

Accelerator modelling with BEAMnrc

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BEAM code

- general purpose code to simulate **radiotherapy beams**
 - accelerators -electrons & photons
 - ^{60}Co units
 - x-ray units
- originally part of the **OMEGA project** done in collaboration with **Rock Mackie's** group in Madison (1990-1996)
- **O**ttawa **M**adison **E**lectron **G**amma **A**lgorithm
- many grad students, RAs and TOs involved

BEAM developers

Dave Rogers

Blake Walters

Iwan Kawrakow

Charlie Ma

Bruce Faddegon

George Ding

Geoff Zhang

Jiansu Wei

Michel Proulx

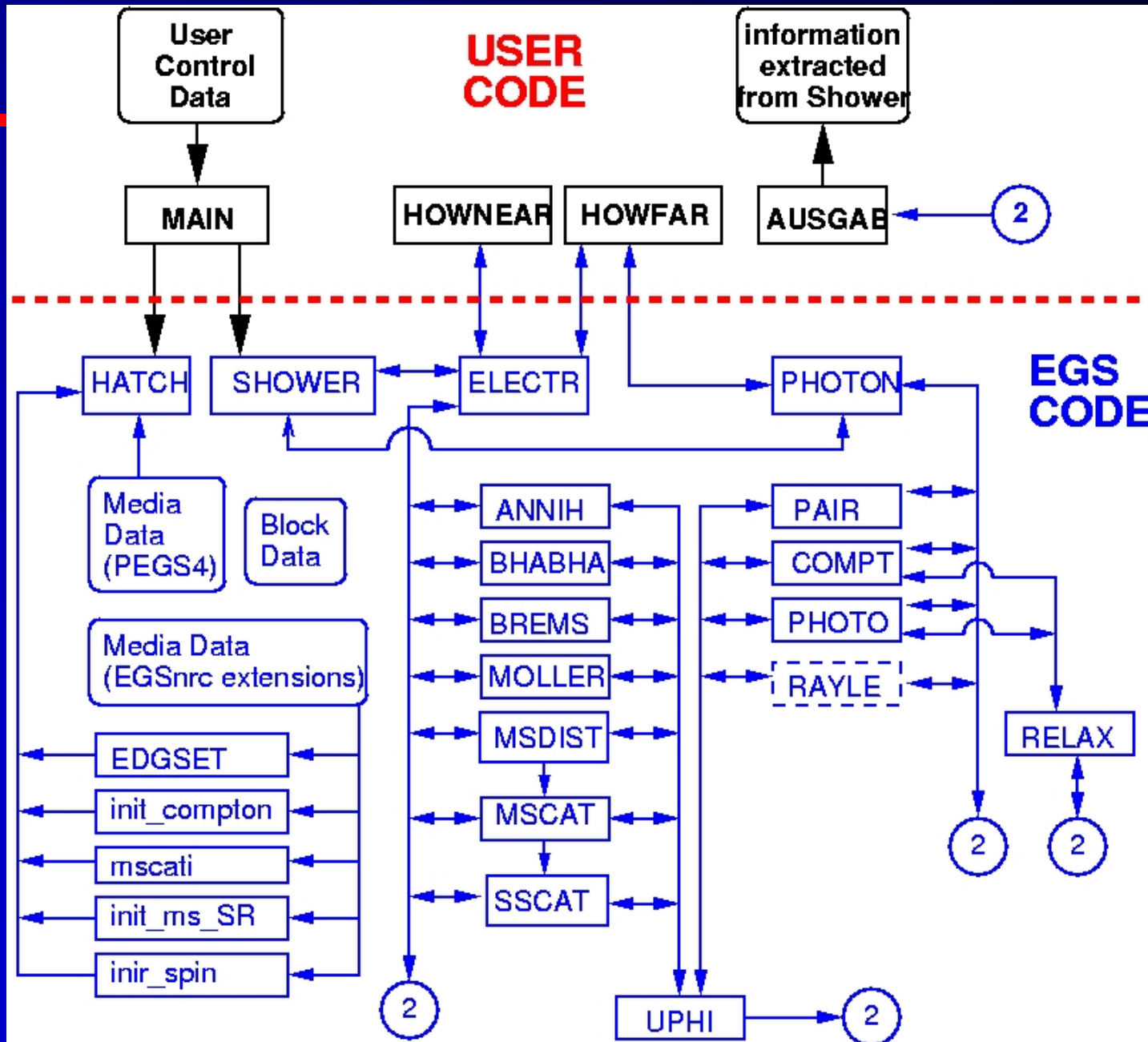
Daryoush Sheikh-Bagheri

Joanne Treurniet

EGS4: Ralph Nelson and Alex Bielajew

EGSnrc: Iwan Kawrakow

BEAMnrc is built on EGSnrc

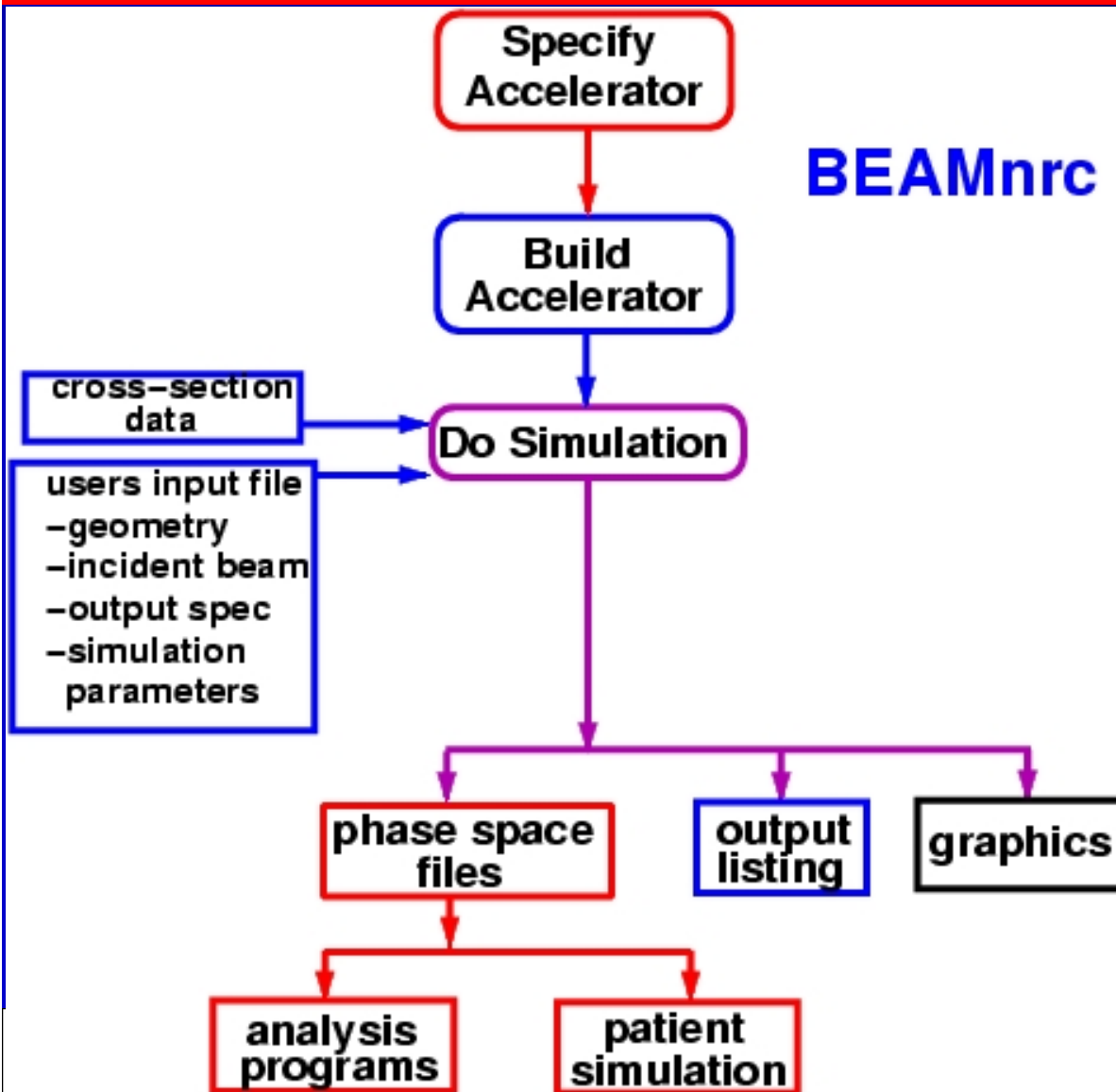


BEAM design features

- **C**omponent **M**odules (**CMs**)
 - between parallel planes
 - can combine in **arbitrary order**
 - builds in **flexibility and extensibility**
- Not restricted to cylindrical symmetry (all prior models had been cylindrical)
- **variance reduction** built in for accelerator modelling
- detailed **testing**
- expert **user friendly** (only need be expert to use it well)

