Bottomonium WG activities

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Outline

B2TiP golden channels / transitions:

$Y(6S) \rightarrow \pi\pi\, h_b(1P, 2P)$	Shanette de la Motte (Melbourne), Bryan Fulsom (PNNL)
$Y(6S) \rightarrow \eta\, b\bar{b}$	U.T. (Torino)

Hyperons:

$Y(3S) \rightarrow$ dibaryon/exaquarks + X	Bianca Scavino (Mainz)

Tools:

Recoil constraint	Torben Ferber (UBC), UT (Torino)
Bottomonium skims	Stefano Spataro (Torino)
(Continuum rejection for bottomonium)	Konstantina Doku, U.T. (Torino)

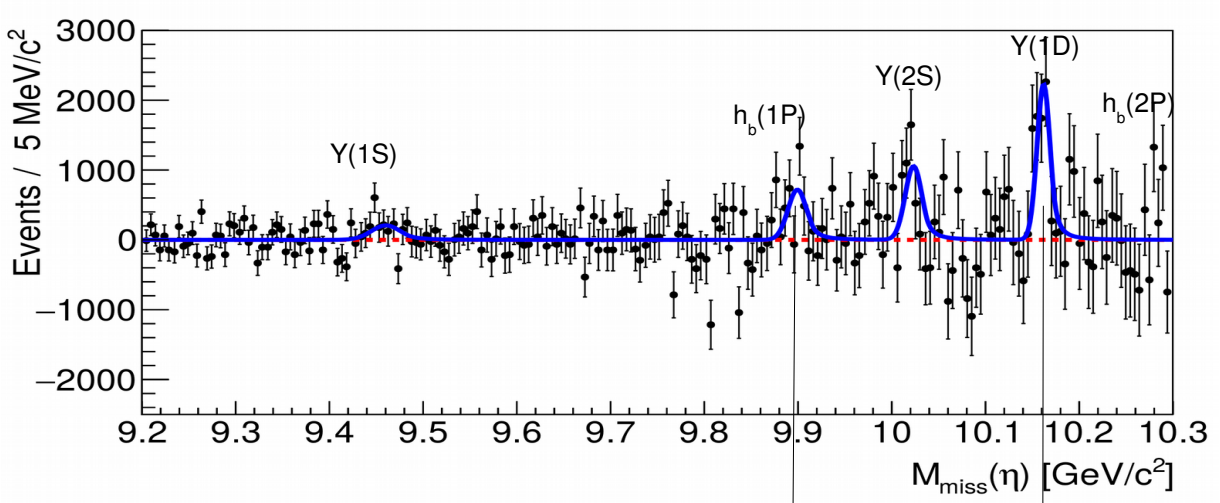
This talk is focused on Italian-related activities only

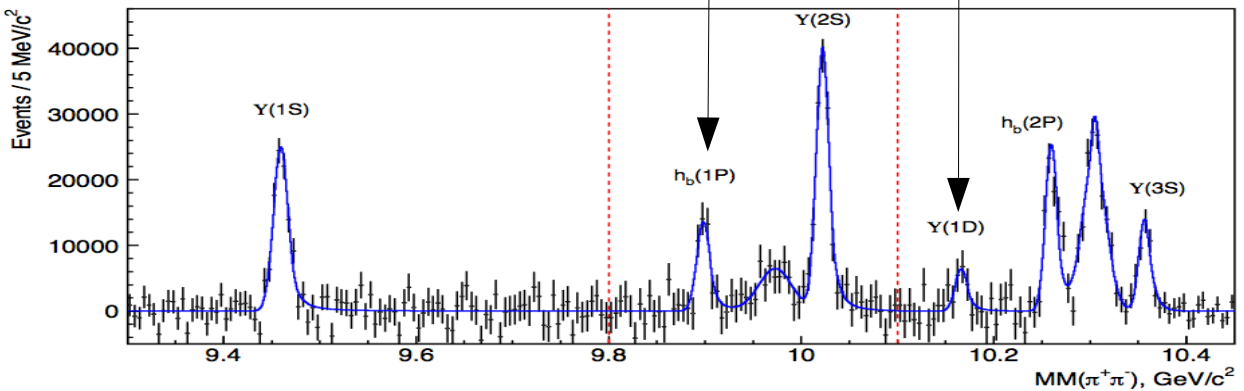
B2TiP Analyses

η trasitions from Y(6S)

Two Physics cases:

1) At Y(5S), the Y(1D) is the only PC = - - state to have BF(η) > BF(ππ)





$\sigma_{Born}[e^+e^- \to \eta\, \Upsilon_{1,2}(1D)] = (1.50 \pm 0.30 \pm 0.20)$ pb

$\sigma_{Born}[e^+e^- \to \eta\, \Upsilon(2S)] = (0.97 \pm 0.31 \pm 0.19)$ pb

$\sigma_{Born}[e^+e^- \to \eta\, \Upsilon(1S)] < 0.61$ pb

$\sigma_{Born}[e^+e^- \to \eta\, h_b(1P)] < 0.92$ pb

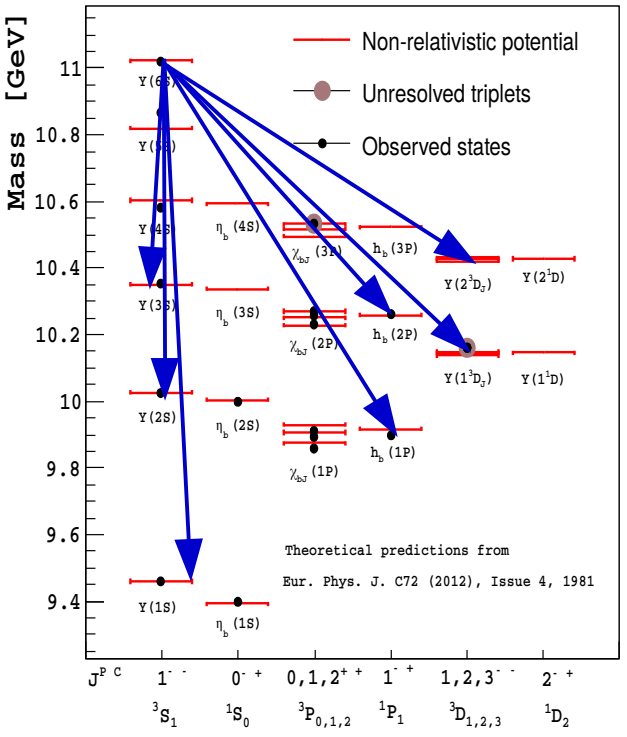
$\sigma_{Born}[e^+e^- \to \eta\, h_b(2P)] < 0.69$ pb

