Summary of CLS Spectromicroscopy Project Design meeting #1

CLS, 27-Jun-00 (CLS-SM-design1-min.doc: last changed: 15-Aug-00)

Attendance
(from CLS) Emil Hallin (EH), Mike Bancroft (GMB) (am only), Barry Hawkins (BH), Jeff Cutler (JC), Mark De Jong (MDJ) (pm only), Dan Lowe (DL) (pm only)
(from BT) Adam Hitchcock (APH), Tolek Tyliszczak (TT), Stephen Urquhart (SGU)
(consultant) Tony Warwick (TW)

BACKGROUND

The CLS soft X-ray spectromicroscopy proposal was generated through a number of workshops (Toronto – Feb-98, Montreal Apr-98, Saskatoon – Feb-99, Nov-99) and was submitted on 10-Feb-00. *(If any reader of this report wishes to have a copy, please request one from aph@mcmaster.ca. It will be sent electronically)* The Facility Advisory Committee review of the proposal included a presentation to them in April-00. The comments and recommendation made by the FAC to the Board of CLS are included as A**ppendix 1**. The CLS Board accepted and approved the FAC recommendations at its meeting on 27-Jun-00. Based on this positive outcome the first design team meeting was held to begin the CLS spectromicroscopy project.

GOALS, and summary of progress at the workshop

DONE?	GOAL
Y	WHO – define the *design team* (Spectromicroscopy BL-developer (offer to be issued); APH, TT, SGU, with TW as contract consultant; CLS design personnel (through DL) as required; EH as overall beamline projects (WP 6) supervisor); consult extensively with beamline team at all stages
Y	HOW – process extensively discussed; many details still to be refined
(a bit)	WHAT – (EPU ; front end; Monochromator; switchyard; end stations) - agree to emphasize use of design-build, with some detailed in-house design and possibly construction for specialized parts
N	Project definition document - defined the content and reached an agreement on the steps needed & their timing to achieve the final detailed design which would be described by the full project definition document – see below
N	PEEM definition – NSERC Major Installation application needs to be prepared which takes into account BT needs (aph & sgu – by 23-Aug-00)
N	Reference Specification document (aph 10-july-00)

WHAT HAPPENED

9:30 How to build a CLS beamline *Emil Hallin* (CLS, Work Package 6 leader)

- vision and objectives of CLS – to lead in science as well as service

- CLS reference specifications were reviewed collectively. These machine parameters, which are basic inputs for beamline design, are attached as **Appendix 2a** (machine) and **Appendix 2b** (source point sizes)
- Canadian Nuclear Safety Commission (CNSC, successor to AECB as of June 1, 2000) says CLS is a "Class 1B nuclear facility". Among other things, this will require a CLS-generated, CNSC-approved Quality Assurance program, the details of which will be prepared in coming months. It is believed this could impact significantly on beamline development and approval procedures. At the minimum it will impose requirements of extensive documentation and safety evaluation / review.

(TW) - strongly encouraged CLS to assemble documentation which would outline PROCEDURES to be followed for specific classes of beamlines (hard, soft, IR, white, pink) and to get these approved by CNSC.

(APH – post-meeting comment) Since the change from AECB to CNSC will impact all nuclear facilities – university and hospital labs using radio-isotopes; etc – whose operations could be tremendously affected – it might be worthwhile seeing how these institutions react to the new CNSC climate before 'going ove

- CLS Project Organization (CLS structure & Org Chart outlined) reviewed **(see Appendix 3a)** (NB this org. chart was approved by Pres. Exec (Jun 20) and by CLS Board (Jun 27) as the operational org. chart for development of all beamlines within the 140 M 'CLS project' envelope.
- Number of technical staff existing at CLS (shared to accelerator & LB) **(see Appendix 3b)**
    - Suggest CLS needs {1 mechanical & 1 Autocad designer} services for every 2 beamlines
    - Role of beamline developer – point person for design, contract specification etc
    - Role of BL design team

NOTE *: the availability of many of the support individuals listed in Appendix 3b is likely to be minimal for the critical first 18 months of the process, when the detailed spectromicroscopy undulator and beamline design is to be developed.*

- Spectromicroscopy project documentation

The content and steps needed to produce the project definition documentation were outlined. As presented by Emil, these are:

	Item	DELIVERY TIME
1.	Mission statement (optional?)	
2.	Reference specifications	now
3.	Concept design & review (FAC)	now
4.	Preliminary design & review *(design-build via specs)*	8-15 months
5.	Final design report & review	Dec 2001
6.	Fabrication design (drawings) *(only if in house)*	Dec 2001
7.	Construction schedule	Dec 2001
8.	Construction budget	Dec 2001
9.	Installation plan	Dec 2001
10.	Commissioning plan	Dec 2001
11.	Operating plan	Dec 2001
12.	Upgrade plan	Dec 2001

FURTHER DETAIL ON SUCCESSIVE STEPS:

<u>Reference Specifications</u> – need to be written for: *(aph to evolve from proposal)*

- ID
- Absorber
- Slits
- Mirrors
- Monochromator
- End stations (STXM , PEEM)
- Shielding
- Positioning, bending and feedback systems
- Control systems for end station & integration with BL and ring controls

(but see TW comment on this below)

<u>Preliminary Design & Review</u> (8-15 months)

- from ref. Spec. to 'description' = full design specs for each component
- examine each for personnel & machine safety
- one doc for each component & overall
- budget and schedule estimates
- identify reviewers
- submit copy for review

<u>Final Design & Review</u>

- address all concerns raised in review
  - finalize
  - update budget & schedule
  - safety report & obtain regulatory approval
  - generate preliminary installation

Throughout Emil's presentation and later in the workshop there was considerable discussion about:

- timing for implementation of engineering design change rules and what that implied
- level of detail needed at each stage of project

See the commentary towards the end of this report for clarification of the steps and process timing, based on the current content of the PIM.

11:45 The CLS Project and its mechanisms for beamline development

Barry Hawkins (Project manager, UMA)

- status of overall CLS project
- OBJECTIVES for beamline design team
  - establish an effective design team
  - deliver a beamline that meets performance criteria
  - deliver for Jan 2004
  - deliver within budget
  - deliver a beamline that meets QA/QC, regulatory, CLS Inc. requirements
- "PIM for beamline project" – must work within CLS PIM structure / rules etc
- COMMUNICATE – external players need to be consulted / brought into play

- What to do NOW (to Nov-00 review (see below)
    - Confirm team members & roles
    - Create and approve work plan & deliverables
    - Create and approve budget
    - Create and approve contracting strategy
    - Review design stages (concept / preliminary / detail)
    - Create commissioning plan
  - How we do it – keep plugging !!
  - Procurement procedures and rules
    - U o S purchasing services
    - Electronic announcements
    - Type – whole gamut
    - Guidelines (<$1 K – discretionary); (<$5 K – 2 written quotes (invited); (5-100K - 3 quotes (invited); (> 100 K – goods & services or >250K – construction contract) – require 3 written quotes with full tendering
- Contract award – invoice process
    - Tender evaluation team will include scientific advisory members (8-day cycle)
    - Depending on level, may need approval up to UoS board
    - 30-60 day evaluation period, as specified in tendering
    - decision results on a letter of intent, followed by final negotiation then issuance of a formal contract or purchase order

12:30 Lunch with discussion

Dan Lowe (head mechanical engineer) outlined existing CLS capabilities with regard to design, drawing, and in-house construction. Existing staff are very heavily committed to supporting the accelerator components of the CLS project, and will be for at least the next 18 months. Work for beamline projects can be accommodated on a case-by-case basis. CLS is considering hiring additional engineering and design / drawing staff. In-house construction Capability is limited to small parts on account of limited machine sizes and personnel resources – best used for one-off or small runs where commercial fabricator does not exist.. Other shops on UoS campus can be used in a contract manner.

