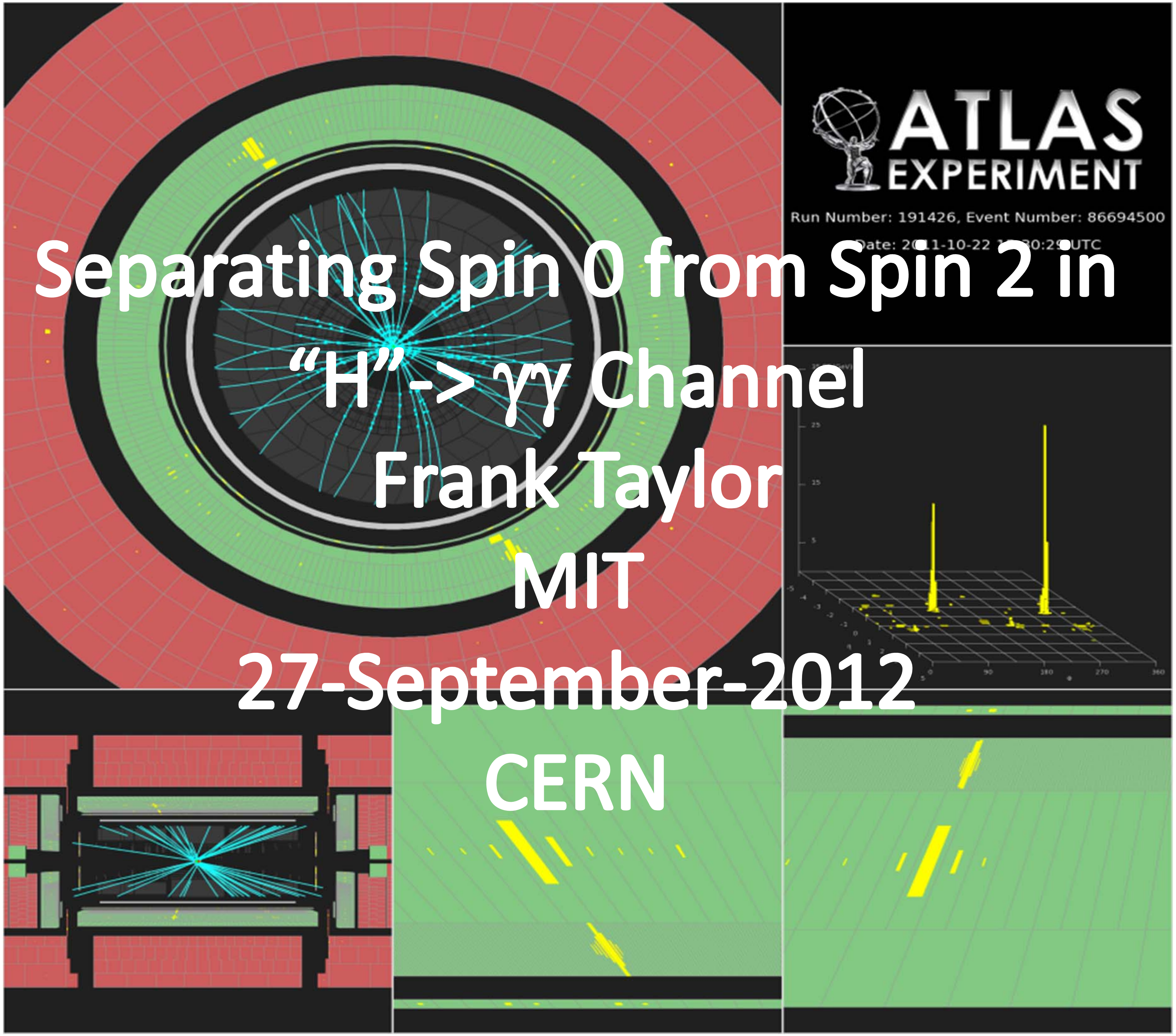


Separating Spin 0 from Spin 2 in "H"-> $\gamma\gamma$ Channel

Frank Taylor
MIT

27-September-2012
CERN

Abstract

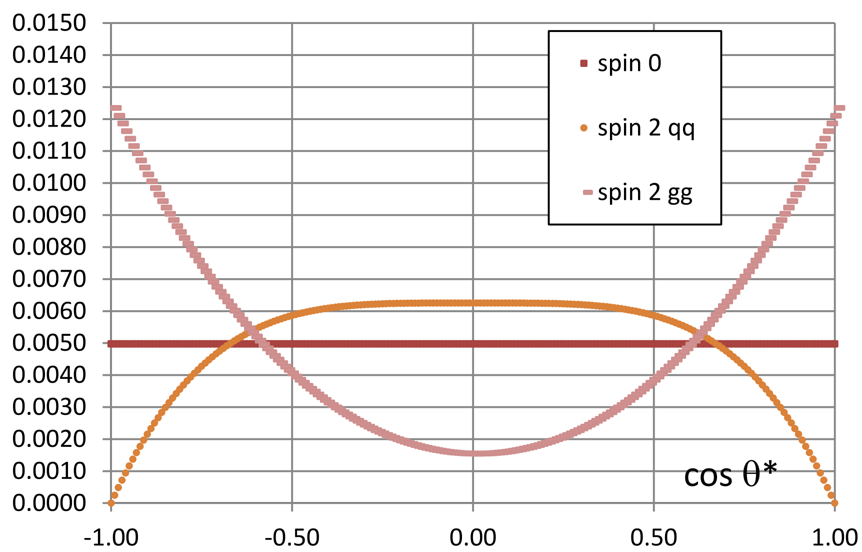
The γ–γ opening angle in a non-rest frame is proposed to study the spin properties of the 126 GeV object. And the opening angle may have utility in separating the signal from the background.

What follows are toy MC results as well as analytic calculations – very primitive.

