EF04 Proposal for Multiboson Studies

Jessica Metcalfe
Argonne National Laboratory

Multiboson Processes

Possible studies:

Q: What measurements to we want to do with multibosons?

→ global SMEFT/ combinations of multiboson processes

- Optimize single aQGC(aTGC) variable

Q: What are the key kinematic variables that we need to study for multiboson processes and what phase space?

→ start to define what a detector would need to look like

- Eta/tracking coverage, momentum range, etc.

Q: How could that detector possibly be practically implemented?

→ understand what (potential) technologies would work best

- Impact on services and cooling

Repeat process for different 1) accelerators. 2) detectors. 3) aQGC variables (or other key measurements)

aQGC

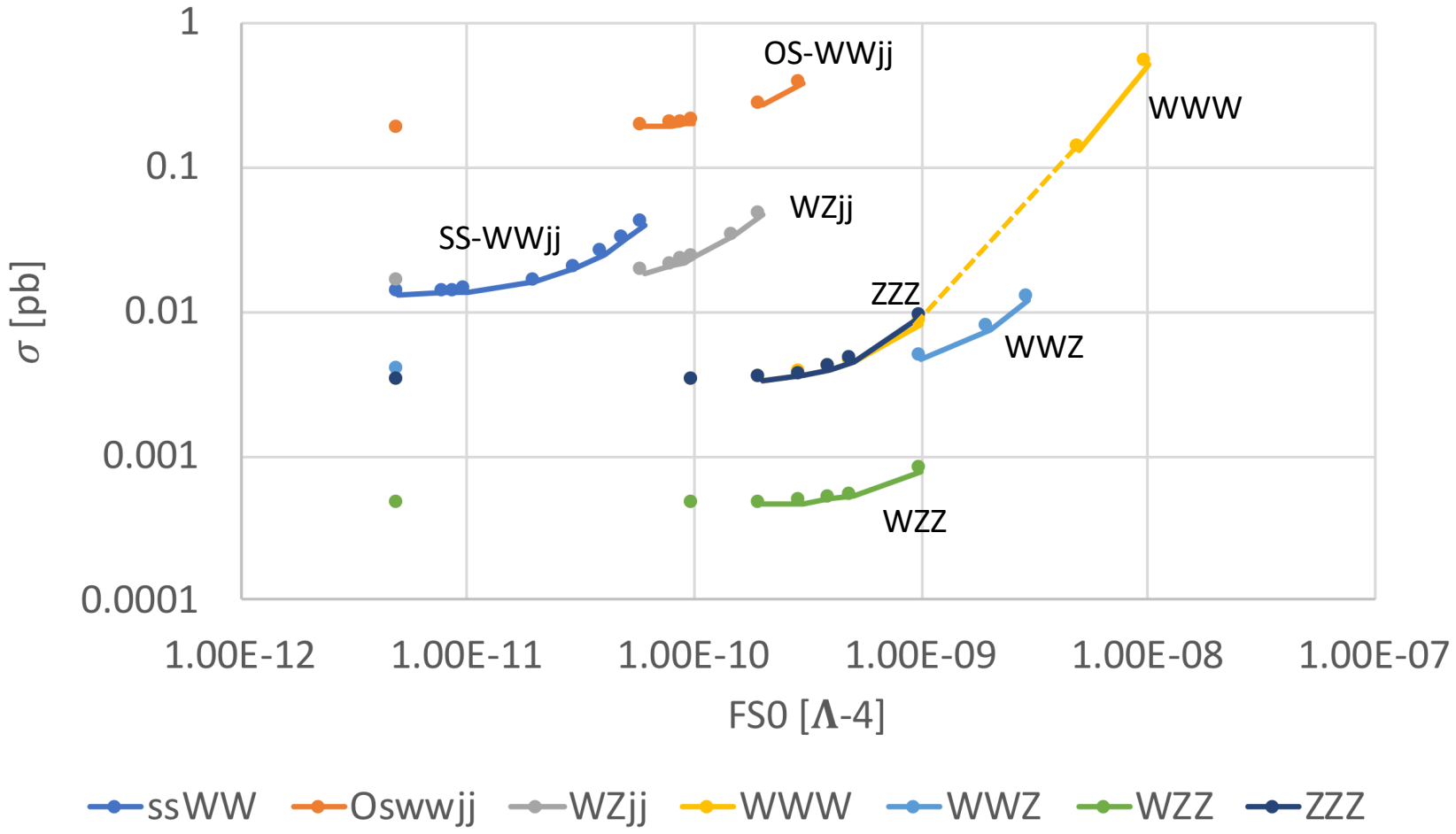
- Many EFT variables and combinations of channels
  - Operators affected by different combinations of processes
- Can choose to study specific operators and all the processes associated with those interactions
- Example O_S0: WWWW, WWZZ, ZZZZ
  - VBS & triboson processes with W, Z

	$WWWW$	$WWZZ$	$WW\gamma Z$	$WW\gamma\gamma$	$ZZZZ$	$ZZZ\gamma$	$ZZ\gamma\gamma$	$Z\gamma\gamma\gamma$	$\gamma\gamma\gamma\gamma$
$\mathcal{O}_{S,0}$, $\mathcal{O}_{S,1}$	✓	✓			✓				
$\mathcal{O}_{M,0}$, $\mathcal{O}_{M,1}$,$\mathcal{O}_{M,6}$,$\mathcal{O}_{M,7}$	✓	✓	✓	✓	✓	✓	✓		
$\mathcal{O}_{M,2}$,$\mathcal{O}_{M,3}$, $\mathcal{O}_{M,4}$,$\mathcal{O}_{M,5}$		✓	✓	✓	✓	✓	✓		
$\mathcal{O}_{T,0}$,$\mathcal{O}_{T,1}$,$\mathcal{O}_{T,2}$	✓	✓	✓	✓	✓	✓	✓	✓	✓
$\mathcal{O}_{T,5}$,$\mathcal{O}_{T,6}$,$\mathcal{O}_{T,7}$		✓	✓	✓	✓	✓	✓	✓	✓
$\mathcal{O}_{T,8}$,$\mathcal{O}_{T,9}$					✓	✓	✓	✓	✓

