Search for non-prompt LeptonJets

COLLIDER CROSS-TALK

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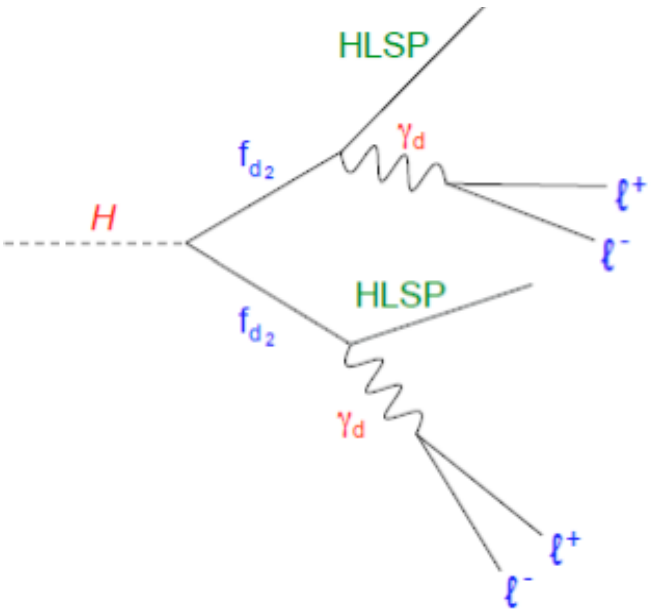
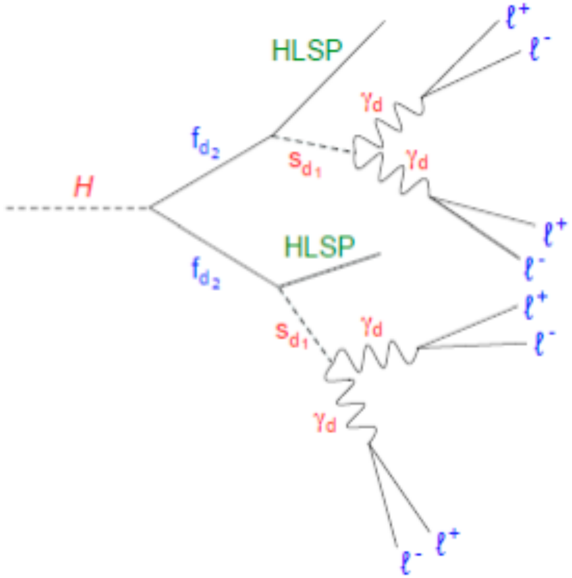
Antonio Policicchio (INFN LNF/CS)

Final Products

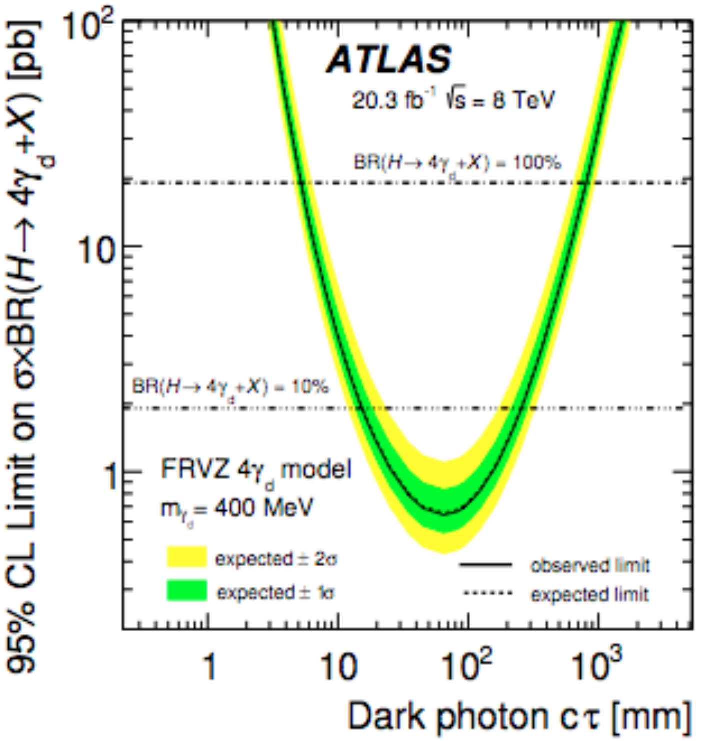
- Specific model for limit-setting, even though the rest of the analysis is model-independent
  - Used two FRVZ models (kinetic mixing portal) as benchmarks with Higgs production via gg fusion

