Synergia: Development and Applications

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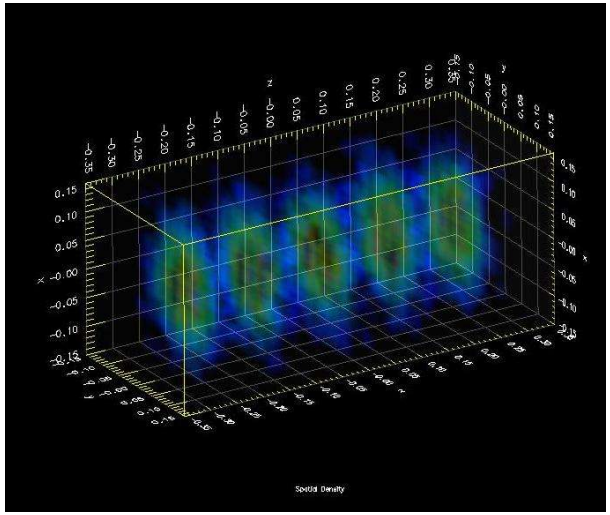
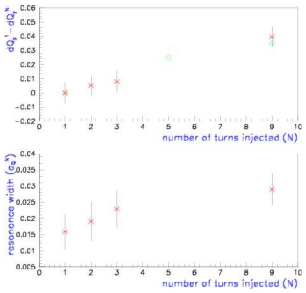
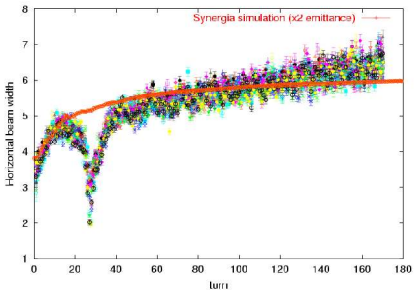
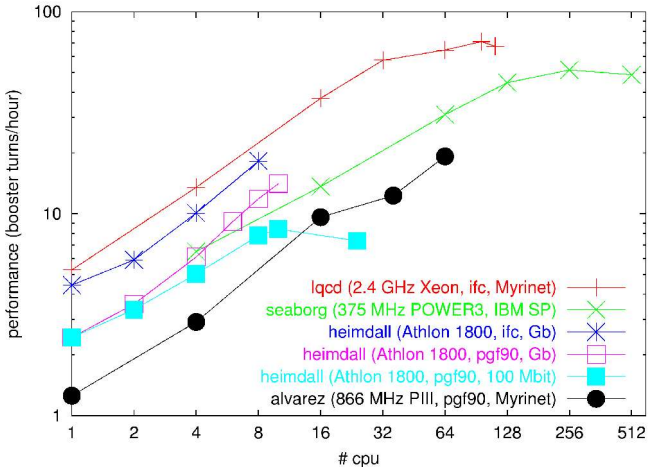
SciDAC Project Meeting, Fermilab
11th August 2004









Συνεργεια

Fermilab SciDAC team activities

- Synergia development
  - interfacing, extending, & encapsulating components
  - job management

http://cepa.fnal.gov/psm/aas/Advanced_Accelera

- Beam studies
  - analysis tools & analysis

J.Amundson & P.Spentzouris in collaboration with R. Ryne, J. Qiang & L. Michelotti

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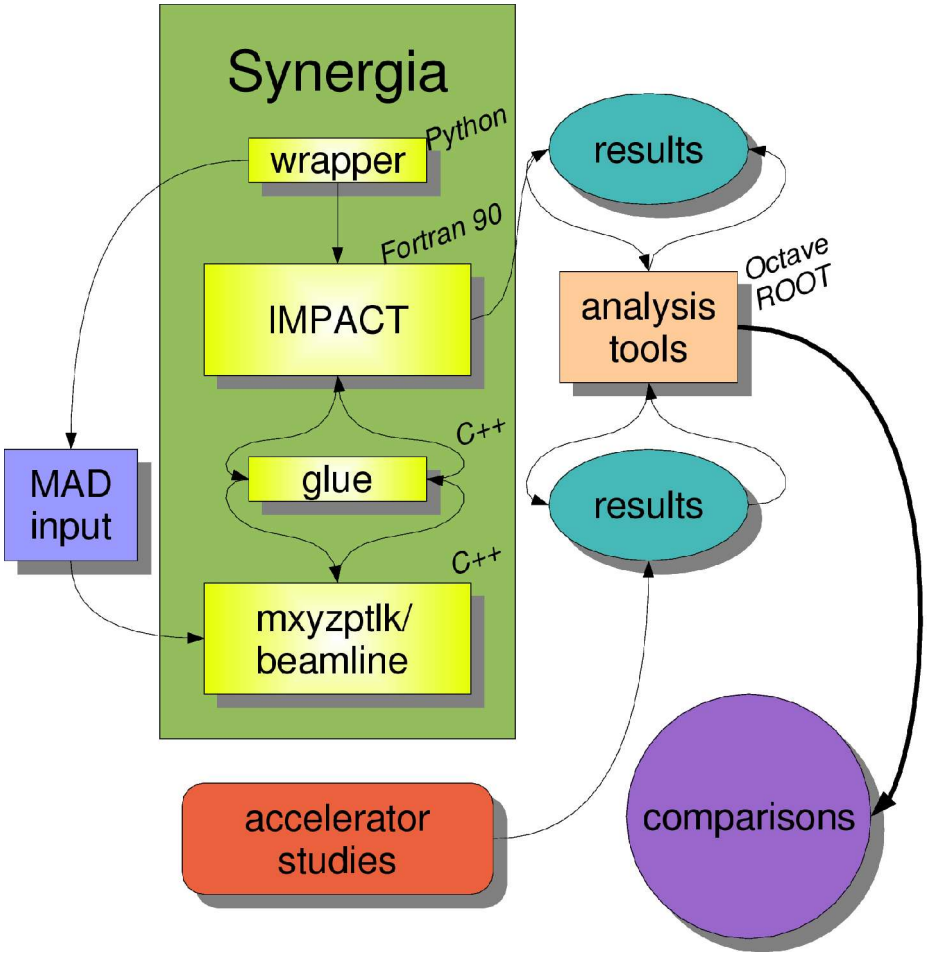
Synergia Objectives

