Recent improvements to TAPAs, the Android application for accelerator physics and engineering calculations

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Abstract

The Android application TAPAs, the Toolkit for Accelerator Physics on Androids, was released in 2012 and has over 300 users. TAPAs provides more than 50 calculations, many of which are coupled together. Updates are released about once a month. Calculations for electron storage rings are a particular emphasis, and have expanded to include CSR threshold, ion trapping, Laslett tune shift, emittance dilution, and undulator brightness curves. Other additions include helical superconducting undulators, rf cavity properties, Compton backscattering, and temperature calculations for mixing water.

1. INTRODUCTION

Physicists and engineers need the ability to "back of the envelope" calculations

- Quickly determine if an idea is feasible
- Answer questions during discussions and meetings
- Get rough answer before committing to full-blown calculation

The TAPAs app was developed to address such needs.

2. FEATURES AND CAPABILITIES

2.1 WHY IS THIS A "TOOLKIT"?

Often the calculations within a topic will share certain input values (e.g., the beam energy), so that changing it one calculation will change it in the others. In addition, *computed* values from one calculation are often shared with other calculations. This allows using the calculations in a coordinated fashion, which is why we used the word "toolkit" in the name.

2.2 HIGHLIGHTS OF CALCULATIONS

Electron Storage Rings

Storage ring scaling with size, energy	
Longitudinal dynamics, with and without harmonic cavity	
Beam loading and rf generator parameters	
Parastic-mode beam loading	Harmonic number optimization
Top-up	Swap-out
Gas scattering lifetime	Quantum lifetime
CSR threshold	Ion trapping
Space-charge tune shift	Crab cavities for short pulses
Emittance dilution	Resonance diagram

New since the last publication is the ability to read lattice data from a file prepared from `elegant` output.

Free Electron Laser

One-dimensional equations	Ming Xie's parametrization

Undulators

Planar hybrid permanent magnet model	
Planar superconducting model	
Helical superconducting model	
Optical effects	Orbit effects
Aperture transformations	

Synchrotron Radiation

Source type	Calculations
Bending magnet	Critical energy, critical wavelength, power Plots of flux and angular distribution
Wiggler	Critical energy, critical wavelength, power Plots of flux
Undulator	Plots of flux density, central-cone flux power density, total power, brightness, coherent flux, and coherent fraction
Compton backscattering	Energy, wavelength, photon flux, pulse energy, power

Electron Linac

- Bunch compression w/ chicane
- Bunch compression w/ alpha magnet
- Energy gain and power for SLAC structures
- Energy loss and spread from CSR
- Charge, current, and beam power

Electromagnetism

Cutoff frequency and attenuation for rectangular waveguide	
Cavity properties (filling time, voltage/power, ...)	
Skin depth for nonmagnetic materials	Pillbox cavity modes
Magnetic fields from wires	Kilpatrick criterion
Pulsed rf heating	Bunch form factors

