Energy deposition by doughnut beams bombarding a (p,xn) target

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Spallation neutron sources as an alternative to reactors

(p,xn) on heavy targets eg. eutectic metals

as presented at the American Nuclear Society Annual Meeting 2010 (Las Vegas); contact me@marychin.org

(p,xn)

one proton in,
many neutrons out (*eg.* ~80)

many neutrons out,
unfortunately none is usable*

* *energy and time characteristics no good for use of neutron as a probe*

SPALLATION NEUTRON FACILITIES
meeting the challenges

1. maximise the number of neutrons emerging the target
2. add moderators to bring the energy down

   (by the time we achieve this
   we spoil the time characteristics)
3. add reflectors, decouplers, poisons etc to undo what we have spoiled

EVERYTHING IN & AROUND THE BEAM must not overheat

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EVERYTHING IN & AROUND THE BEAM must not overheat

PENCIL BEAMS (AND SMALL TARGETS)
MAY GIVE THE BEST NEUTRON OUTPUT
BUT WE DON'T WANT TO
DRILL HOLES IN THE TARGET

BIGGER BEAM FOOTPRINTS (AND BIGGER TARGETS)
MAY SPREAD THE ENERGY DEPOSITION BETTER
BUT THERE'S NO POINT PRODUCING NEUTRONS
WHICH CAN'T GET OUT OF THE TARGET

DOUGHNUT BEAMS?

THIS WORK IS *A STUDY,*

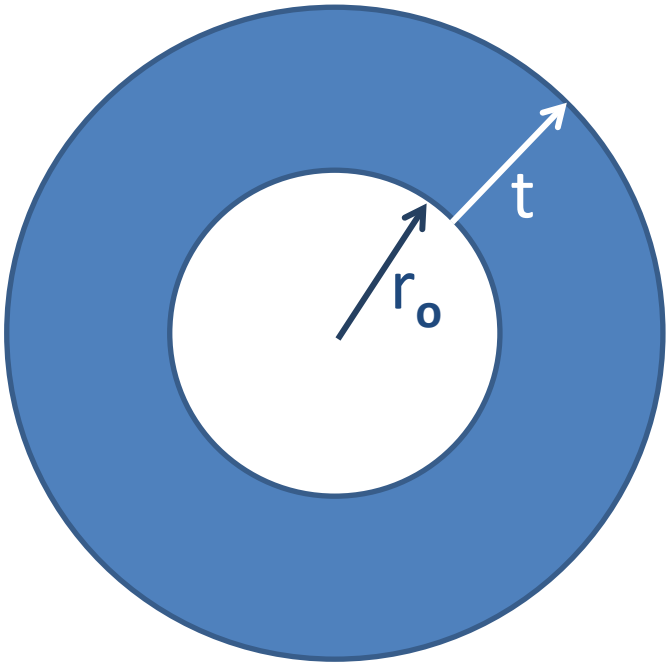
NOT AN ADVOCATE OF DOUGHNUT BEAMS

THIS WORK IS BASED ON FLUKA SIMULATION OF PARTICLE TRANSPORT & ENERGY DEPOSITION,

OUTPUT IS TO BE FED INTO FINITE ELEMENT ANALYSIS LEFT IN THE HANDS OF THE ENGINEERS

DOUGHNUT BEAM

2.5 GeV proton impinges the base of a cylindrical target*



*radius R=30 cm, height Z=150 cm, homogeneous mercury

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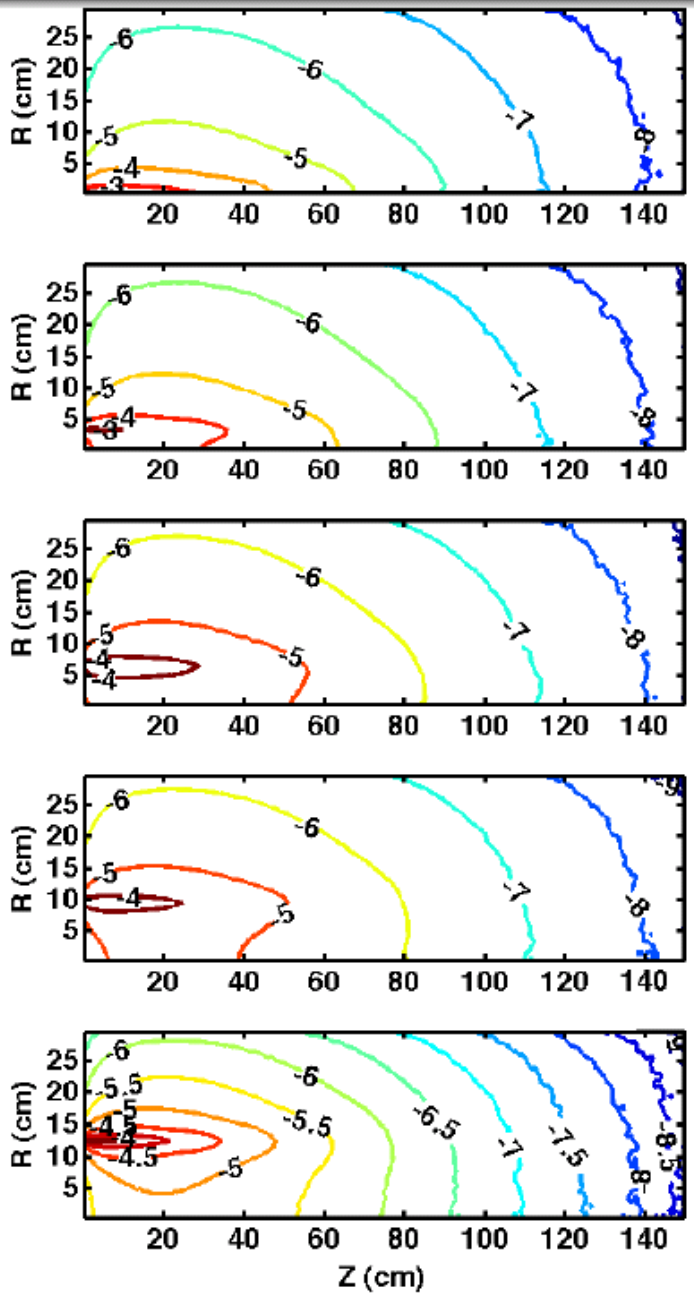


Fig. 2. Energy deposition with the doughnut beam kept constant at $t = 1$ cm while r_o was varied from 0 cm (top) to 12 cm (bottom) in steps of 3 cm. Contour labels indicate $\log_{10}(E)$.