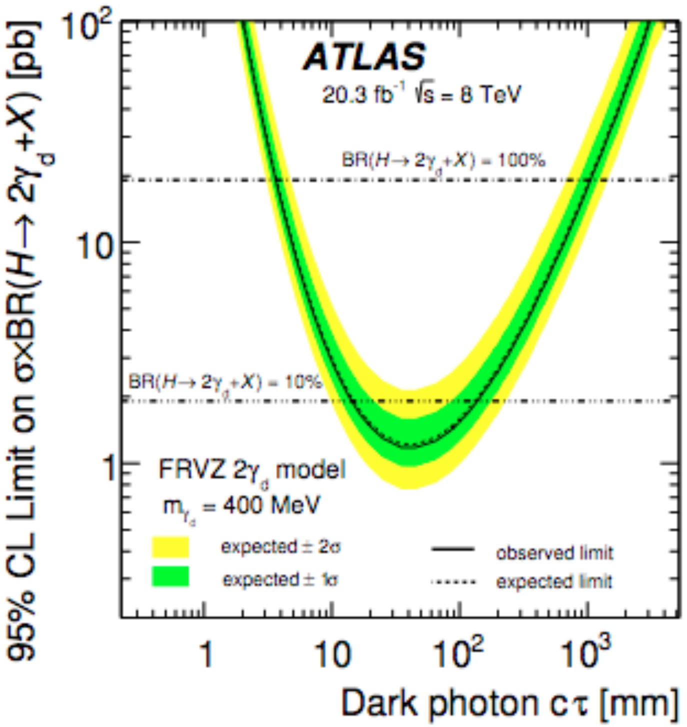




Final Products

- Exclusion limits on Higgs [σ x branching fraction to LJs] in benchmark models, as function of γ_d lifetime

