

$B^0 \rightarrow D^{\star} l \nu_l$ analysis

Michele Mantovano

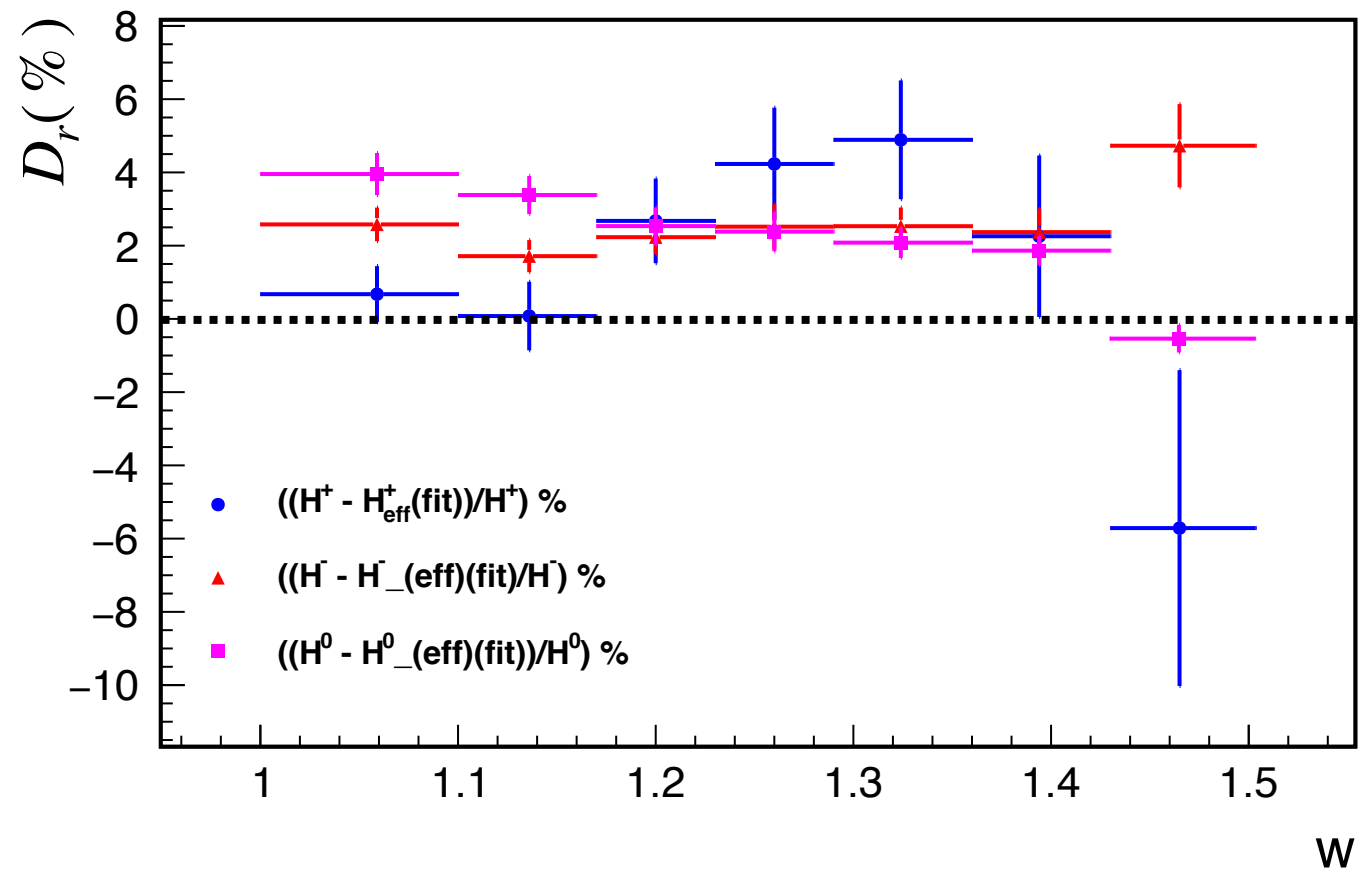
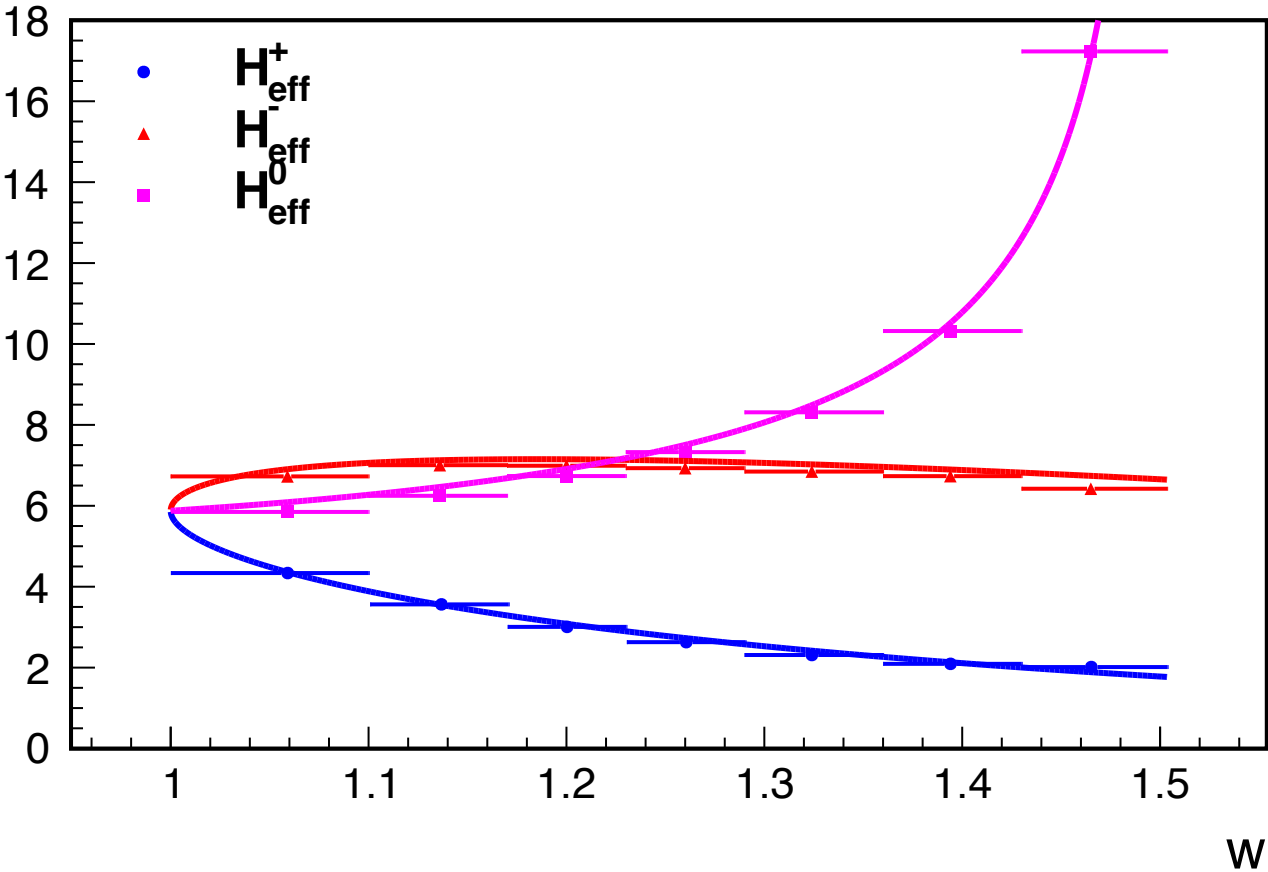
Analysis meeting
January 13, 2023

Fitter

- Simultaneous fit with 21 parameters (3 parameters for each bin);
- Introduce the angular resolutions and fit again to extract the new parameters.

