Linear accelerator simulations for stable and sustainable operation of developing country radiotherapy linear accelerators

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Linac operability is an important consideration in any environment

- Training on linac service personnel is difficult at BC Cancer
- Communication between Medical Physicists and Linac Service technicians is challenging everywhere
- We suggest that this is a critical component of any linac operation plan, especially for challenging environments

Linac Physics is Complicated

- Electron beam acceleration in waveguide is advanced physics.
- There is a convoluted relationship between the basic physics and clinical beam properties.

Teaching Linac Physics

- Should relate basic physical principles to clinical parameters.
- Needs a hands on component.
- Jargon issues between service engineers and physicists.
- Few teaching resources aimed at the radiotherapy physicist

MEDICAL ELECTRON ACCELERATORS

C.J. Karzmark
Craig S. Nunan
Eiji Tanabe

The Accelerated Education Program

Princess Margaret Cancer Centre

Upcoming Course

Accelerator Technology (ATec)

February 28 - March 3, 2017

Led By: Dr. Marco Carlone & Mr. Bern Norrlinger

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putting innovation to work

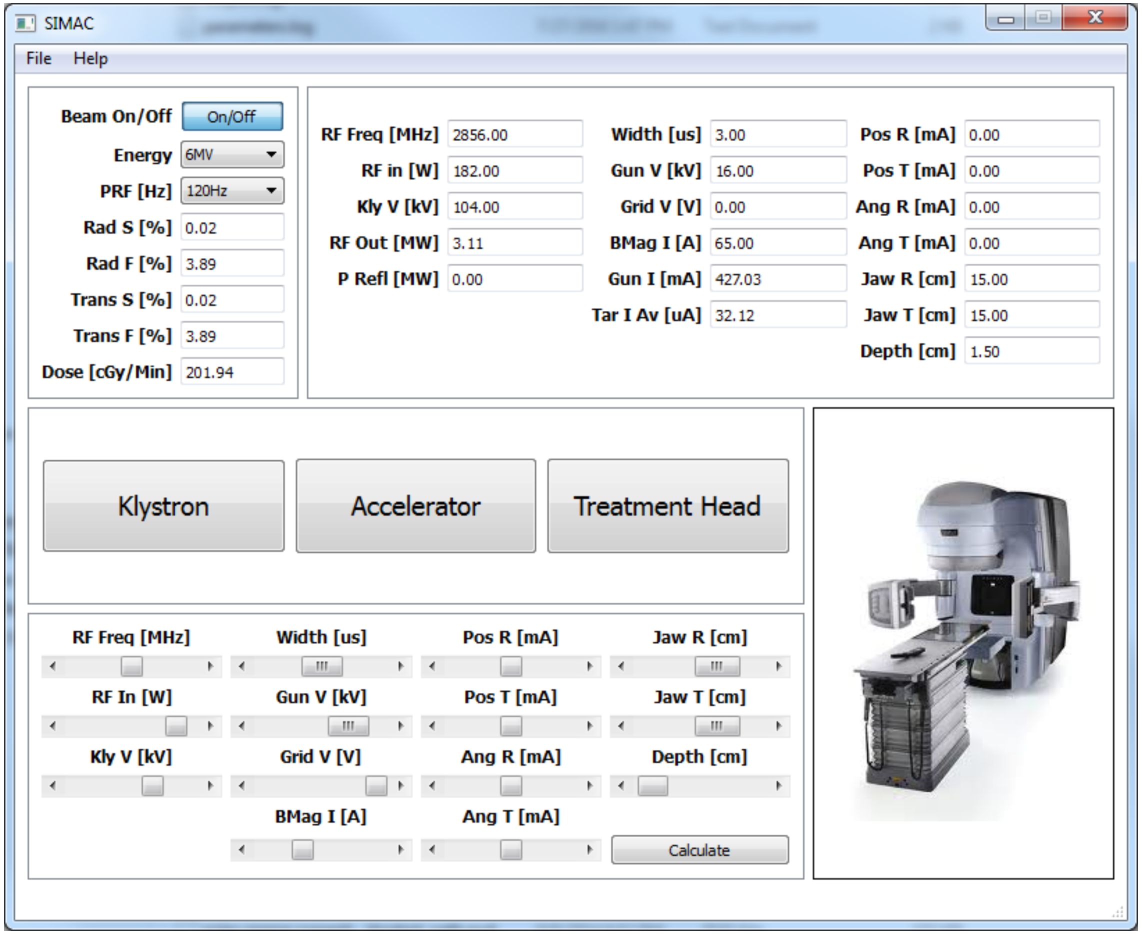
Radiation Oncology UNIVERSITY OF TORONTO

Challenges with the ATec Course

- 4 day length is too short for any in depth teaching.
- Relating linac theory to linac service/QA problems is difficult.
- Clinical linacs at PMH were not available.