BSM: EFT FS0 Contribution

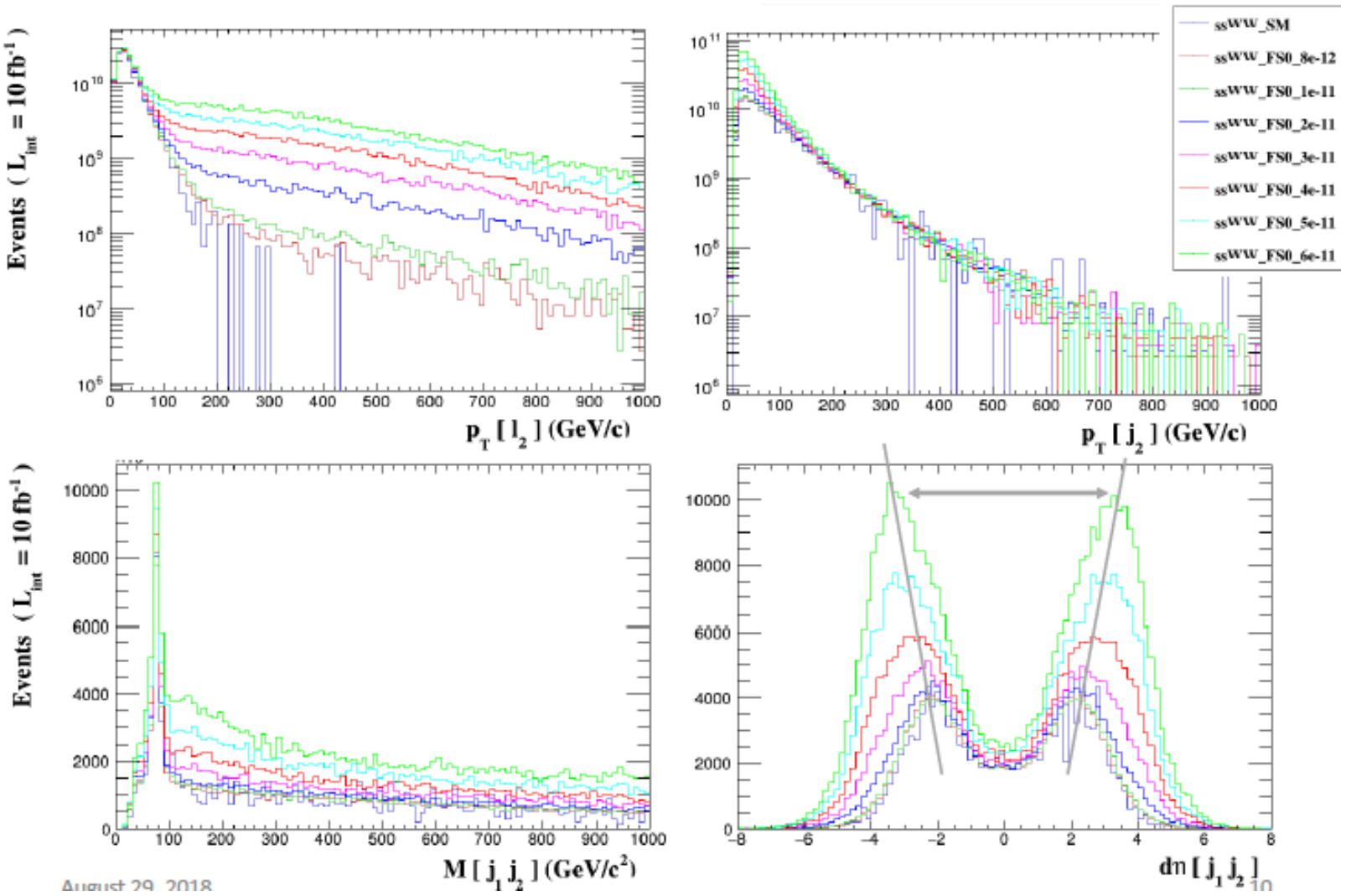
- Dim-8 EFT variable FS0 scalar production for Multiboson channels

$$\mathcal{O}_{S,0} = \left[(D_\mu \Phi)^\dagger D_\nu \Phi \right] \times \left[(D^\mu \Phi)^\dagger D^\nu \Phi \right]$$



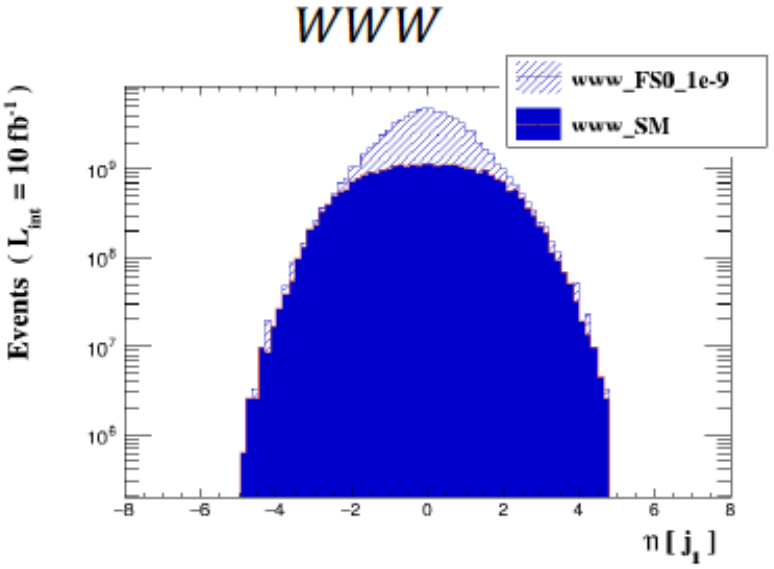
ssWW FS0

How do the kinematic variables turn on?

