Energy Measurements at ANKA

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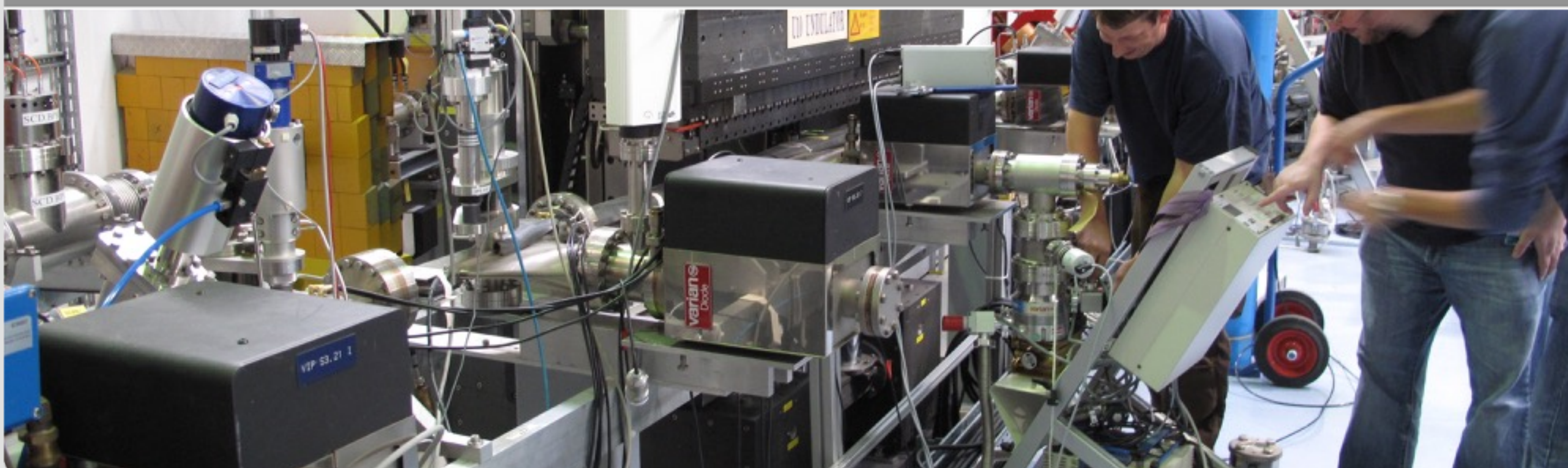
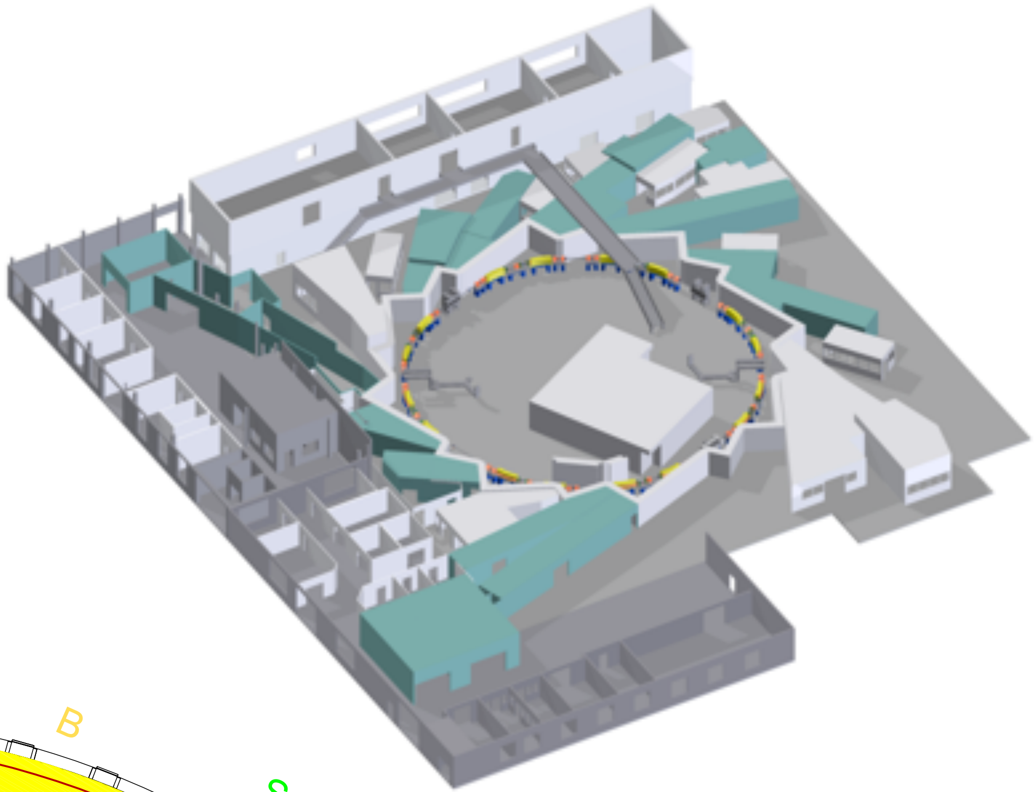
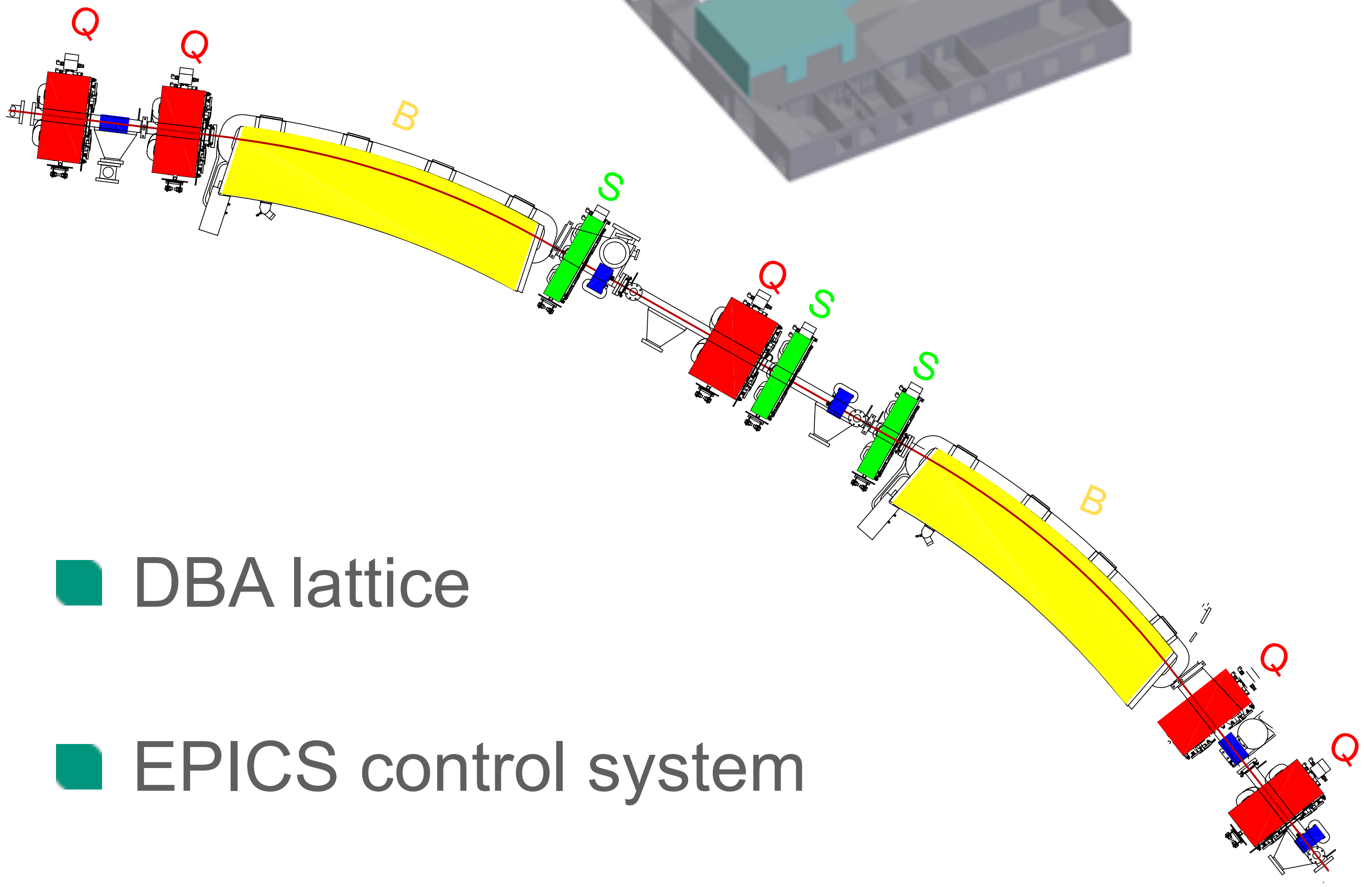


Introduction - ANKA

- Energy: 0.5 - 2.5 GeV
  (0.8 - 1.6 GeV during low-α_c-mode)
- Circumference: 110.4 m
- Revolution frequency: 2.715 MHz
- RMS bunch length:
  45 ps (for 2.5 GeV),
  10 ps down to 1-2 ps (for 1.3 GeV)
- Filling pattern: single- or multi-bunch
  (min. bunch spacing 2 ns)