1:30 The CLS Soft X-ray Spectromicroscopy project: How the scientific goals determine the technical specs *Adam Hitchcock* (BIMR, McMaster University)

The main objective of this project is high brightness zone plate microscopy. The beamline design is being optimized for STXM, but PEEM will have a significant fraction of time. If the FAC recommendations are followed, the PEEM station may become a more stationary component. STXM: Hitchcock, Tyliszczak, Urquhart, Stover, Dutcher. PEEM: Hitchcock, Bancroft, Kasrai…others are interested materials researchers. “Macro” choices: STXM and PEEM are only two of a number of techniques. TXM and SPEM are alternatives. SPEM could be readily implemented on same line; TXM requires very different phase space.

Need an integrated view of the whole package from ID to mono to endstation microscopes. This also includes the facility "operating culture" and how the beamline team interacts with the facility, (e.g. degree of fee-for-service, priority access, scheduling) - but these are not part of mandate of the CLS-SM design team.

The EPU would enable magnetic studies with PEEM and STXM and also full control of the orientation of the polarization vector in linear polarization mode. The capability has not yet been implemented at any synchrotron but it is one that is expected to have a huge impact, especially for NEXAFS microscopy of polymers, or other materials where anisotropic micro regions occur.

Organization

The beamline team wants to be involved in all aspects of the project. At the minimum, want consultation all along the way. There are very significant personnel needs for this project, both in quality and quantity. Involvement of BT members with prior beamline and microscope construction experience is a straightforward way to supplement the limited CLS personnel resources. As an example, two people working full time for over a year have been doing the mechanical design and controls for the upgraded STXM at the ALS.

Barry: during the capital phase, how do you see the team functioning?
Adam: Report will go out to all of the people on the team, with an invitation for a response.
Barry: suggest that, to maintain the continuity of communication, the CLS developer would be the focal point to get things going.
Barry: Will there be one person on the scientific side that would be the lead contact?
Adam: I am currently in that role, and expect to continue. The BT internal structure and some agreement on degree of 'democracy' still needs development.

Monochromator/ID: PGM with EPU

Discussed PEEM Development and whether or not a commercial system should be purchased. If the NSERC major installation application is not successful, it may be necessary to put together a PEEM system in a couple of years through another route. Jeff Cutler believes he can sell time on a PEEM end-station to the US Airforce at least and perhaps to others as well. He needs to investigate the market a little better…the oil industry would probably be involved. Perhaps it would be good to stick with the commercial system.
JC noted that US Airforce (Wright Patterson) not impressed with a STAIB Auger system
APH - Strong desire by some members of BT to have as much as possible of the design and build process 'in CLS hands'. In our experience, one of the problems is that external design build projects can, and do go wrong. Tony is involved in analyzing the EPU / PGM BL 4.0 project at the ALS which did go wrong. Anecdotal evidence about projects at the ALS and commentary on the relative merits of in-house, design-build, and full contract construction of 3rd generation beamlines was provided by TW. In general TW is in favor of very extensive and careful work at the initial stages by both staff and the BT, to ensure everyone understands and agrees on the goals, and to ensure the final design is consistent with these goals. Even if a contract or design-build approach is taken, it is essential to involve CLS engineering staff to properly oversee specification and to monitor the external progress.

ID specifications:

High brightness from 100-2100 eV; full circular control from 600 - 900 eV; control of direction of linear polarization over as full a range of monochromator as possible. Would be willing to compromise on degree of polarization control at some level if absolutely necessary. Full control of orientation of the linear polarization in the C 1s region (280-320 eV) is non-negotiable. An uncertainty in the linear polarization up to 5% is allowable. Circular polarization uncertainty should be considerably smaller - Stephen suggests 2% as a probable level. TW - notes that the EPU settings are adjusted DYNAMICALLY to achieve symmetric operation in XMCD type operations where one wants same intensities and degree of polarization of right and left circularly polarized light.

Where / how can CLS generate unique aspects for this beamline ?

	in-house design	design/build
EPU	N	Y
Front end	Y	Y
Monochromator	?	?
Switchyard	Y	Y
STXM	Y (could be built by the BT, under contract to CLS)	
PEEM	commercial purchase	

Control system – Emil noted that all CLS controls will be written in EPICS. He expressed a strong preference to have beamline instrument control/acquisition executed through EPICS although he also indicated there may be a need from other systems to interact with the EPICS control system. He indicated Eric Norum has recently made significant contributions to EPICS architecture, which significantly enhances speed / flexibility while dramatically reducing costs. Tolek and Adam expressed concerns with a top-down selection of a programming language and control/acquisition philosophy. This concern is solidly based on their experience with STXM control system development. It is essential to have a control and acquisition system that is optimized for microscopy. This has been an 'Achilles heel' for all other STXM. TW suggested that it is better to define the requirements of an instrument control/acquisition system and let those responsible to implement it as they see fit. One possible resolution of this issue could be to contract the STXM, including its control/acquisition system, to an external vendor.

2:20 How the ALS is building high performance soft X-ray spectromicroscopy beamlines *Tony Warwick* (ALS, Experimental Systems Group, CLS consultant)

- ALS BL 5.3.2 bend magnet polymer STXM
  - simple & cheap - dedicated
  - vetting – Shadow ray tracing
- BL 11.0 insertion device STXM / spectroscopy
  - on an EPU,
  - feeding a variable included angle plane grating monochromator (SX-700 type)
  - flexible; switchable to two endstations
  - Design process described – concept – spring 99 & Nov-99
  - Detailed engineering process ongoing – reviewed 2-Jun-00

Optical choices - JenOptik (Zeiss SX-700 spin-off) OR (?) design-build (?) OR (???)

Costing & Scheduling for ALS BL 11.0 project – in house tracking now in place; still has flexibility for revision even though the project is in the 'final design generation' stage

Project monitoring – will be done by Washington DoE at level of major components. Once this process starts there are significant barriers to changes, requiring a formal procedure.

NB In order to make changes in an approved project, CLS procedures require a formal engineering change request / engineering change order (ECR/ECO), which has well defined initiation, review and approval procedures. This requirement will be applied with increasing stringency, as the spectromicroscopy project gets defined. Until the preliminary design is submitted and reviewed, the understanding developed at the workshop is that ECR/ECO procedures would be required only for major deviations from the concepts enunciated in the proposal, such as selection of a linear undulator rather then an EPU, or changing the types of end stations to be built.

3:30 BREAK

3:50 DISCUSSION

a) EPU issues and possibilities for procurement

At the end of the FAC meeting in April, Howard Padmore raised the possibility of CLS ordering an EPU from the ALS / LBNL. Ideally this would be identical to the existing 5.0 cm design currently built for BL 4.0 – several more will be constructed at the ALS in coming years and there could be cost / efficiency advantages to a CLS order. In order to evaluate this proposal, Emil carried out simulations of the performance of the ALS 5.0 cm period EPU on the CLS machine. He concluded it is not suitable because . . .

- when the EPU is operated in circularly polarized mode at 2.9 GeV / K=3, the beam size is so large that it will hit the 'exit aperture' in the take off of the EPU radiation from the ring. The aperture of major concern is the storage ring vacuum wall inside the dipole magnet which has an opening of 10 mm which is already a fixed parameter in the storage ring vacuum design. Among other things, there are significant dangers of damage to the ring if that happened, which means that any EPU operating mode which would result in significant power into the storage ring wall would not be accessible.
- Some of the photon energies in the currently defined spectromicroscopy 'space' would fall into this aperture clipping regime. One consequence is that the degree of L/R circular polarization would vary in unpredictable ways depending on how the fraction of beam lost changed with small storage ring orbit changes. Emil asked the BT to define the tolerable degree of uncontrolled fluctuation in degree of polarization

(from the discussion uncontrolled fluctuations at the 5% level for linear and 2% for circular are suggested targets. These numbers will be checked with experts)

NB The image and curves shown by Emil to illustrate this problem are included as **appendix 4a and 4b**.

