

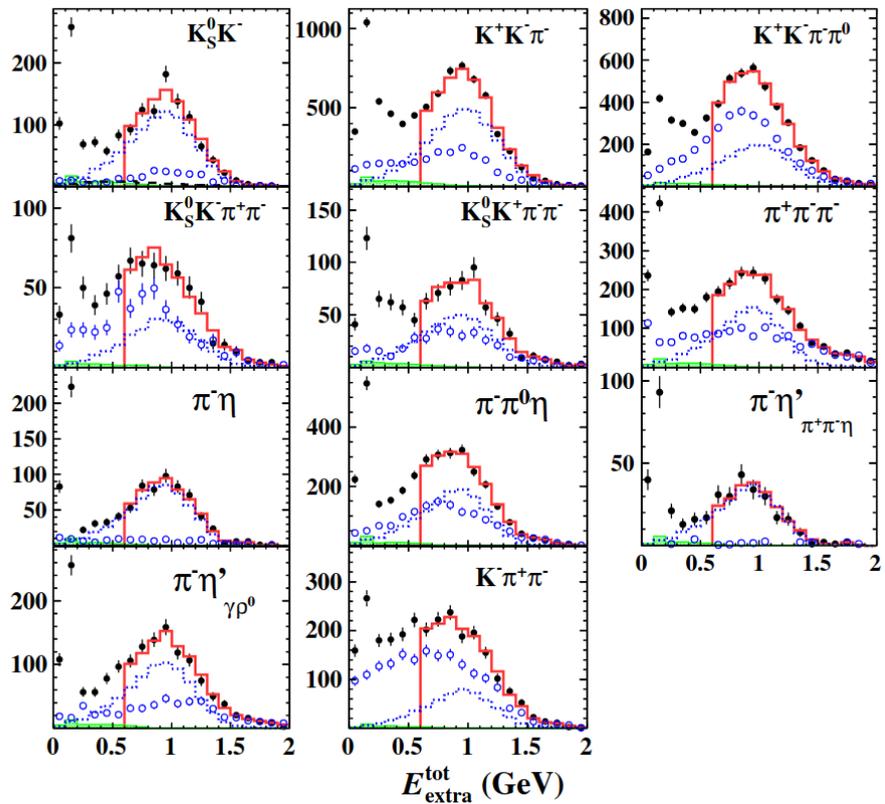
Other Physics Opportunities @ BESIII

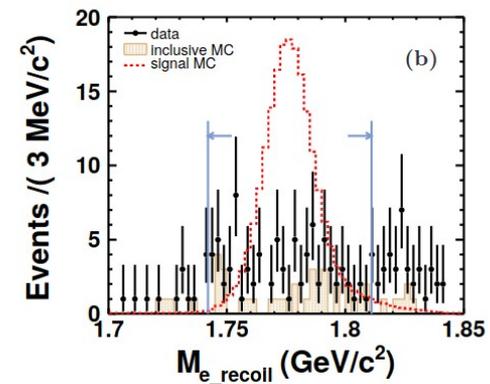
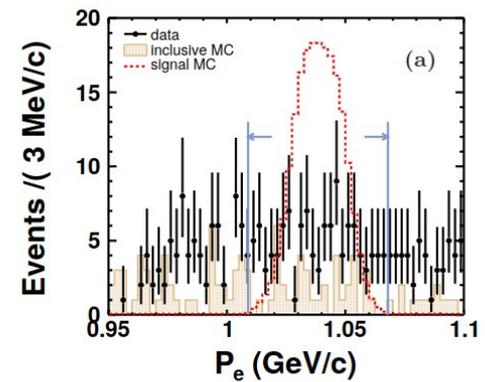
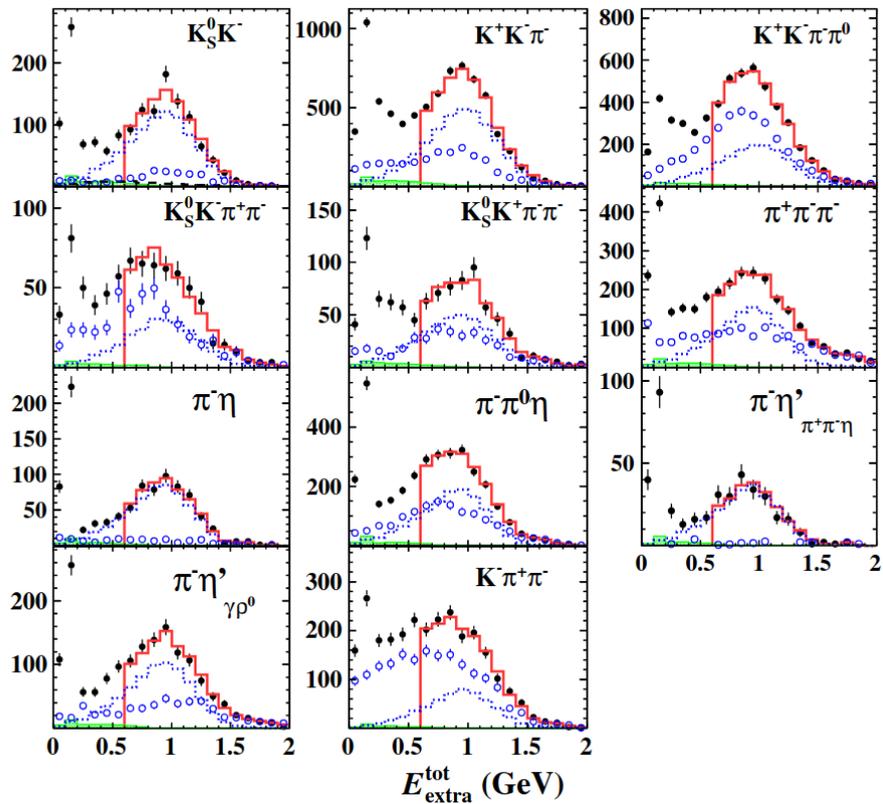


