Digital BPMs - Experience and Vision from Our Perspective

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The Problem

- To fulfill at the same time the requirements for:
  - Real-time operation with sub micrometer resolution and ~micrometer accuracy and reproducibility in a relatively low bandwidth (kHz) for feedback applications
  - More relaxed resolution and accuracy but higher bandwidth (MHz) for commissioning and machine physics studies

A Solution

- 4 channel BPM system with direct sampling of IF (RF) signal
- Advantages
  - Re-configurability (bandwidth, tuning frequency, gain control,…)
  - Extremely good linearity
  - Reproducibility of digital signal processing

Evolution of DBPM

- 1998: I suggested DBPM as an all-in-one solution for the Swiss Light Source
- The project grew into successful collaboration between SLS, ELETTRA and Instrumentation Technologies
- 2001: DBPM becomes commercially available
- 2002, June: We demonstrate DBPM development tool at EPAC 2002
- 2002, October: We started shipping DBPM 2 System

DBPM vs. DBPM 2

	DBPM	DBPM 2
AD granularity	12 bit	14 bit
IF locked to machine RF	No	Yes
Resolution (500 kHz, -10 dBm)	7μm	0.7μm
Linear range upper limit	-8 dBm	+7 dBm
Out 1 dB compression	+4 dBm	+14 dBm
Max No. BPMs per VME crate	6	12

