Magnets in the Target Region

International MUON Collider Collaboration

Science & Technology Facilities Council
ISIS Neutron and Muon Source

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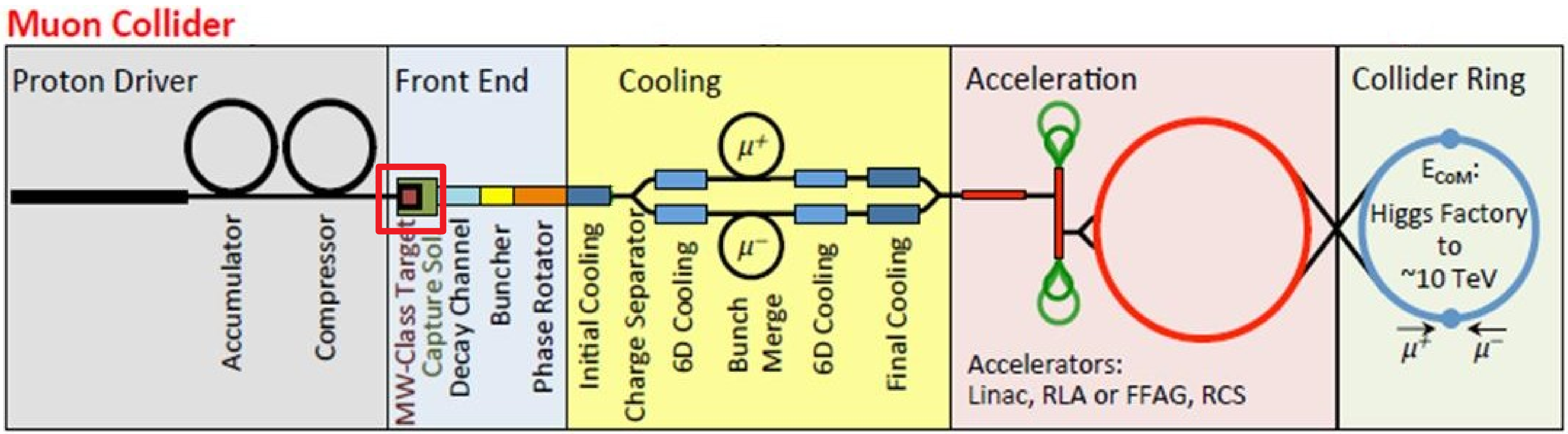
Muon Cooling and Production



- I am not the target expert!
- Original target designers have mostly retired or moved on
  - Harold Kirk, Kirk McDonald, Van Graves, Hisham Sayed, Xiaoping Ding, et al
  - The hard work is there's, the mistakes are mine!
- I designed beam "clean up" for Neutrino Factory
  - Chicane and proton absorber
- Present design for active handling region

Target (2011)

