



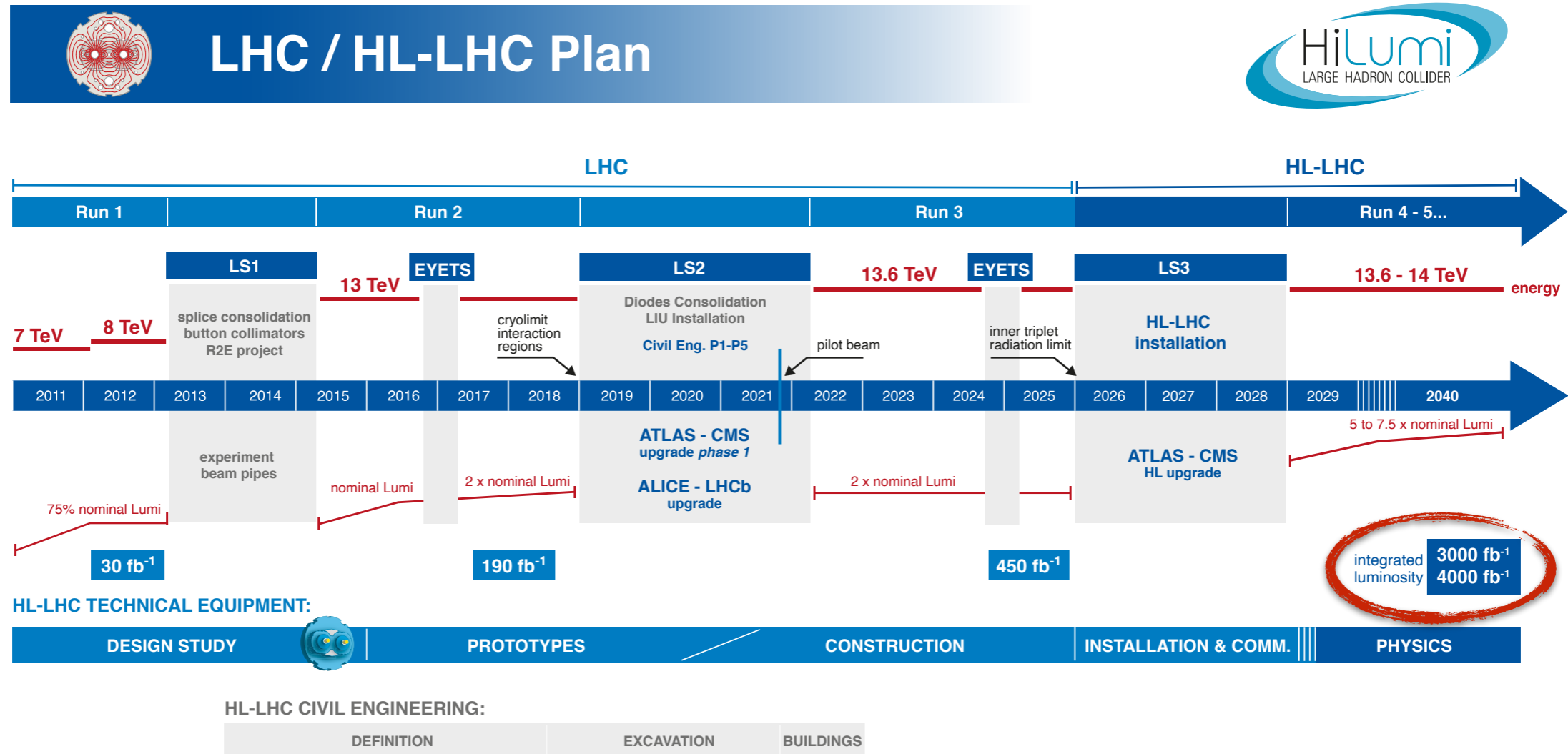
Dispelling the \sqrt{L} myth of the HL-LHC

A. Belvedere, C. Englert, R. Kogler, M. Spannowsky

ICHEP 2024, Prague
17-24th July, 2024

[arXiv:2402.07985](https://arxiv.org/abs/2402.07985)

Physics Potential of the HL-LHC



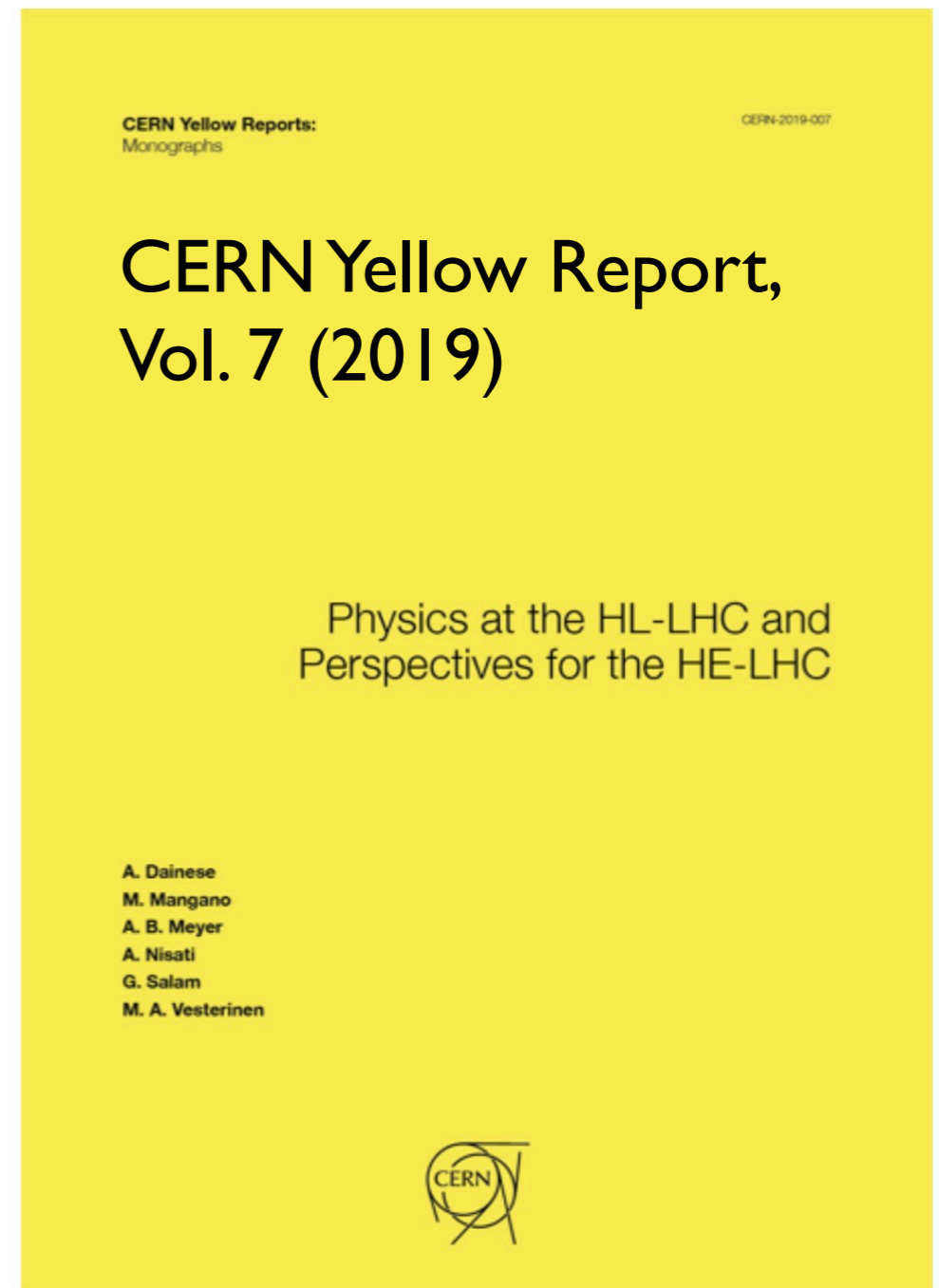
Sensitivity scales with luminosity:
$$\mathcal{S} \approx \frac{S}{\sqrt{B}} \approx \sqrt{L} \frac{\sigma_S}{\sqrt{\sigma_B}}$$

