BDS Instrumentation

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Thanks to: Manfred Wendt (FNAL)

Outline

- **Reminder of RDR**
- **EDR instrumentation issues**
- **Updated instrumentation list**
- **Expressions of interest**
- **Development of WBS**

Reminder of RDR

- **Instrumentation was ‘technical system’ with pan-machine view**
- **Purview: meas. of *beam-related* parameters:**

  eg. beam position, charge, size …

  NOT

  RF control, temperature, pressure, flow, currents …
- **Boundary with Controls defined (NB feedbacks)**
- **Luminosity, energy, polarimetry explicitly excluded**
- **Did not consider monitors for beam-related backgrounds**

RDR instrumentation master table

INSTRUMENT requirements (e.g. resolution)	AREA e^- source	e^+ source	DR	RTML	ML	BDS
Button/stripline BPM resolution (μm)	69 10-30	400 10-30	2 × 747 <0.5			120 <100
C-Band Cavity BPM (warm) resolution (μm)		109 <0.1-0.5		2 × 649 <0.1-0.5		262 <0.1-0.5
S-Band Cavity BPM (warm) resolution (μm)						14 < 0.1-0.5
L-Band Cavity BPM (warm) resolution (μm)				2 × 27 <1-5		42 <1-5
L-Band Cavity BPM (cold) resolution (μm)				2 × 28 ~0.5-2	2 × 280 ~0.5-2	
Laser-wire IP resolution (μm)	8 <0.5-5	20 <0.5-5	2 × 1 <0.5-5	2 × 12 <0.5-5	2 × 3 <0.5-5	8 <0.5-5
Wirescanner	12	8				
Optical Monitors	6	17	2 × 2	2 × 8		11
DMC resolution ΔE ~0.1% / s_z ~100 μm	3	4		2 × 2		2 (cold)
Beam Current Monitors	7	11	2 × 1	2 × 2	2 × 3	10
Beam Phase Monitor	4	2		2 × 3		2
BLM (PMT/IC)	60/2	400/20	2 × 40/4	2 × 75/2	2 × 325/10	100/10
Feedback System	5	10	2 × 2	2 × 1	2 × 10	12

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resolution (μm)		<0.1-0.5		<0.1-0.5		<0.1-0.5
S-Band Cavity BPM (warm)						14
resolution (μm)						< 0.1-0.5
L-Band Cavity BPM (warm)				2 × 27		42
resolution (μm)				<1-5		<1-5
L-Band Cavity BPM (cold)				2 × 28	2 × 280	
resolution (μm)				∼0.5-2	∼0.5-2	
Laser-wire IP	8	20	2 × 1	2 × 12	2 × 3	8
resolution (μm)	<0.5-5	<0.5-5	<0.5-5	<0.5-5	<0.5-5	<0.5-5
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RDR BDS Instrumentation List

• Button / stripline BPMs	120	< 100 um
• Warm C-band cavity BPMs	262	0.1 - 0.5 um
• Warm S-band cavity BPMs	14	0.1 - 0.5 um
• Warm L-band cavity BPMs	42	1 – 5 um
• Laserwire IPs	8	0.5 - 5um
• Optical monitors (bunch size)	11	
• Deflecting-mode (cold) cavities	2	100 um
• Beam current monitors	10	
• Beam phase monitors	2	
• Beam loss monitors (PMT/IC)	100/10	
• Feedback systems	12	

