Status of Charmonium (Exotic) Analyses for the Physics Book

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Overview

- 4 analyses (progress since /started after Dubna meeting)
  - charmonium spectroscopy: $J/\Psi\eta$
  - exotics: $J/\Psi\omega$, $\Psi(2S)\pi^+\pi^-$, $\Psi\eta$ ($\Psi\to\chi_{c1}\pi^0\pi^0$ / $\Psi\to DD^*$)

- improvements in analysis results due to
  - tracking in forward spectrometer
  - muon identification (inclusion of $J/\Psi\to\mu^+\mu^-$ channel)
  - covariance matrix (kinematic fit) for photon candidates
  - beam constraint (4C) fit

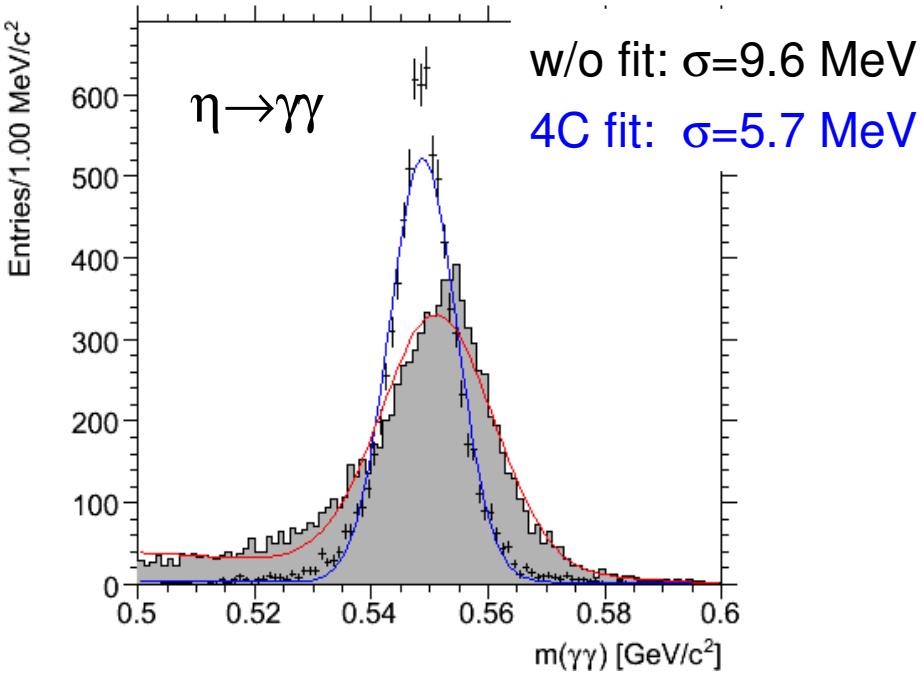
J/Ψη selection

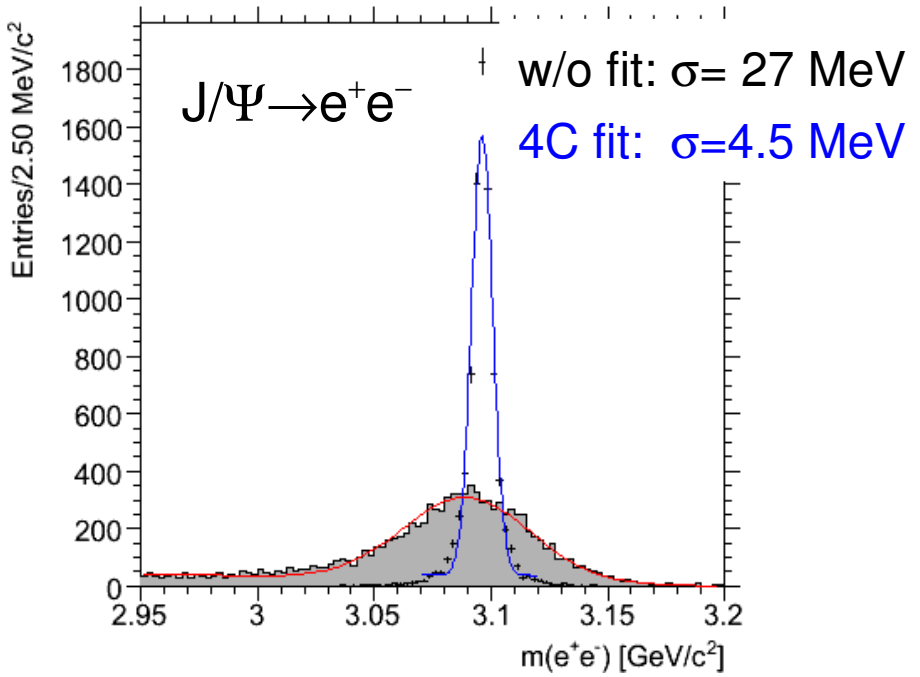
- 20k J/Ψη events at Y(4260)
  - $J/\Psi \to e^+e^-$, $\eta \to \gamma\gamma$
- $J/\Psi \to e^+e^-$ selection
  - PID: $p(e^+)>0.2$, $p(e^-)>0.85$
  - $m(e^+e^-) \in [2.98;3.16]$ GeV
- $\eta \to \gamma\gamma$ selection
  - $m(\gamma\gamma) \in [0.52;0.58]$ GeV
- kinematic fit w/ beam constraint (4C)
  - clear improvement of signal resolution

  tighter mass windows:

