

Title: Scattering Kernel for Aperture Modulated Total Body Irradiation

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URL: <http://pirsa.org/11070076>

Abstract: The goal of Total Body Irradiation (TBI) is to deliver a uniform dose of radiation to the entire body, to destroy cancerous cells. Since the human body is not uniform in either density or thickness, it is difficult to deliver a uniform dose. A novel, Aperture Modulated, Total Body Irradiation (AMTBI) technique was introduced by researchers at the Tom Baker Cancer Centre to address this problem. The AMTBI technique reduces the dose deviation along the midline in the longitudinal direction to less than 5%, as compared to 15% with conventional TBI. This improvement in dose homogeneity is achieved by dynamically changing the apertures of the Multi-Leaf Collimator (MLC) according to the radiative area

Outline

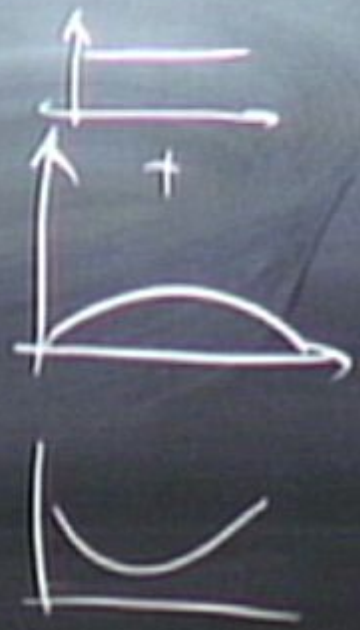
- ◆ Background and Motivation
- ◆ Methods
- ◆ Results
- ◆ Future Work
- ◆ Summary

Total Body Irradiation (TBI)

- ◆ A treatment for blood cancer.
- ◆ Suppress the immune system.
- ◆ Kill cancerous cells that escaped other therapies.
- ◆ Goals include delivering uniform dosage.

Difficulties

- The human body is not uniformly distributed in terms of density or thickness.
- Certain organs require lower dosages.



Total Body Irradiation (TBI)



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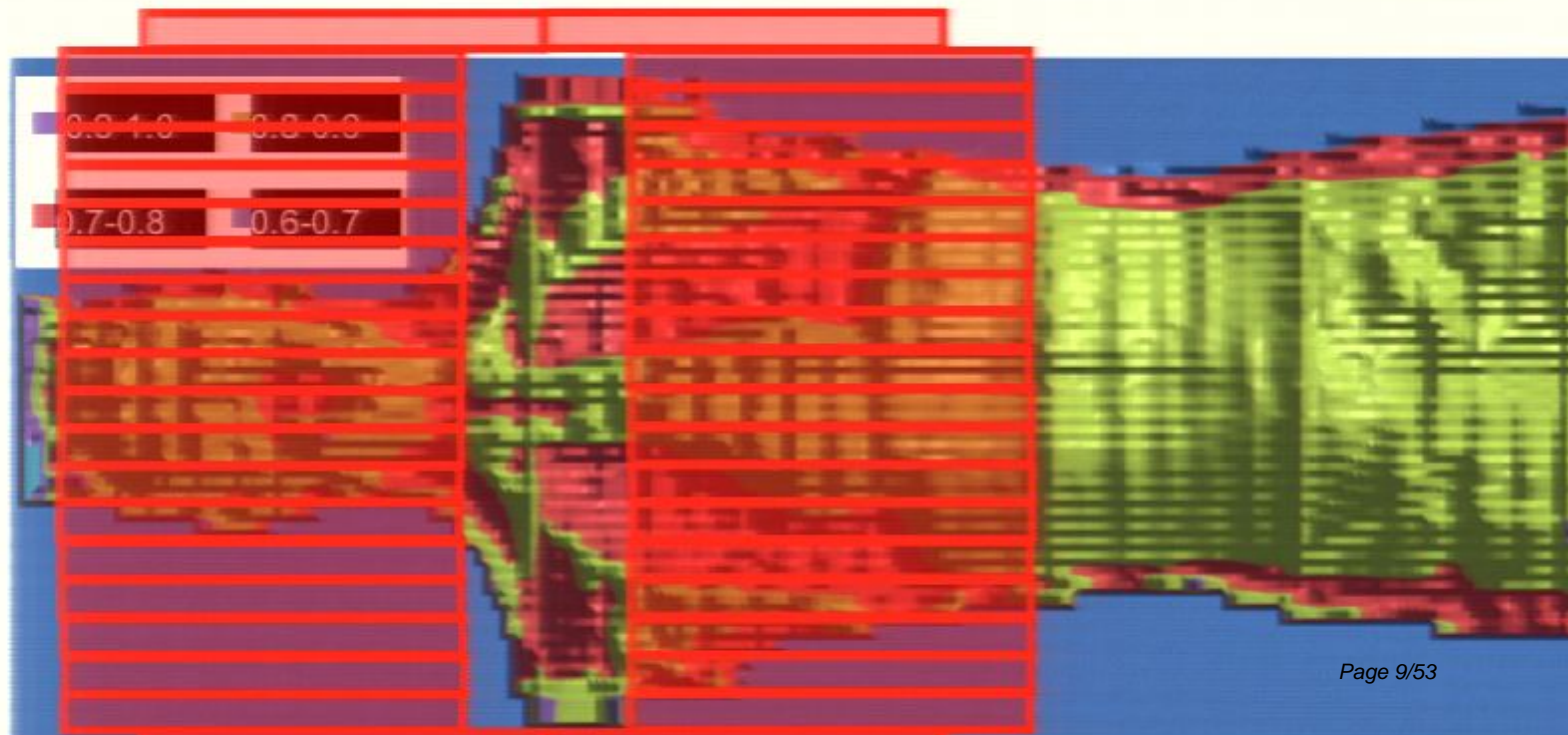
a – Uniform Intensity

b – Uniform Dosage



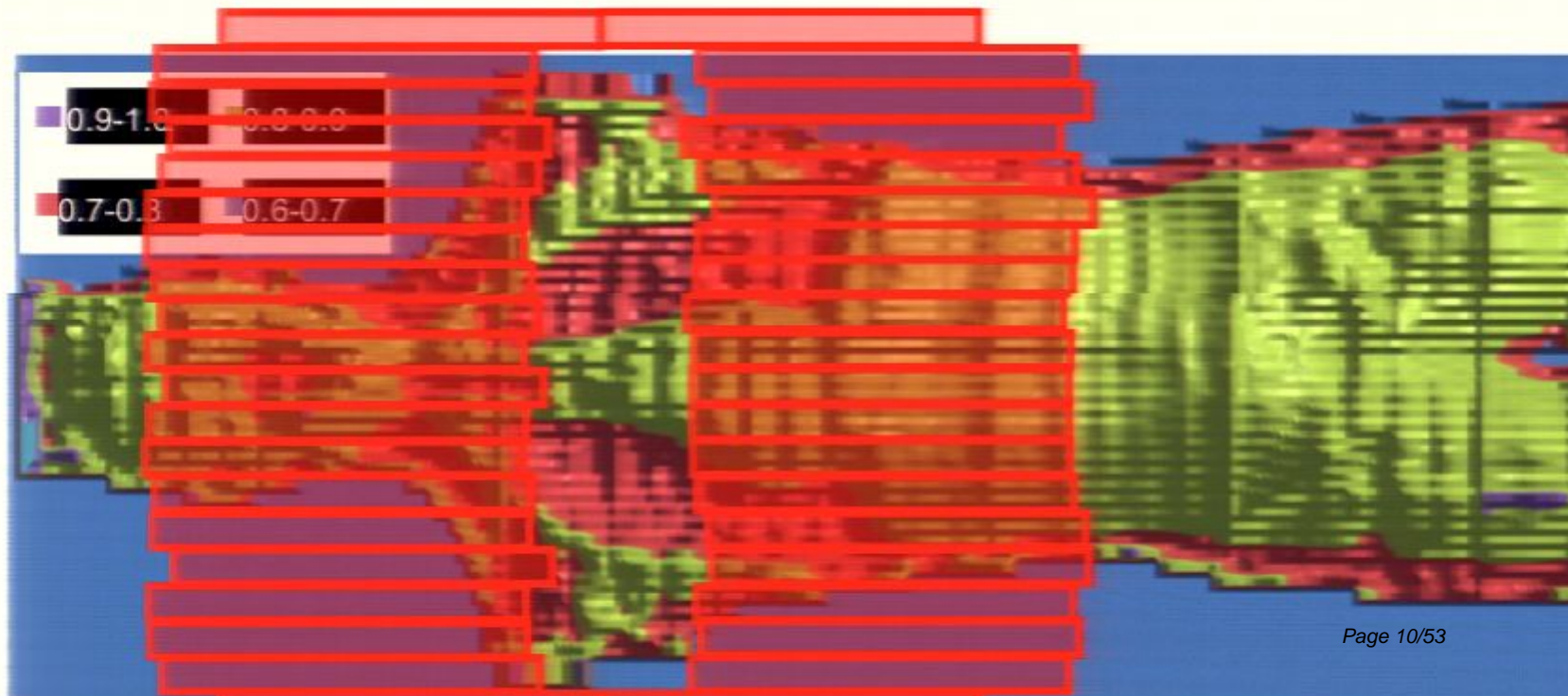
Aperture Modulated Total Body Irradiation (AMTBI)

- In 2010, Brown et al. developed an aperture modulated TBI technique.