SIMAC

Simulate Lin**ac**



- Most linac physics can be modeled using simple analytical approximations
- Response is consistent with a real linac response.
- Meant to simulate the service mode of a clinical linac

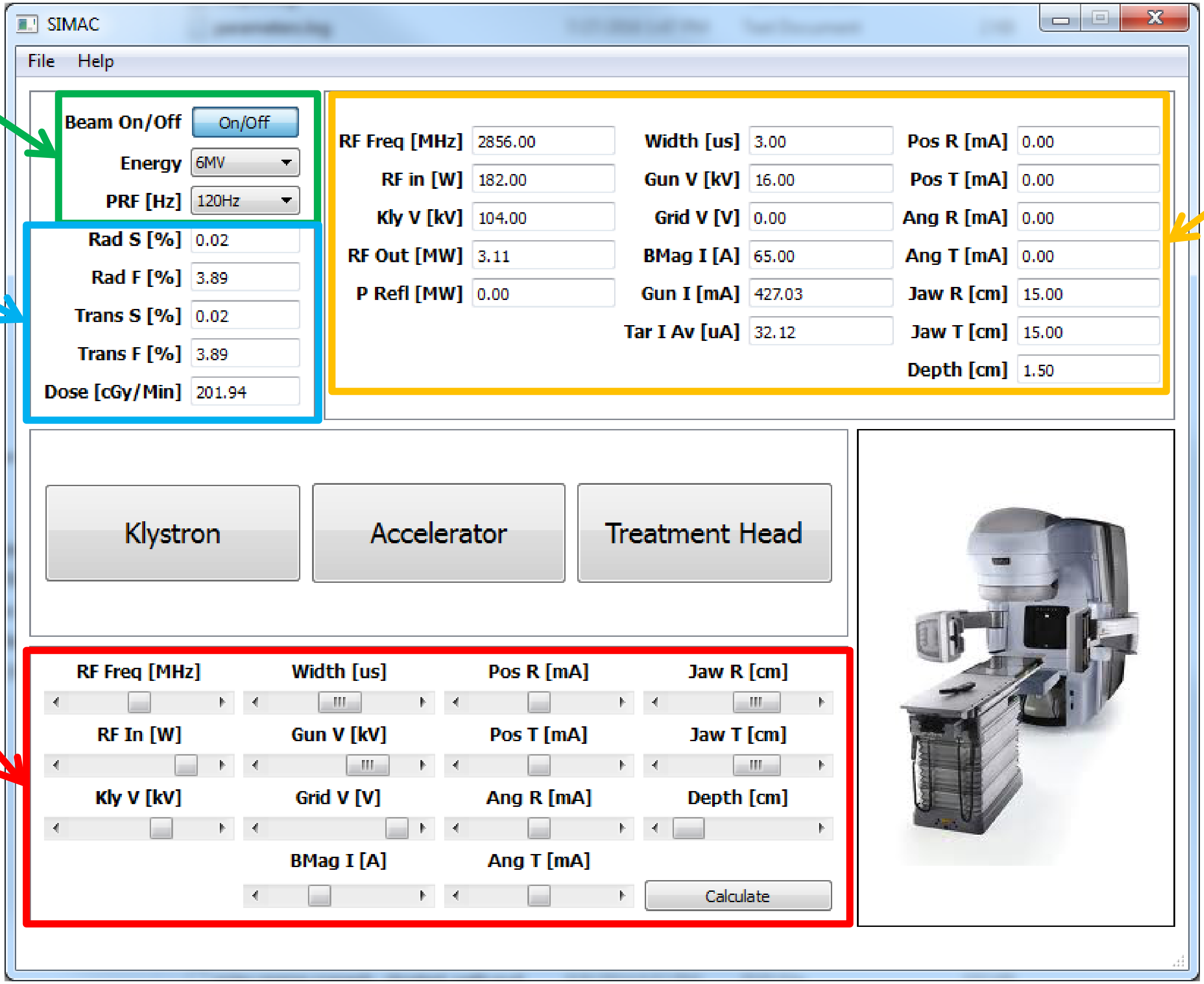
Using SIMAC

Mode selection

Clinical parameters

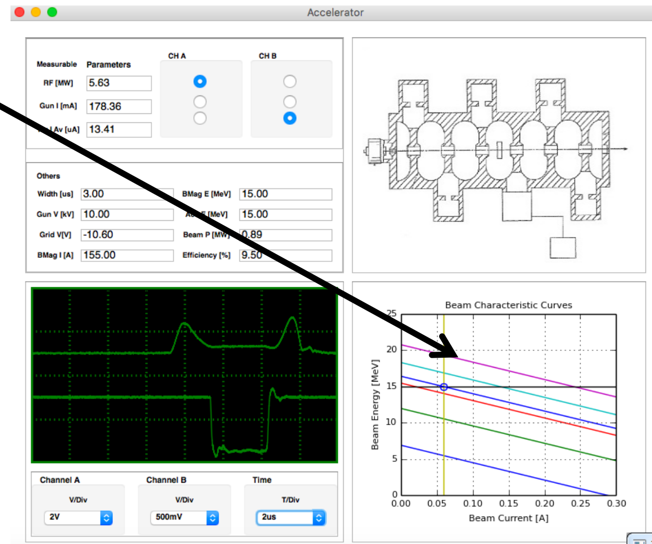
