Developing a Treatment Planning System for Next Generation Rotating-Shield Brachytherapy

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Disclosures

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Funding Overview

- Mechanism/Study Section
  - PAR-13-137: Bioengineering Research Grants (BRG) (R01)
  - Radiation Therapeutics and Biology Study Section
- Grant Title: Developing a Treatment Planning System for Next Generation Rotating-Shield Brachytherapy
- PI, Co-investigator Team
  - Xiaodong Wu (PI) – ECE and Radiation Oncology
  - Weiyu Xu (co-I) – ECE
  - Yusung Kim (co-I) – Radiation Oncology
  - Ryan Flynn (co-I) – Radiation Oncology
  - John Buatti (co-I) – Radiation Oncology
  - Mark Smith (co-I) – Radiaiton Oncology

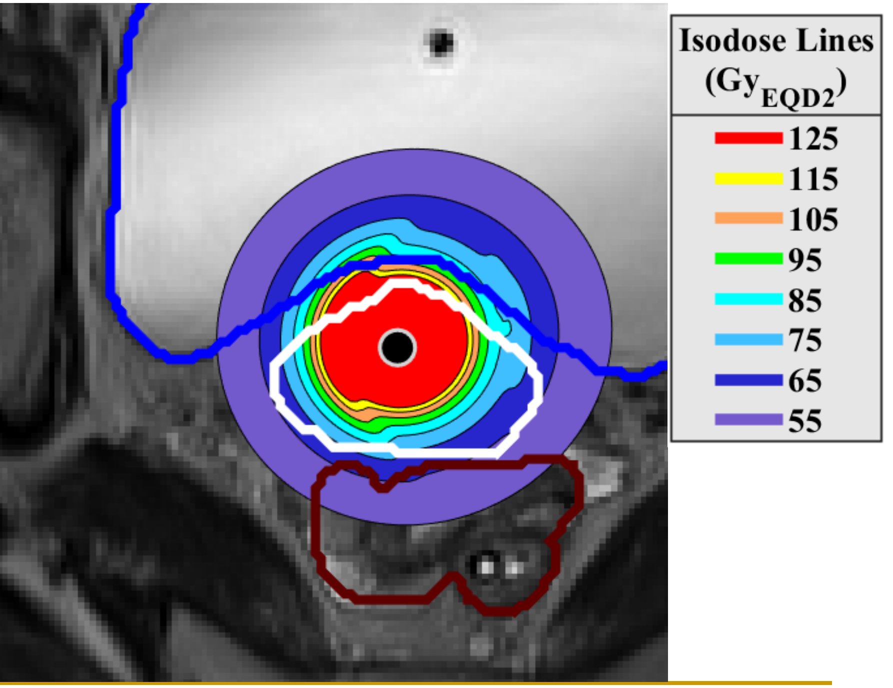
Funding Overview

- Submission History
  - First submission (funded)
    - Impact score: 35
    - Percentile: 16.0
    - New investigator eligible: Yes
    - Payline: 12
    - Payline for the new investigator: 17
  - Did resubmission

Clinical Motivation/Significance

- What clinical problem are you solving?
  - Introduce/Implement the intensity modulation technique with High-Dose-Rate (HDR) brachytherapy
- Why is it important?
  - HDR can only generate symmetric dose distributions
  - Overdose OARs
  - Lowerdose laterally-extended tumors

Create asymmetric dose distributions!



Relevant Prior Experience/ Preliminary Data

- List if anything made you uniquely qualified to lead this work
  - Trained on computer algorithms and optimization
  - Worked on IMRT treatment planning optimization since graduate study
  - Worked on some fundamental algorithms for IMAT
- What preparation work did you do to be well positioned for funding?
  - A long research history on IMRT
  - Worked on RSBT treatment planning since 2010

Relevant Prior Experience/ Preliminary Data

- Describe key preliminary data used in your grant submission
  - Rotating a shielded source along the treatment path to deliver HDR BT can significantly improve the plan quality using appropriate plan optimization techniques.

