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SDC
SOLENOIDAL DETECTOR NOTES

ELECTRONIC SIGNAL TO NOISE RATIO FOR LA, TMP, AND TMS

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Electronic Signal to Noise Ratio for LA, TMP, and TMS

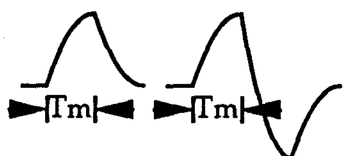
We follow the formulation by Jacques Colas (LBL-27328, Alabama Workshop, 3/89):

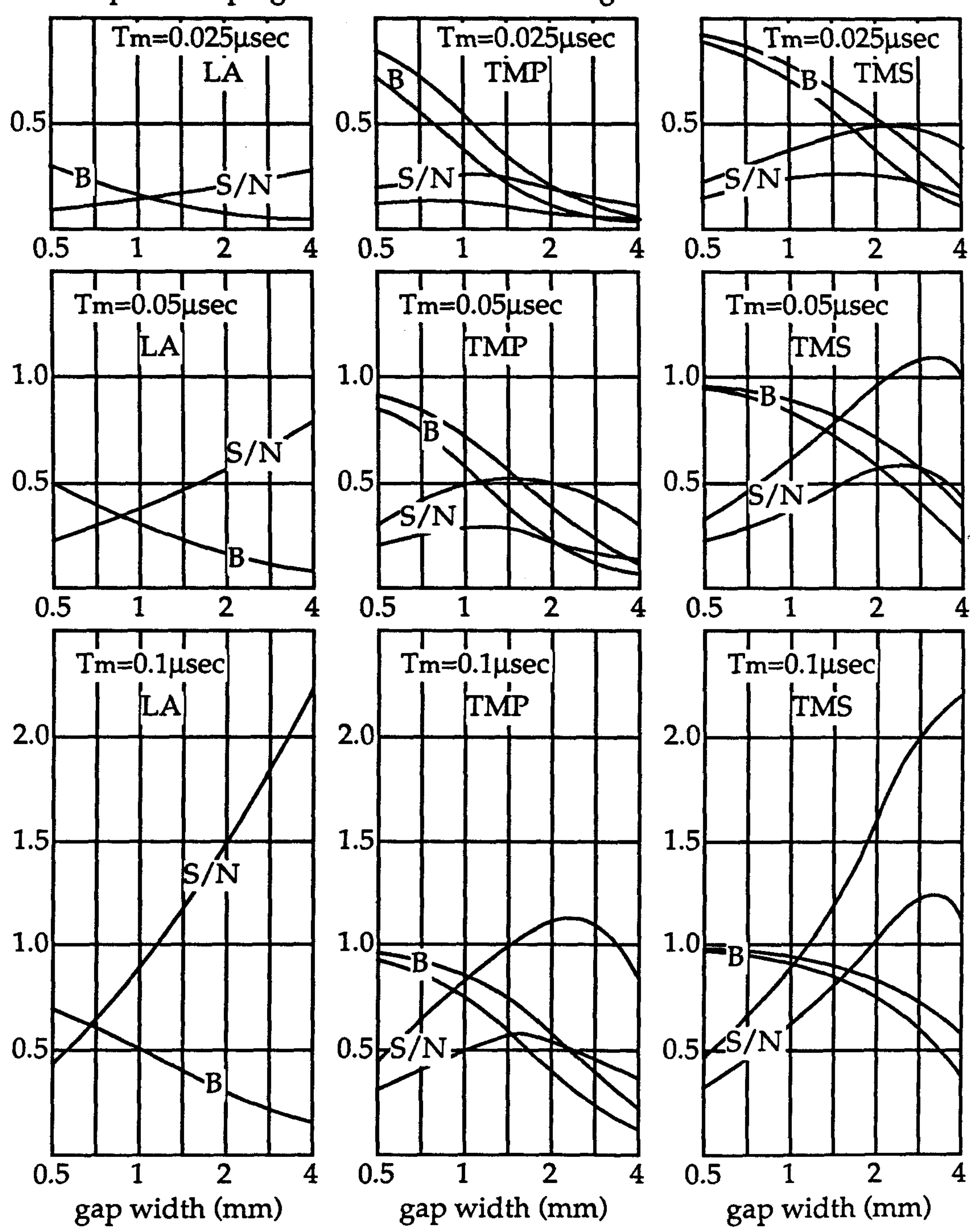
$$S/N = \beta\, I_{max}\, T_{eff}\, \mathrm{sqrt}(T_m L/A) = (\beta B q g/2)\, \mathrm{sqrt}(T_m L/A)$$

