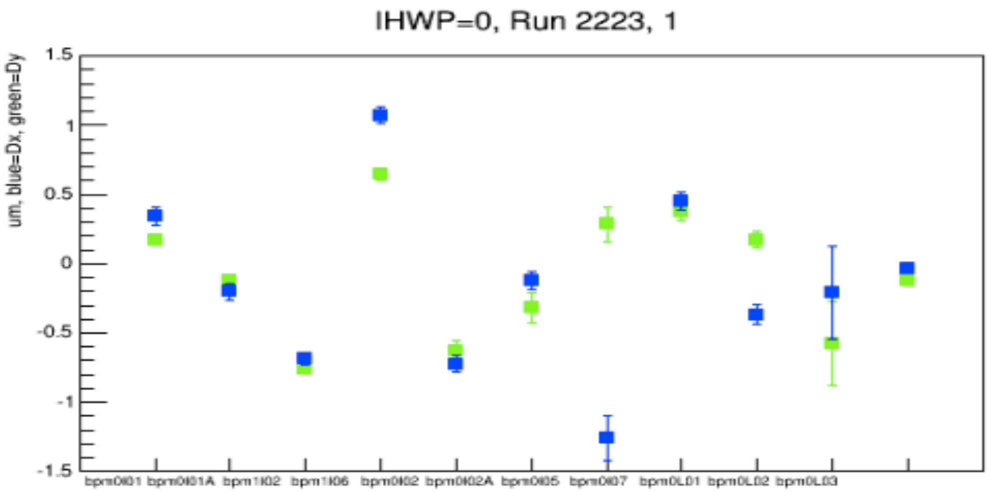
PQB Meeting

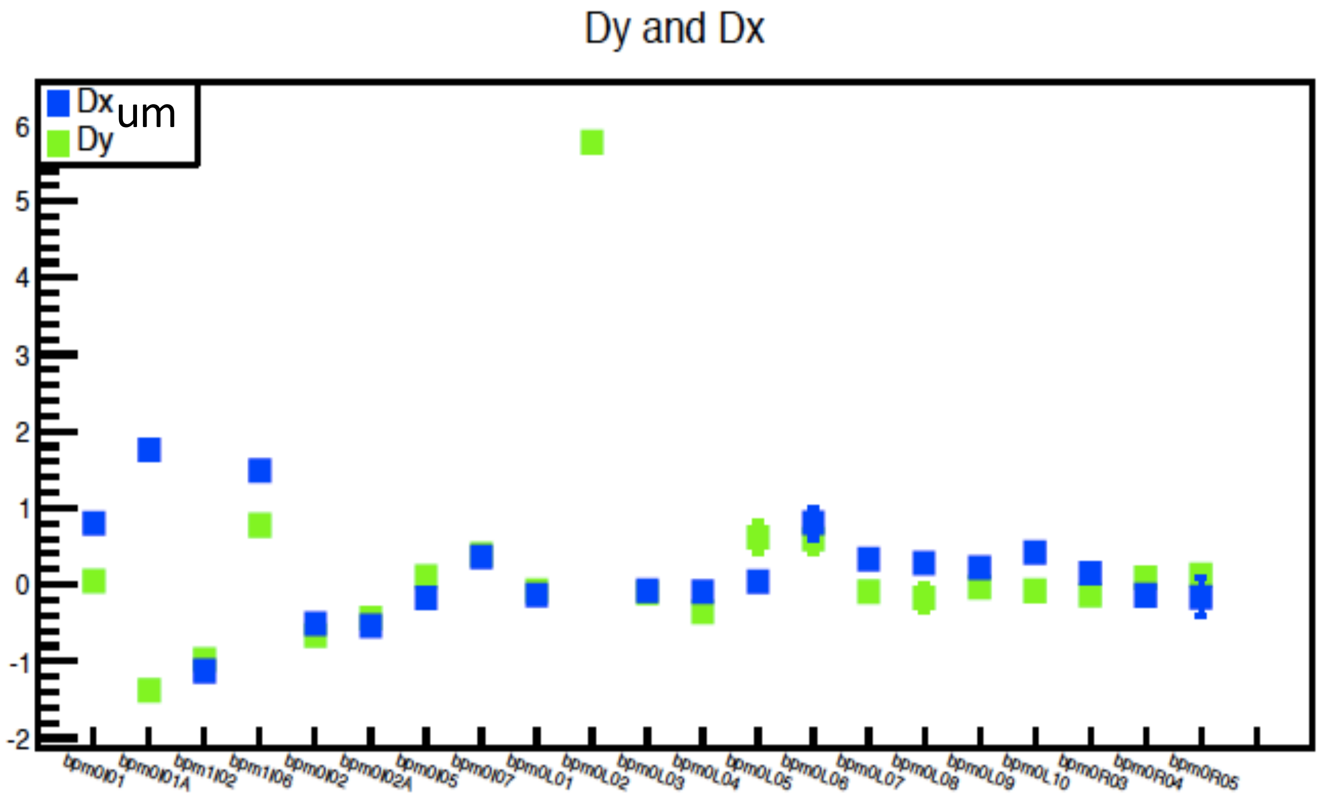
01/26/2017, Caryn Palatchi

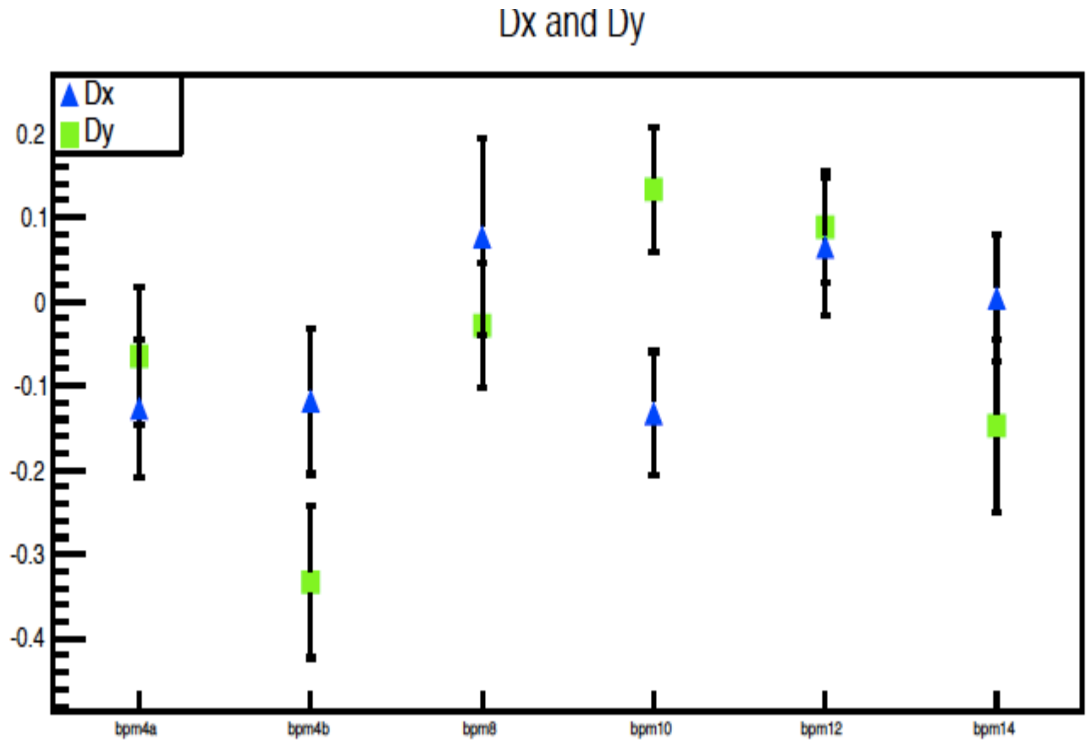
Run down:

- Joe has suggested post-March22 ~1week studies (with intent towards publication with Matt) regarding PC alignment, spot size, injector studies
- Performed Injector Laser table measurements with John & Joe
- Calculation of injector laser beam properties
- Spot size/ pos diff history of previous experiments tabulated
- Working on calculation of different laser setups on injector table – spot size studies