  $m(\gamma\gamma) \in [0.535;0.565]$ GeV

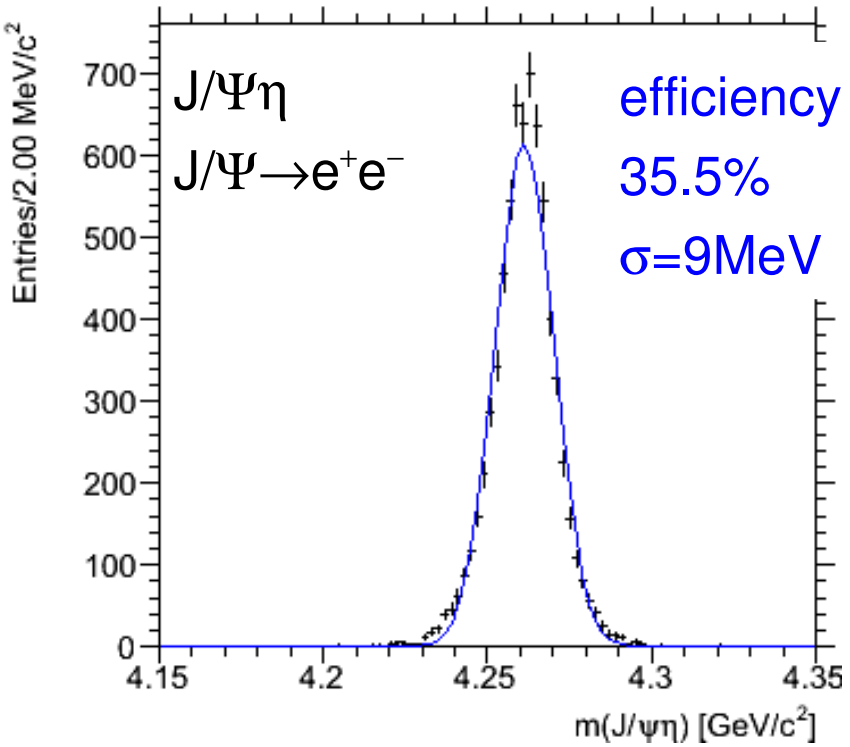
  $m(e^+e^-) \in [3.07;3.12]$ GeV





J/Ψη results

- additional J/Ψ and η mass constraint (6C fit)
  - accept only J/Ψη candidate w/ biggest CL>0.1% per event
- same strategy for $J/\Psi\to\mu^+\mu^-$ yields efficiency of 30.3%



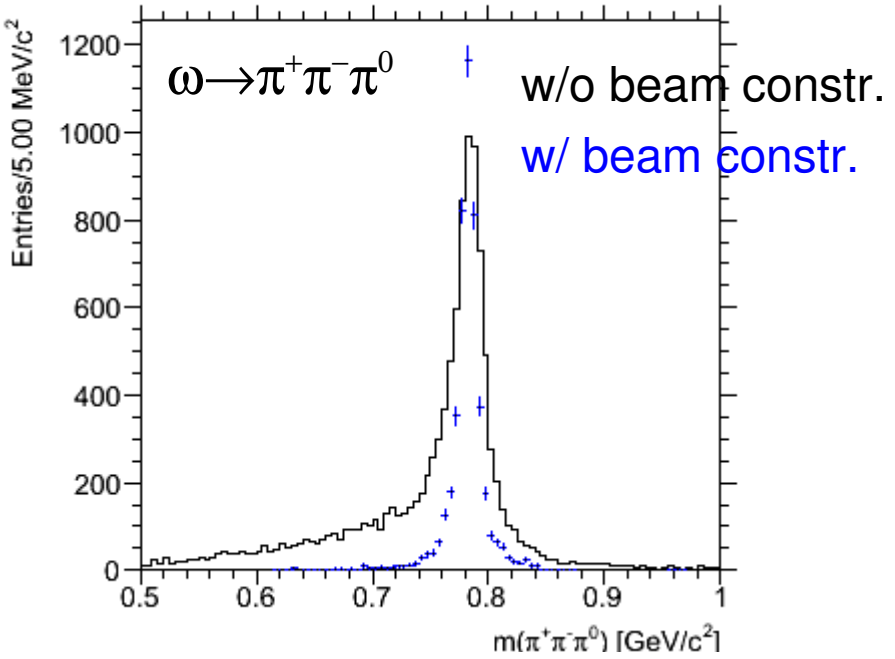
- background supression w/ [w/o] beam constr.
  - $J/\Psi\eta\eta$ ($\eta\to\gamma\gamma$): $<1.3\cdot10^{-6}$ [$1.1\cdot10^{-4}$]
  - $J/\Psi\eta\pi^0$ ($\eta\to\gamma\gamma$, $\pi^0\to\gamma\gamma$): $<2.7\cdot10^{-6}$ [$0.9\cdot10^{-4}$]
  - $J/\Psi\pi^0\pi^0$ ($\pi^0\to\gamma\gamma$): $<5.0\cdot10^{-5}$ [$2.0\cdot10^{-4}$]
  - $J/\Psi\eta\gamma$ ($\eta\to\gamma\gamma$): $3.9\cdot10^{-4}$ [$2.0\cdot10^{-3}$]
  - $J/\Psi\pi^0\gamma$ ($\pi^0\to\gamma\gamma$): $3.7\cdot10^{-4}$ [$1.8\cdot10^{-3}$]

