Checks on $Br(J/\psi \to K_S K_L)$

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2. Efficiency in SIMBES & Sober
3. Efficiency in SIMBES & Data
4. Summary

Existing status of $Br(J/\psi \to K_S K_L)$

	$Br(J/\psi \to K_S K_L)\times 10^4$	author	Ratio BES/PDG
	$1.86 \pm 0.04 \pm 0.14$	Yuan C.Z.	
	$1.75 \pm 0.04 \pm 0.16$	Wang Z.	
	$1.01 \pm 0.12 \pm 0.18$	Mark3	
	$1.18 \pm 0.12 \pm 0.18$	DM2	
	1.08 ± 0.14	averaged	

Without trigger efficiency correction,

Ratio of BESII/PDG = 134%.

Existing status of $Br(J/\psi \to K_S K_L)$

$$Br(J/\psi \to K_S K_L) = \frac{N_{obs}}{N_{J/\psi} \times \varepsilon \times f_{TRG}}$$

Assuming following quantities are correctly measured.

1. $N_{J/\psi}$ = total number of J/ψ events by counting 4 prong events

   see : Fang S.S. et.al., HEP&NP, 2003,27(4):277-281.

2. N_{obs} = number of signal events

   low background level;

   checked w/o Ks fit or 1c-fit by Yuan Changzheng

3. f_{TRG} = correction of trigger efficiency

   given by Yuan Changzheng and checked by Wang Zhe

We pay our attention on efficiency ε calculated by SIMBES (v10402).

Relative difference of detection efficiency for $J/\psi \to K_S K_L$

Relative Efficiency	(SIMBES-Sober)/Sober %			
	HI + $\pi^+ \to \mu^+$ +MS+PR	$\pi^+ \to \mu^+$ +MS+PR	MS+PR	PR
$N_{chrg} = 2 \,\&\, \sum Q_i = 0$ $\& M_{FIT} = 2,-19$	7.4	6.2	5.2	5.4
$0.4 < M_{\pi^+\pi^-} < 0.6 GeV$	13.4	10.6	9.7	9.9
K_s^0 reconstruction	19.2	16.3	14.8	14.7
$L_{xy} < 0.7 cm$	18.6	16.5	15.1	14.4
$K_L cone外, N_\gamma = 0$ $K_L cone内, E_{BSC} \le 1 GeV$	23.4	16.6	15.2	14.4

Note : HI=Hadronic Interaction 6.8%

$\pi^+ \to \mu^+$ 1.4%

MS=Multi-Scattering 0.8%

PR =MDC Position Resolution 14.4%

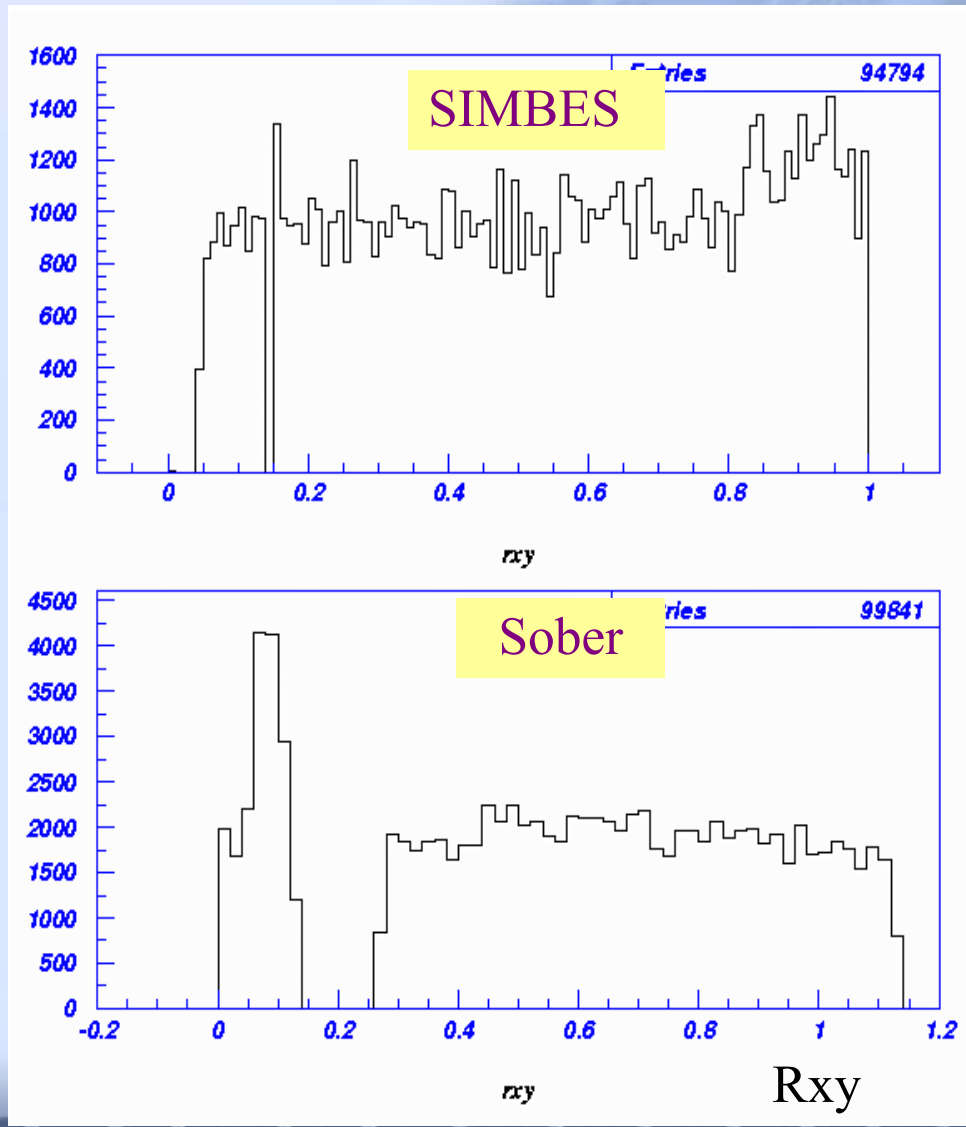
Detection efficiency in SIMBES & Sober

Distance Rxy between origin and $\pi^+ \to \mu^+ \nu$ decay point for $p_\mu = 250 MeV$

- Bug in Sober below Rxy<0.3m
- enhance in SIMBES above Rxy>0.8m needs to be checked