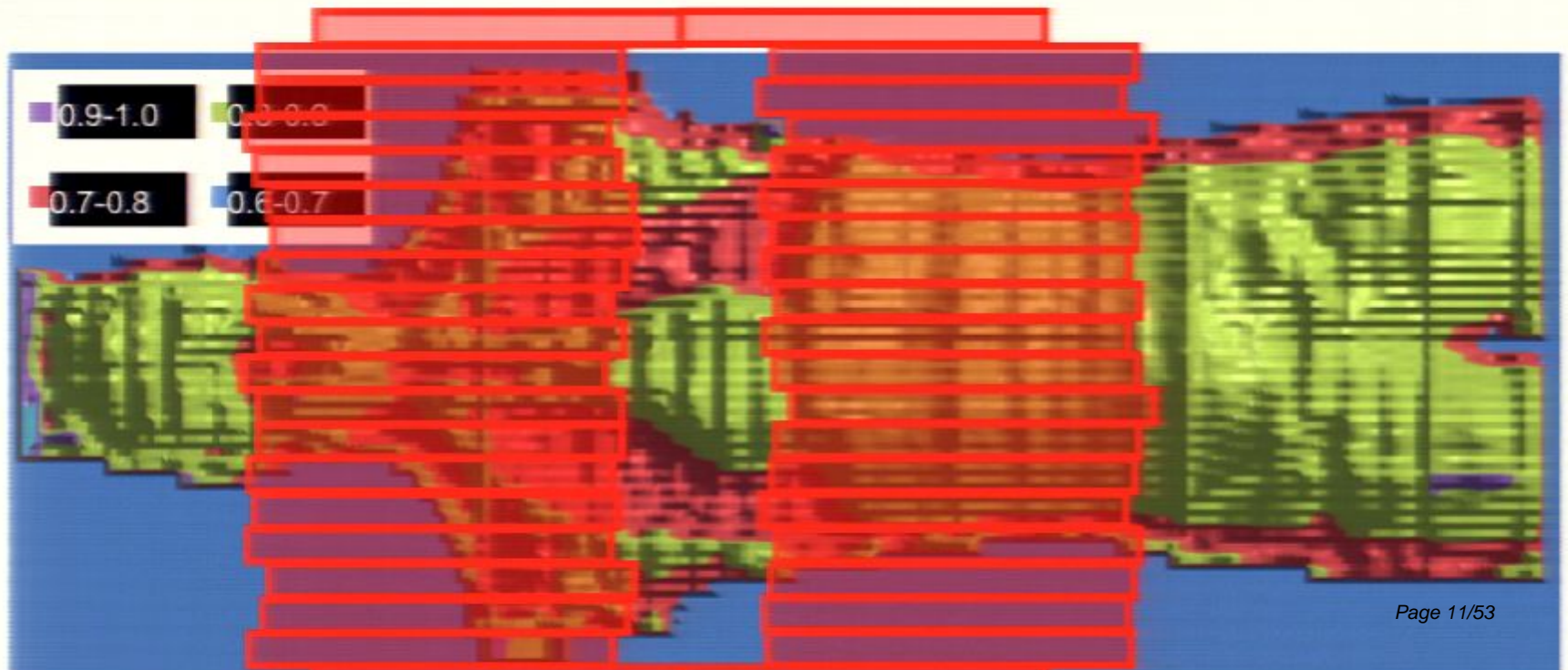
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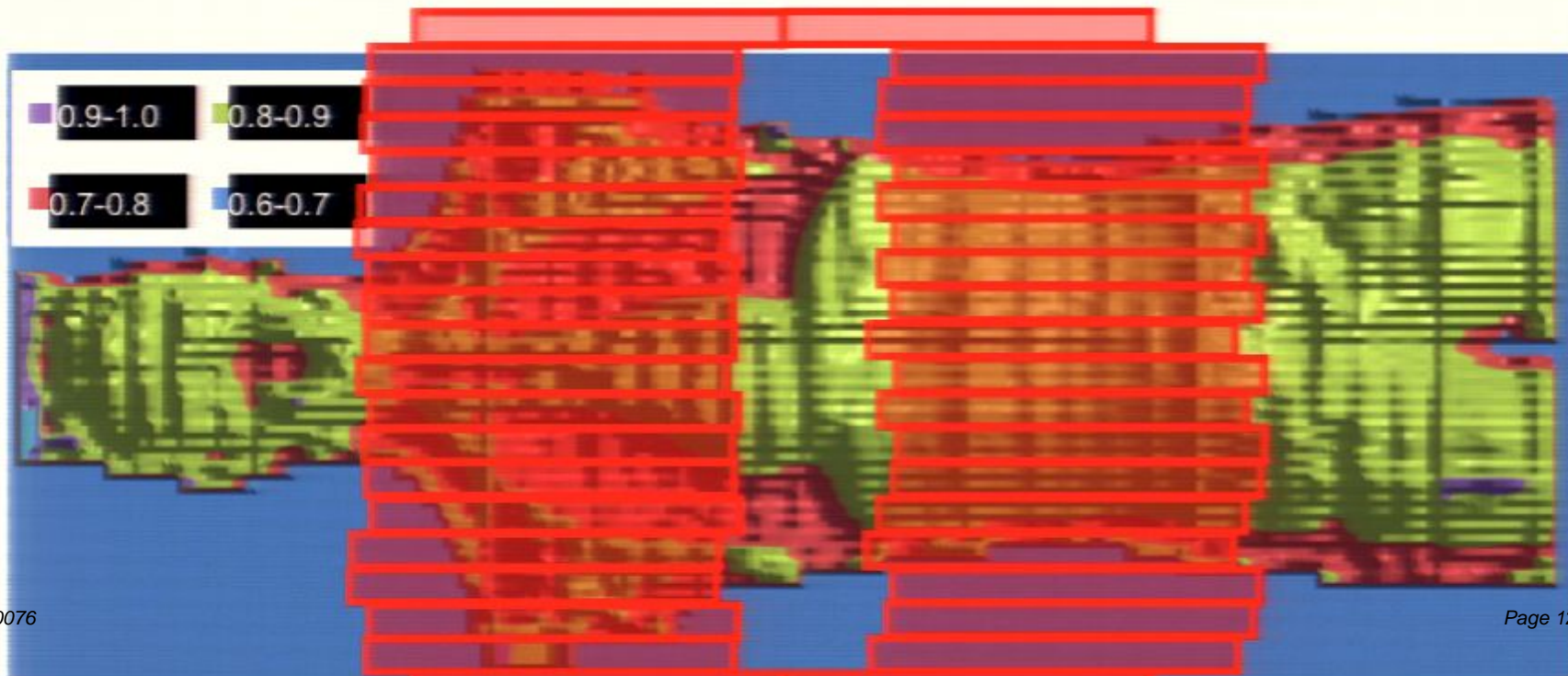
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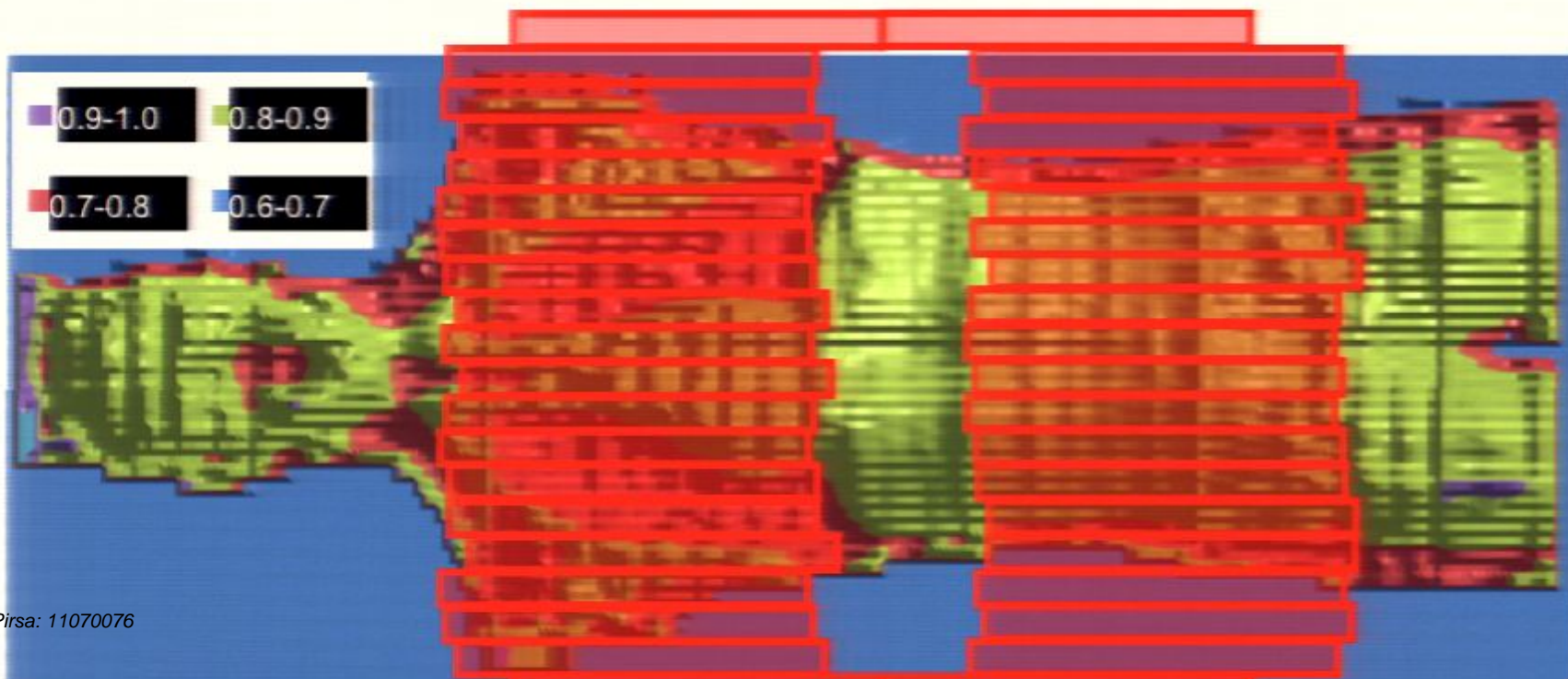
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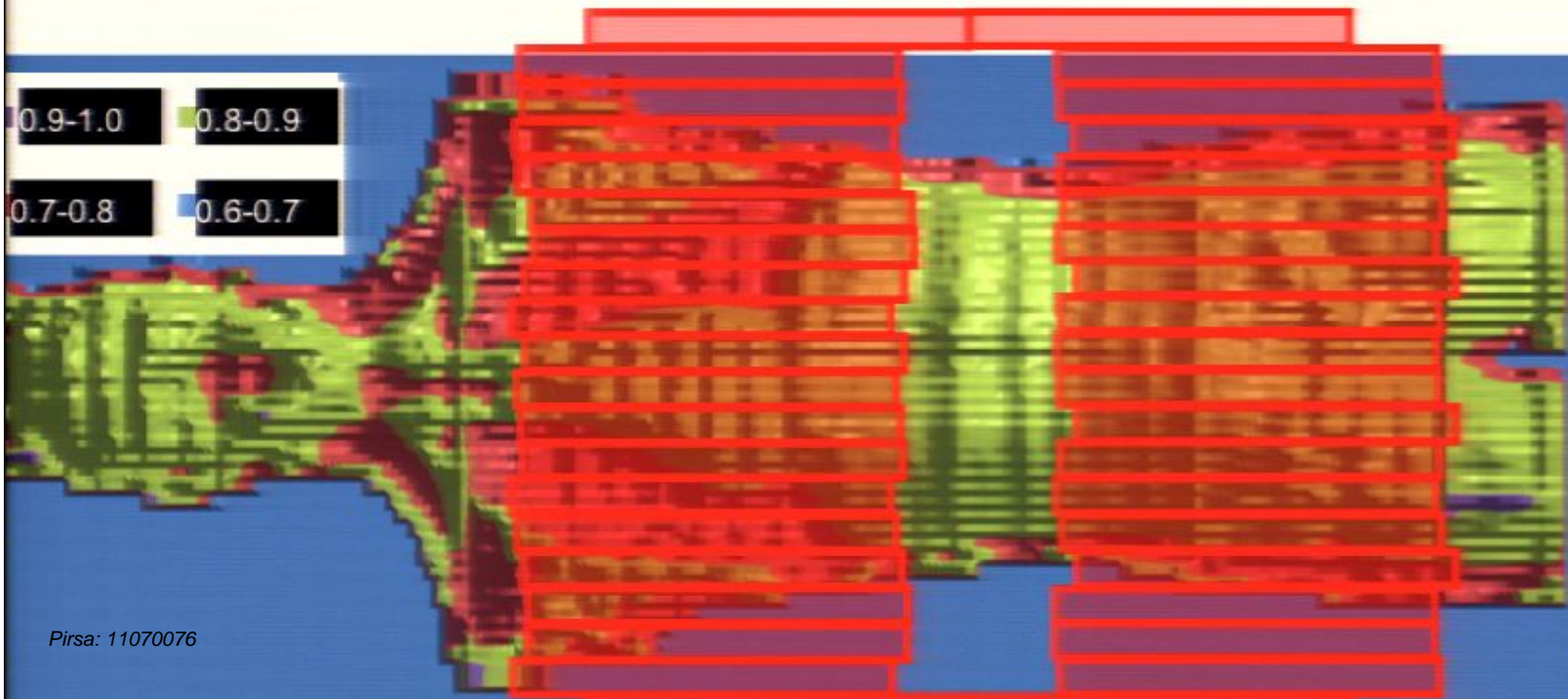
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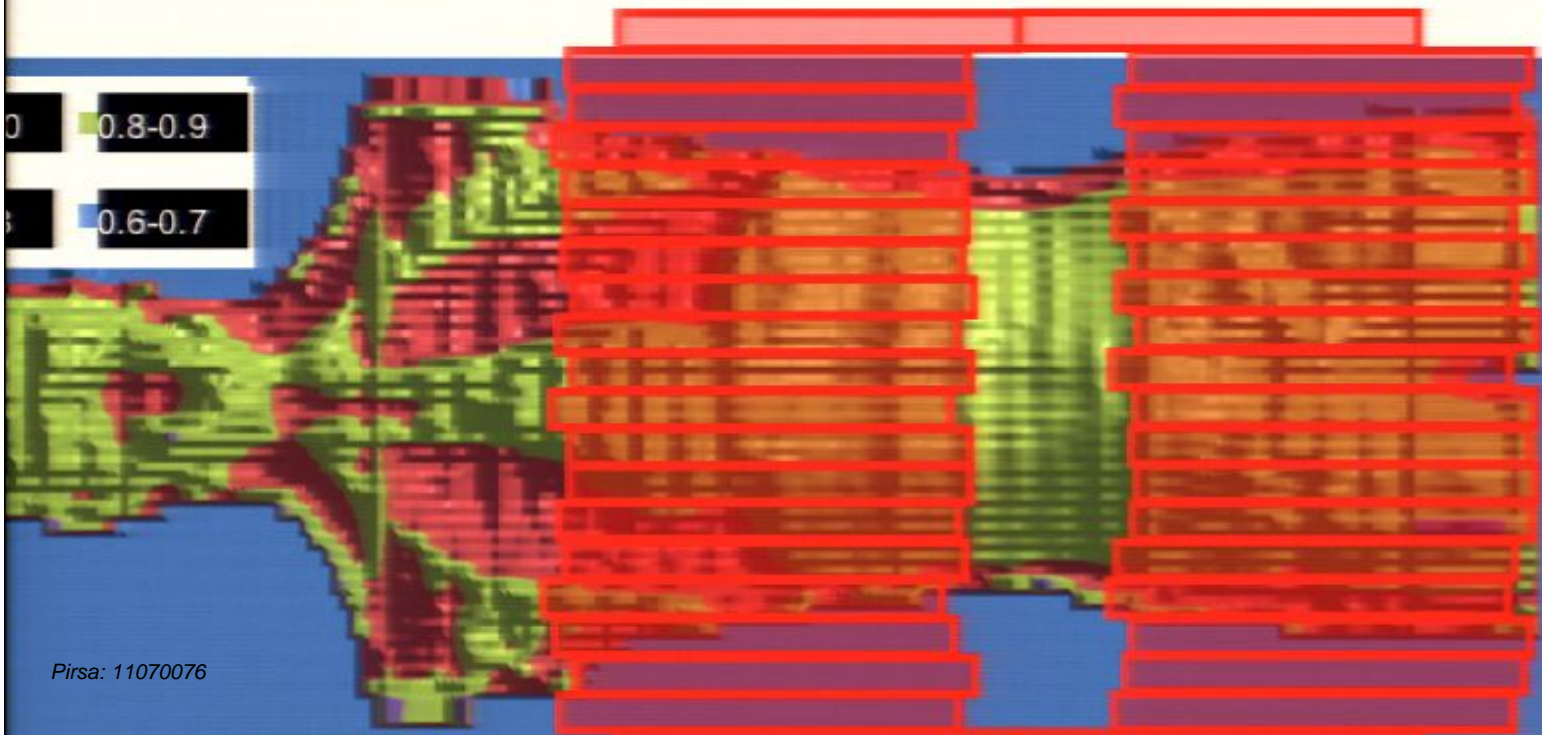
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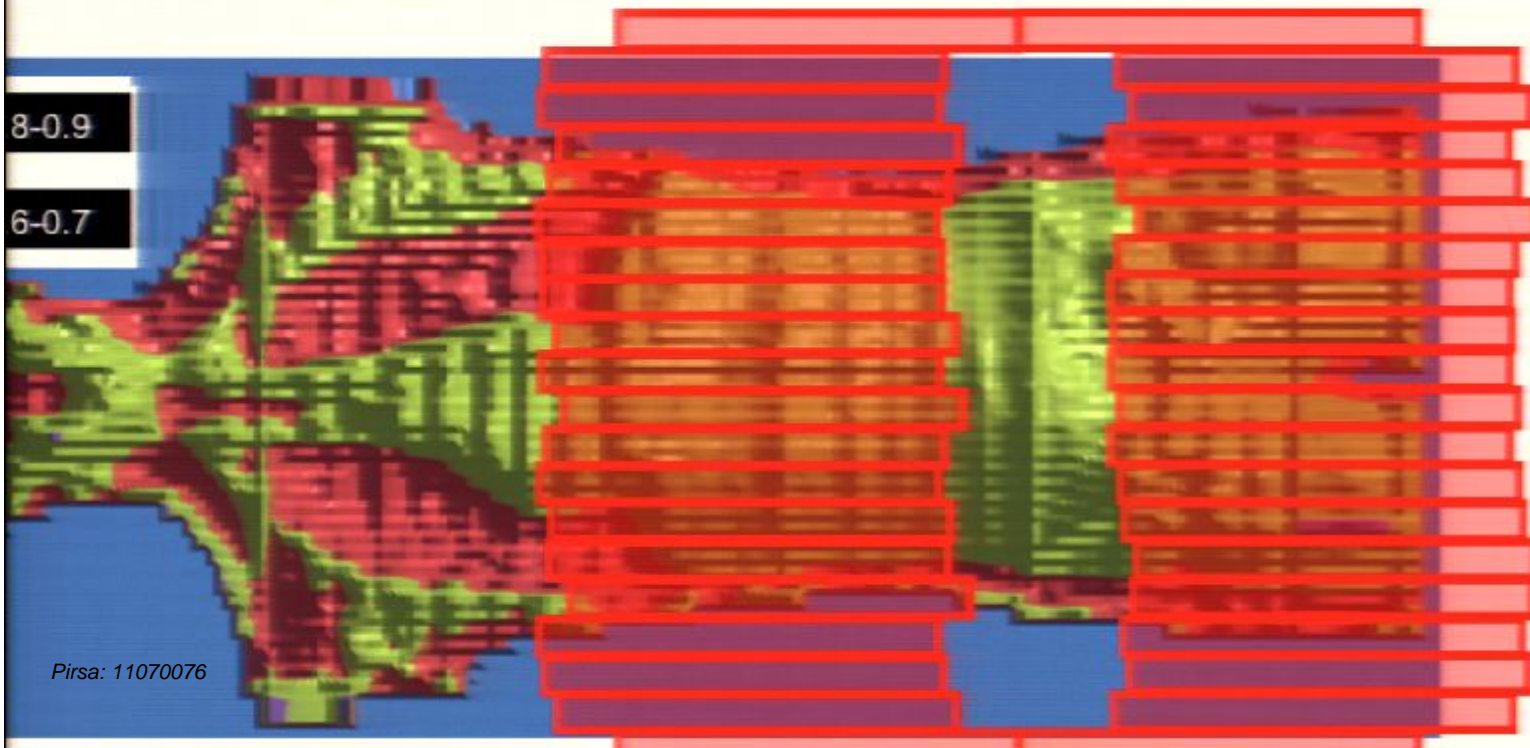
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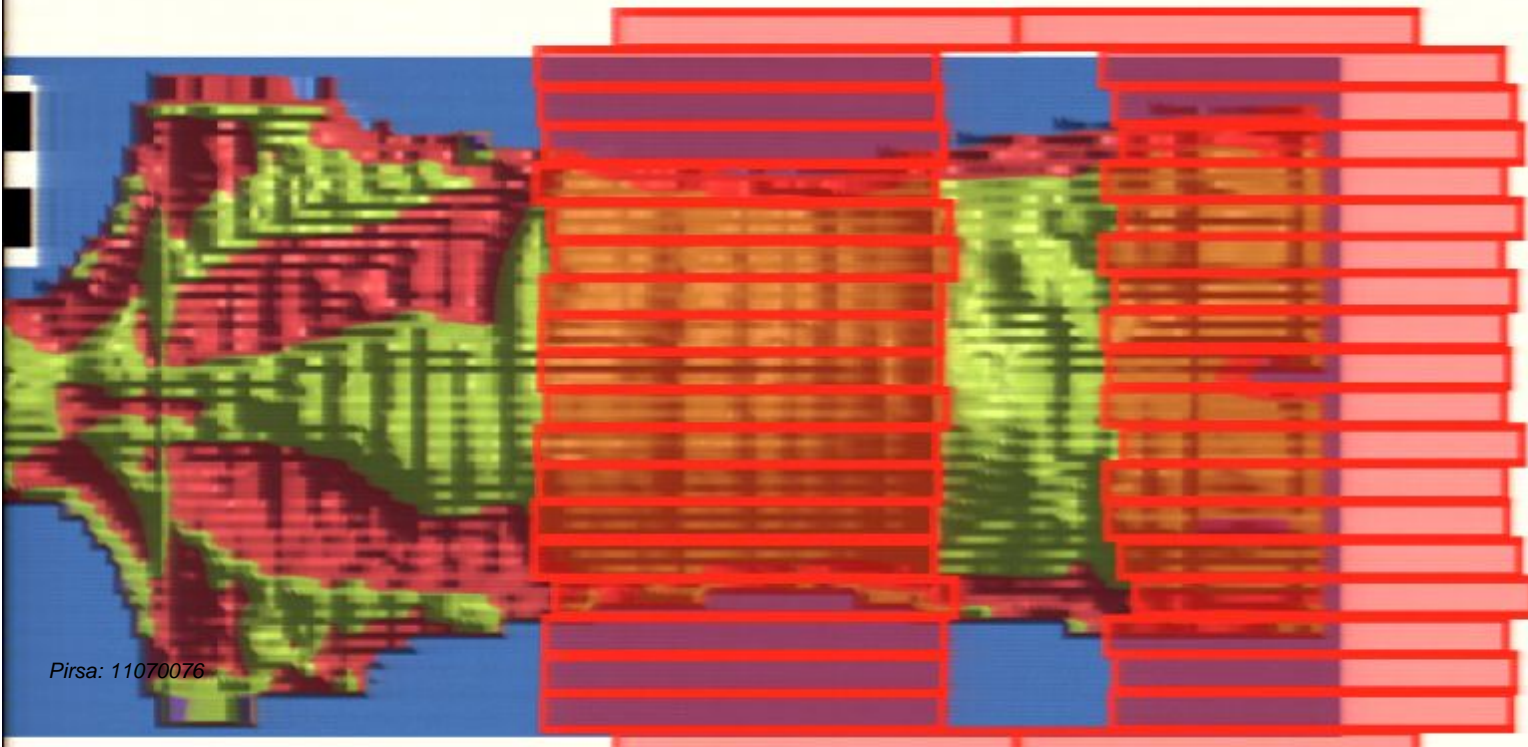
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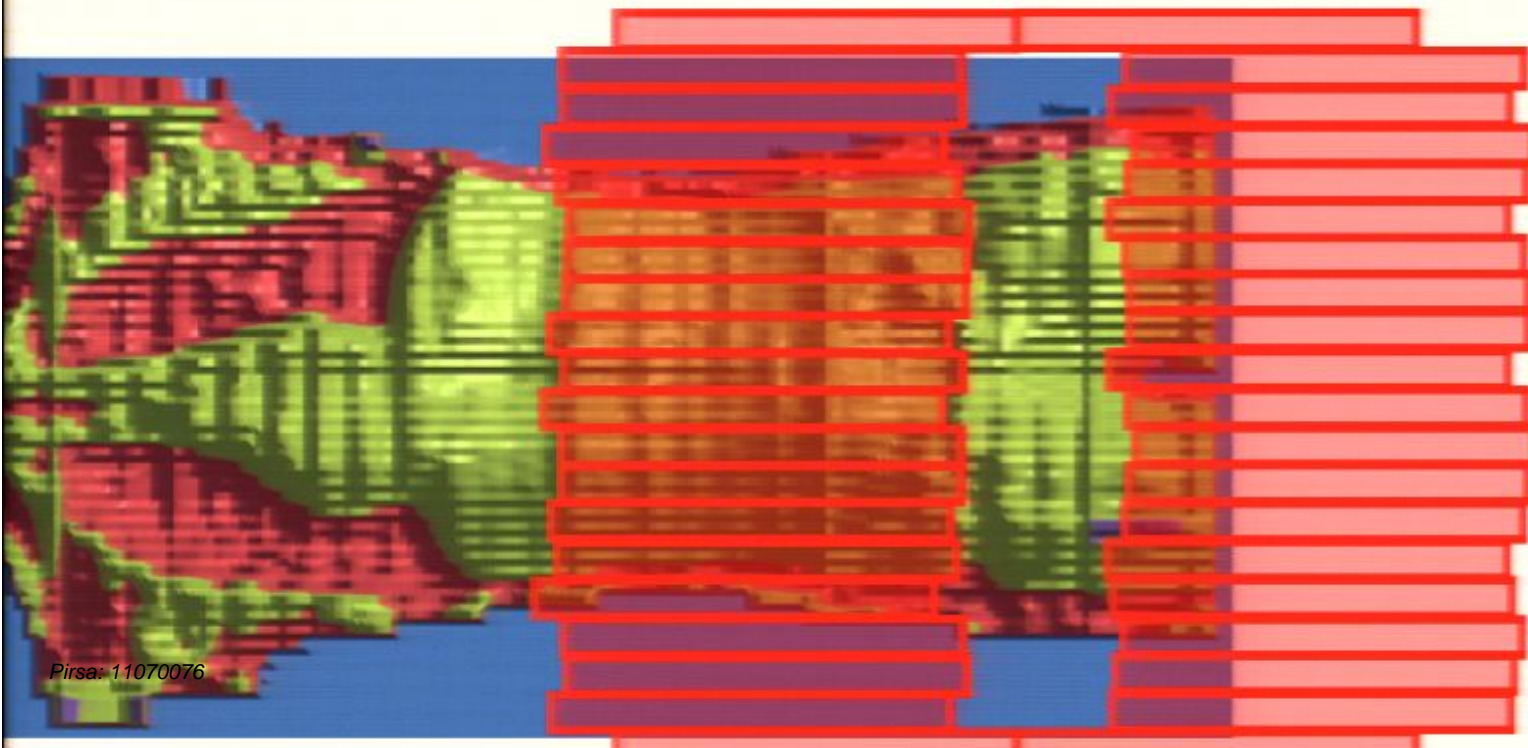
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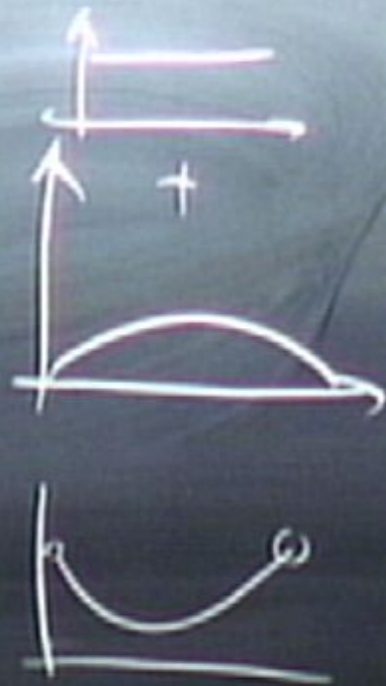


