Search for a long-lived scalar in $b \to s$ transitions.

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Belle II

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

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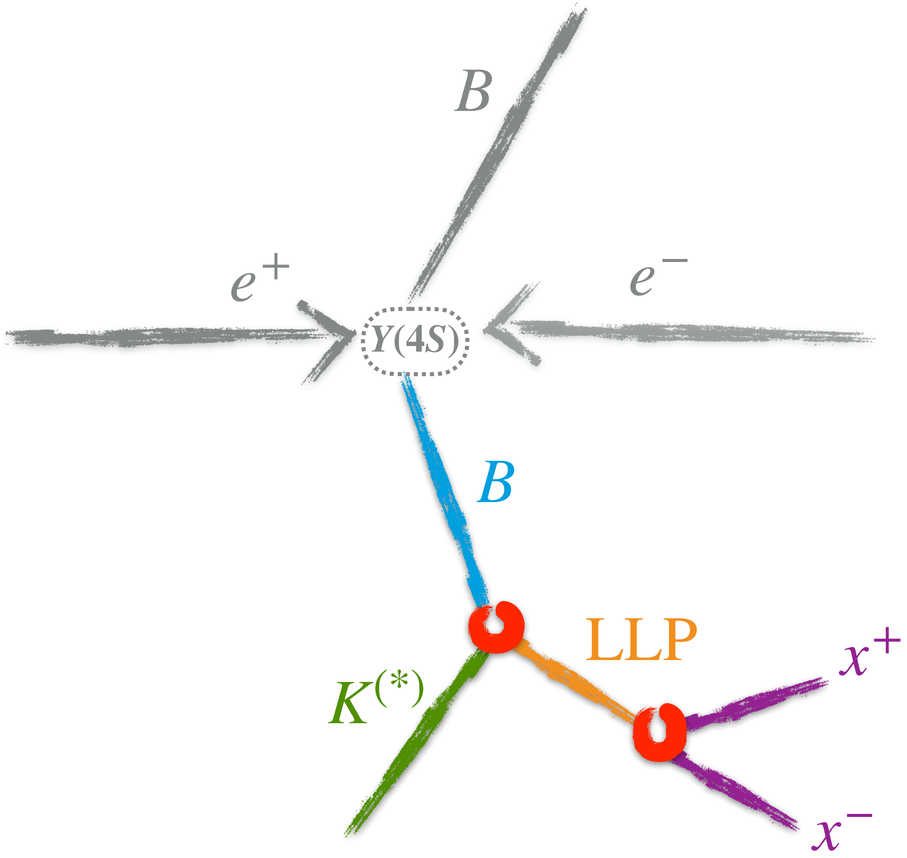
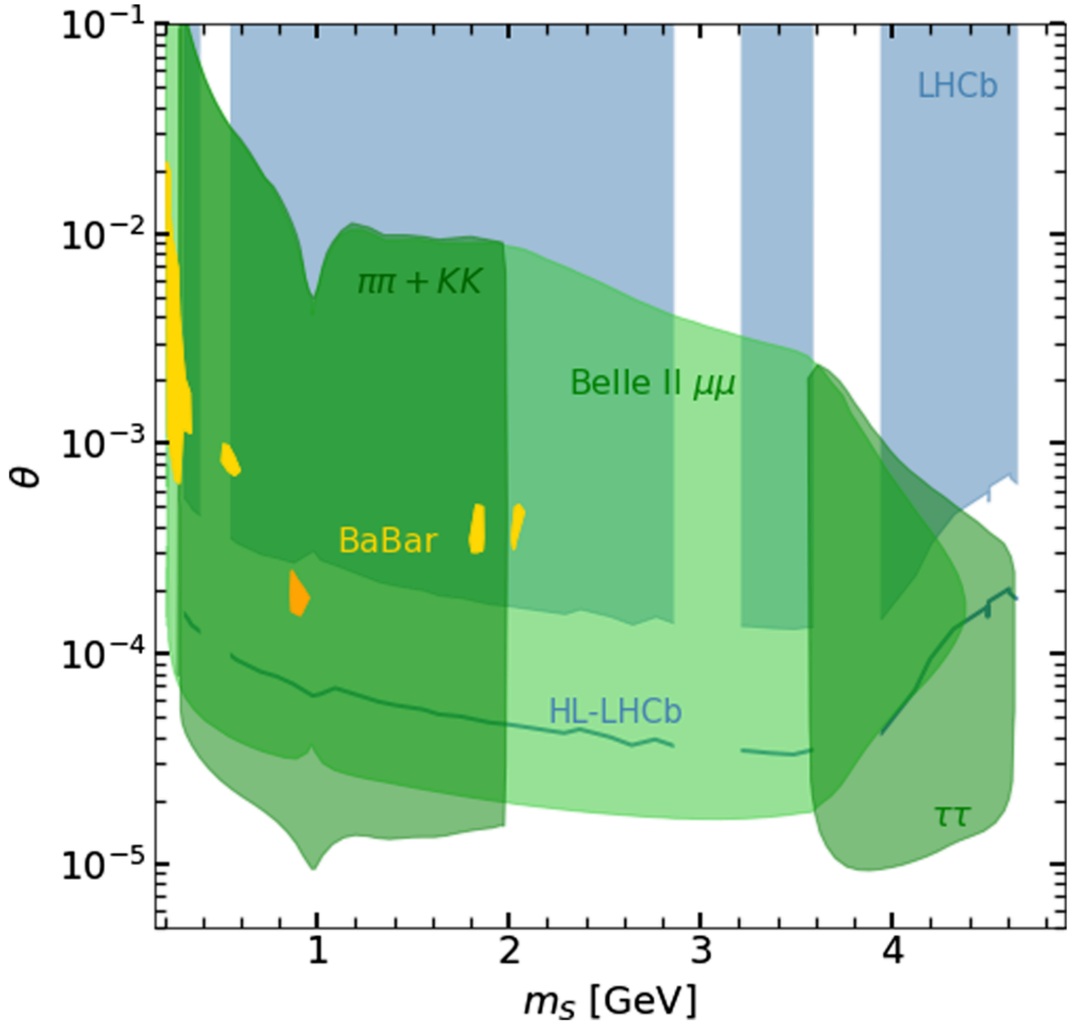
DESY.

A long-lived (scalar) particle in $b \to s$.



A. Filimonova, R. Schäfer, S. Westhoff



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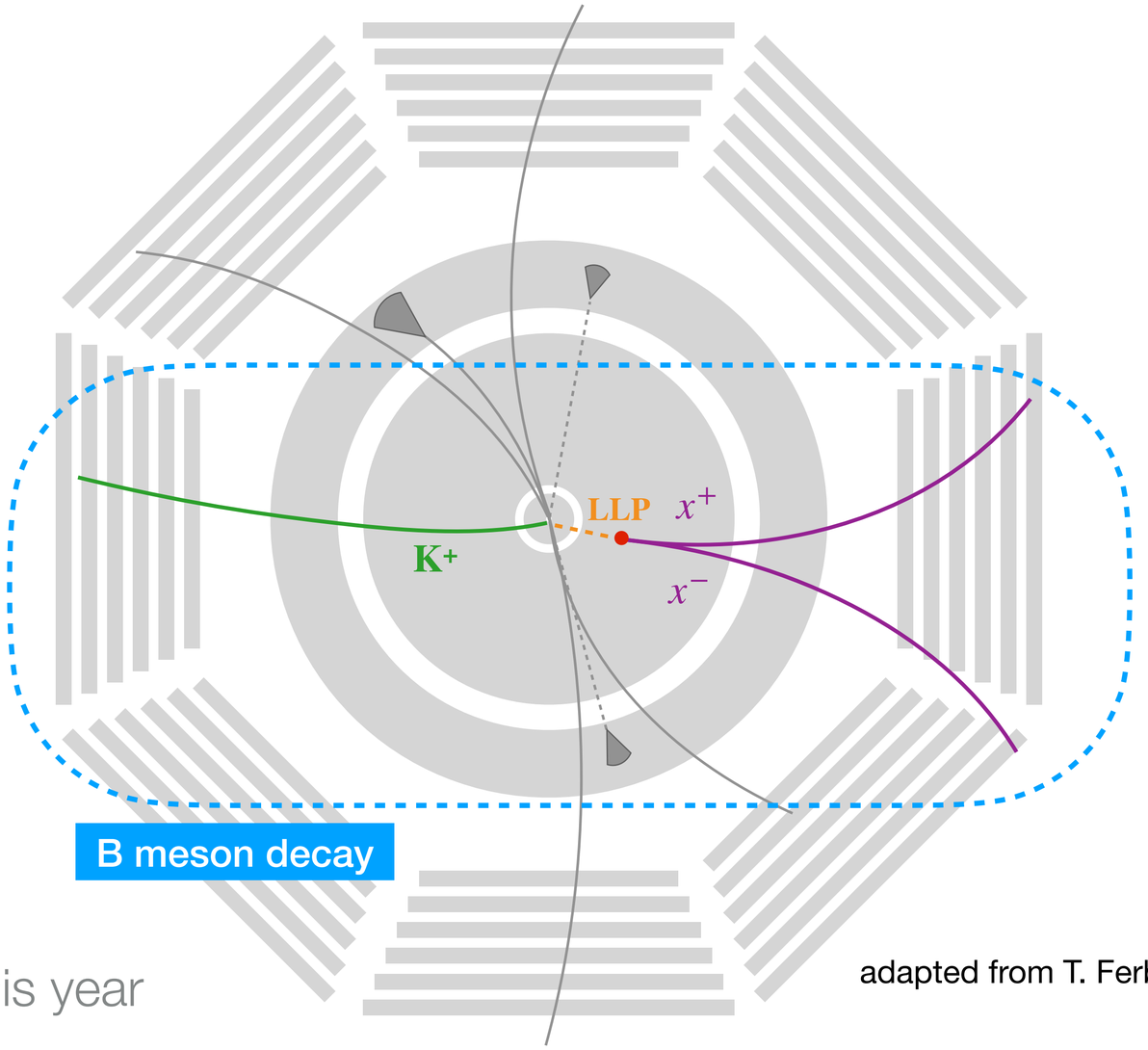
A long-lived (scalar) particle in $b \to s$.

