6DMANX: MANX as a Cooling Demonstration

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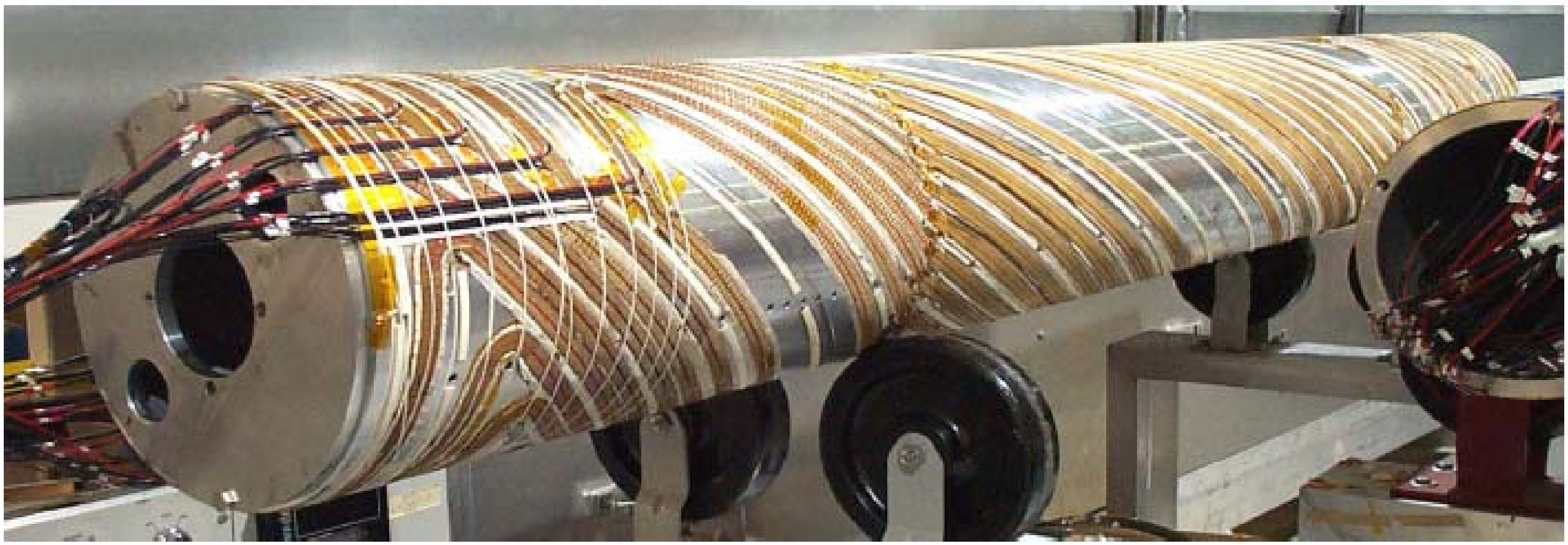
Helical Magnets



Helical coils for the AGS snake

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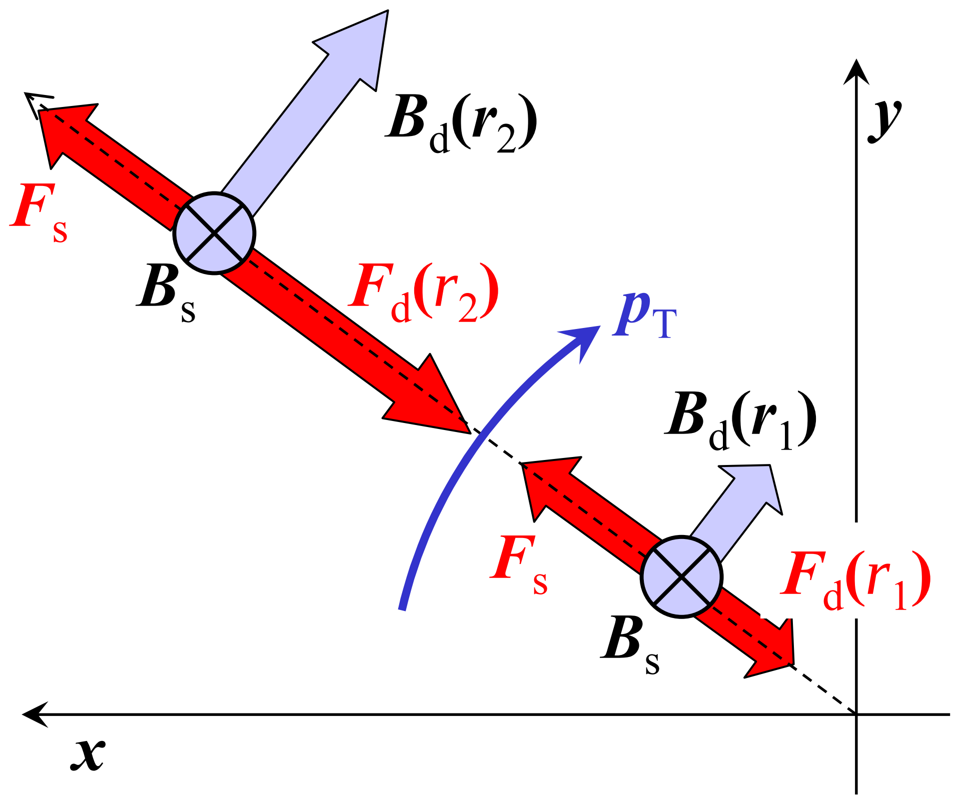
Introduction: Helical Fields

- $\boldsymbol{B}_{\mathrm{d}}$ increases with radius (*Modified Bessel Function*)
- $\boldsymbol{B}_{\mathrm{s}}$ uniform
- $\boldsymbol{F}_{\mathrm{s}}$ and $\boldsymbol{F}_{\mathrm{d}}$ oppose!
- Reference orbit radius:

  $\boldsymbol{F}_{\mathrm{d}}(\boldsymbol{a}) > \boldsymbol{F}_{\mathrm{s}}$
- Pitch angle, $\boldsymbol{\theta}$:

  $\boldsymbol{\kappa} = \boldsymbol{ka} = \tan \boldsymbol{\theta} = \boldsymbol{p}_{\mathrm{T}} / \boldsymbol{p}_{\mathrm{z}}$



