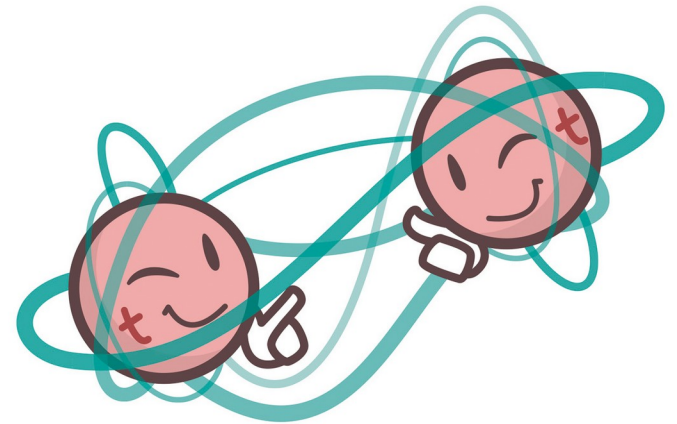


Decoherence studies - status

Marcel Vos,
IFIC, CSIC/UV, Valencia
Decoherence meeting
5 October 2026



PRL editor decision

PRL editor replied:

We have completed the review of your manuscript at Physical Review Letters. Unfortunately, after careful consideration, we are not convinced that this manuscript can meet our acceptance criteria.

You are invited to transfer your manuscript to another APS journal; PRD, PRR are likely to accept it.

The complete message, and the two referee reports are available on Overleaf

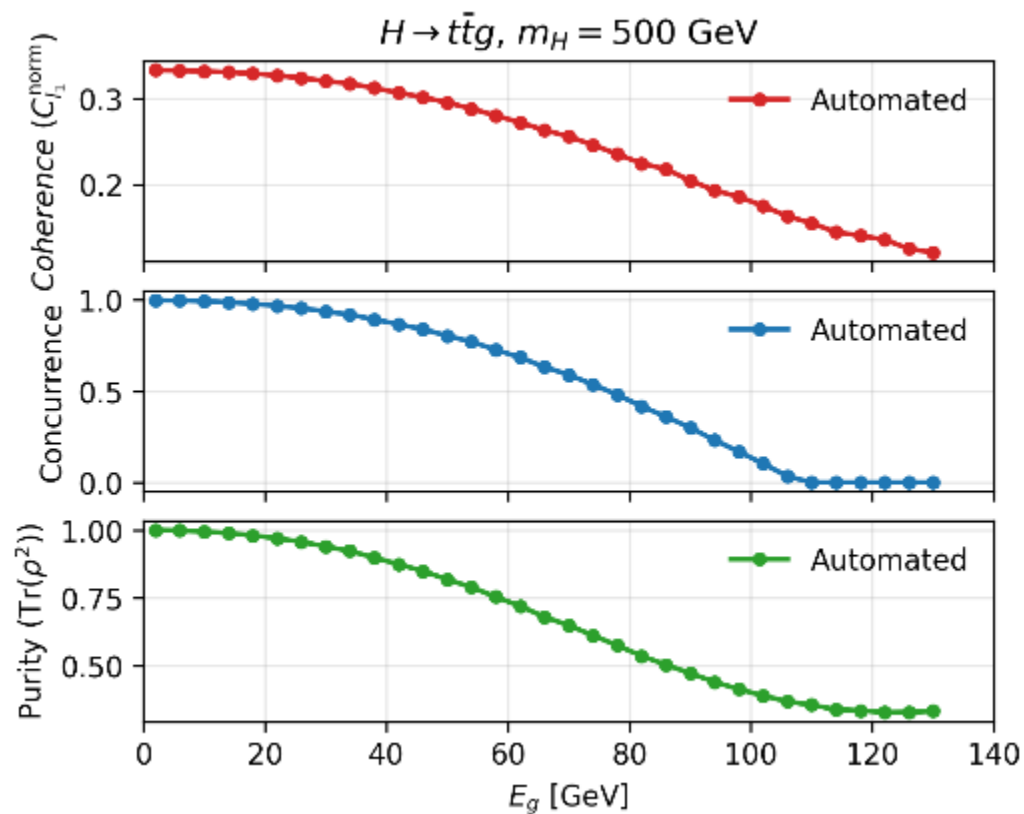
Referee 1: the process-level calculations and the top quark example are interesting

The manuscript convincingly shows that a selection with FSR can have lower entanglement, but does not cleanly isolate [the cause]. Significance numbers are inconsistent. Therefore, I recommend major revision.