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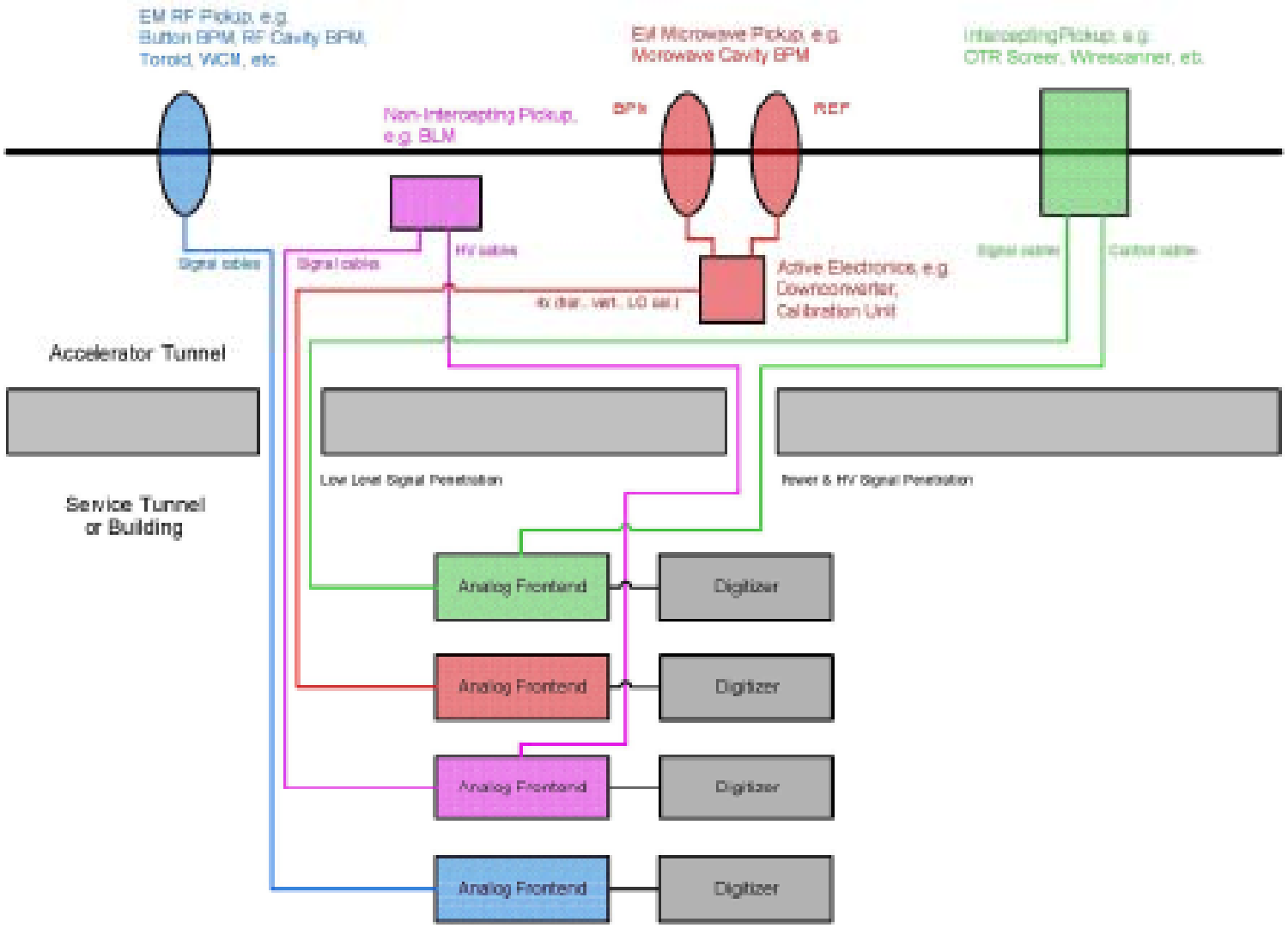
NO SPARES!

What was costed

- Pickup station (typically part of vacuum system)
- ‘Detectors’: PMTs, scintillators, lasers, calib. systems
- RF system + infrastructure for DMCs
- Mechanical setup, incl. motors, switches …
- Signal + control cables, connectors, patch panels
- Dedicated readout electronics (analogue + digital)
- Control, timing, calibration electronics
- Local software + firmware
- Intra-train feedbacks: dedicated DAQ

Boundary with Controls



BDS Feedbacks

- **Train-to-train trajectory 5 Hz**
- **IP collision: intra-train (3 MHz) + 5 Hz**
- ***IP luminosity: intra-train***

NB upstream feedbacks:

- **End-of-linac trajectory: intra-train**
- **RTML feed-forward: intra-train**
- **Linac cascaded trajectory 5 Hz**

RDR costs / cost drivers

Machine-wide:

- **Value: c. 93MILCU**
- **Labour:**

  Prototyping + testing: 257 person-years

  NB: installation labour covered elsewhere
- **Biggest + costliest systems:**

  4500 BPMs (47%) , 68 laserwire IPs (22%)

BDS:

- **12 MILCU (3.4% BDS cost – Andrei), 40 person-years**

EDR Instrumentation: issues

Instrumentation divided among areas; need to:

- **Ensure coordinate design of common devices**

  (BPMs, toroids, bunch length, laserwire …)
- **Avoid duplication of effort**
- **Keep track of interfaces w. Controls**
- **Work closely w. Accelerator Physics group**
- **Define interface with detectors:**

  ‘MDI’ instrumentation: L, E, P, backgrounds?