Needed are full MC simulations with experimental cuts and resolutions for both the 126 GeV signal as well as the digamma background to test the idea.

Spin Analysis Techniques

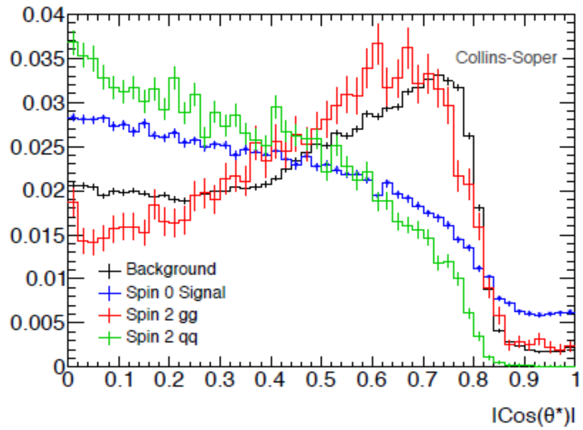
- One approach
  - Study the shape of the cosθ* (|cosθ*|) distribution in γγ-rest-frame (define z-axis by CS frame, boost direction or p-p lab frame)

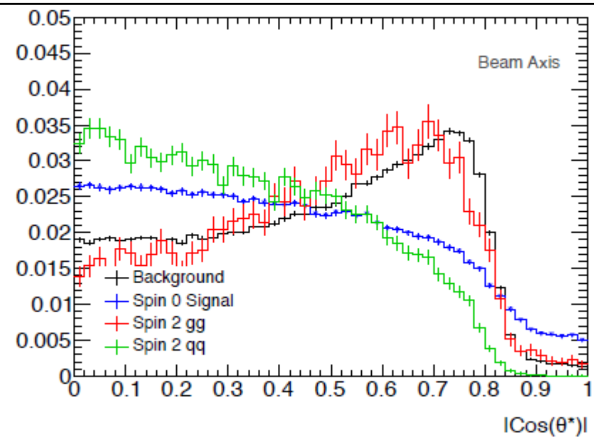


No sensitivity around |cosθ*| ~ 0.6
More sensitivity in central region – especially for Spin 0 vs. Spin 2 gg
Greater sensitivity large |cosθ*|

