J/ψ-pair events at NICA SPD

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SPD Physics and MC meeting

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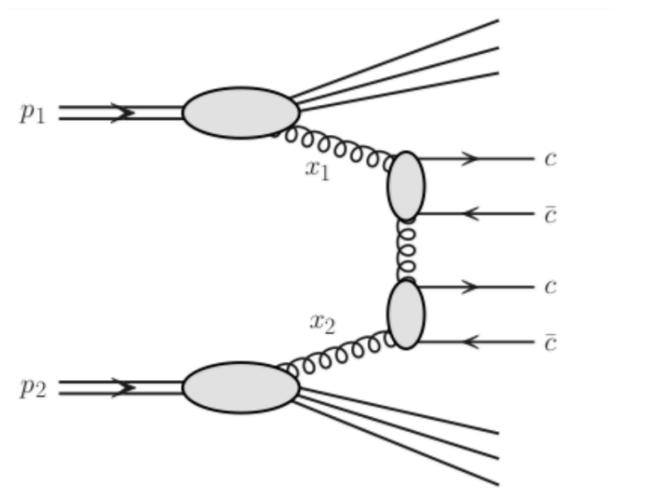
J/ψ pair production

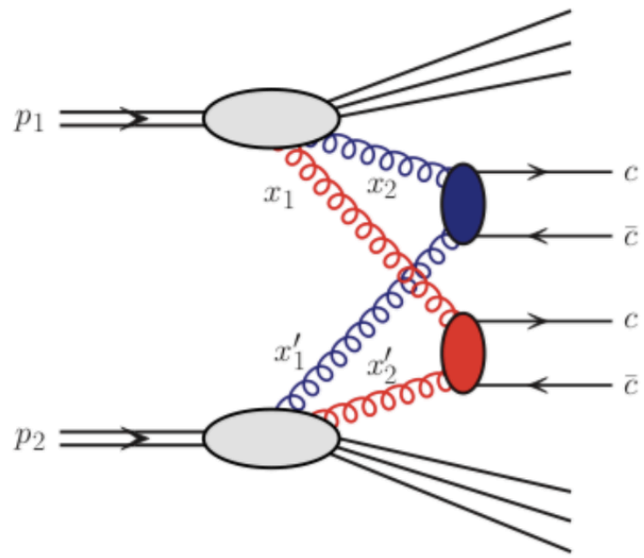
The process $p + p \rightarrow J/\psi J/\psi + X$ could be used to study different physics topics:

