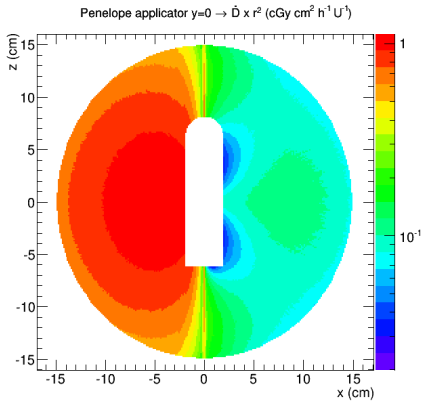
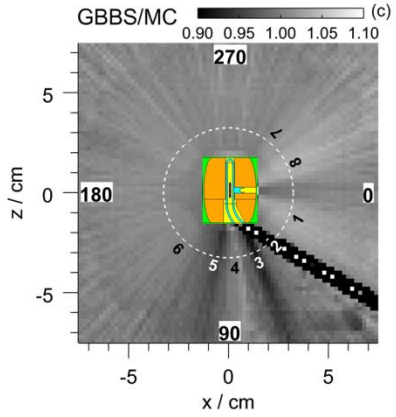
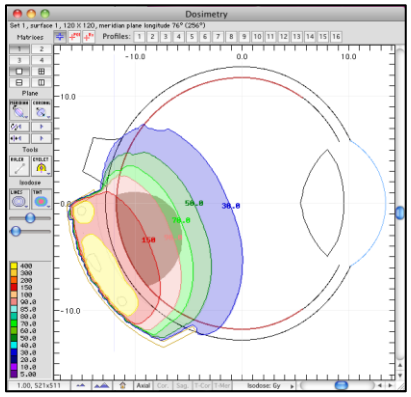
Clinical implementation for advanced brachytherapy dose calculation algorithms beyond the TG-43 formalism:

Dosimetry benchmark for MBDCA







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Learning objectives

- Identify MBDCA commissioning processes for a safe and smooth integration into the clinic

- Provide practical examples for commissioning MBDCA treatment planing systems

Contents

- Background
- TPS commissioning: external vs. brachy
- What should be tested in a TPS based on MBDCAs?
- Current clinical scenarios
- TG-186 commisisoning recommendations
- Examples on MBDCA commissioning
- Conclusions

Commissioning: external vs. MBDCA brachy

- External RT
  - ✓ TPS: CC, SC, MC, GBBS
  - ✓ Literature & vendor doc: agreement with MC and EXP; for a linac ≠ user linac
  - ✓ TPS implementation: pdd, oax, output, … on user linac
  - ✓ User comparison: TPS vs. EXP.
  - ✓ In adition:
    - TPS benchmark against MC
    - IMRT: phantom measurements
    - Dosimetric audits RPC
- MBDCA Brachy
  - TPS: BV-Acuros, OncentraBrachy
  - Literature & vendor doc: agreement with MC and EXP for sources and applicators?
  - TPS implementation: libraries for sources, applicators, shields.
  - User comparison: TPS vs. EXP?
  - In adition:
    - TPS benchmark vs. MC: **WG task**
    - Phantom measurements?
    - Dosimetric audits RPC?

TG-186

Report of the Task Group 186 on model-based dose calculation methods in brachytherapy beyond the TG-43 formalism: Current status and recommendations for clinical implementation

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- Guidance for early adopters of MBDCAs.
- MBDCA commissioning:
  - level 1: MBDCA should fall back to TG-43 data in well controlled conditions (all water).
    2% tolerance
  - level 2: MBDCA should take into account material heterogeneities and scatter conditions

What should be tested?

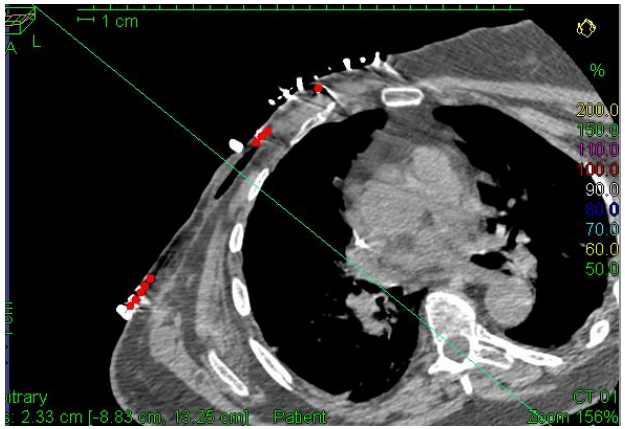
- Applicators, sources and devices (TG-186 section IV.B.1.e)
- TG-186 recommendations:
  - It is responsability of the user
  - TPS vendors should provide analitical modelling schemes and visualization tools
  - The manufacturers should disclose their geometries and material
  - Prior to accepting a device it must also be verified by an independent investigator

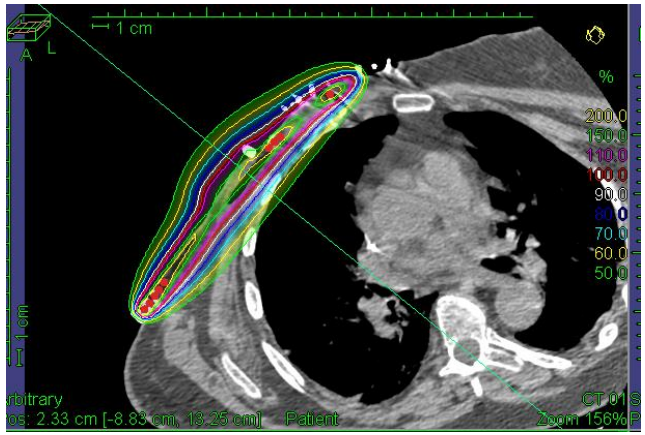
Which test cases to check?

