# MLC’nin kurulum ölçümleri: Dosimetric leaf gap nasıl hesaplanır? MLC transmission nasıl ölçülür?

Medikal Fizik Uzmanı

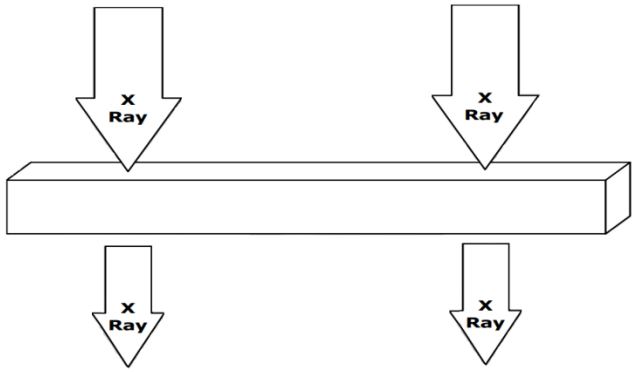
Yücel AKDENİZ

Acıbadem Adana Hastanesi

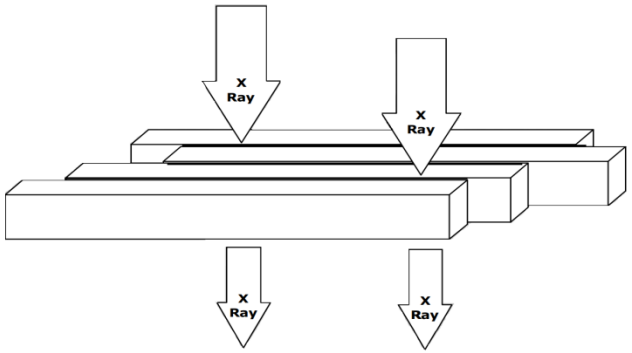
# TG50

MLC Geçirgenliği

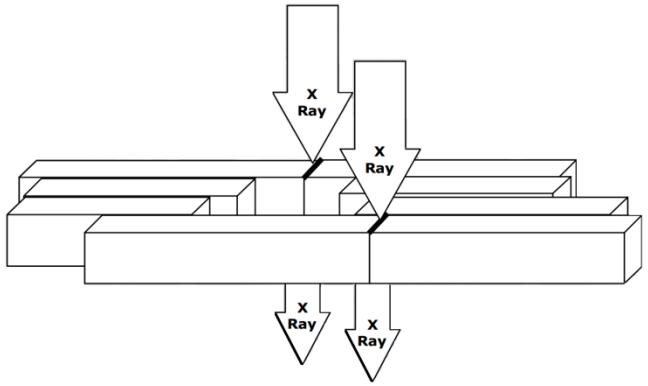
- Lif ortası geçirgenliği
- Lifler arası geçirgenlik (Sızıntı)
- Lif sonu geçirgenliği




*"full height of leaf"*




*"between leaf sides"*

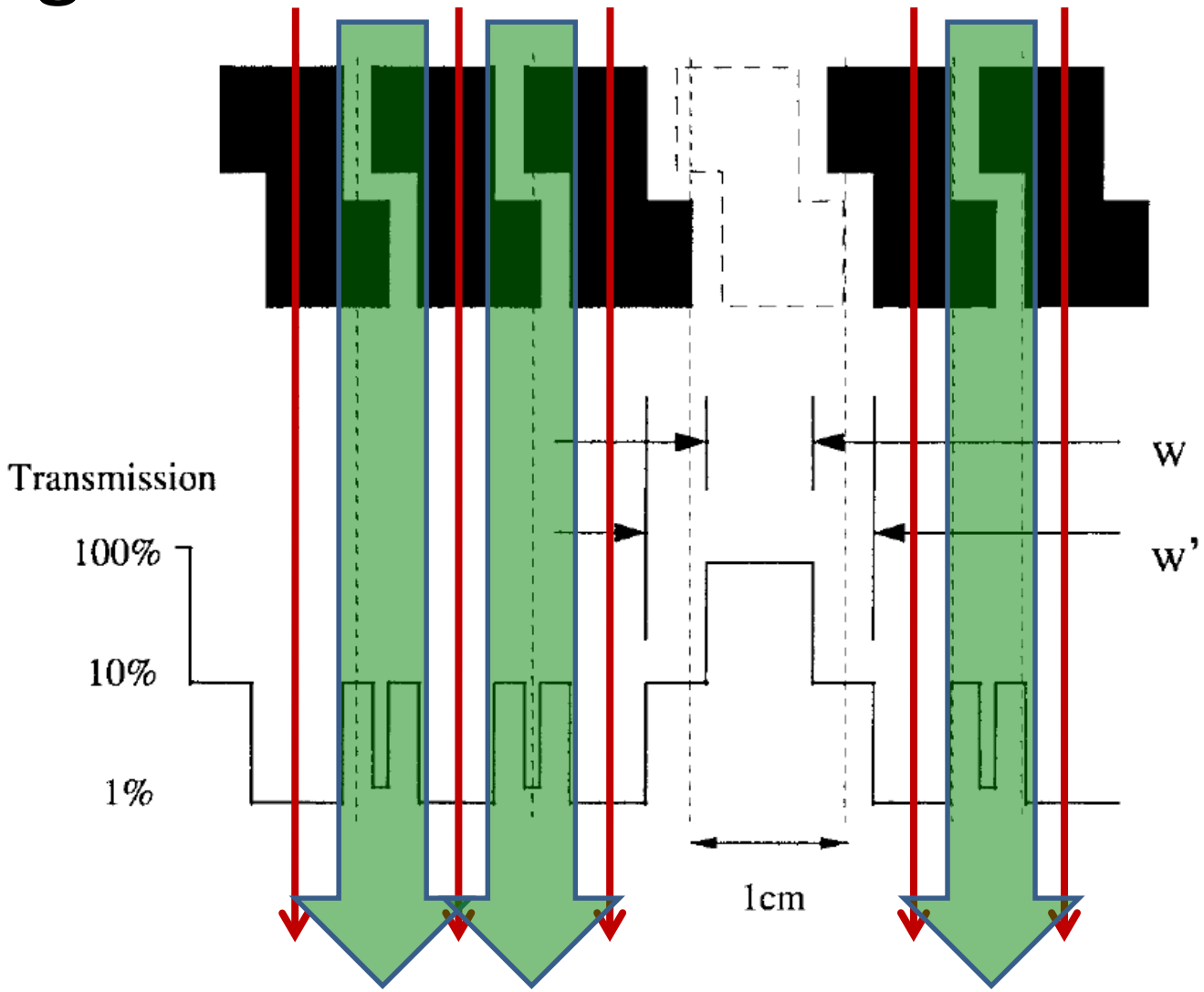



**"between the ends of opposed leaves"**

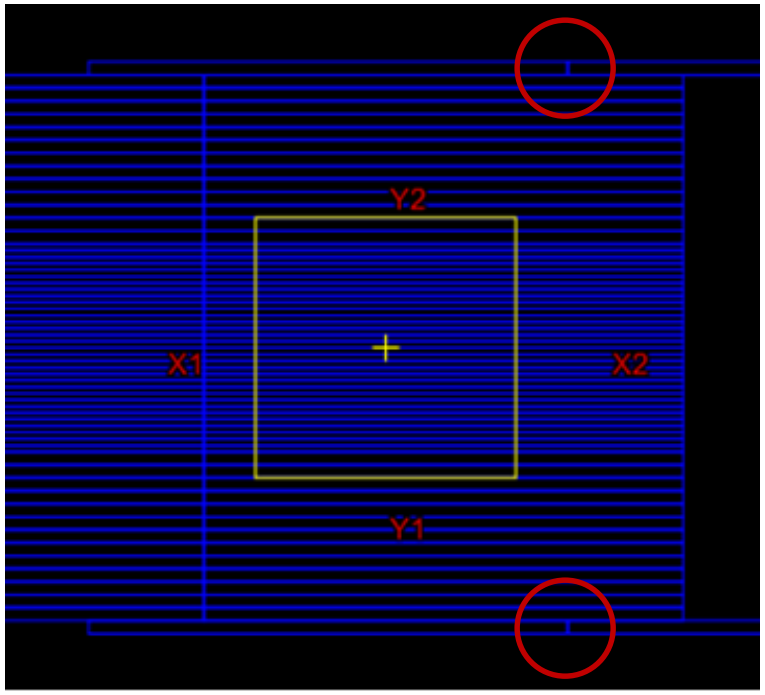
Ortalama Geçirgenlik

Lif ortası geçirgenliği

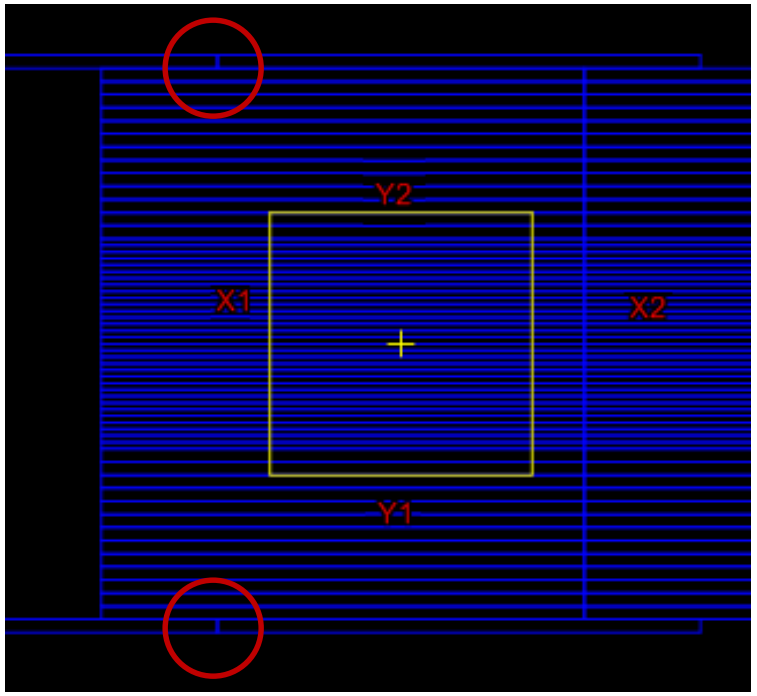
Lifler arası geçirgenlik (Sızıntı)