- Exclusive search in eight channels:
  - $B^+ \to K^+$ LLP
  - $B^0 \to [K^{*0} \to K^+\pi^-]$ LLP
  - LLP $\to x^+x^-$ with $x \in (e, \mu, \pi, K)$
- Reconstruct signal B meson
- Bump hunt in rec. LLP mass distribution
- Separately for different LLP lifetime hypotheses
- Aim at publication with Moriond 22 data end of this year (189 fb^{-1}, proc12 + buckets 16-25)



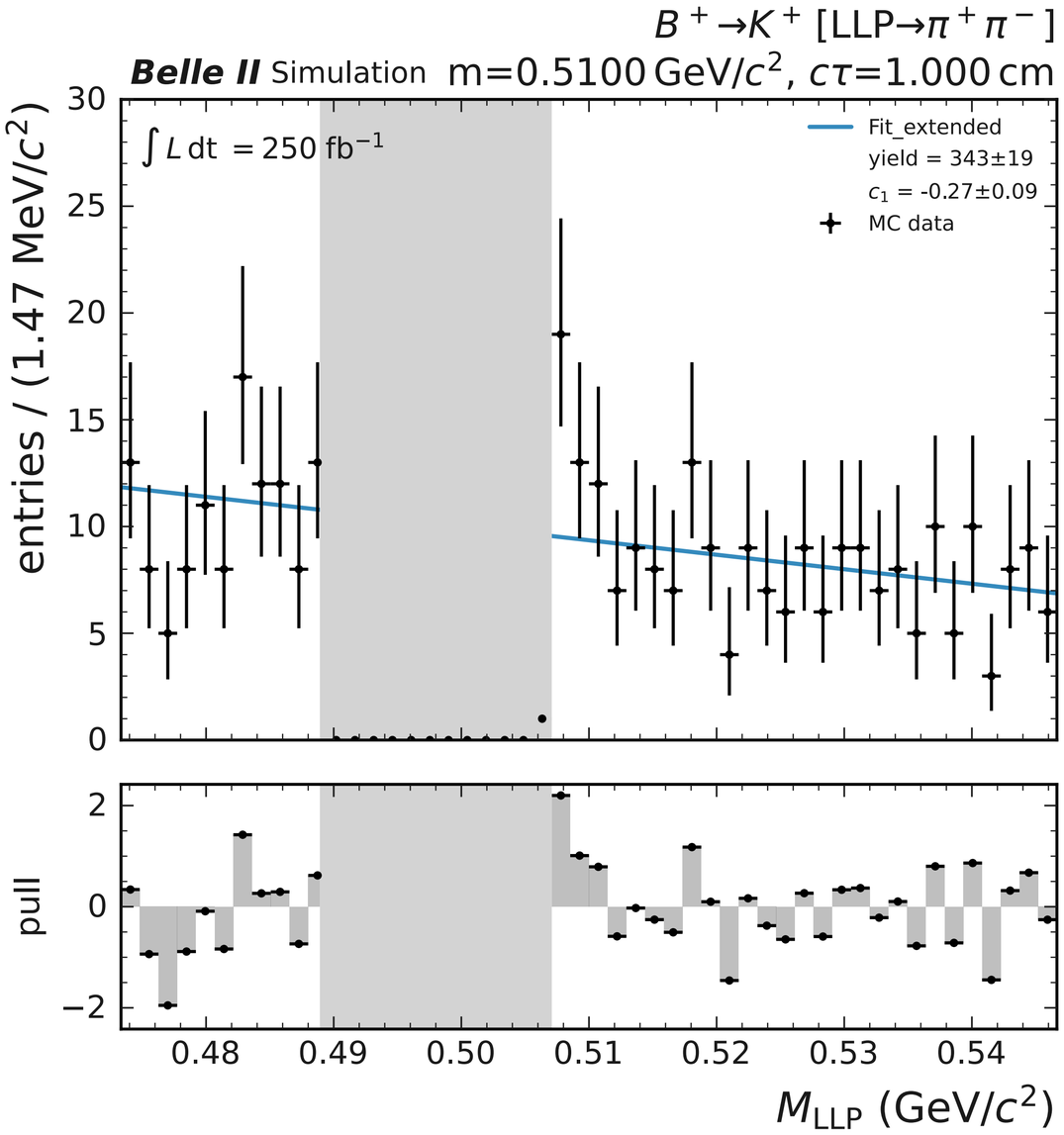
adapted from T. Ferber

Selection.

Background sources:

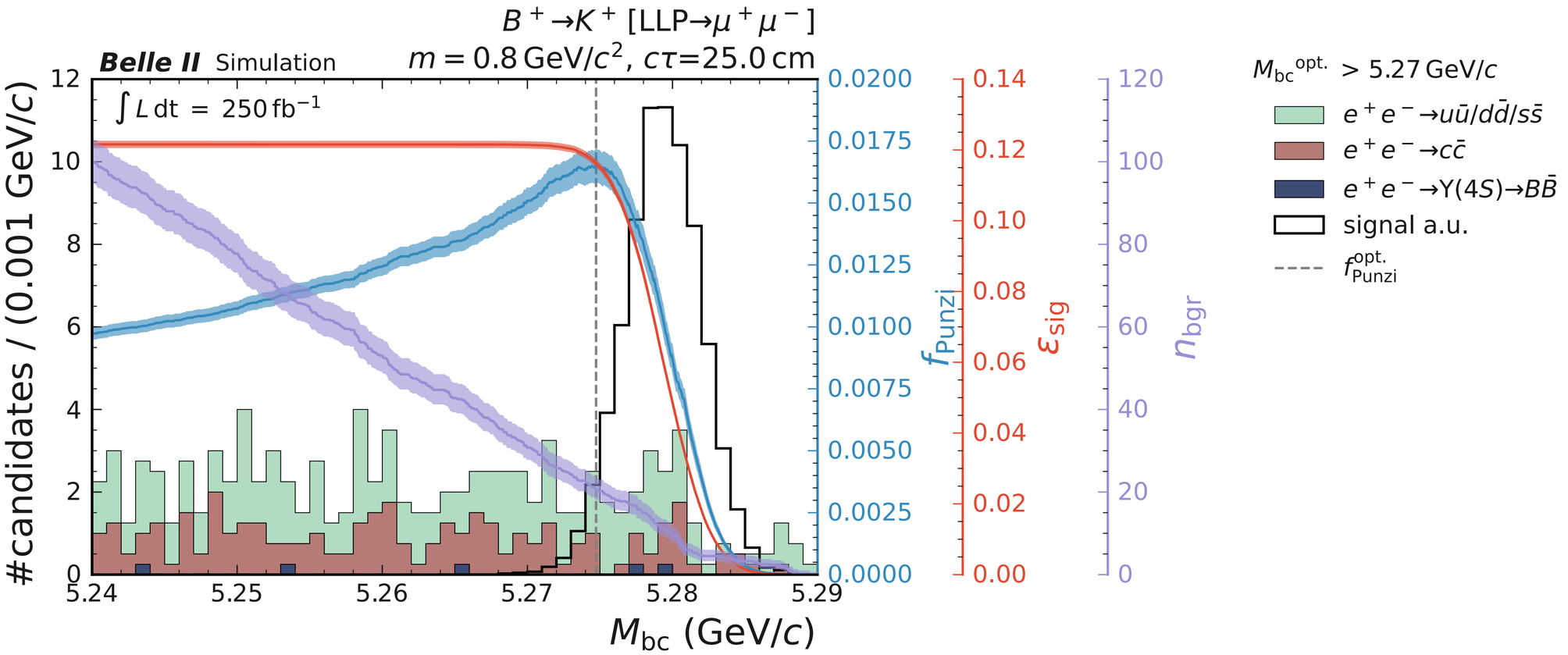
- K_S^0
- Combinatorics in $e^+e^- \to q\bar{q}$
- Peaking B decays

