Diagnosis with CR pu‘s

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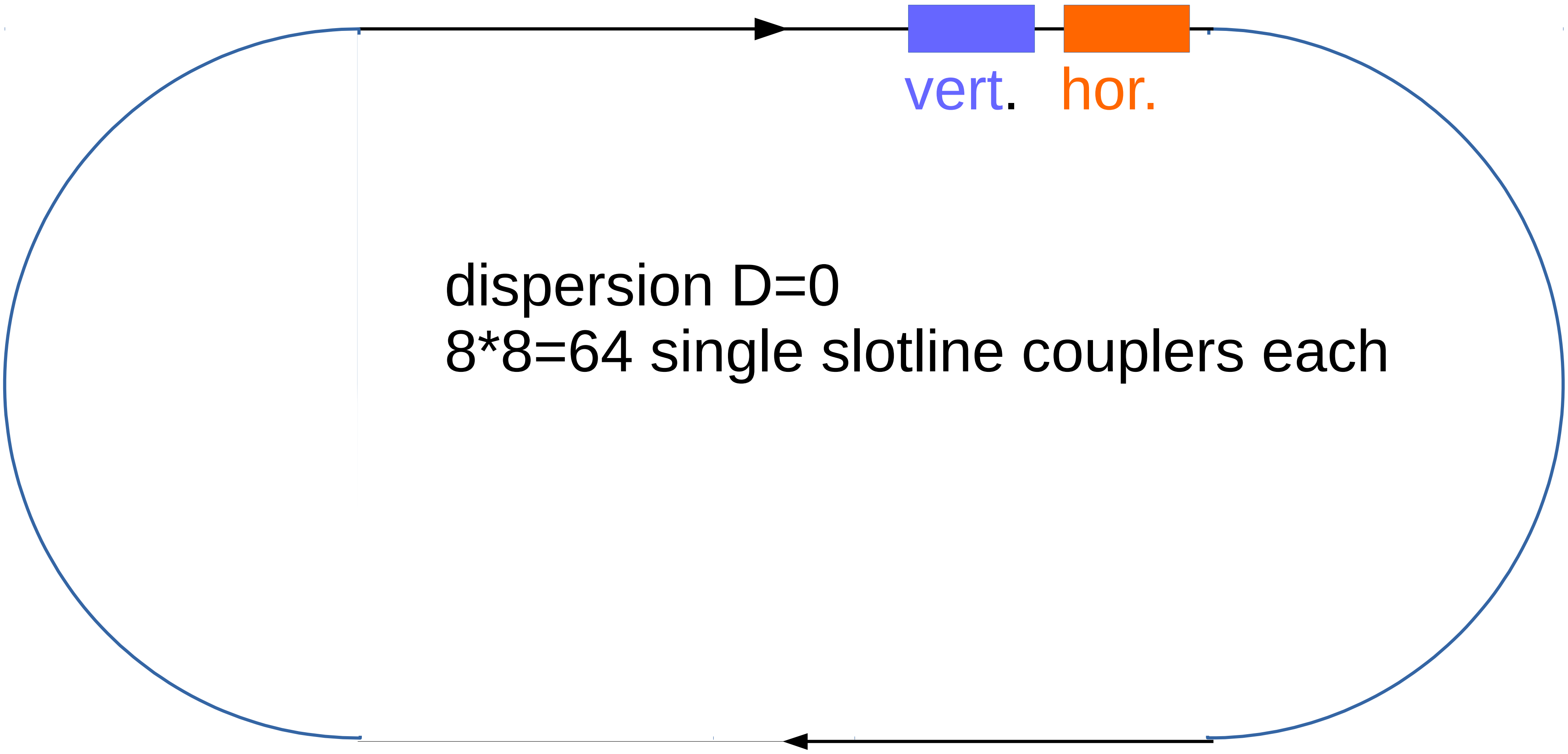
Aim of Investigation

- Is it possible to use CR pu‘s as a tool for position diagnosis?
- Situations to be investigated:
  - bunched beam at injection
  - coasting beam after bunch rotation and debunching
- Methods:
  - Schottky diagnosis
  - time domain diagnosis

