BWA/cg

PS/DI/Note 95-17 (Min.)
7 juillet 1995

Compte rendu de la Réunion Technique du PS N°74 du 5 juillet 1995

<u>Intelligence artificielle et automatique</u>

Présents: *B.W. Allardyce, M. Arruat, B. Autin, J. Boillot, J.M. Bouché, M. Bouthéon, R. Cappi, J. Cuperus, G. Daems, B. Frammery, S. Hancock, H. Haseroth, G.H. Hemelsoet, R. Garoby, R. Giannini, H. Koziol, J. Lewis, M. Lindroos, M. Ludwig, D. Manglunki, M. Martini, S. Maury, F. Perriollat, J.P. Potier, J.P. Riunaud, K. Schindl, P. Skarek, D.J. Simon, H. Ullrich, E. Wildner.*

C.C.: *J. Boucheron, P. Bryant, V. Chohan, J.P. Delahaye, F. Di Maio, J. Gruber, K. Hübner, P. Lefèvre, D. Moehl, J.C. Schnuriger.*

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1. En une brève introduction, M. Bouthéon explique que le but de la réunion est de démontrer à une plus grande audience ce qui a déjà été fait dans la Division dans ce domaine afin d'avoir une discussion sur l'utilité de ce genre de programmation et de voir d'éventuelles autres applications.

2. P. Skarek explique ce que veut dire "l'intelligence artificielle" et rappelle ensuite son utilisation dans BEDES et le projet ARCHON. Voir une sélection des transparents en annexe 1. Il conclut que les nouvelles techniques de IA, les "neural networks", calcul symbolique, logique floue, etc. ne sont que des outils et que l'on ne devrait pas avoir peur de les utiliser car ils fonctionnent déjà. Ce ne sont que de nouvelles méthodes de résolution de problèmes, basées sur la connaissance.

3. G. Daëms montre les résultats du projet de la collaboration avec le PNPI de Gatchina concernant le SETUP, c'est-à-dire le rétablissement des conditions (l'initialisation du CAMAC et VME) lors d'un démarrage général ou partiel du système de contrôle. Ce projet dure depuis 1992 et prendra fin avec l'arrêt du projet de renouvellement des contrôles. Il s'agit d'un système expert et donne des résultats très intéressants. Voir transparents en annexe 2. Les écrans typiques démontrés par G. Daëms ne sont pas reproduits ici mais peuvent être obtenus auprès de lui. Il conclut que SETUP est en utilisation régulière pour 5 de nos accélérateurs et que, c'est une grande réussite, en particulier par l'aspect adaptatif qu'il comporte.

4. J. Lewis explique comment l'on construit les différents cycles de nos machines, et les implications que cela comporte en ce qui concerne le timing. Il présente le cadre où les règles à respecter sont implantées et les écrans que l'on rencontre. Voir annexe 3 pour les transparents, mais les écrans n'y sont pas reproduits. Il conclut que l'outil développé fonctionne bien et donne une aide précieuse aux opérateurs. Mais un problème subsiste: celui du temps d'exécution.

5. E. Wildner présente quelques exemples de l'utilisation de ces nouvelles techniques pour le conditionnement HT des cavités RF, l'optimisation de la source à ions et la détermination des paramètres du faisceau de LEAR, et propose d'autres applications possibles. Voir annexe 4 pour les détails de son exposé.

6. M. Martini présente les programmes utilisés au AAC qui sont très automatisés, par le chaînage d'une suite de programmes utilisant le calcul numérique. Avec la mesure de l'ouverture dynamique au PS, il démontre l'utilité des techniques de calcul complexe. Un autre exemple utilise le "Modelling" via MAD pour des ajustements automatiques des paramètres tels que la chromaticité. La présentation se termine avec des programmes "futés" utilisés déjà au PS, (voir exemples avec les transparents en annexe 5) et qui représentent des systèmes où la boucle est fermée par l'utilisateur. E. Wildner (voir annexe 6) donne d'autres exemples de programmes "futés" comme l'ABS (automatic beam steering), où un gain tangible est déjà sorti, à savoir la démonstration d'un mauvais positionnement d'une station pickup au Booster.

7. De la discussion générale, on déduit que les techniques de programmation exposées ont déjà eu un grand succès et que d'autres applications sont envisageables. Elles aident déjà énormément les opérateurs de nos machines mais l'on doit aller plus loin en les intégrant complètement.

8. Vu le succès de la réunion, il est décidé qu'une autre réunion sera organisée ultérieurement sur le même sujet, en particulier pour déterminer les efforts et priorités pour les années qui viennent.

B.W. Allardyce

ANNEX 1

R.T. 5.7.95
P. SKAREK

I N T R O D U C T I O N

D E F I N I T I O N S : ? plustôt des explications

IA, IAD - Intelligence Artificielle
(Distribuée)

Systèmes Expert (aux règles ?)

SMA - Systèmes Multi-Agents

SYSTEMES BASES SUR LA CONNAISSANCE

séparation données / algorithme

implementer, comprendre, maintenir

Désenchantement, Démystification

Ideés, Aspects pratiques.

ANNEX 1

R.T. 5.7.95
P. SKAREK

S. E. P R O T O T Y P E :

I N J E C T I O N B O O S T E R ("BEDES") → 2a

échec: - fragilité
- manque de soutien de cadre. → 2b

P R O J E C T E S P R I T (ARCHON) → 2c

2 S.E. / 2 Agents coopérants

Communications / Coopération*) / Distribution

échec: logiciel (trop lourd)

Résultat très positif: Méthodologie
(découpage / synthè__)
Integration des systhème

*) plusieurs méthodes, p.ex: échange des résultats préliminaires

SKAREK

ANNEXI

R.T. 5.7.95
? SKAREK

D I F F E R E N T E S N I V E A U X

de Programmation:

"en vrac" - piloté par des données -

S. basé sur la connaissance (S.E., base de donnees...)

Numérique - (symbolique) [formel] (arithmétique - algèbre)

VARIABLE	-	OBJET	-	AGENT
p.e. FORTRAN		OOP		IAD

Transition:

Objet, Tâche, Module --> AGENT: [réprésenté explicitement]
- but
- connaissance
- croyance
- accointances
- redondance (?)

CONCEPTS - LANGAGES - OUTILS !!

↑ LANGAGES: orienté objects / orienté agents

↑ OUTILS: par une Langue

SKAREK

LE CALCUL "MOU" (Soft Computing)

N N - Reseaux des Neurons

Algorithmes Génétiques

Logique des Systèmes Flous (Fuzzy Logic)

.....

Imitation de la façon et des processus de penser et de réfléchir.... I A ?

Calcul sans preuve mathematique stricte (pas de théorie derrière)

L'Antropomorphisme en IA:

Controverses philosophiques ne portent pas sur des CONSIDERATION TECHNIQUES et des PROBLEMES des UTILISATEURS en IA.

l'INTELLIGENCE - ce n'est pas seulement que ce que quelqu'un a "dans la tête", mais surtout le produit d'une INTERACTION avec d'autres sujets ou des diapositifs technologiques (DAI).

COMMUNIQUER AVEC "LES AUTRES"

- MODELISATION INFORMATIQUE de l'IAD de SMA: "des AGENTS qui interagissent" en vue de la:

  RESOLUTION distribueé d'un PROBLEME

- Explorer des NOUVELLES METHODES de résolution de problème et l'interaction avec l'UTILISATEUR

ANNEX 2 G. DAEMS

SETUP-PROJECT

- **Why do we need SETUP?**
  - After shutdown, power fail, replacement of faulty HW, etc..
  - Reset and/or setup tentative of faulty specific equipment (power conv., RF equipm., motors, etc..)
  - Initialization of an operational process (instrument,...)
  - Non destructive testing of any equipment

ANNEX 2 G. DAEMS

SETUP-PROJECT

- **System specification**
  - adapted to our environment
    - flexible to follow systems evolution
    - evolving nature of the operation
  - easy to describe the system and his modifications
  - central and unique descriptions of setup algorithms
  - adapted to the huge variety of systems either in camac or VME
  - flexible grouping of objects
    - process oriented (process, subprocess)
    - HW oriented (machine, DSC, camac-loop, -crate, module, equip)
  - treats HW-coupled equipment
  - run-time and post mortem analysis
  - fully integrated in our control system
  - simulation facilities, graphical user interface, reasonable fast

ANNEX 2 G. DAEMS

SETUP-PROJECT

- **PROSC**- **P**rocedural **R**easoning **O**bject **S**ystem for **C**ontrol
  - PNPI expert system shell
  - object oriented knowledge description
    - inheritance and inclusions
  - procedural reasoning techniques
  - real-time features, react on changes
  - easy to extend with new interfaces
  - direct connection with Oracle

