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Operation, Beam monitoring, Controls: a brief proposal for a B factory in ISR tunnel

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This is a very preliminary study made at the request of D.Moehl and Working Groups conveners in charge of a proposal of a B-Meson factory at CERN . The collider would be installed in the ex-ISR tunnel and fed from the PS machines. Many thanks to K.Huebner who spent a lot of his time making fruitful comments and corrections. The form of this note is intended to be considered as a draft.

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1 OPERATIONAL ASPECTS

Geography

As was the case for every accelerator built these last years in the PS environment there will be

= one local control room used for the commissioning
running-in
special studies

This local control room should contain the information gathering equipment.

The "old" ISR Control Room could be a possibility benefitting from the existing communication tunnels

= Meyrin Control Room will be used for OPERATION (Physics production, usual Machine Experiments)

As for the existing machines, all complete visualization and control tools will be present here as well as all the communication channels. The now common tools general WorkStations will be used, presenting on their screens video pictures

spectrum analyzers frames

sampling scopes output

control/acquisition results from application programs.

Real implantation in present MCR will depend on pbars activity. It will be easier if BFI start after 1994.

If absolutely needed an extension of MCR is possible. More details about central tools in Controls part.

Operation staff

There are now 7 operation teams (7 MCR + 1 Power supplies) keeping in production 24/24 h the 10 PS accelerators.

If duties are re-arranged (foreseen anyway in near future) it should be possible to maintain a B Factory (two rings added) in operation by hiring only one more team (6 to 7 people) .

If pbars have been phased out at the time of starting the B factory, probably the now present Operation staff would be sufficient.

The running-in phase needs more staff obviously. The setting-up mode requires also much more persons. Engineers-in-charge (shift workers) are also needed for an initial period (one year ?). After that operational machine conditions have been obtained , Engineering level is insured on an "on-call" basis ("Supervisors") as usual at PS Complex.

The overhead incurred in the other general services like power supplies, cooling, magnets maintenance, Radio Frequency systems,..etc.. is not evaluated here. But we have not to forget to increase the CONTROL MAINTENANCE & EXPLOITATION team (by one or two people) as experience has already shown the needs.

Operating mode summary

This proposal is based on tables computed by JP Riunaud (Ref 1) and among the numerous possibilities, we present here the most interesting cases.

Except when mentioned the limits used are the bunch stability in PS or SPS. The particle accumulation rate in EPA are supposed to reach :

4.2 x 10E11 e+ / s and 0.8 x 10E11 e- / s for a target luminosity of 10E33 cm-2 s-1 (asymmetrical B fact.)

8.4 x 10E11 e+ / s and 1.6 x 10E11 e- / s for " " " 10E34 " " "

4.2 x 10E11 e+ / s and 3.4 x 10E11 e- / s " " " 4 x 10E33 " (symmetrical B fact.)

This allows the following filling times and filling frequencies as seen from a PS accelerators complex operation point of view.

Three cases are presented:

= *1/3 topping-up* where BFI is refilled periodically in order to complete the circulating beams to the maximum (when about 1/3 of particles are lost). This represents only an example Ref. 2 gives a complete view of evolution of the integrated luminosity vs. filling schemes parameters. Optimization will depend upon compromises between operation, physics needs and priorities.

= *filling* where the BFI rings are filled from empty situation to maximum currents

= *continuous topping-up* where lepton beams are sent to BFI regularly permanently keeping the Luminosity at maximum. The feasibility for this mode must still be verified : see Ref 2.

Several operating modes where compared:

case **A** = Where the PS machines are used exclusively for BFI (except when notified) and particles of one type only is delivered e+ or e-

case **B** = Where the PS machines can serve their usual clients like SPS Fixed target, LEAR pbars, East Hall tests,... and the BFI rings are filled one after the other (one type of particle available)

At last case **C** = where the PS machines can serve their usual clients and BFI as well and the two e+ e- beams are available simultaneously.

The case where the PS machines are used exclusively for BFI and e+ and e- are delivered simultaneously to both rings was studied but showed no advantage for filling time optimization)

<u>FILLING TIME</u> (commutations, detectors setup not included)

	3.5 GeV e+ >< 8 GeV e-		5.3 >< 5.3 GeV e+e-
Target luminosity (cm-2s-1)	10E33	10E34	4x10E33
1/3 top-up (once each hour)	*A 5.9 min* B 17.8 min	*A** 6.1 min*	A 2 min B 5.8 min *C*** 6.4 min*
filling	*A 17.8 min*	*A** 18.3 min*	*A* 5.8 min*
continuous (T = 14.4 s)	B e+ 21.5 mA/T e- 3.4 mA/T *C*** e+ 10.7 mA/T* *e- 1.7 mA/T*	B e+ 21.5 mA/T e- 3.4 mA/T *B** e+ 43 mA/T* *e- 6.8 mA/T*	B e+ 21.5 mA/T e- 17.2 mA/T *C*** e+ 10.7 mA/T* *e- 8.6 mA/T*

NOTES

* : In order to leave SPS Fixed Target operation in p+ or ions without interruption this filling time should be increased to 6.9 or 8.7 minutes resp.

