



Συνεργεια

Accelerator Simulation

P. Spentzouris

Accelerator activity coordination meeting 03 Aug '04



Συνεργεια

Accelerator modeling activities

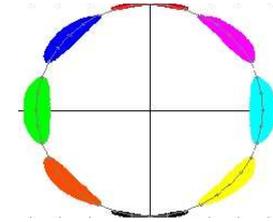
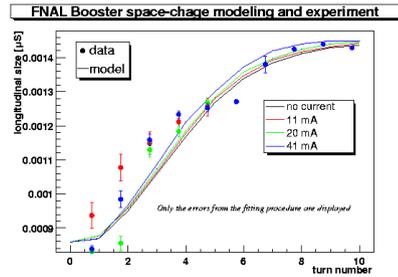
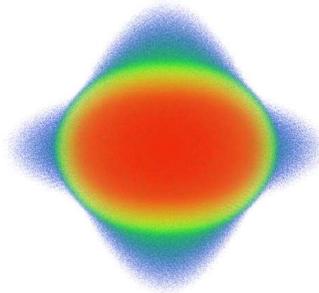
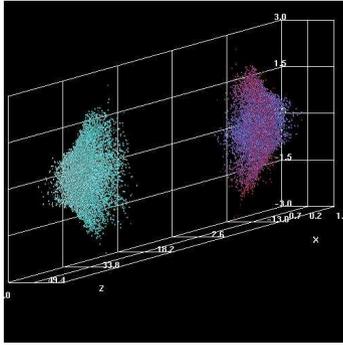
- Note I did not say projects...
- SciDAC accelerator modeling **project**
http://cepa.fnal.gov/psm/aas/Advanced_Accelerator_Simulation.html
- Booster beam studies
 - analysis tools & analysis
- MCR optics software
- ➔ contributors: J.Amundson & P.Spentzouris



Συνεργεια

SciDAC Accel. Modeling Project

- What we have accomplished
 - the first 3 years of SciDAC
- What we would like to accomplish (baseline)
 - the next 2 years & setting up future projects
- Opportunities (additional manpower)
 - developing the foundation for a long term program. Investing now for a larger return later!



LBL
 Beam-beam modeling,
 space charge in linacs &
 rings, parallel Poisson
 solvers, collisions

UC Davis
 Visualization,
 multi-resolution
 techniques

FNAL
 Software Integration, Lie
 methods, space charge in
 rings, Fermilab Booster
 simulation and experiment.

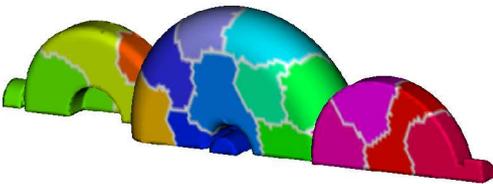
BNL
 Wakefield effects,
 Space charge in rings,
 BNL Booster simulation



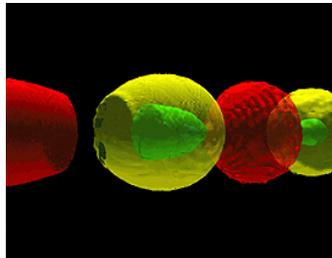
$$M = e^{f_2} e^{f_3} e^{f_4} \dots$$

$$N = A^{-1} M A$$

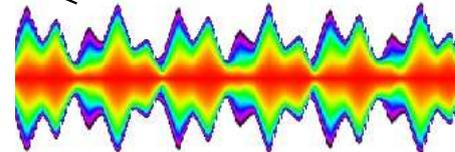
U. Maryland
 Lie Methods in
 Accelerator
 Physics, MaryLie



SLAC
 Electromagnetic component modeling



UCLA
 Parallel PIC
 Frameworks



LANL
 High order optics,
 beam expts, collisions,
 multi-language support,
 statistical methods

Multi-institution collaboration, \$3M/3 years, FNAL ~0.32M/3years
 2 year extension, 30% bump up for FNAL, flat project budget!