Motivation

- The Multi-Leaf Collimator (MLC) opening sizes are calculated according to the radiological depths.

$$d_r = \sum_i d_i \cdot \rho_i / \rho_{water}$$

- The scattered dose is not considered in the calculation.



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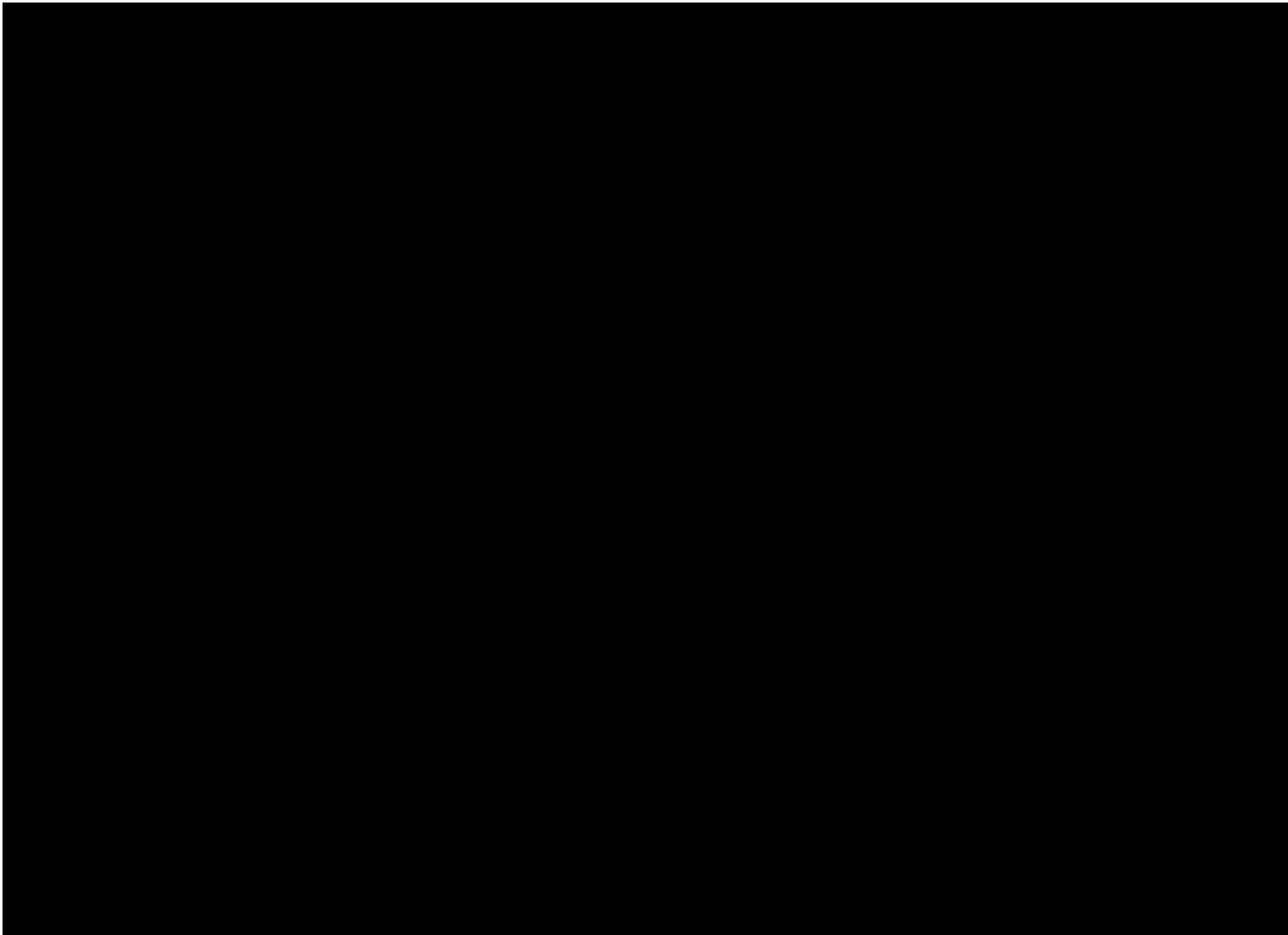
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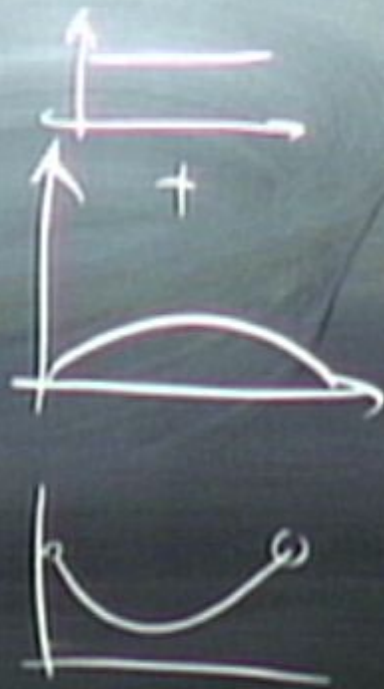
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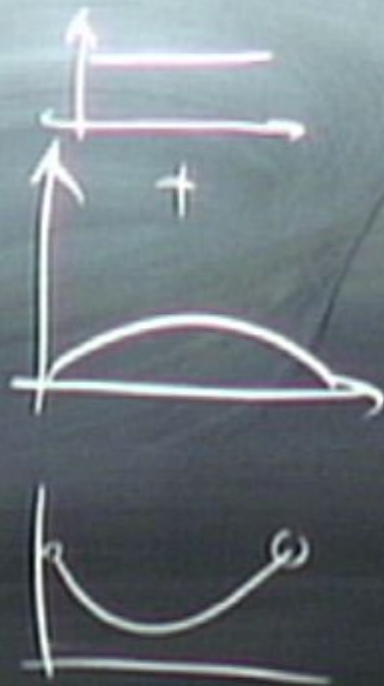
Methods

$$SMR(d, r_d) = TMR(d, r_d) \cdot \frac{S_p(r_d)}{S_p(0)} - TMR(d, 0)$$

- TMR: Tissue Maximum Ratio
- SMR: Scatter Maximum Ratio
- S_p : Phantom Scatter correction factor
- d : depth in phantom
- r_d : radius of circular field size

