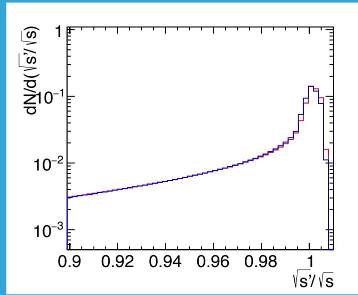
OUTLINE

UNCERTAINTY ON THE CLIC LUMINOSITY SPECTRUM

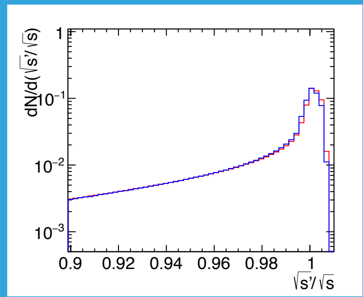


WHAT IS THE IMPACT ON PHYSICS(*)?

(*) HERE BY PHYSICS WE MEAN THE TOP MASS MEASUREMENT FROM RADIATIVE EVENTS BUT I AM WILLING TO SEE IT THROUGH MORE ANALYSIS

OUTLINE

UNCERTAINTY ON THE CLIC LUMINOSITY SPECTRUM

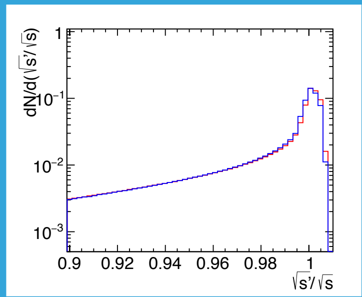


WHAT IS THE IMPACT ON PHYSICS(*)?

IN ORDER TO DETERMINE THE LUMINOSITY SPECTRUM YOU NEED A GUESS (MATHEMATICAL MODEL) AND A DETECTOR SIMULATION
(PLUS DATA – BHABHA SCATTERING – BUT NOT COVERED YET)

OUTLINE

UNCERTAINTY ON THE CLIC LUMINOSITY SPECTRUM



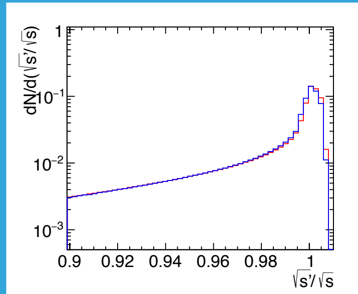
WHAT IS THE IMPACT ON PHYSICS?

ASSUMING IMPERFECT GUESS ON THE LUMINOSITY SPECTRUM BUT PERFECT SIMULATION OF THE DETECTOR

1st Part of the talk : study made by Pablo Gomis who apologies for not being here and I am presenting it in his behalf

OUTLINE

UNCERTAINTY ON THE CLIC LUMINOSITY SPECTRUM



WHAT IS THE IMPACT ON PHYSICS?

ASSUMING A PERFECT GUESS ON THE LUMINOSITY SPECTRUM BUT IMPERFECT SIMULATION OF THE DETECTOR

2nd Part of the talk : study made by Philipp Zehetner as part of his Summer Student project that Pablo propagated to the top mass uncertainty

CLIC DETECTOR AND PHYSICS 2018

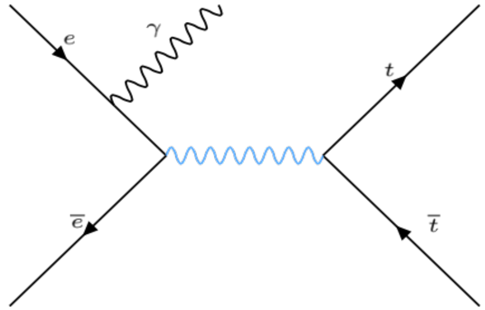
TOP MASS MEASUREMENT FROM RADIATIVE EVENTS

M. BORONAT*, E. FULLANA*, J. FUSTER*, I. GARCÍA*, P. GOMIS*, A. H. HOANG°, V. MATEU+, M. PERELLÓ*, E. ROS*, M. A. VILLAREJO*, M. VOS*, A. WIDL°

