LUMINOSITY MONITOR

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Luminosity monitors are needed in each experiment doing spin physics at RHIC. We concentrate on the luminosity aspects here because, for example, with a 10^- 3 raw asymmetry in an experiment, an error of 10^-4 in the luminosity is as significant as a 10% polarization error.

Because luminosity is a property of how two beams overlap, The luminosity at an interaction region must be measured at that interaction region in order to be relevant to the experiment at that interaction region.

We will have to do the physics and the luminosity measurements by using labels on the event sums according to the polarization labels on the colliding bunches. Most likely we will not have independent polarization measurement on each bunch, but only on all the filled bunches in a ring, or perhaps all the bunches that are actually used in an experiment.

Most analyses can then be handled by using the 9 combinations gotten from 3 kinds of benches in each ring, +, - and empty bunches. The empty bunches are needed to measure beam-gas background, (and some, like 6 in a row, are needed for the beam abort.)

Much of the difficulty comes from the fact that we must use a physics process to represent the luminosity. This process must have kinematic and geometric cuts both to reduce systematics such as beam-gas backgrounds and to make it representative of the part of the interaction diamond from which the physics events come.

See Also
AGS/RHIC/SN No 035
AGS/RHIC/SN No 071

DEFINITIONS OF BEAM LUMINOSITY FOR RHIC SPIN

There could be two ways of defining the spin luminosity quantities:

1) Label the Bunches:

Luminosity Labels are based on Bunch Labels

A particle luminosity with Labels (+, -)
Independent of the Magnitude of Polarizations (+, -), etc

(eg + - for + bunch in A and – bunch in B)

Polarization of bunch labeled + in beam A $= \frac{n(up) - n(dn)}{n(up) - n(dn)}$

This is related to the useful Luminosity definition for experiments

Even though we can't usually measure this polarization for a single bunch.

We could still in principle do <L up dn > for all up , dn protons in the beams
By doing proper sums
(but in practice we compromise)

2) Label an Ensemble of Particles with definite Spin Independent of Bunches:
Lum. = A product of fluxes of particles with Definite Spin direction
L+ - from all up protons in beam A with all down protons in beam B

This has a form similar to parton fluxes used in some calculations.

This is not possible to measure because
The best we can do is either polarization of a bunch or polarization of a beam.

(And we can't get L accurately from the flux of one beam x the flux of the other even if we could label particles.)

Note: Luminosity is really a property of 2 beams
You can't get it from individual beam properties without extra information.

WHAT WE WANT:

$$\frac{\text{EVENTS}^{++}}{\sum_{0}^{N_{BUNCH}} \sum_{0}^{N_B} P_{A_i}^{+} P_{B_j}^{+} \mathcal{L}_{ij}^{++}} \quad , \quad \frac{\text{EVENTS}^{+-}}{\sum_{0}^{N_A} \sum_{0}^{N_B} P_{A_i}^{+} P_{B_j}^{-} \mathcal{L}_{ij}^{+-}}$$

WHAT WE ARE MORE LIKELY TO GET:

$$\frac{\text{EVENTS}^{++}}{\langle \alpha_{STAR} \mathcal{L}_{STAR}^{++} \rangle \langle P_A \rangle \langle P_B \rangle}$$

α COMES FROM
- PHYSICS PROCESSES
- KINEMATIC CUTS
- GEOMETRIC CUTS
- COUNTING METHODS
- STATISTICS

P IS LIKELY AN AVERAGE OVER +, −
BECAUSE OF SYSTEMATIC ERRORS
IN POLARIMETERS

WE CAN ACTUALLY DO SLIGHTLY BETTER
THAN TAKING P FOR ALL OF ONE BEAM.

REQUIREMENT:

AVOID SATURATION EFFECTS IN COUNTING.

IMPLEMENTATION:

$<<$ 1 COUNT/CROSSING AT FULL $\mathcal{L}$

CHOOSE PROCESS

CHOOSE DETECTOR KINEMATIC THRESHOLD

REQUIREMENT:

HAVE A WAY TO MEASURE ASYMMETRY IN LUMINOSITY MONITOR ITSELF.