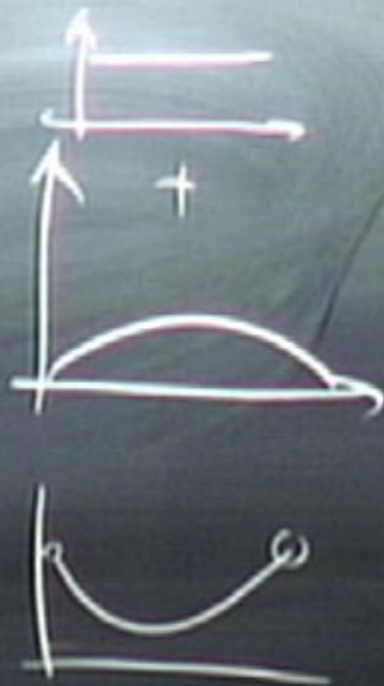






$$T = P + S$$

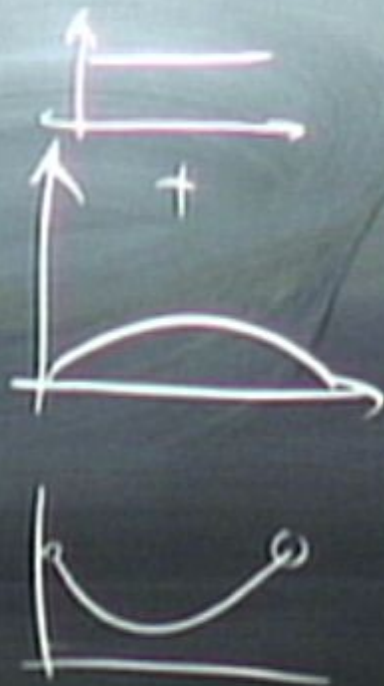
$$T - P = S$$



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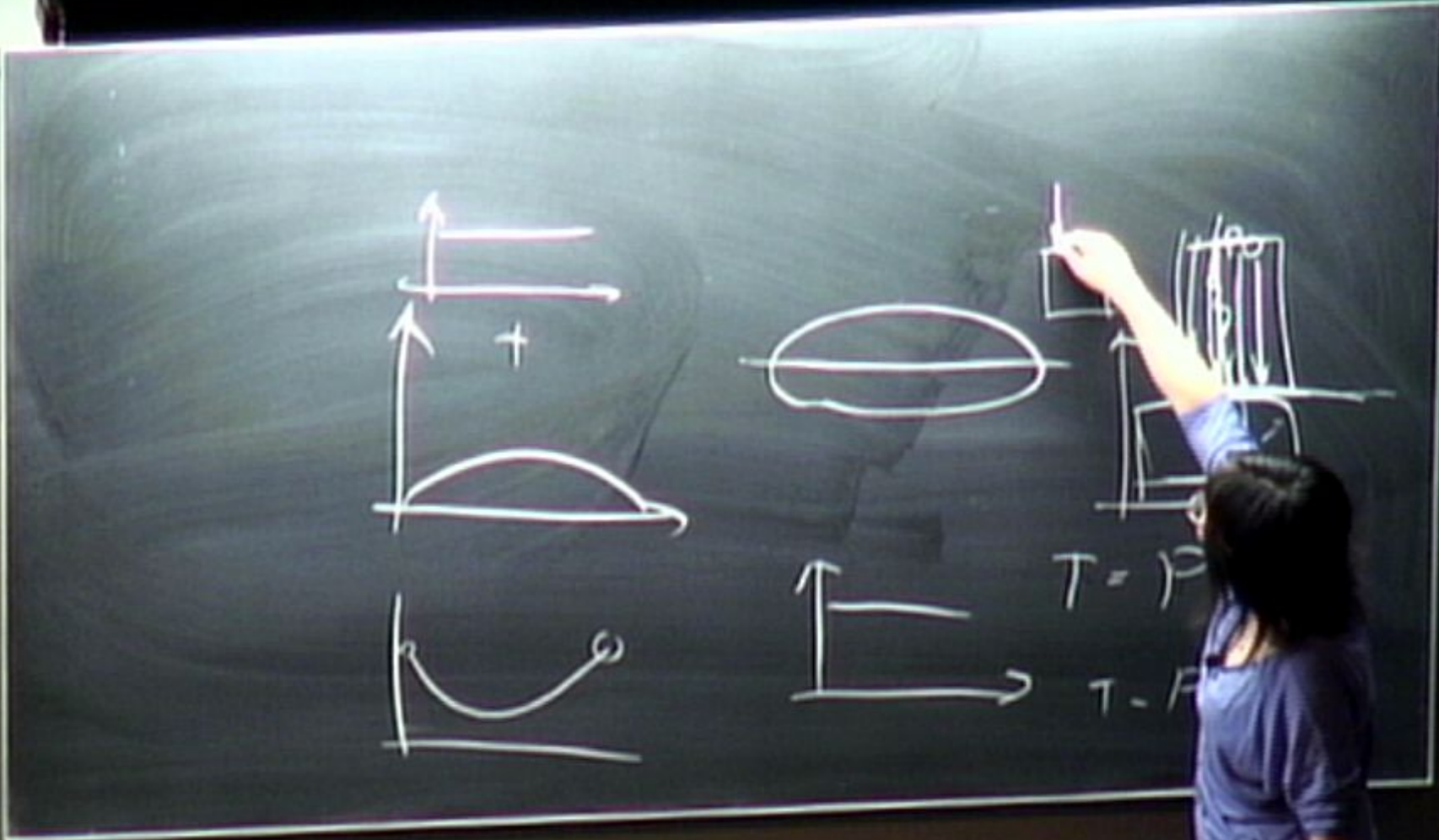
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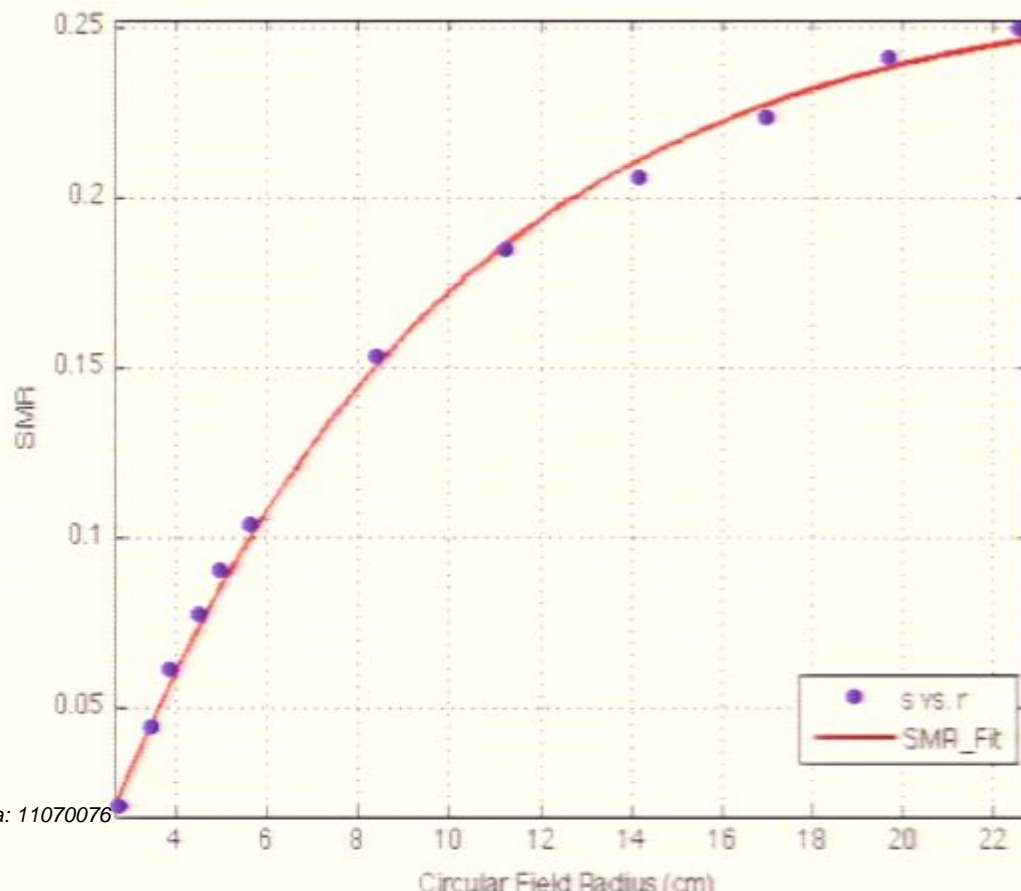
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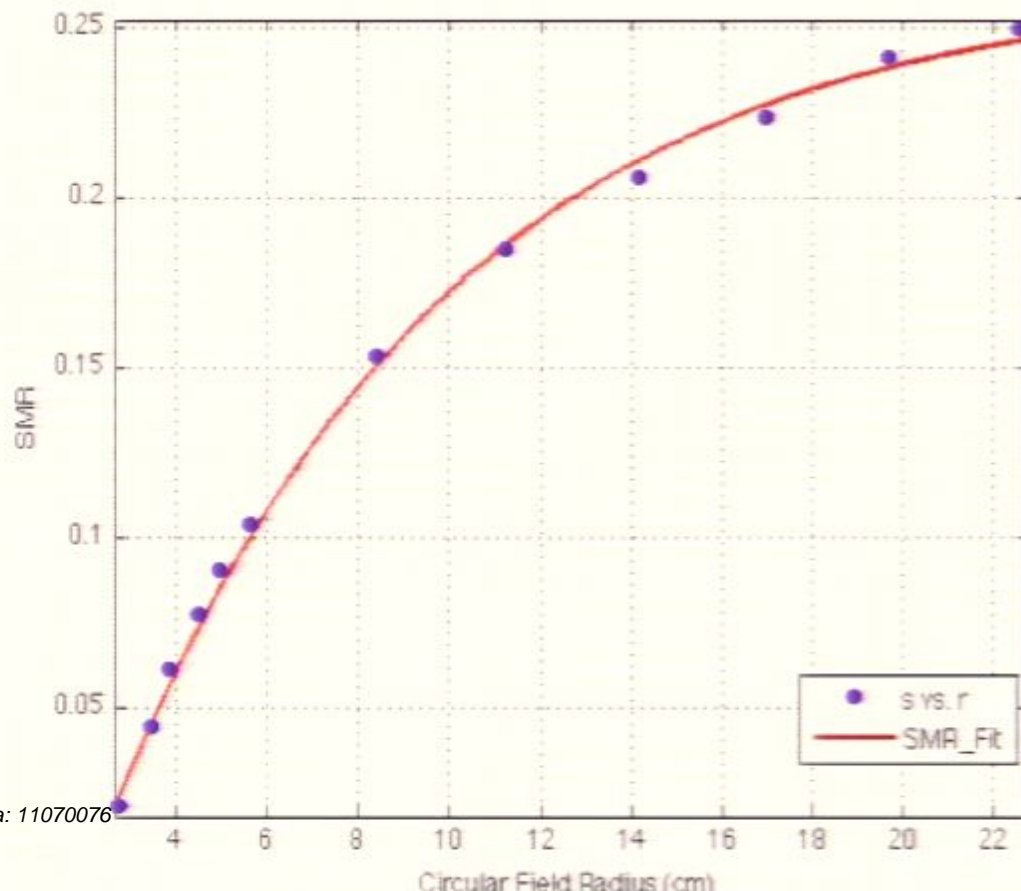
SMR (d = 10 cm, r_d)



$$SMR = -a \cdot e^{-b \cdot r} + c$$

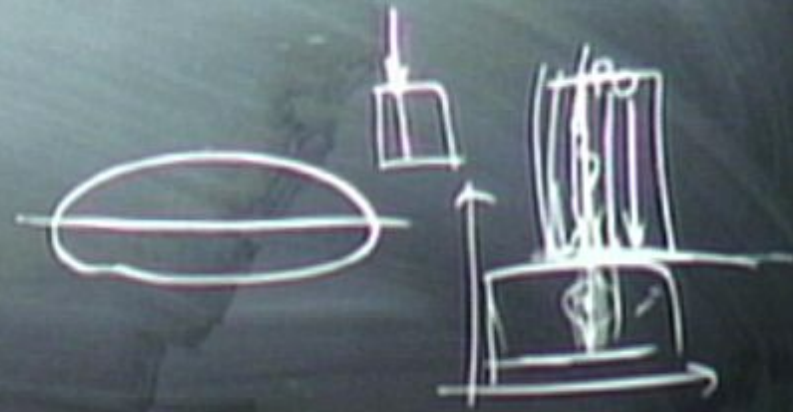
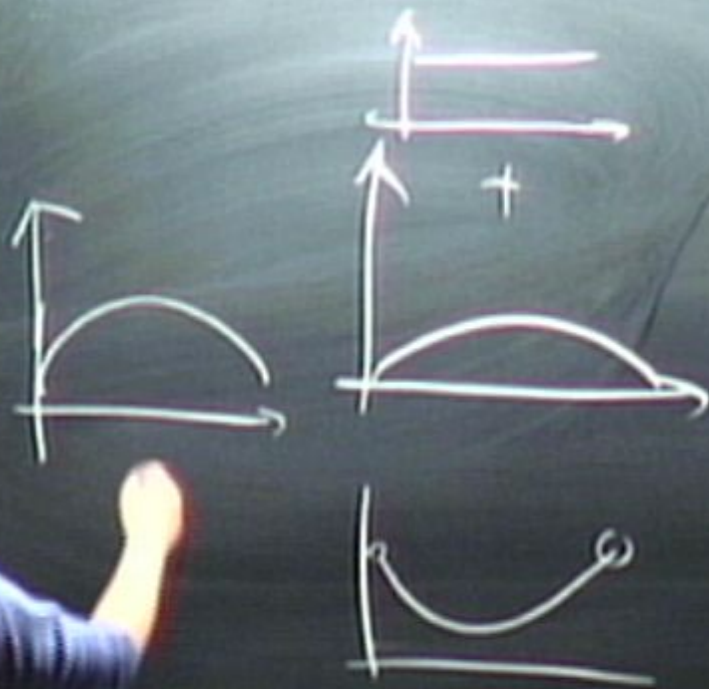
$$R^2 = 0.9985$$

