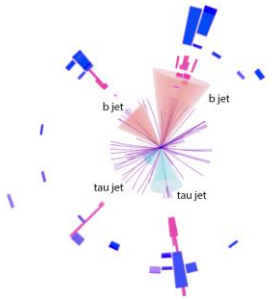
GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN IN PUBLICA COMMODA SEIT 1737

ATLAS EXPERIMENT



Trigger Optimization studies at the ATLAS search for $hh \rightarrow b\bar{b}\tau^{-}\tau^{+}$ channel

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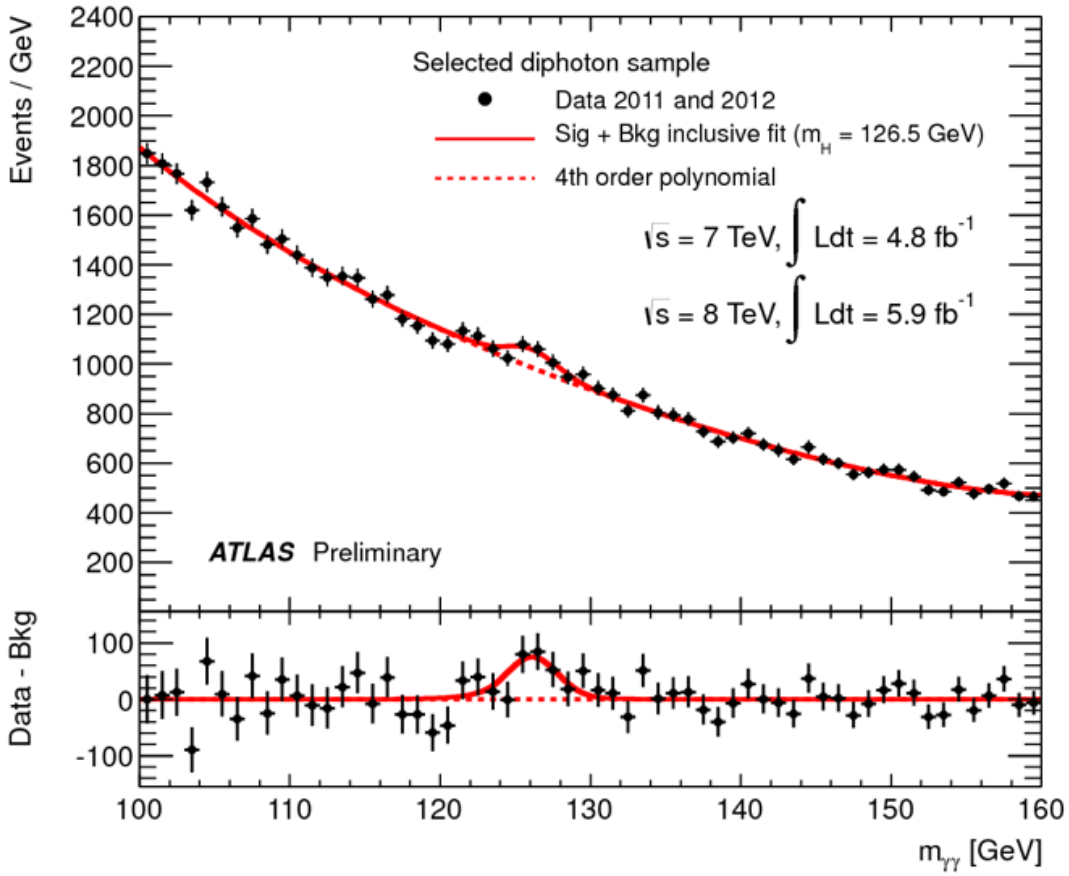
Supervised by

Stan Lai

The Higgs Boson

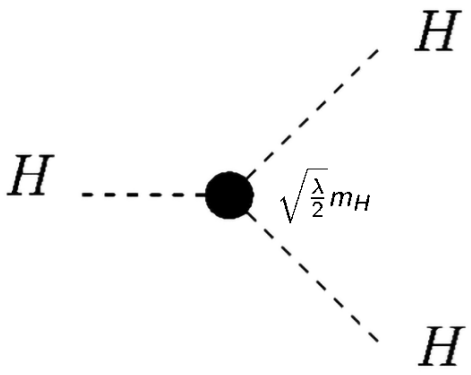
- A Spin 0 scalar particle in the Standard Model, theorized in the 1960s
- Observed in 2012 at the Large Hadron Collider
- Responsible for generating the mass of fundamental particles without local gauge symmetry violation

