Karlsruhe Institute of Technology

KARA
Karlsruhe Research Accelerator

IBPT
Institute for Beam Physics and Technology

Beam test at KIT/KARA – Update to ongoing discussions

Bastian Härer on behalf of the KIT team

Personal conclusions

1. definitely interesting to practice the resonant depolarization measurement in a situation where polarization time is 10 minutes!

2. It is impossible to perform the spin precession measaurement unless a 3D compton polarimeter is implemented (interesting, long term proposal)

3. It is difficult (to be studied further) to measure the polarization level precisely in view of optimizing it.

4. it should be feasible to study the implementation of spin knobs and
-- use them to measure the polarization and depolarization rate in a controlled way
-- thus possibly extract the absolute polarization level
-- use them to search for impact of spin resonances on the relationship between resonant depolarization frequency and beam energy

5. Procedures
-- it is of great importance to simulate these experiments , at least conceptually, before executing them!
-- understanding of the assignment of uncertainties is crucial!

Alain Blondel

Comments and suggestions for experements at KARA:

- KARA is a normal ring with high enough synchrotron tune $\nu_s = .01$ and low RMS value of the modulation index $B = \nu_0 \sigma_E / \nu_s = 0.567,\ J_0(B) = 0.92$.
- No any problems with RD!
- Our idealized simulation show a potential to further squeeze the RD uncertainty in the resonance spin tune down to Δν=1e-6 or even better.
- We do not include noise from the power supply and from a RF station. Then depolarization could become not as sharp, as in our simulation.
- We recommend to work with the reduced value of the depolarizer's harmonic w, especially at 2.3 GeV, where F3 is 10 times higher compared with its value at 2.5 GeV. With strong depolarizer a beam will become not depolarized but spin flipped! There is some optimal value of w, when polarization vanishes completely after crossing a resonance - jump in Touschek counting rate is sensitive to $\Delta\langle P_y^2 \rangle$, not to $\Delta\langle P_y \rangle$! It is better to fully depolarize a beam!

Ivan Koop

Outline

Issues currently under discussion:

- Implementation of spin knobs: Correctors & BPMs and optics
- Touschek polarimeter: data analysis (and polarization measurements?)
- Long-term proposal for a Compton polarimeter

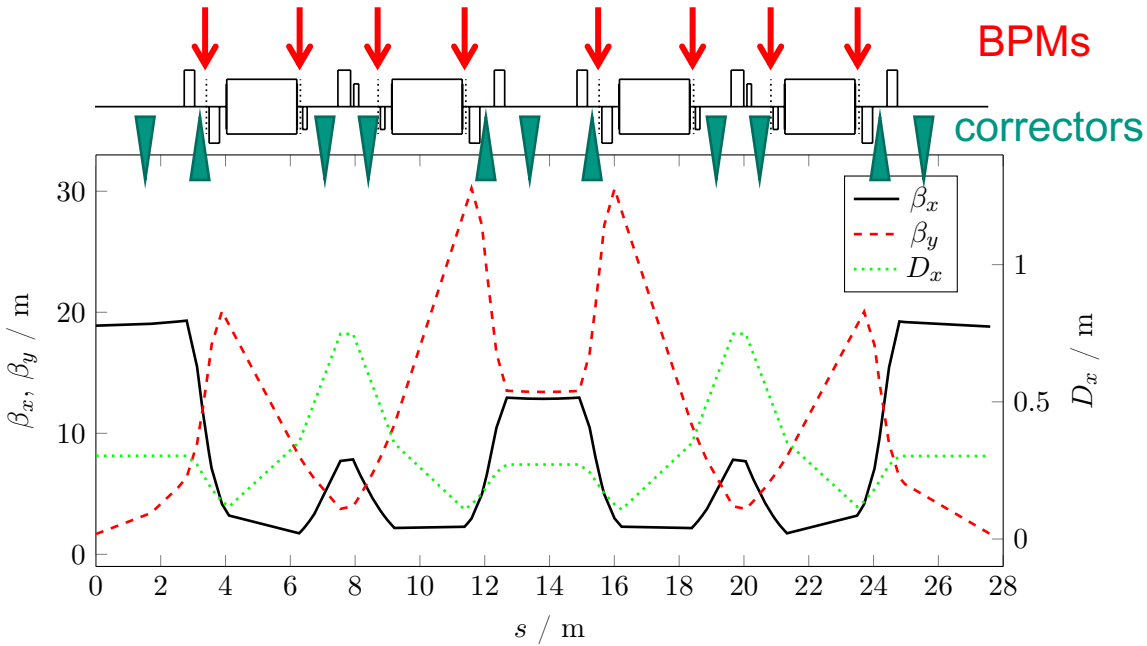
1) Towards spin knobs

- Why are they interesting? → Alain:
  - **-- use them to measure the polarization and depolarization rate in a controlled way**
    - **-- thus possibly extract the absolute polarization level**
  - **-- use them to search for impact of spin resonances on the relationship between resonant depolarization frequency and beam energy**

- Can they implemented in KARA?