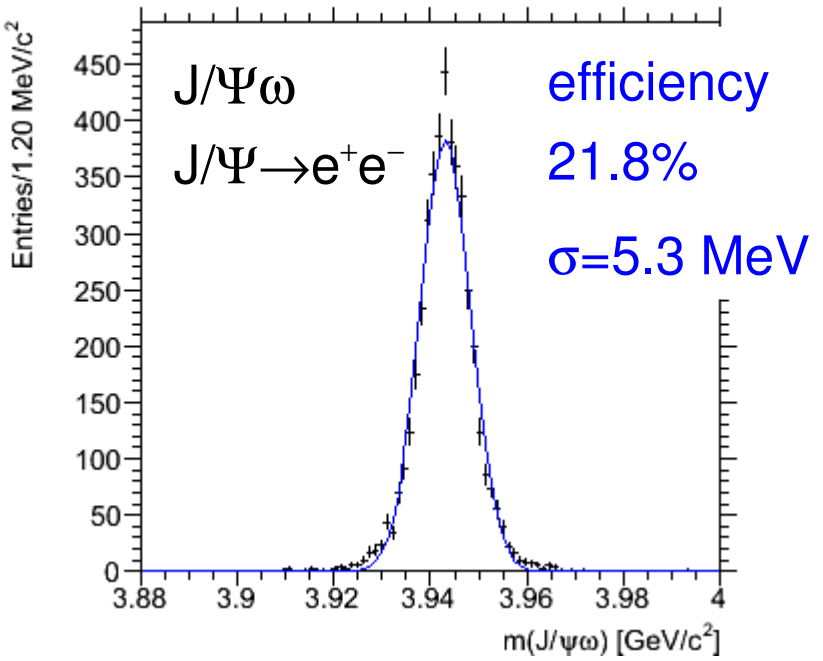
results from Dubna meeting:
efficiency ($J/\Psi\to e^+e^-$): 33%
resolution: 9.69 MeV

J/Ψω selection

- 20k J/Ψω events at Y(3940)
  - $J/\Psi \to e^+e^-$, $\omega \to \pi^+\pi^-\pi^0$
- $J/\Psi \to e^+e^-$ selection
  - PID: $p(e^+)>0.2$, $p(e^-)>0.85$
  - $m(e^+e^-) \in [2.98;3.16]$ GeV
- $\omega \to \pi^+\pi^-\pi^0$ selection
  - PID: $p(\pi^+)>0.2$, $m(\gamma\gamma) \in [115;150]$ MeV
- 6C fit: beam, J/Ψ and π^0 mass constraint
  - $m(e^+e^-) \in [3.07;3.12]$ GeV
  - J/Ψω cand. w/ biggest CL>0.1%

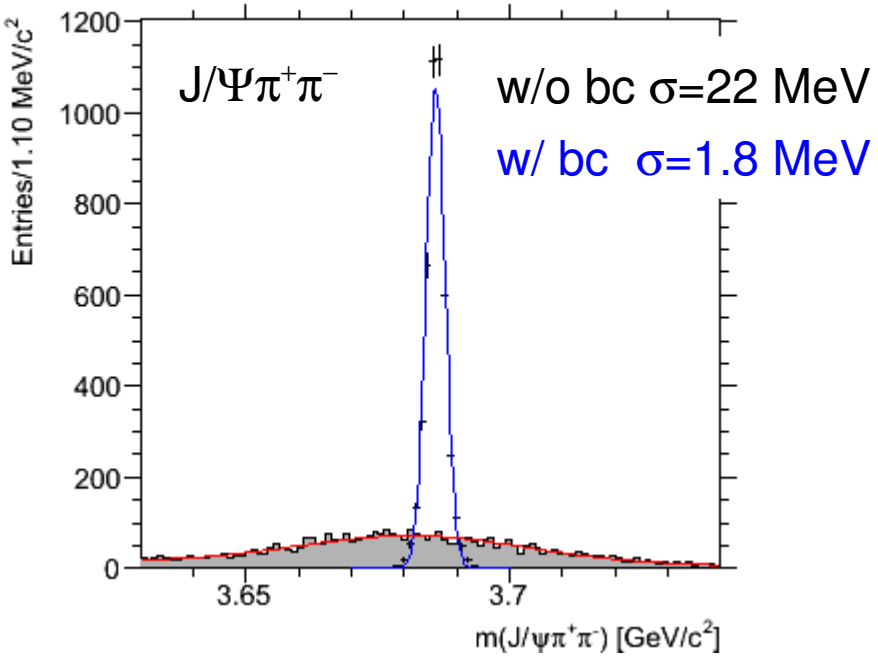
- same strategy for $J/\Psi \to \mu^+\mu^-$ yields efficiency of 16.8%

