$B^0 \to D^\star l \nu_l$ analysis

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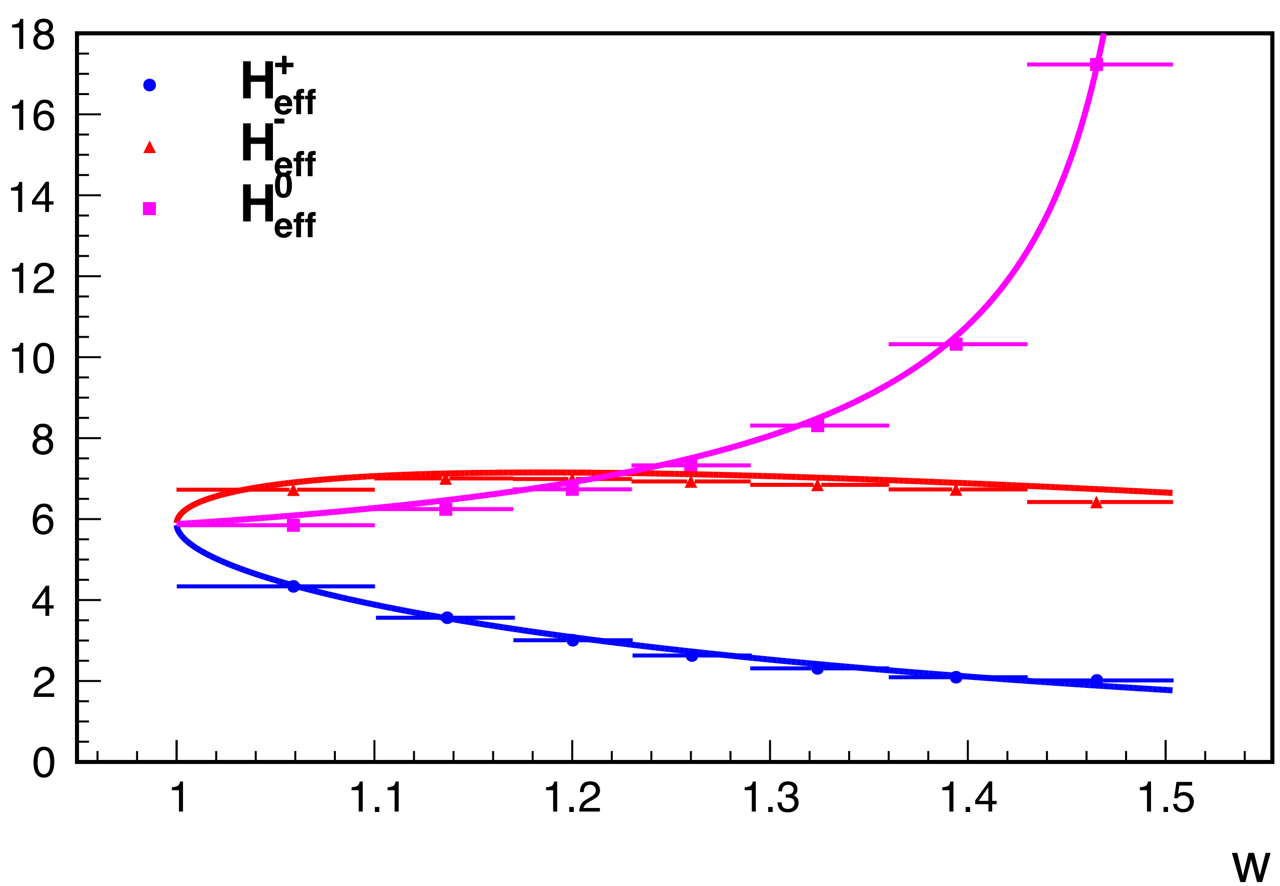
Analysis meeting
January 13, 2023

