

$Z \rightarrow \tau\tau$ Embedding in ATLAS

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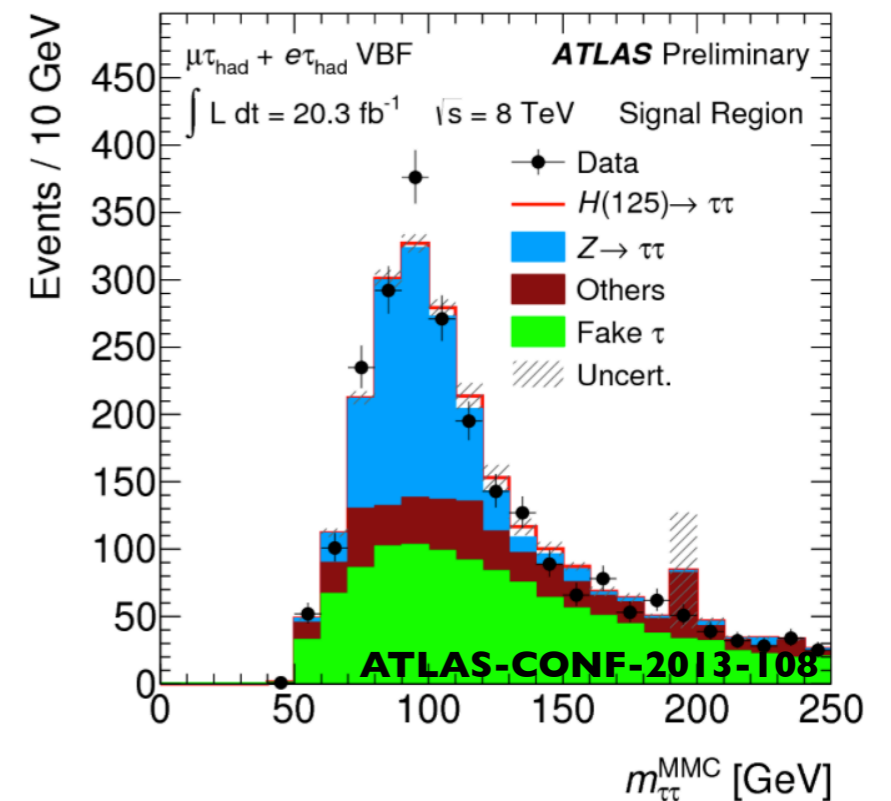
$m_{\tau\tau}$ workshop Hamburg

4.4.2014

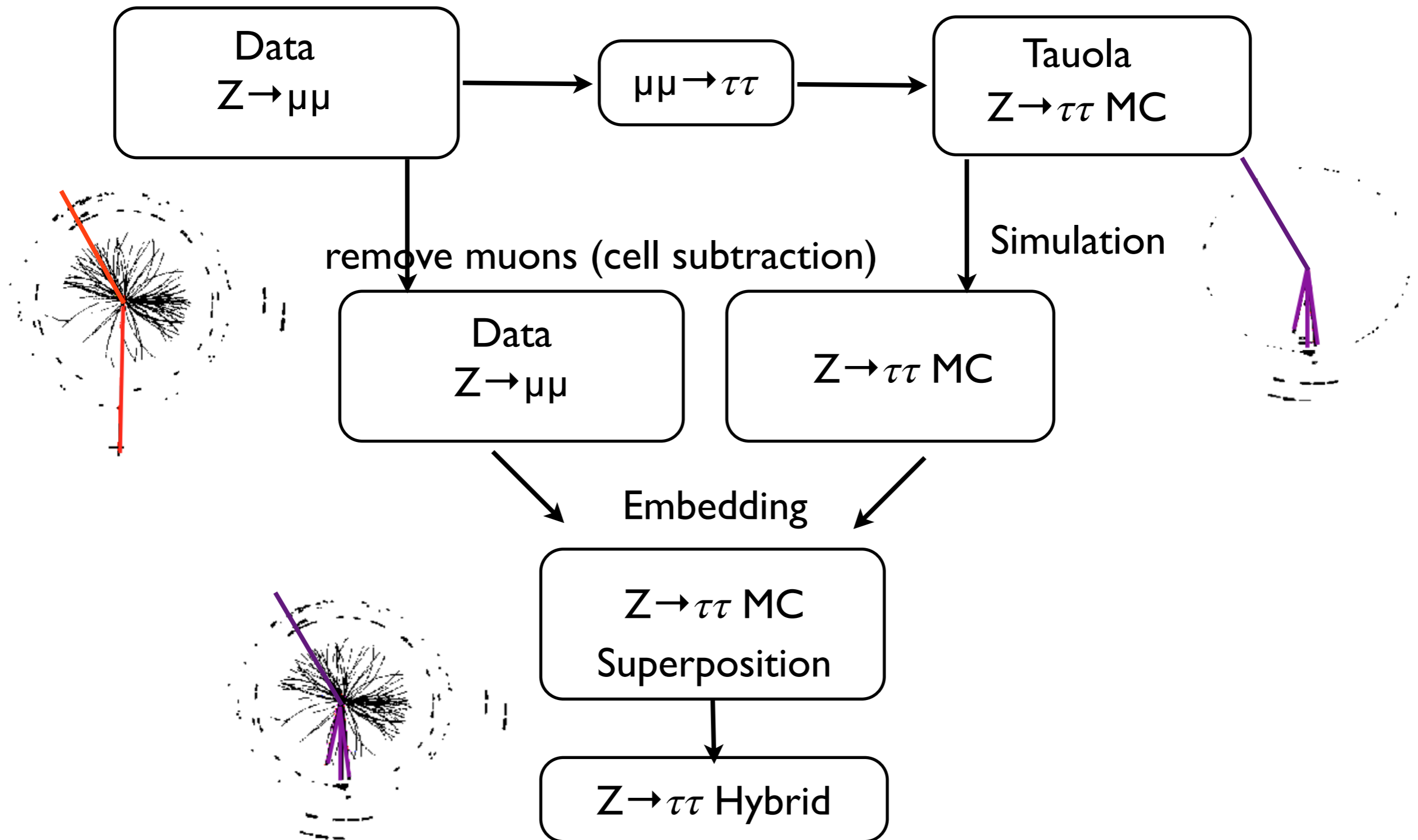


Motivation

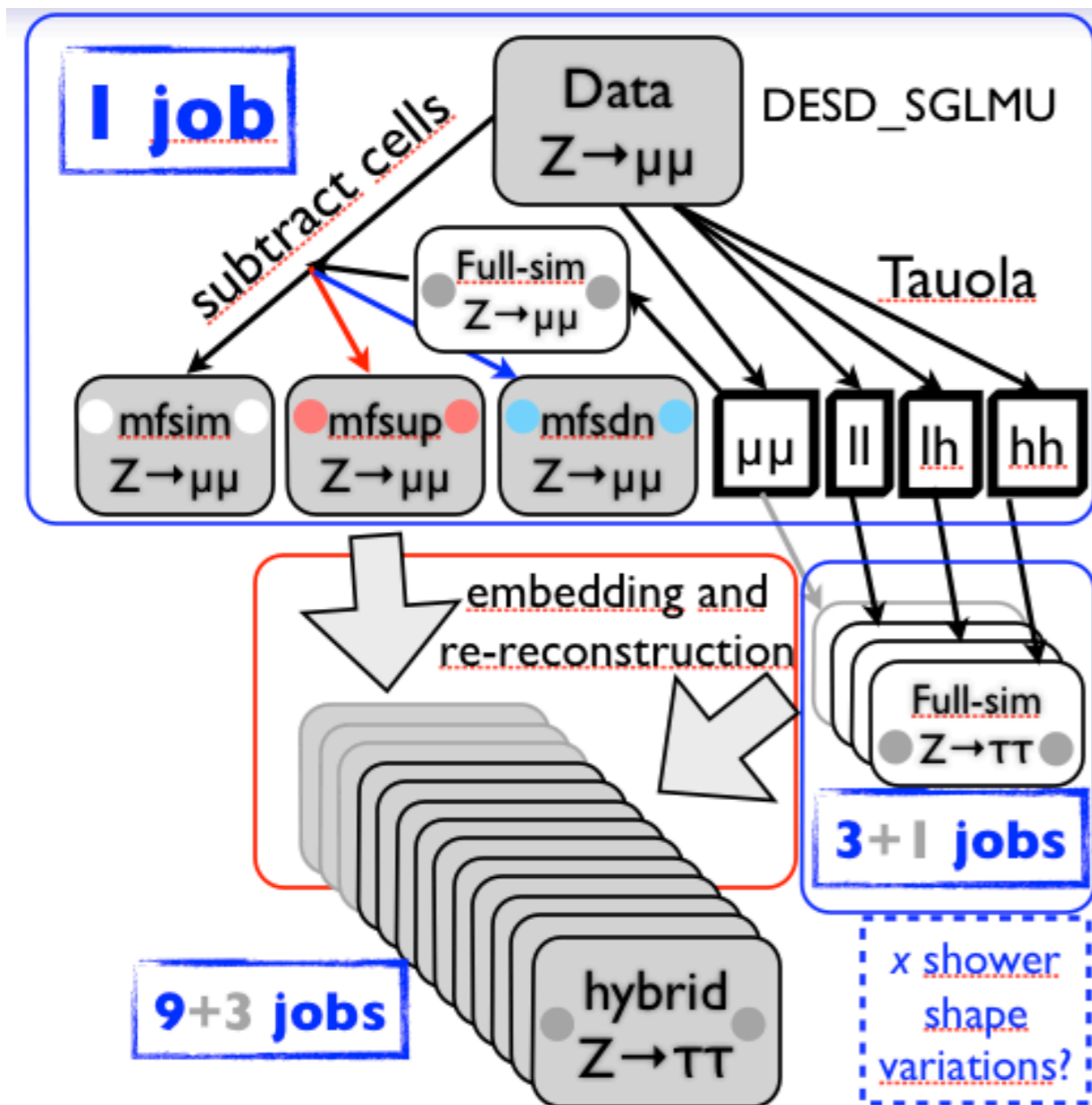
- $Z \rightarrow \tau\tau$ most important background for $H \rightarrow \tau\tau$ searches
- No signal-free $Z \rightarrow \tau\tau$ samples available from data
 - overlap with $H \rightarrow \tau\tau$ signal
- Large systematic errors if derived from MC (modelling of MET, jets)
- $Z \rightarrow \tau\tau$ background estimated using embedded samples
 - Advantage: no pile-up modelling necessary
 - Exploit that $Z \rightarrow \mu\mu$ has same decay kinematic
 - Very pure selection possible
 - Weak Higgs-to-muon coupling \rightarrow signal free selection