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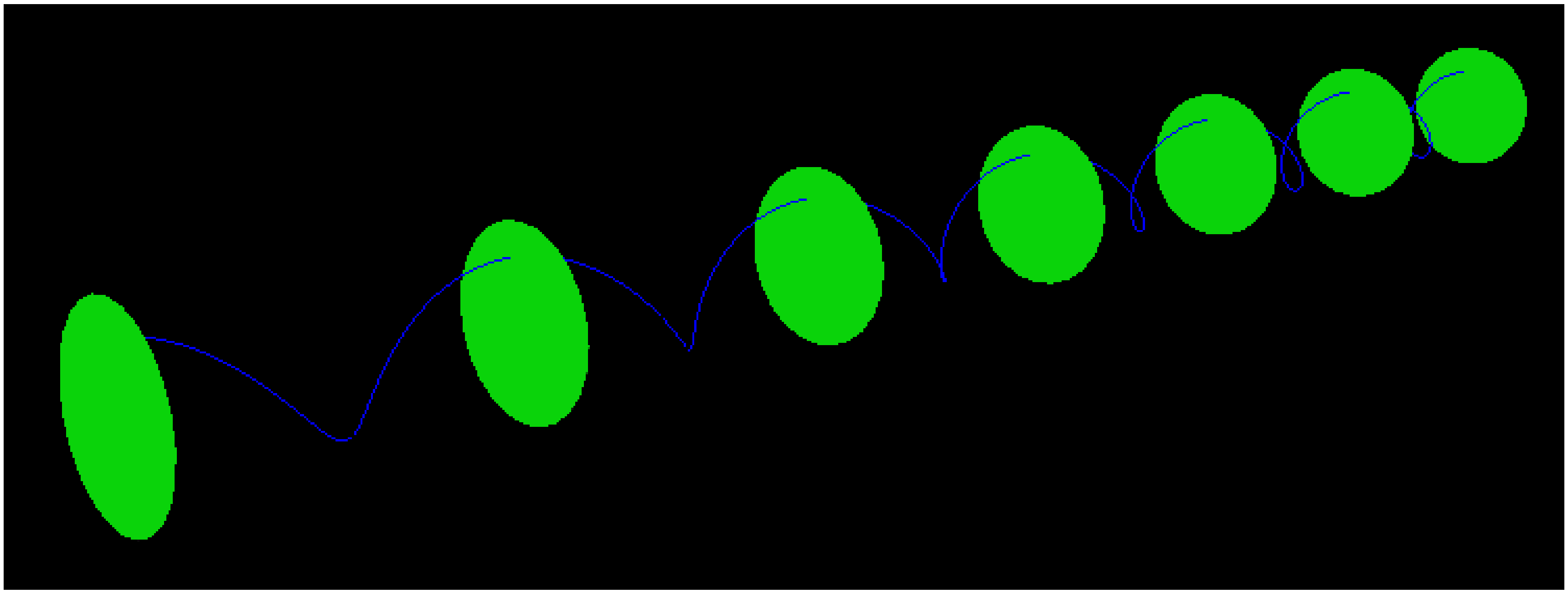
The Reference Orbit



- Helical Period: 1 m
- Total Length: ~5 m
- Pitch Angle: 45°
- Radius of Orbit: 15.92 cm

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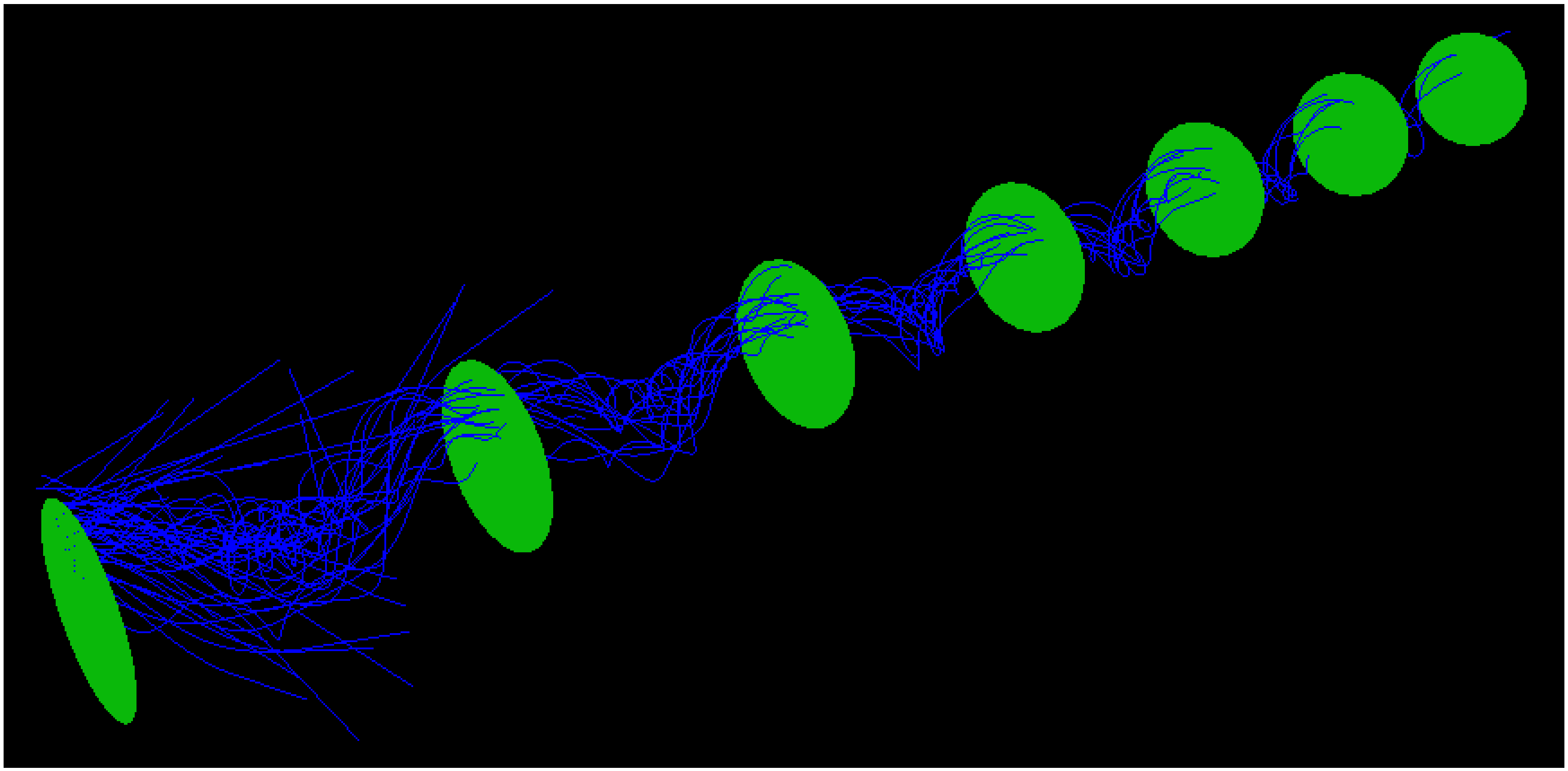
The Beam



