Opportunities in B_s physics at a linear super B-factory

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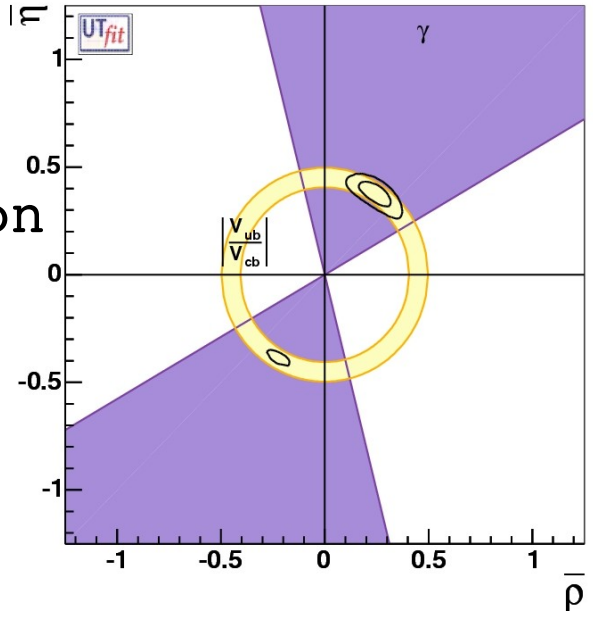
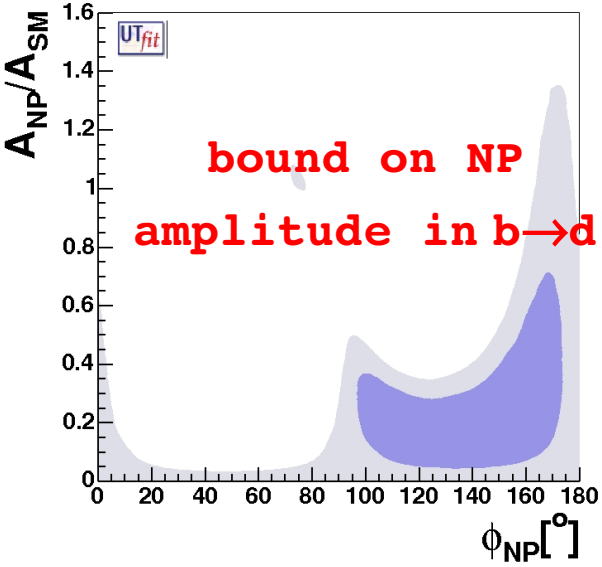
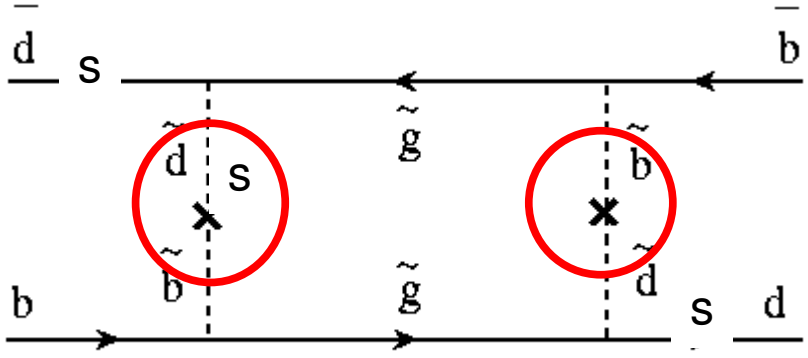
Why studying the B_s

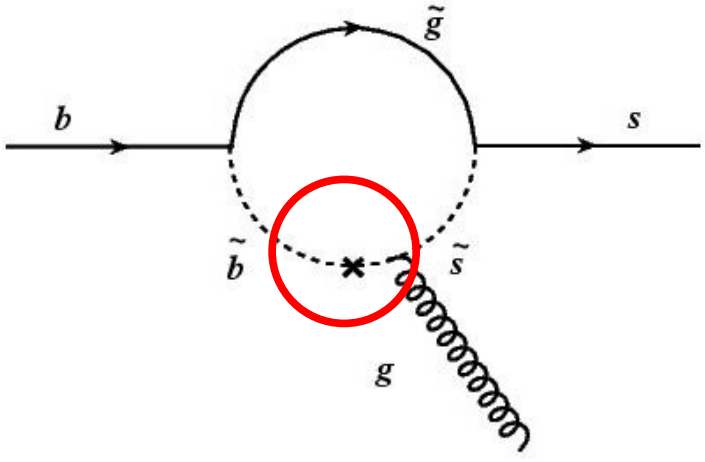
- Present experimental measurements on b→d mixing and CP violation strongly bound the possibility of having New Physics
- b→s transitions are still unconstrained
- Study of b→s penguin decays offers the unique possibility of correlating NP effects in decay and mixing