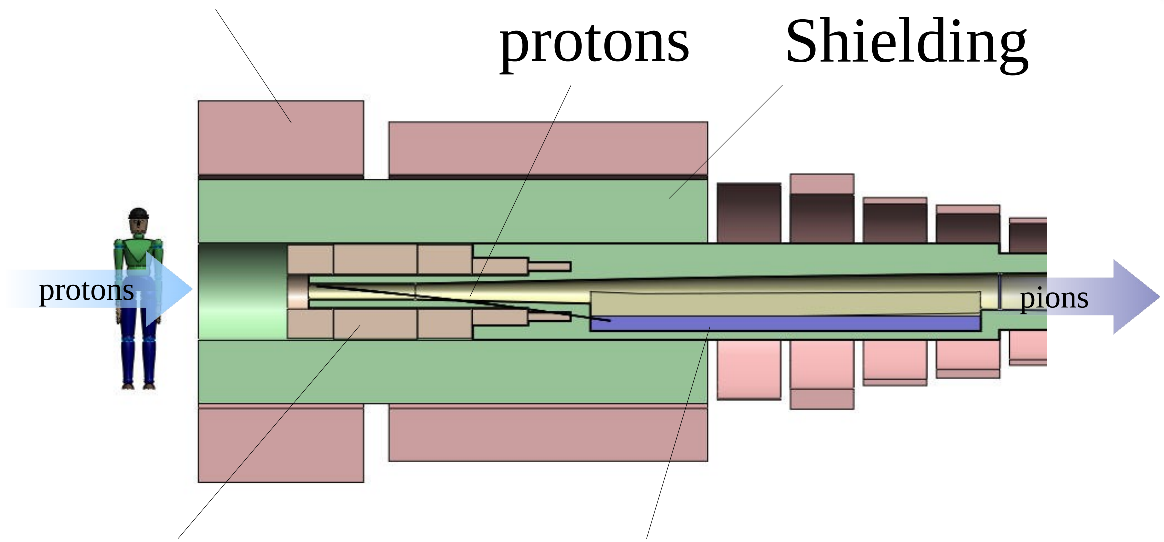
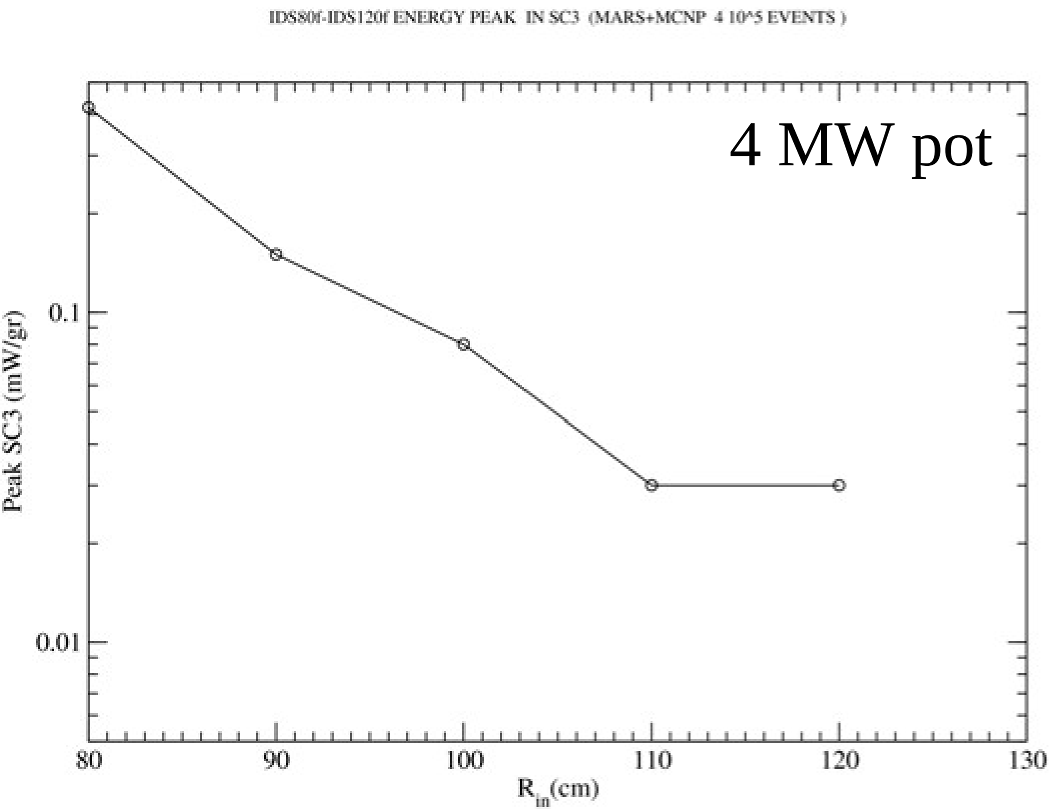


Table 3. Baseline magnet parameters (IDS120f).

Magnet	z_{min} (cm)	Δz (cm)	r_{min} (cm)	Δr (cm)	I (A/mm^2)	Conductor
RC1	-131.3	47.3	17.8	30.24	16.56	Cu
RC2	-84	86.2	17.8	30.88	16.56	Cu
RC3	2.1	56.2	17.8	30.25	16.56	Cu
RC4	58.3	57	17.8	16.6	16.56	Cu
RC5	115.3	43.5	21.88	7.96	16.56	Cu
SC1	-222.6	169.4	120	75.85	23.22	Nb3Sn
SC2	-53.1	26.1	120	54	0	Nb3Sn
SC3	-27.1	327.1	120	54.07	23.1	Nb3Sn
SC4	310	65	110	1.16	29.96	Nb3Sn
SC5	385	65	100	20.76	33.31	Nb3Sn
SC6	460	65	90	6.4	35.85	Nb3Sn
SC7	535	65	80	8.71	38.21	Nb3Sn
SC8	610	65	70	5.61	40	Nb3Sn
SC9	685	65	60	6.06	40	Nb3Sn
SC10	760	65	50	4.72	40	NbTi
SC11	835	65	45	4.6	40	NbTi
SC12	910	65	45	4.42	40	NbTi
SC13	985	65	45	4.31	40	NbTi
SC14	1060	65	45	3.85	40	NbTi
SC15	1135	65	45	3.83	40	NbTi
SC16	1210	65	45	3.51	40	NbTi
SC17	1285	65	45	3.53	40	NbTi
SC18	1360	65	45	3.44	40	NbTi
SC19	1435	140	45	3.24	40	NbTi

- 2 orders of magnitude more beam power
- 1 order of magnitude more field
- Compared to other solenoid capture schemes

