Collimation of Beam Halo for Compton Spectrum Diagnostics after the Interaction Point of ATF2

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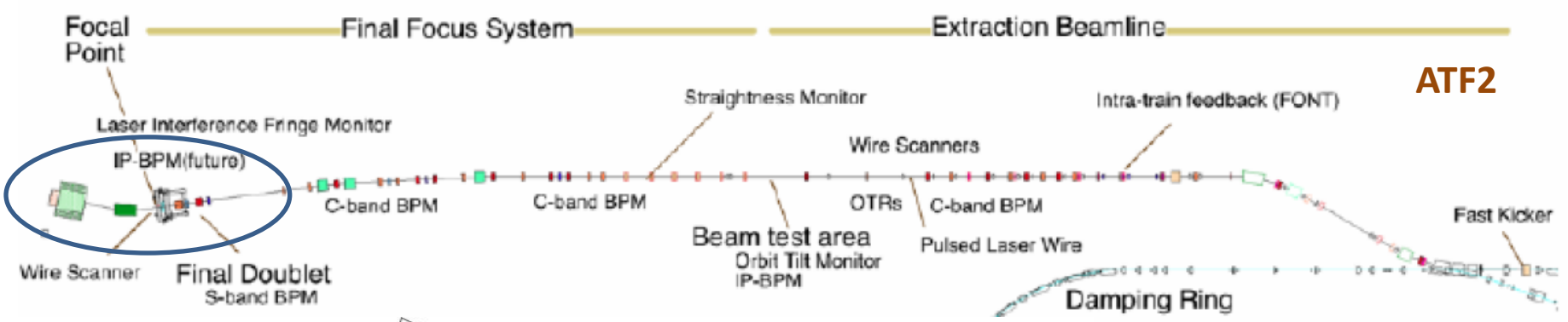
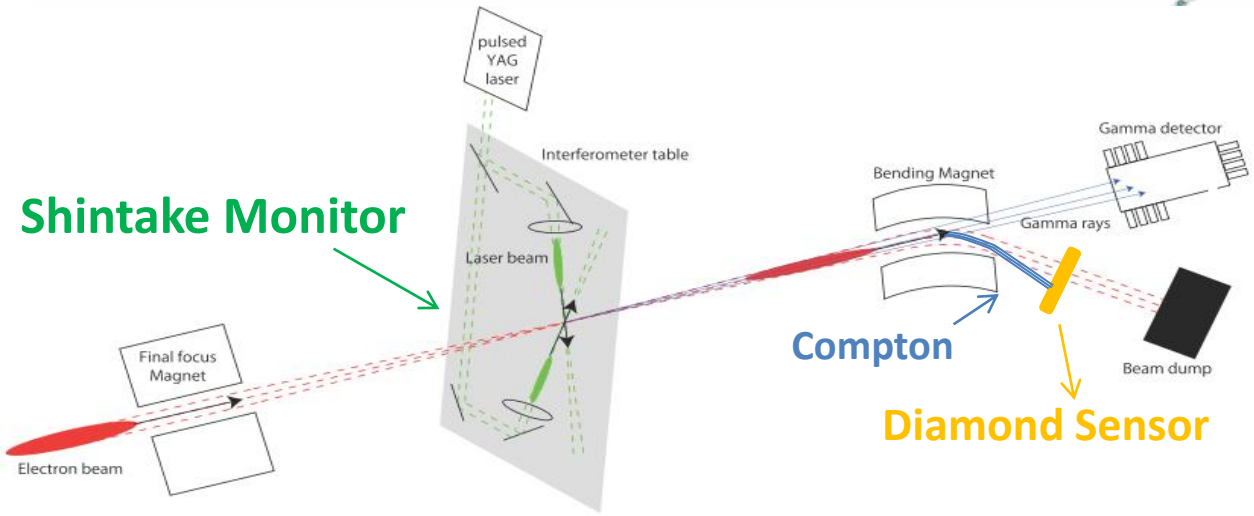
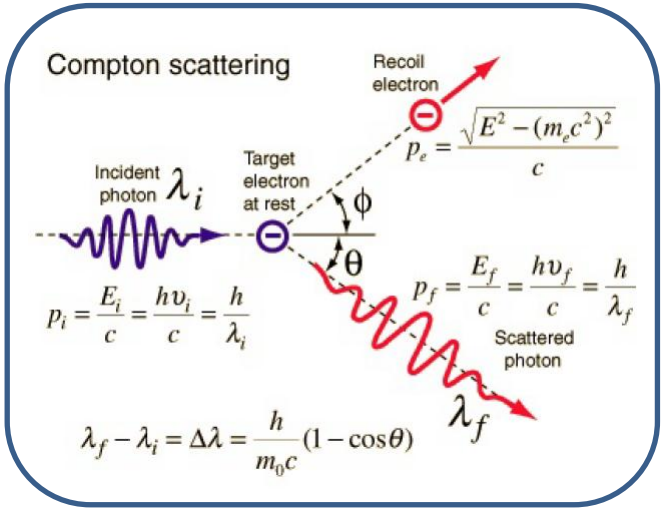
Outlines

- **Introduction**
- **Halo Generator**
- **Mad-X Simulation Results**
- **Halo Distribution with Small Energy Spread**
- **Vertical Collimation of Halo**
  - Vertical Halo Loss at BDUMP
  - Vertical Collimation at QD10
- **Halo Distribution with Large Energy Spread**
- **Horizontal Collimation of Halo**
  - Horizontal Collimation at QF1X
  - Horizontal Collimation at QF6X
- **Conclusions & Issues**

Introduction







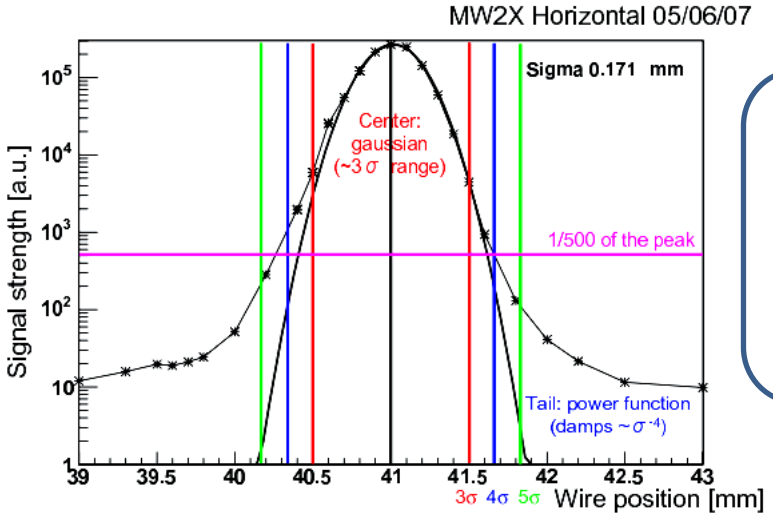
Halo on Y axis :

Hit BDUMP → may re-generate halo of off-momentum beam particles → GENT4 Simulation ;

Halo on X axis :

May cover the Compton signal in case of large initial energy spread.