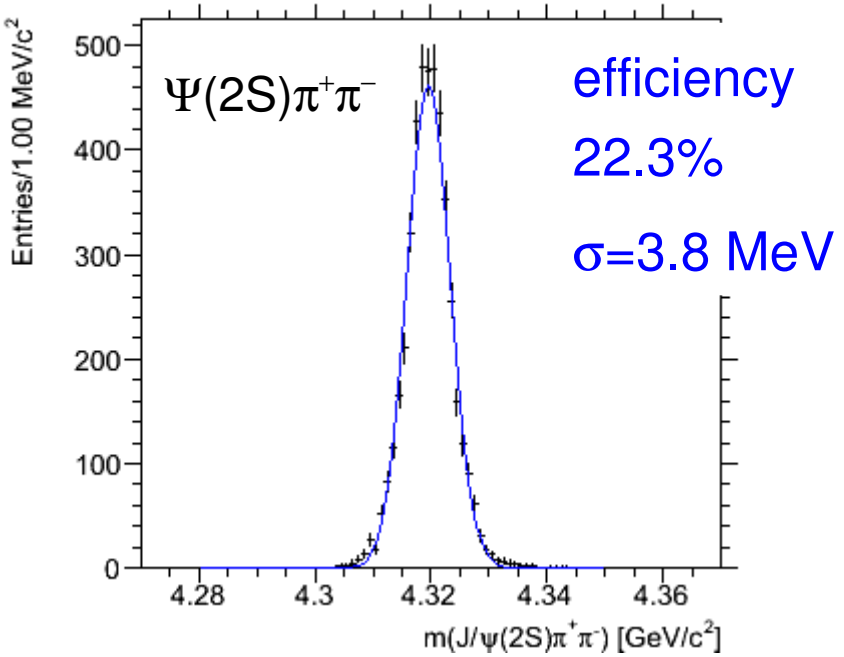




$\Psi(2S)\pi^+\pi^-$ selection

- 20k $\Psi(2S)\pi^+\pi^-$ events at Y(4320)
  - $\Psi(2S)\to J/\Psi\pi^+\pi^-$, $J/\Psi\to e^+e^-$
- $J/\Psi\to e^+e^-$ selection
  - PID: $p(e^+)>0.2$, $p(e^-)>0.85$
  - $m(e^+e^-)\in[2.98;3.16]$ GeV
- $\Psi(2S)\to J/\Psi\pi^+\pi^-$ selection
  - PID: $p(\pi^+)>0.2$
  - kinematic fit w/ J/Ψ mass constraint
- 6C fit: beam, J/Ψ and $\Psi(2S)$ mass constr.
  - $m(e^+e^-)\in[3.07;3.12]$ GeV
  - best candidate w/ CL>0.1%



