$B^0 \to \eta'(\to \eta\pi^+\pi^-)K^0_S$ Time Dependent $\not{CP}$ analysis

B2TIP practice talk

(plus other minor stuff not for B2TIP)

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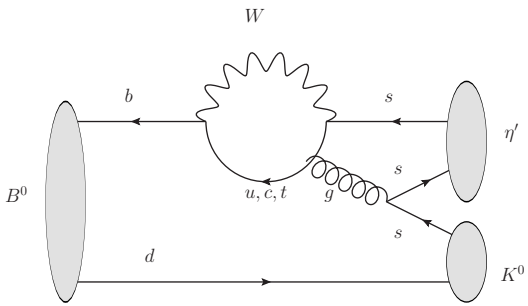
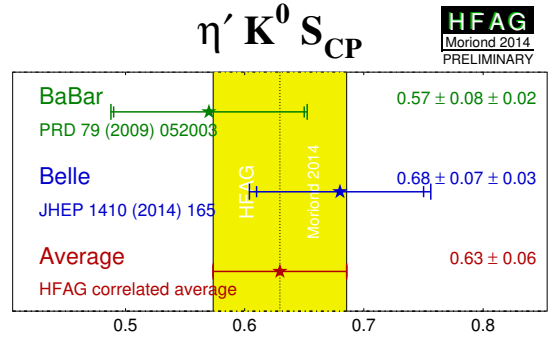
Introduction and motivations

A sensitivity study for Time-Dependent CP violation analysis in the $B^0 \to \eta' K^0$ channel, a charmless $b \to sq\bar{q}$ decay

- CP asymmetry from time-dependent decay rate into CP eigenstates;
- $S_{\eta' K^0} = \sin 2\phi_1^{eff}$ tightly related to $\sin 2\phi_1$
  - identical if only penguin diagram were present;
  - QCD factorization: $\Delta S_{\eta' K^0} \in [-0.03, 0.03]$ [Williamson and Zupan(2006)]
  - $SU(3)_F$ approach: $\Delta S_{\eta' K^0} \in [-0.05, 0.09]$ [Gronau et al.(2006)]
  - new physics can enter in the loop, shifting $\Delta S_{\eta' K^0}$ more than SM expectation





- actual uncertainties $\sigma_{stat} = 0.07, \sigma_{syst} = 0.03$ [Belle(2014)]
- projected for 50 ab^{-1} $\sigma_{stat} = 0.008, \sigma_{syst} = 0.008$ [Urquijo(2015)]

Current results

- Channel have been analyzed in B-factory [BABAR(2009), Belle(2007), Belle(2014)];
  - large BR: $BR \sim 6.6 \cdot 10^{-5}$ [CLEO(1998)] constructive interference between penguin diagrams
- analysis based on quasi-two body approach;
- uncertainties are mostly statistical ($\sim$ 3500 events for all final states);
  - $\sin 2\phi_1^{eff} = +0.68 \pm 0.07 \pm 0.03$
  - syst: ± 0.025 from Δt resolution, ± 0.014 from vertexing, ± 0.013 from $\eta' K_S^0$ fraction;

many decay channels available $B^0 \to \eta' K_S^0$

decay channel			
$\eta' \to \rho^0(\to \pi^+\pi^-)\gamma$	BR=29%	not yet	
$\eta' \to \eta\pi^+\pi^-$	43%	today	
$\searrow \eta_{\gamma\gamma}$	$\eta \to \gamma\gamma$	40%	
$\searrow \eta_{3\pi}$	$\eta \to \pi^+\pi^-\pi^0$	23%	
$B_0 \to \eta'(\to \eta_{\gamma\gamma}/\eta_{3\pi}\pi^+\pi^-)K^0$	BR=27%		

$K_S^0 \to \pi^+\pi^-$	today
$K_S^0 \to \pi^0\pi^0$	just started
K_L^0	not yet

- Complex final state, neutrals, large combinatorics;
- no competition from LHCb (neutrals);

Selection

candidate selection: main cuts

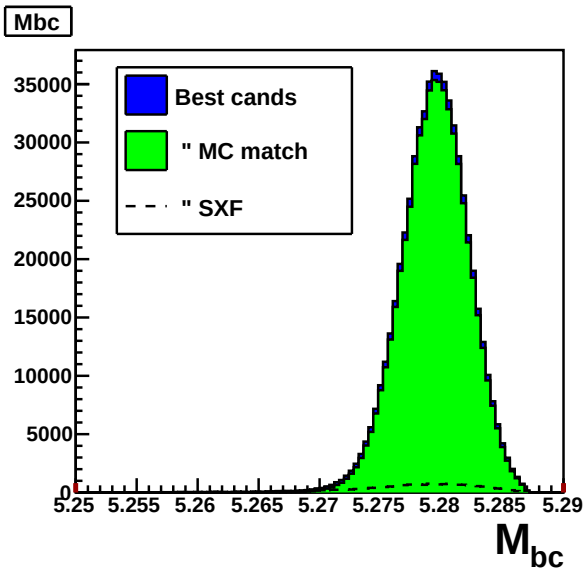
- Reconstruct decay chain with mass constrains for π^0, η, η', K^0_S,
  - vertex only (w/o mass) for B^0 (more later)

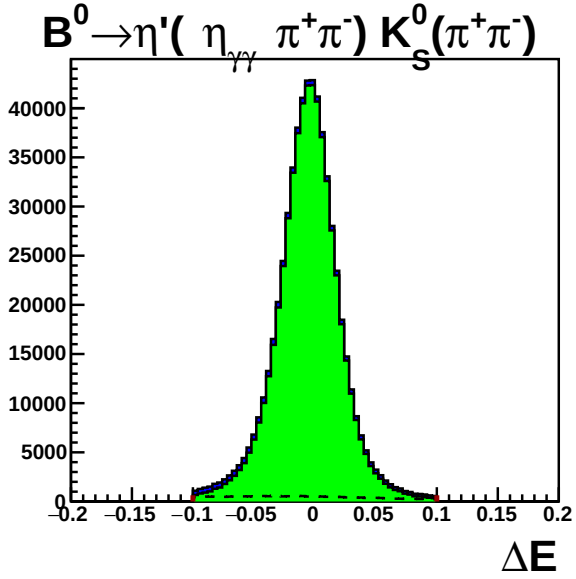
- π^0, $\eta_{\gamma\gamma}$:
  - $0.06 < E_\gamma < 6\,\text{GeV}$, $E_9/E_{25} > 0.75$
  - $M(\pi^0) \in [100, 150]\,\text{MeV}$
  - $M(\eta_{\gamma\gamma}) \in [0.52, 0.57]\,\text{GeV}$;
- $\eta' \to \eta_{\gamma\gamma}\pi^+\pi^-$:
  - $d_0(\pi^\pm) < 0.08\text{mm}$; $z_0(\pi^\pm) < 0.1\text{mm}$;
  - N hits$_{PXD}(\pi^\pm) > 1$, PID
  - $M(\eta') \in [0.93, 0.98]\,\text{GeV}$;
- $\eta' \to \eta_{3\pi}\pi^+\pi^-$:
  - $M(\eta') \in [0.93, 0.98]\,\text{GeV}$;
- $K^0 \to \pi^+\pi^-$:
  - $M(K^0_S \to \pi^+\pi^-) \in [0.48, 0.52]\,\text{GeV}$;
- $B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\,\pi^-)K^{0+-}_S$
  - $M_{bc} > 5.25\,\text{GeV}$;
  - $|\Delta E| < 0.1\,\text{GeV}$;
- $B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K^{0+-}_S$
  - $|\Delta E| < 0.15\,\text{GeV}$;

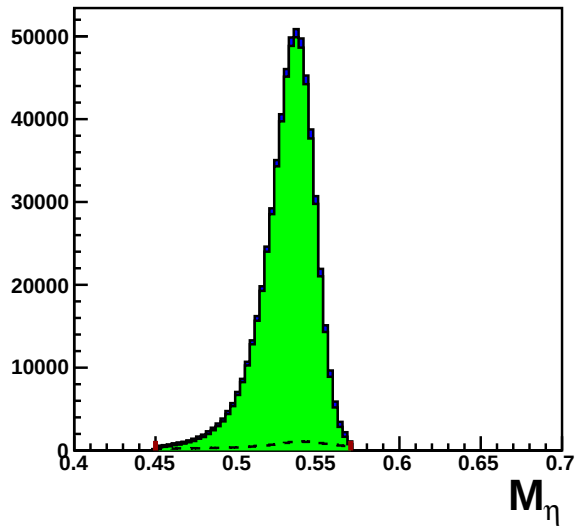
if $N_{cands} > 1$, select that with best reduced χ^2 for η, η', K^0_S inv. masses

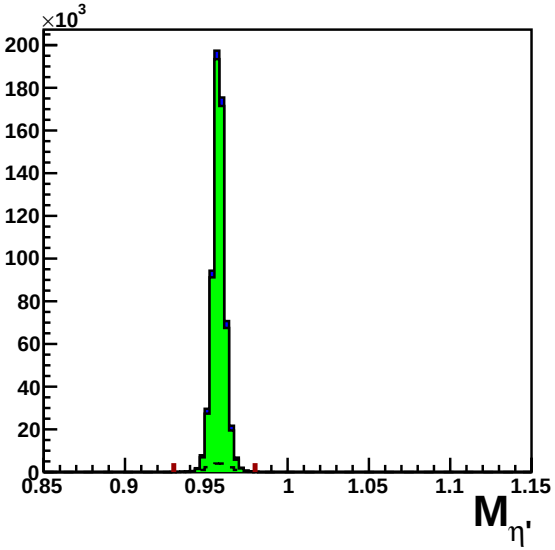
Signal distribution $B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K_S^{0+-}$

