Top mass measurement using B hadron decay length

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Outline

- Method description
- Analysis details
- Results
- Background contributions
- Top mass sensitivity
- Systematic effects
- Conclusions

Method description

- Method proposed by C.S Hill, J. R. Incandela and J. M.Lamb
  (University of California Santa Barbara - **hep-ex/0501043**)
- B quark momentum
  sensitive gauge for the top quark mass measurement
- top mass direct measurement through the b jet energy
  jet energy scale uncertainty
- top mass measurement
  based on charged track reconstruction by
  correlating the B hadron decay length to the top mass (mass estimator)
- B hadron decay length
  average (transverse) distance of the displaced vertices of the b hadrons
- Various systematics uncertainties
  factors affecting both top quark momentum and b hadron decay length,
  light jet mistagging, tracking performance, background etc.

Analysis details

Dileptonic decay channel

- From reduced background and combinatorics more efficient track and secondary vertex reconstruction expected
- Disadvantage:
  Branching ratio only ~5%
  (400K ttbar events per year @ L= 10 fb^{-1})
- Only electrons and muons considered

Initial phase of analysis

- Private production of 20K ttbar events (PYTHIA)
- Settings following basic configuration from Rome dataset details
- Athena Release 10.0.1
- PYTHIA v. 6.2
- Top quark constrained in W decay to e/mu only

