BSM Monte Carlo: ATLAS

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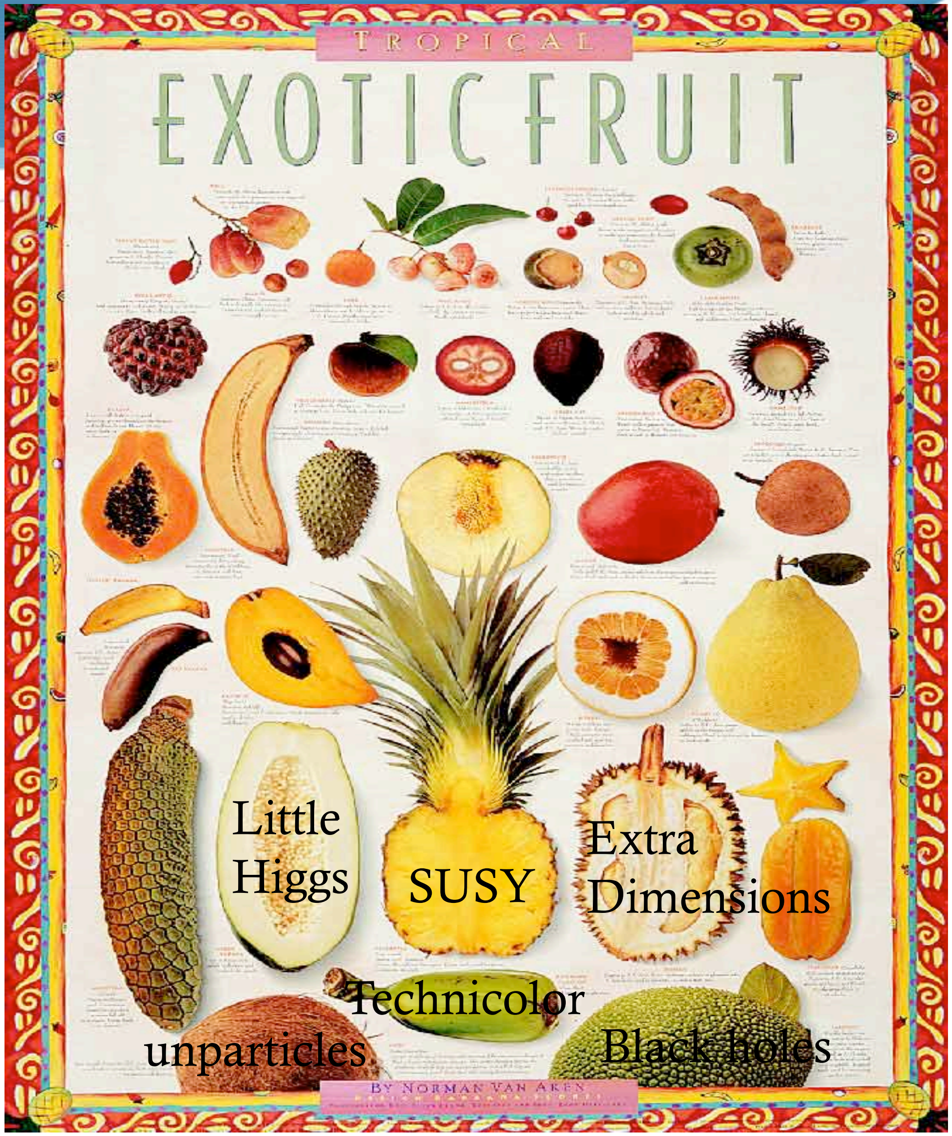
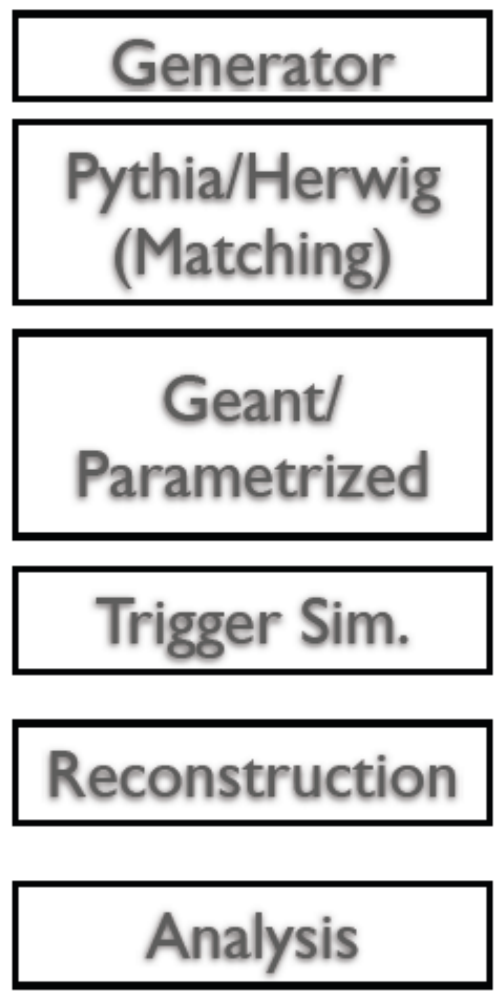
Outline

- Overview of MC Simulation with ATLAS
- Generators in ATLAS
- Incorporating new Monte Carlo in ATLAS
- Some specific requests from ATLAS