- Develop beam dynamics framework to model 3-D collective beam effects
  - model future and operating accelerators
- The code should
  - Integrate/utilize existing packages
  - Be easily distributable & portable
- First application: Fermilab Booster
  - benchmark code & help optimize machine performance

Συνεργεια

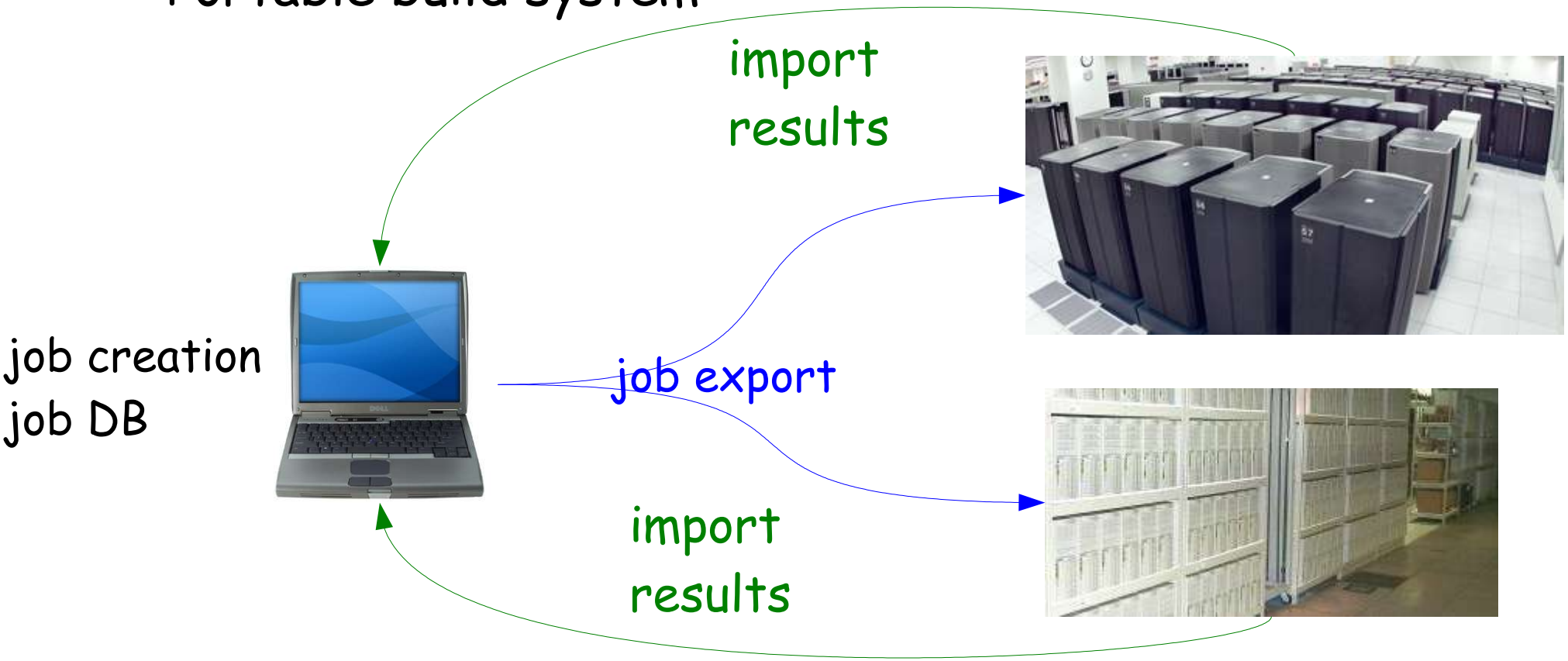
Synergia update

- Fully functional & tested space charge package
  - modularized and encapsulated components
  - prototype of more flexible framework for new physics modules (w/TechX SBIR I)
- Higher order maps



Synergia update, cont.

