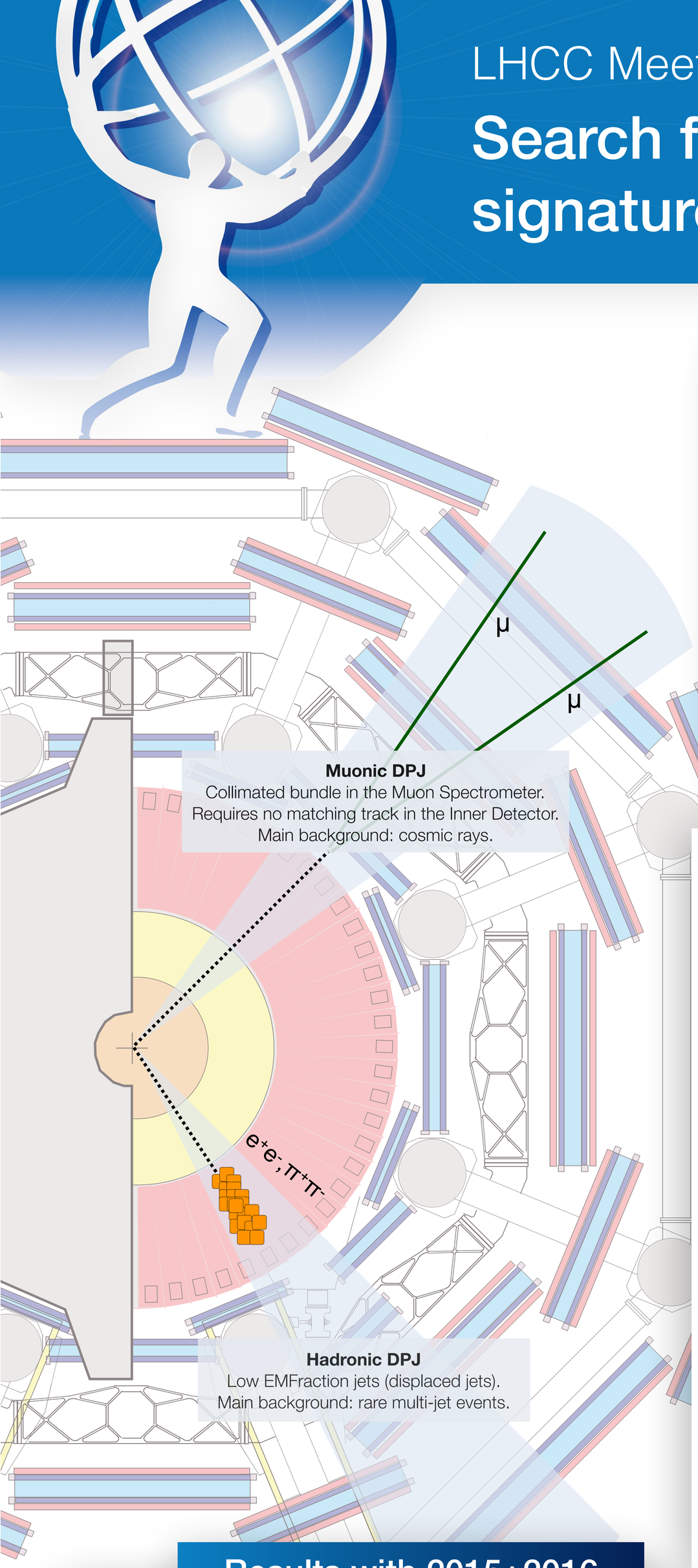
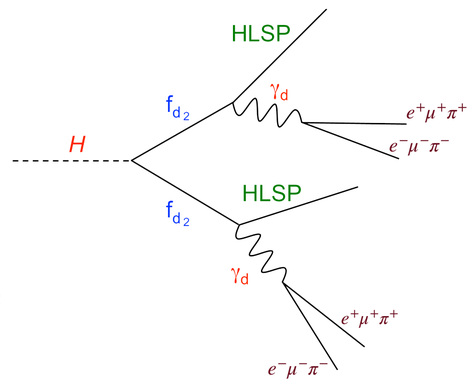
LHCC Meeting - CERN, 19/20 February 2020

