Future Circular Collider Technical and Financial Feasibility Study
2d FCC Energy Calibration, Polarization and Mono-chromatisation workshop

Overview: Status and goals WP1

Ivan Koop (BINP)

19 September 2022 at CERN

https://indico.cern.ch/e/EPOL2022

WP1. Simulations of polarization and spin-tune to beam energy relationship.

Conveners: Ivan Koop (BINP), **Tatiana Pieloni** (INFN), **Eliana Gianfelice** (Fermilab)

- **-- simulations of spin polarization in realistic machine (also able to calculate emittances, luminosity)**
- **-- res. depolarization at Z and WW threshold**
- **-- design and integration of wigglers, RF kickers, in FCC-ee**

Presenters:

Zhe Duan (IHEP), **Taho Chen** (IHEP), **Yi Wu** (EPFL), **Yuhao Peng** (University of Victoria, CA), **Anton Bogomyagkov** (BINP), **David Sagan** (Cornell), **Gerd Kotzian** (CERN), **Jorg Wenninger** (CERN), **Sergei Nikitin** (BINP), **Jeremie Bauche** (CERN), **Michael Hofer** (CERN), **Felix Carlier** (CERN), **Francois Meot** (BNL), **Jacob Asimov** (Cornell), ...

Task 1. How misalignments and intrinsic spin resonances may affect on the attainable polarization degree and on the spin tune - energy relationship?

-- how to measure and suppress the spin resonances strengths – polarimeters quality plays most roles here!!! (**shall workout requirements for the sensitivity of 3d-polarimeters**)

-- harmonic spin matching technique by the closed orbit correction (**again, its effectiveness depends strongly on the polarimeters capabilities!**)

-- optimization of polarization wigglers operation (**Fine balance between their strengths and the maximal attainable polarization degree.**)

-- probably shall spent more than 2 hours to prepare polarized bunches with higher polarization degree?

Addendum to Task 1:

-- our dream: incorporate spin tracking into existing program codes, like MAD-x, BMAD and others

-- one of a problem: code becomes too slow due to thousands of elements in the FCC-ee lattice and many thousands of particles to be tracked

-- therefore much more simple and fast simulations one can do with a lumped description of a ring's spin transport - useful for study of specific issues.

-- another difficulty for a simulation of virtual ring: need include the SR damping and the coherent losses. Code becomes non Hamiltonian.

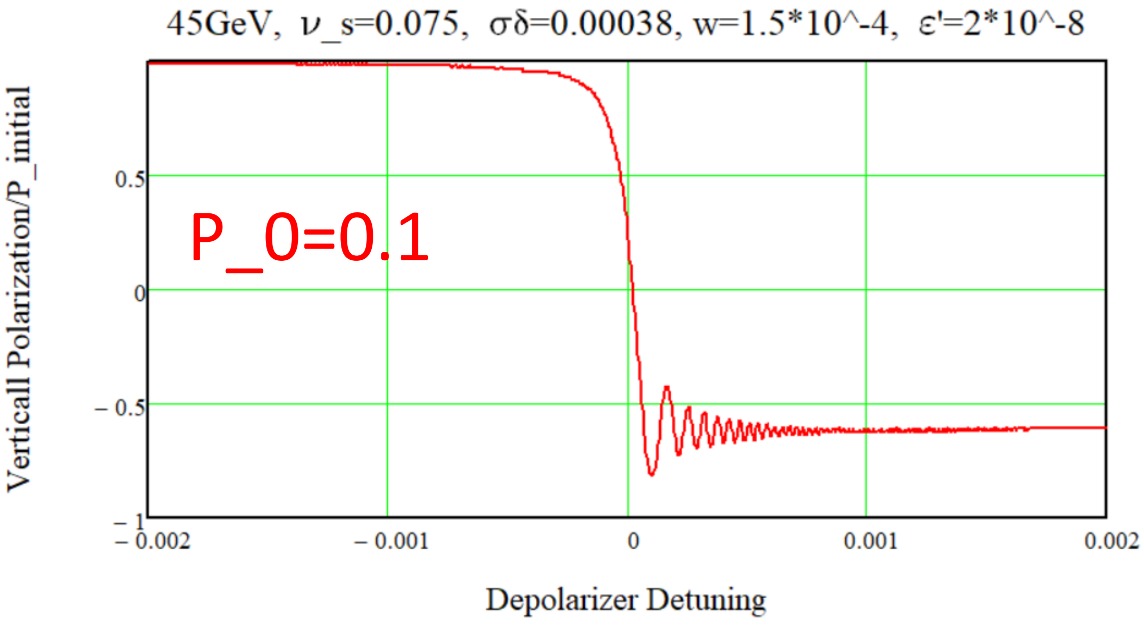
Task 2. Resonance Depolarization process - spin flip by Froissart-Stora tune scan, and alternatively – fast spin rotation and then the free spin precession observation with subsequent Fourier spectrum analysis