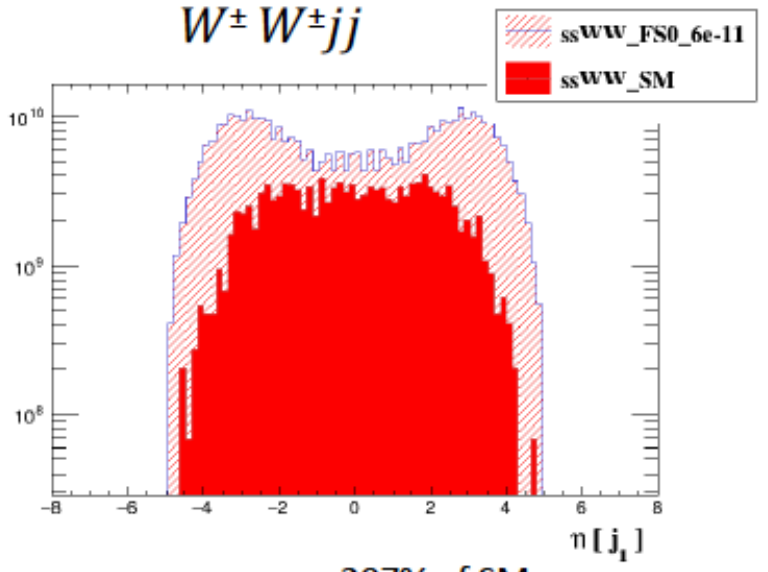


Would not want to use eta of leading jet to combine WWW and ssWW

- Could define two signal regions

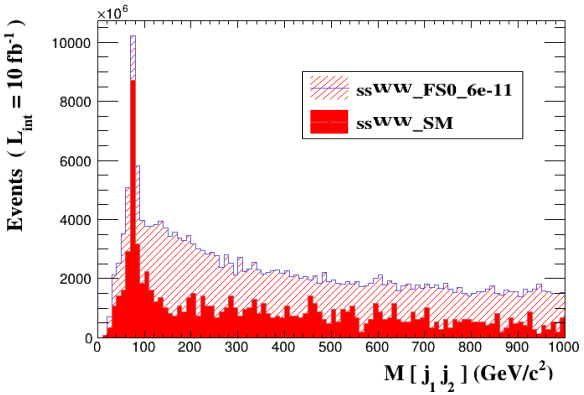


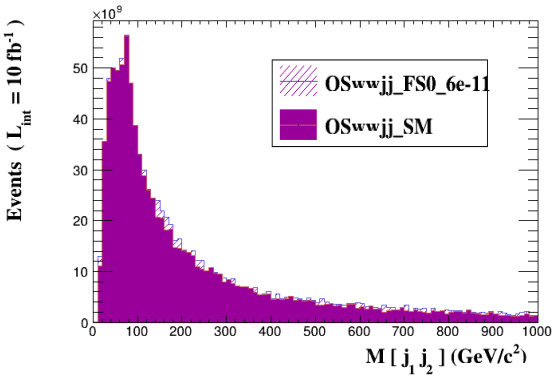
156% of SM

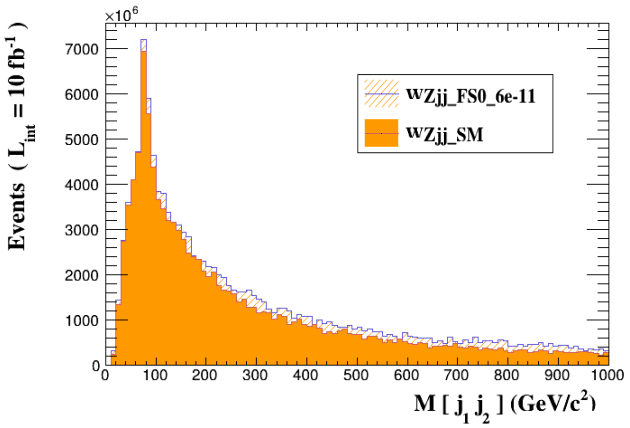


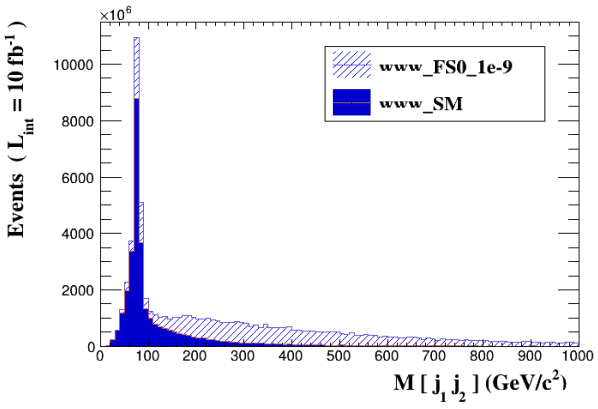