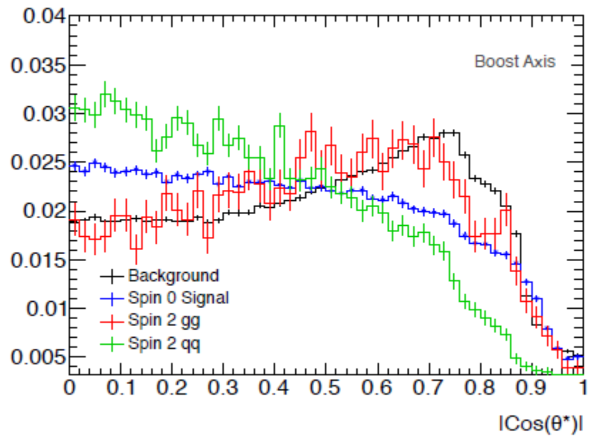
Spin Summary Talk 13-Sep-12

Schaarschmidt, et al





<u>Bkg:</u>
Similar to Spin 2 gg production – peaked at larger |cosθ*|



Analysis based on testing distributions for consistency with spin hypothesis

(plots: M. Kuna)

6

jeudi 13 septembre 2012

Analysis Techniques – cont'd

- Another approach:
  - Consider the $\gamma\gamma$ opening angle in a 'standardized' Lorentz frame to exploit the peaked distribution

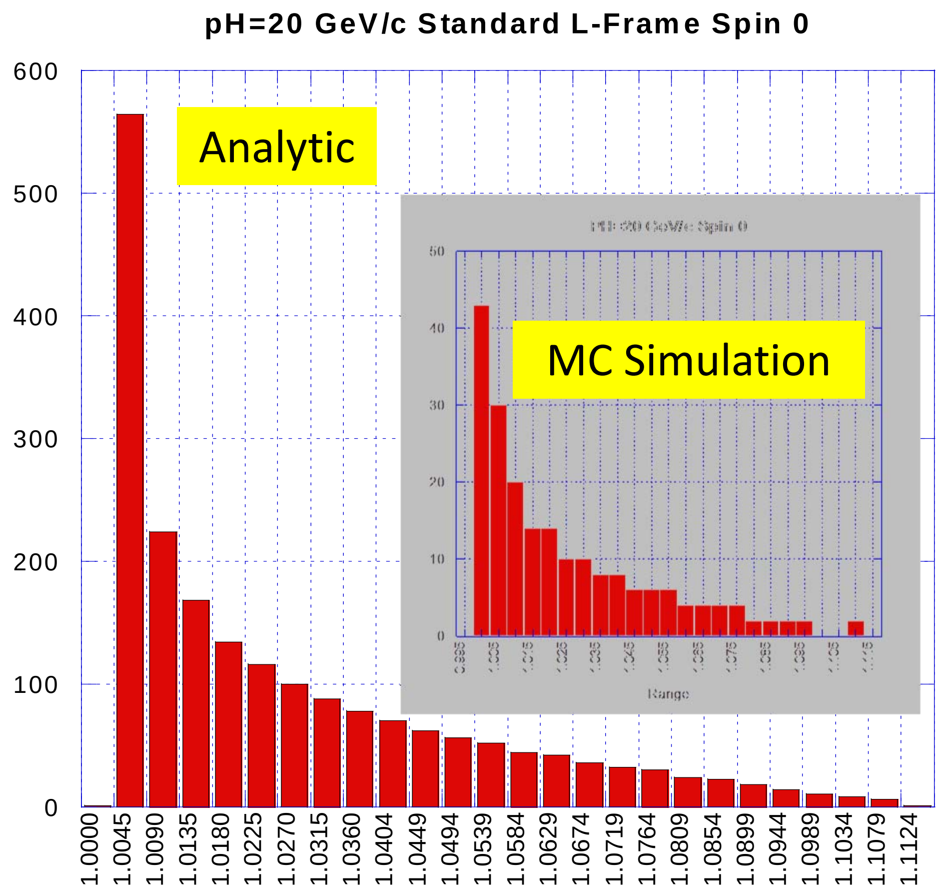
  - p_H = 20 GeV/c defines the standardized L-frame but any value ≠ 0 will work

Analysis Techniques – cont'd

- Choose the $\mathbf{p}_{\gamma\gamma}$ direction for z-axis
  - Note that the $\gamma\gamma$ opening angle has a minimum value : θ^0_{12} = 2aTan($1/\beta\gamma$) where β and γ are the boost values of $\gamma\gamma$ mass from COM to standard L-frame
  - Notice that θ_{12} distribution is strongly peaked around minimum value, especially for a scalar digamma decay
  - Define the scaled opening angle as the variable of choice $\mathrm{Nor}(\theta_{12}) \equiv \theta_{12} / \theta^0_{12}$