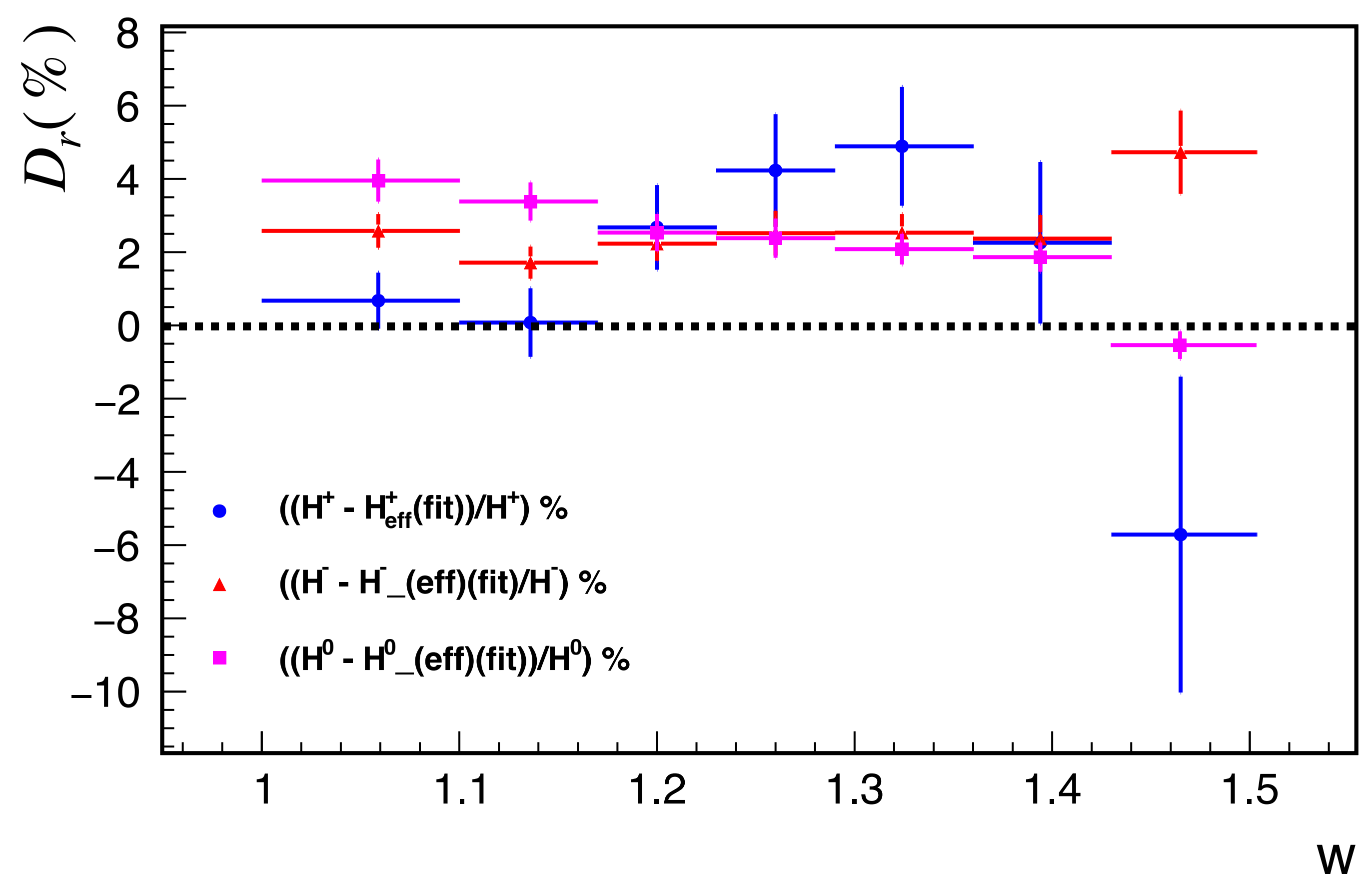
Fitter

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

Simultaneous fit

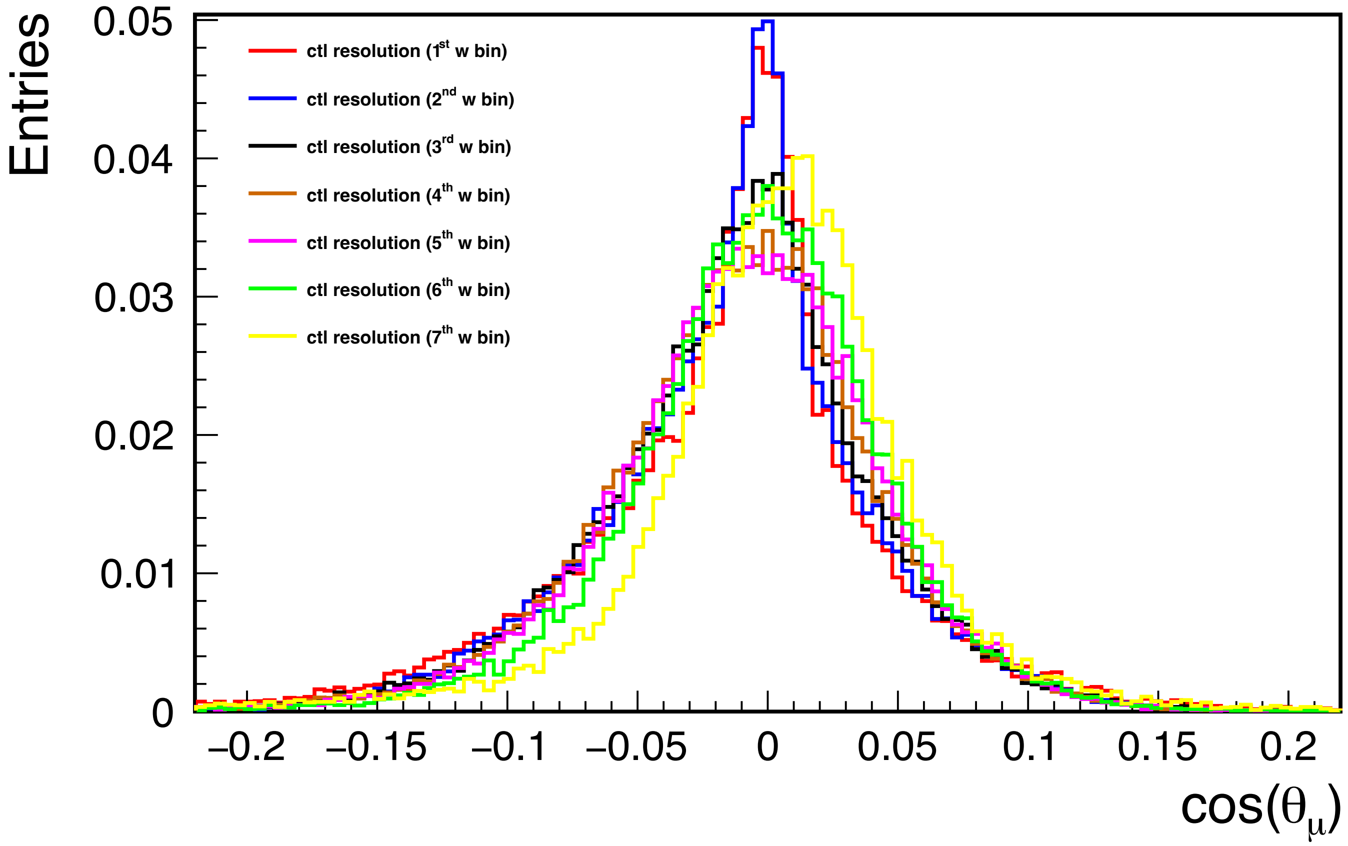
w	H^+	H^-	H^0
1 bin	4.33 +- 0.03	6.73 +- 0.03	5.85 +- 0.04
2 bin	3.55 +- 0.03	7.00 +- 0.03	6.25 +- 0.03
3 bin	3.00 +- 0.04	6.99 +- 0.03	6.74 +- 0.04
4 bin	2.61 +- 0.04	6.93 +- 0.04	7.33 +- 0.04
5 bin	2.30 +- 0.04	6.85 +- 0.04	8.31 +- 0.04
6 bin	2.08 +- 0.05	6.73 +- 0.04	10.33 +- 0.04
7 bin	1.99 +- 0.08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

