Impact of energy spread on New Physics probes: $B \rightarrow \phi K_S$ and $\tau \rightarrow \mu\gamma$

Nicola Neri
Università di Pisa & INFN Pisa
Maurizio Pierini
University of Wisconsin, Madison

The Idea

A super B factory is meaningful only if it has high potentiality in discovering New Physics.

We studied two of the available smoking guns

- Time dependent CP measurement in $b \to s$ decays (ϕK_S, but also $\eta' K_S$ and $K_S \pi^0$)
  - We expect $S \sim \sin 2\beta$ and $C \sim 0$ in the SM (up to theoretical errors that will go down increasing experimental precision)
  - We can observe deviations, coming from NP contributions
- Measurement of $BR(\tau \to \mu\gamma)$
  - Small in the SM, enhanced in NP. $\sim 10^{-10}$ is the goal.
- These two "smoking guns" are strongly correlated in GUT models (see talk by M.Ciuchini)
- We use a fast toy Monte Carlo simulation to extrapolate the improvement in the statistical error we will have

WARNING

This is a fast simulation based on toys. We will cross check the results in a more detailed simulation in the next future

For b→s time dependent analyses

- We assume that present yields will scale with luminosity
- We assume the same number of events for different energy spread values (so they do not correspond to the same lumi.)
- We are (for the moment) ignoring any background rejection improvement that WILL come from looking at the D vertex on the tag side (work in progress)

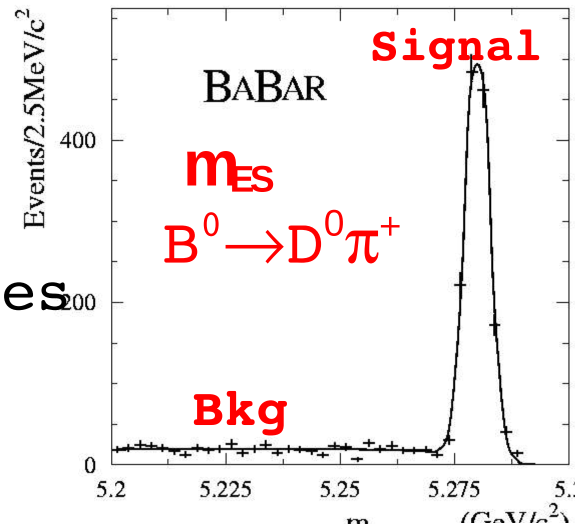
For $\tau \to \mu\gamma$

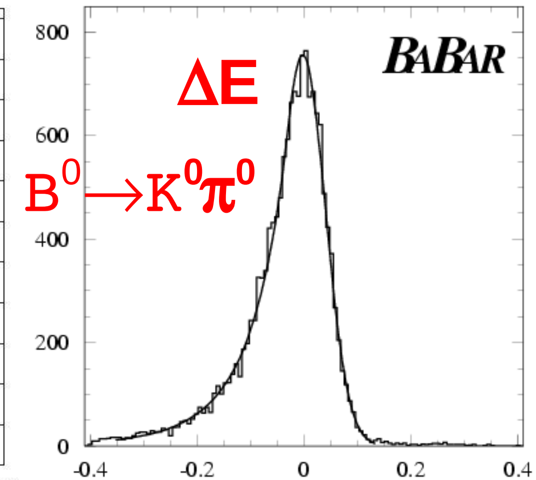
- Work is very preliminary
- We are assuming a (too) conservative approach, with worse energy spread, but same vertexing power (now vertexing improves $\tau\gamma$ mass resolution by a factor 2)
- With more time, we will provide more accurate simulation of the improvements coming from a better vertex resolution

