Quadrupole Effective Lengths

v.2 from 11/21/14

- Introduction
  - ✓ SLAC
  - ✓ M5789 (FLNR/JINR)
  - ✓ NSCL #1
  - ✓ NSCL #2
  - ✓ NSCL #3
  - ✓ SHELS (FLNR/JINR)

- Quadrupole effective lengths in LISE^{++}
  - ✓ Effective values in the Optic Setup dialog

- Supplementary: Quad B(I) calibration

Introduction: SLAC 63

Coef=1.0

TN-63-10
J. J. Murray
February, 1963.

EFFECTIVE LENGTH MEASUREMENT FOR

QUADRUPOLE MAGNETS

The effective length of a quadrupole magnet can be defined as

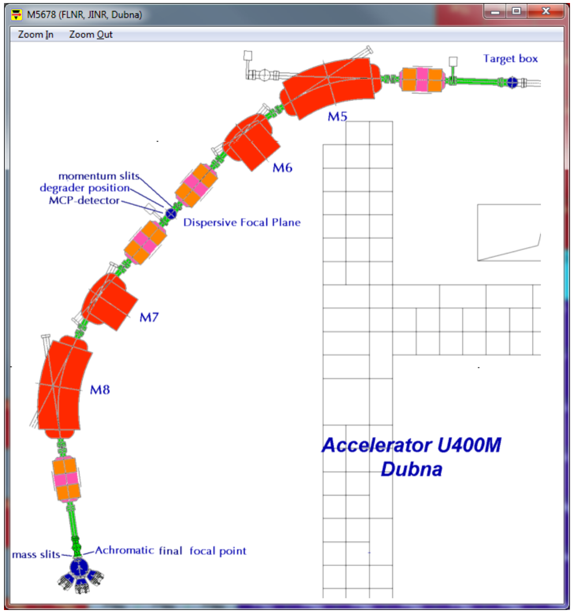
$$L_{eff} = \frac{\int_{-\infty}^{\infty} \frac{\partial B_y}{\partial x}\, dz}{\left(\frac{\partial B_y}{\partial x}\right)_o} \quad \text{in one plane}$$

To fair approximation the effective length is given by

$$L_{eff} = l_p + a$$

where l_p is length of the iron poles and a is the apperture radius.

Introduction : M5678



	7k30-1500	11k-30.600	2ML-5-2
	U400M	U400	
Half-Aperture(cm)	3.5	5.5	6.93
Gradient(G/cm)	1500	600	*262.3456342*
Limit(A)	20	17	*6*
Limit from Ap. (kG)	5.25	3.3	*1.8*
Slope(kG/A)	0.263	0.194	
Limit1(A)	*17*		*2*
Slope(kG/A)	*0.309*		
B(Melnikov)	**308.627**	**196.637**	**303.037**
	1.000	1.001	1.000
Gradient(G[I]/cm)	88.176	35.707	43.724
Slope(kG/I) Mel'nikov	**0.309**	0.196	0.303
Limit(kG)	6.2	3.3	1.8
Length(m)	0.3	0.3	0.3
LengthEff(m)	**0.3315**	**0.3495**	**0.3624**
LengthEff(m)	**Length + 0.9 * HalfAperture**		
Limit(A)	17		
Limit from Ap. (kG)	25.5		
		Melnikov	
	2ML-5-2	1.833 kG	7.12A
			6.66A
		kG/A	A
		0.266	6.89

	Limit,A	kG/A
L1	7	0.303
L2	7	0.303
L0(L2)	2	0.303
L3	17	0.196
L4	17	0.196
L5	17	0.309
L6	17	0.309
L7	17	0.309
L8	17	0.309
L9	17	0.309
L10	17	0.309
L11	17	0.309
L12	17	0.309
L13	17	0.309
L14	17	0.309
L15	17	0.309
L16	17	0.309
L17	17	0.309
L18	17	0.309
L19	17	0.309
L20	17	0.309
L21	17	0.309
L22	17	0.309

Coef=0.9

Introduction : NSCL #1 (A.Zeller)

Courtesy by Mauricio

Based on drawings				Reference: A. F. Zeller et. al., Adv. Cryo. Eng., Y. 1998, vol. 43, A, pages 245-252.							
						Iron length	**Effective length**	Pole tip radius	Warm bore radius	Multipoles	**Leff= L+ coef * R**
Type	Type ref.	Lyoke[m]	R[m]	type	Qt.	[m]	[m]	[m]	[m]		**coef**
A	1	0.6500	0.132999	QA	4	0.65	0.723	0.133	0.100	no	**0.55**
B	2	0.3250	0.149987	QB	12	0.325	0.400	0.150	0.100	yes	**0.50**
C	3	0.7151	0.149987	QC	4	0.715	0.790	0.150	0.100	yes	**0.50**
D	4	0.3810	0.210033	QD	2	0.381	0.486	0.210	0.170	no	**0.50**
E	5	0.6250	0.149987	QE	2	0.625	0.700	0.150	0.116	no	**0.50**

Coef=0.5

Introduction : NSCL #2   (Transport file)