3. EXAMPLES

3.1 MBA STORAGE RING

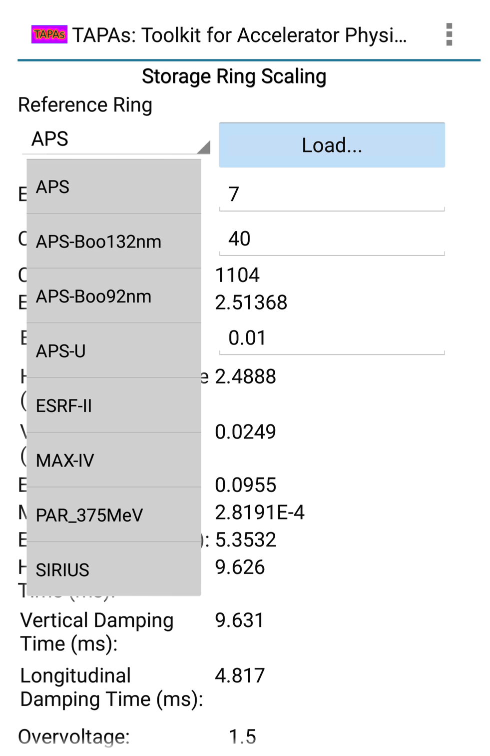

Figure 1: *Electron storage ring scaling lattice selection.*

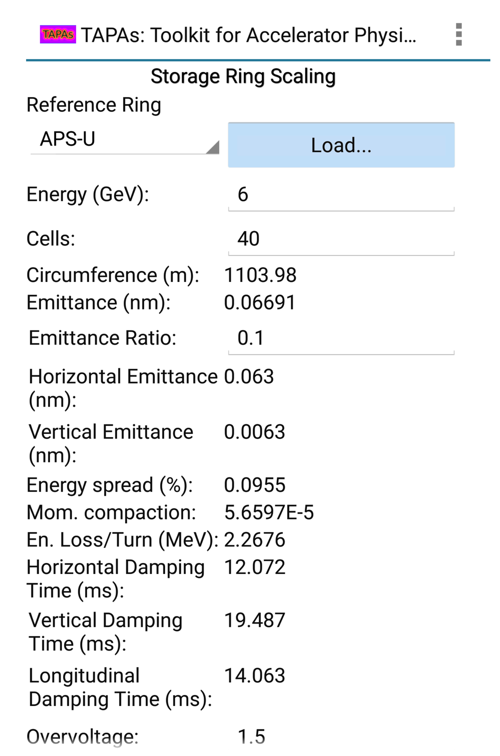

Figure 2: *67-pm APS-U lattice with* $\epsilon_y/\epsilon_x = 0.1$

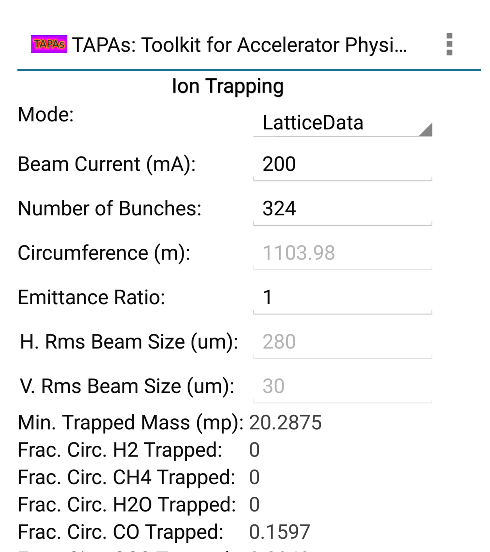

Figure 3: *Ion trapping calculation, showing trapping of CO and* CO_2 *for* $\epsilon_y/\epsilon_x = 1$ *in APS-U.*

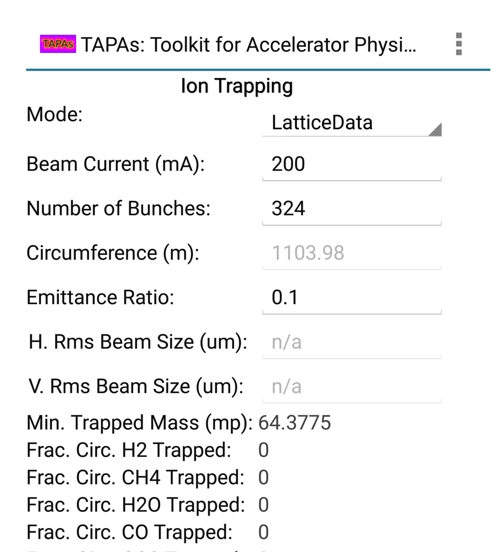

Figure 4: *Ion trapping calculation, showing absence of trapping for* $\epsilon_y/\epsilon_x = 0.1$ *in APS-U.*

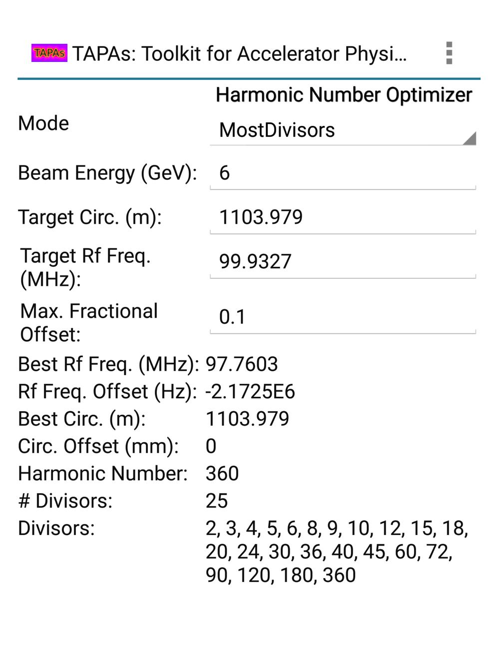

Figure 5: *Choosing a harmonic number for APS-U near 100 MHz to maximize the number of divisors.*

