1. Motivation

The $B_\text{s}^0 \rightarrow \eta' \phi$ decay has never been observed.

- It belongs to the family of $b \rightarrow s\bar{s}s$ transitions $B^0 \rightarrow XX$ ($X = \eta'$, $\phi$), useful to measure the $B_s$ mixing-induced CP violation.
- Wide range of predictions in Standard Model.
  Poor knowledge of $B \rightarrow \phi$ form factor, $\omega \rightarrow \phi$ mixing angle.
- Branching fraction prediction is small due to strong cancellation of PV and VP final states.

2. LHCb detector

The search is performed using Run1 dataset (3 fb$^{-1}$) and the $B^0 \rightarrow \eta' K^0$ decay as normalization channel in the determination of the branching fraction.

3. Strategy

Yields obtained for signal and normalization channel from two-dimensional simultaneous unbinned maximum likelihood fit to the invariant mass distributions $\eta' K^+ K^-$ and $\pi^+ \pi^- \gamma$.

4. Event selection

$B_\text{s}^0 \rightarrow \eta' \phi$ candidate selection:
- **Trigger**: select inclusive $B$ decays
- **Loose pre-selection**
- **PID** helpful in reducing physics backgrounds:
  - $B^0 \rightarrow \phi K^0$
  - Modes with resonances decaying to $K^\pi \pi$
- **Selection** with **Boosted Decision Tree**:
  - Input: topological and kinematical variables
  - Most powerful: quality of $B$ vertex and $p_T$ of the photon
- **Similar selection** for normalization channel to reduce systematics

**Total efficiency ratio**

<table>
<thead>
<tr>
<th>Source</th>
<th>Relative uncertainty [%]</th>
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<tr>
<td>BDT efficiency calibration</td>
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<td>PID efficiency calibration</td>
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<td>Photon reconstruction</td>
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<td>Hadron interactions</td>
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<tr>
<td>Simulation statistics</td>
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<tr>
<td>Total</td>
<td>4.3</td>
</tr>
</tbody>
</table>

5. Signal yields

No signal is found. Fitted signal yield $N_{\text{signal}} = (3.2_{-3.5}^{+4.5} \pm 1.0) \times 10^{-4}$

6. Results and conclusions

Upper limit calculated using Bayesian approach. Uniform prior assumed for the branching fraction:

$$Br(B_\text{s}^0 \rightarrow \eta' \phi) < 0.82 (1.01) \times 10^{-6} \text{ at 90\% (95\%) CL}$$

Result incompatible with the central values of many predictions, although the large uncertainties on these predictions do not exclude them.

Reference

[1] Roel Aaij et al. [LHCb collaboration], Search for the $B_\text{s}^0 \rightarrow \eta' \phi$ decay, [hep-ex/1612.08110]