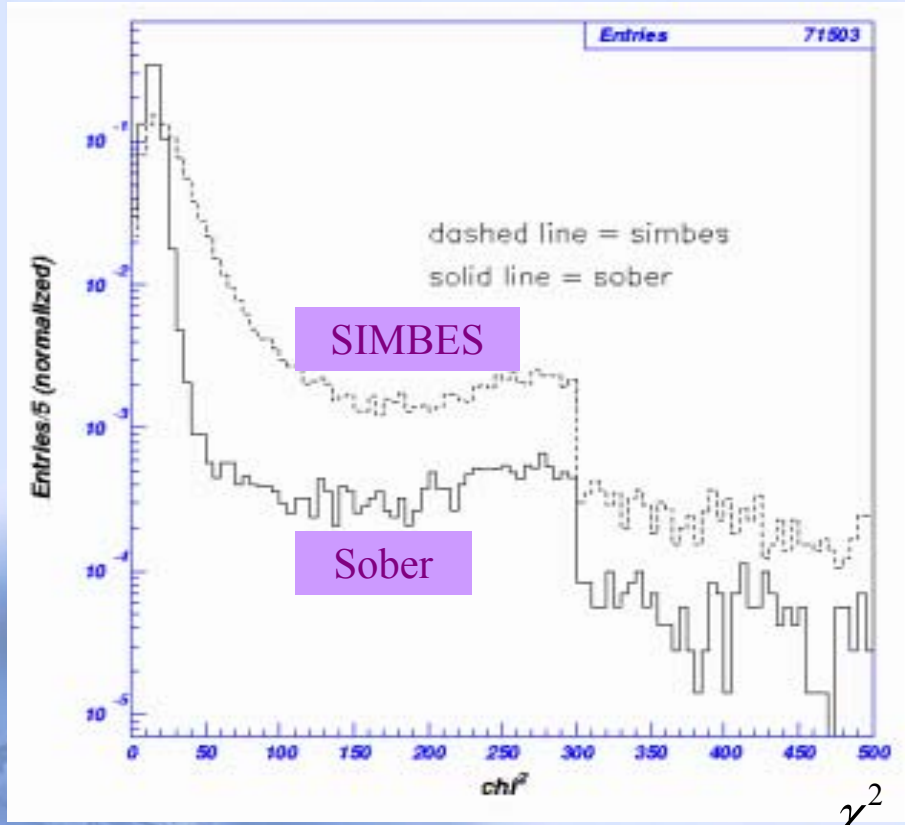
Decay rate in Rxy=(0.3,1.0)m

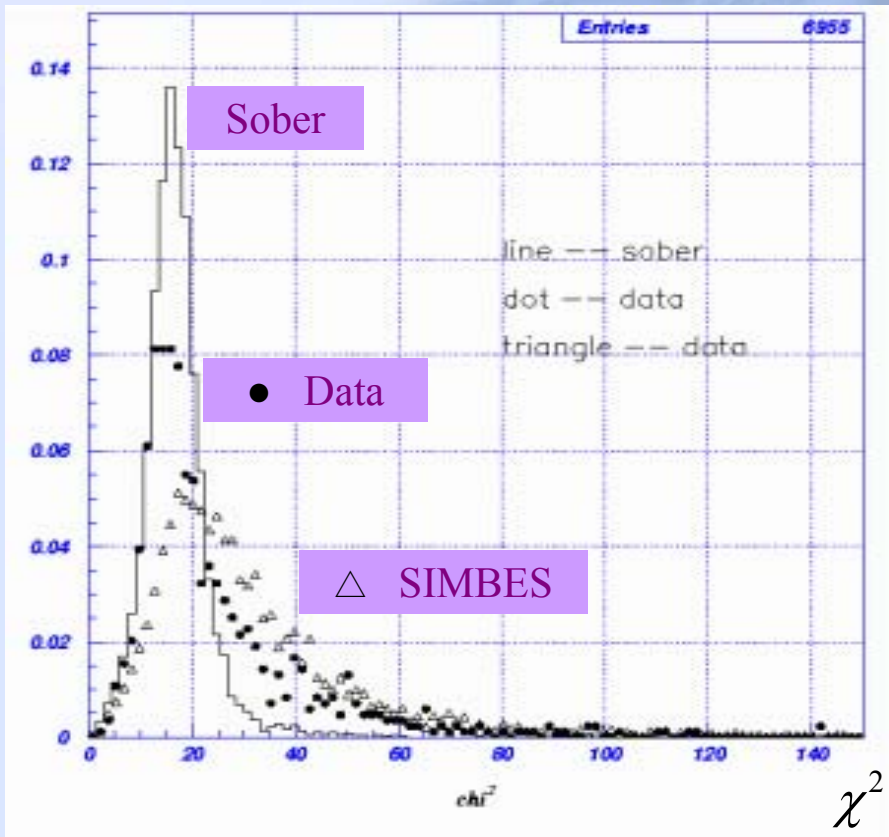
type	$N_{\pi^+ \to \mu^+ \nu} / N_{\pi^+}$ %
SIMBES	7.9
Sober	6.9
SIMBES – Sober	1.0



Detection efficiency in SIMBES & Sober

MC study with $J/\psi \to K_S K_L$

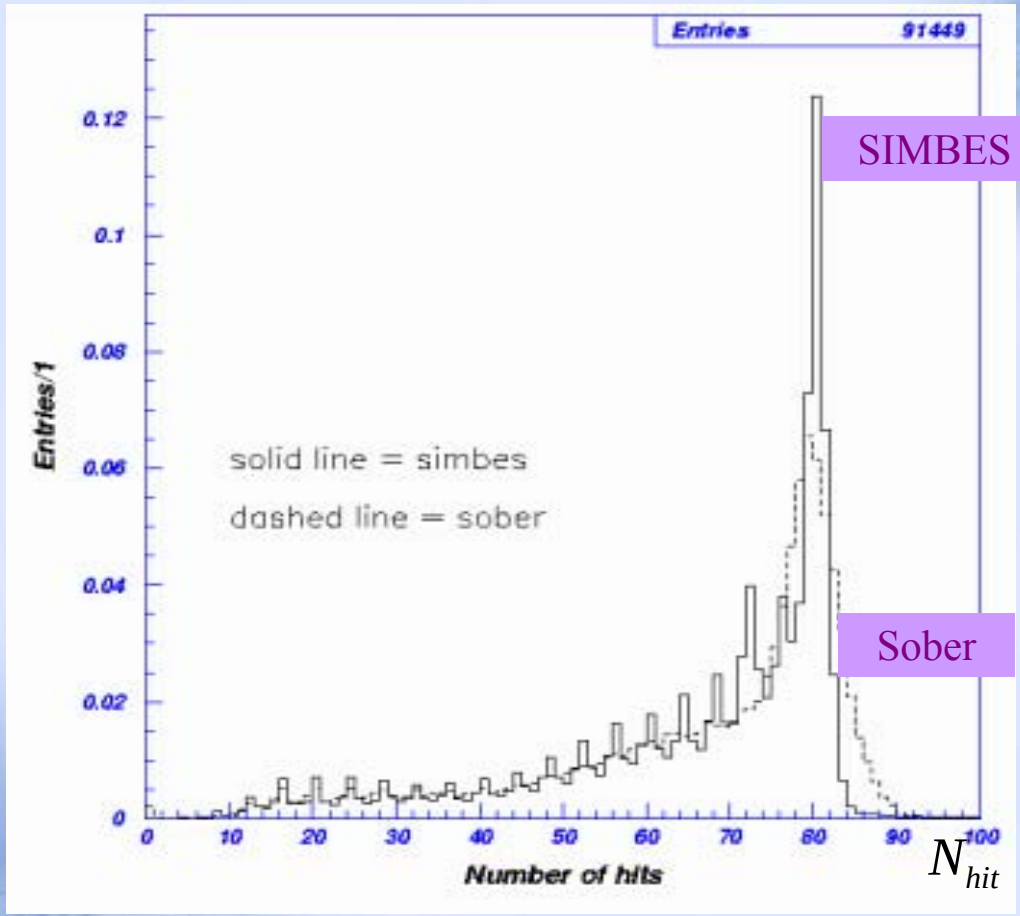




- SIMBES with HOWL generator
  - HI, $\pi^+ \to \mu^+ \nu$ and MS removed
  - χ^2 from Helix fit wider than Sober

Detection efficiency in SIMBES & Sober

MC study with $J/\psi \to K_S K_L$



- Peak structure in N_{hit} for raw data (caused by 100% efficiency in SIMBES?)

