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Memo

Date: April 1, 2011

To:

From: F. Willeke

Topic: Assumptions on NSLS-II Accelerator Operations Budget

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1) Revisions

First Version 1 April, 2011
2nd Revised version, April 15 April, 2011

2) Purpose and Context

A first version on the NSLS-II Accelerator Operation Budget has been estimated which serves as a base for further development, refinement, discussion, and integration of the entire future NSLS-II budget. This Memo summarizes the assumptions which have been made to generate the operations budget to document the base of the estimate and to facilitate the discussion of the budget.

3) Parameters used to create the budget

Average labor rates (as used for the budget of the NSLS-II project) have been used to calculate the costs of the evaluated labor efforts. They are listed in Table 2.1. The labor is assumed to be covered by five categories:

- Manager
- Scientist,
- Engineer,
- Technician,
- Administrative support

The reference year is 2014. The cost for later years has been corrected by a constant inflation rate of 3.2 %. The yearly labor hours are assumed to be 1760 hrs/a. The direct labor estimates includes only the time to carry out a particular task. As every BNL employee spends a non-negligible amount of time for training, safety instruction, administrative tasks, knowledge and skill development, reporting and similar, the labor for each specific task is augmented by a certain factor. The amount of working annual hours need for the above activity has been estimated to 337 hrs/a. This leads to an enhancement factor of 1.24. Note that these parameters need to be agreed upon and need to be updated for consistency when this budget estimate is to combined with the non-accelerator operations budgets. A Laboratory burden rate of 25% has been used to estimate the cost for materials and services.

Table 2.1 Global parameters and scale factors used for cost estimation

Labor Enhancement Factor	1.24	
Escalation	3.2%	
Burden	25%	
Labor Hrs per year	1760	hrs/year
Hourly rate Scientist	65	$/hr
Hourly rate manager	65	$/hr
Hourly rate Engineer	59	$/hr
Hourly rate technician	43	$/hr
Hourly rate admin	44	$/hr
G&A+time off correction factor	2.02	

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4) Basic Assumptions

The goal of accelerator operations is to provide a stable high quality beam for synchrotron radiation users at times which have previously agreed upon with the users and with the funding agencies. In order to perform this task, the following main activities have to be performed:

- Coordinate operation activities
- Provide safe operation conditions for users and staff
- Manage resources for operations
- Perform beam operations by operators in the main control-room.
- Carry out accelerator studies to improve and develop accelerator including studies of phenomena and difficulties which have been encountered during routine operation.
- Carry out regular reoccurring maintenance, preventive maintenance and address any current problem and issue
- Perform interventions, trouble shouting and repair as needed to restore operations after a failure
- Develop, upkeep and modernize the accelerator systems to keep them well functioning and maintainable
- provide and preserve an adequate spare's repository

The success of operations can be simply measured by the beam time made available for the users. A more sophisticated metric would be to fold in beam parameters such as beam current, beam emittance, 6-D orbit stability. The following operation goals are assumed as a base for this operational cost estimate:

- The accelerator is in a **matured state** with quasi constant operational parameters
- The scheduled user time per year for the accelerator in a matured stage will be **5000 hpa**.
- The accelerator reliability, defined as beam time delivered to the users at scheduled times divided by the total scheduled time, is assumed to be larger than **A= 95%.**

It must be understood that these numbers are for an accelerator in a mature state. In the first year, the number of user hours is expected not to be larger than 2000 h and the reliability will be only 80%. At the same time a significant larger effort in studies, trouble shooting and repairs will be necessary to achieve the reduced level of performance. This will gradually improve in the first few years of operation depending on the level of effort in accelerator maturing as compared to providing more and new features (insertion devices, front-ends, special beam optics) and operations. It is also assumed that the

maintenance effort will require more time and resources as all the systems are new and the available experience will be limited. Any deviations from the basic assumptions matured accelerator, 5000h operating per year, 95% reliability and corresponding impact on the operations budget will be discussed below (section xx).

