FIPs in the ALPs
Roundtable

15 May 2023

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Past & current work
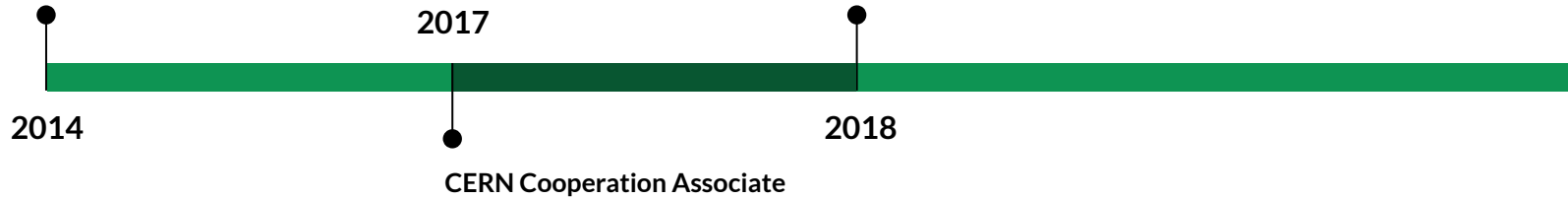
Overview

PhD in Physics in Padova (IT)

Search for heavy diboson resonances at CMS

PostDoc in Hamburg University (DE)

Searches for long-lived particles at CMS

2017

2014

2018

CERN Cooperation Associate

Data analyses

- Searches for long-lived particles (LLPs) at CMS:
  - Compelling and under-investigated BUT very challenging!
  - Non-standard reconstruction: low-level detector information
  - Non-standard backgrounds (non-collision)

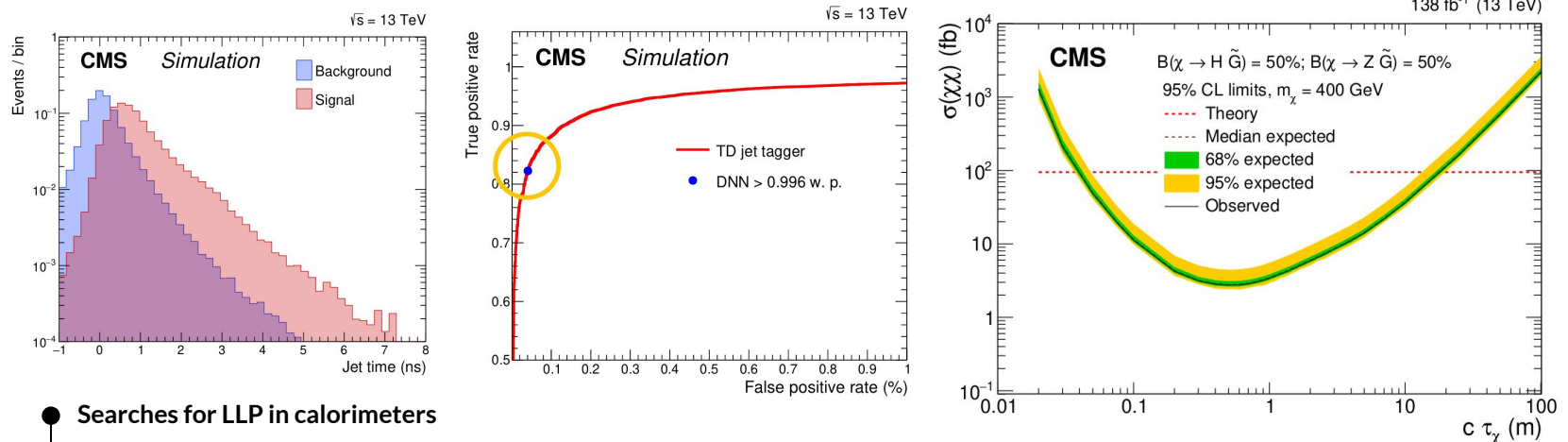**Searches for LLP in calorimeters**

2018

Data analyses (I)

