Update on Bkg studies in FastSim

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Outline

- Updated results considering all bkg sources:
  - use updated efficiencies and t0 resolutions from Lodovico and Luca studies;
  - Impact on track parameter resolutions;
  - Impact on time-dependent measurements.
- Status of TDR paragraph on performances
- Summary

Including all Bkg sources in FastSim

- Used higher statistics sample for determine bkg rates of QED Pairs generated in FastSim. Update table is below. Results are consistent with the previous ones.

- Scaling the offline time windows to obtain identical rates as in FullSim using the factor R=Rate(FullSim)/Rate(FastSim) evaluated on cluster rates. All bkg sources are effectively included in this way in FastSim.

- Use t0 resolutions for nominal peaking times.

Layer	Trk rate FastSim MHz/cm^2	Cluster FastSim MHz/cm^2	Track FullSim All Bkg MHz/cm^2	Cluster FullSim All Bkg MHz/cm^2	Ratio FullSim/FastSim R	RMS t0 σ(t0) (ns)	Effective window (μs) ±5σ(t0)×R
L0	1.23E+00	2.86E+00	1.625E+00	4.103E+00	1.43E+00	10	1.43E-01
L1	6.76E-02	1.91E-01	2.169E-01	5.397E-01	2.83E+00	15	4.24E-01
L2	3.20E-02	9.12E-02	1.623E-01	3.928E-01	4.31E+00	15	6.46E-01
L3	6.87E-03	1.70E-02	7.939E-02	2.080E-01	1.22E+01	25	3.06E+00
L4	4.61E-04	1.44E-03	2.237E-02	3.699E-02	2.57E+01	46	1.18E+01
L5	2.55E-04	8.36E-04	1.402E-02	2.234E-02	2.67E+01	80	2.14E+01

Sensitive time windows

- Bkg hits are considered if they are inside the offline sensitive time windows. Use nominal peaking times for this study. Some improvements are possible using shorter peaking times or reducing the sensitive time window (TW) from $\pm 5\sigma$ to $\pm 3\sigma$ of t0 resolution.

Layer	Peaking time (ns)	Frascati exercise (ns)	This study: $\pm 5\sigma \times R$ (ns)
L0	25	60	143
L1	100	100	424
L2	100	100	646
L3	200	150	3060
L4	500	400	11800
L5	1000	400	21400

From Lodovico Ratti presentation

Based on MC simulation results, the uncertainty in t_0 can be expressed as

$$\sigma_{t0} = \sqrt{\frac{T^2_{CK,TS}}{12} + 0.0625 \cdot T^2_{CK,TOT}}$$

where the worst case value of σ_{walk}, ~0.25 $T_{CK,TOT}$ for TOT→0, is assumed

Layer	t_p [ns]	$t_p/T_{CK,TOT}$	$f_{CK,TS}$ [MHz]	σ_{walk} [ns]	σ_{t0} [ns]
0	25	4	30	1.6	9.8
1	100	4	30	6.2	11.4
2	100	4	30	6.2	11.4
3	200	4	30	12.5	15.8
4	500	4	30	31.2	32.6
5	1000	4	30	62.5	63.2

Actually σ_{walk} gets smaller for larger values of TOT, so better estimation of t_0 could be obtained

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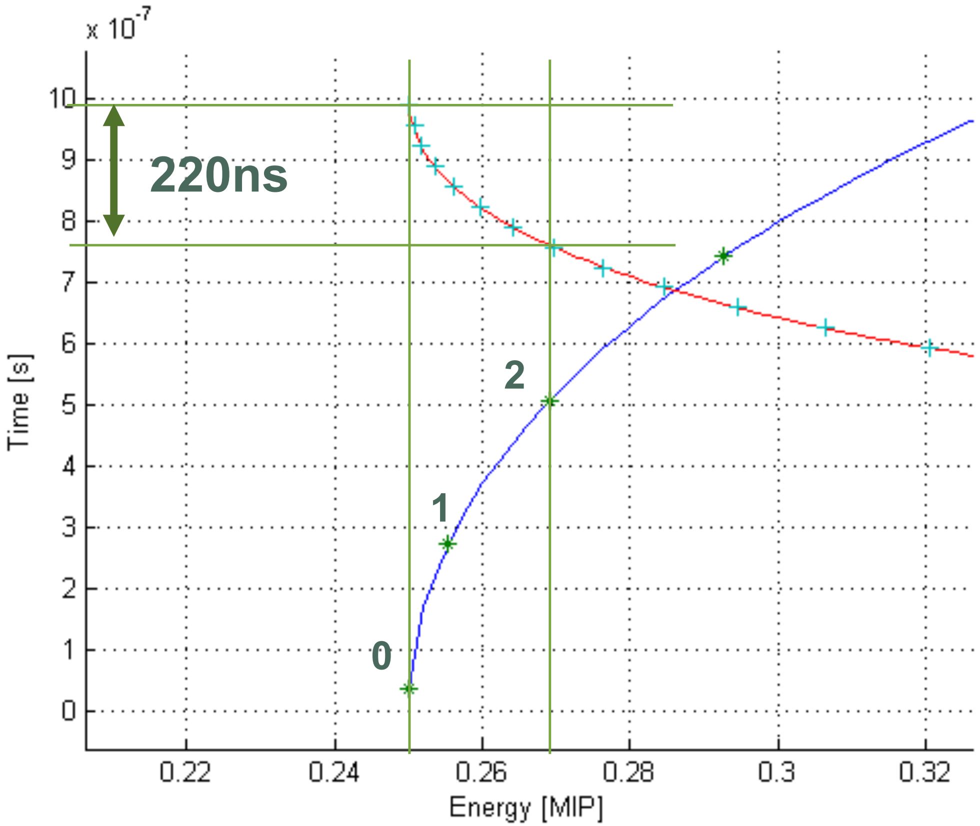
From Luca Bombelli presentation

Phase error of TOT clock when TOT should count "1"



Peaking Time = 1us

TOT = 4 bits

TOT clock = 4.25 MHz

Max error = 220ns

(including only Phase error of TOT clock)

From Luca Bombelli presentation

Timing Resolution with TOT

Peaking time [ns]	TOT bit	TOT clock [Mhz]	Max Time window [ns]	Time Error rms [ns]	Preliminary Jitter for 1 MIP [ns]	Preliminary Jitter for 0.3 MIP [ns]
375	4	11.3	114	33	10.3	34.6
	6	47.5	54	15		
500	4	8.5	141	41	12.7	43.3
	6	35.7	60	17		
750	4	5.66	196	56	17.6	60.3
	6	23.8	74	21		
1000	4	4.25	250	72	22.9	77.9
	6	17.8	87	25		

Efficiencies

- Use efficiencies at nominal peaking times for this study. Some improvements are possible using shorter peaking times.

