Dark Photons with LHCb

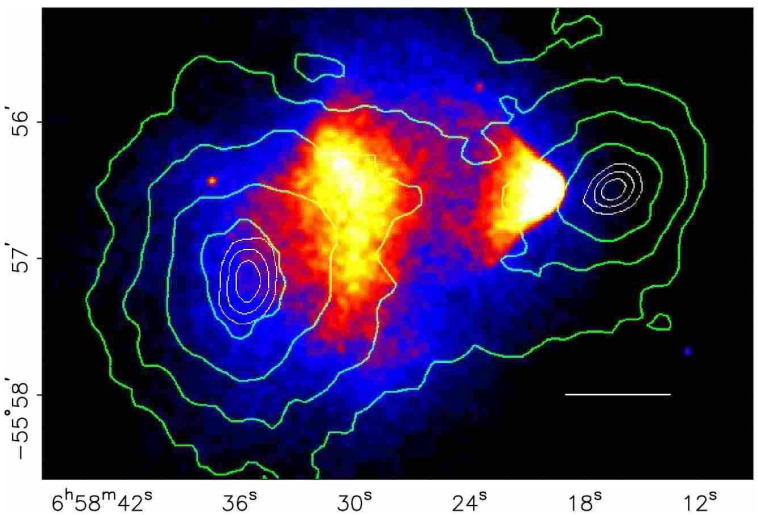
Philip Ilten

Massachusetts Institute of Technology

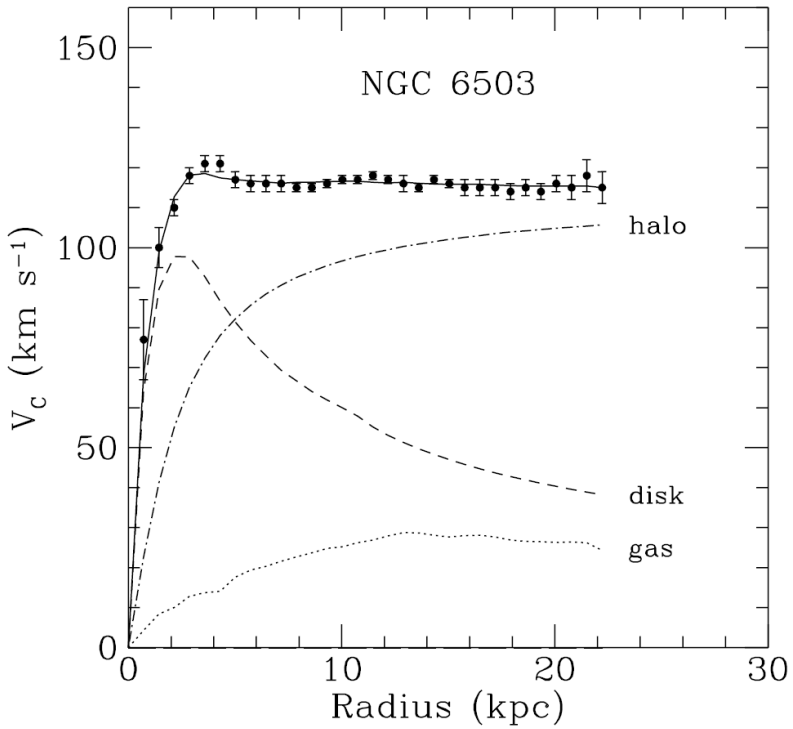
US LHC Users Association

Dark Matter

- large body of experimental evidence (Phys. Rept. **405** (2005) 279)
  - spiral galaxy rotation curves
  - merging clusters and galaxies
  - cosmic microwave background
  - ...