5) Methodology

4.1 **WBS**

For the purpose of creating an integrated resourced-loaded and resourced-leveled schedule and corresponding staff planning for all the activities of the PS Directorate which includes operating of the PS facilities as well as several, simultaneous projects, the operations budged planning is based on a work-break-down-structure for the accelerator operations. This way, the same planning tools can be used for operations and project which will facilitate the creation of an integrated staffing plan. The level three of the dictionary is structured into:

- Accelerator Development WBS 2.1.3,
- Operation Resource Management 2.1.1,
- Operational Safety 2.1.2, and
- Coordination of Accelerator Operation 2.1.4.

WBS 2.1.4 comprises most of the labor to be performed. It is sub-structured according to technical subsystems. The overall operations oversight for each of the accelerators in the NSLS-II complex and the main control room activities are WBSA elements on the same level. In order to minimize the number of activities and associated cost accounts. The WBS is spelled out in five levels in some branches of the WBS. The last level contains up to 12 activities.

In contrast to the activities of a project WBS, the elements of the operations WBS are assumed to be reoccurring. The workloads are not uniformly distributed which would be unrealistic. Some activities cannot be planned in advanced. These are trouble shooting and repair activities. The proposal is to use placeholders in the schedule which occur regularly at the expected rates. The operations schedule is updated weekly to reflect the reality of operations. This practically excludes any EVMS-type of controlling.

4.2 **Dictionary**

The corresponding operations WBS dictionary is defined to level 4, the highest level called “NSLS-II” operations which comprise besides “NSLS-II Accelerator Operations 2.1” other level 2 operation activities. The corresponding level 4 WBS dictionary entries make reference to a level 5 WBS which, at this point, is not spelled out in detail.

4.3 Activity Categories

Most of the operation activities within the level 4 control accounts of technical subsystem operations have and identical categorization of the activities:

- Activity 0: organize operations
- Activity 1: monitor performance
- Activity 2: generate optimized settings
- Activity 3: plan and execute maintenance

- Activity 4: perform trouble shooting,
- Activity 5: perform or organize repair
- Activity 6: perform small improvements
- Activity 7: generate on-call plans
- Activity 8: manage assets and spare inventory
- Activity 9: power consumption
- Activity 10: maintenance contracts
- Activity 11: miscellaneous consumables
- Activity 12: continuous investments

These 12 items cover most of the activities in every subsystem with only a few exceptions.

Other important activities are:

- Perform operations
- Support accelerator physics of operations

In order to illustrate the work which is labeled “maintenance” , “trouble shooting”, “repair” and “perform operating”, table 4.1 shows as an example a detailed list of work to be performed to operate the LINAC.

4.4. Determination of Labor Effort for operation of technical subsystems.

The labor effort is calculated in a bottoms-up fashion. The annual labor effort to maintain an accelerator subsystem (for example instrumentation) is assumed the be proportional to

- the number of technical subsystems (for example BPM system, beam scraper system etc),
- the number of identical devices,
- the annual frequency to the work to be performed,
- the labor effort per occurrence and per device,
- the number of staffed needed for the activity.

The overall labor effort is assumed to be resource leveled without any additional labor effort attributed to the process of resource leveling. However, it should be noted at this point that resource leveling of accelerator operations is impossible as the labor per unit time varies very strongly and on a short time scale unpredictably. Other activities as operations such as project work, R&D activities have to be included into the picture to arrive at a credible realistic staffing plan. The issue is mitigated only partially by the integration of “development and improvement projects” as part of the operations activities to fill the gap. The role of non- operations activities in the context of an overall healthy staffing profile will be further discussed below (section xxx).