η transitions from Υ(6S)

Two Physics cases:

1) At Υ(5S), the Υ(1D) is the only PC = - - state to have BF(η) > BF(ππ)

2) If the Υ(6S) → Υ(nD) is so enhanced at the 6S as well, that's the best channel to look for the missing Υ(2D) triplet

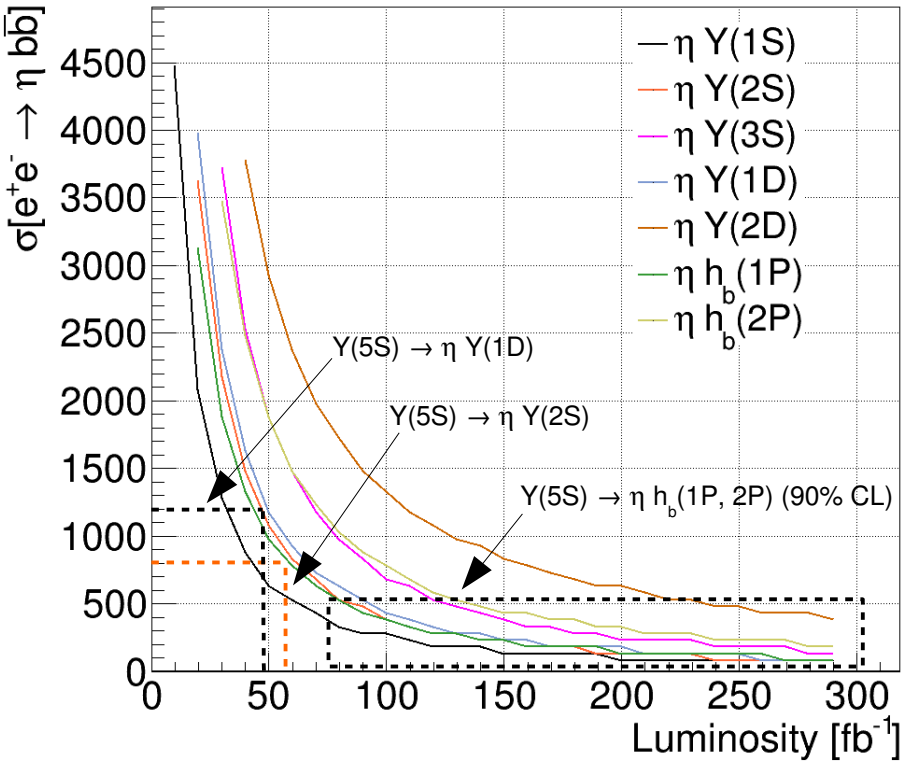


Search for missing conventional bottomonia below BB threshold

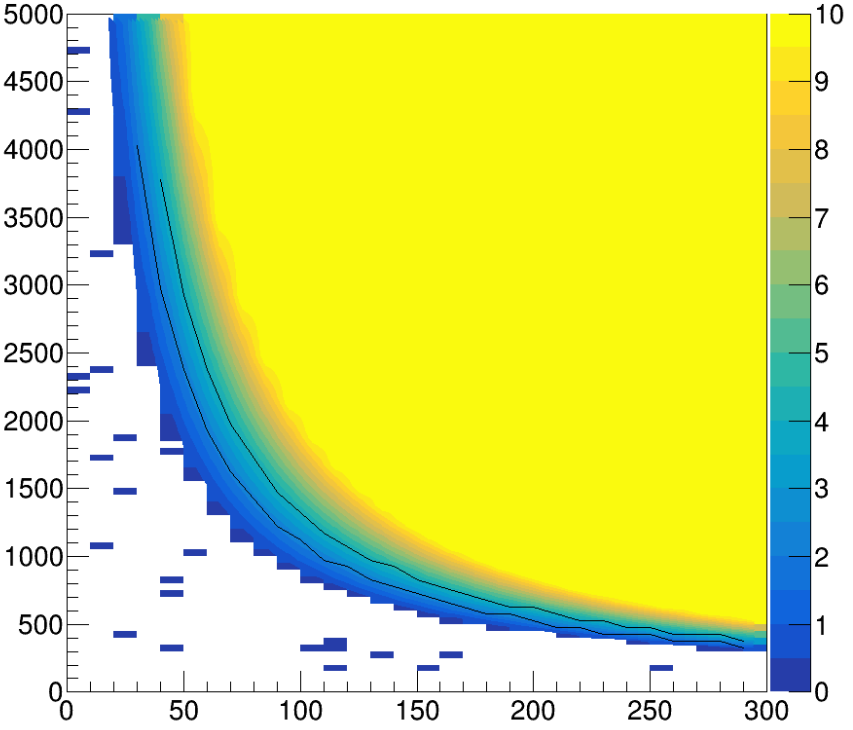
Name	L	S	J^{PC}	Mass, MeV/c^2	Emitted hadrons [Threshold, GeV/c^2]
$\eta_b(3S)$	0	0	0^{-+}	10336	ω [11.12], ϕ [11.36]
$h_b(3P)$	1	0	1^{+-}	10541	$\pi^+\pi^-$ [10.82], η [11.09], η' [11.50]
$\eta_{b2}(1D)$	2	0	2^{-+}	10148	ω [10.93], ϕ [11.17]
$\eta_{b2}(2D)$	2	0	2^{-+}	10450	ω [11.23], ϕ [11.47]
$\Upsilon_J(2D)$	2	1	$(1,2,3)^{--}$	10441 – 10455	$\pi^+\pi^-$ [10.73], η [11.00], η' [11.41]
$h_{b3}(1F)$	3	0	3^{+-}	10355	$\pi^+\pi^-$ [10.63], η [10.90], η' [11.31]
$\chi_{bJ}(1F)$	3	1	$(2,3,4)^{++}$	10350 – 10358	ω [11.14], ϕ [11.38]
$\eta_{b4}(1G)$	4	0	4^{-+}	10530	ω [11.31], ϕ [11.55]
$\Upsilon_J(1G)$	4	1	$(3,4,5)^{--}$	10529 – 10532	$\pi^+\pi^-$ [10.81], η [11.08], η' [11.49]

