

## Transverse forces in the first girder magnets

S. Brooks

April 2017

Collider Accelerator Department  
**Brookhaven National Laboratory**

**U.S. Department of Energy**

USDOE Office of Science (SC), Nuclear Physics (NP) (SC-26)

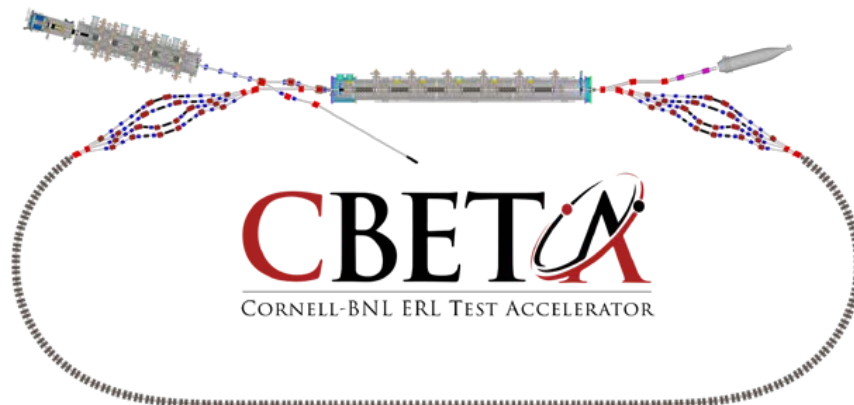
Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-SC0012704 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

## **DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

# Transverse forces in the first girder magnets

S. Brooks



Collider-Accelerator Department, Brookhaven National Laboratory, Upton NY 11973  
U.S. Department of Energy  
Office of Science, Office of Nuclear Physics

Cornell Laboratory for Accelerator-Based Sciences and Education, Ithaca, NY 14850

Funded by NYSERDA contract 102192

Notice: This document has been authorized by employees of Brookhaven Science Associates, LLC under Contract No. **DE-SC0012704** with the U.S. Department of Energy. The United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this document, or allow others to do so, for United States Government purposes.

