National University
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New Signal Region Study Using Single Lepton Trigger

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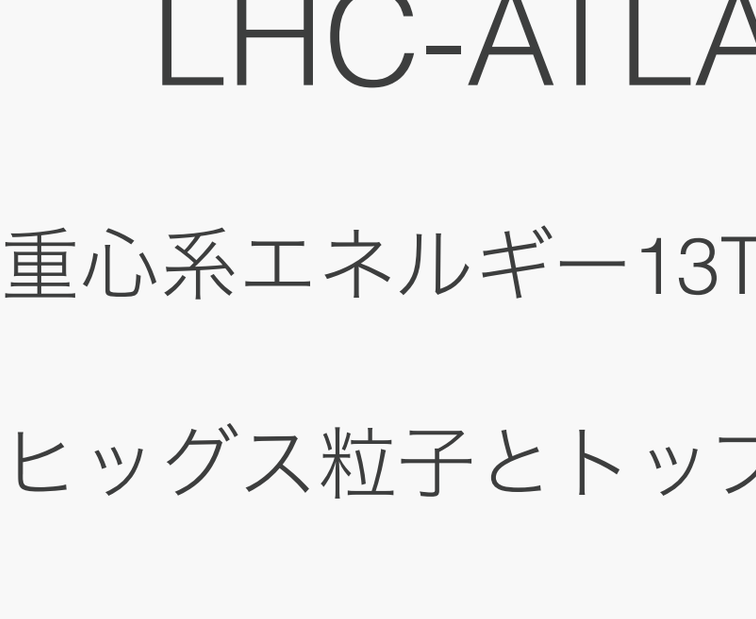
Topics

- What kind of triggers could be added in HIGG1D1?
  - ➡ single lepton trigger
  - ➡ lepton + multi photon trigger
    - ‣ e.g.
      - HLT_e20_lhmedium_2g10_loose
      - HLT_2g10_loose_mu20
- Photon pT threshold optimisation
  - ➡ low pT photon selection might cause dramatical BG increase
- PV selection
  - ➡ photon pointing NN vs hardest vertex

LHC-ATLAS実験でのttH過程探索

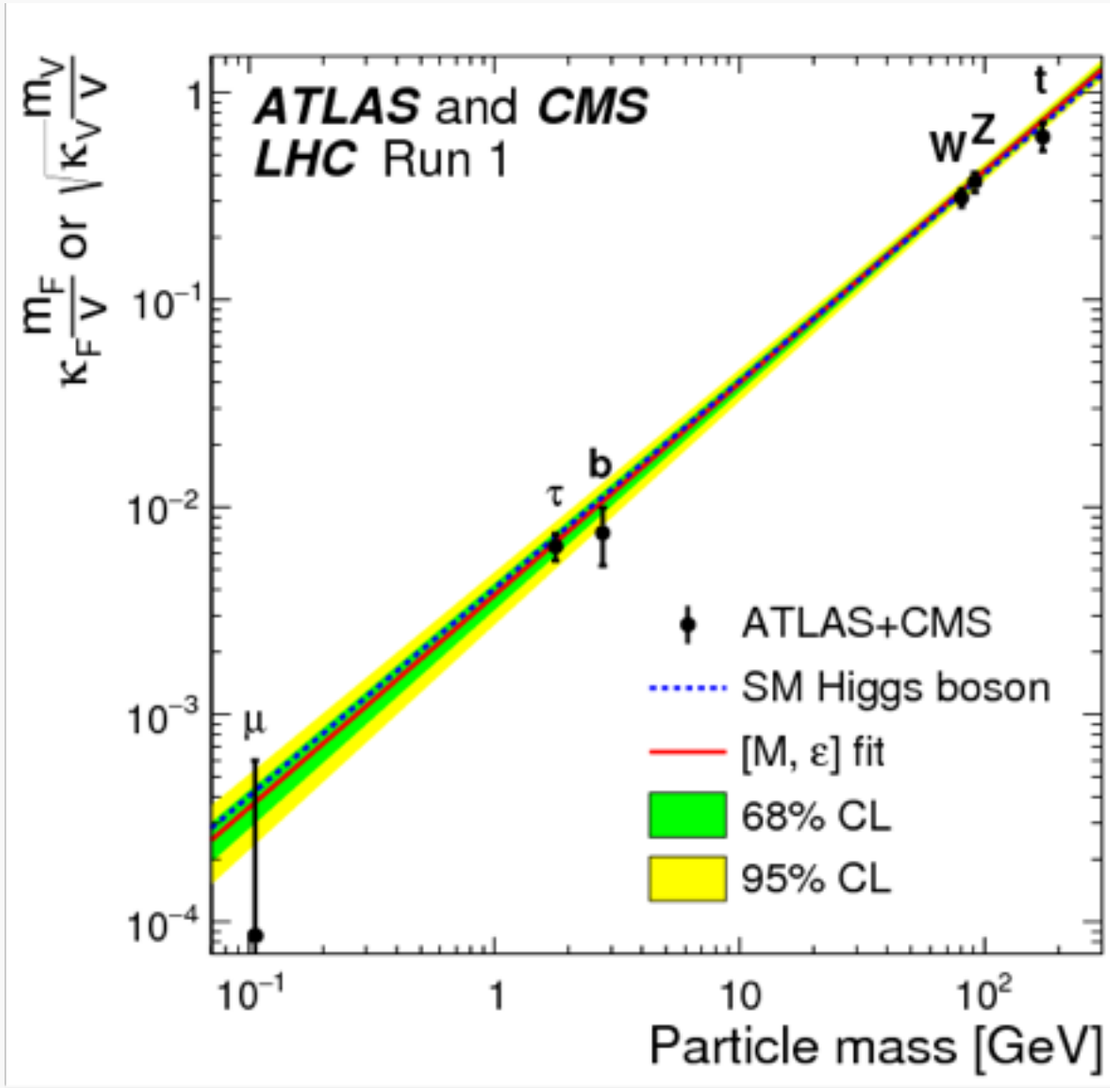
- 重心系エネルギー13TeVでの陽子陽子衝突実験
- ヒッグス粒子とトップクォーク結合(Y_t)の直接探索が可能

  ➡ トップ湯川は結合定数が大 → SMからのズレ(SUSYなどの寄与)の検証



トップクォークからのヒッグス随伴生成過程

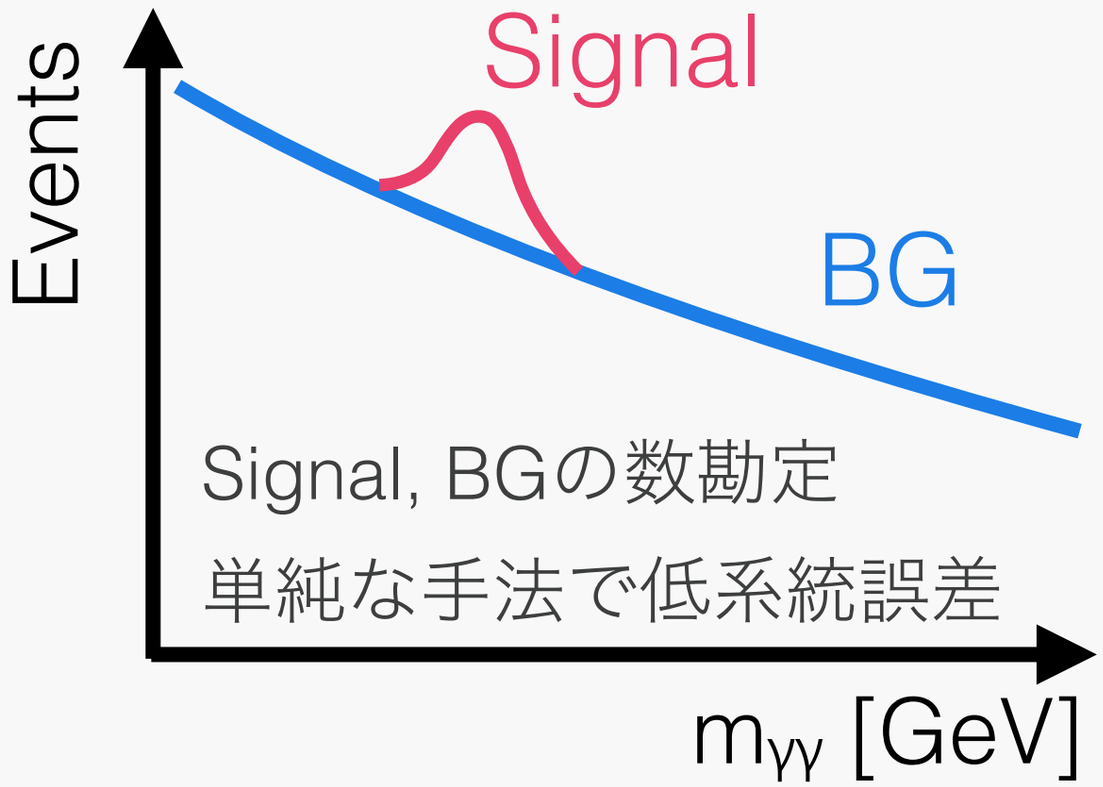
(ttH過程)

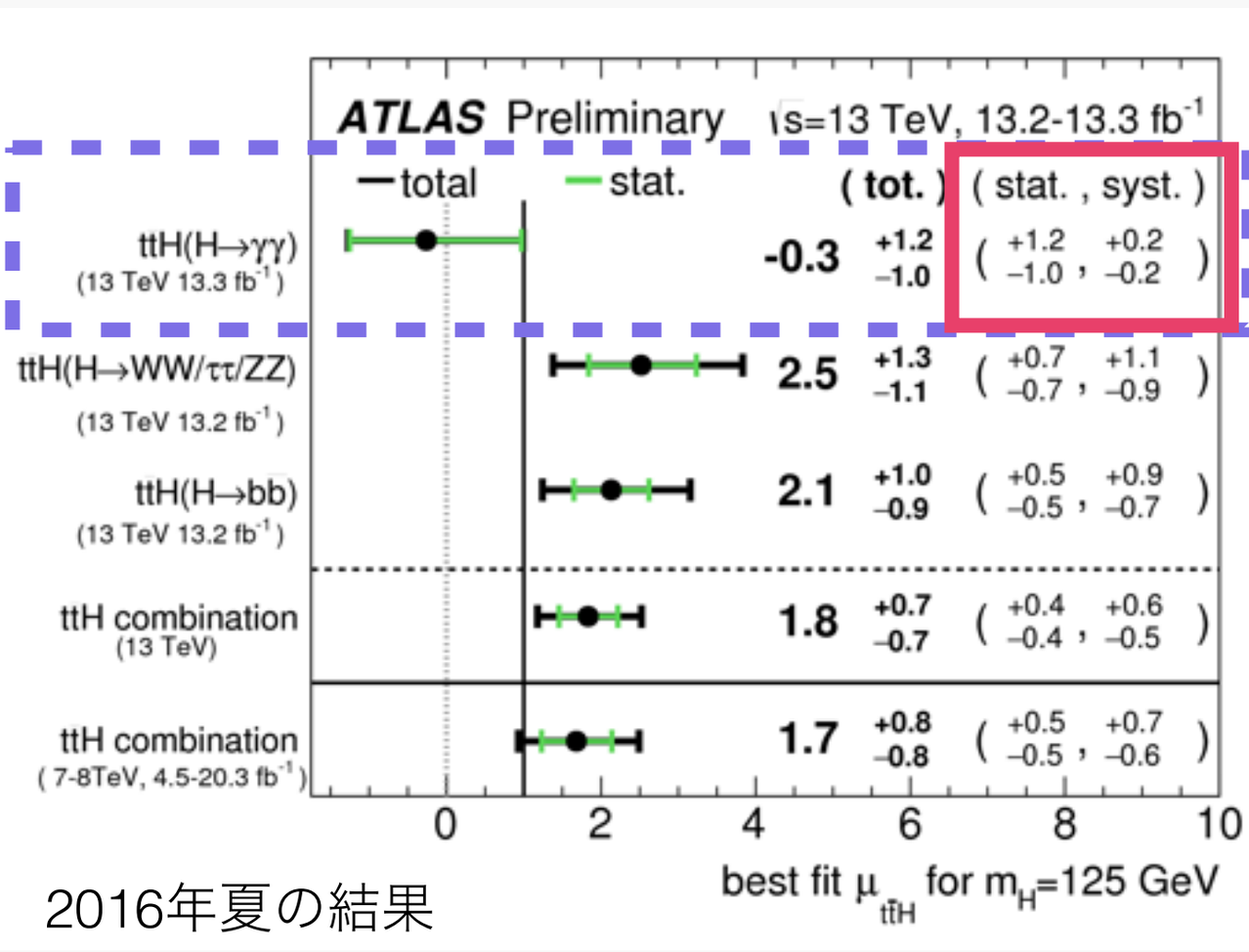


ヒッグス2光子崩壊チャンネル (1)

