Charm production at RHIC energy

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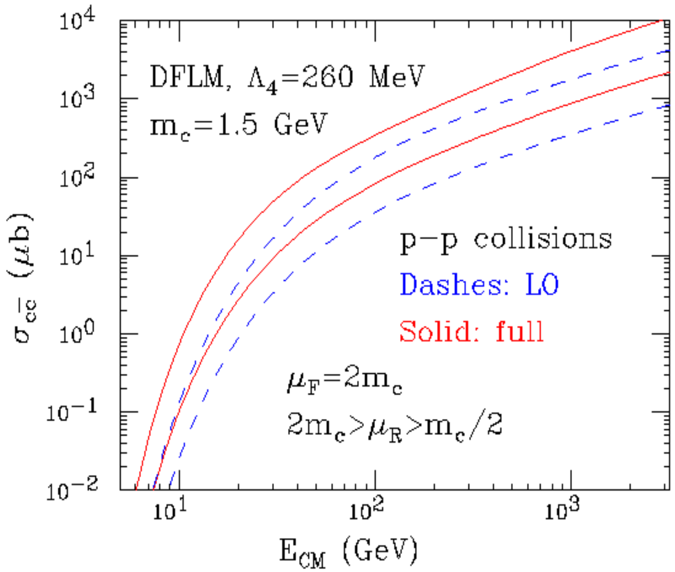
Charm production at RHIC

- Charm production at RHIC is very important
  - It is interesting by itself
    - pQCD
    - Gluon shadowing
    - Pre-equilibrium prodution
    - Thermal production
    - Energy loss effect in QGP
    - Big “enhancement” observed by NA50 (?)
  - A major background for lepton pairs in 1-10 GeV region
  - Base line for J/Psi suppression
- To understand Charm in RHIC A+A, we need to know charm cross section in p+p at RHIC energy
- Q: Do we know the cross section
  - Short answer: NO, not at all.
  - Long answer: ---- this talk.

QCD prediction on charm production

- There is NLO calculation of charm production.

  Nason, Dawson, and Ellis.NPB327,49;
  Mangano, Nason, and Ridorfi. NPB373,295
  MNR HVQlib software
- Large uncertainty from Mc, QCD scale, PDF. The applicability of pQCD is also at the edge because of small c quark mass.
- The data seems to be at the upper edge of the prediction.
- Predicts σ_{cc} = 200 to 600 μb at RHIC energy.



NLO charm cross section
(P.Nason, CTEQ98)

Charm production data

- No “good” data at ISR and above
  - Results from ISR are wildly different by experiment
  - No direct, inclusive measurement at SpS collider and Tevatron
    - UA2 measured single electrons in 1-2 GeV region
    - UA1 reports signals of charmed hadrons
    - CDF measured γ+D* at high pt
- Data in proton and pion beams at FNAL and CERN
  - Direct measurements (Emulsion, bubble chamber, Si-VTX)
  - Indirect measurements (single lepton, lepton+missing E, etc)
  - Measurement with special trigger (lepton tag, D* tag, etc)
- Many many reviews on this subjects (list only a few)
  - S. P. K. Tavernier, Rep. Prog. Phys. 50 (1987) 1439
  - J. A. Appel, Annu. Rev. Nucl. Part. Sci. 42 (1992) 367
  - Frixione, Mangano, Nason, and Ridolfi, hep-ph/9702287

Charm production data in proton induced reactions

Direct measurements

experiment	plab	Target	measured σ (μb/nucleon)	σ_{cc} (μb)(*3)
NA25(ZPC36,577)	200	C_3F_8	σ(charm)=3.6+2.3-1.7(*1)	3.6+2.3-1.7
NA32(ZPC39,451)	200	Si	σ(all D,x_F>0)=1.5±0.7±0.1	1.5±0.7
E769(PRL77,2388)	250	Be,Al,Cu,W	D^+ σ(x_F>0)=3.3±0.4±0.3	13.5±3
			D^0 σ(x_F>0)=5.7±1.3±0.5	
			D^{*+} σ(x_F>0)=1.8±0.6±0.2	
NA25(ZPC36,577)	360	C_3F_8	σ(charm)=23.3+10-7.7(*1)	23.3+10-7.7
NA16(PLB135,237)	360	p	D^+ σ(x_F>0)=5.3+2.4-1.6	23±12
			D^0 σ(x_F>0)=10.2+7.9-4.3	
NA27(PLB189,476)	400	p	D^+ σ(all x_F)=11.9±1.5	22.6±4.4
(also in ZPC40,321)			D^0 σ(all x_F)=18.3±2.5	
E743(PRL61,2185)	800	p	D^+ σ(all x_F)=26±4±6	36±13±12
			D^0 σ(all x_F)=22+9-7±5	
E653(PLB263,573)	800	Emulsion	D^+ σ(all x_F)=38±9±14	57±14±21
			D^0 σ(all x_F)=38±3±13	
E789(PRL72,2542)	800	Be,Au	D^0 dσ/dx_F = 58±3±7	
			D^0 σ(all x_F)=17.7±0.9±3.4 (*2)	27±5?

*1: assume production ratio (D^0 : D^+ :D_s:Λ_c) to obtain efficiency

*2: extrapolation to all x_F and p_t from 0< x_F <0.08 and p_t<1.1GeV/c

3: 1.5(D^++D^0)

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"predictions" at RHIC

- R. Vogt (Int. J. Mod. Phys. A10): 350 μb
  - obtained by "fitting" NLO charm cross section to the experimental data at FNAL and SPS
- Salcevic(PRC51,1433): 200 μb
  - Obtained by NLO charm cross section with m_c=1.5 and $\mu = m_c$. When her calculation is compared with the experimental data, the calculation appears to be lower by factor 2 to 3.
- PYTHIA
  - 90 μb with default setting (CTEQ2L PDF) and charm production switch
  - 150 μb with default if charm content in inclusive jet is calculated
  - 200 μb with GRV94 PDF and charm production switch
  - BraunMinzinger et al(EPJC1(1998)123 observed that PYTHIA reproduces FNAL and SPS charm cross section well if K factor=5 is applied.

Uncertainties in Au+Au at RHIC

- Gluon shadowing
  - Can reduce charm cross section per N+N collisions by factor 2
- Pre-equilibrium parton gas contribution
  - Can increase charm cross section by factor 2 if sufficiently high initial temperature is achieved
- Energy loss effect
  - Strong influence on pt distribution of charm particle

Conclusion

- Charm cross section at RHIC can be anywhere between 150 μb to 600 μb
- There is too much uncertainty in NLO charm cross section and PDF
- The data from FNAL and SPS fixed target experiments seems to prefer upper edge of NLO prediction. But those data really do not help to reduce the uncertainty as the errors in the data are also large.
- My guess --- about 400 μb
- It is absolutely necessary to measure the cross section in p+p at the RHIC energy
- A similar situation exists for J/Psi cross section as well.