Industrial Involvement in the Construction of Synchrotron Light Sources

Canadian Light Source
Centre canadien de rayonnement synchrotron

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European Particle Accelerator Conference – 2004-07-07

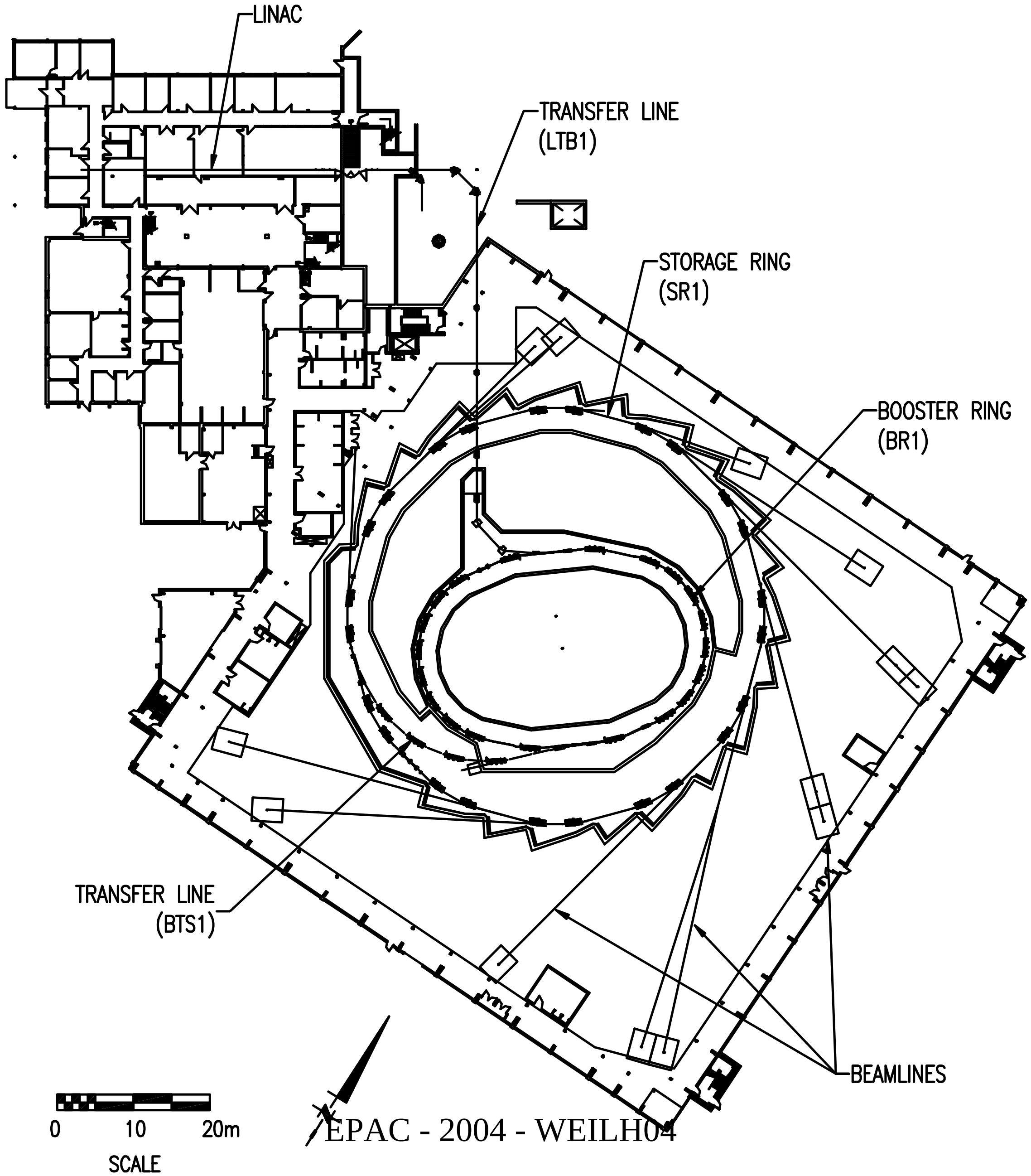
Introduction

- Large demand for synchrotron light sources
  - Completed in past few years:
    - BESSY II, SLS, CLS, SPEAR III
  - Under construction:
    - DIAMOND, SOLEIL, SESAME, Australia, Spain, China
- Many newer sources are “green field”
  - No major national laboratory for support
  - Little pre-existing infrastructure
  - Small design teams
  - Little experience amongst team members
  - Greater reliance on industrial involvement and support

CLS Example

- CLS Project approved on 1999 March 31
  - 140.9 M $C to construct:
    - 2.9 GeV booster and third-generation storage ring
    - at least six beamlines
  - Only 22 staff at the start of the project, including:
    - 2 accelerator physicists
    - 1 mechanical engineer
    - 1 electrical engineer
    - 4-person group for IT, controls, diagnostics
    - 2 scientists
- Challenge:
  - Complete facility in ~ five years
  - Increase technical staff to ~60
  - Build organization for operations and future R & D
- Review industrial involvement through major CLS contracts
  - Examine issues and challenges
  - Determine "lessons learned'

CLS Facility



Status – 1999 June 15

Major Contracts – Project Services

- Canadian Light Source Inc.
  - Not-for-profit corporation controlled by U. of Saskatchewan
    - Permits independent policies and management
  - Responsible for:
    - Overall management and operation
    - Liaison with users, 14 capital funding and 4 operating funding partners
    - Technical design of accelerators, storage ring and beam lines
    - License from Canadian Nuclear Safety Commission
- UMA Management Services
  - Day-to-day project and construction management
  - Design and Engineering of conventional facilities (building and services)
  - Additional technical design and engineering support as needed
- Formed an effective joint project team

Major Contracts - Strategy

- For accelerator systems:
  - Reduce detailed design as much as possible