ANNEX 2 G. DAEMS

SETUP-PROJECT

- **knowledge base**
  - description of object classes
  - corresponding control rules and operation algorithms
- **current structure generation**
  - automatic generation of the concrete object lists (equipment units, camac modules, crates, etc..)
- **inference machine (knowledge interpreter)**
  - compiles the knowledge base, operates with objects and prescribed rules and events occurred during runtime

ANNEX 2

G. DAEMS

SETUP-PROJECT

- **interface facility** to access the control system elements via the standard system facilities (E-M calls, equipment interface,...)
- **user interface** **(OSF Motif widget)**
  - selection of setup action(s)
  - observing in real-time the setup process
  - printing and/or displaying the executed protocols and their results

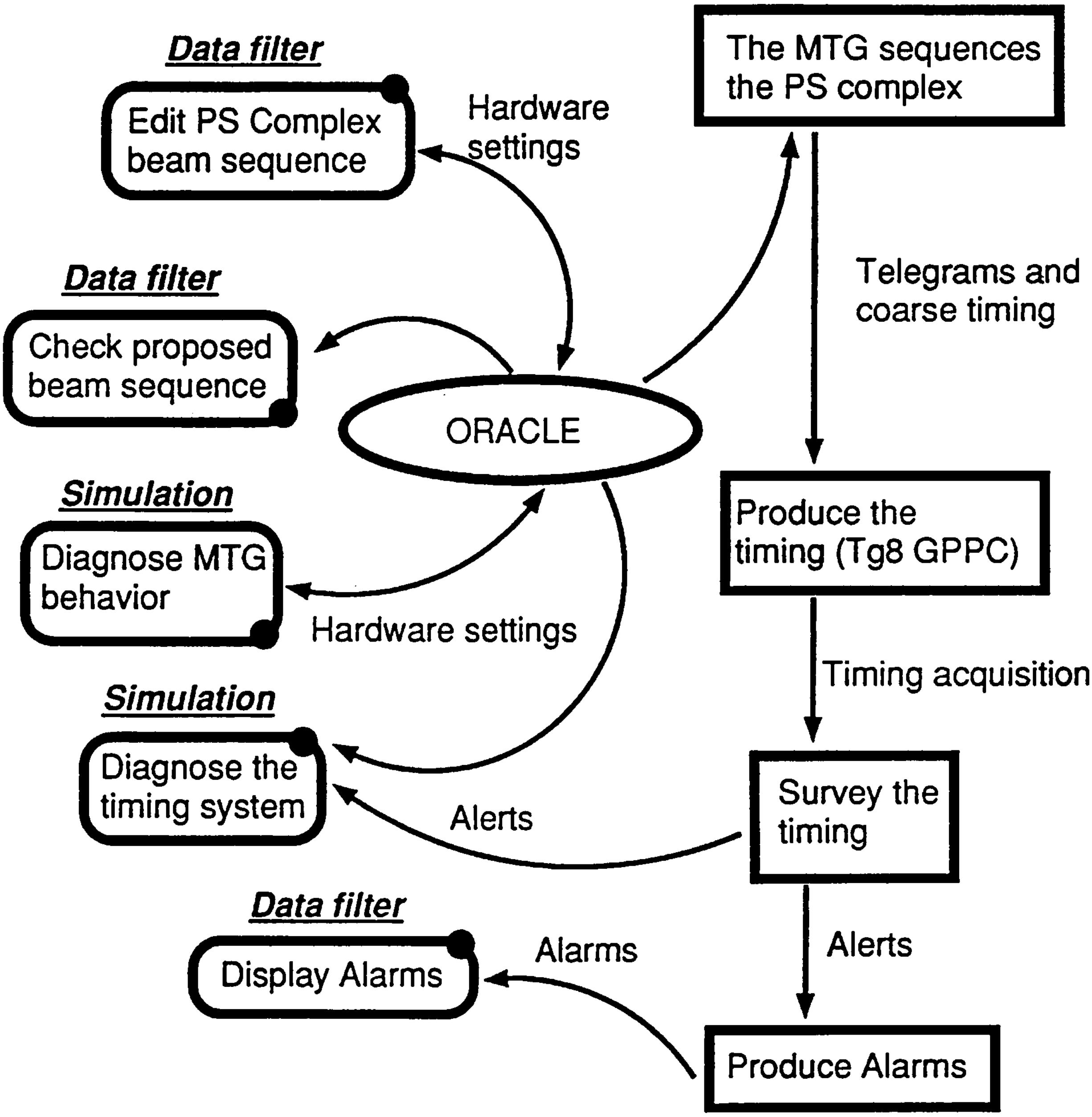
ANNEX 2 G. DAEMS

CONCLUSIONS

- Popular and necessary tool in the daily operation for a complex of 5 accelerators
- The list of objects under control includes (March 1995) about:
  - 50 VME crates with 150 VME modules
  - 130 CAMAC crates connected to 40 CAMAC loops containing more than 700 modules
  - 3000 equipment members based on mentioned HW
  - 100 object classes and 200 control procedures in the current knowledge base
- Reliable and easy to adapt to the evolving environnement
- The structure and the mechanism of the SW can be used for other applications
- A real and useful application of a knowledge based system

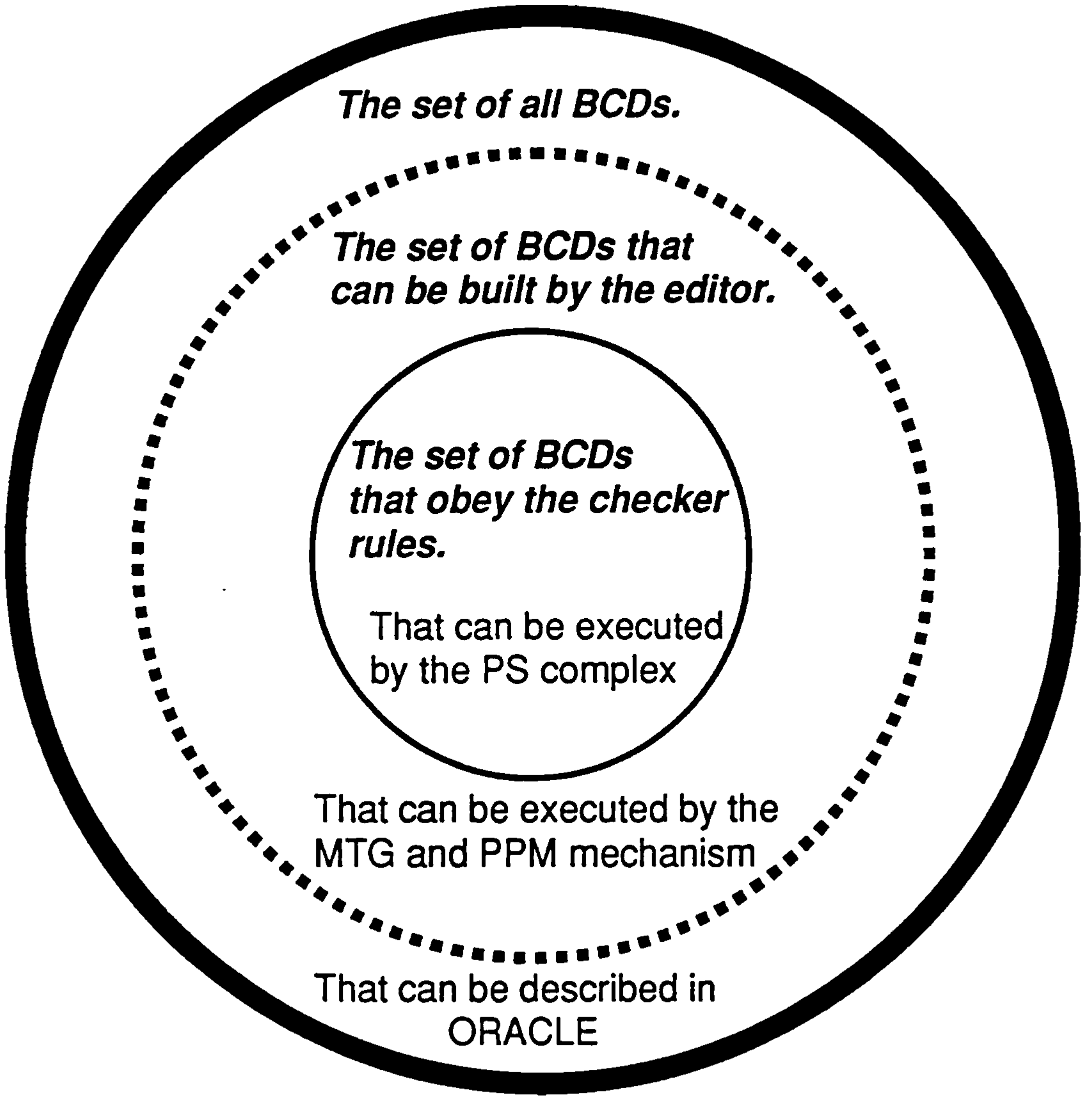
ANNEX 3 J. LEWIS

The problem



Annex 3 J Lewis

Data filter



Select from Tables ***where*** conditions; => A RULE;

Invert the condition, and the selected data is the rule violation.