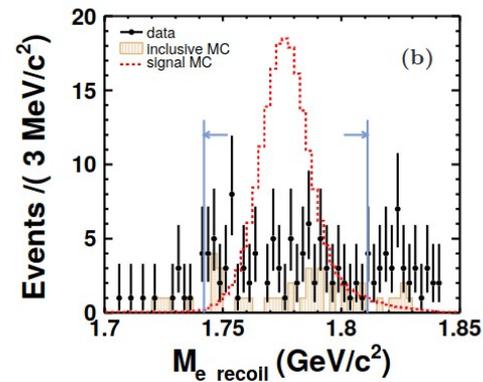
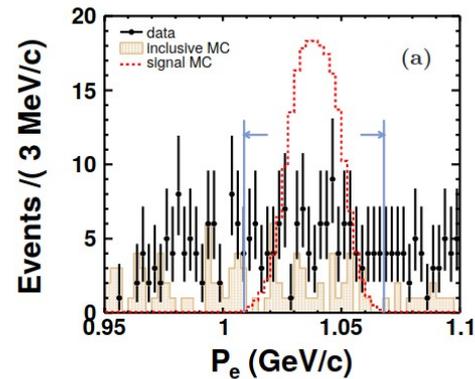
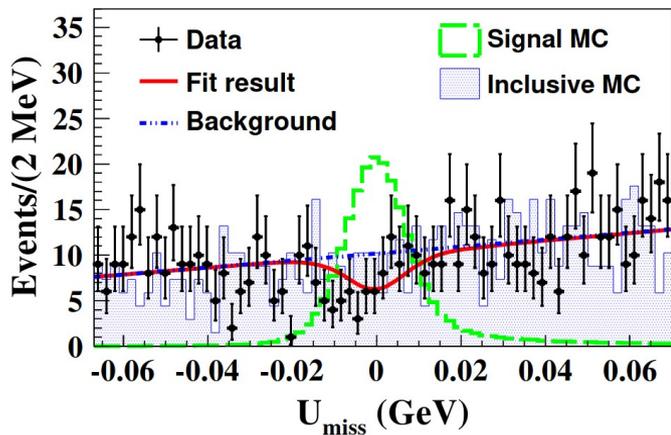
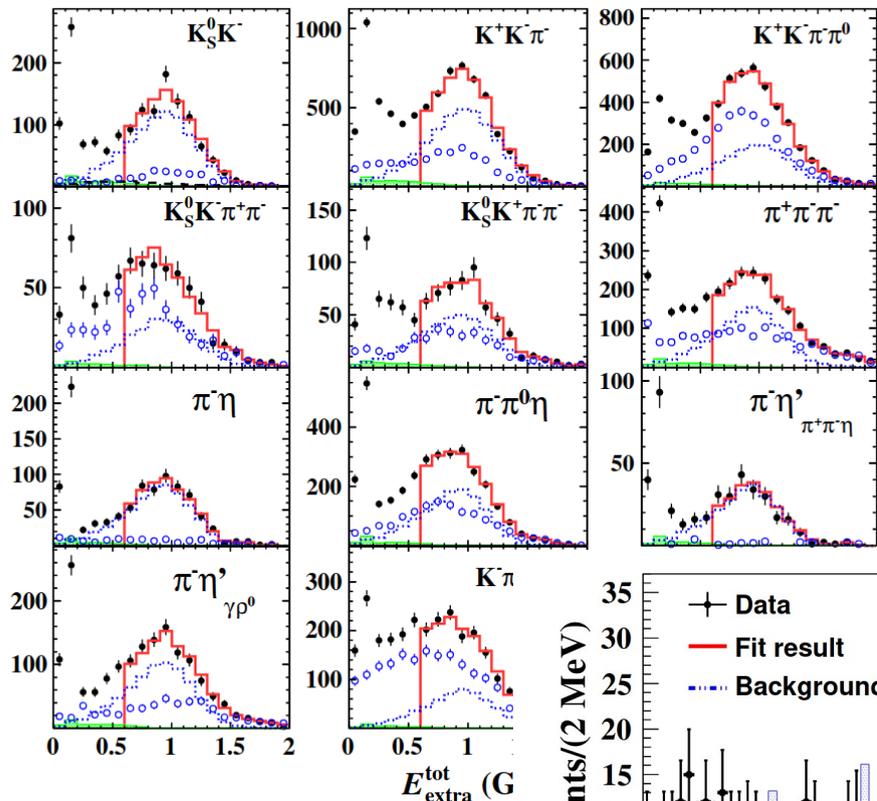
retreat

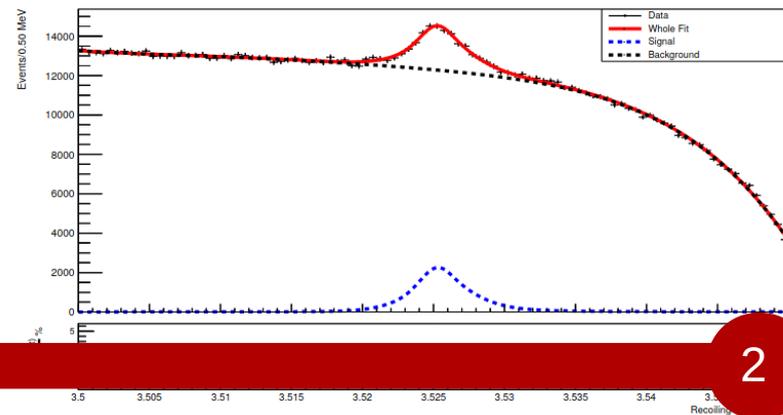
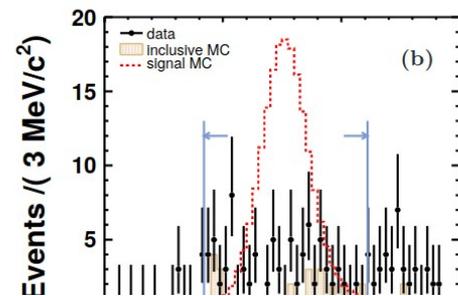
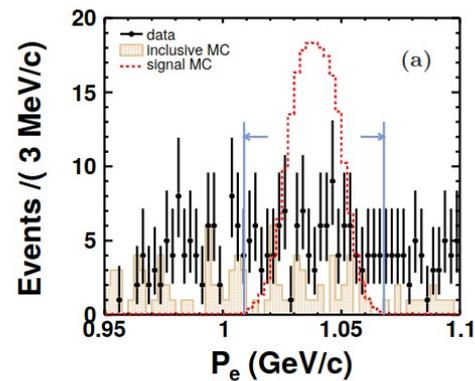
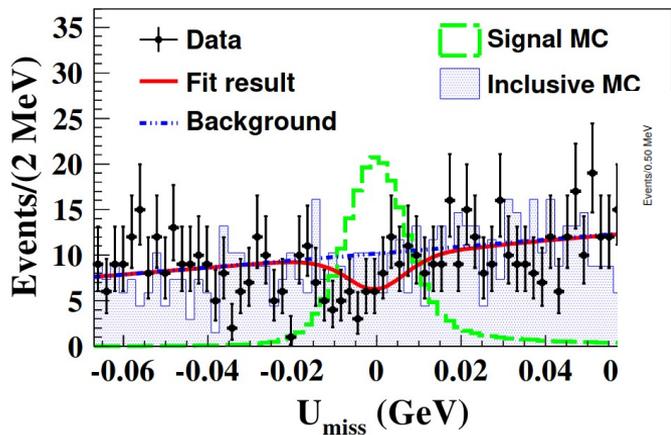
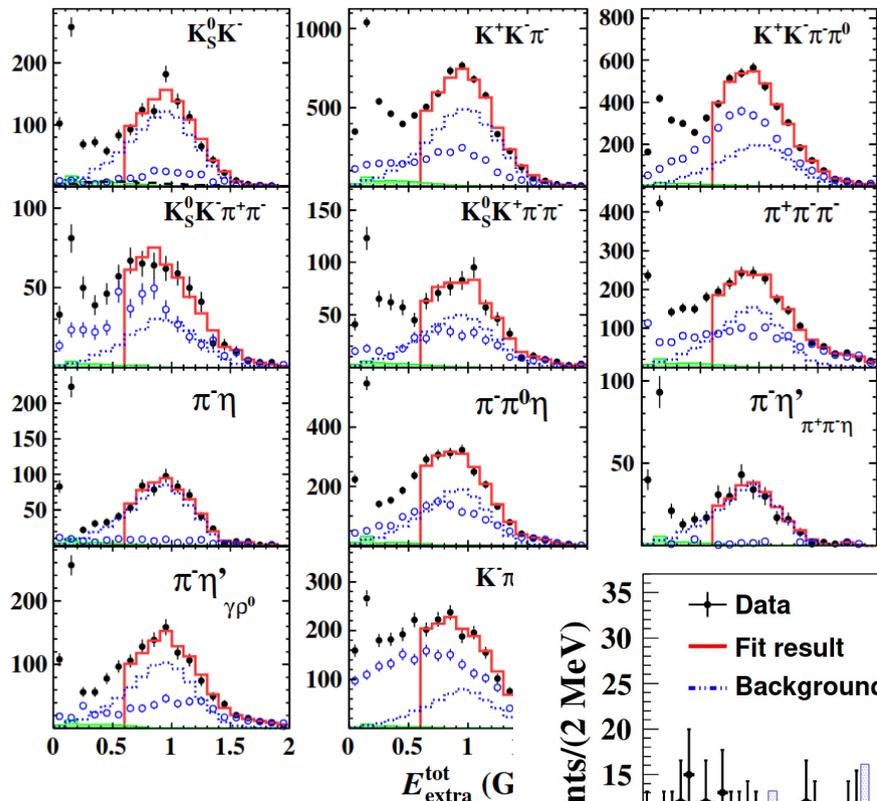
08/09/2021