* IFIC (UNIVERSITAT DE VALÈNCIA/CSIC)
+ UNIVERSIDAD DE SALAMANCA
° UNIVERSITÄT WIEN

WITH MUCH APPRECIATED CONTRIBUTIONS FROM A. SAILER

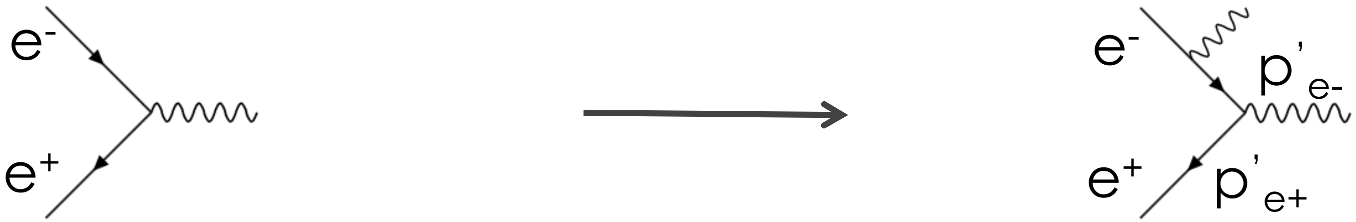
- The idea is to measure the top-quark mass (m_t) measuring the differential cross section of the process $e^+e^- \rightarrow t\,\bar{t}\,\gamma_{\rm ISR}$.



- The $t\,\bar{t}$ production cross section is sensitive to the center of mass energy and m_t:

$$\sigma(e^+e^- \rightarrow t\bar{t}) = f(s, m_t)$$

$$\sigma(e^+e^- \rightarrow t\bar{t}\gamma) = f(s', m_t)$$



$$s = (p_{e^-} + p_{e^+})^2$$

$$s' = (p'_{e^-} + p'_{e^+})^2$$

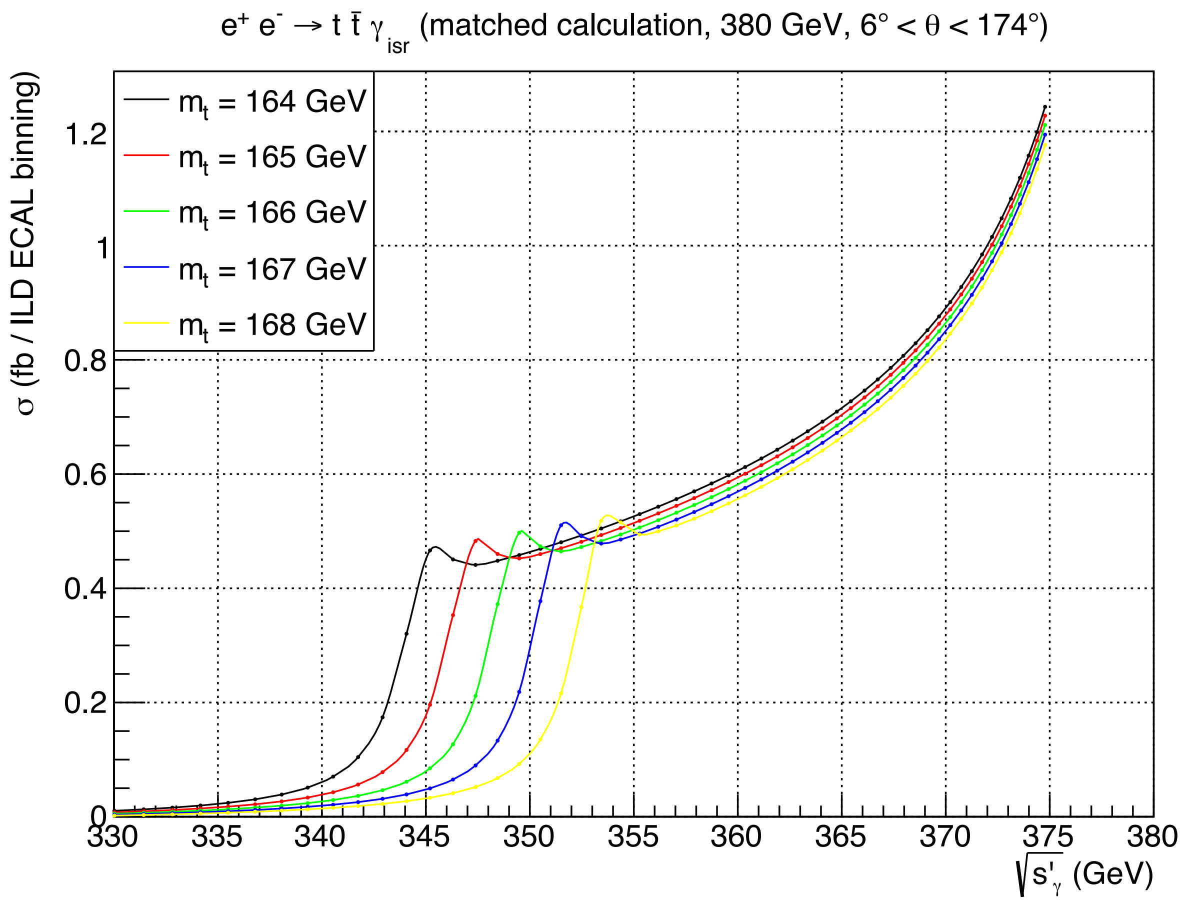
- The emitted $\gamma_{\rm ISR}$ reduces the available phase space for the $t\,\bar{t}$ production.
- Therefore the $t\,\bar{t}\,\gamma_{\rm ISR}$ production cross section is sensitive to the emitted ISR photon energy.