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Helical Channels

- Advantages:
  - Continuous transverse focusing ➡ *Transverse Cooling*
  - Dispersion ➡ *Longitudinal Cooling*
  - Very large acceptances
- Complications:
  - Torsion in reference orbit
  - Strongly coupled dynamics
  - Strong fields at conductors

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Proposal: Helical Cooling Demonstration

- Fill channel with absorbing material
  - LH_2 (*better cooling*)
  - LHe (maybe safer; useful for SC magnets)
- ***No*** RF:
  - Bring conductors closer to central axis
  - Need higher momentum at injection
  - Adiabatically decrease fields with momentum
  - Eject beam before it ranges out

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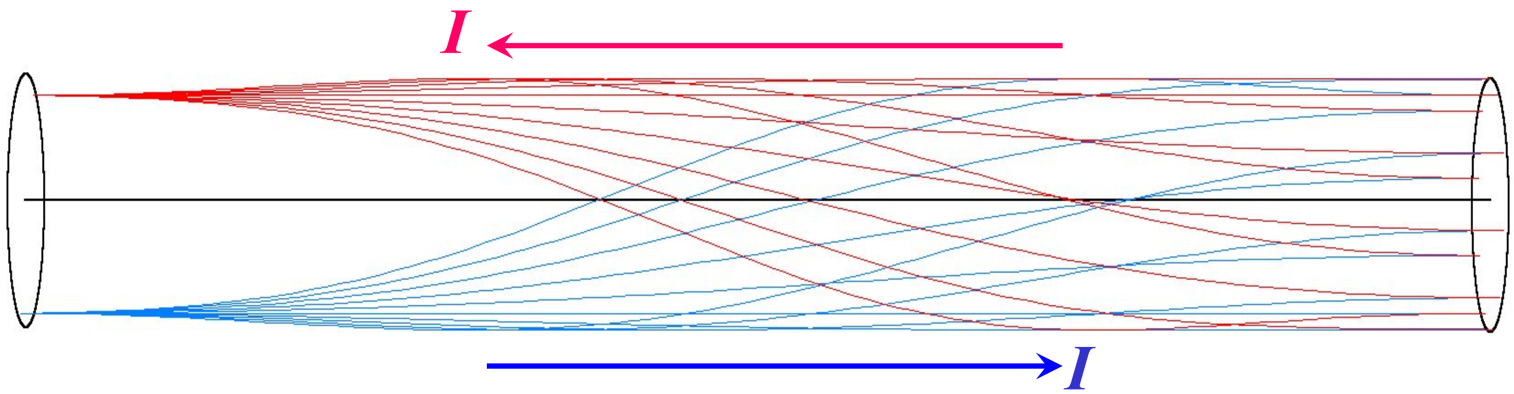
Realizing Adiabatic Fields



- Wires tightly bound at upstream end
- Wires uniformly distributed at downstream end
- Creates one-half of an adiabatically *decreasing* dipole
- "Now, twist!"

Channel Parameters (LH_2)

			Initial	1 m	2 m	3 m	4 m	5 m	6 m
p	*MeV/c*		400	357.9	315.4	272.0	227.2	179.4	124.9
|dE/dx|	*MeV/m*	*PDG 27.1*	28.6	28.7	28.9	29.2	29.9	31.6	36.4
λ	*m*		1	1	1	1	1	1	1
k	*1/m*	2π/λ	6.28	6.28	6.28	6.28	6.28	6.28	6.28
a	*m*		0.159	0.159	0.159	0.159	0.159	0.159	0.159
κ		ka	1	1	1	1	1	1	1
p_T	*MeV/c*	*from* $\kappa = p_T / p_z$	282.8	253.1	223.0	192.4	160.6	126.9	88.3
p_z	*MeV/c*		282.8	253.1	223.0	192.4	160.6	126.9	88.3
B	*T*	*MUC-284 pg 14*	11.8	10.6	9.2	7.9	6.5	5.0	3.4
b_d	*T*	*MUC-284 III.2-3*	3.53	3.12	2.69	2.25	1.79	1.30	0.787
b_q	*T/m*	*MUC-284 III.2-3*	-9.49	-8.20	-6.87	-5.49	-4.07	-2.62	-1.22

