Solenoid Compensation

Super-B Workshop
Frascati
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Problems

- Detector solenoid field may limit excitation of SC quads
  - Main concern at quad ends; windings must turn around, field is parallel to detector solenoid
- Detector solenoid may saturate a Panofsky style QD0
- Detector solenoid causes x-y coupling

Solenoid Compensation

- Use "bucking solenoids" around beamline components
- Nominally cancel B_z at SC and Panofsky quad locations
- Overcompensate B_z where quads are absent
- Goal: $\int_{IP}^{\infty} B_z dz = 0$
  - This cancels coordinate plane rotation at IP (no x-y coupling when IP quads are unexcited)

Parameters

SuperB Parameters July 22 2009

SuperB Parameters		(in bold: computed values)			
Parameter	Units		Super-B		Super-B
			TorVergata		LNF
			1-Mar-09		22-Jul-09
			with SR		with SR LER
E HER (positrons)	GeV		6.9		6.7
E LER (electrons)	GeV		4.06		4.18
Energy ratio			1.70		1.60
r0	cm		2.83E-13		2.83E-13
X-Angle (full)	mrad		60		60
Beta x HER	cm		2		2
Beta y HER	cm		0.037		0.032
Coupling (high current)			0.0025		0.0025
Emit x HER	nm		1.6		1.6
Emit y HER	nm		0.004		0.004
Bunch length HER	cm		0.5		0.5
Beta x LER	cm		3.5		3.2
Beta y LER	cm		0.021		0.02
Coupling (high current)	%		0.0025		0.0025
Emit x LER	nm		2.8		2.56
Emit y LER	nm		0.007		0.0064
Bunch length LER	cm		0.5		0.5
I HER	mA		2200		2120
I LER	mA		2200		2120
Circumference	m		2105		1315
N. Buckets distance			2		2
Gap			0.97		0.97
Frf	Hz		4.76E+08		4.76E+08
Fturn	Hz		**1.43E+05**		**2.28E+05**
Fcoll	Hz		**2.31E+08**		**2.31E+08**
Num Bunch			**1619**		**1011**
N HER			**5.96E+10**		**5.74E+10**
N LER			**5.96E+10**		**5.74E+10**
Sig x HER	microns		**5.657**		**5.657**
Sig y HER	microns		**0.038**		**0.036**