INTRODUCTION TO THE OBSERVABLE

- m_t can be measured by counting the $t\bar{t}$ events produced for a certain s' (i.e ISR energy photon):

$$s' = s\left(1 - \frac{2E_\gamma}{\sqrt{s}}\right)$$

- Our observable is the differential cross section of the $t\bar{t}$ production as a function of $\sqrt{s'}$.



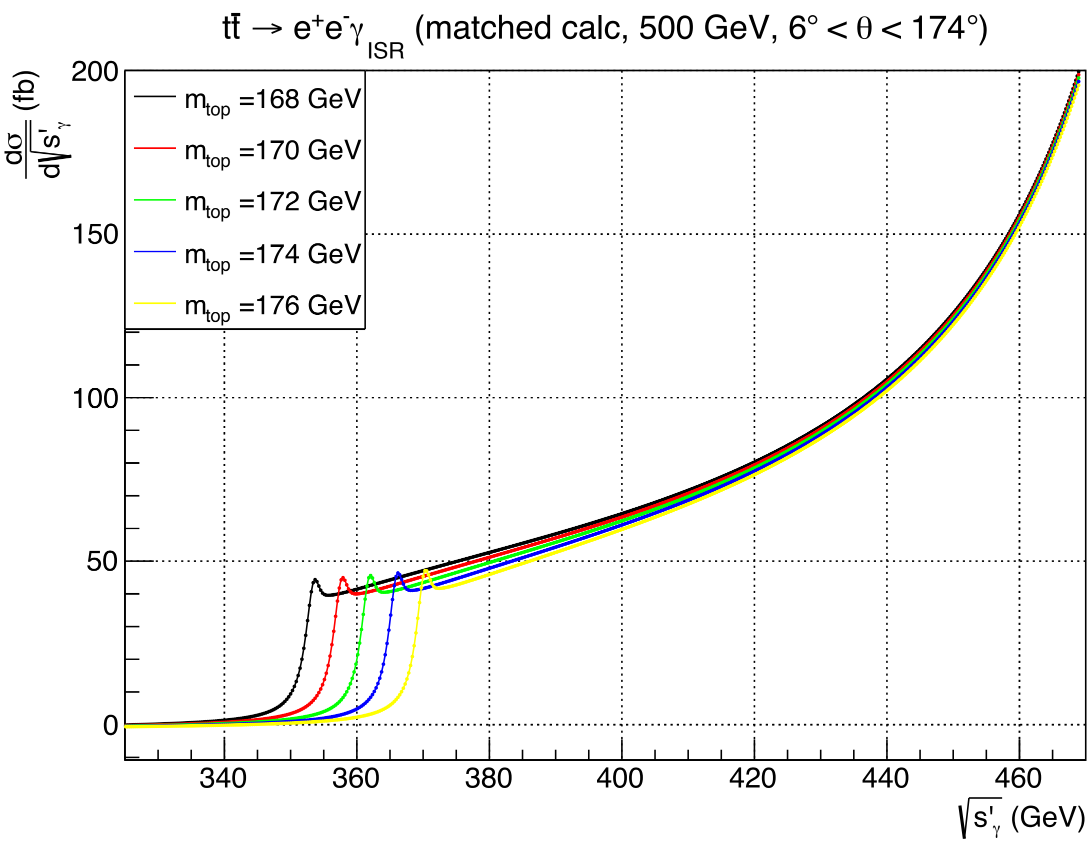
- The observable is more sensitive to m_t near the top production threshold, and the dependence diminishes as $\sqrt{s'}$ grows.

THEORETICAL MATCHED CALCULATION

- A factorization theorem valid at $O(\alpha_{QED})$ and to all orders in α_s (beyond perturbation theory) has been stablished by A. H. Hoang and V. Mateu in which the observable can be calculated analytically:

$$\sigma_{t\bar{t}\gamma_{ISR}}(m_t, s') = \sigma_{ISR}(E_\gamma) * \sigma_{t\bar{t}}(m_t, s')$$

- The model convolutes the ISR calculation with the threshold - continuum matched calculation by A. H. Hoang et al.
- The model outputs the differential cross section of the $e^+e^- \rightarrow t\,\bar{t}\,\gamma_{\rm ISR}$ as a function of the photon energy and polar angle respect to the head-on collision, for a given top mass.



