Istituto Nazionale di Fisica Nucleare
SEZIONE DI TORINO

Bottomonium-related physics during PhaseII

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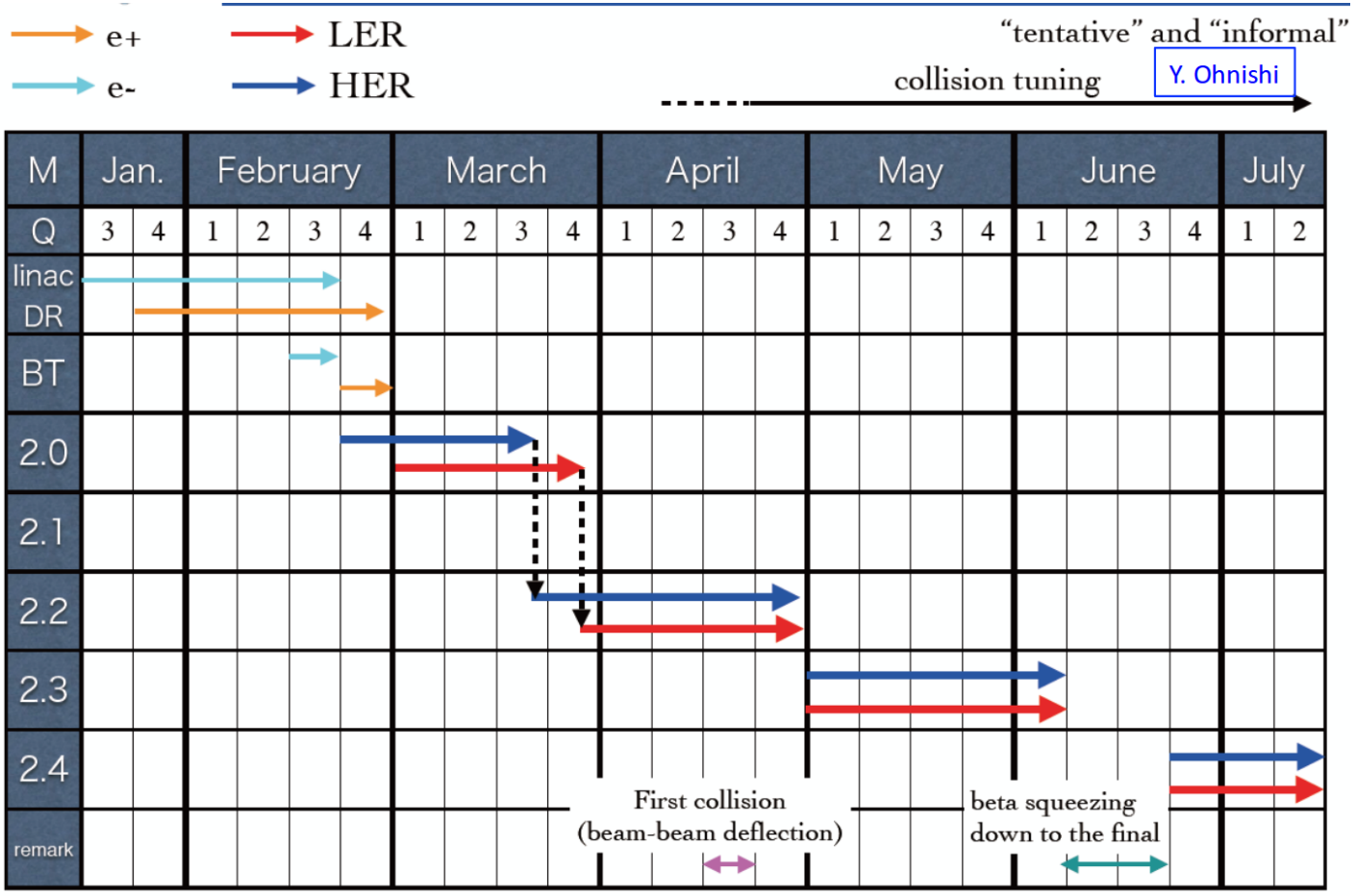
BelleII Italian meeting,
November 20th 2017