Where we are

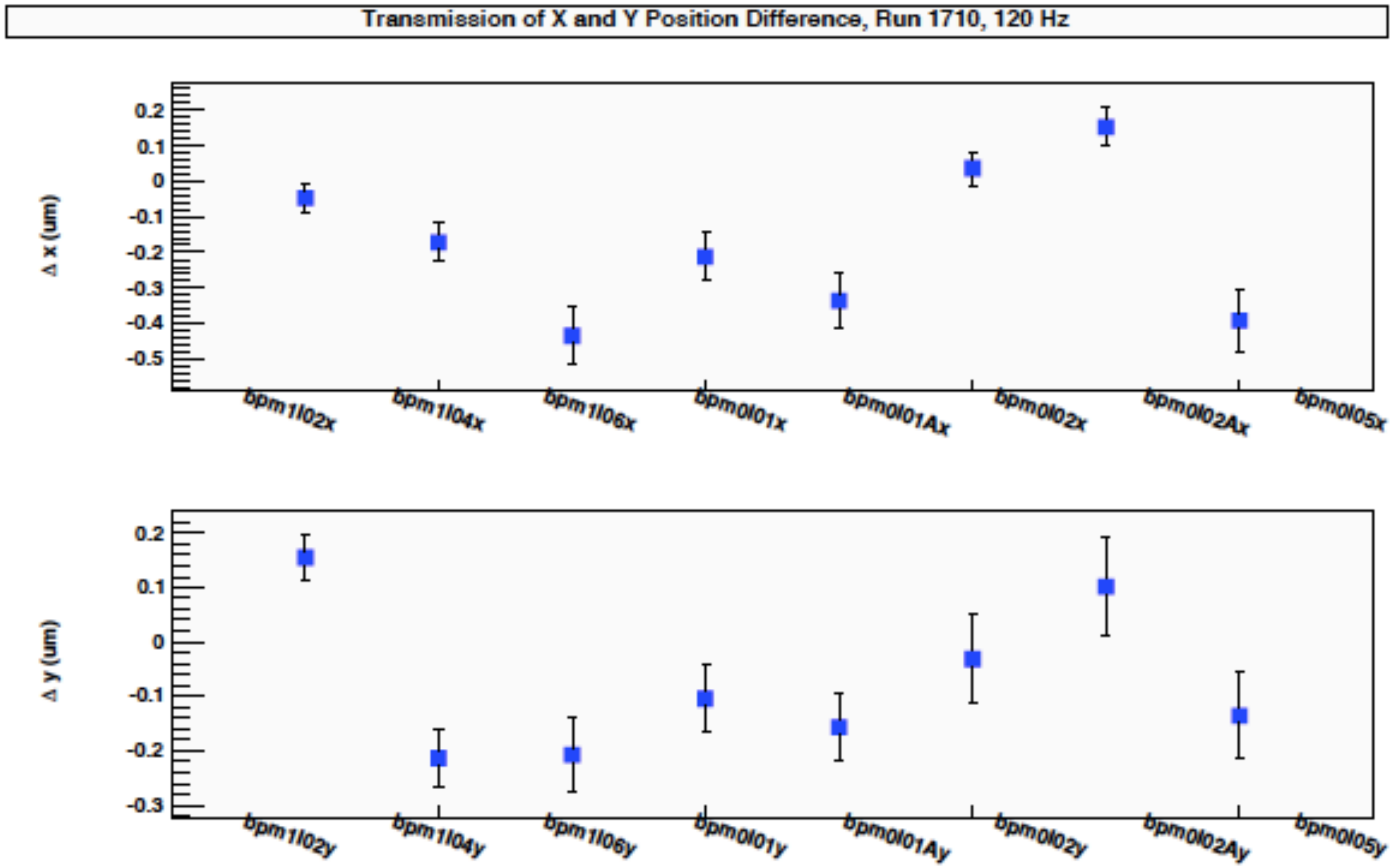






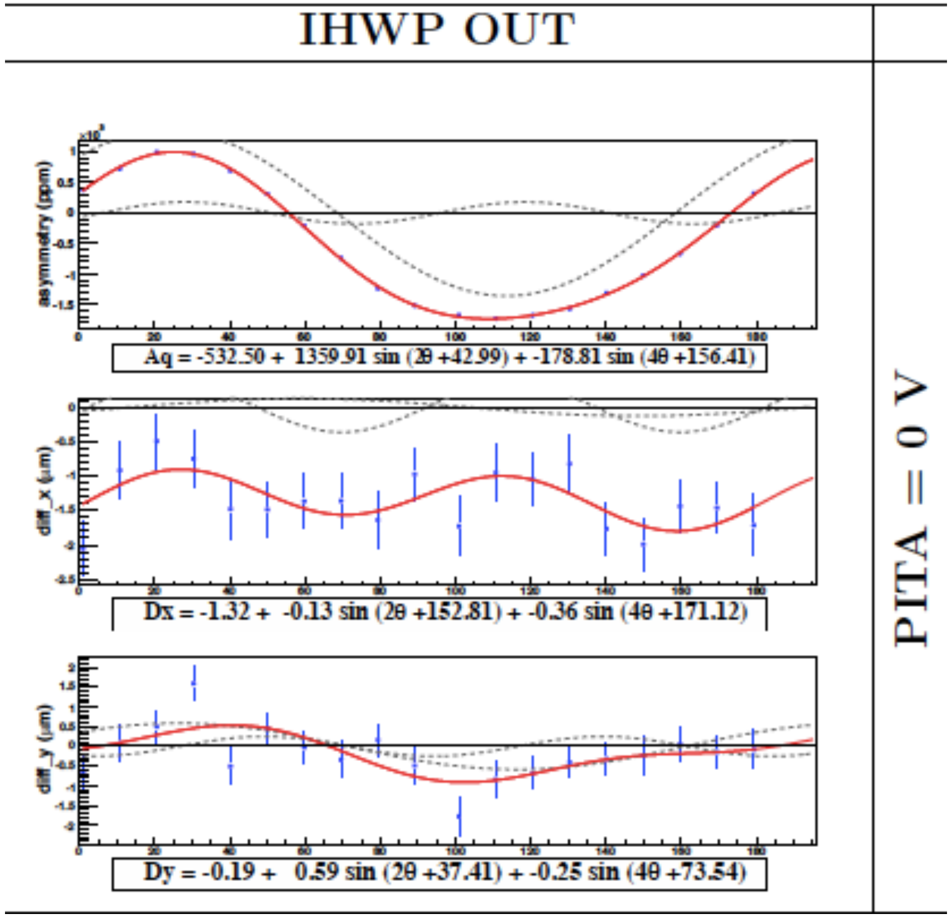
- ~1um posdiff in injector, ~0.3um posdiff in Hall, 6GeV beam

