On Relative Luminosity at RHIC

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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 (+−)

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

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

$L'_{\substack{++ \\ +-}}$ = 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 $\sim 10^{-3}$:

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

$\Rightarrow$ <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

(4) + − + − X + + − −

→| |← ~100ns spacing

→ polarization signs flip every 100ns

⇒ apparatus variation vs. time will not be important

but

→ each bunch is prepared and accelerated, stored independently

$$\Rightarrow \boxed{L'_{++} \neq L'_{+-}}$$

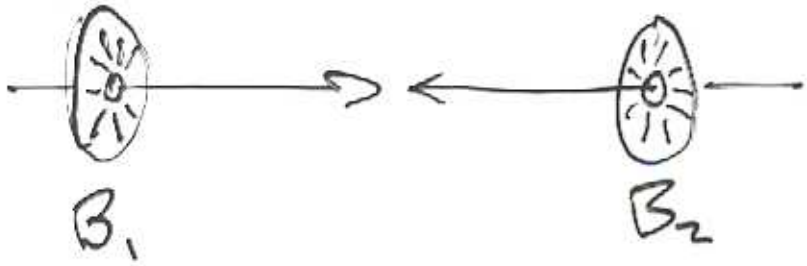
(5) strategies

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

(− recog so that different bunches collide)

⑥ Typical luminosity monitors

beam - beam counters



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

counter telescopes

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

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 $\Delta L'| = 1$ per cross, study requirement on acceptance (efficiency of getting a $\Delta L' = 1$ for a collision) vs. luminosity
    - if accept. x collision rate is large ($>10^{-2}$?), monitor will count 1 hit too often when there are $\underline{2}$ collisions for a crossing
- **accidentals**
  - if $B_{singles} \gg B_1 \cdot B_2$, and probability of 2 collisions in 1 crossing is high $\Rightarrow$ extra counts
- **beam effects** (not from collisions)
  - beam-gas, scraping
    $\rightarrow$ 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.**