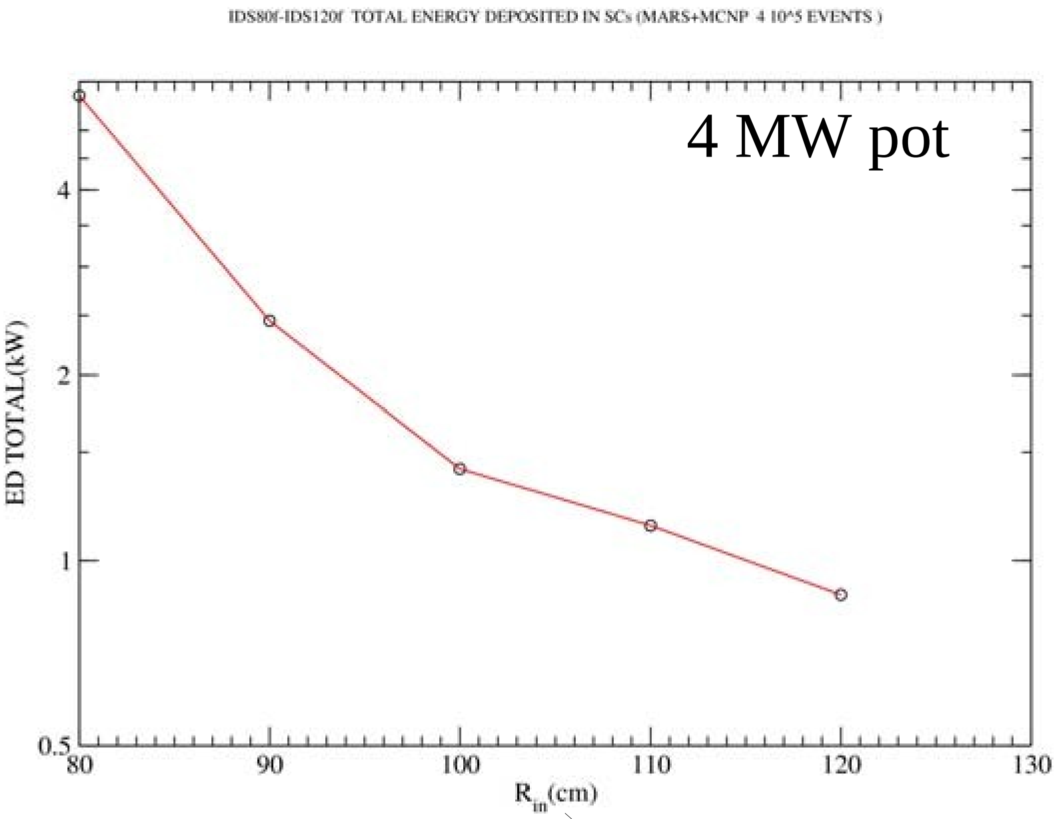
Target (2011)



"Inner radius of SC coils 1-3"

- Concern that power deposition will damage coils
- User ITER spec:
  - < 1 mW/cm^3 peak power

Target (2011)

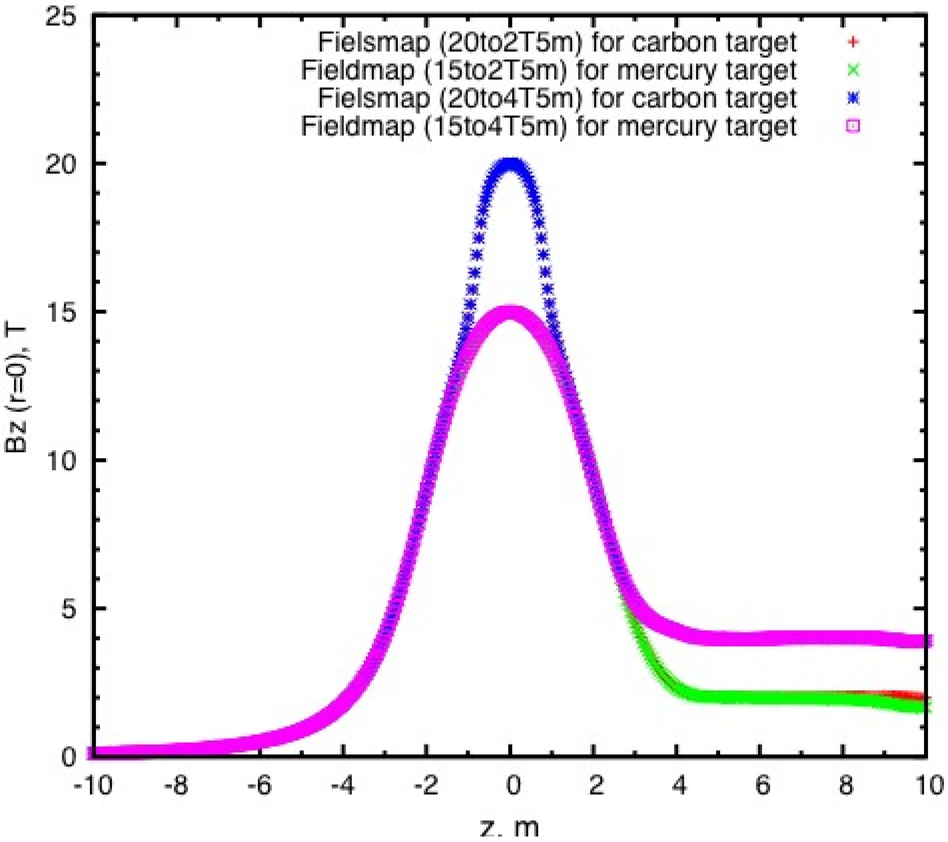


- Concern that cooling requirement is enormous
- Show total power deposited for all SC coils 1-19

