On Relative Luminosity at RHIC

G. Bunce

May 22, 2002

for

RHIC Spin Collaboration Meeting IX

RIKEN BNL Research Center

22 May 02
RHIC Spin Mtg.
G. Bunce

On Relative Luminosity at RHIC

(1) Absolute luminosity → cross sections
→ important to compare to theory
⇒ understand parton subprocesses
→ need to 1% to 10% level

(2) Relative luminosity → asymmetries
→ normalize (++) crossings to (+−)

$$A_{LL} = \frac{1}{P^2} \frac{N_{++} - \mathbf{R} N_{+-}}{N_{++} + \mathbf{R} N_{+-}}$$

$$\mathbf{R} = \frac{L_{++}}{L_{+-}} = \frac{k L'_{++}}{k L'_{+-}}$$

$L'_{++, +-}$ = relative luminosity

→ need to 10^{-3} to 10^{-4} level

(3) At RHIC, L'_{++}, L'_{+-} will be measured by counts in a luminosity monitor

$$R = \frac{L'_{++}}{L'_{+-}} \approx 1 \ ; \quad L'_{++}, L'_{+-} \text{ are } \underline{\text{counts}},$$

$$\Delta L'^{2}_{++} = L'_{++}$$

$$L' = L'_{++} + L'_{+-}$$

$$\boxed{\Delta A_{LL} \approx \frac{1}{P^2}\sqrt{\frac{1}{N} + \frac{1}{L'}}}$$

For many RHIC measurements, for example A_{LL} for π^0 production, the raw asymmetry will have a statistical error of $\sim 10^{-3}$:

$$\Delta A_{LL} \times P^2 \Big|_{\pi^0 \text{ stats}} = \frac{1}{\sqrt{N_{\pi^0}}} \simeq 10^{-3}$$

$\Rightarrow$ <u>want $L' \gg 10^6$</u>

$\Rightarrow$ systematic error in L'_{++}, L'_{+-} <u>also at this level</u> $\ll 10^{-3}$

$\Rightarrow$ monitors <u>free of polarization dependence</u> to this level

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⟶ ⟵

→| |← ~100ns spacing

→ polarization signs flip every 100ns

⇒ apparatus variation vs. time will not be important

but

→ **each bunch is prepared and accelerated, stored independently**

⇒ $\boxed{L'_{++} \neq L'_{+-}}$

⑤ strategies

- flip spins on 1 ring at a time, frequently (++ crossing → +− crossing)
- relative luminosity monitors

(− recog so that different bunches collide)

⑥ Typical luminosity monitors

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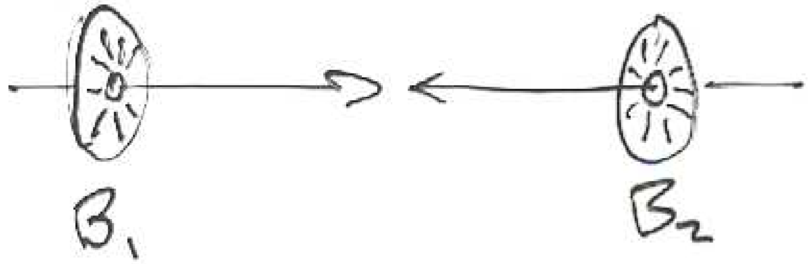
beam-beam counters



$$L'_{++} = \sum_{\substack{\text{crossings} \\ ++}} B_1 \cdot B_2$$

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counter telescopes

$$L'_{++} = \sum_{++} C_1 \cdot C_2 \cdot C_3$$

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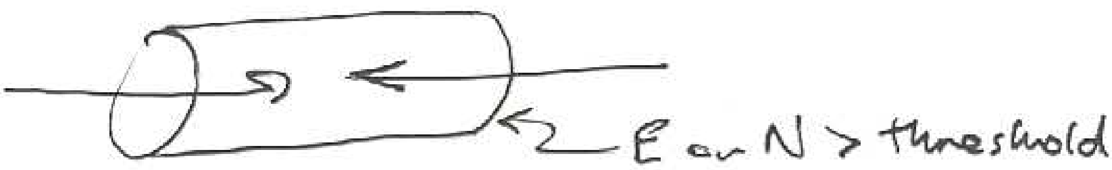
global (or local) energy or multiplicity



$$L'_{++} = \sum_{++} E > E_T \quad \text{or} \quad L'_{++} = \sum_{++} E \ (\text{or } N)$$

(7) Issues to study for each monitor

– saturation

– if $\Delta L'|_{\text{per cross}} = 1$, study requirement on acceptance (efficiency of getting a $\Delta L' = 1$ for a collision) vs. luminosity

– if accept. × collision rate is large ($> 10^{-2}$?), monitor will count 1 hit too often when there are ≥ 2 collisions for a crossing

– accidentals

– if $B_{singles} \gg B_1 \cdot B_2$, and probability of 2 collisions in 1 crossing is high ⇒ extra counts

– beam effects (not from collisions)

– beam-gas, scraping
→ base-line counts

– L' vs. σ (different sensitivity to vertex...)

– L' measures different "luminosity" than σ

(7) cont. – issues for monitors

– polarization dependence

– multiple luminosity monitors, compare 1 vs. 2 ...

(8) <u>But</u>: all of these "issues" are only important if they affect (++) vs. (+-) crossings differently.

<u>However</u>: <u>each</u> can generate a false asymmetry!

One clear conclusion: spin-flipping is crucial.