1		2	3	4	9	5	6	10			(Leff-L)/2			
N	COSy	Block name	Kind of	Start	Rapp(cm)	Length	DriftMode	L_eff(m)	Quad					
or			Block	(m)	R(m)*	(m)	Angle(~)*	Len(m)*	label	Real L	dL_q/2	dL_drift	dL/2_sum	
---		-----------------	-----------	------	---------	----------	---------	---------						
1		tuning	Dipole	0	3.00*	0	+0.0 *	0.00*						
									Mauricio	0.23122	0.445011			
							T3-D2		Mauricio	[illegible]				
25		D2	Dipole	11.812	3.09*	2.43	-45.0 *	2.43*						
							D2-T4		Mauricio	0.36529	0.594934			
						0.5424			Scheme	0.229644				
26	S2L5	z052	Drift	14.242		0.5525	standard			0.6050				
27		Q053-4TA	Drift	14.795	15	0.43	multipole	0.43	B	0.3250	0.0525			
28	S2L6	z054	Drift	15.225		0.1699	standard			0.2818		0.1119	0.1060	0.0059
29		Q055-4TB	Drift	15.394	15	0.732	multipole	0.73	E	0.6250	0.0535			
30	S2L7	z056	Drift	16.126		0.1759	standard			0.3083		0.1324	0.1260	0.0064
31		Q057-4TC	Drift	16.302	21	0.526	multipole	0.53	D	0.3810	0.0725			
32	S2L8	z058	Drift	16.828		0.6578	standard			0.7303				
						0.6527			Scheme	0.259512	0.725162			
							T4-F2		Mauricio	0.46565				
33		Image2(059)	Drift	17.486		0	SLITS							

Based on drawings

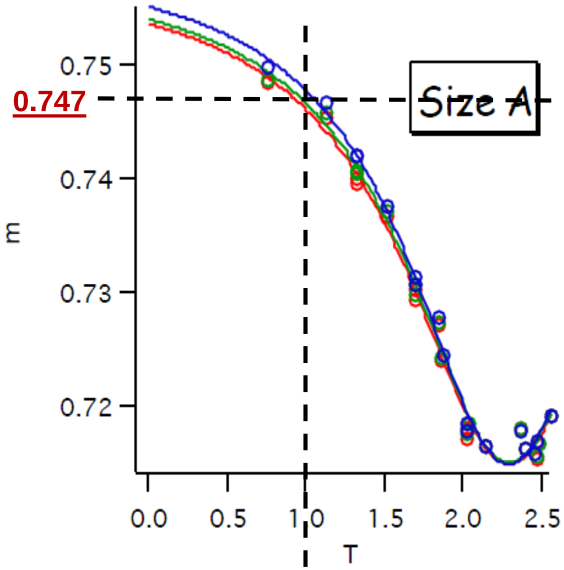
Reference: A. F. Zeller et. al., Adv. Cryo. Eng., Y. 1998, vol. 43, A, pages 245-252.

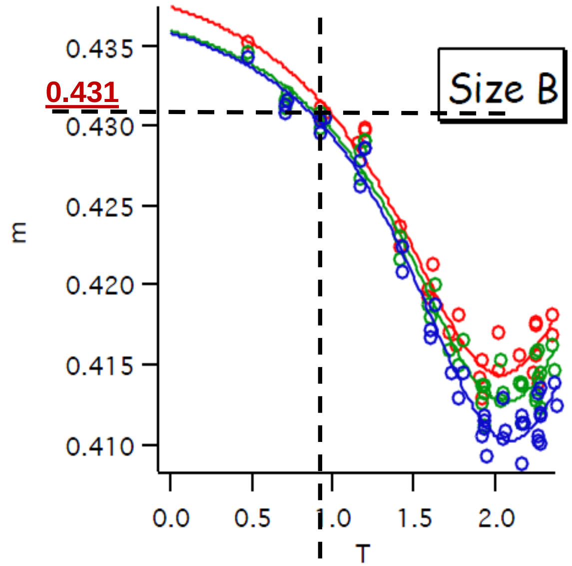
Type	Type ref.	Lyoke[m]	R[m]	type	Qt.	Iron length [m]	Effective length [m]	Pole tip radius [m]	Warm bore radius [m]	Multipoles	A1900 TRANSPORT file L_eff [m]	Leff= L+ coef * R Coef [1/m]
A	1	0.6500	0.132999	QA	4	0.65	0.723	0.133	0.100	no	0.748	**0.74**
B	2	0.3250	0.149987	QB	12	0.325	0.400	0.150	0.100	yes	0.43	**0.70**
C	3	0.7151	0.149987	QC	4	0.715	0.790	0.150	0.100	yes	0.812	**0.65**
D	4	0.3810	0.210033	QD	2	0.381	0.486	0.210	0.170	no	0.526	**0.69**
E	5	0.6250	0.149987	QE	2	0.625	0.700	0.150	0.116	no	0.732	**0.71**
											average	0.70
											median	0.70