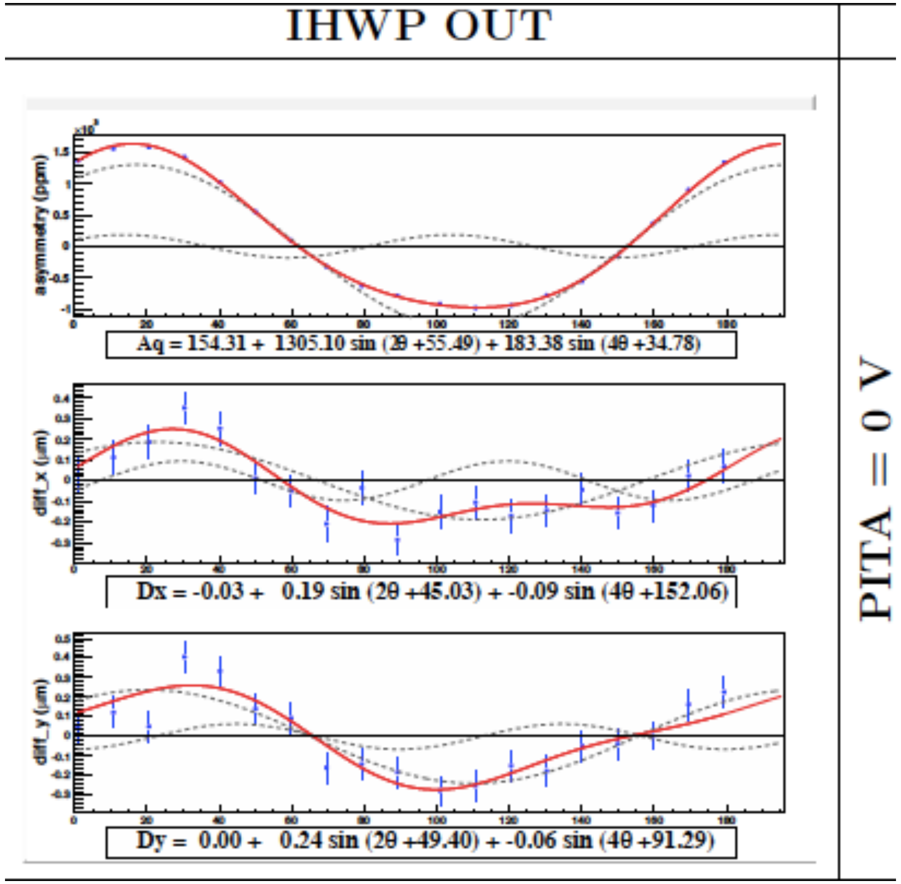
Where we want to be



- Pos diff inj ~200-300nm, Pos diff Hall~30-100nm~60nm, PREXI

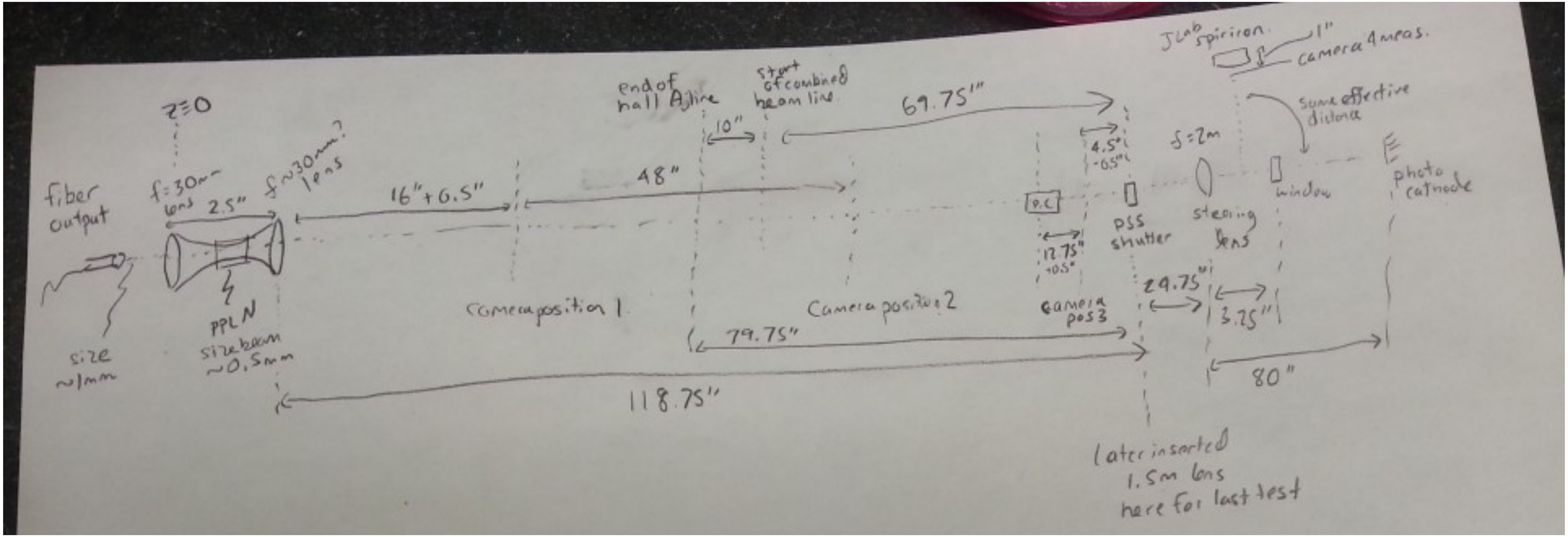
Going from what we have to what we want





- PREXI: Photocathode rotation and PC translation took A->B
- Spot size reduction

