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STUDY ON BESII TELESIS

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I. INTRODUCTION

TELESIS is an essential tool in BES data analysis.Firstly it corrects MDC error matrix by multiple Coulomb scattering(MCS) and dE/dX effects,it also corrects charged tracks' momenta by dE/dX effect,then it does kinematic fit by imposing energy and momentum constraints to energies and momenta of tracks belong to a event,and adjusts them within the measured errors to satisfy the given event hypothesis.TELESIS improves the resolution of charged tracks' momenta and photons' energy,so that it could suppresses background events,which has wrong particle assignment or bad momenta and energies deviation,TELESIS could abstract clear signal from large background.

Error matrix is very important for the kinematic fit.The ratio of signal to background of a data analysis by using kinematic fit is maximum when error matrix is correct,otherwise the fit will give out poor χ^2 distribution,effects on the analysis result directly.Further more,it also need MC could simulate DATA condition exactly,otherwise an extra systematic error will be introduced into the analysis result by different TELESIS selection efficiencies between DATA and MC.

II. BESI TELESIS CHECK

In Nov. 1997[1],Dr. YUAN ChangZheng found that BESI TELESIS caused large negative error for a pure charged channel(-14%,CL>1%) while large positive error for a pure neutral channel(+9%,CL>1%) ,he thought that reconstructed MDC error matrix and BSC error matrix were questionable if he could assume TELESIS was out of question.

Firstly,I think kinematic fit procedure is correct basically,see Fig1. In MC data,Confidiental level is quit flat after MDC error matrix correction which makes three PULL distributions into (0,1) distributions for the channel $J/\psi \to \mu^+\mu^-$,this is well consistent with mathematical expectation.Secondly,I select a pure sample of charged and neutral mixture channel from BESI $\psi(2S)$ data by $\psi(2S) \to \pi^0\pi^0 J/\psi \to \gamma\gamma\gamma\gamma\mu^+\mu^-$.[2] BESI TELESIS result of this sample confirms Dr. YUAN's result.In Fig2,the relative error is defined the difference between the results using TELESIS and no using TELESIS selection relative to the result without using TELESIS selection.Fig2 shows that kinematic fit input errors are not correct both for DATA and MC,and it couldn't aviod to introduce an extract systematic error by BESI TELESIS package.such poor input errors may come from BESI errors reconstruction,or errors correction in TELESIS package.Overall,I suggest CL cut is no more than 1% to reduce the systematic error for BESI data analysis.

III. BESII TELESIS STUDY

BESII TELESIS was just a copy of BESI's when I started my study on it,and only two batches of J/ψ RUNs taken by BESII could be used:RUN 12034-12070 and RUN12099-12121,reconstructed by 200μm MDC wire resolution.

In order to study BESII TELESIS,I selected a pure charged sample by $J/\psi \rightarrow \mu^+\mu^-$. My selection criteria are: 1)a good reconstructed(MFIT=2) event,which have two opposite charged tracks and no neutral track. 2)eack track's point of closest approach to the intersection point to satisfy:Rxy<1.5cm, $|z|$ <15cm. 3)each track to satisfy:1.0GeV/c<P< 2.0GeV/c; $|cos\theta| < 0.8$; hitting BSC,and ratio of deposit energy in BSC to the track momentum $E/P < 0.4$. 4)The angle between the planes spanned by the beam direction and momentum vectors of first and second charged track respectively:θ_{acop} >179°; The angle between the momentum vectors of the tracks:θ_{acol} >177°. 5)Invariant mass of the tracks is between 2.6GeV to 3.6 GeV.This sample is very pure(purity great than about 95%,possible B.G. come from $\mu^+\mu^-\gamma$,$P\overline{P}$,k^+k^- and $\pi^+\pi^-$ final states). The data quality of the first RUN(σ_P=59.8MeV) was much better than second one(σ_P=86.4 MeV).Using BESI TELESIS to select these samples,PULL1-3(1.228,1.856,2.103) for the first,PULL1-3(1.452, 2.355,2.467) for the second,these RUNs' TELESIS χ^2 are too poor to satisfy requirement of data analysis.

