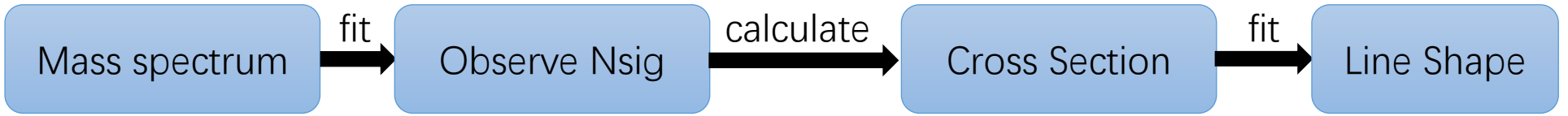
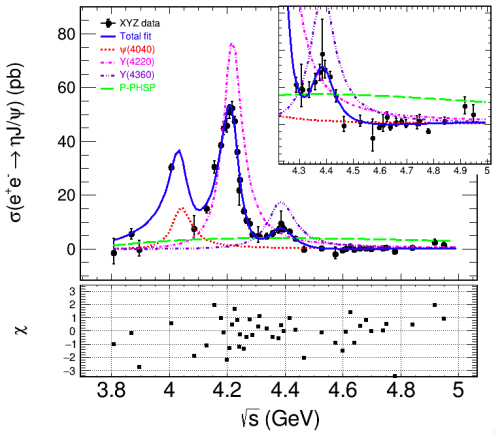
Global Fitting of the Lineshape

Outline

Traditional

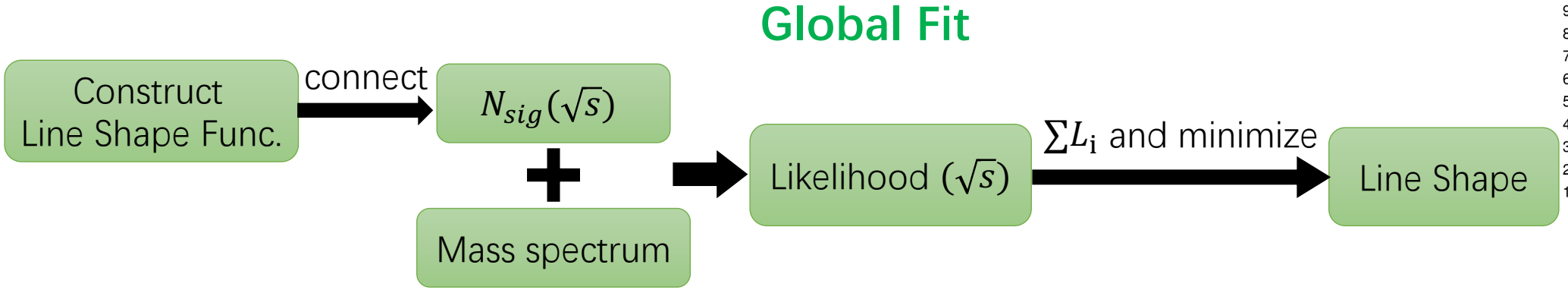


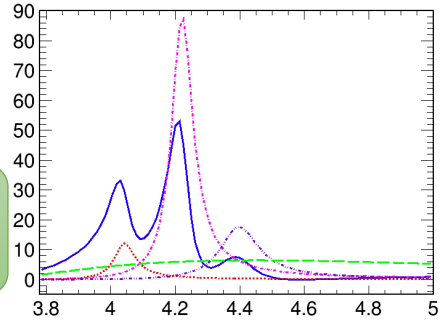


For traditional method, we may only obtain the upper limit of some datasets with little statistics.

But by this global fit, these datasets can be also put into the line shape fitting.

Global Fit





A Simultaneous Fit:

The parameters of the line shape are shared between the datasets in different C.M. energy.

Strategy

Construct my Line Shape Func.

$$\sigma^B(\sqrt{s}) = \left|C_0\sqrt{\Psi(\sqrt{s})} + BW_1(\sqrt{s})e^{i\phi_1} + BW_2(\sqrt{s})e^{i\phi_2} + BW_3(\sqrt{s})e^{i\phi_3}\right|^2$$

- Establish the connection between the fitting variable of individual mass spectrum (RooAbsReal Nsig) and the function of line shape.

$$N_{obs}(\sqrt{s}) = \sigma^B(\sqrt{s}) \cdot \mathcal{L}_{int} \cdot (1+\delta^{ISR}) \cdot (1+\delta^{VP}) \cdot \epsilon \cdot Br \qquad (1)$$