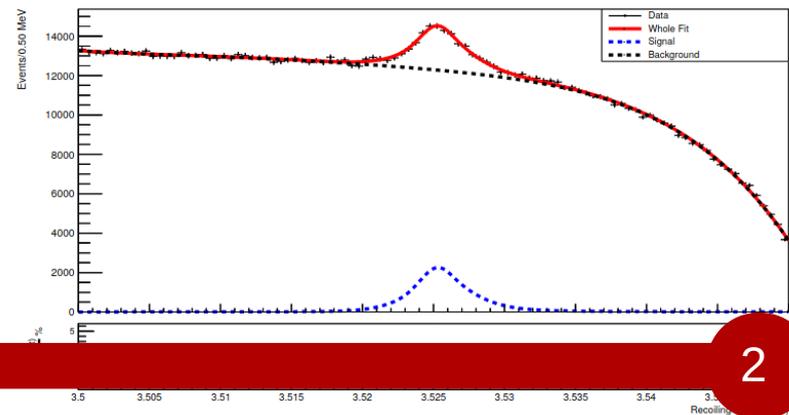
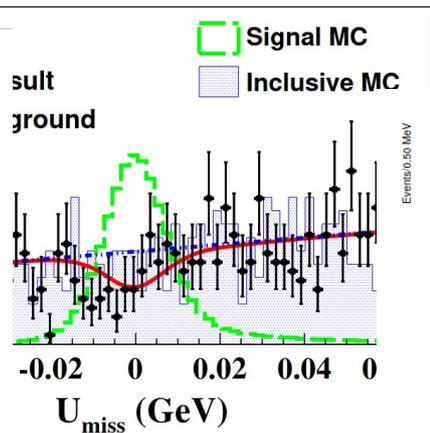
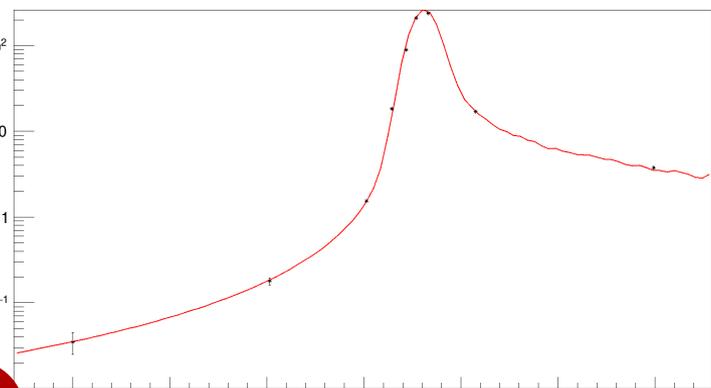
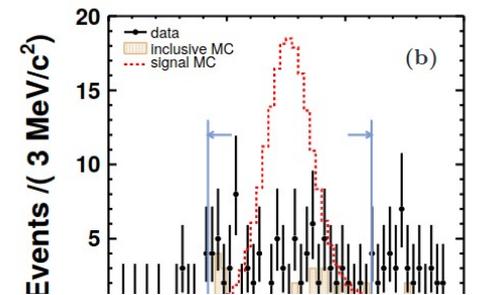
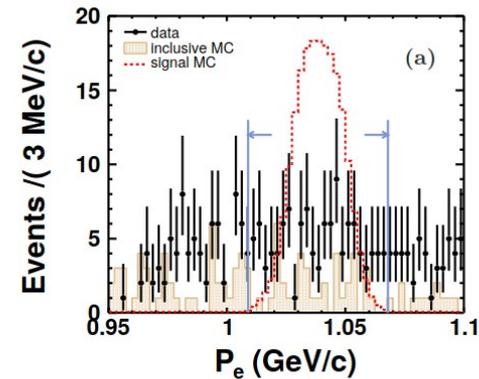
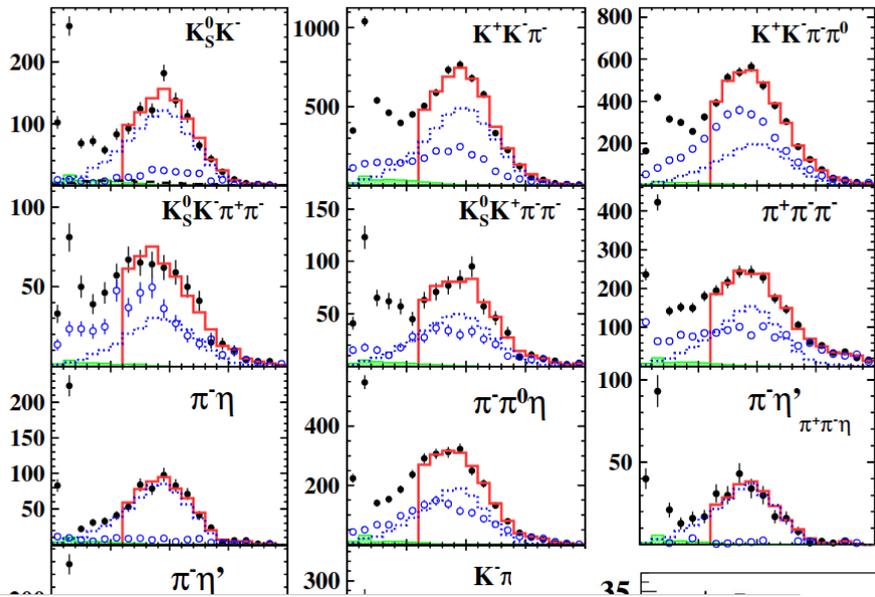
Giulio Mezzadri

