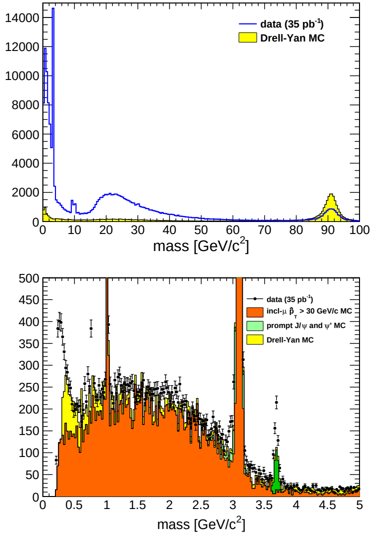
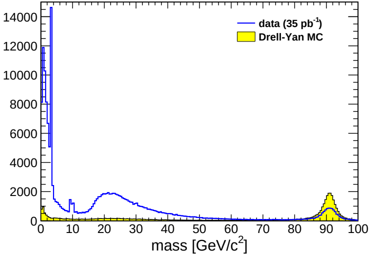
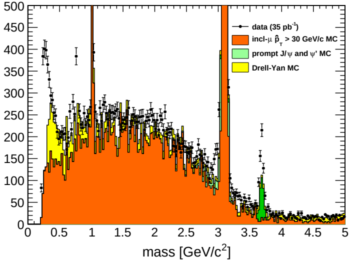
Drell-Yan normalization



- After fixing a few misinterpretations of the Pythia cross-section output, it seems to be about right for the low-mass region and a factor of two too high for the Z

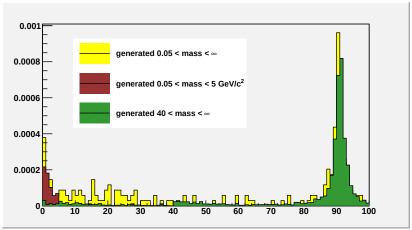
Drell-Yan normalization



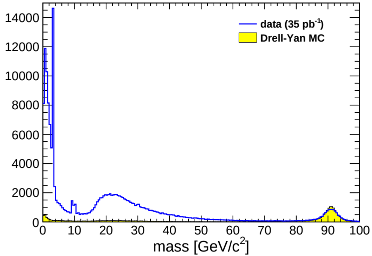


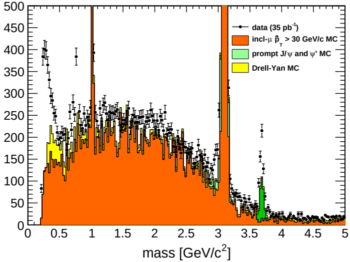
- Changing the generator-level mass cut doesn't give me a factor of two (below)
- The usual mode of operation would be to only run this for masses above 40 GeV/c^2

min $\hat{p}_T$	min m	max m	intlumi (mb^{-1})
10.	0.05	∞	$10000/2.912\times10^{-5}$
10.	0.05	5	$10000/1.137\times10^{-5}$
10.	40	∞	$10000/1.166\times10^{-6}$



Drell-Yan normalization

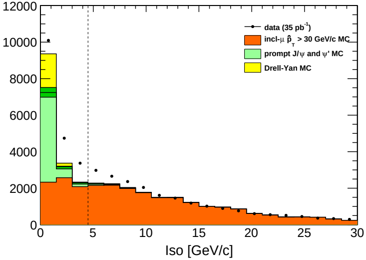


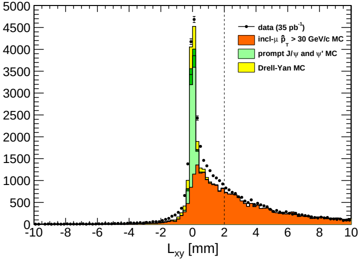


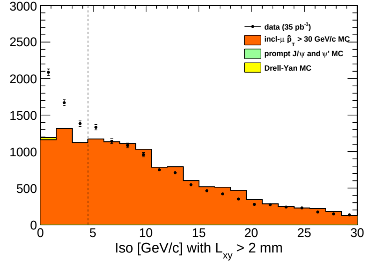
- Explicitly scaling to the Z (left) yields an equally believable spectrum: we don't know how much of the data-excess is actually more $b\bar{b}$, rather than Drell-Yan
- I'll use this scaling for the rest of the talk and minimize dependence on the Drell-Yan MC
- We can, for instance, be guided by the MC's isolation and L_{xy} (flight distance), since that is mostly detector simulation