- 2光子の不変質量($m_{\gamma\gamma}$)の分解能がよい→系統誤差：小
- 崩壊分岐比が小さい (0.3 %) →統計誤差：大

➡signal acceptanceを稼ぐことが重要





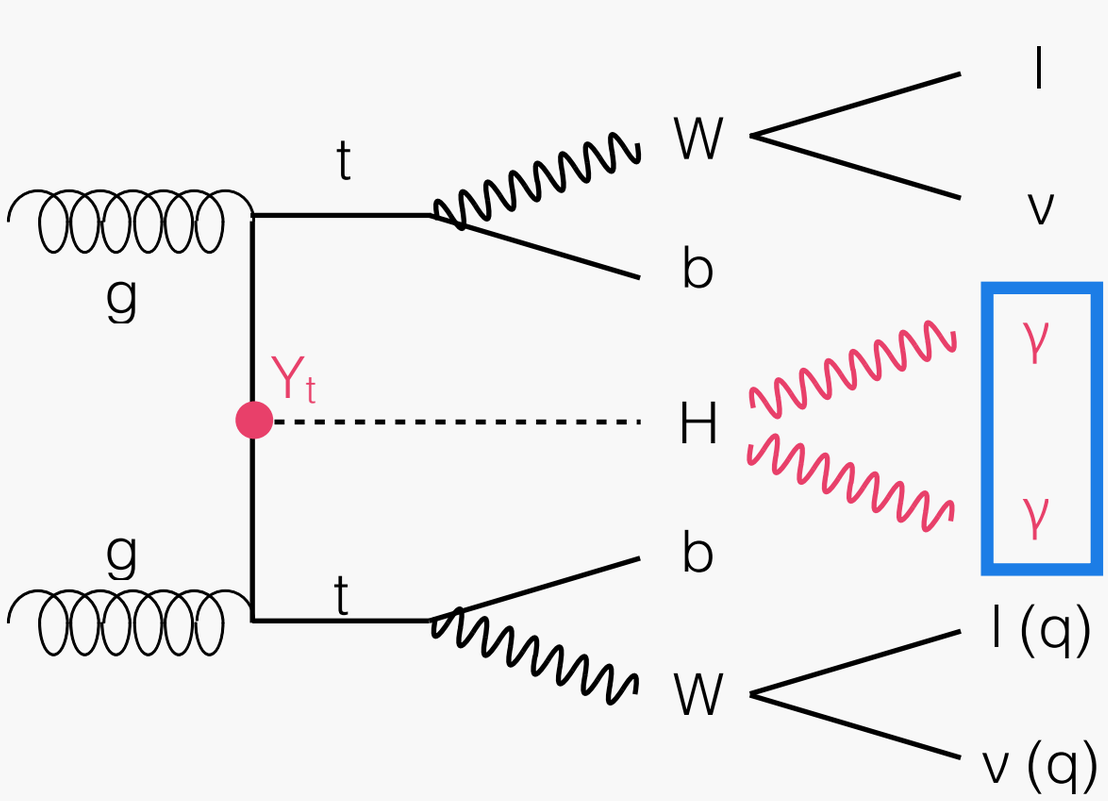
2016年夏の結果

トリガーの選択

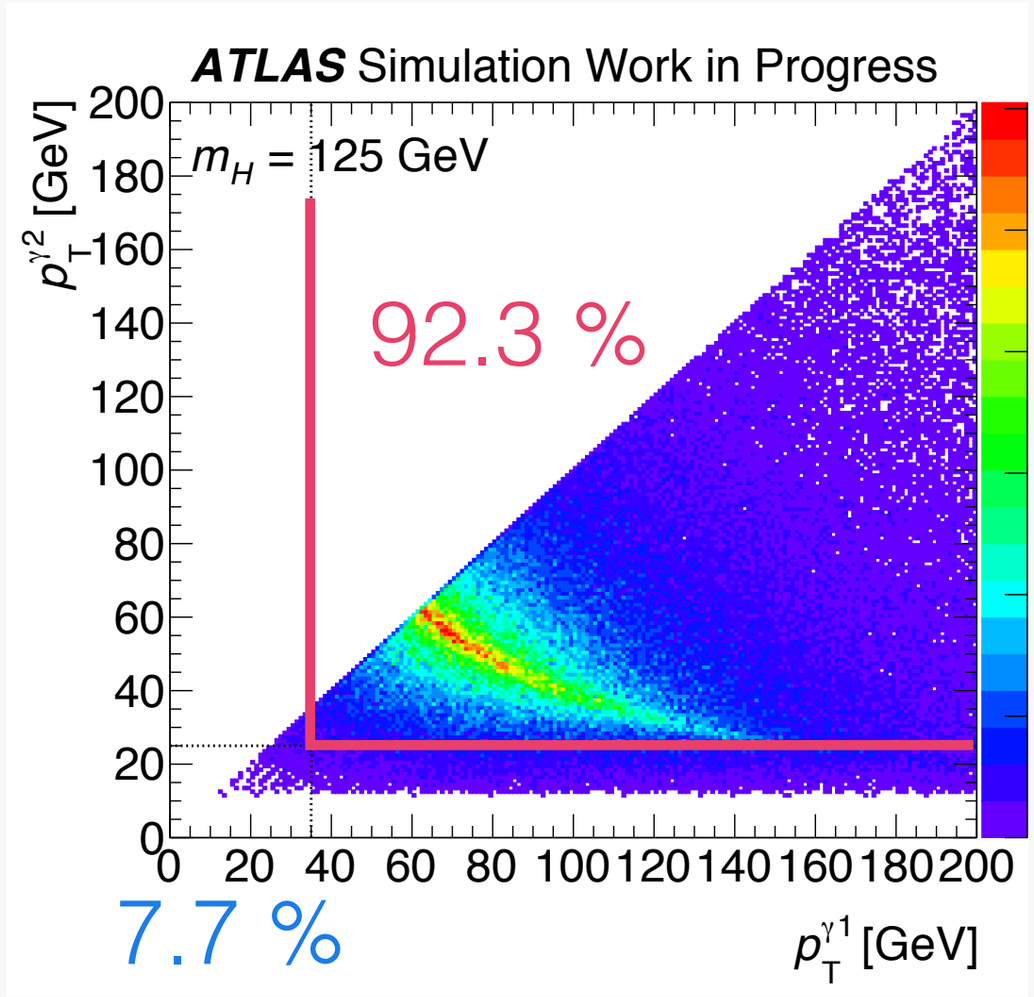
- 従来は2光子トリガーを使用

  ➡横方向運動量 (pT) の高いものから $pT^{\gamma 1} > 35$ GeV, $pT^{\gamma 2} > 25$ GeV

  ➡それより低いpTの信号を 7.7 % 落とす



ttH過程(終状態にレプトンを含むチャンネル)



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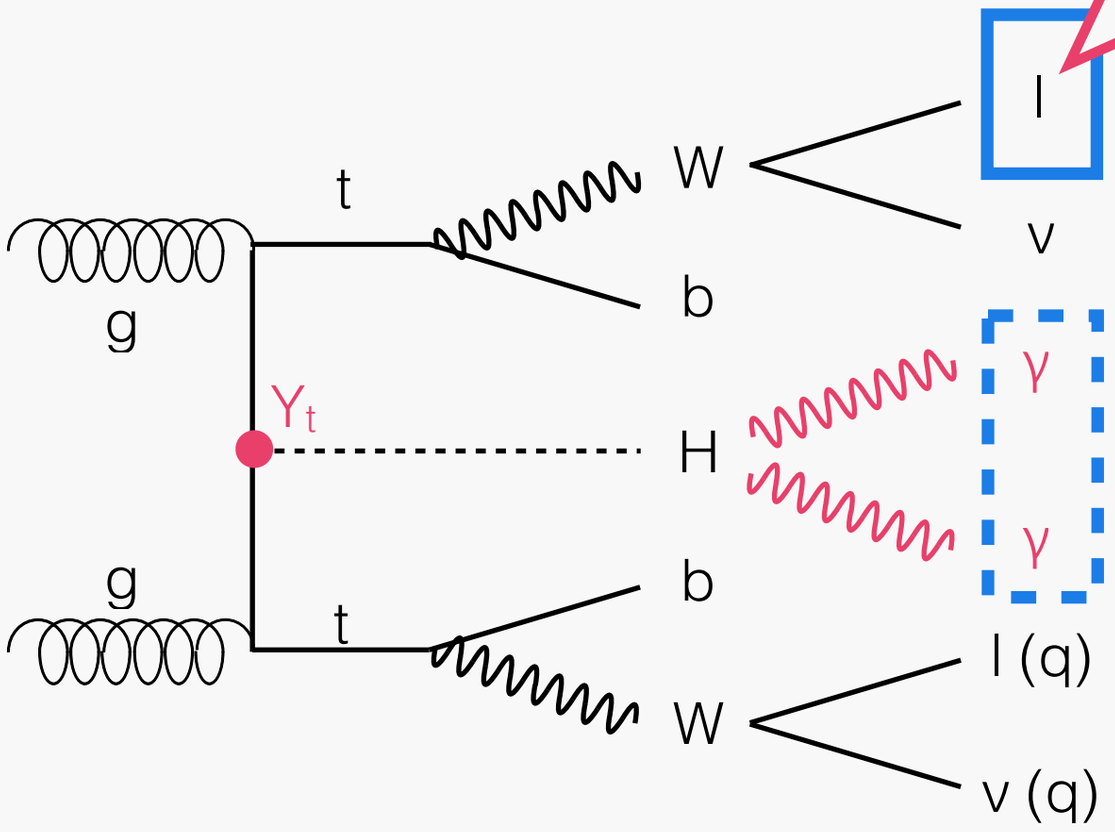
レプトントリガー導入により
pTの低い光子のイベント取得可

研究目的：低いpTの光子を考慮する
ことによる発見感度向上の検証



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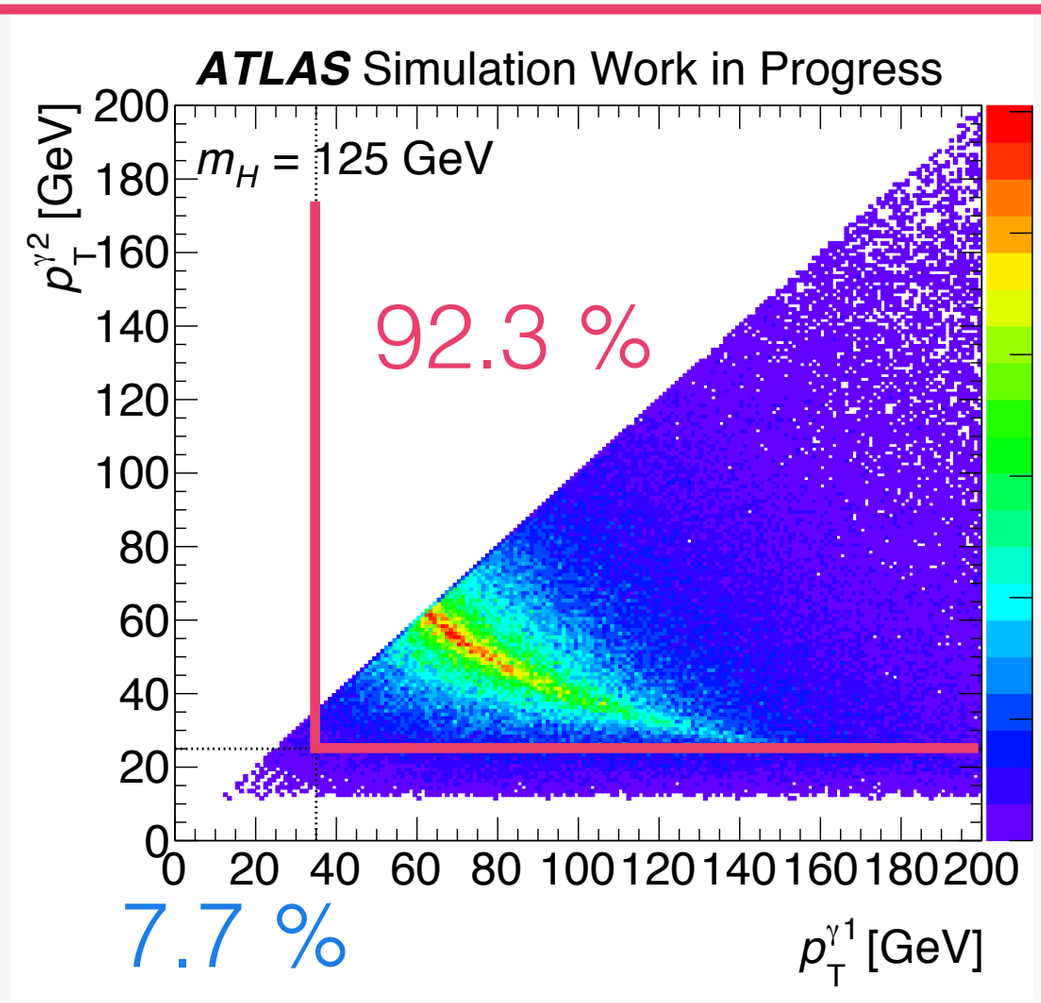
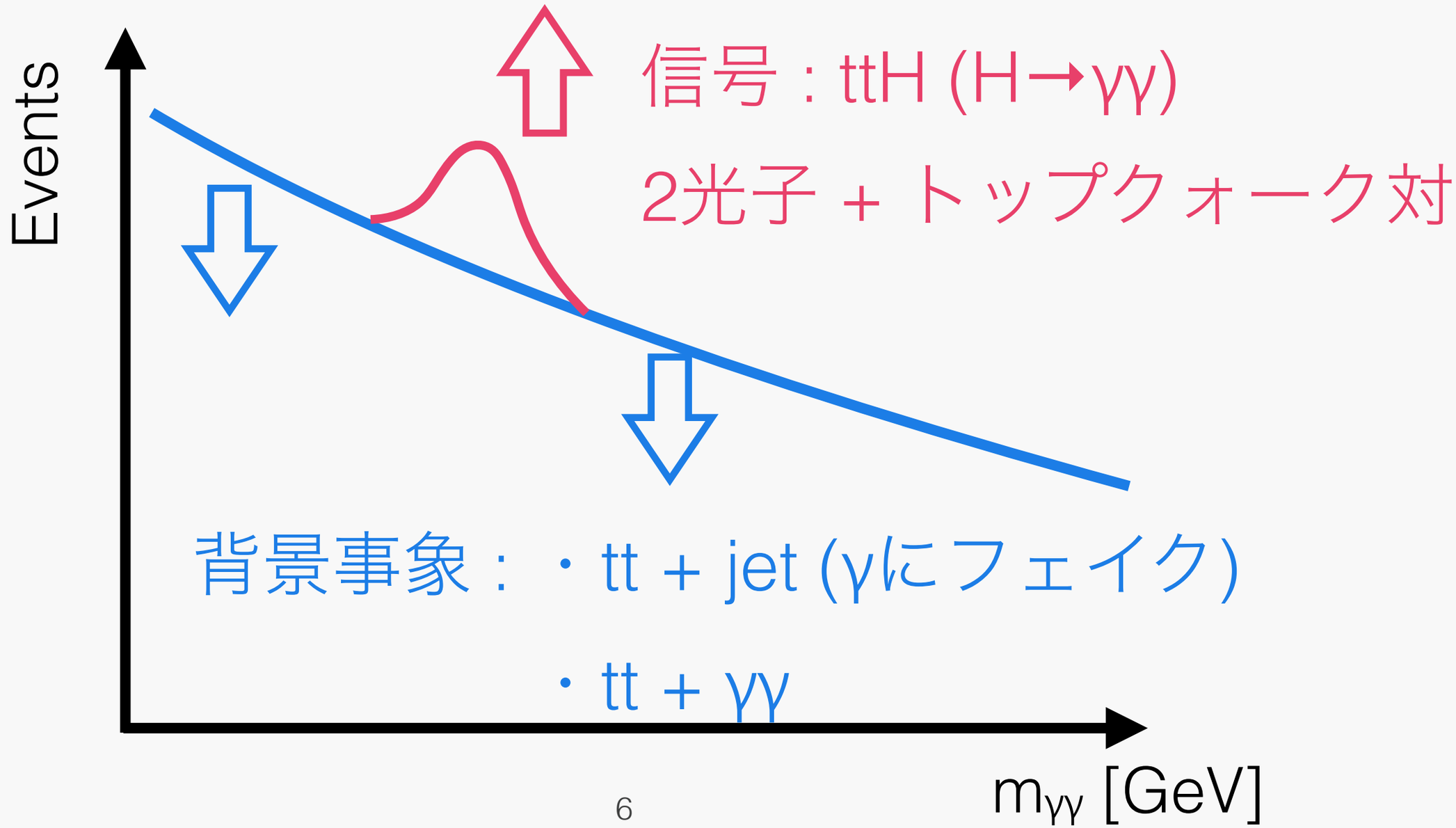