Use RooArgSet to package the parameters of the lineshape

```
RooArgSet  *roo_pars[nums];
roo_pars[i] = new RooArgSet(Mass1, Width1, GamEE1, Phi1,Mass2, Width2, GamEE2, Phi2,Mass3);
roo_pars[i]->add(Width3);
roo_pars[i]->add(GamEE3);
roo_pars[i]->add(Phi3);
roo_pars[i]->add(c0);
roo_pars[i]->add(*LINT[i]);
roo_pars[i]->add(*DEL[i]);
roo_pars[i]->add(*Eff_2ee[i]);
roo_pars[i]->add(*Eff_2mu[i]);
roo_pars[i]->add(*Eff_3ee[i]);
roo_pars[i]->add(*Eff_3mu[i]);
```

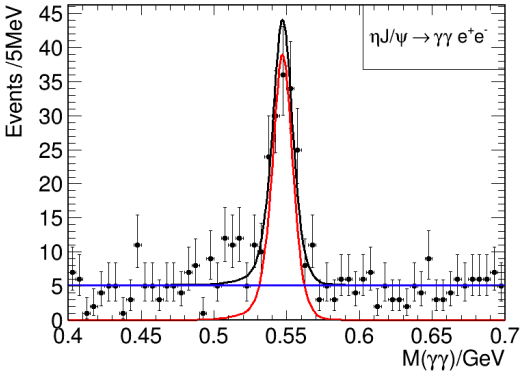
```
RooRealVar Mass1("Mass4040", "Mass4040", vstart[0]);
RooRealVar Width1("Wid4040", "Wid4040", vstart[1]);
RooRealVar GamEE1("GamEe4040", "GamEe4040", iniPar[2],0.0,100);
RooRealVar Phi1("Phi4040", "Phi4040", iniPar[3],0.0,6.284);

RooRealVar Mass2("Mass4220", "Mass4220",iniPar[4],4.190,4.25);
RooRealVar Width2("Wid4220", "Wid4220", iniPar[5],0.0,0.10);
RooRealVar GamEE2("GamEe4220", "GamEe4220", iniPar[6],0.0,100);
RooRealVar Phi2("Phi4220", "Phi4220", iniPar[7],0.001,6.284);

RooRealVar Mass3("Mass4360", "Mass4360",iniPar[8],4.30,4.5);
RooRealVar Width3("Wid4360", "Wid4360", iniPar[9],0.0,0.3);
RooRealVar GamEE3("GamEe4360", "GamEe4360", iniPar[10],0.0,20);
RooRealVar Phi3("Phi4360", "Phi4360", iniPar[11],0.00,6.284);

RooRealVar c0("c0","c0", iniPar[12], 6e+03, 1e+05);
RooRealVar N("N","N", iniPar[13], 0.0, 10);
```

Use bindFunction to build the connection

```
TF1 *n1_func = new TF1("n1_func", N_SIG1, 3.78, 5.0, 19);
TF1 *n2_func = new TF1("n2_func", N_SIG2, 3.78, 5.0, 19);
TF1 *n3_func = new TF1("n3_func", N_SIG3, 3.78, 5.0, 19);
TF1 *n4_func = new TF1("n4_func", N_SIG4, 3.78, 5.0, 19);
RooAbsReal *nsig1[nums];
RooAbsReal *nsig2[nums];
RooAbsReal *nsig3[nums];
RooAbsReal *nsig4[nums];
nsig1[i] = bindFunction(n1_func,*ecms[i], *roo_pars[i]);
nsig2[i] = bindFunction(n2_func,*ecms[i], *roo_pars[i]);
nsig3[i] = bindFunction(n3_func,*ecms[i], *roo_pars[i]);
nsig4[i] = bindFunction(n4_func,*ecms[i], *roo_pars[i]);
```

- The N_SIG* is the function written in C++ symbolize Func.(1)
- The *ecms[i] is a RooRealVar with fixed value symbolize C.M. energy.

Strategy



- Construct PDF of Signal and Background of mass spectrum normally

  Get the likelihood of individual mass spectrum by creaNLL

  (by some tests, we find the likelihood obtained by creatNLL() is same as results from Roofit as following.)

$$-\log L(p) = -\sum_{data} \log\, M(x_i) - \log\, Poisson(N_{expected}, N_{observed})$$

```
RooDataSet *data1[nums];
RooAbsReal *lkl1[nums];
RooAddPdf *sum1[nums];

data1[i] = new RooDataSet("data1_"+DataSet[i],"data1_"+DataSet[i], t_data_2gee[i], x);
sum1[i]=new RooAddPdf("sum1_"+DataSet[i],"sum1_"+DataSet[i],RooArgList(*sig1_pdf[i],*bg1_pdf[i]),RooArgSet(*nsig1[i],*nbkg1[i]));
lkl1[i] = sum1[i]->createNLL(*data1[i]);
```