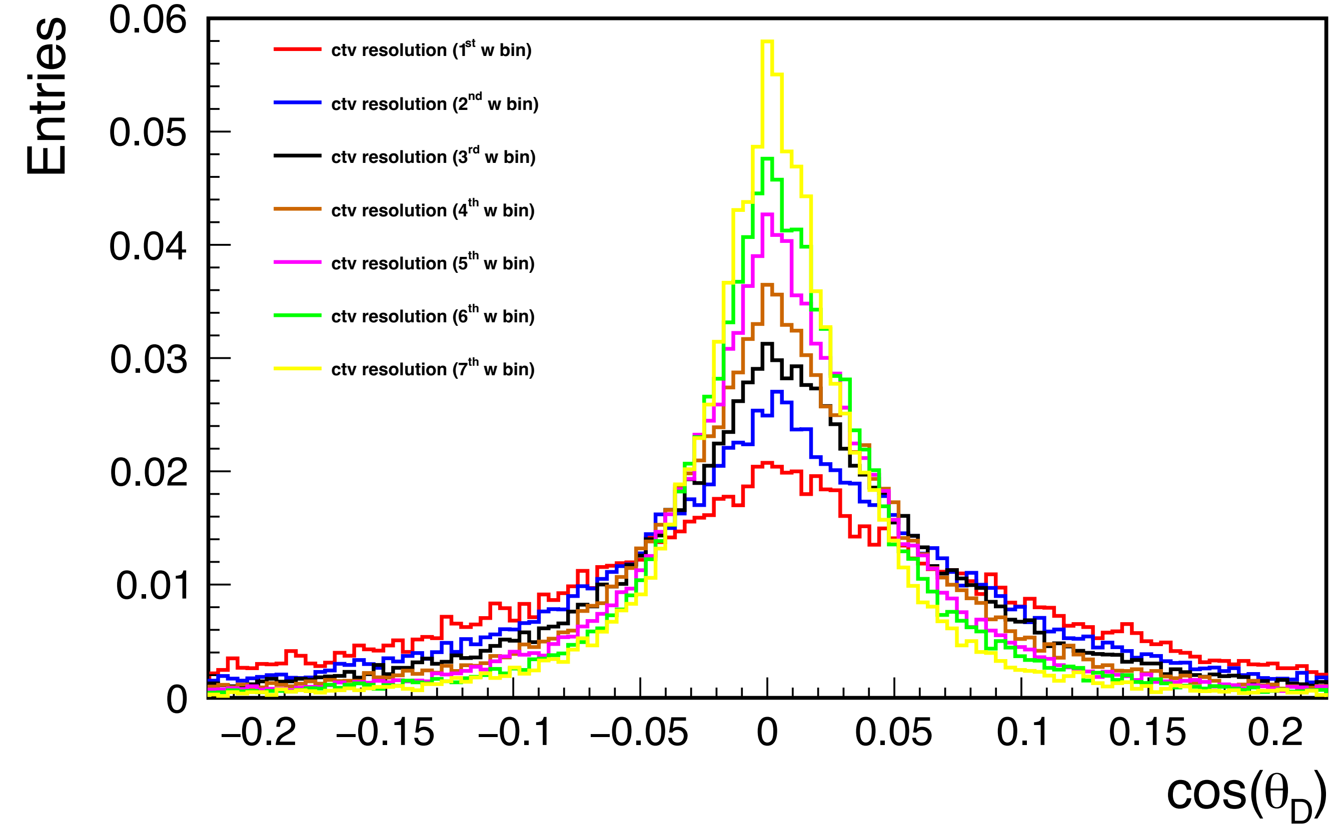


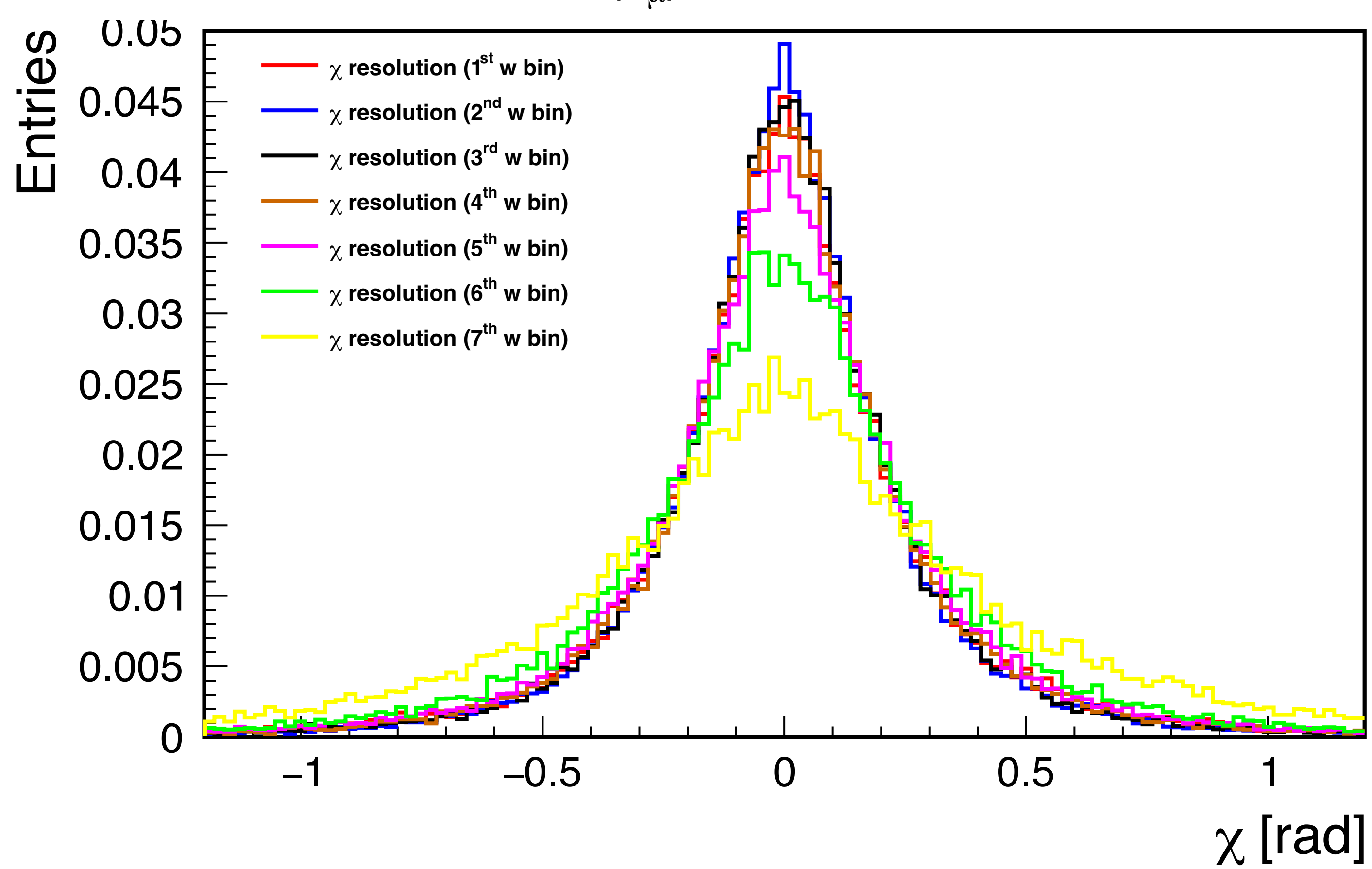


angular resolutions

Study the angular resolutions in each bin.





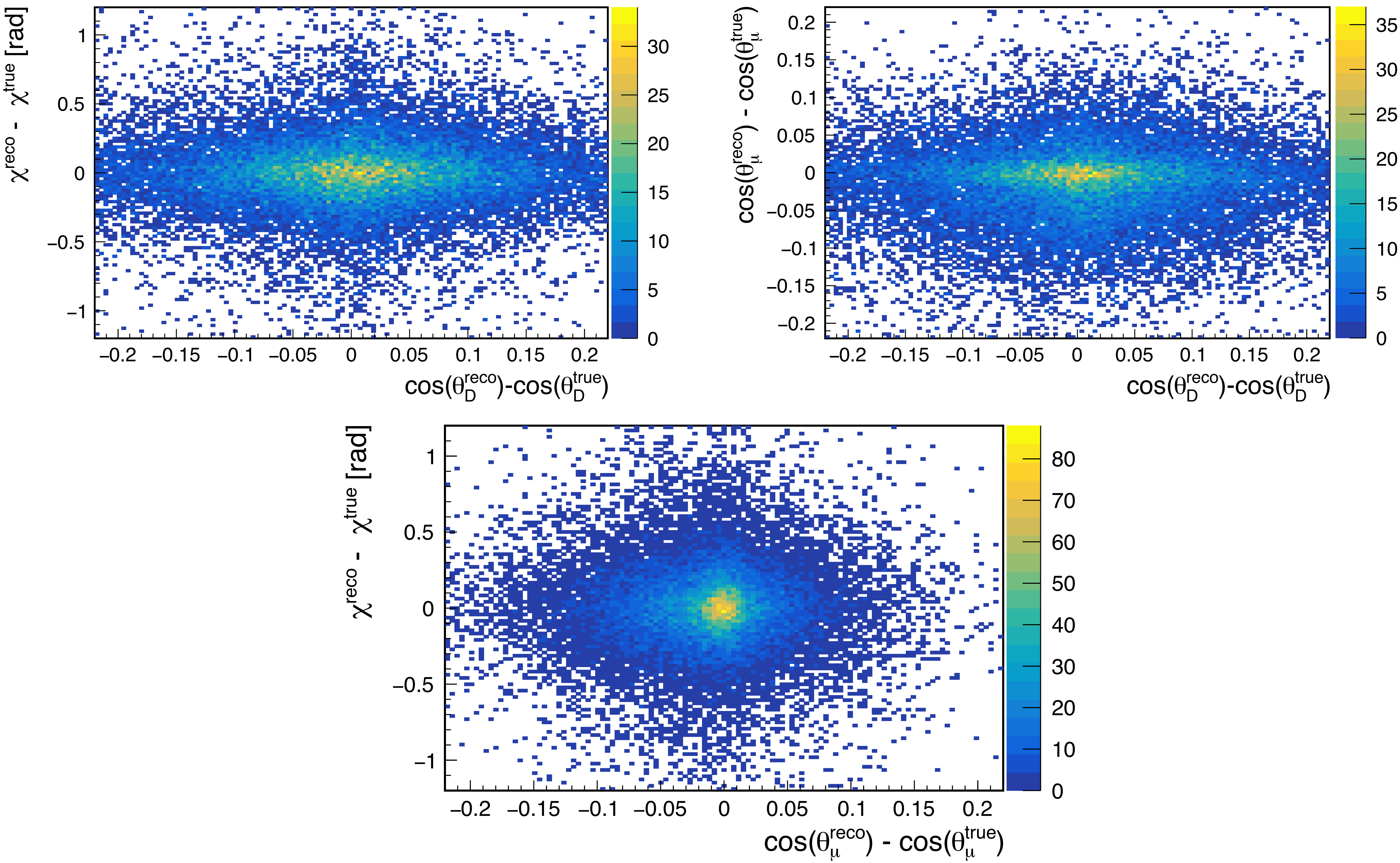


The shape changes in different bins → need to take into account.

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:

angular term= $H_+^2(w)sin^2\theta_v * R(\theta_v)(1-cos\theta_l)^2 * R(\theta_l)+$

$+H_-^2(w)sin^2\theta_v * R(\theta_v)(1+cos\theta_l)^2 * R(\theta_l)+$

$+4H_0^2(w)cos^2\theta_v * R(\theta_v)sin^2\theta_l * R(\theta_l)+$

$-2H_-(w)H_+(w)sin^2\theta_v * R(\theta_v)sin^2\theta_l * R(\theta_l) * cos2\chi * R(\chi)+$

$-2H_+(w)H_0(w)sin2\theta_v * R(\theta_v)sin\theta_l(1-cos\theta_l) * R(\theta_l) * cos\chi * R(\chi)+$

$+2H_-(w)H_0(w)sin2\theta_v * R(\theta_v)sin\theta_l(1+cos\theta_l) * R(\theta_l) * cos\chi * R(\chi)$.

