Tools and Modelling of Collimators

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Outline

- Introduction
- Theorist activity
- Simulation activity
- Conclusion/Plans

Introduction

- LC-ABD WP5.3/EUROTeV WP2 (BDS)
- Collimation is crucial for beam delivery and detector protection/performance
- Quantification of longitudinal and transverse wakefield effects of collimators on the beam
- Optimization of collimator design
- Towards advanced use and understanding of simulation tools, and potential improvements.
- Verification by test beam measurement

Theoretical Studies

- Standard approach for analytical solution of electron beam dynamic systems:
  - Describe a beam by field parameters
  - Solve Maxwell's equations
  - Calculate a momentum kick (integrate wakefield along path)
- New Lancaster Theory Group Approach:
  - Ultrarelativistic descriptions of the coupled EM field and electron beam dynamics (Maxwell's Equations & Lorentz force)
  - Understand the approximations necessary for the calculations.

Assessment/Familiarization of Simulation Tools

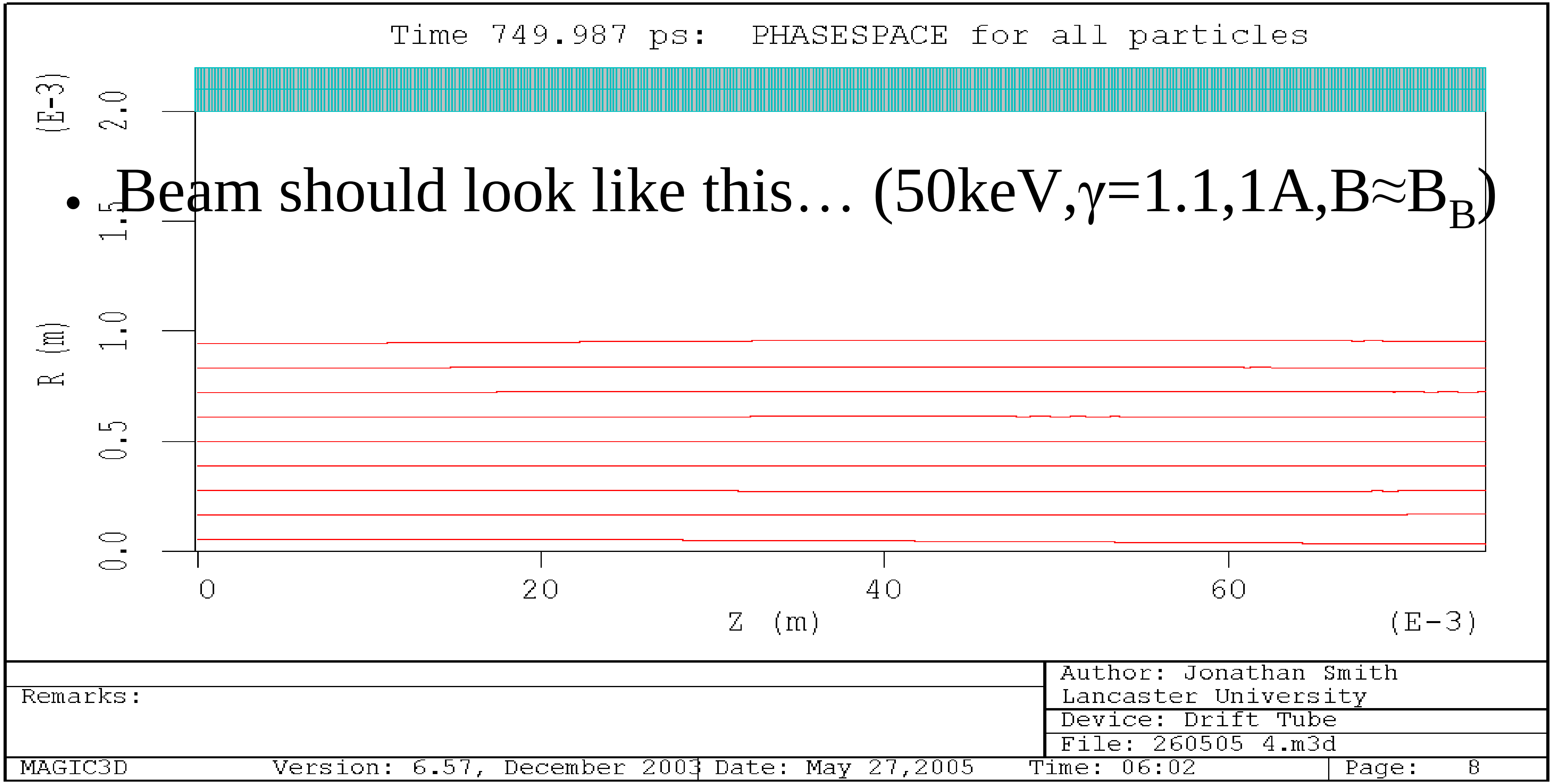
- MAFIA
- MAGIC (easy to use tool for first comparison with calculations)
- ECHO/ECHO3D
  - Thomas Weiland (Darmstadt). Code in development as part of EUROTeV project
- GdfidL
  - Overlapping interest with David Miller and Alexei Liapine (UCL) as part of EUROTeV WP5 (Spectrometry)
- Additional software for research if required:
  - BCI/TBCI/ABCI (old CERN tools), XWAKE, XOOPIC
  - Tau3P, Omega, T3P (next generation SLAC codes)

