Instrumentation Technical System Review

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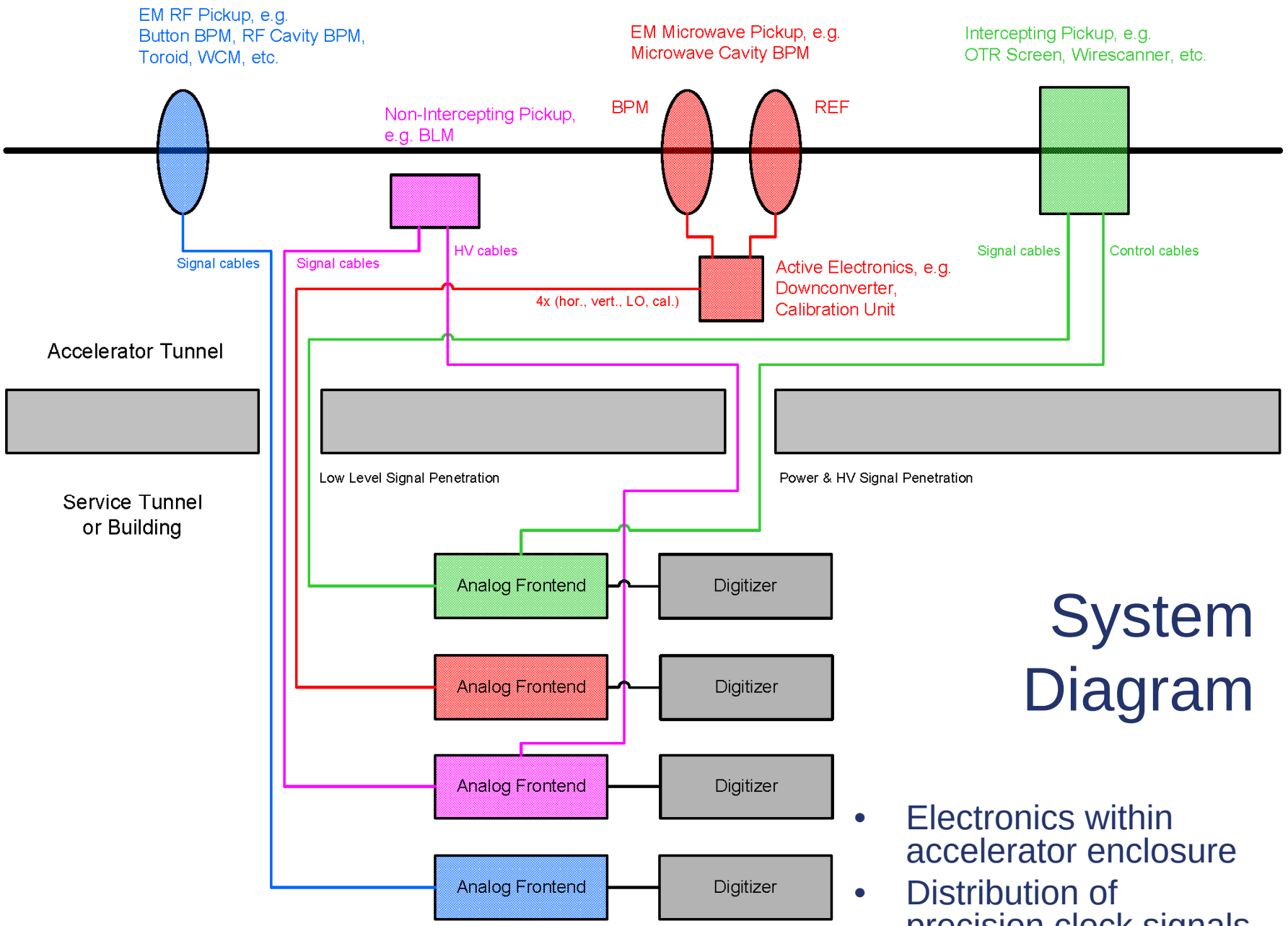
Status: Engineering & Cost Estimate

- Instrumentation TS scope:
  - **Beamline Instrumentation**
    - Vacuum hardware – flange to flange
    - Control/power hardware (e.g. laser, mover…)
    - cables
    - tunnel electronics (possible)
    - digitization electronics up to controls interface
  - **Beam position monitors, profile monitors, loss monitors**
    - Deflecting mode cavity ('LOLA' or crab) system *may be double counted in RTML*
    - This system uses modulator/klystron/distribution/cavity and has been estimated by respective TS

