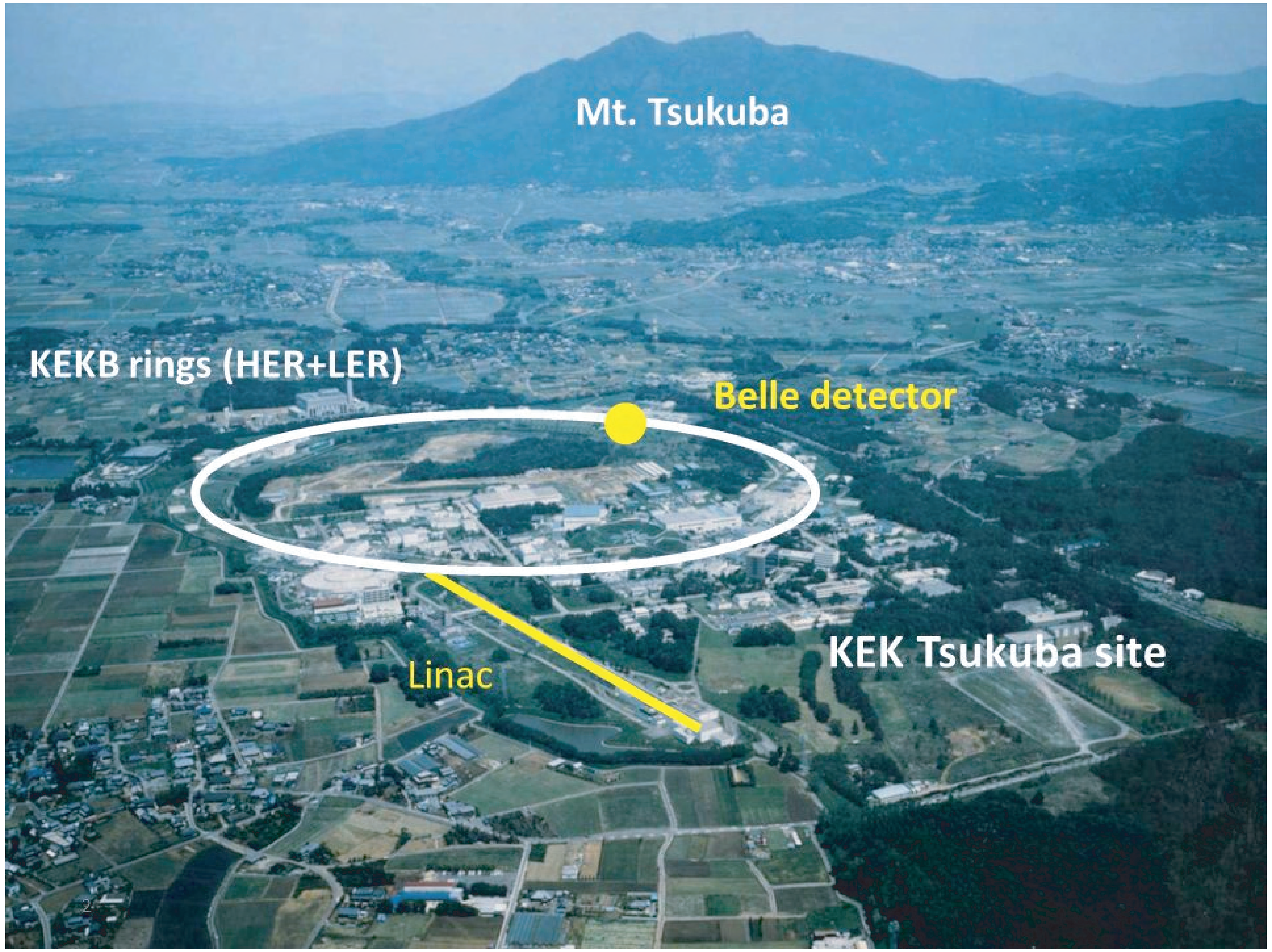
Search for Decays of B Mesons to Charmed Baryons



Mark Farino

The Beginning of Time

-Matter and antimatter should have been produced in equal amounts

-CP violation in Standard Model does not fully explain evident matter-antimatter asymmetry

-One of the greatest mysteries in physics

In 1967 Andrei Sakharov formulated three necessary conditions for baryogenesis, i.e., asymmetry between matter and anti-matter:

Sakharov's Three Conditions for Baryogenesis

- Baryon number violation
- C and CP violation
- Departure from thermal/chemical equilibrium

"According to our hypothesis, the occurrence of charge asymmetry is the consequence of violation of charge-parity (CP) invariance in the nonstationary expansion of the hot universe during the superdense stage, as manifest in the difference between the partial probabilities of the charge-conjugate reactions"

Violation of CP Invariance, C asymmetry, and baryon asymmetry of the universe -Sakharov, A.D. Pisma Zh.Eksp.Teor.Fiz. 5 (1967) 32-35, JETP Lett. 5 (1967) 24-27, Sov.Phys.Usp. 34 (1991) no.5, 392-393, Usp.Fiz.Nauk 161 (1991) no.5, 61-64

C and CP violation have been experimentally observed* and departure from equilibrium is satisfied by expansion of the universe, so all that remains is baryon number violation.

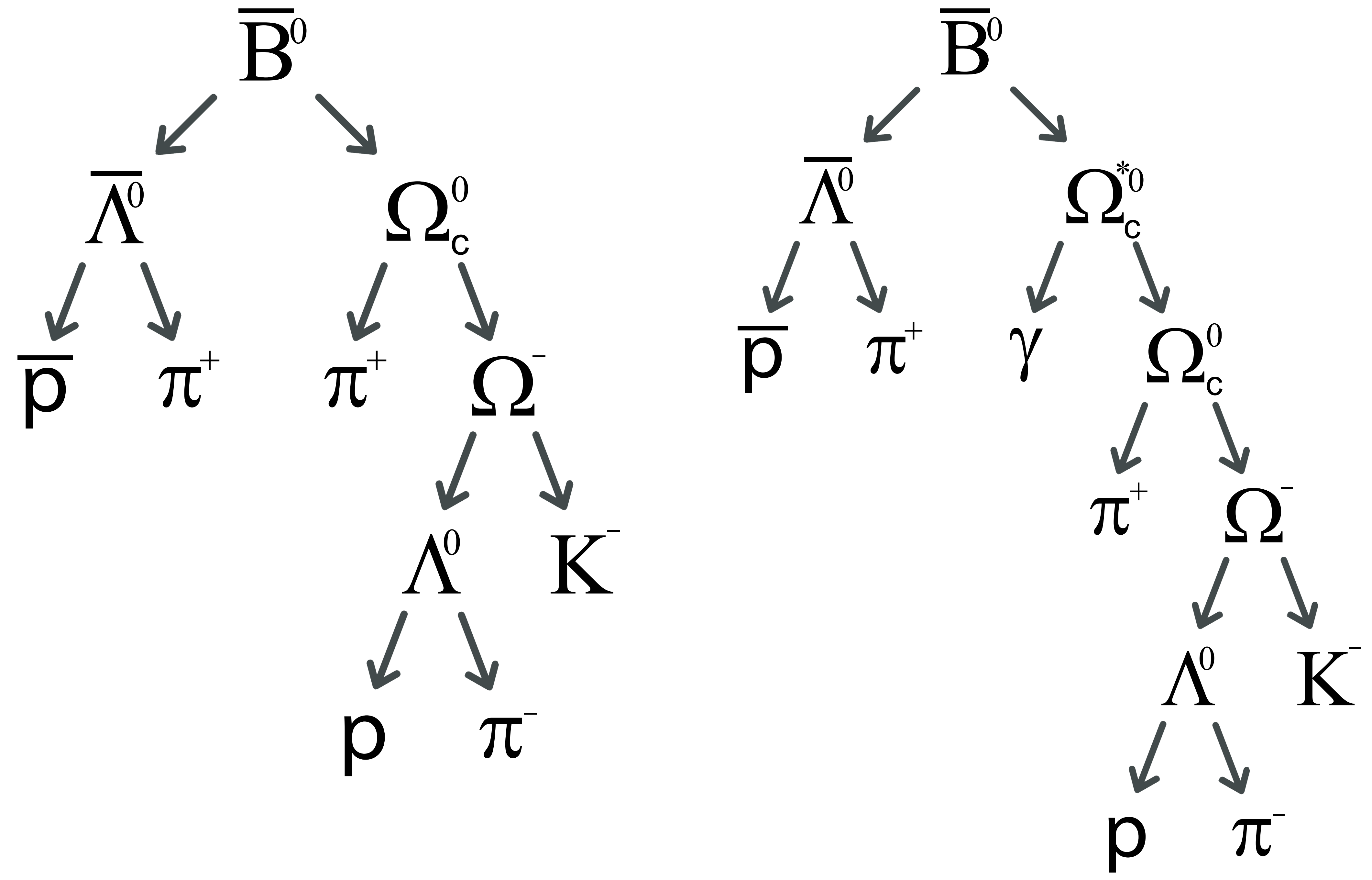
*Abe K., et al. Belle Collaboration (2001) Observation of large CP violation in the neutral B meson system. Phys. Rev. Lett. 87, 091802

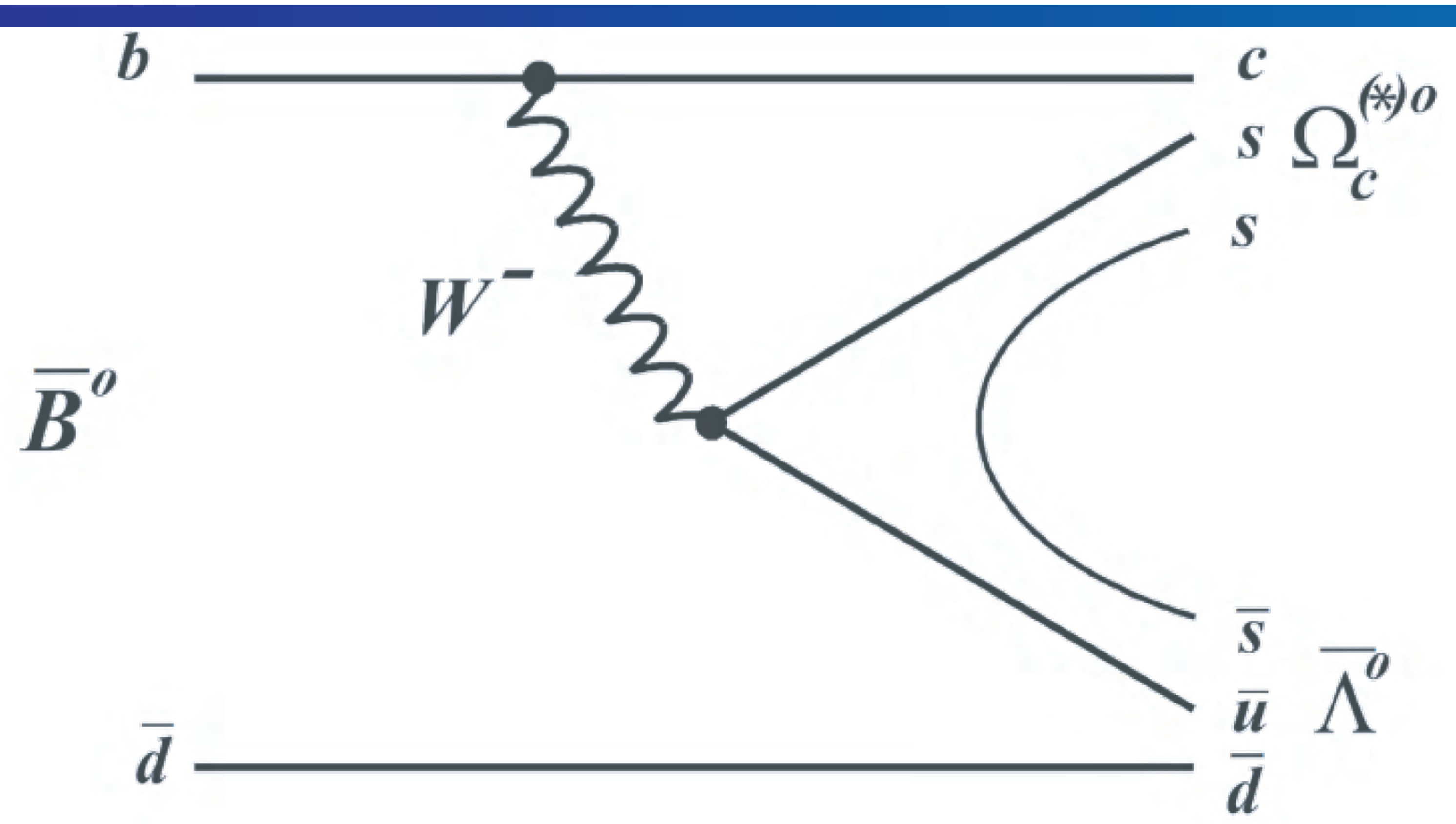
-Recent theoretical assertions suggest baryon number violation could arise from charmed baryon $\Omega_c^0 - \overline{\Omega}_c^0$ oscillations*

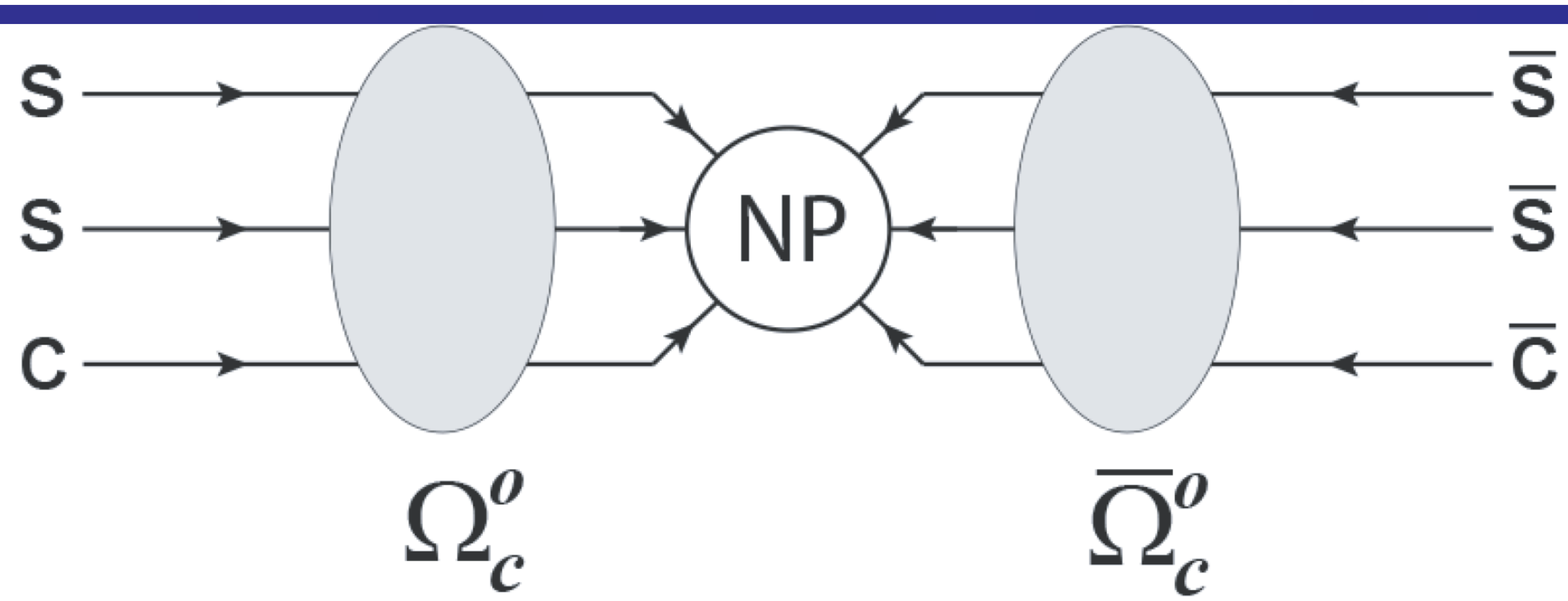
-Hence searching for not yet observed decays $\overline{B}^0 \to \overline{\Lambda}^0 \Omega_c^0$ and $\overline{B}^0 \to \overline{\Lambda}^0 \Omega_c^{*0}$ in data collected at Belle experiment

-First search of this type performed at LHCb (Ξ_b^0 oscillations)**

Decay Channels







*Baryogenesis from Oscillations of Charmed or Beautiful Baryons Phys.Rev. D96.7, 075009 (2017)

**Search for baryon-number-violating Ξ_b^0 oscillations Phys. Rev. Lett. 119, 181807 (2017)

Approach

- Blind analysis

- 'reconstruct' parent particles using information from daughter particles detected by Belle detector

-develop data analysis algorithms to increase sensitivity to possible future discovery of decays

- use Monte Carlo (MC) data to optimize analysis algorithms. example of MC generation on right (using EvtGen)

-signal MC data mirrors searched for decays, generic MC data approximate backgrounds that reduce sensitivity

-optimization completed via application of selection criteria

-will apply analysis to real data when algorithms are finalized

EvtGen Control File

```
# B0bar -> Omega_c0 anti-Lambda0;  Omega_c0 -> Omega- pi+; Omega- -> Lambda0 K-; Lambda0 -> p pi-

Alias My-B0      B0
Alias My-anti-B0 anti-B0
ChargeConj My-B0 My-anti-B0

Alias My-Omega_c0       Omega_c0
Alias My-anti-Omega_c0          anti-Omega_c0
ChargeConj My-Omega_c0 My-anti-Omega_c0

Alias My-Omega-         Omega-
Alias My-anti-Omega+            anti-Omega+
ChargeConj My-Omega- My-anti-Omega+

#Alias My-Lambda0       Lambda0
#Alias My-anti-Lambda0  anti-Lambda0
#ChargeConj My-Lambda0 My-anti-Lambda0

Decay Upsilon(4S)
0.5 My-B0     anti-B0                         VSS;
0.5    B0  My-anti-B0                         VSS;
Enddecay

Decay My-B0
1.000       My-anti-Omega_c0 Lambda0       PHSP;
Enddecay
#
#Decay My-anti-B0
#1.000       My-Omega_c0 anti-Lambda0       PHSP;
#Enddecay
#
CDecay My-anti-B0

Decay My-Omega_c0
#1.00000        PYTHIA 84;
1.00000     My-Omega- pi+       PHOTOS PHSP;
Enddecay
CDecay  My-anti-Omega_c0

# Omega decays in GEANT  2002/04/12 H.Kakuno
#Decay  Omega-
#0.6780    Lambda0   K-                         PHOTOS PHSP;
#0.2360    Xi0   pi-                         PHOTOS PHSP;
#0.0860    Xi-   pi0                         PHOTOS PHSP;
#Enddecay
#CDecay anti-Omega+

# Lambda0 decays in GEANT 2002/04/11 H.Kakuno
#Decay  Lambda0
#0.6390    p+  pi-                            PHOTOS PHSP;
#0.3580    n0  pi0                            PHOTOS PHSP;
#0.0018    n0  gamma                           PHOTOS PHSP;
#0.0005    p+  pi-  gamma                      PHOTOS PHSP;
#0.0006    p+  e-   anti-nu_e               PHOTOS PHOTOS PHSP;
#0.0001    p+  mu-  anti-nu_mu              PHOTOS PHOTOS PHSP;
#Enddecay
#CDecay anti-Lambda0

End
```