A Fast Simulation of b→s

The current analyses use three main ingredients

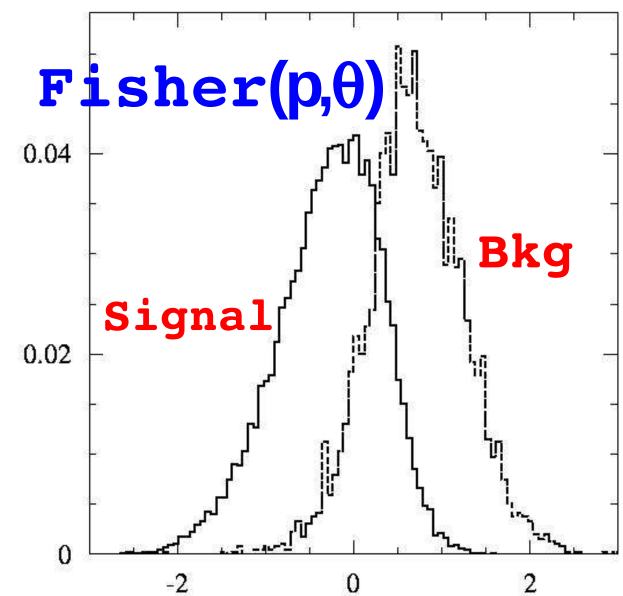
- $m_{ES} = \sqrt{(\sqrt{s}/2)^2 - p_B^{*2}}$
- $\Delta E = E_B^* - \sqrt{s}/2$
- Topological variables (Fisher, NN, ...)





We assume:

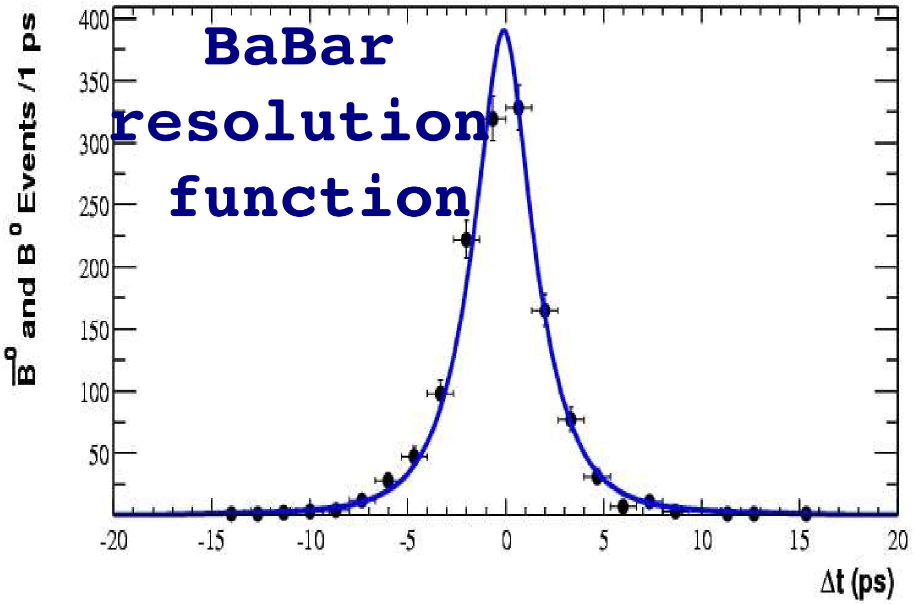
- Gaussian shapes for m_{ES} and ΔE
- $\sigma(m_{ES})$ = ½ energy spread
- $\sigma(\Delta E)$ = sqrt($(20\text{MeV})^2 + \sigma(m_{ES})$)
- We vary $\sigma(\Delta t) \sim \sigma(\Delta z)/c\beta\gamma$
- Same bkg and signal Fisher shapes as now in BaBar
- No $B\bar{B}$ background



Time Dependence

Δt distribution comes from the convolution of the physics model and the Resolution Function (for signal) or from the Resolution Function alone (for background)