Correctors and BPMs in the KARA lattice

Name	Device	Position (m)
MCH.S1.01	hor. corrector	1.708000
MCV.S1.01	vertical corrector	3.299900
BPM.S1.01	beam position monitor	3.484000
BPM.S1.02	beam position monitor	6.389010
MCH.S1.02	hor. corrector	6.742020
MCH.S1.03	hor. corrector	8.542010
BPM.S1.03	beam position monitor	8.777010
BPM.S1.04	beam position monitor	11.492025
MCV.S1.02	vertical corrector	12.065020
MCH.S1.04	hor. corrector	13.330020
MCV.S1.03	vertical corrector	15.415020
BPM.S1.05	beam position monitor	15.600020
BPM.S1.06	beam position monitor	18.505030
MCH.S1.06	hor. corrector	18.858040
MCH.S1.07	hor. corrector	20.658030
BPM.S1.07	beam position monitor	20.893030
BPM.S1.08	beam position monitor	23.608040
MCV.S1.04	vertical corrector	24.181040
MCH.S1.08	hor. corrector	24.966040

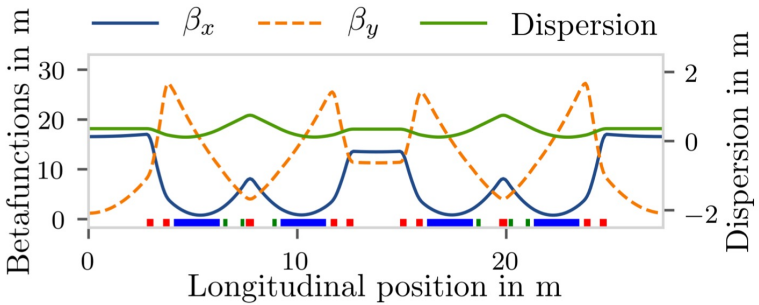


sector 1 (one quarter)

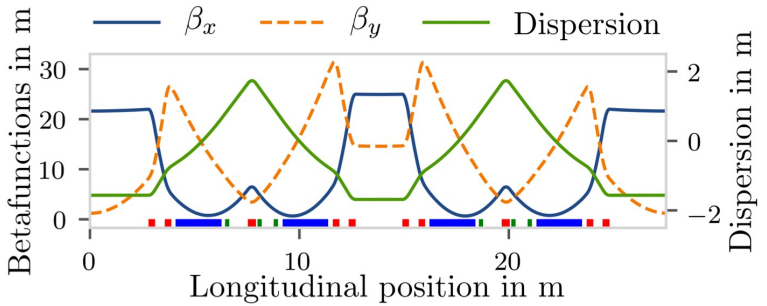
Flexible optics

- Different optics in operation
- New optics for polarization studies can be implemented

- Quadrupole powered in families
- Power supply refurbishment program ongoing
  Proposed: Individual power supplies for quadrupoles