B2TiP: η transitions

5σ discovery for η transitions at Υ(6S)



Significance of Υ(2D) η signal



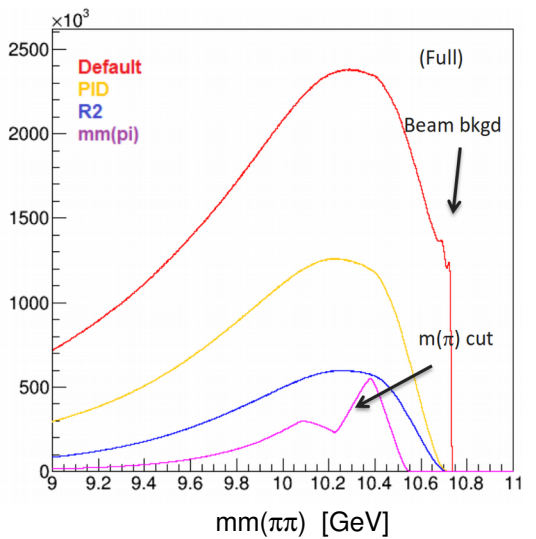
The message is… we can make good physics even with ~50 fb^{-1}, but we need 300 fb^{-1} to discover the Υ(2D)

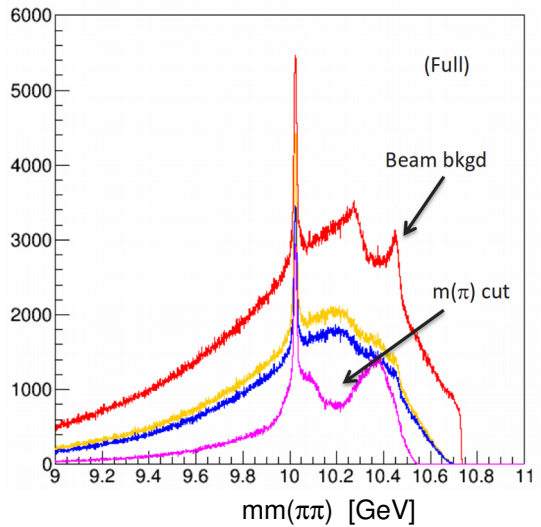
B2TiP: ππ transitions

MC7 analysis

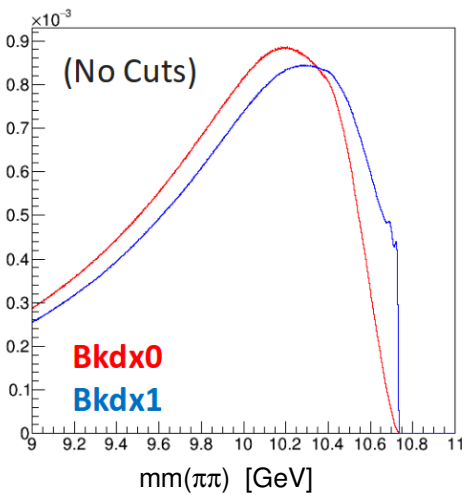
- Signal modes via PHSP or $Z_b^{\pm}(10610,10650)$
  - $\pi^+\pi^-\Upsilon(1,2,3S)(\ell\ell)$
  - $\pi^+\pi^- h_b(1,2,3P)$
  - $\pi^+\pi^- \Upsilon(1,2D)$
  - 100k events, 80/20 bkgd mix, for each Phase 2 and 3

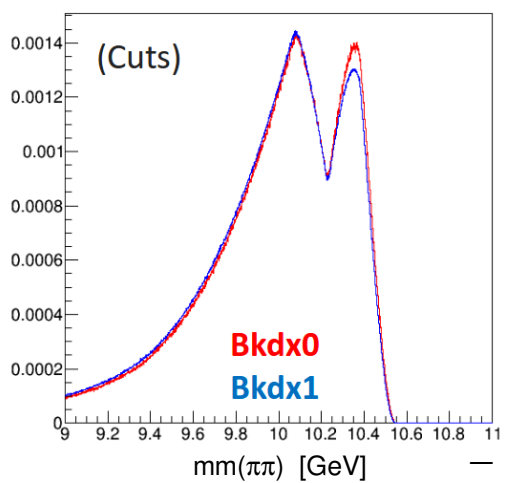
- Background
  - udsc, ττ, $B^{(*)}B^{(*)}$, $B_s^{(*)}B_s^{(*)}$
  - Equivalent of 50 fb^{-1}





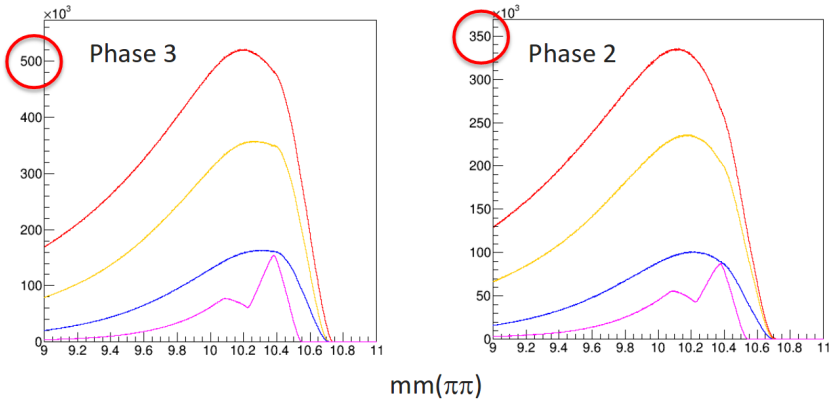
Effect of the beam background (not so much)





B2TiP: ππ transitions

- Analysis started with Phase 3 because MC was available first
- Ran code on Phase 2 once available
- Much less background in Phase 2 compared to Phase 3?