Table 4.1 Detailed list of labor performed to operate LINAC

work	labor	FTE-end			
overall maintenance	tech	0.135			
		time/event [hr]	frequency [1/month]	persons	FTE/Year
Maintain Gun Containment		1	0.083	2	0.001
Check for water leaks, cleaning filters		1	0.250	1	0.002
LINAC RF conditioning		4	0.500	1	0.014
lubricate threaded rods of moving parts		1	0.083	1	0.001
exchange cathode		16	0.017	2	0.004
change klystron		16	0.072	3	0.024
exchange fluroscense screen		2	0.083	1	0.001
clean hV surfaces exposed to air		2	0.167	2	0.005
resurvey the linac		24	0.025	2	0.008
test and maintain safety systems		16	0.167	2	0.036
routine electrical safety check		1	0.083	2	0.001
maintenance on HV PS		4	0.500	2	0.027
replacing solid state switches in the modulator		4	0.208	2	0.011
Maintenance and work planning		2	0.083	1	0.001

work	labor	FTE-end			FTE-int
trouble shooting and repairs	eng	0.1130			
		time/event [hr]	frequency [1/month]	persons	FTE/Year
repair water leaks , water pumps		1	0.0833	1	0.0006
repair power supply		2	0.1042	1	0.0014
repair HV supply incl HV transformers		8	0.4000	2	0.0436
repair gun		8	0.0625	2	0.0068
repair transmitter electronics		2	0.0008	1	0.0000
repair vacuum leak		8	0.0008	3	0.0001
repair electronics failure		1	0.0208	1	0.0001
repair diagnostics device		3	0.5000	1	0.0102
repair safety system		2	0.0833	2	0.0023
LINAC thermal conditioning		8	0.1667	1	0.0091
replace fans		2	1.0000	1	0.0136
repair safety device		4	0.2500	1	0.0068
repair work planning and safety assessment		1	2.6725	1	0.0182

work	labor	FTE-end			
operations	tech	0.2161			
		time/event [hr]	frequency [1/month]	persons	FTE/Year
routine operation, turn on/off, checking parm		0.25	30	1	0.0511
organizing an coordinating repairs		0.5	2.6725	1	0.0091
reporting, documenting, logging		0.1667	17.1233	1	0.0195
trouble shooting with beam		0.5000	4.0000	1	0.0136
LINAC accelerator physics		2.0000	1.0000	1	0.0136
tuning, steering,		2	8	1	0.1091

In order to make a realistic labor estimate, other activities which are a precondition for performing work need to be considered as prerequisite for performing labor need to be taken into account. The associated work hours are varying individually depending on position, required training etc. They are here taken into account by a global factor. Agreement about this procedure and the amount of this factor needs to be agreed upon the entire directorate planning.
This factor is based on the following considerations:
The active working hours are 1760 hrs/a, which takes into account vacation time, sick-time and family related leave.

- Effort for interaction with supervisors/direct reports on non-technical issues: 12 h/a
- Performance appraisal process: 12 h/a
- Effort for training, a number 6 of annual training courses per 2 hours: 12 h/a
- Global safety activities: regular reading of laboratory-, division-, group-wide safety instructions and warnings: 50 h/a
- Lab-wide information: 25 h/y
- Loss of working hours due to lab closing, warning, safety drill 25 h/y
- Loss of working hours due to lab internal commute 25 h/a
- Loss of working hours due to social activities during work-hours 8h/y
- Loss of working efficiency due to performance of several tasks 5% = 88 h/a
- Work hours devoted to job-training classes, increase of knowledge base 8h/a
- Work hours devoted to administrative duties like filling in time cards and similar 12h/a
- Time devoted to mutual information and instruction and training others on the job within the working team: 60 h/a.

This amounts to a total of 337 h/a, which corresponds to a factor of 1.23 for the labor to be planned.

4.5 Determination of Non-Labor Effort

Non-labor efforts are costs of

- Consumables, Coolants, lubricants
- Energy
- replacement spares,
- tools
- calibrations
- investment in modernization,
- computers,
- software licenses

Some of these cost items might be accounted for in other parts of the overall operations budget and care must be taken to avoid double counting. The level of detail and the accuracy in these areas is still fairly low with a 25% error bar.