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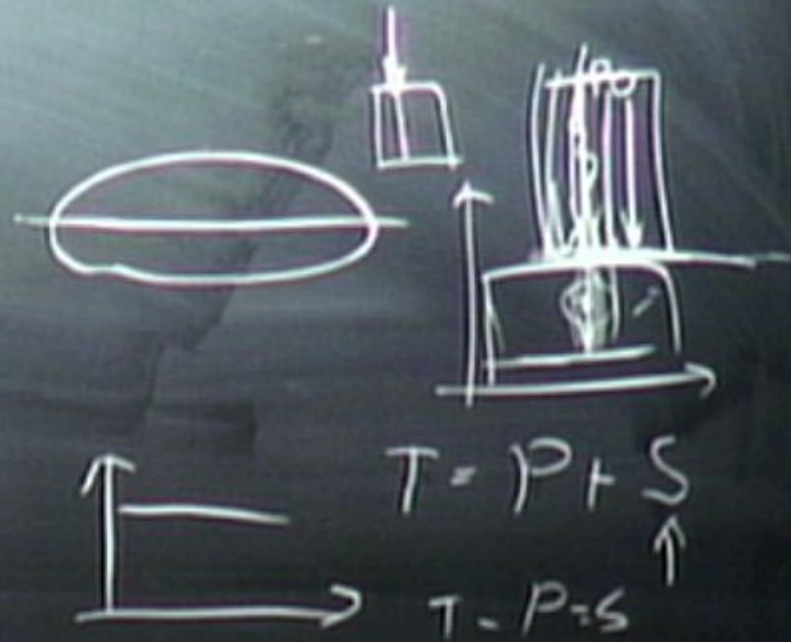
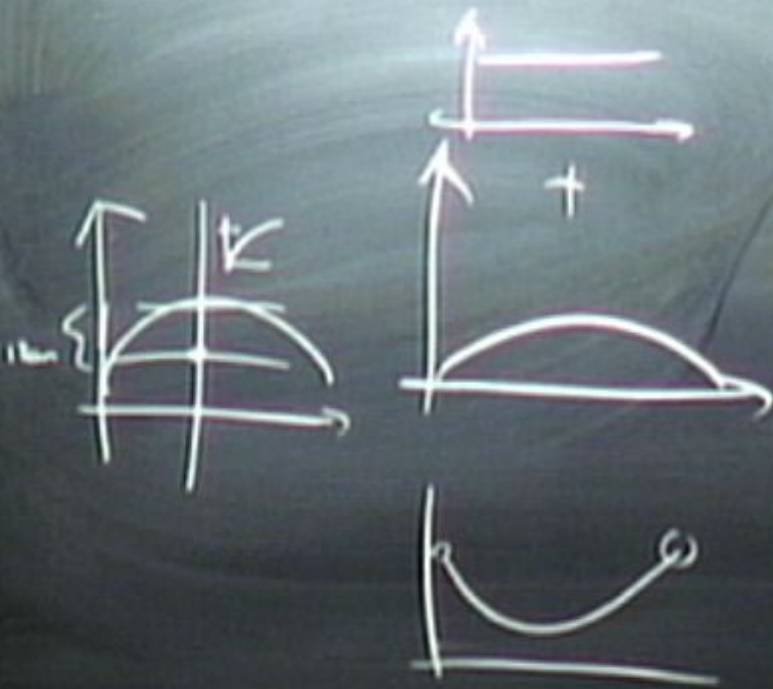
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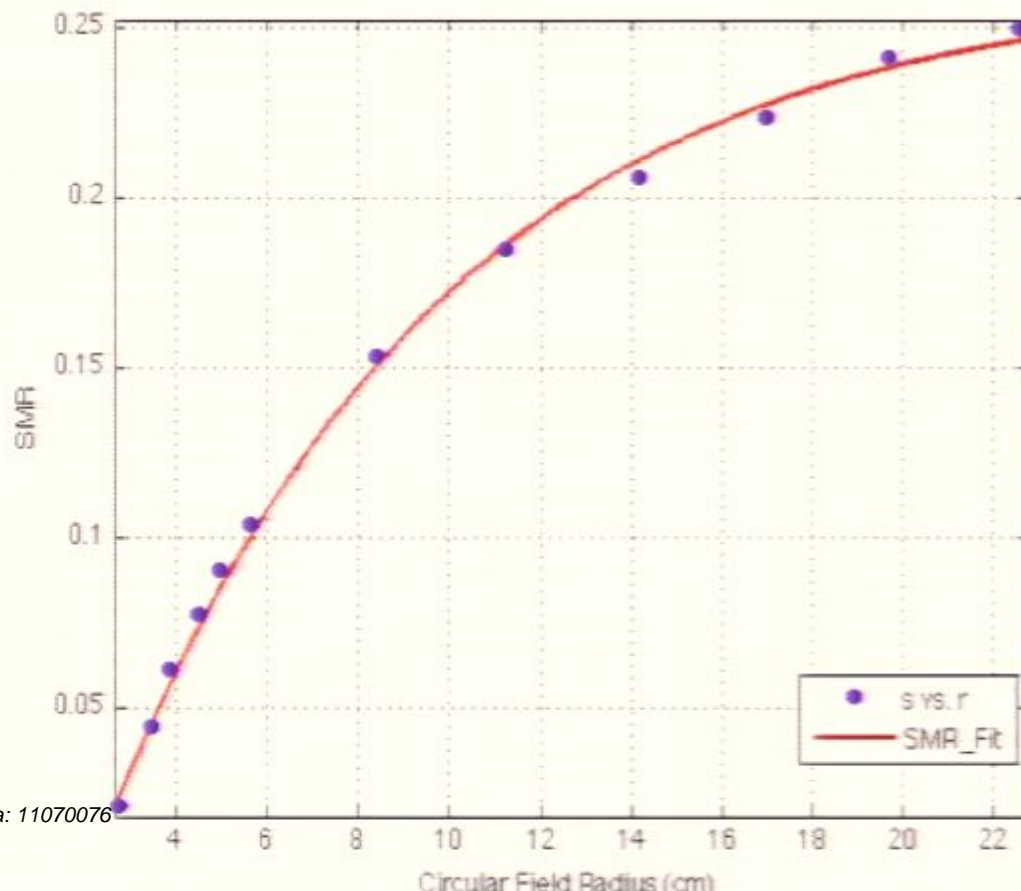


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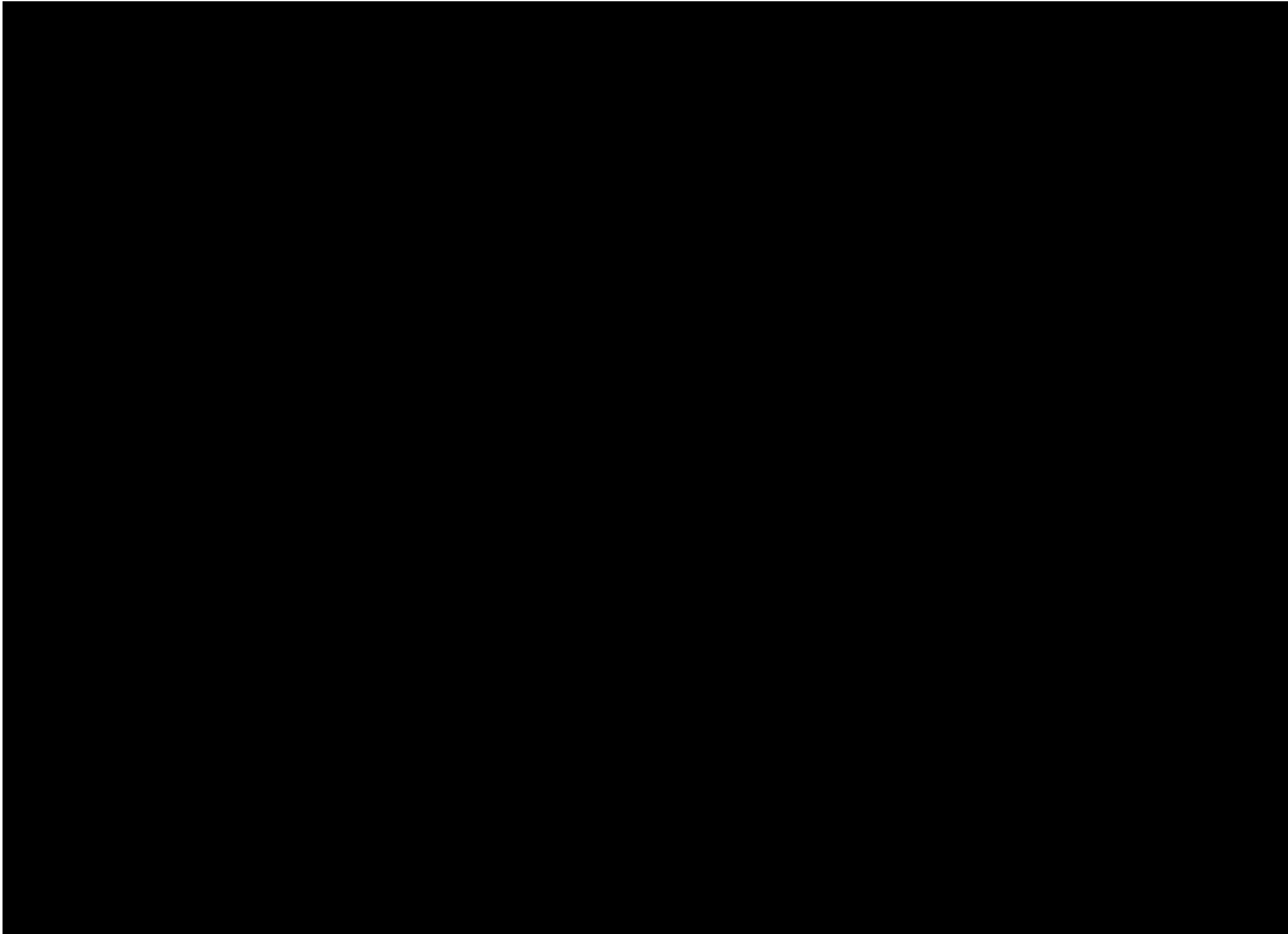


