

HELMHOLTZ | GEMEINSCHA Helmholtz-Institut Mainz

Online Software Trigger @ PANDA

Donghee Kang

Institut für Kernphysik, Universität Mainz



Group meeting, 28. May. 2012





Trigger basic

Level 1 trigger hardware-based

- fastest, keep up full event production in Front-End-Electronics (FEEs)
- discriminate highly in specific hardware : FPGAs & ASIC
- L1 trigger decision sensitive to beam-generated backgrounds

Level 2 trigger mixture of hardware & software

- Level 1 information plus readout from slower detector systems
- Longer processing time, fewer events
- Trigger using fast reconstruction algorithms on particle identification, energy deposits, coincidence, multiplicity, vertexing etc.

Level 3 trigger software-based

- Done on PC's with CPU processes
- Full detector cross-checking
- Errors and incomplete events evaluate with simplified calibrations and geometry
- Output to storage media for physics analysis





Trigger basic

General consideration

- L2 trigger level is being integrated into L1 trigger improvement of network speed and processing time
- Trigger algorithms are generally optimized for specific detectors and experiments
 no common way

• Parameters

- background reduction rates physics signature - is the interesting events surely safe? processing time
- Main key feature for trigger development lies on

fast response detector systems good capacity of electronics in hardware efficient & fast track finding algorithms in software





Trigger in PANDA

HELMHOLTZ GEMEINSCHAFT Helmholtz-Institut Mainz

What is the challenging of online software trigger in PANDA?

• high event rate : 20 ~ 100 MHz ($N = \sigma \cdot L$)

20 MHz average rate = 1 event in every 50 ns

- no first level hardware trigger : continuous data stream
- only online software trigger in high level!
- data sorted by time stamp but no start time t₀ from any detector
- high level software trigger require reconstruction and pattern recognition to be performed online, analyzing data streams under real time condition





PANDA DAQ

HELMHOLTZ GEMEINSCHAFT Helmholtz-Institut Mainz

DAQ concept in PANDA



• Online software trigger means

event building with track finding algorithms

event selection with background rejection algorithms

should be performed before, at, or after CN





Event building



realistic event building strategy

| 1 st level | define t_0 (event time) and spatial information with SciTil | | |
|-----------------------|--|----|-----------|
| | preparing seed(ϕ ,z) for pattern recognition | | |
| 2 nd level | discrimination of charged and neutral particles by means of EMC correlation | | |
| | photon conversion at DIRC | | |
| 3 rd level | central tracks from STT, MVD Helix track \rightarrow circle in 2D \rightarrow conformal transformation \rightarrow hough transformation | | |
| | forward tracks using relative timing w/o. SciTil or from absolute timing w. forward ToF wall | | |
| 4 th level | PID detectors DIRC MDT dE/dx : STT, MVD E/p : EMC | | |
| 5 th level | up to now, a local trigger signals can be generated, then will send to central trigger system | | different |
| | timing operations need to be done : helping from central trigger system | ∫↓ | |

Universität Mainz



Physics trigger @ online

HELMHOLTZ GEMEINSCHAFT Helmholtz-Institut Mainz

Trigger on event topology after event building : physics trigger



then the implementation will be put into the ...

Local Unit with FPGA (VHDL) Computer Node based on FPGA (VHDL) Commercial Grid Computer (C++ online) GPU parallel computing (CUDA)



Physics benchmark channel

G

JOHANNES GUTENBERG UNIVERSITÄT MAINZ



Helmholtz-Institut Mainz

| Production | | Production | |
|--|---------------------------|---|--------------------------------|
| $\bar{p}p \to J/\psi \pi^+ \pi^- \to e^+ e^- (\mu^+ \mu^-) \pi^+ \pi^-$ | $h_c,\psi(2S),X,Y$ | $\bar{p}p \rightarrow J/\psi \omega \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$ | Y(3940) |
| $\bar{p}p \rightarrow J/\psi \pi^0 \pi^0 \rightarrow e^+ e^- (\mu^+ \mu^-) 4\gamma$ | Y | $\bar{p}p \rightarrow \psi' \pi^0 \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$ | |
| $ar{p}p ightarrow \chi_{c1} \gamma ightarrow J/\psi \gamma \gamma ightarrow e^+ e^- (\mu^+ \mu^-) \gamma \gamma$ | $\psi(2S),X,Y$ | $\bar{p}p \rightarrow J/\psi \rho \pi^0 \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$ | |
| $\bar{p}p ightarrow \chi_{c2} \gamma ightarrow J/\psi \gamma \gamma ightarrow e^+ e^- (\mu^+ \mu^-) \gamma \gamma$ | $\psi(2S), X, Y$ | $\bar{p}p \rightarrow J/\psi \rho^+ \pi^- \rightarrow e^+ e^- \pi^+ \pi^0 \pi^-$ | |
| $\bar{p}p ightarrow J/\psi \gamma ightarrow e^+e^-(\mu^+\mu^-)\gamma$ | χ_{c1}, χ_{c2}, X | $\bar{p}p \rightarrow \rho \pi^+ \pi^- \pi^0 \rightarrow \pi^+ \pi^- \pi^+ \pi^- \pi^0$ | |
| $\bar{p}p \rightarrow J/\psi\eta \rightarrow e^+e^-(\mu^+\mu^-)\gamma\gamma$ | $\eta_c(2S),\psi(2S),X,Y$ | $\bar{p}p \rightarrow \rho^+ \pi^+ \pi^- \pi^- \rightarrow \pi^+ \pi^0 \pi^+ \pi^- \pi^-$ | |
| $pp \to \pi^+ \pi^- \pi^+ \pi^-$ | | $\bar{p}p \rightarrow \omega \pi^+ \pi^- \pi^- \rightarrow \pi^+ \pi^- \pi^0 \pi^+ \pi^-$ | |
| $pp \to \pi^+\pi^-\pi^-\pi^- \to \pi^+\pi^-\gamma\gamma\gamma\gamma$ $\bar{n}n \to I/_2/m\pi^0 \to e^+e^-\gamma\gamma\gamma\gamma\gamma$ | | $\bar{p}_{P} \rightarrow \underline{u}' \pi^{+} \pi^{-} \rightarrow e^{+} e^{-} \pi^{+} \pi^{-} \pi^{+} \pi^{-}$ | V(4320) |
| $\bar{p}p \rightarrow J/\psi\omega\pi^0 \rightarrow e^+e^-\pi^0\gamma\gamma\gamma$ | | $\bar{p}p \to \pi^+ \pi^- \pi^+ \pi^- \pi^+ \pi^-$ | 1(4020) |
| $\bar{p}p \rightarrow \pi^+\pi^-\pi^0 \rightarrow \pi^+\pi^-\gamma\gamma$ | | $\bar{p}p \to \phi\phi \to K^+ K^- K^+ K^-$ | $f_2(2230)$ |
| $\bar{p}p \to \pi^+\pi^-\eta \to \pi^+\pi^-\gamma\gamma$ | | $\bar{p}p \rightarrow generic DPM$ | J ₂ (22 00) |
| $\bar{p}p \rightarrow J/\psi \pi^0 \gamma \rightarrow e^+ e^- \gamma \gamma \gamma$ | | $\bar{p}p \rightarrow D^{\pm}D^{*}_{,(2317)^{\mp}} \rightarrow \phi\pi^{\pm} + anything$ | $D_{a}^{*}(2317)$ |
| $\bar{p}p \rightarrow J/\psi \eta \gamma \rightarrow e^+ e^- \gamma \gamma \gamma$ | | $\bar{p}p \rightarrow B_s B_{s0}(2011) \rightarrow \psi \pi + angenerg$ $\bar{p}p \rightarrow \text{generic DPM}$ | 2 s0 (2011) |
| $\bar{p}p \rightarrow J/\psi \eta \eta \rightarrow e^+ e^- \gamma \gamma \gamma \gamma$ | | $\bar{n}p \rightarrow D^{\pm}D^{*}o(2317)^{\mp} \rightarrow anything + D^{\mp}\pi^{0} \rightarrow anything + \phi\pi^{\mp}\pi^{0}$ | |
| $\bar{p}p \to \eta_c(2S)\gamma \to \gamma\gamma\gamma$ | h_c | $\bar{p}p \rightarrow D_s D_{s0}(2011) \rightarrow angenerg + D_s \pi \rightarrow angenerg + \phi \pi \pi$ | |
| $\bar{p}p \rightarrow \pi^0 \pi^0 \rightarrow \gamma \gamma \gamma \gamma$ | | $\bar{p}p \rightarrow D_s^\pm D_s^\pm \pi^0 \rightarrow \phi \pi^\pm D_s^\pm \pi^0 \pi^0$ | |
| $pp \to \pi^0 \gamma \to \gamma \gamma \gamma$ | | $\bar{p}p \rightarrow D_s^* D_s^* \pi^0 \rightarrow \phi \pi^{\pm} D^{*\mp} \pi^0$ | |
| $pp \to \pi^{\circ} \eta \to \gamma \gamma \gamma \gamma$ | | $\overline{pp} + \overline{D_s} \overline{D_s} n + \overline{\phi} n - \overline{D_s} n$ $\overline{p} + \overline{p} - \overline{p} + \overline{p} - \overline{p} - \overline{p} + \overline{p} - p$ | TT |
| $pp \rightarrow \eta\eta \rightarrow \gamma\gamma\gamma\gamma$ | | $pp \to \Xi \equiv \pi^{\circ} \to \Lambda \pi^{+} \Lambda \pi^{-} \pi^{\circ} \to p\pi^{+} \pi^{+} p\pi^{-} \pi^{-} \pi^{\circ}$ | Hyperon |
| $\frac{pp \to \pi^- \eta^- \to \gamma \gamma \gamma \gamma}{\bar{p} r \to r \gamma \to \phi \phi \gamma \to K^+ K^- K^+ K^- \gamma}$ | h | $pp \rightarrow \text{generic DPM}$ | |
| $pp \to \eta_c \gamma \to \phi \phi \gamma \to K^+ K^- K^+ K^- \gamma$ $\bar{p}p \to K^+ K^- K^+ K^- \pi^0 \to K^+ K^- K^+ K^- \gamma \gamma$ | n_c | $pp \to \Lambda\Lambda\pi^+\pi^-\pi^- \to p\pi^+\pi^+p\pi^-\pi^-\pi^-$ | |
| $pp \rightarrow K K K K \pi^{0} \rightarrow K K K K \pi^{0} \gamma^{0}$ $\bar{p}p \rightarrow \phi K^{+} K^{-} \pi^{0} \rightarrow K^{+} K^{-} K^{+} K^{-} \gamma \gamma$ | | $\bar{p}p \to \Sigma^+(1385)\Sigma^-(1385)\pi^0 \to \Lambda\pi^+\Lambda\pi^-\pi^0 \to \bar{p}\pi^+\pi^+p\pi^-\pi^-\pi^0$ | |
| $\bar{p}p \rightarrow \phi \phi \pi^0 \rightarrow K^+ K^- K^+ K^- \gamma \gamma$ | | $\bar{p}p \to p\bar{p}\pi^+\pi^-\pi^+\pi^-\pi^0$ | |
| $\bar{p}p \rightarrow K^+ K^- \pi^+ \pi^- \pi^0 \rightarrow K^+ K^- K^+ K^- \gamma \gamma$ | | $\bar{p}p ightarrow \overline{\Lambda}\Lambda ightarrow \overline{p}\pi^+ p\pi^-$ | Hyperon |
| $\overline{pp} \to D^+ D^- \to K^- \pi^+ \pi^+ K^+ \pi^- \pi^-$ | $\psi(3770)$ | $\bar{p}p \to \overline{\Xi}^+ \Xi^- \to \overline{\Lambda} \pi^+ \Lambda \pi^- \to \overline{p} \pi^+ \pi^+ p \pi^- \pi^-$ | Hyperon |
| $\bar{p}p \rightarrow D^{*+}D^{*-} \rightarrow D^0\pi^+\overline{D^0}\pi^- \rightarrow K^-\pi^+\pi^+K^+\pi^-\pi^-$ | $\psi(4040)$ | $\bar{p}p \rightarrow p\bar{p}\pi^+\pi^-$ | |
| $\bar{p}p \rightarrow \text{generic DPM}$ | | $\bar{p}p \to \overline{\Lambda}\Sigma^0 \to \overline{p}\pi^+ p\pi^- \pi^0$ | |
| $\bar{p}p ightarrow 3\pi^+ 3\pi^- \pi^0$ | | $\bar{p}p \to \overline{\Lambda}\Sigma(1385) \to \overline{p}\pi^+ p\pi^- \pi^0$ | |
| $\bar{p}p 	o 3\pi^+ 3\pi^-$ | | $\bar{n}p \rightarrow \overline{\Sigma}^0 \Sigma^0 \rightarrow \overline{p}\pi^+ \gamma p\pi^- \gamma$ | |
| $\overline{pp} \to K^+ K^- 2\pi^+ 2\pi^-$ | | $\bar{p}p \rightarrow generic DPM$ | |
| $\bar{p}p \to \tilde{\eta}_{c1}\eta \to \chi_{c1}\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\eta$ | $\tilde{\eta}_{c1}(4286)$ | \overline{p} \overline | |
| $\bar{p}p \to \chi_{c0} \pi^0 \pi^0 \eta \to J/\psi \gamma \pi^0 \pi^0 \eta$ | | $pp \rightarrow \Sigma (1385)\Sigma (1385) \rightarrow \Lambda \pi^+ \Lambda \pi^- \rightarrow p\pi^+ \pi^+ p\pi^- \pi^-$ | |
| $pp \rightarrow \chi_{c1} \pi^0 \eta \eta \rightarrow J/\psi \gamma \pi^0 \eta \eta$ | | $\bar{p}p \to D^0 D^{**} \to K^- \pi^+ K^+ \pi^- \pi^0$ | X(3872) |
| $pp \to \chi_{c1} \pi^{\circ} \pi^{\circ} \pi^{\circ} \eta \to J/\psi \gamma \pi^{\circ} \pi^{\circ} \pi^{\circ} \eta$ | | $\bar{p}p ightarrow \pi^+\pi^-\pi^+\pi^-$ | |
| $\frac{pp \to J/\psi \pi^* \pi^* \pi^* \eta}{D^0 \overline{D}^{*0} + U^- + 0} = 0$ | ~ (1000) | $\bar{p}p \rightarrow \text{generic DPM}$ | |
| $pp \to \eta_{c1}\eta \to D^{\circ}D^{\circ}\eta \to K^{-}\pi^{+}\pi^{\circ}K^{+}\pi^{-}\pi^{\circ}\pi^{\circ}\eta$ | $\eta_{c1}(4286)$ | $\bar{p}p \rightarrow e^+e^-$ | EMF |
| $\bar{p}p \to D^0 D^- \pi^0 \to K^- \pi^+ \pi^0 K^+ \pi^- \pi^0 \pi^0 \pi^0$ | | $\bar{p}p ightarrow e^+ e^- \pi^0$ | \mathbf{EMF} |
| $\bar{p}p \rightarrow D^0 \overline{D}^{*o}_{\eta} \rightarrow K^- \pi^+ \pi^0 \pi^0 K^+ \pi^- \pi^0 \pi^0 \eta$ | | $\bar{p}p \rightarrow \pi^+\pi^-$ | |
| $\bar{p}p \rightarrow D^0 \overline{D}^{*0} \eta \rightarrow K^- \pi^+ \pi^0 \pi^0 K^+ \pi^- \pi^0 \pi^0 \pi^0 \eta$ | | $\bar{p}p ightarrow \pi^+\pi^-\pi^0$ | |