Συνεργεια

Objectives (a reminder)

- Create Beam Dynamics code with the ability to **model 3-D collective beam effects**
 - Utilize power of **parallel computing**
 - 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

Status

- Fully functional & tested space charge package
 - modularized and encapsulated components
 - prototype of more flexible framework for new physics modules (w/TechX SBIR I)
- Fully functional job management system
- Portable build system
- Initial test suite & documentation system
- Baby steps on beam-beam modeling



Συνεργεια

Status, continued

- Awarded two year extension proposal (SciDAC), ~30% increase
- Initiated collaboration with university CS
 - submitted proposal to NSF with DePaul
 - supported career grant with IIT
- Got SBIR II with TechX.
 - expect 1 FTE x 2 years resident at Fermilab



Συnergia

Plans from March report

- In Fy04 wrap-up Booster modeling (space-charge studies) [on track]
- Publish Synergia description & Booster studies [submitted]
- In collaboration with LBNL/AD begin incorporating beam-beam effects [started, but...]
- Extend A0 modeling [added 2nd order maps]



Συνεργεια

Other possibilities (FY04)

- Beam-beam studies at the Tevatron
 - It is important to apply beam-beam modeling @ Tevatron using the same approach as with space charge & Booster: **studies, validation, realistic parameters**
 - current level of involvement 1.3 + 0.3 FTE (1 JFA + 0.3 PGS + 0.3 PGS research time) **is not sufficient. Will need additional 1 FTE.**



Συnergia

Plans

- Complete modularization of Synergia
 - SBIR II help
- Complete documentation & test suite
- In depth physics studies of the Booster
- Performance profiling and optimization
- Integration of new physics modules
 - beam-beam first
 - Tevatron application & studies



Συνεργεια

Future plans

- Electron Cooling
- Intra-beam scattering
 - Additional manpower will accelerate development & make effort relevant for Run II.
- Electron cloud effects (LHC)
- Extend job interface to the Grid
 - utilize Grid computing
 - potentially demonstrate Fermilab's MPI capabilities



Συνεργεία

Manpower

- **Blue tasks** require 2 additional FTE for 2 years
- To include **green tasks** requires total of 2.5
 - we can leverage infrastructure projects with other PSM activities
- Beam studies at the Tevatron will require more collaboration with AD.

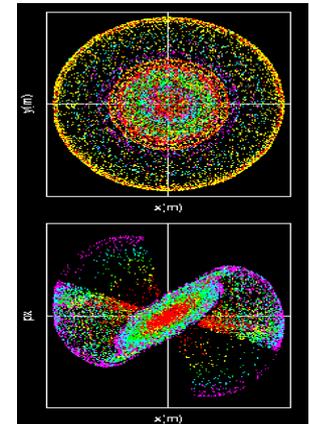


Συνεργεία

High-fidelity Beam Dynamics Code Development Timeline

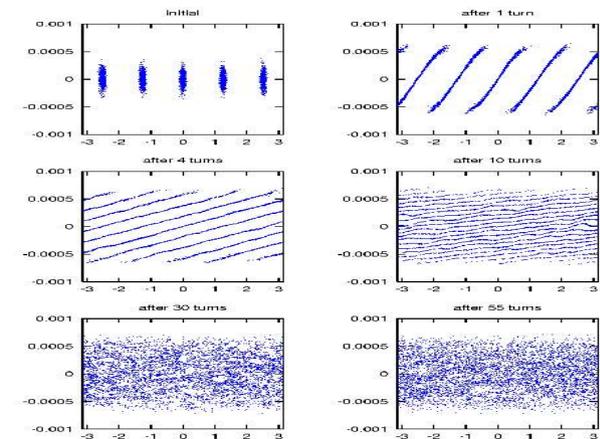
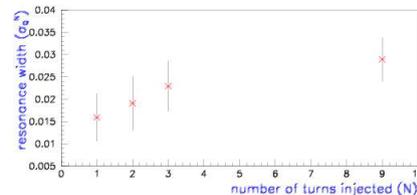
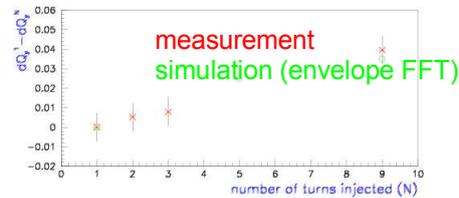
FNAL missed 10 years of funding opportunities