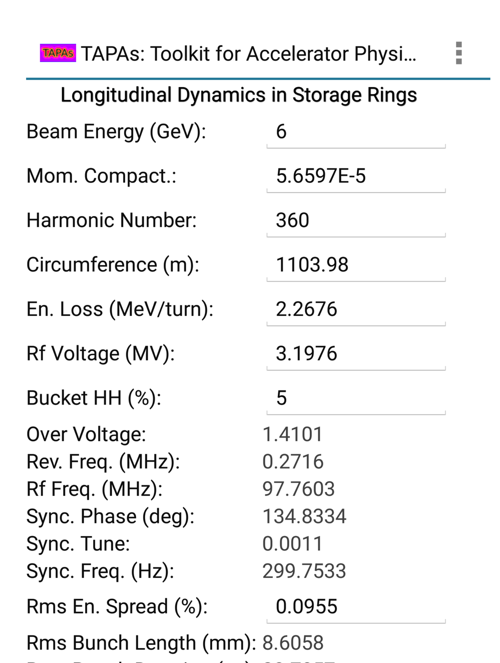

Figure 6: *Computing the natural bunch length for the chosen harmonic number.*

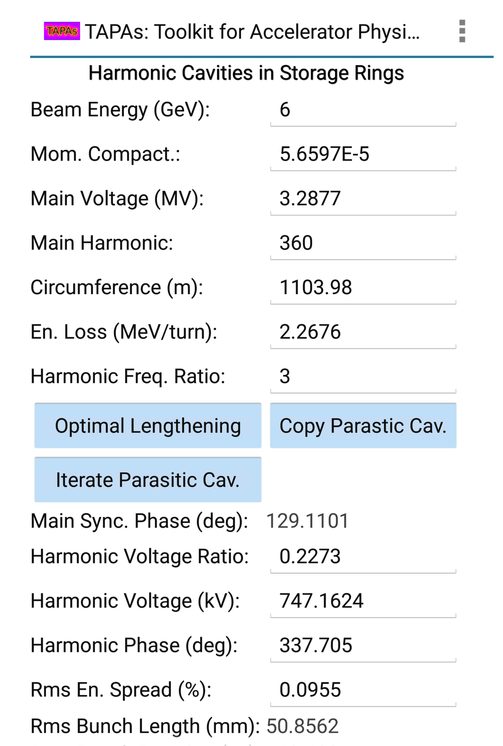

Figure 7: *Adding an optimized harmonic cavity to lengthen the bunch.*

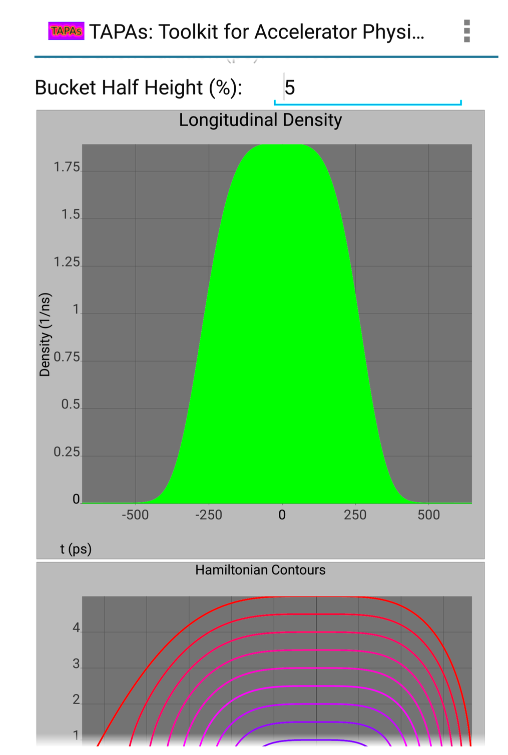

Figure 8: *Viewing the bunch length and Hamiltonian contours for a fixed bucket height of* $\pm 5\%$.

