

Dark showers snowmass LOI (update)

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On behalf of darkshowers snowmass group
(Snowmass restart workshop)

What are dark showers?



arXiv:1907.04346

- Realisation of dark $SU(N)$ gauge theories at colliders
- UV physics contains dark quarks, dark gluons; below confinement scale leads to dark bound states (dark pions, rho mesons)
- Specific focus when confinement scale and dark quark masses are small compared to collider center-of-mass energy \rightarrow production of dark quarks via hard process and subsequent hadronization in dark and visible sector \rightarrow dubbed dark showers
- Collider signatures varied, depend on details of mediator mechanism and dark sector setup
- Fast developing situation with a number of collider searches underway or public

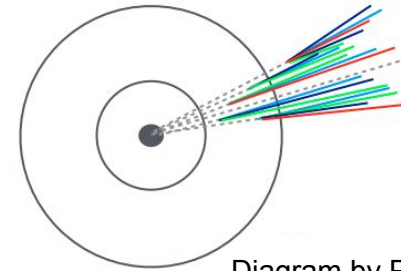
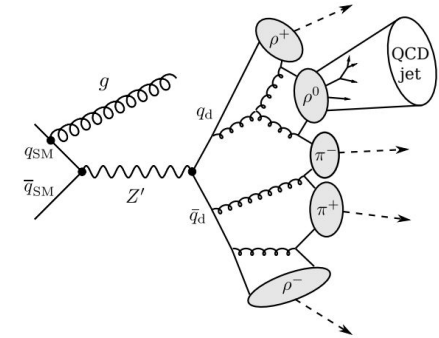
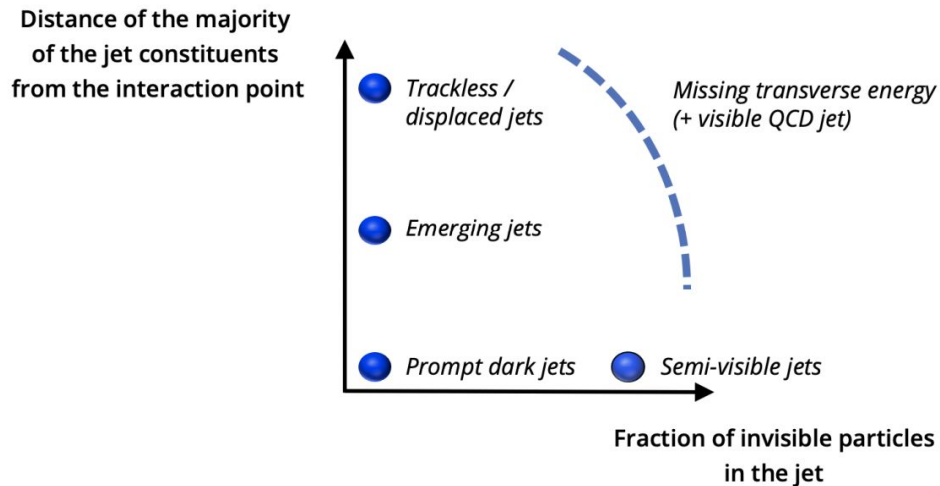


Diagram by P. Schwaller

Signature parameter space



Aims of the LOI



- With our LOI, we aim to contribute a whitepaper to the Snowmass process
 - Content:
 - Phenomenological studies of currently-used LHC jetty benchmarks
 - Baseline: Prompt dark jets, semi-visible jets, emerging jets
 - Time/interest dependent: SUEP, trackless jets
 - Mostly towards answering the following questions: how model-dependent are our searches and how can we improve? How can we catch more models with reasonable sensitivity, at future colliders/HL-LHC?
 - Connect to Theory Frontier review if available, LLP whitepaper
- Practical details:
 - Group mailing list: dark-showers-snowmass21@cern.ch
 - Group meeting Indico entry: <https://indico.cern.ch/category/12893/>
 - Gitlab repository (being populated): <https://github.com/dark-showers-snowmass21>
 - Link to LOI: [here](#)

Work organisation



- Anyone is encouraged to write their own whitepaper with their studies, which we will summarize & cite in the common one from this group
 - Presentations of intermediate work is welcome!
 - Sharing models / code / tools is also part of what we'd like to do - let us know how (we have a git repository for models, more resources to share / run code routines may become available soon)
- In addition to that, we are organizing the common work to plot and understand kinematic distributions of the LHC models
 - A python module to analyse several kinematic distributions is being setup
 - Setup will be shared via github
 - More contributors welcome!