Comments

Some devices are high-volume, with ‘low’ unit cost:

toroids, BPMs …

Some devices are (unique) complex systems:

laserwires, energy spectrometers, polarimeters, LOLA bunch-length monitor, feedback systems …

Vast majority of effort will go into complex systems!

EDR BDS Instrumentation: plan

- **Reviewing instruments list:**
  - **Is it consistent / correct?**
  - **Missing items?**
- **Collecting EoIs**
- **Need to review/define:**
  - **Scope of work for EDR**
  - **Priorities for effort: design + R&D**
- **Develop WBS in more detail**

For each device

- **Review required performance specifications**

  iteration with Accelerator Physics

- **Review RDR technologies:**

  ‘state of the art’ devices: good enough, or R&D needed?

  simpler/cheaper technologies?

  baselines/alternatives?

  fewer (or more!) devices?

- **Refine EDR work plan + deliverables:**

  Specification of ‘off-shelf’ devices?

  Engineering design of (pre-industrial) prototype?

  Significant R&D for complex devices/systems?

PRELIMINARY guess of status

• Button / stripline BPMs	off-shelf / engineering
• Warm C-band cavity BPMs	engineering / R&D
• Warm S-band cavity BPMs	engineering / R&D
• Warm L-band cavity BPMs	engineering / R&D
• Laserwire IPs	R&D / engineering
• Optical monitors (bunch size)	R&D / engineering
• Deflecting-mode (cold) cavities	engineering
• Beam current monitors	off-shelf
• Beam phase monitors	R&D / engineering
• Beam loss monitors (PMT/IC)	engineering
• Feedback systems	R&D / engineering

Comment

- **In some cases (cavity BPMs, toroids …) required performance may have been achieved for SINGLE-bunch mode**
- **Further R&D may be required to demonstrate TIME-RESOLVED performance bunch-by-bunch**

‘Physics’ instrumentation

- **Upstream + downstream**

  energy + energy spread measurement

  polarimeters
- **Luminosity monitoring:**

  Beamcal, Gamcal, rad. Bhabhas …
- **Beam correlations: y-z, x-z, E-z?**
- **IP collision parameters: x, x’, y, y’, offsets, spot sizes, coupling …**
- **Disrupted beam parameters**
- **Beam halo, beam loss monitoring**
- **Background monitoring:**

  muons, neutrons, photons, e+e-

Commissioning strategy

- **If commissioning of BDS and/or IR is anticipated BEFORE the detector(s) are rolled on beamline**

  it may be prudent to plan for appropriate instrumentation at the Machine Detector Interface

- **NOT included so far**

Expressions of interest

Button, stripline, cavity BPMs	**FNAL**
Laserwire	**UK**
Bunch length (also beam phase)	**UK, FNAL**
OTR/ODR monitors	**UK, FNAL**
Toroids	**FNAL**
Feedback systems	**UK, FNAL**
E-spectrometer	**UK, UCB, JINR, DESY, SLAC, Notre Dame, Oregon**
Polarimeter	**Iowa, INFN, SLAC, Tufts**
Gamcal	**BNL, Yale, DESY**
BDS/IR alignment	***UK***
Shintake Monitor (ATF2)	***Tokyo***

Comments on EoIs

- **Not all bases covered by EoIs**
- **Scope of EoIs varies considerably**
- **Levels of resources vary greatly**
- **Not yet 'unpacked' EoIs**
- **Vastly more worldwide expertise than in submitted EoIs**

Towards a WBS

- **Draft WBS for WP9 …**
- **Laundry-list of instrumentation!**

NB: **Overlap with WP2: ATF2**

Coupling with WP3: accelerator physics design

Coupling with WP4: IR + IR integration

Interface with WP10: vacuum system

Interface with Controls

Global approach needed for feedback

→ is a ‘systems’ approach more desirable?

MDI 'Diagnostics'

- **Electromagnetic interference antennae?**
- **Radiation damage monitors?**
- **Crab cavity phase**
- **Magnet vibrations**
- **Alignment**
- **Vacuum**
- **Temperatures**
- **Magnetic fields**
- **Power supply currents**