Linac parameter control

Linac operating values



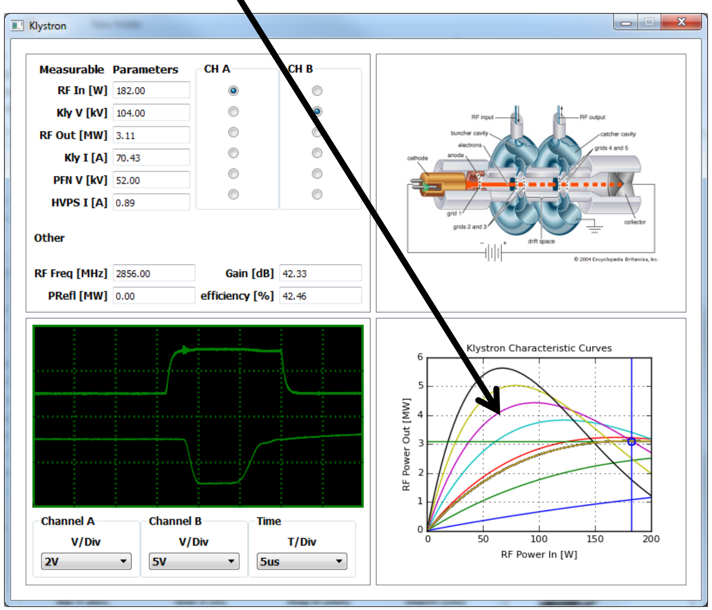
Linac Physics modules in SIMAC

The linac Load line is modelled using the concept of “Shunt Impedance”

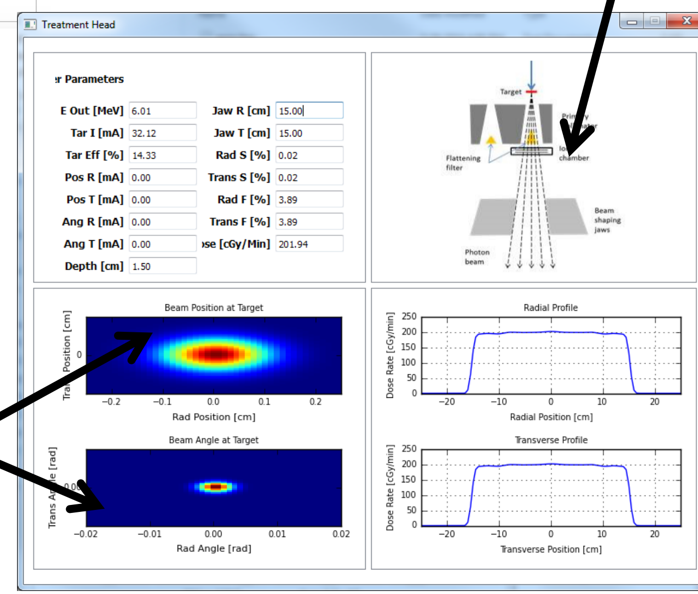


Photon transport is modelled using breamstallung yield tables (NIST) and linear attenuation in the FF and water phantom