- Production mechanisms

Single Parton scattering

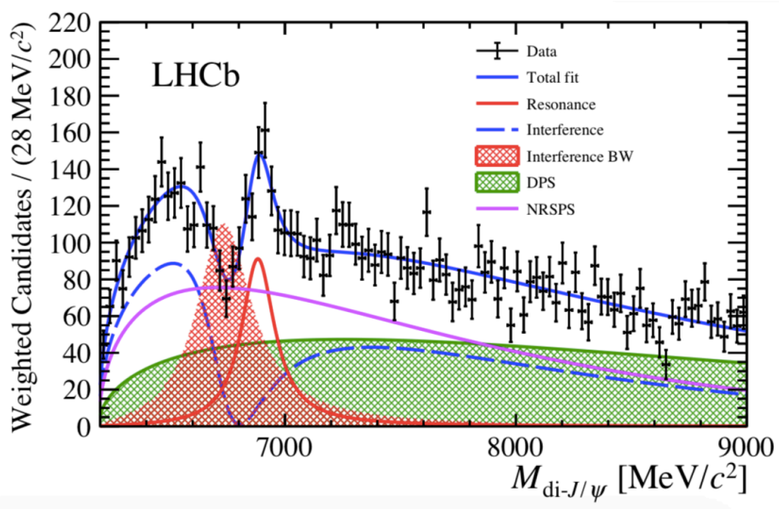


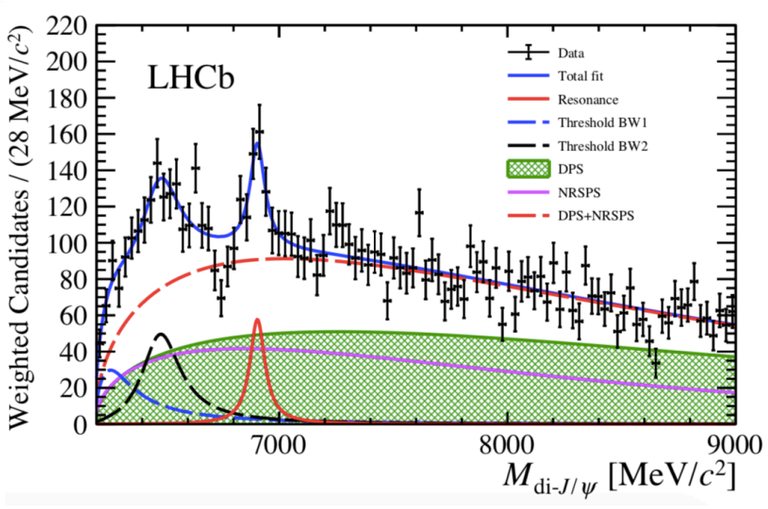
Double Parton scattering



Sci. Bull., V65, №23, p1983-1993 (2020)

- All charm tetraquarks

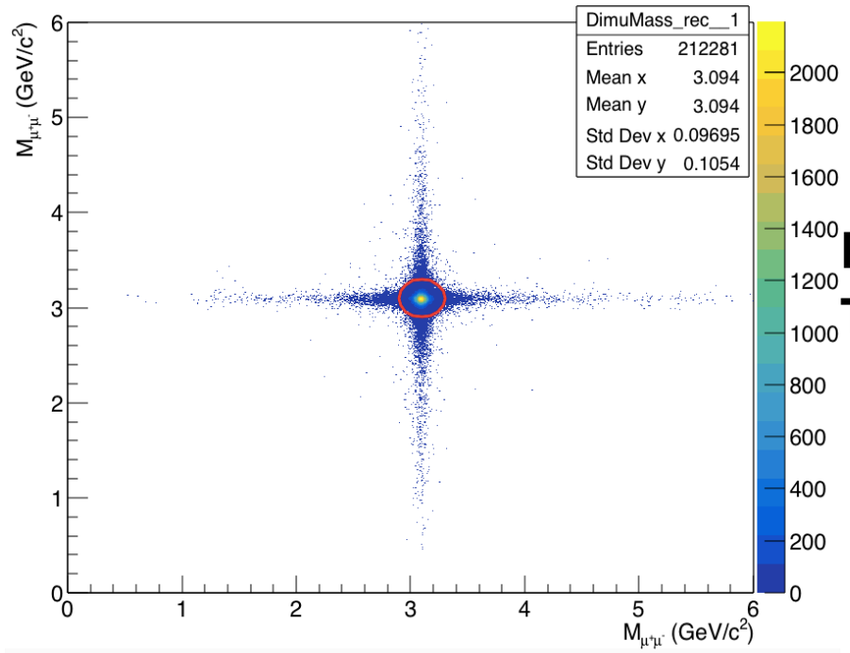




- Angular distributions (Boer-Mulders function)

Preliminary results were shown on SPD Physics and MC meeting #15
https://indico.jinr.ru/event/2332/contributions/13434/attachments/10655/17459/2jpsi_spd_07072021.pdf

Selection criteria



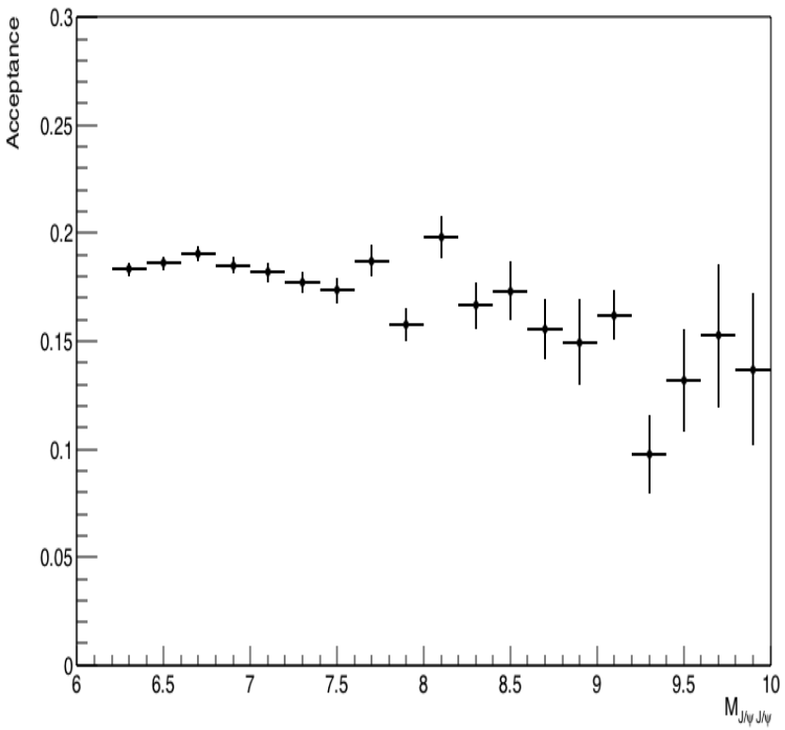
Pythia8 (Color Singlet model) was used for simulation of J/ψ pair events. The size of the generated sample is about 100k events.

