FCC-ee Beam Energy Calibration and Polarization next steps

Basic data for CDR

-- polarization levels at Z and W
near 80% at Z and >10% at W?
-- running scenario:
wigglers and pilot bunches
-- polarimeter-spectrometer set-up
-- depolarizer set-up (LHC TFB kickers)
depolarization technique
-- direct measurements of energy spread
and energy asymmetries in the detectors
-- smallness of effects of beamstrahlung and RF effects
-- smallness of systematic effects
-- CDR section of 45 pages and typing!

We are well on track to achieve center-of-mass Energy calibration systematics at the level of 100 keV at the Z, 300 keV at the W.

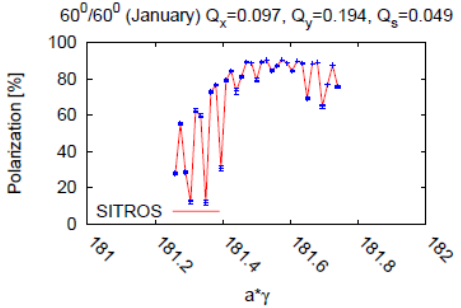
There remains a number of issues

-- -- Opposite sign vertical dispersion : size of effect, correction strategy
-- anti correlation of ECM between expts due to RF
-- statistical treatment: correlation matrix of sum and difference between experiments, between scan points and day to day.
-- Depolarization for W to be iron'd out.
-- general issue of software codes:
(de)polarization, orbit corrections for luminosity and calculations of systematics are not integrated

list of not-to-be-swept-under-the-rug issues that need to be solved (I).

Polarization calculations on toy machines are very optimistic.
on realistic machine there are many difficulties with the simulations:
Polarization at the W: 2% (linear code) or >80% (SITROS)?
Software issue or fundamental issue?

<u>We need to settle this soon.</u>



V= 700 MV

	σ_x (μm)	σ_y (nm)	σ_ℓ (mm)
analytical	13.22	19.5	3.079
SITROS Tracking	12.66	44.1	3.105

list of not-to-be-swept-under-the-rug issues that need to be solved (II).

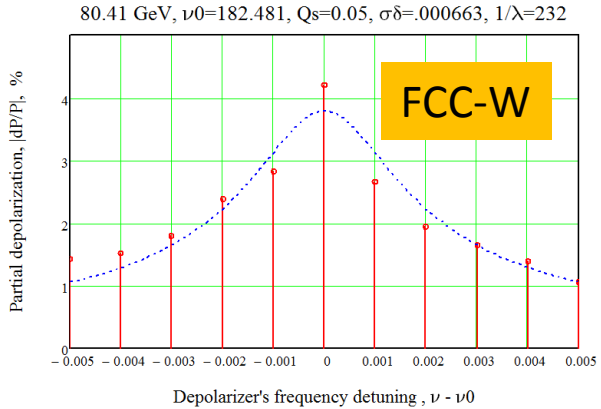
Depolarization at W

Short sweep method (as in LEP)

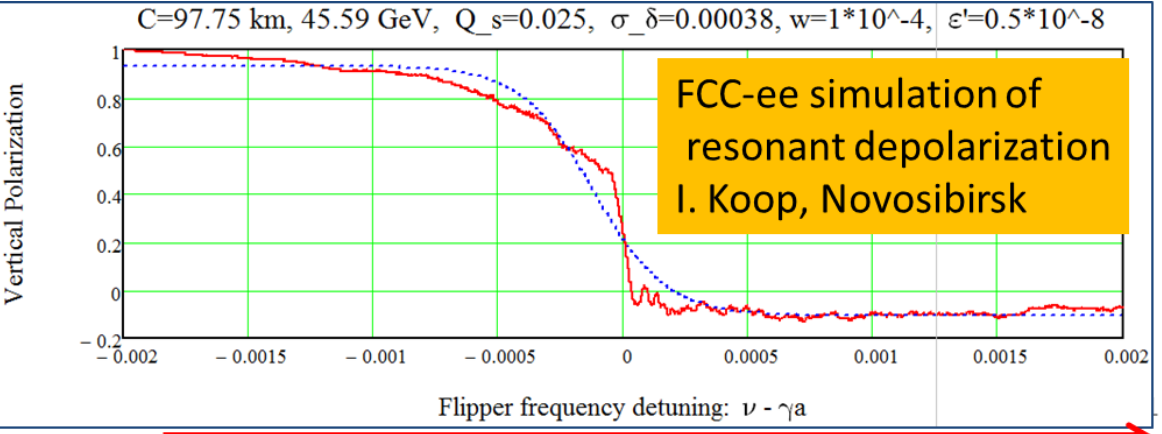
need to play with parameters of depolarizer to find the optimal