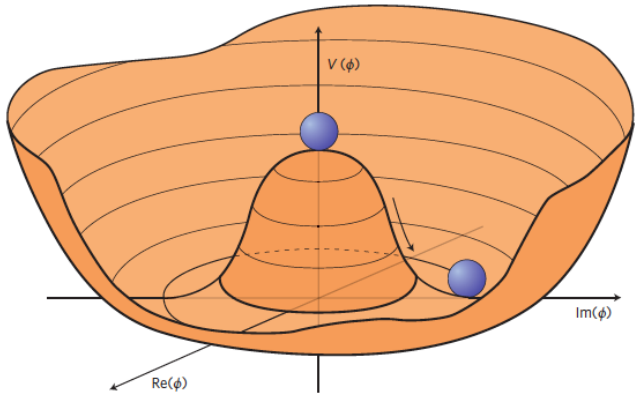


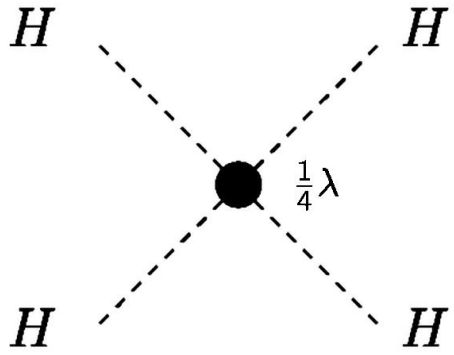
Why Di Higgs ?

$$V_{SM}(\Phi) = -\mu^2(\Phi^*\Phi) + \lambda(\Phi^*\Phi)^2$$

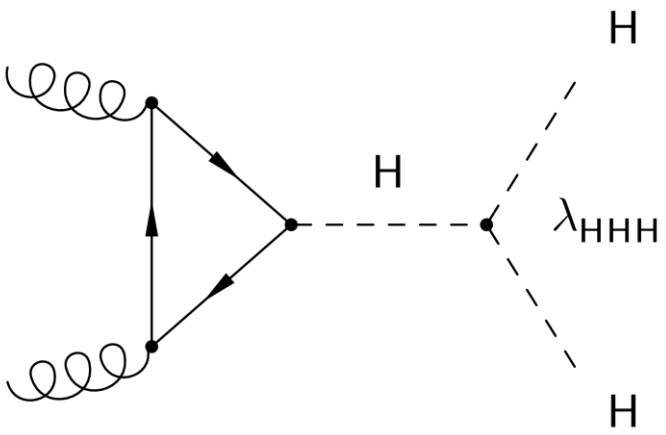
$$V_{SM}(\Phi) \overset{\phi \to v+h}{\supset} \tfrac{1}{2}m_H^2 h^2 + \sqrt{\tfrac{\lambda}{2}}\overset{?}{m_H} h^3 + \tfrac{1}{4}\overset{?}{\lambda} h^4$$