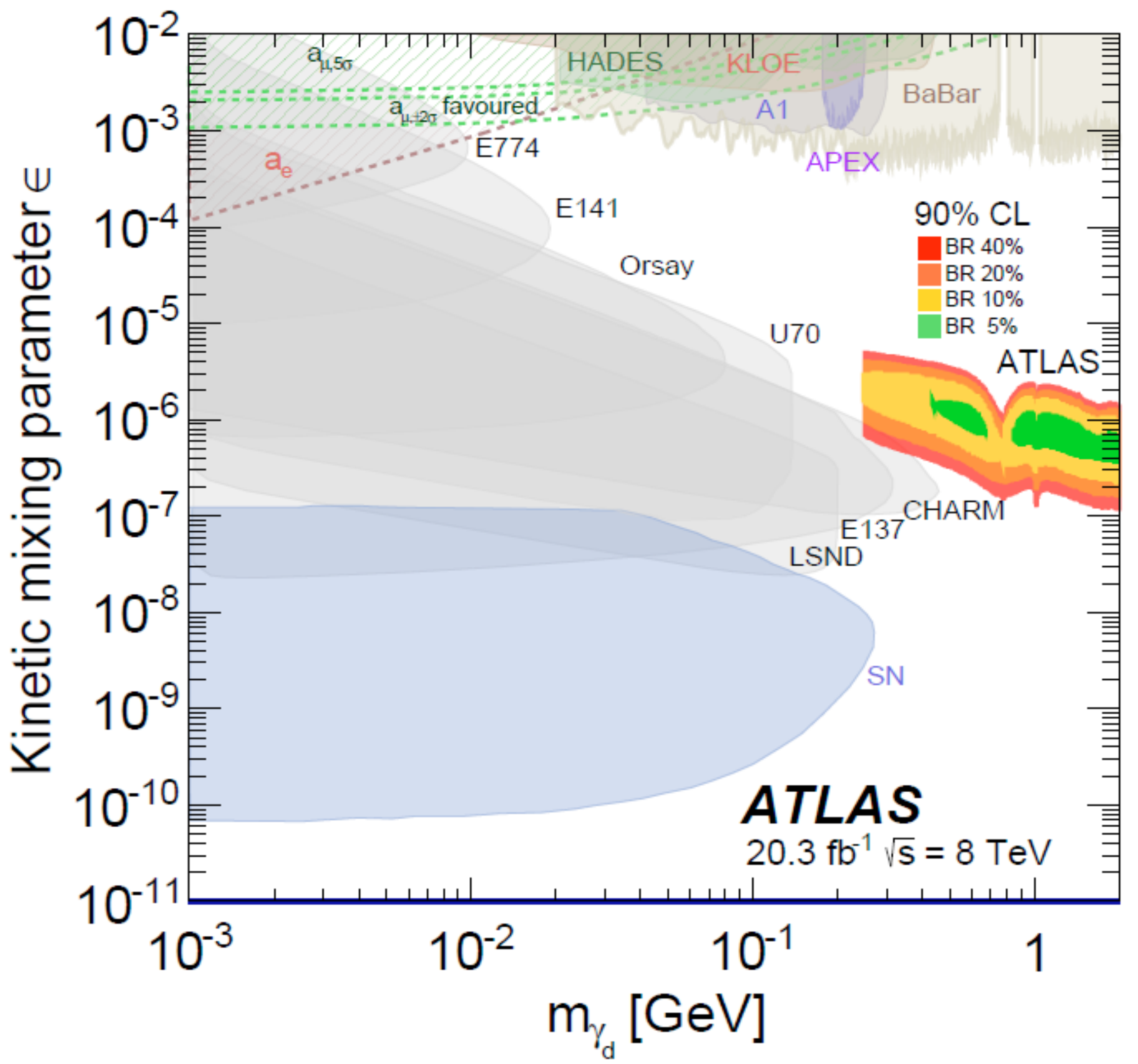




FRVZ model	Excluded $c\tau$ [mm] BR(10%)
$H \to 2\gamma_d + X$	$14 \leq c\tau \leq 140$
$H \to 4\gamma_d + X$	$15 \leq c\tau \leq 260$