    - Proceed with design only far enough to ensure feasibility
    - Functional and performance specifications only
  - Retain responsibility for:
    - Supervisory control
    - Machine protection
    - Personnel protection systems
  - Suppliers to perform as much testing as possible
- For beamlines and insertion devices:
  - Develop some beamline design capability
  - Develop room-temperature ID design and construction capability

Major Contracts - Booster

- First major technical contract awarded to Danfysik
  - CLS supplied nominal lattice design
  - Used to validate cost estimates for storage ring
  - Forced development of facility standards and guidelines
  - Allowed CLS staff to focus on storage ring system design
  - “Turn-key” System included:
    - All magnets supplied, pre-aligned on girders
    - All power supplies
    - RF system
    - Vacuum chambers
    - Diagnostics
  - Included installation supervision and commissioning assistance
  - Supply excluded control system, vacuum pumps
- Awarded in 2000 January
- Installation complete in 2002 July
- Commissioning tests complete in 2002 September

Booster Extraction Area

Major Contracts - IT

- EDS Canada supplied:
  - redundant network and server backbone for **all** data and communications including:
    - Office, control and beamline networks (VLANs)
    - Voice-over-IP telephones
  - IT architecture:
    - Guidelines and recommendations for future IT expansion
    - Analysis of CLS IT requirements
- External Review Committee to monitor contract
  - Valuable comments from expert reviewers
- Difficult contract scope
  - Few CLS management processes had clear IT needs
  - User requirements very difficult to determine so early in project

Major Contracts – Magnets and Power Supplies

- Magnets
  - Developed a magnet measurement laboratory
    - Primarily to support ID development
    - But supplies must measure all accelerator magnets
    - Can be rechecked at CLS, if necessary
  - Dipole magnets (TESLA)
    - Measurements done in Barcelona
  - Quadrupole and Sextupole magnets (Sigma-Phi)
  - All magnets within specifications
- Power Supplies
  - Programmable DC for storage ring magnets (IE Power)
  - Pulsed supplies and magnets (Danfysik)