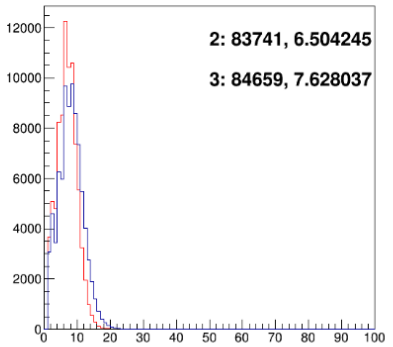
Note: no bkd mixing here

Transitions and tracking

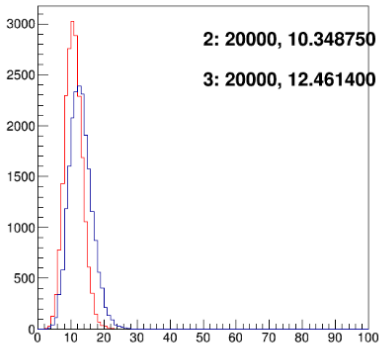
Phase 3 MC has a significant number of pion candidates passing the cuts with no hits at all in the CDC

nTracks/event
All events

uu bkd: 1 file only

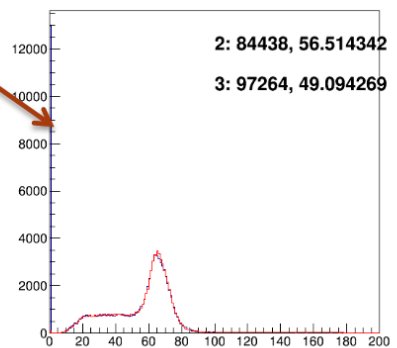


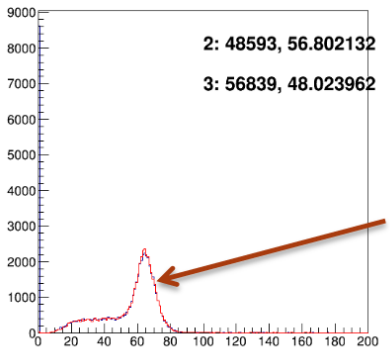
hb sig: 20k



VXD-only: 0-bin entries

CDC hits/event
pions passing cuts





No difference between 2/3

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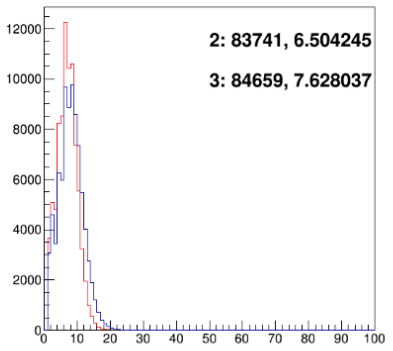

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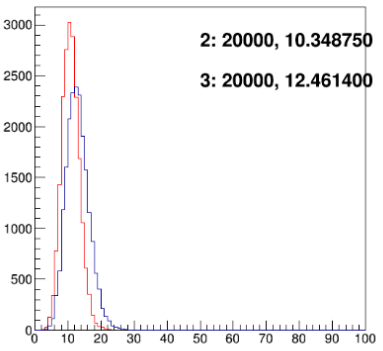

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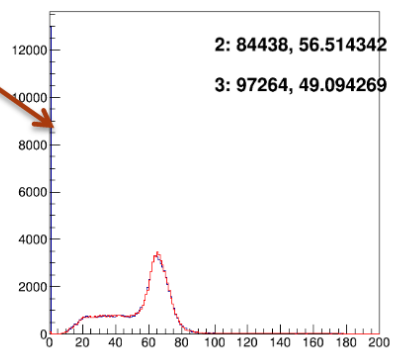
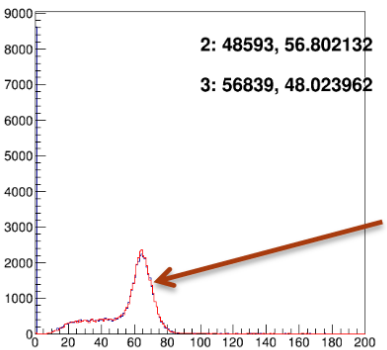
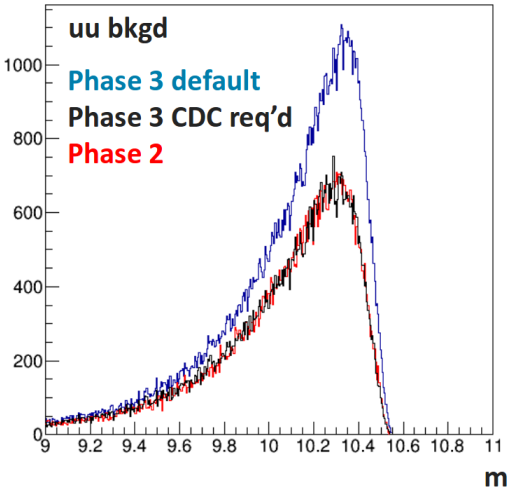
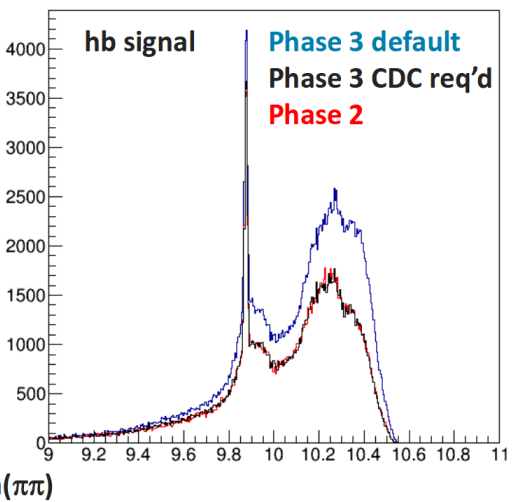




No difference between 2/3

Closure test





The message is… work in progress. We need to better understand the tracking effects