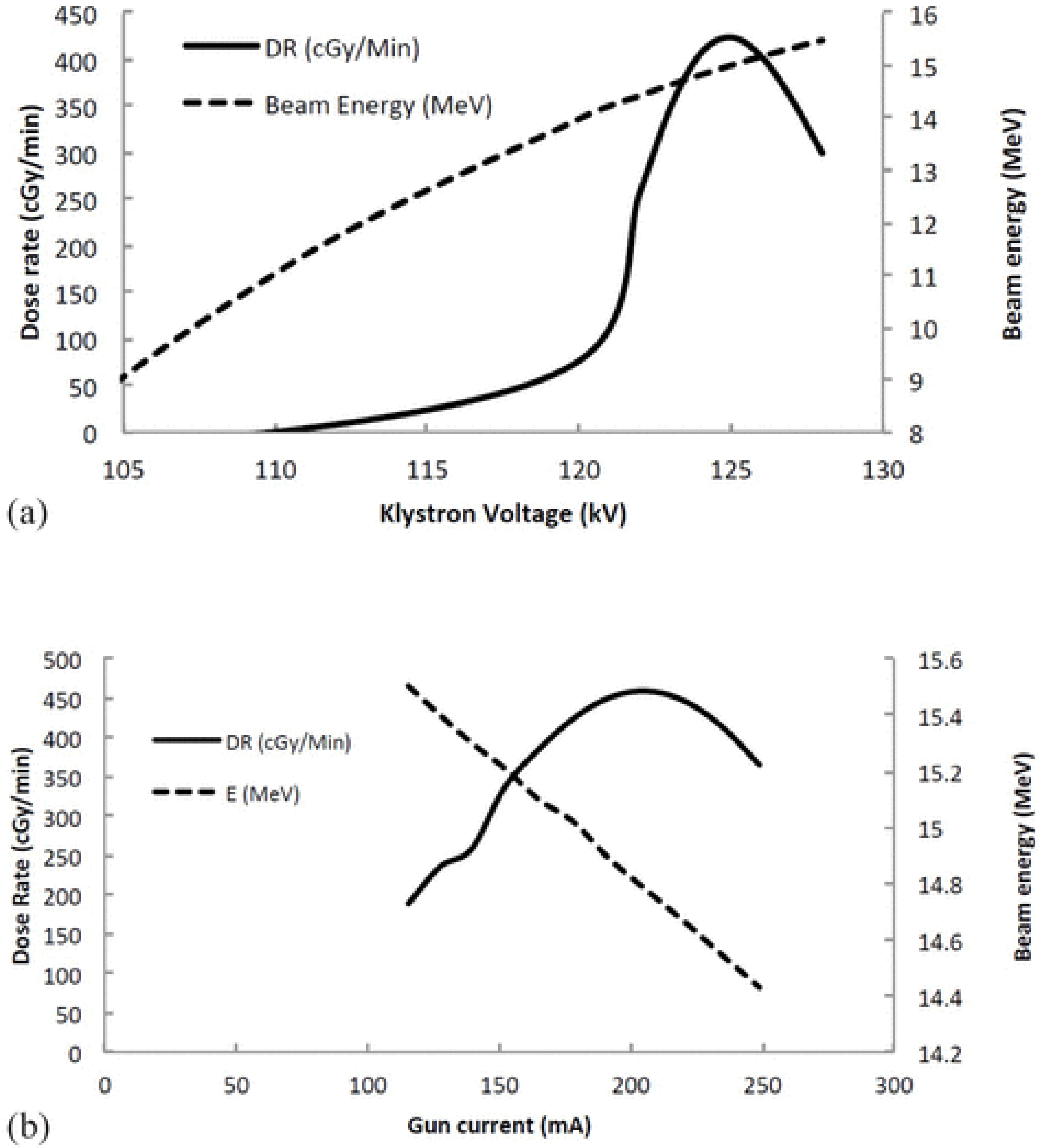
Klystron saturation is modelled using an analytical (Bessel) function