Figure 9: *Estimation of the gas scattering lifetime for a small dynamic acceptance.*

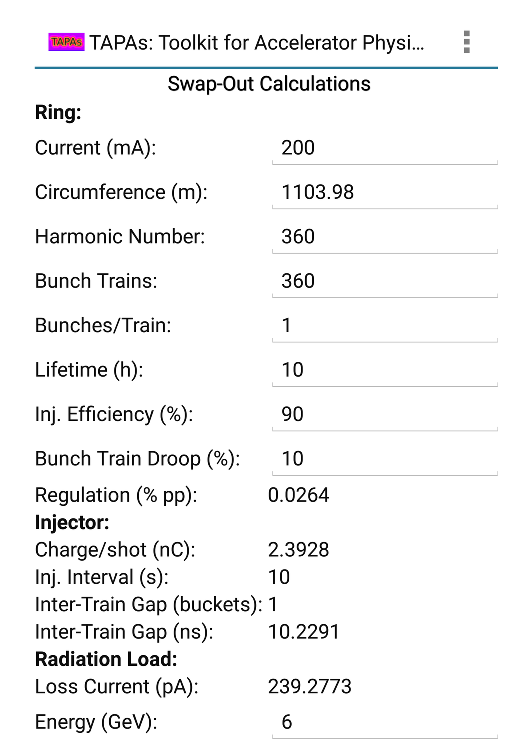

Figure 10: *Calculation of swap-out parameters for on-axis injection with a 10 hour lifetime.*

