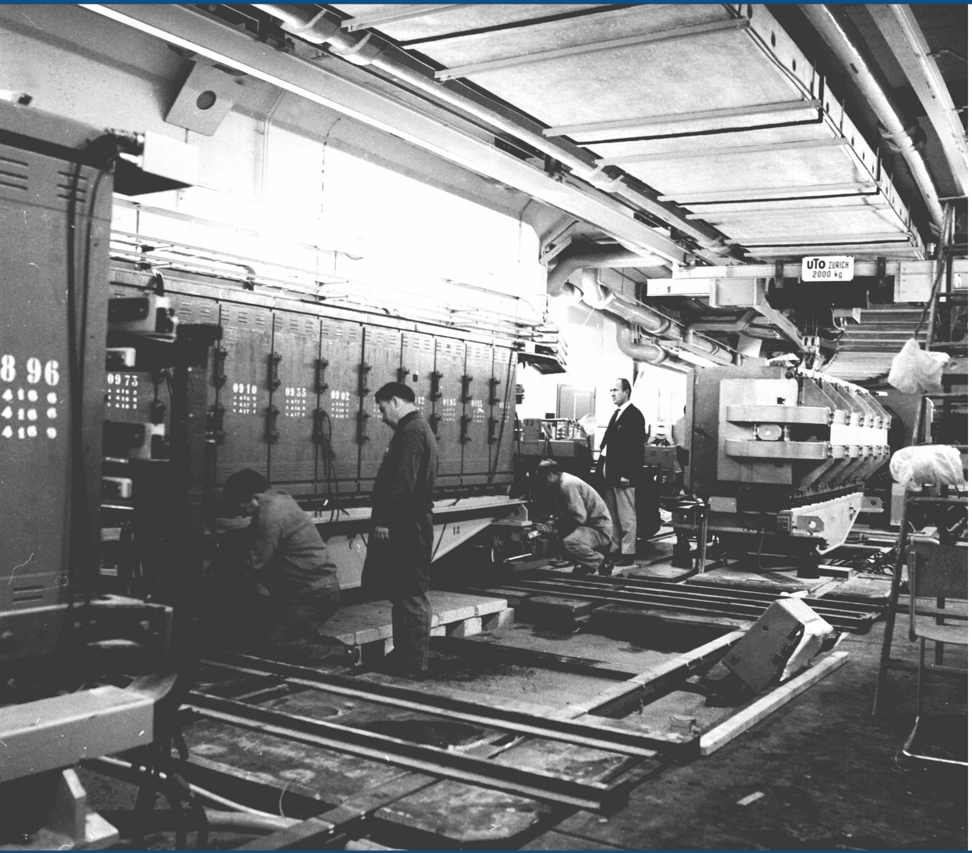
Modeling the PS for PTC simulations

LIS meeting on 12/03/2012



$$J = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & -1 & 0 \end{pmatrix}$$

Cédric Hernalsteens

Acknowledgments: A. Molodozhentsev, E. Forest, F. Schmidt, M. Giovannozzi

Overview

- PTC as a symplectic integrator
  - S-based integration and splitting
  - Data structures: what should we model ?
- A model of the PS lattice
  - New customizable model of the PS
  - Splitting of the lattice
  - How to control the splitting ? Dynamic resplitting
  - “The lattice”
- In practice
  - Lattice preparation for MAD-X/PTC and ORBIT/PTC
  - Tools and lattice repository

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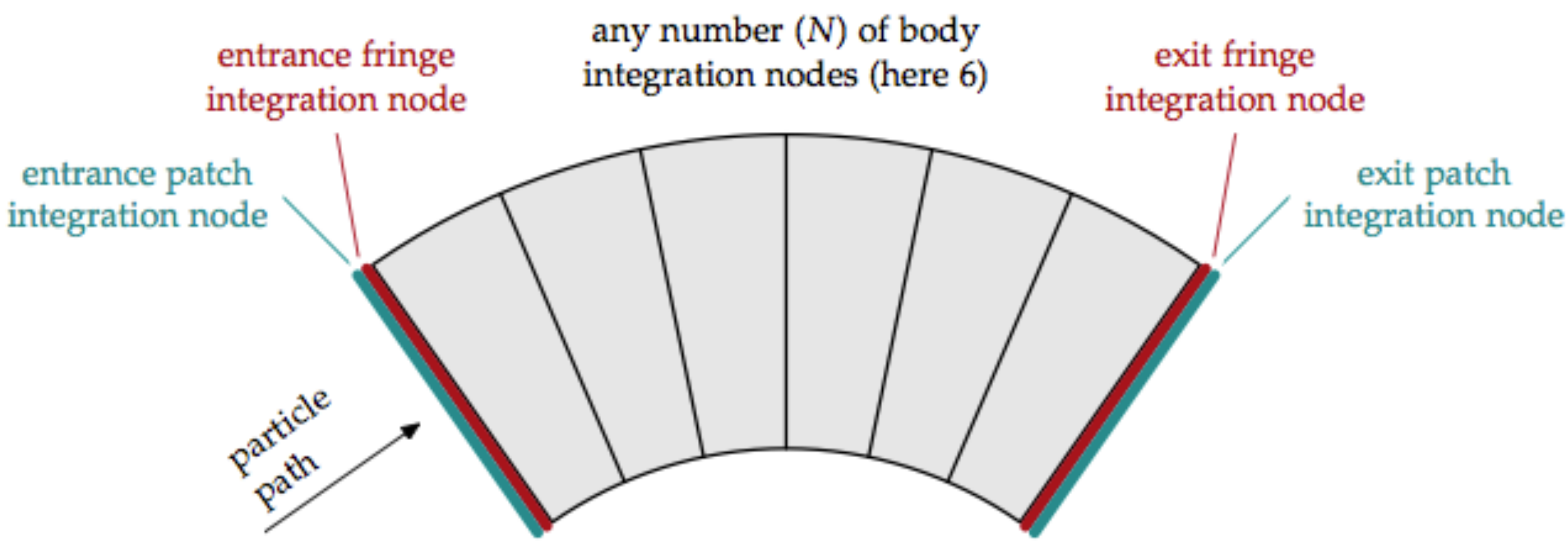
Symplectic integration with PTC

- From now on we forget about MAD-X or ORBIT
- We consider PTC itself, as an integrator
- We are going to set up properly
  - A clean layout/lattice
  - A working integration model