- For more information and details on the matched calculation:

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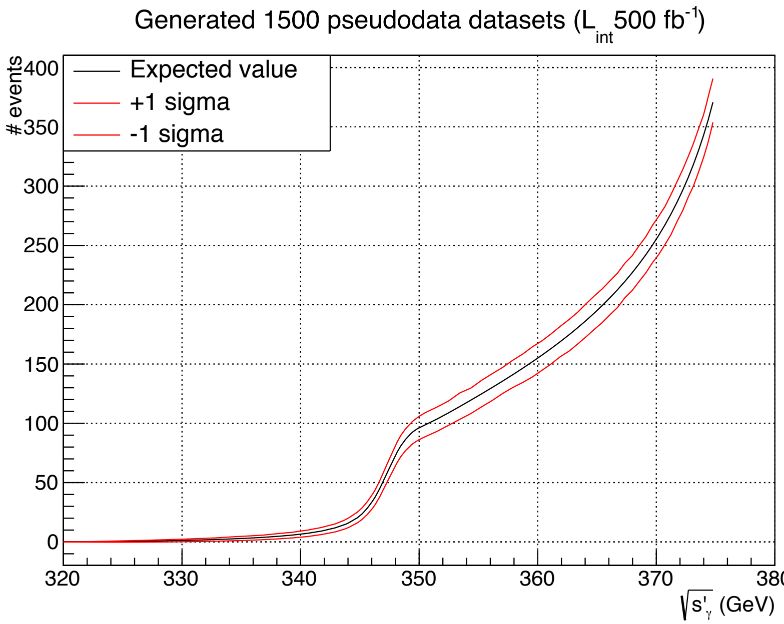
- The input mass can be chosen to be any short-distance mass scheme, in this case we chose the $\overline{\rm MS}$ scheme. For the calculation itself the 1S and MSR masses are used.

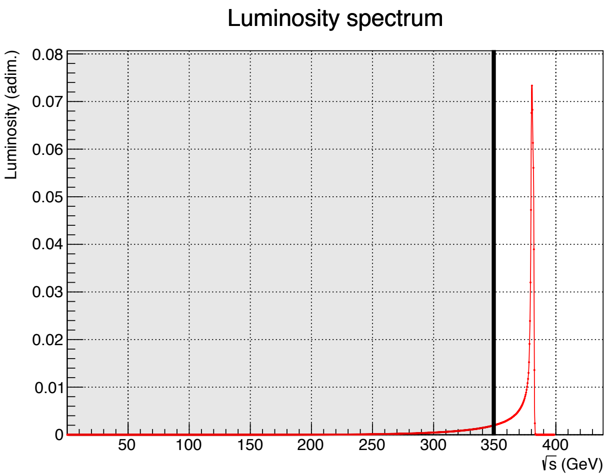
UNCERTAINTY ON THE TOP MASS (STATISTICS)

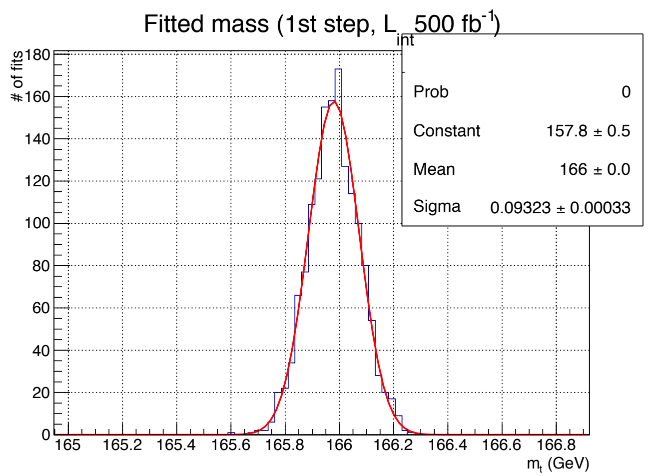
- Propagation of the statistical uncertainty into the top mass though pseudo experiments
- The Luminosity spectrum is propagated into the observable though a weighted sum
- Shift of ~30MeV when you include the Luminosity Spectrum in the observable

	6° < θ < 174°	8° < θ < 172°	10° < θ < 170°
CLIC Spectrum @ 500 fb^{-1}	75MeV (50MeV w/o)	93 MeV (60 MeV w/o.	104 MeV (65 MeV w/o. s.)



- Part of this loss in sensitivity is due to a loss of statistics (ttbar threshold acceptance). The other part, concerns the change in the shape due to bin migrations.
- Work in progress: by taking into account the correlations between these bins we expect to improve the sensitivity prospect.