- Fully functional job management system
- Portable build system



Συνεργεια

Synergia update cont

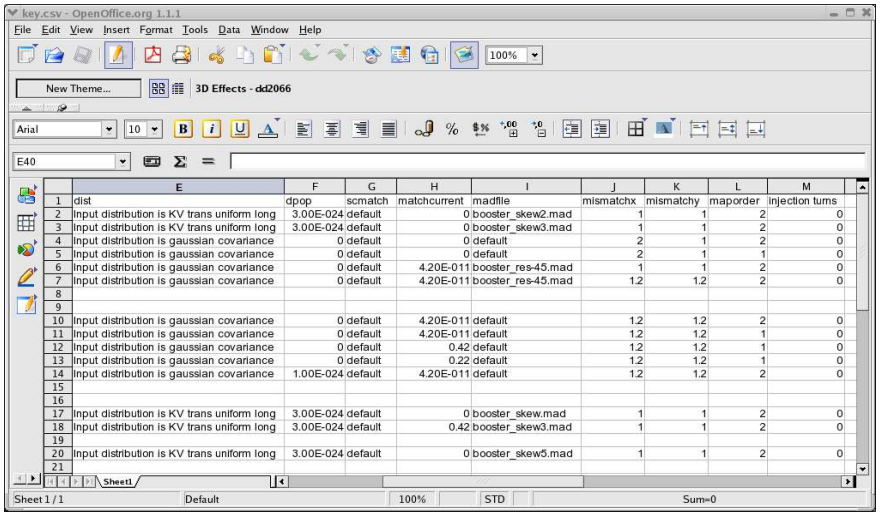
```
mad_file = myopts.get_value("Mfile")
(D_x, D_y) = madcalc.dispersion_initial(mad_file,"bcelinj",
                                        myopts.get_value("energy"))
if myopts.get_value("matchcurrent") != None:
    match_current = myopts.get_value("matchcurrent")
else:
    match_current = ip.current()
[sigma_x,sigma_xprime,r_x,sigma_y,sigma_yprime,r_y] = envelope_match(
    myopts.get_value("emit"), match_current,mad_file)

mismatchx = myopts.get_value("mismatchx")
mismatchy = myopts.get_value("mismatchy")
ip.x_params(sigma = sigma_x * mismatchx, lam = sigma_xprime * pz / mismatchx)
ip.y_params(sigma = sigma_y * mismatchy, lam = sigma_yprime * pz / mismatchy)
```