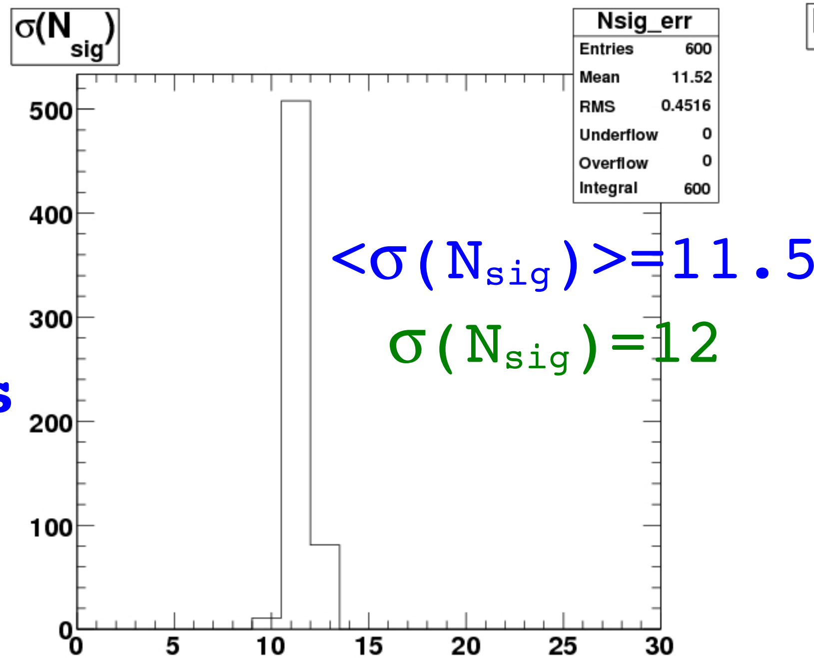
The **physics model is the same** (given by S and C)
Current BaBar RF is described by 3 Gaussians.
We assume a single Gaussian, centered in 0, for simplicity
We vary $\sigma(\Delta t)$ from 0.1 to 0.9 ps^{-1} (current value is 0.6)

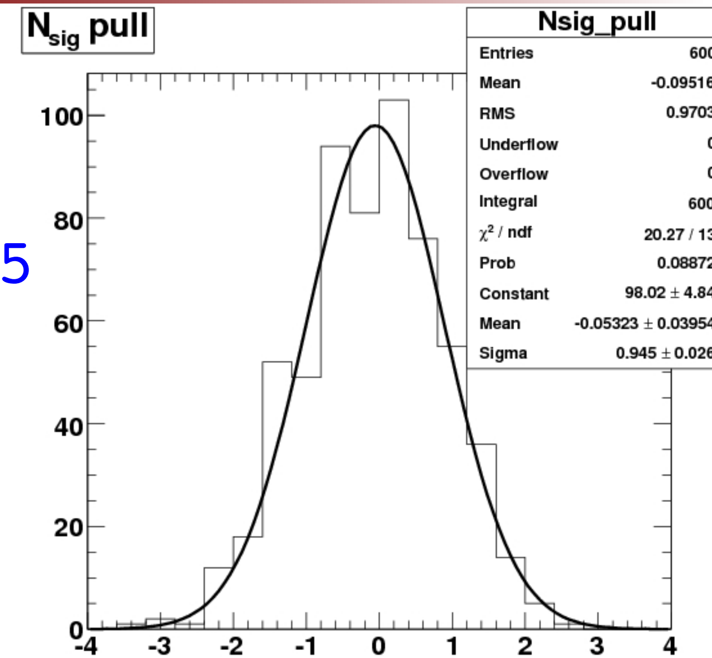


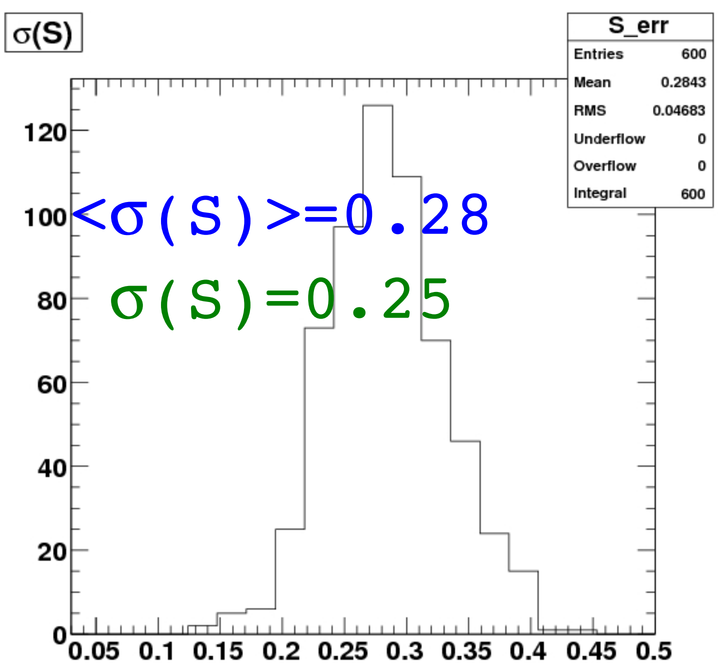
We are loosing the accurate description of the tails, but we are retaining the core of the distribution