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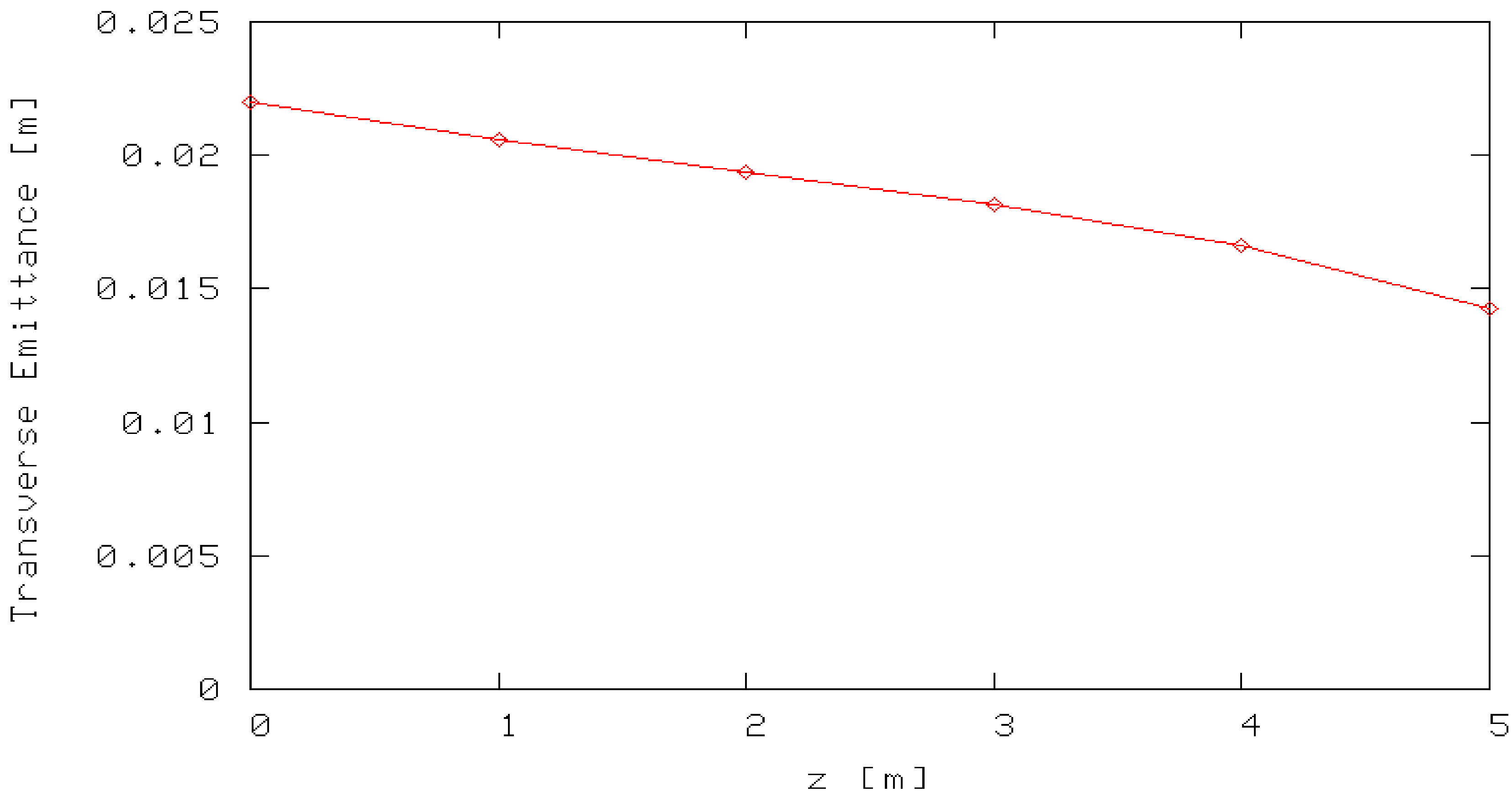
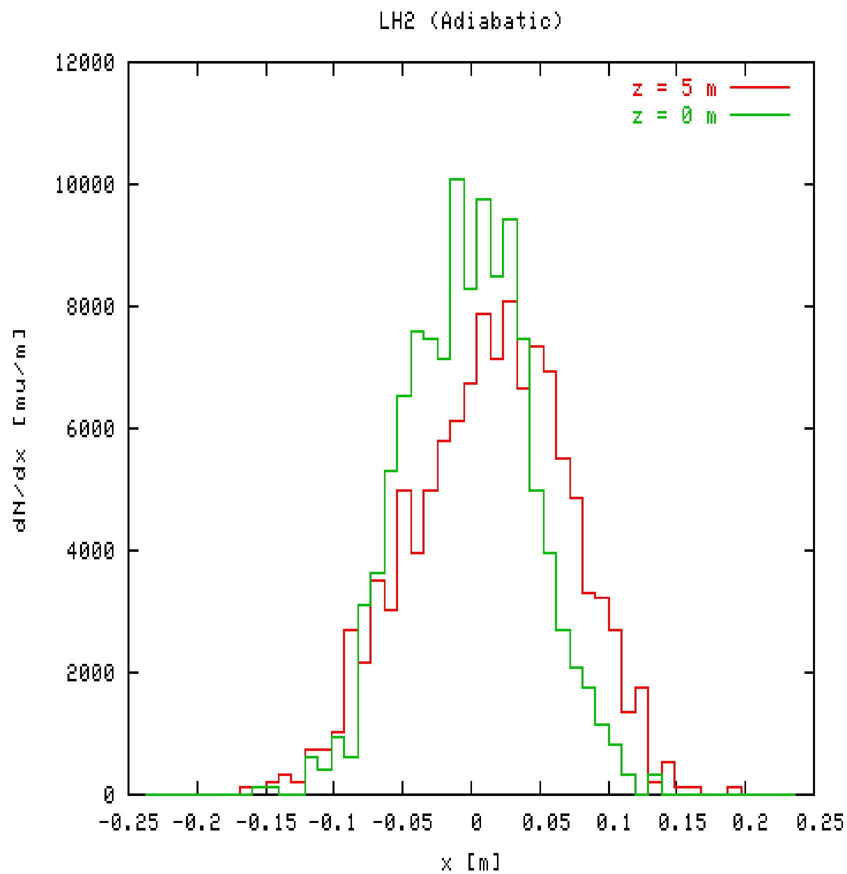
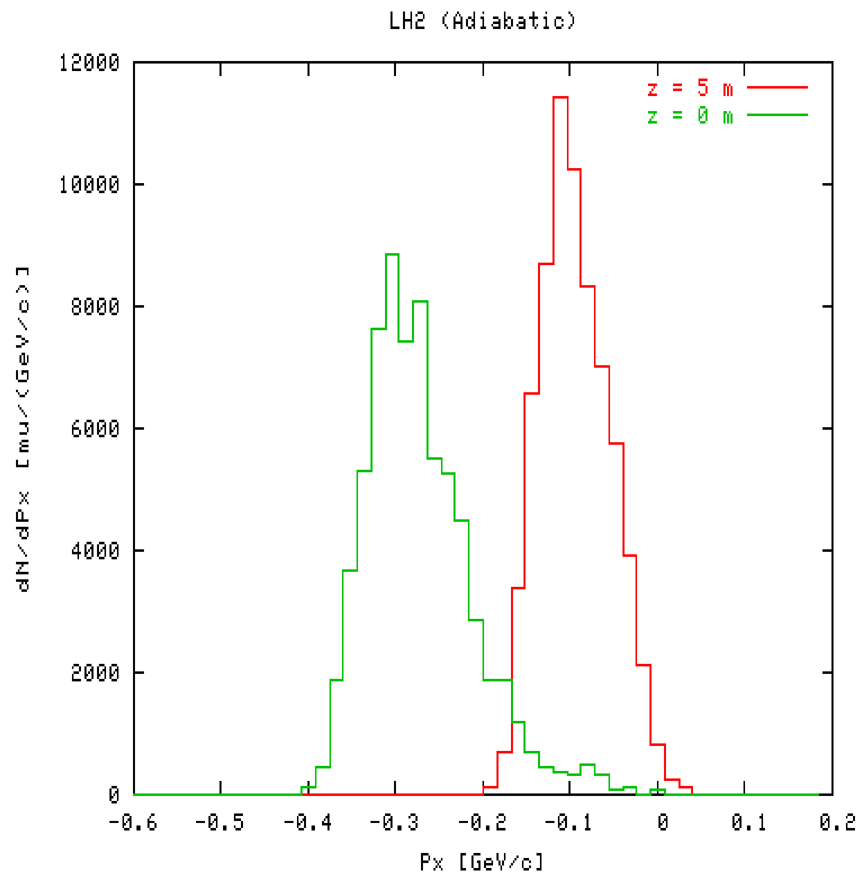
Transverse Cooling (LH_2)