Study on MC $J/\psi \rightarrow \mu^+\mu^-$.TELESIS Material is BESI(4.447% X_0) and MARKIII(1.166% X_0,is about 1/4 of BESI's) respectively,generating MDC wire sigma=200μm and 310-440μm (average value= 358μm),while reconstructing MDC wire sigma= 200μm, results is seen in Fig3.we can see:1)Under same generating MDC wire sigma, TELESIS correction just changes PULL1(ϕ) greatly while no large changes on PULL2($1/P_{xy}$) and PULL3(λ) when material changes greatly,it shows that measured MDC error matrix is questionable. 2)Comparing PULL results of different generating MDC wire sigmas under same reconstructing MDC wire sigma,the large generating MDC wire sigma is,the large PULL sigma is, so the worse TELESIS performance is.Next using MC $J/\psi \rightarrow \mu^+\mu^-$ to study the relation between MDC reconstructed error matrix,reconstructing MDC wire sigma:sigma-rec(fix to 200μm,since DATA's sigma-rec fix to 200μm) and generating MDC wire sigma:sigma-gen(200,375 μm), results are shown in Fig4, which indicates that errors are determinated by MDC sigma-rec mainly, not sensitive to sigma-gen,because errors have no large changes when sigma-gen changes from 200 to 375μm .Comparing sigmas of PULL1-3 between MC and data, we could estimate real MDC wire sigma: RUN 12034-12070:250-310μm; RUN12094-12121:280-375μm.BESII recontructing MDC wire sigma(200μm) is too small !

After reconstrution group re-determined MDC sigma-rec for RUNs after 13500,and put 40 sigma-rec values to 225-295μm, average is 250μm to reconstructed the RUNs,PULL distributions had been well improved.For $J/\psi \rightarrow \mu^+\mu^-$ events selected from RUN 13700-13750,TELESIS using BESI material, PULL (1.228,1.31, 1.498),σ_P=45.79MeV,while MC021 results: PULL (1.146,1.256, 1.27),σ_P= 45.38MeV.

Table 1. Effective Material for BESII Detector

Item	Material	Thickness(mm)	Radius(mm)	Sum. $X/X_0(\%)$
Beam pipe	Ni	0.015	47.62	
	Be	1.270	48.26	
	Ti	0.025	48.907	
				0.536
VC	Mylar	0.500	92.13	
	W	0.0022	92.13	
	$Ar + C_2H_6$	86.411	92.13	
				1.193
VC Out-wall	Kapton	0.051	135.36	
	C/epoxy	0.762	135.76	
	Al	0.076	136.18	
				1.568
MDC inner-wall	Al	0.050	155.00	
	C/epoxy	2.000	156.05	
	Kapton	0.254	157.18	
	Cu	0.038	157.32	
				2.675

Using BESII material parameters listed in table 1 to renew the parameters concerning with charged error matrix in SUPERFUG.f. SUN Liang Feng's BESII dE/dX calculation programme[3] is used to calculate dE/dX energy loss before MDC inner wall after I corrected several little mistakes in SUN's BESII material parameters,then new dE/dX table is put into DEPIPE2.inc in v102 lib,Now the TELESIS becomes real BESII TELESIS.Here I should point out that SUN's dE/dX calculation programme is not strict since the programme uses fixing β(not considering changing β) calculated by MDC measured momentum to calculate dE/dX energy loss.so SUN's calculation results will be larger than real dE/dX energy loss value in low β region(<0.5);But in high β region(>0.7) the calculation is well consistent with real value since the curve of dE/dX changing with β is quit flat in the region.

Preliminary result on magnetic field correction scale study: Using DATA RUN13700-13750 and RUN14135-14170 reconstructed by 1st-rec. using following formula:

$$\textbf{RATM}=\frac{\sqrt{(E_{theory}-dE/dX(\beta_{theory}))^2-m^2}}{P_{measured}}$$

raw value is 0.99634 after calculation. After precise adjustment on RATM, finally I get RATM=0.99659.dE/dX and H correction results are shown in table2(MC,RATM=1.0).

Table 2. dE/dX and Magnetic field correction

ITEM	MC	MC	MC	MC	DATA	DATA	DATA	DATA
	P_μ	σ_{P_μ}	$M_{J/\psi}$	$\sigma_{M_{J/\psi}}$	P_μ	σ_{P_μ}	$M_{J/\psi}$	$\sigma_{M_{J/\psi}}$
BEFORE	1.5427	44.861	3.0928	64.805	1.5482	49.023	3.1033	77.220
AFTER	1.5447	44.791	3.0969	64.704	1.5450	48.722	3.0969	77.008

P_μ: GeV/c,σ_{P_μ}: MeV/c,$M_{J/\psi}$: GeV, $\sigma_{M_{J/\psi}}$: MeV.

