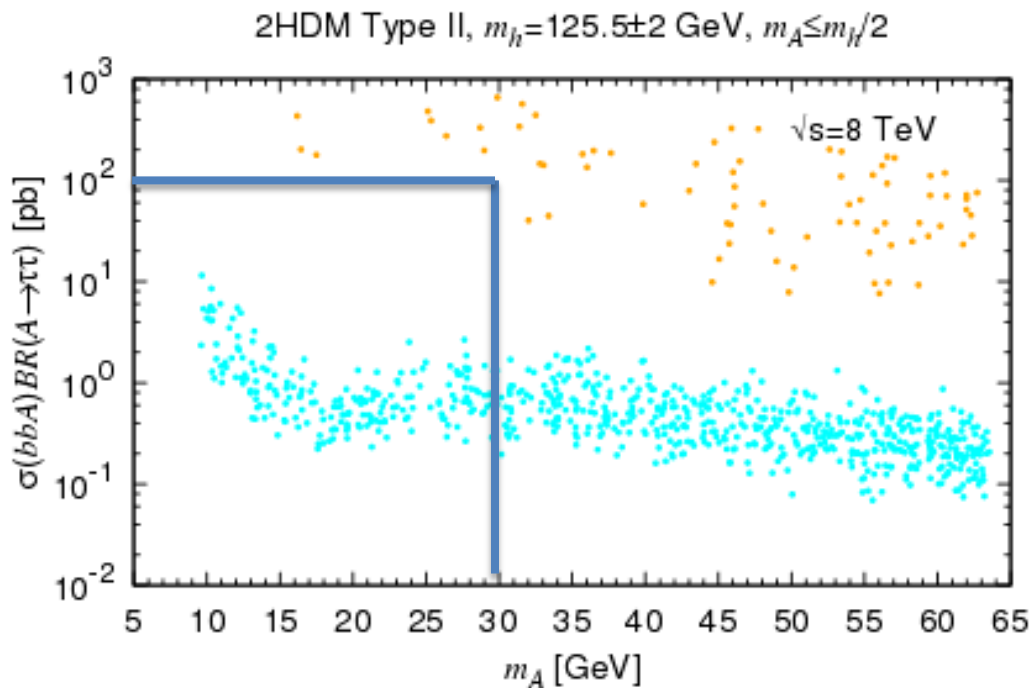# Search for light A in bbA, A->μμ mode

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with non LE contributors
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Physics motivation

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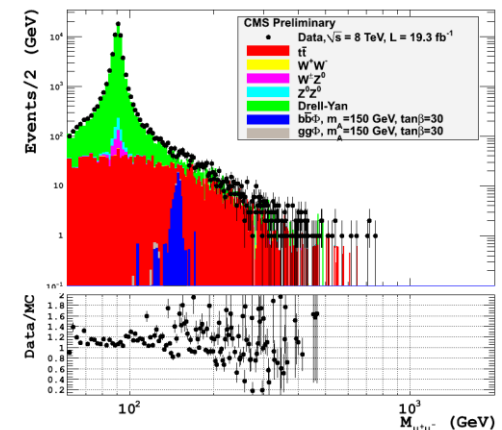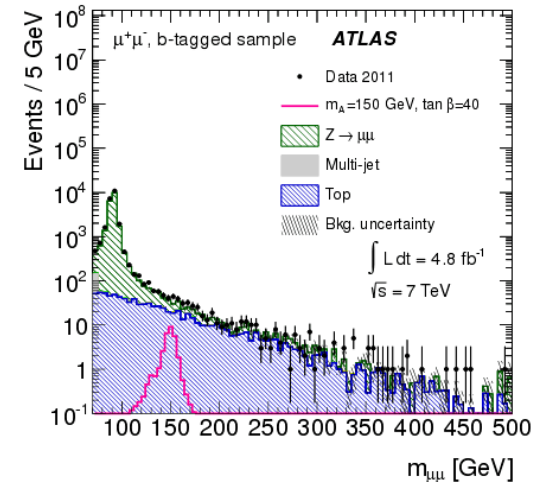 - **J. Gunion et al; arXiv:1412.3385**

