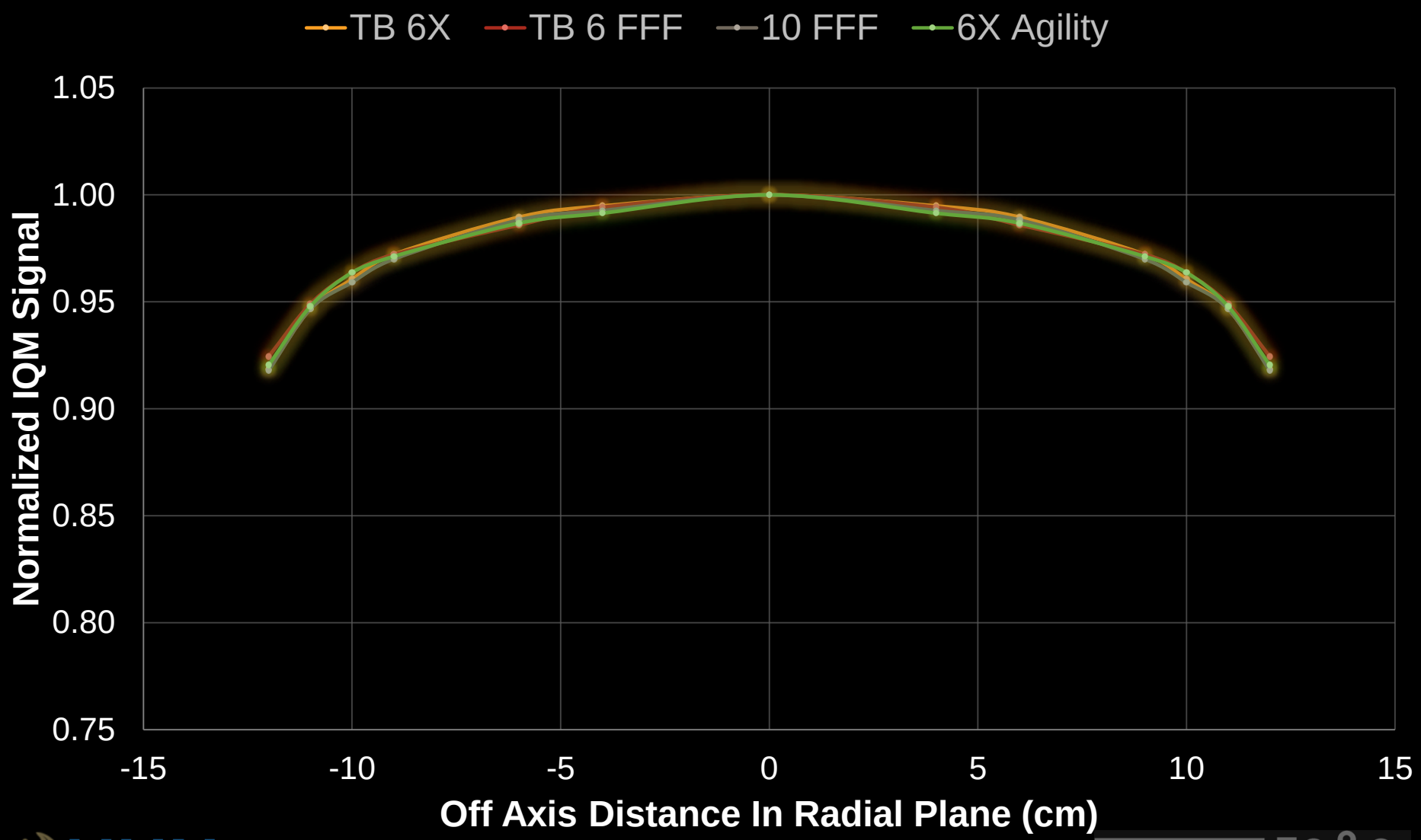
IQM Intrinsic Response (None Gradient Direction)