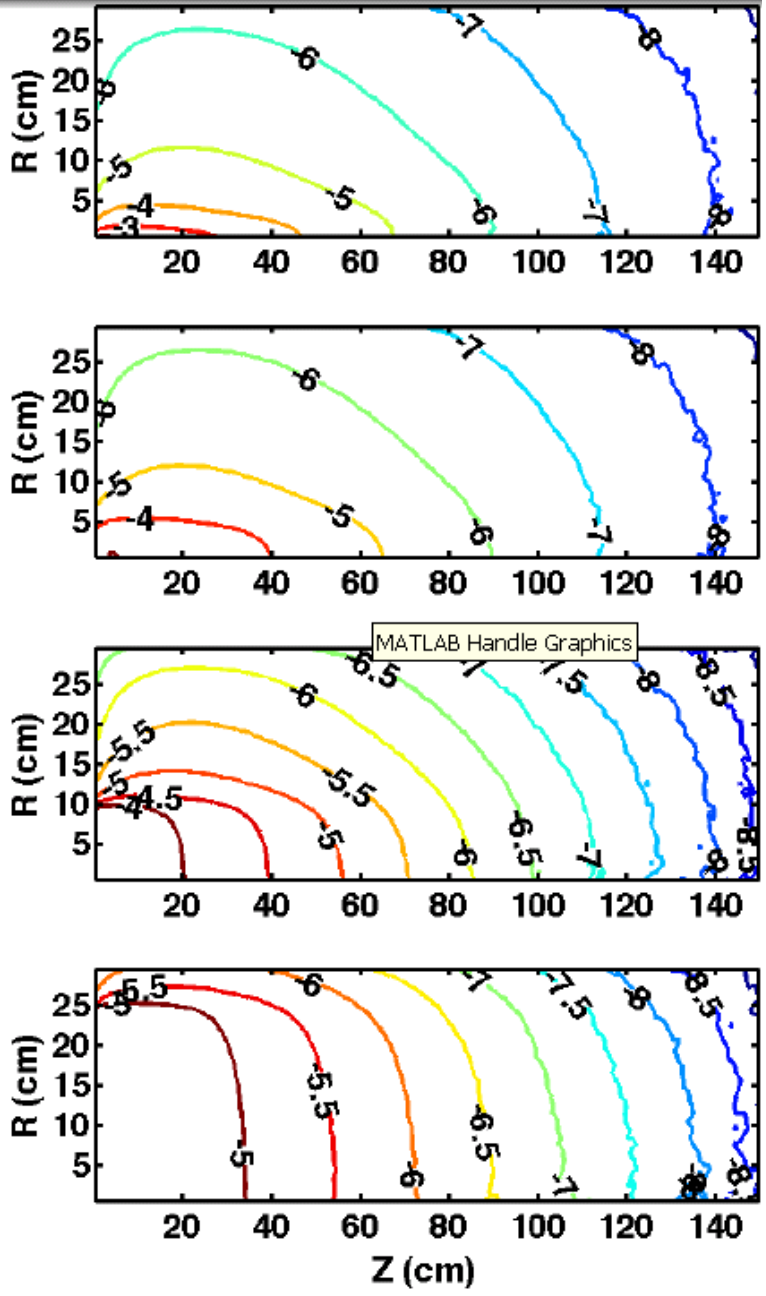
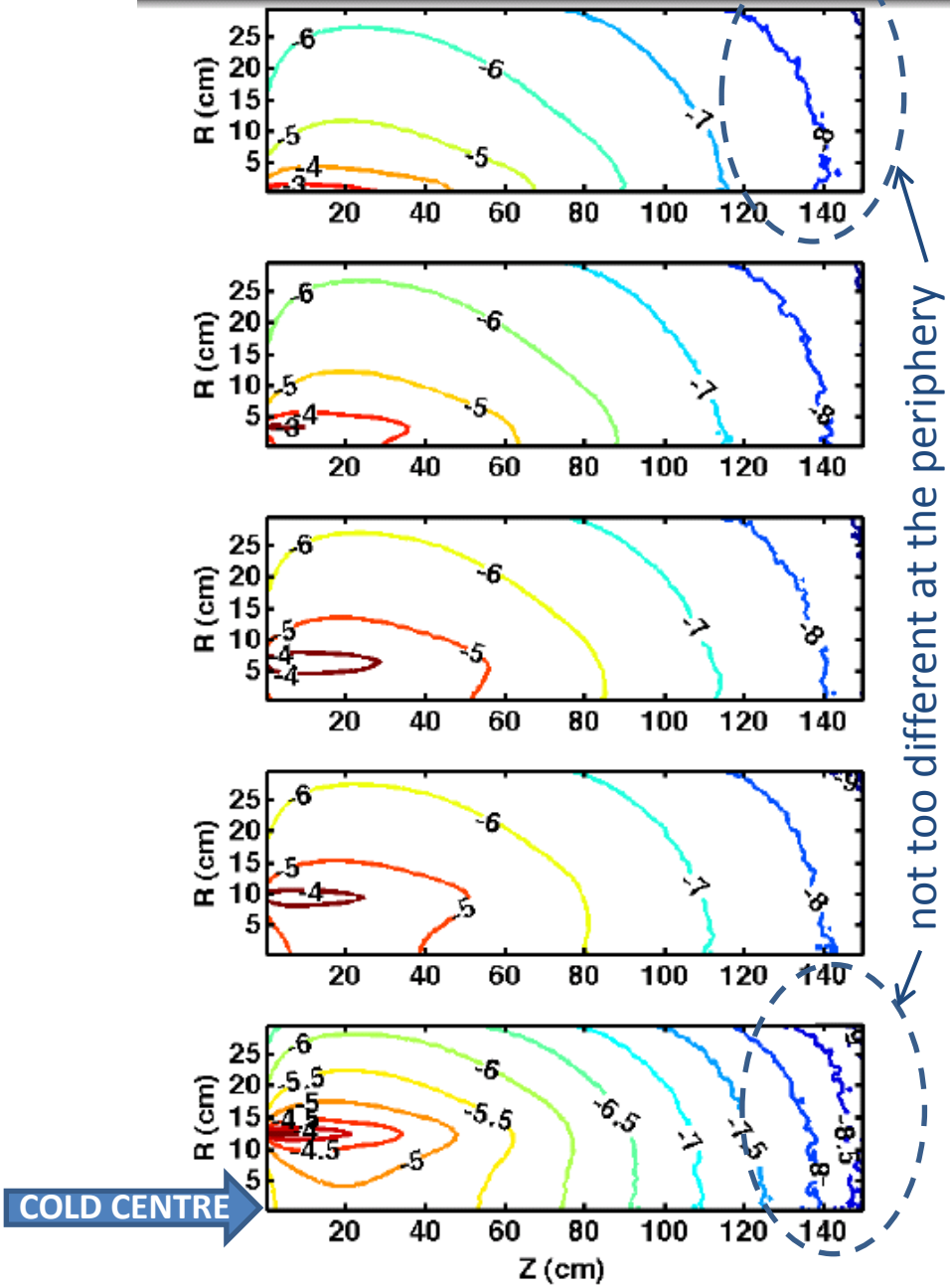


Fig 3. Energy deposition by a doughnut beam of constant $r_o = 0$ cm while t was varied from 1 cm (top) to 4, 10 and 25 cm (bottom). Contour labels indicate $\log_{10}(E)$.



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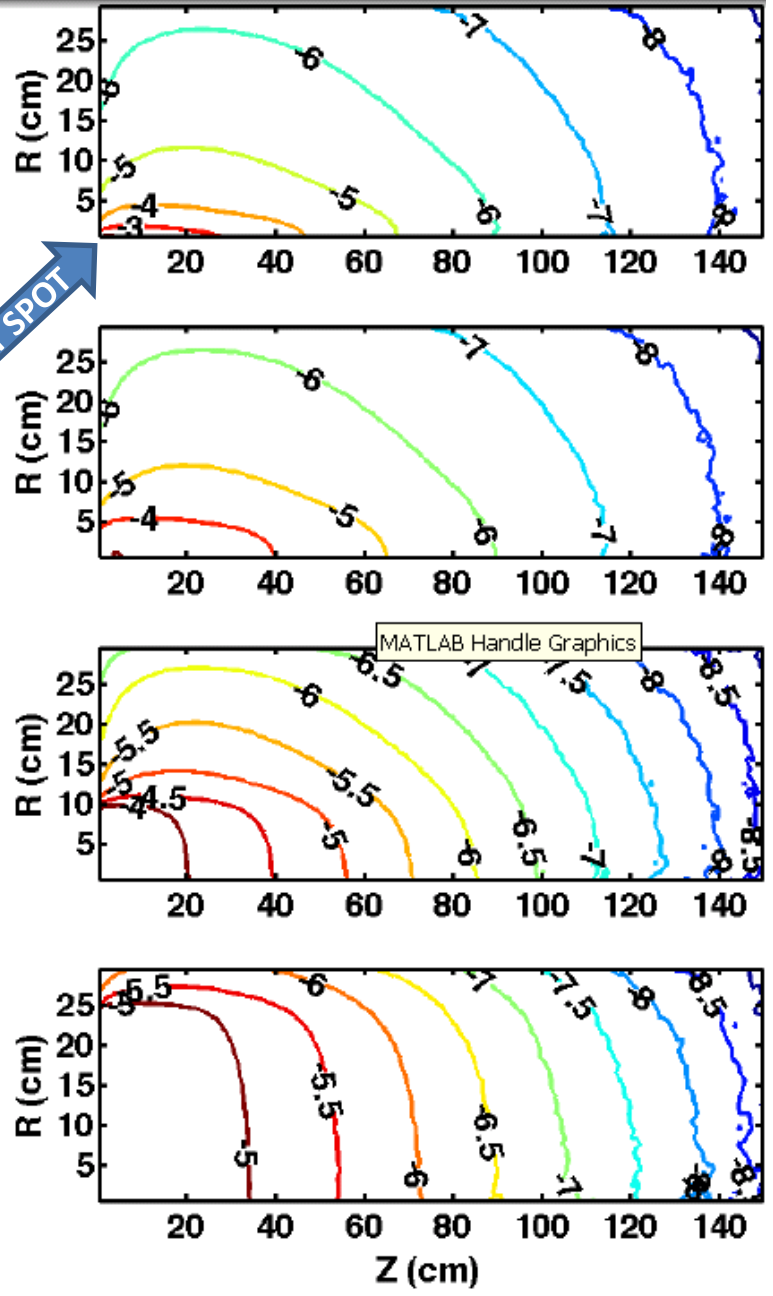