The embedding method



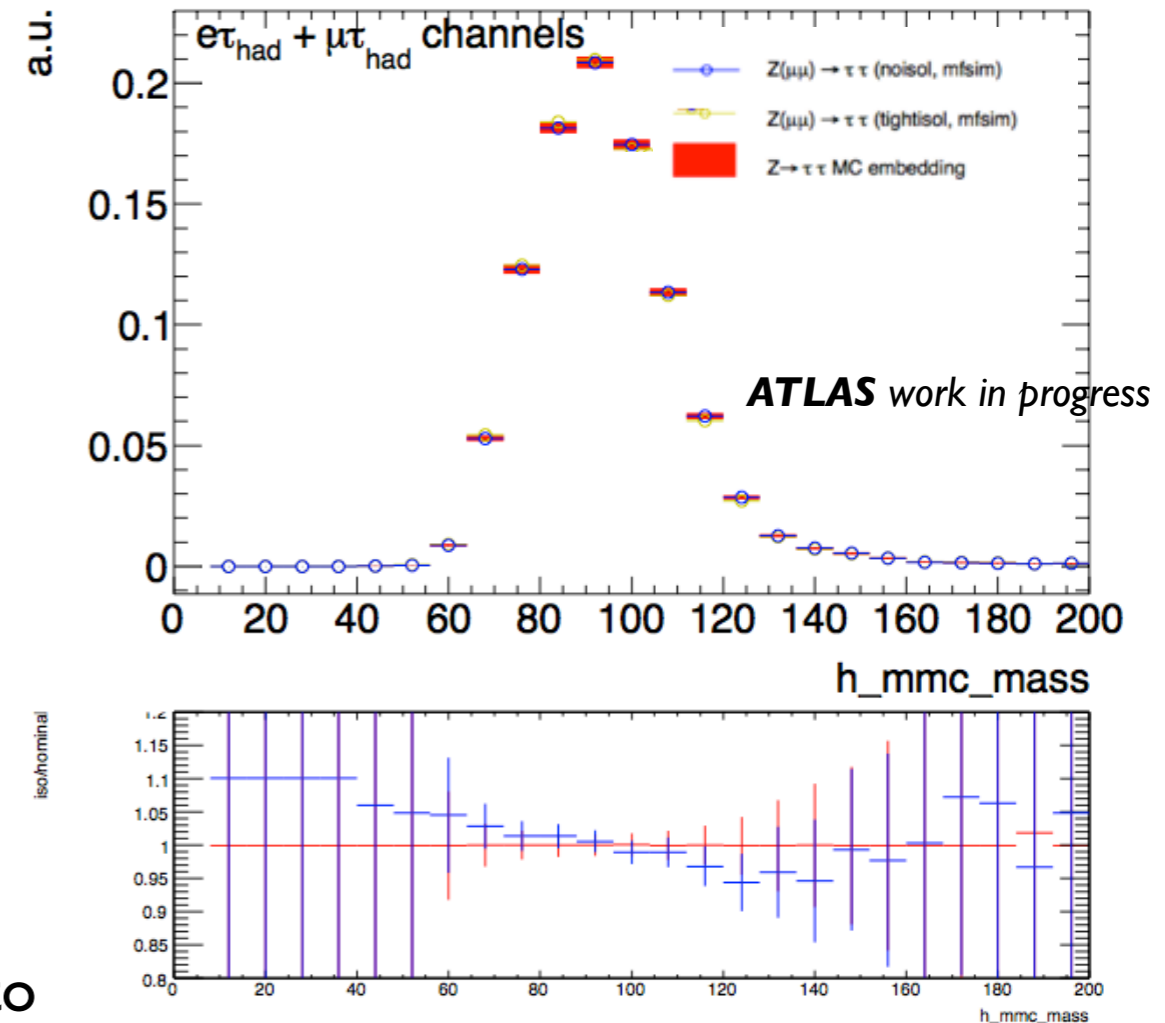
New workflow



- Successfully tested in last production round
- Transforms allow simultaneous production of outputs (nominal/systematics+validation)
 - Reusing intermediate files (more efficient)
 - Only necessary files produced depending on requested output

Isolation Systematics

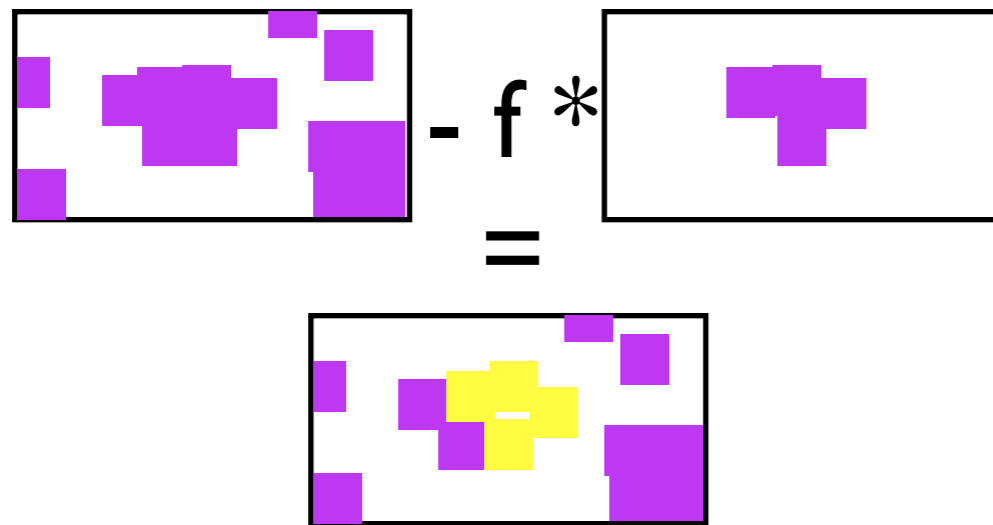
- Refers to $Z \rightarrow \mu\mu$ selection and muon objects to embed
- Isolation systematic covers
 - background contermination (ttbar) in $Z \rightarrow \mu\mu$ selection
 - effect of isolation on embedded muon objects
- Vary isolation requirement for muon preselection
- Information stored in truth container
 - Just need to run embedding once
 - Can modify isolation criteria also after productions
- Almost no difference between dn/nominal (0.1%) due to
 - SLT for $Z \rightarrow \mu\mu$ selection (includes isolation requirement)
 - Analysis preselection (events surviving presel. end up in nominal/up)



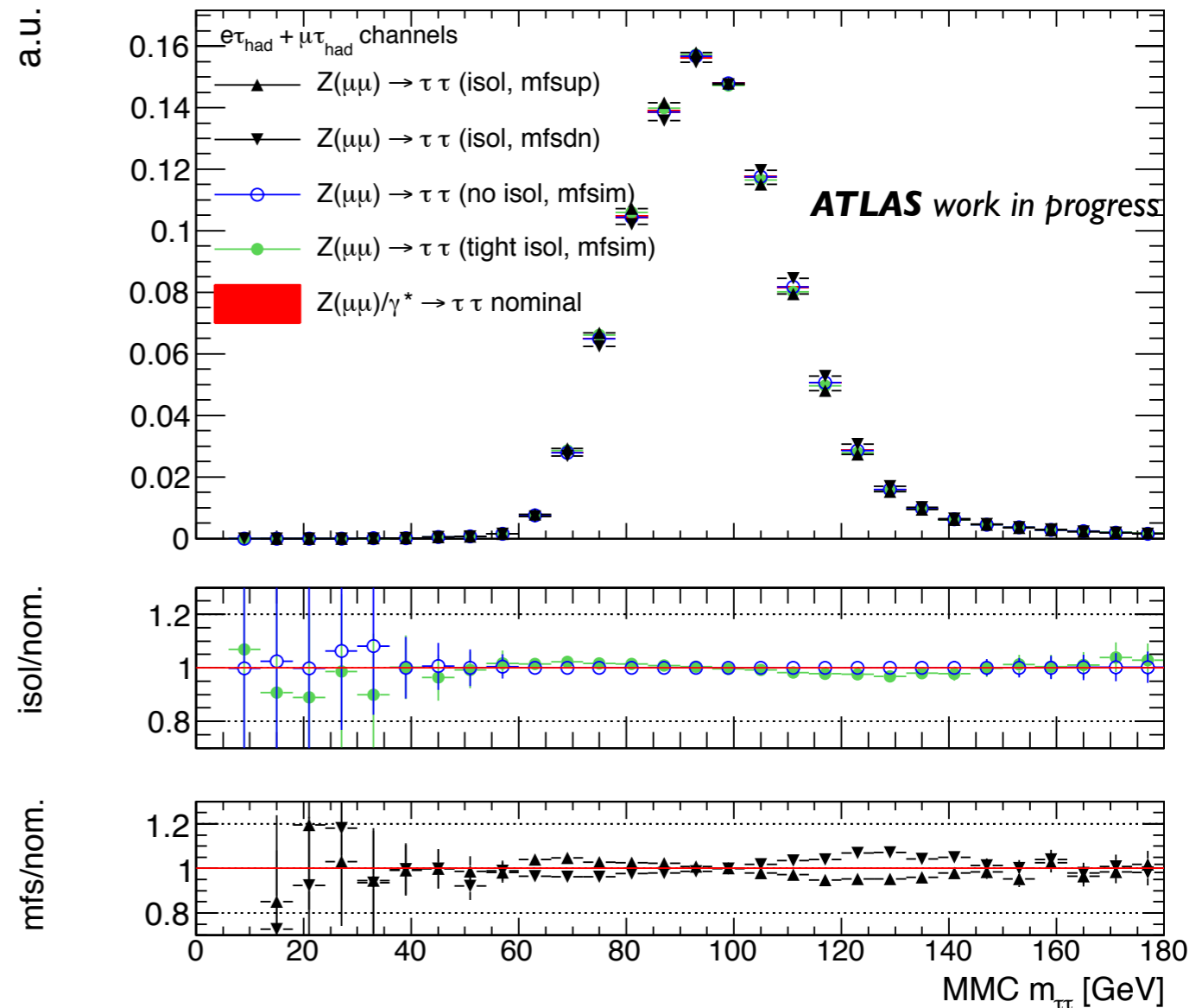
DN	nominal	UP
no iso	ptcone20/pt<0.2	ptcone40/pt<0.06 && etcone20/pt>0.04