Flow of the process

BEAMnrc

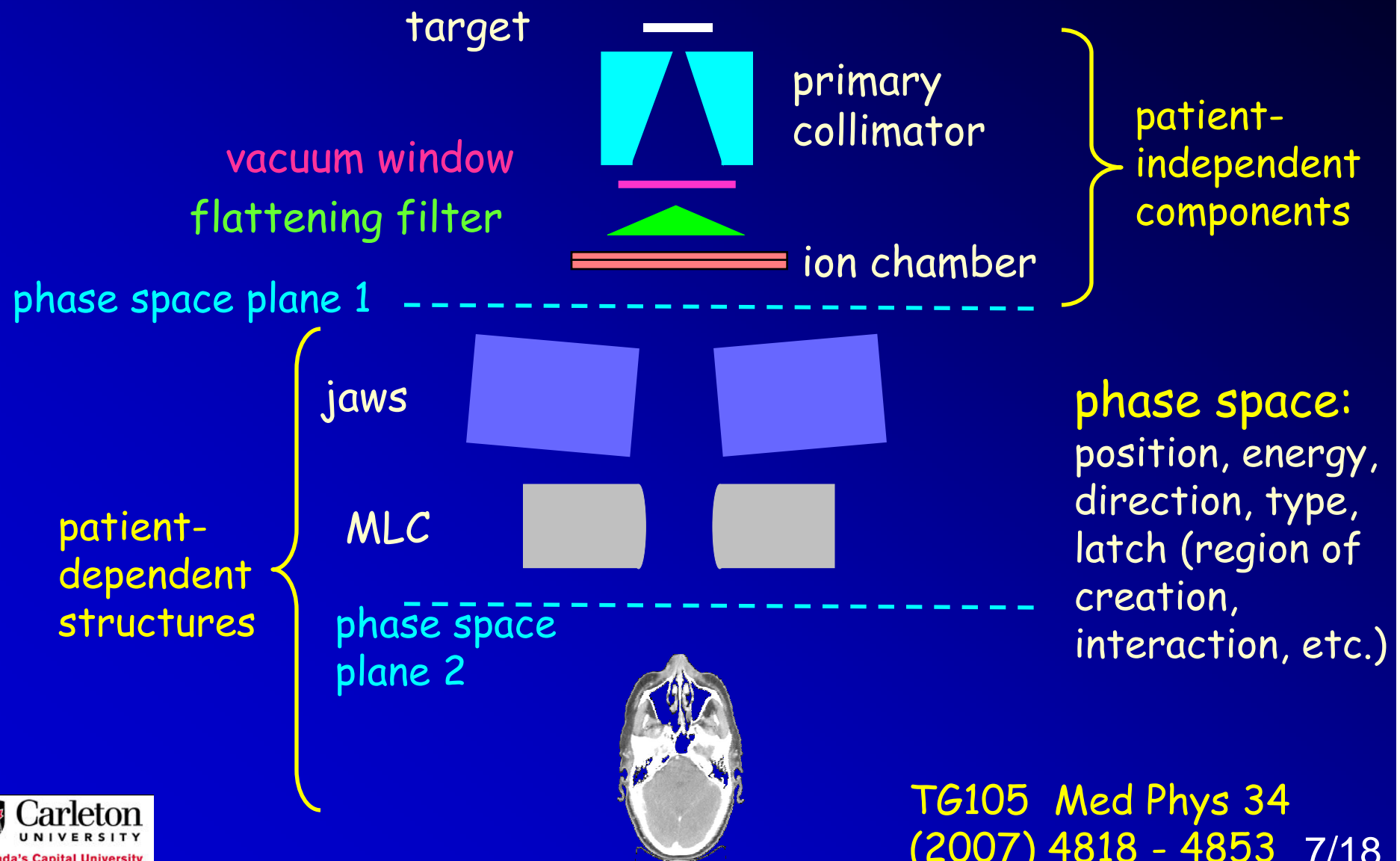


defines a class of
accelerators
-ordered list of CMs

pulls together source code
& compiles it

input file defines specifics
of one accelerator & this
run's parameters

Overview of the entire process



vacuum
exit

scanning
magnet

monitor
chamber

jaws

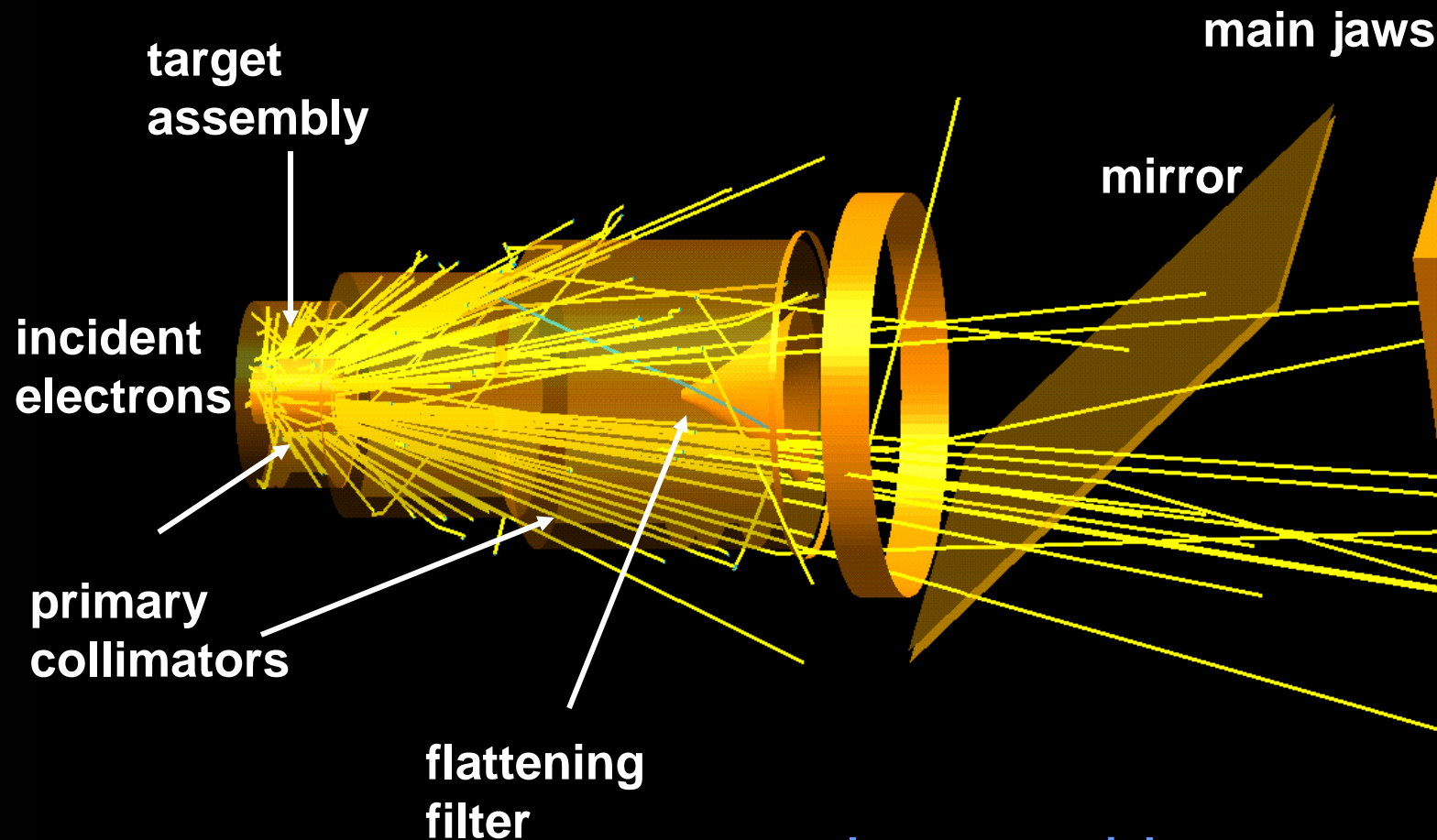
Therac 20
20 MeV
electrons

applicator

patient

