Discussion on damping ring arc design for good dynamic aperture

Yipeng SUN
SLAC
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General discussion

- Arc length->circumference->total number of bunch
- Natural emittance: 5micron -> number of dipoles for given focusing type
- Small momentum compaction -> weak dipole and small dispersion in dipole -> slow damping
- Repetition rate 5Hz -> fast damping in 200ms -> wiggler
- Bunch length -> RF voltage for given momentum compaction
- Tunable bunch length for given RF -> tunable lattice
- Injected e+ with large emittance and energy spread -> good DA

Discuss how to achieve a good dynamic aperture

K. Brown's approach

$$x_i(1) = \sum_j R_{ij} x_j(0) + \sum_{j,k} T_{ijk} x_j(0) x_k(0) + \sum_{j,k,l} U_{ijkl} x_j(0) x_k(0) x_l(0)$$

If all higher order transport matrix elements equal zero, the transport matrix through an arc is reduced to an unity matrix

Any particle's 6-D coordinates are exactly reproduced.

How to achieve this condition

Achromat

K. Brown

Any optics with N (larger than one) identical cells gives a first order achromat if the betatron phase advance equals 2π in both transverse planes (first order transport matrix equaling unity I).

When the cell number N does not equal three, the second order geometric aberrations are also canceled.

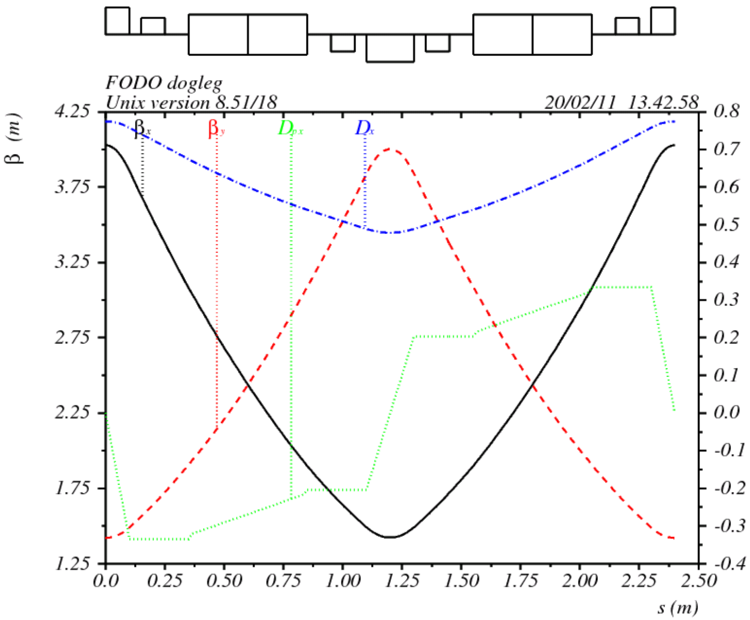
Of all the second order chromatic aberrations only two are independent, which then can be corrected with two families of sextupoles in each transverse plane.