Halo Generator



Halo Density

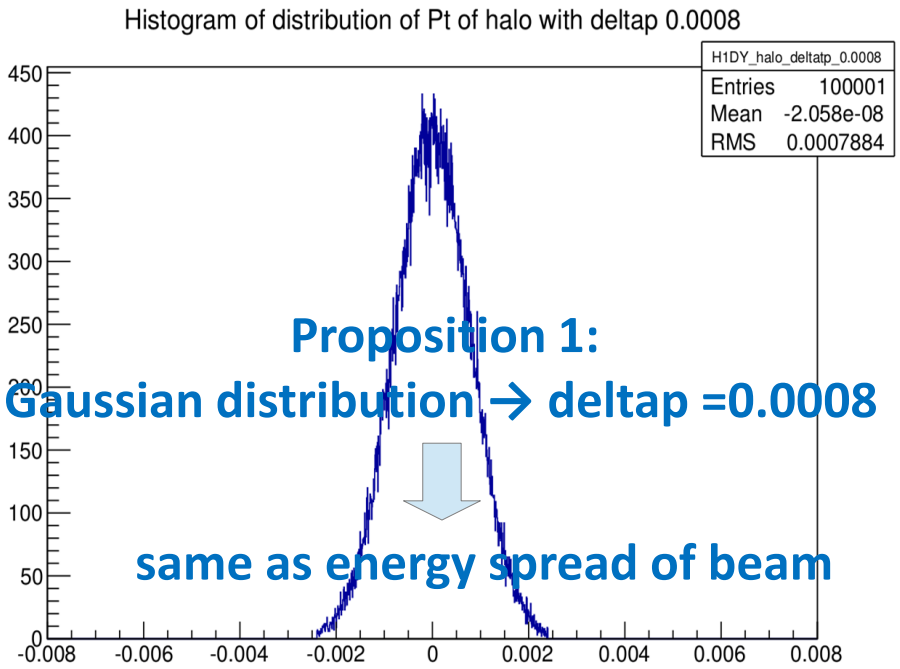
$$\rho_{h1} = 2.2 \times 10^{9} \times x^{-3.5} \qquad \text{(horizontal and vertical until 6 } \sigma\text{)}$$

$$\rho_{h2} = 3.7 \times 10^{8} \times x^{-2.5} \qquad \text{(vertical outside 6 } \sigma\text{)}$$

x-> the distance from the beam center as a unit of σ

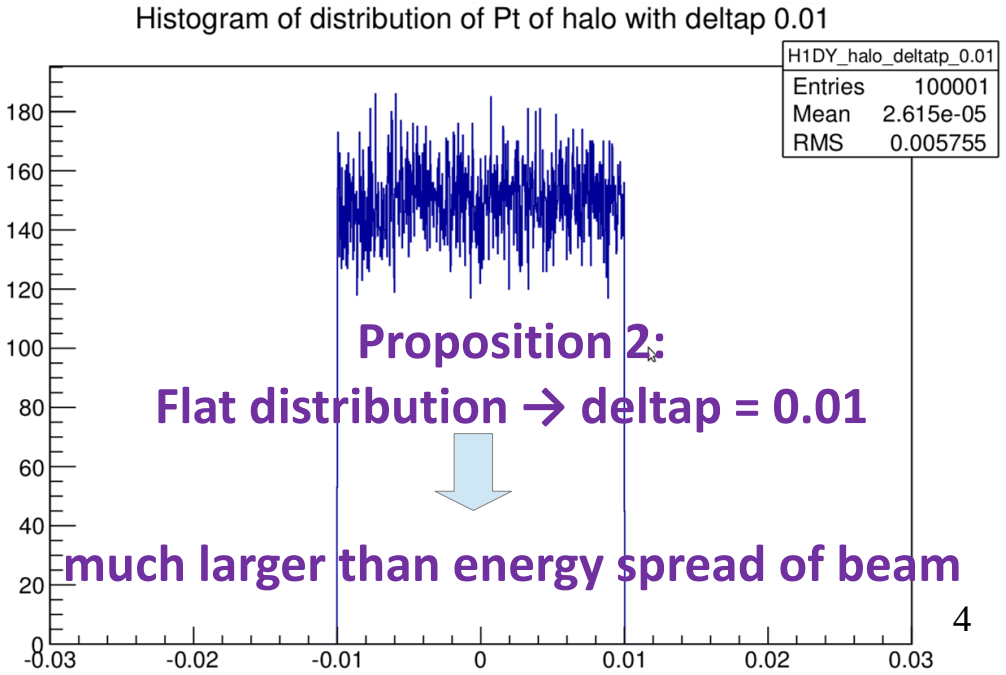
T. Suehara et al., "Design of a Nanometer Beam Size Monitor for ATF2", arXiv:0810.5467v1

Energy spread of halo = ? Unknown;