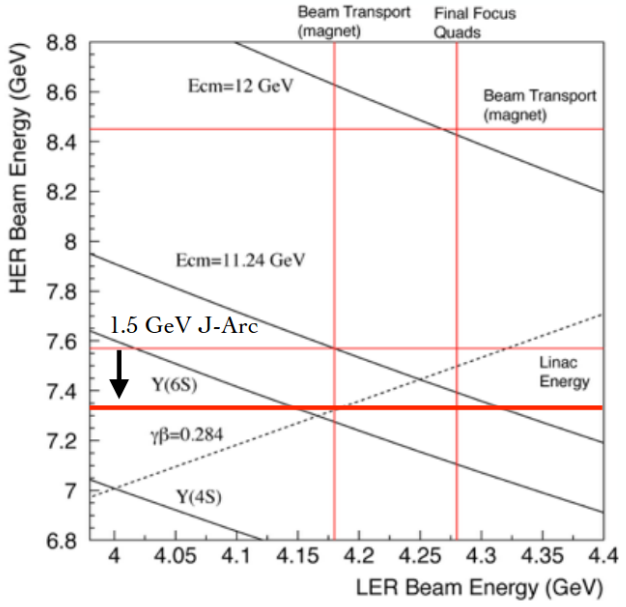
Phase II schedule



BT: tuning of the beam transport lines

20

Accelerator conditions in phase II



Y(4S)
HER: 7 GeV
LER: 4 GeV

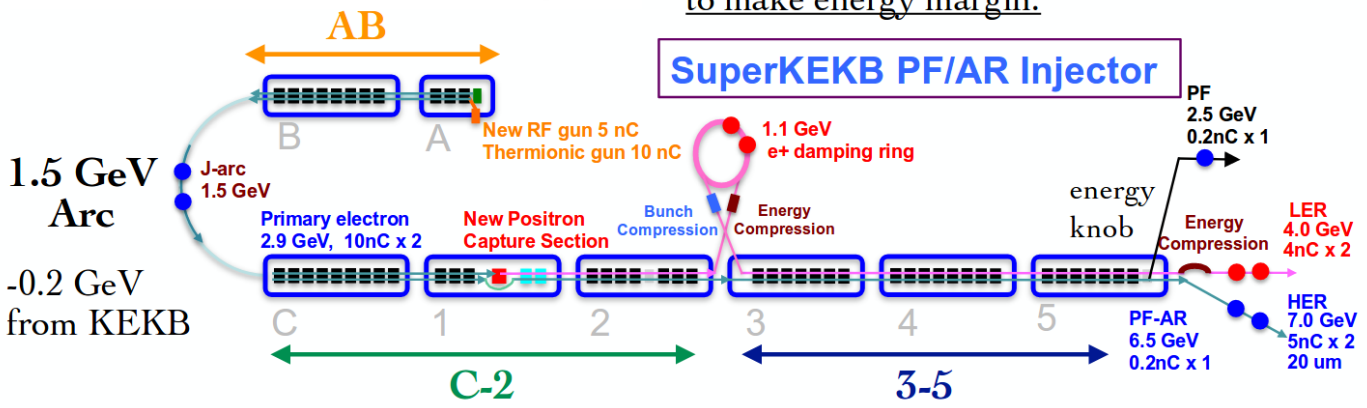
A - B sector : 1 backup unit
C - 2 sector: 1 backup unit
3 - 5 sector: 1 backup unit
(1 unit = 160 MeV)

C - 2 → 2 backup units in Phase 3

Y(6S)
HER: 7.30 GeV
no backup unit in C - 5 sector(max 7.35 GeV)
LER: 4.16 GeV
no backup unit in 3 - 5 sector(max 4.18 GeV)

Risk at higher beam energy

The old accelerating structures should be replaced to make energy margin.



Bottomonium samples

Needs to fulfill the bottomonium program

100 fb^{-1} @ Y(6S) +
300 fb^{-1} @ Y(3S) +
400 fb^{-1} @ Y(5S)-Y(6S) scan +
_____

0.8 ab^{-1} for bottomonium only (1.6% of BelleII dataset)

1 ab^{-1} @ Y(5S) (for Bs also) =
_____

1.8 ab^{-1} for bottomonium + Bs (3.6 % of BelleII dataset)

Bottomonium samples

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1 ab^{-1} @ Y(5S) (for Bs also) =
_____ **1.8 ab^{-1} for bottomonium + Bs** (3.6 % of BelleII dataset)

Minimum needs to produce new results

60 fb^{-1} @ Y(3S) Not enough lumi in PhaseII

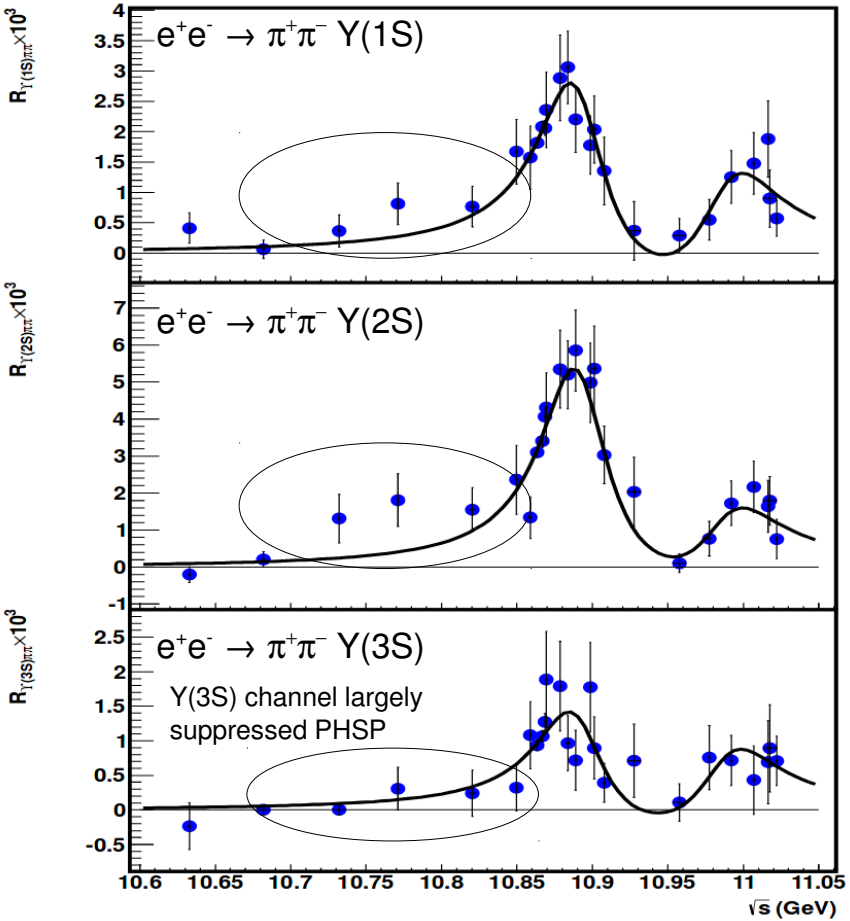
200 fb^{-1} @ Y(5S) Not enough lumi in PhaseII

10 fb^{-1} @ Y(6S) sqrt(s) too high for PhaseII

10-20 fb^{-1} @ 10.7 → 10.8 GeV mini-scan Doable?

Why a mini-scan

Phys. Rev. D 93, 011101 (2016)



Hint of a broad resonance around 10.770 ?

May be just wishful thinking but...

→ No sign yet of 1^{--} exotica in bottomonium, while they are expected in the tetraquark model

→ Vector charmonia are much more complicated that expected. Why bottomonium ones seem to be not?