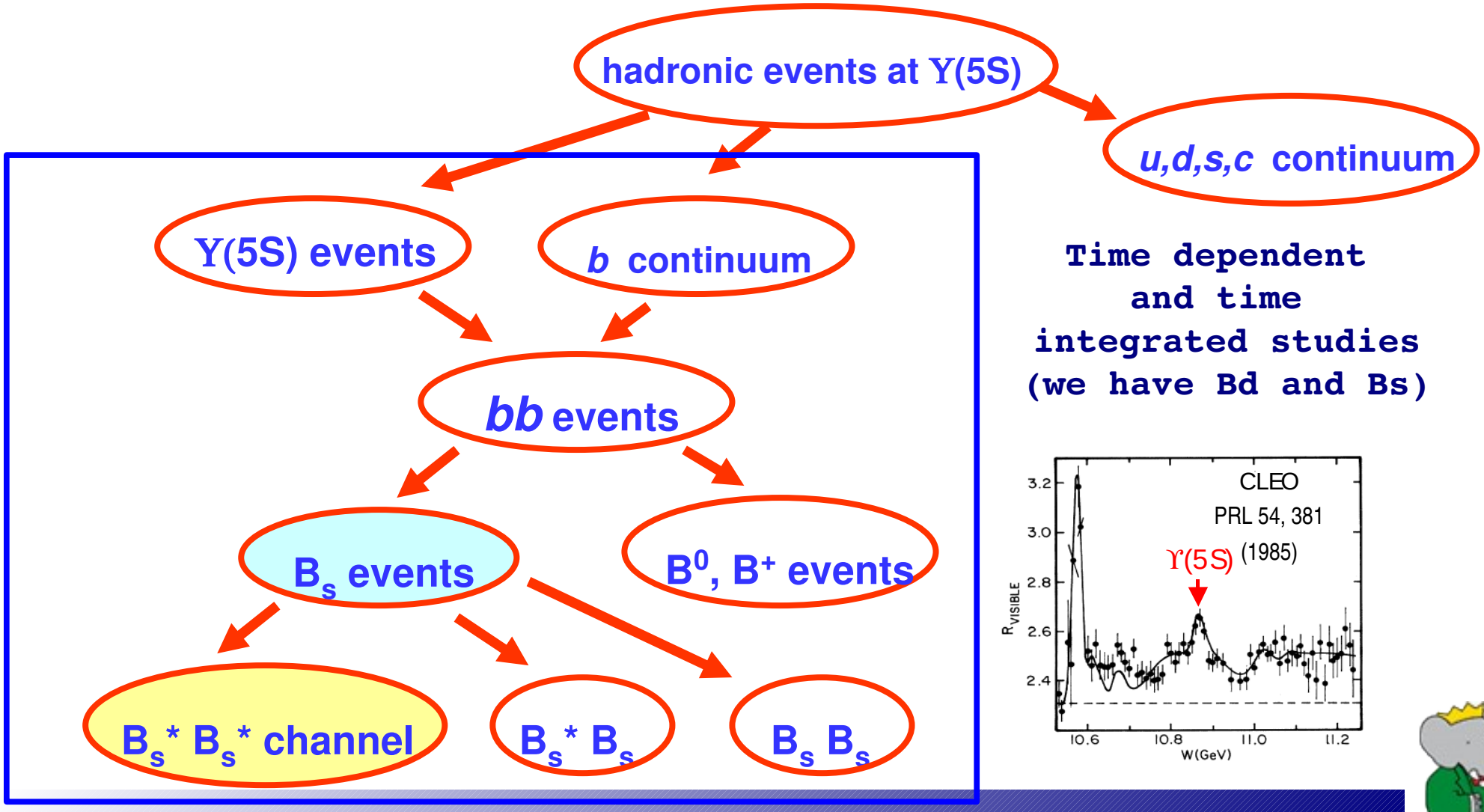


Same SUSY parameter



Running at the Y(5S)

Belle showed the feasibility of running at the Y(5s), providing already some interesting information



Time dependent and time integrated studies (we have Bd and Bs)

The Lesson From Belle

hadronic events at Y(5S)

Lumi = 1.857 fb^{-1}

bb continuum included

bb events

N ev = 561,000 ± 3,000 ± 29,000

f_s = (16.4 ± 1.4 ± 4.1)%

B_s events

N ev = 92,000 ± 8,000 ± 23,000

$f(B_s^* B_s^*)$ = (94 ± $^{6}_{9}$)%

$B_s^* B_s^*$ channel

N ev = 86,500 ± 7,500 ± 22,500

What we can expect in 30 ab^{-1}:

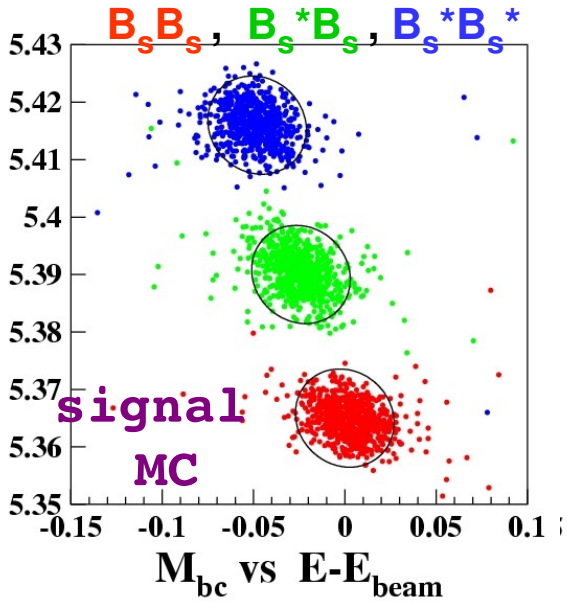
- 1.6×10^9 BsBs pairs
- 10^8 BsBs pairs in coherent state (L=0,1)