Cell Subtraction Systematic

- Remove cell energy of original muons by subtracting cell energy of simulated $Z \rightarrow \mu\mu$ event (same kinematic) from original $Z \rightarrow \mu\mu$ data event



- Vary subtracted cell energy up/down by 20%
 - Effect seen best in lepton isolation variables
 - Up variation: subtracting 1.2 of cell energy \rightarrow less energy around embedded lepton (from tau decay)
 - Down variation: subtracting 0.8 of cell energy \rightarrow more energy around embedded lepton



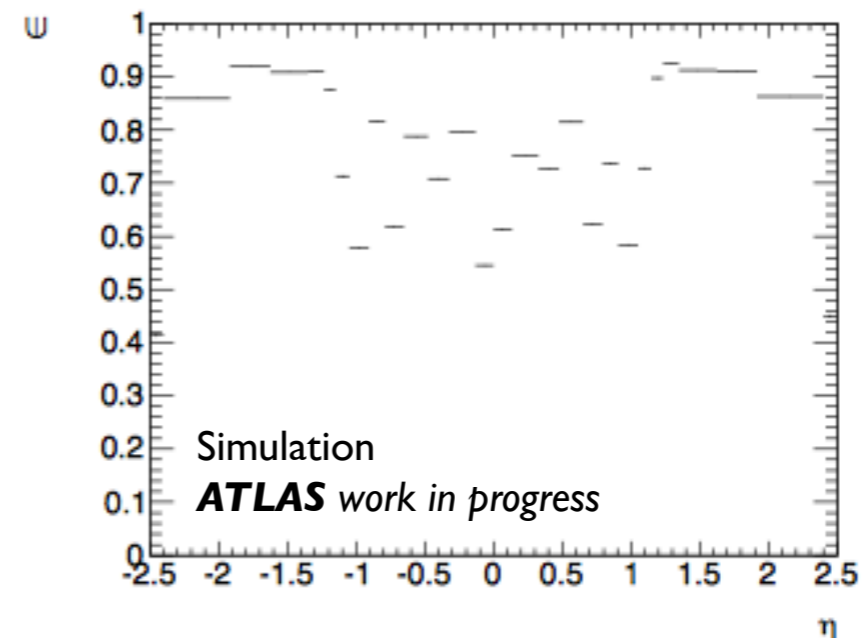
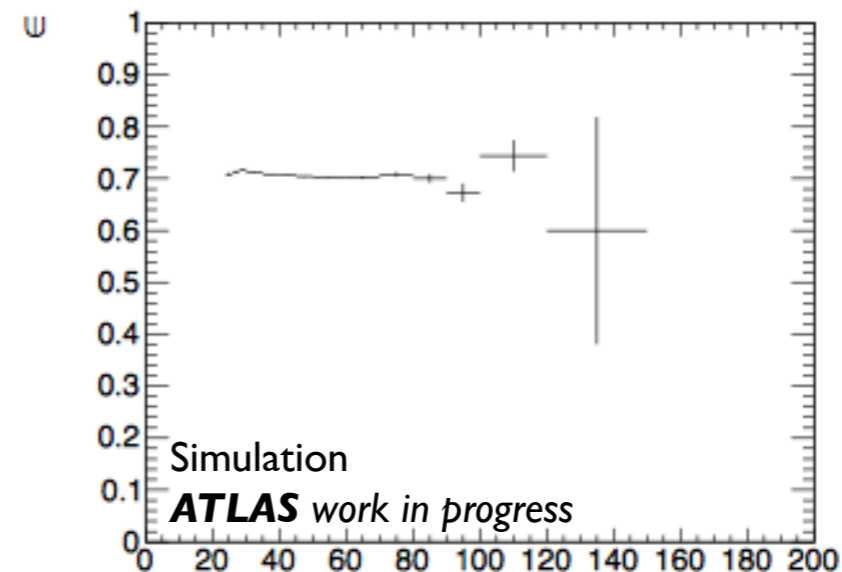
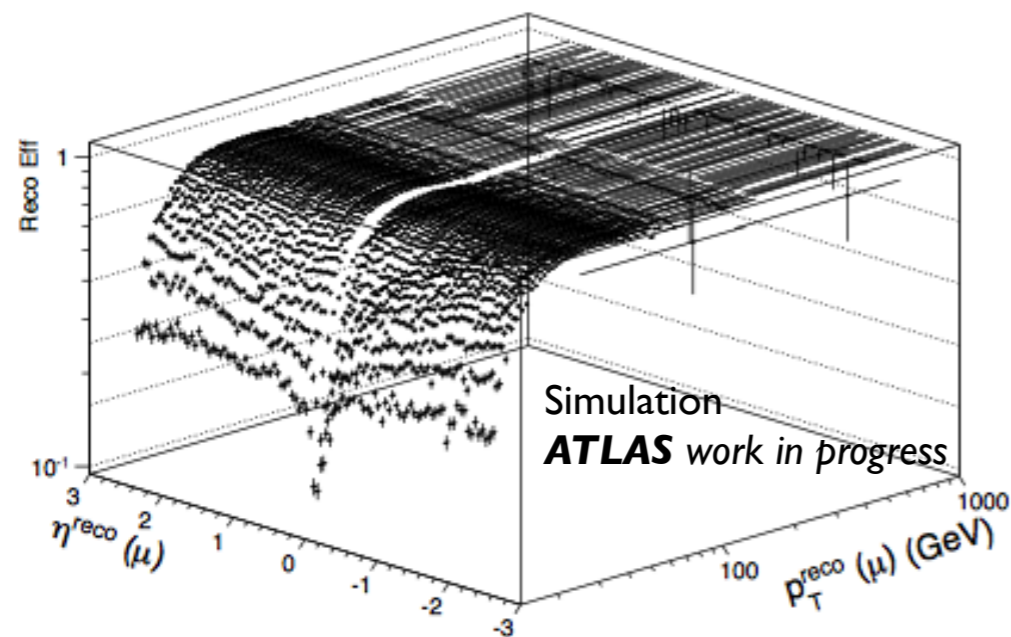
External embedding corrections

- **Reco Eff of original muons**
- **Trigger Eff of original muons**
- Exp B-Layer flag correction
- Analysis trigger emulation
- TauSpinner weight

