Open Source Medical Devices: Lessons Learned From a Complex Collaborative Research Project

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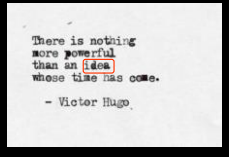
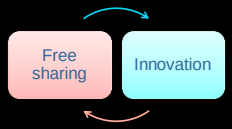


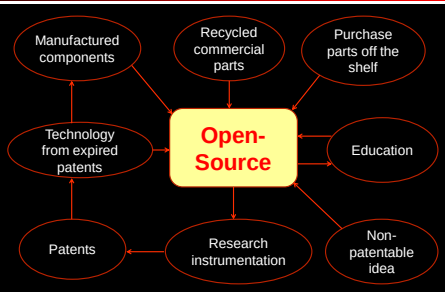
Open-Source Medical Devices (OSMD)

Motivation for OSMD

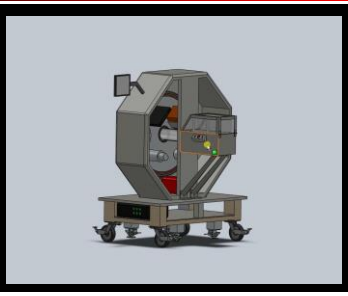
- Forum for free sharing and development of ideas and resources
  - To complete medical devices design that have been left out
  - Involve good ideas from small labs with less resources
  - Networking to provide matching expertise
- Make affordable medical devices for research
  - Goal within 1/3rd- 1/4th cost of commercial systems
  - Only cost is for the physical parts



Significance of OSMD



First OSMD Project



OSMD Conference

- Identify interested researchers and collaborate
- Determine design specifications for integrated micro-CT/PET/RT system
- Collective scientific fun brainstorming

https://morgridge.org/open-source-medical-devices/video-archive/

Sub-Systems

Support systems
- Gantry design/bearing
- Gantry motor
- Slip-ring system
- Animal support and positioning system
- Measure animal vitals
- Radiation shielding
- Outer build support structure
- Power supply
- Laser alignment system
- Live-view camera system
- Computing hardware and electronics

mRT
- X-ray tube and generator
- Detector system
- Beam collimation

mCT
- CT detector system
- X-ray source: same or separate from RT
- CT electronics

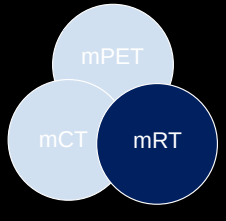
mPET
- Design support and geometry
- PET detector
- PMT electronics

Software
- Dose verification and monitoring
- Treatment planning system
- PET and CT image reconstruction
- Image analysis
- Image co-registration

Management
- QA
- Database management
- Electronic recording
- Scheduling
- Fail-safety
- Record and verify
- PACS

mRT to Initiate OSMD

- Need to kick-off OSMD by giving out our ideas and technology first
- This project is big and multi-faceted
- Chose to develop a portion of mRT system that can deliver IMRT in preclinical settings
- Make it available via OSMD

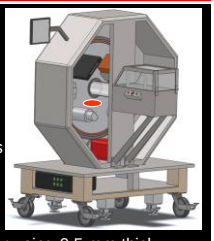


Innovation: mRT with IMRT

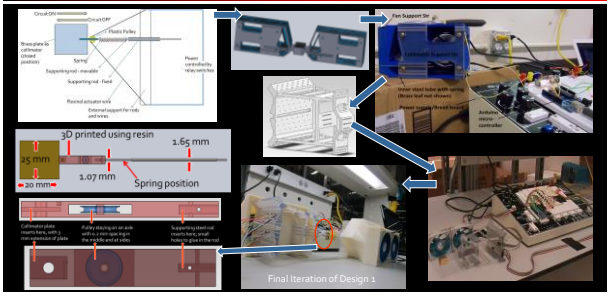
- Critical component 1: mechanical design of binary micro-MLC (bmMLC) for mRT and its dosimetry
- Critical component 2: kV treatment planning system for mRT (WiscPlankV) to enable IMRT dose delivery
  - Validation of WiscPlankV dose calculation using the bmMLC assembly
  - AAPM 2016 Poster: SU-F-T-667

Design of bmMLC

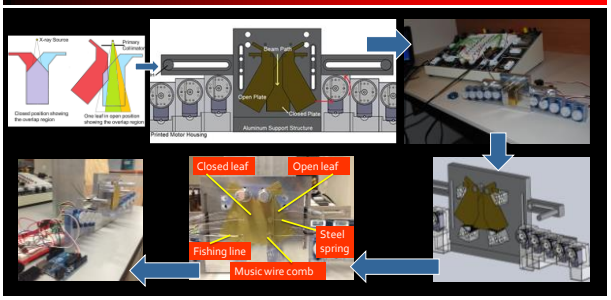
- Simple and concise design
- Smallest dynamic collimator designed for any RT system
- Using 3D printing to fabricate custom-build parts
- Using open-source micro-controller (Arduino)
- Designed to provide 1 mm resolution at isocenter using 0.5 mm thick interleaved brass plates, with leaf motion < 1 sec