Rapid emission angle selection for rotating-shield brachytherapy

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(Received 19 October 2012; revised 6 April
published 30 April 2013)

Purpose: The authors present a rapid emiss
ficient selection of the azimuthal shield angl
method produces a Pareto curve from which
balances the tradeoff between delivery time

Med. Phys. 40 (5),

Dynamic rotating-shield brachy

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(Received 1 July 2013; revised 7 October
published 7 November 2013)

Purpose: To present dynamic rotating shi
rate brachytherapy (HDR-BT) with electr
capable of changing emission angles durin

Med. Phys. 40 (12),

Paddle-based rotating-shield brachytherapy

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(Received 7 October 2014; revised 23 J
published 23 September 2015)

Med. Phys. 42 (1(

Asymmetric dose–volume optimization with smoothness control for rotating-shield brachytherapy

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(Received 17 February 2014; revised 22 August 2014; accepted for publication 25 September 2014;
published 17 October 2014)

Purpose: It is important to reduce fluence map complexity in rotating-shield brachytherapy (RSBT) inverse planning to improve delivery efficiency while maintaining plan quality. This study proposes an efficient and effective RSBT dose optimization method which enables to produce smooth fluence maps.

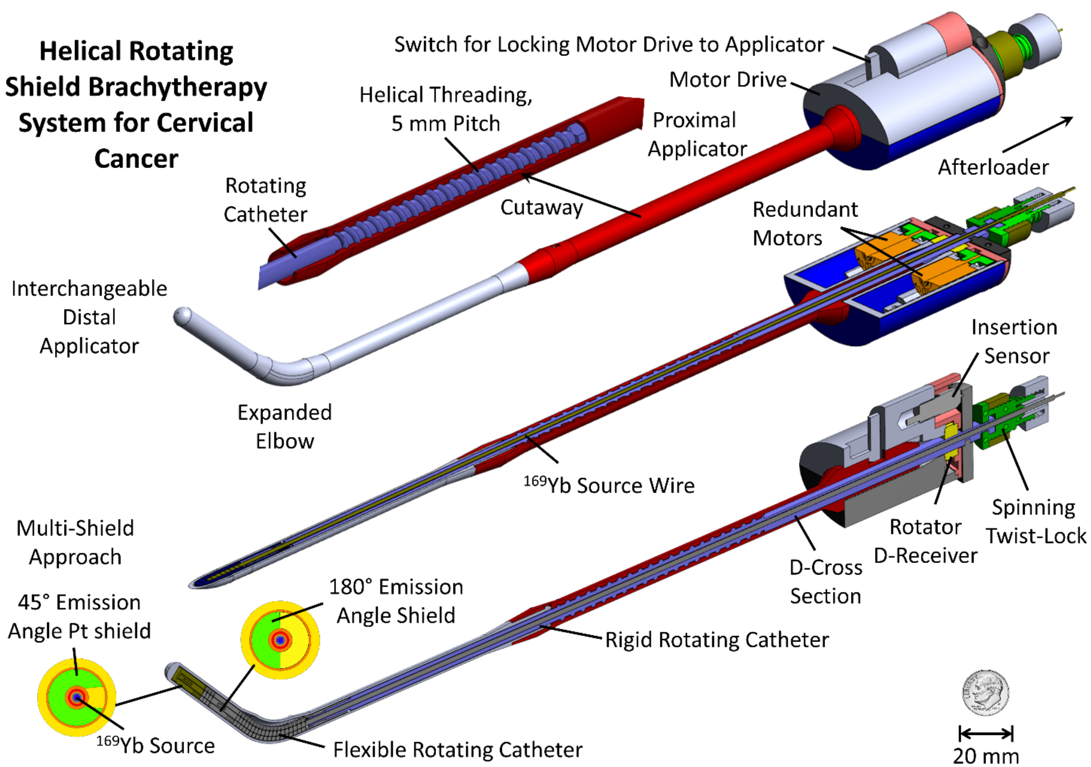
Med. Phys. 41 (11), November 2014

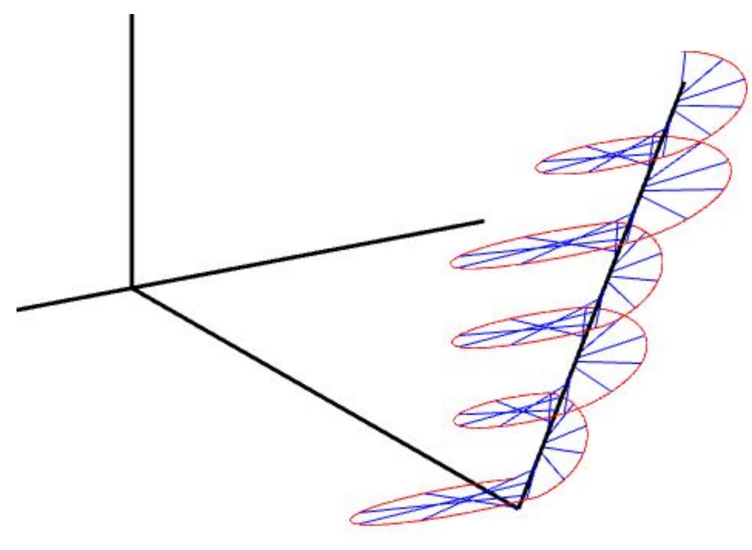
Specific Aims

- **Aim 1:** Develop an efficient compressed sensing based RSBT inverse dose optimization method, enabling sparse intensity modulation and optimized homogeneity of dose distributions with smooth fluence maps in the resulting treatment plan.
- **Aim 2:** Develop efficient shield sequencing methods to optimize the delivery of RSBT treatment plans, striving to achieve the best tradeoff between plan quality and treatment time, and to facilitate clinicians' decision making on selecting the best patient-specific treatment plan.
- **Aim 3:** Dosimetrically validate the RSBT treatment planning system retrospectively with clinical cases of cervical and prostate cancers previously treated with HDR-BT.

Preliminary or Key Scientific Outcomes

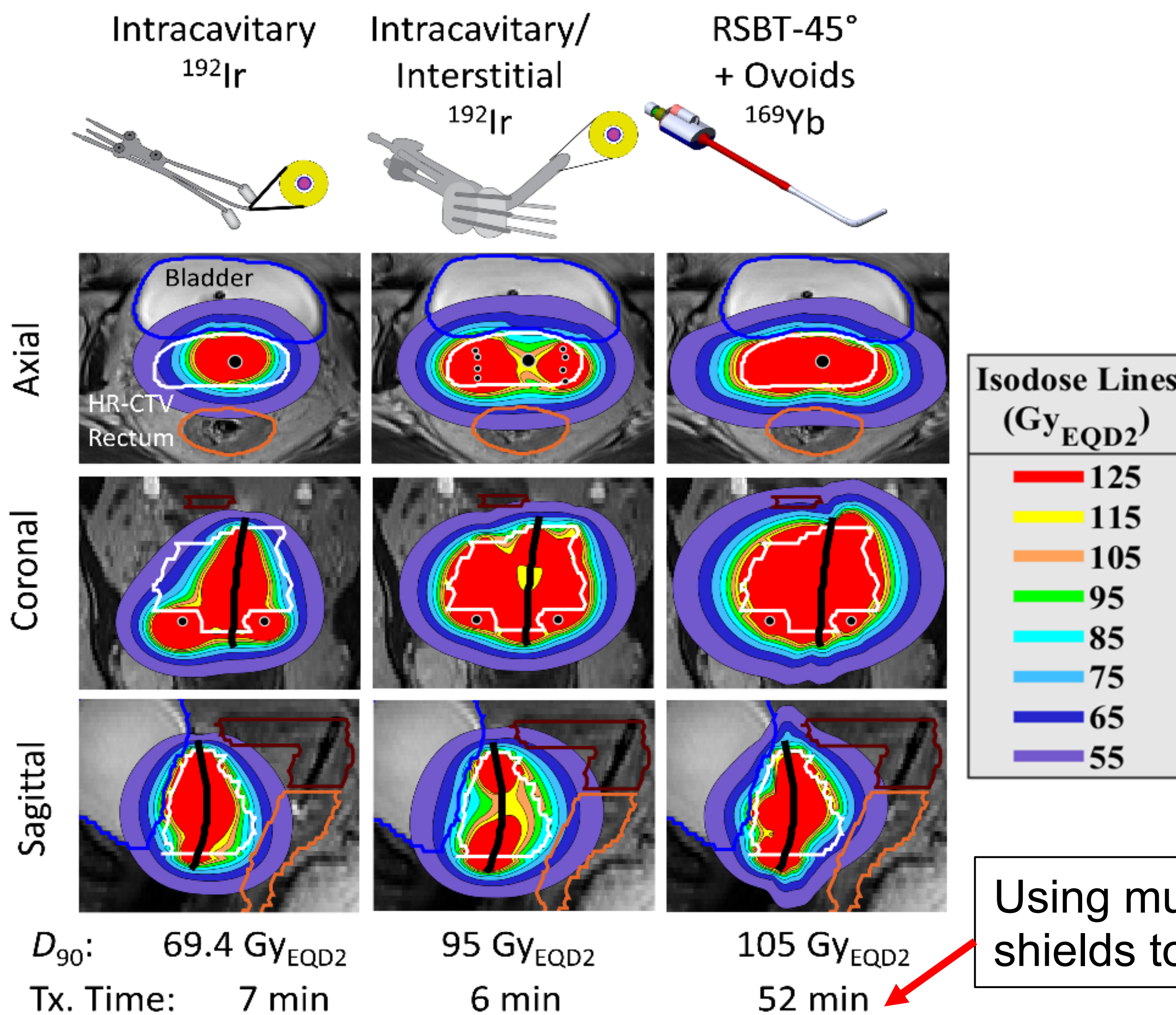
- Publications: 5 Med. Phys. + 3 Red Journal
- Needle-free cervical cancer RSBT applicator design