Spin 0 Opening Angle Distribution

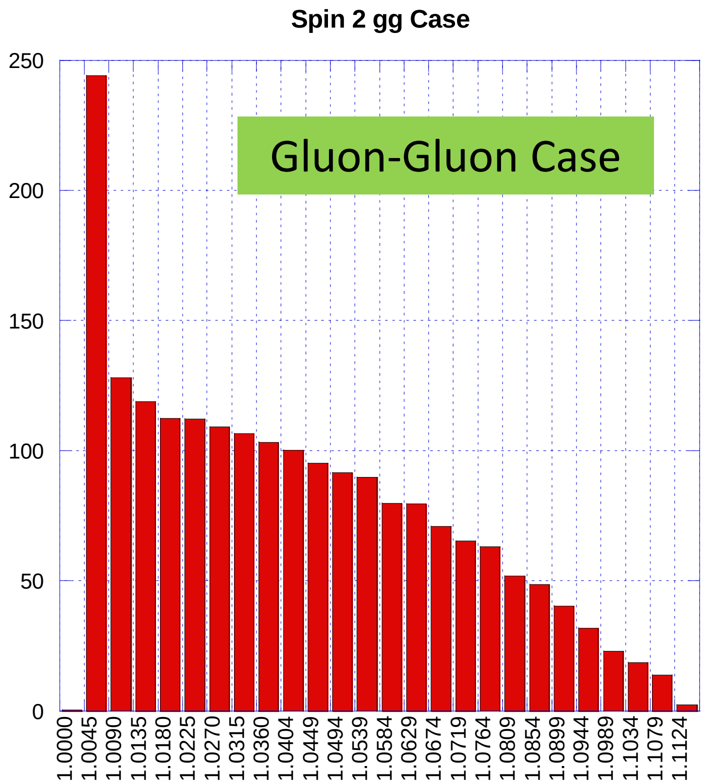
- Take *standard Lorentz frame* to correspond to p_H = 20 GeV/c with boost direction along $\mathbf{p_H}$ direction in ATLAS frame. Any p_H value not 0 is equivalent.
- Lorentz transformation of γ_1-γ_2 opening angle amplifies the region around $|\cos\theta^*| \sim 0$
- A flat $\cos\theta^*$ distribution becomes strongly peaked
- 'Peaks' may be easier to study than 'flats'. This feature may have utility in separating Higgs from BKG and in understanding its Spin

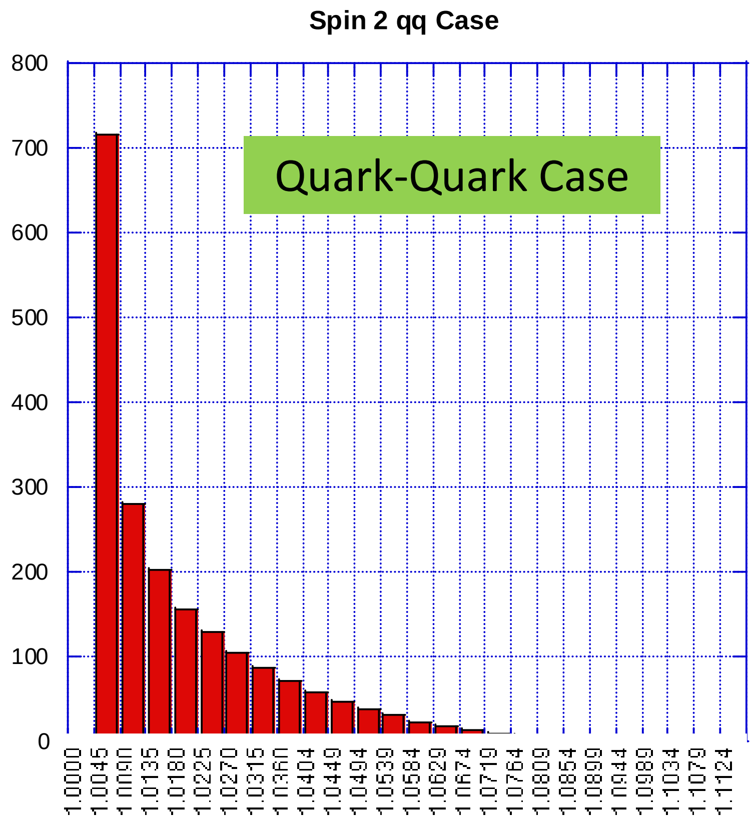


Spin 2 Opening Angle Distributions

Broader distribution because large $|\cos\theta^*|$ transforms to large $\theta12$