Re-scale on MDC error matrix by facters :σ_{PULL1}, σ_{PULL2} and σ_{PULL3},this method was introduced into BESI by Dr. LI XinHua and Prof. Bill Dunwoodie[4],I improve the method by taking out MDC error matrix after MCS and momentum correction while they took them from TRKLST directly.

$$ER1(\phi^2)=ER1 \times \sigma^2_{PULL1}$$
$$ER2(\phi\times\mathrm{k})=ER2 \times \sigma_{PULL1} \times \sigma_{PULL2}$$
$$ER3(k^2)=ER3 \times \sigma^2_{PULL2}$$
$$ER4(\phi \times \lambda)=ER4 \times \sigma_{PULL1} \times \sigma_{PULL3}$$
$$ER5(k \times \lambda)=ER5 \times \sigma_{PULL2} \times \sigma_{PULL3}$$
$$ER6(\lambda^2)=ER6 \times \sigma^2_{PULL3}$$

In order to suppress background from $J/\psi \to P\overline{P}$,further requirement: P_μ >1.4GeV/c is imposed on the $J/\psi \to \mu^+\mu^-$ sample,then adjust MDC error matrix re-scale parameters to make DATA PULL distributions to be (0,1) distribution,after the error correction,χ^2/ndf of gauss fit on DATA any PULL distribution is far from 1.0 indicates that DATA any PULL distribution is not pure single gauss distribution,it maybe consists of many kind of gauss distributions with different standard deviations and mean values,so final CL is not flat. For MC,adjust another set of re-scale parameters to make MC TELESIS efficiency to be consistent with DATA's.χ^2/ndf of gauss fit on MC PULL1,PULL2 distribution is near to 1.0 indicates that they are nearly single gauss distributions while PULL3 sigma is far from 1.0. Results are shown in Fig5 and table 3,table 4.(V102,BESII material,mean sigma-rec=250um, DATA:RUN 13700-13750+ RUN14135-14170,1st reconstruction,MC:021).
This preliminary BESII TELESIS is in BES lib-v102.

Prof. SHEN XiaoYian found ϕ resonance distribution turned worse by using BESII TELESIS instead of BESI TELESIS while BESII TELESIS performed well in resonances with pions.why? I got rid of possibility caused by BESII simple dE/dX calculation,and thought it came from different particle's performance.I used electron sample to estimate kion,proton's performance,and found that for large dE/dX particle,its real MDC error had been reduced,so PULL reduced (0.9434,0.8647,0.8356), this make large dE/dX particle's S/N ratio to be worse.After Q-correction by new reconstruction,see Fig6,electrons; PULL1-3(0.9889, 0.9655,0.9687),which are improved greatly.

Sigma of PULL2 changes with run see Fig7.So re-scale error matrix by run subsection is needed.But CL still rises up although much slowly than before,after re-scaling error matrix by run subsections.

Events TDC hit number and good hit number used to fit tracks are in Fig8.Indicates that DATA is much dirty than MC,different DATA's dirties are different.We know Run12034-12121 is much dirty than RUN13700-. The dirty data is,the large real error it is,the large different between real error and reconstructed error by sigma-rec.It means that sigma-rec should not be fix to 250μm,it should match with DATA's real condition.For the DATA,results with changing sigma-rec are show in Fig9 and table 5.For MC simular results are shown in Fig10 and table6.

Track's RMS distribution changing with good hit number used to fit the track is quit different between DATA and MC, see Fig 11. This creates MDC measured errors are quit different between DATA and MC, And we found that the PULL distributions are consistent

Table 3. 4C-fit efficiency by using no re-scaled MDC error matrix

CL>(%)	$\chi^2 <$	DATA(%)	MC(%)	relative error(%)*
0.0	50.0	97.24	98.67	-1.48
5.0×10^{-4}	30.0	93.95	97.45	-3.72
5.2×10^{-3}	25.0	91.92	96.44	-4.92
5.0×10^{-2}	20.0	88.35	94.39	-6.83
0.473	15.0	81.51	89.17	-9.40
1.0	13.25	77.96	85.78	-10.04
2.0	11.67	73.68	81.25	-10.27
3.0	10.72	70.62	77.62	-9.91
4.0	10.02	68.03	74.86	-10.05
5.0	9.49	65.88	72.16	-9.54
6.0	9.04	64.08	69.79	-8.90
7.0	8.67	62.55	67.79	-8.38
8.0	8.34	60.86	65.74	-8.03
9.0	8.05	59.24	63.90	-7.87
10.0	7.78	57.78	62.22	-7.69

* relative error=(EFF.data-EFF.mc)/EFF.data

Table 4. 4C-fit efficiency by using re-scaled MDC error matrix

CL>(%)	$\chi^2 <$	DATA(%)	MC(%)	relative error(%)*
0.0	50.0	99.43	99.44	-0.01
5.0×10^{-4}	30.0	98.35	98.53	-0.19
5.2×10^{-3}	25.0	97.66	98.14	-0.50
5.0×10^{-2}	20.0	96.58	97.43	-0.88
0.473	15.0	94.40	95.69	-1.47
1.0	13.25	93.19	94.57	-1.48
2.0	11.67	91.48	92.81	-1.46
3.0	10.72	90.08	91.14	-1.17
4.0	10.02	88.84	89.56	-0.81
5.0	9.49	87.85	88.10	-0.28
6.0	9.04	86.78	86.69	+0.11
7.0	8.67	85.86	85.27	+0.68
8.0	8.34	84.90	83.88	+1.21
9.0	8.05	84.08	82.70	+1.64
10.0	7.78	83.30	81.33	+2.35

* relative error=(EFF.data-EFF.mc)/EFF.data

Table 5. DATA RUN13700-13750 + RUN14135-14170,1st recon.