# Geçirgenlik nasıl ölçülür?



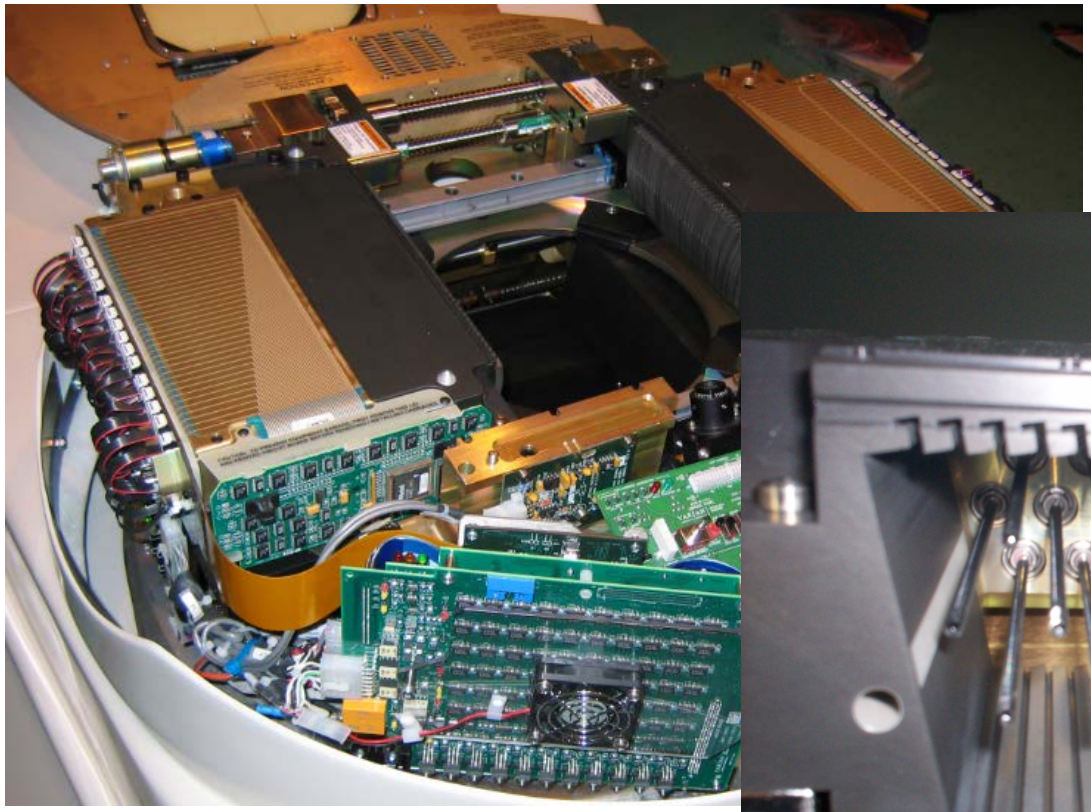

**A tarafı**

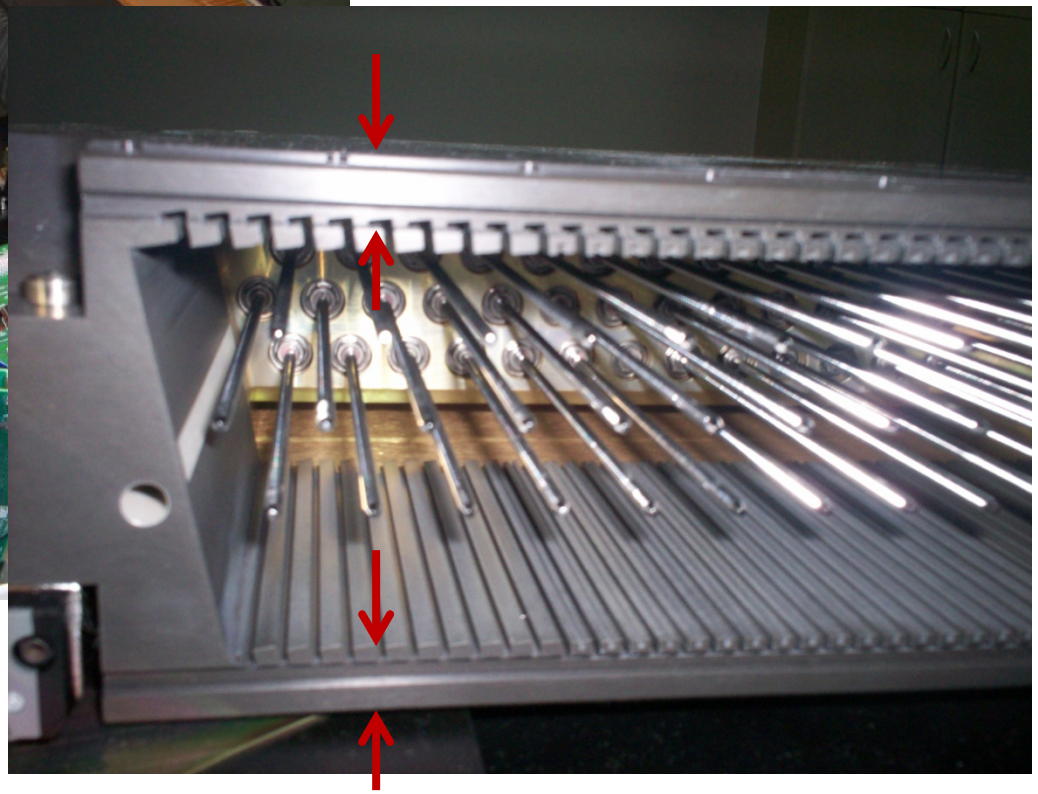



**B tarafı**

***Carriage'*** **dan dolayı ek koruma olmaması için ilk ve son lif çiftleri ters tarafa çekilir.**

# Nasıl ölçülür?

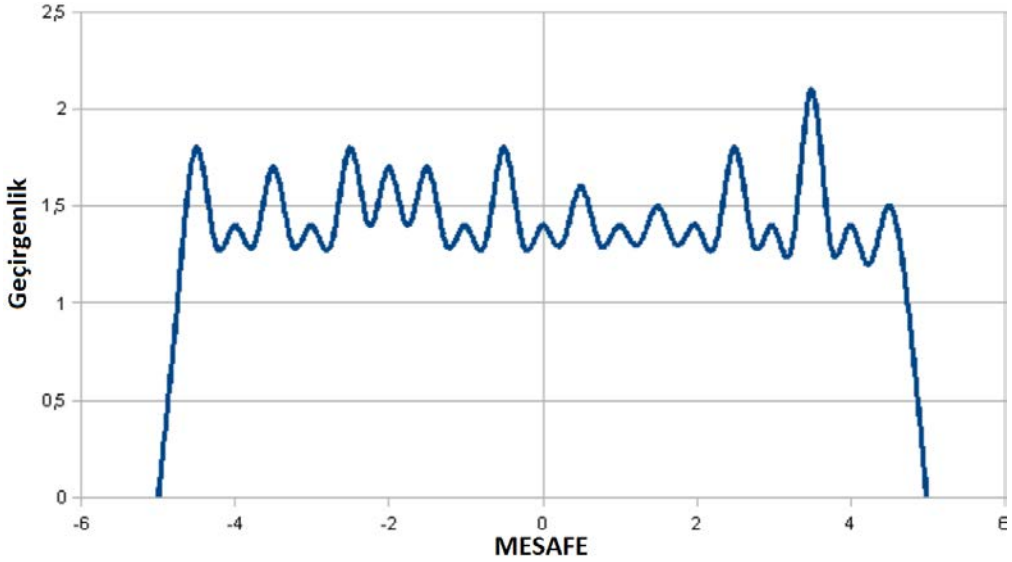




# Nasıl ölçülür?

## İyon Odası

- **Uygun aralıklarla ölçüm alınıp ortalama hesap edilir.**
- **A tarafı ve B tarafı ölçümleri açık alan ölçümüne normalize edilir.**
- **İki tarafın ortalaması alınır.**

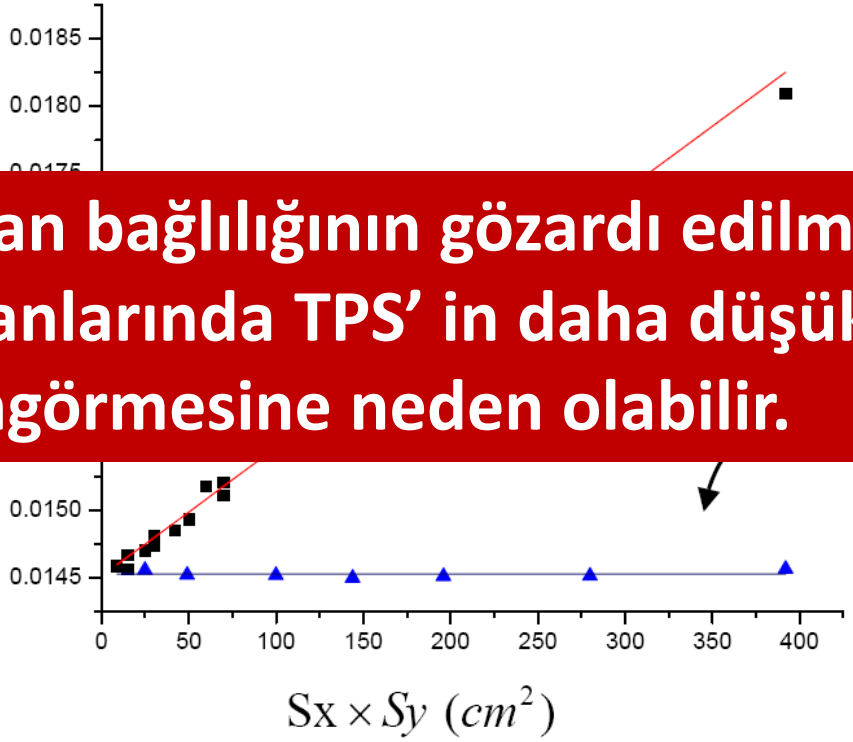



# Alan ve derinlik bağlılığı?

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 8, NUMBER 4, FALL 2007

**Determination of depth and field size dependence of multileaf collimator transmission in intensity-modulated radiation therapy beams**

Piotr Zygmanski,[a] Florin Rosca, Dnyanesh Kadam, Friedlieb Lorenz,




**Alan bağlılığının gözardı edilmesi, geniş IMRT alanlarında TPS' in daha düşük doz öngörmesine neden olabilir.**


* Ölçümler havada alınmıştır.

# Alan ve derinlik bağlılığı?

| | $T_{exp}$ | | |
|---|---|---|---|
| $d$ (cm) | 6EX (6 MV) | 21EXs (6 MV) | 21EXs (10 MV) |
| $d_{max}$ | 0.0144 | 0.0139 | 0.0170 |
| 5 cm | 0.0147 | 0.0144 | 0.0171 |
| 10 cm | 0.0153 | 0.0151 | 0.0174 |

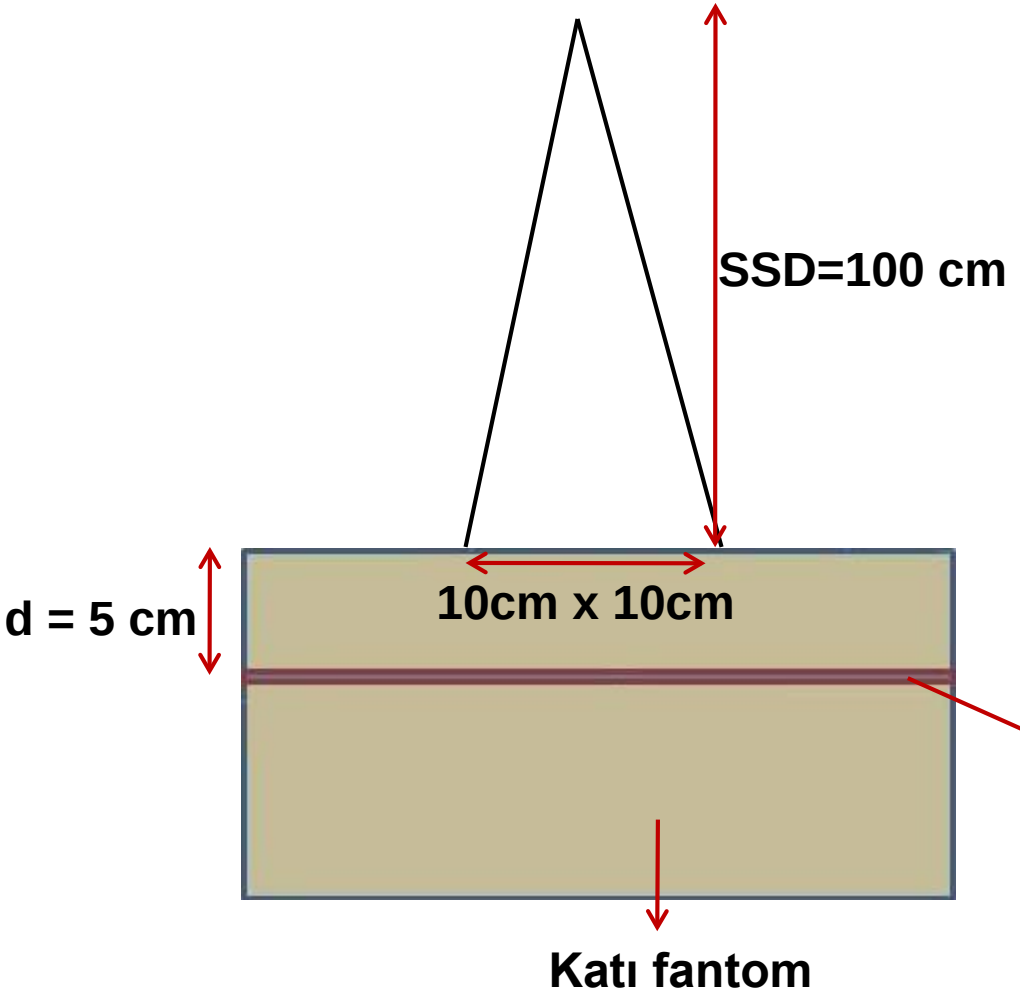
- Geçirgenlik ölçümlerinde derinlik arttıkça faktör artar.
- Açık alana göre MLC'den geçen radyasyon daha enerjiktir. (Beam Hardening)

# Nasıl bir iyon odası?

- Küçük hacimli bir dozimetre ile ölçümlerde uzaysal çözünürlük artacaktır. Lif ortası geçirgenliği ve sızıntı hassas bir şekilde tayin edilebilir.
- TPS'ler genellikle ortalama geçirgenlik niceliğini kullanmaktadır. Farmer tipi "geniş" hacimli bir iyon odasının doğal ortalama alma özelliği kullanılarak kurulum ölçümü alınabilir.