* Bandwidth = 500 kHz, Pin = -10 dBm, X=10mm x Δ/Σ

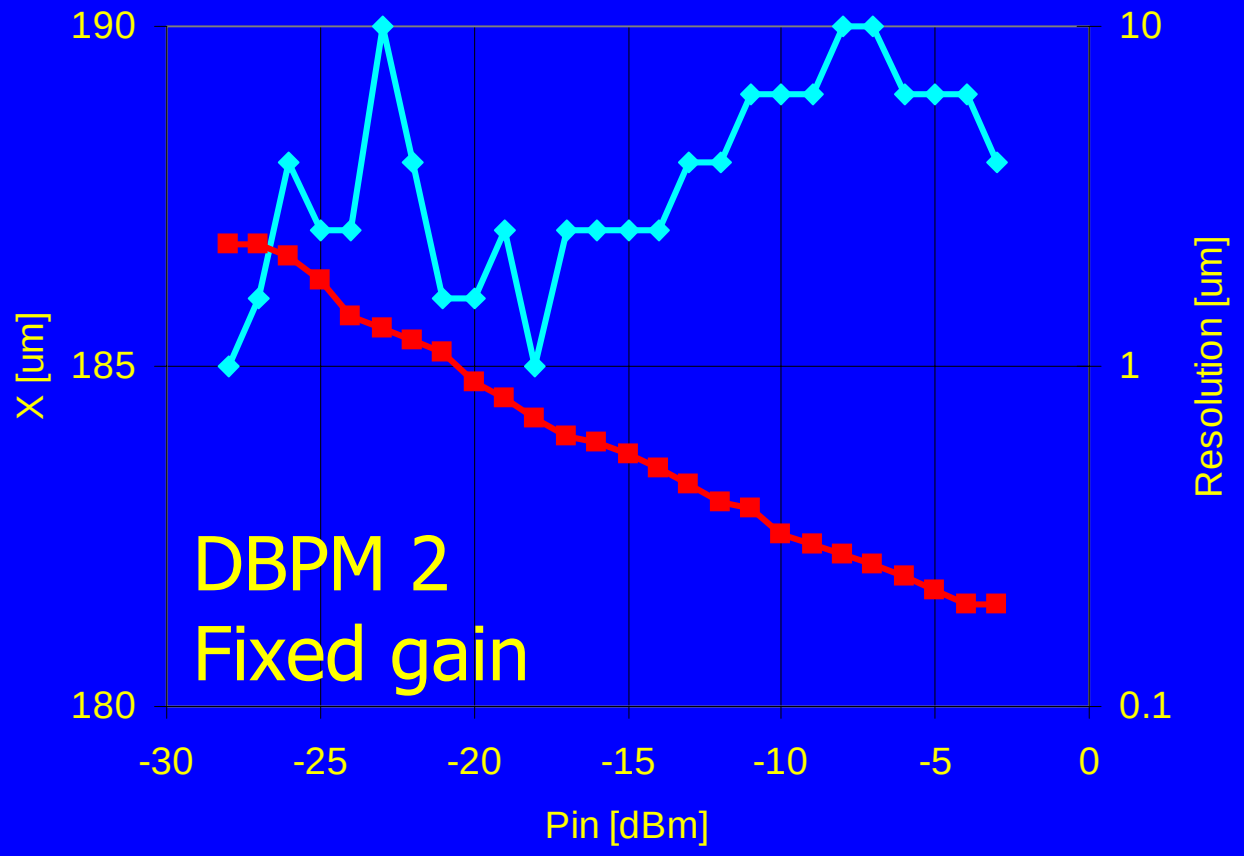
Accuracy

- Versus beam current
  - Usually referred to as a beam current dependence
- Versus time (temperature)
  - Usually referred to as a long term stability
- Resolution

Accuracy Issues

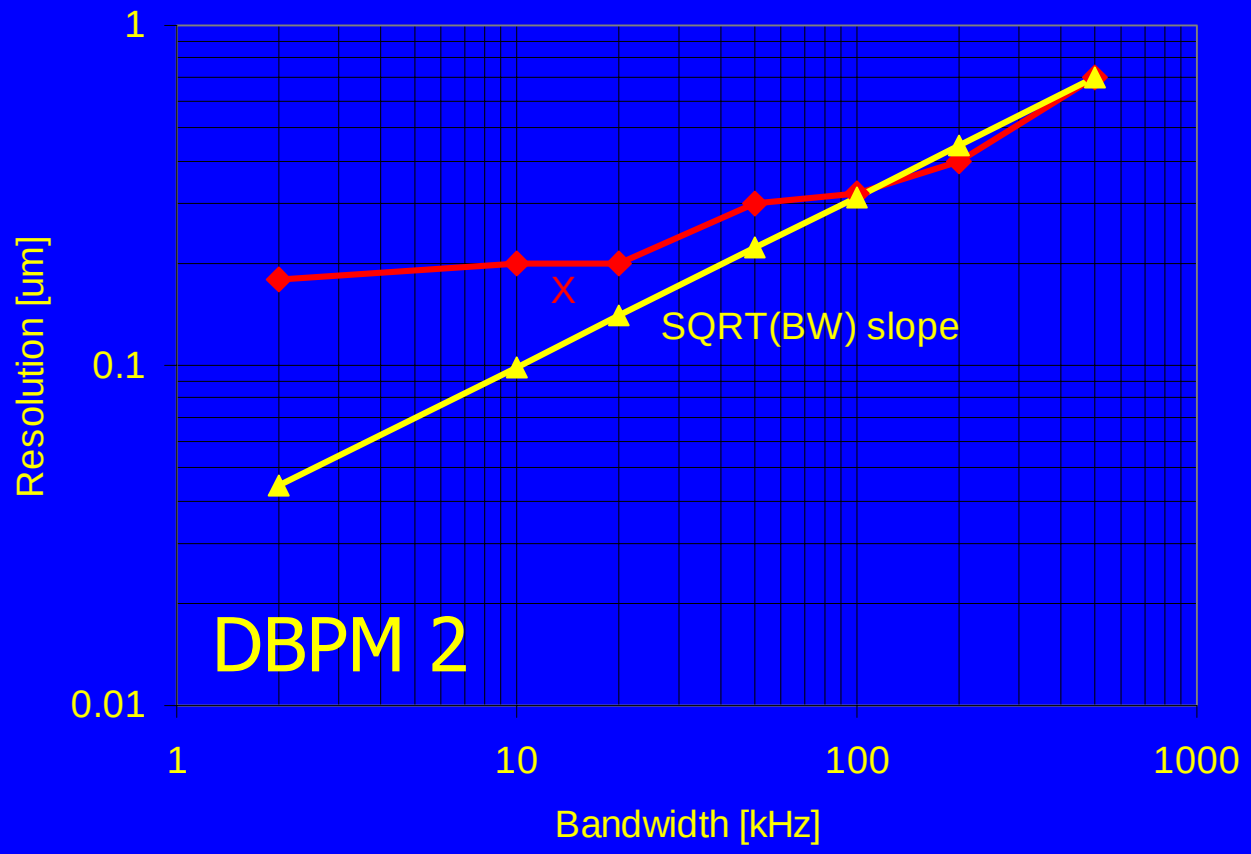
- Relative gain drifts of individual channels with respect to each other
- Cure 1: Pilot signal for calibration implemented on DBPM, DBPM 2
- Cure 2: A new real-time re-configurable architecture and method using beam signals