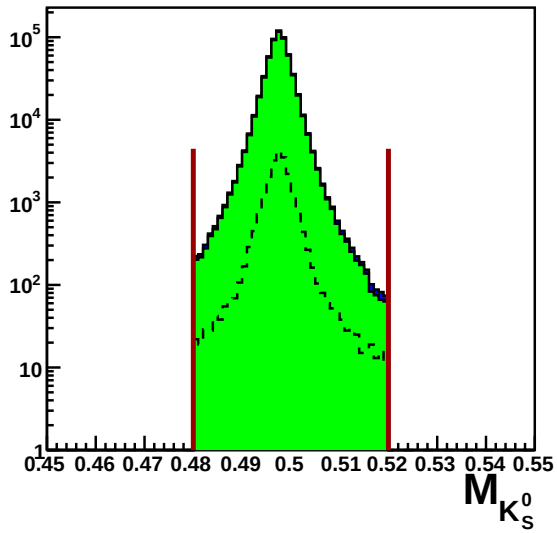
Best candidates, after selections

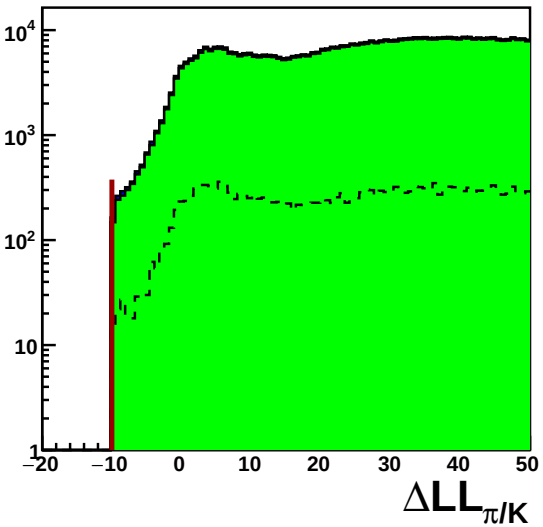






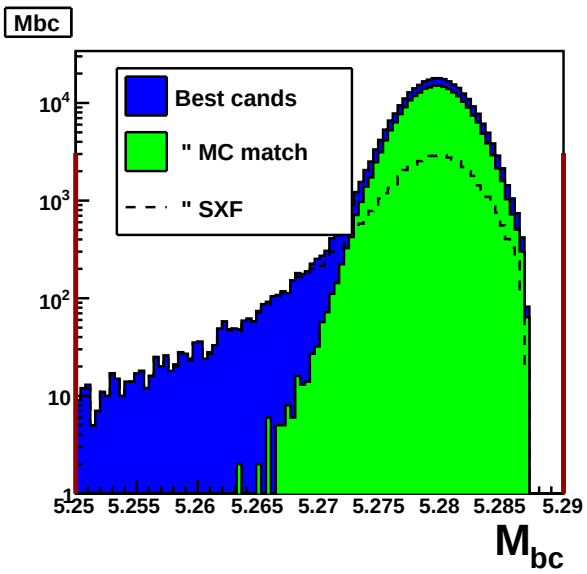


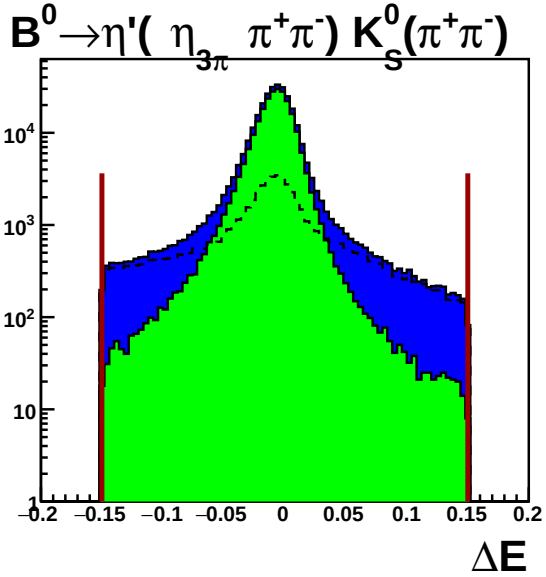


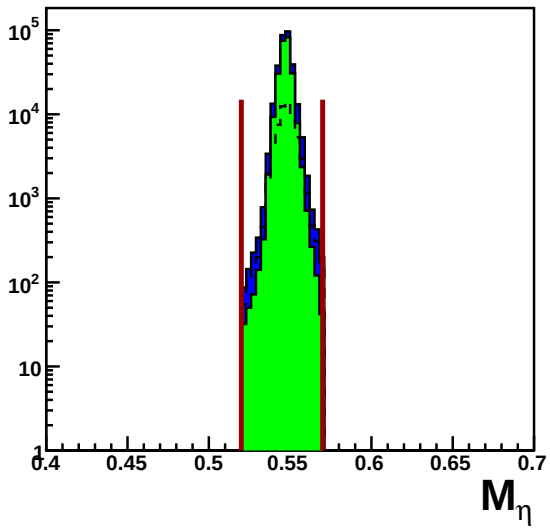


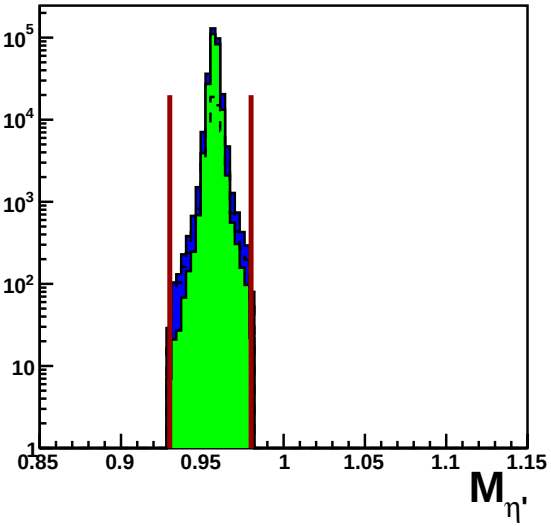
Signal distribution $B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$

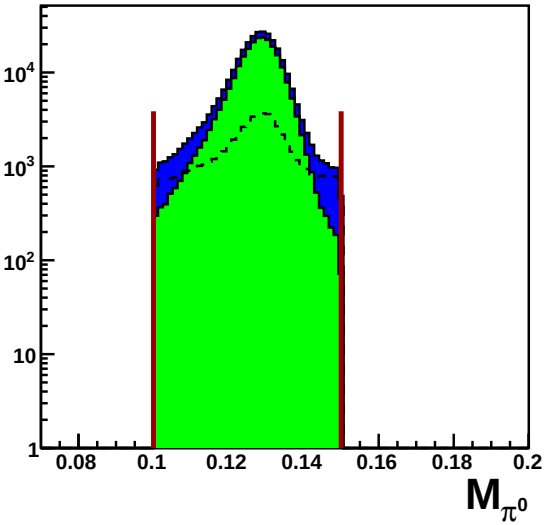
Best candidates, after selections

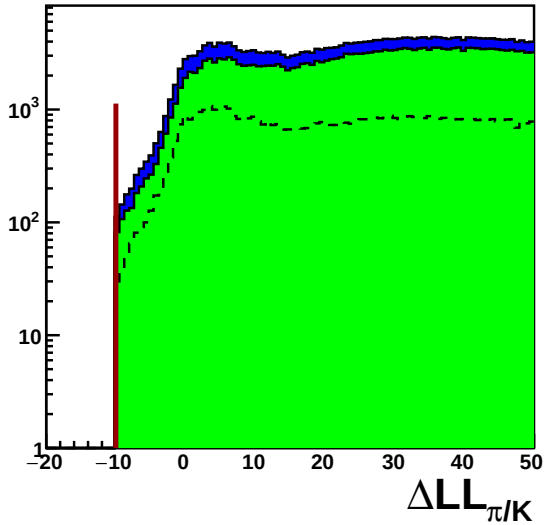












Efficiency and combinatorics

Final state with $K^0_S \to \pi^+\pi^-$

$B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K^{0+-}_S$

Efficiency %	
MC true	29.4
SXF	1.1

1.06 good cands per event

$B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K^{0+-}_S$

Efficiency %	
MC true	12.1
SXF	3.1

1.45 good cands per event

Eff drop due to π^0 reco, likely to improve

Final state with $K^0_S \to \pi^0\pi^0$

$B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K^{0\,00}_S$

Efficiency %	
MC true	13.5
SXF	2.2

5 good cands per event

$B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K^{0\,00}_S$

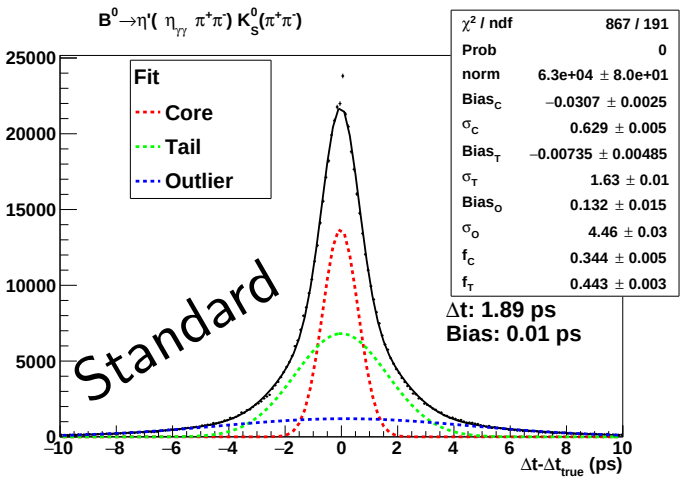
Efficiency %	
MC true	6.0
SXF	3.8

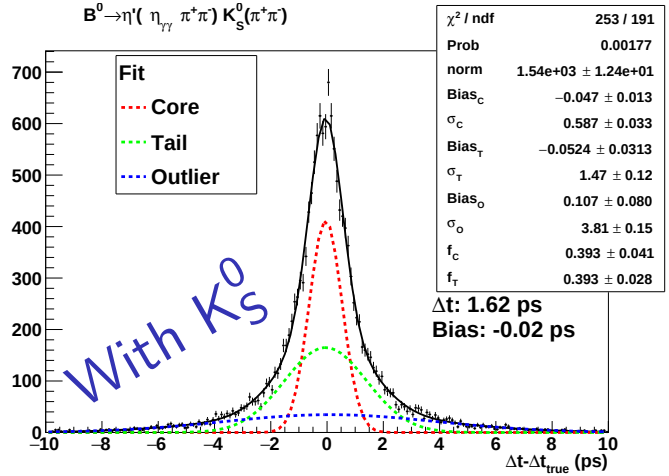
30 *good cands per event*

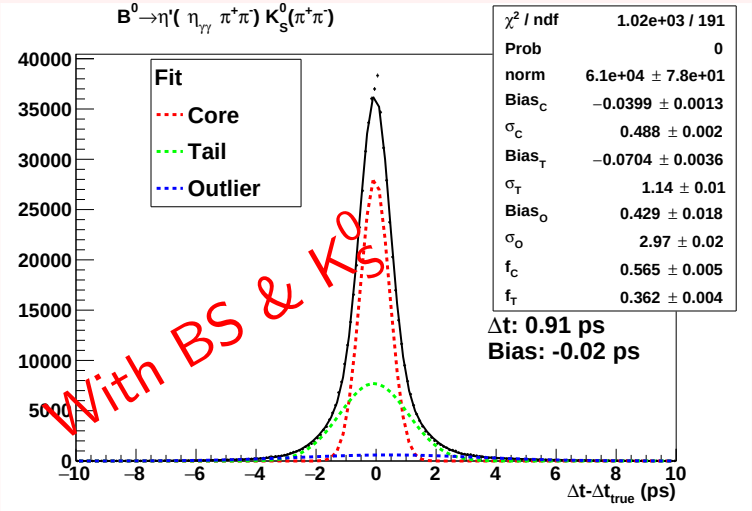
not used in BaBar/Belle

Vtx reco and Δt resolution: $\eta_{\gamma\gamma}$ channel

1. Fit the B_0 vertex from charged tracks; ($\pi^{\pm}$ from $\eta' \to \eta\pi^{\pm}$, $\eta \to \pi^{\pm}\pi^0$)
2. add also constraint from reconstructed K^0_S direction; ($K^0_S \to \pi^+\pi^-$)
3. add also constraint from beamspot, only on transferse plane.







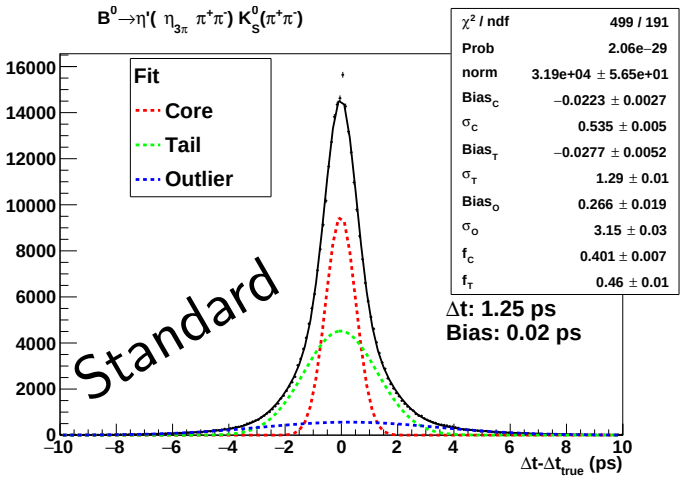
With beamspot (x, y) & K^0_S:

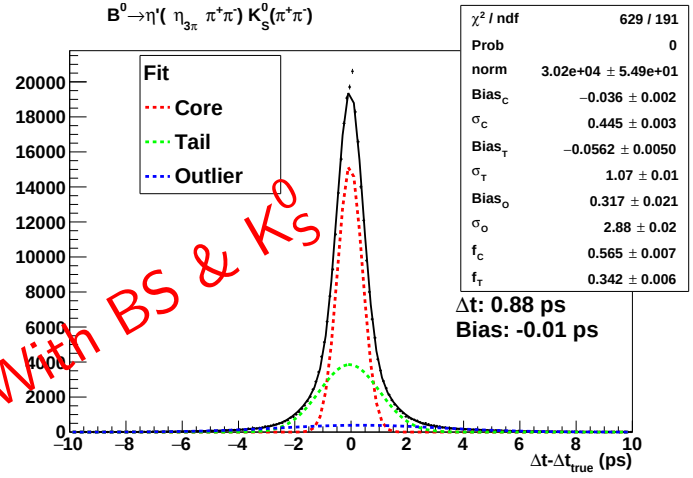
No efficiency loss

substaintial improvement in Δt resolution

$1.89 \to 1.62 \to 0.91$ *ps*

Vtx reconstruction for $B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$





With beamspot (x, y) & K_S^0:

No efficiency loss

$1.25 \to 0.88$ *ps*

Comparison with Belle

Comparison with Belle

- Not been able to find Δt resolutions numbers for Belle, only RMS
- Belle has 4 different events categories, depending on vtx quality reconstruction
- $\eta_{\gamma\gamma}$

Belle RMS: **1.57** (/2.67/5.16/4.52)
BelleII (this study) RMS: **1.12**

- $\eta_{3\pi}$

Belle RMS: **1.2** (1.22/3.18/5.9)
BelleII (this study): RMS: **1.10**

Backgrounds

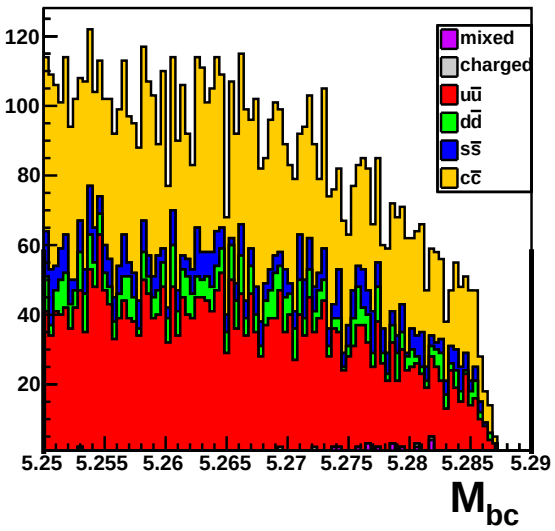
- **Combinatorial**: from continuum background $e^+e^- \to u\bar{u}, d\bar{d}, s\bar{s}, c\bar{c}$
  - evaluated from M_{bc} side bands on real data
  - now from MC production
  - use Continuum Suppression variable
    - ★ multivariate variables sensitive to event topology
    - ★ central (signal) vs jet-like (continuum)
- **Peaking**: any other B decays possibly with real η' and/or K^0_S
  - evaluated from MC of generic $B^0\overline{B}^0$, B^+B^-
    - ★ actual $B^0 \to \eta' K^0$ removed.
- Current results based on BGx0 production, namely w/o machine background
  - impact of machine background under study
- (almost) solved skimming problem for mixed and charged
  - harder cut on skim selections
  - now $L \approx 800$ fb^{-1} for all sources (was ≈ 200 fb^{-1} for mixed/charged)
- Next table numbers before Continuum Suppression cut