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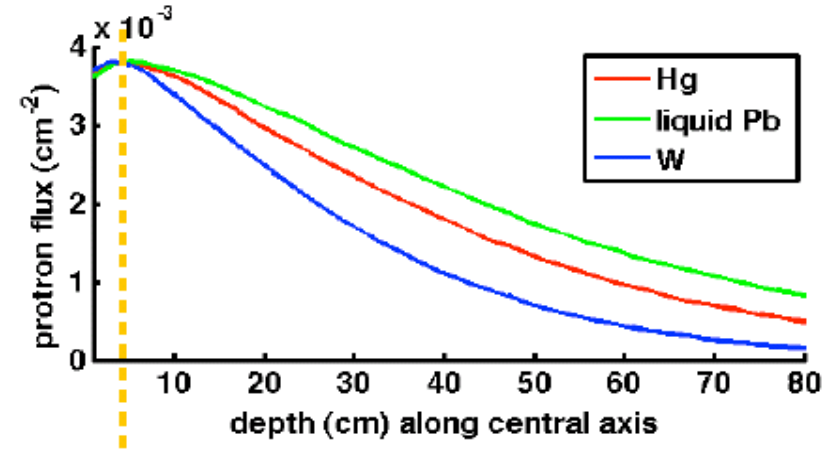
NOW WE'VE GOT THE 2D ENERGY DEPOSITION, WHAT'S NEXT?

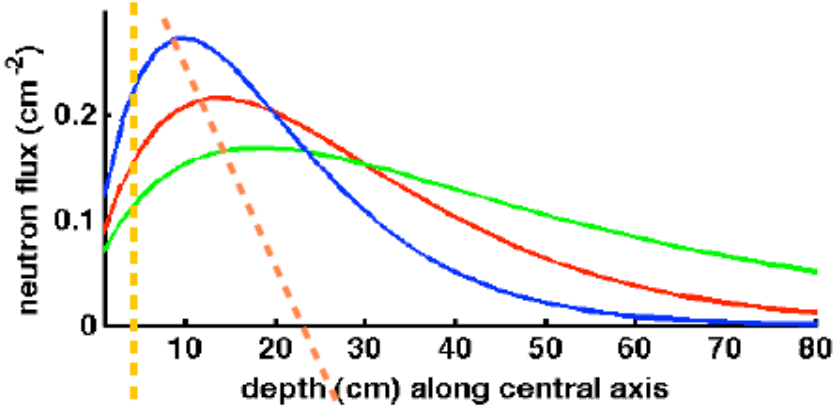
instead of forward what-if iterations

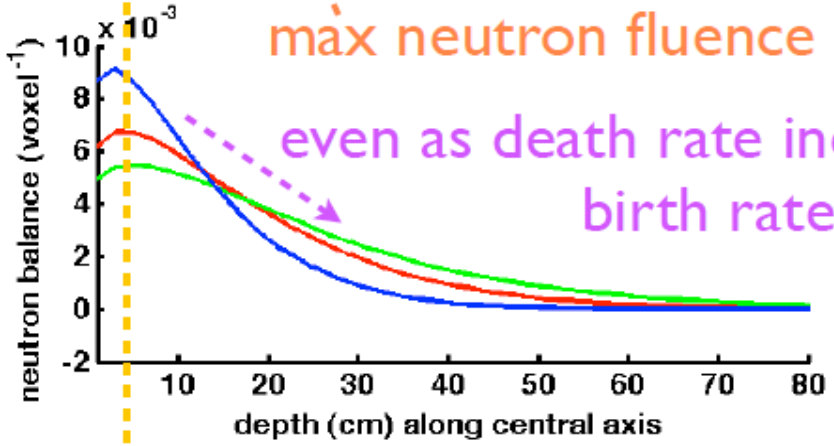
we propose a mixed inverse + forward problem-solving

we think more (tackling the inverse problem) instead of passively leaving to the computers

still computer simulations but less iterations and better human understanding







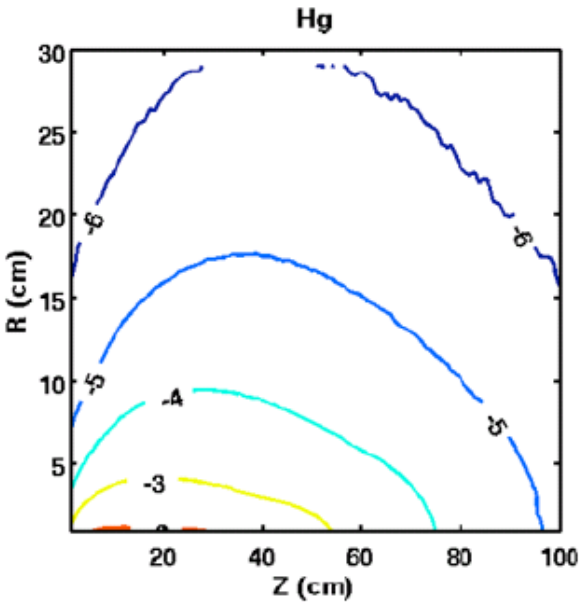
max neutron fluence occurs deeper

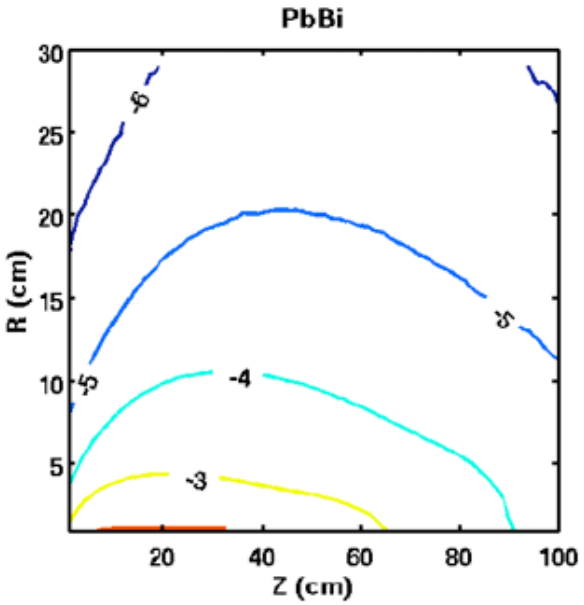
even as death rate increases wrt birth rate

