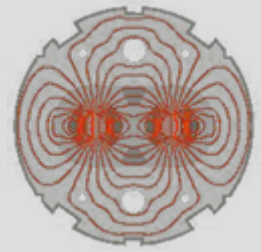




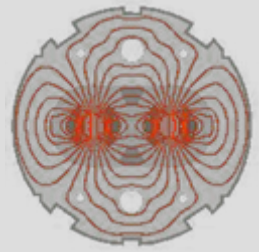
LHC On-Line Modeling



- **The LHC On-line Model: what it is NOT!**
- **What is it then?**
- **The Team and the Tasks**
- **SDDS MAD-X Version**
- **Status of MAD-X**
- **Scheme of the LHC On-line Model**
- **Test of Non-Linear Model and Corrections**
- **Milestones**



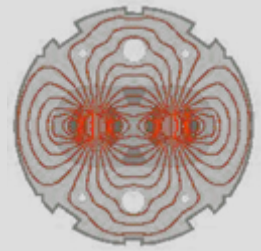
The LHC On-Line Modeling: what it is NOT!



- **Real-time control**
- **Interference with the LHC operation**
- **“Re-invention” of established tools**
- **Lengthy Off-line Analysis**



Then what is the LHC On-Line Modeling?

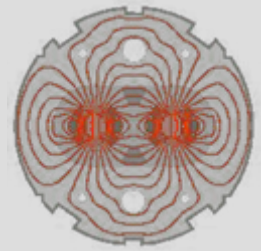


- The LHC machine will be a very demanding accelerator with large nonlinearities to control. Particle loss in the LHC must be actively controlled to avoid damage to the machine. Therefore any critical adjustment to the machine must be checked *beforehand* with a proper MAD-X model of the LHC.
- ABP is convinced that this machine will require a powerful on-line modeling tool that is tested and ready for use in the control room before the LHC will be commissioned.
- Main design features:
 - The SDDS MAD-X version is the principle engine of the LHC on-line model.
 - A complete and trustworthy non-linear model of the LHC will be composed with the databases of the measured magnet errors and beam-based measurements.
 - Access of knobs to and fro the control system for testing with MAD-X *before* send-to-hardware.
 - Experimenters and operators should profit from a fully functional on-line tool!
 - Speed-up the off-line analysis time such that it can be done within minutes directly in the control room.

Reference: <http://cern.ch/fidel>, L. Bottura & L. Deniau; Wise: P. Hagen, JP. Koutchouk, E. Todesco



The Team and Tasks



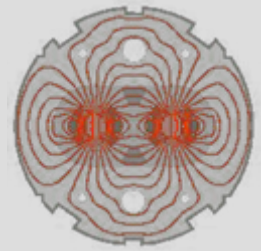
- **Frank Schmidt** - Overall Responsibility, MAD-X General Support, SDDS Interfaces, Non-linear LHC model from Fidel/Wise
- **Werner Herr** – SDDS MAD-X Version, Closed Orbit Correction
- **Ilya Agapov** – Interface to Control System, Application Development, Co-Responsibility for MAD-X Core & PTC_TWISS, Beam-Based Model Adjustments
- **Rogelio Tomás, Masmitsu Aiba & Akio Morita (KEK), Rama Calaga (BNL)** – Beta-Beating
- **Yiton Yan (SLAC)** – MIA (→2nd half 2009)

In Collaboration with:

- **Jörg Wenninger, V. Kain** – SPS Operation, 1000 turn BPM system, Standardization of SDDS
- **LSA Team (Mike Lamont, Greg Kruk, Sandeep Bharade)** – General control system, SDDS issues
- **Alastair Bland** – TECHNET Support



Special SDDS MAD-X Version



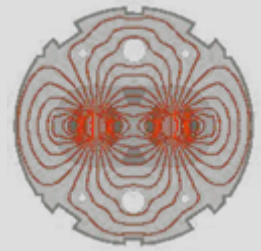
- **Werner Herr** has prepared this special version of **MAD-X**.
- The idea is to read and write **SDDS** files from MAD-X and to transform the back and forth between **TFS Tables**. Only **1-dimensional SDDS arrays** will be considered.
- Input example:

```
select,flag=sdds,clear;  
select,flag=sdds,pattern="^b.*";  
select,flag=sdds,pattern="^d.*";  
! convert: read SDDS and write TFS files  
sddsin,file="cngs-test.sdds",table="sdds_tfs";  
write, table="sdds_tfs",file="tfs1";
```