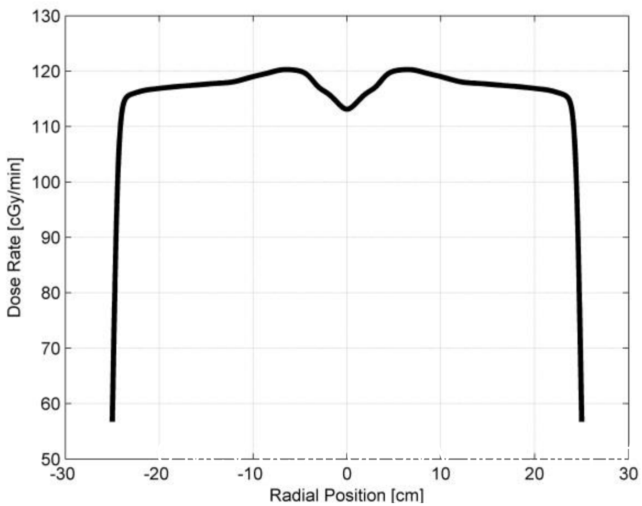
Electron beam position and angle on the target

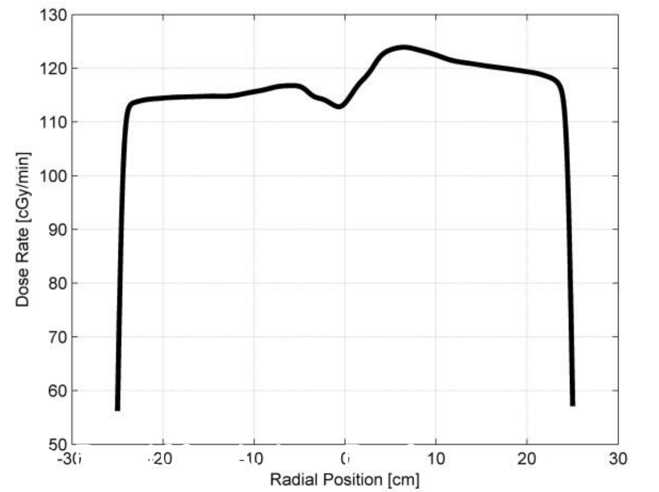


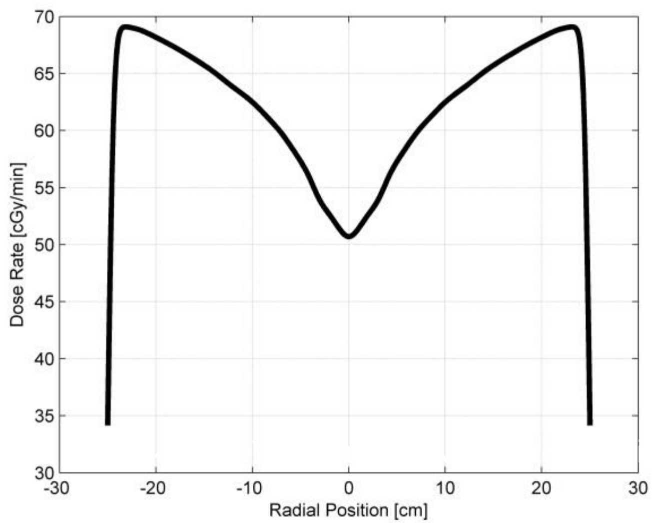
Teaching of beam “tuning” with SIMAC

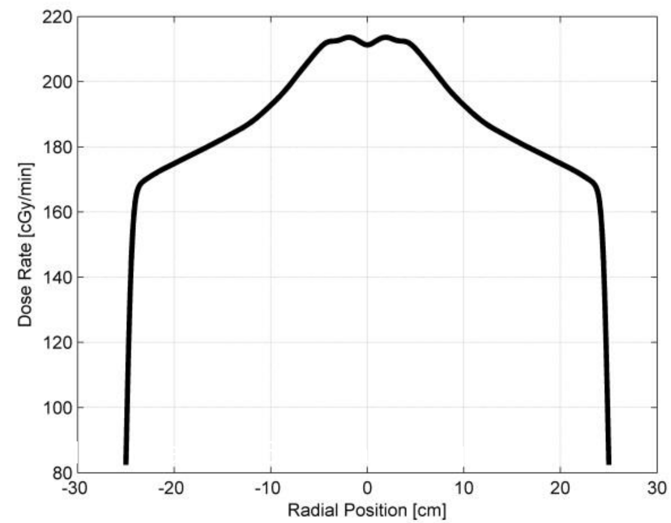


Using SIMAC to teach Flatness & Symmetry as a response to beam steering and energy