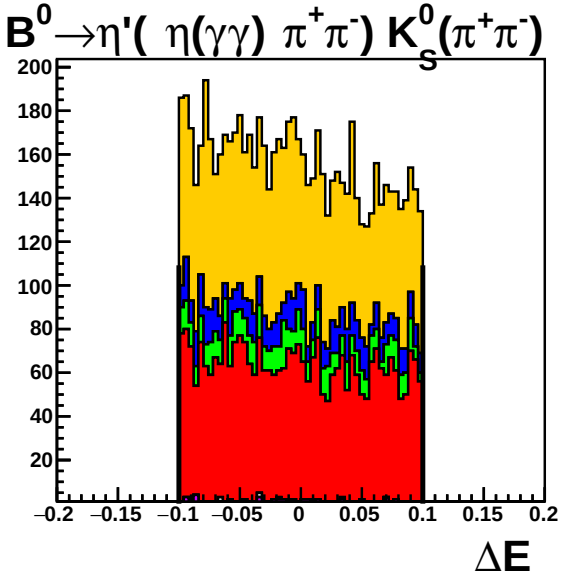
Background reduction (before CS cut)

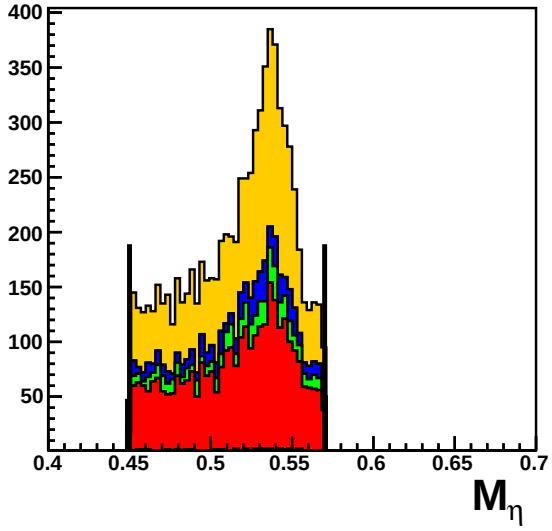
Sample	$u\bar{u}$	$d\bar{d}$	$s\bar{s}$	$c\bar{c}$	contiuum	$B^0\overline{B}^0$	B^+B^-
Input ev (M)	1284	321	306	1063	2974	429	420
$B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K_S^{0+-}$							
$\epsilon_{sel} \cdot 10^{-6}$	2.69	3.06	2.40	3.62	3.0	0.13	0.043
ev for 300 fb^{-1}	1247	369	275	1445	3335	22	7
$B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$							
$\epsilon_{sel} \cdot 10^{-6}$	0.34	0.54	0.17	1.50	0.76	0.14	0.02
ev for 300 fb^{-1}	166	65	20	597	847	24	3

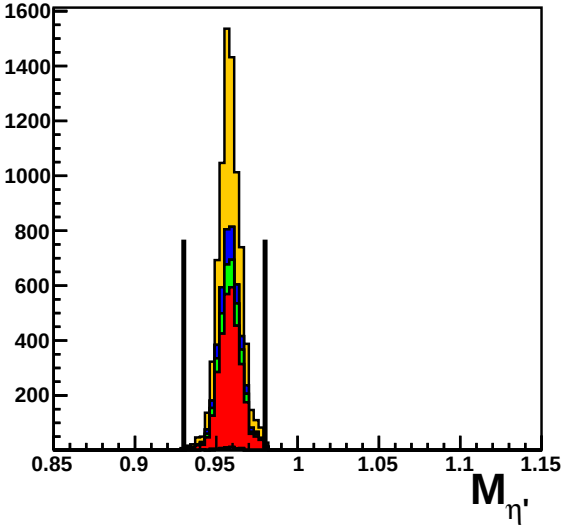
Background distributions

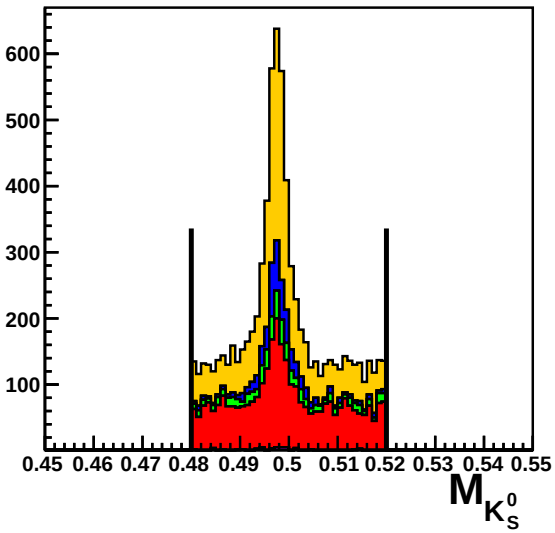
Best candidates, after selections

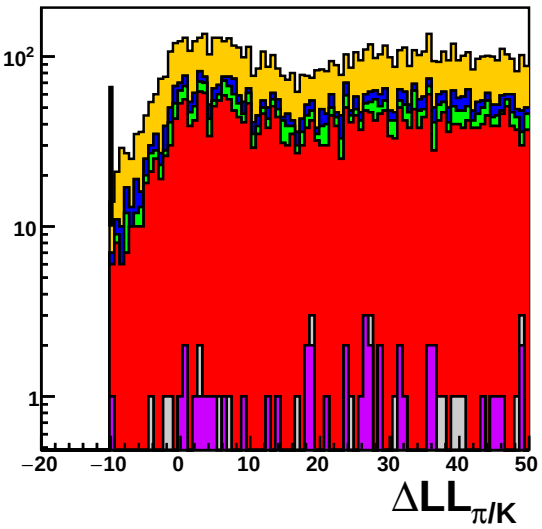






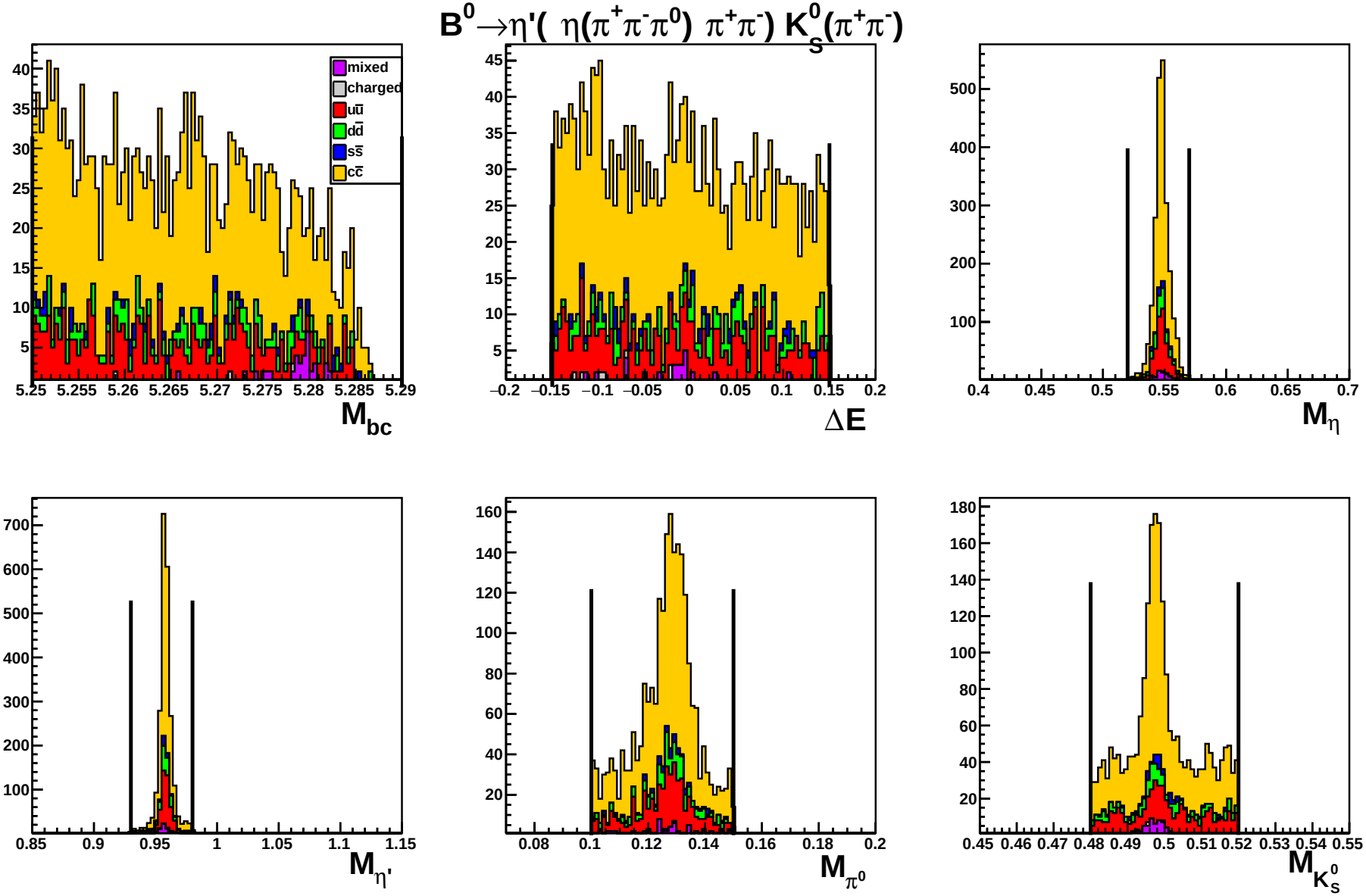




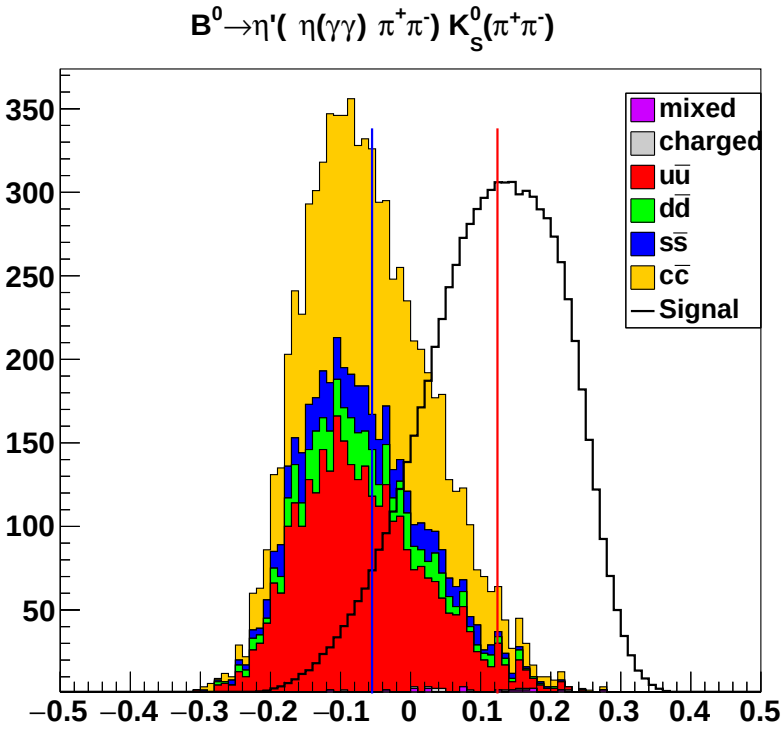


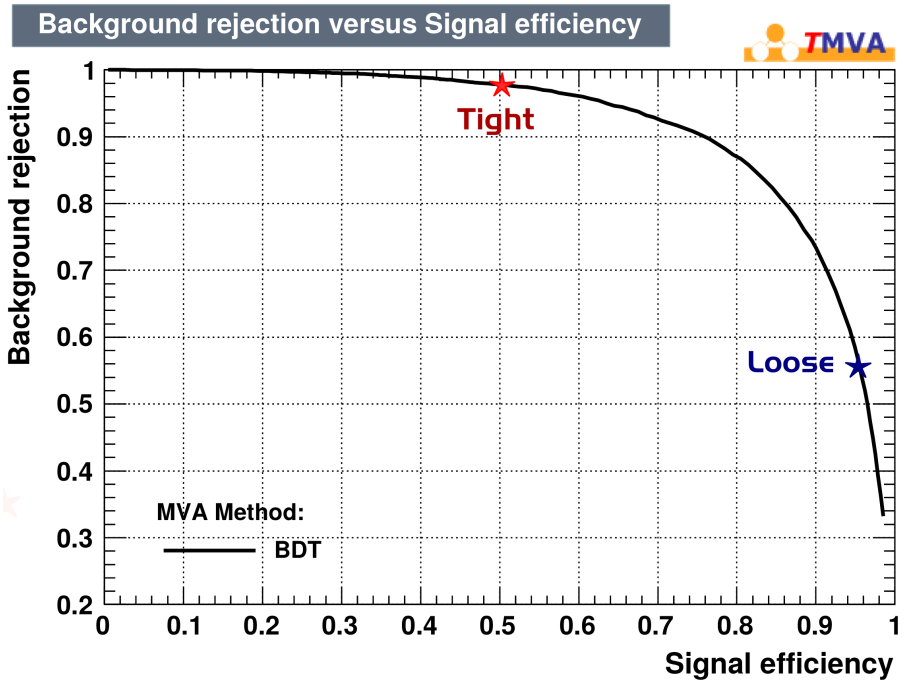
Background distributions

Best candidates, after selections



Continuum suppression





Working points

- **Tight**: $BDT > 0.124$, $\epsilon_{signal} = 50\%$, $(1 - \epsilon_{background}) = 97.5\%$,
- **Loose**: $BDT > -0.055$, $\epsilon_{signal} = 95\%$, $(1 - \epsilon_{background}) = 58\%$,
- **no cut**: just include the BDT in the likelihood not yet

Likelihood fit

Multi dim. extended maximum likelihood fit to extract S and C.