# Nasıl ölçülür?

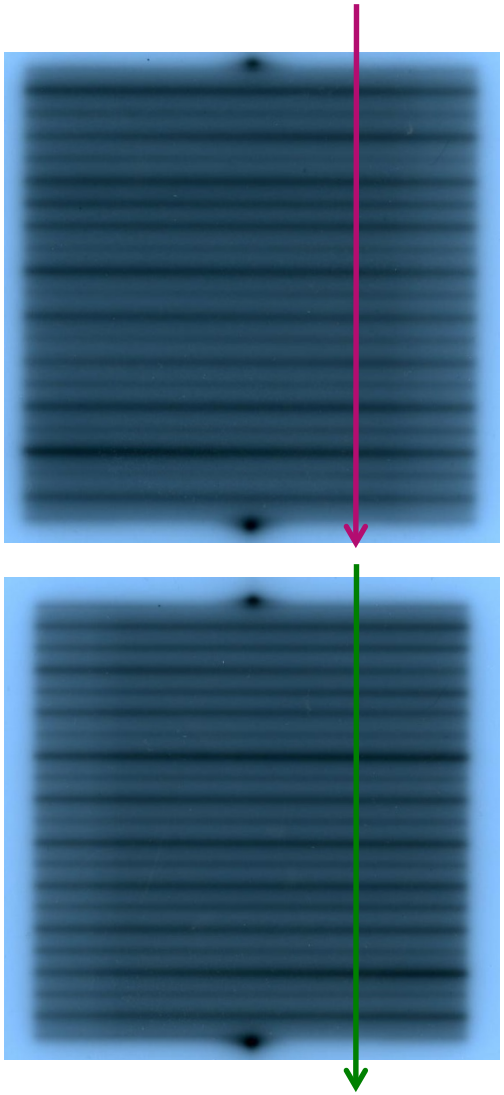
## Film Dozimetre

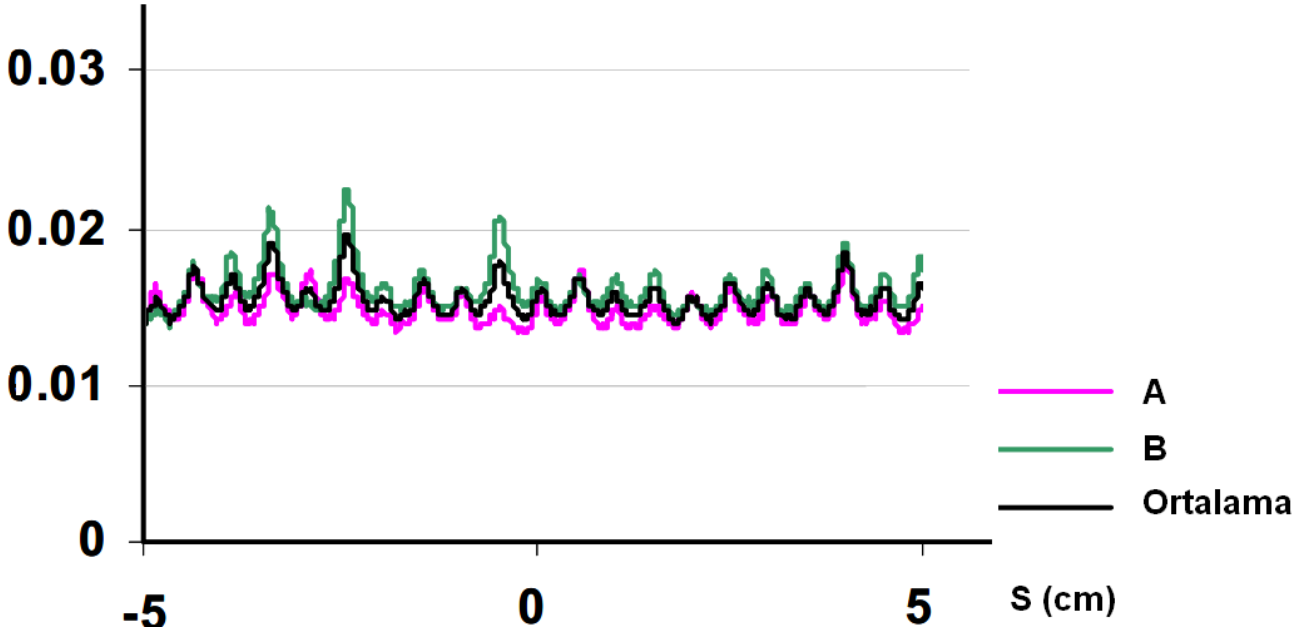



- Uzaysal çözünürlük
- Enerji bağlılığı???

# Nasıl ölçülür?

## Film Dozimetre






$$\frac{Pixel\ value\ -\ Background}{OB\ Average\ -\ Background}$$

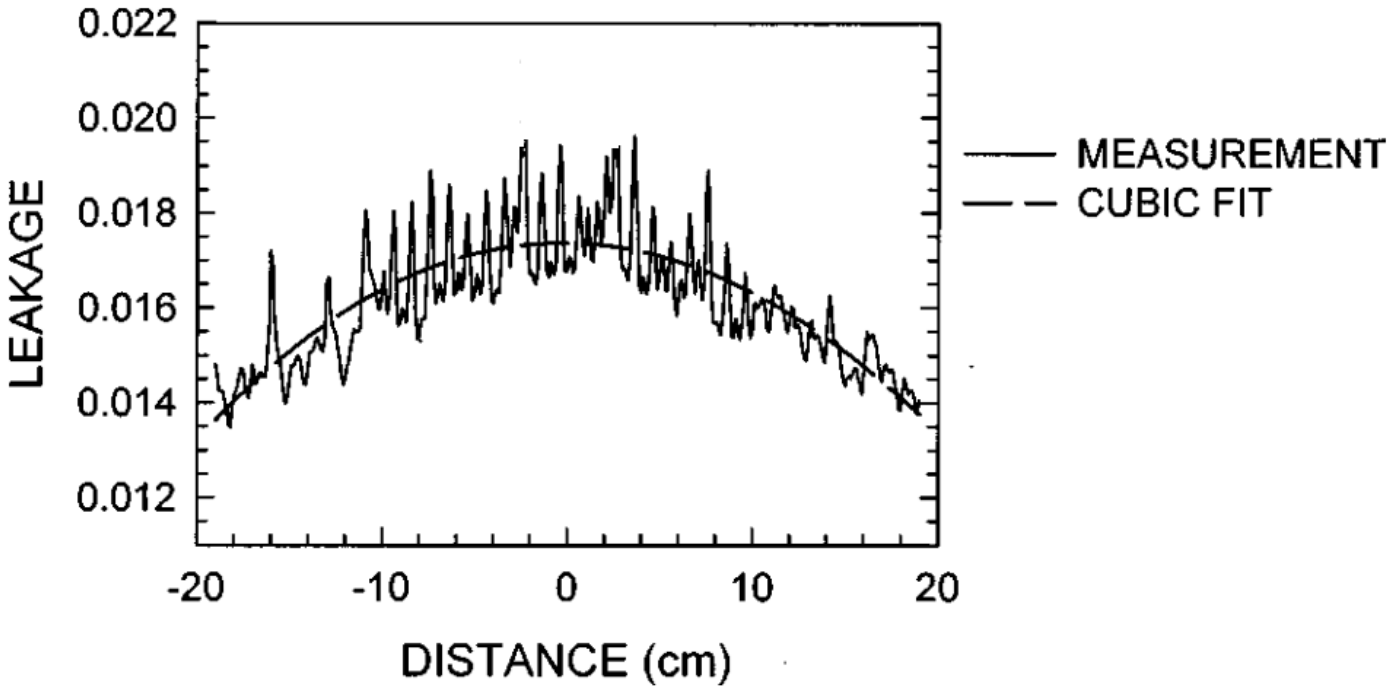
# Geçirgenliğin Uzaysal Dağılımı

**A method for determining multileaf collimator transmission and scatter for dynamic intensity modulated radiotherapy[a)]**

Mark R. Arnfield,[b)] Jeffrey V. Siebers, Jong O. Kim, Qiuwen Wu, Paul J. Keall, and Radhe Mohan

*Department of Radiation Oncology, Medical College of Virginia at Virginia Commonwealth University and McGuire VA Hospital, Richmond, Virginia 23298*

(Received 16 September 1999; accepted for publication 12 July 2000)