"Inner radius of SC coils 1-3"

Target Update (2015)

- By 2015:
  - Front end moved to 325 MHz and 2 T
  - Consider graphite target
  - Consider reduced field on target



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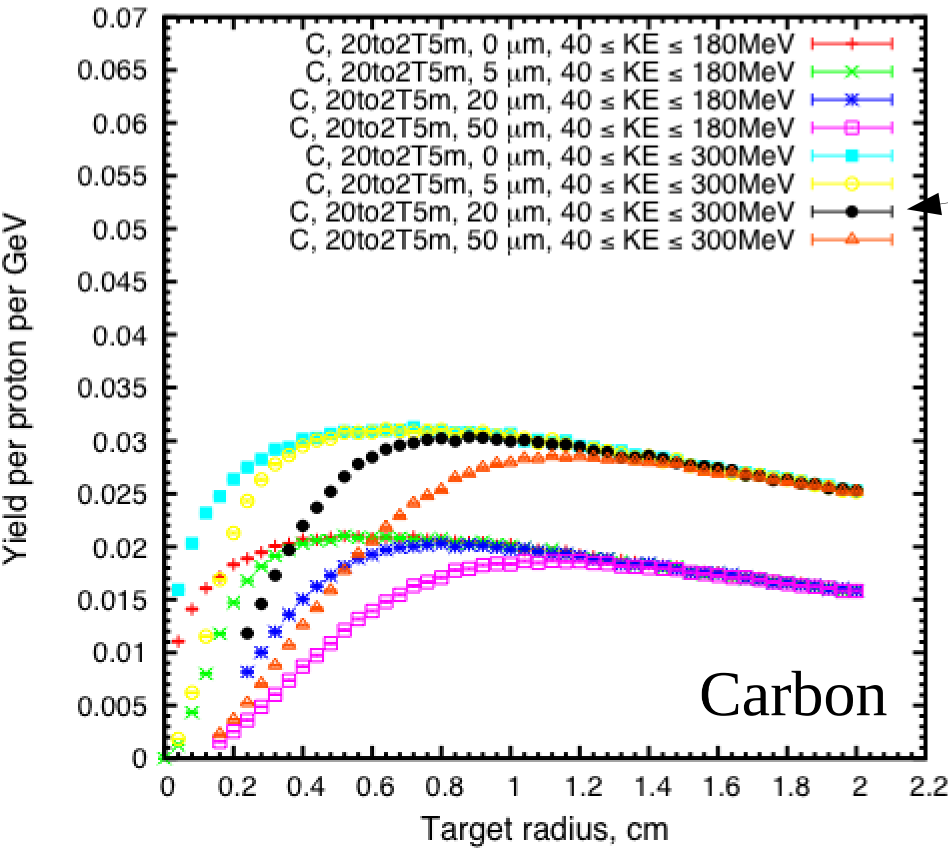
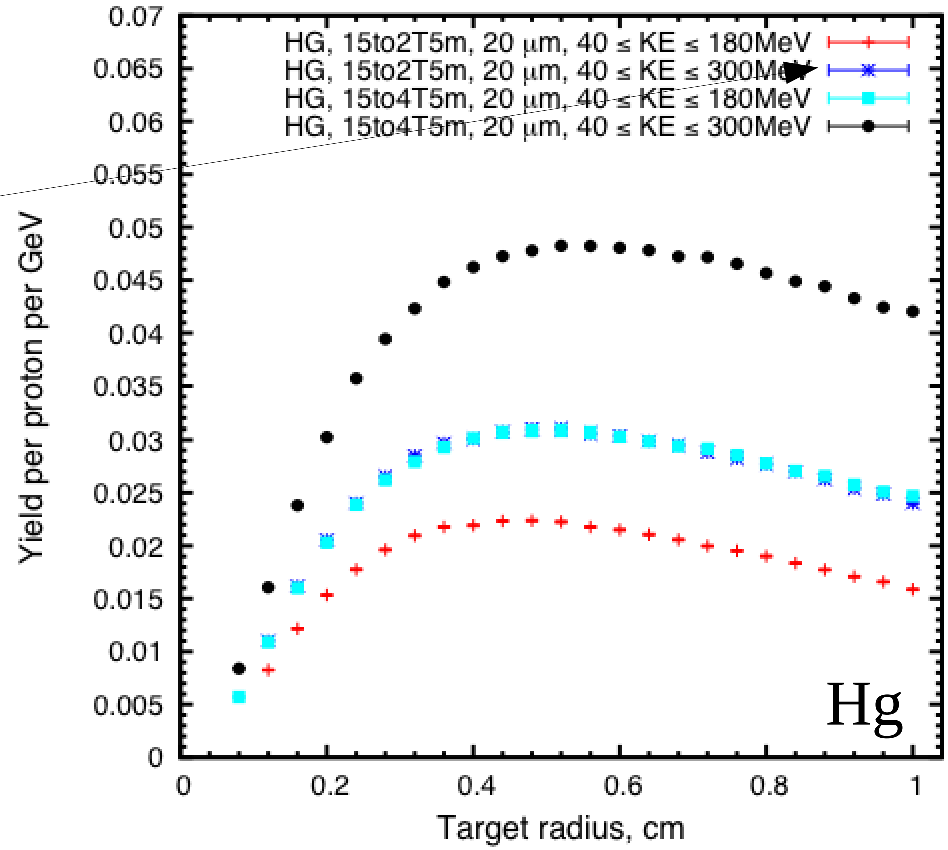
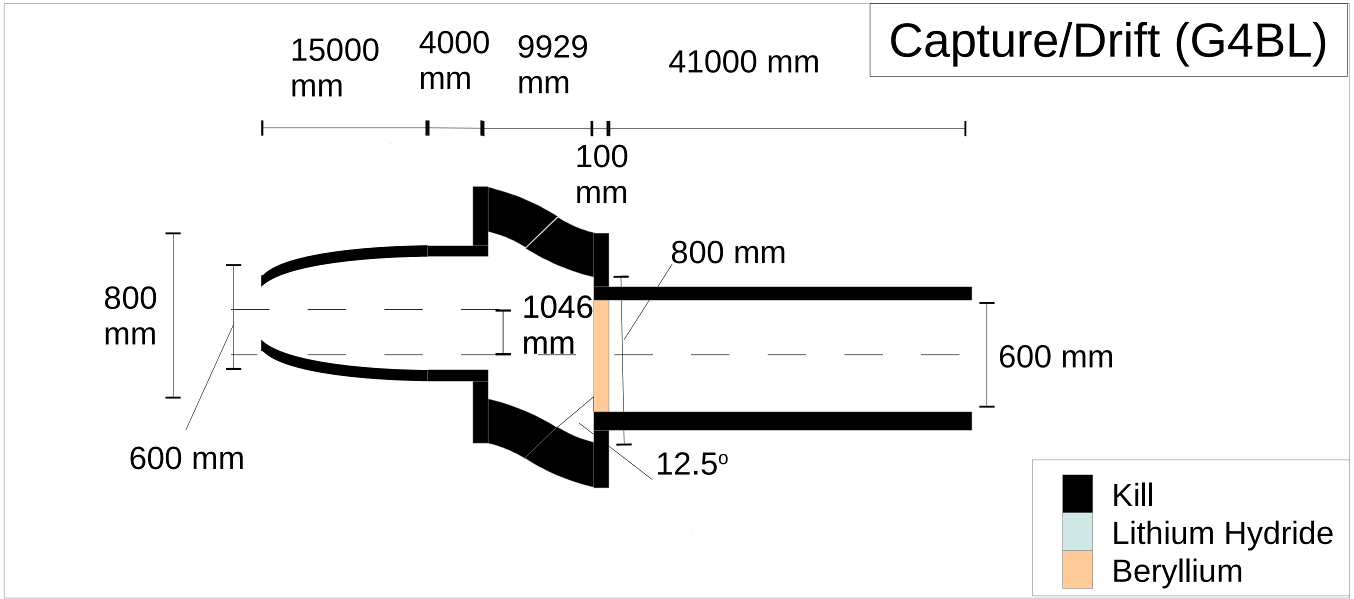
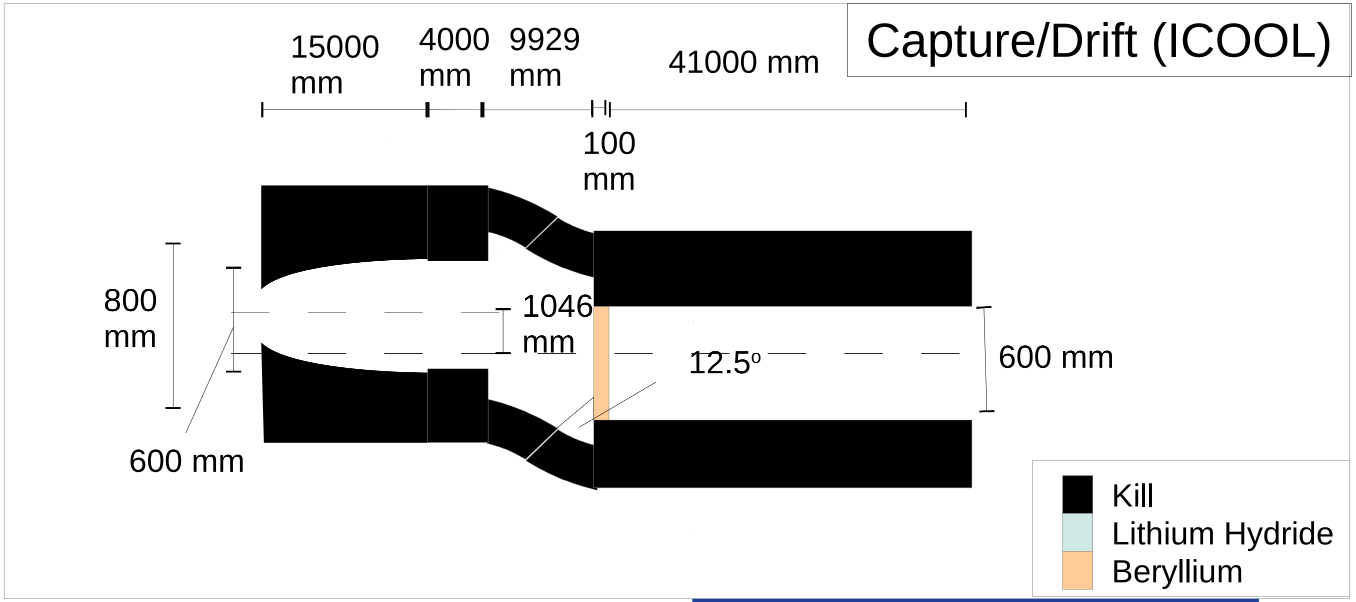
Target Performance (2015)





