GBP MC Update

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Generation of elliptical beam

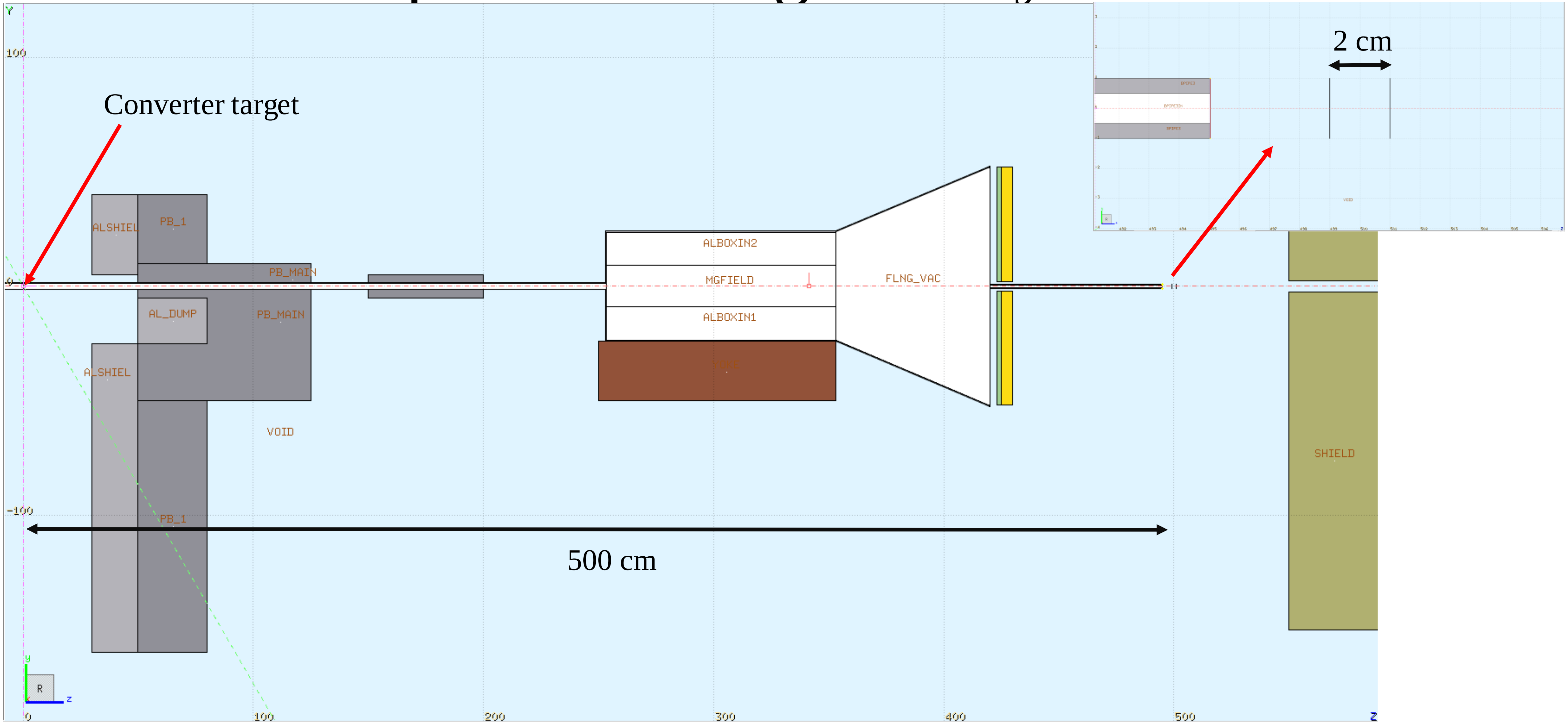
- Elliptical beam generated by random sampling of two parameters: polar and azimuthal angle
- Sample azimuthal angle uniformly from 0 to 2*pi
- Calculate maximum possible polar angle
- Polar angle is r * max polar angle where r is uniformly distributed in [0,1)
- Calculate corresponding direction cosines for use in FLUKA

$$\Theta = \frac{\theta_x \theta_y}{\sqrt{\theta_y^2 \cos^2\phi + \theta_x^2 \sin^2\phi}}$$

