τ-lifetime measurement

Update at τ working group

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HELMHOLTZ

Belle II

KEK
加速器だから見える世界。
Insight through Accelerators.

DESY.

Investigated treatment of systematic uncertainties

- To reduce the impact of statistical fluctuation in the calculation of systematic uncertainties we applied a smoothing algorithmus
- Was optimize on the mayor systematics at that time (misalignment and material budget)
  - Estimated based on 50 (100) fb^{-1} at this time -> Rather strong smoothing needed

Smoothing Ansatz:

1. Estimate decay length distribution for alternative nominal and variation with fit binning
2. Calculate shape ratio between them (correct yield normalization)
   Smooth histograms with neighbouring bins -> For each bin calculate variation combined with neighbouring bins
3. Multiply ratio to default template bin-by-bin -> Final variation template

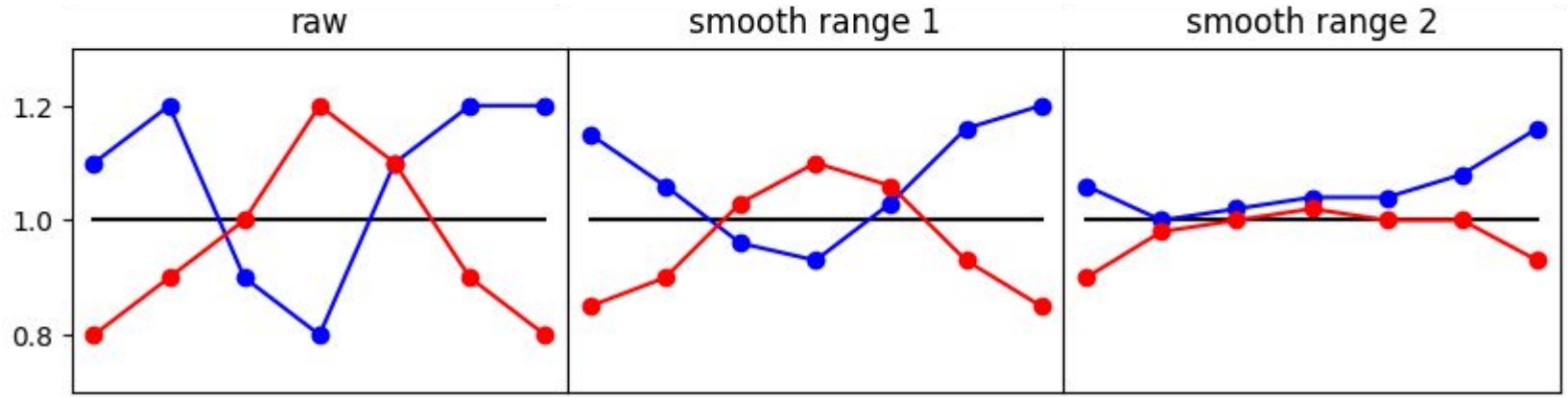
Con:

- Events/Bins are re-used for multiple neighbour bins

Pro:

- No sharp edge between two neighbours

- Smooths out local peaks/spikes (good if fluctuation, bad if real effect)



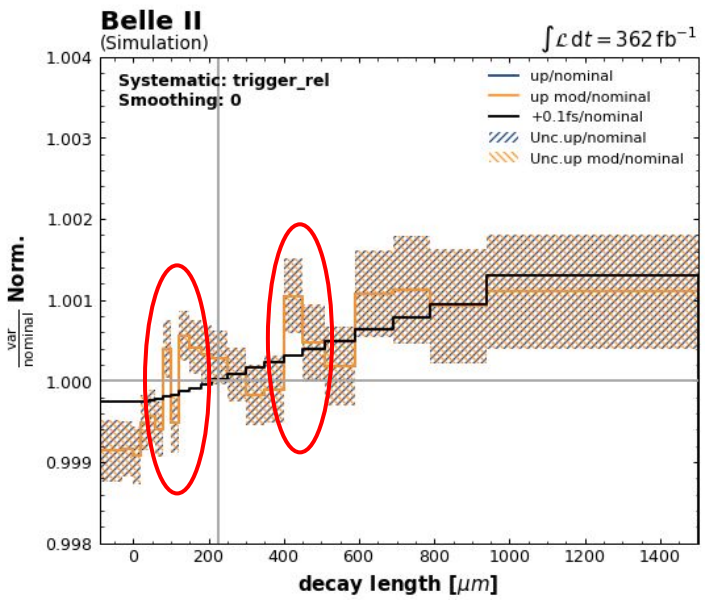
-> Now after going to final systematic setup, revisit every systematic individually and check behaviour

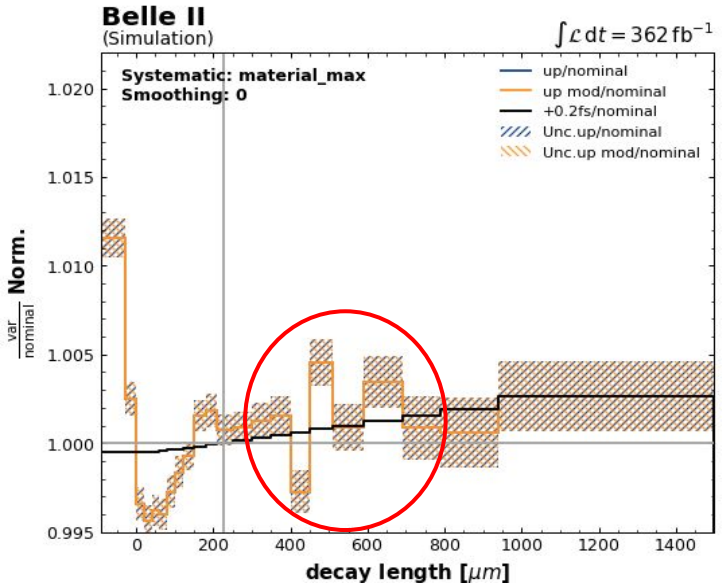
Systematic overview (old setup)

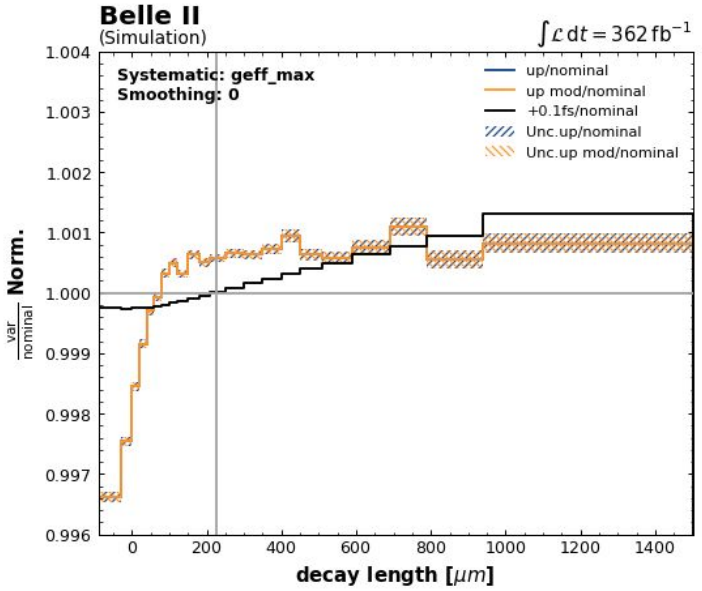
syst	Calculation	sym.	smoothing	impact (very old)	impact (new)
misalignment	RI MC prod. 470fb^{-1} (50 fb) $^{-1}$ Ratio: MC/MC	**one-sided**	**3**	**0.09**	**0.02**
material	RI MC prod. 1ab^{-1} (100 fb) $^{-1}$ Ratio: MC/MC	**max**	**3**	**0.08**	**0.05**
bkg contributions	Based on weight calculation: Estimated and applied on same MC	**one-sided**	**0**	**0.07**	**0.03**
trigger rel	Use orth. ref. trigger: ECL $\wedge$ CDC / CDC Double ratio: Data/Data / MC/MC	**one-sided**	**3**	**0.05**	**0.06**
photon eff.	Nom. production (~1.4 ab^{-1}) with different scaling factors: MC/MC	**max**	**3**	**0.03**	**0.02**
re-weighting	Based on weight calculation: Estimated and applied on same MC	**one-sided**	**0**	**0.02**	**0.02**
photon energy.	Nom. production (340 fb^{-1}) with different scaling factors: Data/Data	**max**	**3**	**< 0.01**	**< 0.01**
vertex resolution	Based on weight calculation: Estimated and applied on same MC	**one-sided**	**0**	**< 0.01**	**< 0.01**
others	Nom. production with different scaling factors: MC/MC or Data/Data	**one-sided**	**3**	**< 0.01**	**< 0.01**

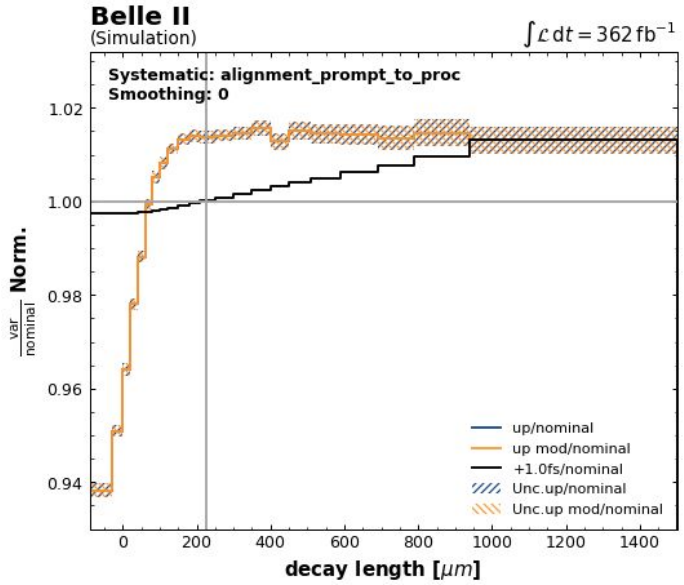
- Misalignment, material and Bkg only important systematics
  -> Optimized for them no careful check of other systematics
- Based on new numbers we should check all six significant systematics sources
  - Re-weighting and Bkg contributions based on weights -> No manipulation needed

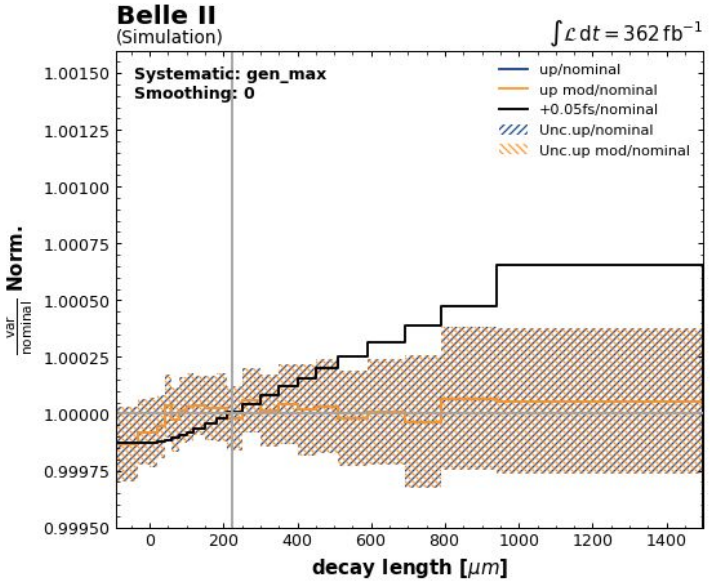
Uncertainties with default fit binning (No smoothing)











- Material and trigger show some relevant fluctuation
- Geff and gen slightly fluctuating
- Overall smoothing with 3 bins each side seems to aggressive
  -> Next slide

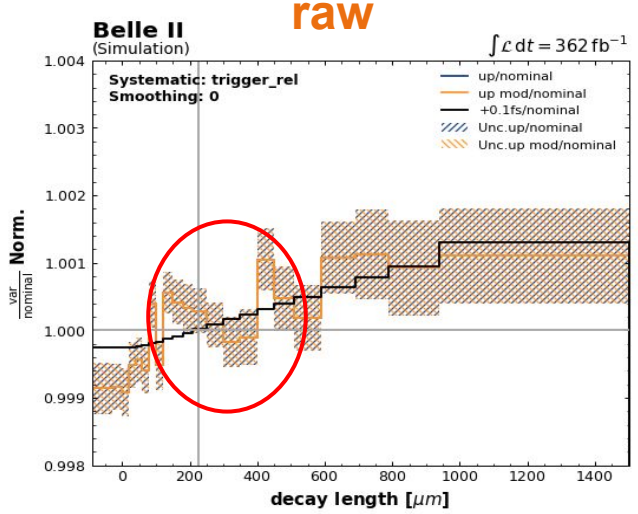
Smoothing on trigger and material

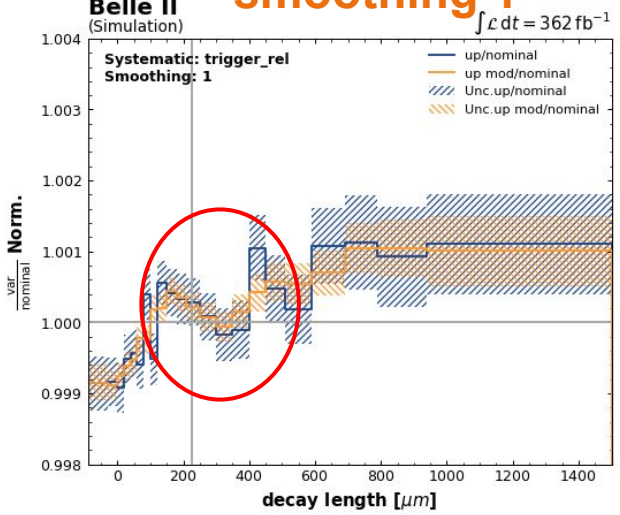
raw

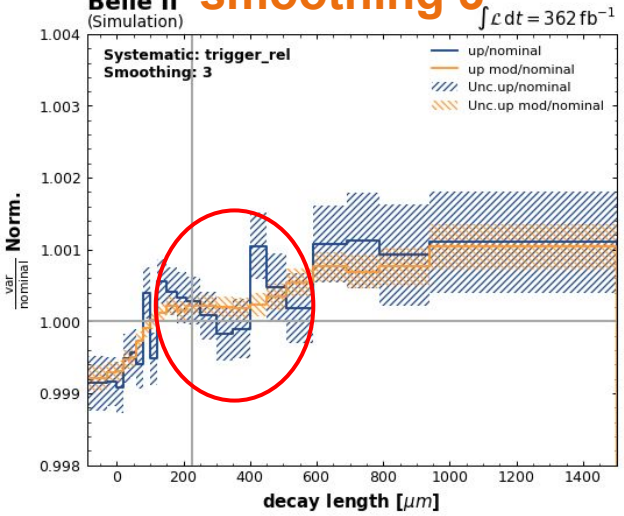
smoothing 1

smoothing 3

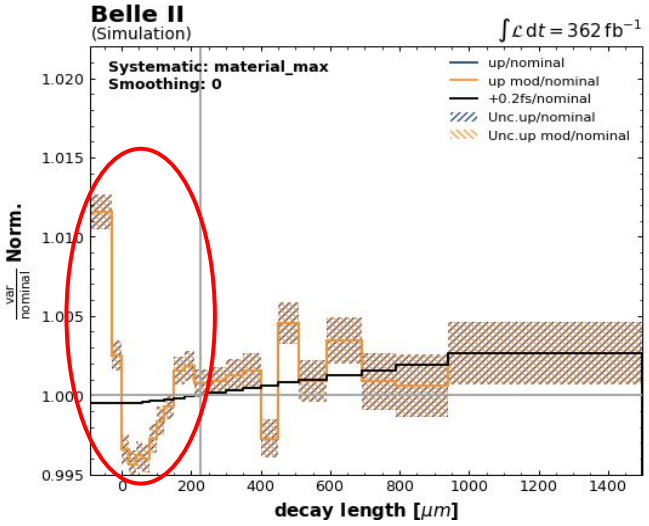
0.2%

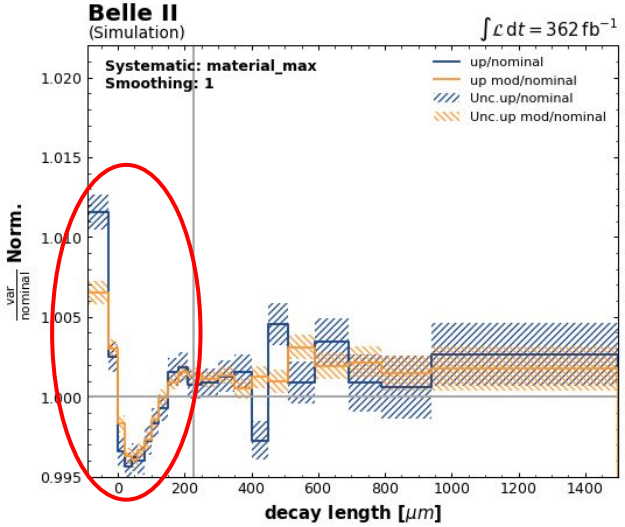


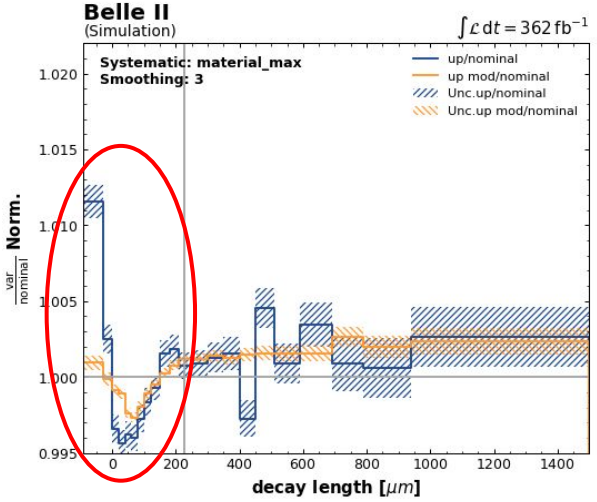




1%



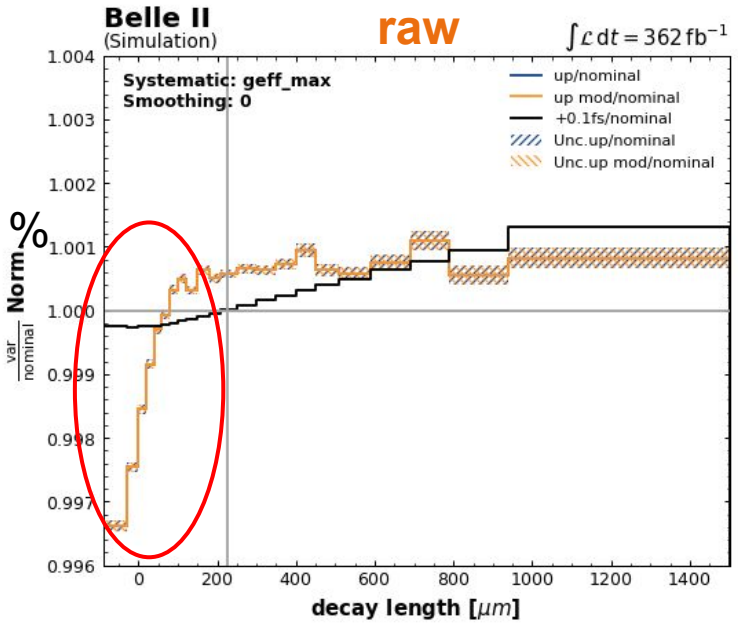


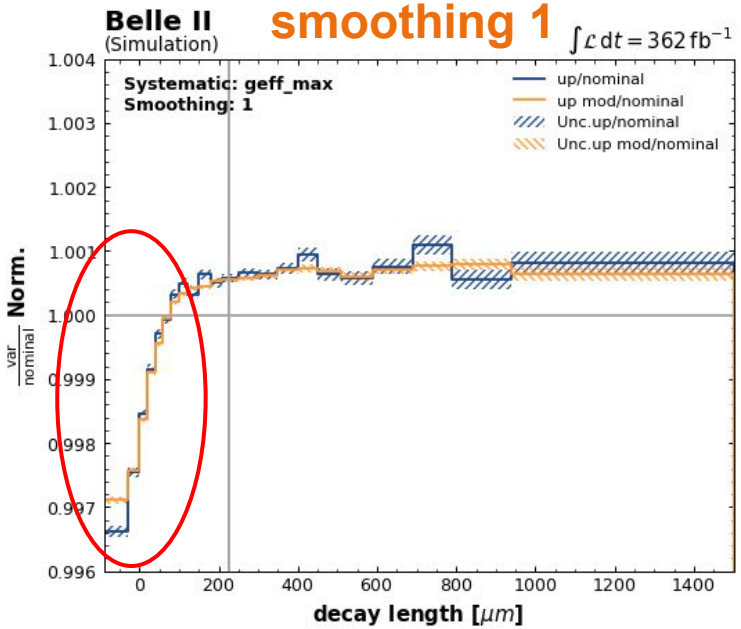


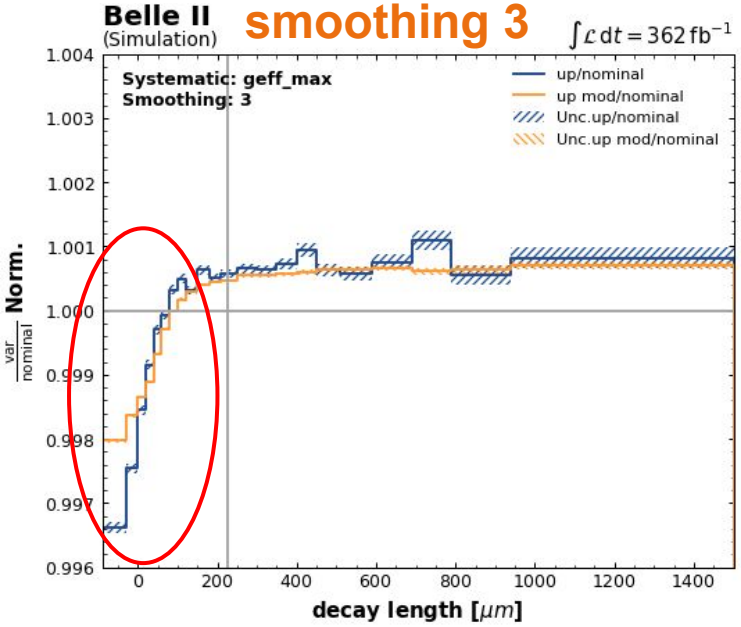
- Smoothing with 3 bins removes some features of the shape (Esp. for material budget)
- Shape gets closer to alternative lifetime shape -> Increases impact of systematic ?

Smoothing on photon efficiency

0.1%



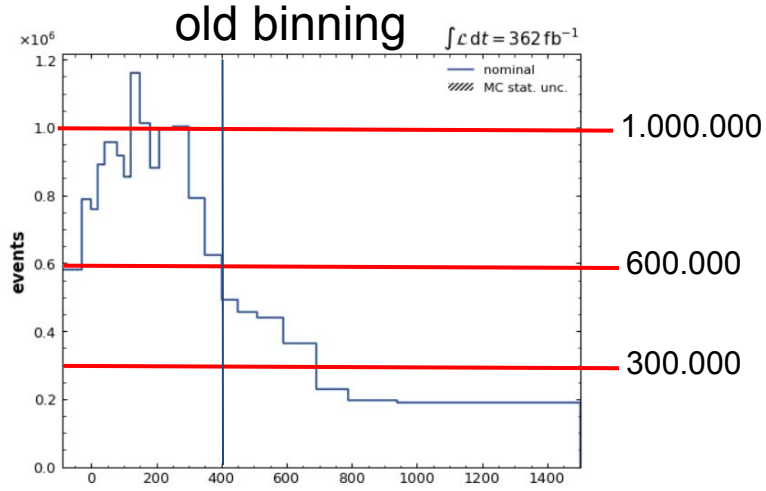




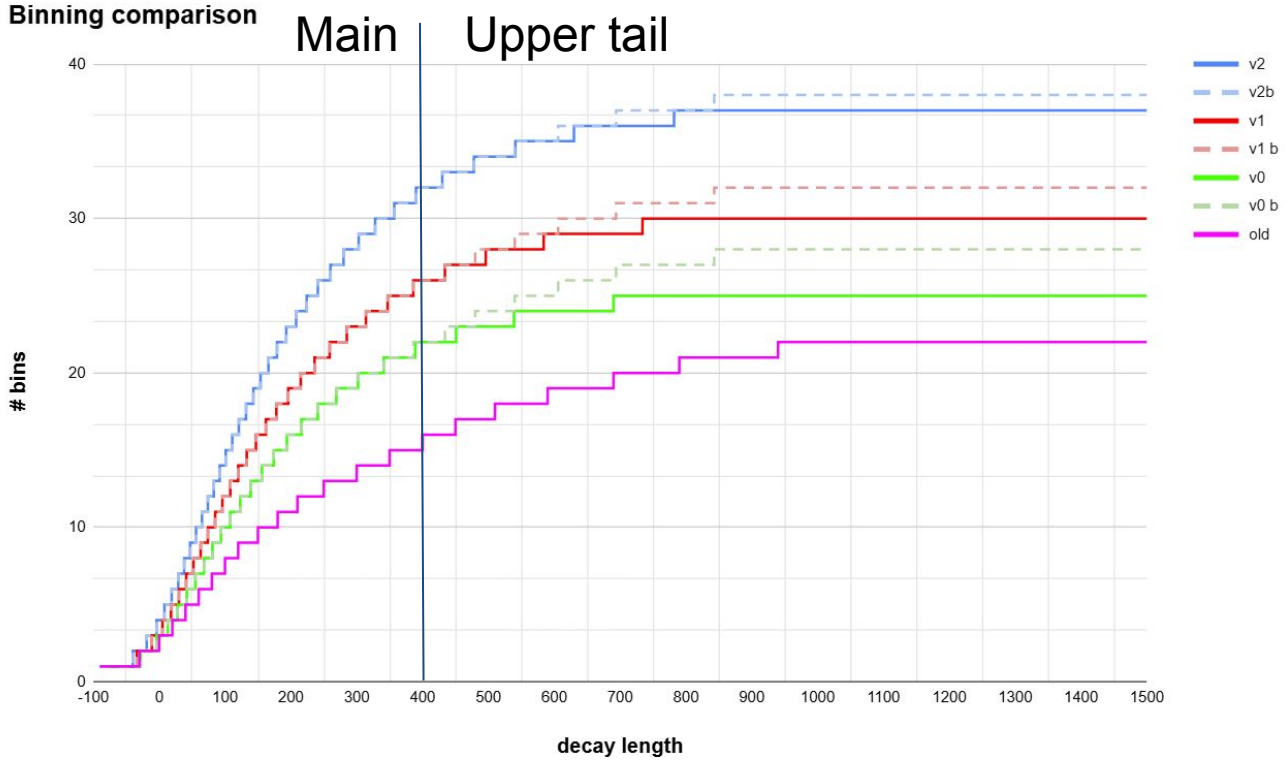
- Smoothing does not remove shape change (as for material and trigger)
- Smoothing reduces over shape difference -> Reduces impact of systematic ?