- It is not possible to validate MBDCA implementation for any possible combination of source + applicator + anatomy
- Test only scenarios relevant to your clinical practice
- AAPM/ESTRO/ABG MBDCA working group is developing a few registry test cases
  - (see WE-C-141-1 Wednesday 10:30AM - 12:30PM Room: 141)
- Test cases will be available at the RPC registry
- Developers of new test cases are encouraged to share their validated results through the RPC registry

Current clinical scenario

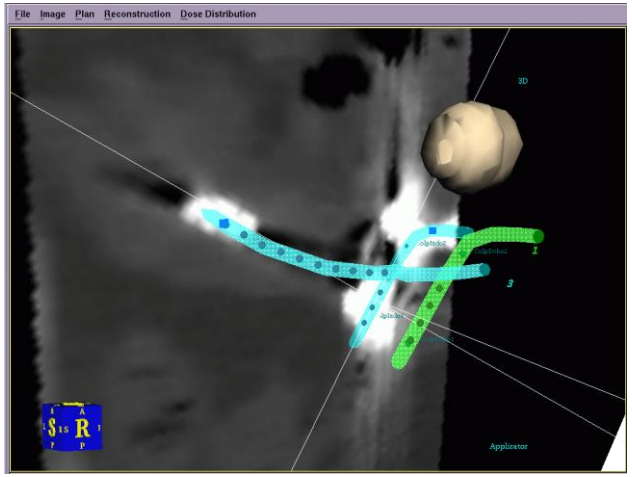
- MBDCA TPS available for HDR Ir-192 only
- Physis effects taken into account for MBDCA-based TPS and its significance in HDR:
  - Scatter default





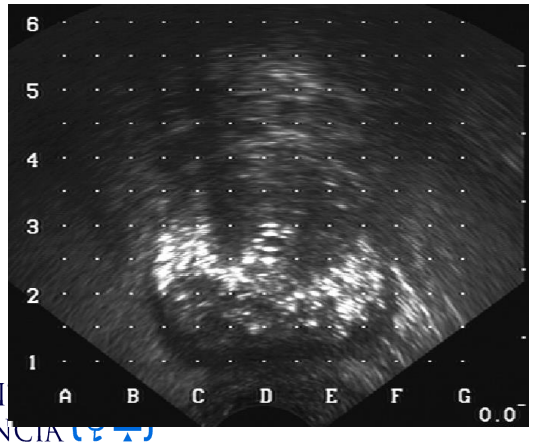
Current clinical scenario

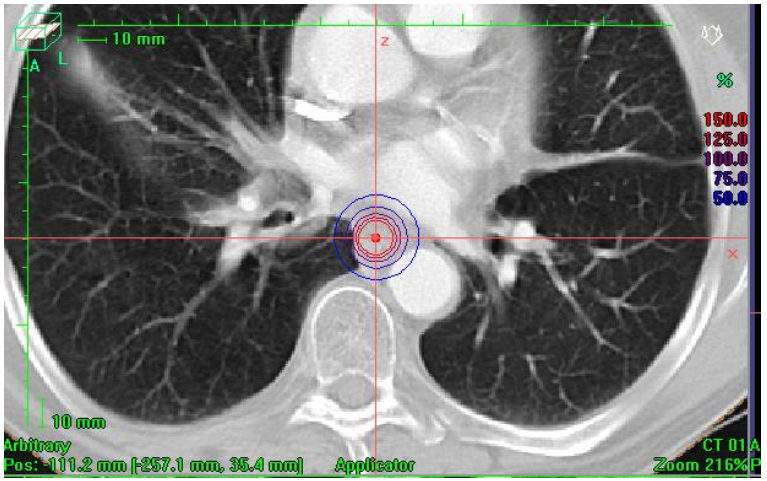
- MBDCA TPS available for HDR Ir-192 only
- Physis effects taken into account for MBDCA-based TPS and its significance in HDR:
  - Scatter default
  - Shielding



Current clinical scenario

- MBDCA TPS available for HDR Ir-192 only
- Physis effects taken into account for MBDCA-based TPS and its significance in HDR:
  - Scatter default
  - Shielding
  - Tissular Heterogeneity





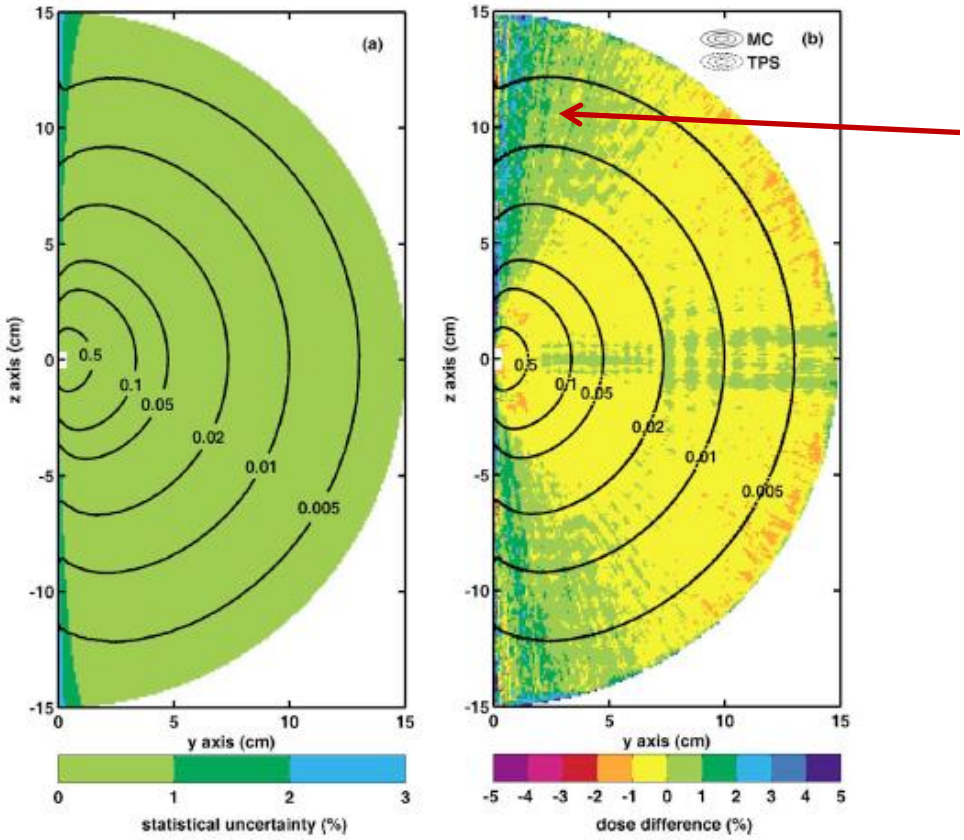
MBDCAs commissioning level 1

Single source in water: MCNPX vs Brachyvision

Zourari et al 2010

MCNPX ose distribution

Dose differences (MCNPX – BV) %



VS2000 Ir-192 at the center of a 15 cm radius sphere

1-5% dose overestimation of TPS is attributed to:

1) an error in the source encapsulation thickness on the TPS

2) spatial discretization on the TPS

Good example of commissioning level 1

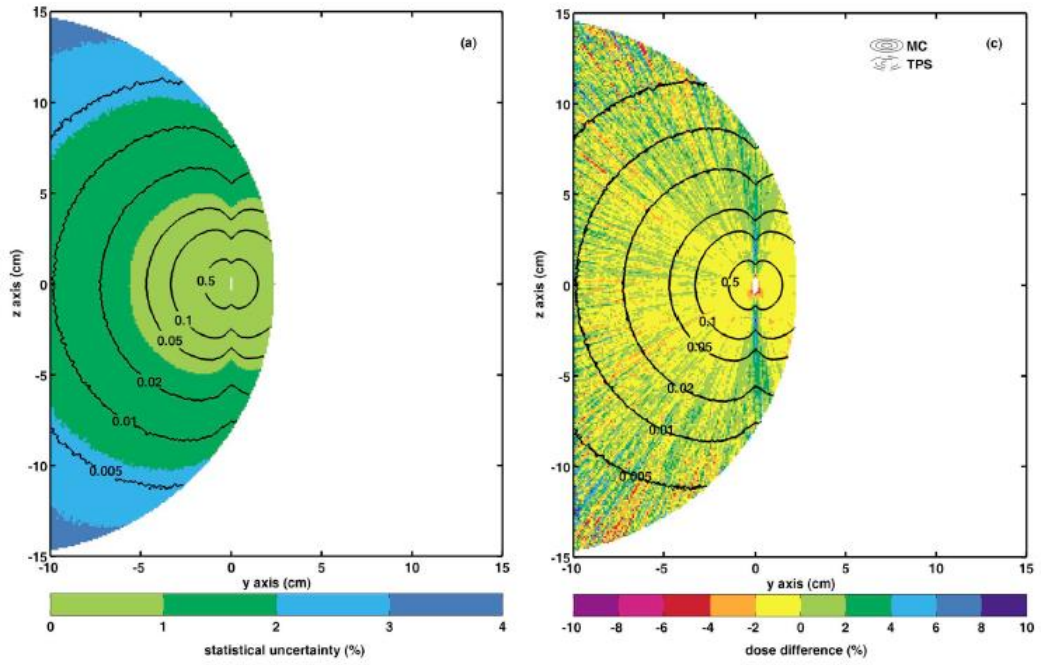
MBDCAs commissioning level 1

Single source in water: MCNPX vs Brachivision

Zourari et al 2010

MCNPX Dose distribution

Dose differences (MCNPX – BV) %



VS2000 Ir-192 at 12.5 cm from the center of a 15 cm radius sphere

Evaluation of scatter conditions

Overall agreement between MC and TPS within statistical uncertainties

MBDCAs commissioning level 1

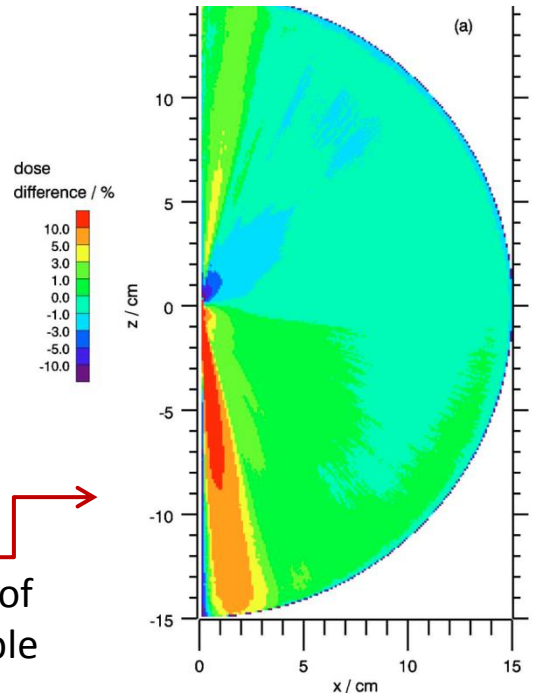
Single source in water:

Mikell & Mourtada 2010

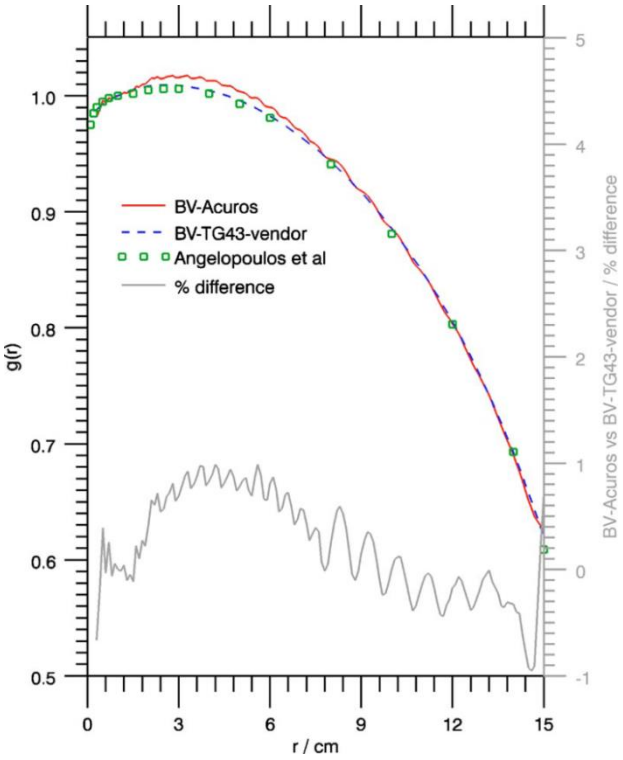
BRACHYVISION-ACUROS against MCNPX

MC (150 mm cable) – BV (1 mm cable)