信号と背景事象の選別

- 信号のacceptanceを稼ぐ
- 背景事象の除去



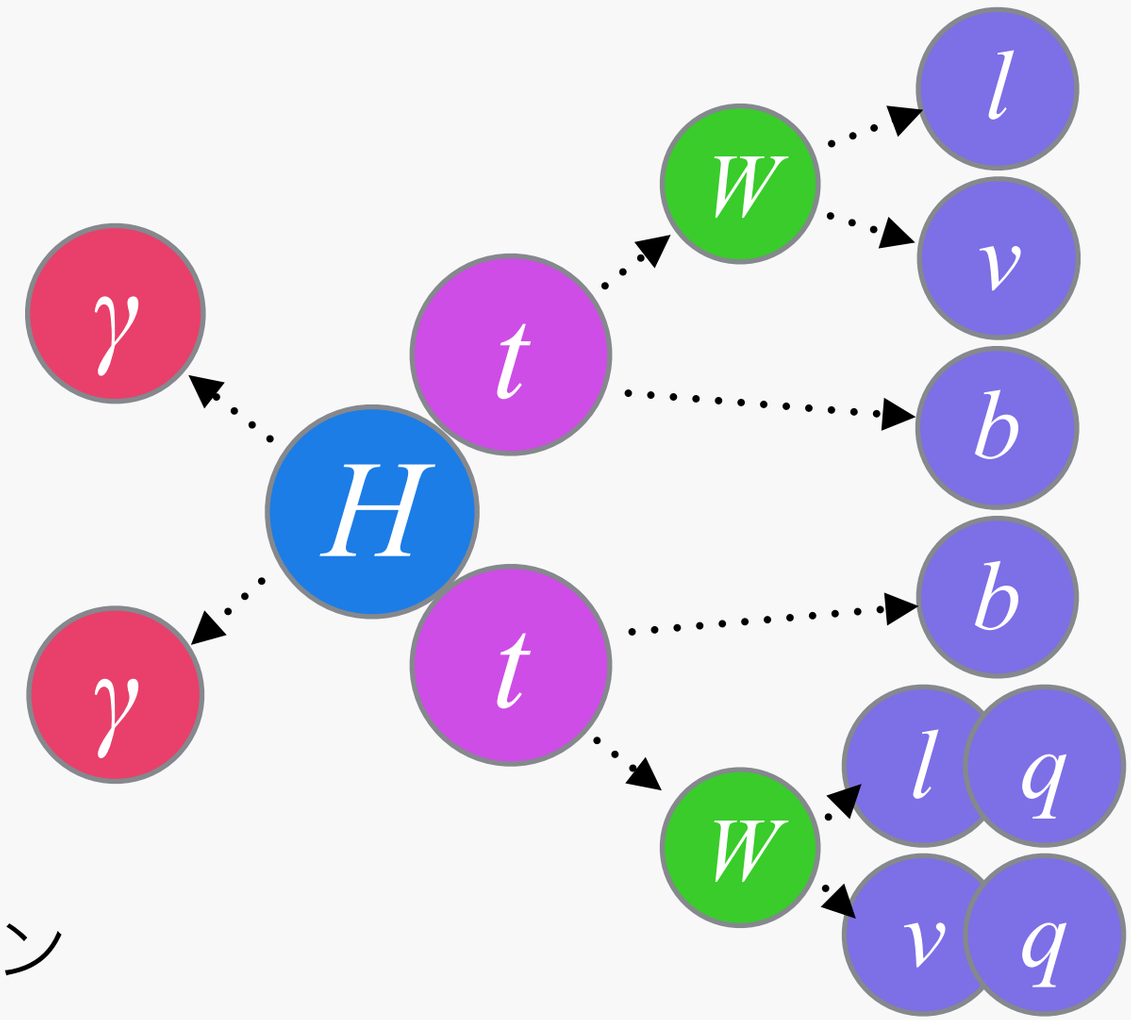
事象選別 (従来)

pT > 35 GeV
pT / $m_{\gamma\gamma}$ > 0.35

pT > 25 GeV
pT / $m_{\gamma\gamma}$ > 0.25

+アイソレーション

+光子のID (Tight)



lepton (e or μ) 1個以上

(pT > 10 GeV)

jet 2個以上

(pT > 25 GeV),
うちb-tag jet 1個以上

Missing E_T > 20 GeV
or b-tag jet 2個以上

事象選別 (従来)

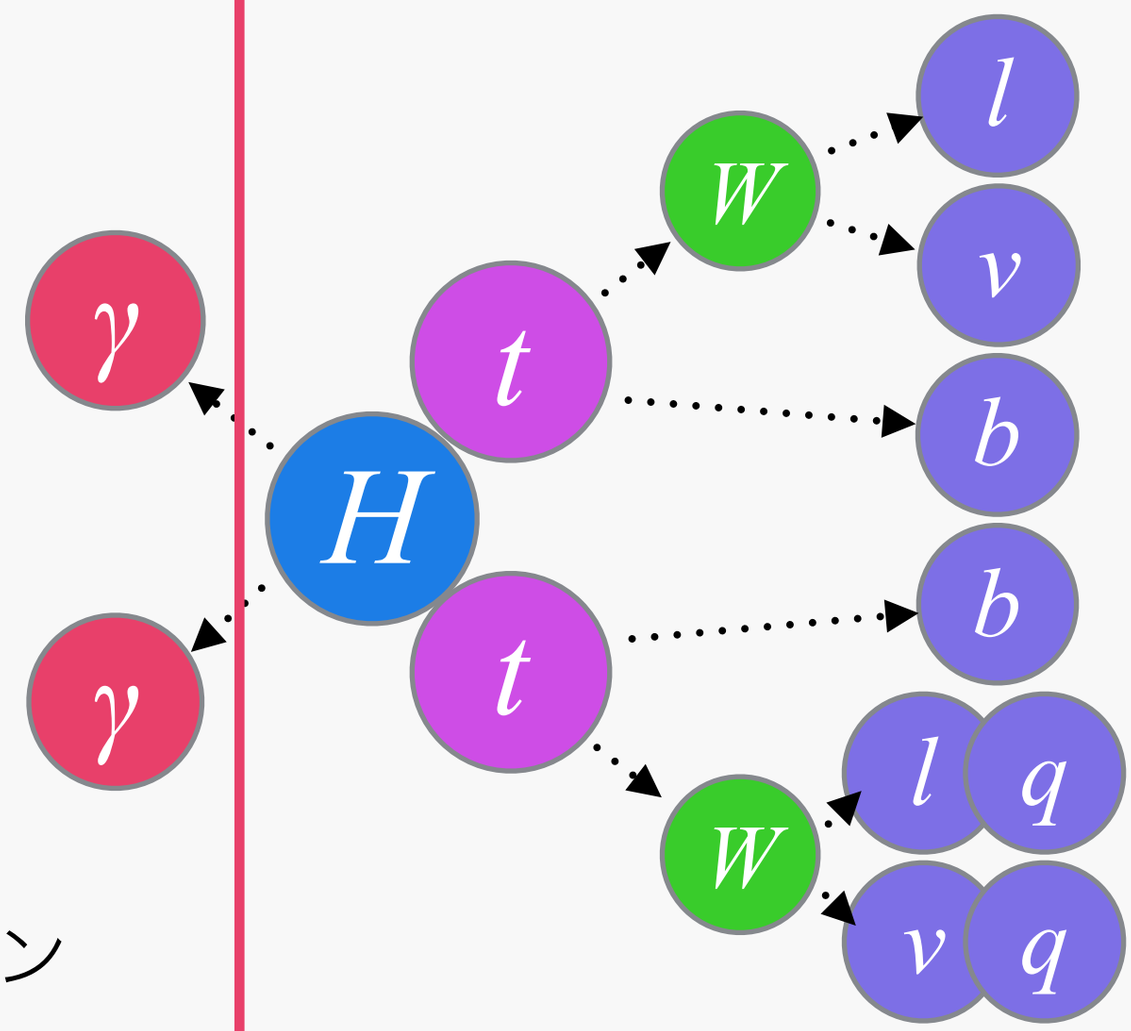
pT > 35 GeV
pT / $m_{\gamma\gamma}$ > 0.35

pT > 25 GeV
pT / $m_{\gamma\gamma}$ > 0.25

+アイソレーション

+光子のID (Tight)

光子のフェイクの削減



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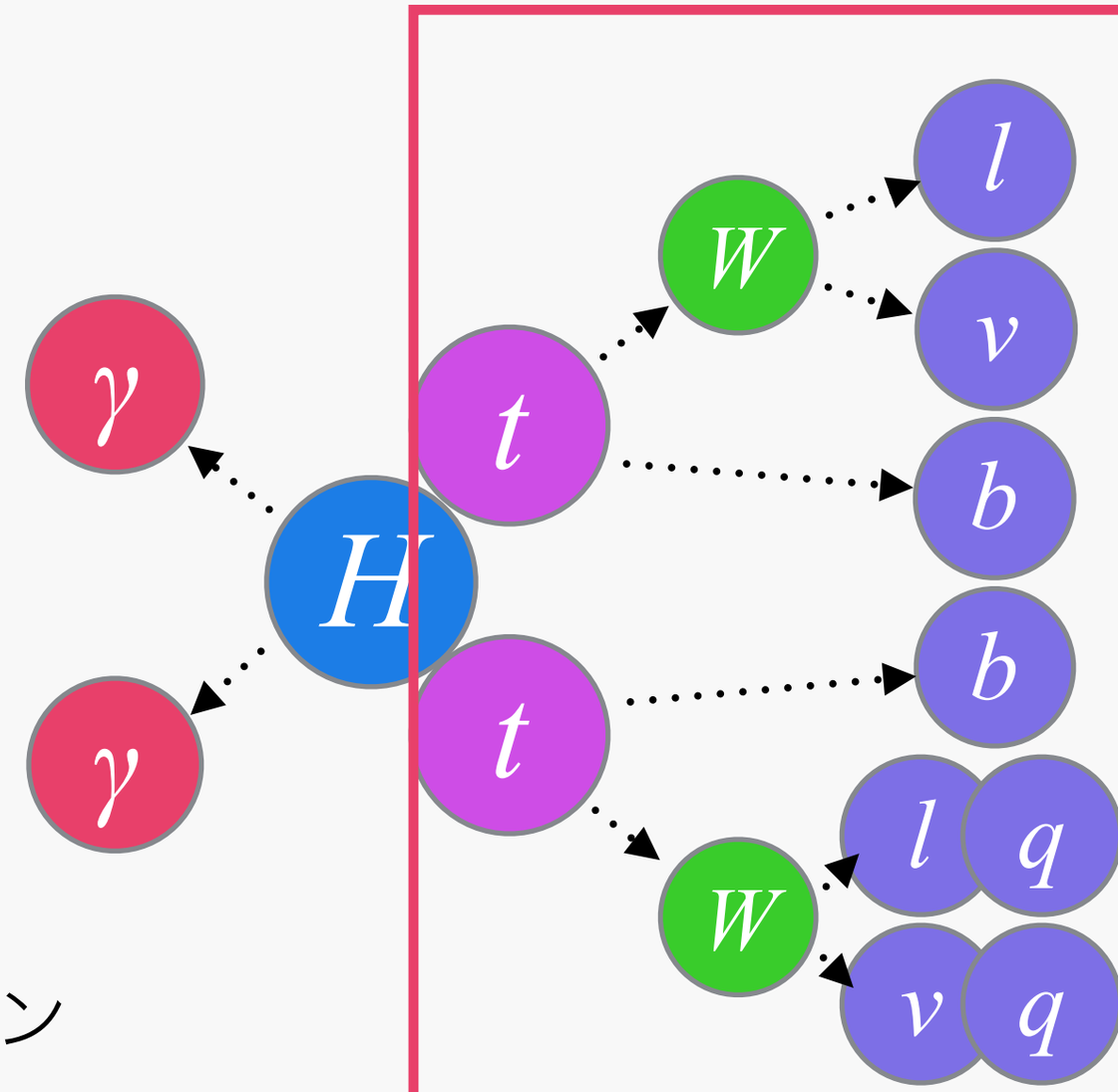