New ansatz to reduce impact of smoothing on result

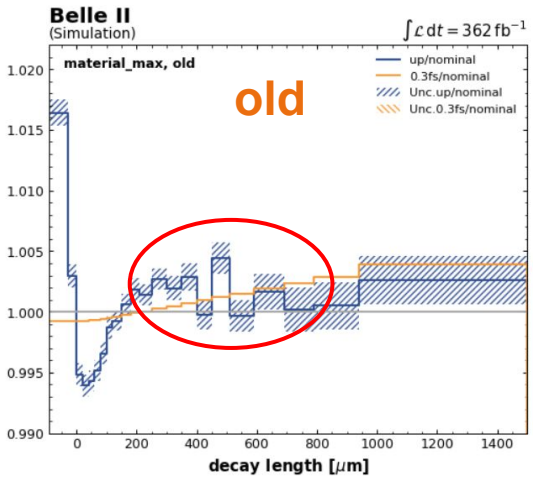
- Re-optimize binning -> Binning with more equal statistic per bin
- For material and trigger unc. special case
  - Trigger: Double ratio -> more stat. fluctuations
  - Material: Signal only variation -> Different decay length shape
- Use coarse binning to estimate these systematics
- Transfer weights of coarse binning to final fit binning

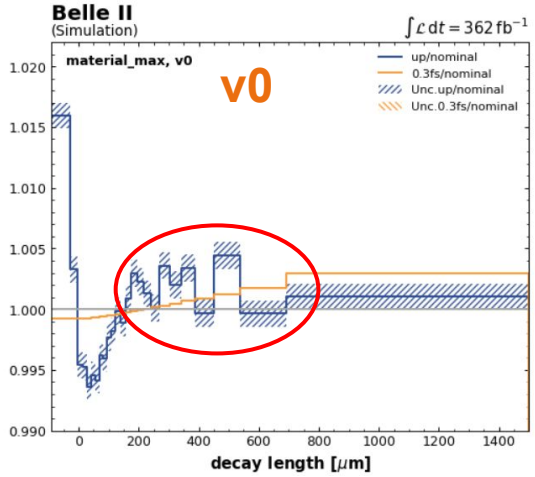


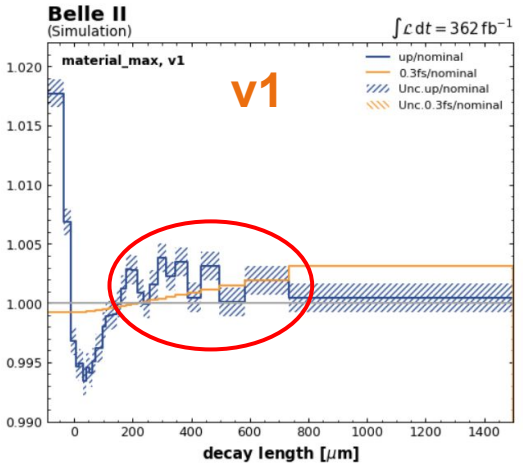
version	Main (N/Bin)	Upper tail (N/Bin)
v0	600.000 (0.13%)	600.000 (0.13%)
v0 b	600.000 (0.13%)	300.000 (0.18%)
v1	500.000 (0.14%)	500.000 (0.14%)
v1 b	500.000 (0.14%)	300.000 (0.18%)
v2	400.000 (0.16%)	400.000 (0.16%)
v2 b	400.000 (0.16%)	300.000 (0.18%)

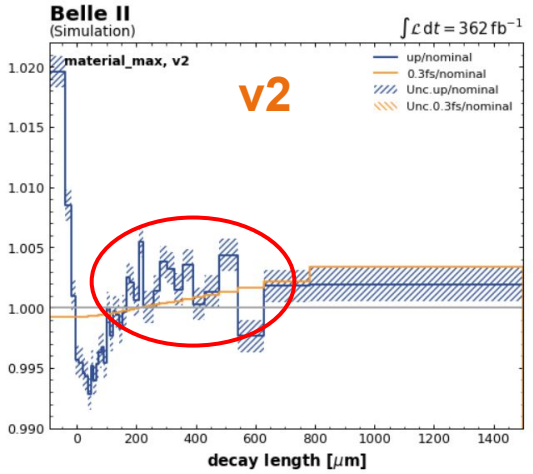


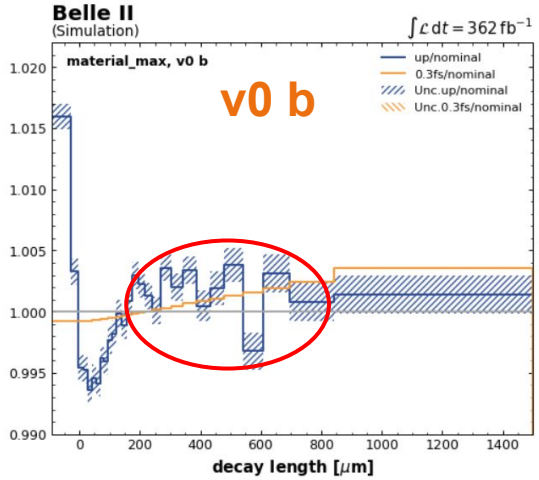
Material no manipulation

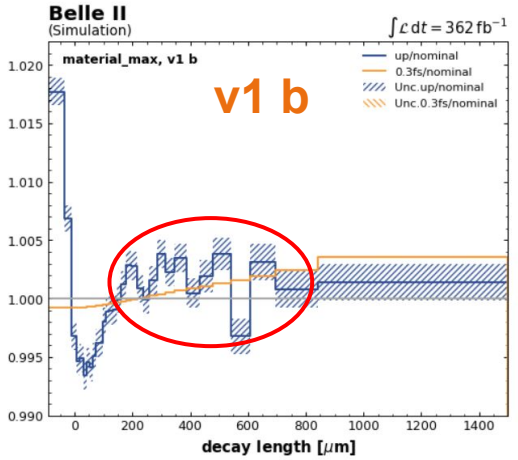


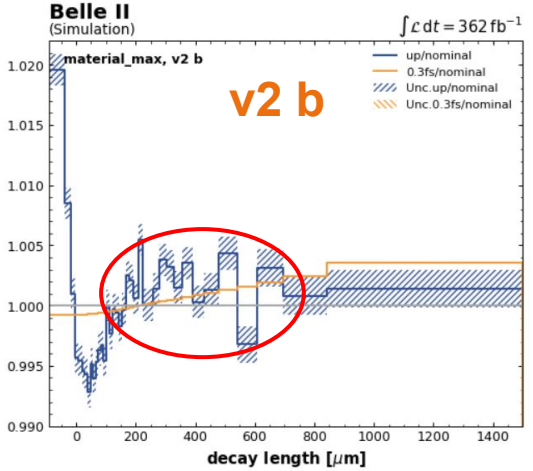






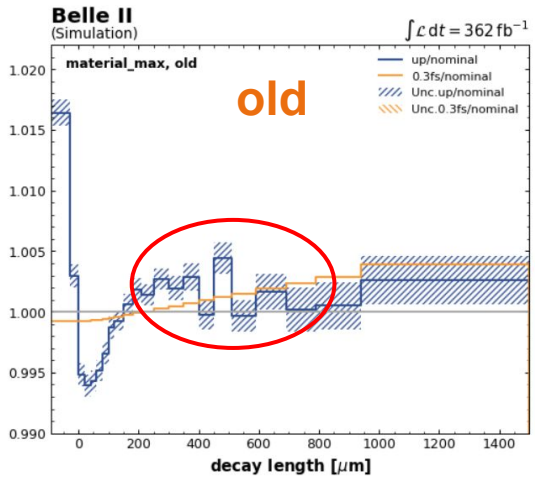


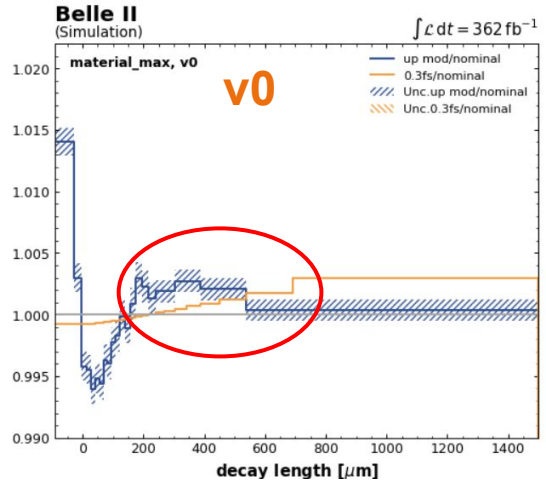


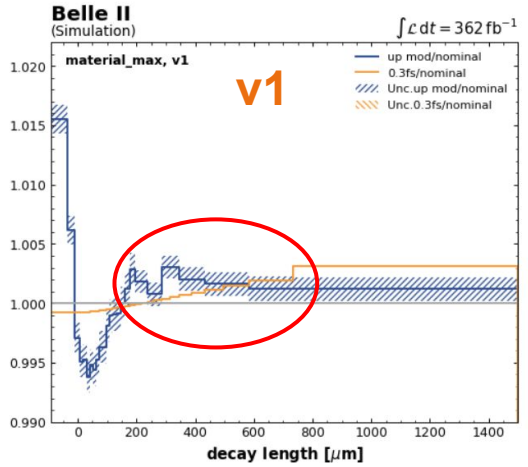


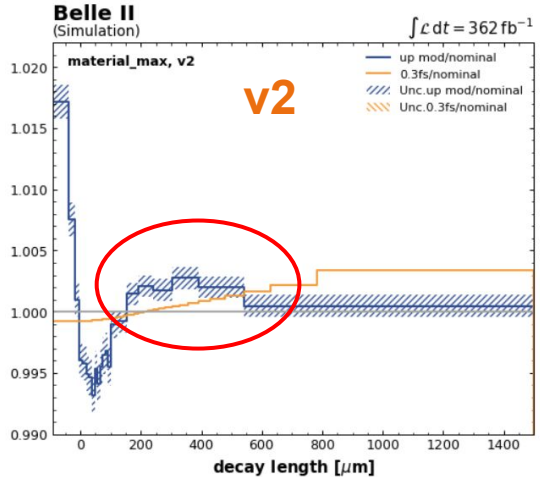
- Mid range tail has quite some fluctuation -> Shape very depending on bin boarders

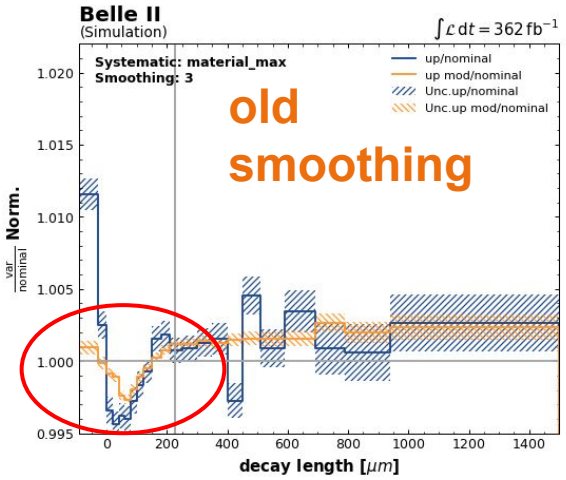
Material with manipulation

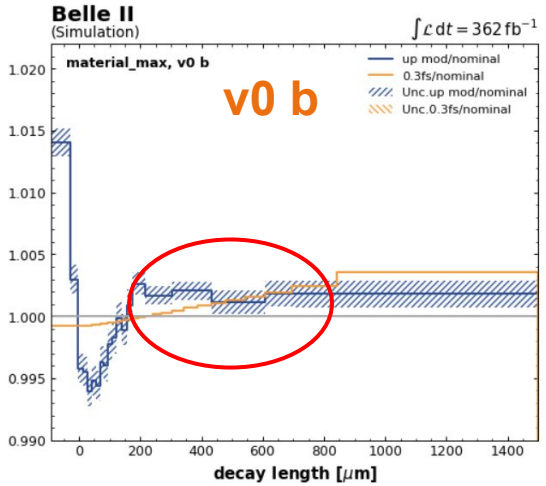


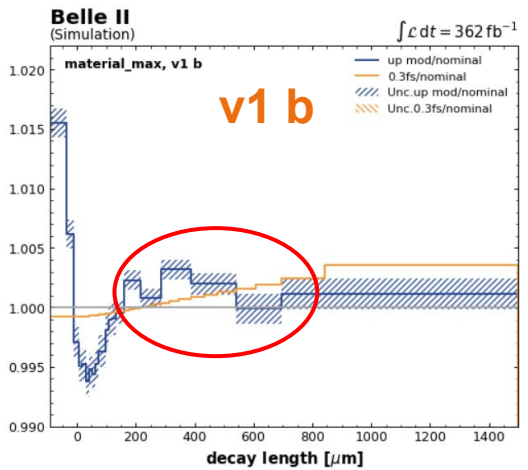


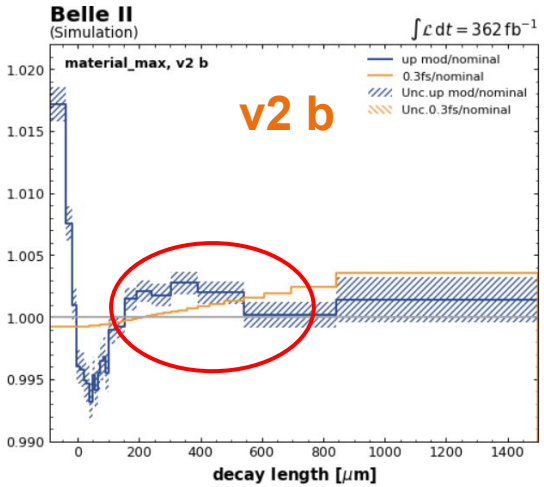






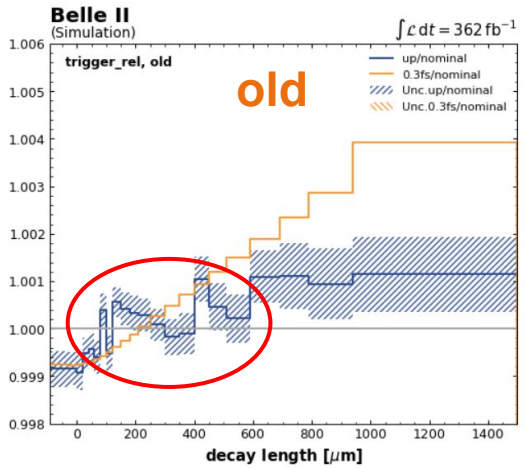


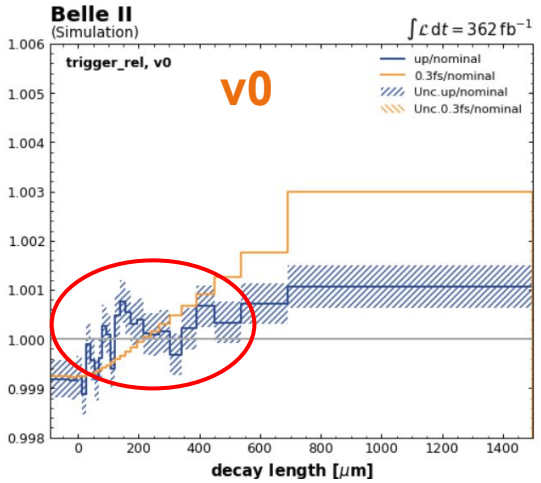


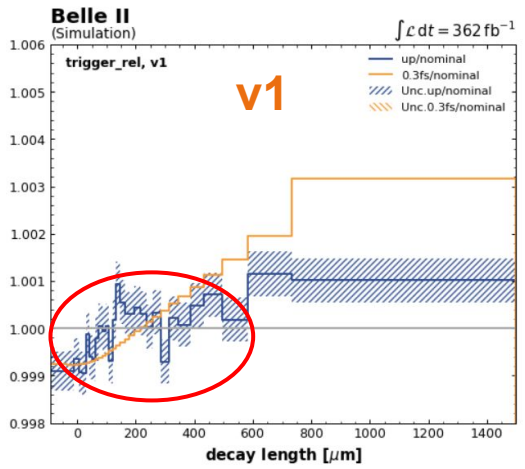


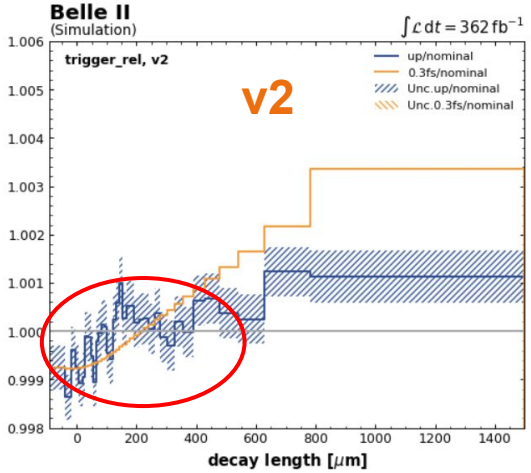
- Instead of smoothing over all distribution use coarse binning to derive systematics
- Merge bins in tail region for material (signal only -> lower stat in in tail)

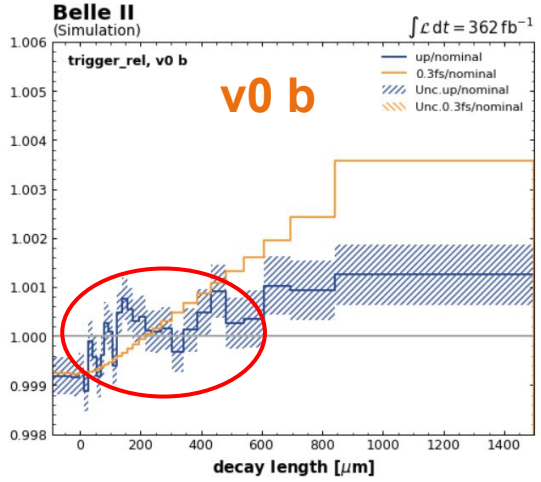
Trigger no manipulation

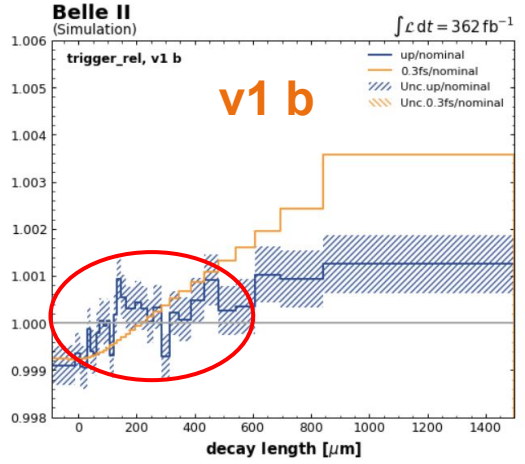


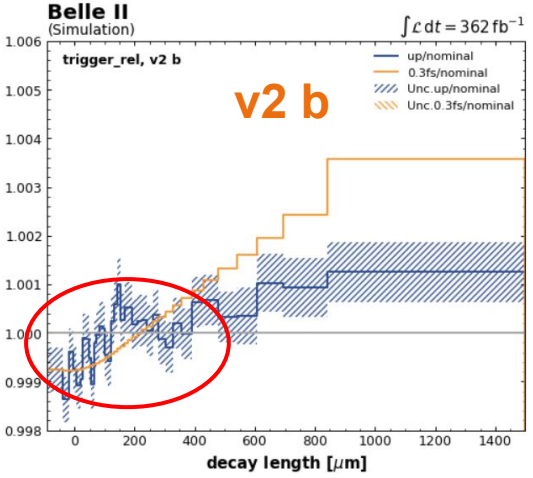






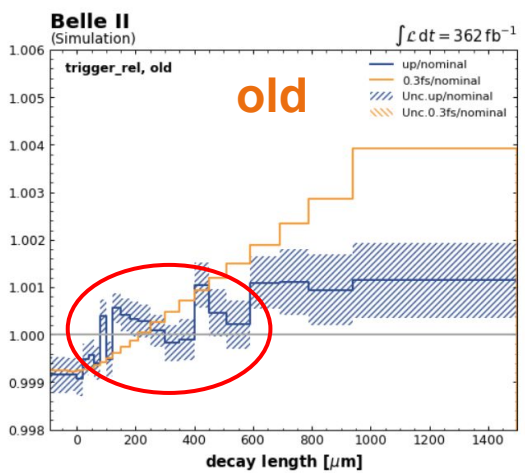


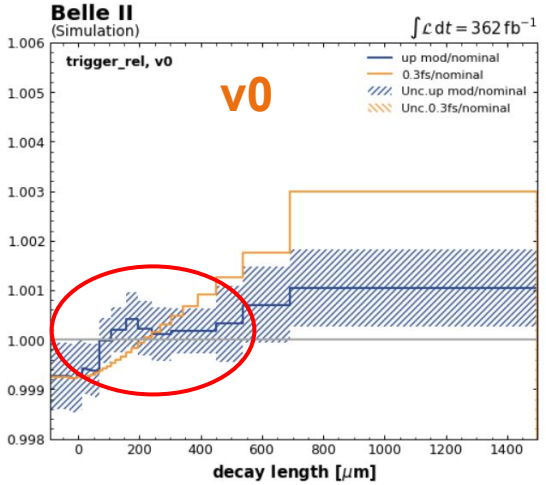


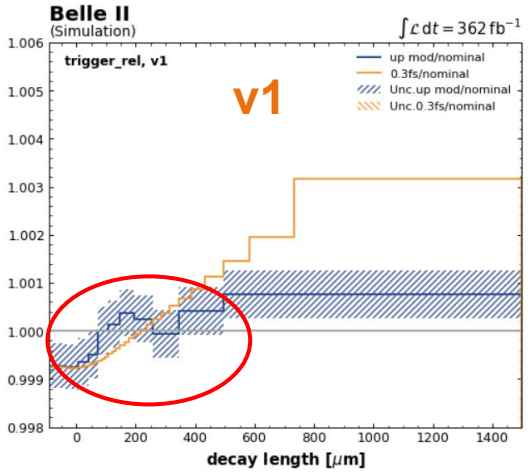


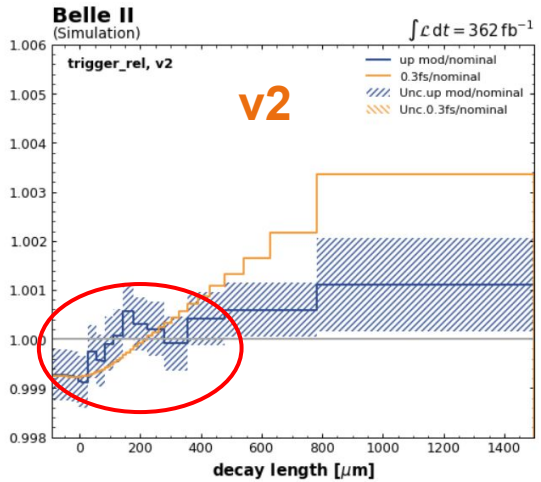
- [0 , 400] range vary fluctuation -> Double ratio (data/data / MC/MC)