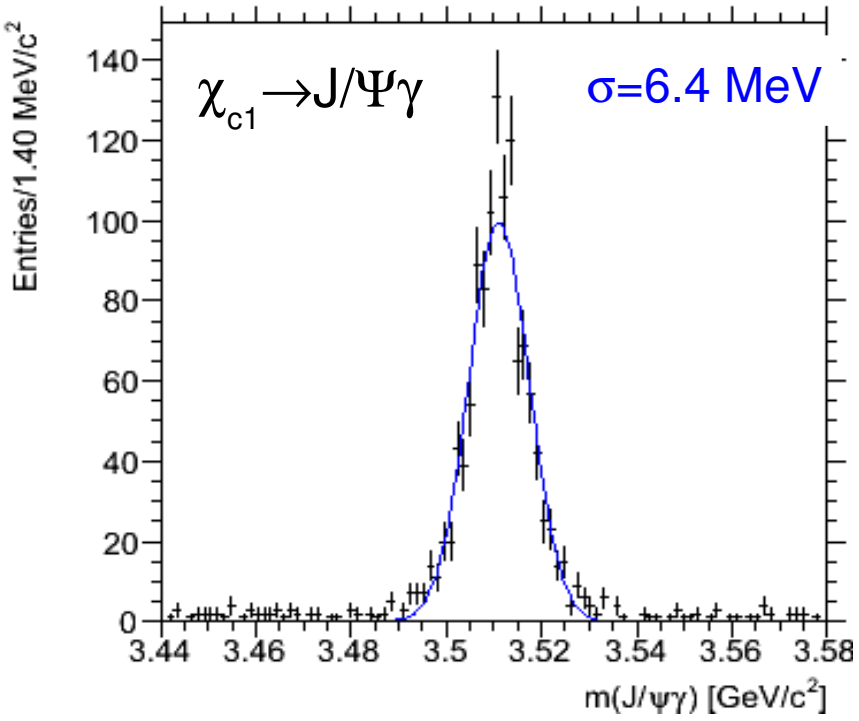


Charmonium hybrid

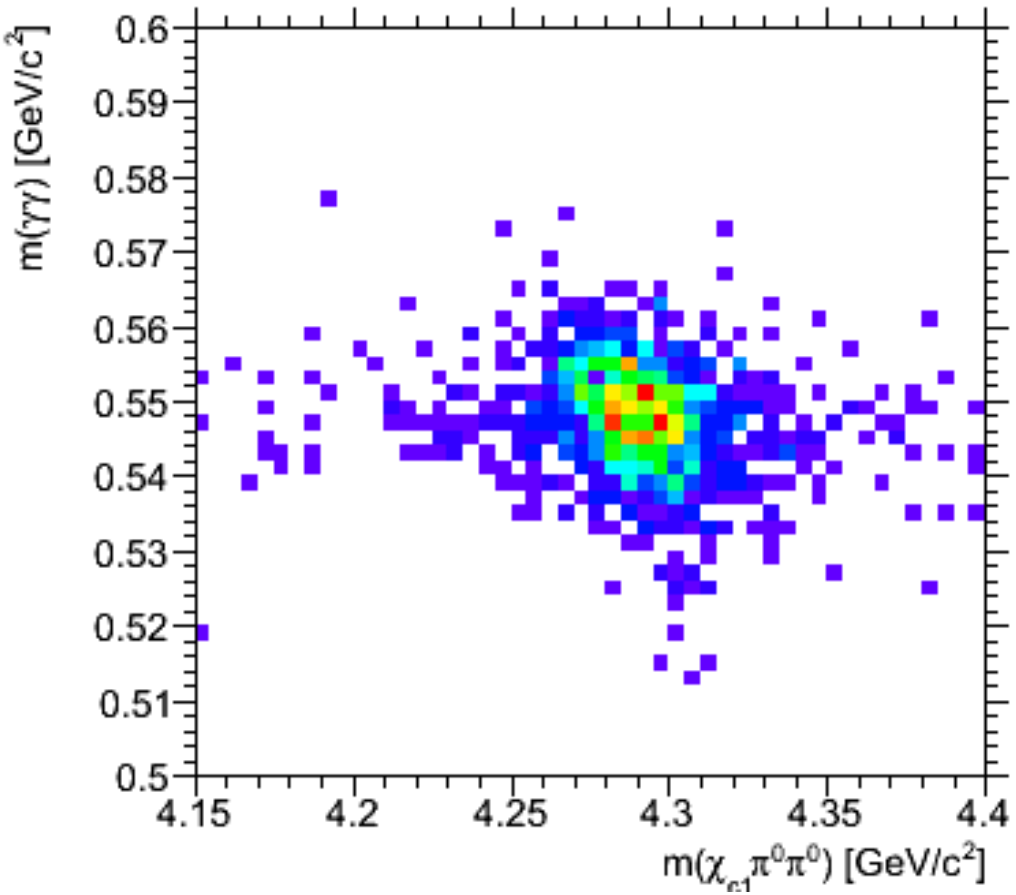
- hypothetical $J^{PC}=1^{-+}$ charmonium hybrid state Ψ
  - m=4290 MeV; Γ=20 MeV
  - production: $pp \rightarrow \Psi\eta$ at 15 GeV/c
  - decay modes: $\Psi \rightarrow \chi_{c1}\pi^0\pi^0$ and $\Psi \rightarrow D^0D^{0*}$

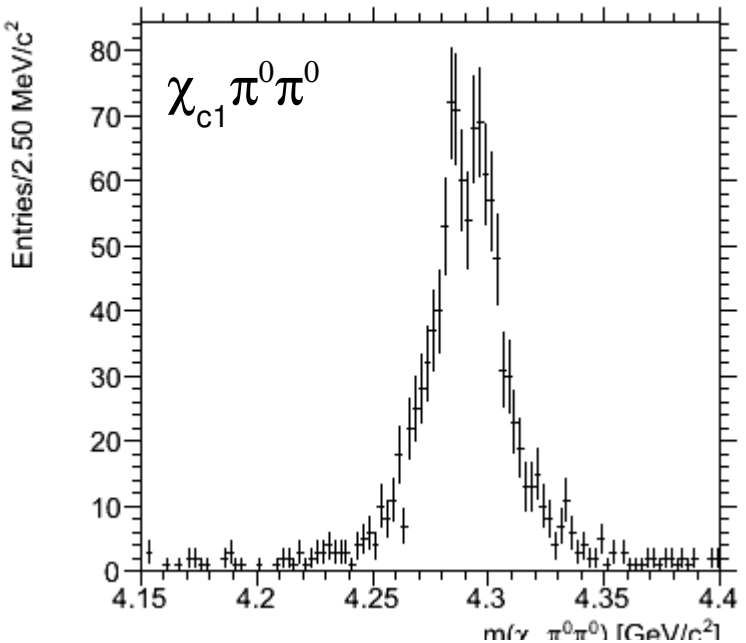
Charmonium hybrid: $(\chi_{c1}\pi^0\pi^0)\eta$