4.6 Labor Effort for the control room Activities

The control room activities are considered as a level of effort type activities because control room staff has to be present in the control room covering the entire 5000 h operating hours. As NSLS-II will be a more complex accelerator than NSLS, it is assumed that the one-operator mode will not be feasible for a

number of years. It is assumed that there will be always 2 operators in the control room. The floor coordinators are not covered under the accelerator operations work plan. This is a point which needs more discussion and an agreement should be made where floor coordinator will be located and where their efforts will be budgeted budgeted. Besides being in the control room, additional effort will be necessary to train new/existing operators, to develop operating procedures, to communicate information about operations and to perform shift planning.

4.7 Labor Effort for accelerator operation coordination

Coordination of the large accelerator subsystems Storage ring, Booster and LINAC is a level of effort activities which requires a full FTE for each accelerator. The storage ring requires two full coordination staff, one of them more scientifically, the other one more technically oriented.

4.8 Labor Effort for Accelerator Physics and Operational Development

5. Assumptions on how achievable Goals will scale with available resources

The operations budget will be considered for three different operating goals:

- **Nominal,** which stands for operating efficiency of 95% and 5000 hrs of user operation per year,
- **Marginal,** which stand for operating efficiency of 80% and 3000 hrs of user operation per year,
- **Ultimate,** which stands for operating efficiency of 98% and 5500hrs of user operating per year.

Efficiency is defined as the number of beam-time made available to users divided by the total scheduled beam time for users.

It is assumed that even with “nominal” resources, the “nominal” operating goals cannot be achieved in the first year of operation because it is assumed that further insertion devices, front-ends and beamlines will have to be commissioned which reduces user-operating hours and that the accelerator systems will suffer from “teething problems” and from “infant mortality” of the components which will make if unlikely to achieve higher than 80% operational efficiency. Thus the nominal scenario assumes a mature accelerator in routine operation.

The following assumptions are made to determine the staff resources to achieve the performance goals for the three operating scenarios:
A detailed, bottoms-up resource plan has been created to achieve the “nominal” conditions.
This results in a necessary staff of 156 FTE.

For the “marginal” scenario (80% efficiency, 3000 hrs user operating), the following is assumed:

- Operations planning, operation monitor, and operating activities, shift planning, communication on operating status will scale with operating hours 3/5.
- Maintenance activities will be reduced by a factor of 2.
- Trouble shooting and repairs will go up by a factor of 1.5

This scaling results in a staff of 140 FTE.

For the “ultimate” scenario (98% efficiency and 5500hrs of operating) the following is assumed:

- Operations planning, operation monitor, and operating activities, shift planning, communication on operating status will scale with operating hours 5.5/5.
- Maintenance activities will be increased by a factor of 2
- Trouble shooting and repairs will be scaled by a factor of 1/1.5

This scaling results in a staff of 170 FTE.

Basis for the scaling is professional experiences and comparison with various existing accelerators. It is also assumed that certain operation activities such as management, planning, accelerator development will not scale with the operating goals.

Table 5.1 shows how the operation labor is distributed over the operating activities for the three different operating scenarios.

Table 5.1: Distribution of operating labor resources for the three operating scenarios.