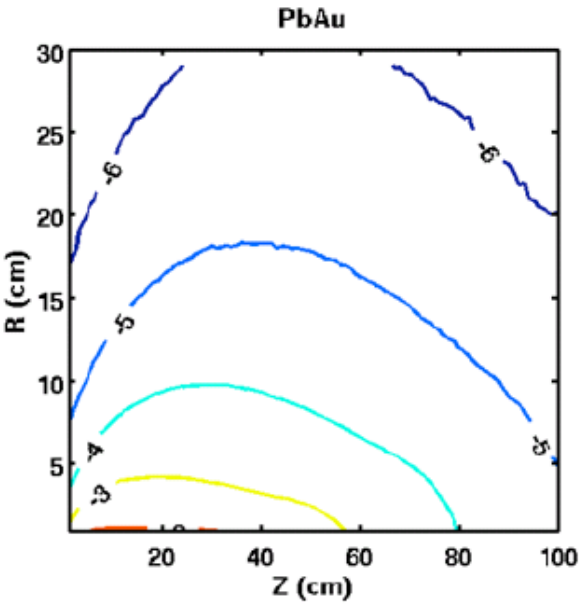
proton build-up occurs first

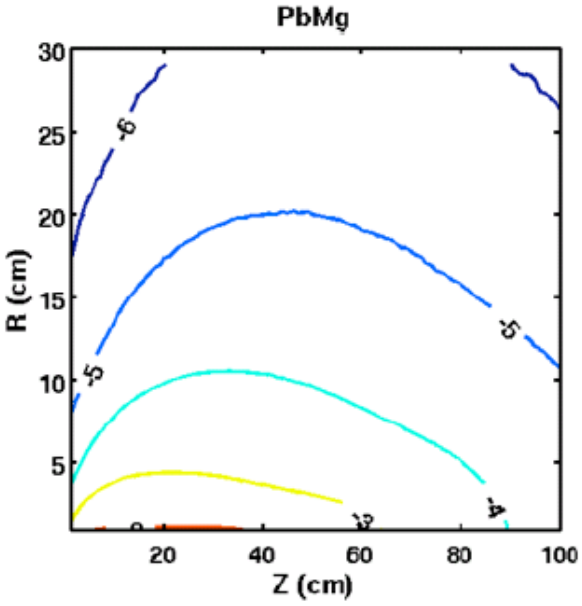
PROTON FLUENCE

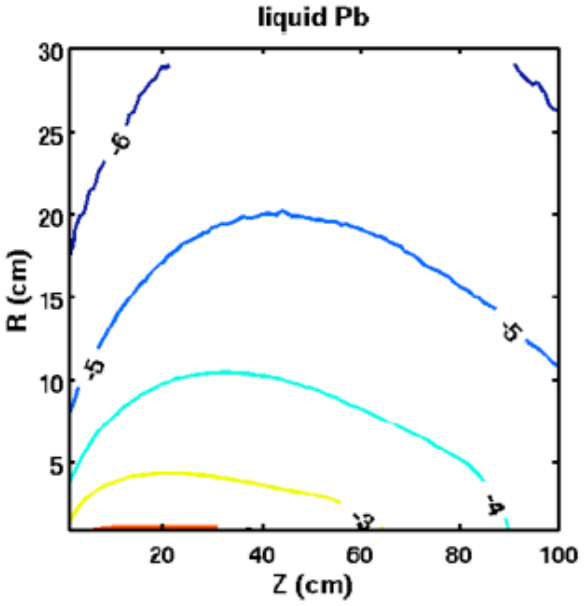
2.5 GeV pencil beam

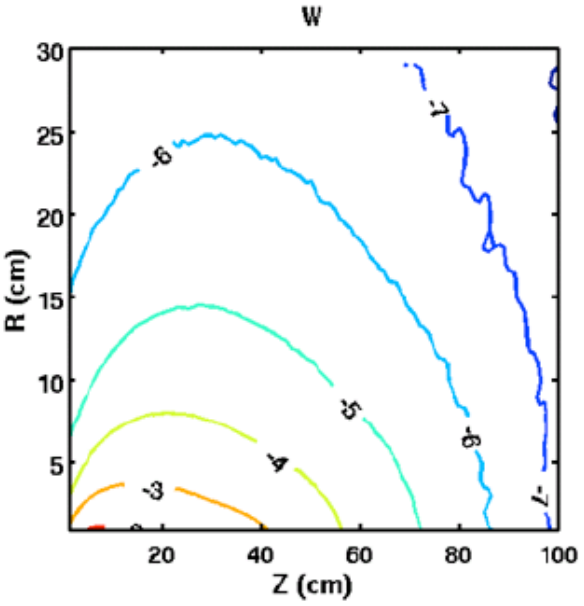






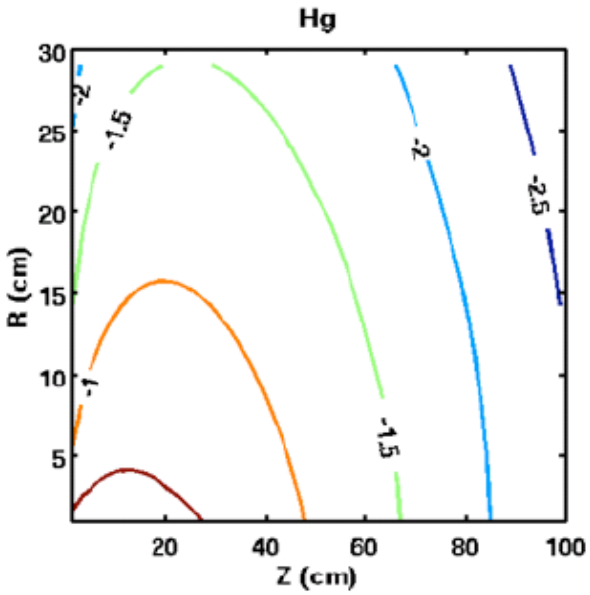


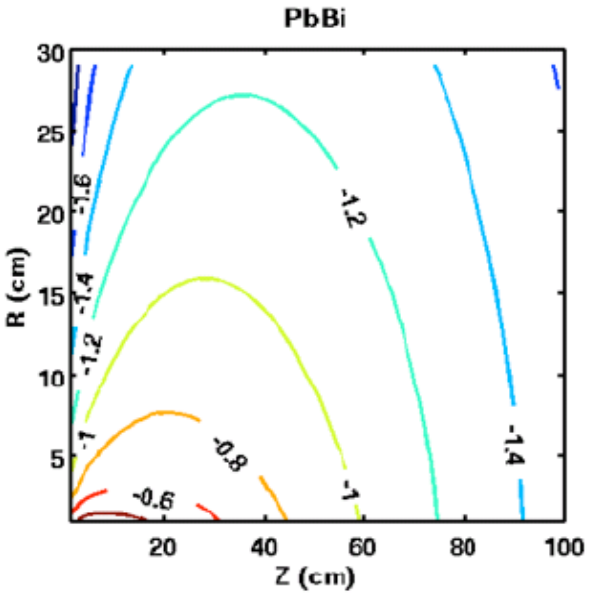


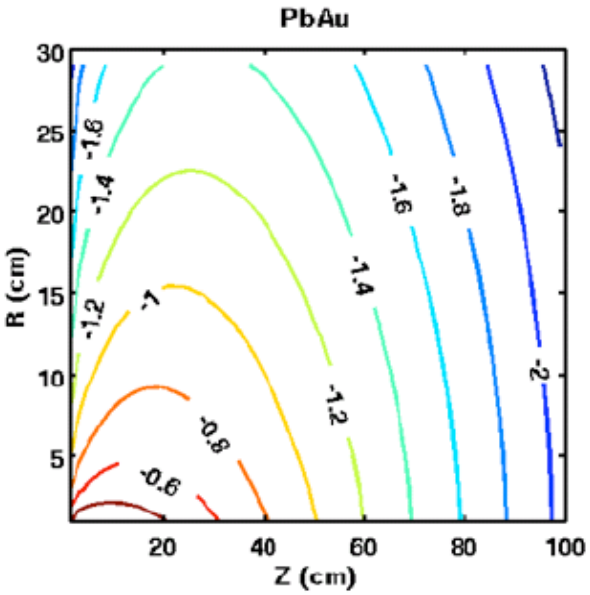