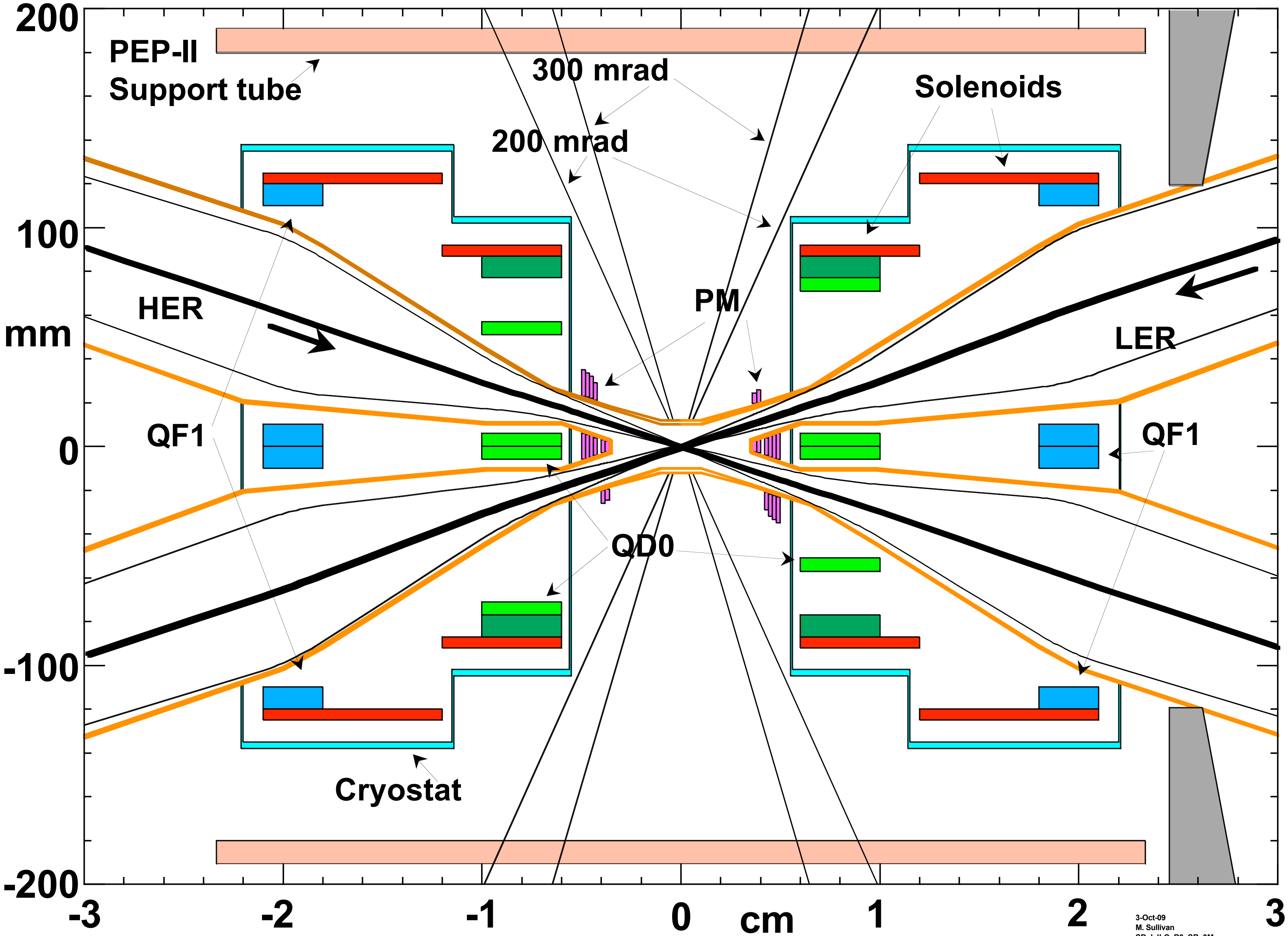
SuperB Parameters July 22 2009

Sig x LER	microns		**9.899**		**9.051**
Sig y LER	microns		**0.038**		**0.036**
Piwinski angle HER	rad		**26.52**		**26.52**
Piwinski angle LER	rad		**15.15**		**16.57**
Sig x HER effective	microns		**150.15**		**150.15**
Sig x LER effective	microns		**150.37**		**150.32**
X-angle factor HER			**0.038**		**0.038**
X-angle factor LER			**0.066**		**0.060**
Cap Sig X	microns		**11.402**		**10.673**
Cap Sig Y	microns		**0.054**		**0.051**
R (hourglass factor)			0.900		0.900
Cap Sig X eff	microns		212.13		212.13
Lumi calc	/cm2/s		**1.02E+36**		**1.02E+36**
Tune shift x HER			**0.0018**		**0.0017**
Tune shift y HER			**0.1271**		**0.1170**
Tune shift x LER			**0.0052**		**0.0045**
Tune shift y LER			**0.1220**		**0.1170**
Damping_long HER	msec		21		14.5
Damping_long LER	msec		20.0		22.0
Uo HER	MeV		2.3		2.03
Uo LER	MeV		1.40		0.83
alfa_c HER			3.50E-04		4.04E-04
alfa_c LER			3.20E-04		4.24E-04
sigma-EHER			5.80E-04		6.15E-04
sigma-E LER			8.20E-04		6.57E-04
CM sigma_E			**1.00E-03**		**9.00E-04**
SR power loss HER	**MW**		**5.06**		**4.30**
SR power loss LER	**MW**		**3.08**		**1.76**
Touschek lifetime HER	min		33		35
Touschek lifetime LER	min		17		16
Luminosity lifetime HER	min		5.20		4.95
Luminosity lifetime LER	min		5.20		4.95
Total lifetime HER	**min**		**4.49**		**4.34**
Total lifetime LER	**min**		**3.98**		**3.78**
RF plug power	MW		**16.28**		**12.13**

IR Parameters

Parameter	HER	LER
Energy (GeV)	7	4
Current (A)	2.12	2.12
Beta X (mm)	20	32
Beta Y (mm)	0.32	0.20
Emittance X (nm-rad)	1.60	2.56
Emittance Y (pm-rad)	4.0	6.4
Sigma X (μm)	5.66	5.66
Sigma Y (nm)	38	36
Crossing angle (mrad)	+/- 30	