- GMSB neutralino → cτ~1 m
- Decay in calorimeters: out-of-time and trackless jets
  - EM calorimeter hits and tracks as inputs → low level info → challenging data processing
  - Machine-learning jet tagger → combine time delay + track info
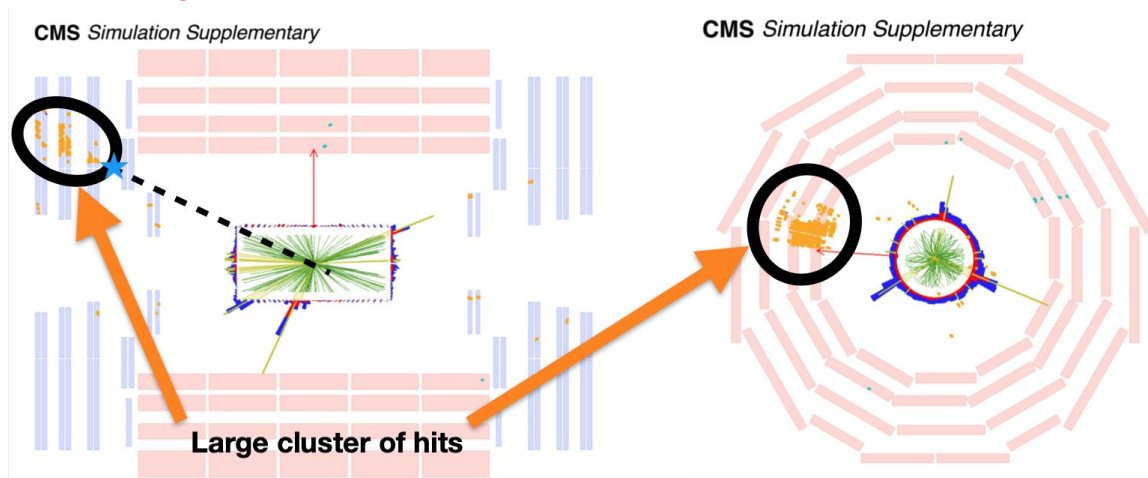 - Challenging backgrounds (cosmic muons, beam induced particles)

- Searches for LLP in calorimeters

2018
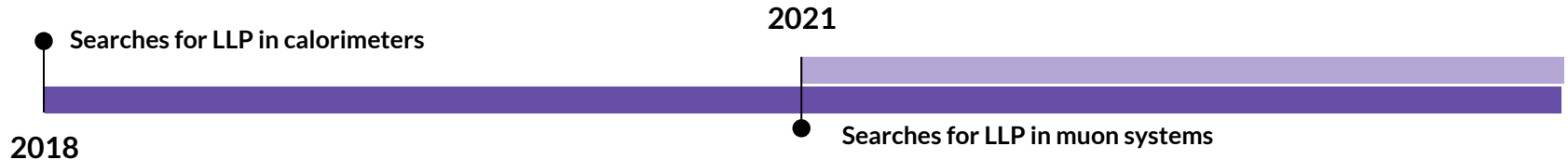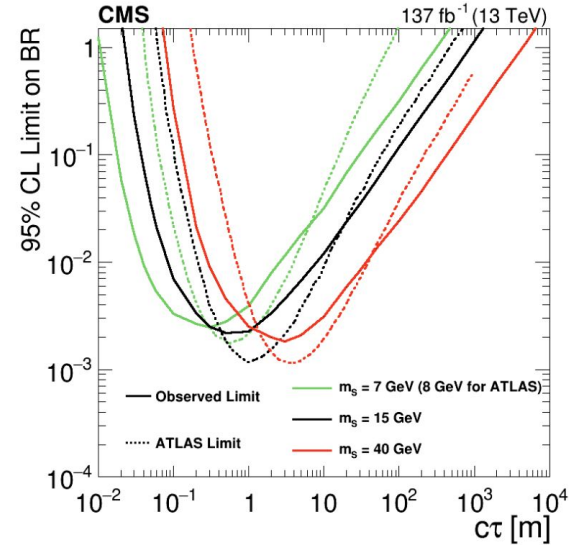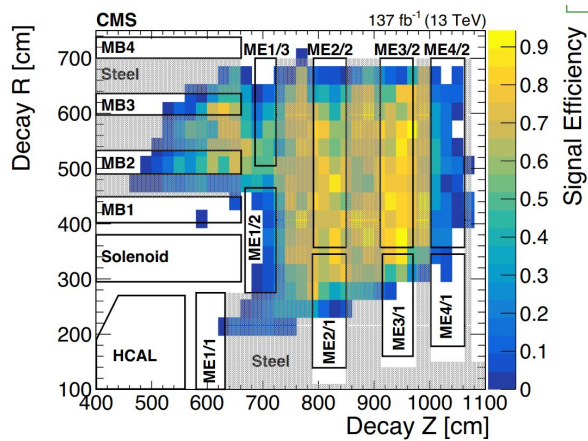
Data analyses (II)