Di Higgs at LHC

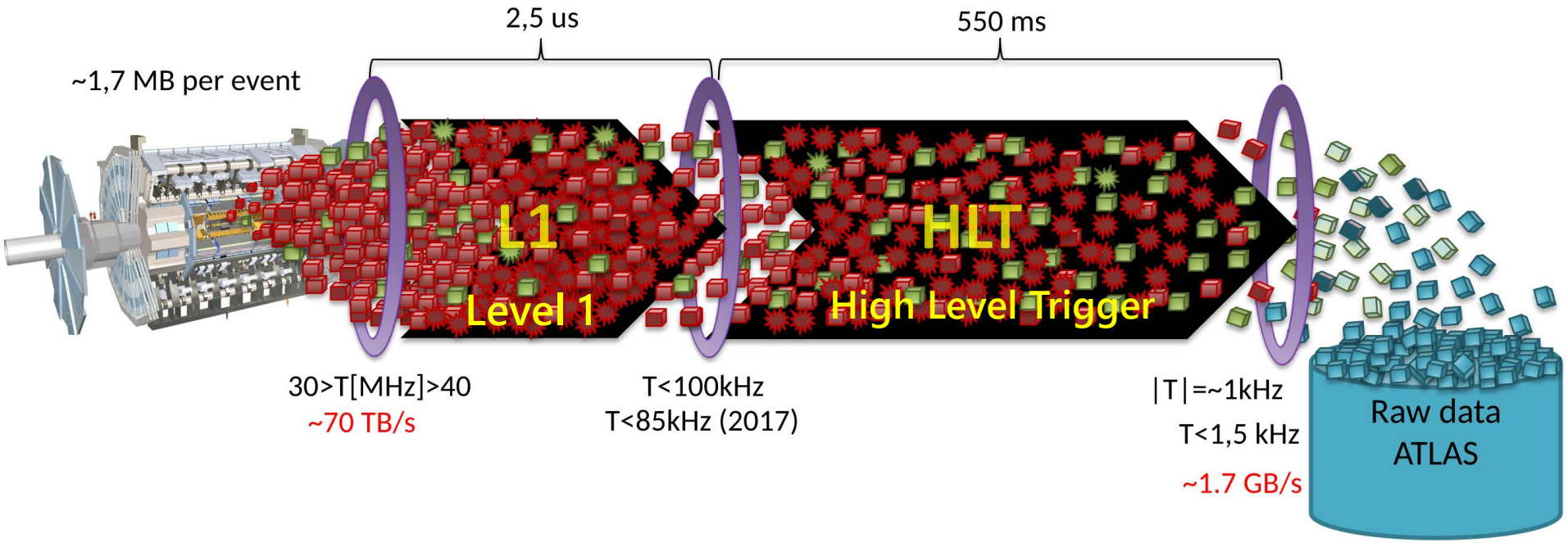


$$\sigma_{ggf}^{SM} \approx 31.05^{+1.41}_{-1.99}\text{fb}$$

	bb	WW	ττ	ZZ	γγ
bb	34%				
WW	25%	4.6%			
ττ	7.3%	2.7%	0.39%		
ZZ	3.1%	1.1%	0.33%	0.069%	
γγ	0.26%	0.10%	0.028%	0.012%	0.0005%

$bb\tau\tau$: Moderate Background and Branching fraction

Managing The Data Avalanche

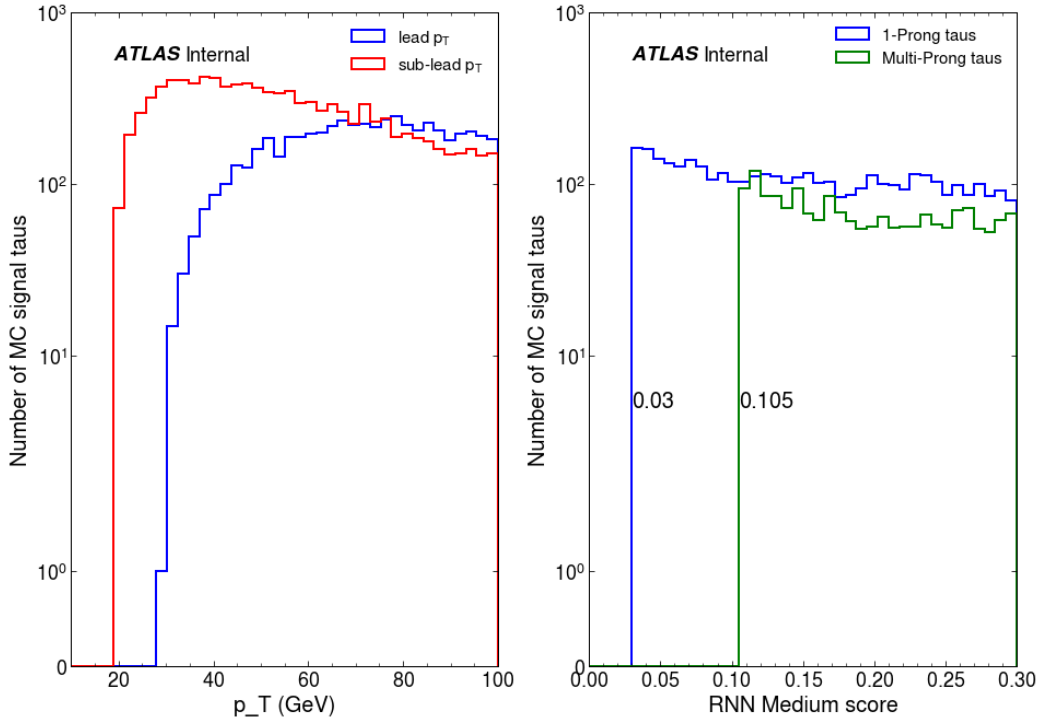


Focus on $b\bar{b}\tau^{-}_{had}\tau^{+}_{had}$ triggers for this analysis

Sifting Di Higgs with HLT$_{\text{L1Topo}}$

HLT_tau30_mediumRNN_tracktwoMVA_tau20_mediumRNN _tracktwoMVA_03dRAB30_L1DRTAU20ITAU12I-J25

- $p_T\ (GeV)$ thresholds of the lead(sub-l) τ
- RNN Working points of the τs
- Angular separation ΔR between the τs
- Efficiency : 0.5272
- Background Rate : 42.36 Hz (Lumi = $1 \times 10^{34}\ cm^{-2}s^{-1}$)



Room for improvement?

Efficiency Emulation

- Use MC sample of the signal events (Signal events contain only the MC simulation of the physics process of concern, in this case $hh \rightarrow b\bar{b}\tau^{-}_{had}\tau^{+}_{had}$)