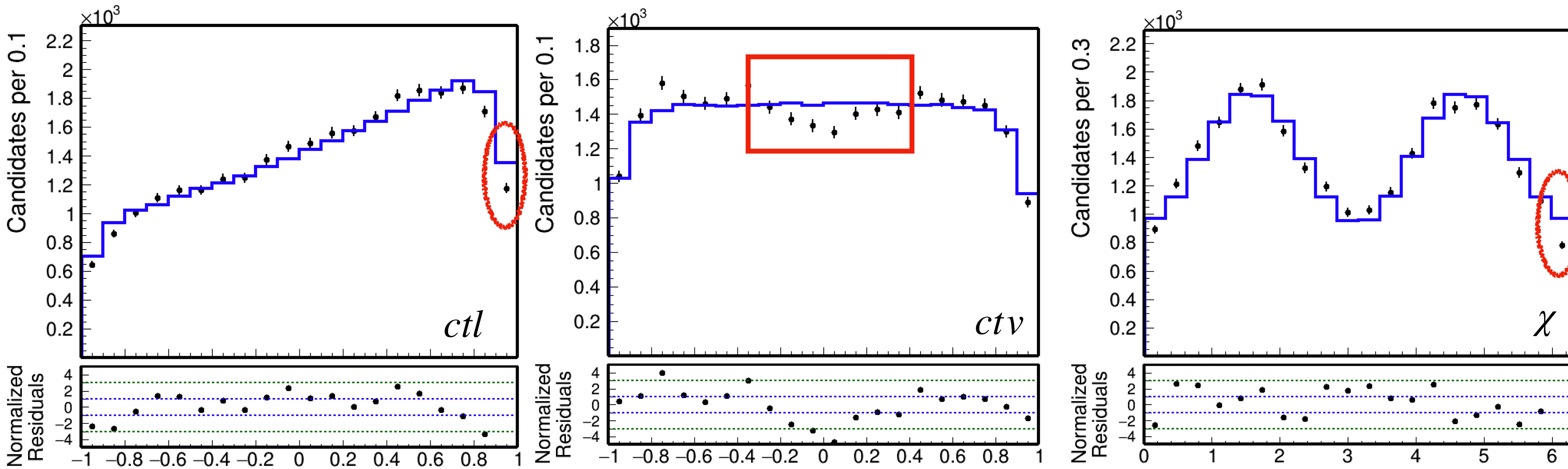
where $f(x) * R(x) = \sum_{x'} f(x')R(x-x')$

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

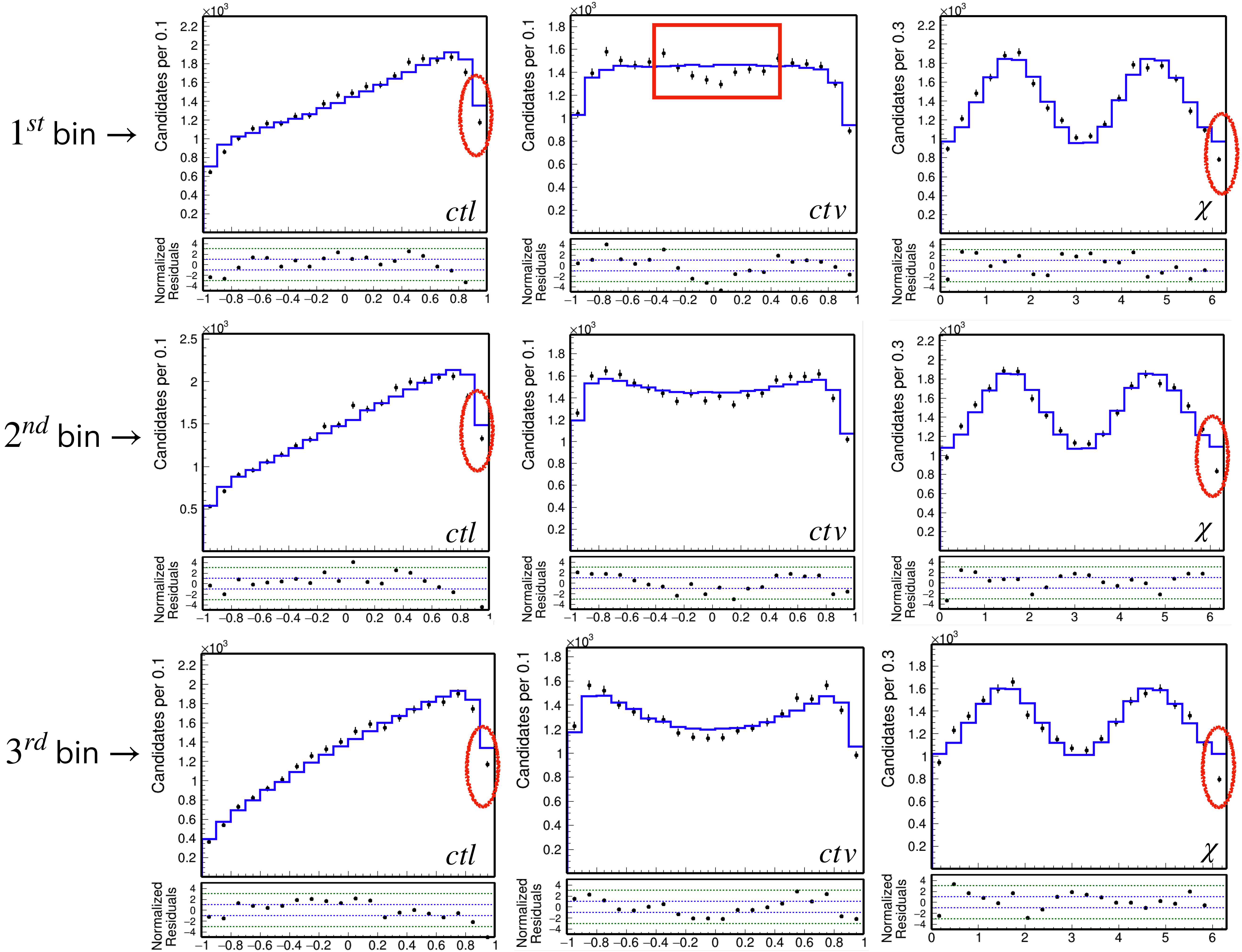


Fit with angular resolutions

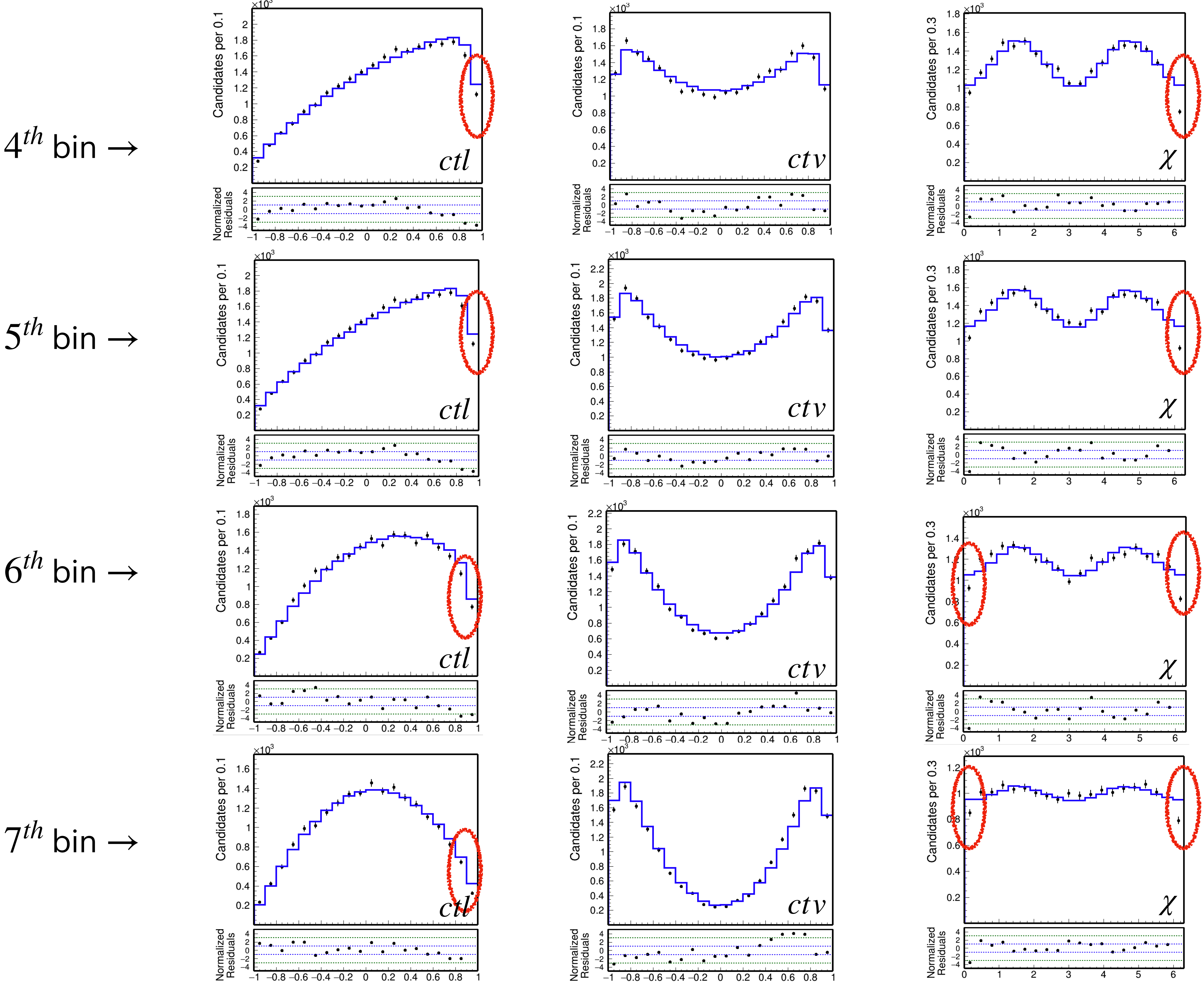
Fit in all bins.