$$u = \sin\theta\cos\phi$$
$$v = \sin\theta\sin\phi$$
$$w = \cos\theta$$

```
*  Cosines (tx,ty,tz)
      ! Generate a beam with elliptical cross section
      XANGLE = WHASOU(1)
      YANGLE = WHASOU(2)

      ! Generate random azimuthal angle and the corresponding maximum
      ! polar angle
      RAZIMUTH = 2 * PIPIPI * FLRNDM(DUMMY1)
      VNORM = SQRT((XANGLE*COS(RAZIMUTH))**2
     &       + (YANGLE*SIN(RAZIMUTH))**2)
      POLARMAX = XANGLE*YANGLE / VNORM

      RPOLAR = POLARMAX * FLRNDM(DUMMY2)

      WRITE(11, *) POLARMAX , RAZIMUTH

      ! Calculating direction cosines
      TXFLK  (NPFLKA) = SIN(RPOLAR) * COS(RAZIMUTH)
      TYFLK  (NPFLKA) = SIN(RPOLAR) * SIN(RAZIMUTH)
*      TZFLK  (NPFLKA) = WBEAM
      TZFLK  (NPFLKA) = SQRT ( ONEONE - TXFLK (NPFLKA)**2
     &                        - TYFLK (NPFLKA)**2 )
```