- **Reference: W.Herr and F. Schmidt, "Using SDDS data sets with MAD-X", AB-Note-2006-043 (ABP)**



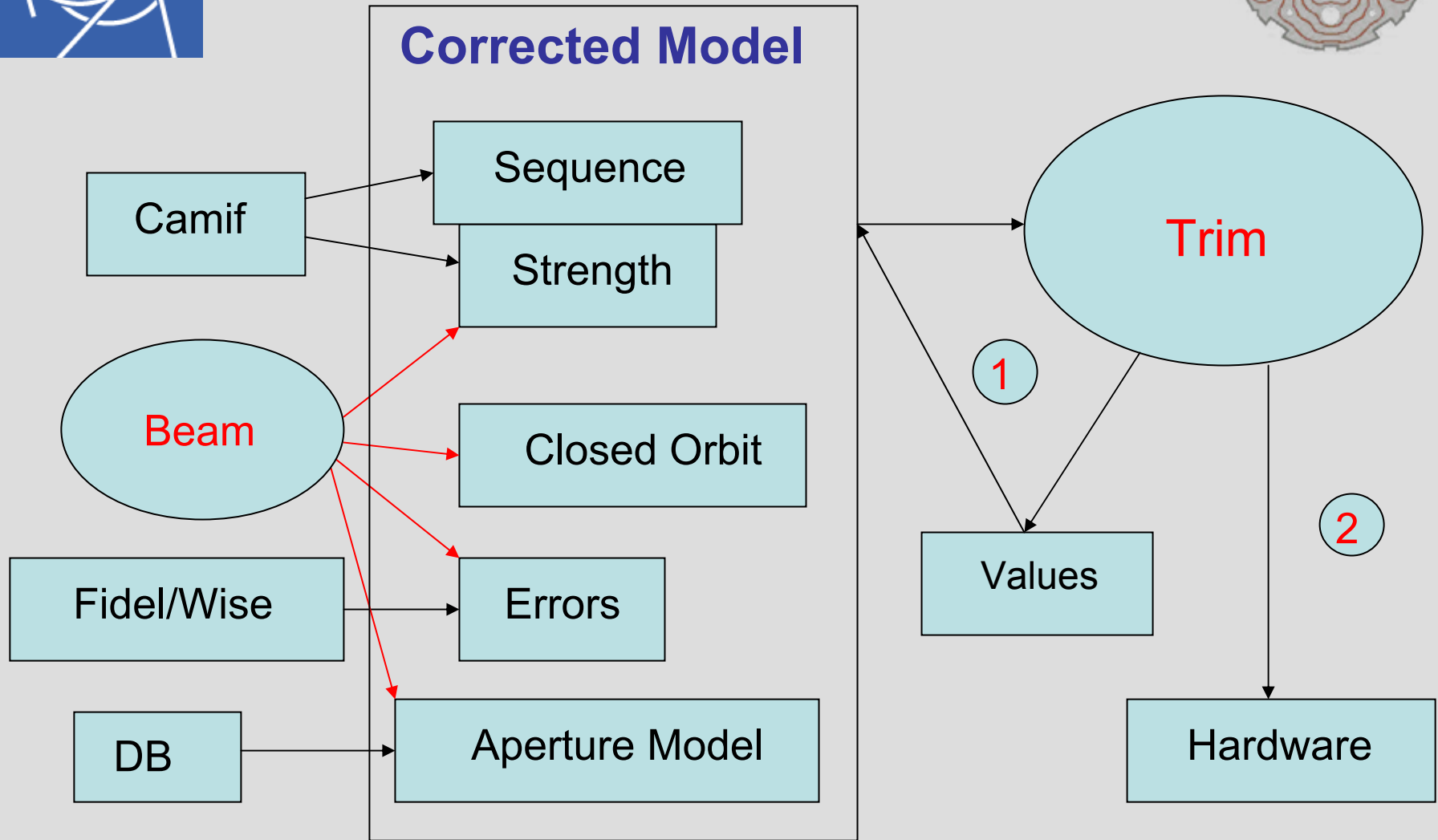
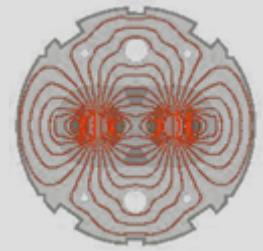
Status of MAD-X