$\sigma_{rec.}$(μm)	Number	$\sigma_P(MeV/c)$	PULL sigma
resk(250)	11150	46.31	1.241,1.336,1.557
+15	11133	46.24	1.222,1.296,1.494
+30	11110	46.12	1.194,1.254,1.438
+45	11104	46.08	1.182,1.220,1.380
+60	11100	46.08	1.167,1.185,1.331
+100	11082	45.93	1.117,1.098,1.220
+120	11066	46.29	1.089,1.061,1.167
-50	11111	47.03	1.280,1.508,1.821
-100	11063	47.23	1.298,1.657,2.125

Table 6. MC021

$\sigma_{rec.}$(μm)	Number	$\sigma_P(MeV/c)$	PULL sigma
resk(250)	8220	42.92	1.1.139,1.258,1.282
+80	8242	40.42	1.023,1.024,0.9682
300250	8069	39.27	$1.9 \times 10^{-3}, 1.8 \times 10^{-3}, 2.0 \times 10^{-3}$

between DATA and MC when two tracks' RMS1+RMS2<1.7.But quit different when RMS1 +RMS2>1.7. Any diviation between DATA and MC will introduce extra systematic error into analysis result by using TELESIS.

IV. SUMMARY

We have established preliminary BESII TELESIS: 1)MDC wire average sigma-rec is put as 250 μm from 200μm. 2)Add Q-correction into MDC reconstruction. 3)Renew TELESIS material and dE/dX table according to BESII material condition. 4)Re-scale MDC error matrix for charged tracks to make efficiencies be consistent between DATA and MC by $J/\psi \to \mu^+\mu^-$. 5)Use NEUERROR.f which writted by Dr. LI HaiBo in $\psi(2S)$ to re-scale BSC measurements and error matrix for BESII neutral tracks temporarily.

Some studies on BESII TELESIS should be continue: 1)Measured MDC error matrix is still smaller than it should be,it means that sigma-rec is still smaller. 2)Large different performances between DATA and MC,since MC couldn't simulate DATA's MDC bad hits and changing condition. 3)Different DATA has different real error size,correspounding different sigma-rec, but present reconstruction treat all RUNs with same sigma-rec. 4)The method of using re-scaled errors for DATA and MC repectively is available while confidental level performances of DATA and MC are quit different,but it should be calibrated with DATA RUN changes after removing bad RUNs. 5)Re-scale BSC measurements and error matrix for BESII condition.

Detail information coulf be found in"SUMMARY on BESII TELESIS",LU Feng,J/ψ group meeting ,25,April 2000.

ACKNOWLEDGEMENT

I'm very grateful for Prof. ZHANG Chang Chun,this work is under his direction,we usually have close discussion on TELESIS problem,he gave me great help and encouragement,without his pushment,it is impossible to change MDC wire sigma from 200 to 250um,and add Q-correction into reconstruction. I thank a lot for Prof. Russell Malchow and Prof. CHEN YuanBo for providing me exact data about beam pipe,VC and MDC;I also would like to thank Prof. MAO ZePu,Prof. SHENG XiaoYan,Mr. SUN LiangFeng for their warm help.Finally I thank for all members of data production group for their effort on data reconstruction.

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[1] Yuan XhangZheng, Is TELESIS Reliable? ψ' group meeting, Oct. 1997.
[2] LU Feng, Branching Ratio Measurement of $\psi(2S) \to J/\psi$ Plus Neutrals,BES annual meeting, Jun. 1999.
[3] SUN LiangFeng,B.S. Thesis: Energy Loss Correction on BESII Beam Pipe Area, Jun. 1997.
[4] LI XinHua, Error Matrix of Charge Track, BES monthly meeting,Dec. 1997.
[5] LU Feng, Summary on BESII TELESIS, J/ψ group meeting,25 April,2000.