Jlab table layout



Noted that previously: distance from steering lens to vacuum widow was 0.154m, and distance from window to cathode was 2m

UVa spiricon hallA laser 1/19/16	from PSS shutter to ND filter on camera				UVa spricon horizontal =y, vertical =x, camera rotated						
					mm	mm	mm	mm	mm	mm	notes on measurement
					Sqrt(2Ln(2)) w	Sqrt(2Ln(2)) w	2 w	2 w	2 w	2 w	
					2 Sqrt(2Ln(2)) σ	2 Sqrt(2Ln(2)) σ	4 σ	4 σ	4 σ	4 σ	
upstream from shutter to orange filter	z(inches)	z(inches)	z(m)	z(m) from records	FWHM vertical	FWHM horizontal	4sigma vertical	4sigma horizontal	gaus width vertical	gaus width horizontal	
fiber output					"~1mm"						
f=30mm lens		0	0.000								
PPLN crystal					"~0.5mm"						
"f~30mm" lens, possibly different lens, can be changed, distance can be changed		2.5	0.064								
UVa spiricon position 1	102.75	19	0.483		0.44	0.42	1.2	0.83	0.9	0.73	before IA, extra NDs, 180atten
Last place to put a lens only affecting HallA beam		41.5	1.054								
First place to put al lens affecting all Halls beamlines		51.5	1.308								
UVa spiricon position 2	54.75	67	1.702		0.81	0.69	2.57	2.1	2.37	2.14	upstream of pc, 1.5mW, 180atten
Pockels Cell center		104	2.642								
UVa spiricon position 3	4.5	117.25	2.978		1.85	1.65	3.79	3.24	3.66	3.4	downstream from pc, 1.5mW, 180atten
PSS shutter		121.25	3.080								
steering lens f=2m (has been 1.5m on past occasions)		146	3.708								
vacuum window		149.25	3.791	3.862							
UVa spiricon position 4	-103.75	225	5.715	5.837	1.34	1.22	2.2	2.2	2.16	2.12	within 1" of Jlab spiricon
photocathode		226	5.740	5.862							
JLab spiricon 4.4um/pix, horizontal = x, vertical = y		226	5.740				2.19	2.2			
lens f=1.5m placed at pss shutter, JLab spiricon		226	5.740	5.862			2.4	2.9			
Jlab spiricon hall b laser		226	5.740				2.33	2.14			
Jlab spiricon hall c laser		226	5.740				1.9	2			
Jlab spiricon hall d laser		226	5.740				2.05	2			
Jlab spiricon 8/24/16 4sigma measurement		81	2.057				3.1	2.5			background ight not be subtracted well
Jlab spiricon 8/24/16 4sigma measurement		99.5	2.527				3.4	2.9			background ight not be subtracted well
Jlab spiricon 8/24/16 4sigma measurement		110.5	2.807				3.9	3.1			background ight not be subtracted well
Jlab spiricon 8/24/16 4sigma measurement		135.5	3.442				4.5	3.7			background ight not be subtracted well
Jlab spiricon 8/24/16 4sigma measurement		147.5	3.747				4.7	3.9			background ight not be subtracted well