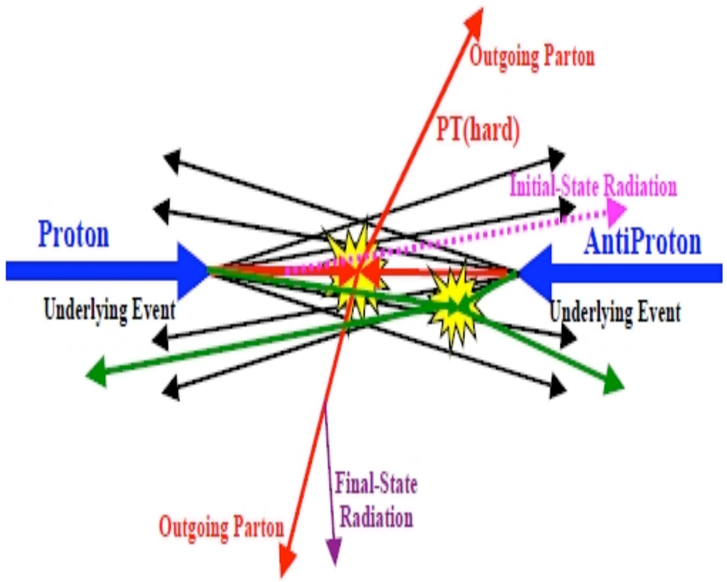
Simulation/Real Life

- Hard Scatter
- Parton Shower/Hadronization
- Interaction with Detector
- Readout with Electronics
- Record Some Fraction of events
- Reconstruct the event from electronic signals (tracking, jets, etc..)
- Infer back to hard scattering (including unfolding detector effects)

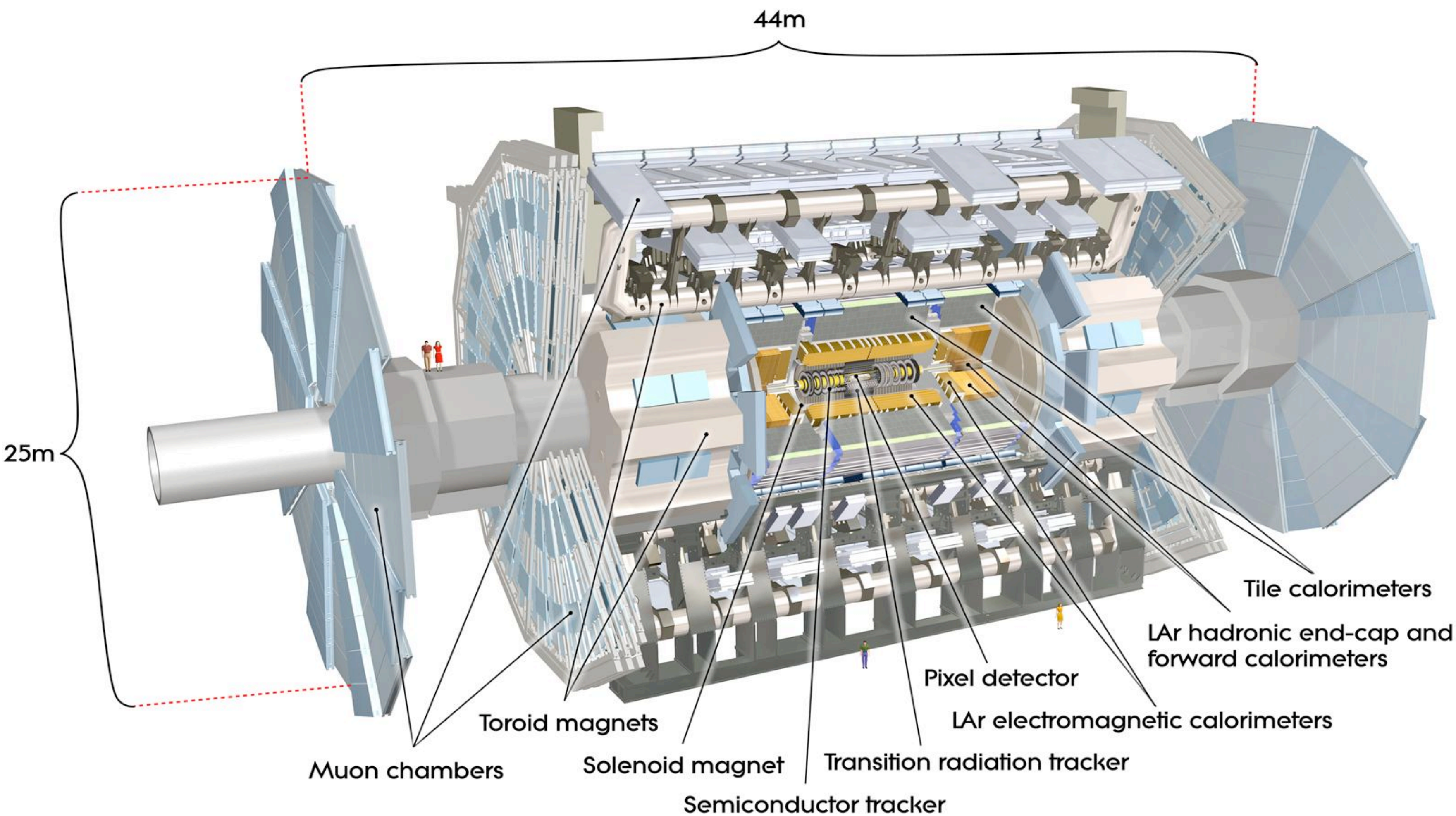


Generator/Shower/ Hadronization

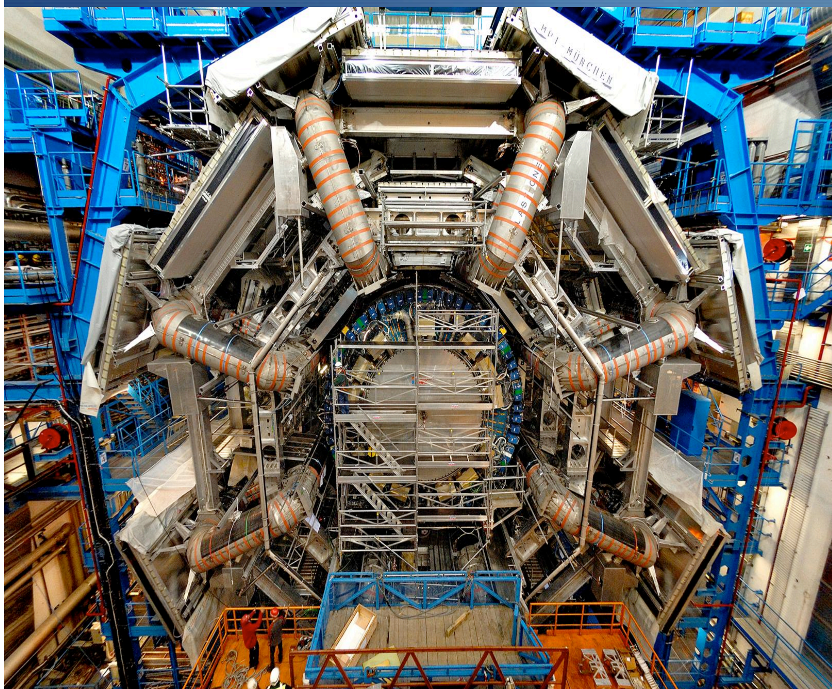
- Generate Event according to differential cross-section (matrix element + PDF)
- Parton Shower – radiate quarks and gluons
  - Match matrix element description to shower
- Hadronize and Decay: form 'stable' particles to shoot through ATLAS detector