Present IR Design



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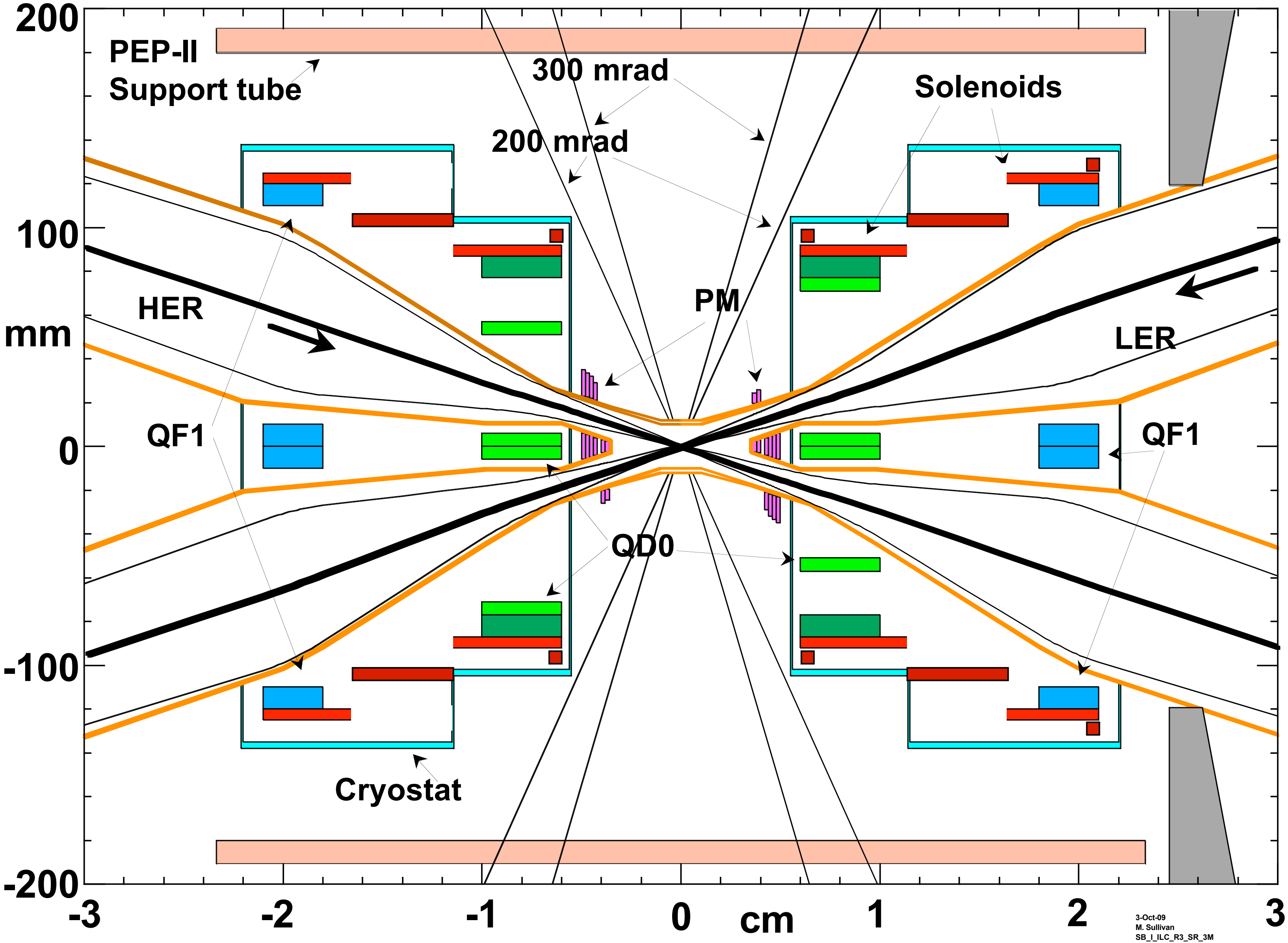
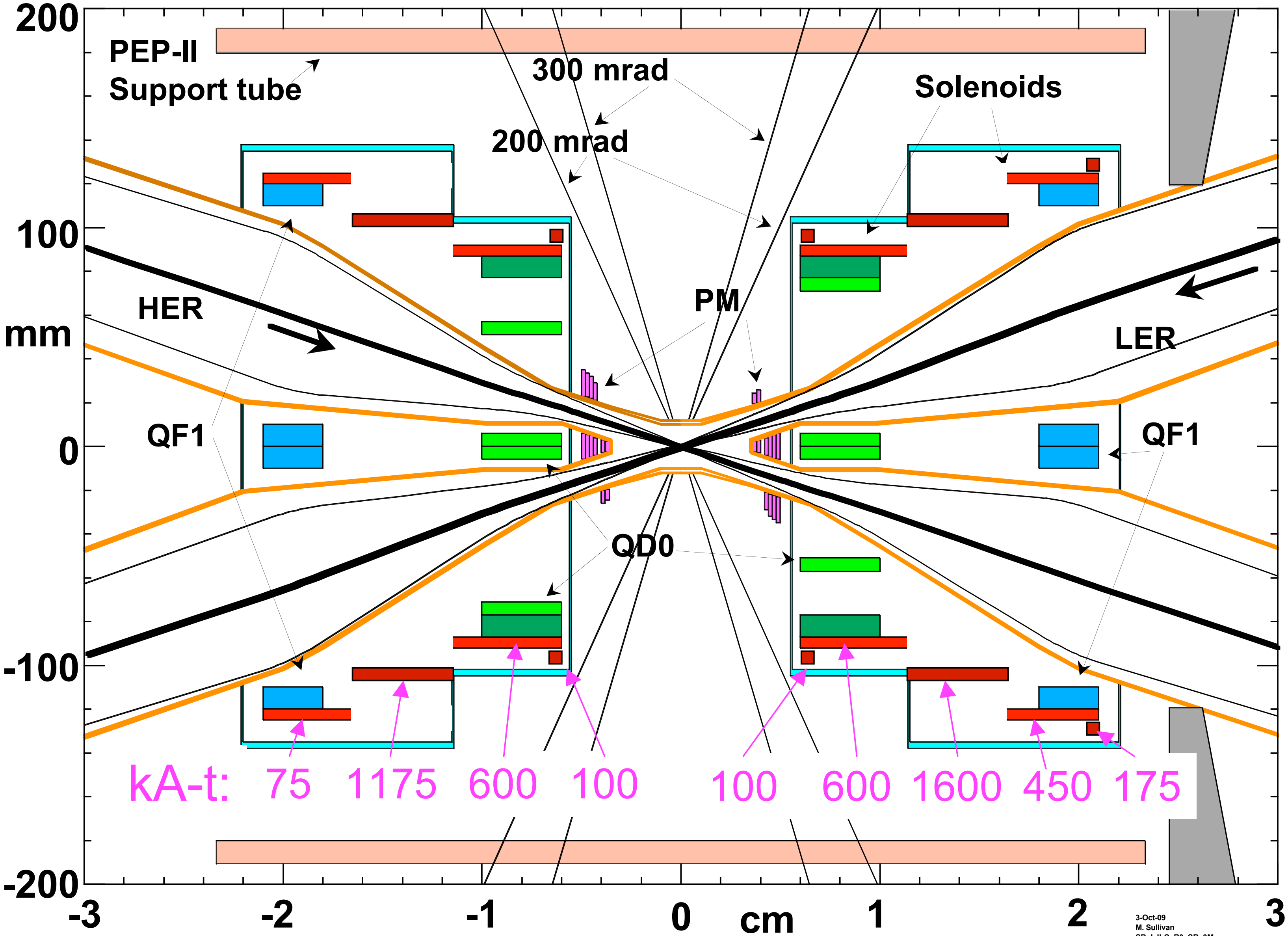
IR With Extra Solenoids