- **Is MAD-X ready for the LHC commissioning?** →
- **Is MAD-X properly maintained?** ABP no longer provide several exclusive FTEs for program development and maintenance, instead there is one code custodian and a large group of [MAD-X Module Keepers](#).
- **Is MAD-X still further developed?** ABP has stopped the full blast development of MAD-X since the code fulfills the minimum LHC requirements. However, work is going on for CLIC from which LHC will profit. →
- **Is MAD-X reliable?** MAD-X has made use of the well debugged MAD8. Moreover, the independent programs SixTrack and PTC provide a continuous check such that any inconsistency could be eliminated.
- **Is MAD-X fast?** Indeed there are speed issues due to the mixture of Fortran and C code, dynamic memory allocation and the heavy access of tables → a speed-up will be investigated.

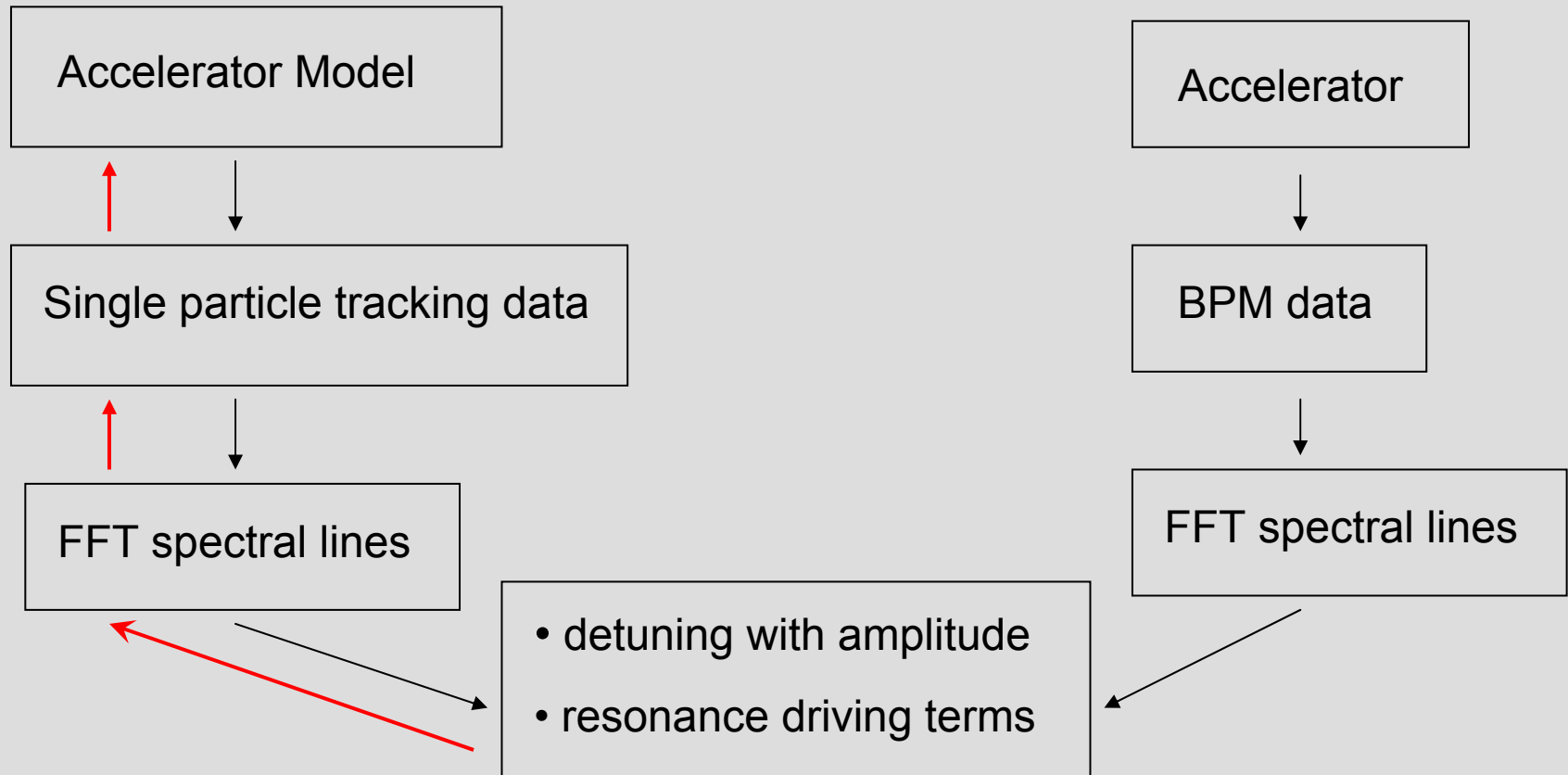
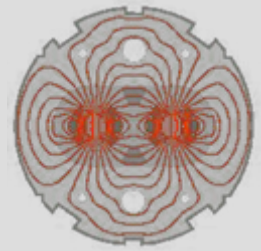