electrons blue
photons yellow

Siemens 6MV KD2



vacuum
exit

*NRC accelerator
20 MeV electrons*

Lead
scattering
foil

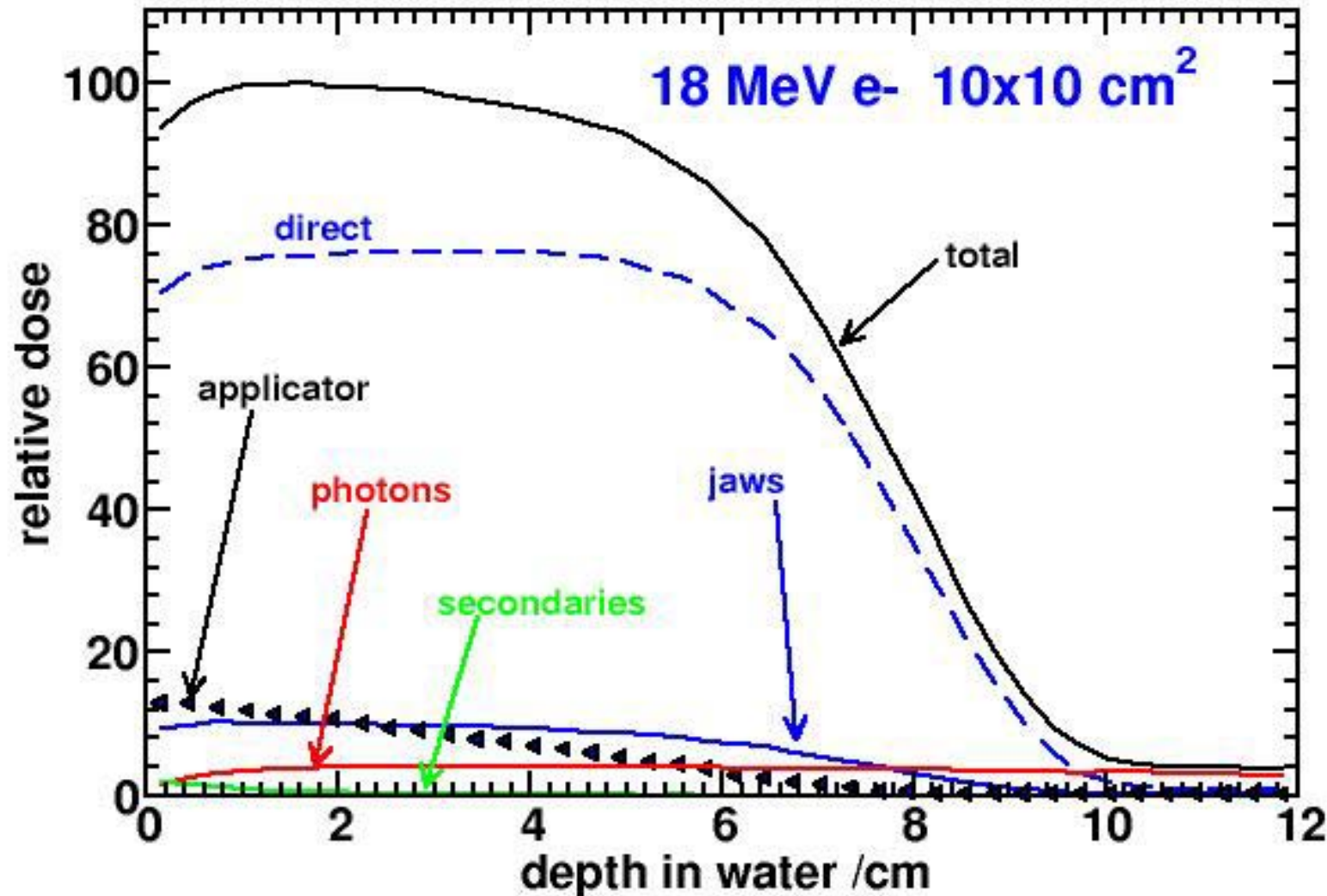
electrons blue
photons yellow

jaws

monitor
chamber

phantom

Dose Components via LATCH

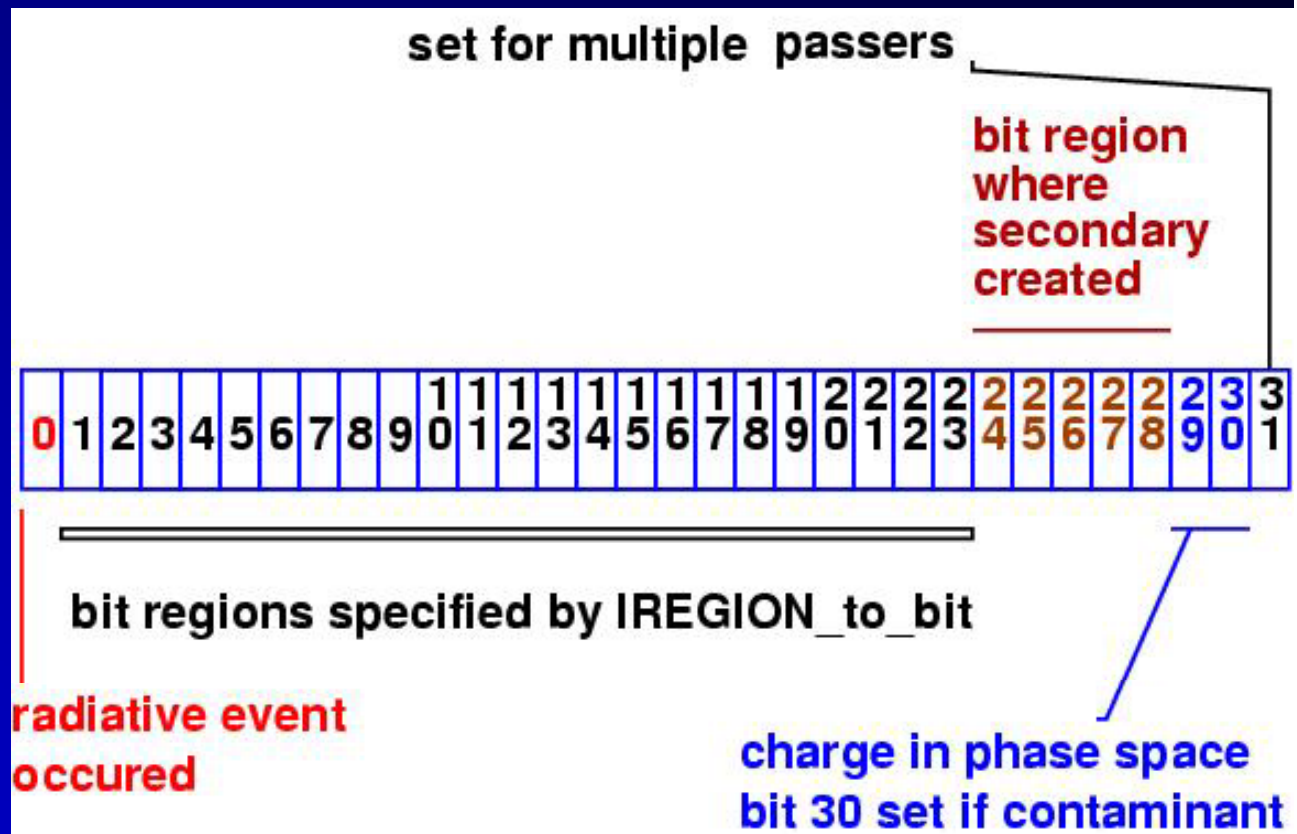


LATCH bits in BEAMnrc

BEAM associates
regions or groups of
regions with
LATCH-bits(1-→23)

Bits are **set** by
particle **interacting**
in these regions

LATCH is part of
phase-space file



Allows a simple method of tracking a
particle's history

Uses of BEAM

- accelerator design
- study physics of beams
- dosimetry studies
- beam characterization
 - 1st step to **treatment planning**
- commissioning accelerators

Doing it with BEAMnrc an interactive demonstration

- use EX10MeVe accelerator model (comes with code)
- run beamnrc_gui
 - show a compilation
 - look at inputs for accelerator
 - note on-line help, LATCH dose components
 - show previews and how to run job
- look at .egsinp file, .egslst file
- beamdp_gui use to show spectrum, scatter plot
- demonstrate EGS_Windows, dosxyz_show

BEAM Graphical User Interface

Ionizing Radiation Standards Group
Institute for National Measurement Standards
National Research Council Canada