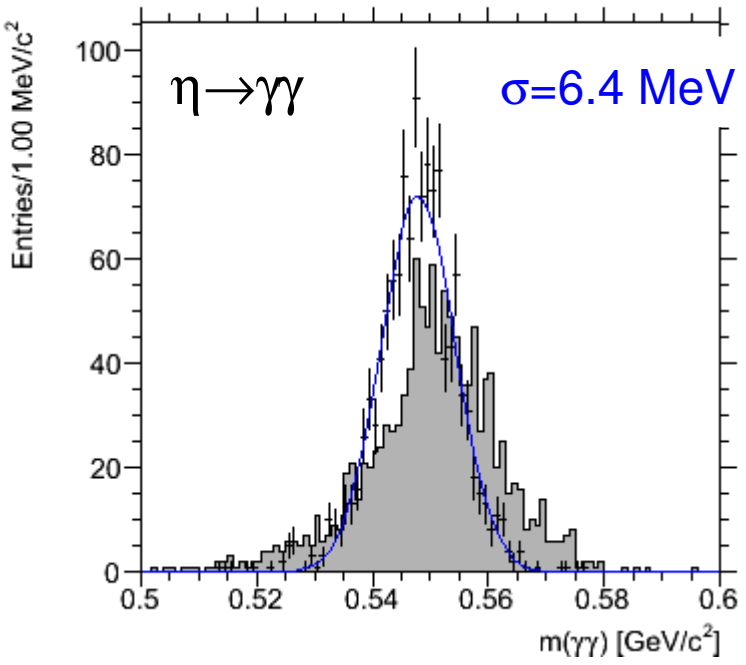
- 20k $\Psi\eta$ events at 15 GeV/c
  - $\Psi \to \chi_{c1}\pi^0\pi^0$, $\chi_{c1} \to J/\Psi\gamma$, $J/\Psi \to e^+e^-$, $\mu^+\mu^-$
- $J/\Psi \to e^+e^-$, $\mu^+\mu^-$ selection
  - electron PID: $p(e^+)>0.2$, $p(e^-)>0.85$
  - muon PID: $p(\mu^+)>0.2$, $p(\mu^-)>0.45$
  - $m(l^+l^-) \in [2.98;3.16]$ GeV
- $\chi_{c1} \to J/\Psi\gamma$ selection
  - $m(J/\Psi\gamma) \in [3.48;3.54]$ GeV
- π^0 / η mass windows
  - $m(\gamma\gamma) \in [115;150]$ and $m(\gamma\gamma) \in [530;565]$ MeV
- 9C fit: beam, η, χ_{c1}, J/Ψ and π^0 mass constraint
  - $(\chi_{c1}\pi^0\pi^0)\eta$ cand. w/ biggest CL>0.1%



Charmonium hybrid: $(\chi_{c1}\pi^0\pi^0)\eta$







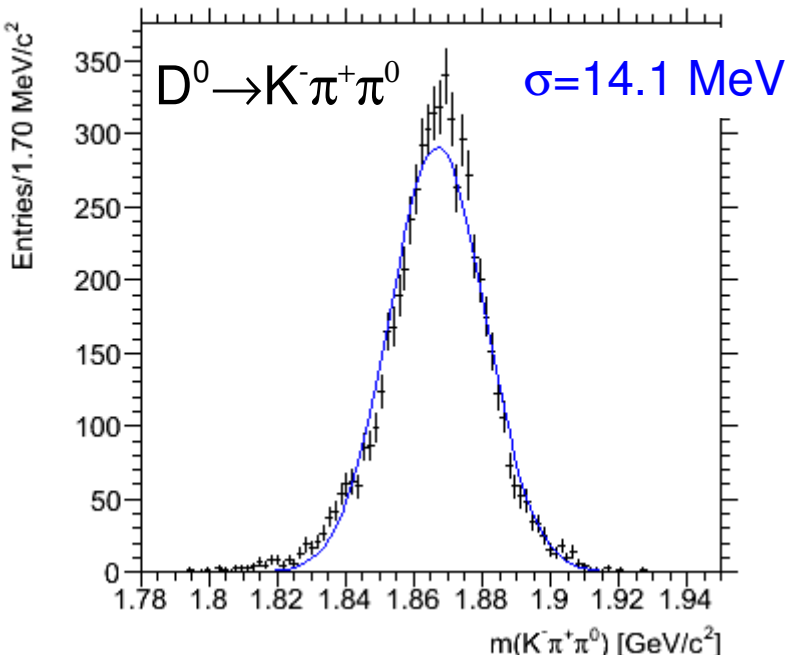
Efficiency ($J/\Psi\to e^+e^-$): 4.8%

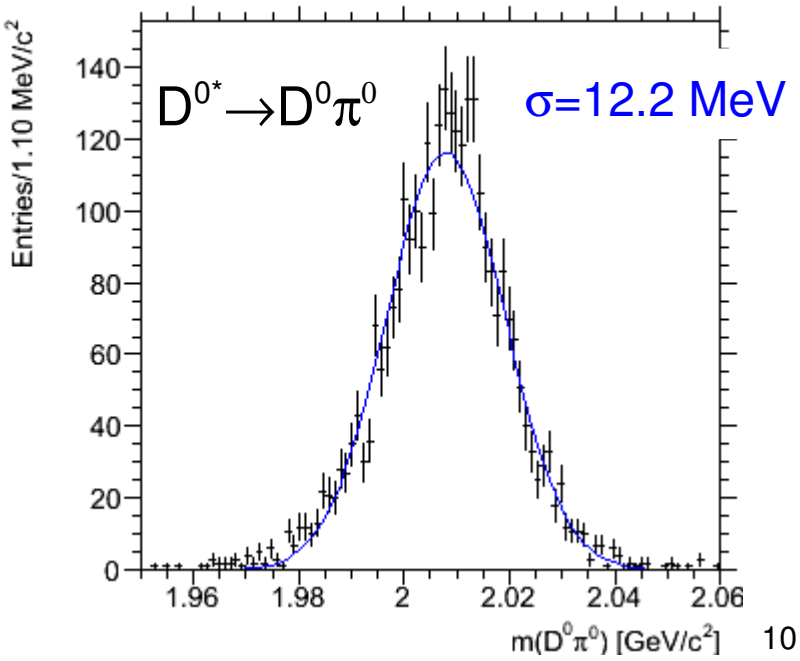
Efficiency ($J/\Psi\to \mu^+\mu^-$): 5.6%