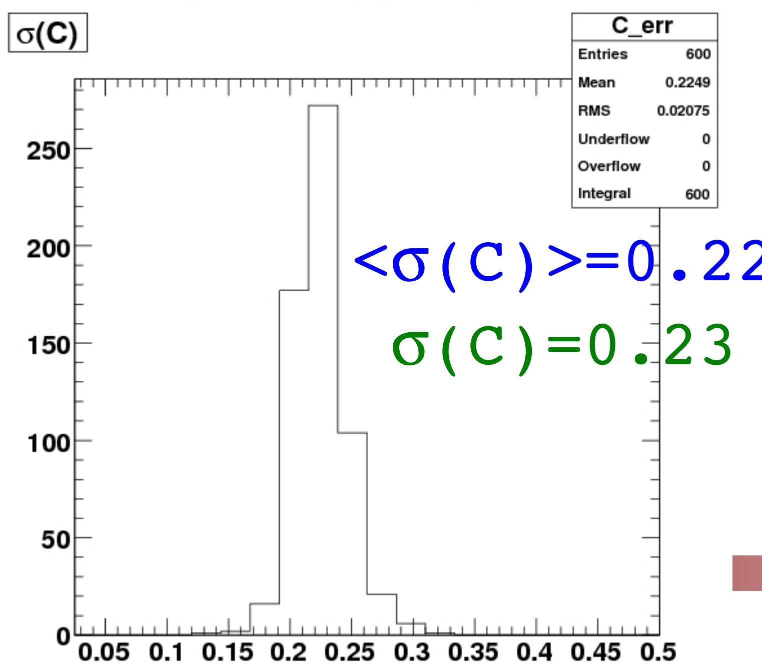
Reproducing Current Analysis

Comparing our **average results** to **BaBar analysis**







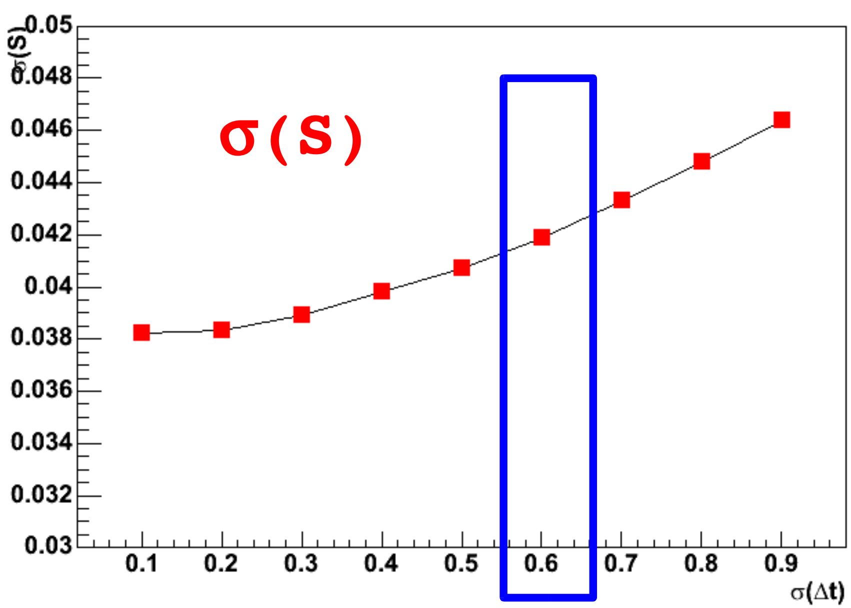


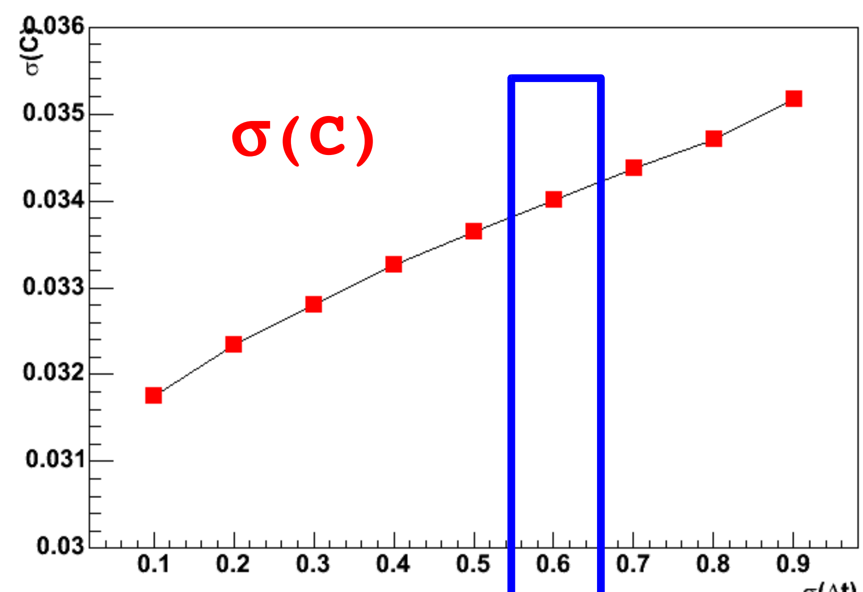
We are not simplifying things too much

Going Up in Statistics