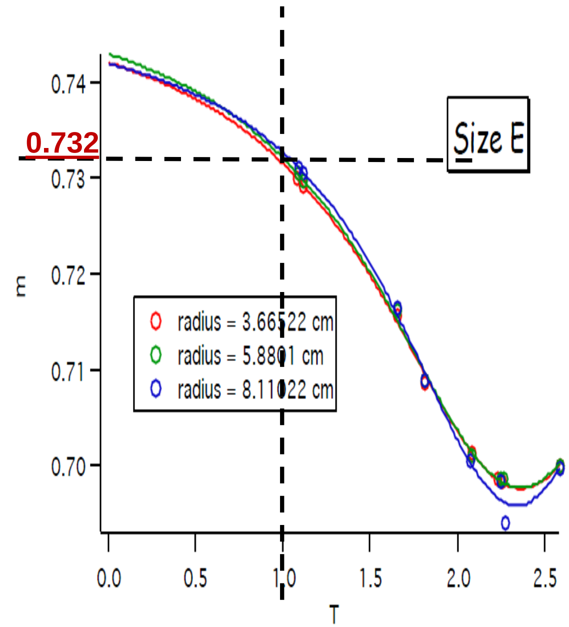
Coef=0.7

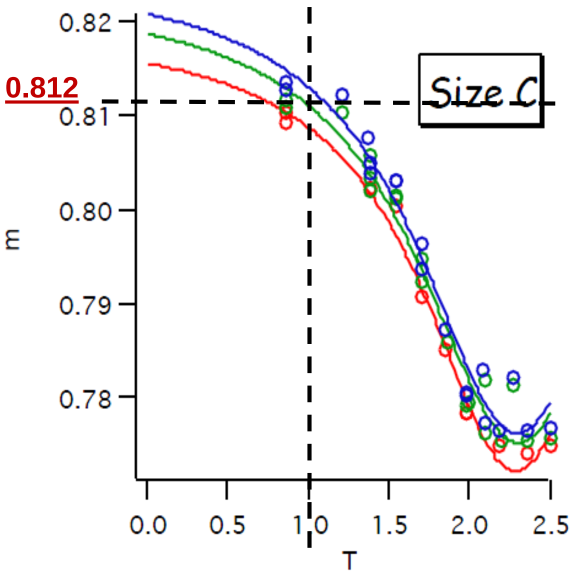
Introduction : NSCL #3 (Eff. length measurements)

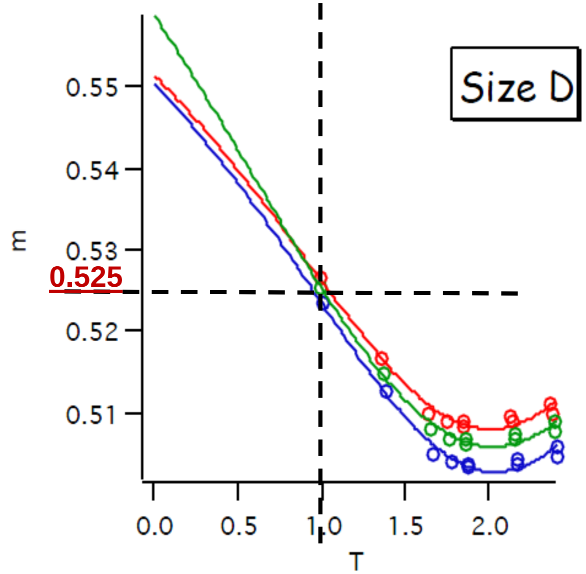
Courtesy by Daniel











Type	Iron length [m]	A1900 TRANSPORT file L_eff [m]
A	0.65	0.748
B	0.325	0.43
C	0.715	0.812
D	0.381	0.526
E	0.625	0.732

It looks like the Effective lengths at 1 T were used in the TRANSPORT file

Introduction : SHELS (FLNR-JINR)