The proposal:

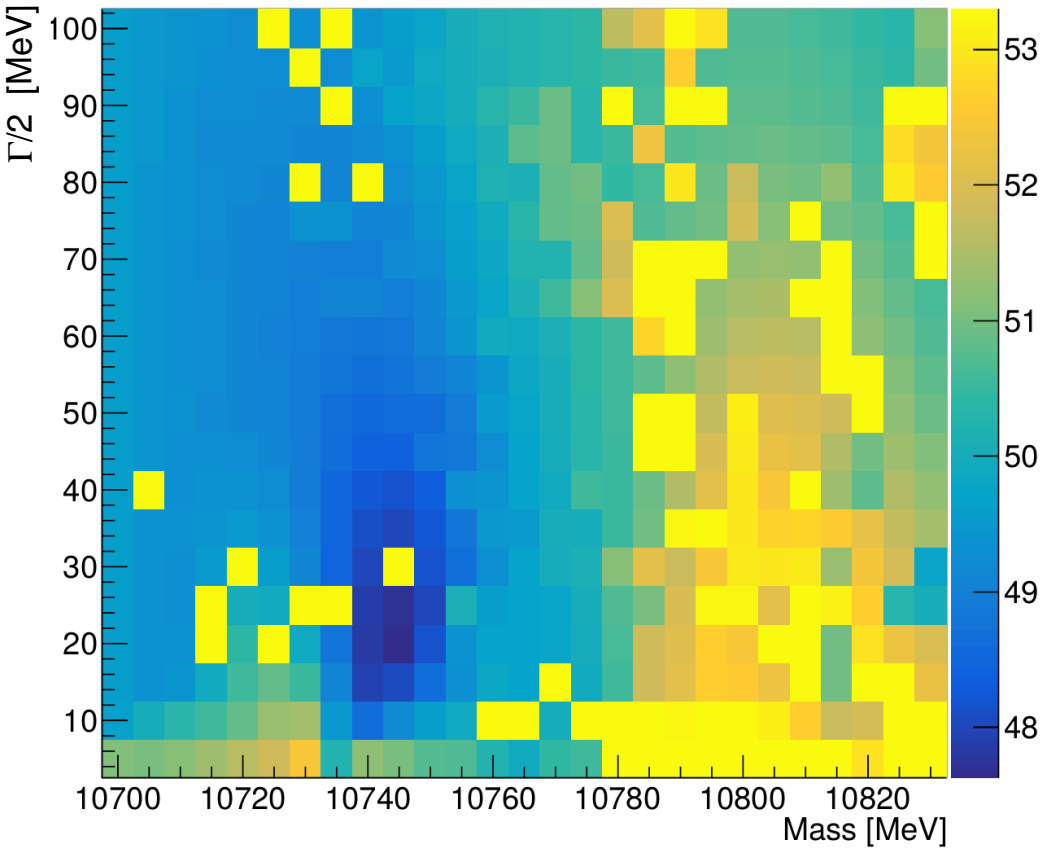
→ Belle points are 1 fb-1 each

→ Add one one or two points around 10.750 and redo the Belle analysis

Where to look for a new resonance?

Refit Belle data with an additional BW

$$A = PHSP\, x\left(A_{5S} BW\left(m_{5S}, \Gamma_{5S}\right) e^{i\delta_1} + A_{6S} BW\left(m_{6S}, \Gamma_{6S}\right) e^{i\delta_2} + A_{Yb} BW\left(m_{Yb}, \Gamma_{Yb}\right)\right)$$



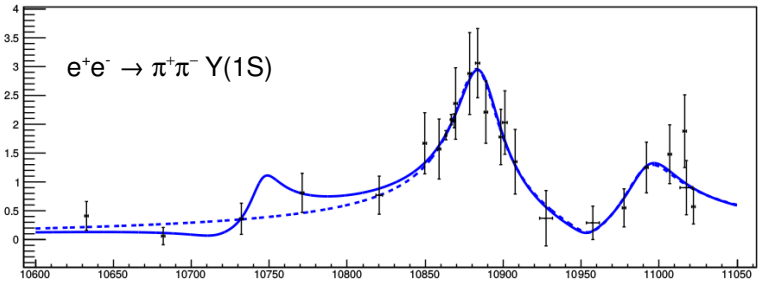
→ Simultaneous fit of Y(1S), Y(2S) and Y(3S) cross section

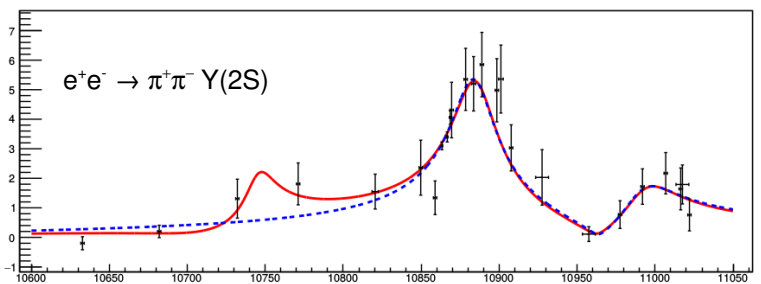
→ Very unstable if the Yb parameters are floating unconstrained.

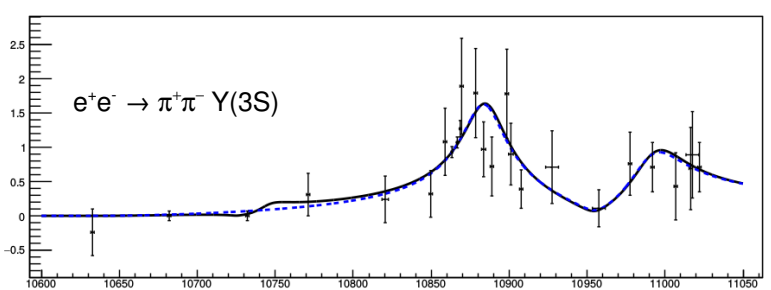
→ Chi2 scan points to a 20-60 MeV wide resonance around m = 10745 MeV

Where to look for a new resonance?