job creation script

MAD files

matching module



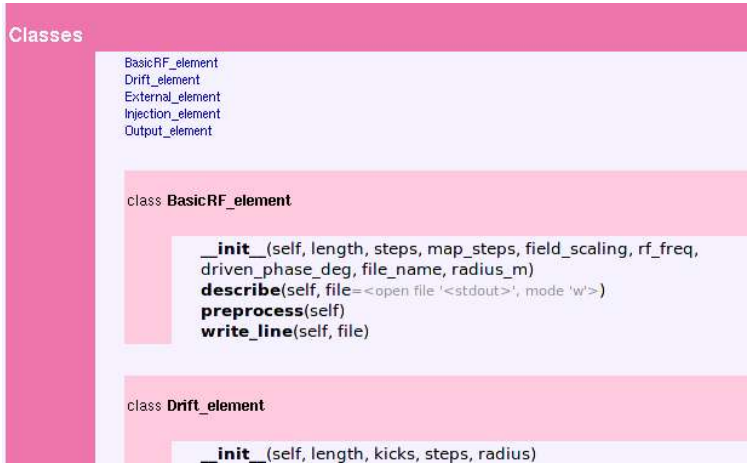
key.csv - OpenOffice.org 1.1.1

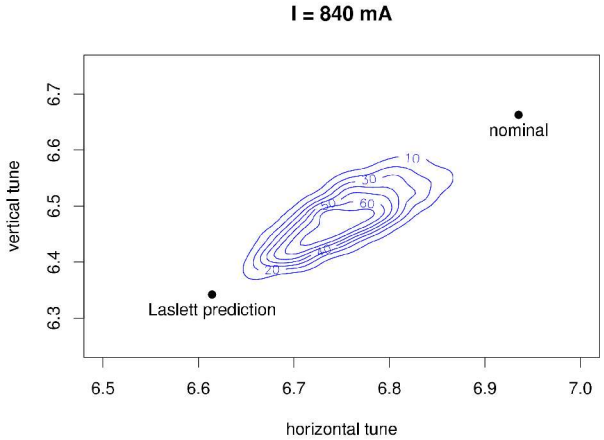
	E	F	G	H	I	J	K	L	M
1	dist	dpop	scmatch	matchcurrent	madfile	mismatchx	mismatchy	maporder	injection turns
2	Input distribution is KV trans uniform long	3.00E-024	default	0	booster_skew2.mad	1	1	2	0
3	Input distribution is KV trans uniform long	3.00E-024	default	0	booster_skew3.mad	1	1	2	0
4	Input distribution is gaussian covariance	0	default	0	default	2	1	2	0
5	Input distribution is gaussian covariance	0	default	0	default	2	1	1	0
6	Input distribution is gaussian covariance	0	default	4.20E-011	booster_res-45.mad	1	1	2	0
7	Input distribution is gaussian covariance	0	default	4.20E-011	booster_res-45.mad	1.2	1.2	2	0
8									
9									
10	Input distribution is gaussian covariance	0	default	4.20E-011	default	1.2	1.2	2	0
11	Input distribution is gaussian covariance	0	default	4.20E-011	default	1.2	1.2	1	0
12	Input distribution is gaussian covariance	0	default	0.42	default	1.2	1.2	1	0
13	Input distribution is gaussian covariance	0	default	0.22	default	1.2	1.2	1	0
14	Input distribution is gaussian covariance	1.00E-024	default	4.20E-011	default	1.2	1.2	2	0
15									
16									
17	Input distribution is KV trans uniform long	3.00E-024	default	0	booster_skew.mad	1	1	2	0
18	Input distribution is KV trans uniform long	3.00E-024	default	0.42	booster_skew3.mad	1	1	2	0
19									
20	Input distribution is KV trans uniform long	3.00E-024	default	0	booster_skew5.mad	1	1	2	0
21									

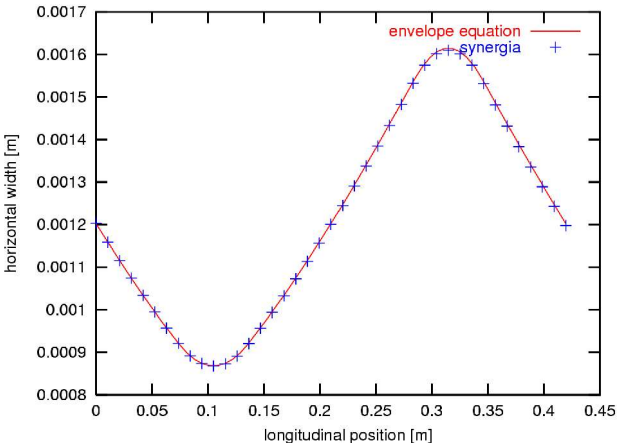
automatic job DB

Synergia update cont

- Initial test suite & documentation system
- Improved memory management
- Improved particle data structures
- More general & accurate input distributions







Συνεργεια

Booster beam studies

- Use the Booster IPM
  - turn by turn data for entire cycle
  - calibrated response (PRSTAB 6, 102801 (2003))
- Offline analysis of data
  - Octave/C++ analysis package
- Collaboration with AD personnel over the past 3 years
- Fermilab AD already using our tools