Embedded samples biased due to $Z \rightarrow \mu\mu$ selection on data

- Muon trigger efficiency
- Muon offline reconstruction efficiency

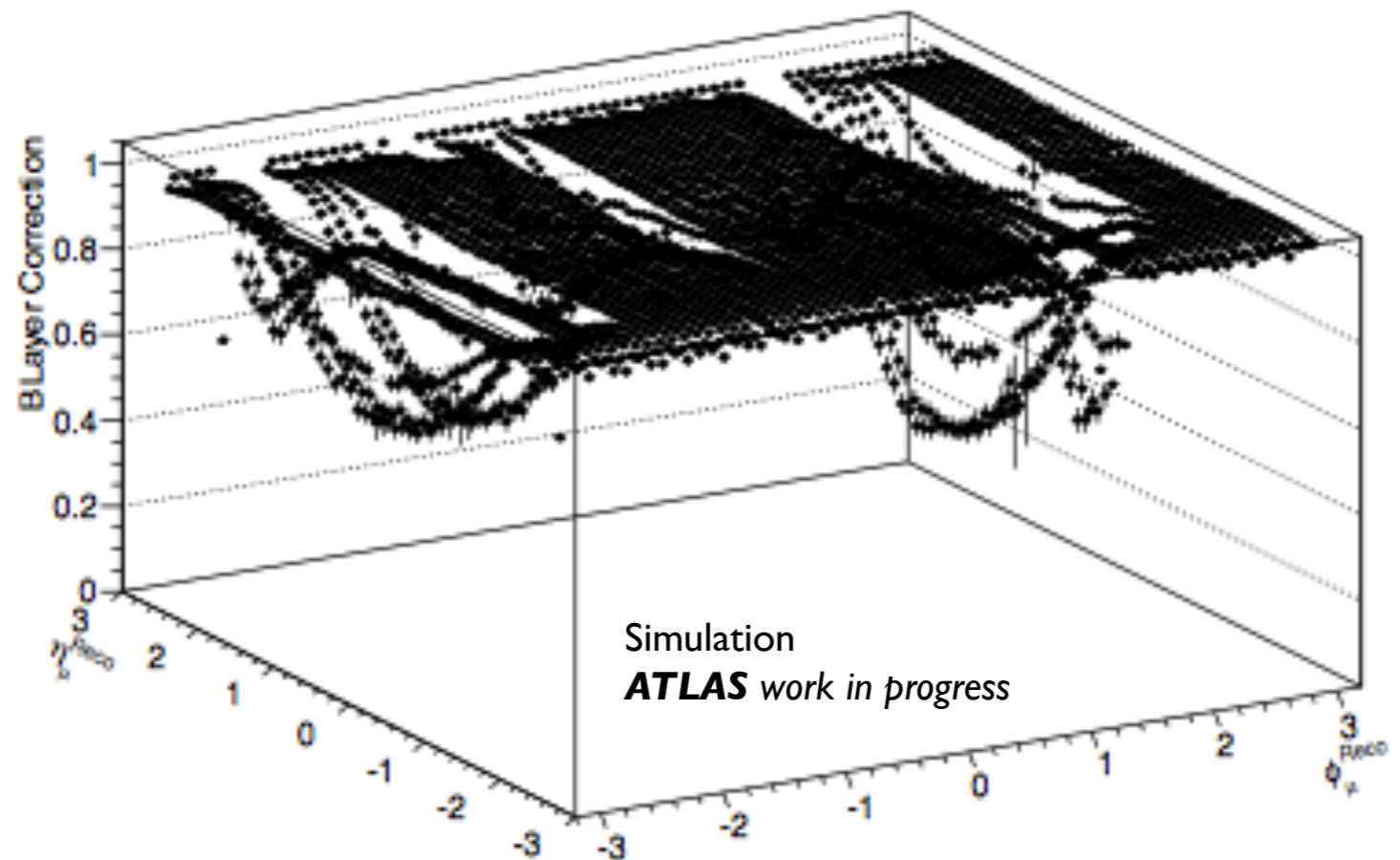
→ Efficiency correction needed



External embedding corrections

- Reco Eff of original muons
- Trigger Eff of original muons
- **Exp B-Layer flag correction**
- Analysis trigger emulation
- TauSpinner weight

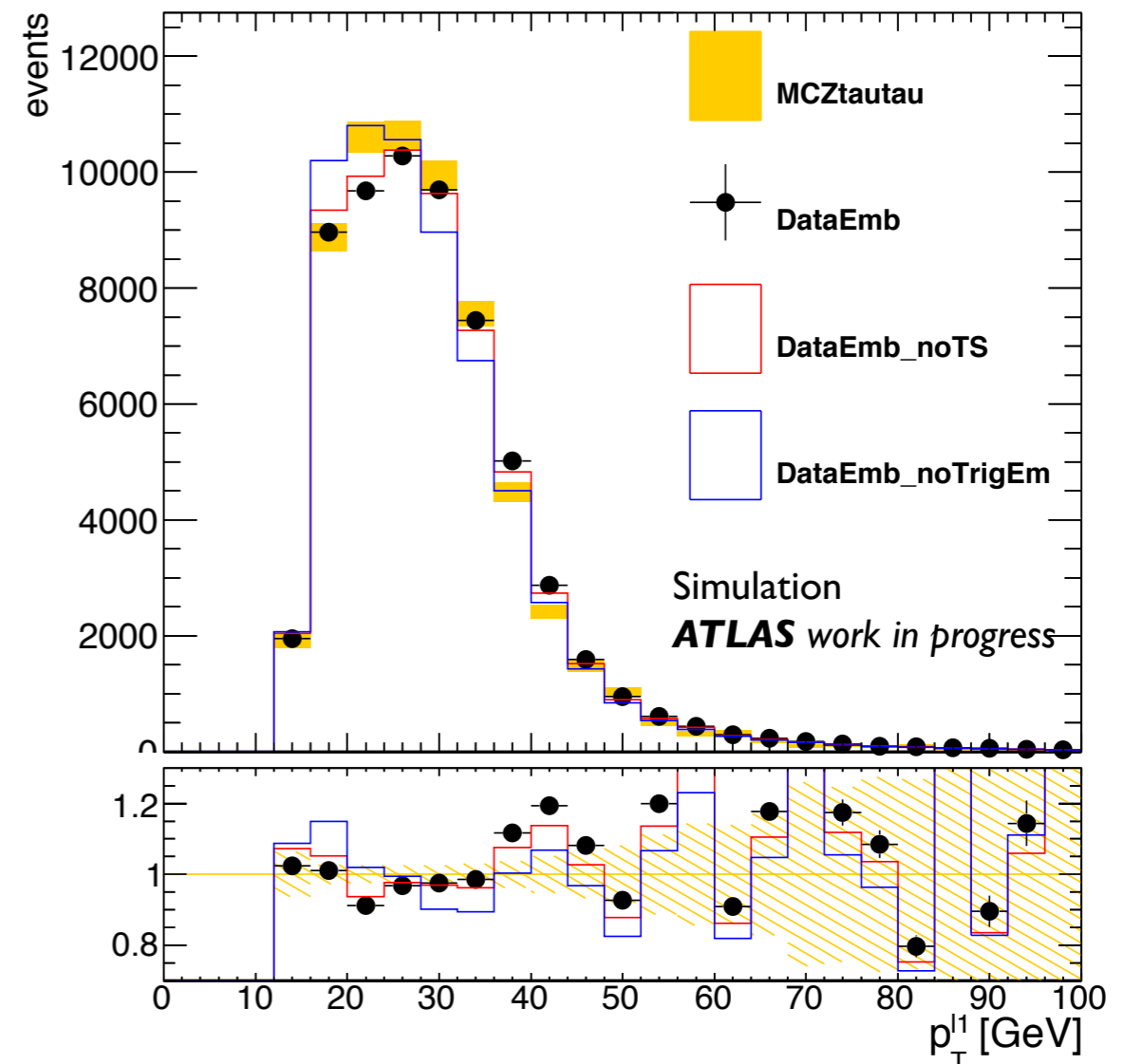
due to bug expected BLayer flag always set true
→ BLayer correction



External embedding corrections

- Reco Eff of original muons
- Trigger Eff of original muons
- Exp B-Layer flag correction
- **Analysis trigger emulation**
- TauSpinner weight

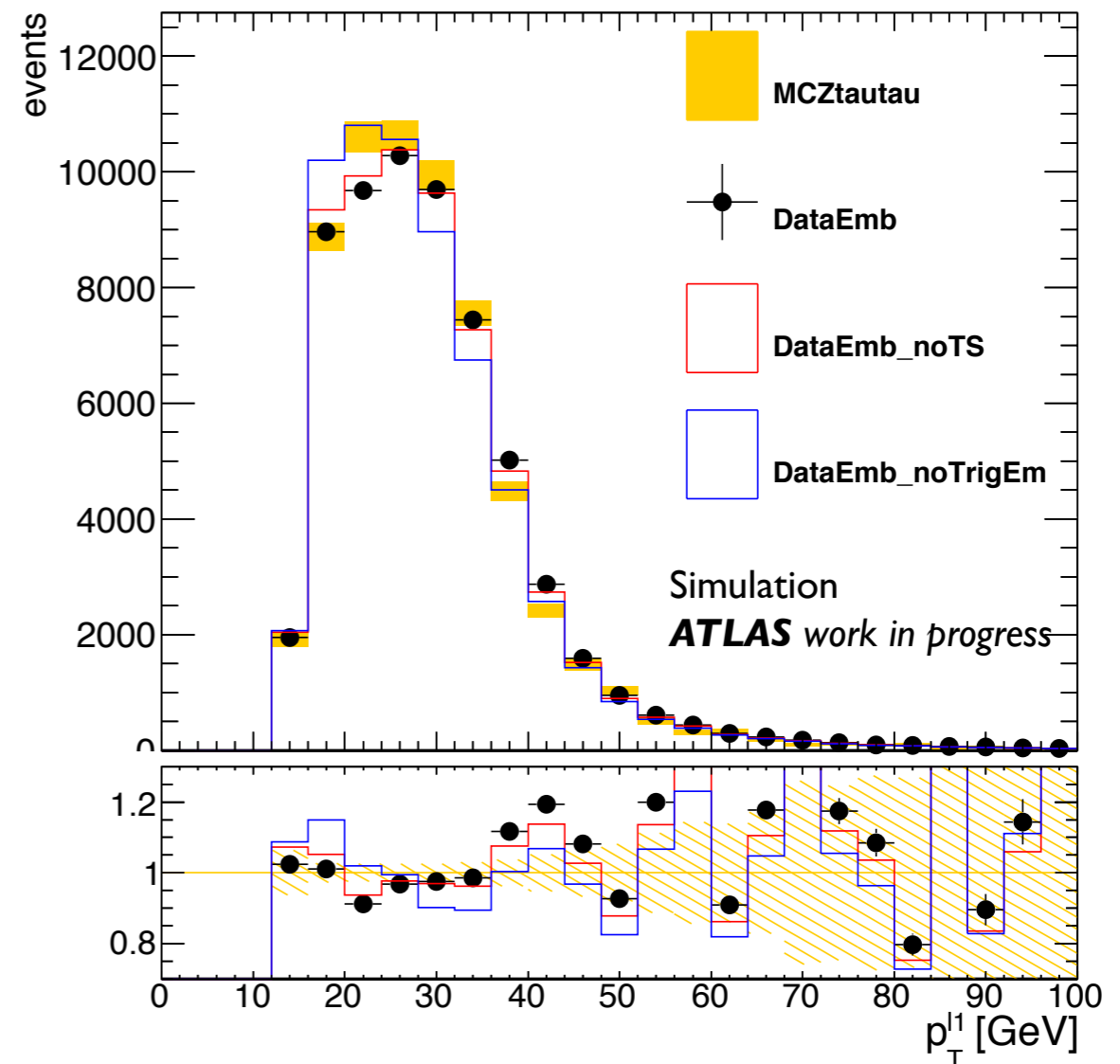
account for missing trigger information in embedding