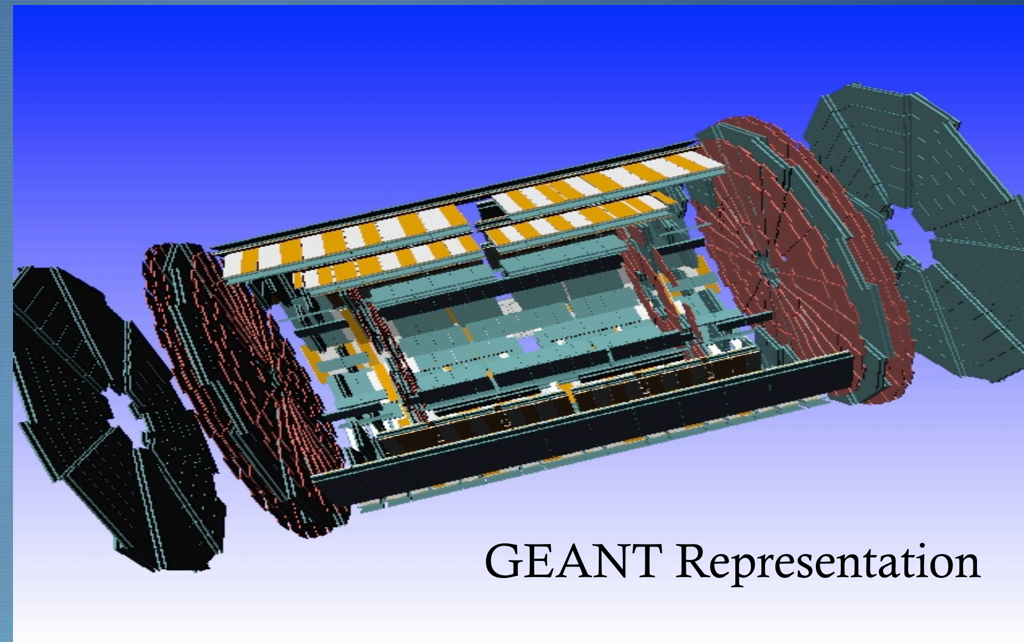
ATLAS



44m
25m
Tile calorimeters
LAr hadronic end-cap and forward calorimeters
Pixel detector
LAr electromagnetic calorimeters
Toroid magnets
Muon chambers
Solenoid magnet
Transition radiation tracker
Semiconductor tracker