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



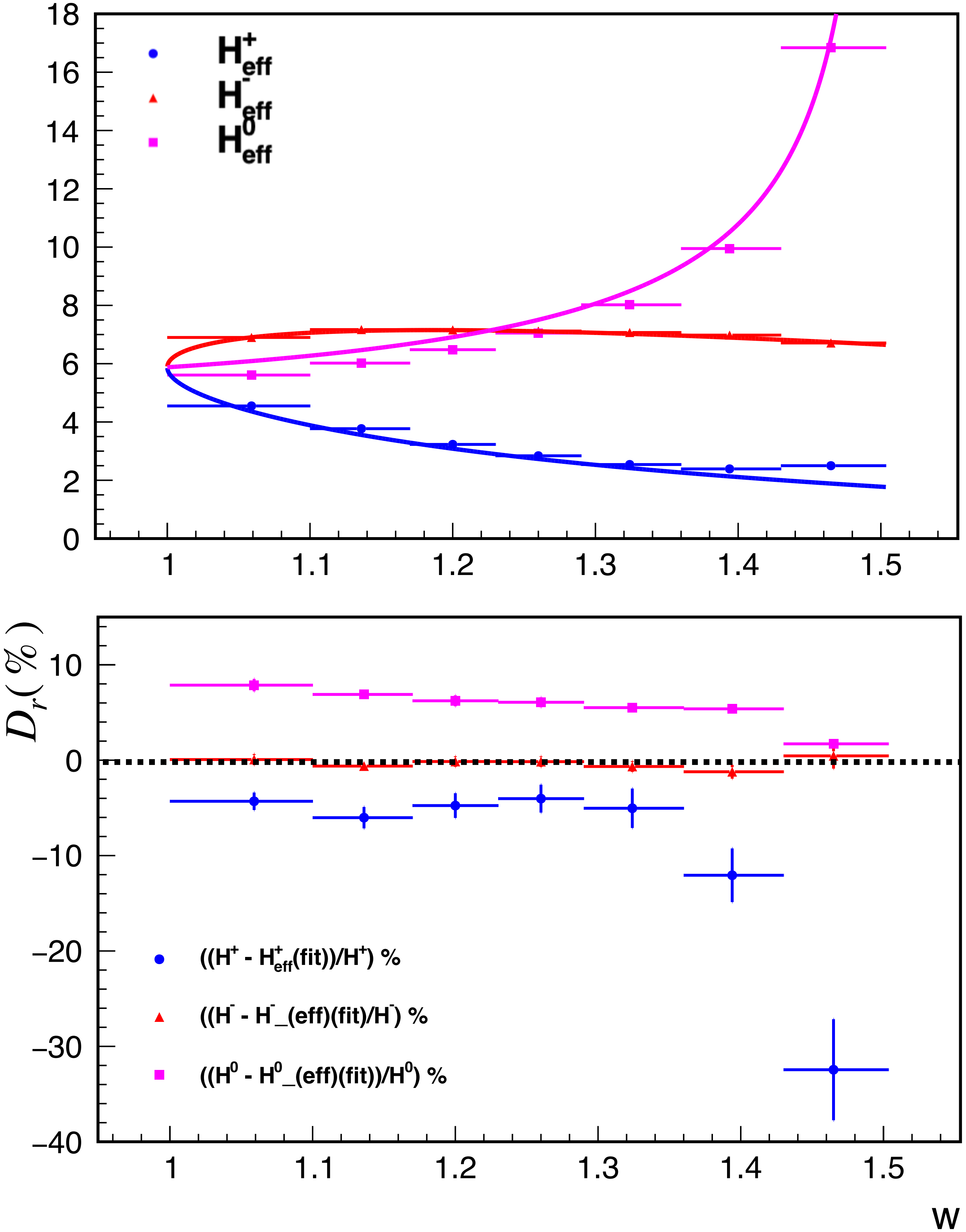
1^{st} bin →
2^{nd} bin →
3^{rd} bin →
Candidates per 0.1
Candidates per 0.3
Normalized Residuals
$\times 10^3$
ctl
ctv
χ



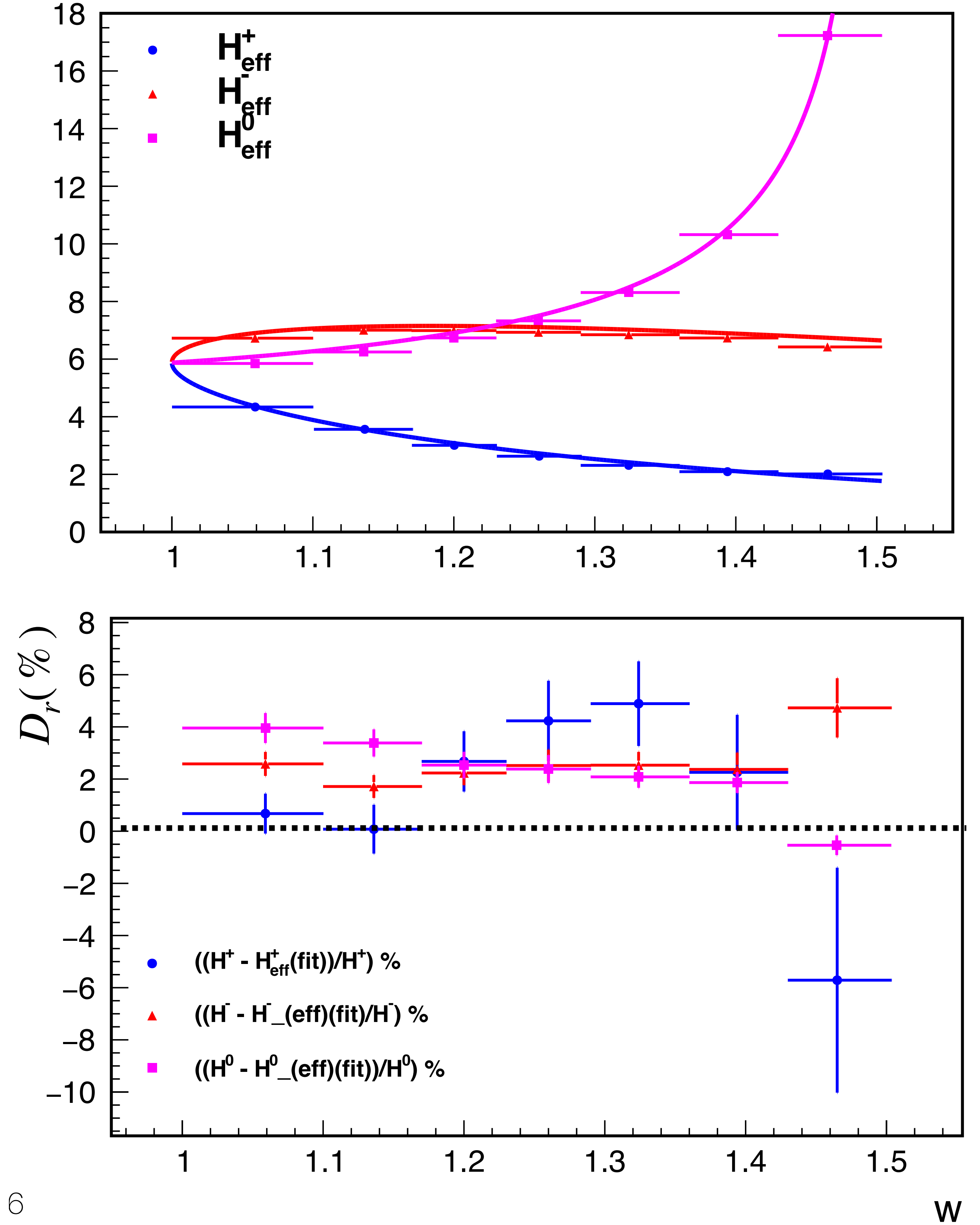
4th bin →
5th bin →
6th bin →
7th bin →
Candidates per 0.1
Candidates per 0.3
Normalized Residuals
×10³
ctl
ctv
χ