ANNEX 3 J. LEWIS

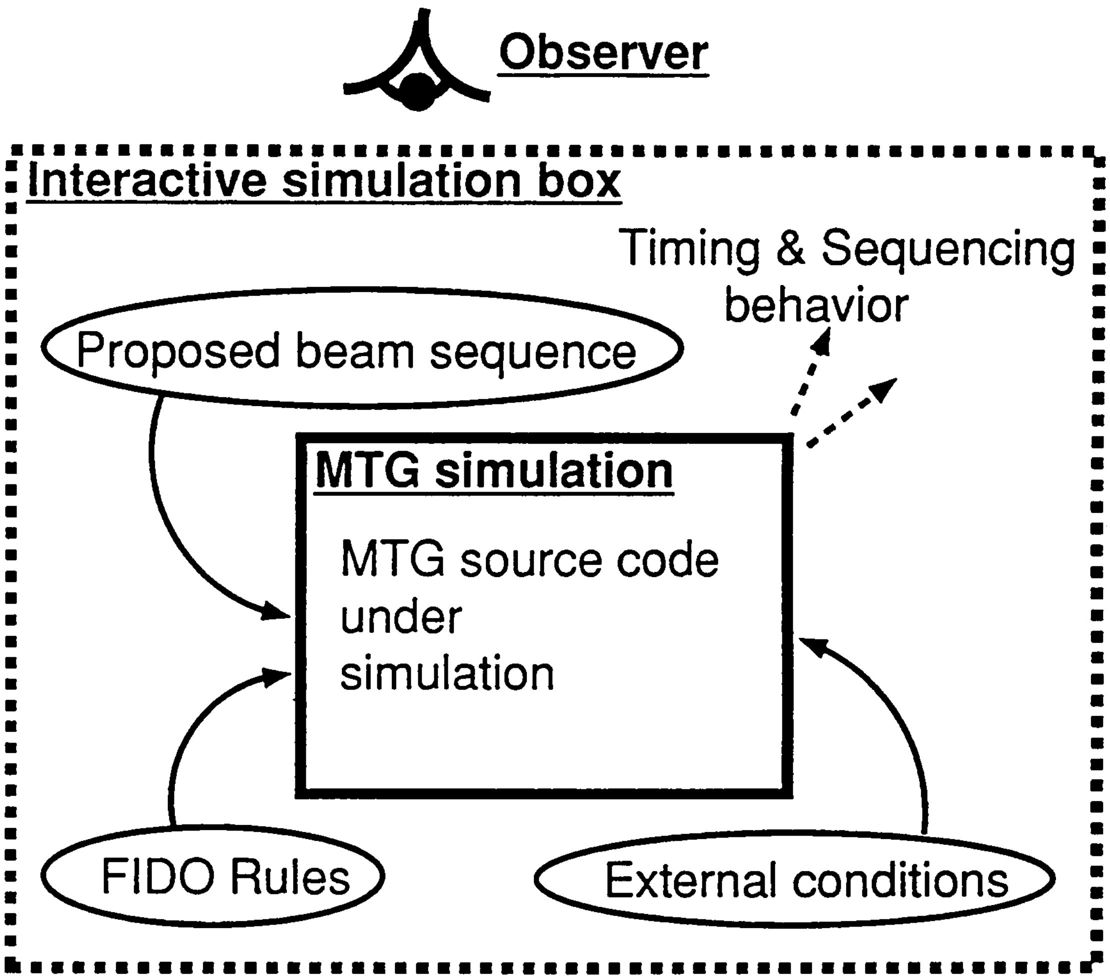
Simulation

Why is the MTG behaving the way it is ?

Is the MTG behaving correctly ? (Surveillance !!)

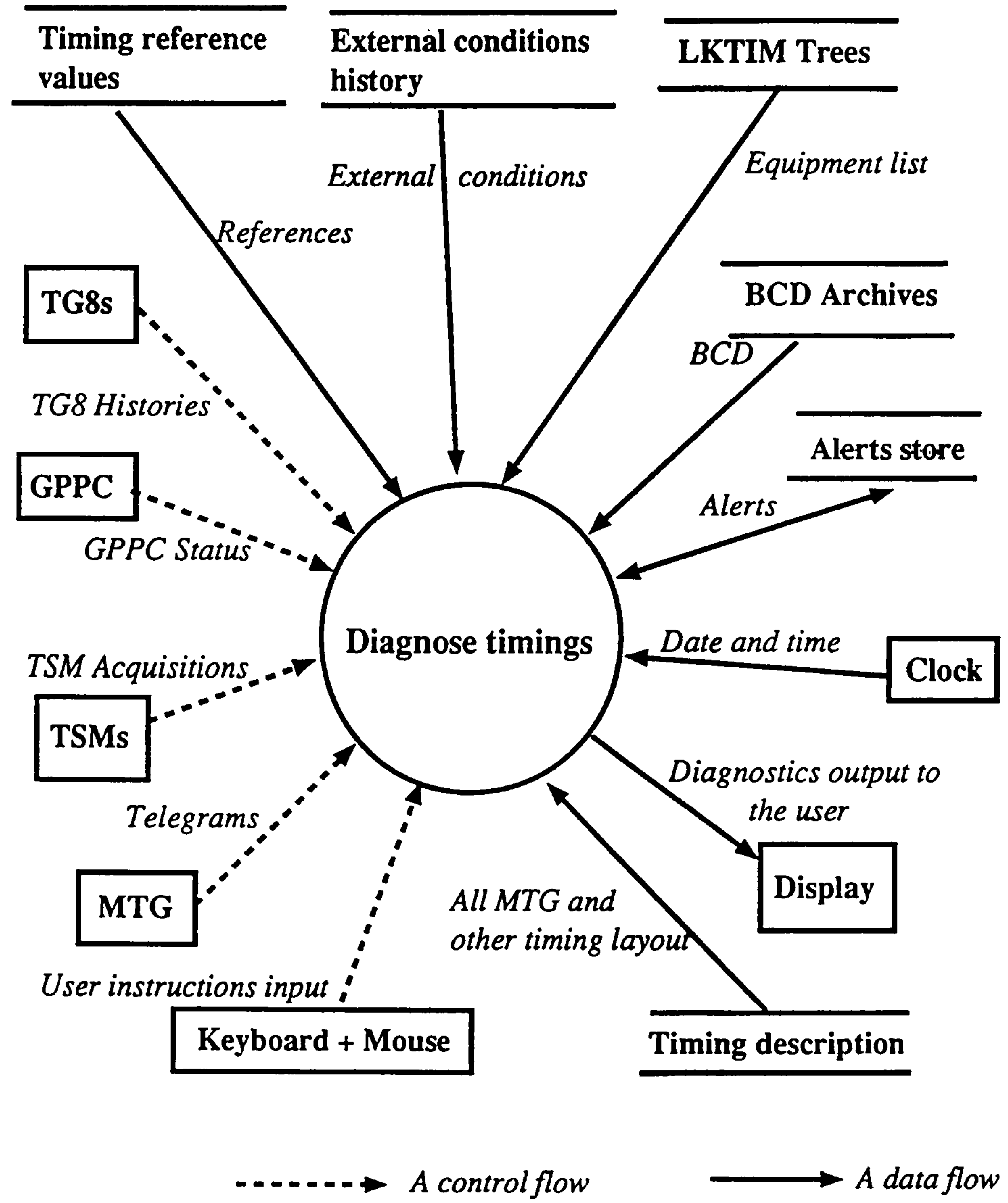
What would happen if I changed this to that ?

Observing potential new rule behavior.



ANNEX 3 J. LEWIS

Context diagram



ANNEX 4

E WILDNER

Artificial intelligence and optimization
"AUTOMATION"

E.Wildner

5/6 -95

Not only cerebral gymnastics for some engineers and physicists but:

AIMS

1) -Conceptualization
-Organization of heavy bulk of information
-Understanding
-Rigor
-Efficiency of task solving
-Generalization to other machines or similar tasks
-AI comes in where the task cannot be solved as easily with classical methods. We try to mix the methods and use the different technologies where appropriate which raises the question of integration and maintenance.

2) Repetitive "stupid" tasks done by machines (computers).