- Make a reasonable selection of the signal events

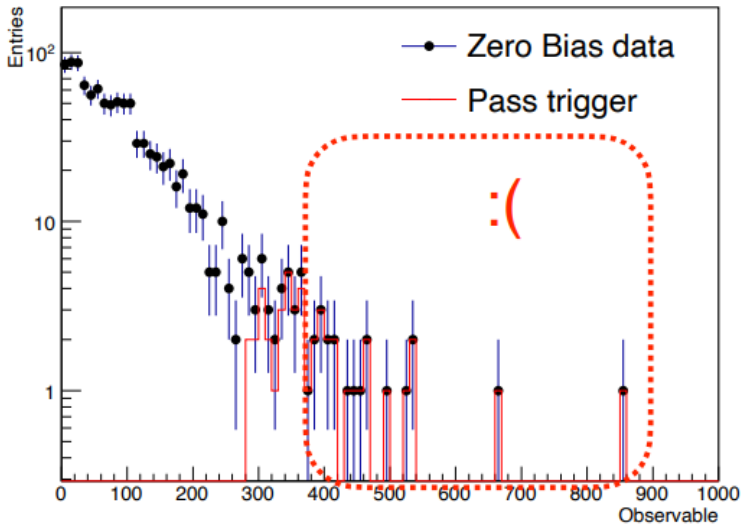
- Emulate the HLT triggers

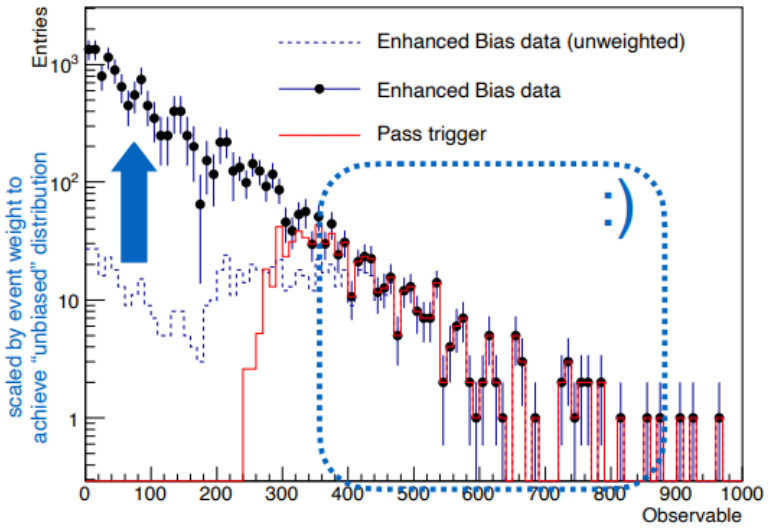
- See what fraction of selection events pass the emulated triggers. $\epsilon = \frac{HLT_{pass}\ events}{Selection_{pass}\ events}$