Pdf is of the form: $\mathcal{P}_j^i = \underbrace{\mathcal{T}_j\left(\Delta t^i, \sigma_{\Delta t}^i, \eta_{CP}^i\right)}_{\text{time-dep part}} \prod_k \underbrace{\mathcal{Q}_{k,j}(x_k^i)}_{\text{time integrated}}$

time-dependent part, taking into account mistag rate ($\eta_f = \pm 1$ is CP state):

$$f(\Delta t) = \frac{e^{-|\Delta t|/\tau}}{4\tau}\Big\{1 \mp \Delta w \pm (1-2w) \times \big[-\eta_f S_f \sin(\Delta m \Delta t) - C_f \cos(\Delta m \Delta t)\big]\Big\}$$

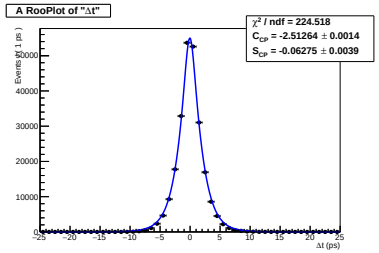
variables (x_k) used, in addition to Δt

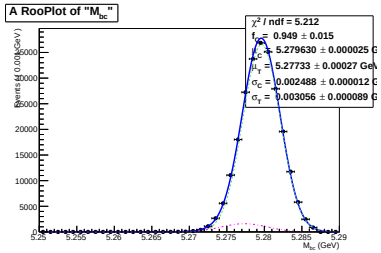
- M_{bc}
- ΔE
- ~~$M_{\eta'}$~~ removed, not useful
- Cont. Suppr. not yet

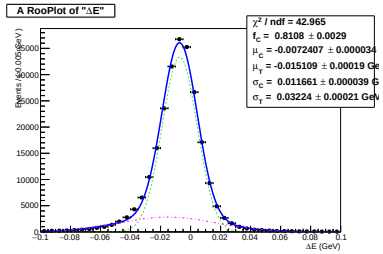
Parameters:

- effective tagging efficiency: $Q = \epsilon(1-2w)^2 = 0.33$
- $w = 0.21$, $\Delta w = 0.02$
- Δt resolution as shown previously convoluted.
- τ, Δm from PDG

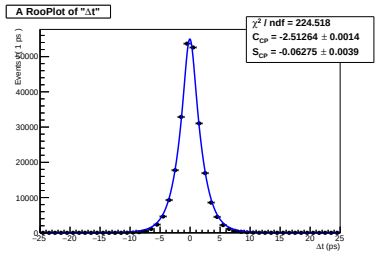
PDF fit results examples

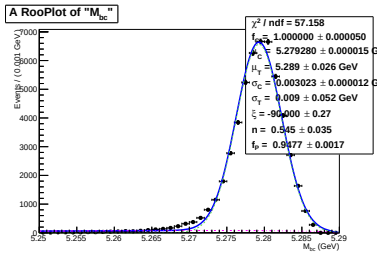


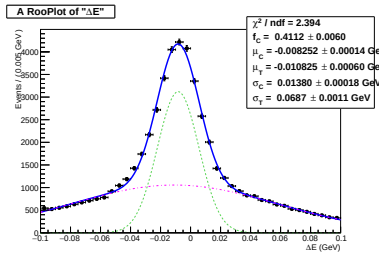




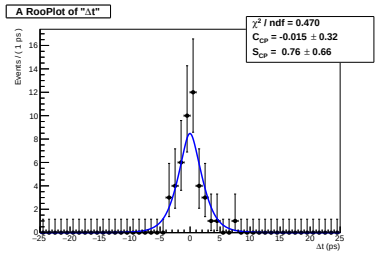
Signal

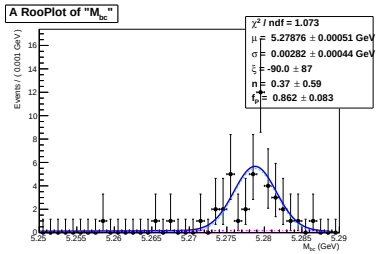


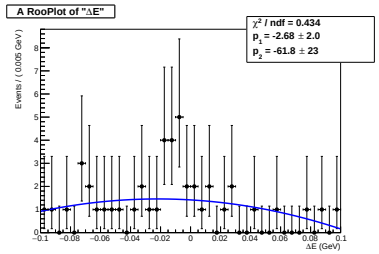




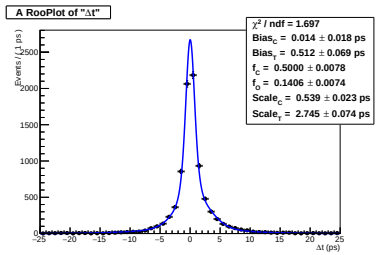
SxF

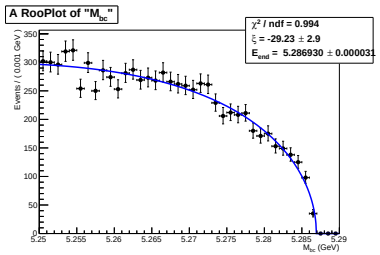


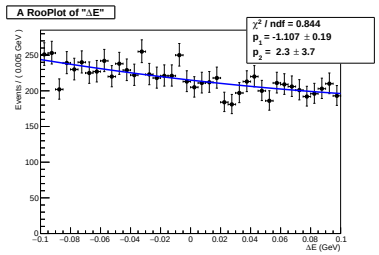




Peaking bkgnd







Continuum

ΔT M_{bc} ΔE

Still problem to fit the continuum suppression variable: very spiky

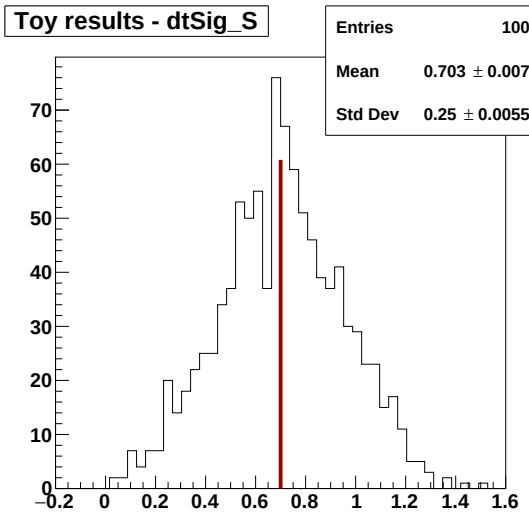
Toy MC

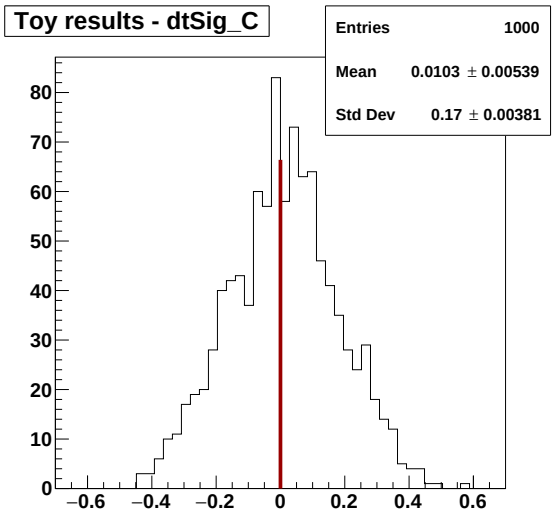
- Testing fit machinery with Toy MC;
- Yield estimated for $L = 300\ \text{fb}^{-1}$
- width of distribution related to the expected statistical uncertainty;
- check also for bias ($RMS/\sqrt{N_{toys}}$)
- Toys now are converging, fixed problem with Δt resolution
- input CP asymmetry parameter: S=0.7 C=0.0
- testing two different CS scenarios:
  - Tight
  - Loose
- Partially embedded toys
  - Signal and SXF from MC;
  - Continuum and Peaking background from pdf;

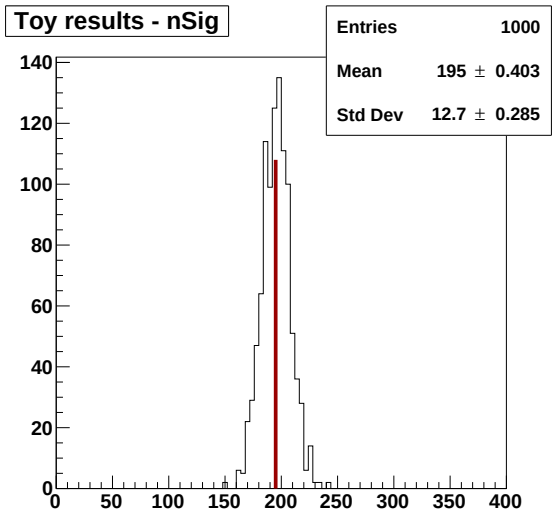
Toy results $B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K_S^{0+-}$ Tight CS

Tight: $\epsilon_{sig,sxf,peaking} = 50\%$, $\epsilon_{continuum} = 2.5\%$

$N_{sig} = 195$, $N_{sxf} = 8$, $N_{cont} = 83$, $N_{peak} = 15$





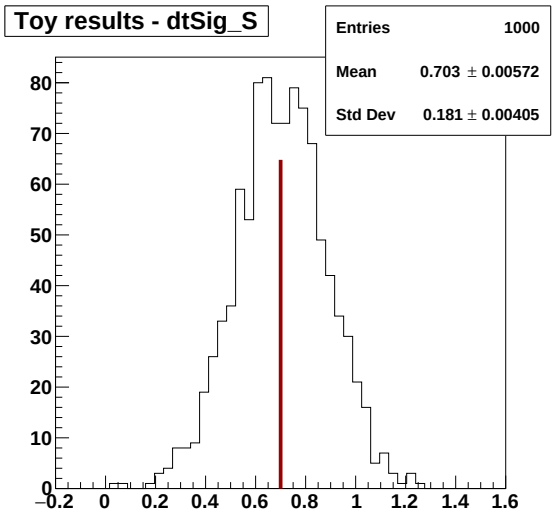


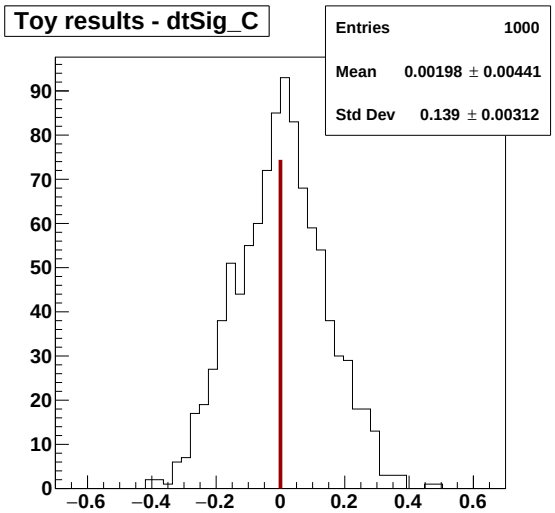
Par	Bias	RMS
S (0.7)	0.703 ± 0.008	0.25
C (0.0)	0.010 ± 0.005	0.17
nSig	195.4 ± 0.4	12.7

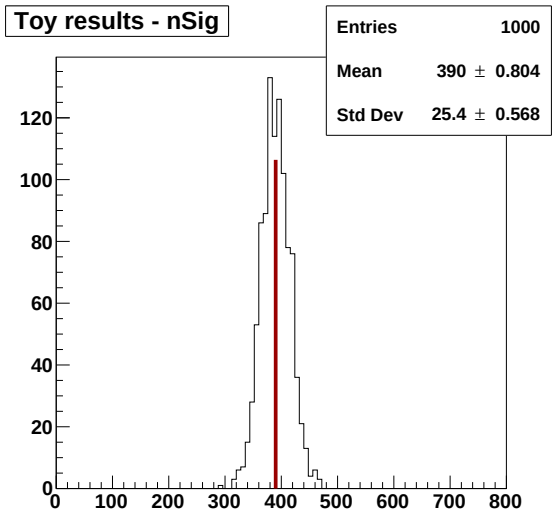
Toy results $B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K_S^{0+-}$ Loose CS

Loose: $\epsilon_{sig,sxf,peaking} = 95\%$, $\epsilon_{continuum} = 42\%$

$N_{sig} = 390$, $N_{sxf} = 14$, $N_{cont} = 1400$, $N_{peak} = 28$





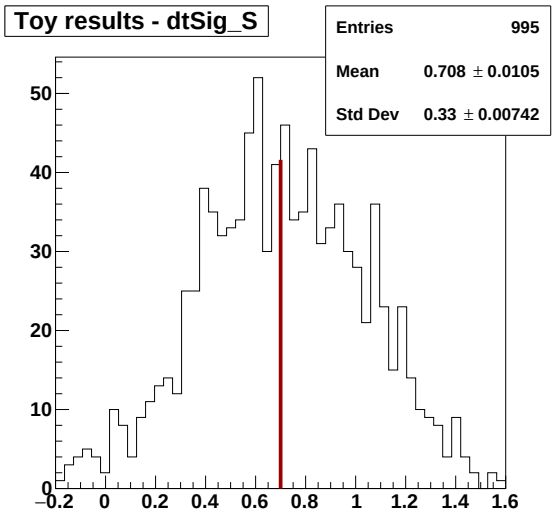


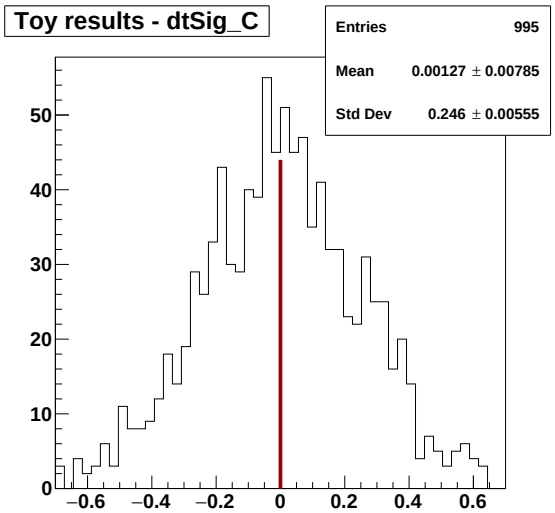
Par	Bias	RMS
S (0.7)	0.703 ± 0.005	0.18
C (0.0)	0.002 ± 0.004	0.14
nSig	389.8 ± 0.8	25.4