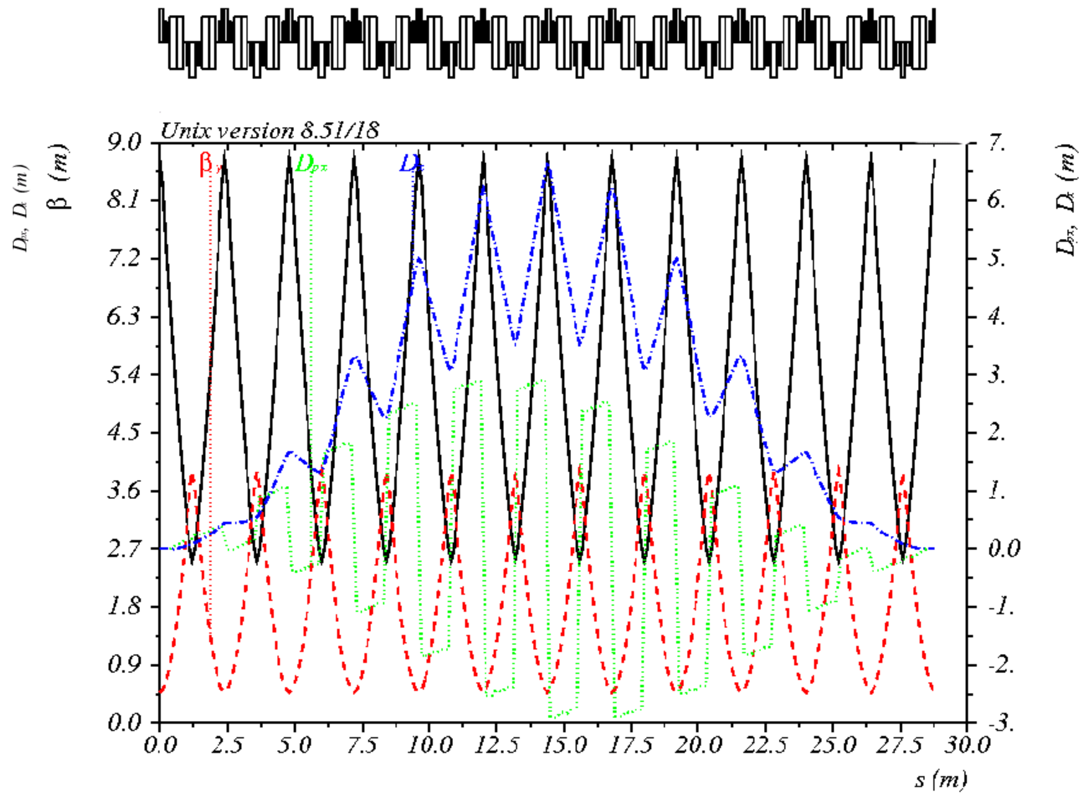
Plus, if non-interlaced sextupole arrangement (minus I) is applied, there is no higher order geometric aberrations from chromaticity correction sexutpoles.

W. Wan

W. Wan developed another approach with Lie algebra to design general achromat to arbitrary order, taking advantage of the midplane symmetry and using multipole magnets for each order (for example, octupoles for third order achromat).

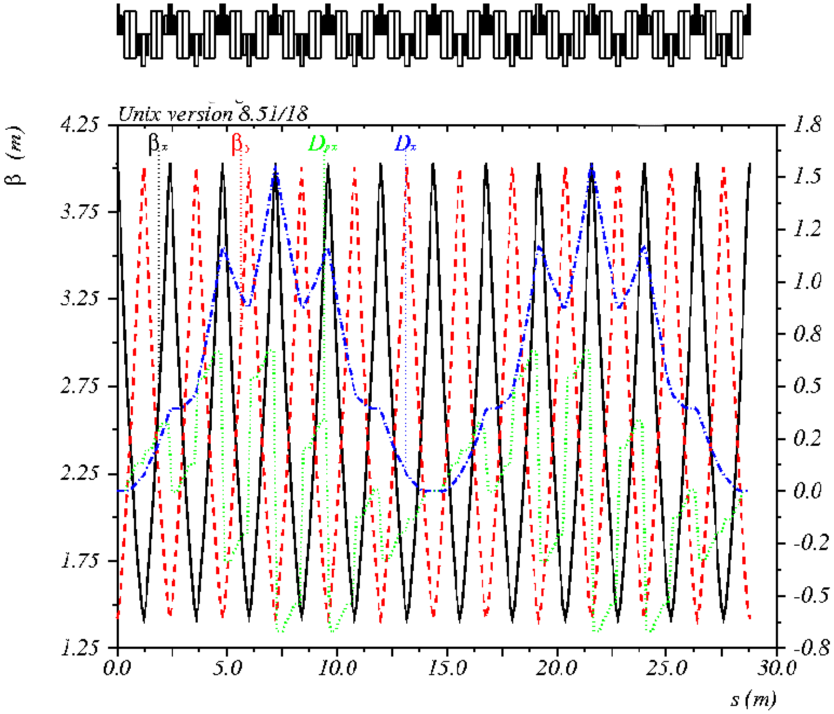
An example with FODO (1)