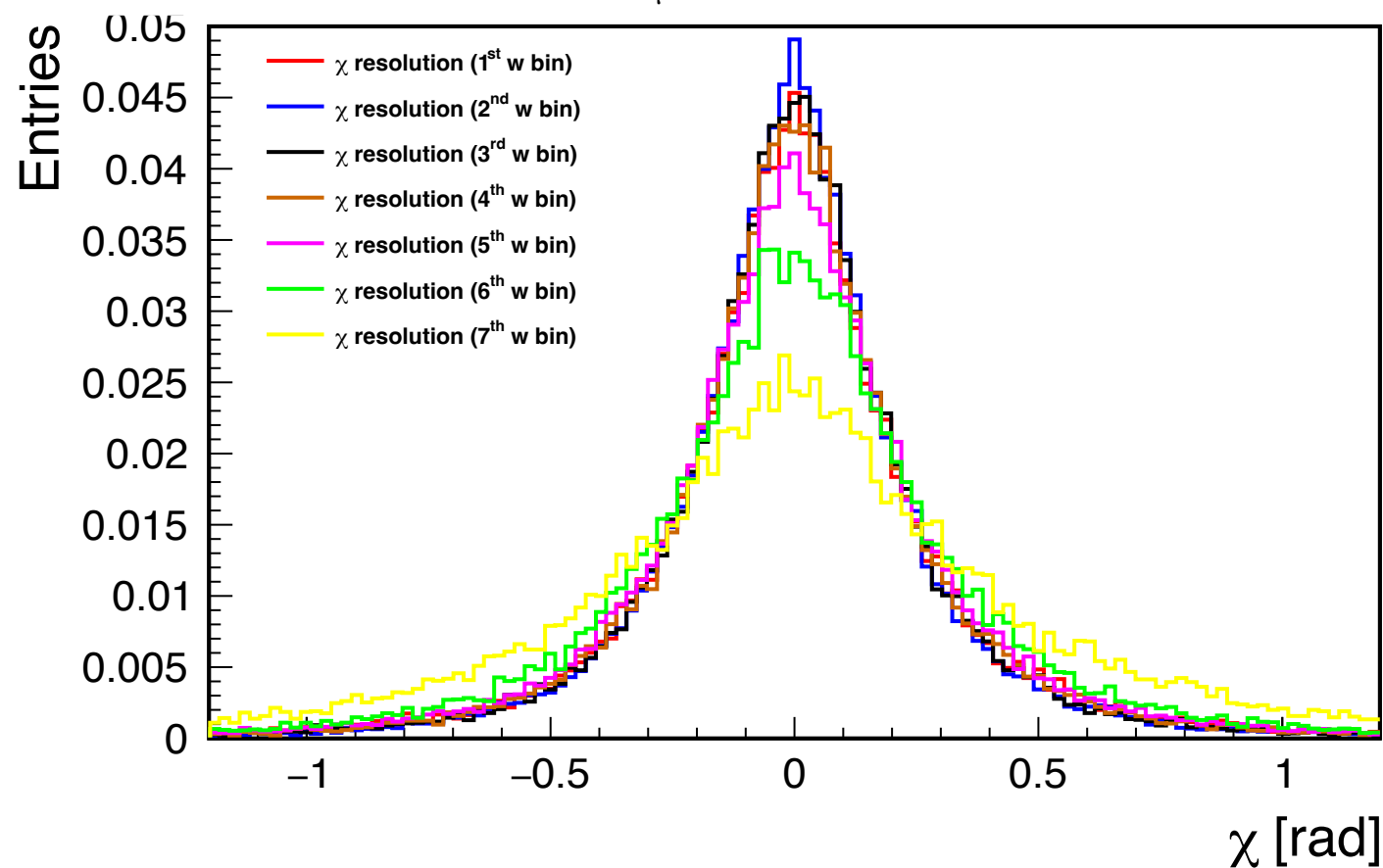
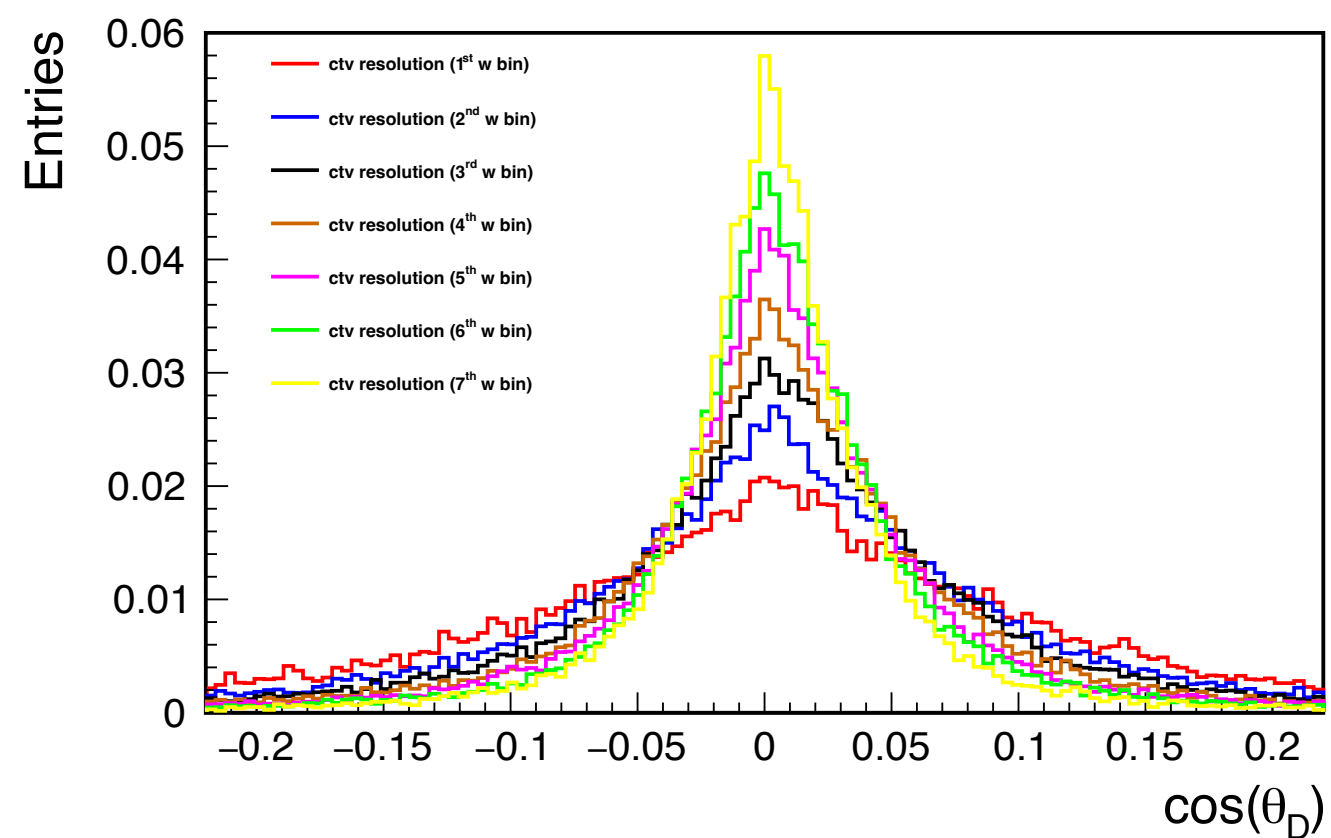
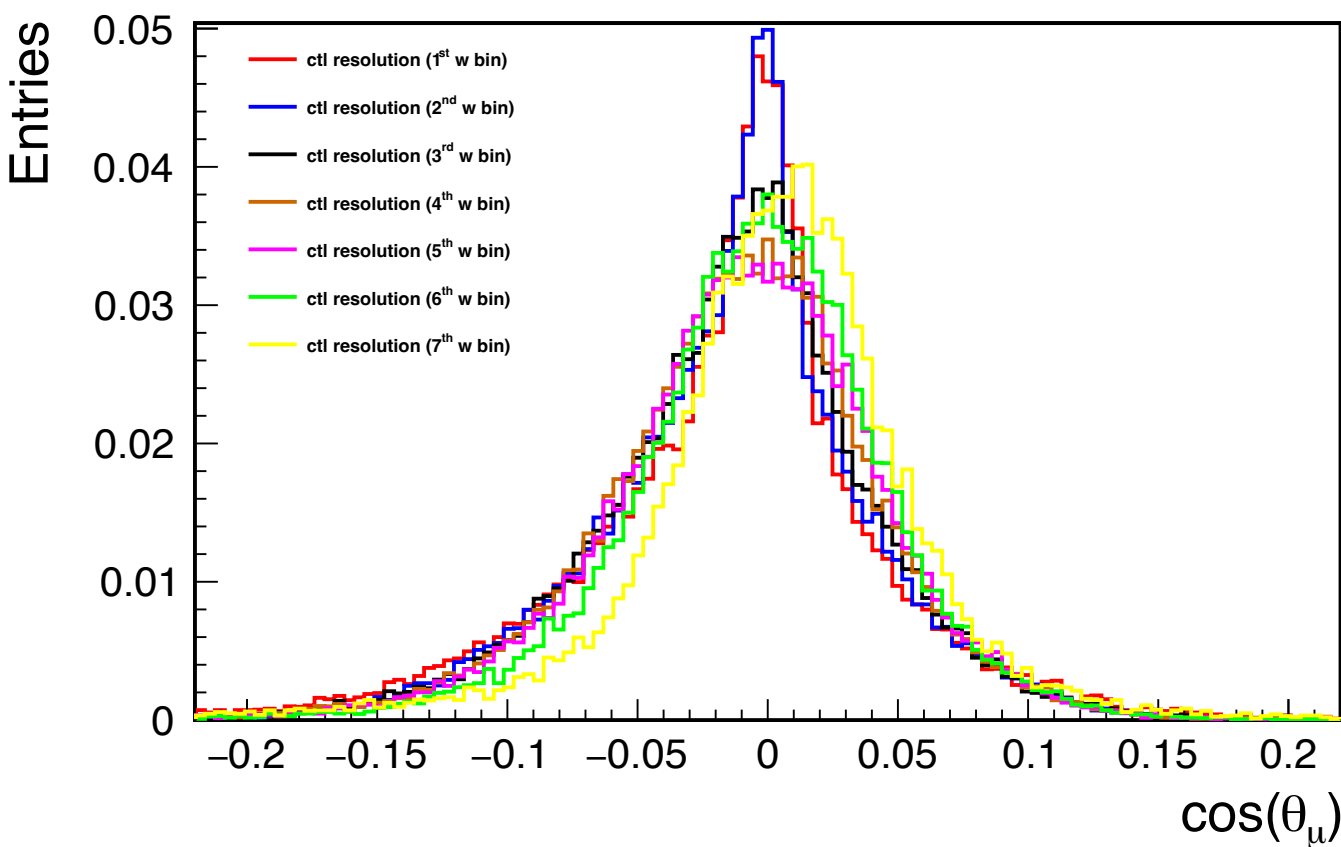
Simultaneous fit

w	H^+	H^-	H^0
1 bin	4.33 +- 0.03	6.73 +- 0.03	5.85 +- 0.04
2 bin	3.55 +- 0.03	7.00 +- 0.03	6.25 +- 0.03
3 bin	3.00 +- 0.04	6.99 +- 0.03	6.74 +- 0.04
4 bin	2.61 +- 0.04	6.93 +- 0.04	7.33 +- 0.04
5 bin	2.30 +- 0.04	6.85 +- 0.04	8.31 +- 0.04
6 bin	2.08 +- 0.05	6.73 +- 0.04	10.33 +- 0.04
7 bin	1.99 +- 0.08	6.42 +- 0.08	17.23 +- 0.06



angular resolutions

Study the angular resolutions in each bin.

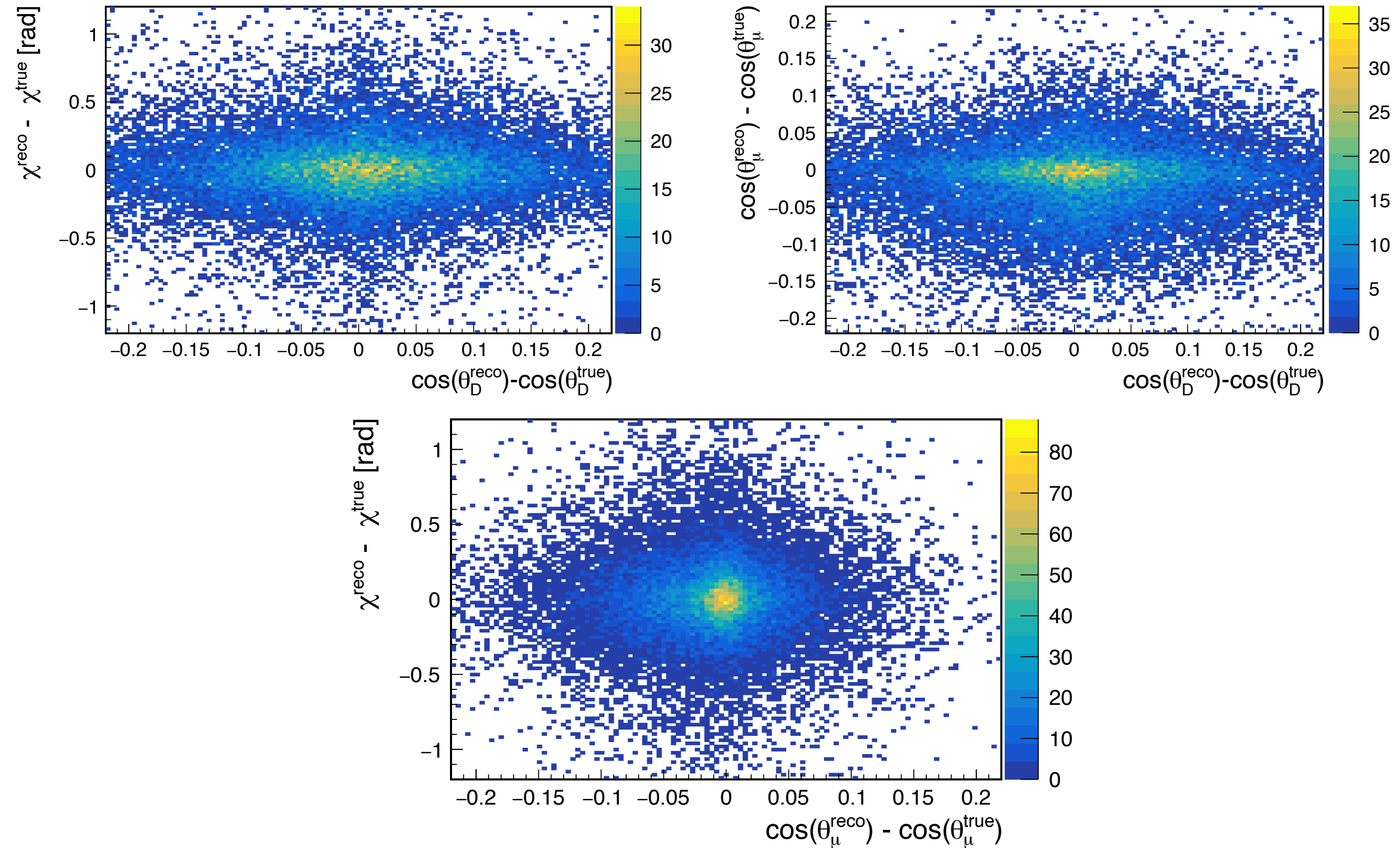


The shape changes in different bins $\rightarrow$ need to take into account.

angular resolutions:
correlation

Angular resolution: correlation

Example: 1bin



No correlation

pdf with angular resolutions

pdf with angular resolutions

Rewrite my pdf including also the angular resolutions.

The new angular term is:

$$\begin{aligned} \text{angular term} = & H_+^2(w) \sin^2 \theta_v * R(\theta_v) (1 - \cos \theta_l)^2 * R(\theta_l) + \\ & + H_-^2(w) \sin^2 \theta_v * R(\theta_v) (1 + \cos \theta_l)^2 * R(\theta_l) + \\ & + 4H_0^2(w) \cos^2 \theta_v * R(\theta_v) \sin^2 \theta_l * R(\theta_l) + \\ & - 2H_-(w) H_+(w) \sin^2 \theta_v * R(\theta_v) \sin^2 \theta_l * R(\theta_l) * \cos 2\chi * R(\chi) + \\ & - 2H_+(w) H_0(w) \sin 2\theta_v * R(\theta_v) \sin \theta_l (1 - \cos \theta_l) * R(\theta_l) * \cos \chi * R(\chi) + \\ & + 2H_-(w) H_0(w) \sin 2\theta_v * R(\theta_v) \sin \theta_l (1 + \cos \theta_l) * R(\theta_l) * \cos \chi * R(\chi). \end{aligned}$$