- Muon system: CSC and DT as sampling calorimeters → showers of hits
- Clusters of hits → zero background
- Big improvement: introduced muon showers at trigger level!

2021

Searches for LLP in calorimeters

2018

Searches for LLP in muon systems

Data analyses (II)

- ○ Twin Higgs model: $H \rightarrow SS \rightarrow bbbb$ (hadrons)
- ○ We can also detect EM showers
  - ■ Sensitive to anything that is not a muon (with a muon detector!)
  - ■ Sensitive to low mass (<1 MeV) → can't be probed anywhere else in CMS

2021

● Searches for LLP in calorimeters

2018

● Searches for LLP in muon systems

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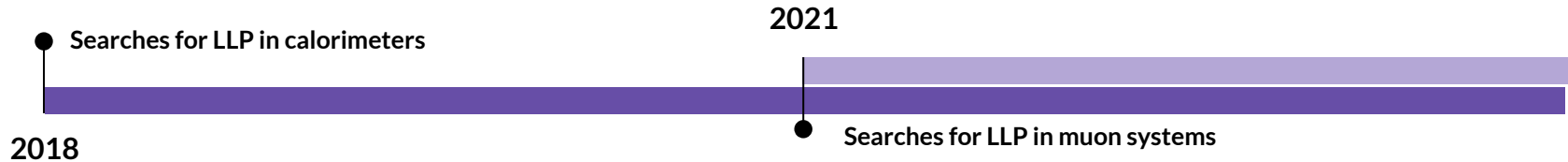
Future plans and interests

Building my own project

- Expertise in detecting hadronic decays of LLPs with cτ>0.5 m with masses down to <1 MeV

- New signatures in CMS?
  - Heavy neutral leptons
  - Twin Higgs
  - Vector-like leptons
  - ALPs and dark photons
  - Inelastic dark matter
  - Emerging jets?
  - Stopped particles (decaying when there is no beam in LHC)?

- Looking for connections with theory/phenomenology
  - What can I probe that is interesting for you?
  - Can put some machine-learning in that!