For measurements:
$$\delta \sim \sqrt{S} \sim \sqrt{L}$$

More realistic estimates

Huge effort by the LHC Collaborations + Theory to estimate the physics potential

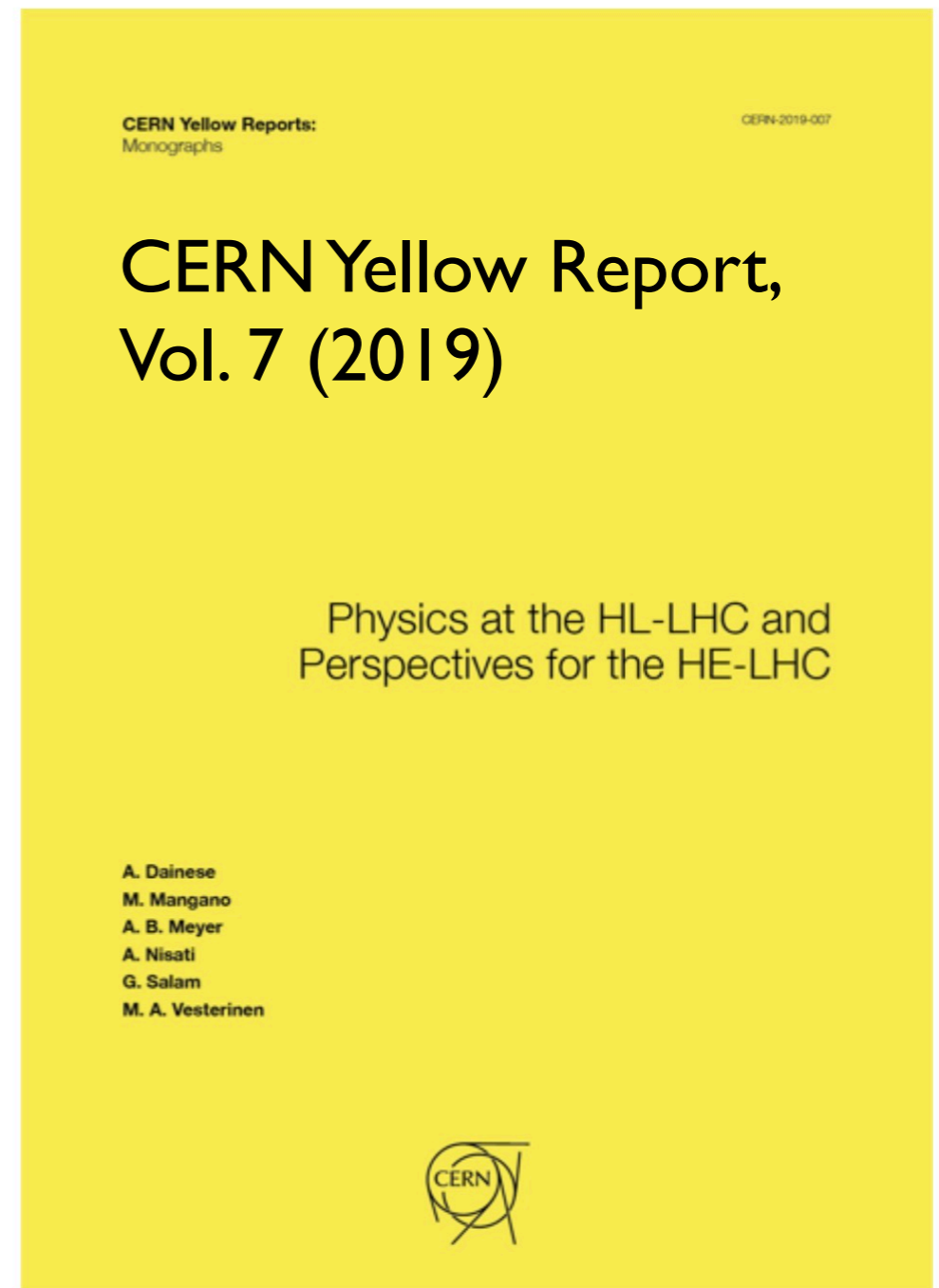
- ▶ Cumulated in CYRM-2019-007
 - Standard model
 - Higgs physics
 - BSM searches
 - Flavour physics
 - Heavy ions
- ▶ Existing analyses derived expected sensitivities
 - Higher luminosity
 - Better systematic uncertainties