TW: suggests that these problems arise largely because of the choice of K. They can be avoided by running the ID differently. In fact, these issues are not specific to the ALS design, but are fundamental to EPUs. In order to avoid too-big beam, ii is necessary to reduce

K from the value of 3; go to K=1 to make fundamental at 700 eV; place restrictions on K (gap & magnet strength limits), etc., to avoid 'danger zones' such as the above.

Computations were made by TW during the meeting using a Mathematica script (based on undulator equations in the orange synchrotron reference book) for an EPU that would meet the nominal scientific needs. A device with 8.0 cm period, Kmin=1 in horizontal, Kmin=3 in vertical, on a 2.9 GeV machine would provide

- 1^{st}, 3^{rd}, 5^{th} pattern to cover 100 – 2000 eV at high brightness with no brightness gaps
- horizontal linear polarization over full photon range
- vertical linear polarization ONLY above 250 eV
- first harmonic, circularly polarized light from 600-900 eV

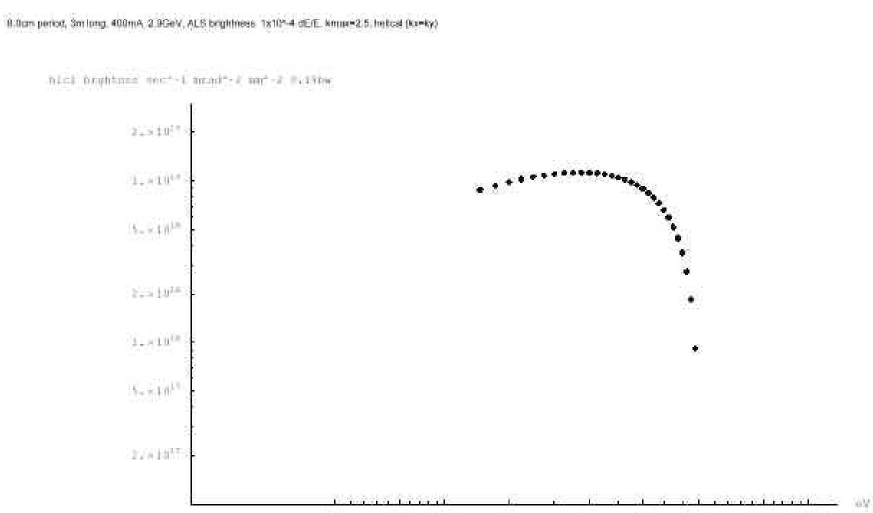
A "BACK-OF-ENVELOPE" EPU design by Tony Warwick (received 28-Jun-00)

The quantity plotted in the following figures is spectral brightness of the harmonic, as the undulator gap is varied. Helical plot for first harmonic (**EPU-1**), but the other two plots (**EPU-2, EPU-3**) are for linear mode, for harmonics n=1, 3, 5 and 7.

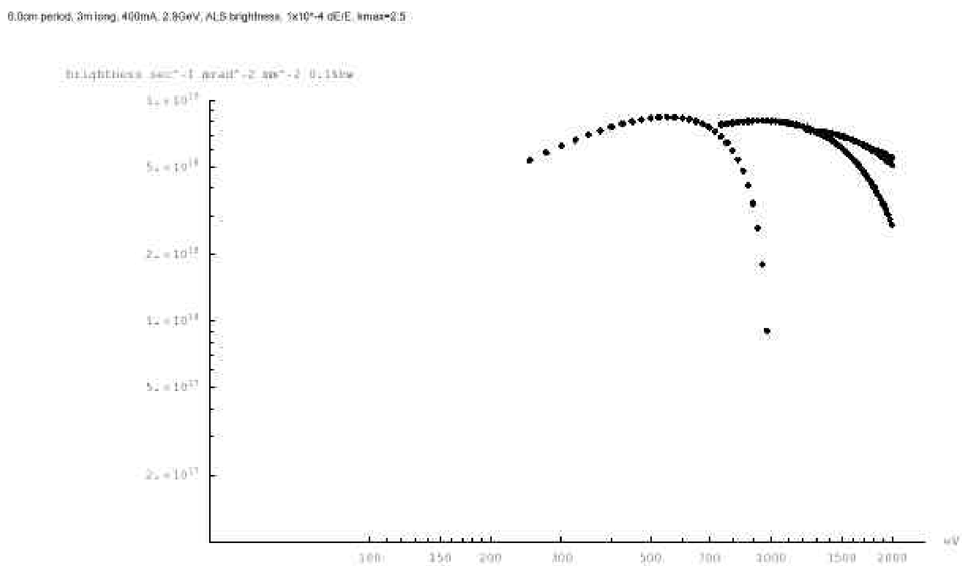
The choice of period is a compromise at 2.9 GeV. We would like to have the helical first harmonic extend up to 900 eV, to cover Fe, Ni, Cr L edges for magnetic studies. This requires the 8.0 cm (short) period. (see Figure **EPU-1**)

With an 8.0 cm period the continuity from n=1 to n=3 requires larger K values. But we don't want to go to large K because in the horizontal field mode we heat the storage ring chamber by the wings of the undulator beam hitting the walls. (The undulator gap also gets smaller, but that seems a secondary consideration). At an 8 cm period we just make it to 900 eV with n=1, then we need K=2.5 to achieve continuity between n=1 and n=3 in linear mode, and at the same K-value we would run with n = 1 below the C 1s edge at 300 eV.

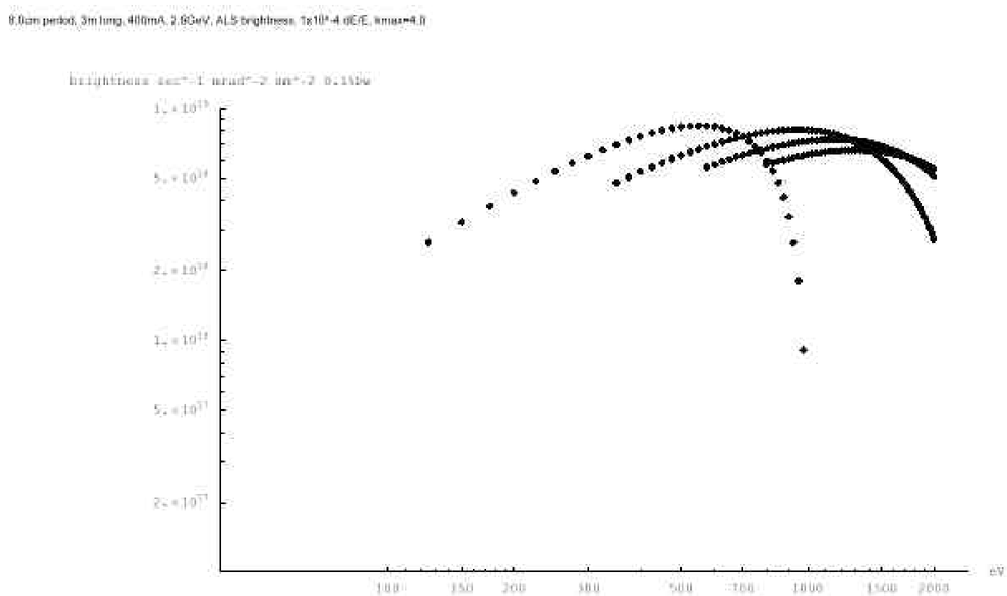
Then for lower energies (with vertical field only) this EPU design can go to K = 4 for 120 eV (with reduced performance from the beam line, I guess and no storage ring chamber heating problem)



EPU-1 - Circularly polarized first harmonic range includes 600-900 eV at high brightness (for magnetic studies).