2HDM Type II, $m_h = 125.5 \pm 2$ GeV, $m_A \leq m_h/2$

- $\sigma(bbA)BR(A->\tau\tau) = 100$ pb at $m_A = 30$ GeV
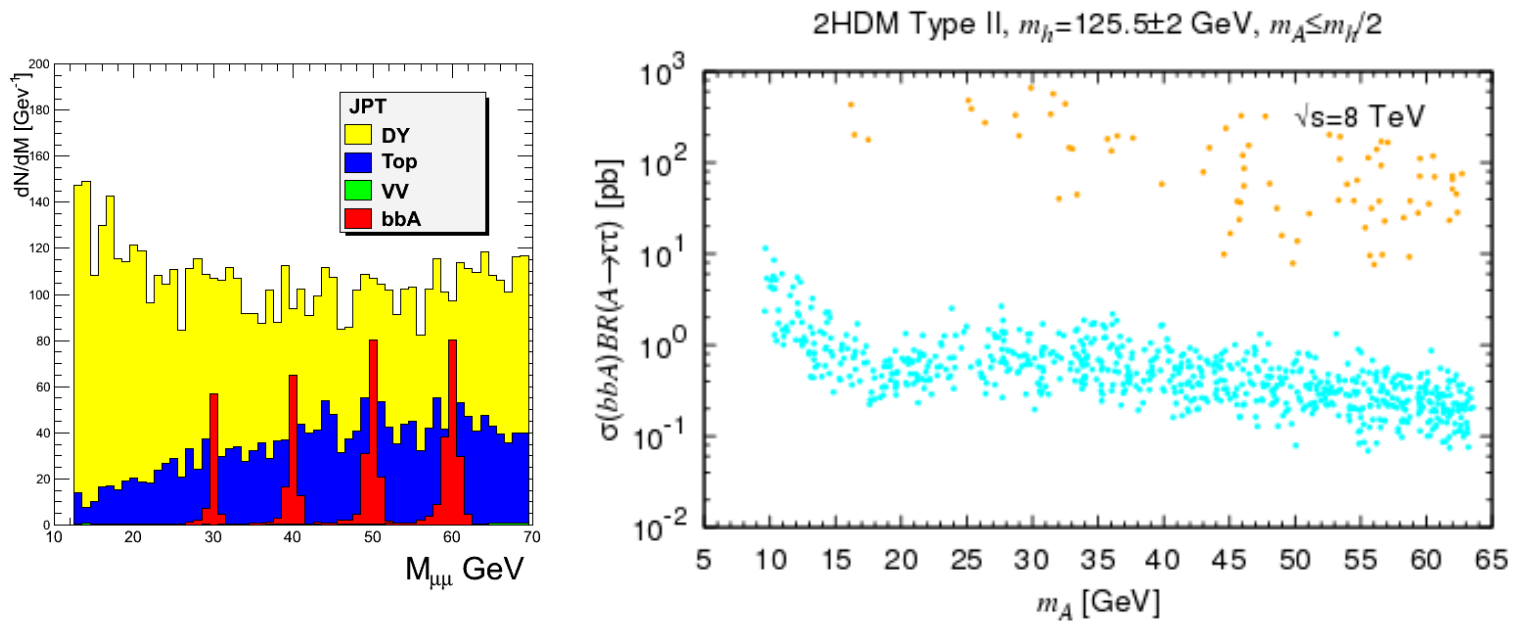 - for $\mu\mu$ mode it is scaled by factor $m_\mu^2/m_\tau^2 = 3.5 \times 10^{-3}$
  - $\sigma(bbA)BR(A->\mu\mu) = 350$ fb used in our analysis

Signal and bkgs. after b-tagging

- **Expected bbA, A->μμ signal with 8 TeV data, 20 fb^{-1}, assuming σ(bbA)xBR(A->ττ)=100 pb**

Together with bbA, A->ττ analysis (HIG-14-033, paper to be soon) expected to exclude "wrong sign b-quark Yukawa coupling " scenario

LE – contribution of gg->A in b-tagged category

- **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**

2HDM Type II, m_h=125.5±2 GeV
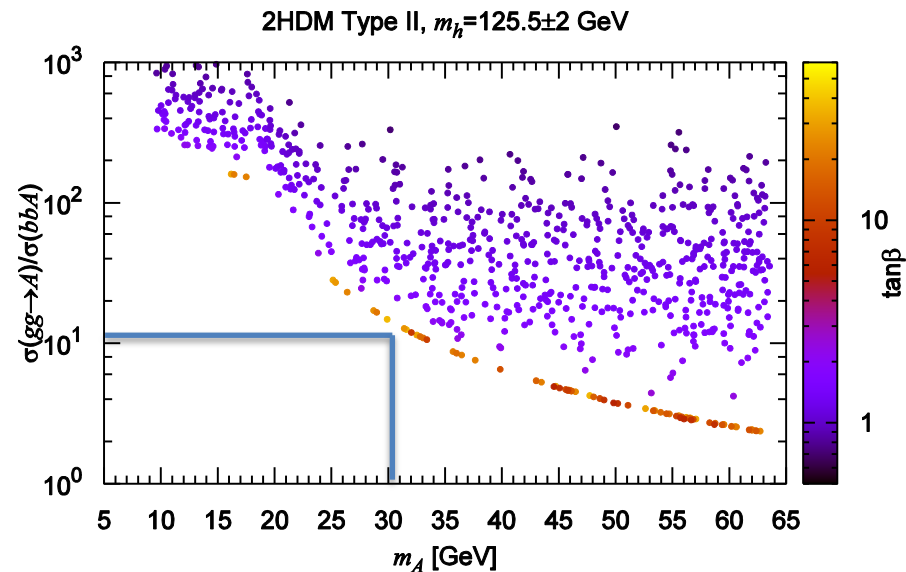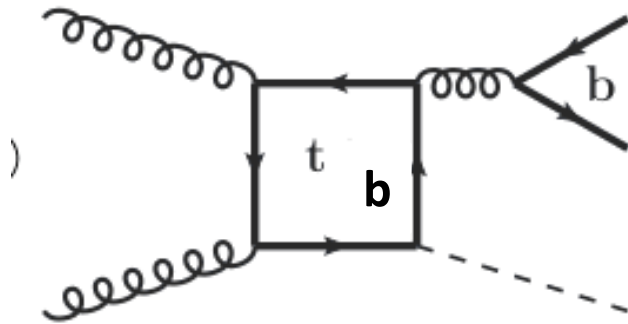
Parton level analysis with:
   - gg->h at NLO (POWHEG, MG5_aMC@NLO), g->bb from PY8 shower
   - full LO ME lhe event file produced by Olivier Mattelaer