Referee 2: The paper is technically solid, the analysis appears correct, and the results are physically reasonable. However, I do not recommend publication of this manuscript in Physical Review Letters, since I do not find that the main result reaches the level of novelty and impact expected for PRL.

Later: the effect is expected.... This is the standard behaviour for a sub-system interacting with additional degrees of freedom.... This is certainly interesting, but I am not convinced that the quantitative observation of an otherwise expected effect provides the level of novelty and significance required for publication in PRL.

Referee comments



Referee 1:

--- separation of FSR effect from other sources of mixing

(isolate FSR in $S \rightarrow t\bar{t}g$ sample, that is otherwise a pure state, check 3 TeV samples)

Referee comments

Referee 1 (continued):

- clarification of Born vs. Inclusive vs. Orthogonal no-FSR sample
(note: entanglement agrees within few % for these definitions of the control sample)
- significance results are inconsistent
(this is correct; we forgot to update one column and confirm at least one other issue)
- hadronic top decays; how to account for spin analyzing power
(spin analyzing power is actually 1; it's the down-type tagging that fails, we assume 60% tagging efficiency and a correct subtraction of mis-tags)
- jet definitions are unclear
(this is LO; there is no clustering; jet = quark or gluon)
- ISR and detector controls for Belle 2 and FCCee
(ISR is included in the calculation; it dilutes the effect, but not very much as it's naturally suppressed for operation at resonance peaks; detector effects must be estimated with a complete detector simulation; this is currently ongoing, but beyond the scope of this paper)

Referee 1 (minor):

- provide unpublished analytic results (longer write-up?)
- clarify conventions; helicity basis vs. $C=(C_{kk}, C_{rr}, -C_{nn})$
- careful with C uncertainties close to 0
- provide version numbers for MadGraph, scale and PDF choices, matching settings, etc.

Referee comments

Referee 2:

--- novelty, effect is expected

In our view, this paper proposes an entirely novel set of measurements at high-energy colliders that will enable - for the first time - a quantitative comparison of precise measurements of a decohering quantum system with exact predictions in the open quantum system framework. The fact that quantum decoherence is expected in the Standard Model does not make it less interesting (quite the contrary!) and is not an argument against observing the effect. The Higgs boson and top quark were expected, but that didn't prevent PRL from publishing phenomenological studies as to how to observe them.

--- minor comments on error bars, toponium + requests for clarification

--- explain more explicitly the separation between “system” and “environment”; under which conditions should the reduced entanglement of the fermion pair be interpreted as decoherence of an open system or simply as the reduced description of a larger closed quantum system

The open system view is adopted when the additional degrees of freedom are impossible to track. In calculations, we have the choice. Both descriptions are valid and must eventually yield a consistent picture.

S → ttg: tripartite system is entangled, loss of entanglement is due to tracing out the FSR

More general processes: tripartite entanglement is lost; the system genuinely becomes classical due to FSR

Opinions?

Fabio: “PRD sucks”

Fabio: “Sometimes you have to fight PRL and this is one of those times”

Please, let me know your opinions!!

Proposed reply to the editor

Polite, but firm

We thank the editor and the referees for your careful scrutiny of our manuscript. The concrete questions and suggestions by the referees have been very valuable to us in improving our draft. We strongly disagree with the assessment of referee 2 of the novelty and impact of this study and do not understand the editorial decision to reject our submission for publication in PRL.

In our view, this paper proposes an entirely novel set of measurements at high-energy colliders that will enable - for the first time - a quantitative comparison of precise measurements of a decohering quantum system with exact predictions in the open quantum system framework. The fact that quantum decoherence is expected in the Standard Model does not make it less interesting (quite the contrary!) and is not an argument against observing the effect. The Higgs boson and top quark were expected, but that didn't prevent PRL from publishing phenomenological studies as to how to observe them.