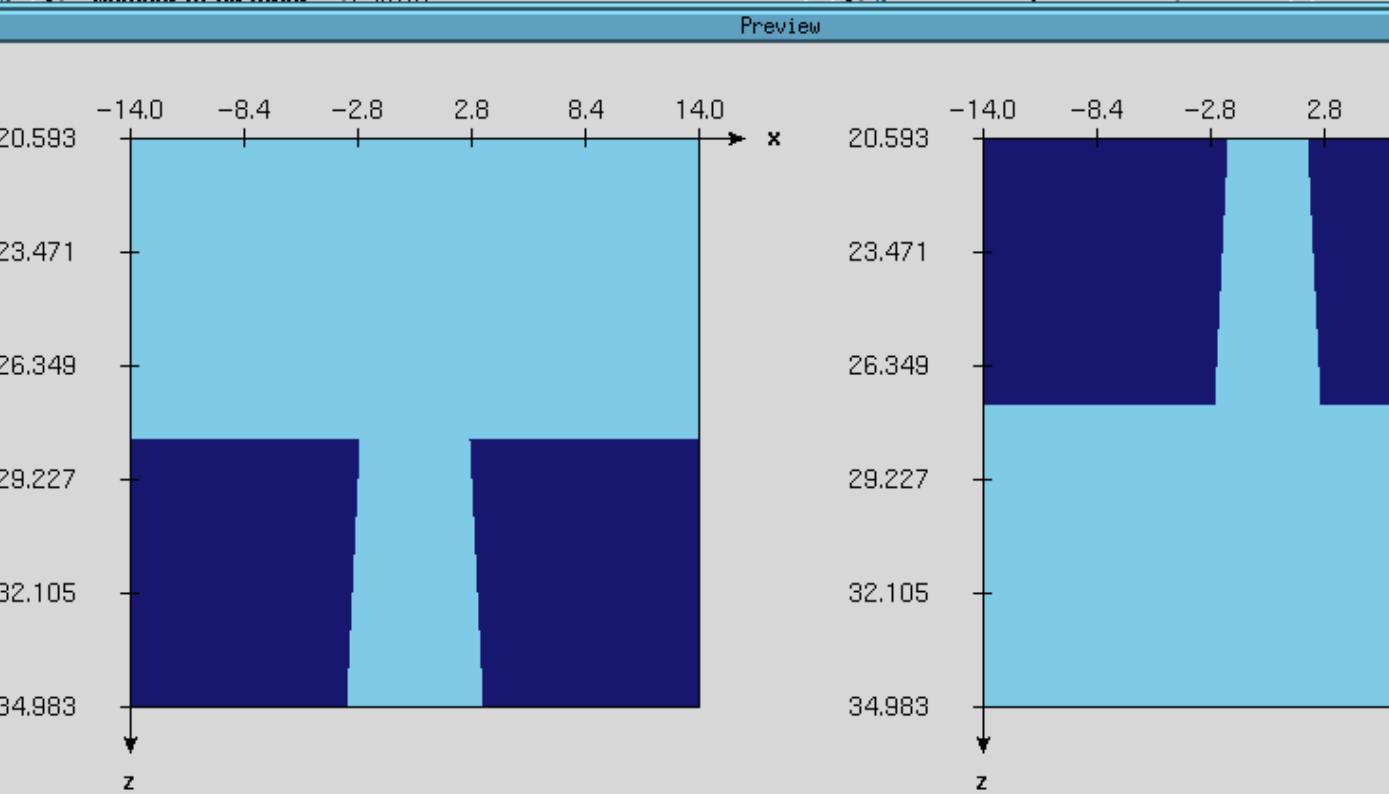
Copyright 1998 National Research Council Canada

