Backgrounds in the ESS High Energy BeamTransport

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April 17th 2013

Radiation in the HEBT?

Sources:

- Source backsplash
- Beam losses
- The Collimator

Possible effects

- Components (magnets etc) become active
- Hall becomes unsafe – even with beam off
- Air and water become active
- Energy deposition damages materials
- High neutron background for instruments

Studies

Using MCNPX with GEANT4 as a check:

Current study:
Energy deposition
^{64}Cu (12 h) from ^{63}Cu(n,γ)
^{65}Cu (5 min) from ^{65}Cu(n,γ)
^{60}Co (5.1 y) from ^{63}Cu(n,α)

Future isotopes to study:

From Zinc (in solder and alloys)
^{65} Zn(244 days) from ^{64}Zn(n,γ)

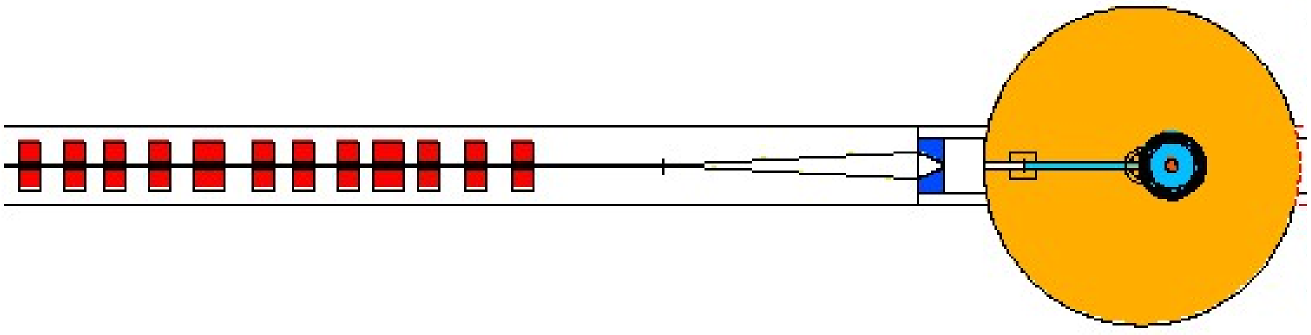
From Air
^{41} Ar(109 min) from ^{40}Ar(n,γ)
^{11}C, ^{13}N, ^{15}O

From Copper
^{57}Co(272 days)
^{58}Co(71 days)
^{54}Mn(312 days)
^{51}Cr(28 days)
^{59} Fe (45 days)

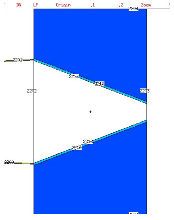
From Iron, Tungsten, etc

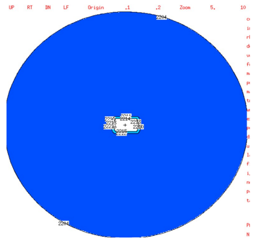
Geometry

Standard description + beampipe +magnets +collimator



February 2012 baseline model of monolith
Collimator is 1 m long,
external radius 1m
internal radius 50 cm, narrowing to slit
Copper with 2cm Tungsten lining





Magnets modelled as cylinders, 50% Fe, 50% Cu

Results-
Source 1: the target

Source 1: Spallation source, coming back down the beam pipe.
Normalise to 2 mA
30 hours to simulate 1,000,000 particles
Magnet values low: large statistical errors
Other magnets (further upstream) even lower
Decay of Co during the year (5 year half life) not considered

	Collimator	Magnet 1
Energy (MeV/g)/particle	$1.1\ 10^{-8}$	$2\ 10^{-11}$
For 2 mA, Gy/s	0.56	0.001
Per 225 day year, kGy	10800	20
^{64}Cu/particle	0.0013	$1.9\ 10^{-5}$
^{66}Cu/particle	0.00032	$4.4\ 10^{-6}$
^{60}Co/particle	$7.6\ 10^{-6}$	$6.8\ 10^{-8}$
^{60}Co/ year (nuclei)	$18.2\ 10^{17}$	$16\ 10^{15}$
^{60}Co/ year	7.7 GBq	68 MBq

Results- Source 2: beam losses

Source 2: Losses in the beam pipe. Grazing incidence, 2.5 GeV, uniform from 50m to 20m upstream. Normalise to 1W/m
37 minutes for 100,000 particles
Errors 1-2%. Credible.