User optics: $\alpha_C = 9 \times 10^{-3}$



Negative alpha optics: $\alpha_C = -8 \times 10^{-3}$

Status towards spin knobs

- Work has started

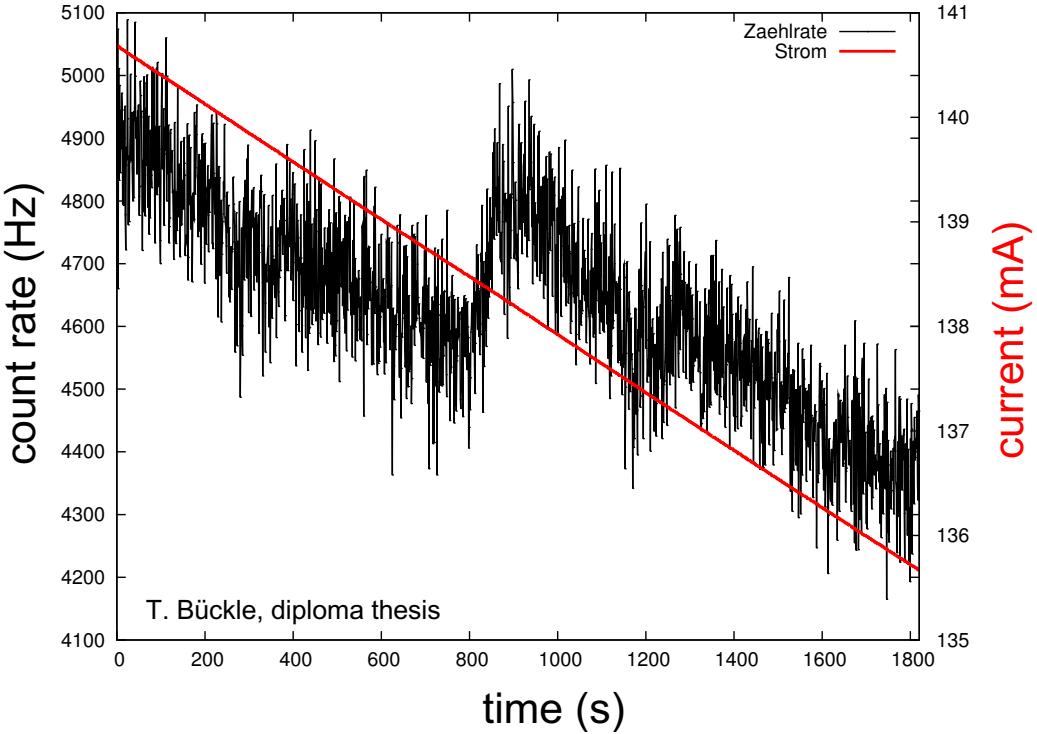
- I need to learn more about what “spin knobs” are.
  - Desmond already provided many references
    - Thank you again! ☺
  - What lattice/optics conditions have to be fulfilled?
  - Are there specific references on that topic?

2) Existing setup based on Touschek scattering

- Investigation of details of data analysis ongoing
- Most comprehensive written documentation:
  T. Bückle, diploma thesis, 2008 (in German)
  https://publikationen.bibliothek.kit.edu/1000022044

  → Starting point of my investigation

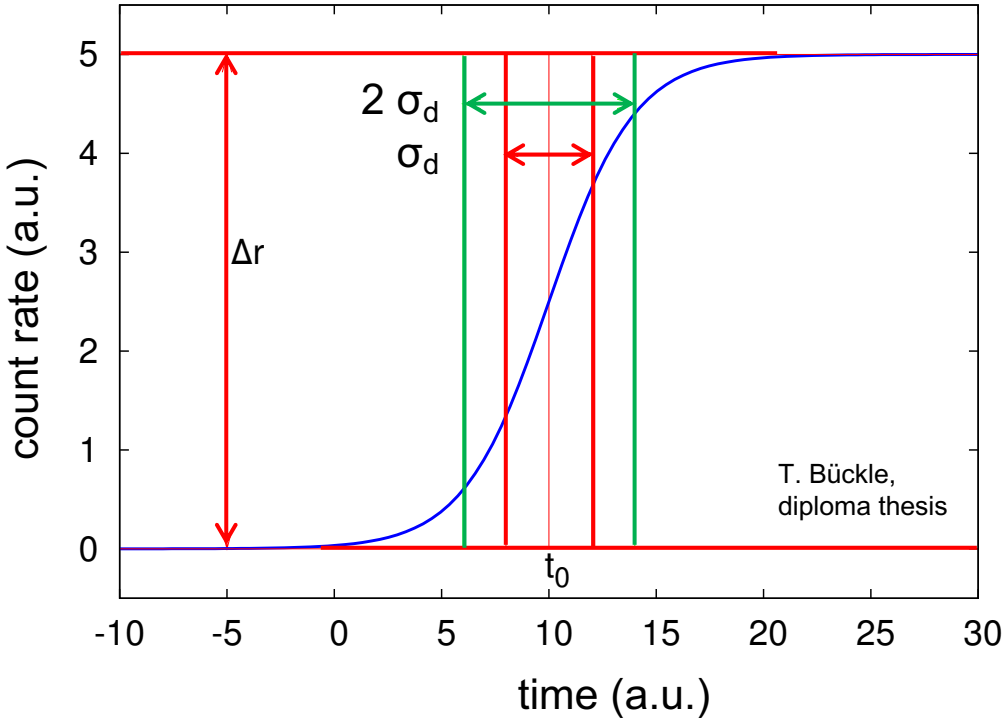
Count rate follows step function



$$r(t) = a - b \cdot t + \frac{\Delta r}{1 + \exp\left(-\frac{t - t_\mathrm{d}}{\sigma_\mathrm{d}}\right)}$$