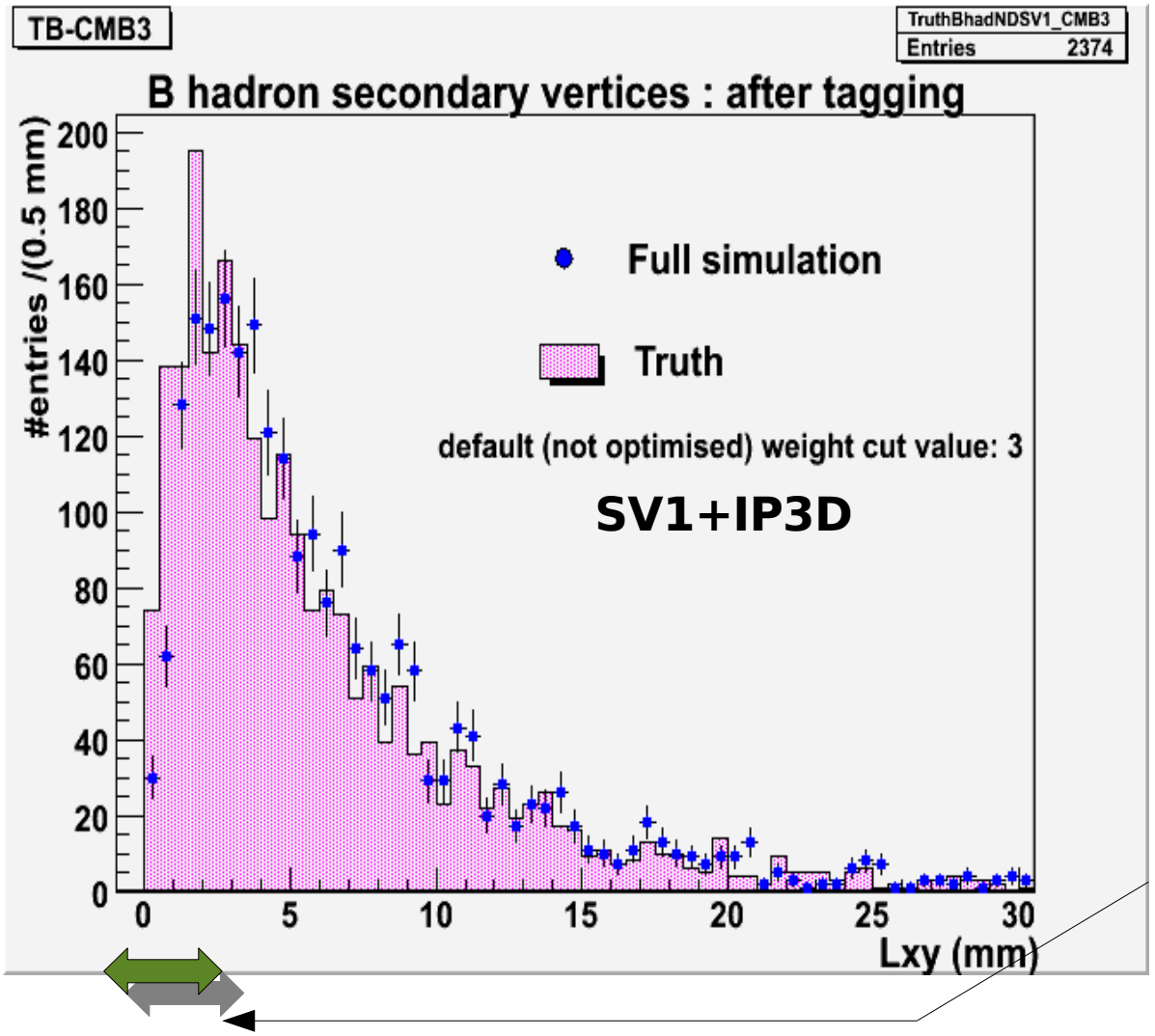
Current datasets

- ~ 15K ttbar with TopRex
- Athena Release 11.0.41

Event selection

- Initially cut selection soft (avoiding biasing effects)
- At least 2 leptons with Pt > 25 GeV && |Eta| < 2.5
- 'isEM' condition + EtCone20 < 10. GeV for electrons
- No more than 4 neighbouring tracks (pt> 5GeV/c) to leptons
- Lepton pair Z boson VETO (Δm=2 GeV)
- 2 highest Pt leptons having opposite charge (reordering allowed)
- Jets with Pt> 15 GeV && |Eta|<2.1
- Pt_{mis} > 40 GeV
- b-tagging algorithms with not optimised weight cut
- [For the b-signal study] b jets match a B hadron (R-cone =0.3)]

B hadron decay length



- **Lepton pt reorder: 5.8%**
- **Lepton truth match: 93.4%** correctly to a truth W boson as a mother particle
- **b jets efficiency : 45.6 %** (#tag b-jets / # b-labelled jets)
- **Decay vtx: VkalVrt algorithm - SV1 tagger** (while with Athena rel. 10.0.1 SVBU tagging algorithm was used)
- **Low length range:** probably deviation due to negative values of decay length

Background: Diboson samples

Preliminary study on background contribution using Rome datasets :

- WW [rome.004130.recov10.McAtNlo_WW_Jim_leplep] @ 30K
- ZW^+ [rome.004135.recov10.McAtNlo_ZW+_Jim_leplep] @ 27K
- ZW^- [rome.004134.recov10.McAtNlo_ZW-_Jim_leplep] @ 6K
- ZZ [rome.004160.recov10.McAtNlo_ZZ_Jim_leplep] @ 20K

Lower statistics: only **one** boson constrained to decay decaying leptonically

$\sigma_{WW\text{-->leplep}}$	=	**12.0 ± 0.17 pb**
$\sigma_{ZZ\text{-->leplep}}$	=	**0.5 ± 0.01 pb**
$\sigma_{ZW^+\text{--> leplep}}$	=	**7.1 ± 0.09 pb**
$\sigma_{ZW^-\text{-->leplep}}$	=	**4.4 ± 0.04 pb**
$\sigma_{tt\text{->leplep}}$	=	**22.0 ± 0.15 pb**

Results

	WW	ZZ	ZW-	ZW+
Total Event Number in dataset.....	28975	19220	6231	26777
Dibosons decay-->leplep (effective).....	**6273**	**1157**	**1302**	**5937**
2 High Pt leptons	2028	858	790	3393
Lepton pair Z peak veto.....	1980	453	552	2290
Opposite charge leptons.....	1665	293	326	1369
Jets passing Pt/Eta cut.....	2022	520	526	2107
TAGGING				
[Likelihood > 0.9]	49	12	15	59
[Weight > 3]				
IP2D	67	19	21	63
IP3D	72	16	23	61
SV1+IP3D.....	65	12	18	51
LF2D	21	8	11	25
# Events expected at 10 fb^{-1}(1 b jet,@ least)	**1241**	**56**	**605**	**607**
Nb ttbar Events expected at 10 fb^{-1}		**200K - 300 K**		