Rates Emulation

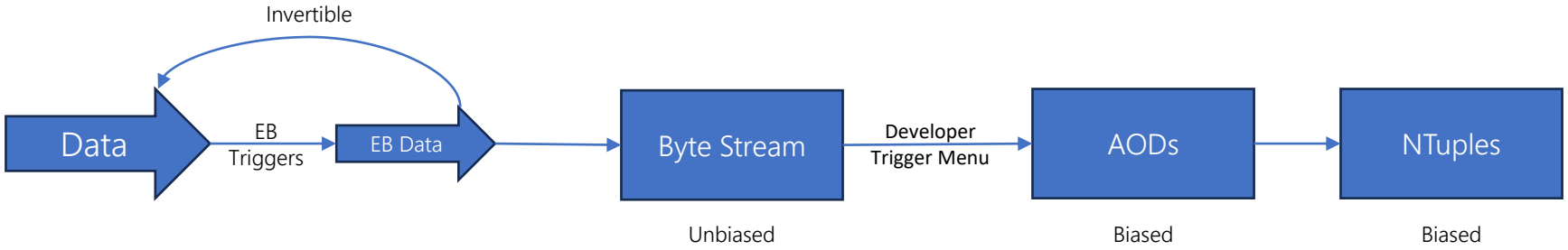
Use Enhanced Bias Sample

Using Random Trigger





Using EB trigger



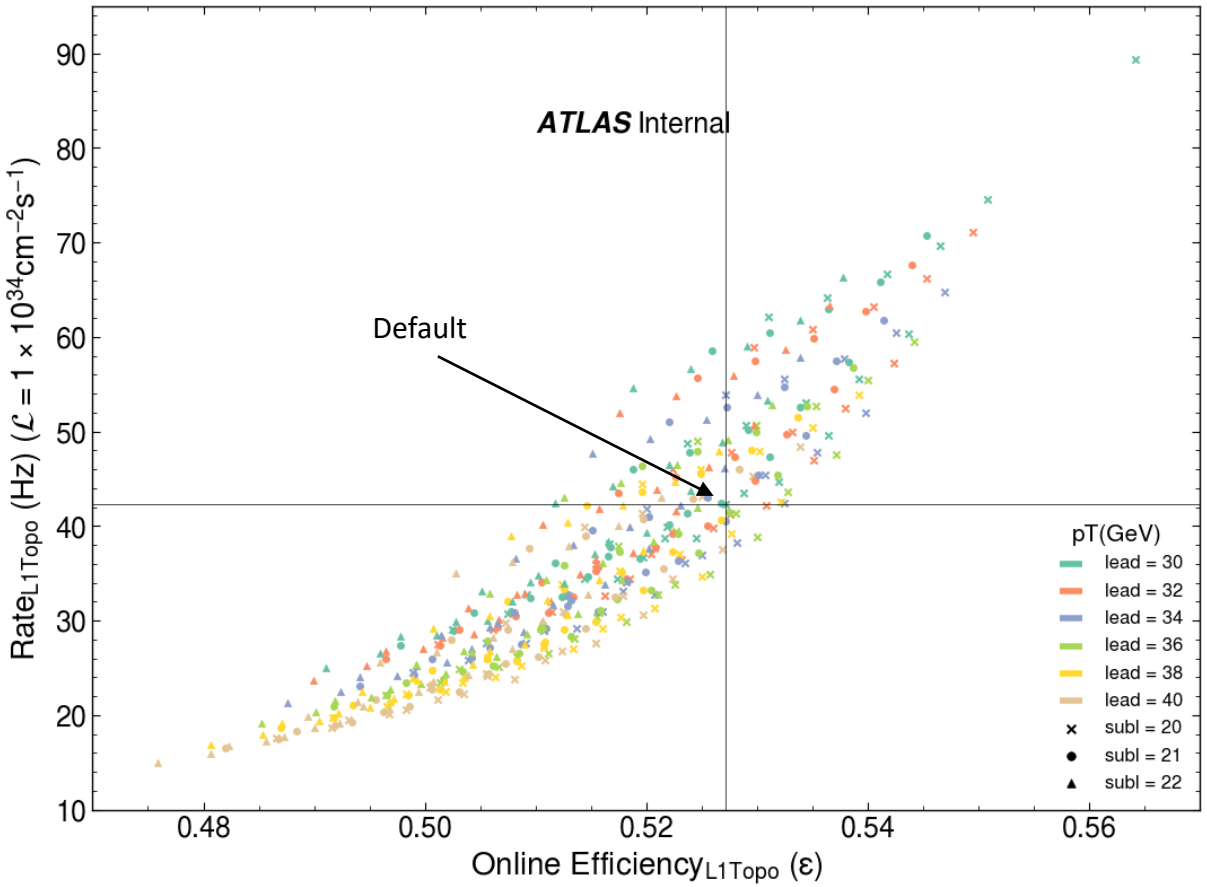
Rates Emulation

- Emulate chains tighter than the standard trigger in the menu
- We know the rates of the Standard trigger chain from weekly reprocessing
- Use the standard rate and events passed by the standard chain to scale the events of the emulated chain

$$\mathrm{Rate}_{\mathrm{emu}} = \frac{\mathrm{Rate}_{\mathrm{std}}}{N_{\mathrm{std}}} \times N_{\mathrm{emu}}$$