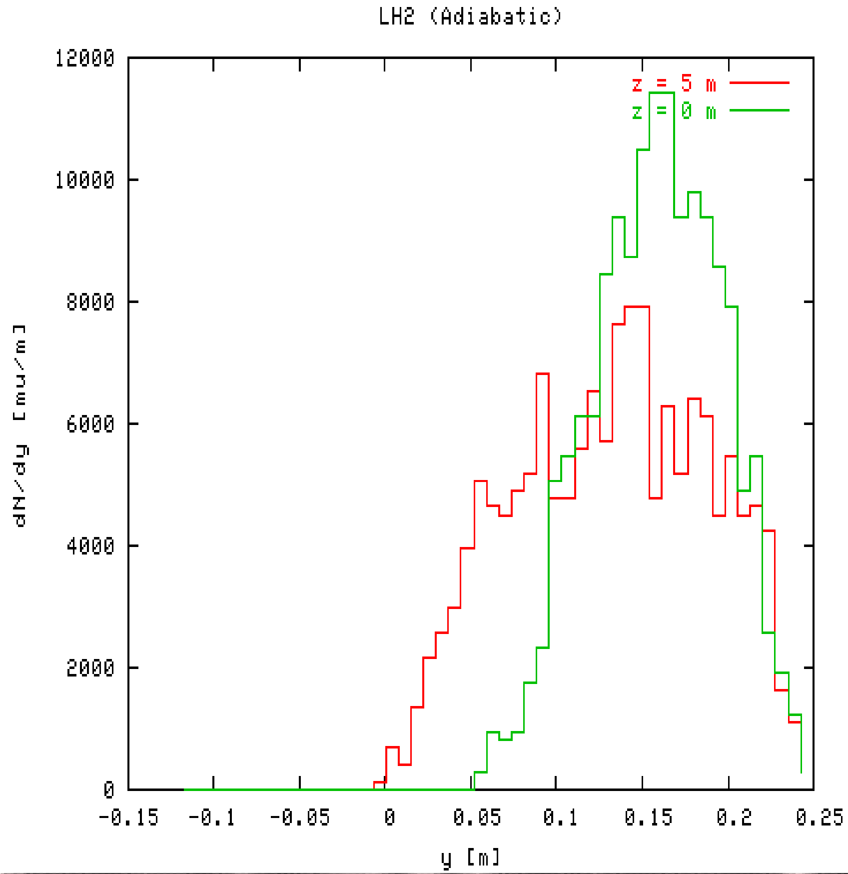


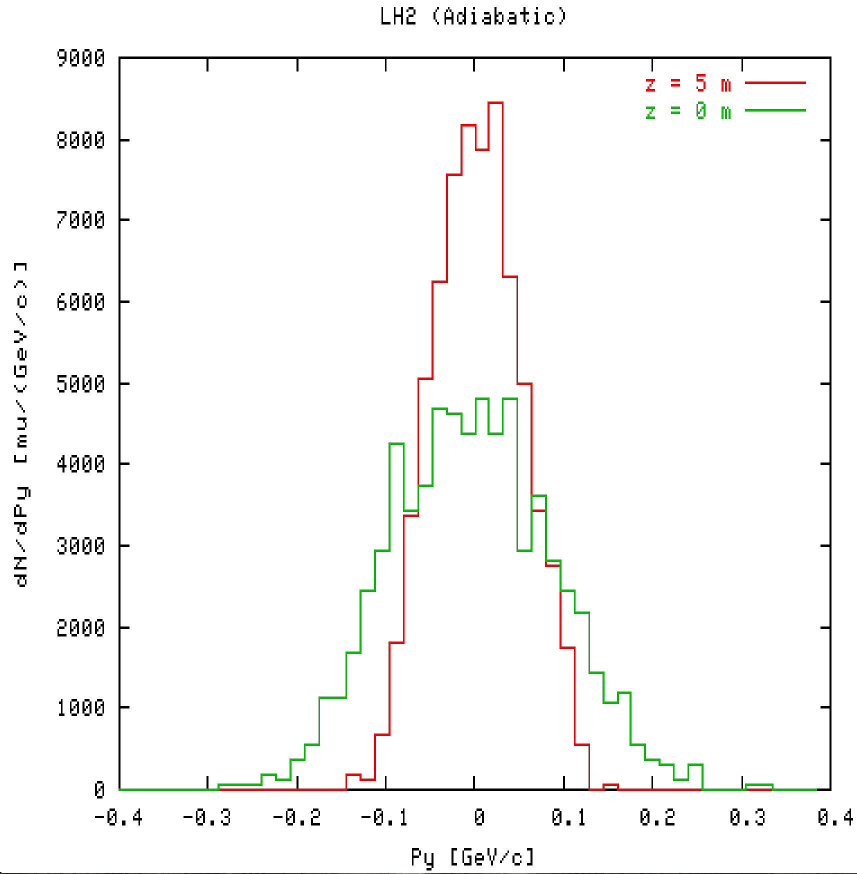
Azimuthal Distribution (LH_2)