PANDA physics book

- 118 physics benchmark channels (data sets with both signal & background)
- 22 beam momentum $p_{min} = 1.431 \text{ GeV/c}, \dots p_{mac} = 15.0 \text{ GeV/c}$
- 6 DPM MC
 10 M events / channels
- 2 extra physics channel (EMF e+e- and X(3872) -> D*D)
- 10 selection algorithms

$$D^{0}(K\pi) D_{s}(\phi\pi) \phi(K^{+}K^{-}) D^{0}(K\pi\pi^{0}) h_{c}(\eta_{c}\gamma \rightarrow \gamma\gamma\gamma)$$

$$J/\psi(e^{+}e^{-}) D^{\pm}(K\pi\pi) e^{+}e^{-} J/\psi(\pi^{+}\pi^{-}\pi^{0}) \Lambda(p\pi)$$

momentum resolution

JOHANNES GUTENBERG

UNIVERSITÄT



online (FPGA Helix tracking @ barrel)

| $p_{T}(\theta)$ | 1 GeV/c | 2 GeV/c | 5 GeV/c |
|-----------------|---------|---------|---------|
| $\Delta P/P$ | 3.8% | 5.5% | 12.2% |







- EMC PID at online should be same as like offline (at least gamma)
- Seeking to find out hadron PID using DIRC, dE/dx(STT, MVD), ToF
- At the moment. 5 X 5 simple PID probability, impurity can be varied



PID application

HELMHOLTZ GEMEINSCHAFT

$\overline{p}p \rightarrow \psi(3770) \rightarrow D^+ D^- \rightarrow K^- \pi^+ \pi^+ K^+ \pi^- \pi^-$



JOHANNES GUTENBERG

UNIVERSITÄT MAINZ

JOHANNES GUTENBERG

UNIVERSITÄT MAINZ

HELMHOLTZ GEMEINSCHAFT Helmholtz-Institut Mainz

Probability table : 5 X 5 simple PID probability, impurity can also be varied

IOHANNES GUTENBERG

UNIVERSITÄT MAIN

| | | MC input | | | | | MC input | | | | | | |
|-------|---|----------|----|----|----|----|----------|---|-----|-----|-----|-----|-----|
| | | e | μ | π | K | Р | | | e | μ | π | K | Р |
| | е | 80 | 80 | 80 | 80 | 80 | | е | 80 | 1.2 | 1.2 | 1.2 | 1.2 |
| | μ | 80 | 80 | 80 | 80 | 80 | | μ | 1.2 | 80 | 1.2 | 1.2 | 1.2 |
| Reco. | π | 80 | 80 | 80 | 80 | 80 | Reco. | π | 1.2 | 1.2 | 80 | 1.2 | 1.2 |
| | K | 80 | 80 | 80 | 80 | 80 | | K | 1.2 | 1.2 | 1.2 | 80 | 1.2 |
| | Р | 80 | 80 | 80 | 80 | 80 | | Р | 1.2 | 1.2 | 1.2 | 1.2 | 80 |
| | | | | | | | | | | | | | |

20 steps

determine signal and background efficiency

 $Br(J/\psi \to e^+e^-) = 5.94\%$ $Br(J/\psi \to \pi^+\pi^-\pi^0) = 2.07\%$

Efficiency, PID probablity = 100% γ $\Delta E = 5\%, \Delta \theta = 0.003 \deg, \Delta \phi = 0.003 \deg$

F

HELMHOLTZ

Helmholtz-Institut Mainz

GEMEINSCHAF

 $\overline{p}p \to \eta_c \gamma \to \phi \phi \gamma \to K^+ K^- K^+ K^- \gamma$ $\overline{p}p \to \phi \phi \to K^+ K^- K^+ K^ \overline{p}p \to D_s D_s^{*0}(2317) \to \phi \pi^+ X \to K^+ K^- \pi^+ X$