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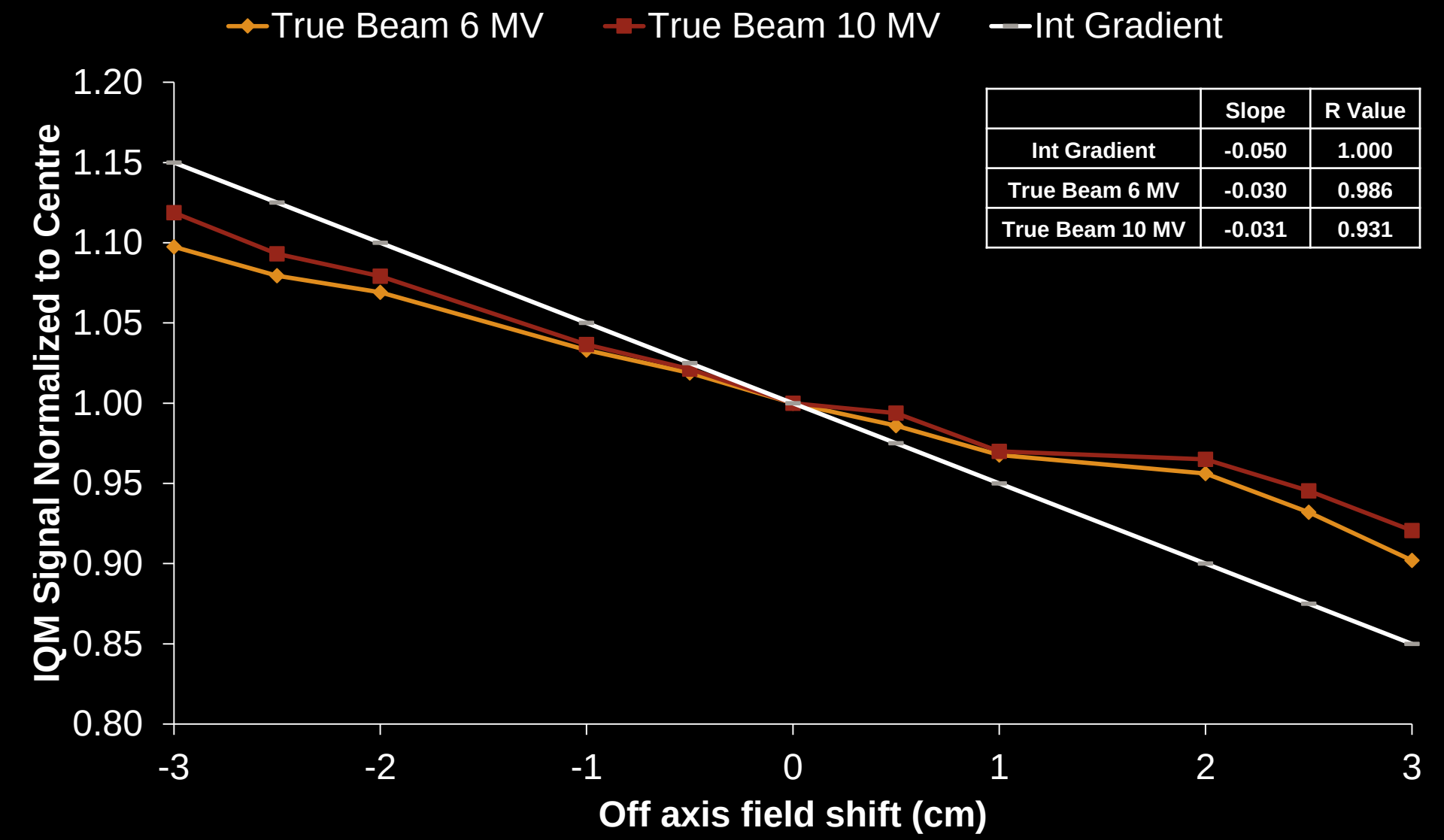
Effective IQM Spatial Sensitivity for a 3X3 cm2 field



	Slope	R Value
Int Gradient	-0.050	1.000
True Beam 6 MV	-0.030	0.986
True Beam 10 MV	-0.031	0.931

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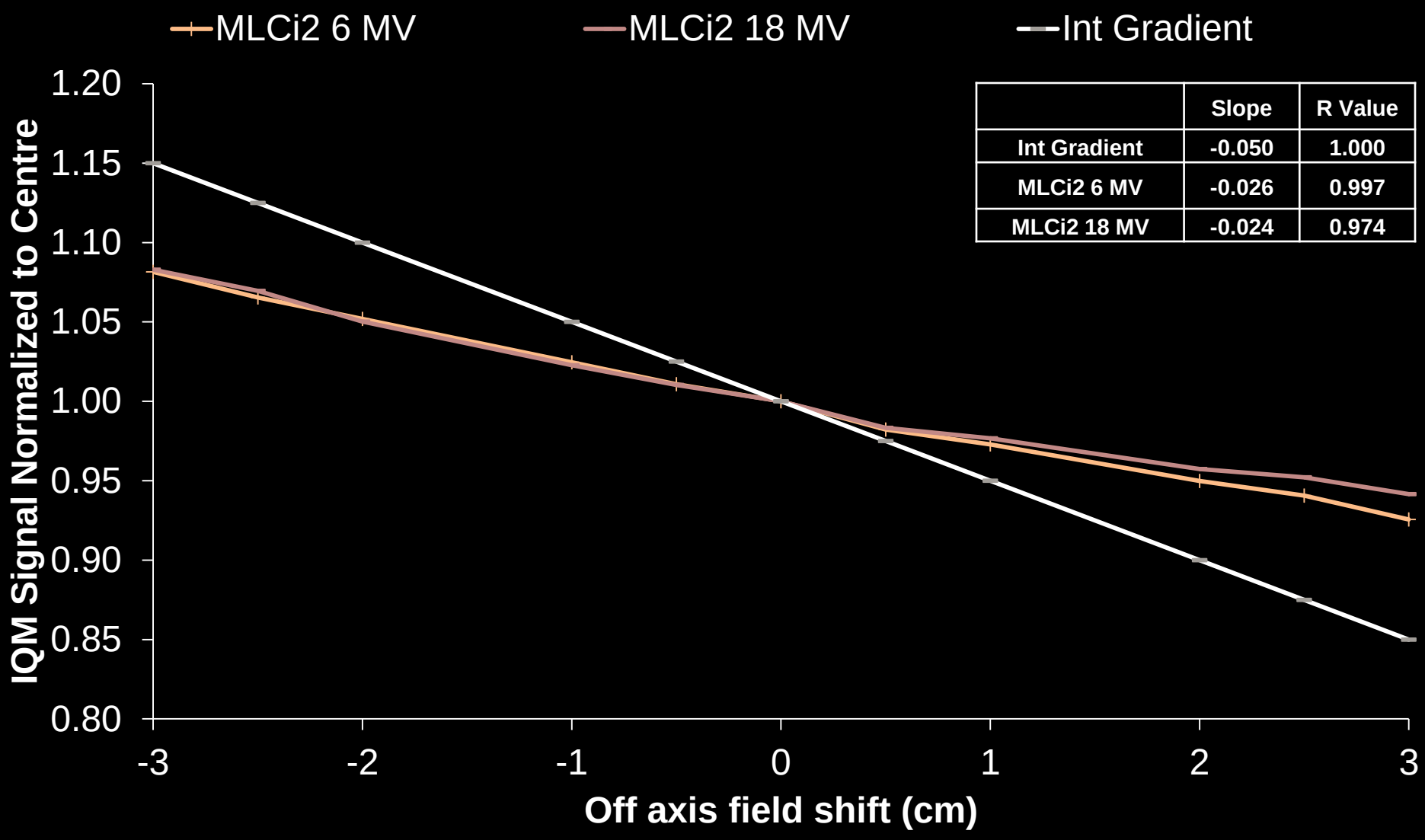