More realistic estimates

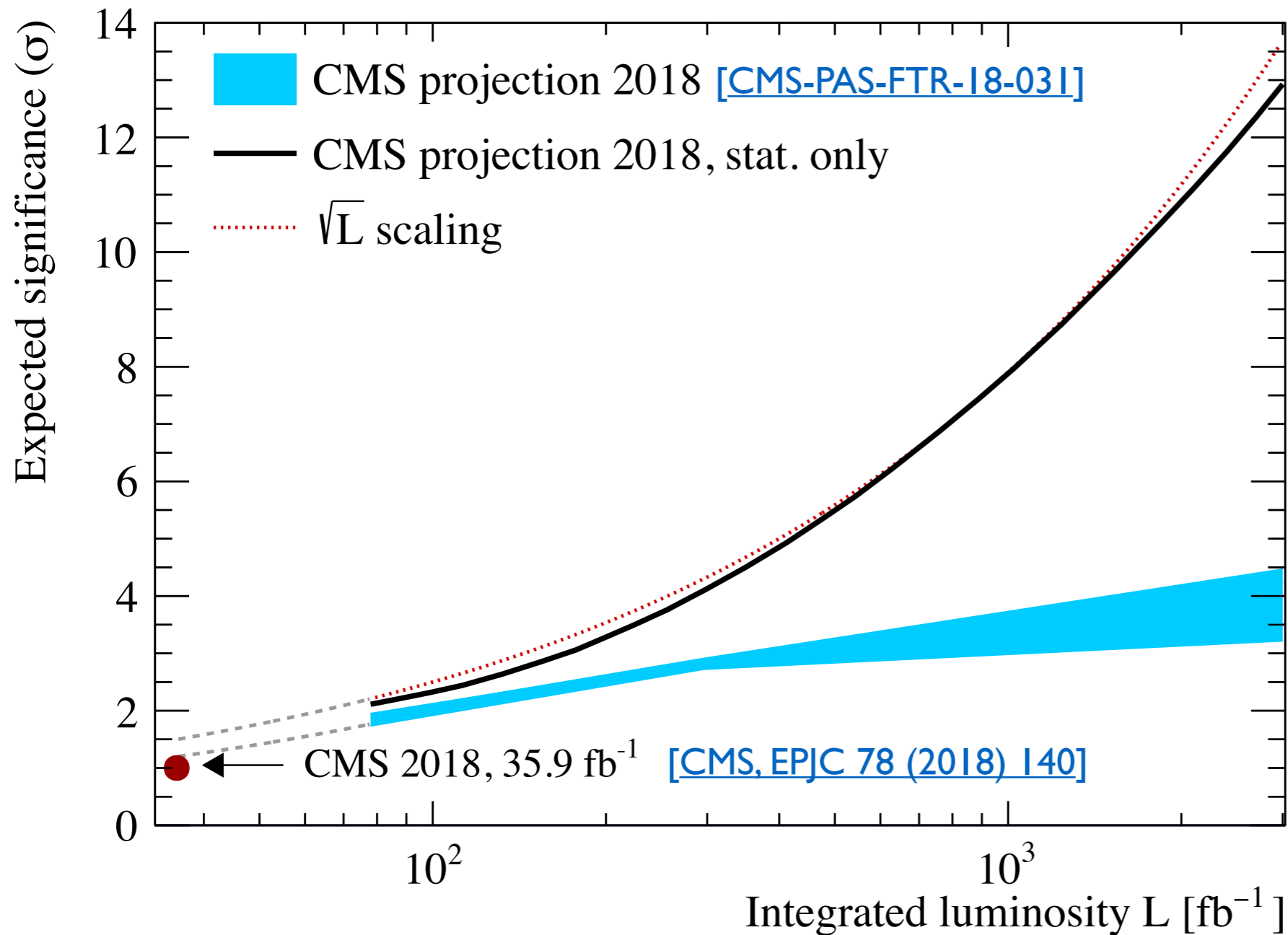
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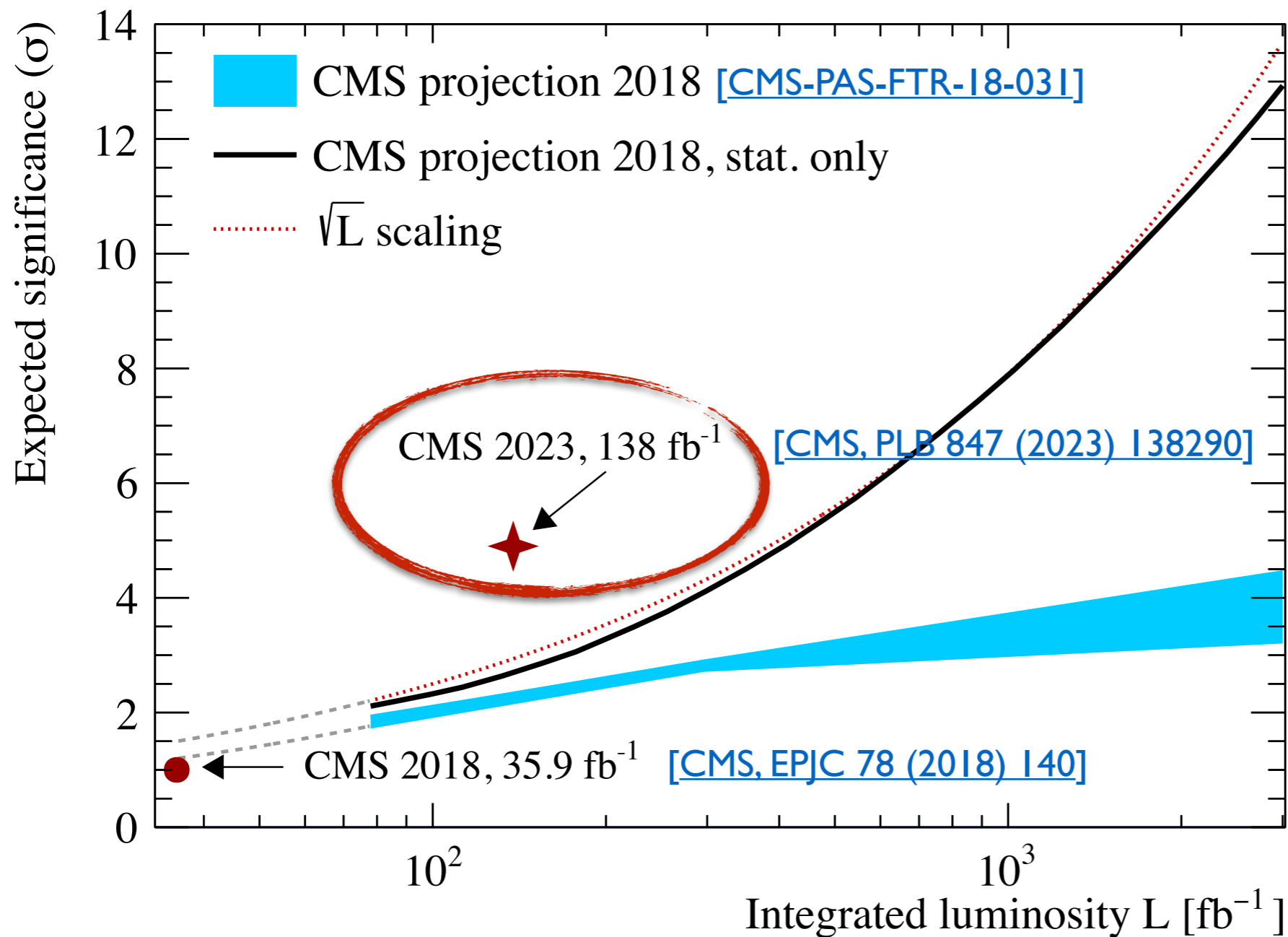
Somewhat bleak outlook for collider physics

Example: Four tops



- ▶ $\sigma(\text{tttt}) \approx 13 \text{ fb}$
- ▶ same-sign dileptons and multileptons
- ▶ extrapolation to HL-LHC reaches 4.1σ for optimistic uncertainties