- DBA lattice
- EPICS control system
- DIMTEL 3D BBB feedback system

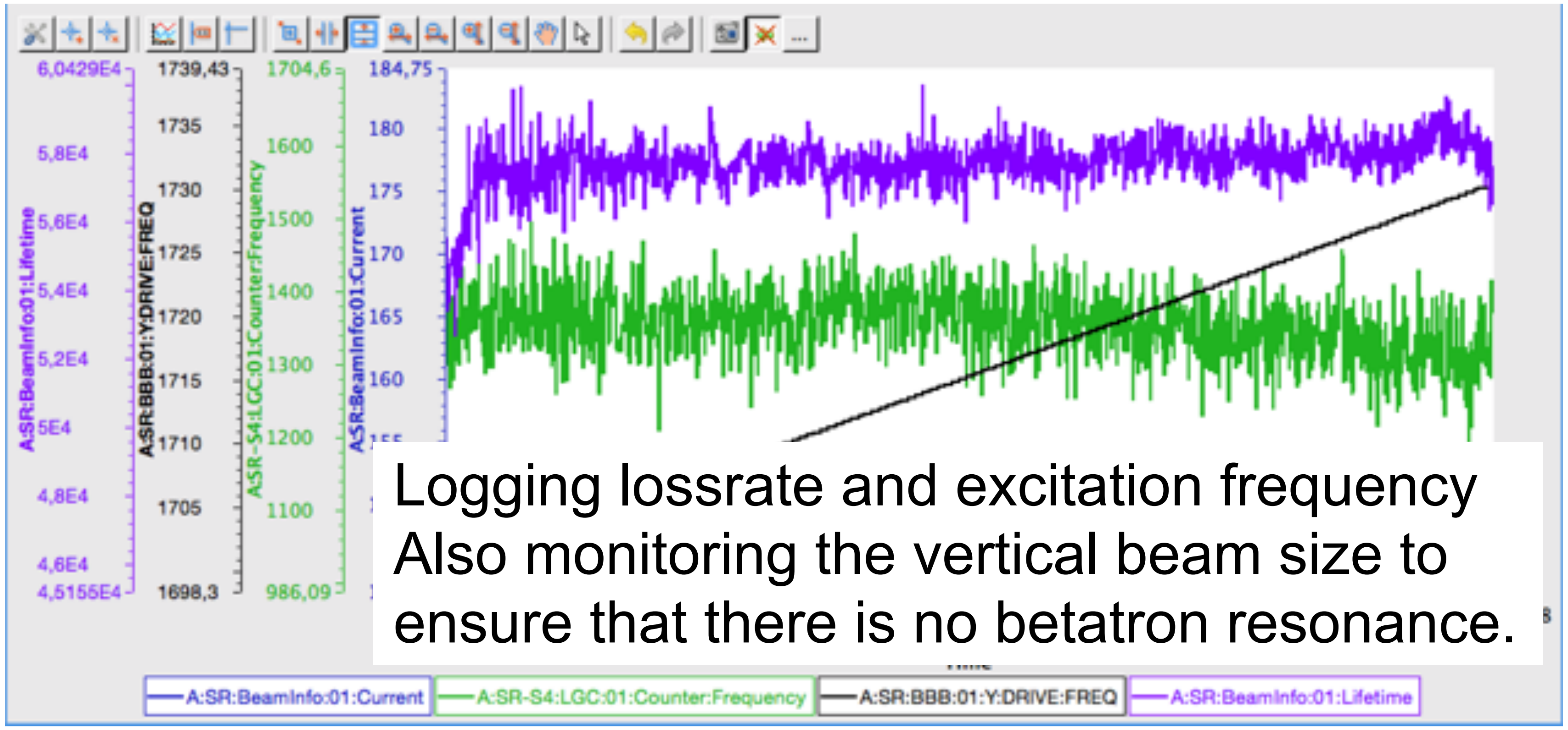
Resonant Depolarization - Theory

- Beam becomes polarized after a while
- If vertical excitation with spin-tune resonance is applied, polarization is resonantly destroyed
- Change in Touschek lifetime because Møller scattering is dependent on polarization ➜ can detect change in loss rate
- Resonance is very narrow, so if frequency is swept slow enough, resolution is very good

$$a\gamma = \nu = k + [\nu] = \frac{\Omega_D}{\Omega_c} = \frac{f_d}{f_{rev}}$$

$$a := \frac{g-2}{2} = (1159.6521811 \pm 0.0000007) \cdot 10^{-6}$$

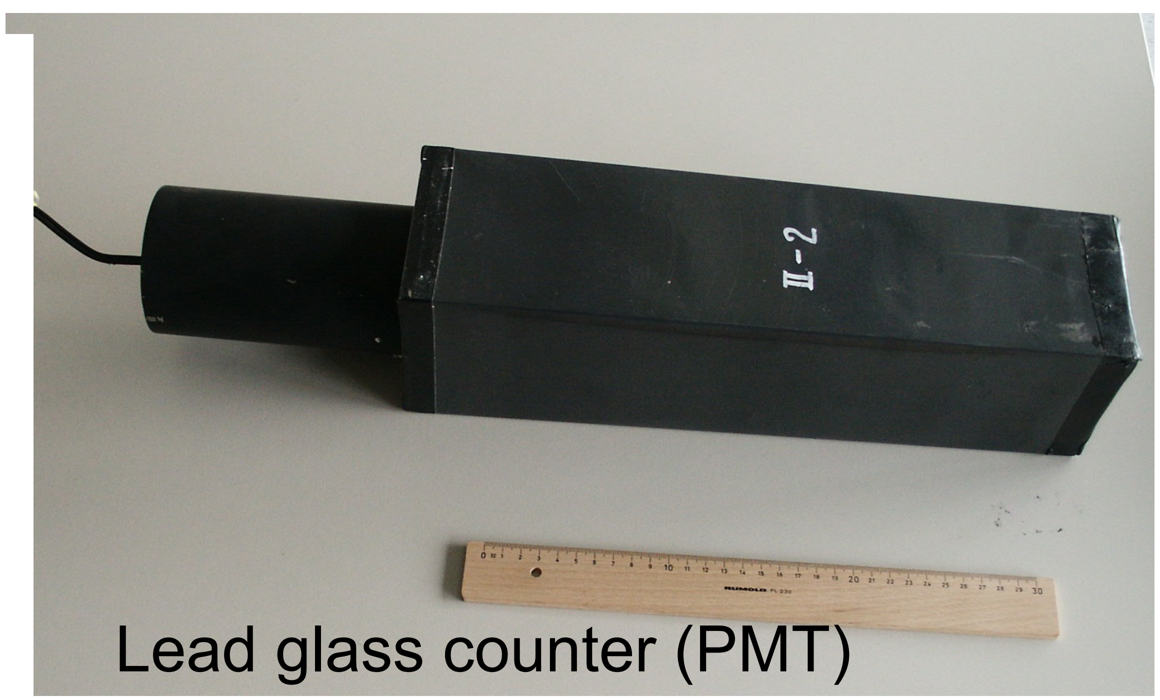
Resonant Depolarization - Setup



Logging lossrate and excitation frequency
Also monitoring the vertical beam size to ensure that there is no betatron resonance.

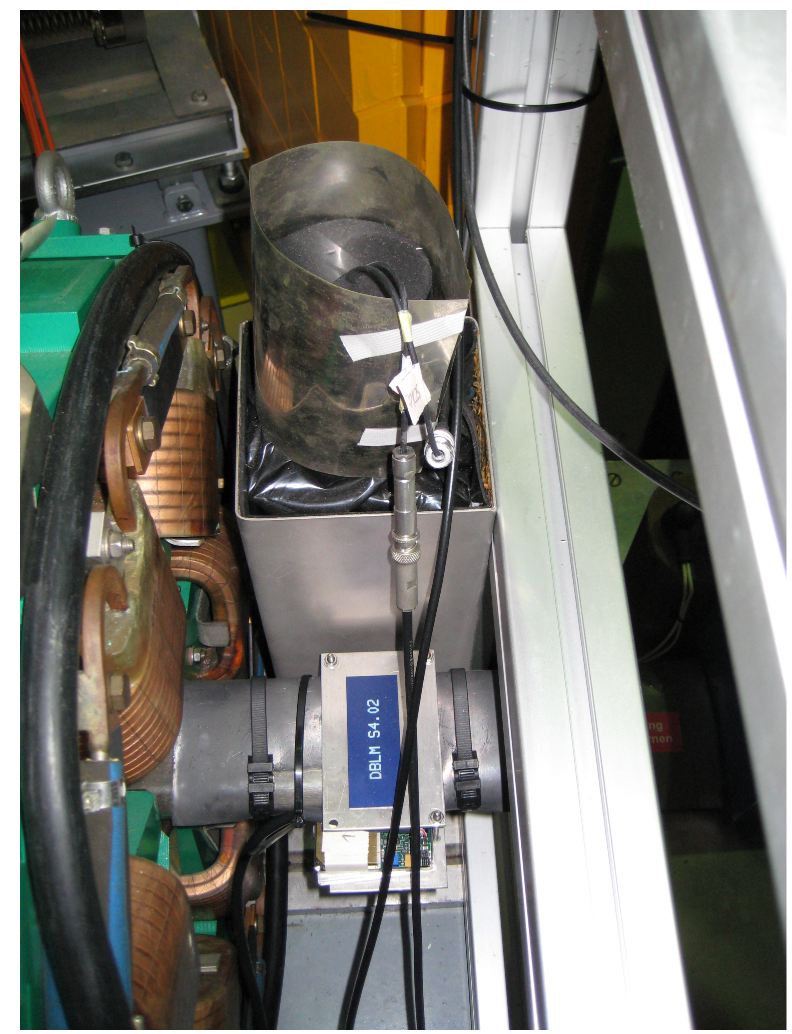
BBB for excitation (f_{exc} changed by MATLAB script)

signal from PMT
⬇
constant fraction discriminator
⬇
counter unit



Lead glass counter (PMT)