	Slope	R Value
Int Gradient	-0.050	1.000
MLCi2 6 MV	-0.026	0.997
MLCi2 18 MV	-0.024	0.974

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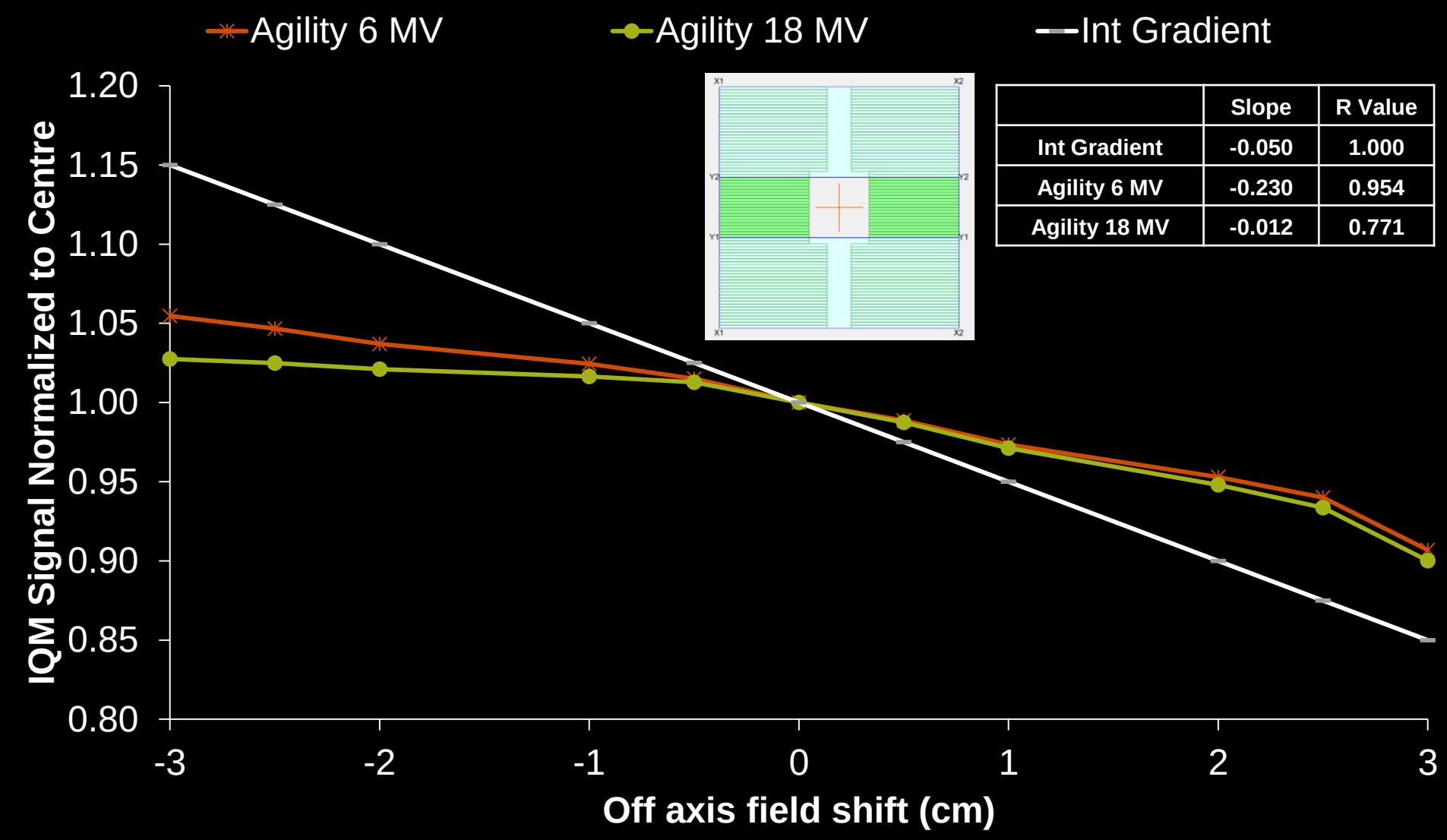
Effective IQM Spatial Sensitivity for a 3X3 cm2 field