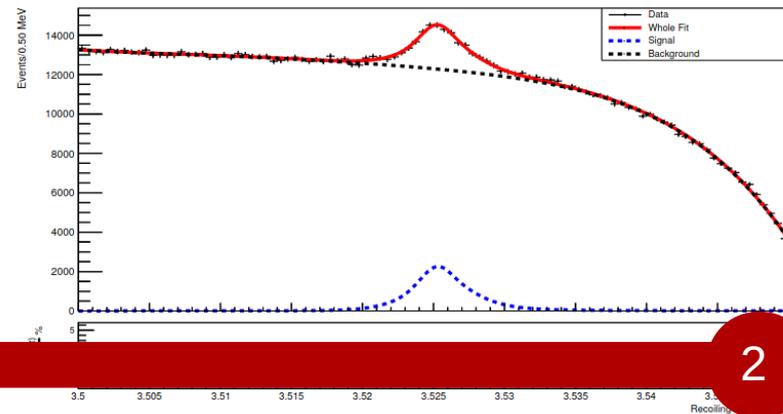
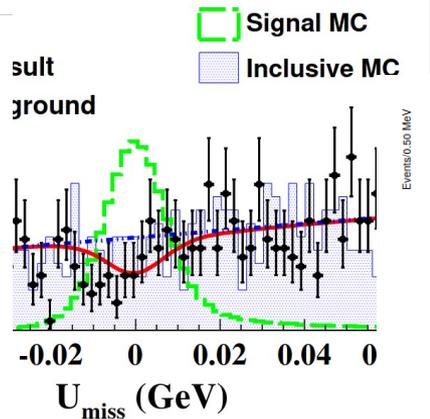
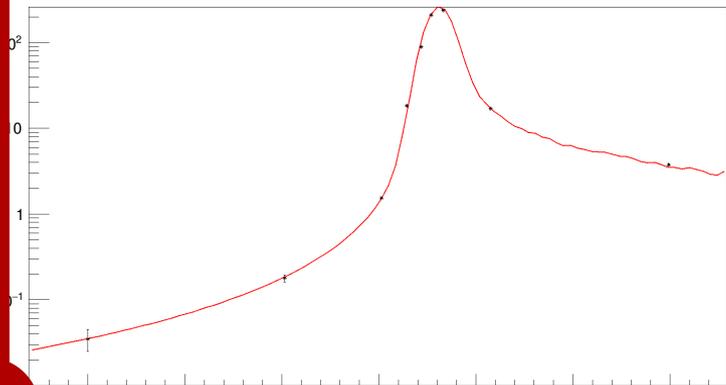
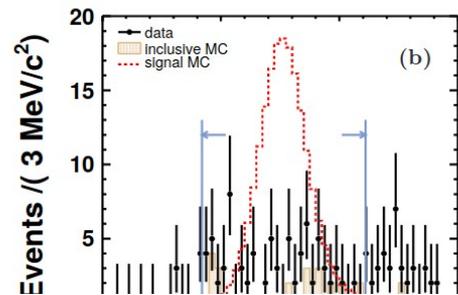
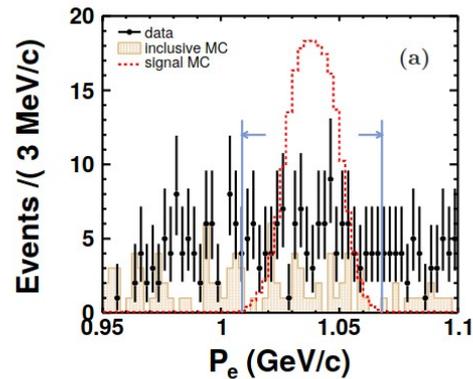
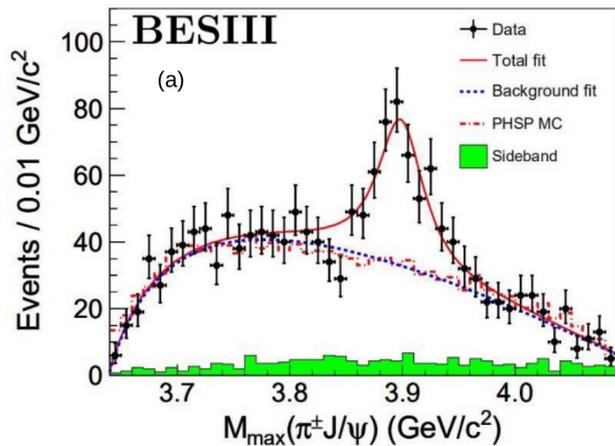
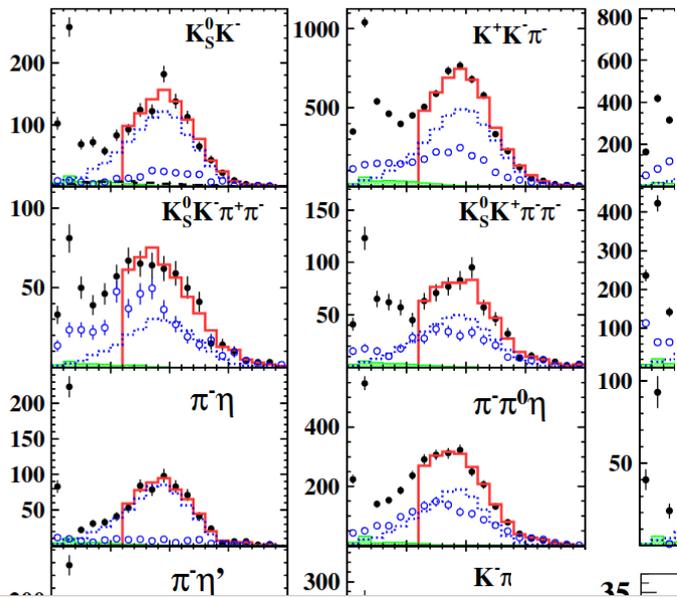






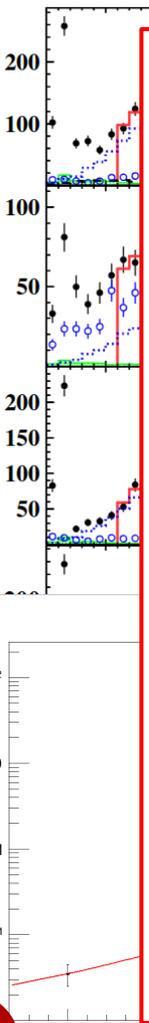






BESIII

20



C'è rischio di fare confusione!



BESIII

+

20

data
Inclusive MC
signal MC

(a)

1.1

(b)

Data
Whole Fit
Signal
Background



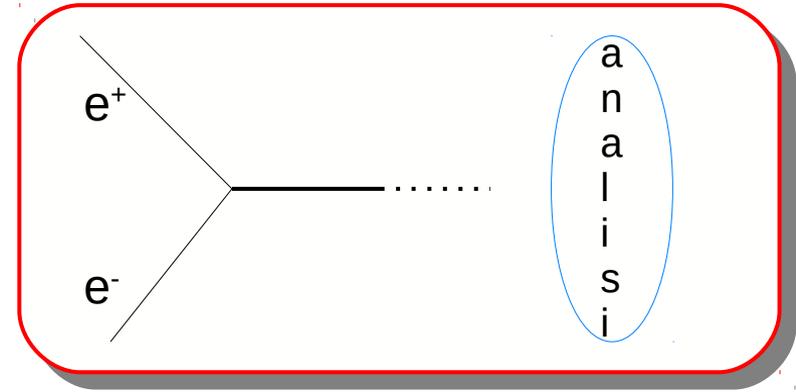
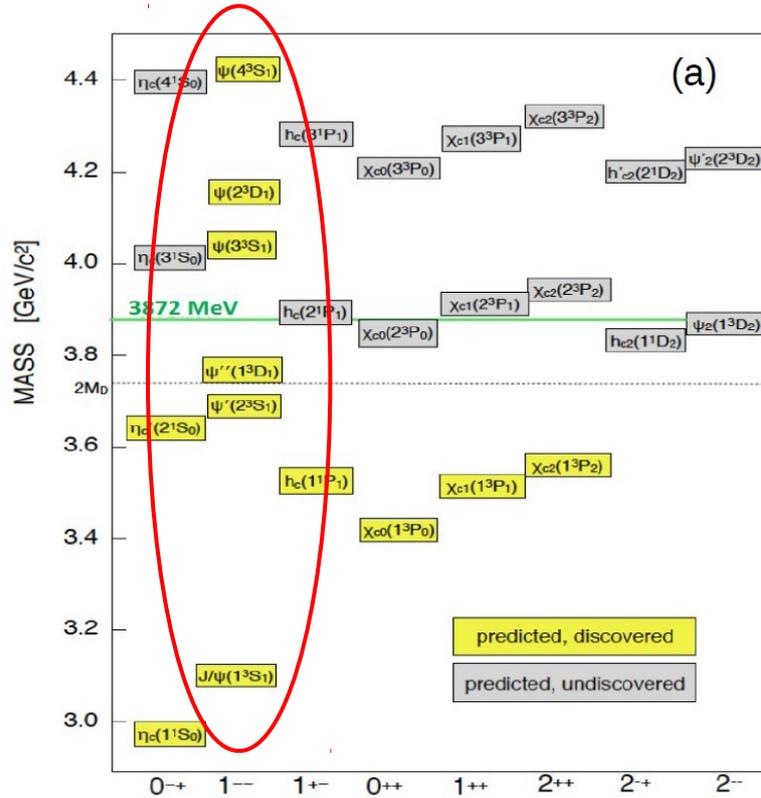
C'è rischio di fare confusione!

Facciamo un po' di ordine!