Selection — K_S^0 rejection.



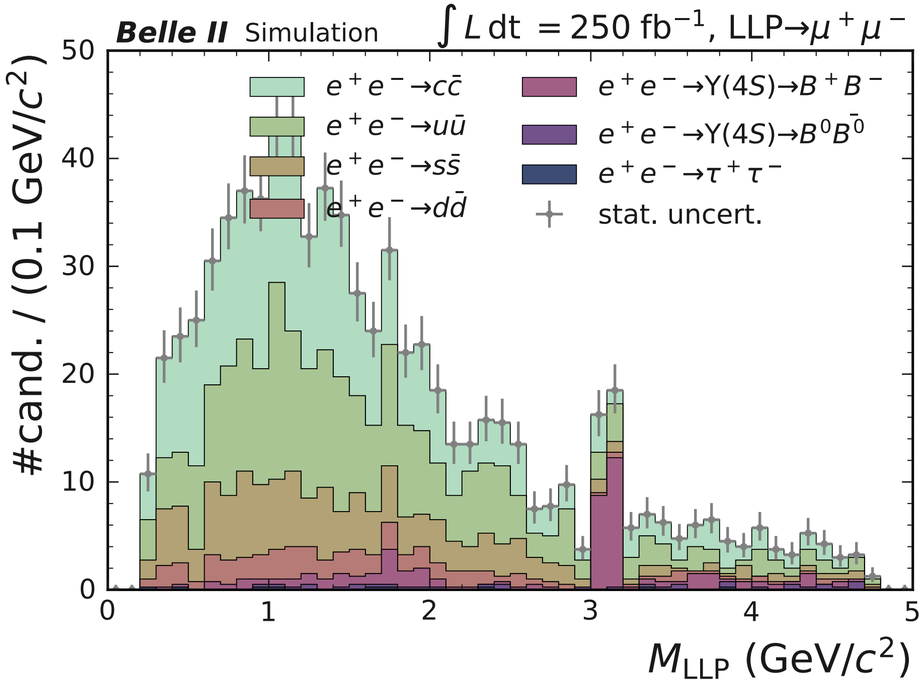
- Veto mass region around K_S^0 peak
- In all final-state channels using $M_{\pi^+\pi^-}$

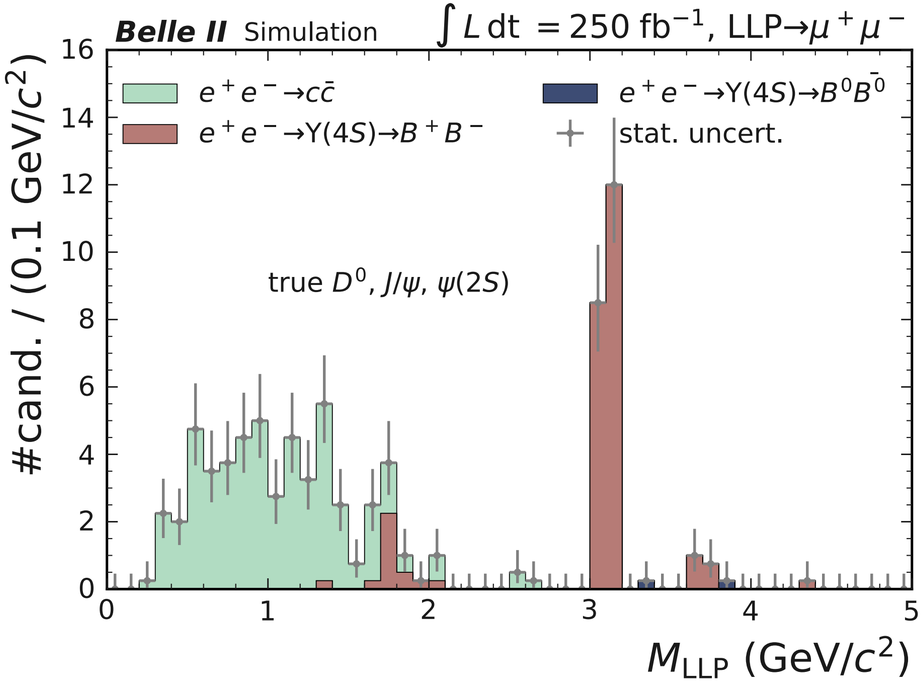
Selection — Combinatorial $e^+e^- \to q\bar{q}$ rejection.

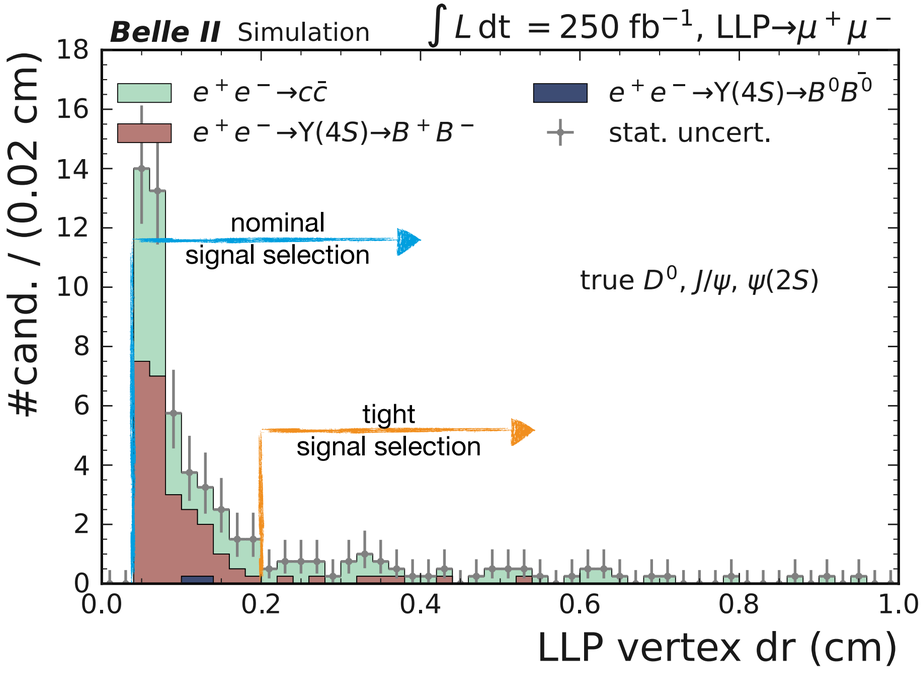


- Optimise a set of rectangular selections using the Punzi figure-of-merit

Selection — Peaking B decays rejection.