- … we’ll go back to MAD-X and ORBIT latter

Symplectic integration with PTC

- PTC integrates the dynamics of an element using a local Hamiltonian
  - S-based integration $z_2 = f(z_1)$



Symplectic integration with PTC

$$-(1+\kappa_0 x)\sqrt{(1+\delta^2)-p_x^2-p_y^2}+(1+\kappa_0 x)\frac{q}{p_0}A_s(x,y)$$

- The Hamiltonian is split in integrable and non integrable parts
  - DRIFT-KICK or MATRIX-KICK

Tune and closed orbit related

MODEL=1,2

- In the integrable part we can keep or truncate the square root

$$H=-\sqrt{(1+\delta)^2-p_x^2-p_y^2}$$

$$H=\frac{p_x^2+p_y^2}{2(1+\delta)}-\delta$$

Off momentum related

EXACT=TRUE,FALSE

Symplectic integration with PTC

$$-(1+\kappa_0 x)\sqrt{(1+\delta^2)-p_x^2-p_y^2}+(1+\kappa_0 x)\frac{q}{p_0}A_s(x,y)$$

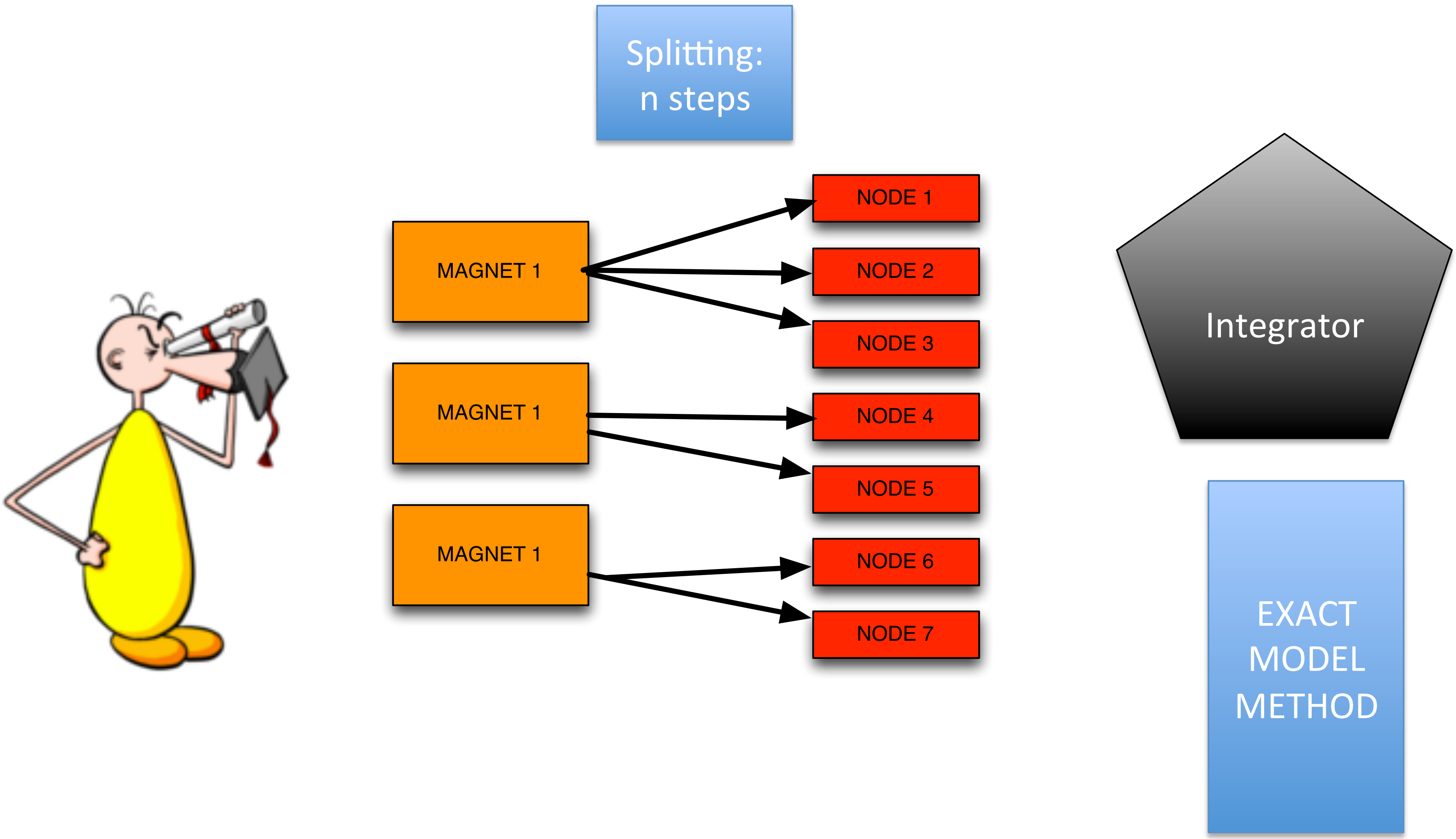
- The non integrable part is modeled as a set of kicks mixed with drift-like transformation
  - That's where we have to care about symplecticity
  - Different integration orders* are "available": more than 1 kick per integration step
- To preserve the integrity of the magnets, those should not be split in the layout (misalignments, …), however the integration through one magnet can be done in a different number of steps (nst=1,2,3,4,5…)

* Cf. common numerical integration (rectangle, trapezoidal methods, Simpson's rule, …)

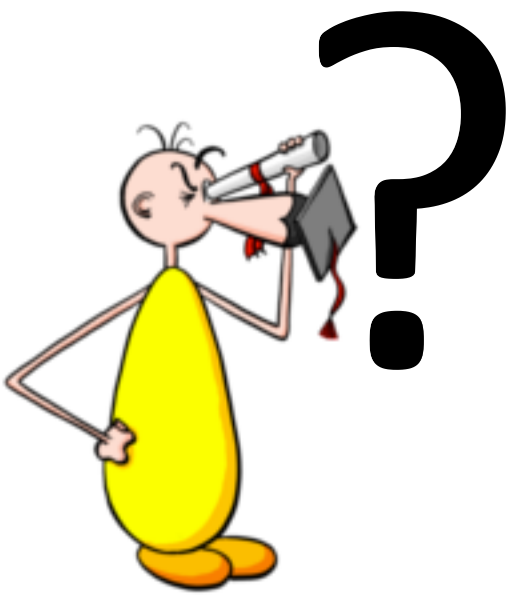
What do we need to track with PTC ?