- Interest in experiments beyond CMS
  - LHC-based existing experiments
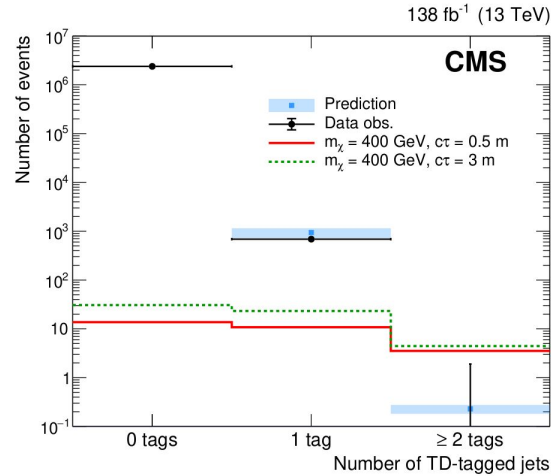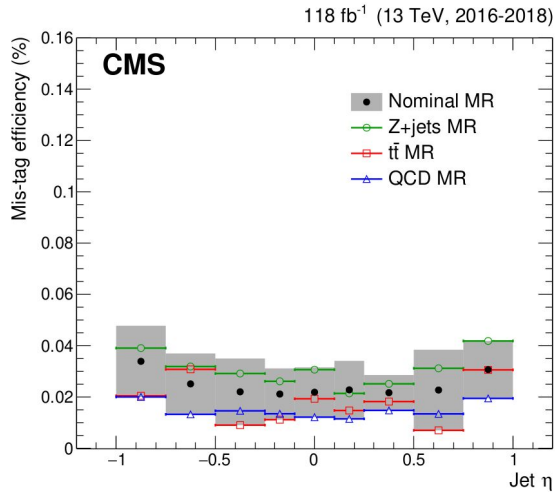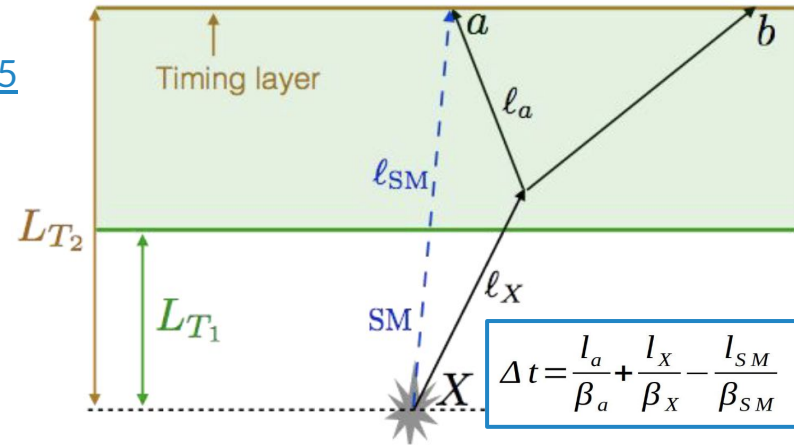 - Future experiments
  - Non-collider experiments

Backup

Delayed and Trackless Jets

Calorimeter-based searches: https://arxiv.org/abs/2212.06695

- sensitivity relies on **delay** from slow-moving LLPs and the path length increase due to the displaced decays
- increase sensitivity at lower masses combining ECAL delay with track information in a DNN jet tagger
- based on MET trigger
- jet time: energy weighted time of ECAL rec hits in barrel

$$\Delta t = \frac{l_a}{\beta_a} + \frac{l_X}{\beta_X} - \frac{l_{SM}}{\beta_{SM}}$$

118 fb^{-1} (13 TeV, 2016-2018)

CMS

Nominal MR
Z+jets MR
$t\bar{t}$ MR
QCD MR

138 fb^{-1} (13 TeV)