3) Motivation of staff (Physicists, Operators, Instrumentation, Programmers)

ANNEX 4 E. WILDNER

Projects in AI (OP group)

- Conditioning of HT RF Cavities (E.W)

6 + 8 months tech. student

- Neural Net Model of ion source for optimization purposes (E.W)

Already existing data produced for performance statistics used. Data processed (one week) and sent to specialists in dept. Theoretical Physics, Lund, S)

- Determination of Beam Parameters for LEAR with Neural Nets (M.L)

~ 1 month full time + 3 weeks PC calculations in parallel with other things

ANNEX 4 E. WILDNER

No automation can be done without some kind of MODELING

- Classical (ABS)

- Rules (ES and Fuzzy logic applications)

- Databases (ABS, ES, models and control in general)

- Models of uncertain data ("closed loop", Fuzzy applications)

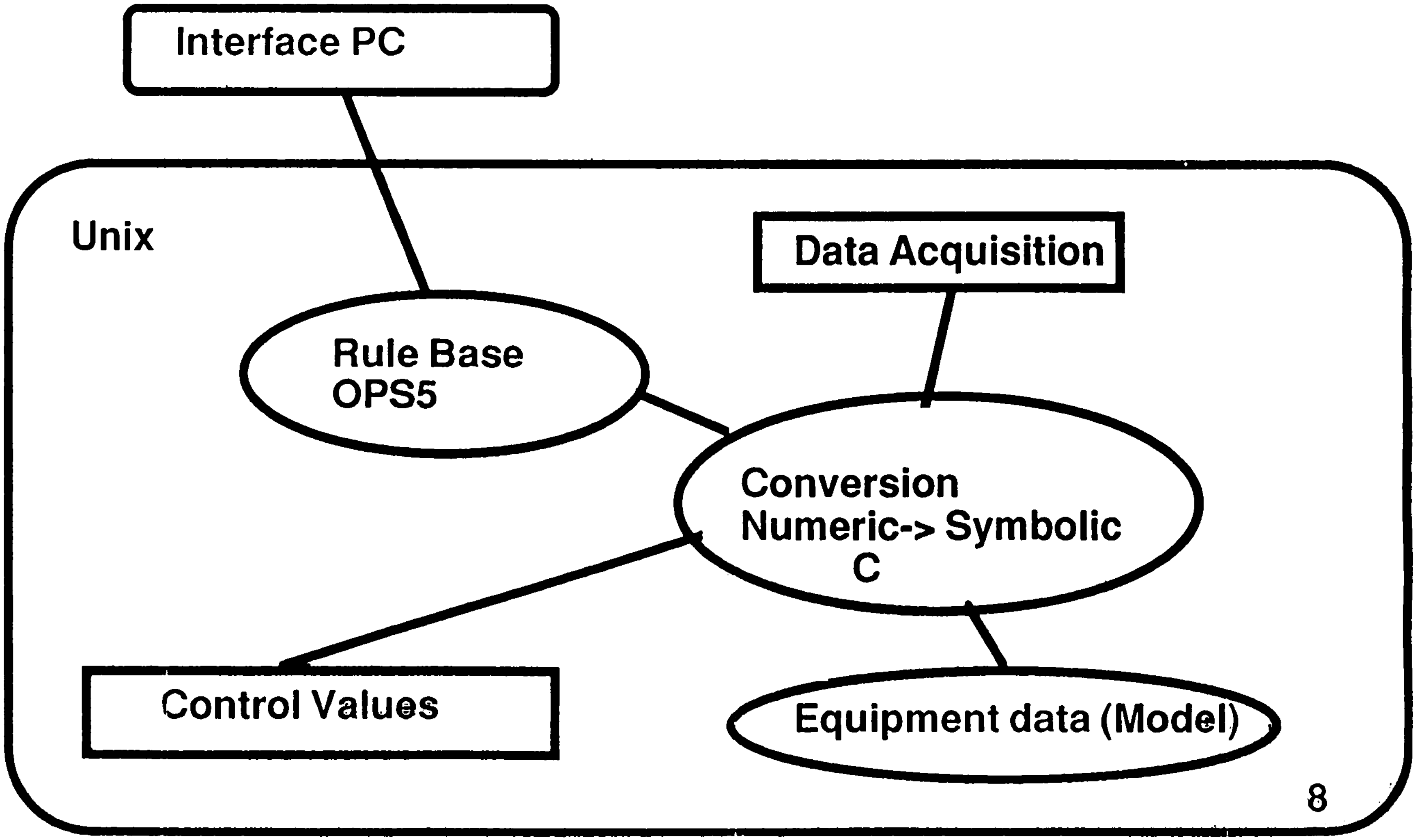
- Black box models (NN, Error treatment for signal processing)

- OO, Data-Relationship and Nets (ES, Fuzzy, DB)

ANNEX 4

E. WILDNER

Layout for HV Conditioning



ANNEX 4

E WILDNER

PSB

High Voltage Conditioning

Process Conveniently expressed in Rules
Example: if vacuum bad --> decrease voltage

Problem of Converting a Continuous Input to a Continous Output
Example: "bad" is how many torr?

Construction of a Generic Application
Example: RFQ, Clystrons

ANNEX 4 E. WILDNER

Status HT Conditioning:

-Unix/Prolog ("public domain") version worked well with simulated data.

-For the LPI Klystrons the application works on simulated data with the Unix/Prolog model (G.Rossat)

-PC with Fuzzy Shell was tested on line for the RFQ (passerelle) and giving satisfactory behavior (Dixit Maurizio Vretenar)

ANNEX 4

E. WIGNER

Optimizing ION Sources

Aim: Optimum Yield from the Lead Ion Source

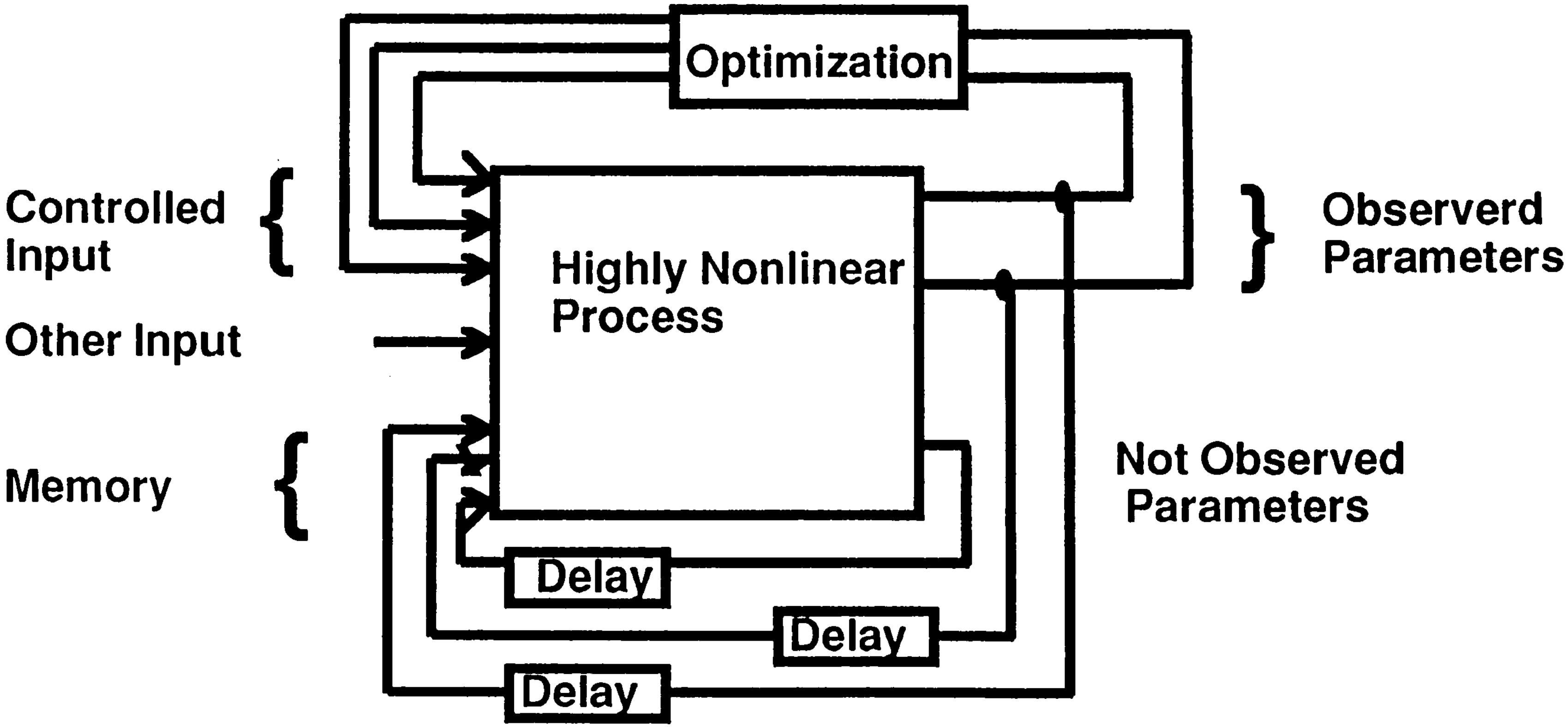
Difficult Modelling: Highly Nonlinear Behavoiur

Process has memory

From Operations Point of View: Art like Cooking

Annex 4 E Widner

Is This Problem Possible to Treat?