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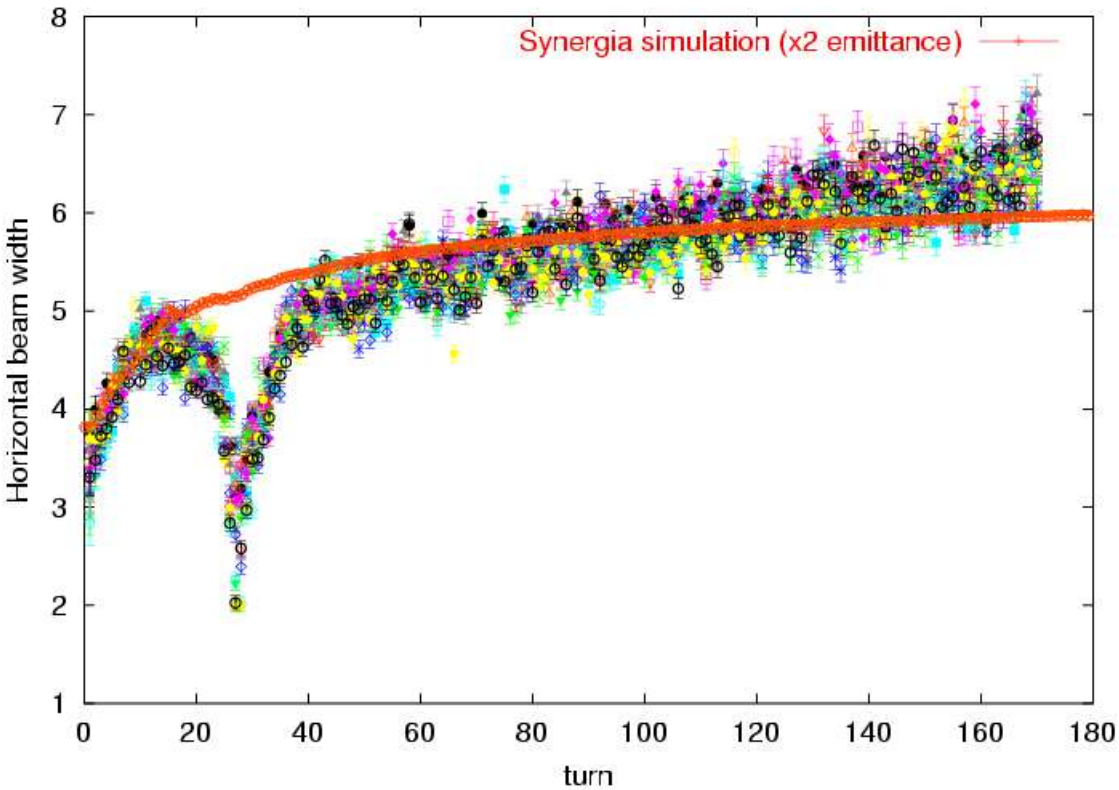
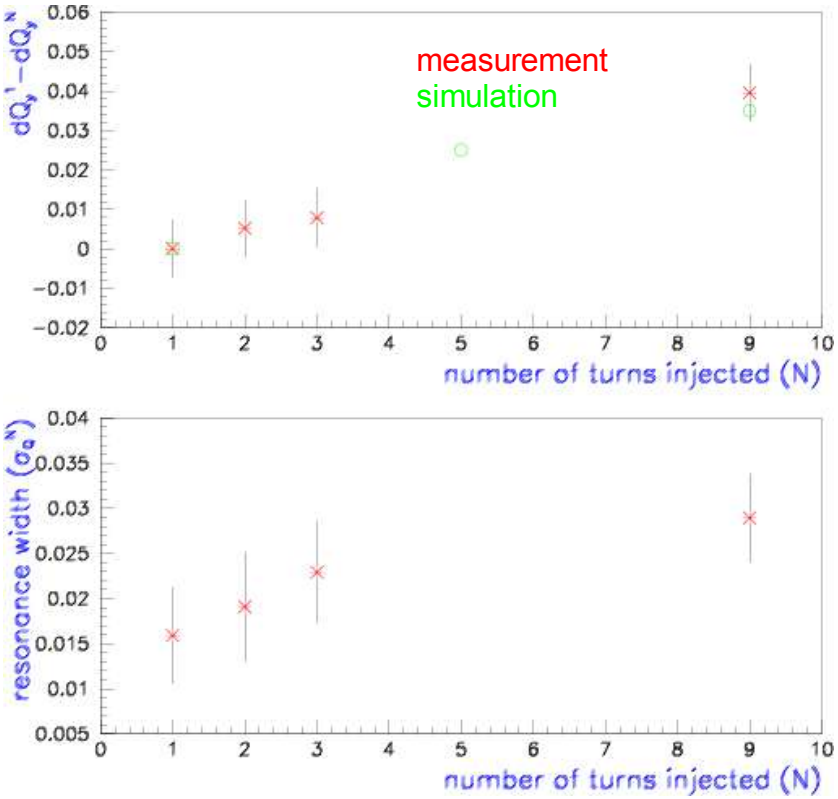
Booster studies