Ltot	3.099
Leff (2m)	2.0149312
Leff(1.5m)	1.6536416

Beam waist propagation fundamentals

$$q = z - zR + i\,zR$$

$$zR = \frac{\pi\, wi^2}{M^2\, \lambda}, \quad M \geq 1$$

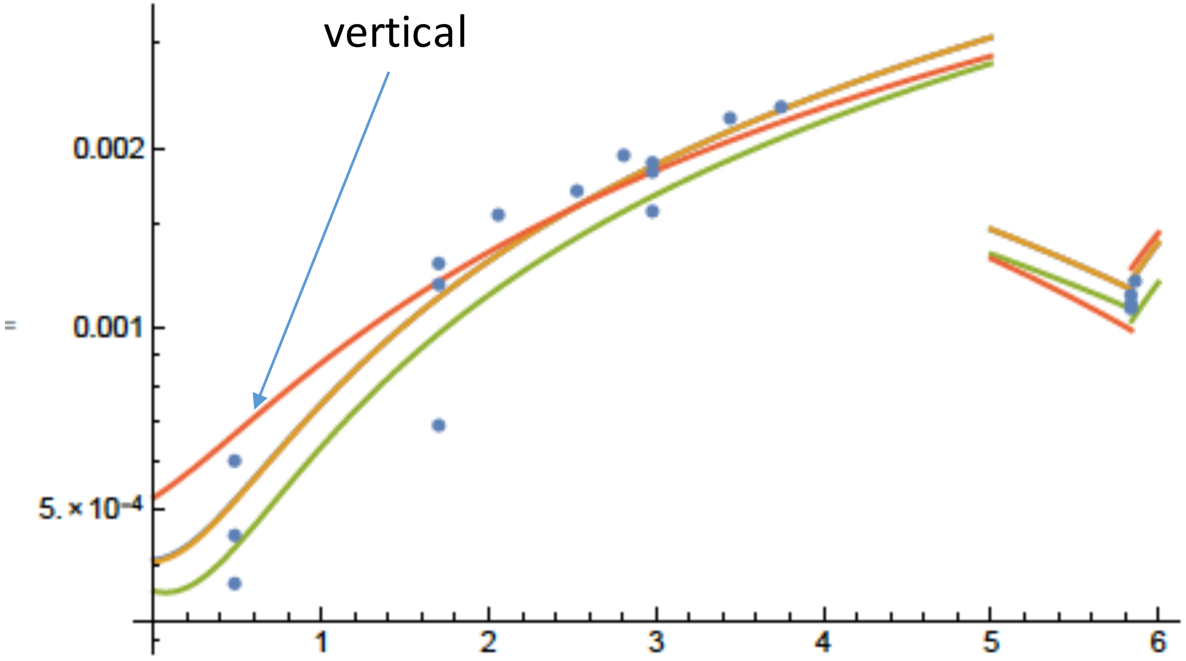
$$w = w0\sqrt{1 + \frac{(z - z0)^2}{zR^2}} = 2\,\sigma = \frac{\text{FWHM}}{\sqrt{2}\,\sqrt{\text{Ln}[2]}} = \frac{1}{e^2}\ \text{radius}$$

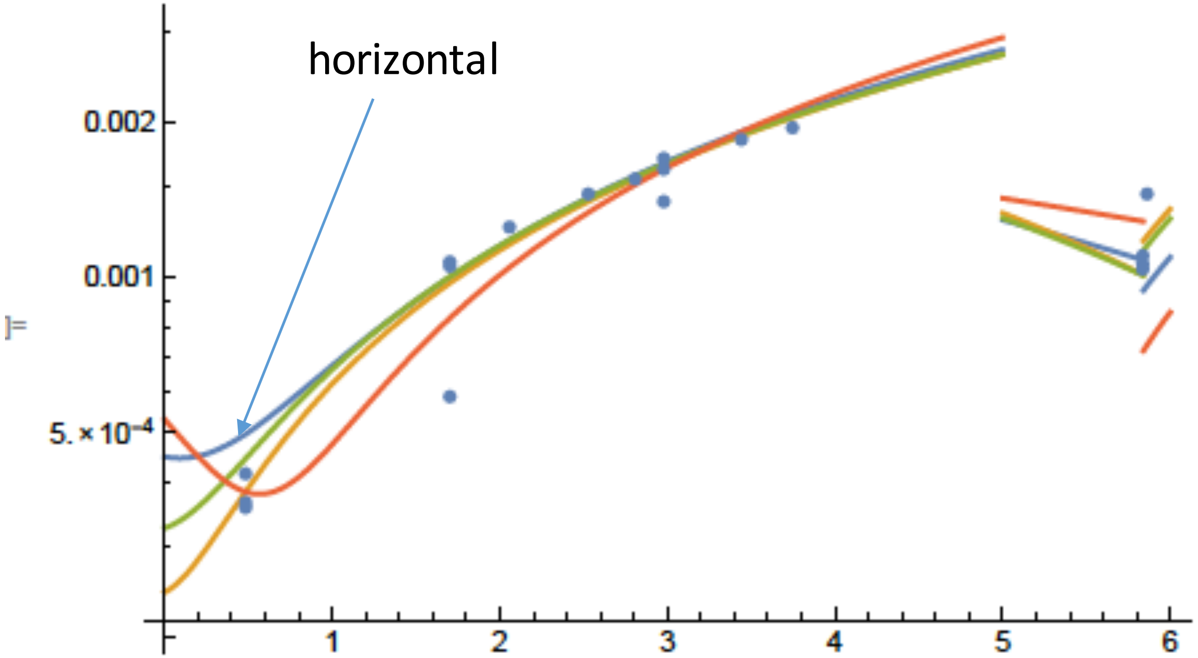
$$\begin{pmatrix} qf \\ 1 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} qi \\ 1 \end{pmatrix}, \quad \text{define 2 nd row to always be 1}$$

$$qf = \frac{B + A\,qi}{D + C\,qi} = z - z0f + i\,zRf = \text{Re}[qf] + i\,\text{Im}[qf]$$

$$\theta halfangle = dw / dz = \frac{M^2\,\lambda}{\pi\, w0}\sqrt{\frac{1}{1 + \frac{zR^2}{\Delta z^2}}}$$

Fit to Jlab data results





There are 2 additional sets of data points (1) after the steering lens (2) after the steering lens with a 1.5m lens at the PSS shutter. These were included in the data and w0, z0, and M2 were the fit parameters.