Proposition 1:
Gaussian distribution → deltap =0.0008

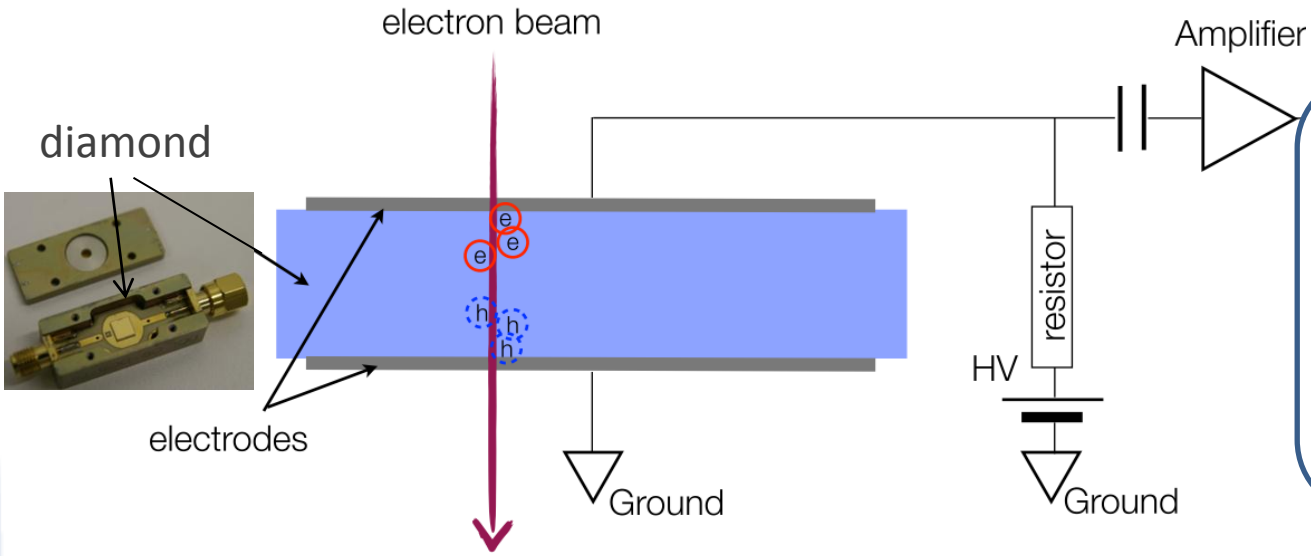
same as energy spread of beam



Proposition 2:
Flat distribution → deltap = 0.01

much larger than energy spread of beam

Mad-X Simulation Results for Beam & Halo & Compton Signal @ Sensor

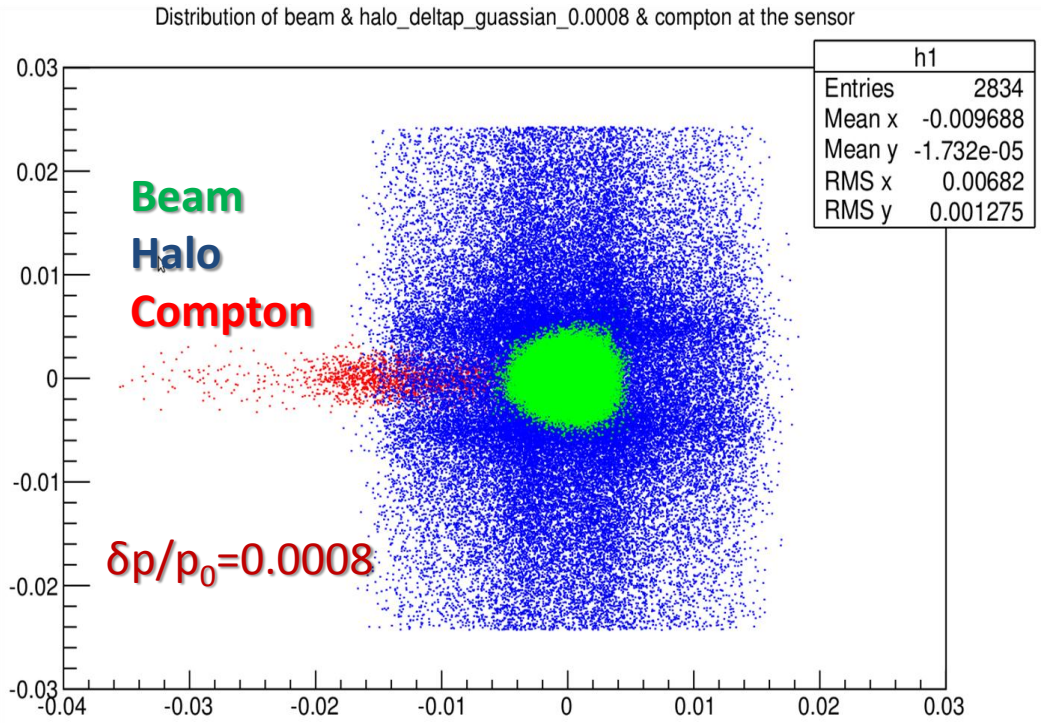


Single crystal 4.5x4.5mm CVD diamond pad sensor

- ✓ **Charge created by 1MIP in diamond: 2.74 fC;**
- ✓ **Signal pulse length of diamond: t=1ns.**

	Total Number (in simulation)	Total Number (in experiment)	Min.～Max. Number/mm² @ Sensor	Charge signal/mm²
Beam	10^5	10^{10}	$6163*10^5$	$1.6887*10^{-6}$C=1.6887μC
Halo ($\delta p/p_0$=0.01)	10^5	10^7	$114*10^2$	$3.1236*10^{-11}$C=31.236pC
Halo ($\delta p/p_0$=0.0008)	10^5	10^7	$224*10^2$	$6.1376*10^{-11}$C=61.376pC
Compton	2834	28340	3*10～52 *10	82.2fC～1.4284pC

Halo Distribution with Small Energy Spread



Main assumptions

- Same small energy spread for halo and beam;
- No off-momentum regeneration from vertical halo losses in the BDUMP beam pipe.

⇩

Not true in real case ?

Possible Mitigations

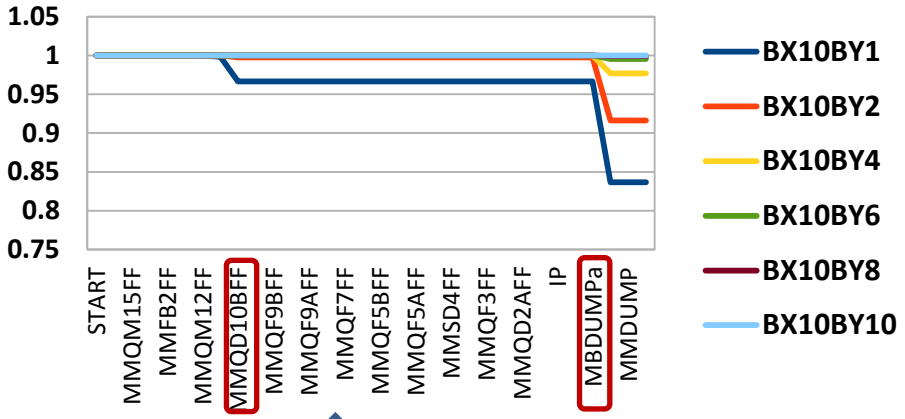
✓ Change the beta_y* ;

✓ Collimate halo in Y ;

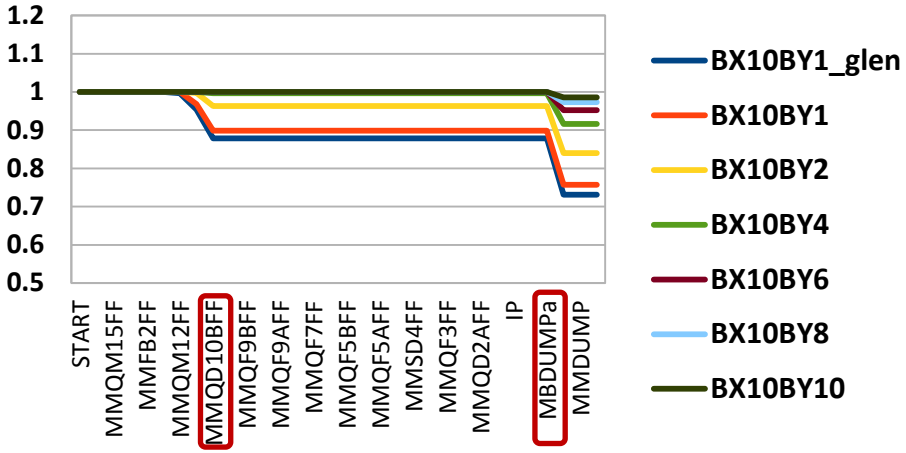
✓ Collimate halo in energy in case of large energy spread of halo.