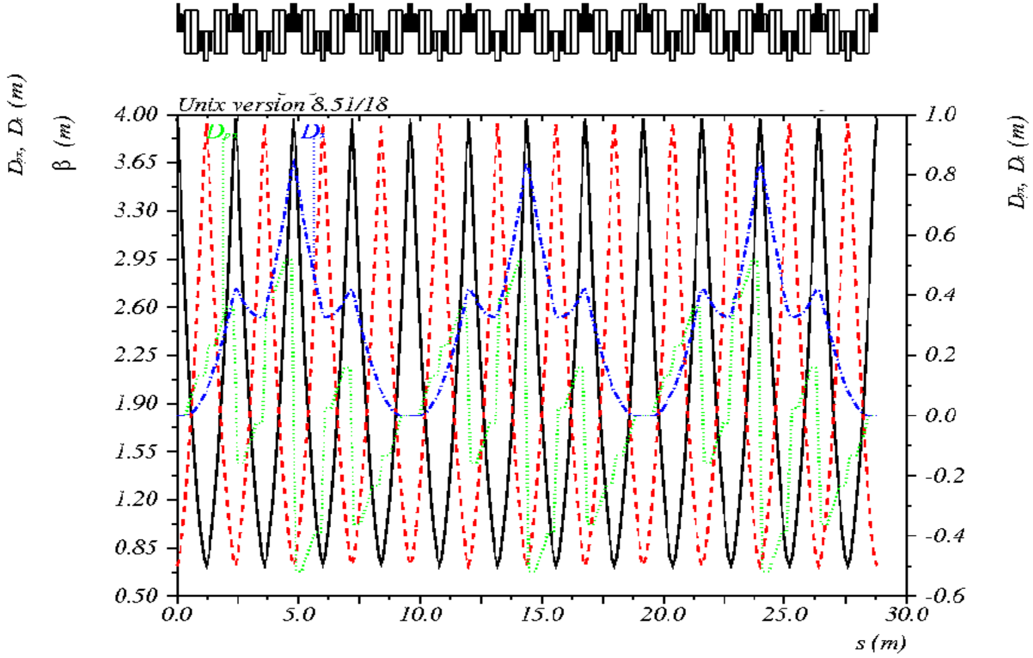




30 degree

An example with FODO (2)