Storage Ring Sector

Major Contracts – RF System

- Early decision to change to Superconducting RF
  - Determined frequency (change to 500 MHz)
  - Availability of cavity suppliers
- Cavity (ACCEL)
  - Single cavity (+spare) based on 500 MHz Cornell design
  - Includes cold valve box and instrumentation
- 300 kW RF Amplifier (Thales)
  - Turn-key system: power supply, klystron, circulator and loads
- Cryoplant (Linde)
  - >250 W cooling at 4.4 K
- CLS is first light source to use SRF storage ring acceleration!
  - Operations support part of responsibility of two technicians
  - CLS only provided waveguide and low-level RF control

Superconducting RF Cavity

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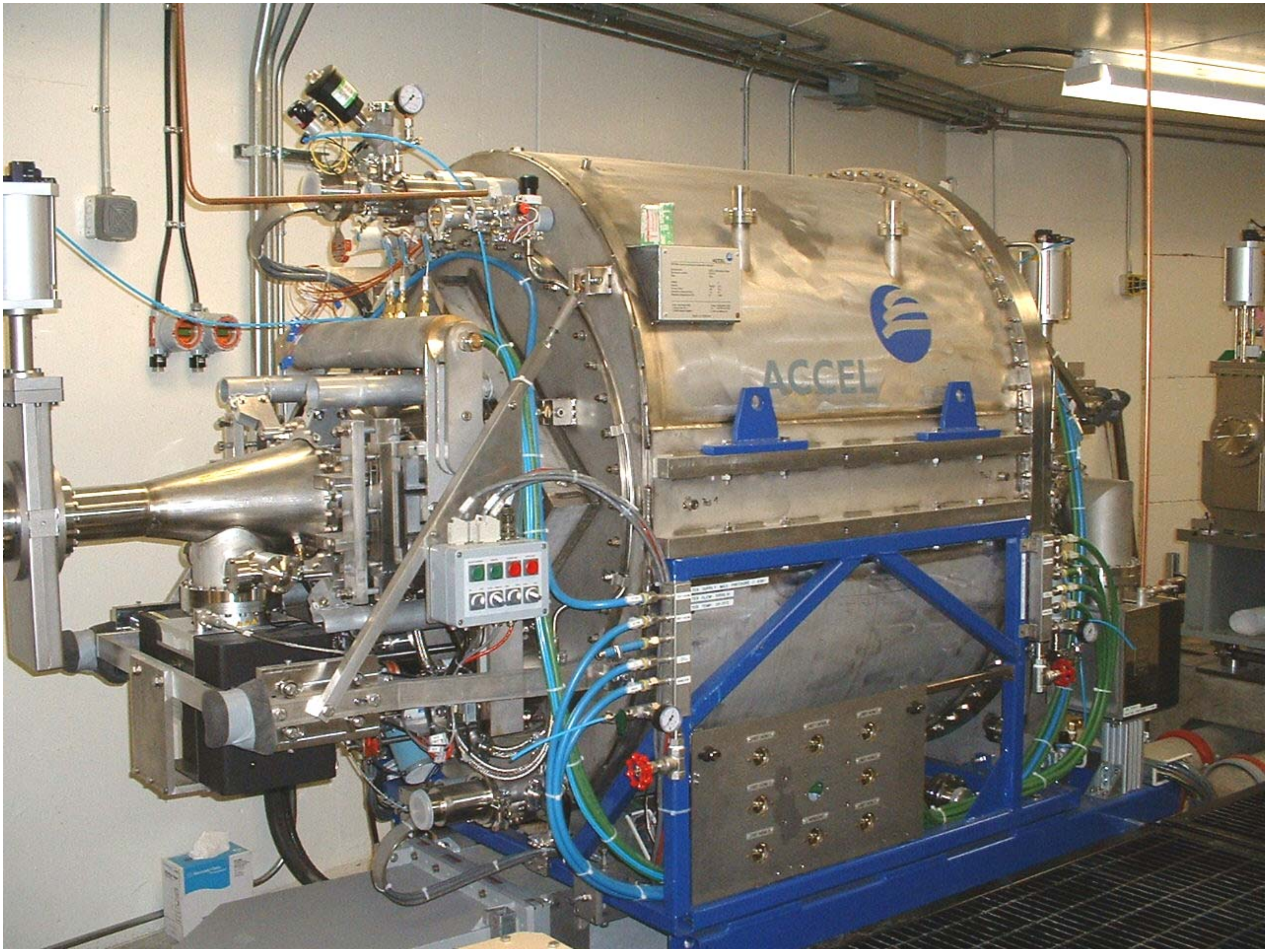