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(pT > 10 GeV)

jet 2個以上

(pT > 25 GeV),
うちb-tag jet 1個以上

Missing E_T > 20 GeV
or b-tag jet 2個以上

トップクォーク対 (ttHらしいもの) の選択

光子のpTに要求のないトリガーを用いた新信号領域

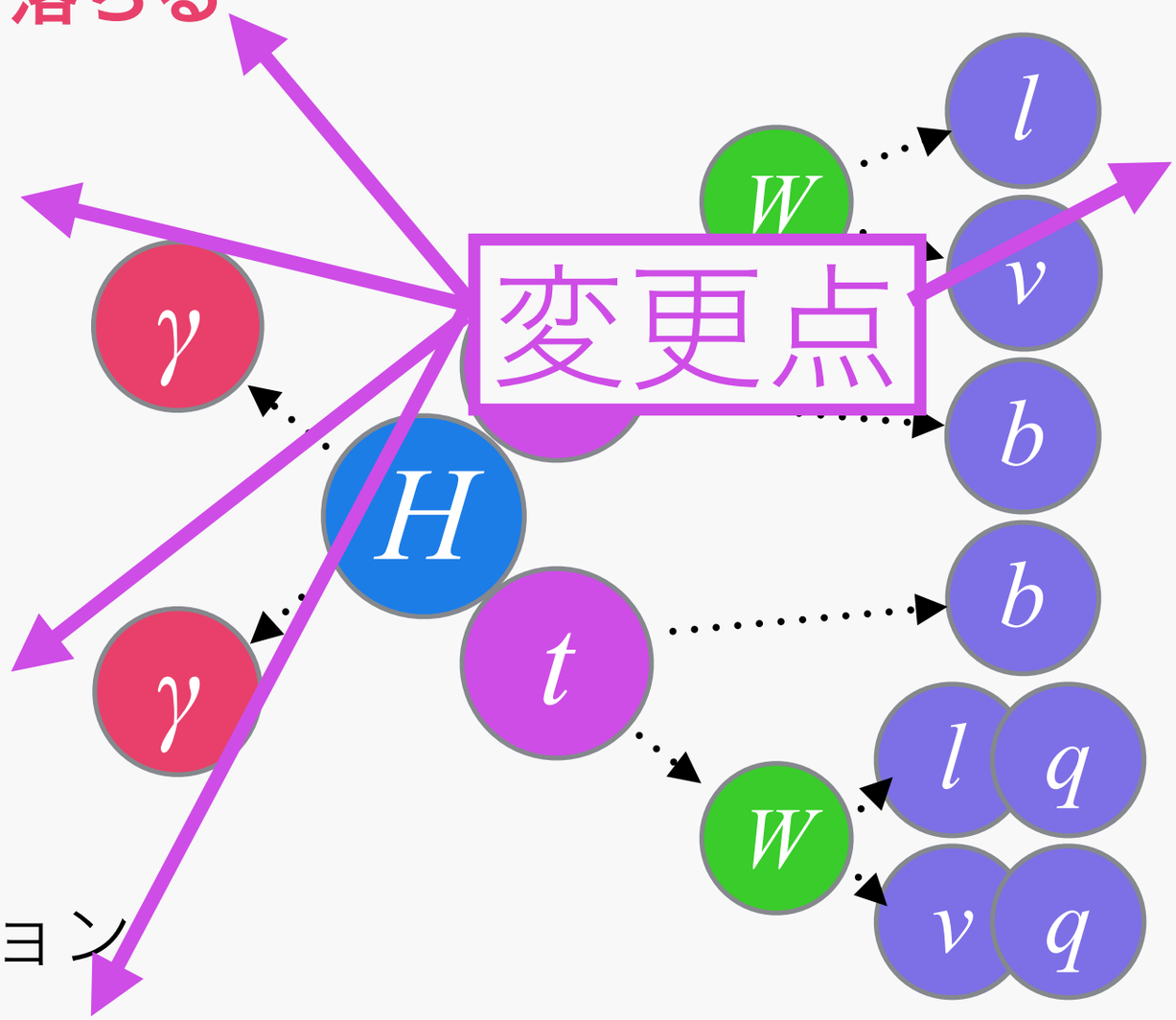
従来の選定から落ちる

pT > **18** GeV
pT / $m_{\gamma\gamma}$ > **0.18**

pT > **18** GeV
pT / $m_{\gamma\gamma}$ > **0.18**

+アイソレーション

+光子のID (**Loose**)



lepton (e or μ) 1個以上

(pT > 26 GeV)

トリガー

jet 2個以上

(pT > 25 GeV),
うちb-tag jet 1個以上

Missing E_T > 20 GeV
or b-tag jet 2個以上

※選定の最適化は未着手

光子のpTに要求のないトリガーを用いた新信号領域

従来の選定から落ちる

pT > **18** GeV
pT / $m_{\gamma\gamma}$ > **0.18**

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+アイソレーション

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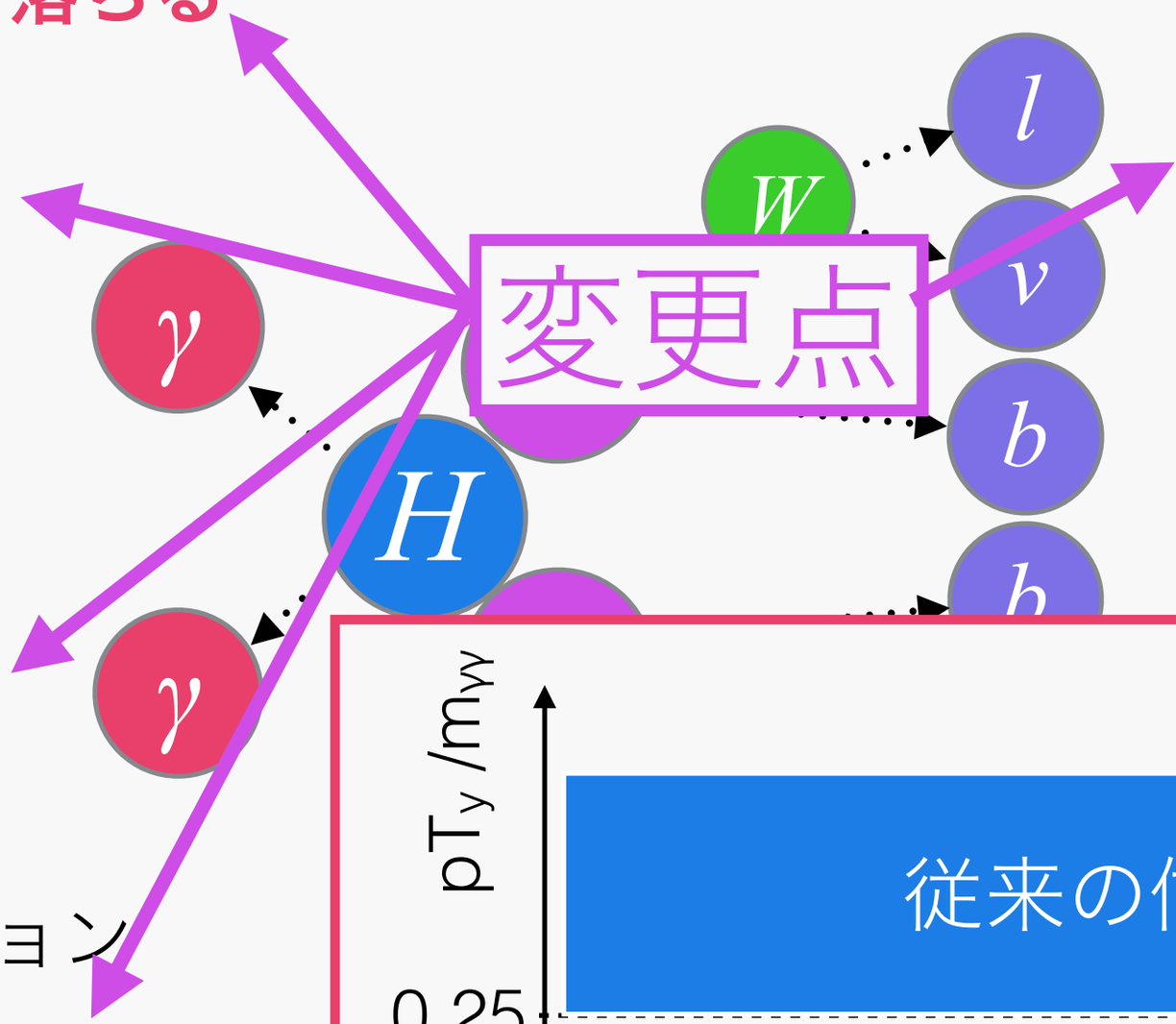


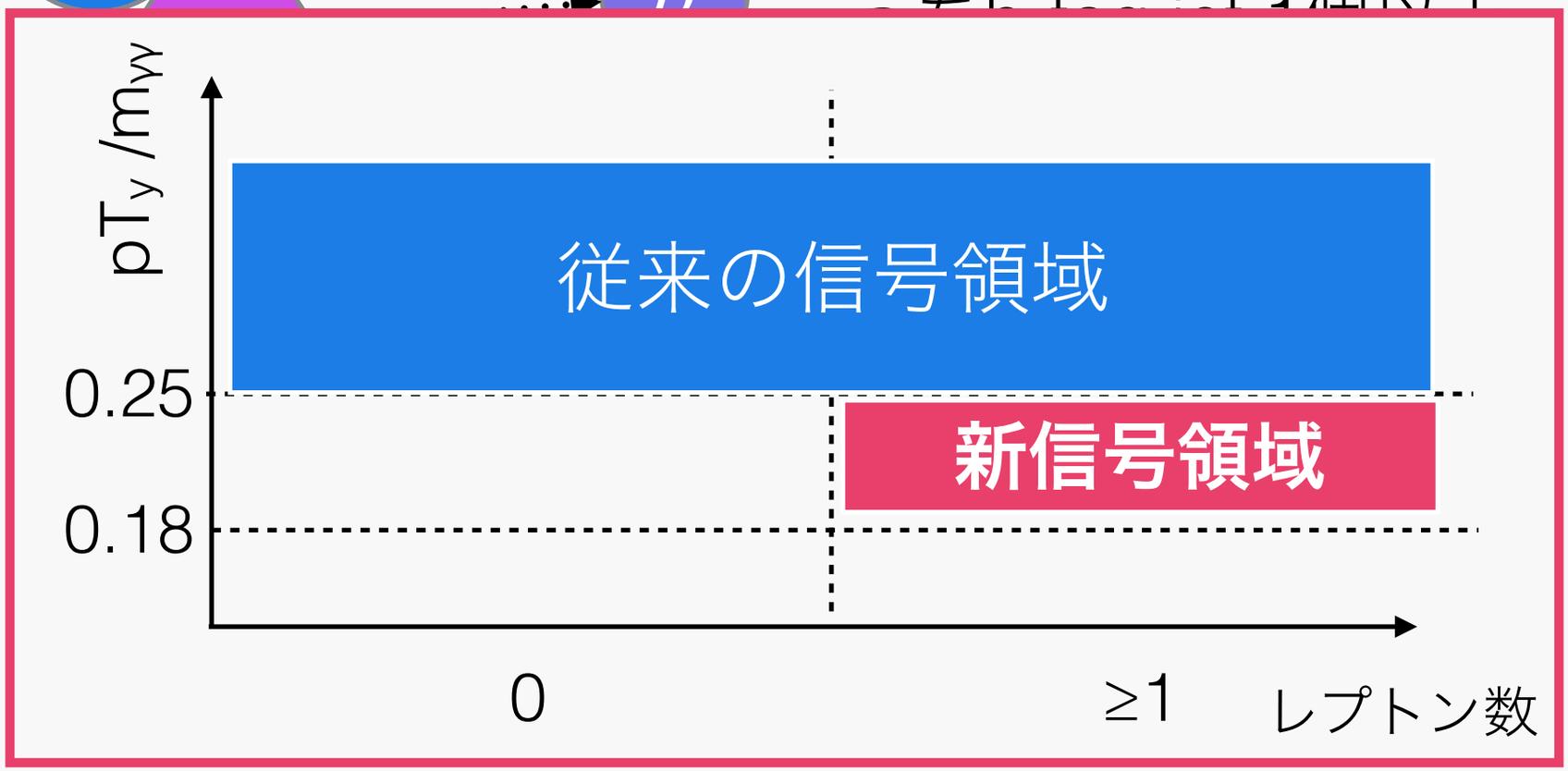
lepton (e or μ) 1個以上

(pT > 26 GeV)