beam width evolution



coherent tune shift

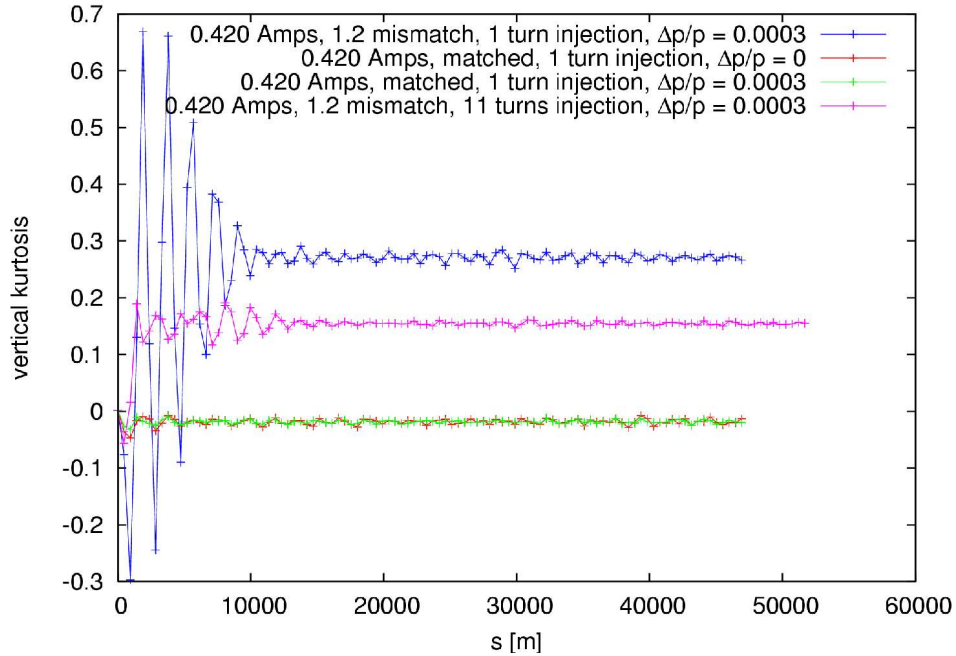


Studying Halo Formation

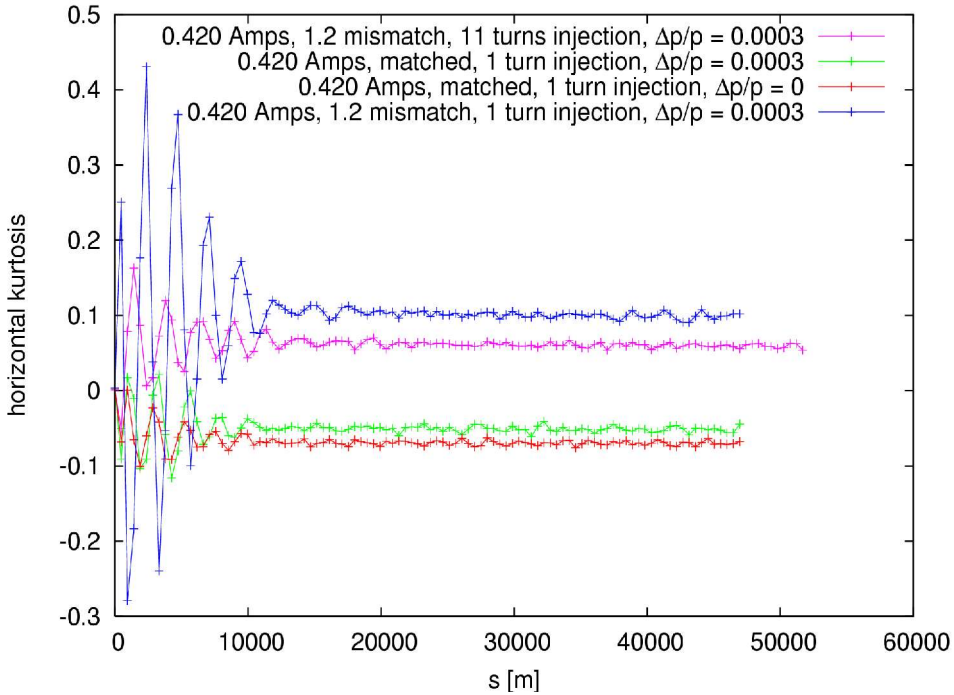
Συνεργεια

kurtosis $k \equiv \frac{\left\langle (x - \langle x \rangle)^4 \right\rangle}{\left\langle (x - \langle x \rangle)^2 \right\rangle^2} - 3$

