

# Use of EPIDs for Routine Linac QA

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## Disclosure

Our group has previously received research funding from *CancerCare Manitoba Foundation* and *Varian Medical Systems*



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## Introduction



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## Motivation

- TG-142 (& 40) outlines a number of linac QA tests to be performed daily, monthly, and annually
- Due to constrained resources, efficiency is desired!
- EPIDs are well-suited for performing many of these tests
- We will review our approach to several routine linac QA tests, including: daily outputs, picket fences, RapidArc QA, and profile constancy

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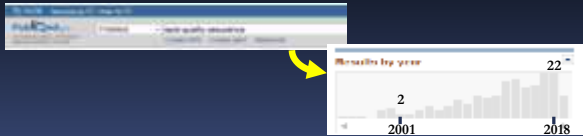
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## EPIDs

- EPID – **e**lectronic **p**ortal **i**maging **d**evice
- Developed in the 1980's and 1990's for anatomic imaging of the patient
- Investigated for dosimetry sporadically in the 1990's
- significant interest for dosimetry (and QA) in 2000's




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## EPIDs suited for QA dosimetry

- Commonly available
- Automated deployment
- Real-time digital imaging
- Dosimetric properties are favourable (linear, no deadtime...) – see Chapter 7
- Integrated - automated analysis and reporting




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EPID – uses megavoltage x-rays (therapy beam)

kV imaging system – diagnostic quality imaging

- Good positional reproducibility
- <1mm lat/long, <3mm vert sag for Varian E-arm  
(Rowshanfarzad et al., Med Phys, 2012)

L. ARNDT/FAU

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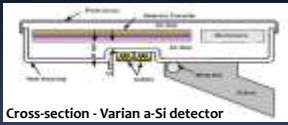
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mid-1990's prototype a-Si detector



Antonuk et al, Red Journal, 1996



Cross-section - Varian a-Si detector

Siebers et al, Med Phys, 2004

- current EPID design is a-Si flat panel imager
- metal plate, phosphor scintillator, array of photodiodes
- typically  $\sim 40 \times 40 \text{ cm}^2$  size (1024x1024 pixels)
- pixels  $\sim 0.39 \text{ mm}^2$

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# Automated QA framework

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### Photon Outputs



- Run by therapists during morning warm up
- Delivered in QA mode
- Fully automated analysis, PDF emailed to dosimetry group in the event of marginal/fail results.

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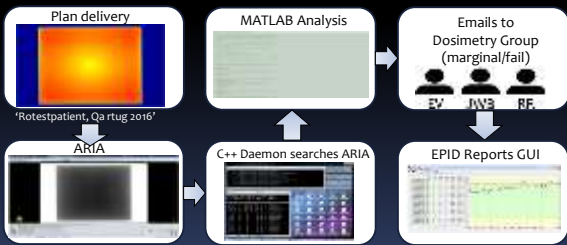
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### Process flow (for photons)



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### What about electron outputs?



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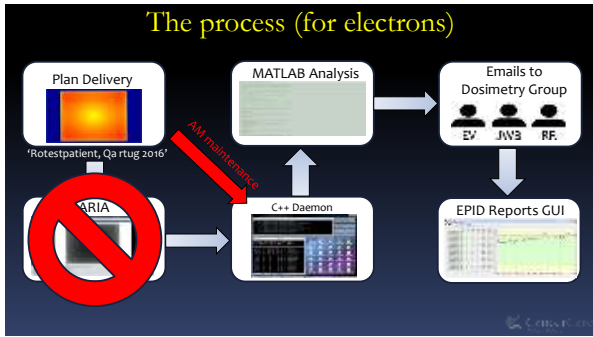
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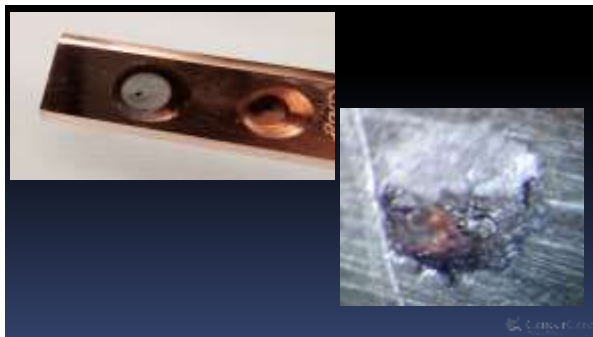
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### Who watches the watchers?