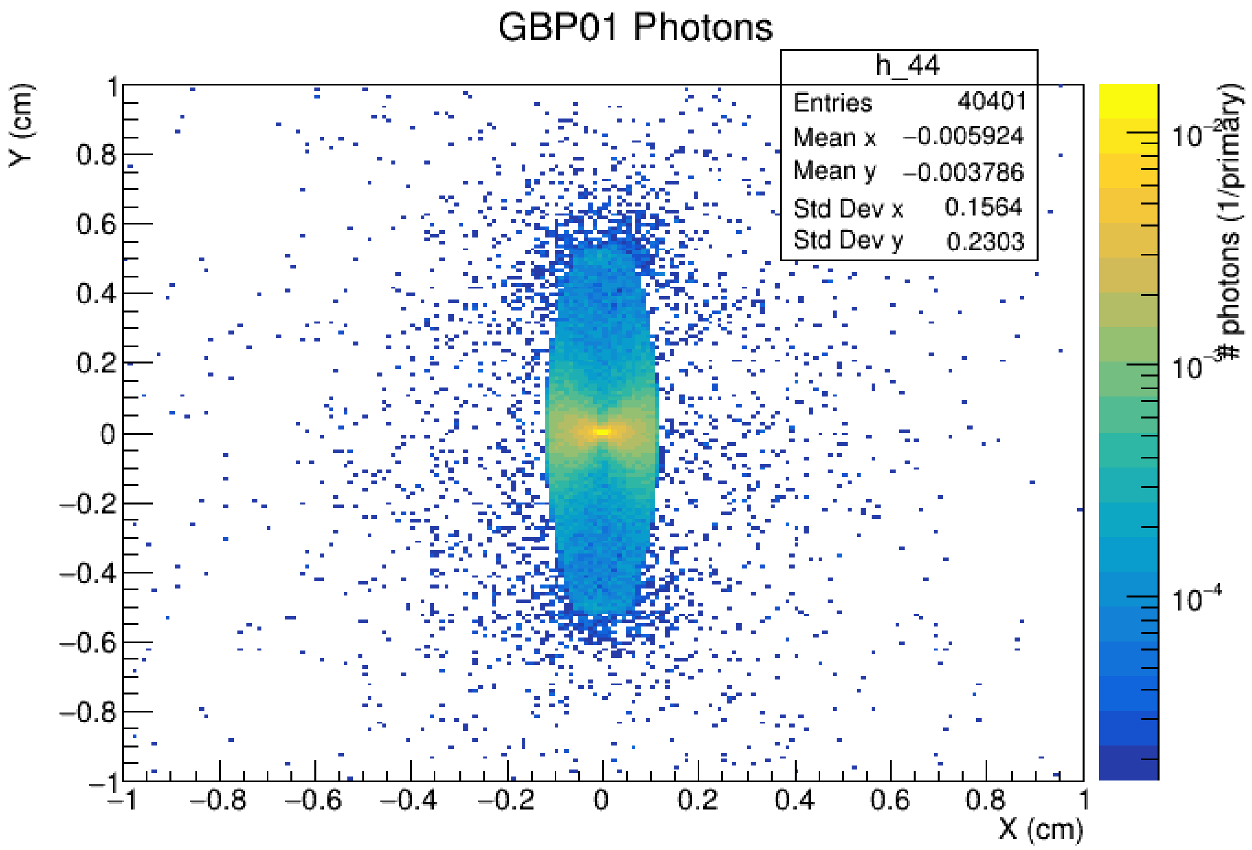
FLUKA spectrometer geometry

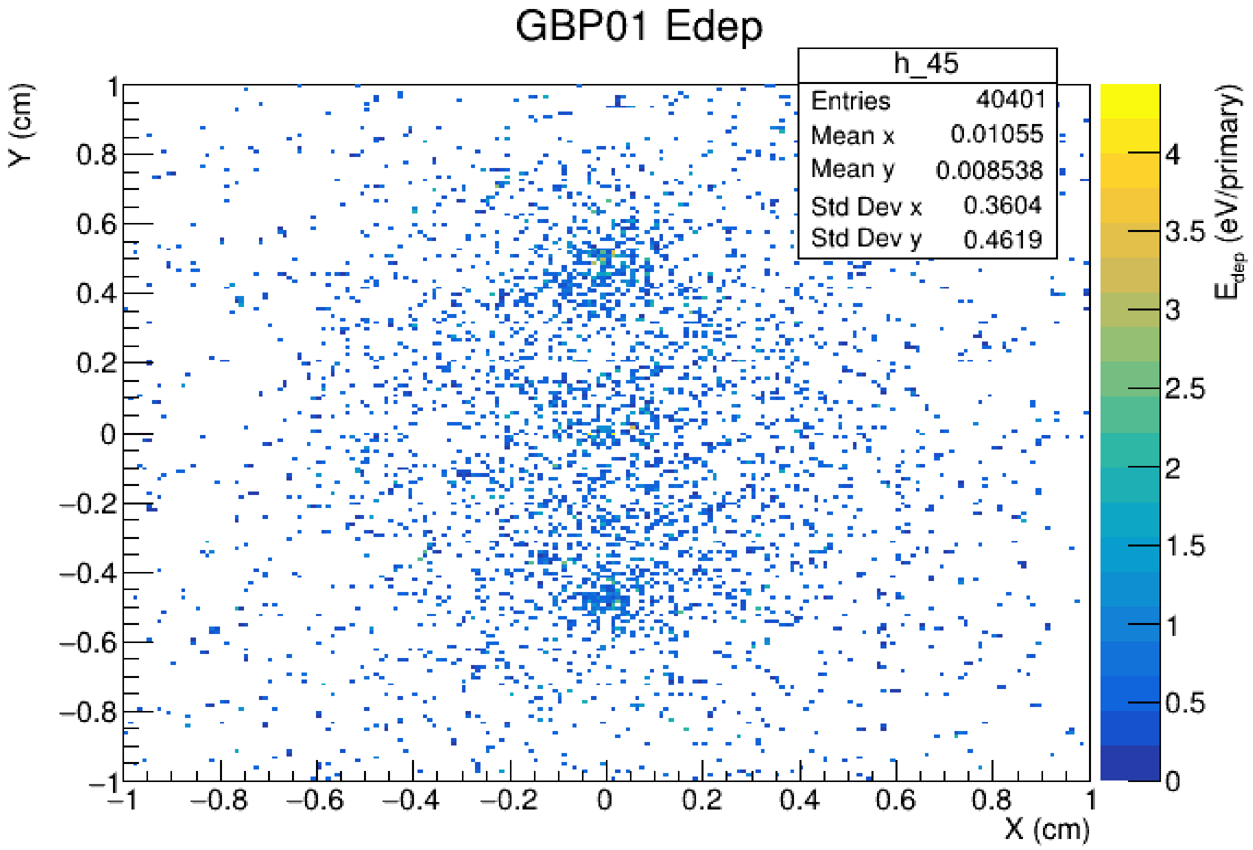


FLUKA simulation parameters

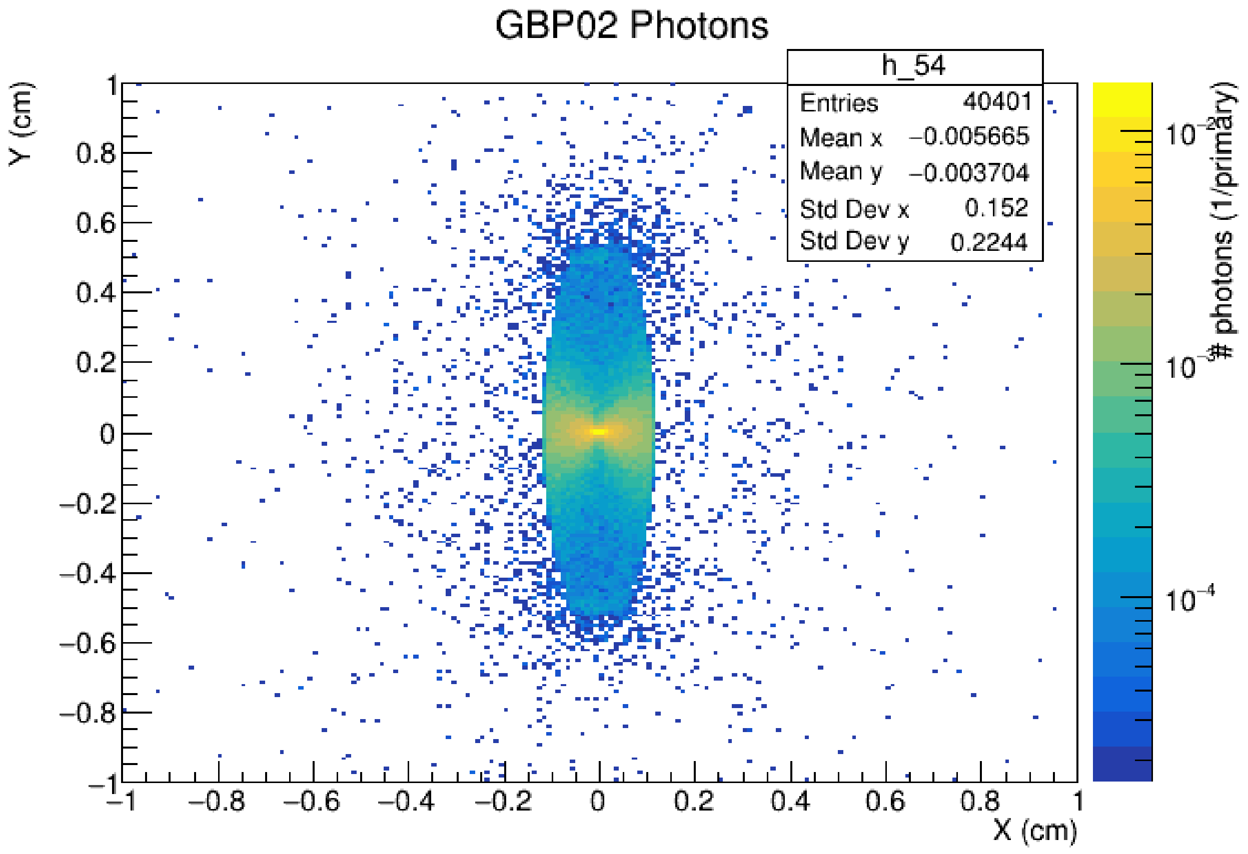
- Beam energy – 10.0 ± 0.2 GeV (mono-energetic)
- Beam radius – 0.01 cm
- Distance from source to converter – 650.0 cm
- Beam divergence
  - X – 0.1 mrad
  - Y – 0.5 mrad
- Equivalent number of primaries for Ptarmigan input
  - Xi = 0.15 - 8350500 (~8.35e6)
  - Xi = 2.00 - 228150000 (~2.28e8)
  - Xi = 5.00 - 578910000 (~5.89e8)