Detection efficiency in SIMBES & Sober

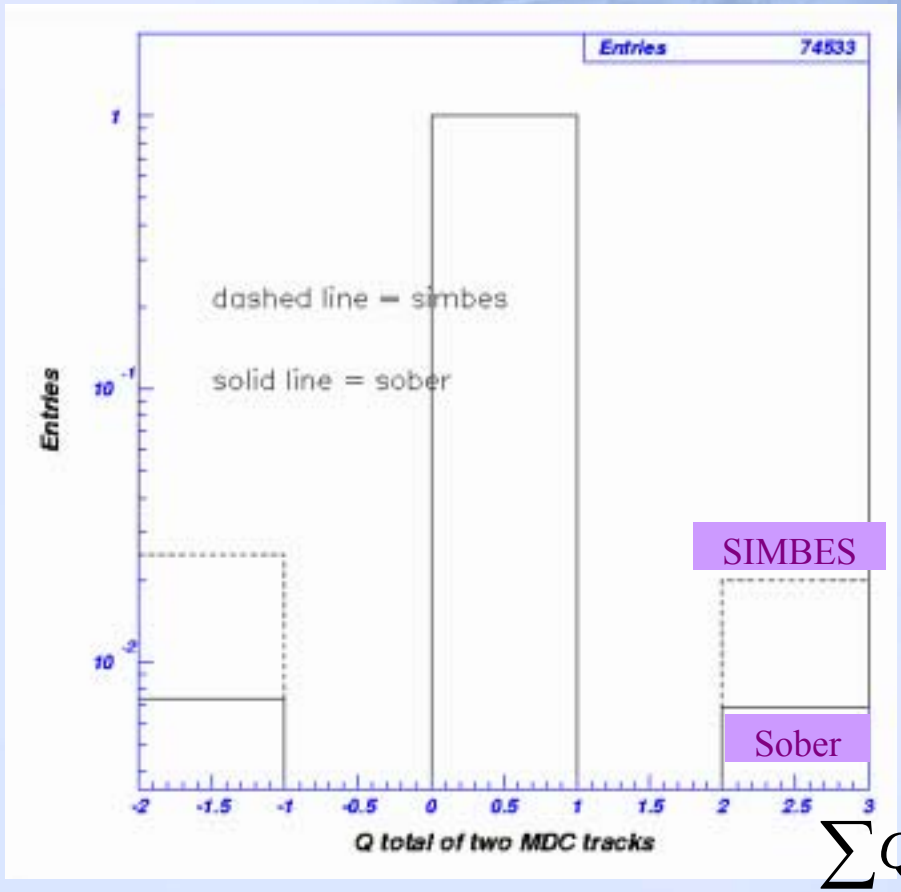
MC study with $J/\psi \to K_S K_L$

Rate of WS charge for pion in SIMBES

- HI, $\pi^+ \to \mu^+ \nu$ and MS removed
- Normalized by entries in bin $\sum Q_i = 0$
- Rate of WS per track : 2.1% in SIMBES
  0.7% in Sober

only contributed by PR

$N_{\pi^\pm,tot}$	73353x2
$N_{\pi^\pm,RS}$	70216x2
$N_{\pi^\pm,WS}$	3137
$Rate_{\pi^\pm,WS}$	$(2.14 \pm 0.04)\%$



Detection efficiency in SIMBES & Sober

MC study with single muon or charged pion

type	Momenta GeV	$Rate_{WS}$ %	Note
μ^+	1.0	0.6	without MS
π^+	0.5	0.7	without HI, $\pi^+ \to \mu^+\nu$ with MS
	1.0	0.5	without HI, $\pi^+ \to \mu^+\nu$ & MS
	1.0	0.6	without HI,$\pi^+ \to \mu^+\nu$ with MS

- SIMBES :10K events per MC sample
- ❖ Rate of WS muon or pion for single track event
  1) comparable with Sober
  2) has weak dependence on momenta and MS
- ❖ Rate of WS charge per track is 0.6%

- ❖ Rate of WS from $J/\psi \to K_S K_L$ is much higher (2.1%)
- ❖ $\theta_{\pi+\pi-} = (20^0, 40^0)$
- ❖ It seems the rate depends on its opening angle to closest track or decay length of Ks(?)

Detection efficiency in SIMBES & Data

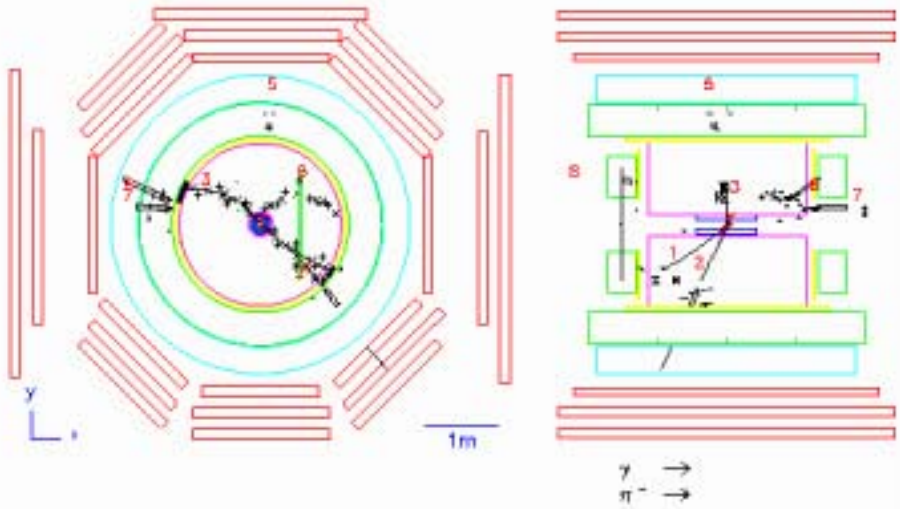
$J/\psi \rightarrow anything$

- 4 to 6 prong events are scaned
  - ❖ Full hit-like track
  - ❖ good MDC hits but no track reconstructed

BES Ver. 10.3 Run: −300, Record: 127, Energy: 3.097

Trk	ID	Mfit	P	E	TOF Likelihood Olt	TOF Likelihood e μ π K p	dE/dx Likelihood Hits	dE/dx Likelihood e μ π K p	combined e μ π K p	combined μID	Neutrals Trk	Neutrals E	Neutrals Iso	Neutrals En
1	K^-	2	0.543	0.016	8		33			2	5	0.066	35	
2	$?^+$	2	0.810	0.268	1		17			0	6	0.797	34	
3	μ^-	2	0.125		1		23				7	0.568	46	
4	$?^+$	2	0.420		1						8	0.096	53	W

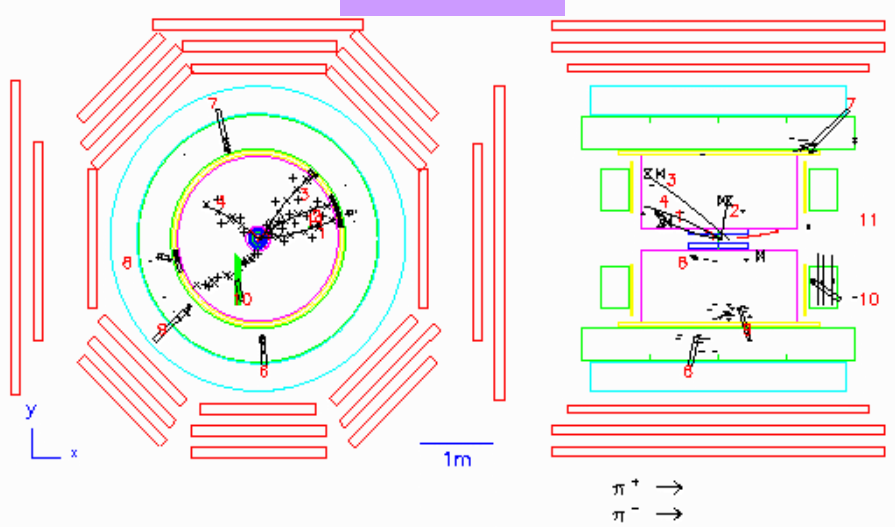
SIMBES



BES Ver. 10.3 Run: −300, Record: 281, Energy: 3.097

Trk	ID	Mfit	P	E	TOF Likelihood Olt	TOF Likelihood e μ π K p	dE/dx Likelihood Hits	dE/dx Likelihood e μ π K p	combined e μ π K p	combined μID	Neutrals Trk	Neutrals E	Neutrals Iso	Neutrals En
1	μ^-	2	0.529	0.072	1		30			2	6	0.375	92	
2	μ^+	2	0.306		1		31				7	0.768	49	
3	$?^+$	2	0.408		1		34				8	0.163	46	
4	μ^-	2	0.375		3		27				9	0.656	80	
5	$?^-$	2	0.224								10	0.473	27	E
											11	0.030	27	E