Comparison: MAGIC-Theory

- Test consists of a comparison between simulation and calculations for Brillouin flow
- Analytic solutions exist in literature
- Comparison of $B_B(r_{eq},I_{beam},V_{beam})$
  - Literature review
  - MAGIC
  - Analytical solutions using MAPLE.
- Agreement of B_B between MAGIC & analytic formula of ~20%
- $E_r(r)$ and $\omega(r)$ fields inconsistent between calculations and model
- Spurious $E_z \neq 0$ field

Brillouin Flow Simulation in MAGIC

- Beam should look like this… (50keV,γ=1.1,1A,B≈B_B)



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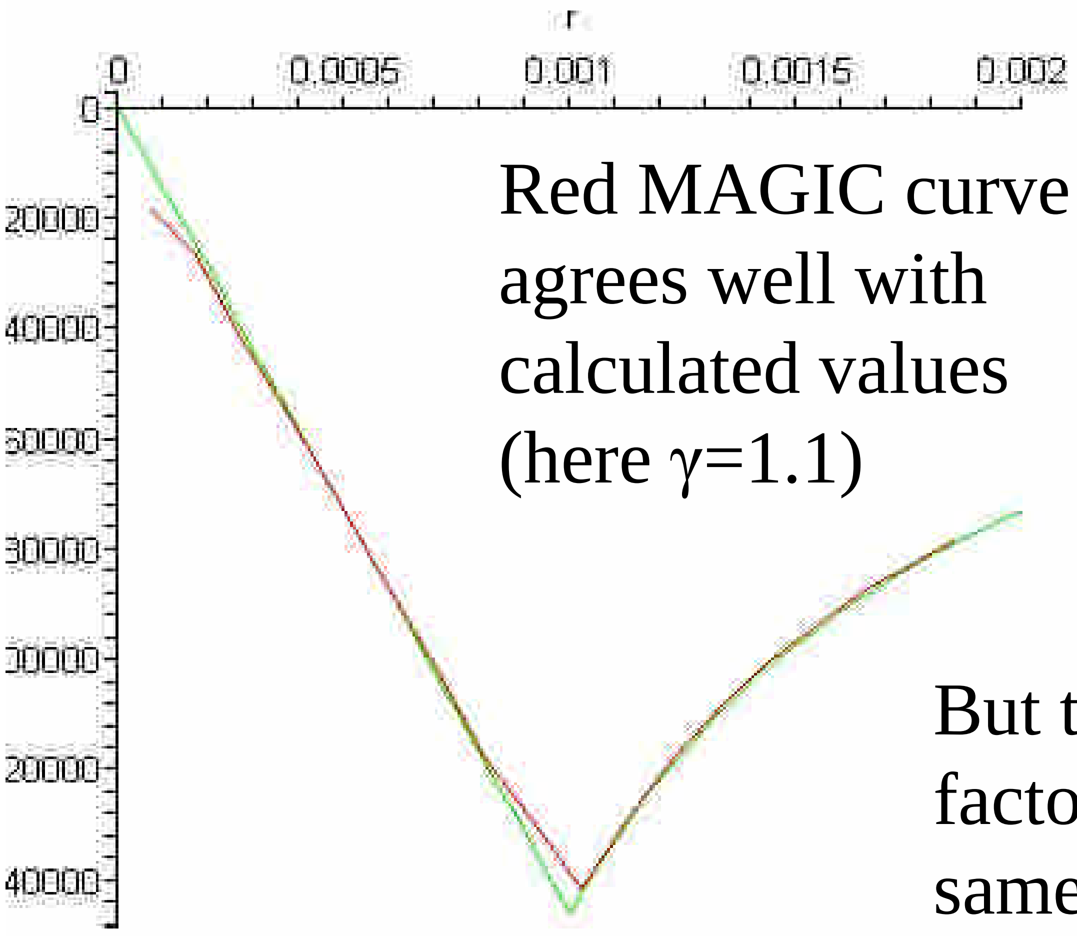
$E_r(r)$ Comparison:



Radius/m

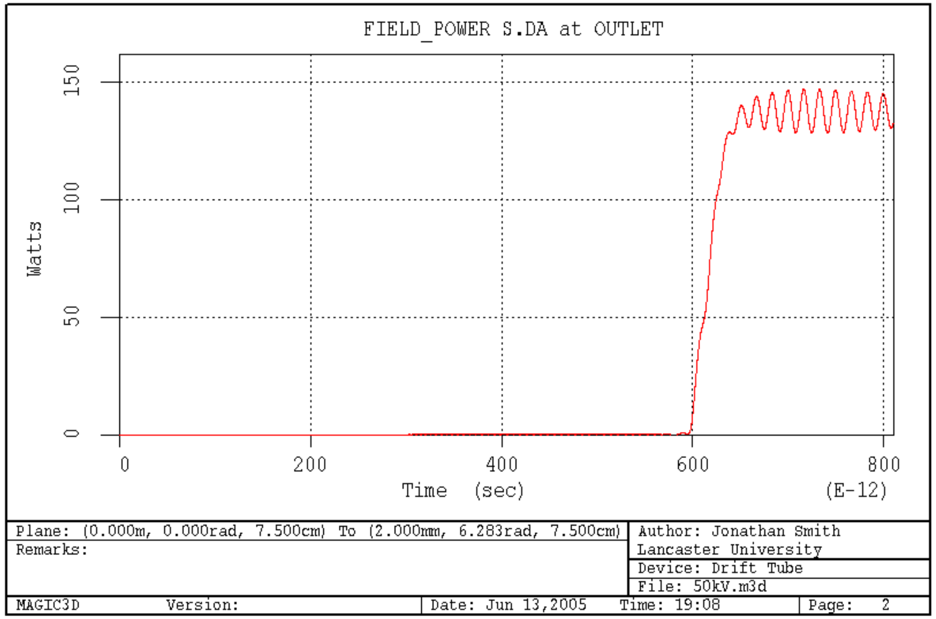
E_{radial}/Vm^{-1}

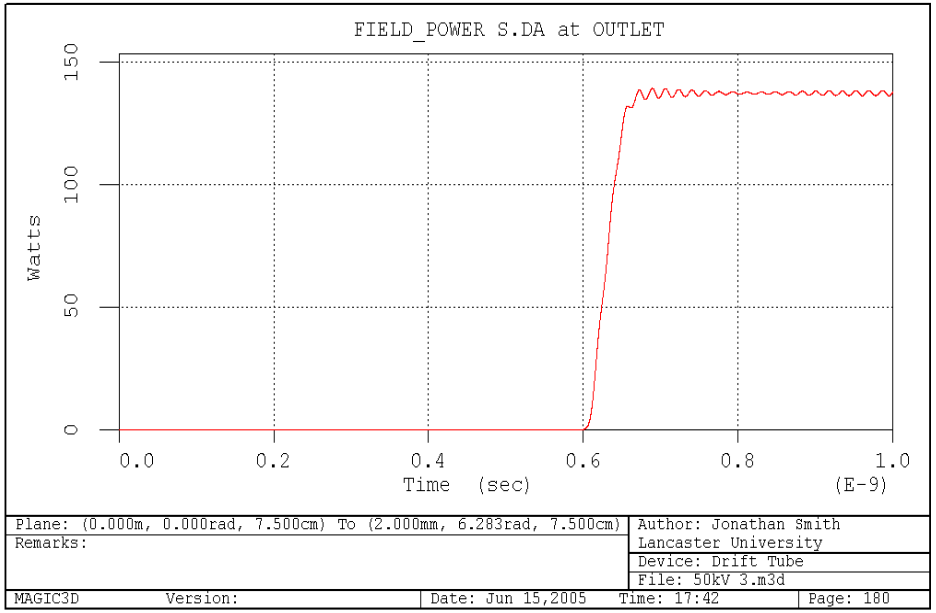
Red MAGIC curve agrees well with calculated values (here γ=1.1)

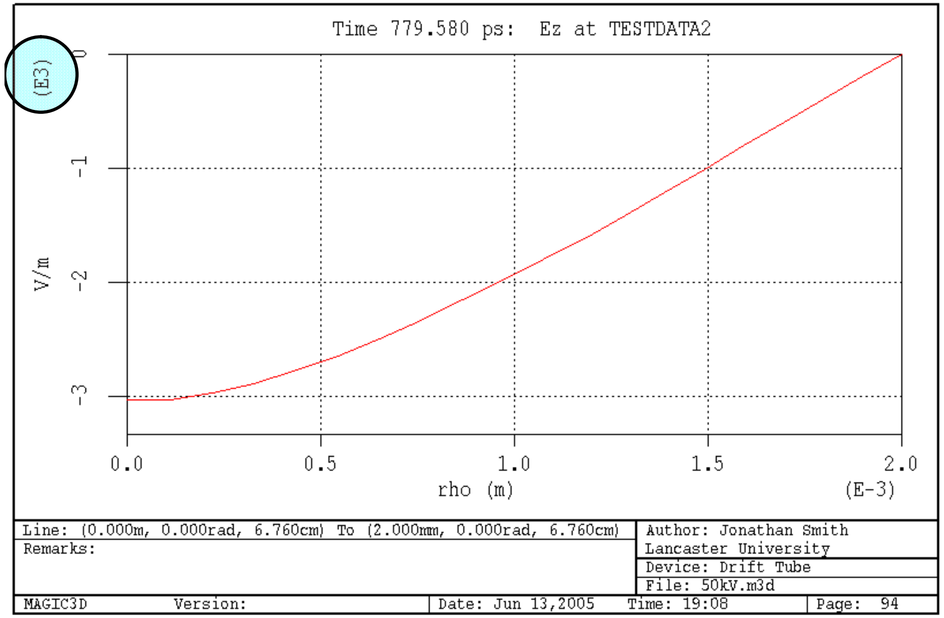
But theory model factor 2 out still for same $\omega(r)$