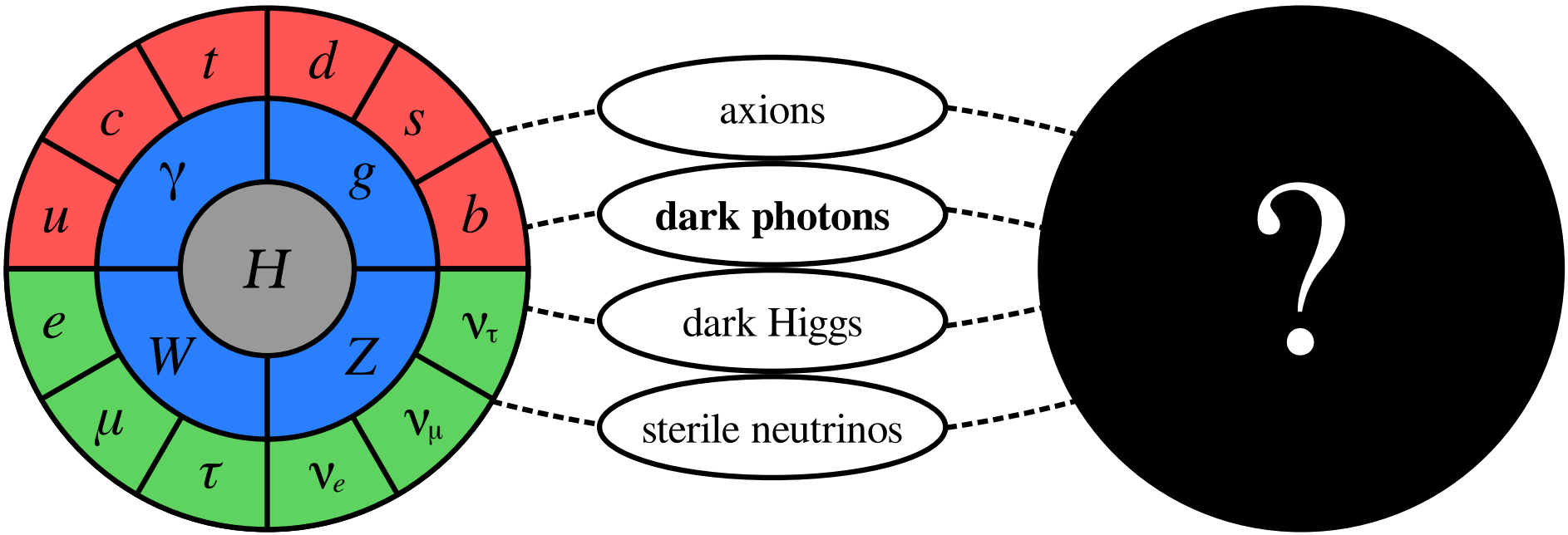
Astrophys. J. **648** (2006) L109



MNRAS **249** (1991) 523

- **standard model of particle physics cannot be complete**

Connecting the Dots

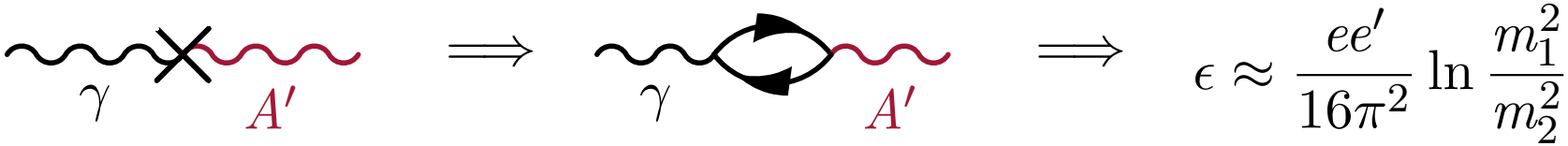


Dark Photons

- introduce a new $U(1)$ dark force

$$\mathcal{L} \supset -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + e J^{\mu}_{\mathrm{EM}} A_{\mu} - \frac{1}{4} F'_{\mu\nu} F'^{\mu\nu} + \frac{m^2_{A'}}{2} A'_{\mu} A'^{\mu} + e\epsilon J^{\mu}_{\mathrm{EM}} A'_{\mu}$$