Vertical Halo Loss at BDUMP

Ratio of halo (40 sigma) loss on Y axis



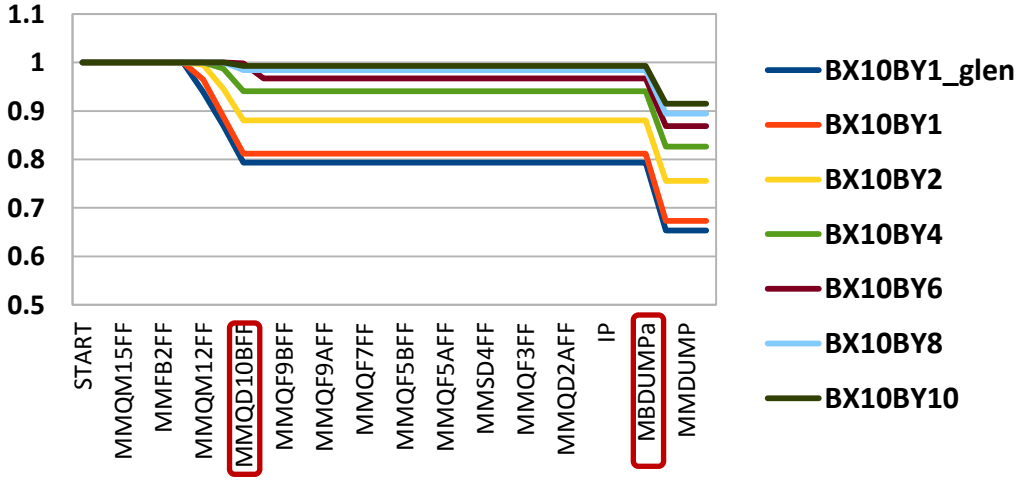
Ratio of halo (60 sigma) loss on Y axis



Almost no halo loss at BDUMP for BX10BY10

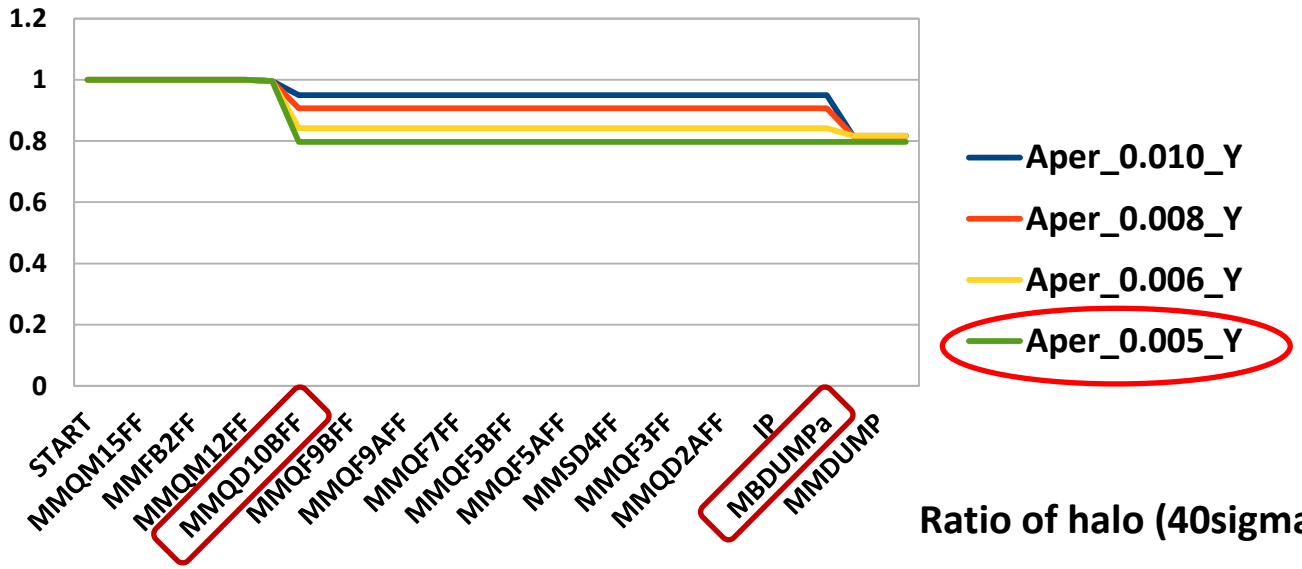
Larger beta_y* can reduce vertical halo hitting BDUMP beam pipe

Ratio of halo (100 sigma) loss on Y axis



Vertical Collimation at QD10

Ratio of halo (40sigma) loss on Y axis with deltap_0.0008



Initial Aperture Size:

R=0.01m

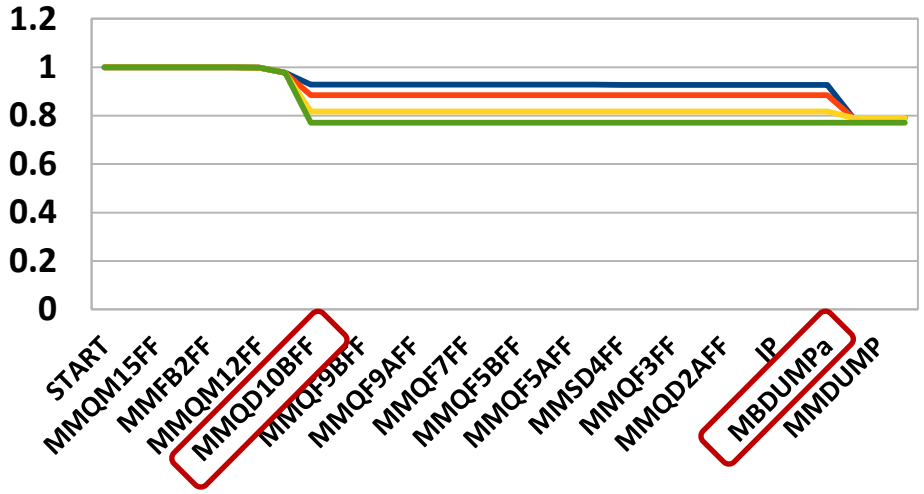
No halo loss at BDUMP

Vertical Beam Size @ QD10:

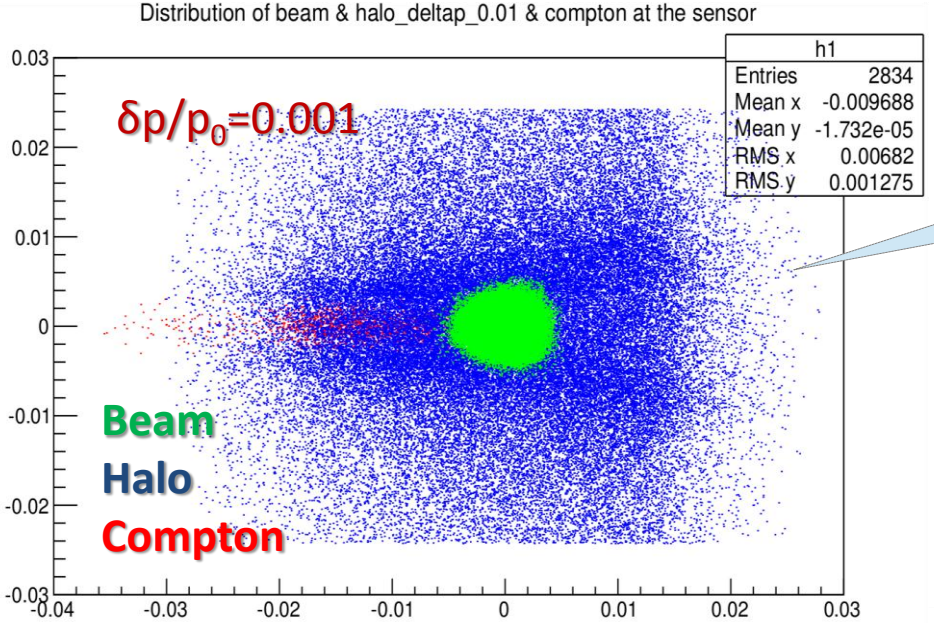
σ_y =0.3336mm

$15\sigma_y$

Ratio of halo (40sigma) loss on Y axis with deltap_0.01



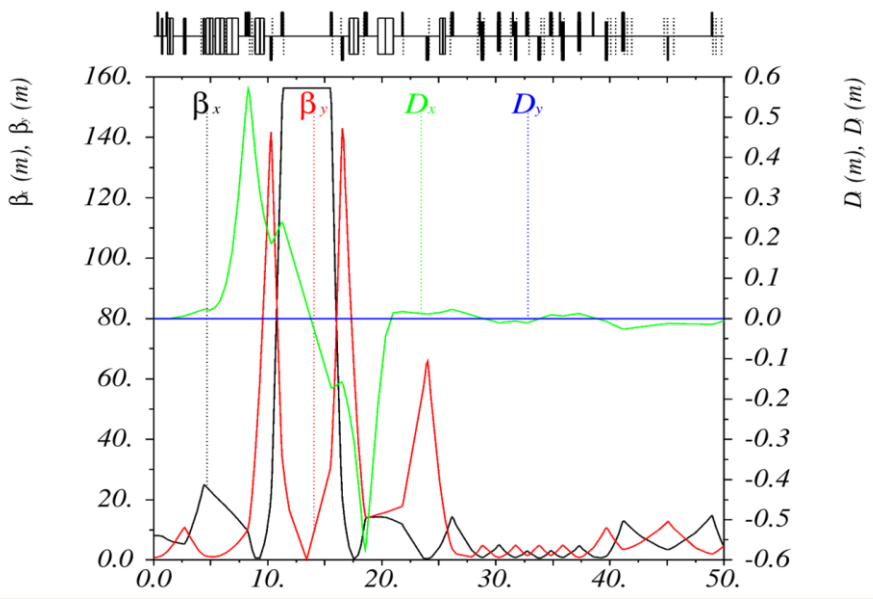
Halo Distribution with Large Energy Spread

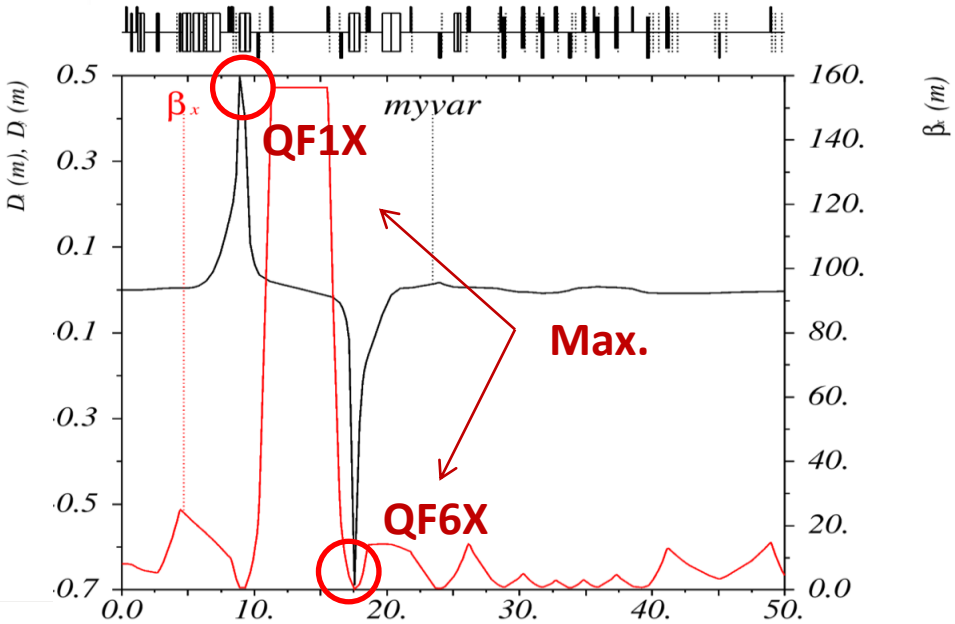


Most of Comptons are covered by halo

$$\sigma_\beta = \sqrt{\varepsilon \cdot \beta}, \quad \sigma_p = D \cdot \frac{\delta_p}{P}$$