CMS

Prediction
Data obs.
m_χ = 400 GeV, cτ = 0.5 m
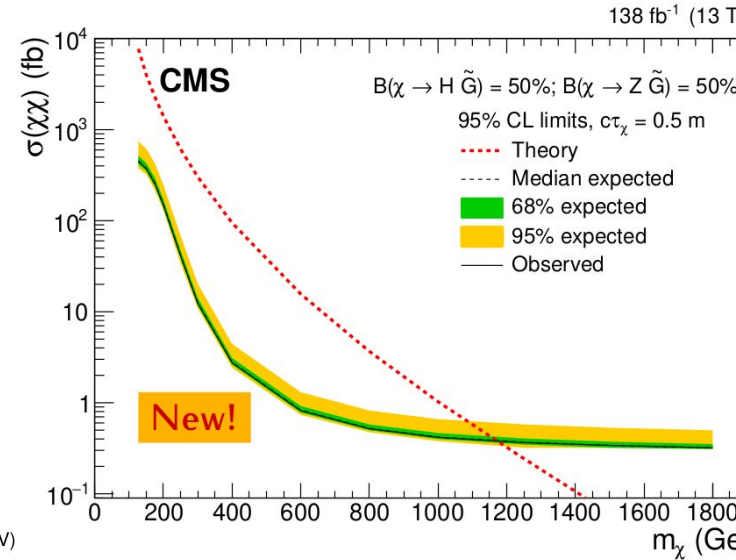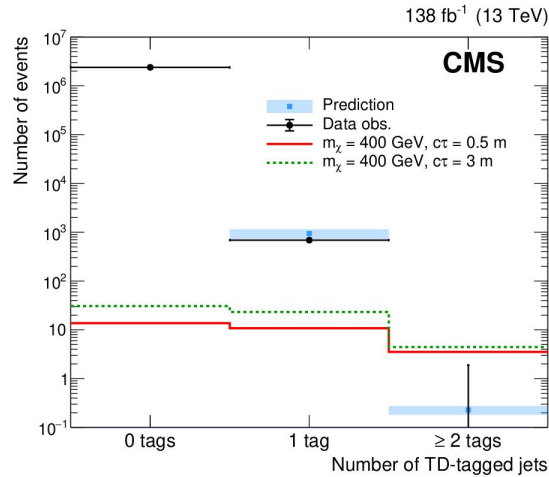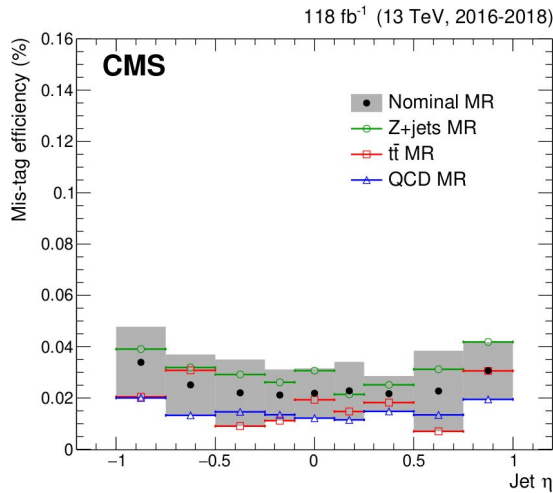m_χ = 400 GeV, cτ = 3 m

- SR: at least 2 tagged jets
- Zero background
- Mis-tag rate evaluated in CRs as a function of eta
- Jet composition differences propagated as uncertainty

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Delayed and Trackless Jets

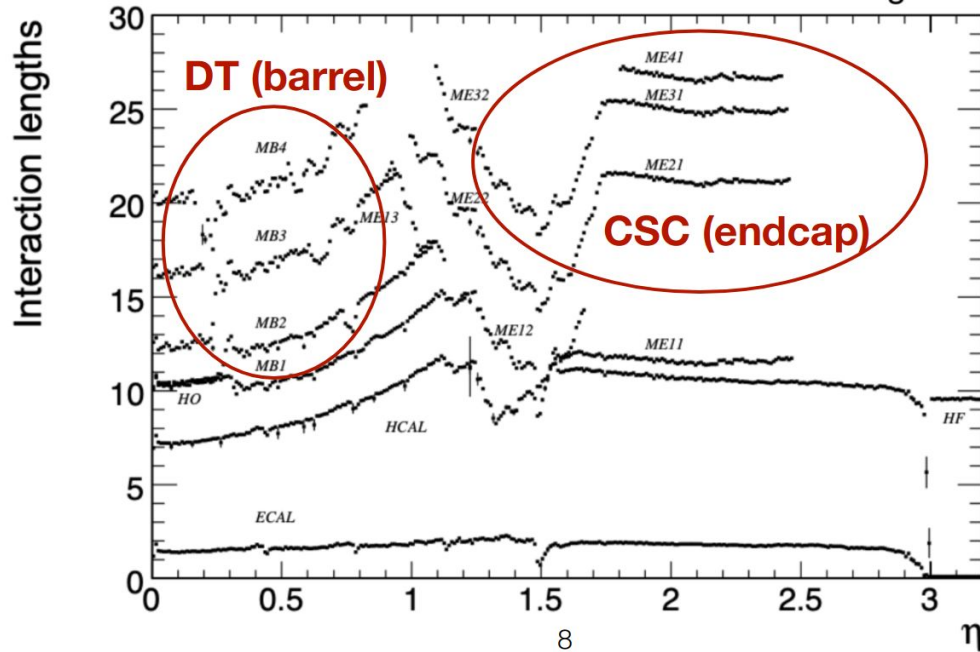Calorimeter-based searches: https://arxiv.org/abs/2212.06695

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New!