Location of pbar pu‘s



dispersion D=0
8*8=64 single slotline couplers each

Main Parameters

- Kinetic energy of pbars: 3 GeV
- $\beta = 0.97$
- $\gamma = 4.1974$
- $f_0 = 1.31$ MHz, $T_0 = 761$ ns
- $\delta p/p$ (fwhm) 2e-2 at inj, 3e-3 after debunching
- frequency slip (pos. under transition)

optical mode	pbar1	pbar2	RIB
η (total)	0.005	-0.018	0.176

L. Thornbahl‘s impedance estimates (2004)

L. T.‘s definition

$$\left.\begin{aligned} P_{output} &= \frac{Z_{pu}(f)\, I^2_{peak}(f)}{2} \\ P_{input} &= \frac{U^2_{peak}(f)}{2\, Z_{ki}(f)} \end{aligned}\right\}$$

‚longitudinal‘ harmonics power per harmonic

Reciprocity for same geometry: $Z_{pu} = \frac{Z_{ki}}{4}$

Output Voltage

The output voltage on a transmission line with impedance Z_{line} (typically 50 Ω) is calculated by

$$P_{output} = \frac{U^2_{peak}}{2 Z_{line}} = \frac{Z_{pu}(f) I^2_{peak}(f)}{2}$$

$$U_{peak} = \sqrt{Z_{pu} Z_{line}} I_{peak}(f)$$

with current per particle (revolution frequency f_k)

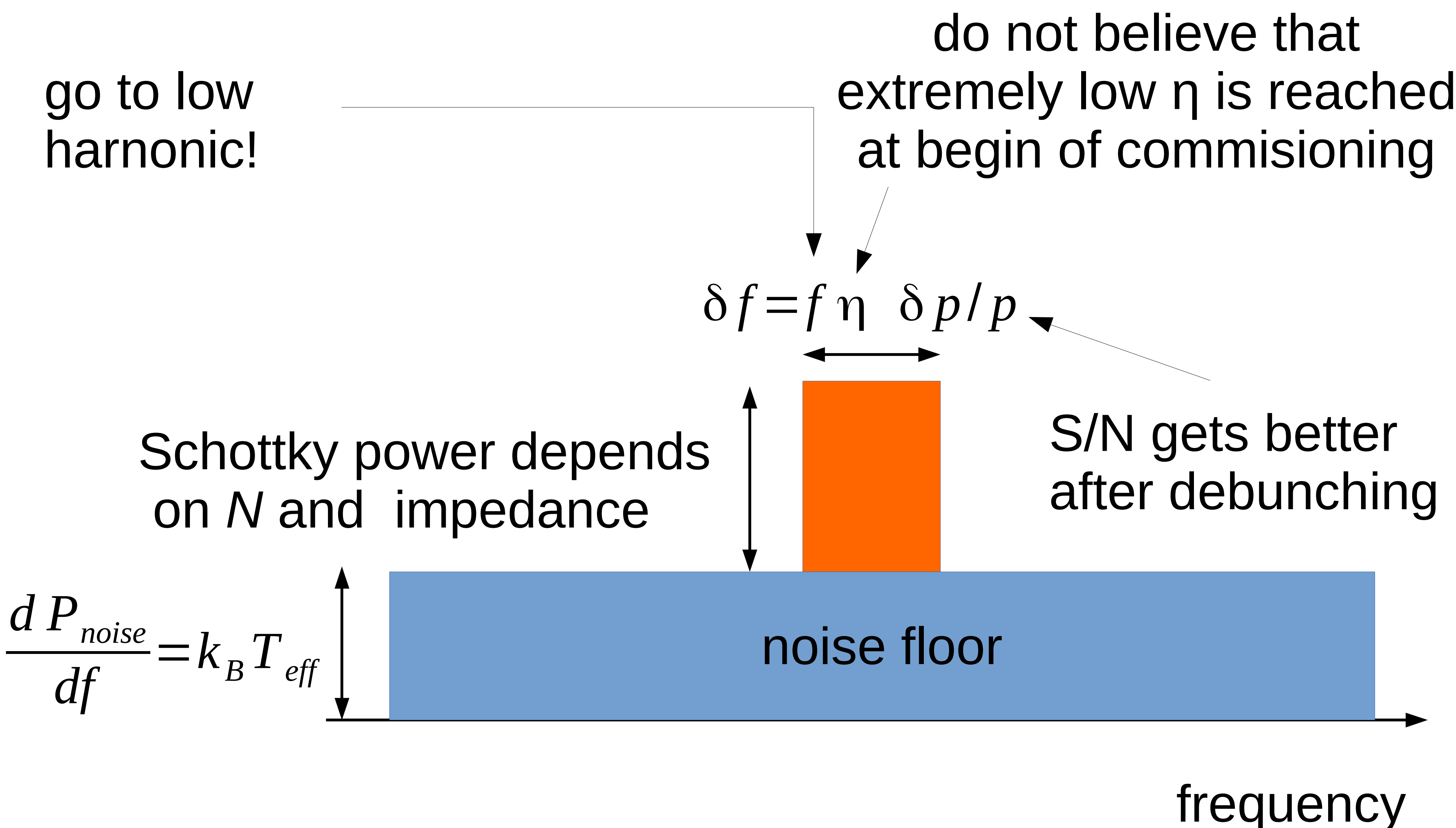
$$I_{peak}(f) = Qef_k = 2.17 * 10^{-13} \text{ A}$$