Courtesy by A.Popeko

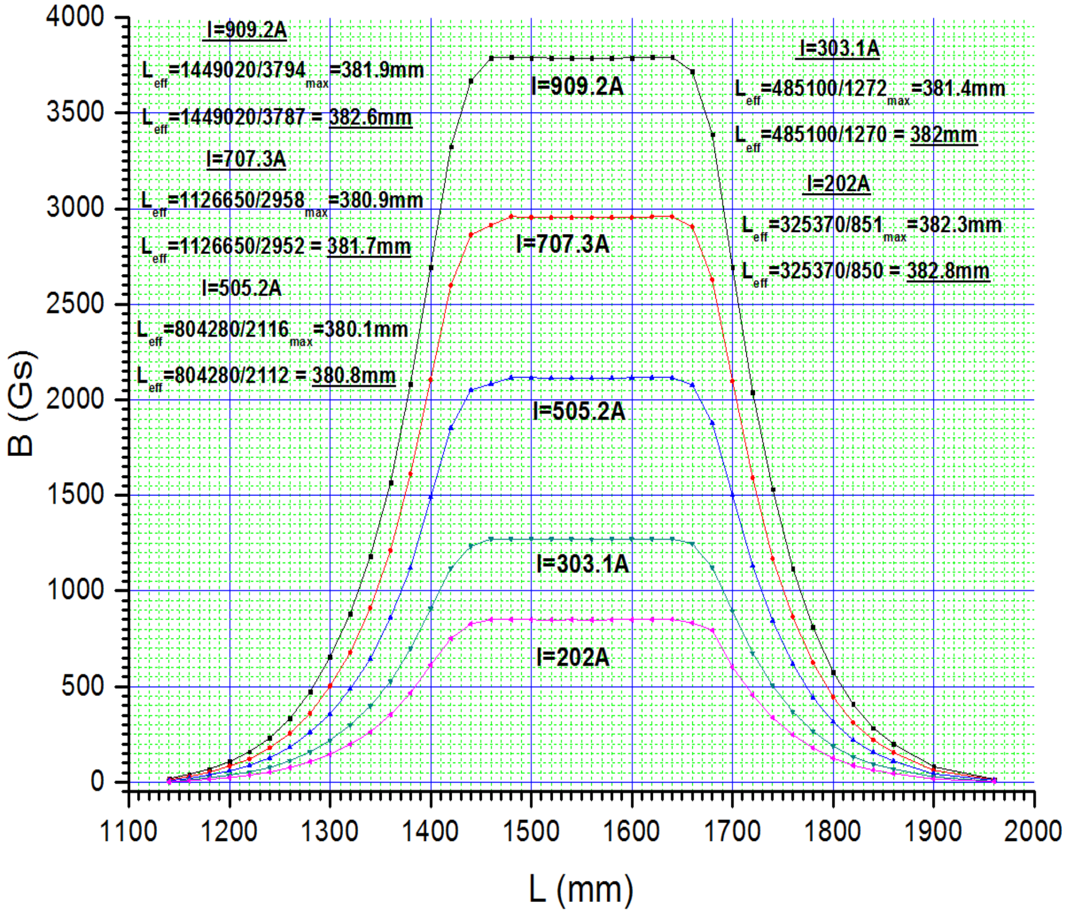
6 identical quads

Used in simulations:

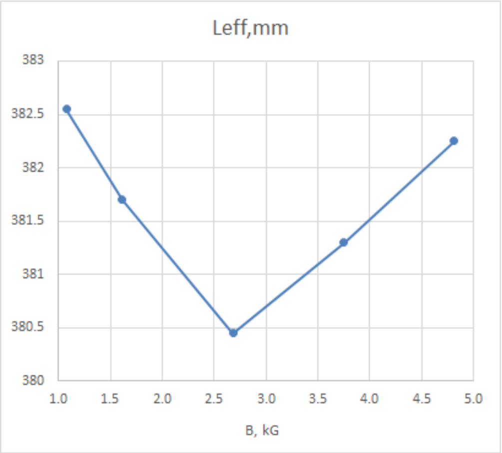
LQ = 310; {Length of quadrupole iron in mm}	~~coef~~
LQeff = 380; {Effective length of quadrupole in mm}	~~0.778~~

Coef=0.7

Q1 (pole 4) effective length on R rel.=0



I	B, kG	Leff,mm
202	1.08	382.55
303	1.615	381.7
505	2.68368	380.45
707	3.7504	381.3
909	4.8124	382.25
	average	381.65



Introduction : SHELS (FLNR-JINR)

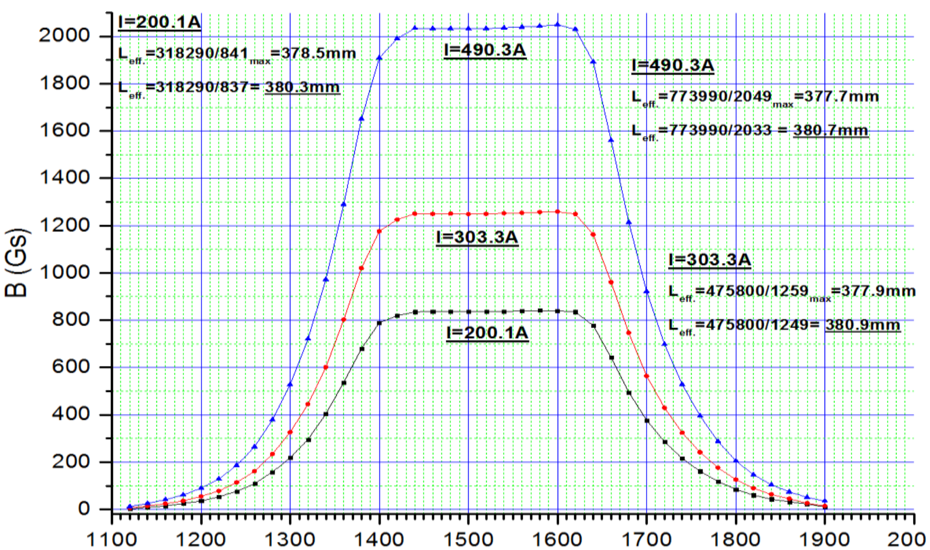
Courtesy by A.Popeko

Used in simulations:

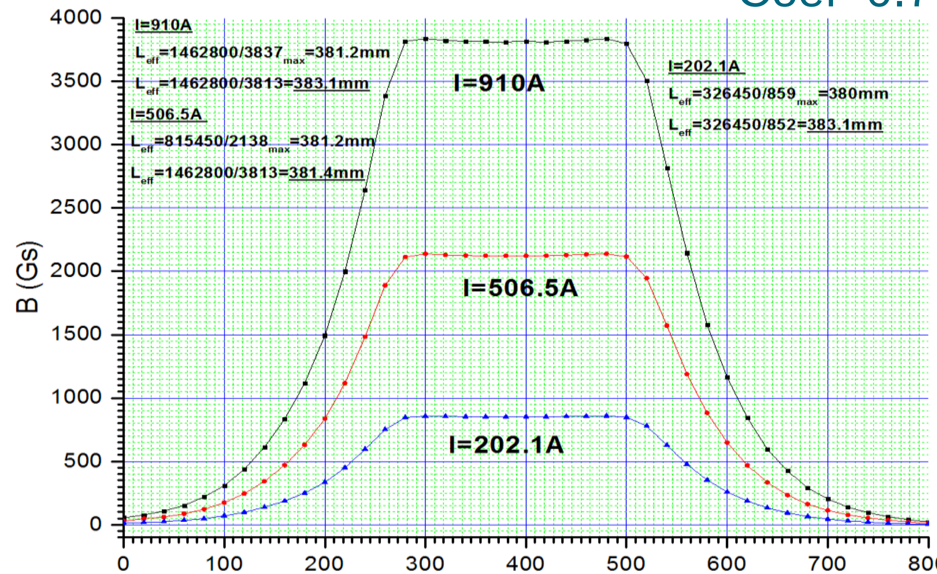
LQ = 310; {Length of quadrupole iron in mm}	~~coef~~
LQeff = 380; {Effective length of quadrupole in mm}	~~0.778~~