- a, b: linear slope
- Δr: change of count rate
- t_d: time of depolarisation
- σ_d: duration of depolarisation

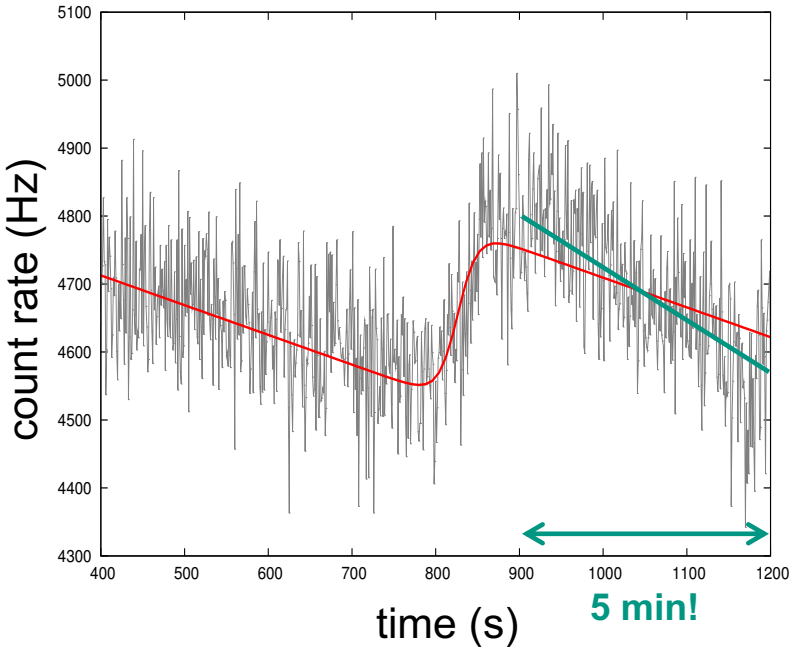
Step function



$$r(t) = a - b \cdot t + \frac{\Delta r}{1 + \exp\left(-\frac{t - t_\mathrm{d}}{\sigma_\mathrm{d}}\right)}$$

- a, b: linear slope
- Δr: change of count rate
- t_d: time of depolarisation
- σ_d: duration of depolarisation

Example fit (in this case by root)



$$r = a - b \cdot t + \frac{\Delta r}{1 + \exp\left(-\frac{t - t_{\mathrm{d}}}{\sigma_{\mathrm{d}}}\right)}$$

depolarisation time	$t_d\,[s]$	826.4 ± 3.6
duration of depolarisation	$\sigma_d\,[s]$	11.8 ± 2.7
change of count rate	$\Delta r\,[Hz]$	259.2 ± 11.7
ordinate	$a\,[Hz]$	4887.7 ± 6.9
negative slope	$b\,[Hz/s]$	0.438 ± 0.014

10 min polarization time
→ beam polarizes again

T. Bückle, diploma thesis

T. Bückle’s error discussion

Systematic errors

- Manual start of the frequency sweep
- Real duration of sweep compared to reference value
- Time difference between start of sweep and data taking
- → Δt_d = 10s, Δf_d = 0.3 kHz

→ not up-to-date since measurement procedure changed

Statistic

- Errors from fit
- Fluctuations of count rate, calculation of mean value
- → Δt_d up to 100s, Δf_d up to 1-2 kHz

Not included (to my understanding)

- Re-polarization effect

2) Status

- Investigation of previous work and data analysis process has stared
- Deeper understanding of measurement process and error sources required
  - → Have a look at the Matlab scripts for the details of the data anlysis
  - → Is the polarisation build-up included?
- Anke mentioned during a discussion that a detailed and systematic study might even allow to measure the polarization level with Touschek polarimeter
  - → Have a look at the study at VEPP-4M
  - → Detailed machine study pending
  - → Master's topic defined

3) Compton polarimeter in KARA

- In general possible as a long-term perspective.