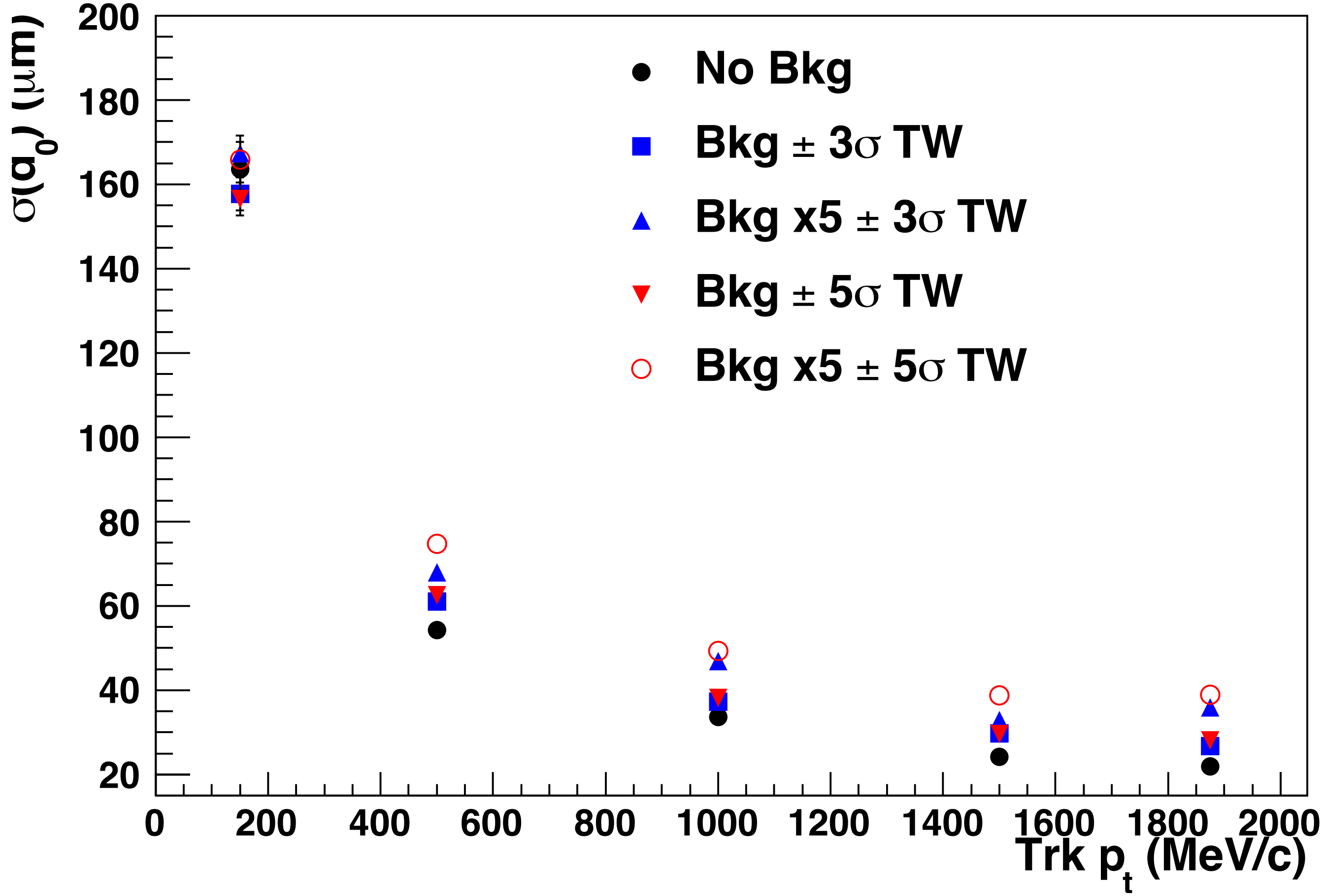
Layer	Peaking time (ns)	Bkg (%) (r-ϕ/z)	Bkg x5 (%) (r-ϕ/z)
L0	25	99/99	96/96
L1	100	98/98	88/89
L2	100	98/98	89/89
L3	200	95/95	77/86
L4	500	98/98	89/93
L5	1000	98/98	86/91

Impact of Pairs Bkg on track parameters resolution

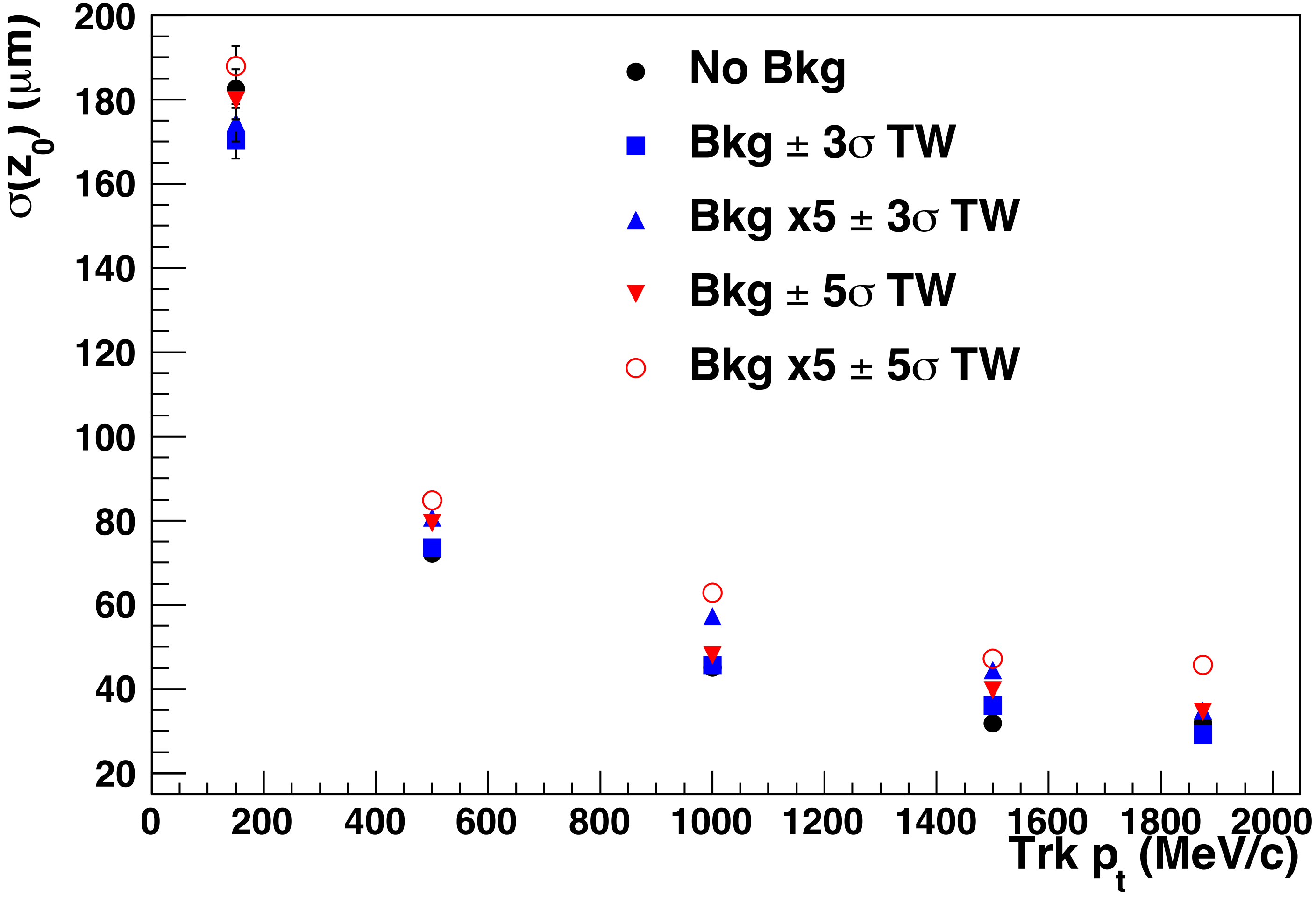
- generate single track pion events:
  - $p_t \in [0.05, 2.0]$ GeV/c
- over impose pairs bkg events;
- hit merging and pat rec confusion algorithms add bkg hits to the track;
- fit for track parameters: $P \equiv \left(d_0, \ \varphi_0, \ \omega, \ z_0, \ \tan\lambda \right)$

$$\vec{F}(P:l) = \begin{cases} \left(\frac{\sin(\varphi_0+\omega l)}{\omega} - (1/\omega + d_0)\sin\varphi_0\right)\hat{x} \\ \left(-\frac{\cos(\varphi_0+\omega l)}{\omega} + (1/\omega + d_0)\cos\varphi_0\right)\hat{y} \\ (z_0 + l\tan\lambda)\,\hat{z} \end{cases}$$