Coef=0.7

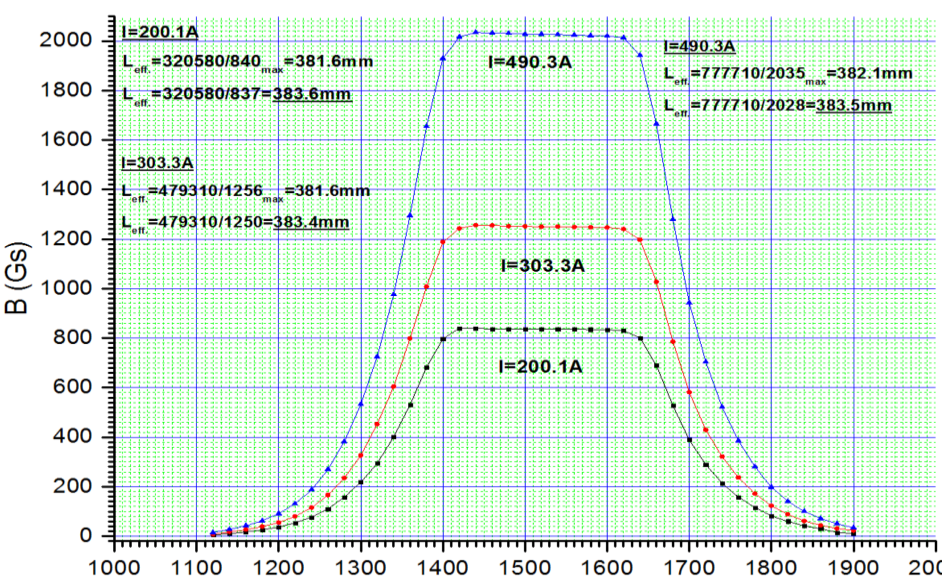
Q6 (pole4) eff. length



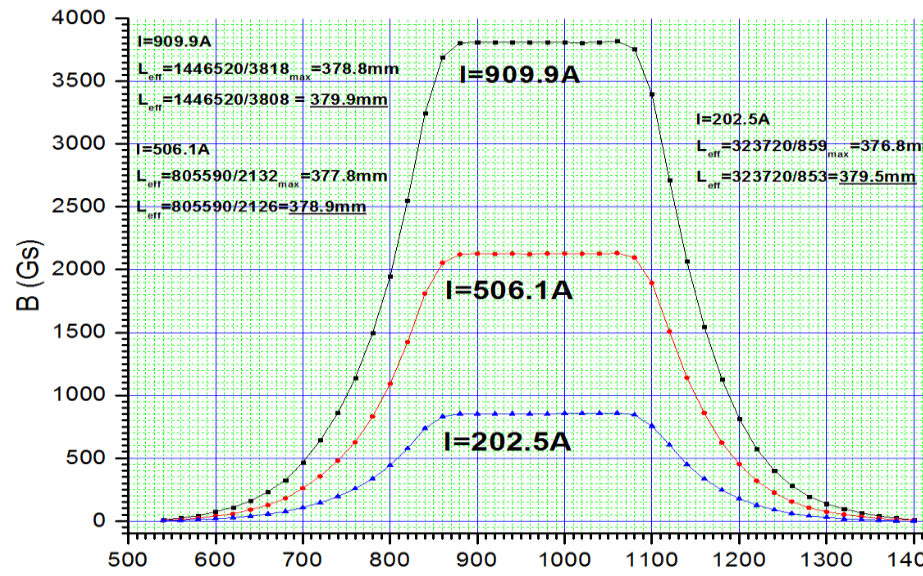
Q3 (pole 3) effective length



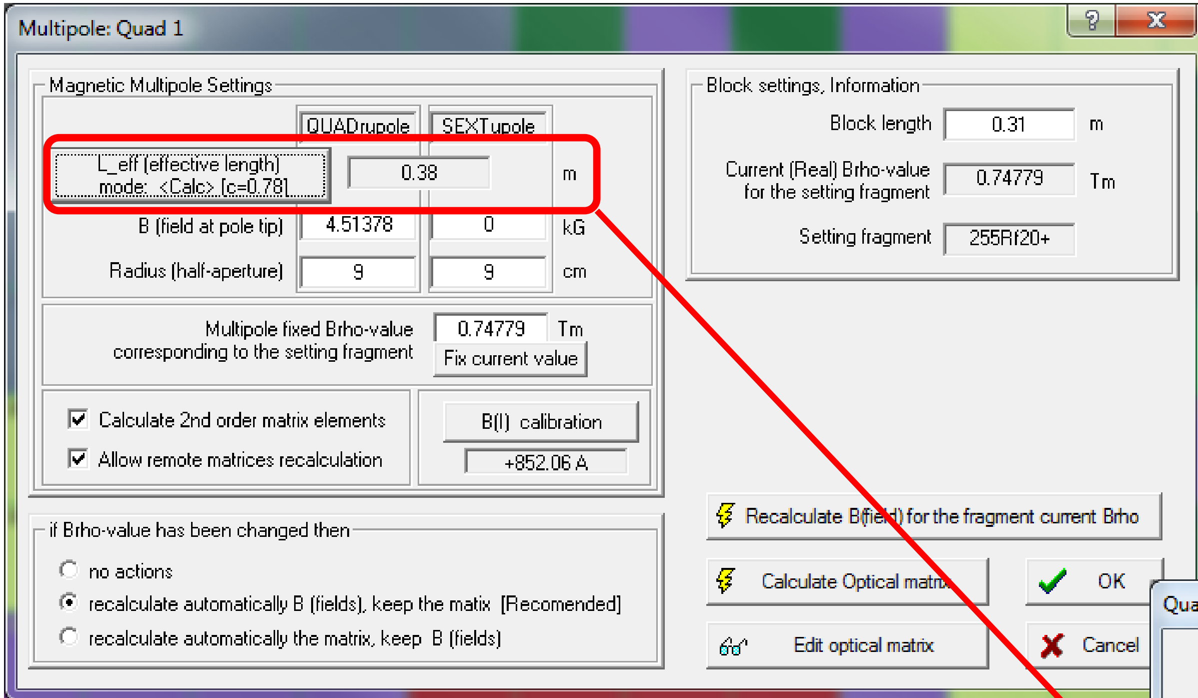
Q6(pole3) eff. length

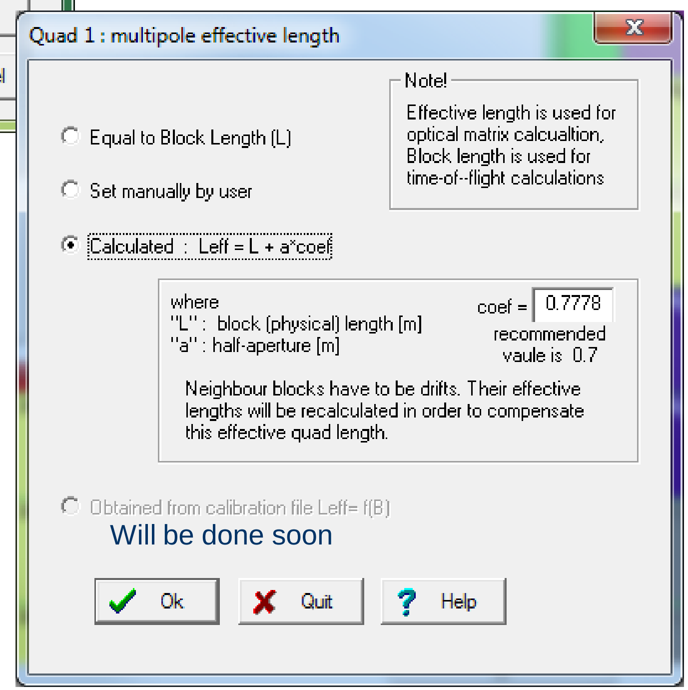


Q2 (pole3) effective length



