Luminosity Calculation Cross Check in Tau Mass Data

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1 Motivation

We have been doing R pre-study work using tau mass data for a long time. The luminosity determined from large angle Bhabha events, however, has big discrepancy with small angle one. Two different sets of Bhabha event selection criteria have been used, and they agree with each other. Moreover, we want to find other channel or method for cross checking.

In fact, for any kind of event, we have the relation,

$$N_{obs} = L \cdot \sigma \cdot \varepsilon \cdot \varepsilon_{trg} \tag{1}$$

So, it is possible in principle to use channels other than Bhabha to determine luminosity.

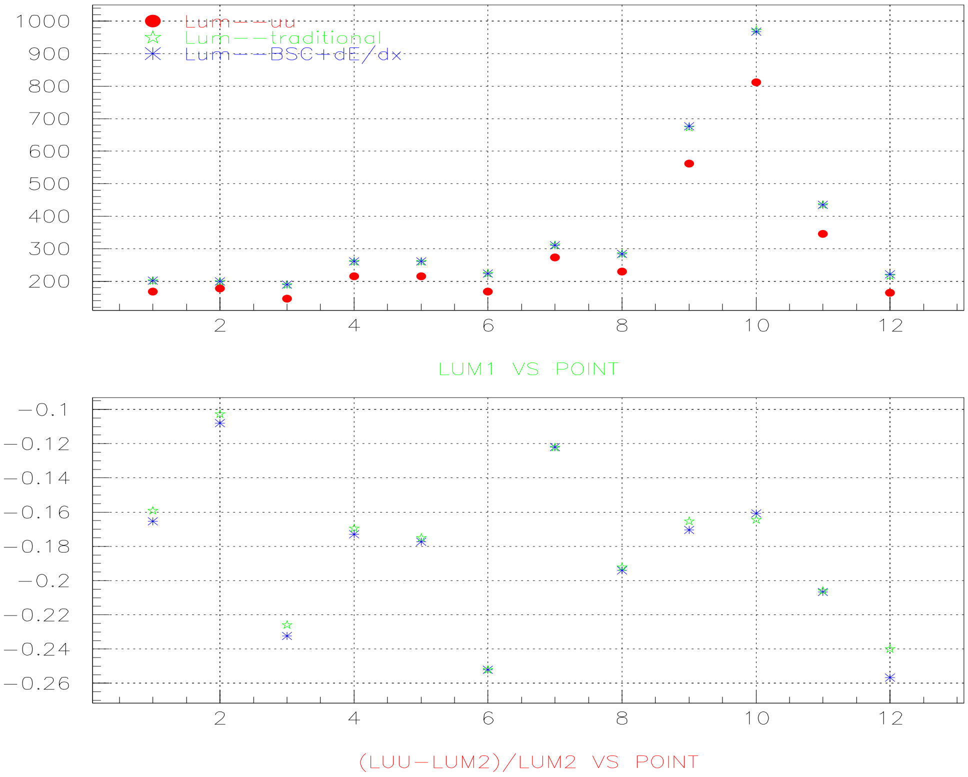
2 Dimu Channel

Dimu events are often used to determine luminosity, and usually the result agree with Bhabha within 5%. I have tried to use dimu events in tau mass data, but the result is disappointing. This is due to the high threshold trigger during data collection, a large fraction of dimu events is lost. And dimu events are relatively fewer than Bhabha events, so the statistics is not good. A rough comparison between dimu and Bhabha shows that they have a discrepancy about 10-20%. Trigger efficiency is taken 0.837 according to Yu Zhongqiang in '92 BES Annual Meeting, and the polar angle range is set to be $0.2 < |cos\theta| < 0.6$ because of big drop in large angle region. The results from dimu events and comparison with the ones from Bhabha events are shown in Fig.1.

3 $e^+e^- \rightarrow \gamma\gamma(\gamma)$ Channel

The integral cross section of $e^+e^- \rightarrow \gamma\gamma(\gamma)$ at $E_{cm} = 3.55GeV$ is about $193nb^{-1}$, it is much bigger than dimu channel, so we could obtain better statistics using this channel. Unfortunately, neutral trigger is not applied during tau mass data collection, so we can hardly find any $\gamma\gamma(\gamma)$ events. This channel is helpless to us in tau mass data.