Fit with angular resolutions

with angular resolution



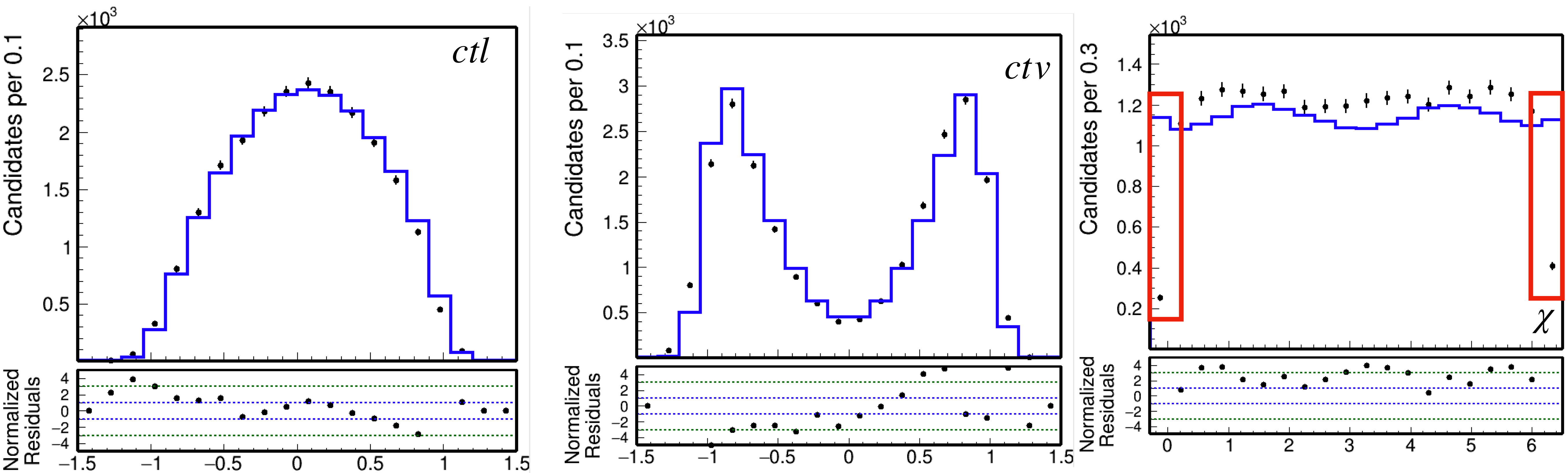
without angular resolution



Backup

Fit with angular resolutions

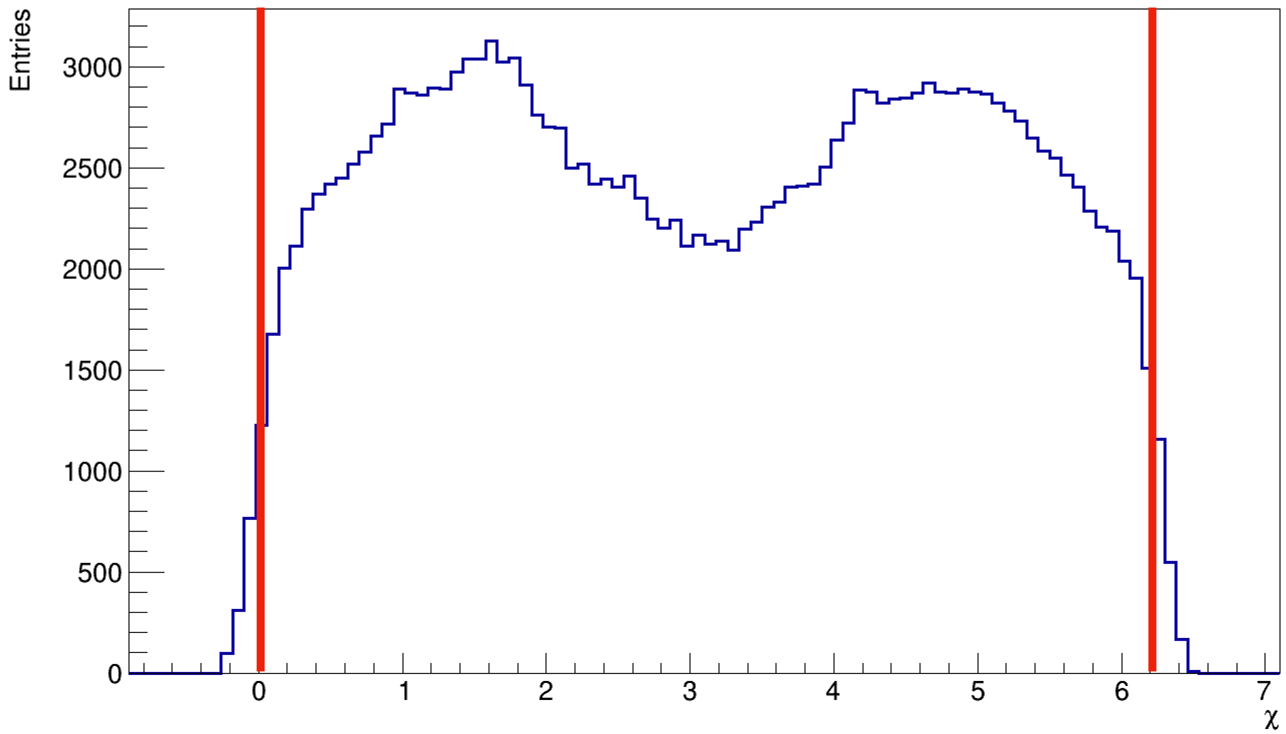
	H_+	H_-	H_0
$[1.43, w_{max}]$	2.54 +- 0.10	6.79 +- 0.09	17.02 +- 0.07