Hyperons

Exaquarks and di-baryons

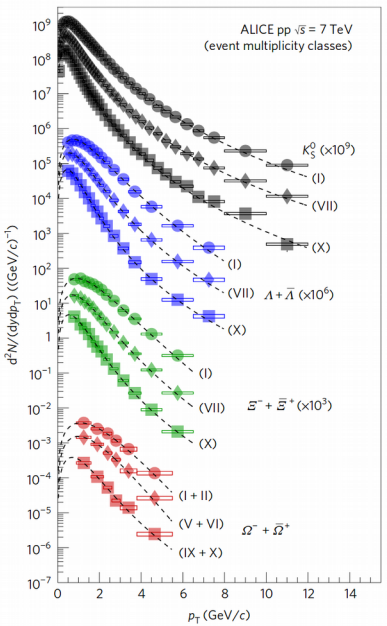
Stefan Prestel, DIS2017

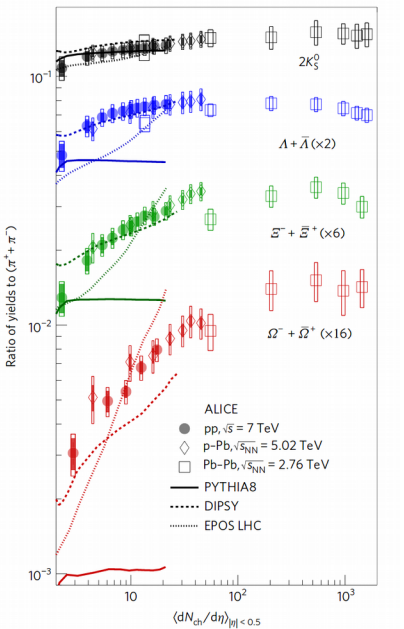
"The strangeness production in dense color fields is something we don't understand yet"

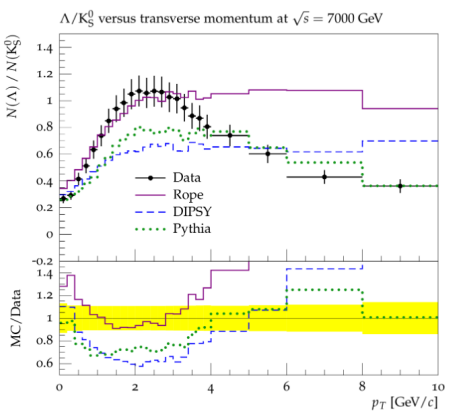
Ideas about dense color fields

JHEP 1503 (2015) 148, JHEP 1508 (2015) 003

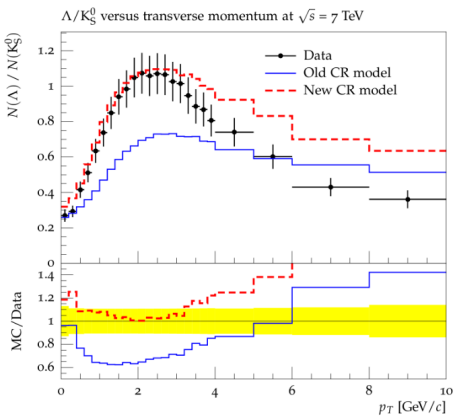
New ALICE experiment results show novel phenomena in proton collisions







Color ropes in DIPSY:



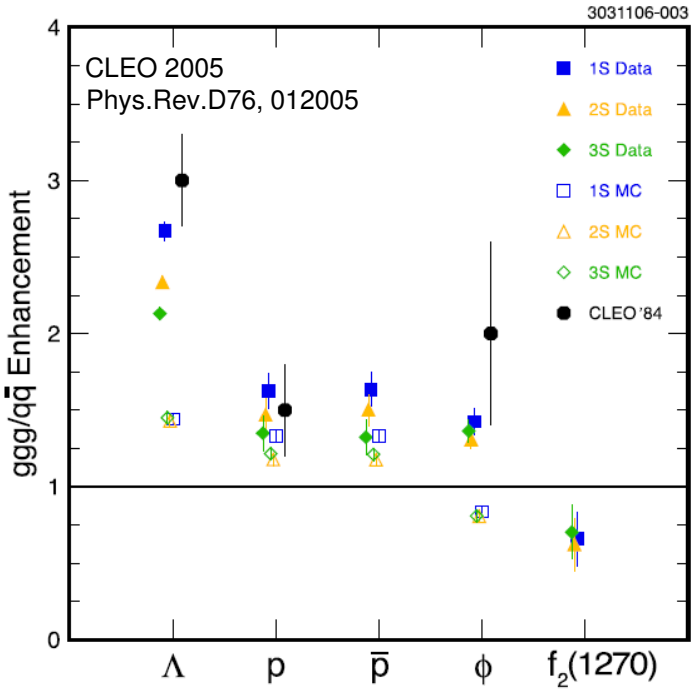
New color-recon^n in PYTHIA:

Exaquarks and di-baryons

Not a new phenomenon in bottomonium either...

Enhancement for baryon $\mathcal{B}$:

$$\frac{\sigma[e^+e^- \to \Upsilon(nS) \to \mathcal{B} + X]}{\sigma[e^+e^- \to q\bar{q} \to \mathcal{B} + X]}$$