Refit Belle data with an additional BW: $A = PHSP \times (A_{5S} BW(m_{5S}, \Gamma_{5S}) e^{i\delta_1} + A_{6S} BW(m_{6S}, \Gamma_{6S}) e^{i\delta_2} + A_{Yb} BW(m_{Yb}, \Gamma_{Yb}))$







→ Constraining the fit parameters using the chi2 scan results, we get the fit to converge.

→ However, the fit passes exactly by two points: the scan is too coarse

→ Local significance: 1.6 σ

Conclusion of the analysis of the Belle Data

→ No statistically significant signal

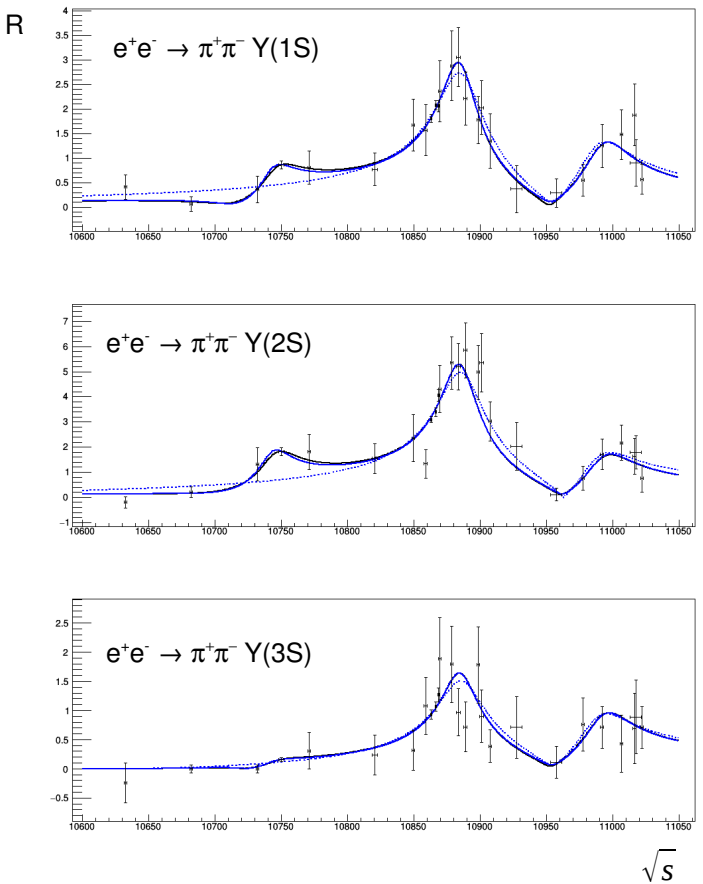
→ The most likely position for a new resonance is at 10.745 GeV, but it could just be an artifact of the coarse scan

→ the “by eye” solution (broad resonance at 10.770) that triggered this study is very hard to accomodate

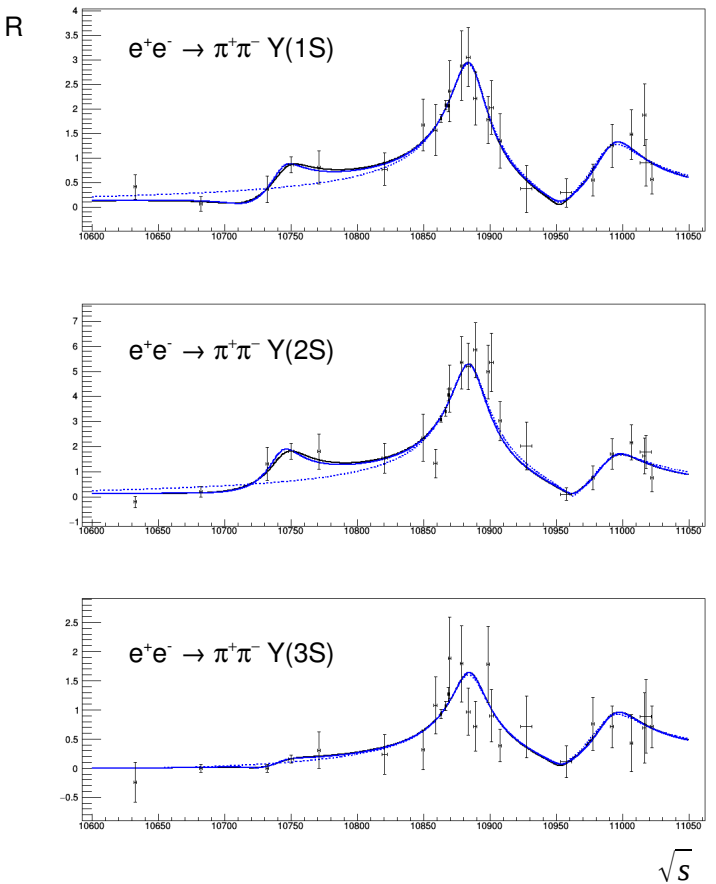
Adding one point (in the right place)

What if we add one point to the scan?
→ Use the Belle data “best fit” as model and add a simulated point at 10.750 GeV