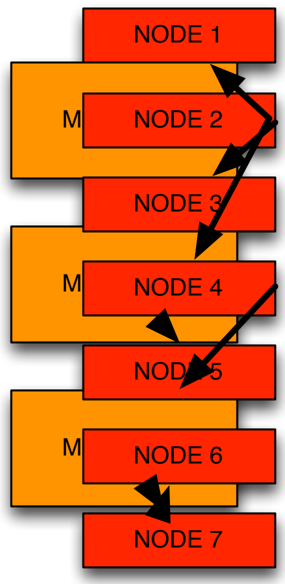
- A layout preserving the integrity of the magnets
  - The integrator will split that in integration nodes
- Choose the models used by the integrator
  - Split of the Hamiltonian
  - Order of integration
  - Truncation of the Hamiltonian
- Beware !
  - Not all integration models actually exists in practice !
  - For intensive tracking we do care about performance

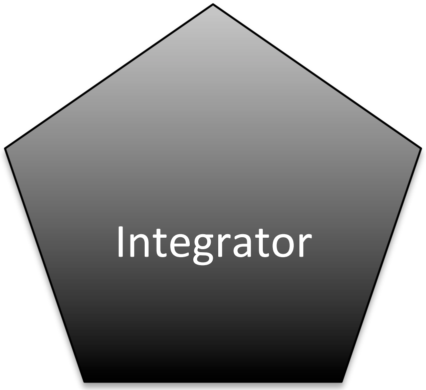
Data structures: what should we model ?



Data structures: what should we model ?







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PS lattice

- The current MAD-X model of the PS lattice is composed of
  - Definitions of all the magnets types
    - Including the definition of the 100 MMU
  - Numerical values of the current-gradient transfer functions
  - For a large set of elements, knobs are defined in term of MAD-X variables
  - Sequences for all the straight sections
    - "Database effect"
- Available on the CERN Optics webpage and AFS

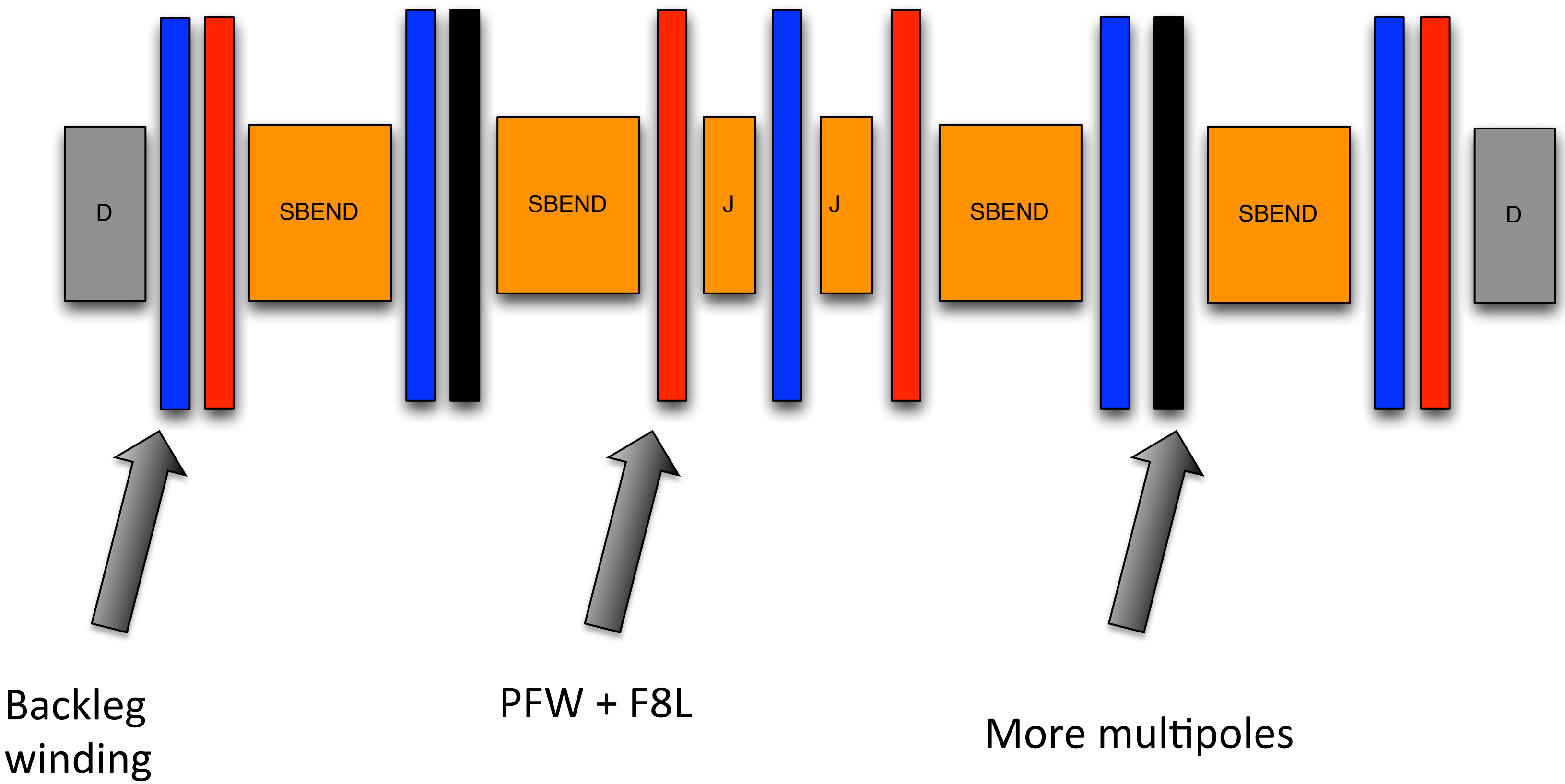
Modification of the PS lattice

- Cleaning of the main files
  - Clear definition of the .str file
  - Old “Z” variable (for thin lattices in MAD-8 ?)