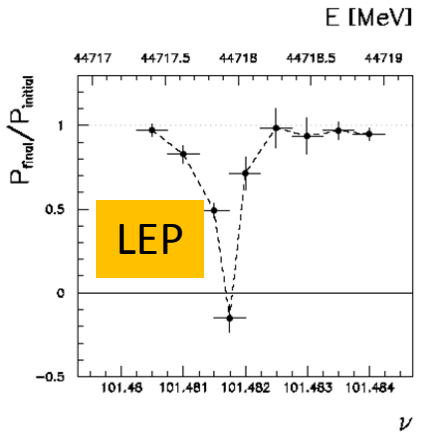
-- kicker strength, duration and extent of frequency sweep.

-- important to know if a different set of kickers is needed.



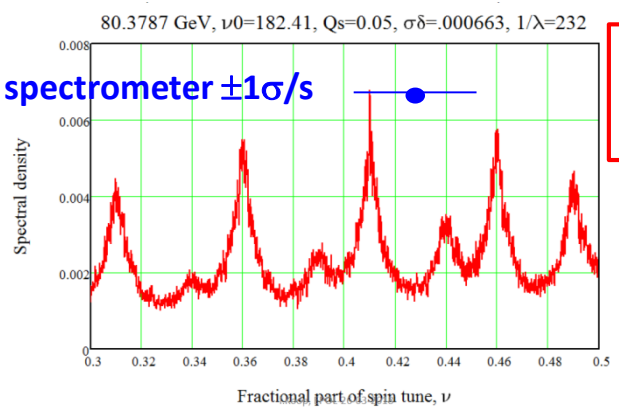
4% depolarization is too small.





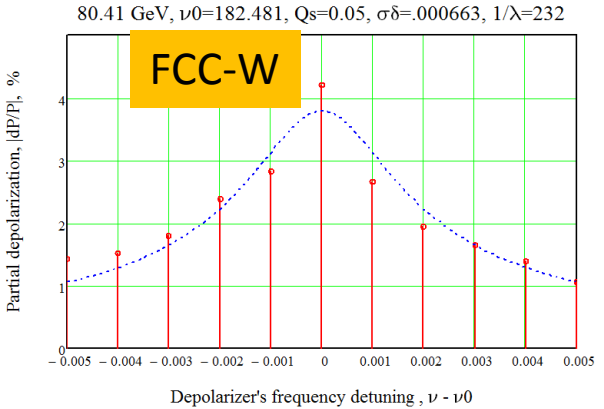
260 seconds sweep of depolarizer frequency

long sweep works well at the Z. Several depolarizations needed: eliminate Qs side band and 0.5 ambiguity
Less well at the W: the Qs side bands are much more excited because of energy spread, need iterations with smaller and smaller sweeps – work in progress. see *I. Koop* presentation.



← Fourier analysis shows the side band situation at W.

First attempt at 'LEP' multiple sweep technique →



Statistical treatment of errors

for each data point:

1. the uncertainties related to imperfections may have a systematic component (defects in the planarity of the ring will be there to stay between physical re-alignments)
2. but they are also expected to vary with time (ground motion, tides etc…), and randomness due to continuous orbit adjustments.
3. there will be 100 beam energy calibrations a day. What is the degree of correlation and randomness between uncertainties.
4. of course these can be studied from orbits etc…
5. can data from detector be used to evaluate these
   -- for instance the energy difference between the two beams will be measured with 40 KeV precision every few minutes
   -- and the two polarimeter/spectrometers will track the energy of beam with 4MeV precision every 10 seconds