SIMBES



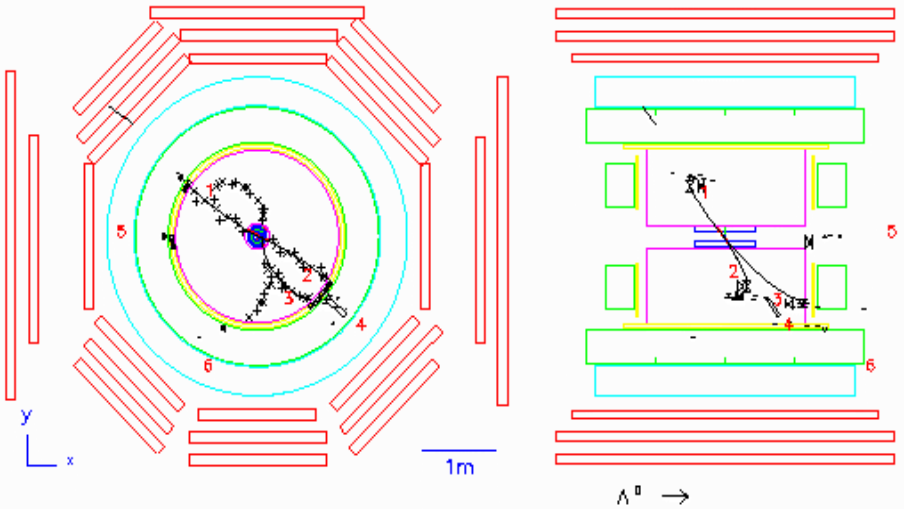
Detection efficiency in SIMBES & Data

$J/\psi \rightarrow anything$

BES Ver. 10.3 Run: −300, Record: 402, Energy: 3.097

Trk	ID	Mfit	P	E	TOF Likelihood Olt	TOF e μ π K p	dE/dx Likelihood Hits	dE/dx e μ π K p	combined e μ π K p	μID	Neutrals Trk	E	Iso	En
1	P+	2	0.672	0.054	1	____□	30	____□	____□	0	4	0.342	13	
2	P+	2	0.496		1	____□	33	____□	____□		5	0.045	79	
3	e−	2	0.158		1	□____	25	□□___	□____		6	0.048	47	

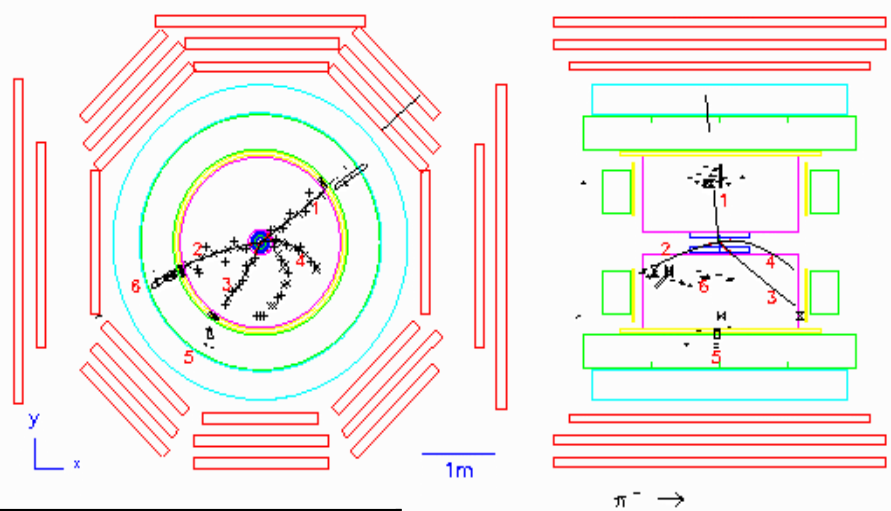
SIMBES



BES Ver. 10.3 Run: −300, Record: 556, Energy: 3.097

Trk	ID	Mfit	P	E	TOF Likelihood Olt	TOF e μ π K p	dE/dx Likelihood Hits	dE/dx e μ π K p	combined e μ π K p	μID	Neutrals Trk	E	Iso	En
1	μ−	2	1.133	0.509	1	□□□___	33	□□□□_	□□□__	0	5	0.127	49	
2	π−	2	0.671	0.403	1	□□□___	33	□□□□_	□□□__	2	6	0.120	32	
3	π+	2	0.596		1	___□___	30	□□□__	___□__	2				
4	μ+	2	0.134		3	□□□□□	21	□□□___	□□□___					

SIMBES



Number of events scaned		N_{track}	$N_{missing-track}$
4-prong	105	695	4
5-prong	43		
6-prong	10		

Detection efficiency in SIMBES & Data

$J/\psi \rightarrow anything$

- missing track rate = 0.58% in SIMBES v10402
- missing event rate = 2.5% (4-6 prong)
- The rate is zero in data (632 tracks/140 4-6 prong events from run16117).
- Similar rate for SIMBES v1040e
- Sober : missing track rate = 0.13%

  missing event rate = 0.52% (4 prong, $J/\psi \rightarrow \overline{K}^{*0} K_S$)

Detection efficiency in SIMBES & Data

$$J/\psi \to \overline{K}^{*0}(892)K_S$$

- Select $K^{\mp}\pi^{\pm}\pi^{\pm}$ as tagging side
  - $N_{chrg} = 3,4$ with MFIT=2,-19 and good TOF quality
  - $R_{xy} \le 2\,cm$, $Z_V \le 20\,cm$
  - $K^{\mp}\pi^{\pm}\pi^{\pm}$ with PID
  - $0.4 \le \cos\theta_{K^{\mp}\pi^{\pm}} \le 0.72$, $0.88 \le M_{K^{\mp}\pi^{\pm}} \le 0.92\,GeV$
  - $M_{K^{\mp}\to\pi^{\mp},\pi^{\pm}} > 0.6\,GeV$ to reduce contamination from K_s^0
  - Recoiling mass squired of $K^{\mp}\pi^{\pm}\pi^{\pm}$ within (-0.05,0.05) GeV
  - $\theta_{K^{\mp}(K^{*0})\pi^{\pm}(non-K^{*0})} > 135^0$, $\theta_{\pi^{\mp}(K^{*0})\pi^{\pm}(non-K^{*0})} > 120^0$
  - $1.35 \le p_{K^{*0}} \le 1.4\,GeV$
  - $|\cos\theta_{K^{\mp},\pi^{\pm},\pi^{\pm}}| \le 0.75$, $|\cos\theta_{mis\ sing-\pi^{\mp}}| \le 0.7$
- Look at recoiling pion of $\overline{K}^{*0}(892)\pi^{\pm}$