Quadrupole effective lengths in LISE^{++}



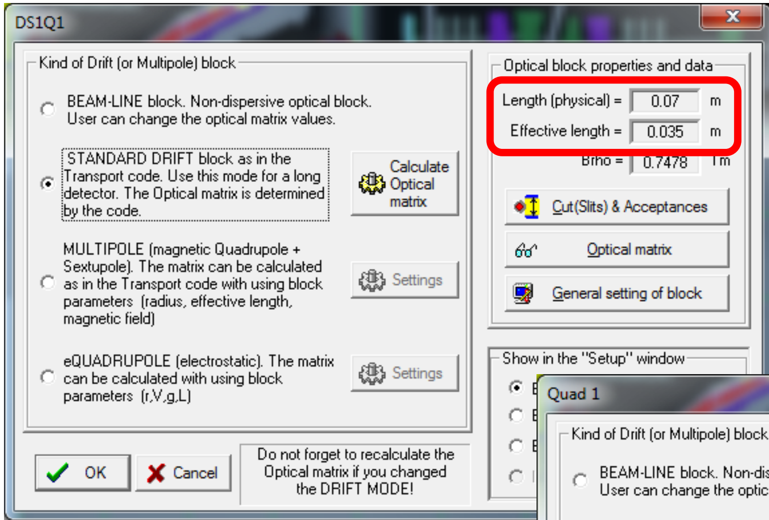


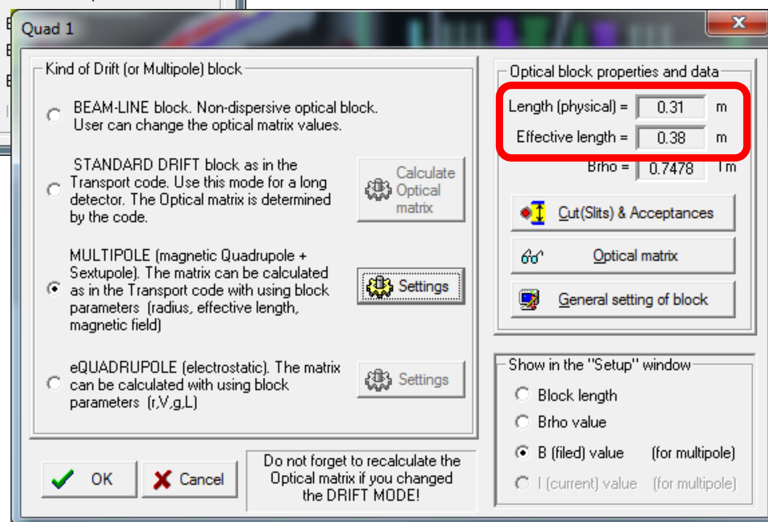
A1900 extended configurations will be rebuilt soon
Using Effective quad lengths

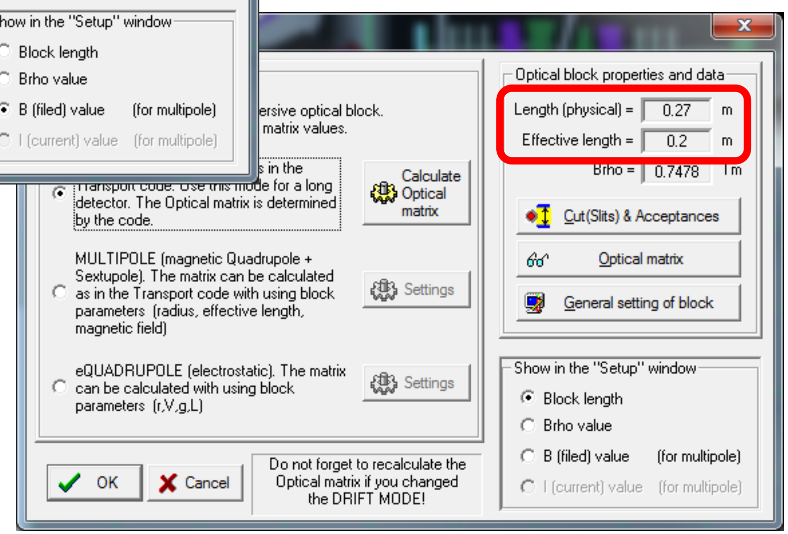
Quadrupole effective lengths in LISE^{++}