	Slope	R Value
Int Gradient	-0.050	1.000
Agility 6 MV	-0.230	0.954
Agility 18 MV	-0.012	0.771

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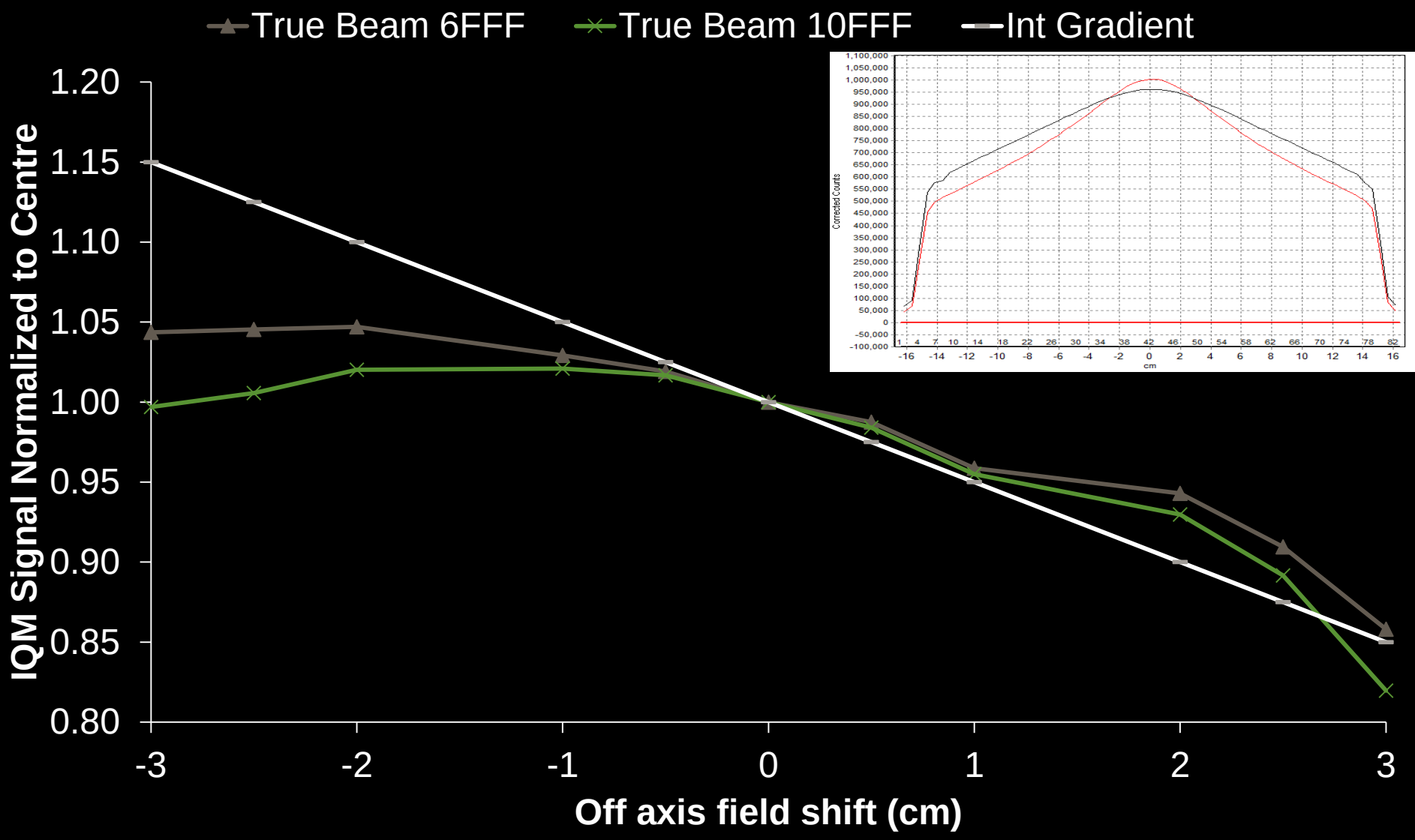
Effective IQM Spatial Sensitivity for a 3X3 cm2 field



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IQM Response Characteristics