EPU-2 - Linearly polarized first, third, fifth and seventh harmonic range. This is for E-vector in vertical orientation where the 10 mm internal vacuum tank size limits the lower energy achievable.



EPU-3 - Linearly polarized first, third, fifth and seventh harmonic range. This is for E-vector in horizontal. Due to the ability of the vacuum tank to accommodate a larger horizontal size, one can use this device to much lower energies without risk of heating the vacuum chamber. Note this mode of operation is IDENTICAL to a conventional linear undulator, and should be considered the curve for comparison to competitive linear undulator designs (e.g. for the undulator to fee the SGM beamline repatriating from CSRF/SRC).

EPU – further work to do

a) explore large period performance for vacuum aperture size issues
b) specify scientific needs of degree of polarization and stability in degree of polarization. APH and SGU proposed
    - fluctuation in degree of linear polarization +/-5%
    - linear polarized at 75% or better – typically 85% for BM and ~100% for a linear undulator)
    - fluctuation in degree of circular polarization of +/-2%
    - *(CHECK with XMCD experts)*

CLARIFICATION OF ISSUES - discussion needed over next stage
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1. BROAD SCOPE PERFORMANCE SPECIFICATIONS (aph to draft Reference Specs)
    - undulator
    - beam line
    - stxm
    - peem

(TW: *Keep it simple, don't worry about front ends or shielding, just the resolution, polarization, energy range, number and nature of end stations, special needs, eg microscope hut for environmental control.*
The front end, shielding etc. can be described in the conceptual design report, which must promise to deliver to your ref. specs. I believe the ID will be dealt with separately by the ID person.)

2. Contract for design consultation (TW, BH, EH) - time ? scope ?

TW - *I see a lot of work needed for the conceptual design, and I propose that we do enough of it ready for Nov 19th to verify that it will deliver the reference specs, then take until Feb 2001 to generate the final version of the conceptual design report, I'm going to say to Emil that I can do almost everything that is required for this conceptual design report.*
The preliminary design needs some engineering drawings (CLS) and some vendor identification and cost verification (TW), a couple of months should do, which gets us back on track to 5/31/01 for the prelim design report, as we discussed at the workshop.
Then the detailed design report will have heavy CLS input, to generate the fabrication drawings and the tender packages, deadline 12/01/01

3. DOCUMENT GENERATION

Reference specifications - APH by 10 July-00
Draft preliminary design – (TW and BL-developer)
- start ? ; draft to design team ~1-Oct-00
- review at SM workshop Nov 17/00 and design group meeting Nov 19/00

TIMELINES
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The project timing from the proposal is given in **Appendix 5**.
Emil – please update this with your Project-98 version. Note, this is a guideline. A major purpose of the design work over the next 6-9 months will be to lock this down completely.

Discussion with Barry Hawkins and review of the PIM, indicated the purposes and staging of the design process to be used by CLS is different than Emil described. The section of the Project Implementation manual (PIM) which deals with this is given verbatim in
Appendix 6 (*pp. 5.5 – 5.8 of PIM*

<u>TIMING OF THE STEPS IN THE DESIGN PHASE FOR THE CLS-SM PROJECT</u>

a. CONCEPT DESIGN – target Nov 19th, 2000 for final approval

b. PRELIMINARY DESIGN – May 31st, 2001 – submission of doc; review in June 2001

c. DETAILED DESIGN – Nov 30, 2001; review in Dec 2001
full engineering drawings for in-house constructed elements;
full specs for out of house constructed and design/build

<u>Other timing estimates</u>

CONSTRUCTION PHASE (2002 to mid-2003)
Jan 2002- Dec 2002 for formal safety evaluation and approval, procurement and tendering documentation, issuing RFP etc. Deliveries staged as needed.

INSTALLATION and ALIGNMENT PHASE (mid-2003 to end-2003)

COMMISSIONING PHASE (last 1/3rd of 2003)

TARGET FOR FIRST REGULAR OPERATION (1 Jan 2004)

5:30 SUMMARY (APH, EH)
++++++++++++ task assignments to **next in-person meeting (Nov-00)** ++++++++++
APH
- workshop summary – distribute for corrections ASAP (<u>distribute to BT</u> by 30-Jun-00)
- reference specification finalize (10-July-00)

SGU, APH
- develop NSERC MI application for PEEM (summary, draft budget by23-Aug-00)

TW
- EPU calculations
- Exploration of ALS-EPU option – how much can the design be changed ? – period ?
- Establish consulting contract with CLS
- Draft preliminary design – circulate to design team by mid to late Sep-00

SOME OTHER ISSUES NOT DISCUSSED IN WORSHOP due to time limits
(comments appreciated from design team members)

a) communication between {CLS – design team – BT} . Can / should we use the CLS web pages ? – or develop a parallel structure ?
(see http://www.chembio.uoguelph.ca/thomas/CISRbeam/index.html for a draft of a set of CLS beamline web pages by Dan Thomas)

b) Possible new scientific goals mentioned BUT NOT INCORPORATED in scope

X-ray emission side station (Alex Moews, Physics UoS) – probably a mismatch

Combined STXM and STM for atomic resolution STXM (Steve Patistas , Physics, Lethbridge) – worth pursuing if the needed STXM design changes can be accommodated without sacrificing STXM performance. Note a zone plate device is needed to concentrate sufficient photon density in the region of the STM tip, which would be used as the detector for photoelectrons. This has already been shown to work (K. Tsuji et al, Jpn J. Appl Phys,37, p 2208, 1998; K. Tsuji et al, Jpn J. Appl Phys, 37, p L1271, 1998)

APPENDICES

1. FAC report on spectromicroscopy proposal
2a CLS machine parameters
2b CLS source size parameters
3a. CLS org chart
3b. CLS scientific & technical staff for beamline work
4a. Image of light emitted by ALS 5.0 EPU at 2.9 GeV
4b. Current through exit aperture – effect on symmetry of circular polarization
5. Current spectromicroscopy project timing scheme
6. PIM manual pages for stages in beamline design (conceptual, preliminary, detailed).
7. PIM pages on ECR/ ECO

Appendix 1: Report on Spectromicroscopy from FAC

SOFT X-RAY SPECTROMICROSCOPY

Report on Soft X-ray Spectromicroscopy Proposal of A. Hitchcock et al.

Presentations were made by Profs. A. Hitchcock and S. Urquhart on the proposed spectromicroscopy program. The proposal outlined is extremely strong, and in many respects a model of how beamline teams (BTs) should put together a scientific and technological development program. The proposal covers a range of excellent cutting edge science, from self-organization in polymeric materials, through biomaterials, environmental science to magnetic materials. The program clearly uses the ultra-high brightness capability of CLS undulators to the full, and in the use and development of STXM will be the equal of any program in the world.

The use of an elliptically-polarized undulator (EPU) is critical to the success of this program. The ability to undertake linear dichroism measurements on polymers (and any other system with directional order, for example antiferromagnets) is of fundamental importance, as is the ability to rapidly change the helicity of circularly polarized radiation for magnetic materials. The alternative of sample rotation is a practical impossibility for high resolution imaging. The proposal would use ½ of a straight section, and it is recommended that the adjacent straight section be reserved for a 2^{nd} EPU. The latter could then be used (in a chicane) for rapid modulation spectroscopy, possibly on a pixel by pixel basis. This should be considered as a potential upgrade path. Extremely careful planning needs to go into the use of the EPU in the storage ring (effect on dynamics; problems were recently seen at BESSY 2) with feedforward and local feedback systems operational early in the commissioning of the undulator, to dynamically correct the beam position and angle. Some thought also ought to go into studies of EPU induced tune shifts, and whether dynamic tune correction is required,

The beamline plan is well thought out, and the decision to use a consultant on this and the STXM design is a prudent and ultimately cost saving step. The STXM being designed by Hitchcock in collaboration with Warwick at the ALS is clearly the next evolutionary step in STXM design, and should take the field into a new regime of performance. The ability to test out this design on the ALS bending magnet beamline 5.3 for a number of years prior to use at the CLS is clearly a huge advantage. Costs associated with the BL, STXM and PEEM construction appear well thought out and accurately reflect the expected costs.