ANNEX 4

E. WILDNER

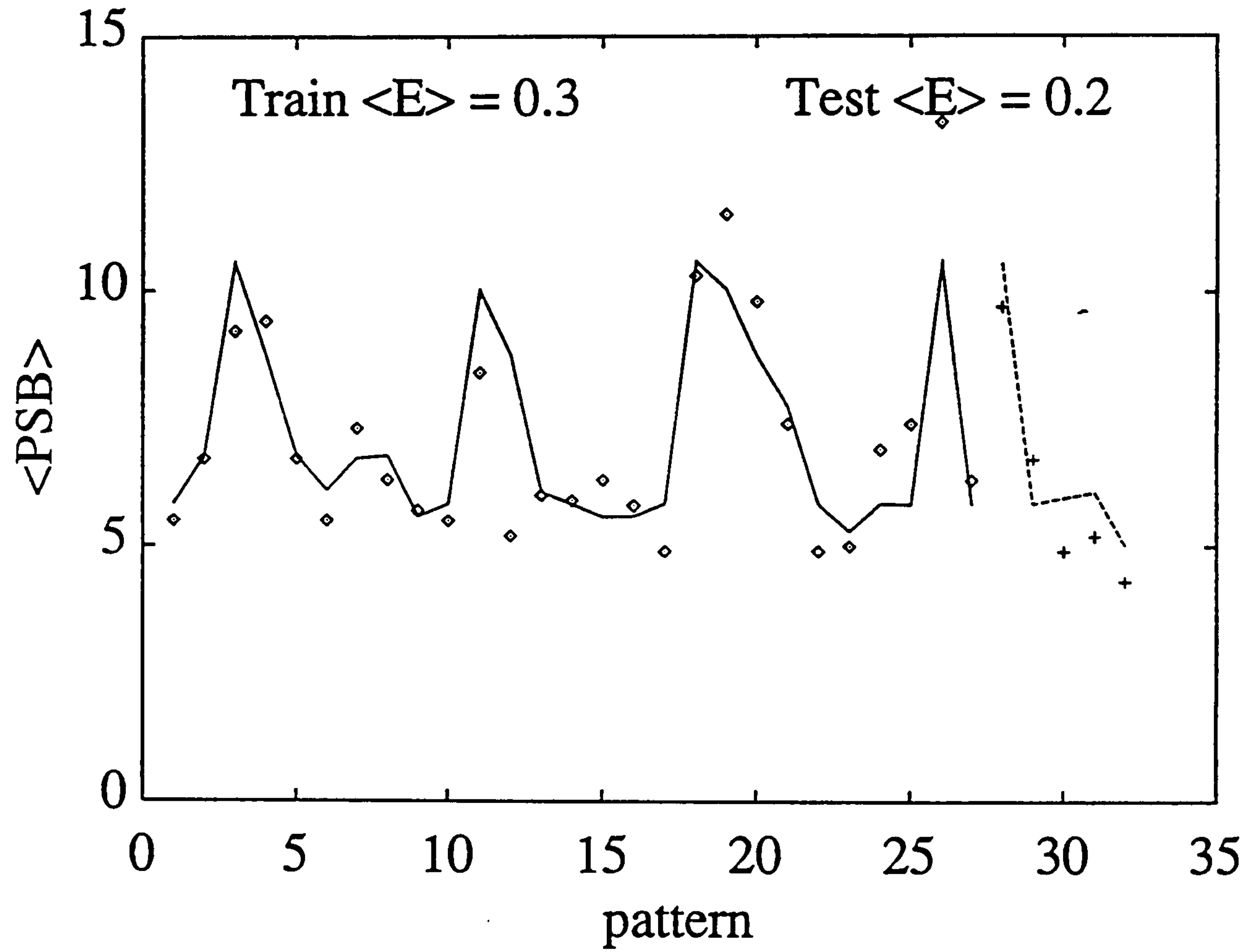
Neural Net Application

Carsten Petersson, Theoretical Physics, Lund, Sweden

Source Input Data
=> NN, JETNET => Model
Ion Yield

Model for old source Oxy + Sulphur

The Model is capable of predicting the output corresponding to the Input



4 inputs
3 hidden nonlinear units
1 linear output

◇ measured   × test points
— calculated
---- predicted

ANNEX 4

E. WILDNER

Immediate Future NN Model

Lead Source Running in

Data taking

Building Model for new Source

Building the Optimization part

Writing an interface for Advising Program

On-line Closed Loop ?

Linac RF optimization

ANNEX 4 E. WILDNER

Status of Beam Parameter Determination in LEAR

Simulated Schottky scan data used to construct an NN that can calulate local tunes. The net **predicts astonishingly well** (using again simulated data) the parameters with a drastically decreased computing time.

Continuation

Operational phase need thinking and investment concerning integration in the controls environment (software, interfacing etc.) and some refinement concerning the construction of the NN.

ANNEX 4 E. WILDNER

Conclusion:

Positive:

-A relatively **small amount of manpower** was put into these developments (prototypes).

- This type of technology can solve problems that cannot be solved with classical methods

- A certain number of applications can very easily **be expressed in rules** and doing **(quasi-) feed back on such systems is ideal with Fuzzy Logic which converts numerical/linguistic input/output data**.
Gives also potential to **decompose and modularize** the application and define **generic, reusable parts.**

- NN software can be written in C and relatively easily maintained. Fuzzy Logic can be compiled into C.

- Increases execution speed (LEAR), automizes tasks (Ion Source and Conditioning application).

- NN models for highly nolinear **processes can be modeled for control purposes** even if not possible with classical modelling (ion source, multiturn injection/capture).

ANNEX 4 E WILDNER

Negative:

-Difficult with **integration of full fledged shells** in the control system. In Prolog all the software had to be written from scratch and Prolog is not maintained. For the PC we got a **shell via the collaboration with Dortmund University**, which if put on Nice gives lot of work from my side that I cannot furnish, like research on which shell is best, and evaluation of products etc.

- **Tuning of the systems can be difficult** for both NN and Fuzzy and I'm not convinced there are defined "approaches" to the problem **yet**. Needs some feeling and know-how for the moment.

ANNEX 4 E. WILDNER

Miscellaneous:

- To use students of a **certain level with knowledge in the field is important**, with if possible expertise support from their universities (doctoral level). We learn from them and the supervision is easier. For NN we should try to get help from experts at CERN or Universities.

- Try to find a policy for support from CO for operational applications.

- ABS policy for Application development could be interesting to try:

Standard CO/OP User Interface/ Equipment interface

Standard interface from Standard application to AI software for algorithms. (Possible application Betatron Stacking PSB using Fuzzy logic)

- What about hardware for NN and Fuzzy applications? Can this be put in the specific equipment? Are there applications already for PID control in the specific equipment?

ANNEX 4 E. WILDNER

Continuation:

-Choice of software for integration?

-Investment in hardware for certain acquisition for the Klystrons?

Several doctoral students have asked to come to the PS to work with us since such development exists rarely in the physics field.
They often get money from institutes and industry. For one of them I proposed optimization of the

-multiturn injection into the Booster.

This is a lengthy task for operation. ***N.B. Work is going on in the*** **classical way for setting** ***up of this type of injection in parallel (ABS); we are*** **not replacing rigorous studies by fuzzy studies.** ***They are just a complement for help in the control room.***

ANNEX 5

M. MARTIN

Technical Meeting - 5 July 1995

M. Martini

From Modelling to Automation via Numerical and Symbolic Computations

1. Automatic measurements in AAC
2. Dynamic aperture
3. Optics example
4. "Wily" programs (programmes futés)

ANNEX 5 M. MARTINI

1. Automatic measurements in AA and AC

AA and AC: Highly automated machines for operation, machine experiments, setting-ups, and beam measurements.

1.1. Operation

The AA-AC rings exchange beams (pbars and protons) in two directions with the PS depending on the required functionality.

An example: "Pbar production mode"

(i) Select a series of timing file which are sent to hardware,
(ii) turn on the required equipment for operation (kickers, RF cavities, ...) and turn off the unused equipment (damper, beam stopper, ...),
(iii) perform checks on power supplies and cooling systems.

Another example: "AA-AC performance check"

Do stacking statistics (e.g. "yield") and performance verifications (e.g. efficiencies) to monitor pbar progress from the production target through the AC, the transfer line, and into the AA.

ANNEX 5 M MARTA

1.2. Machine experiment and setting-up

For machine experiments or after shutdowns: the AA and AC machines have to be properly adjusted and set up with proton beams. Use combinations of beam instrumentation (Schottky pick-ups, digitizers, ...) and control of equipment (timings, RF, kickers, ...).

