NuFact Oscillation Working Group

CERN, 8 May 2000

Is muon polarization useful?

Alain Blondel and Mario Campanelli

http://cern.ch/dydak/polarisation.ppt

Is MUON Polarization useful?

Alain Blondel + Mario Campanelli

Treat one example, PRELIMINARY, stat. only

Principle of Experiment:

. take half data with +P, half with -P

. “ “ “ “ μ^+ “ “ μ^-

Take detector and data of super ICARUS
Bueno/Campanelli/Rubbia, hep-ph 0005007

4 event classes: $e^\pm$, right sign μ, wrong sign μ, NC

Fit for δ while leaving all other parameters free,
see if error on δ is reduced when |P| ↗

Input Parameters

$\Delta m^2_{12} = 10^{-4}$
$\Delta m^2_{23} = 3.5\ 10^{-3} ev^2$
$\theta_{12} = 45^o$
$\theta_{23} = 45^o$
$\sin^2 2\theta_{13} = 0.05$
$\delta = 0$ or $\pi/2$

L= 2900 km
10 ktons fiducial
2 10^{21} useful muons (5 10^{20} for each sign-polarity)

detector classes:
1. "electrons": any event with an electron (no energy cut)
2. "right sign muon": event with muon (P>2 GeV) of beam sign
3. "wrong sign muon": event with muon (P>2 GeV) of sign opposite beam
4. "NC": all other events.

Decays in flight of hadrons -> muons are included
no background for electrons
no systematic errors on beam (yet)
matter density is left as free parameter in the fits

Some numbers

Surprise: there is a big δ–effect in electron event numbers

$\mu^- (\to \bar{\nu}_e \ \nu_\mu)$

ELECTRON CLASS:

	$\delta=\pi/2$		$\delta=0$
P=0	**59550**	**(-510)**	**60060**
P=-1	**6003**	**(-604)**	**6607**
P=+1	**113100**	**(-400)**	**113500**

Kills anti-ν_e → P=-1

$\delta=\pi/2$ **decreases the** $\nu_\mu \to \nu_e$ **oscillation**.

Some numbers

Surprise: there is no big δ–effect in wrong sign muon event numbers

$\mu^+ (\to \nu_e \ \bar{\nu}_\mu)$

WRONG SIGN MUON CLASS:

	$\delta=\pi/2$		$\delta=0$
P=0	1919	(+43)	1876
P=-1	3795	(+83)	3712
P=+1	41	(-)	41

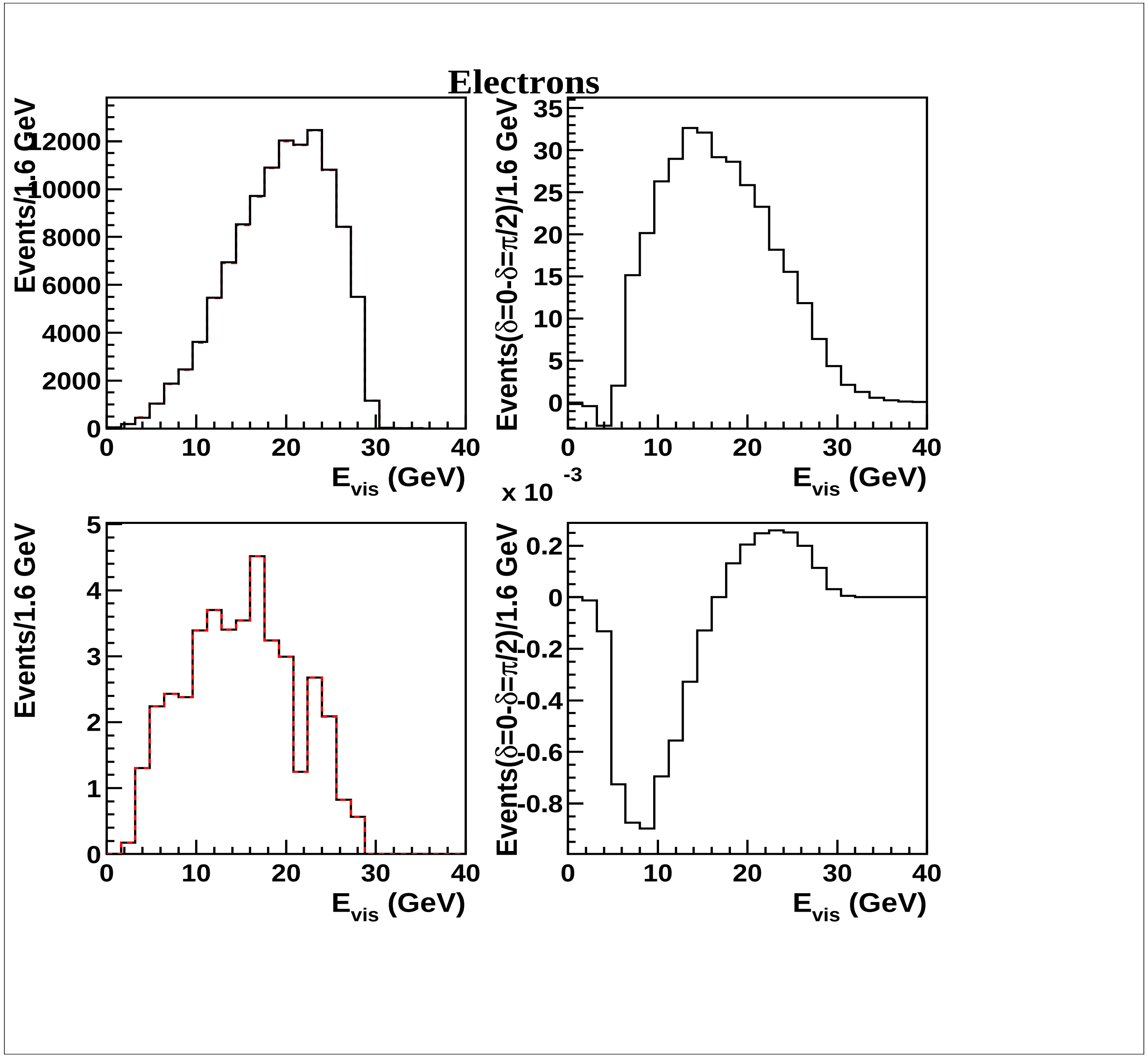
Kills ν_e → (P=+1)