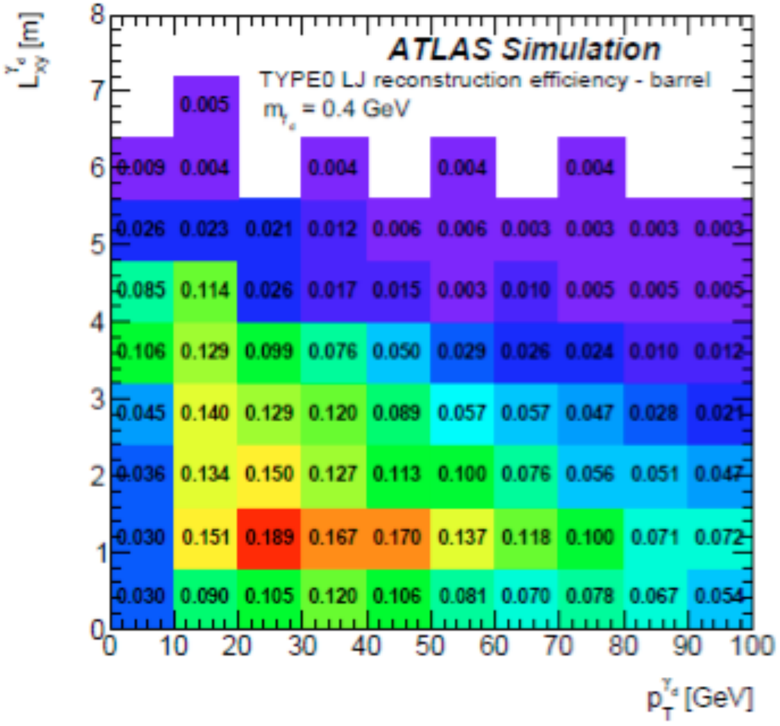
Final Products

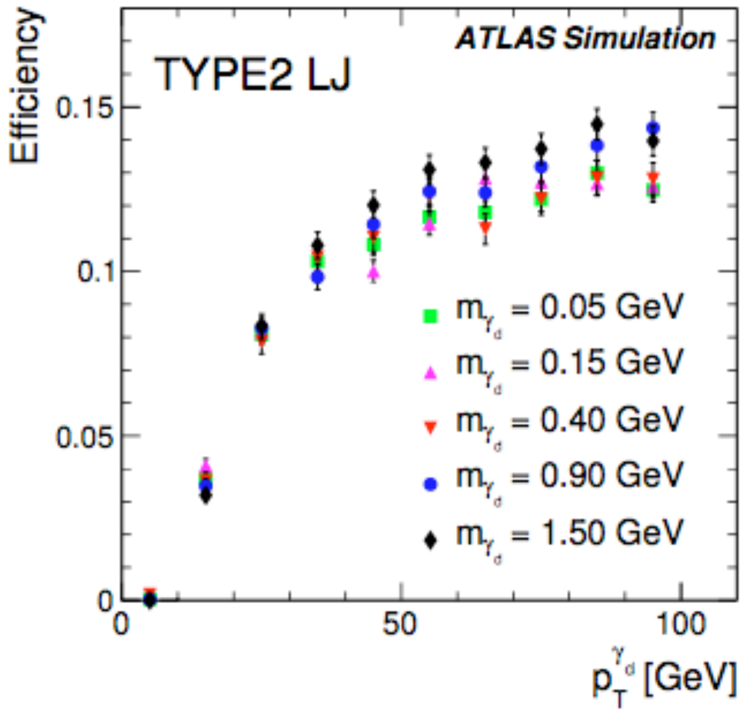
- Interpretation os ATLAS results as exclusion contours in [γ_d mass, ε] plane

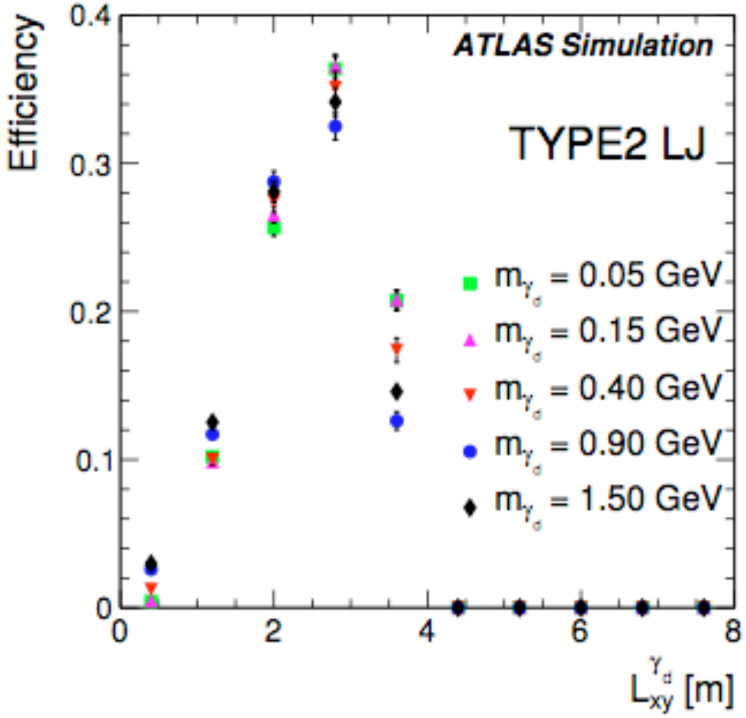


Final Products

- Detection efficiency tables obtained with the LJ gun MC tool
- Useful for “recasting” analysis using somewhat different model assumptions







Backup

90% upper limits on σ x BR for FRVZ models

The likelihood-based simultaneous CLs ABCD method is used to set 90% CL upper limit on the cross section times branching ratio (σ×BR) for the proc
Higgs → 2γ_d + X and Higgs → 4γ_d + X

- simultaneous data-driven background estimation and signal hypothesis test in the signal and control regions (from stat. forum https://twiki.cern.ch/tw pub/AtlasProtected/ATLASStatisticsFAQ/ABCD.pdf)
- takes into account contaminations from other sources of background (cosmics) and possible signal leakages in the control regions
- all systematics included