Intrinsic spatial sensitivity

Effective IQM spatial sensitivity with different beams

- Response as a function of field size

Response as a function of beam energy

IQM response as a function of dose rates

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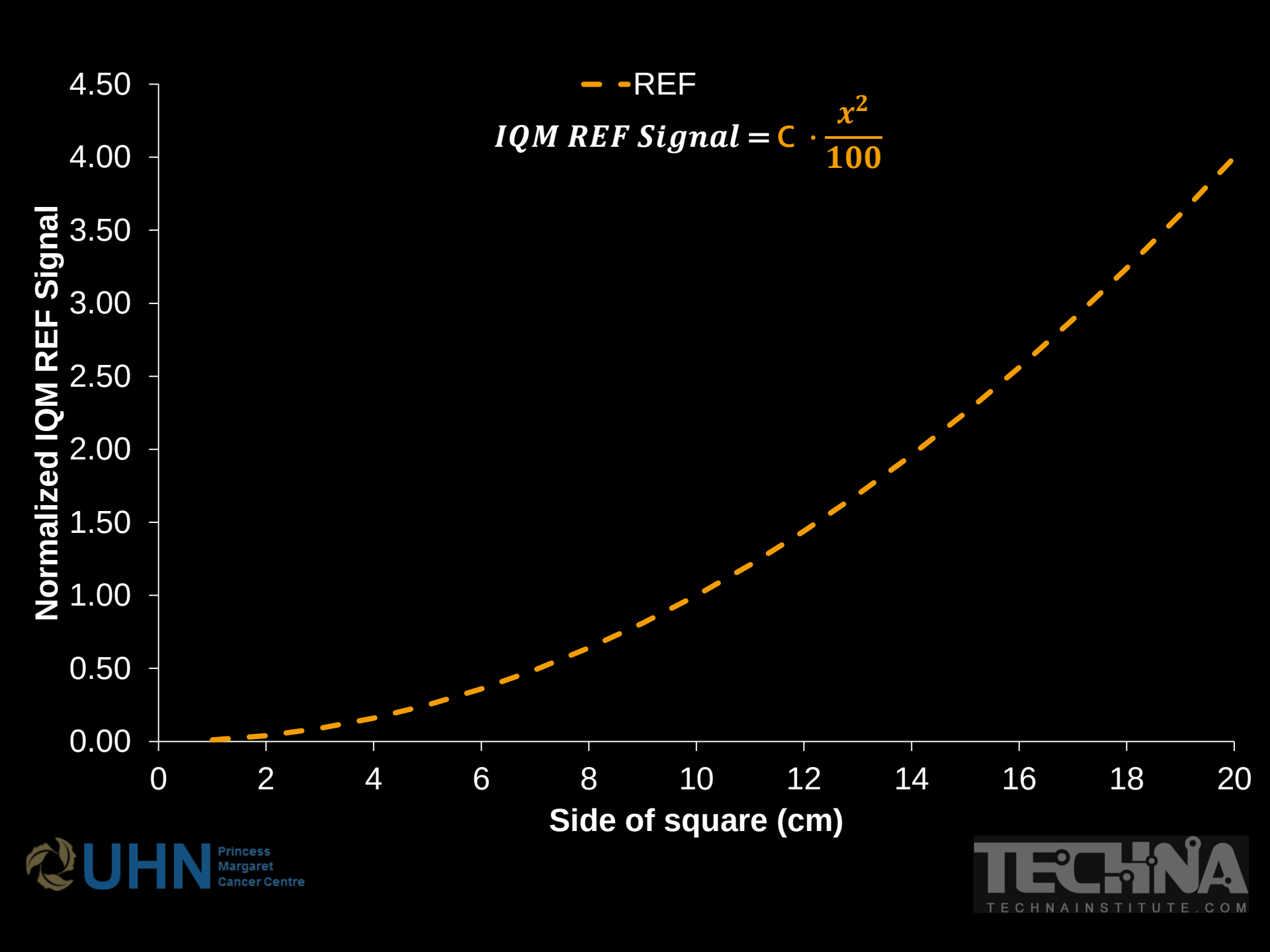

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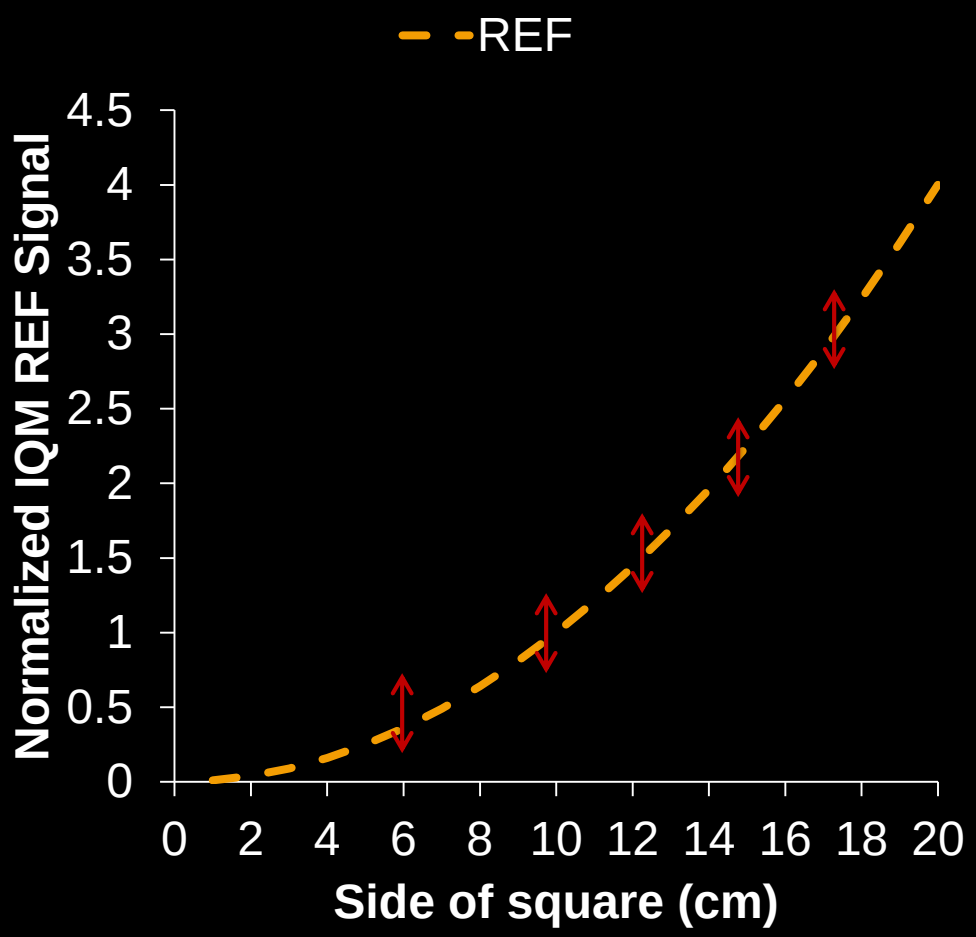