## **DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

# Transverse Forces in the First Girder Magnets

---

Stephen Brooks

2017-Apr-14

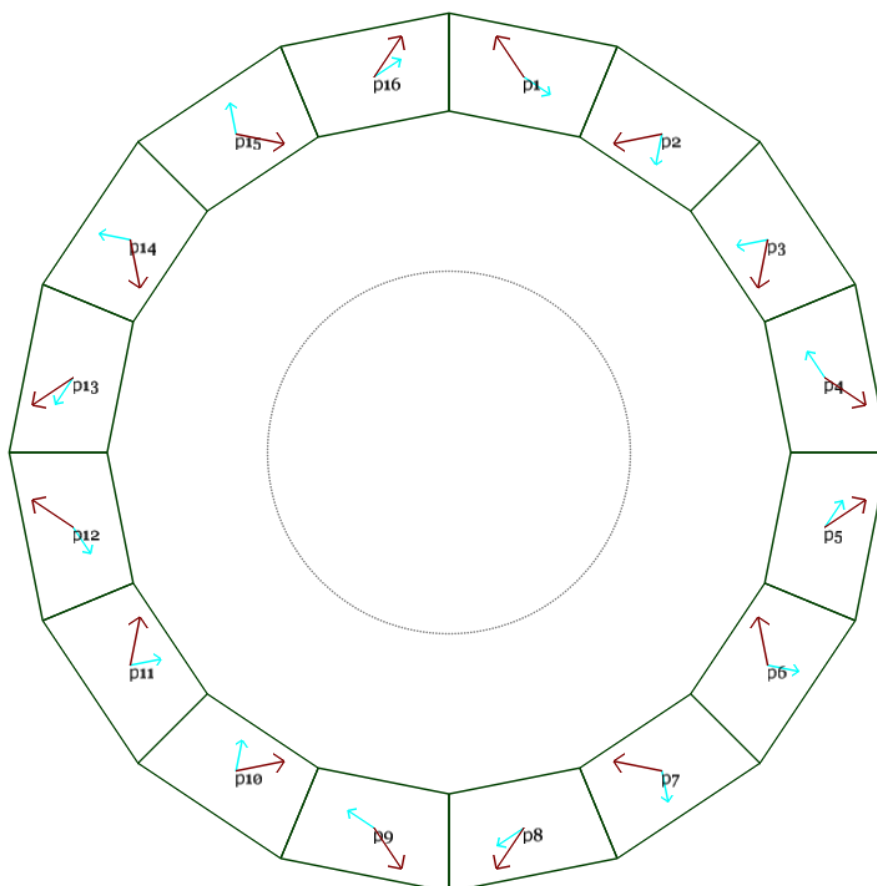
CBETA machine note #11

## 1. Introduction

These force calculations were done for the Halbach magnets for the CBETA “First Girder” as described in note [CBETA001] and purchased for the assembly of that girder.

## 2. QF Magnet

The picture below shows the transverse forces on each block as vectors (dark red), when the QF magnet is assembled. The light blue arrows are the magnetisation direction.



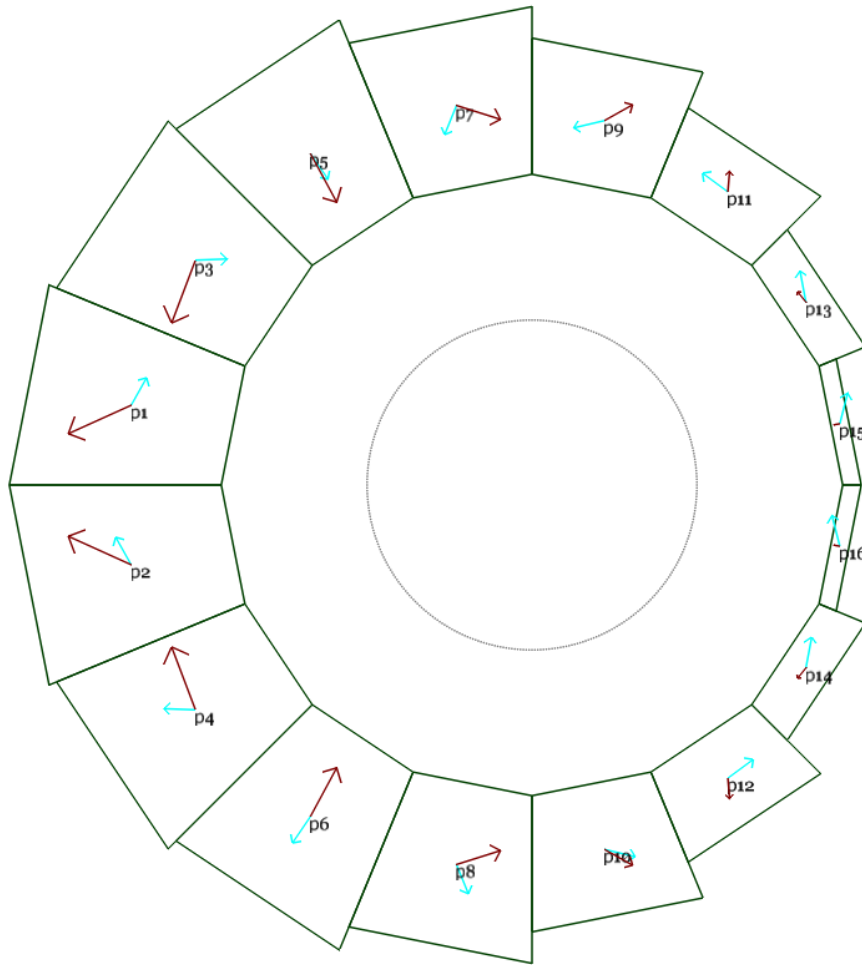
The pieces are labelled arbitrarily p1-p16 so that the corresponding forces can be written in the table below. For actual block type names from the factory, consult the assembly instructions.

The force can be stated as a force per unit length (Newtons/metre), or a force per block, or for the two blocks constituting the total length of the magnet. The latter gives the force on the outer aluminium shell. (Fx,Fy) force vectors are given in each cell.