Operating Scenarios:	95%/5000hr	80%, 3000hr	98%,5500hr
Activity 0 organize operations	4.26	2.56	4.69
Activity 1 monitor performance	9.74	0.58	10.71
Activity 2 generate optimized settings	2.17	1.30	2.38
Activity 3 plan and execute maintenance	14.27	7.13	28.54
Activity 4 perform trouble shooting,	11.02	16.53	7.35
Activity perform or organize repair	6.12	9.18	4.08
Activity 6 perform small improvements	23.01	23.01	23.01
Activity 7 generate on-call plans	0.99	0.99	1.09
Activity 8 manage assets and spare inventory	11.66	11.66	11.66
Perform operations	8.91	5.35	9.80
Train Operators	0.16	0.16	0.18
Develp operating Procedures	0.23	0.23	0.23
communicate info	0.15	0.09	0.17
Shift planning	0.09	0.05	0.10
Sumary	110.55	93.92	123.89
Other Activites	45.74	45.74	45.74
Total needed staff	156.28	$140	169.63

6. On the mutual support of R&D, Project, and Operation Activities

Operating activies will not be uniform in time. Some of the activities are uniform when the accelerator is operating. Other activities will peak during scheduled breaks and other will peak with a random distribution over the operating period. The result is a non-leveled labor profile. But not only is the operating labor non-uniformly distributed, but even more so is the needed skill set non-uniformly distributed. While low and medium skill set is required for routine operating procedures, highest skills is required to diagnose problems and resolve them quickly and efficiently with a minimum of operating time lost. Thus the ability of efficiently handling interventions and non-planned actions, the peak staff number will be different from the average staff number and the peak-skill set will be higher than the average required skill set. In other words, an accelerator with a staff level corresponding to the average staff will perform only poorly and some problems may take a large interruption of operations to be resolved. In operating facilities, this problem is resolved by undertaking upgrades, R&D and construction projects in parallel to operations. The staff for this activities needs to a large extent to be highly specialized, knowledgeable and experience. This high quality staff is usually the one which has been involved in designing and building the operated systems. This staff forms the emergency task force which helps to solve a crisis in operations quickly. For this reason, in a certain sense, the presence of new projects, R&D and Development is essential for an operating organization. A secondary effect is that new development

and modernization find their way quite naturally into matured operated systems. The relationship of the NSLS-II project and the NSLS operating has several examples for this synergy between operating and creation of new systems. For this reason, a healthy fraction of work on new-systems and work on operation is felt necessary for successful operation of NSLS-II. New systems are not a luxury which can be excluded in the organization without an impact on operations.

7. Assumptions on Early Operations

Once NSLS-II subsystems are completed and tested or commissioned, they need to be operated to allow for completion of the subsystems remaining to be commissioned. The following systems have been identified as in need for early operation support within the duration of the NSLS-II project:

Major Subsystems

- LINAC and Linac-to-Booster-Transfer-Line
- Booster and Booster-to-Storage-Ring-Transfer-Line
- Storage Ring

The LINAC will be operated from January 2012, thus during 75% of FY12 and 100% the flowing years. All its technical subsystems need to be supported after commissioning.

The Booster will be operated starting in the last quarter of FY12 and to 100% in the following years. All its technical subsystems need to be supported after commissioning.

The storage ring will be commissioned in the 2nd half of FY13 and in the 1st half of FY14 and needs during this time its utilities in operating mode. After the 2nd half of FY14, the storage ring with all its subsystem is operating mode and needs full operating support. Some subsystems such as insertion devices, frontend, controls, and safety systems will grow with number of beam-lines and will need increased resources, the increment scaling with the number of beamlines

Technical Subsystems

- Mechanical Utilities (DI-Water, Cyrosystem, Compressed air etc)
- Electrical Utilities
- RF Systems
- Pulsed Magnet Systems
- Safety Systems
- Diagnostic Systems
- Control Systems
- Mechanical Systems
- Insertion Devices

The basis for the evaluation of operation labor needs is the detailed bottoms up operating labor need for the nominal operations scheme. This is somewhat optimistic because of “teething problems” and “infant mortality”. Early operations will require a fraction of each labor resource specified in this estimate.
It is assumed that the annual labor for operating particular subsystems of a main system will scale with the annual operating time of the main system and with a factor specifies the fraction of a technical subsystem in a particular main system. For example it is assumed 10% of all power supplies are in the booster. The booster will operate 25% in FY12. Thus 2.5% of the full power supply operating resources is needed to cover booster power supply in 2012. This is a somewhat simplified approach but the precision

of the corresponding evaluated resources within the project competes well with the precision of the NSLS-II cost estimate. The scale factors are based on count of components in each subset whenever possible. Global support function such as management and accelerator physics support is assumed to scale with:

5% for the LINAC
10% for the Booster, and
85% for the storage ring.