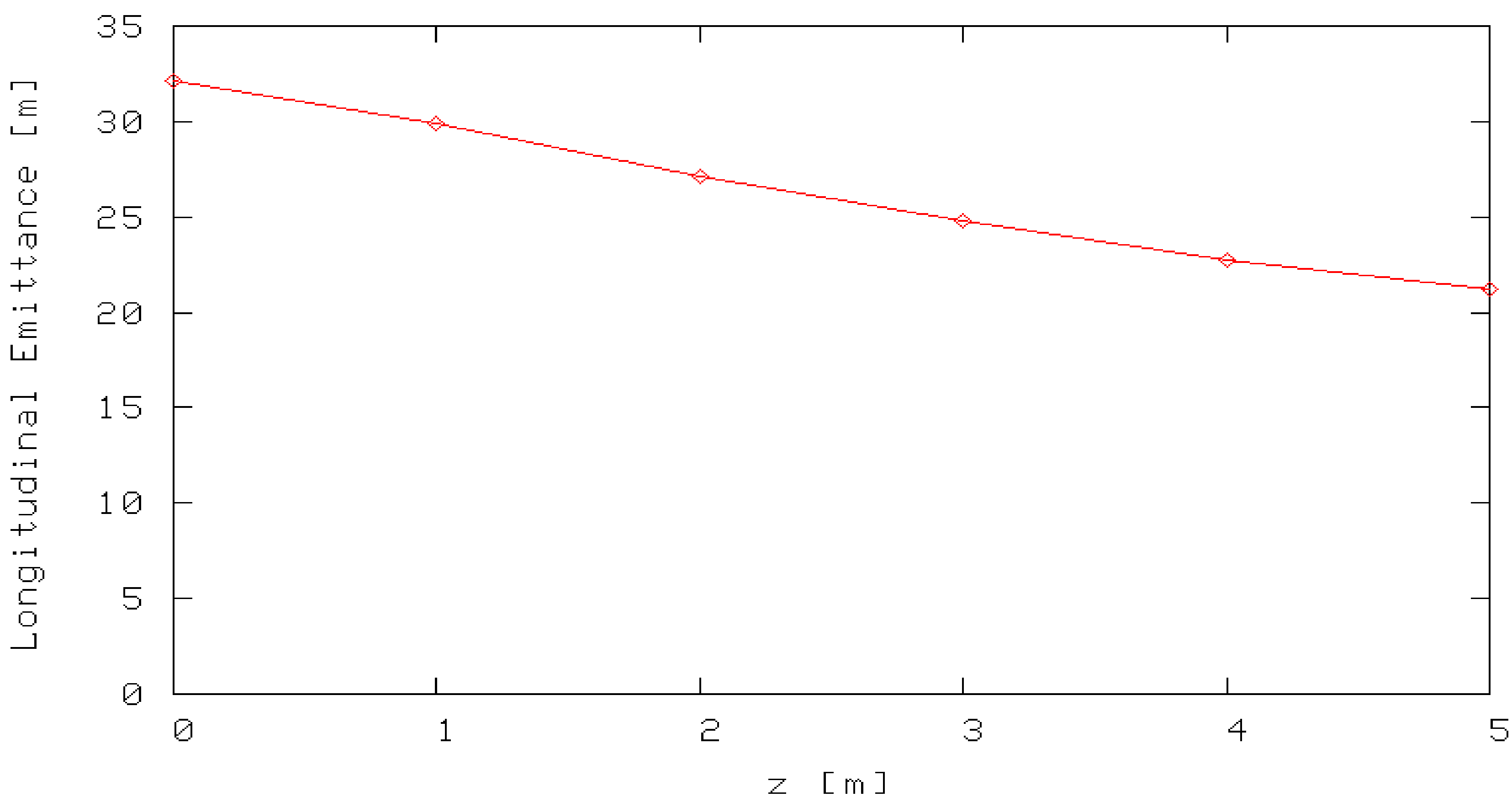


Radial Distribution (LH_2)