Limits as a function of the γ_d lifetime

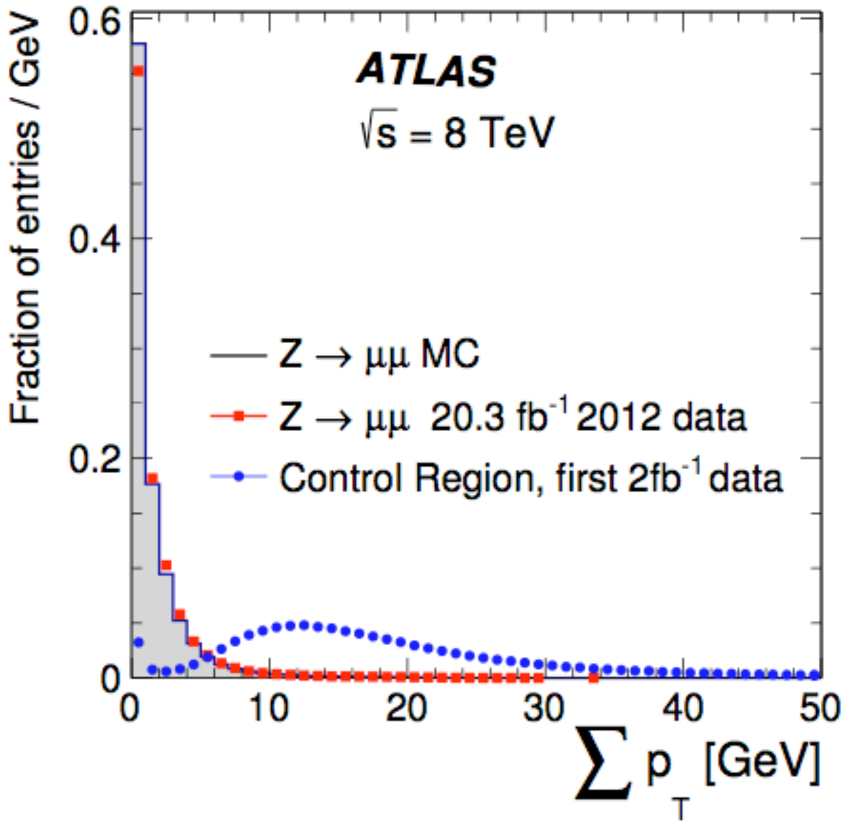
- evaluate the detection efficiency as a function of the decay position L_{xy} of the γ_d for the simulated FRVZ models with lifetime $c\tau_0$
- generate a large numbers of pseudo experiments with different cτ (ranging from 0.5 to 4750 mm)
- for each γ_d extract the p_T according to the FRVZ distributions at truth level and decay time c·t from an exponential distribution with lifetime cτ
- compute decay position L_{xy} and weight by the detection probability of the γ_d
- compute at the end the averaged integrated efficiency for a given cτ
- this is done for a cτ and at the same time for the $c\tau_0$ of the reference FRVZ sample
- from the ratio of the two efficiencies, rescale the number of selected events of the FRVZ sample to the one expected from each cτ

- Two possible sources of systematics:
  - resolution effects
    - compare truth γ_d p_T distribution with the reconstructed one (resolution effects ~ 10%-20%)
    - variation of the number of estimated events was below 1% level
  - statistics of the detection efficiency (L_{xy}) tables
    - additional 10% systematics il CLs limit setting

Major Backgrounds (I)