Capture/Drift (2012)





In target region fields are defined by a coil set

Beampipe radius in target area follows

$$r^2 = \frac{(r_1^2 - r_0^2)\,z}{z_1} + r_0^2$$

with

R_0 = 75 mm
r_1 = 300 mm
z_1 = 15000 mm

In G4BL this is implemented as a volume of rotation with rotation surface found by linear interpolation off grid points every 5 mm in r. In ICOOL a series of cylinders are used with inner edge every ~ 5 mm in r.

The chicane consists of a bend and reverse bend through 12.5° with radius of curvature 22917 mm to the centre of the beam pipe. In ICOOL this is simulated using an idealised $B_s \sim 1/r$; in G4BL this is simulated using coils arranged periodically on the toroid.

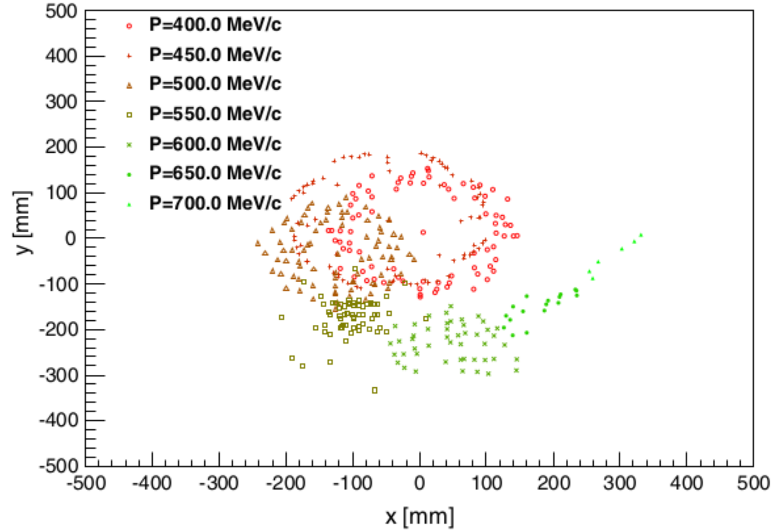
Note due to the "cartoon" nature of the schematic the transverse displacement in the chicane looks deceptively small – it is in fact a little more than 1 beam pipe diameter.

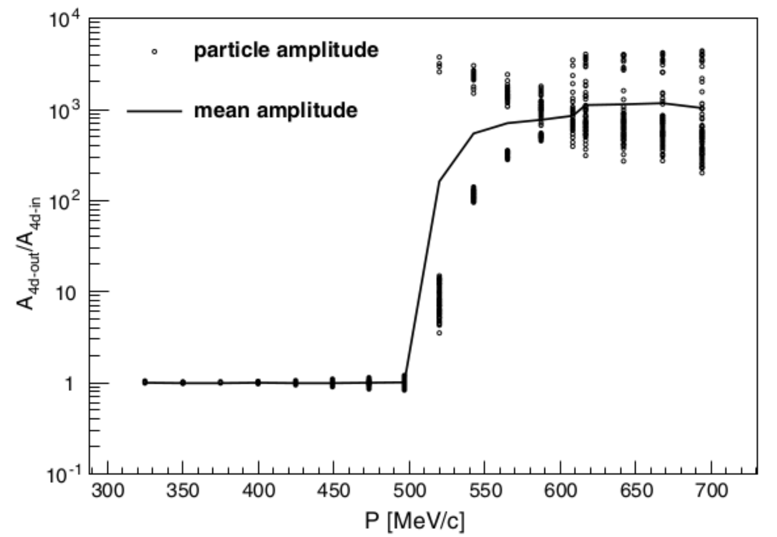
G4BL chicane coils have:
Inner radius: 430 mm
Outer radius: 530 mm
Length: 180 mm
Current Density: 16.57 A/mm²
Placed at 0.625° intervals (250 mm in *s*)