Roadmap

1. KEKB + The Belle Experiment

2. Reconstruction Criteria Overview

3. Background Suppression
   (Reconstruction Criteria Optimizations)

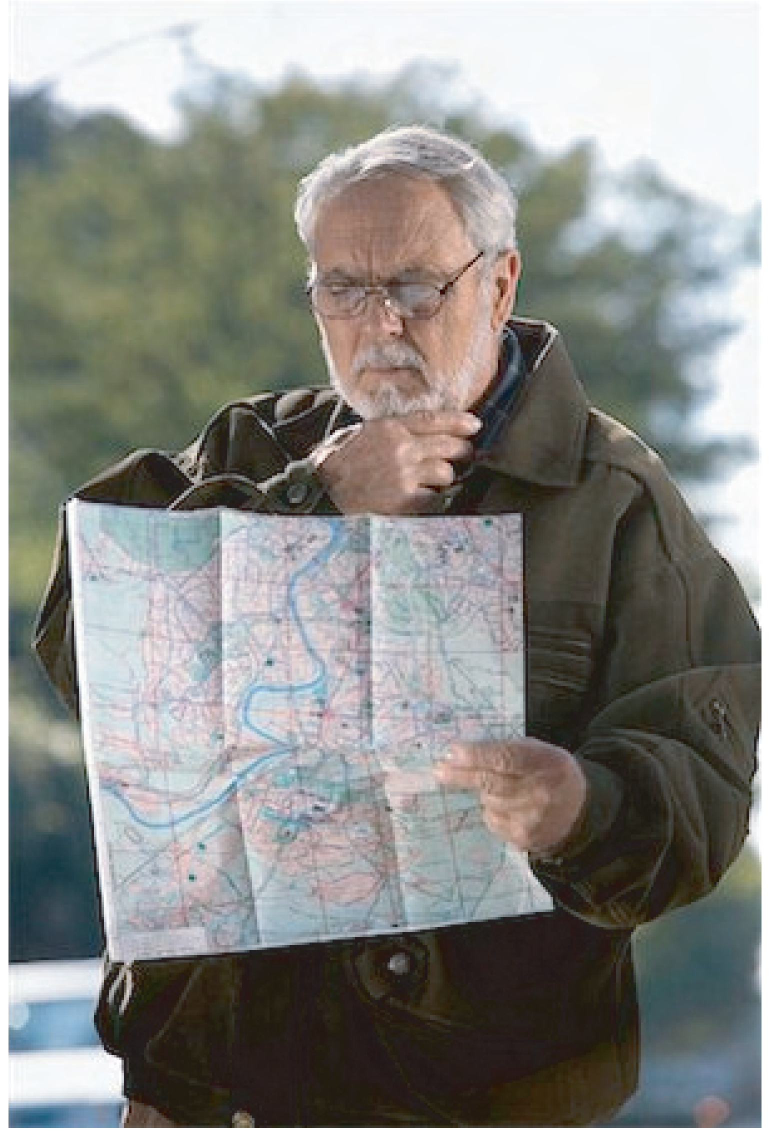
4. Signal MC Distributions

5. Blinded Data & Generic MC Comparison

6. Estimated Expected Signal in Data

7. Fitting (Ensemble Tests, Confidence Belts, Sensitivity)

8. Outlook

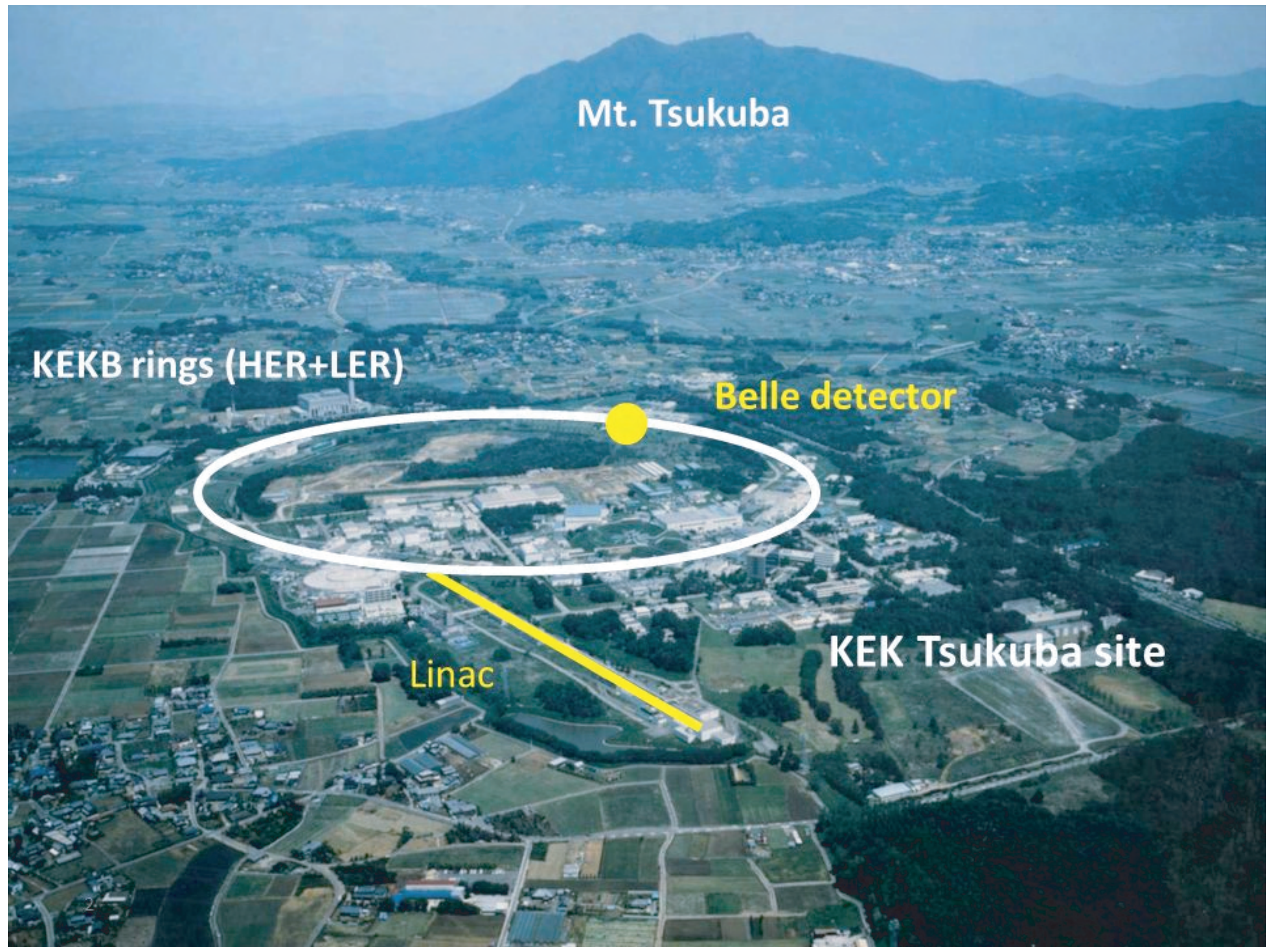


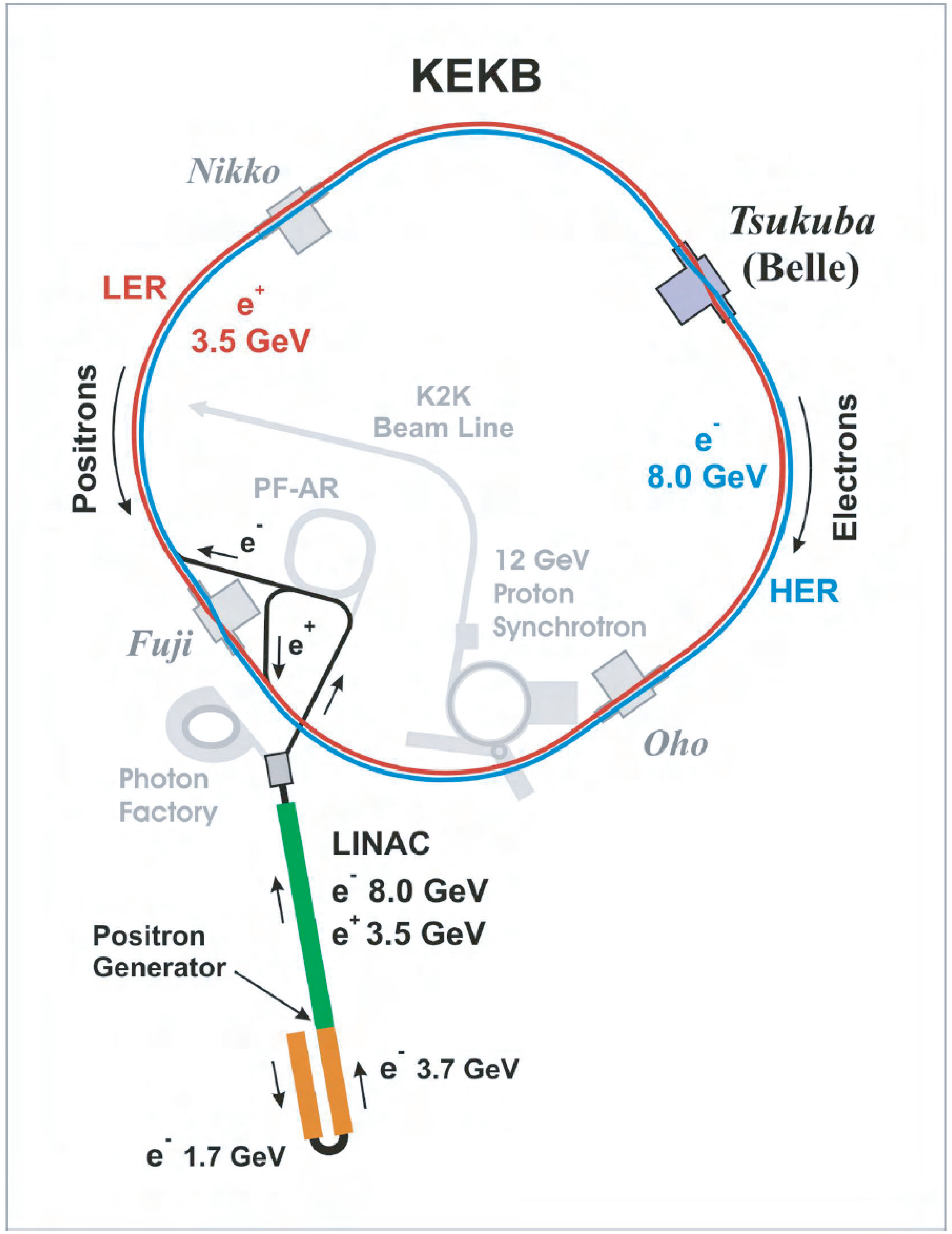
- asymmetric-energy e^+e^- collider

- Electrons and positrons are respectively injected into the high energy ring (8.0 GeV) and low energy ring (3.5 GeV)

- B-factory

- produced $B\bar{B}$ pairs at center of mass energies of 10.58 GeV and 10.86 GeV (invariant masses of $\Upsilon(4S)$ and $\Upsilon(5S)$)





S. Kurokawa and E. Kikutani. Overview of the KEKB accelerators. *Nuclear Instruments and Methods A*, 499(1):1 – 7, 2003.

-Collected data between 1999 and 2010 at the circular electron-positron collider KEKB in Japan

-used to obtain evidence of CP violation for particles containing heavy b quark

-data could be used to investigate baryon number violation

- Important variables: $\Delta E = E_{B^0} - E_{\text{beam}}$

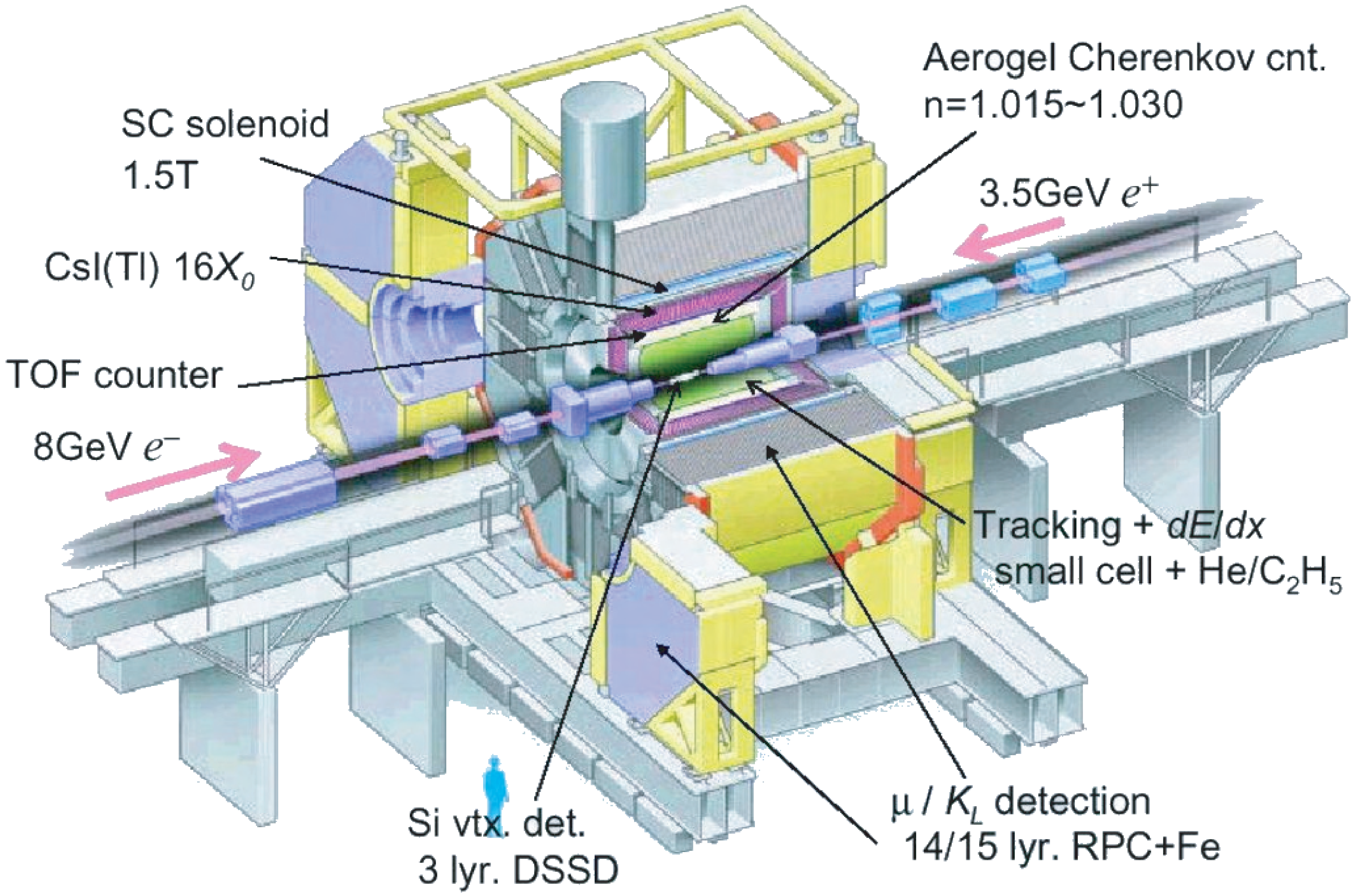
$$M_{\text{bc}} = \sqrt{E_{\text{beam}}^2 - p_{B^0}^2}$$

Belle Detector

- B meson decay vertices measured by silicon vertex detector (SVD)

- Charged particle tracking performed by wire drift chamber (CDC)

- Particle identification performed by measurements in CDC, aerogel Cherenkov counters (ACC), and time of flight counters (TOF)



A. Abashian *et al.* [Belle], "The Belle Detector," Nucl. Instrum. Meth. A **479**, 117-232 (2002) doi:10.1016/S0168-9002(01)02013-7

Reconstruction Criteria

$$R_{i/j} = L_i/(L_j+L_i),\ i,j \in \{\pi, K, p, e\}$$

- decay length := distance traveled between particle's birth and decay

- bvf := 'before vertex fit'

- avf := 'after vertex fit'

- vertex fitting procedure:
    - vertex fit and mass constraint performed simultaneously (and we record degrees of freedom of fit).

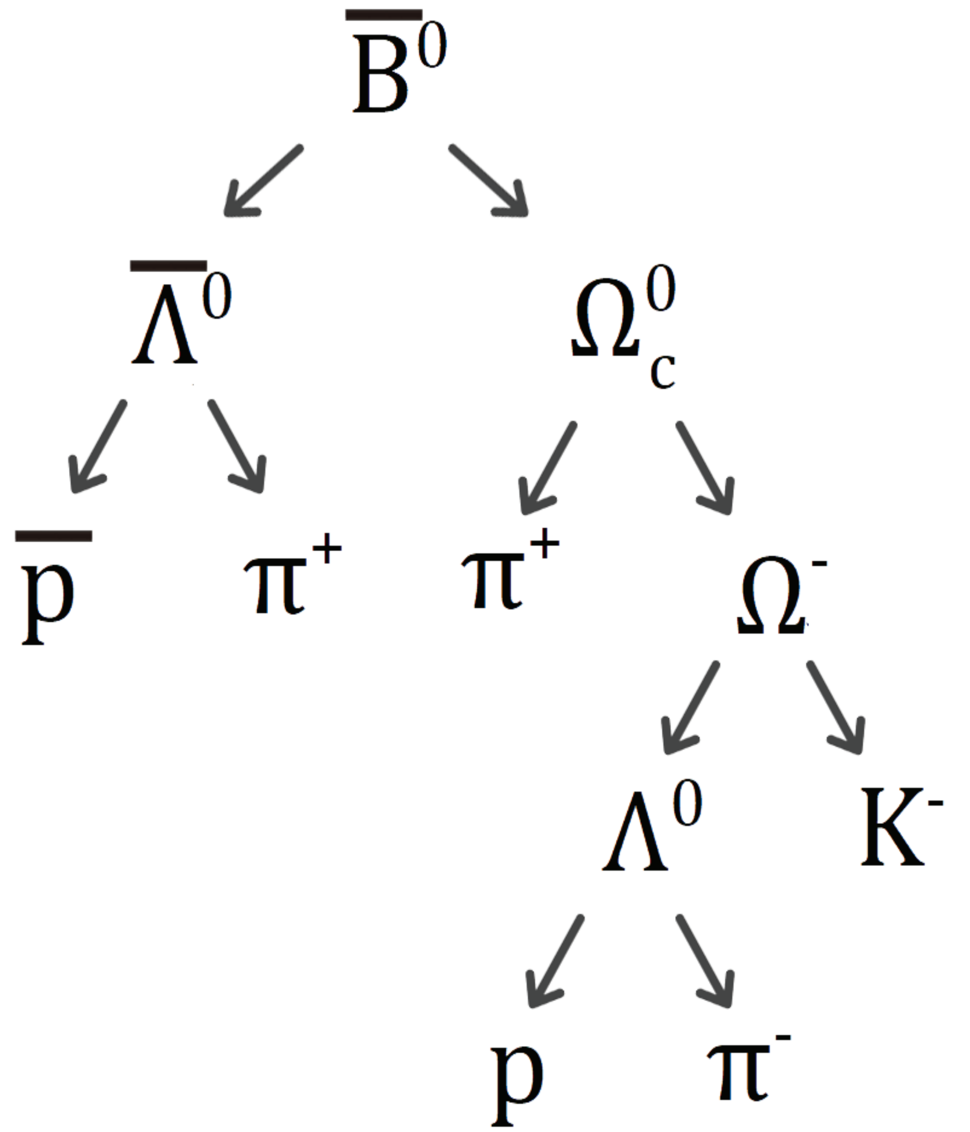
- Transverse momentum cuts shown on next slide

Parameter	Requirement
π candidates (not applied to π daughters from Λ^0 and $\bar{\Lambda}^0$)	$R_{\pi/K} \geq 0.6$ and $R_{e/\pi} < 0.95$
K candidates	$R_{K/\pi} \geq 0.4$ and $R_{e/\pi} < 0.95$
p candidates	$R_{p/K} \geq 0.1$
Ω^- candidates	Decay Length ≥ 0.60 cm
$\Lambda^0/\bar{\Lambda}^0$ candidates' reconstructed invariant masses (avf)	$\lvert \mathrm{mass}_{\mathrm{avf}}$ - Λ^0 invariant mass $\rvert \leq 8$ MeV ($5.4\ \sigma$)
Ω^- candidates' reconstructed invariant masses (bvf)	$\lvert \mathrm{mass}_{\mathrm{bvf}}$ - Ω^- invariant mass $\rvert \leq 60$ MeV ($15.1\ \sigma$)
Ω^- candidates' reconstructed invariant masses (avf)	$\lvert \mathrm{mass}_{\mathrm{avf}}$ - Ω^- invariant mass $\rvert \leq 9$ MeV ($5.7\ \sigma$)
Ω_c^0 candidates' reconstructed invariant masses (bvf)	$\lvert \mathrm{mass}_{\mathrm{bvf}}$ - Ω_c^0 invariant mass $\rvert \leq 100$ MeV ($17.5\ \sigma$)
Ω_c^0 candidates' reconstructed invariant masses (avf)	$\lvert \mathrm{mass}_{\mathrm{avf}}$ - Ω_c^0 invariant mass $\rvert \leq 18$ MeV ($3.9\ \sigma$)
$\Lambda^0, \bar{\Lambda}^0, \Omega^-, \Omega_c^0$ candidates	$\frac{\chi^2 \text{from vertex fit}}{\text{number of deg. of freedom}} \leq 100$
ΔE	-0.4 GeV $\leq \Delta E \leq 0.3$ GeV
M_{bc}	$M_{\mathrm{bc}} \geq 5.2\ \mathrm{GeV}/c^2$

- Transverse momentum selection criteria for channels $\overline{B}^0 \rightarrow \overline{\Lambda}^0\ \Omega_c^0$ and $\overline{B}^0 \rightarrow \overline{\Lambda}^0\ \Omega_c^{*0}$

- Analogous cuts applied to charge conjugated channels

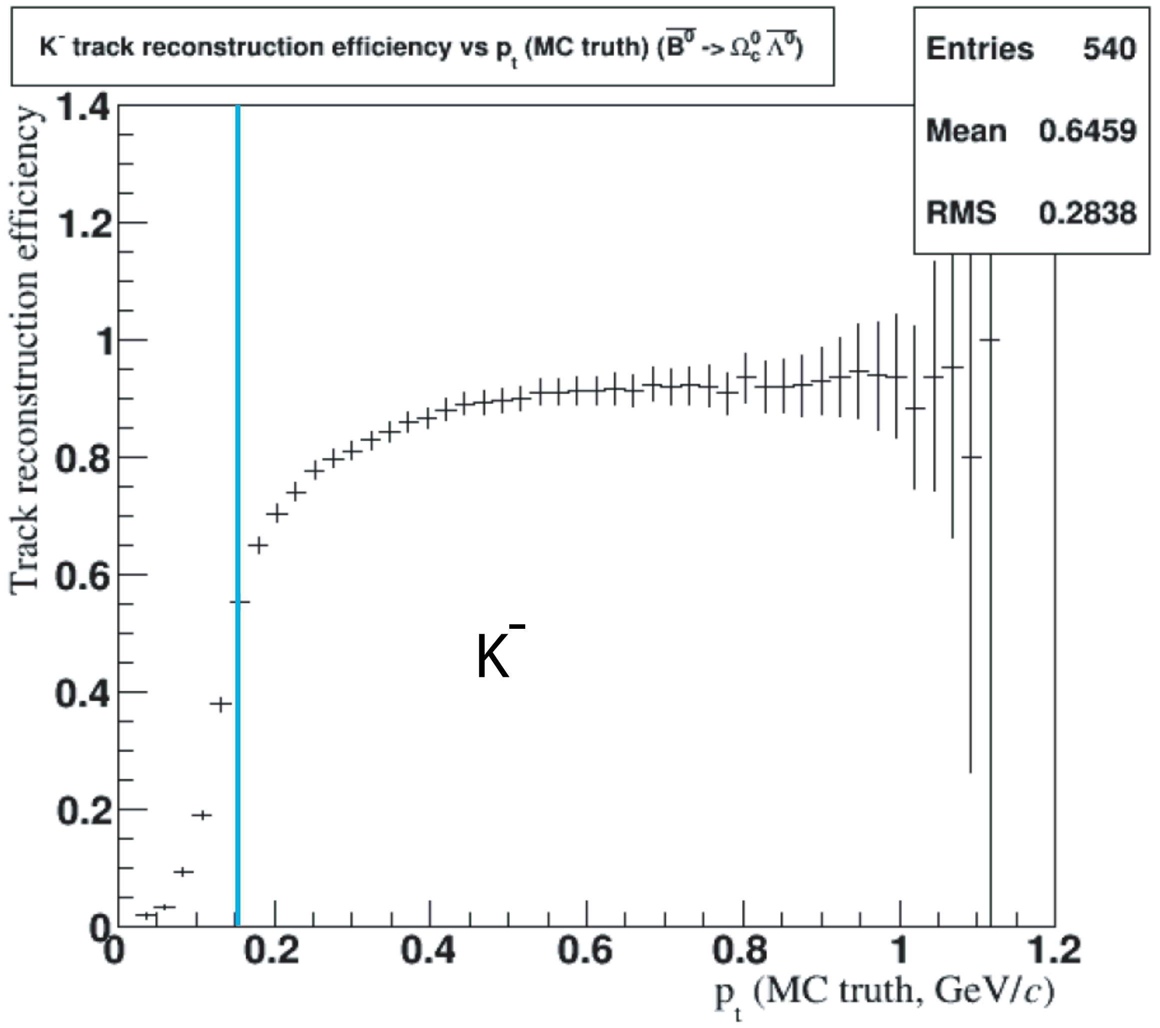
Particle	Requirement
p	$p_\perp \geq 0.250$ GeV/c
$\overline{p}$	$p_\perp \geq 0.600$ GeV/c
K^-	$p_\perp \geq 0.150$ GeV/c
π^-	$p_\perp \geq 0.070$ GeV/c
π^+ (from $\overline{\Lambda}^0$)	$p_\perp \geq 0.070$ GeV/c
π^+ (from Ω_c^0)	$p_\perp \geq 0.300$ GeV/c

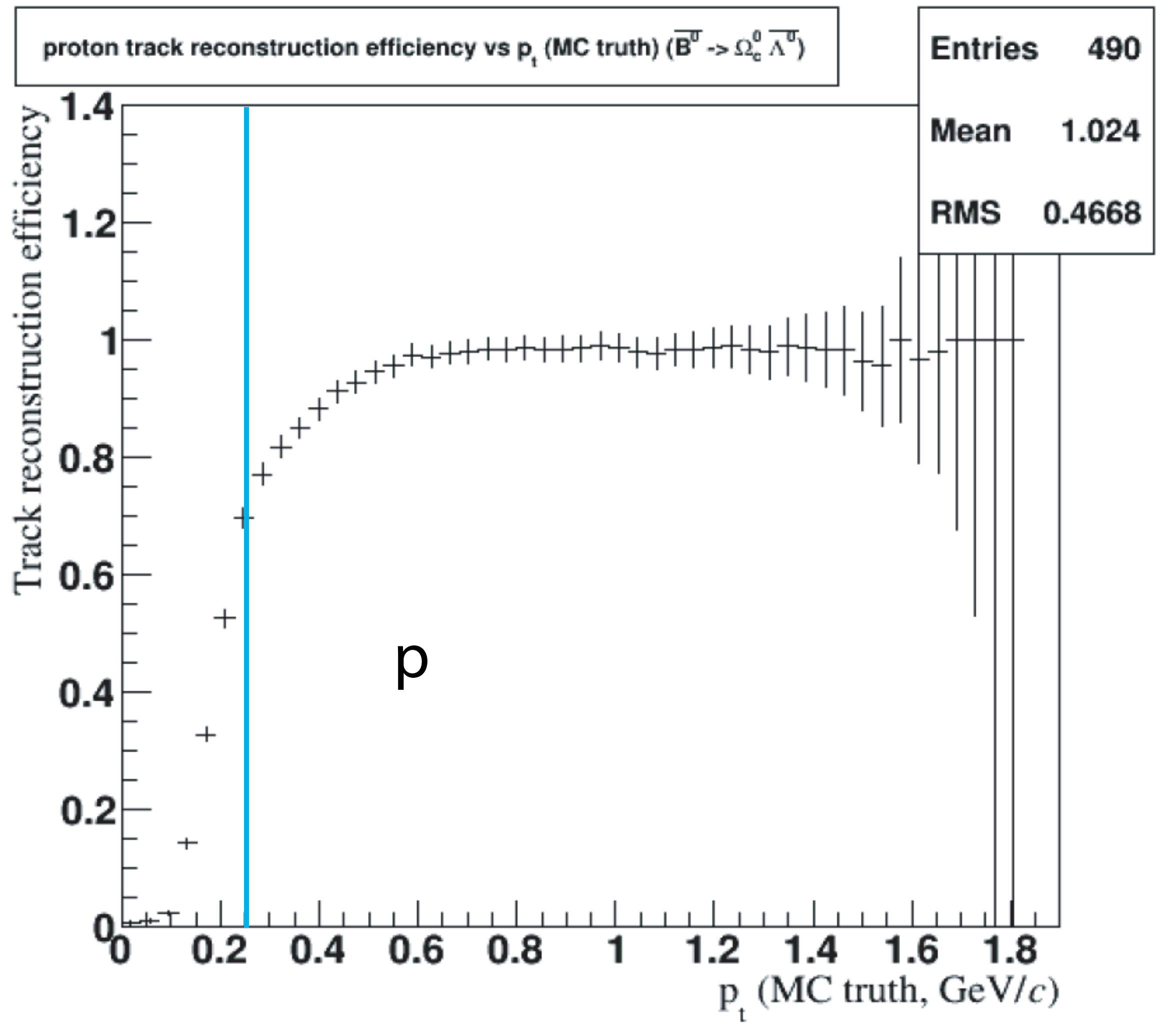


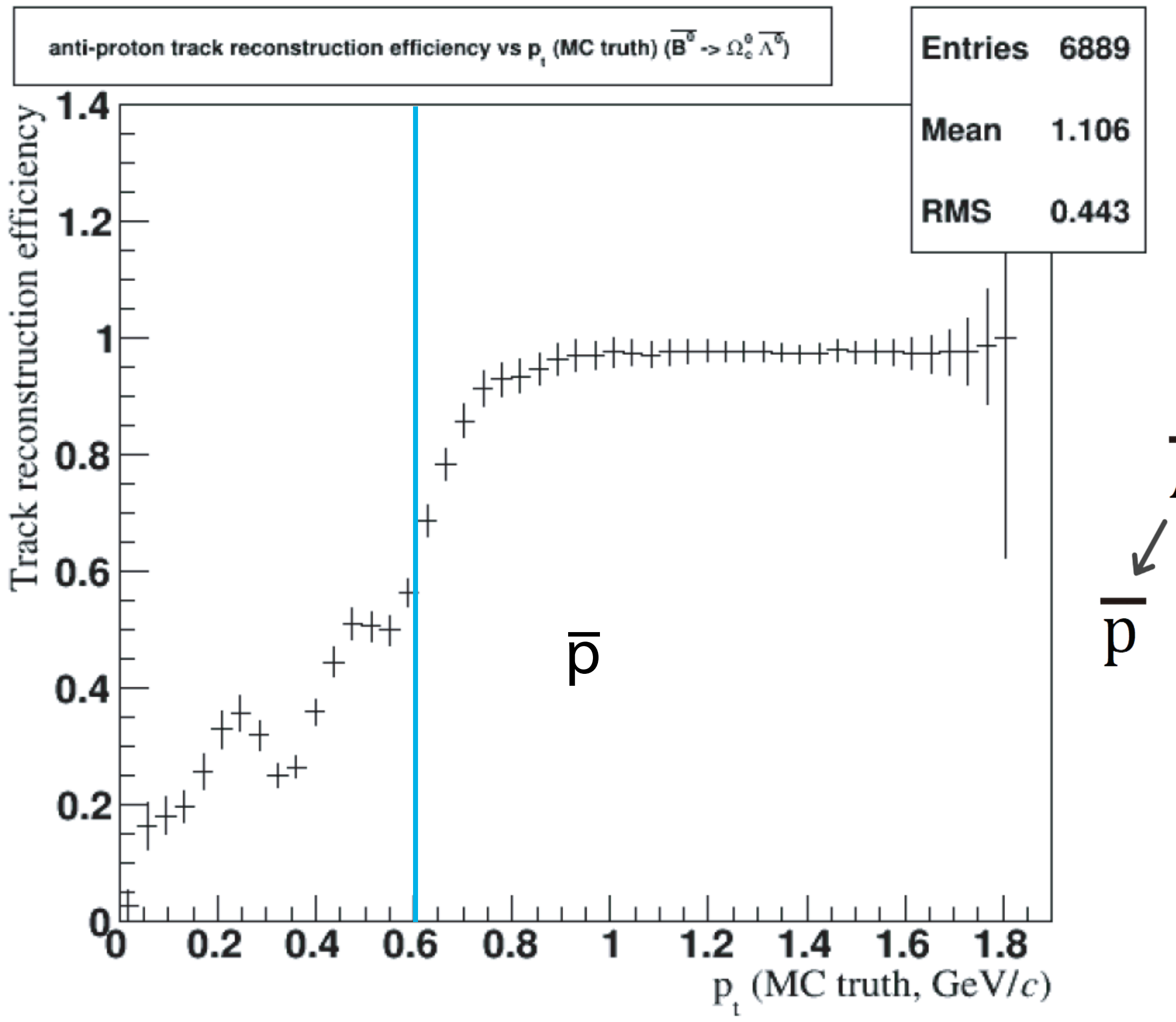
Reconstruction efficiency of $\overline{B}^0$ channel: 10.8% ($\pm$ 0.1%)
Reconstruction efficiency of B^0 channel: 11.1% ($\pm$ 0.1%)
($\overline{B}^0 \rightarrow \overline{\Lambda}^0 \Omega_c^0$)