An example: "Automatic AA setting-up"

(i) Inject a beam,
(ii) measure and reduce the coherent injection oscillations (transversely and longitudinally),
(iii) measure orbits on central frequency and tunes on the stack orbit (after capture and displacement),
(iv) adjust the "trim" supplies, central field and quadrupole strengths until the required tunes are obtained,
(v) measure the energy matching between PS and AA (gives the AA frequency error and the PS field error) to be later used for pbar transfers.

Another example: "Acceptance measurement"

(i) Inject a beam on the requested frequency (and measure the tunes),
(ii) blow up the beam in one plane until the beam hits the aperture,
(iii) scrape the beam to find the beam edge and compute the acceptance,
(iv) go in (ii) to treat the other plane,
(v) select another frequency and go in (i) until all the frequency range is scanned.

ANNEX 5

M. MARTINI

	REQUIRED	MEASURED
QH } 1855.09	2.2555	2.2553
QV } kHz	2.2598	2.2598
TRIM	0	0 mm
DP/P	0	0 E-3
COH.OSC. H	0	.4 mm
V	0	0 mm
COS COMP.L	0	0 deg

Coherent oscillations are adjusted with cooldown tunes. Accumulation tunes restored now.

RESULTING VALUES		SAVED IN
BENDING	1944.73 A	
TRIM	8.73 A	REFERENCE
QD	1058.59 A	+ FILE
QF	1464.62 A	
SEPTUM	3878.39 A	REFERENCE
DVT8022	-1.46 A	+ FILE
BTI8002	410.53 A	
EJ.KICKER	59.52 kV	
SYNC PH.	66.2 deg	FILE
f INJ.	1845.83kHz	
INJ.EFFICIENCY	85 %	

The tunes have been adjusted to accumulation values on the stack orbit. These values are saved.

Results from the automatic setting-up program for the AA.

ANNEX 5 M. MARTINI

	REQUIRED	MEASURED
QH } 1855.09	2.2555	2.2553
QV } kHz	2.2598	2.2598
TRIM	0	0 mm
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COH.OSC. H	0	.4 mm
V	0	0 mm
COS COMP.L	0	0 deg

Coherent oscillations are adjusted with cooldown tunes. Accumulation tunes restored now.

RESULTING VALUES			SAVED IN
BENDING	1944.73	A	REFERENCE + FILE
TRIM	8.73	A	
QD	1058.59	A	
QF	1464.62	A	
SEPTUM	3878.39	A	REFERENCE + FILE
DVT8022	-1.46	A	
BTI8002	410.53	A	
EJ.KICKER	59.52	kV	
SYNC PH.	66.2	deg	FILE
f INJ.	1845.83	kHz	
INJ.EFFICIENCY	85	%	

The tunes have been adjusted to accumulation values on the stack orbit. These values are saved.

Results from the automatic setting-up program for the AA.

ANNEX 5 M. MARTINI

2. Dynamic aperture

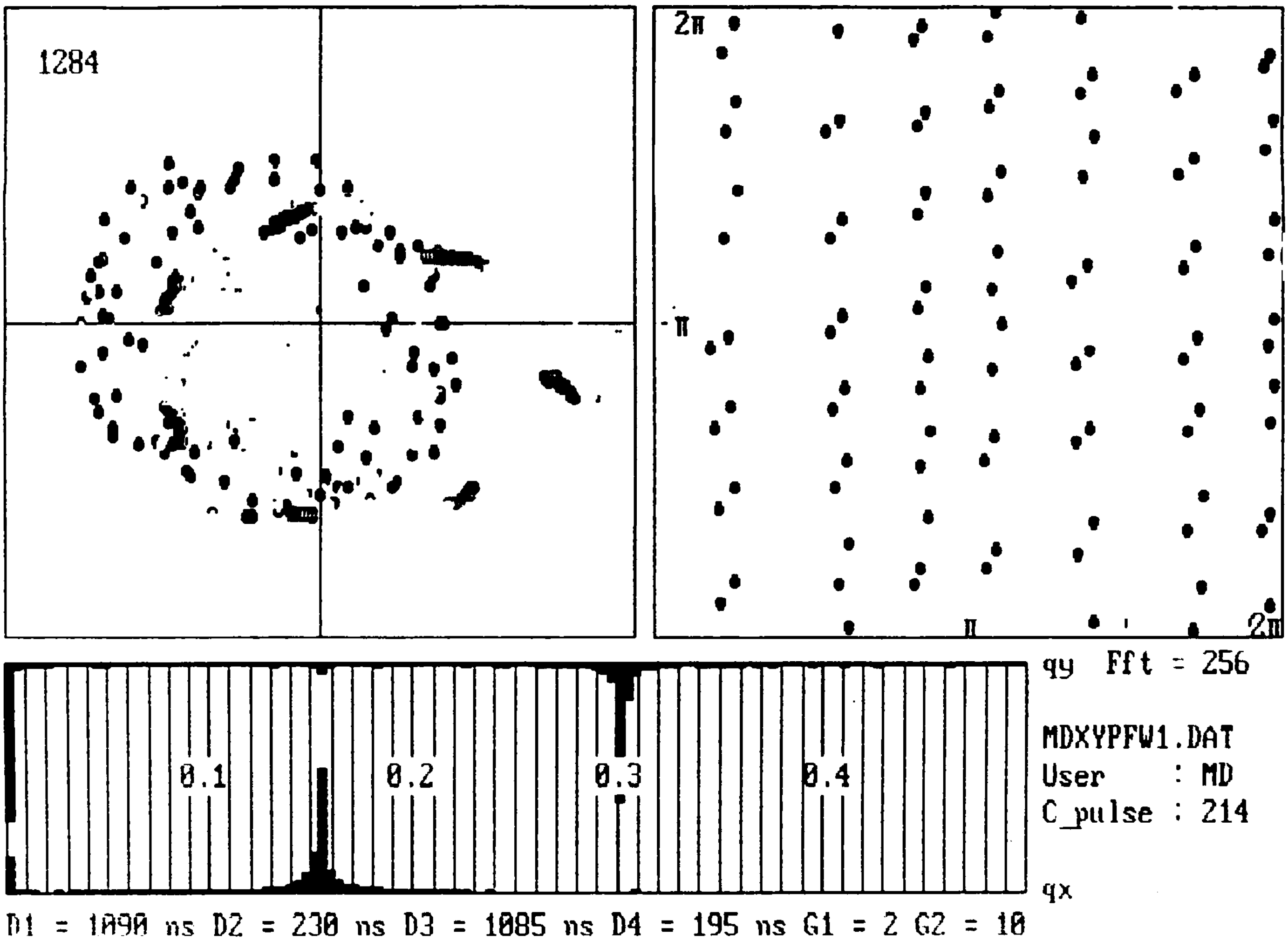
A definition:

***Dynamic aperture*: largest stable domain of the particle phase space.**

An example: "Dynamic aperture measurement in the PS"

(i) Kick the beam with a pulse function (or use intrinsic beam instabilities) to get coherent beam trajectories,
(ii) observe beam trajectories by sampling each turn a bunch position at two pick-ups 1/4 betatron wave length out of phase,
(iii) **2-dimensional phase plane motion**:
plot the trajectories to trace out closed (open) patterns in the normalized (x, x') and (y, y') planes:
- *circles for irrational tunes, dots for rational tunes, chains of islands or chaotic layers at higher amplitudes for tunes near nonlinear resonances,*
(iv) **3-dimensional** (J_x, θ_x, θ_y) **motion**:
plot the action J_x or (J_y) vs. the angles θ_x and θ_y and the projection onto the angle plane (θ_x, θ_y). The square root of J_x is the "radius" and θ_x the "angle" of the polar plot (x, x'),
(v) **2-dimensional** (θ_x, θ_y) **motion**:
project the (J_x, θ_x, θ_y) motion onto the plane (θ_x, θ_y).