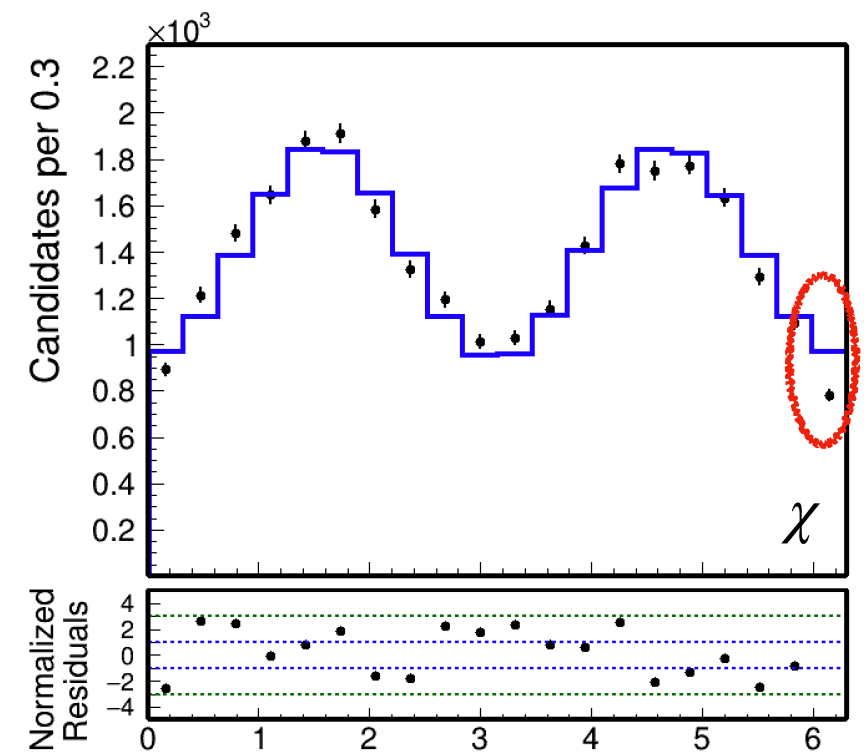
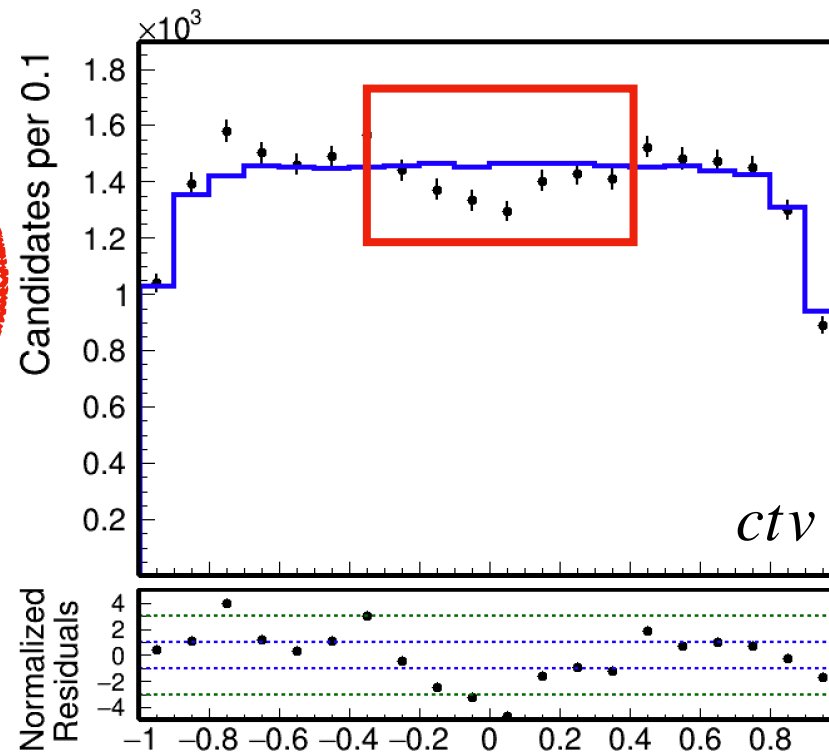
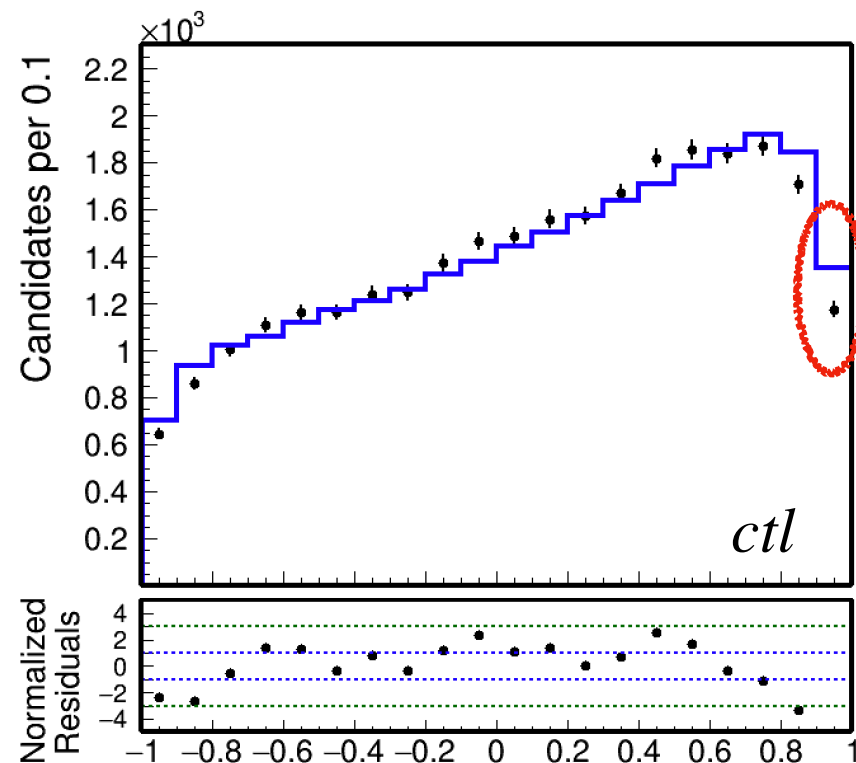
$$\text{where } f(x) * R(x) = \sum_{x'} f(x') R(x - x')$$

$$\text{Assume : } R(x - x') = e^{-\frac{(x - x')^2}{2\sigma^2}}, \mu = 0, \sigma = 0.1$$

Fit with angular resolutions

Try to fit in the first bin of w [1,1.1]. Total events: 27840

H_+	H_-	H_0
4.55 +- 0.04	6.90 +- 0.04	5.61 +- 0.04



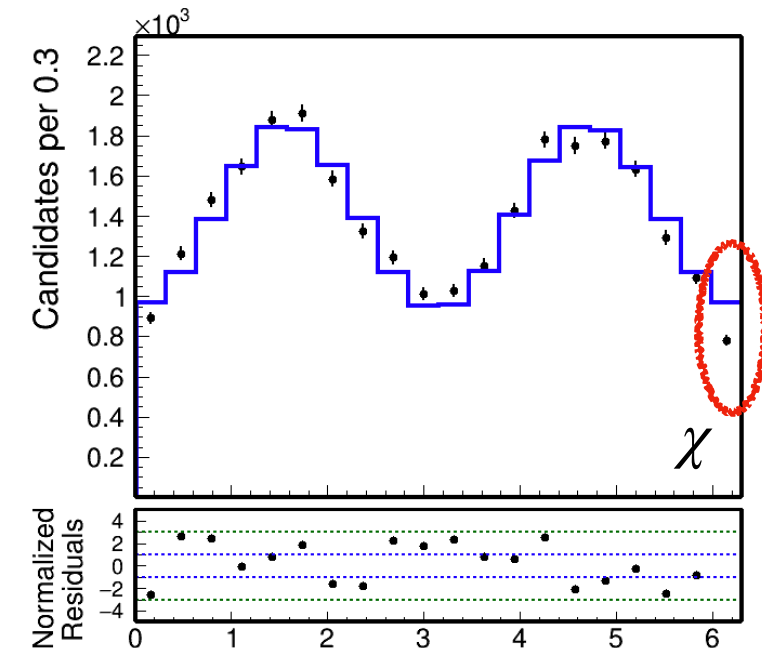
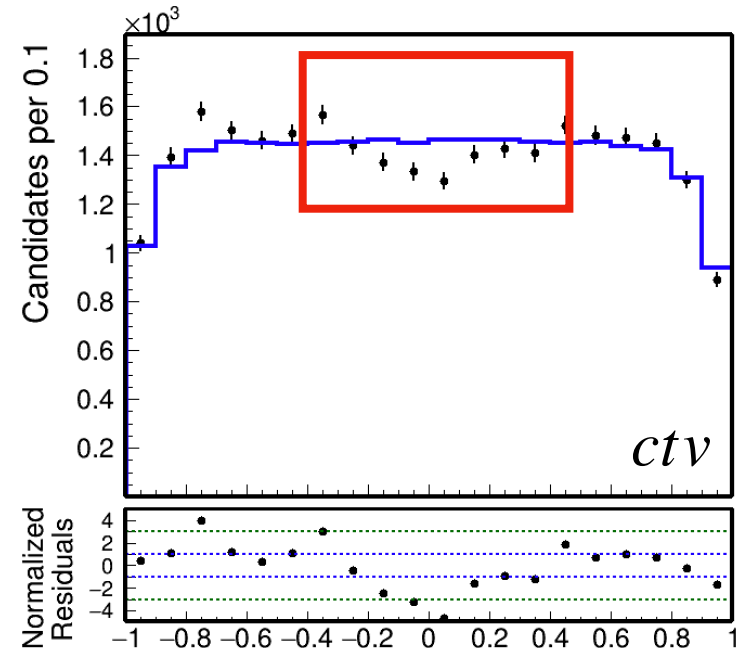
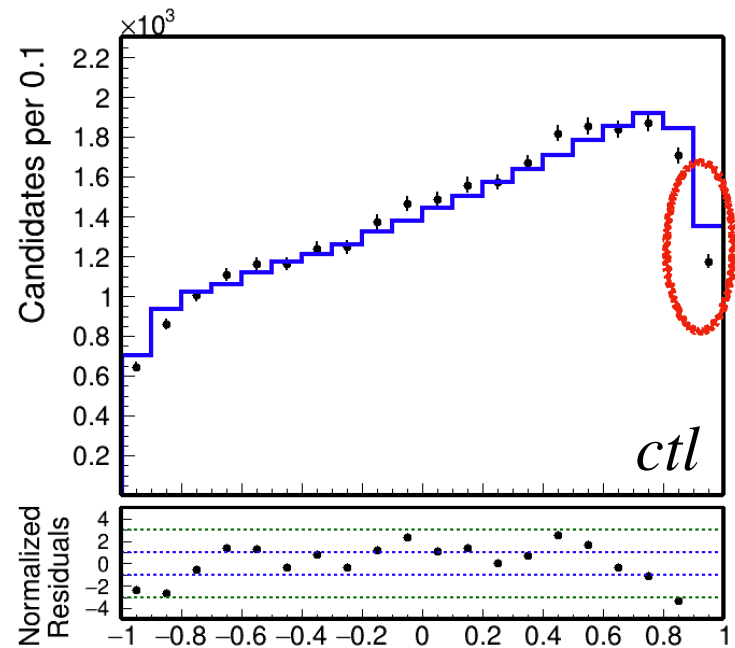
Fit with angular resolutions

Fit in all bins.

