SUN NUCLEAR corporation

ArcCHECK, ein neuartiger QS-Ansatz bei der Rotationsbestrahlung

Treffen des Arbeitskreises IMRT der DGMP
Würzburg, 26 + 27.03.2009

Salih Arican

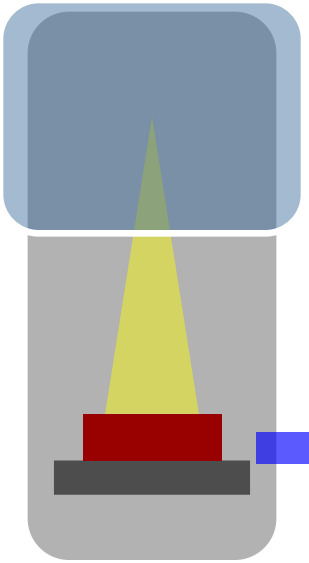
Sun Nuclear Corporation

Your Most Valuable QA & Dosimetry Tools

QA Challenge for Rotational Beams

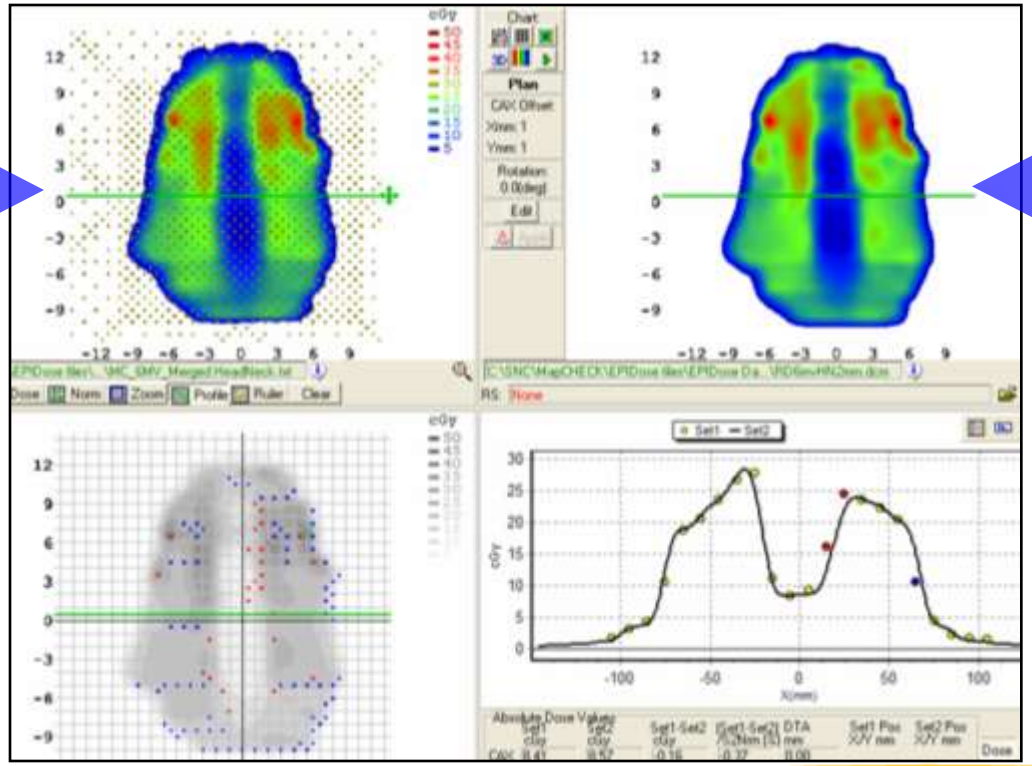
- Modern technologies are becoming rotational.
  - (RapidArc®, VMAT, TomoTherapy, …)
- Rotational beam delivery creates a challenge for patient specific QA.

What is essential for IMRT QA?



dose-to-dose comparisons!!!

TPS



Audit the ***Delivery System***

Audit the ***TPS***

PA PLAN QA RO ROTATIONAL

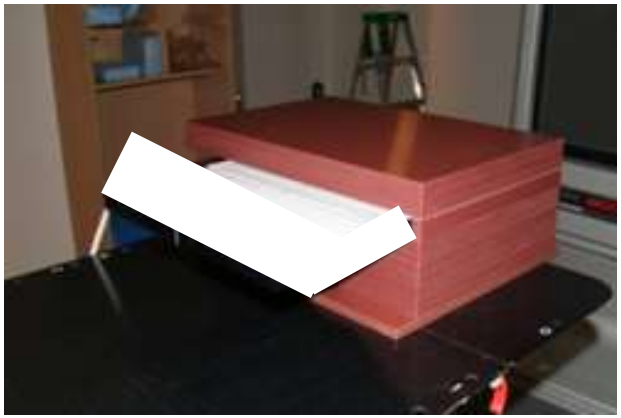
Your Most Valuable QA & Dosimetry Tools

Proof of concept:

A Study Using 2D Arrays for Rotational Beam QA

MapCHECK™

Chamber Array



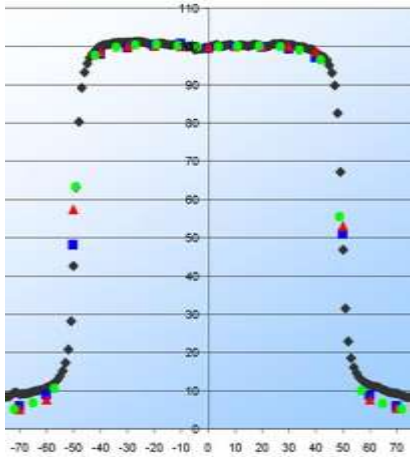
Chamber Array

EBT film

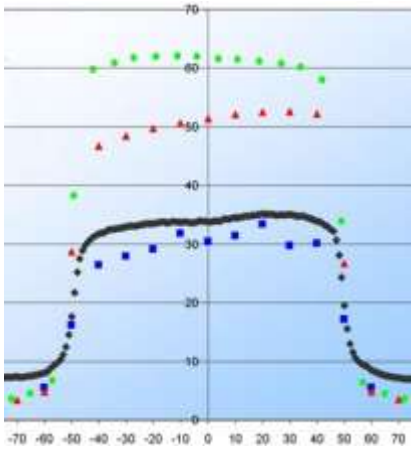
The SDD and buildup followed manufacturer instructions
Study performed by SNC without cooperation of other manufacturers

0° (10 x 10cm field)

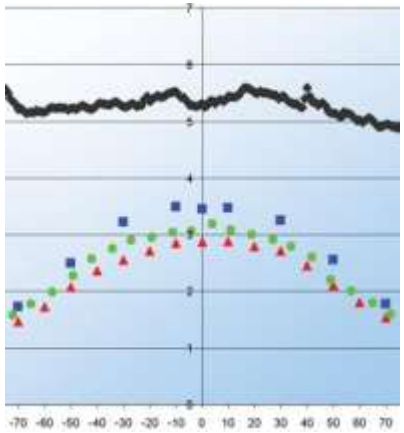
Legend: **Black:** film, Blue: MapCHECK, **Red:** Chamber Array, **Green:** Chamber Array



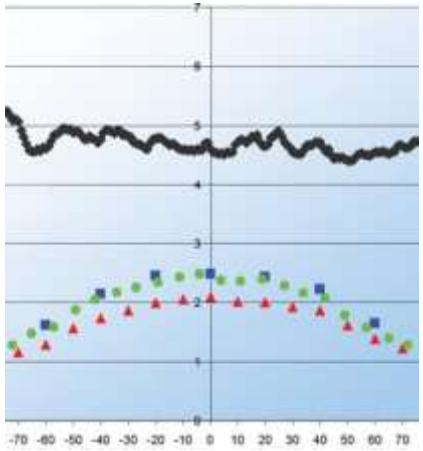
0 mm
calibration position



50 mm
field edge, chamber
over response



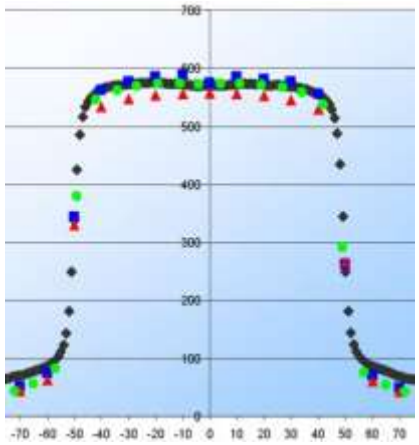
80 mm
scatter region,
film over response



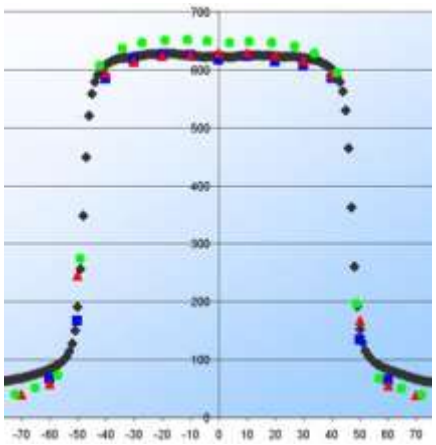
90 mm
scatter region,
film over response

Composite (10 x 10cm field); Gantry angles = 0, 60, 80,85, 90, 95, 120, 150)

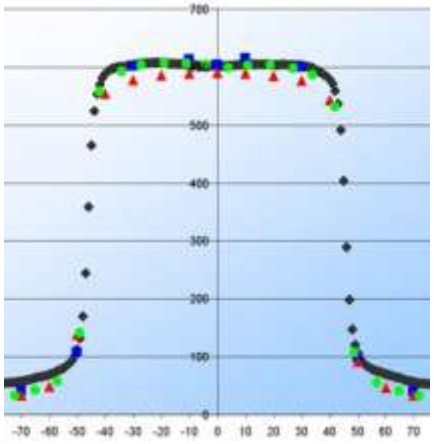
Legend: **Black:** film, Blue: MapCHECK, **Red:** Chamber Array, **Green**: Chamber Array