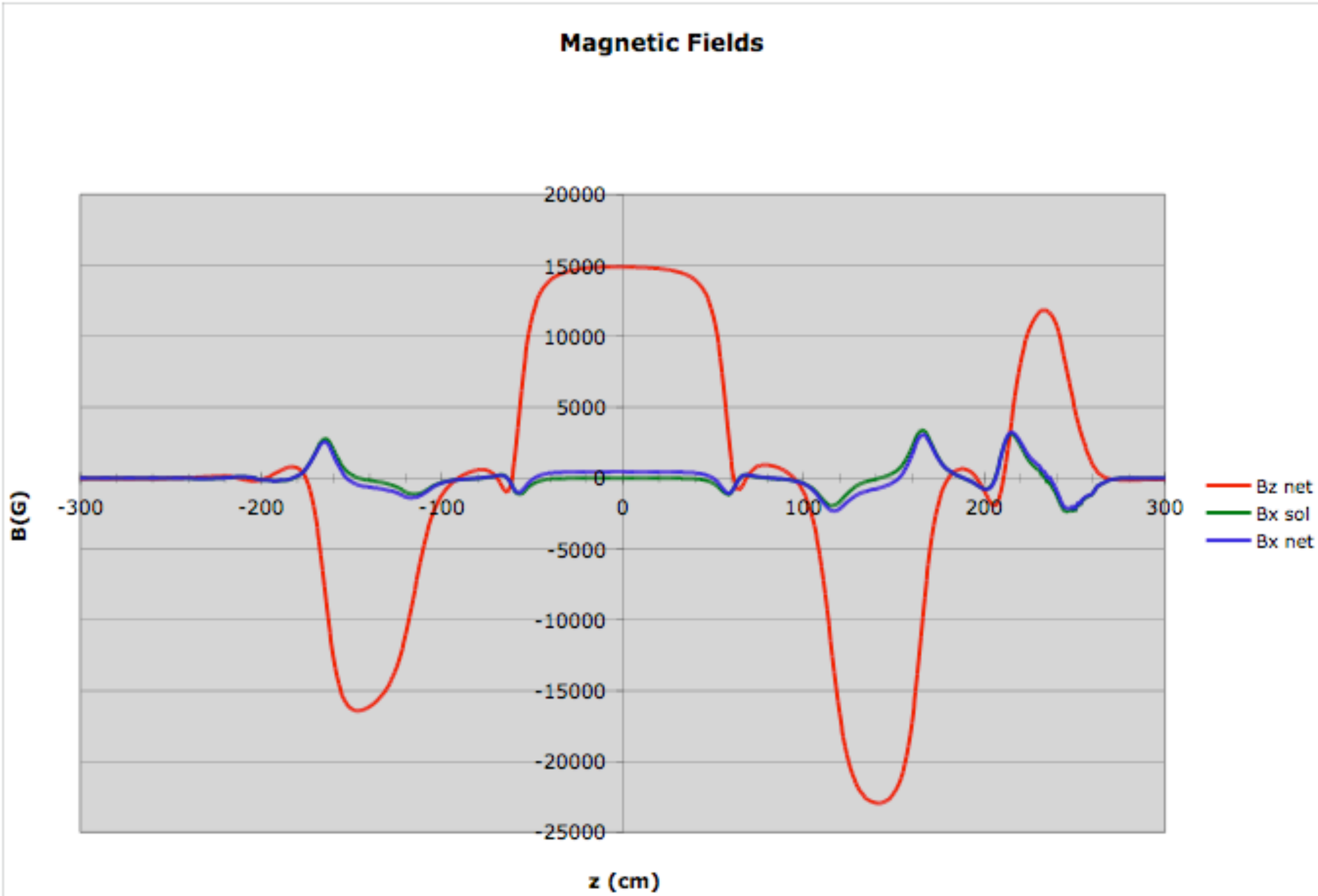
SuperB



Solenoid Excitations

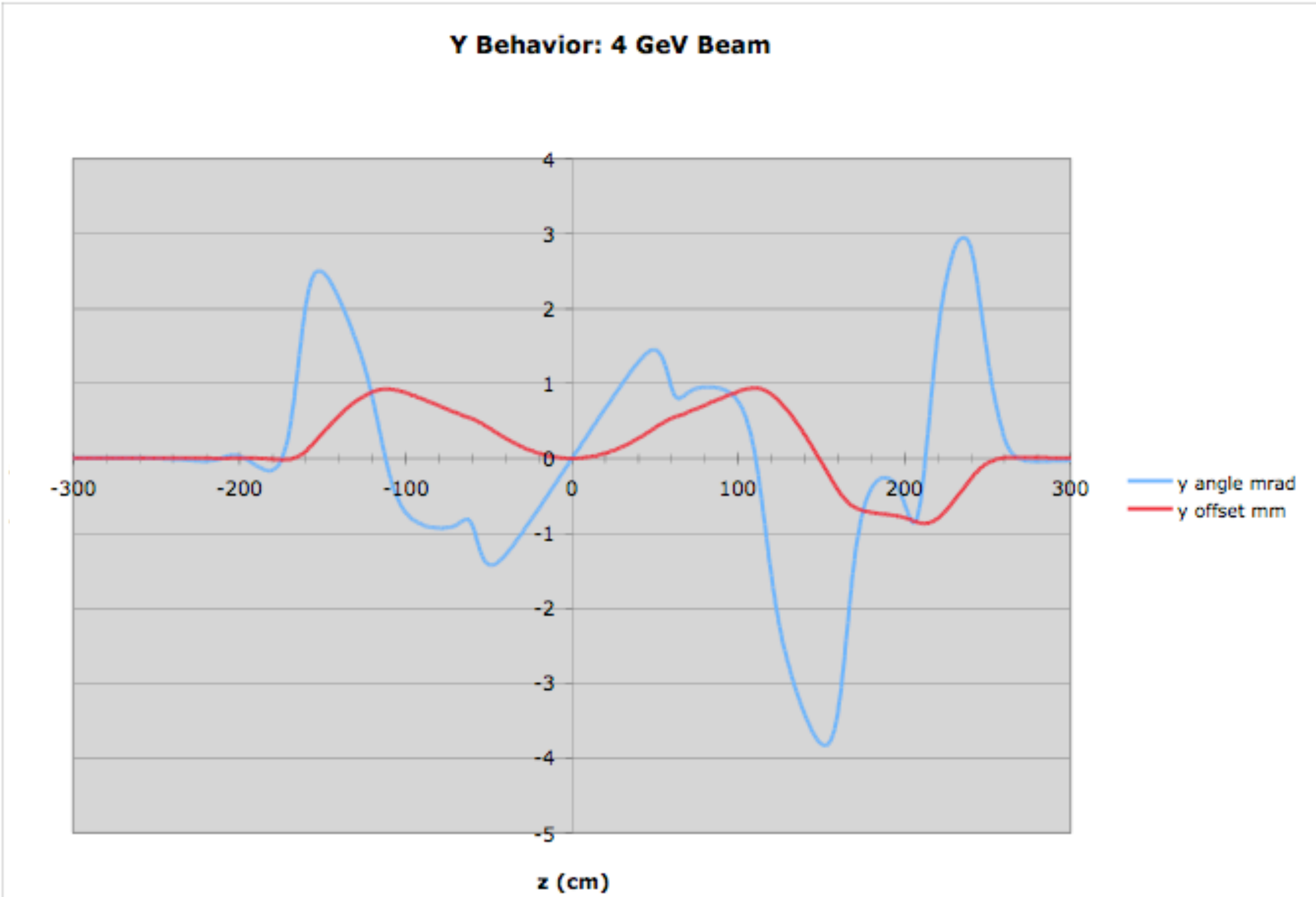


B Fields