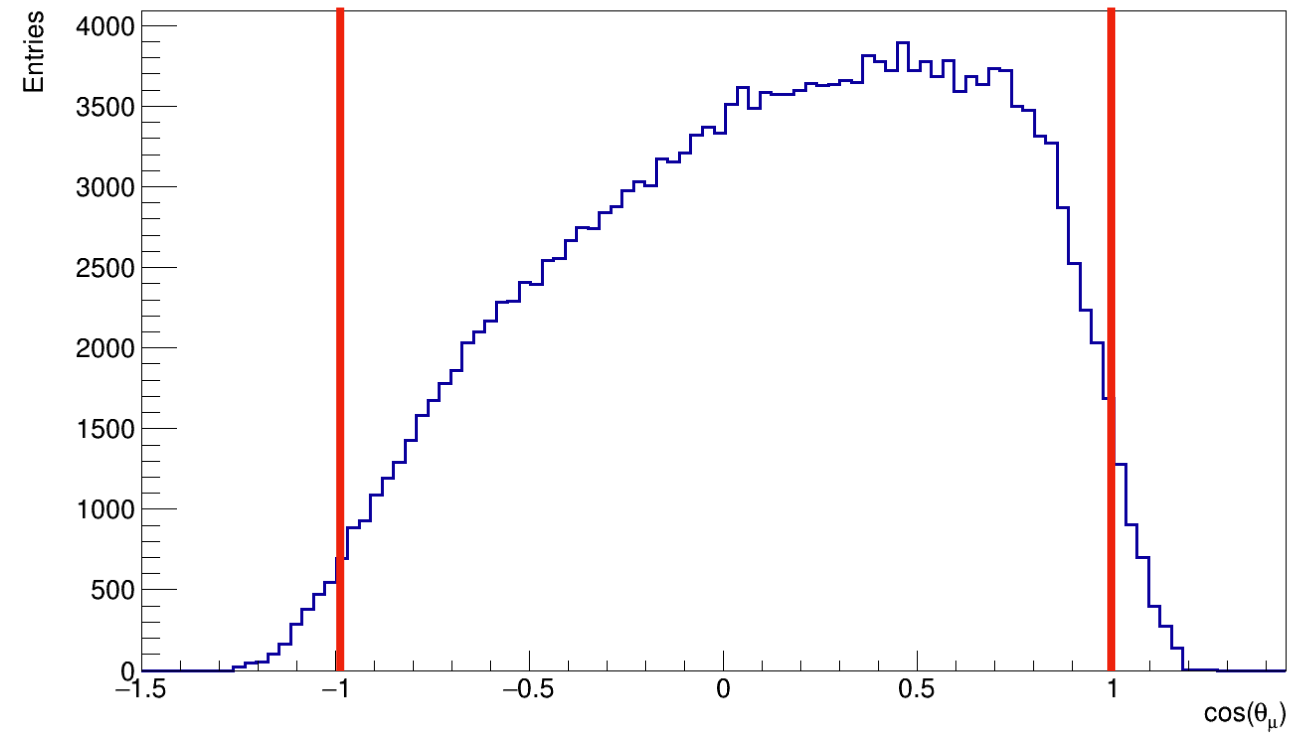


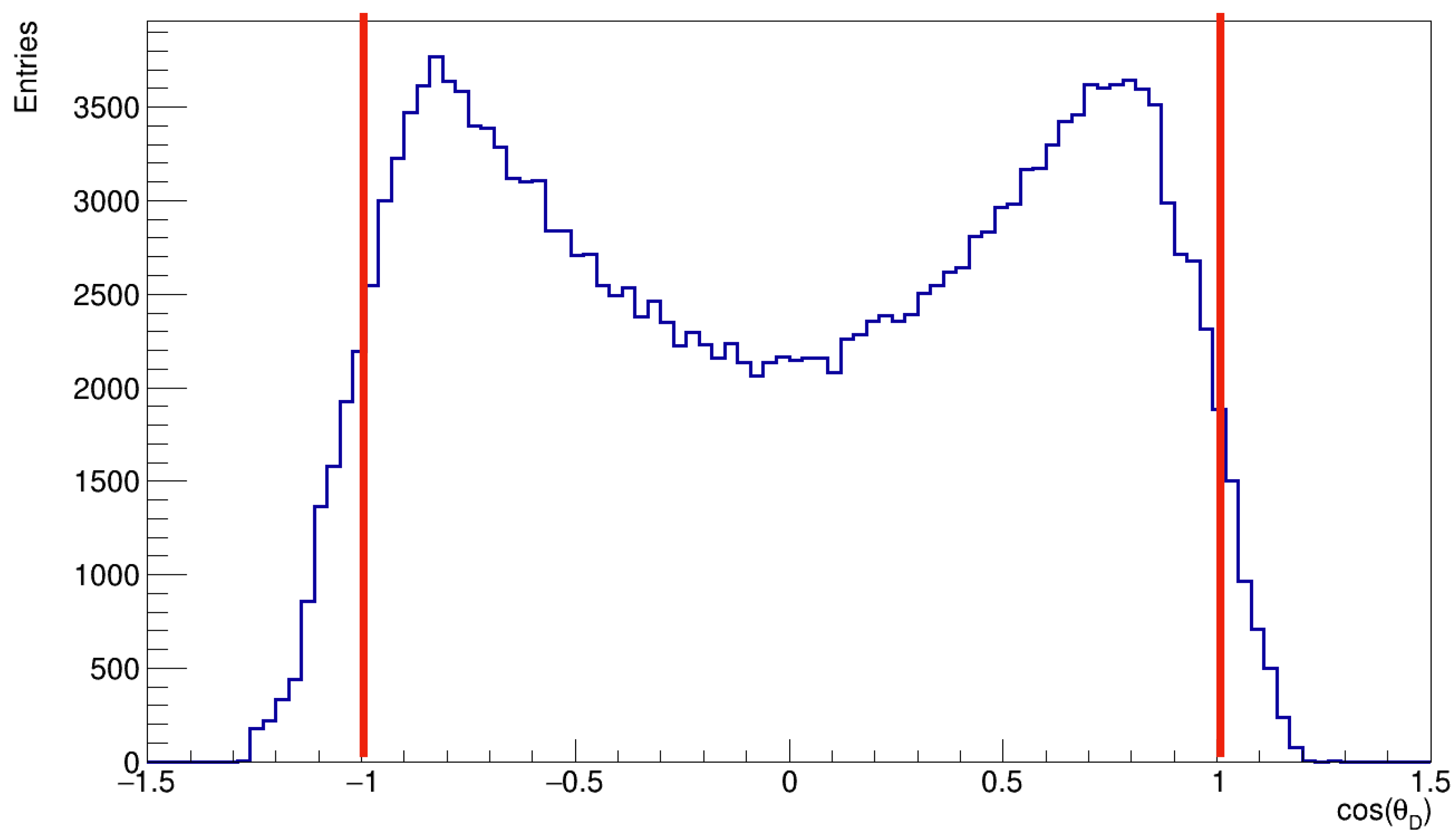
Drop still remains.

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.

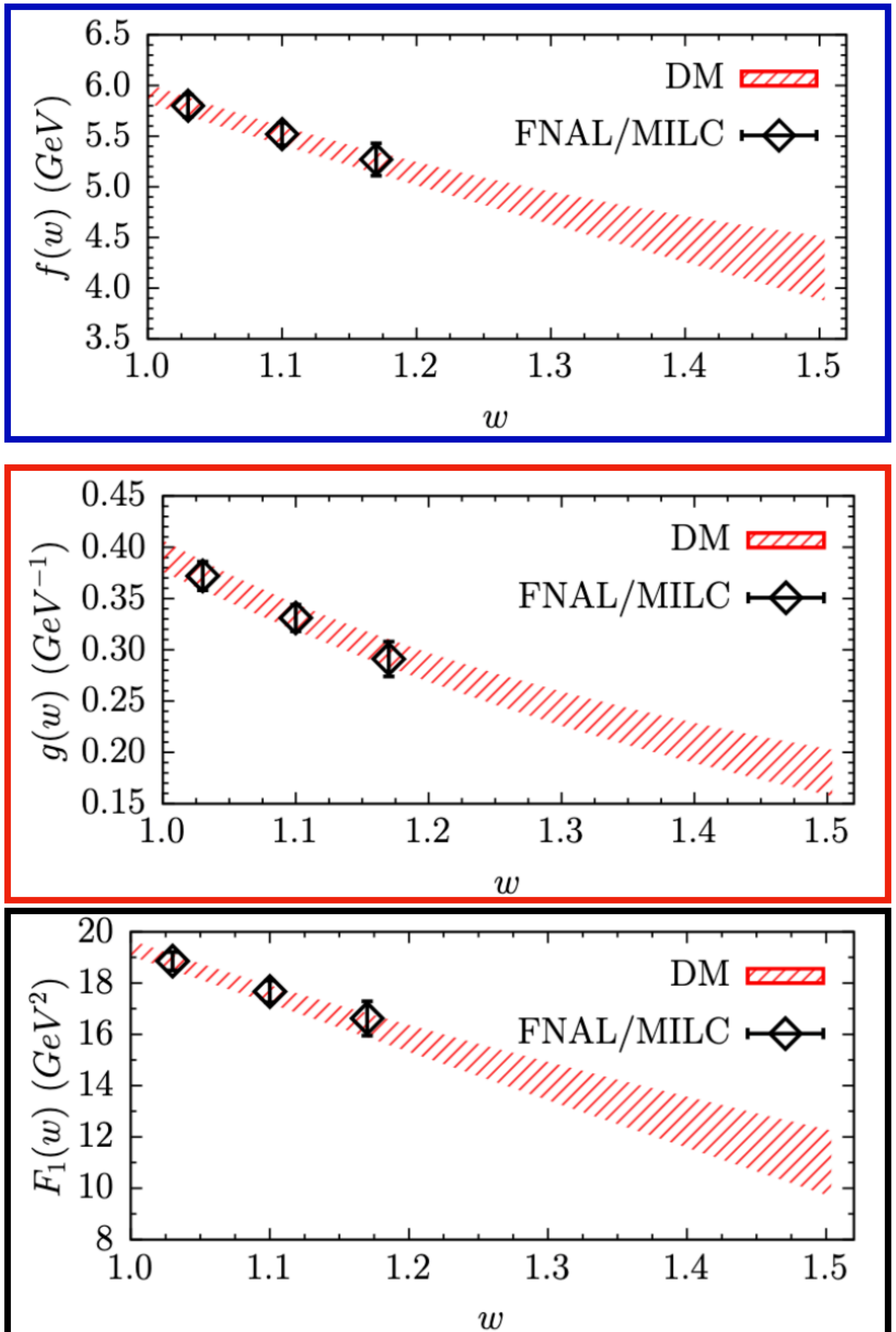
These parameters are linked to the $H_\pm$ and H_0 parameters:

$$
\begin{aligned}
g(w) &= \frac{1}{r\sqrt{w^2-1}} \frac{H_+(w) - H_-(w)}{2m_B^2} \, , \\
f(w) &= \frac{H_+(w) + H_-(w)}{2} \, , \\
F_1(w) &= m_B\sqrt{1-2rw+r^2}\, H_0(w) \, .
\end{aligned}
$$