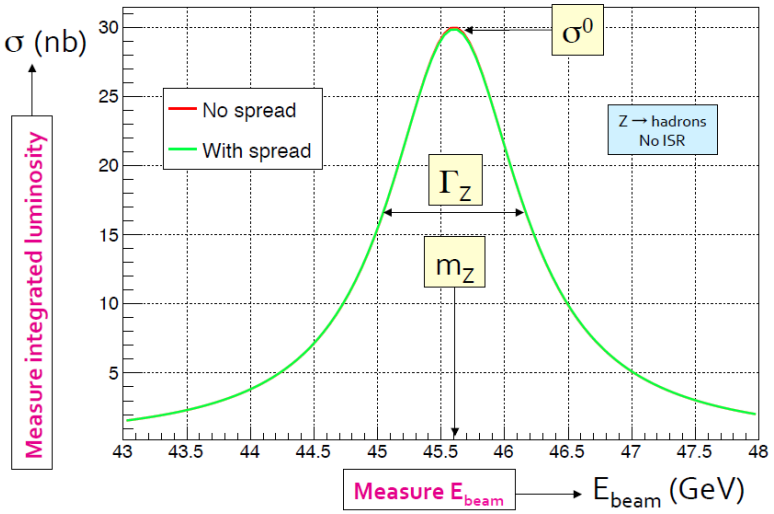
Statistical treatment of errors

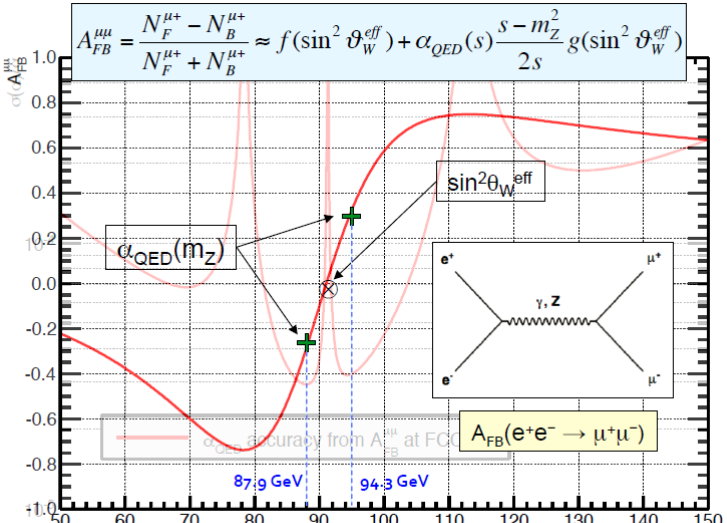
Between data points, there will be common sources of errors: the LEP scans were organized so that data taken at different scan energies were interleaved.

Expect error on Z width (relative) to be smaller than that on the mass (absolute)

What will be the uncertainty on the points at which the $A_{FB}^{\mu}(Ecm)$ data are taken with respect to the Z mass?

this has important implication for the precision on $\Delta\sin^2\theta^{lept}_{W}$





scan proposed for FCC-ee

E(peak)= 91.2 GeV spin tune = 103.5
E(-4) = 87.9 GeV spin tune = 99.5 `-4'
E(+4) = 93.8 GeV spin tune = 107.5 `+4'
E(+5) = 94.7 GeV spin tune = 108.5 `+5'

2/3 at peak 1/3 off peak.

P. Janot

Point-to-point errors

	$A_{FB}^{\mu\mu}$ @ FCC-ee	$A_{FB}^{\mu\mu}$ @ FCC-ee 90% correlation
visible Z decays	$5\ 10^{12}$	
muon pairs	$2.5\ 10^{11}$	
$\Delta A_{FB}^{\mu\mu}$ (stat)	$1.2\ 10^{-6}$	
ΔE_{cm} (MeV)	0.1	**0.01 ? 0.023**
$\Delta A_{FB}^{\mu\mu}$ (E_{CM})	$9.2\ 10^{-6}$	**$9.2\ 10^{-7}$? $2.4\ 10^{-6}$**
$\Delta A_{FB}^{\mu\mu}$	$1.0\ 10^{-5}$	**$2.3\ 10^{-6}$? $3.2\ 10^{-6}$**
$\Delta \sin^2\theta^{lept}_W$	$5.9\ 10^{-6}$	**$1.3\ 10^{-6}$? $1.9\ 10^{-6}$**

est. by M.K.

What matters for $A_{FB}^{\mu\mu}$ is the relative error between the Z peak point and the two off-peak points which determine the Z mass. Understanding the point-to-point errors in the energy calibration will be crucial. Presumably quite smaller.

This question has been touched on by M. Koratzinos, needs revisiting.

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