%



Influence of source cable

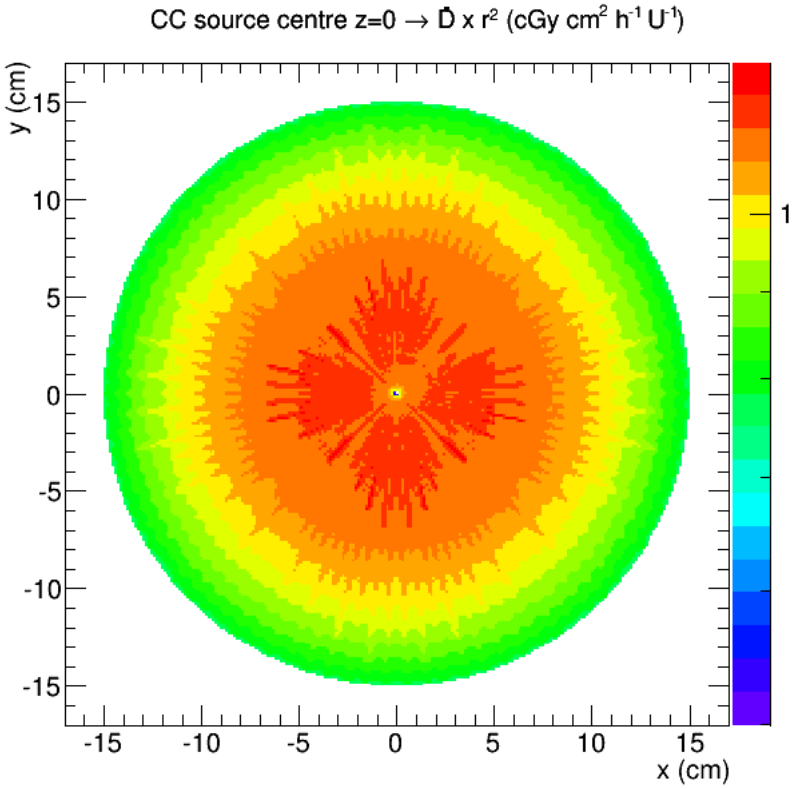


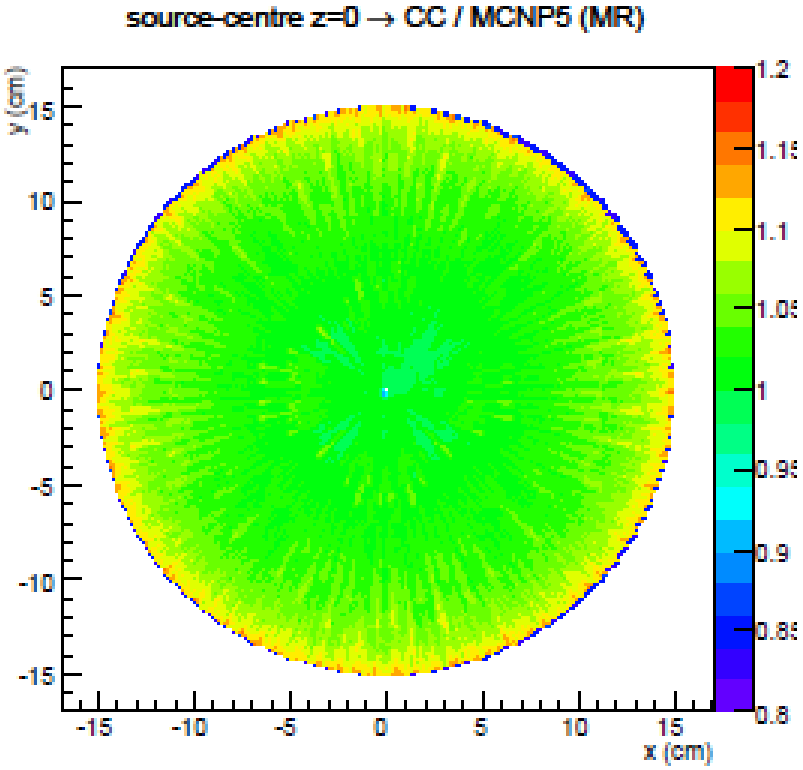
Differences should not have impact on clinical dosimetry in water