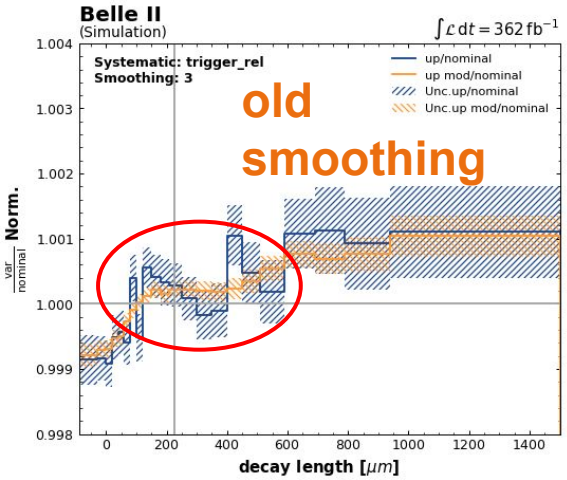
Trigger with manipulation

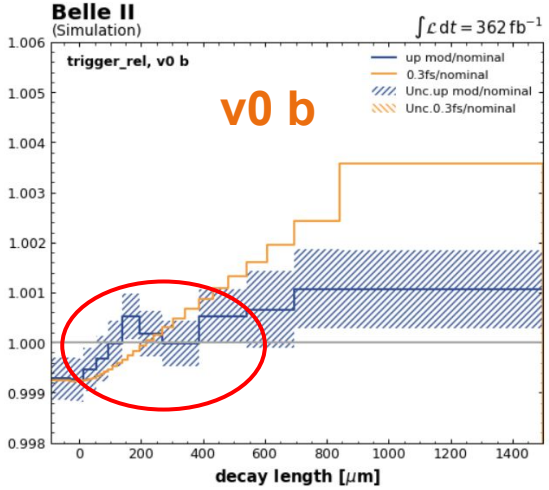


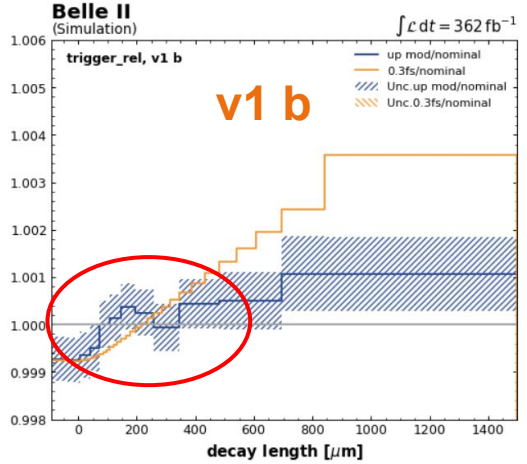


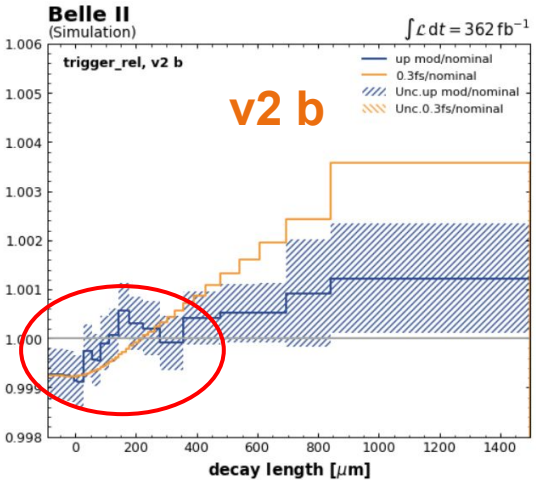






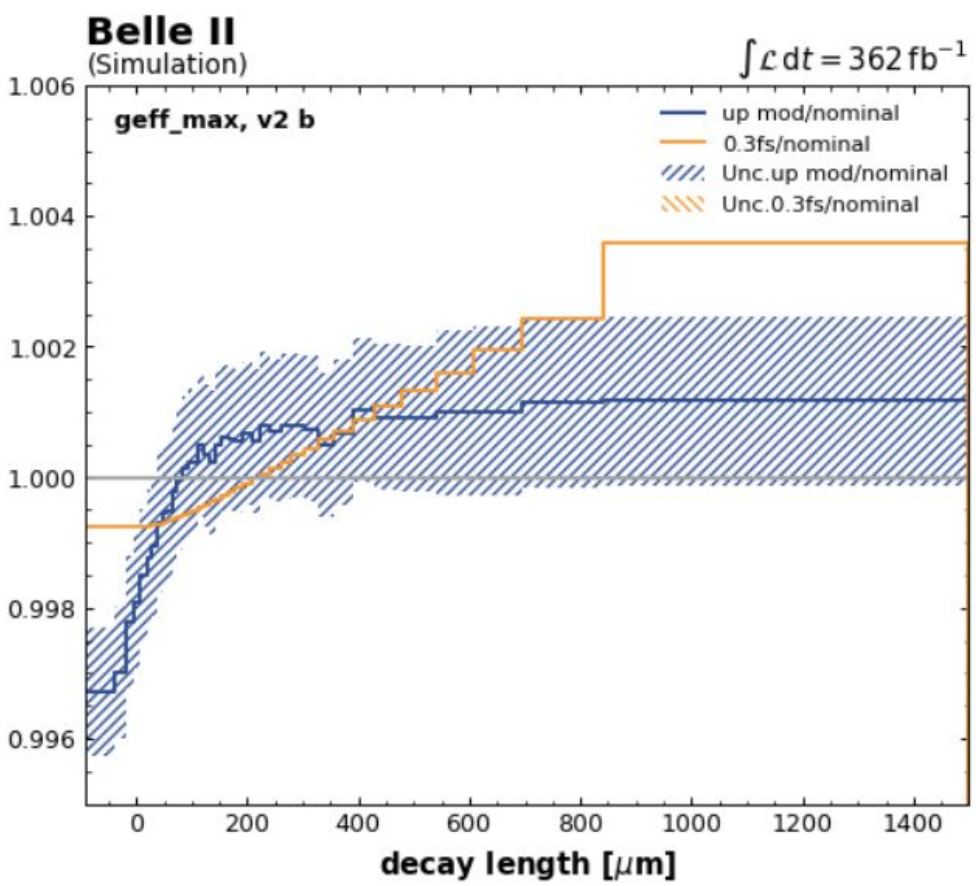


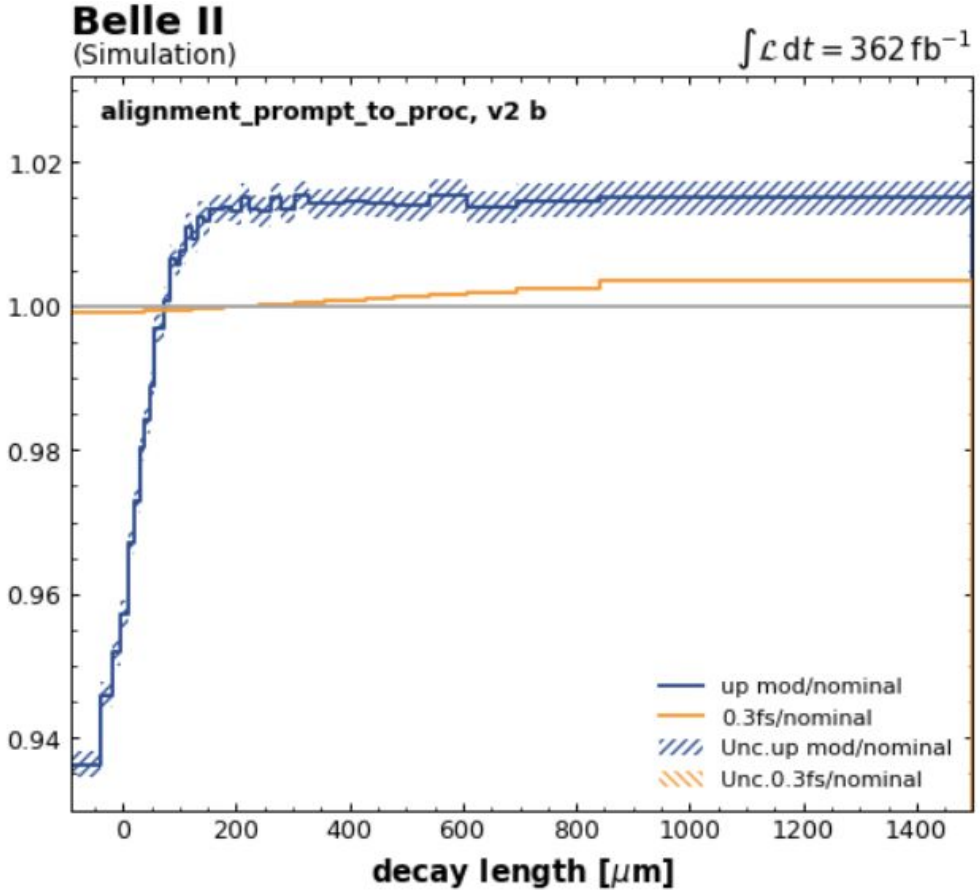




- Use as well coarse binning
- Previous binning removed slope between 180-350 μm

Geff and alignment



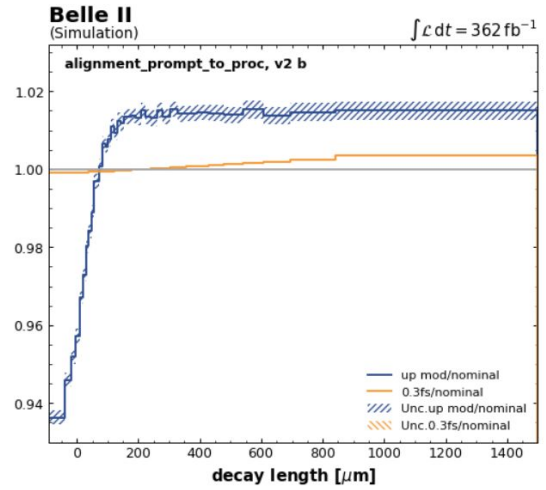


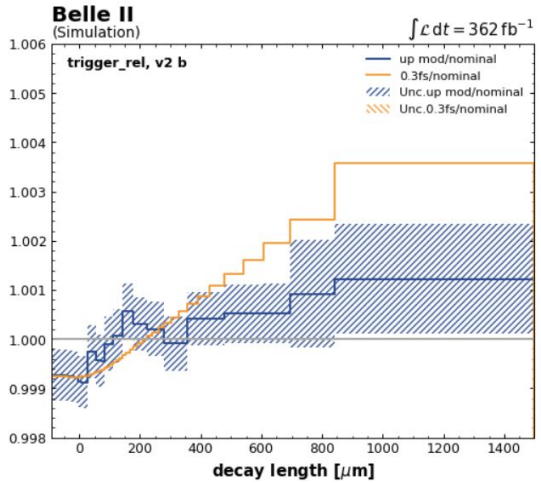
- For both fluctuation small compared to variation size (even for finest binning option v2 b)
- Do not apply any manipulations

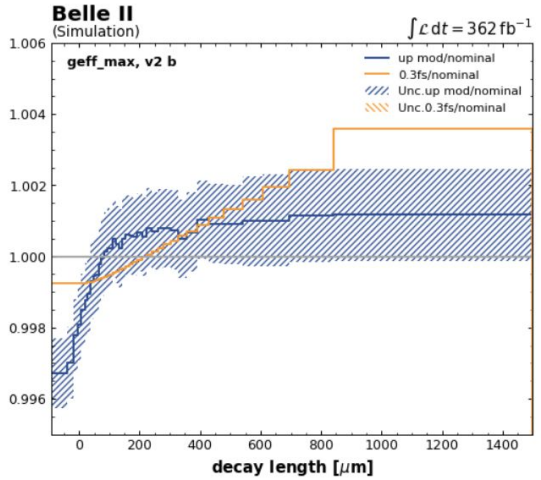
Systematic overview

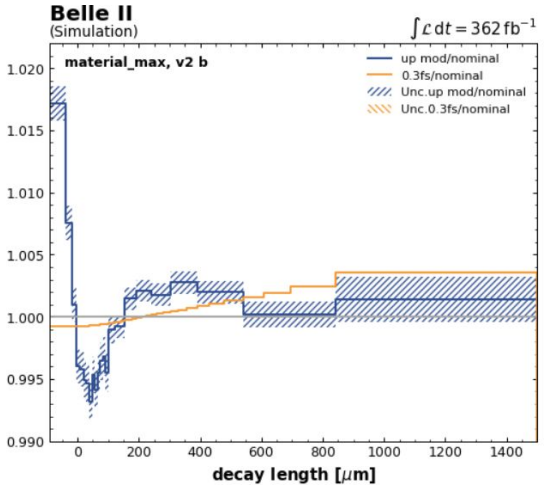
syst	Calculation	sym.	smoothing
misalignment	RI MC prod. 470fb^{-1} (50 fb) $^{-1}$ Ratio: MC/MC	**one-sided**	~~3~~ None
material	RI MC prod. 1ab^{-1} (100 fb) $^{-1}$ Ratio: MC/MC	**max**	~~3~~ Rebin
bkg contributions	Based on weight calculation: Estimated and applied on same MC	**one-sided**	**0**
trigger rel	Use orth. ref. trigger: ECL $\wedge$ CDC / CDC Double ratio: Data/Data / MC/MC	**one-sided**	~~3~~ Rebin
photon eff.	Nom. production (~1.4 ab^{-1}) with different scaling factors: MC/MC	**max**	~~3~~ None
re-weighting	Based on weight calculation: Estimated and applied on same MC	**one-sided**	**0**
photon energy.	Nom. production (340 fb^{-1}) with different scaling factors: Data/Data	**max**	**3**
vertex resolution	Based on weight calculation: Estimated and applied on same MC	**one-sided**	**0**
others	Nom. production with different scaling factors: MC/MC or Data/Data	**one-sided**	**3**

Uncertainties overview v2 b

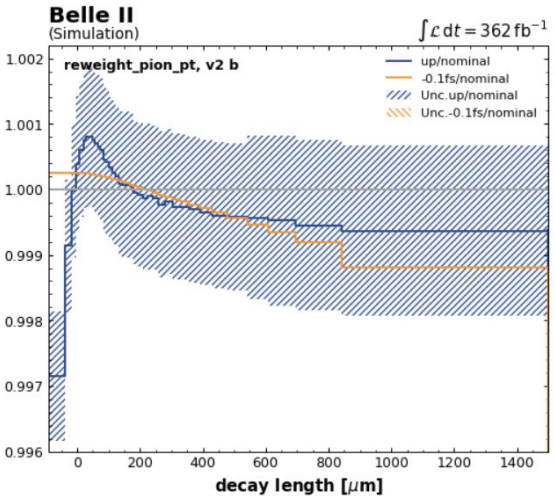


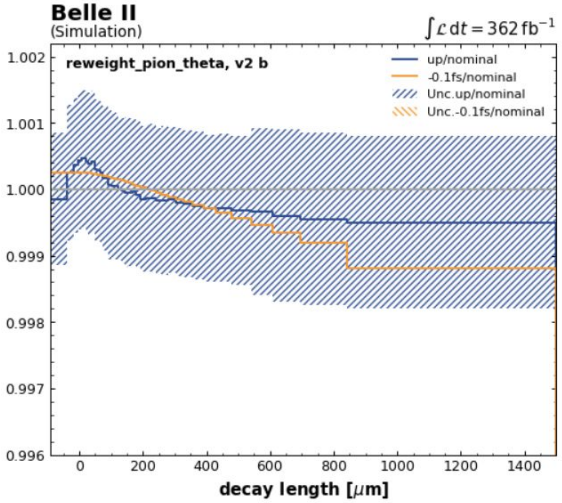


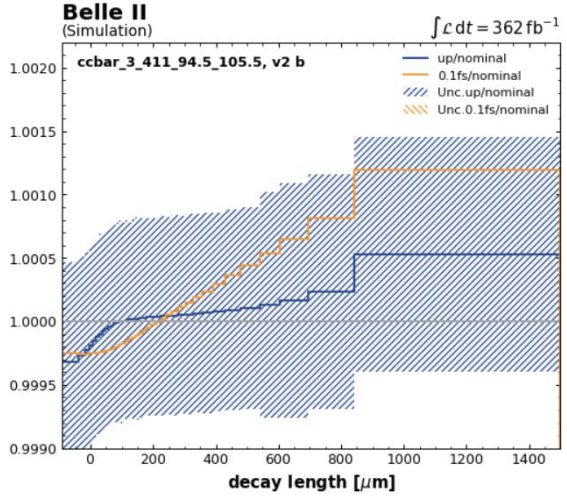




+0.3fs







+/-0.1fs

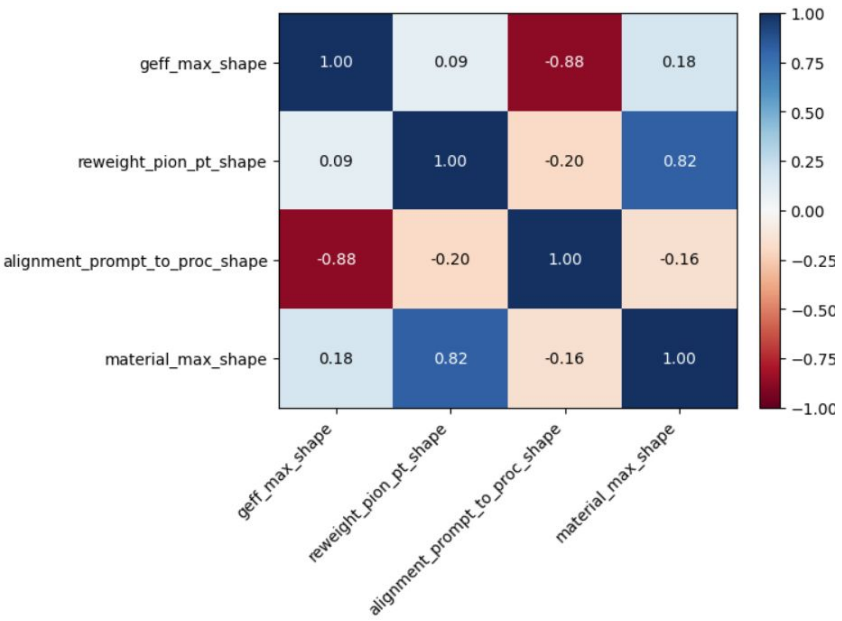
Fit study

syst	old		v0	v0 b	v1	v1 b	v2	v2 b
total	0.12		0.133	0.129	0.126	0.127	0.126	0.126
MC stat.	0.06		0.06	0.06	0.06	0.06	0.06	0.06
misalignment	0.02		0.04	0.04	0.04	0.04	0.04	0.04
material	0.05		0.02	0.02	0.02	0.02	0.02	0.02
bkg contributions	0.03		0.02	0.02	0.02	0.02	0.02	0.02
trigger rel	0.06		0.05	0.05	0.05	0.05	0.05	0.05
photon eff.	0.03		0.06	0.05	0.05	0.05	0.05	0.05
re-weighting	0.02		0.06	0.05	0.05	0.06	0.06	0.06
photon energy.	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
vertex resolution	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
others	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

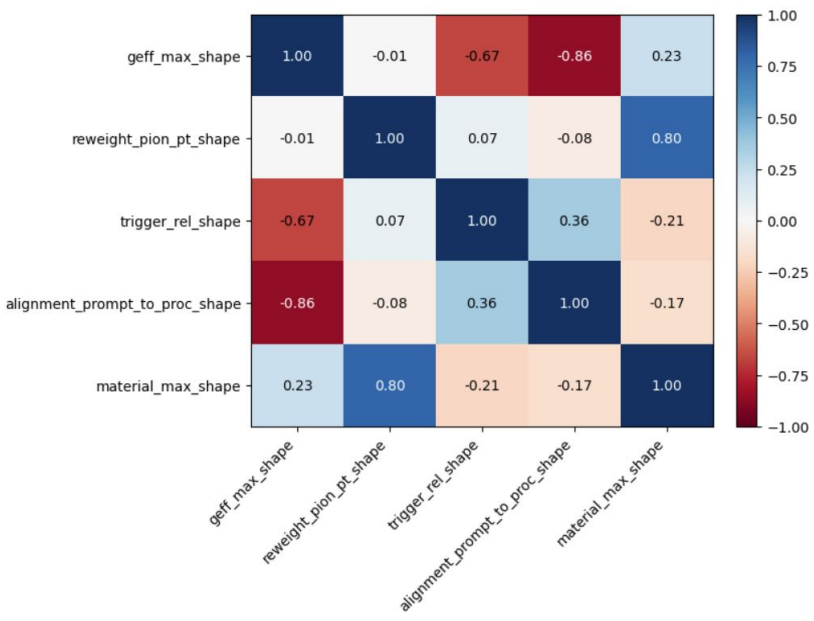
- Total uncertainty still stable
- Impact of several systematic uncs. change with new setups
- Within new setup breakdown stable! -> finer binning seems slightly more sensitive -> choose v2 for now
- Photon eff. now one of the leading systematics -> see next slide

Fit study

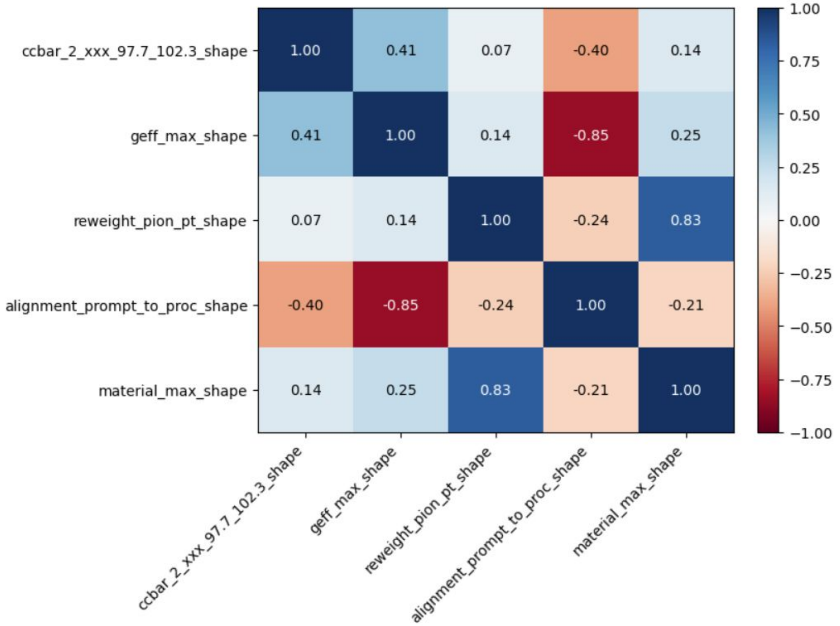
v0



v1



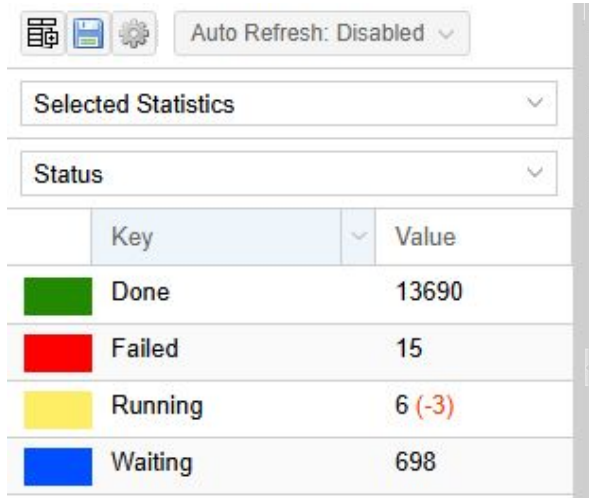
v2

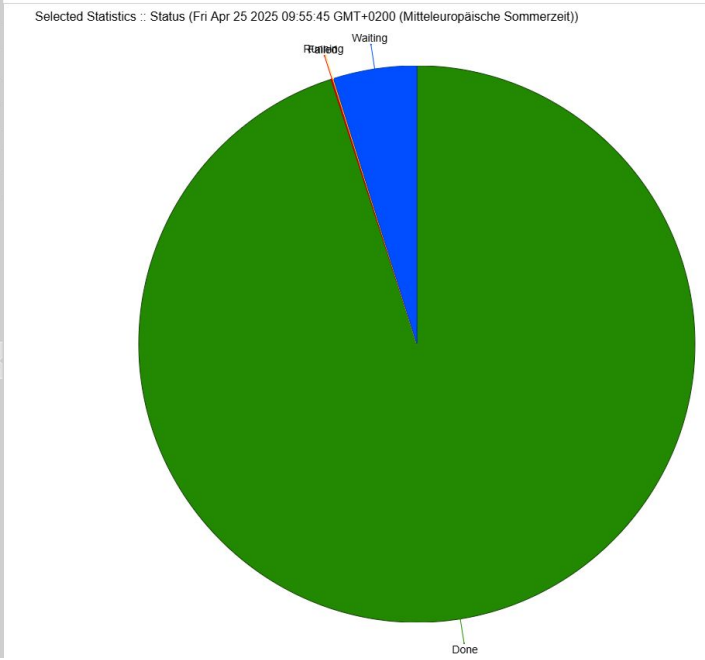


- Two very strong correlations (geff:alignment ~ -0.85 and material:reweight_pt ~ +0.80)
- Depending of binning other correlations appear (v1: trigger:geff -0.67, v2: geff:ccbar_2_xxx 0.41)