We repeat the previous exercise as a function of $\sigma(\Delta t)$, scaling signal and background yields to 10 ab^{-1}(we don't change energy spread for the moment).

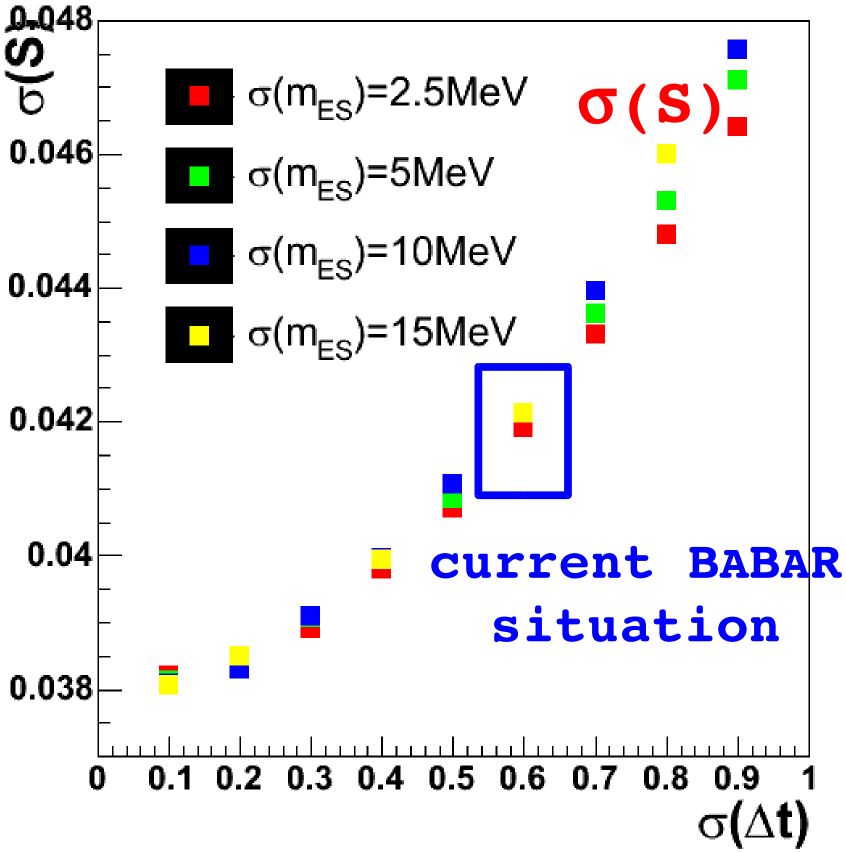
- 114 signal events/ 211 fb^{-1} $\rightarrow$ 5K events/10 ab^{-1}
- 4100 bkg events/211 fb^{-1} $\rightarrow$ 180K events/10 ab^{-1}