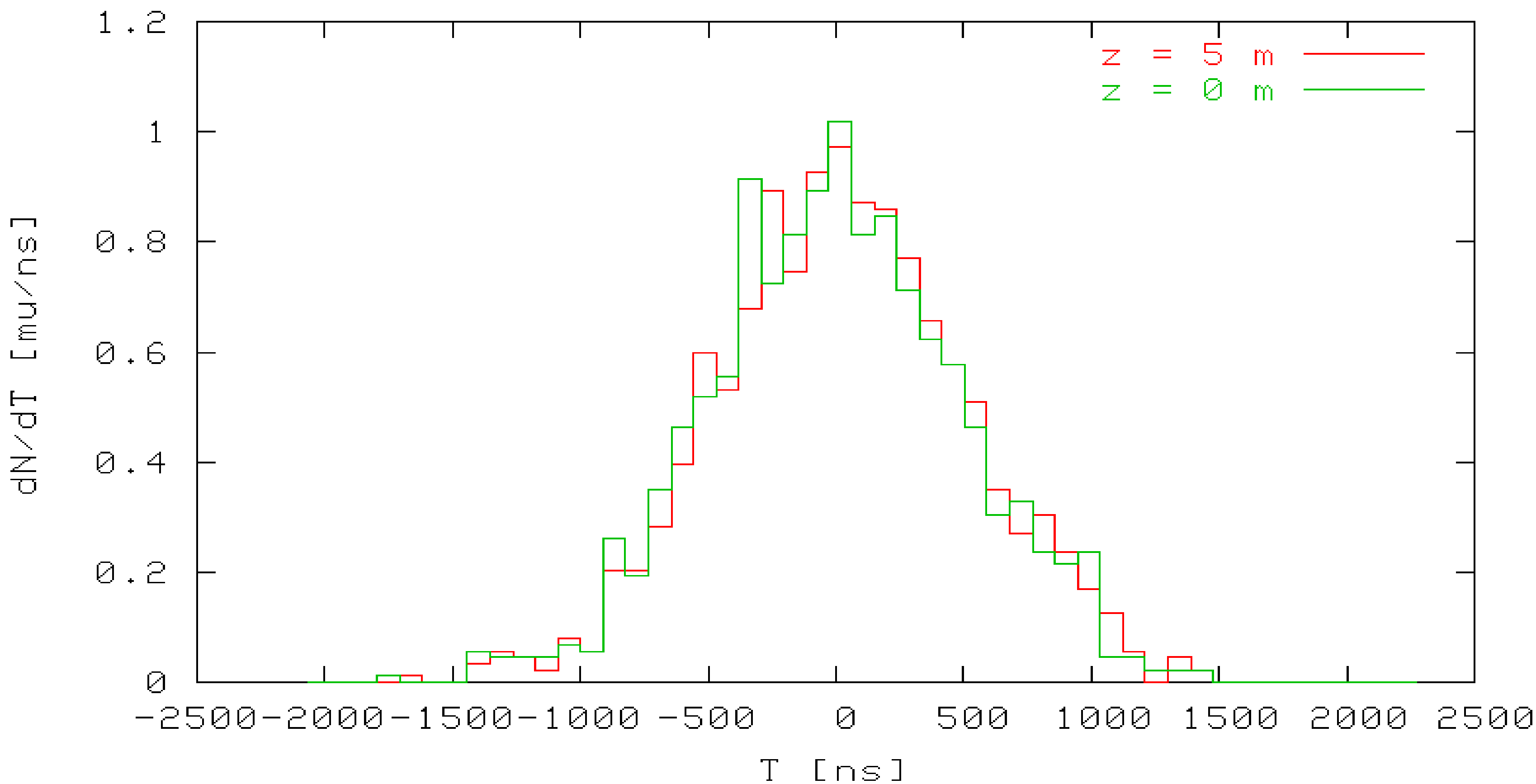




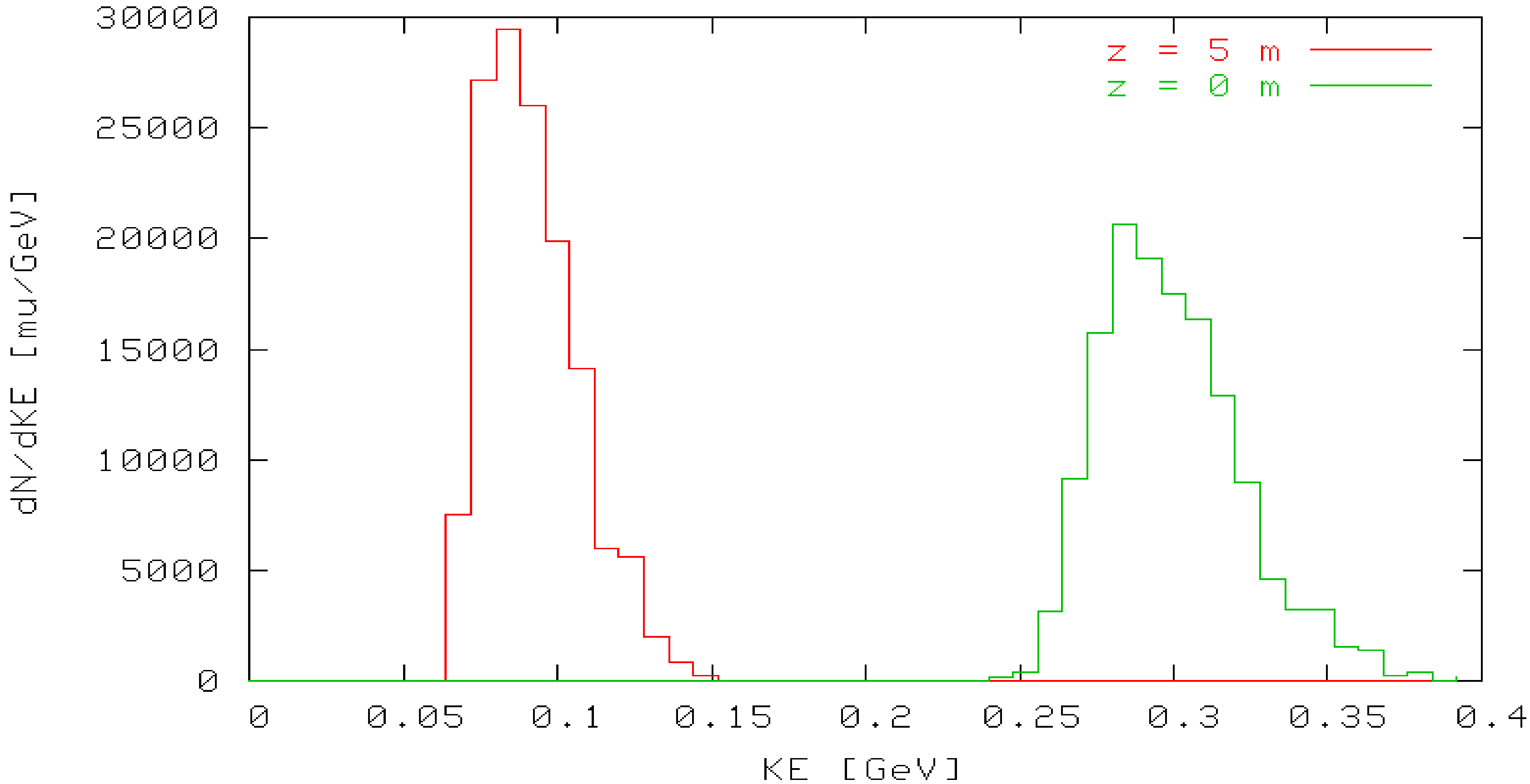
Longitudinal Cooling (LH_2)



Time of Flight Distribution (LH_2)



Kinetic Energy Distribution (LH_2)



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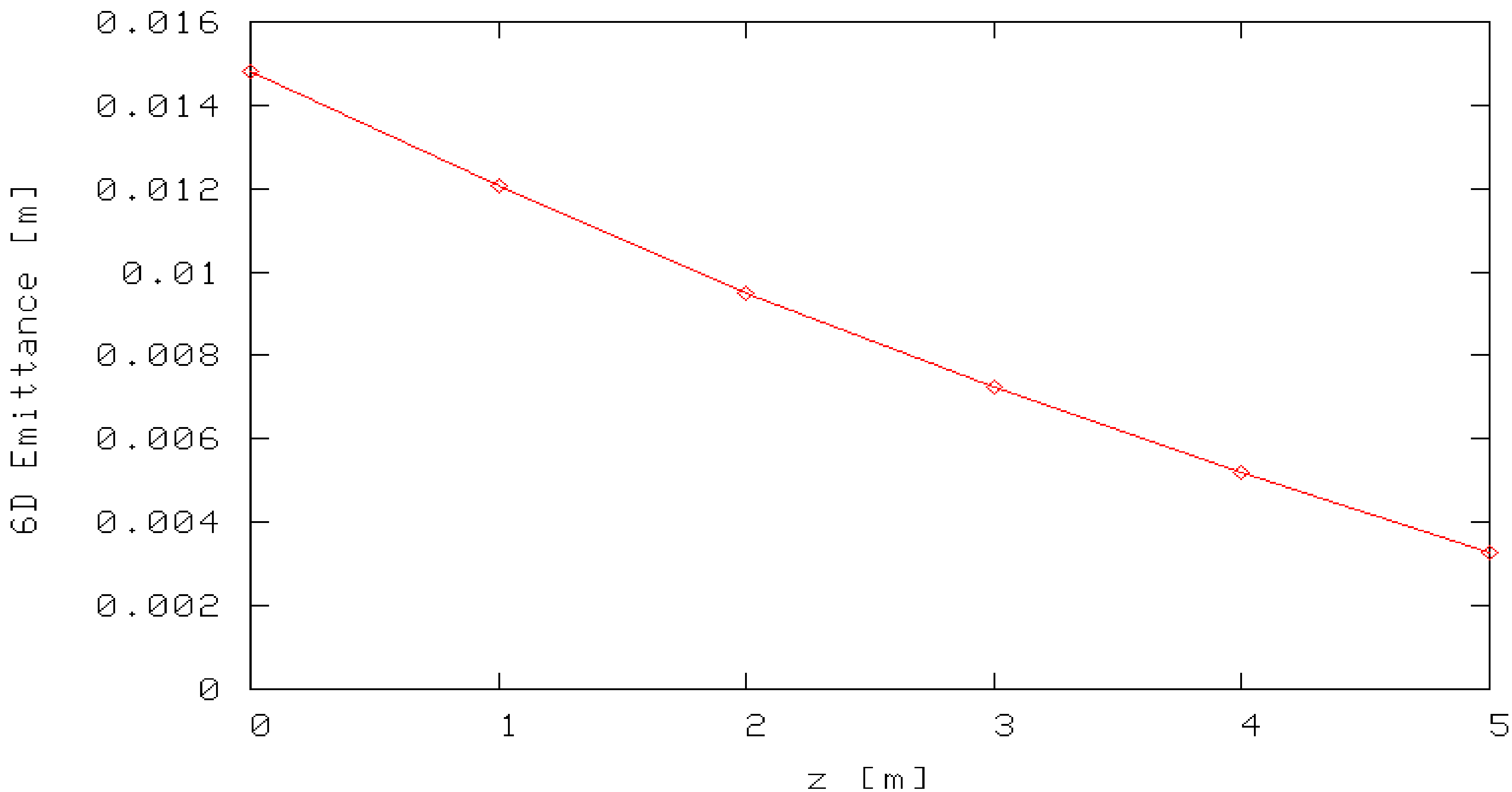
6D Cooling (LH_2)