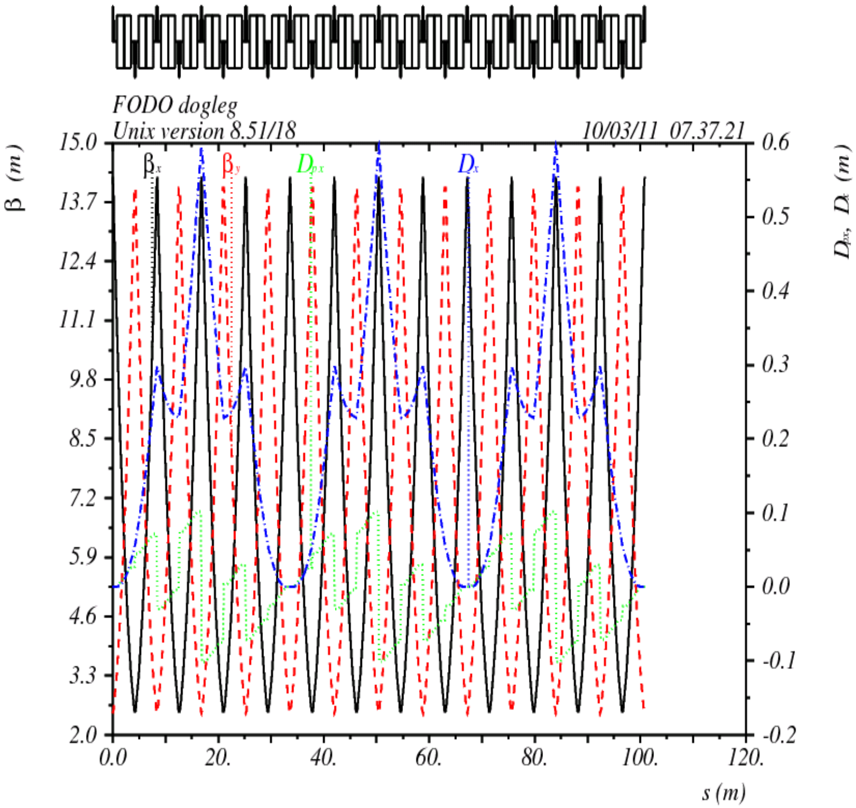


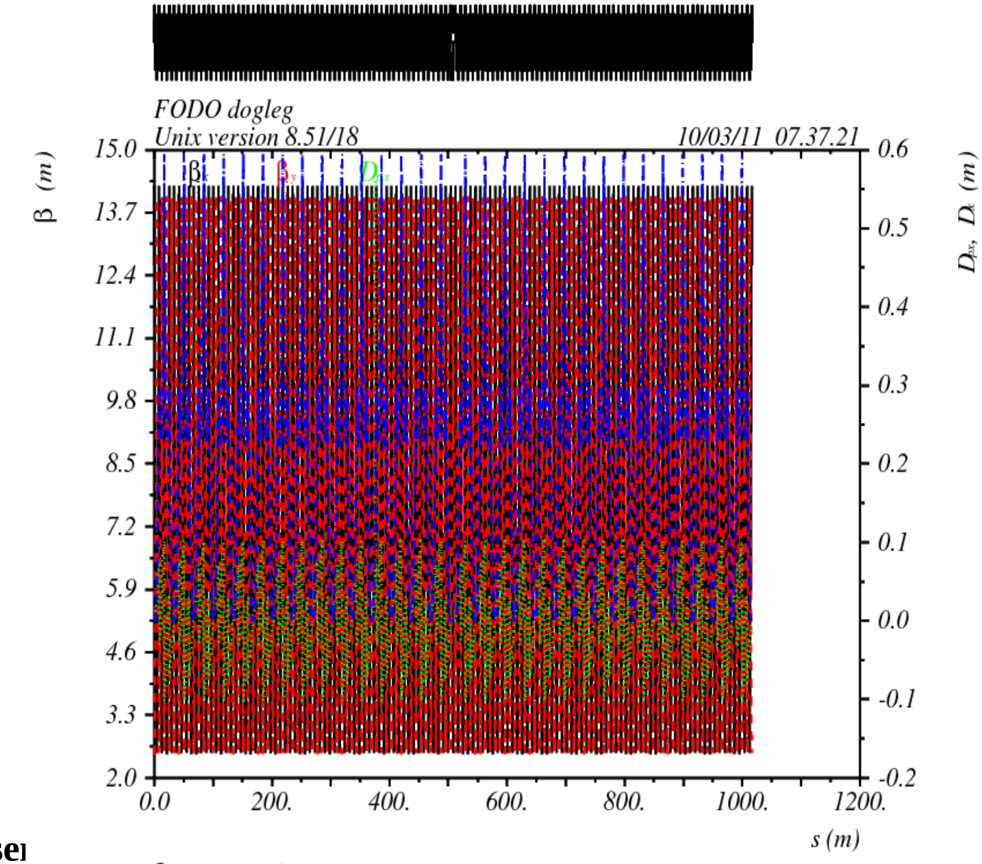


60 degree **90 degree**

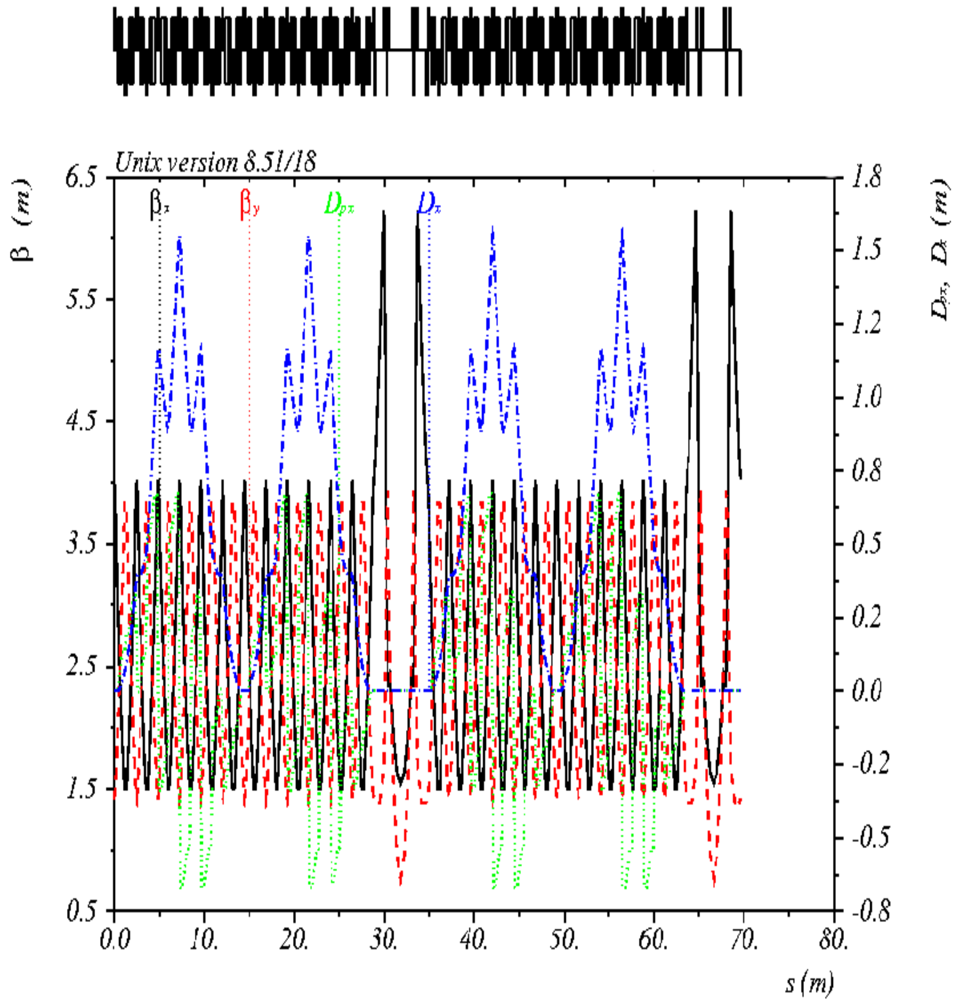