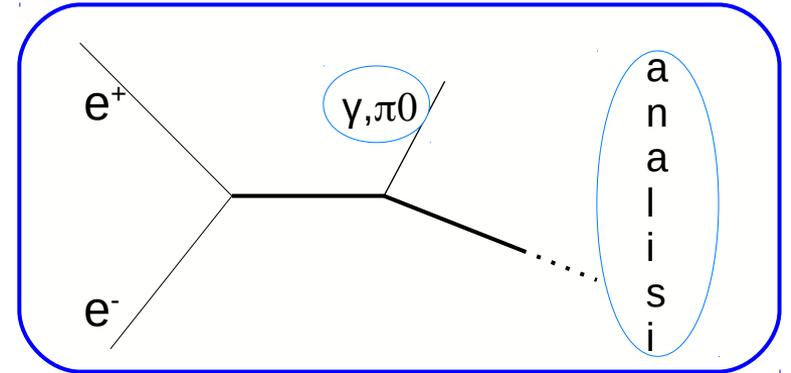
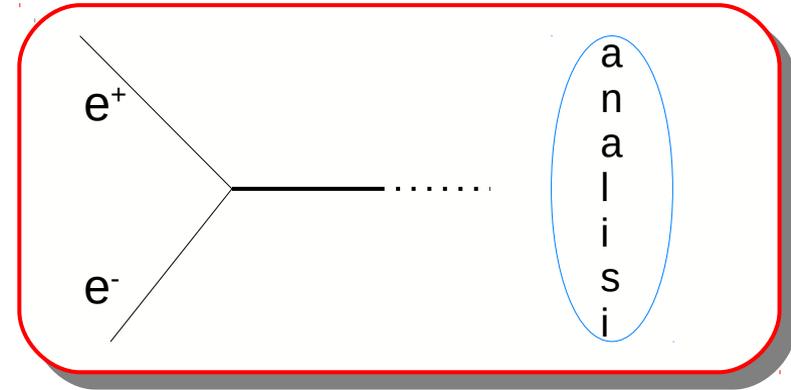
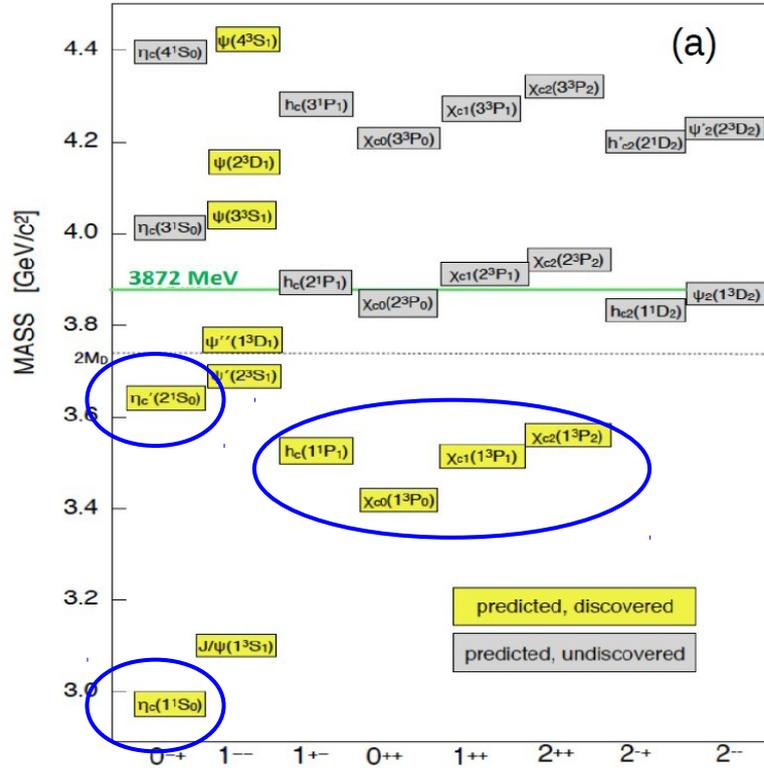


<https://arxiv.org/pdf/1912.05983.pdf>

Studio di decadimenti e transizioni del charmonio



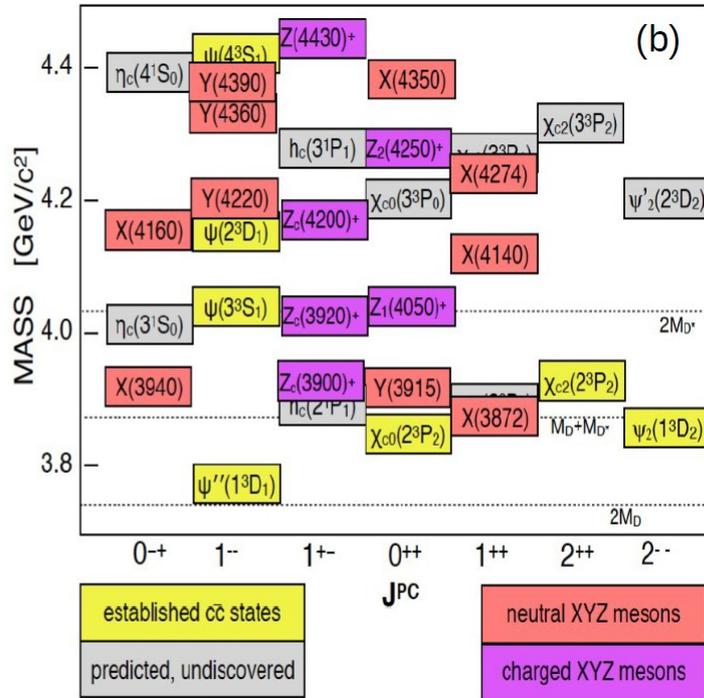
Studio di decadimenti e transizioni del charmonio



Studio di stati esotici



Studio di stati esotici

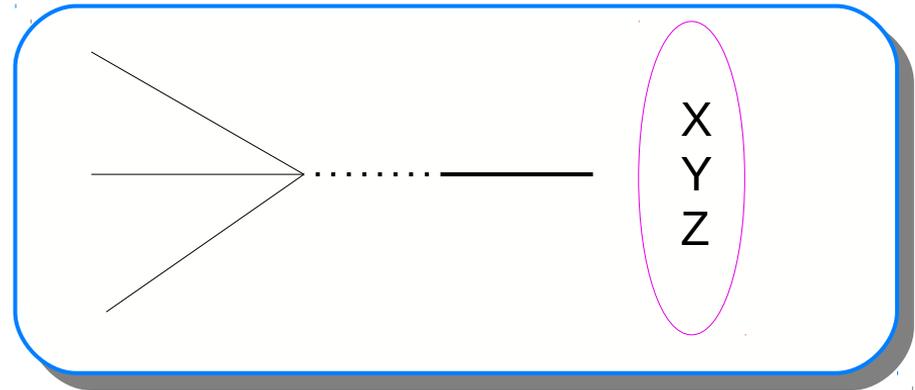


Una nuova famiglia di stati del charmonio:

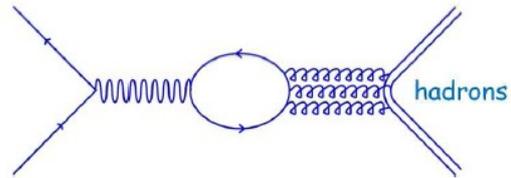
Y - Stati neutri vettoriali

Z - Stati carichi (a quattro quark)

X - Stati neutri non vettoriali

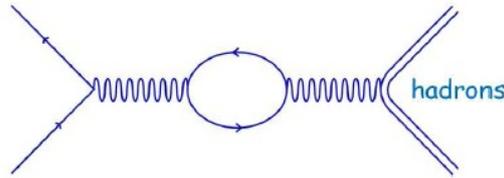


Studio della fase relativa tra le ampiezze di decadimento forte ed elettromagnetica del charmonio

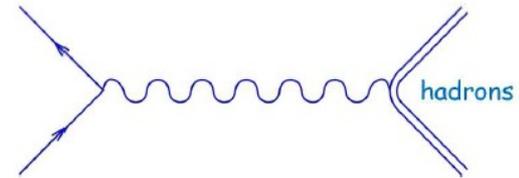


(a)

QED+QCD



(b)



(c)

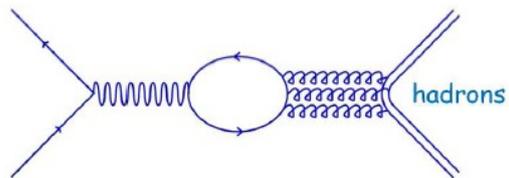
QED

Tutto noto, calcolabile

Scan attorno ad una risonanza del charmonio

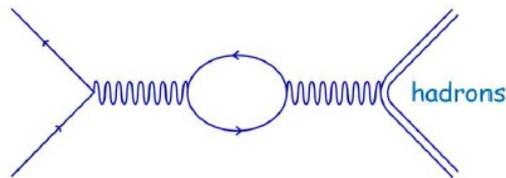
Dall'informazione di come varia la sezione d'urto attorno al picco determino se c'è interferenza