Thermal Noise

Average thermal noise of a source with bandwidth δf and effective temperature T_{eff} seen at a line with impedance Z_{line} (power matching):

$$\langle P_{th} \rangle = \frac{\langle U_{th}^2 \rangle}{Z_{line}} = k_B T_{eff} \delta f$$

Sketch of S/N

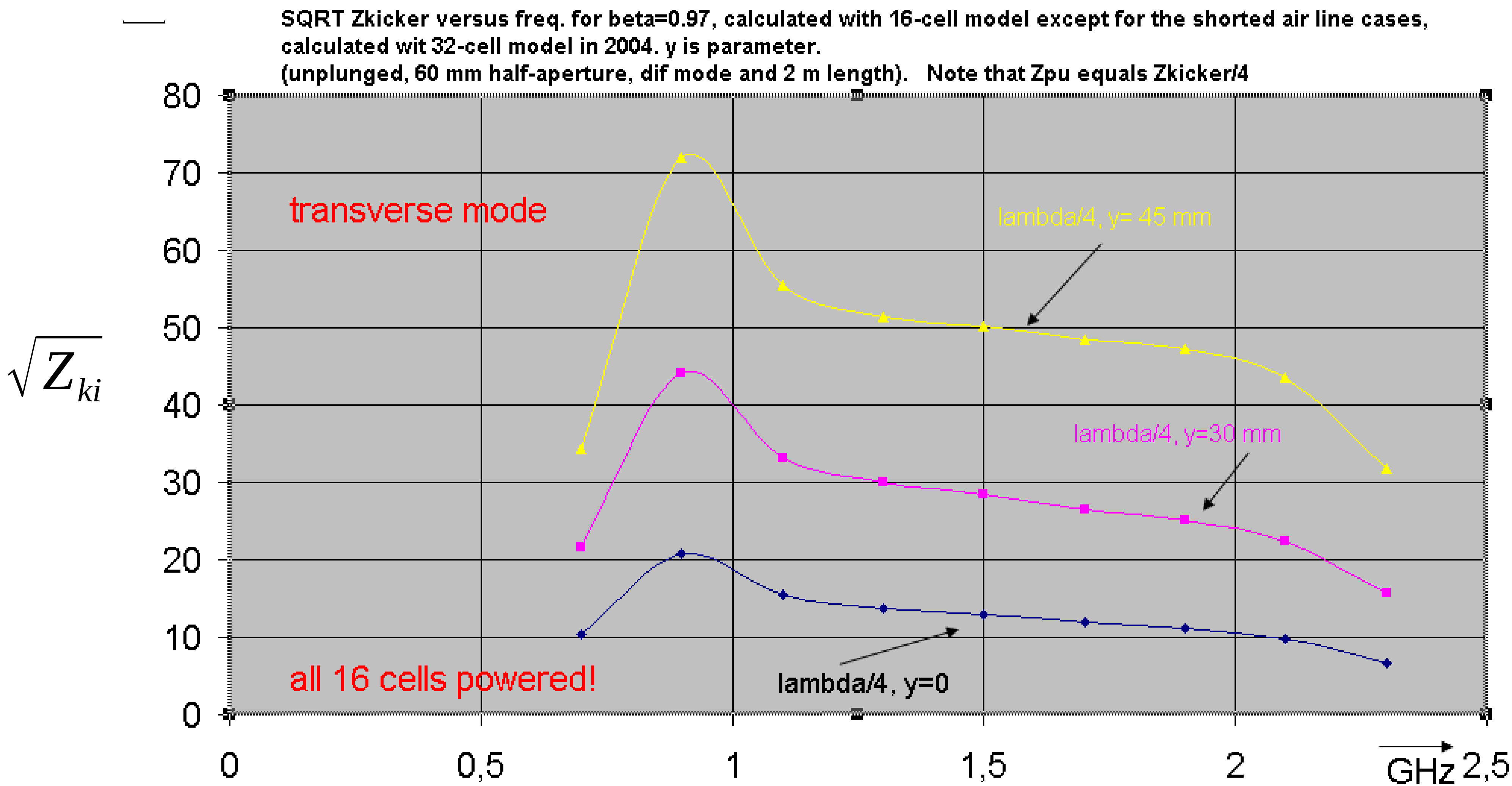


do not believe that
extremely low η is reached
at begin of commisioning
go to low
harnonic!
$\delta f = f\, \eta\ \ \delta p / p$
Schottky power depends
on *N* and impedance
S/N gets better
after debunching
$\frac{dP_{noise}}{df} = k_B T_{eff}$
noise floor
frequency

Measurement Conditions

- Choose f=1 GHz, because
  - spectra are less broad at low frequency
  - impedance is highest
- Assume 10^5 (!) stored antiprotons at commisioning time
- Use local bumps to investigate signal as function of bump amplitude
- Maybe emittance scraping can be used
- pbar2 optics with larger η is not too optimistic

Example: Vertical Pu



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Schottky: noise under line

- frequency 1 GHz
- effective temperature 20 K

δp/p	2 %	0,3 %
	δf [kHz]	
pbar1	102	15
pbar2	366	55
	noise power [dBm]	