result from Dubna meeting:
efficiency ($J/\Psi\to e^+e^-$): 3%

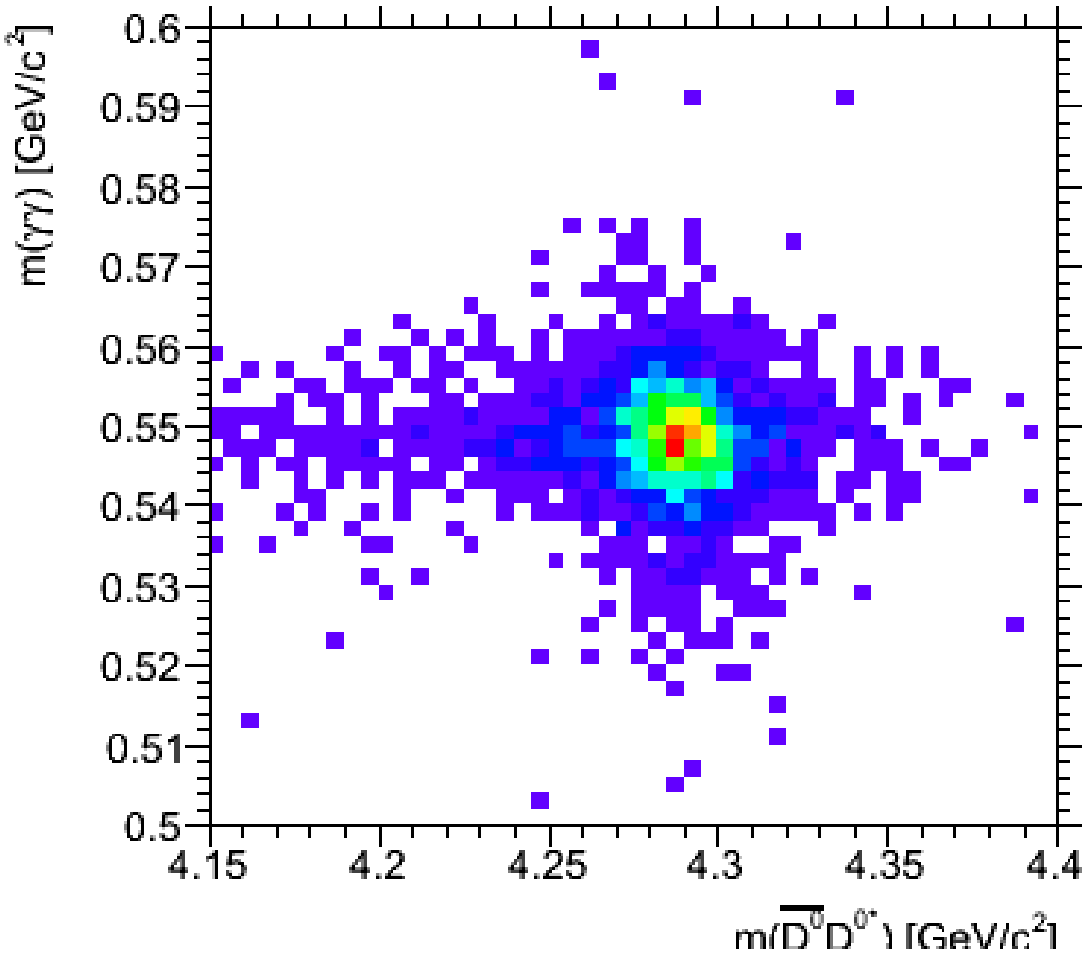
Charmonium hybrid: $(D^0D^{0*})\eta$

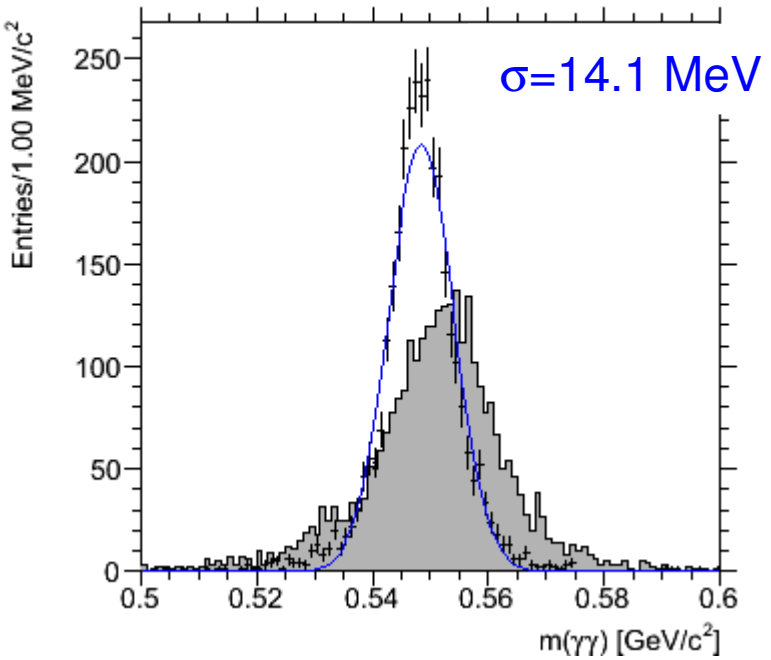
- 50k $\Psi\eta$ events at 15 GeV/c
  - $\Psi \to D^0D^{0*}$, $D^{0*} \to D^0\pi^0$, $D^0 \to K^-\pi^+\pi^0$, $\eta \to \gamma\gamma$
- $D^0 \to K^-\pi^+\pi^0$ selection
  - PID: $p(K^+)>0.2$, $p(\pi^+)>0.2$
  - kin. fit w/ π^0 mass constraint, CL>0.1%
  - $m(K^-\pi^+\pi^0) \in [1.79;1.93]$ GeV
- $D^{0*} \to D^0\pi^0$ selection
  - kin. fit w/ D^0 and π^0 mass constr., CL>0.1%
  - $m(D^0\pi^0) \in [1.95;2.05]$ GeV
- 11C fit: beam, D^0,D^{0*},π^0 and η mass constr.
  - $(D^0D^{0*})\eta$ cand. w/ biggest CL>0.1%

