LEP Motion Analysis

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Goals of the study

• **Goal:** to analyze data on 1993-99 LEP motion
  – *Thanks to Michel Mayoud and Rainer Pitthan for providing access to the data*

• **Plan:**
  – Evaluate systematic LEP motion
  – On top of systematic motion, try to evaluate properties of “the remainder” motion
  – Understand, is it possible to distinguish between measurement errors and diffusive motion in case with large contribution of systematic motion
LEP motion in 1993-1999

Figure 1 from Rainer Pitthan, SLAC-PUB-8286, (1999)
Difference of neighboring quads

Figure 17 from Rainer Pittham, SLAC-PUB-8286, (1999)
Approach

- Suppose \( u(t,s) \) is measured position (7 points in time and \(~700\) in space)
- Consider **difference** motion of neighboring quads \( w(t,s_i)=u(t,s_i)-u(t,s_{i+1}) \)
- Fit smooth curve (in time) \( v(t,s_i) \) to \( w(t,s_i) \) (use linear or parabola)
- Find **rms** of the difference \( w-v \) versus time difference

- Make modeling: use smooth curve \( v(t,s_i) \) determined above and add to this either **ATL** motion or **measurement errors** and try to run this data through the above described algorithm
Difference of position of one of the pairs of neighboring quads

Shown are:
- original data
- fit of smooth curve
- remainder if smooth curve subtracted

Displacement of one pair of neighboring quads before/after smooth curve removal
Rms vs dT for all LEP data

- Rms of difference of the neighboring quads for all LEP original data:
  - Rms is ~ constant with dTime
  - Rms depends on smooth curve: ~20% difference for linear or parabola fit

- Is this rms explained by measurement errors?
- Is there contribution of ATL motion?
- To find out, let us do some modeling (see next pages)
Suppose LEP is **ideally aligned** and there is **no motion**, then if we:
- add **measurement errors** (error in one year are independent from another year)
- or add **ATL motion**

In this case the rms versus dTime **allows to distinguish** between this two cases, as seen below:

N.B. The values at dTime=1 year are different by $\sqrt{2}$, as they should
Suppose LEP is **ideally aligned** and there is **no motion**, then if we:

- add **measurement errors** (error in one year are independent from another year)
- or add **ATL motion**
- and apply the same treatment as in other cases

In this case the rms versus dTime is still **distinguishable**:
Suppose there is only smooth systematic motion in LEP, then if we:
- add measurement errors (error in one year are independent from another year)
- or add ATL motion
- or combination of both

And then fit and subtract smooth curve and find rms versus dTime

In this case the measurement errors and ATL still seem to be distinguishable from the rms versus dTime since error of definition of each point are very small \(\sim 1/\sqrt{700}\)
Preliminary conclusion

- If there is no other errors that can mimic ATL, then the diffusive component in LEP motion is about $0.09\pm0.02\text{ mm}^2/\text{km/year}$
- One need to check if there is something more that is model dependent here
- One need to know in particular the measurement errors which are not independent on previous year(s)