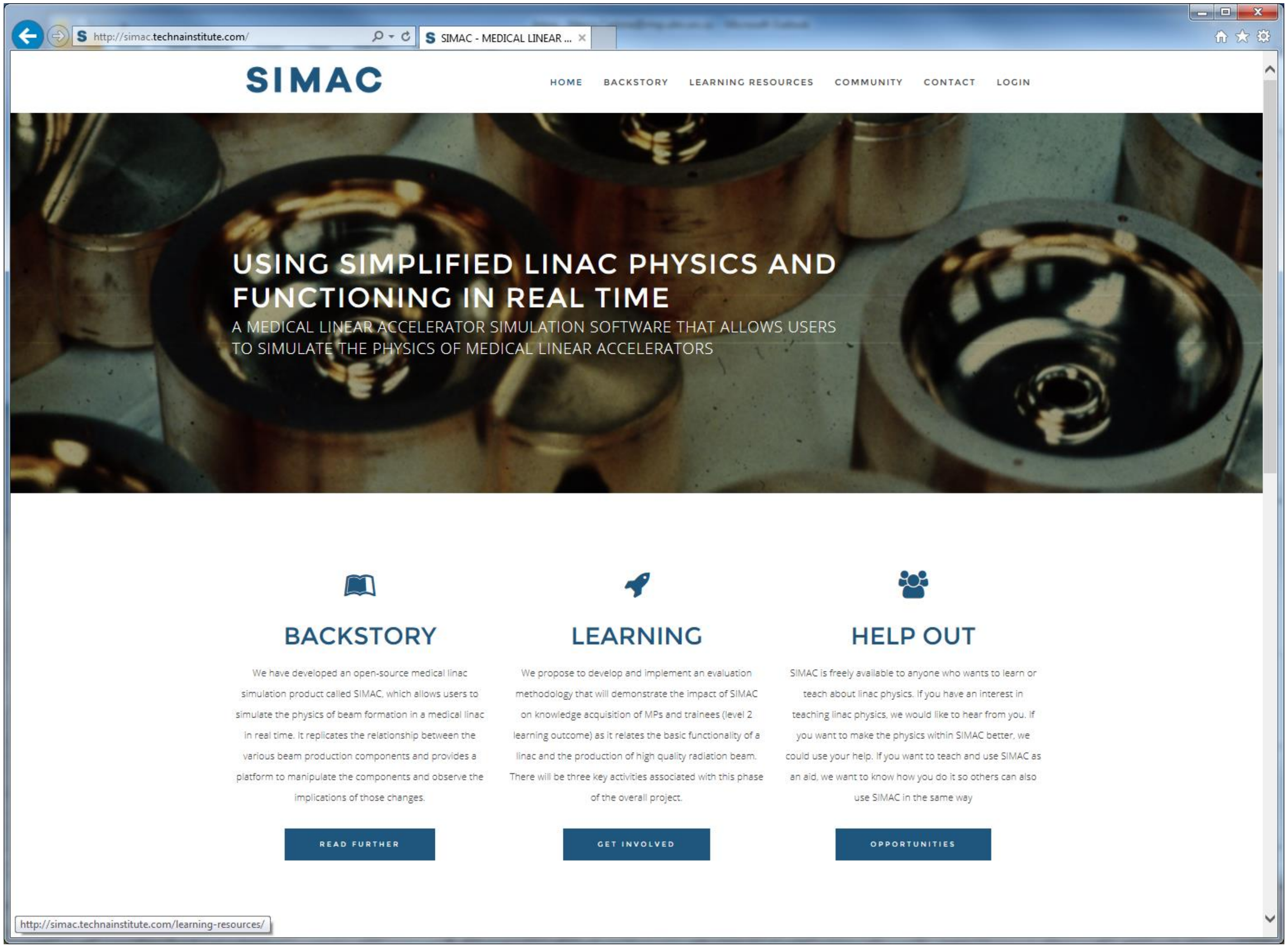








www.simaclinac.com



Simac is freely available

SIMAC

SIMAC BACKSTORY DOWNLOAD SIMAC LEARNING RESOURCES COMMUNITY CONTACT LOGIN

SIMAC BETA DOWNLOAD

SIMAC is going through many changes, as we're always working to make it a better learning tool.