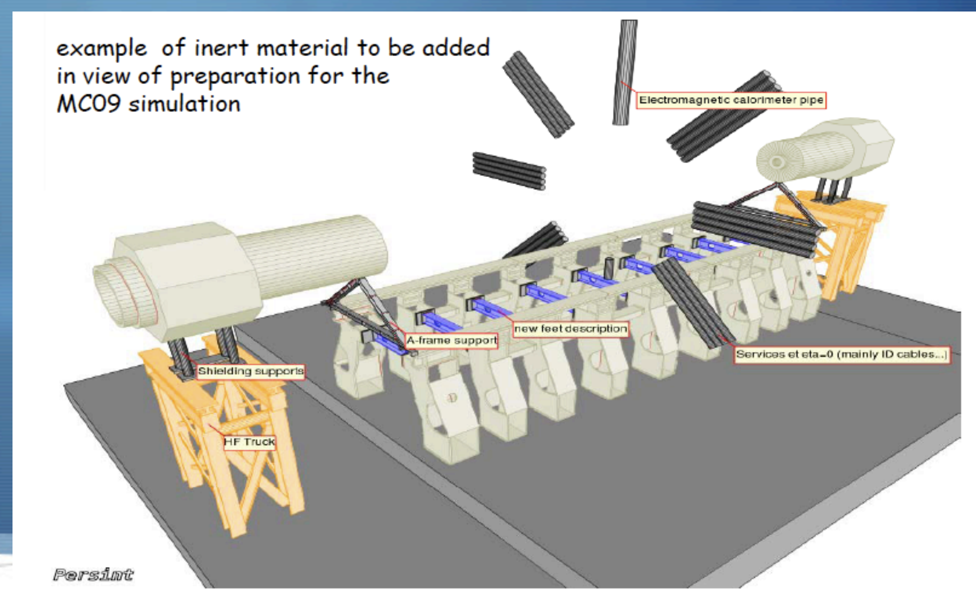


Real Detector



GEANT Representation

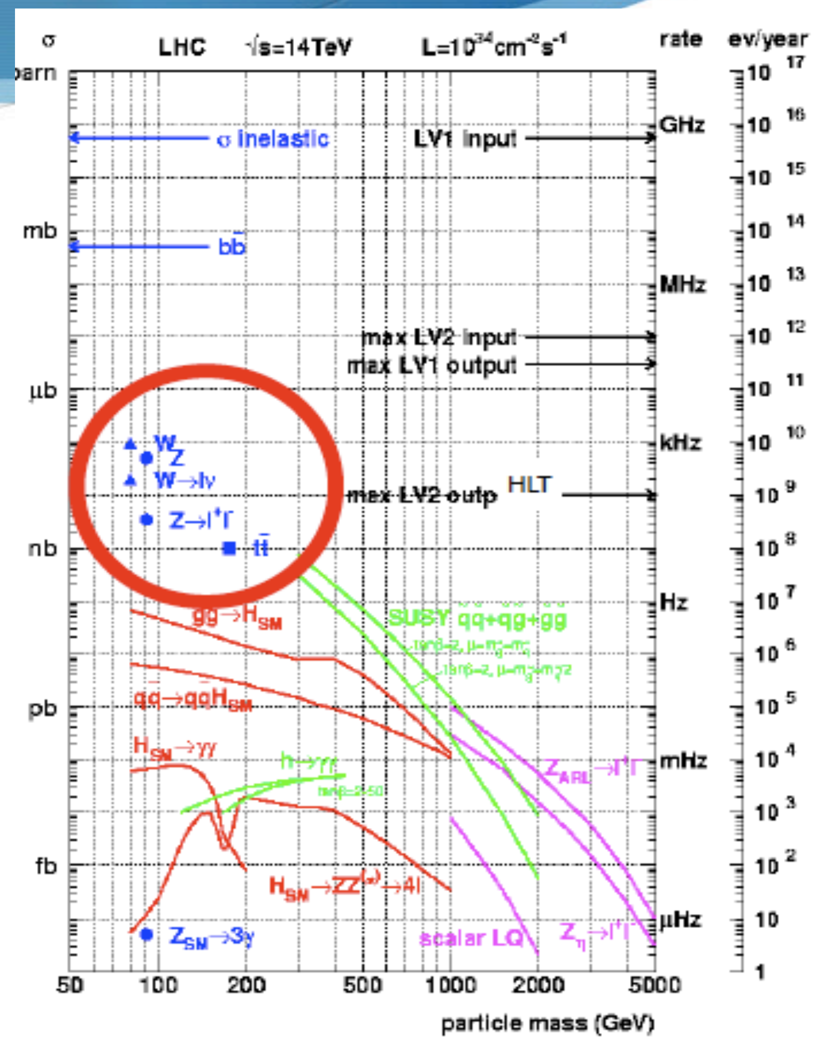
Crucial – What does signature X look like in our detector!



Adding in yet more Material…

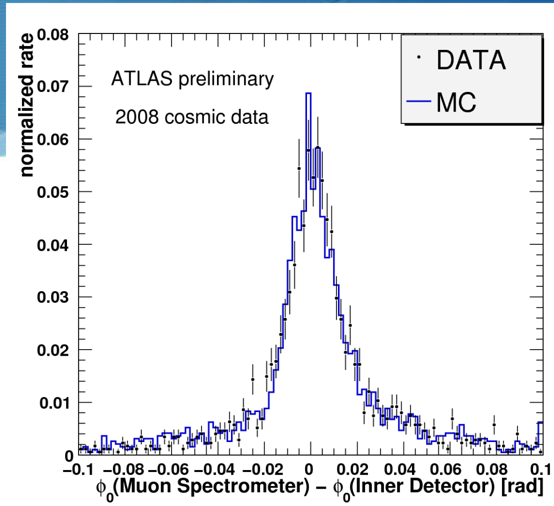
Validation

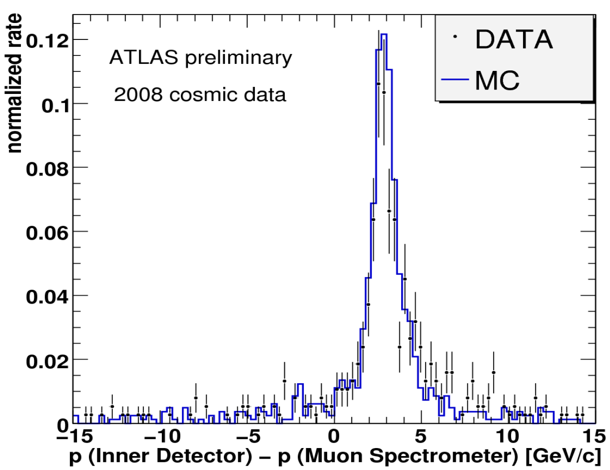
- Need to validate that monte carlo represents data:
  - Need high statistic processes (disagreement doesn't get lost in statistical uncertainty)
  - Needs to be reasonably well identifiable, triggerable
  - Often need to resort to 'scale' factors or oversmearing (even after many years of Tevatron running)



Validation…It starts now!

- No LHC data yet – but ~300 million cosmic rays per experiment
- Simple / Clean events
  - Only the first baby step!
- Some details hard to match because of different timing and event topology (don't point to IP!)