Reconstruction efficiency of $\overline{B}^0$ channel: 10.4% ($\pm$ 0.1%)
Reconstruction efficiency of B^0 channel: 10.3% ($\pm$ 0.1%)
($\overline{B}^0 \rightarrow \overline{\Lambda}^0 \Omega_c^{*0}$)

Track Reconstruction as a Function of Transverse Momentum

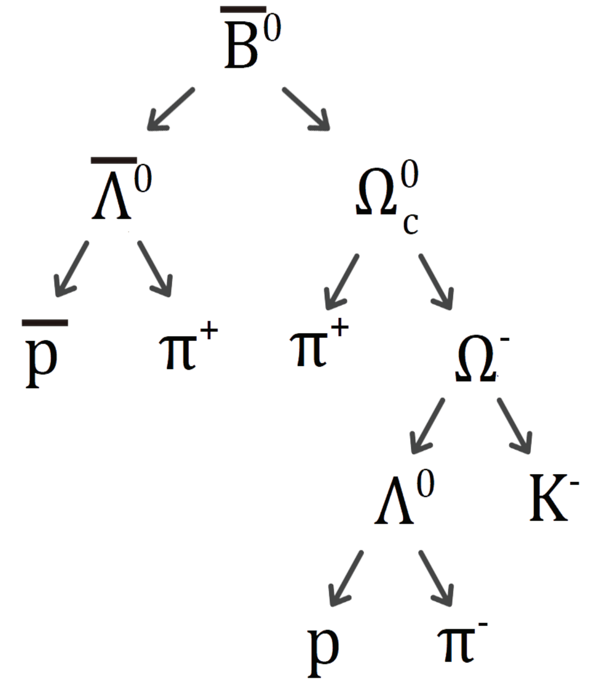


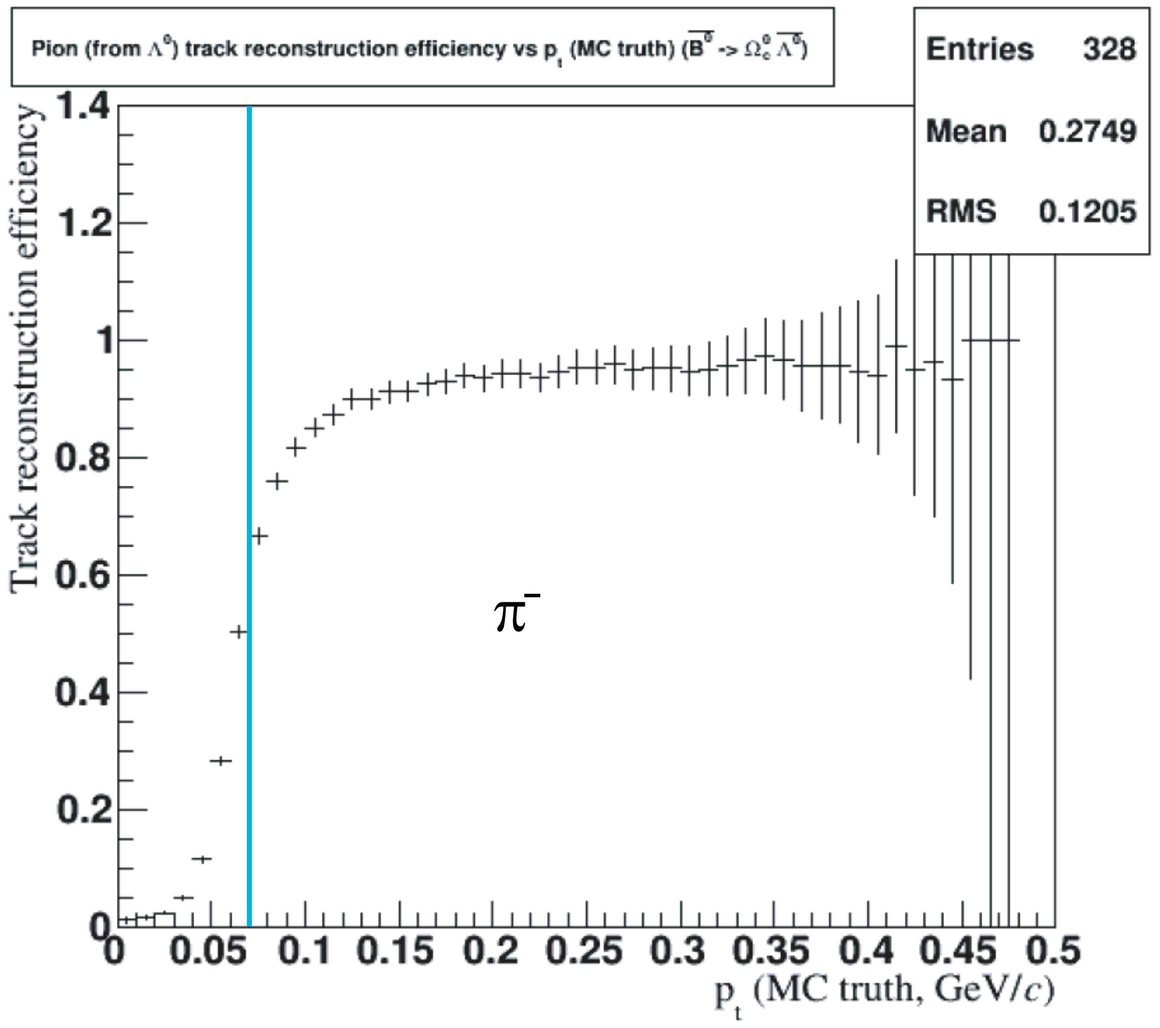


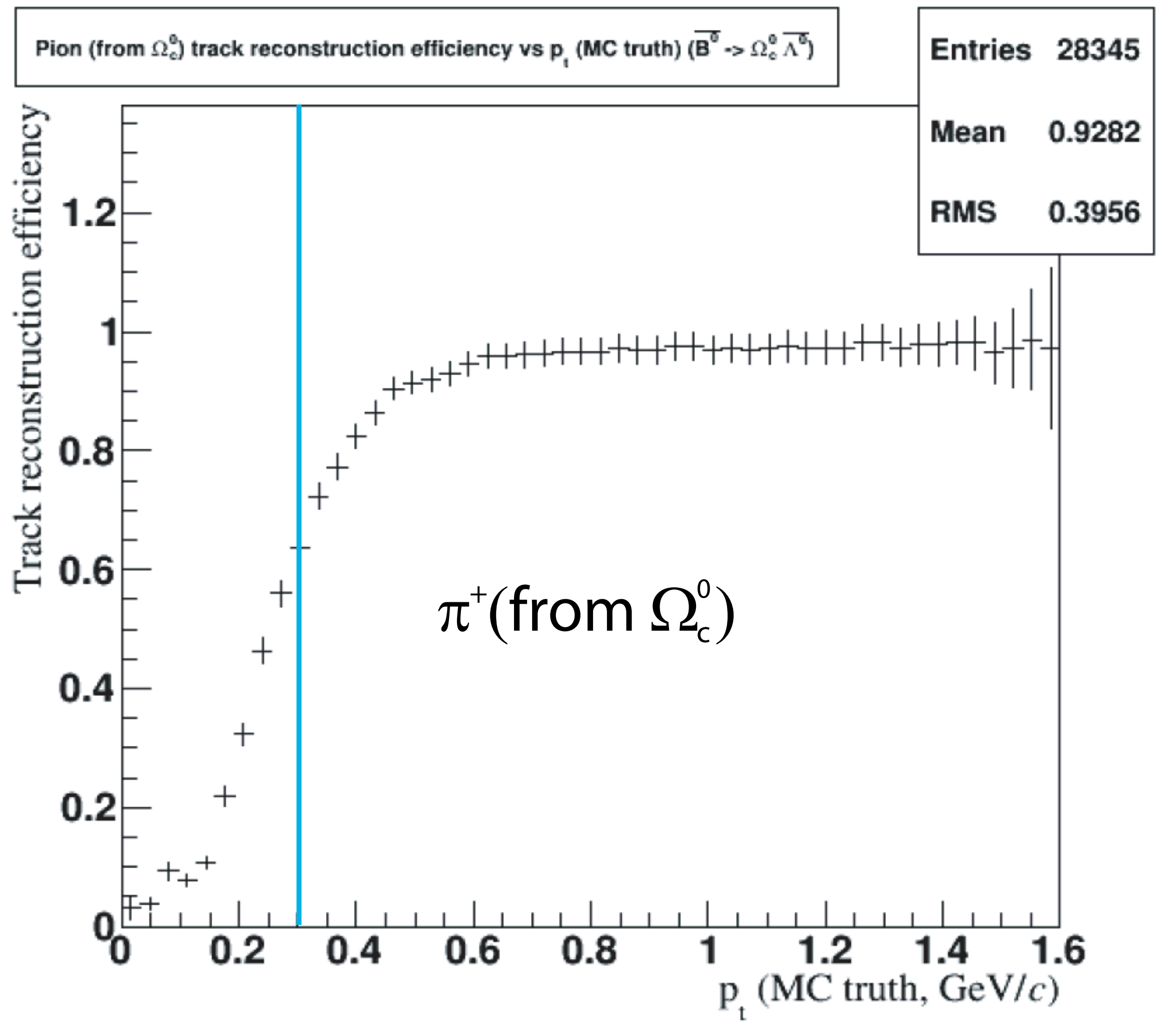


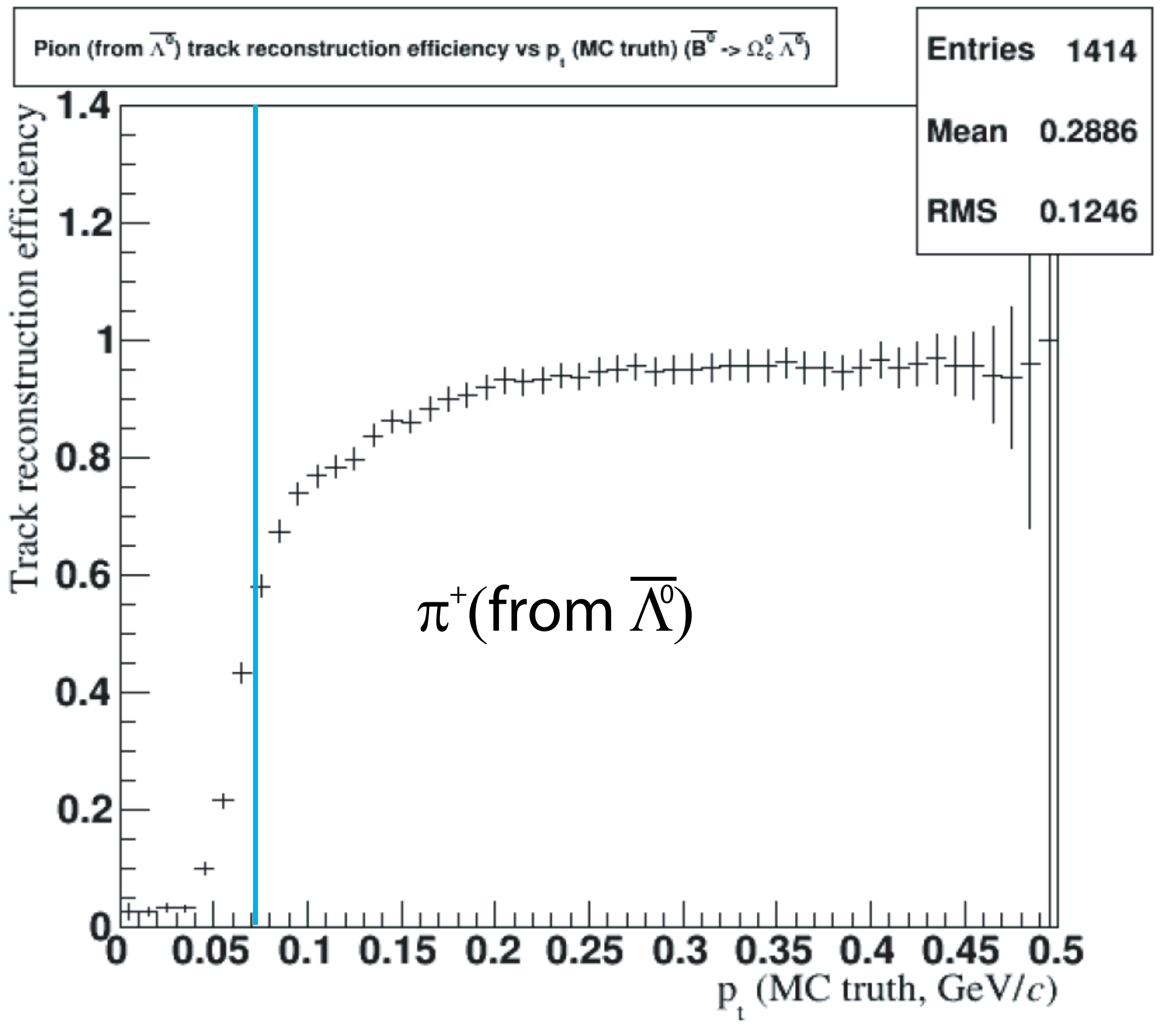
pt cut placement

~60% reconstruction efficiency









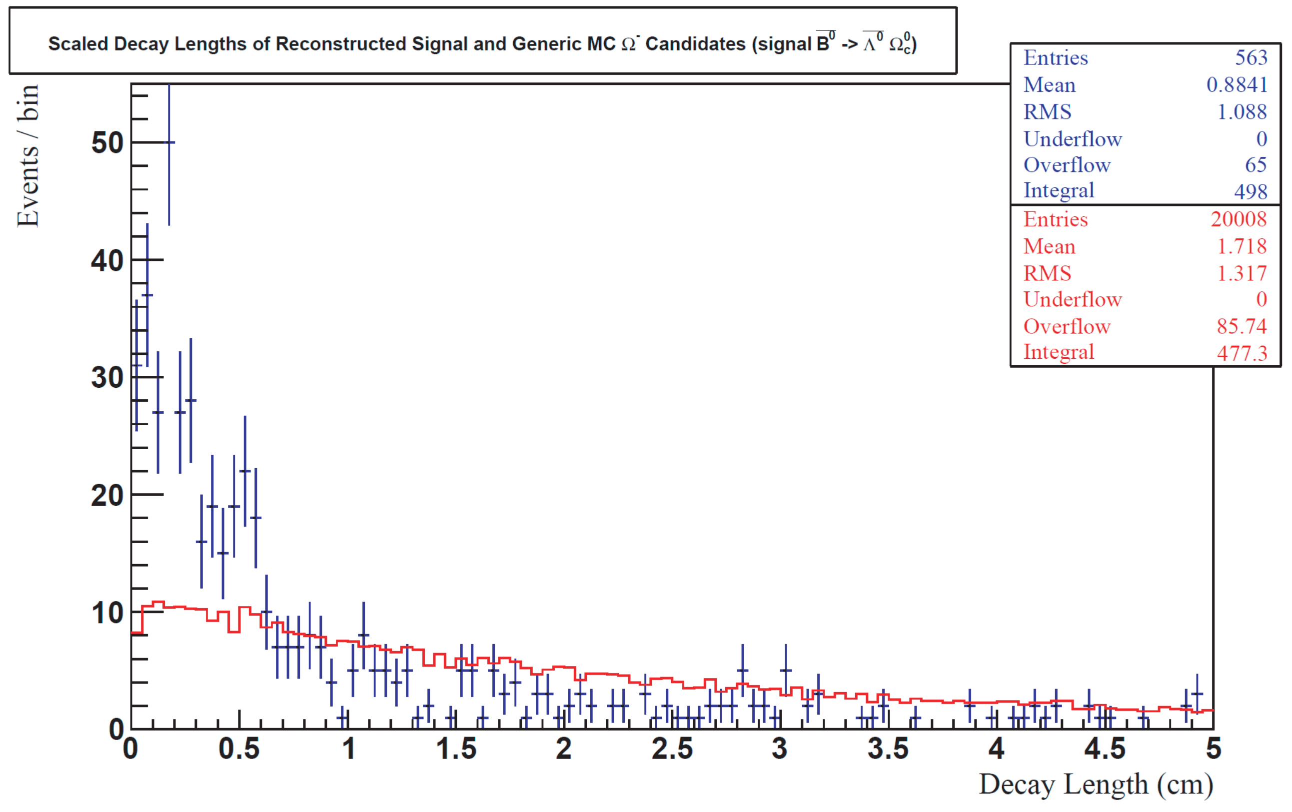
Determined on basis of differences between signal and generic MC

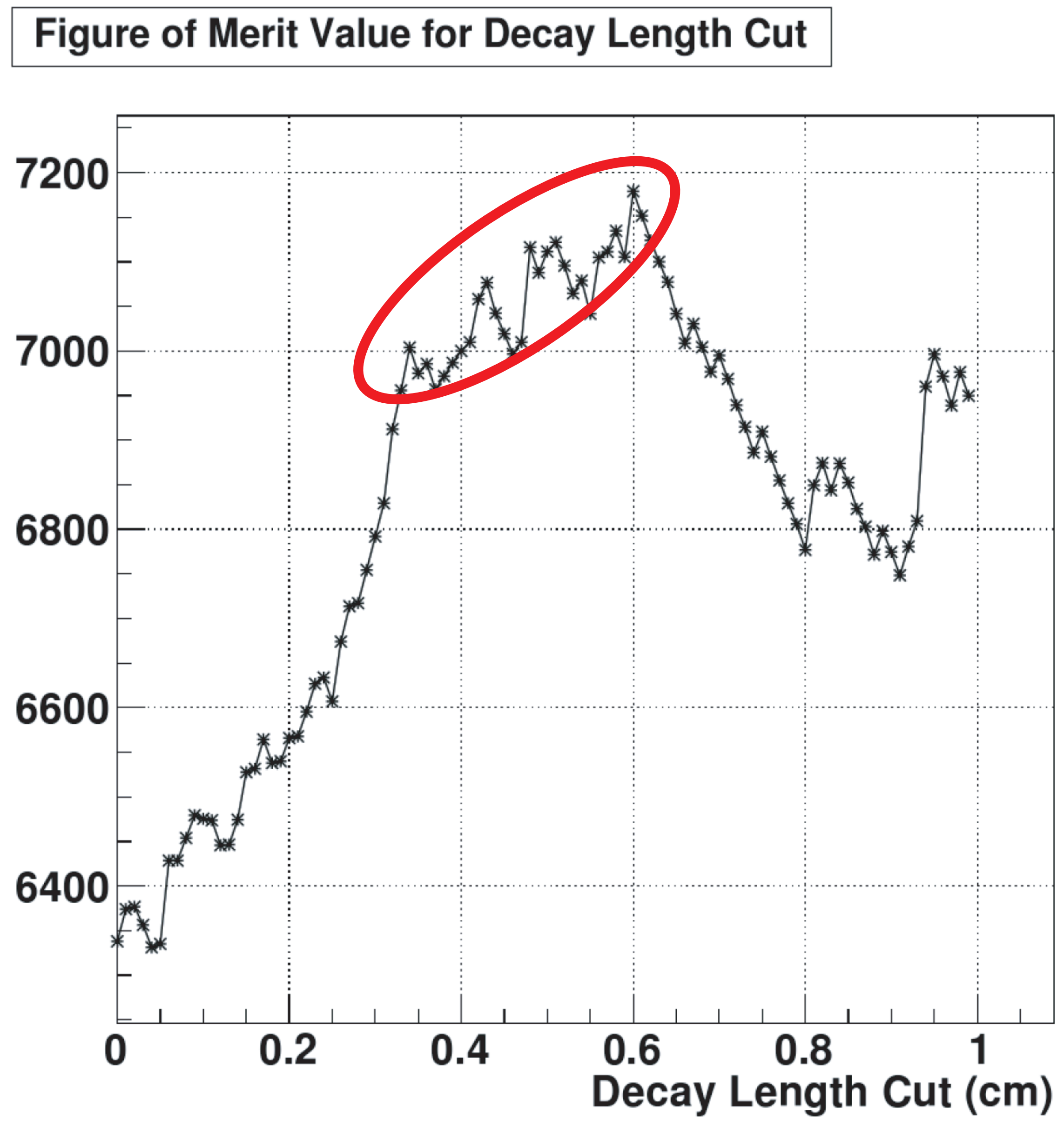
Optimization of S/sqrt(B) to determine Ω^- decay length selection criterion.

Decay Length Cut: ~0.4 - 0.6 cm (0.6 cm chosen)

Here, we only consider background in the signal region; B is calculated as:

events in blinded data * (# gen MC in sig region/# gen MC in blinded reg.)





Optimized Punzi figure of merit to determine Ω^- and Ω_c^0 mass cuts/windows.

