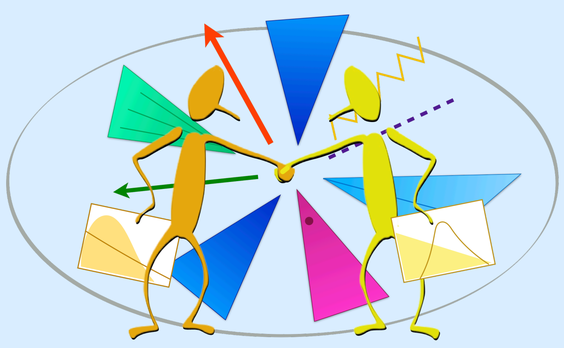

The **A**nalysis **D**escription **L**anguage ecosystem: Latest developments and physics applications

Sezen Sekmen[1], Gökhan Ünel[2], Harrison B. Prosper[3], Grigory Fedyukovich[3], Danıel Riley[3], Burak Şen[4], Wolfgang Waltenberger[5], Junghyun Lee[1], Aytül Adıgüzel[6], Erkcan Özcan[7], Ahmetcan Sansar[6], Demircan Demirbağ[7], Kağan Şahan[6], Feyza Başpehlivan[8], *et. al.*

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Language

The language

Analysis Description Language (ADL) is a declarative, domain specific language (DSL) that describes the **physics logic** of a HEP analysis in a standard and unambiguous way.

- External DSL: Custom syntax for physics analysis concepts.
- Declarative: Tells what to do but not how to do it.
- Easy to read & communicate: Clear, self-describing syntax
- For everyone: experimentalists, phenomenologists, students, interested public…

ADL consists of

- a plain text ADL file describing the analysis physics logic.
- a library of self-contained functions encapsulating variables that are non-trivial to express with the ADL syntax (e.g. aplanarity, M_{T2}, machine learning models, …).

ADL example for a simple new physics analysis

```
# OBJECTS
object selMuons
  take muon
  select pT(muon) > 20
  select abs(eta(muon)) < 2.4

object selEles
  take ele
  select pT(ele) > 20
  select abs(eta(ele)) < 2.5

object selLeps
  take union(selEles, selMuons)

object selJets
  take jet
  select pT(jet) > 30
  select abs(eta(jet)) < 2.4
  reject dR(jet, selLeps) < 0.4

# EVENT VARIABLES
define HT = sum(pT(selJets))
define MTl = Sqrt( 2*pT(selLeps[0]) *
MET*(1-cos(phi(METLV[0]) -
phi(selLeps[0]) )))

# EVENT SELECTION
region baseline
  select size(selJets) >= 2
  select HT > 200
  select MET / HT <= 1

region signalregion
  baseline
  select Size(selLeps) == 0
  select dphi(METLV[0], jets[0]) > 0.5

region controlregion
  baseline
  select size(selLeps) == 1
  select MTl < 120
```

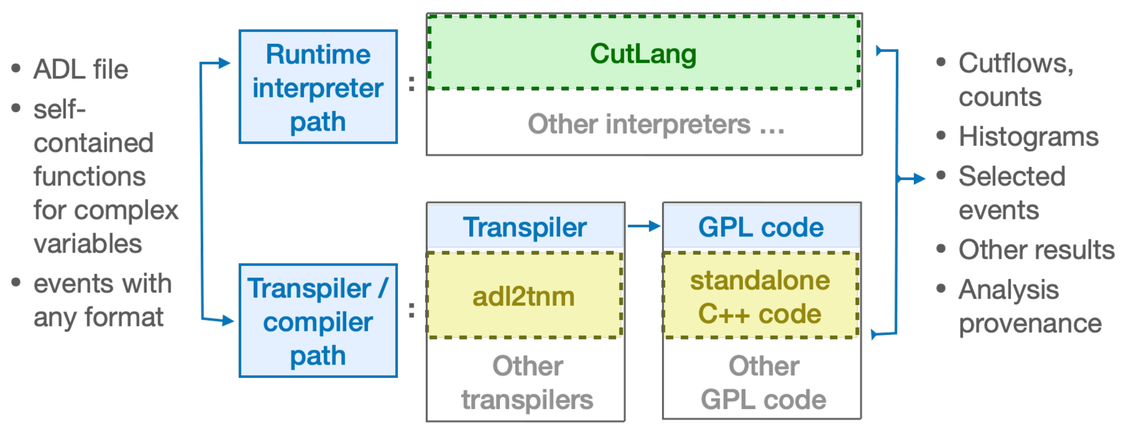
Interpreting

Making ADL executable

ADL is framework-independent. Decouples physics information from software / framework details.

- Multi-purpose use: Can be translated / integrated into any general purpose language or framework for various tasks.
- Portability & preservation of physics content.

