6(A, B, D, E, F, i):

Systematic errors of an experiment are defined by the detector design and correlation between Michel parameters. For example, most accuracy muon decay experiment (ρ measurement, Phys. Rev. D37(1988)587-617) has following values (in unit of 10^{-4}) of the systematic errors (Table VIII):

- because the detector design:
  δ parameter – 26, $P_\mu\xi$ parameter – 41;
- because the correlation:
  δ parameter – 11 (world value of ρ error), $P_\mu\xi$ parameter – 17 (world value of ρ error).

The $P_\mu\xi$ parameter in the above experiment can not be measured better than $17\cdot10^{-4}$ separately because the world value of ρ parameter.

Therefore we are proposed the detector design to measure the all Michel parameters at the same time using one Michel spectrum. A correlation between the parameters is included in statistic error at 10^9 of total statistics: $\sigma\rho = 0.5\cdot10^{-4}$, $\sigma(P_\mu\xi) = 10^{-4}$, $\sigma\delta = 0.8\cdot10^{-4}$, $\sigma\eta = 130\cdot10^{-4}$.

The systematic detector errors of the above experiment been caused of a hysteresis in the beam-line bending magnets (the M13 line has been used for energy calibration of spectrometer), an acceptance of spectrometer, a positron energy loss in about $300 \mathrm{mg}\cdot\mathrm{cm}^{-2}$ of a matter before the positron spectrometer, a muon depolarization at B=0. Total systematic error of most accuracy $P_\mu\xi\delta/\rho$ experiment (Phys.Rev. D34 (1986) 1967–1990) was +/– $7.5\cdot10^{-4}$ (Table IV). It been caused of difference in energy calibration between spin-held and spin-precessed data, of +/–2 mm uncertainty of proportional chamber position, of a muon depolarization at B =0.

The TWIST does not use the M13 line for energy calibration. World value of positron energy edge E^{max} = (52.8304141 +/– 0.0000026) MeV at muon decay will be used for the absolute energy calibration. Accuracy of the calibration is +/– 2keV, as that been proved by Monte Carlo calculations (NIM A396 (1997) 135-146). The single energy point is enough for calibration of our spectrometer because it is a regular wire grid placed into a homogeneity magnetic field. Second point $E \cong E^{max}/2$ with $\delta = 0$ can be used for the calibration also.

About $10 \mathrm{mg}\cdot\mathrm{cm}^{-2}$ of a matter only is between decaying positron and positron detector in the TWIST spectrometer. In addition to the small amount of the matter a real energy deposit inside the matter can be measured from a Michel spectrum itself at different angle of θ because the energy deposit is proportional to $1/\cos\theta$ (NIM A396 (1997) 135-146).

Homogeneity of the TWIST detector is very high. A possible influence of inefficiency on the detector acceptance is discussing below.

We use a longitudinal magnetic field B = 2T always to exclude a muon depolarization.

Accuracy of the TWIST detector is much less than 2mm. It is about a few microns. It is measured during chamber production and it will be checked using a particle beam at B = 0.

Systematic errors of the TWIST spectrometer have been estimated before. They are (in unit of 10^{-4}) 0.92, 1.0, 0.95 and 250 for ρ, $P_\mu\xi$, δ and η correspondingly. The sufficient improvement of the parameter accuracy is defined by the TWIST spectrometer design:

• The selected planar drift chamber (PDC) design allows manufacture a single plane with high precision. Inaccuracy of distance between wires is about +/– 3μ (requirement is < +/– 20μ). Average distance between wires in a plane is 4mm with offset less than 0.5μ (requirement is < 2μ). Requirement to inaccuracy of distance between wire and cathode plane is < +/– 20μ according to GARFIELD calculations. Tool for the measurement is underway. A possible cathode offset can be reduced for selected removable cathode design.

• Requirement to distances inaccuracy between PDC planes is 2μ. It is defined by cital spacer thickness. All spacer thickness has been measured with accuracy of +/– 0.3μ. Scale nonidentity between Z-axis of the detector (distance between planes) and X, Y-axis (distance between wires) has been measured. It is $< 1.3\cdot10^{-4}$ (requirement is $\leq 5\cdot10^{-4}$).

• Methods of alignment between muon spin and magnetic field, muon spin and detector, detector and magnetic field are designed with needed accuracy.

• Energy losses in the detector are proportional to $1/\cos\theta$ (θ is a polar angle between magnetic field and positron momentum). It is most important peculiarity of the TWIST detector. We can measure absolute energy losses at any θ before positron detector using a part of Michel spectrum near E^{max} with accuracy of +/– 2keV (requirement is < +/– 10keV) and exclude systematic errors constrained with the energy losses.

• The suggested planar detector design requires only one point for an absolute energy calibration near E^{max} = 52.8304141MeV. It can be done with accuracy of 2keV (requirement is < 10keV). This fact together with the previous one allows reducing the most important systematic error of Michel parameters to less than 10^{-4}.

• "Sliding techniques" allow fitting of positron helices with confidence level more than 0.5.