(a)

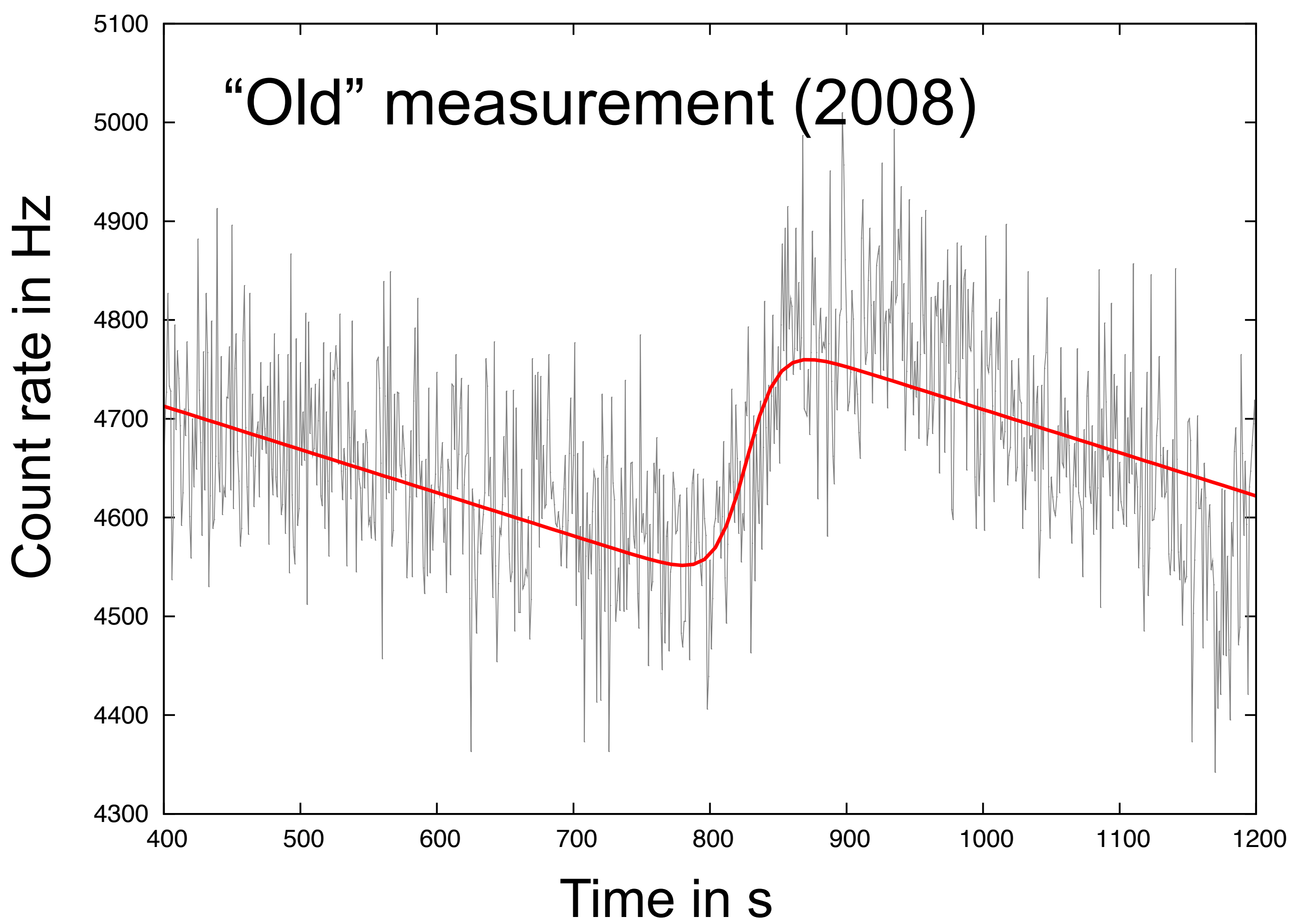


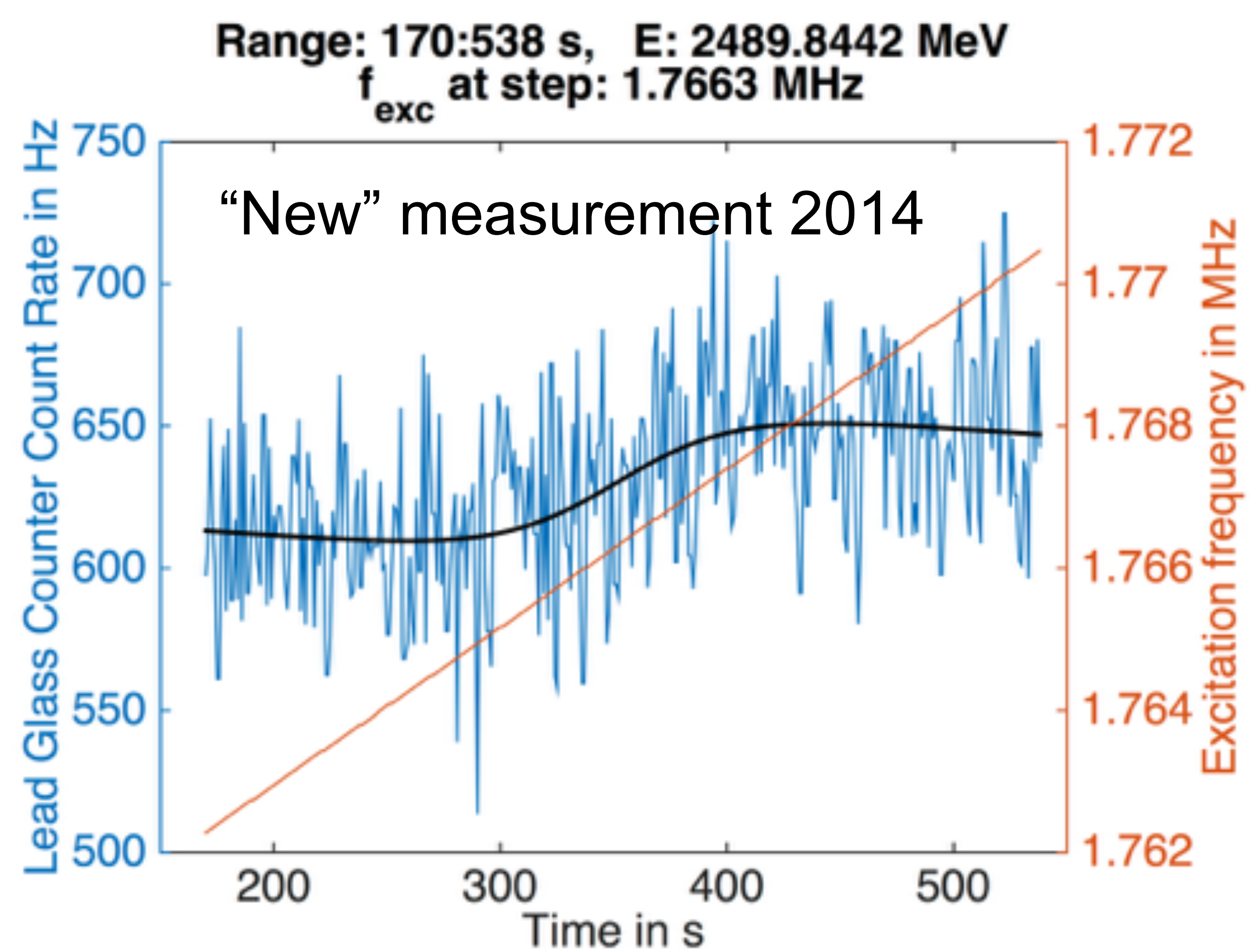
(b)

Resonant Depolarization - Results

- Step function fit to determine frequency at which depolarization occurs

$$r(t) = a - b \cdot t + \frac{\Delta r}{1 + \exp\left(-\frac{t - t_d}{\sigma_d}\right)}$$