Block label in diagram	Force per unit length (N/m)	Force per block (N)	Force per block (lbf)	Force full length (N)	Force full length (lbf)
p1	(-3470,5177)	(-231,345)	(-52,77.6)	(-463,690)	(-104,155.2)
p2	(-6129,-1228)	(-408,-82)	(-91.8,-18.4)	(-817,-164)	(-183.7,-36.8)
p3	(-1228,-6129)	(-82,-408)	(-18.4,-91.8)	(-164,-817)	(-36.8,-183.7)
p4	(5177,-3470)	(345,-231)	(77.6,-52)	(690,-463)	(155.2,-104)
p5	(5177,3470)	(345,231)	(77.6,52)	(690,463)	(155.2,104)
p6	(-1228,6129)	(-82,408)	(-18.4,91.8)	(-164,817)	(-36.8,183.7)
p7	(-6129,1228)	(-408,82)	(-91.8,18.4)	(-817,164)	(-183.7,36.8)
p8	(-3470,-5177)	(-231,-345)	(-52,-77.6)	(-463,-690)	(-104,-155.2)
p9	(3470,-5177)	(231,-345)	(52,-77.6)	(463,-690)	(104,-155.2)
p10	(6129,1228)	(408,82)	(91.8,18.4)	(817,164)	(183.7,36.8)
p11	(1228,6129)	(82,408)	(18.4,91.8)	(164,817)	(36.8,183.7)
p12	(-5177,3470)	(-345,231)	(-77.6,52)	(-690,463)	(-155.2,104)
p13	(-5177,-3470)	(-345,-231)	(-77.6,-52)	(-690,-463)	(-155.2,-104)
p14	(1228,-6129)	(82,-408)	(18.4,-91.8)	(164,-817)	(36.8,-183.7)
p15	(6129,-1228)	(408,-82)	(91.8,-18.4)	(817,-164)	(183.7,-36.8)
p16	(3470,5177)	(231,345)	(52,77.6)	(463,690)	(104,155.2)

### 3. BD Magnet

The picture below shows the transvers forces on each block as vectors (dark red), when the BD magnet is assembled. The light blue arrows are the magnetisation direction.



The force vectors on each piece of the BD magnet are written in the table below.

Block label in diagram	Force per unit length (N/m)	Force per block (N)	Force per block (lbf)	Force full length (N)	Force full length (lbf)
p1	(-8764,-3967)	(-533,-241)	(-119.9,-54.3)	(-1067,-483)	(-239.8,-108.5)
p2	(-8764,3967)	(-533,241)	(-119.9,54.3)	(-1067,483)	(-239.8,108.5)
p3	(-3330,-8775)	(-203,-534)	(-45.6,-120)	(-405,-1068)	(-91.1,-240.1)
p4	(-3330,8775)	(-203,534)	(-45.6,120)	(-405,1068)	(-91.1,240.1)
p5	(3695,-6845)	(225,-417)	(50.6,-93.6)	(450,-833)	(101.1,-187.3)
p6	(3695,6845)	(225,417)	(50.6,93.6)	(450,833)	(101.1,187.3)
p7	(6137,-1937)	(373,-118)	(83.9,-26.5)	(747,-236)	(167.9,-53)
p8	(6137,1937)	(373,118)	(83.9,26.5)	(747,236)	(167.9,53)
p9	(3909,2199)	(238,134)	(53.5,30.1)	(476,268)	(107,60.2)
p10	(3909,-2199)	(238,-134)	(53.5,-30.1)	(476,-268)	(107,-60.2)
p11	(241,2846)	(15,173)	(3.3,38.9)	(29,346)	(6.6,77.9)
p12	(241,-2846)	(15,-173)	(3.3,-38.9)	(29,-346)	(6.6,-77.9)
p13	(-1170,1438)	(-71,88)	(-16,19.7)	(-142,175)	(-32,39.3)
p14	(-1170,-1438)	(-71,-88)	(-16,-19.7)	(-142,-175)	(-32,-39.3)
p15	(-806,-139)	(-49,-8)	(-11,-1.9)	(-98,-17)	(-22.1,-3.8)
p16	(-806,139)	(-49,8)	(-11,1.9)	(-98,17)	(-22.1,3.8)