ANNEX 5 M. MARTINI



$7Q_x = 43$

ANNEX 5 M. MARTINI

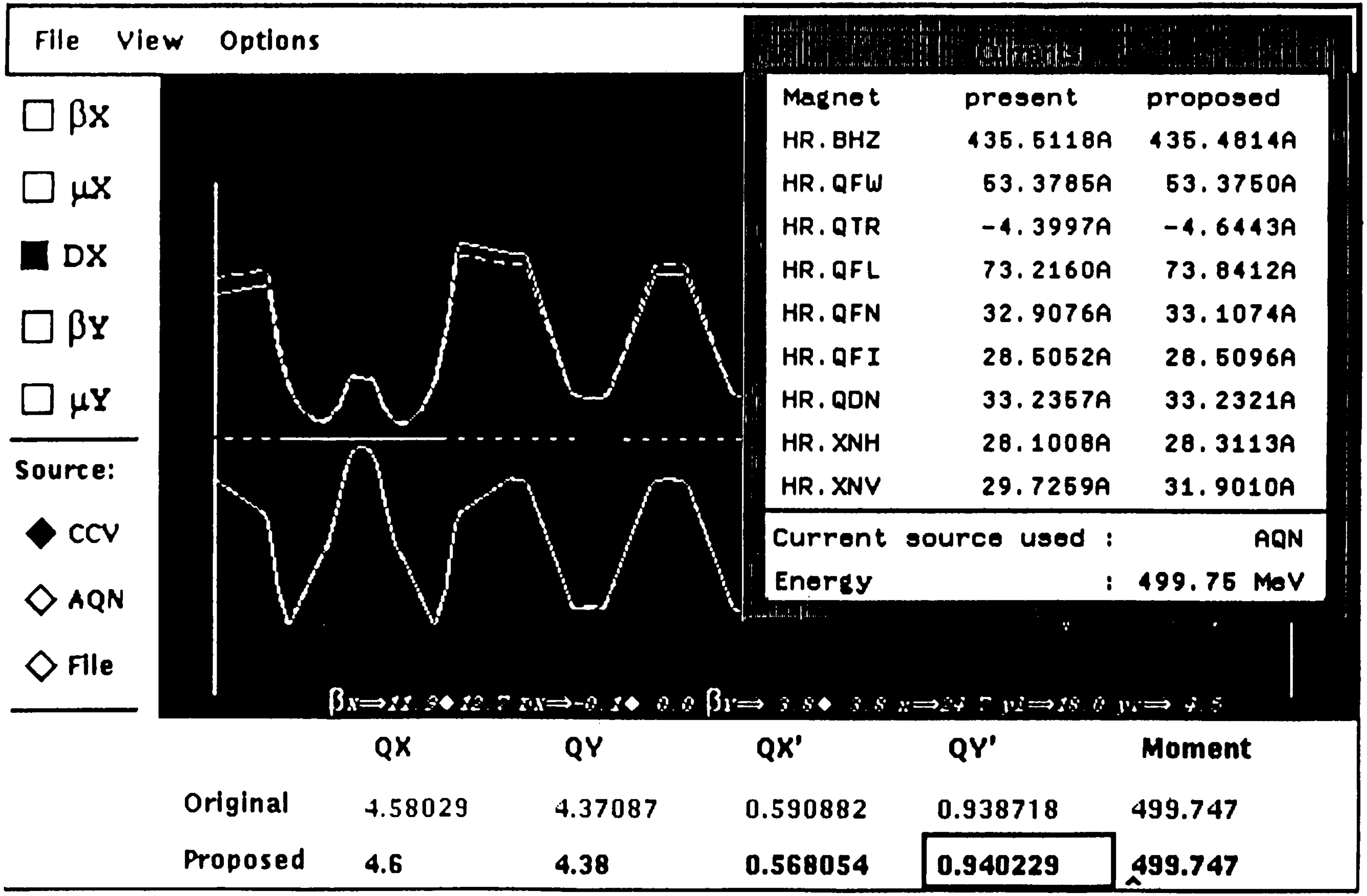
3. Optics example

- Modelling EPA ring with MAD lattice program for automatic tune and chromaticity adjustment (the modelling is energy dependent).

- On-line generation of input data and viewing optical parameters on workstations.

- Direct access to equipment from workstations (with automatic conversion from currents to normalized strengths).

ANNEX 5


File View Options
βX
μX
DX
βY
μY
Source:
CCV
AQN
File
Magnet present proposed
HR.BHZ 435.5118A 435.4814A
HR.QFW 53.3785A 53.3750A
HR.QTR -4.3997A -4.6443A
HR.QFL 73.2160A 73.8412A
HR.QFN 32.9076A 33.1074A
HR.QFI 28.5052A 28.5096A
HR.QDN 33.2357A 33.2321A
HR.XNH 28.1008A 28.3113A
HR.XNV 29.7259A 31.9010A
Current source used : AQN
Energy : 499.75 MeV
QX QY QX' QY' Moment
Original 4.58029 4.37087 0.590882 0.938718 499.747
Proposed 4.6 4.38 0.568054 0.940229 499.747

ANNEX 5 M. MARTINI

4. Wily programs (programmes futés)

Definitions:

<u>Futé</u>: Qui est plein de finesse, de malice (qui, à force d'expérience, a appris à déjouer les pièges).

<u>Wily</u>: Full of tricks.

<u>Wily programs</u>: High-level modelling programs involving complex treatments for the control and measurement of physical machine or beam parameters relevant to the process.

Some examples in PS

"Slow extraction tuning"
"Lepton acceleration and damping tuning"
"Low energy working point tuning"
"Injection timing control"

"Tune and trajectory measurements"
"Emittance measurements (flying wires and SEM-grids)"

ANNEX 6 E.WILDNER

ABS

E.Wildner

Status:

-The transfer from the Booster to the PS operational

including Closed orbit modification at ejection and minimization of coherent oscillations at PS injection.
All four rings are globally optimized to minimize emittance growth in the PS.

-TT2 steering on semgrids operational

Team work:
B.Autin, M.Martini, E Wildner
for the optics, calculations and algorithms
G.H. Hemelsoet, M.Arruat
for the User Interfaces

ANNEX 6

E WILDNER

Mathematica

ABS

Data to send to MathLink

Ring: All Rings

Plane: Vertical

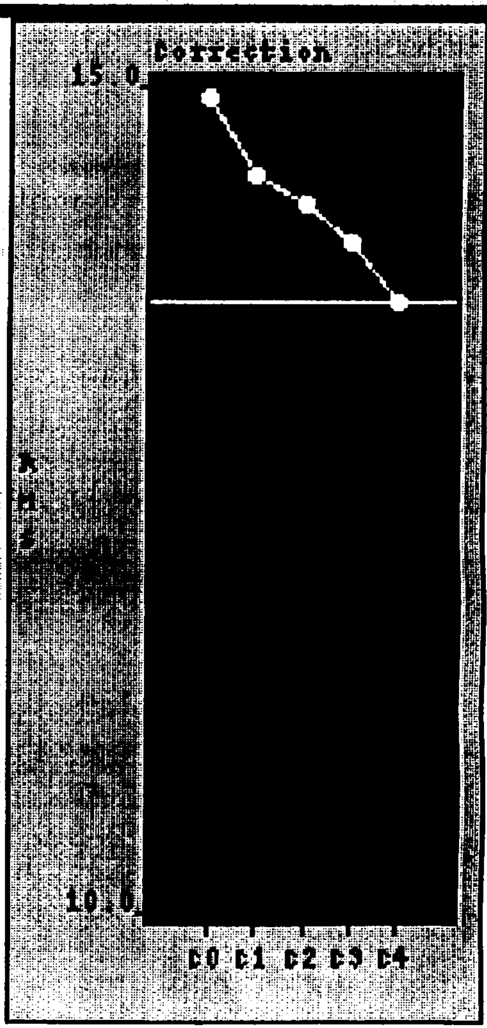
Reference: Zero

Nbr of Correctors: 4

Dismiss | Compute

RMS	
initial	14.93
Corrector 1	14.45
Corrector 2	14.29
Corrector 3	14.05
Corrector 4	13.69

Correctors	
BE3.DVT11L1	1.28 A
BTP.DVT20	-0.02 A
BT.DVT50	1.62 A
BT.DVT60	-2.18 A