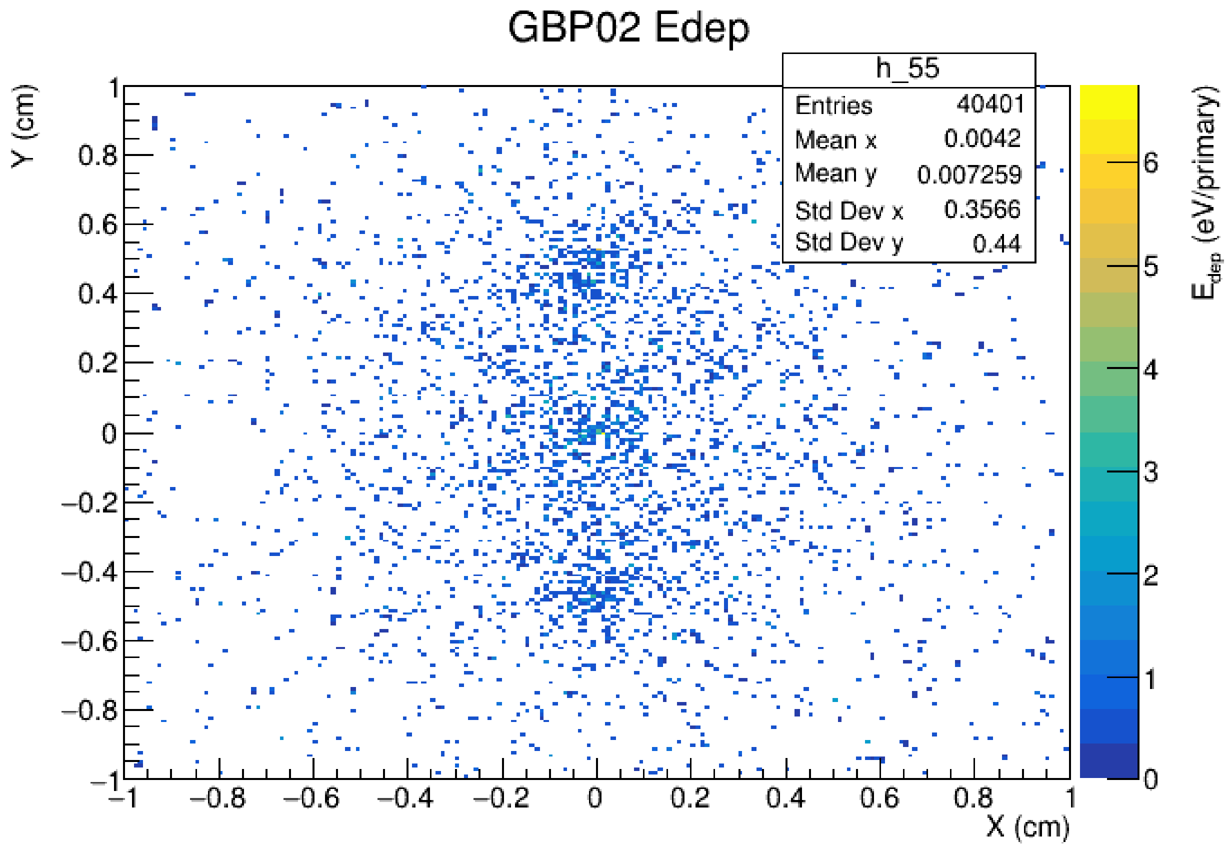
Upstream detector





Downstream detector



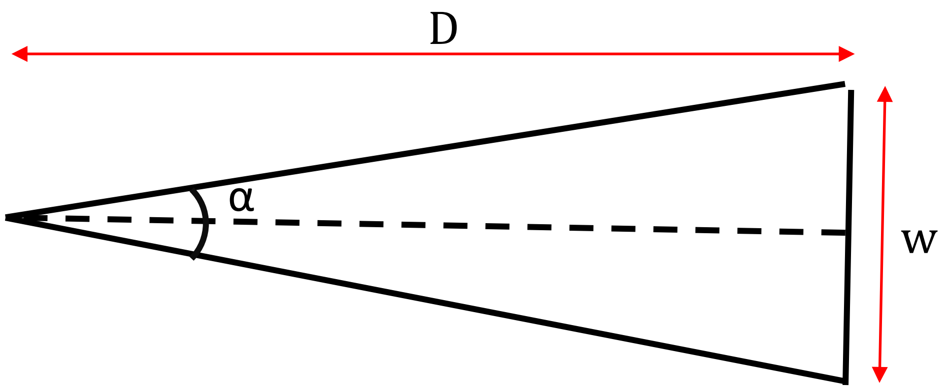


Extracting width information

- Width information taken in two forms
  - FWHM of distribution
  - Standard deviation of a Gaussian fit to distribution
- FWHM calculated using user-defined function
- Can be compared to FWHM calculated using standard deviation
- Using a width parameter, divergence can be determined
- D = 650.0 + 500.0 = 1150.0 cm

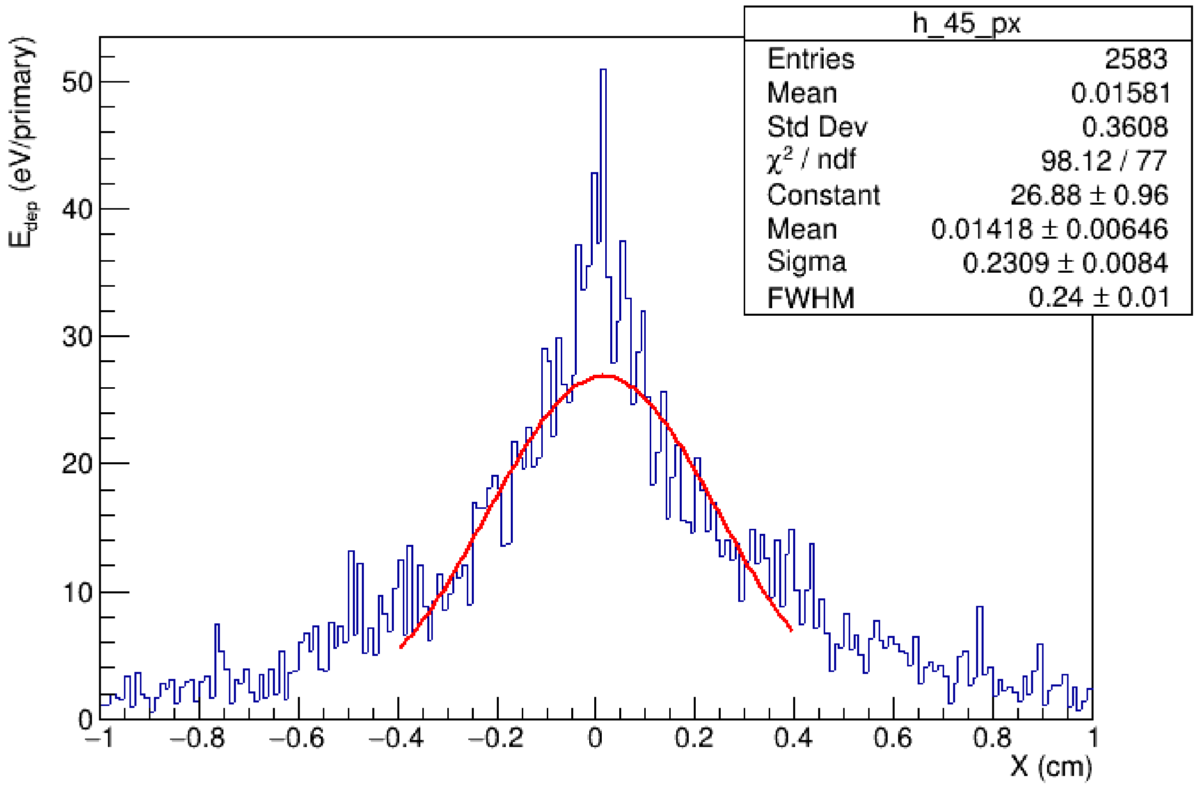
```
double GetFWHM(TH1D* hist) {
    double lower = hist->GetBinCenter(hist->FindFirstBinAbove(hist->GetMaximum()/2.0));
    double upper = hist->GetBinCenter(hist->FindLastBinAbove(hist->GetMaximum()/2.0));

    return (upper - lower);
}
```