External embedding corrections

- Reco Eff of original muons
- Trigger Eff of original muons
- Exp B-Layer flag correction
- Analysis trigger emulation
- **TauSpinner weight**

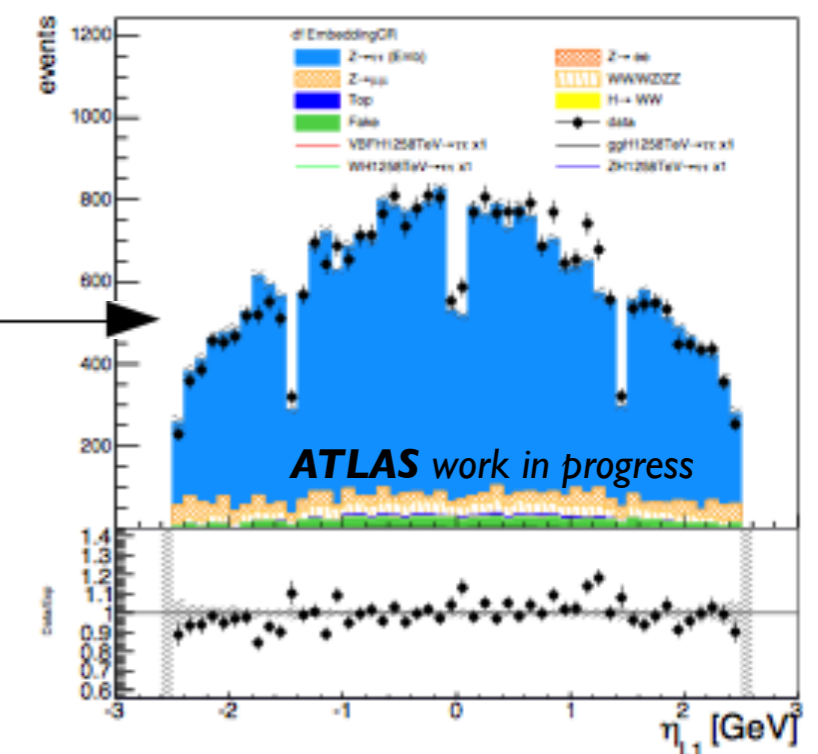
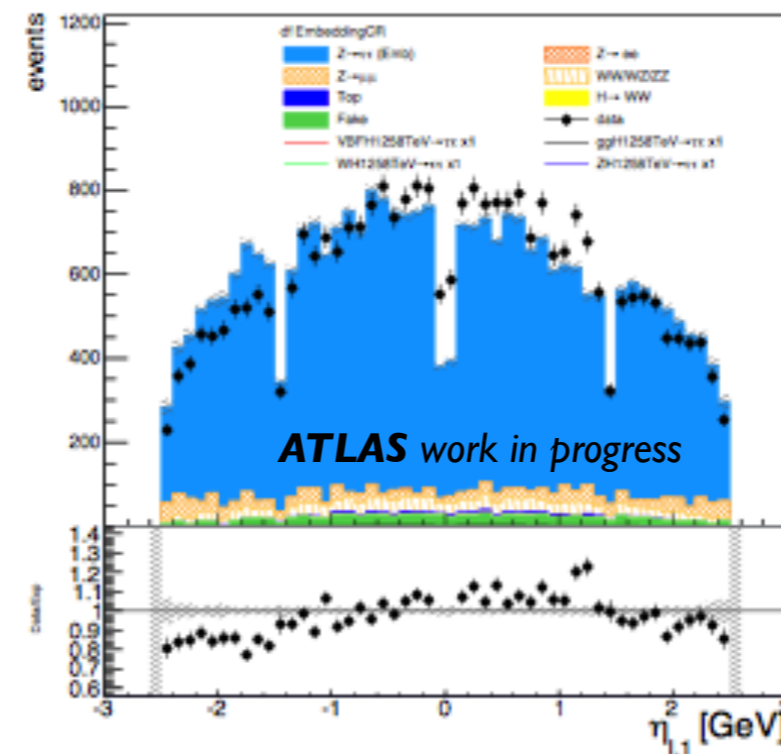
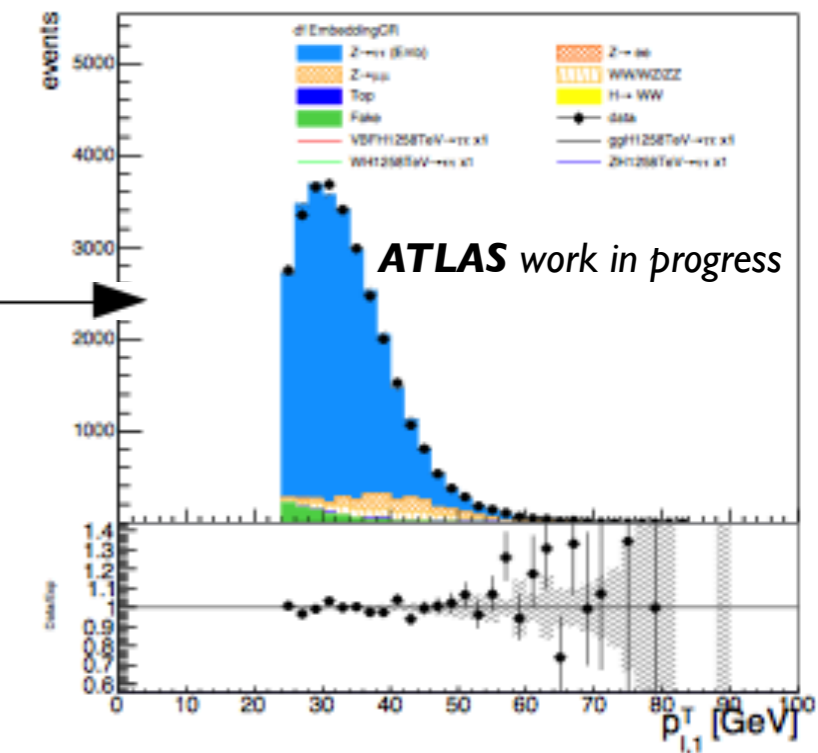
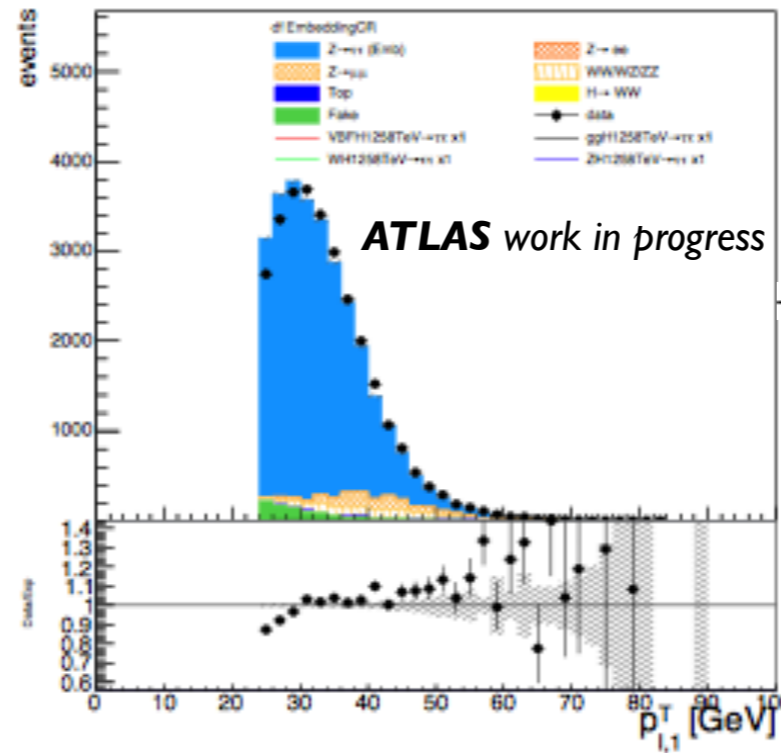
in embedding only spin correlations considered, not Z polarisation
→ correct spin effects