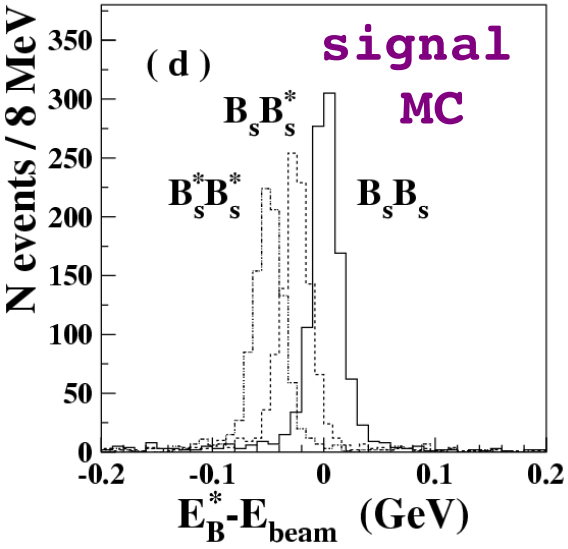
94% of events goes to $B_s^* B_s^*$

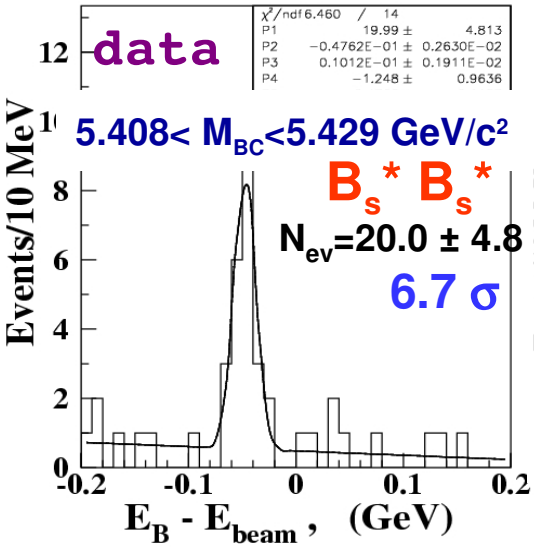
How much do we loose/gain going to continuum below Bs*Bs* threshold?

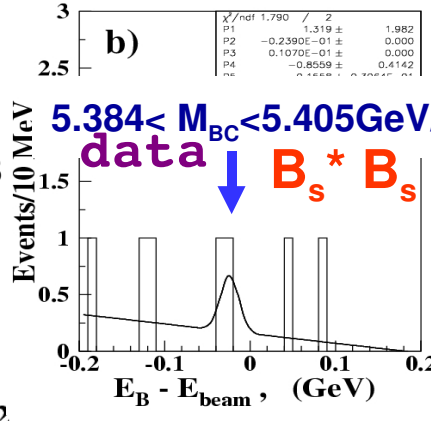
Separation of $B_s^{(*)}B_s^{(*)}$ events

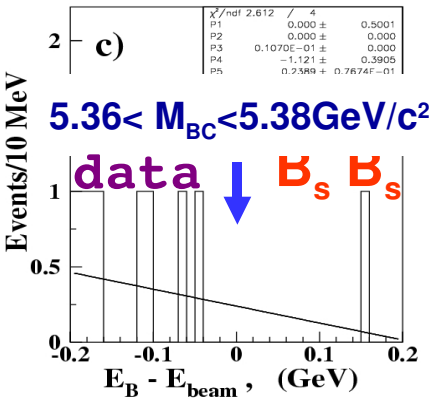
The different BsBs events can be separated on the usual ΔE vs mES plane











What we can measure

Assuming that:

- Δm_s will be known (measured at **Tevatron** or eventually by **LHCb**)
- **CMS/ATLAS/LHCb** will measure $B_s \to \mu\mu$
- **LHCb** will determine **B_s mixing phase**

a large fraction of B physics is still uncovered (because this is a physics of decays to neutrals)

- A large part of **BaBar/Belle physics program** that cannot be (well) accessed at hadronic machines ($\eta^{(')}$, π^0, **Ks vtx, ...**)
- Measurement of **γ through time-integrated**, tree-level $B_s \to D\phi$ decays **Grossman** **Ciuchini, Pierini, Silvestrini hep-ph/0602207**
- Measurement of **γ through time-integrated**, penguin $B_s \to K^+\pi^+\pi^0$

And (if we can access time-dependent B_s observables...)

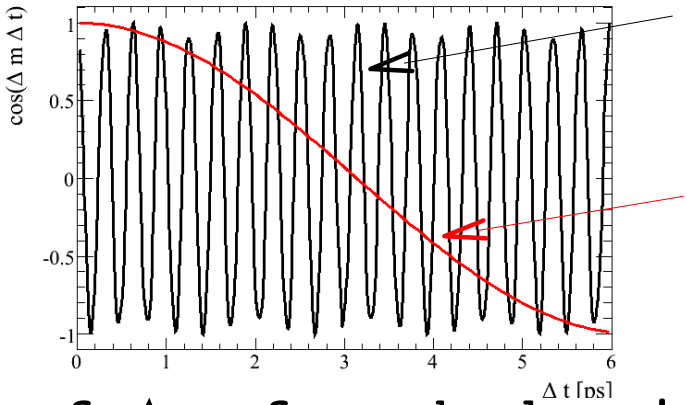
- determination of penguin from a full isospin fit of $B_s \to KK$ and $B_s \to K^*K$ decays (no "elegant" u-spin!!!) **Ciuchini et al., in preparation**
- Who knows (yet) what else?

just few examples

Can we see Bs oscillations?

