Muon Cooling In Gas Filled Cyclotrons

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Introduction

Lattices

Beam Simulation

Magnet Design

Introduction

The use of compressed gas for muon ionization cooling has been introduced by Roland Johnson and a design for a linear system has been made by Derbenev.

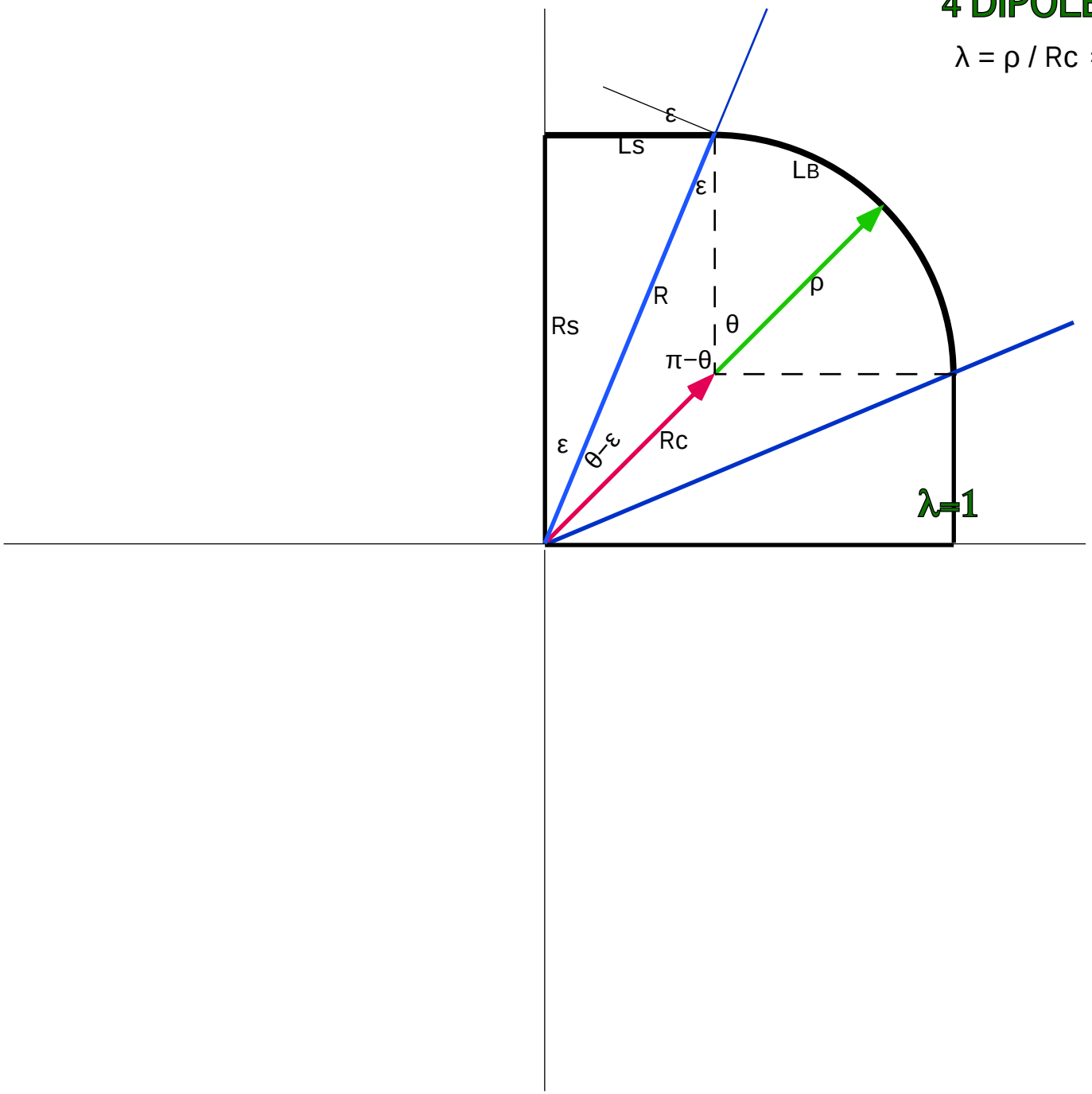
We have been investigating the possibility of such cooling in cyclotrons. There are several reasons this approach may be effective. One is that since the gas absorber is present everywhere along the beamline, one should have rather uniform beta function values. Another is that positive dispersion is present everywhere, which is necessary for longitudinal cooling. Also cyclotrons have very large momentum aperture.