トリガー

jet 2個以上

(pT > 25 GeV),



※選定の最適化は未着手

Photon pT Threshold Scan

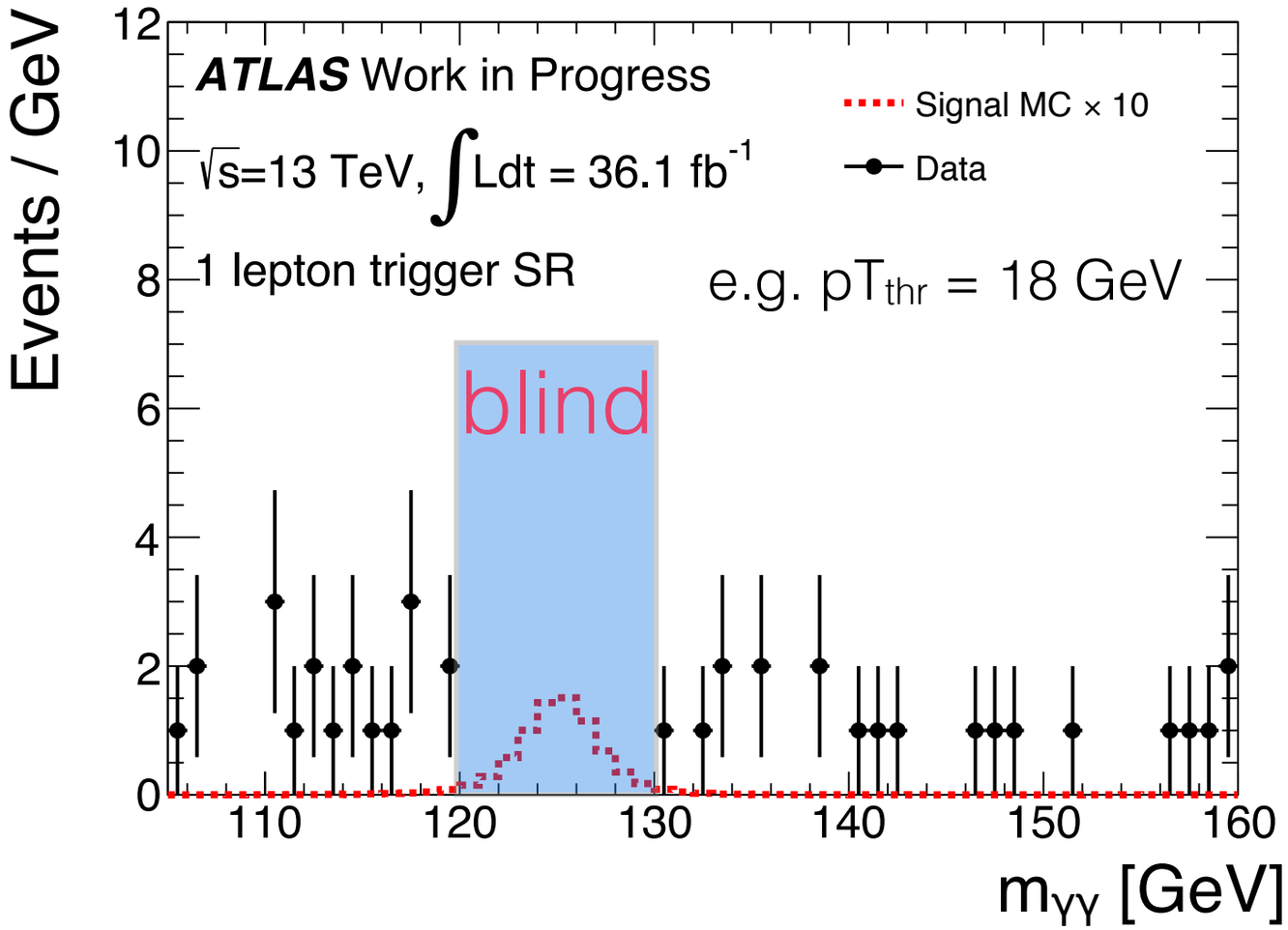
- Requirement for new SR
  - ➡ Fail nominal ttH selection
  - ➡ Relaxed photon selection:
    - pT_y > **X** GeV for all photon
      - scanning 12 GeV < **X** < 25 GeV
    - **Loose** / **Tight** photon ID
    - pT / myy > **X/100** for leading & sub-leading photons
      - scanning 0.12 < **X/100** < 0.25
  - ➡ Other requirement: same as nominal lepton category (need to be optimized for new SR)
  - ➡ Additional selection is required for leading lepton (offline cut to emulate online cut)

object	variable	di-photon trigger	single lepton trigger*
electron	pT	> 10 GeV	> 26 GeV
	PID	Medium	Tight
	Isolation	Loose	ivarloose
muon	pT	> 10 GeV	> 26 GeV
	PID	Medium	Medium
	Isolation	Gradient Loose	ivarmedium

*only for leading lepton

How to Estimate Significance

- Calculated by #events in blind region: $120 < m_{yy} < 130$ GeV (counting analysis)
  - ➡ only statistics is considered
    - Signal : #MC events
    - BC : #events estimated by sidebands (regarded as flat distribution)



Significance (Z):

$$Z = \sqrt{2((S+B)\ln(1+\frac{S}{B}) - S)}$$

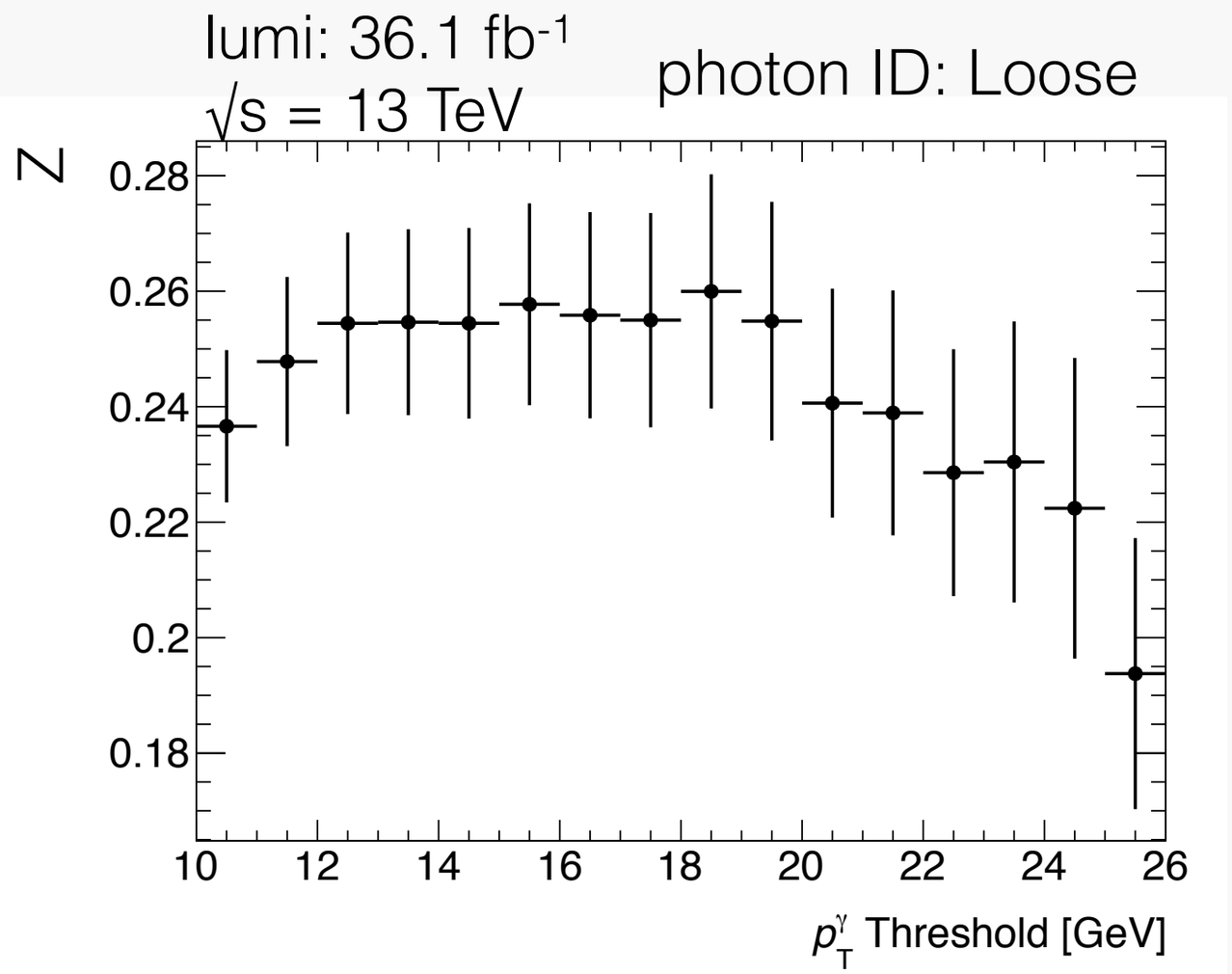
#events in blind region and significance

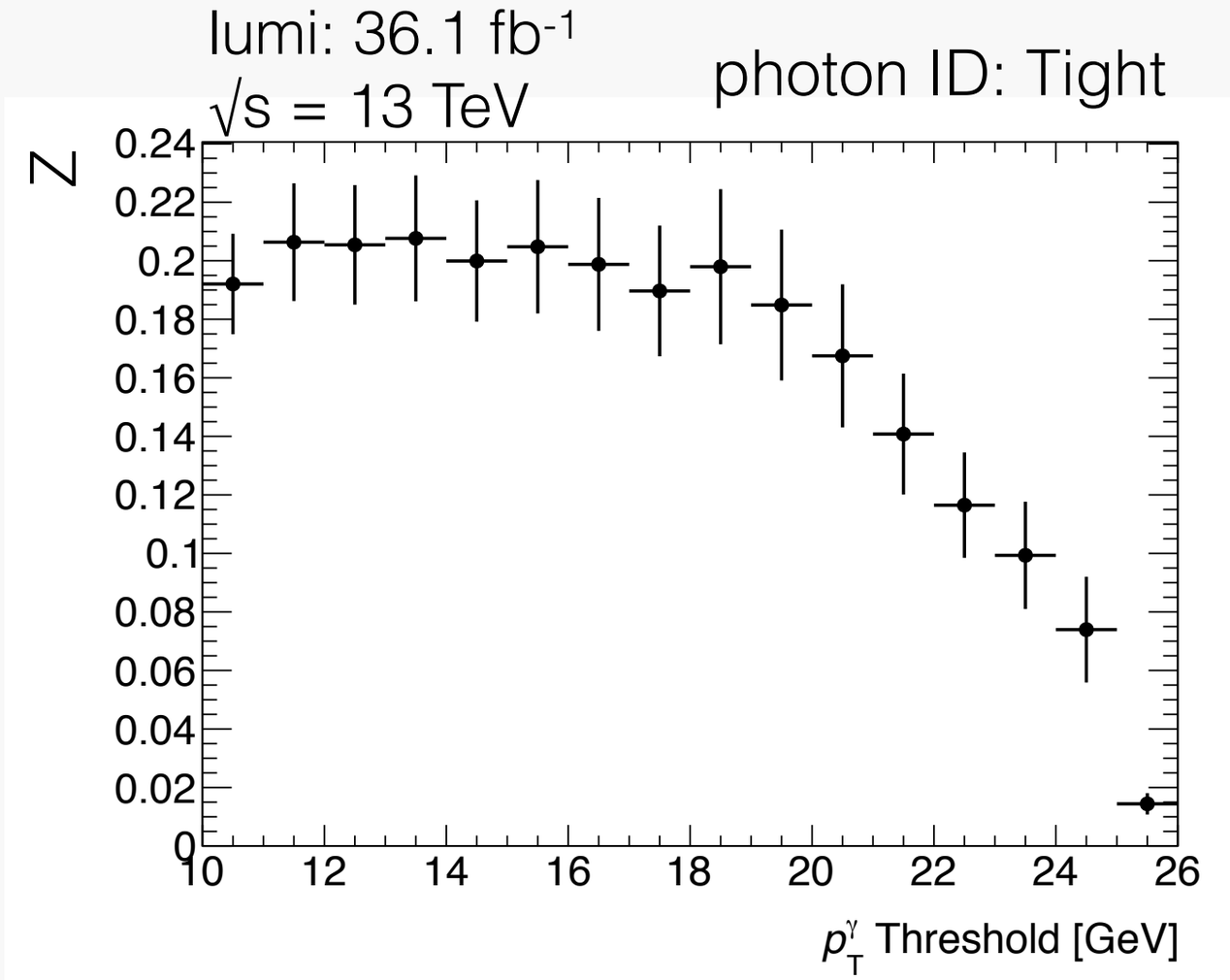
	S	B	Z
Lepton Cat.	3.5(*)	6.2(*)	1.3(*)
New SR	0.8	8.7	0.3