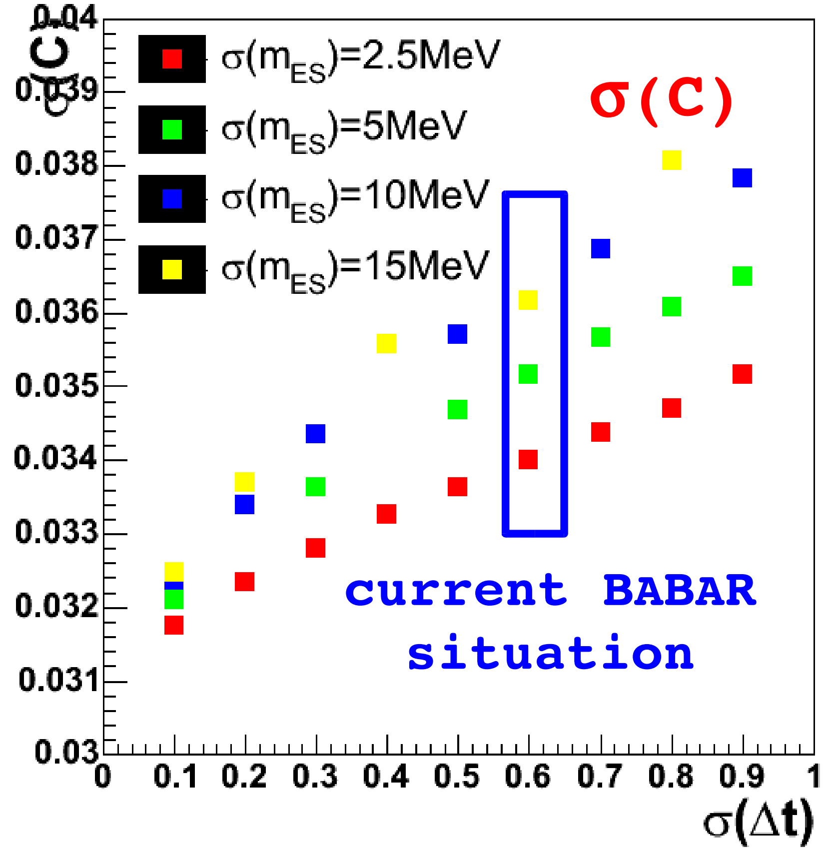




The effect of Energy Spread

The test is redone increasing $\sigma(m_{ES}) \sim \frac{1}{2}$ energy spread and $\sigma(\Delta E) \sim \sqrt{(20\text{MeV})^2+\sigma(m_{ES})^2}$





The good resolution on Δt compensates the reduction of background rejection because of increasing $\sigma(m_{ES})$.
It does not work for large $\sigma(\Delta t)$

Fast simulation of $\tau \to \mu\gamma$

The current analysis is based on a maximum likelihood fit on two kinematic variable

- τ mass (in the range [1.3,2.3] GeV)
- ΔE, defined as before (in the range [-0.1,0.2])