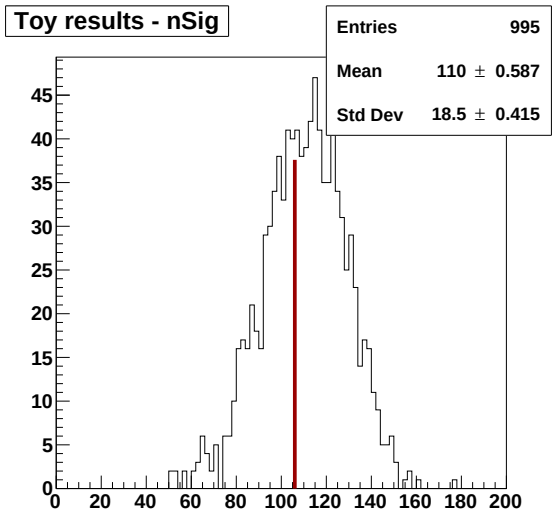
Toy results $B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$ Loose CS

Loose: $\epsilon_{sig,sxf,peaking} = 95\%$, $\epsilon_{continuum} = 42\%$

$N_{sig} = 106$, $N_{sxf} = 25$, $N_{cont} = 360$, $N_{peak} = 27$







Par	Bias	RMS
S (0.7)	0.708 ± 0.010	0.330
C (0.0)	-0.013 ± 0.008	0.246
nSig	110.2 ± 0.6	18.5

Comparison with Belle/BaBar

	This analysis*			Belle[Belle(2014)]			BaBar[BABAR(2009)]		
mode	(340 M B $\overline{\text{B}}$)			(772 M B $\overline{\text{B}}$)			(467 M B $\overline{\text{B}}$)		
$\eta' \to \pi^{\pm}\eta$	N_{sig}	σ_S	σ_C	N_{sig}	σ_S	σ_C	N_{sig}	σ_C	σ_S
$\eta_{\gamma\gamma}K_S^{0\,+-}$	390	0.18	0.14	648	0.15	0.098	472	0.17	0.11
$\eta_{\gamma\gamma}K_S^{0\,00}$	Just started			104	0.21†	0.18†	105	0.34	0.30
$\eta_{3\pi}K_S^{0\,+-}$	106	0.33	0.25	174	0.26	0.18	171	0.26	0.20
$\eta_{3\pi}K_S^{0\,00}$	Will try			Not used					
$\eta' \to \rho^0\gamma K_S^{0\,+-}$	Not yet			1411	0.098	0.069	1005	0.12	0.09
$\eta' \to \rho^0\gamma K_S^{0\,00}$	Not yet			162	0.21†	0.18†	206	0.33	0.26

*Very preliminary estimate based on toy MC, $L = 300$ fb^{-1}

Warning: no machine background yet

†Results combining $\eta' \to \pi^{\pm}\eta_{\gamma\gamma}$ and $\eta' \to \rho^0\gamma$

TODO: toys with Belle statistics for direct comparison

Summary

- First presentation on sensitivity study for ~~CP~~ in $B^0 \to \eta' K^0_S$ channel;
- not complete, yet, but preliminary results are encouraging;
  - comparison with Belle and BaBar results looks fine;
- many thing to do:
  - complete $K^0_S \to \pi^+\pi^-$ channels;
  - study $K^0_S \to \pi^0\pi^0$ final states;
  - add $\eta' \to \rho^0\gamma K^{0\,+-}_S / K^{0\,00}_S$ channel;
  - systematics uncertainties evaluation;
  - documentation
  - ...

More results (and work) for next B2TIP workshop.

Additional stuff

Additional or backup slides

Selection

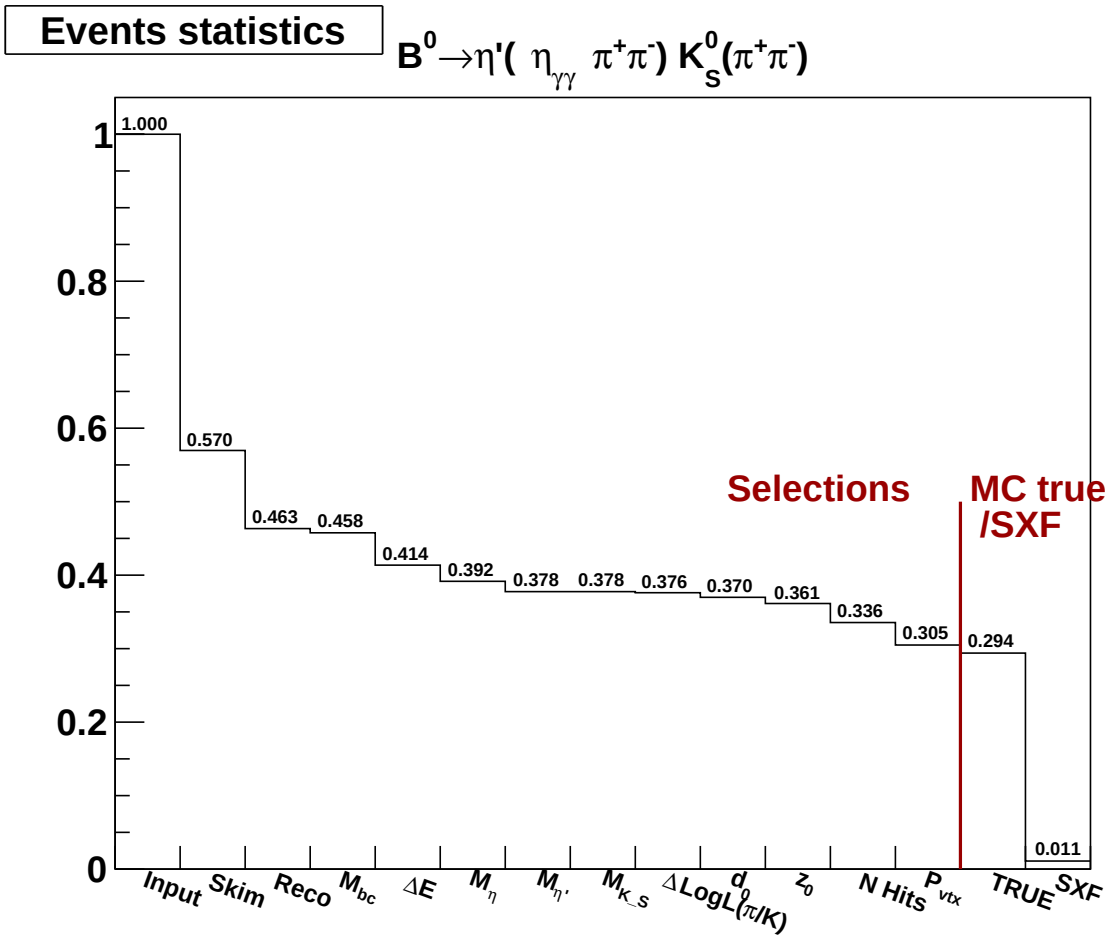
good candidate selection $B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\,\pi^-)K_S^{0+-}$:

- Reconstruct decay chain with mass constrains for η, η', K_S^0,
  - vertex only (w/o mass) for B^0

- $\eta \to \gamma\gamma$:
  - `gamma:all`: $0.06 < E_\gamma < 6\,\text{GeV}$, $-150 < clus_{time} < 0$, $E_9/E_{25} > 0.75$
  - $M(\eta_{\gamma\gamma}) \in [0.52, 0.57]\,\text{GeV}$;
- $\eta' \to \eta_{\gamma\gamma}\pi^+\pi^-$:
  - `pi:all`
  - $\Delta\log\mathcal{L}(\pi, K) > -10$; new
  - $d_0(\pi^\pm) < 0.08\text{mm}$;
  - $z_0(\pi^\pm) < 0.1\text{mm}$;
  - N hits$_{PXD}(\pi^\pm) > 1$
  - $M(\eta') \in [0.93, 0.98]\,\text{GeV}$;
- $K^0 \to \pi^+\pi^-$:
  - `K_S0:mdst`
  - $M(K_S^0 \to \pi^+\pi^-) \in [0.48, 0.52]\,\text{GeV}$;
- $B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\,\pi^-)K_S^{0+-}$
  - $M_{bc} > 5.25\,\text{GeV}$;
  - $|\Delta E| < 0.1\,\text{GeV}$;
  - P-value$_{vtx}(B_0, \eta', K_S^0) > 1 \cdot 10^{-5}$

if $N_{cands} > 1$, select candidate with highest P-value$_{vtx}(B_0, \eta', \eta, K_S^0)$

Selection breakdonw



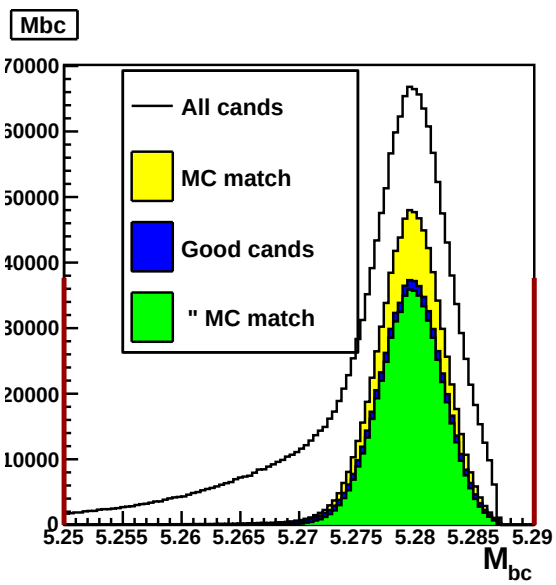
Combinatorics

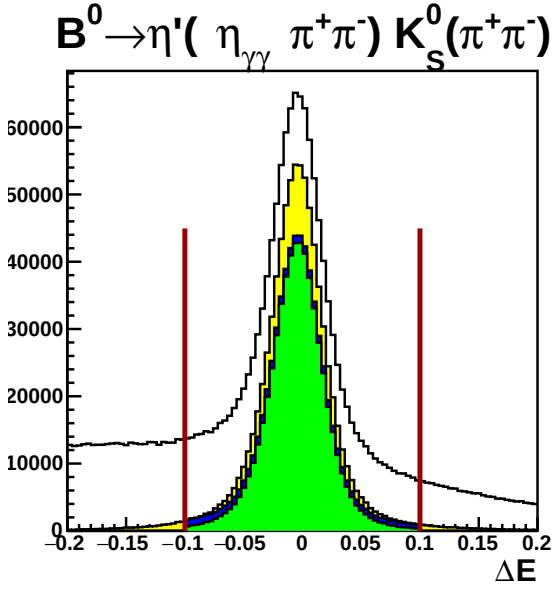
Cands mult.: 1.88

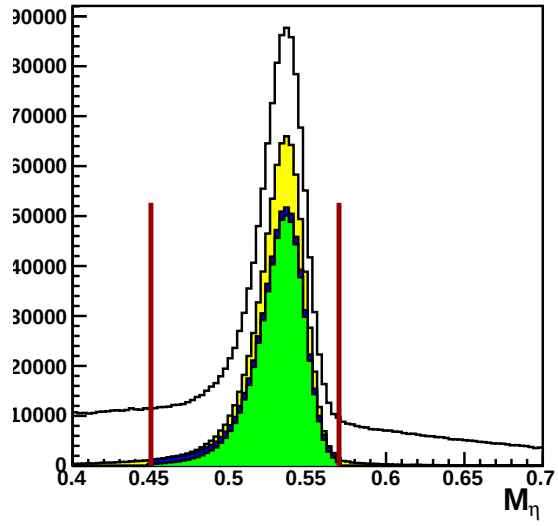
Good cands mult.: 1.06

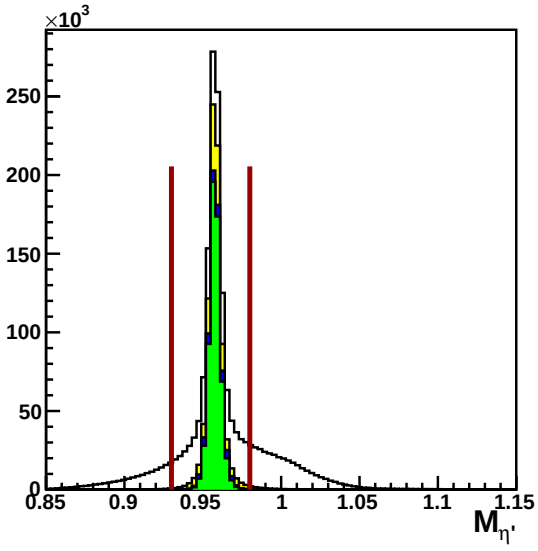
Efficiency %	
skim	57.0
preselection	46.1
good cands	30.5
MC true	29.4
SXF	1.1