- BaBar and Belle measured Δm_d with very high accuracy
- Vertex separation guarantied for B_s ($\tau_{B_s} \sim \tau_{B_d}$)
- B_s oscillates ~40 times faster in SM (or more in NP case)
- We are assuming a vertex 10 times better in superB simulations (see N.Neri's talk at November workshop)
- We need to access the period of oscillation

$$<\Delta t> \simeq \frac{\pi}{\Delta m_s}$$

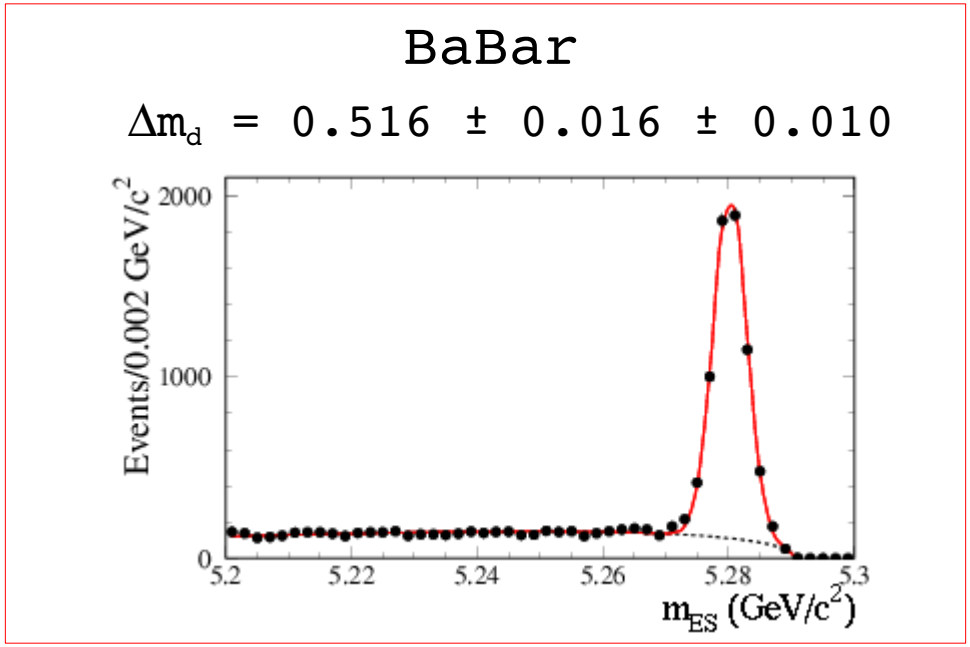


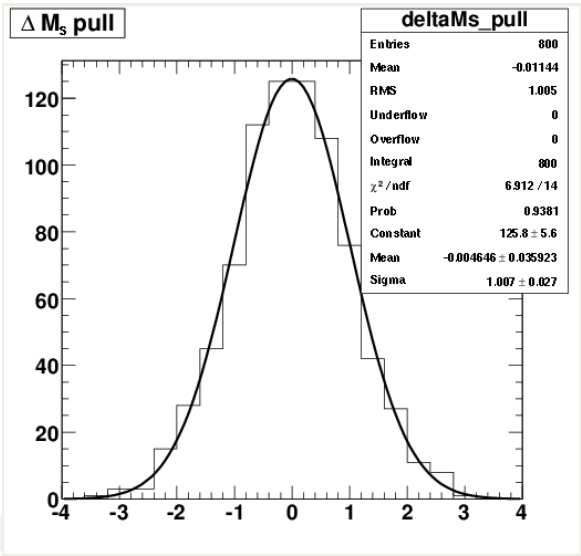
- We start reproducing measurement of Δm_d from hadronic decays in BaBar, using toy MC
- We use Pravda to simulate $B_s \to D_s \pi$ decays ($D_s \to \phi\pi$, $\phi \to KK$)
- We run toy MC as a function of the boost to determine the sensitivity to Δm_s

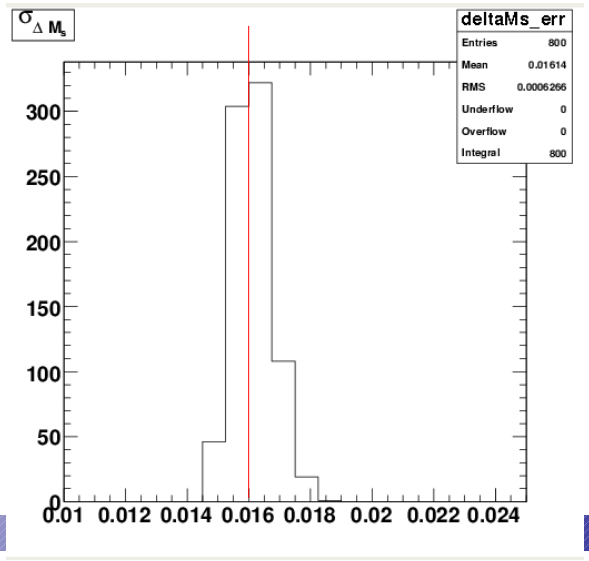
Simulating Δm_d analysis (sanity check)

We copycat BaBar 30 fb^{-1} measurement (hep-ex/0112044)