The type of cyclotron we have concentrated have radial sector, zero gradient magnets. These are automatically scaling machines.. However we have done some work with magnet gradients, but we have not yet used true FFAG designs with reverse bends.

A drawback to this approach is that the typical circumference is small, which complicates cooling a long bunch train.

4 DIPOLE RING

$\lambda = \rho / Rc = 1$



$\lambda = \rho / Rc$

$\sigma = (1 + \lambda^2 + 2\lambda \cos \theta)^{1/2}$

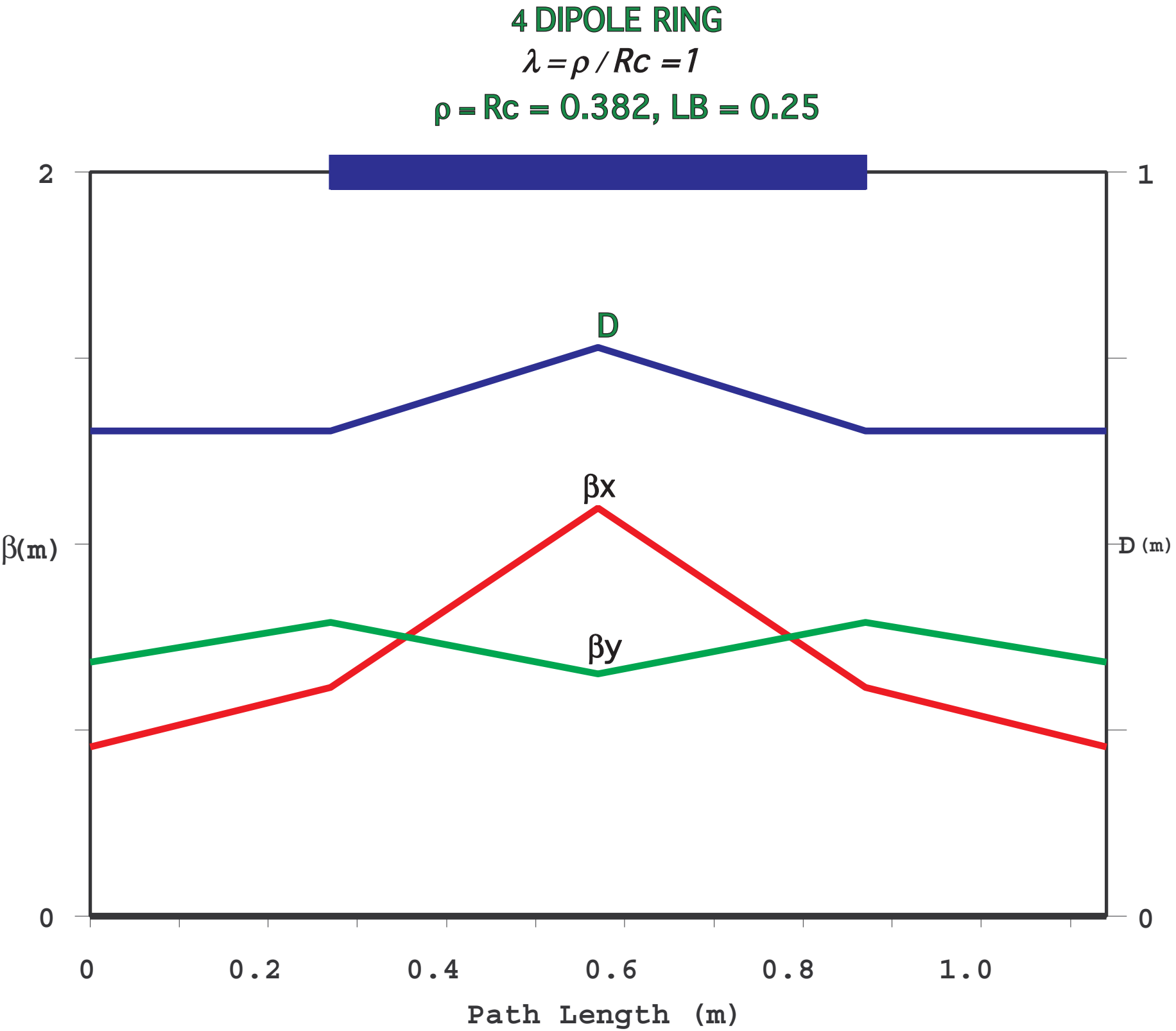
$R = Rc \ \sigma$

$\varepsilon = \sin^{-1}(\sin \theta / \sigma)$

