

Search for Dark Photons in radiative D^{*0} decays

Master's project

LHCb FSP meeting at Siegen

André Günther

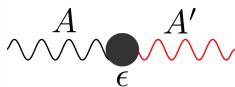
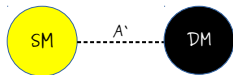
Uni Heidelberg

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Dark Photon A'

- ▶ Motivation: mediator between SM matter and Dark Sector
- ▶ achieved by adding extra $U(1)$ symmetry to SM gauge group
 $\rightarrow SU(3)_C \times SU(2)_L \times U(1)_Y \times U(1)'$
- ▶ symmetry allows for mixing of kinetic terms $\mathcal{L}_{kin} \supset -\frac{\epsilon}{2} F_{\mu\nu} F'^{\mu\nu}$
- ▶ mixing leads to small coupling of A' to electromagnetic current $\rightarrow \mathcal{L} \supset \epsilon e A'_\mu J_{EM}^\mu$
- ▶ parameters of minimal scenario:

kinetic mixing ϵ and mass $m_{A'}$



Dark Photon search in charm meson decays

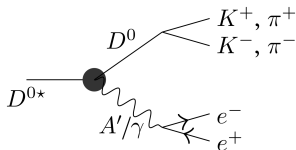
Decay Modes

\overline{D}^* (2007)⁰ modes are charge conjugates of modes below.

Mode	Fraction (Γ_i / Γ)	Scale Factor/ Conf. Level	P (MeV/c)
Γ_1 $D^0 \pi^0$	$(64.7 \pm 0.9)\%$	S=1.0	43
Γ_2 $D^0 \gamma$	$(35.3 \pm 0.9)\%$	S=1.0	137

constrained fit information

- ▶ promising channel $D(2007)^{*0} \rightarrow D^0 \gamma$
arXiv:1509.06765
- ▶ search for $D^{*0} \rightarrow D^0 A'$ in
 - prompt $A' \rightarrow e^+ e^-$ (large ϵ)
 - displaced $A' \rightarrow e^+ e^-$ (small ϵ)
- ▶ accessible mass range is set by
 $m_{D(2007)^{*0}} - m_{D^0} \approx 142 \text{ MeV} \implies$
- ▶ complementary to inclusive Dark Photon search with muons ($m_{A'} \geq 214 \text{ MeV}$)

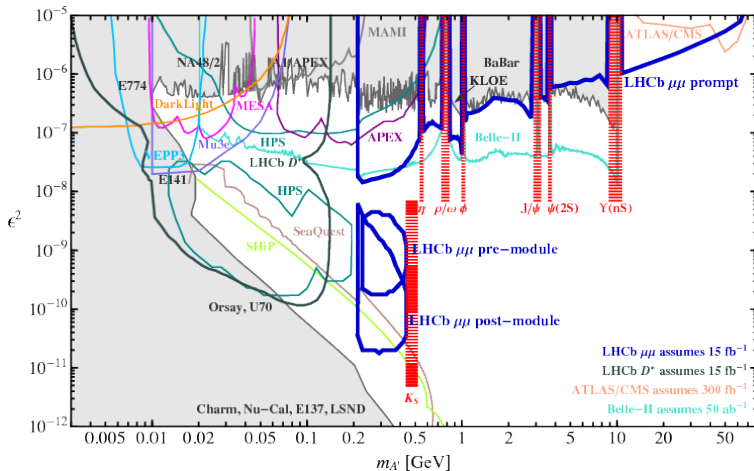


$$m_{A'} \in [2m_e, 142 \text{ MeV}]$$

LHCB-PAPER-2017-038

$\epsilon^2 - m_{A'}$ Parameter Space

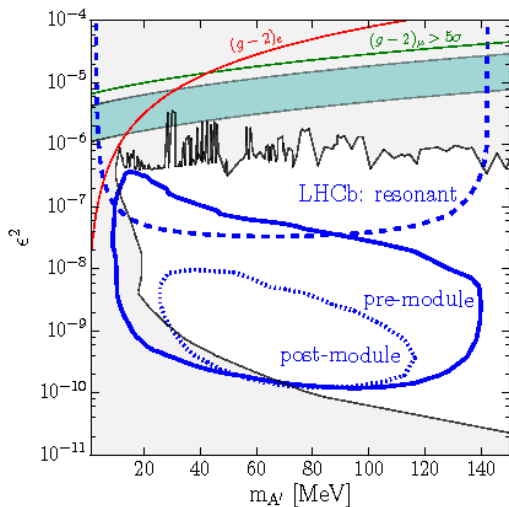
Potential bounds after Run III of LHCb



arXiv:1603.08926

ϵ^2 - $m_{A'}$ Parameter Space

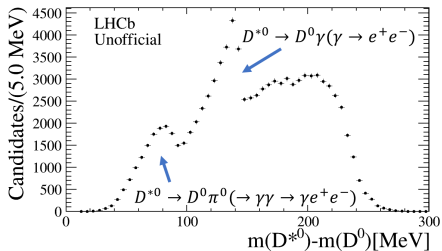
Potential bounds from $D^{*0} \rightarrow D^0 A' (A' \rightarrow e^+ e^-)$ after Run III