- Secondary monthly solid water check in addition to yearly TG-51 calibration
- Recalibrate EPID baseline if necessary



UCLA EPID

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### Who watches the watchers?

- Scheduled task running on a separate Windows machine ensures that all outputs have been gathered and processed.
- Checks photon beams at noon and electron beams at 8pm



UCLA EPID

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### Picket Fence/RapidArc QA

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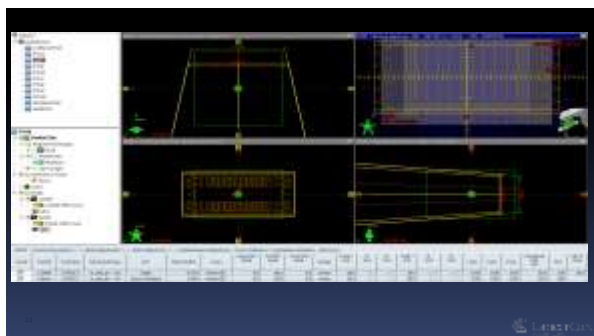
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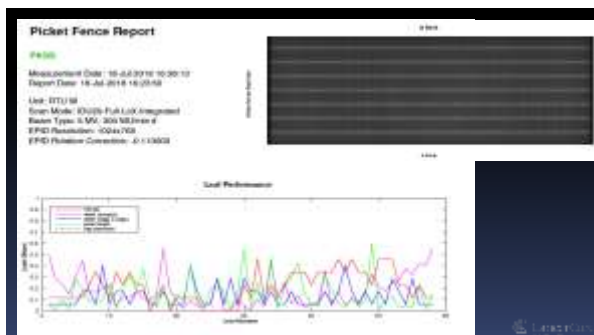
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## RapidArc QA

**Characterizing and quality assurance of RapidArc radiotherapy delivery system.**

**Author Information**

**Purpose:** The Varian RapidArc is a system for intensity-modulated radiotherapy (IMRT) treatment planning and delivery. RapidArc incorporates capabilities such as variable dose rates, variable gantry speed, and accurate and fast dynamic multileaf collimators (DMLC) to reduce dose set-up time, reduce efficiency, accuracy, and stability. We developed RapidArc's system characterization and quality assurance (QA) procedures.

**METHODS AND MATERIALS:** Tests have been designed to evaluate RapidArc's performance in a detector-based Picket Fence, the accuracy of DMLC position during gantry rotation, beam-on, the ability to vary and control the dose rate and gantry speed is evaluated. Test, the corrected use of variable DMLC speed and dose rate is studied.

**RESULTS:** Adapting the picket fence test for RapidArc, we compared the patterns obtained with stationary gantry and in RapidArc mode, and showed that the effect of gantry rotation on leaf accuracy was minimal ( $< 0.2$  mm). We then combine different dose rates (111.400 MU/min), gantry speeds (0.4-2 degrees/s), and gantry range (0.0005-1.00708 degree/s) to give the same dose to every part of a film. After normalization to a corresponding speed field (to account for electron and secondary), the dose of the entire portfolio were good agreement, with a mean deviation of 2.7%. To assess DMLC speed (0.45, 0.92, 1.81, and 2.76 units) during RapidArc, the analysis of integrated relative pattern indicates good agreement, with a mean deviation of 0.4%.

**CONCLUSIONS:** The results of these tests provide strong evidence that DMLC movement, variable dose rates and gantry speeds can be precisely controlled using RapidArc.