Figure 1: Luminosity from dimu events and comparison with Bhabha



4 Using Endcap Information

Endcap shower counter can be considered as a large luminosity detector, and it has the obvious advantage that it is not so sensitive to position precision comparing with small angle monitor. But endcap information has never been used before, its reliability remains unknown, however it is worthwhile trying.

It has been taken for granted that Bhabha events and $\gamma\gamma(\gamma)$ events can not be distinguished by endcap shower counter. Even so, it does not affect luminosity calculation, since

$$N_{obs} = L \cdot (\sigma_1 \cdot \varepsilon_1 \cdot \varepsilon_{trg1} + \sigma_2 \cdot \varepsilon_2 \cdot \varepsilon_{trg2}) \tag{2}$$

so if the total number of Bhabha and $\gamma\gamma(\gamma)$ events can be obtained, the luminosity can be determined in the same way.

In fact, Bhabha and $\gamma\gamma(\gamma)$ events in endcap shower counter can be separated by their ϕ distribution, this is shown in Fig.2 and Fig.3,

So far for tau mass data, as neutral trigger is not applied, we have no reason to think there are neutral events collected in endcap shower counter, therefore, only Bhabha events should be used to calculate luminosity. Based on above considerations, I got the luminosity values from endcap shower counter information, as shown in Fig.4. Discrepancy between luminosity from endcap and one from large angle Bhabha is about 6% in average, this is very encouraging.

Figure 2: $|\phi_1 - \phi_2|$ distribution in Endcap SC with M.C. Bhabha sample

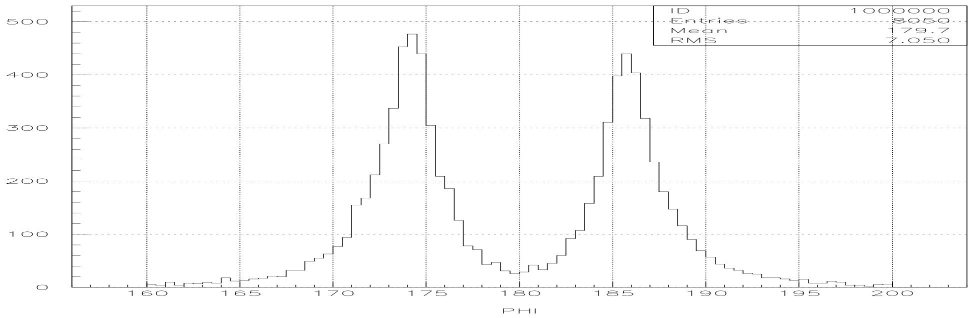


Figure 3: $|\phi_1 - \phi_2|$ distribution in Endcap SC with M.C. $\gamma\gamma(\gamma)$ sample