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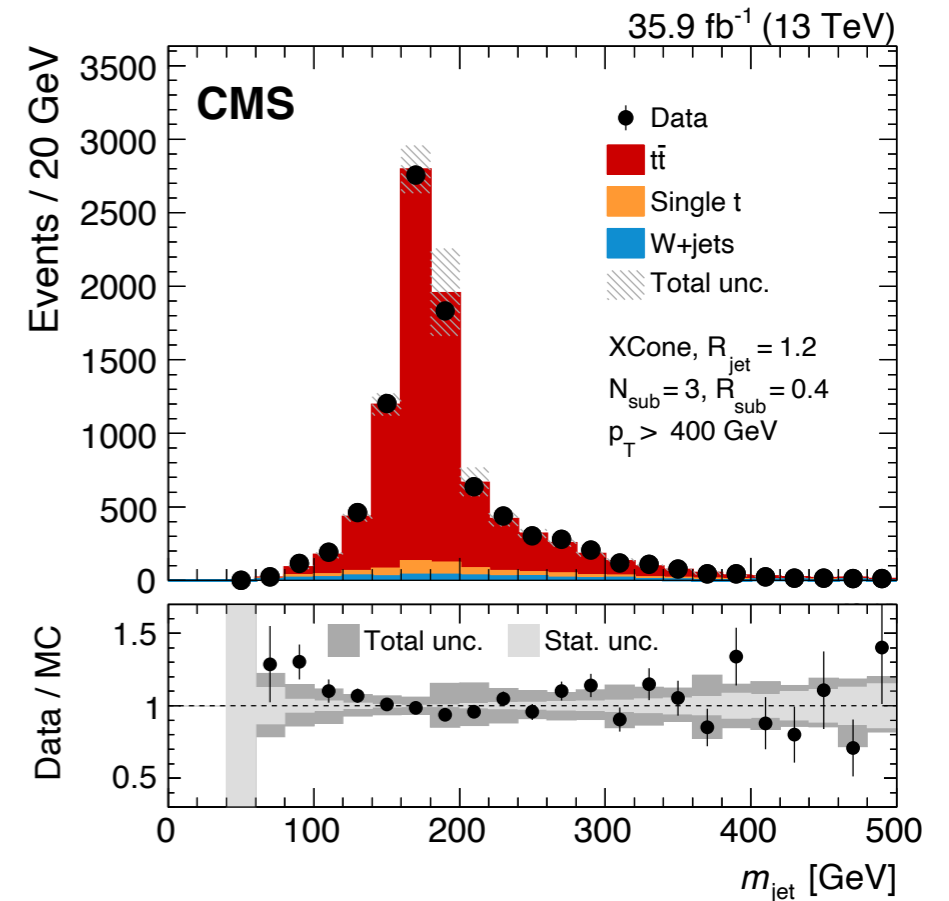
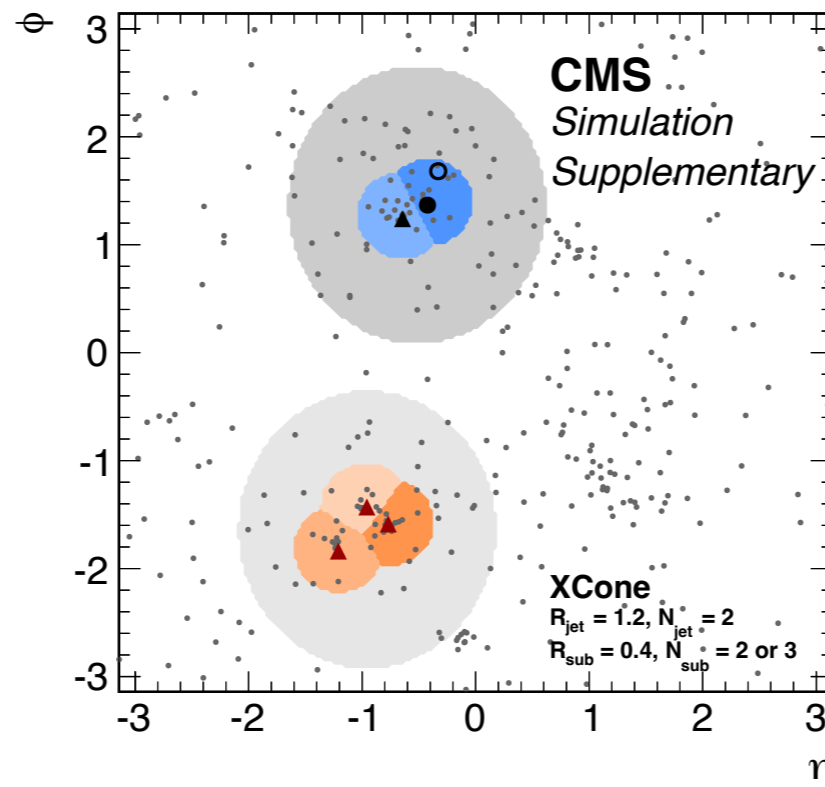
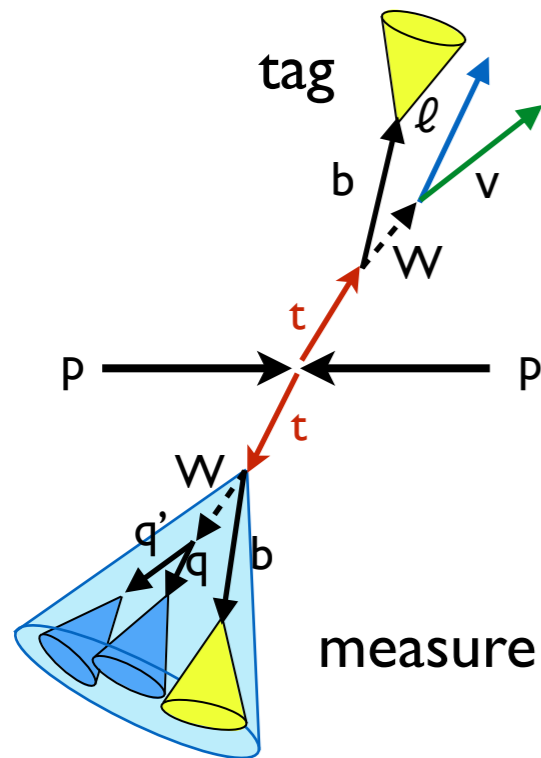


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2023: Updated methods and systematics: MVA lepton ID, BDTs to isolate signal