Experimental / phenomenology analysis model with ADL



CutLang

Code: https://github.com/unelg/CutLang

- C++ runtime interpreter for ADL. Based on ROOT.
- Formal grammar parsing by Lex & Yacc.
- Reads TTree-like formats: NanoAOD, Delphes, Open Data, …
- Many external functions, including kinematic variables. ML model interface via ONNX.
- Runs in linux, macOS. Available in Docker, Conda. Jupyter kernel exists (binder or conda).
- Outputs cutflows, histograms, events, analysis description, i.e. provenance.

Latest developments

- Semiautomated interface with physics data types.
- Decoupled grammar implementation from input data types and external functions.
- Automatic generation of abstract syntax tree (AST).
- adl2flowchart: Tool to visualize ADL analyses as graphs / flowcharts.

Code: https://github.com/danielmriley/adl2flowchart

Physics applications

Multipurpose use

Distinguishing strength of ADL: Navigating and exploring the multi-analysis landscape.

Analysis with ADL

- Design
- Perform
- Visualize
- Preserve
- Reinterpret
- Query
- Compare
- Combine
- Educate

Many LHC analyses implemented in ADL.

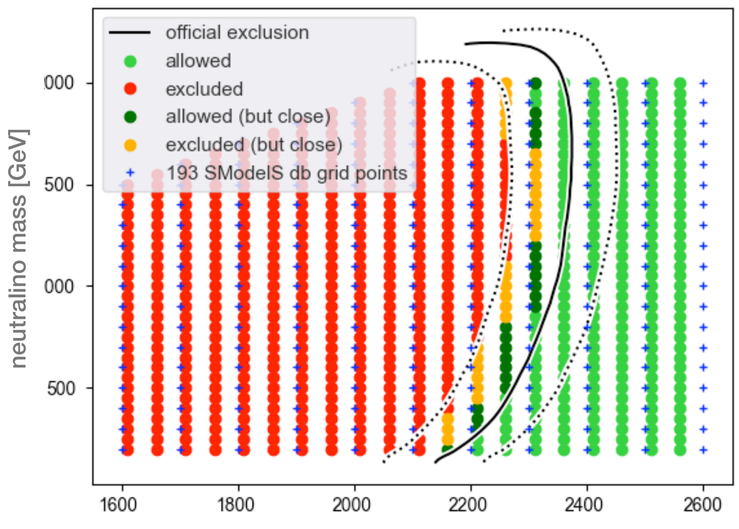
ADL analysis databases are the starting point of diverse applications.

ADL analysis repository: https://github.com/ADL4HEP

Reproduction of CMS SUSY search with photon + jets + E_T^{miss} using ADL/ CutLang: Limits agree with CMS.

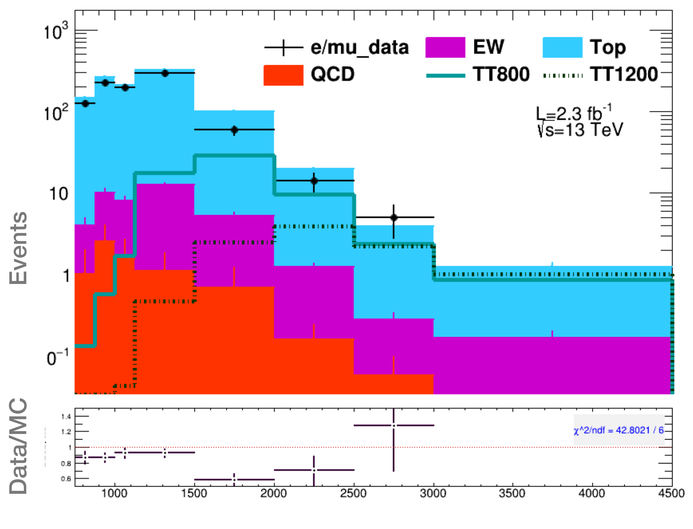
$pp \to \tilde{g}\,\tilde{g},\ \tilde{g} \to q\,\bar{q}\,\tilde{\chi}_1^0,\ B(\tilde{\chi}_1^0 \to \gamma\,\tilde{G}) = B(\tilde{\chi}_1^0 \to H\,\tilde{G}) = 50\%$

CMS-SUS-21-009



CMS Run 1 vector-like quark search with boosted W and Higgs bosons with ADL/CutLang on CMS Open Data:

CMS-B2G-16-024



[1] H. B. Prosper, S. Sekmen, G. Unel, "Analysis Description Language: A DSL for HEP Analysis", contribution to Snowmass 2021, arXiv:2203.09886.

[2] S. Sekmen and G. Unel, “CutLang: A Particle Physics Analysis Description Language and Runtime Interpreter,” Comput. Phys. Commun. 233 (2018), 215-236, arXiv:1801.05727.

[3] G. Unel, S. Sekmen, et. al., ”CutLang V2: towards a unified Analysis Description Language", Frontiers in Science, Big Data, 2021, doi:10.3389/fdata.2021.659986, arXiv:2101.09031

cern.ch/adl