The PEEM proposed will only have a relatively modest spatial resolution, and one probably far less than the STXM. The PEEM is ideally suited to studying surface and near surface phenomena, but suffers the problem of needing relatively conductive (or very thin), flat surfaces to achieve good imaging. However it is a very good complement to the bulk sensitivity of STXM. In the area of magnetic materials the PEEM is an ideal tool, and this could be an area of huge application for both basic and applied research. The Pis are encouraged to consider a rapid route from the relatively low resolution PEEM proposed to the new generation of aberration corrected systems that should be coming on line in the next 2 years. Due to the long planning and construction periods required, it is probably prudent to start to lobby for the funds (and people) necessary to carry off construction of a 2 nm aberration corrected microscope. PEEM will then be able to access a size scale where quantum size effects dominate electronic and chemical structure, and could open up a whole new area of activity for the CLS. Due to the complexity of any microscopy system, we strongly advise against a `portable' PEEM. The system should be arranged in a permanent location on a branchline, allowing push-button interchange of beam from STXM to PEEM.

It is clear that one of the roles the Pis have taken on is that of educators of a new Canadian user community in the application of STXM. They are to be commended on their development of this community, and it is clear that the enthusiasm and commitment of the Pis is being handed down to new users of xray microscopy techniques.

The question of beamtime access is currently under active discussion at CLS. The fraction of beamtime requested by the beamline team in this proposal is 60% of the total. This is reasonable considering the time, energy and intellectual leadership that this beamline team is devoting to the program. It is recommended that 2 years after the official commissioning of the STXM and two years after the official commissioning of the PEEM, the beamline team will present its results to the FAC for review of its scientific program.

It is noted that 20% of the priority beamtime will be allocated internally to BT members from Quebec and the U.S. Neither Quebec nor the States involved have made any direct financial contribution to the estimated 6M$ cost of the beamline. This group describes interesting scientific research that would enhance the reputation of the soft x-ray microscopy beamline. But there is no explicit statement of the time, energy and intellectual contribution they make to the design, construction and commissioning of the beamline. Unless their efforts can be clarified satisfactorily, the FAC recommends that this subgroup be classified as general users and be given access to the beamline only on the basis of ratings of peer-reviewed proposals.

We recommend that within 3 months of the start of the project, the beamline team hold a conceptual design review. This process should be documented and monitored by the CLS staff. This should involve national, and if necessary international experts so that design problems can be identified and easily corrected early in the design process. Part of this review (or a separate CLS review) ought to address the issues of floor space, and the safe operation of the beamline (personnel and equipment). This is necessary to make sure that radiation shielding is designed correctly, the best designs are chosen, and that the design does not preclude the full development of adjacent beamlines. It also aims to ensure safe operation of the facility if accidents happen (eg. if water flow is halted to some elements for some reason).

The proposed 6 M$ total construction budget is proposed to be funded by an NSERC proposal for 0.5 M$, 2.2 M$ from the beamline component of the CFI grant, and 3.3 M$ to be funded from current funding initiatives to Alberta and Ontario if these are successful. NRCan may provide 0.25 M$, and the Alberta proposal explicitly identifies 1 M$ for this spectromicroscopy program. This would leave 2.05 M$ to come from the Ontario funding. If these funding proposals are not successful, the beamline team would apply directly to their provincial CFI funding agencies. These seem to offer a good chance of success, and the FAC therefore approve use of the CLS funds identified above.

The operating budget for the beamline is 174 K$, made up of salary for a scientist, technologist and with 50 k$ for maintenance & operating expenses. This is a basic minimum to sustain operation of a mature facility, and it is clearly lean if there is to be either substantial development work, or substantial external or industrial users who may not be expert in the use of spectromicroscopy techniques. Considering the dual end stations, STXM and PEEM, the operating personnel are clearly going to be extremely stretched, even with a strong beamline team taking much of the load. The team is encouraged to identify other sources of operating funds to enable hire of a more substantial operational support team.

Finally it should be noted that the involvement of a local faculty member from the University of Saskatoon, Prof. S. Urquhart, is a very strong component of this proposal and hopefully can be emulated in many of the key areas of the CLS program.

Owing to the complex financial arrangements which are still in flux, and the complexity of the operational model, it is strongly recommended that as soon as all the financial commitments and obligations are settled, the CLS should draw up a memorandum of understanding with the beamline team that will spell out the division of financial and operational responsibility.

Recommendation:

A soft X-ray microscopy beamline be constructed taking into account comments in the report.

Appendix 2a   CLS Reference specifications

CLS Reference Specs

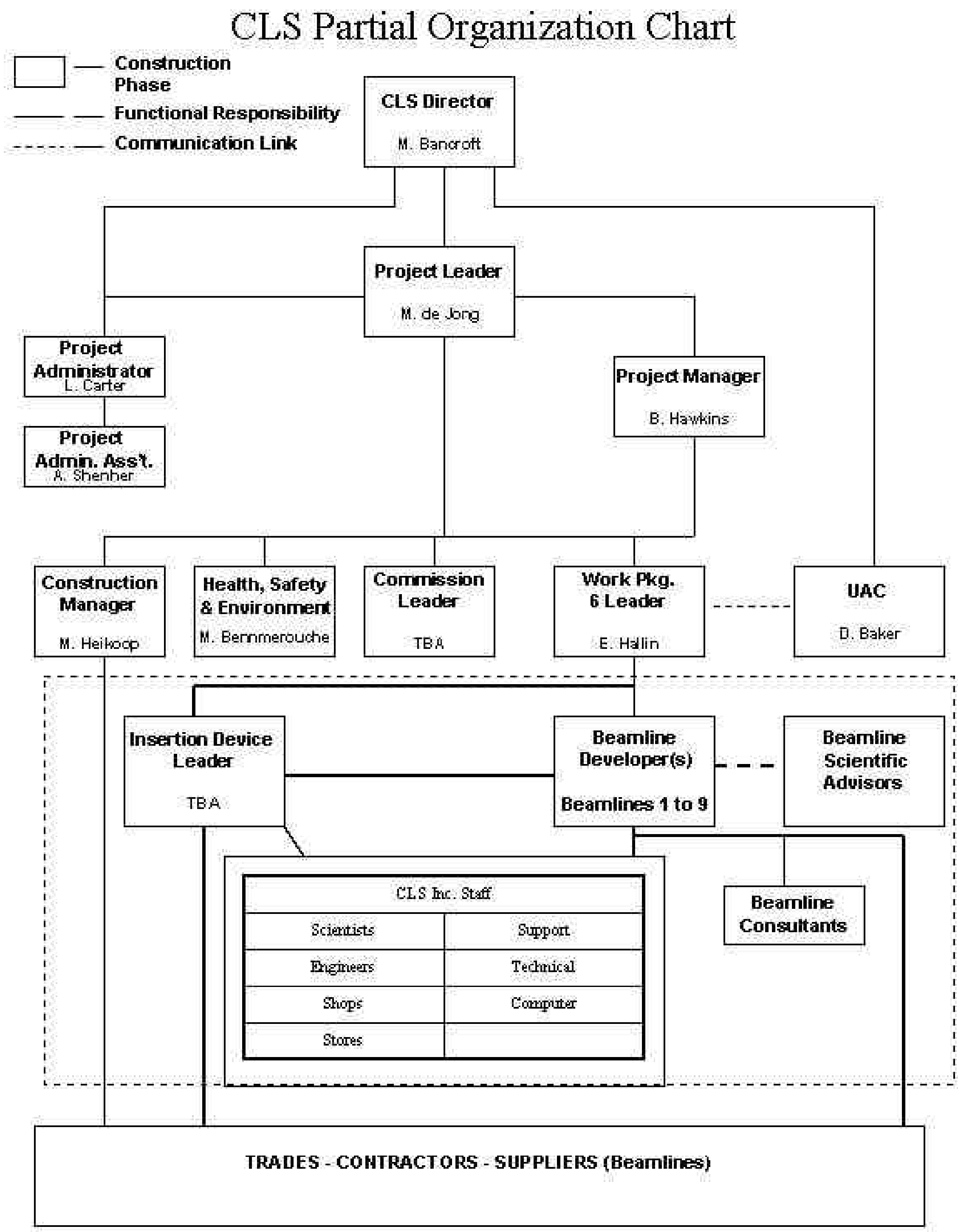
	(2003)	(2004 - 2005)	(> 2008)
Energy (GeV)	2.9	2.9	< 2.9
Current (mA)	100	200	500
x-y Coupling (minimum)	<10%	<1%	< 0.2%
Horizontal Emittance (nm-rad)	< 30	< 20	< 18
Time structure	multi-bunch	multi-bunch	multi-bunch or single-bunch
Lifetime (h)	> 4	> 6	> 10 (or Top-up)
Maximum uncorrected closed-orbit distortion in x or y (mm)	10	10	3
rms uncorrected closed orbit distortion in x or y (mm)	5	5	1
Maximum corrected closed-orbit distortion in x or y (μm)	100	100	30
rms corrected closed-orbit distortion in x or y (μm)	30	30	10
Long-term rms (> 10^2s) horizontal stability (μm)	30	30	10
Short-term rms (10^{-2}s to 10^2s) horizontal stability (μm)	3	3	1
Long-term rms (> 10^2s) vertical stability (μm)	5	3	1
Short-term rms (10^{-2}s to 10^2s) vertical stability (μm)	2	1	0.2