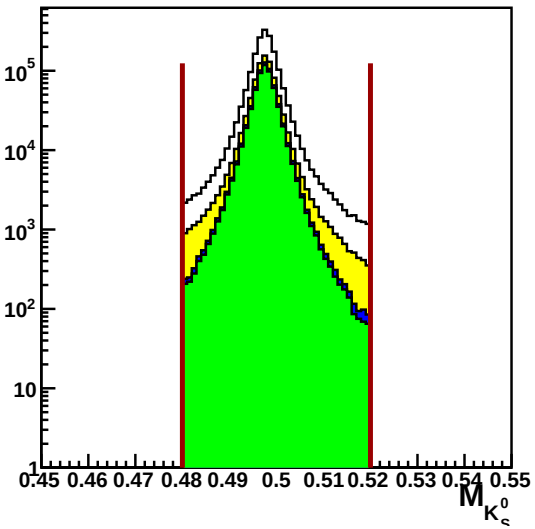
Signal distribution $B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K_S^{0+-}$

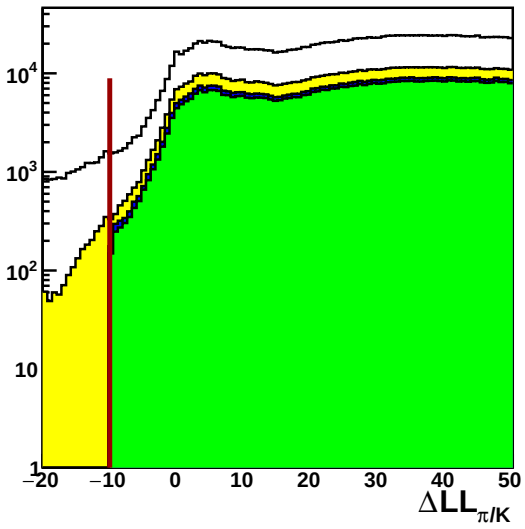












Selection

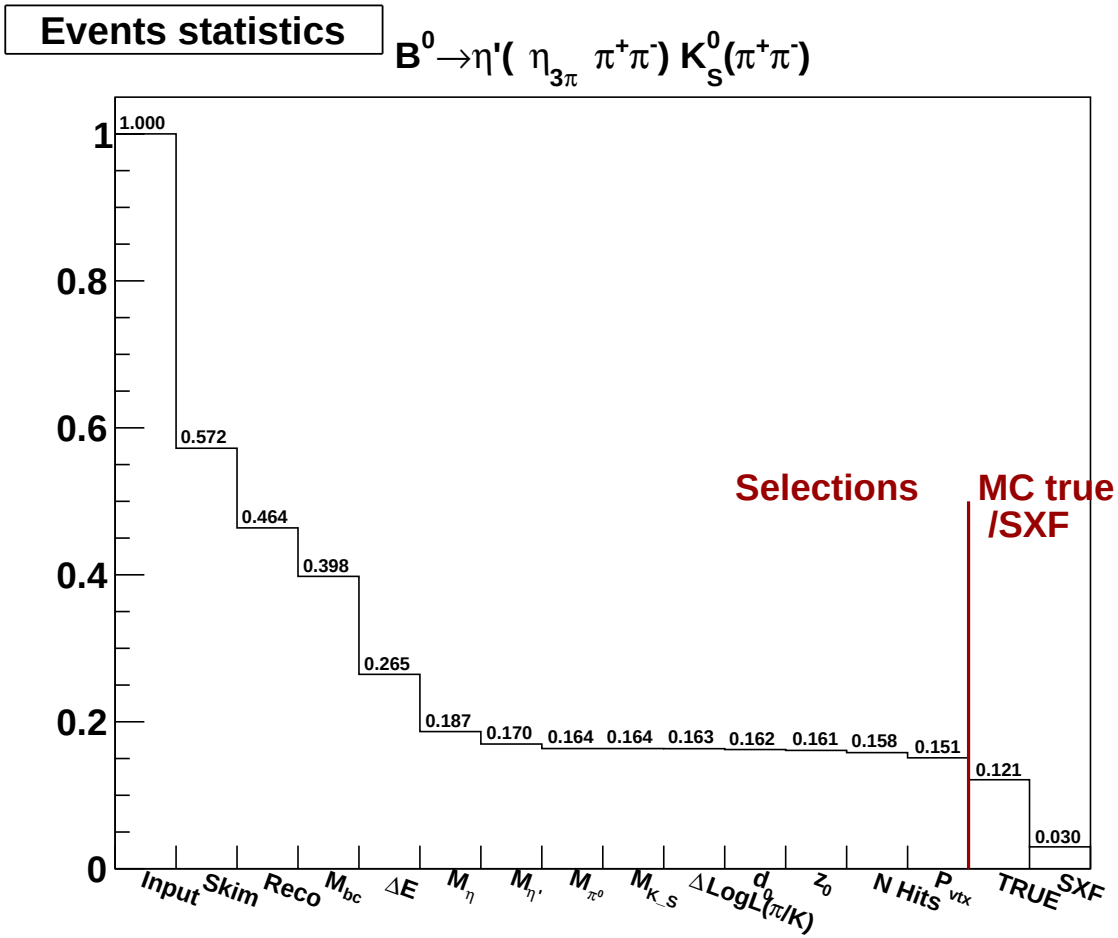
good candidate selection $B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$:

- Reconstruct decay chain with mass constrains for η, η', K_S^0,
  - vertex only (w/o mass) for B^0

- π^0:
  - `gamma:all`: $0.06 < E_\gamma < 6\,\text{GeV}$, $-150 < clus_{time} < 0$, $E_9/E_{25} > 0.75$
  - $M(\pi^0) \in [100, 150]\,\text{MeV}$
- $\eta \to \pi^+\pi^-\pi^0$:
  - `pi:all`
  - $\Delta\log\mathcal{L}(\pi, K) > -10$; new
  - $M(\eta_{3\pi}) \in [0.52, 0.57]\,\text{GeV}$;
  - $d_0(\pi^\pm) < 0.08\text{mm}$;
  - $z_0(\pi^\pm) < 0.1\text{mm}$;
  - N hits$_{PXD}(\pi^\pm) > 1$
- $\eta' \to \eta_{3\pi}\pi^+\pi^-$:
  - $M(\eta') \in [0.93, 0.98]\,\text{GeV}$;
- $K^0 \to \pi^+\pi^-$:
  - `K_S0:mdst`
  - $M(K_S^0 \to \pi^+\pi^-) \in [0.48, 0.52]\,\text{GeV}$;
- $B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$
  - $M_{bc} > 5.25\,\text{GeV}$;
  - $|\Delta E| < 0.15\,\text{GeV}$;
  - P-value$_{vtx}(B_0, \eta', K_S^0) > 1 \cdot 10^{-5}$

if $N_{cands} > 1$, select candidate with highest P-value$_{vtx}(B_0, \eta', \eta, K_S^0)$

Selection breakdonw



Combinatorics

Cands mult.: 21.5

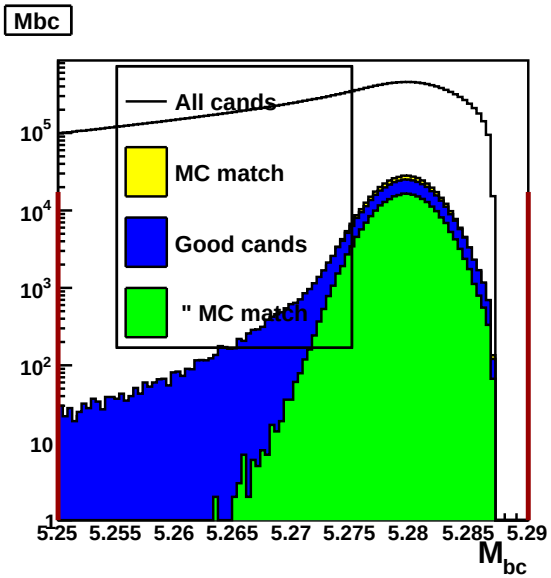
Good cands mult.: 1.45

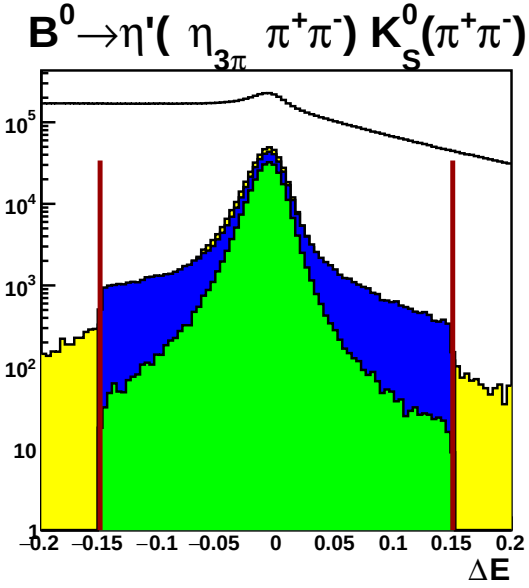
Efficiency %	
skim	57.2
preselection	46.2
good cands	**15.1**
MC true	12.1
SXF	3.0

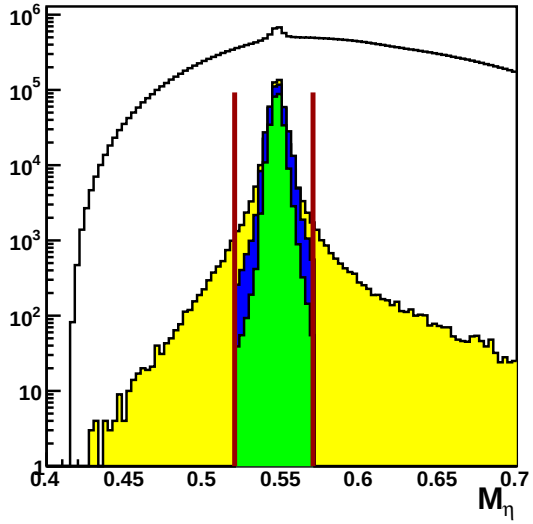
Reco eff is as good as $\eta_{\gamma\gamma}$ channel.

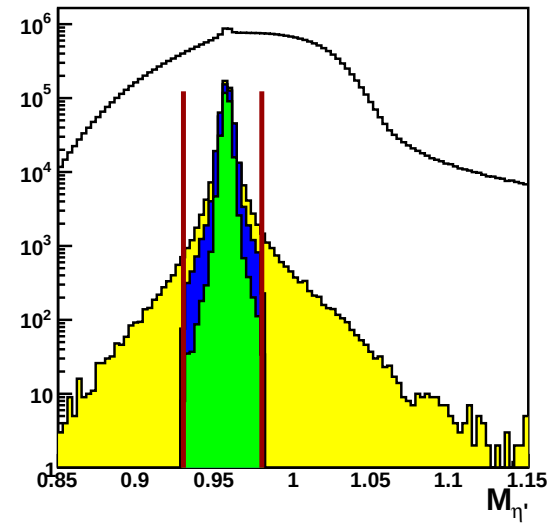
50% eff drop due to poor resolution on M_{bc}, ΔE, M_η all coming from π^0 reconstruction in $\eta \to \pi^+\pi^-\pi^0$ decay

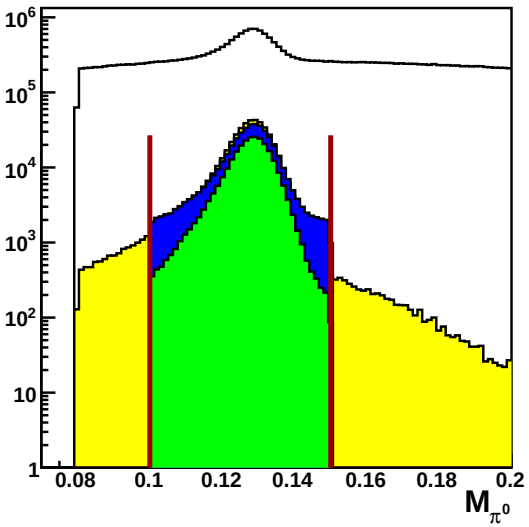
Signal distribution $B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$

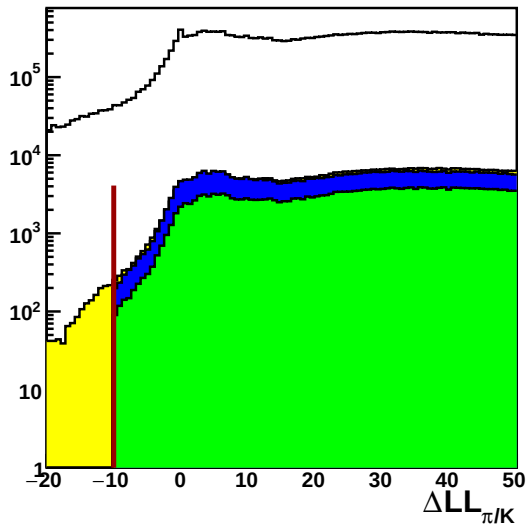












Final state with $K^0_S \to \pi^0\pi^0$

- A very preliminary study has been performed also with $K^0_S \to \pi^0\pi^0$ decay.
- The efficiency is roughly $\frac{1}{2}$ of that of the corresponding $K^0_S \to \pi^+\pi^-$channel.
- events combinatorics is larger for $\eta_{\gamma\gamma}$ ($\sim$ 5 cands/ev), huge for $\eta_{3\pi}$ ($\sim$ 30 cand/ev)
- SXF $\sim$stable, but fractionally larger due to lower signal efficiency.
- Δt resolution is same as for $K^0_S \to \pi^+\pi^-$.