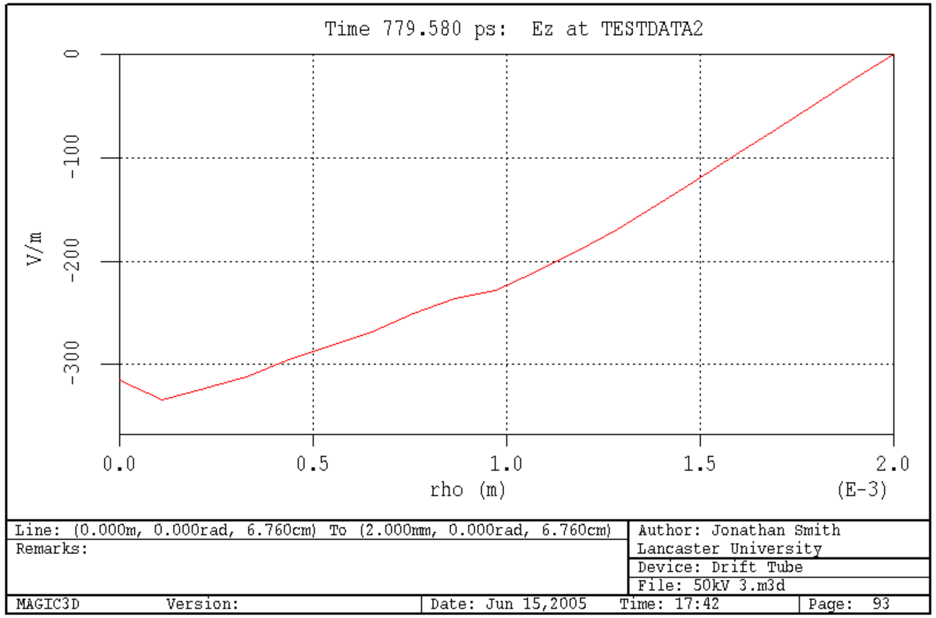
Jonathan Smith/André Sopczak, June 2005, RHUL