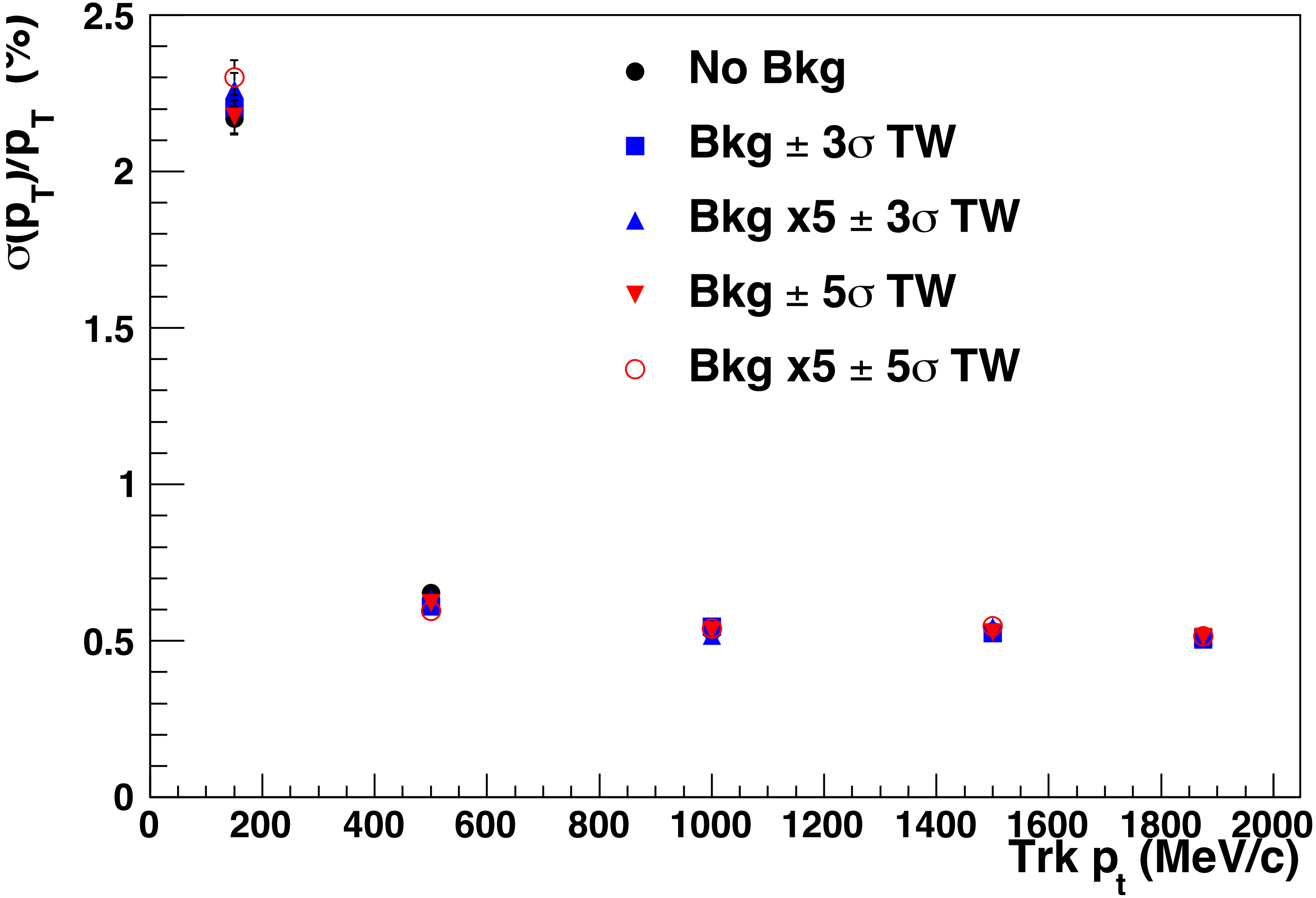
d_0 resolution



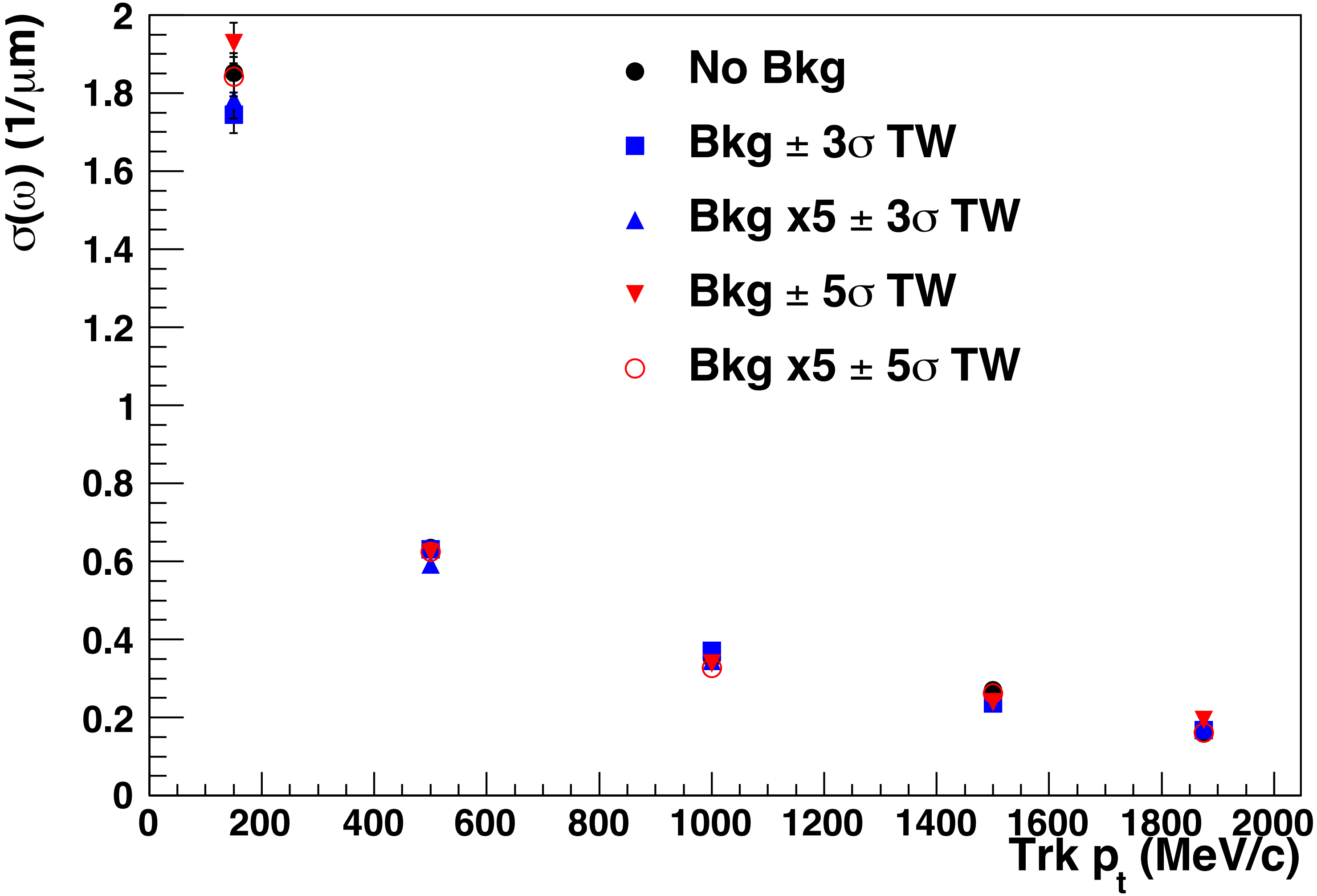
z_0 resolution



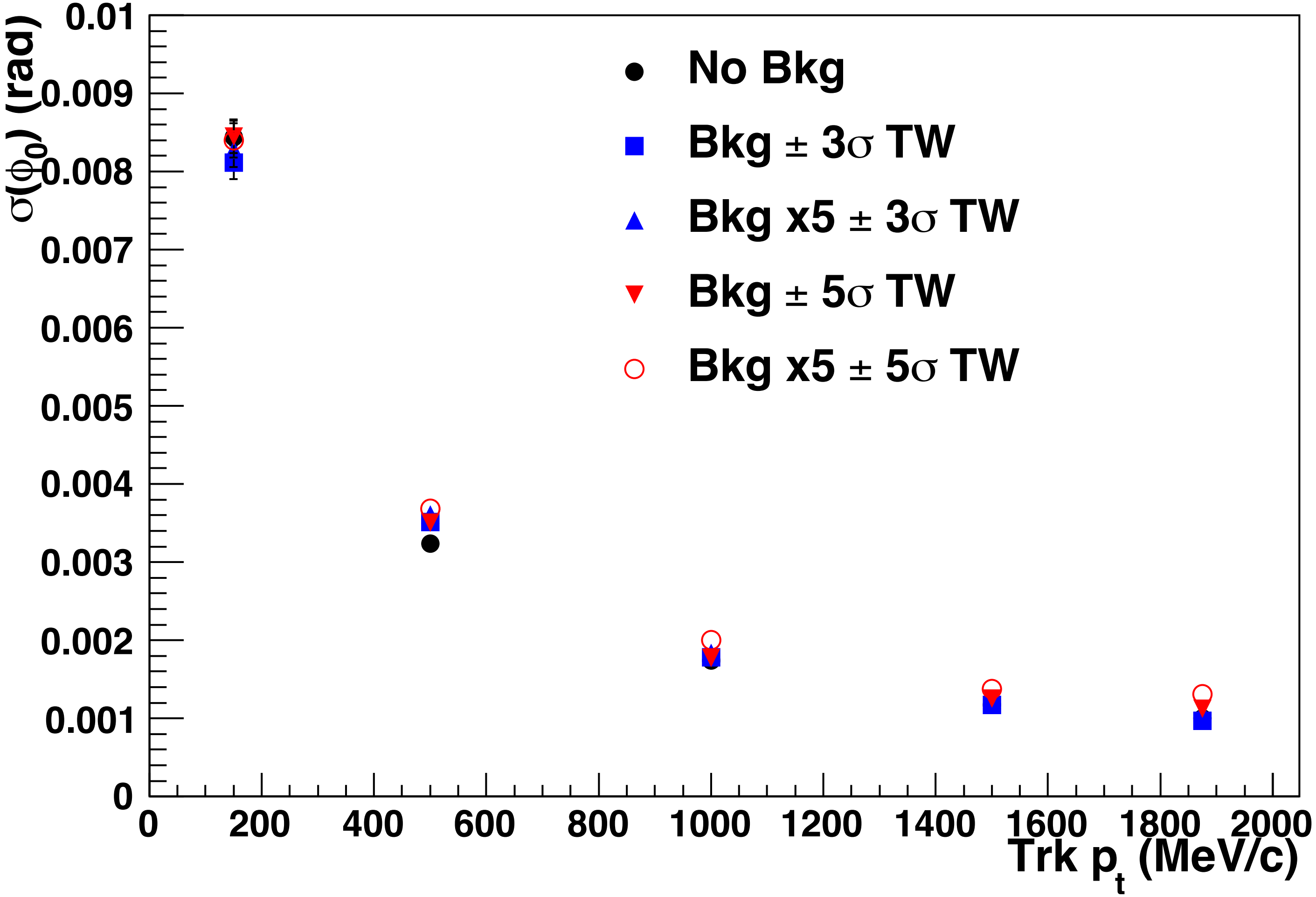
p_t resolution



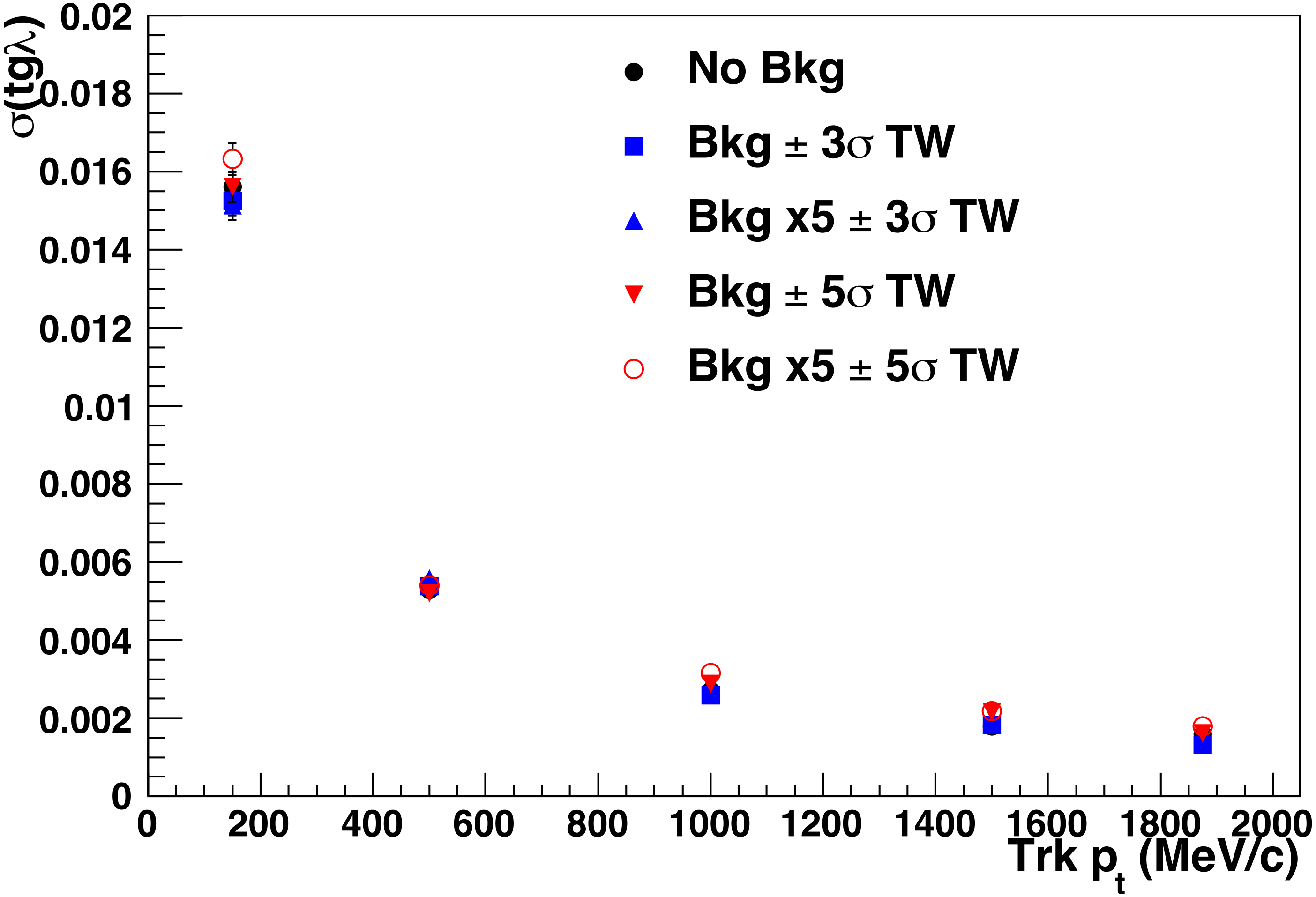
ω resolution



Φ_0 resolution



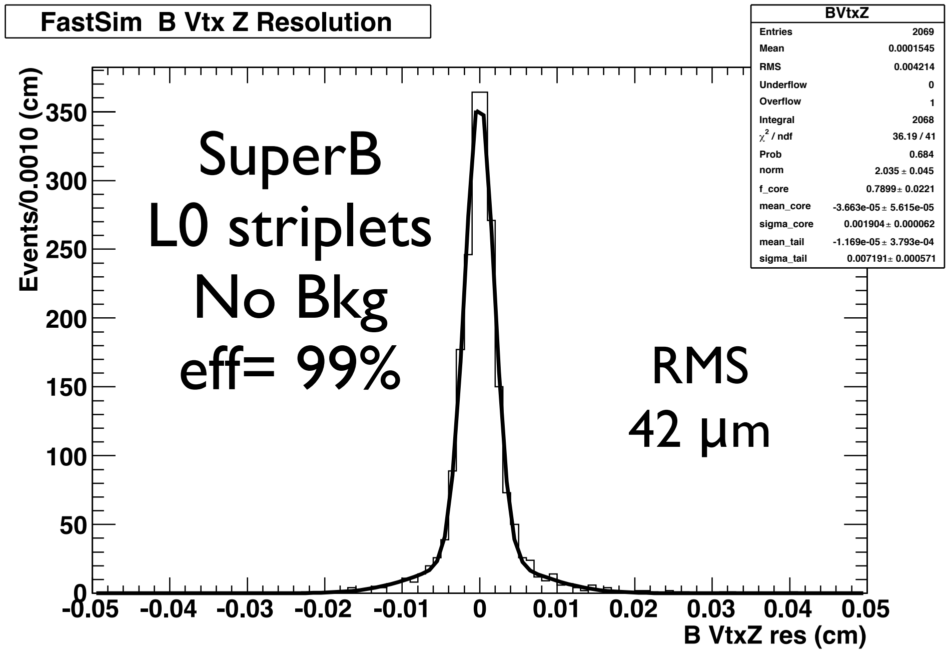
tan(λ) resolution