Steps so far



- Regular meetings since since October 2020
- Work done so far:
 - literature survey
 - connections to broader community
 - identifying interesting scenarios and strategies
- Well attended by both theory and experimental community

The screenshot shows the Indico website interface for the project 'DarkShowers-Snowmass2021'. The top navigation bar includes the Indico logo, location (Europe/Zurich), language (English (United Kingdom)), and a Login button. Below the navigation bar, there are links for Home, Create event, and Room booking. The main content area shows the project title 'DarkShowers-Snowmass2021' and a search bar. A calendar view for June 2021 is displayed, showing one event on 17 Jun titled 'Dark showers snowmass project meeting'. A sidebar on the right shows the 'Managers' section with one user listed: 'dark-showers-snowmass21-admin'.

Organisation of darkshower simulation tutorial



- In collaboration with the LLP WG workshop
- Introduction to pythia Hidden Valley module, SUEP simulation tool
- Hands-on exercise in simulating dark showers semi-visible jet and SUEP signal
- Common discussion with theorists about possible limitation of simulation tools
- Docker container/pythia codes/python codes publicly available
- Well attended by over 60 participants
- Link to tutorial material + discussion google doc + recording: [here](#)

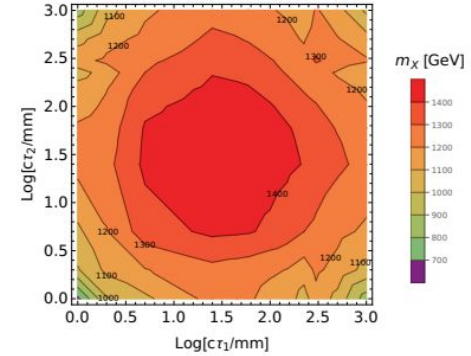
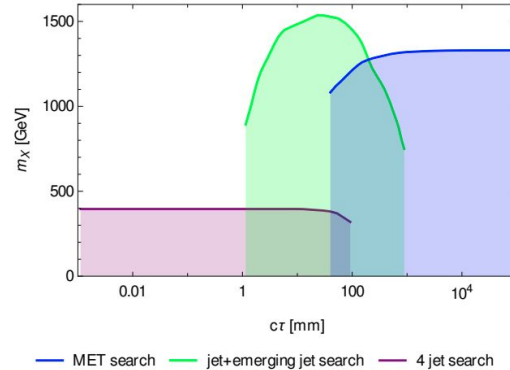
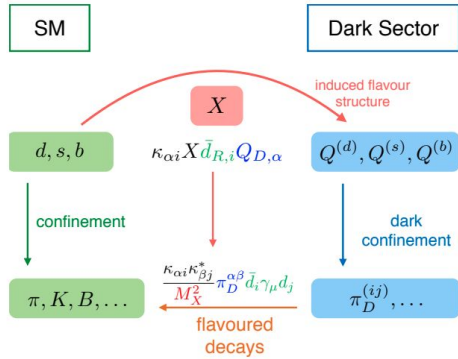
The screenshot shows a Zoom meeting agenda for the 'Dark showers simulation tools session: Tutorial'. The agenda is organized into time slots:

- 14:48 → 15:00**: Coffee (12m)
- 15:00 → 17:00**: **Dark showers simulation tools session: Tutorial**
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 - Conveners: Marie-Helene Genest (LPSC-Grenoble, CNRS/UGA (FR)), Nishita Desai (Tata Institute of Fundamental Research), Suchita Kulkarni (University of Graz)
 - Links: DarkShowers_Setup..., Google doc with su..., Recording
 - 15:00**: **Simulating semi-visible jets via pythia HV module**
 - Speakers: Daniel Stolarski (Carleton University (CA)), Simon Knapen (CERN), Suchita Kulkarni (University of Graz)
 - Links: DS_clean.zip, Kulkarni_DS_tutorial...
 - 16:00**: **Simulating SUEP signatures**
 - Speaker: Karri Folan Di Petrillo (Fermi National Accelerator Lab. (US))
 - Links: 2020.05.26.kdp.SUE..., dropboxsuepHepMC, githubsuep_genera..., githubsuepTutorial
- 17:00 → 17:15**: Coffee (15m)
- 17:15 → 18:00**: **Dark showers simulation tools session: Discussion**
 - Conveners: Marie-Helene Genest (LPSC-Grenoble, CNRS/UGA (FR)), Nishita Desai (Tata Institute of Fundamental Research), Suchita Kulkarni (University of Graz)
 - Links: DarkShowers_Setup..., Google doc with su..., Recording
 - 17:15**: **Discussion on limitations of Pythia HV module**
 - Participants: Marat Freytsis, Torbjörn Sjöstrand, Simon Knapen, Karri Folan Di Petrillo, Matt Strassler
 - Speakers: Marat Freytsis (Rutgers University), Marat Freytsis (Harvard University)
 - Link: LLPWorkshop0521...
- 18:00 → 18:15**: Coffee (15m)