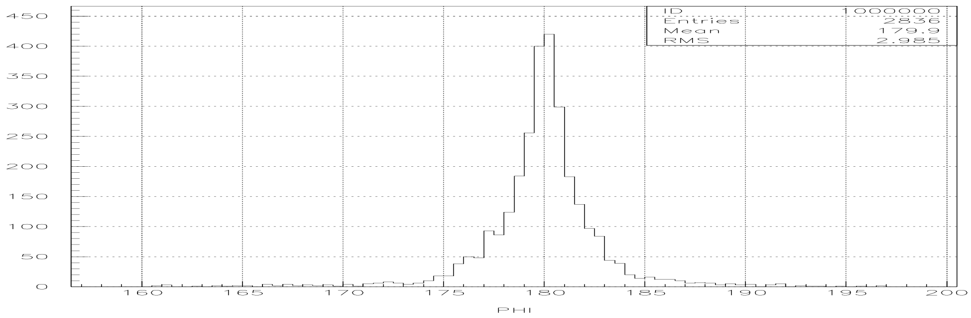
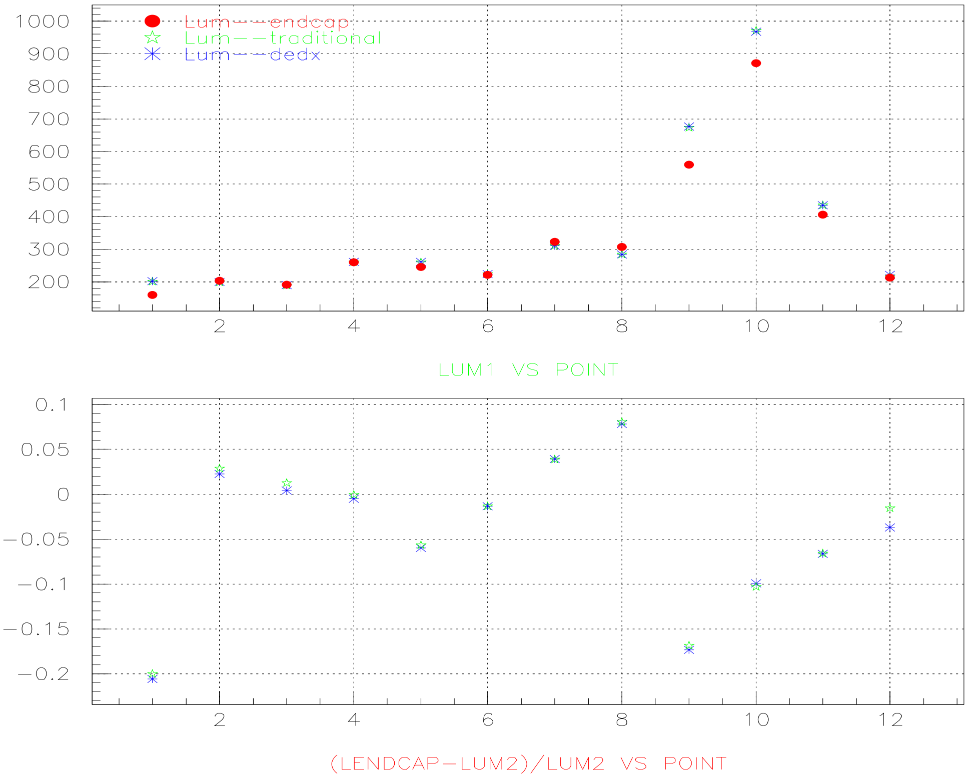


Figure 4: Luminosity from endcap information



5 Summary

The luminosity values of all 12 points obtained from different methods or information in different detectors are listed in the following table, and the errors relative to traditional result are also given.

Table 1: luminosity cross check

#	E_{cm} (GeV)	$L_{ADC}(nb^{-1})$	$L_1(nb^{-1})$	$L_2(nb^{-1})$	$L_3(nb^{-1})$	$L_{ec}(nb^{-1})$	$L_{\mu\mu}(nb^{-1})$
1	3.56838	245.8	200.18	201.64	200.73	160.1	168.3
2	3.56198	248.9	197.70	198.88	198.57	203.4	177.4
3	3.54418	232.8	188.51	190.09	193.49	190.9	145.9
4	3.55314	323.0	259.70	260.78	259.15	259.5	215.7
5	3.55698	322.5	260.22	261.00	259.69	245.4	214.7
6	3.55190	296.9	223.80	223.84	221.34	220.8	167.4
7	3.55350	384.0	311.13	311.02	307.86	323.2	273.1
8	3.55396	360.8	283.63	284.25	283.10	306.5	229.1
9	3.55290	794.1	672.55	676.65	673.99	559.3	561.4
10	3.55324	1109.1	971.89	967.65	948.84	871.5	812.0
11	3.59902	499.7	434.92	435.23	425.69	406.3	345.3
12	3.57910	250.0	216.42	221.33	215.37	213.1	164.5
	sum	5067.6	4220.6	4232.4	4187.8	3960.0	3474.8
	err.	20%	*	0.3%	-0.8%	-6.2%	-17.7%

The discrepancy between large angle luminosity and small angle one bothers us for a long time. We have tried every possible method for cross checking. It is not enough to say the cross checks mentioned above are so persuasive, but at least we are more confident on large angle through our efforts.