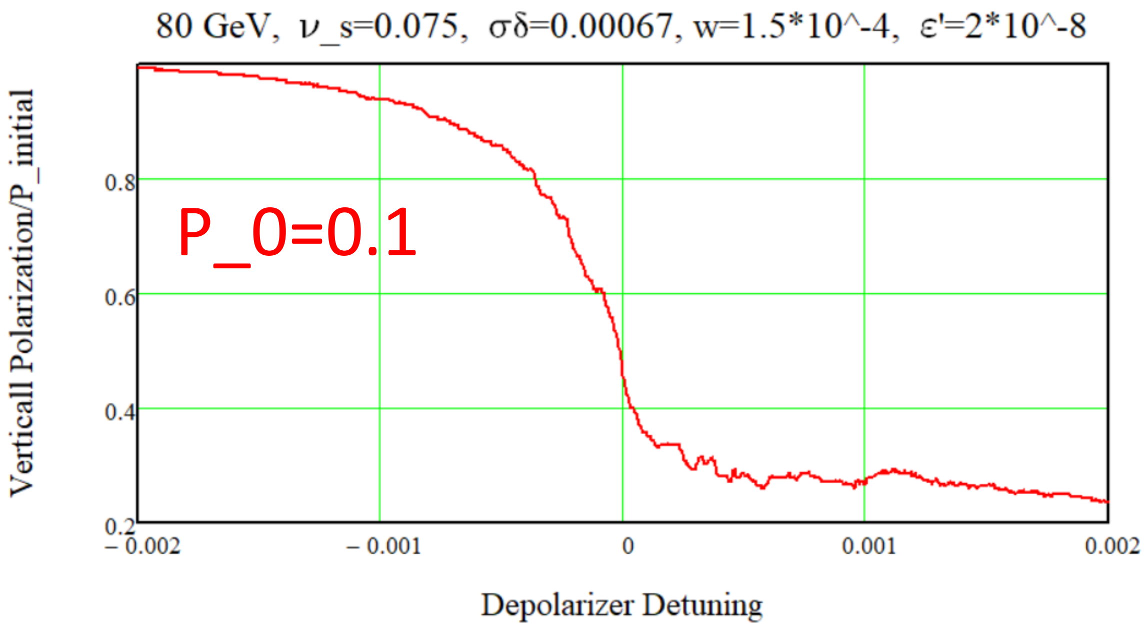
-- optimization of a depolarizer parameters (**strength, tune scan speed, tune scan width**)

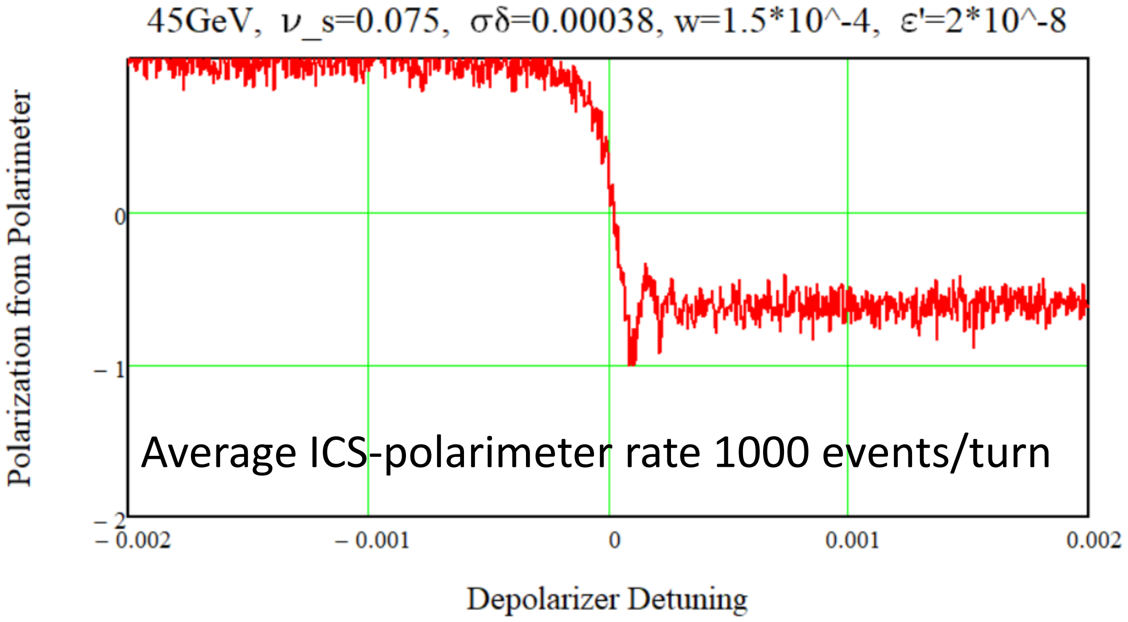
-- parameters of RF-kickers for both techniques (**optimal locations, strengths, simple single or with orbit deviation compensated pi-pairs?**)