Precision: New Techniques

Example: Top quark mass



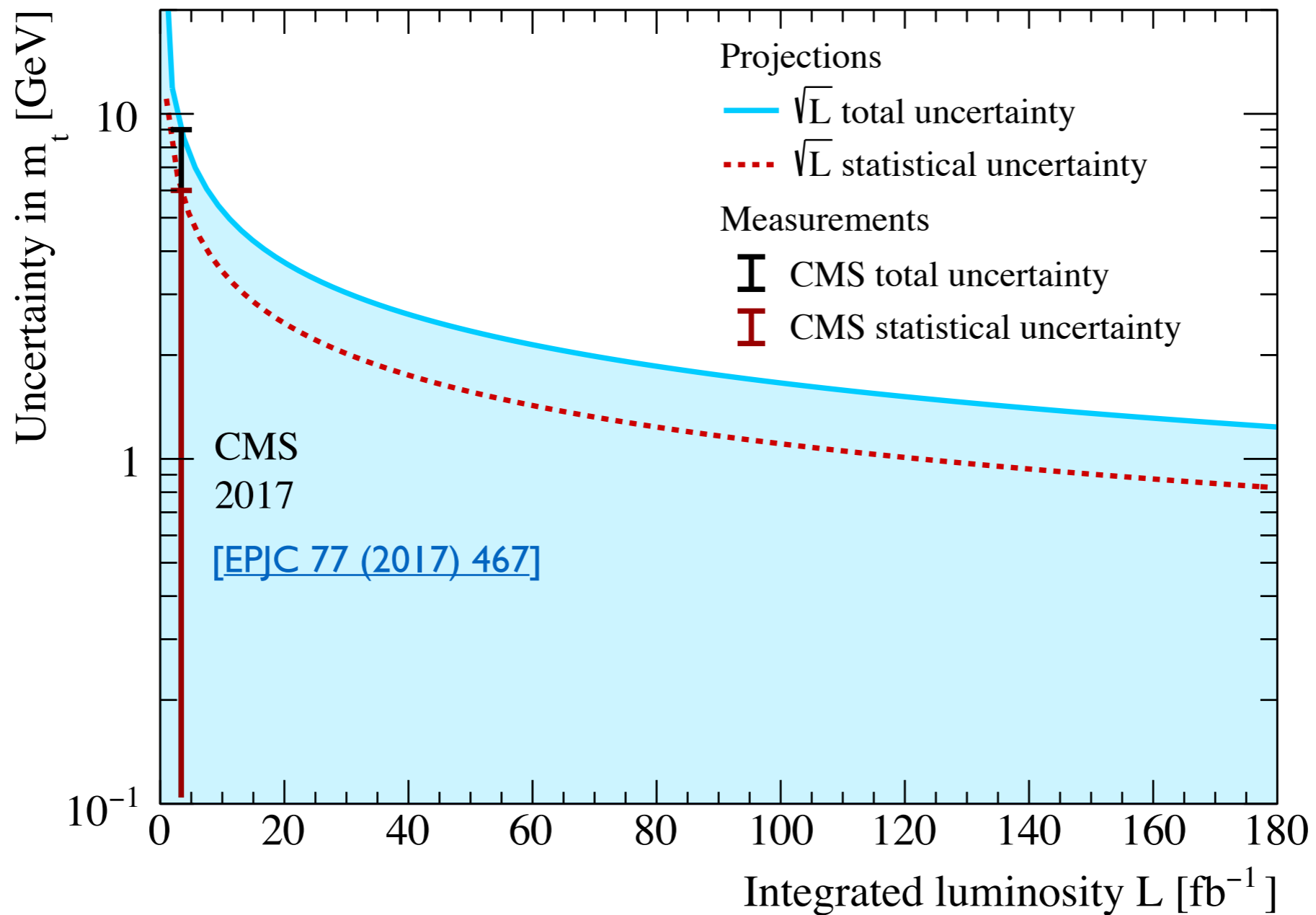
Measure m_t from the unfolded jet mass
in boosted tops

Became possible with higher \sqrt{s} and more L

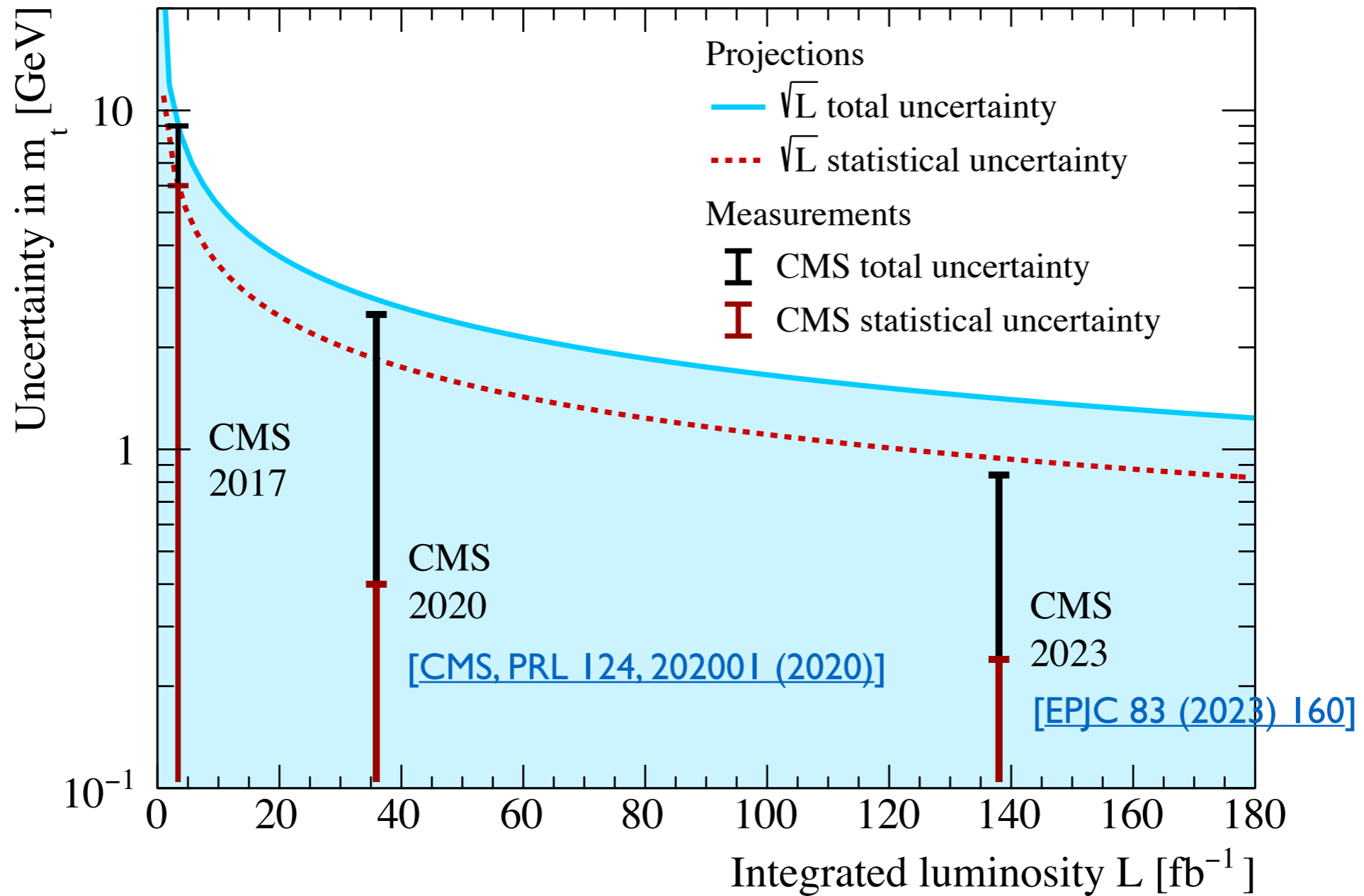
[\[CMS, PRL 124, 202001 \(2020\)\]](#)

Details by A. Paasch
on Saturday

What do we expect?