Accelerator parameters
Using PEGS4 file /usr/people/peo

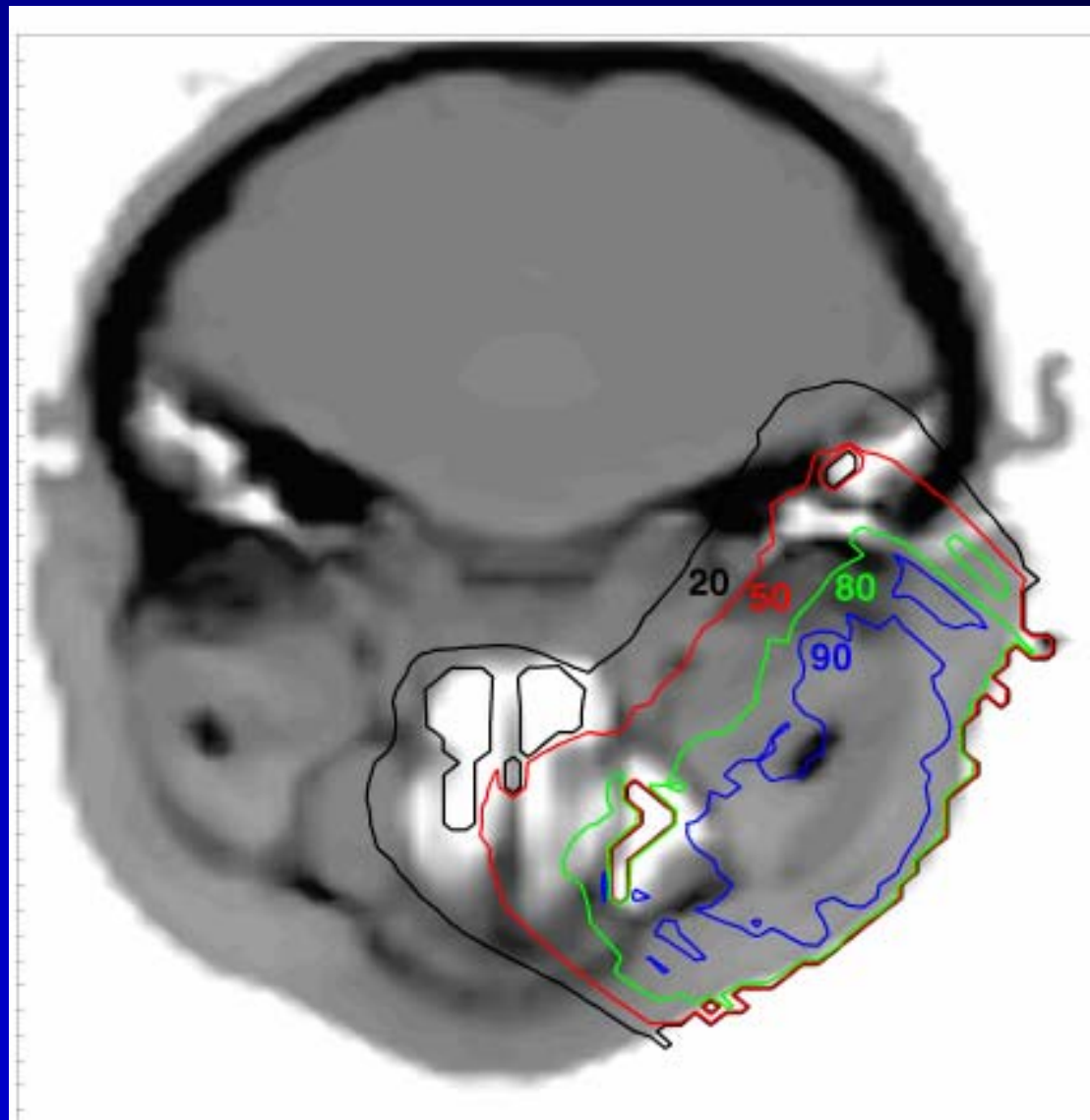
Selected components		
Edit main input parameters		
CONESTAK	FOIL	Edit...
FLATFILT	COLFOIL	Edit...
CHAMBER	MONITOR	Edit...
JAWS	MAINJAWS	Edit...
APPLICAT	APP1	Edit...
BLOCK	APP2	Edit...

Main Inputs

Title	10_13Mup: MD2, no last appli. 13 MeV, 10x10cm field
Medium	AIR521ICRU
IWATCH Output	none
Run option	first time
Output Options	phase space at each scoring plane
Store Data Arrays	yes
LATCH option	inherited latch - set by passage
Score Last Z	no
Number of histories	1.3e+07
Incident particle	ele



CT Treatment Planning



Parameter selection with BEAMnrc

- for electron beams, **match measured R_{50}**
 - little else matters (assuming symmetric energy)
- for photon beams,
 - determine the incident electron **energy** by matching the depth-dose curve in a narrow beam
 - determine the **radius** of the incident electron beam by matching an off-axis ratio or dose profile for a large beam (40x40)

Acknowledgements

- The work described here has been done in conjunction with many colleagues, grad students and research associates. BEAM developers are listed on **slide 4**.
- I would particularly like to acknowledge that **Iwan Kawrakow and Blake Walters** have been the major developers of BEAMnrc for the last few years.
- Support from the Canada Research Chairs program and



Bibliography re BEAM/BEAMnrc

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pdf versions of this & related publications are available at:
<http://www.physics.carleton.ca/~drogers/pubs/papers/>
- BEAMnrc, DOSXYZnrc related manuals** available via the
BEAM home page
<http://www.irs.inms.nrc.ca/BEAM/beamhome.html>
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brem splitting,** Med Phys 31 (2004) 2883-2898
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Med Phys 33 (2006) 2683-2690
- Efficiency improvements of x-ray simulations in EGSnrc user-codes using bremsstrahlung cross section enhancement (BCSE), Med Phys 34 (2007) 2143-2154
- On the efficiency of treatment head simulation
Med Phys 34 (2007) 2320-2326
- Sensitivity of megavoltage photon beam Monte Carlo simulations to electron beam parameters
Med Phys 29 (2002) 379-390