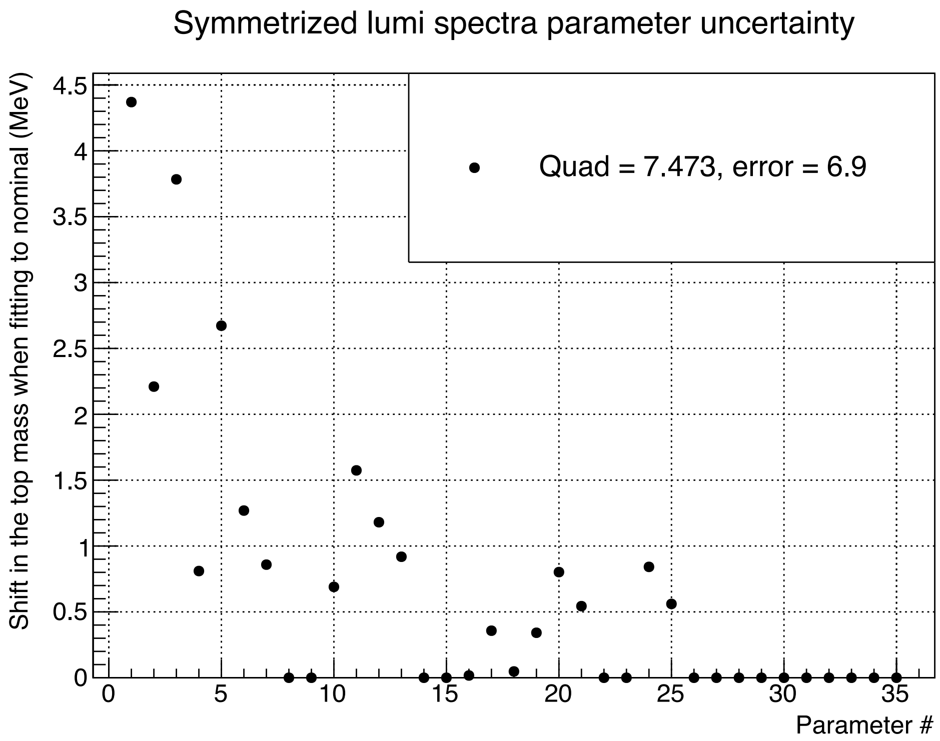




PROPAGATION OF THE UNCERTAINTY ON THE LUMINOSITY SPECTRUM INTO THE TOP MASS

- To estimate the effect of the luminosity spectrum uncertainty in our study we propagate the error from its 19 free parameters.
- Using the 19 parameter errors from the luminosity spectrum reconstruction we generate 38 (19 parameters x 2 σ up, σ down) spectrums.
- We weight the spectrums with the observable and we fit it to the model weighted with the “nominal” reconstruction.

- The propagated error for each parameter is taken as the symmetrisation (σ up, σ down) of the mass shifts obtained through the fits.
- The total uncertainty is found by performing $E = E_p \, Cov \, E_p^T$.
- We find a total uncertainty of **7 MeV.**