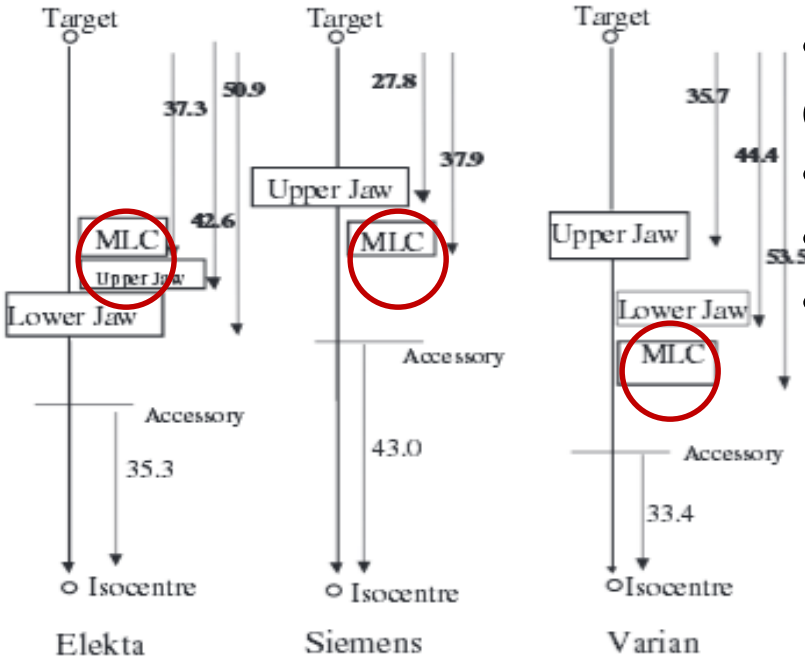


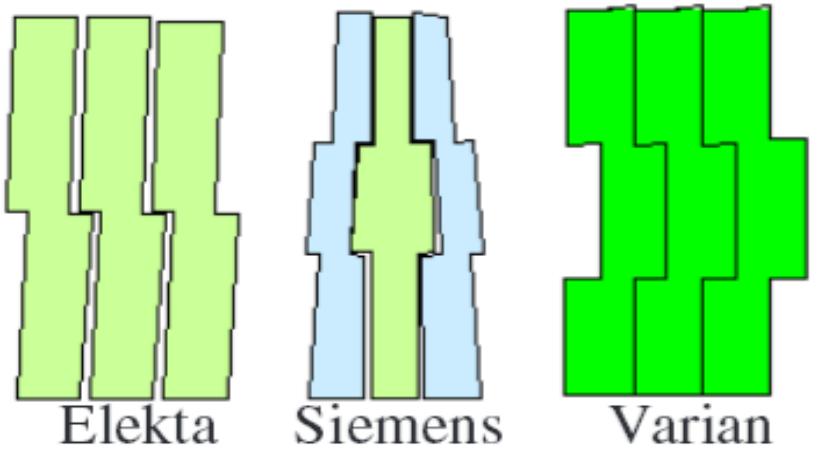
# Film Dozimetre

| **BrainLAB m3-mMLC (6MV)** | ***Transmission (%)*** | ***Leakage (%)*** | ***Detector type*** |
|---|---|---|---|
| **(Agazaryan 2000)** | 1.53 | 2.1 | X-OMAT V2 |
| **(Aaronson 2002)** | 1.30 | 2.1 | EDR2 |
| **(Gardino 2008)** | 0.93 ± 0.05 | 1.18 ± 0.11 | GafChromic EBT |

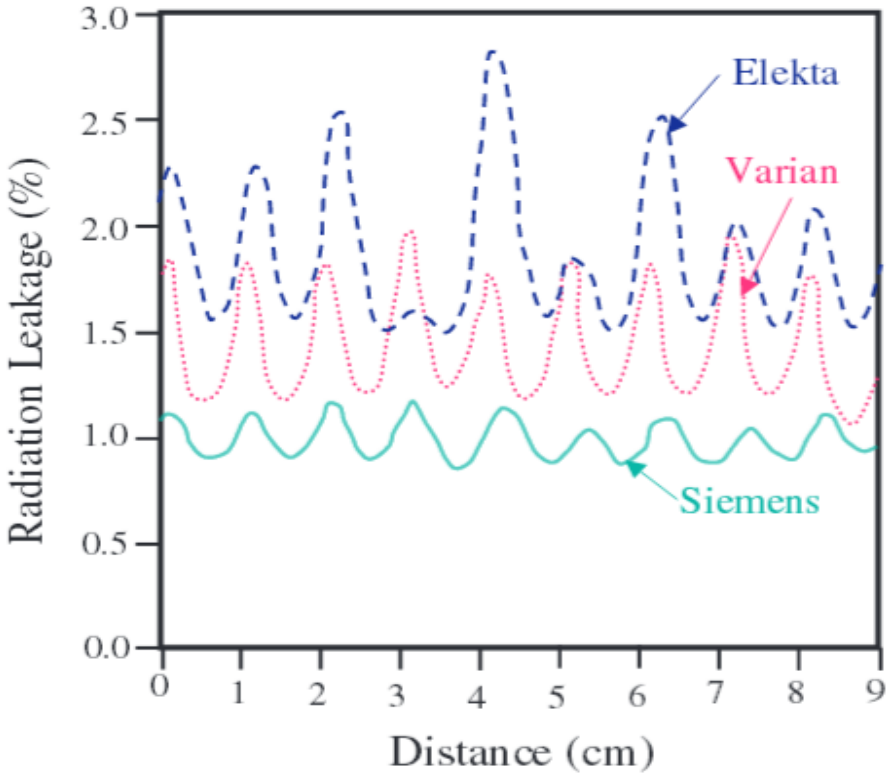
- Filmin Enerji bağlılığı,
- Laboratuar koşulları

# Çeşitli cihazların lif geçirgenlikleri




- Dosimetric comparison of various multileaf collimators, **2002, Huq ve ark.**
- 6 MV ,SSD=100cm, dmaks, 10cm x 10cm
- MLC lif kalınlığı 1cm , backup jaw var.
- Film dozimetresi kullanılmıştır.



# Güncel cihazların lif geçirgenlikleri

160 ML

VARIAN
medical systems

**MLC Physical Specificati**

Physical specifications are ranges

| Element |
| --- |
| Transmission where collimator bac |
| Leaf transmission (average across a |
| Interleaf transmission peaks |
| Leaf end penumbra vs. collimator ( |

Inte
aver

Inte
max

Inte
leaf

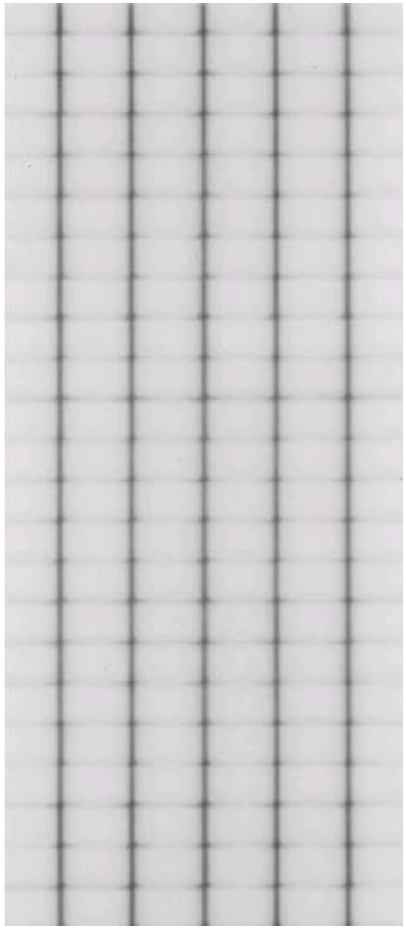
Agility™
Intelligent beam shaping

ELEKTA

- 40 x 40 cm field size
- 160 interdigitating leaves with 5 mm width at isocenter
- Integrated digital control of leaves and dynamic leaf guides
- Accurate leaf positioning with Rubicon optical technology
- Rapid leaf speed
- Extremely low leaf transmission (<0.5%)
- 45 cm isocentric clearance

# TG - 142

**Task Group 142 report: Quality assurance of medical accelerators**[a)]



- Haftalık Picket Fence testi ile sızıntının görsel testi.

- Her kullanılan her enerji için ortalama geçirgenlik değerinin yıllık olarak ölçülmesi tavsiye ediliyor.

$\pm 0.5\%$ from baseline

# TG50

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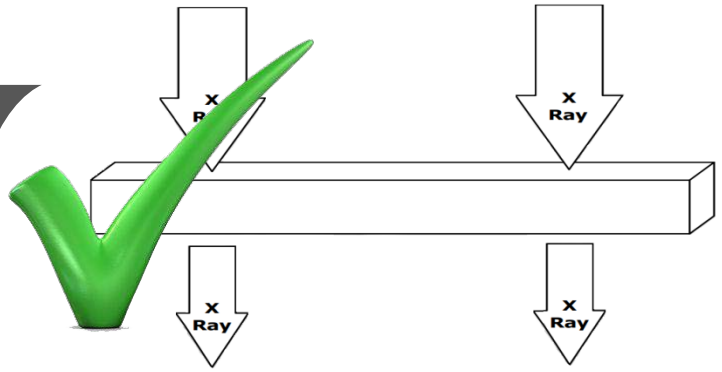
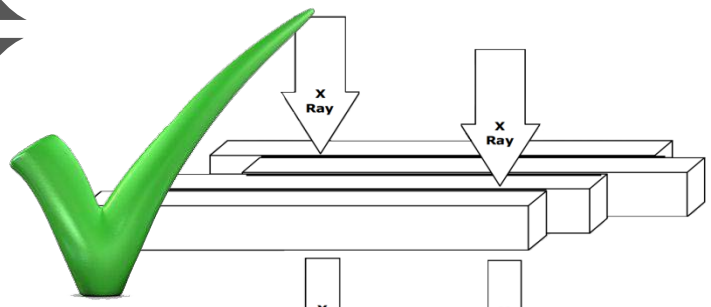
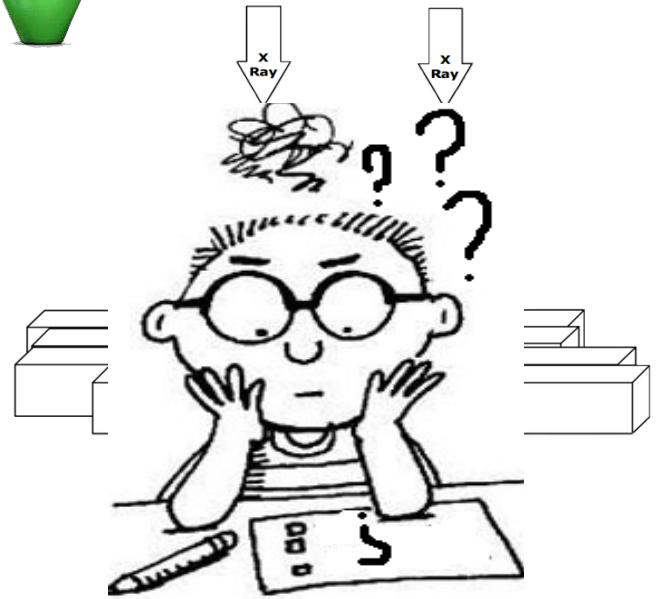