Detection efficiency in SIMBES & Data

Ks detection Efficiency from $J/\psi \to \overline{K}^{*0}(892)K_S$

Note : **hadronic interaction included** in SIMBES

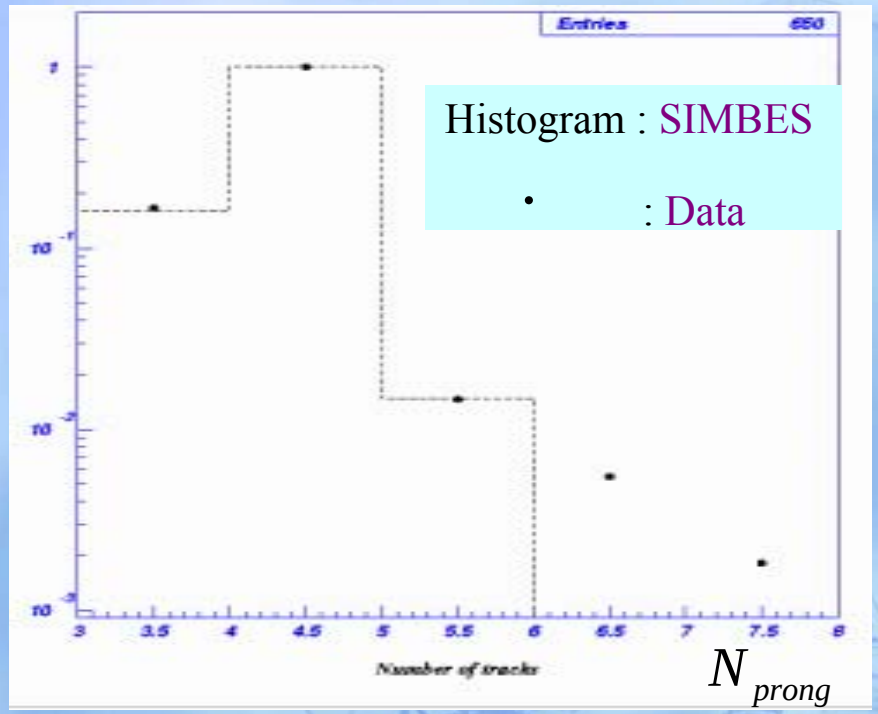
# of events	Data	SIMBES
$N_{prong} \geq 3$	650	1033
$N_{prong} = 3,4$	638	1020
$N_{prong} = 4$	547	879
$\sum Q_i = 0$ $M_{EIT} = 2,-19$	538	861
$0.4 < M_{\pi^+\pi^-} < 0.6 GeV$	477	823
K_s^0 reconstruction	366	720

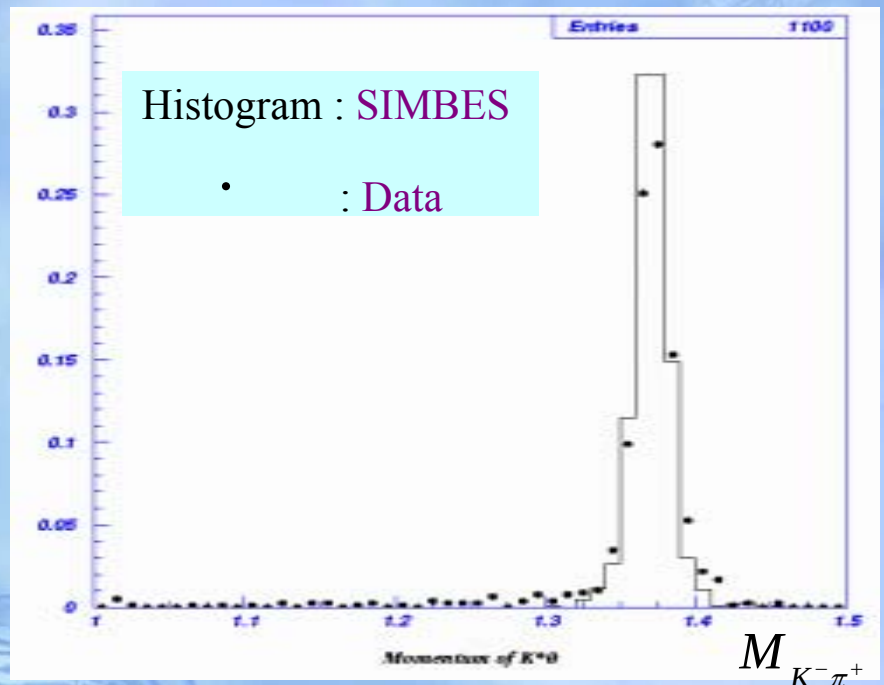
efficiency	Data %	SIMBES %	$SIMBES/Data$ %
$N_{chrg} = 2 \,\&\, \sum Q_i = 0$ $M_{EIT} = 2,-19$	84.3	84.4	1.00
$0.4 < M_{\pi^+\pi^-} < 0.6 GeV$	74.8	80.7	1.08
K_s^0 reconstruction	57.4	70.6	1.23

- Ks detection efficiency in Data is not reasonable due to background contamination
- Rate of WS charge per track 2.0% in SIMBES is resoanable, but 1.6% in Data is suspicious

Detection efficiency in SIMBES & Data

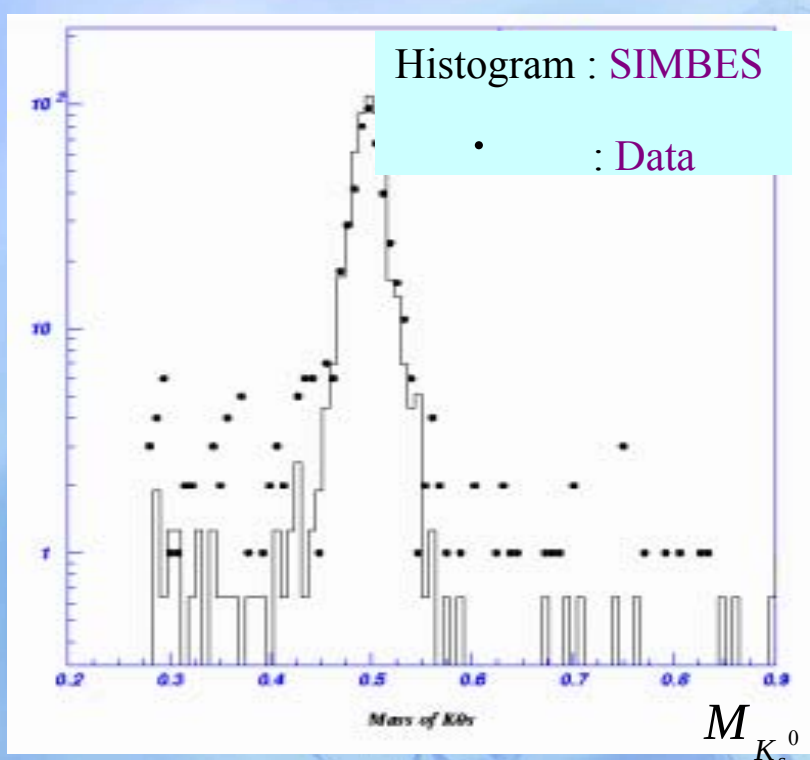
Ks detection Efficiency from $J/\psi \to \overline{K}^{*0}(892)K_S$