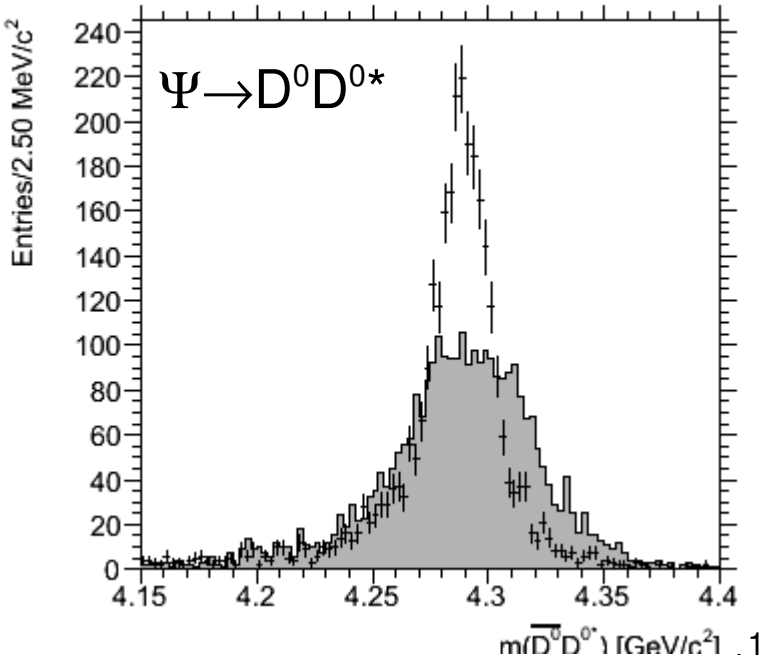




Charmonium hybrid: $(D^0D^{0*})\eta$







Efficiency: 5%

Expected signal entries

reconstructed signal events/day

assume: int. luminosity of 8pb^{-1}/ day and cross section of 1nb

$Y(4260)\rightarrow J/\Psi\eta$, $J/\Psi\rightarrow e^+e^-$: BR($Y(4260)\rightarrow J/\Psi\eta$)x 169 events/day

$J/\Psi\rightarrow \mu^+\mu^-$: BR($Y(4260)\rightarrow J/\Psi\eta$)x 144 events/day

$Y(3940)\rightarrow J/\Psi\omega$, $J/\Psi\rightarrow e^+e^-$: BR($Y(3940)\rightarrow J/\Psi\omega$)x 91 events/day

$J/\Psi\rightarrow \mu^+\mu^-$: BR($Y(3940)\rightarrow J/\Psi\omega$)x 70 events/day

$Y(4320)\rightarrow \Psi(2S)\pi^+\pi^-$, $J/\Psi\rightarrow e^+e^-$: BR($Y(4320)\rightarrow \Psi(2S)\pi^+\pi^-$)x 34 events/day

$pp\rightarrow(\chi_{c1}\pi^0\pi^0)\eta$, $J/\Psi\rightarrow e^+e^-$: BR($\Psi\rightarrow\chi_{c1}\pi^0\pi^0$)x 3.1 events/day

$J/\Psi\rightarrow \mu^+\mu^-$: BR($\Psi\rightarrow\chi_{c1}\pi^0\pi^0$)x 3.6 events/day

$pp\rightarrow(D^0D^{0*})\eta$: BR($\Psi\rightarrow D^0D^{0*}$)x 1.9 events/day

Summary

- signal (and first background) studies
  - charmonium spectroscopy: $J/\Psi\eta$
  - exotics: $J/\Psi\omega$, $\Psi(2S)\pi^+\pi^-$, $\Psi\eta$ ($\Psi\to\chi_{c1}\pi^0\pi^0$ / $\Psi\to DD^*$)
- improvements since Dubna meeting
  - tracking in forward spectrometer
  - muon identification (addition of $J/\Psi\to\mu^+\mu^-$)
  - beam constraint (4C) fit (including photon candidates)
- to do
  - expected signal for $pp\to\Psi\eta$ very low
    - addition of further D^0 and D^{0*} decay modes?
  - background studies (i.e. DPM events)