- two free parameters
  - mass of the dark photon, $m_{A'}$
  - kinetic mixing, $\epsilon^2 \equiv \frac{\alpha'}{\alpha}$

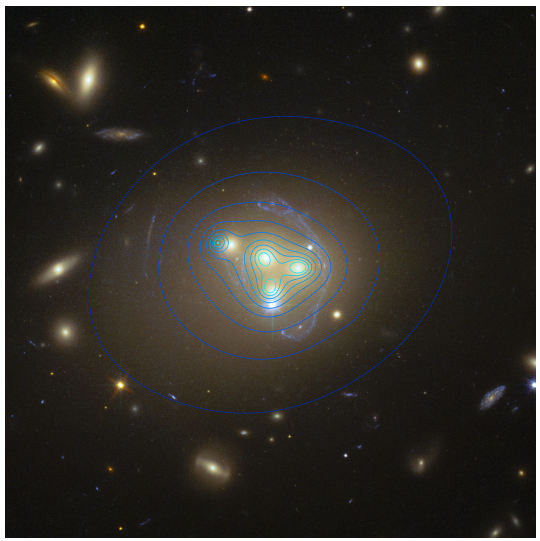


$$\epsilon \approx \frac{e e'}{16\pi^2} \ln \frac{m_1^2}{m_2^2}$$

- $\epsilon^2 \approx 10^{-6}$ if heavy lepton with SM and DM charge
- $\epsilon^2 \approx 10^{-10}$ if SM embedded in GUT symmetry

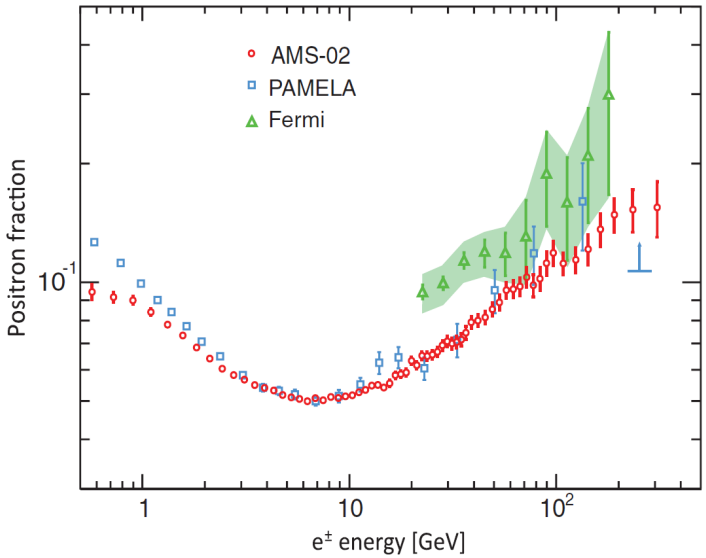
Why?

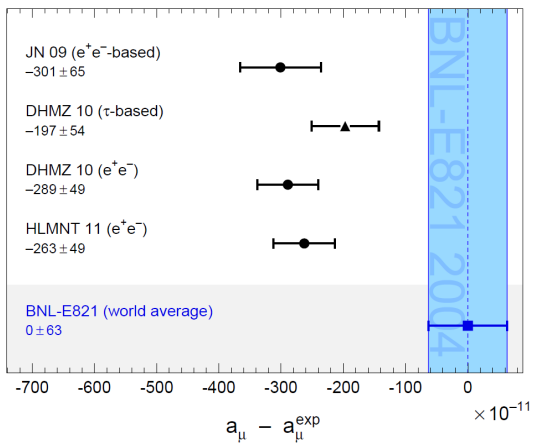
- unexpected rise in positron to electron ratio
- self interacting dark matter
- muon anomalous magnetic moment
- . . .