THIS IS THE END OF THE FIRST PART OF THE TALK

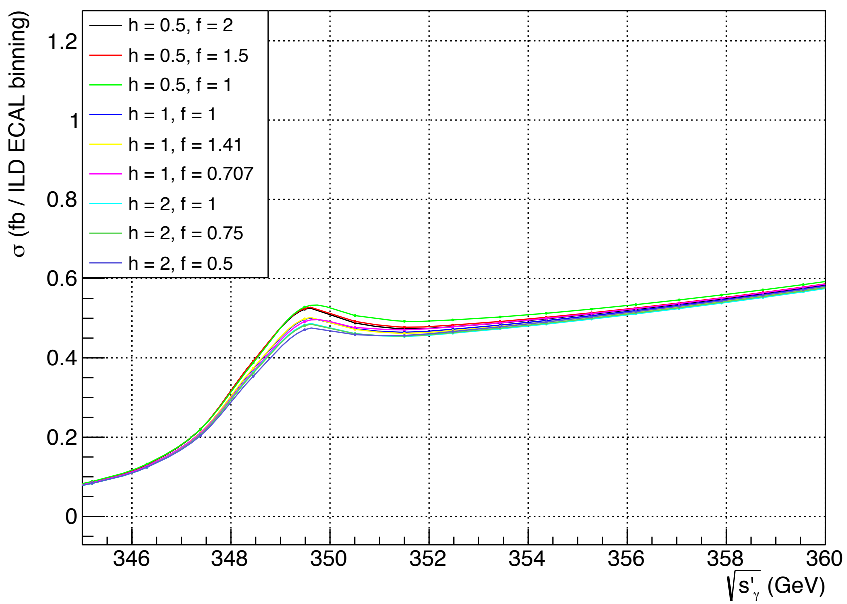
THEORETICAL MODEL UNCERTAINTY

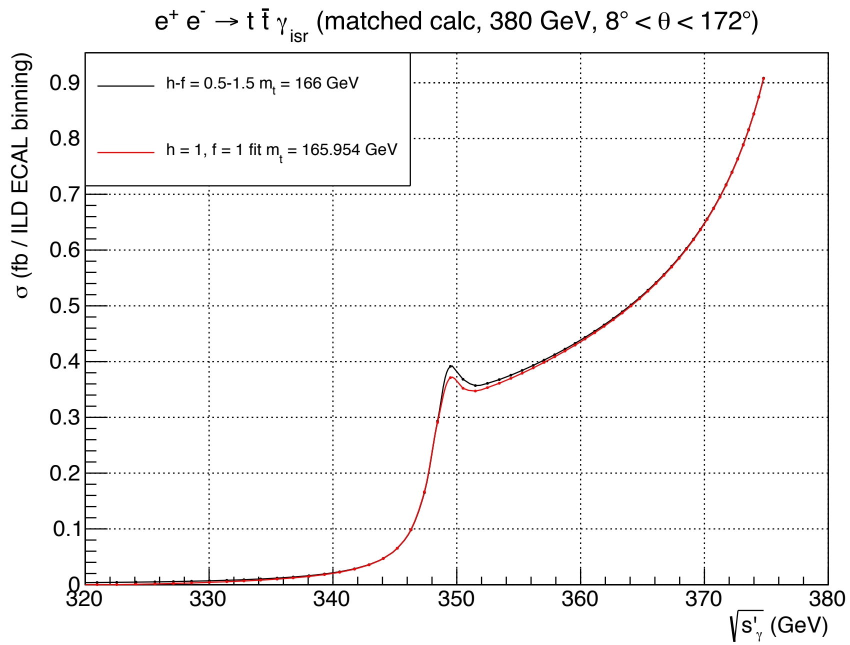
- The main sources of uncertainty in the matched calculation come from the hard, soft and ultra soft scales in the NRQCD calculation, which can be parametrized as a function of the *h* and *f* parameters.

* results for 8° < θ < 172°

Proposed scale parameters variations (A. Hoang , M. Stahlhofen)									
h	1/2	1/2	1/2	1	1	1	2	2	2
f	2	3/2	1	1	√2	√(1/2)	1	3/4	1/2
Δm (MeV) @380 GeV	-44	-46	-43	0	-1	8	29	30	45
Δm (MeV) @500 GeV	-55	-58	-54	0	-2	12	32	34	51

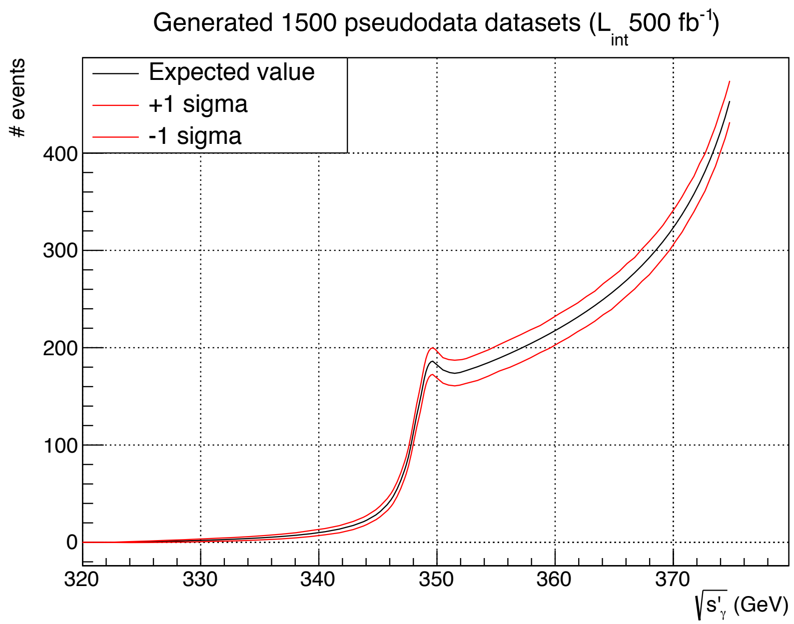
- We evaluate the theoretical uncertainty by fitting the model (at 380/500 GeV, 500 fb^{-1}) with modified scales and a given top mass (166 GeV) to the same model with the nominal scales and with the top mass as a fit parameter.
- The fits lead to an estimation of ~50 MeV theoretical uncertainty for the model at both energies.