20 fb^{-1}, significance = 9 σ



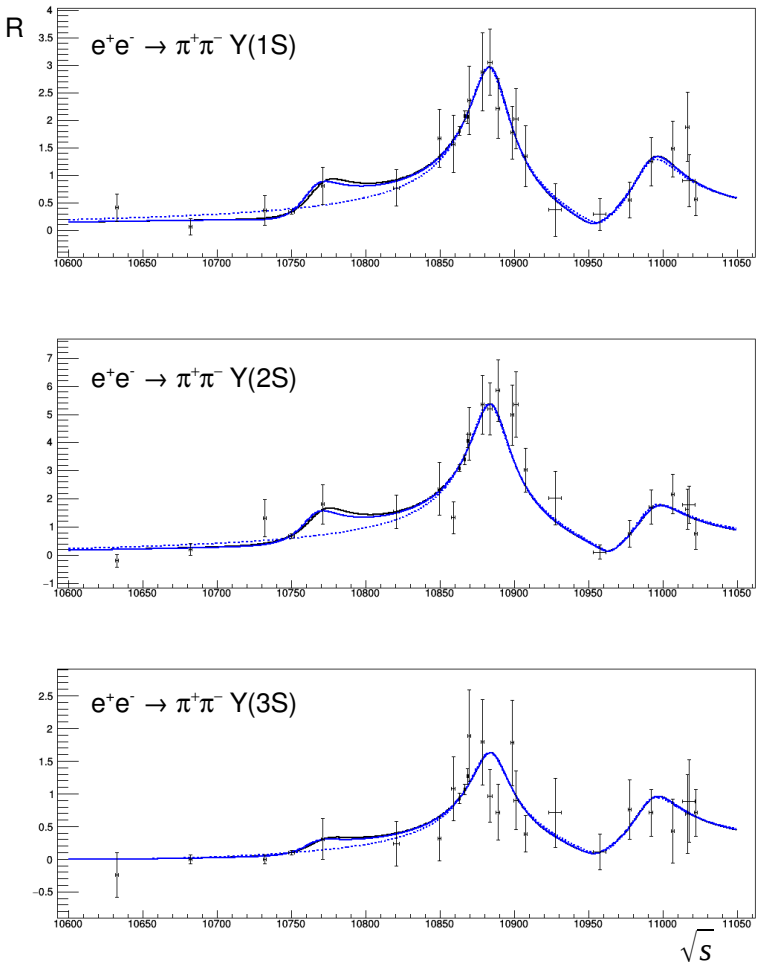
5 fb^{-1}, significance = 4 σ



Model:
Mass = 10.745 MeV
Γ/2 = 25 MeV

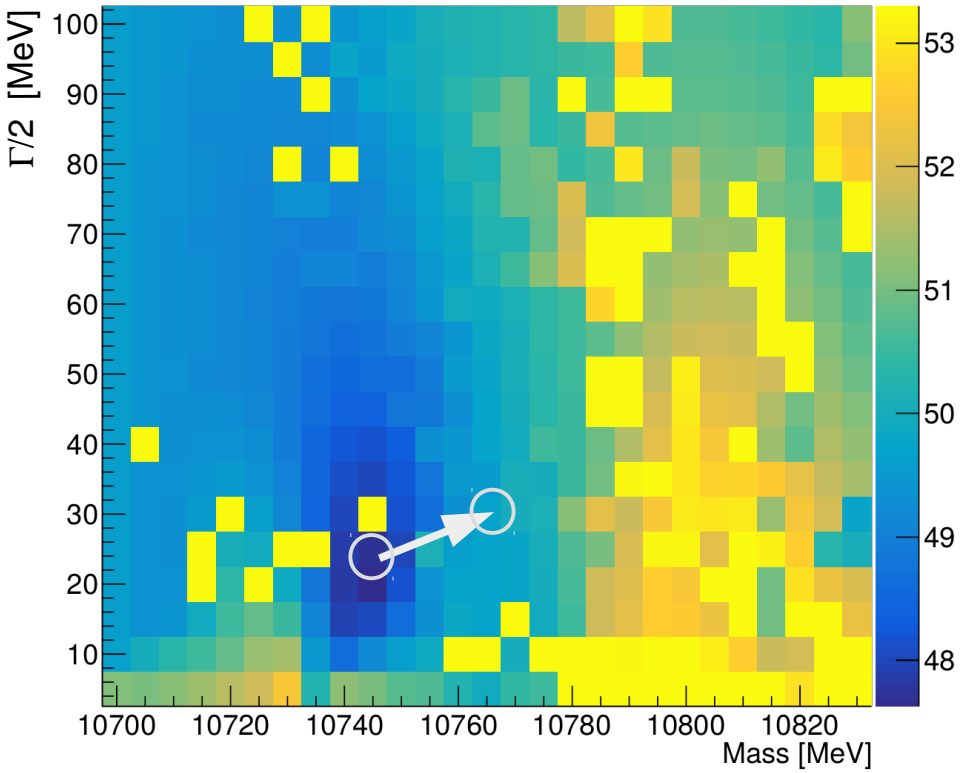
Adding one point (in the wrong place)

What if we add one point to the scan?
→ Belle best fit is wishful thinking, what if the actual resonance is in a different place?



Model:
Mass = 10.745 MeV
$\Gamma/2$ = 25 MeV

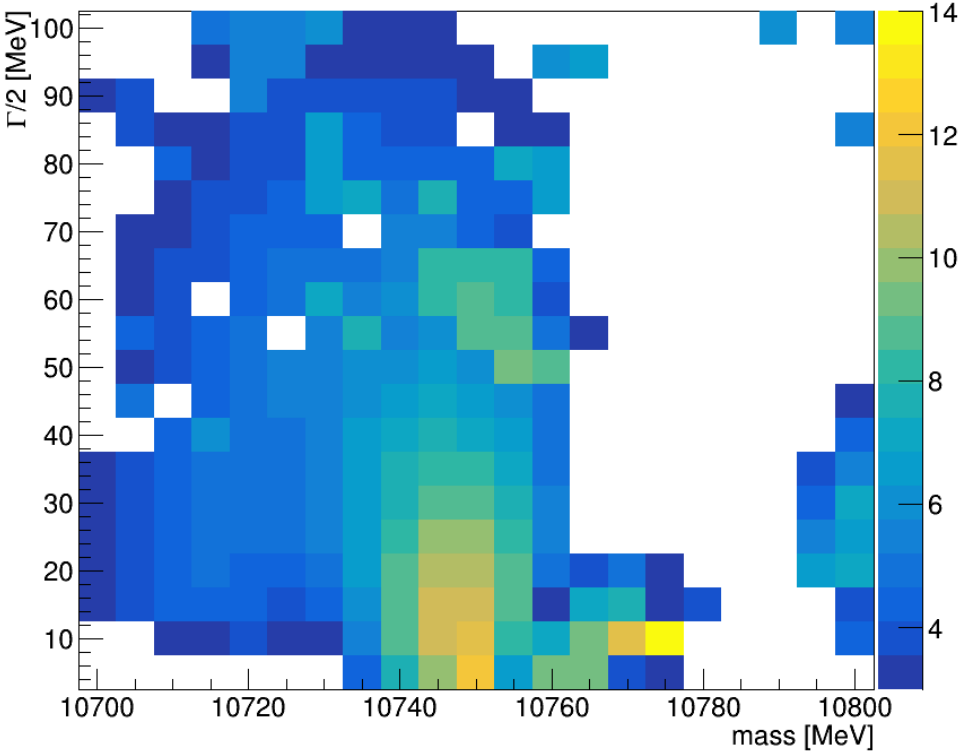
Even with 20fb^{-1}, the significance is only 1.5 σ because we "took data" in the wrong place.