Fig1. J/psi to muon pair, BESII MC

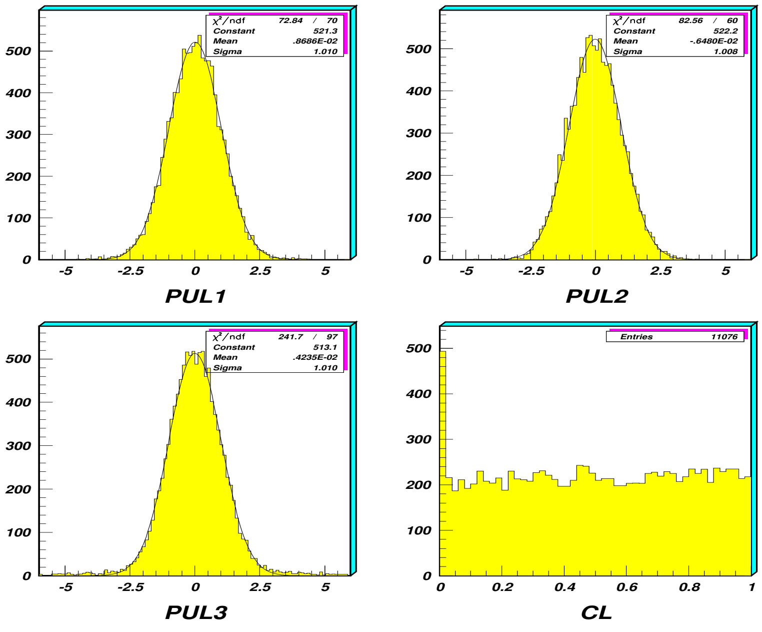


Fig2. BESI Comparation with YUANCZ: (a)-(c)