*extrapolated from ICHEP result

Worse S/B wrt. nominal lepton category (even if it is naively expected…)

pT Treshold Scan Result



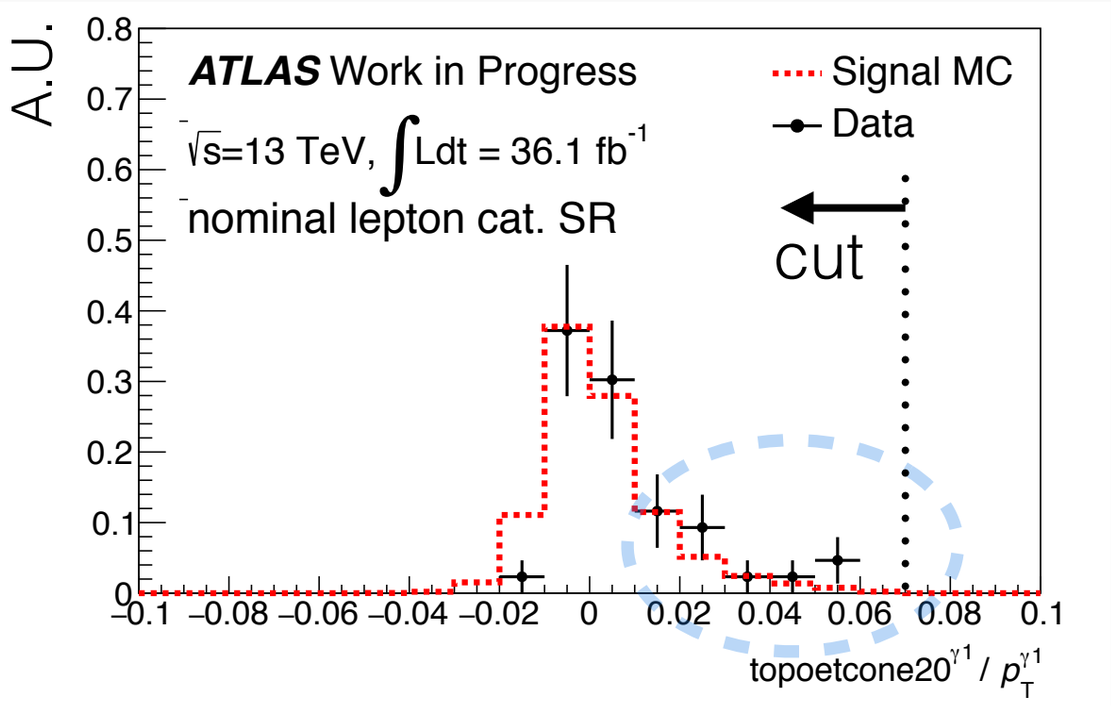


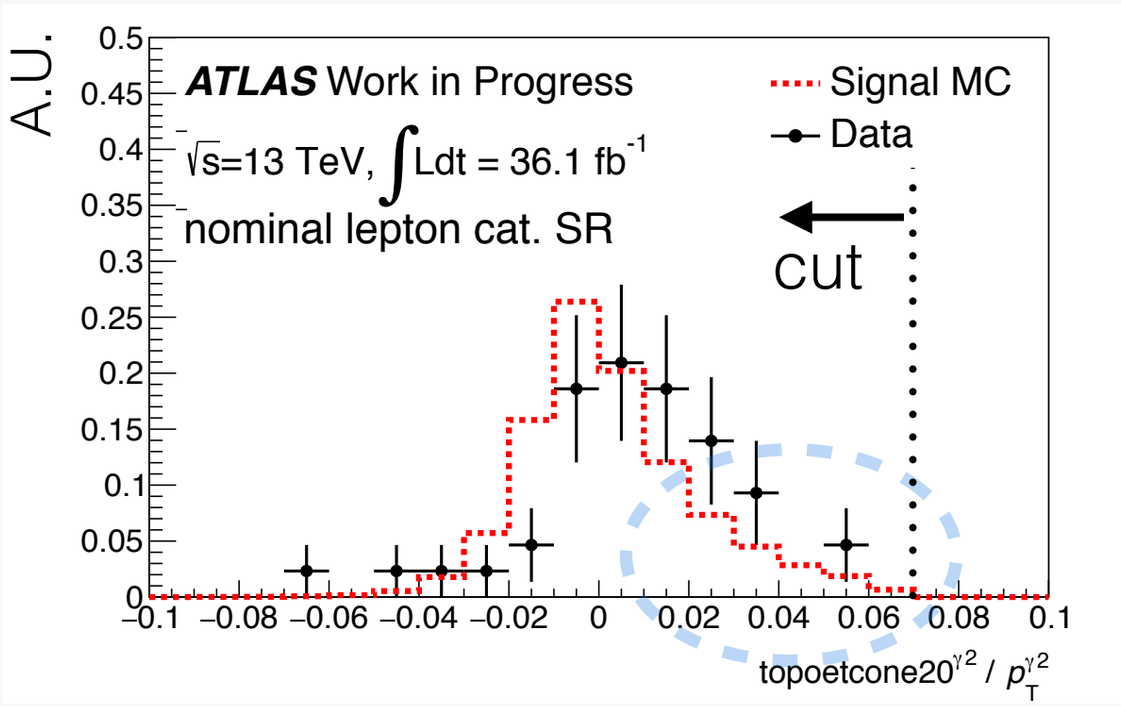
~ 18 GeV is the best point in case of loose photon selection (but almost flat in lower pT region)

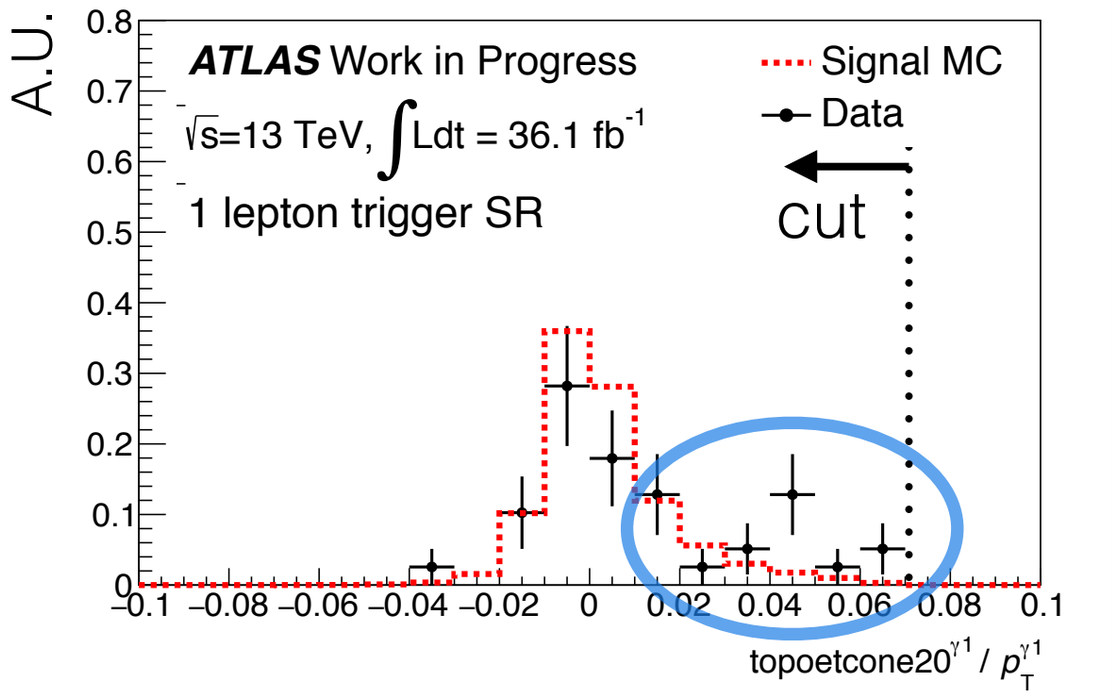
Naive Ideas to Reduce BG (1)

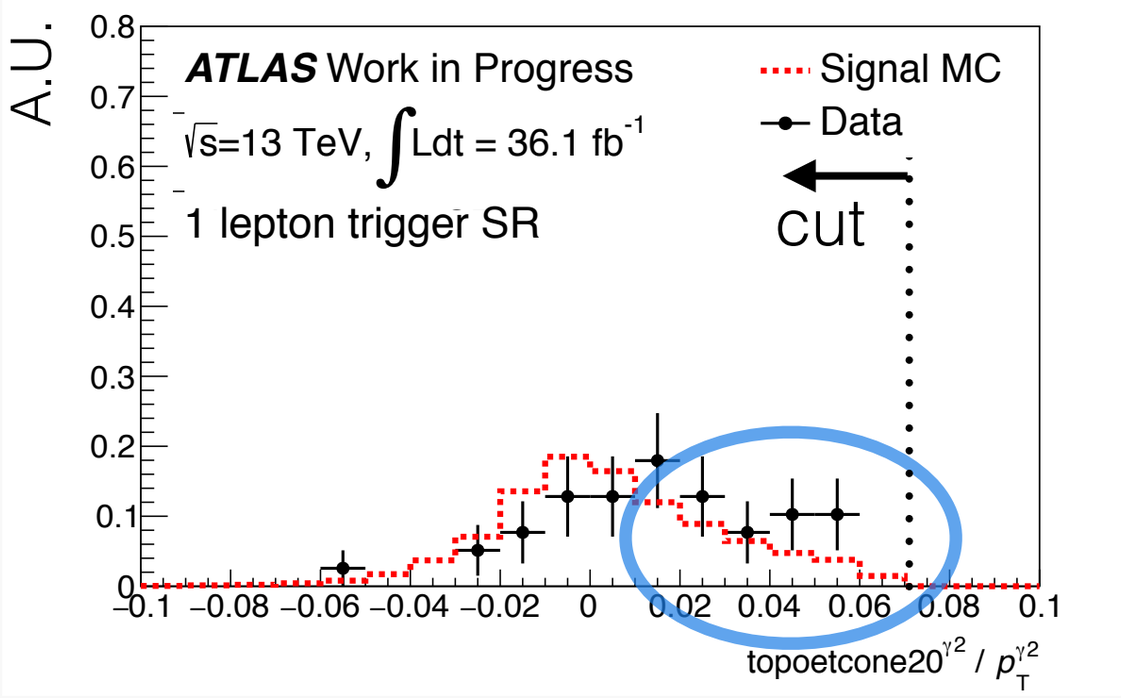
- tt + jet (jet fakes to photon)

  ➡ S/B will be improved by optimise isolation cut in 1 led trigger SR?







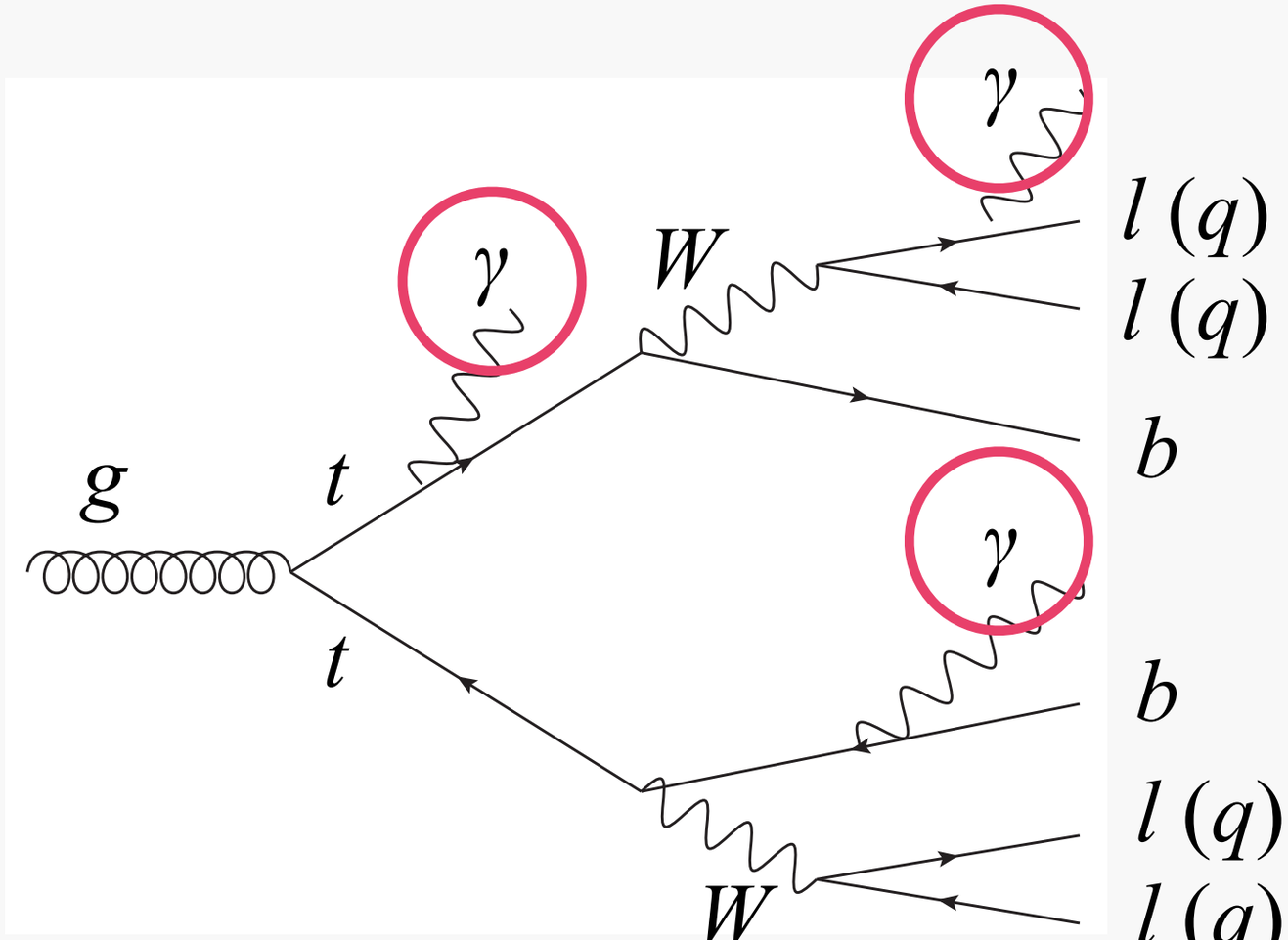


Naive Ideas to Reduce BG (2)