Spurious E_z

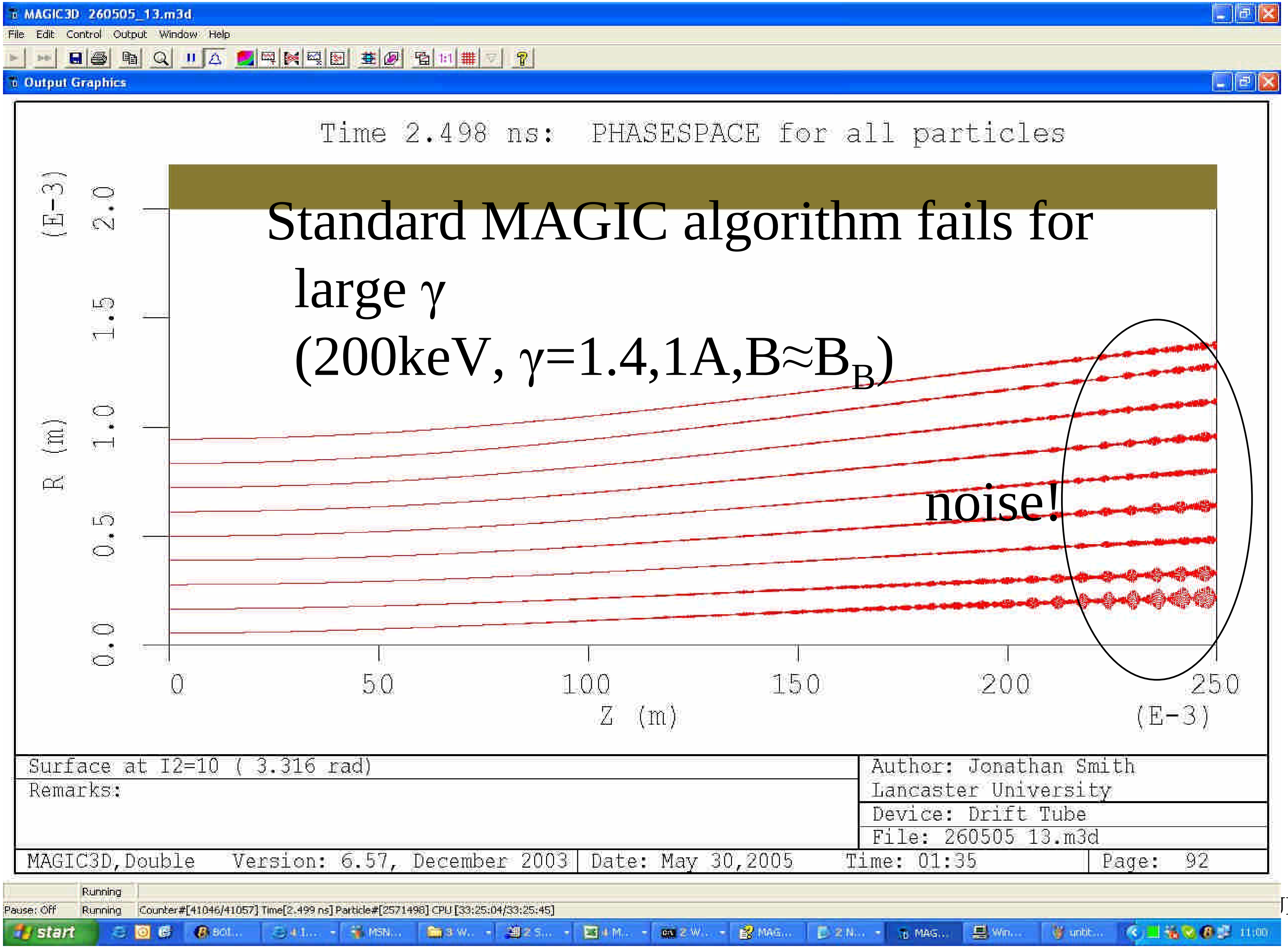

FIELD_POWER S.DA at OUTLET
Watts
0 50 100 150
0 200 400 600 800
Time (sec) (E-12)
Plane: (0.000m, 0.000rad, 7.500cm) To (2.000mm, 6.283rad, 7.500cm)
Remarks:
Author: Jonathan Smith
Lancaster University
Device: Drift Tube
File: 50kV.m3d
MAGIC3D Version: Date: Jun 13,2005 Time: 19:08 Page: 2


FIELD_POWER S.DA at OUTLET
Watts
0 50 100 150
0.0 0.2 0.4 0.6 0.8 1.0
Time (sec) (E-9)
Plane: (0.000m, 0.000rad, 7.500cm) To (2.000mm, 6.283rad, 7.500cm)
Remarks:
Author: Jonathan Smith
Lancaster University
Device: Drift Tube
File: 50kV 3.m3d