 $\overline{p}p \to \widetilde{\eta}_{c1}\eta \to D^0 \overline{D}^{*0}\eta \to K^- \pi^+ \pi^0 K^+ \pi^- \pi^0 \pi^0 \eta$

HELMHOLTZ

 $\overline{p}p \to \psi(3770) \to D^+D^- \to K^-\pi^+\pi^+K^+\pi^-\pi^ \overline{p}p \to X(3872) \to \overline{D}^{*0}D^0 \to \overline{D}^0\pi^0D^0 \to K^+\pi^-\pi^0K^-\pi^+$ $\overline{p}p \to \psi(4040) \to D^{*+}D^{*-} \to D^0\pi^+\overline{D}^0\pi^- \to K^-\pi^+\pi^+K^-\pi^-\pi^ \overline{p}p \to \widetilde{\eta}_{cl}\eta \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\eta$

 e^+e^-

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

HELMHOLTZ GEMEINSCHAFT Helmholtz-Institut Mainz

MC Data

| Production | |
|--|------------------|
| $\bar{p}p \rightarrow J/\psi \pi^+ \pi^- \rightarrow e^+ e^- (\mu^+ \mu^-) \pi^+ \pi^-$ $h_c, \psi(2)$ | 2S),X,Y |
| $\bar{p}p \rightarrow J/\psi \pi^0 \pi^0 \rightarrow e^+ e^- (\mu^+ \mu^-) 4\gamma$ Y | |
| $\bar{p}p \rightarrow \chi_{c1}\gamma \rightarrow J/\psi\gamma\gamma \rightarrow e^+e^-(\mu^+\mu^-)\gamma\gamma$ (v(28) | .X.Y |
| $\bar{p}p \rightarrow \chi_{c2}\gamma \rightarrow J/\psi\gamma\gamma \rightarrow e^+e^-(\mu^+\mu^-)\gamma\gamma$ (28) | ,X,Y |
| $\bar{p}p \rightarrow J/\psi\gamma \rightarrow e^+e^-(\mu^+\mu^-)\gamma$ χ_{cl,χ_c} | 2,X |
| $\bar{p}p \rightarrow J/\psi \eta \rightarrow e^+e^-(\mu^+\mu^-)\gamma\gamma$ $\eta_c(2S)$ | $),\psi(2S),X,Y$ |
| $\bar{p}p \rightarrow \pi^+\pi^-\pi^+\pi^-$ | |
| $\bar{p}p \rightarrow \pi^+\pi^-\pi^0\pi^0 \rightarrow \pi^+\pi^-\gamma\gamma\gamma\gamma$ | |
| $\bar{p}p \rightarrow J/\psi \eta \pi^0 \rightarrow e^+ e^- \gamma \gamma \gamma \gamma$ | |
| $\bar{p}p \rightarrow J/\psi \omega \pi^{0} \rightarrow e^{+}e^{-}\pi^{0}\gamma\gamma\gamma$ | |
| $\bar{p}p \rightarrow \pi^+\pi^-\pi^- \rightarrow \pi^+\pi^-\gamma\gamma$ | |
| $\bar{p}p \rightarrow \pi^+\pi^-\eta \rightarrow \pi^+\pi^-\gamma\gamma$ | |
| $pp \rightarrow J/\psi \pi^{"}\gamma \rightarrow e^{+}e^{-}\gamma\gamma\gamma$ | |
| $pp \rightarrow J/\psi \eta \gamma \rightarrow e^+e^-\gamma \gamma \gamma$ | |
| $pp \rightarrow J/\psi \eta \eta \rightarrow e^+e^-\gamma\gamma\gamma\gamma$ | |
| $pp \rightarrow \eta_c(2S)\gamma \rightarrow \gamma\gamma\gamma$ \dot{h}_c | |
| $pp \rightarrow \pi^{\sigma}\pi^{\sigma} \rightarrow \gamma\gamma\gamma\gamma$ | |
| $pp \rightarrow \pi^{*}\gamma \rightarrow \gamma\gamma\gamma$ | |
| $pp \rightarrow \pi^- \eta \rightarrow \gamma \gamma \gamma \gamma$ | |
| $pp \rightarrow \eta\eta \rightarrow \gamma\gamma\gamma\gamma$ | |
| $pp \rightarrow \pi^{\mu} \eta^{\nu} \rightarrow \gamma \gamma \gamma \gamma$ | |
| $pp \rightarrow \eta_c \gamma \rightarrow \phi \phi \gamma \rightarrow K^+ K^- K^+ K^- \gamma$ h_c | |
| $\bar{p}p \rightarrow K^+K^-K^+K^-\pi'' \rightarrow K^+K^-K^+K^-\gamma\gamma$ | |
| $pp \rightarrow \phi K^+ K^- \pi^+ \rightarrow K^+ K^- K^- K^- \gamma \gamma$ | |
| $pp \rightarrow \phi \phi \pi^{\sigma} \rightarrow K^+ K^- K^+ K^- \gamma \gamma$ | |
| $\bar{p}p \rightarrow K^+K^-\pi^+\pi^-\pi^0 \rightarrow K^+K^-K^+K^-\gamma\gamma$ | |
| $\bar{p}p \rightarrow D^+D^- \rightarrow K^-\pi^+\pi^+K^+\pi^-\pi^-$ $\psi(377)$ | 0) |
| $\bar{p}p \rightarrow D^{*+}D^{*-} \rightarrow D^{0}\pi^{+}D^{0}\pi^{-} \rightarrow K^{-}\pi^{+}\pi^{+}K^{+}\pi^{-}\pi^{-}$ $\psi(404)$ | 0) |
| $\bar{p}p \rightarrow \text{generic DPM}$ | |
| $\bar{p}p \rightarrow 3\pi^+ 3\pi^- \pi^0$ | |
| $\bar{p}p \rightarrow 3\pi^+ 3\pi^-$ | |
| $\bar{p}p \rightarrow K^+ K^- 2\pi^+ 2\pi^-$ | |
| $\bar{p}p \rightarrow \bar{\eta}_{c1}\eta \rightarrow \chi_{c1}\pi^{0}\pi^{0}\eta \rightarrow J/\psi\gamma\pi^{0}\pi^{0}\eta$ $\bar{\eta}_{c1}(42)$ | 286) |
| $\bar{p}p \rightarrow \chi_{c0} \pi^0 \pi^0 \eta \rightarrow J/\psi \gamma \pi^0 \pi^0 \eta$ | |
| $\bar{p}p \rightarrow \chi_{c1}\pi^{a}\eta\eta \rightarrow J/\psi\gamma\pi^{a}\eta\eta$ | |
| $\bar{p}p \rightarrow \chi_{c1} \pi^o \pi^o \pi^o \eta \rightarrow J/\psi \gamma \pi^o \pi^o \pi^o \eta$ | |
| $\bar{p}p \rightarrow J/\psi \pi^{\mu} \pi^{\nu} \pi^{\mu} \eta$ | |
| $\bar{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow D^0 \overline{D}^{*0}\eta \rightarrow K^- \pi^+ \pi^0 K^+ \pi^- \pi^0 \pi^0 \eta$ $\tilde{\eta}_{c1} (42)$ | 286) |
| $\bar{p}p \rightarrow D^0 \overline{D}^0 \pi^0 \rightarrow K^- \pi^+ \pi^0 K^+ \pi^- \pi^0 \pi^0 \pi^0$ | |
| $= 0.075^{-7}$, $D_{2} = \pm 0.075^{-7}$, $D_{2} = \pm 0.075^{-7}$ | |
| $pp \rightarrow D^{\sigma}D^{-}\eta \rightarrow K^{-}\pi^{+}\pi^{\sigma}\pi^{\sigma}K^{+}\pi^{-}\pi^{\sigma}\pi^{\sigma}\eta$ | |

 $D^0(K\pi)$ $D^0(K\pi\pi^0)$ $D^{\pm}(K\pi\pi)$ $J/\psi(e^+e^-)$ $J/\psi(\pi^+\pi^-\pi^0)$ $h_c(\eta_c\gamma \to \gamma\gamma\gamma)$ $\Lambda(p\pi)$ $e^+e^ \phi(K^+K^-)$ $D_s(\phi\pi)$

HELMHOLTZ

Helmholtz-Institut Mainz

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

HELMHOLTZ

Helmholtz-Institut Mainz

HELMHOLTZ

 $\sqrt{s} = 3.770 \text{ GeV}$

 $D^{+}D^{-} \to K^{-}\pi^{+}\pi^{+} + c.c \qquad \overline{\Xi}^{+}\Xi^{-}\pi^{0} \to \Lambda X$ $\overline{p}p \to K^{+}K^{-}\pi^{+}\pi^{-}\pi^{+}\pi^{-}$ $\overline{p}p \to \overline{p}\pi^{+}p\pi^{-}\pi^{+}\pi^{-}\pi^{0}$

 $\overline{p}p \rightarrow 3\pi^+ 3\pi^-$

DPM

HELMHOLTZ

lelmholtz-Institut Mainz

DPM data in detail ...

 $\sqrt{s} = 3.770 \text{ GeV}$

Identified as a signal in each selection criteria

 $\epsilon = 10^{-3}$: mainly due to $K\pi$ combination

background reduction rate ~ 1 / 1000 if we can achieve 80% PID probability and with 5% impurities for each particles

Summary

apply more realistic values into the test

- online tracking @ target, target-endcap, and forward
- PID probability depending on θ , p, particle types.
- precise γ , μ efficiency and so on...