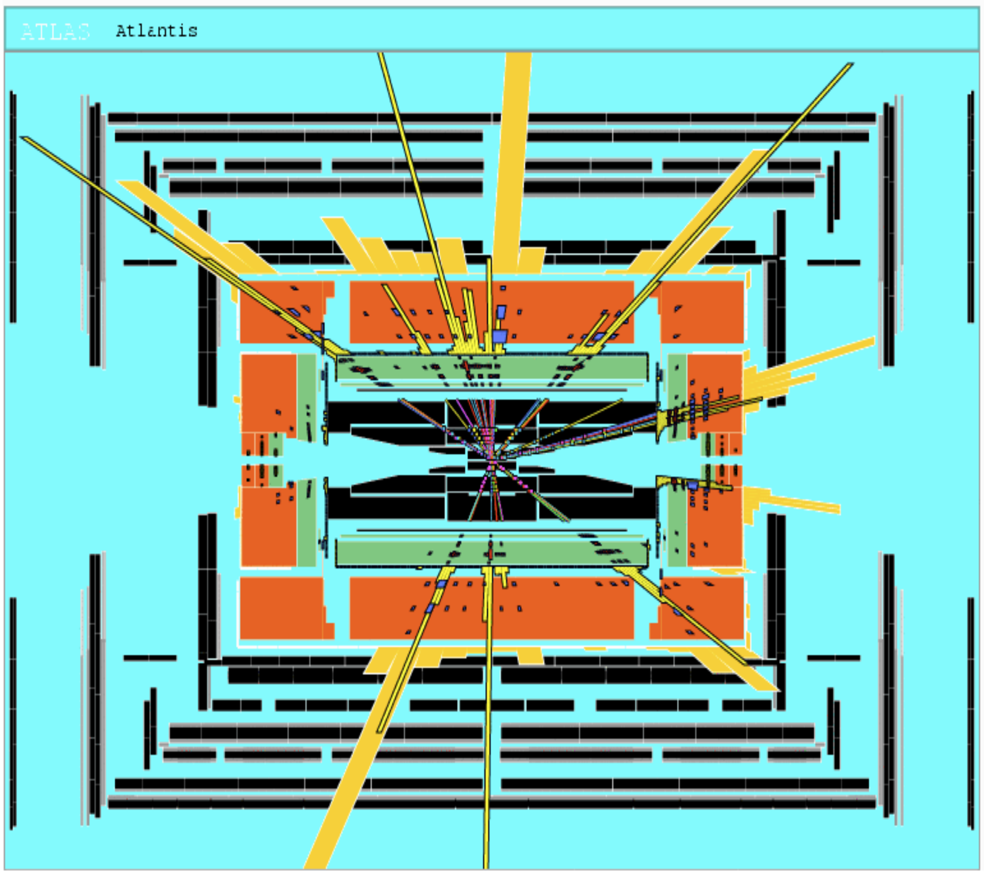
Monte Carlo Used in ATLAS

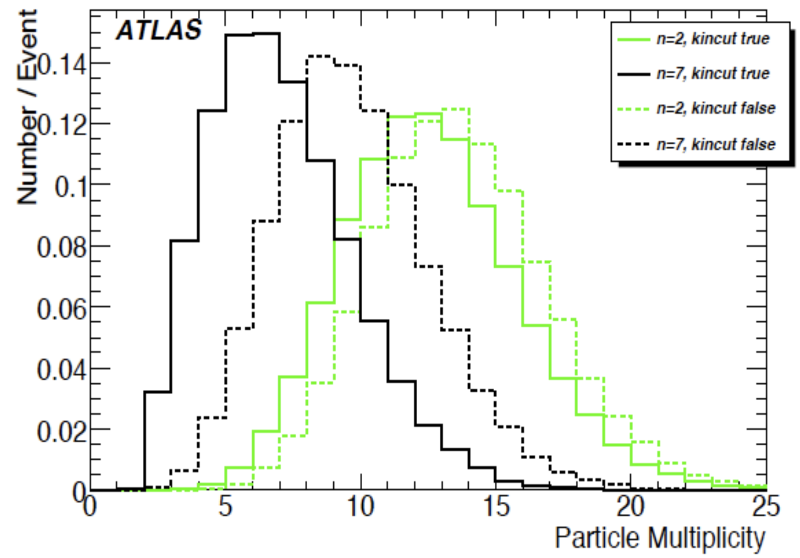
- AcerMCForAtlas
- AlpGenForAtlas
- BeamHaloGenerator
- BaurForAtlas
- CascadeForAtlas
- CavernBkgGenerator
- CharybdisForAtlas
- CompHepForAtlas
- CosmicForAtlas
- DpemcForAtlas
- EvtGenForAtlas
- ExhumeForAtlas
- HerwigForAtlas
- HerwigppForAtlas
- HijingForAtlas
- HoraceForAtlas
- IsajetForAtlas
- JimmyForAtlas
- MatchigForAtlas
- MCatNLOForAtlas
- MadGraphForAtlas
- PhojetForAtlas
- PhotosForAtlas
- PomwigForAtlas
- PythiaForAtlas
- Pythia8ForAtlas
- SherpaForAtlas
- TauolaForAtlas
- TopRexForAtlas ?
- WinHacForAtlas
- GraceForAtlas
- WhizardForAtlas
- W2PForAtlas

