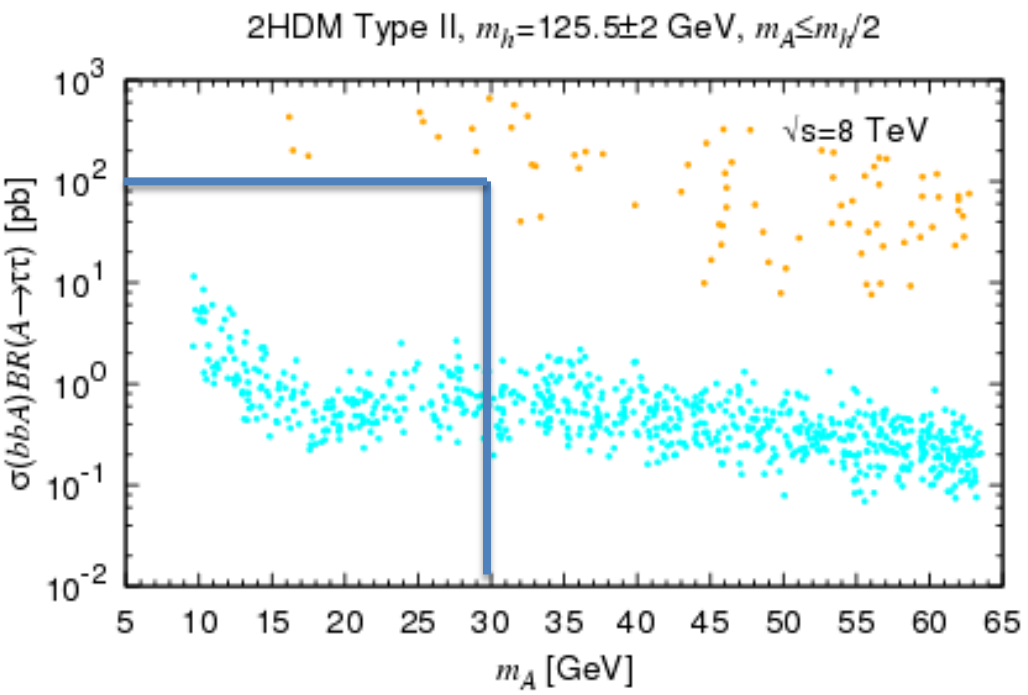
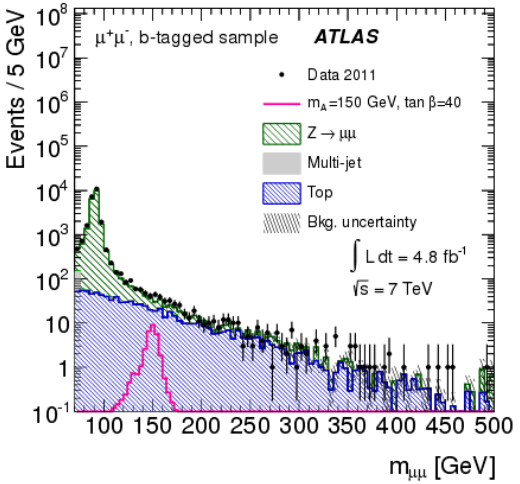
2HDM: pp->bbA, A->μμ, m_A=20-60 GeV
Les Houches 2015

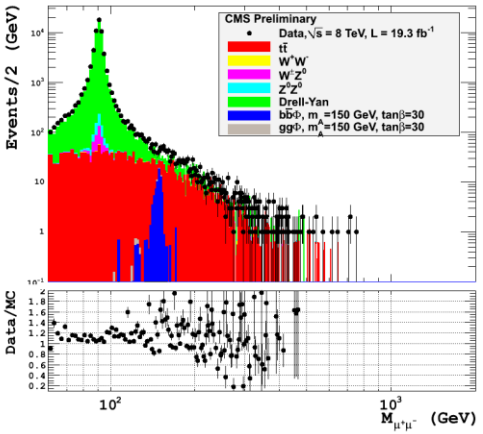
A. Nikitenko, IC, 13th June

Physics motivation

- **bbA, A->ττ/μμ cross-section in 2HDM Type II can be very large for light m_A**
  - **J. Gunion et al; arXiv:1412.3385**