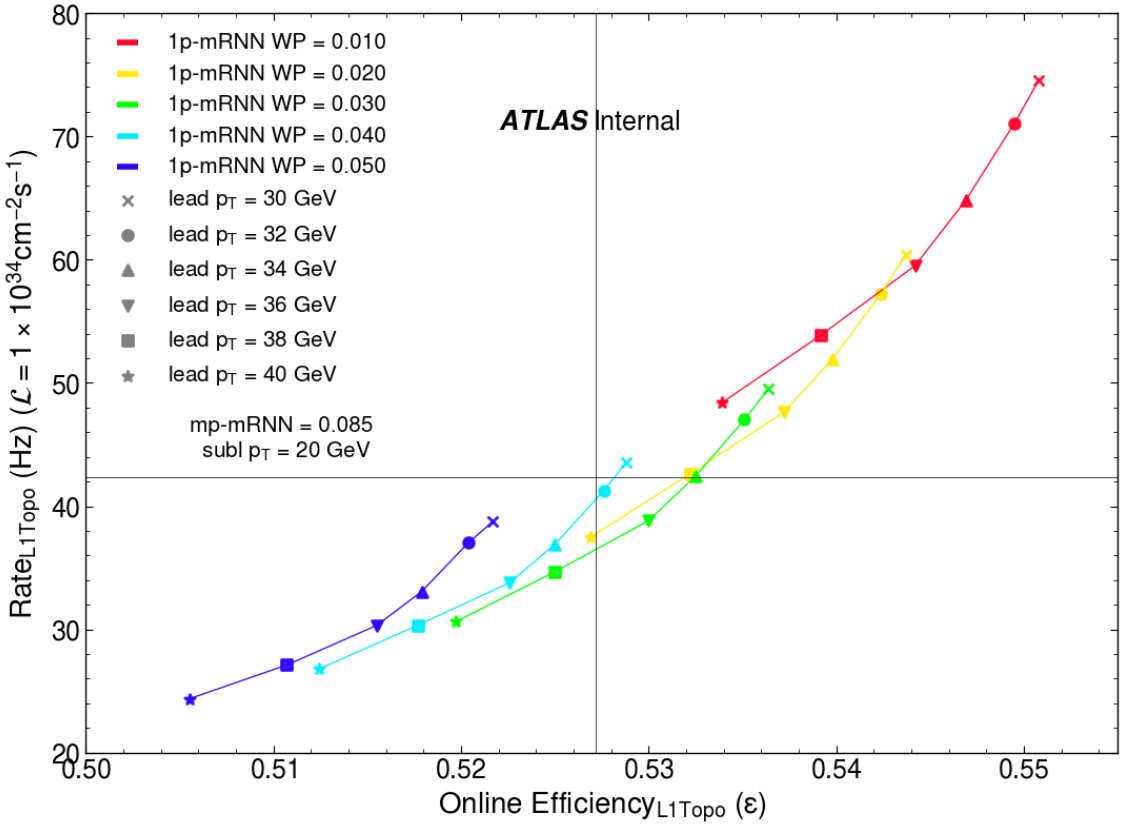
Efficiency vs Rates – L1Topo

- Intersection point: *Default*
  - $p_T - lead$ = 30GeV
  - $p_T - subl$ = 20GeV
  - Medium RNN 1 p Working Point = 0.03
  - Medium RNN multi-p Working Point = 0.105
- Emulation:
  - $p_T - lead$ = [30,40] steps of 2GeV
  - $p_T - subl$ = [20,22] steps of 1GeV
  - mRNN 1p WP = [0.01,0.05] steps of 0.01
  - mRNN mp WP= [0.085, 0.125] steps of 0.01



Efficiency vs Rates – L1Topo

HLT_tau30_mediumRNN_tracktwoMVA_tau20_mediumRNN_tracktwoMVA_03dRAB30_L1DRTAU20ITAU12I-J25

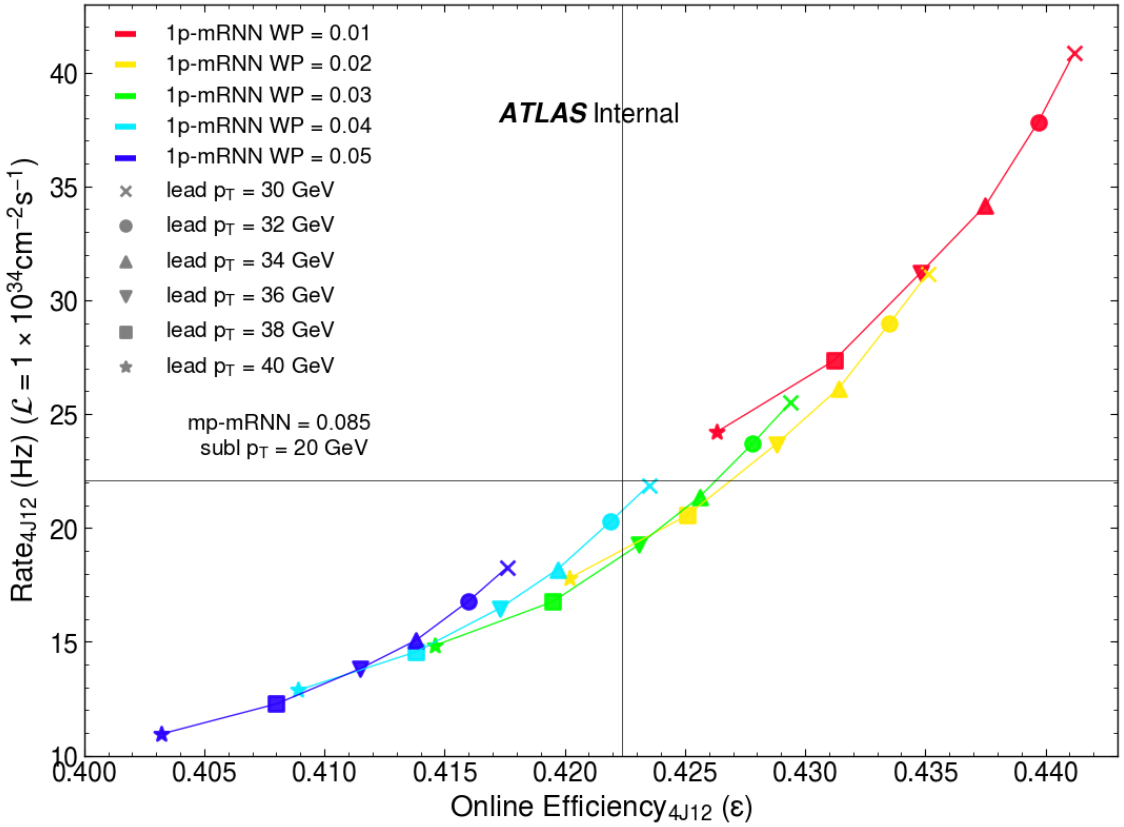


Fix $subl\ p_T$ to 20GeV & mp-mRNN WP to 0.085

Marker	$lead\ p_T$ (GeV)	1p-mRNN WP	Efficiency (wrt default)	Rate (wrt default)
▼	36	0.03	0.53% ↑	8.30% ↓
▲	34	0.03	1.00% ↑	0.16% ↑
■	38	0.02	0.94% ↑	0.58% ↑