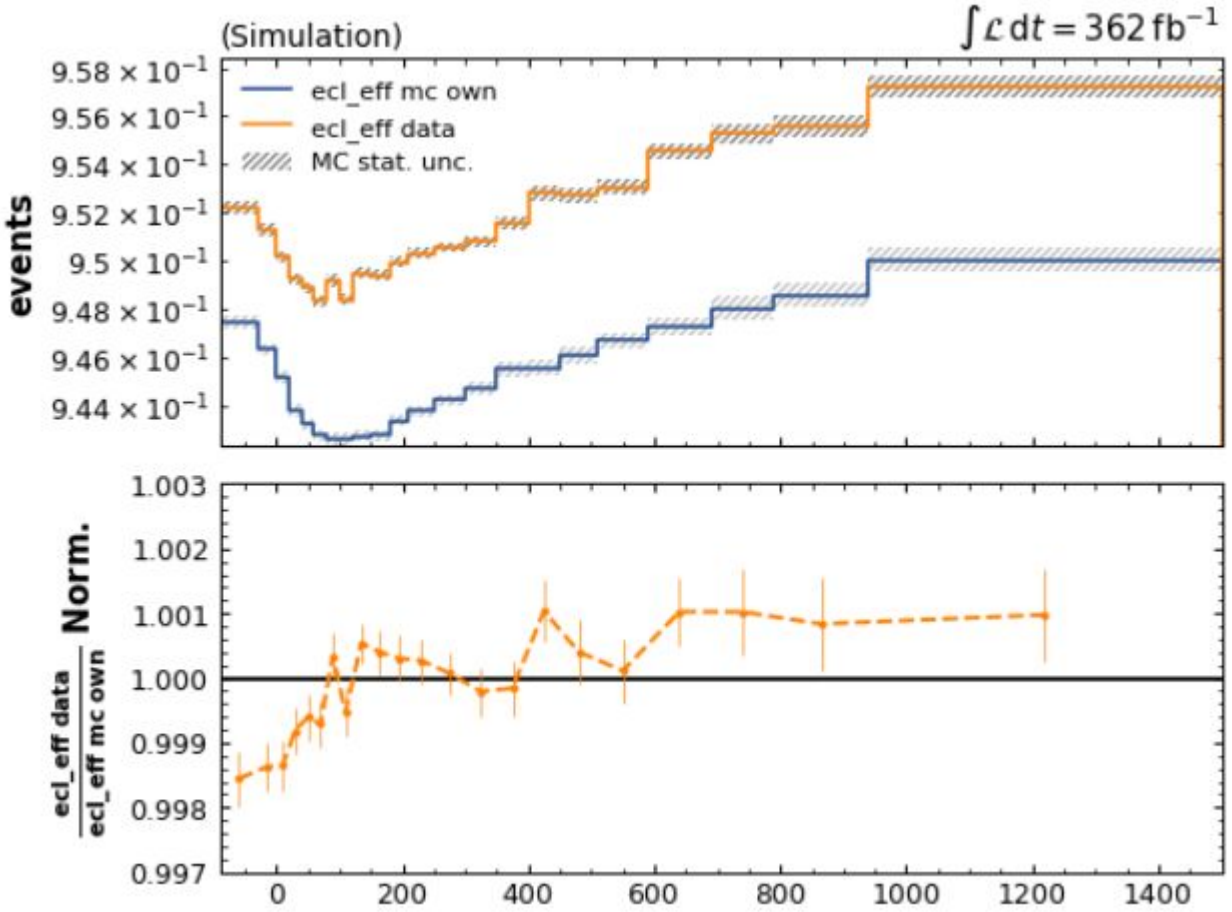
Correction of nominal template and systematics

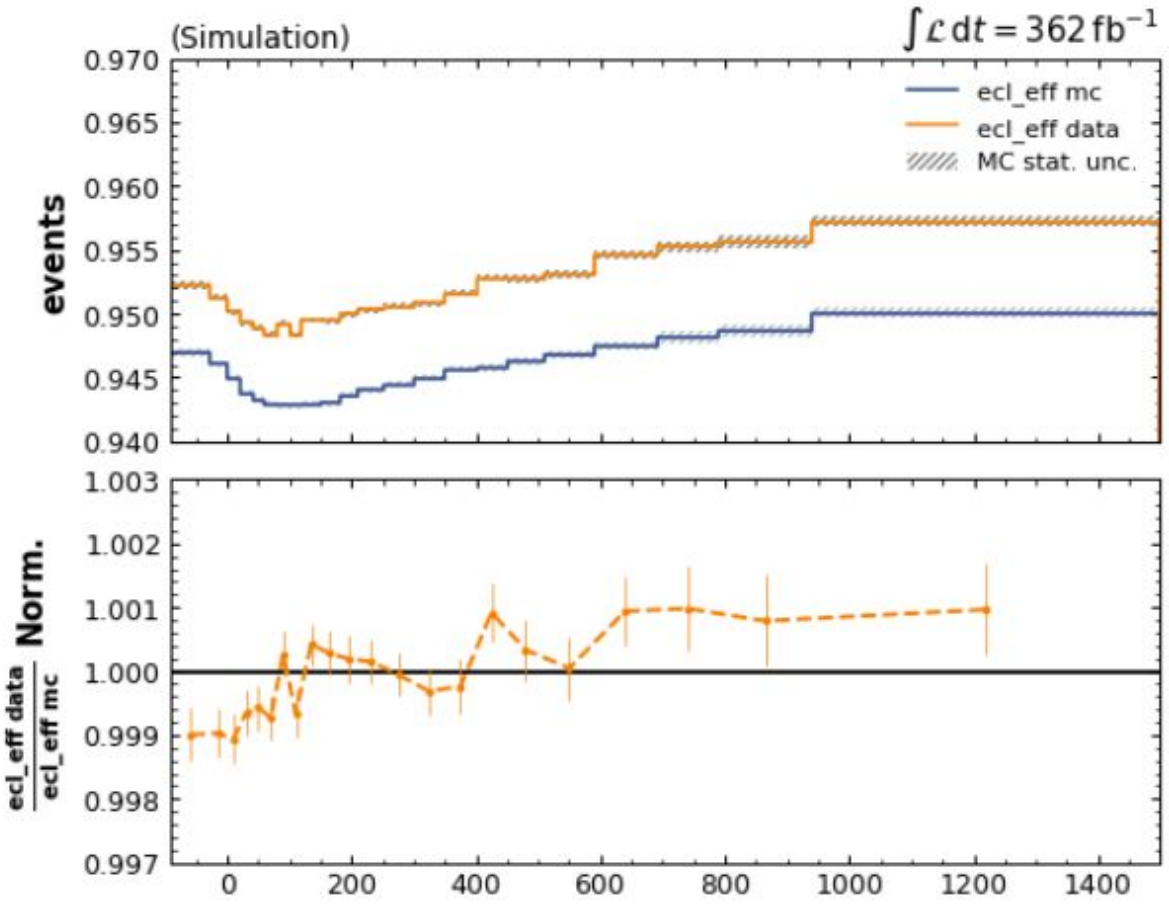
- We apply two correction to the templates
  - Yield corrections -> Rescale signal, usdbar, ccbar_2_xxx and ccbar_3_411
  - 2D-reweighting in tau 3p pT and theta
- Derive corrections after all corrections would be best solution
- But we added in new production truth information to nominal template for ccbar split
  - Not available in the moment for scaling systematics (photons eff., energy, etc.)
- New production done for rel. trigger systematic
  - Check impact of reweightings
- New production for photon eff. started but due to grid upgrade now very slow
  -> At least 15-20 jobs are permanently failing
  -> Seems that it is related to the KIT site
  -> Will request to relocate them





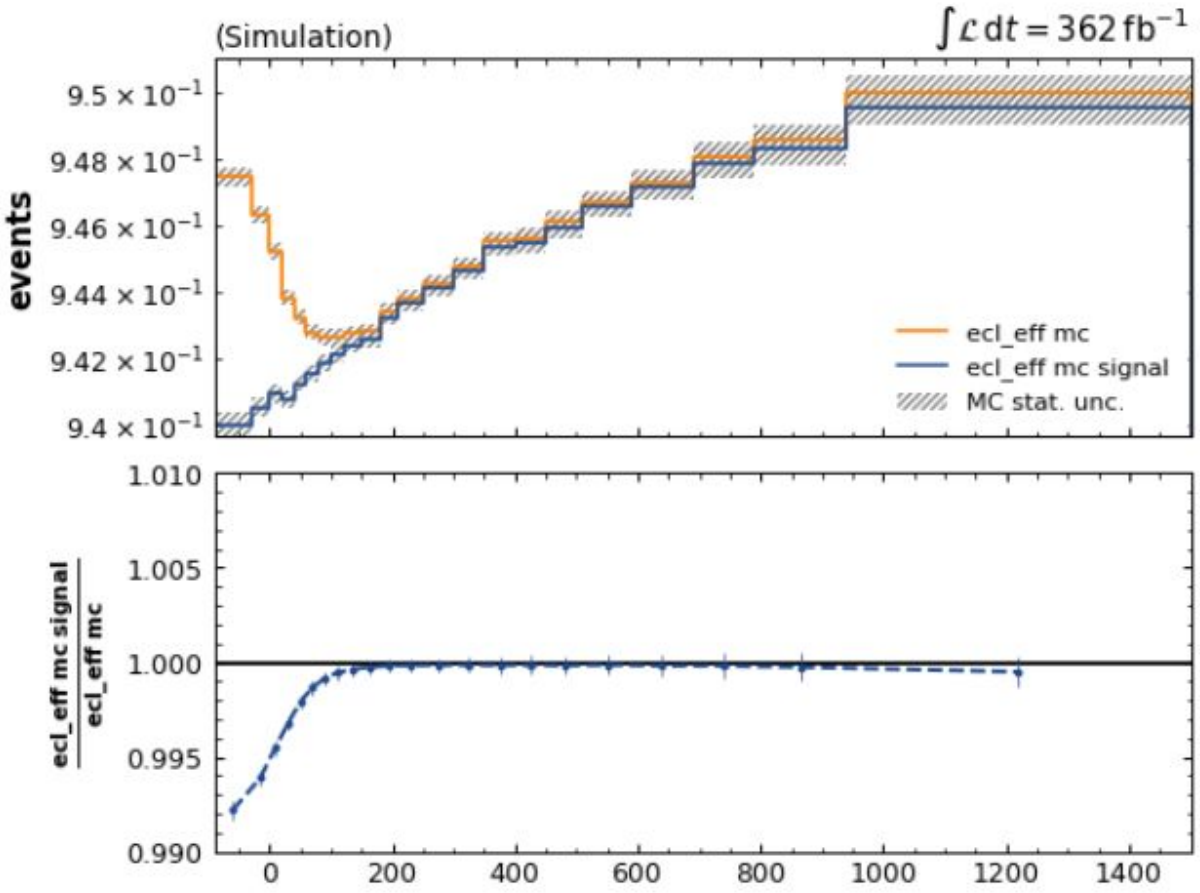
Trigger systematic no correction vs full correction

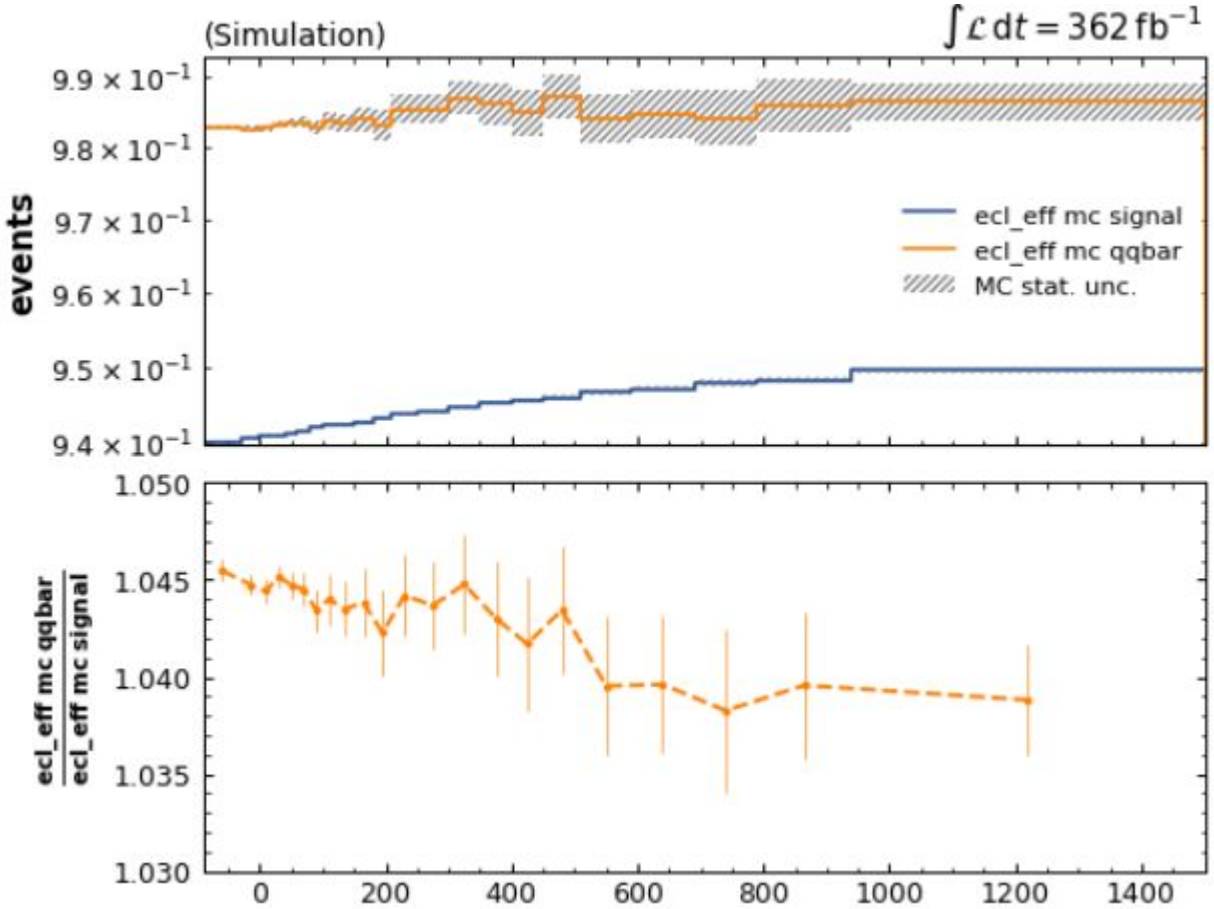




- Trigger systematic is affected by re-weighting -> gets smaller
- Basically only affected by yield re-weighting

Trigger systematic signal vs qqbar

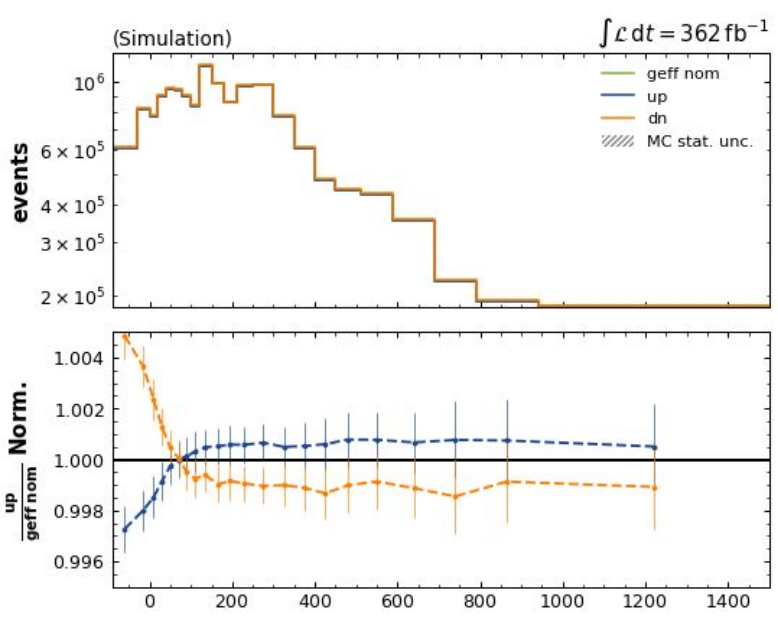




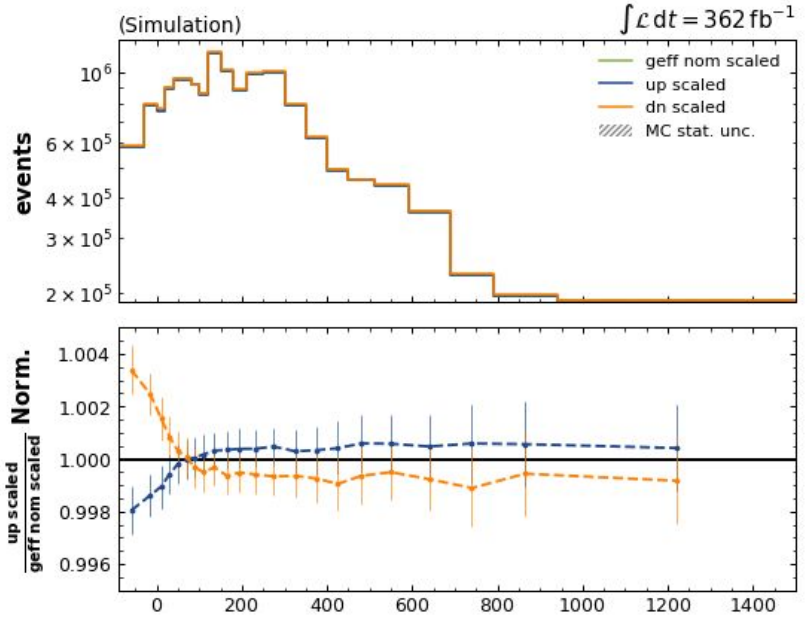
- usdbar efficiency flat in decay length, while signal increasing
- Change of signal to background ratio changes total MC eff. shape

Photon efficiency

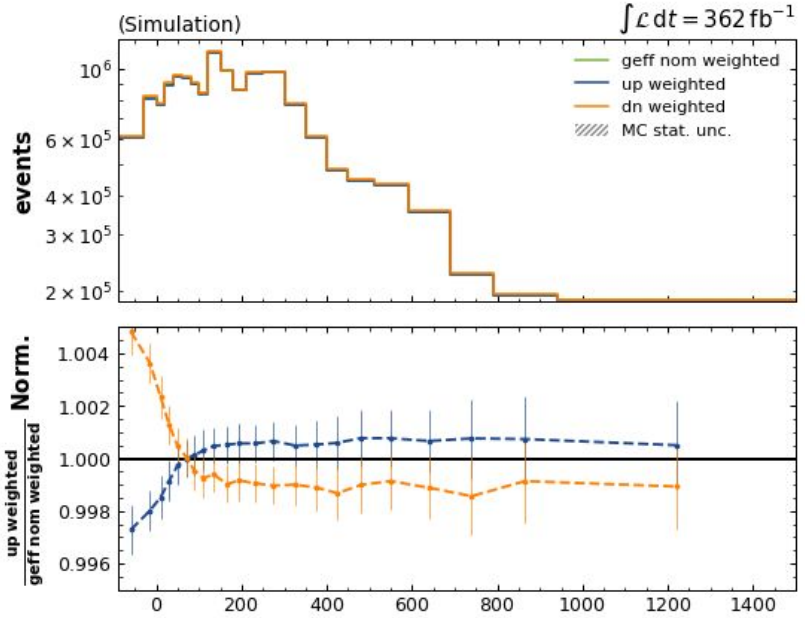
raw



yield



re-weighted



- For photon efficiency no ccbar split available yet
- Use old yield correction for now -> Scaling of signal, usdbar and all ccbar combined
- Yield correction has some impact on geff, but unclear if additional ccbar will have some effect
- Since geff is now one of the leading systematic we should probably wait for input before further studies
- Gen not affect (derived on data), unclear if it is worth to check all other systematics which had no impact

Stability test and different approach to calc stat. error

Strategy A

- Run default fit with all NP (fit1)
- Run fit with fixing all NP to post-fit values -> Stat. err. (fit2)
- Calculate syst. err with $\sqrt{(\text{fit1 err.}^2 - \text{fit2 err.}^2)}$

Pro:

- We can estimate impact of sub-set of NPs (breakdown)

Con:

- Ignores impact of data stat. on NPs (second fit reduce DoF)

Strategy B

- Run multiple fits with pseudo-data set
  - For each data set vary data in each bin by random Gauss
- Best-fit will vary for each data set
- Create histogram of variation and estimate width of Gauss distribution -> Stat. err.
- Estimate syst. err with $\sqrt{(\text{tot. unc.}^2 - \text{stat. err}^2)}$

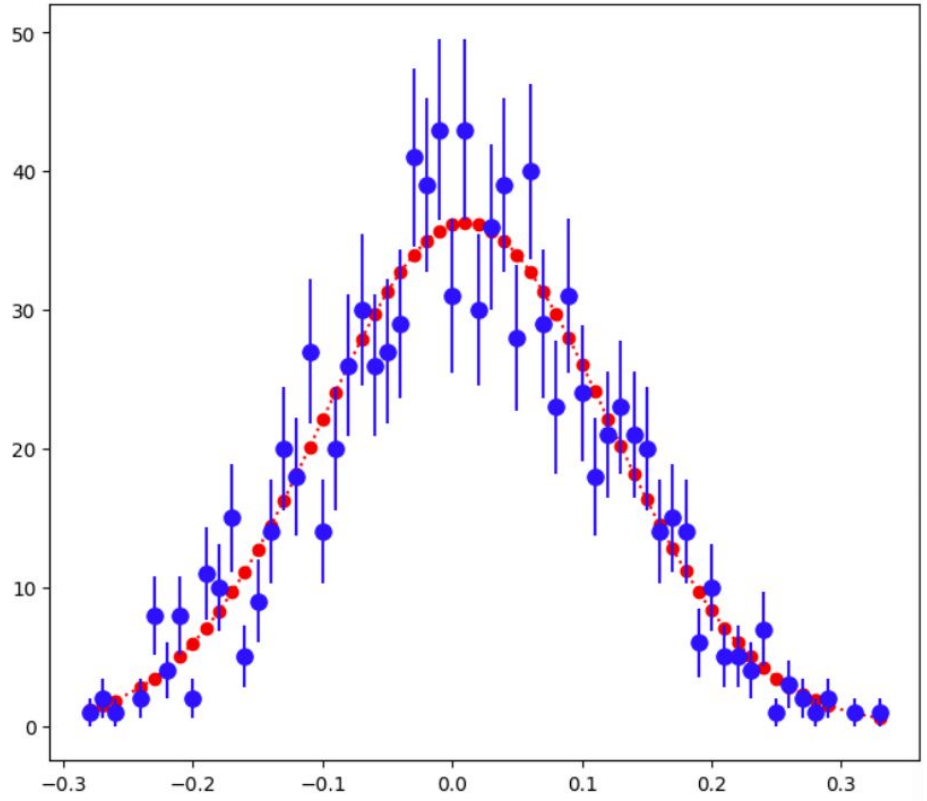
Pro:

- Impact of data stat. on NPs included

Con:

- No breakdown possible

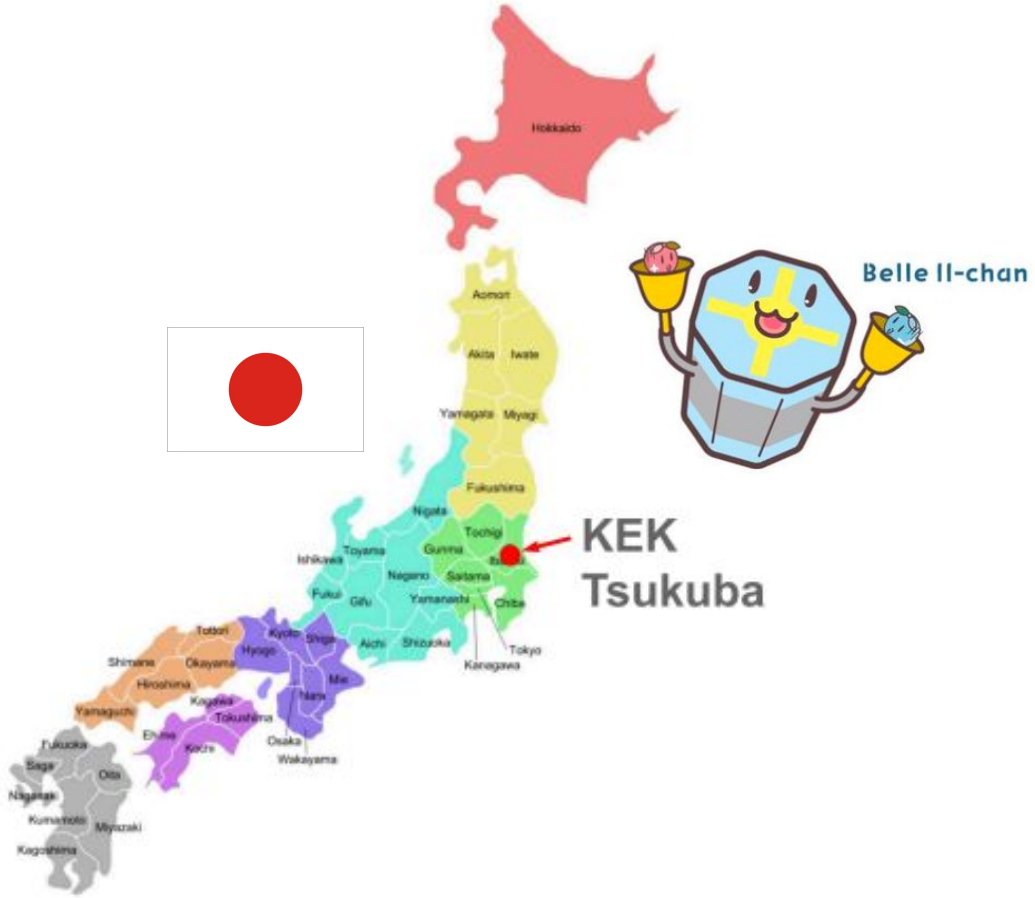
Strategy B for v2 with n_fits = 1000



	A	B
total	**0.150**	**0.150**
stat.	**0.082**	**0.111**
syst.	**0.126**	**0.102**

-> As expected part. of syst. now in stat. unc

Thank you!