Achievement in precision



Top Electroweak Interactions

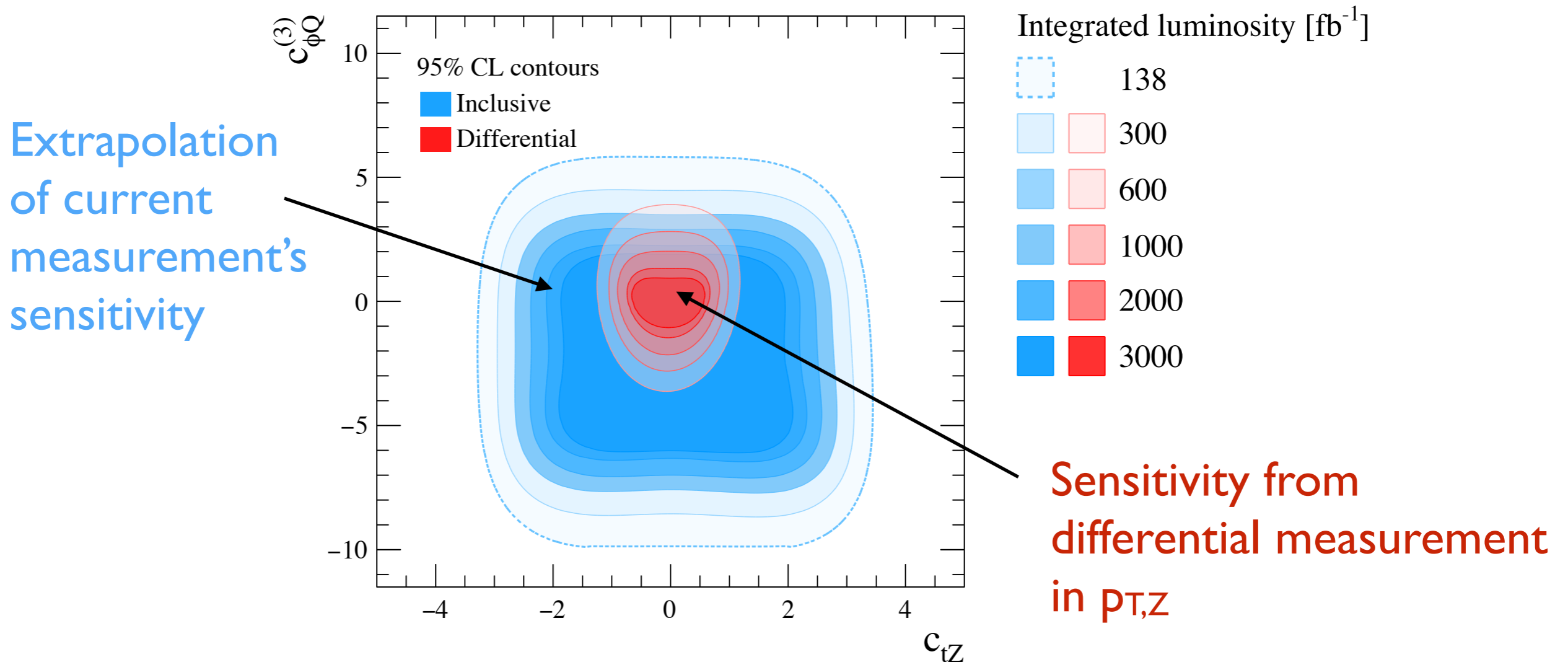
BSM effects in top-EW section poorly constrained

- ▶ $pp \rightarrow tWZ$ powerful probe of BSM effects
- ▶ Recent “evidence” for tWZ production by CMS [[CMS,PLB 855 \(2024\) 138815](#)]
- ▶ Can constrain SMEFT Operators ([A. Belvedere’s talk on Saturday](#))

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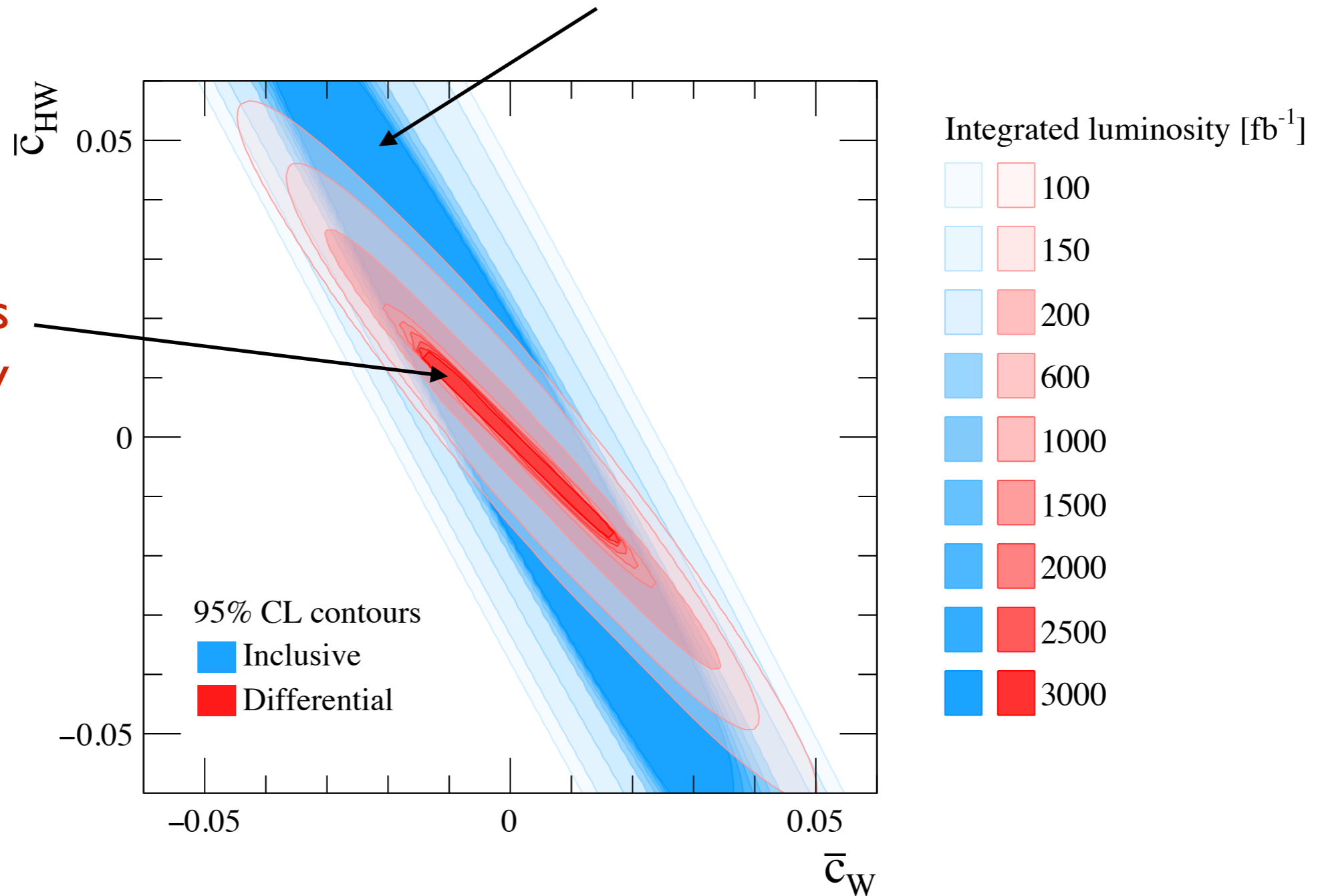
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Higgs Physics