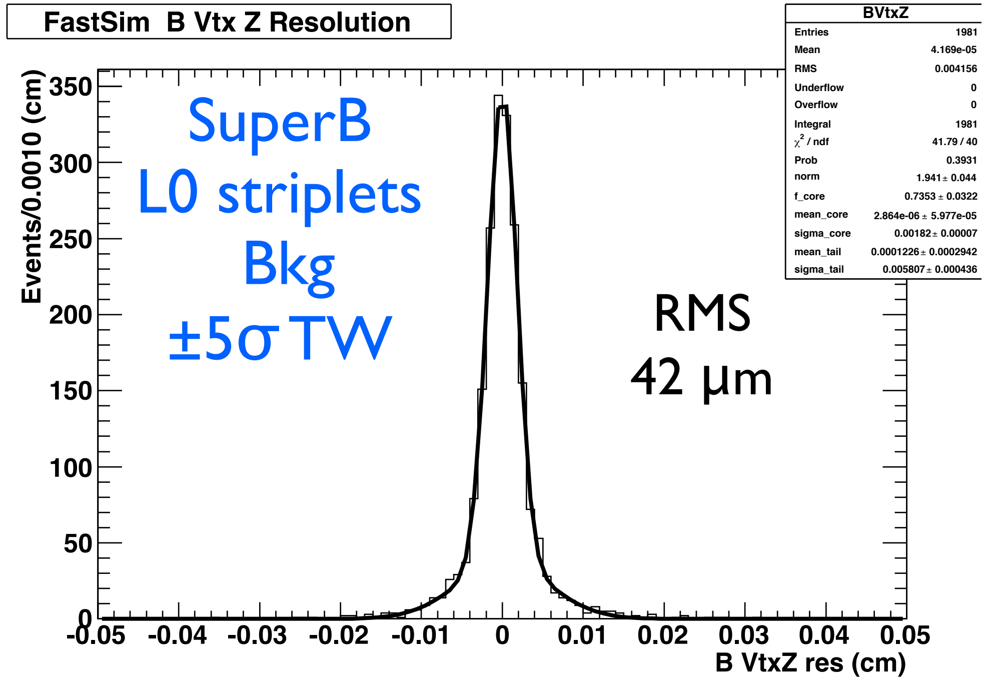


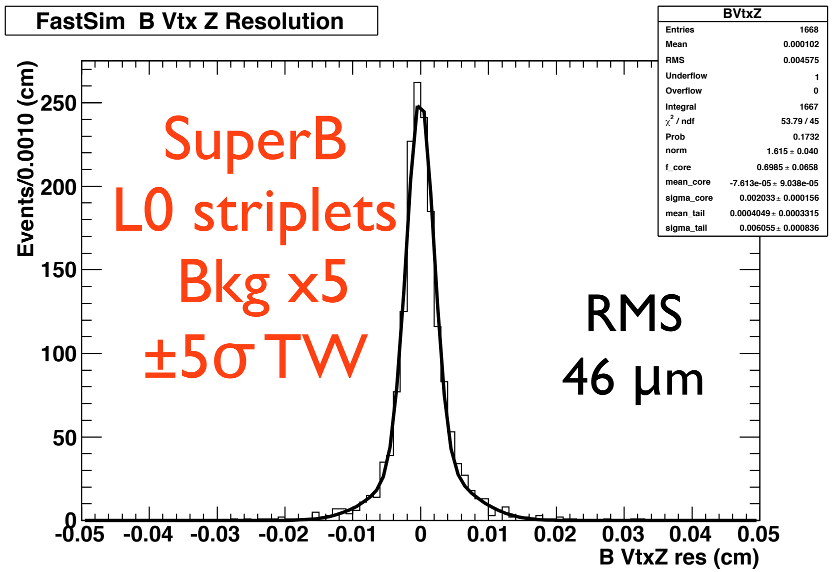
Impact on time-dependent measurements

- Generate 5k $B \to \phi K_s$ signal events with over imposed bkg events as discussed before;
- Do not reject low momentum electrons using dE/dx. Use GoodTracksTight selection for determination of Tag vertex position. Use GoodTracksLoose for $\phi \to K^+K^-$ tracks and ChargedTracks for $K_s \to \pi^+\pi^-$.
- Bkg mixing and efficiency variations are included. For hit efficiency use values provided by Lodovico and Luca for nominal bkg and 5x bkg reported in previous slides.