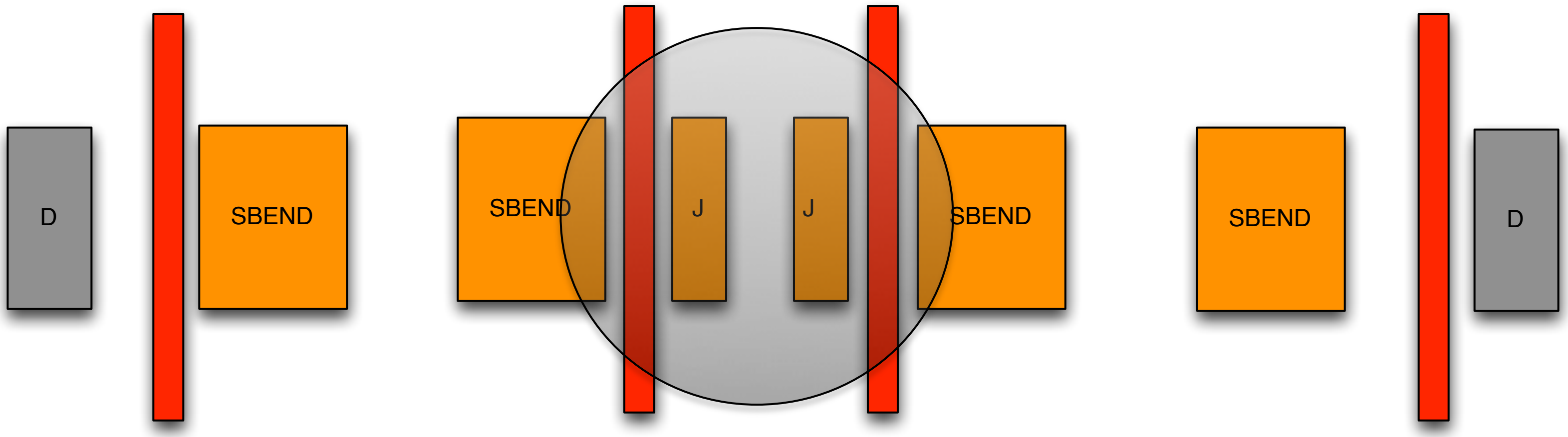
Modification of the PS lattice

- A system of "flags" to activate only useful elements
  - Based on large seqedits
  - Remove all the unused elements
  - Flags can configure the actual sequence based on the needs of the user
    - Injection, extraction, gamma jump, …
    - We can define more flags to automatically set-up "standard" configurations of the machine

Modification of the MMU model



Modification of the MMU model



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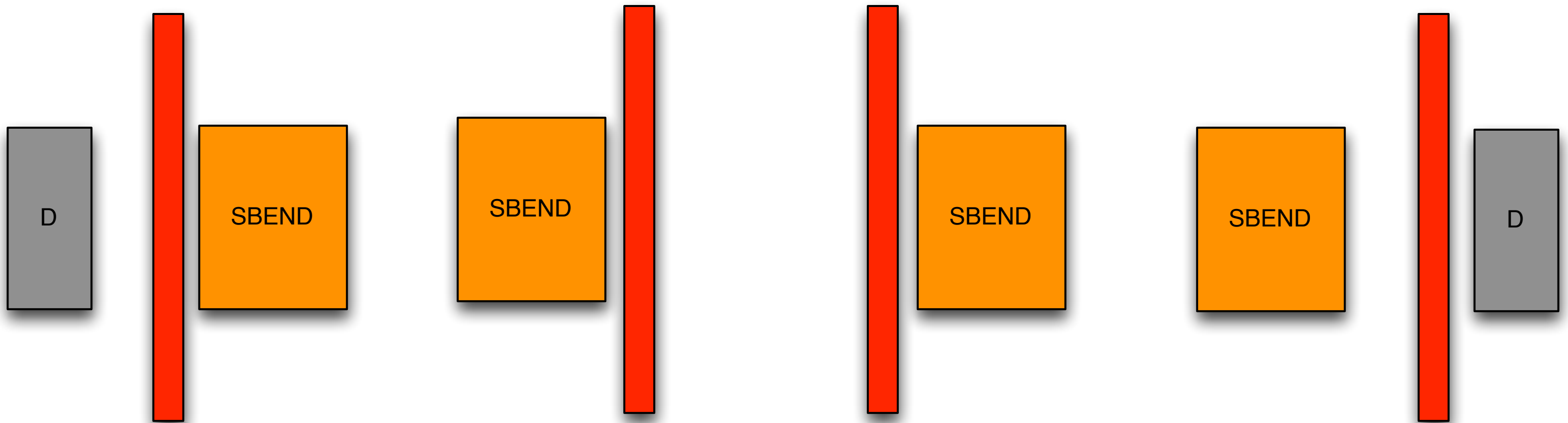
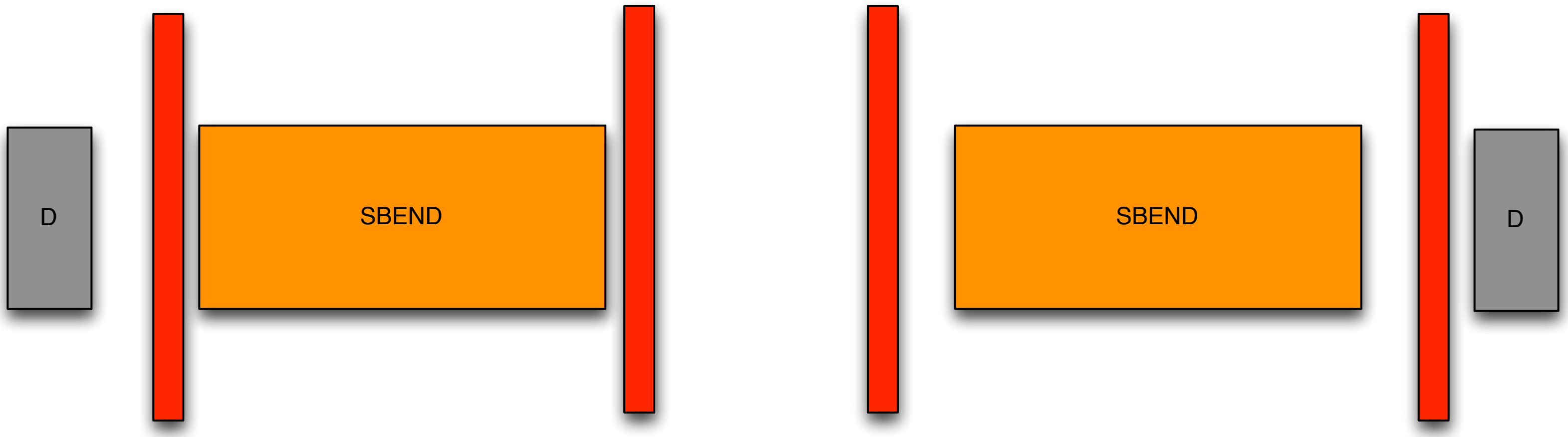