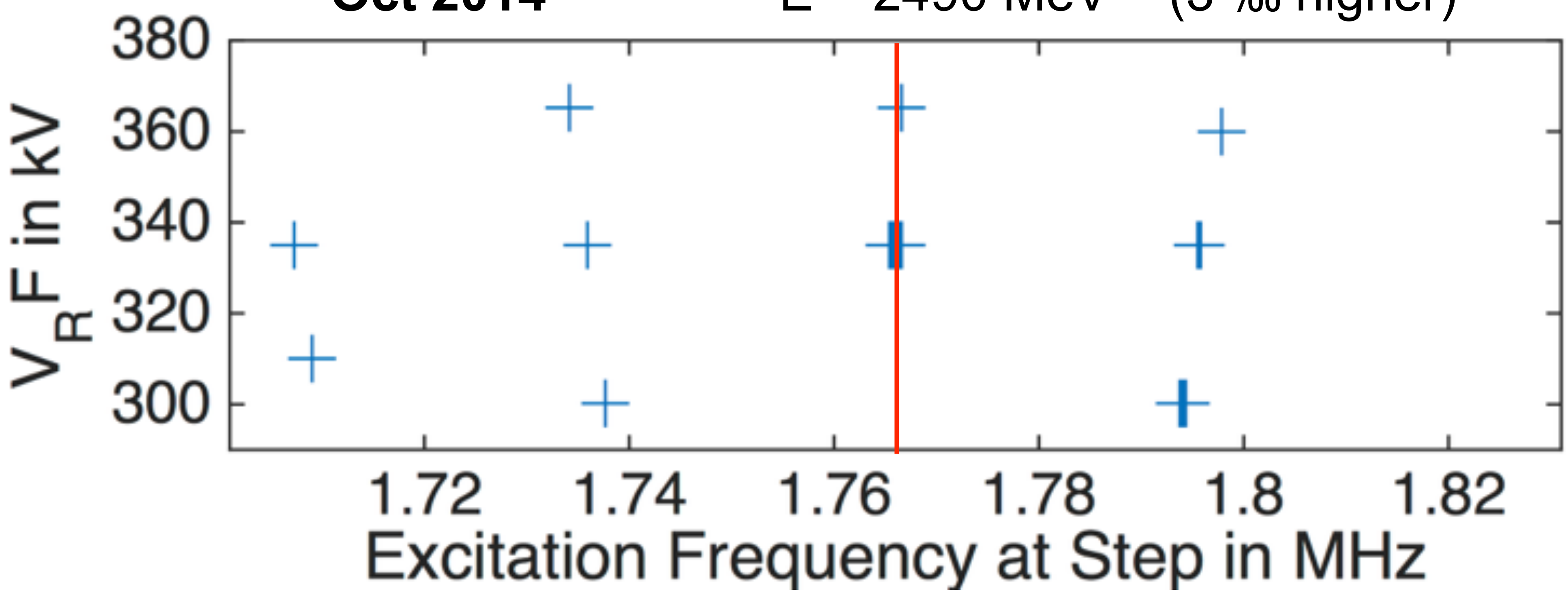




Had only one weekend, so not optimized yet.

Resonant Depolarization - Results

Oct 2014 E = 2490 MeV (3 ‰ higher)

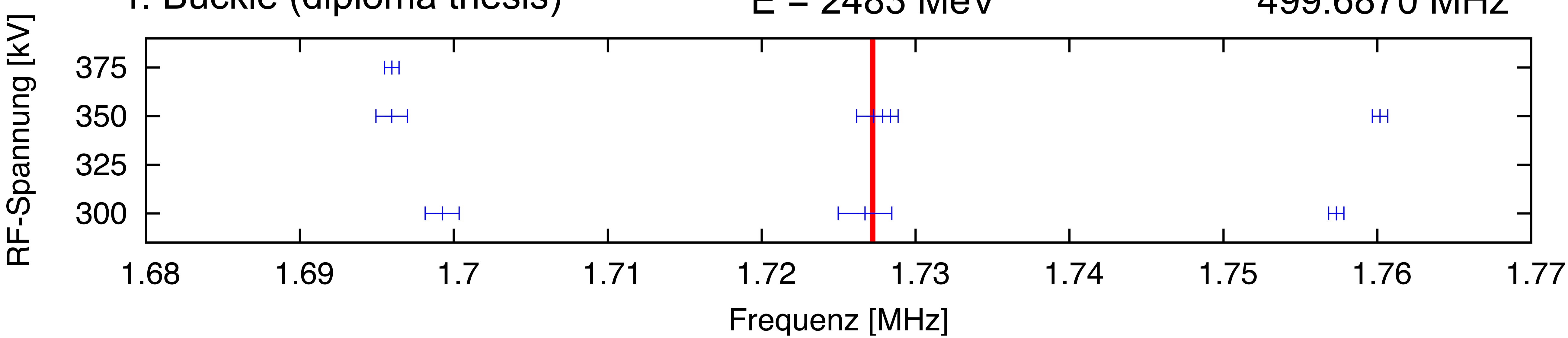


f_{RF} for measurement:
499.6928 MHz
f_{RF} after orbit correction:
499.7121 MHz

Orbit was off-center (would expect 4 ‰ difference)

Old data from **2008**
T. Bückle (diploma thesis)

E = 2483 MeV 499.6870 MHz



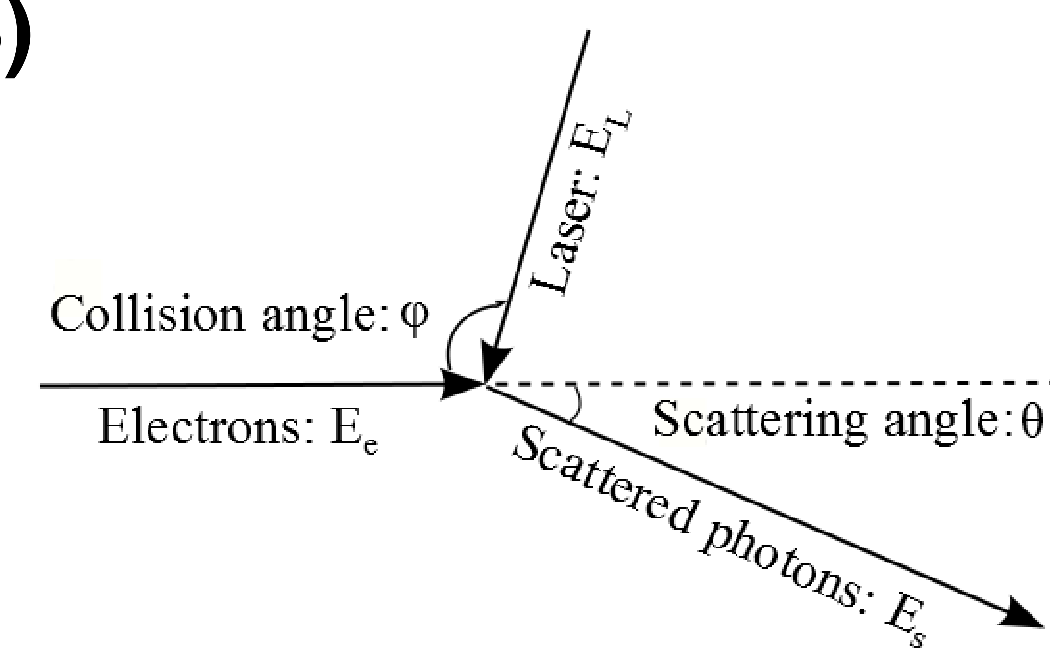
Resonant Depolarization - Issues we have had with the new setup

- Change in loss rate due to resonant depolarization is very weak
- Betatron resonances nearby
- BBB cannot do a slow continuous frequency sweep (need to script it externally)

Compton Backscattering - Theory

Compton Back-Scattering (CBS)

$$E_s = \frac{E_L\,(1-\beta\cos\varphi)}{1-\beta\cos\theta + E_L\,/\,E_e[1-\cos(\theta-\varphi)]}$$



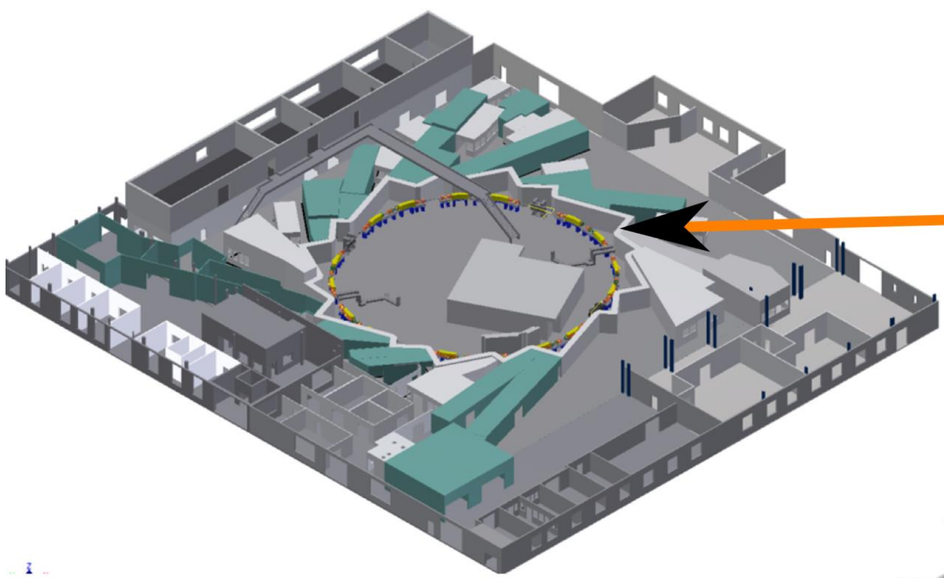
➔ $$E_e \approx \frac{mc^2}{2\sin\frac{\phi}{2}}\sqrt{\frac{E_{max}}{E_L}} \qquad (\theta=0)$$