$B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\ \pi^-)K_S^{0\,00}$

Efficiency %	
MC true	13.5
SXF	2.2

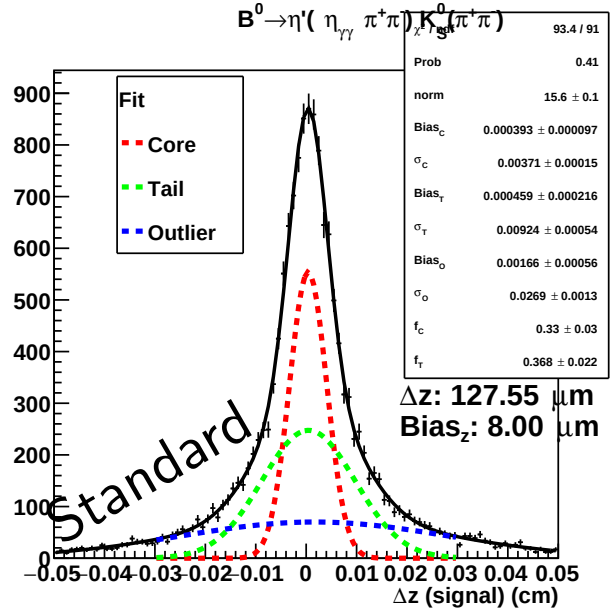
$B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0\,00}$

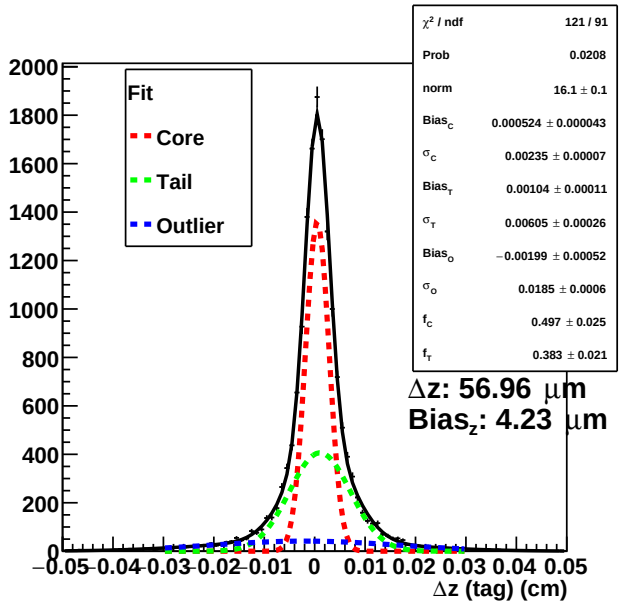
Efficiency %	
MC true	6.0
SXF	3.8

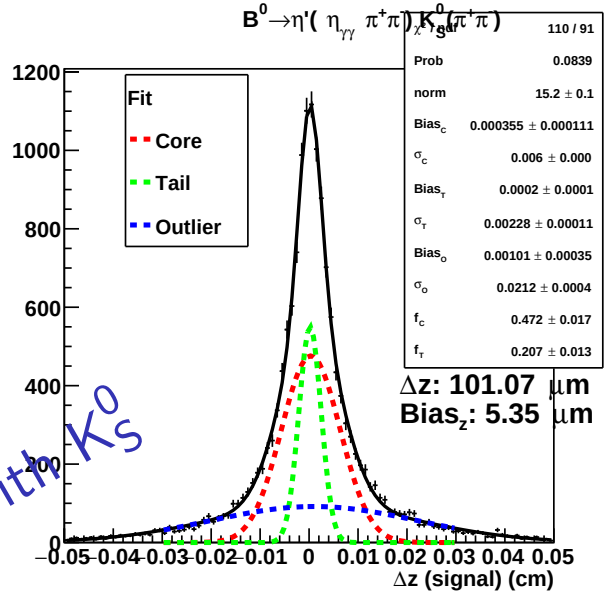
not used in Belle

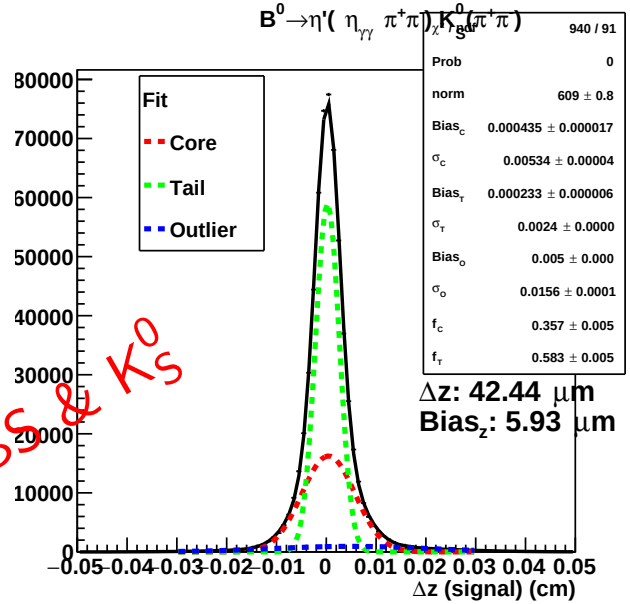
Vtx reco: signal and tag side

$B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K^{0+-}_S$





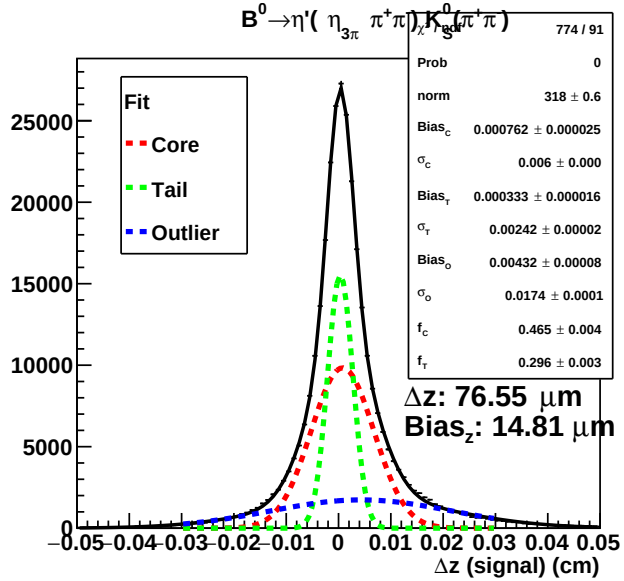


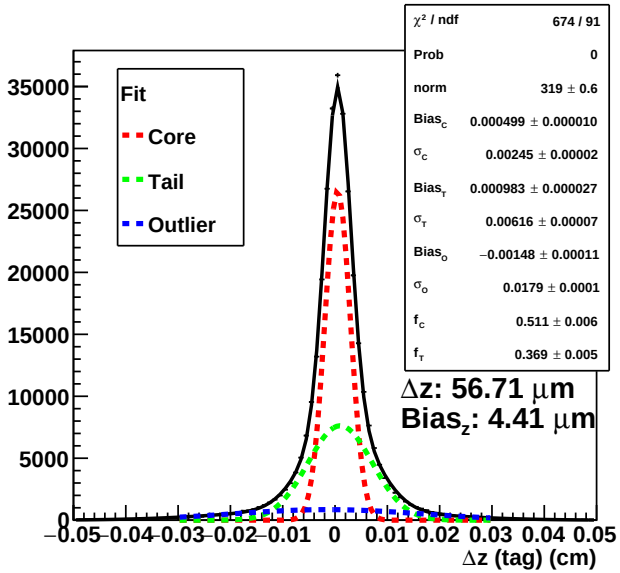


Vtx reco: signal and tag side

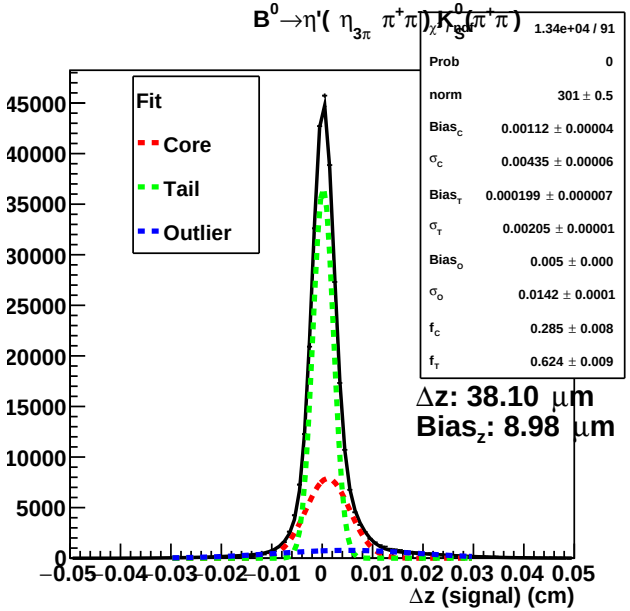
$B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$

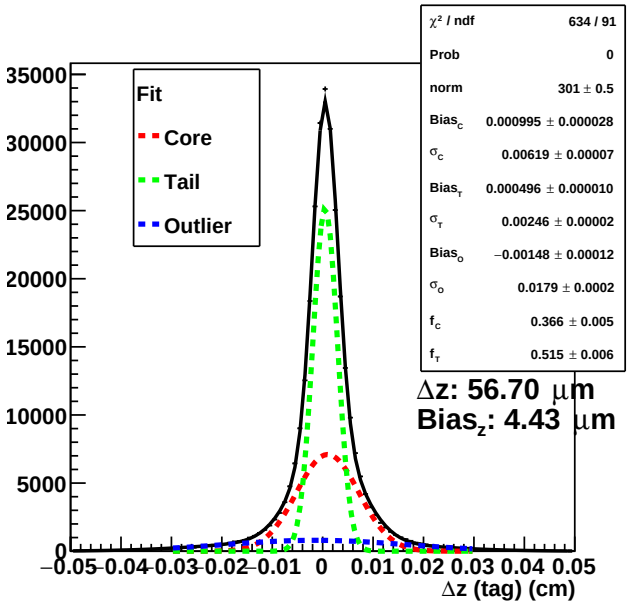
Standard





With BS & K_S^0





Background reduction (before CS cut)

$$B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\,\pi^-)K_S^{0+-}$$

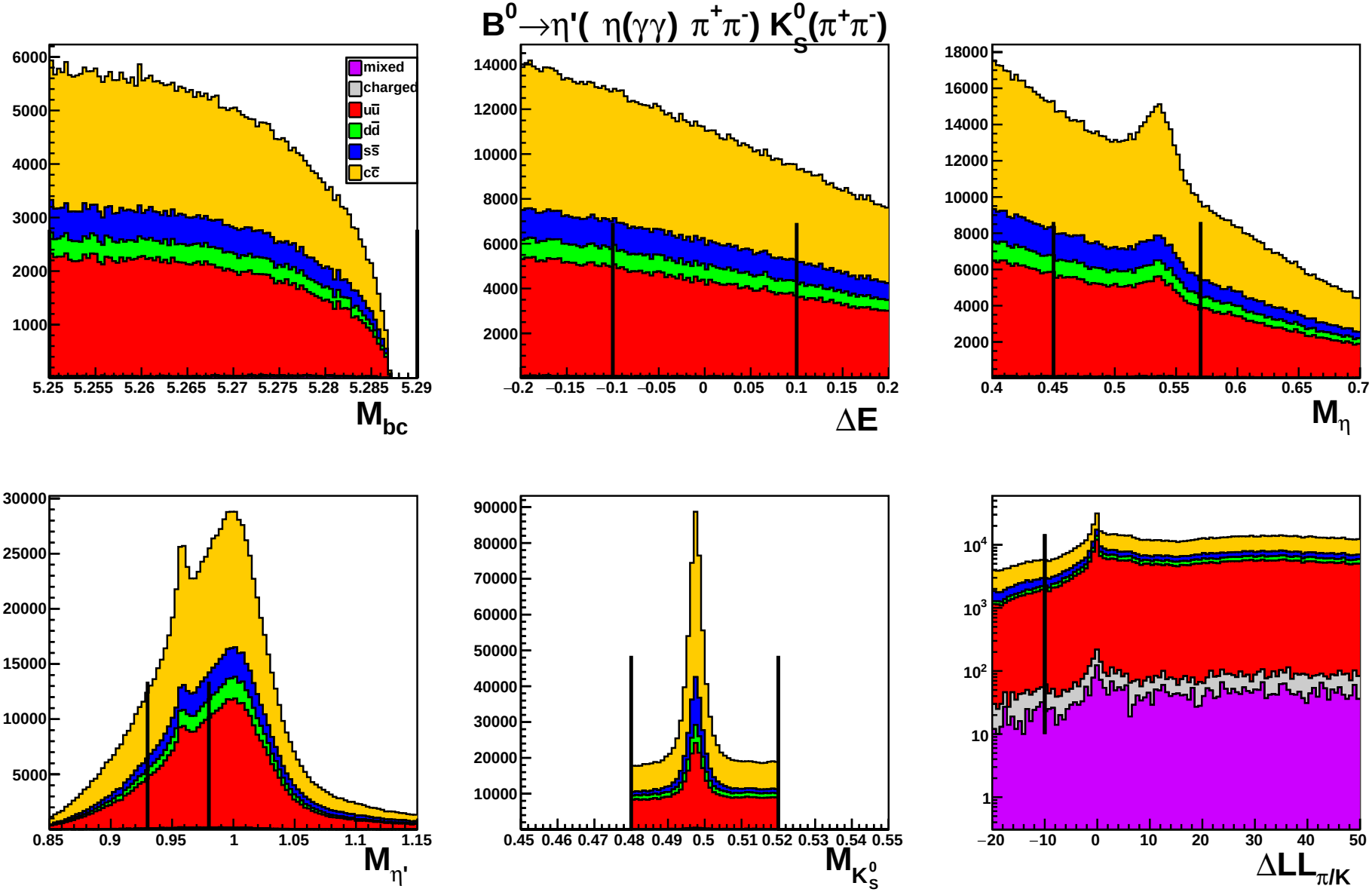
Sample	# Ev (M)	Skim (M)	ϵ_{skim}	pre-sel	sel	ϵ_{sel}
$u\bar{u}$	1284	10.8	$0.84 \cdot 10^{-2}$	235388	3324	$2.69 \cdot 10^{-6}$
$d\bar{d}$	321	2.88	$0.90 \cdot 10^{-2}$	66138	983	$3.06 \cdot 10^{-6}$
$s\bar{s}$	306	3.82	$1.25 \cdot 10^{-2}$	67205	734	$2.40 \cdot 10^{-6}$
$c\bar{c}$	1063	18.3	$1.72 \cdot 10^{-2}$	255161	3852	$3.62 \cdot 10^{-6}$
$B^0\overline{B}^0$	429	.153	$0.036 \cdot 10^{-2}$	1949	55	$0.13 \cdot 10^{-6}$
B^+B^-	420	.169	$0.04 \cdot 10^{-2}$	1818	18	$0.043 \cdot 10^{-6}$
total	3620	36.2	$0.95 \cdot 10^{-2}$	627659	8966	$2.34 \cdot 10^{-6}$