Higher background contribution from diboson samples

Drell-Yan

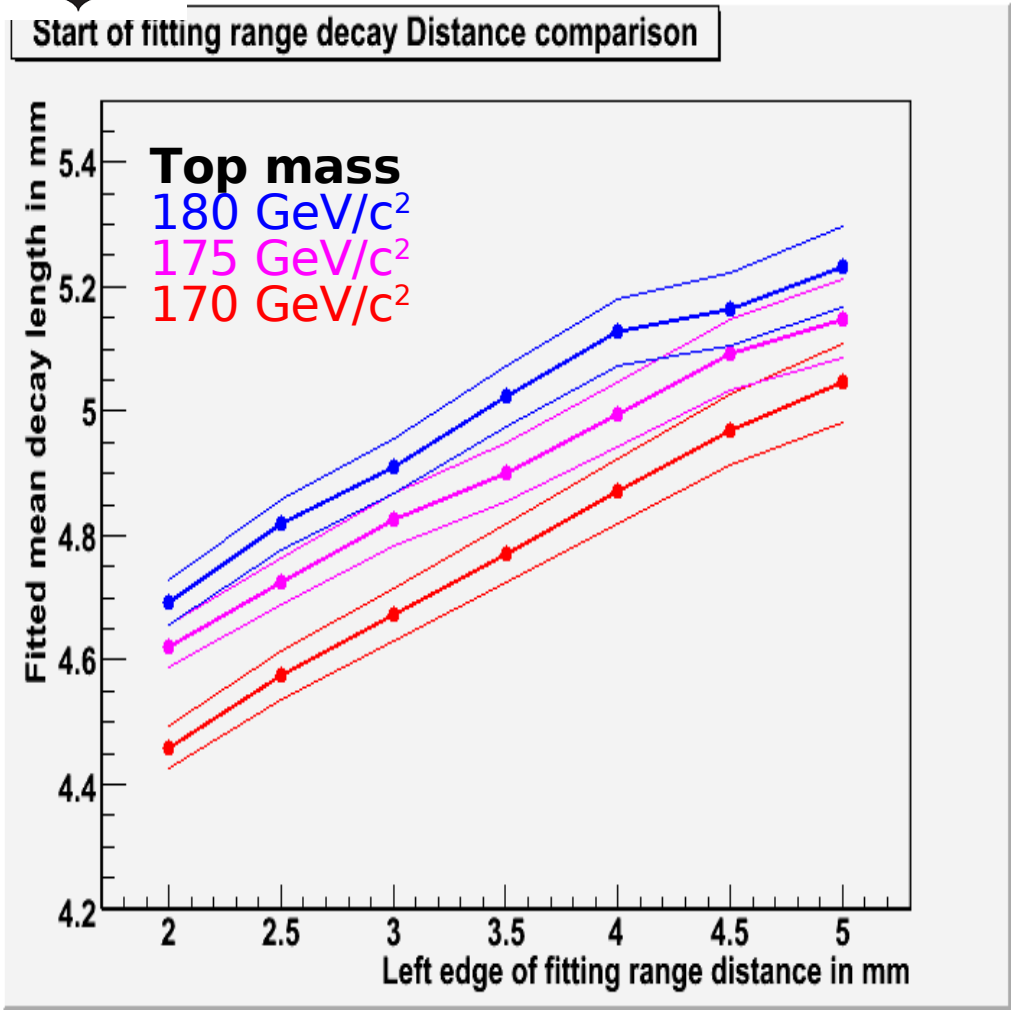
In Athena rel. 11.0.41 the next csc datasets are analyzed:

csc11.005110.JimmyZeeLowM.recon.AOD.v11004107
csc11.005112.JimmyZeeHighM.recon.AOD.v11004107
csc11.005191.JimmyZmumuRadiative.recon.AOD.v11004205
csc11.005141.JimmyZmumu.recon.AOD.v11004204 (previous analysis)