S/N ratio with considering cross section and branching ratio

Need your help, must have more realistic MC and precise information about σ , for instance,

 e^+e^- , $\pi^+\pi^-$, $e^+e^-\pi^0$, and $\pi^+\pi^-\pi^0$

Outlook

efficiency

| Production | |
|--|---|
| $\bar{p}p \rightarrow \bar{J}/\psi \pi^+\pi^- \rightarrow e^+e^-(\mu^+\mu^-)\pi^+\pi^-$ | $h_{\mu,\psi}(28), X, Y$ |
| $p_P \rightarrow J/\psi \pi^0 \pi^0 \rightarrow e^+ e^- (\mu^+ \mu^-) 4\gamma$ | Y |
| $\bar{p}p \rightarrow \chi_{e1}\gamma \rightarrow J/\bar{\psi}\gamma\gamma \rightarrow e^+e^-(\mu^+\mu^-)\gamma\gamma$ | $\psi(235), X, Y$ |
| $p \rightarrow \chi_{aff} \rightarrow J(p_{ff} \rightarrow e^+e^-w^+\mu^-)m$ | e (28) X Y |
| $pp \rightarrow J/\psi\gamma \rightarrow e^+e^-(\mu^+\mu^-)\gamma$ | X_{c1}, X_{c2}, X |
| $bb \rightarrow \gamma/bd \rightarrow c.c. (h, h, M)$ | 9,(29),9(29),A,Y |
| | |
| | |
| $p_{\mu} \rightarrow \sigma_{\mu} p_{\mu} p_{\mu} \rightarrow e^+ e^- p_{\mu} p_{\mu}$ $p_{\mu} \rightarrow I h h m = 0 \rightarrow e^+ e^- m^2 m m m$ | |
| bh - Alema - e.e. a 111 | |
| for a state a state of | |
| in a Jhink a chrono | |
| $\bar{m} \rightarrow J/\bar{m} \rightarrow e^+e^-mn$ | |
| $\bar{n}n \rightarrow J/\bar{c}nn \rightarrow c^+c^-\gamma\gamma\gamma\gamma$ | |
| in -+ n.(22): -+ eee | h. |
| $\bar{\mu}\mu \rightarrow \pi^0\pi^0 \rightarrow \gamma\gamma\gamma\gamma$ | |
| $in \rightarrow \pi^{2}n \rightarrow mn$ | |
| io -> a ⁰ n -> system | |
| $\bar{p}p \rightarrow \eta \eta \rightarrow \gamma \gamma \gamma \gamma$ | |
| | |
| $\bar{p}n \rightarrow n_c \gamma \rightarrow c \bar{c} \phi \gamma \rightarrow K^+ K^- K^+ K^- \gamma$ | h. |
| $\bar{p}p \rightarrow K^+K^-K^+K^-\pi^0 \rightarrow K^+K^-K^+K^-\gamma\gamma$ | |
| $\bar{p}p \rightarrow \phi K^+ K^- \pi^0 \rightarrow K^+ K^- K^+ K^- \gamma \gamma$ | |
| $\bar{p}p \rightarrow \phi\phi\pi^0 \rightarrow K^+K^-K^+K^-\gamma\gamma$ | |
| $pp \rightarrow K^+K^-\pi^+\pi^-\pi^0 \rightarrow K^+K^-K^+K^-\gamma\gamma$ | |
| $pp \rightarrow D^+D^- \rightarrow K^-\pi^+\pi^+K^+\pi^-\pi^-$ | $\psi(3770)$ |
| $pp \rightarrow D^{*+}D^{*-} \rightarrow D^{0}\pi^{+}\overline{D^{0}}\pi^{-} \rightarrow K^{-}\pi^{+}\pi^{+}K^{+}\pi^{-}\pi^{-}$ | ÷(4040) |
| $\bar{p}p \rightarrow generic DPM$ | |
| $\bar{p}p \rightarrow 3\pi^+ 3\pi^- \pi^0$ | |
| $\phi \rightarrow 3\pi^{-}3\pi^{-}$ | |
| $pp \rightarrow K^+K^-2\pi^+2\pi^-$ | |
| $\bar{p}p \rightarrow \bar{\eta}_{cl}\eta \rightarrow \chi_{cl}\pi^{c}\pi^{c}\eta \rightarrow J/\psi\gamma\pi^{c}\pi^{c}\eta$ | $\tilde{p}_{c1}(4286)$ |
| $p_P \rightarrow \chi_{ab} \pi^0 \pi^0 \eta \rightarrow J/\psi \gamma \pi^0 \pi^0 \eta$ | |
| $p_p \rightarrow \chi_{e1} \pi^{\mu} \eta \eta \rightarrow J/\psi \eta \pi^{\mu} \eta \eta$ | |
| $pp \rightarrow \chi_{c1} \pi^{-} \pi^{-} \pi^{-} \eta \rightarrow J/\psi_{2} \pi^{-} \pi^{-} \pi^{-} \eta$ | |
| $pp \rightarrow J/\psi \pi^{\mu} \pi^{\mu} \pi^{\mu} \eta$ | |
| $\tilde{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow D^*D^-\eta \rightarrow K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\eta$ | $\bar{\eta}_{c1}(4266)$ |
| $pp \rightarrow D^{\mu}\overline{D}^{\nu}e^{\mu} \rightarrow K^{-}e^{+}e^{\mu}K^{+}e^{-}e^{\mu}e^{\mu}e^{\mu}$ | |
| | |
| $pp \rightarrow L^{\mu}D^{\mu}\eta \rightarrow K^{\mu}\pi^{\mu}\pi^{\mu}\pi^{\mu}\pi^{\mu}\pi^{\mu}\pi^{\mu}\pi^{\mu}\pi$ | |
| $pp \rightarrow D^{\mu}D^{\mu}\eta \rightarrow K^{\mu}\pi^{\mu}\pi^{\mu}K^{\nu}\pi^{\mu}\pi^{\mu}\eta$ $pp \rightarrow D^{\mu}\overline{D}^{\mu}\eta \rightarrow K^{\mu}\pi^{\mu}\pi^{\mu}\pi^{\mu}K^{\mu}\pi^{\mu}\pi^{\mu}\pi^{\mu}\eta$ | |
| $\begin{array}{l} pp \rightarrow D^{*}D^{-\eta} \rightarrow K^{-}\pi^{+}\pi^{0}\pi^{0}K^{+}\pi^{-}\pi^{0}\pi^{0}\pi^{0}\eta \\ pp \rightarrow D^{0}\overline{D}^{-0}\eta \rightarrow K^{-}\pi^{+}\pi^{0}\pi^{0}K^{+}\pi^{-}\pi^{0}\pi^{0}\pi^{0}\eta \end{array}$ | |
| $pp \rightarrow L^{P}D^{-}\eta \rightarrow K^{-}\pi^{+}\pi^{+}\pi^{-}\pi^{-}\pi^{-}\pi^{-}\pi^{-}\eta$ $pp \rightarrow D^{P}\overline{D}^{0}\eta \rightarrow K^{-}\pi^{+}\pi^{0}\pi^{0}K^{+}\pi^{-}\pi^{0}\pi^{0}\pi^{0}\eta$ Production | |
| $pp \rightarrow D^{r}D^{-}\eta \rightarrow K \pi^{+}\pi^{-}\pi^{0}K^{-}\pi^{-}\pi^{0}\pi^{0}\pi^{0}\eta$ $pp \rightarrow D^{r}\overline{D}^{0}\eta \rightarrow K^{-}\pi^{+}\pi^{0}\pi^{0}K^{+}\pi^{-}\pi^{0}\pi^{0}\pi^{0}\eta$ Production $\bar{p}p \rightarrow J/\bar{\psi}\omega \rightarrow e^{+}e^{-}\pi^{+}\pi^{-}\pi^{0}$ | Y(3940) |
| $p \mapsto D^*D^*\eta \to K^*\pi^*\pi^*\pi^*\pi^*\eta$ $p \mapsto D^*\overline{D}^*\eta \to K^*\pi^*\pi^*\pi^*\pi^*\pi^*\eta$ Production $\overline{p} \mapsto J/\overline{y} \mapsto e^+e^-\pi^+\pi^-\pi^0$ $\overline{p} \mapsto e^+g^0 \to e^+e^-\pi^+\pi^-\pi^0$ $\overline{p} \mapsto e^+g^0 \to e^+e^-\pi^+\pi^-\pi^0$ | Y(3940) |
| $p \mapsto D'D' = \eta \to K = \pi + \pi^{-}\pi^{-}\pi^{-}\pi^{-}\pi^{0}\pi^{0}\pi^{0}\eta$ $pp \to D'\overline{D} = \eta \to K^{-}\pi + \pi^{0}\pi^{0}K^{+}\pi^{-}\pi^{0}\pi^{0}\pi^{0}\eta$ Production $\tilde{p}p \to J/\psi\omega \to e^{+}e^{-}\pi^{+}\pi^{-}\pi^{0}$ $\tilde{p}p \to \psi^{-}\pi^{0} \to e^{+}e^{-}\pi^{+}\pi^{-}\pi^{0}$ $\tilde{p} \to J/\psi\omega \to e^{+}e^{-}\pi^{+}\pi^{-}\pi^{0}$ | Y(3940) |
| $p \mapsto D^*D^* \eta \to K^* \pi^+ \pi^+ \pi^- \pi^+ \pi^- \eta$ $p \mapsto D^*\overline{D}^* \eta \to K^* \pi^+ \pi^+ \pi^0 \pi^0 \pi^0 \eta$ Production $\overline{p} p \to J [\phi \omega \to e^+ e^- \pi^+ \pi^- \pi^0$ $\overline{p} p \to g^+ \pi^- \to e^+ e^- \pi^+ \pi^- \pi^0$ $\overline{p} p \to J [\phi \mu \pi^0 \to e^+ e^- \pi^+ \pi^- \pi^0$ $\overline{p} p \to J [\phi \mu \pi^0 \to e^+ e^- \pi^+ \pi^- \pi^0$ | Y(3940) |
| $p \rightarrow D^* D^* \rightarrow K = \pi^* \pi^* \pi^* \pi^* \pi^* \pi^* \pi^* \pi^* \pi^* \pi^*$ | Y(3940) |
| $\begin{array}{l} p \rightarrow D^{*}D^{*}\eta \rightarrow K \pi^{*}\pi^{*}\pi^{*}K \stackrel{\pi}{=}\pi^{*}\pi^{*}\eta \\ p \rightarrow D^{*}\overline{D}\stackrel{\pi}{=}\eta \rightarrow K \pi^{*}\pi^{*}\pi^{*}\theta^{*}K^{*}\pi^{*}\pi^{*}\theta^{*}\pi^{*}\eta \\ \hline P \operatorname{roduction} \\ \overline{p} \rightarrow J/\psi \omega \rightarrow e^{+}e^{-}\pi^{+}\pi^{-}\pi^{0} \\ \overline{p} p \rightarrow J/\psi \omega \rightarrow e^{+}e^{-}\pi^{+}\pi^{-}\pi^{0} \\ \overline{p} p \rightarrow J/\psi \mu^{*}\pi^{*} \rightarrow e^{+}e^{-}\pi^{+}\pi^{*}\pi^{0} \\ \overline{p} p \rightarrow J/\psi \mu^{*}\pi^{*} \rightarrow e^{+}e^{-}\pi^{+}\pi^{0}\pi^{*} \\ \overline{p} p \rightarrow \mu^{*}\pi^{*}\pi^{*}\pi^{*}\pi^{*}\pi^{*}\pi^{*}\pi^{*}\pi$ | ¥(3940) |
| $\begin{array}{l} p \rightarrow D^* D^* \rightarrow K \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | Y(3940) |
| $\begin{array}{l} p \rightarrow D \; D \; p \rightarrow K \; \pi^+ \pi^- \pi^- K \; \pi \; \pi^- \pi^- \eta \\ p \rightarrow D^- \overline{D} \; \overline{\eta} \rightarrow K \; \pi^+ \pi^0 \pi^0 K^+ \pi^- \pi^0 \pi^0 \pi^0 \eta \\ \hline P \; reduction \\ \overline{\eta} p \rightarrow J/(\psi \omega \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow d \; \psi \; \varphi \; \pi^- \phi \; e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow J/\psi p^+ \pi^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow J/\psi p^+ \pi^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow d \; \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{\eta} \\ \overline{p} p \rightarrow p^+ \pi^- \pi^- \rightarrow \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{\eta} \\ \overline{p} p \rightarrow \mu^+ \pi^- \pi^- \rightarrow \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | Y(3940) |