Contact

Deutsches Elektronen-
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www.desy.de

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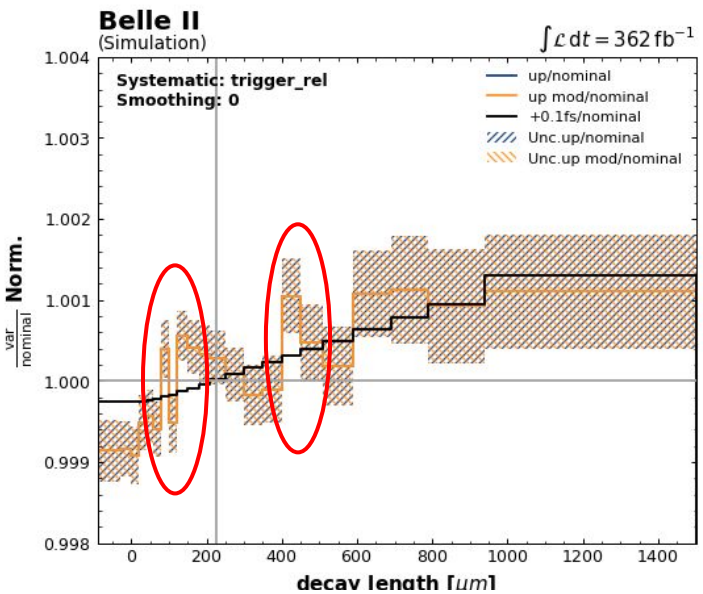
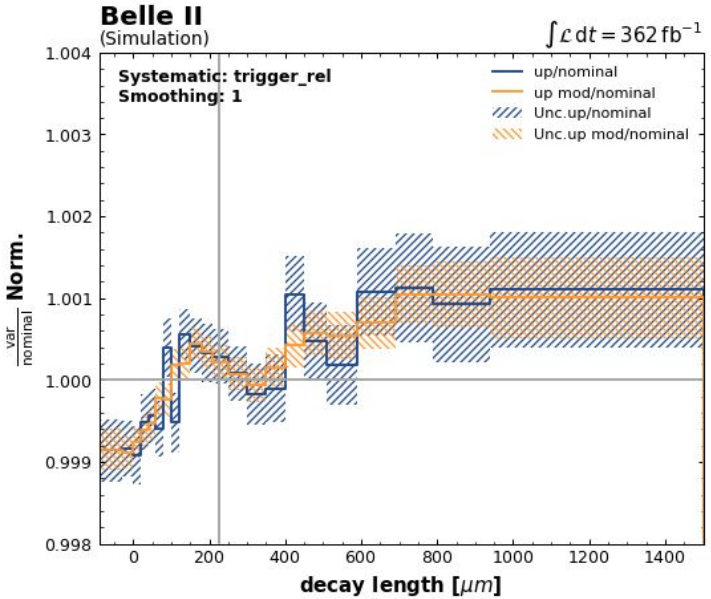
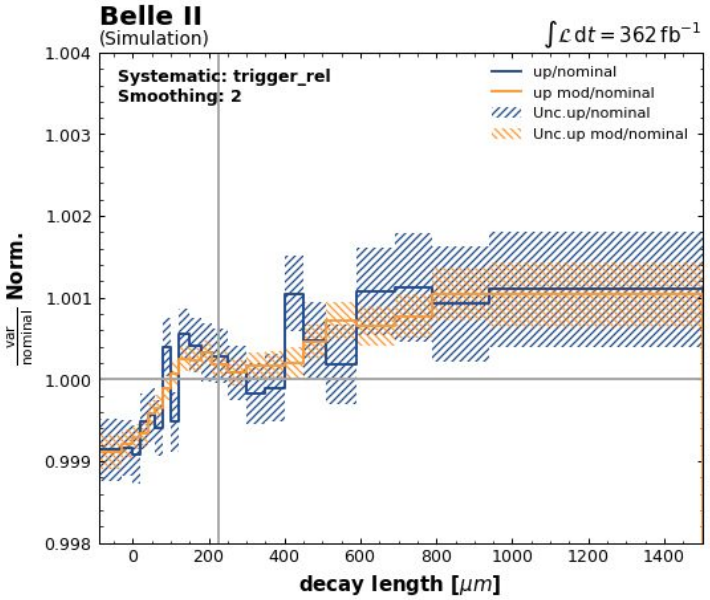
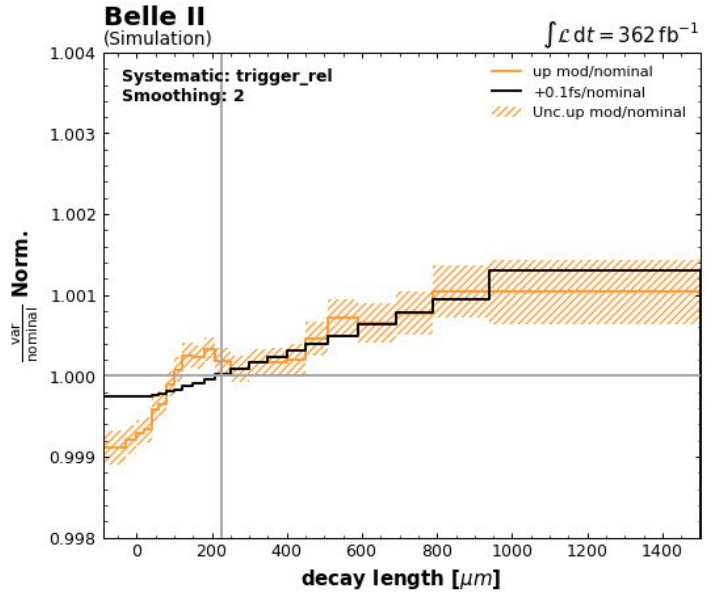
HELMHOLTZ

Trigger rel


Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_rel
Smoothing: 0
up/nominal
up mod/nominal
+0.1fs/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
decay length [μm]


Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_rel
Smoothing: 1
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
decay length [μm]


Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_rel
Smoothing: 2
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
decay length [μm]


Belle II
(Simulation)
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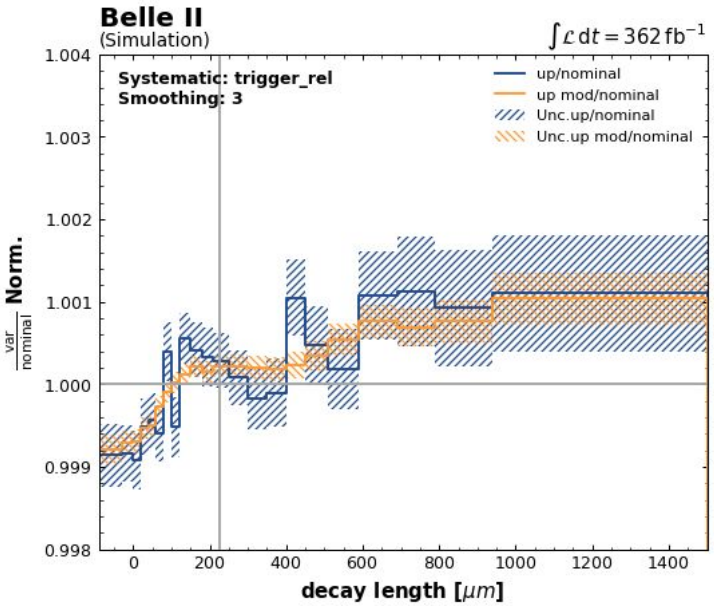
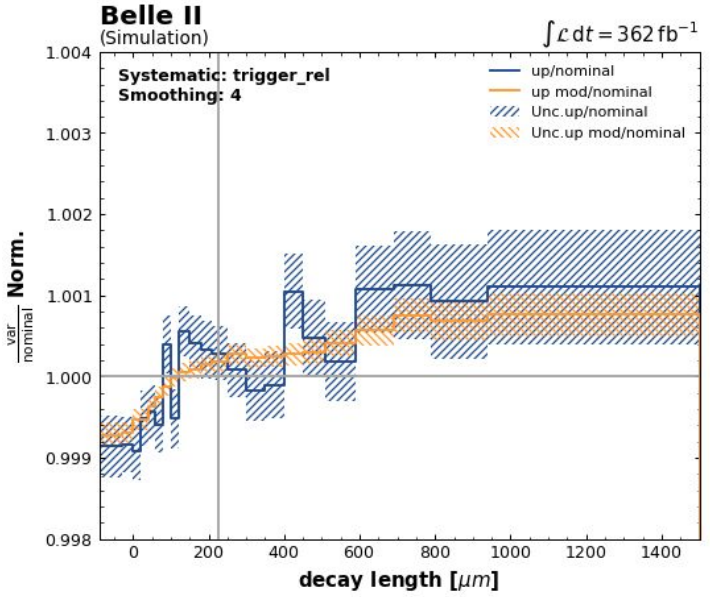
Systematic: trigger_rel
Smoothing: 2
up mod/nominal
+0.1fs/nominal
Unc.up mod/nominal
Norm.
decay length [μm]


Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_rel
Smoothing: 3
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
decay length [μm]


Belle II
(Simulation)
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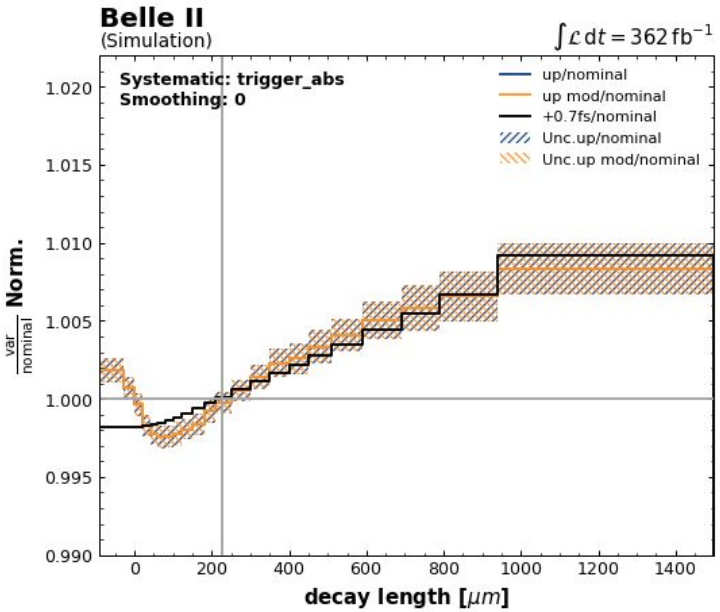
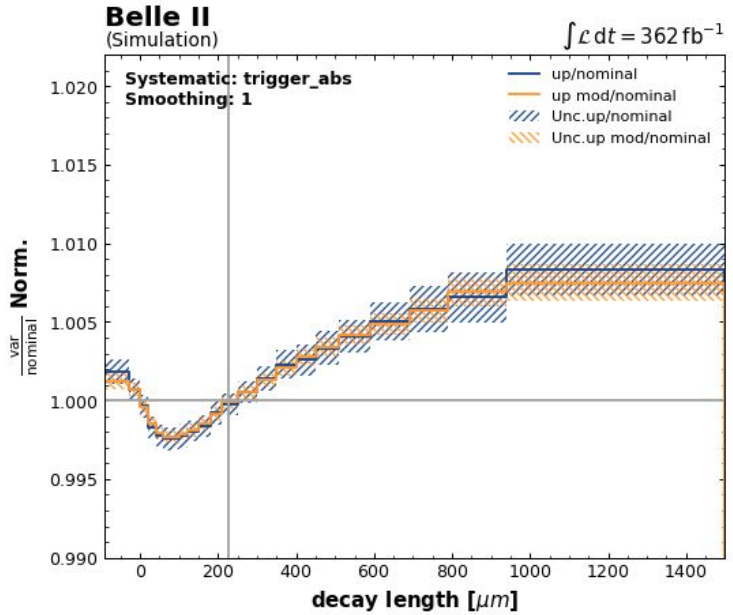
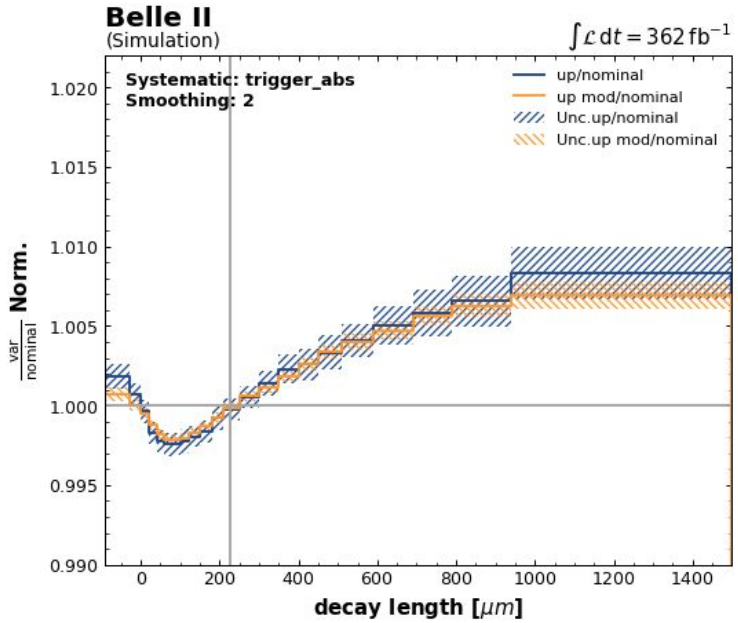
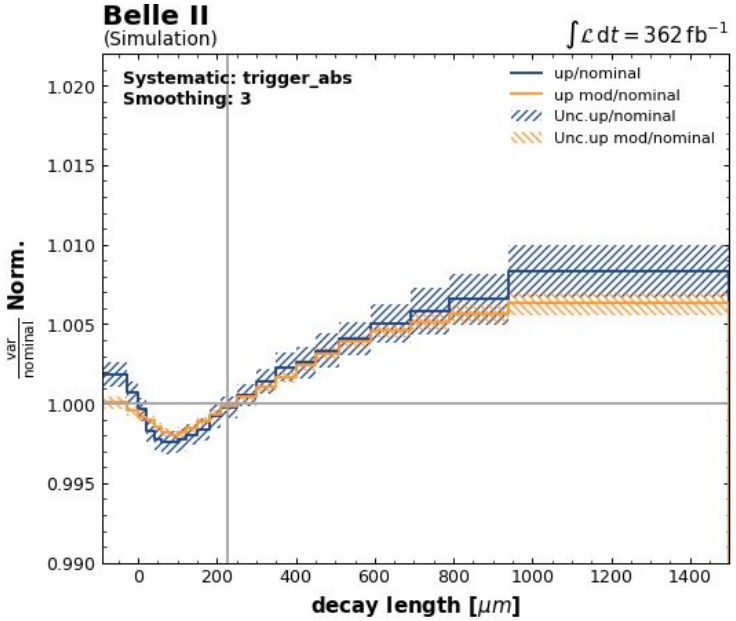
Systematic: trigger_rel
Smoothing: 4
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
decay length [μm]

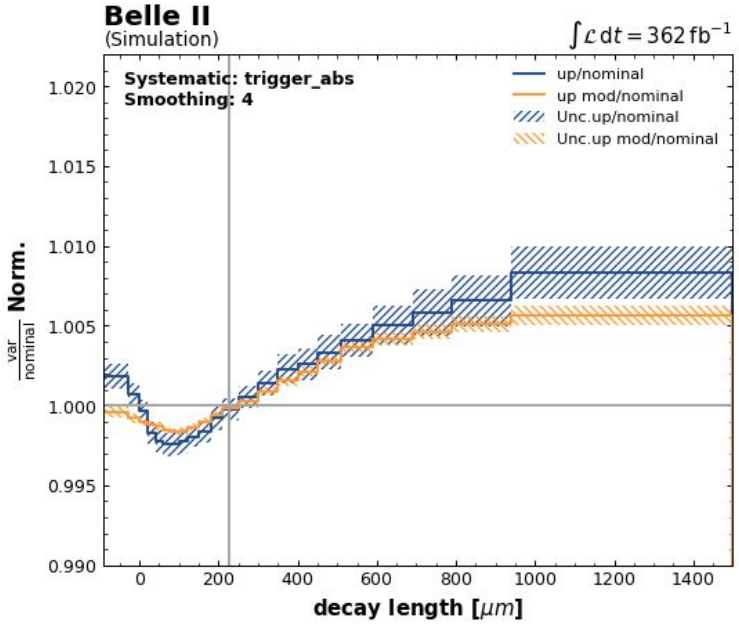
Trigger abs


Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_abs
Smoothing: 0
up/nominal
up mod/nominal
+0.7fs/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var / nominal
decay length [μm]

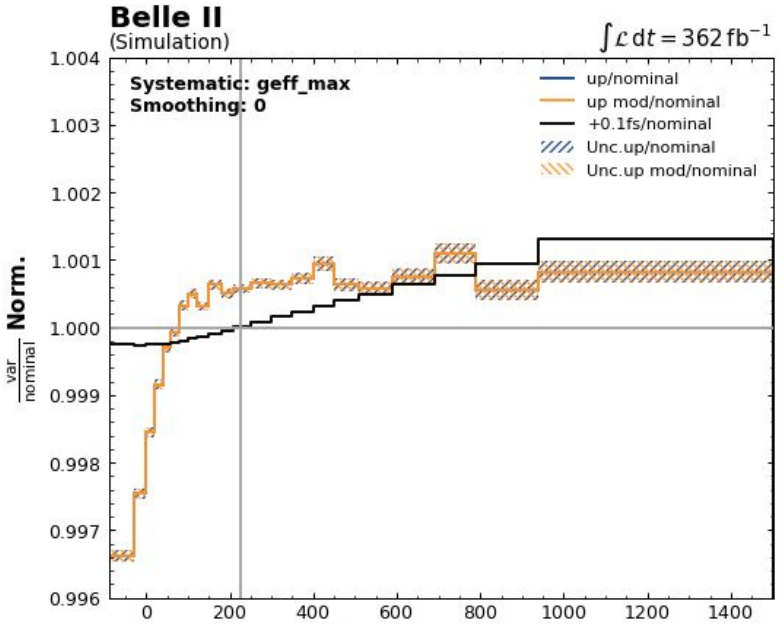

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_abs
Smoothing: 1
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var / nominal
decay length [μm]

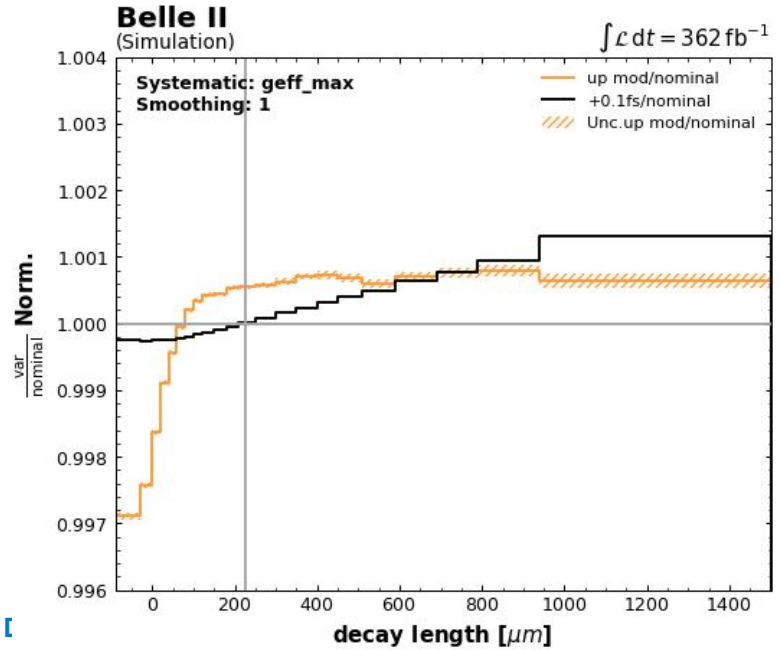

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_abs
Smoothing: 2
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var / nominal
decay length [μm]

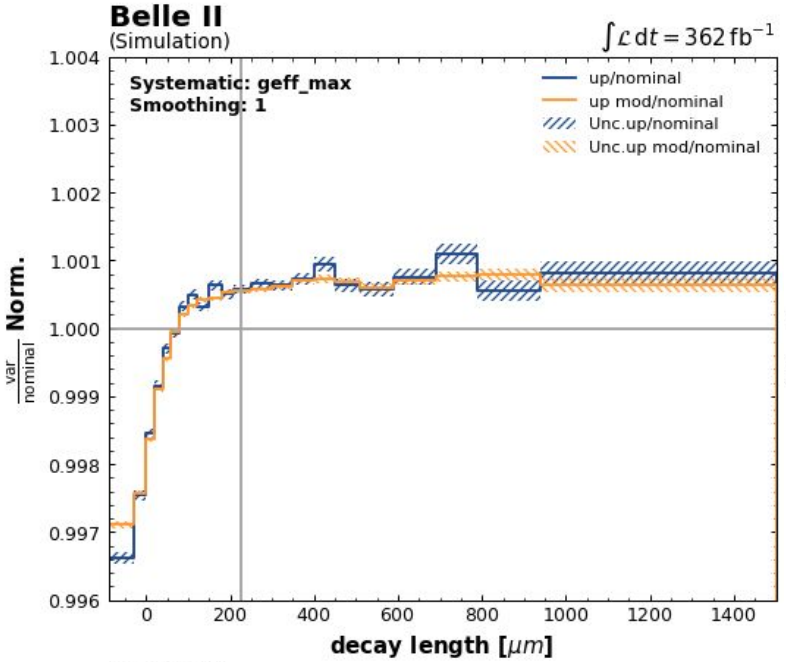

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_abs
Smoothing: 3
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var / nominal
decay length [μm]

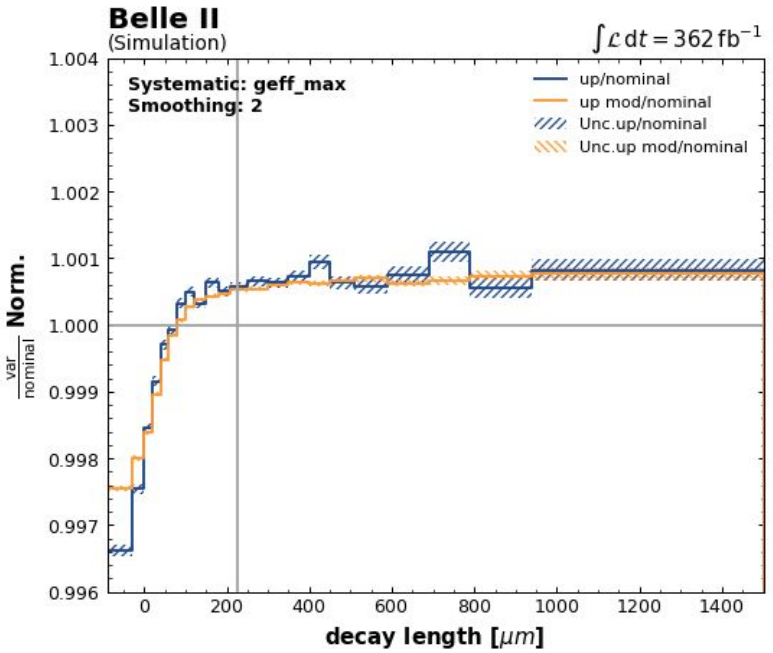

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: trigger_abs
Smoothing: 4
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var / nominal
decay length [μm]