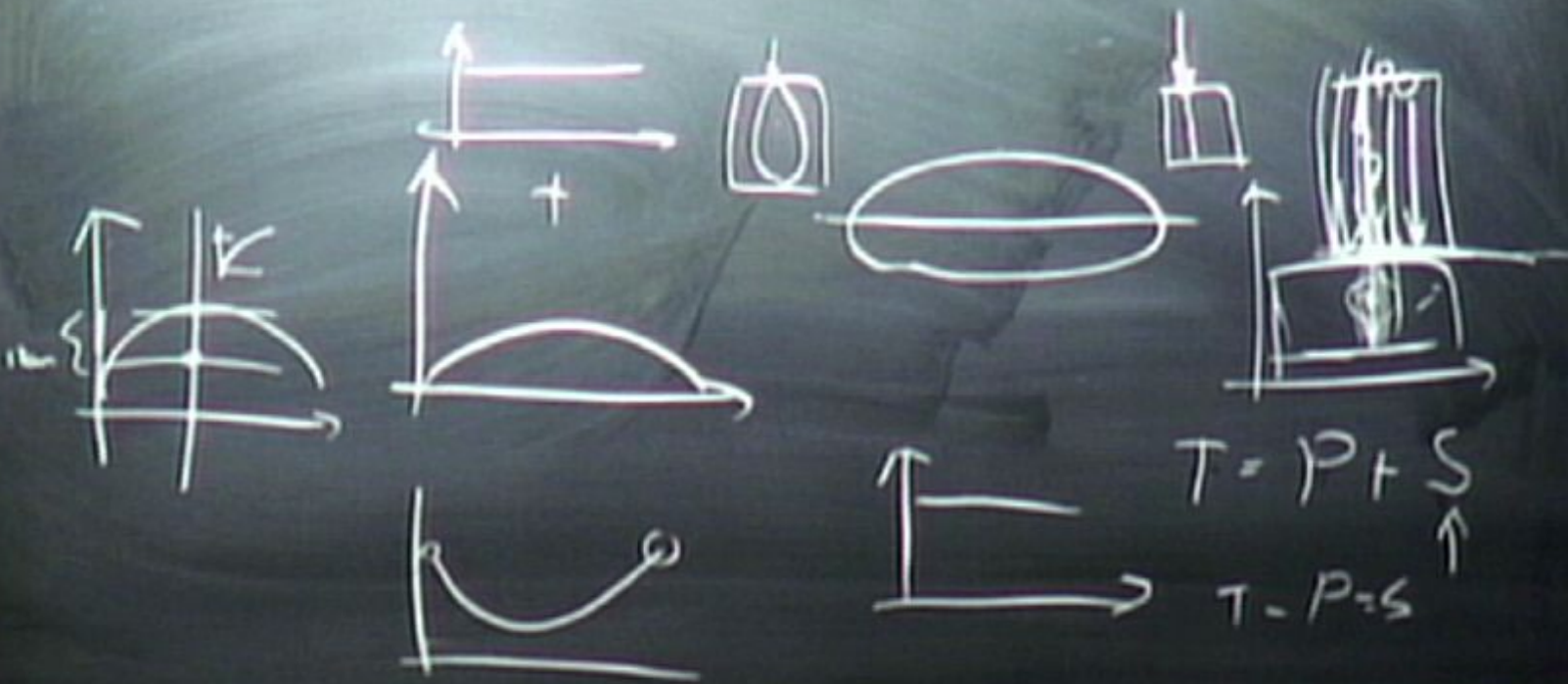
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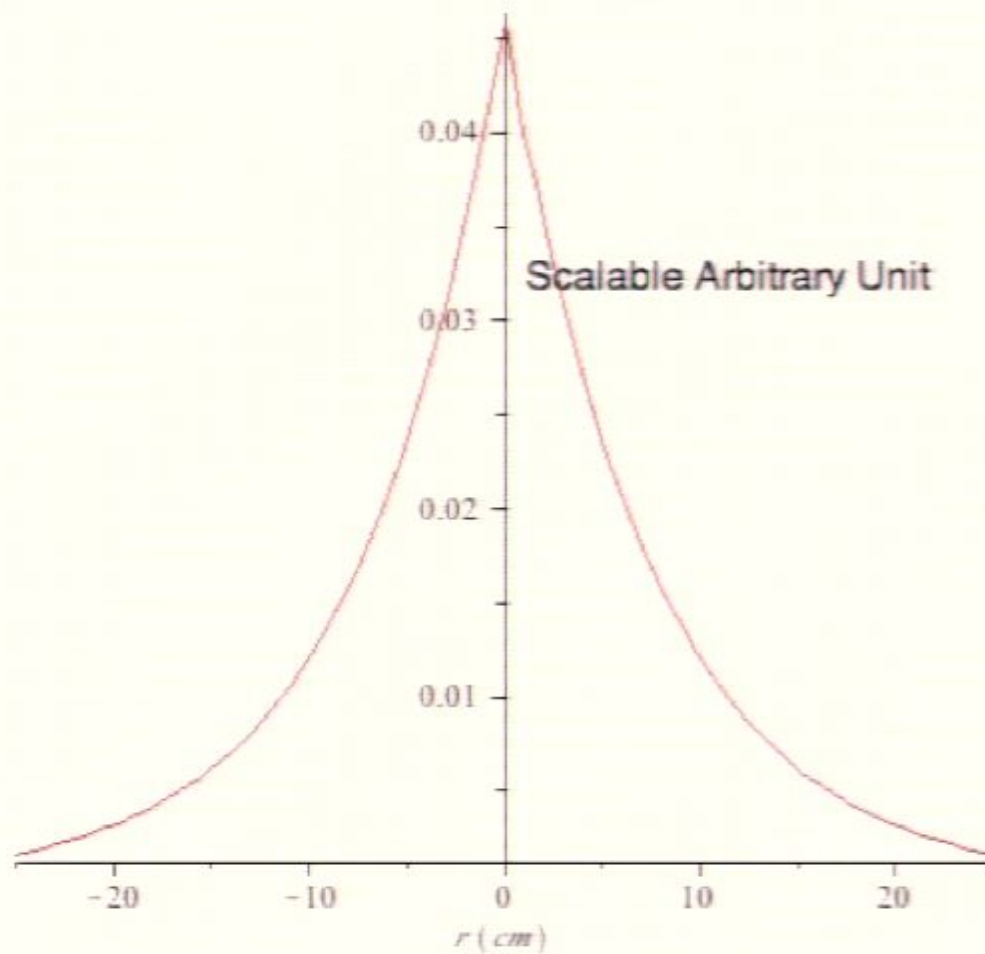
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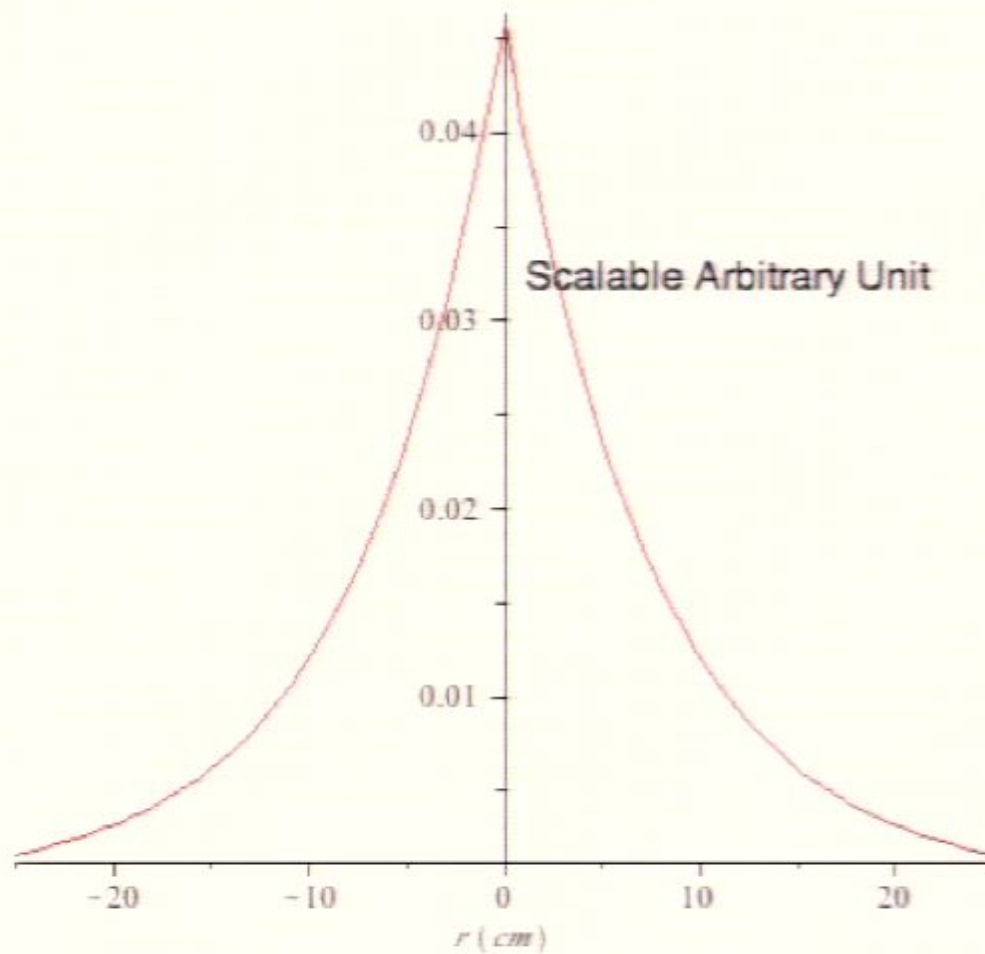




Scattering Kernel at 10 cm Depth

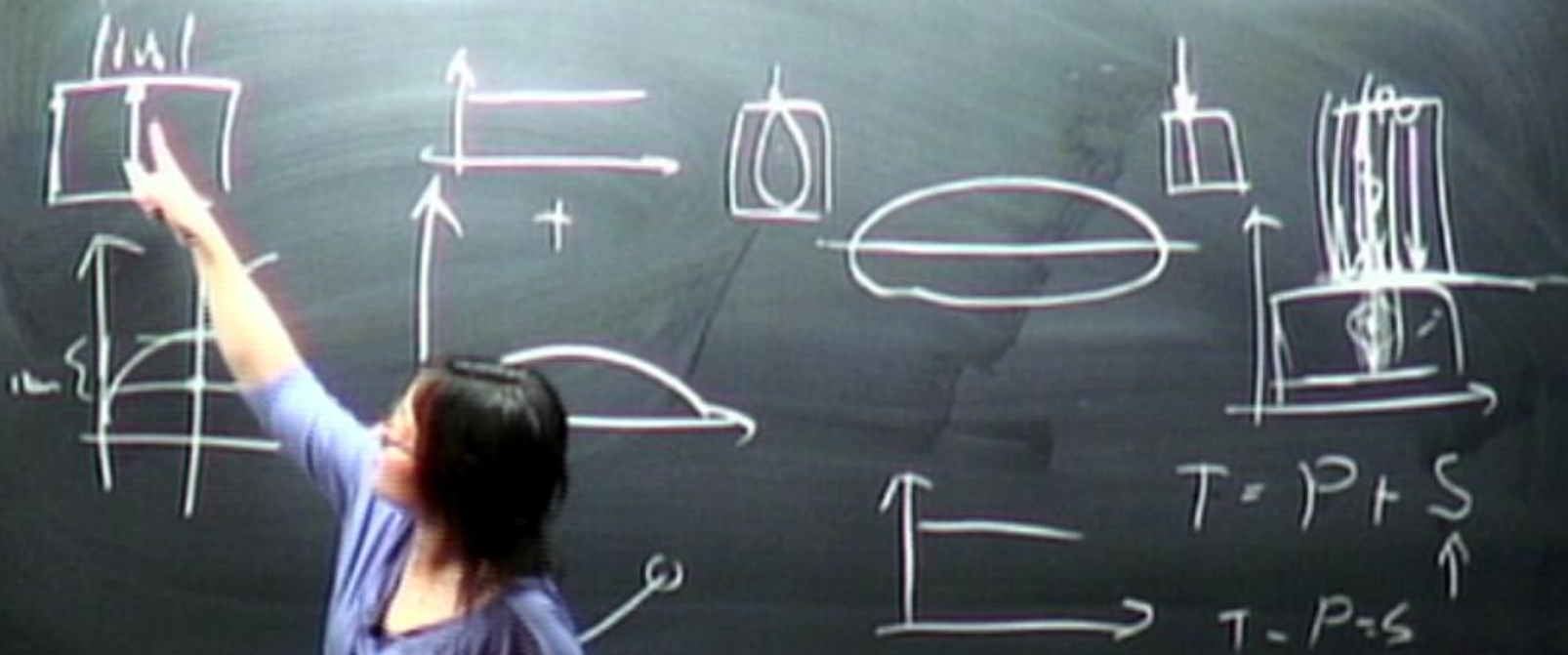


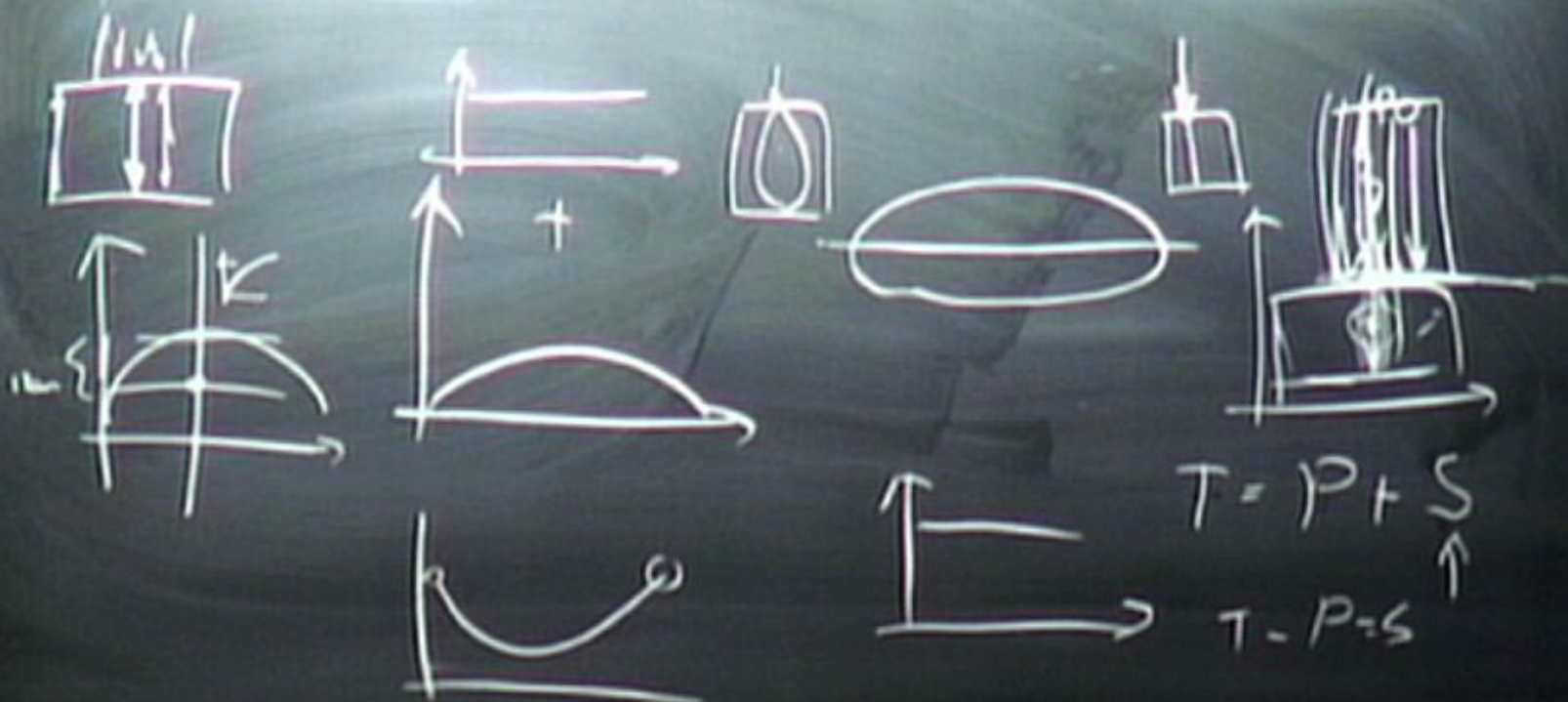
Scattering Kernel at 10 cm Depth



Results

- ◆ Scattering kernels for central axis
- ◆ Scattering kernels for off-central axis
- ◆ Comparison between central and off-central axis kernels