horizontal

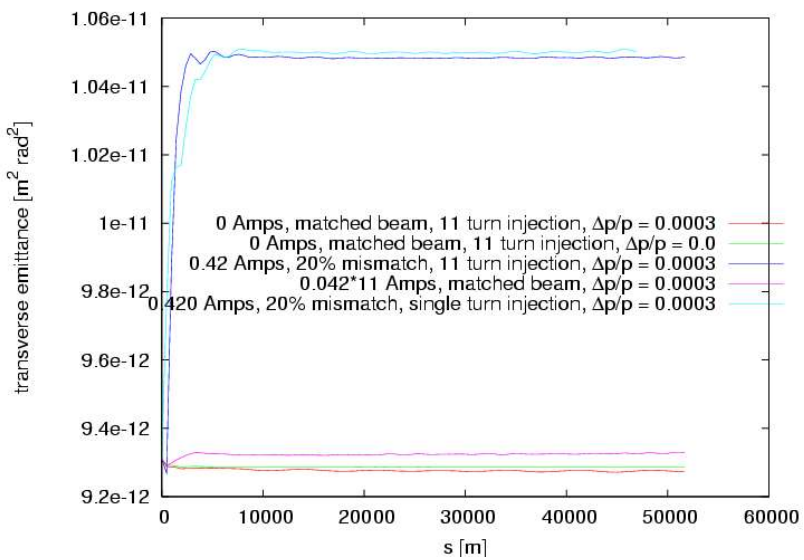


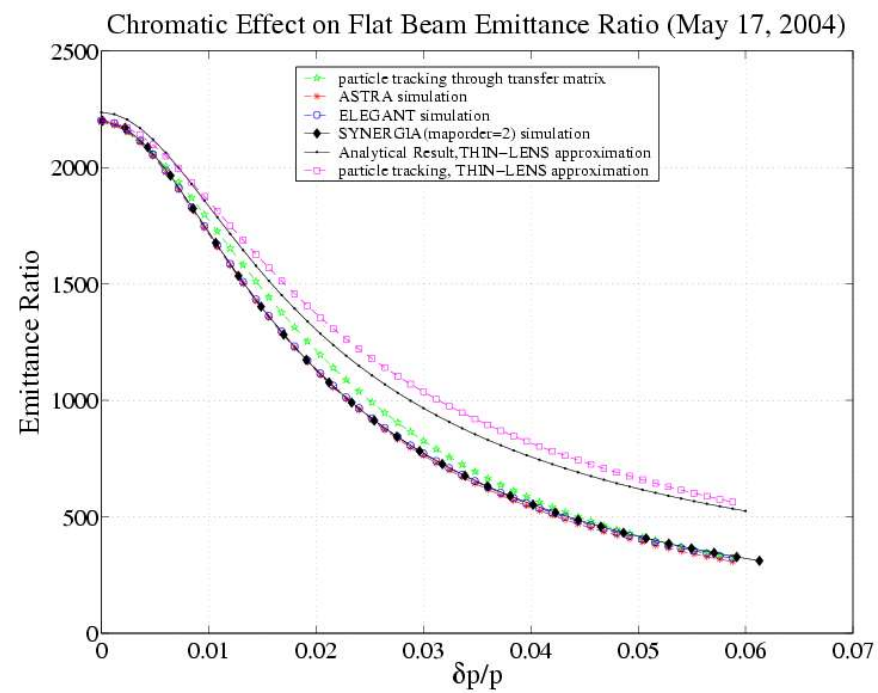
vertical



Higher order maps

- A0 photoinjector emittance transformer
- Booster chromatic effects





mxyzptlk provides arbitrary order maps

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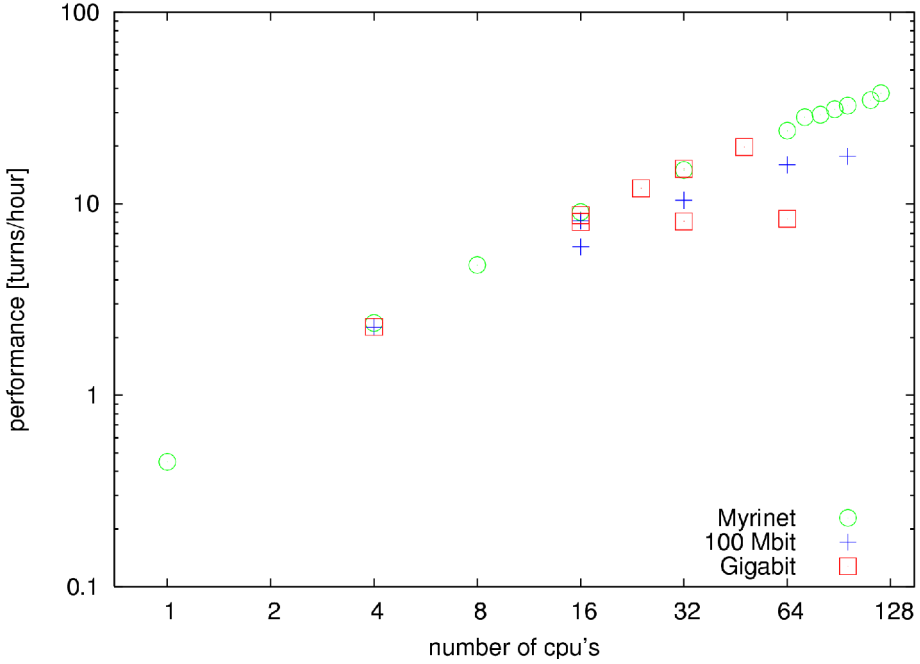
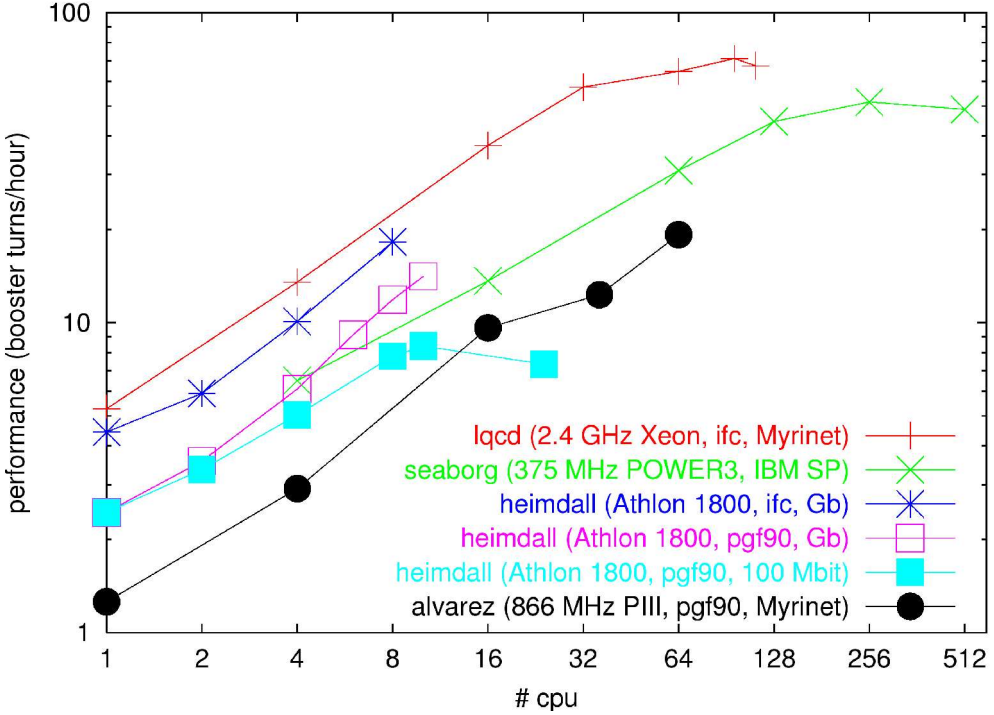
Performance