Search for Long-Lived Dark Photon signatures with the ATLAS detector at LHC



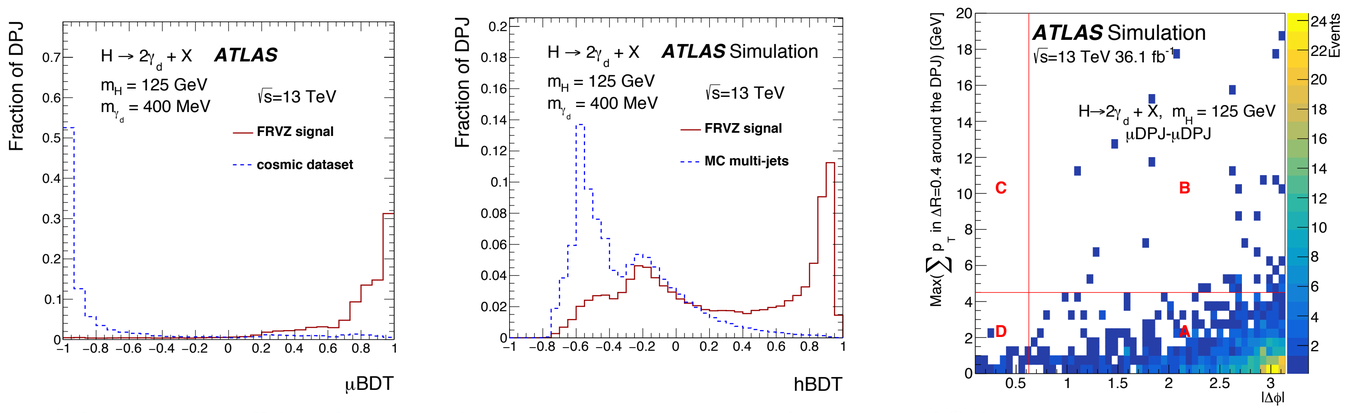
A Dark Sector of new particles…

- **Dark Sectors** are predicted as possible Standard Model extensions
- Minimal approach: $U_D(1)$ gauge field (**Dark Photon,** γ_d) [1] coupled to the SM photon via kinetic mixing (ϵ)
- Low ϵ → long dark photon lifetime
- Low γ_d mass → highly collimated decay products
- The experimental signature is a pair of back to back **Displaced Dark Photon Jets (DPJs)** [2]
- This search aims to find this particular signature, looking for long-lived light Dark Photons (γ_d) with the ATLAS detector [3]



… and how to find them

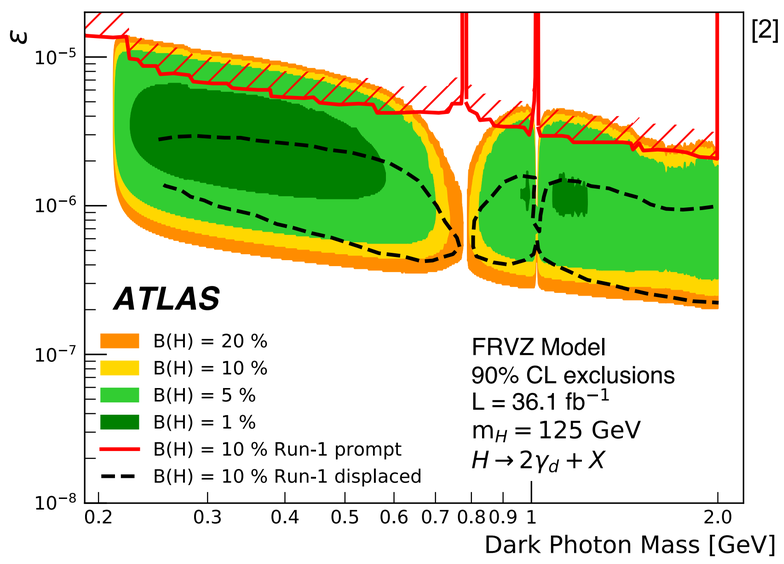
- **Dedicated triggers** are used to perform a preliminary event selection, searching for collimated muons and narrow jets with low electromagnetic (EM) fraction, both with no associated track in the ID
- **Muonic DPJs** are discriminated from the cosmic muon background exploiting RPC timing and muon track parameters (η,ϕ,z_0)
- **Hadronic DPJs** can be discriminated from the QCD multi-jet background exploiting EMFraction, jet width, Jet Vertex Tagger output, jet timing, charge and mass
- **2 back-to-back DPJs** are requested for each event
- **BDT cuts on each DPJ:** for each DPJ type a dedicated BDT is used, with variables mentioned above as input