Scheme of the On-Line Model





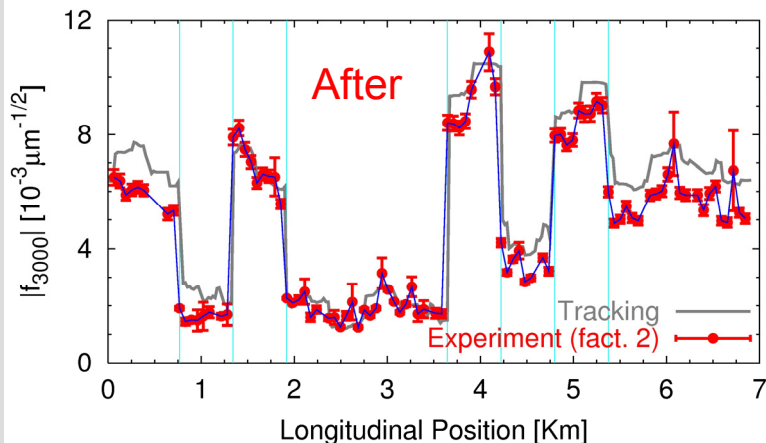
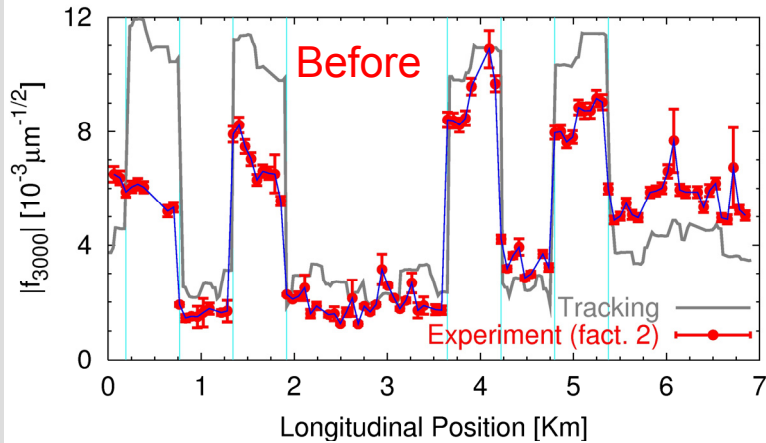
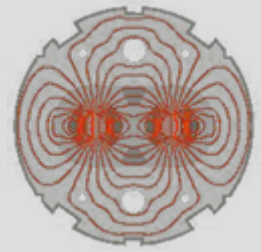
Test of the Non-Linear Model





Missing Sextupoles (SPS)

(F. Schmidt, R. Tomas et al.)