ESO/R. Massey

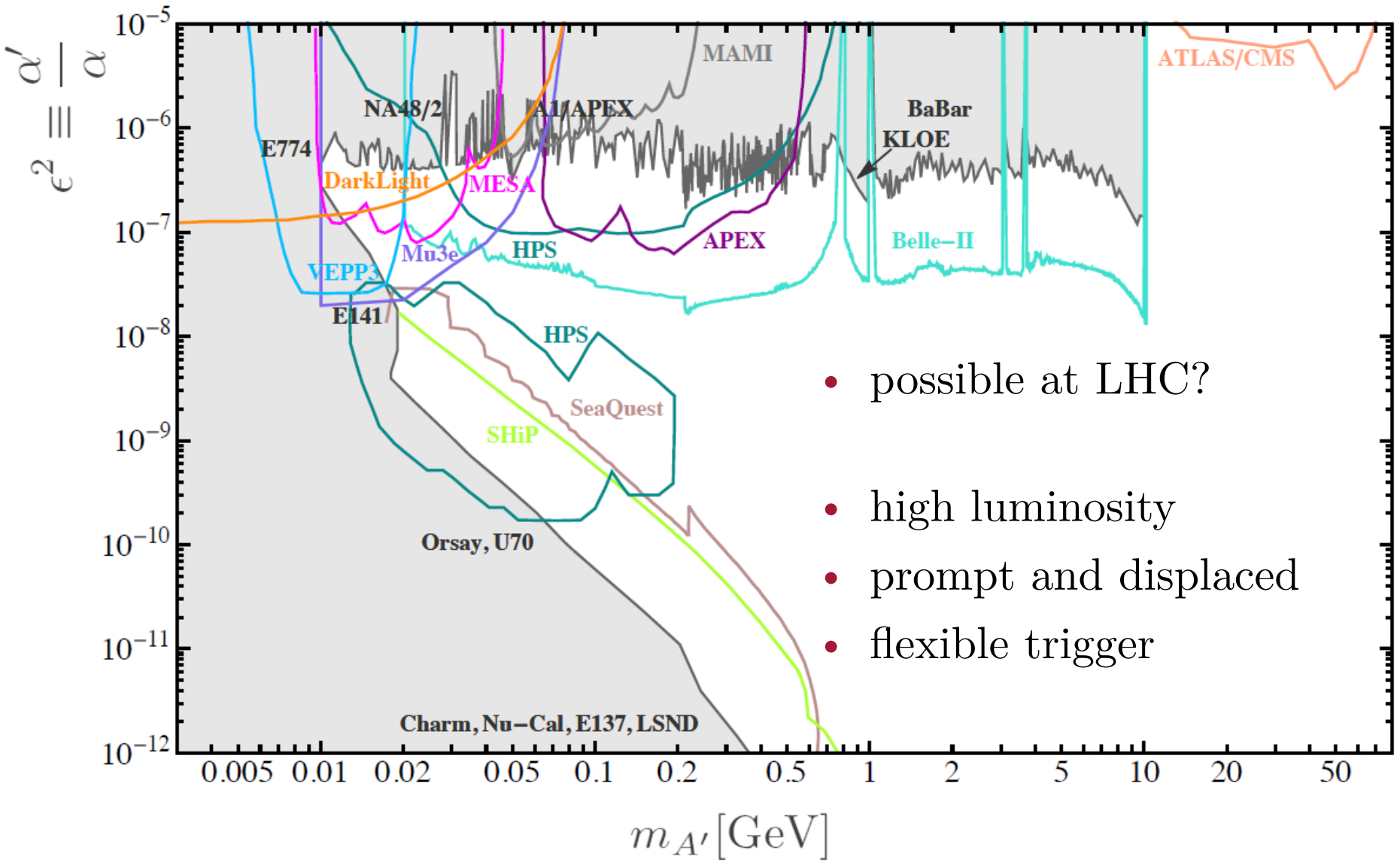
Phys. Rev. Lett. **110** (2013) 141102





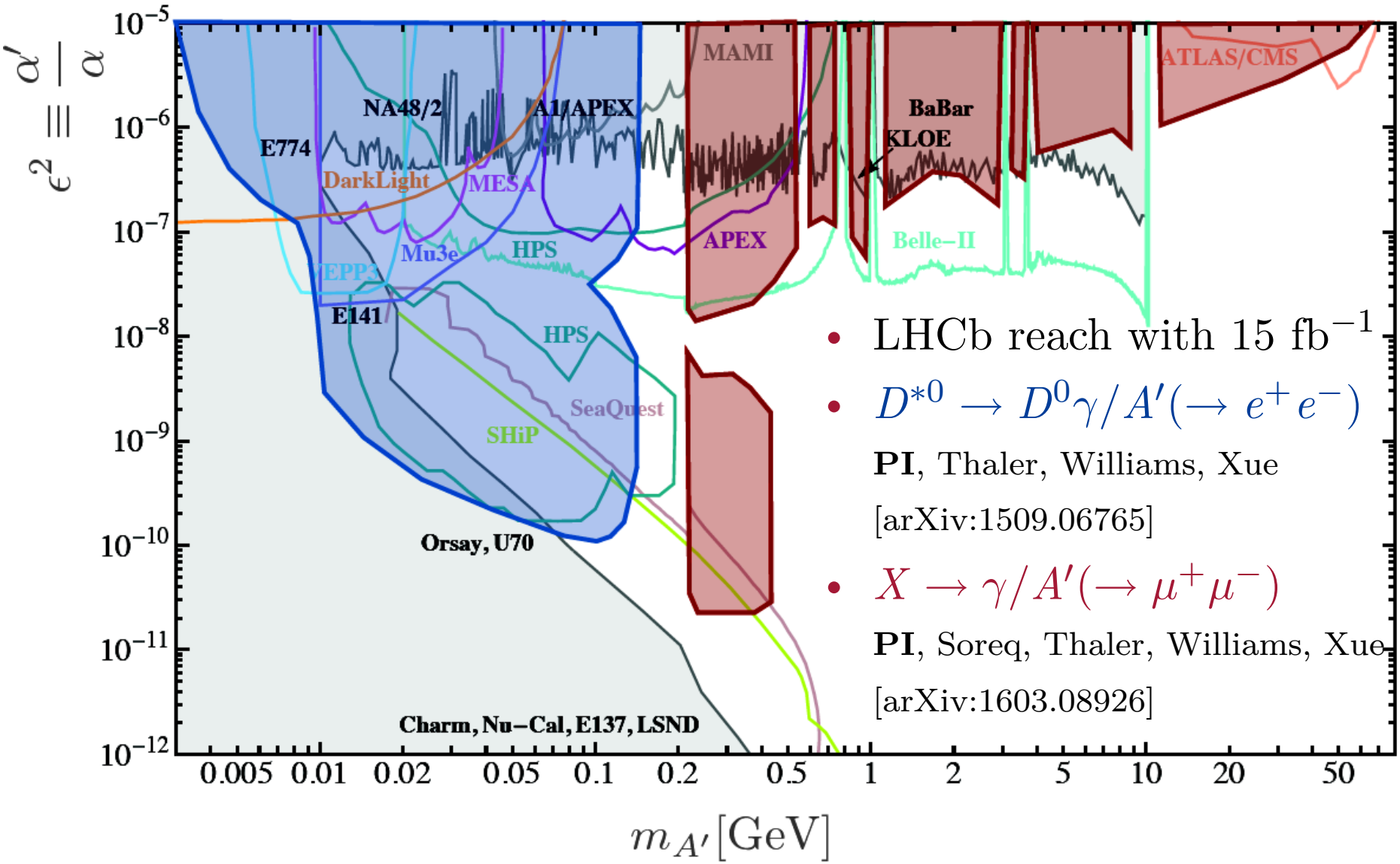