$Rs = R \cos \varepsilon$

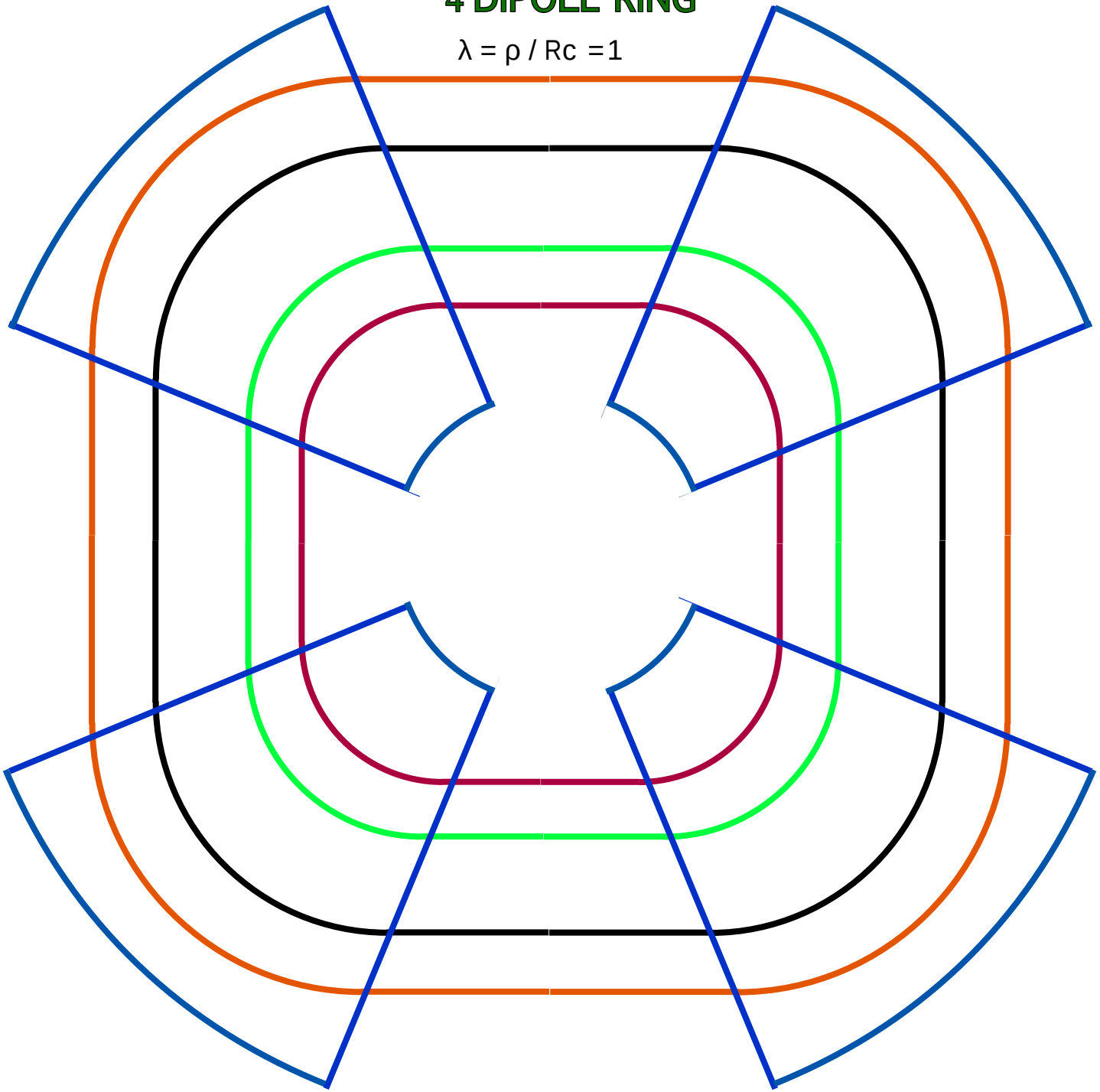
$Ls = R \sin \varepsilon$

$LB = \rho \theta$


4 DIPOLE RING
λ = ρ / Rc = 1
ρ = Rc = 0.382, LB = 0.25
2
1
D
βx
βy
β(m)
D (m)
0
0
0 0.2 0.4 0.6 0.8 1.0
Path Length (m)

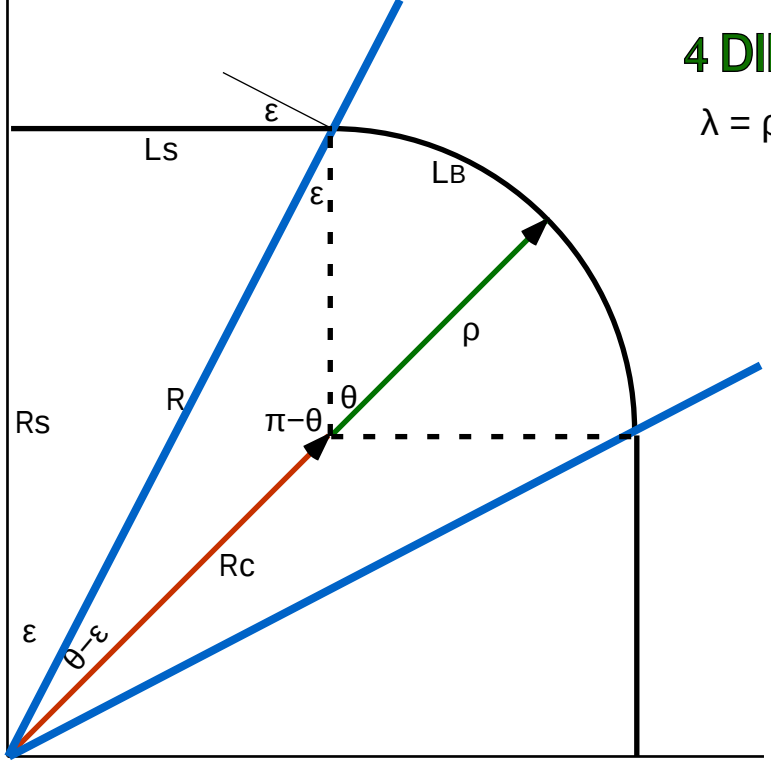