MAGIC3D Version: Date: Jun 15,2005 Time: 17:42 Page: 180


Time 779.580 ps: Ez at TESTDATA2
(E3)
V/m
0 -1 -2 -3
0.0 0.5 1.0 1.5 2.0
rho (m) (E-3)
Line: (0.000m, 0.000rad, 6.760cm) To (2.000mm, 0.000rad, 6.760cm)
Remarks:
Author: Jonathan Smith
Lancaster University
Device: Drift Tube
File: 50kV.m3d
MAGIC3D Version: Date: Jun 13,2005 Time: 19:08 Page: 94

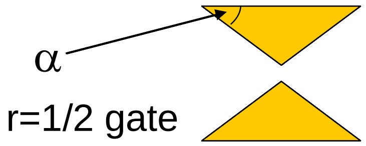
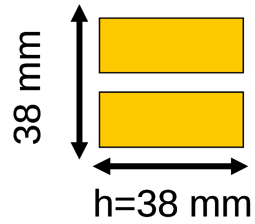
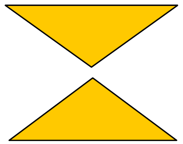
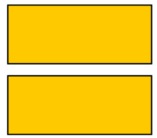
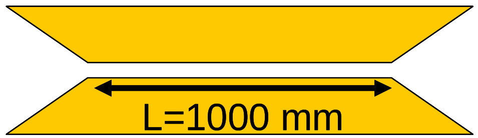
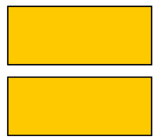
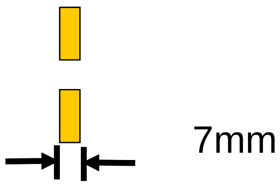