The τ mass is evaluated after an energy-constrained vertexing

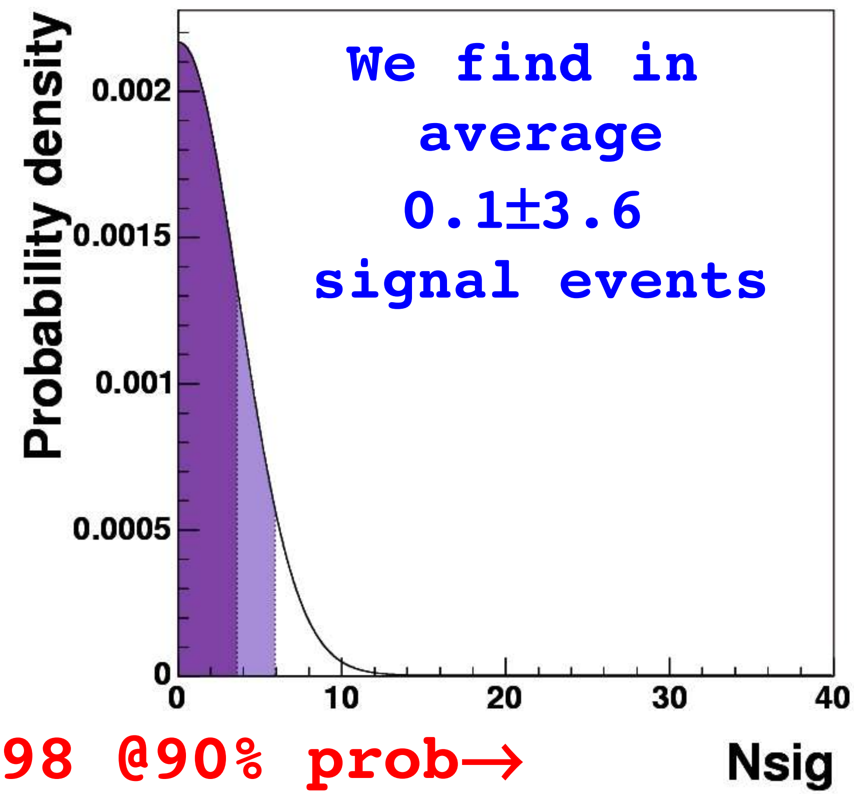
- The resolution is related to the energy spread
- The increase of vertex resolution can compensate the effect of increasing the energy spread

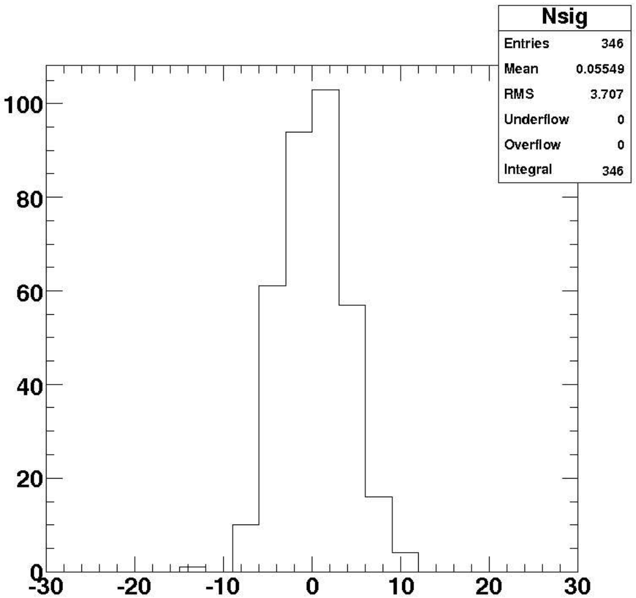
We simplify the analysis respect to what is done in BaBar

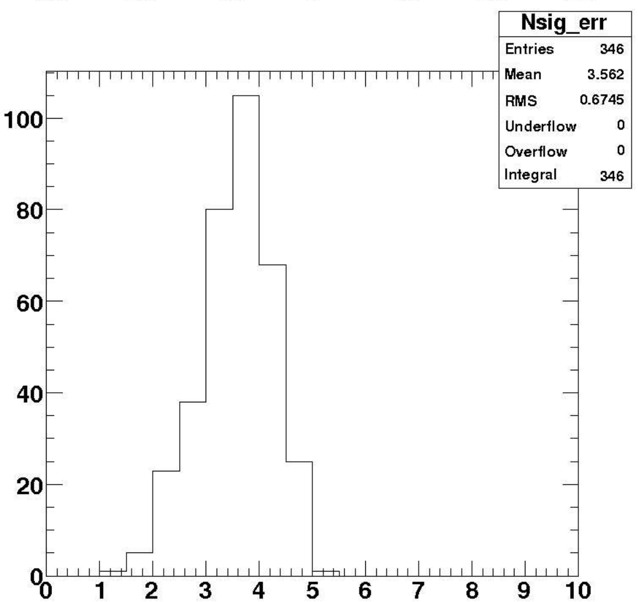
- No distinction between 3 prong and 1 prong events (now present because of pour statistics)
- We parameterize signal according to the outcome of Pravda
- We parameterize background according to the present analysis (forcing ΔE pdf to be flat to simplify things)

Reproducing Current Analysis

We produce a set of Toy Monte Carlo experiments assuming 0 signal events and 442 background events