Model used now
No physics change

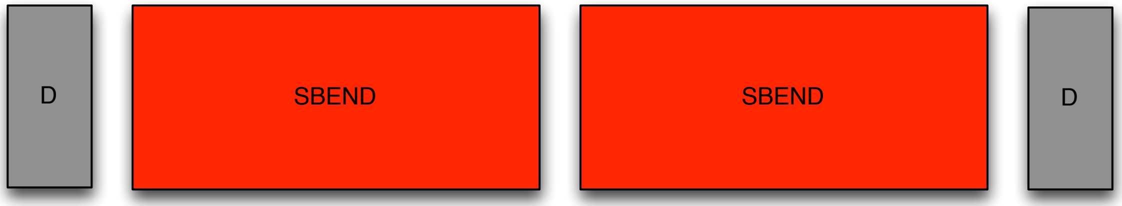
Modification of the MMU model



Should check the effect of fringe fields !

Modification of the MMU model

Thick model (PTC only)



Cf. Mariusz

Reduction of the size of the layout

- PTC layout contains all the information for every "fiber"
- Tracking is done fiber per fiber…

Modification	# fibers
Initial lattice	3030
Clean MMU	2330
Remove unused	1880
Injection configuration	1826
New PTC version (no marker)	1403

Integration: what should we expect ?

- The model is not ideal in the PTC sense
  - Still presence of thin elements
- Main magnet model uses thin elements for the nonlinear components
  - Therefore the integration order and/or number of steps should not have a huge impact
- The SBEND are thick and the machine is not very big
  - So truncation of the Hamiltonian should matter

Splitting

- The goal is to determine the ideal "split lattice"
- An extensive set of simulations has been performed, one simulation for each {model, method, nst, exact} set
- For each simulation the tune is matched (according to the integration method)
- The comparison is based on the beta-beating and on a subset of nonlinear parameters: $D_x, D'_x, \xi, \xi', \xi'', A^x_{10}, A^x_{01}, A^x_{20}, A^x_{02}, A^x_{11}$
- The case {model=2, method=6, nst=5, exact=true} was taken as a reference
  - Convergence was indeed observed towards the results of that simulation

Splitting

- Machine was in a "MTE like" configuration
  - Sextupoles and octupoles
- We always use time=false (i.e. canonical longitudinal momentum is δ_p
  - Correct definition !

Results: nonlinear parameters

DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00	6.00	5.00	TRUE
9.25E-09	1.10E-07	2.18E-08	1.02E-09	1.87E-08	6.01E-09	1.83E-09	4.67E-08	9.96E-09	1.05E-08	2.00	6.00	4.00	TRUE
6.64E-08	8.00E-07	1.58E-07	8.33E-09	1.35E-07	4.46E-08	1.36E-08	3.40E-07	7.16E-08	7.67E-08	2.00	6.00	3.00	TRUE
7.91E-07	9.52E-06	1.88E-06	9.97E-08	1.61E-06	5.29E-07	1.63E-07	4.04E-06	8.51E-07	9.13E-07	2.00	6.00	2.00	TRUE
5.08E-05	6.12E-04	1.21E-04	6.43E-06	1.03E-04	3.40E-05	1.05E-05	2.60E-04	5.47E-05	5.87E-05	2.00	6.00	1.00	TRUE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
5.28E-06	6.28E-05	3.45E-05	2.80E-07	1.68E-05	3.68E-06	1.41E-06	2.33E-05	5.37E-06	6.26E-06	2.00	4.00	5.00	TRUE
1.29E-05	1.54E-04	8.43E-05	6.80E-07	4.10E-05	9.00E-06	3.44E-06	5.71E-05	1.32E-05	1.53E-05	2.00	4.00	4.00	TRUE
4.10E-05	4.88E-04	2.67E-04	2.13E-06	1.30E-04	2.86E-05	1.09E-05	1.81E-04	4.18E-05	4.86E-05	2.00	4.00	3.00	TRUE
2.11E-04	2.51E-03	1.36E-03	1.04E-05	6.64E-04	1.47E-04	5.58E-05	9.34E-04	2.15E-04	2.50E-04	2.00	4.00	2.00	TRUE
3.62E-03	4.31E-02	2.26E-02	1.24E-04	1.11E-02	2.51E-03	9.29E-04	1.65E-02	3.79E-03	4.31E-03	2.00	4.00	1.00	TRUE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
1.21E-02	1.52E-01	5.27E-02	7.70E-04	3.20E-02	8.16E-03	2.90E-03	5.73E-02	1.23E-02	1.37E-02	2.00	2.00	5.00	TRUE
1.90E-02	2.39E-01	8.15E-02	1.06E-03	5.06E-02	1.30E-02	4.79E-03	8.71E-02	1.85E-02	2.13E-02	2.00	2.00	4.00	TRUE
3.46E-02	4.27E-01	1.41E-01	1.30E-03	9.23E-02	2.40E-02	9.52E-03	1.46E-01	3.02E-02	3.76E-02	2.00	2.00	3.00	TRUE
8.34E-02	9.77E-01	2.97E-01	1.72E-03	2.26E-01	6.14E-02	2.87E-02	2.74E-01	4.79E-02	8.31E-02	2.00	2.00	2.00	TRUE
[redacted]										2.00	2.00	1.00	TRUE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	5.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	4.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	3.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	2.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	1.00	FALSE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	5.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	4.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	3.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	2.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	1.00	FALSE