** : these only cases need to have **0.6 s rep. rate** in PS/SPS and request **8.4x10E11 e+/s** accumulated in EPA. Computer control will impose some sequential filling between e+ and e- Staying at 1.2 s would leave easier stacking rate in EPA and would double the filling and topping up times.

*** : this mode is used TODAY when LEP is in operation. From the point of view of the cycling of the different PS machines no special problems are anticipated.

The implications of the LEP filling (representing today less than one hour interruption for BFI every 4 hours) can be estimated through the above table.

CONCLUSION: From the preceding considerations we suggest to use the topping-up mode as a regular basis (1/3 case being given as an order of magnitude), complete filling being used when BFI beams are accidently lost. All this being done at 1.2 s rep.rate. at least for the first years. The 0.6 s repetition rate for PS machines is needed to reach a 10 E34 cm^{-2} s^{-1} BFI luminosity. The recommended modes are shown *in italic* in the preceding table.

2 BEAM INSTRUMENTATION

Machine (2 rings)	Unit cost KFS	Est. price KFS
- 2 * 140 button P.U. stations R/V LEP type special precision near IR	10	2800
partially equipped for 1 turn acquis. 0.1mm closed orbit accur.		
- stripline P.U. wb(feedbacks, tune measure,shaking) 2 * 2 sets R/V	10	80
- current monitor fast electronics (bunch) 10E10-10E14 range	60	120
slow precise electron. (lifetime) DC and AC type		
- luminescent screens (injection + beam dumping) 2 * 2 (+ 2 * 2)	10	80
- synchrotron radiation monitors 2 * 2 (Dx = 0, Dx <> max.)	50	200
equipped and visible/UV synchrotron light transported to optics lab: fast diode,		
video, CCD devices . Streak camera not counted here. Borrowed if needed		
- interaction monitors (1 per IP): luminosity measurement and survey	100	200
- scrapers/collimators R/V several sets for : detector protection,		
aperture definition/measurement , halo/background conditions		
separators protection total 3 * h/v * 2 IP * 2 r = 24	10	240

- beam losses monitors: not used for diagnosis. See radiation safety.
- vacuum chamber temperature monitoring => **Vacuum system**
- polarimeter : not counted . Evaluated later on.
- ions collection electrodes and associated low current measurement: not counted here (they will

probably not be present due to impedances problems).

sub total	3720 KFS
Spare parts (at minimum)	260

- 750 KFS for spectrum analyzers, network analyzers, sampling scopes owning to instrumentation system

Beam Monitoring ~	4. 75 MSF
Cabling (10 %)	.45
Total ~	**5.2 MSF**

Vacuum monitors should be counted in **Vacuum system**

Use of SEMGrids in the ring has been eliminated according to discussion with injection specialists (JP Potier)

Additional Commercial equipments must be also listed (spectrum analyzers, FFT analyzers,..) as **normal instrumentation equipments in the different systems** i.e. the above lump sum is probably not sufficient to cover the whole BFI needs.

Specialized magnet devices even used for diagnosis have to be part of Magnets system. Dedicated RF loops, feedbacks, kickers..etc.. used for beam manipulations and/or adjustments must be foreseen by corresponding groups budgets. To be verified at the end !

Transfer Lines : not treated here see Ref 3

As usual in beam transfer lines: luminescent screens, electrostatic P.U.stations, beam current monitors and some grid monitors (SEMgrids) are all needed. Their position and numbers depend on the optics.

- Rmk: TT2 TT10 TT70 FT16 FA58 lines are already partially equiped with usable devices.

3 CONTROLS

General frame

The computer control in charge of BFI machines must be compatible with the planned future PS complex control system. Not entering in details we can foreseen that end user interfaces in control rooms will be several WorkStations, transmissions will be based certainly on Ethernet links and related protocols, and interfaces will be the now industrial well implanted VME standard..

1 NETWORK

The software protocols will be the CERN used recommended ones: TCP/IP family.

The computer network at the ISR site can be a standard LAN (Ethernet or other) since the distances are not too large. For the longhaul to the PS it is assumed that DD will provide the necessary infrastructure, FDDI or other backbone architecture.

2 ANALOG/DIGITAL DATA CONCENTRATORS

To handle the remote operation of the B-factory in production mode it is requested to use the MCR control room. This must entail a certain concentration of data and conversion of analog to digital signals in the local control room context for transportation to the MCR. Modern instruments contain remote access points, either with PC or with HPIB CAMAC/VME interface systems that allows easy programming access to all functions including transfer of display data. A duplication of the more expensive devices, such as spectrum analyzers and network analyzers can be avoided with a reasonable amount of programming effort.