Results:

Vertical - w0~0.409mm, half-angle-divergence=0.605mrad, z0~ -3.5cm (from lens immediately after PPLN crystal)

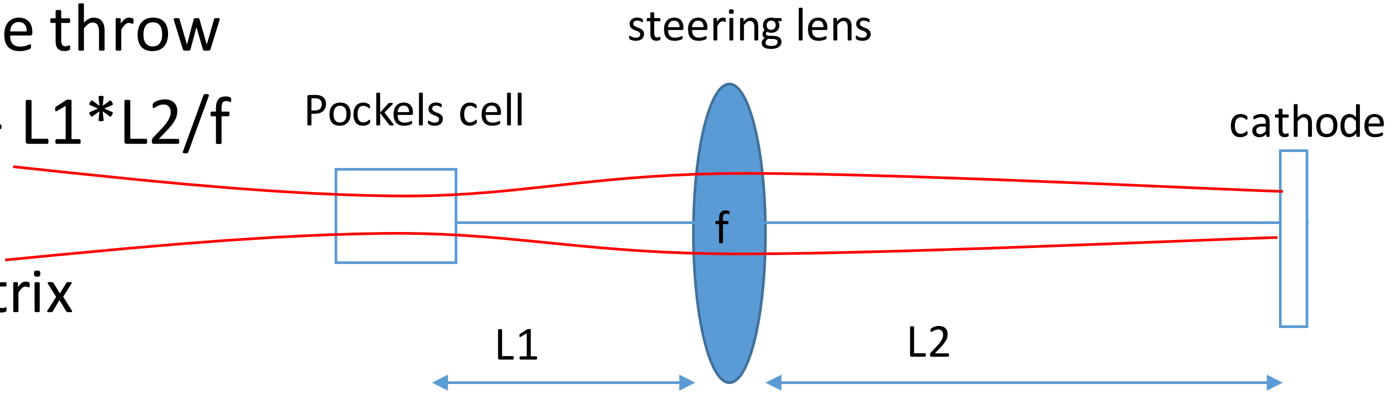
Horizontal - w0~0.445mm, half-angle-divergence=0.555mrad, z0 ~ 9cm (from lens immediately after PPLN crystal)

What previous experiments have had

- HAPPEX 2004
  - wpc=0.7mm, wc=0.9mm, Leff(1.5m lens?)=1.65m
  - Injector Pos diffs: 500-1000nm, ~3X adiabatic damping, wpc*wc~0.63
- HAPPEX 2005
  - wpc>0.7mm, wc~0.5mm, Leff(1.5m lens?)=1.65m
  - Injector Pos diffs: <400nm, ~25X adiabatic damping, wpc*wc<0.35
- PREX I
  - wpc=0.7mm, wc=0.5mm, Leff(1.5m lens)=1.65m
  - Injector Pos diffs: 200-400nm, ~3X adiabatic damping, wpc*wc~0.35
- QWEAK
  - wpc=?, wc=1mm, Leff(2m lens)=2.014m
  - Injector Pos diffs: (50-100nm)x2, NO adiabatic damping, wpc*wc~?
- NOW
  - wpc=1.9mm, wc=1.1mm, Leff(2m lens)=2.014m
  - Injector Pos diffs: ~1000nm, ~3X adiabatic damping (for 6GeV), wpc*wc~2.09
- PREXII/CREX (with 1m lens added for example)
  - wpc=0.53mm, wc=0.85mm, Leff(2m lens)=2.014m
  - Injector Pos diffs: ~(1000nm)*(0.63/2.09)~200nm, >3X adiabatic damping, wpc*wc~0.45

Position Differences at Cathode

- Quadratic terms and beam widths/divergences produce offset terms in Aq
- Anal Pos diff ~ spot size * gradient * analyzing power
- Steering pos diff ~ effective throw
- Effective throw = L1 + L2 - L1*L2/f



Leff is the B of the ABCD matrix

Leff = L1+L2-L1*L2/f

for Leff = 0 → rf=(1-L2/f)r

& for L1=L2=2f → rf=-r

$$\begin{pmatrix}A & B\\ C & D\end{pmatrix} = \begin{pmatrix}1 & L2\\ 0 & 1\end{pmatrix}\begin{pmatrix}1 & 0\\ -1/f & 1\end{pmatrix}\begin{pmatrix}1 & L1\\ 0 & 1\end{pmatrix} = \begin{pmatrix}1-\frac{L2}{f} & L1+L2-\frac{L1\,L2}{f}\\ -\frac{1}{f} & 1-\frac{L1}{f}\end{pmatrix} = \begin{pmatrix}1-\frac{L2}{f} & Leff\\ -\frac{1}{f} & 1-\frac{L1}{f}\end{pmatrix}$$

$$\begin{pmatrix}rf\\ \theta f\end{pmatrix} = \begin{pmatrix}1-\frac{L2}{f} & L1+L2-\frac{L1\,L2}{f}\\ -\frac{1}{f} & 1-\frac{L1}{f}\end{pmatrix}.\begin{pmatrix}r\\ \theta\end{pmatrix} = \begin{pmatrix}\left(1-\frac{L2}{f}\right) r + \left(L1+L2-\frac{L1\,L2}{f}\right)\theta\\ -\frac{r}{f} + \left(1-\frac{L1}{f}\right)\theta\end{pmatrix} = \begin{pmatrix}\left(1-\frac{L2}{f}\right) r + Leff\\ -\frac{r}{f} + \left(1-\frac{L1}{f}\right)\end{pmatrix}$$