Low emittance ring

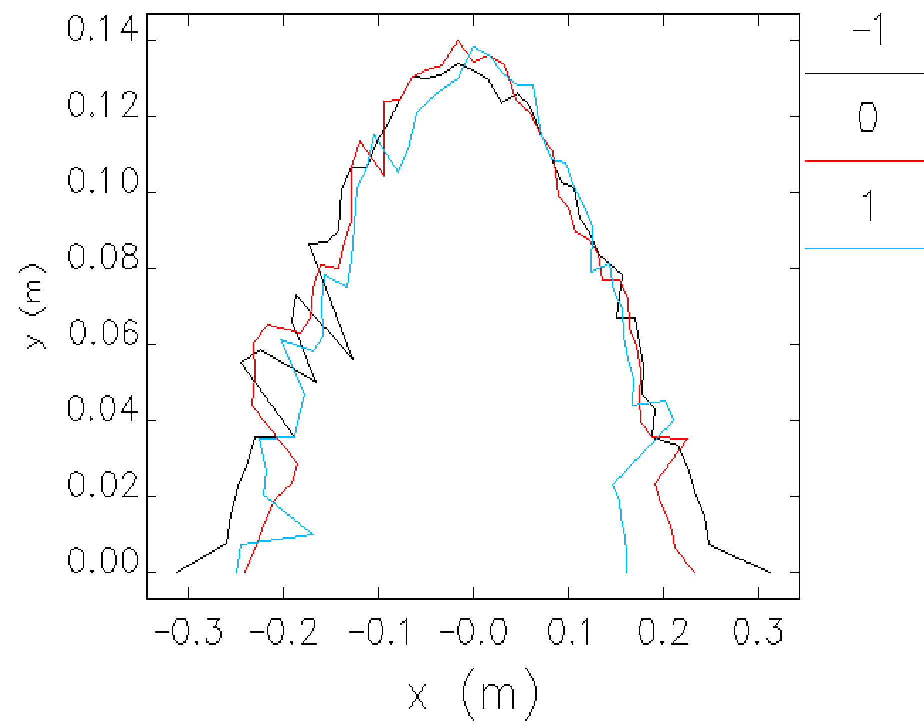
- 5 GeV, 2km arc, 480 dipoles --> 0.5 nm emittance
- 2 GeV, 1km arc, 240 dipoles --> 0.7 nm emittance