ANNEX 6

E. WILDNER

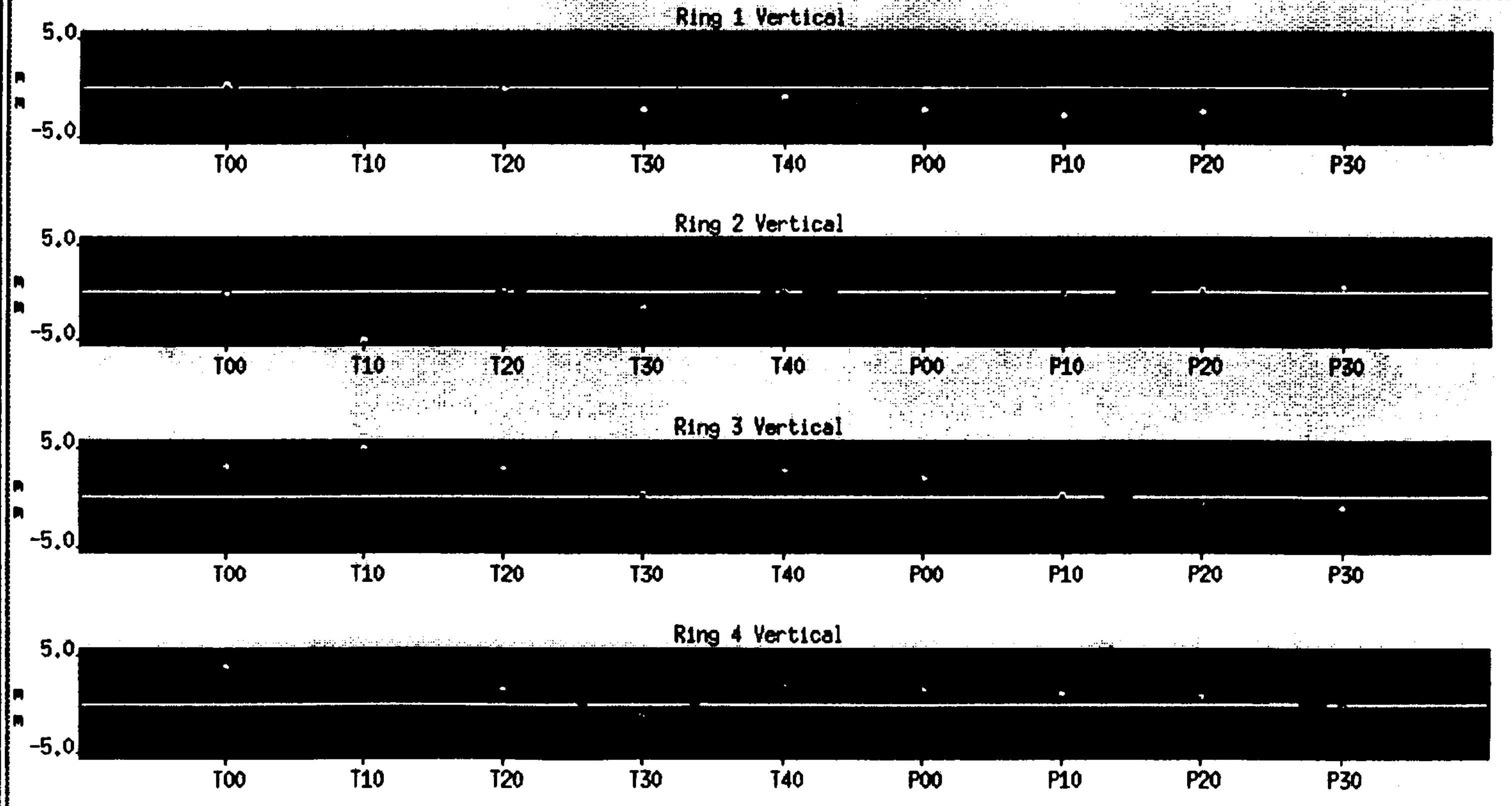
trajcorr

File View Control Help

Automatic Beam Steering [PSB PS]

MDPRO *** Jun 30 15:40:09

Equipments	Vertical R1	R2	R3	R4
BT.U00	-2.96 mm	-6.65 mm	6.66 mm	4.44 mm
BT.U10	-28.44 mm	23.87 mm	-22.08 mm	23.63 mm
BT.U20	0.47 mm	0.79 mm	-0.97 mm	-2.45 mm
BT.U30	-16.00 mm	-15.23 mm	8.64 mm	7.04 mm
BT.U40	-2.60 mm	-1.51 mm	0.99 mm	0.32 mm
BTP.U00	-1.73 mm	-0.13 mm	2.39 mm	2.03 mm
BTP.U10	-3.36 mm	-0.90 mm	-0.05 mm	0.54 mm
BTP.U20	-3.13 mm	-0.43 mm	-1.17 mm	-0.05 mm
BTP.U30	-0.13 mm	0.80 mm	-0.78 mm	0.11 mm



Update Unfreeze Freeze

6. The different phases in the development of the steering.

For the steering we need *optics parameters* for the contruction of a *steering matrix*. In the present software scheme for the beam steering, this matrix can also be obtained experimentally. The steering matrix is used by an *optimizer*. The optimizer is used by an *application program*, that acquires values of pickups and magnets and decides according to suggestions from the optimizer what steering to do. See fig. 5.

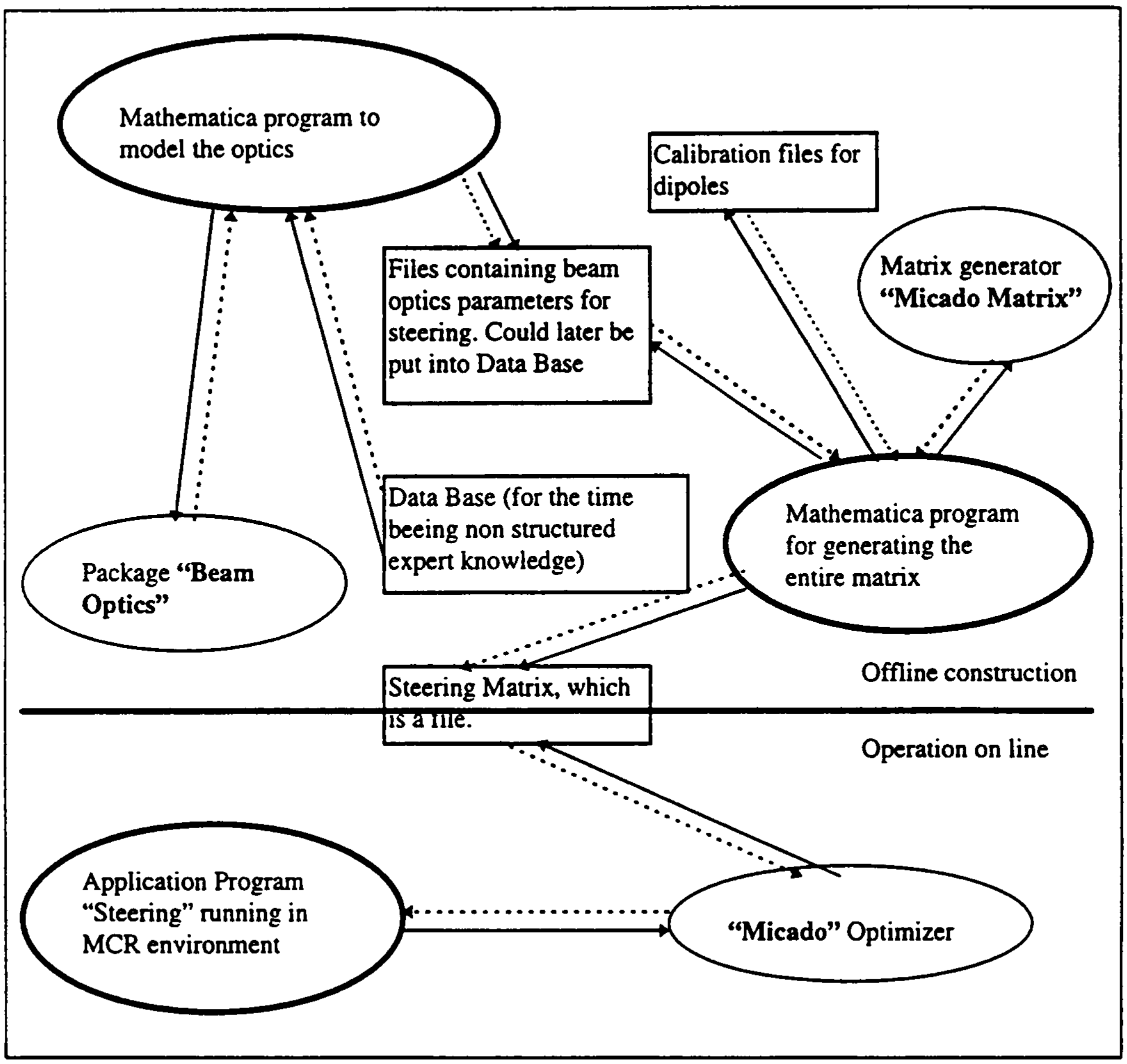


Fig. 5 Construction and use of data structures for beamsteering. Bold ellipses are programs, thin ellipses are packages or functions and rectangles are data files. Filled arrows are calls, dotted arrows are information flow.

The optics calculations have been made by using Mathematica (Unix). Access to the standard control system is available via Mathematica commands ReadEquipment and WriteEquipment, for acquiring and setting values in magnets and for acquiring pickup values.

The Mathematica program models the lattice and the beamline by using a package, also written in Mathematica, called Beam Optics. See ref. [6]. This reference

ANNEX G E WILDNER

Projects Steering

-Linac Booster injection
with global optimization for the injection of 4 rings

-Coherent oscillation minimization
injectionPSB

-ISOLDE

-ML

we hope to finish this year

Projects Beam shaping:

-ISOLDE

-TT2

Making one, instead of two, application program for the complete steering between the Booster and the PS.

ANNEX 6 E. WILDNER

Continuation:

-Algorithms: **M.Martini**

-Research for a completely **automatic construction** of steering matrice via database.

This **already works in principle** (tried out on injection into the Booster)
Data Base Prototyping using tools developed for LHC.
Data collection (**Heavy but necessary work** for the Booster concerning all optics elements and geometry). This also serves for generating a new **parameter list for the Booster**.

-Object oriented thinking.

Team work: **B.Autin, M.Lindroos, E.Wildner, K.Schindl**
Support: **J.Schinzel**

PROTOTYPE:
EXCEL->Database->textfile->ABS offline for steering matrix construction