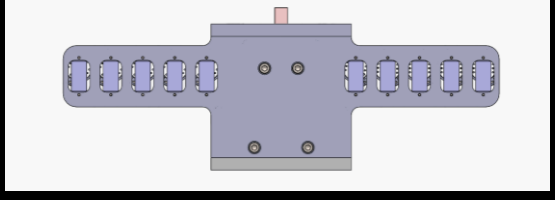
bmMLC Design 1: Iterations



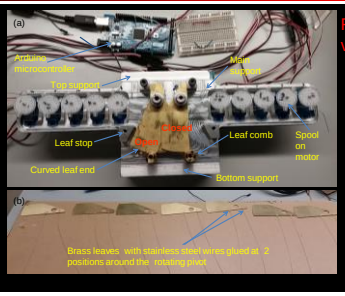
bmMLC Design 2: Iterations



Current bmMLC Design

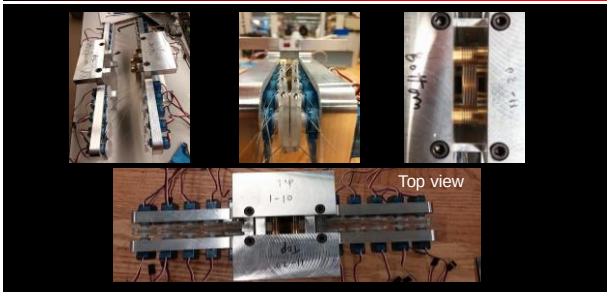


Current Design Prototype: One Side And Leaf Fabrication

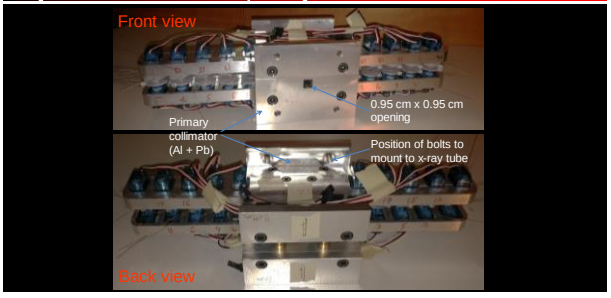


Front view

Current Design Prototype Assembling

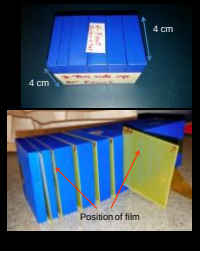


Current Design Prototype: Full Assembly (Material Cost < $500)

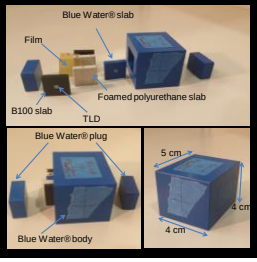


Phantom Design and Fabrication

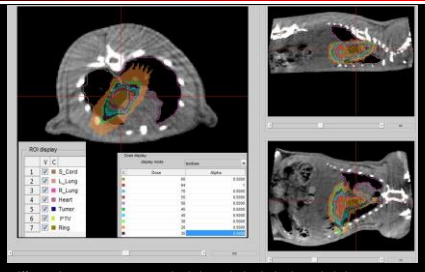
- Homogeneous stack phantom



- Heterogeneous stack phantom



WiscPlankV: Dose Distribution



Difference between measurement, simulation and WiscPlankV dose calculation < 5%

OSMD Impact

- OSMD was featured in the Economist (2012)
  - http://www.economist.com/node/21556098

- Several medical device engineers contacted us with questions on how to open-source their ideas
- There has been a lot of interest shown by medical physics community
- We have openly shared our idea
- WiscPlan TPS has been used by several researchers as we have shared with it freely

Our OSMD Challenges

- We started a very ambitious project
- Interest by several outside researchers but their interest would come into play in later part in the project
  - I had no experience to manage interests for future project
  - We received no outside interest for hardware project
- Hardware design collaboration is still challenging
- Proposal for inter-university collaboration turned into mostly a inter-department collaborations
  - Got help from different research groups at UW-Madison
  - A lot of colleagues (who are not in the project) shared ideas for mRT project

General OSMD Challenges

- A lot of work, not easy to begin
- Driven by passion not interest from institute, need a critical mass
- Not transparent information from vendors
- Funding
- Potential regulatory obstacle for clinical developments

Conclusions

- OSMD initiative was a good start and a great learning experience
- A part of an OSMD project on mRT was completed
  - bmMLC Design was demonstrated
  - Both bmMLC and WiscPlankV are available via the OSMD website: https://morgridge.org/open-source-medical-devices/
- We hope that our effort to open-source our ideas and technology will kick-off the OSMD and involve many research groups in the future
- We need a consortium organization or AAPM tasks group (critical mass) with a web platform to share ideas and collaborate

Thank you!

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