Specially arranged SPS configuration for extraction sextupoles

++++-----

(3,0) resonance driving terms

Data fully decohered (factor 2 correction applied)

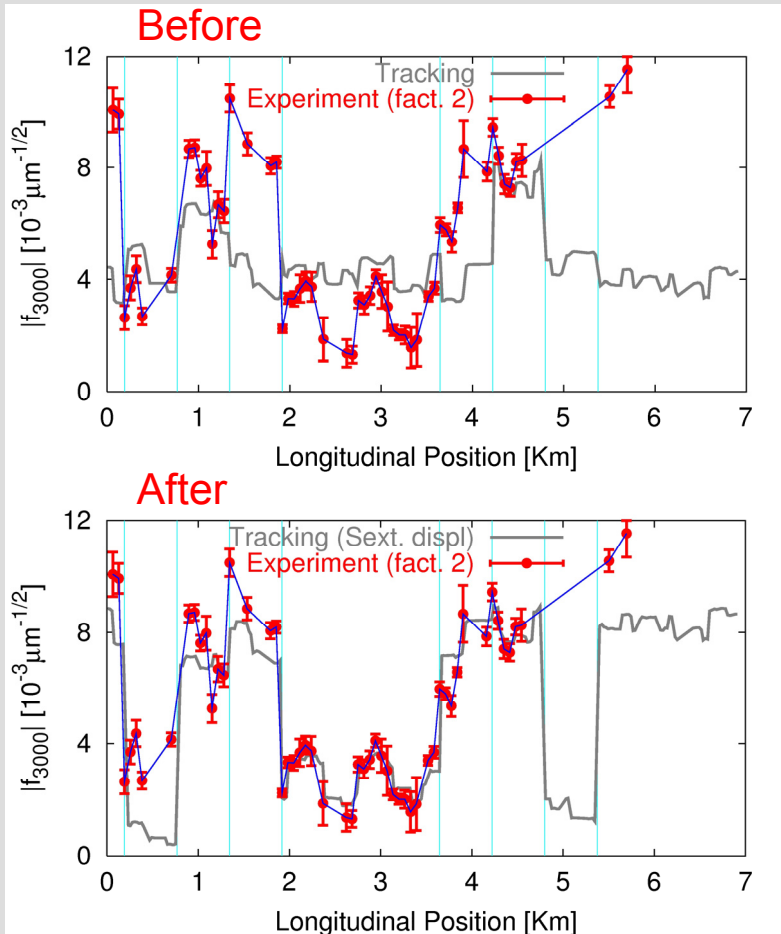
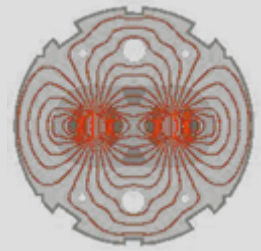
Comparison with nominal model

One extraction sextupole accidentally disconnect



Effect of Beta-Beating (SPS)

M. Hayes, F. Schmidt, R. Tomas et al EPAC02



Specially arranged SPS configuration for extraction sextupoles

+ + + + - - - -

(3,0) resonance driving terms

Data fully decohered (factor 2 correction applied)

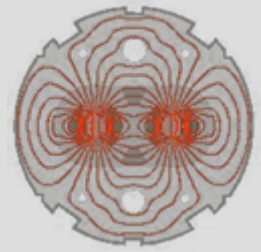
Comparison with nominal model

and model including closed orbit distortion at the extraction sextupoles

(better description of beta-beating in the model)



Uncompensated Skew Sextupole Resonance (PSBooster) (P. Urschütz, M. Benedikt)