Performance of external corrections

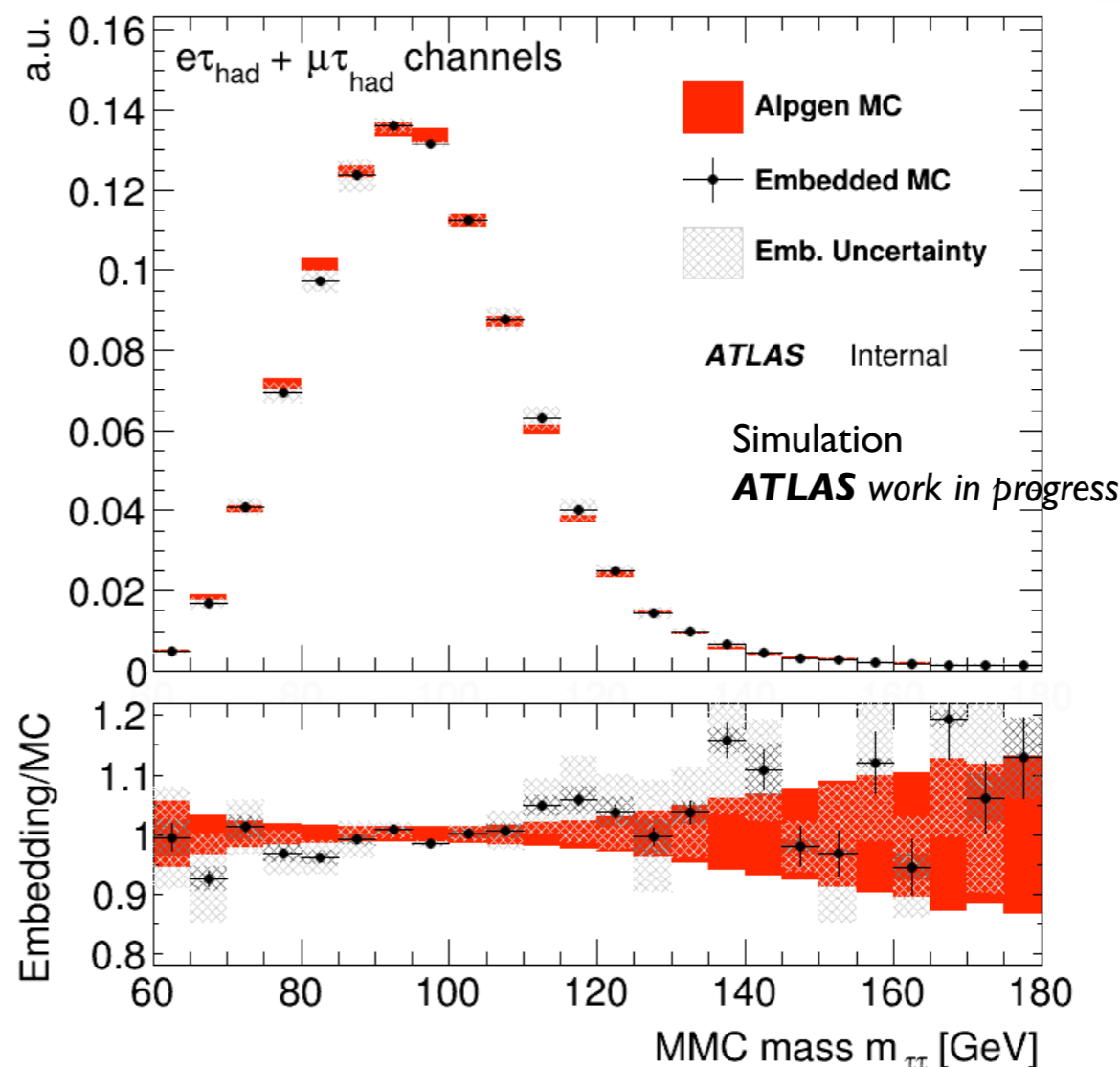
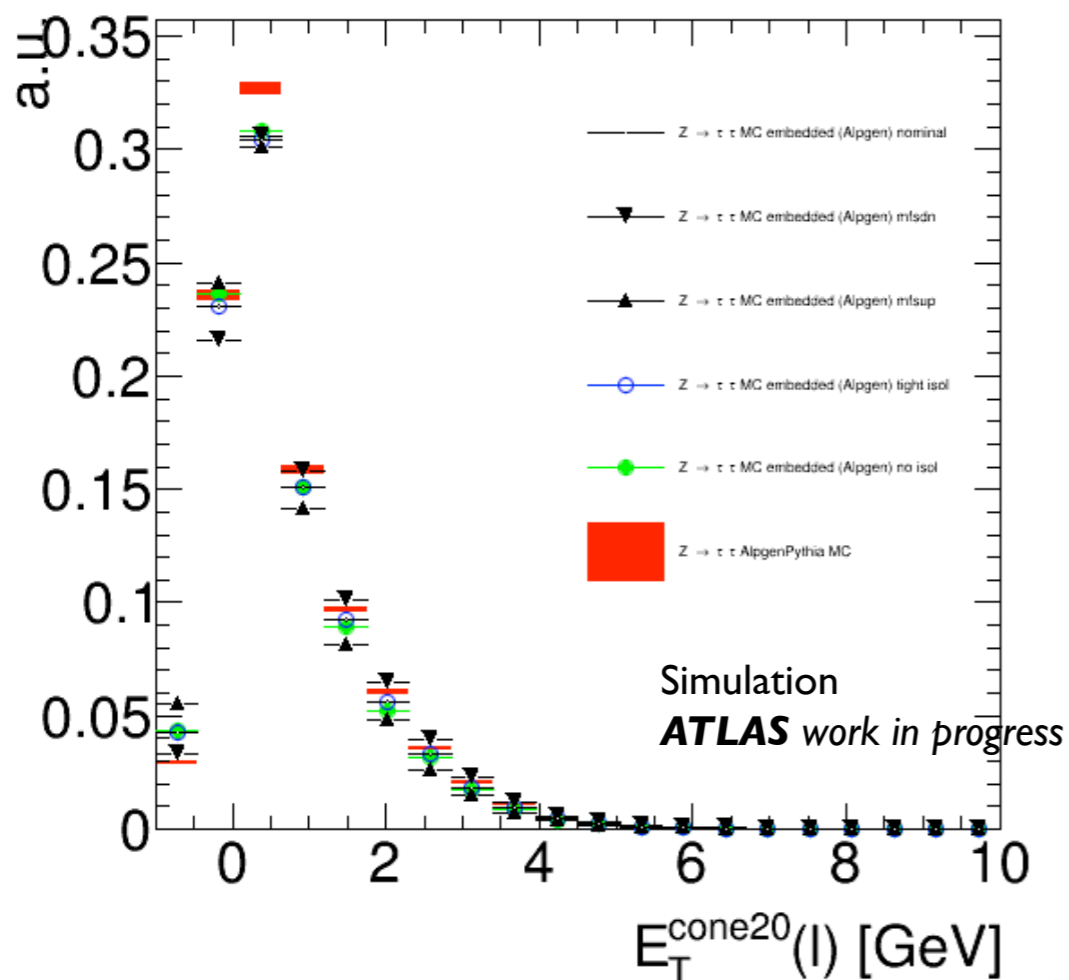
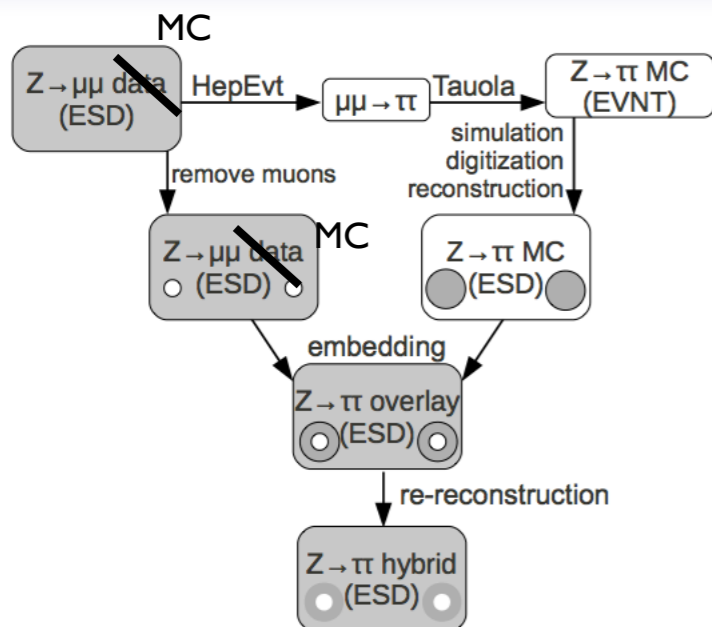
Performance of external corrections in Ztautau control region

- ▶ $40 < m_{e\mu} < 90$ GeV
- ▶ bVeto
- ▶ $p_T^{l1} > 24$ GeV and $p_T^{l2} > 20$ GeV
- ▶ $p_T^e + p_T^\mu + \sum p_T^j + E_T^{miss} < 150$ GeV
- ▶ $\cos \Delta\phi(E_T^{miss}, e) + \cos \Delta\phi(E_T^{miss}, \mu) > -0.7$