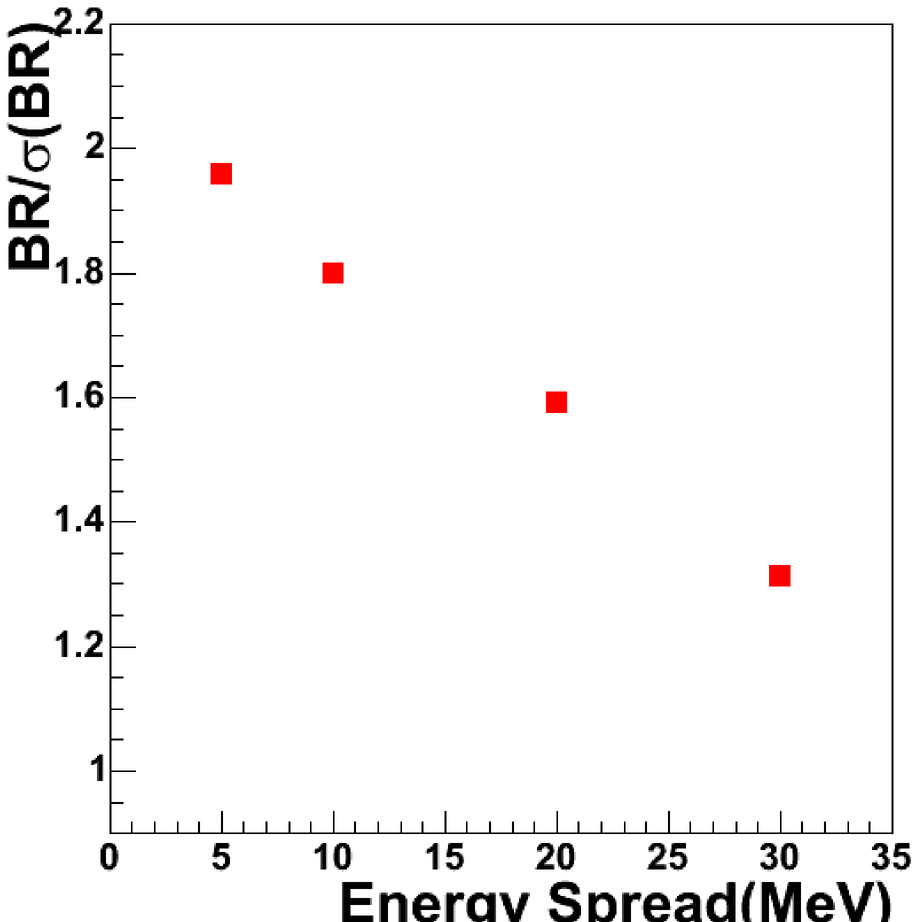




Nsig<5.98 @90% prob→
BR($\tau \to \mu\gamma$)<10^{-7} @ 90% prob
(Reference analysis finds ~7±7 events)

Going Up in Statistics

Assuming 75 signal events and scaling bkg to 50 ab^{-1}



WARNING: We are *very pessimistic*

- We make kinematic variables worse
- But the actual resolution depends on a kinematic fit
- We are neglecting (for the moment) the fact that even in this case
  - the better vertex will reduce the impact of energy spread

Work In Progress

Conclusion

Starting from the experience we have in BaBar, we can perform realistic fast simulations of superB factory performances using a Toy Monte Carlo approach.

This technique allows to simulate the effect of the energy spread on physics analyses

- In the case of ϕK_S, a good resolution on Δt can compensate the worse background rejection on kinematic variables. **$\sigma(S)$~0.039, $\sigma(C)$~0.033 with 10 ab^{-1} (which means having an effect of ~5σ with the current central value!!!!). And we might have ~5 times that /year.**
- Simulation of $\tau \to \mu\gamma$ still in progress. We need a detailed simulation to have a more accurate description of the impact of energy spread on non-Gaussian tails (present values are PESSIMISTIC)

Backup Slides

The effect of Energy Spread

The test is redone increasing $\sigma(m_{ES}) = \frac{1}{2}$ energy spread and $\sigma(\Delta E) = \sqrt{(20\mathrm{MeV})^2+\sigma(m_{ES})^2}$