- **"Data-driven" background estimation,** made using the **ABCD** method. Discriminating variables: isolation in the ID (Σp_T) and angular separation between the two DPJs. Only highly isolated back to back DPJs are expected in the signal region (A)

Results with 2015+2016 dataset

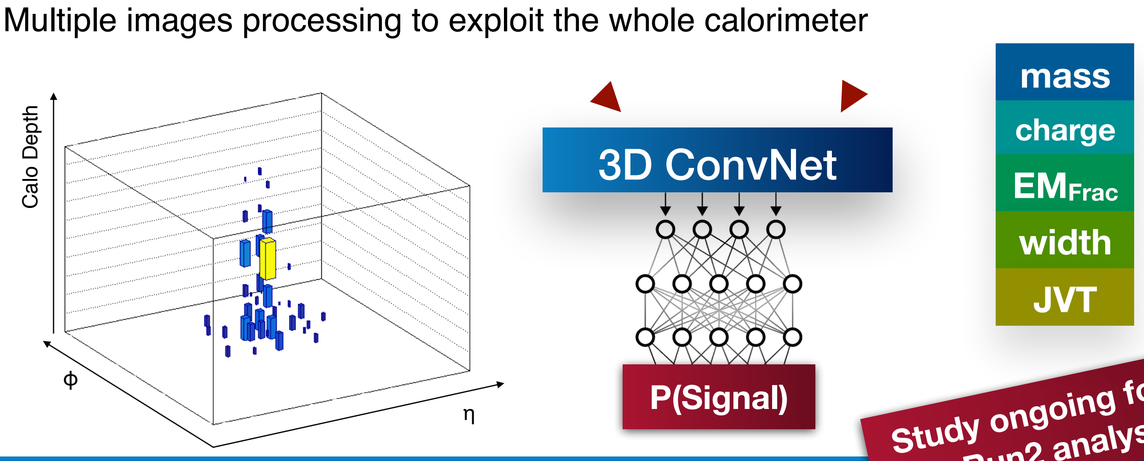
- **No excess** found in data, different exclusion regions are set, following various assumptions on Higgs decay branching ratio to a pair of Dark Photons



- Analysis sensitivity dominated by **muonic channel**, improvements are under study

(Deep) Learn from raw data

- Jet calorimetric energy deposits as images (**Jet Images**), alongside with jet **high-level variables** can provide new features for a better event selection
- Images are processed with a **Convolutional Neural Network**, exploiting Jet Images to improve selection for dark photon decays in the calorimeter
- Multiple images processing to exploit the whole calorimeter



Study ongoing for Full Run2 analysis

[1] A. Falkowski, J. T. Ruderman, T. Volansky and J. Zupan, *Hidden Higgs Decaying to Lepton Jets*, JHEP 05 (2010) 077, arXiv: 1002.2952 [hep-ph].
[2] ATLAS Collaboration, Search for light long-lived neutral particles produced in pp collisions at √s = 13 TeV that decay to collimated pairs of leptons or light hadrons with the ATLAS detector, (2019) arXiv:1909.01246
[3] ATLAS Collaboration, The ATLAS experiment at the Cern Large Hadron Collider. *Journal of Instrumentation* 3(08):S08003, 2008

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