	Collimator	Magnet 1
^{64}Cu/particle	0.28	0.43
^{66}Cu/particle	0.073	0.11
^{60}Co/particle	0.0028	0.0029
^{60}Co/year (nuclei)	$4.1\ 10^{15}$	$4.3\ 10^{15}$
^{60}Co/year (Bq)	17.1 MBq	17.6 MBq

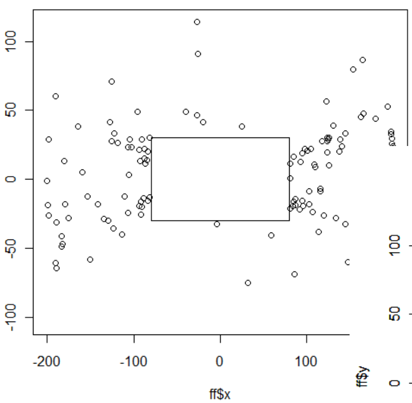
	Coll	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
µGy/s	67	27	27	22	21	27	24	28	24	26	24	27	57

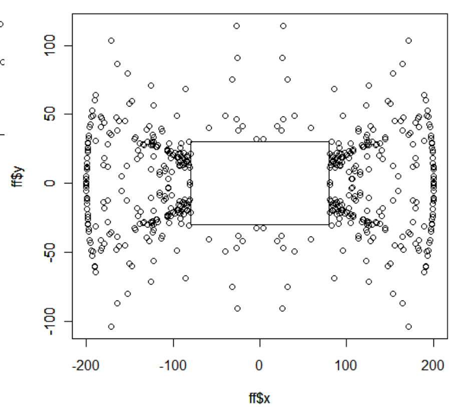
Results-
Source 3: the Collimator

Source 3: Losses on the collimator.
500,000 protons: 136 strike collimator.
Symmetry → 544 xy values for simulation
Normalise to 2 mA x 136/500000

102 min to simulate 100,000 particles
Other magnets doses even lower

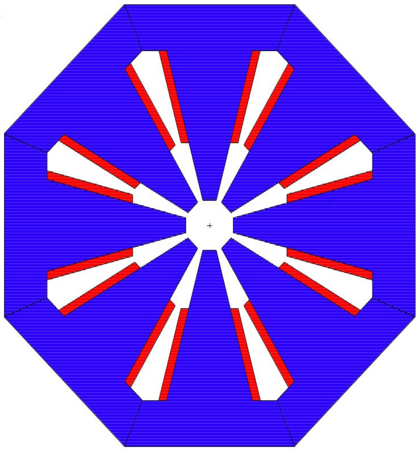
	Collimator	Magnet 1
For 2 mA, Gy/s	2.00	$4.0\ 10^{-5}$
Per 100 day year, kGy	2550	0.77
^{64}Cu/particle	4.49	0.0012
^{66}Cu/particle	1.16	0.00030
^{60}Co/particle	0.045	$6.1\ 10^{-6}$
^{60}Co/225-day-year (nuclei)	$4.7\ 10^{18}$	$6.5\ 10^{14}$
^{60}Co/225-day-year (Bq)	19.8 GBq	2.7 MBq (~90 μCi)

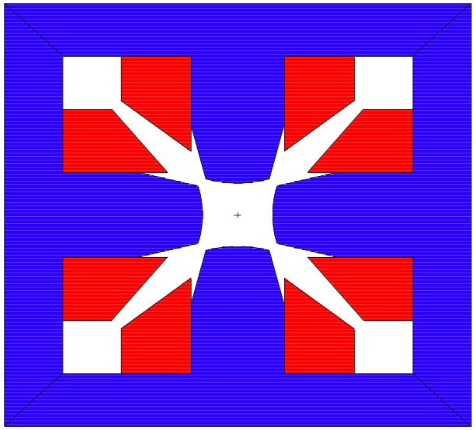




Magnets

Change from Cu/Fe 50:50 cylinders to more realistic models





Copper activation much less, by ~ factor 10:

Previous model was too large and had too much copper

The Collimator

Effect of changing the inner face of the collimator from Tungsten to Copper

Originally 0.045 ^{60}Co produced in collimator for each proton hitting the collimator.

Replacing Tungsten by Copper changes this to 0.040

Despite extra volume of Copper in exposed position which would (on its own) cause a rise to 0.061 !

Future plans

More detailed geometry (with shielding) and more isotopes.

Air and water contamination

Beam losses in spikes at magnets rather than uniformly

Time dependence (Bafeman equations)

Activity during shutdown – gamma ray fluxes from active nuclei, using same geometry

Improve speed and credibility of simulation

Further geometries. Optimisation of shielding.

Estimate neutron backgrounds for instruments