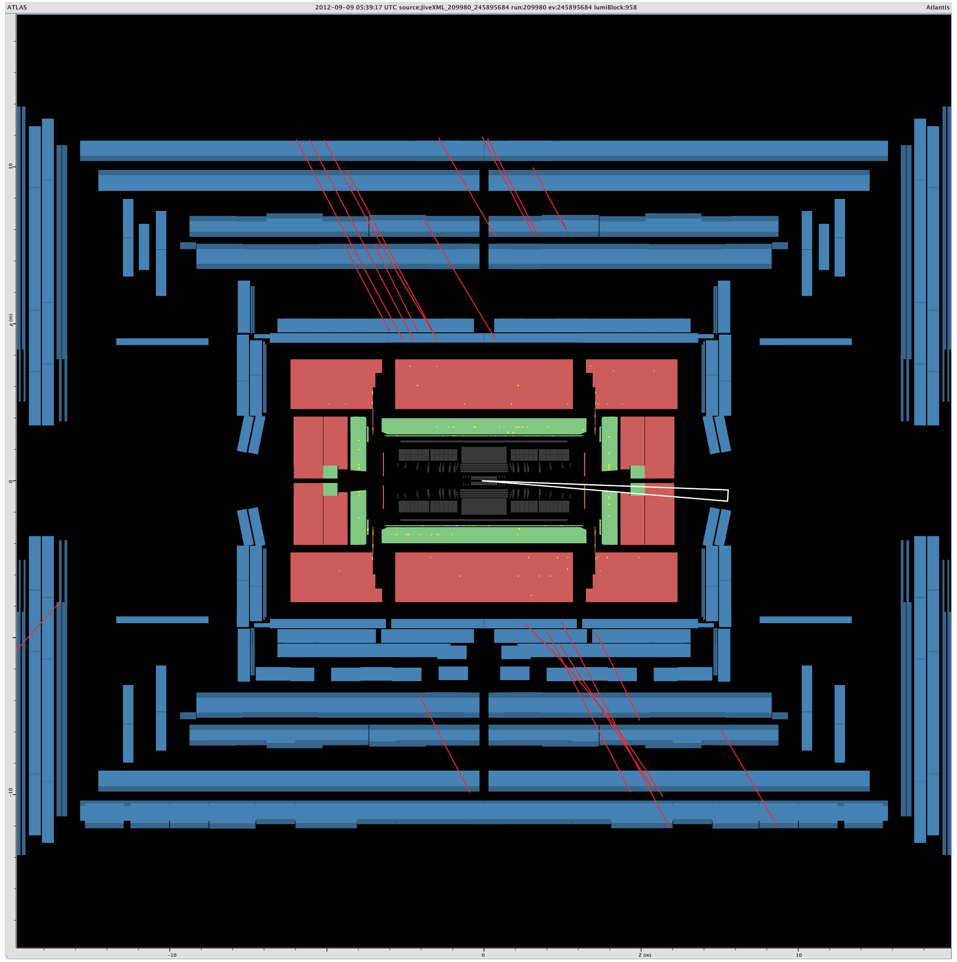
- QCD multi-jets
  - Cuts:
    - Small EM fraction
    - Narrow jet width
    - Track isolation around LJ direction in ID
  - Dijet background estimation: data-driven method, ABCD
  - Investigate use of BDT multivariate technique for Run 2
  - Also investigate use of jet substructure, possibly using particle-algorithms

Isolation in ID



Major Backgrounds (II)

- Cosmic ray muons
  - Cuts:
    - Perigee parameters of muon tracks
    - Jet timing
  - Background estimation: data-driven, using empty bunch crossings
  - For Run 2, investigate cosmic muon bundle removal
- Beam-induced
  - Some cuts available at the trigger level
  - For Run 2, investigate removal using muon segments in EndCap to further reduce BIB



Major Systematics

Cosmic-ray bg estimation	22%
Multi-jet bg estimation	15%
p_T resolution for γ_d	10%
Higgs production σ	8%
Trigger	5.8% (multi-muon), >11% (CalRatio)
Muon reco efficiency	5.4%
Pile-up effect on isolation	4.1%
Luminosity	2.8%
JES	0.9% - 1.7%