207% of SM

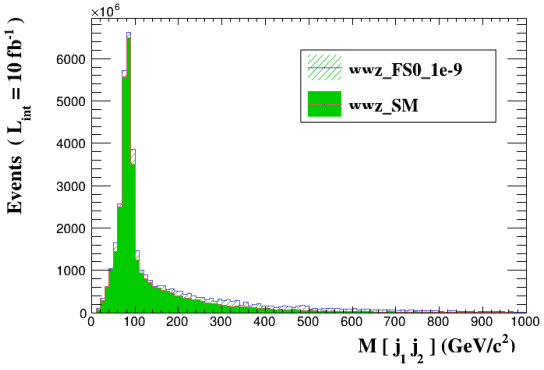
BSM: FS0 Signature

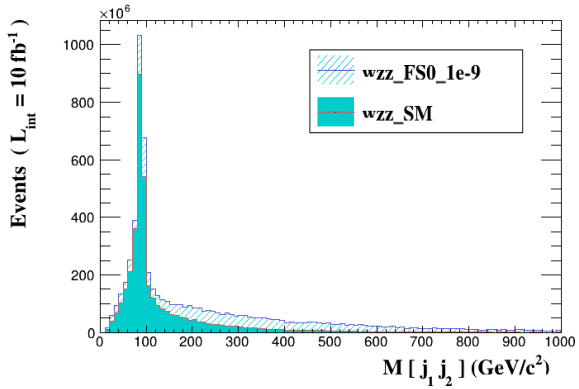


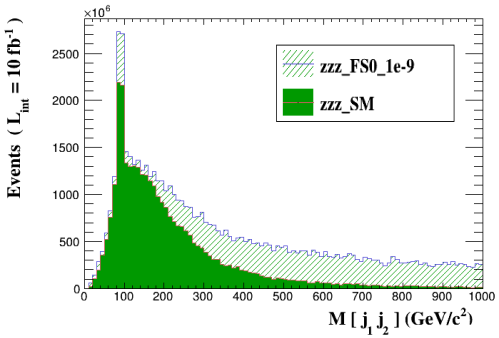






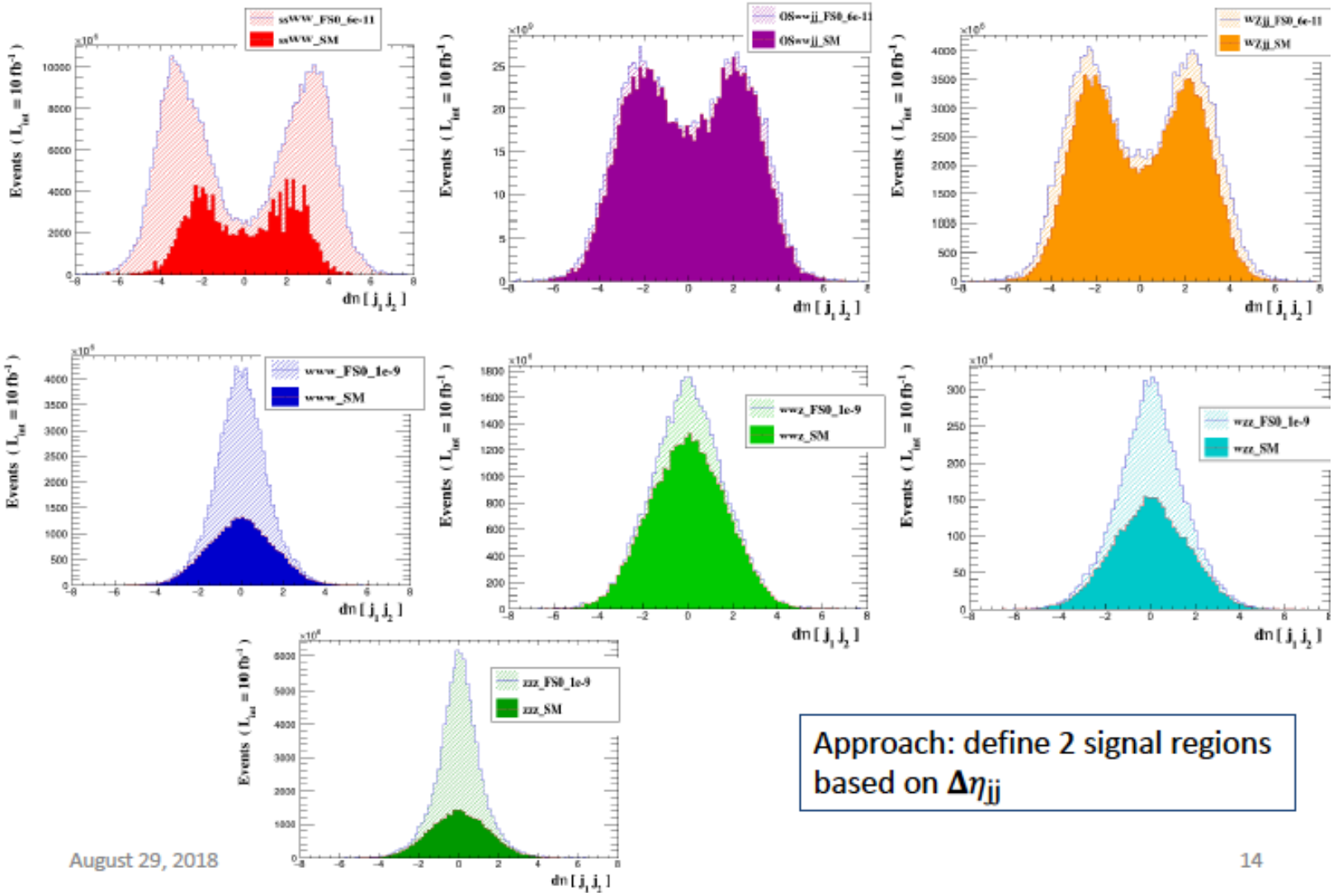






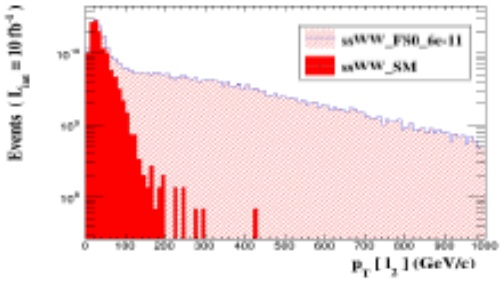
- Mjj distributions for multiboson channels
- FS0 aQGC emerges in tails