Convincing?

Concerning your suggestion to publish in PRD or PRR, we appreciate the offer, but have to decline. We set a very high bar for the journals we publish in, and we are not convinced the journals you suggest meet our standards.

Funny?

ATLAS analysis

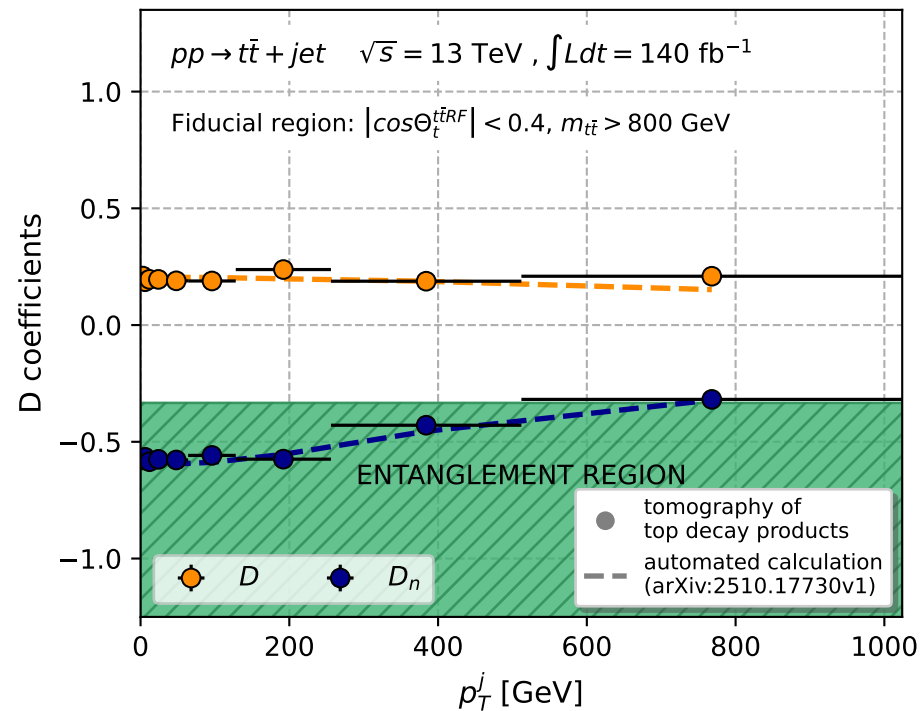
Short Time Associate proposal for Kazuki, Rafael and Leonardo has the support of the ATLAS physics coordinators and spokesperson (still needs to be signed off by EB)

- contribution to paper by Bologna, Columbia, DESY, Valencia and others
- predictions for D3 in boosted $t\bar{t}$ fiducial region, differential in $m(t\bar{t})$, $p_T(\text{jet})$
- interpretation of decoherence results, tripartite predictions

Exceptional authorship for the experimental publication is usually granted when there is a tangible contribution by the theory team

STA tied to the duration of the analysis; currently starting approval pipeline
(count on at least 6 months before the result is public; extensions have been granted)

ATLAS analysis



Unfolded parton-level results for angular distributions in boosted $t\bar{t}$ + jets events:

--- $\cos(\theta_t')$ distributions $[m_{t\bar{t}} > 800 \text{ GeV}, \cos(\theta_t) < 0.4]$

Observation of entanglement (D3) on boosted region:

--- $D3 = -0.59 \pm 0.04$ (stat.+syst.) $[\text{Asimov}, m_{t\bar{t}} > 800 \text{ GeV}, \cos(\theta_t) < 0.4]$

Differential analysis vs. $m(t\bar{t})$

--- 50.000 events in run 2+3, nearly all towards low $m(t\bar{t})$

Differential analysis vs. $p_T(\text{jet})$

--- only few 1000 events in decoherence region ($p_T > 200 \text{ GeV}$)

Hypothesis test of SM vs. No-decoherence scenario (i.e. $D3=\text{constant}$)

--- 1-2 sigma preference for decoherence (in Asimov, still blinded)