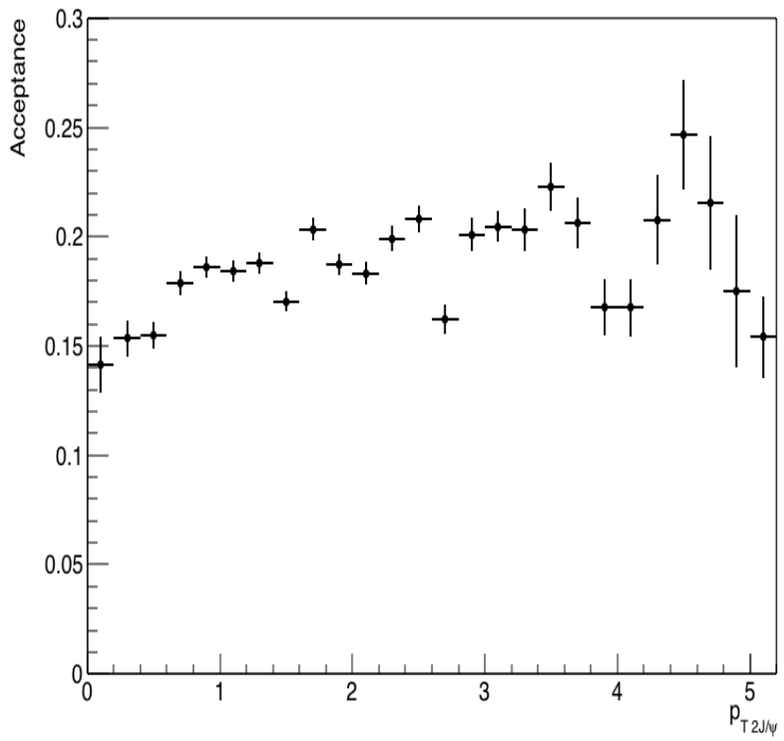
$\Delta M < 0.2\ GeV/c^2$	IsFittedOk	IsGood	IsAcceptable	All
$A_{2J/\psi}$	0.96	0.96	0.57	0.35	0.18