BUT $\delta=\pi/2$ modifies the shape of the $\nu_e \to \nu_\mu$ oscillation.

Positive polarisation (100%!)

μ−, P=+1

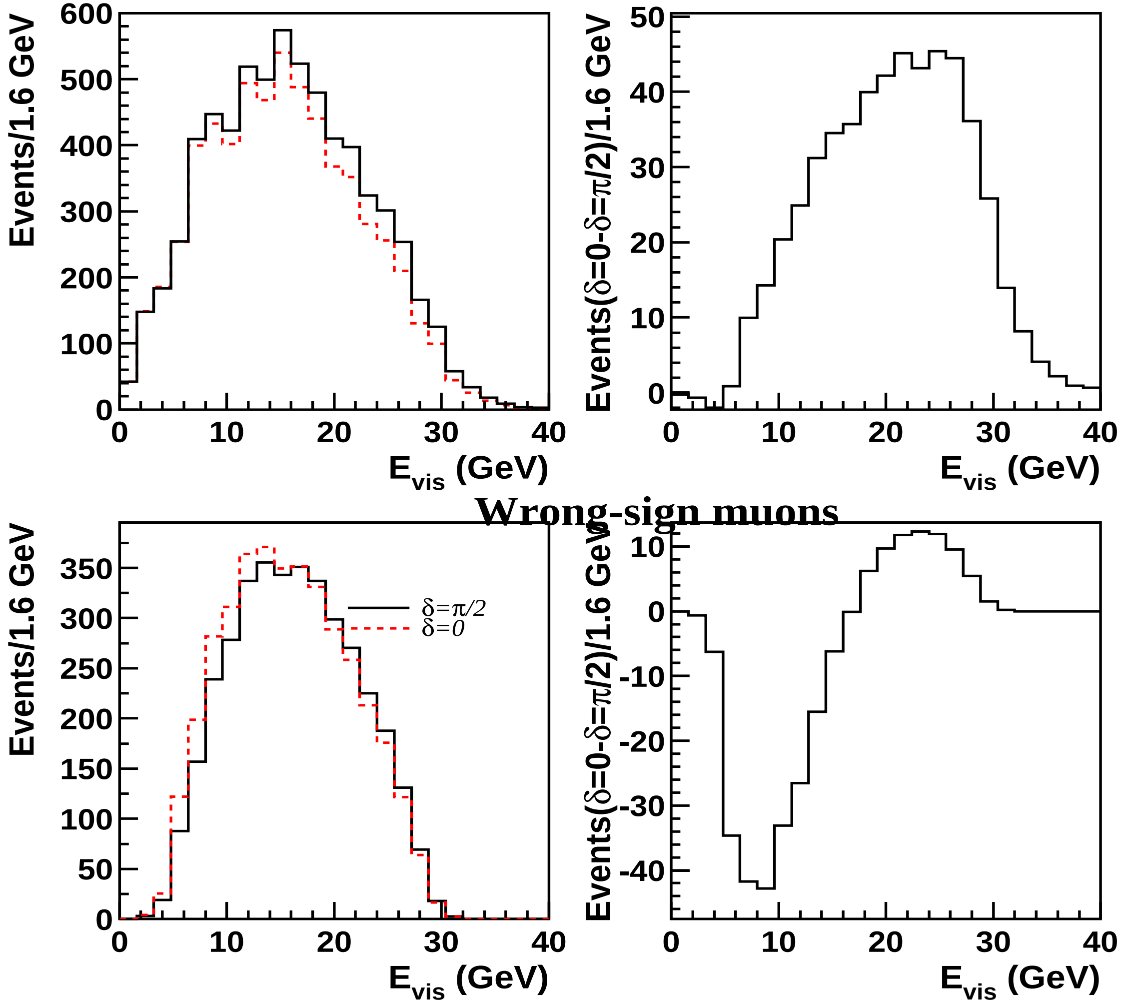
μ+, P=+1



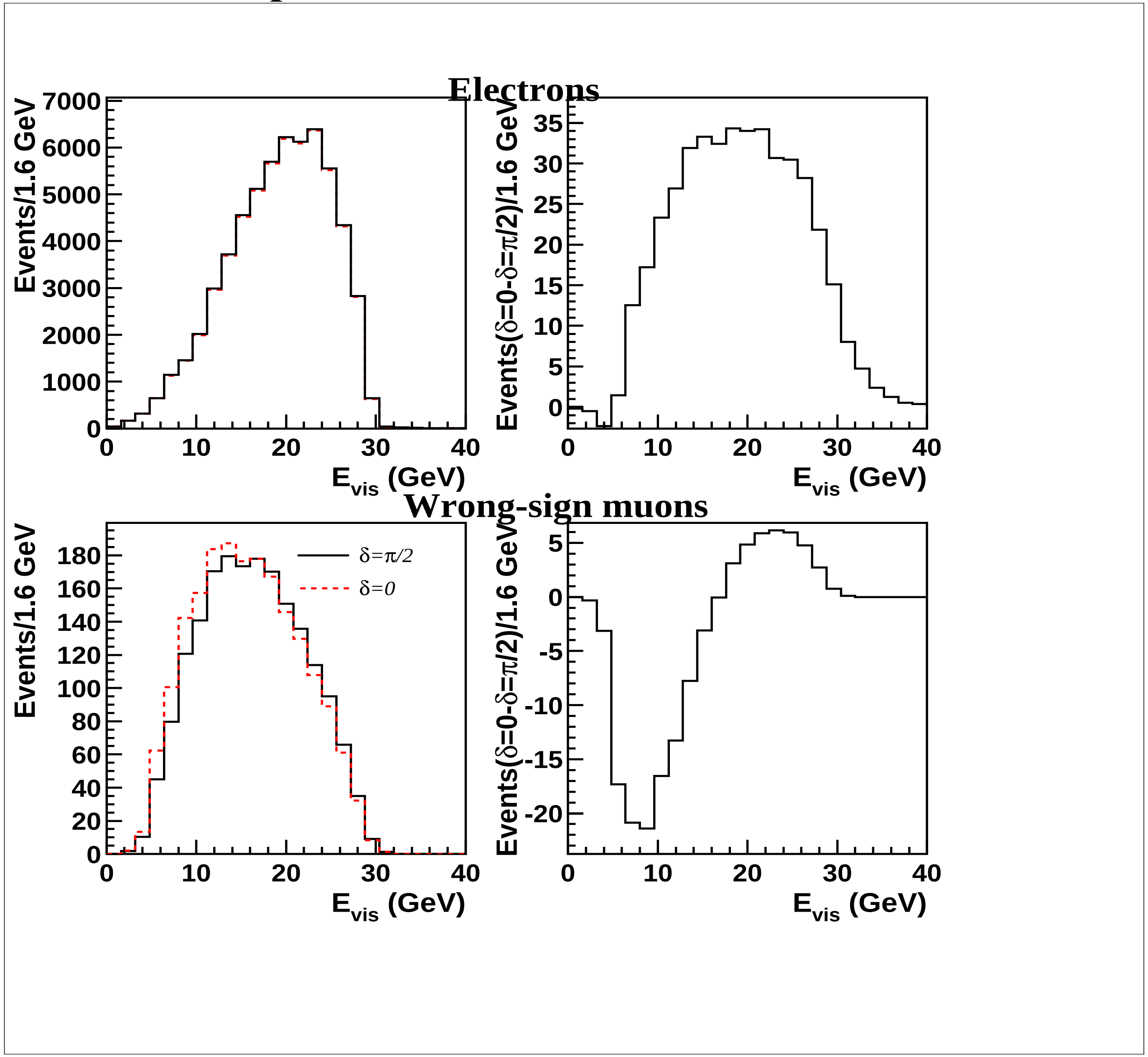
Negative polarisation(100%)