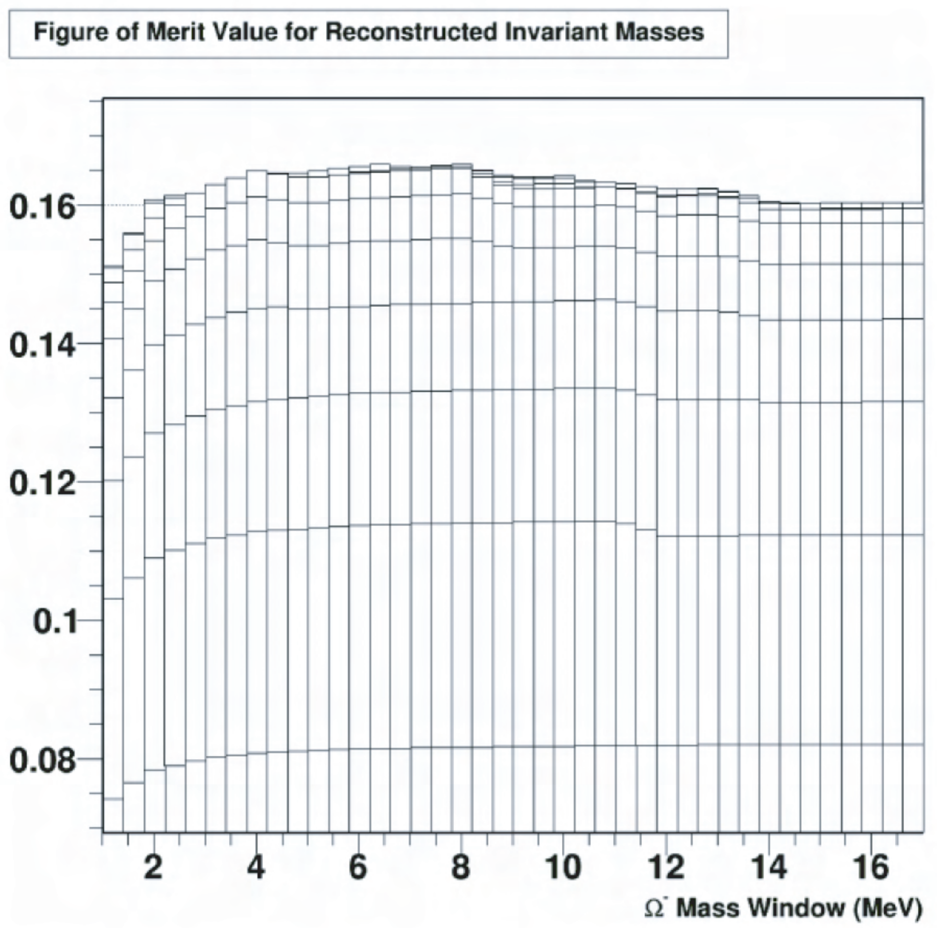
Ω^-: 9 MeV

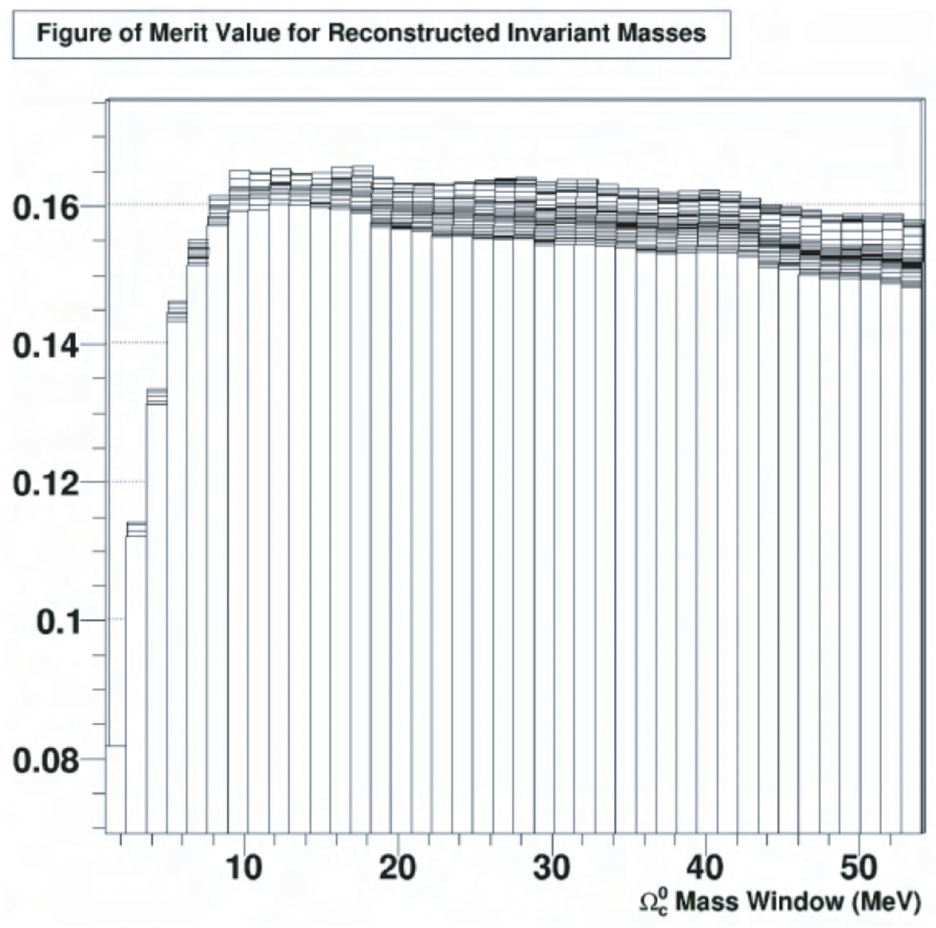
Ω_c^0:18 MeV

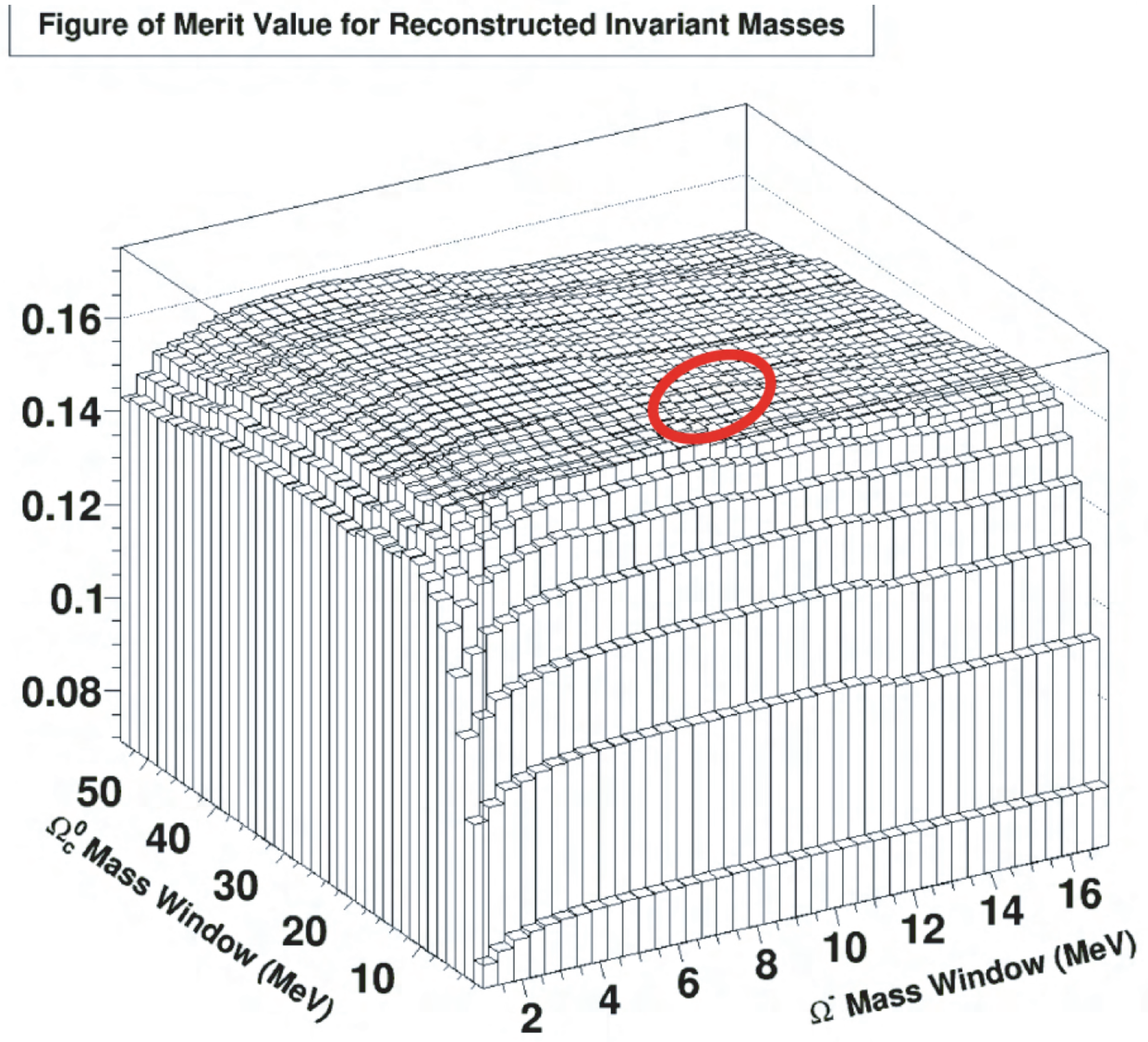
$\varepsilon(t)$: efficiency of signal MC as a function of mass cut
B(t): number of background events in signal region as a function of cut*
a: significance (chosen to be 10)

*B(t) is described by events in blinded data multiplied by scaling factor obtained from gen MC (i.e. # in sig region/# in blinded reg.)

$$\frac{\epsilon(t)}{a/2+\sqrt{B(t)}}$$







*Punzi, Giovanni. (2003). Sensitivity of searches for new signals and its optimization. Proceedings of PHYSTAT2003: Statistical Problems in Particle Physics, Astrophysics, and Cosmology.

Cutflow Table

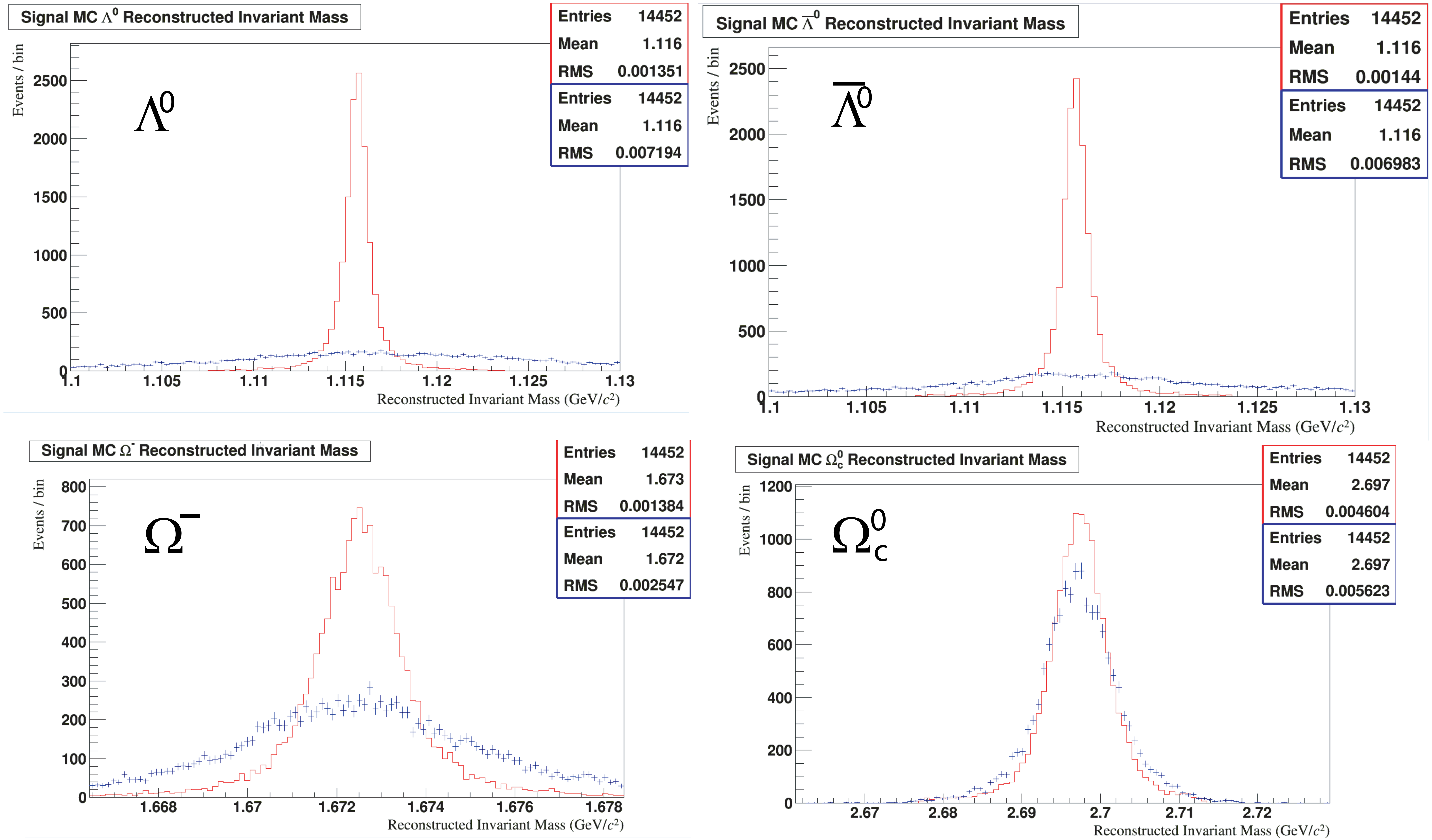
Parameter	Requirement	Efficiency (this cut)	Efficiency (overall)	Signal region	Single-cand events	MC tagged fraction	MC tagged fraction (sig region)	Gen MC Events (6 str.)	Gen MC Events in Sig Region (6 str.)	Gen MC Events in Side-band (6 str.)	Events in Blinded Data
Baseline selection	at least one candidate identified	27.22	27.22	66.75	53.10	61.69	89.79	50414	752	47326	7763
p_t cuts (ambitious)	*	83.74	23.38	80.90	59.29	75.64	91.01	26431	540	24189	4057
π candidate (from Ω_c^0)	$R_{\pi/K} \leq 0.4$ and $R_{e/\pi} \leq 0.95$	92.00	21.51	82.69	64.80	77.36	91.10	21960	464	20024	3290
K candidate (from Ω^-)	$R_{\pi/K} \geq 0.4$ and $R_{e/\pi} \leq 0.95$	85.48	18.39	90.35	79.95	87.99	94.81	16682	397	15059	2405
p candidates	$R_{p/K} \leq 0.9$	97.64	17.96	91.40	81.33	89.02	94.89	5885	150	5256	1009
$\Lambda^0, \overline{\Lambda}^0, \Omega^-, \Omega_c^0$ cands.	$\frac{\chi^2 \text{from vertex fit}}{\text{number of deg. of freedom}} \leq 100$	83.26	14.95	95.92	90.98	94.07	96.85	563	17	510	144
Ω^- candidates	Decay Length $\geq$ 0.60cm	79.15	11.83	95.85	91.26	93.99	96.85	259	9	235	72
$\Lambda^0/\overline{\Lambda}^0$ candidates	|rec. mass - Λ^0 inv. mass | $\leq$ 8 MeV	96.55	11.42	96.34	92.13	95.04	97.66	218	7	198	63
Ω^- candidates	|rec. mass - Ω^- inv. mass | $\leq$ 9 MeV	98.52	11.26	96.52	92.31	95.25	97.79	95	2	87	29
Ω_c^0 candidates	|rec. mass - Ω_c^0 inv. mass | $\leq$ 18 MeV	96.58	10.87	97.44	94.75	96.39	98.06	35	0	33	9
$M_{\rm bc}$	$M_{\rm bc} \geq 5.2$ GeV/c^2	99.42	10.81	98.30	95.91	97.26	98.07	28	0	26	7
ΔE	-0.4 GeV $\leq \Delta E \leq 0.3$ GeV	99.92	10.80	98.40	95.97	97.33	98.07	27	0	25	7

* p: pt > 0.250 GeV/c, $\overline{\text{p}}$: pt > 0.600 GeV/c, π^-: pt > 0.070 GeV/c,

π^+(from Ω_c^0): pt > 0.300 GeV/c, π^+(from $\overline{\Lambda}^0$): pt > 0.070 GeV/c, K^-: pt > 0.150 GeV/c

Reconstructed Invariant Masses (Before & After Vertex Fit)

Red: After
Blue: Before



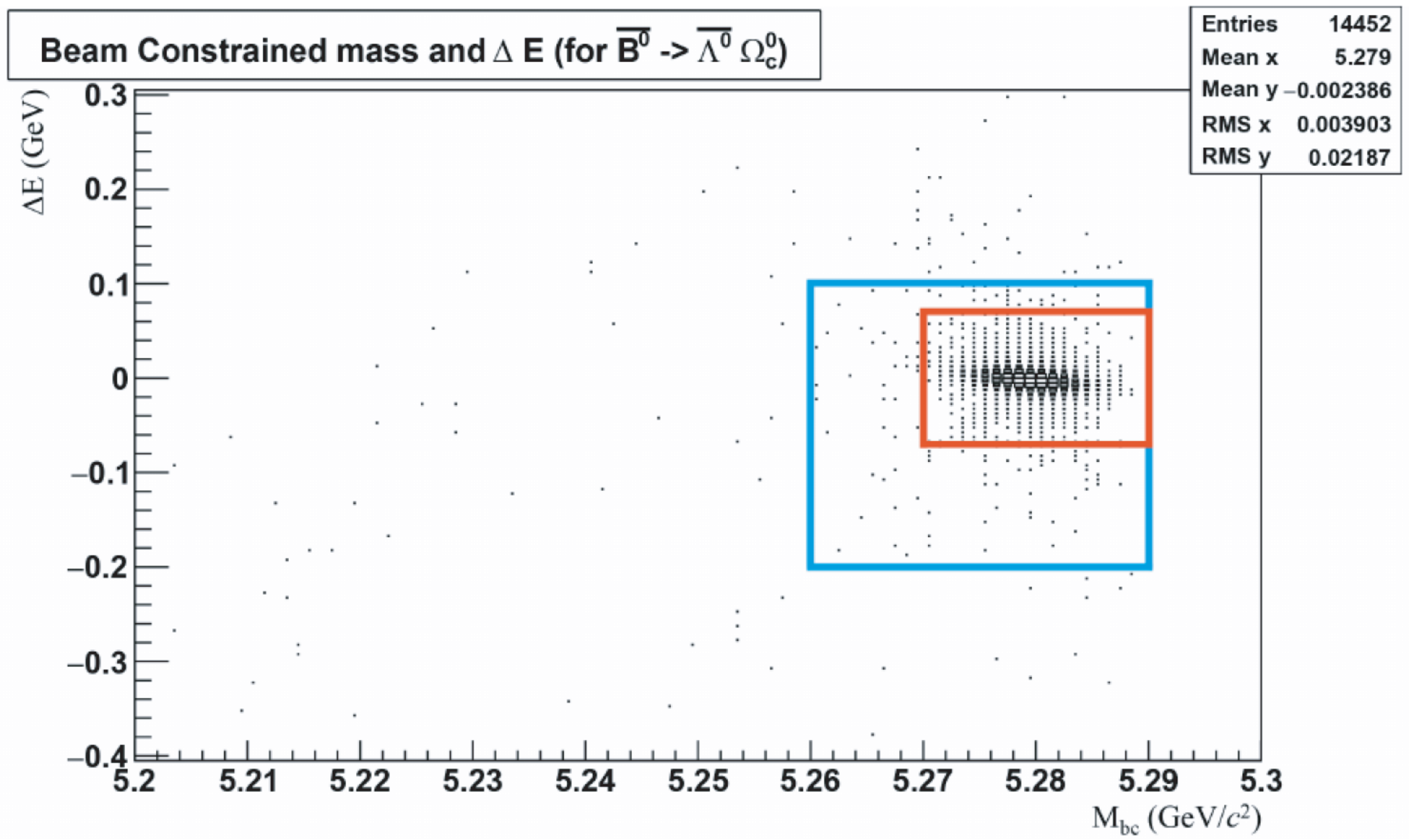
ΔE and Beam-Constrained B Mass Distributions for Signal MC ($\bar{B}^0 \text{->} \bar{\Lambda}^0 \Omega_c^0$)

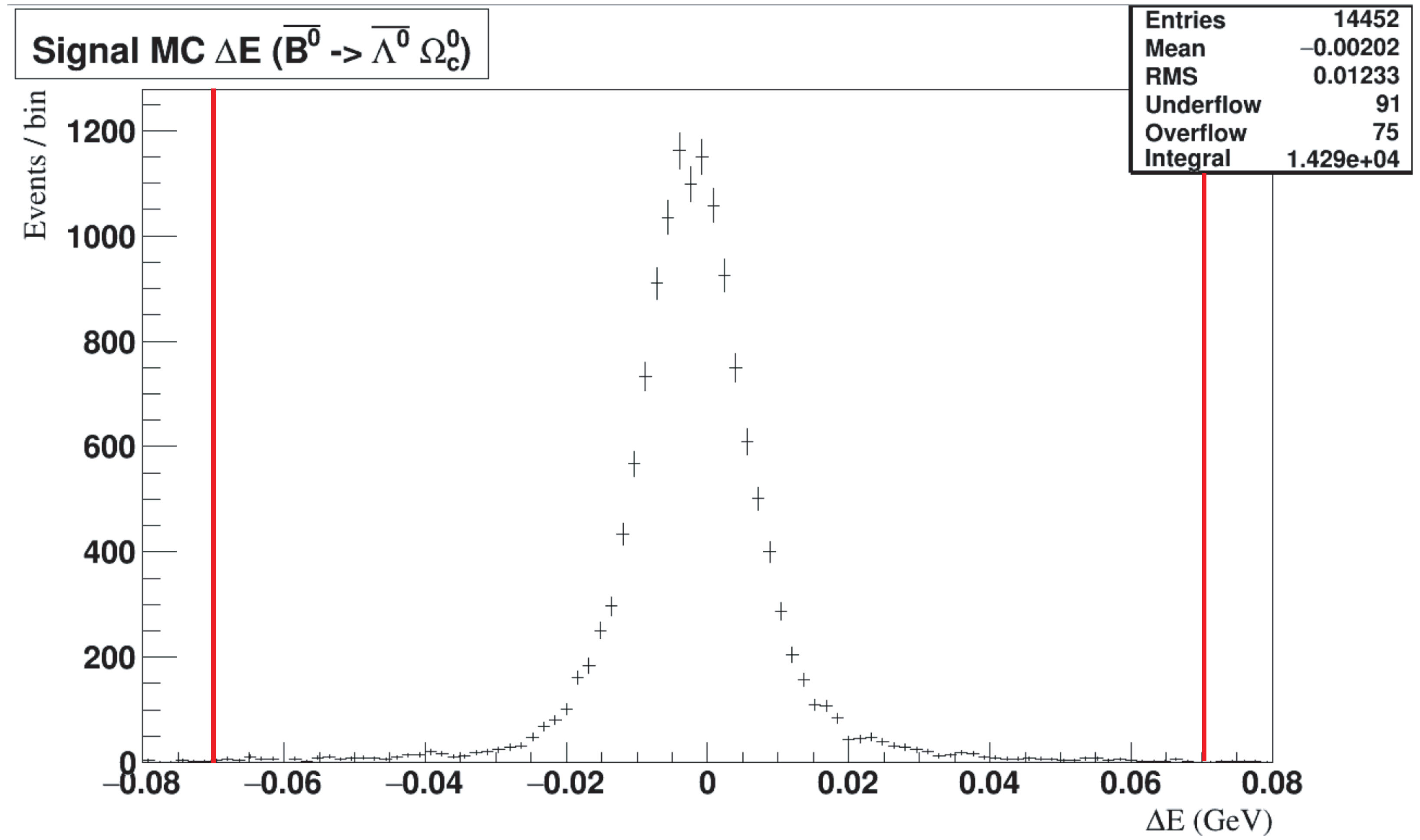
Signal Region (Red)

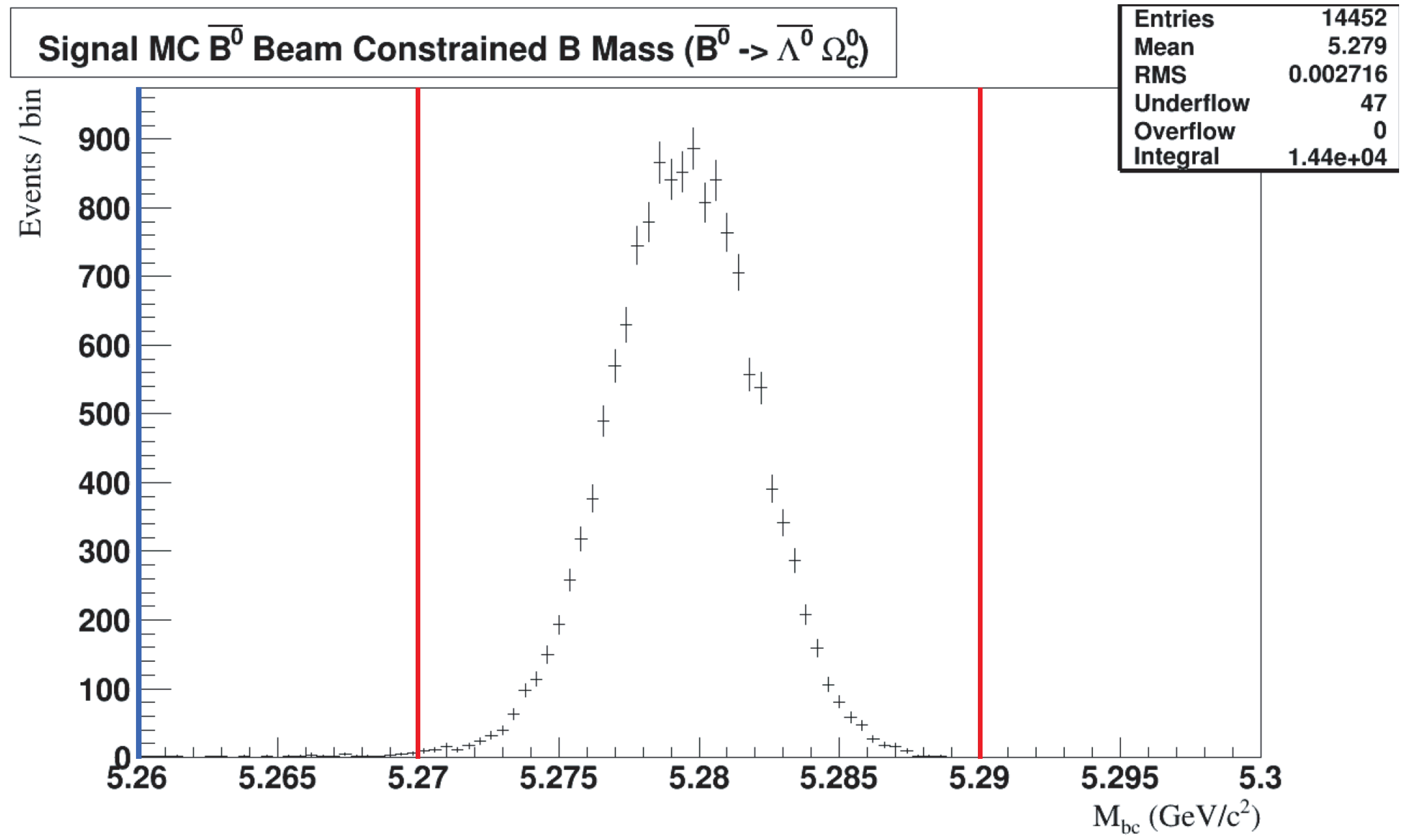
- Mbc > 5.27 GeV/c^2 and (-0.07) GeV < ΔE < 0.07 GeV
- 98.4% of all signal MC events lie in this region

Region Blinded in Data (Blue)

- Mbc > 5.26 GeV/c^2 and (-0.2) GeV < ΔE < 0.1 GeV
- 99.3% of all signal MC events lie in this region







ΔE and Beam-Constrained B Mass Distributions for Signal MC ($\bar{B}^0$-> $\bar{\Lambda}^0 \Omega_c^{*0}$)

Signal Region (Red)