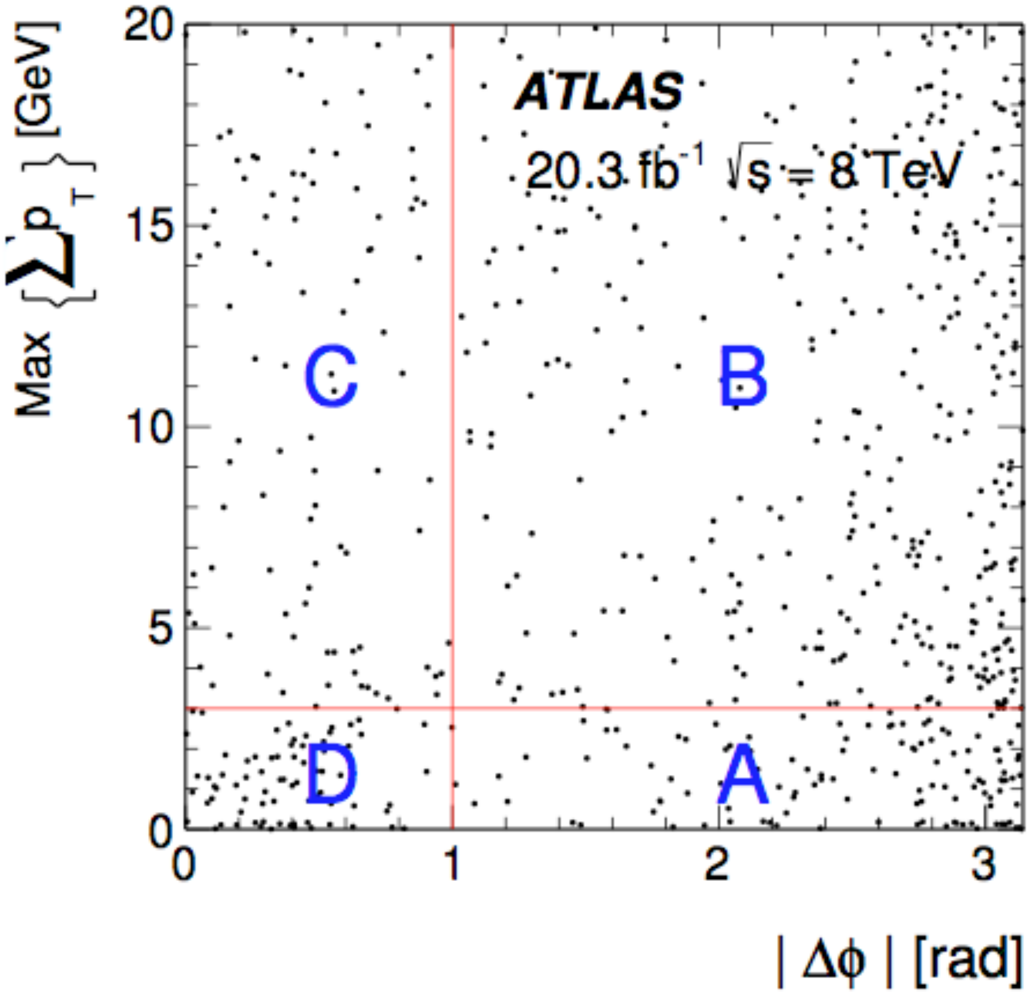
Cut-flow

Requirement	Description
Two reconstructed LJs	select events with at least two reconstructed LJs
η range (TYPE1)	remove jets with $\|\eta\| > 2.5$
η range (TYPE2)	remove jets with $\|\eta\| > 2.5$ and $1.0 < \|\eta\| < 1.4$
EM fraction (TYPE2)	require EM fraction of the jet < 0.1
Jet width W (TYPE2)	require width of the jet < 0.1
Jet timing (TYPE1/TYPE2)	require jets with timing -1 ns $< t < 5$ ns
NC muons (TYPE0/TYPE1)	require muons without ID track match
ID isolation	require $\max\{\Sigma p_{\mathrm{T}}\} \leq 3\,\mathrm{GeV}$
$\Delta\phi$	require $\|\Delta\phi\| \geq 1$ rad between the two LJs

Cut-flow on data

LJ pair types	0-0	0-1	0-2	1-1	1-2	2-2	All
Trigger selection	9.226×10^6						
Good primary vertex	9.212×10^6						
Two reconstructed LJs	946	1771	16676	1382	19629	82653	123057
η range (TYPE1/TYPE2)	946	1269	5063	701	3838	25885	37702
EM fraction (TYPE2)	946	1269	393	701	172	4713	8194
Jet width W (TYPE2)	946	1269	350	701	148	3740	7154
Jet timing (TYPE1/TYPE2)	946	1054	216	547	92	578	3433
NC muons (TYPE0/TYPE1)	27	3	42	5	5	578	660
ID isolation	12	0	19	4	3	160	198
$\|\Delta\phi\|$	11	0	11	4	3	90	119

Background estimation



ALL LJ PAIR TYPES

Data Type	Events in B	Events in C	Events in D	Expected Events in A
Cosmic-ray data	0	0	60 ± 13	40 ± 10
Data (cosmic rays subtracted)	362 ± 19	99 ± 10	19 ± 16	70 ± 58

TYPE 2-2 EXCLUDED

Data Type	Events in B	Events in C	Events in D	Expected events in A
Cosmic-ray data	0	0	3 ± 3	29 ± 9
Data (cosmic rays subtracted)	29 ± 5	15 ± 4	6 ± 4	12 ± 9