pbar 1	-136	-144
pbar 2	-130	-138

Signal power

y [mm]	$Z_{ki}^{1/2}$ (16 Pairs)	Z_{ki} (16 Pairs)	Z_{pu} (64 Pairs)	Total power per line 10^5 pbars [dBm]
15	18	324	324	-151
30	40	1600	1600	-144
45	65	4225	4225	-140

Estimated Signal to Noise

y [mm]	pbar1		pbar2	
	δp/p			
	2 %	0.3 %	2 %	0.3 %
	S/N [dB]			
15	-16	-7	-21	-13
30	-9	0	-14	-6
45	-5	4	-10	-2

Remark:
With K spectral averages, the spectral noise variation can be limited to $K^{-1/2}$.
Example:
K=100 yields an average variation of 1/10

Beam size due to betatron oscillations

			beam amplitude [mm]			
	$ß_x$ [m]	$ß_y$ [m]	E_{xy} =200*10^{-6} m		E_{xy} =50*10^{-6} m	
hor. pu	8.7	14.3	±41.8	±53.6	±20.9	±26.8
vert. pu	15.2	8.2	±55.1	±40.5	±27.5	±20.3

Remark:
Large emittance requires very good non-linear chromaticity control.

Doubtful to be reached at begin of commisioning!

Bunched beam after injection (idea)

- bunching factor at injection: 50 ns / 760 ns = 7%
- requires bandwidth Δf ≈ 2* (50 ns)-1 ≈ 40 MHz
- use 50 MHz bandfilter to reduce noise
- frequency down conversion?
- debunching is only 4 ns after 100 turns (pbar2)
- time domain averaging (sample separation 760 ns)