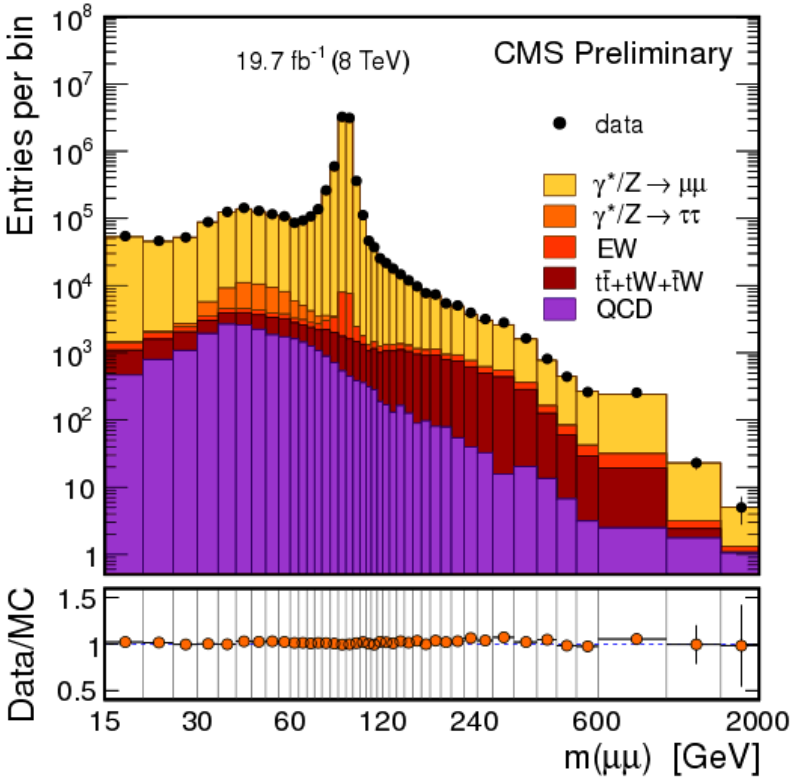


- **σ(bbA)BR(A->ττ)=100 pb at m_A=30 GeV**
  - **for μμ mode it is scaled by factor m_μ^2/m_τ^2 = 3.5x10^{-3}**
  - **σ(bbA)BR(A->μμ) = 350 fb used in our analysis**

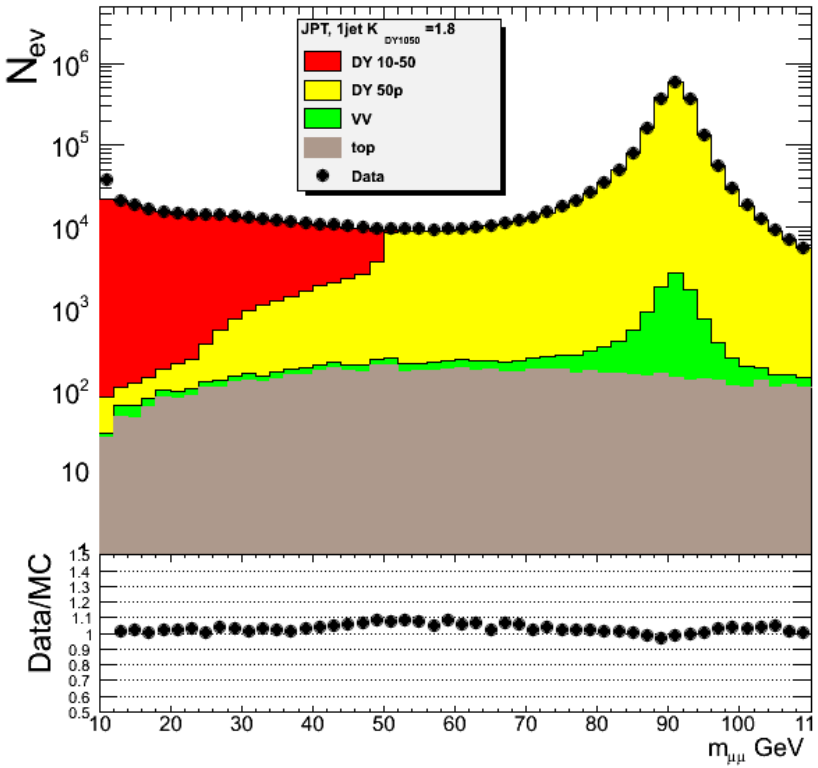
optimized selections:

- **Single muon trigger HLTMu24**
  - ***muons in offline:***
    - **two leading p_T, OS, isolated muons**
    - **$p_T^{\mu 1} > 25$ GeV, $|\eta^{\mu 1}| < 2.1$, $p_T^{\mu 2} > 5$ GeV, $|\eta^{\mu 2}| < 2.4$**
- **Jets**
  - **at least one b-jet with $p_T > 20$ GeV, $|\eta| < 2.4$**
  - **$\Delta R(\mu\text{-jet}) > 0.5$**
- **E_T^{miss}**
  - **$E_T^{miss} < 40$ GeV (against tt~)**

- **DY inclusive**
  - **public plot, $p_T^{\mu's} > 20$ GeV**

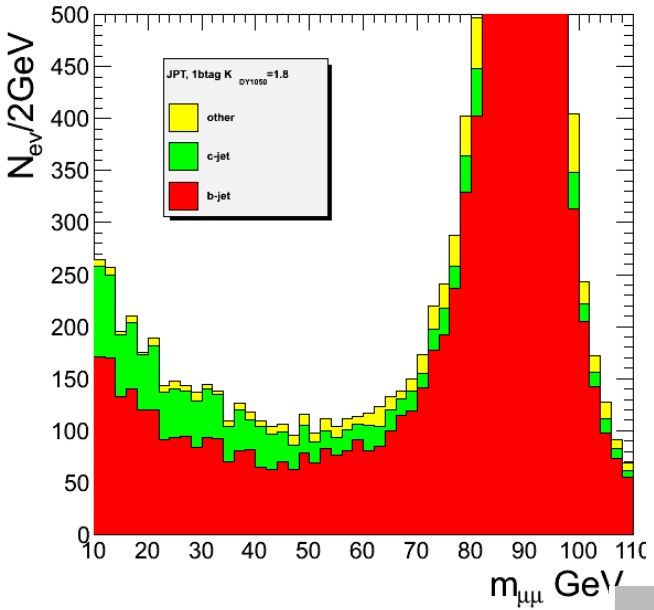


- **DY + >= 1 jet**
  - **signal selections, no b-tag**
    - **semi-public plot**