We list costs for *almost all* requested instrumentation

- **missing a few 'special systems'**
  - e+ production photon diagnostics
  - ring monitors (injection, tune…)
- **(we also recommended additions)**
  - profile monitors
  - loss monitor systems
  - feedback loops
    - those loops using hardware not included in standard controls / instrumentation package
      - » links
      - » fast processors, digitizers, actuators
      - » pickups
      - » (DR coupled bunch feedback NOT included)



System Diagram

- Electronics within accelerator enclosure
- Distribution of precision clock signals

Project construction model similar to LLRF

- In-house design (possibly commercial)
- contract printed circuit assembly and test
- contract pre-termination of cables
- installation and test managed in-house

Cost Drivers – example roll up

Material cost

RTML interface				14.6%
	4.1	Cavity BPM (C-Band)	beam (bunch) position	48.6%
	4.2	Cavity BPM (L-Band, cold)	beam (bunch) position	3.3%
	4.3	Laserwire	tr. beam size (emittance)	29.9%
	4.4	OTR, OTRI	tr. beam size (emittance), beam energy	0.5%
	4.5	X sync light	tr. beam size (emittance)	2.6%
	4.6	DMC (LOLA)	bunch length, long. bunch tomography	12.6%
	4.7	Toroid	beam (bunch) current	0.2%
	4.8	Pickup phase monitor	time-of-flight and bunch-to-RF phase	0.1%
	4.9	BLM - ion chamber	machine protection	0.3%
	4.10	BLM - PMT - discrete IC	machine protection	1.4%
	4.11	Feedback - special	Feedback systems not otherwise covere	0.5%

Labor – design to install

RTML interface				
	4.1	Cavity BPM (C-Band)	beam (bunch) position	20.5%
	4.2	Cavity BPM (L-Band, cold)	beam (bunch) position	15.2%
	4.3	Laserwire	tr. beam size (emittance)	35.5%
	4.4	OTR, OTRI	tr. beam size (emittance), beam energy	5.6%
	4.5	X sync light	tr. beam size (emittance)	7.4%
	4.6	DMC (LOLA)	bunch length, long. bunch tomography	4.6%
	4.7	Toroid	beam (bunch) current	2.2%
	4.8	Pickup phase monitor	time-of-flight and bunch-to-RF phase	2.9%
	4.9	BLM - ion chamber	machine protection	0.4%
	4.10	BLM - PMT	machine protection	0.5%
	4.11	Feedback - special	Feedback systems not otherwise covere	5.3%

MS estimate by area:

		Cost %
1	Electron Source	2.9%
2	Positron Source, incl. keep alive source and transfer lines	23.6%
3	Damping Rings (1x e-, 2x e+)	26.8%
4	RTML interface	14.6%
5	Main Linacs	13.9%
6	Beam Delivery System	18.2%

- Note that ½ of the instrumentation MS cost is in the 'upstream part' of ILC

Button BPM	beam (bunch) position	**19.7%**
Cavity BPM (warm)	beam (bunch) position	**13.5%**
Cavity BPM (cold)	beam (bunch) position	**9.2%**
Pickup phase monitor	time-of-flight and bunch-to-RF phase	**0.0%**
Faraday cup	beam and dark current (gun region)	**0.0%**
Toroid	beam (bunch) current	**0.3%**
WCM	bunch length	**0.0%**
Common Hardware		**23.1%**
	subtotal for below	**34.1%**
Wirescanner	tr. beam size (emittance)	**0.4%**
Laserwire	emittance and energy spread	**20.5%**
OTR, ORTI	tr. beam size (emittance), beam energy	**0.3%**
X sync light	tr. beam size (emittance)	**2.5%**
Streak camera	bunch length	**0.6%**
DMC (LOLA)	bunch length, long. bunch tomography	**5.4%**
BLM - Long Ion chamber	machine protection	**0.7%**
BLM - discrete ion chamber	machine protection	**2.1%**
Feedback - specials	all feedback hardware not incl in nominal sys.	**1.7%**

MS estimate by subsystem

Cost Drivers:

- Beam position monitors
  - **MS / Labor used recent FNAL system costs**
- Laserwire subsystem
  - **Laser**
    - used costed systems, (a purchased item in our model)
    - (including 2006 bids for single laser systems)
    - scaling will be important but not large
      - total 20 lasers;
      - 3 completely different types
        - » injection systems
        - » ring
        - » damped beam
      - 20 to 30% ?
  - **IP (77 each)**
    - – costs taken from ongoing RD project efforts