Good agreement with data after
applying corrections

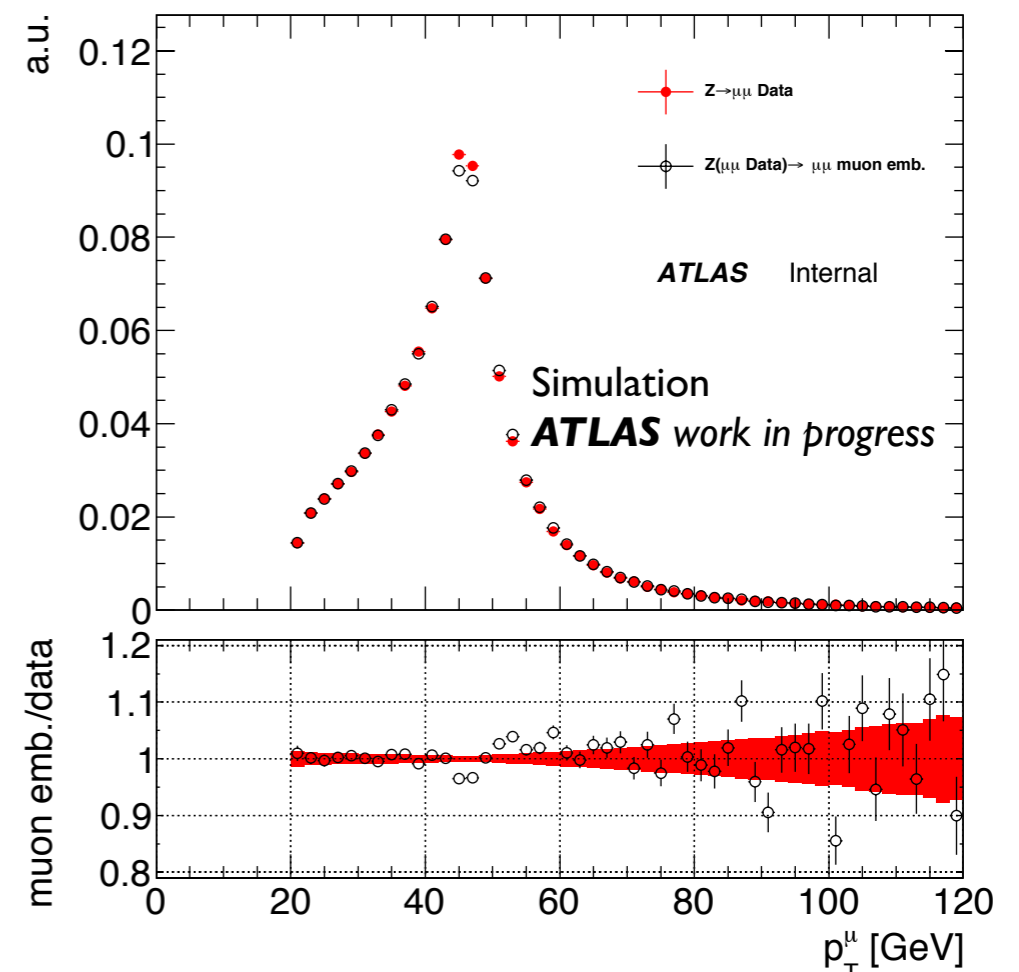
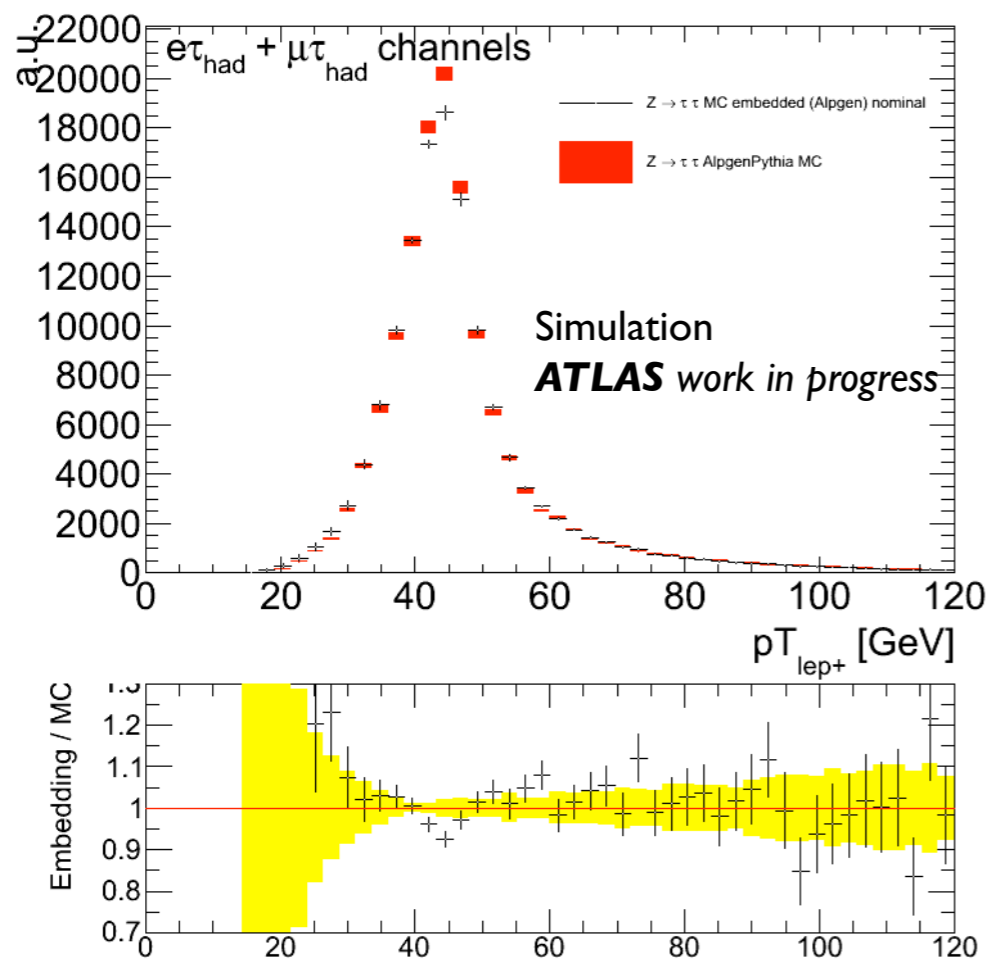
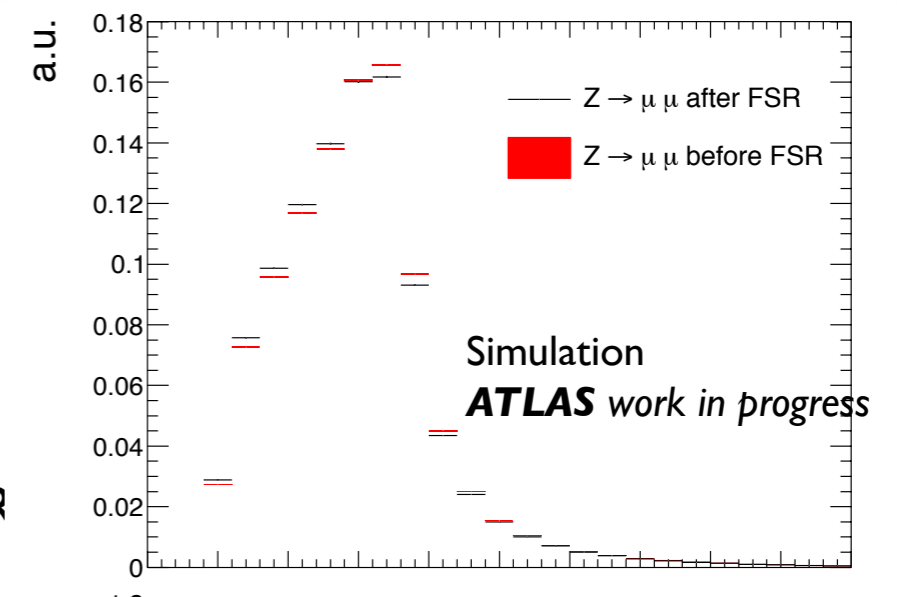
MC closure check



- Use $Z \rightarrow \mu\mu$ MC instead of data as input
 - Apple to apple comparisons between MC embedding/Pythia MC
 - Provided same simulation conditions
- Check if MC embedding matches with $Z \rightarrow \tau\tau$ MC within systematic uncertainties

Final state radiation

- effects from modification of input muon kinematic due to FSR
- not obviously negligible but...
 - a) MC closure \rightarrow effect already covered by embedding related systematics
 - b) differences between tau embedded Zmumu MC default Ztautau MC at generator level mostly compatible with muon momentum resolution
 - other differences compatible with systematics shift due to FSR restricted to low tails with sizeable systematics uncertainties