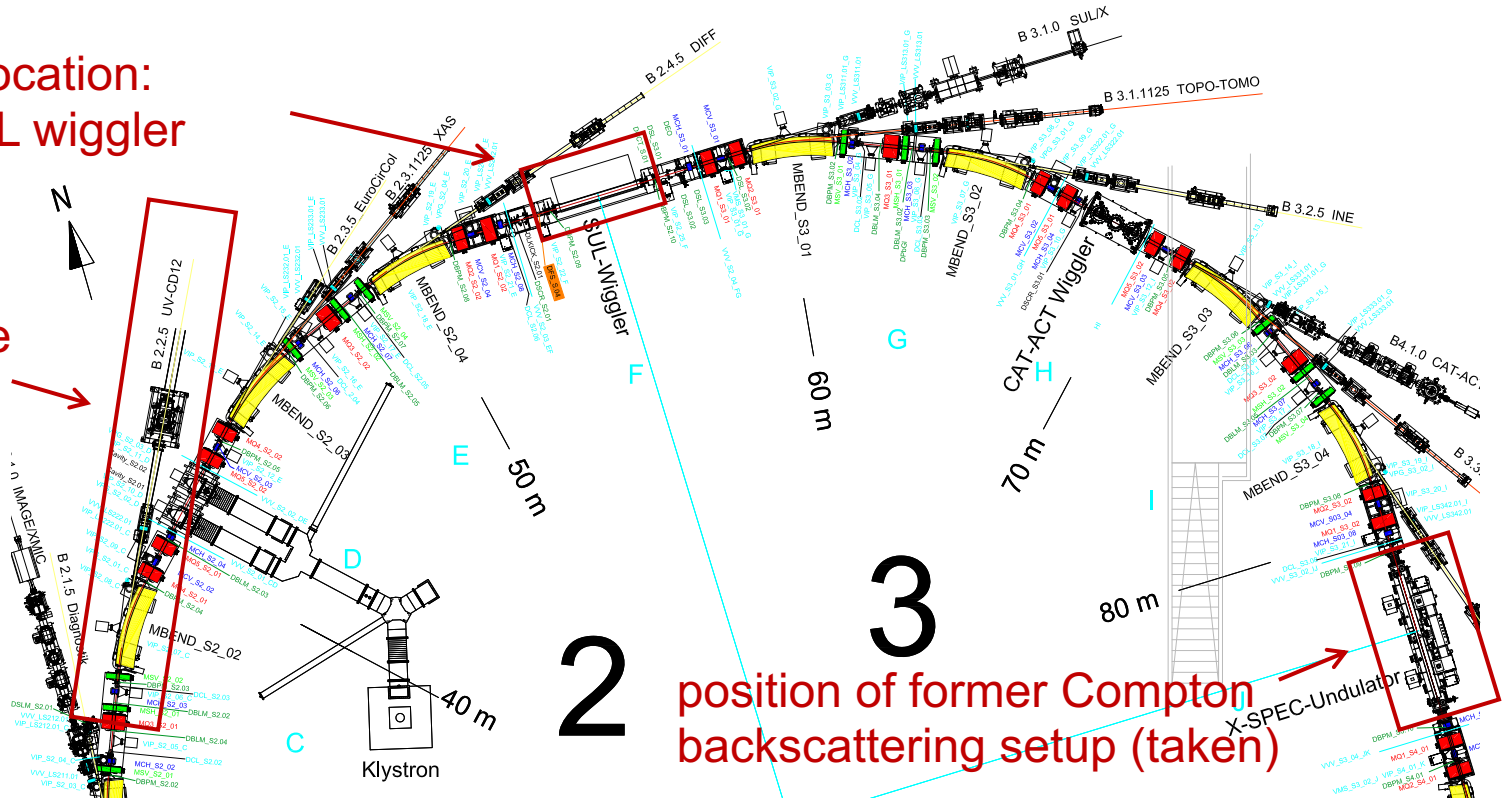
- Experience with 90° Compton backscattering setup for energy measurements
  See: https://indico.cern.ch/event/1181966/contributions/5041347/
- 90° setup because of space constraints at that time
- CO_2 laser still available

- Feasibility for 180° setup is currently under investigation
- Two possible locations have been identified:

Possible locations for a Compton polarimeter

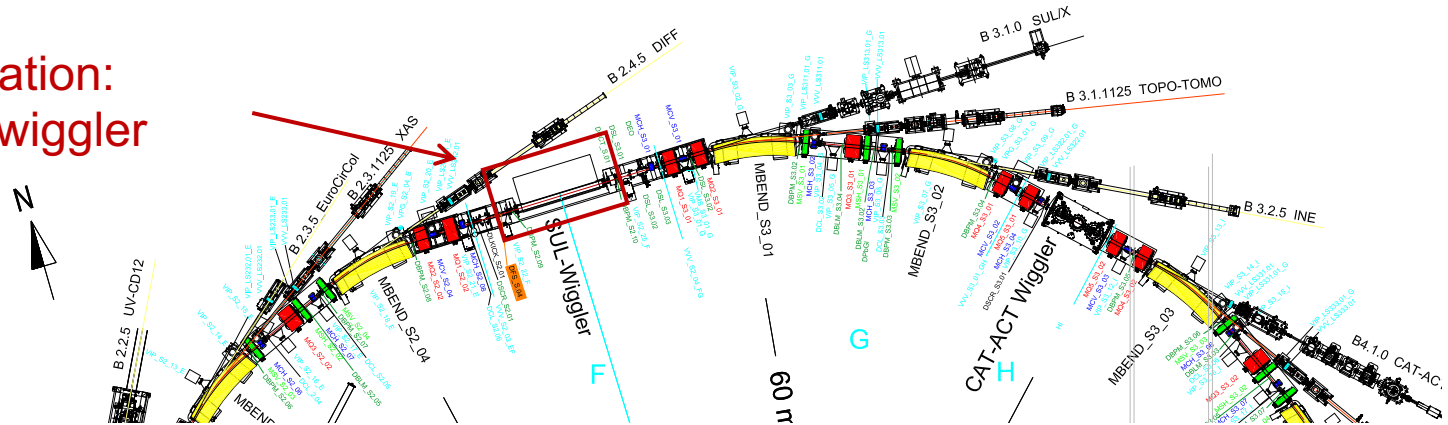
1st possible location:
replacing SUL wiggler

2nd possible location:
dismantled beamline



Possible locations for a Compton polarimeter

1st possible location:
replacing SUL wiggler

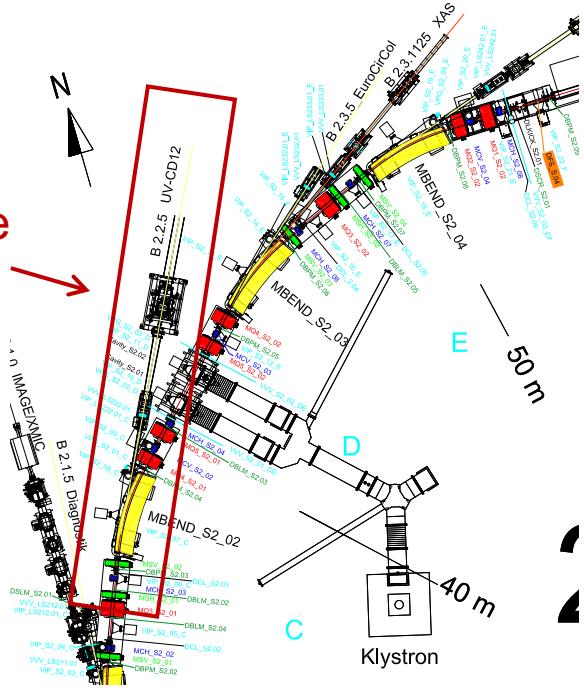


Location 1:

- Insertion device has to go
  → Users would have to give up one undulator-based beamline
- In that case sufficient space (~1.8 m) in the ring (and for detection?) available

Possible locations for a Compton polarimeter

2nd possible location: dismantled beamline



Location 2:

- Little space in the ring for additional equipment
- No beamline equipment available, needs to be re-build completely
- Since beamline is not used: No negotiations with users necessary

Open tasks and next steps

1) Spin knobs

- Study of existing publications
- Check implementation of spin knobs
- Verification of simulation models: ocelot online model, MAD-X

2) Touschek polarimeter

- Deeper understanding of measurement process and error sources required
  → Have a look at the Matlab scripts for the details of the data anlysis
  → Is the polarisation build-up included?
- Systematic study in context of a master's (project including Ivan's remarks)

3) Compton polarimeter

- Monte-Carlo Simulation to benchmark basic parameters
- Discuss time frame and financial aspects (considerable reconstruction required)

Karlsruhe Institute of Technology

KARA
Karlsruhe Research Accelerator

IBPT
Institute for Beam Physics and Technology

Thank you for your attention!

Thanks a lot to A. Blondel, I. Koop, E. Blomley, A. Mochihashi, A.-S. Müller for their contributions and the discussions during preparation of this talk!