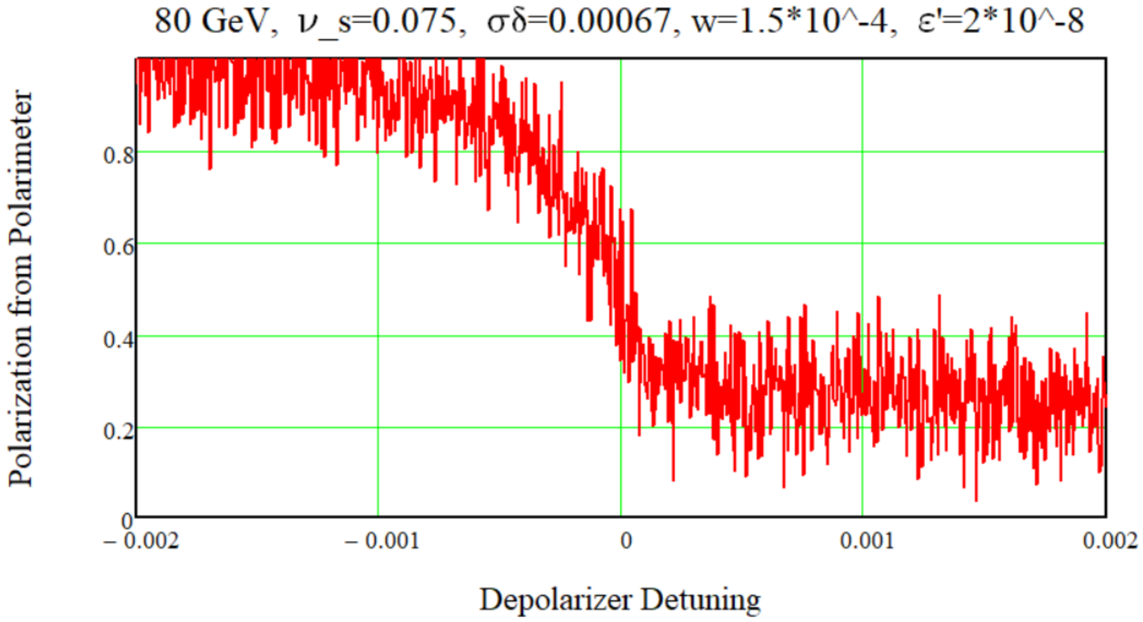
-- optimization of the fractional part of the spin tune
-- optimization/choice of the synchrotron tune value
-- analysis of the attainable spin tune measurement accuracies, taking into account many factors (such as beam energy noise etc…) and the polarimeter statistics limitations