Decay vertex resolution

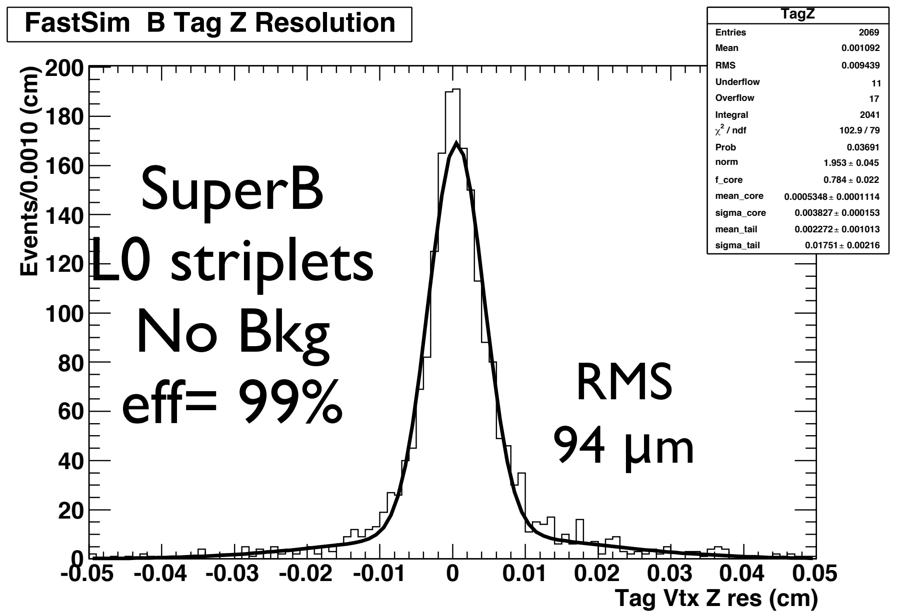


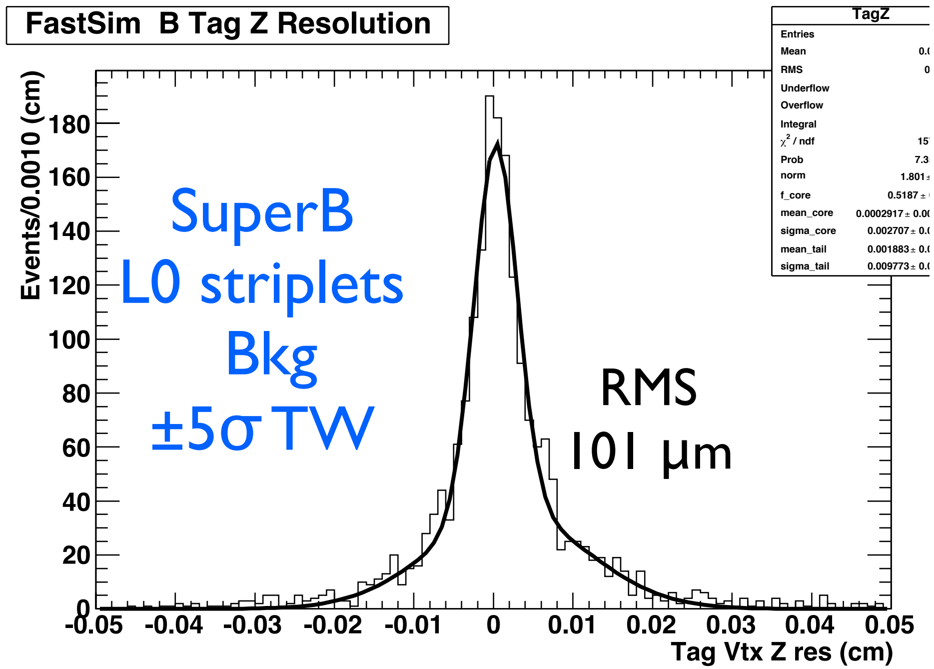


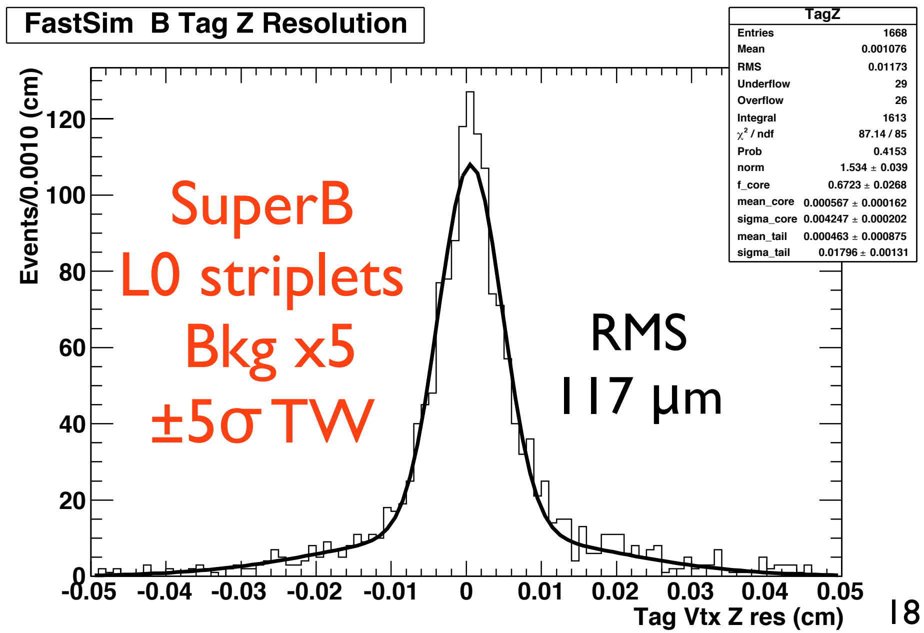


- Not removing low momentum electrons using SVT dE/dx information in this study.
- Use GoodTracksLoose for $\phi \rightarrow K^+K^-$ and ChargedTracks for $K_s \rightarrow \pi^+\pi^-$.
- *Probably some margin of improvement using an optimized selection in presence of bkg.*