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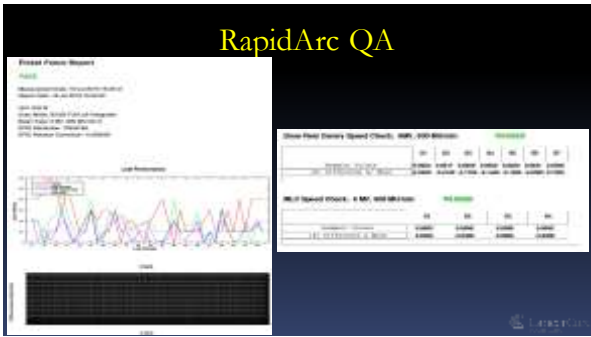
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## Profile Constancy

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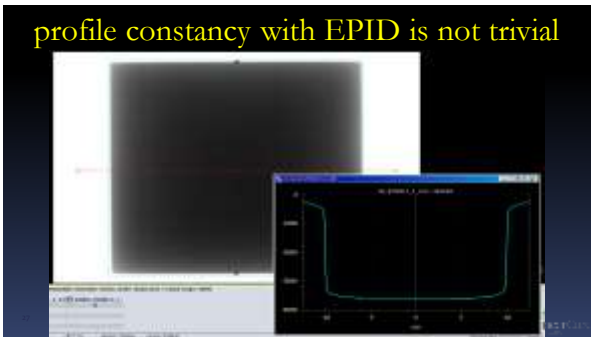
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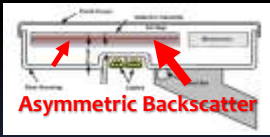
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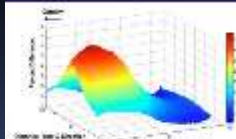
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### EPID profile constancy is not trivial



aS500/1000 EPID:  
 For 40x30 cm<sup>2</sup> field,  
 (EPID+arm)-(EPID)  
 Max diff = 6%



Rowshanfarzad et al., Med Phys, 2010

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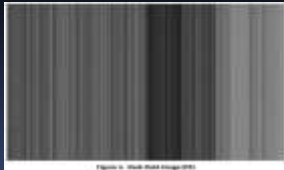
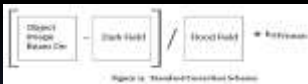
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### Important profile information removed




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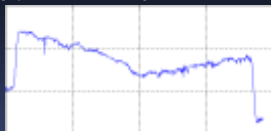
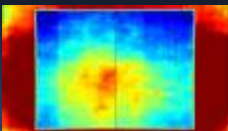
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### Important profile information removed



Cannot simply reverse the operation




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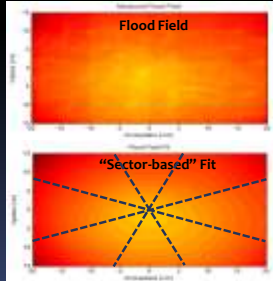
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### So we fit the flood field



- Keep the beam profile, remove other effects
- Divide flood field into eight radial 'sectors'
- Fit n-degree polynomial to radial vector at centre of each sector
- Final corrected image is applied to acquired EPID image via division to "reintroduce" the actual profile
- Analyse once a month

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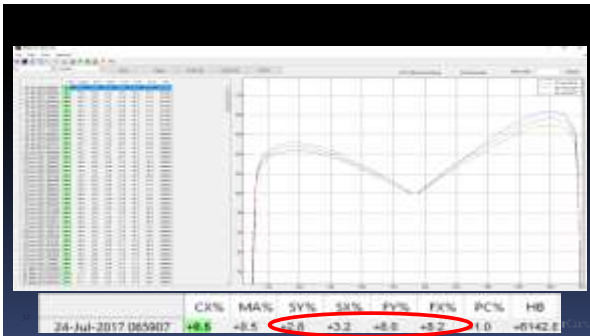
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Winston-Lutz