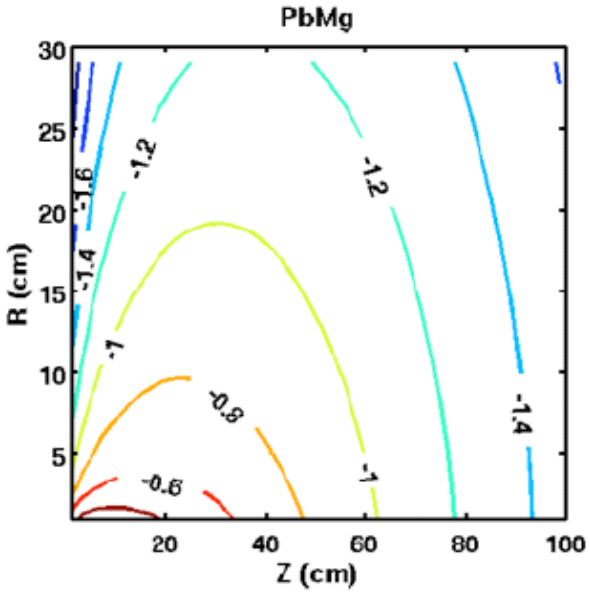
NEUTRON FLUENCE

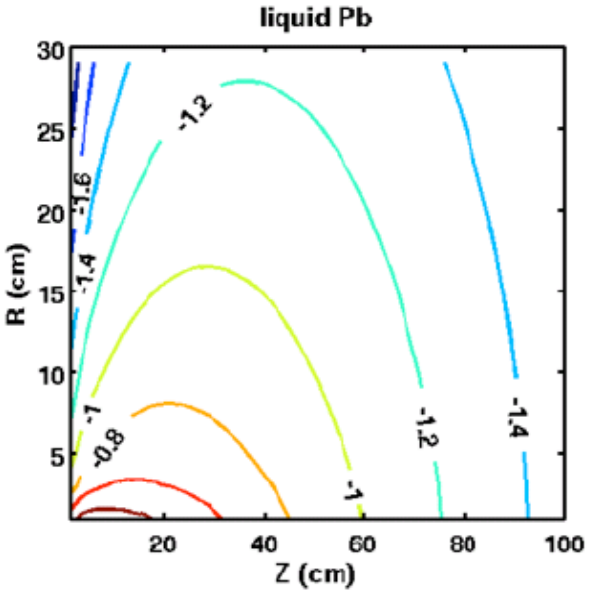
2.5 GeV pencil beam

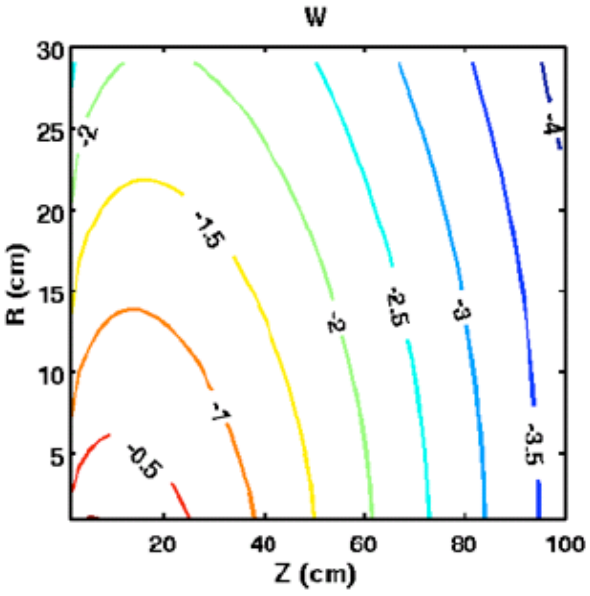






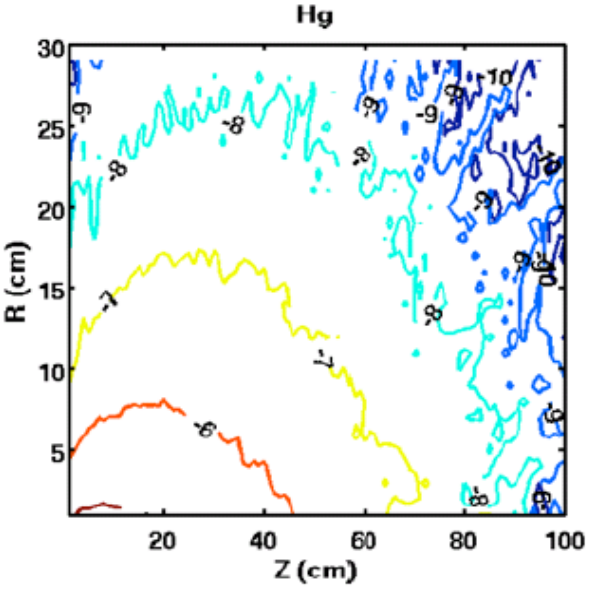


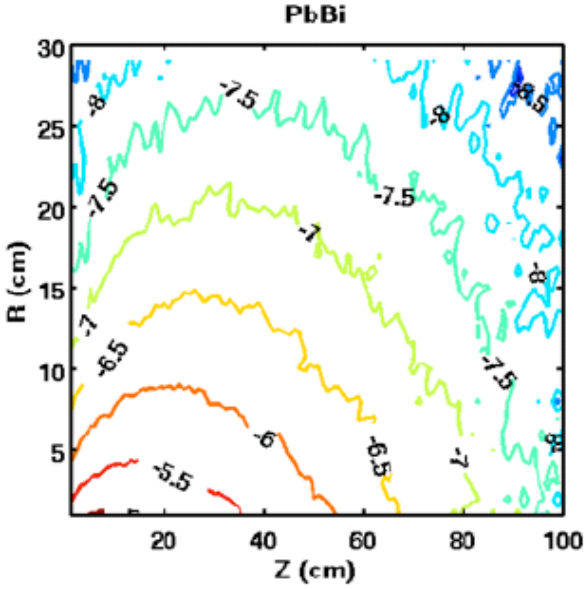


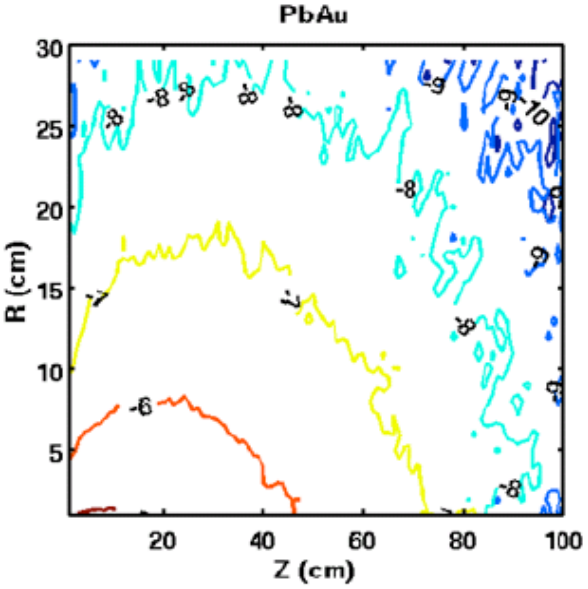


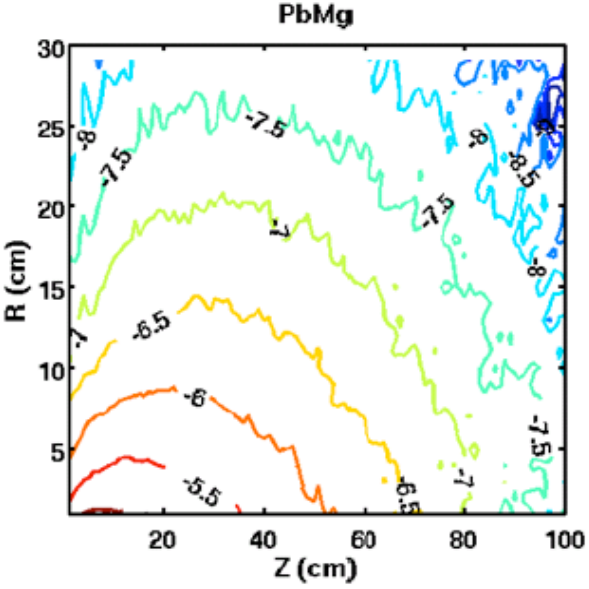
MUON+ FLUENCE

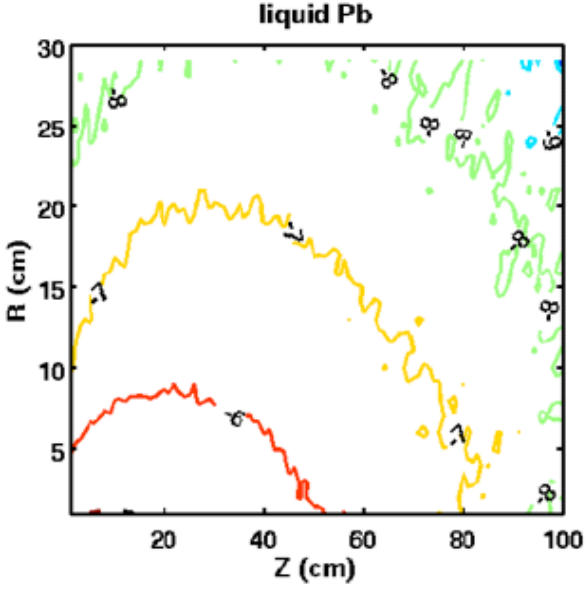