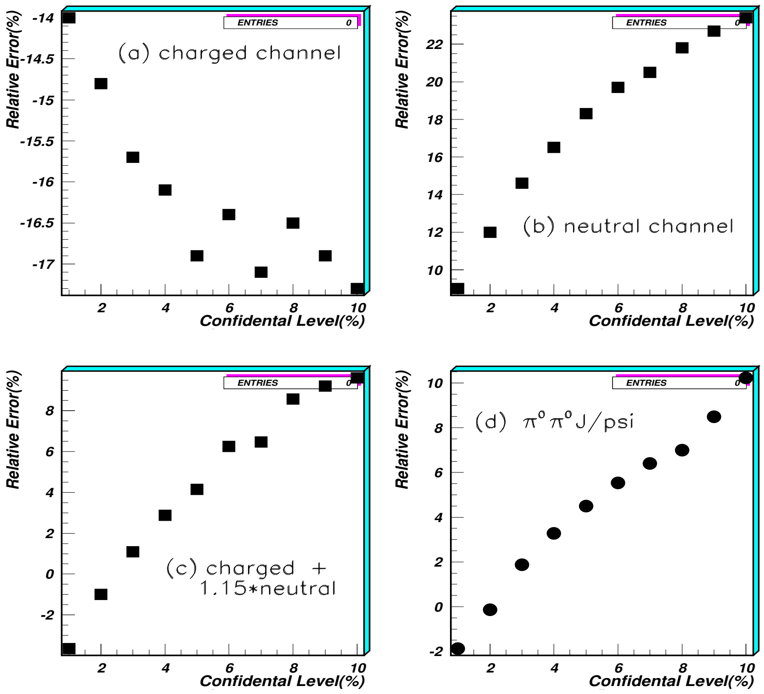


Fig3 MC 1:BESI 2:MARK3 REC=200um GEN= a:200 b:358um

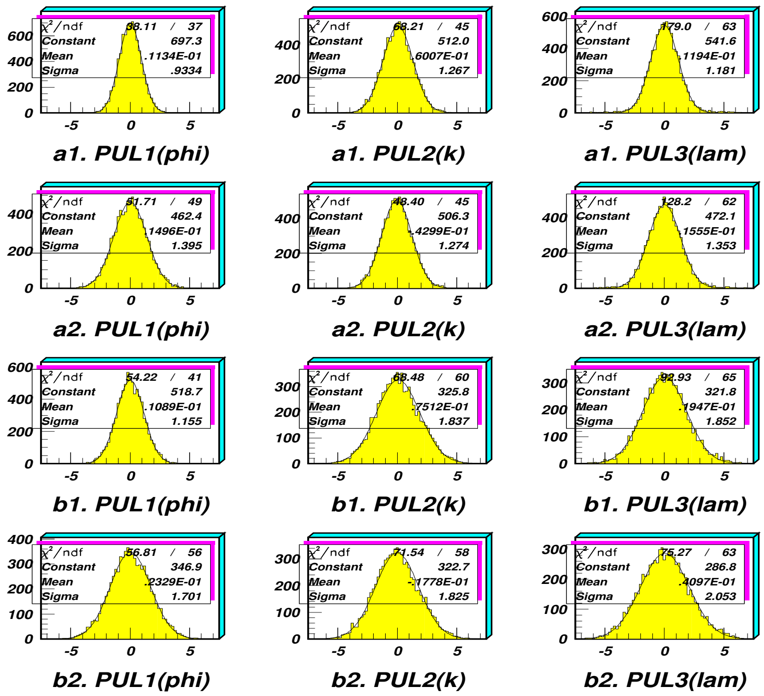


Fig4. MC REC=200um, GEN= a:200 b:375um

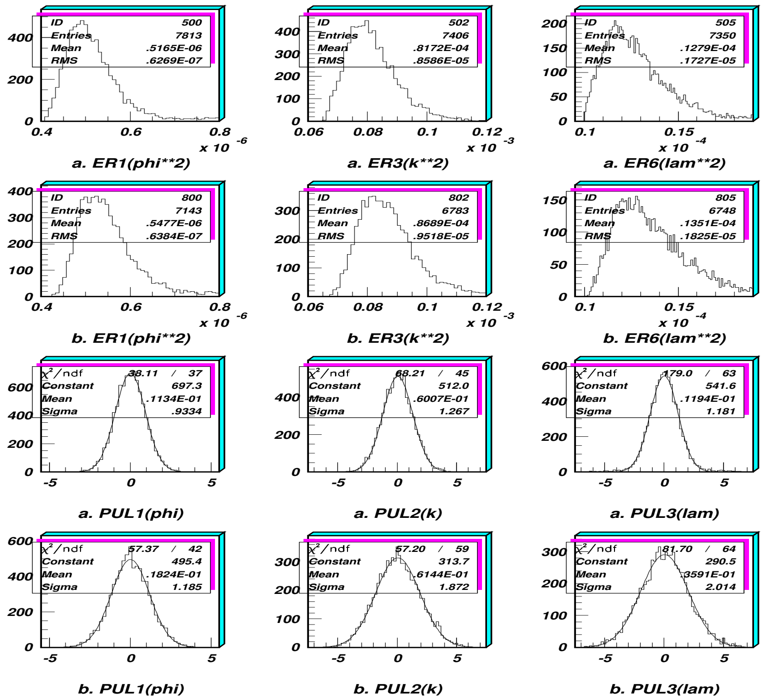
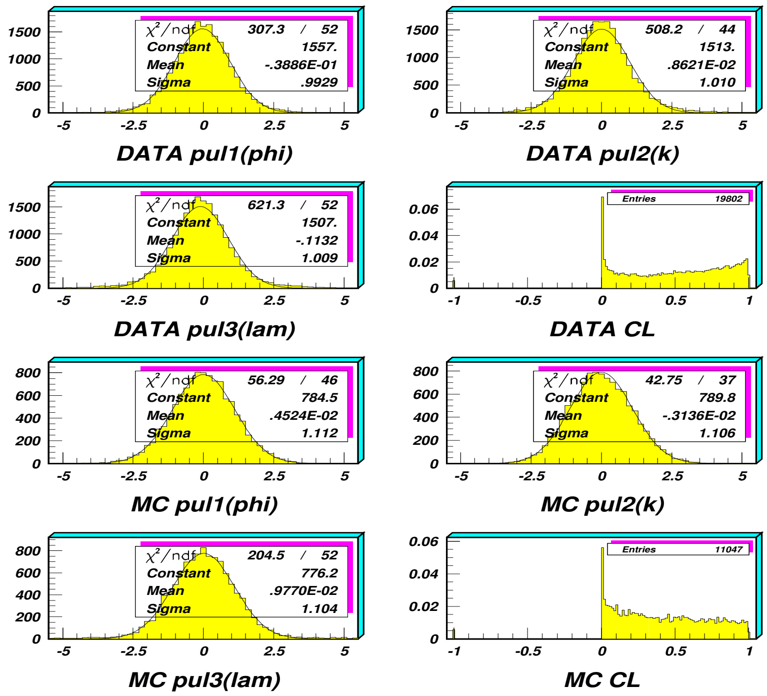