Simulated Black Hole Event

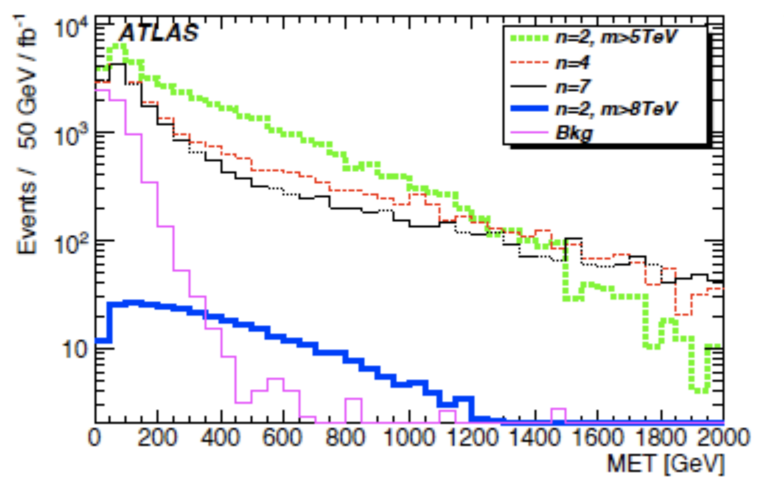
The truly exotic…

Charbydis

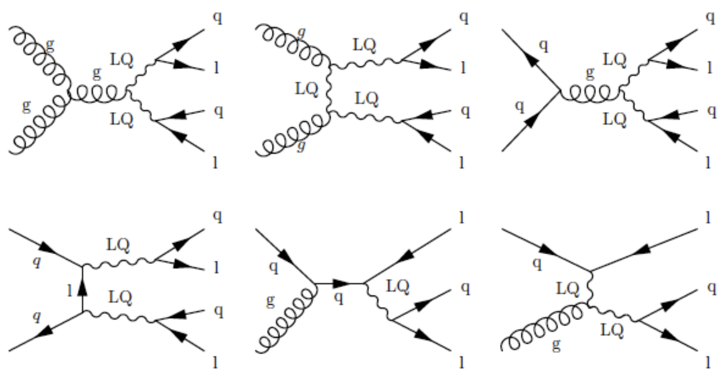


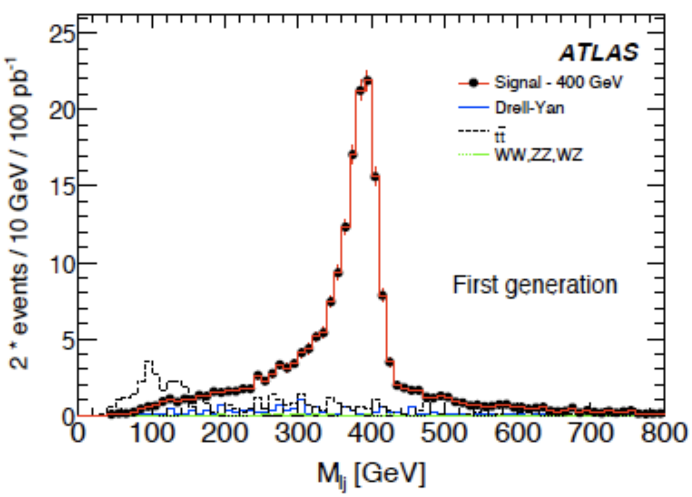


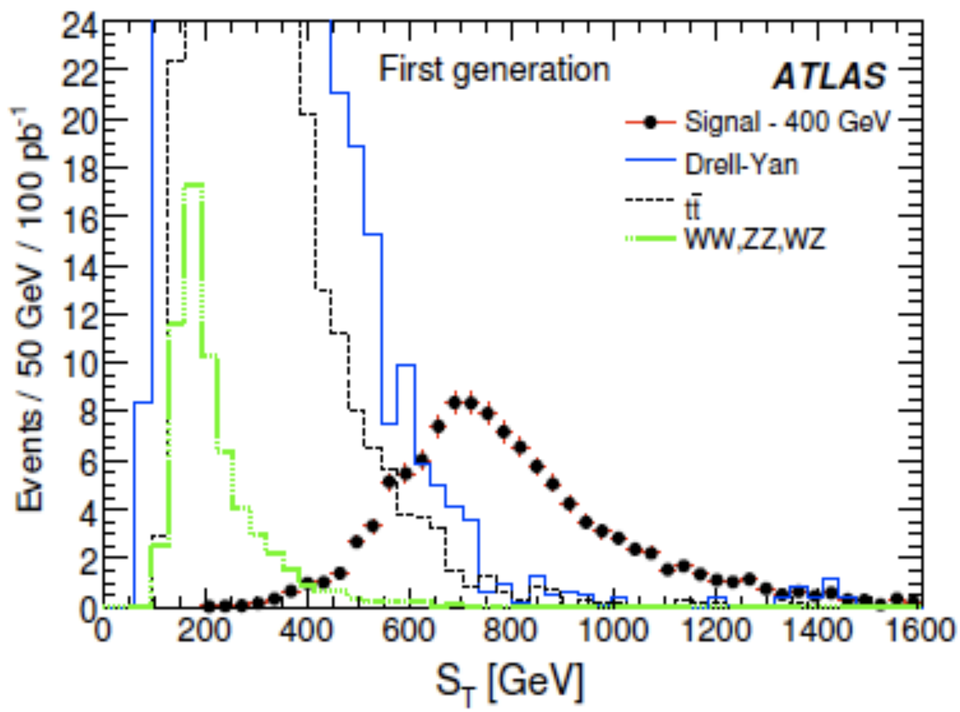
$\sum |p_T| > 2.5\,\mathrm{TeV}$



Leptoquarks



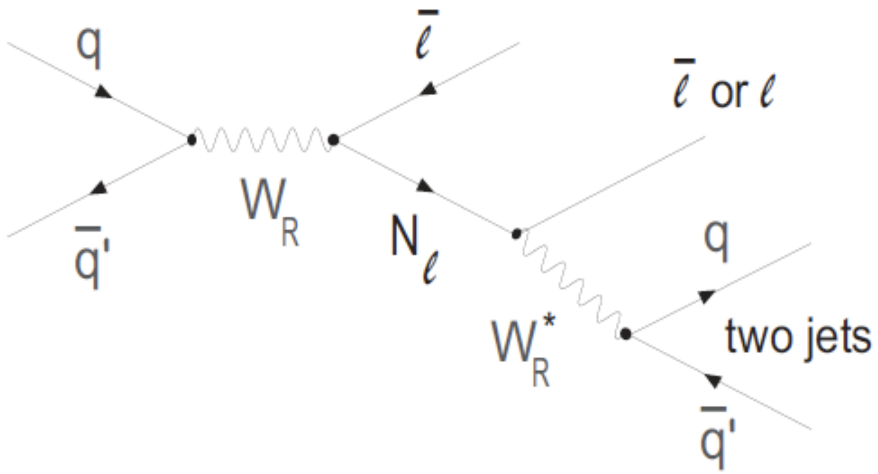




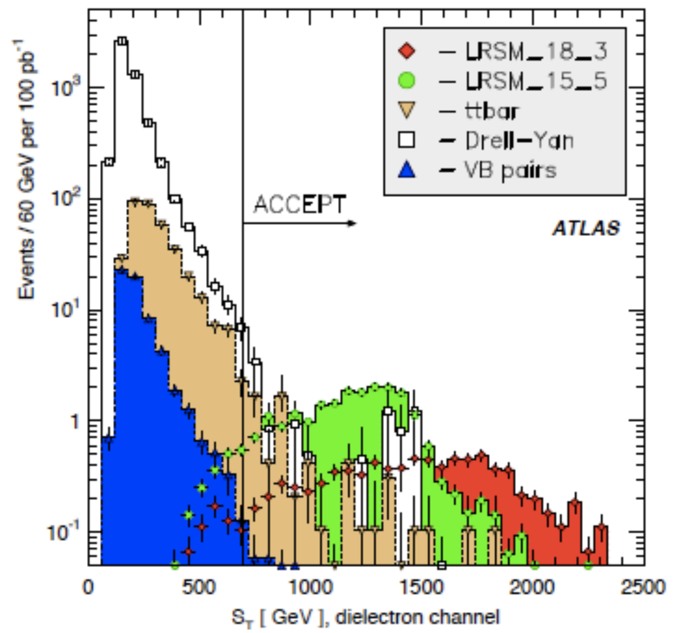
$$S_T = \Sigma |\vec{p}_T|_{jet} + \Sigma |\vec{p}_T|_{lep}$$