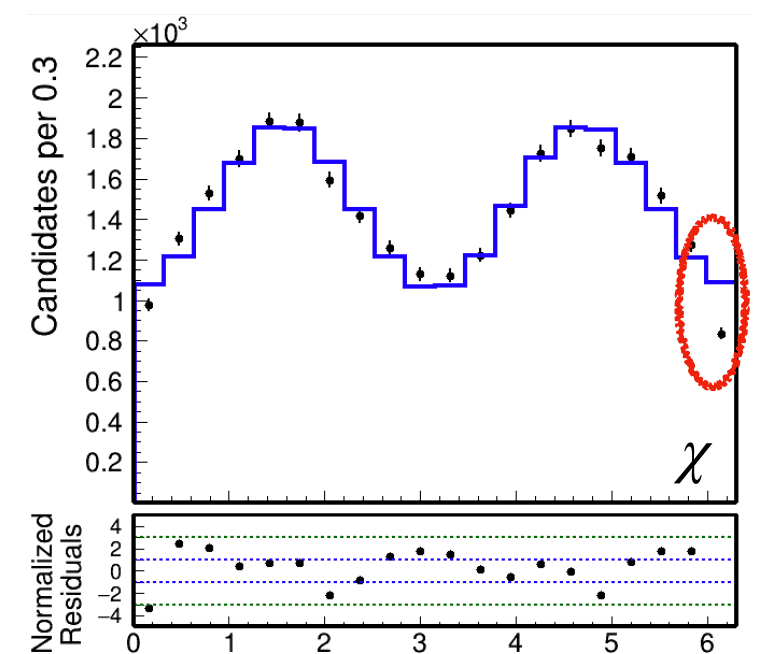
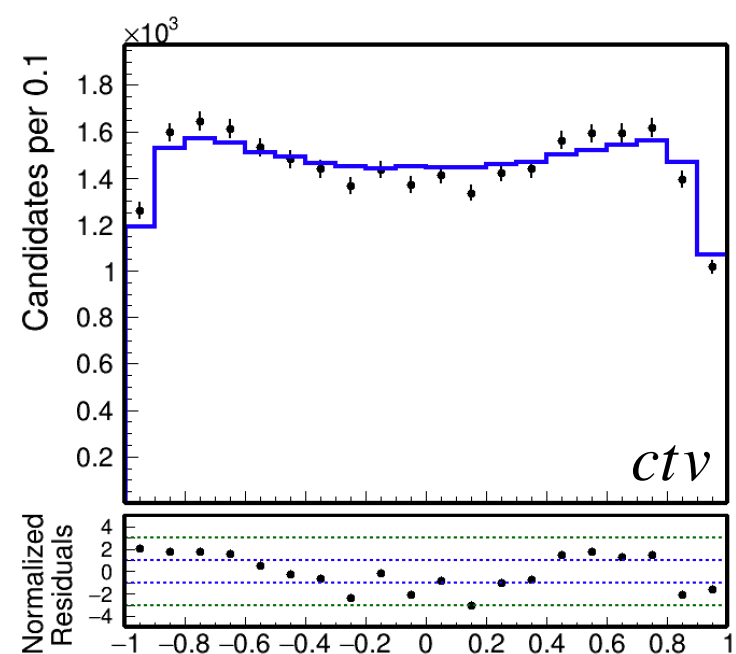
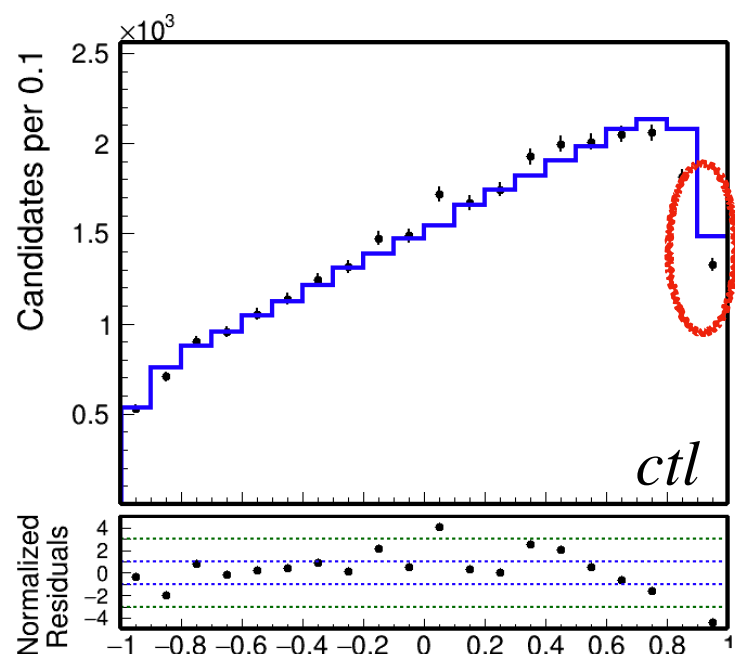
w	H_+	H_-	H_0
1 bin	4.55 +- 0.04	6.90 +- 0.04	5.61 +- 0.04
2 bin	3.77 +- 0.04	7.17 +- 0.03	6.02 +- 0.03
3 bin	3.23 +- 0.04	7.16 +- 0.04	6.48 +- 0.04
4 bin	2.84 +- 0.04	7.12 +- 0.04	7.05 +- 0.04
5 bin	2.54 +- 0.05	7.07 +- 0.04	8.02 +- 0.04
6 bin	2.39 +- 0.06	6.98 +- 0.05	9.95 +- 0.05
7 bin	2.50 +- 0.10	6.71 +- 0.09	16.84 +- 0.07

Fit with angular resolutions:
projections

1st bin →



2nd bin →



3rd bin →

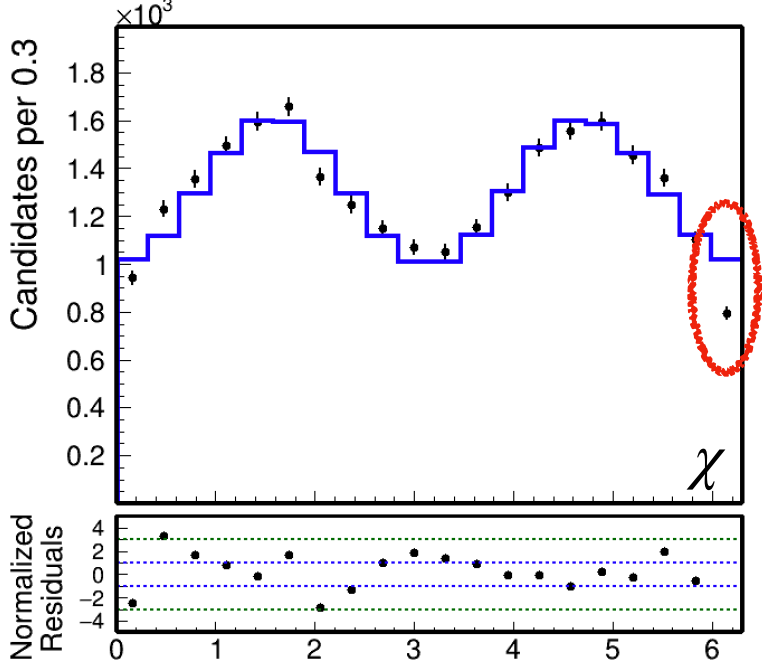
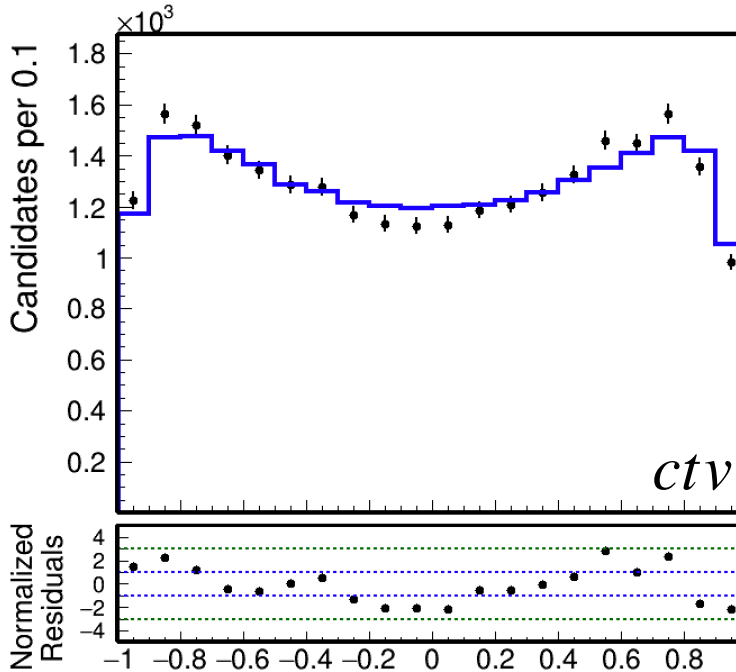
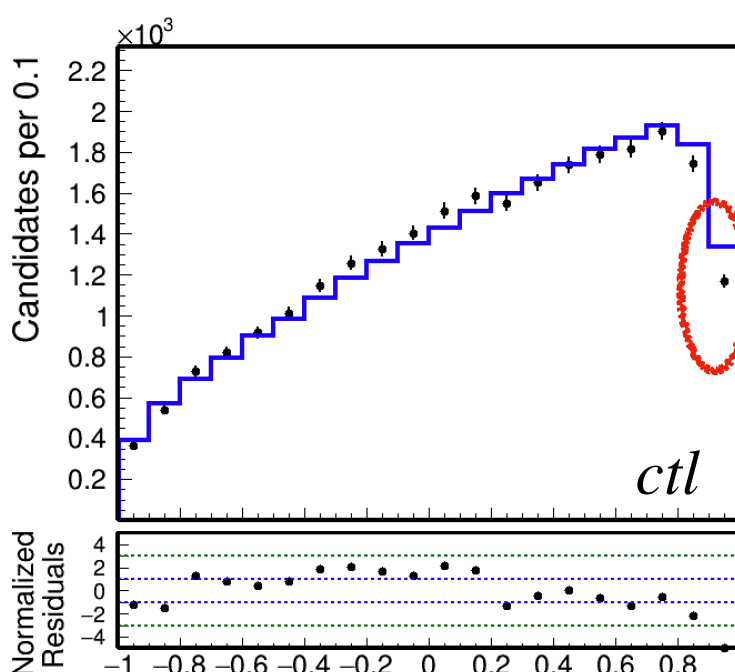


Figure 1 consists of two panels. The top panel is a histogram showing the number of candidates per 0.1 (y-axis, ranging from 0.2 to 2.0, with a multiplier of $\times 10^2$) versus $\log_{10}(\text{likelihood ratio})$ (x-axis, ranging from -1 to 1). The data points are black dots, and the histogram is a blue step function. A red dashed circle highlights the region where the number of candidates drops sharply from approximately 1.8 to 1.2 at $\log_{10}(\text{likelihood ratio}) \approx 0.8$. The bottom panel shows the normalized residuals (y-axis, ranging from -4 to 4) versus $\log_{10}(\text{likelihood ratio})$ (x-axis, ranging from -1 to 1). The residuals are black dots, and horizontal dashed lines (blue and green) indicate the expected distribution.

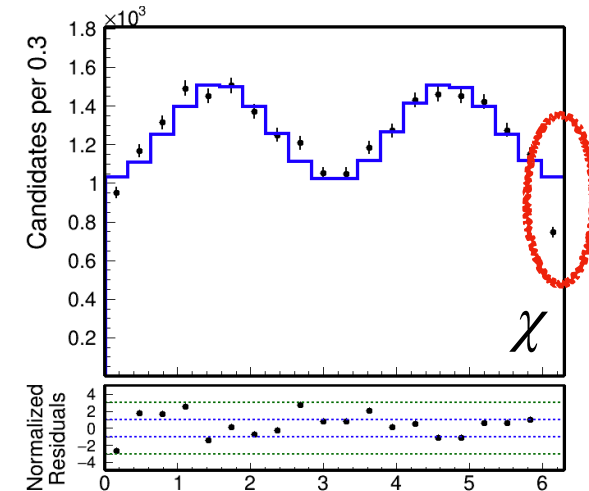
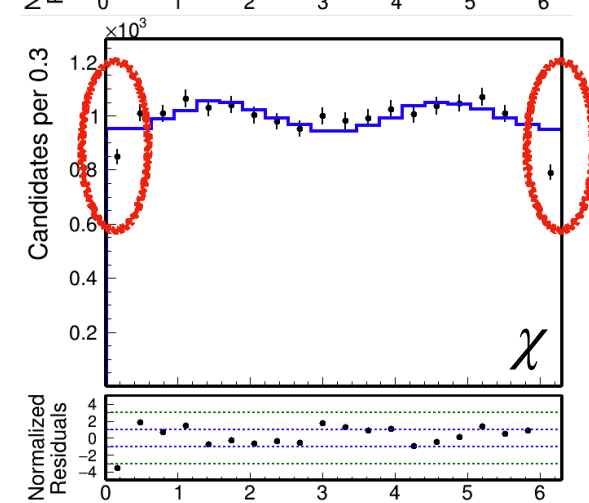
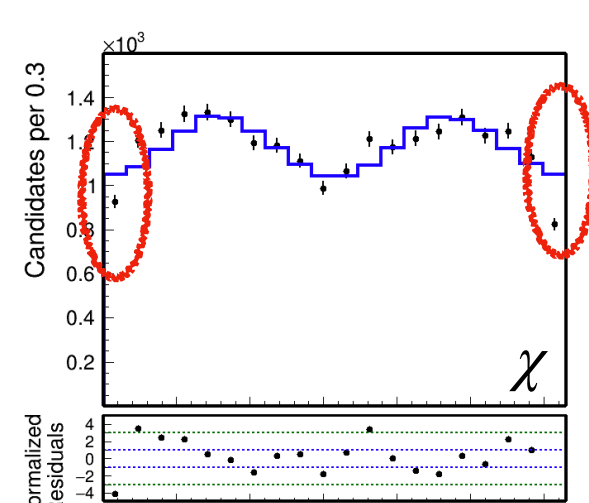
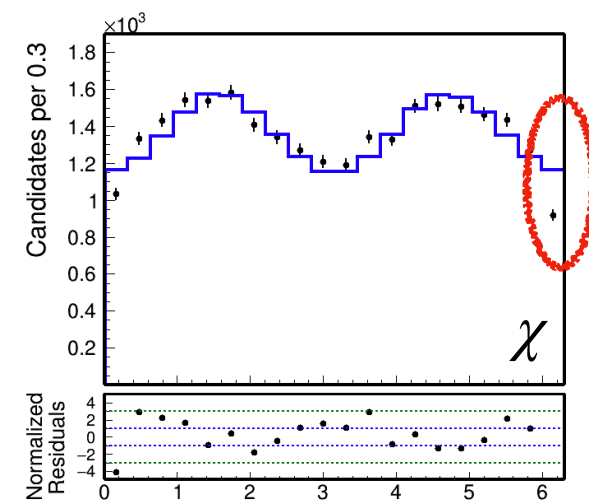
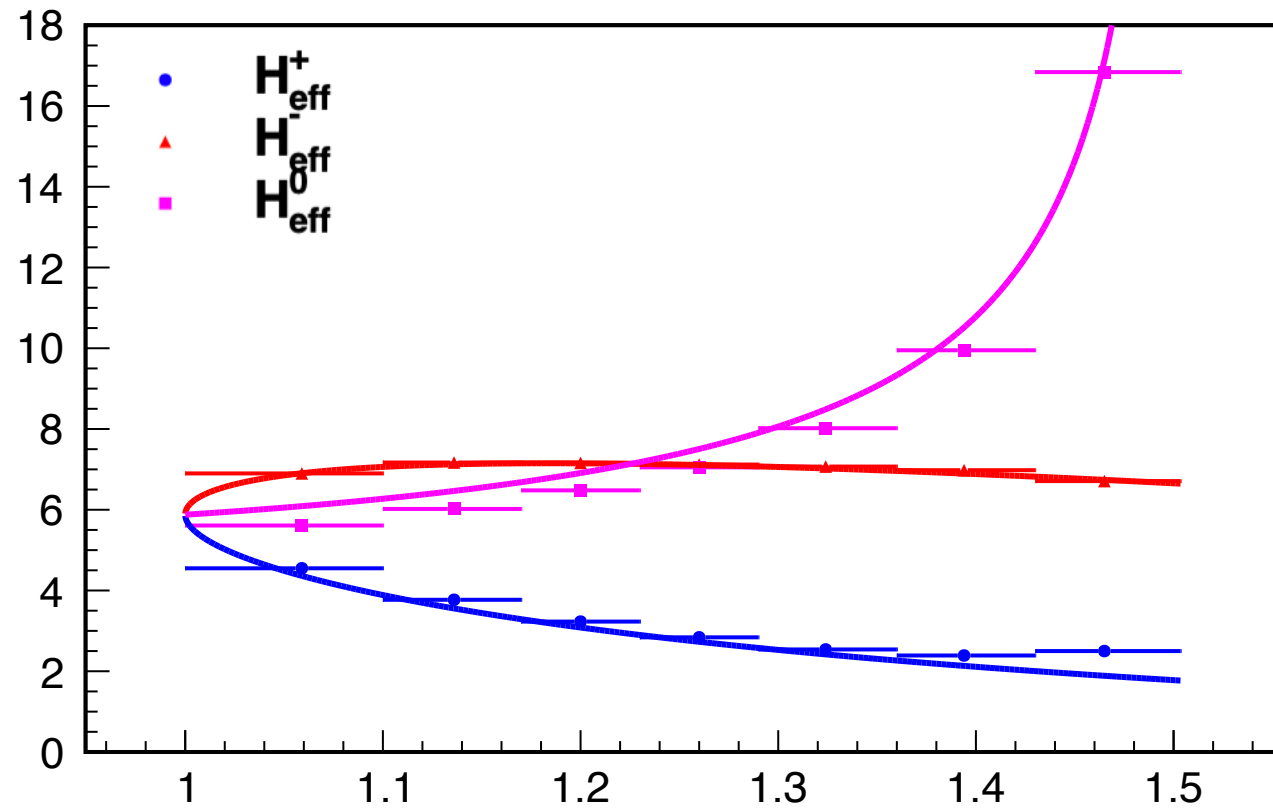