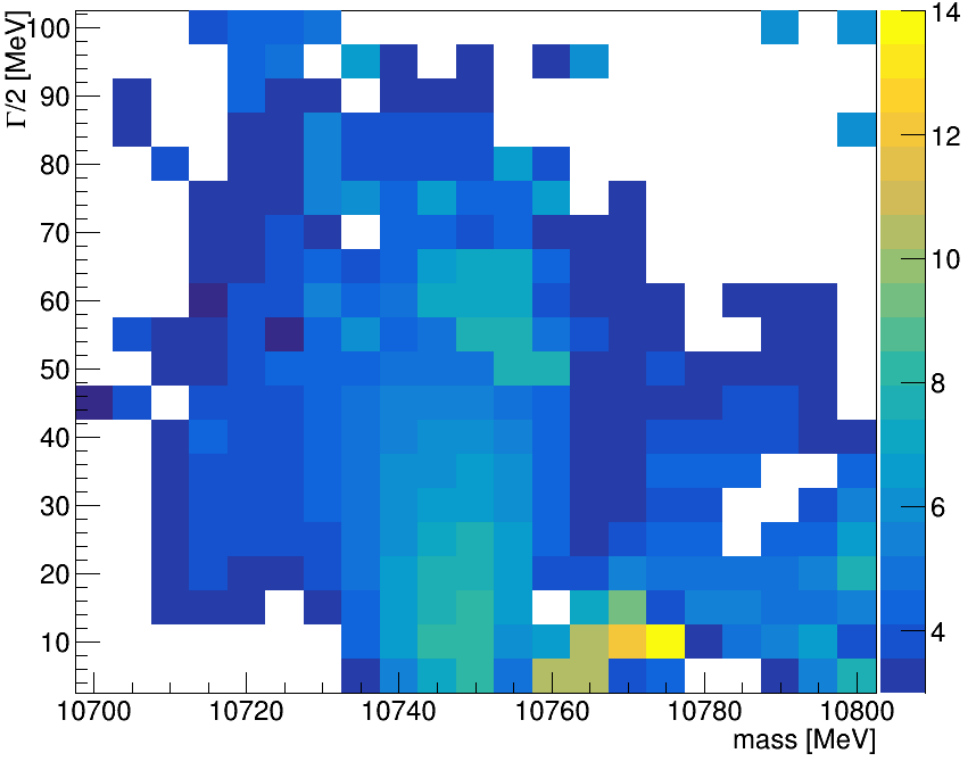
Local significance scan: 20 fb^{-1}

Scan of the **local significance (if > 3 σ)** of an additional resonance, as function of its mass and width

20 fb^{-1} at 10.750 GeV



10 fb^{-1} at 10.750 GeV + 10 fb^{-1} at 10.850 GeV



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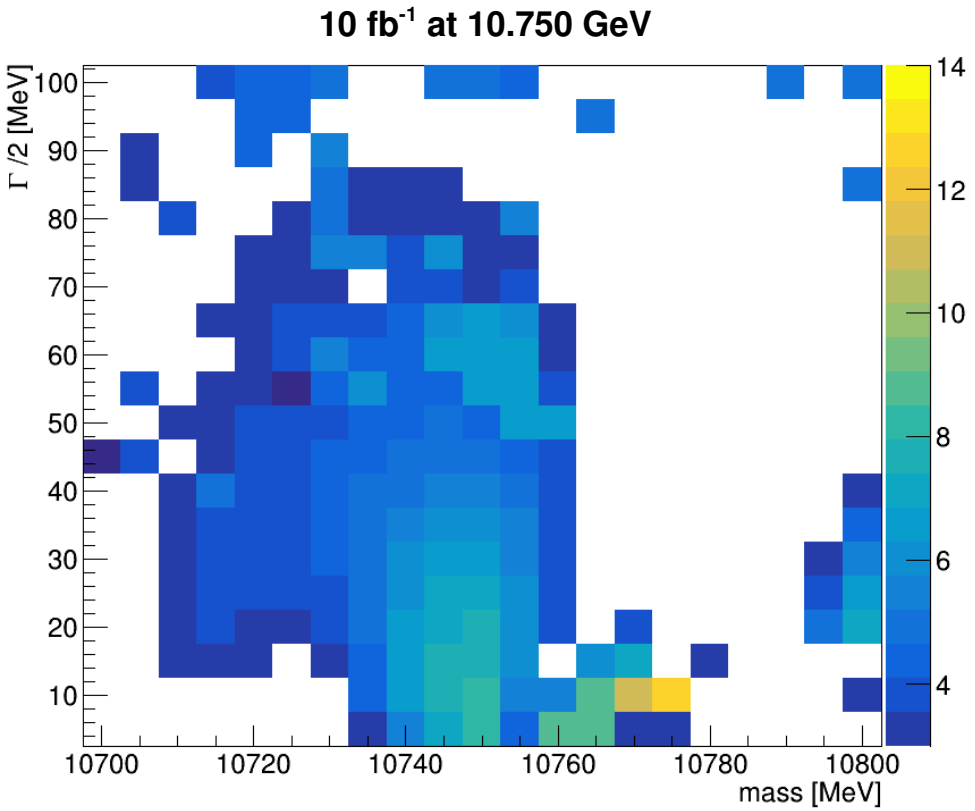