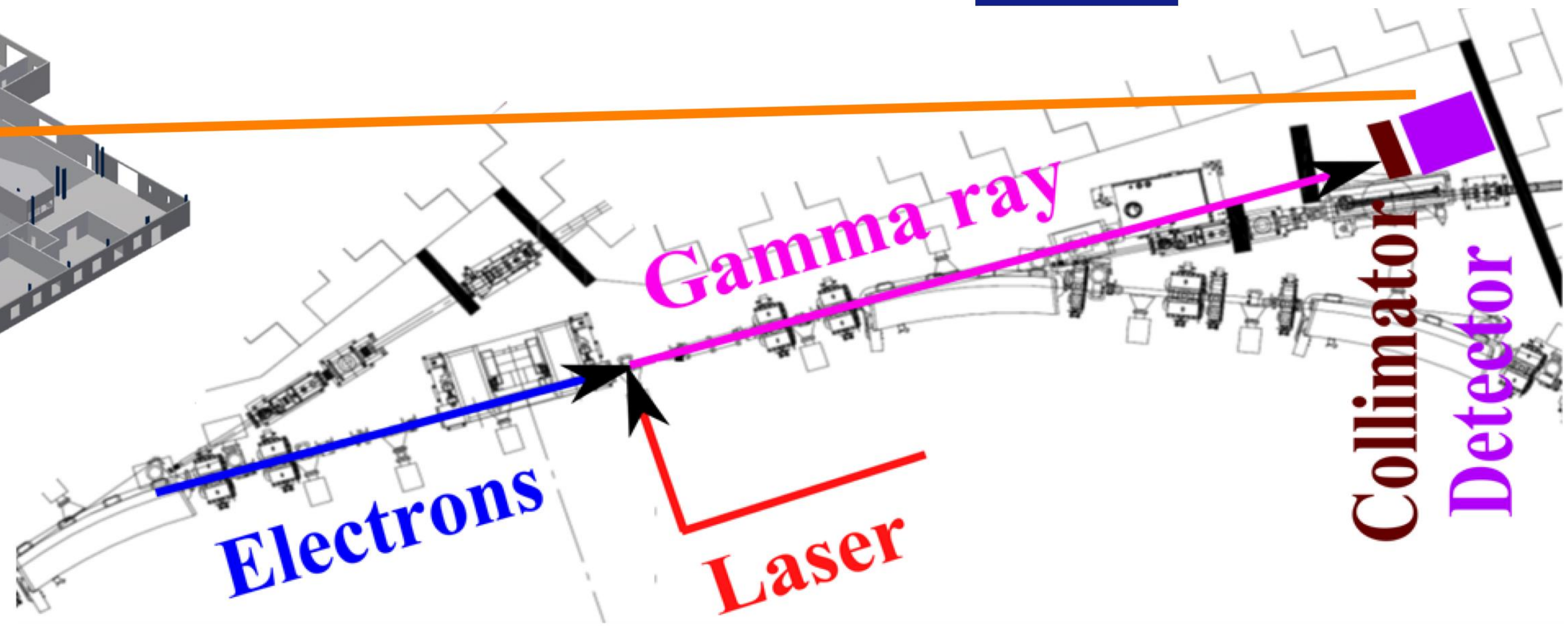
- With measured φ, E_{max} & known mc^2 and E_L ➔ E_e can be determined
- Relative uncertainty

$$\frac{\sigma_{E_e}}{E_e} = \sqrt{[\frac{\sigma_{E_L}}{2E_L}]^2 + [\frac{\sigma_\phi}{2\tan(\phi/2)}]^2 + [\frac{\sigma_{E\max}}{2E_{\max}}]^2}$$