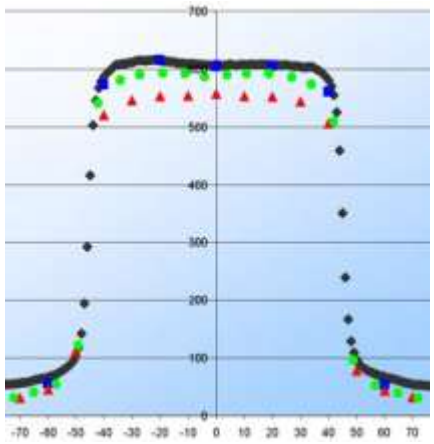
0 mm



50 mm



80 mm



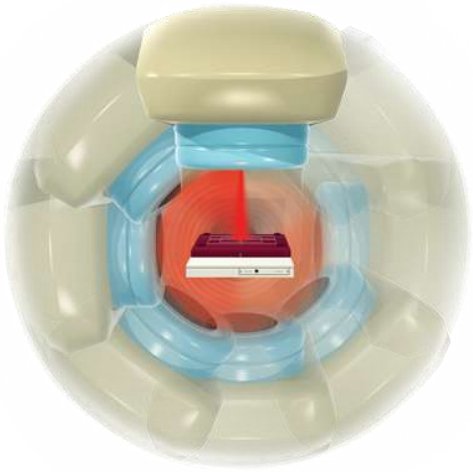
90 mm

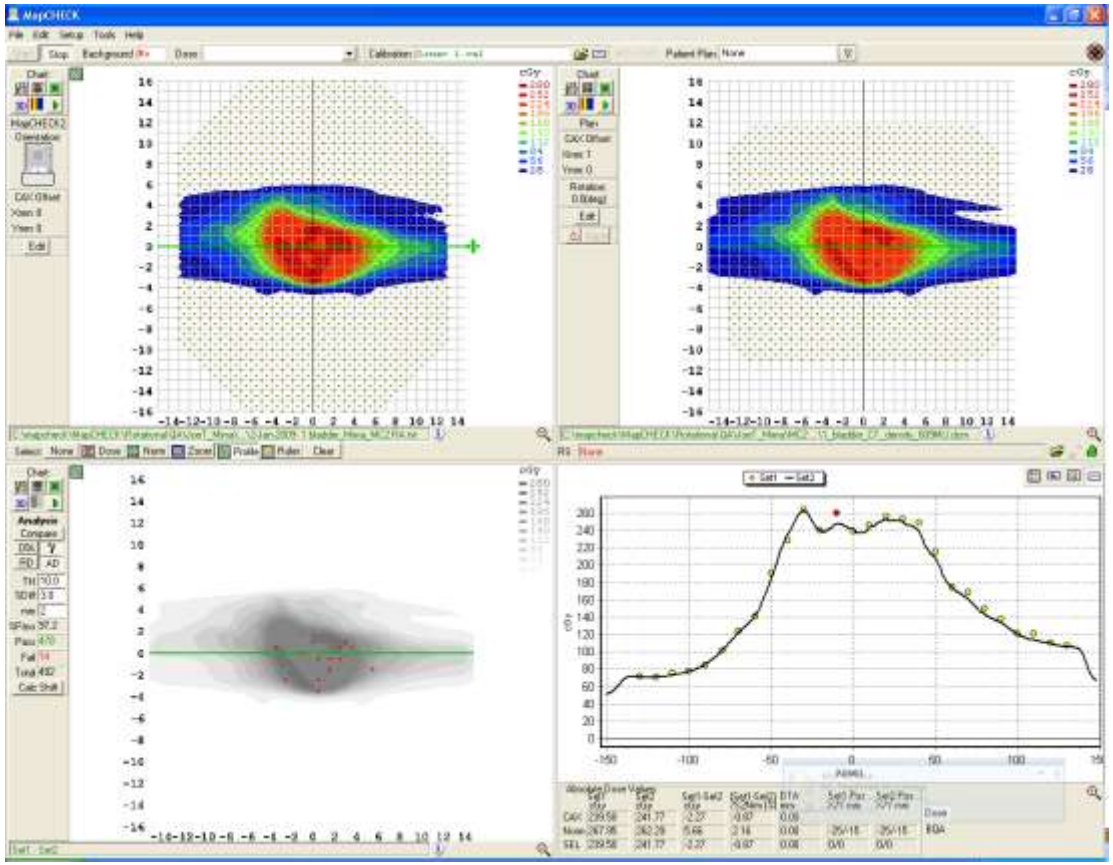
Study Conclusions

- All 2D arrays have directional dependence, more or less at different angles
- When summing the dose at all the angles, all the 2D arrays agreed with film reasonably well and thus can be used for rotational beam QA