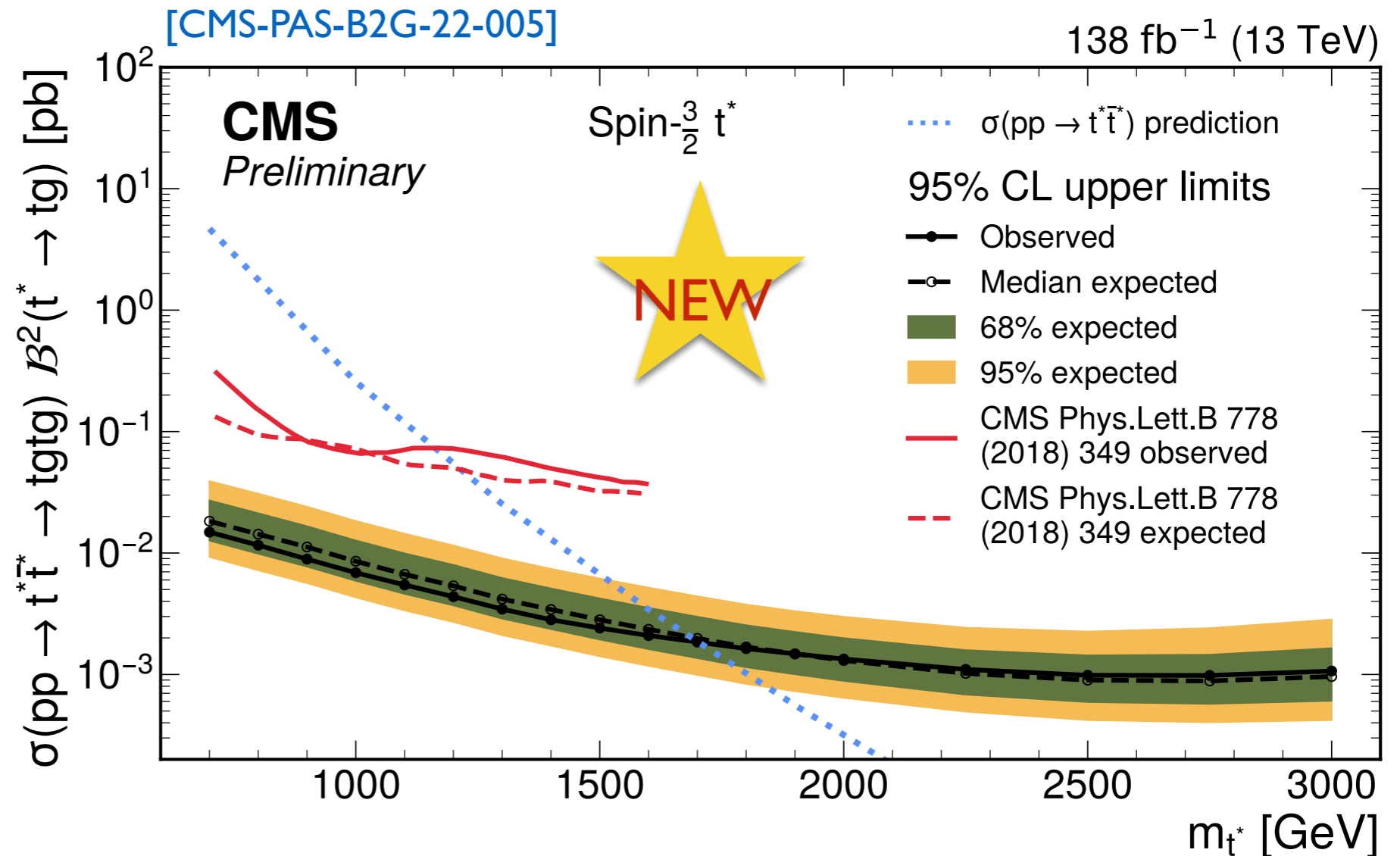
Blind directions in SMEFT fits: compensating effects