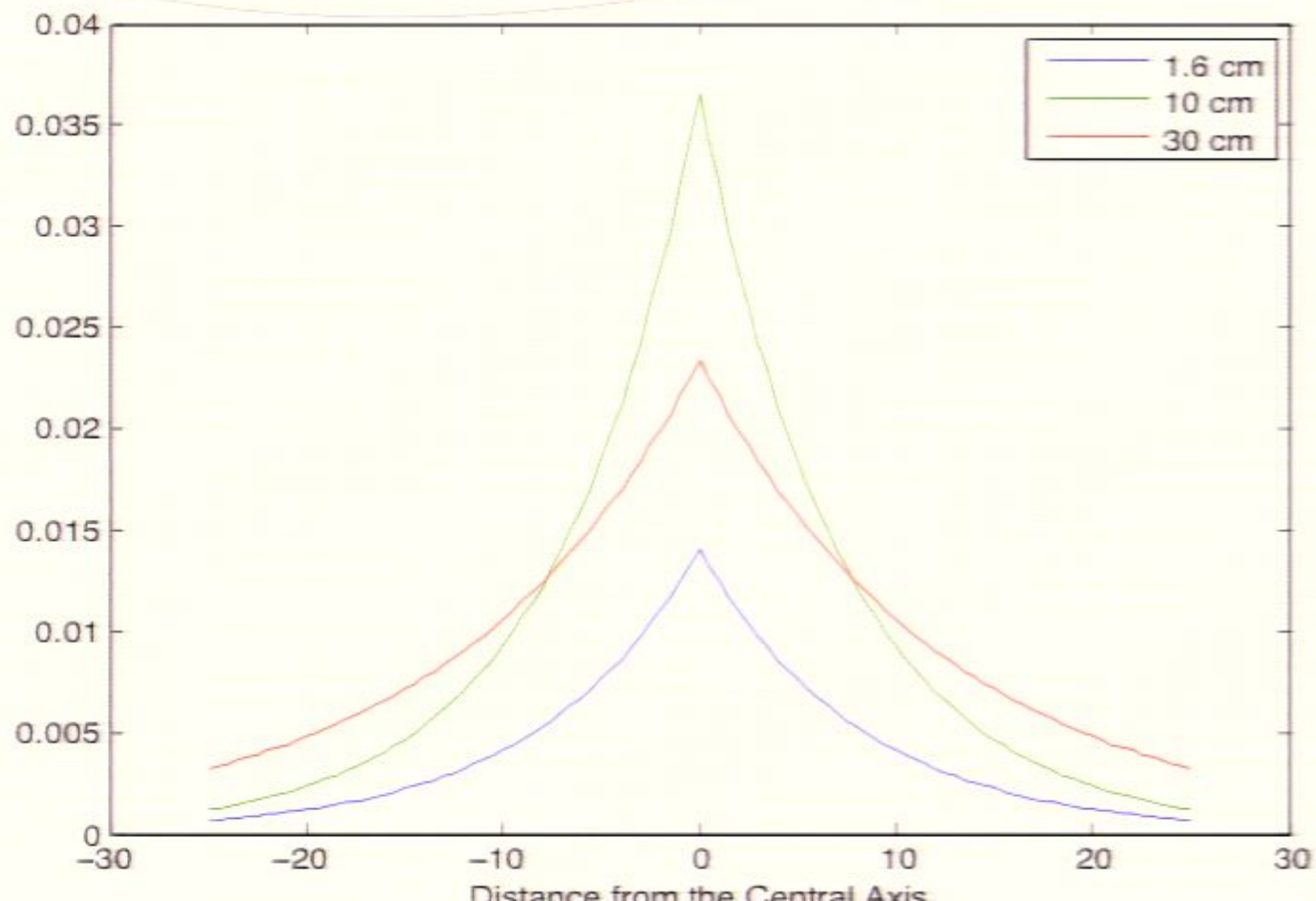




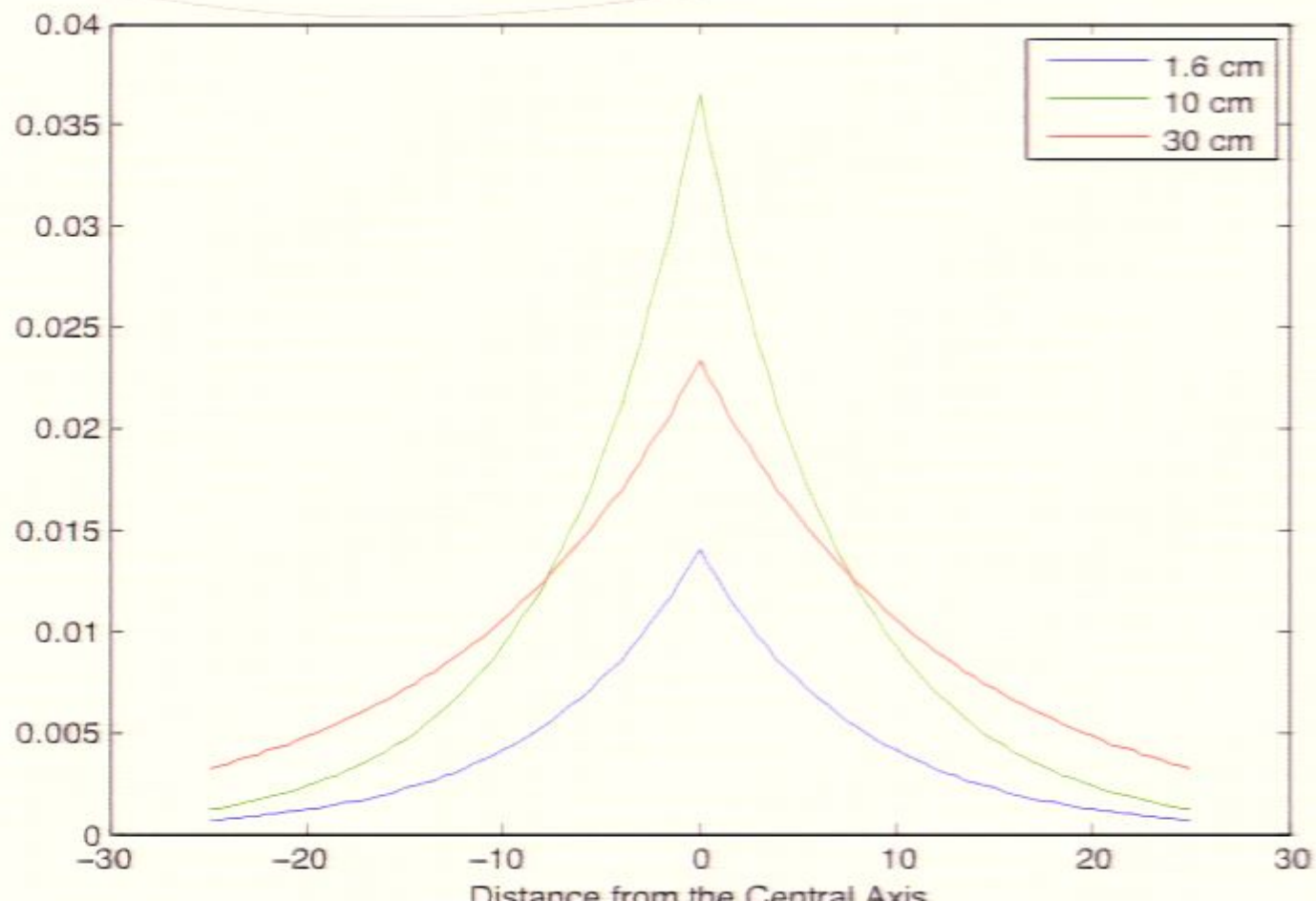
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Scattering Kernels (Central Axis)



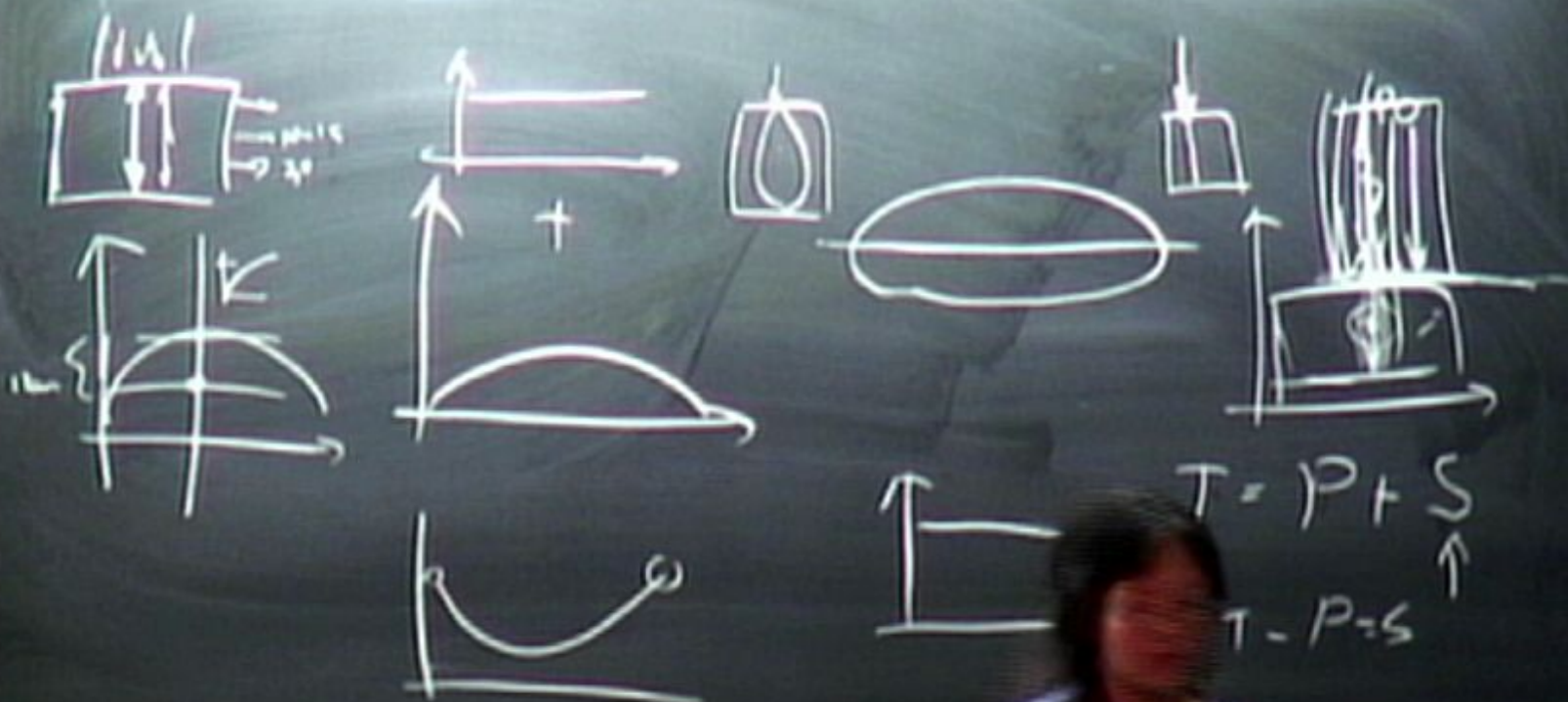
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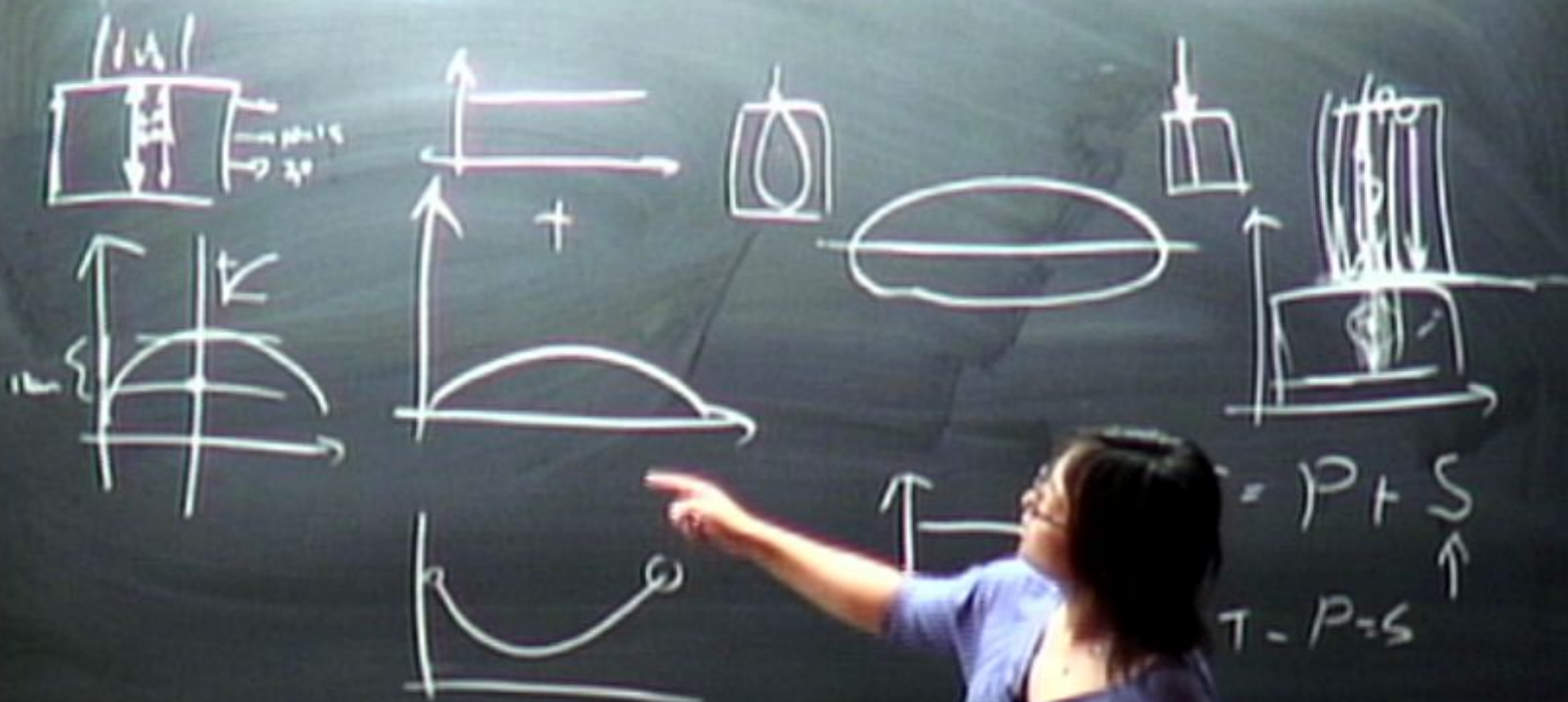
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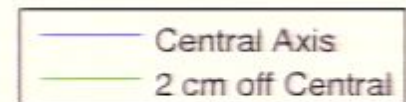
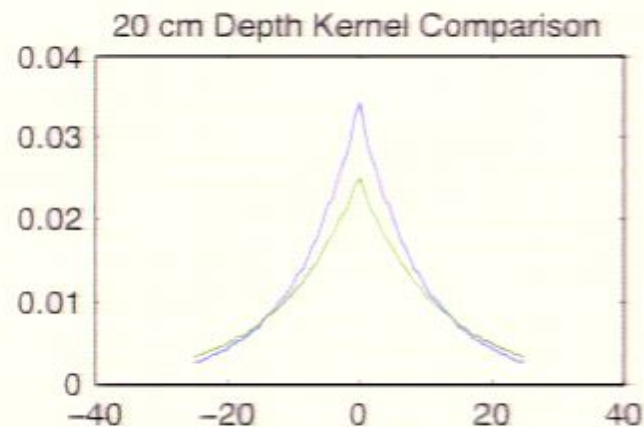
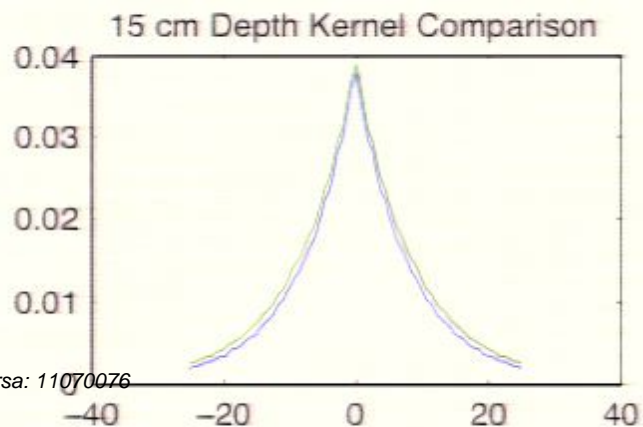
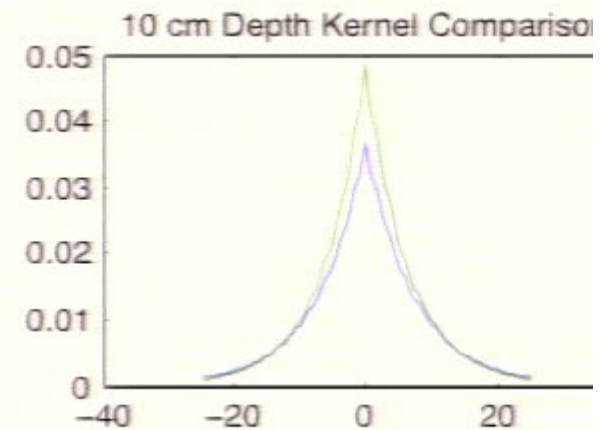
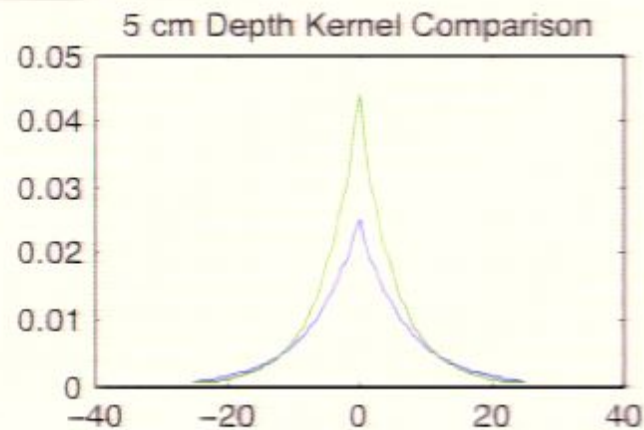
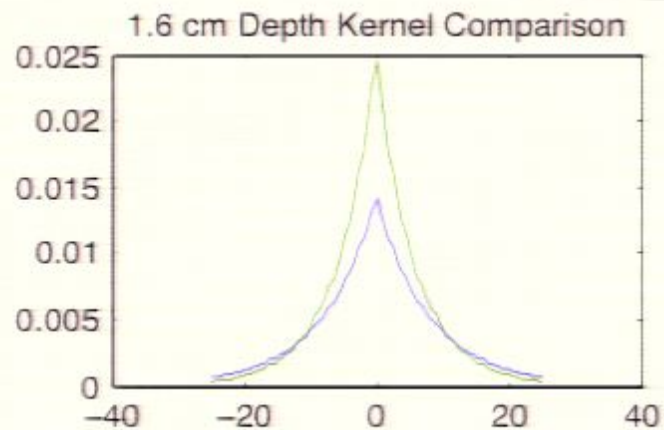
$$T - P = S$$