- ~ 5500 signal events
- ~ 900 background events
- m_{ES} to separate the two (Gaussian vs Argus)
- Δt (BaBar RF model) with C=1 & S=0 to determine Δm_d







$$pull = \frac{\Delta m_{FIT} - \Delta m_{GEN}}{\sigma_{\Delta m}}$$

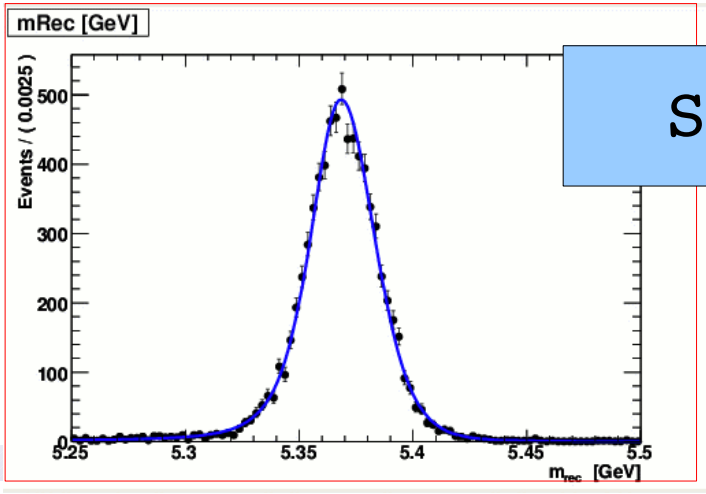
Moving to Y(5S)

- We assume 30 ab^{-1} taken at Belle CM energy (10.689 GeV)
- We use a symmetric version of the detector (improvement since November)
- We assume that only 1/3 of non Bs*Bs* decays are good (conservative?)
- We simulate and reconstruct the decay $B^0 \rightarrow D_s\pi$.

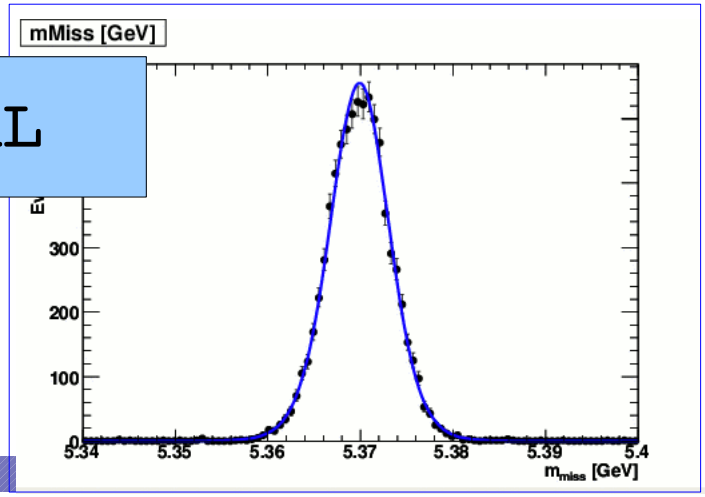
Estimated ~2500 signal and ~2000 background events

$$m_{REC} = |p_B|$$

$$m_{MISS} = |p_{ee} - p_B(m_B = m_B(PDG))|$$



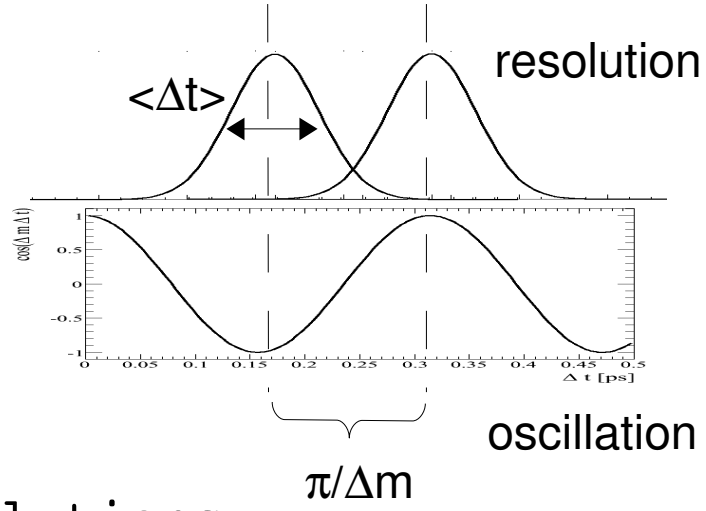
SIGNAL



Δm_s: Which resolution?(I)

- Rough estimate (using $\Delta m = 20\ ps^{-1}$):

$$<\Delta t> \simeq \frac{\pi}{\Delta m_s} \simeq 0.16\ ps$$



- Toy MC studies with different Δt resolutions:

  Generation and Multivariate ML fit using reasonable parameterizations extracted from Pravda Simulation

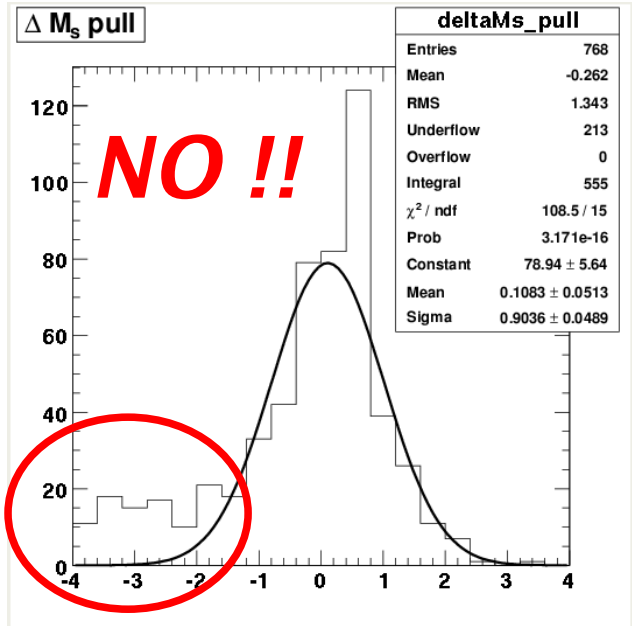
$m_{REC} = |p_B|$ $\quad$ $m_{MISS} = |p_{ee} - p_B(m_B = m_B(PDG))|$ $\quad$ Δt