Figure 1 consists of two panels. The top panel is a histogram showing the number of candidates per 0.1 degree bin for the control sample (ctl). The y-axis is labeled 'Candidates per 0.1' and ranges from 0 to 2.0, with a multiplier of $\times 10^3$ at the top. The x-axis ranges from -1 to 1. The distribution is shown as a blue step histogram with black data points. A red dashed ellipse highlights the tail region of the distribution, which is centered around 0.8. The bottom panel shows the normalized residuals for the control sample. The y-axis is labeled 'Normalized Residuals' and ranges from -4 to 4. The x-axis ranges from -1 to 1. The residuals are plotted as black dots, and horizontal dashed lines represent the mean and standard deviation of the residuals.

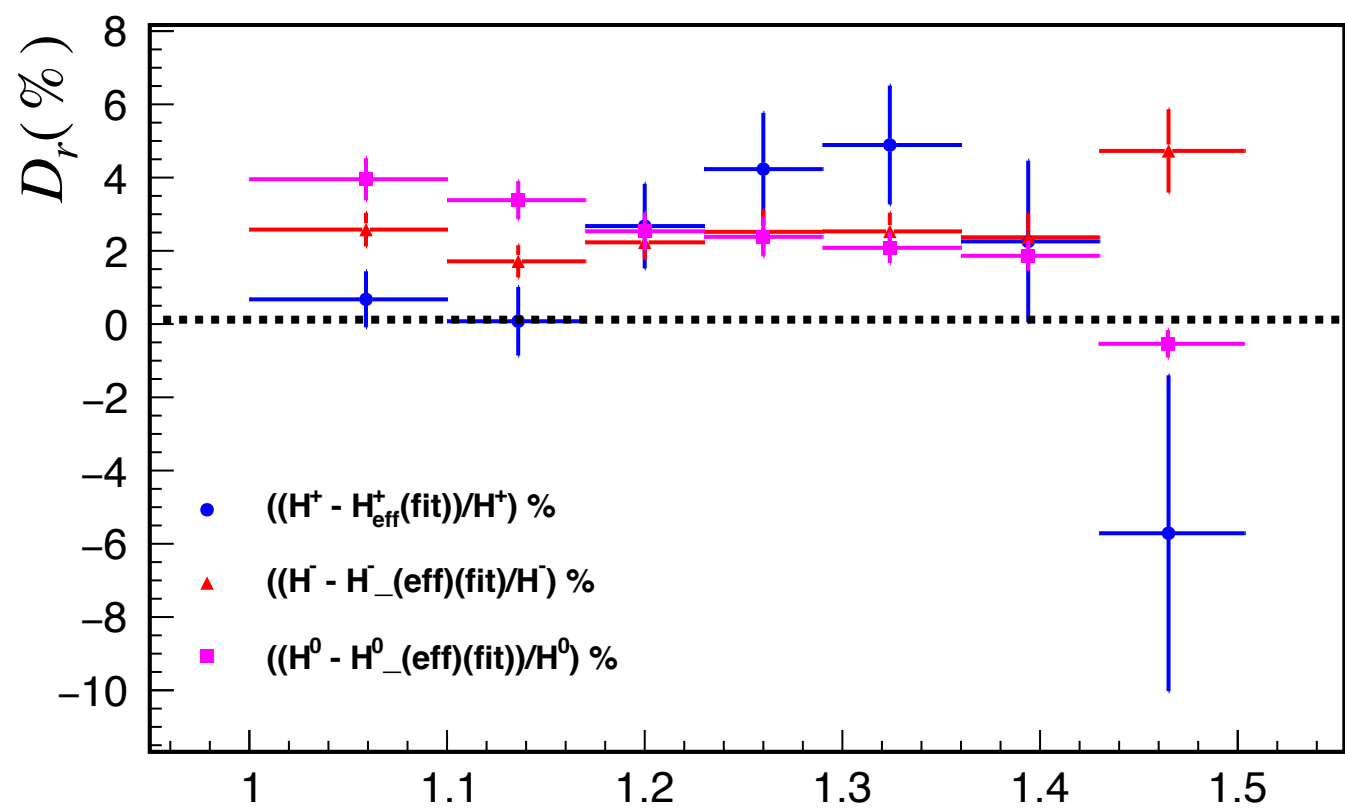
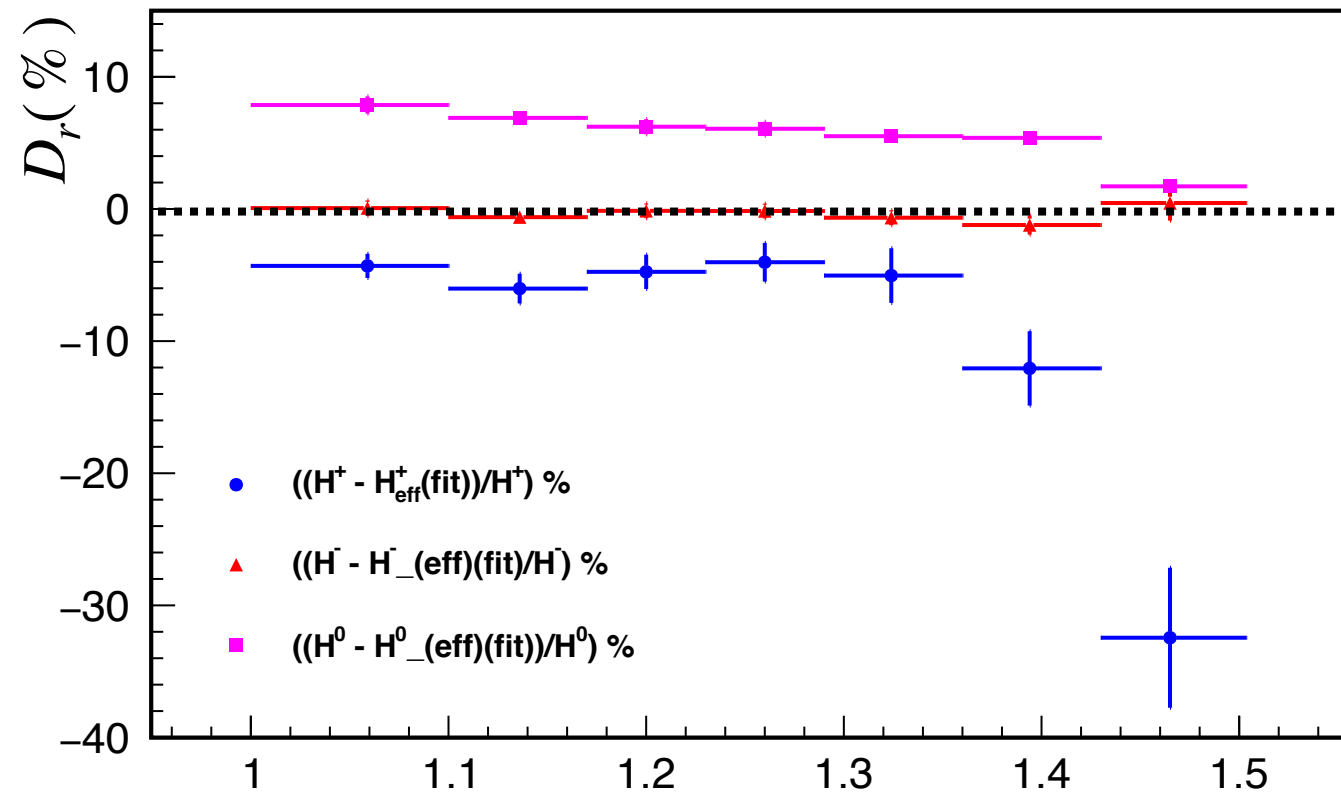
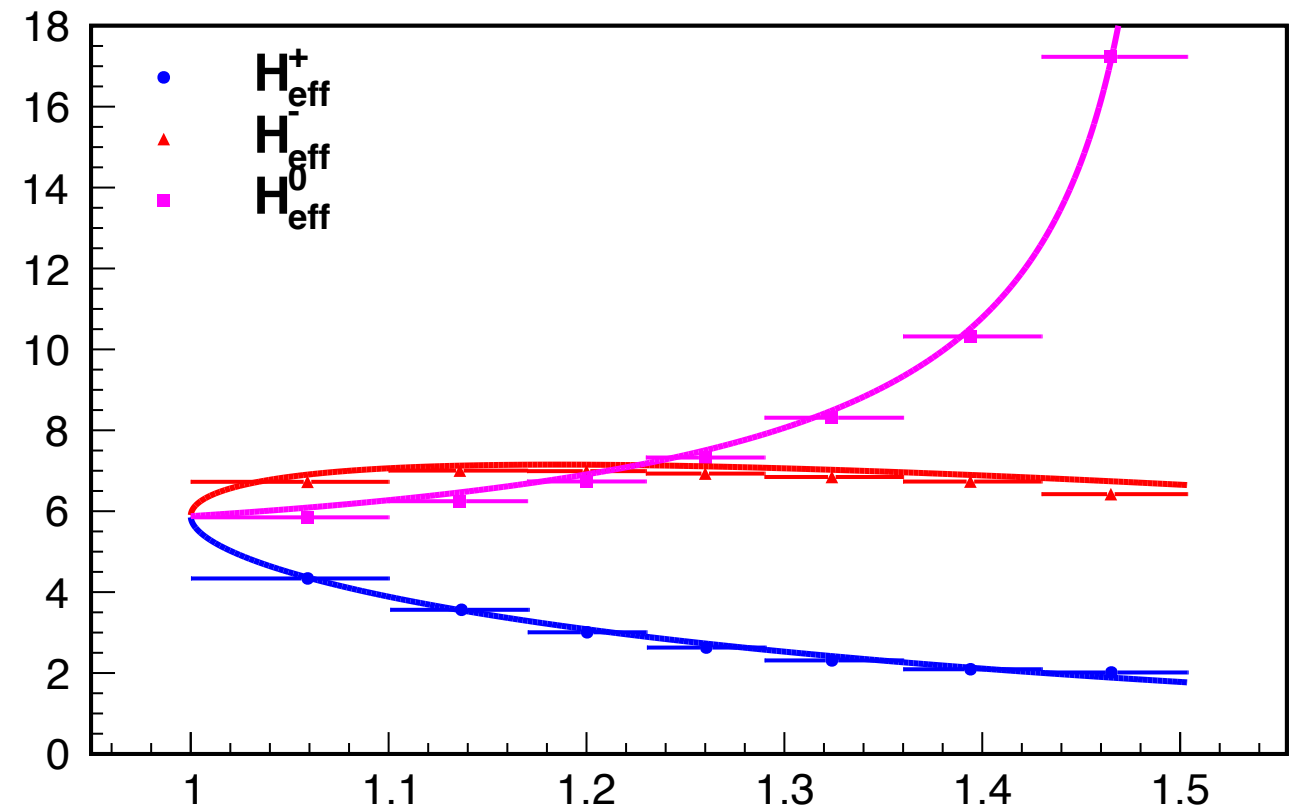