$$\text{myvar} = D_x / \sqrt{\beta_x}$$

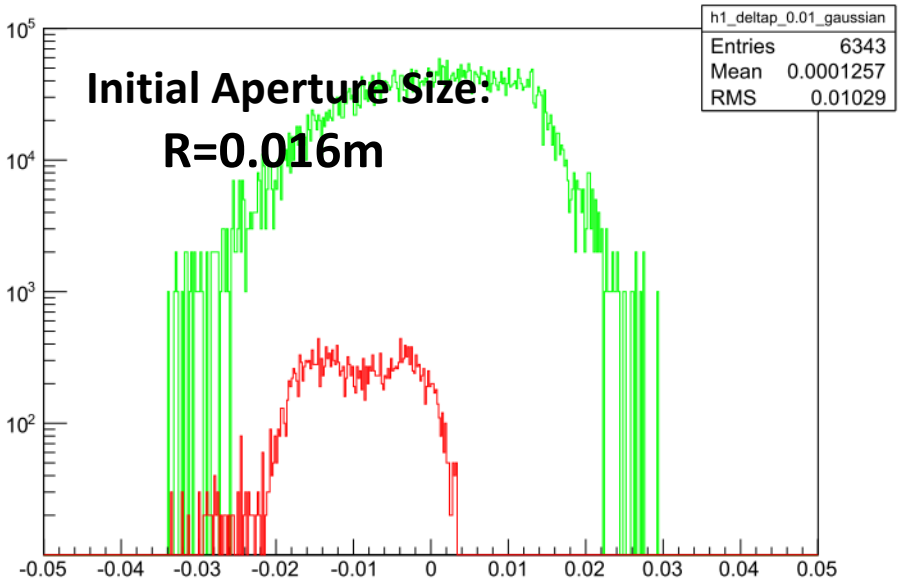




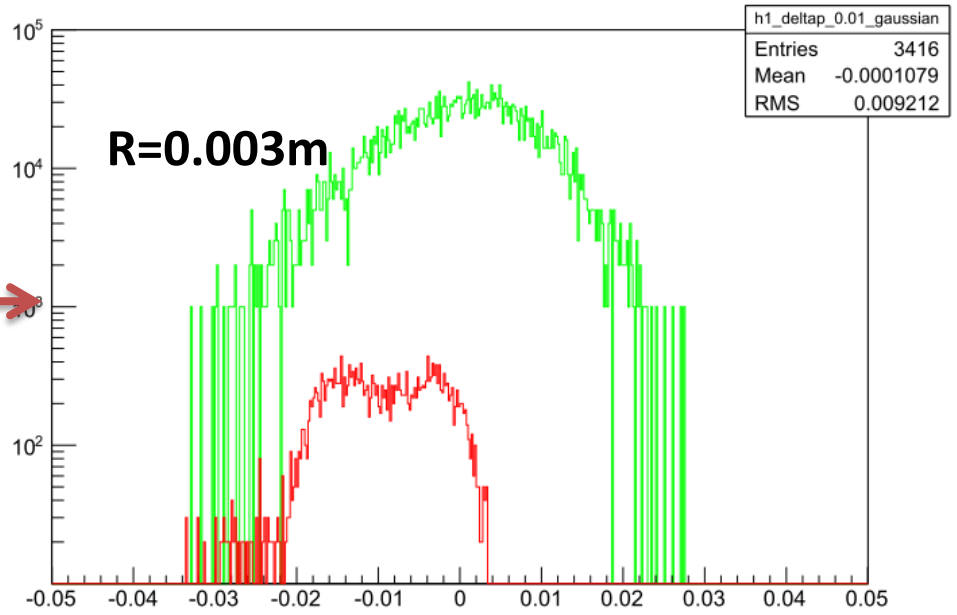
Horizontal Collimation at QF1X

Energy Spread:

Flat deltap= 0.01



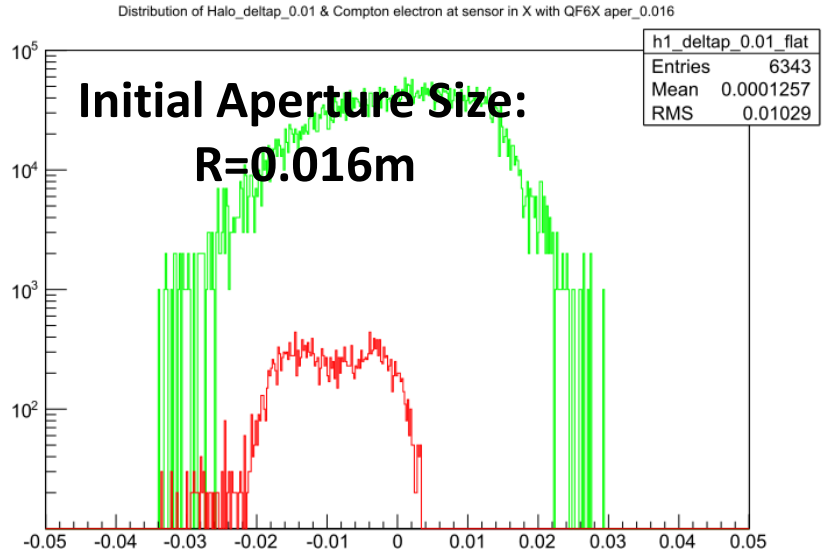
Compton still covered by halo

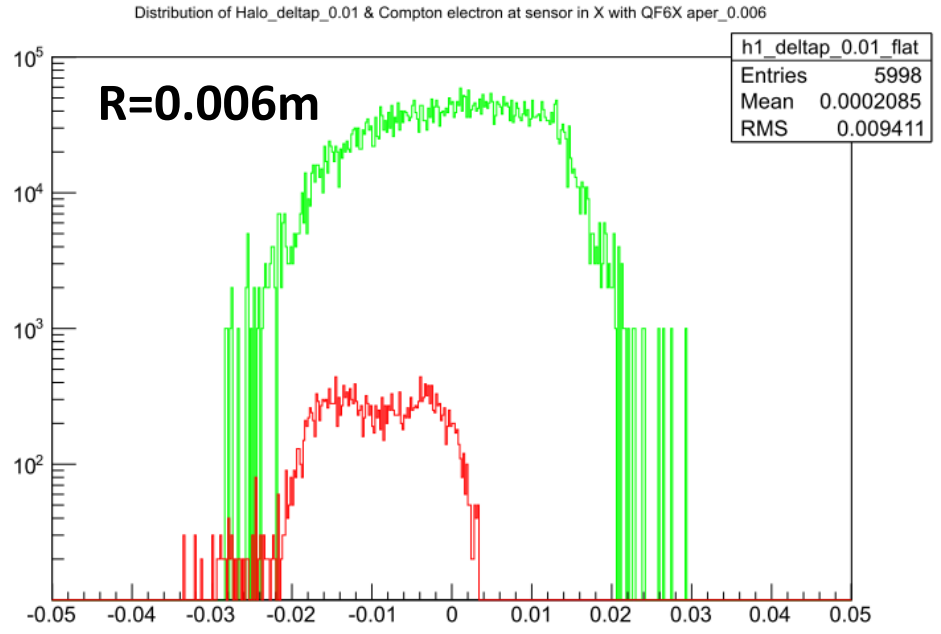


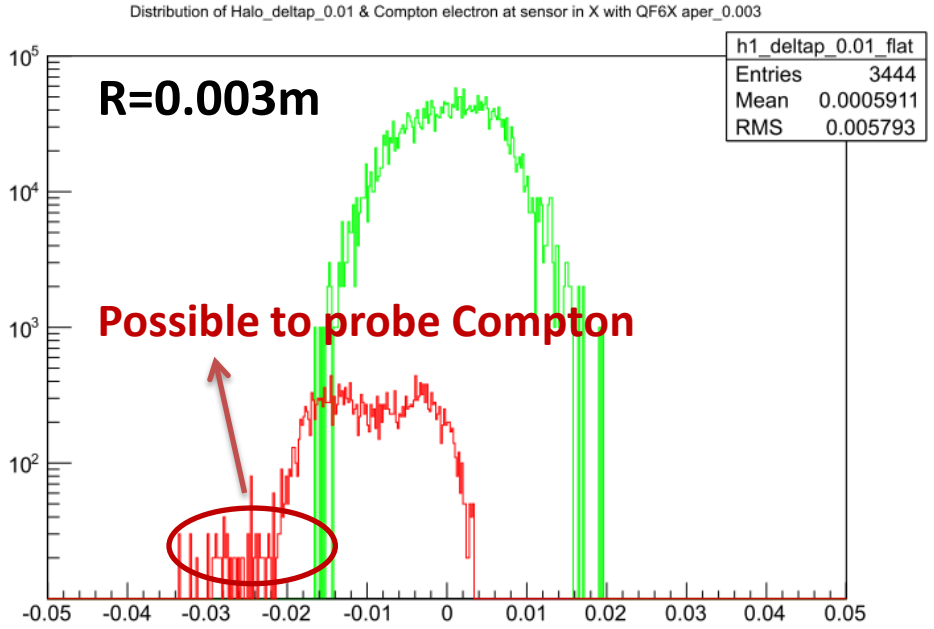
Horizontal Collimation at QF6X

Energy Spread:

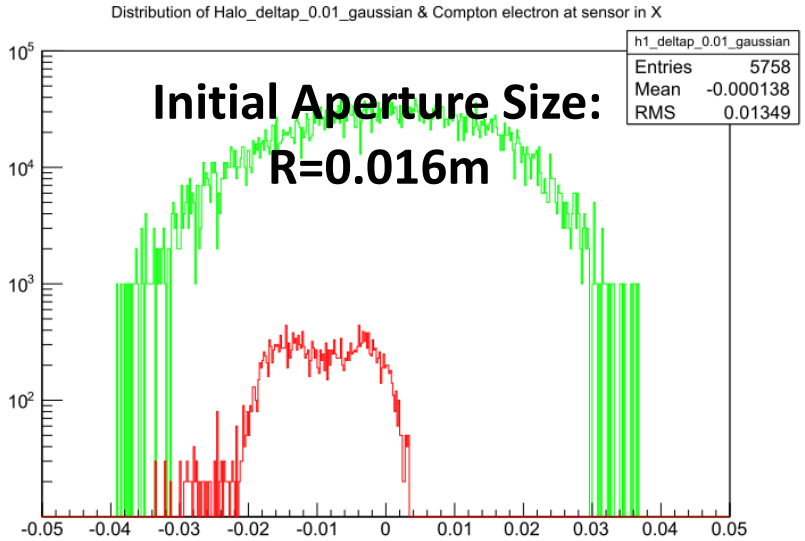
Flat deltap= 0.01



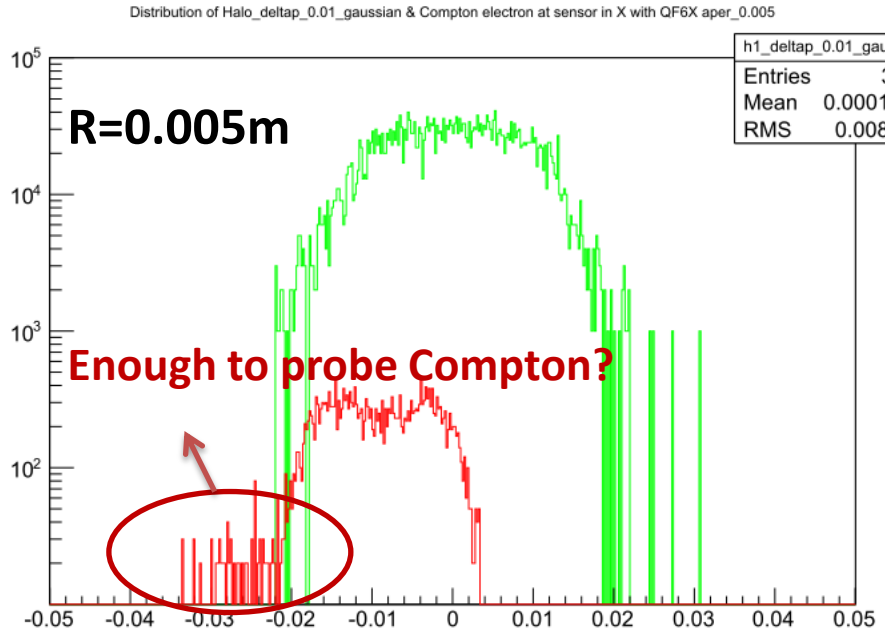


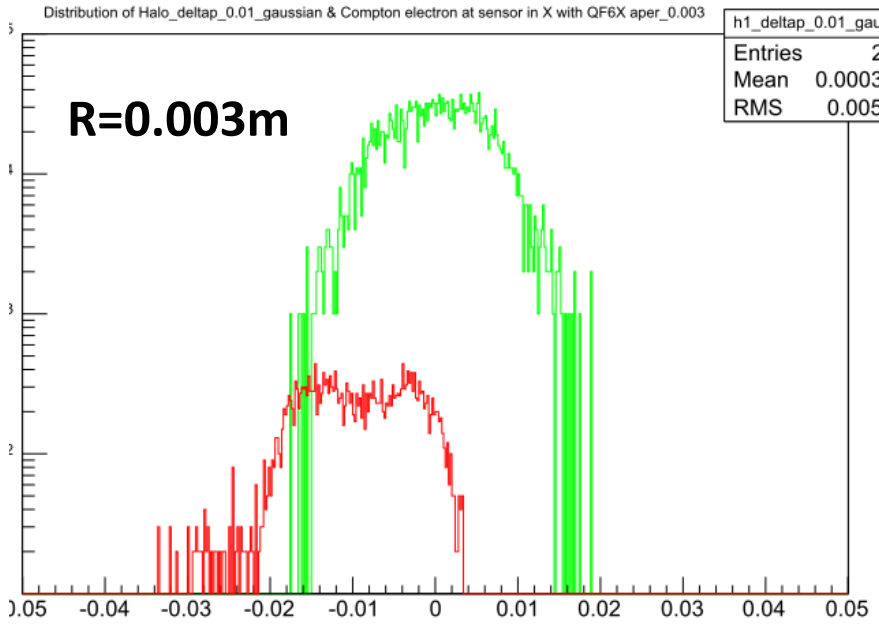


Horizontal Collimation at QF6X



Energy Spread:
Gaussian deltap= 0.01





Conclusions

- We probably need to cut the beam halo signal to probe the Compton spectrum;
- We can investigate halo propagating model by configuring BX & BY and by measuring the beam halo using diamond sensor;
- For Y axis collimation we need to change the aperture size at QD10BFF from 0.01m to 0.005m to avoid second generation particle from BDUMP;
- For X axis collimation we need to change the aperture size at QF6X from 0.016m to 0.005m (with deltap_gaussian=0.01) or to 0.003m (with deltap_flat=0.01) to diagnostic the Compton signal apart from the beam halo.