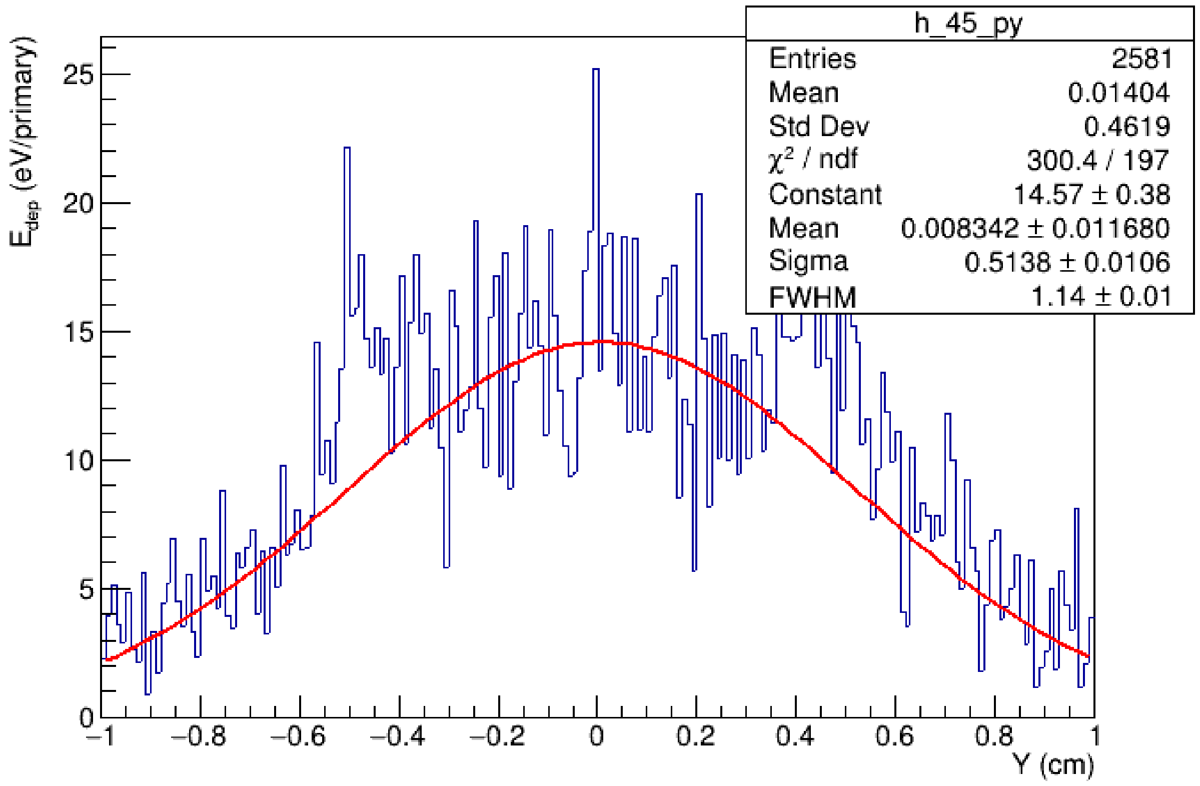
$$\mathrm{FWHM} = 2\sigma\sqrt{2\ln 2}$$