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Cooling Summary

- Transverse Cooling over 5 m:
  - LH_2: 22 mm•rad → 14 mm•rad (-36%)
- Longitudinal Cooling over 5 m:
  - LH_2: 32 m → 21 m (-34%)
- 6D Cooling over 5 m:
  - LH_2: $0.015\ m^3 \rightarrow 0.003\ m^3$ (-80%)

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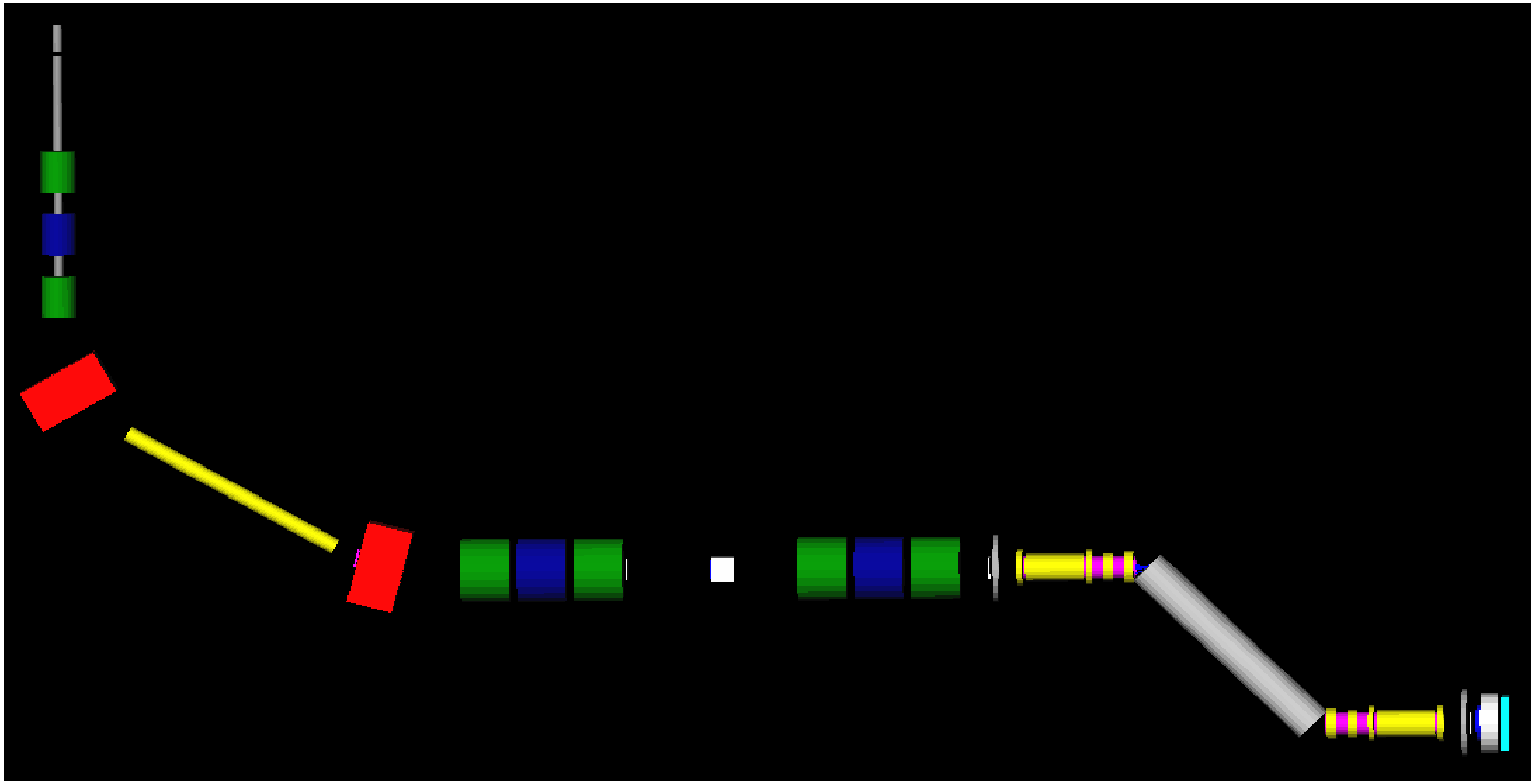
MANX



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Future Considerations (Phase II)

- Additions to the design:
  - Windows (MICE?)
  - Scifi (MICE?)
- Beam parameters:
  - Can RAL get up to 400 MeV/c?
  - Realistic beam characteristics
- Other realistic considerations:
  - Hydrogen refrigeration (H2Cryo Phase II)
  - HTSC (may help determine maximum achievable fields)

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