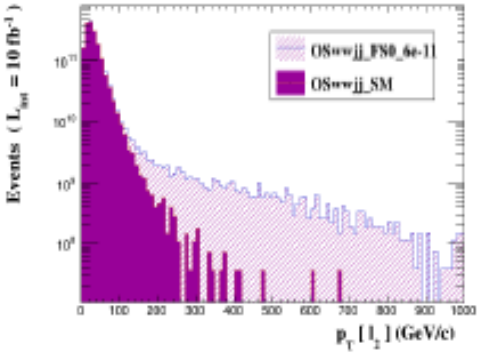
ssWW FS0

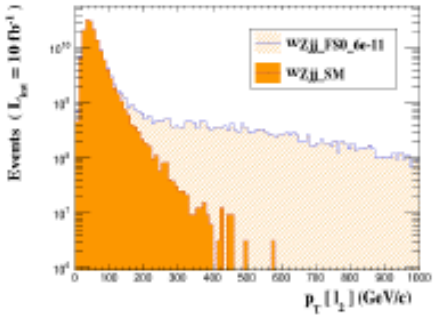


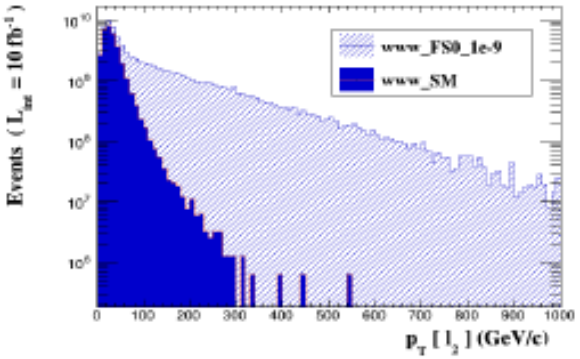
Approach: define 2 signal regions based on $\Delta\eta_{jj}$

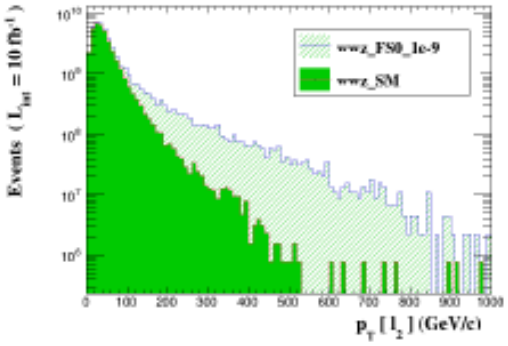
ssWW FS0

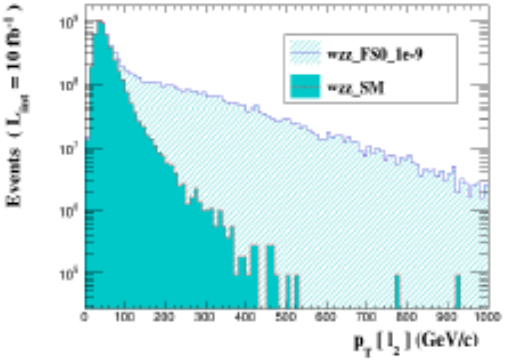


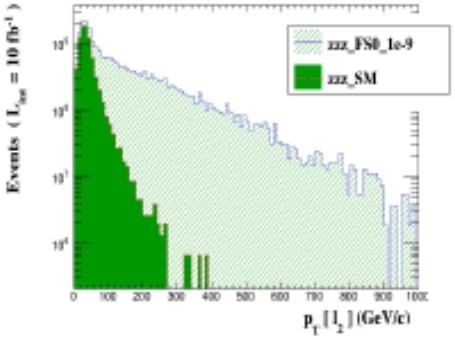












Select a kinematic variable with similar shape where aQGC contributes, i.e. $p_T(l_2)$

August 29, 2018

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Detector Design

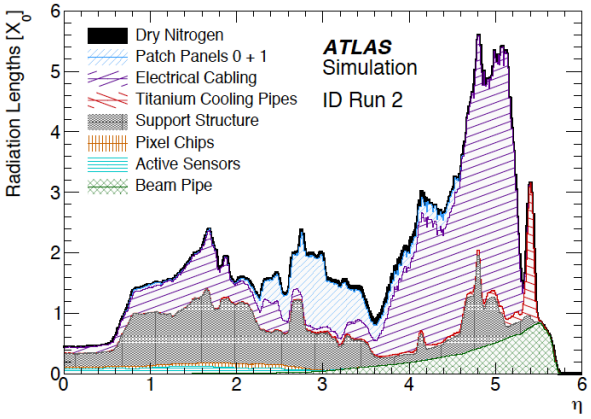
Determine what impact the efficiencies, resolutions, fakes, etc. have on the analysis

- aQGC sensitivity dependence on track coverage, lepton momentum range, fakes, charge flip, pileup (will vary depending on the accelerator machine as well)