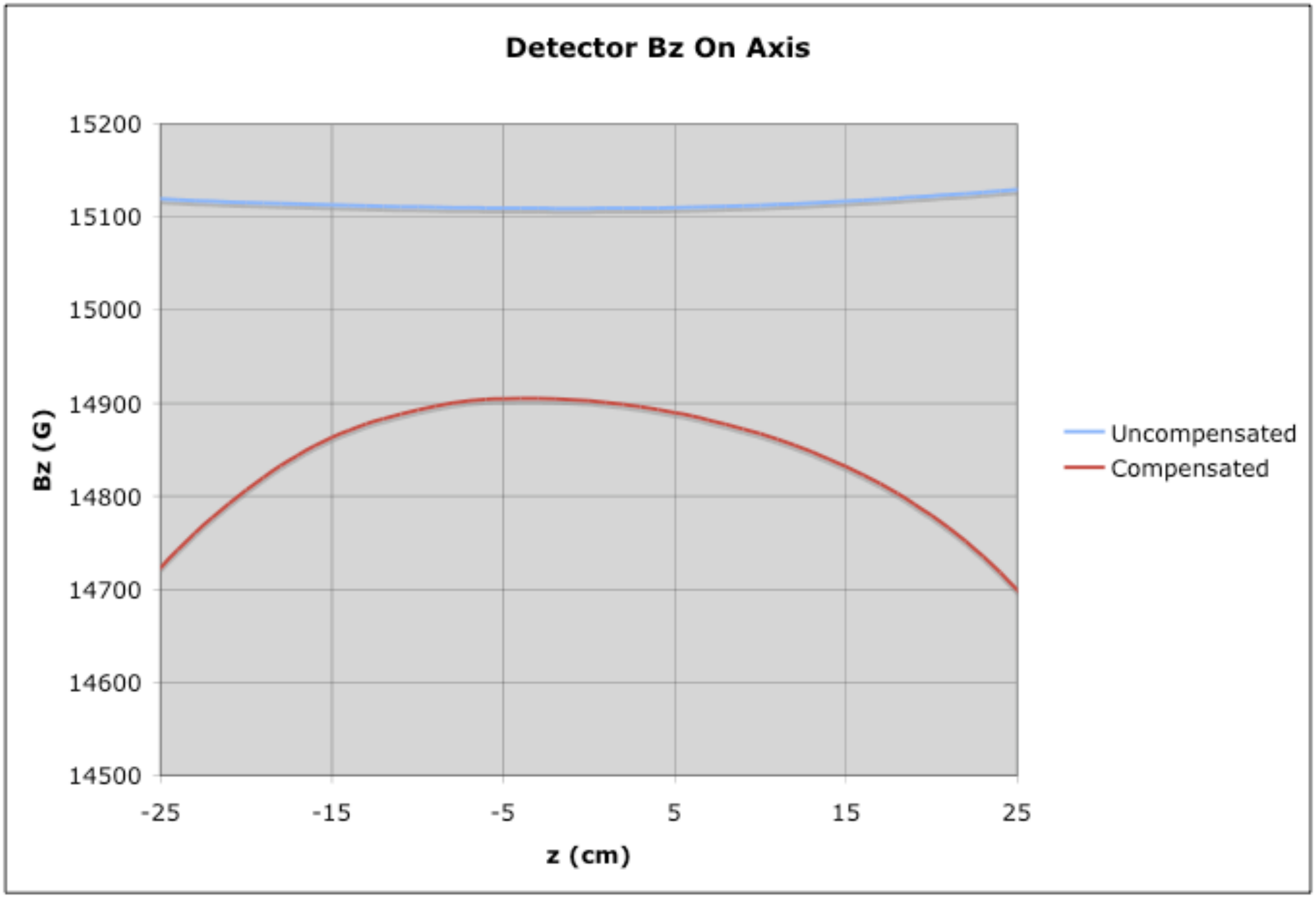
- B_z < 1.5 kG in SC quads, but high gradient at ends
- Modifications to trim windings can improve this