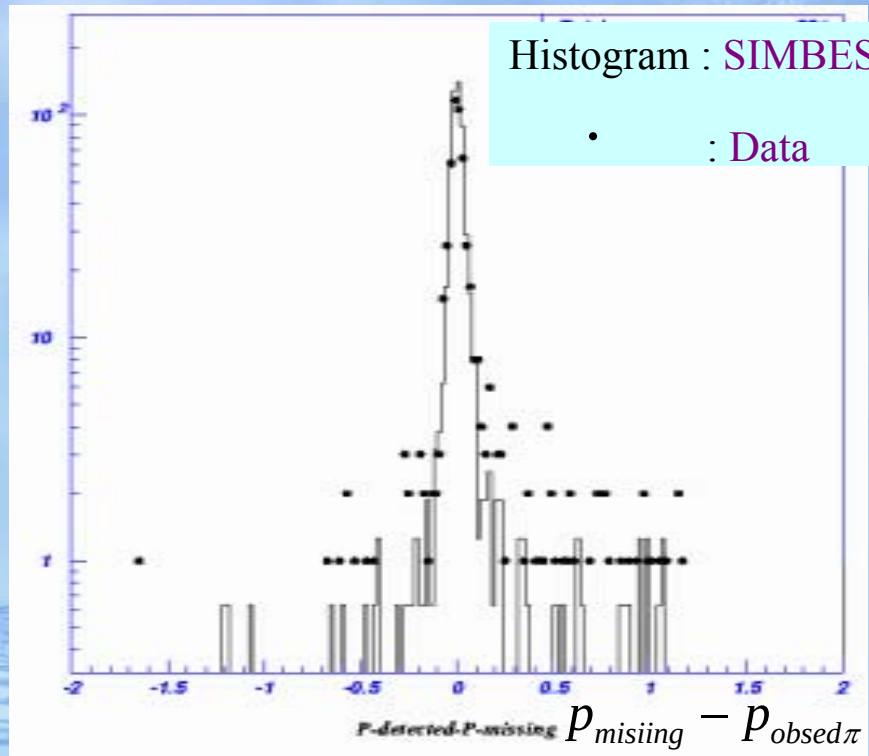




Detection efficiency in SIMBES & Data

Ks detection Efficiency from $J/\psi \to \overline{K}^{*0}(892)K_S$





- 3-4 prong sample of $J/\psi \to \overline{K}^{*0}(892)K_S$
  - ❖ Background contamination in Data
  - ❖ clean in MC

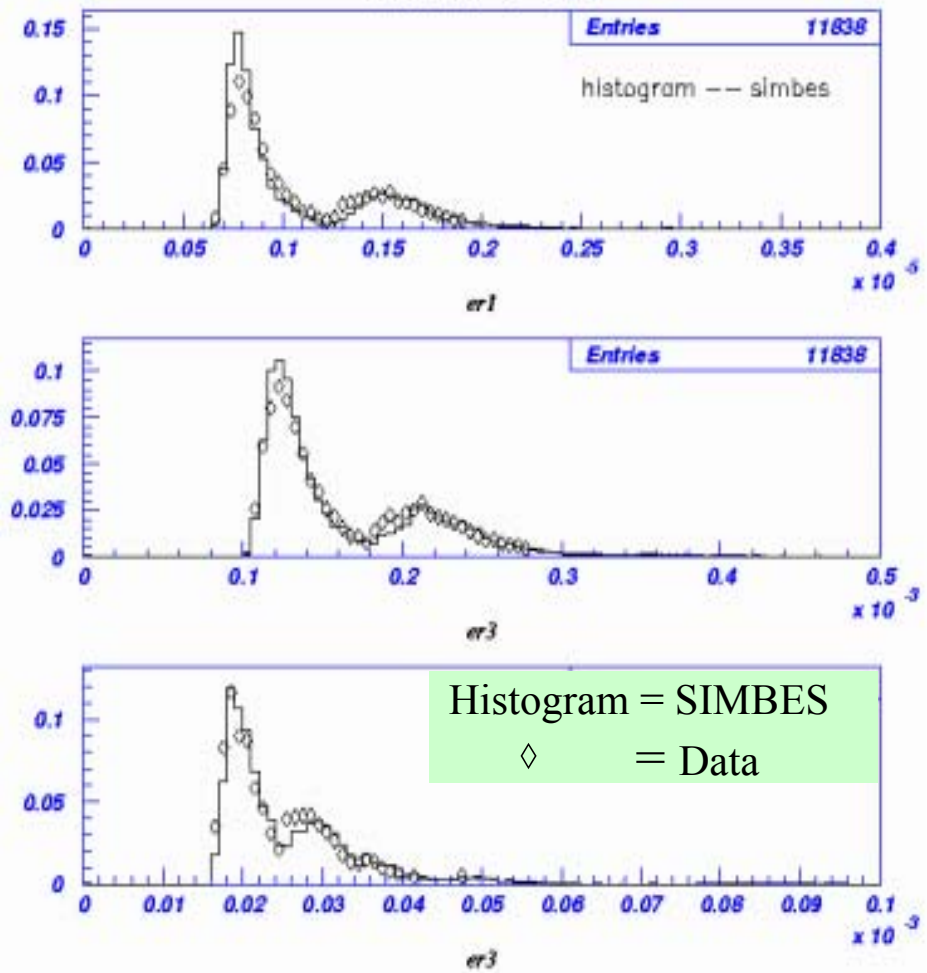
Detection efficiency in SIMBES & Data

- Select $\mu^+\mu^-$ with two muons
  - $N_{chrg} = 2$ with no MFIT requirement
  - $p_\mu \leq 2\,GeV$
  - $\sum Q_i = 0$
  - Number of hits in muon counter $N_{hit} = 6$
  - $|TOF\ (\mu^+) - TOF\ (\mu^-)| \leq 0.3\,ns$
  - $\sum E_i(BSC) \leq 450\ MeV$
  - $R_{xy} \leq 1\,cm$

