# E760-E835 legacy

ppbar to charmonium is good for:

a) precise determination of KNOWN states:

- mass measurements at ~100 keV level
- total width measurements (ideal for narrow states)
  (see Stancari's talk on Wednesday)

b) through the detection of:

EM final states ( e.g.: electrons and photons)

few body final states

# E760-E835 legacy /2

ppbar to charmonium was limited by :
- non hermeticity of the detector
- low energy photon threshold : 20 MeV
- calorimeter granularity:
- multiple scattering for tracks below 1 GeV
- physical occupancy of the jet target
- 2x extra rate induced by e-antiproton interactions
- no momentum measurement on hadrons (no magnet)

# Physics priorities

$J^{PC}$ of newly discovered states (*)

Precise mass determination (especially for states close to open charm thresholds)

Total width determination through resonance scans

Partial decay widths (complementary measure)

(*) I will focus on OBSERVED decay modes: $\psi\gamma$, $\psi$ + pions, $D\bar{D}$

# PANDA physics cases

Already thoroughly discussed (see YR):

- $h_c$ width
- $\chi_c$ radiative angular distributions : M2/E1
- $\eta_c(2s)$ radiative widths: $\gamma\psi$(M1 hindered), $\gamma h_c$(E1)

New puzzles:

- the nature of X(3872)
- how many states lie in the 3930-3940 range ?
- the window at 4260-4290

# Physics case

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- $h_c$ width
- $\chi_c$ radiative angular distributions : M2/E1
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New puzzles:

- $\eta_c(1s)$ line shape
- the nature of X(3872/5)
- the X,Y,Z zoo in 3930-3940 range
- the window at 4260-4290

# DD* Threshold at 3.872 GeV

Investigations on X(3872):

$\psi\pi^+\pi^-$ , $\psi\pi^0\pi^0$ ,

$\psi\gamma$ , $\psi'\gamma$

$\psi''\omega''$ : $\psi\gamma\pi^0$,$\psi\pi^0\pi^+\pi^-$

All these channels do not need a magnetic detector

Cherenkov+ECAL for trigger

Background from continuum with 4-5 pions

# Doublet of states at 3.875 GeV

Investigations on X(3875):

$D^o\bar{D}^o\pi^o$ , $D^o\bar{D}^o\gamma$

Slowly moving D mesons vertices merge

dE/dX + good momentum resolution to see D peak

Background from continuum with 4-5 pions

# X,Y,Z zoo at 3.93 GeV

Investigations on X,Y,Z states around 3930-3940:

$\psi\,\omega$ : $\psi\gamma\pi^0, \psi\pi^0\pi^+\pi^-$

Scan across the whole region to measure widths
Disentangling of all JPC through angular distribution analysis

# Can we really form higher onia from ppbar?

*Is the $M^{-8}$ scaling dooming higher onia?*

$\Gamma(0^{-+} \rightarrow p\bar{p})$: 20 keV (2980), 4 keV (3630), 2keV(3940)

$\Gamma(0^{++} \rightarrow p\bar{p})$: 2 keV (3415) , 0.6-0.7 keV (3900-3940)

$\Gamma(1^{++} \rightarrow p\bar{p})$ : 60 eV (3510) , 30 eV (3870)

$\Gamma(2^{++} \rightarrow p\bar{p})$: 150 eV(3556) , 66 eV (3930)

# Can we really form higher onia from ppbar?

*What peak cross section can we expect?*

*BR(X,Y,Z $\to p\bar{p}$) ~ $10^{-5}$ , BR(X,Y,Z $\to \psi$+...) ~ 5%,*

$\sigma(p\bar{p} \to 0^{-+} \to \psi + ...)$: 0 (2980), <1pb (3630), 12pb(3940)

$\sigma(p\bar{p} \to 0^{++} \to \psi + ...)$: 120 pb (3415) , 12pb (3900-3940)

$\sigma(p\bar{p} \to 1^{++} \to \psi + ...)$ :2 nb (3510) , 40 pb (3870)

$\sigma(p\bar{p} \to 2^{++} \to \psi + ...)$: 2.2 nb(3556) , 60 pb (3930)