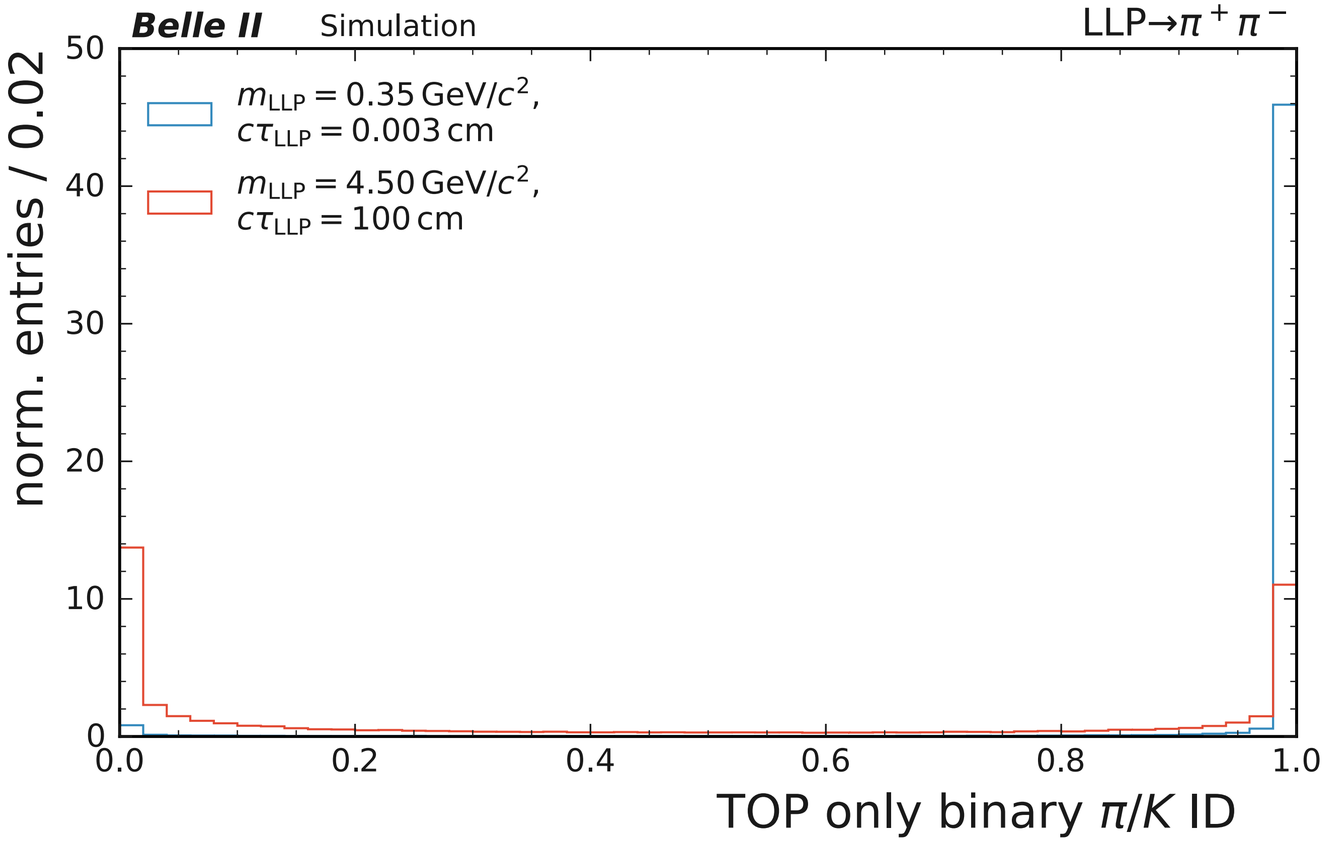






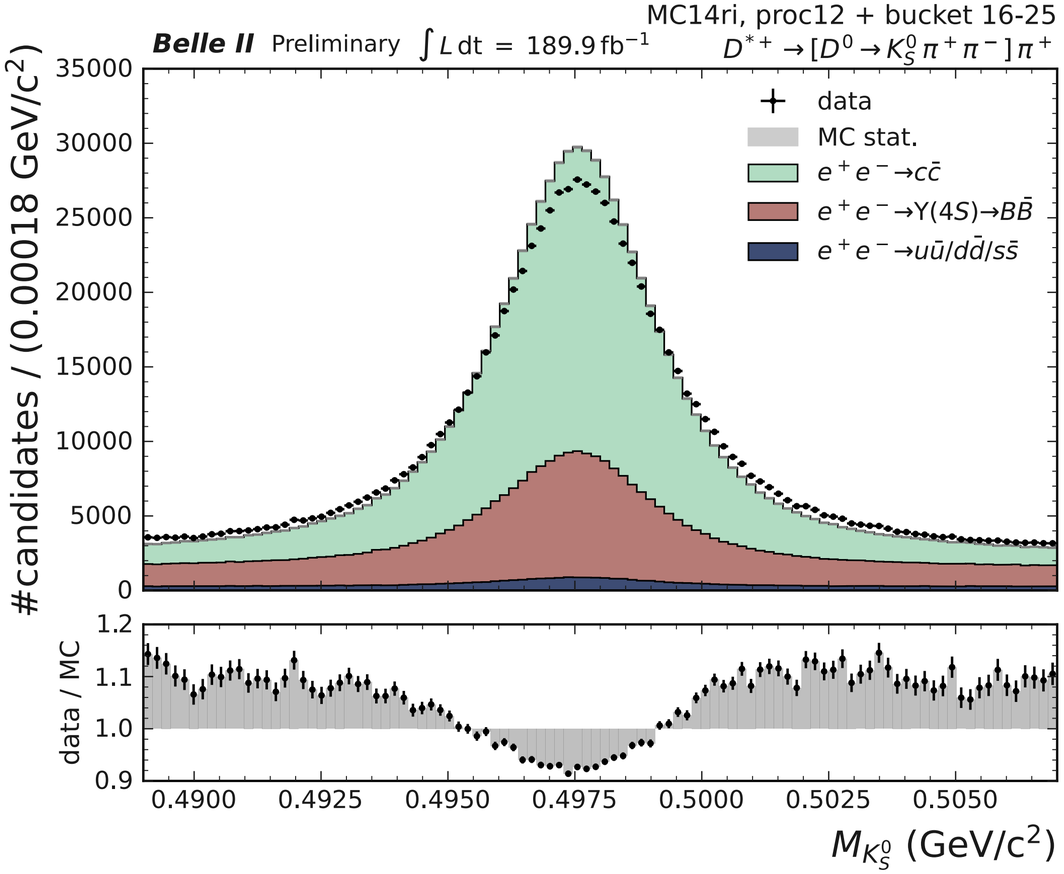
- Tighten selections in vertex displacement

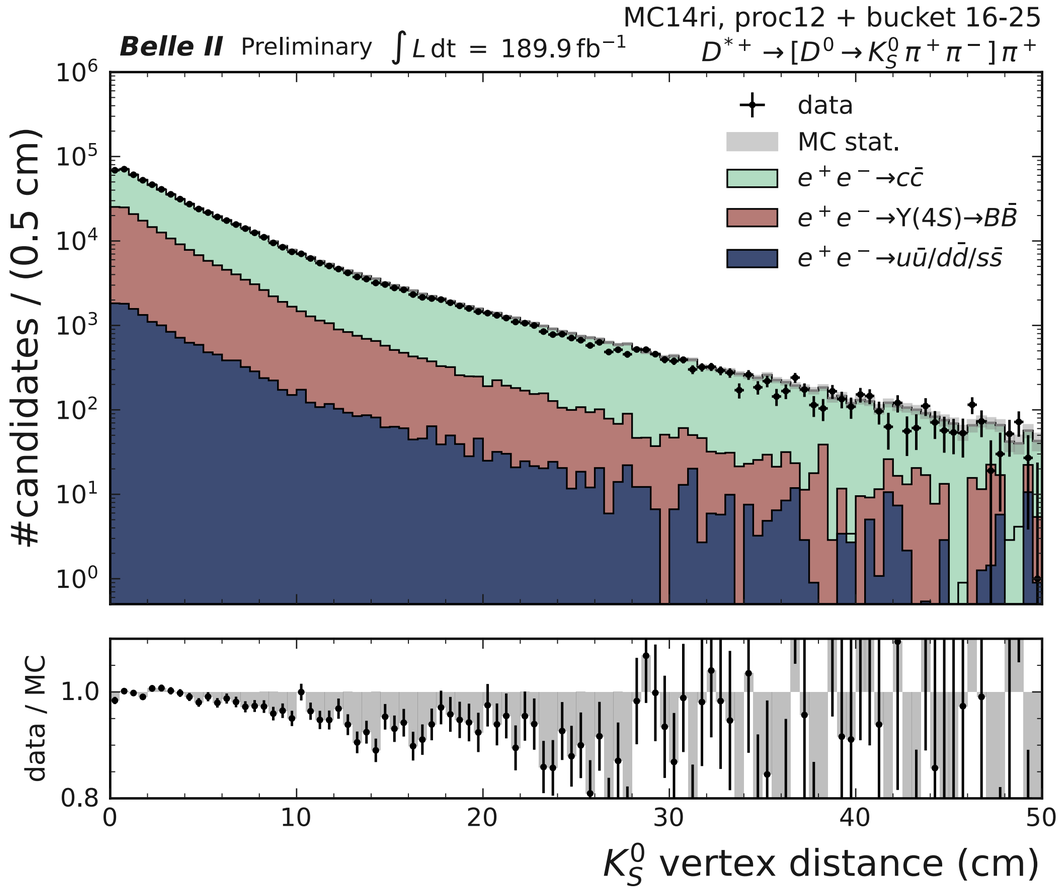
Selection — Particle identification for LLP daughters.