Appendix 2b Source points for CLS Bend Magnets and Undulators
(note these sizes are in RMS not full width half maximum)

CLS Source Point Sizes

		Horizontal		Vertical	
		σ_{rms} (μm)	$divergence_{rms}$ (μrad)	σ_{rms} (μm)	$divergence_{rms}$ (μrad)
BM 1	2003	190	237	278	54
	2005	159	194	72	14
	2008	152	182	30	6
BM 2	2003	198	276	284	39
	2005	178	243	73	10
	2008	173	235	31	4
ID	2003	559	56	86	35
	2005	465	45	22	9
	2008	441	43	9	4

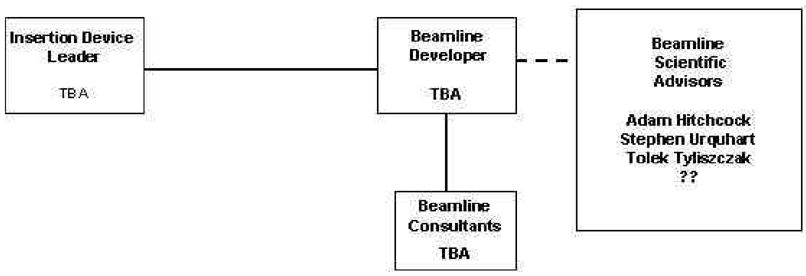
Appendix 3a CLS Organization chart (passed by CLS Board on 27-jun-00)



Appendix 3b Next-level CLS organization chart indicating support personnel POTENTIALLY available to assist with beamline design.

Emil noted in the Jun 28th BPAC meeting that the people in the support category are essentially 100% committed to supporting the accelerator development for the foreseeable future. As Work Package 6 leader, he has requested CLS to find ways to use external contract CAD and design engineering support for the more routine parts of the accelerator tasks in order that a significant fraction of the work for beamlines can be performed by the CLS engineering staff. Basically, accelerator design and construction is a 'terminal' activity whereas beamline design and construction is an activity which will carry on throughout the whole life of CLS (20-30 years). Thus it is relatively more important to RETAIN within CLS the growth and knowledge about beamline design, etc. At this point there is no firm plan for how to deliver engineering support to beamline projects. **THIS IS A CRITICAL ISSUE.**

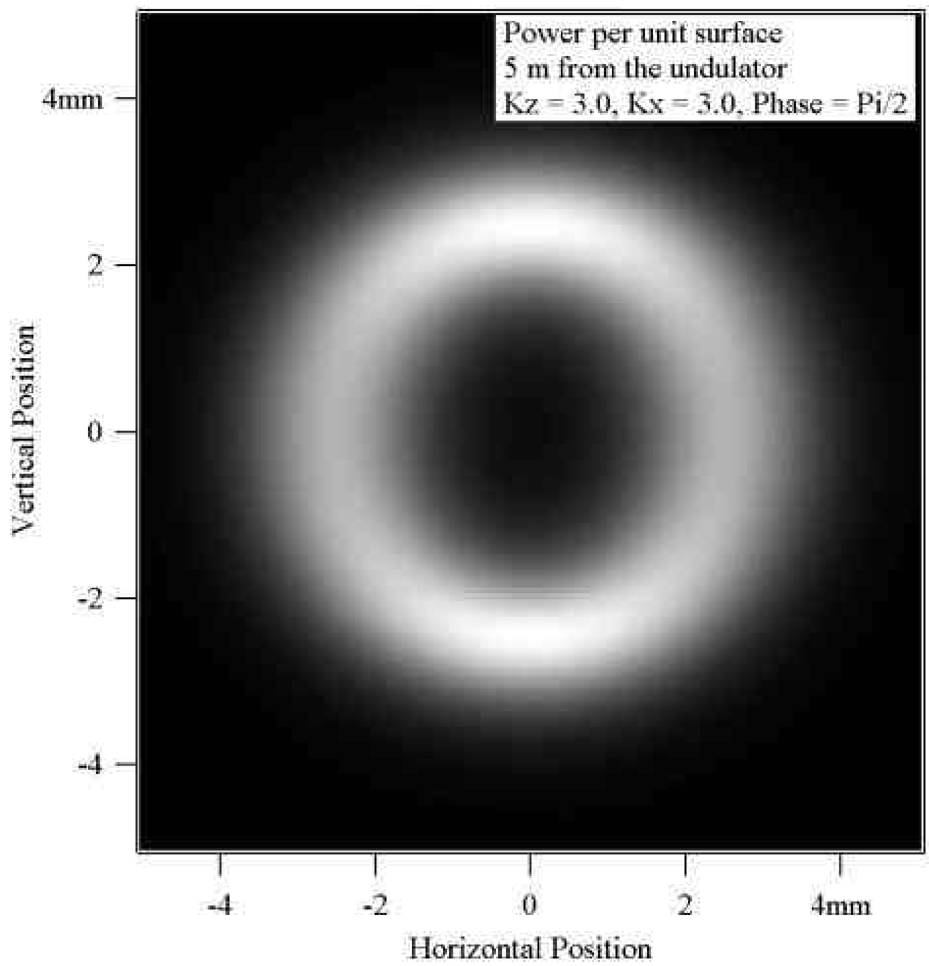
Spectromicroscopy Organization Chart



Scientists	Support
Juhachi Asai, Jack Bergstrom, Jeff Cutler, Emil Hallin, De-Tong Jiang, Johannes Vogt	**Safety:** Mohamed Benmerrouche, Chris Bergstrom
Engineers **Mechanical:** Dan Lowe, Jason Fielden, **Electrical:** Eric Norum, Neil Johnson	**Technical** Simon Chow **AutoCAD:** John Swirsky, Chris Bodnarchuk **Vacuum:** Dimo Yosifov
Shops & Install/Align **Mechanical:** John Greefkes, Norm Strunk, Noel Craddock, Mark Besse **Electronics:** Tom West, Heinz Buchmann, Bob Crosby, Don Leclair, Wayne McWilley, Roy Thompson	**Computer** **Office:** Skeeter Abell-Smith, Darren Gilchrist **Controls:** Glen Wright, Tony Wilson
Stores Andy Brown Randy Mackenzie	**Accelerator:** Les Dallin, Xiaofeng Shen, Mark Silzer