Rotational Dosimetry Example with MapCHECK2/MapPHAN2

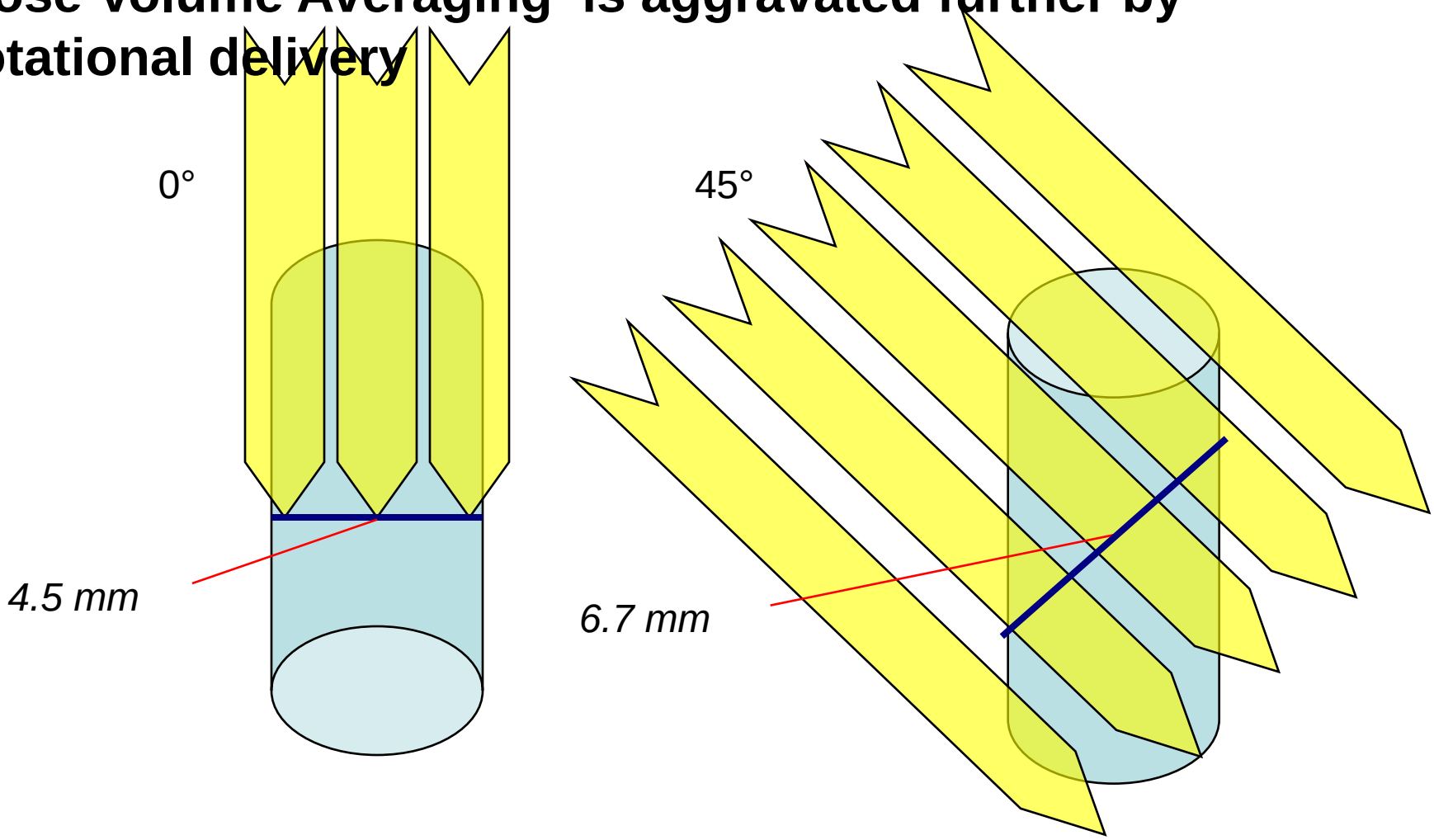
- RapidArc™
- Bladder
- 3%, 3mm
  - **97.2% pass rate**
- 3%, 2mm
  - **97.2% pass rate**