Differential measurements lift degeneracy



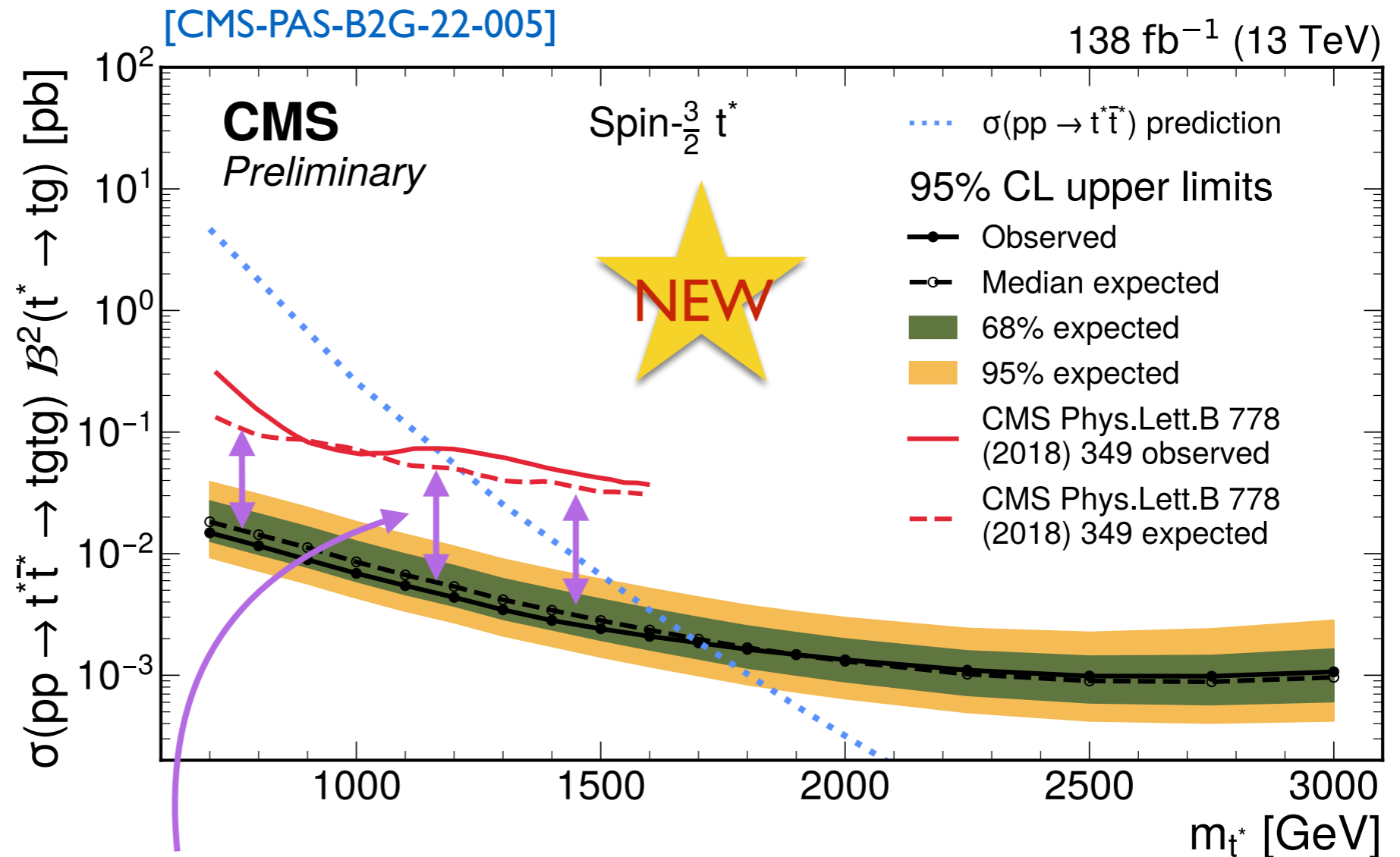
BSM Searches

- ▶ Excited top quark search
- ▶ $t^* \rightarrow tg$
- ▶ l+jets
- ▶ See F. Labe's talk on Sat. (BSM)



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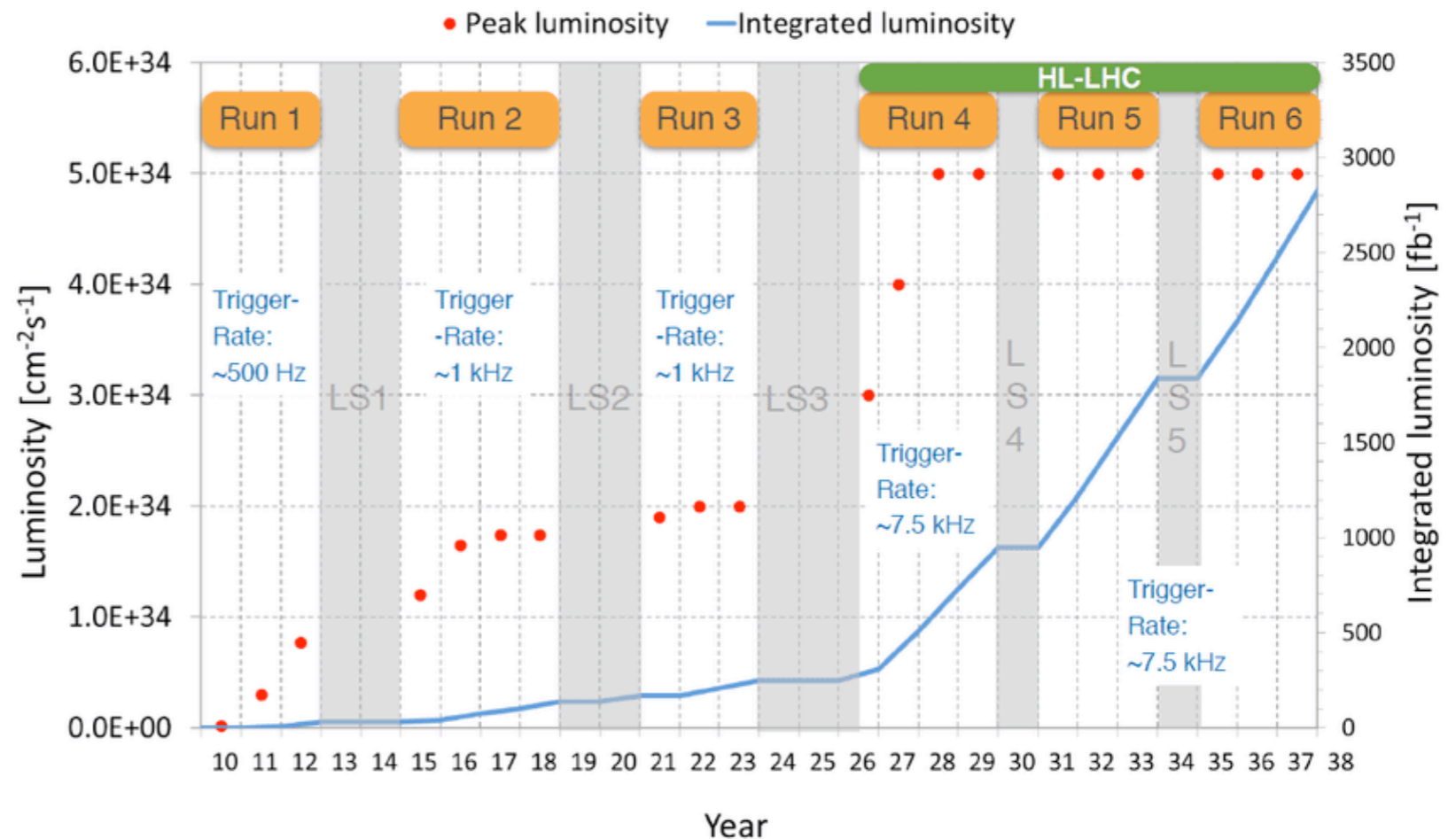


Sensitivity improved by factor of 10!

Expected from \sqrt{s} scaling: factor 2

Conclusions

- ▶ We live in exciting (particle physics) times
- ▶ Times will continue to be exciting
- ▶ Unprecedented physics potential of the HL-LHC
- ▶ Precision of future analyses has been underestimated, **expect to increase much better than \sqrt{L}**
- ▶ **New techniques, uncovered corners of phase space, theory developments and bright ideas will shape the field**



Further reading: [arXiv:2402.07985](https://arxiv.org/abs/2402.07985)