Beam Offset & Angle (4 GeV)



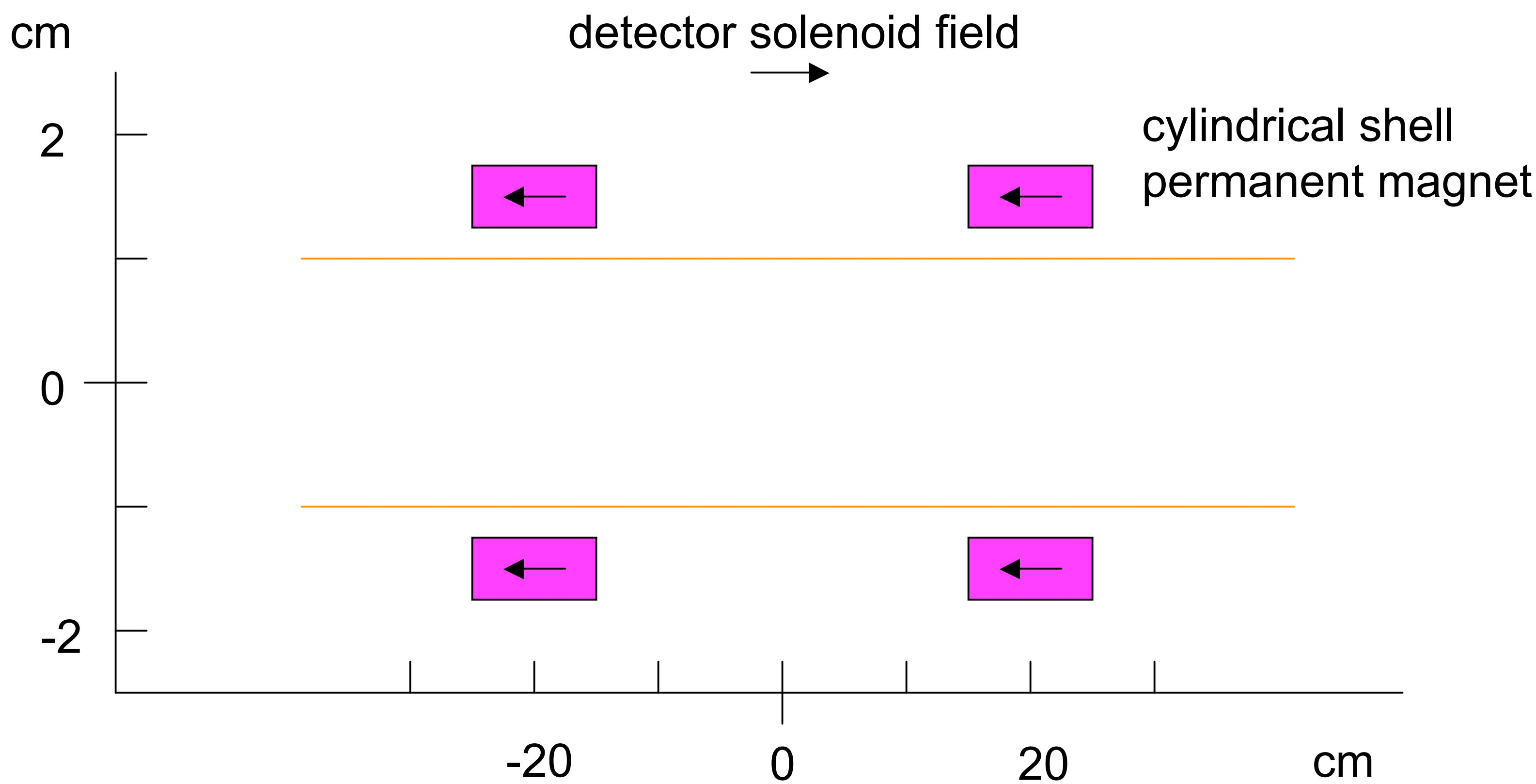
- Does not include quad kicks (small and correctable?)