Fit with angular resolutions

with angular resolution



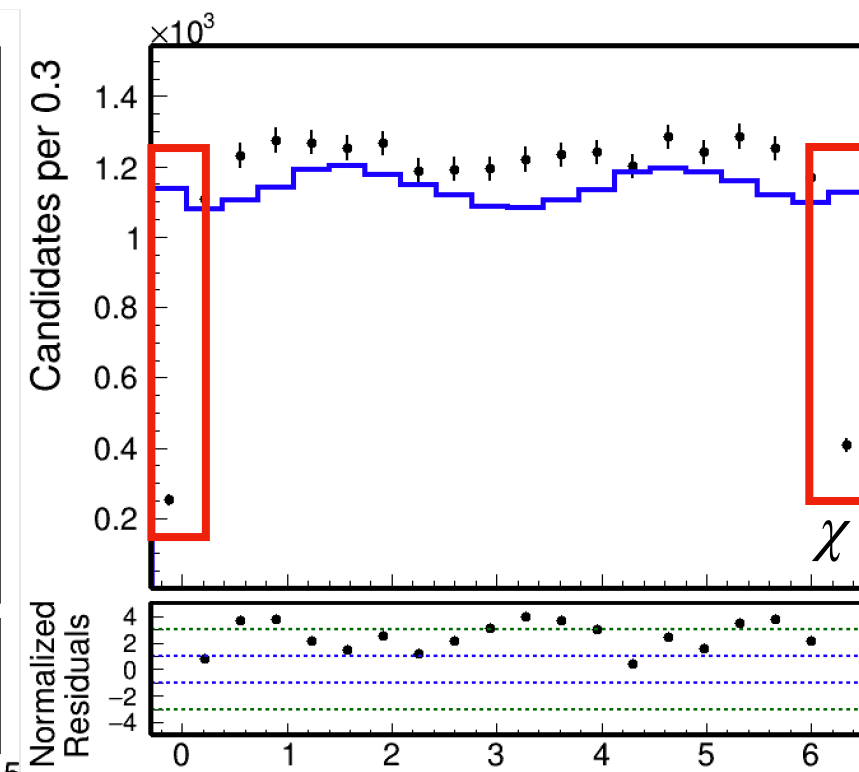
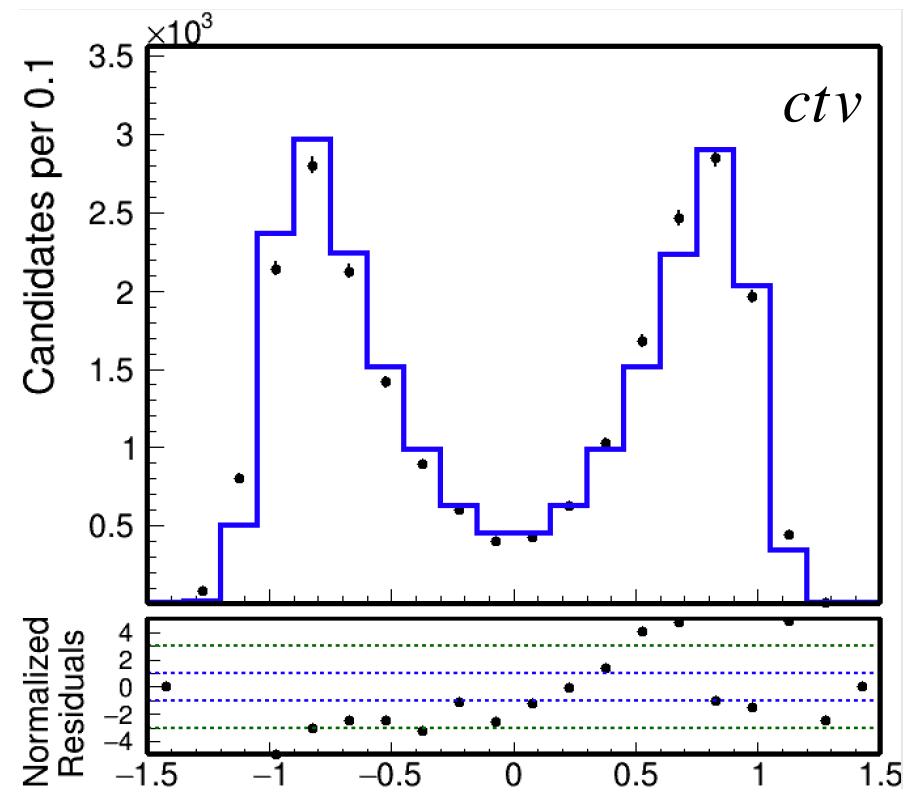
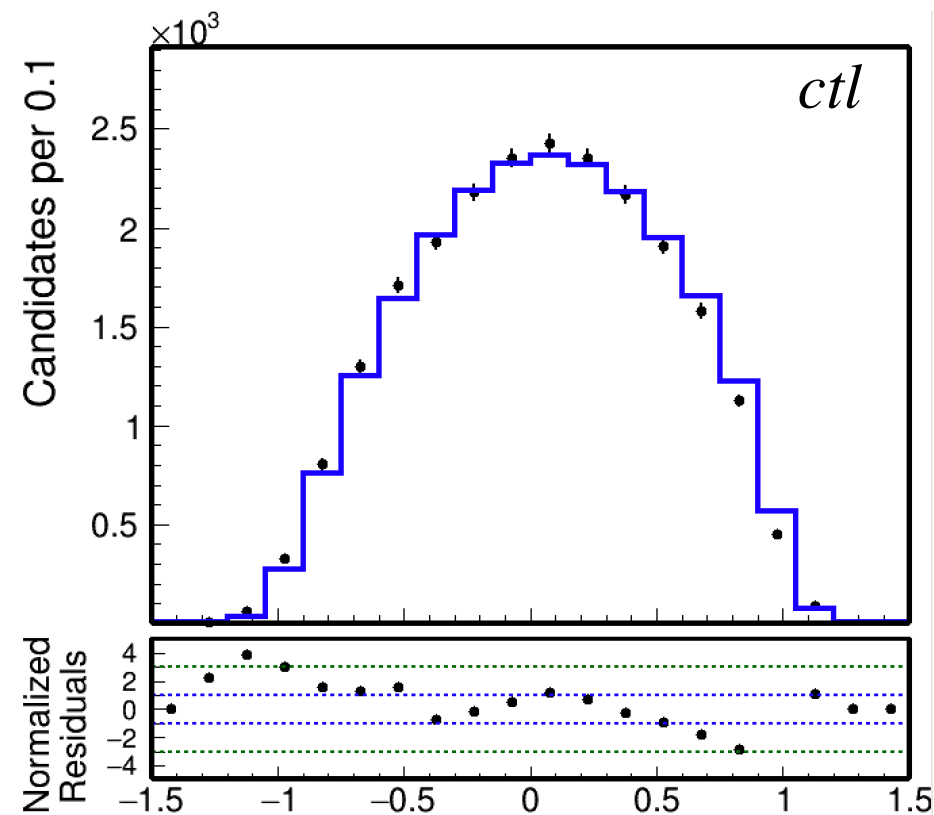
without angular resolution