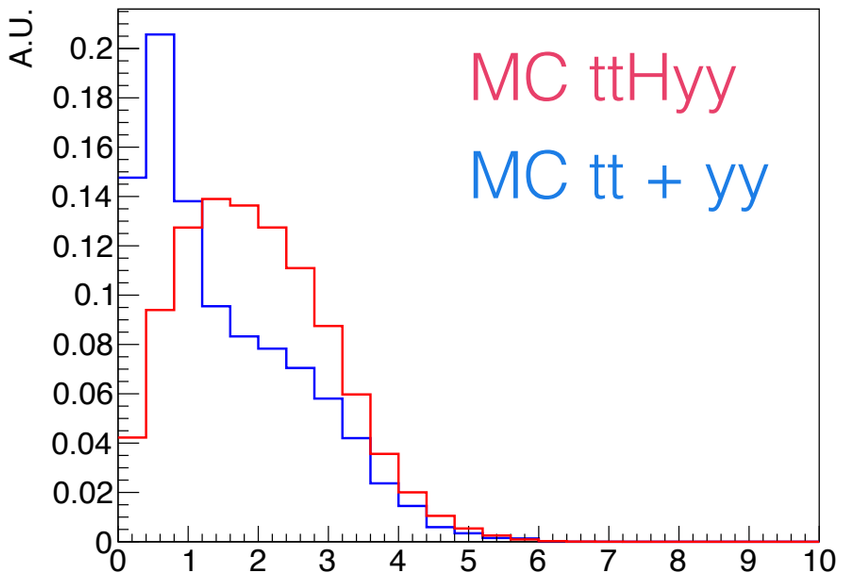
- tt + yy

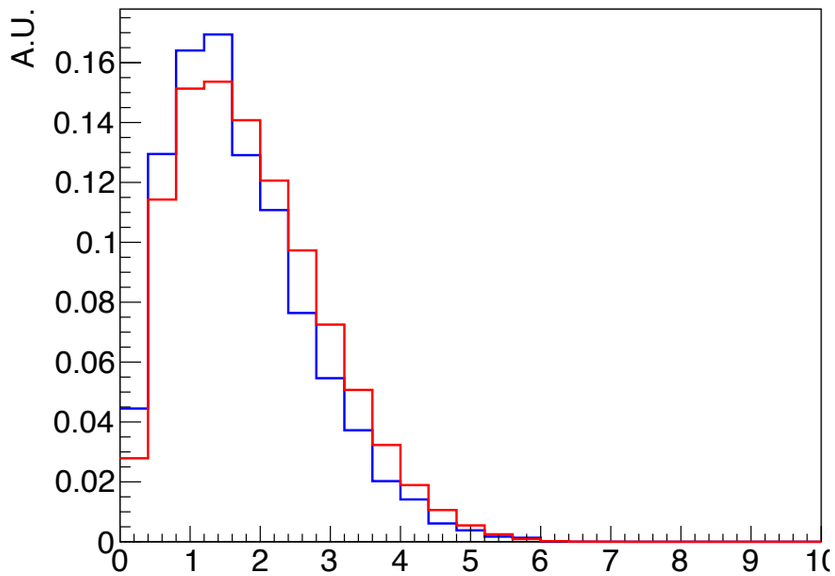
  ➡ truthによるとprompt photonとFSRが~80%

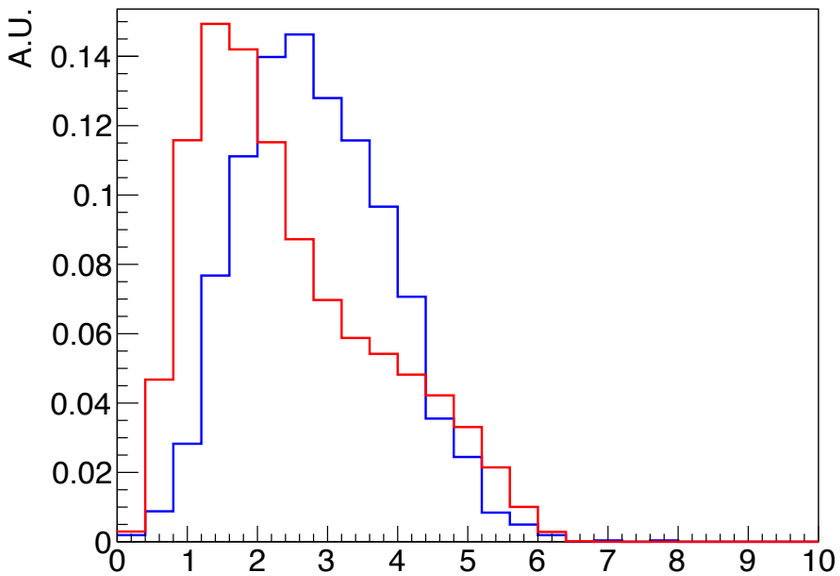
  ➡ topや他の生成objectに近い (dRが小さい)？

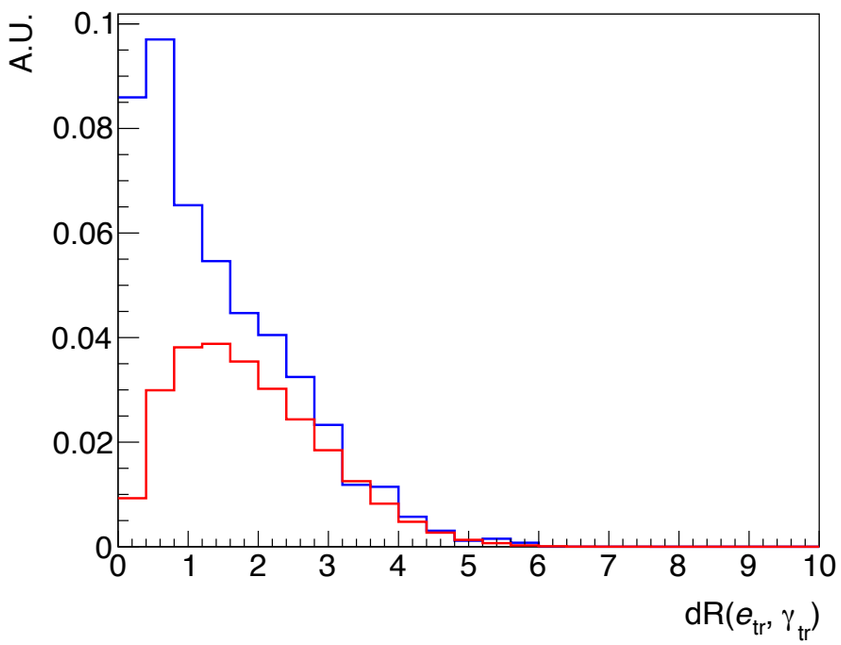


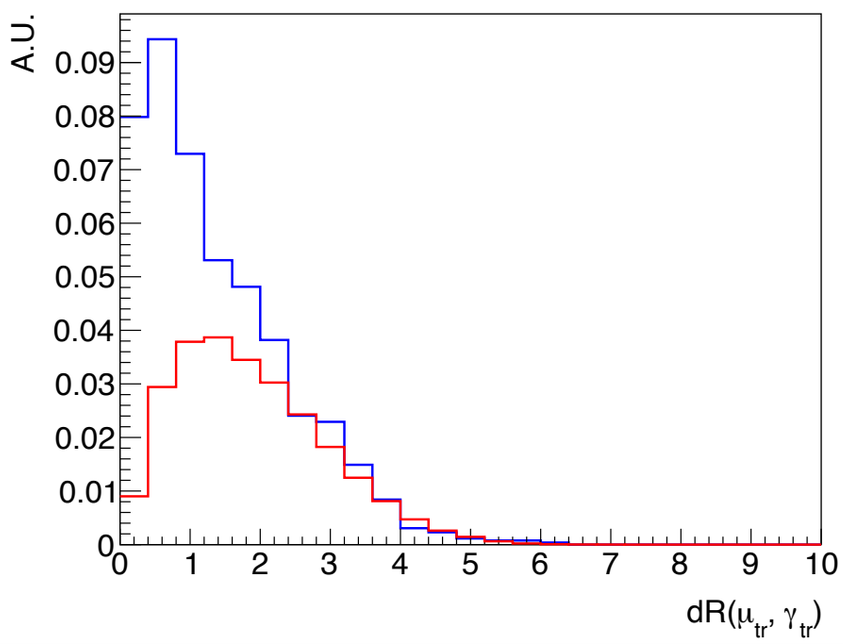
Distance between y and something









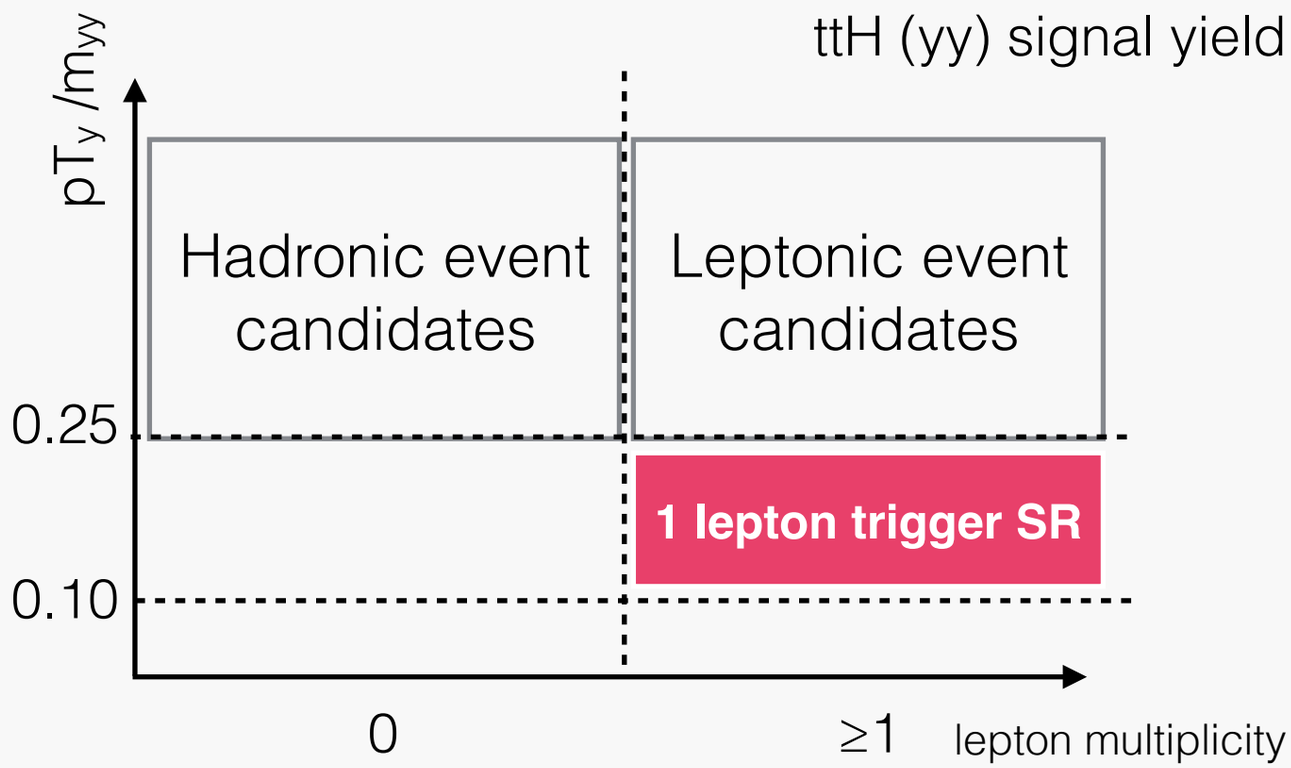


- Inclusive photon selection
  - ➡ pT > 25 GeV
  - ➡ no tt selection

Backup

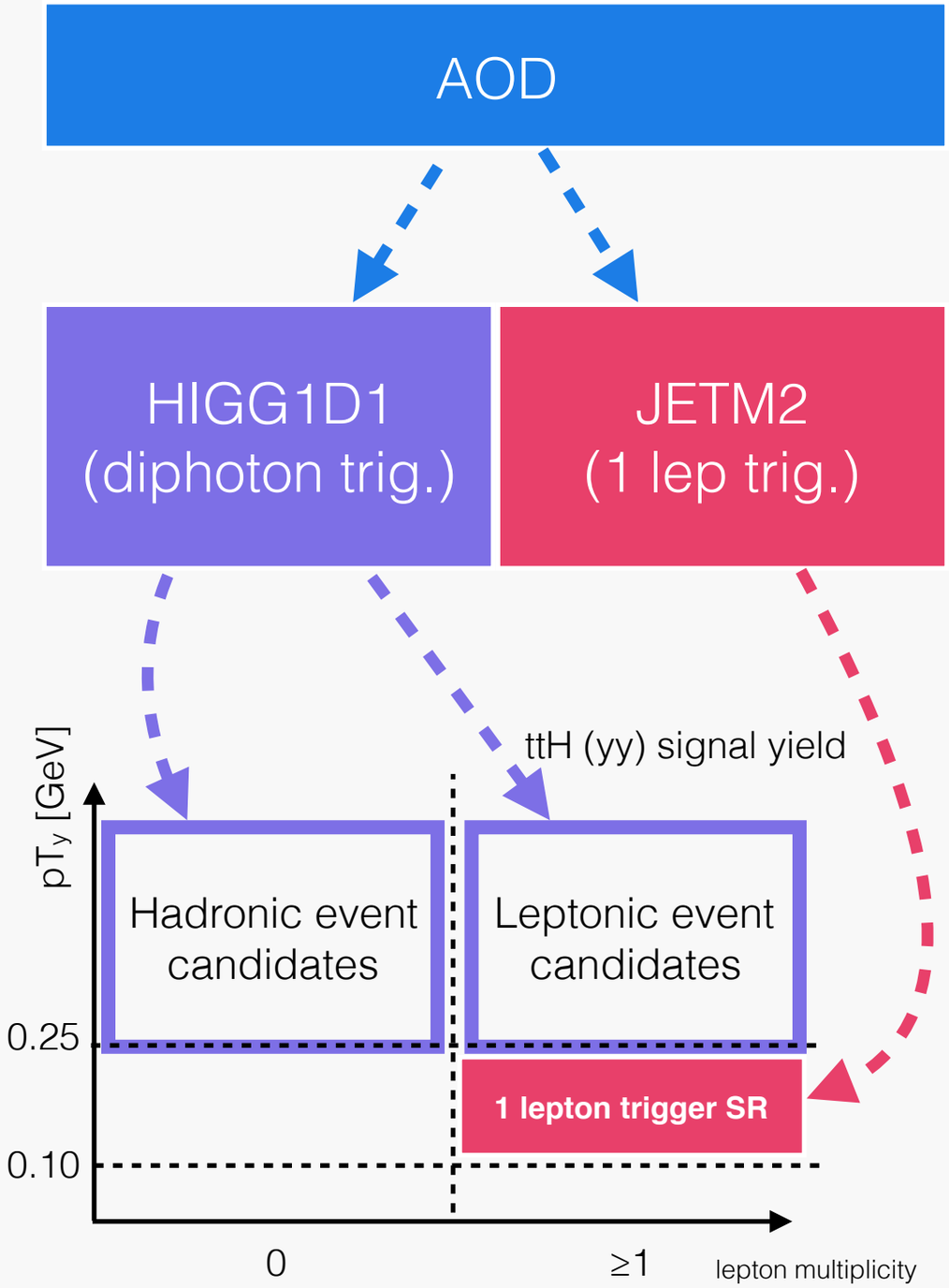
(Review) Idea for adding “1 Lepton Trigger” SR