Dataset	Int Lum.(pb^{-1})	#Events	Norm @ L= 10 fb^{-1}	%
5110	165.6	29K	664	<<1
5112	12.7	10K	787	<<1
5191	**65.4**	**7K**	**4961**	**1.5**
5141	*77.7*	*46K*	*9402*	*2.9*

The most 'dangerous' Drell-Yan dataset : Z/γ* ---> μμ

Top mass sensitivity



- Results from previous work: (Athena rel. 11.0.41)
- TOPREX/PYTHIA - Fast Simulation 125K events
- top mass range (175 ± 5 GeV)
- Variation left edge of the fit range
- Fitting function : pure exponential
- Fairly good sensitivity of the top mass independently of the start point
- Unfortunately this introduce another systematic uncertainty to control and minimize

B hadron lifetime {i}

Four most frequent B hadron flavors considered: **B^0** , **$B^{\pm}$** , **B_s** and Λ_b^0

		B^0	$B^{\pm}$	B_s^0	Λ_b^0
Lifetime (ps)		1.536	1.671	1.461	1.229
Uncertainty on lifetime (ps)		0.014	0.018	0.057	0.080
Correction factor $1\pm(\Delta\tau/\tau)$		+: 1.009 -: 0.991	+: 1.011 -: 0.989	+: 1.039 -: 0.961	+:1.065 -: 0.935
Mass (MeV)		5279.4	5279.0	5369.6	5624.0
Mass value	*B entries*	Specific hadron's entries in sample (% rel. contribution)			
170 GeV	***97.6 %*** *of 105138*	41158 (**39.1**)	41293 (**39.3**)	12491 (**11.9**)	7696 (**7.3**)
175 GeV	***97.6 %*** *of 106441*	41774 (**39.2**)	41657 (**39.1**)	12758 (**12.0**)	7748 (**7.3**)
180 GeV	***97.6 %*** *of 107859*	42241 (**39.1**)	42407 (**39.3**)	12863 (**11.9**)	7868 (**7.3**)

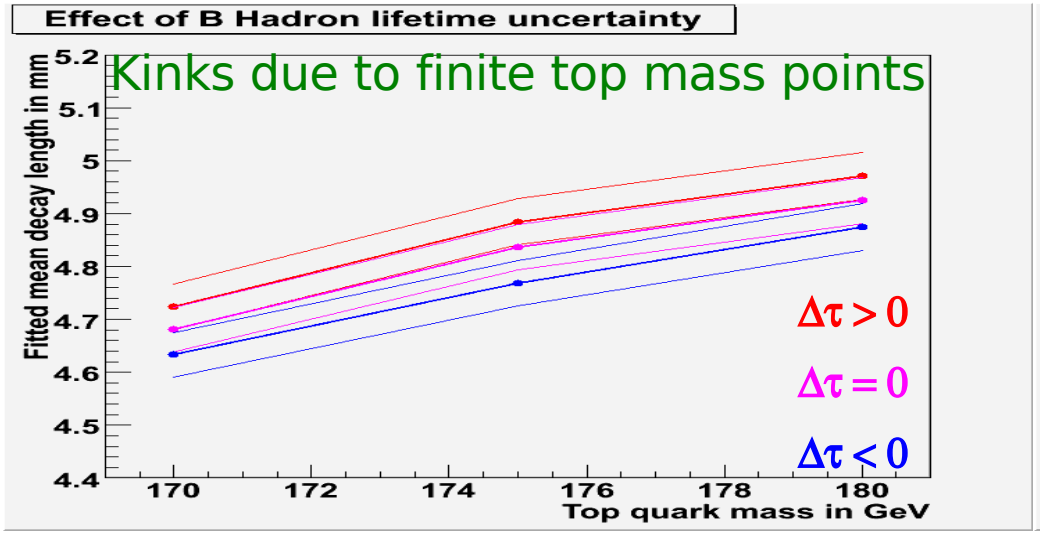
Study on the effect of a correlated variation on the B hadron lifetime to the top mass sensitivity