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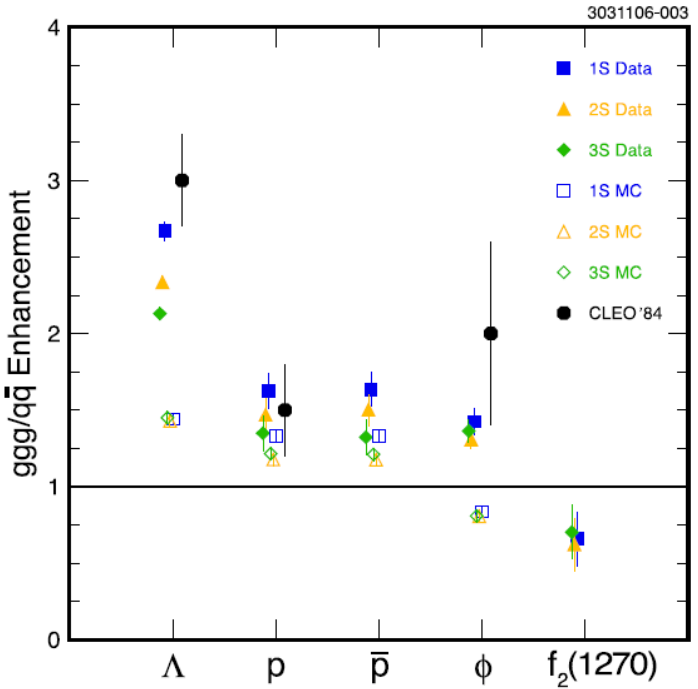
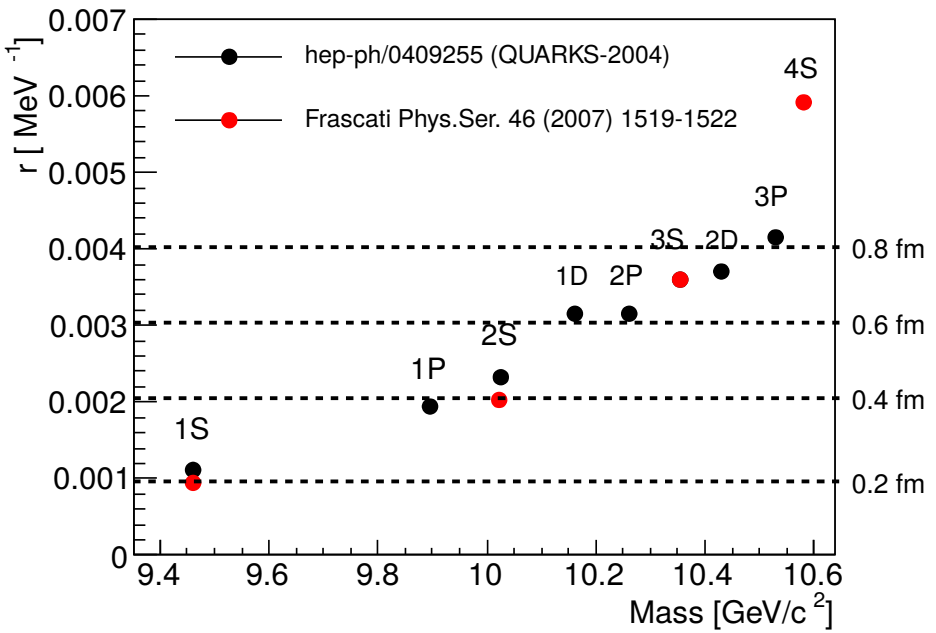
A process via a dense gluonic state: 10 GeV in a sphere of ~ 0.3 fm (really 0.3 fm?)

A process via smaller density state

(how much smaller? Good question indeed...)

A complete different chapter should open here, about partonic density and 2-meson Interferometry.
Sooner or later…





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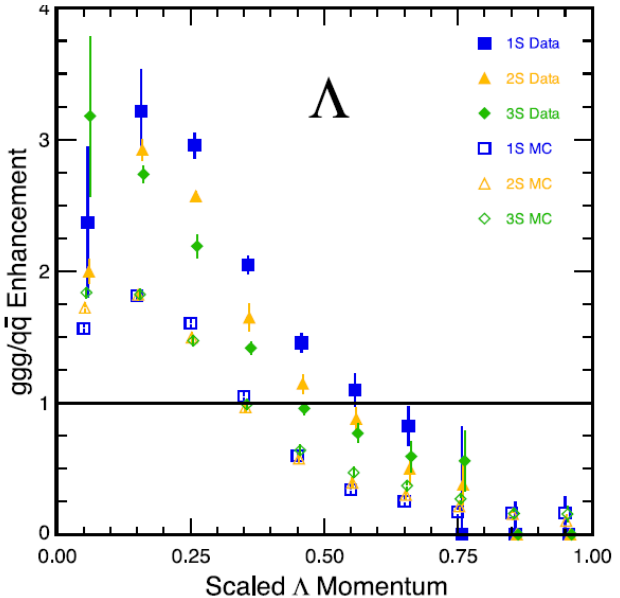
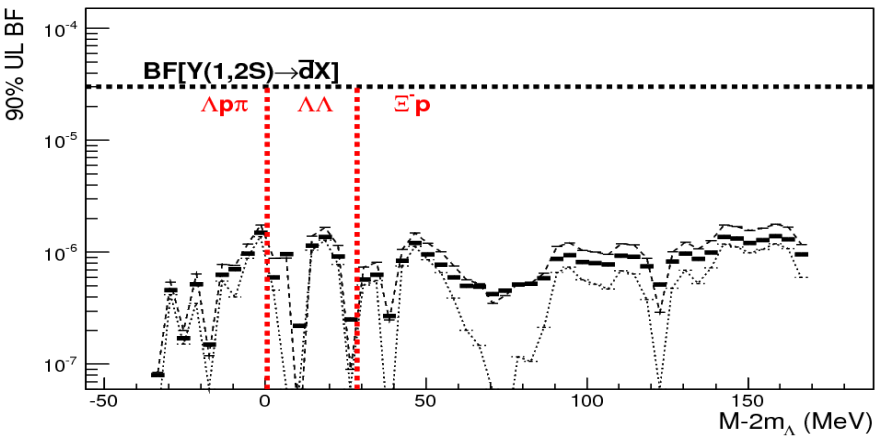
CLEO 2005
Phys.Rev.D76, 012005



Several low momentum baryons in a dense state.
Coalescent formation of the H di-baryon?



→ stable H dibaryon? (di-baryon or exaquark?)
→ non-coalescent formation?

Not with deuteron-like rates

Exaquarks and di-baryons

The goal is to extend Belle's analysis
→ Larger statistics
→ Search for stable H

Channels:
Y(3S) → H + X, H → ΛΛ, Ξπp
Y(3S) → S + ΛΛ + nπ , missing mass

Whatever study of double-stange baryonic exotica requires good lambda reconstruction….