Pythia Normalized to NLO calculation

Heavy Neutrinos



Pythia

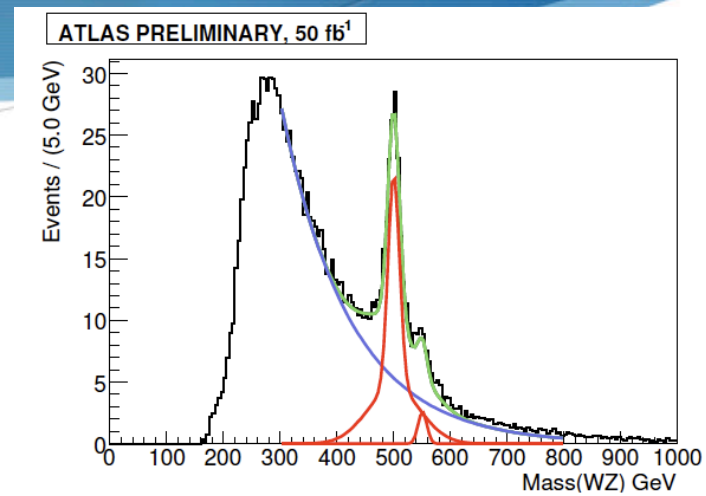


Physics sample	Before selection	Baseline selection	m_{ejj} ≥ 100 GeV	m_{eejj} ≥ 1000 GeV	m_{ee} ≥ 300 GeV	S_T ≥ 700 GeV
LRSM_18_3	0.248	0.0882	0.0882	0.0861	0.0828	0.0786
LRSM_15_5	0.470	0.220	0.220	0.215	0.196	0.184
$Z/\gamma^*, m \geq 60$ GeV	1808.	49.77	43.36	0.801	0.0132	0.0064
$t\bar{t}$	450.	3.23	3.13	0.215	0.0422	0.0165
VB pairs	60.9	0.610	0.522	0.0160	0.0016	0.0002
Multijet	10^8	20.51	19.67	0.0490	0.0444	0.0444

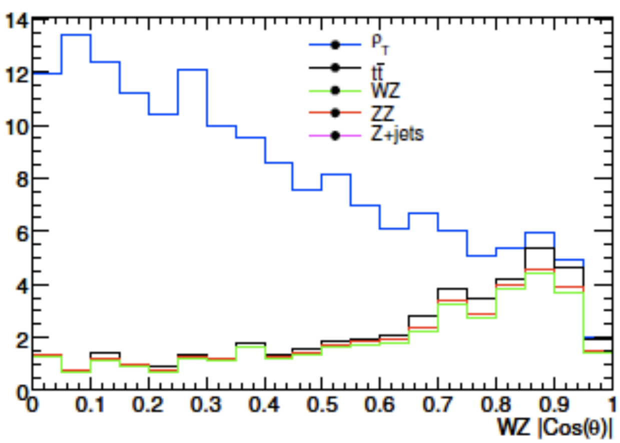
$$S_T = \sum |\vec{p}_T|_{jet} + \sum |\vec{p}_T|_{lep}$$

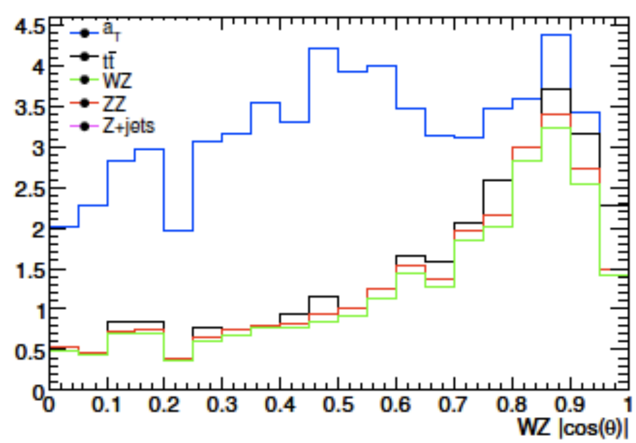
Technicolor

- K.B, Adam Martin, Ken Lane, S. Mrena
    - 'new' technicolor resonances in pythia strawman model…



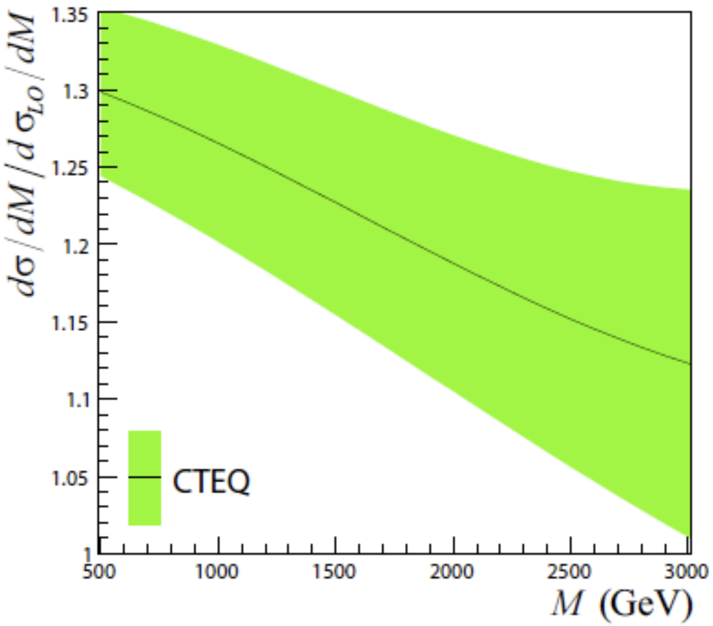
Pythia

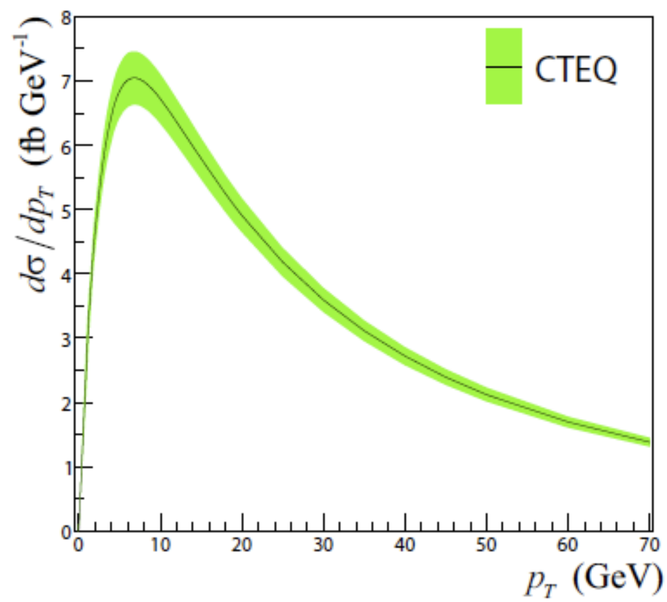




Collaborative work..