The result of the procedure is summarized in Table 7.1 for the time between 2012 and 2018.

Table 7.1 NSLS-II Accelerator Operations Labor Staffing Profile 2012-2018

Activity	labor hrs per year	Labor type	FY12	FY13	FY14	FY15	FY16	FY17	FY18
NSLS-II Operations [FTE]	**157.59**		**16.42**	**50.10**	**108.30**	**158.81**	**151.41**	**159.44**	**159.19**
Operations Management	4,975.61	0.00	559.76	1,243.90	2.63	4,975.61	4,975.61	4,975.61	4,975.61
Operational Safety	5,254.41	0.00	591.12	1,576.32	2,298.81	5,254.41	5,254.41	5,254.41	5,254.41
Accelerator Development	37,221.75	0.00	4,187.45	4,187.45	18,145.60	37,221.75	37,221.75	37,221.75	37,221.75
Coordinate Accelerator Operations	229,913.04	0.00	23,565.77	81,160.63	170,165.92	232,059.88	219,031.83	233,160.12	232,715.31
coordinators effort	7,346.65	0.00	551.00	1,010.16	3,214.16	7,346.65	7,346.65	7,346.65	7,346.65
Coordinate LINAC Operations	2,101.77	0.00	1,576.32	2,101.77	2,101.77	1,576.32	2,101.77	2,101.77	1,576.32
Coordinate Booster Operations	2,101.77	0.00	525.44	2,101.77	2,101.77	525.44	2,101.77	2,101.77	525.44
Coordinate Stroage Ring Operations	6,305.30	0.00	0.00	0.00	3,152.65	6,305.30	-6,305.30	6,305.30	6,305.30
Accelerator Physics Support of operations	12,875.58	0.00	1,448.50	3,218.90	8,047.24	12,875.58	12,875.58	12,875.58	12,875.58
Beam Operation of the Accelerator Compl	20,016.38	0.00	2,251.84	5,004.10	20,016.38	20,016.38	20,016.38	20,016.38	20,016.38
Operation of Mechanical Utilities	19,118.68	0.00	4,076.34	9,490.65	16,874.79	18,978.56	18,978.56	19,118.68	19,118.68
Operation of the Electrical Utilities	9,832.07	0.00	1,106.11	6,145.04	9,832.07	9,832.07	9,832.07	9,832.07	9,832.07
Operation of RF-Systems	11,863.54	0.00	3,094.68	5,163.15	6,985.51	8,807.88	8,807.88	11,863.54	11,863.54
Operation of Pulsed Magnet systems	3,370.69	0.00	406.06	1,624.22	2,497.46	3,370.69	3,370.69	3,370.69	3,370.69
Operation of Vacuum Systems	31,984.02	0.00	3,598.20	19,990.01	31,984.02	31,984.02	31,984.02	31,984.02	31,984.02
Operation of Power Supply Systems	19,934.13	0.00	1,311.92	11,632.88	19,934.13	19,934.13	19,934.13	19,934.13	19,934.13
Operation of Safety Systems	7,053.90	0.00	1,007.70	4,534.65	7,053.90	7,053.90	7,053.90	7,053.90	7,053.90
Operation of Diagnostic Systems	12,590.58	0.00	684.05	1,666.14	5,492.42	12,590.58	12,853.42	13,129.40	13,419.18
Operation of Insertion Devices	8,019.06	0.00	0.00	0.00	2,004.76	8,820.96	9,622.87	10,375.84	11,128.80
Operation of Controls Systems	33,212.43	0.00	1,245.47	4,981.86	19,097.15	39,854.91	36,533.67	33,212.43	33,212.43
Operation of Mechanical Systems	22,186.50	0.00	682.13	2,495.33	9,775.76	22,186.50	21,923.78	22,537.98	23,152.19