arXiv:1509.06765

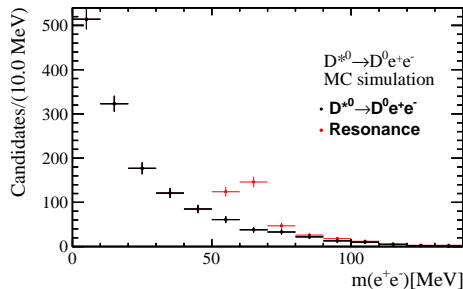
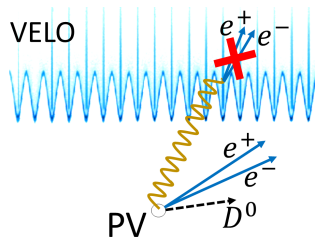
My Project

- ▶ focus on prompt (resonant)
 $A' \rightarrow e^+ e^-$ search
- ▶ use 2017 data from Turbo Stream (TurboSP)
- ▶ irreducible background
 $D^{*0} \rightarrow D^0 e^+ e^-$ has not been measured so far
- ▶ $\mathcal{B}(D^{*0} \rightarrow D^0 e^+ e^-) \approx 2 \times 10^{-3}$ expected from QED



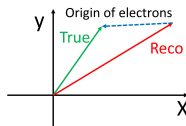
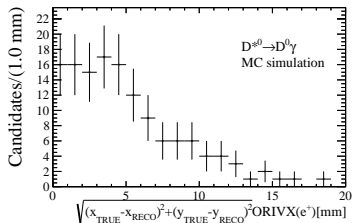
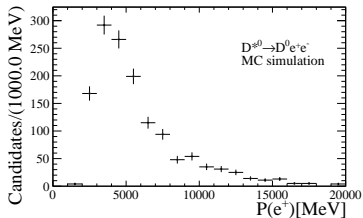
Analysis Baseline

- ▶ measure irreducible background $D^{*0} \rightarrow D^0 e^+ e^-$
 - veto photon conversion background
 - apply MVA techniques
 - use $D^{*0} \rightarrow D^0 \gamma (\rightarrow e^+ e^-)$ as normalisation to determine BR
- ▶ look for resonance in di-electron invariant mass



Challenges

- ▶ electrons have comparably low momentum
 - large electron background
- ▶ electrons from photon conversions are very collimated
 - bad vertex resolution
- ▶ official simulation (with large statistics) not available yet



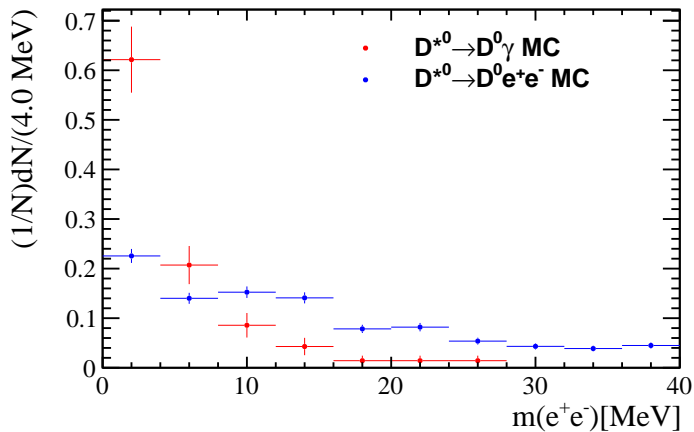
Next Steps

- ▶ identify best photon-conversion-background veto
 - e.g. with map of VELO material
- ▶ train Boosted Decision Tree

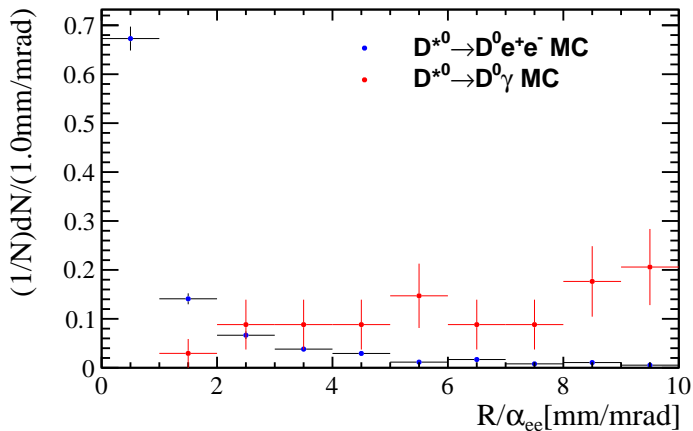
Thank you for your attention!

Back Up

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