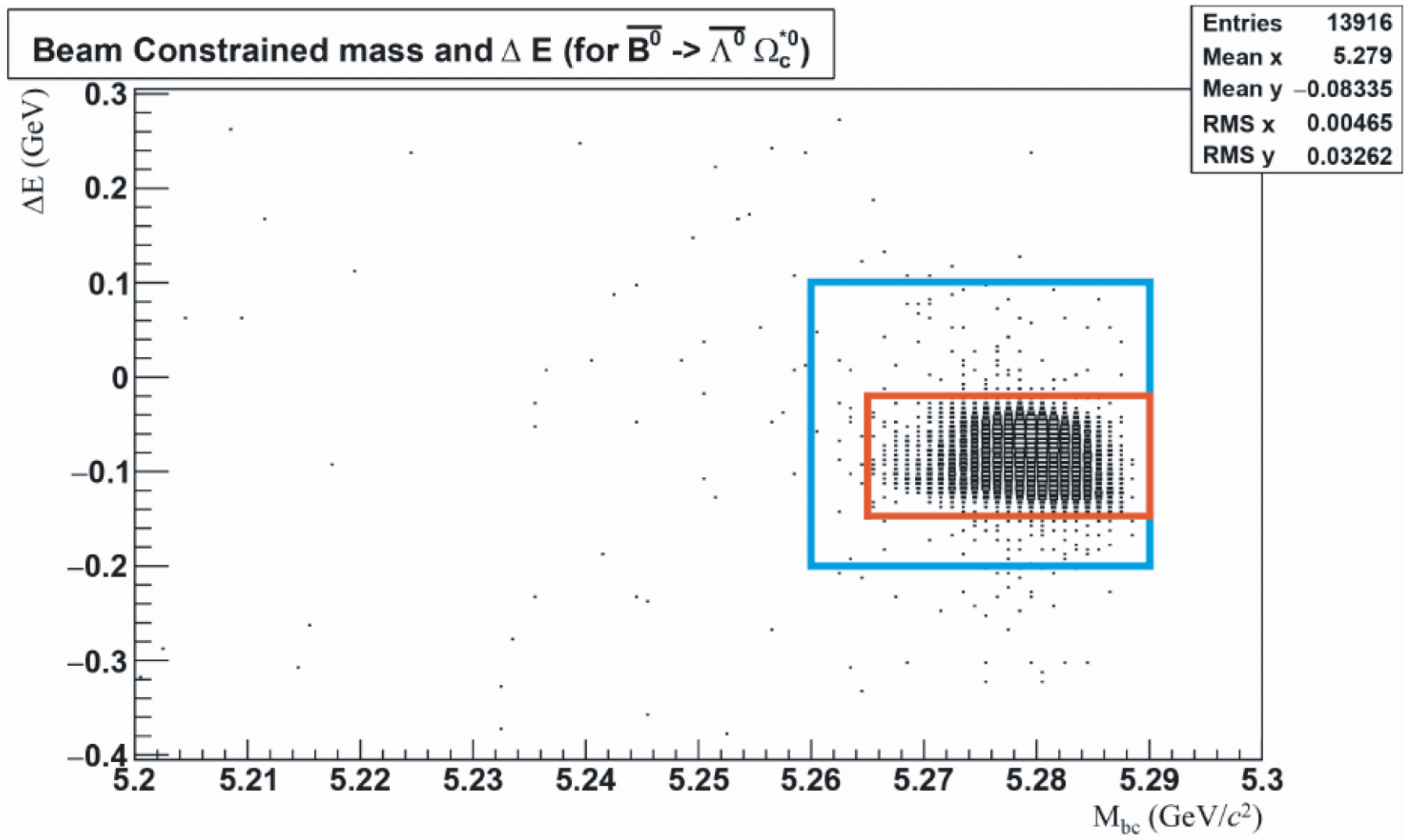
- Mbc > 5.265 GeV/c^2 and (-0.145) GeV < ΔE < (-0.020) GeV

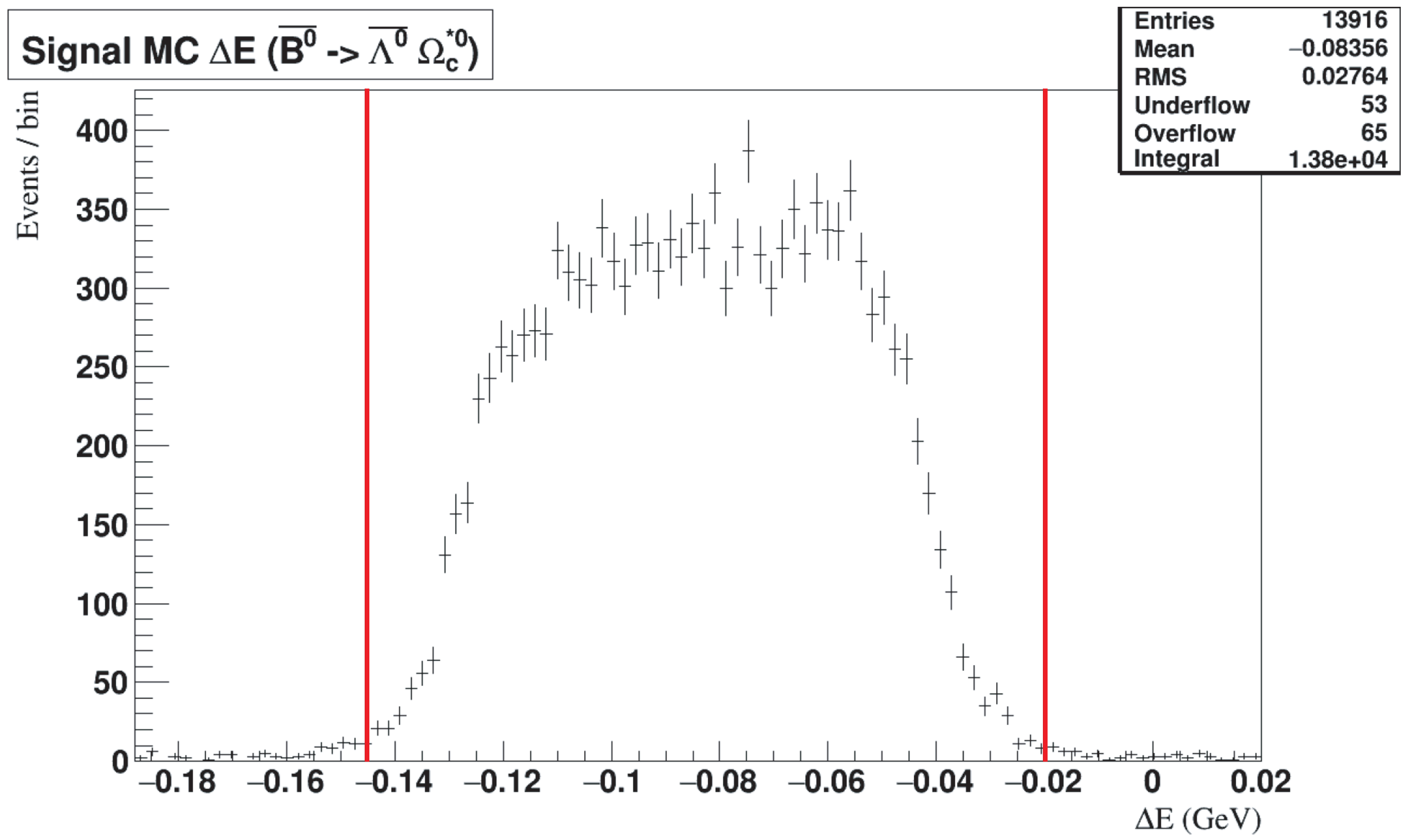
- 97.8% of all signal MC events lie in this region

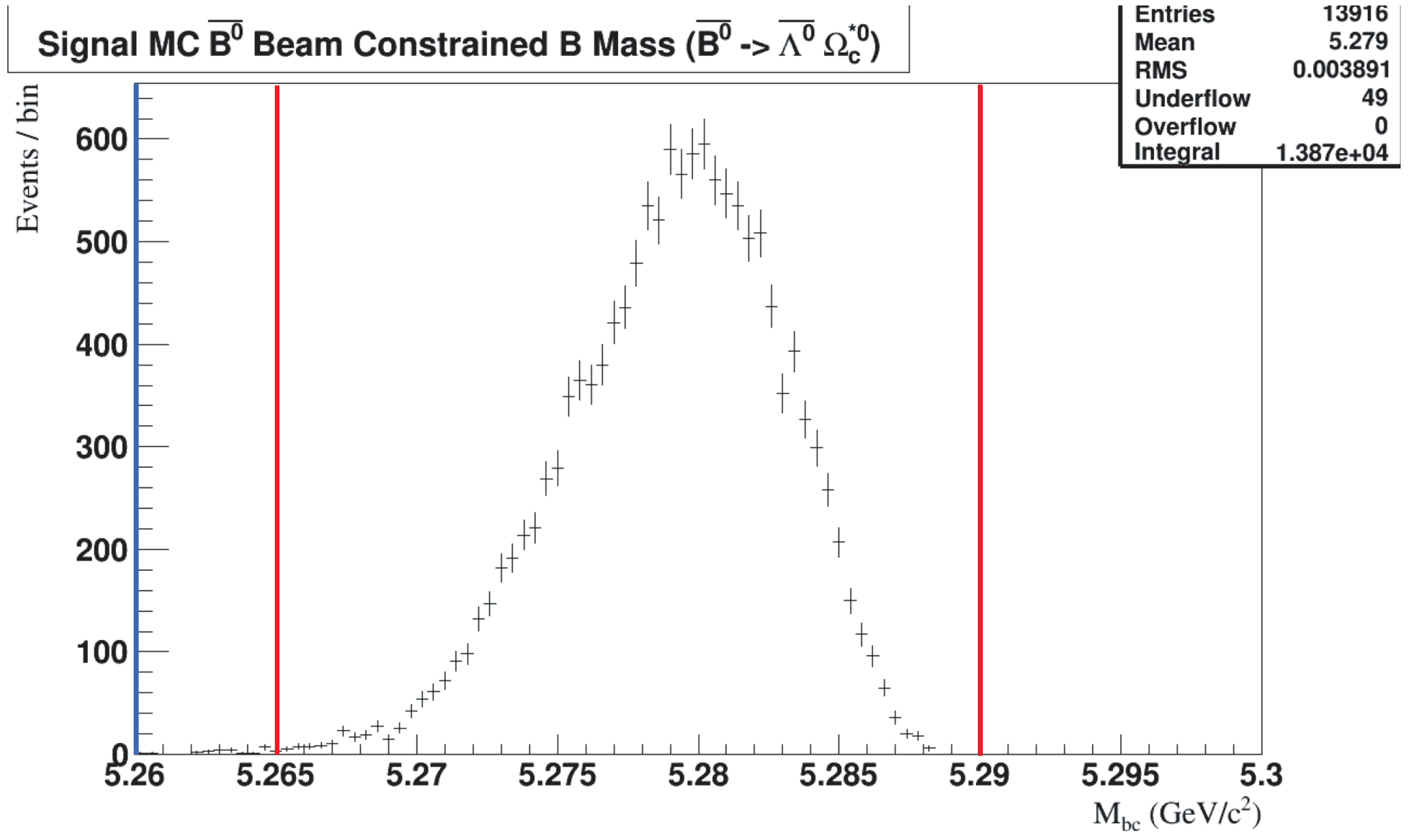
Region Blinded in Data (Blue)

- Mbc > 5.26 GeV/c^{2}and (-0.2) GeV < ΔE < 0.1 GeV

- 99.3% of all signal MC events lie in this region





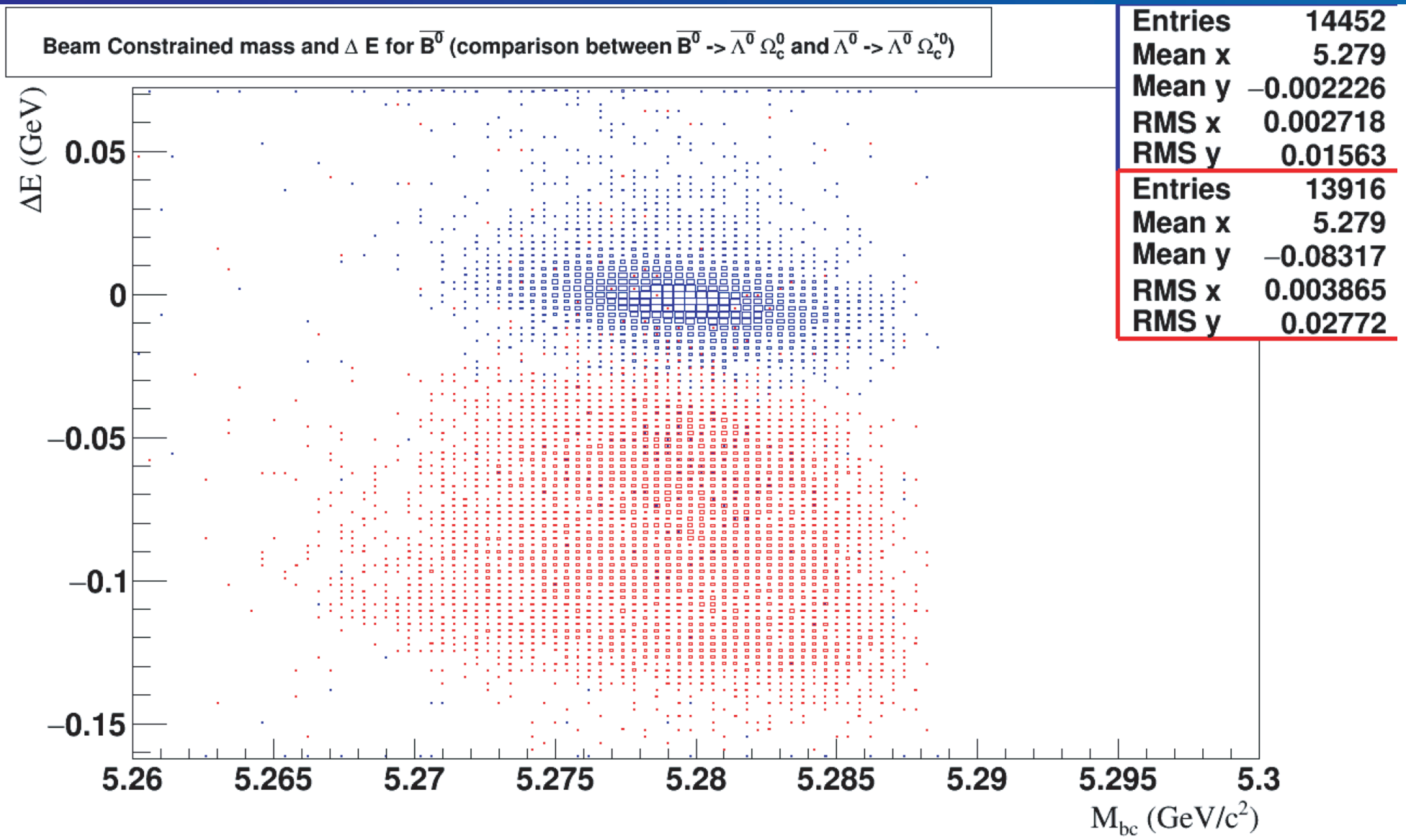


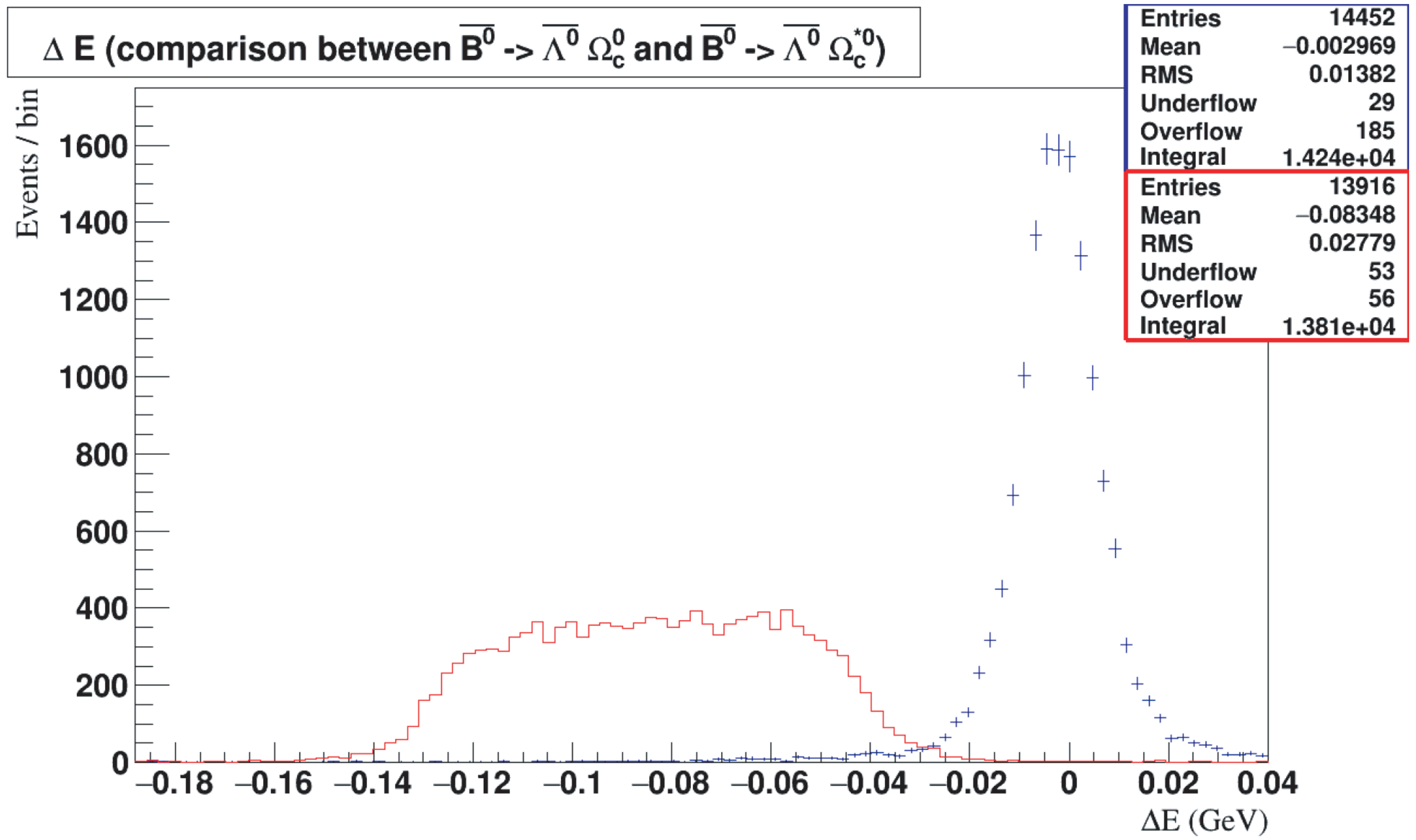
Signal MC Comparison

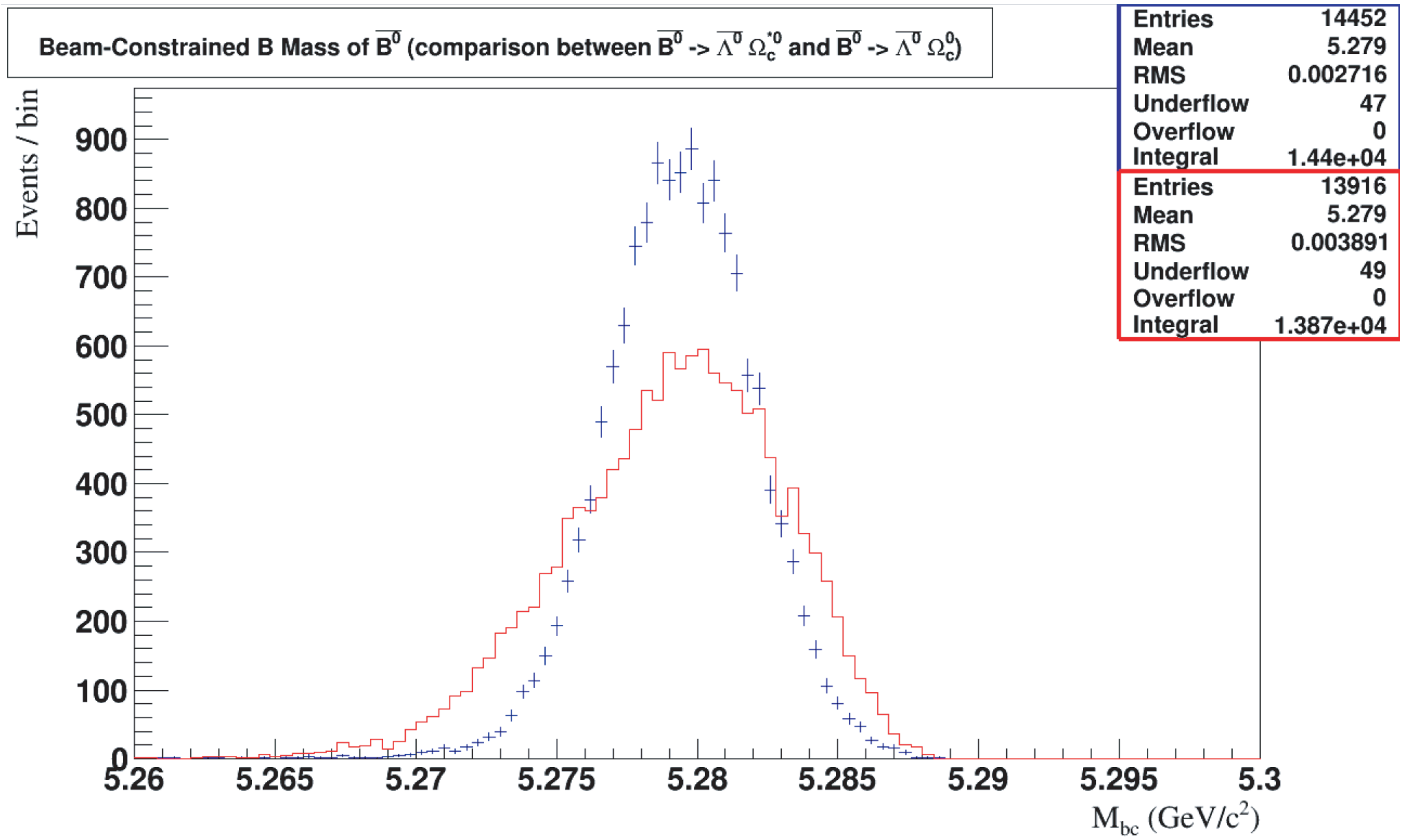
Red: $\bar{B}^0 \to \Omega_c^{*0} \bar{\Lambda}^0$