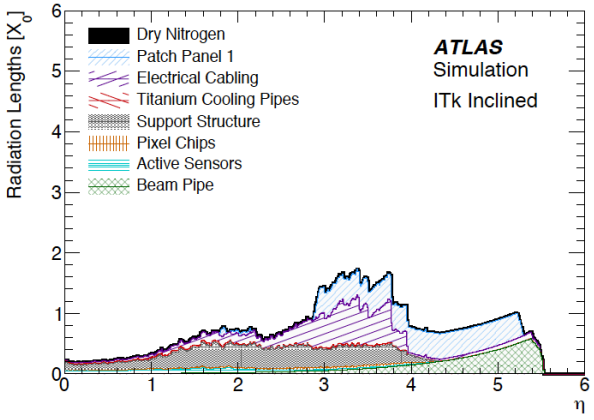
From here you can start to define what a detector might look like

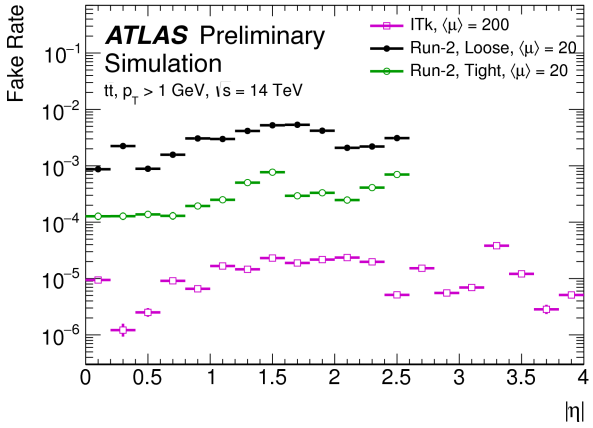
- Define a target/requirements → feed back to Instrumentation group
- Build a full detector concept including services, cooling, supports, etc.
- Plug this back into the analysis to get achievable sensitivities