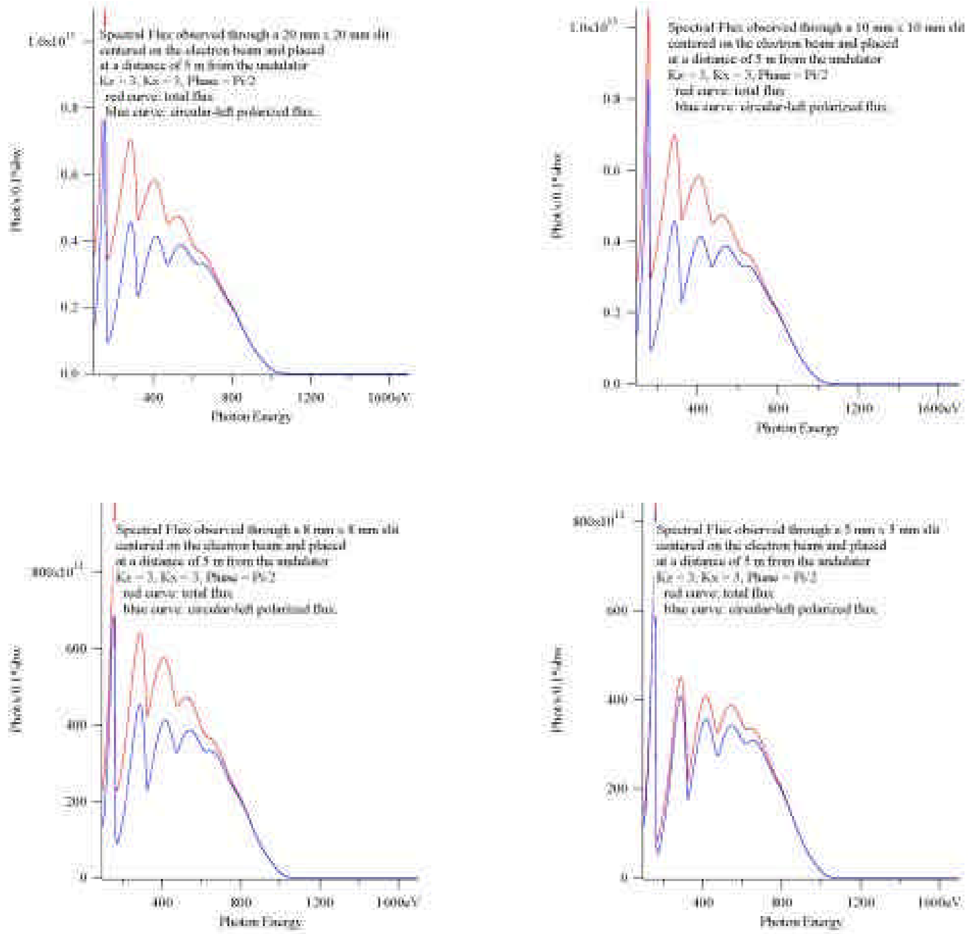
Appendix 4a Evaluation of ALS 5.0 cm period EPU on CLS 2.9 GeV machine

ALS Style EPU at CLS: Power Density



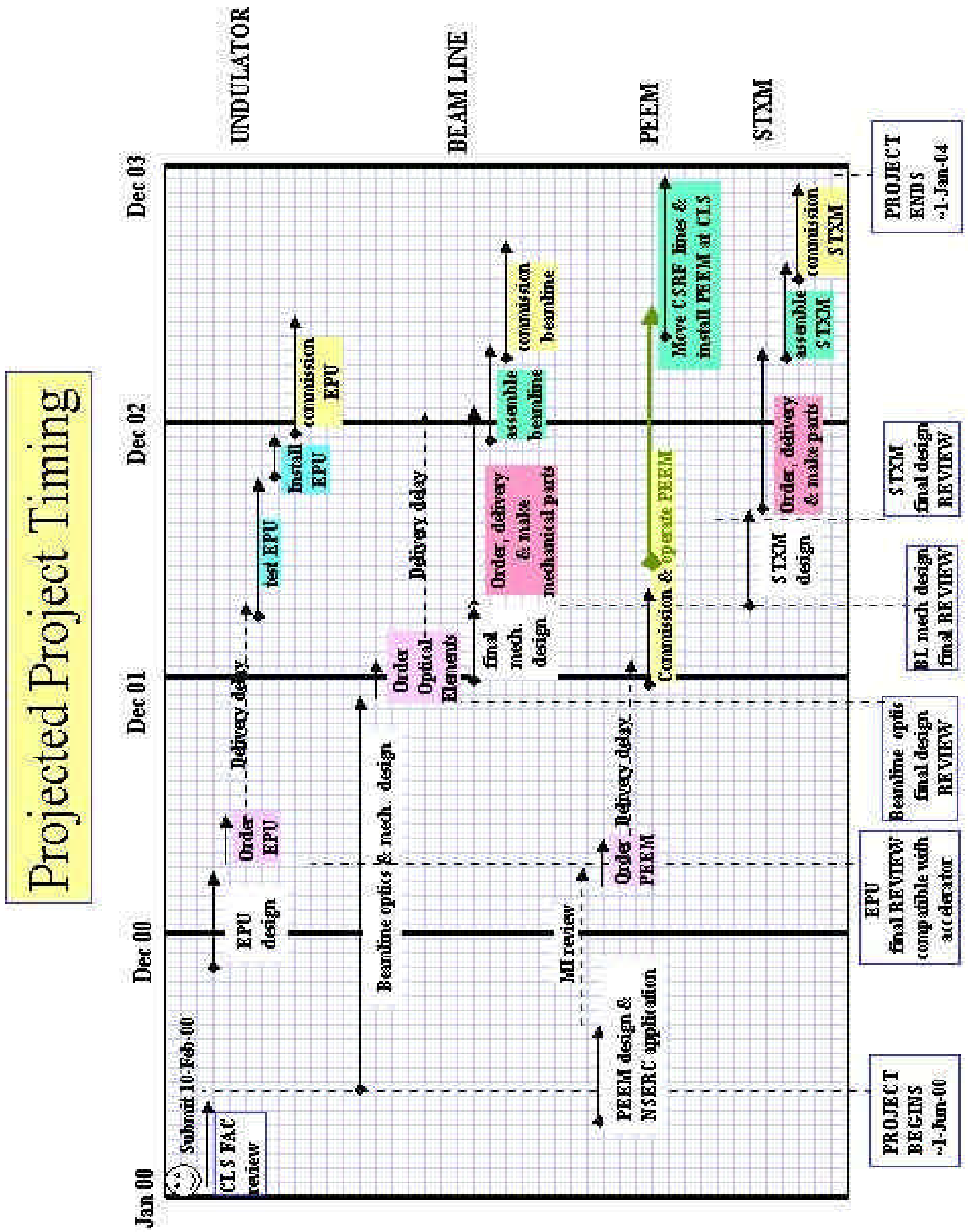
Appendix 4b Effect on degree of polarization of left and right circularly polarized light under conditions of beam clipping.

Spectral Flux through Vacuum Outrun for ALS U5 style EPU, used at CLS



Appendix 5 Current estimates of project timing

Ideally this should be the Project98 rework by Emil Hallin of the time scheme provided in the 10-Feb-00 proposal. Until that is supplied this is the time projection. A major issues which will drive the ACTUAL install and commission timing will be when the accelerator can be sufficiently commissioned to allow insertion devices to be installed. Current estimates, which range from late 2003 to mid-2004, are very dependent on the timing of the delivery of the superconducting RF system. Once this order is placed timing should become clearer.