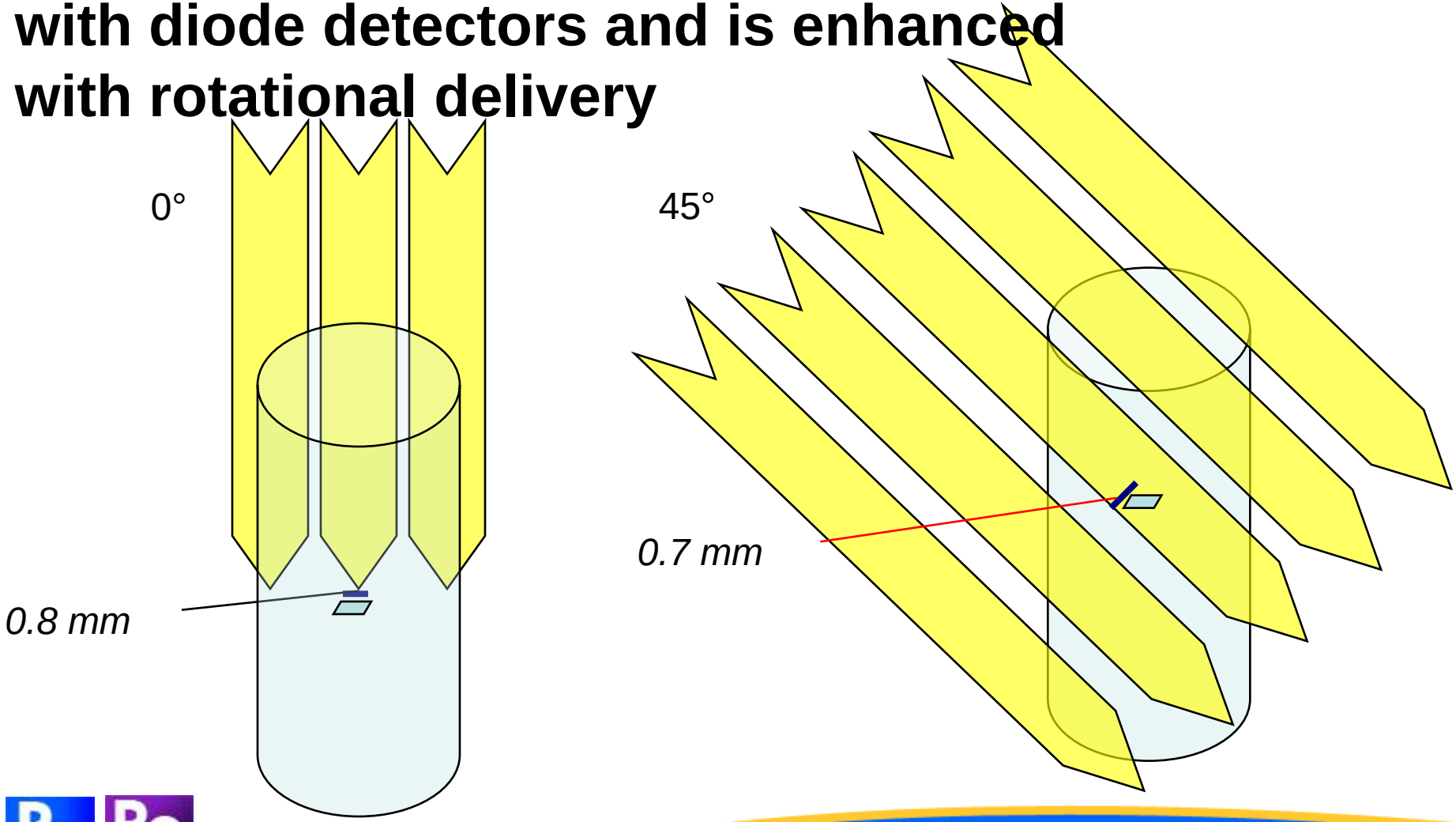
Variable Volume Averaging Chambers

Dose Volume Averaging is aggravated further by rotational delivery

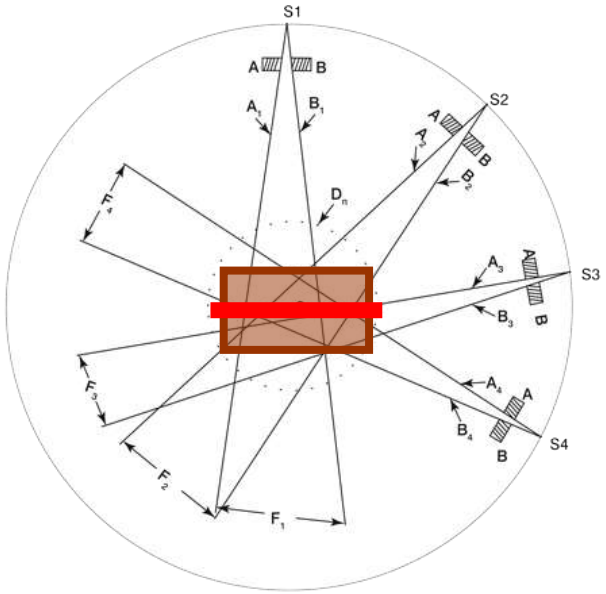


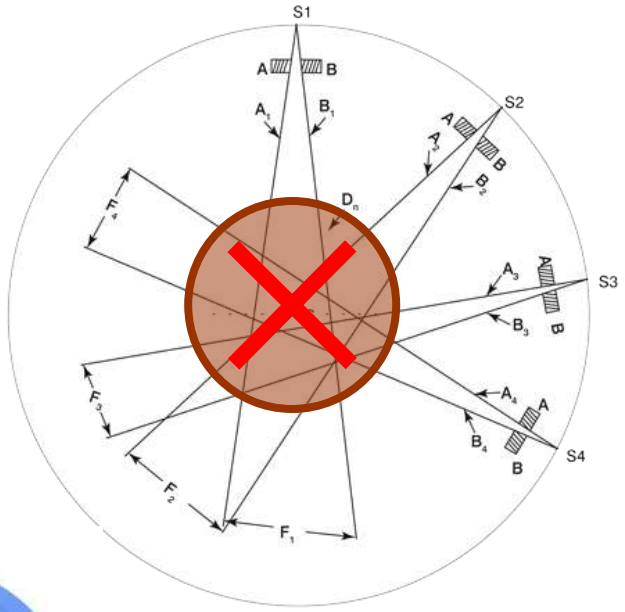
Variable Volume Averaging Diodes

The problem of Dose Volume Averaging reverses with diode detectors and is enhanced with rotational delivery

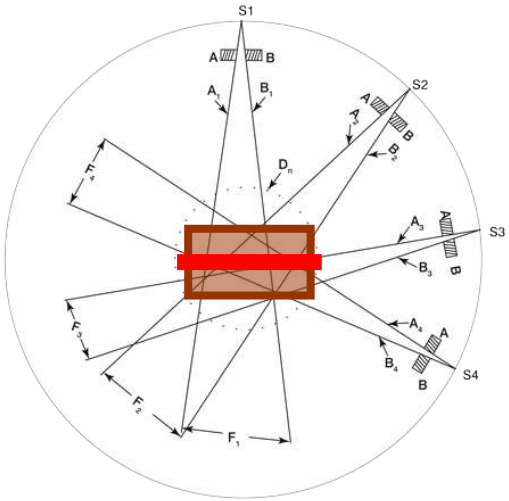


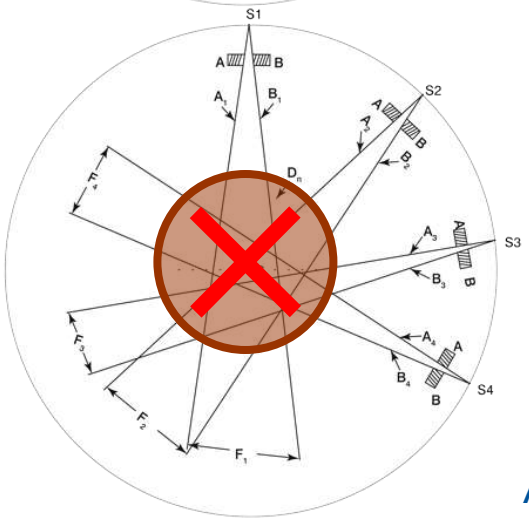
What is 3D?