Fig5. AFTER ERROR CORRECTION



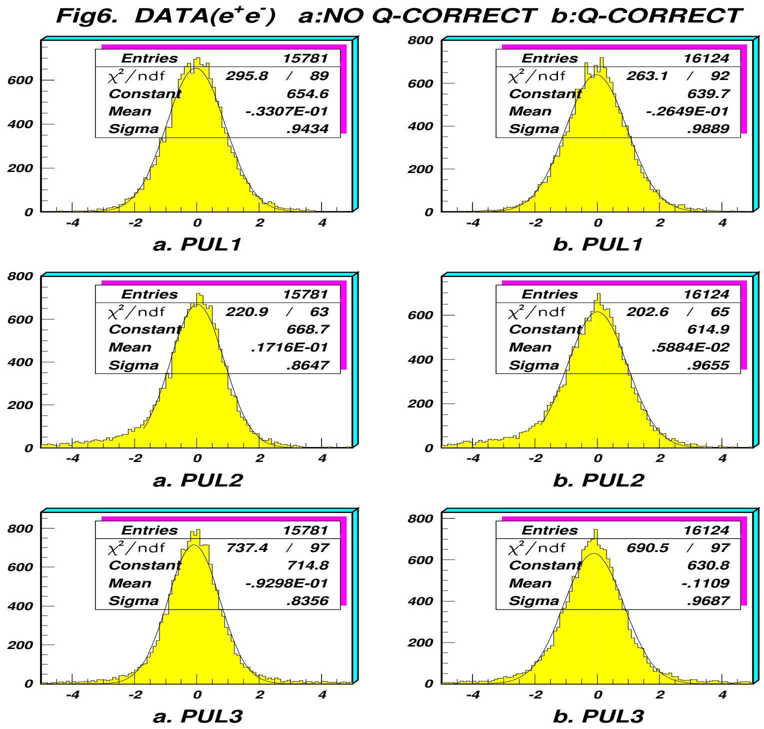


Fig6. DATA(e+e-) a:NO Q-CORRECT b:Q-CORRECT
Entries 15781
χ²/ndf 295.8 / 89
Constant 654.6
Mean -.3307E-01
Sigma .9434
a. PUL1
Entries 16124
χ²/ndf 263.1 / 92
Constant 639.7
Mean -.2649E-01
Sigma .9889
b. PUL1
Entries 15781
χ²/ndf 220.9 / 63
Constant 668.7
Mean .1716E-01
Sigma .8647
a. PUL2
Entries 16124
χ²/ndf 202.6 / 65
Constant 614.9
Mean .5884E-02
Sigma .9655
b. PUL2
Entries 15781
χ²/ndf 737.4 / 97
Constant 714.8
Mean -.9298E-01
Sigma .8356
a. PUL3
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χ²/ndf 690.5 / 97
Constant 630.8
Mean -.1109
Sigma .9687
b. PUL3

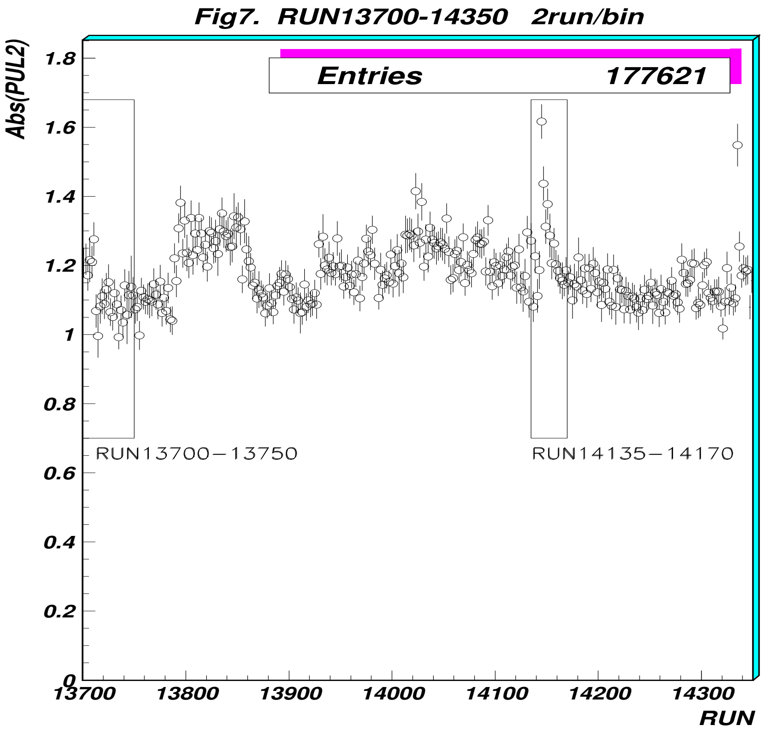
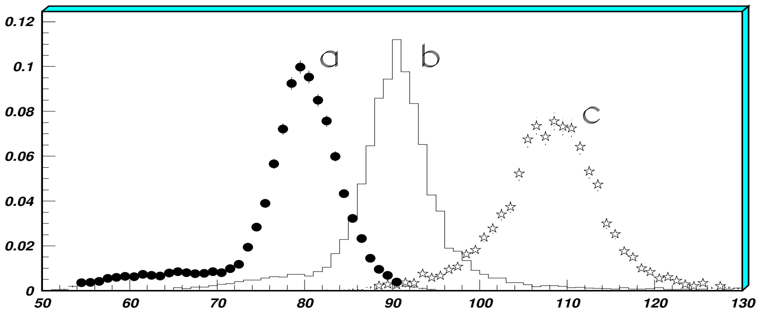