*"full height of leaf"*

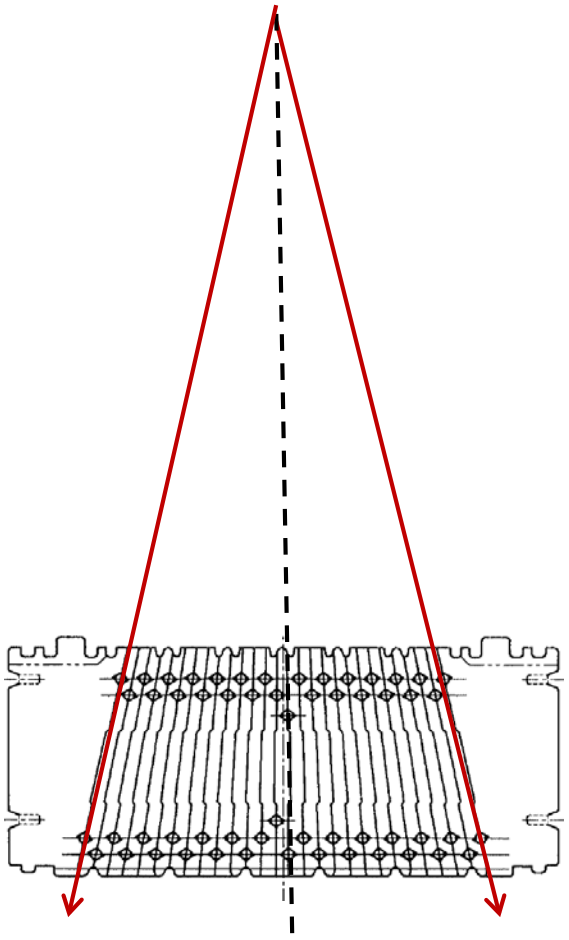



*"between leaf sides"*

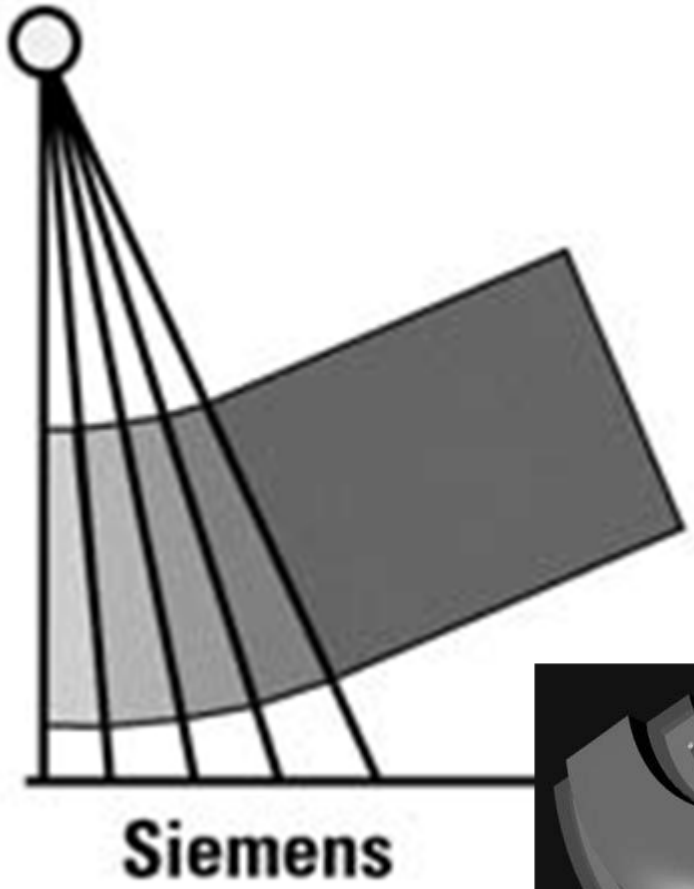



**"between the ends of opposed leaves"**

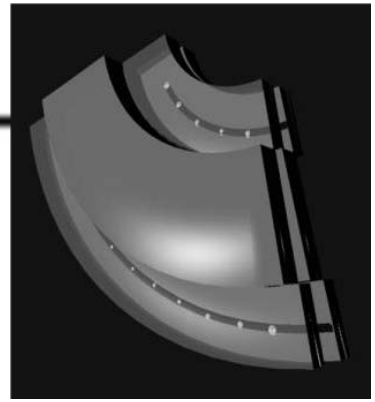
# Lif tasarımı – Çift odaklı



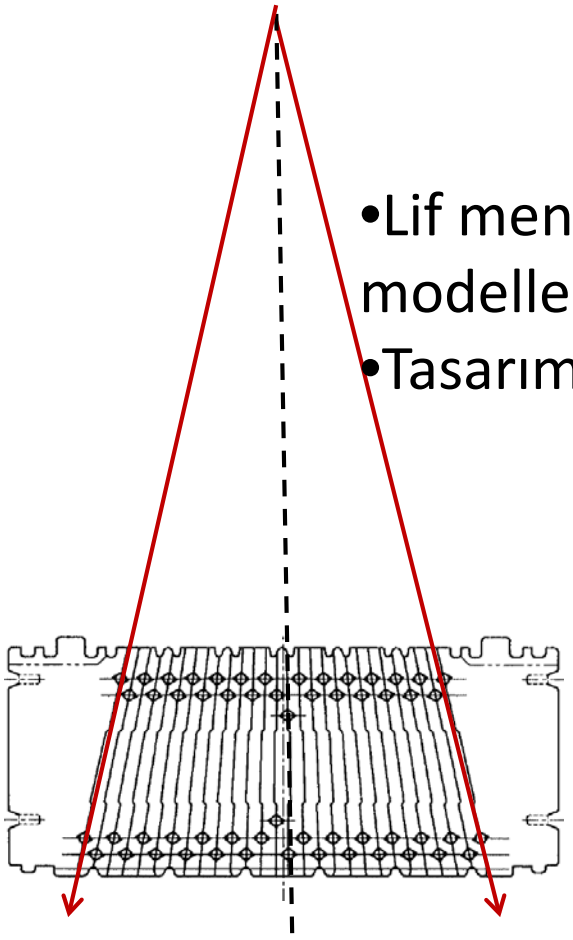
in - plane




cross - plane



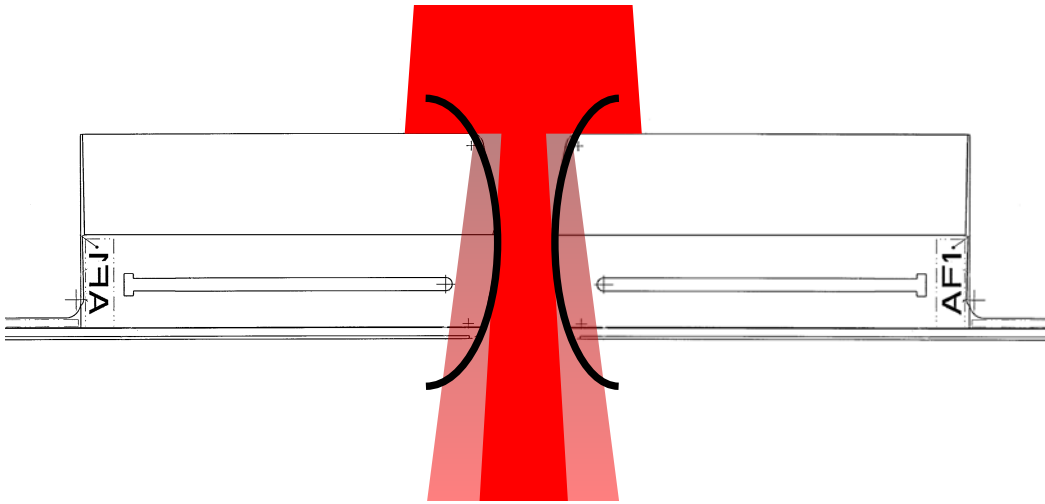
# Lif tasarımı – Tek odaklı



**in - plane**

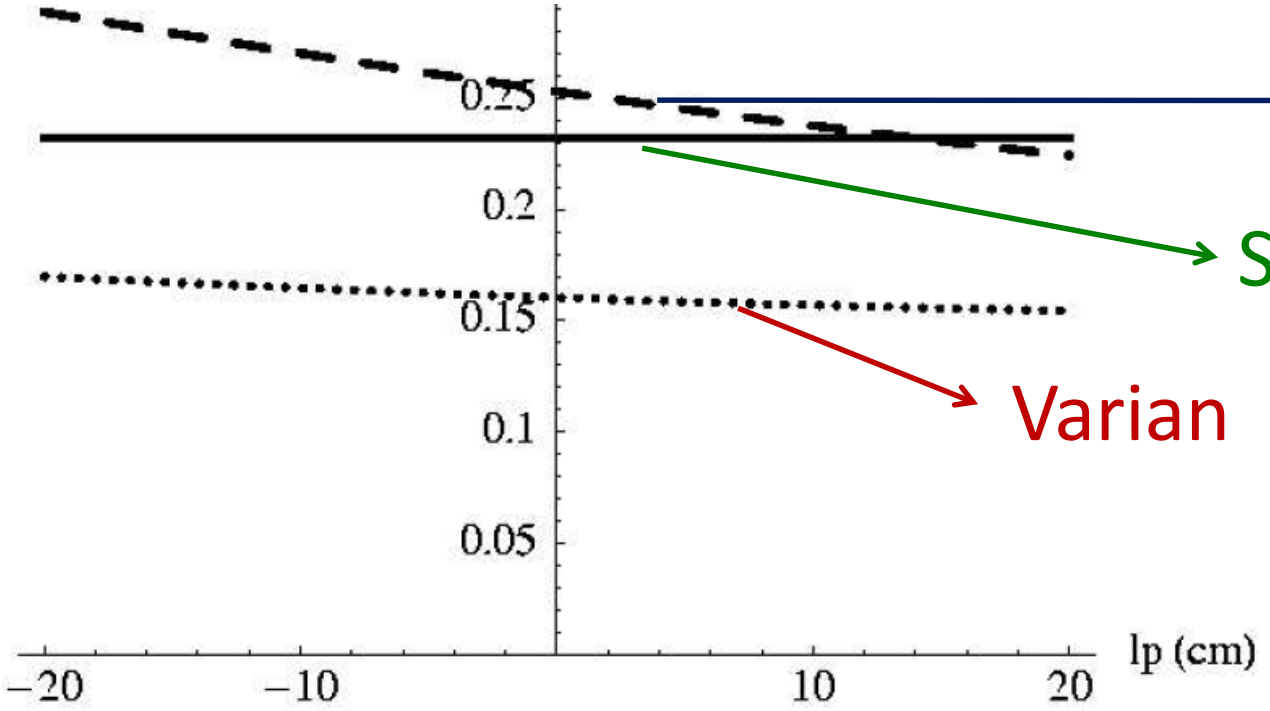
**Neden yuvarlatılmış lif sonları?**

- Lif menzili boyunca “Sabit” MLC Penumbra – TPS modellemesi kolay.
- Tasarımda sadelik – Lifler doğrusal hareket eder.



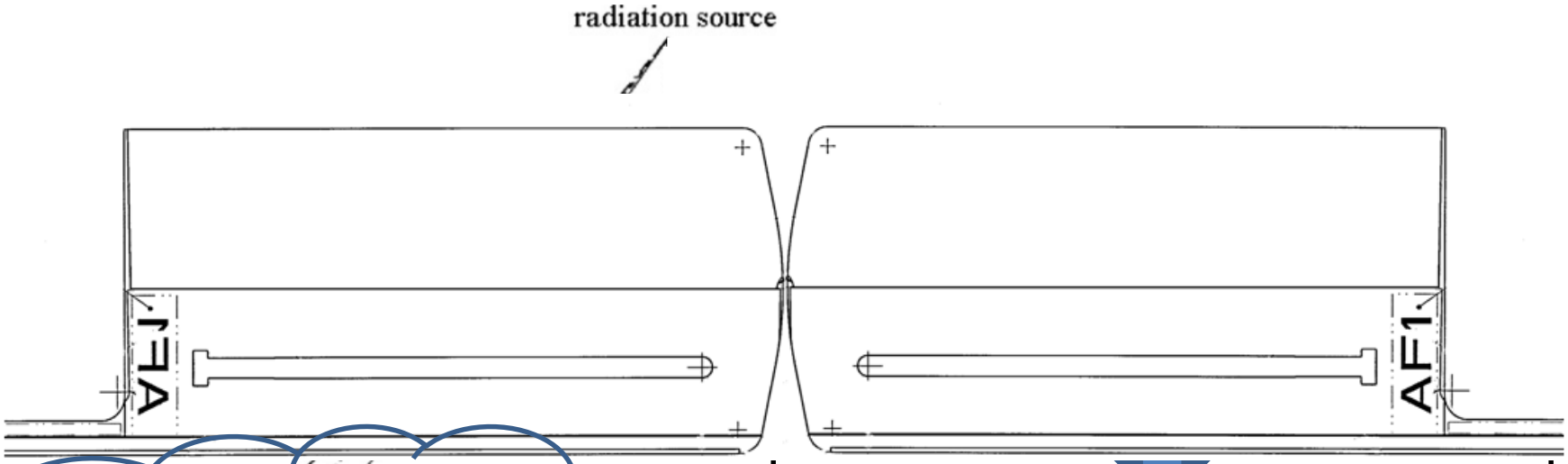

**cross - plane**

# Yuvarlatılmış lif sonları Sabit Penumbra???



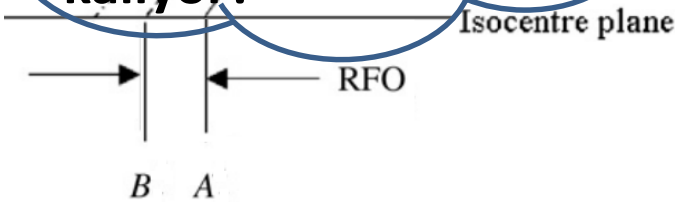

- Lif pozisyonu değişimi ile Toplam Penumbra (%20-%80) değişimi
- Hesaplamalara göre " Tamamen Sabit" Penumbra olası değil
- Lif karşı tarafa geçtiğinde Penumbra (+)
- Kaynak MLC mesafesi (-) Geometrik Penumbra ve değişimi (+)