S1
S2
S3
S4
A
B
A_1
B_1
A_2
B_2
A_3
B_3
A_4
B_4
D_n
F_1
F_2
F_3
F_4

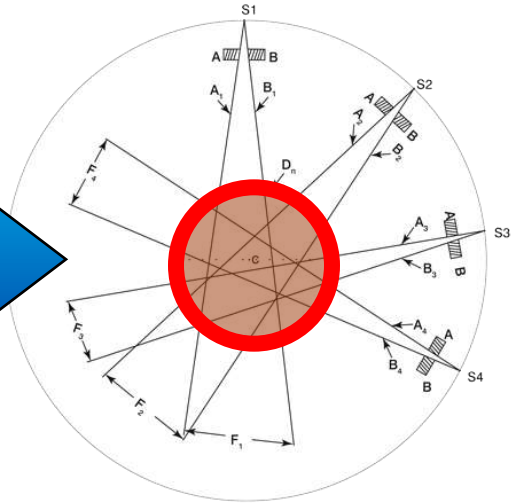

S1
S2
S3
S4
A
B
A_1
B_1
A_2
B_2
A_3
B_3
A_4
B_4
D_n
F_1
F_2
F_3
F_4

The Future in 3D



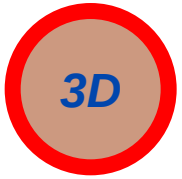


Make the detector plane "coherent" to the beam



Is this 3D?

→ ***Yes!***



An isotropic 3D array is defined by the detector geometry, not just by the phantom shape around the detectors!

ArcCHECK

- Designed for Helical & Arc Delivery
  - RapidArc™, TomoTherapy®, VMAT

Key Features

- **1386** diodes in cylindrical geometry
  - This detector orientation is patent pending
- Small detector size of **0.64mm^2** & **0.000019cm^3**
- 21cm diameter, 21cm length
- 1cm spacing
- 4th Dimension = Time
  - **50ms** update frequency

Applications

- Fast plan QA
  - Composite and *real-time* measurement
- Find failure mechanisms
  - TPS, Linac, MLC
- Ability to measure
  - Gantry angle
  - Leaf end position
  - Dose
- Time synchronized analysis
- Routine machine QA, imaging QA, setup QA
- RapidArc, VMAT, helical delivery commissioning

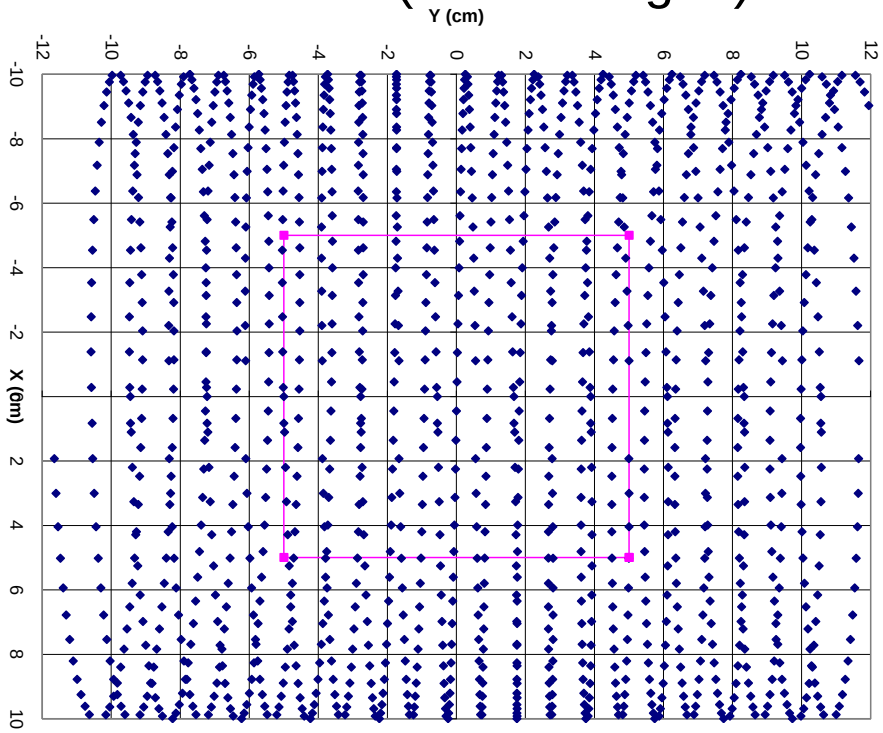
Composite vs. Control Point

- Composite
  - The entire treatment dose shell consisting of all control points
  - Typical rotational QA will be composite
- Control points
  - Sub-sections of the treatment dose shell
  - Up to 177 control points on a RapidArc delivery
  - Tomotherapy does not use control points

- ArcCHECK can measure composite, individual control points, and ranges of control points
  - 50ms update speed of ArcCHECK enables fast dose data parsing
- Benefits of control point QA
  - If there is a problem with composite, then drill down to evaluate individual control points
  - Use control point analysis to help improve treatment planning process

HeliGrid™

- Detectors do not overlap from a BEV perspective
  - Benefit is increased detector density
- Each detector row is offset, creating what can be called a helical or spiral effect, hence HeliGrid™ (hee – li – grid)