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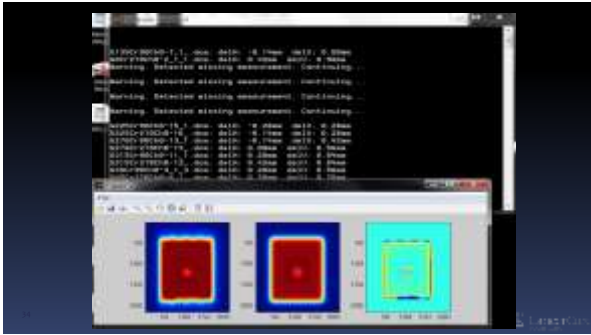
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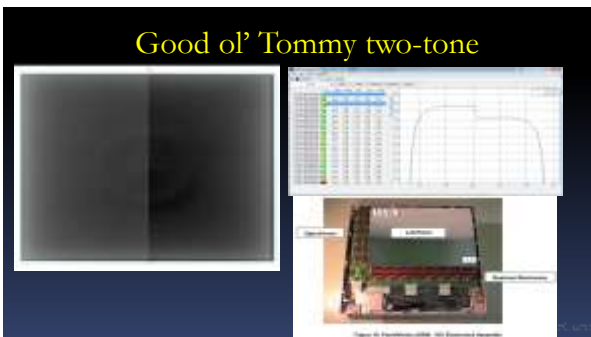
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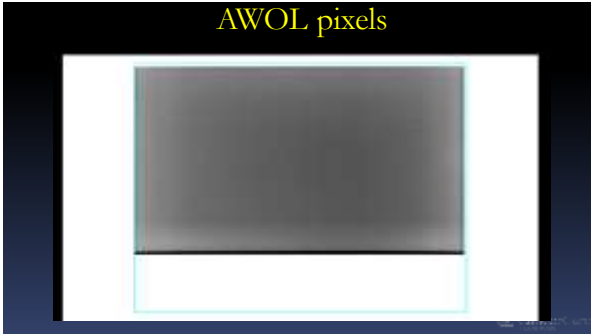
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### AWOL pixels



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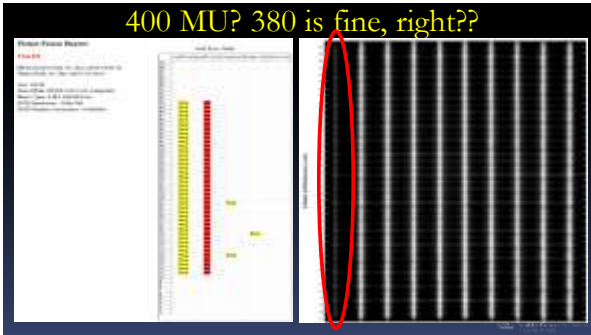
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### 400 MU? 380 is fine, right??



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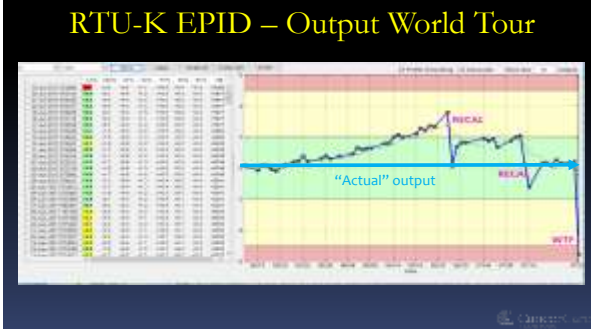
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### RTU-K EPID – Output World Tour



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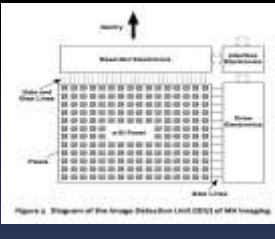
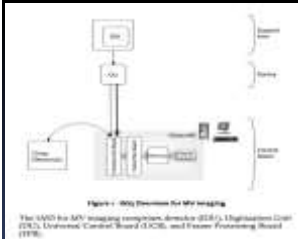
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## Complicated hardware



Varian image acquisition reference guide, March 2011




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## Big payoff... worth a few headaches



Total time savings per day over 7 linacs: 56 minutes  
 Equivalent to 4 more patients treated per day during clinical hours  
 (2% overall increase in patient throughput)




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## Discussion

- EPIDs provide a fast, convenient, efficient, and relatively cheap solution to some of the challenges of routine linac QA
- It's not a panacea... EPIDs themselves must be QA'd and closely monitored for performance
- There is a significant overall benefit and increase in efficiency




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Thank you, eh?



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MEANWHILE  
McDonald's  
IN CANADA

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