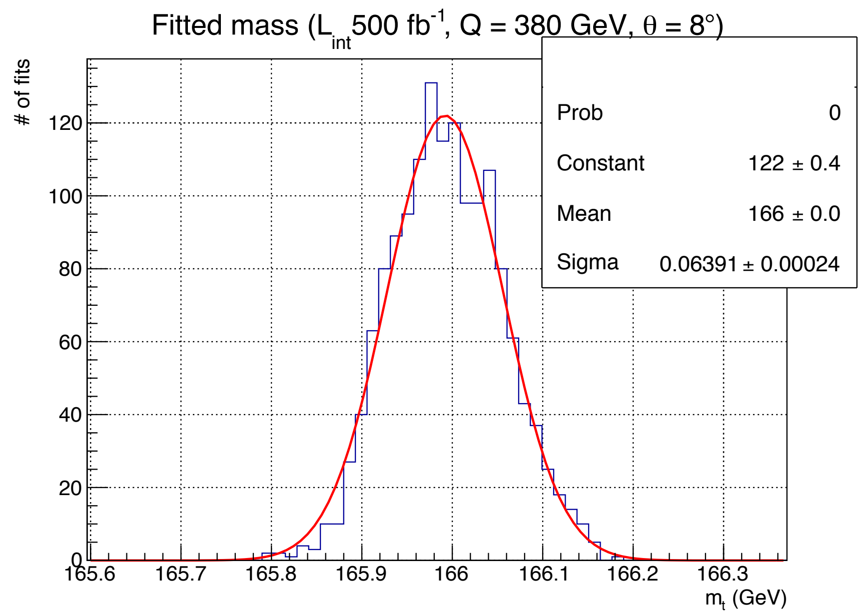




SENSITIVITY TO THE TOP QUARK MASS

- In order to evaluate the sensitivity of the observable to the top mass we generate pseudo data of certain luminosities.
- We assume that the real number of events in that bin will follow a Poisson distribution with a mean equal to the multiplication of the cross section expected for each of the bins by the integrated luminosity.
- By generating thousands of datasets and fitting them to the theoretical model we obtain thousands of values for the mass, which then are used to fill a histogram.
- Then we fit the histogram to a gaussian and we estimate the precision for the mass measurement as its sigma.





SENSITIVITY TO THE TOP QUARK MASS (II)

Considering a detector coverage of 6° < θ < 174°

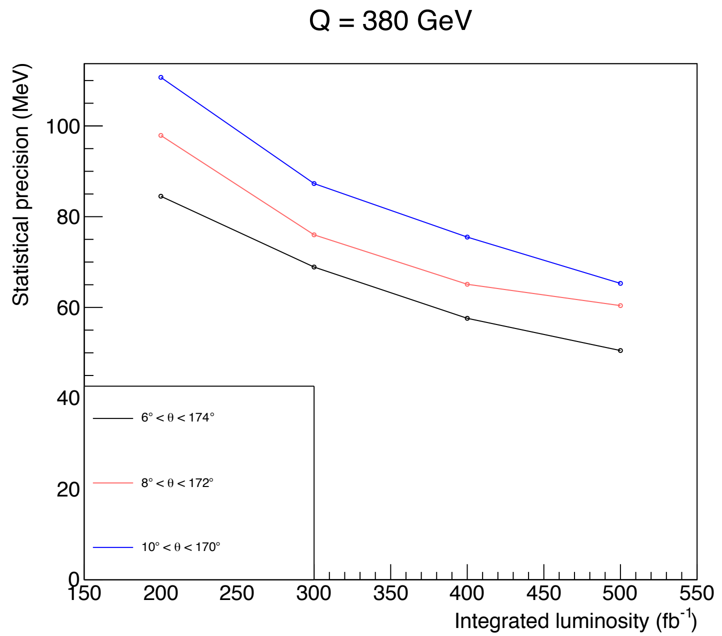
	200 fb^{-1}	500 fb^{-1}	1000 fb^{-1}	4000 fb^{-1}
σ_m (MeV) @380 GeV	85	50		
σ_m (MeV) @500 GeV	247	152	110	56

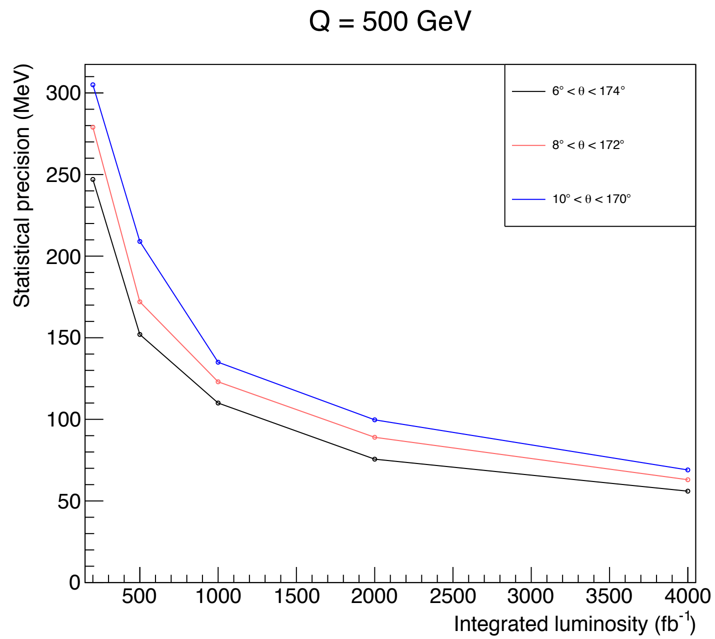
Considering a detector coverage of 8° < θ < 172°