8. Assumptions on Scheduling Operations for Start-up of operations

In the first period of operation, the time with accelerator beam on is devoted to the following activities:

8.1 <u>Commissioning of new insertion devices with low intensity beam</u>

This activity includes

- to implement the beam optics corrections needed to accommodate the insertion device,
- to verify correct compensation of linear and nonlinear beam optics errors
- to empirically correct the residual distortions of beam linear and nonlinear beam optics
- to verify the empirical correction
- to generate feed-forward correction tables which keep the optics well corrected while the gap is closed or opened
- to mature the corresponding procedures and implement them as part of the standard operating procedures

The total accelerator beam time which is needed for these activities 108 hrs of 13.5 8-hour-shifts.

8.2 <u>Commissioning of ID and front-ends with low and high intensity beam</u>

This activity includes (this list is not necessarily complete but captures a god fraction of the activities):

:

- Verify calculated safe beam current limit due to temperature raise in ID, dipole and front end vacuum
- Center the beam in the apertures of the insertion devices (low intensity)
- Determine the free aperture inside ID and in insertion devices
- Set EPS safety limits on Beam orbit in the straight section
- Increase the beam current and verify that no component is overheating
- Vacuum condition ID chamber and frontend vacuum with beam
- Verify personal protection system function with beam stored
- Commission photon BPMs
- If applicable: test closing feedback loop around X-BPMs
- Test top-off safety

The time needed for these activities is 168hrs or 21 8-hour shifts per frontend.

8.3 Commissioning of new beam lines

This activity includes:

- Adjust beam positions for beamline
- If needed adjust beamline or frontend components
- If applicable, adjust shims at ID to optimize spectrum

Time needed for this activity is 16 hours or 2 8-hour shifts. This beam time might be useable by other users which need to have lower priority.

8.4 General accelerator physics studies

The accelerator performance will be continuously improved by optimizing (this list is not necessarily complete but captures a god fraction of the activities):

- corrector settings,
- optimizing orbit stability, and
- optimizing procedures,
- identifying sources of distortions,
- Implementing special beam optics according to better serve the users.
- Verifying beam optics
- Beam based alignment

This process will take a considerable time in the first year(s) of operation and is assumed to take place at regular intervals of 24hrs per week in the first year of operation.

8.5 High Beam intensity studies

To bring up the beam to high intensity and full top-off mode bears many challenges and require intense study and set-up work interleaved with high intensity beam operation. The main activities are (this list is not necessarily complete but captures a god fraction of the activities) :

- Improve and fine-tune injection efficiency
- Test overall top-off safety system functionality
- Verify adequateness of shielding

- Check impedances and heating of vacuum components
- Study intensity effects on the beam orbit
- Verify suppression of radiation dose on experimental floor by ALARA systems: LCM-system, Area radiation-monitor system
- Vacuum conditioning with beam
- Set-up cavity systems for high intensity operation: beam-loading control loop parameter optimization
- Optimize settings for passive bunch lengthening cavities
- Optimize bunch lengthening over the bunch train
- Set-up and test broad band damper systems
- Study damper effect on vertical beam emittance

In order to improve the conditions for users quickly, these studies will be performed on a regular base in the first year of operation. The intensity will be ramped up in steps of 50 mA each step is assumed to take 96 hrs or 12 hour shifts.

It is assumed that the project insertion devices and frontends will be commissioned before the end of the project. It is further assumed that there will be 4 NIH insertion devices, front-ends and beam-lines to be commissioned after start up of operations.

Distribution

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