CERN PS data

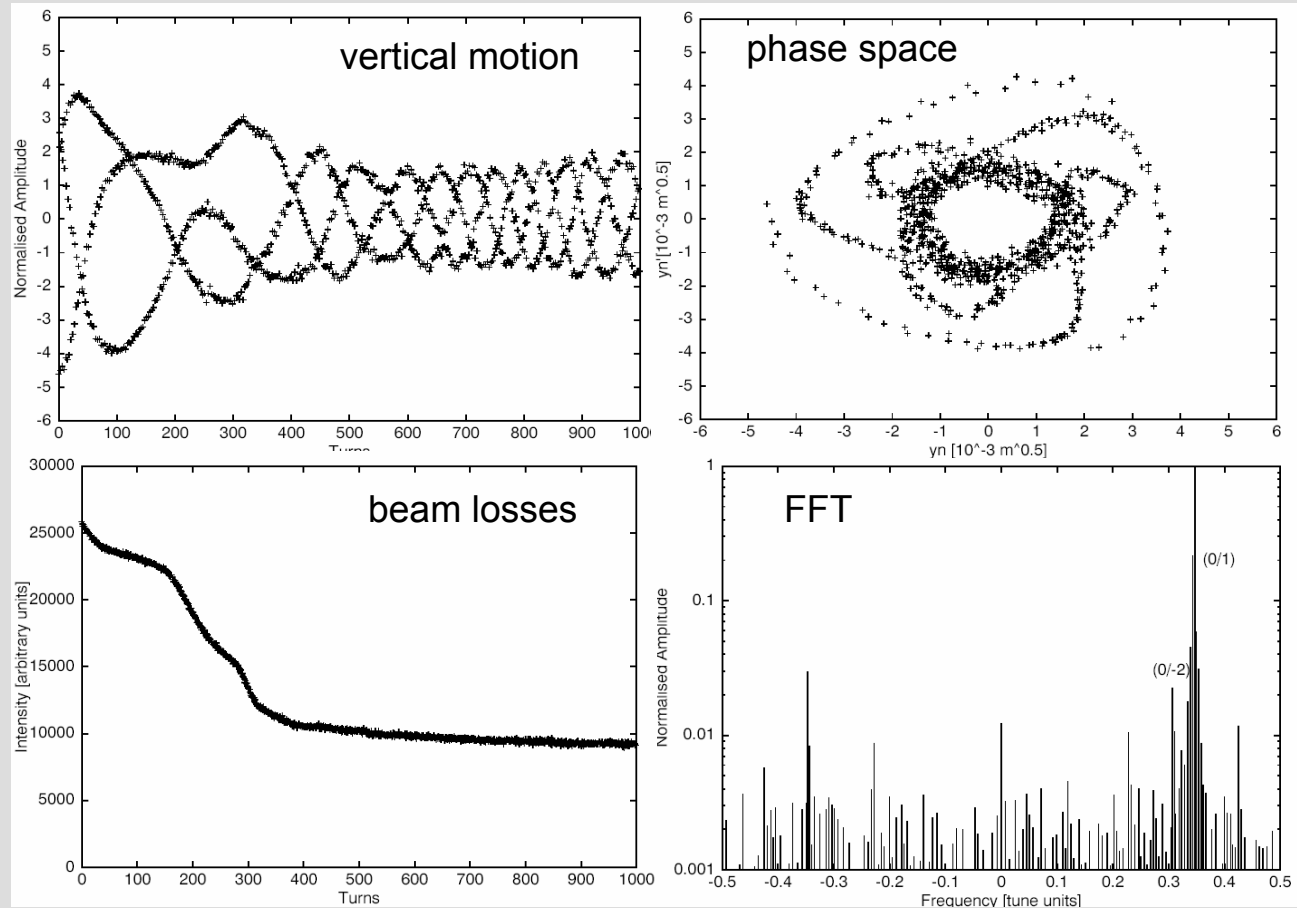
vertical plane

$$3Q_y = 16$$

and

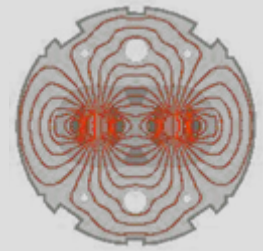
(0, -2) spectral line

Uncorrected machine





Corrected Skew Sextupole Resonance (PSBooster) (P. Urschütz, M. Benedikt)