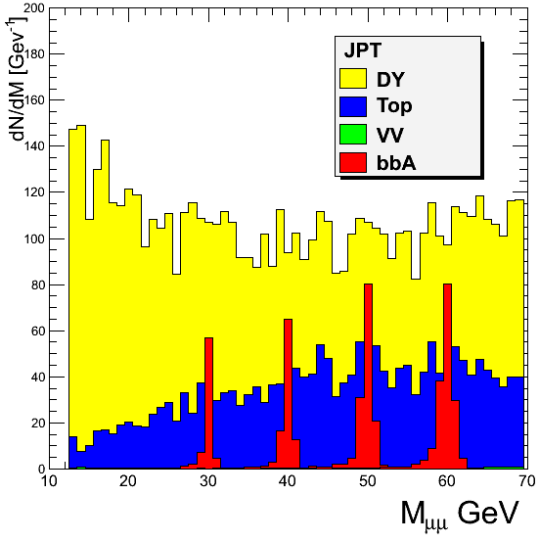


Signal and bkgs. after b-tagging

- composition of DY+jets background after b-tag

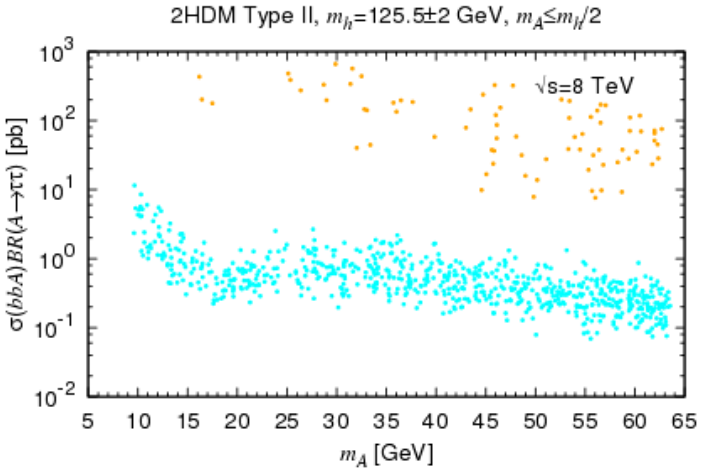


- Expected signal assuming σ(bbA)xBR(A->ττ)=100 pb



Exp. Limits (ττ) in pb

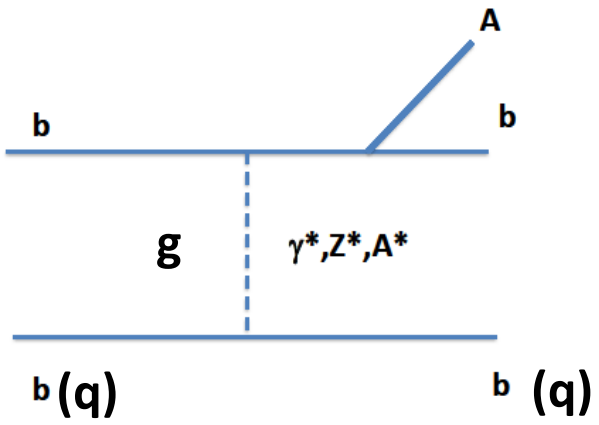
	30	40	50	60
-2σ	0.20	0.16	0.13	0.12
-1σ	0.28	0.22	0.18	0.17
Med	0.40	0.32	0.26	0.24
1σ	0.60	0.48	0.39	0.36
2σ	0.88	0.70	0.57	0.52



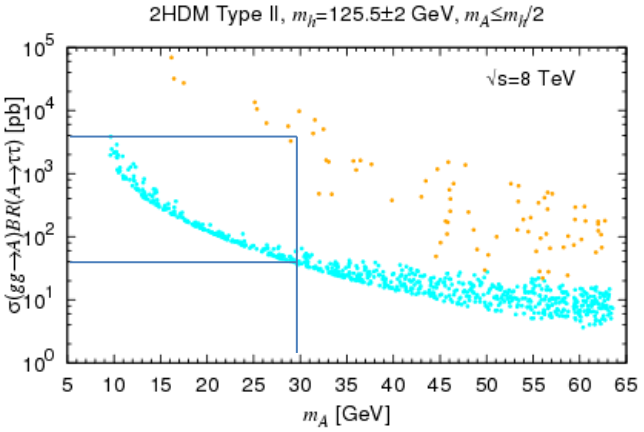
Two items still to be addressed
(in Les Houches)

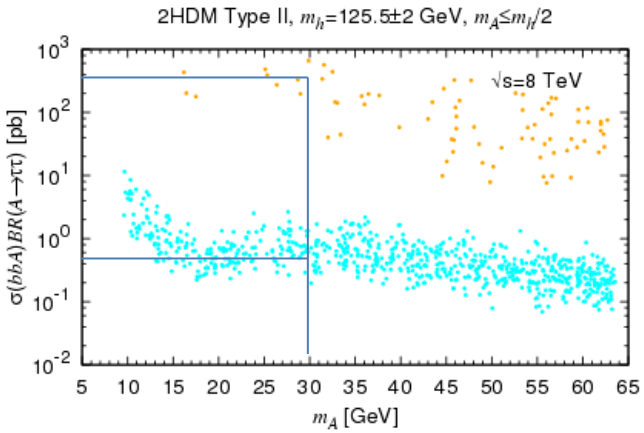
- "contamination" of gg->A in b-tag event category
- contribution of bb(q)->bb(q)A

for example:



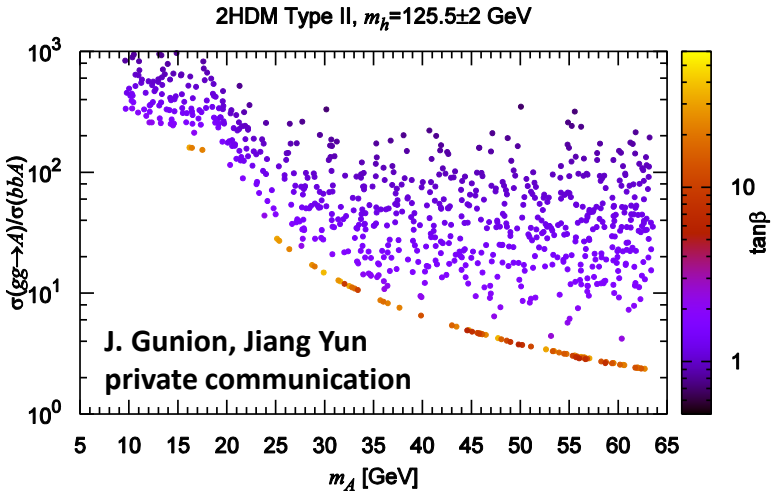
- **Contribution from gg->A in to b-tag category in 2HDM scenarios considered in J. Gunion's paper** arXiv:1412.3385