Appendix 6 Excerpts from PIM manual on beamline project design stages

5.2.1 Design Stages

Design of the CLS and its systems will travel through three (3) design stages. The completion of each stage will be a milestone event. The design stages are:

- issue of the concept design(s),
- issue of the preliminary design(s),
- issue of the detailed working document(s).

5.2.6.1 Design Stage Review Process

Background

The rationale for the design review process are:

- to provide assurances the Project will be completed as approved,
- to define, record and share the approved design assumptions or basis for the Project systems and components,
- to provide a record of changes to Project deliverables (scope, budget and schedule) and associated approvals,
- to ensure technical completeness and consistency,
- to provide a mechanism for the Project Team to share a common understanding of each Project component or system,
- to provide a record or audit trail documenting internal or external changes to the Project once the system or component has reached configuration control.

Objectives

The objectives of the design stage status monitoring and approval process are to:

- establish the Project parameters (scope, budget and schedule) for all Project systems and components,

- monitor refinements to the design at key points,
- encourage “Design to Budget,”
- obtain approvals for changes within the overall Project scope and budget,
- provide a process to record, present and gain approvals for changes to the Project parameters or overall scope of the Project.

Near completion of the concept design, preliminary design and detailed working document stages, the Design Co-ordinator will submit for review and approval, a Design Status Report, see Sample 5H.

<u>Stage 1 - Concept Design</u>

The objective of the concept design is to evaluate the practicality of a design approach, or to select a specific design approach over design alternatives. The concept design is to clearly delineate a design solution and the identification of deliverables. In addition, the concept design stage requires the assembly of relevant information such as design notes, studies, etc., needed prior to commencement of preliminary design drawings and specifications.

Completion of the concept design stage will occur when a Concept Design Report has been issued, reviewed and approved as the basis to start preliminary design activities. Concept design documentation will include:

- the description of the basic philosophy, function and purpose of the design subject,
- description of design alternatives and evaluation conducted of each alternative,
- definition of procurement strategy,
- identification of deliverables for the subsequent phases,
- identification of Project restrictions or limitations, if any,
- schedule definition, including resource requirements,
- cost estimates and budget updates.

Concept design approval is a critical milestone within the design process as it marks the point when the Project Design Team commits to a specific design solution. The concept design is now under configuration control and changes proposed will follow the ECR process identified within PIM Section 5.7.3. The Project Team must be confident the design meets the Project criteria of scope, budget, time and performance. Once approved, a major assignment of design resources will be allocated to move the design from the concept design stage through to completion of the detailed working document stage.

It is the responsibility of the relevant Work Package Leader to secure written approval of each concept design. Approval of the concept design utilizes the CLS Design Status Report shown in Sample 5H.

Stage 2 - Preliminary Design

The objective of preliminary design is to achieve an effective design solution while incorporating research, design, engineering and technological criteria. The preliminary design phase is complete when the Preliminary Design Report has been issued, reviewed and approved to proceed to the detailed working document stage.

The preliminary design documentation will include:

- the outline specifications, plans and details,
- a description of material or system performance criteria,
- the schematic level plans and riser diagrams for component(s) or system(s),
- the Process Flow Diagrams (PFD's) and Process and Instrumentation Diagrams
- completion of a design co-ordination check has been completed,
- the updated schedule to include resource requirements,
- the update of deliverables for subsequent phases,
- a report on operation and maintenance issues, spares and special tooling,
- the base documentation for the Request for Proposals (RFP's) if design build procurement contracts will be sought,
- the cost estimate updates, using supplier verifications where necessary,
- confirmation that the concept design basis has been followed or, where necessary, describe variance from the approved concept design.

The Project Team must be confident the preliminary design meets the approved Project criteria of scope, budget, time and performance, which were originally approved as the basis of the concept design. The preliminary design, once approved, advances to either the detail working documents stage or to a design build RFP basis.

It is the responsibility of the relevant Work Package Leader to secure written approval of each preliminary design. The approval of the preliminary design utilizes the CLS Design Status Report shown in Sample 5H. It is the responsibility of the relevant Work Package Leader to ensure the design process proceeds in a co-ordinated manner to its conclusion. The co-ordination across work packages is the responsibility of the PL for Technical Facilities and the Conventional Design Manager for the Conventional Facilities.

Stage 3 - Detailed Working Documents

The objective of the detailed working document phase is to produce working drawings, specifications and documents "suitable for construction." "Suitable for Construction" will vary depending on the delivery method or strategy for the construction or fabrication. If CLS resources carry out the construction or fabrication, detailed working documents of fabrication quality are needed. If external resources are to carry out the construction or fabrication, tender quality documents will be needed.

The detailed working document phase is complete when the Detail Design Report has been issued, reviewed and approved to proceed to tender or fabrication.

The detail working documentation will include:

- final specifications, plans and details,
- the tender document(s), commercial and technical basis,
- final design verification,
- definition of material or system performance criteria,
- QA/QC standards and process requirements,
- spares identification,
- the updated schedule and resource requirements,
- the pre-tender cost estimate update.

It is the responsibility of the relevant Work Package Leader to secure written approval for each detailed design. Approval of the Detail Design utilizes the CLS Design Status Report shown in Sample 5H. The co-ordination across work packages is the responsibility of the PL for Technical Facilities and the Conventional Design Manager for the Conventional Facilities.

Appendix 7 Excerpts from CLS PIM dealing with changes to approved projects via engineering change requests (ECR) and engineering change orders (ECO)

5.7.3 Engineering Change Request (ECR)

The purpose of an ECR is:

- to identify the need for potential changes to a CLS element previously approved as a basis for design;
- to notify design team members of a potential change that may affect Project costs, schedule and definitions
- to allow design team to make decisions on potential changes effectively and under control, thereby minimizing reactive responses or critical situations

Any design team member may propose an ECR If the ECR is proposed by an external individual, the Design Co-ordinator is to issue the ECR. If the ECR is generated within the design team, the originator of the ECR suggestion issues a completed ECR from to the design co-ordinator for distribution.

The procedure for an ECR is as follows:

- each ECR is issued with a distinct identification number and distinct Project Record Index (PRI) number which is obtained from the Project Administrative Assistant
- all ECRs are to be copied and distributed as per the Document Distribution Index contained within PIM, section 4, p. 4.5
- the Work Package leader will collect ECR review comments, review and make a recommendation on the ECR proceeding to implementation. If approved, the ECO is issued. If the ECR is not approved, it will be returned to the originator with specifics.
- If the ECR is to be issued to an external supplier, fabricator or contractor for quotation, this will be carried out by the ?CM,
- See sample 5G fro the ECR/ECO form
- See sample 5J for an illustration of the ECR/ECO process.

5.7.4 Engineering Change Order (ECO)

The purpose of an ECR is:

- To document and track approved changes to the CLS design, which may change the design scope Project costs or Project schedule.
- To provide history on the development of the design which will be reflected in the final CLS design documentation. If the final design is being carried out by a third party as in a design-build contract, the ECO will also form the basis for contractual changes.
- To provide the design team with a common and consistent information basis as to design status.

The ECO is a product or result of the ECR process described in 5.7.3. The ECO may be issued as an internal CLS design directive or an external design directive to suppliers, fabricators or contractors.

The procedure for an ECO is as follows:

- Results of an ECR review must be approved by the PM and PL prior to issuing an ECO. The ECR process must identify schedule and cost implications of the ECR.
- The ECO will be issued by the PM to the CLS team, and external bodies if required.
- Circumstances may require conditional approval and issue of an ECO prior to identification of all issues and implications. Any ECO issued under these circumstances must note the outstanding conditions on the ECO; i.e. costs or schedule results etc. The PM must follow up on any outstanding ECO issues and resolve them as soon as possible.
- See sample 5G for the ECR/ECO form
- See sample 5J for an illustration of the ECR/ECO process.