Work done on both clusters and seaborg. Most jobs done on clusters due to queue latency.



optimization needed:

- cluster networking
- solvers, particle manager

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Plans

- Complete modularization of Synergia
  - SBIR II with TechX
- Complete documentation & test suite
- In-depth physics studies of the Booster
- Performance profiling and optimization
- Add new physics modules

Synergia framework design goal

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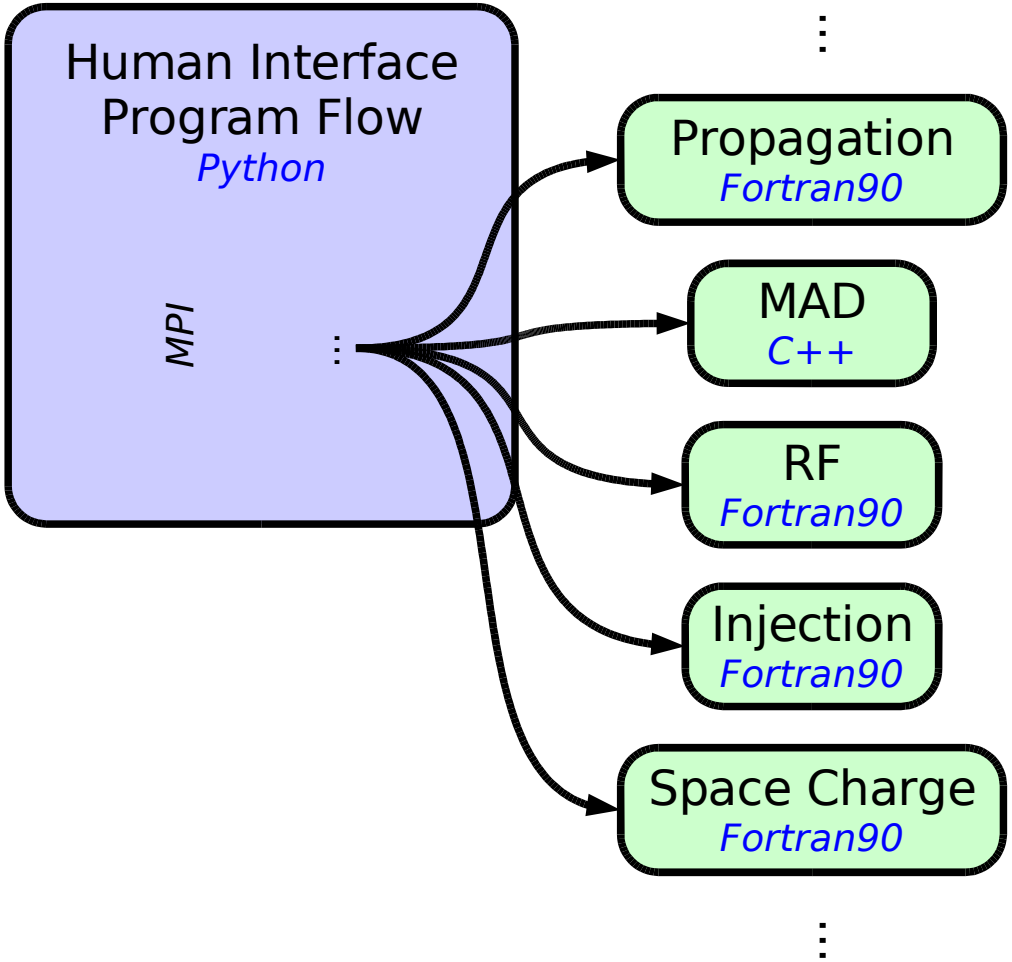
- Advantages
  - greatly enhanced flexibility
    - new physics modules can be trivially added
    - dynamic loading possible
  - better interface definition



work to be done with TechX

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New Physics

- Wakefields
- Beam-Beam
  - strong-strong applications for Tevatron
- Intra-beam scattering
- Electron cooling
  - Recycler
- Electron cloud effects (LHC)

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Summary

- Synergia is a distributable beam dynamics framework
  - incorporates and extends existing codes
  - provides job management system
  - documentation & test suite
- Used to compare with beam studies
- Will be extended to include more physics
- Would benefit from optimization work