- Deviations from REF caused by:
  - Difference in LINAC output with field size
  - Difference in beam flatness and symmetry
  - Difference in beam transmission through collimating elements

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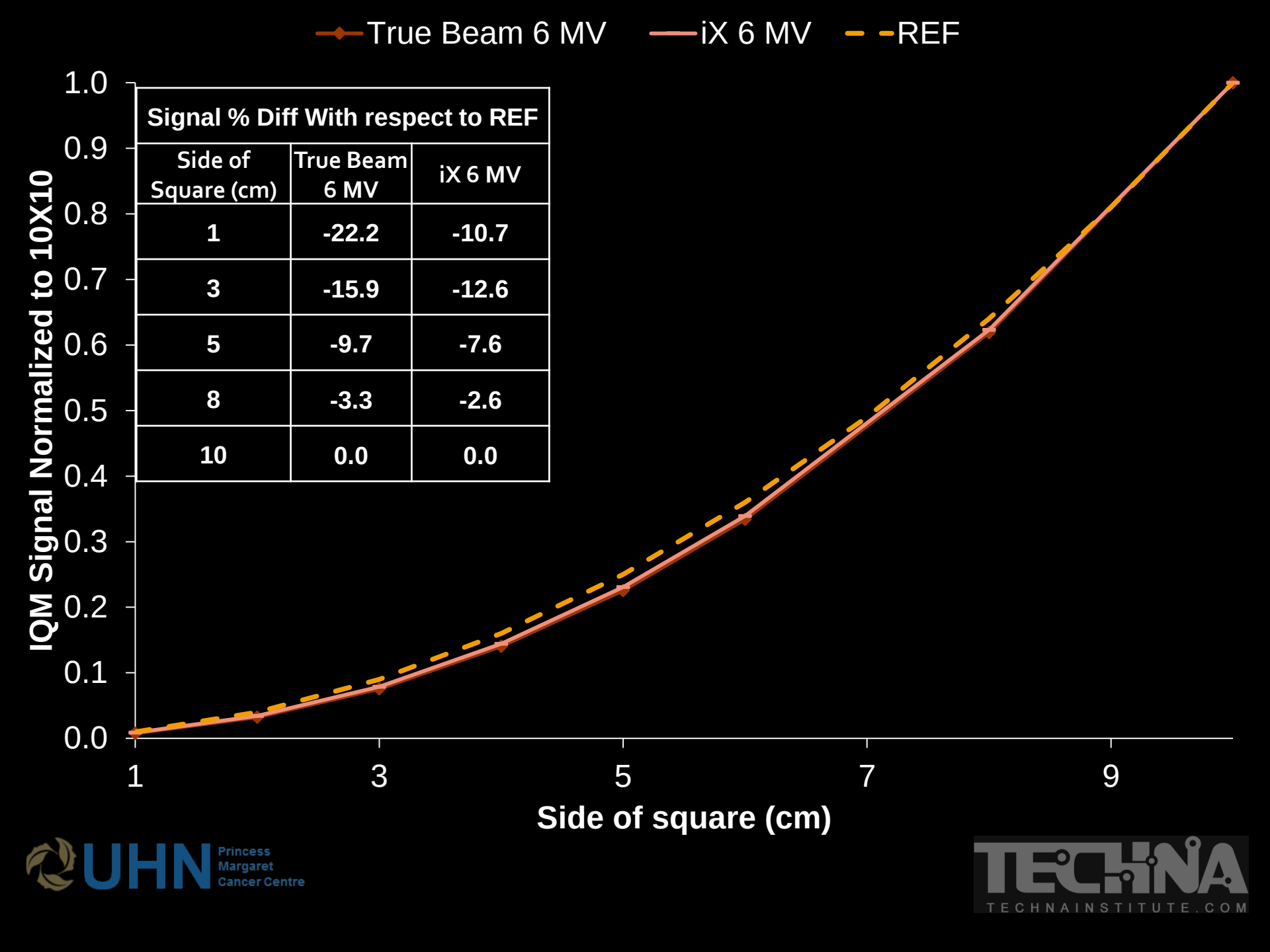

Signal % Diff With respect to REF		
Side of Square (cm)	True Beam 6 MV	iX 6 MV
1	-22.2	-10.7
3	-15.9	-12.6
5	-9.7	-7.6
8	-3.3	-2.6
10	0.0	0.0