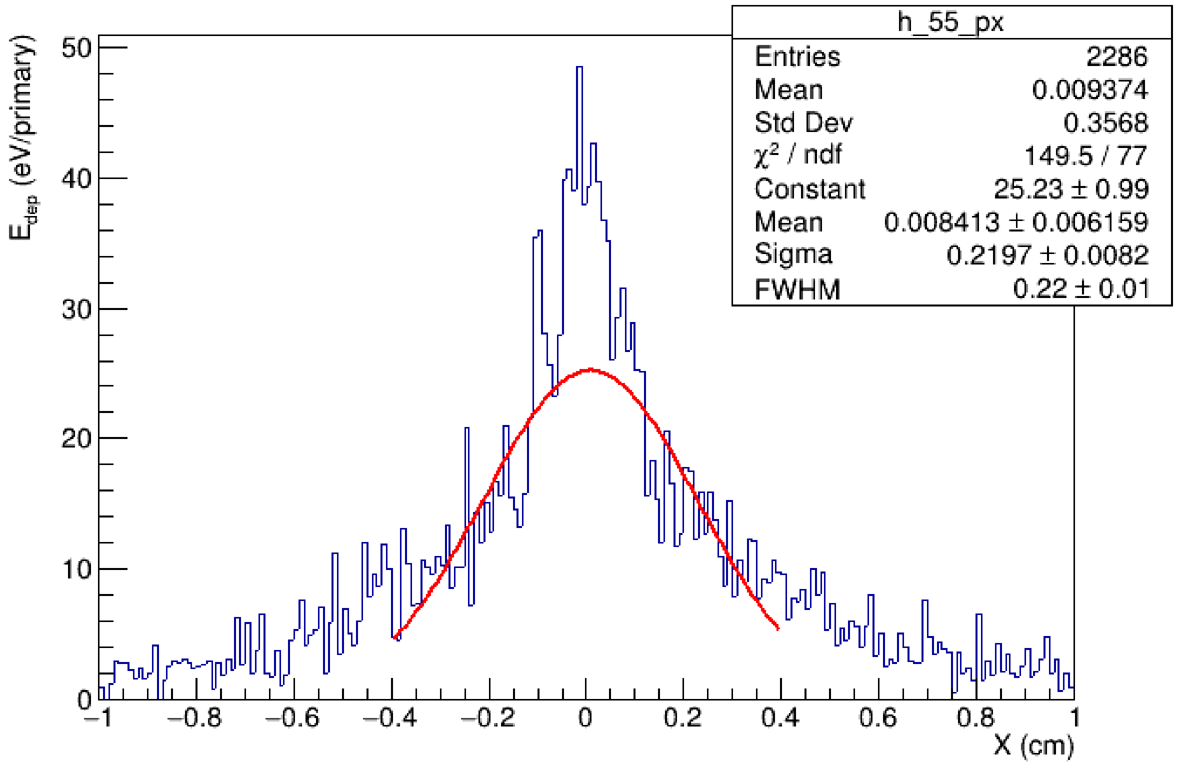
$$\tan\alpha \approx \frac{w}{D}$$

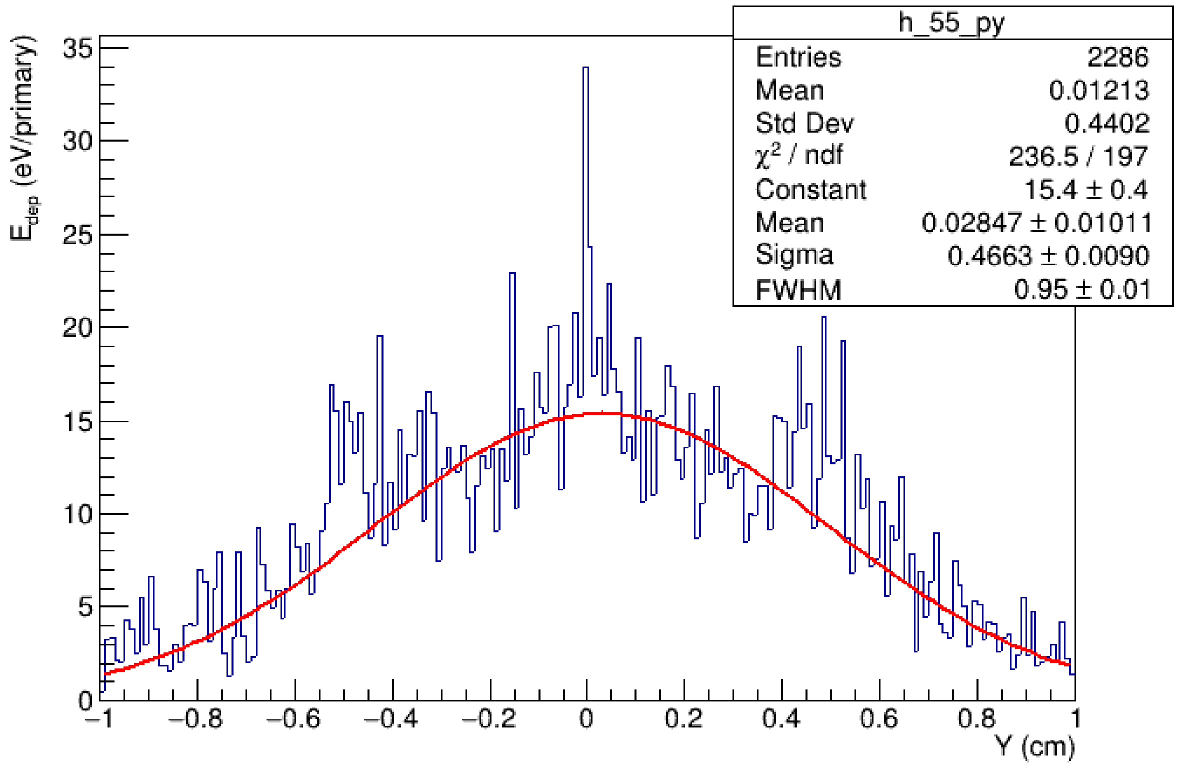
Upstream detector





Downstream detector





Summary of results

	FWHM (cm)	Half-angle divergence (mrad)	Sigma (cm)	Half-angle divergence (mrad)	FWHM (cm)	Half-angle divergence (mrad)
GBP01-X	0.24 ± 0.01	**0.104 ± 0.005**	0.231 ± 0.008	0.201 ± 0.007	0.544 ± 0.019	0.237 ± 0.008
GBP01-Y	1.14 ± 0.01	**0.496 ± 0.005**	0.514 ± 0.011	0.447 ± 0.010	1.210 ± 0.026	0.526 ± 0.011
GBP02-X	0.22 ± 0.01	**0.096 ± 0.005**	0.220 ± 0.008	0.191± 0.007	0.518 ± 0.019	0.225 ± 0.008
GBP02-Y	0.95 ± 0.01	0.413 ± 0.005	0.466 ± 0.009	0.405 ± 0.008	1.097 ± 0.021	**0.477 ± 0.009**