From the end of the chicane onwards both lattices use constant 1.5 T field

Chicane (2012)

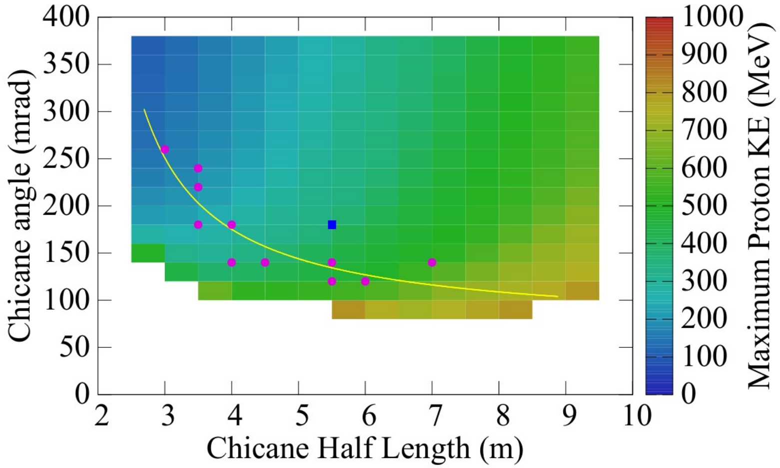
- Secondary particles in the beam from target
  - O(kW/m) of hadronic power deposition in the buncher/phase rotator
  - Needs to be cleaned!
- Pure solenoid chicane
  - No dipoles
- Induces vertical dispersion
  - Momentum acceptance depends on bend parameters
  - Sharp cut-off
- Off-momentum particles are lost on the chicane aperture
  - 100s of kW