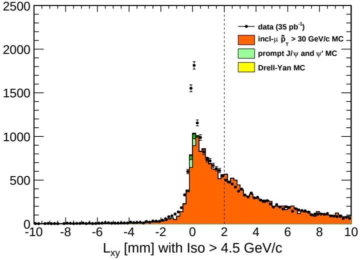
$b\bar{b}$ cuts for mass template

- Only $b\bar{b} \to 2\mu X$, $2\mu X$ can appear in the dimuon-dimuon sample, so our mass template must be constructed from $b \to 2\mu X$



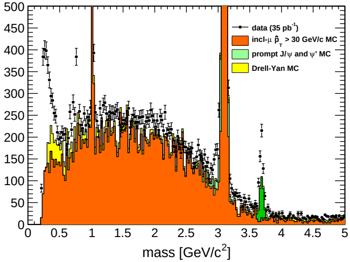


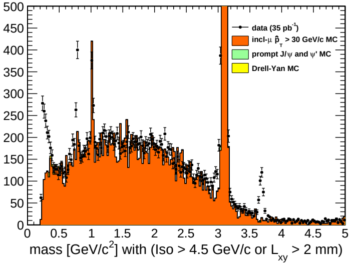


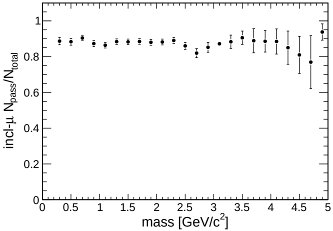


$b\bar{b}$ cuts for mass template

- Select *Iso* > 4.5 GeV$/c$ **or** $L_{xy} > 2$ mm
- Efficiency for $b \to 2\mu X$ (in incl-μ MC) is $\sim$90% and uniform in mass







Dimuon-dimuon mass template

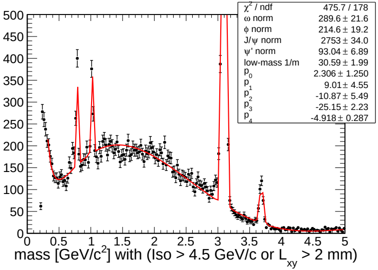
- Can either get a histogram from the FitNtuple:

```
tfile.Get("FitNtuple/lowdimuon").Draw("mass", "muontrigpt > 12.  && (iso > 4.5 ||
((pluspx+minuspx)*vx + (pluspy+minuspy)*vy)/sqrt((pluspx+minuspx)**2 +
(pluspy+minuspy)**2) > 0.2)")
```

- Or use this parameterized shape for smoothness:

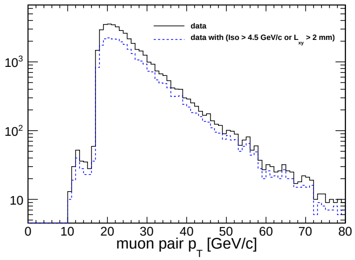
```
289.65*exp(-(x-0.78265)**2 / 2.  / 0.011**2) + 214.63*exp(-(x-1.019455)**2 / 2.  /
0.014**2) + 2753.22*exp(-(x-3.096916)**2 / 2.  / 0.025**2) + 93.04*exp(-(x-3.68609)**2 /
2.  / 0.029**2) + 30.59/(x-2.*0.105658367) + 2.31 + 9.01*(x-5) + -10.87*(x-5)**2 +
-25.15*(x-5)**3 + -4.92*(x-5)**4
```