Detector Field Distortion



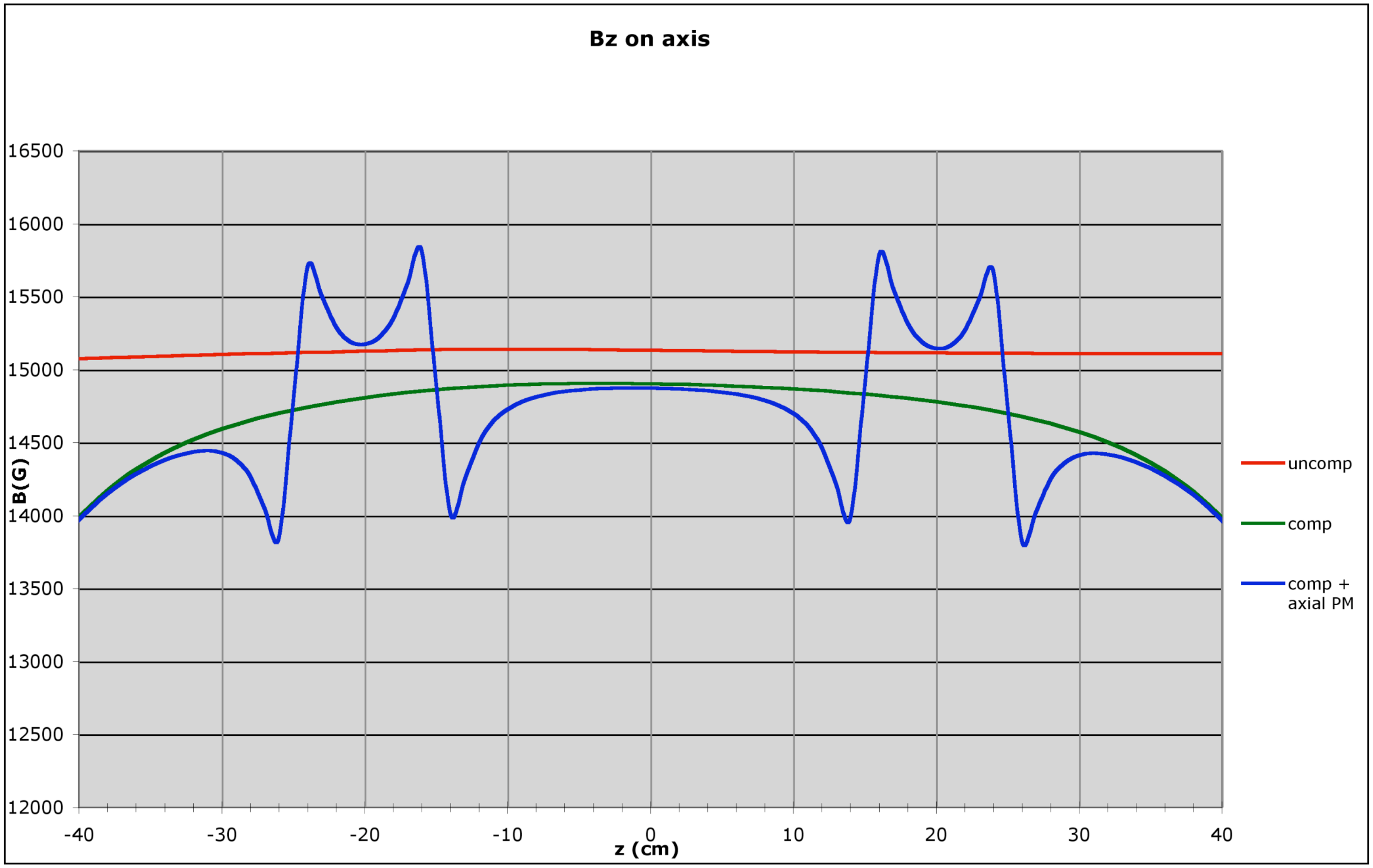
- Compensating solenoids distort detector field slightly
- Additional trim windings around PM quads or closer to IP could help

With Axial PM "Solenoids"



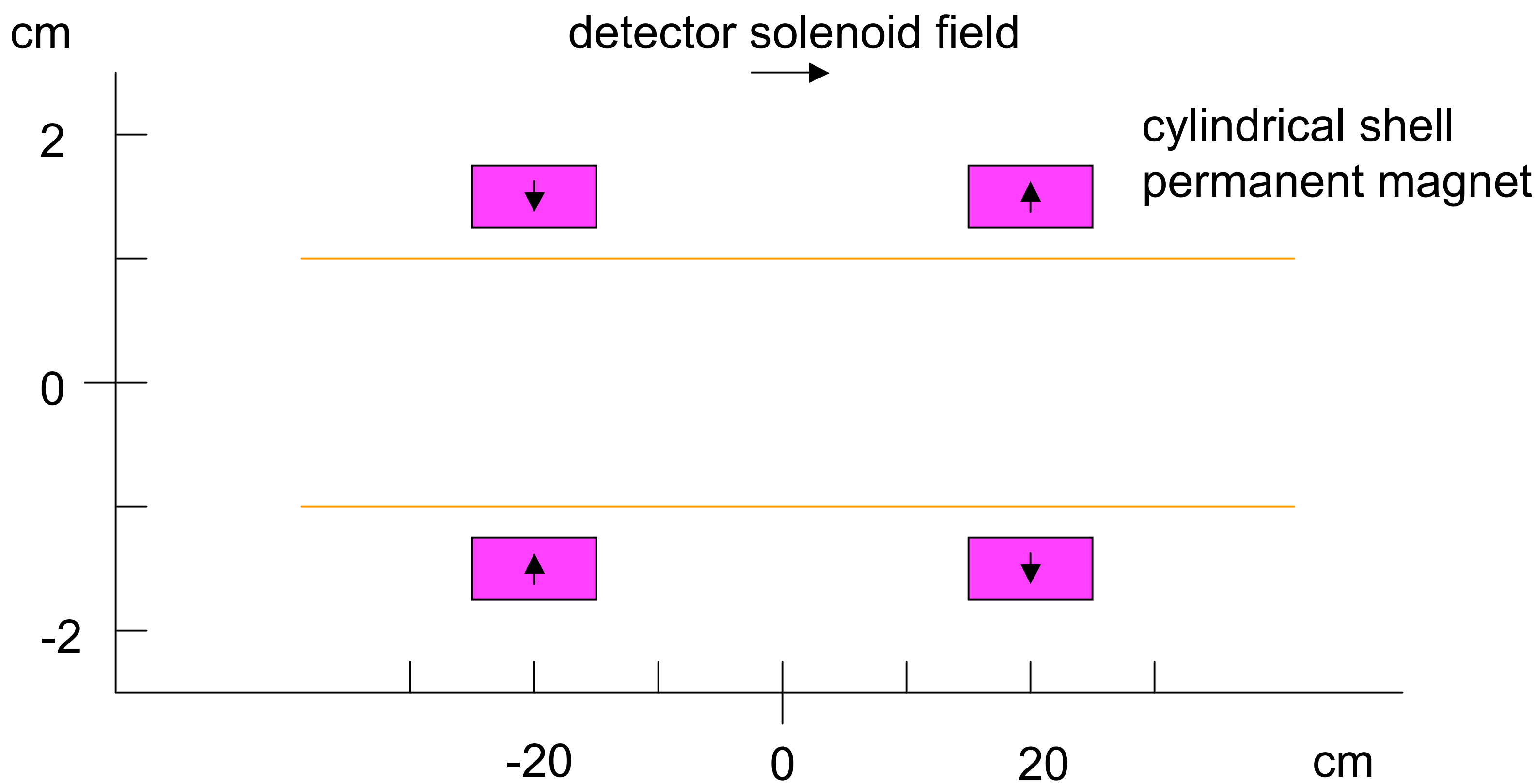
- Cylindrical shells of PM material with axial polarization
- Produces bumps in B_z near IP (if desired)