2.5 GeV pencil beam

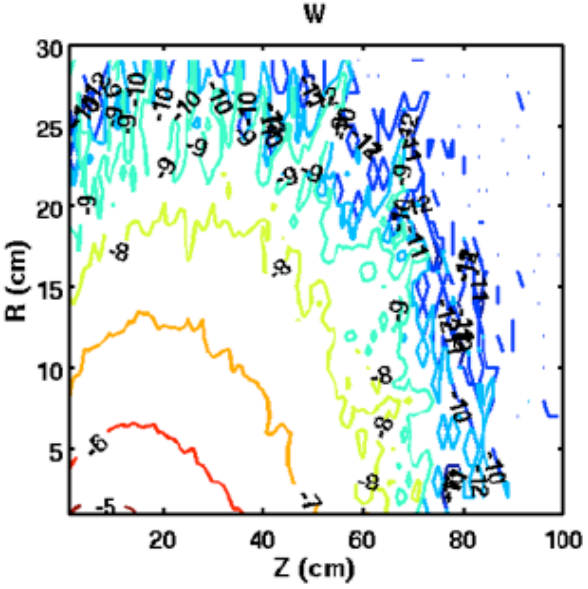












MUON- FLUENCE

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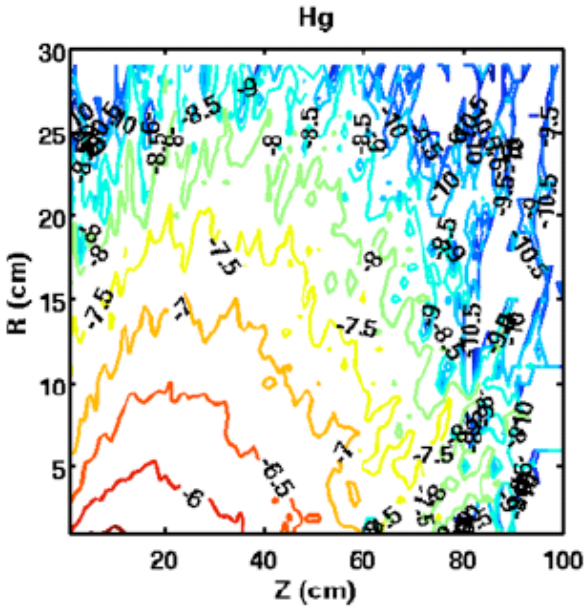
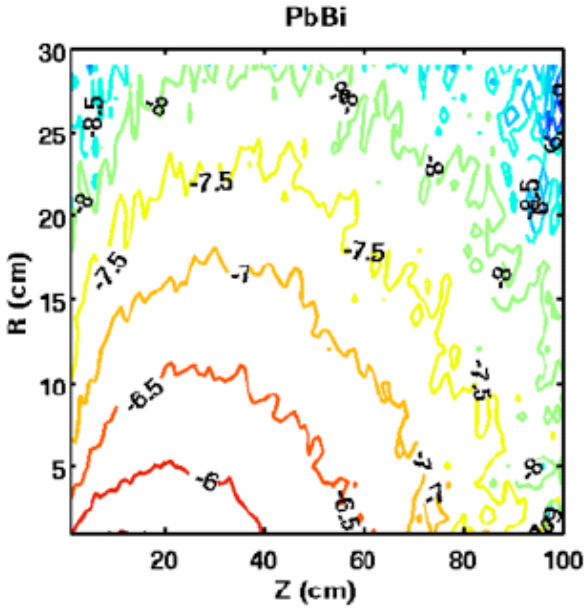
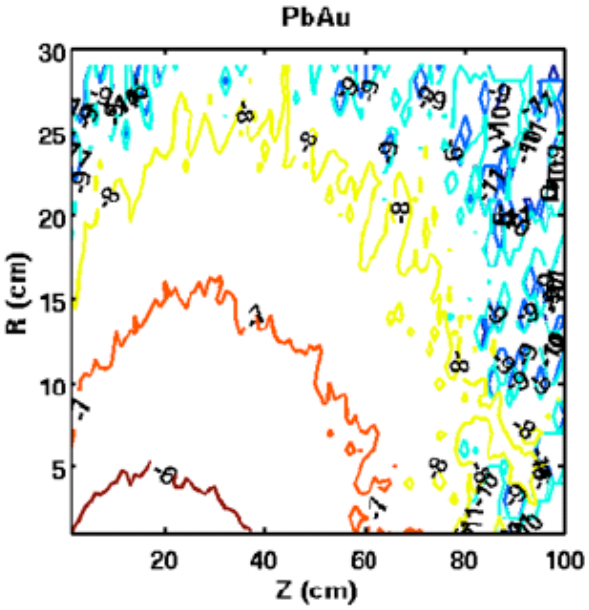
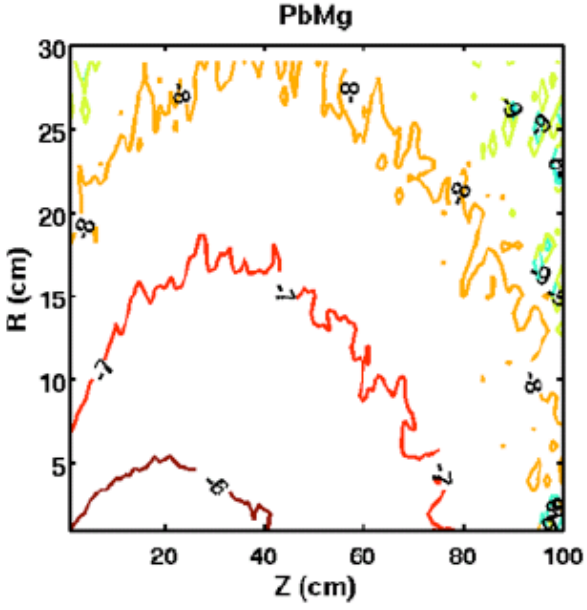
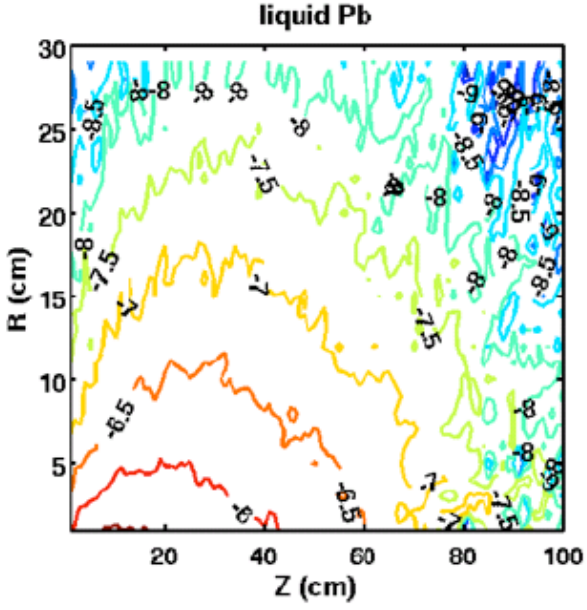
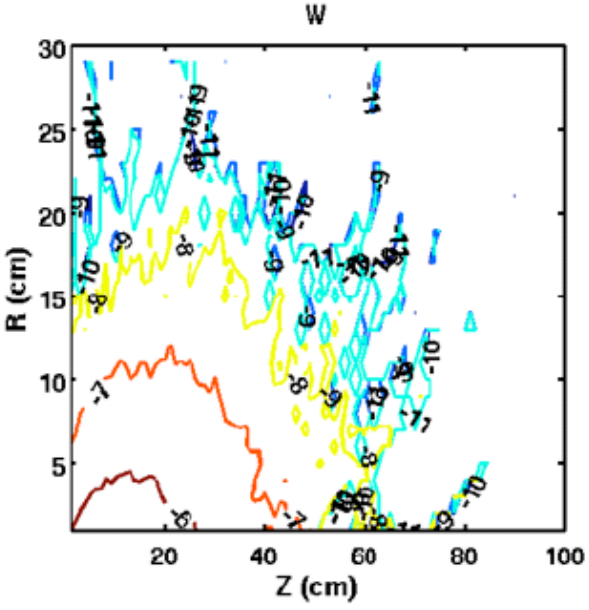