Babar-like PDF

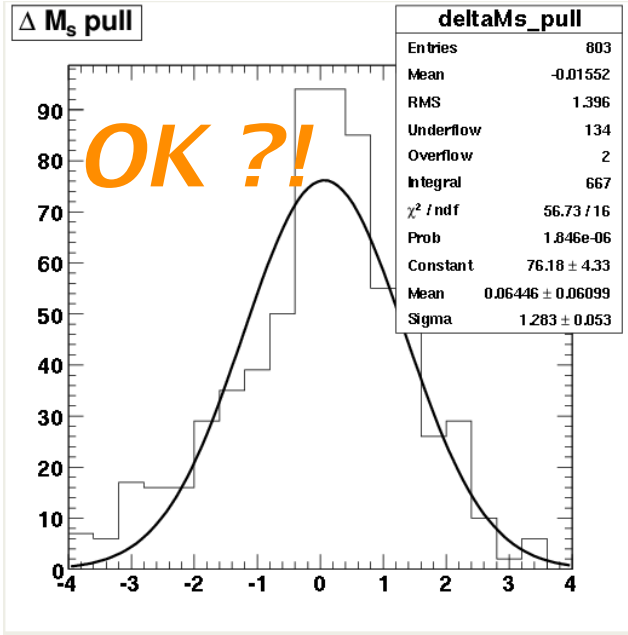
sig: Gaussians + exponential tails
bkg: Pol2 and Argus

Δm_s: Which resolution?(II)