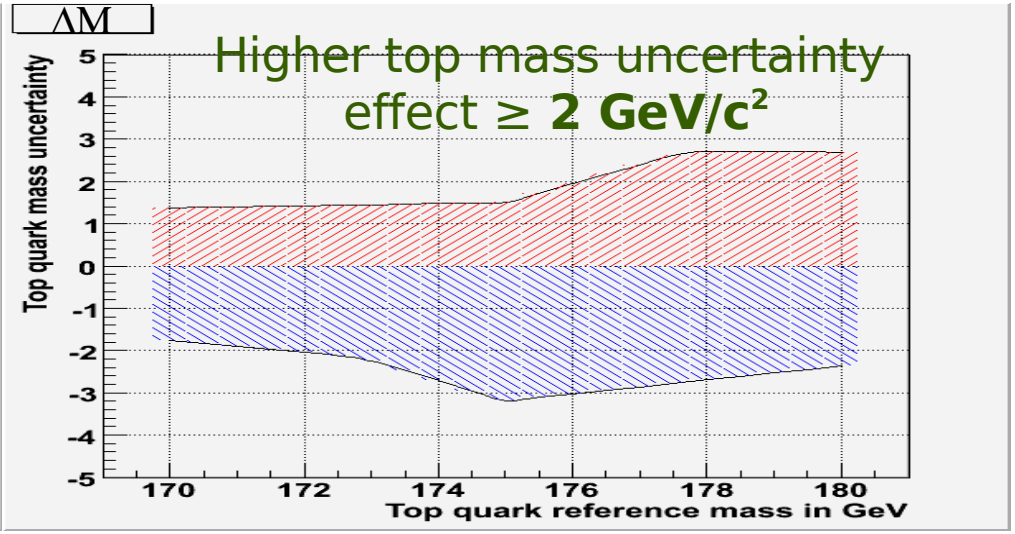
B hadron lifetime variation in 2 ways with use of :

- Individual B hadron's τ
- Average B hadron lifetime (ADMIXTURE MEAN LIFE-PDG)