Blue: $\bar{B}^0 \to \Omega_c^0 \bar{\Lambda}^0$

ΔE facilitates separation of the two channels



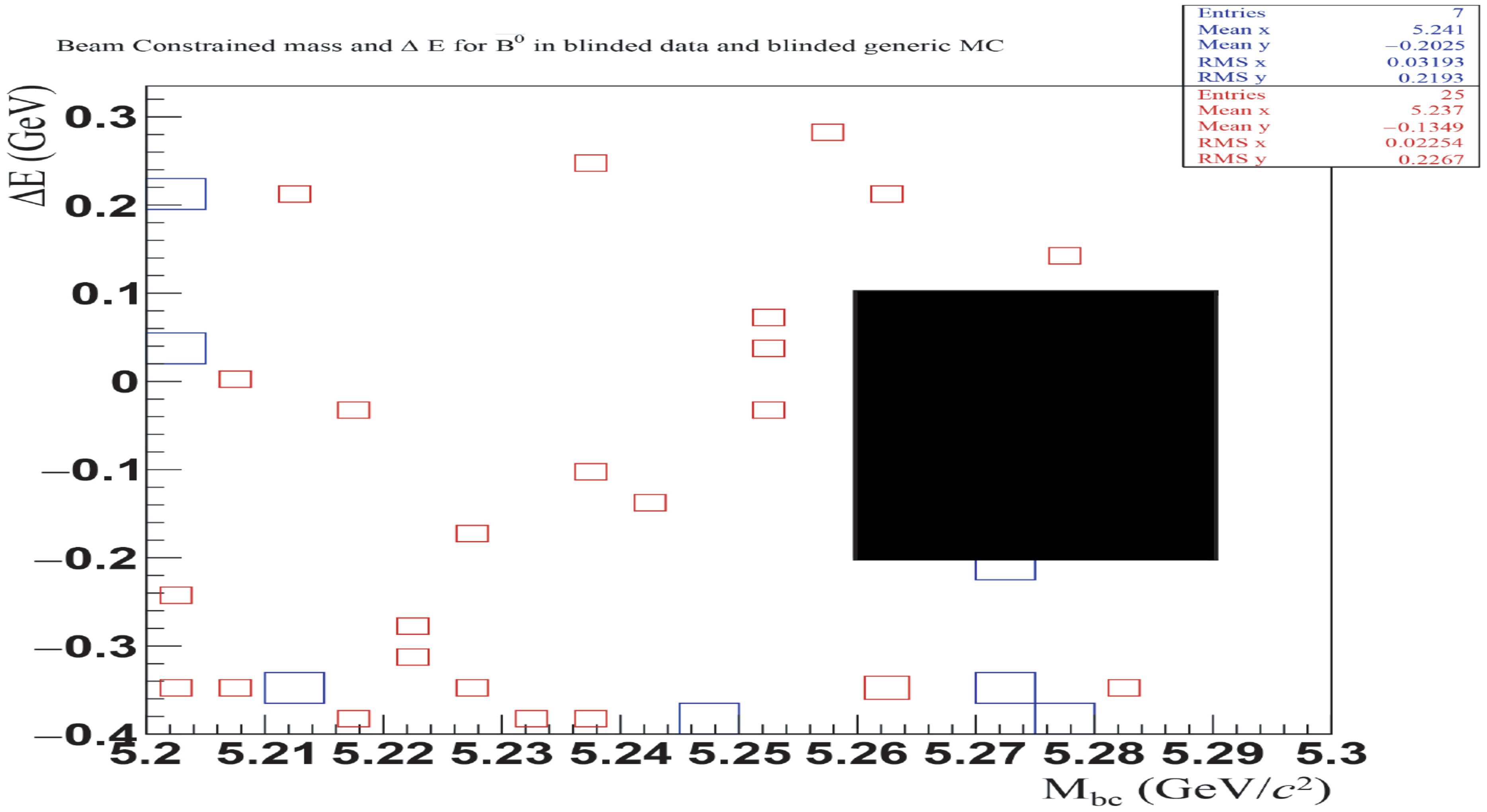


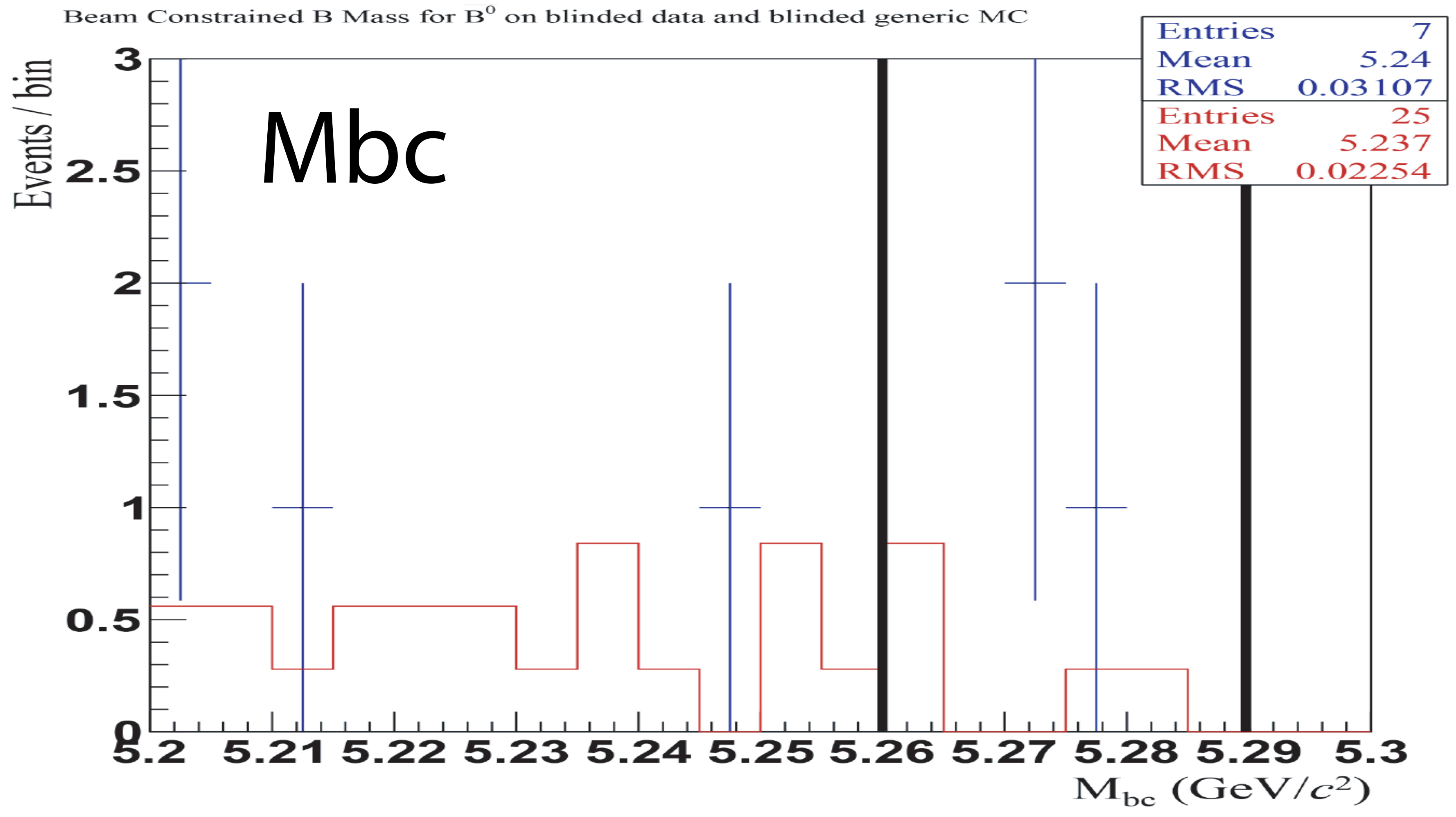


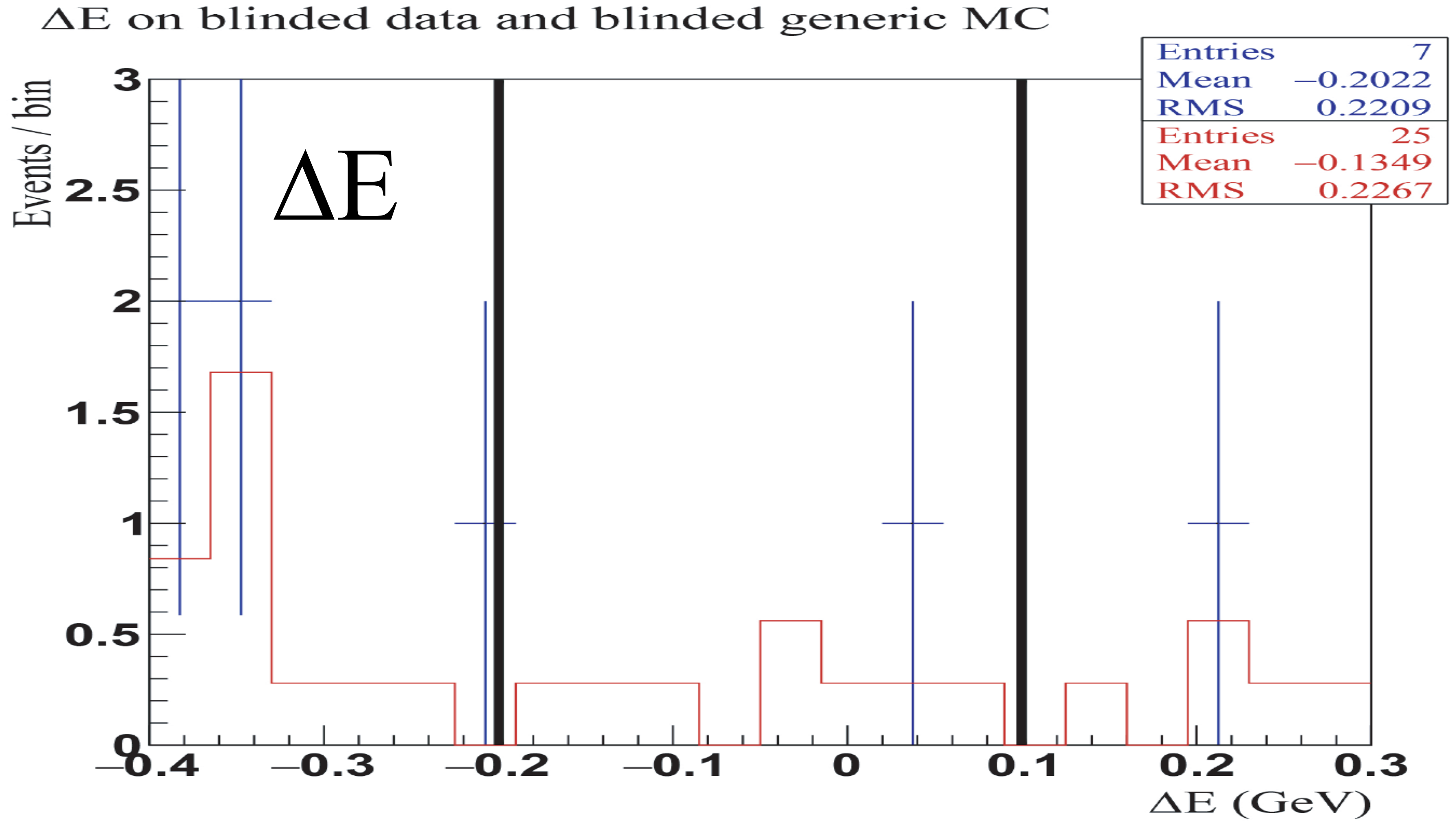
Blinded Data vs Blinded Generic MC

Blue: blinded data (7 events)
Red: six streams of generic MC (25 events)

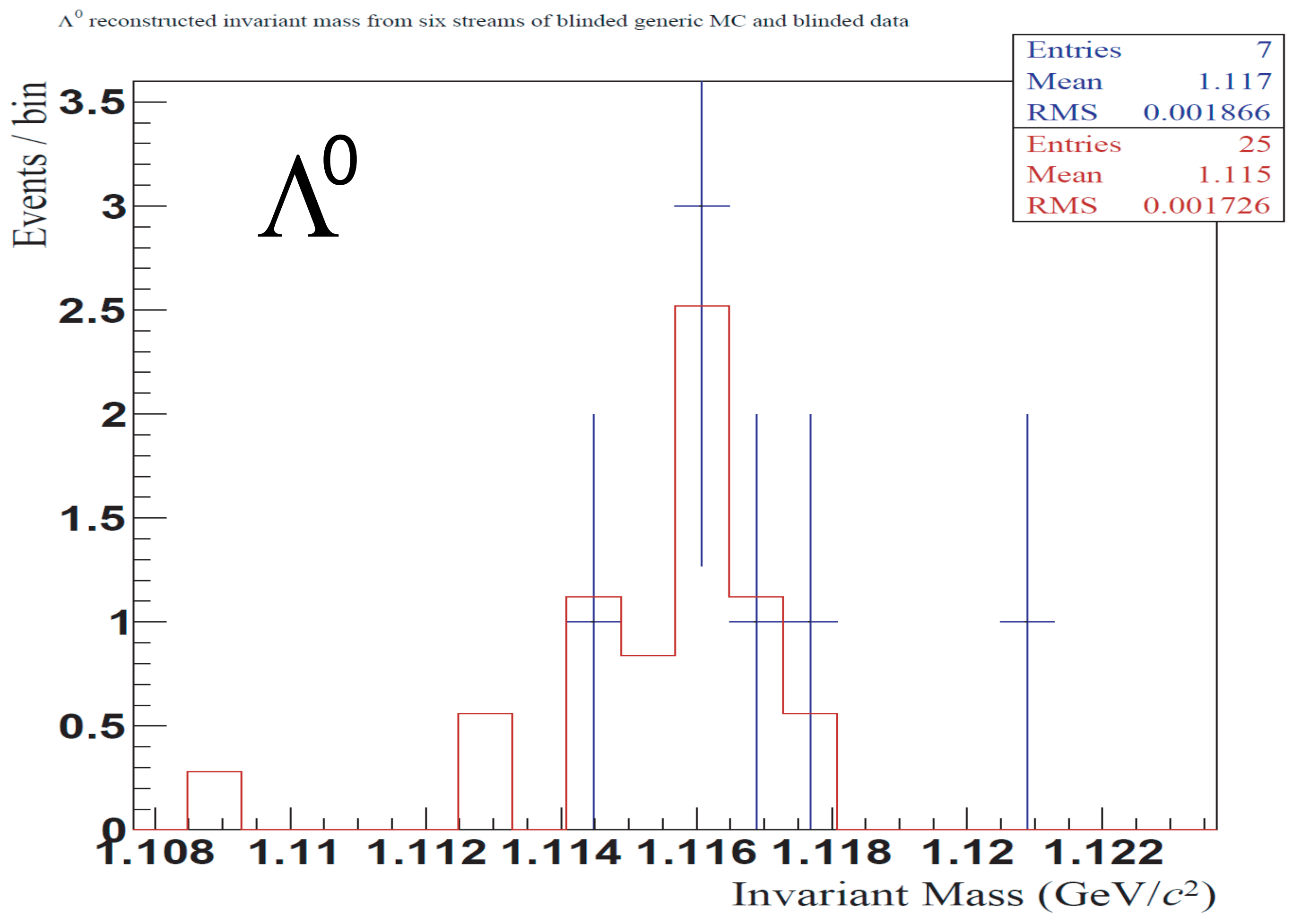
Compare to ensure generic MC reflects backgrounds in data

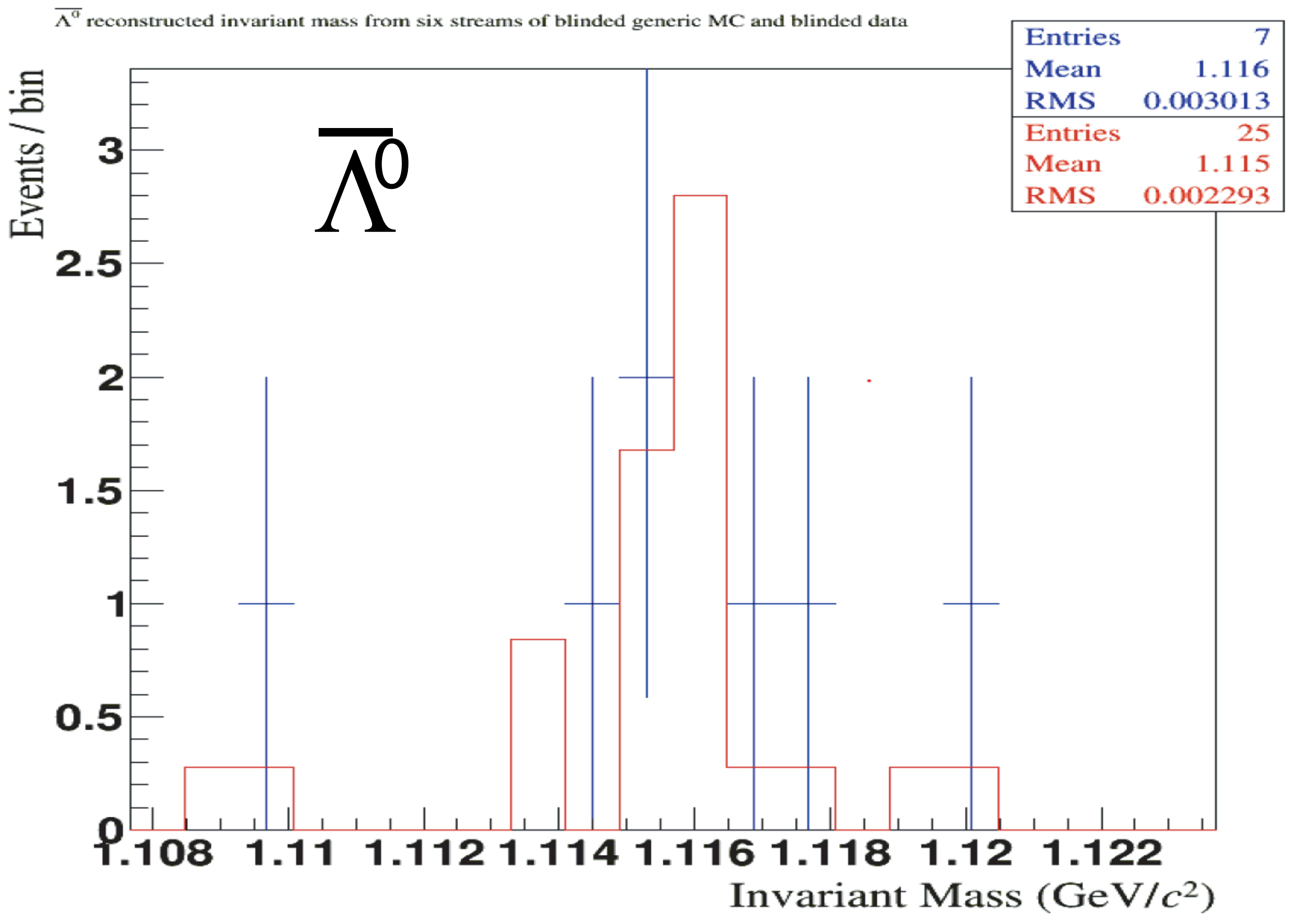


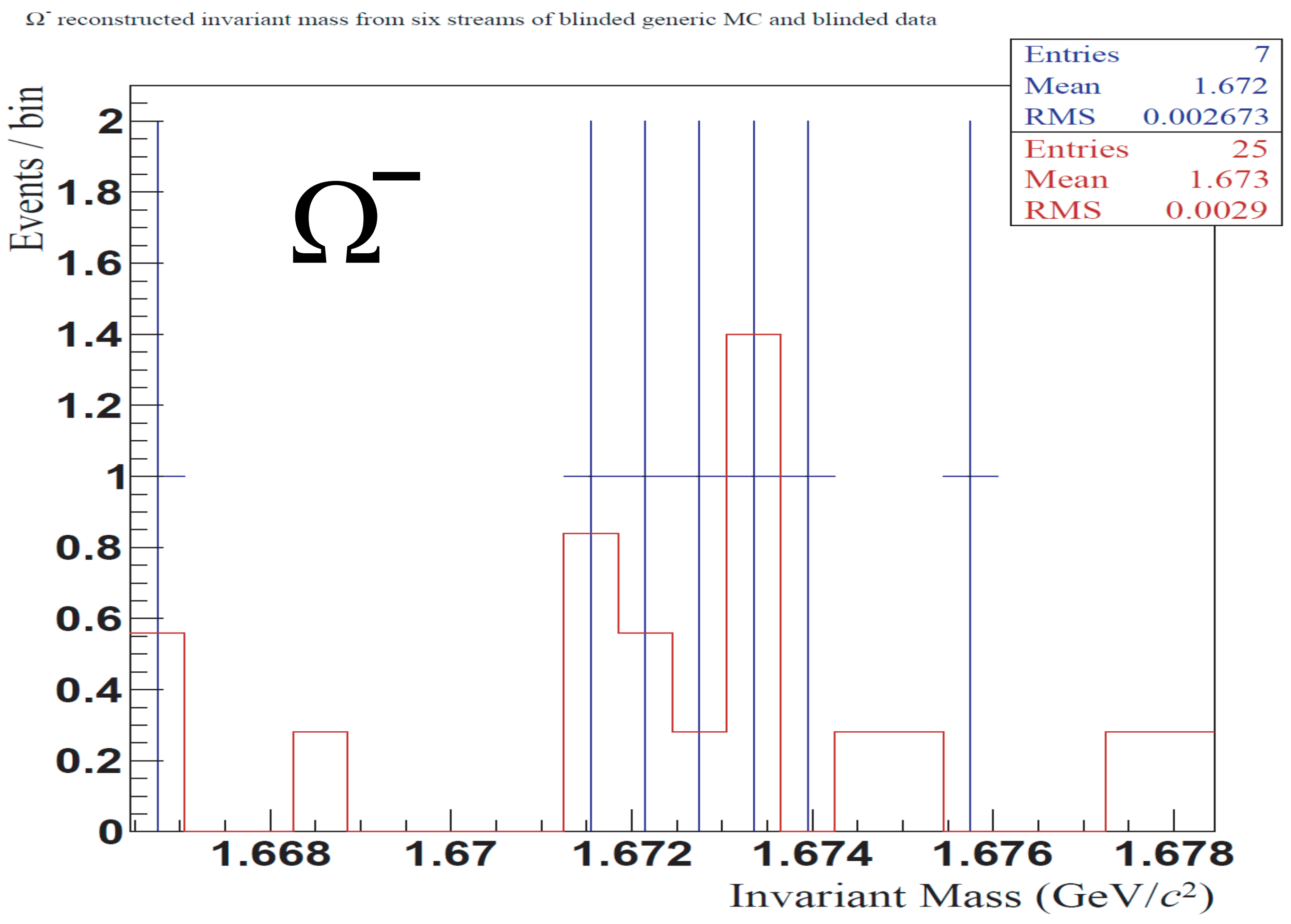


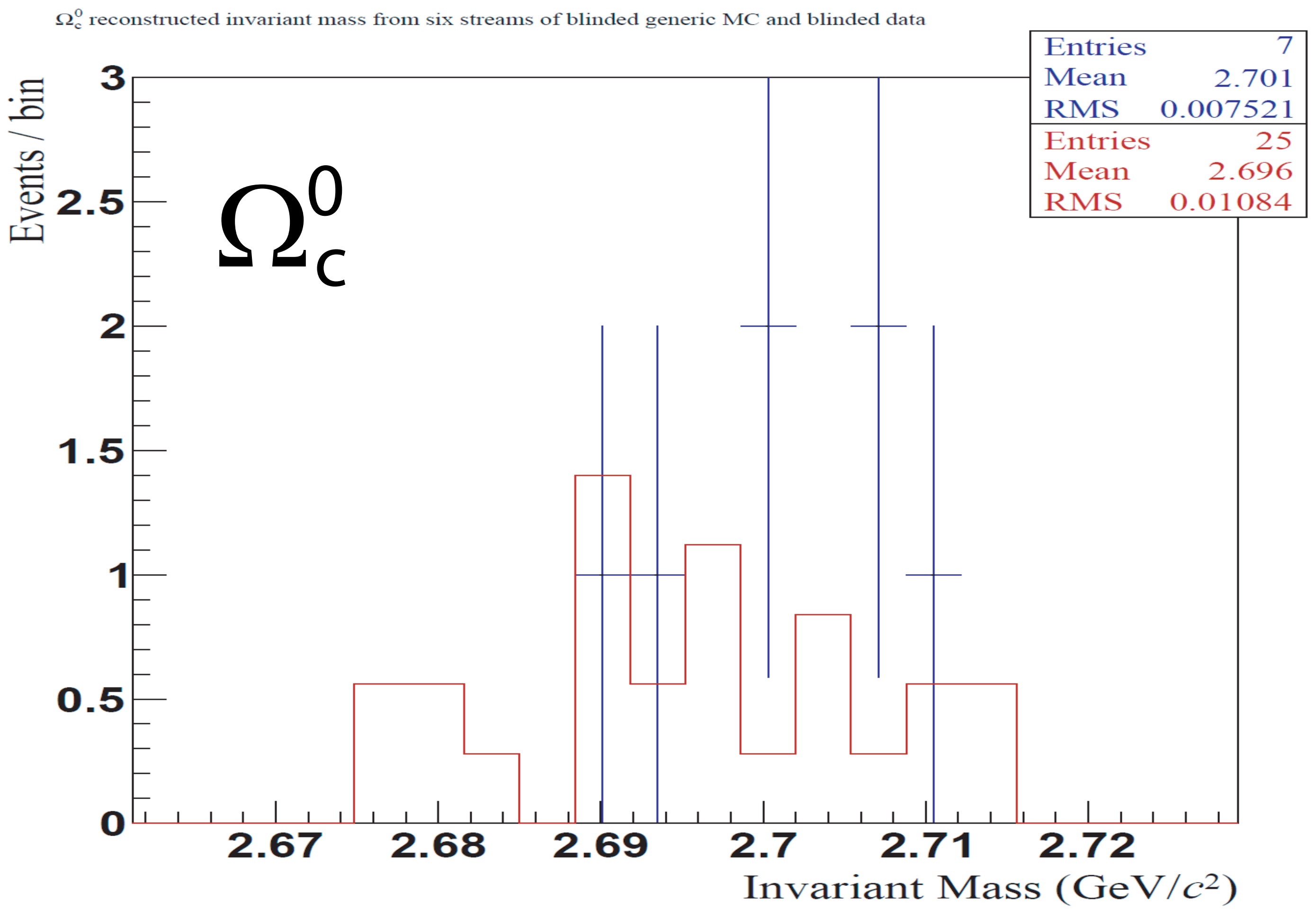


Blinded Data vs Blinded Generic MC (Invariant Masses)