| $\begin{array}{l} p \rightarrow D^* D \xrightarrow{0} q \rightarrow K \pi^+ \pi^- \pi^- K \pi \pi^+ \pi^- \eta \\ p \rightarrow D^* D^* \overline{D} \xrightarrow{0} \eta \rightarrow K^- \pi^+ \pi^+ \eta^+ \rho K^+ \pi^- \pi^+ \eta^+ \pi^+ \eta \\ \hline P \operatorname{roduction} \\ p \rightarrow \partial_1^* f \varphi \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} \rightarrow \partial_1^* f \varphi \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} \rightarrow \partial_1^* f \varphi \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} \rightarrow \partial_1^* f \varphi \rightarrow \pi^+ \pi^- \pi^+ \pi^+ \pi^- \pi^0 \\ \overline{p} \rightarrow \rho^+ \pi^+ \pi^- \gamma \rightarrow \pi^+ \pi^+ \pi^+ \pi^- \\ \overline{p} \rightarrow \rho^+ \pi^+ \pi^- \gamma \rightarrow \pi^+ \pi^+ \pi^+ \pi^- \\ \overline{p} \rightarrow \varphi^+ \pi^+ \pi^- \gamma \rightarrow \pi^+ \pi^- \pi^+ \pi^- \\ \overline{p} \rightarrow \varphi^+ \pi^+ \pi^- \gamma \rightarrow \pi^+ \pi^- \pi^+ \pi^- \\ \overline{p} \rightarrow \varphi^+ \pi^+ \pi^- \gamma \rightarrow \pi^+ \pi^- \pi^+ \pi^- \\ \overline{p} \rightarrow \varphi^+ \pi^+ \pi^- \gamma \rightarrow \pi^+ \pi^- \pi^+ \pi^- \end{array}$ | Y(3940) Y(4320) |
| $\begin{array}{c} p \rightarrow D \left[P D \right] & \eta \rightarrow K \pi^+ \pi^- \pi^- K \cdot \pi^- \pi^- \pi^0 \pi^0 \pi^- \eta \\ p \rightarrow D \left[\overline{D} \right] & \eta \rightarrow K \pi^+ \pi^0 \pi^0 F^+ \pi^- \pi^0 \pi^0 \pi^0 \eta \\ \hline P \operatorname{roduction} \\ \overline{p} p \rightarrow J \left[\psi \omega \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow J \left[\psi \mu \right] & \sigma \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow J \left[\psi \mu \right] & \pi^- \sigma \rightarrow e^+ e^- \pi^+ \pi^0 \pi^- \pi^- \\ \overline{p} p \rightarrow \mu \pi^+ \pi^- \pi^- \rightarrow \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} p \rightarrow \mu \pi^+ \pi^- \pi^- \rightarrow e^+ \pi^- \pi^- \pi^- \pi^- \\ \overline{p} p \rightarrow \mu \pi^+ \pi^- \pi^- \rightarrow e^+ e^- \pi^- \pi^- \pi^- \\ \overline{p} p \rightarrow \mu \pi^+ \pi^- \pi^- \rightarrow e^+ e^- \pi^- \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^- \pi^- \overline{p} \pi^- \overline{p} \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \overline{p} \pi^- \overline{p} \pi^- \\ \overline{p} p \rightarrow \varphi \pi^+ \pi^- \pi^+ \pi^- \pi^- \overline{p} \pi$ | Y(3940) Y(4320) 5.(2220) |
| $p \rightarrow D^* D^*_{\alpha} \rightarrow K^- \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+$ | Y(3940) Y(4320) J ₂ (2230) |
| $\begin{split} p & \rightarrow D^* D \xrightarrow{q} \gamma \leftarrow K^- \pi^+ \pi^+ \pi^- \pi^+ \pi^+ \pi^+ \pi^- \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+$ | Y(3940) Y(4320) J ₂ (2230) D [*] (2217) |
| $p \rightarrow D P D = 0 \rightarrow K \ \pi^+ \pi^+ \pi^+ \pi^- K + \pi^- \pi^+ \eta$ $p \rightarrow D P D = 0 \rightarrow K \ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \eta$ Production $\bar{p} p \rightarrow d P = 0 \rightarrow \bar{r} \pi^- \pi^- \pi^0$ $\bar{p} p \rightarrow d P \to \bar{r} \bar{r} \pi^- \pi^0$ $\bar{p} p \rightarrow d P \bar{r} \pi^- \pi^- \pi^- \pi^0$ $\bar{p} p \rightarrow d P \bar{r} \pi^- \pi^- \pi^- \pi^- \pi^0 \pi^-$ $\bar{p} p \rightarrow d P \bar{r} \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ $\bar{p} p \rightarrow \bar{q} \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ $\bar{p} p \rightarrow \bar{q} \pi^+ \pi^- \pi^- \pi^- \pi^-$ $\bar{p} p \rightarrow \bar{q} \sigma^+ \pi^- \pi^- \pi^- \pi^-$ $\bar{p} p \rightarrow \bar{q} \sigma^+ \pi^- \pi^- \pi^-$ $\bar{p} p \rightarrow \bar{q} \sigma^- \pi^- \pi^- \pi^- \pi^-$ $\bar{p} p \rightarrow \bar{q} \sigma^- \pi^- \pi^- \pi^- \pi^-$ $\bar{p} p \rightarrow \bar{q} \sigma^- \pi^- \pi^- \pi^-$ | Y(3940) Y(4320) $f_2(2230)$ $D^*_{20}(2317)$ |
| $\begin{split} p & \rightarrow D^{-1}D^{-1} = \gamma + K + \pi^+ \pi^+ \pi^- K + \pi^- \pi^+ \pi^+ \pi^- \eta \\ p & \rightarrow D^{-1}D^{-1} = \gamma + K^- \pi^+ \pi^+ \pi^- \pi^0 + \pi^+ \pi^- \eta \\ \hline P & \text{roduction} \\ p & \rightarrow J/\psi a \to + \pi^+ \pi^- \pi^+ \pi^- \pi^0 \\ p & \rightarrow J/\psi a \to + \pi^+ \pi^- \pi^- \pi^0 \\ p & \rightarrow J/\psi a \to + \pi^+ \pi^- \pi^- \pi^0 \\ p & \rightarrow J/\psi a \to + \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow \mu^+ \pi^- \pi^- \to \pi^+ \pi^- \pi^- \pi^0 \\ p & \rightarrow \mu^+ \pi^- \pi^- \to \pi^+ \pi^- \pi^- \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^- \to \pi^+ \pi^- \pi^- \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^- \pi^+ \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^+ \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^- \\ p & \rightarrow \psi \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+$ | Y(3940) Y(4320) $J_2(2230)$ $J_2(2230)$ |
| $p \rightarrow U^{T}D_{-\eta} \rightarrow K^{-}\pi^{+}\pi^{-}\pi^{-}\pi^{-}\pi^{-}\pi^{-}\pi^{-}\pi^{-}\pi^{-$ | \$Y(3940)\$ Y(4320) $f_2(2230)$ $D_{g0}^*(2317)$ π^{\oplus} |
| $\begin{array}{l} p \rightarrow D^{*}D^{*}a \rightarrow K^{*}\pi^{*}\pi^{*}\pi^{*}\pi^{*}\pi^{*}\pi^{*}\pi^{*}\pi$ | (3340) Y(3340) Y(4320) f_2(2230) f_2(2230) D_{g0}^*(2317) |
| $\begin{split} p & \rightarrow D^* D^* \eta \rightarrow K^* \pi^+ \pi^+ \pi^- K^* \pi^- \pi^+ \eta \pi^+ \eta \\ p & \rightarrow D^* \overline{D^*} \eta \rightarrow K^* \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \eta \\ p & \rightarrow J^+ \psi \omega \rightarrow e^+ \pi^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow J^+ \psi \omega^+ \psi - \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow J^+ \psi \omega^+ \psi - e^+ e^- \pi^+ \pi^- \eta \\ \overline{p} & \rightarrow J^+ \psi \mu^+ \pi^- \to e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow J^+ \psi \mu^+ \pi^- \to \pi^+ \pi^- \pi^- \pi^0 \\ \overline{p} & \rightarrow \chi^+ \pi^- \pi^- \to \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^+ \pi^- \pi^- \to e^+ e^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^+ \pi^- \pi^+ \pi^- \\ \overline{p} & \rightarrow \chi^+ \pi^- \pi^+ \pi^- \\ \overline{p} & \rightarrow \chi^- \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^- \pi^+ \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^- \pi^+ \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \overline{p} \\ \overline{p} & \rightarrow \chi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi$ | $\begin{tabular}{ c c c c c }\hline & $Y(3940)$ \\ \hline & $Y(4320)$ \\ \hline & $f_{2}(2230)$ \\ \hline & $f_{2}(2230)$ \\ \hline & $D_{e0}^{*}(2817)$ \\ \hline & $+\pi^{0}$ \\ \hline \end{tabular}$ |
| $\begin{split} p & \rightarrow D^* D^*_{\alpha} \rightarrow K^- \pi^+ \pi^+ \pi^- \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | (3940) Y(3940) $f_{2}(2230)$ $f_{2}(2230)$ $D_{20}^{*}(2317)$ |
| $\begin{split} p & \rightarrow D^* D^* \eta \rightarrow K^* \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \eta \\ p & \rightarrow D^* \overline{D}^* \eta \rightarrow K^* \pi^+ \pi^0 \pi^0 K^* \pi^- \pi^0 \pi^0 \pi^0 \eta \\ \hline \\ & \text{Production} \\ \hline & p \rightarrow J_1^* \psi \omega \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ & p \rightarrow J_1^* \psi \mu^0 \rightarrow e^+ e^- \pi^+ \pi^- \eta^0 \\ & p \rightarrow J_1^* \psi \mu^0 \rightarrow e^+ e^- \pi^+ \pi^0 \pi^0 \\ \hline & p \rightarrow J_1^* \psi \mu^0 \rightarrow \pi^+ \pi^- \pi^- \pi^0 \\ \hline & p \rightarrow \mu^+ \pi^- \pi^- \rightarrow \pi^+ \pi^0 \pi^+ \pi^- \pi^- \\ \hline & p \rightarrow \phi^+ \pi^+ \pi^- \pi^- \rightarrow \pi^+ \pi^0 \pi^+ \pi^- \\ \hline & p \rightarrow \phi^+ \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \\ \hline & p \rightarrow \phi^+ \pi^- \pi^- \pi^+ \pi^- \pi^- \\ \hline & p \rightarrow \phi^+ \pi^- \pi^- \pi^+ \pi^- \pi^- \\ \hline & p \rightarrow \phi^+ \Phi^- K^+ K^- K^- \\ \hline & p \rightarrow \phi^+ D^+_{\pi^+} K^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \theta^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \Phi^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^- \phi^+ D^+_{\pi^+} \pi^- \theta^- \\ \hline & p \rightarrow D^+_{\pi^+} D^+_{\pi^+} \Phi^{\pi^+} \Phi$ | Y(3940) Y(4320) $f_g(2230)$ $f_g(2317)$ π_{π}^{-9} Hyperon |