# Dosimetric Leaf Gap (DLG)



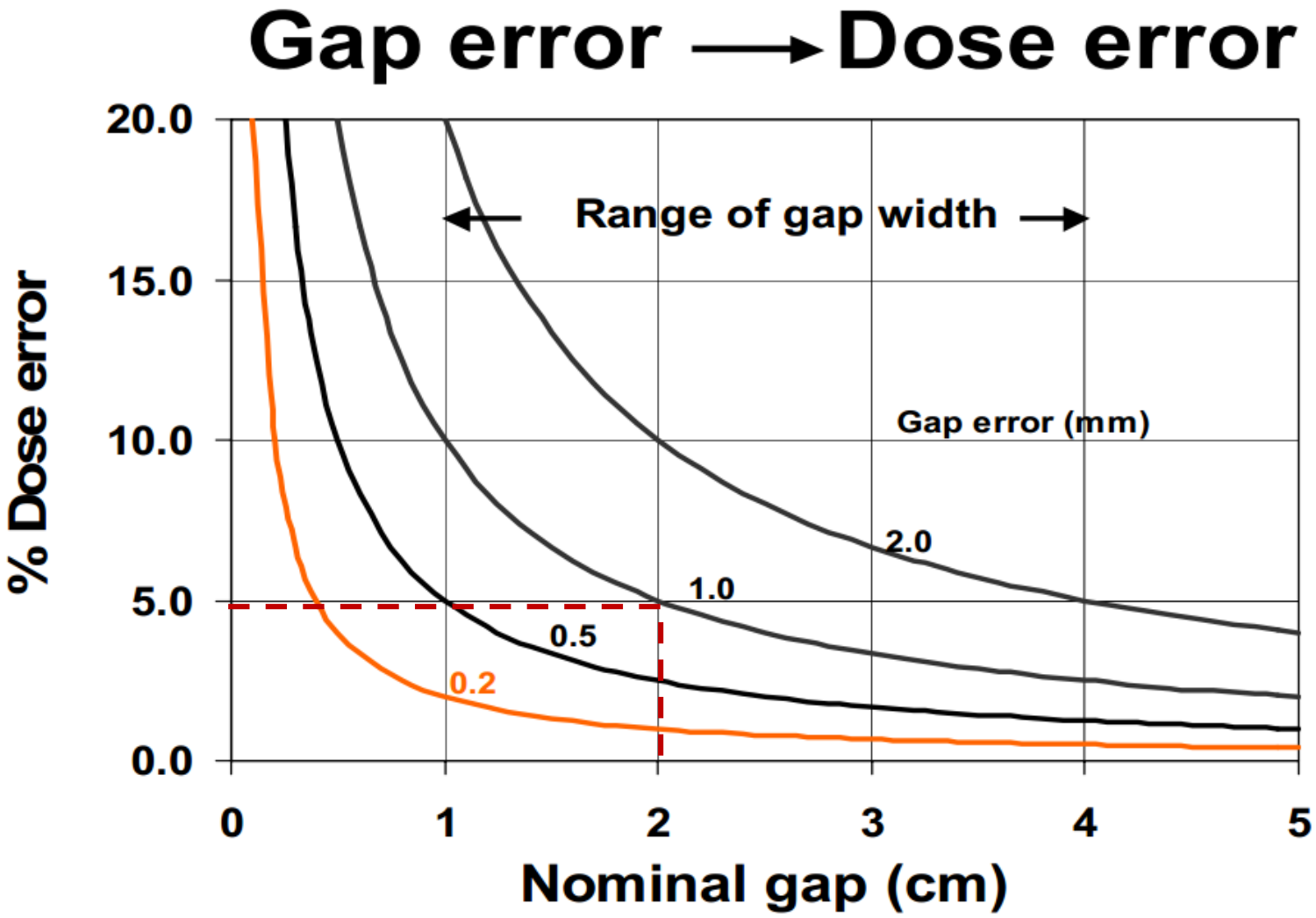

Fiziksel Pozisyon - Geometrik Pozisyon

**Karşılıklı lifler tam olarak kapansa da arada dozimetrik bir boşluk kalıyor?**




**DLG = 2 x RFO**

# DLG neden önemli?



# DLG : Yerçekimi etkisi nedir?

**Physical and dosimetric aspects of a multileaf collimation system used in the dynamic mode for implementing intensity modulated radiotherapy**

Thomas LoSasso,[a] Chen-Shou Chui, and C. Clifton Ling
*Department of Medical Physics, Memorial Sloan–Kettering Cancer Center, 1275 York Avenue, New York, New York 10021*

(Received 19 May 1997; accepted for publication 3 August 1998)

**An experimental investigation into the radiation field offset of a dynamic multileaf collimator**

**Philip Vial[1,2], Lyn Oliver[1,2], Peter B Greer[3,4] and Clive Baldock[2]**

[1] Northern Sydney Cancer Centre, Radia
Australia
[2] Institute of Medical Physics, School of
[3] Newcastle Mater Hospital, Newcastle,
[4] University of Newcastle, Newcastle, N

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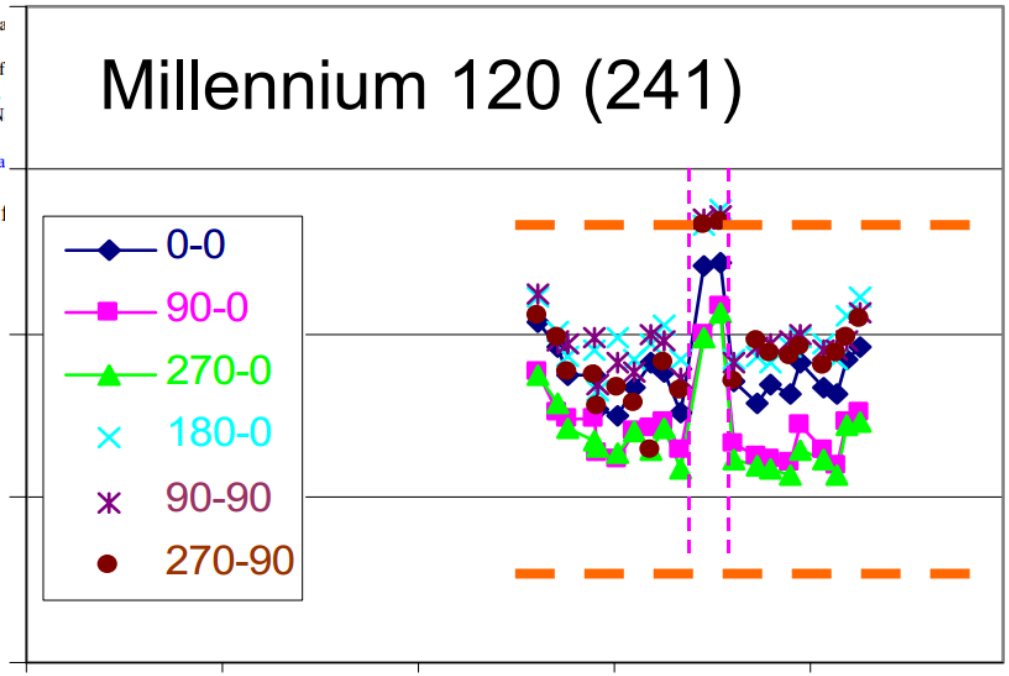
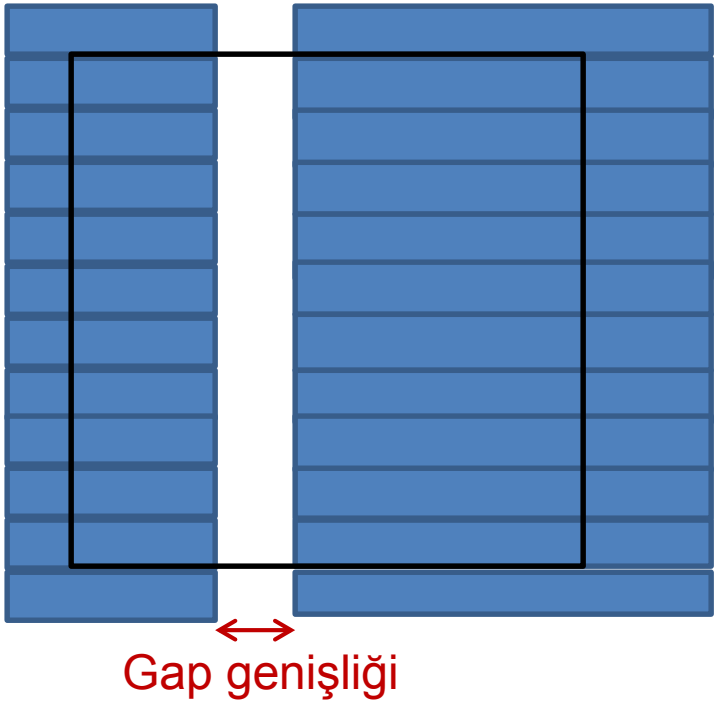
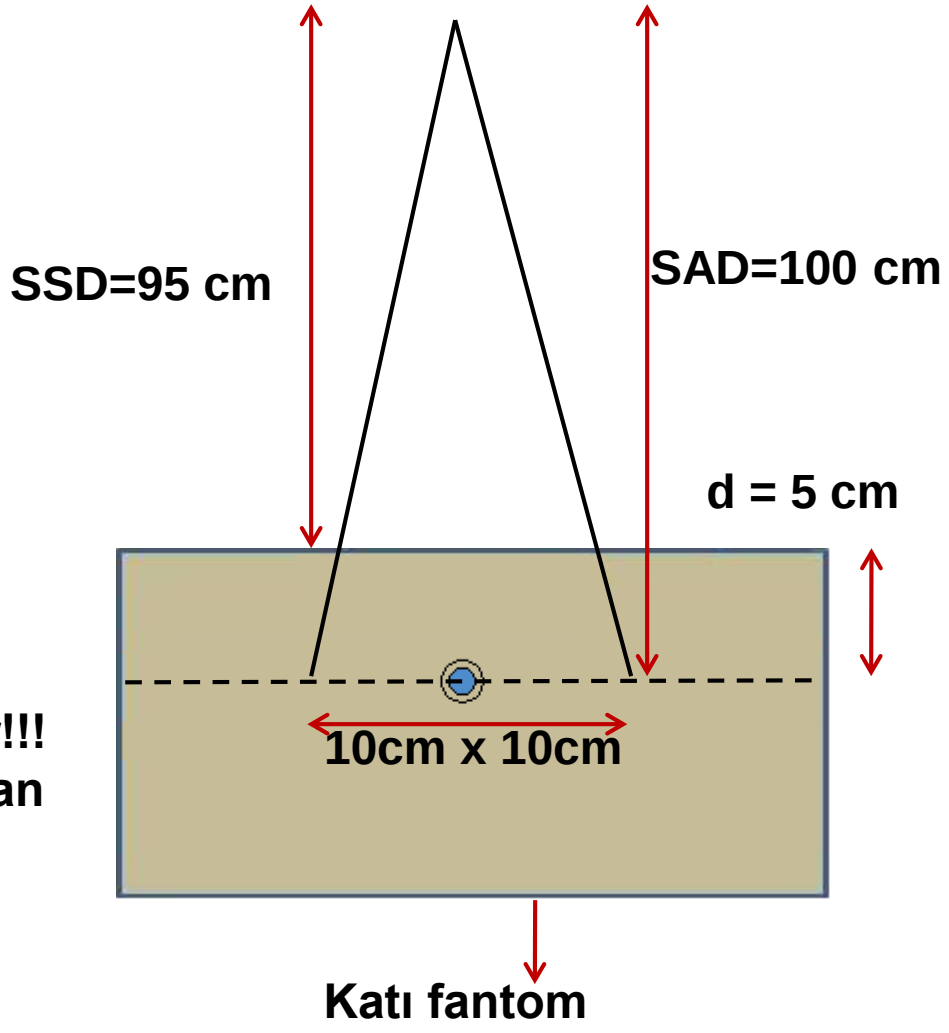
Received 14 June 2006, in final
Published 9 October 2006