Major Contracts - Vacuum

- Vacuum pumps and controllers (Varian)
  - Single supply contract for the entire facility
  - Negotiate standard prices for all procurement
  - CLS supplies pumps and controllers to all contractors
- Storage ring vacuum chambers (FMB)
  - Based on BESSY II and SLS design
  - Installation by local construction contractors under CLS supervision

Major Contracts - Beamlines

- Insertion devices
  - 4 designed and assembled in-house
    - Two PPM, one hybrid in-vacuum SGU, one EPU
    - Support structures by ADC (PPM+EPU) and RMP (SGU)
  - Superconducting multi-pole wiggler (BINP)
- Front-ends based on APS design (Johnsen Ultravac)
- Seven beamlines
  - 2 IR beamlines
    - spectrometers (Bruker) and optical chicane (ADC)
  - Five x-ray beamlines
    - Two turn-key (IDT+Koizu, ACCEL)
    - Two functional specification of components (Jobin-Yvon, Oxford Danfysik, and McPherson)
    - One build-to-print (Johnsen Ultravac) based on ALS design

Issues and Challenges - 1

- Project management view: scope, cost and schedule
- Scope:
  - Need “standard” scope for technical specifications
    - Availability of good sample technical specification important
    - no “bonus points” for originality in specifications
  - Need design standards and guidelines very early in project
    - Difficult with new or inexperienced staff
  - Desirable to have at least 3 bids
    - Can determine scope of major tenders
- Cost:
  - Importance of competitive bids
    - Typically factor of two or more in price if 3 or more bids for design-build tenders
    - Restrictive tendering practices will increase cost
  - Frequently used fixed price + incremental rates for most labour contracts
  - Competent installation labour will challenge design team to keep ahead

Issues and Challenges - 2

- Schedule:
  - Most design-build contracts arrived late
    - 10 major CLS accelerator contracts
      - 8 deliveries were late by between 5 and 8 months
    - Overall project schedule needs to allow for this possibility
      - CLS targeted all contracted deliveries by end of 2002
    - Approximately ¼ to 1/3 of delay was due to CLS
    - **Delays CANNOT be used to justify other schedule slippage**
  - Control of scope and design changes essential
    - Need engineering change control
    - New staff often unfamiliar with process
  - Used bonus-penalty contract for two smaller contracts - effective
- Communications (internal and external):
  - Need good tracking of issues raised and their resolution
  - Plan on 3 – 5 face-to-face meetings over contract duration
  - Use weekly teleconference with email of issue-tracking form
  - Difficult to reduce internal delays when contractor questions arise