Studio della fase relativa tra le ampiezze di decadimento forte ed elettromagnetica del charmonio

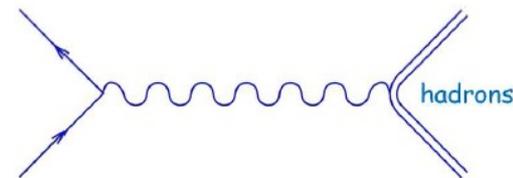


(a)

QED+QCD



(b)



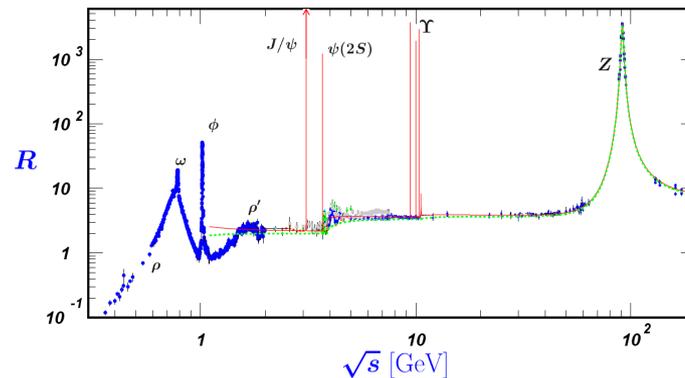
(c)

QED

Tutto noto, calcolabile

Scan attorno ad una risonanza del charmonio

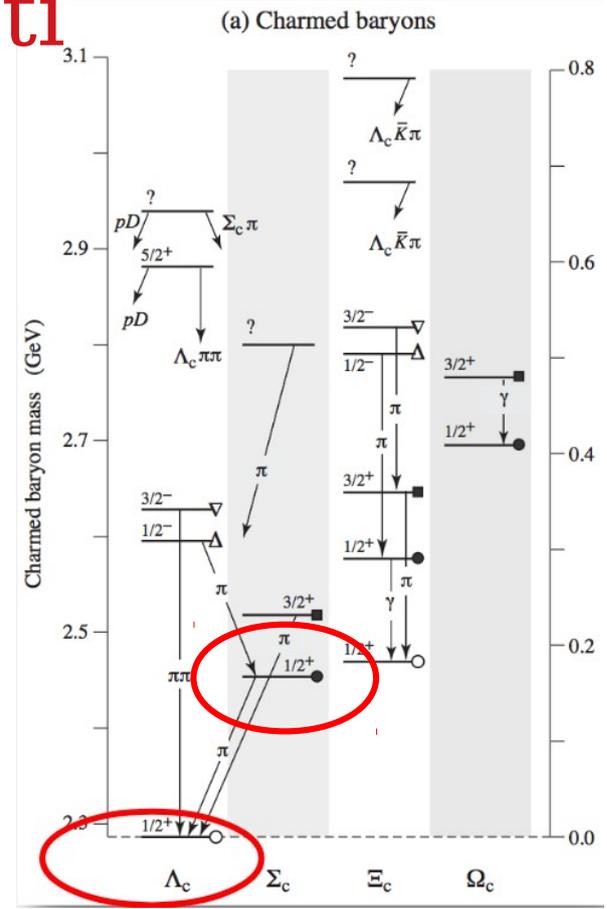
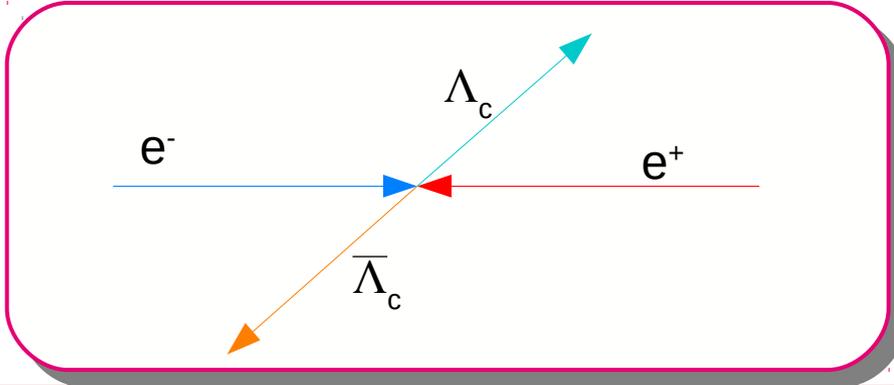
Dall'informazione di come varia la sezione d'urto attorno al picco determino se c'è interferenza



Studio di decadimenti di mesoni e di barioni charmati

State	J^P	Mass (MeV)	Width (MeV)	Experiments	Observed Modes
D^0	0^-	1864.83 ± 0.05	$(410.1 \pm 1.5) \times 10^{-15}$ s	Mark I [328]	$K\pi$ and $K3\pi$
D^\pm	0^-	1869.58 ± 0.09	$(1040 \pm 7) \times 10^{-15}$ s	Mark I [329]	$K2\pi$
D^{*0}	1^-	2006.85 ± 0.05	< 2.1	Mark I [330]	$e^+e^- \rightarrow DD^*$
$D^{*\pm}$	1^-	2010.26 ± 0.05	$(83.4 \pm 1.8) \times 10^{-3}$	Mark I [330]	$e^+e^- \rightarrow DD^*$

State	J^P	Mass (MeV)	Width (MeV)	Experiments	Observed Modes
D_s	0^-	1968.27 ± 0.10	$(500 \pm 7) \times 10^{-15}$ s	DASP [360]	$\eta\pi^\pm$
D_s^*	1^-	2112.1 ± 0.4	< 1.9	DASP [360]	$D_s\gamma$
$D_{s0}^*(2317)$	0^+	2317.7 ± 0.6	< 3.8	BaBar [112]	$D_s^+\pi^0$





Opportunità vicine

Studio di decadimenti e transizioni del charmonio

Opportunità: $\psi(2S) \rightarrow \tau^+\tau^-$

$$R_{\tau/\ell}^V \equiv \frac{\Gamma(V \rightarrow \tau^+\tau^-)}{\Gamma(V \rightarrow \ell^+\ell^-)}, \quad (V = \psi, \Upsilon; \ell = e, \mu),$$

$V(nS)$	SM prediction	Exp. value $\pm \sigma_{\text{stat}} \pm \sigma_{\text{syst}}$
$\Upsilon(1S)$	$0.9924 \pm \mathcal{O}(10^{-5})$	$1.005 \pm 0.013 \pm 0.022$
$\Upsilon(2S)$	$0.9940 \pm \mathcal{O}(10^{-5})$	$1.04 \pm 0.04 \pm 0.05$
$\Upsilon(3S)$	$0.9948 \pm \mathcal{O}(10^{-5})$	$1.05 \pm 0.08 \pm 0.05$
$\psi(2S)$	$0.390 \pm \mathcal{O}(10^{-4})$	0.39 ± 0.05

Iniziato da Isabella, con giusto supporto si può utilizzare il 1B di $\psi(2S)$ per confrontare contro la predizione del Modello Standard

- Se va male → Misura di precisione di decadimenti del charmonio
- Se va (molto) bene → **Stoccolma!**

Studio della fase alla $\psi(2S)$ in $\rho\pi$, $p\bar{p}$

Prendendo un modello, si può calcolare, con i dati disponibili:

- J/ψ
 - VP (1 \cdot 0 \cdot) (e.g. $J/\psi \rightarrow \rho\pi$) fase = $106^\circ \pm 10^\circ$
 - PP (0 \cdot 0 \cdot) (e.g. $J/\psi \rightarrow \pi\pi$) fase = $89.6^\circ \pm 9.9^\circ$
 - BB ($\frac{1}{2}$ $\frac{1}{2}$) (e.g. $J/\psi \rightarrow p\bar{p}$) fase = $89^\circ \pm 8^\circ$
- At $\psi(2S)$
 - VP (1 \cdot 0 \cdot) fase = $159^\circ \pm 12^\circ$
 - PP (0 \cdot 0 \cdot) fase = $95^\circ \pm 11^\circ$

Per entrambe le analisi, abbiamo il codice di analisi (praticamente) già pronto!