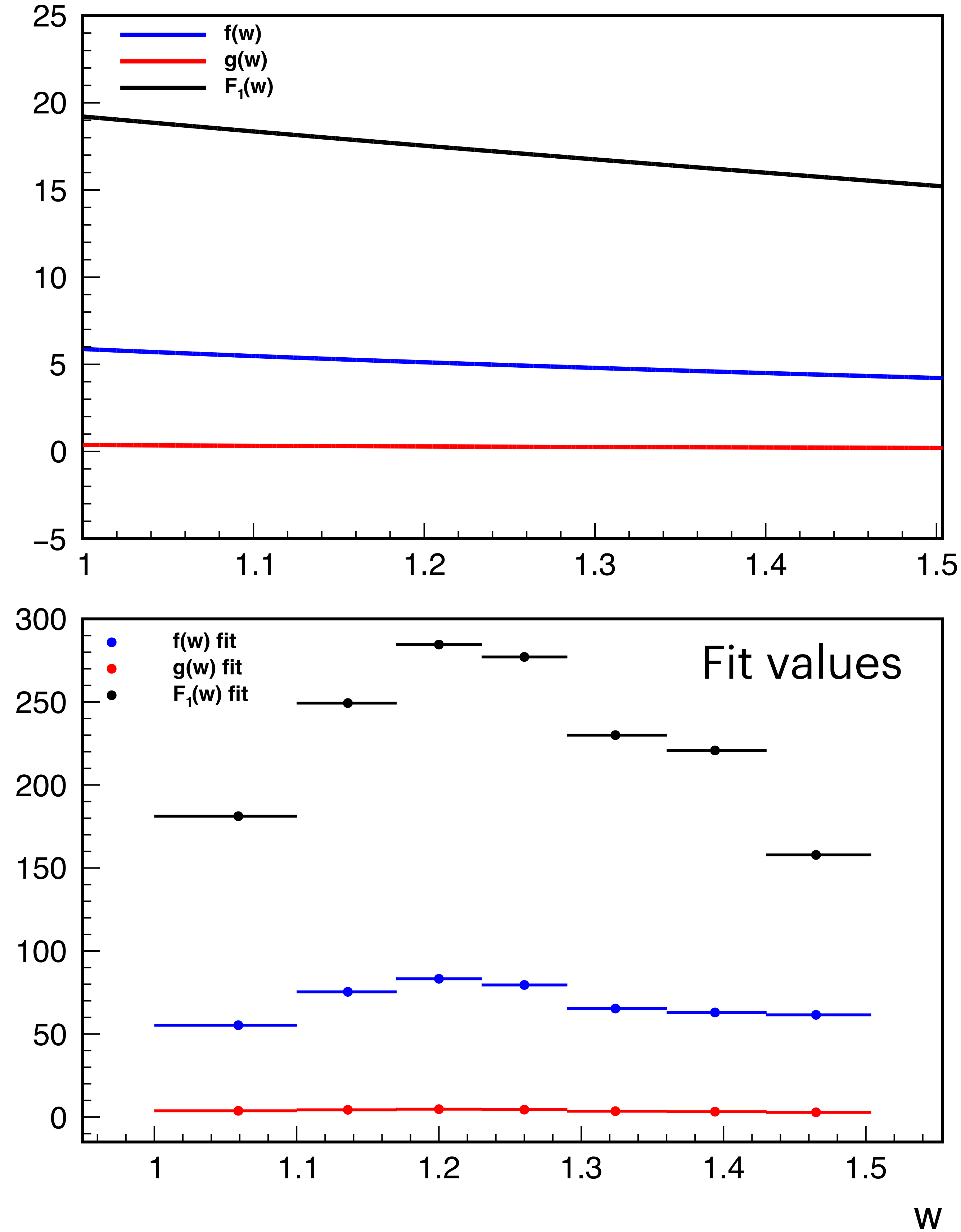
w	$f(w)$	$g(w)$	$F_1(w)$
1 bin	-55.30 +- 0.23	3.73 +- 0.07	-181.19 +- 1.09
2 bin	-75.41 +- 0.33	4.34 +- 0.06	-249.33 +- 1.35
3 bin	-83.26 +- 0.41	4.73 +- 0.06	-284.59 +- 1.49
4 bin	-79.54 +- 0.45	4.42 +- 0.07	-277.12 +- 1.55
5 bin	-65.33 +- 0.39	3.52 +- 0.04	-230.02 +- 0.98
6 bin	-62.98 +- 0.48	3.22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

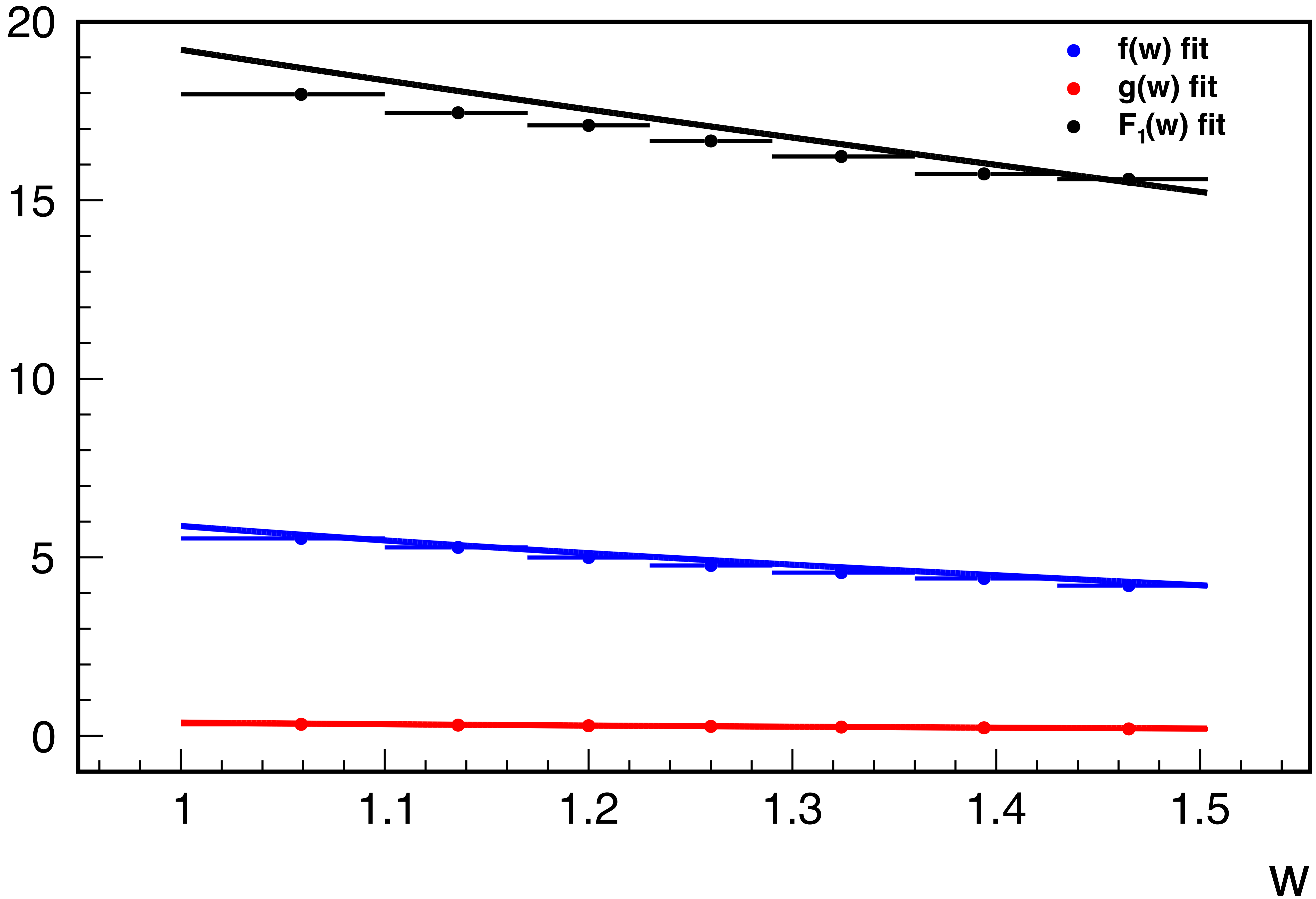


Generation functions



$f(w)$, $g(w)$ 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 $\mathscr{A}_{\text{det}}$ for $B^0 \to K^+\pi^-$, $B^+ \to K_s^0\pi^+$, $B^+ \to \pi^+\pi^0$ and $B^+ \to K^+\pi^0$ using $D^0 \to K^-\pi^+$ and $D^- \to K_s^0\pi^-$ ($\sim$ 360/fb).

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

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

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

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

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

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

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