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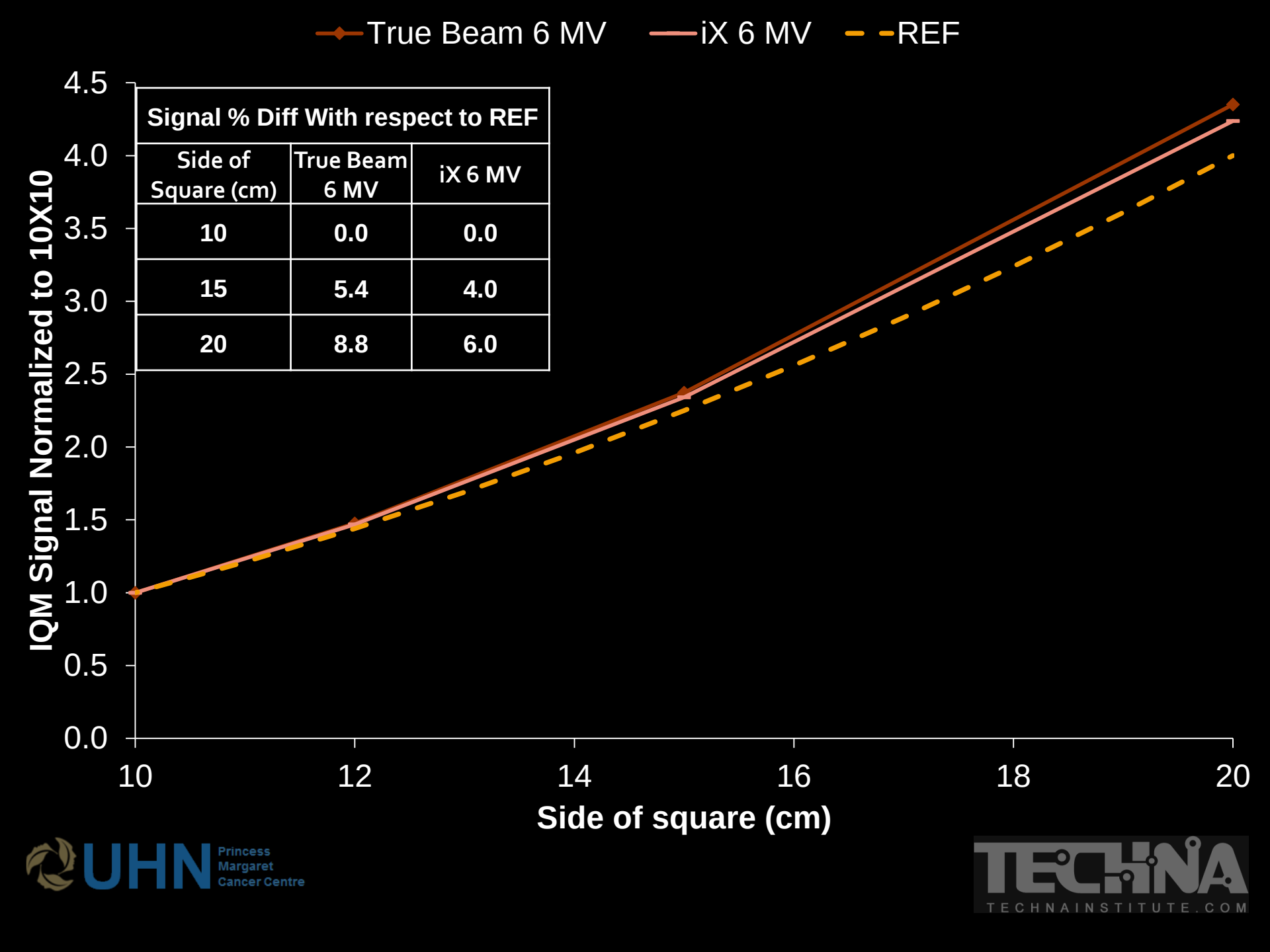

Signal % Diff With respect to REF		
Side of Square (cm)	True Beam 6 MV	iX 6 MV
10	0.0	0.0
15	5.4	4.0
20	8.8	6.0

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IQM Response Characteristics

Intrinsic spatial sensitivity

Effective IQM spatial sensitivity with different beams

Response as a function of field size

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IQM response as a function of dose rates