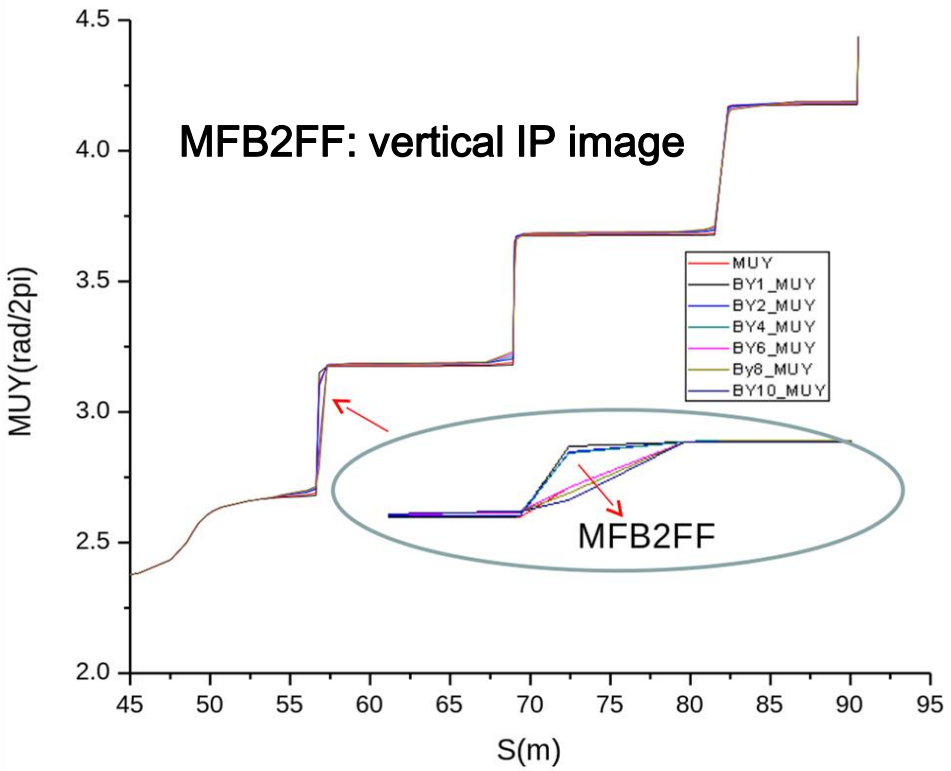
Issues

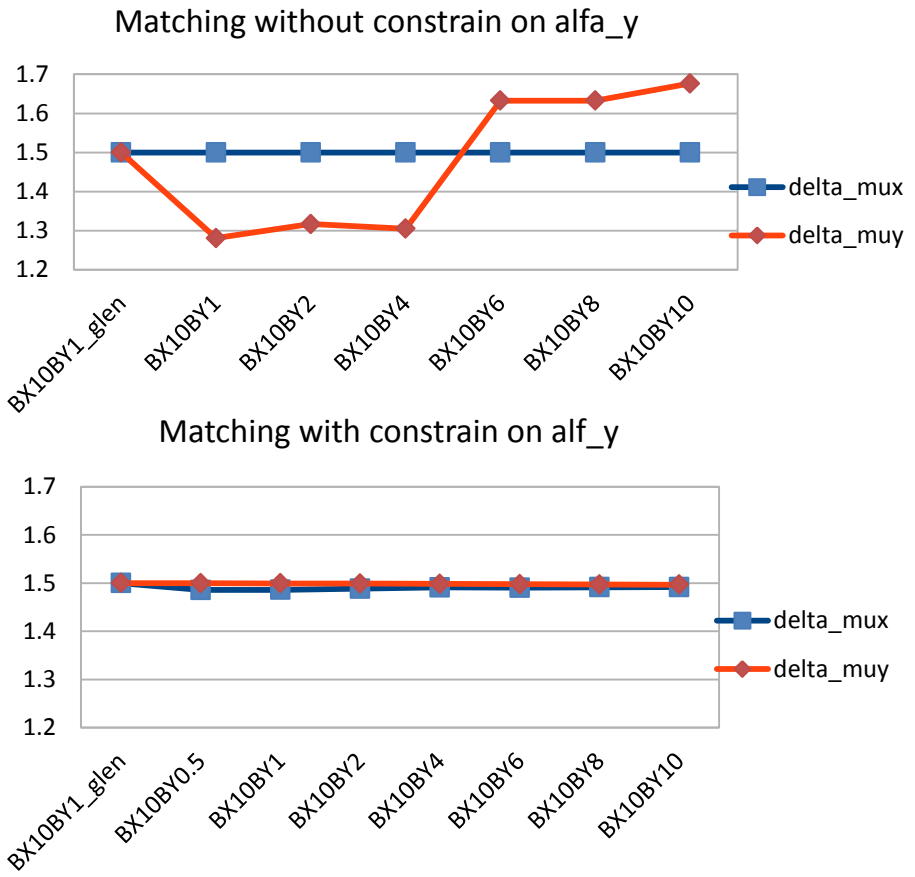
- How tightly can we collimate without impacting the beam emittance too much ? → Design a collimator with a special shape to minimize wakefield emittance growth effects?
- How large is really the energy spread of the halo and what is the distribution ?
- Do we really have a large re-generated halo from off-momentum beam particles induced by soft photon emissions when halo hits the beam pipe in BDUMP ?
- …..

Thank You For Your Attention !

Backup Slides

Variable Beta* Configurations with Phase Advance Constraint for Upstream Feedback





Delta_mu= mu(MFB2FF)– mu(IP)

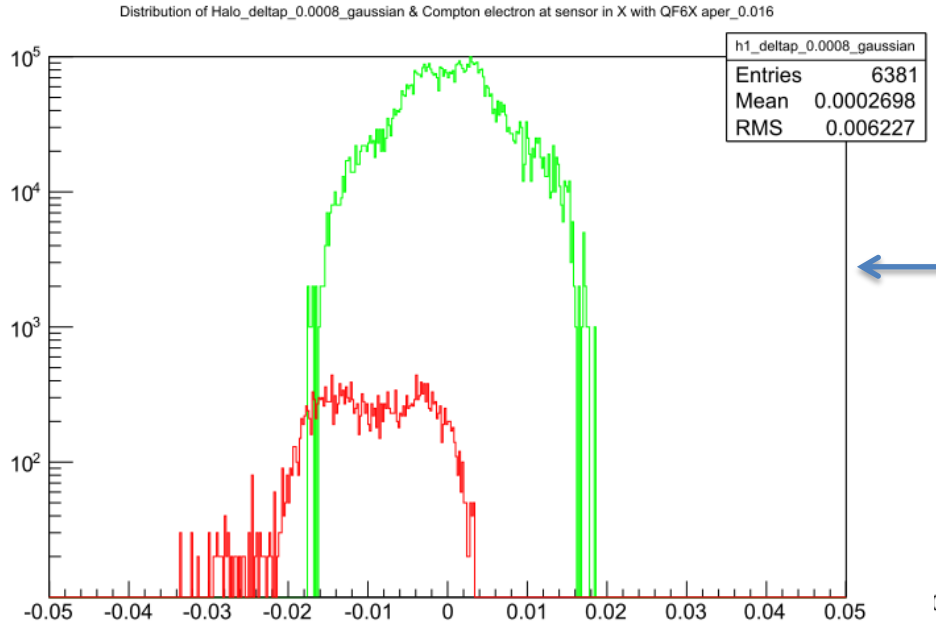
For BX10BY1 : delta_muy= 1.49956

$$M = \begin{pmatrix} \sqrt{\frac{\beta_0}{\beta}}(\cos\Psi + \alpha_0 \sin\Psi) & \sqrt{\beta\beta_0}\sin\Psi \\ \frac{(\alpha_0 - \alpha)\cos\Psi - (1+\alpha_0\alpha)\sin\Psi}{\sqrt{\beta\beta_0}} & \sqrt{\frac{\beta_0}{\beta}}(\cos\Psi - \alpha\sin\Psi) \end{pmatrix} \Rightarrow \begin{pmatrix} y(s) \\ y'(s) \end{pmatrix} = M \begin{pmatrix} y_0 \\ y_0' \end{pmatrix}$$

$$\Delta y(s) = \sqrt{\beta \cdot \beta_0} \cdot \sin\Delta\Psi \cdot \sqrt{\frac{\varepsilon}{\beta_0}}$$

$$\Rightarrow 0.001486 \cdot y(s)$$

Halo Distribution with Different Energy Spread



Gaussian deltap= 0.0008

Gaussian deltap= 0.01