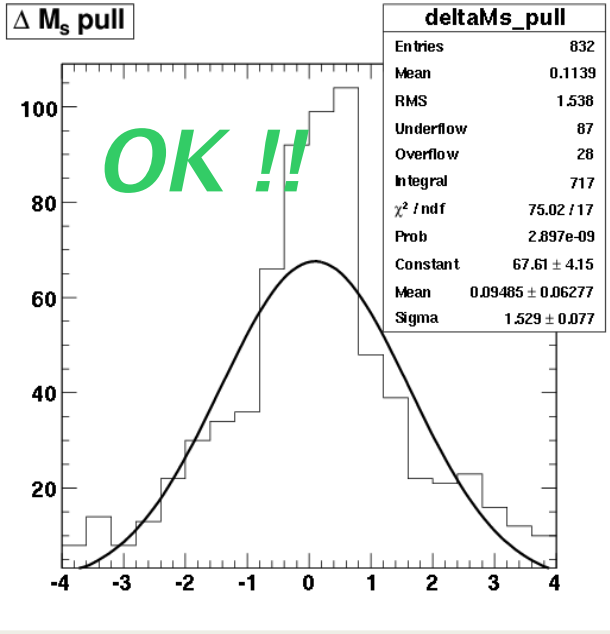
Δt resolution 0.17 *ps*



Δt resolution 0.16 *ps*



Δt resolution 0.15 *ps*

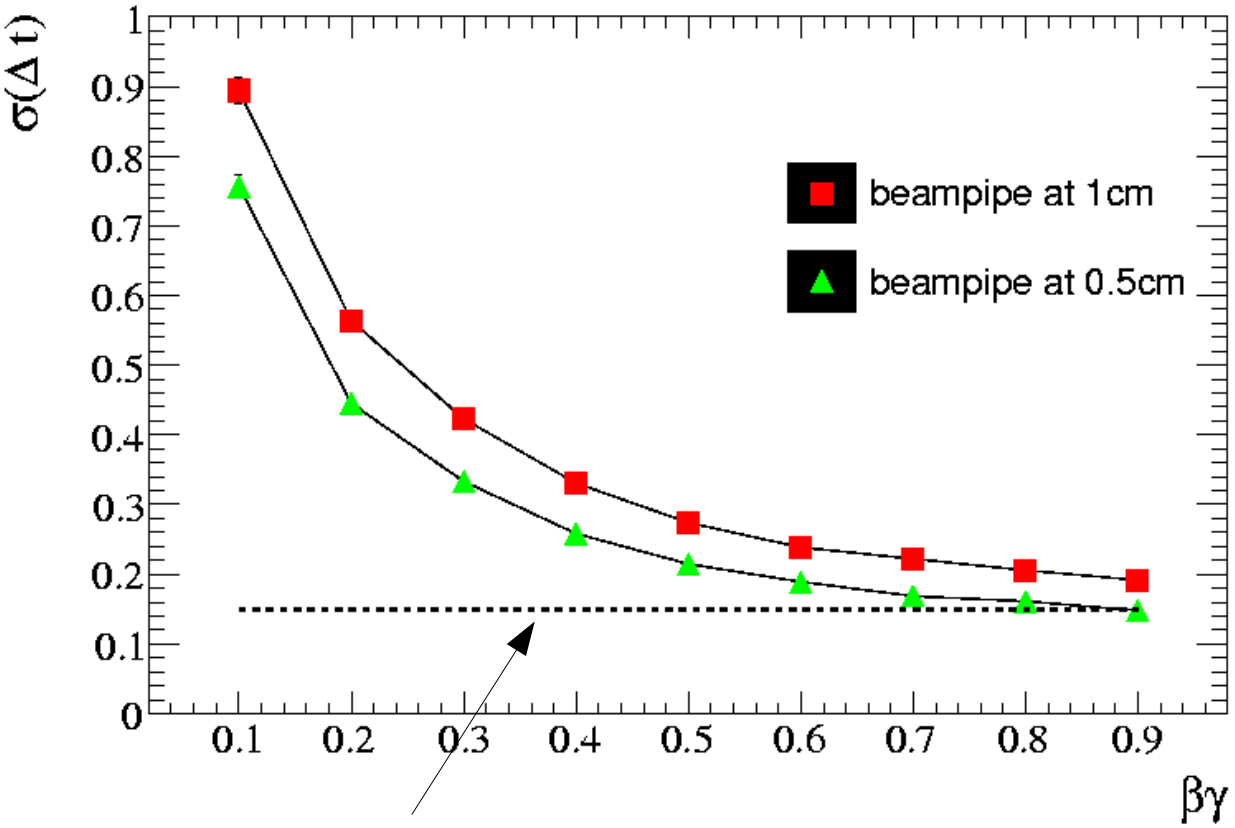


$$pull = \frac{\Delta m_{FIT} - \Delta m_{GEN}}{\sigma_{\Delta m}}$$

Rough estimate confirmed (need ~ 0.16 *ps*)

Δm_s: $\sigma_{\Delta t}$ vs boost $\beta\gamma$

From Pravda Simulations



$\sigma_{\Delta t}$ = 0.16 *ps*

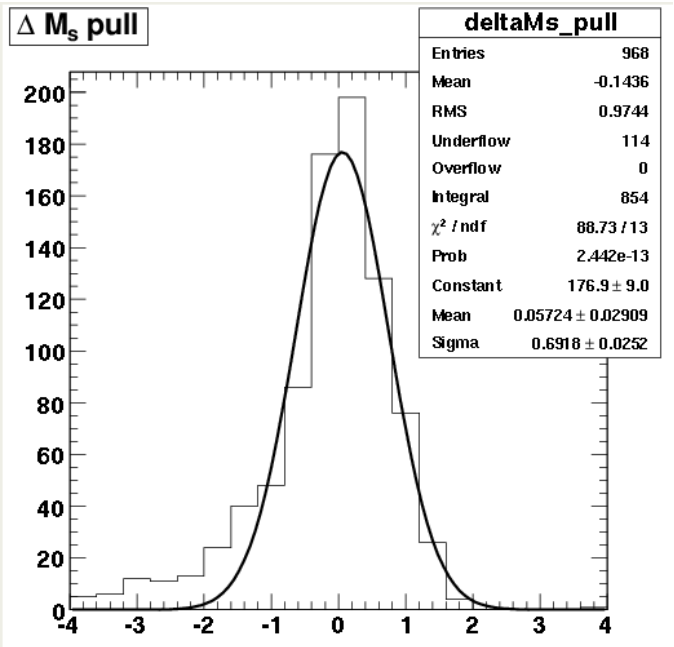
Needed resolution:

~ 0.16 ps

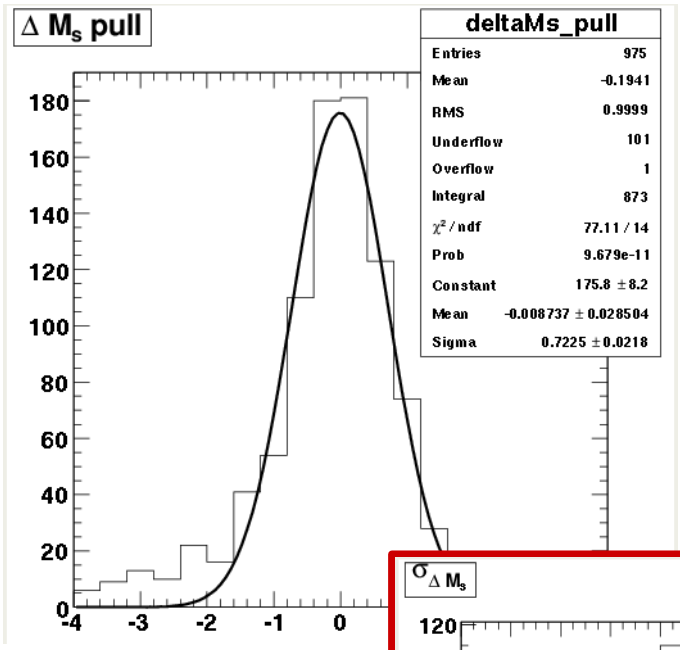
- Not achievable with 1cm beam pipe;
- Can be obtained with 0.5cm beam pipe and large boost ($\beta\gamma$ = 0.6-0.7)