| $\begin{split} p & \rightarrow D^* D^*_{0} \rightarrow K^- \pi^+ \pi^+ \pi^+ \pi^- K^- \pi^- \pi^+ \pi^+ \pi^- \pi^- \mu^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi^+ \pi$ | Y(3940) Y(4320) $f_2(2230)$ f_{π^0} D [*] ₀₀ (2317) + π^0 Hyperon |
| $\begin{split} p & \rightarrow D^* D \xrightarrow{a} 0 \rightarrow K^- \pi^+ \pi^a \pi^b K^+ \pi^- \pi^a \pi^a \pi^a \eta \\ p & \rightarrow D^* \overline{D} \xrightarrow{a} \eta \rightarrow K^- \pi^+ \pi^a \pi^b K^+ \pi^- \pi^b \pi^a \pi^a \eta \\ \hline P \operatorname{roduction} \\ \overline{P} p \rightarrow Q^+ \overline{Q} \xrightarrow{a} 0 \rightarrow \overline{Q} \xrightarrow{c} \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow Q^+ \overline{Q} \xrightarrow{a} 0 \rightarrow \overline{q} \xrightarrow{c} \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow Q^+ \overline{Q} \xrightarrow{a} 0 \rightarrow \overline{q} \xrightarrow{c} \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow Q^+ \overline{Q} \xrightarrow{a} 0 \rightarrow \overline{q} \xrightarrow{c} \pi^+ \pi^- \pi^0 \\ \overline{p} p \rightarrow Q^+ \overline{q} \xrightarrow{c} \pi^+ \pi^- \pi^- \pi^0 \\ \overline{p} p \rightarrow \overline{Q} \xrightarrow{c} \overline{Q} \xrightarrow{c} \pi^+ \pi^- \pi^- \pi^0 \\ \overline{p} p \rightarrow \overline{Q} \xrightarrow{c} \overline{Q} \xrightarrow{c} \pi^+ \pi^- \pi^- \pi^0 \\ \overline{p} p \rightarrow \overline{Q} \xrightarrow{c} \overline{Q} \xrightarrow{c} \overline{Q} \xrightarrow{c} \pi^+ \pi^- \pi^- \\ \overline{p} p \rightarrow \overline{Q} \xrightarrow{c} \overline{Q} \\ \overline{p} \rightarrow \overline{Q} \xrightarrow{c} Q$ | Y(3940) Y(4320) $f_2(2230)$ $f_2(2217)$ $\pi = 0$ Ityperon |
| $\begin{split} p & \rightarrow D^* D^*_{0} \rightarrow K \pi^+ \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | $\begin{tabular}{ c c c c c } \hline $Y(3940)$ \\ \hline $Y(4320)$ \\ \hline $f_2(2230)$ \\ \hline $f_{22}(2230)$ \\ \hline $D_{g0}(2317)$ \\ \hline π_{\pm}^0 \\ \hline $Hyperon$ \\ \hline \end{tabular}$ |
| $\begin{split} p & \rightarrow D^* D^*_{\alpha} a^{-\gamma} K^- \pi^+ \pi^{\alpha} a^{\alpha} K^+ \pi^- \pi^0 a^{\alpha} \pi^+ \eta \\ p & \rightarrow D^* \overline{D}^* \eta \rightarrow K^- \pi^+ \pi^0 a^{\alpha} K^+ \pi^- \pi^0 a^{\alpha} \pi^0 \\ \overline{p} & \rightarrow \phi^+ \pi^0 - \overline{r}^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow \phi^+ \pi^0 - \overline{r}^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow J^+ \phi \mu^0 \rightarrow - e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow J^+ \phi \mu^0 \rightarrow - e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow J^+ \phi \mu^0 \rightarrow \pi^+ \pi^- \pi^- \pi^0 \\ \overline{p} & \rightarrow \rho^+ \pi^+ \pi^- \pi^- \rightarrow \pi^+ \pi^- \pi^0 \pi^0 \rightarrow \overline{r}^+ \pi^- \rightarrow \overline{r}^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow \phi^+ \pi^+ \pi^- \pi^- \rightarrow \pi^+ \pi^- \pi^0 \pi^+ \pi^- \\ \overline{p} & \rightarrow \phi^+ \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \phi^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} & \rightarrow \phi^+ \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \phi^+ \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \phi^+ \pi^+ \pi^- \pi^- \\ \overline{p} & \rightarrow \phi^- \Phi^+ K^- K^+ K^- \\ \overline{p} & \rightarrow \phi^- \Phi^+ K^- K^+ K^- \\ \overline{p} & \rightarrow D^+ D^- Q^+ Q^+ \eta^- \pi^- \pi^- \\ \overline{p} & \rightarrow D^+ D^- Q^+ Q^+ \eta^+ \pi^+ \pi^- \\ \overline{p} & \rightarrow D^+ D^- \chi^0 \rightarrow \phi^+ \pi^+ D^+ \pi^+ \pi^- \\ \overline{p} & \rightarrow D^+ D^- \chi^0 \rightarrow \phi^+ D^+ \pi^+ \pi^- \\ \overline{p} & \rightarrow D^+ D^- \chi^0 \rightarrow \phi^+ D^+ \pi^+ \pi^- \\ \overline{p} & \rightarrow D^+ D^- \chi^0 \rightarrow \phi^+ D^+ \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow \overline{g} (1385) \Sigma^- (1385) \Sigma^- (1385) \Sigma^- \Lambda \pi^+ \Lambda^- \pi^0 \rightarrow \overline{p} \pi^+ \pi^+ p \pi^- \pi^- \pi^0 \\ \overline{p} & \rightarrow \overline{g} (1385) \Sigma^- (1385) \Sigma^- \Lambda \pi^+ \Lambda^- \pi^0 \rightarrow \overline{p} \pi^+ \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow \overline{g} (1385) \Sigma^- (1385) \Sigma^- (1385) \overline{g} \rightarrow \overline{\Lambda} \pi^+ \Lambda^- \pi^0 \rightarrow \overline{p} \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow \overline{g} & - \overline{g} \pi^- \pi^- \pi^- \overline{g} \end{pmatrix}$ | $\begin{array}{ c c c c c c c c c c c c c c c c c c c$ |
| $\begin{split} p & \rightarrow D^* D^*_{a} \rightarrow K \pi^+ \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | V(3940) $Y(4320)$ $f_2(2230)$ $D_{g0}^*(2317)$ π^0 Hyperon Hyperon |
| $\begin{split} p & \rightarrow D^* D^*_{,0} \rightarrow K \pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | $Y(3940)$ $Y(4320)$ $f_2(2230)$ $f_2(2317)$ π_{π}^{-9} Hyperon Hyperon |
| $\begin{split} p & \rightarrow D^* D^*_{-0} \rightarrow K = \pi^+ \pi^+ \pi^- \pi^- K + \pi^- \pi^+ \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | Y(3940) Y(4320) $f_x(2230)$ $f_x(2230)$ $D_{x0}^*(2317)$ π^{-9} Ilyperon Hyperon |
| $\begin{split} p & \rightarrow D^* D^*_{0} \rightarrow K \pi^+ \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | Y(3940) Y(4320) fg(2230) fg(2317) #± ⁰ Иурегол Нурегол Нурегол |
| $\begin{split} p & \rightarrow D^* D^*_{\alpha} \rightarrow K^- \pi^+ \pi^+ \pi^- K^- \pi^- \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | Y(3940) Y(4320) J _k (2230) J _k (2230) D _{s0} (2317) *± [±] Hyperon Hyperon Hyperon |
| $\begin{split} p & \rightarrow D^* D^*_{0} \rightarrow K^- \pi^+ \pi^0 \pi^* K^+ \pi^- \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0$ | У(3940) У(4320) ƒ2(2230) ƒ2(2230) ƒ2(2230) Пуретов Нуретов Нуретов |
| $\begin{split} p & \rightarrow D^* D_{-n}^{-n} \rightarrow K^- \pi^+ \pi^n \pi^n T^+ \pi^+ \pi^- \pi^- \eta \\ p & \rightarrow D^* \overline{D}^+ \eta \rightarrow K^- \pi^+ \pi^n \pi^n T^+ \pi^- \eta \\ \hline P \ roduction \\ \overline{P} & \rightarrow d_1^+ \overline{\sigma}^+ \pi^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow d_2^+ \overline{\sigma}^+ \pi^- \overline{\sigma}^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow d_1^+ \overline{p} \mu^n \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow d_1^+ \overline{p} \mu^n \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ \overline{p} & \rightarrow d_1^+ \overline{p} \pi^- \rightarrow \pi^+ \pi^- \pi^- \pi^0 \\ \overline{p} & \rightarrow d_1^+ \overline{\sigma}^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^0 \\ \overline{p} & \rightarrow d_1^+ \pi^- \pi^- \rightarrow \pi^+ \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow d_1^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow d_1^+ \pi^- \pi^+ \pi^- \pi^- \\ \overline{p} & \rightarrow d_1^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow d_1^- \pi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow d_1^- \pi^- \pi^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow D^*_1 D^+_1 \pi^- \sigma^- \eta^- \pi^- \pi^- \\ \overline{p} & \rightarrow D^*_1 D^+_1 \pi^0 \rightarrow \eta^- \pi^+ \pi^+ \pi^- \\ \overline{p} & \rightarrow D^*_1 D^+_1 \pi^0 \rightarrow \eta^- \pi^+ \pi^+ \pi^- \\ \overline{p} & \rightarrow D^*_1 D^+_1 \pi^0 \rightarrow \eta^- \pi^+ \pi^+ \pi^- \\ \overline{p} & \rightarrow D^*_1 D^+_1 \pi^- \pi^- \pi^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 T^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \overline{D}^+_1 T^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \overline{D}^+_1 T^- \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \pi^- \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \\ \overline{p} & \rightarrow \overline{D}^+_1 T^- \pi^- \pi^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 T^- \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 T^- \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^+_1 \pi^- \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^1 \overline{p} \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 D^1 \overline{p} \pi^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 \overline{D}^+_1 \overline{p}^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 \overline{D}^+_1 \overline{D}^1 \overline{p}^- \eta^0 \\ \overline{p} & \rightarrow \overline{D}^+_1 \overline{D}^+_1 \overline{D}^1 \overline{D}^1 \overline{p}^1 \overline$ | Y(3940) Y(4320) J ₂ (2230) J ₂ (2230) J ₂ (2217) #π ⁰ Hyperon Hyperon Hyperon |
| $\begin{split} p & \rightarrow D^* D^*_{0} \rightarrow K^- \pi^+ \pi^+ \pi^- K^- \pi^- \pi^+ \pi^+ \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^-$ | Y(3940) Y(4320) fg(2230) fg(2230) gas(2317) +π ⁰ Пуресов Нуресов Нуресов Нуресов |
| $\begin{split} p & \rightarrow D^* D_n^{-1} \rightarrow K^- \pi^+ \pi^0 \pi^0 K^+ \pi^- \pi^0 \pi^0 \pi^0 \\ p & \rightarrow D^* D^* D_n^{-1} \rightarrow K^- \pi^+ \pi^0 \pi^0 K^+ \pi^- \pi^0 \pi^0 \pi^0 \\ p & \rightarrow Q^+ \pi^0 \pi^- \pi^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ q^0 \pi^0 \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ q^0 \pi^0 \rightarrow e^+ e^- \pi^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ q^0 \pi^+ \pi^- \rightarrow \pi^+ \pi^- \pi^0 \pi^0 \\ p & \rightarrow q^+ \pi^- \pi^- \pi^- \pi^- \pi^0 \pi^0 \pi^+ \pi^- \pi^0 \\ p & \rightarrow q^+ \pi^- \pi^- \pi^- \pi^- \pi^0 \pi^0 \pi^+ \pi^- \pi^- \\ p & \rightarrow q^+ \pi^- \pi^- \pi^- \pi^- \pi^0 \pi^0 \pi^+ \pi^- \\ p & \rightarrow q^+ \pi^- \pi^- \pi^+ \pi^- \pi^0 \pi^0 \\ p & \rightarrow q^+ \pi^- \pi^- \pi^+ \pi^- \pi^0 \pi^0 \\ p & \rightarrow q^+ \pi^- \pi^- \pi^+ \pi^- \pi^0 \\ p & \rightarrow q^+ \pi^- \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow q^+ \pi^- \pi^- \pi^+ \pi^- \\ p & \rightarrow q^+ \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ D_{-} Q^+ Q^+ q^+ d^+ T^+ \pi^- \\ p & \rightarrow Q^+ D_{-} Q^+ Q^+ q^+ d^+ T^+ \pi^- \\ p & \rightarrow Q^+ D_{-} Q^+ Q^+ q^+ d^+ T^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ D_{-} Q^+ q^+ d^+ T^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ D_{-} Q^+ \pi^0 \rightarrow q^+ \pi^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ D_{-} Q^+ \pi^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ D_{-} Q^+ \pi^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ D_{-} Q^+ \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ D_{-} Q^+ \pi^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ D_{-} Q^+ \pi^+ \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^- \pi^0 \\ p & \rightarrow Q^+ T^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi^- \pi$ | Y(3940) Y(4320) J ₂ (2230) J ₂ (2230) J ₂ (2217) +π ⁰ Hyperon Hyperon Hyperon |
| $\begin{split} p & \rightarrow D^{-} D^{-}_{\alpha} a \rightarrow K^{} \pi^{+} \pi^{+} \pi^{-} \pi^{+} \pi^{-} \pi^{+} \pi^{+} \pi^{+} \pi^{+} \pi^{-} \pi^{+} \pi^{+} \pi^{+} \pi^{-} \pi^{+} \pi^{+} \pi^{+} \pi^{-} \pi^{+} \pi^{+} \pi^{-} \pi^{+} \pi^{-} \pi^{+} \pi^{-} \pi^{+} \pi^{-} \pi^{+} \pi^{-} \pi^{-} \pi^{+} \pi^{-} \pi^{-} \pi^{-} \pi^{+} \pi^{-} \pi^{-}$ | Y(3940) Y(4220) fz(2230) fz(2230) Ityperon Hyperon Hyperon Hyperon Y(1870) |
| $\begin{split} p & \rightarrow D^* D_{-} \eta^{-1} \times K \cap \pi^+ \eta^+ \eta^- \pi^+ \eta^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta^-$ | Y(3340) Y(4320) J ₂ (2230) J ₂ (2230) J ₂ (2217) #π ⁰ Hyperon Hyperon Hyperon X(3872) |
| $\begin{split} p & \rightarrow D^{-} D^{-} q \rightarrow K \pi^{+} \pi^{+} \pi^{-} \pi^{0} K^{+} \pi^{-} \pi^{+} \pi^{+} \pi^{0} \\ p & \rightarrow D^{-} D^{-} D^{-} q \rightarrow K^{-} \pi^{+} \pi^{+} \pi^{0} P^{-} K^{+} \pi^{-} \pi^{+} \pi^{+} \pi^{0} \\ p & \rightarrow D^{-} D^{-} q \rightarrow D^{-} \pi^{+} \pi^{-} \pi^{0} \\ p & \rightarrow D^{+} D^{-} q \rightarrow D^{-} e^{-} \pi^{+} \pi^{-} \pi^{0} \\ p & \rightarrow D^{+} D^{-} q \rightarrow \pi^{+} \pi^{-} \pi^{+} \pi^{-} \pi^{0} \\ p & \rightarrow D^{+} D^{-} q \rightarrow \pi^{+} \pi^{-} \pi^{+} \pi^{-} \pi^{0} \\ p & \rightarrow D^{+} D^{-} \pi^{-} \pi^{-} \pi^{+} \pi^{-} \pi^{-} \pi^{-} p^{-} \\ p & \rightarrow D^{+} \pi^{+} \pi^{-} \pi^{-} \pi^{+} \pi^{-} \pi^{-} \pi^{-} \\ p & \rightarrow D^{+} \pi^{+} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \\ p & \rightarrow \Phi^{+} \pi^{+} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \\ p & \rightarrow \pi^{+} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \\ p & \rightarrow \pi^{+} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \\ p & \rightarrow \pi^{+} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \\ p & \rightarrow D^{+} D^{-} D^{-} D^{-} (\pi^{+} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} \pi^{-} p^{-} p^{-} \pi^{-} \pi^{-} \pi^{-} p^{-} p^{-} D^{-} D^{-} \pi^{-} \pi^{-} \pi^{-} p^{-} p^{-} D^{-} D^{-} D^{-} \pi^{+} \pi^{+} p^{-} \pi^{-} \pi^{-} \pi^{0} \\ p & \rightarrow D^{+} D^{-} D^{-} D^{-} D^{-} \pi^{+} \pi^{+} p^{-} \pi^{-} \pi^{-} \pi^{0} \\ p & \rightarrow D^{+} D^{-} D^{-} D^{-} \pi^{+} \pi^{+} p^{-} \pi^{-} \pi^{-} \pi^{0} \\ p & \rightarrow D^{+} D^{-} D^{-} p^{-} \pi^{+} p^{-} \pi^{-} \pi^{-} p^{-} \\ p & \rightarrow D^{+} D^{-} D^{-} p^{-} \pi^{-} \pi^{-} p^{-} p^{-} p^{-} \pi^{-} \pi^{-} p^{-} p^{-} p^{-} \pi^{-} \pi^{-} p^{-} p^{-} \pi^{-} \pi^{-} p^{-} p^{-} p^{-} \pi^{-} \pi^{-} p^{-} p^{-} p^{-} \pi^{-} p^{-} p^{$ | Y(3940) Y(3940) Y(4320) fz(2230) fz(2230) P _{#0} (2317) +π ⁰ Hyperon Hyperon Hyperon X(3872) |
| $\begin{split} p & \rightarrow D^* D_{n} \to K^- \pi^+ \pi^0 \pi^0 K^+ \pi^- \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0$ | Y(3340) Y(4320) J2(2230) J2(2230) J2(2230) Hyperon Hyperon Hyperon X(3872) X(3872) |
| $\begin{split} p & \rightarrow D^+ D^- q \rightarrow K \pi^+ \pi^- \pi^0 K = \pi^- \pi^+ \eta^- q + \pi^- \eta^- \eta^- q + \pi^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta^- \eta$ | Y(3940) Y(3940) Y(4320) fz(2230) fz(2230) D _{e0} (2317) +=0 Ityperon Hyperon Hyperon X(3872) EMP |
| $\begin{split} p & \rightarrow D D _{a} \eta \rightarrow K \ \pi^{+} \pi^{+} \pi^{+} \pi^{+} \eta \\ p & \rightarrow D D _{a} \eta \rightarrow K \ \pi^{+} \pi^{+} \eta^{+} \rho K^{+} \pi^{-} \pi^{+} \eta^{+} \eta^{+$ | Y(3940) Y(3940) Y(4320) J ₂ (2230) J ₂ (2317) #π ⁰ Hyperon Hyperon Hyperon Hyperon Hyperon EMF |
| $\begin{split} p & \rightarrow D^{+}D^{-}\pi^{+} \rightarrow K^{-}\pi^{+}\pi^{+}\pi^{+}K^{+}\pi^{-}\pi^{+}\pi^{+}\pi^{+}\pi^{+}\pi^{+}\pi^{+}\pi^{+}\pi^{+$ | Y(3940) Y(3940) J Y(4320) J ₂ (2230) J ₂ (2230) D [*] ₂₀ (2817) ## ⁰ Hyperon Hyperon Hyperon K(3872) EMF EMF |
| $\begin{split} p & \rightarrow D^{+}D^{-}\eta^{-} \rightarrow K^{-}\pi^{+}\pi^{+}\pi^{-}K^{+}\pi^{-}\pi^{+}\pi^{+}\eta^{-}\pi^{+}\eta^{-}\eta^{-}\\ p & \rightarrow D^{+}D^{-}T^{-}\pi^{+}\eta^{-}\eta^{-}h^{+}\pi^{+}\pi^{-}\eta^{-}\eta^{-}\\ p & \rightarrow D^{+}D^{-}\eta^{-}\eta^{-}\eta^{-}\eta^{-}\eta^{-}\eta^{-}\eta^{-}\eta$ | Y(3940) Y(4320) fg(2230) fg(2230) gg(2317) Hyperon Hyperon Hyperon K(3872) EMF |