Accuracy vs. Beam Current



* Bandwidth = 10 kHz, X=10mm x Δ/Σ

Resolution vs. Bandwidth



* Pin = -10 dBm, X=10mm x Δ/Σ

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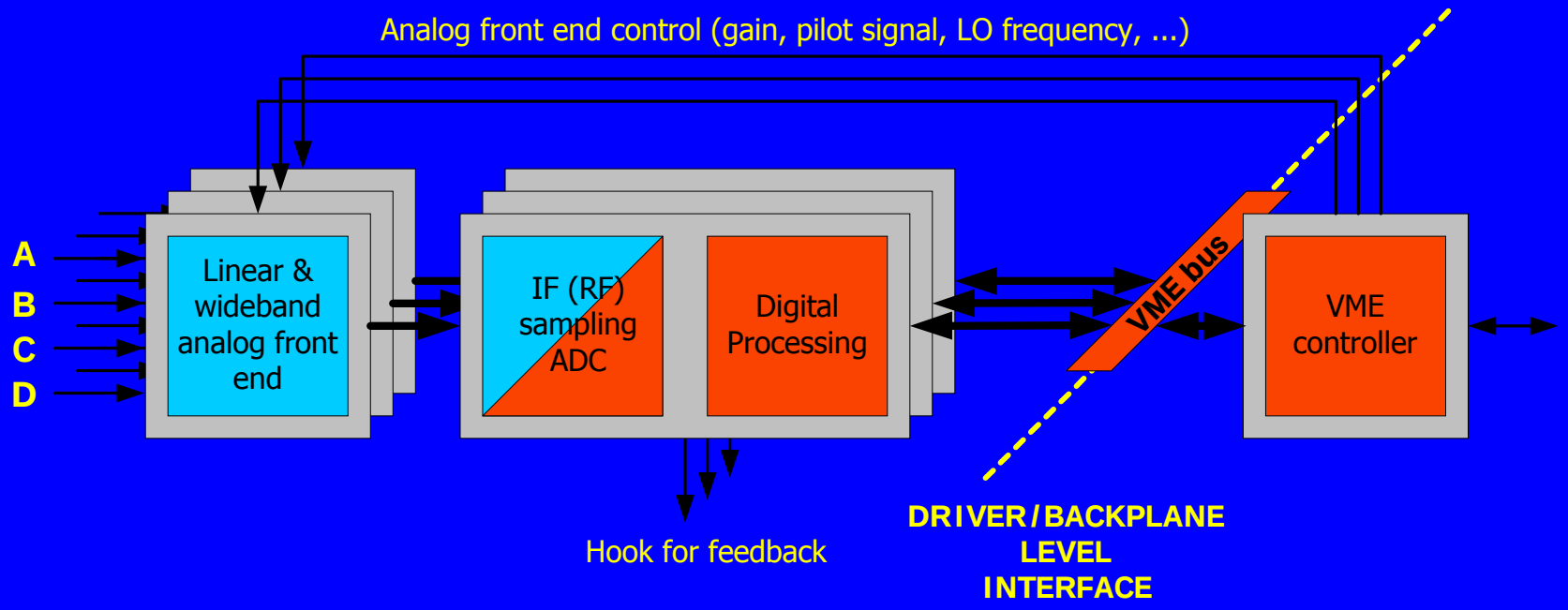
Gain Control Issues