CERN PS data

vertical plane

$$3Q_y = 16$$

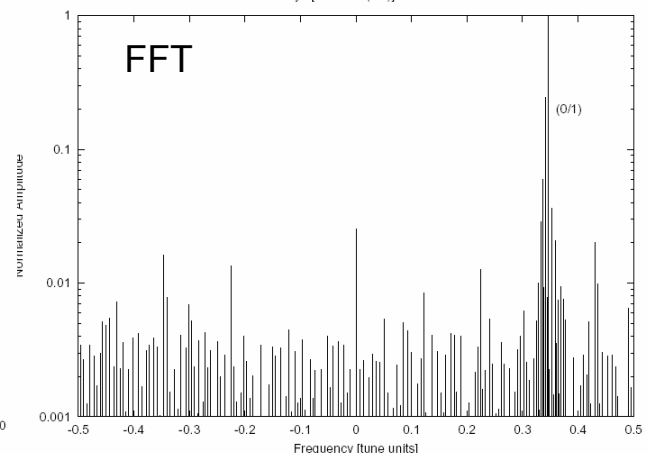
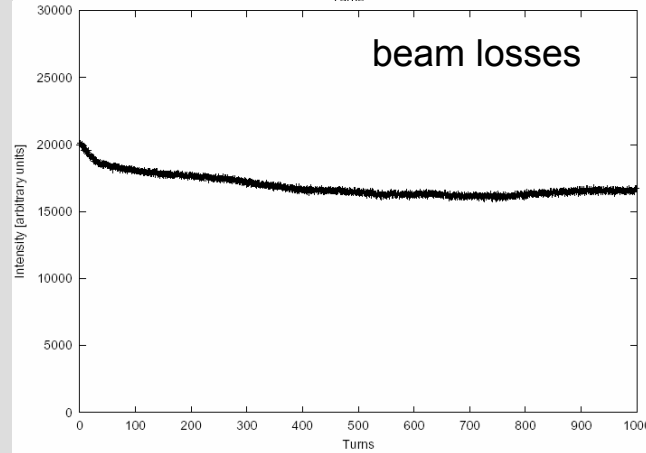
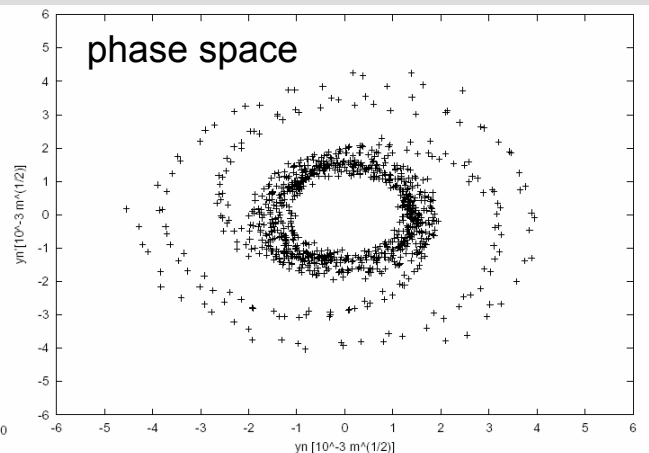
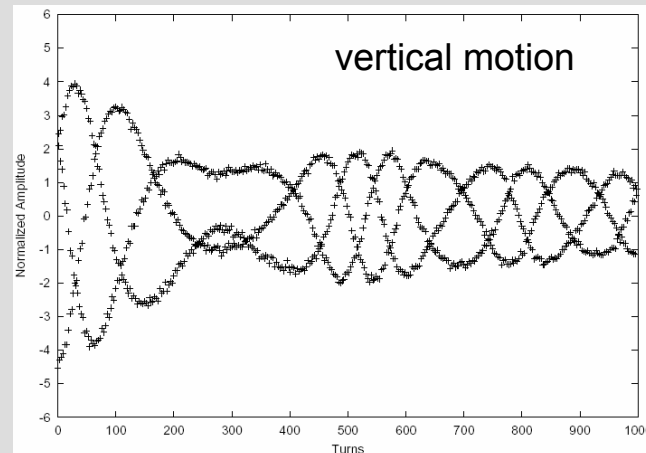
and