μ–, P=–1

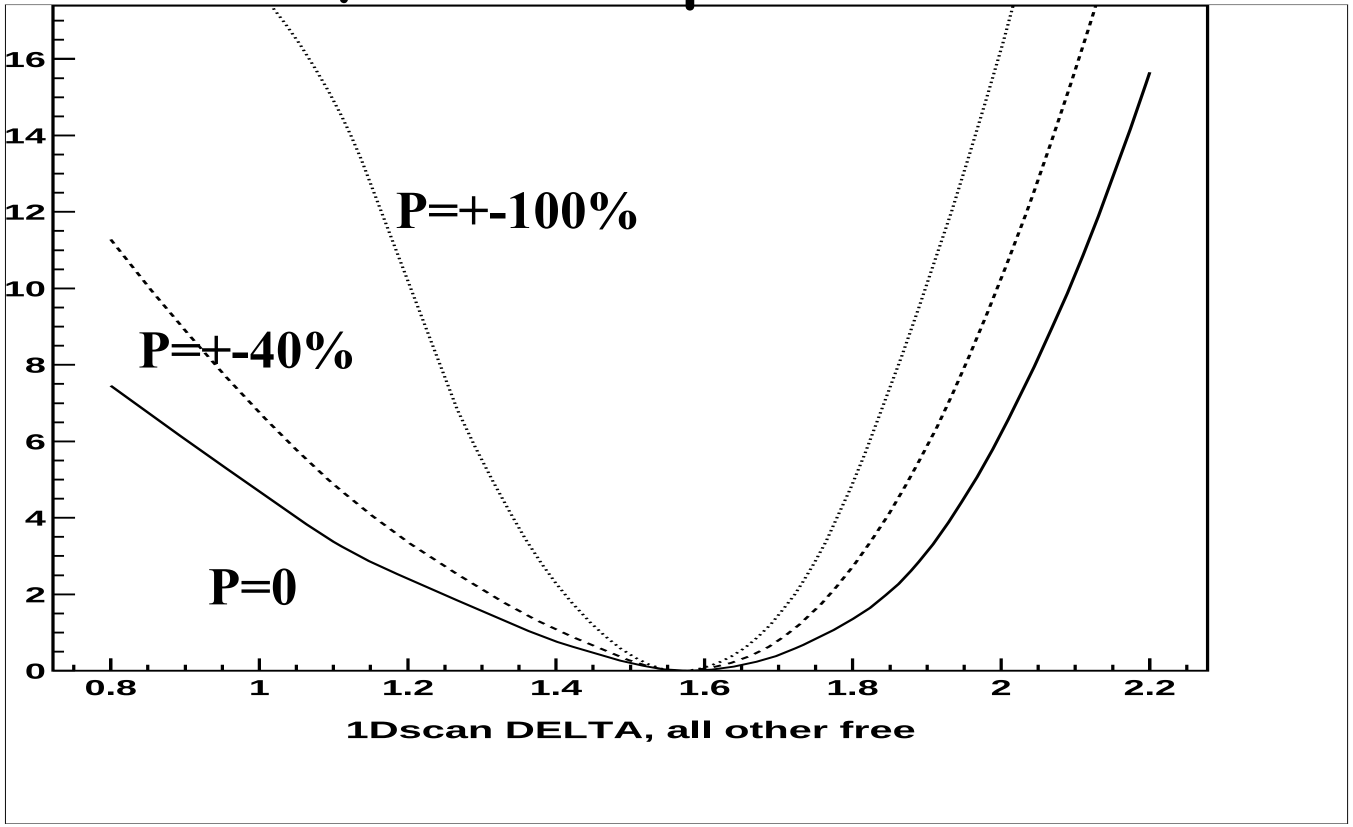
μ+, P=–1



No polarisation



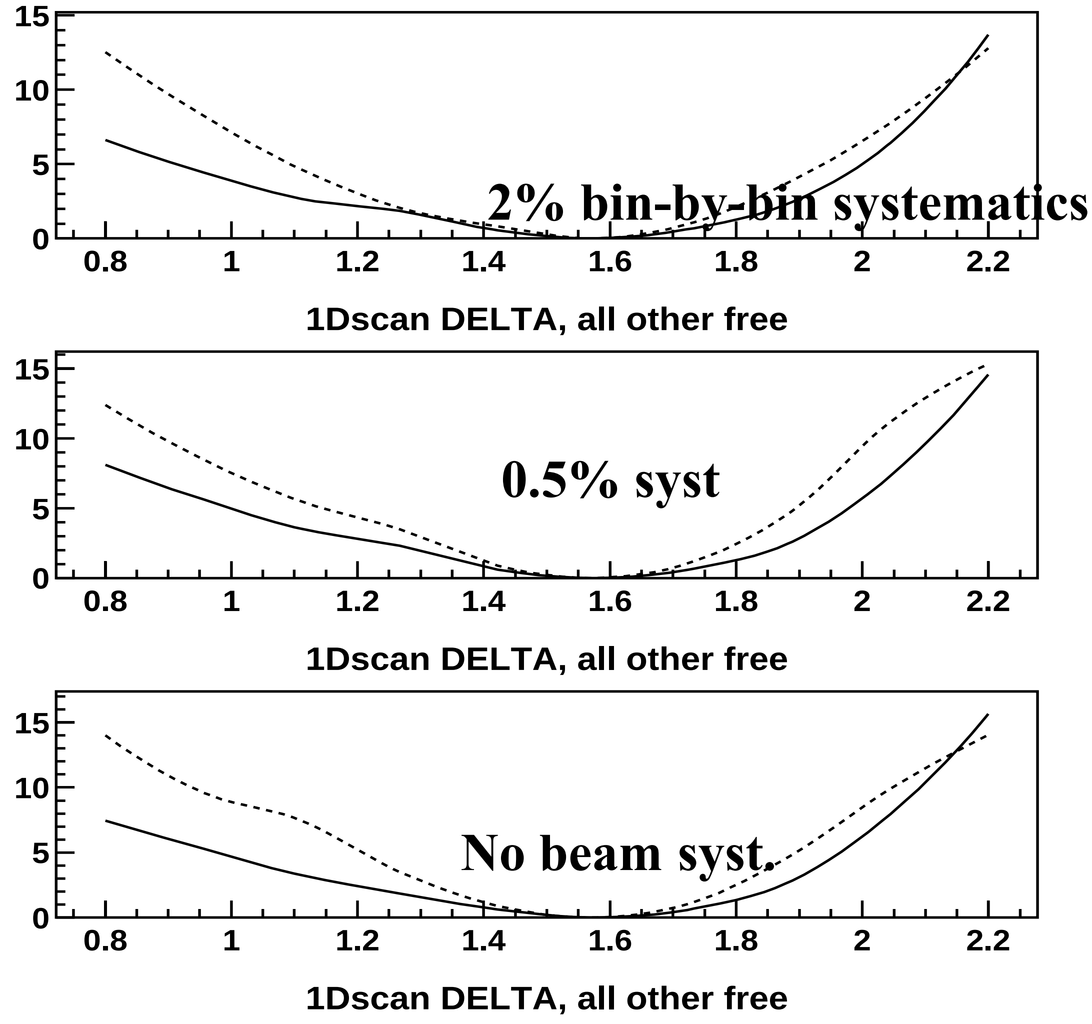
Fit to δ, all other parameters free



P = 0 :	$\delta = 1.57 \pm 0.20$
P= ±40%	$\delta = 1.57 \pm 0.15$
P= ±100%	$\delta = 1.57 \pm 0.10$

±40 % polarisation is equivalent, for this example, to increasing the muon flux by 1.77

χ^2 with systematic errors



Conclusions

In one particular example, we were able to evaluate, quantitatively for the first time, the gain offered by muon polarization at the neutrino factory.

This does not take more qualitative aspects into account, such as
-- separation of T-violation from CP violation
-- parameterization of individual oscillation phenomena
-- control/cross-check of systematics using polarization.

Much more to do, but on the right track ….