RD frequency sweeps with increased v_s=0.075

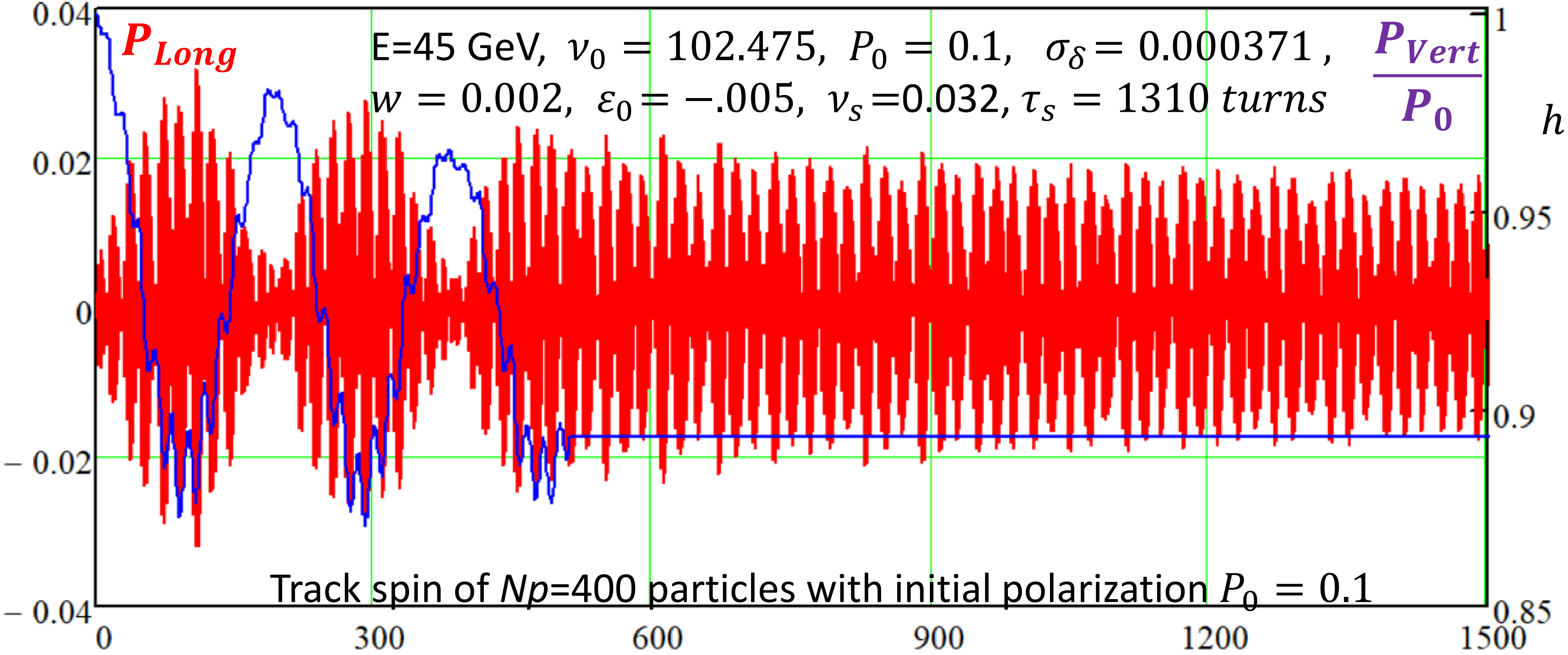


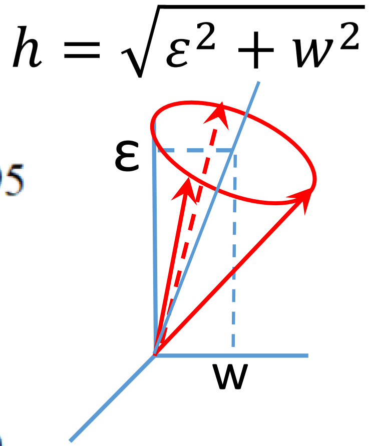






Excitation of the coherent spin precession at Z by Flipper

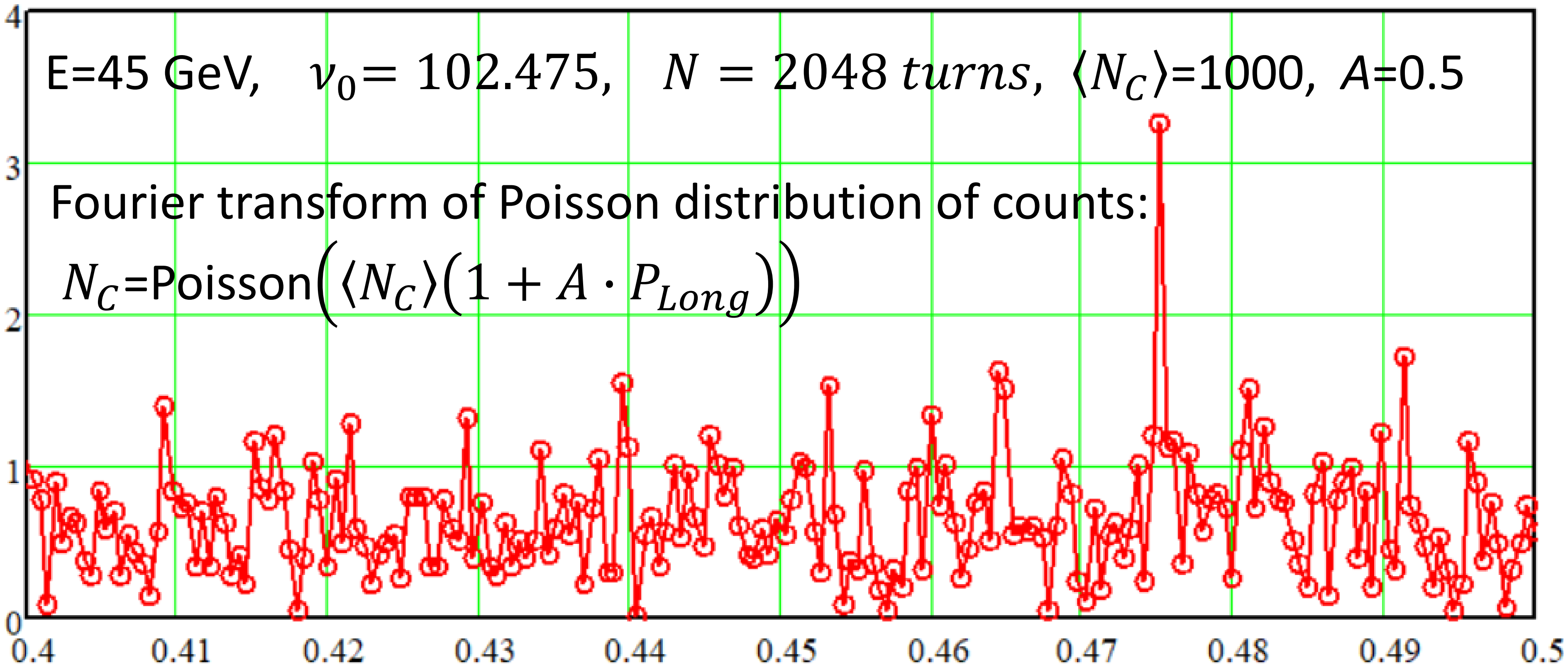




Spin precession in resonance frame

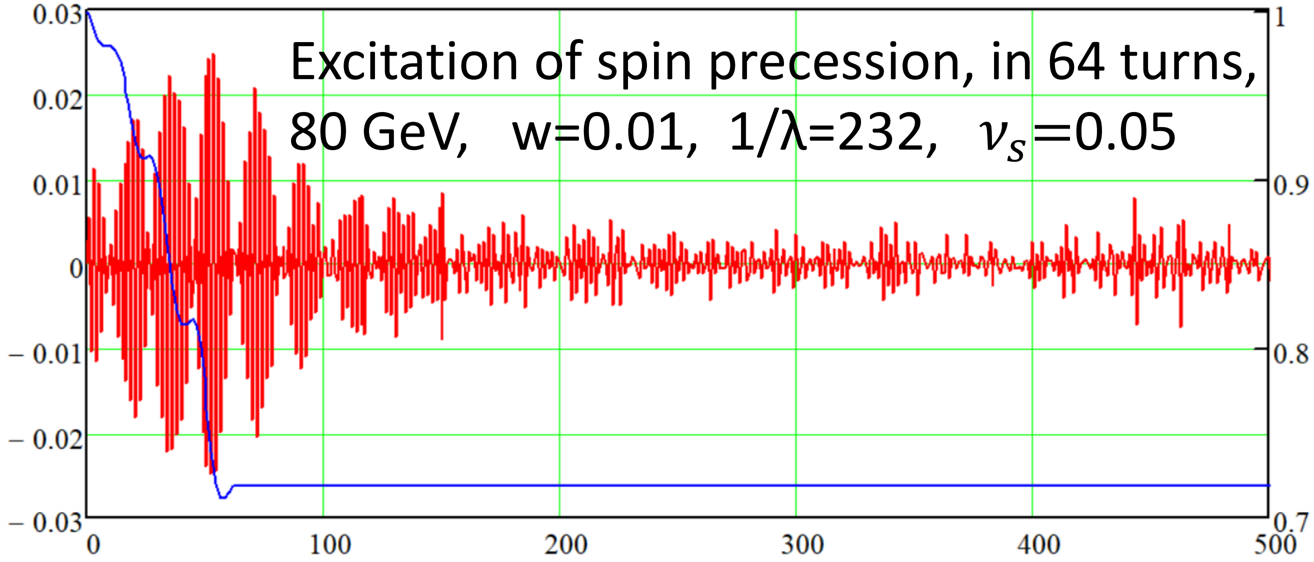
Coherent rotation of the total spin ensemble is done by powerfull Flipper device: w=0.002. Its frequency is shifted from the resonance by small detuning factor: $\varepsilon_0 = -.005$. Flipper is on 512 turns. After that we observe free spin precession during 2048 turns. Polarization loss is only 10%. In principle, Flipper kicks effectively spin only first 100 turns, or so!