Phys. Rev. D **86** (2012) 010001

Search Strategies

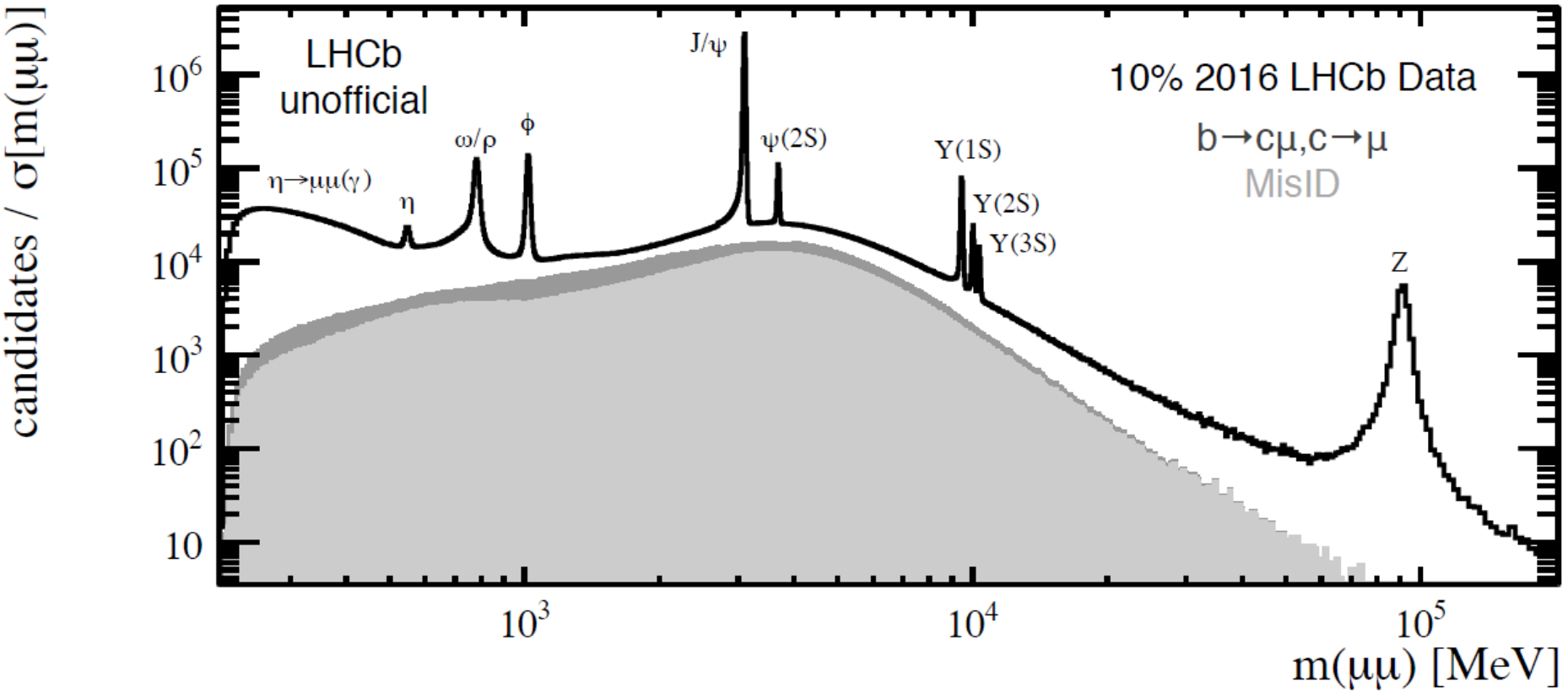


- possible at LHC?
- high luminosity
- prompt and displaced
- flexible trigger

LHCb Searches



Sneak Peek



- just the beginning, exciting times ahead!