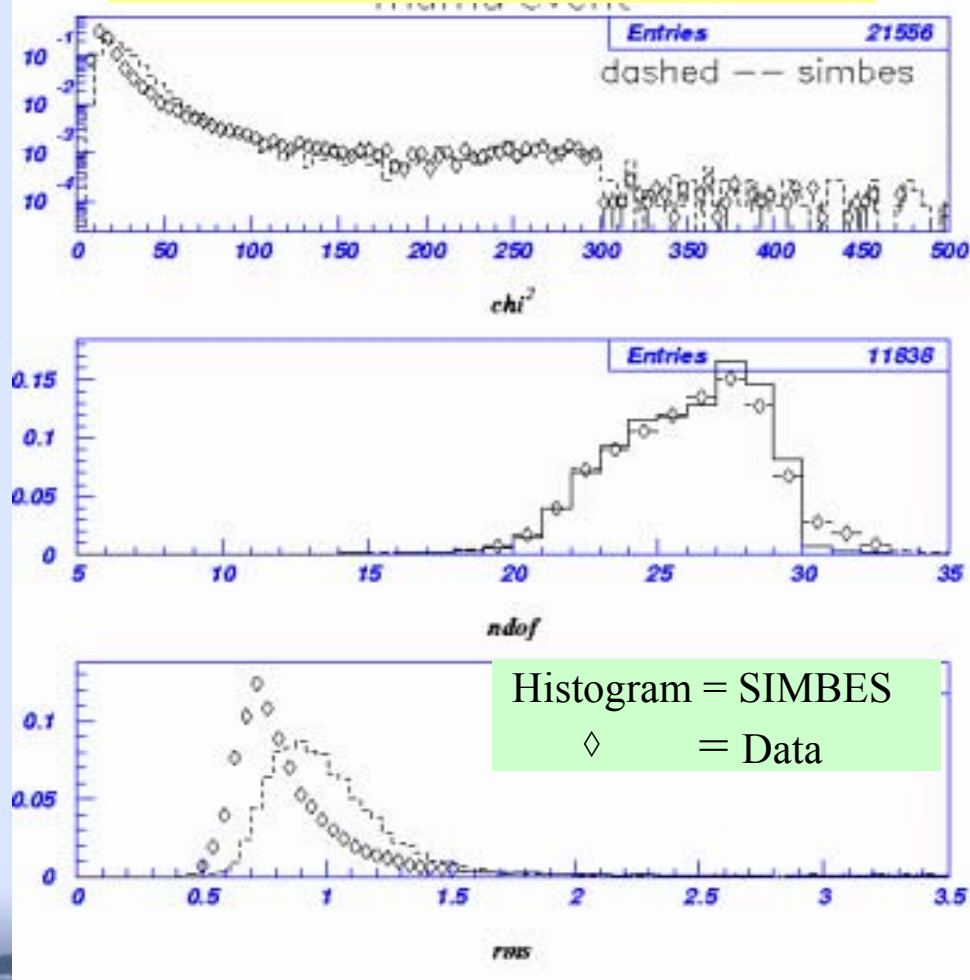
Detection efficiency in SIMBES & Data

$\mu\mu$ pair events

Error of $\varphi, 1/P_{xy}, tg\lambda$



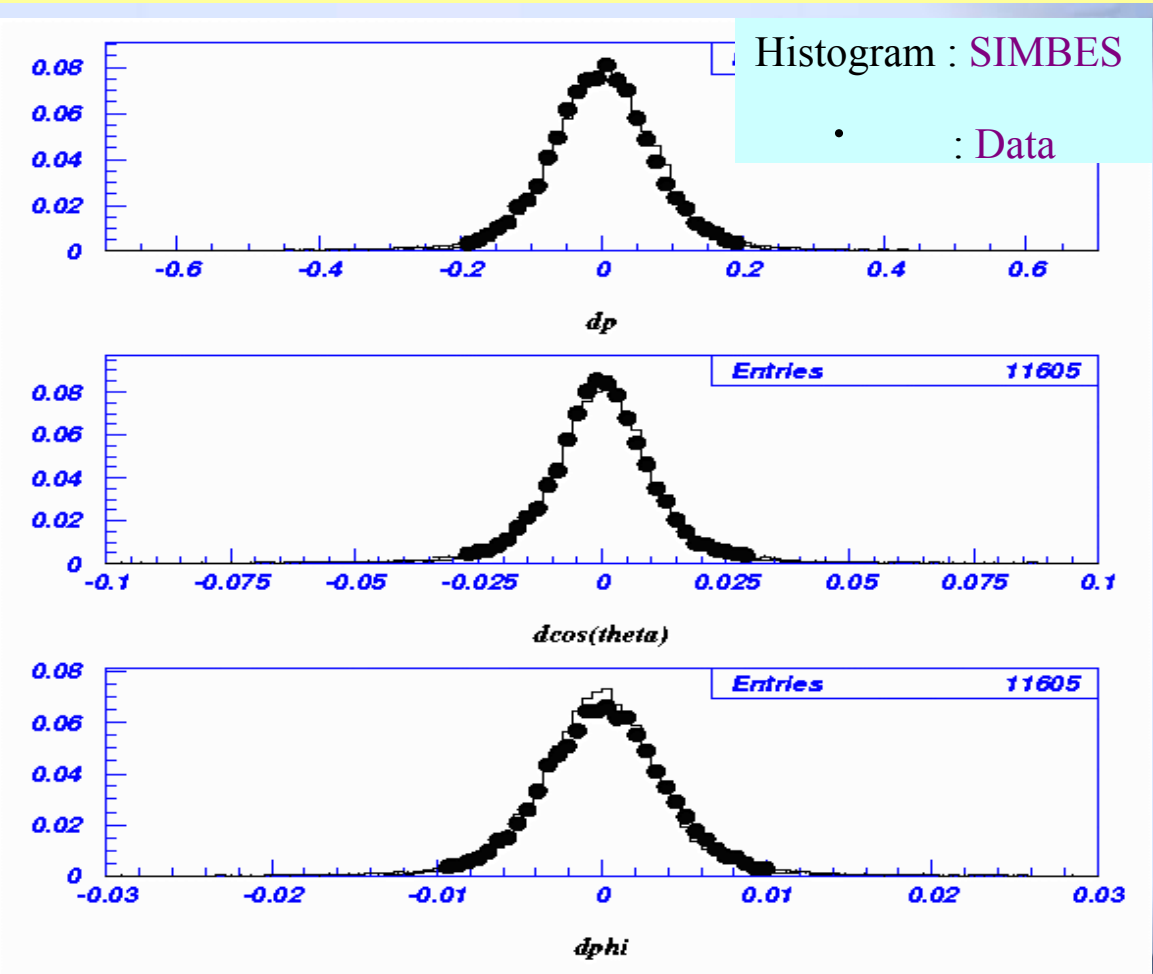
χ^2, N_{hit}, rms from helix fit



Detection efficiency in SIMBES & Data

$\mu\mu$ pair events

Difference of $p, \cos\theta, \varphi$ between μ^+ and μ^-



Detection efficiency in SIMBES & Data

- Select $\mu^+\mu^-$ with single tagging $\mu^{\pm}$
  - $R_{xy} \le 1cm\ ,\ Z_V < 10\ cm$
  - $Mfit = 2, -19$
  - $1.4 \le p_\mu \le 1.7\ GeV$
  - $150 \le E_\mu(BSC) \le 250\ MeV$
  - $300 \le E_{tot}(BSC) \le 500\ MeV$
  - $0.1 \le E_\mu / p_\mu \le 0.2$
  - good TOF quality
  - Number of matched hits in μ counter $N_{hit} = 3$
- Look at recoiling $\mu^{\mp}$
  - $Mfit = 2, -19$
  - $1 \le p_\mu \le 2\ GeV$
  - $\sum Q_i = 0$