$\varepsilon_{x,1}$ = #MC $_{x,\ track}$ / #MC $_{x}$

$\varepsilon_{x,2}$ = #MC $_{x,\ track}$ / #MC $_{x,\ trackCand}$

$\sigma_\varepsilon = \sqrt{\varepsilon\,(1-\varepsilon)\,/\,N^2}$

x : p, π, Λ from Λ → p π

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[INFO] ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
[INFO] ~ V0 Finding Performance Evaluation ~ SHORT SUMMARY ~
[INFO]
[INFO]  + overall, normalized to MC particles:
[INFO]
[INFO]    efficiency pi = (51.8129 +/- 0.113974)%
[INFO]    efficiency pr = (78.613 +/- 0.0935285)%
[INFO]    efficiency L0 = (29.2459 +/- 0.10376)%
[INFO]
[INFO]  + overall, normalized to TrackCands:
[INFO]
[INFO]    efficiency pi = (60.8301 +/- 0.120642)%
[INFO]    efficiency pr = (89.2253 +/- 0.075347)%
[INFO]    efficiency L0 = (37.9853 +/- 0.126169)%
[INFO] ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
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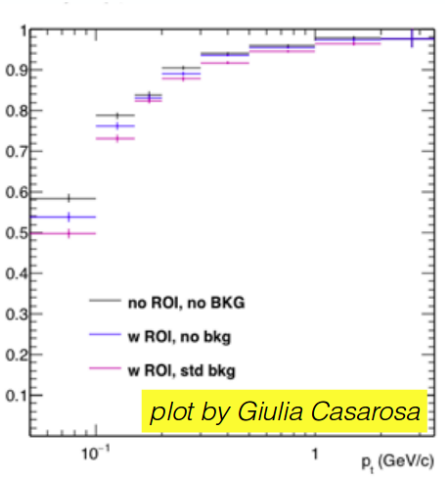
- comparison with $\varepsilon_{tracking}$ (~85% integrated)
  - ε_π low (due to low $p_{T,\pi}$)
  - ε_p comparable
  - ε_Λ lower than expected (simply from $\varepsilon_p\,\varepsilon_\pi$)

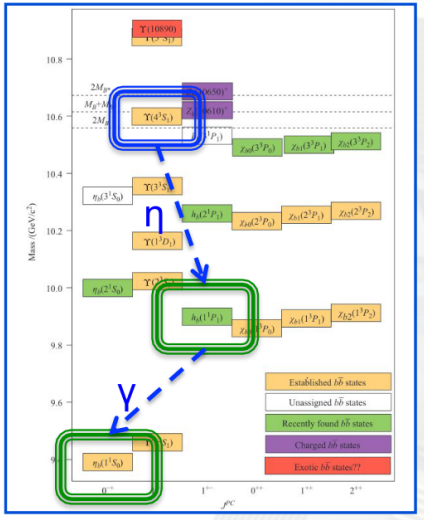


Tools

Tools: skims

→ Several Y(3S, 6S) analyses cannot be skimmed
- Small datasets (< 1ab^{-1}), probably not an issue

→ At Y(4S) and Y(5S) the situation is more complicate
- Exclusive Y(1S) → μμ skim is ok
- Some analyses (light higgs) can exploit other groups' skims



Search for $h_b(1P)$ rare decays

Measurement of η_b parameters and decays

Gold channel:

➢ $\Upsilon(4S) \rightarrow \eta h_b$; ($h_b$ inclusive)

$h_b \rightarrow \gamma\eta_b$ ~50% (η_b inclusive)

✓ $h_b \rightarrow \gamma\eta_b$ with large branching fraction

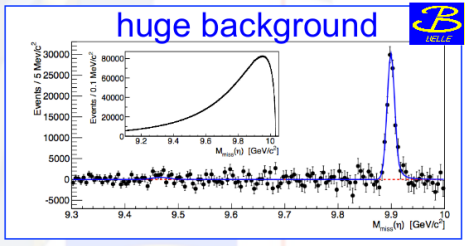
$h_b(1P)$ inclusive

✧ Reconstruct a η (from γγ or $\pi^+\pi^-\pi^0$)

✧ η recoil mass corresponding to h_b mass window

✧ Selections on Fox-Wolfram moments (R2)

huge background



$\eta_b(1S)$ inclusive

✧ Also γη recoil mass corresponding to η_b mass window

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Inclusive h_b(1P) skim

Channel	# events	Retention	Size mDST kB/evt	Size μDST kB/evt	CPU time ms/evt
taupair	200k	0.0305	0.09	0.10	0.84
mupair	90k	0.0007	< 0.01	< 0.01	4.68 ?
bhabha	180k	0.0005	< 0.01	< 0.01	0.70
photon	180k	0.0006	< 0.01	< 0.01	0.53
mixed	100k	0.9086	6.34	8.78	0.69

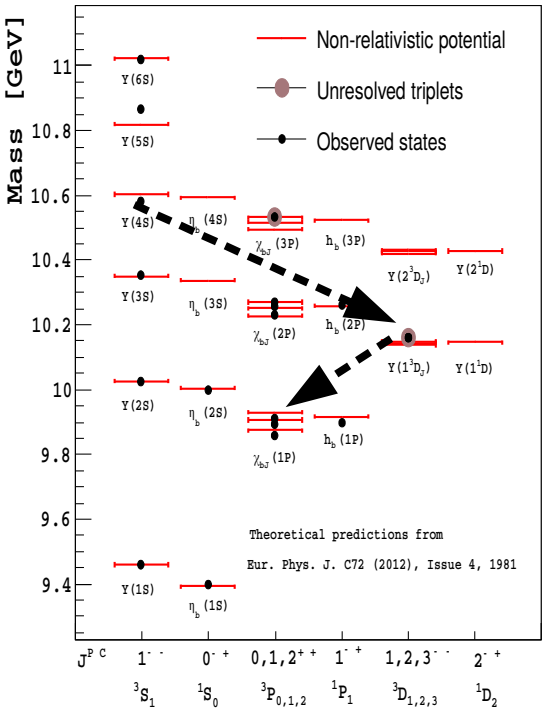
Inclusive η_b(1P) skim

Channel	# events	Retention	Size mDST kB/evt	Size μDST kB/evt	CPU time ms/evt
mixed	90k	0.37	2.69	4.19	3.27
charged	900k	0.40	3.26	6.41	7.74
uubar	2757k	0.16	0.87	1.06	1.08
ddbar	890k	0.17	0.87	1.08	1.02
ssbar	256k	0.17	0.88	1.09	0.98
ccbar	2445k	0.26	1.54	2.02	1.61

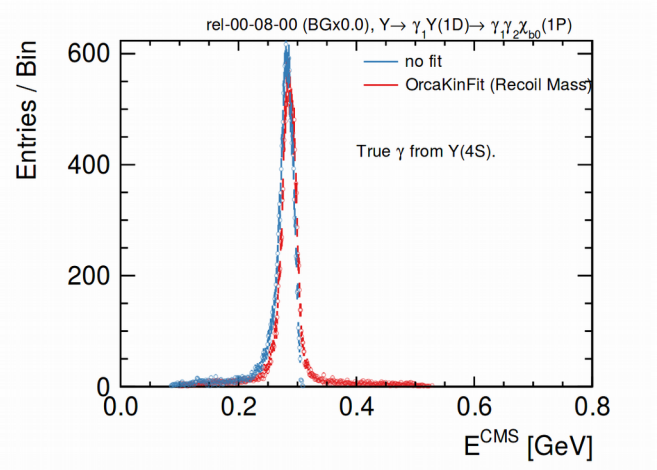
Tools: recoil constraint

Goal: improve the resolution on the intermediate transitions in a cascade that endson a known state, reconstructed in recoil mass.