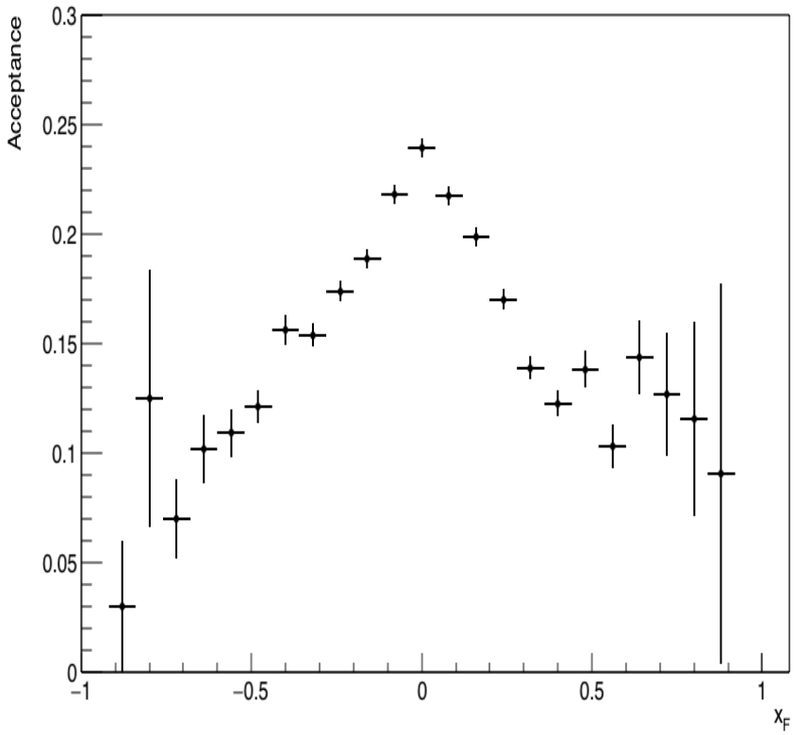
```
inline Bool_t SpdTrackFitPar::GetIsFittedOk() const
{
    if (fErrorFlag != 0) return false;
    if (!fFirstState) return false;
    if (!fLastState) return false;
    return true;
}

//-------------------------------------------------------
inline Bool_t SpdTrackFitPar::GetIsGood() const
{
    if (fErrorFlag != 0) return false;
    if (HasErrorMesg()) return false;
    //if (fNFailedHits > 0) return false;
    if (fConvergencyGF != 1) return false;
    return true;
}

//-------------------------------------------------------
inline Bool_t SpdTrackFitPar::GetIsAcceptable() const
{
    if (fErrorFlag != 0) return false;
    if (HasErrorMesg()) return false;
    //if (fNFailedHits > 0) return false;
    if (fNDF < 3) return false;
    if (GetChi2overNDF() < 2) return true;
    return false;
}
```

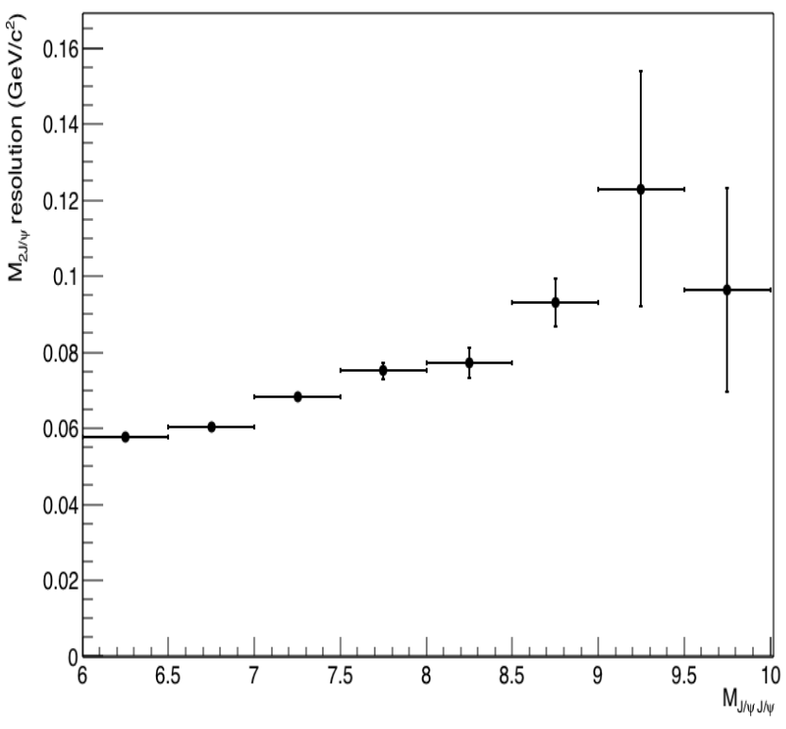
- The flags could be used in other SPDroot examples ($J/\psi \to \mu\mu, J/\psi \to ee, \chi_c \to J/\psi\gamma$).
- The $A_{2J/\psi} \approx 0.18$ is expected in a real experiment.