# DLG : Nasıl Hesaplanır?



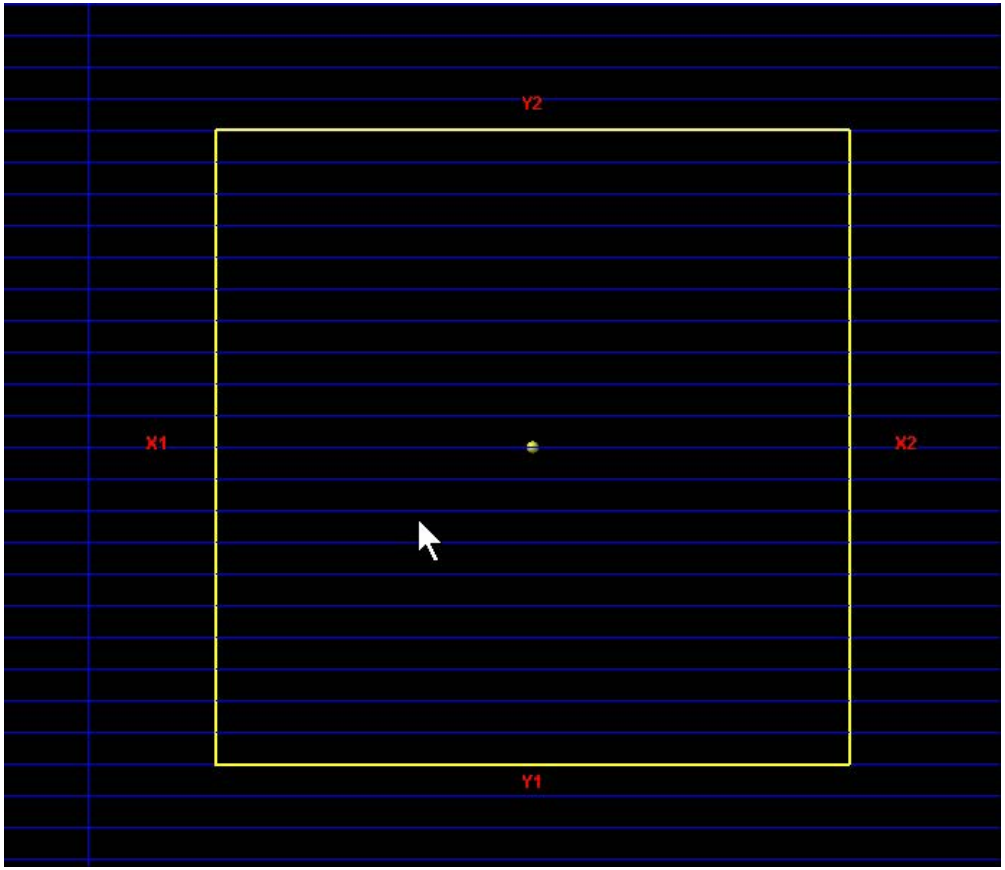

- **Setup kosullarında geçirgenlik ölçülür!!!**
- **2,4,6,10,14,16,20 mm genişliğinde kayan MLC gap dosyaları üreticiden temin edilir yada olusturulur.**

- **LoSasso ve ark.**

# DLG : Nasıl Hesaplanır?

**Ortalama geçirgenlik A tarafı**

**Ortalama geçirgenlik B tarafı**



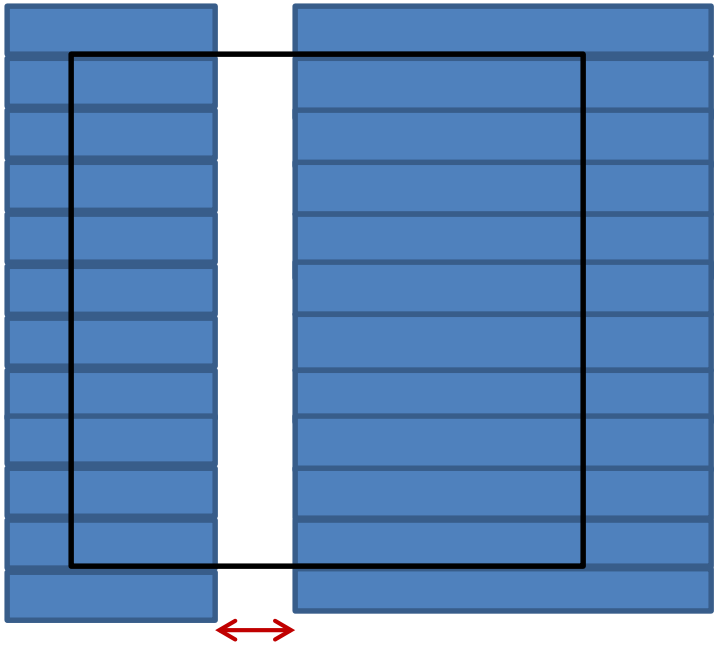

| | |
|---|---|
| $T_A$ (pC) | 40.5 |
| $T_B$ (pC) | 42.5 |
| $T_o$ (pC) | 41.5 |

| Gap [mm] | Rg (pC) |
|---|---|
| 2 | 110.5 |
| 4 | 165.5 |
| 6 | 219.5 |
| 10 | 331.0 |
| 14 | 440.5 |
| 16 | 495.0 |
| 20 | 606.0 |

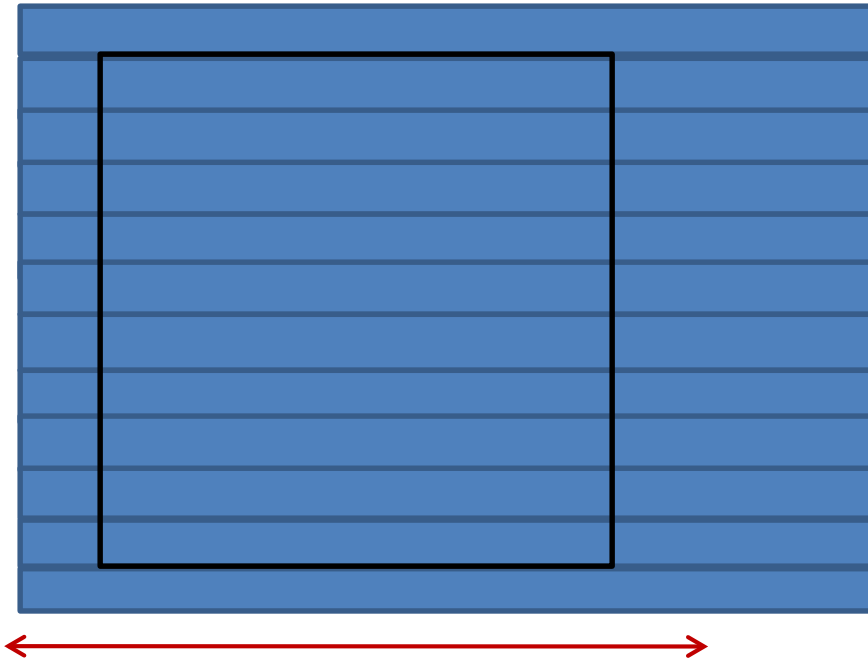
* Her ölçüm için eşit MU verilir. (100MU)

*Işınlama esnasında farklı genişlikteki lif gap 12 cm boyunca haraket eder.

# DLG : Nasıl Hesaplanır?



Gap genişliği
g[mm]



Gap hareketi
120[mm]

**Ölçüme Geçirgenlikten gelen katkı**

$$R_{gT} = T_o \cdot \left(1 - \frac{g[mm]}{120[mm]}\right)$$

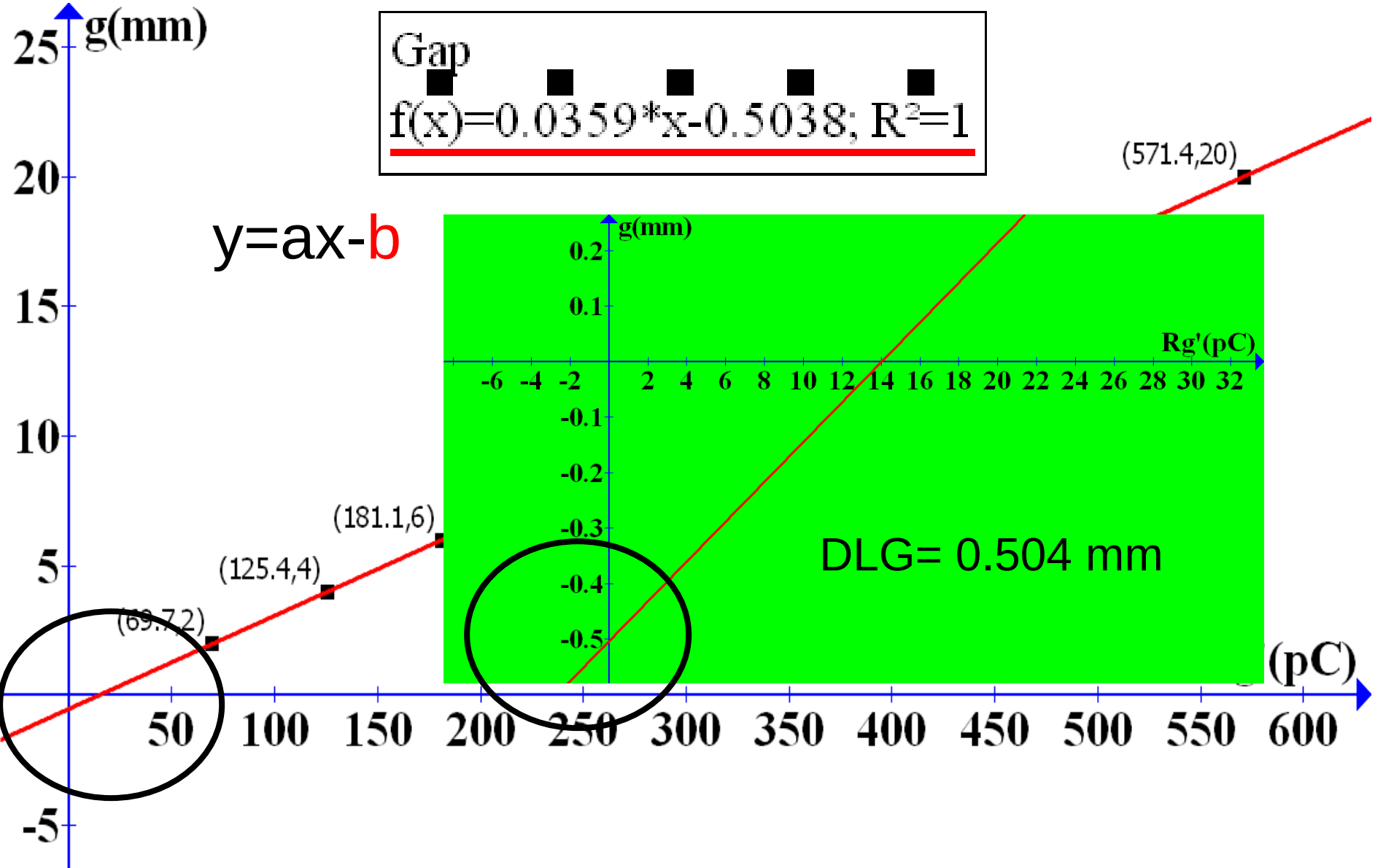
# DLG : Nasıl Hesaplanır?