MBDCAs commissioning level 1

DICOM sphere water tests: source centre

CCC *vs*. MCNP5



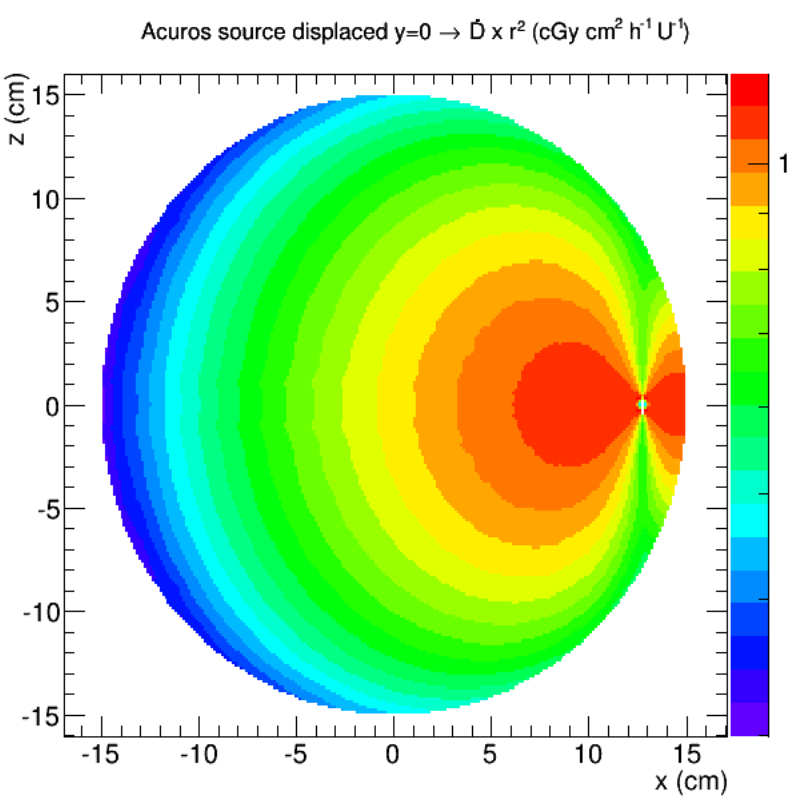


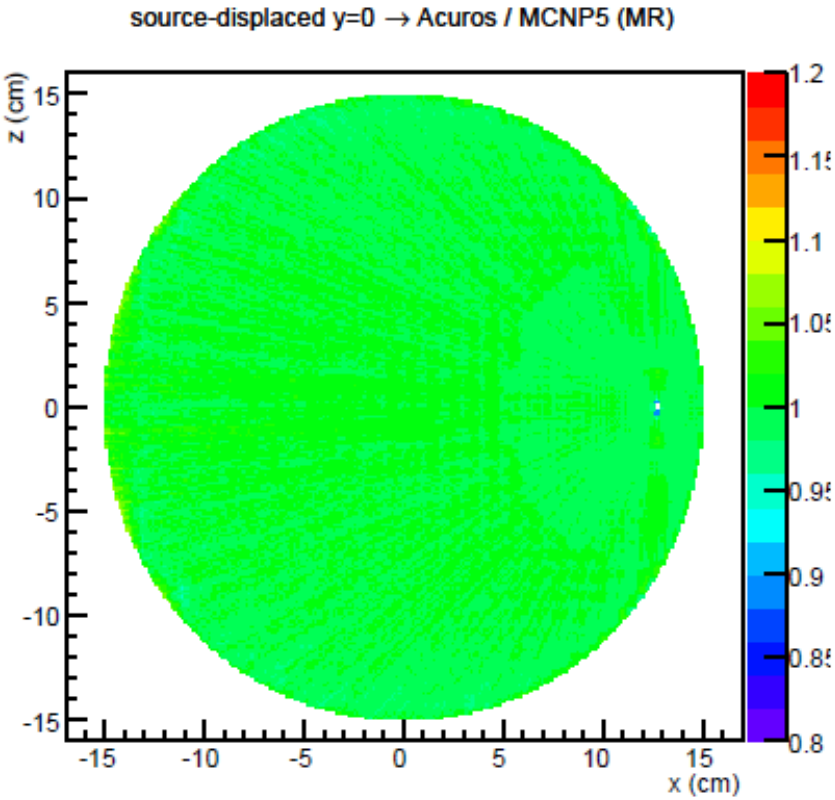
See **WE-C-141-1** Wednesday 10:30AM - 12:30PM Room: 141

MBDCAs commissioning level 1

DICOM sphere water tests: source displaced

Brachyvision *vs*. MCNP5





See **WE-C-141-1** Wednesday 10:30AM - 12:30PM Room: 141

MBDCAs commissioning level 2

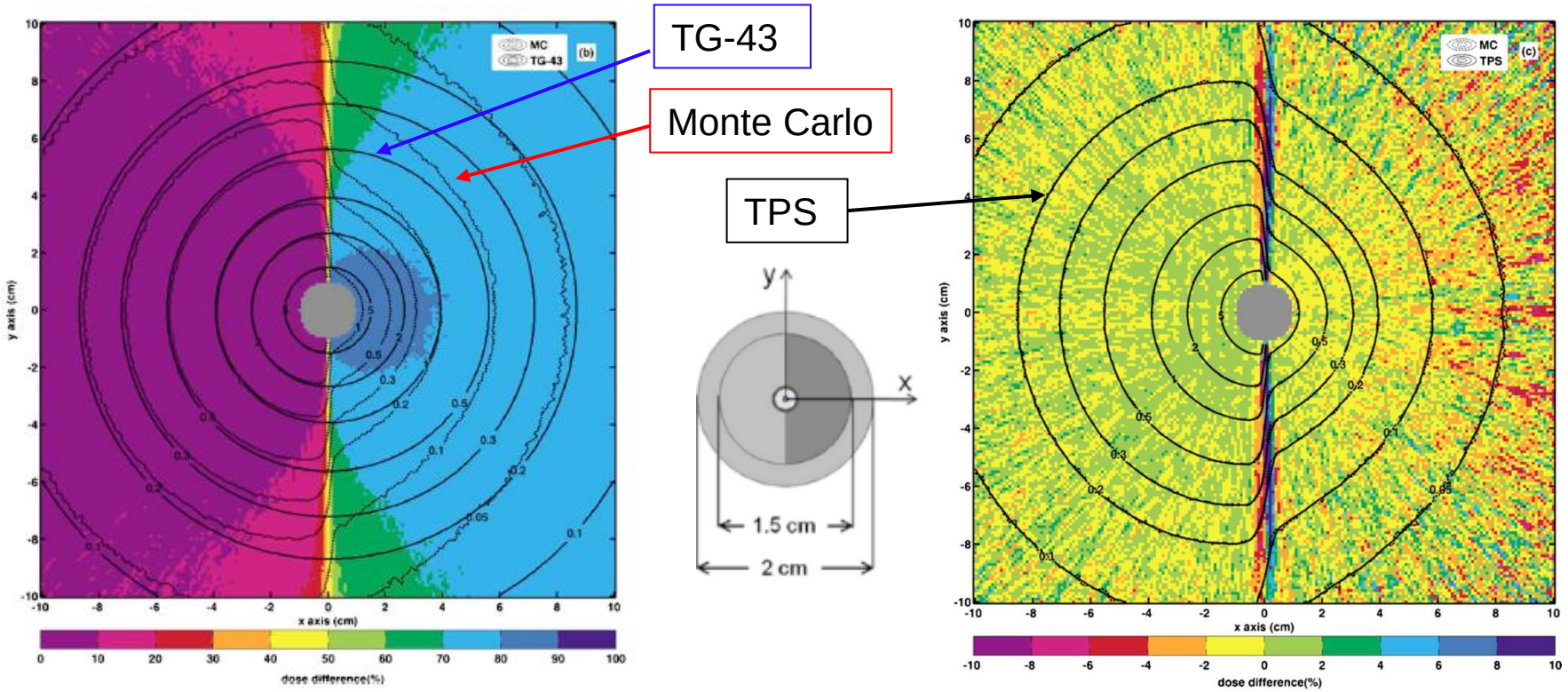
7 dwell positions plan in shielded applicator:

Zourari et al 2010

BV-ACUROS against MCNPX

MCNPX – TG43 (%)

MCNPX – BV (%)