- Default PID performs poorly for daughters of highly displaced LLPs
- Excluding TOP likelihood and restricting tested particle hypotheses recovers performance

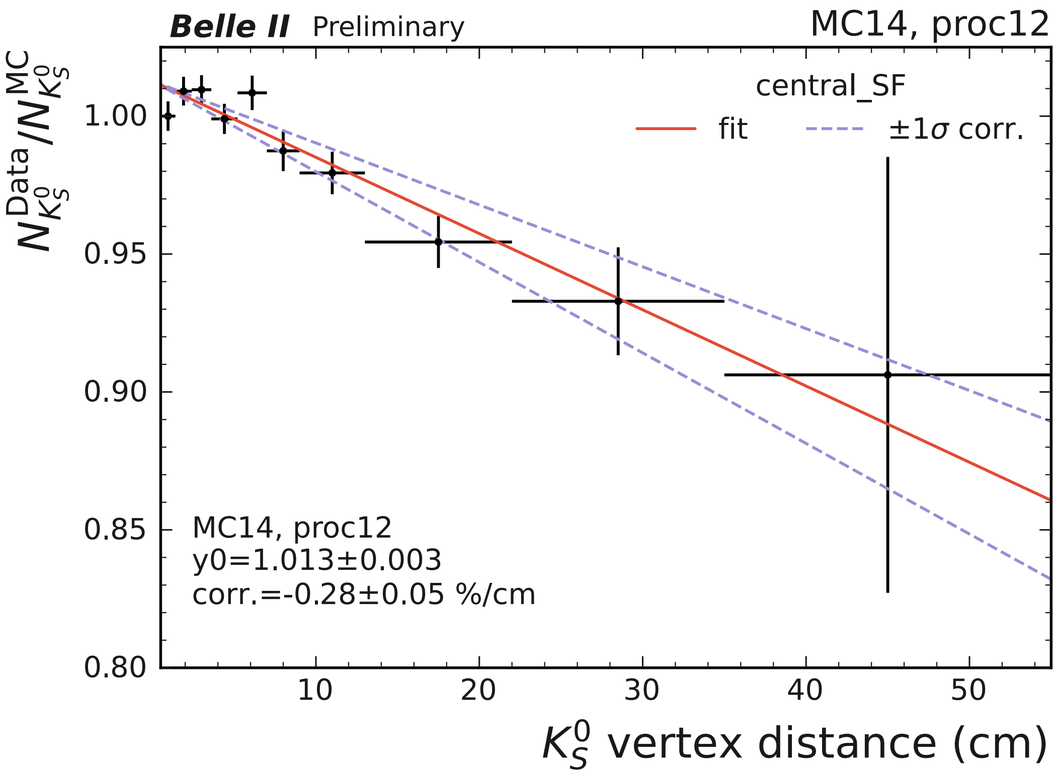
K_S^0 control channel.

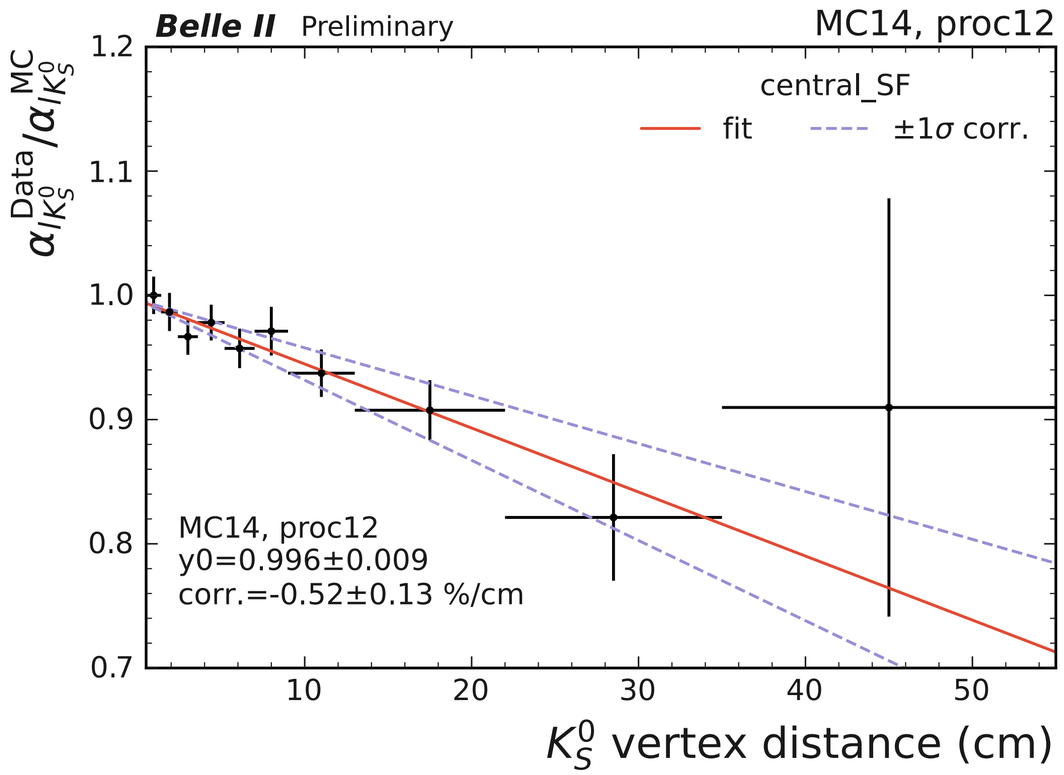




- The vetoed K_S^0 are used to study LLP performance

K_S^0 control channel — correction factors.

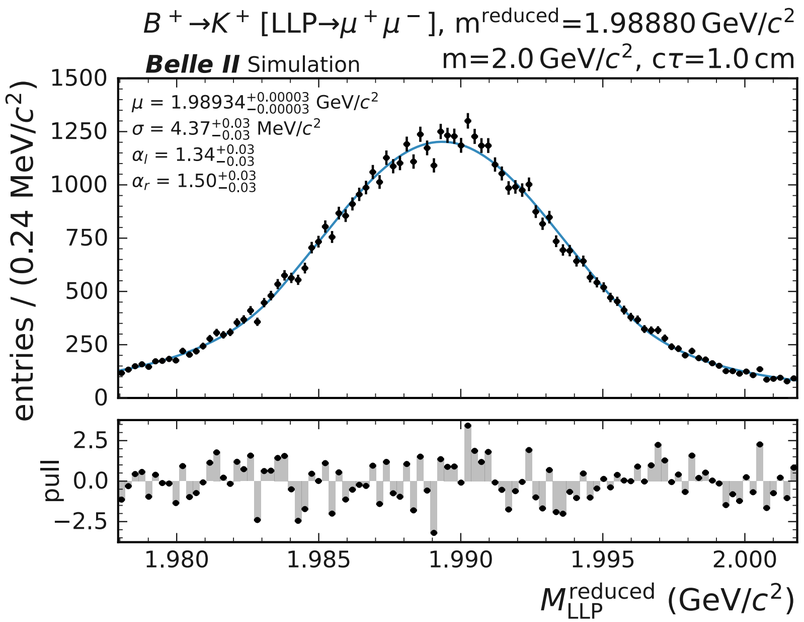


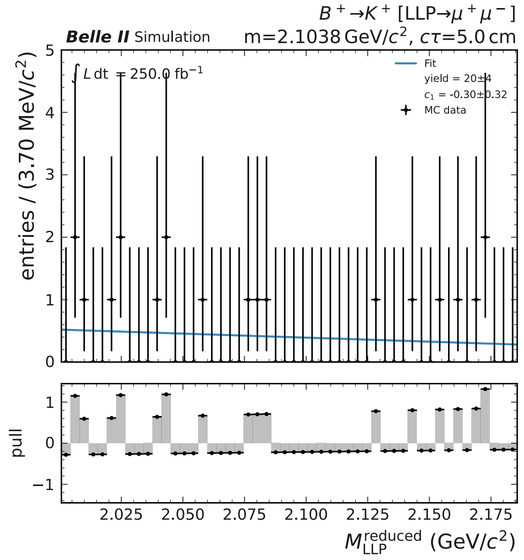


- K_S^0 data/MC discrepancy is used to determine correction factors
- Corrections on LLP efficiency & template parameters as a function of vertex displacement

Signal extraction.