Fig7. RUN13700-14350 2run/bin
Entries 177621
Abs(PUL2)
RUN13700−13750
RUN14135−14170
RUN

Fig8. a.MC b.RUN13712-13750 c.RUN14154-14170



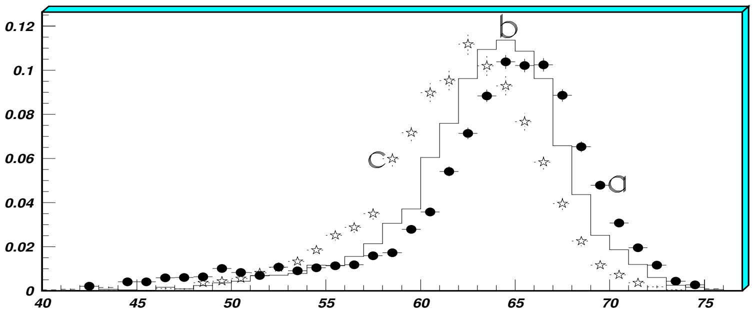


Fig9. RUN13700-13750 a.REC b.REC+100 c.REC-50um

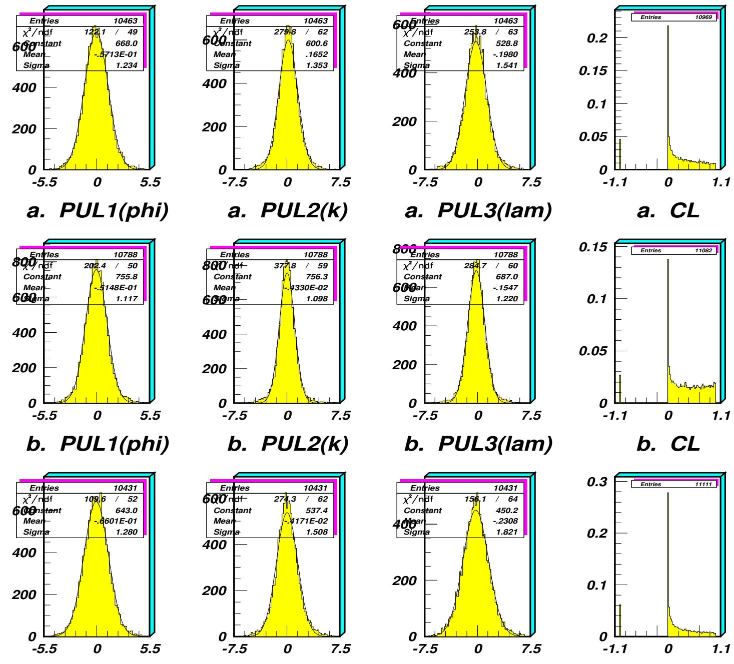


Fig10. MC GEN=resk(250um) a.REC=resk b.REC=resk+80um

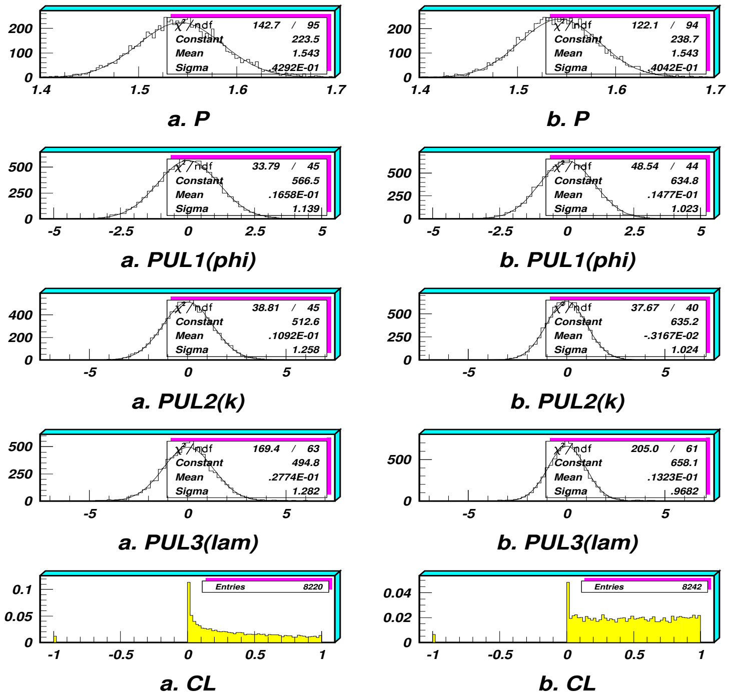


Fig11 a.MC b.RUN13700-13750 c.RUN14135-14170