- $pT_y \leq 25$ GeV event cannot be picked up due to di-photon trigger
  - ➡ requiring $pT_{y1} / m_{yy} \geq 0.35$, $pT_{y2} / m_{yy} \geq 0.25$
- Adding single lepton trigger category as new SR
  - ➡ can extend acceptance to low photon pT region



(Review) BG Estimation

- Estimating the number of BG in the SR with data
- HIGG1D1 doesn't contain low pT photon
  - ➡ Using **JETM2** derivation
    - 1 lep trigger skimming
  - ➡ In JETM2, photon pointing NN method cannot be used to decide PV
    - because some track info. is thinned
    - so hardest vertices are chosen as PV for both derivation



New Trigger Requirements

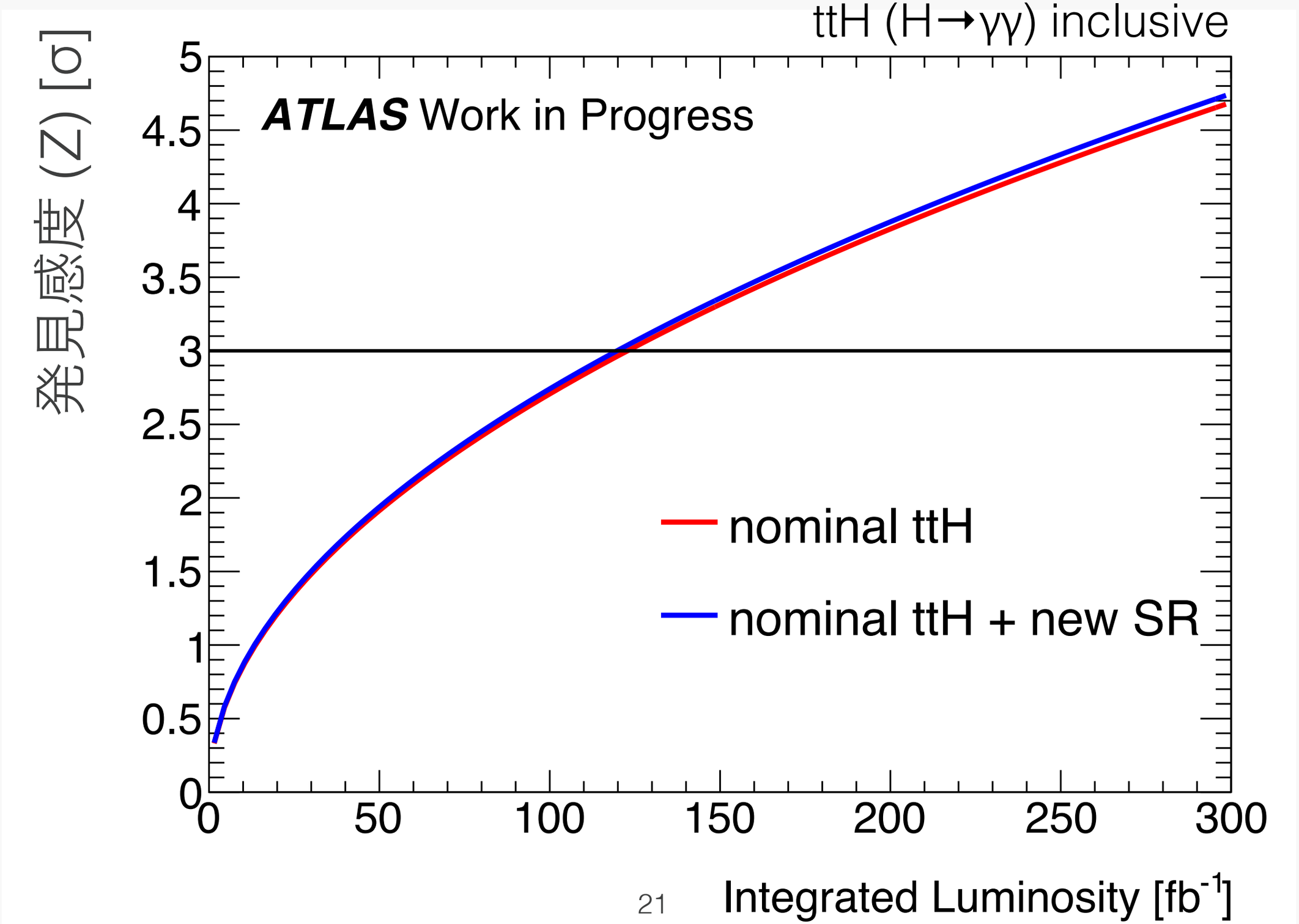
- Selection
  - ➡ lower pT leptons are available if 1 let + multi photon triggers are chosen

object	variable	1 lepton trigger	1 lepton + 2 photon trigger
electron	pT	> 26 GeV	> 20 GeV
muon	pT	> 26 GeV	> 20 GeV
photon	pT	-	> 10 GeV
	N_{photon}	-	>= 2

- File size
  - ➡ select 1 xAOD file and applying above trigger to HIGG1D1 derivation
    - xAOD file size: 2,537,680 KB
    - <μ> = 21.5
  - ➡ Di-photon trigger (nominal HIGG1D1) : 25,860 KB
  - ➡ Di-photon || 1 lepton trigger : 178,496 KB (×6.90 wrt. nominal HIGG1D1)
  - ➡ Di-photon || 1 lepton + multi photon trigger : 36,736 KB (×1.42 wrt. nominal HIGG1D1)

2016年以降の発見感度の見積もり

- 統計量のみによる評価



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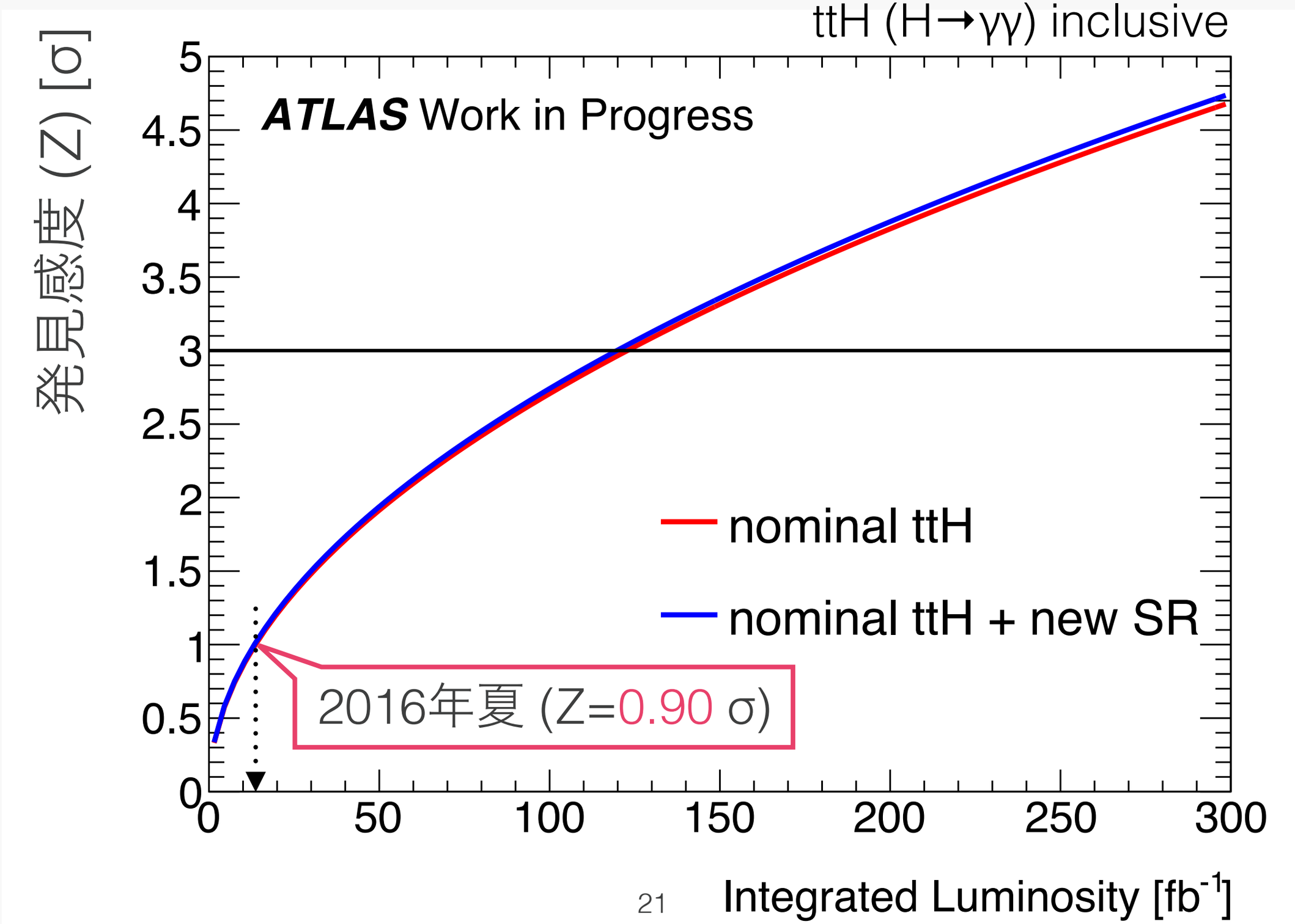

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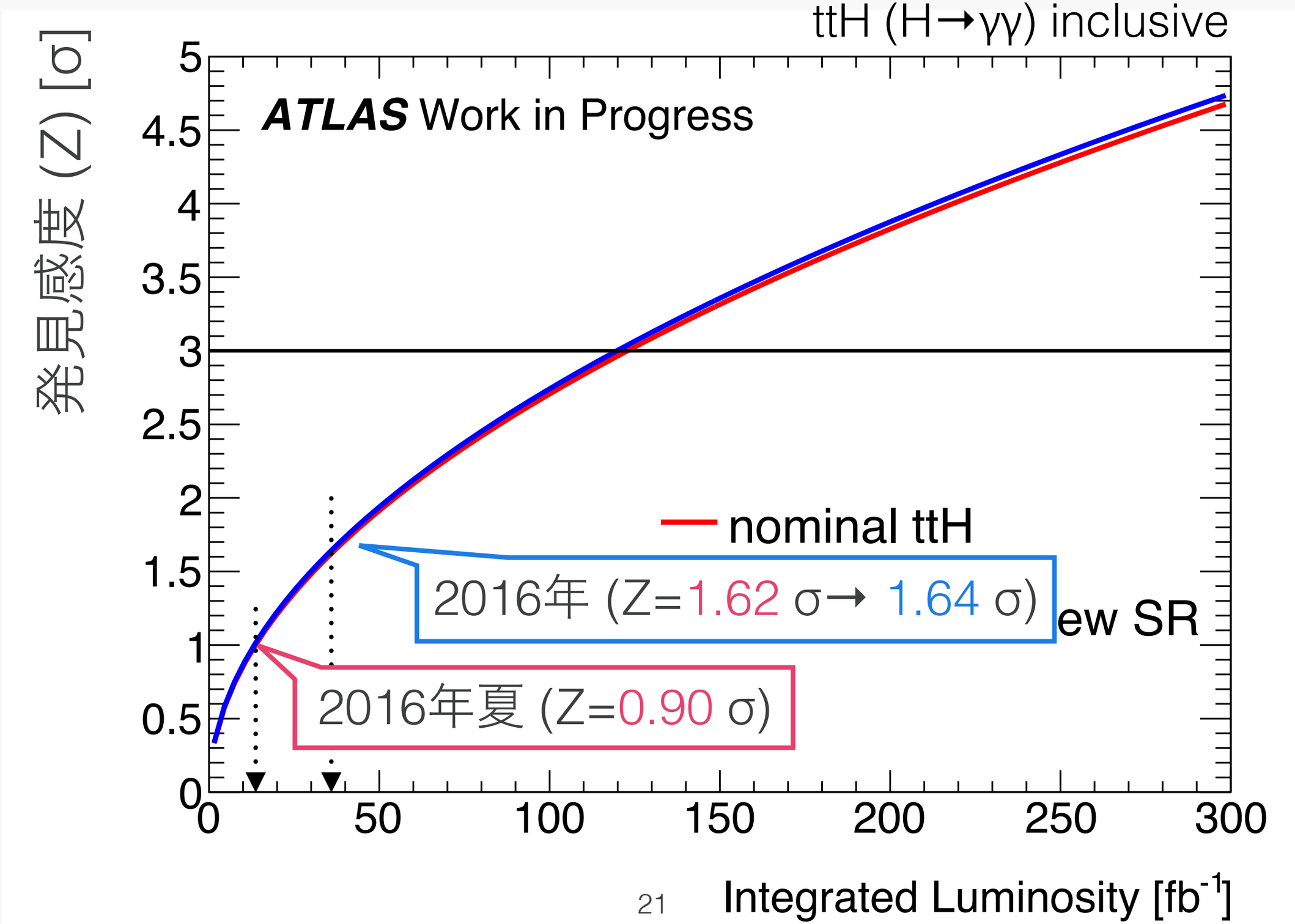

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