Compton Backscattering - Setup @ ANKA

C. Chang (PhD)

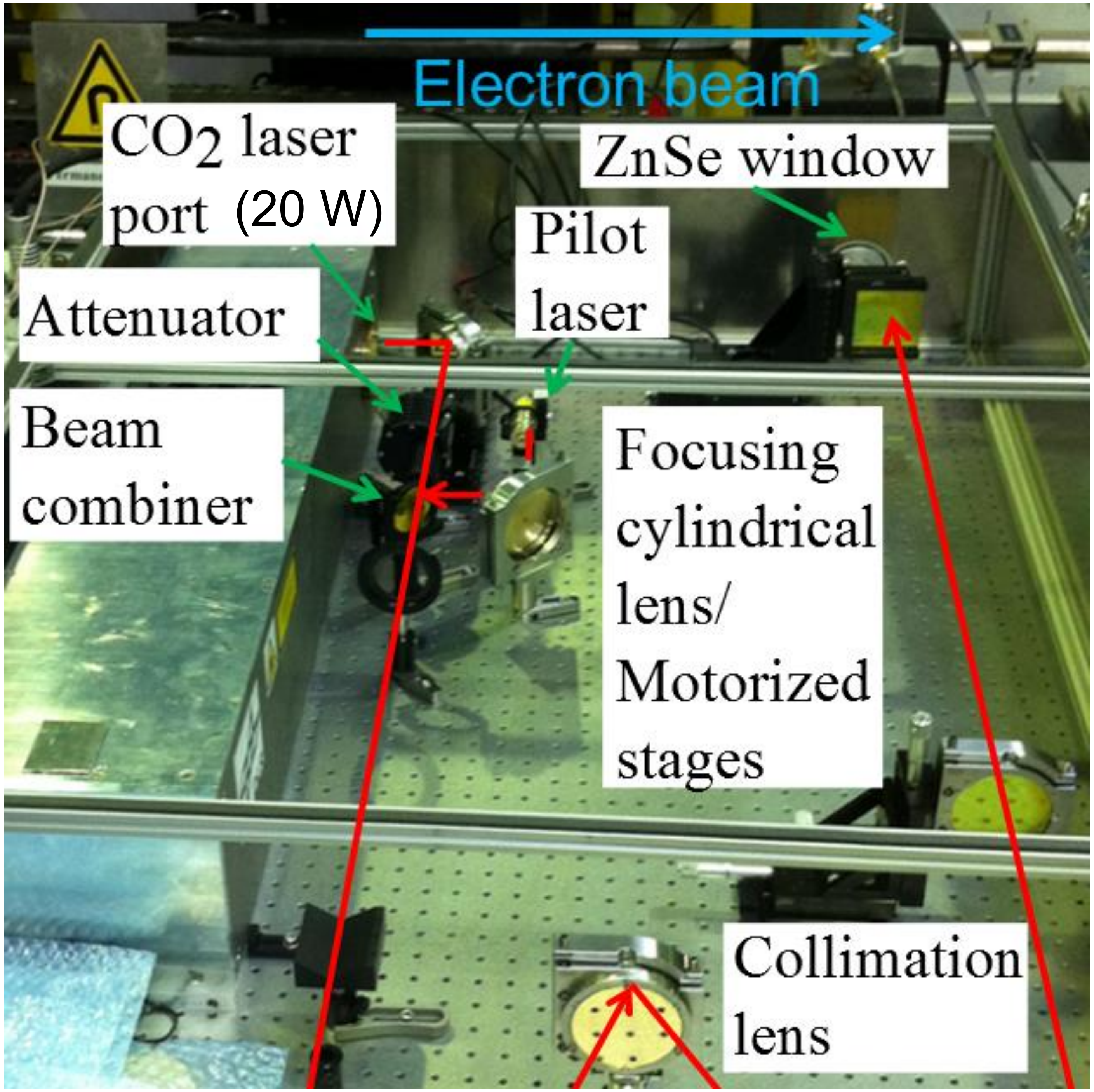


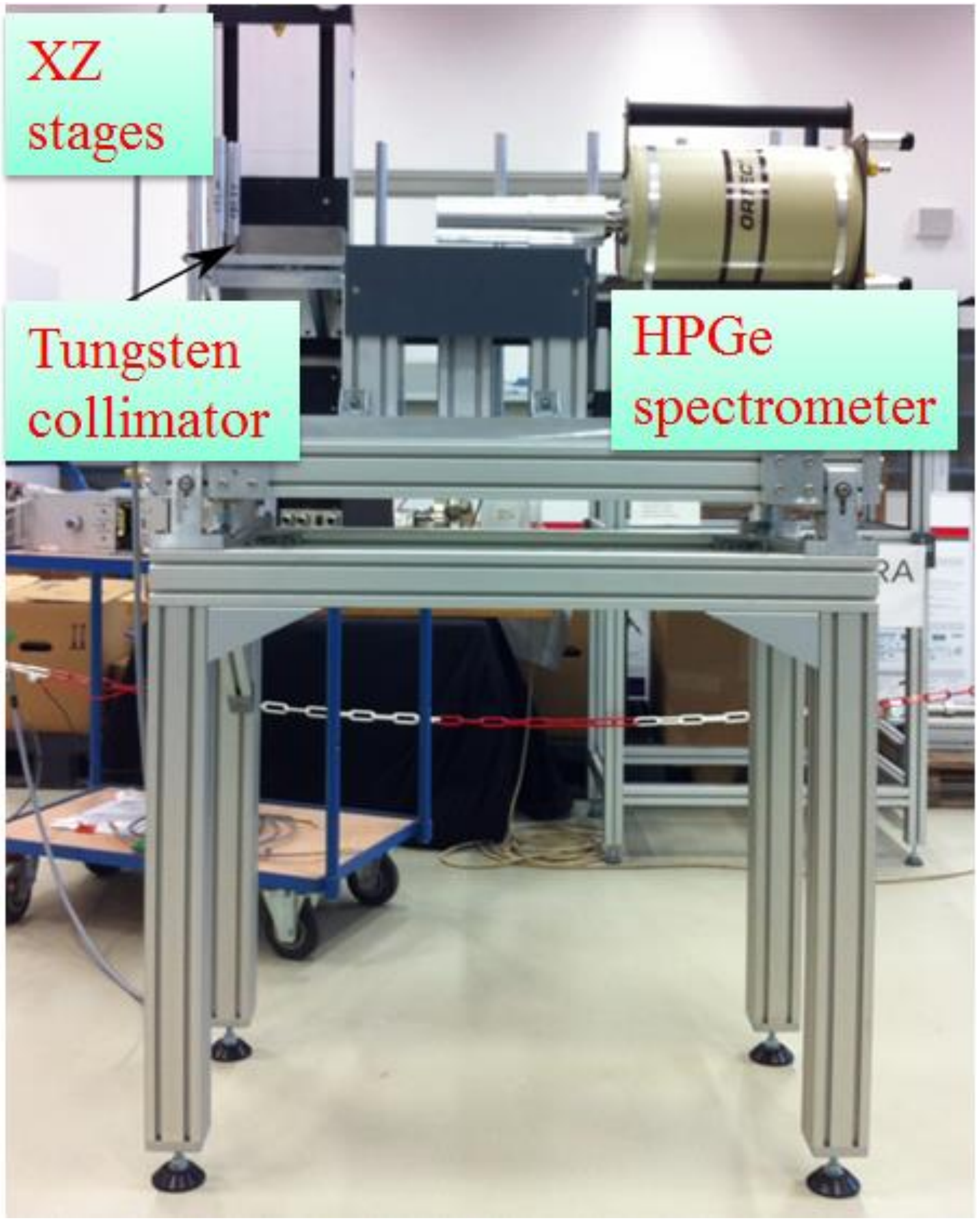


- 90° collision angle
- 0° scattering angle
- Very compact setup (laser coupled in via ion pump port)
- Detector uses a temporarily free 0° frontend

C. Chang et al. MOPHA040, IPAC'15

Compton Backscattering - Setup

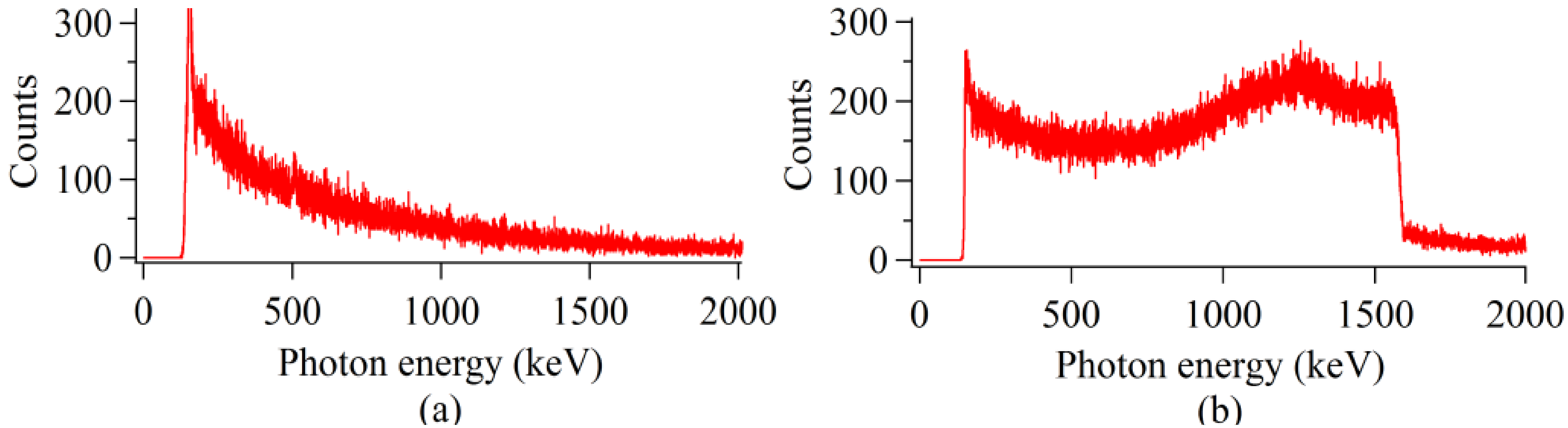




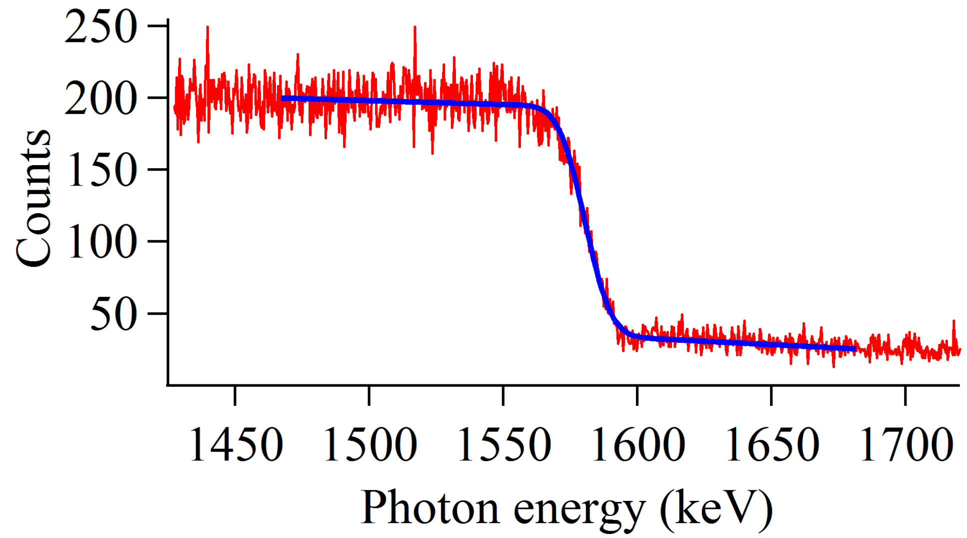
Laser kindly on loan from DLR-Berlin.

Compton Backscattering - Evaluation

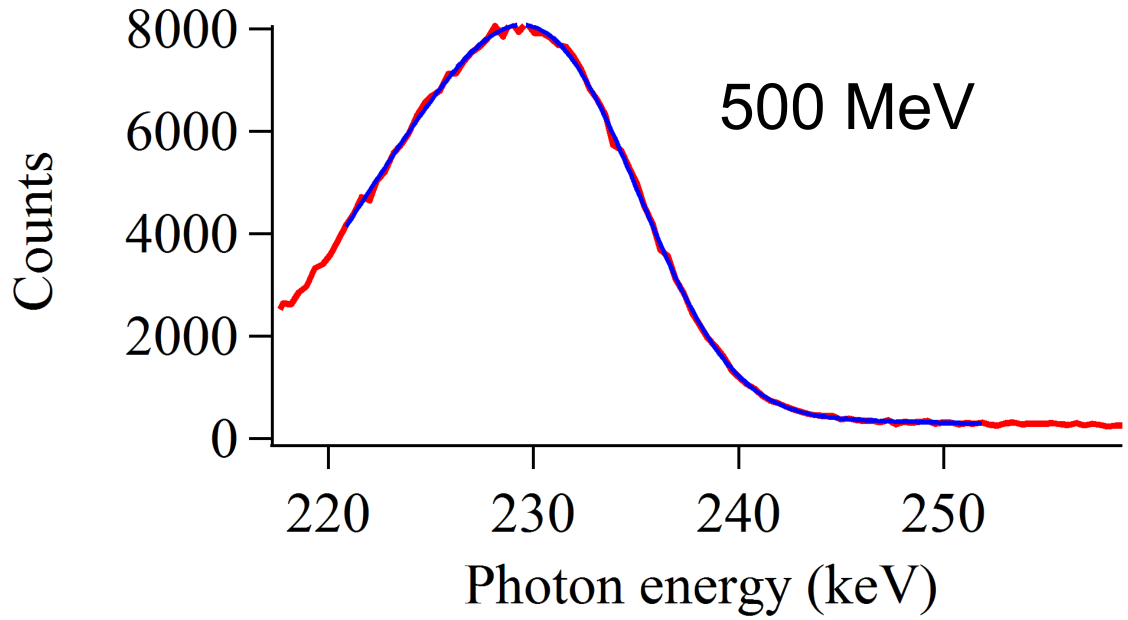
Determination of E_{max} by edge fitting