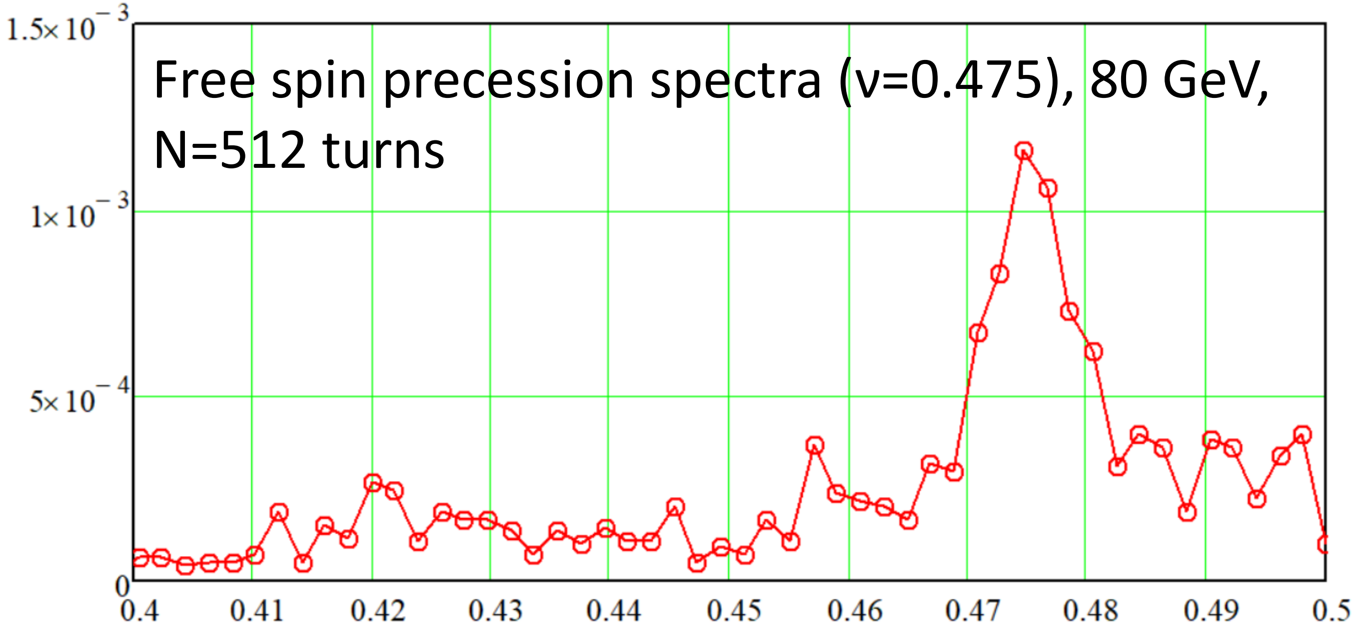
Fourier transform of the counted electrons with high energy loss (at Z)



At Z polarization asymmetry of the Compton cross section relative to the longitudinal spin component could easily exceed A>0.5 and the free precession peak at ν=0.475 is well above the statistical noise.