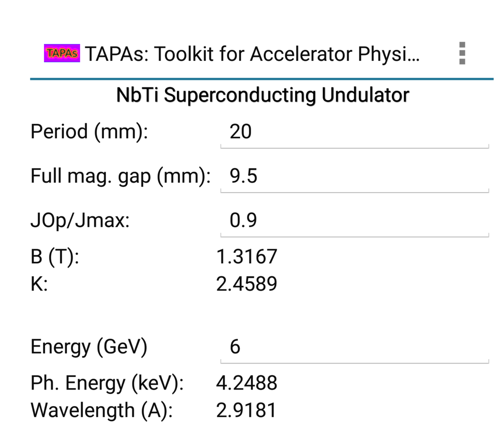

Figure 11: *Estimation of maximum K in a 20-mm-period planar SCU.*

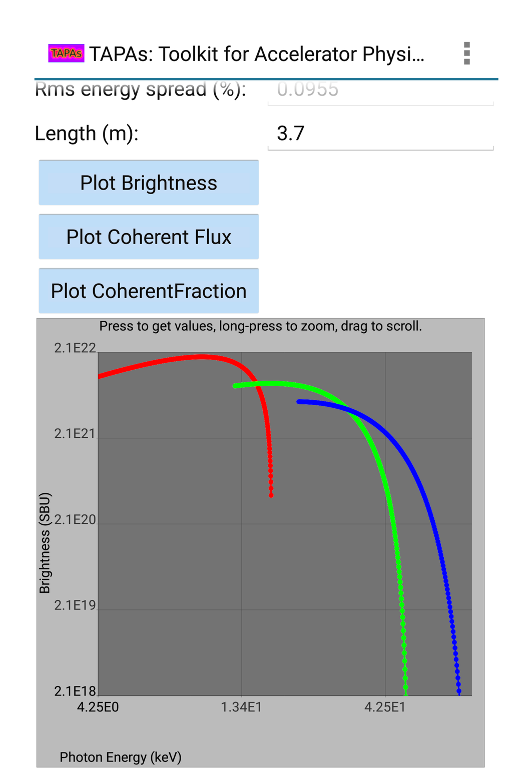

Figure 12: *Brightness for 3.7-m, 20-mm-period planar SCU in APS-U.*

3.2 OTHER EXAMPLES

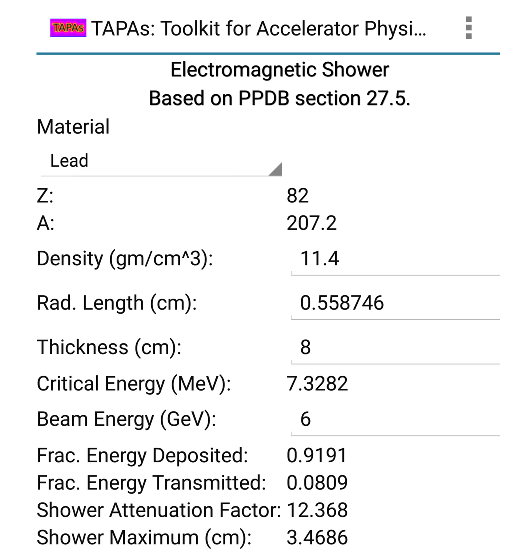

Figure 13: *Attenuation of an electromagnetic shower by 8 cm of lead.*

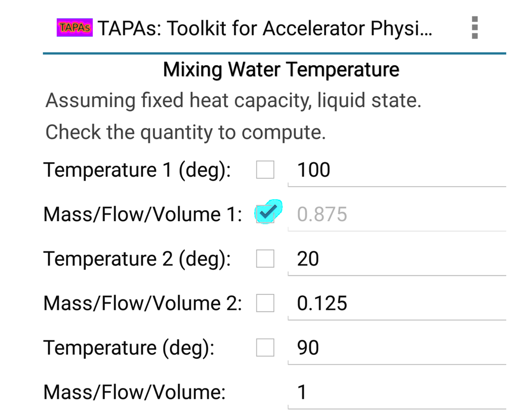

Figure 14: *Calculation of the amount of boiling and room-temperature water to combine to make 1 liter of 90° water for green tea.*

4. RPN CALCULATOR ENTRY PAD

A calculator entry pad is provided for number entry, which allows

- Pre-calculation of entries.
- Perform calculations with values from the activity.
- Review values in full precision.

To prevent invalid calculations, the calculator interface is sensitive to the valid return values for the quantity being entered.

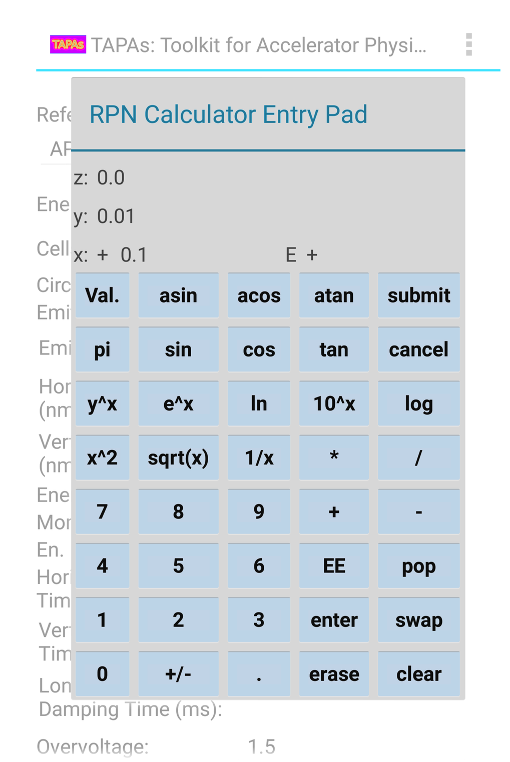

Figure 15: *Rpn calculator entry pad.*

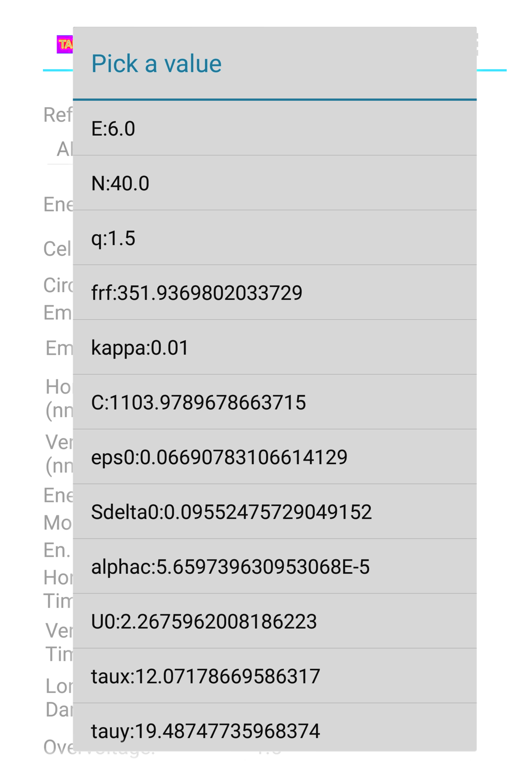

Figure 16: *Pressing the "Val." button brings up a list of all values in the activity, for use in calculations.*

5. CONCLUSIONS

The cost- and ad-free TAPAs application for Android devices provides a number of quick, convenient calculations for use in back-of-the-envelope estimates and for analysis that would typically be performed with a handbook and calculator. The author hopes that it will prove useful and encourages users to send comments, suggestions, and bug reports to michael.d.borland@gmail.com.