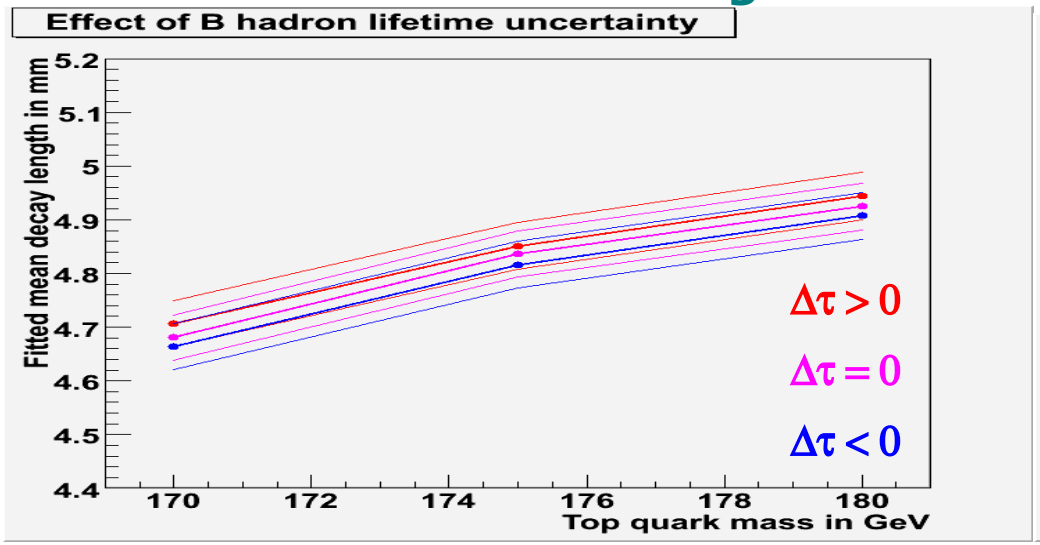
B hadron lifetime {ii}

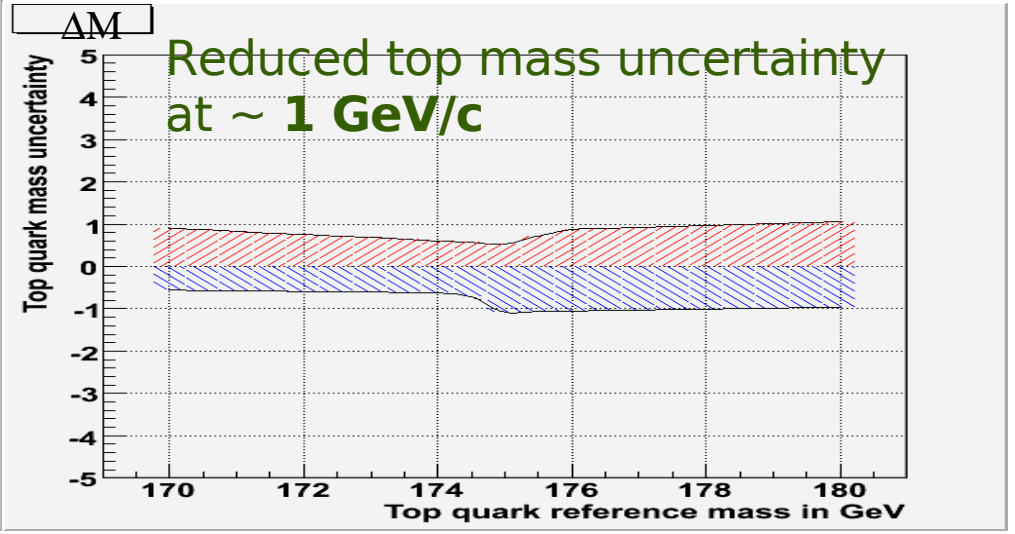
Pessimistic scenario : distinct B hadron flavor lifetime variation