Efficiency vs Rates – 4J12

HLT_tau30_mediumRNN_tracktwoMVA_tau20_mediumRNN_tracktwoMVA_03dRAB_L1TAU20IM_2TAU12IM_4J12p0ETA25

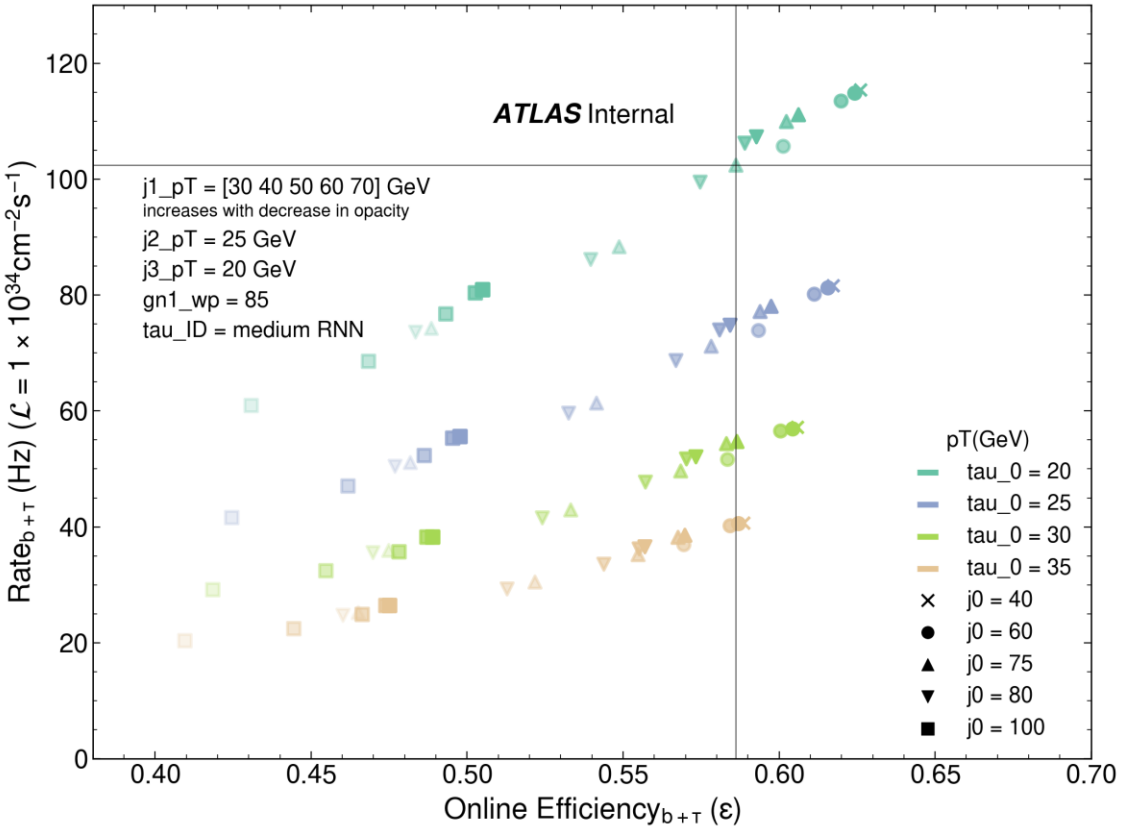


Fix $subl\ p_T$ to 20 GeV & mp-mRNN WP to 0.085

Marker	$lead\ p_T$ (GeV)	1p-mRNN WP	Efficiency (wrt default)	Rate (wrt default)
▲	34	0.03	0.75% ↑	3.35% ↓
●	32	0.03	1.27% ↑	7.20% ↑
▼	36	0.02	1.15% ↑	7.17% ↑
■	38	0.02	0.64% ↑	6.96% ↓

Efficiency vs Rates – b+τ

HLT_tau20_mediumRNN_tracktwoMVA_j75c_020jvt_j50c_020jvt_j25c_020jvt_j20c_020jvt_SHARED_j20c_020jvt_bgn180
_pf_ftf_presel3c20XX1c20b85_L1J45p0ETA21_3J15p0ETA25



