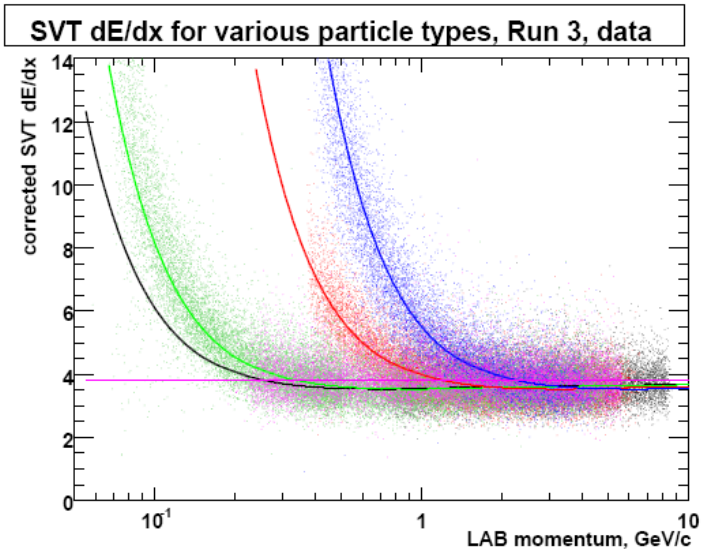
Analog info for SVT hits

- Analog info on pulse height is useful in SVT:
  - to improve spatial resolution w.r.t digital response
  - to correct timewalk and improve time resolution on SVT hits
  - to measure the dE/dx for low momentum tracks (high energy deposition --> high dynamic range required 10-15 MIP)
  - Other less critical motivations



Time over threshold (TOT)

- Assume shaping CR-RC^2 (as in the ATOM chips) with τ_p varying from 25 ns (L0) to ~1 us (L4-5).
- Which TOT clock period is needed?
  - The ratio τ_p/T_{TOT} will affect the spatial resolution and the SVT hit time resolution
- How many TOT bits do we need?
  - This determines the dynamic range with a given TOT clock
  - For pulse height of 10 MIPs TOT= 4.5τ_p $T_{TOT} \cdot 2^N = TOT_{MAX}$
    - Assume no saturation and theoretical TOT response!

Which time over threshold (TOT) clock? Spatial resolution

- From studies performed for BaBar TDR (BaBar Note-161):
  - Spatial resolution depend on the ratio between the shaping time τ_p and the TOT clock_period: τ_p/T_{TOT}
  - The gre.ater is the ratio the more closely the time-over-threshold method should resemble a perfect analog readout.
  - With τ_p/T_{TOT}=1 the resolution is already fairly good and there is a 20% improvement having this ratio =10. In Babar was = 3 in all layers. (skip control set T_TOT/T_TS)
- Lower limit on TOT clock frequency imposed from spatial resolution=$1/\tau_p$

$$f_{TOT} = \frac{1}{T_{TOT}} \geq \frac{1}{\tau_P}$$

  - Huge variations among layers
  - L0=25 ns L1-3=50-200 ns, L4-5=300-1us shaping

Which time over threshold (TOT) clock? Dynamic Range (dE/dx)

- If we want to have a dinamic range of 10 MIPs (probably ok for dE/dx) the max TOT ~ 4.5 τ_p
- With N bit the max value of TOT is 2^N

$$\frac{TOT_{MAX}}{T_{TOT}} = \frac{4.5\tau_P}{T_{TOT}} \leq 2^N$$

- TOT with N bits, with a given dynamic rage, imposes an upper limit on TOT clock freq.

=3.56 with N=4 bits

$$f_{TOT} = \frac{1}{T_{TOT}} \leq \frac{2^N}{4.5}\frac{1}{\tau_P}$$

layer	tau p ns	Min TOT freq MHz (1/taup from spatial resolution)	N bit	Max TOT/taup for 10 MIP	F TOT MHz sugge sted from BaBar
0	25	40	4	4.5	120
1	75	13.3	4	4.5	40
2	100	10	4	4.5	30
3	150	6.7	4	4.5	20
4	375	2.7	4	4.5	8
5	750	1.4	4	4.5	4

- BaBar experience: F_TOT=**3**x1/ tau_peek in all layers.
- This ratio is ok for resolution and dynamic range with 4 bits.
- In SuperB
- Layer0 TOT could be also 60 MHz (no dE/dx)
  - Is that ok for time walk correction?
  - yes from latest time resolution simulation

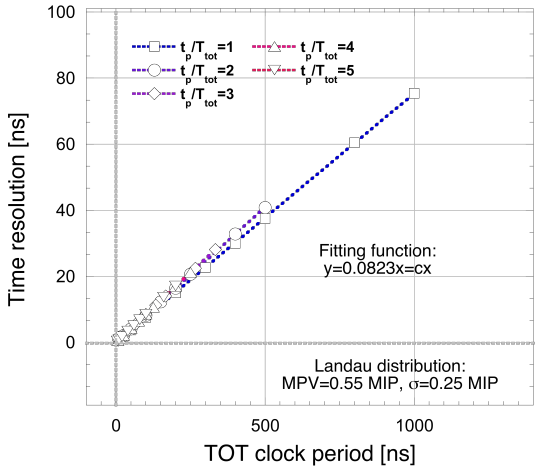
Which time over threshold (TOT) clock? Time resolution

- From latest time resolution simulation (Ratti July 2012)

$$\sigma_{t0}=\sqrt{\frac{T_{CK,TS}^2}{12}+c^2T_{CK,TOT}^2}\approx\sqrt{\frac{T_{CK,TS}^2}{12}+6.77\cdot10^{-3}T_{CK,TOT}^2}$$

- When including the noise contribution to t0 resolution terms due to TOT and TS clock are "negligible" in external layers
- With 30 MHz TS clock and a TOT clock 2xf_τp time resolution is still acceptable.

Time walk contribution to hit time resolution



If represented as a function of the TOT clock period ($T_{Ck,TOT}$), the time walk contribution to time resolution does not depend on the $t_p/T_{CK,TOT}$ ratio

L. Ratti, Hit time resolution study – SVT-TDR phone meeting, 27/07/2012

10

Which time over threshold (TOT) clock? Conclusions

1. A fast TOT clock is better for spatial resolution and time resolution
   - $f_{TOT}=1 \times f\_\tau_p$ is the minimum allowed for good spatial resolution
   - $f_{TOT}=2 \times f\_\tau_p$ is the minimum allowed for good time resolution
2. A slow TOT clock is better for dynamic range
   - With 4 bits $f_{TOT}=3 \times f\_\tau_p$ is the maximum allowed to get 10-15 MIPs as in BaBar.

- A TOT clock in the range between 2-3 x f_τ_p should be used

layer	tau p ns	(1/taup) MHz	N bit	Min TOT freq MHz (2x1/ taup ok for time resolution	Max TOT freq MHz (ok for dynamic range) suggested from BaBar
0	25	40	4	80	120
1	75	13	4	27	40
2	100	10	4	20	30
3	150	7	4	13	20
4	375	3	4	5	8
5	750	1	4	3	4