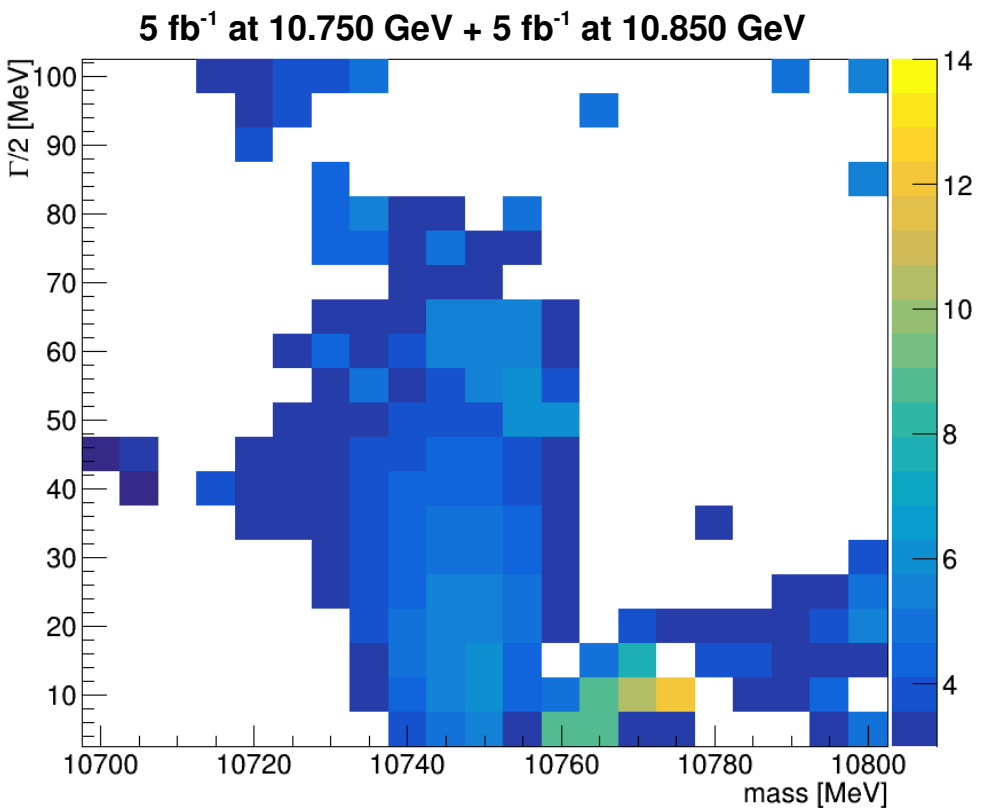

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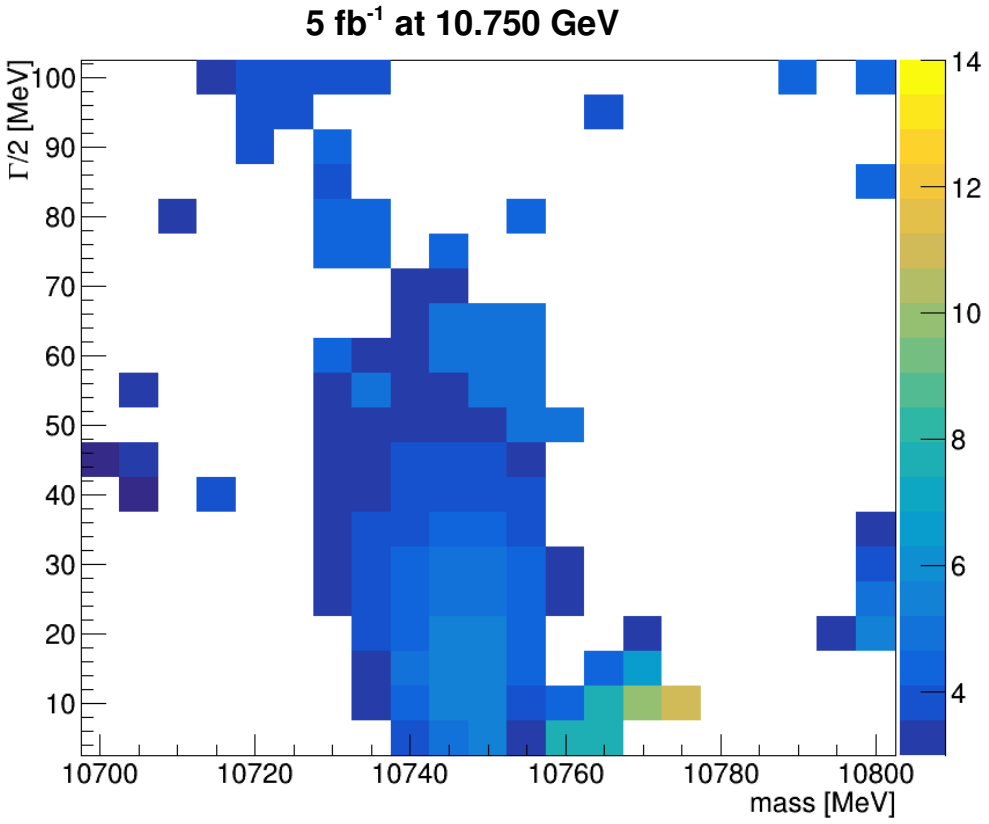
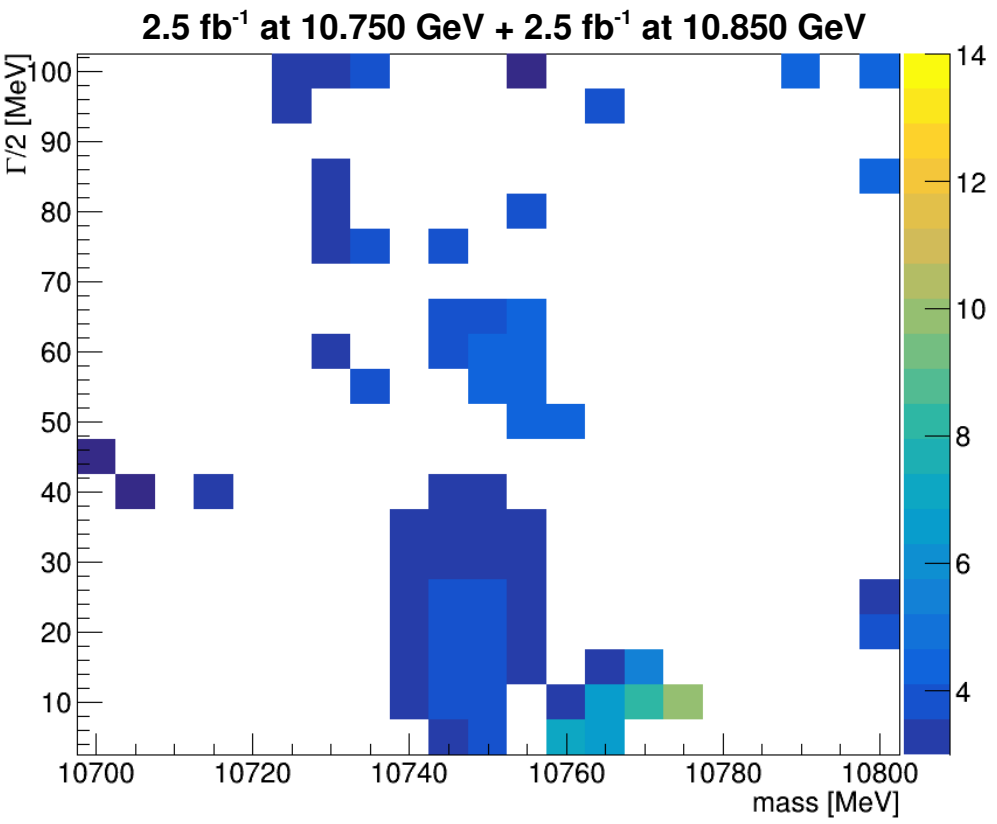
Scan of the **local significance (if > 3 σ)** of an additional resonance, as function of its mass and width





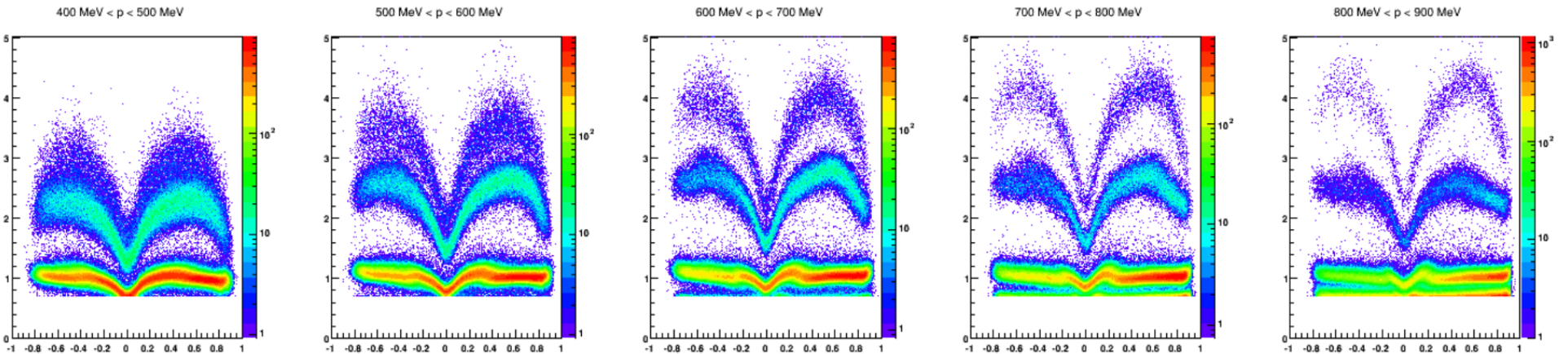
Other activities

Skims / backgrounds

1) Validate Y(nS) → μμ skim using ISR events
2) Measure the backgrounds to $\eta_b(1S) \to \gamma\gamma$ using $e^+e^- \to \gamma_{ISR}\gamma\gamma$

Tracking / PID

1) Looking at Belle data, we expect 1 deuteron scattered from the inner material (beam pipe/SVD/CDC wall) every 1000 hadronic events.
   → PID validation
   → dE/dx saturation correction: **strong angular dependence of dE/dx at fixed momentum in the Belle CDC!**



2) Λ reconstruction and systematics (hyperons are part of the bottomonium WG at the moment)

Summary

Most of the bottomonium program is not feasible in phaseII unless superKEK-B reaches the Y(6S)

→ Maximum number of analyses, **10 fb^{-1} would be enough.**
→ Sounded quite unlikely during the latest discussion with acceleratorists.

However, a 1 or 2 point scan below Y(5S) can potentially discover the first vector exotica in bottomonium

→ 10 fb-1 at one single point seems to be the most realistic request
→ with 20+ fb^{-1}, two points give higher sensitivity
→ Safer than Y(6S) for the accelerator (2/3 of backup units are needed), potential relevant physics result
→ But… almost no B mesons at that energy.

Backup