Tag side vertex resolution

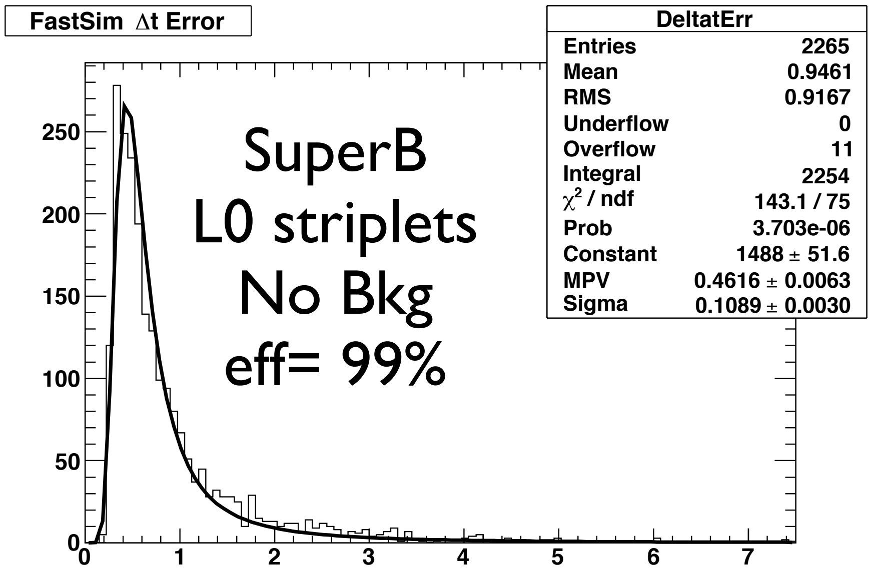


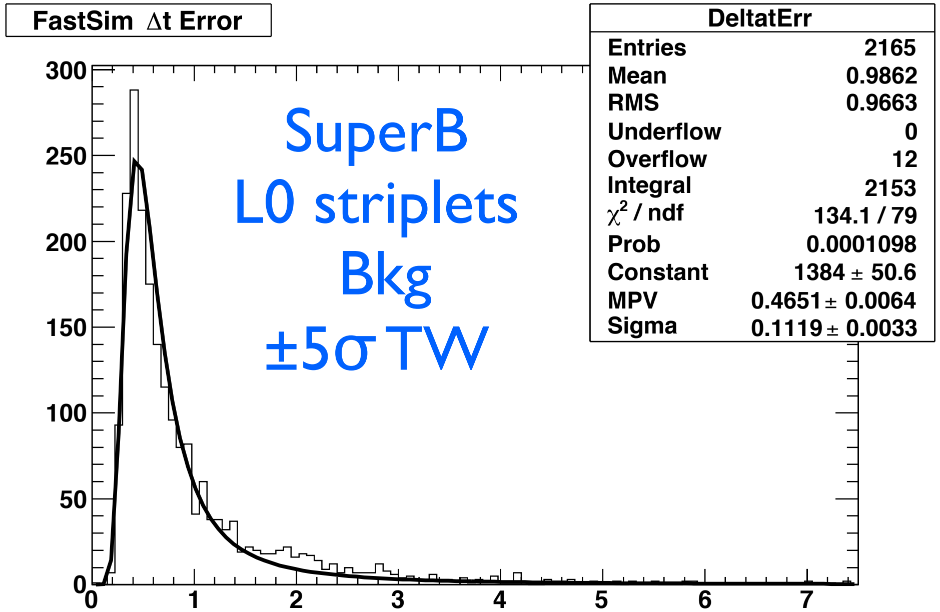


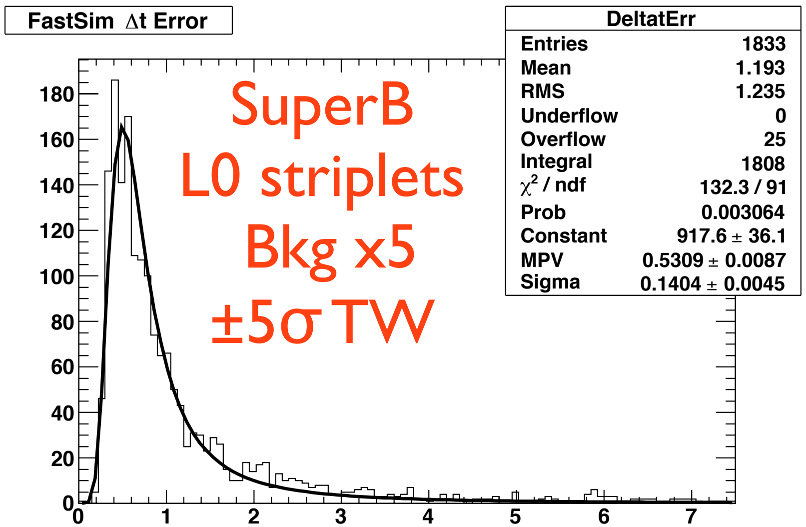


- Not removing low momentum electrons using SVT dE/dx information in the SVT.
- Use GoodTracksTight selection for determination of B Tag vertex position.

Δt error distribution

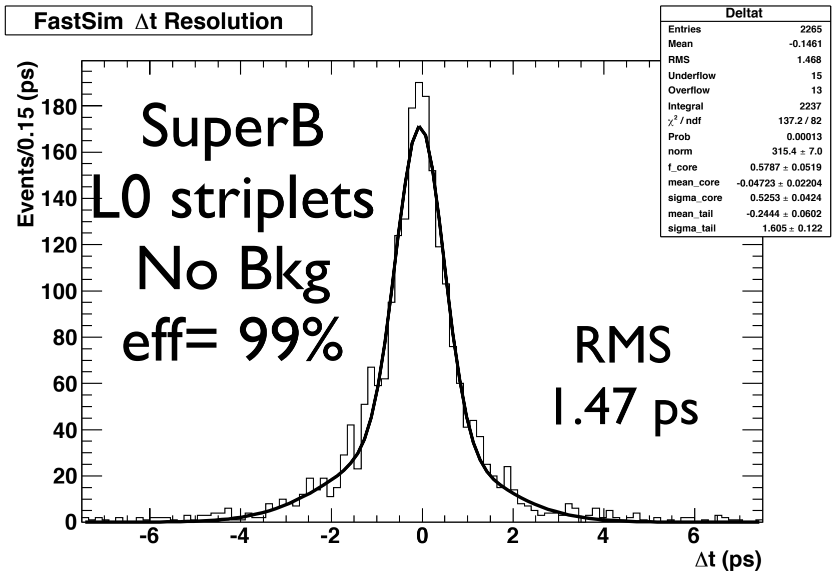


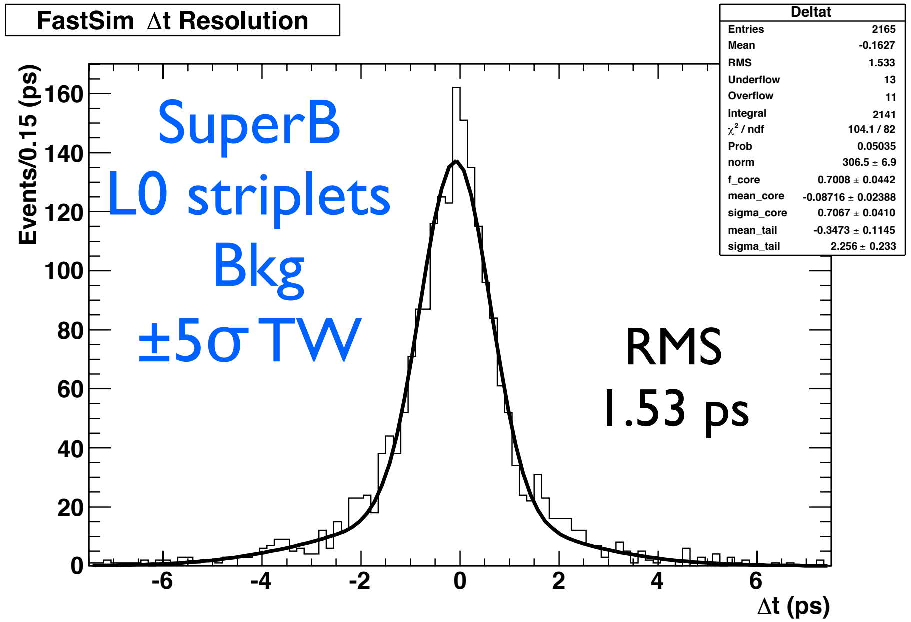


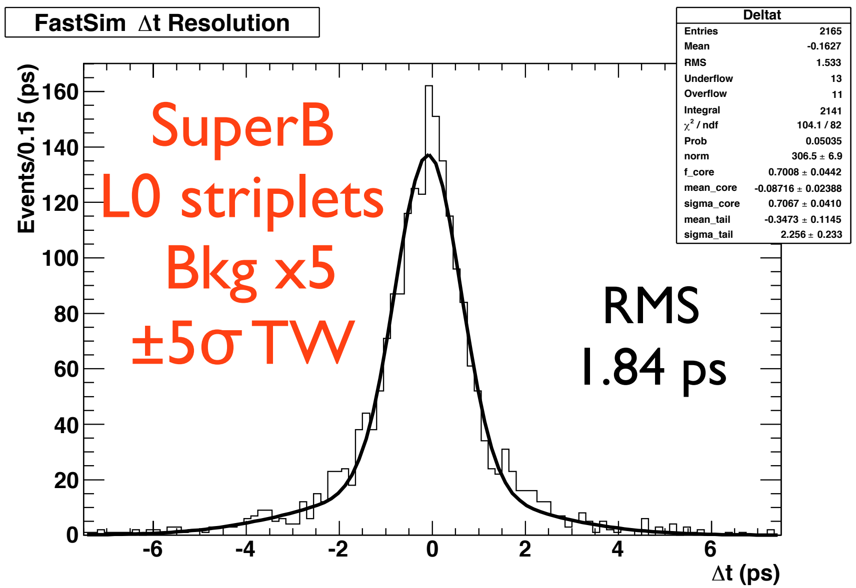


- 5%, 25% change in mean Δt error value wrt no bkg.