Studio della fase alla $\psi(2S)$ in $\rho\pi$, $p\bar{p}$

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Differenza di fase in processi VP potrebbe essere origine del $\rho\pi$ puzzle, una delle osservazioni fenomenologiche più "longeve" senza spiegazione

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Studio della fase alla $\psi(2S)$ in $\rho\pi$, $p\bar{p}$

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Per entrambe le analisi, abbiamo il codice di analisi (praticamente) già pronto!

CAVEAT:

Questo lavoro è effettivamente la prima evidenza sperimentale diretta di buco nero



Altre idee “mature”

Opportunità: Update di $\psi(2S) \rightarrow \pi^0 h_c$

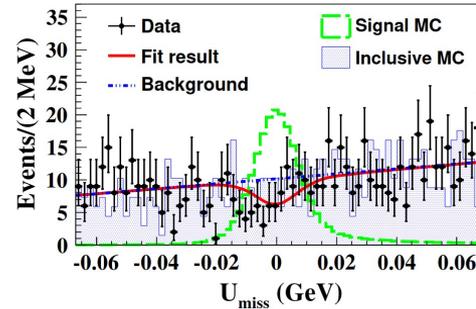
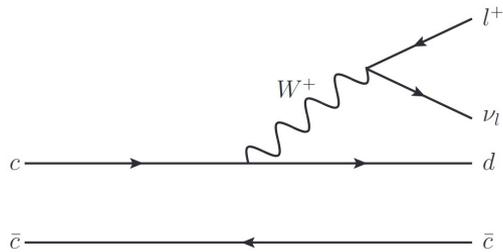
Opportunità: Studio di $\psi(2S) \rightarrow \pi^0 h_c, h_c \rightarrow e^+e^-\eta_c$

Opportunità: Ricerca di pentaquark in $\Lambda_c \rightarrow p\phi\pi^0$



Opportunità
per il futuro

Studio del decadimento debole della J/psi



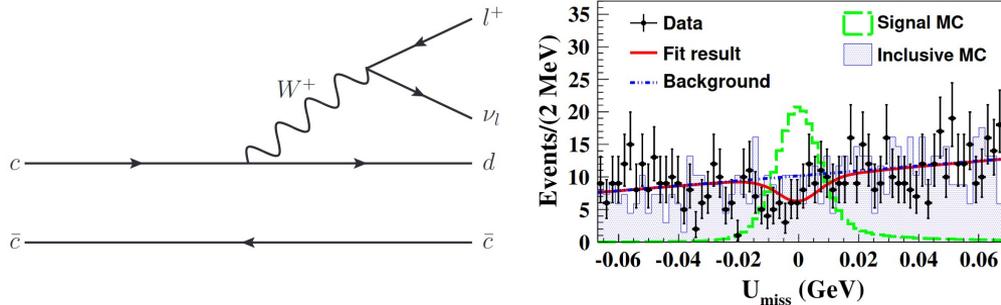
- $\Gamma_{298} D^- e^+ \nu_e + \text{c.c.}$
- $\Gamma_{299} \bar{D}^0 e^+ e^- + \text{c.c.}$
- $\Gamma_{300} D_s^- e^+ \nu_e + \text{c.c.}$
- $\Gamma_{301} D_s^{*-} e^+ \nu_e + \text{c.c.}$
- $\Gamma_{302} D^- \pi^+ + \text{c.c.}$
- $\Gamma_{303} \bar{D}^0 \bar{K}^0 + \text{c.c.}$
- $\Gamma_{304} \bar{D}^0 \bar{K}^{*0} + \text{c.c.}$
- $\Gamma_{305} D_s^- \pi^+ + \text{c.c.}$
- $\Gamma_{306} D_s^- \rho^+ + \text{c.c.}$

Weak decays

< 1.2	$\times 10^{-5}$	CL=90%
< 8.5	$\times 10^{-8}$	CL=90%
< 1.3	$\times 10^{-6}$	CL=90%
< 1.8	$\times 10^{-6}$	CL=90%
< 7.5	$\times 10^{-5}$	CL=90%
< 1.7	$\times 10^{-4}$	CL=90%
< 2.5	$\times 10^{-6}$	CL=90%
< 1.3	$\times 10^{-4}$	CL=90%
< 1.3	$\times 10^{-5}$	CL=90%

Grazie ai 10B di eventi, è possibile ridurre di molto gli attuali limiti sperimentali sul decadimento debole della J/psi

Studio del decadimento debole della J/psi



Grazie ai 10B di eventi, è possibile ridurre di molto gli attuali limiti sperimentali sul decadimento debole della J/psi

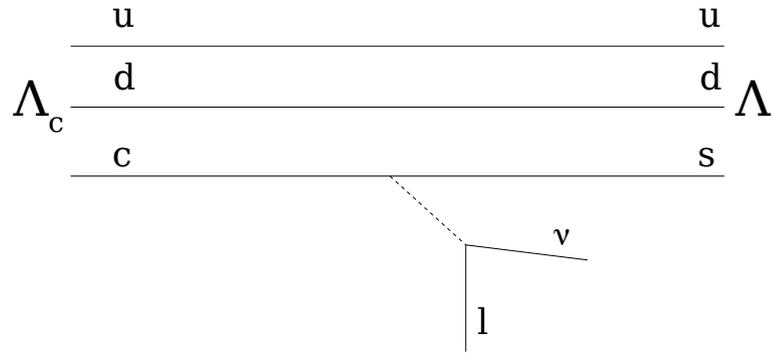
Specie i canali adronici, hanno limiti relativamente poco stretti e predizioni “quasi” accessibili

Weak decays

Γ_{298}	$D^- e^+ \nu_e + \text{c.c.}$	< 1.2	$\times 10^{-5}$	CL=90%
Γ_{299}	$\bar{D}^0 e^+ e^- + \text{c.c.}$	< 8.5	$\times 10^{-8}$	CL=90%
Γ_{300}	$D_s^- e^+ \nu_e + \text{c.c.}$	< 1.3	$\times 10^{-6}$	CL=90%
Γ_{301}	$D_s^{*-} e^+ \nu_e + \text{c.c.}$	< 1.8	$\times 10^{-6}$	CL=90%
Γ_{302}	$D^- \pi^+ + \text{c.c.}$	< 7.5	$\times 10^{-5}$	CL=90%
Γ_{303}	$\bar{D}^0 \bar{K}^0 + \text{c.c.}$	< 1.7	$\times 10^{-4}$	CL=90%
Γ_{304}	$\bar{D}^0 \bar{K}^{*0} + \text{c.c.}$	< 2.5	$\times 10^{-6}$	CL=90%
Γ_{305}	$D_s^- \pi^+ + \text{c.c.}$	< 1.3	$\times 10^{-4}$	CL=90%
Γ_{306}	$D_s^- \rho^+ + \text{c.c.}$	< 1.3	$\times 10^{-5}$	CL=90%