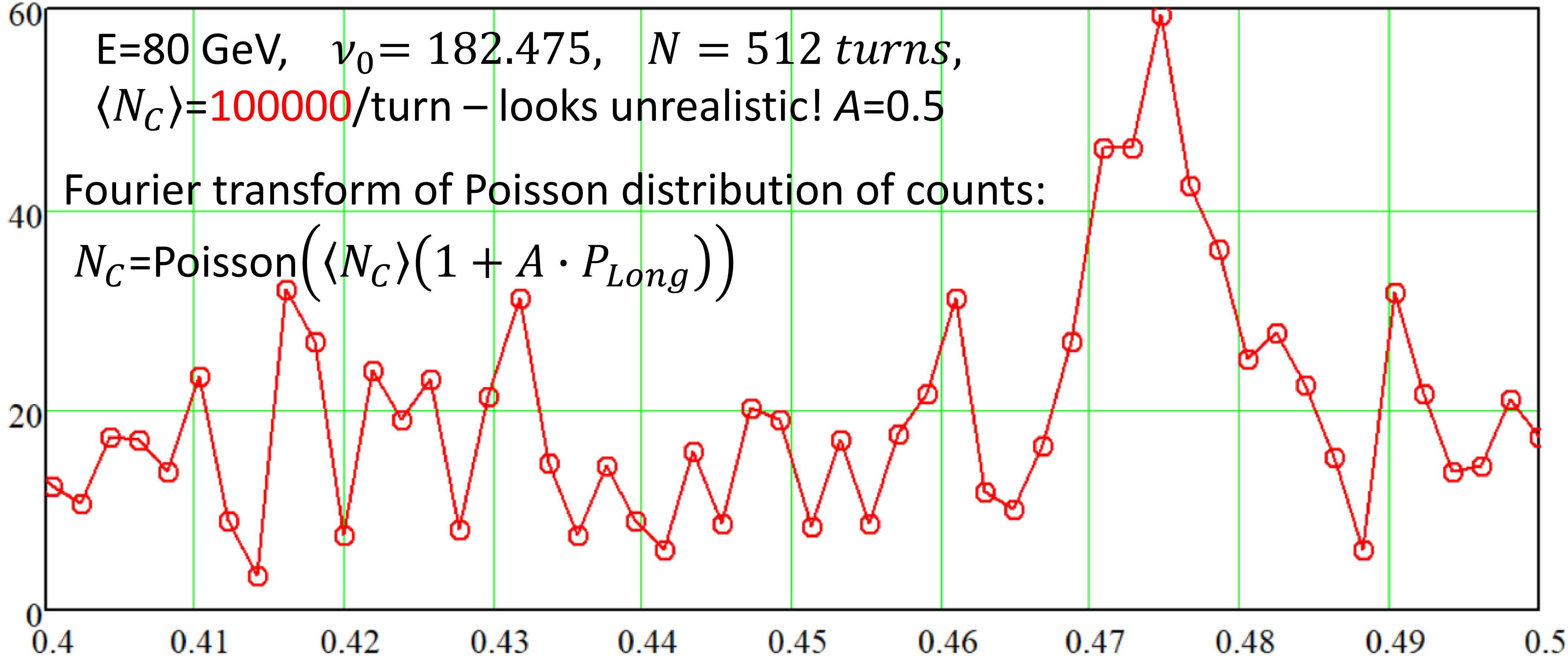
Excitation of the coherent spin precession at W by Flipper





Track spins of *Np*=400 particles with initial polarization $P_0 = 0.1$

Fourier transform of the counted electrons with high energy loss (at W)



At W polarization asymmetry is very high (here we assume only A=0.5). Still free precession peak at ν=0.475 is visible only with very high statistics level: $\langle N_C \rangle$=100000/turn.

Task 3. Analysis of different sources of systematics. Corrections for them.

-- attend Anton's, Sergei's and Dmitry's talks!

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Task 4. Transition from the measured average beam energy to the local energy at IP – common issue with WP2.

-- how to constrain a saw tooth curve (energy loss integrals between IPs)?

-- could the free spin precession phase measurements (by few longitudinal polarimeters placed near IPs) help us to solve this problem?

-- could we disentangle the coherent losses from the SR and beam strahlung losses?

-- could we use energy boosts information from the detectors to derive the energy loss integrals between IPs?

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Let’s start to work!