2003 December

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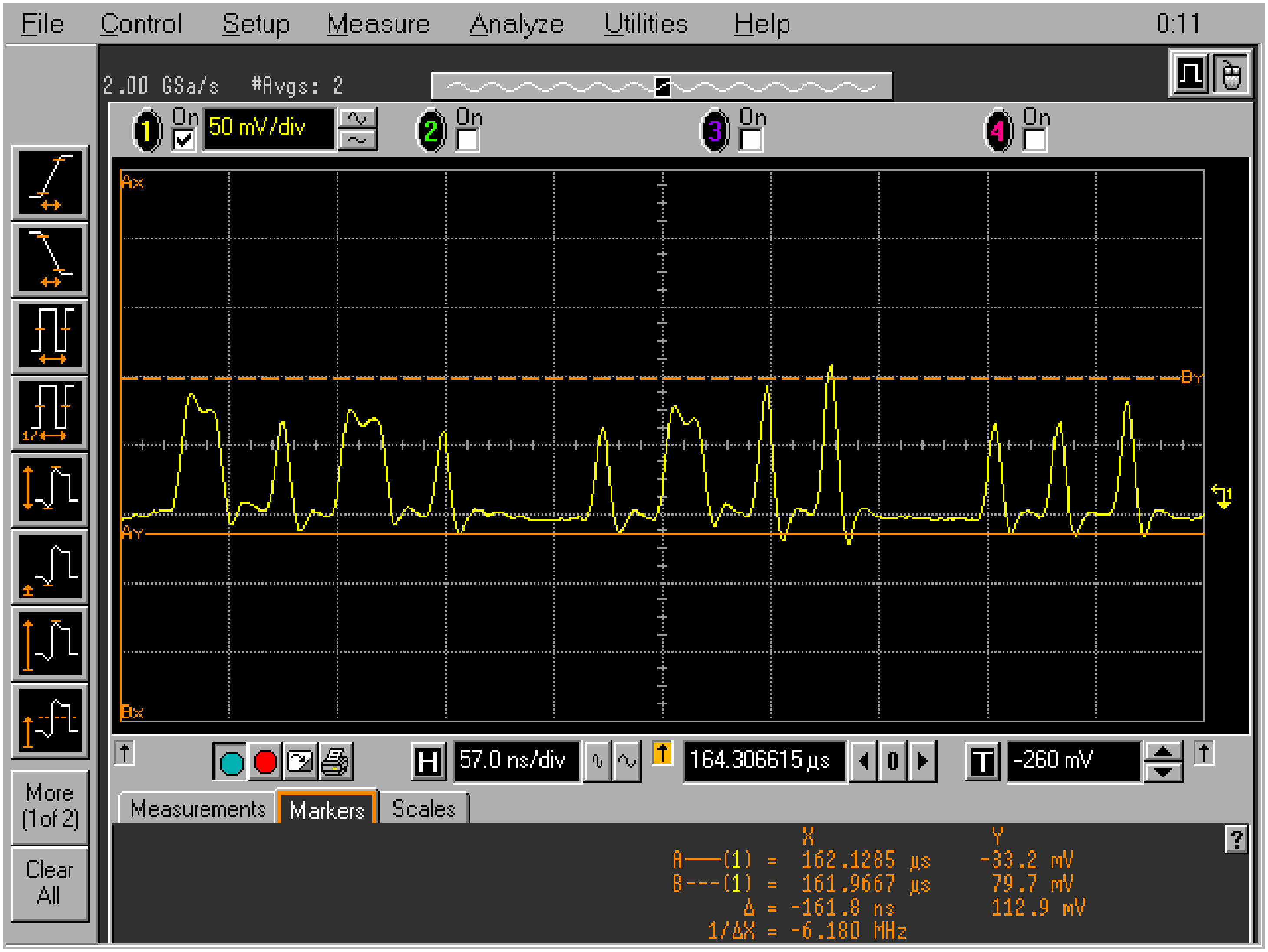
- SUCCESS: 10 mA Stored beam in “C L S” fill pattern



Conclusion

- Storage ring commissioning finished in 2004 May
  - Approximately six months behind original schedule
  - Cost over-run is approximately 0.05%
- Start Routine Operation in 2004 August
- I wish to acknowledge the huge contribution to our success by:
  - All CLS suppliers and vendors for their commitment to high quality work
  - University of Saskatchewan management and staff
  - UMA Engineering
  - All CLS staff