BV-Accuros comparable to MC accounting for shielding

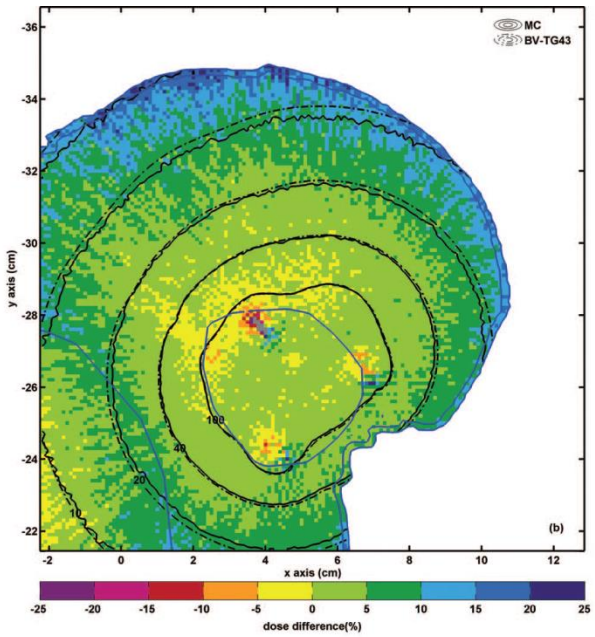
MBDCAs commissioning level 2

Breast patient computational model:

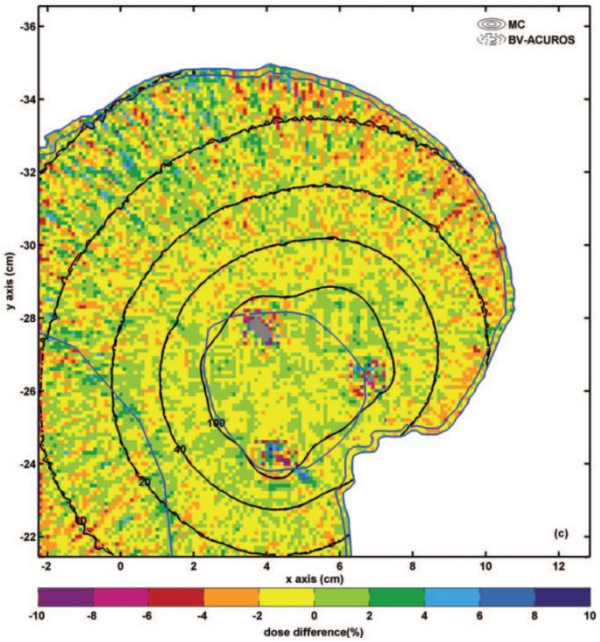
Zourari et al 2012

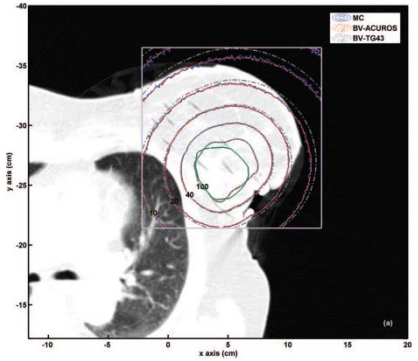
BV-ACUROS against MCNPX

TPS TG43 - MC (%)



TPS - MC (%)





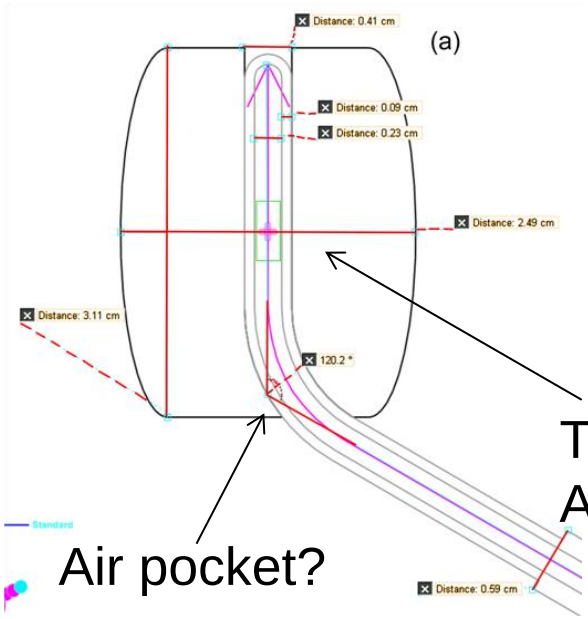
BV-Accuros comparable to MC patient dosimeetry accuracy