GetFWHM() function

Std dev of Gaussian fit

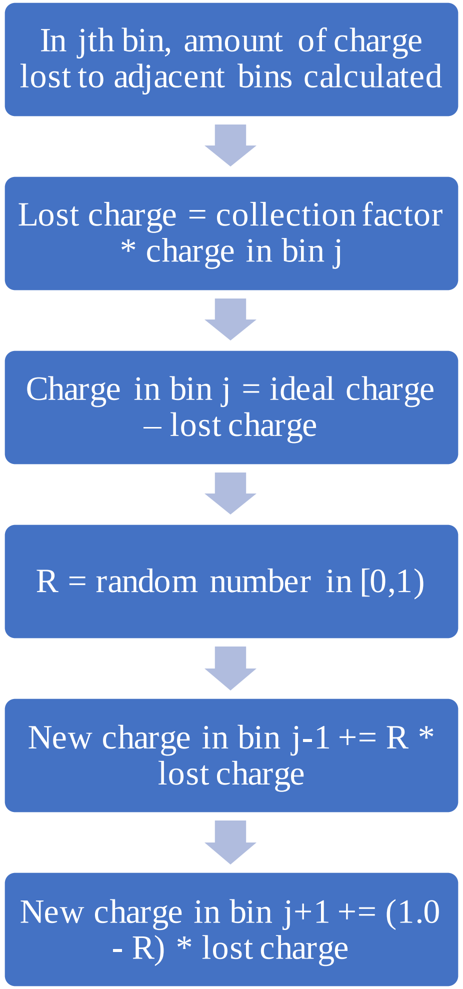
$$\mathrm{FWHM} = 2\sigma\sqrt{2\ln 2}$$

Green values - < 10% error between calculated value and simulation value; if bold, < 5% error

Red values – poor accuracy due to ill-fitting of Gaussian to central peak; gives over-estimate of standard deviation

Simplified charge share model

- Applied a simplified version of a charge sharing model (script available on Confluence)
- For a given charge share fraction, amount of charge lost to adjacent bins is calculated from ideal collection
- This is then randomly split between neighbouring bins
- Performed iteratively for each bin



Simplified charge share model