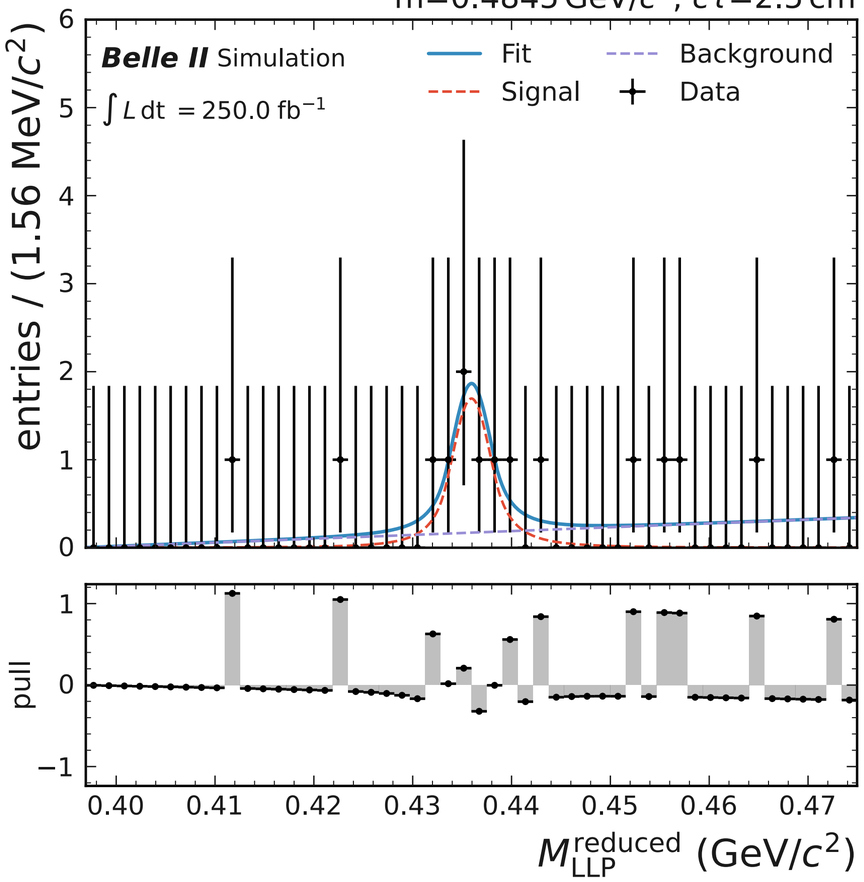
$$M_{\mathrm{LLP}}^{\mathrm{reduced}} = \sqrt{M_{\mathrm{LLP}}^2 - 4m_{\mathrm{final-state}}^2}$$