Δm_s : beam pipe=0.5cm

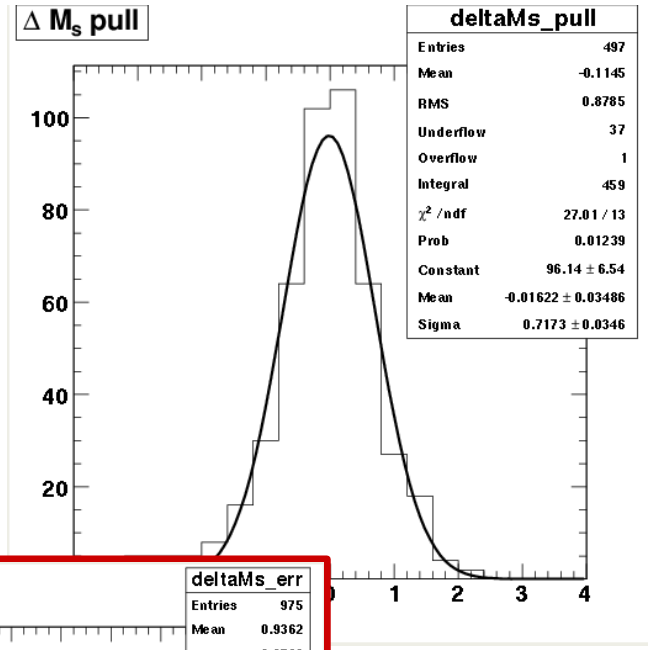
$\beta\gamma = 0.6$



$\beta\gamma = 0.7$

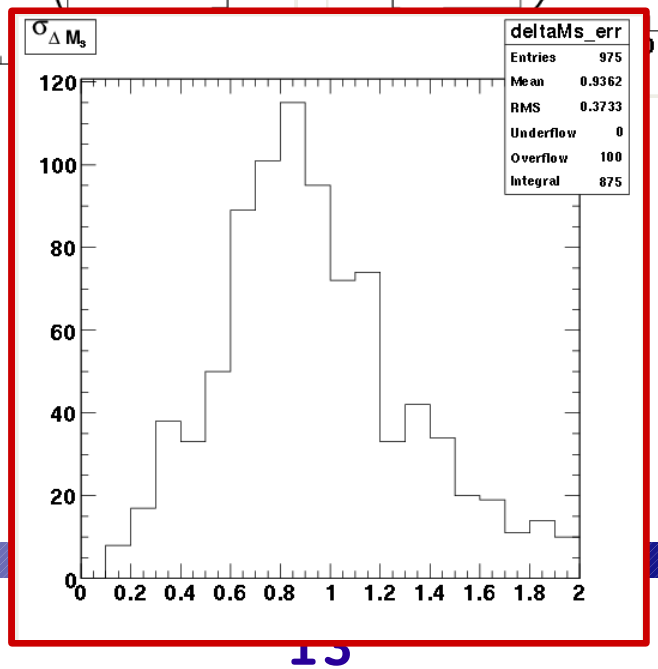


$\beta\gamma = 0.8$



$\sigma_{\Delta m} \sim 1\ ps^{-1}$

Probably not competitive but Δm_s measurement is NOT the goal but a TEST about the feasibility of TD measurements



A still open question...

- We presented a very preliminary study (hasty and not accurate) about Bs potential of a super *B-factory*;
- Bs oscillations could be accessed if $\beta\gamma > 0.6$ and/or with improvements on the Δt resolution (hardware and/or vertexing algorithm):
  - important to perform time dependent analysis, also if the Δm_s measurement should not be competitive;
  - detector and machine requests seems in contrast with the current orientation...

What's the case for a Υ(5S) running?

Backup Slides

Masses, widths, lifetimes, CM momenta

Particle	Mass, MeV/c^2	Width, MeV/c^2	ΔM, MeV/c^2	$c\tau$, μm	$P_{cm}(BB)$, MeV/c
Y(4S)	10580.0 ± 3.5	$20 \pm 2 \pm 4$			
Y(5S)	10865 ± 8	110 ± 13			
B+	5279.0 ± 0.5			502	1282
B^0	5279.4 ± 0.5			462	1281
B*	5325.0 ± 0.6		45.8 ± 0.4		1075
B_s	5365.5 ± 1.3			438	851
B_s^*	5416.6 ± 3.5		51 ± 4		415

Number of *bb* events.

$N_{cont}(5S) = N_{cont}(E=10.519) * \mathcal{L}(5S) / \mathcal{L}(cont) * (E_{cont}/E_{5S})^2 \ (\varepsilon_{5S}/\varepsilon_{cont})$

Y(5S) : Lumi = 1.857 ± 0.001 (*stat*) fb^{-1}

Cont : Lumi = 3.670 ± 0.001 (*stat*) fb^{-1}

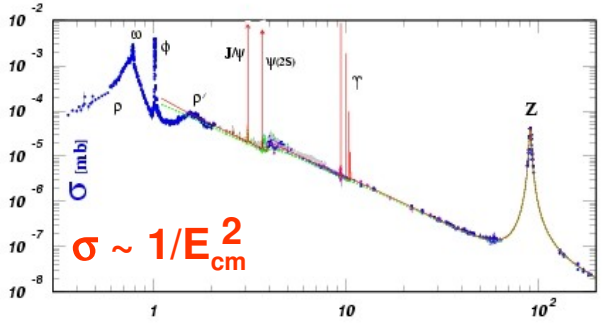
$(1.857/3.67)*(10.5189/10.869)^2 = 0.4740 \pm 0.0019$

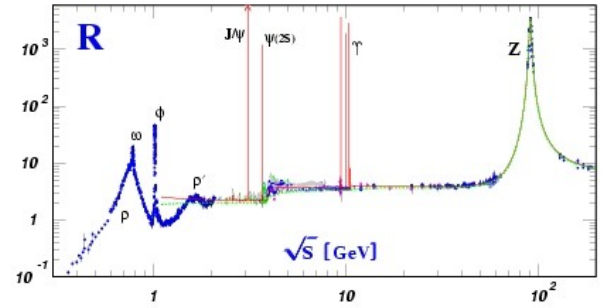
$\varepsilon_{5S}/\varepsilon_{cont} = 1.007 \pm 0.003$

$N_{bb}(5S) =$ 561,000 ± 3,000 ± 29,000

$N_{bb}(5S) / fb^{-1} = 302{,}000 \pm 15{,}000$

CLEO : 0.42 fb^{-1} $N_{bb}(5S)/ fb^{-1} = 310{,}000 \pm 52{,}000$





R = σ(hadrons) / σ(μμ)