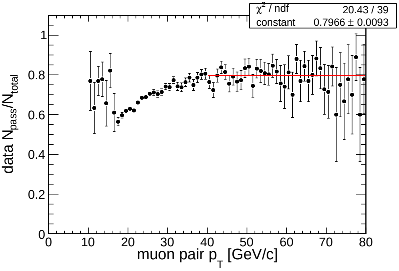
- Taken from a fit to single dimuon data with the *b*-cut:



Single dimuon mass template

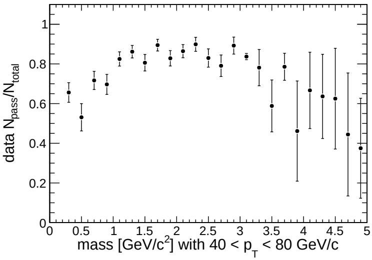
- For the "single $p_T > 80$ GeV/c dimuon" signal channel, we should not exclude the isolated, $L_{xy} \sim 0$ part of the distribution (Drell-Yan can contribute to *this* signal region)
- We should, however, find derive the template from a part of the spectrum where the two contributions scale the same way in p_T (that is, get away from turn-on curves and prompt production)
- For $40 < p_T < 80$ GeV/c, the ratio is flat: we *assume* it is still flat for $p_T > 80$ GeV/c, since this is far away from any relevant scales





Single dimuon mass template

- For the "single $p_T > 80$ GeV/c dimuon" signal channel, we should not exclude the isolated, $L_{xy} \sim 0$ part of the distribution (Drell-Yan can contribute to *this* signal region)
- We should, however, find derive the template from a part of the spectrum where the two contributions scale the same way in p_T (that is, get away from turn-on curves and prompt production)
- The ratio is not flat in mass, but this is because $b\bar{b}$ contributes to a different part of the spectrum than Drell-Yan. We want both.



Single dimuon mass template

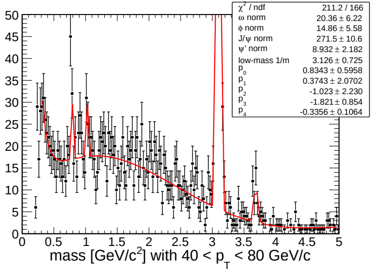
- Can either get a histogram from the FitNtuple:

```
tfile.Get("FitNtuple/lowdimuon").Draw("mass", "muontrigpt > 12.  && 40.  < pt && pt <
80.")
```

- Or use this parameterized shape for smoothness:

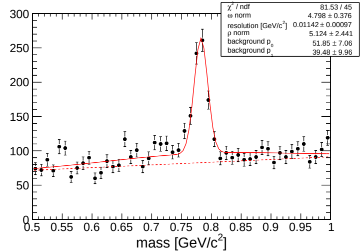
```
20.36*exp(-(x-0.78265)**2 / 2.  / 0.011**2) + 14.86*exp(-(x-1.019455)**2 / 2.  /
0.014**2) + 271.55*exp(-(x-3.096916)**2 / 2.  / 0.025**2) + 8.93*exp(-(x-3.68609)**2 / 2.
/ 0.029**2) + 3.13/(x-2.*0.105658367) + 0.83 + 0.37*(x-5) + -1.02*(x-5)**2 +
-1.82*(x-5)**3 + -0.34*(x-5)**4
```

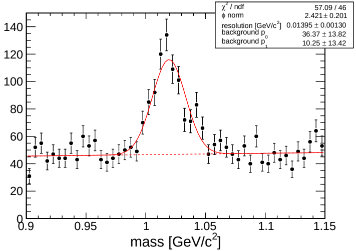
- Taken from a fit to single dimuon data with $40 < p_T < 80$ GeV$/c$:

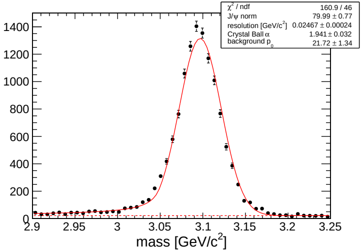


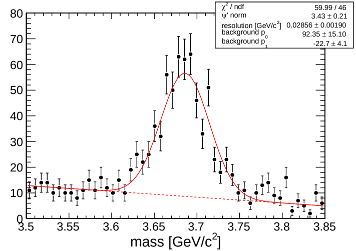
Mass resolution

- Fit our four "standard candle mu-jets" for detector resolution (masses fixed to PDG, width of ρ fixed to PDG, J/ψ has FSR (Crystal Ball α) but simpler backgrounds)



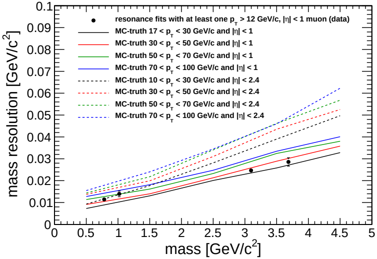


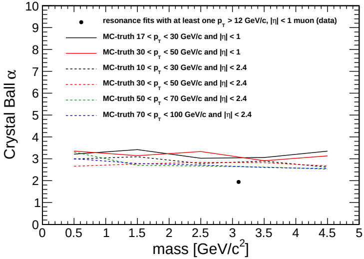




Mass resolution

- Compare to mass resolution from dimuon gun MC
  - solid lines: containing a triggerable muon ($p_T > 12$ GeV/c, $|\eta| < 1$)
  - dashed lines: no special muon constraints ($p_T > 5$ GeV/c, $|\eta| < 2.4$)
  - also split by p_T (slight dependence, worse resolution at higher p_T)
- Most of the difference is due to allowing the endcap
- MC has larger FSR tails (Crystal Ball α parameter)





Mass parameterization

Crystal Ball function with $n = 1$ (see Wikipedia)

```
norm*((exp(-(x-mass)**2 / 2.  / res**2) / sqrt(2.*3.1415926) / res)*((x-mass)/res > -alpha) +
(0.4/res)*(exp(-alpha**2/2.)/abs(alpha)/(1./abs(alpha) - abs(alpha) -
(x-mass)/res))*((x-mass)/res < -alpha))
```

- `norm` floats (cross-section limit parameter)
- `mass` is scanned from 0.3–5 GeV/c^2 (background parameteriztions are valid down to 0.3 GeV/c^2)
- `res` has two parameterizations:
  - central: 0.007 + 0.006*mass (nuisance parameter: allow the constant 0.007 to increase or decrease by at most 0.003)
  - other: 0.007 + 0.010*mass (same nuisance parameter)
- `alpha` is somewhere between 2 and 3 (another nuisance parameter)

The "central" dimuon is either the only dimuon in the event (single dimuon channel) or is the dimuon that contains the most central muon with $p_T > 12$ GeV/c (dimuon-dimuon channel)

(When we require one $p_T > 12$ GeV/c, $|\eta| < 1$ muon in the event, the "central" dimuon is sufficient for triggering)

- In the dimuon-dimuon channel, we can't simply randomize the two dimuons to make the plane symmetric. Since we require one high-p_T barrel muon to satisfy the trigger, we are effectively requiring one of the two dimuons to be higher-p_T and in the barrel. The other one is not constrained. We therefore have an asymmetry we can't throw away: mass resolutions are different due to a looser η requirement (pages 11, 12) and the shape of the backgrounds distribution is different due to a looser p_T requirement (not shown here). One axis will have to represent the "central" dimuon ($p_T > 17$ GeV/c, $|\eta| < 1$) while the other represents the "other" dimuon ($p_T > 10$ GeV/c, $|\eta| < 2.4$). The mass template for the "central" dimuon is derived on page 6; to get a mass template for the "other" dimuon, we will need to use dimuon-muon events (3 muons total), where the trigger is satisfied by the "orphan" muon (we have enough data for the basic shape).
- Mass templates for all channels with a quadmuon in it come from trimuon + track or dimuon + 2 tracks. This is still on the to-do list.