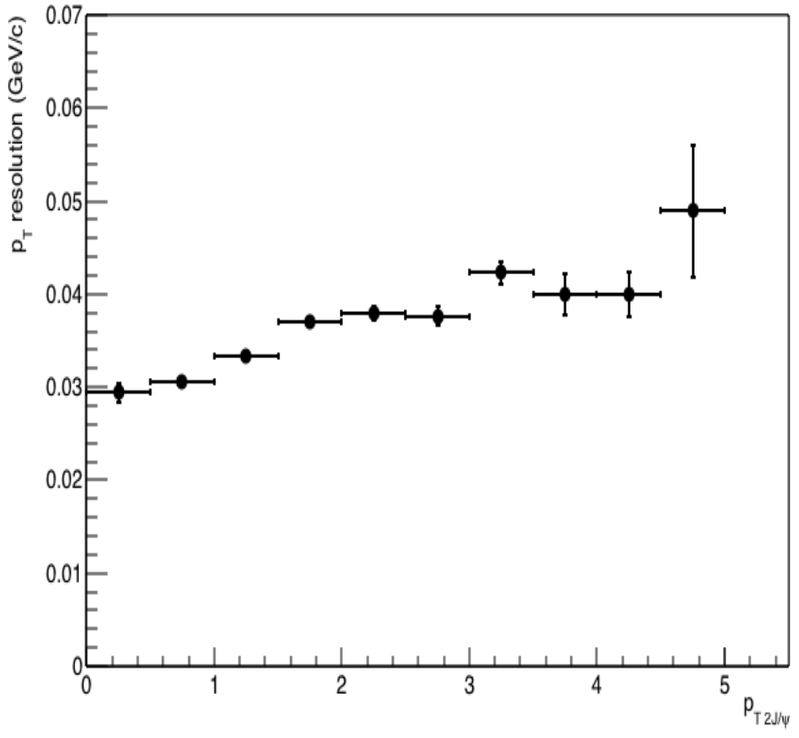
Acceptances and resolutions



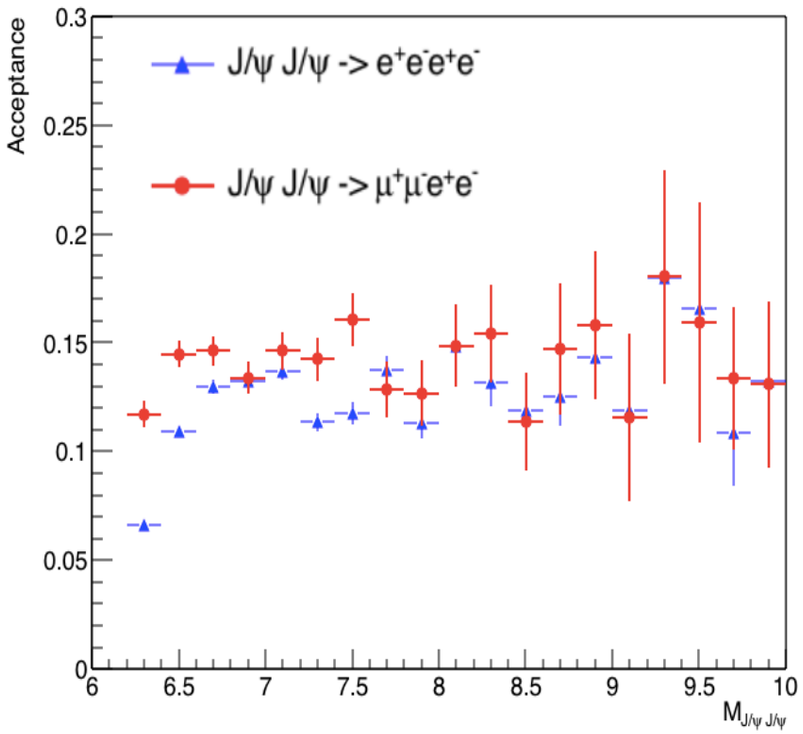


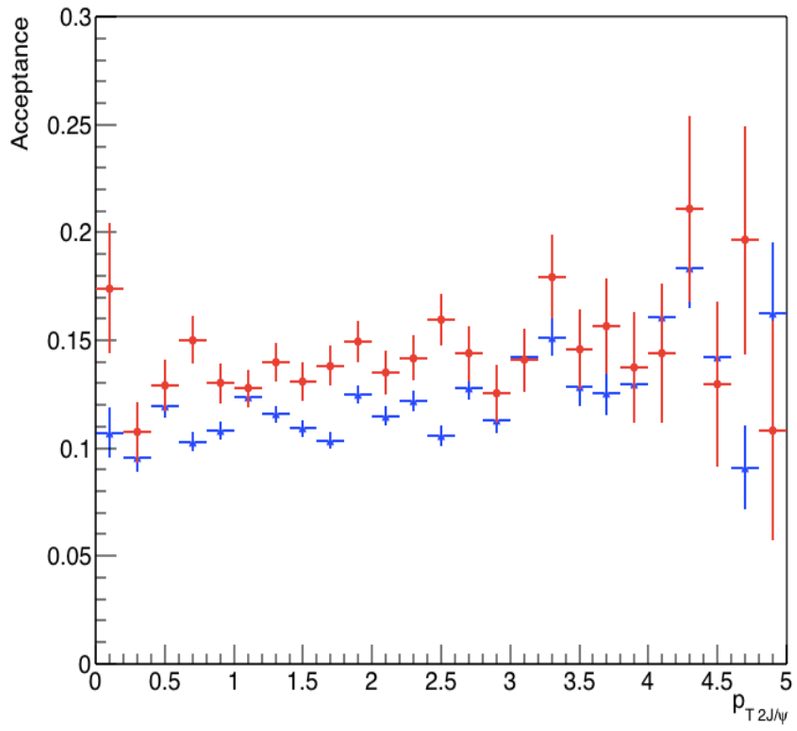


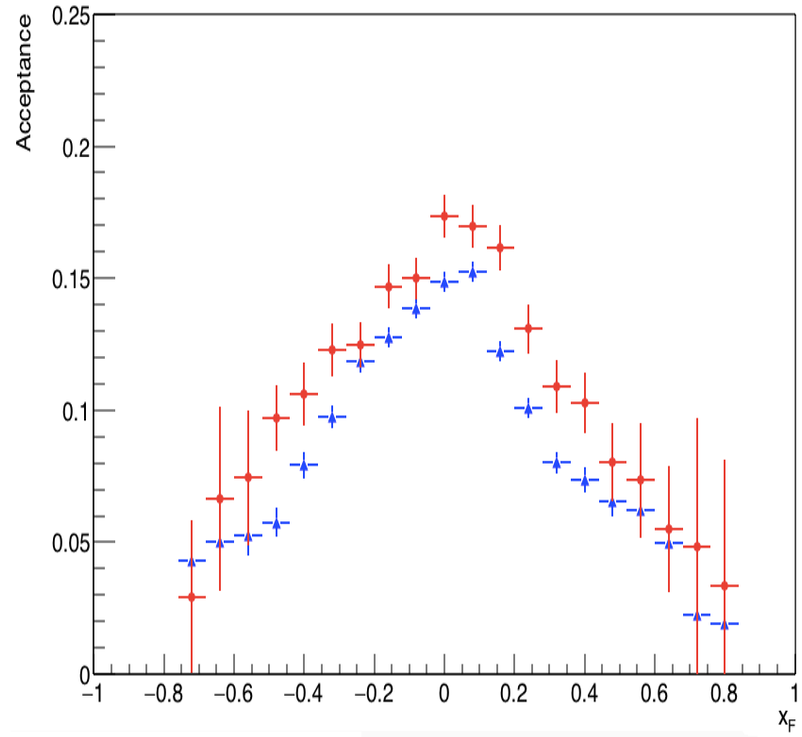


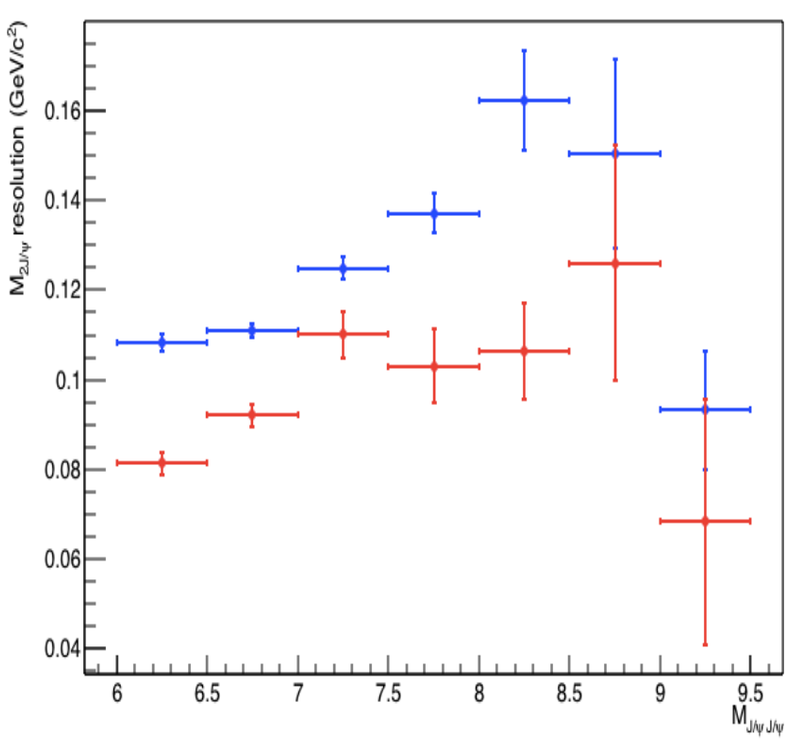


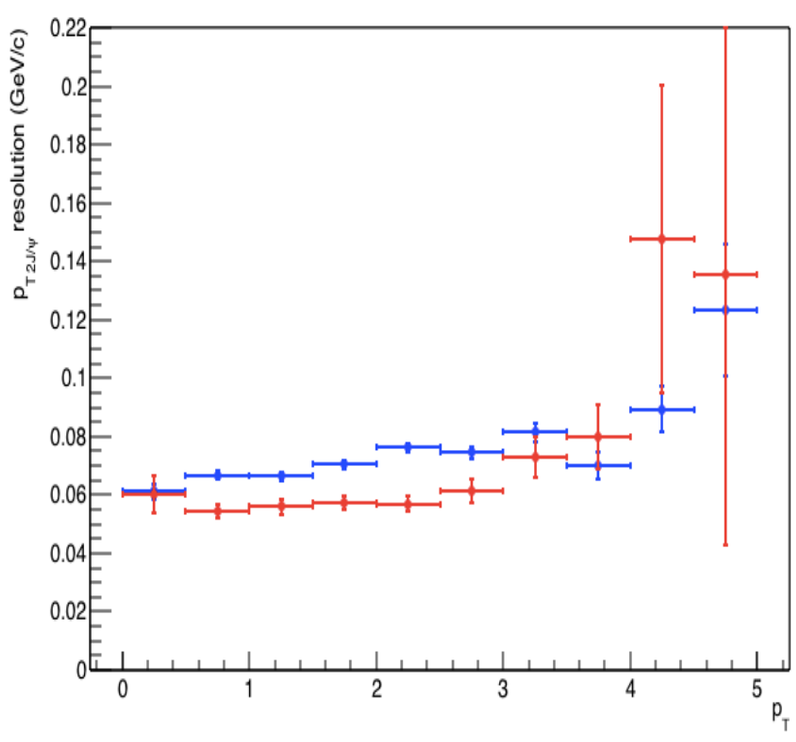
e^+e^- channel





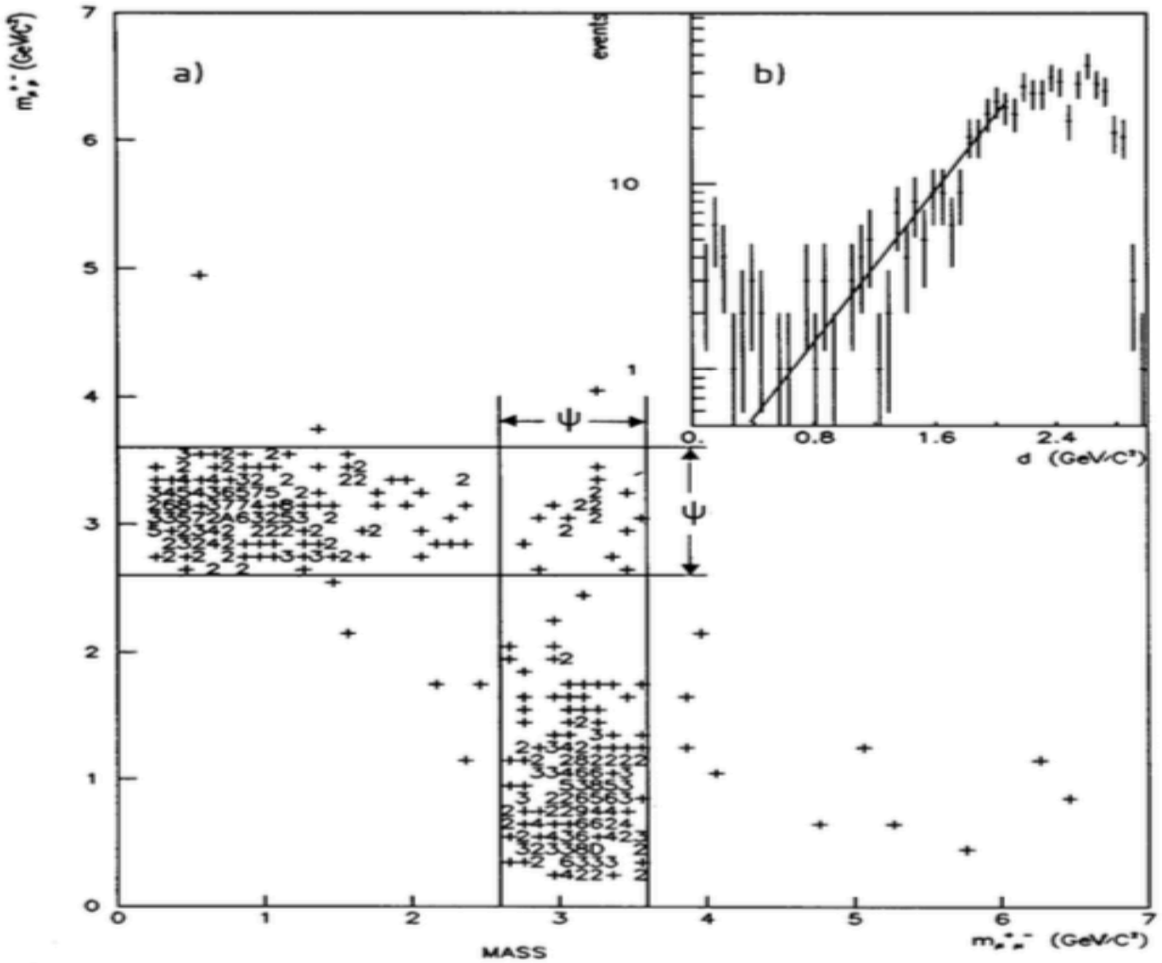






The average acceptance is 0.14 for $\mu^+\mu^-e^+e^-$ channel and 0.11 for $e^+e^-e^+e^-$ channel.