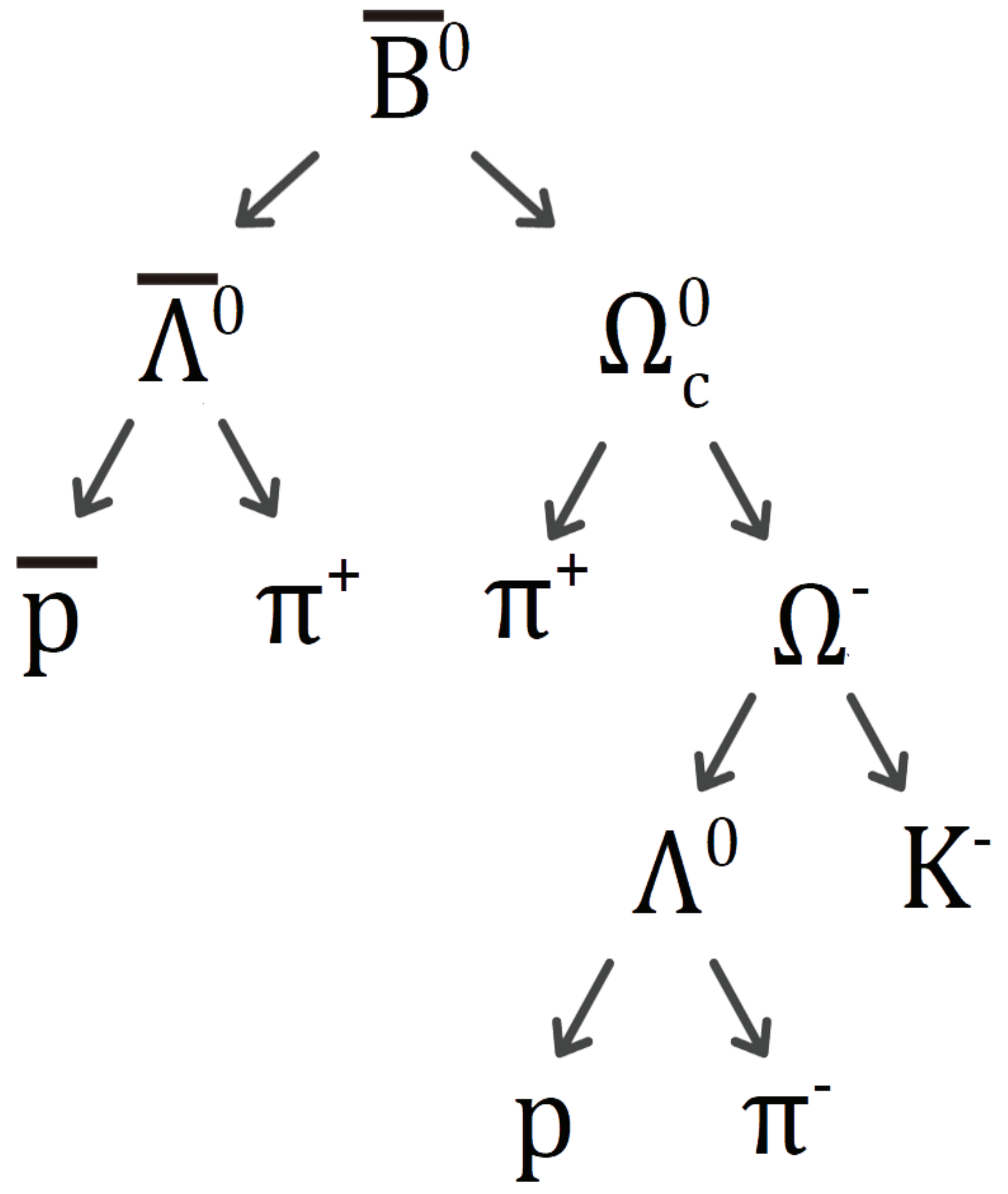






Calculation for Number of Expected Events in Belle Data

Parameter	Factor	Notation
The number of $B\overline{B}$ pairs	772×10^6	$N_{B\bar{B}}$
Reconstruction efficiency	0.108	ϵ
PID correction to efficiency	0.9828	ρ
Branching fraction estimate for $\overline{B}^0 \to \overline{\Lambda}^0 \Omega_c^0$	$1.1 \times 10^{-3} \times 0.05$	$\mathcal{B}(\overline{B}^0 \to \overline{\Lambda}^0 \Omega_c^0)$
Branching fraction estimate for $\Omega_c^0 \to \Omega^- \pi^+$	0.0143	$\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)$
Branching fraction for the decay $\Omega^- \to \Lambda^0 K^-$	0.678	$\mathcal{B}(\Omega^- \to \Lambda^0 K^-)$
Branching fraction for the decay $\Lambda^0 \to p\pi^-$	0.639	$\mathcal{B}(\Lambda^0 \to p\pi^-)$
Cabibbo-suppression factor	0.05	$\tan^2 \theta_C$



$$N_{\text{signal}}^{\text{data}} = N_{B\bar{B}} \times \epsilon \times \rho \times \mathcal{B}(\overline{B}^0 \to \overline{\Lambda}^0 \Omega_c^0) \times \mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+) \times \mathcal{B}(\Omega^- \to \Lambda^0 K^-) \times \mathcal{B}(\Lambda \to p\pi^-)^2$$

Calculation for Number of Expected Events in Belle Data

Ω^-

Mode		Fraction (Γ_i/Γ)
Γ_1	ΛK^-	$(67.8 \pm 0.7)\%$

Λ^0

Mode		Fraction (Γ_i/Γ)
Γ_1	$p\pi^-$	$(63.9 \pm 0.5)\%$

Ω_c^0

Mode	Fraction (Γ_i/Γ)	Conf. Level	(MeV/c)

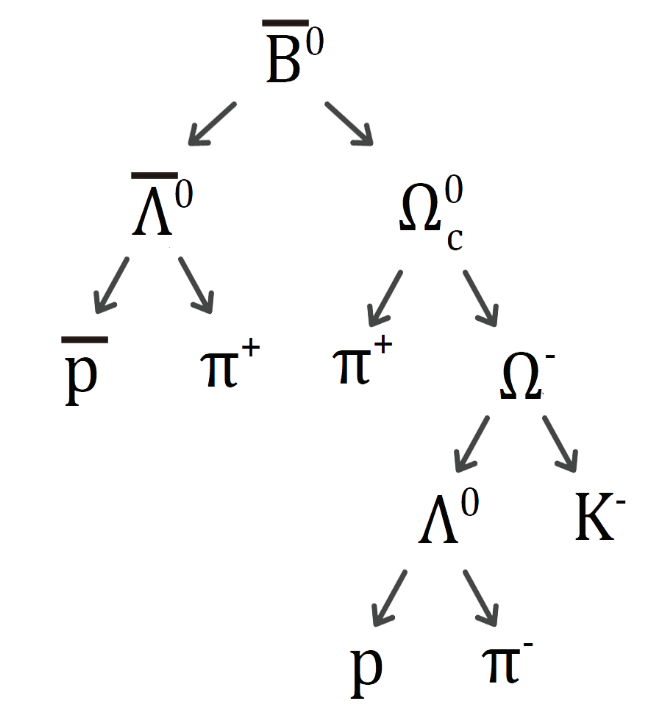
- No absolute branching fractions have been measured. The following are branching *ratios* relative to $\Omega^-\pi^+$.

Λ_c^+

Γ_{28}	$\Lambda\pi^+$	$(1.30 \pm 0.07)\%$

Ξ_c^0

Γ_8	$\Xi^-\pi^+$	$(1.43 \pm 0.32)\%$



[For approximation of $\overline{B}^0 \to \Omega_c^0 \overline{\Lambda}^0$ branching fraction]

Γ_{558}	$\overline{\Xi}_c^0 \Lambda_c^+$	$(9.5 \pm 2.3) \times 10^{-4}$
Γ_{519}	$\overline{\Xi}_c^- \Lambda_c^+$	$(1.2 \pm 0.8) \times 10^{-3}$

~ 1.1 * 10^(-3) used as a reference to estimate Cabibbo-suppressed branching fraction for two-body decays to baryons

$\Omega^- \to \Lambda^0 K^-$ $\quad$ $\Lambda^0 \to p\,\pi^-$

Number of expected events = (772 * 10^6) * (0.108) * 0.9828 * (0.678) * (0.639^2) * (0.014) * (1.1 * 10^(-3)) * (0.05) = 18 events

772,000,000 $B^0\overline{B}^0$ pairs

Reconstruction efficiency of channel (10.8± 0.1%)

~$\Omega_c^0 \to \Omega^- \pi^+$

Cabibbo-suppressed

*No absolute branching fractions have been measured for this decay, so fraction is determined based on other charmed baryon decays ($\Xi_c^0 \to \Xi^- \pi^+$ & $\Lambda_c^0 \to \Lambda\,\pi^+$)

- We perform a 2-dimensional extended unbinned maximum likelihood fit to Mbc and ΔE to statistically separate our signal from background

- Both signals are modeled by smoothed histograms

- Background is modeled by analytic functions (below)

$$\mathcal{L} = \frac{e^{-\sum_j n_j}}{N!} \prod_{i=1}^{N} \left(\sum_j n_j \mathcal{P}_j(M^i_{\mathrm{bc}}, \Delta E^i) \right)$$

Likelihood Function

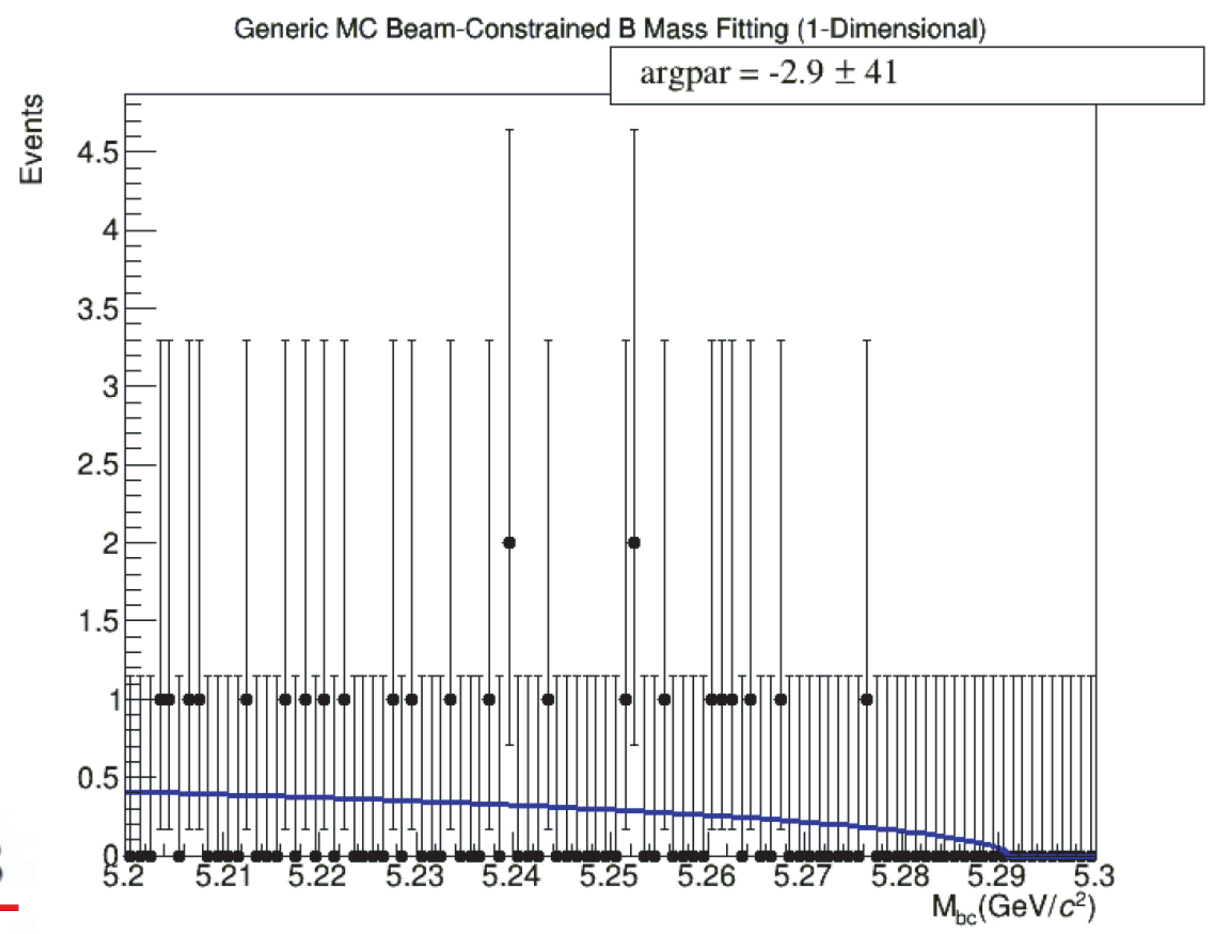
Mbc modeled with ARGUS function
ΔE modeled by first-order Chebyshev polynomial

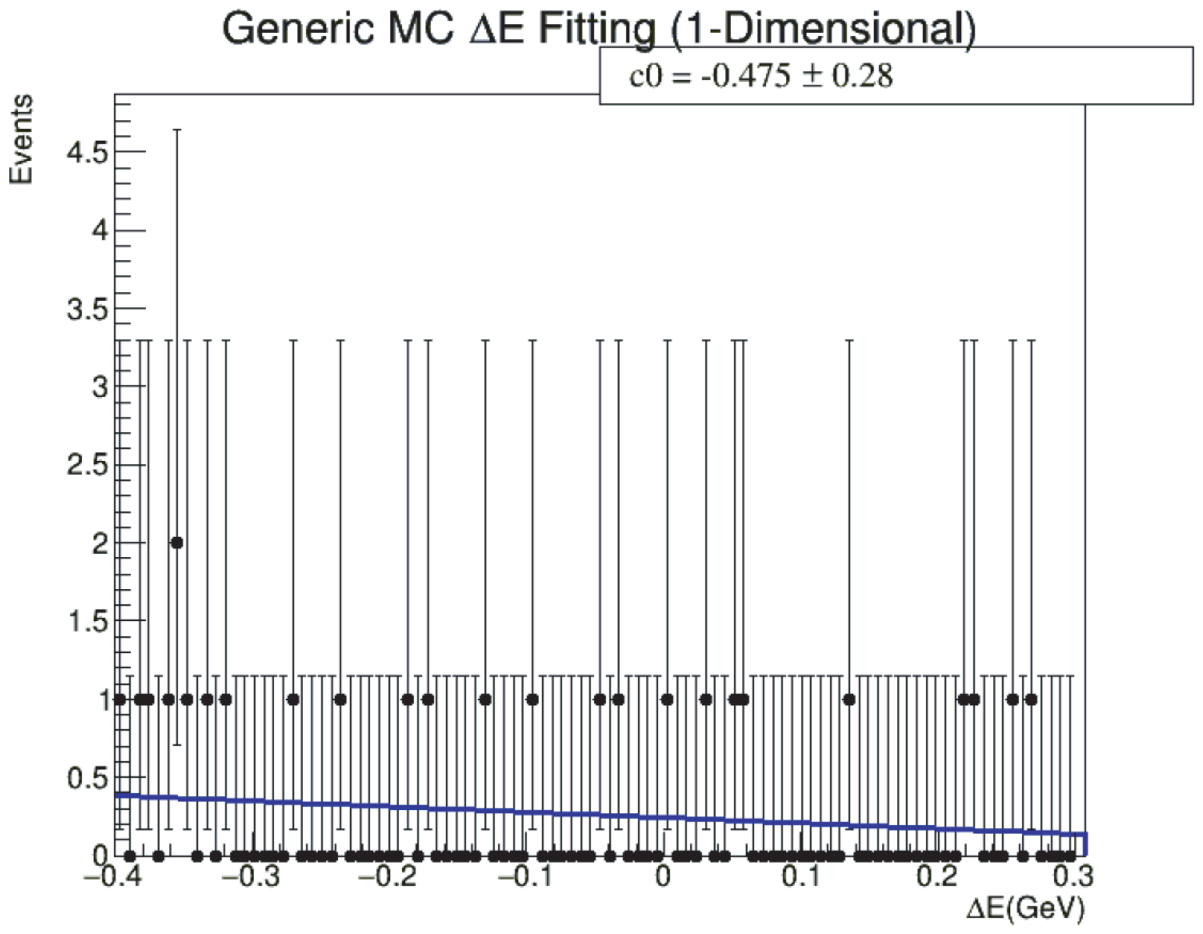
Fit Parameter	Value ± Uncertainty
ARGUS parameter	-2.9 ± 41

Fit Parameter	Value ± Uncertainty
slope coefficient	-0.475 ± 11

Estimate for number of background events:

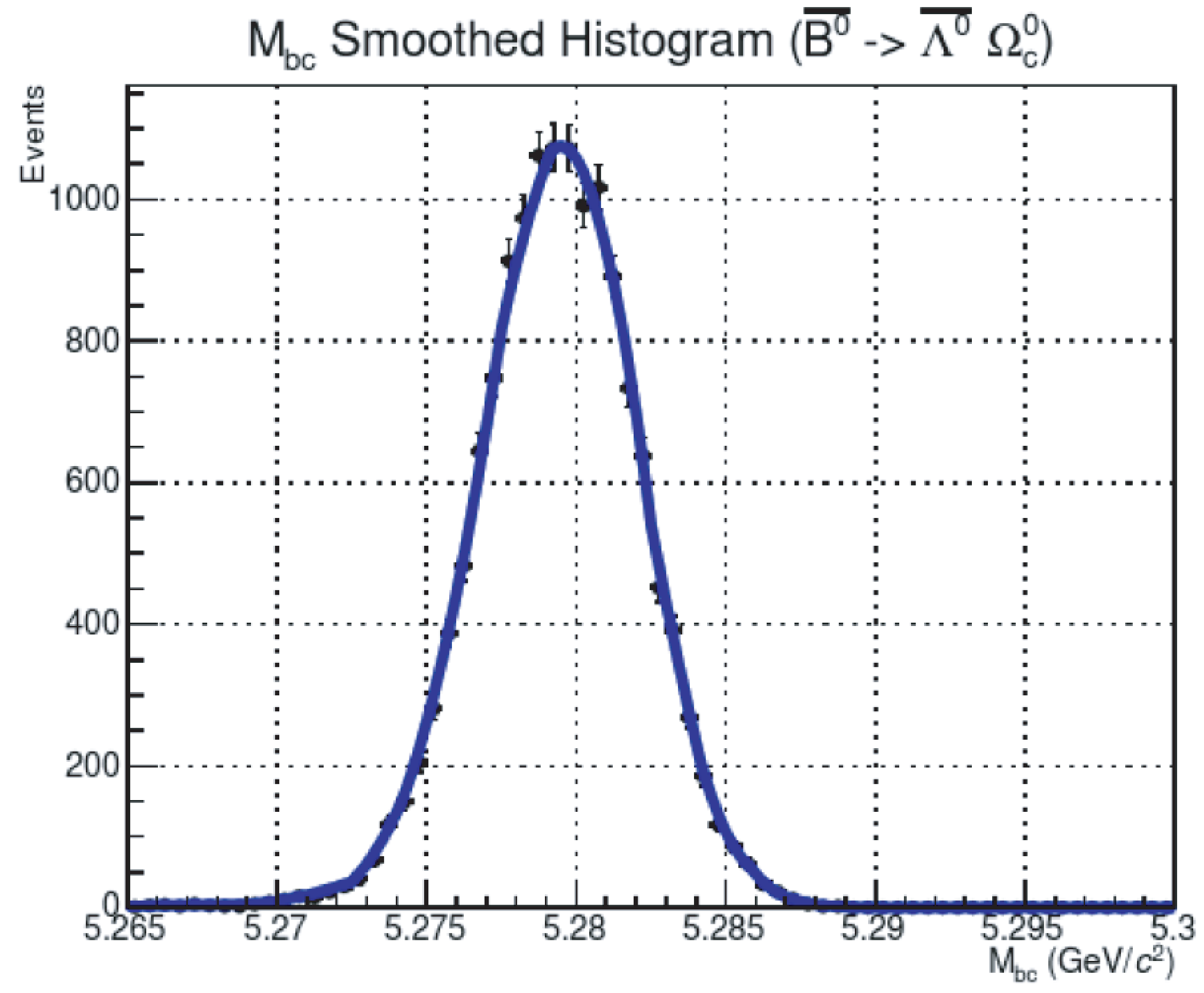
$$\#\text{ of events in blinded data} \times \frac{\text{total genMC}}{\text{genMC in blinded reg.}} = 7 * \frac{27}{25} \approx \underline{8}$$

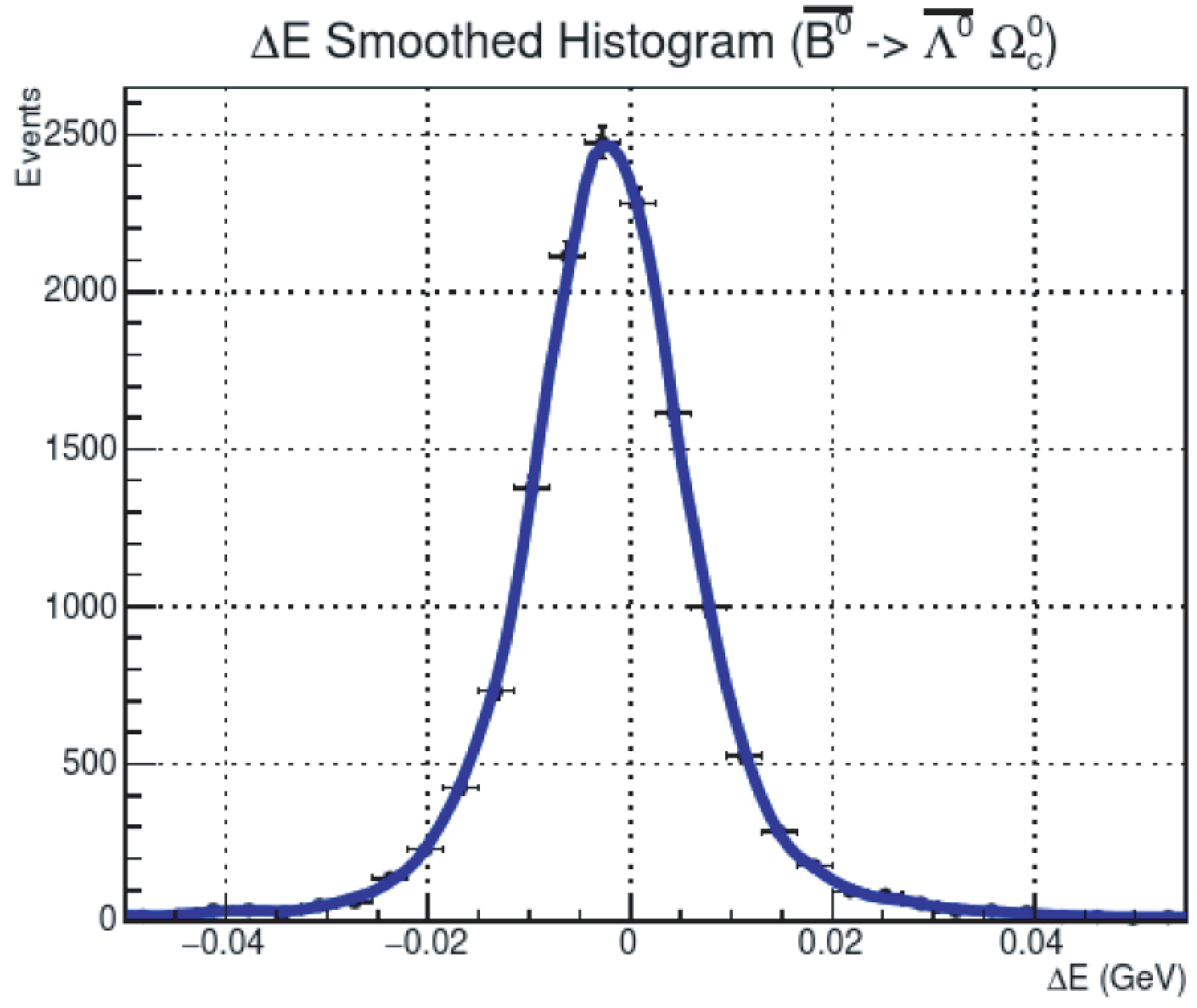




2D Smoothed Histogram for Channel $\bar{B}^0 \to \bar{\Lambda}^0\, \Omega_c^0$

Projections integrating over other variable:

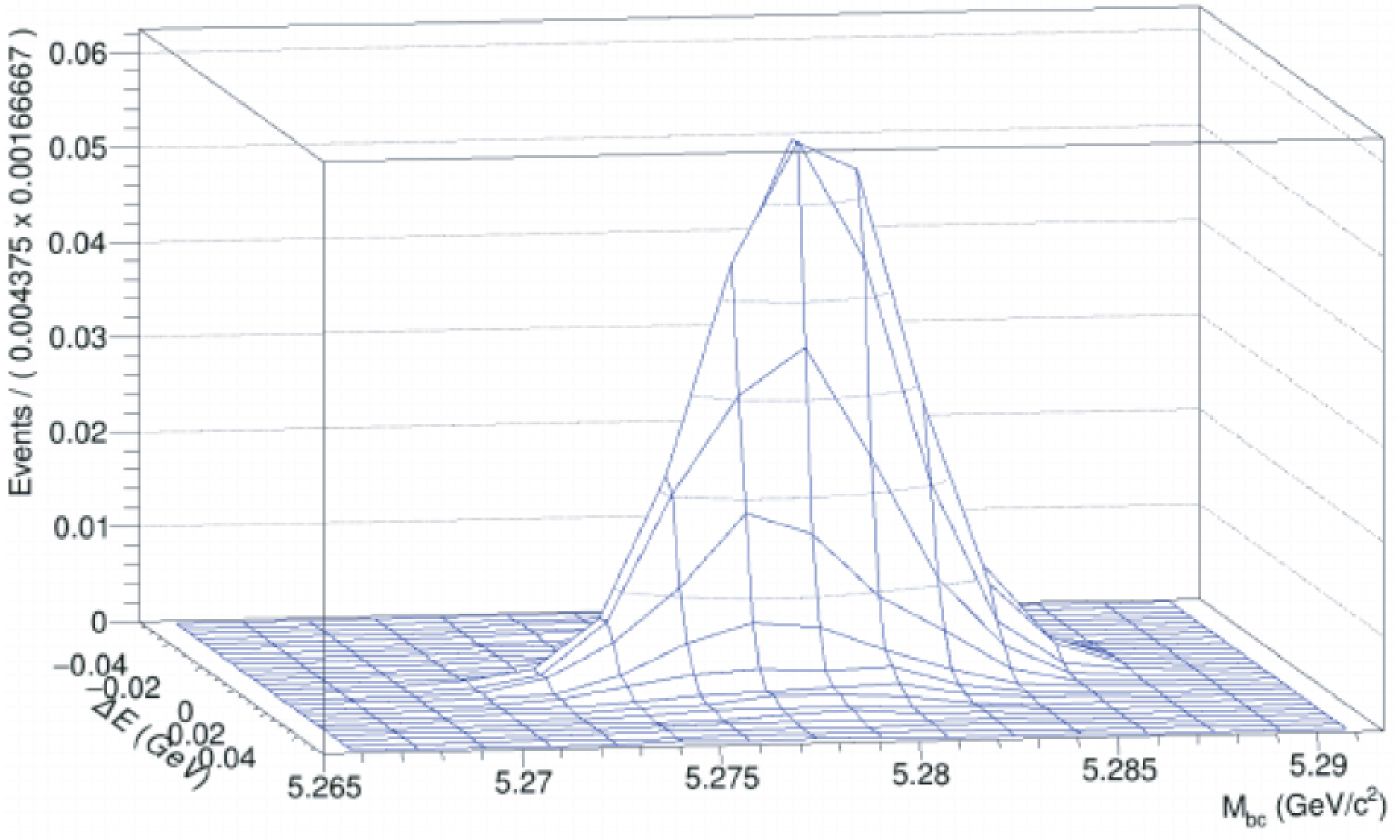


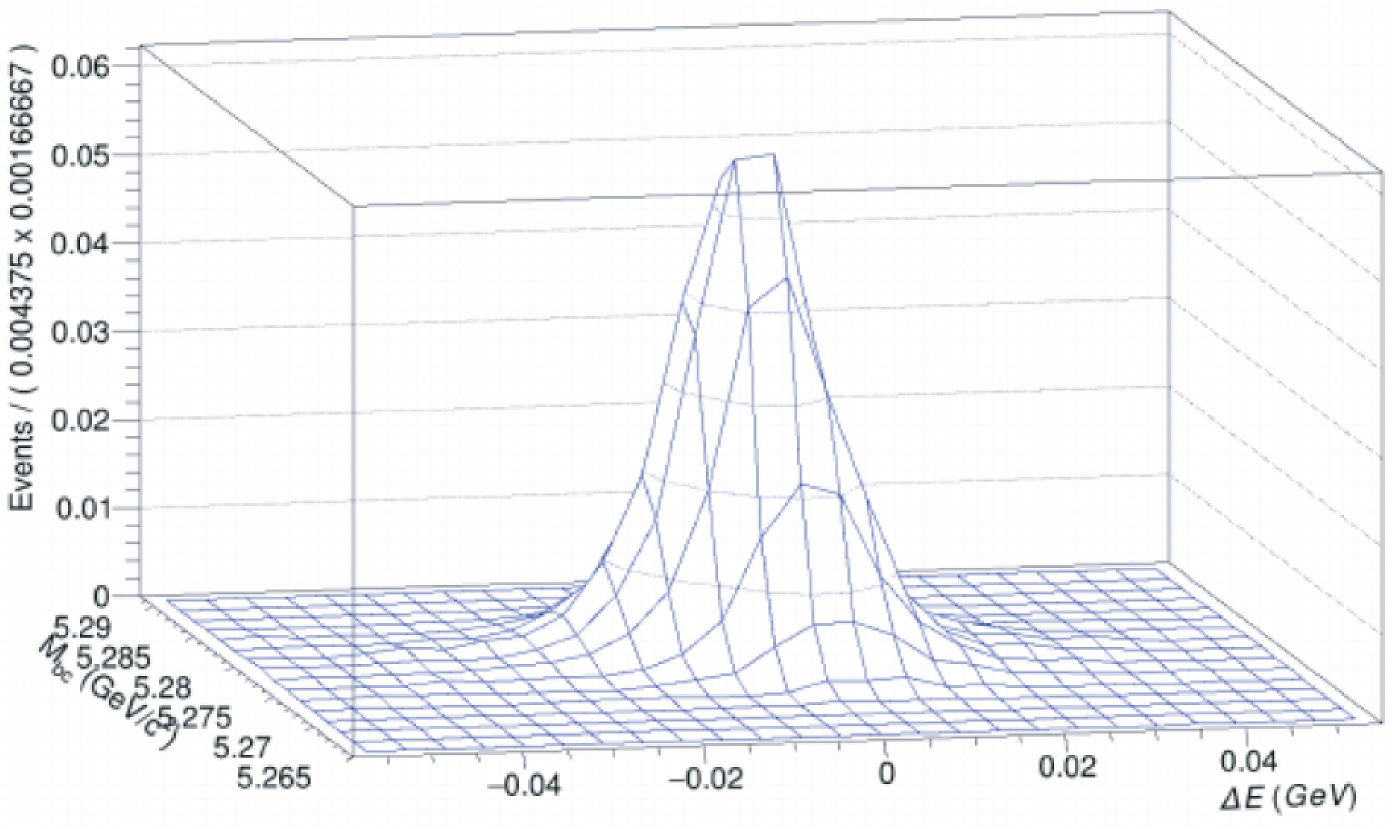


-Binning (over full ranges):