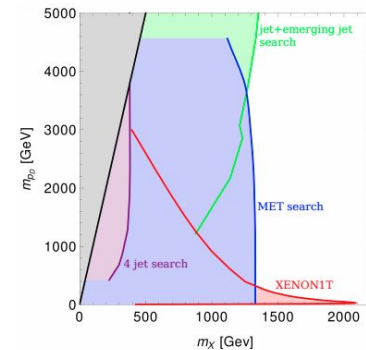
Example presentation



- Interplay of collider and non-collider constraints for t-channel flavoured dark sector models



(a) 2 dark flavours



(a) $\kappa_0 = 0.1$

arXiv:1803.08080

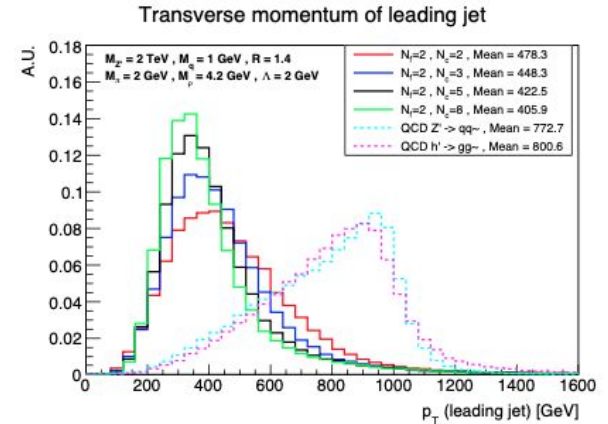
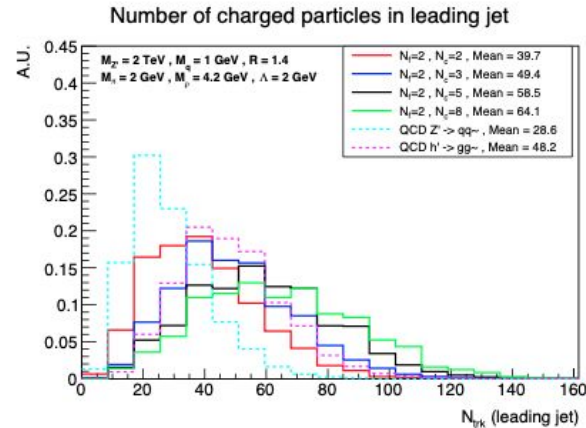
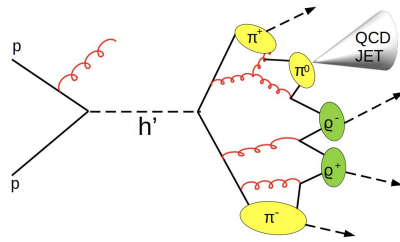
- Includes effect of dark pions/rho lifetime
- Recasting of emerging jets search
- Ways to simulate non-standard signal with Pythia8
- Complementarity with non-collider experiments

Example of an ongoing project

G. Albouy, M.H. Genest, S. Kulkarni,
H. Nair, A. Singh



- Central question: How do dark sector parameters such as number of flavours, colors and mediator mechanisms affect collider observables?
- Scenario: $SU(N_D)$ theories with mass degenerate vector quarks, scalar and vector s-channel mediator to the Standard Model
- Varied number of colors N_D , flavours N_f , dark quark mass, confinement scale, α_D , etc



- Results presented at [EPS-HEP conference](#)

Other presentations



Finding dark showers at the LHC	Elias Bernreuther
Dark showers and LLP community	James Beacham
Overview of the dark gluon LOI	Chih-Ting Liu
Semi-visible jets studies: pythia setup and workflow discussion	Deepak Kar
Emerging jets - CMS benchmark model	Yi-Mu Chen
Event-level observables for semivisible jet production with additional objects	Hugues Beauchesne
SUEP	Karri Folan Di Petrillo
Perturbative benchmark models for a dark shower search program	Simon Knapen
Triggering on emerging jets	Dylan Linthorne
Search for strongly interacting massive particles generating trackless jets in proton-proton collisions at $\sqrt{s}=13$ TeV	Steven Lowette

Restart plans



- A common meeting between theorists and experimentalists to discuss semi-visible jet scenarios is being organised
 - Survey different benchmarks used by experimental collaborations
 - Kick-start common discussions in collaboration with the LLP WG
- Meeting foreseen at the end of September (details to be announced)
- Got in touch with all groups who submitted plans for LOI contributions
 - Some works ongoing and expected to be completed soon
 - Contributors with common interests are being put in touch with each other for smooth collaborative effort going forward

We welcome anyone interested to join us



- Practical details:
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