| Gap [mm] | Rg (pC) | $Rg_T$ (pC) |
|---|---|---|
| 2 | 110.5 | 40.8 |
| 4 | 165.5 | 40.1 |
| 6 | 219.5 | 38.4 |
| 10 | 331.0 | 38.0 |
| 14 | 440.5 | 36.7 |
| 16 | 495.0 | 36.0 |
| 20 | 606.0 | 34.6 |

$$Rg' = Rg - Rg_T$$

| Rg’ (pC) |
|---|
| 69.7 |
| 125.4 |
| 181.1 |
| 293.0 |
| 403.8 |
| 459.0 |
| 571.4 |

# DLG : Nasıl Hesaplanır?



# DLG: Derinlik bağlılığı “yok”???

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 8, NUMBER 4, FALL 2007

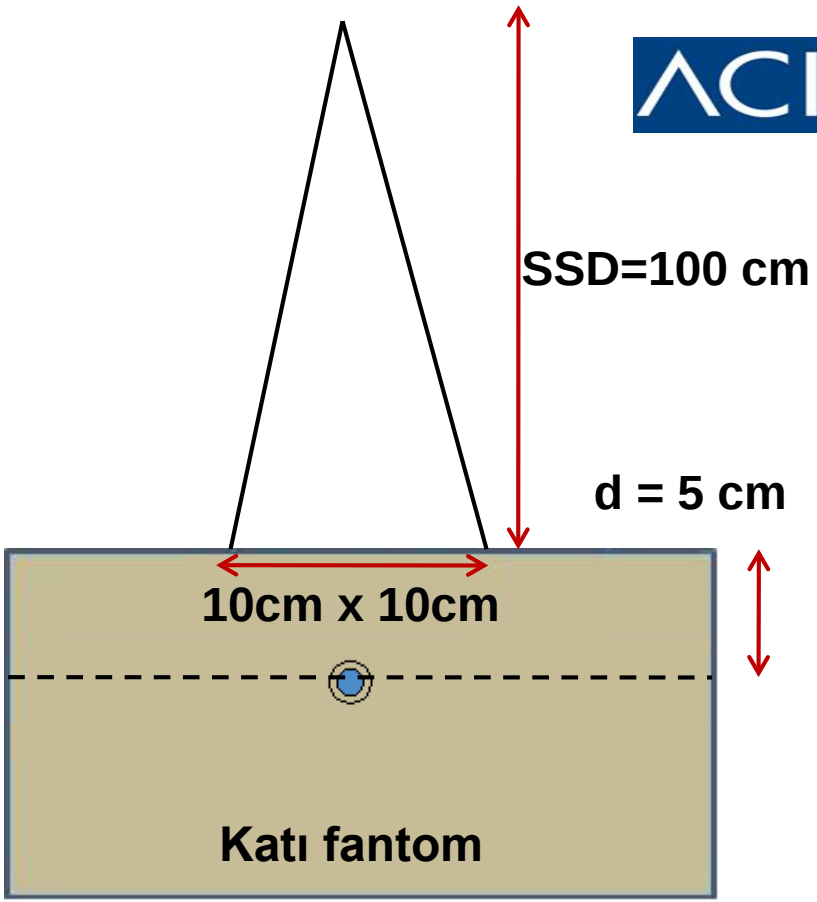
**Determination of depth and field size dependence of multileaf collimator transmission in intensity-modulated radiation therapy beams**

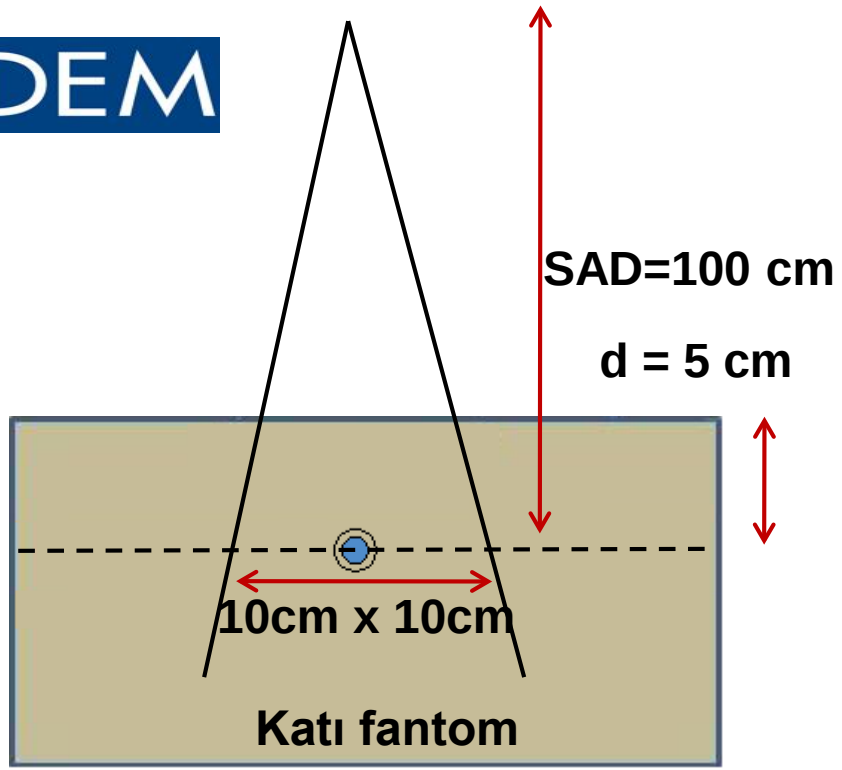
Piotr Zygmanski,[a] Florin Rosca, Dnyanesh Kadam, Friedlieb Lorenz, Adrian Nalichowski, Laurence Court, and Lee Chin
*Department of Radiation Oncology, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts, U.S.A.*
*pzy*

| | $\Delta G_{exp}$ (cm) | | |
|---|---|---|---|
| $d$ (cm) | 6EX (6 MV) | 21EXs (6 MV) | 21EXs (10 MV) |
| $d_{max}$ | 0.146 | 0.157 | 0.174 |
| 5 cm | 0.147 | 0.159 | 0.176 |
| 10 cm | 0.148 | 0.162 | 0.177 |

**0.02 cm**
**%1**

# DLG: Derinlik bağlılığı “yok”???

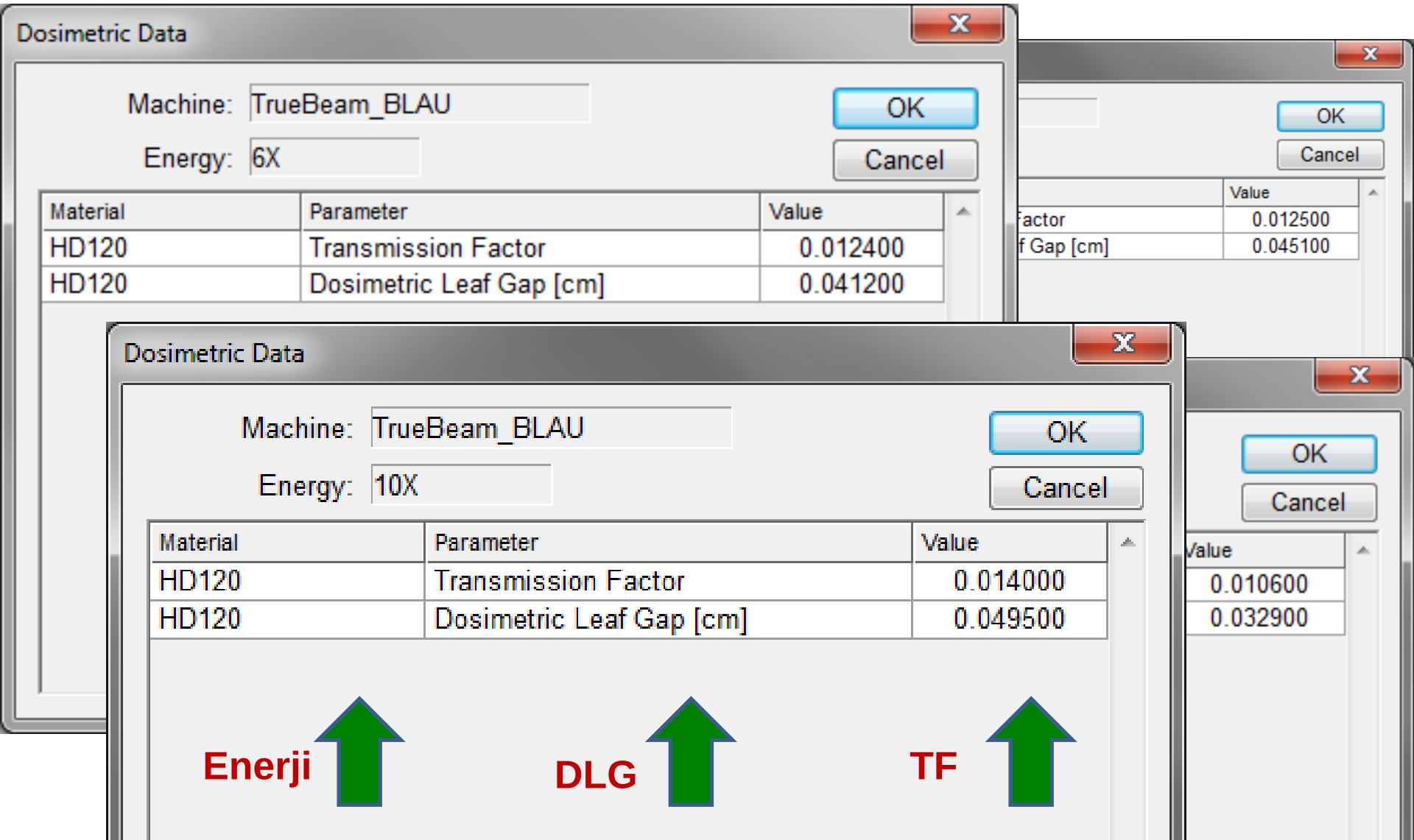



**0.2 mm**
**%1**

| Adana ,Rapidarc, 6 MV, d= 5cm | |
|---|---|
| SSD=100 cm | SAD=100 cm |
| 1.376 mm | 1.352 mm |

# TPS: Dosimetric Data



# CMO (*Center Mechanical Offset*)

- Aynı cihaz, aynı ölçüm düzeneği,her şey aynı fakat DLG farklı hesaplanıyor?


CMO ≈ 0

# Daha doğru doz hesaplaması için

- Geçirgenlik faktörü hangi derinlikte hangi alan boyutunda ölçüm alınmalı? (Tek değer)
- Geçirgenliğin alan bağlılığı ve derinlik bağlılığı TPS'e tanıtılabilir. (LMC algoritmaları geliştirilmeli)
- Geçirgenliğin uzaysal dağılımı göz ardı ediliyor, daha hassas hesaplamalar için geniş alanlarda uzaysal dağılım hesaba katılabilir.
- DLG derinlik bağlılığı hesaba katılmalı???

# Teşekkürler…