- Mbc: 60 bins
- ΔE: 160 bins

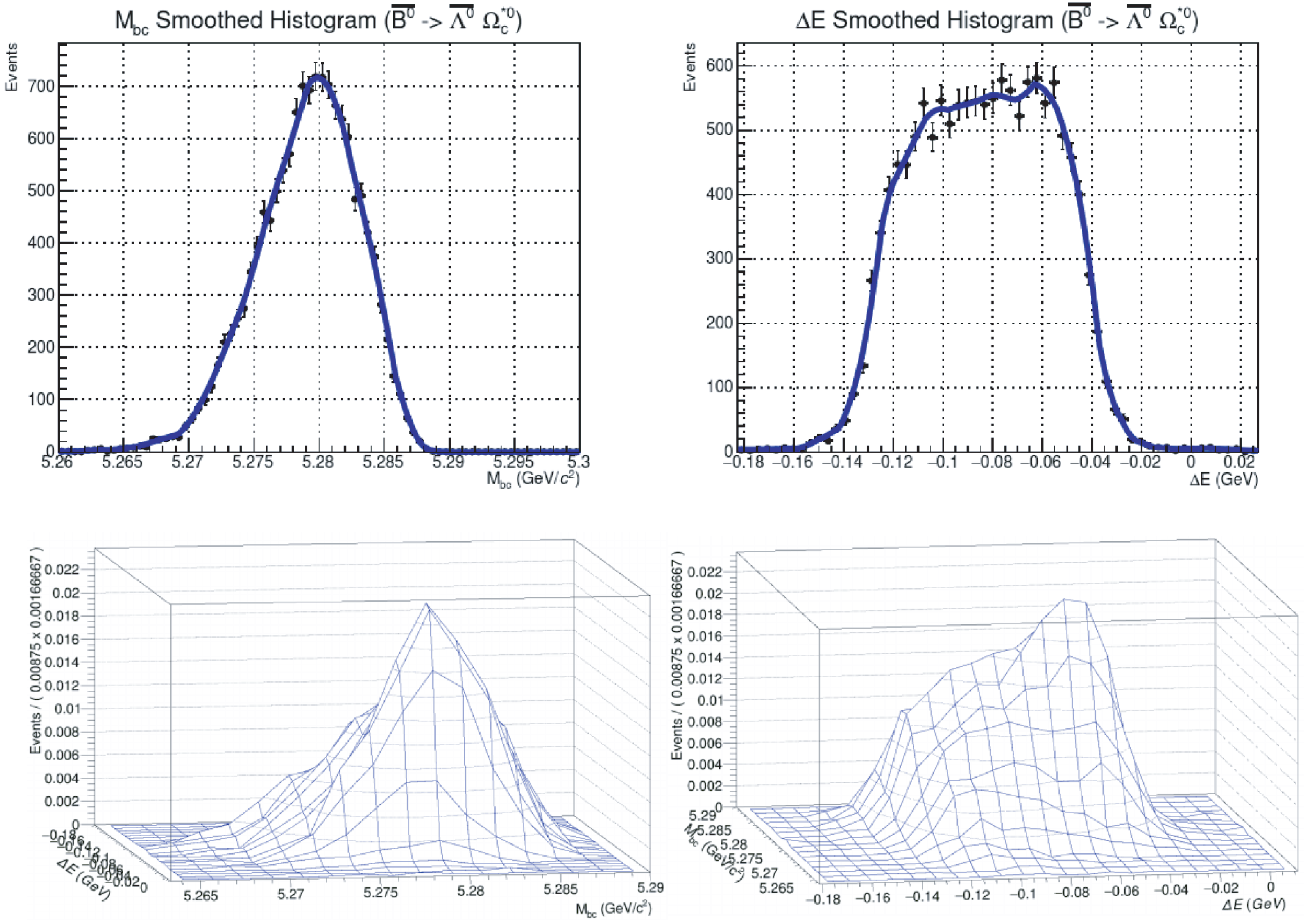
-Integration order 2





2D Smoothed Histogram for Channel $\overline{B}^0 \to \overline{\Lambda}^0 \Omega_c^{*0}$

Projections integrating over other variable:



-Binning (over full ranges):

- Mbc: 60 bins
- ΔE: 80 bins

-Integration order 2

Ensemble Test Procedure

Overview

- studies performed fitting both signals simultaneously

- fitting variables ΔE and Mbc
  (1-D fits are with respect to ΔE only)

- toy MC experiments performed 1000 times for each signal hypothesis (where we specify number of events for each channel)

- generate total number of background + signal events (both channels) selected from combined PDF describing signals and background in each toy MC experiment

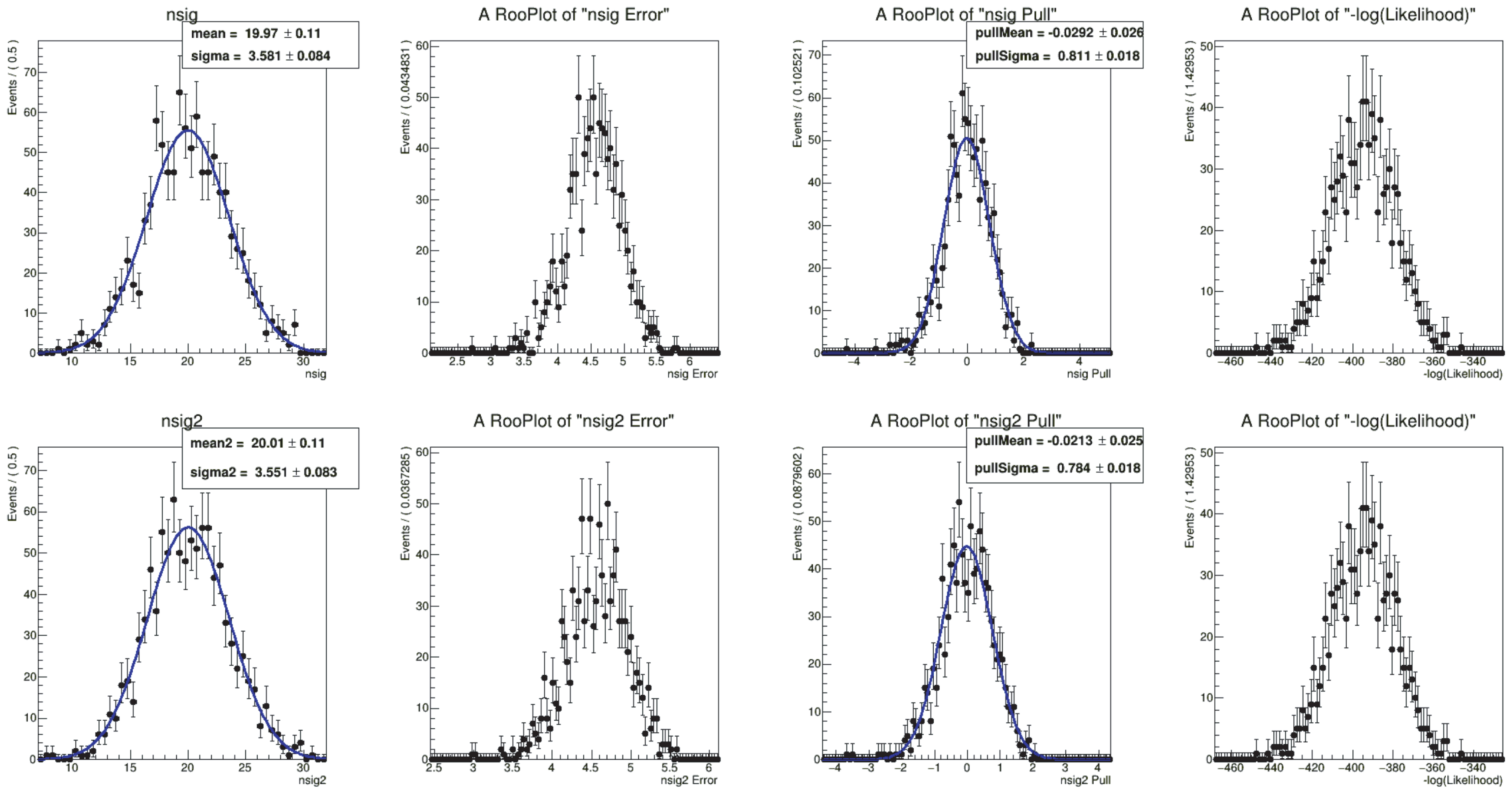
- can generate confidence belts from ensemble tests via interpolation

Approach for Data

- Peform 2D fit; if there is no presence of signal, then perform a 1D fit to ΔE to establish upper limit

Example Test

for $\bar{B}^0$ -> $\bar{\Lambda}^0$ Ω_c^0: 20
for $\bar{B}^0$ -> $\bar{\Lambda}^0$ Ω_c^{*0}: 20
for background: 8

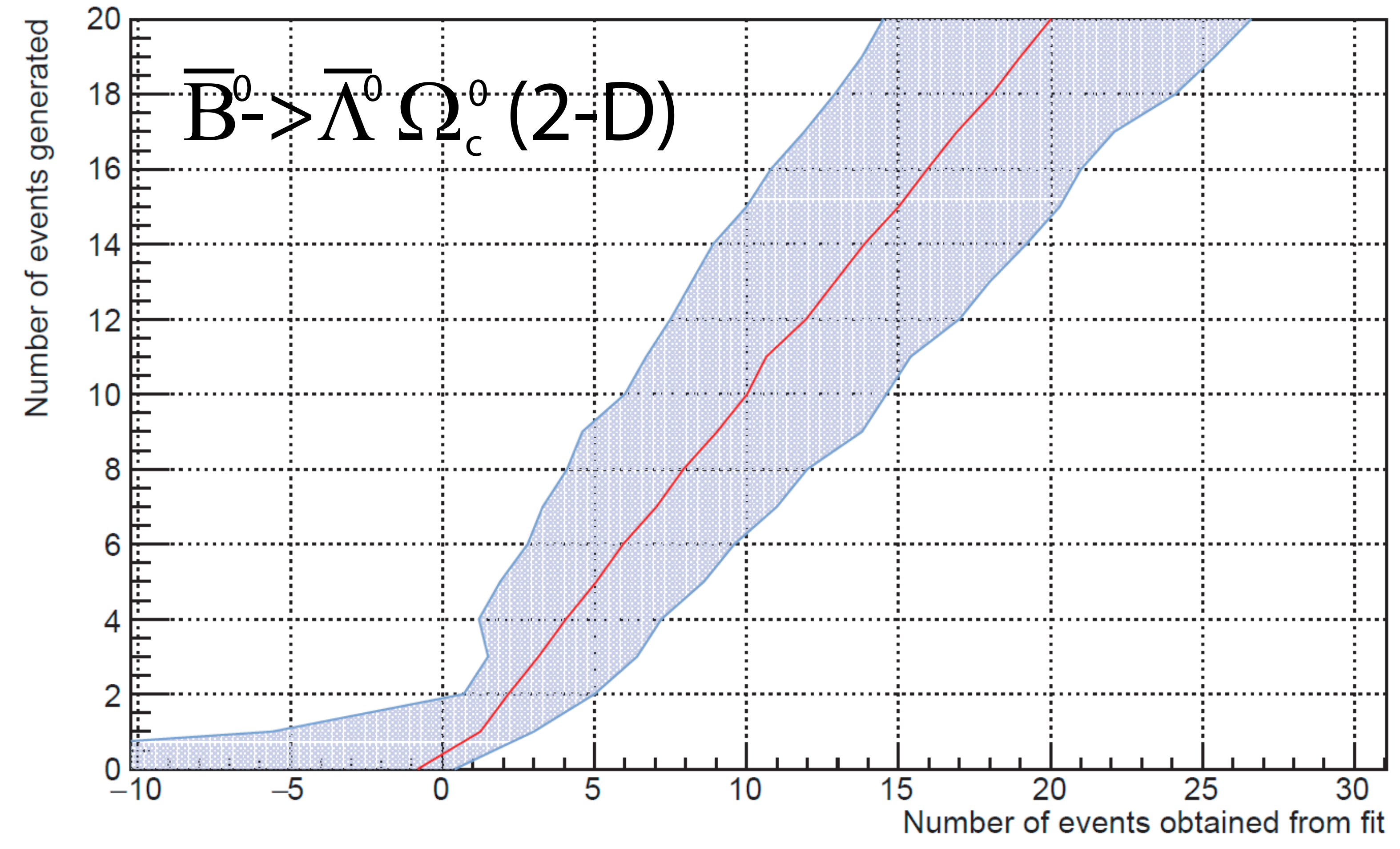


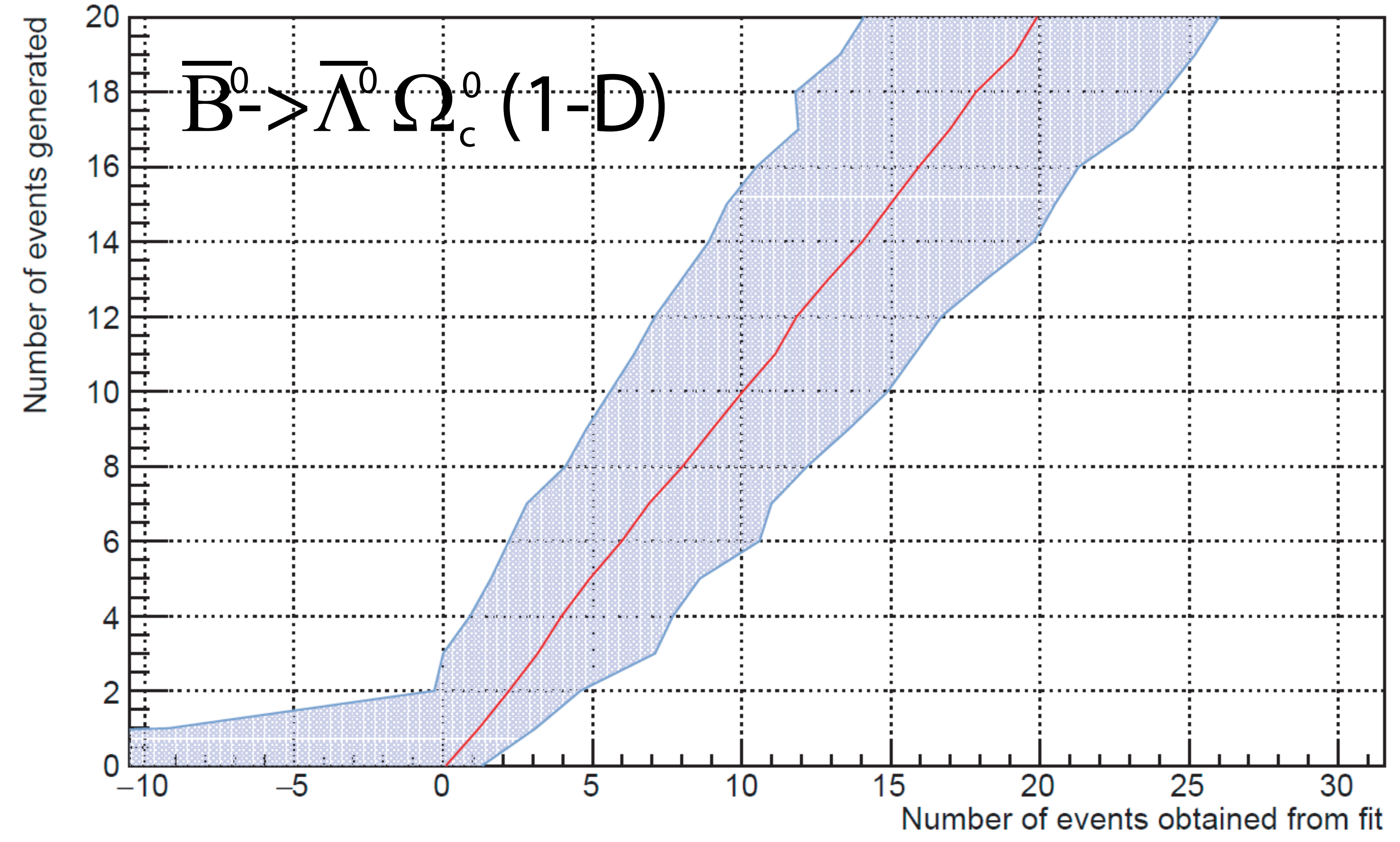
- Boundaries of confidence belts determined by ensemble tests

- 90% of MC results contained within blue region for any given hypothesis

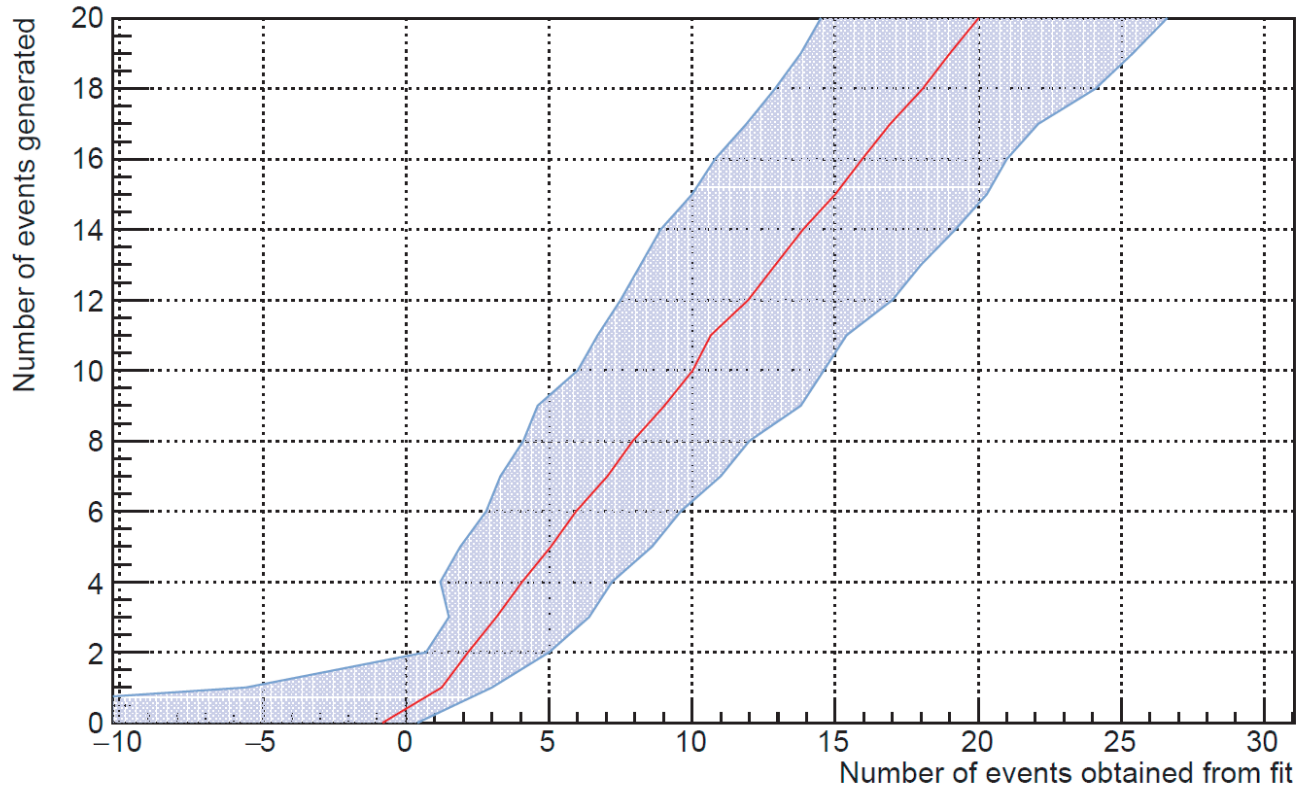
- Belts shown on right for $\overline{B}^0 \to \overline{\Lambda}^0 \Omega_c^0$ (where we integrate over various hypotheses of number of $\overline{B}^0 \to \overline{\Lambda}^0 \Omega_c^{*0}$ events)

- Can be used to estimate sensitivity of analysis





Upper Limit Calculation Example (Preliminary Estimate)



Assume we observe 5 events in data:
=> 95% upper limit is 9 by confidence belt

$$\mathcal{B}^{95}_{\mathrm{UL}}(\overline{B}^0 \to \overline{\Lambda}^0\Omega_c^{(*)0}) = \frac{9}{N_{B\bar{B}} \times \epsilon \times \rho \times \mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+) \times \mathcal{B}(\Omega^- \to \Lambda^0 K^-) \times \mathcal{B}(\Lambda^0 \to p\pi^-)^2}$$

where

- $N_{B\bar{B}}$ is the number of $B\overline{B}$ pairs,
- ϵ is our reconstruction efficiency for this channel,
- ρ is our PID correction to efficiency
- $\mathcal{B}(\Omega_c^0 \to \Omega^-\pi^+)$ is our estimate of the branching fraction for $\Omega_c^0 \to \Omega^-\pi^+$,
- $\mathcal{B}(\Omega^- \to \Lambda^0 K^-)$ is the branching fraction for $\Omega^- \to \Lambda^0 K^-$,
- $\mathcal{B}(\Lambda^0 \to p\pi^-)$ is the branching fraction for $\Lambda^0 \to p\pi^-$ (hence squared because the decay has two Λ^0 candidates).

$$\mathcal{B}^{95}_{\mathrm{UL}}(\overline{B}^0 \to \overline{\Lambda}^0\Omega_c^{(*)0}) = \frac{9}{(772 \times 10^6) \times 0.108 \times 0.9828 \times 0.0143 \times 0.678 \times 0.639^2} = \underline{2.8 \times 10^{-5}}$$

Outlook

Me thinking about systematics

Recap: searching for decays of $\overline{B}^0$->$\overline{\Lambda}^0\,\Omega_c^0$ and $\overline{B}^0$->$\overline{\Lambda}^0\,\Omega_c^{*0}$ in Belle data by reconstructing a final state containing 3 pions, 2 protons, and 1 kaon. The analysis is 'blind' and selection criteria are optimized via MC samples.

Continuing discussions with internal review committee and hope to unblind 10% of data and apply aforementioned methods soon

Upon unblinding, we hope to claim a discovery (and search for baryon oscillations); will otherwise report upper limit on decay rate

Will perform detailed studies of systematic uncertainties to understand how they impact our results

Acknowledgements