Use RooAddition to add the likelihood together

```
RooAddition* ll_ttl[nums];
ll_ttl[i] = new RooAddition("ll_ttl"+DataSet[i],"ll_ttl"+DataSet[i], RooArgSet(*lkl1[i],*lkl2[i],*lkl3[i],*lkl4[i]));
```

Add the total likelihood and use RooMinuit to make a fit

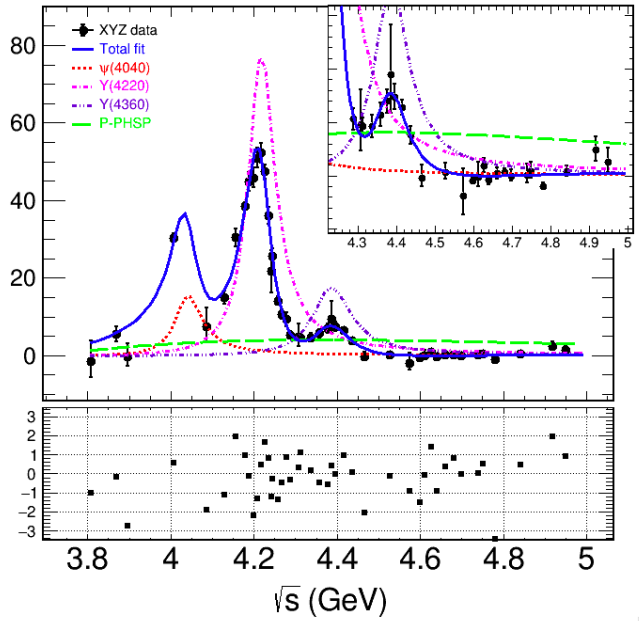
```
RooMinuit m(*likelihood);
m.migrad();
m.hesse();
```

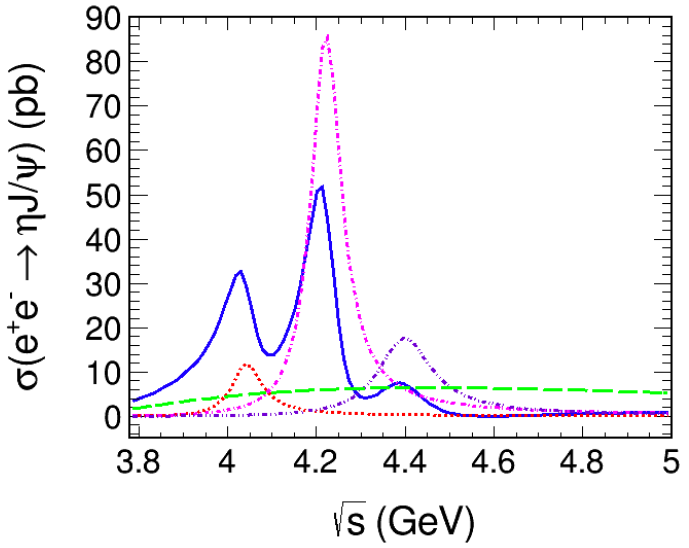
*likelihood is the addition of the total likelihood

Comparison

$$\sigma_{fit} = \left| C_0 \sqrt{\Psi(\sqrt{s})} + BW_1(\sqrt{s})e^{i\phi 1} + BW_2(\sqrt{s})e^{i\phi 2} + BW_3(\sqrt{s})e^{i\phi 3} \right|^2 \qquad \Psi(\sqrt{s}) = \frac{q^3}{s^n}$$

	Old_45	new
$\Gamma^{e^+e^-}_{4040} Br_{4040}\ (eV)$	1.36 ± 0.22	1.07 ± 0.16
$\phi_{4040}\ (rad)$	3.02 ± 0.20	3.24 ± 0.11
$M_{4220}\ (MeV/c^2)$	4215.6 ± 2.17	4218.8 ± 1.19
$\Gamma_{4220}\ (MeV)$	79.45 ± 4.44	80.24 ± 1.84
$\Gamma^{e^+e^-}_{4220} Br_{4220}\ (eV)$	7.44 ± 1.00	8.56 ± 0.29
$\phi_{4220}\ (rad)$	4.12 ± 0.13	4.21 ± 0.06
$M_{4360}\ (MeV/c^2)$	4383.3 ± 12.41	4392.5 ± 4.37
$\Gamma_{4360}\ (MeV)$	112.44 ± 26.92	144.95 ± 7.60
$\Gamma^{e^+e^-}_{4360} Br_{4360}\ (eV)$	2.58 ± 0.96	3.36 ± 0.31
$\phi_{4360}\ (rad)$	2.47 ± 0.16	2.72 ± 0.11
C_0	$9.29\times10^3 \pm 1.66\times10^4$	$6.36\times10^3 \pm 2.41\times10^2$
n	5.70 ± 1.20	5.29 ± 0.04





Back up

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Comparison of results from a simultaneous fit by Roofit and RooMinuit.