where β=4.3 for LA and 3.8 for TMP or TMS, I_{max} is the initial current in ke/μsec in the triangular pulse of length T_d=drift time. T_m is the measurement time; we use the shaper response shown in the left figure below. L(m) and A(sq m) are the sum in depth of gap widths, and the area of each gap, respectively. T_{eff} is the effective time during which the shaper collects charge. Using the drift velocity v_d(cm/μsec)=$g/T_d = I_{max}/q$, N may be expressed also in terms of the gap width g(cm), the linear charge density q(ke/cm), and a 'ballistic' factor:

$$B = 2T_{eff}/T_d \approx (1.27T_m/T_d)[1-\exp(-T_d/1.27T_m)] \le 1,$$

which measures the effective fractional charge utilization. A small value for B implies a greater relative sensitvity to pile-up. Greater rejection of pile-up could be achieved, with a factor sqrt(3) increase in noise, using the fast bipolar shaping function shown at the right below.





Single Gap

At the right we show S/N and B for mips in one gap: i.e., we take:
L(m)=0.01g(cm)
A=0.01 sq m.

For LA
- E=V/g is taken to be 0kV/cm; the performance is not sensitive to this value.
- $S/N \propto T_m\, \mathrm{sqrt}(gT_m)$
- B is generally small for large g.

For TMP and TMS
- Both T_d and q are functions of E. We use V = 5 or 10 kV. The maximum voltage is assumed to be set by the feedthroughs and insulators rather than the liquid gap width.
- For both S/N and B the 10kV curves lie above those for 5kV.
- Trade-off of I_{max} and capacitance produces a peak in S/N vs g with:
- $(S/N)_{max} \propto VT_m$
- $g_{max} \propto \mathrm{sqrt}(VT_m)$.
- $B(g_{max}) \approx 0.5$.
- $S/N_{TMS}\, /\, S/N_{TMP} \approx 2$

In the calculations above we have ignored the implications of the g-dependence of calorimeter density, absorber thickness, relative gap tolerances, etc, each of which affects the resolution. As an example, the total depth of liquid may be limited to achieve e/h compensation or to maintain a large average calorimeter density. Then larger gap width implies poorer sampling and resolution.

Fixed Liquid Depth

If the total liquid depth ($L=\Sigma g$) is specified, there is a trade-off between gap width and gap number. e.g., L=0.1m represents 50 gaps of 2mm width or 100 gaps of 1mm width, etc. Here we consider specifically S/N for a liter of liquid, i.e., with:

L=0.1 m, A=0.01 sq m.

Then each S/N is obtained from that calculated previously by multiplying by sqrt[10/g(cm)]. B(g) is unchanged. Below are calculated values of S/N and B for the same liquids and values of Tm used in the single gap example above.

- Compared with the single gap solution, S/N is now maximized at smaller gaps, where B is larger.
- For most cases, S/N>1; hence mips are detectable in this tower section.

For LA

- B values are small, but S/N is only moderately, if at all, dependent on g; a small gap minimizes pile-up.

For TMP, TMS

- S/N peaks are shifted to smaller gaps.
- $(S/N)_{max} \propto Tm$; the dependence on V is slightly less than linear.
- $g_{max} \propto \mathrm{sqrt}(Tm)$; the dependence on V is slightly less than sqrt.
- $B(g_{max}) \approx 0.7\text{-}0.8$ - pile-up is small -
- At each V and Tm, the peak value of S/N for TMS is sqrt(2) times larger than for TMP.
- At Tm=0.05μsec, the S/N peaks are at:
  - g ≈ 1 mm for TMP
  - g ≈ 2 mm for TMS