3 LOCAL CONSOLE SYSTEMS

The local console system should consist of a number, as many as needed, of workstations with all analog instrumentation conveniently installed close to the analog instrumentation cf. the LEAR with several mobile workstations located in both the control room and in the electron cooling building. These workstations will be identical to the main control rooms workstation, to enhance the standardization of all software, both general application and equipment specialist types.

4 CENTRAL CONSOLE SYSTEM

The central consoles should in all respect adhere to the future PS consoles with complete control of the B-factory possible from one single console or two. It is assumed that there will be enough, at least three workstations in such a console that can easily be supervised by a single operator. The analog signals that today are available on the PS consoles on digital oscilloscopes are most probably only available via a digital interface from the local B-factory control room. It thus seems reasonable to assume that also some kind of analog signal multiplexing must be available in the local control room with remote control and observation available for restricted special cases.

5 DISTRIBUTED LOCAL ENTRY POINTS

To manage the different subsystems it is necessary that access points to the control system are distributed close to these equipment areas with workstations/terminals available for tests and fault handling.

A goal of the control system should be to provide an as general as possible coverage of all interaction needs on all levels to the various subsystems to avoid a proliferation of disparate local systems. The more of subsystem diagnostics that can be handled from a single point the more efficient the operations team will become to find and correct faults.

6 OPERATING SYSTEM

The computer operating system will be the same as used in the PS and LEP/SPS new systems : there will be UNIX for general facilities and OS9 for front-end real time processors.

7 GENERAL TOOLS

It is assumed here that the PS and SL controls systems will provide the general tools such as synoptic display programs, log programs ,archive programs ..etc. that are part of a software tool box for accelerator control system as well as all hardware dependant routines which request professional programming techniques.

8 APPLICATION SOFTWARE

The application software will be written by the machine physicists, provided the control system can offer a user friendly environment and tool boxes.

9 EXPLOITATION ISSUES

The main goal here is to impose an as small as possible extra load on the current control system exploitation teams by using standard software and standard, industry maintained computer hardware. All non accelerator specific software should be common to the CERN control systems.

10 CONTROL SYSTEM COSTS **(hardware + software licenses)**

This cost "calculation" is based on a rough estimate of the number of control channels in both the transfer lines and in the two machines. The number of magnetic elements are taken from the lattice layouts as they have become available, the number of instrumentation and diagnostic channels have been guestimated starting with existing machines.

To control a standard power supply four control channels are needed:

- Two channels for actuations, controls and status
- Two channels for acquisitions, data and status

Other devices might need more or less channels depending on their complexity but this number has been used as a reasonable average.

A study by F.Perriollat & C. Serre (Ref 4) shows that the average cost of a control channel, using either CAMAC or VME technology is of the order of 1000 SFR including crate/embedded computer hardware overheads and cables. The number of channels per CAMAC/VME crate is of the order of 120-160 in current systems. The given prices are those of the currently used technologies at CERN.

The table below gives a distribution of the estimated control system costs:

Control channels	- 8000*1000 SF =	8.0 MSF
Workstations	- 20*60000 SF =	1.2 MSF
(Incl local WS + infrastructure + licenses + central support)		
Timing system + Other special hw	~	1. MSF
Analog signal obs.	- 1000*1.500 SF =	1.5 MSF

	~	12 MSF

The Timing system costs are extrapolated from the EHF project. The analog system cost is derived from the PS analog observation system cost. Cabling is estimated to be 5 % of the total cost:

Total Controls ~ **12.6 MSF**

Access control (radiation safety)

At this very early stage, only an overall idea can be given, following the general rules applied in CERN radiation safety matter.

Zones definition One zone including the machine and both experimental areas (A4 + A8 or A1 + A5)

Emergency doors Estimated number: 20 (10 + 2 + 6 + 2)

Controlled access doors Three should be sufficient: Area 4, Area 8, machine (near ISR CR)

Beam stoppers 2 (one per ring)

Switching magnets 2 (addition to existing transfer line bendings)

Controls. Interfaces Video cameras, intercom, computer control

Cost estimate Very rough estimation gives 0.65 MSF

Radiation monitoring (16 x 2 positions) 0.32 MSF

Total ~ **1. MSF**

References:

1 J.P.Riunaud Note PS/PA/Note 90 - 04 : The PS as injector of the BFI

2 H.Braun, K.Huebner, W.Joho PS/LP Note 89 - 11 : Average to peak luminosity of BFI

3 P.Bryant, S.Pichler Tech. Note AT - MA 90 - 01 : Beauty Factory: Beam Transfer

4 F.Perriollat C.Serre PS/OP/WP 89-18 : Budget du systeme de controle du LPI. Comparaison avec la proposition de budget de controle du Linac a plomb.