	200 fb^{-1}	500 fb^{-1}	1000 fb^{-1}	4000 fb^{-1}
σ_m (MeV) @380 GeV	98	60		
σ_m (MeV) @500 GeV	279	172	123	63

Considering a detector coverage of 10° < θ < 170°

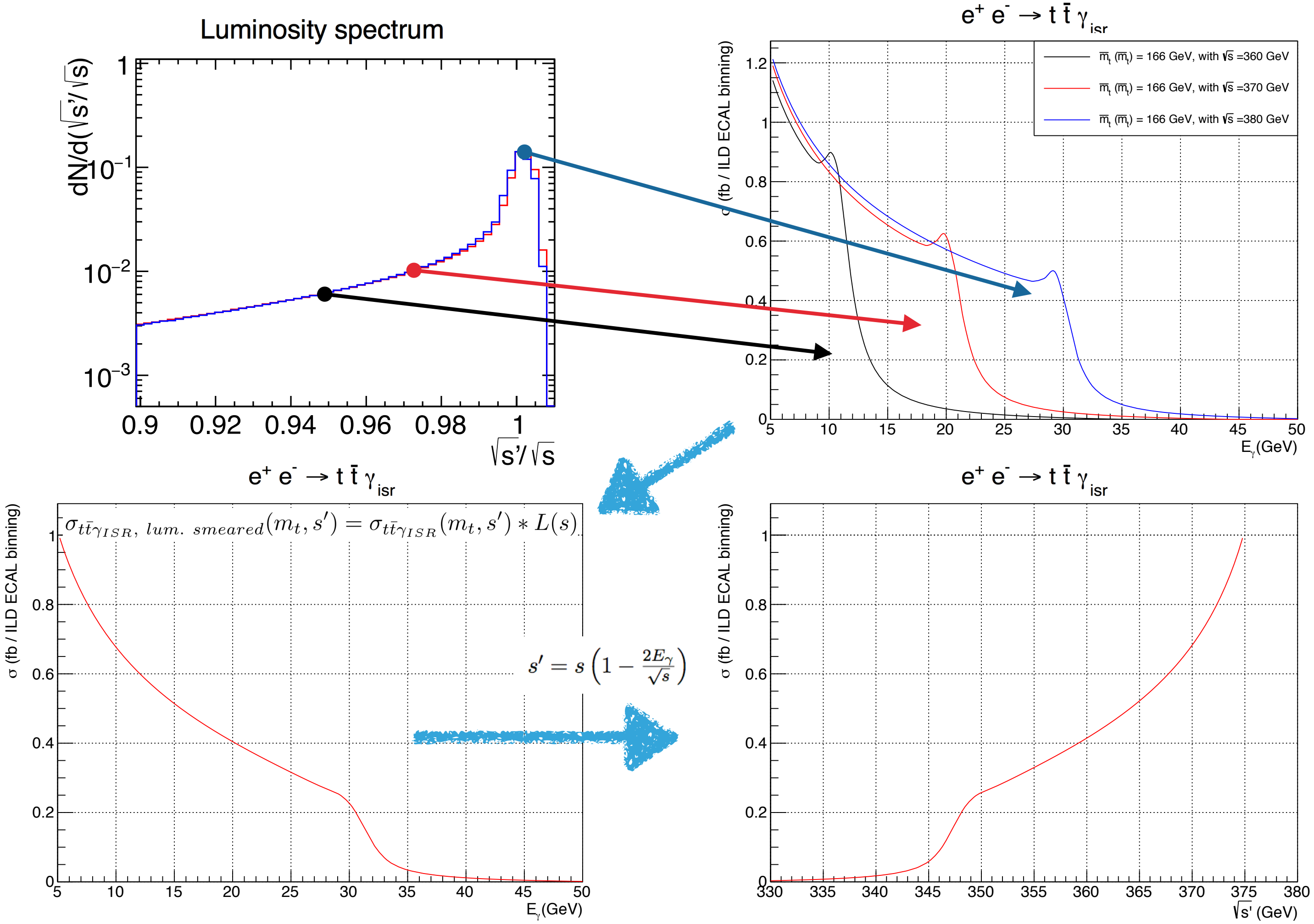
	200 fb^{-1}	500 fb^{-1}	1000 fb^{-1}	4000 fb^{-1}
σ_m (MeV) @380 GeV	111	65		
σ_m (MeV) @500 GeV	305	209	135	69





LUMINOSITY SPECTRUM WEIGHTING

- In the experiment, *s* isn't fixed to 380 GeV, but instead, it has a spectrum. To account for that, we fold our model with the luminosity spectrum.



- We weight our observable distributions of a given Q with the luminosity spectrum.