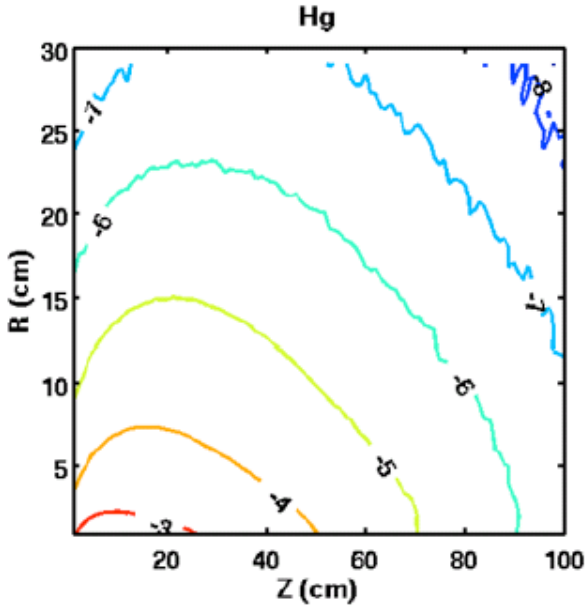


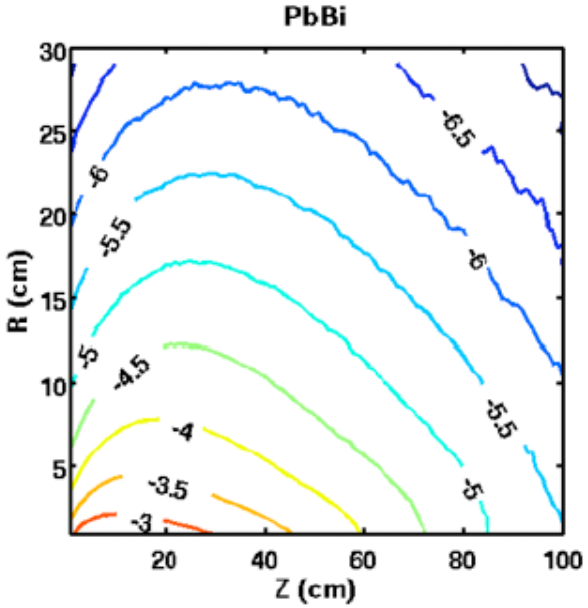


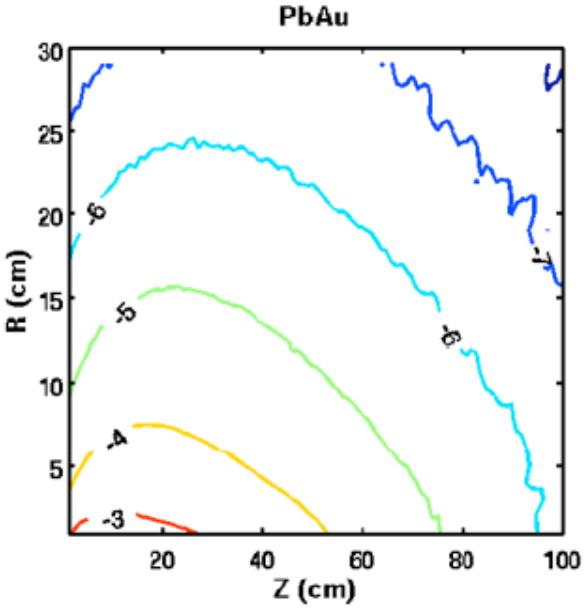


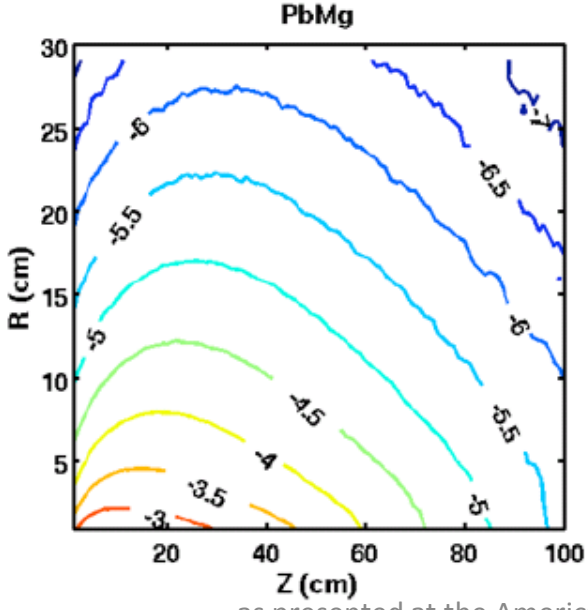
PION+ FLUENCE

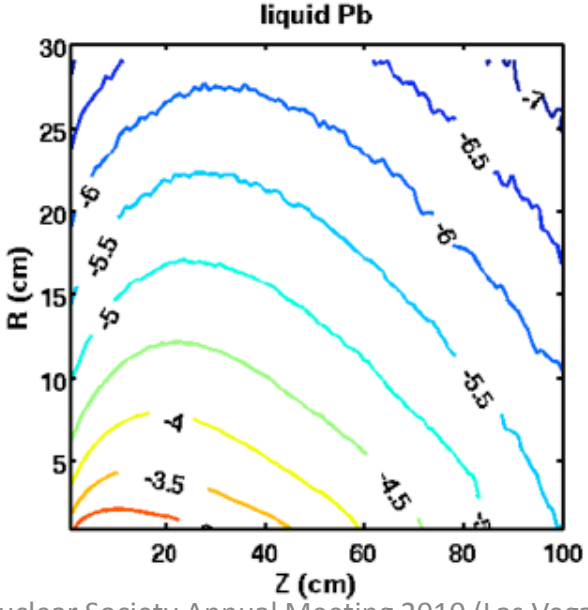
2.5 GeV pencil beam

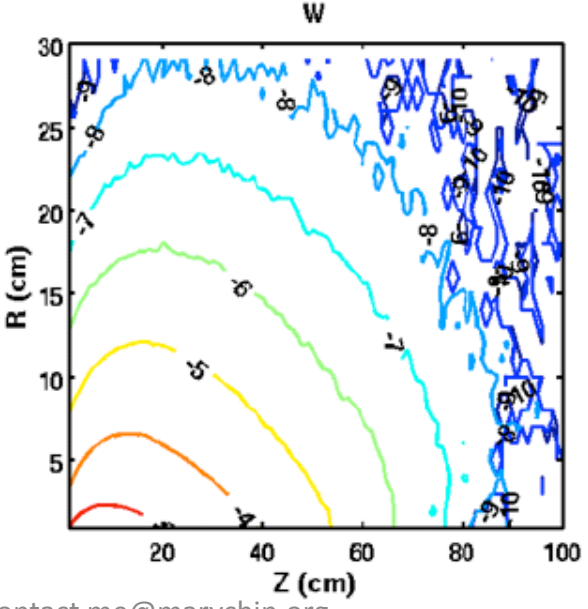