- Early 1990s: LANL-funded 2D PIC code development
- Mid 1990s: DOE Grand Challenge
 - LANL/SLAC/Stanford/UCLA
- 1999: DOE/HENP bridge funding to SciDAC project
 - introducing **FNAL** {space-charge in ionization cooling}



→ 2001: **SciDAC Project**. **FNAL is a major contributor**

- Modeling of high intensity beams in circular machines
- Beam studies and analysis
- Extensible framework, integrated components





Συνεργεια

Other activities

- Collaboration with AD, data taking and computing
 - data for model comparisons
 - unique within SciDAC project
 - useful to AD operations
 - build collaborative ties with AD
 - important for long term involvement



Συνεργεια

Beam Studies

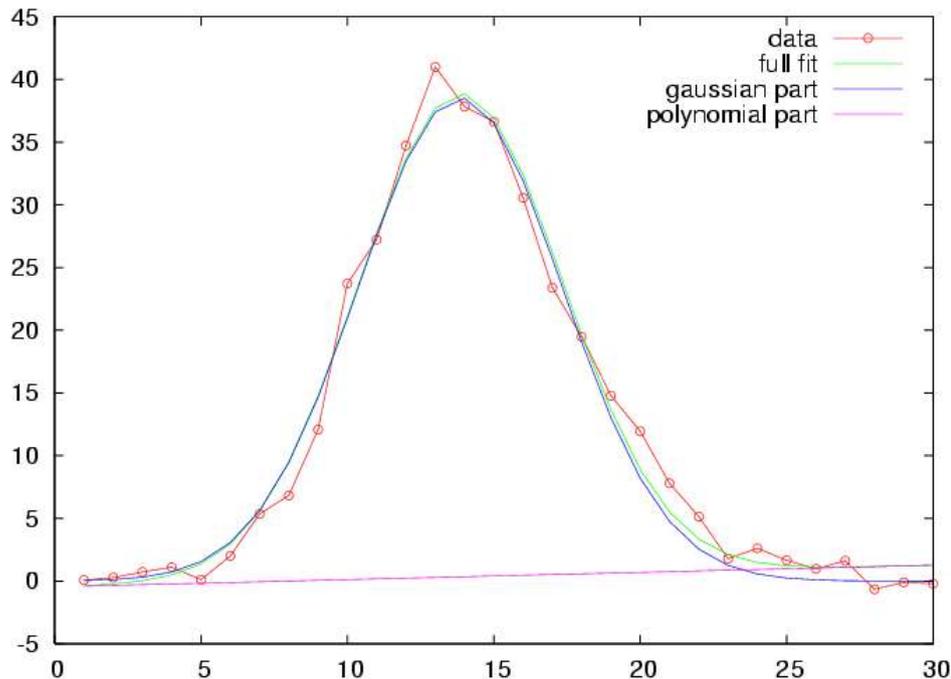
- Use the Booster IPM
 - turn by turn data for entire cycle
 - calibrated response ([PRSTAB 6, 102801 \(2003\)](#))
- Offline analysis of data
 - Octave/C++ analysis package
- Collaboration with AD personnel (J. Lackey, B. Pellico, T. Sullivan) over the past 3 years
- AD already using calibration and analysis tools



Συνεργεια

First quantitative measurement of collimator effects!

horizontal beam profile



To quantify the size of the “non-Gaussian” bgnd:

- take 5 data sets with and without collimators
- average **turns 100-200** and **turns 5100-5200**
- take the difference of no collimator minus nominal

Horizontal plane results:

early: 0.2699 ± 0.0411

late: 0.45052 ± 0.03992

Excess ~5% to 10% in non-Gaussian part .

Integral of non-Gaussian part is (40 to 90/400) = 10 to 22% of the total



Συνεργεια

MCR optics software

- Development of modeling tools to assist tuning in MCR
 - Collaborate with L. Michelotti and F. Ostiguy
 - Participate in design
 - testing and infrastructure
 - MCR application early users
- useful for Fermilab operations, long term relationship with AD