Results: nonlinear parameters

DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00	6.00	5.00	TRUE
9.25E-09	1.10E-07	2.18E-08	1.02E-09	1.87E-08	6.01E-09	1.83E-09	4.67E-08	9.96E-09	1.05E-08	2.00	6.00	4.00	TRUE
6.64E-08	8.00E-07	1.58E-07	8.33E-09	1.35E-07	4.46E-08	1.36E-08	3.40E-07	7.16E-08	7.67E-08	2.00	6.00	3.00	TRUE
7.91E-07	9.52E-06	1.88E-06	9.97E-08	1.61E-06	5.29E-07	1.63E-07	4.04E-06	8.51E-07	9.13E-07	2.00	6.00	2.00	TRUE
5.08E-05	6.12E-04	1.21E-04	6.43E-06	1.03E-04	3.40E-05	1.05E-05	2.60E-04	5.47E-05	5.87E-05	2.00	6.00	1.00	TRUE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
5.28E-06	6.28E-05	3.45E-05	2.80E-07	1.68E-05	3.68E-06	1.41E-06	2.33E-05	5.37E-06	6.26E-06	2.00	4.00	5.00	TRUE
1.29E-05	1.54E-04	8.43E-05	6.80E-07	4.10E-05	9.00E-06	3.44E-06	5.71E-05	1.32E-05	1.53E-05	2.00	4.00	4.00	TRUE
4.10E-05	4.88E-04	2.67E-04	2.13E-06	1.30E-04	2.86E-05	1.09E-05	1.81E-04	4.18E-05	4.86E-05	2.00	4.00	3.00	TRUE
2.11E-04	2.51E-03	1.36E-03	1.04E-05	6.64E-04	1.47E-04	5.58E-05	9.34E-04	2.15E-04	2.50E-04	2.00	4.00	2.00	TRUE
3.62E-03	4.31E-02	2.26E-02	1.24E-04	1.11E-02	2.51E-03	9.29E-04	1.65E-02	3.79E-03	4.31E-03	2.00	4.00	1.00	TRUE
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1.21E-02	1.52E-01	5.27E-02	7.70E-04	3.20E-02	8.16E-03	2.90E-03	5.73E-02	1.23E-02	1.37E-02	2.00	2.00	5.00	TRUE
1.90E-02	2.39E-01	8.15E-02	1.06E-03	5.06E-02	1.30E-02	4.79E-03	8.71E-02	1.85E-02	2.13E-02	2.00	2.00	4.00	TRUE
3.46E-02	4.27E-01	1.41E-01	1.30E-03	9.23E-02	2.40E-02	9.52E-03	1.46E-01	3.02E-02	3.76E-02	2.00	2.00	3.00	TRUE
8.34E-02	9.77E-01	2.97E-01	1.72E-03	2.26E-01	6.14E-02	2.87E-02	2.74E-01	4.79E-02	8.31E-02	2.00	2.00	2.00	TRUE
[redacted]										2.00	2.00	1.00	TRUE
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3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	4.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	3.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	2.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	6.00	1.00	FALSE
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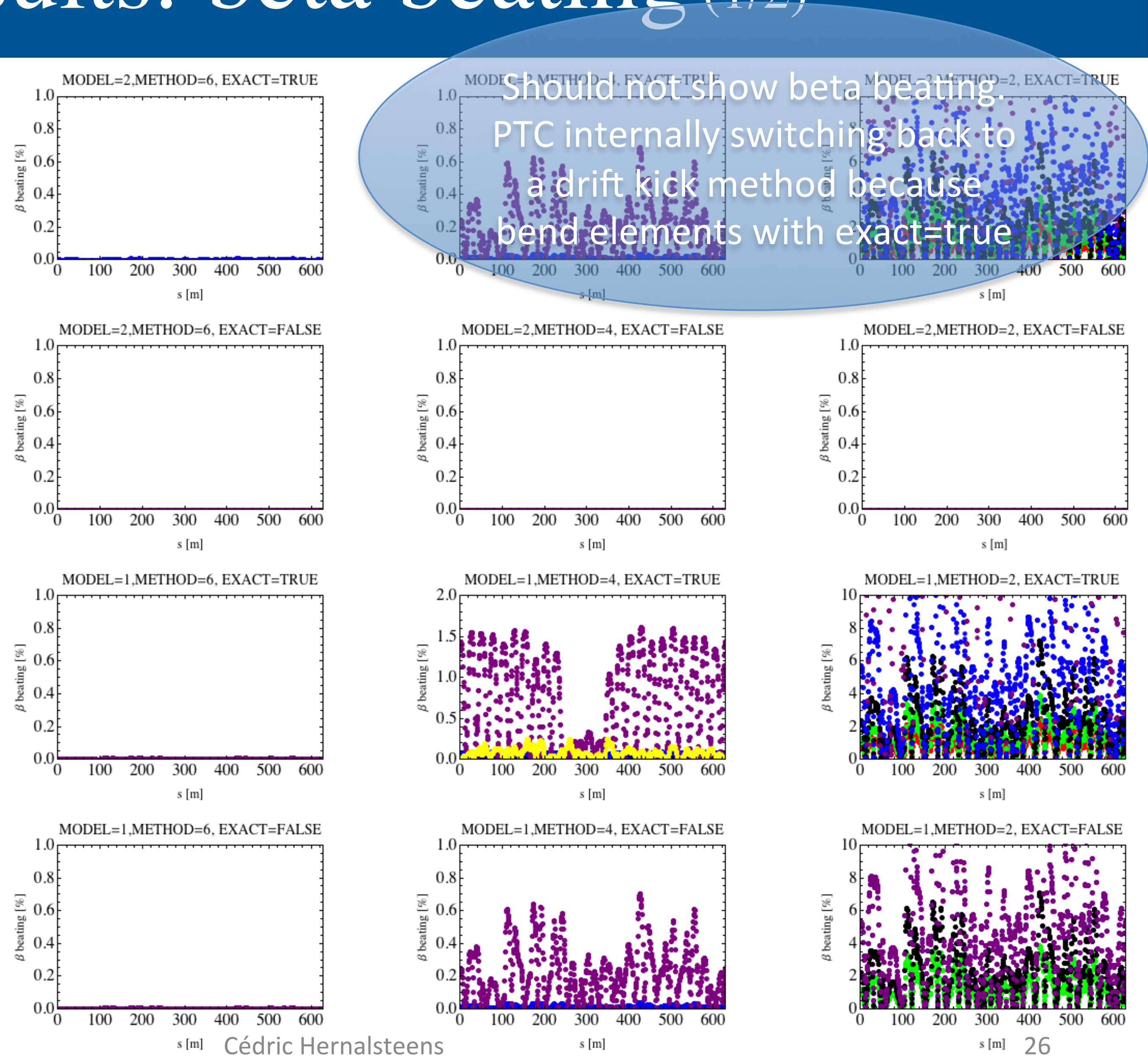
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	4.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	3.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	2.00	FALSE
3.30E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	4.00	1.00	FALSE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
3.30E-09	1.81E-01	1.62E+00	2.56E-03	3.39E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	2.00	5.00	FALSE
3.30E-09	1.79E-01	1.62E+00	2.51E-03	3.38E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	2.00	4.00	FALSE
3.30E-09	1.76E-01	1.60E+00	2.40E-03	3.34E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	2.00	3.00	FALSE
3.30E-09	1.65E-01	1.56E+00	2.08E-03	3.24E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	2.00	2.00	FALSE
3.30E-09	1.07E-01	1.35E+00	3.40E-04	2.72E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	2.00	2.00	1.00	FALSE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
0.00E+00	3.41E-09	9.80E-09	1.46E-10	3.46E-09	0.00E+00	0.00E+00	5.80E-10	3.78E-09	1.62E-09	1.00	6.00	5.00	TRUE
8.92E-09	9.74E-08	5.93E-08	5.85E-10	3.18E-08	6.51E-09	1.42E-09	4.90E-08	2.40E-08	1.69E-08	1.00	6.00	4.00	TRUE