Run2



Phase II Upgrade



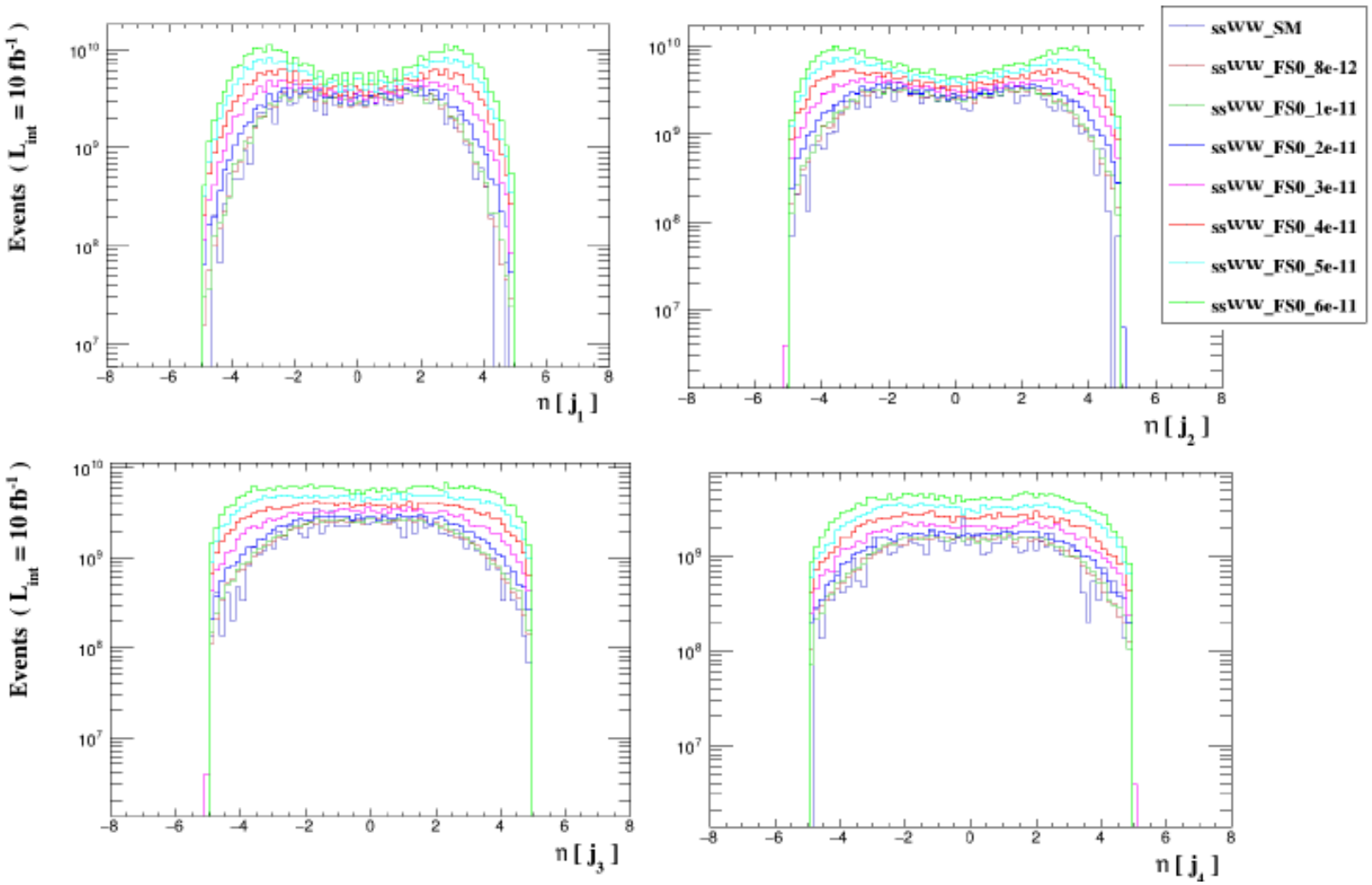


Conclusion

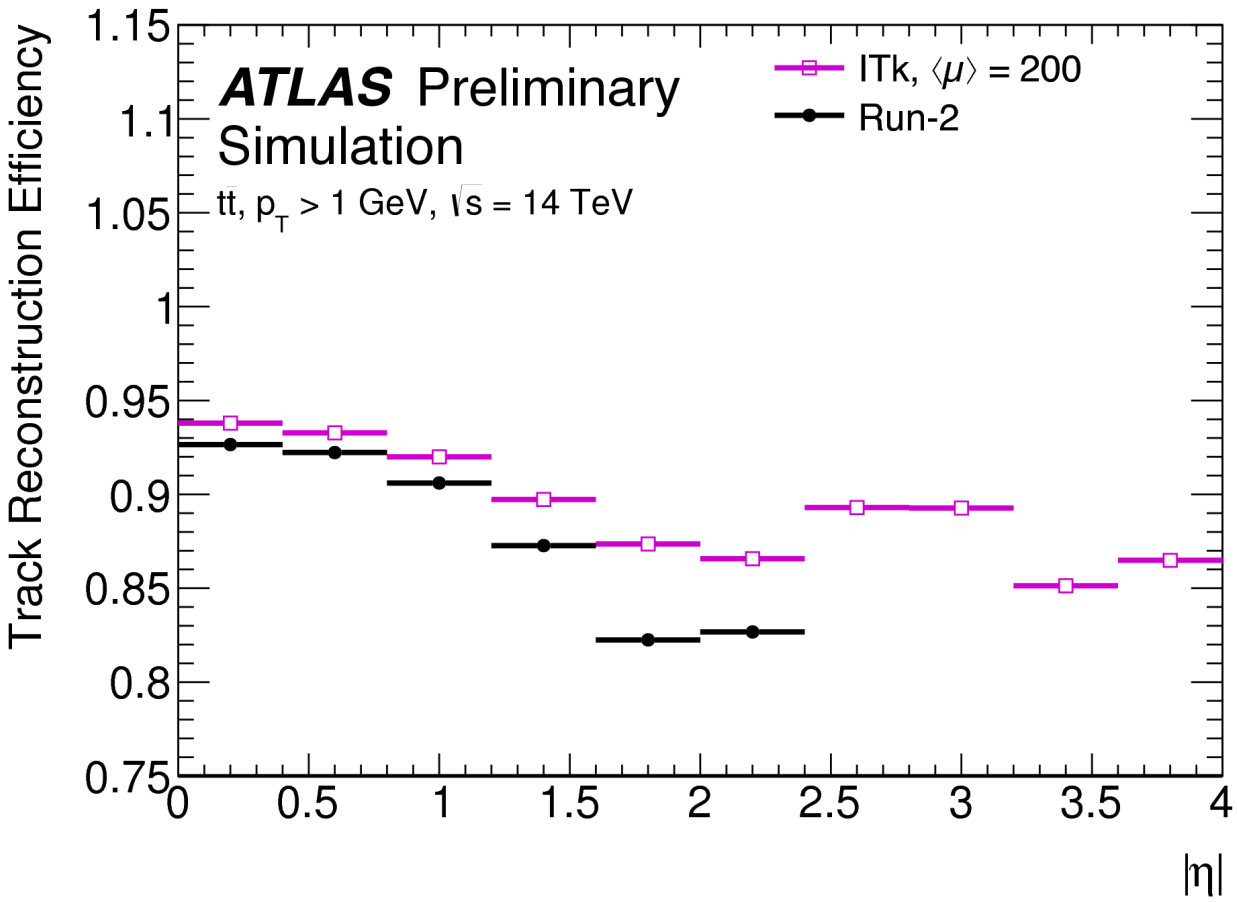
- Big project—just a proposal at this point
  - More than I can do on my own
  - Find out if others are interested to work on this
- Can use existing MC generation frameworks
  - Improved models from theorists would be welcome
- Close interaction with Instrumentation

Backup

Backup

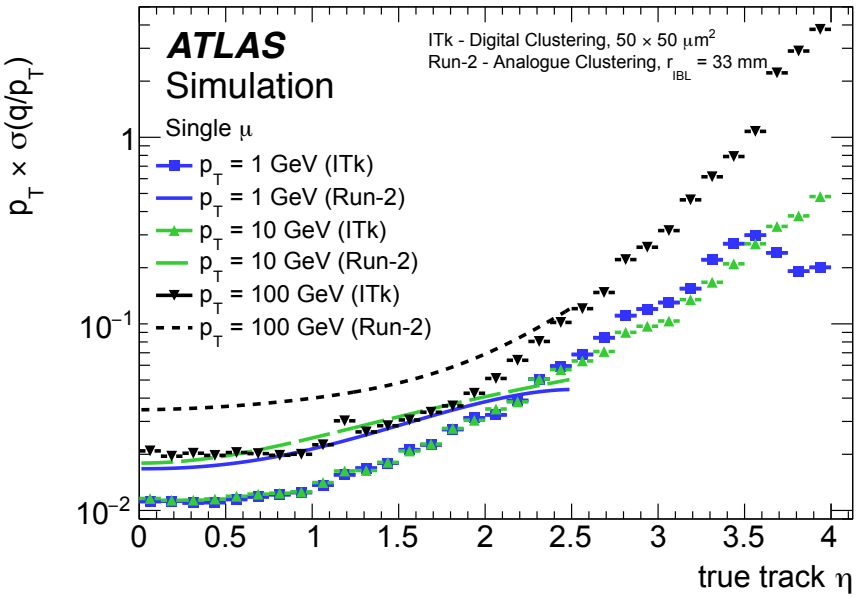

Events (L_{int} = 10 fb^{-1})
η [j_1]
η [j_2]
η [j_3]
η [j_4]
ssWW_SM
ssWW_FS0_8e-12
ssWW_FS0_1e-11
ssWW_FS0_2e-11
ssWW_FS0_3e-11
ssWW_FS0_4e-11
ssWW_FS0_5e-11
ssWW_FS0_6e-11