- **Full ME generation with MG5_aMC@NLO by Olivier Mattelaer**
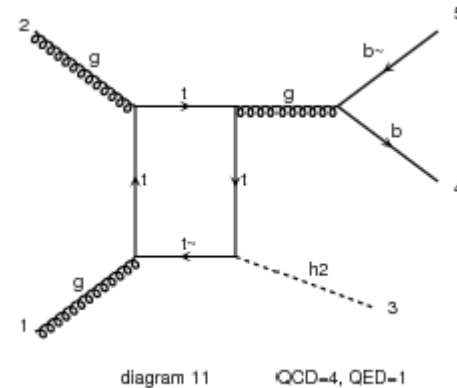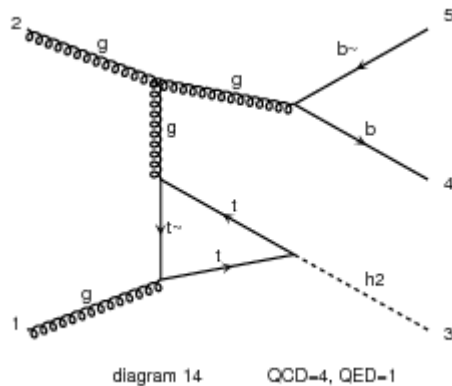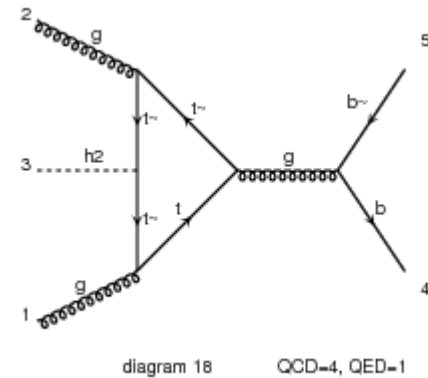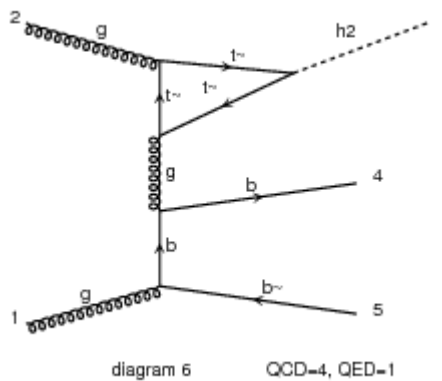
b-loop induced SM cross-section gg->bbA, mA=30 GeV. aMC@NLO = 3.457 x10^{-2} pb
SM gg->A with b-loop only cross-section = 88.7 pb (aMC@NLO), M. Spira HIGLU – 105 pb
Ratio of cross-sections R = 3.9 x 10^{-4}

Selection efficiencies (at parton level) for bbA and gg->A processes for m_A=30 GeV PY8 for showering

* Stat accuracy

	bbh with Q_{sh} variation 0.5, 2.0 of the nominal α=0.25 (small numbers in [])	gg->h with b-quark only in the loop + g->bb (in POWHEG generation Q_b is varied as 0.5, 2.0 of nominal scale Q_b=15 GeV: see small numbers in [])		
	MG5_aMC@NLO	aMC@NLO	POWHEG	aMC@NLO
		ME gg->bbA	g->bb from PY8 shower	
		R = 3.9 x 10^{-4}		
$p_T^{\mu1,2}$> 25, 5 GeV $|\eta^{\mu1,2}|$ < 2.1, 2.4	0.113 [0.105-0.124]	0.194	0.029 [0.021-0.038]	0.038
>=1 jet, p_T>30 GeV, $|\eta|$<2.4	0.375 [0.345-0.451]	0.378	0.160 [0.172-0.156]	0.108
>=1 b-jet, p_T^b > 30 GeV, $|\eta^b|$ < 2.4	0.789 [0.812-0.738]	0.524	0.032 (10%*) [0.030-0.027]	0.021 (10%)
total eff, ε	3.32x10^{-2}	1.5x10^{-5}	1.5x10^{-4}	0.9x10^{-4}
Ratio ε(gg->A)/ε(bbA)		0.00045	0.0045	0.0027

conclusion

- **In wrong sign Yukawa coupling scenario contribution of gg->A process to b-tag category is small ~ 4 %**

- **Large difference (~ 30 %) in acceptance between gg->A in POWHEG and MG5_aMC@NLO**

- **Very large difference (factor 10) in acceptance for full ME and PY8 shower for g->bb in b-loop induced gg->bbA production**