6.54E-08	7.28E-07	3.71E-07	5.56E-09	2.10E-07	4.61E-08	1.10E-08	3.52E-07	1.51E-07	1.13E-07	1.00	6.00	3.00	TRUE
7.78E-07	8.69E-06	4.34E-06	6.78E-08	2.47E-06	5.48E-07	1.32E-07	4.18E-06	1.77E-06	1.33E-06	1.00	6.00	2.00	TRUE
4.99E-05	5.53E-04	2.91E-04	4.25E-06	1.63E-04	3.53E-05	8.31E-06	2.70E-04	1.18E-04	8.76E-05	1.00	6.00	1.00	TRUE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
3.54E-06	3.25E-04	7.53E-04	5.76E-06	2.69E-04	7.80E-06	7.70E-06	5.36E-05	2.66E-04	1.24E-04	1.00	4.00	5.00	TRUE
8.60E-06	7.92E-04	1.84E-03	1.40E-05	6.58E-04	1.91E-05	1.88E-05	1.31E-04	6.51E-04	3.03E-04	1.00	4.00	4.00	TRUE
2.70E-05	2.50E-03	5.81E-03	4.43E-05	2.08E-03	6.03E-05	5.95E-05	4.16E-04	2.06E-03	9.59E-04	1.00	4.00	3.00	TRUE
1.33E-04	1.26E-02	2.94E-02	2.22E-04	1.05E-02	3.06E-04	3.03E-04	2.14E-03	1.05E-02	4.88E-03	1.00	4.00	2.00	TRUE
1.65E-03	2.02E-01	4.73E-01	2.94E-03	1.74E-01	4.46E-03	5.38E-03	4.16E-02	1.80E-01	8.32E-02	1.00	4.00	1.00	TRUE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
1.18E-02	1.43E-01	8.50E-02	4.70E-04	4.23E-02	8.37E-03	2.48E-03	5.86E-02	2.42E-02	1.90E-02	1.00	2.00	5.00	TRUE
1.86E-02	2.25E-01	1.32E-01	5.81E-04	6.62E-02	1.33E-02	4.14E-03	8.90E-02	3.71E-02	2.96E-02	1.00	2.00	4.00	TRUE
3.38E-02	4.09E-01	2.32E-01	3.98E-04	1.19E-01	2.47E-02	8.38E-03	1.49E-01	6.34E-02	5.23E-02	1.00	2.00	3.00	TRUE
8.17E-02	9.81E-01	5.04E-01	4.05E-03	2.79E-01	6.31E-02	2.61E-02	2.76E-01	1.25E-01	1.16E-01	1.00	2.00	2.00	TRUE
[redacted]										1.00	2.00	1.00	TRUE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
0.00E+00	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	1.00	6.00	5.00	FALSE
9.25E-09	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	1.00	6.00	4.00	FALSE
6.67E-08	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.08E-04	7.89E-03	5.39E-04	1.00	6.00	3.00	FALSE
7.94E-07	1.84E-01	1.64E+00	2.65E-03	3.42E-01	3.36E-03	4.68E-03	1.04E-04	7.89E-03	5.40E-04	1.00	6.00	2.00	FALSE
5.11E-05	1.84E-01	1.64E+00	2.66E-03	3.42E-01	3.33E-03	4.69E-03	1.57E-04	7.95E-03	5.98E-04	1.00	6.00	1.00	FALSE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
6.17E-06	1.84E-01	1.64E+00	2.66E-03	3.42E-01	3.37E-03	4.68E-03	1.33E-04	7.89E-03	5.32E-04	1.00	4.00	5.00	FALSE
1.51E-05	1.84E-01	1.64E+00	2.66E-03	3.42E-01	3.37E-03	4.68E-03	1.68E-04	7.88E-03	5.23E-04	1.00	4.00	4.00	FALSE
4.79E-05	1.84E-01	1.64E+00	2.67E-03	3.42E-01	3.39E-03	4.67E-03	2.98E-04	7.85E-03	4.89E-04	1.00	4.00	3.00	FALSE
2.45E-04	1.86E-01	1.64E+00	2.71E-03	3.43E-01	3.51E-03	4.63E-03	1.09E-03	7.67E-03	2.81E-04	1.00	4.00	2.00	FALSE
4.17E-03	2.11E-01	1.66E+00	3.48E-03	3.56E-01	5.87E-03	3.73E-03	1.73E-02	3.98E-03	3.91E-03	1.00	4.00	1.00	FALSE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT
1.21E-02	9.98E-02	1.58E+00	4.16E-03	3.04E-01	4.65E-03	7.59E-03	5.82E-02	2.02E-02	1.44E-02	1.00	2.00	5.00	FALSE
1.91E-02	5.29E-02	1.56E+00	4.85E-03	2.82E-01	9.39E-03	9.47E-03	8.86E-02	2.64E-02	2.21E-02	1.00	2.00	4.00	FALSE
3.47E-02	4.69E-02	1.50E+00	5.91E-03	2.35E-01	2.03E-02	1.42E-02	1.49E-01	3.80E-02	3.86E-02	1.00	2.00	3.00	FALSE
8.36E-02	3.19E-01	1.36E+00	5.02E-03	9.77E-02	5.72E-02	3.34E-02	2.79E-01	5.57E-02	8.43E-02	1.00	2.00	2.00	FALSE
[redacted]										1.00	2.00	1.00	FALSE
DX	DX'	DQ1	DQ1'	DQ1''	AX10	AX01	AX20	AX02	AX11	MODE	METH	NST	EXACT