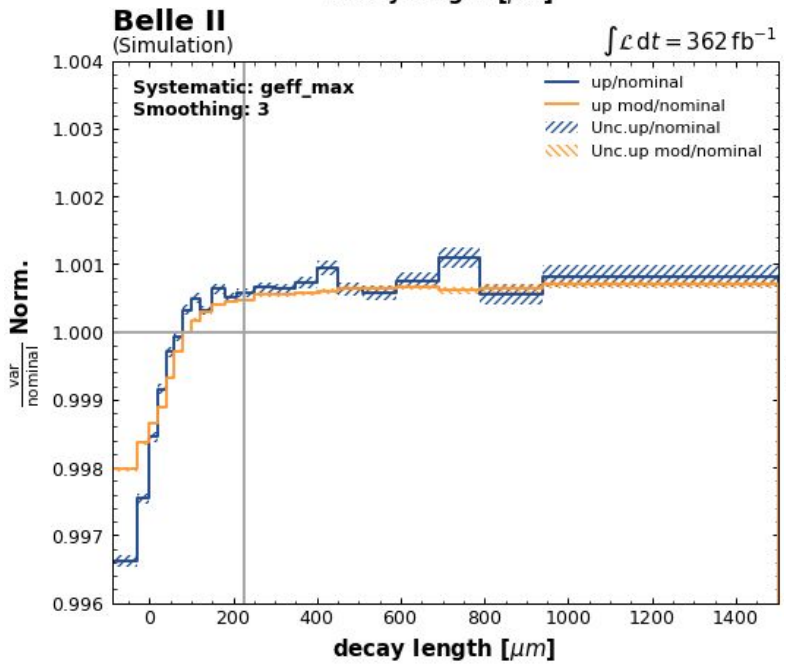
Photon eff

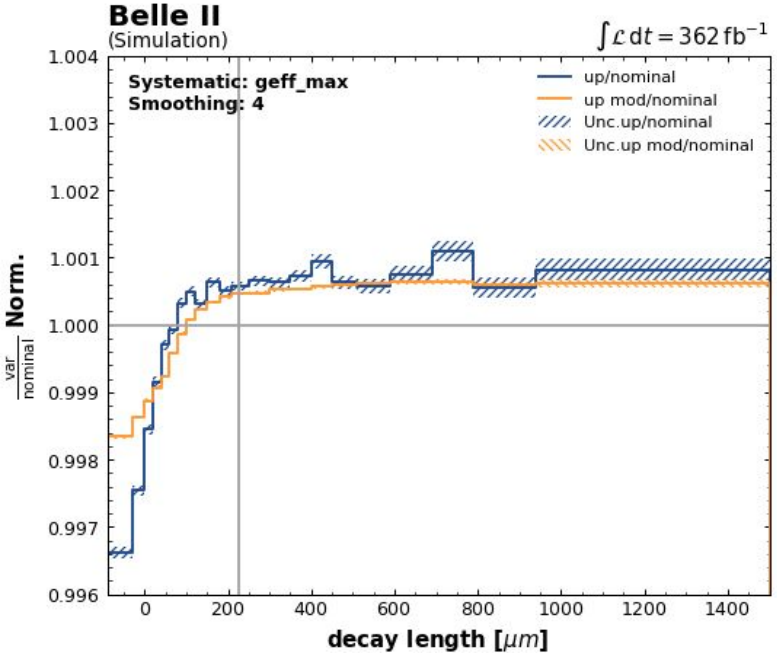

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: geff_max
Smoothing: 0
up/nominal
up mod/nominal
+0.1fs/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var/nominal
decay length [μm]


Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: geff_max
Smoothing: 1
up mod/nominal
+0.1fs/nominal
Unc.up mod/nominal
Norm.
var/nominal
decay length [μm]

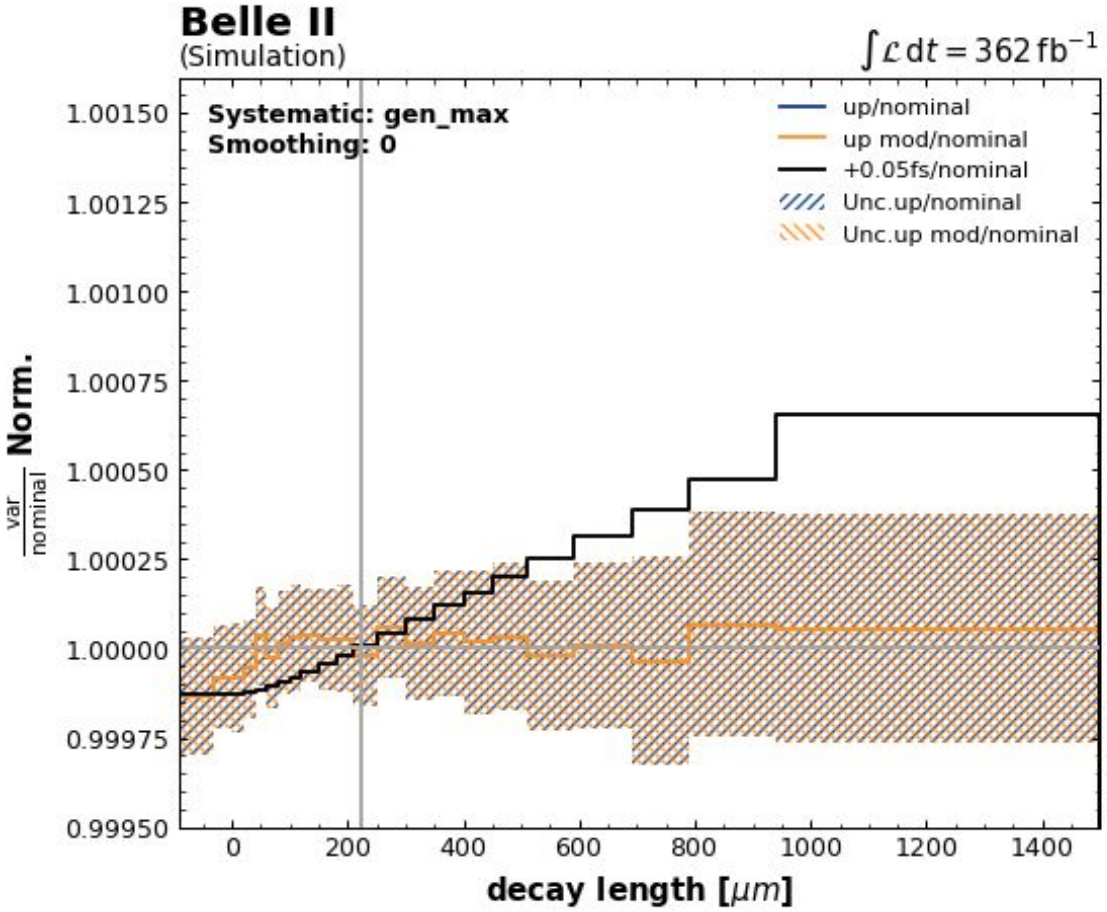

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: geff_max
Smoothing: 1
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var/nominal
decay length [μm]

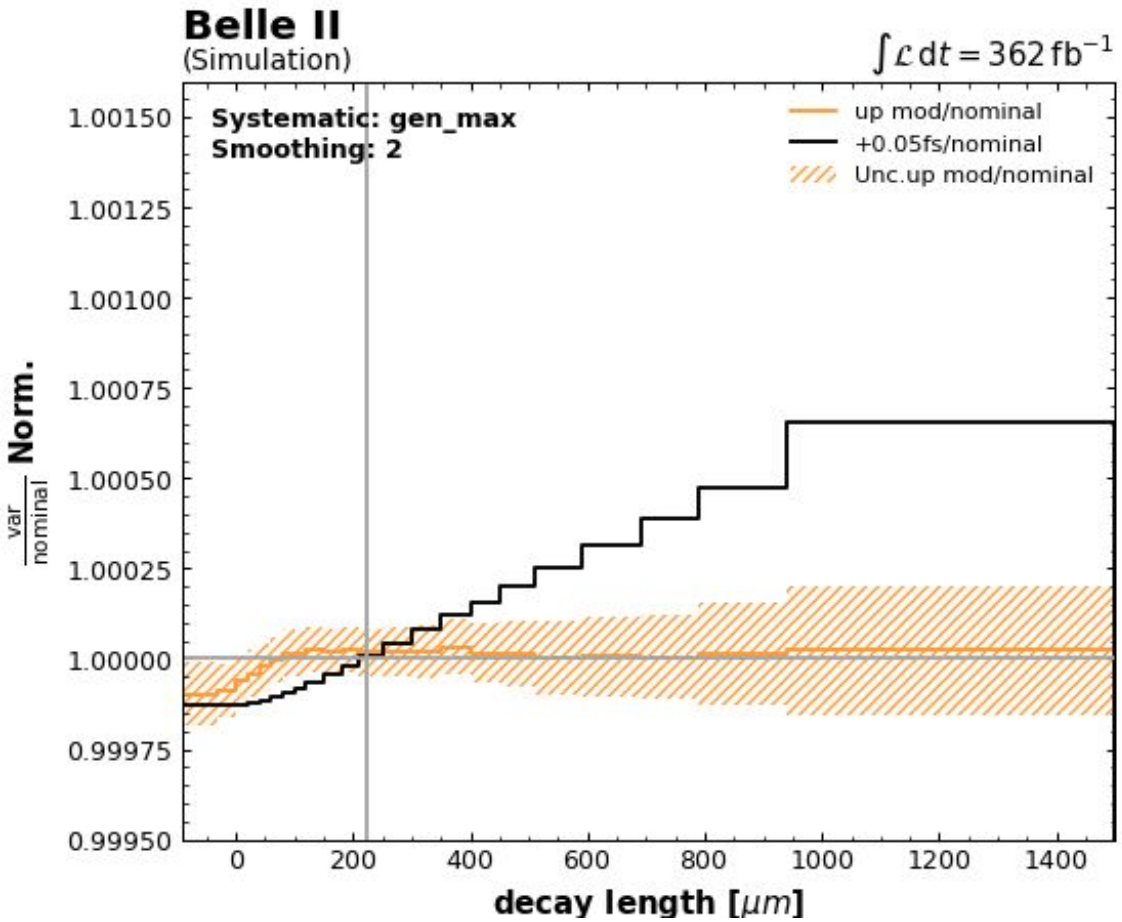

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: geff_max
Smoothing: 2
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var/nominal
decay length [μm]


Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: geff_max
Smoothing: 3
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var/nominal
decay length [μm]

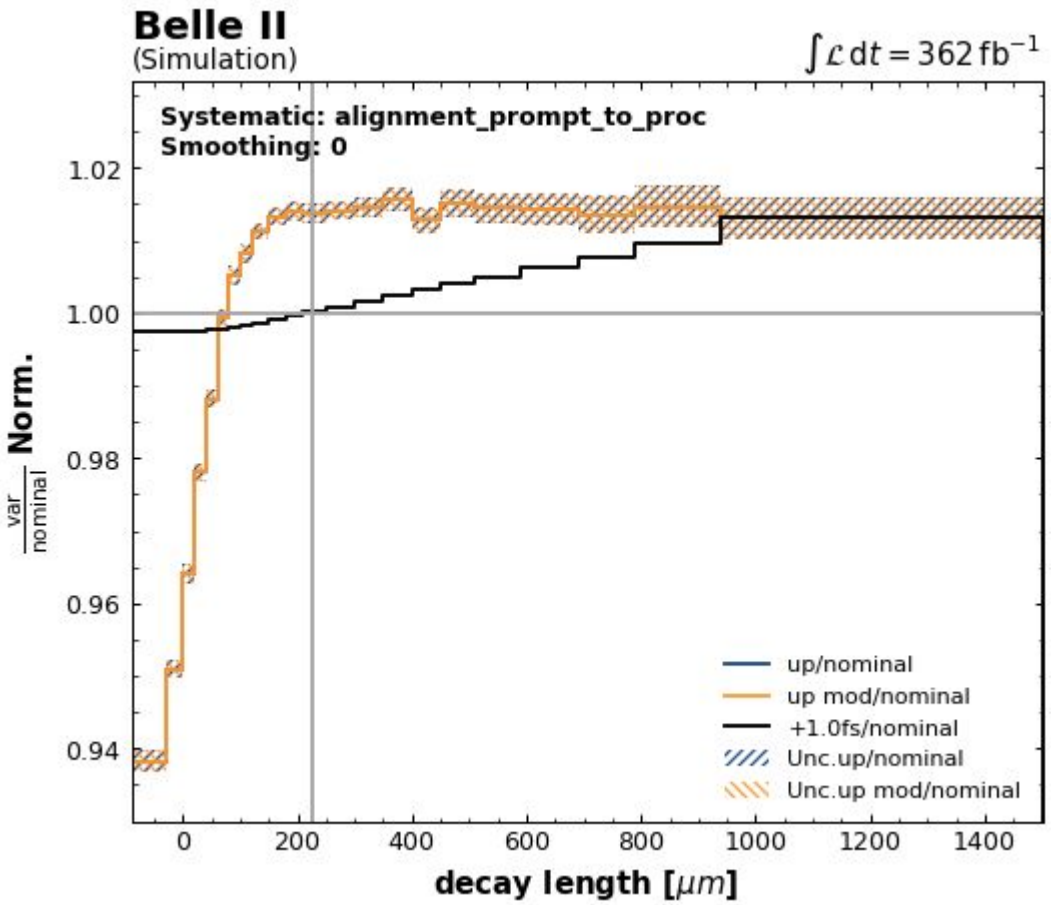

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
Systematic: geff_max
Smoothing: 4
up/nominal
up mod/nominal
Unc.up/nominal
Unc.up mod/nominal
Norm.
var/nominal
decay length [μm]