Backup

Fit with angular resolutions

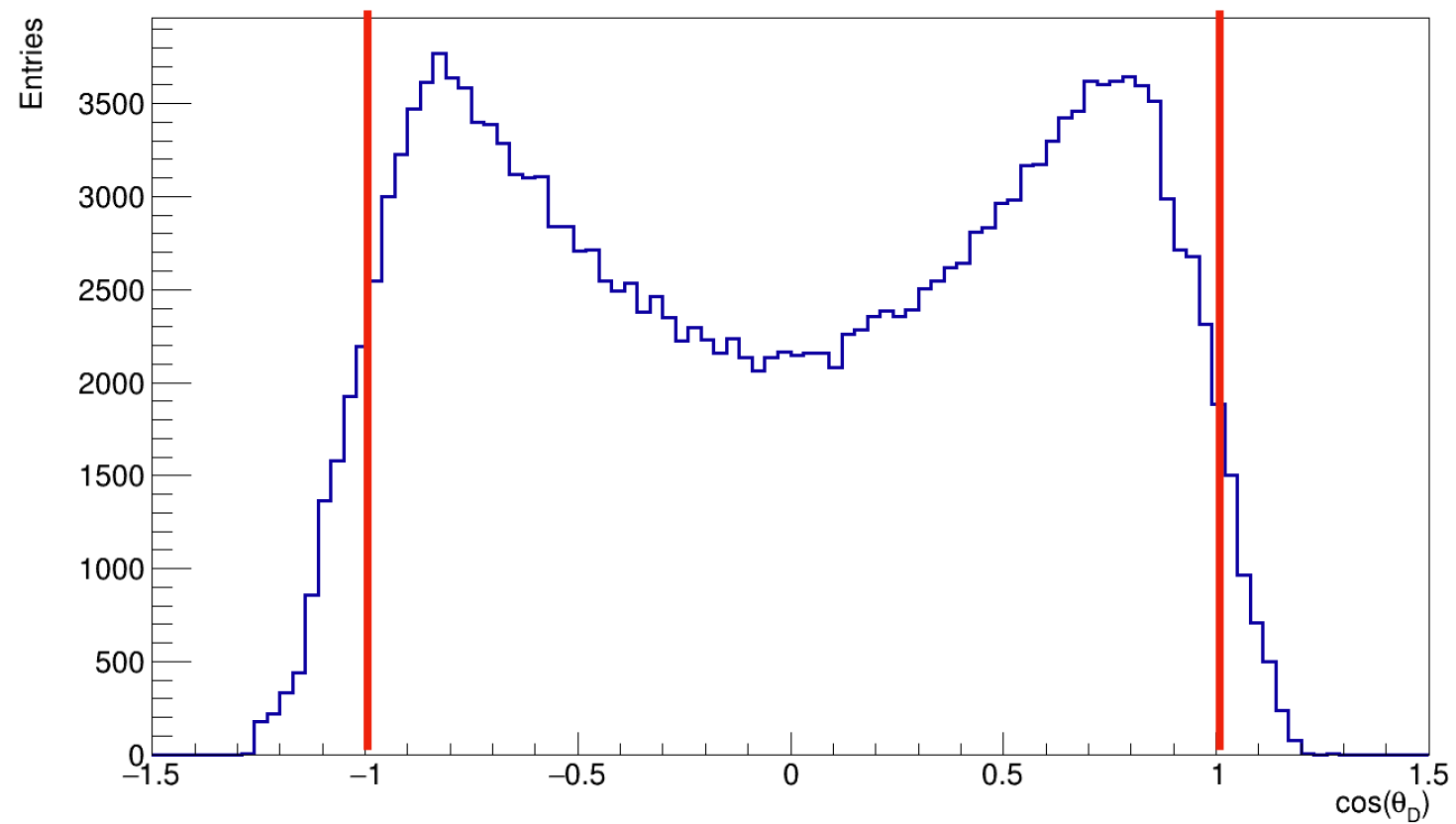
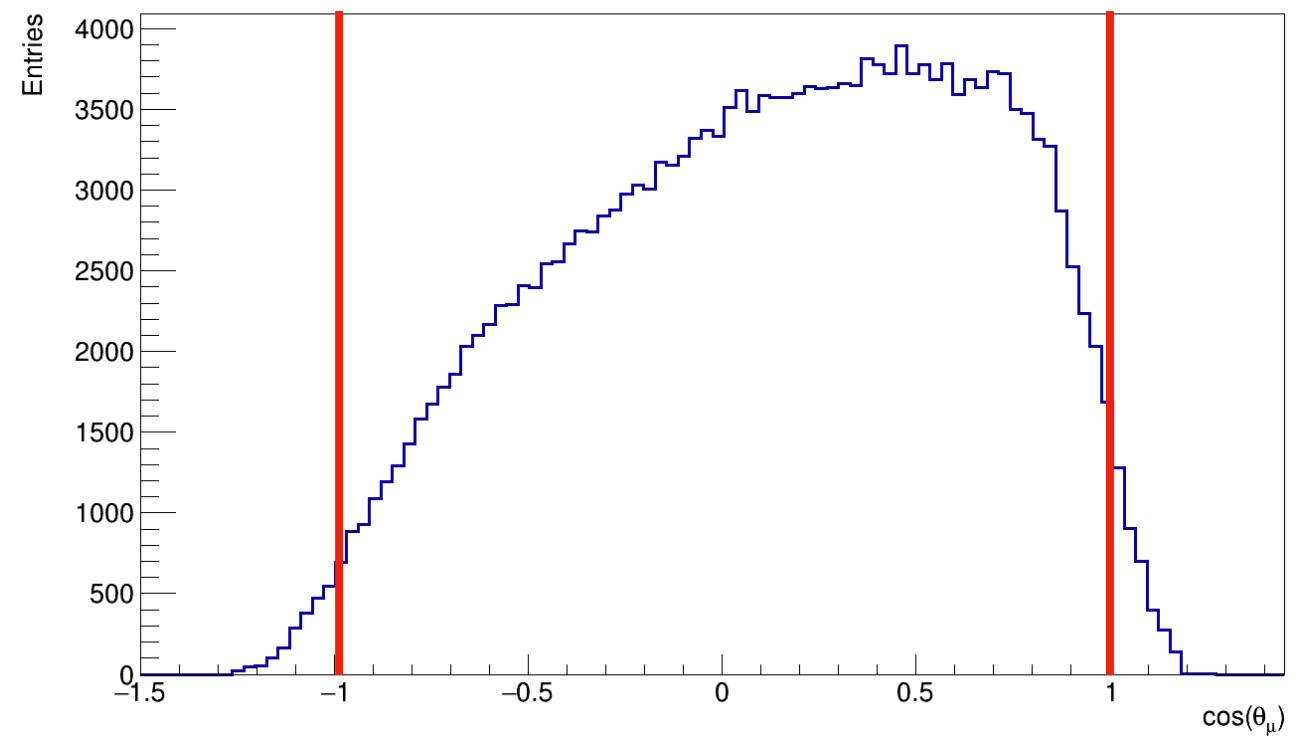
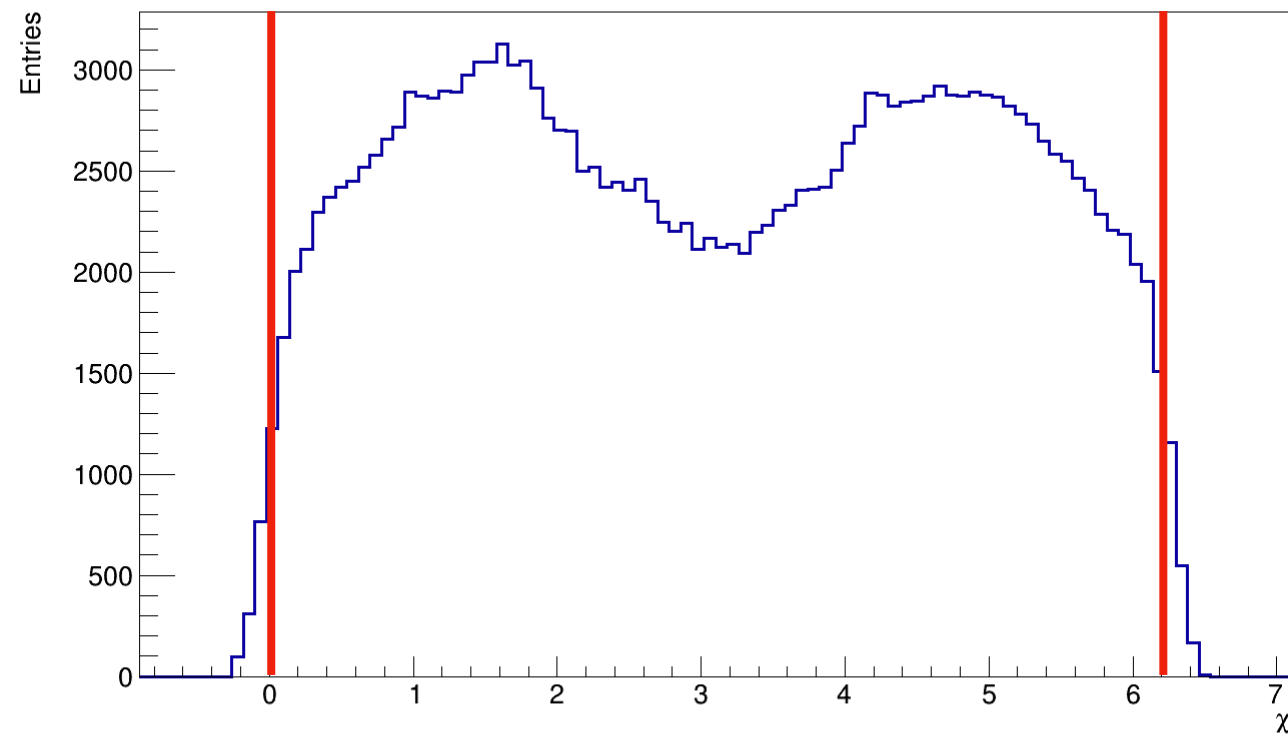
	H_+	H_-	H_0
$[1.43, w_{max}]$	2.54 ± 0.10	6.79 ± 0.09	17.02 ± 0.07



Drop still remains.

angular distributions

Distributions with angular resolutions.



$f(w)$, $g(w)$ and $F_1(w)$ parameters

$f(w)$, $g(w)$ and $F_1(w)$ parameters

Try to fit $f(w)$, $g(w)$ and $F_1(w)$ parameters.

These parameters are linked to the $H_{\pm}$ and H_0 parameters:

$$g(w) = \frac{1}{r\sqrt{w^2 - 1}} \frac{H_+(w) - H_-(w)}{2m_B^2} ,$$

$$f(w) = \frac{H_+(w) + H_-(w)}{2} ,$$

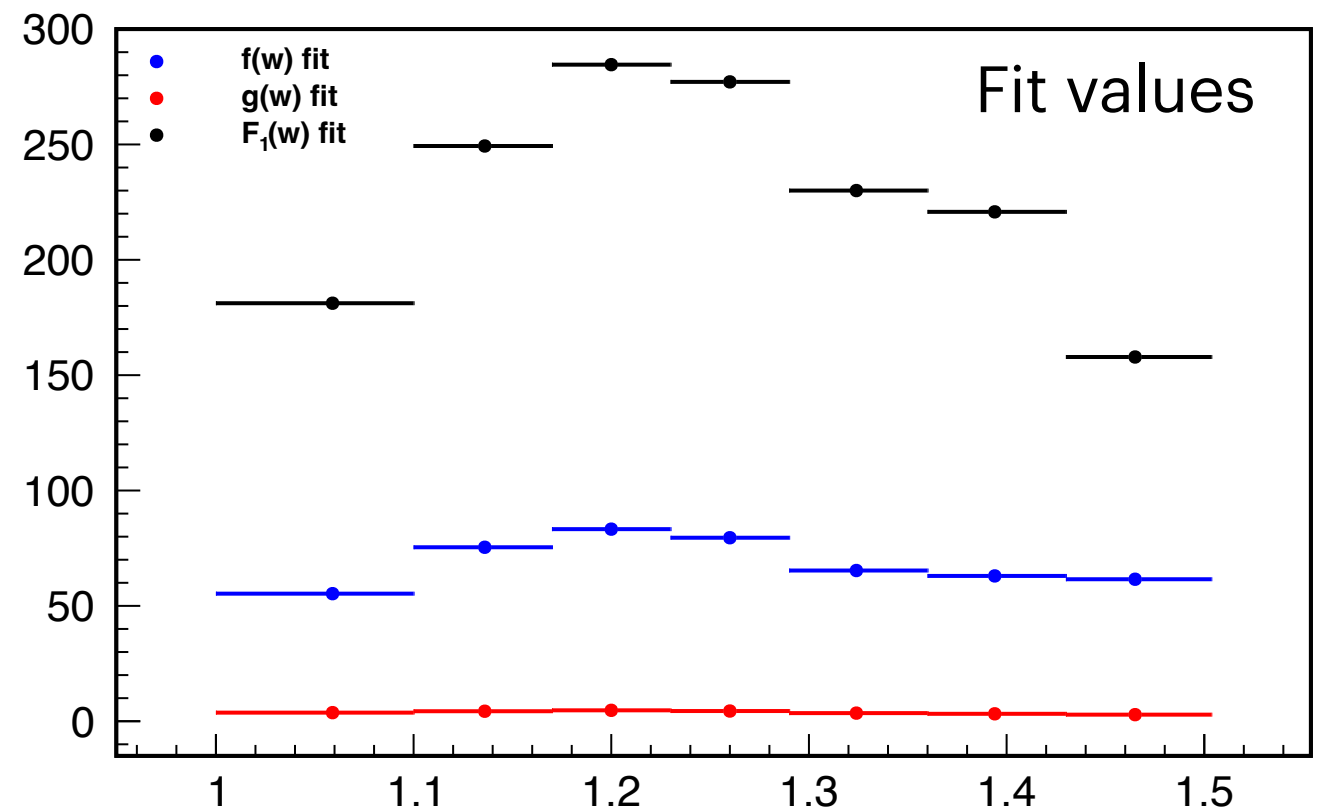
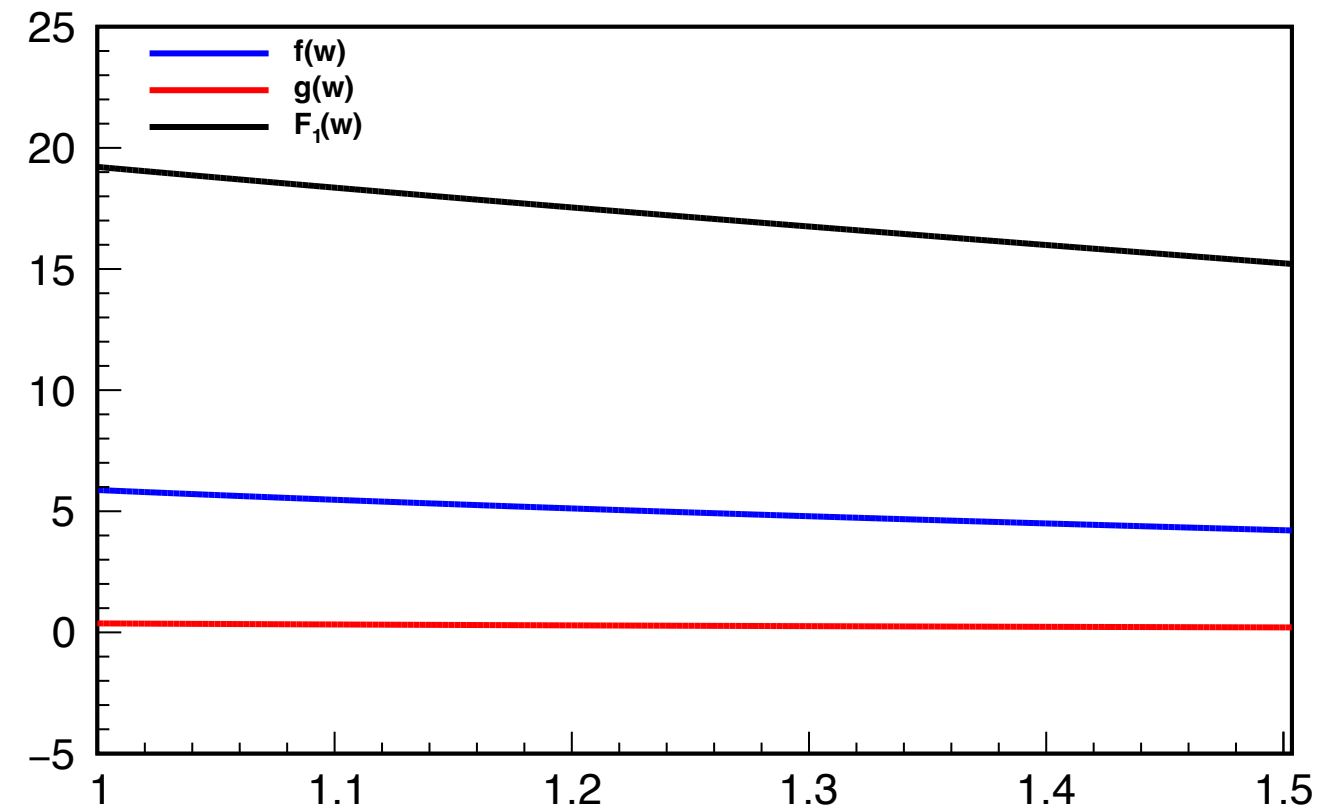
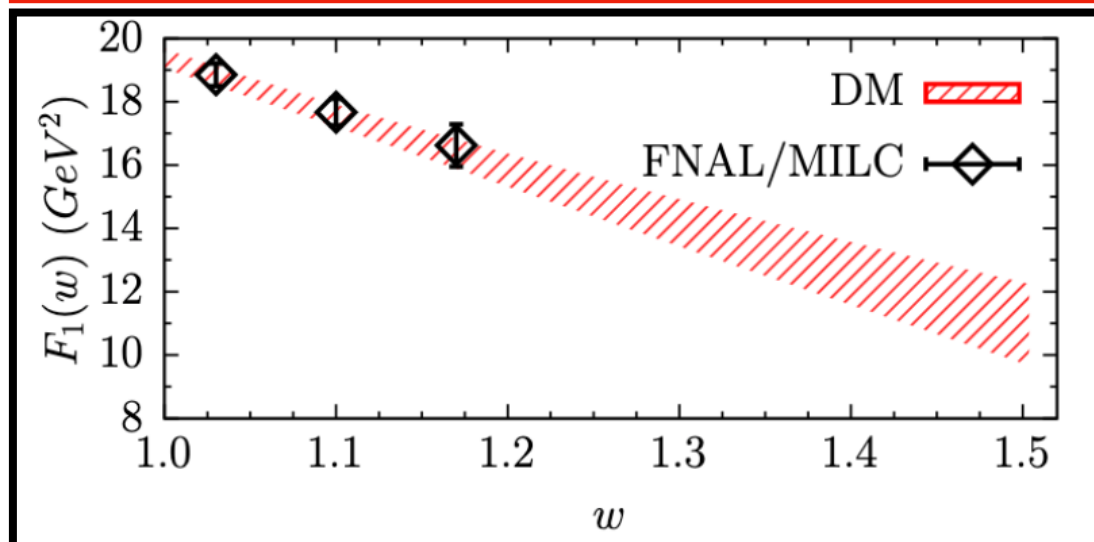
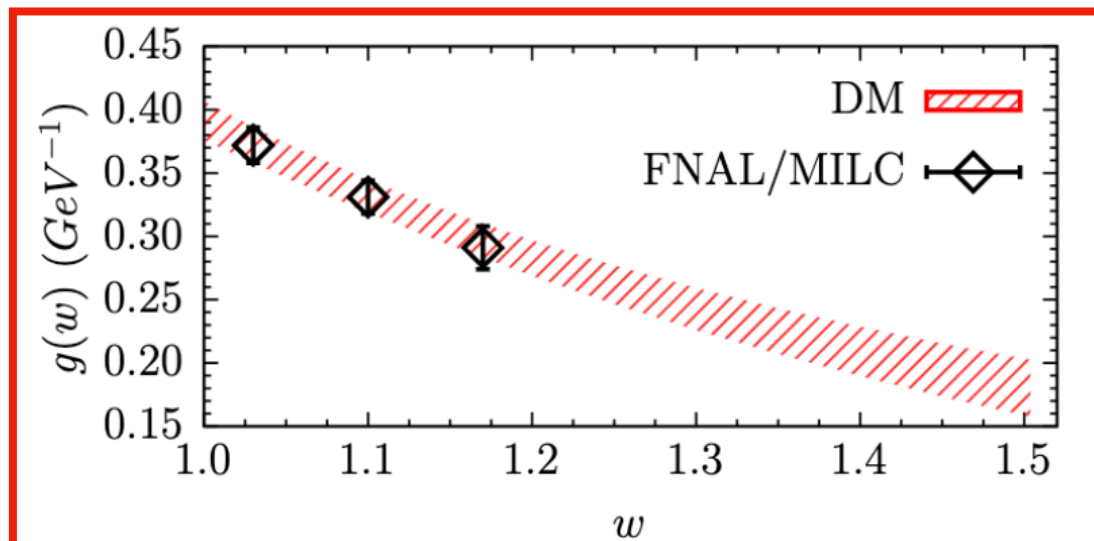
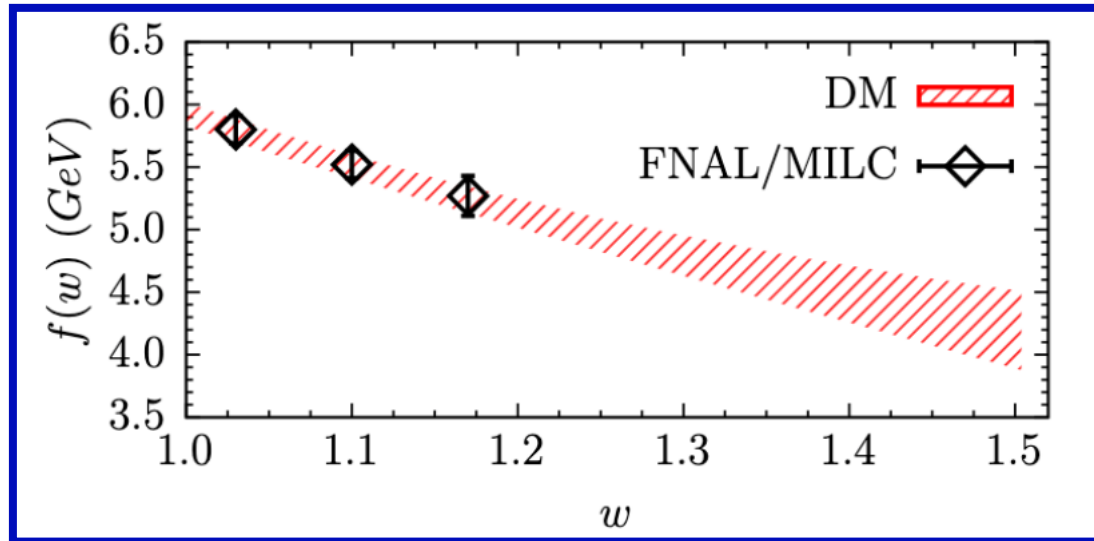
$$F_1(w) = m_B \sqrt{1 - 2rw + r^2} H_0(w) .$$