MICHIGAN STATE UNIVERSITY

LISE++





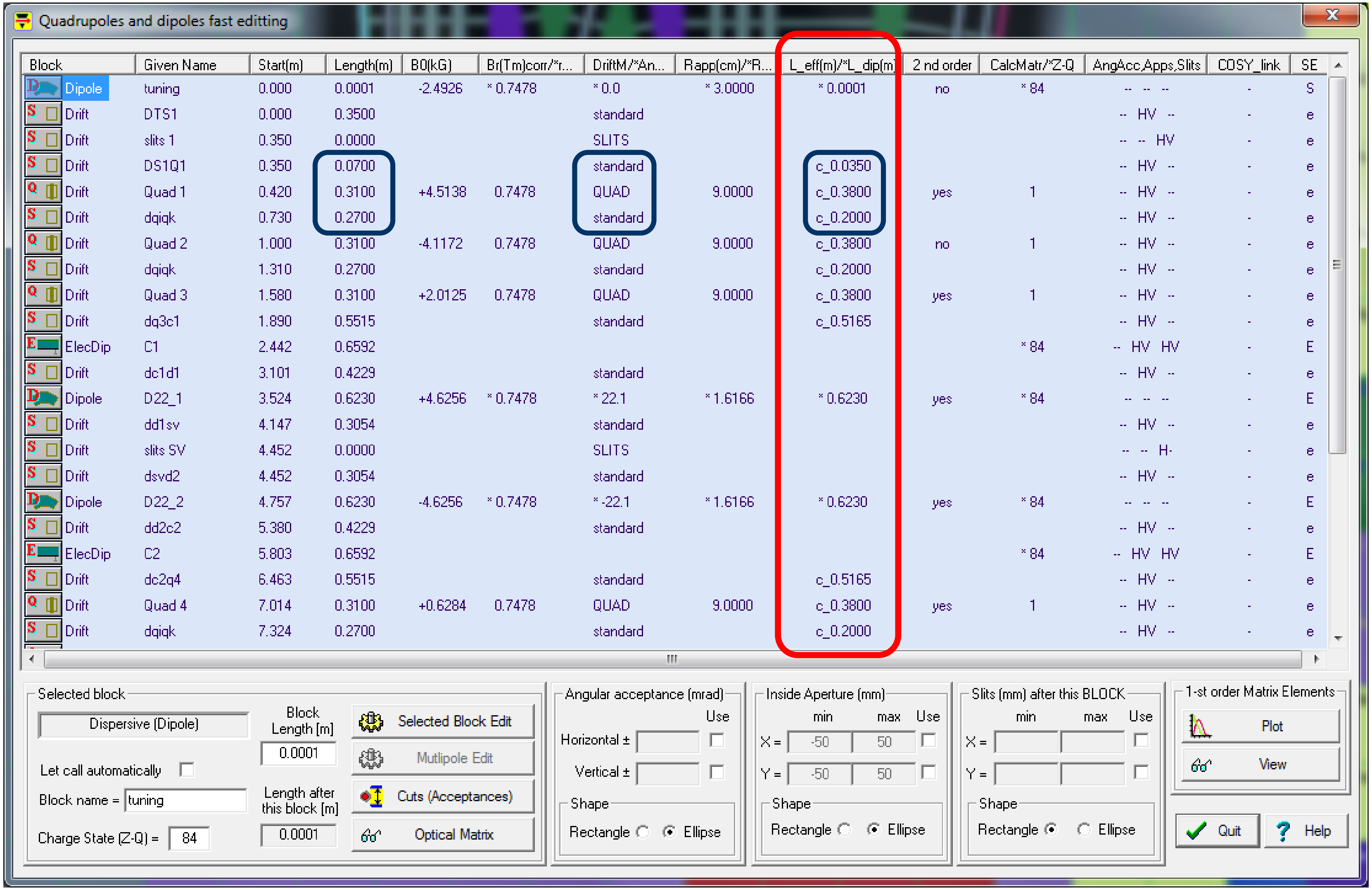


Drift + Quad + Drift

- Quads with calculated effective lengths should be surrounded by non-zero length drifts
- LISE^{++} checks for drift blocks existence and for their new positive effective length values

Effective values in the Optic Setup dialog

The char "c" denotes calculated value



Block	Given Name	Start(m)	Length(m)	B0(kG)	Br(Tm)corr/*r...	DriftM/*An...	Rapp(cm)/*R...	L_eff(m)/*L_dip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc,Apps,Slits	COSY_link	SE
Dipole	tuning	0.000	0.0001	-2.4926	* 0.7478	* 0.0	* 3.0000	* 0.0001	no	* 84	-- -- --	-	S
Drift	DTS1	0.000	0.3500			standard					-- HV --	-	e
Drift	slits 1	0.350	0.0000			SLITS					-- -- HV	-	e
Drift	DS1Q1	0.350	0.0700			standard		c_0.0350			-- HV --	-	e
Drift	Quad 1	0.420	0.3100	+4.5138	0.7478	QUAD	9.0000	c_0.3800	yes	1	-- HV --	-	e
Drift	dqiqk	0.730	0.2700			standard		c_0.2000			-- HV --	-	e
Drift	Quad 2	1.000	0.3100	-4.1172	0.7478	QUAD	9.0000	c_0.3800	no	1	-- HV --	-	e
Drift	dqiqk	1.310	0.2700			standard		c_0.2000			-- HV --	-	e
Drift	Quad 3	1.580	0.3100	+2.0125	0.7478	QUAD	9.0000	c_0.3800	yes	1	-- HV --	-	e
Drift	dq3c1	1.890	0.5515			standard		c_0.5165			-- HV --	-	e
ElecDip	C1	2.442	0.6592							* 84	-- HV HV	-	E
Drift	dc1d1	3.101	0.4229			standard					-- HV --	-	e
Dipole	D22_1	3.524	0.6230	+4.6256	* 0.7478	* 22.1	* 1.6166	* 0.6230	yes	* 84	-- -- --	-	E
Drift	dd1sv	4.147	0.3054			standard					-- HV --	-	e
Drift	slits SV	4.452	0.0000			SLITS					-- -- H-	-	e
Drift	dsvd2	4.452	0.3054			standard					-- HV --	-	e
Dipole	D22_2	4.757	0.6230	-4.6256	* 0.7478	* -22.1	* 1.6166	* 0.6230	yes	* 84	-- -- --	-	E
Drift	dd2c2	5.380	0.4229			standard					-- HV --	-	e
ElecDip	C2	5.803	0.6592							* 84	-- HV HV	-	E
Drift	dc2q4	6.463	0.5515			standard		c_0.5165			-- HV --	-	e
Drift	Quad 4	7.014	0.3100	+0.6284	0.7478	QUAD	9.0000	c_0.3800	yes	1	-- HV --	-	e
Drift	dqiqk	7.324	0.2700			standard		c_0.2000			-- HV --	-	e

Supplementary: Quad B(I) calibration