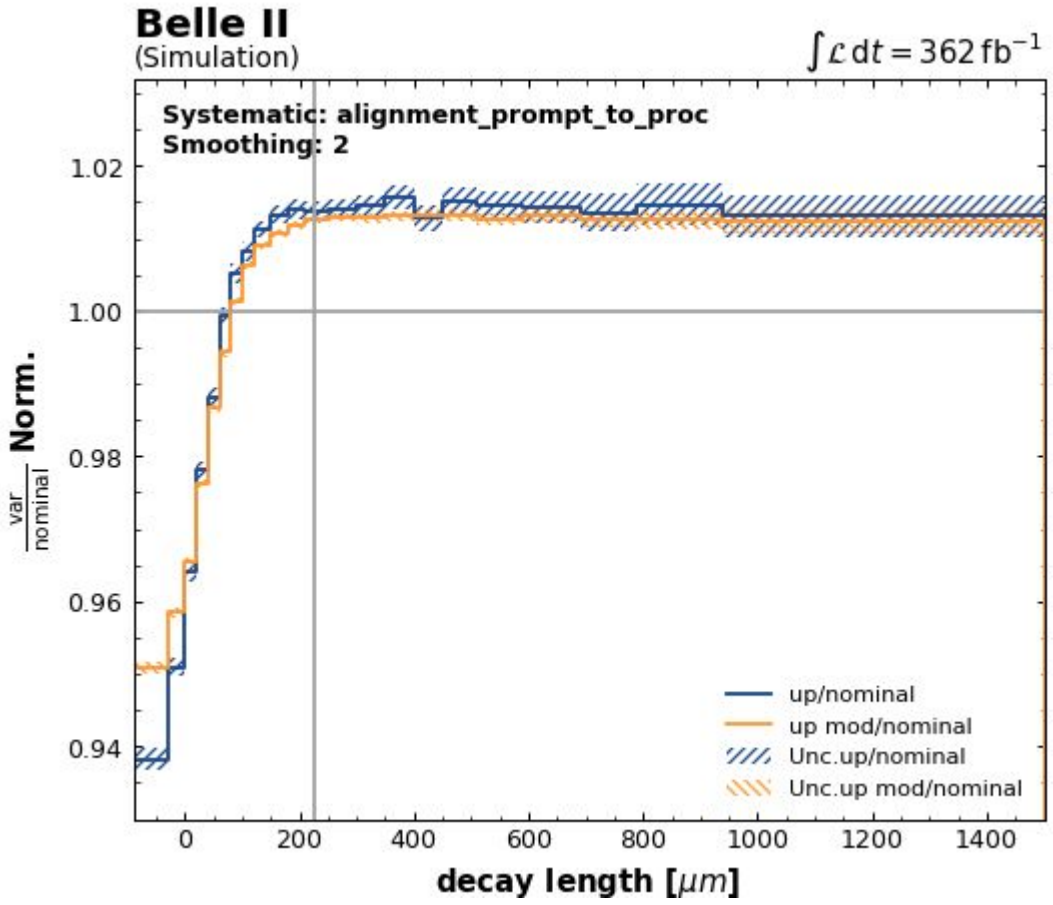
Photon energy



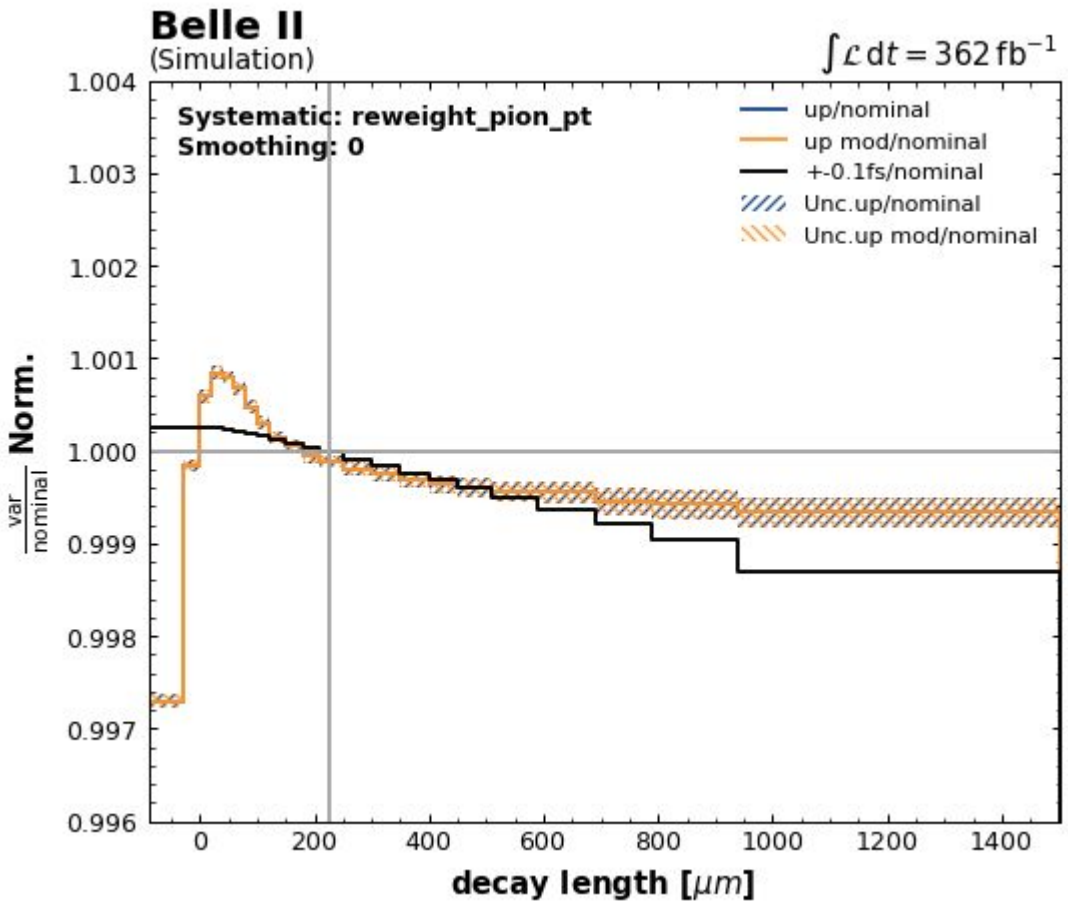


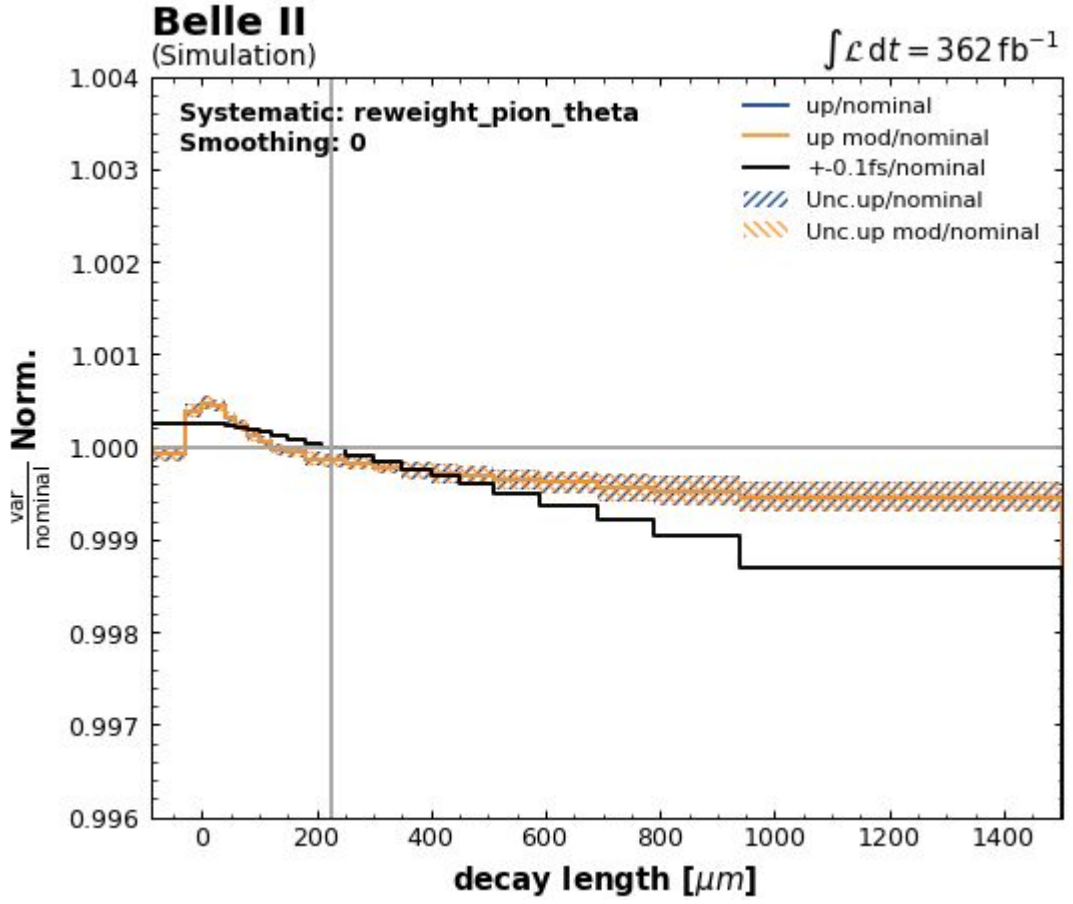
Misalignment



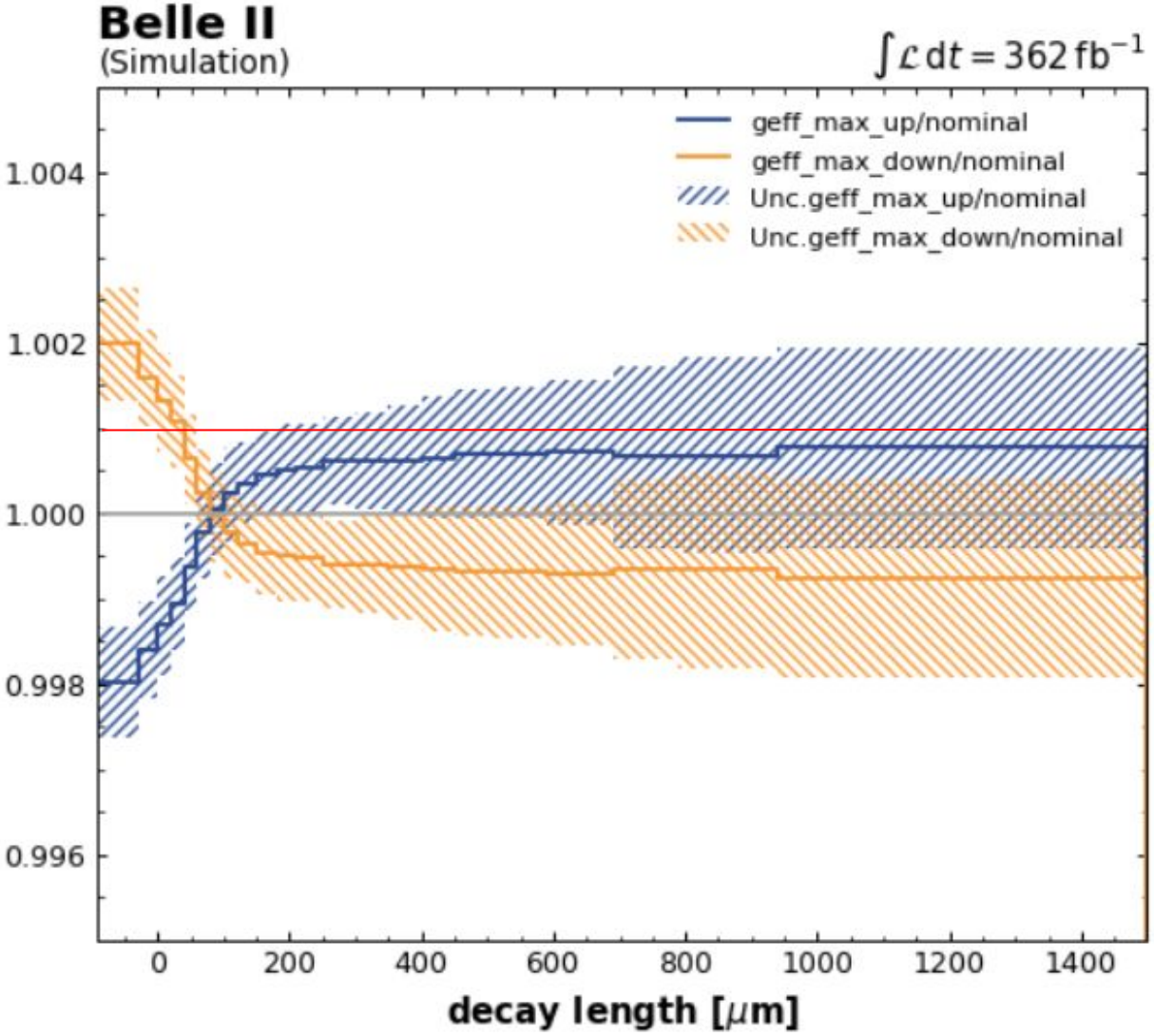


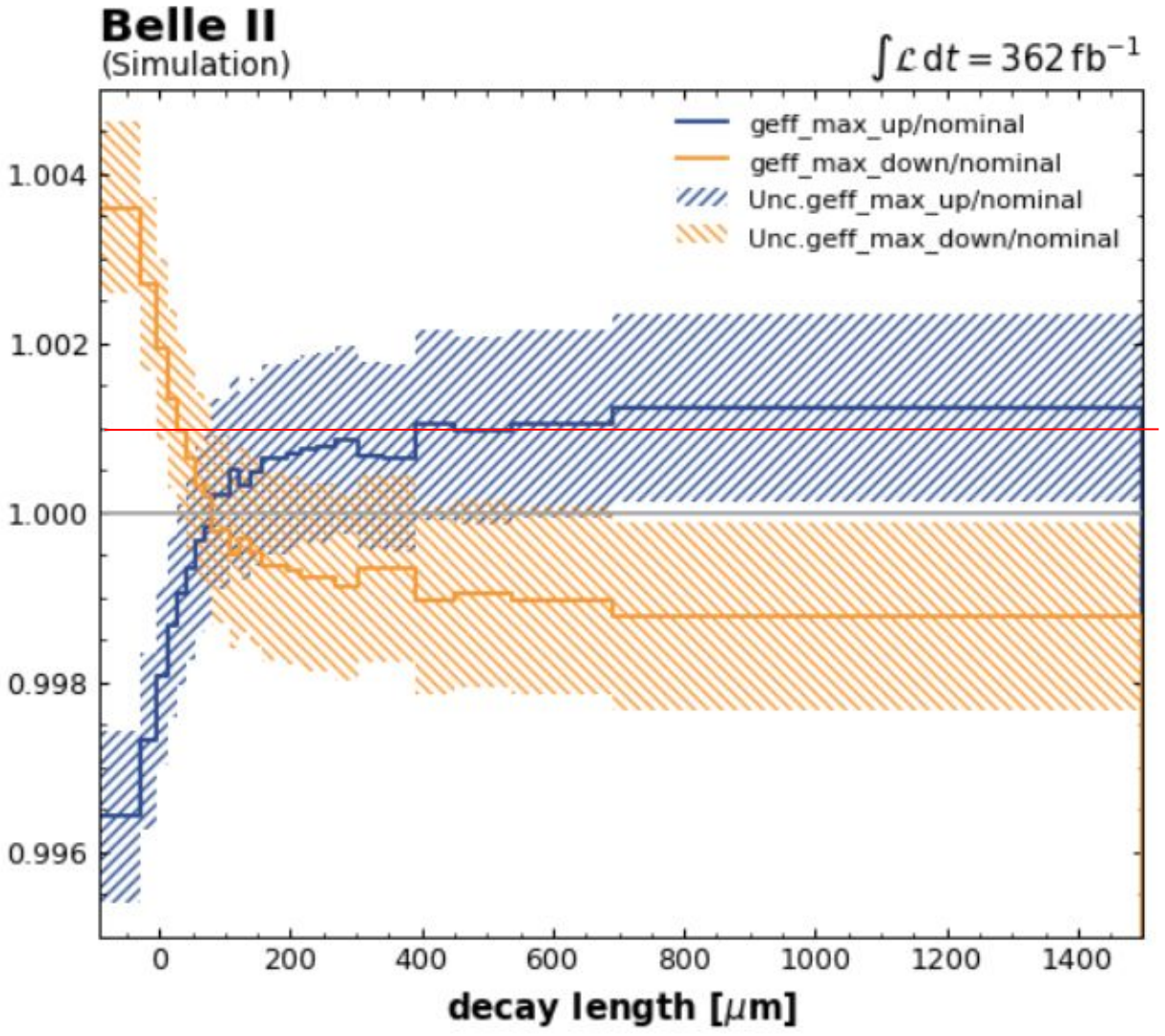
Reweighting



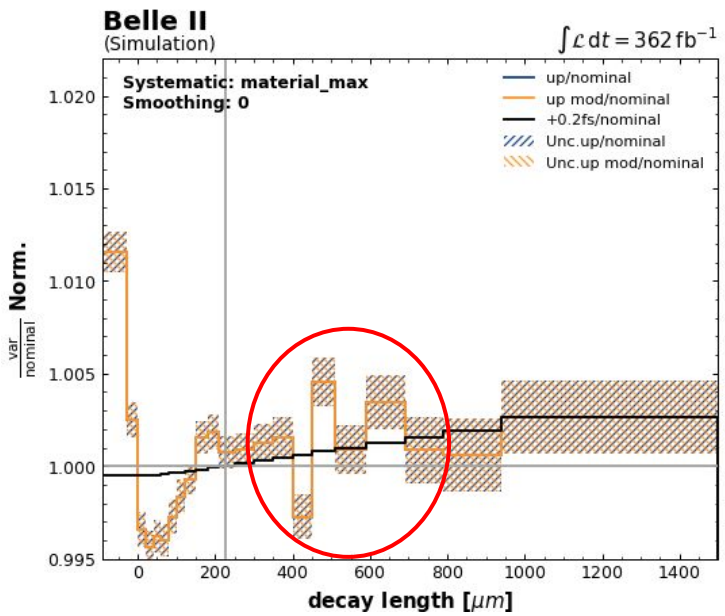


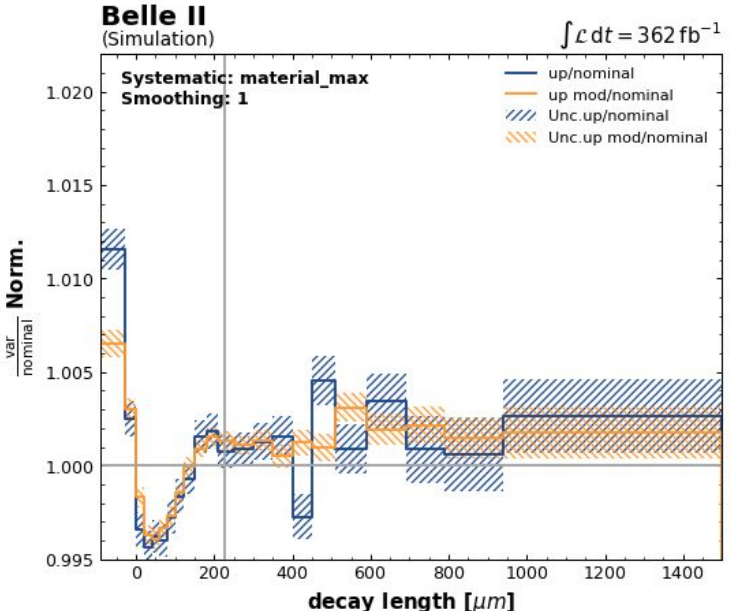
Smoothing on photon efficiency

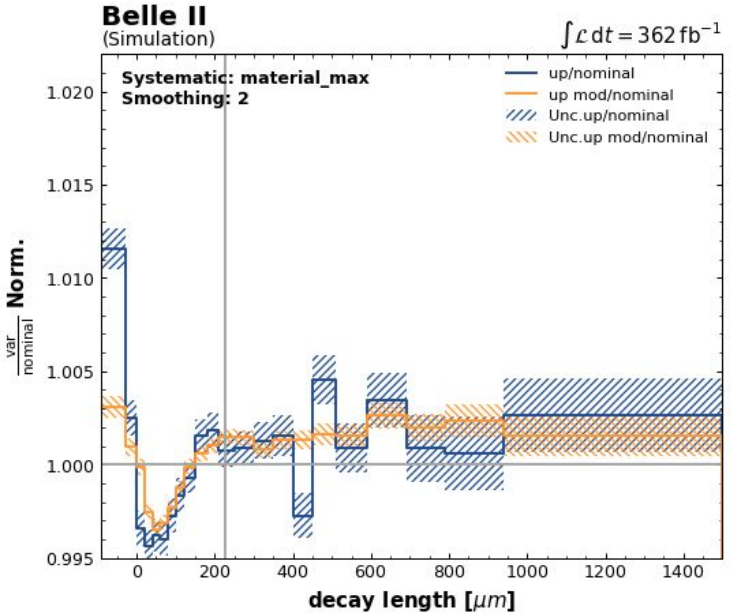


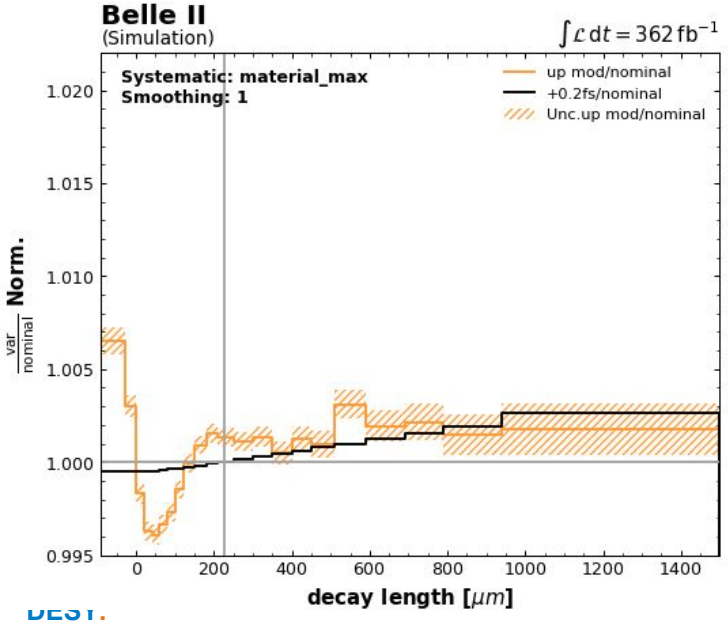


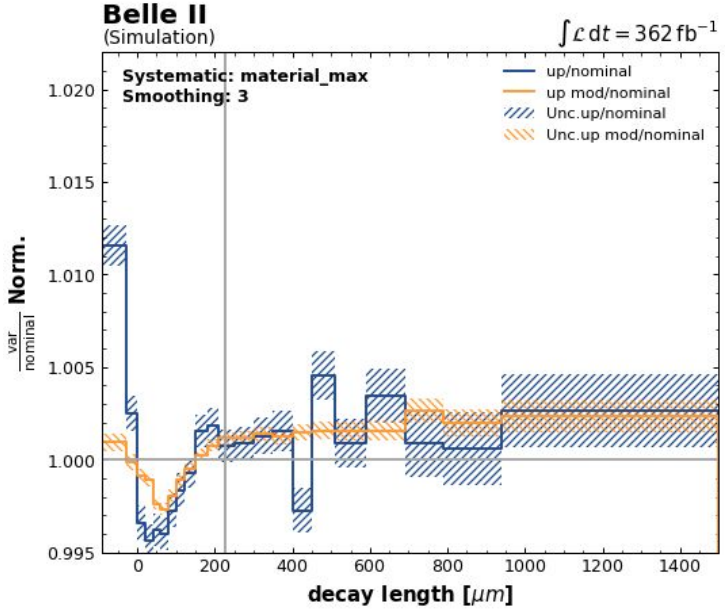
Material budget

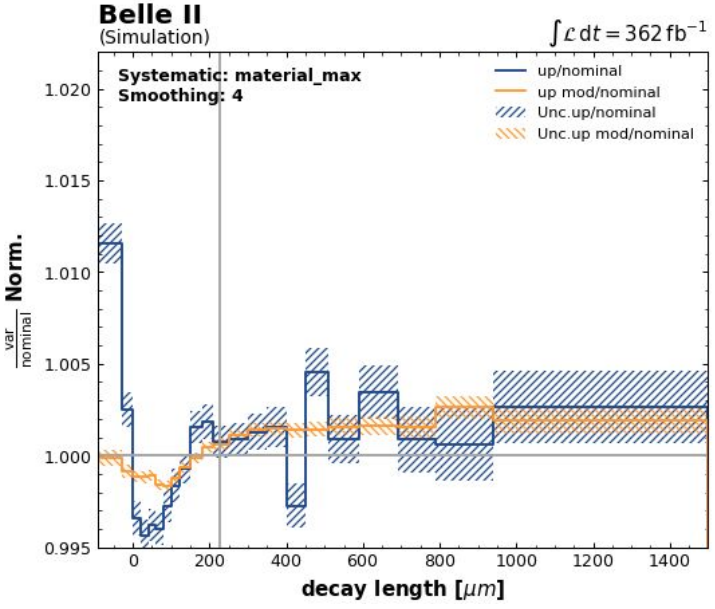




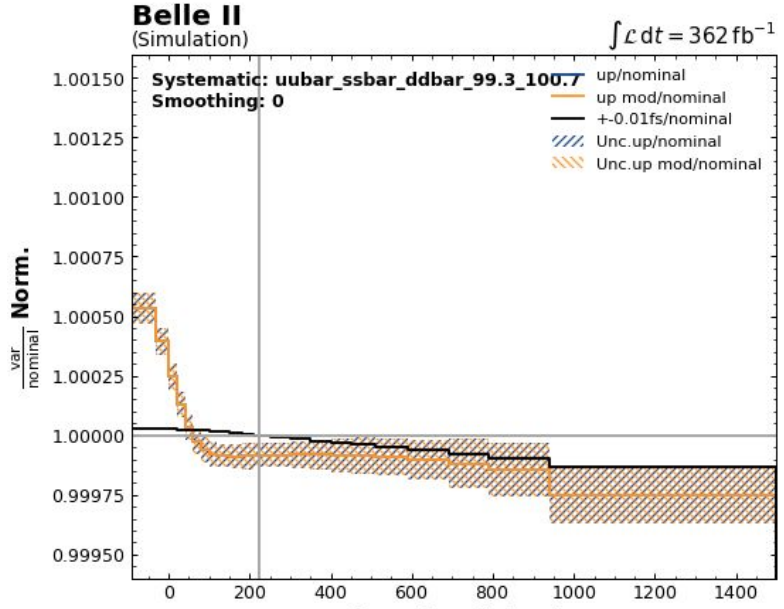


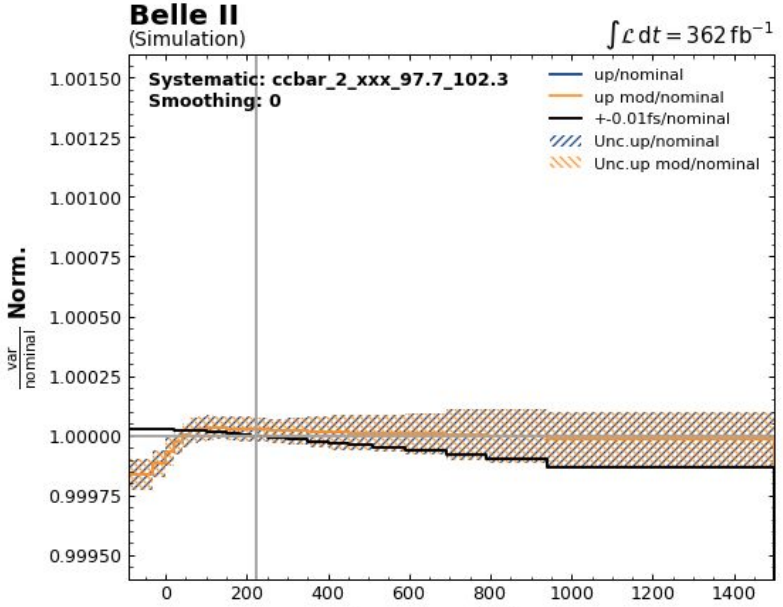


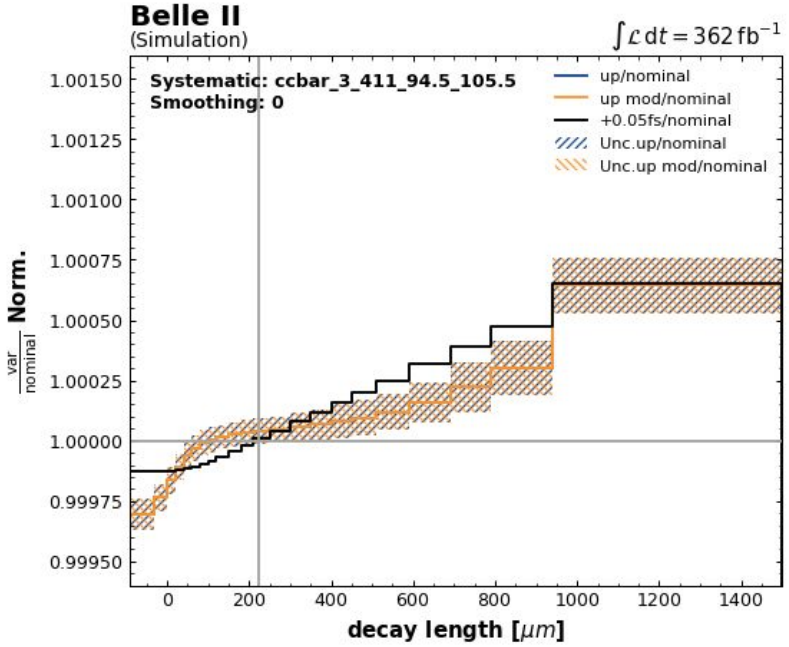


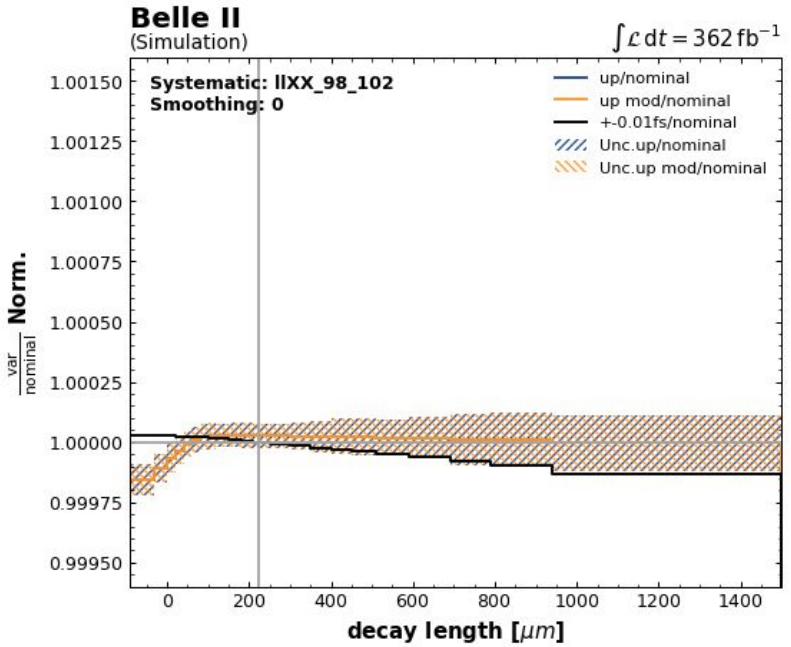


Bkg contribution

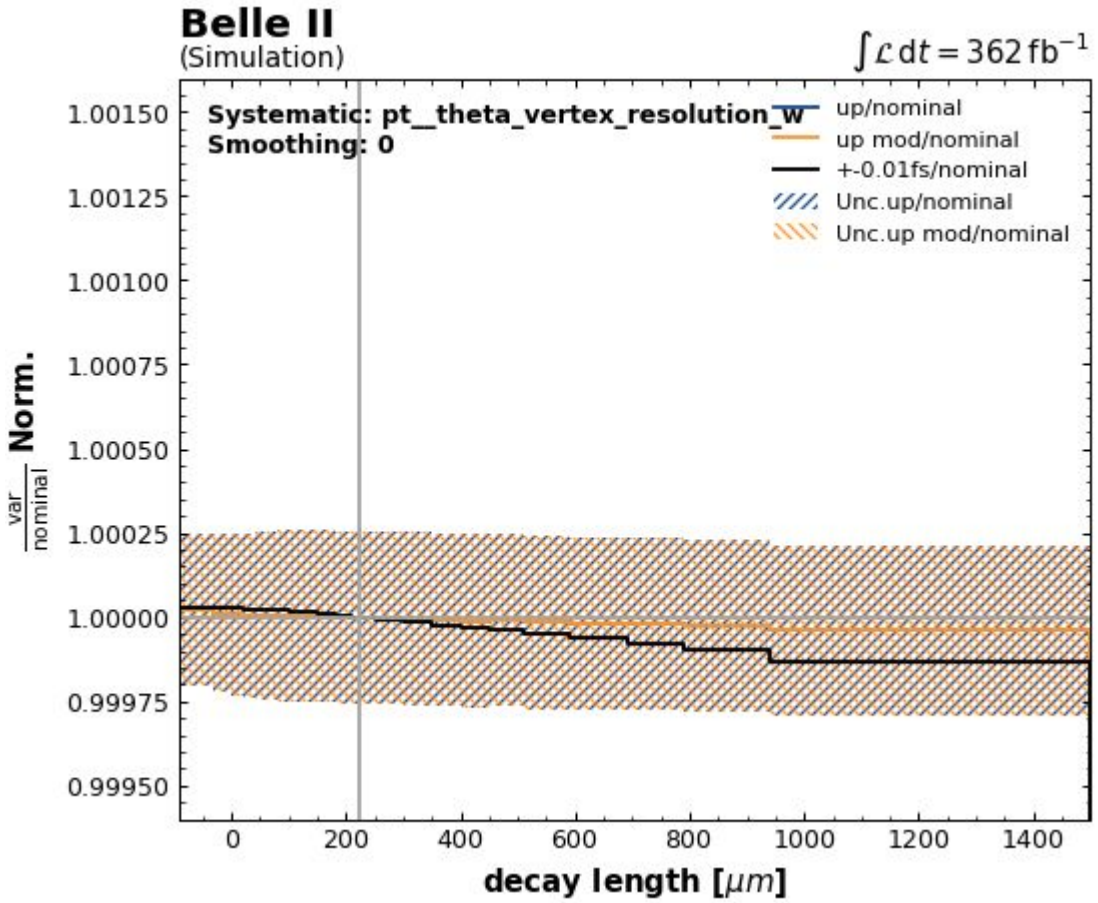






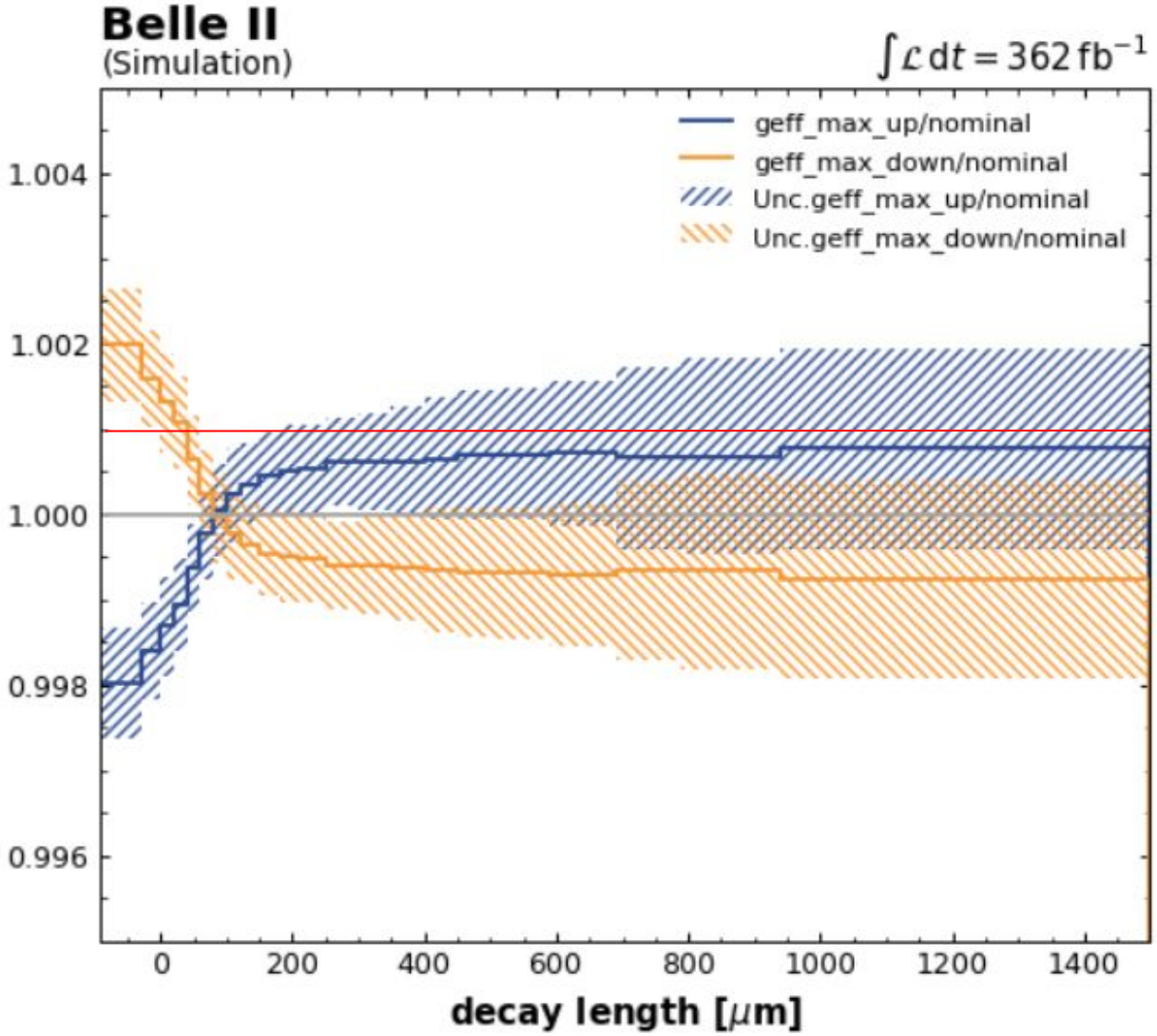


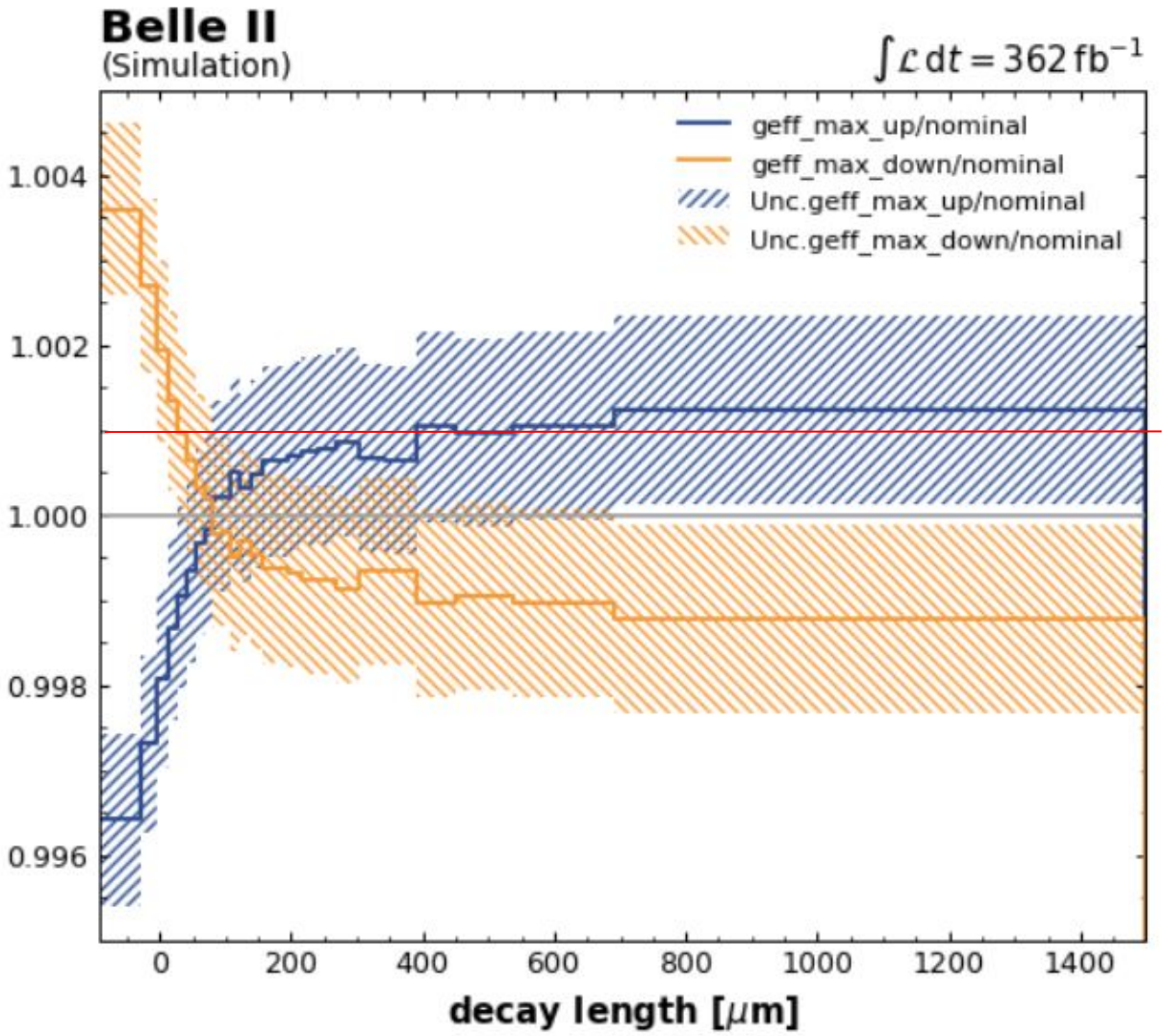
Vertex resolution



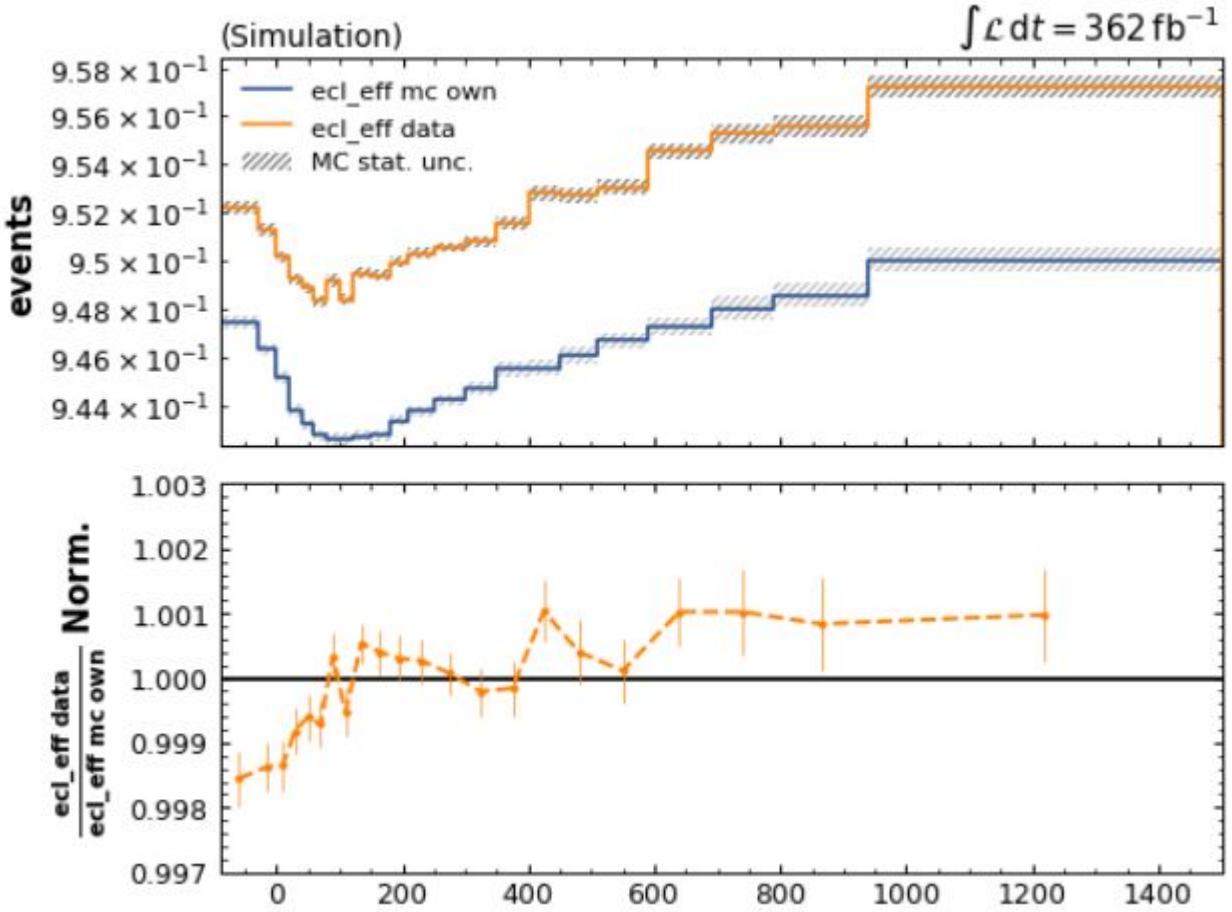
Results old

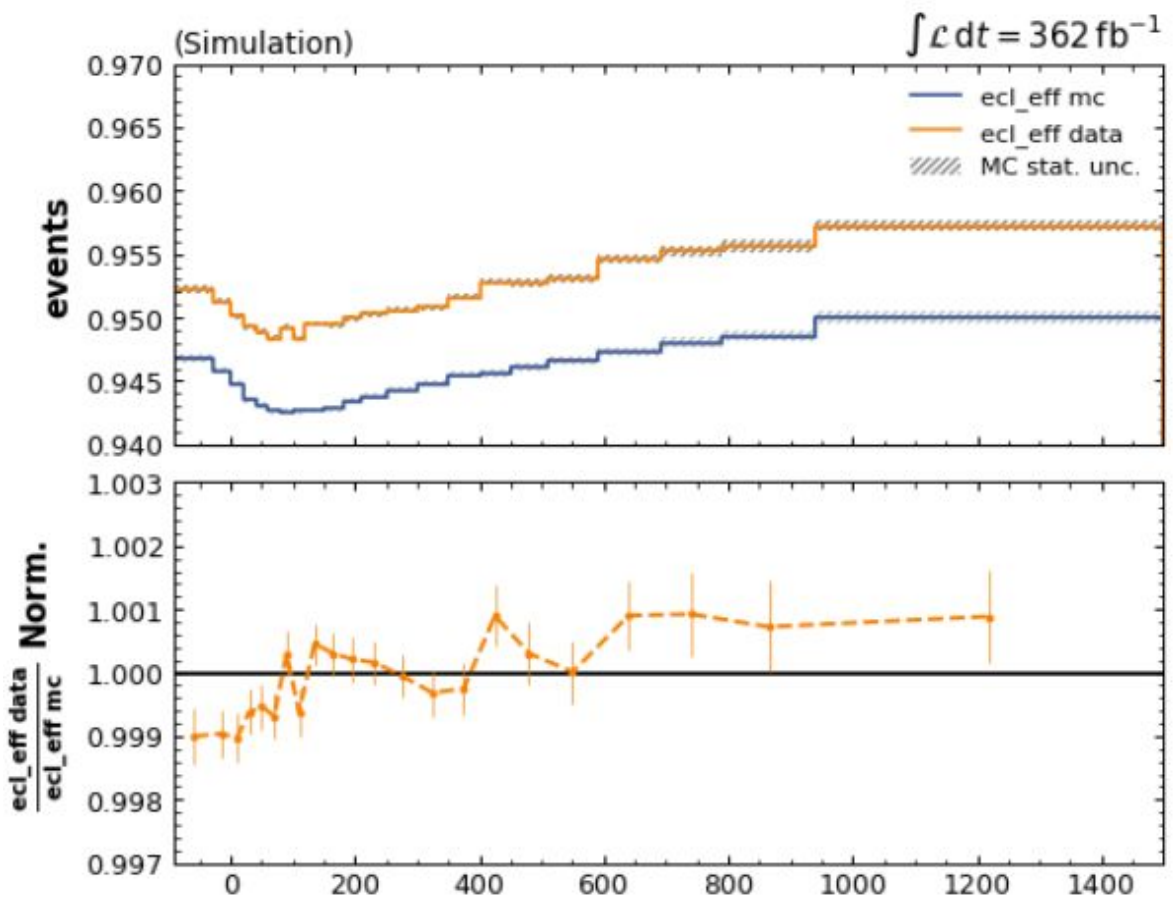
	no smoothing	default	all smoothing +1	all smoothing +2	all smoothing +3
group	unc.	unc.	unc.	unc.	unc.
total	**0.14**	**0.15**	**0.15**	**0.16**	**0.18**
data statistic	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
total systematic	**0.11**	**0.12**	**0.13**	**0.14**	**0.16**
MC statistic	**0.06**	**0.06**	**0.06**	**0.07**	**0.07**
reweighting	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**
bkg contribution	**0.03**	**0.03**	**0.03**	**0.04**	**0.04**
qq_{usd}	<0.01	<0.01	0.02	<0.01	<0.01
ccbar 2_xxx	<0.01	<0.01	<0.01	<0.01	<0.01