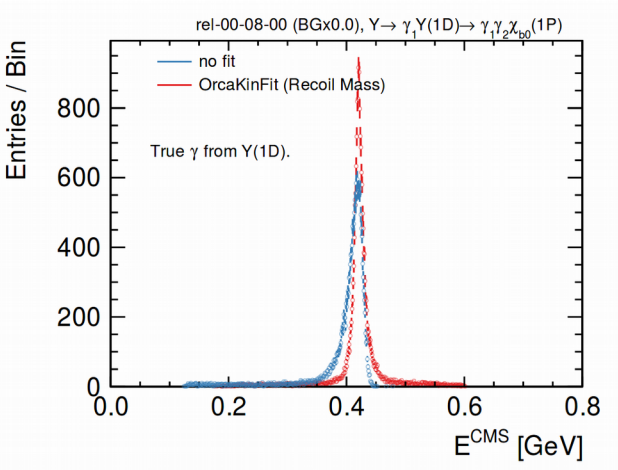
- $\Upsilon(5S) \to \pi Z_b$, $Z_b \to \pi h_b(1P)$
- $\Upsilon(3S) \to \gamma\gamma \Upsilon(1D)$, $\Upsilon(1D) \to \gamma \chi_b(1P)$
- ...



Dummy test using orcafit and the **non-existing cascade**
$\Upsilon(4S) \to \gamma \Upsilon(1D) \to \gamma\gamma \chi_b(1P)$



(a) True photon from $\Upsilon(4S)$.



(b) True photon from $\Upsilon(1D)$.

Summary

New analyses:

→ The group got the responsibility for the Hyperon-related searches.

→ The B2TiP-related analyses are close to be finalized

New tools:

→ recoil mass constraint

→ skims

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New tools:
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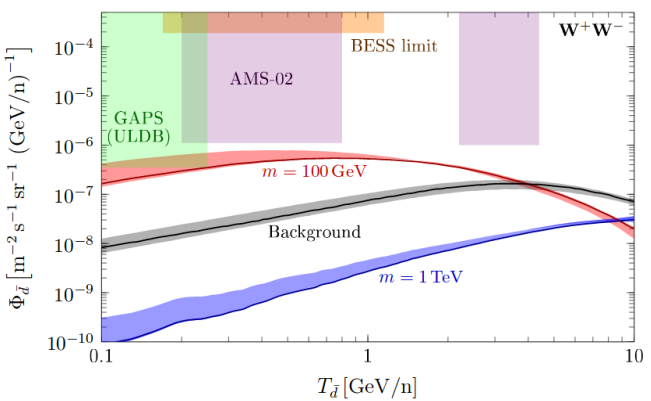
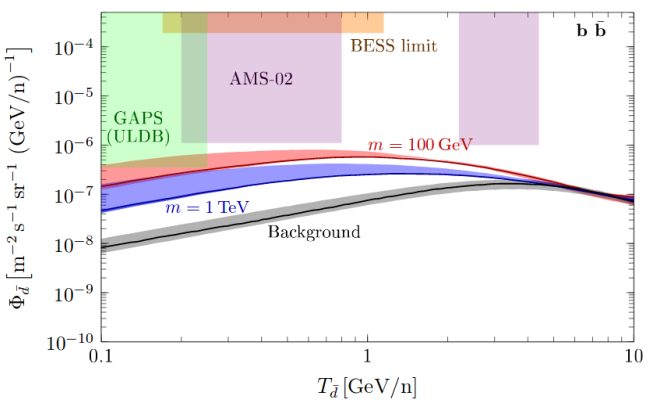
New activities in the future:
→ Charged higgs contribution to scalar → ll
→ anti-deuteron measurement for astrophysics





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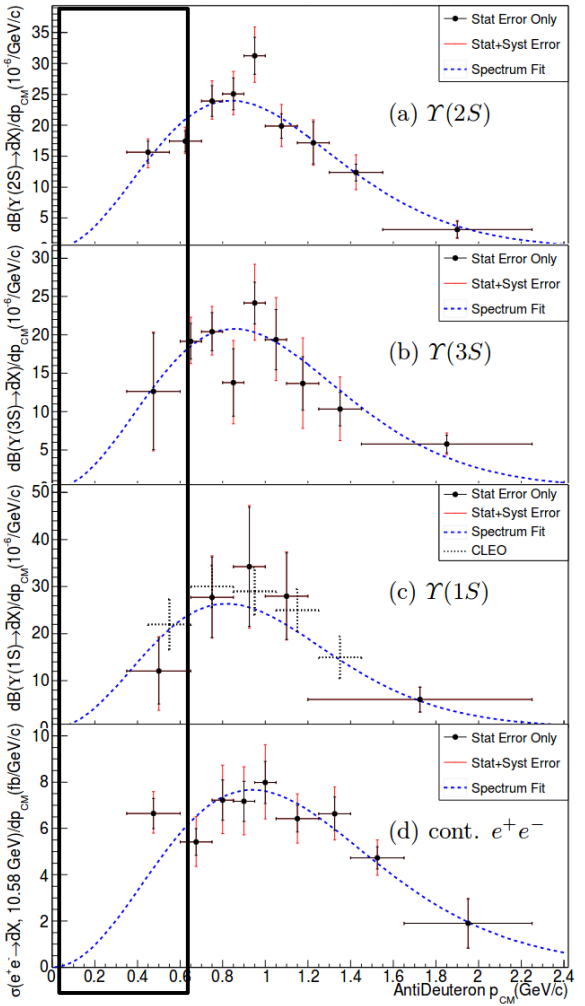

PhaseII workshop

B2TiP & First Physics Workshop

15-17 June 2017

Asia/Tokyo timezone

https://kds.kek.jp/indico/event/24227/