SIMAC 0.3.4 was released Oct. 6th, 2016

DOWNLOAD THE 64 BIT BETA VERSION OF SIMAC FOR WINDOWS

DOWNLOAD

DOWNLOAD THE 32 BIT BETA VERSION OF SIMAC FOR WINDOWS

DOWNLOAD

DOWNLOAD THE BETA VERSION OF SIMAC FOR MAC

DOWNLOAD

Work Package 5

Address the operability of a medical linac

1. Address the knowledge issues around linac service by improving the SIMAC experience
   - (Have good linac drivers)
2. Provide automation tools to assist linac repairs by modeling include linac failures
   - (Provide a driver assist mode for already good drivers)

Work Package 5

- Deliverable 1: Help expand the online SIMAC community by making SIMAC fully web-based.
- Deliverable 2: Demonstrate the feasibility of a diagnostic data collection system.
- Deliverable 3: Report on potential algorithms to implement a machine learning model to interpret fault data.

Deliverable 1

- SIMAC is mature and has been used
- Assemble a complete set of linear accelerator physics modules
  - Building a comprehensive “flight simulator” for LINACS
  - Maintain code in GitHub repository to maximize community involvement

Deliverable 2

Install data loggers on existing linacs and demonstrate the feasibility of collecting this data

Deliverable 3

- Collection of data from existing machines
- Consultation on potential machine learning algorithms and implementations
- Demonstration of simple predictive model of known failures

Linac failure categories

- Modulator/injector failure
- Beam delivery error (steering)
- MLC malfunctions
- Power supply failures
- Control system failures
- Mechanical failures
- Broken wires
- Many others (some simple, sone not)

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- Modulator/injector failure
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- **MLC malfunctions**
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- Mechanical failures
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- Many other smaller categories

I would guess these are the majority

Linac failure categories

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- Many other smaller categories

These are the most intimidating, and most difficult to teach

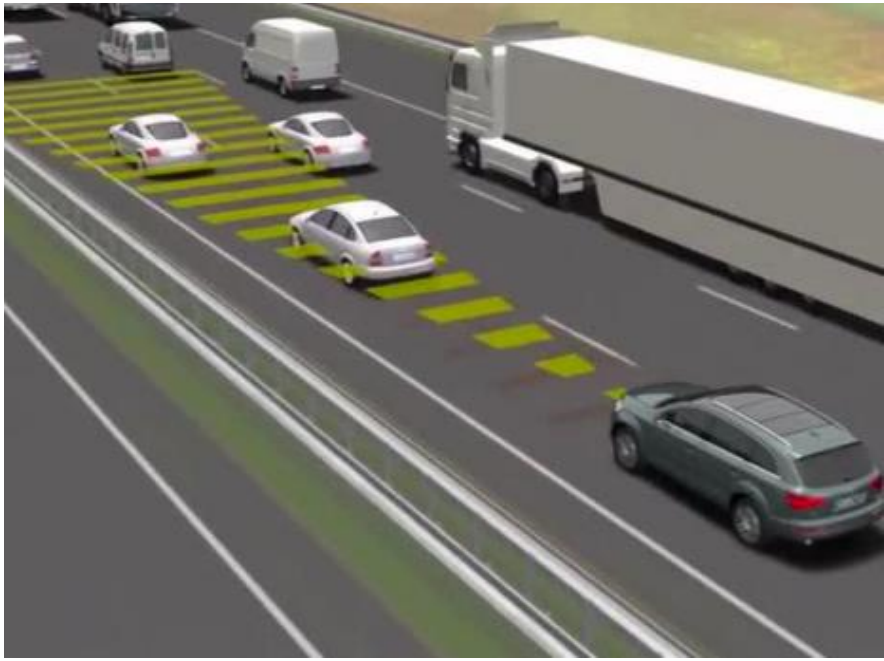
The Art of Linac Maintenance

There is a challenging learning curve

- Service technicians are not physicists
- Distinguishing between electronics/control system problems and linac physics problems can be challenging when learning

Objective with deliverable 3

- To assist service technicians with diagnosis problems involving linac physics.
- To reduce the “fear factor” of a large complicated machine.
- It is not intended to provide a comprehensive linac fault diagnosis repair automation



Deliverable 3 is more like driver assist as opposed to a driverless car.

Questions/comments?