Detection efficiency in SIMBES & Data

$\mu\mu$ pair events

Number of tagging μ

Tag	μ^+	μ^-
Data	21752	21988
SIMBES	11877	12038
Sober	18119	17810

Number of recoiling μ

Recoil	μ^+	μ^-
Data	20152	20127
SIMBES	11264	11294
Sober	18074	17751

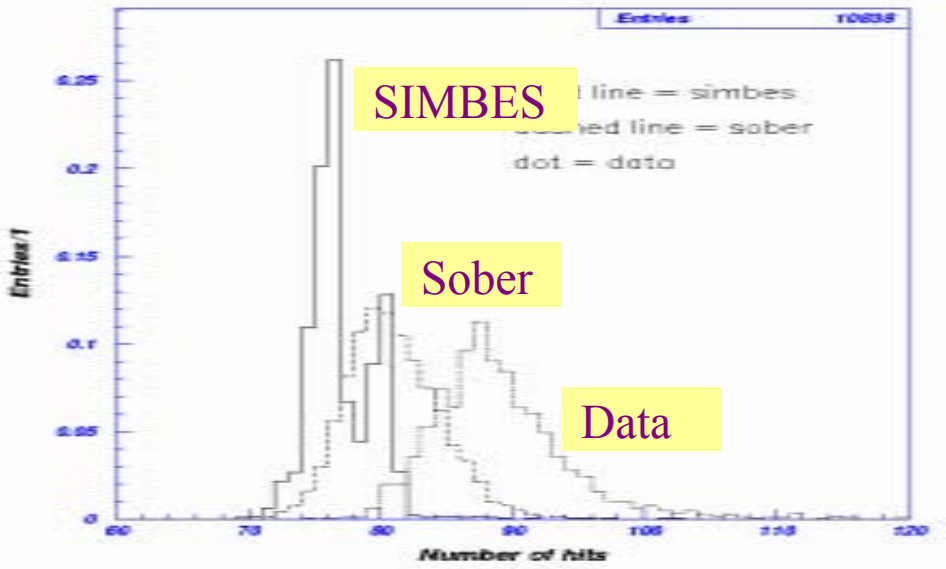
Efficiency for μ track

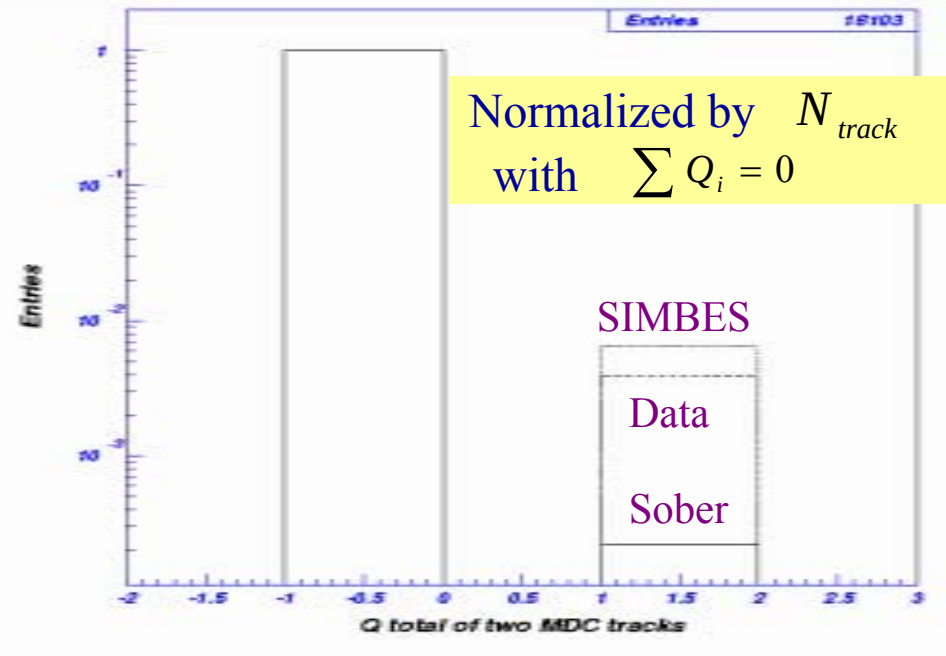
Eff	μ^+ %	μ^- %	Averaged %
Data	92.6	91.5	92.1
SIMBES	94.8	93.8	94.3
Sober	99.8	99.7	99.7

Note :

1. Multi-Scattering and MDC resolution included
2. realization in Sober : 021
3. Background in data needs more check

Detection efficiency in SIMBES & Data





- # of MDC raw hits per events
  - ❖ Two peaks in SIMBES
  - ❖ Noisy hits in Data

- Rate with wrong-sign charge
- Differ in SIMBES & Sober :
  1. MDC resolution
  2. MS (He K.L.)

Type	Rate of WS charge	R(Data)-R(MC)
Data	$(39 \pm 4) \times 10^{-4}$	
SIMBES	$(65 \pm 7) \times 10^{-4}$	-26×10^{-4}
Sober	$(2 \pm 1) \times 10^{-4}$	37×10^{-4}

Detection efficiency in SIMBES & Data

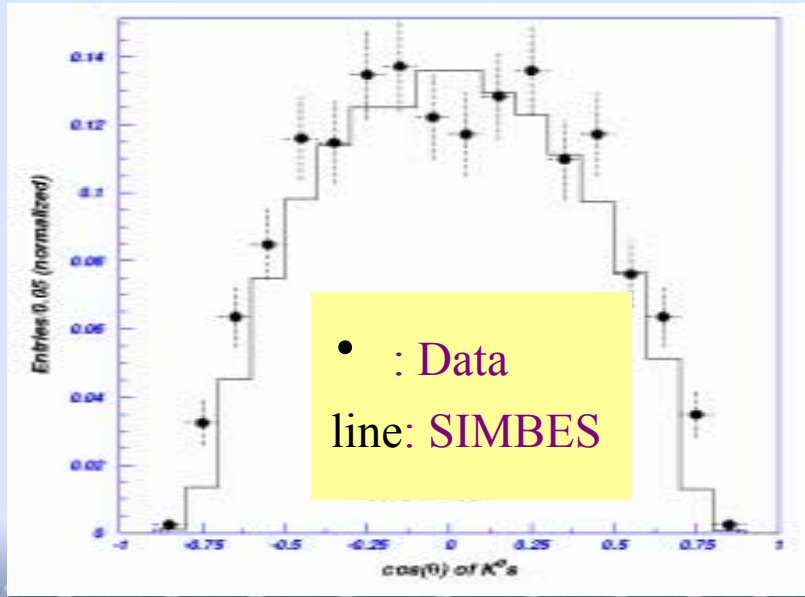
- μ track analysis
  - Disagree in Nhit shape between SIMBES & Data
  - Detection efficiency in SIMBES higher than in Data by 1.3% (relative)
  - Rate of WS charge in SIMBES higher than in Data by 67% (relative)

Detection efficiency in SIMBES & Data

- $\cos(\theta_{\pi^+\pi^-})$ from $J/\psi \to K_S K_L$
  - disagree between MC & Data due to HOWL generator
  - Agree well between SIMBES & Sober

- $\cos(\theta_{K_s})$ distribution

1. normalized by entries in (-0.4,0.4)
2. N(Ks) in SIMBES is more than in data



Detection efficiency in SIMBES & Data

$B_r(J/\psi \to K_S K_L)$ for $\cos\theta_{\pi^\pm} \le 0.85$ & $\cos\theta_{\pi^\pm} \le 0.6$

	$\cos\theta_{\pi^\pm}$ cut	
	< 0.85	< 0.6
N_{obs}	2183 ± 56	1551 ± 54
$N_{J/\psi}$	57.7×10^6	
ε	28.4%	21.0%
f_{TRG}	76.4%	76.4%(??)
$B_r \times 10^4$	1.75 ± 0.04	1.67 ± 0.06

- f_{TRG} moves up, if $\cos\theta_{\pi^\pm} \le 0.6$
- Consistent in $B_r(J/\psi \to K_S K_L)$ after $\cos\theta_{\pi^\pm} \le 0.6$ cut

Summary

- Difference in efficiency for $J/\psi \to K_S K_L$ between SIMBES & Sober
  1) dominated by MDC resolution simulation(14.4%)
  2) its second large contribution come from HI(6.8%) in SIMBES
- Rate of WS charge per track for $J/\psi \to K_S K_L$ is 2.1% in SIMBES. But effort to estimate the rate in Data is not succeeded yet due to background contamination.
- From a study of $\mu^{\mp}$ beam with $\mu^{\pm}$ tagged, rate of WS charge in SIMBES is higher than in Data.
- Missing MDC track and higher rate of WS charge in SIMBES possibly caused by existing MDC resolution simulation. Its effect in efficiency estimate is accumulated in $M_{\pi^+\pi^-}, K_S^0$ cuts.
- Correct simulation of MDC resolution is essential for good estimate of detection efficiency.

Thank You !