Fix j^{2}_{pT} to 25 GeV
j^{3}_{pT} to 20 GeV
τ^{0}_{RNN} to medium
gn1 WP to 85

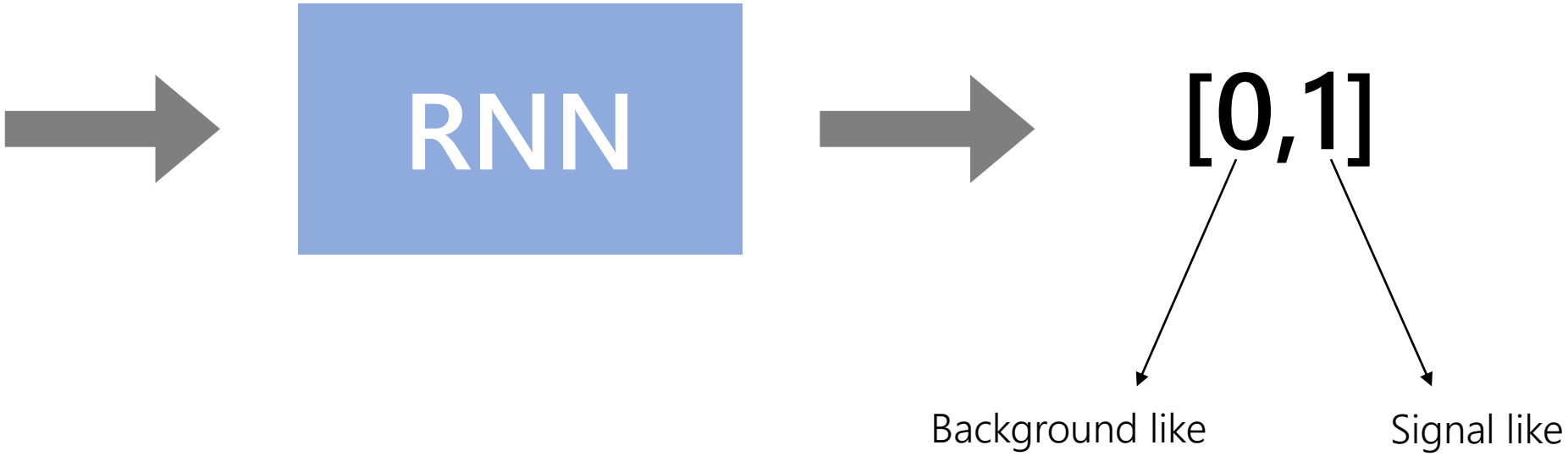
- Tighten the $\tau^{0}_{P_T}$
- Loosen $j^{0}_{P_T}$ and $j^{1}_{P_T}$


ATHUL
HLT
ATLAS
IMPRS
L1Topop
GOTTINGEN
TRIGGER
HIGGS

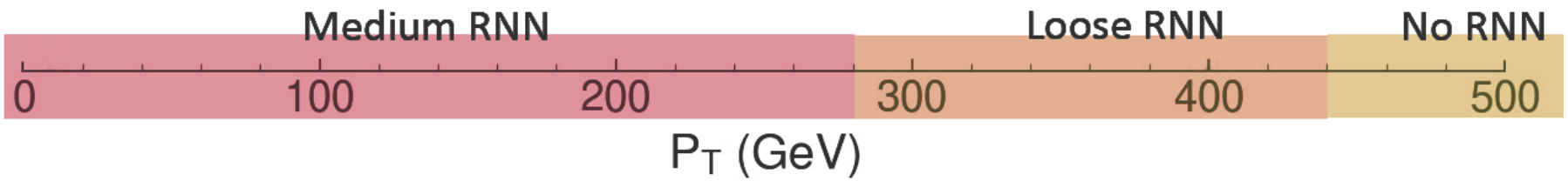
Backup

Recurrent Neural Network

Observable	1-prong	3-prong
$p_T^{\text{seed jet}}$	•	•
p_T^{track}	•	•
$\Delta\eta^{\text{track}}$	•	•
$\Delta\phi^{\text{track}}$	•	•
$\lvert d_0^{\text{track}}\rvert$	•	•
$\lvert z_0^{\text{track}}\sin\theta\rvert$	•	•
$N_{\text{IBL hits}}$	•	•
$N_{\text{Pixel hits}}$	•	•
$N_{\text{SCT hits}}$	•	•
$p_{T_{\text{jet seed}}}$	•	•
E_{cluster}	•	•
$\Delta\eta_{\text{cluster}}$	•	•
$\Delta\phi_{\text{cluster}}$	•	•
λ_{cluster}	•	•
$\langle\lambda^2_{\text{cluster}}\rangle$	•	•
$\langle r^2_{\text{cluster}}\rangle$	•	•
$p_{T_{\text{uncalibrated}}}$	•	•
f_{cent}	•	•
$f^{-1}_{\text{leadtrack}}$	•	•
ΔR_{max}	•	•
$\lvert S_{\text{leadtrack}}\rvert$	•	
S_T^{flight}		•
$f^{\text{iso}}_{\text{track}}$	•	•
$f^{\text{EM}}_{\text{track}}$	•	•
$p_T^{\text{EM track}}/p_T$	•	•
$m^{\text{EM track}}$	•	•
m^{track}		•



RNN Regions



L1Topo - Fix pt1 to 20 GeV