Beam's Eye View
Cylinder 21 cm dia
66 per wrap, 1 cm between wraps

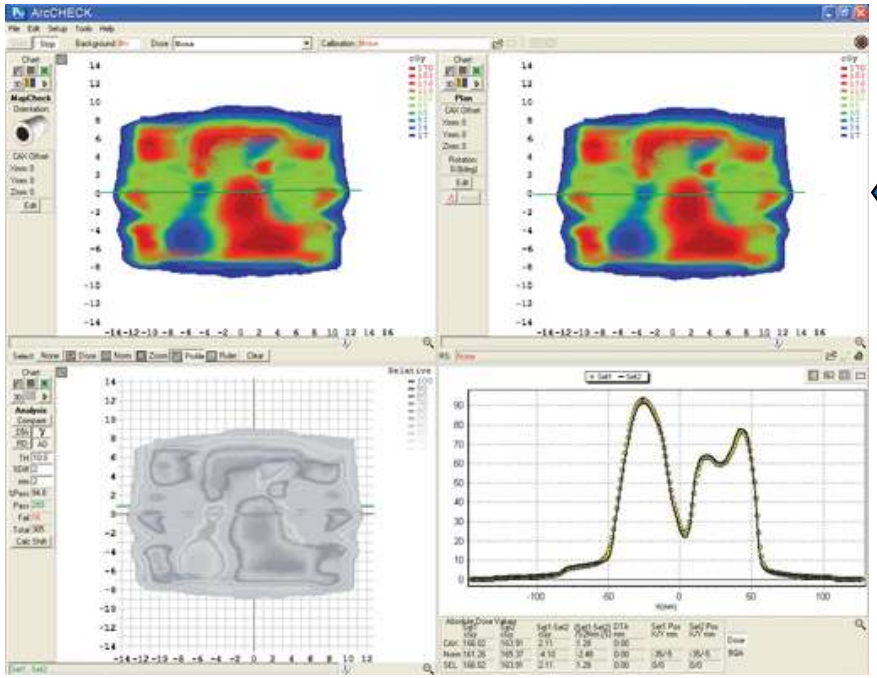
World Map

- The detectors are “wrapped” around the phantom and irradiated.
- The result is a data file that is unwrapped like a “world map”

Data Display

- ArcCHECK dose unrolls like a world map
- ArcCHECK mathematically extracts same dose from TPS
- ArcCHECK performs comparisons

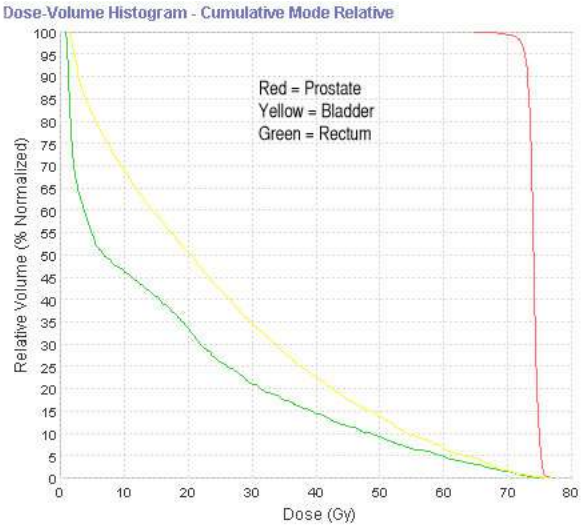
Unroll ArcCHECK Dose



Unroll TPS Dose

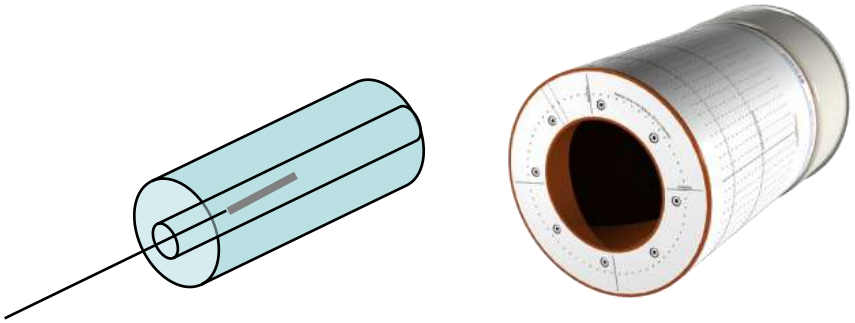
Compare!

DVH Analyse


Dose-Volume Histogram - Cumulative Mode Relative
Red = Prostate
Yellow = Bladder
Green = Rectum
Relative Volume (% Normalized)
Dose (Gy)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80

Cavity Plug

- Cavity plug addresses desire to have measurement on CAX
- Standard plug will have insert that accommodates different detectors