(0, -2) spectral line

Resonance

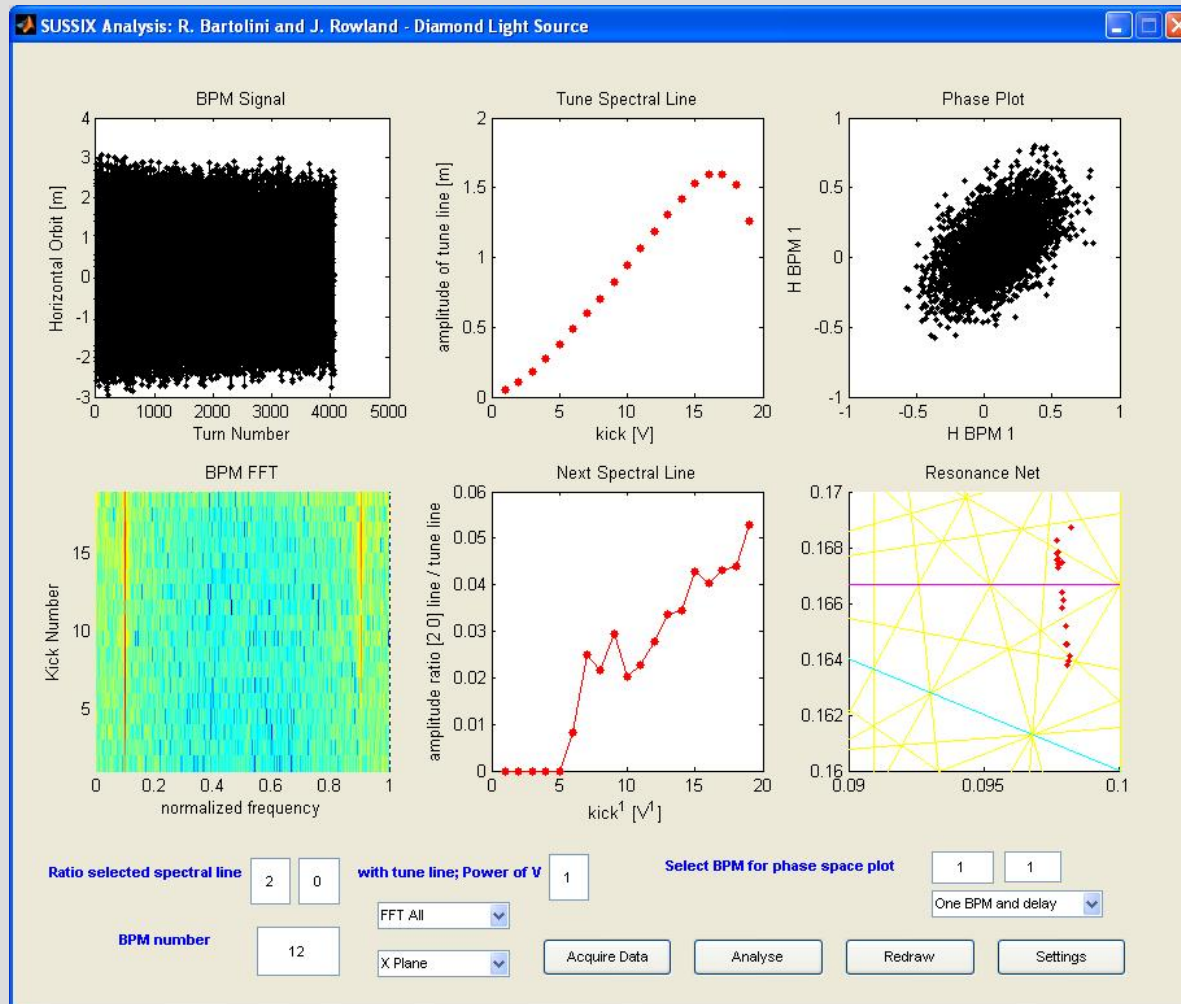
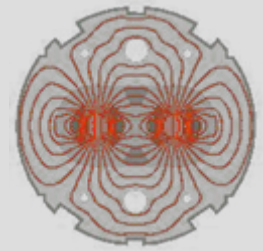
compensated with skew
sextupoles

Setting based on the
reduction of the (0, -2)
line amplitude





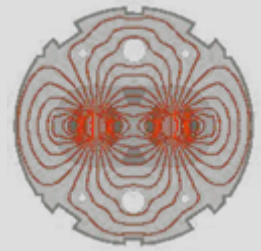
Example for Driving Term GUI



Courtesy R. Bartolini & J. Rowland from Diamond



Milestones



- Defining the principle purpose of the LHC on-line model (~May 2007).
- Consolidation of the SDDS tools (end of 2006).
- Definition of Structure of the SDDS for SPS, LHC and Transfer Lines (~May 2007).
- Non-linear model of the LHC via Fidel/Wise (~June 2007).
- Provide mechanism to exchange knob settings to and fro the control system in collaboration with the LSA team (~June 2007).
- Development of the Applications needed for the On-Line Modeling (~August 2007).
- Testing at existing SPS (knobs & lattice checks) (SPS start-up & dedicated MD).
- **Be ready for the LHC Commissioning Start-Up in 2007/2008!**