Bz with Axial PM cylinders



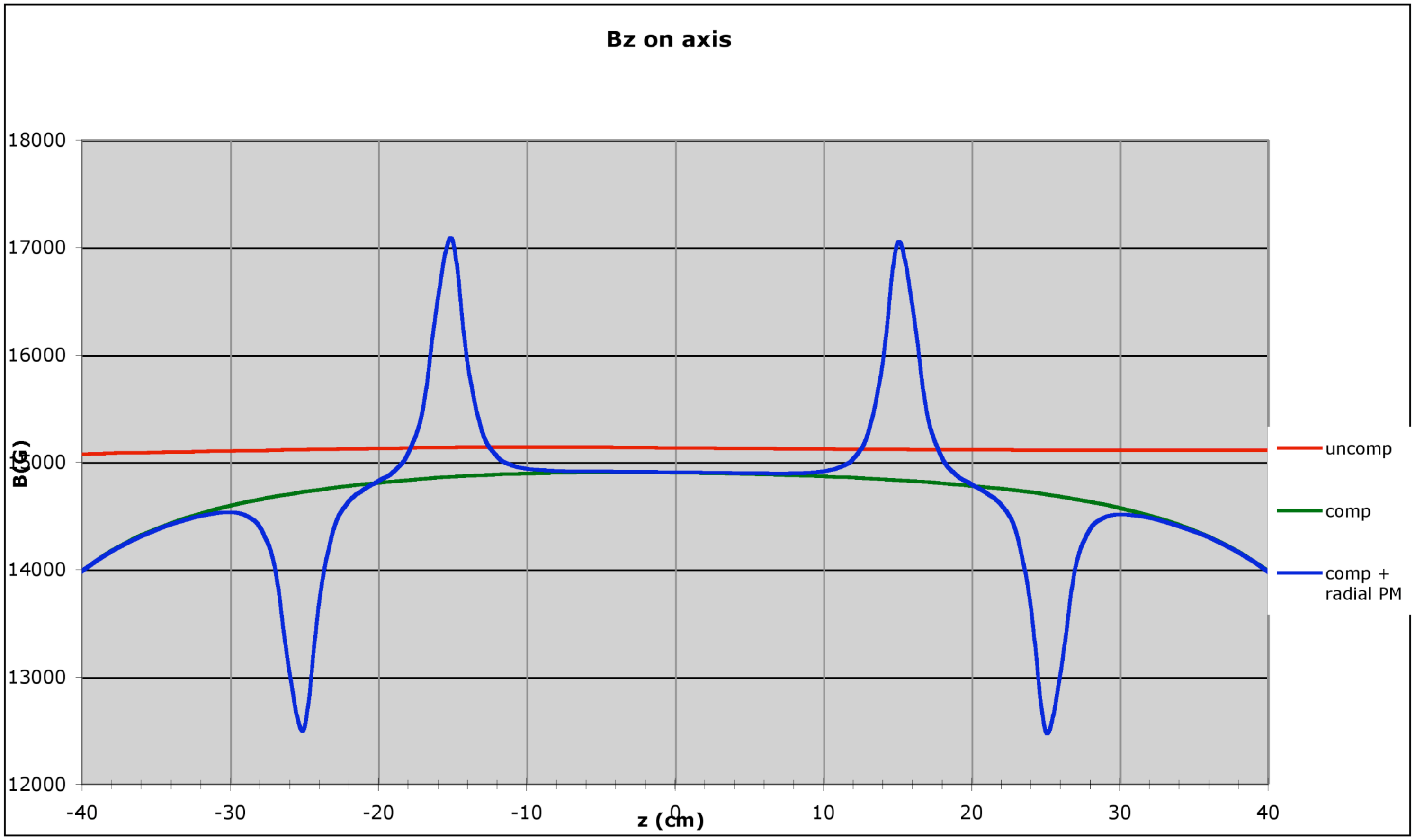
- Cylindrical shells of NdFeB (14 kOe), axial polarization

With Radial PM "Solenoids"



- Cylindrical shells of PM material with radial polarization
- Produces bumps in B_z near IP (if desired)

Bz with Radial PM cylinders



- Cylindrical shells of NdFeB (14 kOe), radial polarization

Comments

- Assumes quads do not steer or couple
  - True if quads are rolled and shifted to follow beam
  - Effects should be small, but need detailed simulation
- Assumes solenoids have circular cross-section
  - Oval cross-section is attractive; will perturb trajectories but will not change integral of B_z
- Will slightly perturb detector field
- PM rings could be added to modify B_z near IP
- Assumes beamline components are iron-free
  - Panofsky style QD0 may need additional solenoid to reduce detector field perturbations