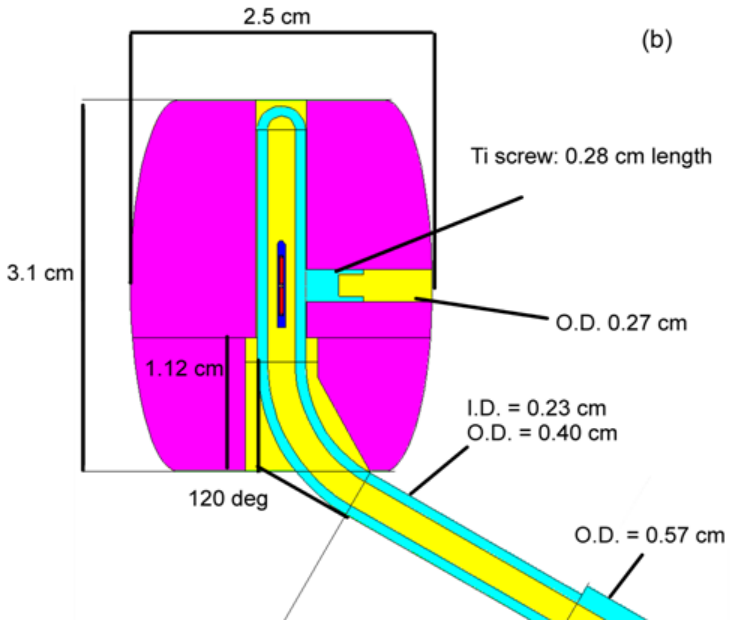
Courtesy F. Mourtada

MBDCAs commissioning level 1

Applicator Geometry & Composition Verification

Mikell et al. Brachytherapy 2013





BV TPS Applicator Library - Solid Model

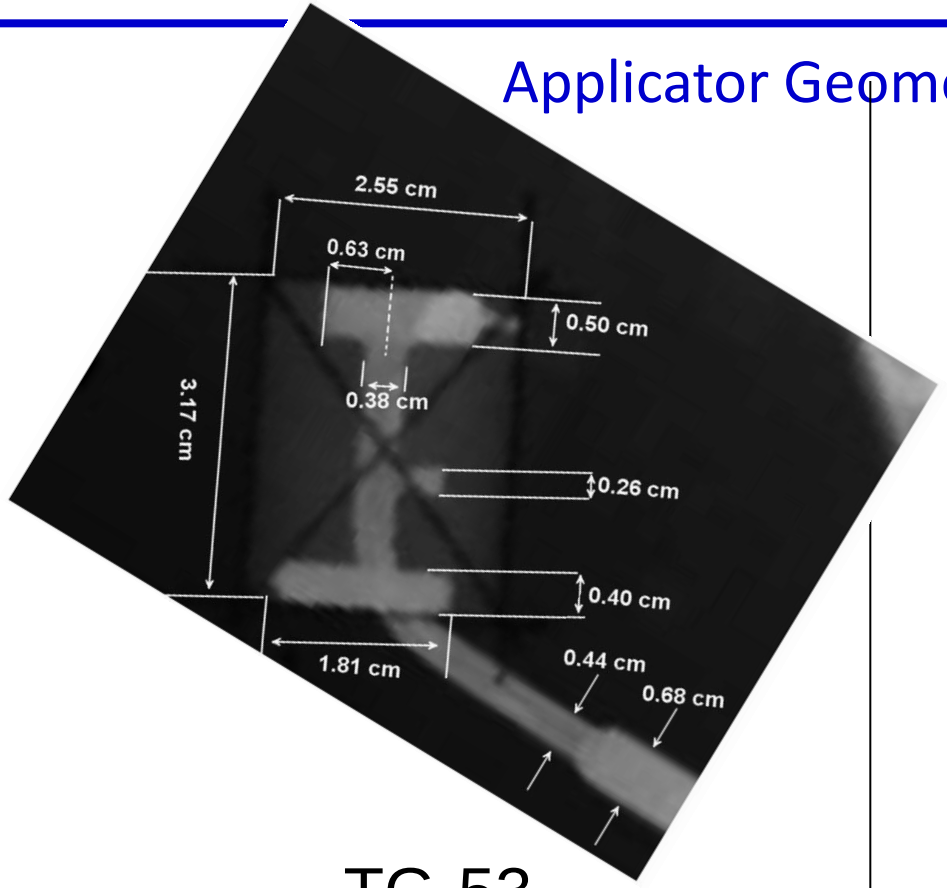
In house MC model derived from physical verification and vendor CAD