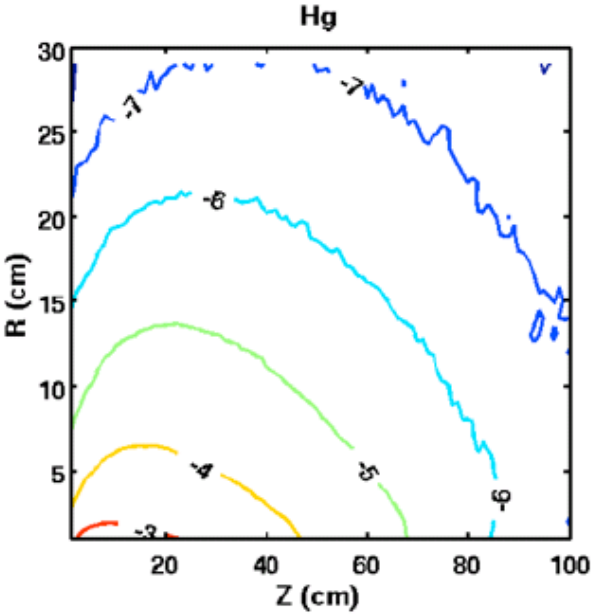


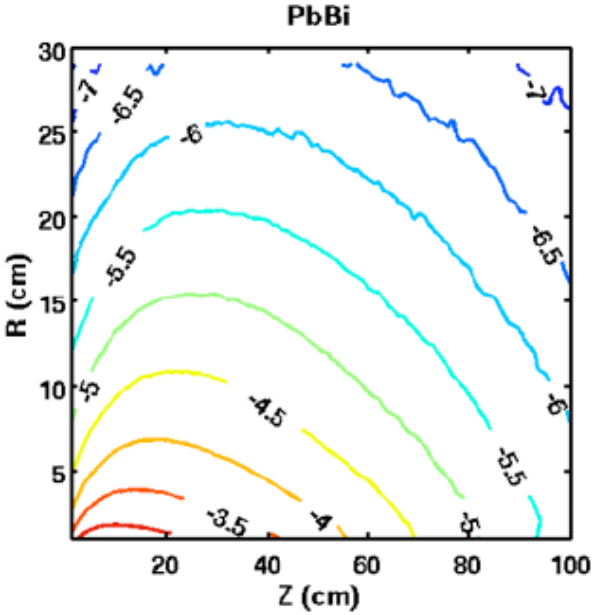


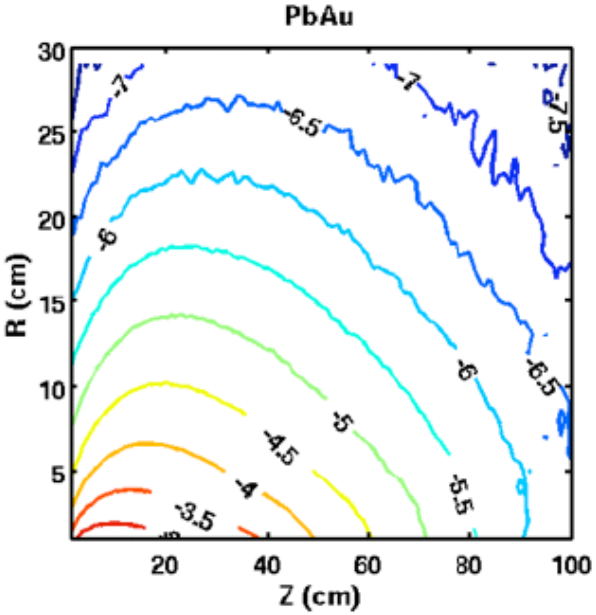


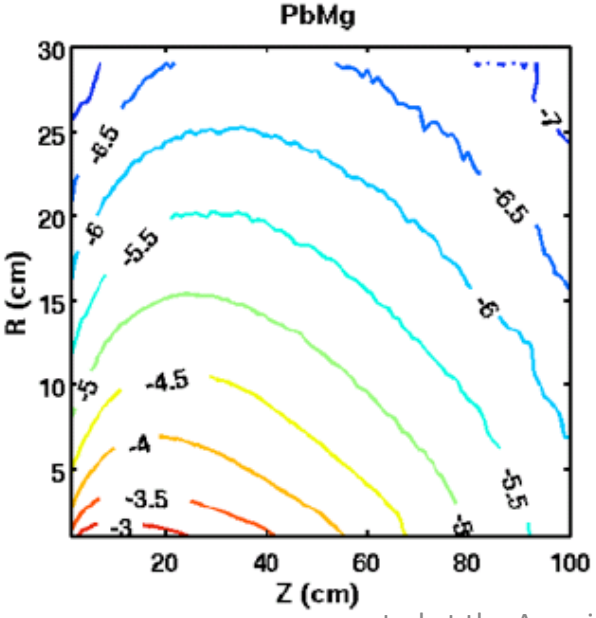
2.5 GeV pencil beam

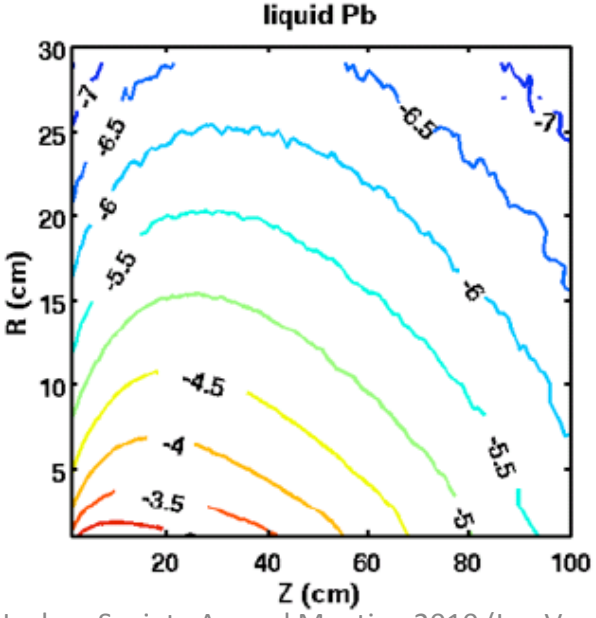
PION- FLUENCE

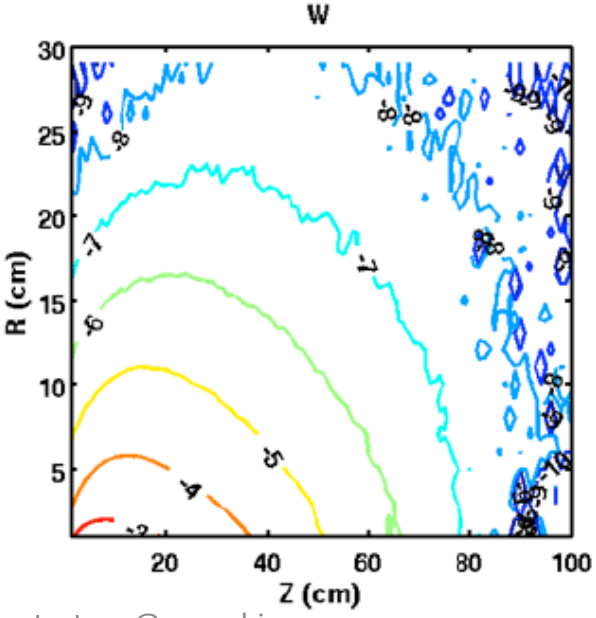












2.5 GeV pencil beam

PHOTON FLUENCE