w	$f(w)$	$g(w)$	$F_1(w)$
1 bin	-55.30 +- 0.23	3.73 +- 0.07	-181.19 +- 1.09
2 bin	-75.41 +- 0.33	4.34 +- 0.06	-249.33 +- 1.35
3 bin	-83.26 +- 0.41	4.73 +- 0.06	-284.59 +- 1.49
4 bin	-79.54 +- 0.45	4.42 +- 0.07	-277.12 +- 1.55
5 bin	-65.33 +- 0.39	3.52 +- 0.04	-230.02 +- 0.98
6 bin	-62.98 +- 0.48	3.22 +- 0.04	-220.79 +- 0.15
7 bin	-61.55 +- 0.87	2.85 +- 0.07	-157.88 +- 0.62

$f(w)$, $g(w)$ and $F_1(w)$ parameters

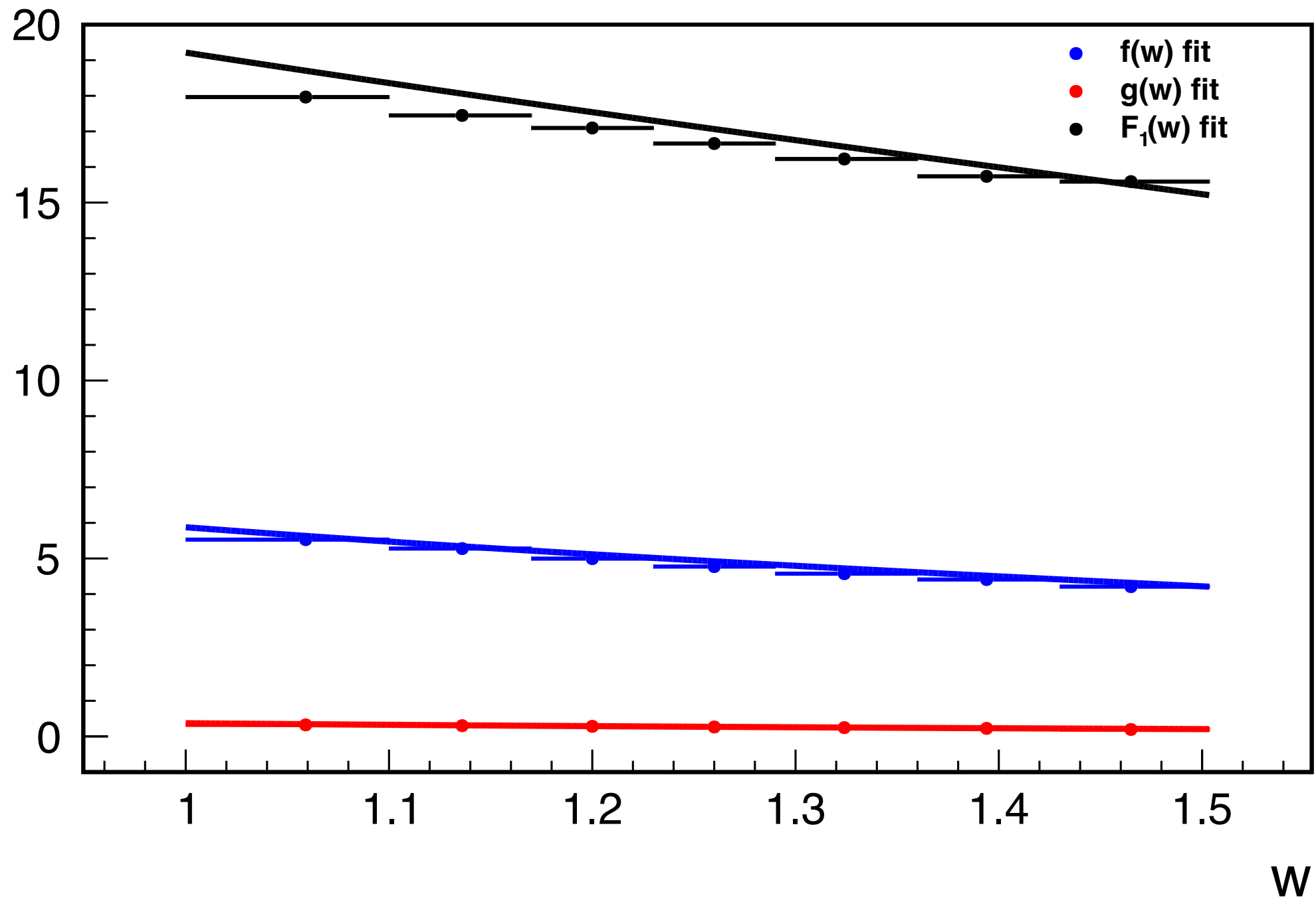
<https://arxiv.org/pdf/2211.11305.pdf>

Generation functions



$f(w)$, $g(w)$ and $F_1(w)$ parameters

$f(w)$, $g(w)$ and $F_1(w)$ values obtained starting from the values of the fitted H.



Instrumental Asymmetries

Inputs for Moriond23

- Measure $\mathcal{A}_{\text{det}}$ for $B^0 \rightarrow K^+\pi^-$, $B^+ \rightarrow K_s^0\pi^+$, $B^+ \rightarrow \pi^+\pi^0$ and $B^+ \rightarrow K^+\pi^0$ using $D^0 \rightarrow K^-\pi^+$ and $D^- \rightarrow K_s^0\pi^-$ ($\sim 360/\text{fb}$).

Strategy: measure $\mathcal{A}_{\text{det}}$ in D channels from data ($\mathcal{A}_{\text{det}}^{\text{control,data}} \pm \sigma^{\text{control,data}}$) and assign a systematic uncertainties ($\Delta\mathcal{A}_{\text{det}}^{\text{MC}}$) as the difference between control and target (B decays) values in MC:

$$\mathcal{A}_{\text{det}}(\text{for a target decay}) = \mathcal{A}_{\text{det}}^{\text{control,data}} \pm \sigma^{\text{control,data}} \pm \Delta\mathcal{A}_{\text{det}}^{\text{MC}}$$

$$\mathcal{A}_{\text{det}}(\pi^+) \text{ (for } B^+ \rightarrow \pi^+\pi^0 \text{)} : (0.78 \pm 0.17 \pm 0.38) \% \rightarrow (0.78 \pm 0.42) \%$$

$$\mathcal{A}_{\text{det}}(\pi^+) \text{ (for } B^+ \rightarrow K_s^0\pi^+ \text{)} : (0.78 \pm 0.17 \pm 0.38) \% \rightarrow (0.78 \pm 0.42) \%$$

$$\mathcal{A}_{\text{det}}(K^+) \text{ (for } B^+ \rightarrow K^+\pi^0 \text{)} : (1.41 \pm 0.18 \pm 0.42) \% \rightarrow (1.41 \pm 0.46) \%$$

$$\mathcal{A}_{\text{det}}(K^+\pi^-) \text{ (for } B^0 \rightarrow K^+\pi^- \text{)} : (0.62 \pm 0.05 \pm 0.67) \% \rightarrow (0.62 \pm 0.67) \%$$

- Plan to measure $\mathcal{A}_{\text{det}}$ for Riccardo's channel after his status report on 11st January.