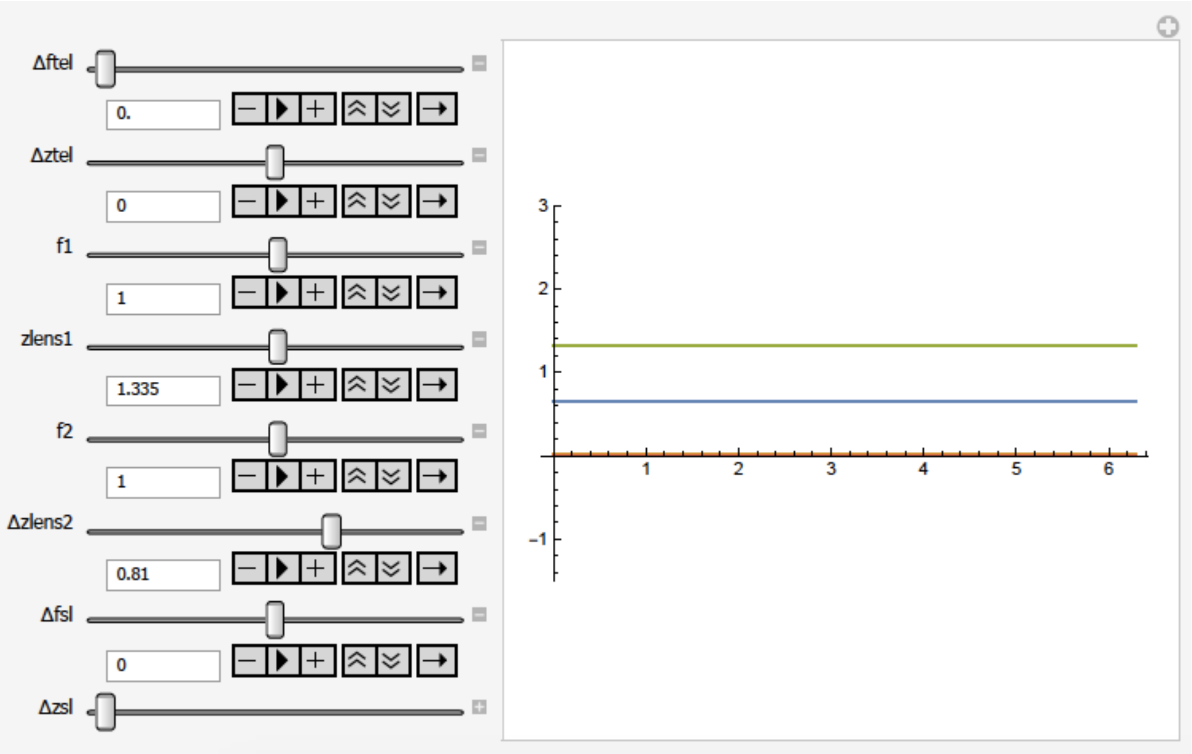
$$rf = \left(1-\frac{L2}{f}\right) r + Leff\,\theta$$

- To obtain an effective throw of 0 for current configuration, put 0.7m lens where steering lens is now. L2=2.154m, so rf=-2.08r. (DO NOT DO THIS FOR RTP, need Leff for control)

Predicting spot sizes/divergences for different layouts

Spot Size and Divergence adjustments we can make

- ~1m lens upstream of cell, just far enough to affect all Hall's beams
  wpc=0.53mm, wc=0.85mm,
  Leff(2m lens)=2.014m, zero divergence at cell
- Different steering lens
- Lens before PC and compensating lens after cell to keep cathode size the same



Summary

- Wish to reduce spot size, realign PC, & rotate photocathode with beam in injector
- Joe has suggested post-March22 ~1week studies (with intent towards publication) regarding PC alignment, spot size, injector studies
- Jlab laser/conditions/setup characterized and modeled
- Possible: Putting in a 1m lens at Jlab reduces spot sizes sufficiently

Spot Size and Divergence adjustments we can make

- 1m lens upstream of cell, 1.335m downstream of telescope's second lens, just far enough to affect all Hall's beams
  - wpc=0.53mm, wc=0.85mm, Leff(2m lens)=2.014m, zero divergence at cell
- A steering lens of 0.7m would reduce Leff to zero, and Rcathode = 2*Rpockelscell.
- A 1m lens before and 1m lens after the cell would keep the cathode the same wc=1.1mm and reduce wpc from 1.9mm to 0.53mm.
- A lm lens 0.2m after the Pockels cell, would keep the wpc the same=1.9mm and enlarge the wc from 1.1mm to 2.05mm (so 4sigma~4mm).