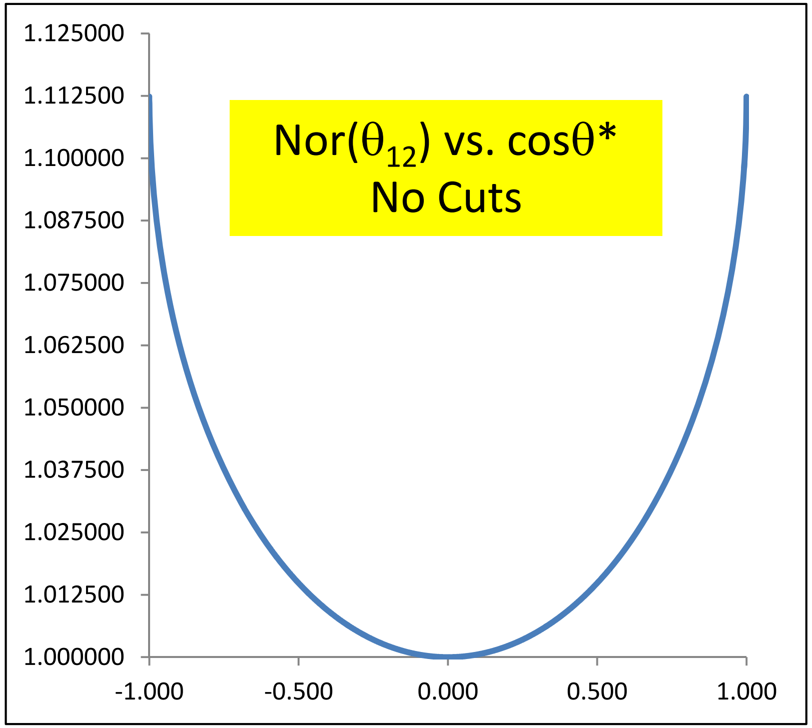
More narrow distribution because small $|\cos\theta^*|$ transforms to small $\theta12$

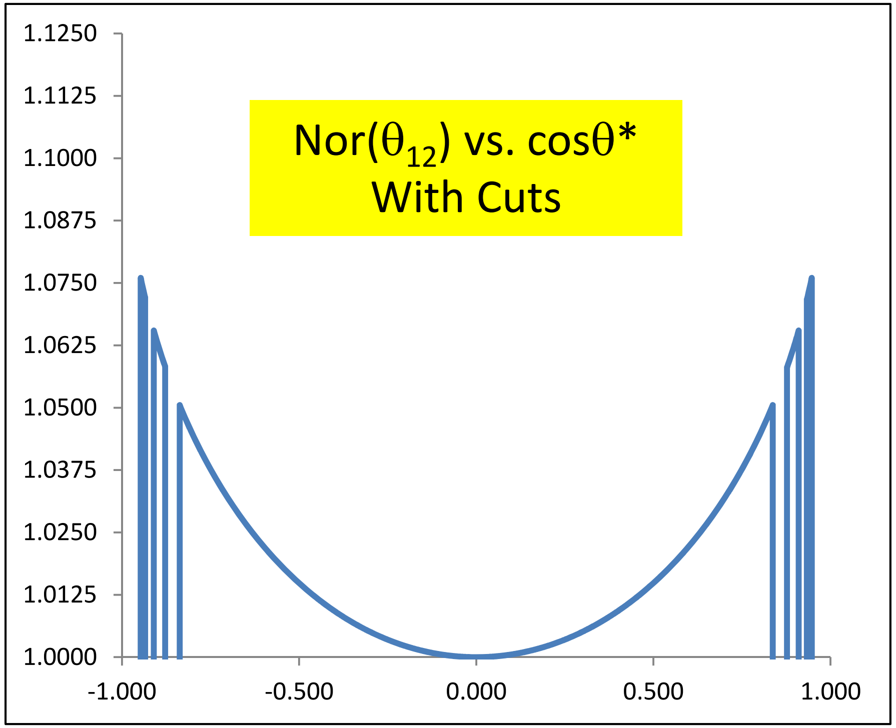




Acceptance Cuts: Nor(θ_{12}) vs. cos θ*

Example of affect of acceptance cuts for $p_{HT} = 0$:
$p_{T\gamma 1,2} > 20$ GeV/c, $|\eta| < 2.37$ and region $1.37<|\eta|< 1.52$ excluded