$$B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K_S^{0+-}$$

Sample	# Ev (M)	Skim (M)	ϵ_{skim}	pre-sel	sel	ϵ_{sel}
$u\bar{u}$	1284	10.8	$0.84 \cdot 10^{-2}$	515531	442	$0.34 \cdot 10^{-6}$
$d\bar{d}$	321	2.88	$0.90 \cdot 10^{-2}$	213980	172	$0.54 \cdot 10^{-6}$
$s\bar{s}$	306	3.82	$1.25 \cdot 10^{-2}$	84005	52	$0.17 \cdot 10^{-6}$
$c\bar{c}$	1063	18.3	$1.72 \cdot 10^{-2}$	$1.94 \cdot 10^{6}$	1593	$1.50 \cdot 10^{-6}$
$B^0\overline{B}^0$	429	.131	$0.036 \cdot 10^{-2}$	34668	60	$0.14 \cdot 10^{-6}$
B^+B^-	420	.324	$0.04 \cdot 10^{-2}$	38631	9	$0.02 \cdot 10^{-6}$
total	3620	36.3	$0.95 \cdot 10^{-2}$	$2.75 \cdot 10^{6}$	2259	$0.59 \cdot 10^{-6}$

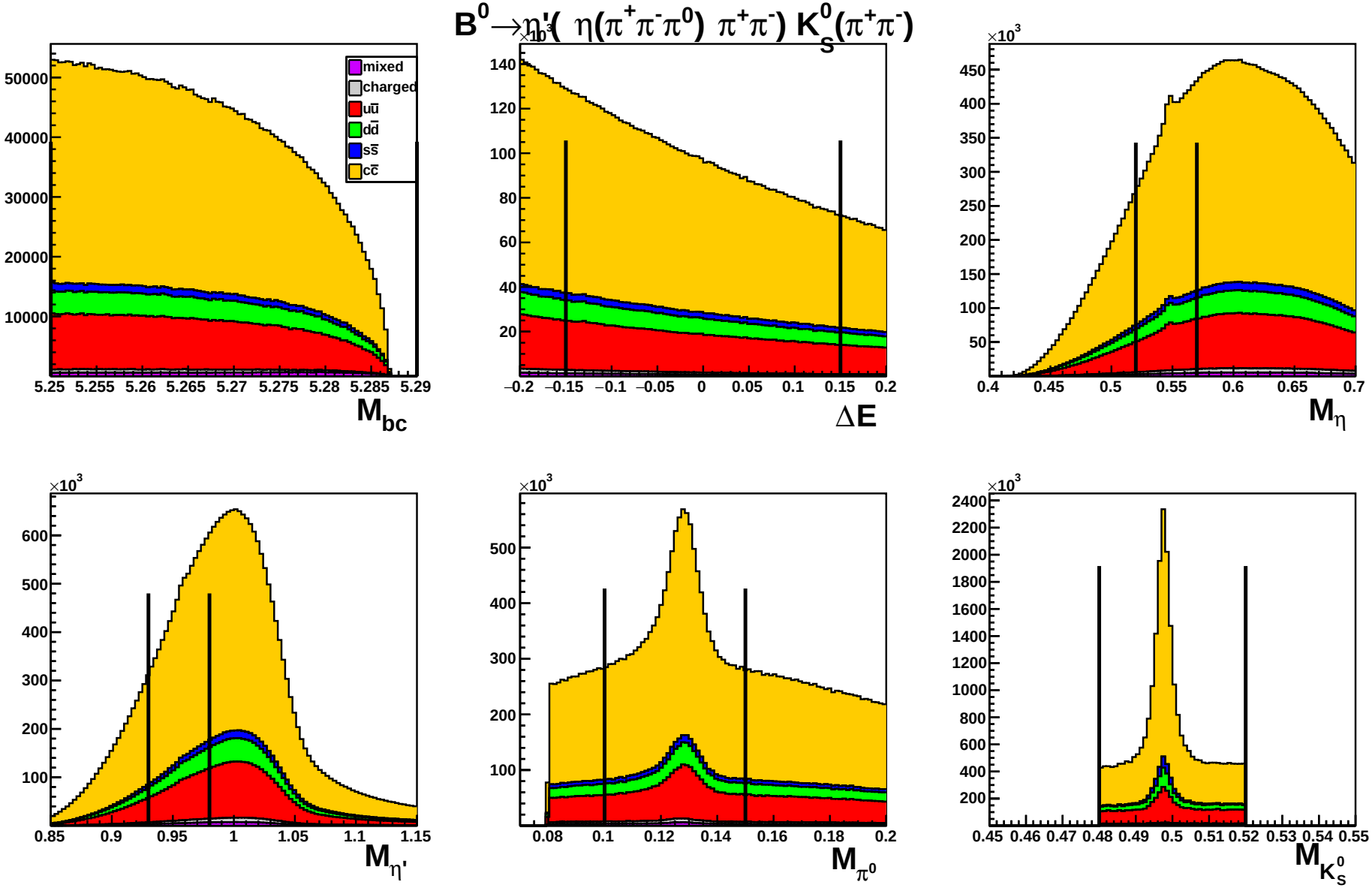
Background distribution

All candidates



Background distribution

All candidates



Yields

Expected yield for $L = 300\,\mathrm{fb}^{-1}$

$$N_{B^0} = 2 \cdot N_{B^0\overline{B}^0} = 2 \cdot L \cdot 1.1\ nb \cdot 0.486 = 2 * 170 \cdot 10^6 = 340 \cdot 10^6$$

$$N_{B^0 \to \eta' K^0} = N_{B^0} \cdot BR(= 6.6 \cdot 10^{-5}) = 22000,\ N_{B^0 \to \eta' K^0_S} = 11000$$

$B^0 \to \eta'(\to \eta_{\gamma\gamma}\pi^+\pi^-)K^{0+-}_S$

$$\begin{aligned} N =& N_{B^0 \to \eta' K^0_S} \cdot BR \cdot \epsilon \\ =& 11000 \cdot (0.43 \cdot 0.40 \cdot 0.69) \cdot .30 \\ =& 390 \text{ events} \end{aligned}$$

$$\begin{aligned} SXF =& 15 \\ Continuum \approx& 3300 \\ Peaking \approx& 30 \end{aligned}$$

Before Continuum Suppression cut

$B^0 \to \eta'(\to \eta_{3\pi}\pi^+\pi^-)K^{0+-}_S$

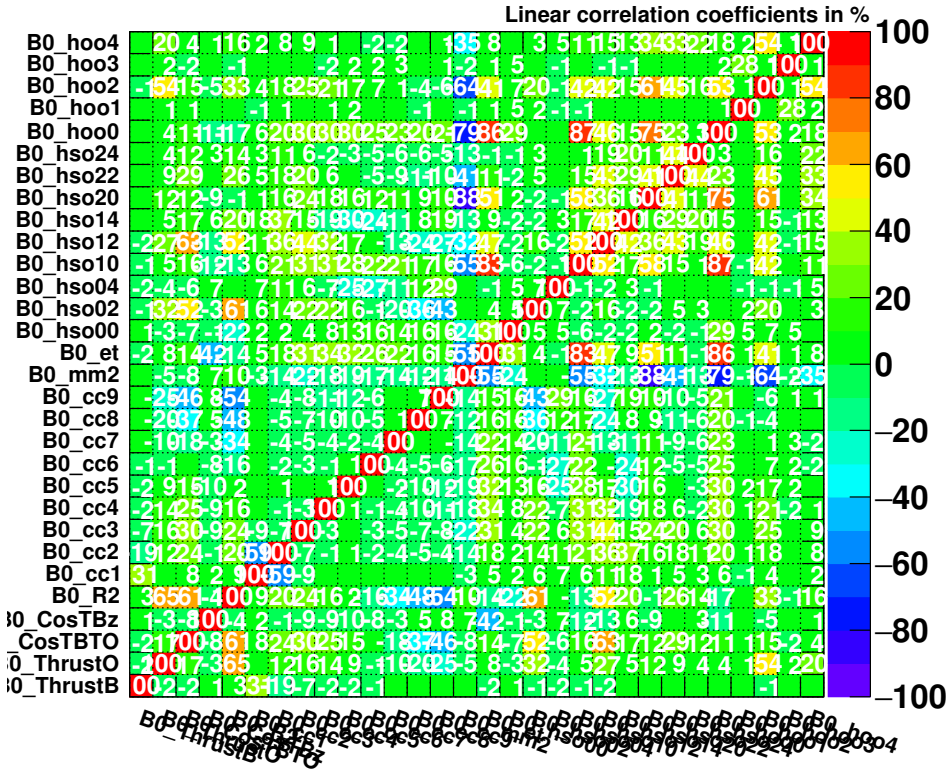
$$\begin{aligned} N =& N_{B^0 \to \eta' K^0_S} \cdot BR \cdot \epsilon \\ =& 11000 \cdot (0.43 \cdot 0.23 \cdot 0.69) \cdot .15 \\ =& 112 \text{ events} \end{aligned}$$

$$\begin{aligned} SXF =& 27 \\ Continuum \approx& 850 \\ Peaking \approx& 27 \end{aligned}$$

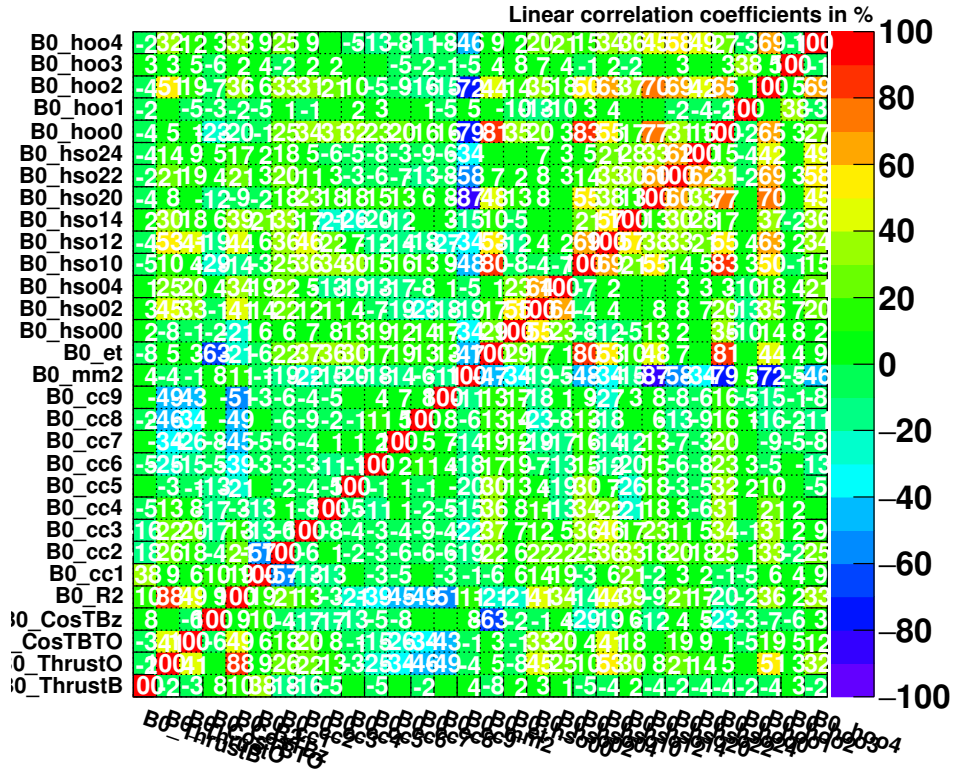
Before Continuum Suppression cut

Continuum Suppression correlation matrix

Correlation Matrix (signal)



Correlation Matrix (background)



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