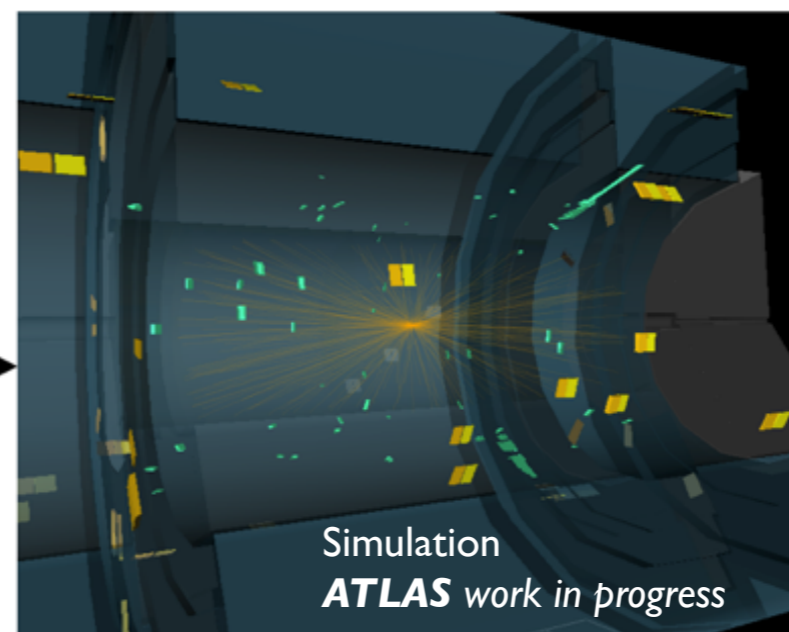
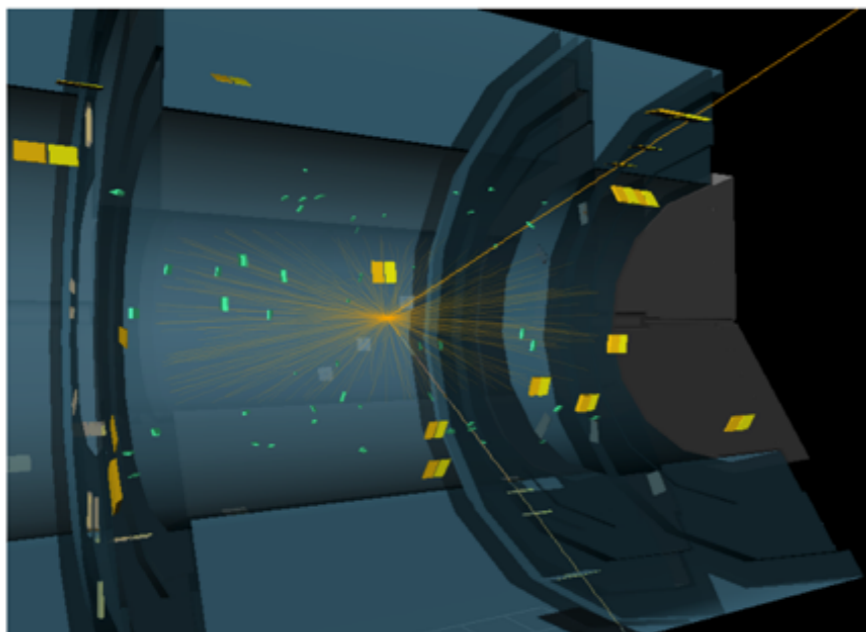
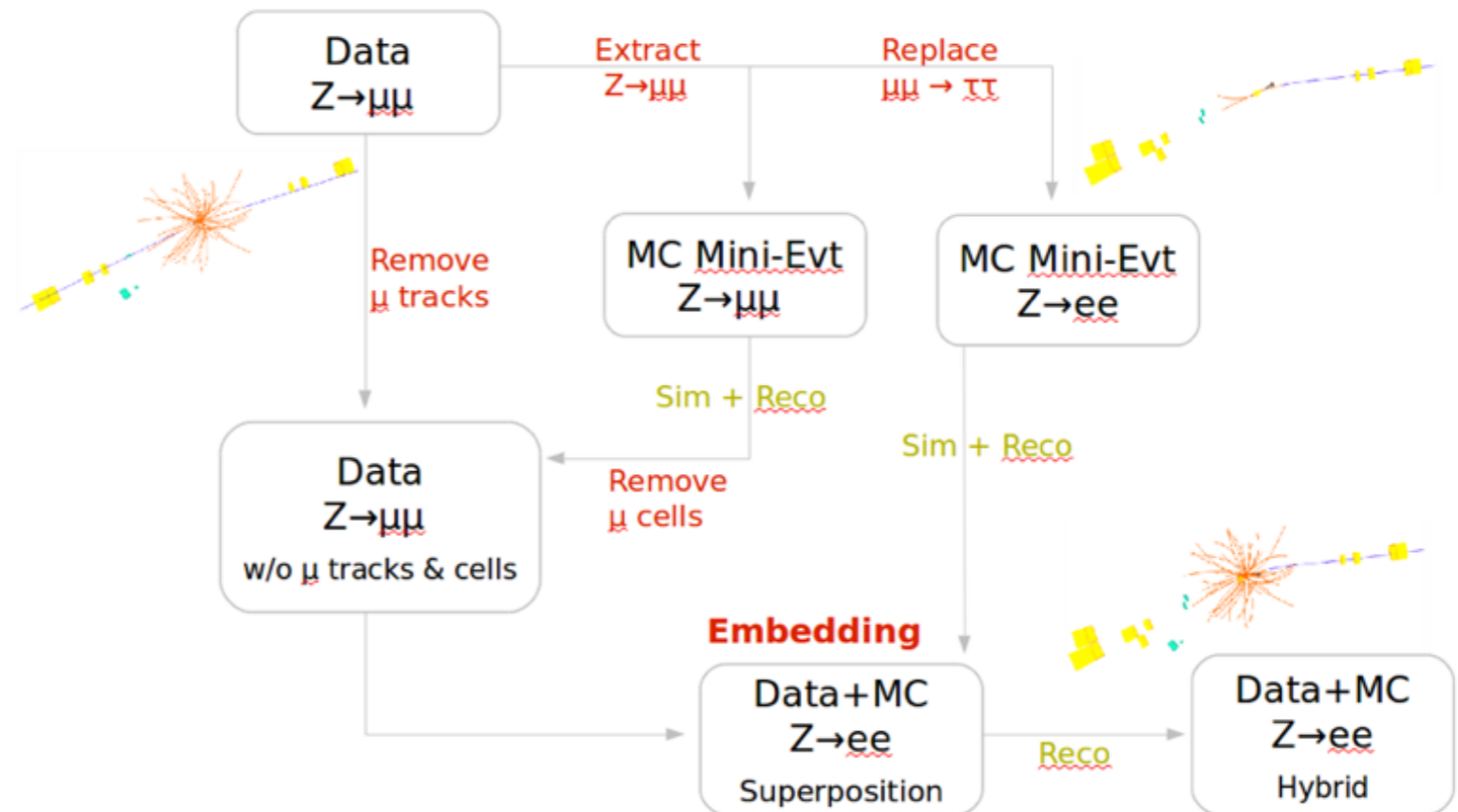


Electron embedding

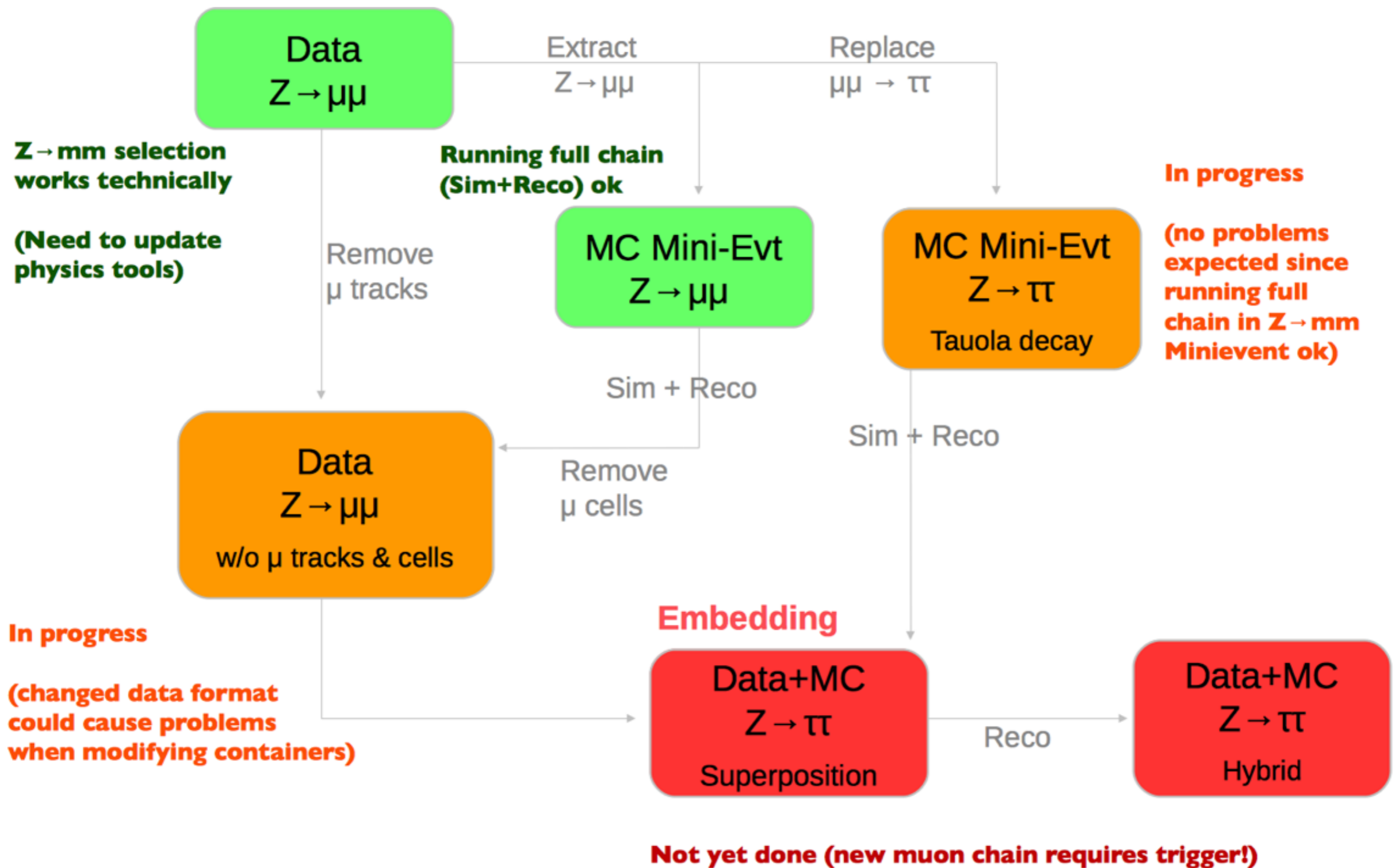
- Additional cross-check of embedding method:

*Data/MC Zee vs
Data/MC Zmm → ee embedding*

- Good validation sample for external corrections
- Work in progress



Preperation for run2



Summary

- **Systematic uncertainties**

- Isolation systematic
- Cell subtraction systematics
- FSR effects compatible with muon smearing effects

- **Finalized MC closure test**

- Differences between MC embedding/MC covered by systematics

- **Embedding corrections & their performance**

- **Preparations for run2 ongoing**

- Electron embedding
- Software migration

Backup

The embedding method