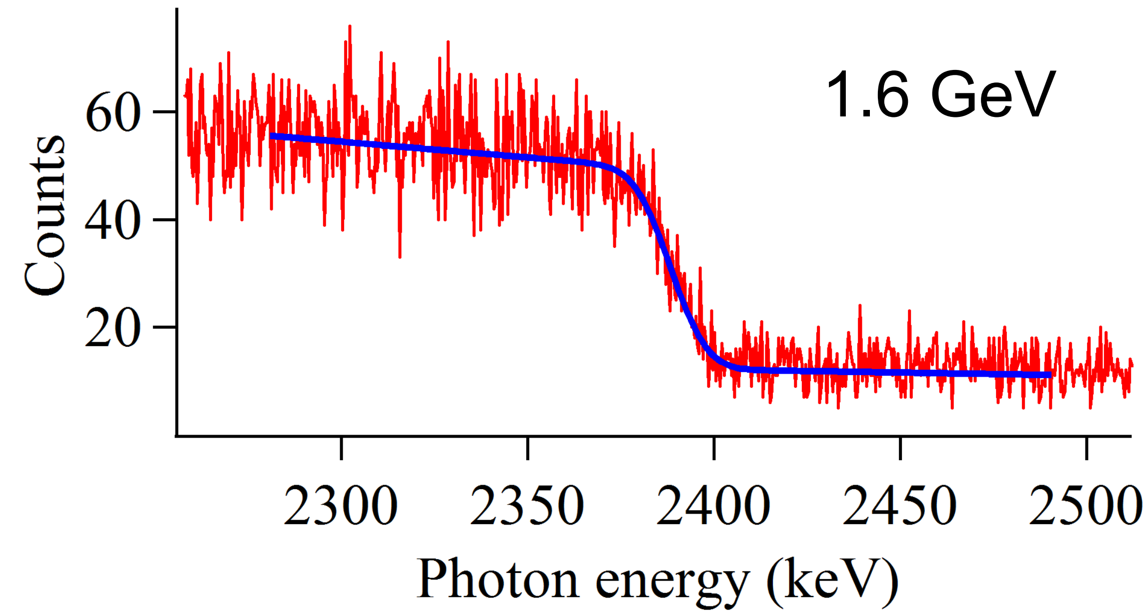


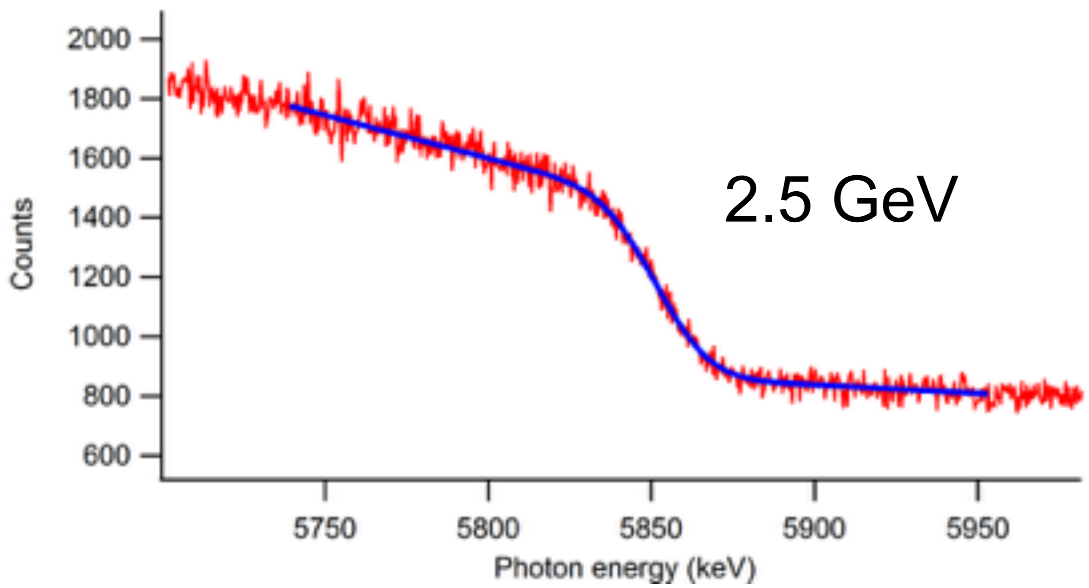
- (a) laser off; (b) laser on. S/N~3
- Compton edge curve fit by a six-parameter erfc-like function
- E_{max} = 1580.44 keV $\pm$ 0.28 keV, $\sigma_{Emax}/E_{max} = 1.8 \times 10^{-4}$ (χ^2/ndf~524/555)

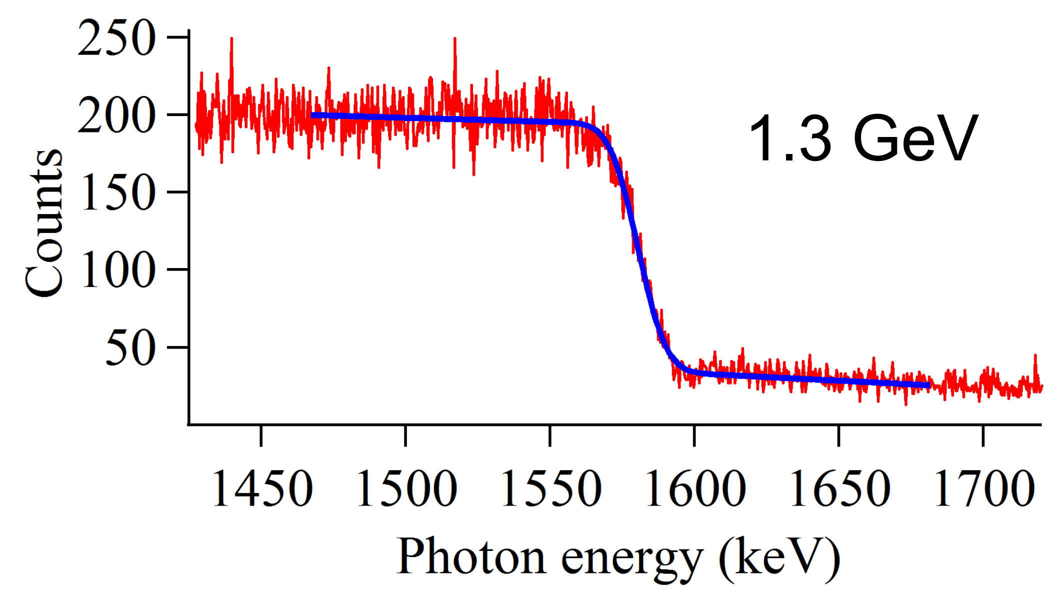


Compton Backscattering - Results









Preliminary results

- 1.3 GeV: $E_e \pm \sigma_{Ee}$= 1287.0 MeV ± 0.2 MeV
- 0.5 GeV: $E_e \pm \sigma_{Ee}$= 495.65 MeV ± 0.06 MeV
- 1.6 GeV: $E_e \pm \sigma_{Ee}$= 1582.1 MeV ± 0.2 MeV

2.5 GeV: 2476.4 ± 0.3 MeV

Nicole.Hiller@kit.edu - Energy Measurements at ANKA

2nd DEELs Workshop - 15-16 June, 2015, ALBA, Spain

Compton Backscattering - Challenges we have had

- Angle between laser and electron beam needs to be well known
- For us: Biggest uncertainty from drifts of the laser spot over time
- Longer integration times at higher energies
- Detector needs to be recalibrated when it warms up
- Detector calibration above 3 MeV requires dedicated sources
- Alignment of the detector & the collimator
- Misalignment of the intensity absorber (small aperture)
- Currently works best at low (~10 mA) beam current otherwise the detector is saturated

Summary

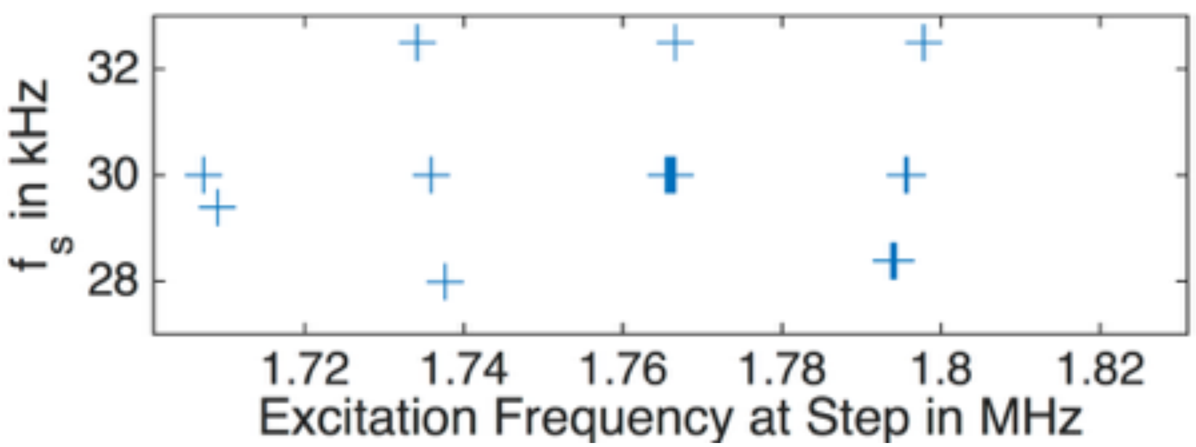
- Successfully repeated resonant depolarization energy measurements, but optimization of new setup still required.
- Compton backscattering measurements under 90° work really well (1e-4 precision) and provide a compact alternative to smaller-angle-setups.