Signal / background ratio



NA3 (1984, p beam, $\sqrt{s} = 27$ GeV):

21 candidates of J/ψ pair events

Background: 6 ± 4

Signal: 15 ± 4

Phys, Lett. 124B (1983) 265

Number of expected J/ψ pair events assuming $A_{2J/\psi} = 1$ and realistic acceptance

$J/\psi J/\psi \to \mu\mu\mu\mu$	100	18
$J/\psi J/\psi \to \mu\mu ee$	100	14
$J/\psi J/\psi \to eeee$	100	11

Main sources of background:

- Combinatorial background
- Pileup
- B-mesons decays.

J/ψ, $\psi(2S)$ and χ_c pair production

	Estimated acceptance
$J/\psi\psi(2S)$	**< 1 %**
$\psi(2S)\psi(2S)$	**< 1 %**
$J/\psi\chi_c$	**17 %**
$\chi_c\chi_c$	**16 %**

- J/ψ and $\psi(2S)$ were simulated by Pythia8 in SPDroot. The acceptance is low because of pion track reconstruction.
- Only the estimation of acceptance for $J/\psi\chi_c$ and $\chi_c\chi_c$ is provided. To simulate such events in SPDroot one needs to provide events as an ascii file.

Summary

- Realistic acceptance for J/ψ pair events is taken into account.

- e^+e^- channel could be used for J/ψ pair events reconstruction. But, even taking these channels into account we will be able to collect up to 50 J/ψ pair events per year.

- There is no sense to reconstruct $\psi(2S)$ states, but $J/\psi\chi_c$ and $\chi_c\chi_c$ looks promising.