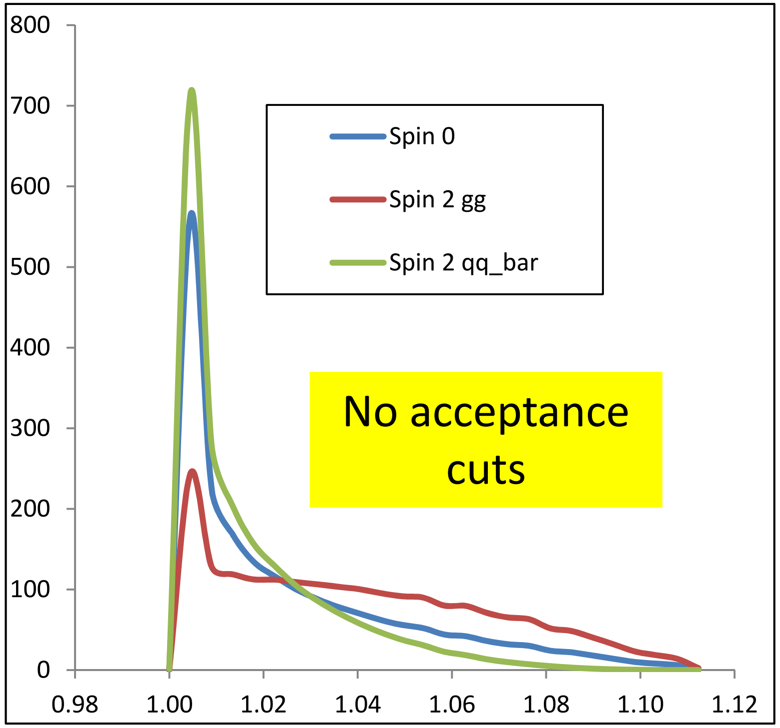


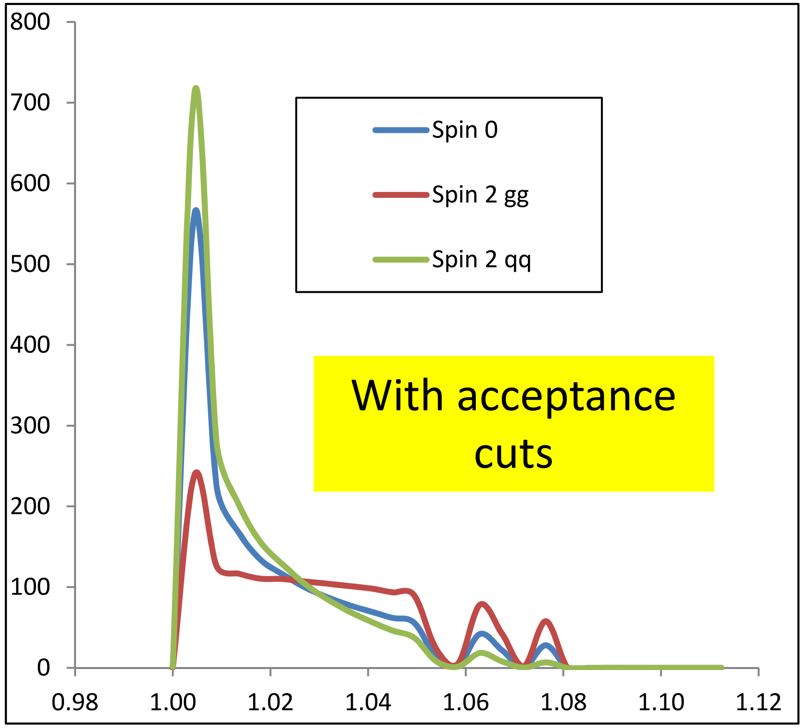


Affect of Acceptance Cuts

Example of affect of acceptance cuts:

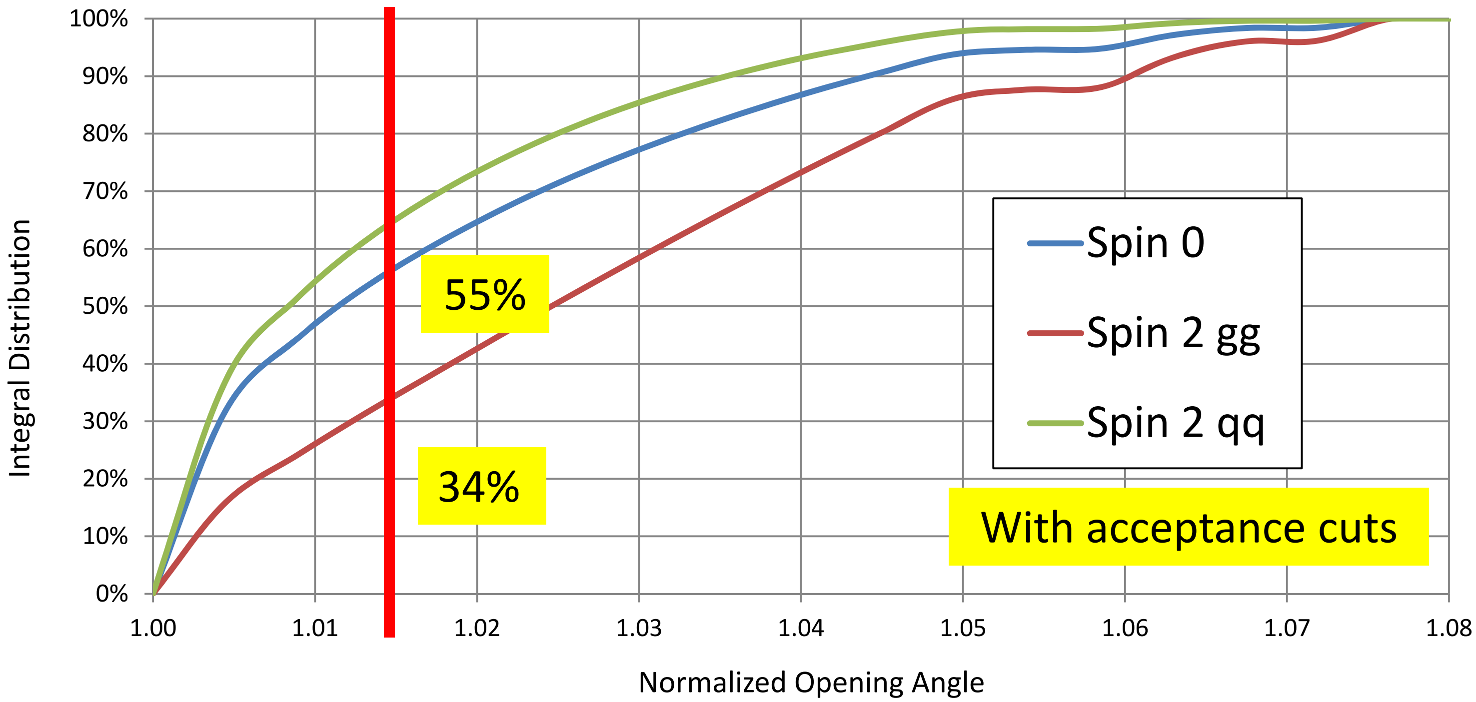
$p_{T\gamma 1,2}$ > 20 GeV/c, |η| < 2.37, 1.37<|η|< 1.52 excluded





Cut Nor(θ_{12})

- Spin 0 and Spin 2 qq can be enhanced over Spin 2 gg with a cut of Nor(θ_{12}).
- In as much as the $\gamma\gamma$ background is strongly peaked at large $|\cos\theta^*|$ (slide 4) a cut requiring small Nor(θ_{12}) will enhance Spin 0 signal over background



Summary

- The digamma opening angle in L-boosted frame is strongly peaked near its minimum value especially for scalar particle decay
  - It transforms the central $|\cos\theta^*| \sim 0$ region into small opening angles near the minimum and spreads out the large $|\cos\theta^*|$ regions to larger opening angles, where the irreducible digamma background generally is
- Acceptance cuts in p_T and $|\eta|$ tend to eliminate large digamma opening angles but have little affect on the peak near minimum
- Use of this variable may have utility in suppressing backgrounds as well as distinguishing Spin 0 from Spin 2 gg.
  - A full MC simulation is needed to fully assess its utility