We don't need $ to begin checking the estimate:

- relative costs of key components provide critical information
- typical (PEP-II, SNS) project instrumentation costs are
  - **80% BPM's**
  - **20% profile and beam loss monitors**
- ILC Instrumentation RDR MS (Vancouver)
  - **65% BPM's**
  - **20% Laserwires**
  - **3% other profile monitors**
  - **6% longitudinal**
  - **3% loss monitors**
  - **Feedback, toroids etc**
- difference driven by the cost of the laserwires – in most regions

Button BPM example (level 3)

		M/S	Total labor	Design	Prod
				77.4%	22.6%
Vacuum mechanics		34.1%	36.9%	32.2%	52.9%
RF feedthrough		1.1%	0.9%	1.1%	0.1%
Coaxial cable (1/2")		2.6%	3.0%	0.0%	13.2%
Analog frontend		22.7%	28.3%	32.2%	14.9%
Digitizer (4 ch)		28.4%	30.9%	34.4%	19.0%

- Production labor covers:
  - **inspection, calibration, test, installation and pre-commissioning**
  - **need to review cable installation costs for double counting and uniformity with controls etc**

Scaling

Usage	Item	each
all BPM's, phase pickups, Fcups	RF feedthrough	25919
everything, except DR BPM's and WCM	Coaxial cable (1/2")	14837
DR BPM's (alcove install.)	DR Coaxial cable (1/	11199
BPM's, toroids, not IC	Digitizer (4 ch)	6421.5

- Common hardware:
  - **50 m length / (DR 150 m) ½" cable slightly discounted**
  - **electronics discounted ~30%**

Level of detail: BDS laserwire example

6.5	Laserwire		27.4%
6.5.1		Software	
6.5.2		Laser	24.3%
6.5.3		laser power	3.4%
6.5.4		laser controls	2.7%
6.5.5		laser cables	0.1%
6.5.6		laser room	2.5%
6.5.7		laser cooling	0.3%
6.5.8		transport (500 ft seg)	16.9%
6.5.9		transport controls	1.7%
6.5.10		transport cables	0.8%
6.5.11		IP	33.8%
6.5.12		IP controller	13.5%
6.5.13		IP cables	0.7%
6.5.14		Detector	0.8%
6.5.15		detector controls	0.3%
6.5.16		detector cables	0.1%

BDS has:
20 IP's and
4 lasers

Status – Level of detail and problems

- **level of detail:**
  - Level 3 – major components
- **what you know you have not dealt with**
  - Level 4 – ‘cost driver’ breakdowns
    - e.g. laserwire laser
  - Special instruments
    - e.g. undulator photon diagnostics; MDI
    - damping ring
  - BPM subsystems
    - calibration
    - detail cost of cleaning cold cavity BPM’s
  - Software labor costs
  - Design labor apportionment for common hardware

What information is missing from your estimate?

- **where are the weaknesses in your estimates**
  - Labor estimate in general
  - Optics integration
    - where are the laserwires located?
    - do the feedback systems fit?
    - what is the optics for ‘LOLA’
- **what cost-critical information did you not receive**
  - Physical layout
    - distances from support to beamline equipment
    - e.g. laser enclosure locations and LOLA source location
  - BPM scale issue in the linac
- **what do you estimate is the impact of the above on your cost estimate**
    - 20 to 30% ?

Who / How

- BPM and related devices → M. Wendt FNAL
- Laserwire → M. Ross and Oxford/RHUL group
- Feedback → Oxford U group
- Loss monitors → SLAC group
- Other → M. Ross

- Reviewed by Junji Urakawa, Grahame Blair and Philip Burrows, July 4, 2006 at Oxford.

Possibilities for Cost Reductions

- outline possible cost reductions by the Valencia workshop:
  - **component-level cost reduction**
    - Cavity BPM systems
    - propose using cavity HOM for primary cold linac BPM
  - **design-level cost reduction**
    - laserwire ‘integration’, i.e. planning where they will go and what they are supposed to do…

Plans and Goals

- goals for Vancouver:
  - **review specifications and counts (esp. e+, DR and BDS)**
  - **checking…**
- goals ‘until’ Valencia workshop
  - **consistency, single counting**
    - cables
    - controls
    - infrastructure

Towards the TDR

- Instrumentation design is supported by a relatively large RD effort
  - **test facilities usage is key**
  - **goals of RD have been ‘soft’, i.e. educational**
  - **TDR work will involve a shift to hard, cost driven goals**
    - laserwire
    - cavity BPM’s
    - LOLA