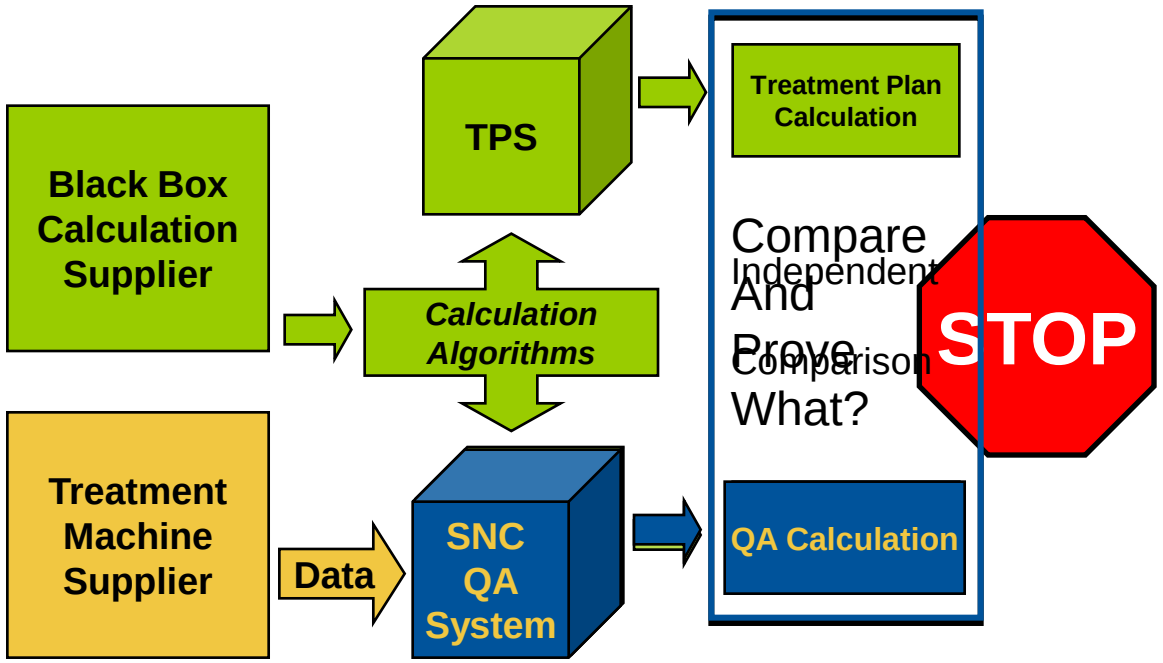


- Goal will be to show through research and publications that a measurement on CAX is not necessary
- Cavity plug is an insurance policy, and acknowledgement that physicists are comfortable with seeing dose on CAX
  - AAPM survey indicated xx% want to see dose on CAX

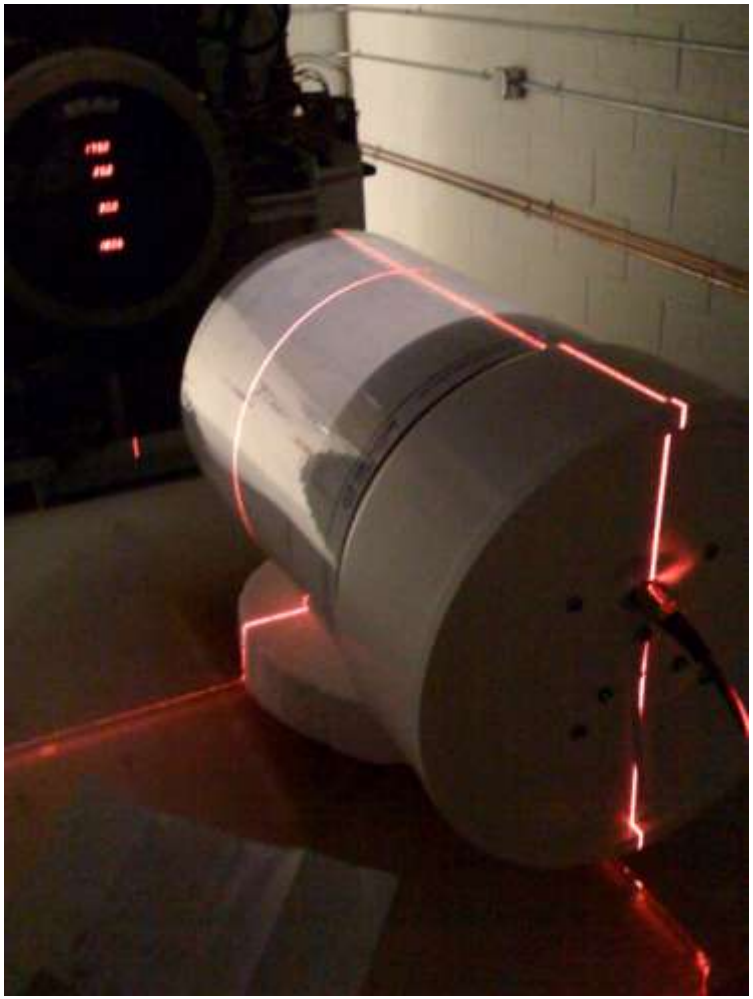
Beta Testing

Unit #	Clinic	Machine	TPS	Location
Research Unit	University of Florida	Varian, Elekta	Pinnacle	USA, Gainesville
1	PMH	Elekta	Pinnacle	Canada, Toronto
2	St. James Institute of Oncology, Leeds University Hospital	Elekta	CMS, 3DLine Ergo	UK, Leeds
3	Universitätsklinikum Mannheim, Germany	Elekta	CMS	Germany, Mannheim
3a	Clinic of the Technical University Munich Rechts der Isar	Varian, Tomotherapy		Germany, Munich
5	Tohoku Univ Hospital	Varian		Japan
6	North Coast Cancer Institute	Varian	CMS	Australia
7	MD Anderson Orlando	Varian, Tomotherapy	Pinnacle	USA, Orlando
8	Arcispedale S.Maria Ospedale Reggio	Tomotherapy		Reggio Emilia, Italy

Caution: Shared DNA



The Future of Dosimetry QA



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Thank you,

Questions?

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