- Drell-Yan at NLO
  - mc@nlo including Z'



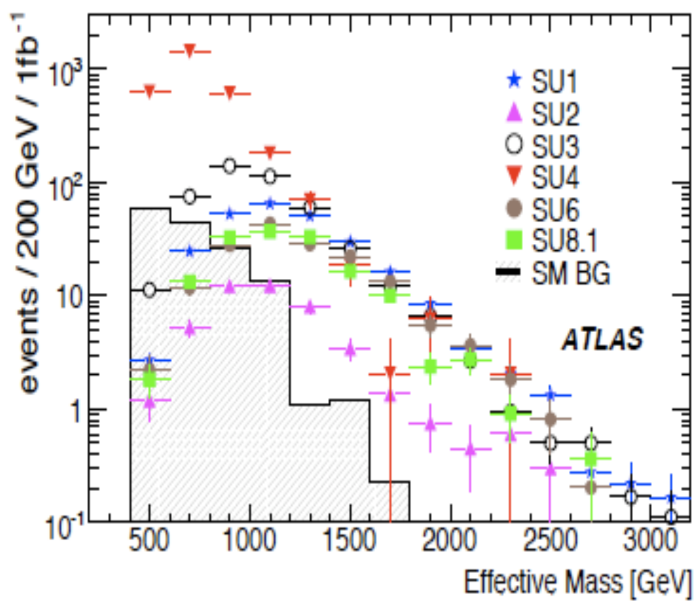


B. Fuks, M. Klasen, F. Ledroit, Q. Li, and J. Morel, *Nucl. Phys.* **B797** (2008) 322–339.

SUSY

Process	CSC ID	short description	Sigma
SU1	005401	Coannihilation	7.43pb
SU2	005402	Focus point	4.86pb
SU3	005403	Bulk	18.59pb
SU4	006400	Low mass	262pb
SU6	005404	Funnel	4.48pb
SU8–1	005406	Coannihilation	6.44pb
SU8–2	005407	Coannihilation	6.40pb
SU8–3	005408	Coannihilation	6.32pb
SU9	006404	Higgs	2.30pb
GMSB1	005410	neutralino short life	7.6pb
GMSB2	005411	neutralino middle life	7.6pb
GMSB3	005412	neutralino middle life	7.6pb
GMSB4	005413	co–NLSP short life	23pb
GMSB5	005414	co–NLSP long life	23pb
GMSB6	005415	large tan(beta)	3.9pb
GMSB7	005416	neutralino long life	7.6pb
Direct1	006401	slepton pair prod.	
Direct2	006402	gauginos prod.	
lightstop	006403	light stop	412pb
GMSB8	006405	GMSB1 like point, higher SUSY Scale TBD	
GMSB9	006406	GMSB1 like point, higher SUSY Scale TBD	
GMSB10	006407	GMSB2 or 3 like point, longer ctau TBD	
GMSB11	006408	GMSB5 like point, higher SUSY Scale Lambda=60TeV	
GMSB12	006409	GMSB5 like point, higher SUSY Scale Lambda=90TeV	
R–Hadron1	006418	Gluinos, 300 GeV	
R–Hadron2	006419	Gluinos, 600 GeV	
R–Hadron3	006420	Gluinos, 1000 GeV	
R–Hadron4	006421	Gluinos, 1300 GeV	
R–Hadron5	006422	Gluinos, 1600 GeV	
R–Hadron6	006423	Gluinos, 2000 GeV	
R–Hadron7	006424	stops, 300 GeV	
R–Hadron8	006425	stops, 600 GeV	
R–Hadron9	006426	stops, 1000 GeV	

Herwig, Isasugra, Pythia..



SUSY, but which SUSY…

Backgrounds for BSM

- Of course depends on channel – but can be difficult
  - Typically looking into extreme corners of phase space
    - Extreme tails of MET distribution, etc..
  - Substantial use of madgraph/mad event
    - Diboson +jets for eg..
  - mc@nlo tt, Alpgen /Madgraph W/Z+jets, Acer W/Z+ heavy flavor, etc..
    - Parton level matching (MLM, etc)

Incorporating new generators into ATLAS

- Getting new generator code into software is hard
  - Private tests
  - Put into 'development' release (built every ~few weeks/month)
  - Code validated (doesn't crash, results make sense, etc)
  - Code goes into 'production' release (built every several months)
  - More validation of production samples
  - Detailed Analysis + approval
- ATLAS software is complex ~few THOUSAND packages that all have to work together
  - Time scale often longer then we would like it to be
  - Unrelated problems can mean parts of the process have to be done again
- Time scale can be quite long depending on the program (e.g. a new Pythia version can be long) – likely to get longer in LHC data era

‘Official’ Code

- Can always provide LHEF files that can be simulated in ATLAS but..
- Easiest way is to have code in publically available and documented
- Can be most easily integrated into ATLAS code
  - Reproducibility
  - Validation

Specific Requests

- Vector-like heavy quarks: some models in CompHep
- Heavy Leptons with different coupling
- Higgsless models: in particular WZ resonances in WZ scattering
- ttbar resonances with spin correlations (now in madgraph- other generators?)

General Request

- Some models (eg. Straw Man Technicolor Model) have many parameters
  - In general need input for these!
- Make code for new models publically available and documented
- New ideas – what aren't we looking at!
- More studies can be found at…

http://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/EXOTICS/