- SR: at least 2 tagged jets
- Zero background
- Mis-tag rate evaluated in CRs as a function of eta
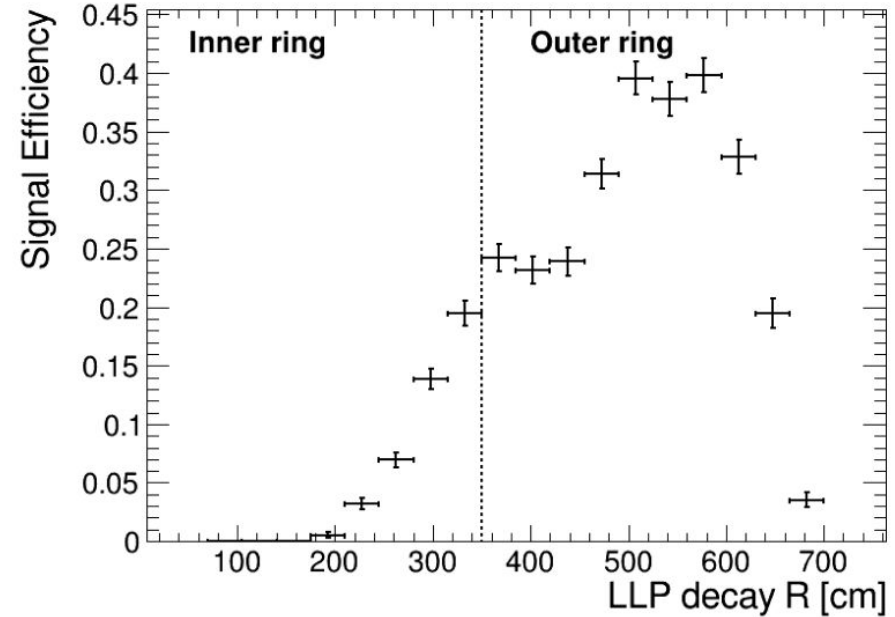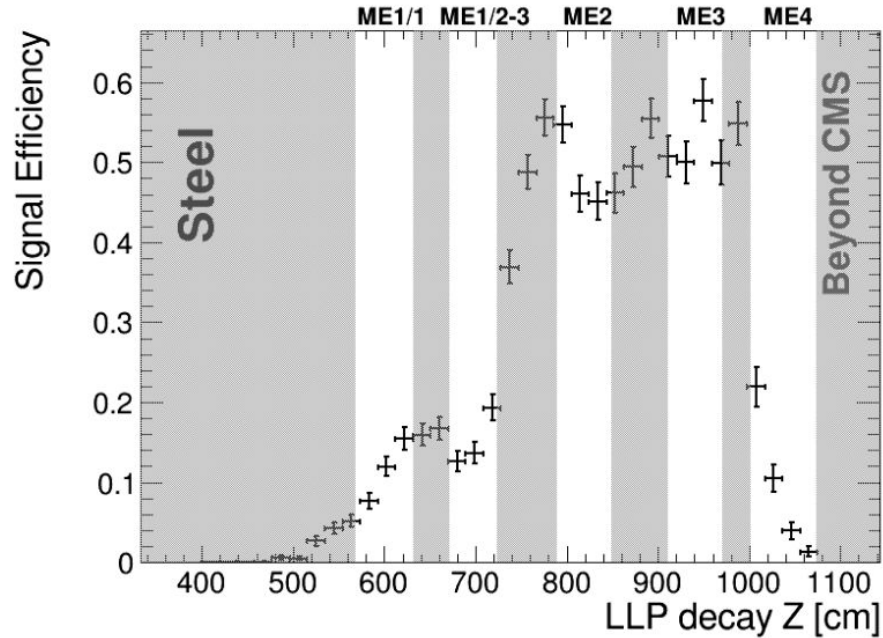- Jet composition differences propagated as uncertainty

Muon system material map

CMS TDR: LHCC-2006-001 Fig 1.4

CSC analysis

CSC analysis

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