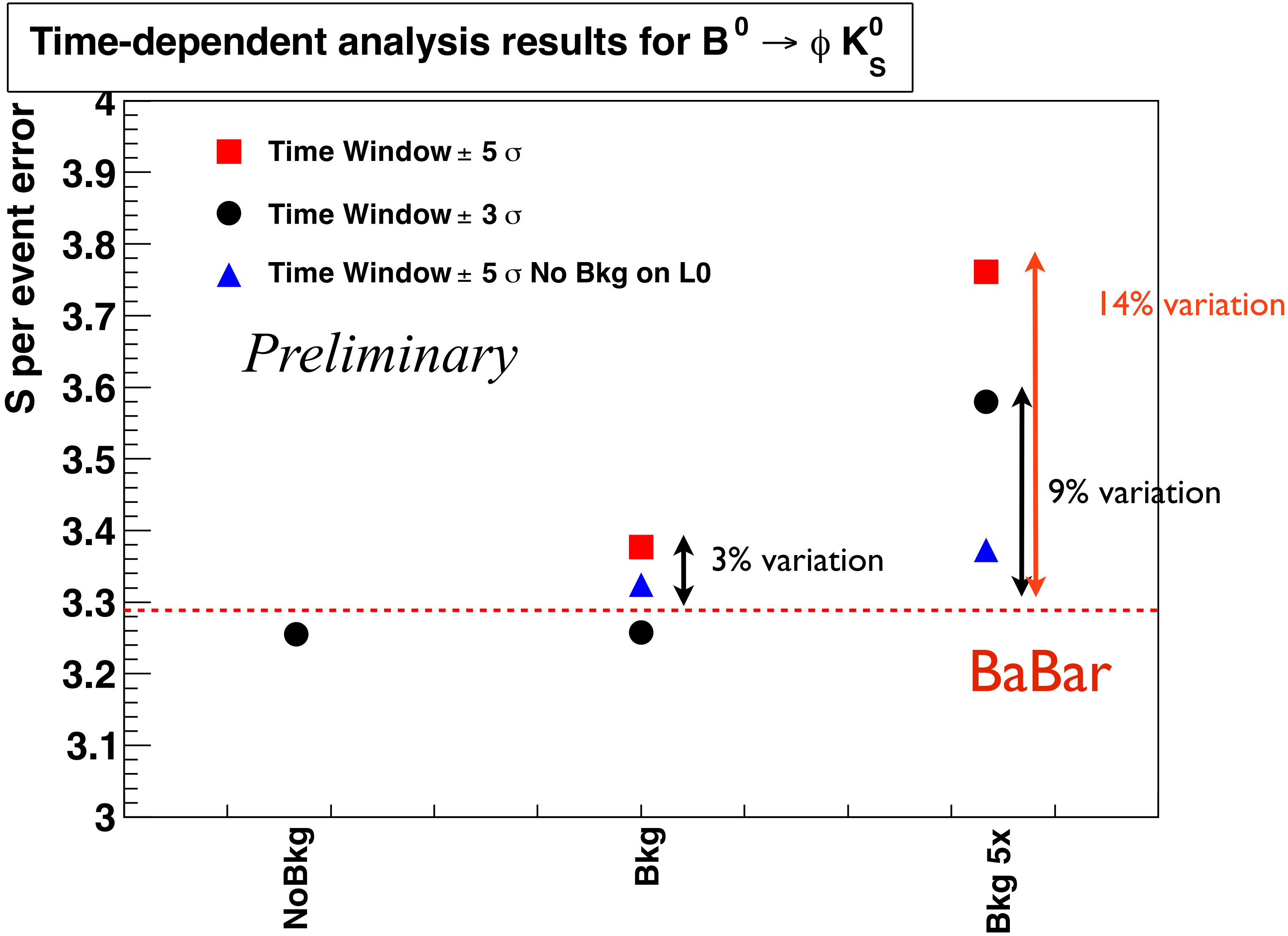
Δt resolution







- 4%, 25% change in RMS of Δt residual wrt no bkg.



Time-dependent analysis results for $B^0 \rightarrow \phi K^0_S$
S per event error
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
Time Window ± 5 σ
Time Window ± 3 σ
Time Window ± 5 σ No Bkg on L0
Preliminary
14% variation
9% variation
3% variation
BaBar
NoBkg
Bkg
Bkg 5x

Status of TDR paragraph on detector performances

- Relatively good shape.
  - discussion of Patter Recognition and tracking performances with bkg (Isabelle is working on this topic);
  - PID performances (help is welcome here for dedicated study for electron ID);
  - Performance with Layer0 pixel detectors. Need some inputs for the latest pixel technology to simulate.

Layer0 striplets material budget

Cu based fanout

Sensor	rad length cm	thickness cm	rad length %	density g/cm3
Si sensor	9.37	0.02	0.213447172	2.329
Fanout	rad length cm	thickness cm	rad length %	density g/cm3
Cu lines	1.436	0.00045	0.031337047	8.96
Glue	35.5	0.0025	0.007042254	1.2
Kapton	28.6	0.004	0.013986014	1.42
			0.052365315	
Support CF	rad length cm	thickness cm	rad length %	density g/cm3
	25.5	0.022	0.08627451	1.7
Total Material			0.404452311	

Al based fanout

Sensor	rad length cm	thickness cm	rad length %	density g/cm3
Si sensor	9.37	0.02	0.213447172	2.329
Fanout	rad length cm	thickness cm	rad length %	density g/cm3
Al lines	8.9	0.001	0.011235955	2.7
Glue	35.5	0.0025	0.007042254	1.2
Kapton	28.6	0.004	0.013986014	1.42
			0.032264223	
Support CF	rad length cm	thickness cm	rad length %	density g/cm3
	25.5	0.022	0.08627451	1.7
Total Material			0.364250127	

- There is still some discussion ongoing about possible optimizations of the fanout material;
- Overlap of fanout between adjacent layers is not included in this evaluation.

Summary

- Impact of Bkg on SVT performances has been evaluated using cluster rates in the different layers according to FullSim results with all bkg sources included.
- Effective FullSim bkg rates in FastSim have been achieved by applying scale factor on offline sensitive time windows for each layer.
- Main results
  - sizable worsening in d0 and z0 resolution at x5 bkg rates.
  - sizable effect on S per event error: 9% (14%) worsening with x5 bkg and $\pm 3\sigma$ ($\pm 5\sigma$) time window cut. Small change with nominal bkg (3%).
- SVT performance seems to be very good in presence of bkg and reasonably good in presence of 5x bkg.
- TDR paragraph on SVT performances is in relatively good shape. Possibility to help with specific studies.

Backup

Exercise shown in Frascati with Pair Bkg only and reduced offline time windows