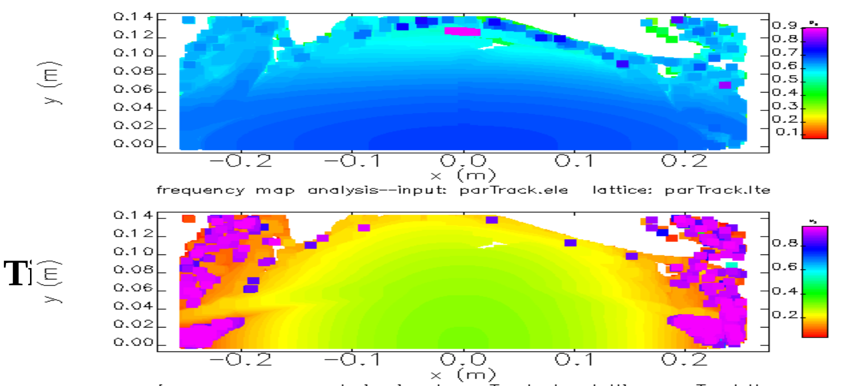




A compact ring with 60degree supercell

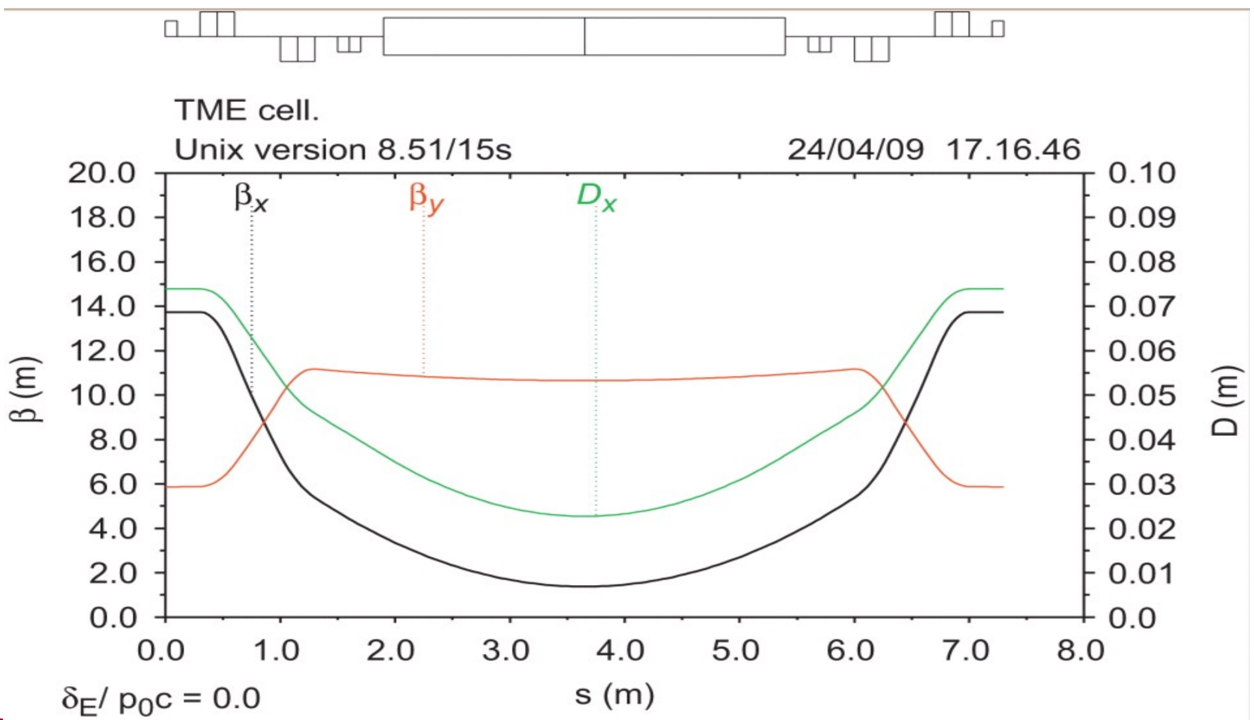






A TME lattice by Y. Cai NIM A, doi:10.1016/j.nima.2010.12.002

Recently Y. Cai has demonstrated that all driving terms up to fourth order resonance from chromaticity correction sextupoles can be canceled out within each arc achromat section, by derivations using Lie algebraic method. An example lattice composed of TME arc cell is given, where one section consists of eight TME cell and the horizontal and vertical betatron phase advance is chosen to be 135/45 degree in each cell.



DA of Y. Cai's lattice NIM A, doi:10.1016/j.nima.2010.12.002