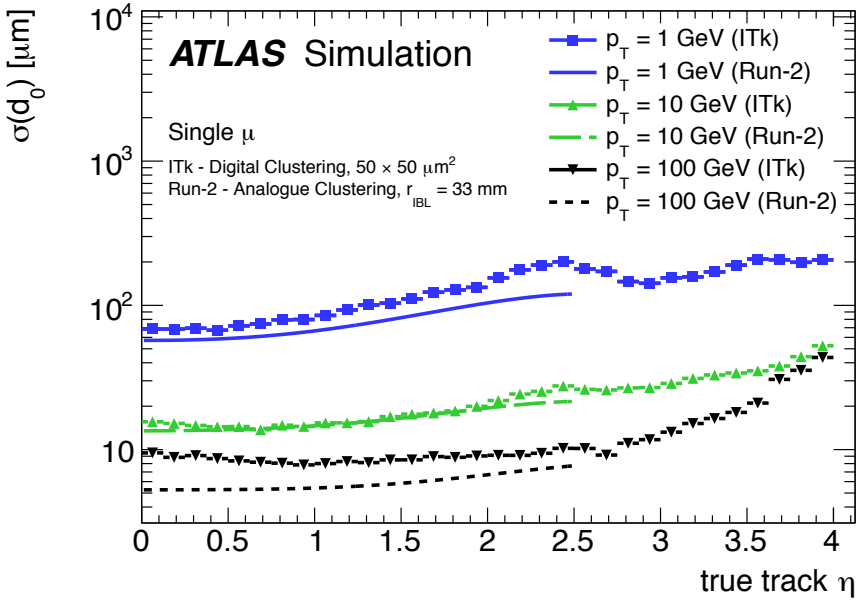
ATLAS HL-LHC Performance Benchmarks



- Track reconstruction efficiency is improved overall for both detectors
- Range extended to $|\eta| = 4$

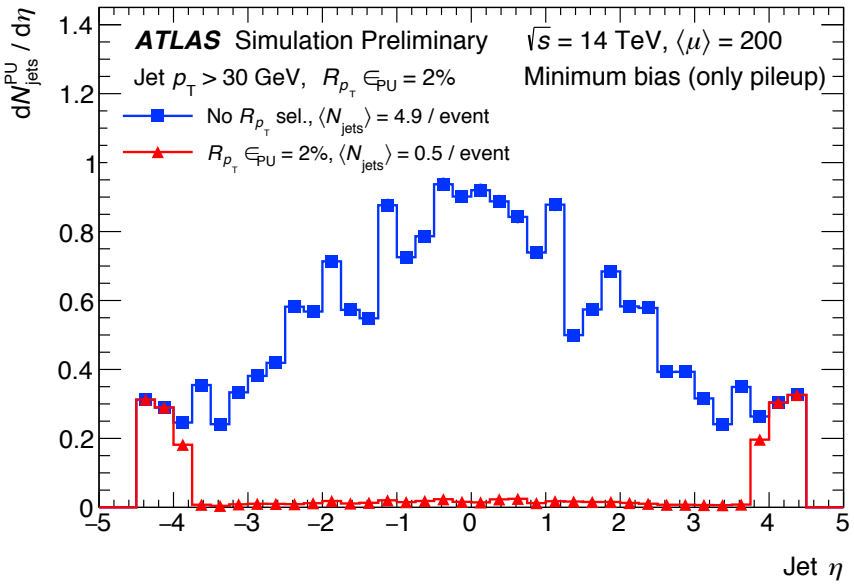
ATLAS-TDR-030

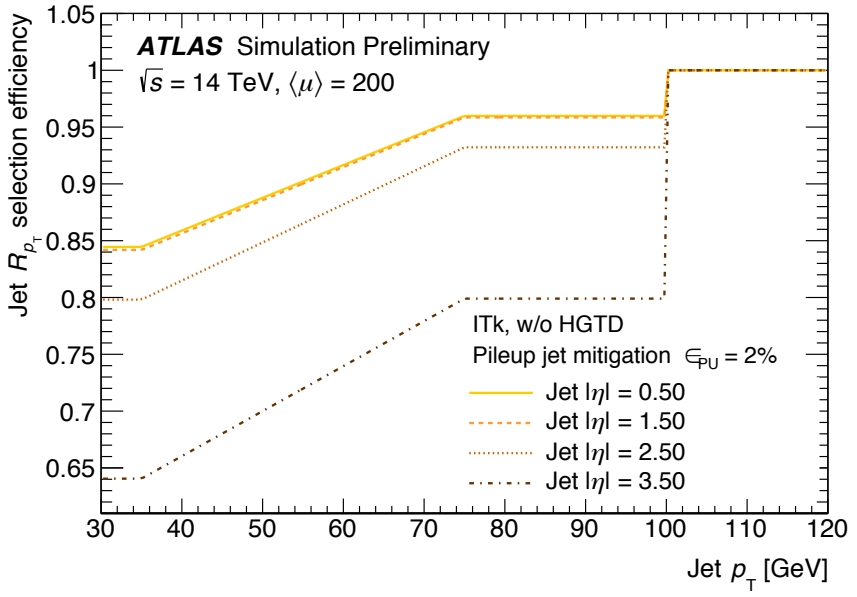




Yellow Report CERN-LPCC-2019-01

ATLAS HL-LHC Performance Benchmarks





- ITk and HGTD added to improve detector performance and mitigate pileup
- Jet R_{pT} is the fraction of the sum of p_T from hard scatter tracks divided by the jet p_T from the calorimeter

Yellow Report CERN-LPCC-2019-01