	Decay type	Example	exp. sensitivity ($\times 10^{-6}$)	predicted \mathcal{B} [7-10] ($\times 10^{-10}$)
$c \rightarrow s$	$D_{(s)}P$	$J/\psi \rightarrow D_s^- \pi^+$	9.9	2.00 ~ 8.74
		$J/\psi \rightarrow D^0 K^0$	13.0	0.36 ~ 2.80
	$D_{(s)}V$	$J/\psi \rightarrow D_s^- \rho^+$	2.0	12.60 ~ 50.50
		$J/\psi \rightarrow D^0 K^{*0}$	0.38	1.54 ~ 10.27
	$D_{(s)}^*V$	$J/\psi \rightarrow D_s^{*-} \rho^+$	1.7	52.60
$c \rightarrow d$	$D_{(s)}P$	$J/\psi \rightarrow D_s^- K^+$	9.8	0.16 ~ 0.55
		$J/\psi \rightarrow D^- \pi^+$	0.21	0.08 ~ 0.55
		$J/\psi \rightarrow D^0 \eta$	0.72	0.016 ~ 0.070
		$J/\psi \rightarrow D^0 \eta'$	0.25	0.003 ~ 0.004
		$J/\psi \rightarrow D^0 \pi^0$	0.48	0.024 ~ 0.055
	$D_{(s)}V$	$J/\psi \rightarrow D_s^- K^{*+}$	5.4	0.82 ~ 2.79
		$J/\psi \rightarrow D^- \rho^+$	0.35	0.42 ~ 2.20
		$J/\psi \rightarrow D^0 \rho^0$	0.77	0.18 ~ 0.22
		$J/\psi \rightarrow D^0 \omega$	0.35	0.16 ~ 0.18
	$D_{(s)}^*V$	$J/\psi \rightarrow D^0 \phi$	0.22	0.41 ~ 0.65
		$J/\psi \rightarrow D_s^{*-} K^{*+}$	4.5	2.6
		$J/\psi \rightarrow D_s^{*-} \rho^+$	0.083	2.8
		$J/\psi \rightarrow D_s^{*-} K^{*+}$	0.027	9.6

Studio del decadimento semi-leptonico della Λ_c con il neutrone



$$\Gamma_{72} \quad \Lambda e^+ \nu_e$$

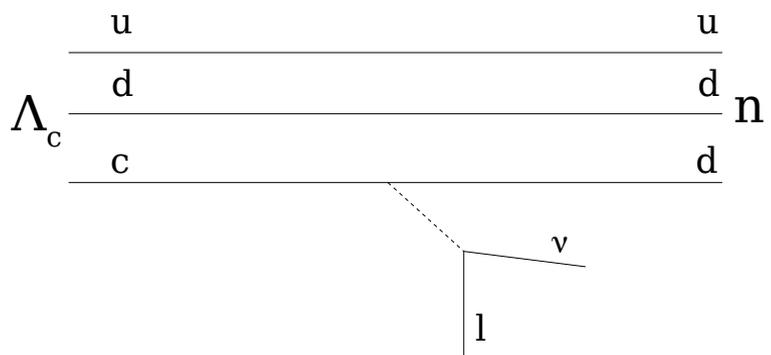
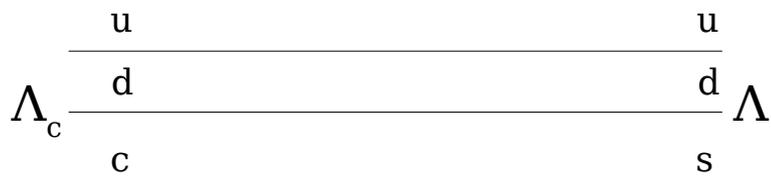
$$\Gamma_{73} \quad \Lambda \mu^+ \nu_\mu$$

Semileptonic modes

$$(3.6 \pm 0.4) \%$$

$$(3.5 \pm 0.5) \%$$

Studio del decadimento semi-leptonico della Λ_c con il neutrone



$$\Gamma_{72} \quad \Lambda e^+ \nu_e$$

$$\Gamma_{73} \quad \Lambda \mu^+ \nu_\mu$$

Semileptonic modes

$$(3.6 \pm 0.4) \%$$

$$(3.5 \pm 0.5) \%$$

Sarebbe la prima misura in assoluto di questo processo

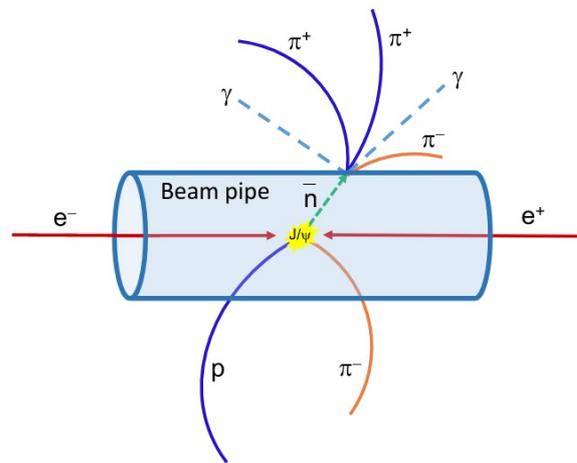
Difficoltà:

- è un processo soppresso rispetto al caso con la Λ nello stato finale
- ricostruire il neutrone e cercare il neutrino come massa mancante

Positivo: Abbiamo tantissimi dati!

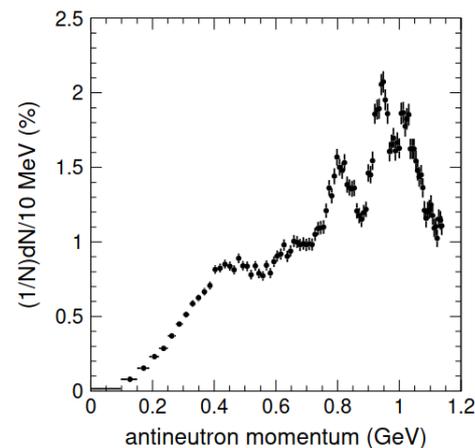
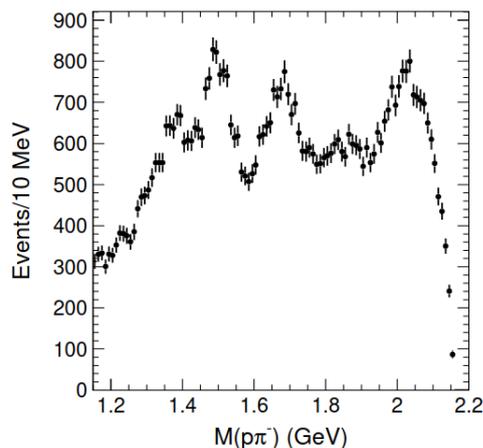
Studio di interazioni nucleari con antineutroni

Phys.Rev.Lett. 127
(2021) 1, 012003



Disponibili circa 8 milioni di antineutroni usando tutto il sample di J/ψ con processo $n+\text{Be}$ o $n+\text{C}$

Sorgente unica di anti-neutroni con processo $J/\psi \rightarrow p\pi n$



Per la fisica, review di Tullio Bressani e Alessandra Filippi, Phys.Rept. 383 (2003) 213-297

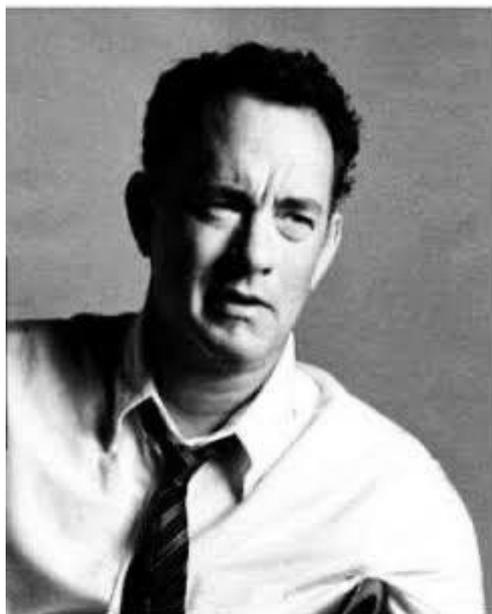
“Complementare” con Urania!

Raccogliendo le idee

- BESIII continuerà a raccogliere dati fino al 2030
- Finestra unica per accedere a tantissime diverse analisi
- PiFE ha sviluppato una forte competenza nell'analisi, in particolare nel charmonio e negli adroni leggeri
- L'unico limite è l'immaginazione (ed il tempo per finire i lavori...

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T.HANKS



T.hanks a lot