IMPLEMENTATION:

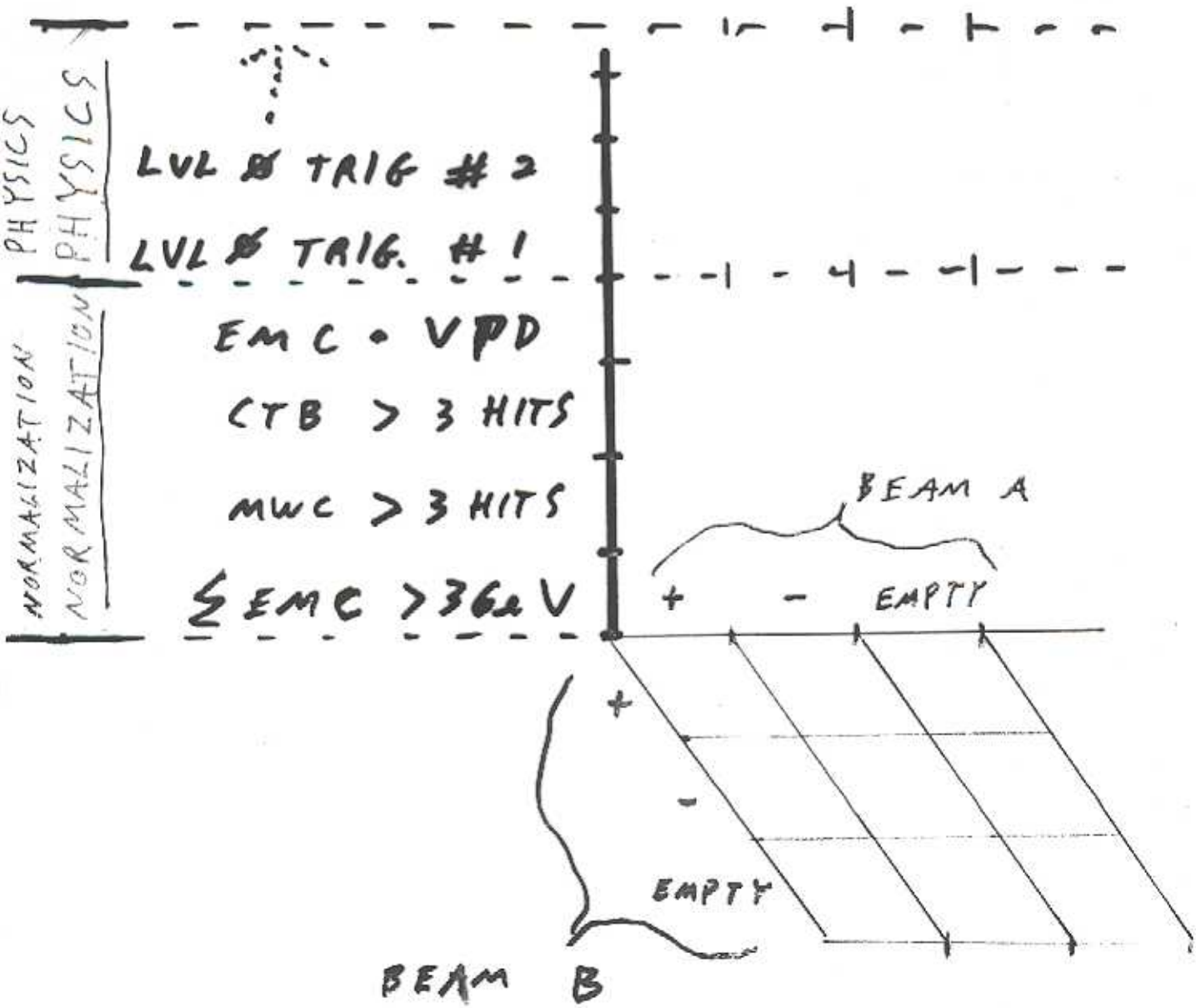
1) USE MULTIPLE KINEMATIC THRESHOLDS AND COMPARE. (NORMALIZE ONE TO ANOTHER)

2) FOR ALL THERE ARE CERTAIN BUNCH COMBINATIONS THAT WORK. SEE PAPER AGS/RHIC/SN

SPIN LUMINOSITY MONITOR

STAR CONCEPTUAL EXAMPLE

THIS SIMPLE EXAMPLE HAS $3 \times 3 \times 6 = 54$ SCALERS



ADIABATIC FLIPPER SWAPS +,- IN EACH BEAM