Courtesy F. Mourtada

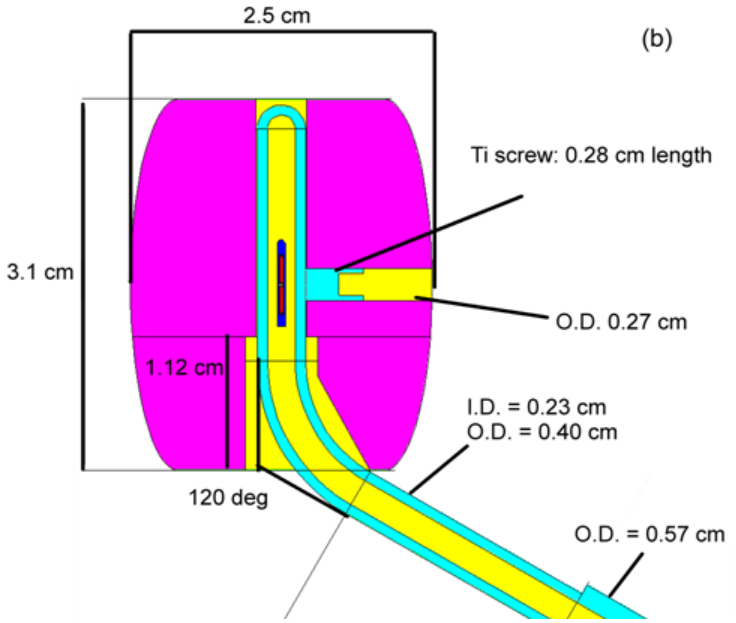
MBDCAs commissioning level 1

Applicator Geometry & Composition Verification

Mikell et al. Brachytherapy 2013



TG-53

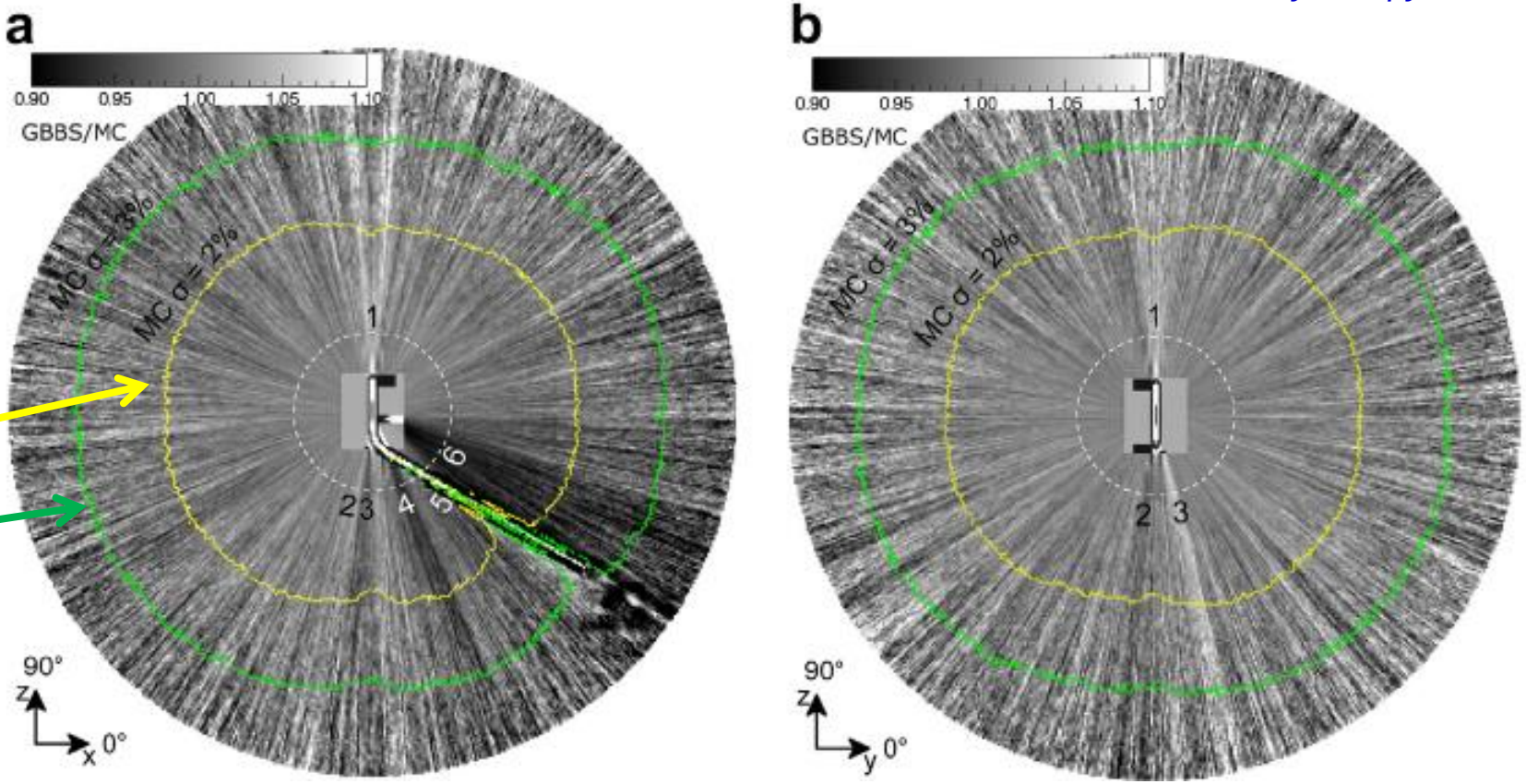


In house MC model derived from physical verification and vendor CAD

MBDCAs commissioning level 2

Dosimetry comparison: GBBS / MCNP5

Mikell et al. Brachytherapy 2013



MC error

2%

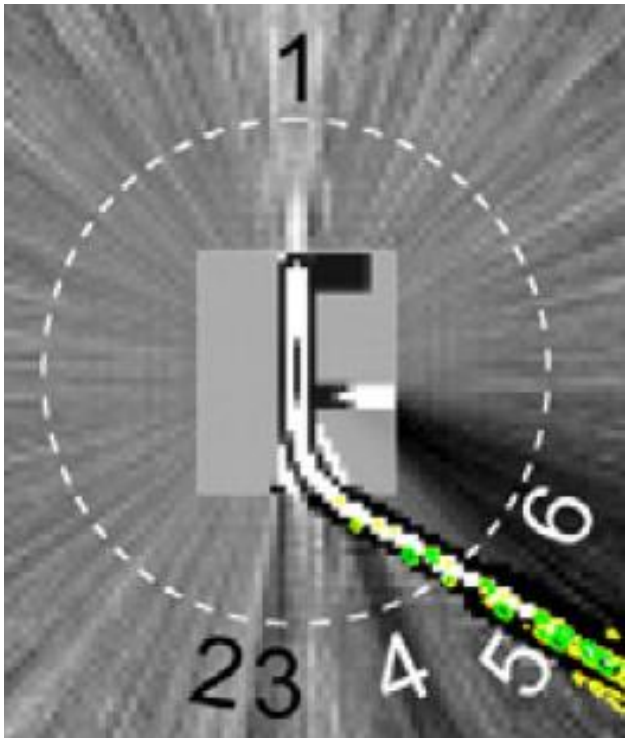
3%

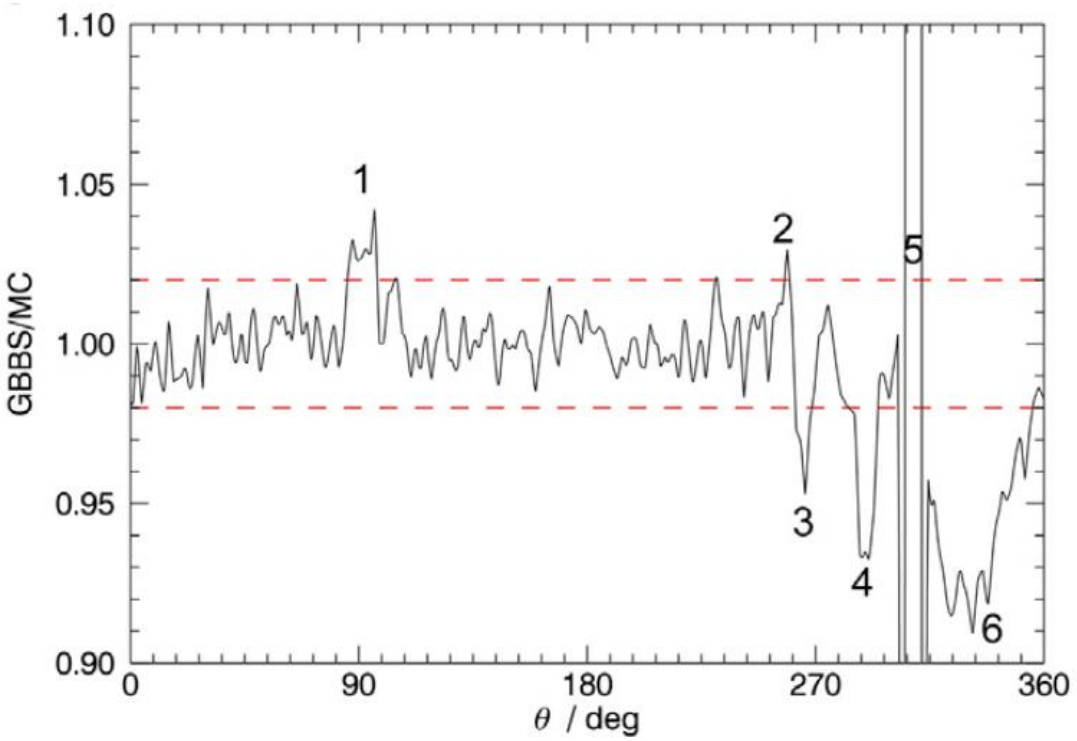
MBDCAs commissioning level 2

Dosimetry comparison: GBBS / MC

Mikell et al. Brachytherapy 2013

At 2 cm from colpostat





Conclusions

- MBDCA-based TPS implies the following assupmtions:
  - Radioactive sources are sufficiently modelled
  - Applicator models in TPS libraries are correctly implemented
  - CT and MRI are properly converted to materia/densities
  - Radiation transport algorithm sufficiently approximates a solution to the GBBS
- MBDCA-based TPS commissionig should validate them

Acknowledgements

MBDCA WG members

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