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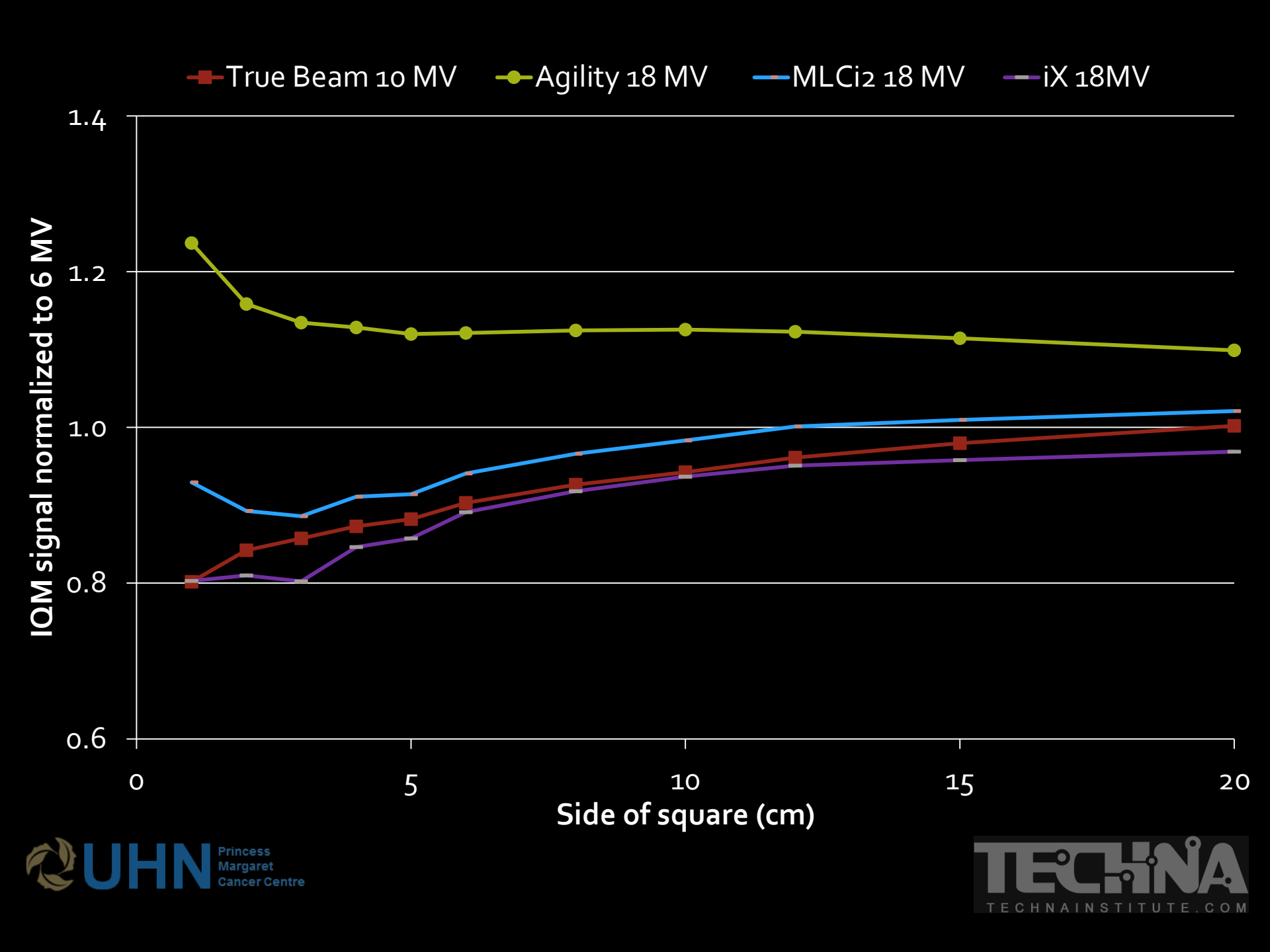

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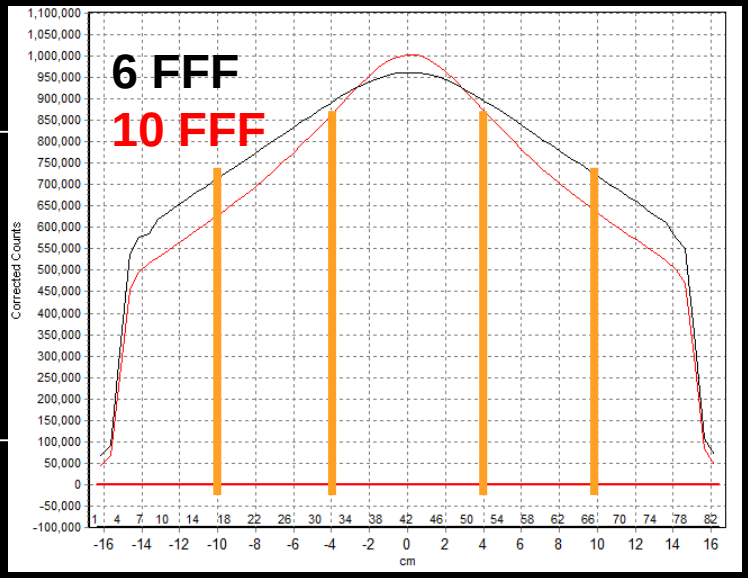
True Beam 10FFF

IQM signal normalized to 6 MV FFF

1.2
1.0
0.8
0.6

0
5
10
15
20

Side of square (cm)



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IQM Response Characteristics

Intrinsic spatial sensitivity

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IQM Dose Rate Dependency (Varian TB)

	Signal Normalized To 600 MU / Min For 6 MV ,10 MV, 6 FFF And Normalized to 800 MU / Min For 10 FFF			
Dose Rate	6 MV IQM	10 MV IQM	6 FFF IQM	10 FFF IQM
20	1.000	0.999	-	-
40	1.001	0.999	-	-
100	1.001	0.999	-	-
400	1.000	1.000	1.000	-
600	1.000	1.000	1.000	-
800	-	-	0.999	1.000
1000	-	-	1.000	-
1200	-	-	1.000	0.999
1400	-	-	1.000	-
1600	-	-	-	0.999
2000	-	-	-	0.999
2400	-	-	-	0.999

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Summary

- Only minor deviations in IQM intrinsic spatial sensitivity was observed across different energies and platforms
- The effective spatial sensitivity is affected by beam profile parameters and beam attenuation
- The signal for square field size depends on the design of the LINAC head components
- The IQM energy discrimination varies with field size, design of the LINAC head components, and beam profile
- IQM system exhibits negligible dose rate dependency

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Acknowledgments

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- Dr. Robert Heaton
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- Dr. Ivan Yeung
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Thank You

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