Preliminary or Key Scientific Outcomes

- RSBT can provide superior dose distributions to IC/IS



Using multiple shields to improve

Preliminary or Key Scientific Outcomes

- Cervical cancer RSBT
  - ^{169}Yb-based RSBT provided a greater percentage of the 37 patients considered with HR-CTV D_{90}-values of 85 Gy_{EQD2} than IC/IS
  - ^{169}Yb-based RSBT median treatment times were 1/3 those of IC/IS
    - Source age accounted for
    - Needle placement and planning time accounted for
  - The multi-shield approach is the key to ensuring rapid treatment times

Preliminary or Key Scientific Outcomes

- Prostate cancer RSBT
  - Major dosimetric advantage relative to conventional HDR-BT
    - 30.8% boosting on average (n = 26) for dose escalation
    - 23.9% urethral sparing on average (n = 26) for boost therapy
  - Uses an FDA-approved ^{169}Yb radiation source and afterloader
  - Delivery times reasonable with fresh sources – under 50 minutes for monotherapy, under 30 minutes for boost therapy

Future Research Directions

- Optimize to use multiple shield openings to minimize treatment time.
- RSBT treatment planning while considering delivery uncertainty
- AI for RSBT treatment planning
- Implement a prototype for cervical cancer RSBT

Grant Advice for AAPM Members

- My suggestions focus more on translational research – improving outcome of a specific patient group for a specific treatment modality.
- Clinical relevance of the project is critical.
- Strive to apply fundamental engineering solutions to a clinical problem for project innovation.
- Put less weights on conceptual novelty and "advancing a field"
- Research plan is built on preliminary data with thoughtful experimental design
- It's easy to ignore to include an expertise of statistics in research team.

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- Yusung Kim, Ph.D.
- Ryan Flynn, Ph.D.
- John Buatti, M.D.
- Mark Smith, M.D.

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- Yulong Liu (ECE)
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- Anh Le, Ph.D. (ECE)
- Quentin Adams, M.D. (Rad Onc)
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Thank You!

Questions?