Time 779.580 ps: Ez at TESTDATA2
V/m
0 -100 -200 -300
0.0 0.5 1.0 1.5 2.0
rho (m) (E-3)
Line: (0.000m, 0.000rad, 6.760cm) To (2.000mm, 0.000rad, 6.760cm)
Remarks:
Author: Jonathan Smith
Lancaster University
Device: Drift Tube
File: 50kV 3.m3d
MAGIC3D Version: Date: Jun 15,2005 Time: 17:42 Page: 93

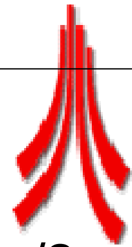
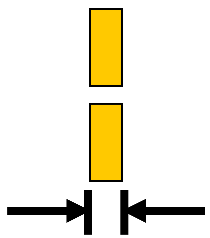
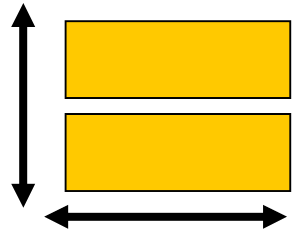
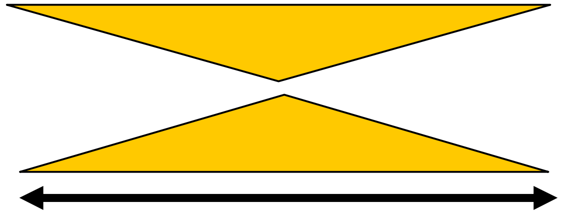
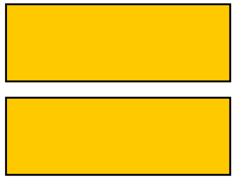
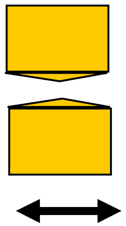
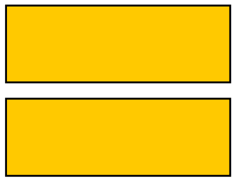
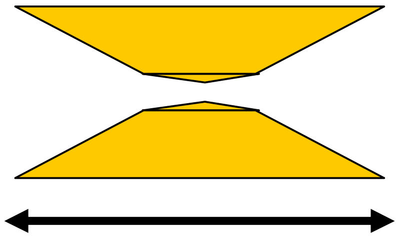
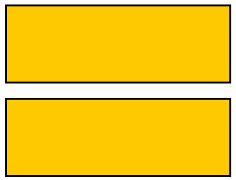
Standard MAGIC algorithm fails for large γ (200keV, γ=1.4,1A,B≈B_B)



Future Plans

- Proposed collimator designs for beam test.
- Study of these designs with test beam at End Station A at SLAC
- Analysing and comparison of future test beam data

Slot	Side view	Beam view	
1	 α, r=1/2 gate	 38 mm, h=38 mm	α=335mrad r=1.9mm
2			α=335mrad r=1.4mm
3	 L=1000 mm		α=335mrad r=1.4mm
4	 7mm		α=π/2rad r=3.8mm

Slot	Side view	Beam view	
1	 7 mm	38 mm  h=38 mm	$\alpha=\pi/2$rad r=1.4mm
2	 208mm		$\alpha=$168mrad r=1.4mm
3	 28mm		$\alpha_1=\pi/2$ rad α_2=168mrad r_1=3.8mm r_2=1.4mm
4	 159mm		α_1=298mrad α_2=168mrad r_1 =3.8mm r_2 =1.4mm

Conclusions

- Familiarisation of different software packages
- Gaining understanding of theoretical aspects
  - Development of schemes that permit a more accurate analysis of beam dynamics than is currently available.
- In preparation for test beam at SLAC End Station A:
  - Simulation of collimator inserts
  - Test beam proposal submitted