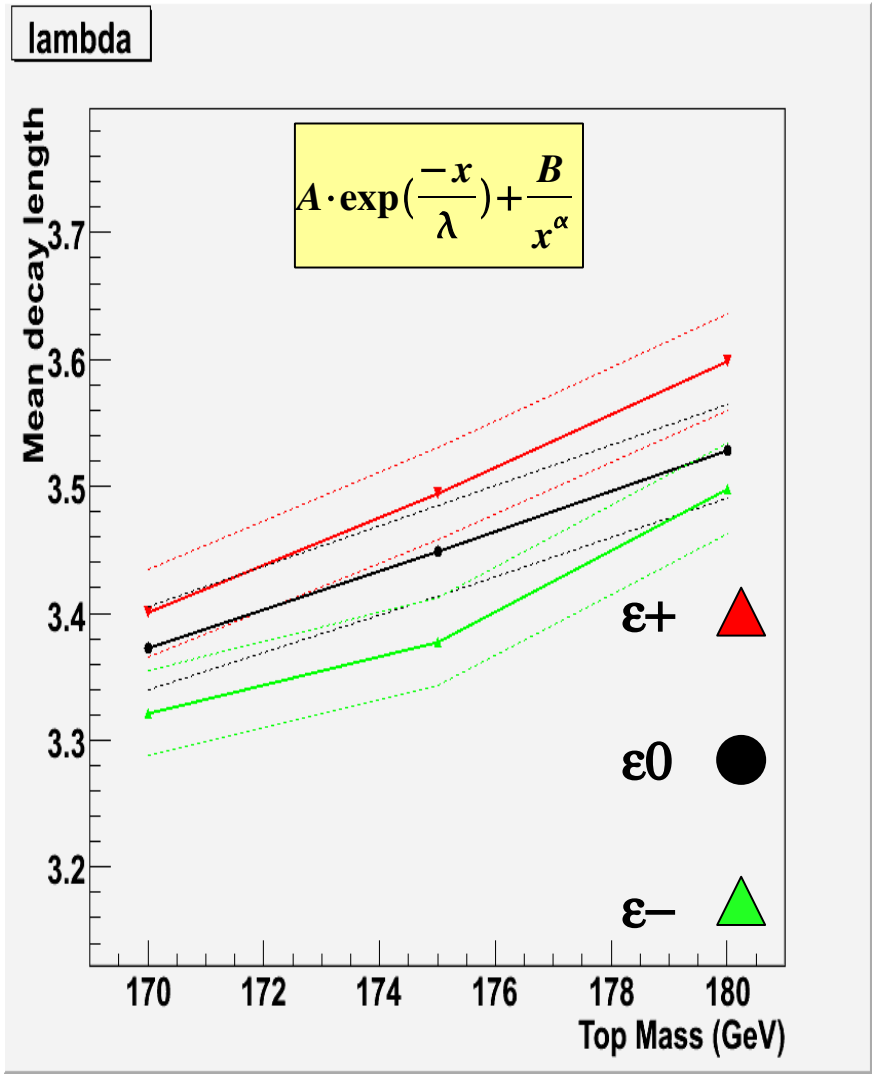


Average B hadron lifetime variation



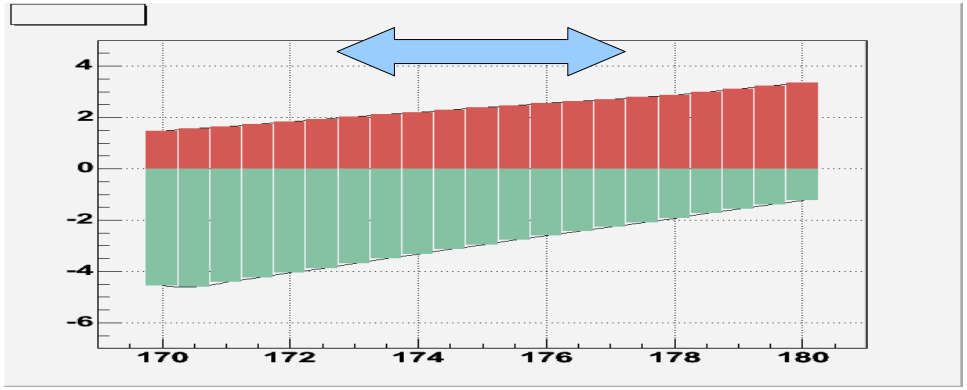


B Fragmentation



- Preliminary aspects (Athena rel. **10.0.1)**
- B Fragmentation effect on decay length for fast simulated data (PYTHIA - 120K)
- Standard top mass value (175 ± 5 GeV/c^2)
- Variation of Peterson parameter around the default value ($\Delta\varepsilon = 0.0025$)
- Analytical solution from ε– to ε+ :

~ 2 GeV/c^2 (central region)



Conclusions

- B hadron secondary vertex reconstruction
  - Fairly good agreement with truth
- The most significantly contributing background
  - Diboson: **WW**
  - Drell-Yan: **Z/γ* ---> μμ**
- Top mass sensitivity
  - Positive in variation of the left edge for the fitting range – systematic effect to control
- Systematics uncertainties (I: B hadron lifetime effect)
  - Correlated variation of B hadron lifetime:
    - individual B flavor [higher effect on top mass]
    - with average lifetime value [top mass uncertainty reduced]
- Systematics uncertainties (II: B fragmentation)
  - Top mass uncertainty at ~ 2 GeV/c^2 (central top mass values)

STILL A LOT OF THINGS TO DO …

Analysis to be updated (lepton identification/isolation)
Vertex resolution
Extension of analysis on further systematics
Track reconstruction and ID efficiency
Use of new csc datasets

Thank you for your attention !