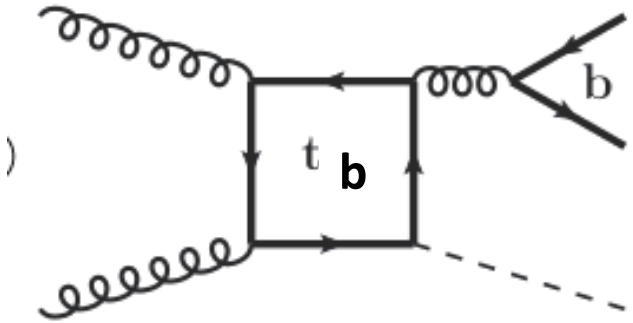


Brown = "wrong sign Yukawa" scenario: $k_D < 0$.

Blue = "normal sign Yukawa" scenario: $k_D > 0$



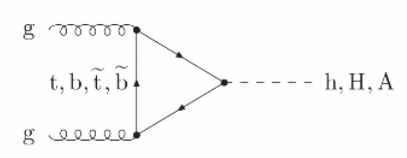
- σ(gg->A) at low m_A can be much bigger than σ(bbA)
  - gg->A contamination in b-tag category can be significant from to two sources:
    - gg->A+gluon
      - gluon->bb
      - gluon is misstaged as b-jet



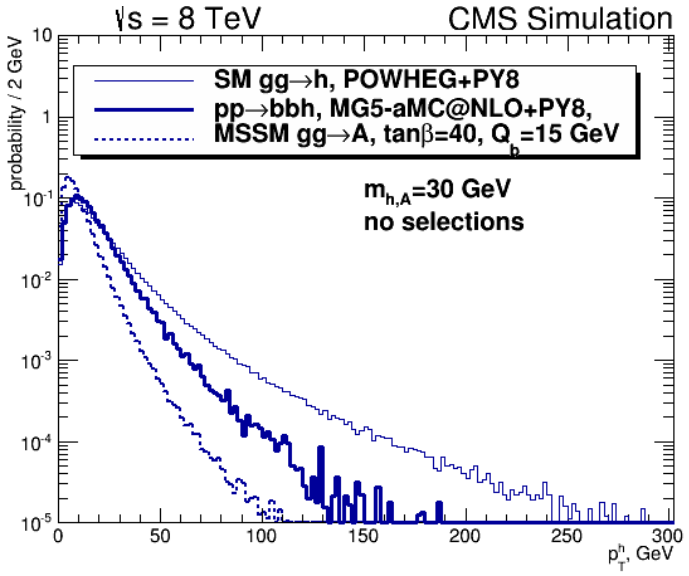
Present generation:

gg->h at NLO (POWHEG, MG5_aMC@NLO)
produce g->bb from shower MC: PY8

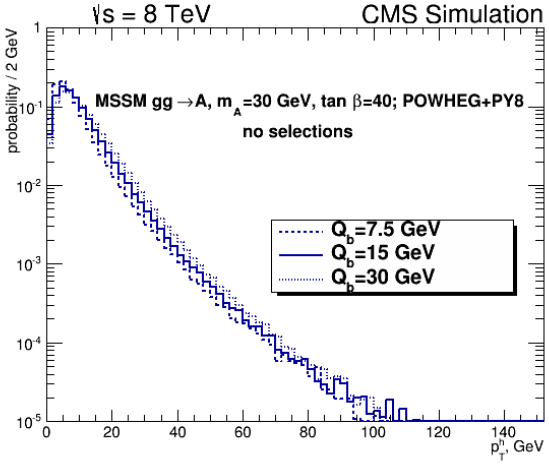
p_T^H in gg->A at low and high tanβ



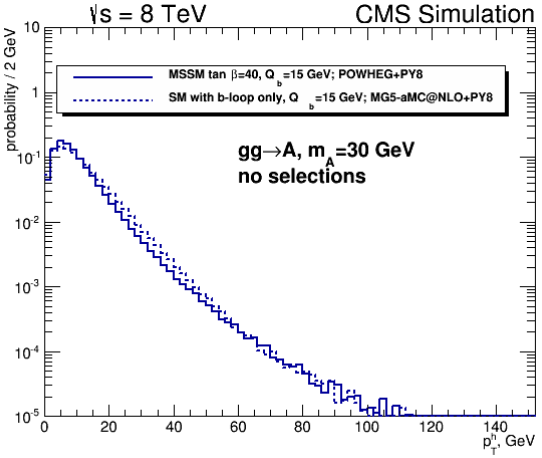
1. *Spira et al. hep-ph/0604156*
2. *J. Alwall, Q Li, F. Maltoni arXiv:1110.1728*
3. *E.Bagnaschi, G. Degrassi, P. Slavich, A.Vicini. arXiv:1111.2854*



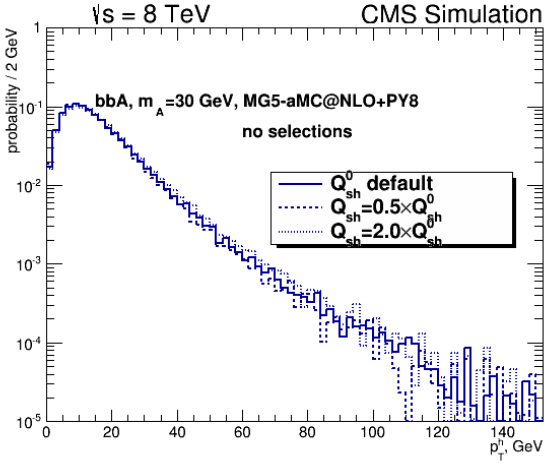
p_T^H in gg->A vs Q_b resummation scale



p_T^H in gg->A: aMC@NLO* vs POWHEG



p_T^H in bb->A vs Q_{sh} shower scale



*** generation done by M. Wiesemann**

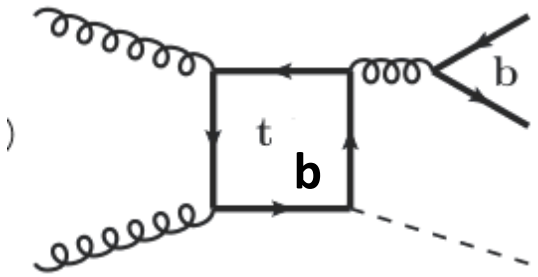
Selection efficiencies (at parton level) for bbA and gg->A processes for m_A=30 GeV with $p_T^{\mu 1,\mu 2}$ > 25, 5 GeV

* Stat accuracy

MC generator	bbh, NLO MG5_aMC@NLO+PY with Q_{sh} variation 0.5, 2.0 of the nominal α=0.25 (small numbers)	gg->h, NLO (in MSSM generation Q_b is varied as 0.5, 2.0 of nominal scale Q_b=15 GeV: small numbers)		
Parton level selections		Normal sign Yukawa use SM gg->h POWHEG+PY8	Wrong sign Yukawa use b-quark only in loop	
			POWHEG MSSM tanβ=40	aMC@NLO SM gg->A Q_b=15 GeV
$p_T^{\mu 1,2}$> 25, 5 GeV $\lvert\eta^{\mu 1,2}\rvert$ < 2.1, 2.4	0.113 0.105/0.124	0.151	0.029 0.021/0.038	0.038
>=1 jet, p_T>30 GeV, $\lvert\eta\rvert$<2.4	0.375 0.345/0.451	0.417	0.160 0.172/0.156	0.108
>=1 b-jet, p_T^b > 30 GeV, $\lvert\eta^b\rvert$ < 2.4	0.789 0.812/0.738	0.035	0.032(10%*) 0.030/0.027	0.021
total eff, ε	3.32×10^{-2}	2.18×10^{-3}	1.5×10^{-4}	0.9×10^{-4}
Ratio ε(gg->A)/ε(bbA)		0.07	0.0045	0.0027

Conclusion from previous slides (I)

- **In wrong sign Yukawa cases (high tanβ) gg->A contamination to b-tag category is negligible (~3-5%)**
- **In normal sign Yukawa cases (low tanβ) gg->A contamination in b-tag category is dominant - ~10 times bigger than bb->A !**
  - ***how certain are predictions for gg->A+gluon, gluon->bb ?***
    - ***T. Sjostarnd:* "g->bb from shower gives qualitative rather than quantitative description"**
  - ***want to compare with full ME gg->h+bb***



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