- For the nonlinear parameters we can say that the DRIFT KICK method is not worse
- The truncated Hamiltonian leads to wrong results for the chromaticities
- Sixth order integration seem to be an overkill, second order is too weak, fourth order is a compromise
- A small number of steps is allowed (nst ~ 3)

Results: beta beating (1/2)

- The truncation of the Hamiltonian doesn't influence much
- For 6th order integration no beating is observable
- For 2nd order integration, the beating is large for any number of steps
- 4th order is therefore a good compromise (as for the nonlinear parameters)



Results

- From these results it appears that these two sets of parameters provide good results (better than 0.5% agreement with the reference)

MODEL	METHOD	NST	EXACT
MATRIX KICK	4	2	true
DRIFT KICK	4	3	true

- What did we learn
  - Control on the error
  - Performance gain
  - Confidence: convergence toward “reality”

Performances

- "Qualitative" results obtained on my machine
  - Average of 3 simulations for each set of parameters

MODEL	METHOD	NST	<TIME> [s]
MATRIX KICK	6	5	86
MATRIX KICK	4	2	47
DRIFT KICK	4	3	52
MATRIX KICK	4	3	53
MATRIX KICK	2	2	40

- MATRIX or KICK models show no difference
- Some "best" case can be obtained !

Splitting

- An optimum with respect to “precision” and performance is obtained
- A benchmark should be done again
  - With the new main magnet model (thick multipoles, results are expected to change !)
  - MTE multipoles are thin lenses

How do we control the splitting ?

- "PTC preserves the integrity of the magnets"
  - All the integration-related parameters can be defined element by element
  - We just used single global values for these parameters
  - We obtained a split lattice for one configuration only
  - Beware: a different integration model was used for some elements !
- Can we do better ?
  - Set the values magnet by magnet
    - Not practical
    - Although could be useful for MTE
  - Dynamics resplitting !

Resplitting

- The splitting should depend on the strength of the elements
  - A strong quadrupole should be split more than a weak short sextupole
- (Simple) Algorithms are available in PTC to split the elements based on their strengths
  - Magnets with a quadrupolar component can be resplit based on an equivalent thin lens strength
  - Bends can be resplit based on an equivalent strenght
  - We can force an even or odd splitting

What do we do with that for PS ?

- We obtained a global static splitting for a given configuration
- If we reproduce that result with resplitting, then we can resplit for any configuration and automatically generates the split lattice
- As we have combined function magnets the "bend resplitting" is hidden in the quadrupole resplitting

Resplit lattice of the PS

- Reproduce our manual global splitting

Thin lens equivalent [1/m]	0.01
Limit order 2 to order 4	5
Limit order 4 to order 6	1000

“The lattice”

- We obtain “the lattice”
  - Starting point for all PTC simulations
- Behaves the same for different configurations of the machine
- Generated dynamically
  - With flags for the layout
  - Dynamics resplitting for the integration step

➢Improved the performances, known errors on the linear and nonlinear parameters

Overview

- PTC as a symplectic integrator
  - S-based integration and splitting
  - Data structures: what should we model ?
- A model of the PS lattice
  - New customizable model of the PS
  - Splitting of the lattice
  - How to control the splitting ? Dynamic resplitting
  - "The lattice"
- In practice
  - Lattice preparation for MAD-X/PTC and ORBIT/PTC
  - Tools and lattice repository

Using the lattice with MAD-X/PTC

- Set the flags
- Load the lattice
- Initialize PTC
- Load a PTC script to resplit the lattice

- Stick to that model !
  - Split in the same way in your matching macro !

Using the lattice with MAD-X/PTC

- The new lattice is available on AFS

  /afs/cern.ch/user/c/chernals/public/PS/lattice

- Examples are also provided

  /afs/cern.ch/user/c/chernals/public/PS/ps-madx-example

Using the lattice with ORBIT/PTC

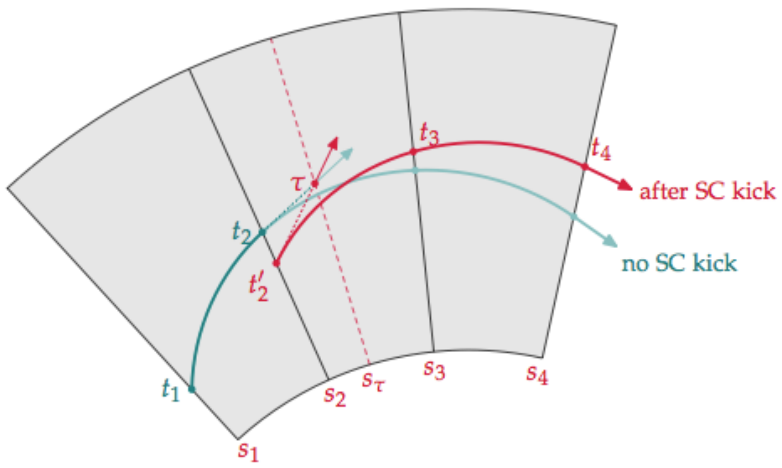
- In MAD-X/PTC, we have MAD-X acting as a manager for the lattice
  - ORBIT doesn't have that
  - Preliminary step is needed …
- Prepare the flatfile
  - With a MAD-X/PTC script

    /afs/cern.ch/user/c/chernals/public/PS/flatfile

  - Additional splitting: LMAX business

Using the lattice with ORBIT/PTC

- Two ways to consider it
  - Space charge nodes should not be more than LMAX apart
  - We can turn an s-based integrator into a first order time based integrator



Using the lattice with ORBIT/PTC

- After the resplitting, lengths of elements are checked one by one:

$$\text{if } dl > \text{LMAX} * \text{FUZZY} \rightarrow \text{nsteps} = \frac{\text{length}}{\text{LMAX}} + 1$$

- The algorithm can choose to apply that criteria to
  - None (0)
  - Drifts (1)
  - All (2)
- I added an option to resplit based on the length only (3)

Conclusions

- A new clean PS lattice
  - Gain in performance
- Splitting better understood, set of “gold” values for the integration parameters
  - Control of the error
- Code trivialities
  - Have ORBIT running as an interface for multiparticles tracking

/afs/cern.ch/user/c/chernals/public/PS