ccbar 3_411	0.03	0.03	0.03	0.04	0.04
llXX	<0.01	<0.01	<0.01	<0.01	<0.01
material budget	**0.00**	**0.02**	**0.05**	**0.08**	**0.10**
photon eff.	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
trigger eff.	**0.04**	**0.05**	**0.05**	**0.05**	**0.04**
misalignment	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**
other	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**


Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
geff_max_up/nominal
geff_max_down/nominal
Unc.geff_max_up/nominal
Unc.geff_max_down/nominal
1.004
1.002
1.000
0.998
0.996
0
200
400
600
800
1000
1200
1400
decay length [μm]

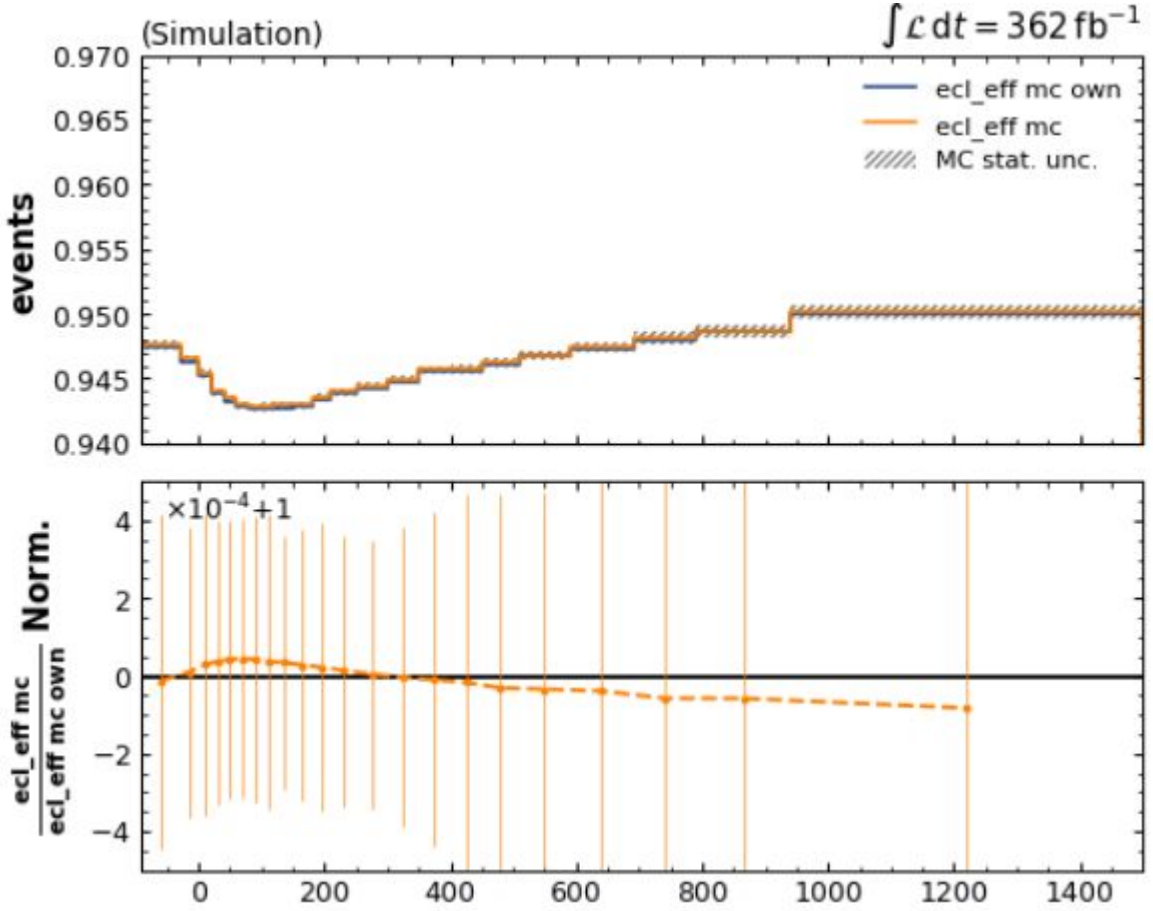

Belle II
(Simulation)
$\int \mathcal{L}\,dt = 362\,\mathrm{fb}^{-1}$
geff_max_up/nominal
geff_max_down/nominal
Unc.geff_max_up/nominal
Unc.geff_max_down/nominal
1.004
1.002
1.000
0.998
0.996
0
200
400
600
800
1000
1200
1400
decay length [μm]

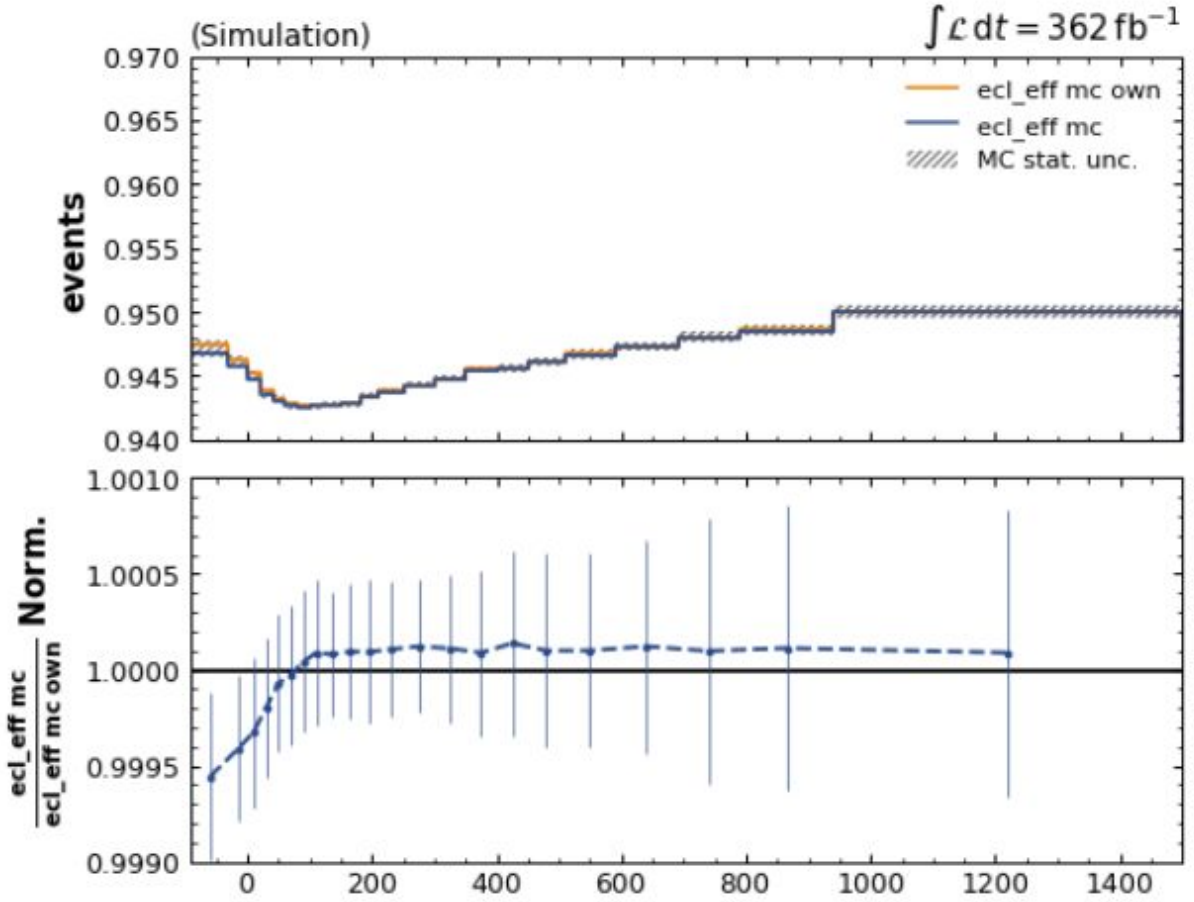
Trigger systematic mc scaling



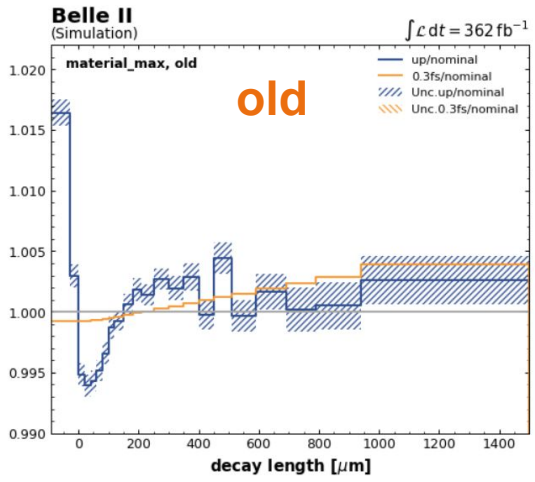


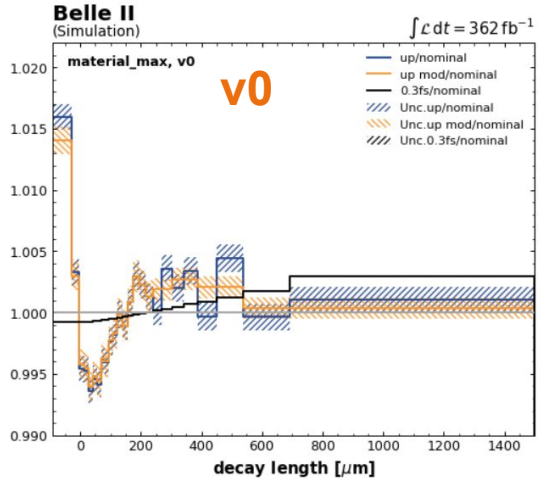
Trigger systematic mc comparison

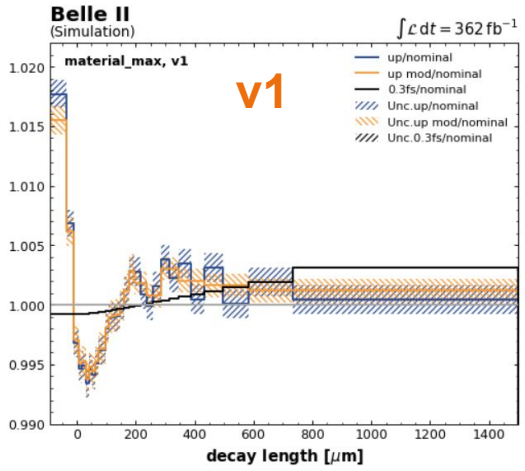


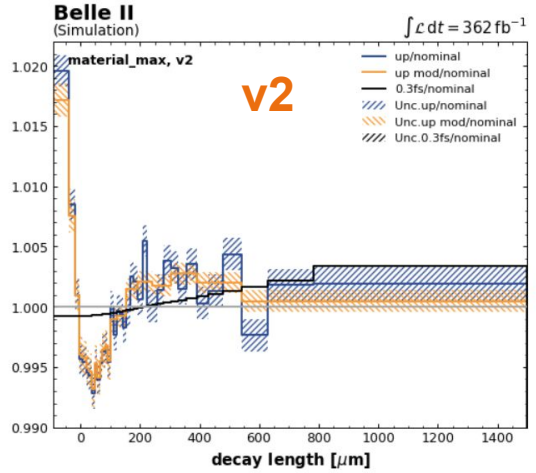


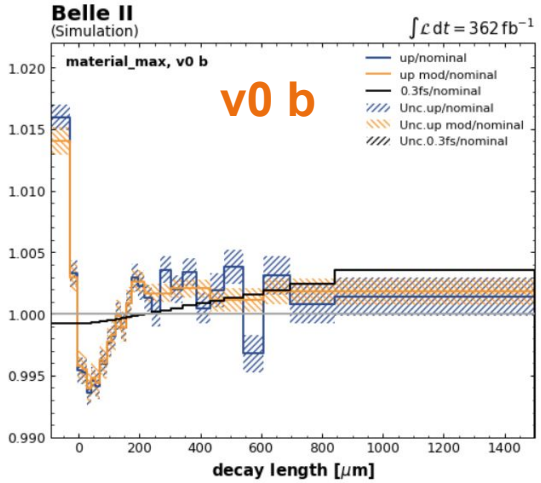
Material with manipulation

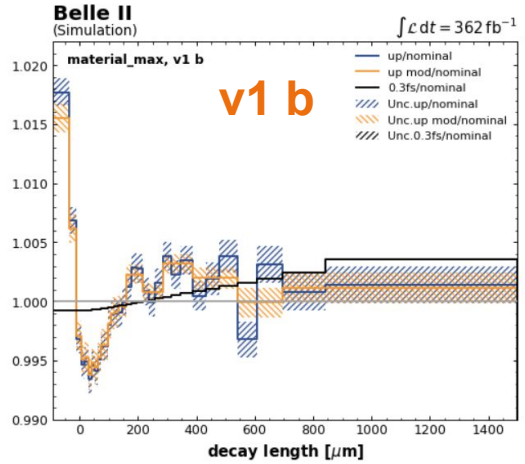


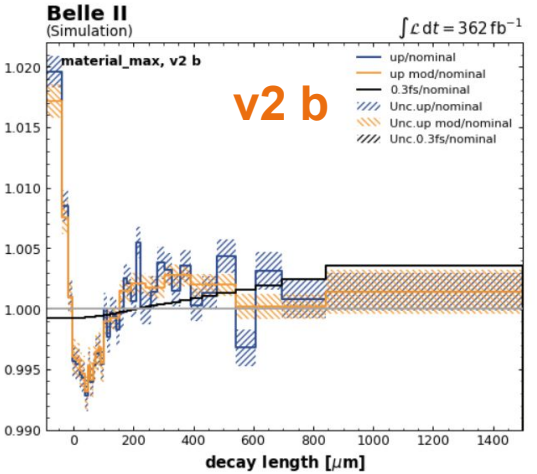












- Smoothing with 3 bins removes some features of the shape (Esp. for material budget)
- Shape gets closer to alternative lifetime shape -> Increases impact of systematic ?