signal

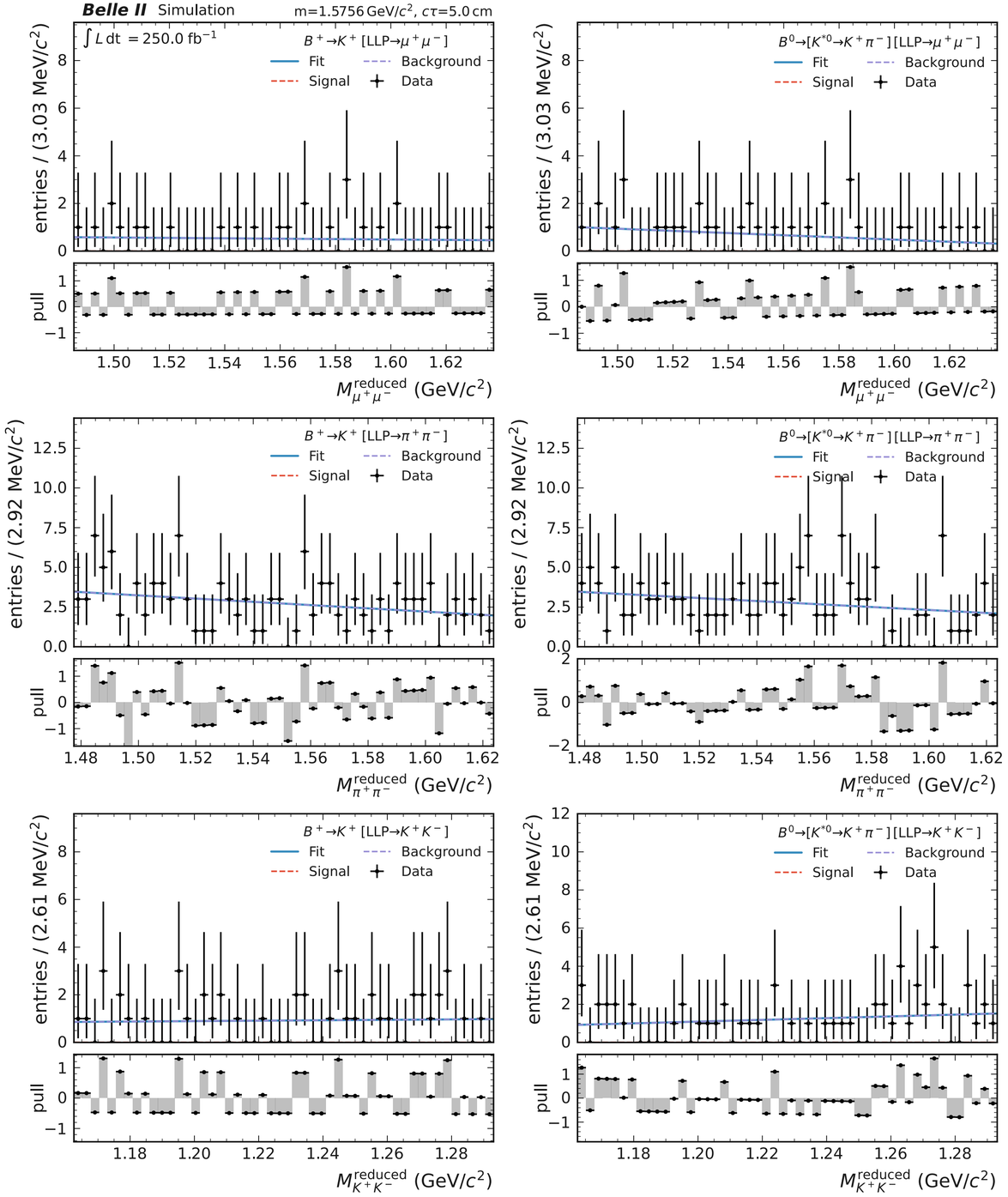
background



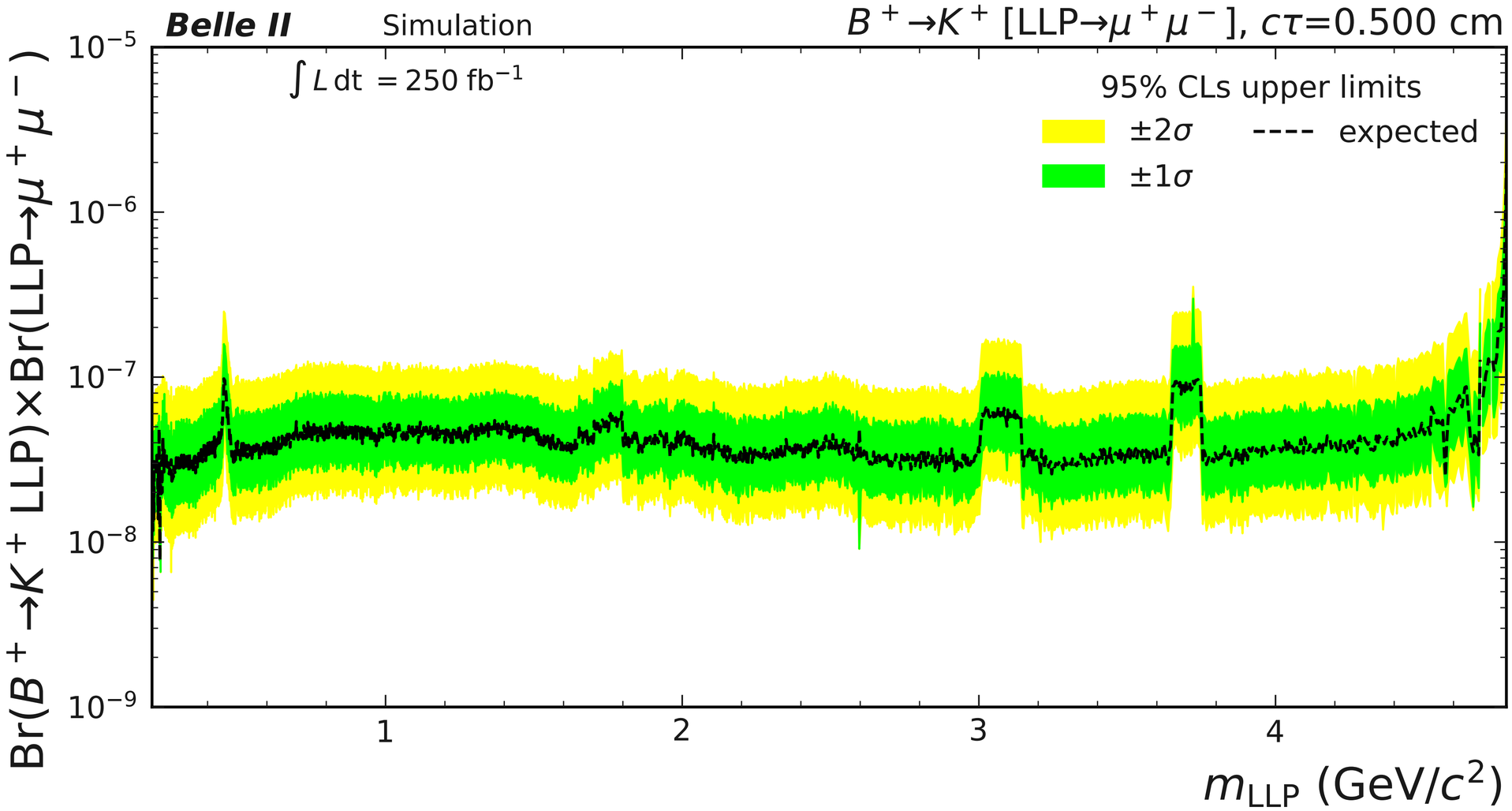
- Double sided crystal ball models signal
- First order Chebyshev polynomial models background

Signal extraction — simultaneous.

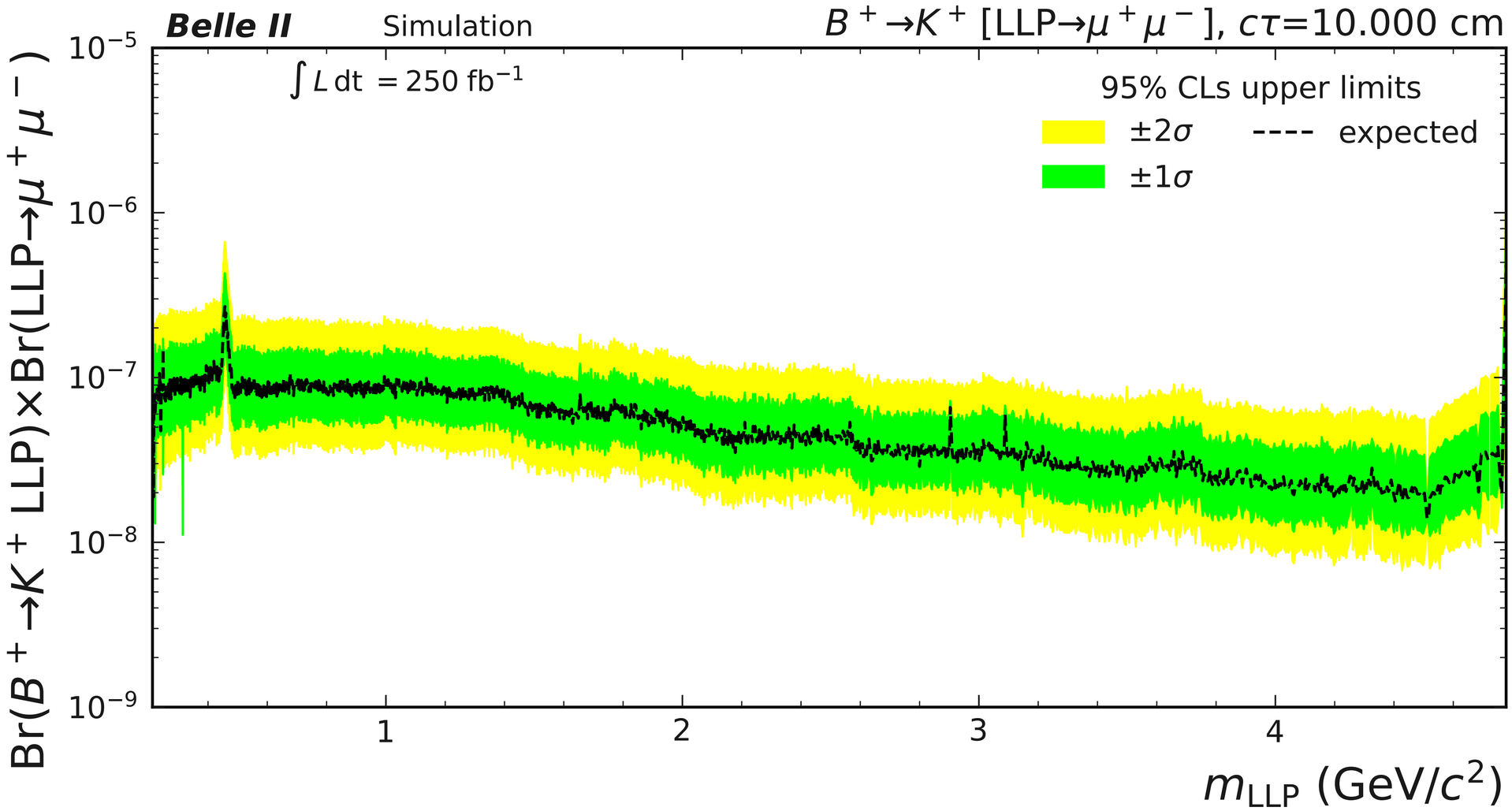
- Extract signal yield in all channels with a simultaneous fit
- Use model prediction for the signal branching fractions in different channels



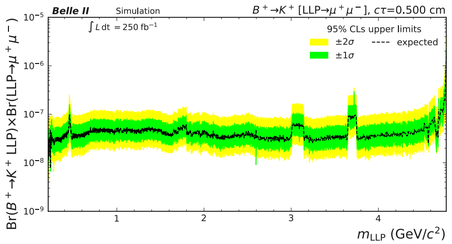
Upper limit on the branching fraction — small lifetime.

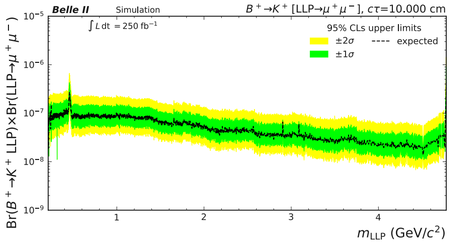


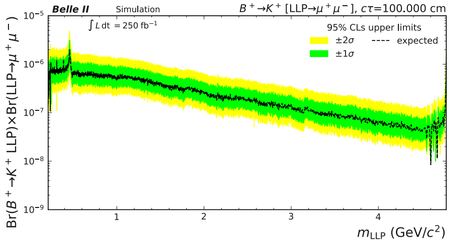
Upper limit on the branching fraction — medium lifetime.