- Digital gain control has advantages
  - Can be optimized for resolution or accuracy
  - Can be configured to support CW and pulsed measurements
- But it is not trivial to implement
  - Algorithm development
  - Software coding
- Fixed gain ranges: trade-off between accuracy and resolution

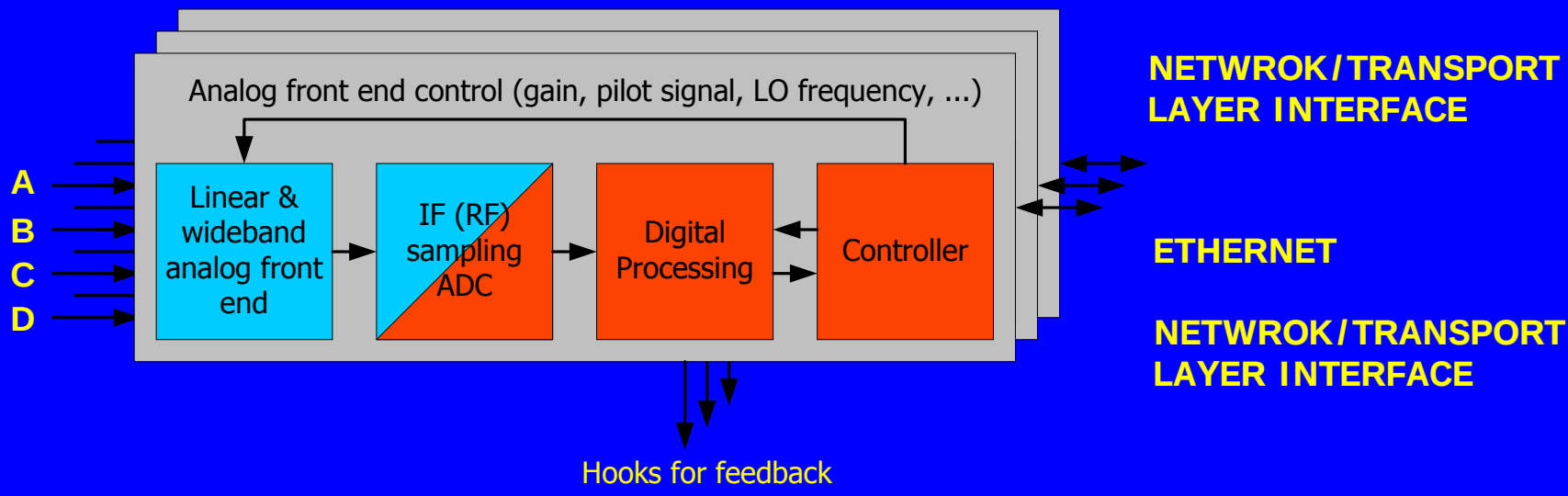
Simplified DBPM Architecture



Architectural Issues

- Digital implementation of gain control
- Single processor shared by multiple BPMs
- Facilities use different operating systems
- Facilities use different control systems
- How did we respond
  - Providing a PC based development tool
  - Offering technical support
  - Developing new architectures

Towards a New Architecture



Conclusions

- Digital BPM is an all-in-one solution
- Cost trend makes possible to equip complete machines with a single system (maintenance!)
- Performance is limited by hardware but explored by software
- Good tools are prerequisites to fully exploit the potential
- New architectures and schemes offer unprecedented performance and simplify system integration