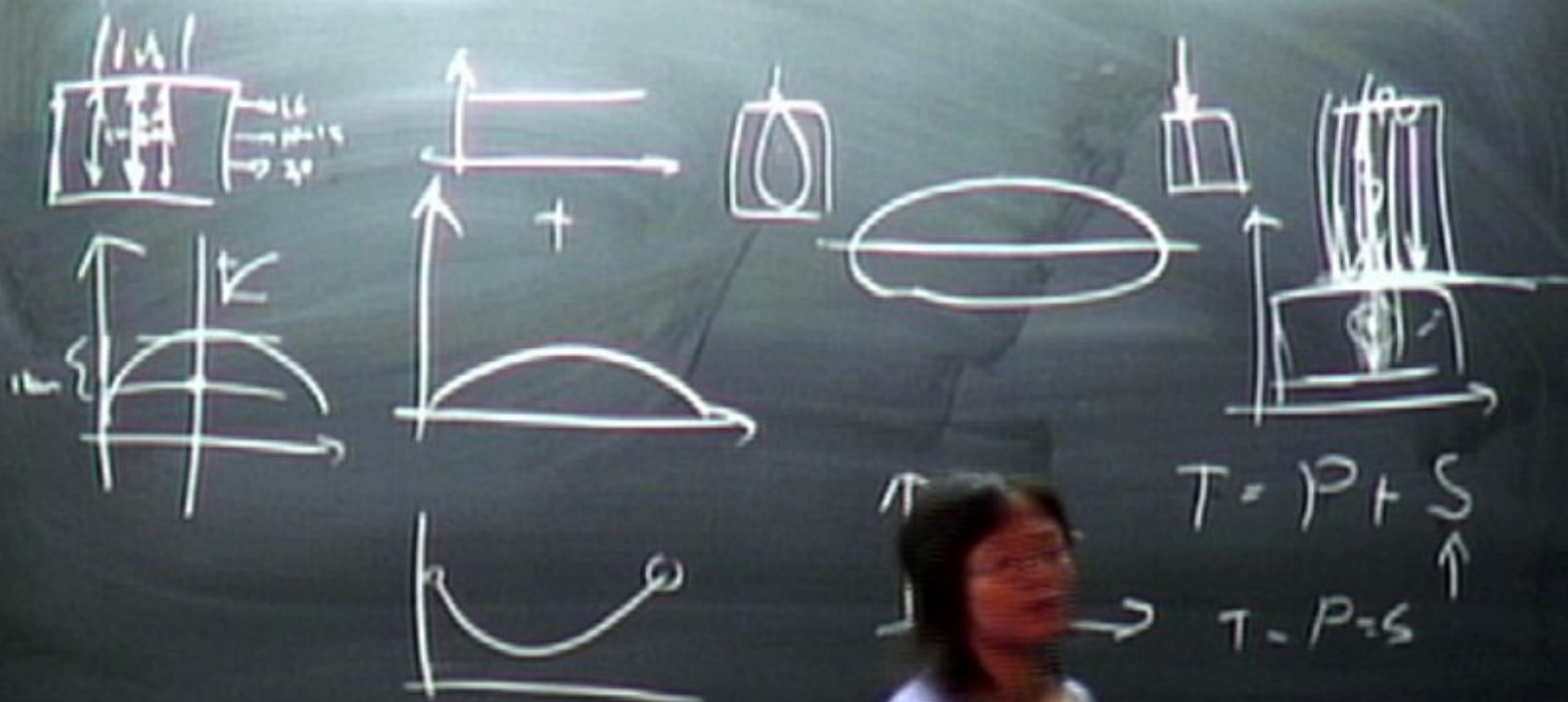


$$= P + S$$

$$T - P - S$$

Scattering Kernels Comparison





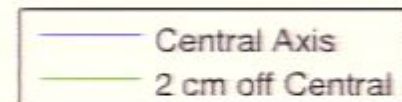
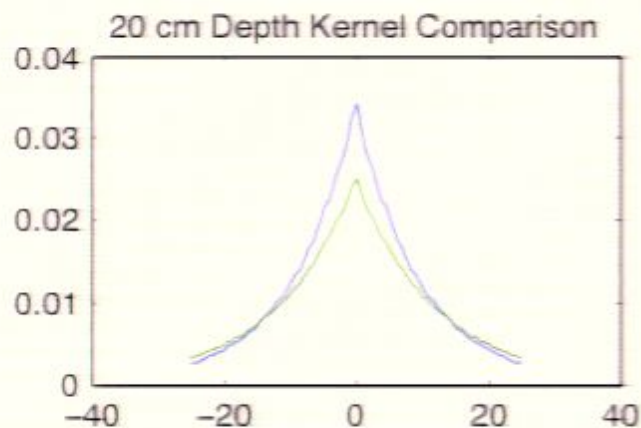
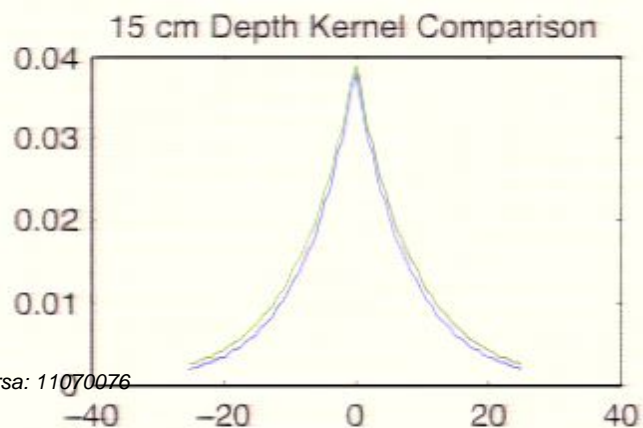
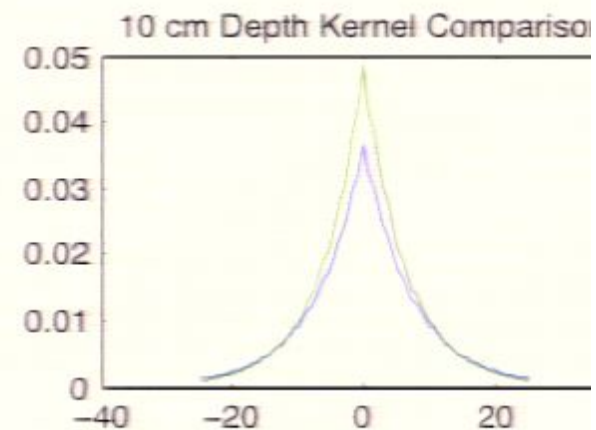
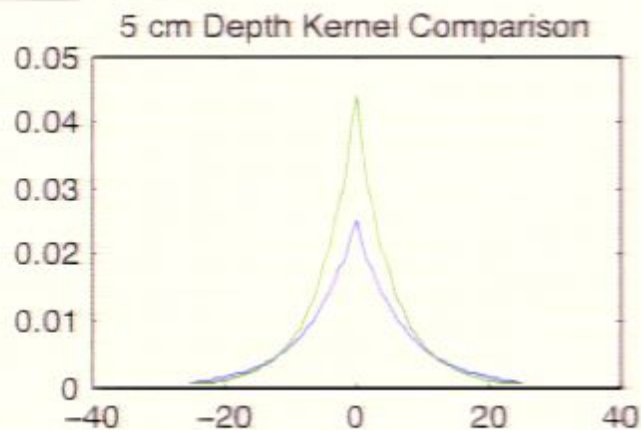
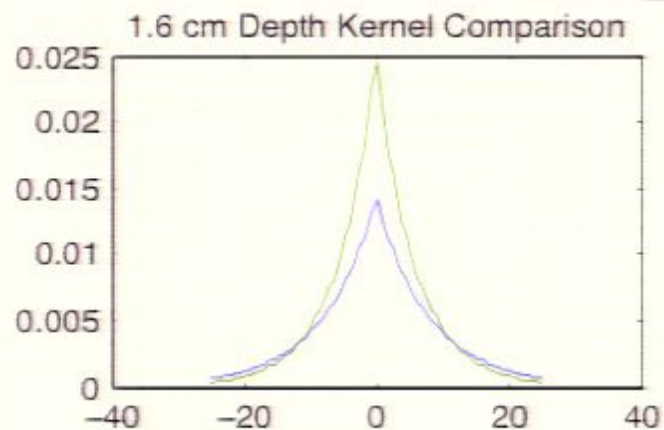
$$T = P + S$$

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Future Work

- ◆ Recalculate MLC field sizes according to the radiological depth and the scattering kernels.
- ◆ Examine the mid plane dose to see if there is any improvement.

Scattering Kernels Comparison



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Summary

- ◆ Scattering kernels were found for central axis and 2 cm off-central axis.
- ◆ More data needed to perform comparison between central axis and off-central axis kernels.
- ◆ No theoretical model to support these findings.

Acknowledgements

- ◆ Dr. Derek Brown
- ◆ Amjad Hussain
- ◆ Ambrish Raghoonundun
- ◆ Michael Durocher

References

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- ◆ [5] M. Chretien et al. A variable speed translating couch technique for total body irradiation. *Med. Phys.*, 27(5):1127–1130, 2000.
- ◆ [6] A. Hussain, et al. Aperture modulated, translating bed total body irradiation. *Med. Phys.*, In Press, 2010.