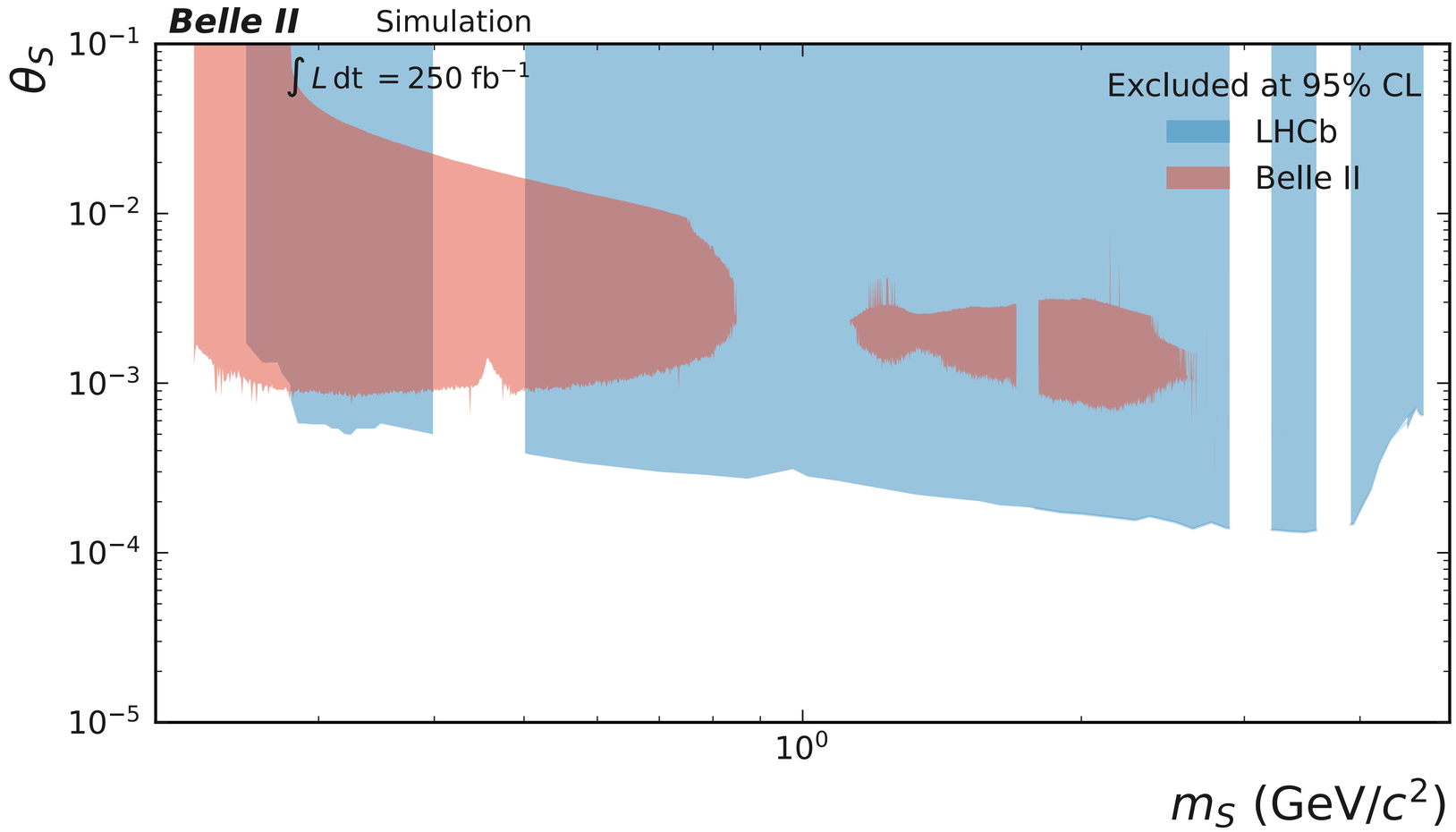


Upper limit on the mixing angle.



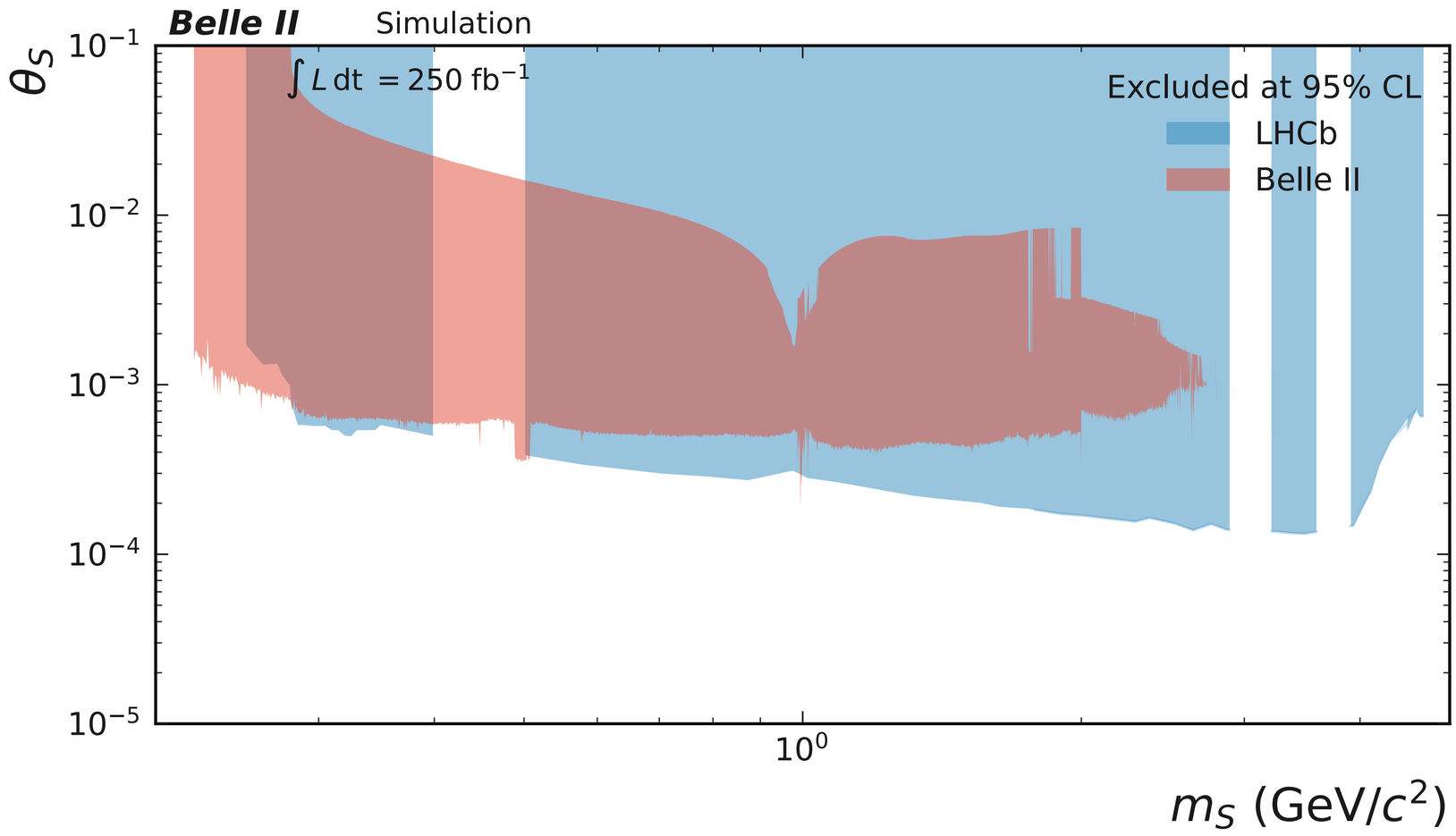






Upper limit on the mixing angle — simultaneous extraction.

- Model constrained more strongly by combining information from multiple channels
- Expect best limits at low masses < 280 MeV/c^2 and in the K_S^0 mass region



Summary.

- Search for a long-lived scalar in $b \to s$ transitions
- In working group review — started studying sideband data
- Plan to publish using Moriond dataset expecting competitive results ~ end of the year
- Stay tuned …

Internal note