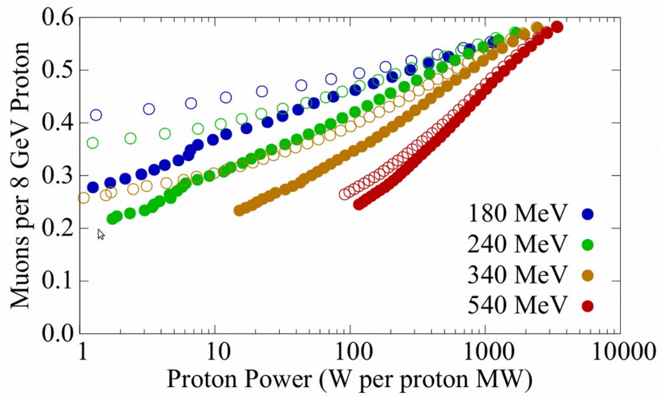




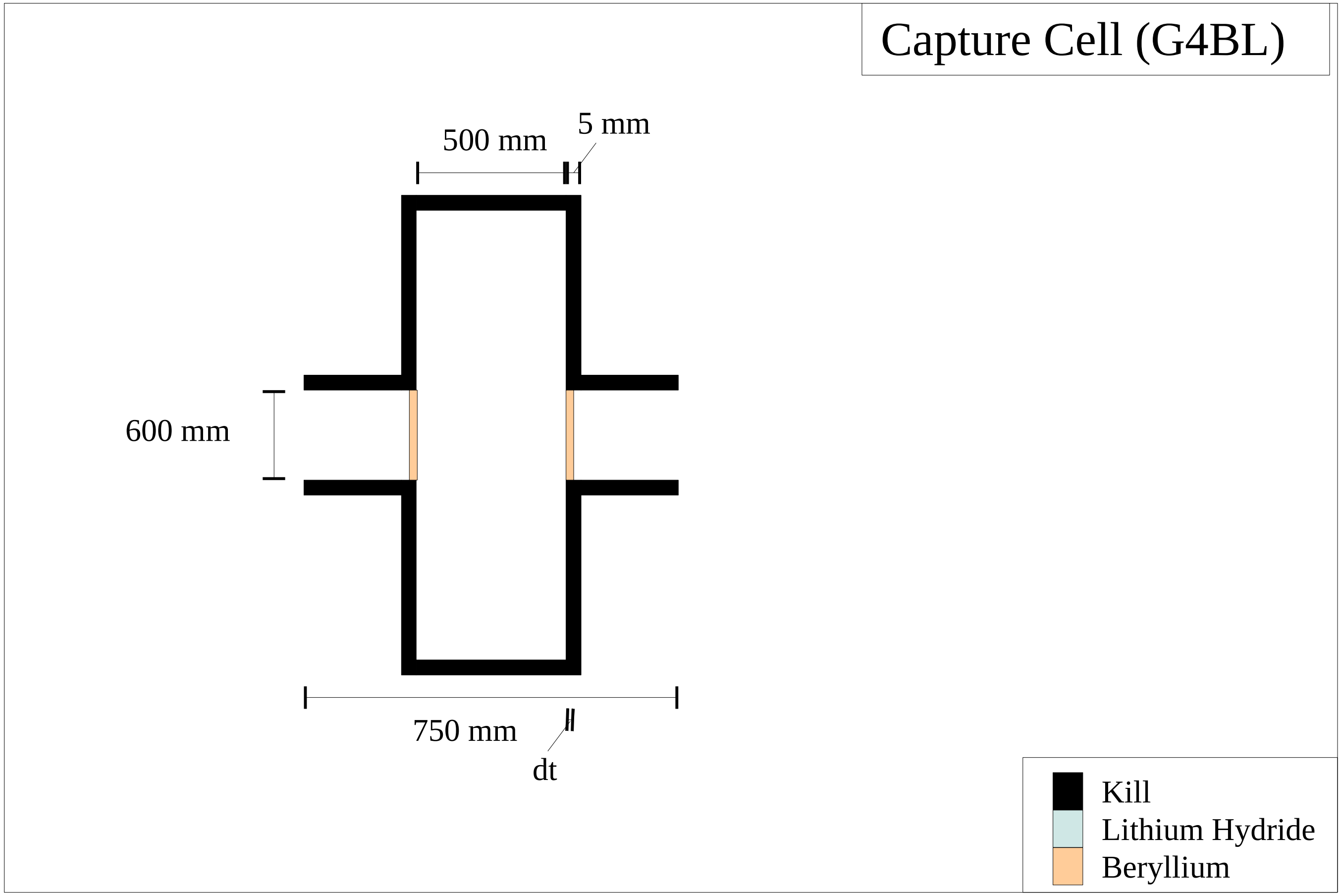
Chicane (2014)

- Capture region field updated to 2 T
- Bend angle re-optimised
- Proton absorber moved 30 m downstream
  - Not sure I agree with the optimisation that was done here





Buncher/Phase rotator (2012)

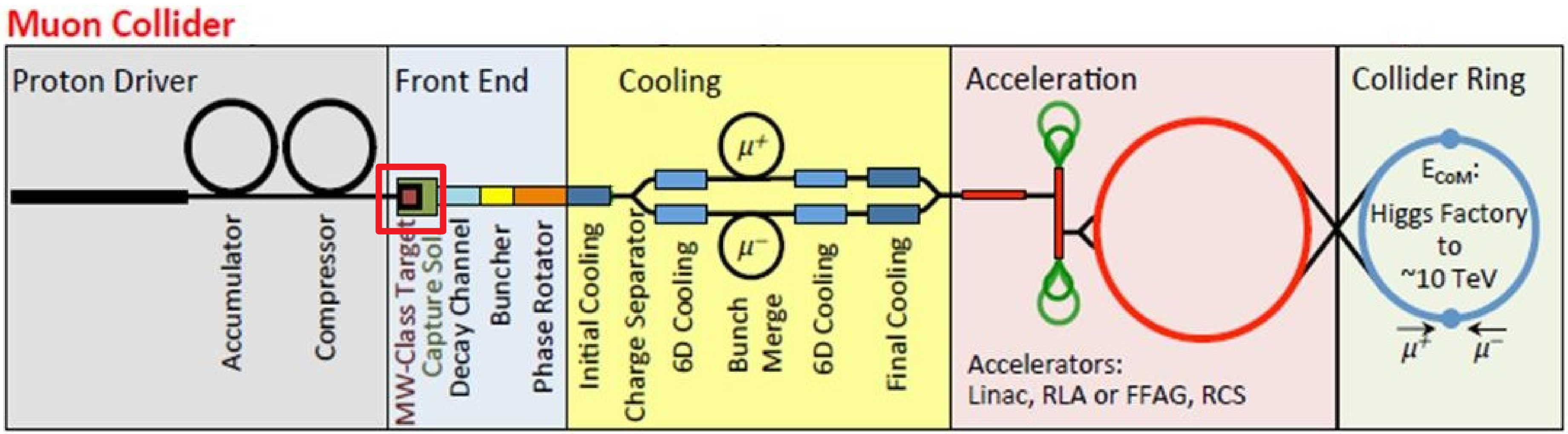


Uniform 2 T field assumed

92 cells

0.75 m long

Muon Production – Issues for Magnets



- Demanding magnets
- Significant radiation load and heat load
- Note concern about beam dump