• Geometrical acceptance homogeneity of the detector is very high. PDC inefficiency at a positron helix registration can make difficult the helix reconstruction. We have ≥ 8 registered points on a helix and 6 free parameters (including χ^2 parameter) for the helix fitting. It means a helix reconstruction is not possible if we lost > 1 point because a PDC inefficiency. Experimental PDC inefficiency using DME gas is $< 5\cdot10^{-4}$ (measured value of the inefficiency was $\cong 5\cdot10^{-5}$). The measurement has been done using positron beam with momentum 35MeV/c at $\theta = 0°$. It allows confirm the above inefficiency for positron registration at 20MeV < E < 50MeV and $\theta > 10°$. Probability to lose 2 points is $< 0.7\cdot10^{-5}$, that is less than statistical error of 10^{-5} at total statistics of 10^{10} of muon decays. It is most important argument (together with small Lorentz drift angle at B = 2T) for using the DME gas. Overlap between incoming muon track and outgoing upstream positron helix can induce inefficiency for positron registration because long time positive ions cloud dissipation. The dead zone after muon registration has length less than

1mm along a wire, therefore a probability of an overlap between muon and positron track is small at $\theta > 10°$. Obvious way to improve the situation is increasing in "sliding techniques" number of PDC planes from 8 to 10. It can be done because confidence level value is 0.78 (normal value is 0.5) using 8 PDC planes for fitting.
(Remark: I used "sliding method" and do not use the Kalman filtering (KF) because I do not know how the KF can shift an original energy and angle. If the KF will be approved we could weaken the above inefficiency requirement.)

• About $10 mg/cm^2$ of a matter is between decaying positron point and positron detector in the TWIST spectrometer instead of $300 mg/cm^2$ in the above both experiments. It allows reducing of systematic errors because an uncertainty in external radiative corrections of a positron before positron spectrometer. 10^9 muon decay events have been simulated in TWIST stopping target by EGS-4 package. Michel spectrum has been accumulated and fitted on input of positron detector for both upstream and downstream parts of the detector (NIM A396 (1997) 135-146). Systematic shifts of Michel parameters were (in unit of 10^{-4}) 5.9, 6.5, 9.6 and 670 for ρ, $P_\mu\xi$, δ and η correspondingly. It means we can calculate the radiative corrections by Monte Carlo with accuracy 10% to reduce the systematic errors lower the corresponding statistical errors taking to account that we can reconstruct a positron helix in the TWIST detector itself with systematic energy shift < 2keV. The radiative corrections in the above reference (Phys. Rev. D37 (1988) 587-617) have been calculated with accuracy of 3-5%. The inaccuracy gives systematic shift about of $5 \cdot 10^{-4}$ to δ parameter.

• Amplitude analysis of signals from PC(-2) and PC(-1) together with veto signal from PC(+1) allows reducing of muon stops outside the stopping target to negligible level, and exclude therefore a possible muon depolarization in chamber gas and mylar foils.

• Ratios $N_{PC(-1)}/N_{PC(+1)}$ and $N_{PC(-2)}/N_{PC(+2)}$, as it has been demonstrated by GEANT, allow keeping a center of gravity of muon stop distribution in the target along Z axis with accuracy of < +/- 1μm. It corresponds to positron loss energy inaccuracy of < 1keV. The above method allows keeping a central surface muon beam momentum with a needed accuracy in order to exclude a possible P_μ shift because multiple scattering of muon inside a production target. Second one, we can keep the center of gravity to provide the same energy loss of positrons for both the upstream and the downstream parts of TWIST detector. It allows combined reconstruction of the both spectra with joint normalization factor to reduce a statistical error of Michel parameters in about 2 times.

• Muon low pressure TEC detector will measure X, Y coordinates with accuracy of 50μm and angle with accuracy of 2mr for each muon. It allows control of possible beam instability because proton beam shifts on production target, and bending magnet field instability. Besides the TEC defines a muon trajectory in fringe field area with a needed accuracy in order to calculate event-by-event muon depolarization with 10% accuracy at least. It corresponds to < 10^{-4} shift of $P_\mu\xi$ parameter. Muon track in reference Phys. Rev. D34 (1986) 1967-1990 registered by PCs with normal pressure. It contributes a systematic error of $P_\mu\xi\delta/\rho$ of $5 \cdot 10^{-4}$.

• We propose to upgrade the production 1AT1 target design to reduce possible $P_\mu\xi$ systematic errors. The target used in the above reference has several disadvantages: 1) a surface muon source has a profile with long tail in horizontal (momentum byte) plane because the M13 channel sees a side surface of the target; 2) possible coordinate instability of proton beam on the target can change central beam momentum and angle, and shift therefore surface muon momentum, muon stops distribution in stopping target along Z axis, and increase muon spin depolarization by fringe field; 3) cloud muon contamination was about 0.7%. We propose to rotate the existing target on angle 45° to provide long axis parallel with M13 axis, and front surface of the target be orthogonal to M13 line axis. It will reduce sufficiently the above errors.