branching fraction

| pi0 (gg) | 98.82% |
|-----------------------|-------------------|
| eta (gg) | 39.31% |
| J/psi (ee) | 5.94% |
| chi_c0 (J/psi g) | 1.16% |
| chi_c1 (J/psi g) | 34.40% |
| chi_c2 (J/psi g) | 19.50% |
| omega (pi0 g) | 8.28% |
| eta_c (gg) | 6.30E-05 |
| eta' (gg) | 2.22% |
| phi (K+K-) | 48.90% |
| eta_c (phi phi) | 2.70E-03 |
| D+ (K- pi+ pi+) | 9.40% |
| D0 (K- pi+) | 3.89% |
| D0 (K- pi+ pi0) | 13.90% |
| D+* (D0 pi+) | 67.70% |
| eta_c1~ | 30.00% assumption |
| D0* (D0 pi0) | 61.90% |
| D0 (K- pi+ pi0 pi0) | 5.00% assumption |
| omega (pi+ pi- pi0) | 89.20% |
| rho0 (pi+ pi-) | 100.00% |
| Y(3940) (J/psi omega) | 30.00% assumption |
| psi' (J/psi pi+ pi-) | 33.60% |
| f2(2230) (phi phi) | 20.00% assumption |
| Ds (phi pi) | 4.50% |
| Ds (K+ K- pi+) | 5.50% |
| Ds* (Ds g) | 94.20% |
| Xi (Lam pi+) | 99.89% |
| Lam (p pi-) | 63.90% |
| Sig (1385) (Lam pi+) | 87.00% |
| Sig0 (Lam g) | 100.00% |
| e+ e- (EMP) | 100.00% |
| X(3872) (Db*0 D0) | 5.00E-03 |

cross section S/N \rightarrow

| Physics Book Data/Channels | | |
|--|--------------|--------------|
| | (assumption) | |
| Channel | X-sec [barn] | total BR [%] |
| J/psi (ee) pi+ pi- | 5.00E-11 | 5.94% |
| (VPIPI) | 5.00E-11 | 5.94% |
| | 5.00E-11 | 5.94% |
| | 6.00E-11 | 5.94% |
| | 5.00E-11 | 5.94% |
| | 5.00E-11 | 5.94% |
| J/psi (ee) pi0 (gg) pi0 (gg) | 3.00E-11 | 5.80% |
| chi_c1 (J/psi (ee) gamma) gamma | 5.00E-11 | 2.04% |
| | 5.00E-11 | 2.04% |
| | 5.00E-11 | 2.04% |
| chi_c2 (J/psi (ee) gamma) gamma | 5.00E-11 | 1.16% |
| | 5.00E-11 | 1.16% |
| | 5.00E-11 | 1.16% |
| J/psi (ee) gamma | 1.00E-09 | 5.94% |
| | 2.00E-09 | 5.94% |
| | 1.00E-09 | 5.94% |
| J/psi (ee) eta (gg) | 1.00E-10 | 2.34% |
| | 1.00E-10 | 2.34% |
| | 1.00E-10 | 2.34% |
| | 1.00E-10 | 2.34% |
| pi+ pi- pi+ pi- | 4.60E-05 | 100.00% |
| pi+ pi- pi0 (gg) pi0 (gg) | 5.00E-05 | 97.65% |
| J/psi (ee) eta (gg) pi0 (gg) | 3.00E-11 | 2.31% |
| J/psi (ee) omega (pi0 (gg) g) pi0 (gg) | 1.00E-11 | 0.48% |
| pi+ pi- pi0 (gg) | 1.20E-04 | 98.82% |
| | 2.90E-04 | 98.82% |
| | 3.00E-05 | 98.82% |
| pi+ pi- eta (gg) | 1.54E-06 | 39.31% |
| J/psi (ee) pi0 (gg) g | 5.00E-11 | 5.87% |
| | 5.00E-11 | 5.87% |
| | 5.00E-11 | 5.87% |
| | 5.00E-11 | 5.87% |
| J/psi (ee) eta (gg) g | 5.00E-11 | 2.34% |
| | 5.00E-11 | 2.34% |
| | 5.00E-11 | 2.34% |
| | 5.00E-11 | 2.34% |
| J/psi (ee) eta (gg) eta (gg) | 3.00E-11 | 0.92% |