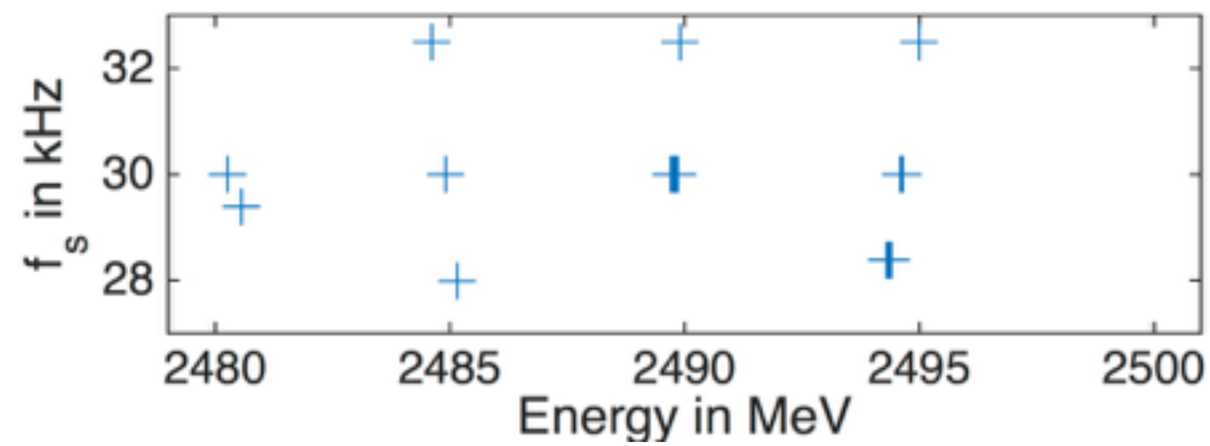
Outlook

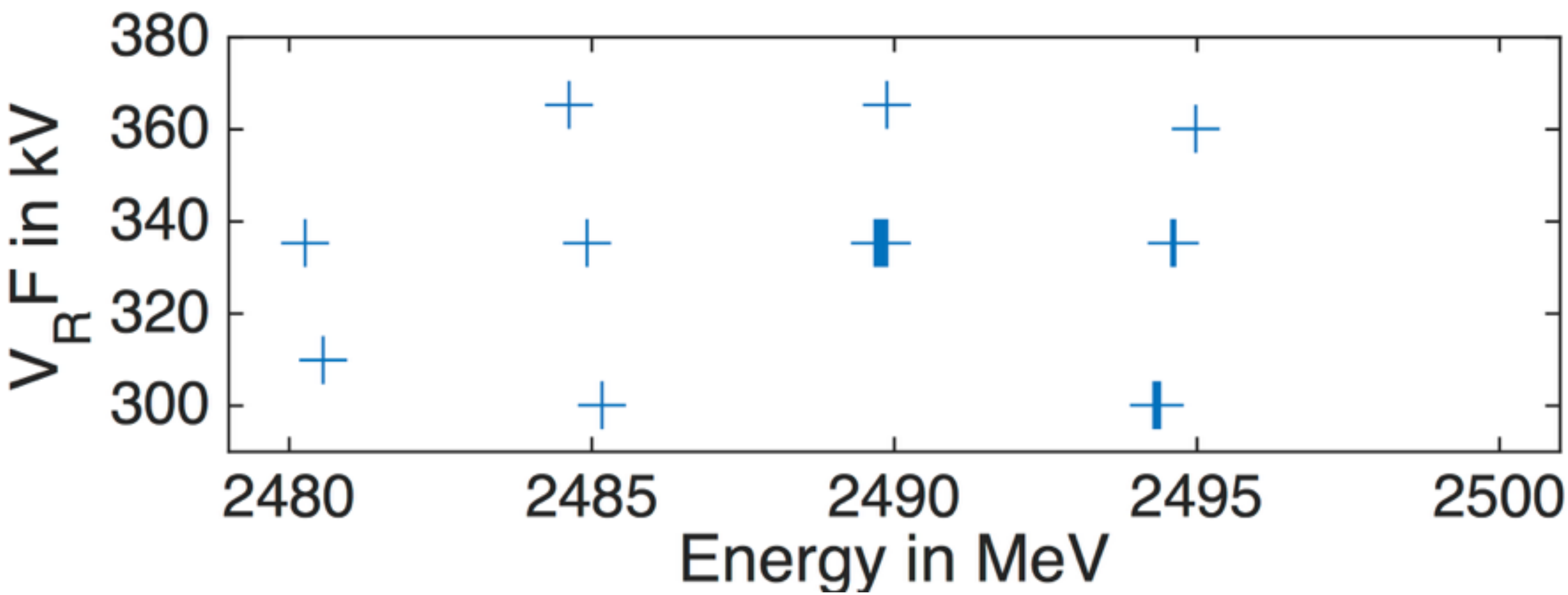
- Optimize resonant depolarization and put it into a standard routine
- Verify central frequency of ring again

Backup Slides

Resonant Depolarisation with Different Scales

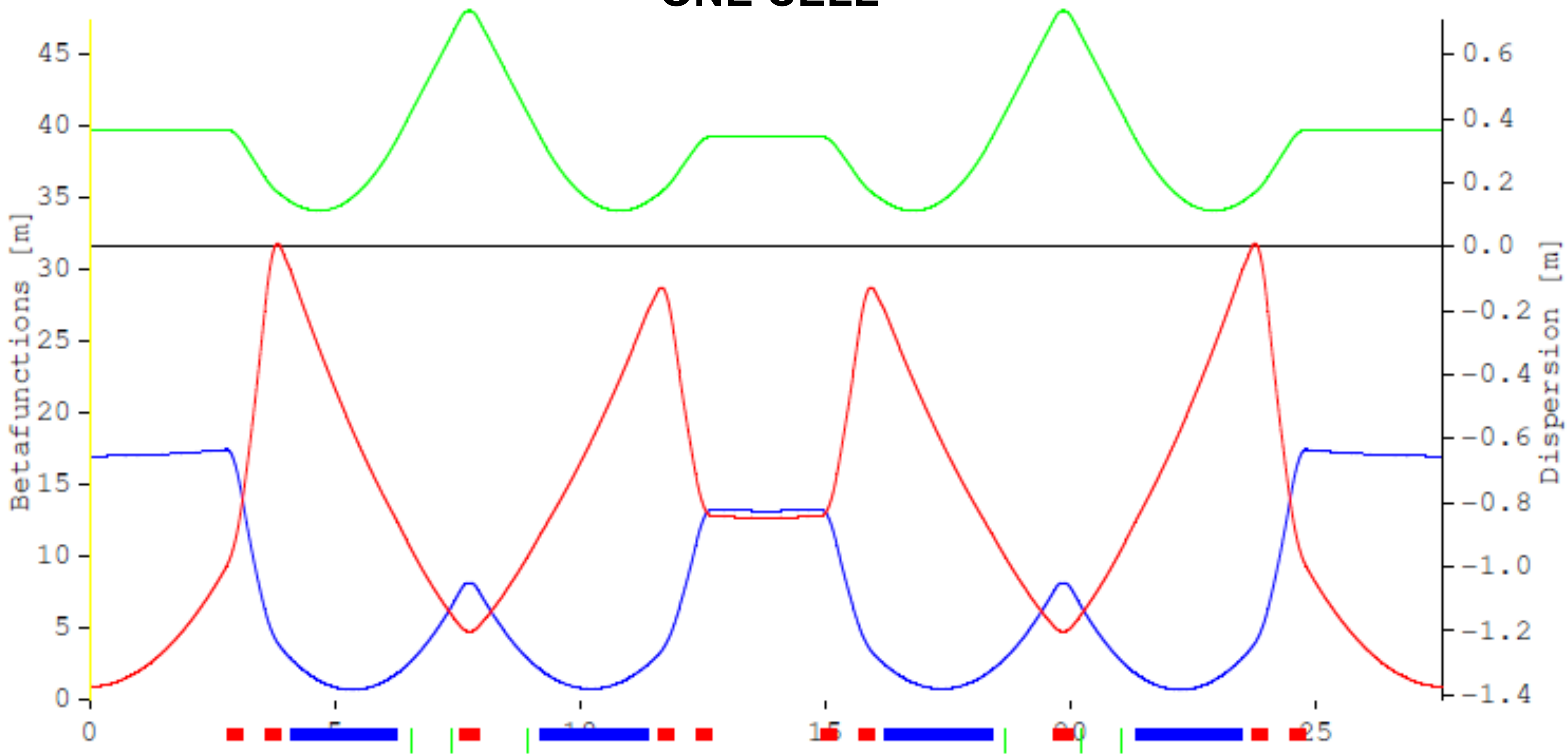






ANKA LATTICE
DISTRIBUTED DISPERSION
ONE CELL

Courtesy of A. Papash



Circumference	[m]	110.40	Energy [GeV]		2.5
Horizontal Tune		6.771	Radiated energy/turn	[MeV]	0.606
Vertical Tune		2.718	Natural Emittance (***DBA***)	[nm]	**90**
Nat. hor. Chromaticity		-12.59	<u>Natural Emittance (distrib ***D***)</u>	<u>[nm]</u>	<u>**56.6**</u>
Nat. vert.Chromaticity		-13.21	Approx. vert. Emittance	[nm]	2.6 E-3
Momentum compaction		9.67 E-03	Natural energy spread		9.E-04
Hor.damp.partition Jx		0.97			