4 DIPOLE RING

$\lambda = \rho / Rc = 1$



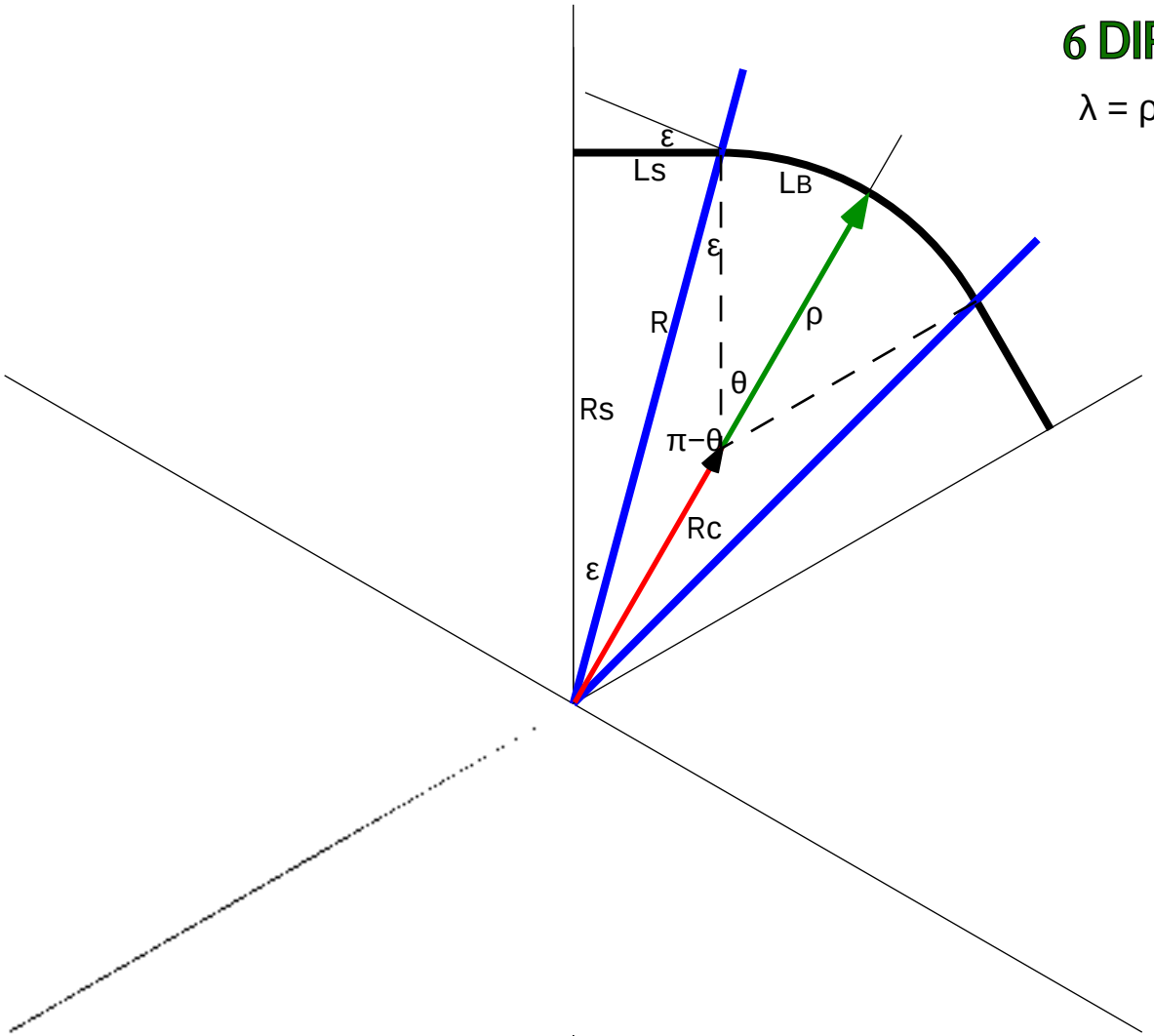
4 DIPOLE RING

$\lambda = \rho / Rc = 2/3$

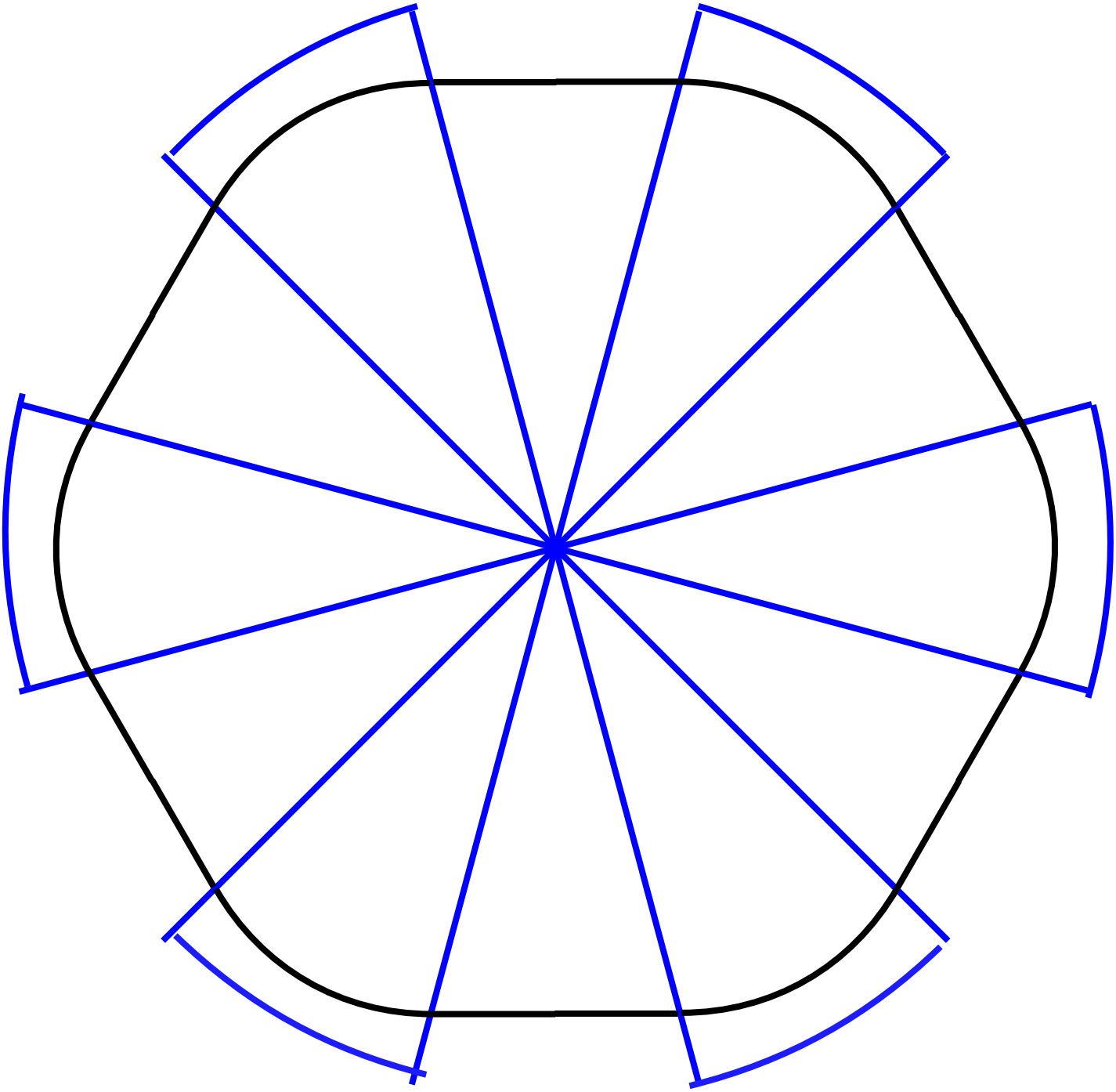


6 DIPOLE RING

$\lambda = \rho / Rc = 1$



6 DIPOLE RING



Parameters of 6-Sector Ring

Momentum	0.25	GeV/c
Magnetic field	2.62	T
Magnet half length LB	0.167	m
Gap half length LS	0.159	m
Rho	0.318	m
Rc	0.318	m
Cell length	0.637	m
Circumference	3.82	m
RS	0.594	m
R	0.615	m
Bx, max	0.719	m
By, max	0.645	m
D, max	0.637	m
mux	0.173	
muy	0.169	
Bend angle/half cell	30	deg
Edge angle	15	deg