Operational Experience with the CNGS Beam Position Measurement System

OUTLINE

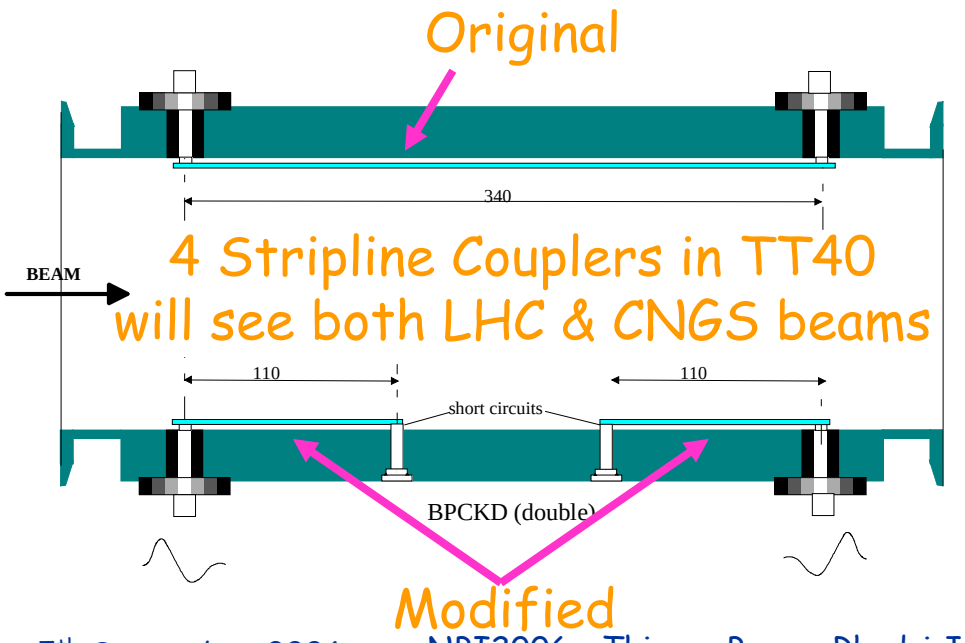
1. Introduction to the CNGS BPM system
2. Laboratory results
3. Performance of the system with beam
4. Problems encountered during commissioning
5. Summary

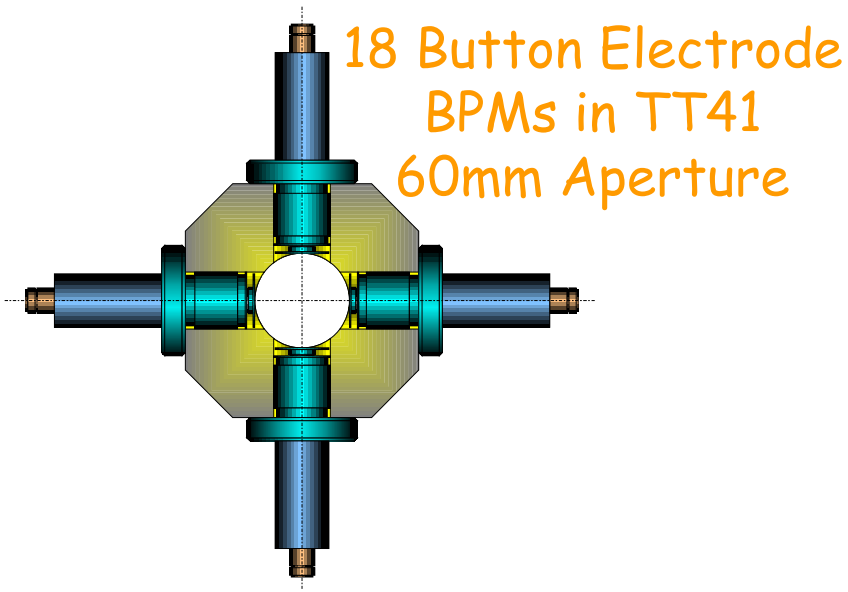
The CNGS Beam Line Position Monitors

CNGS Beam Position Measurement Requirements

source	rms uncertainty	tolerance
BPM (global accuracy)	0.25 mm	± 0.5 mm
Alignment	0.20 mm	± 0.4 mm
Total	0.32 mm	± 0.6 mm

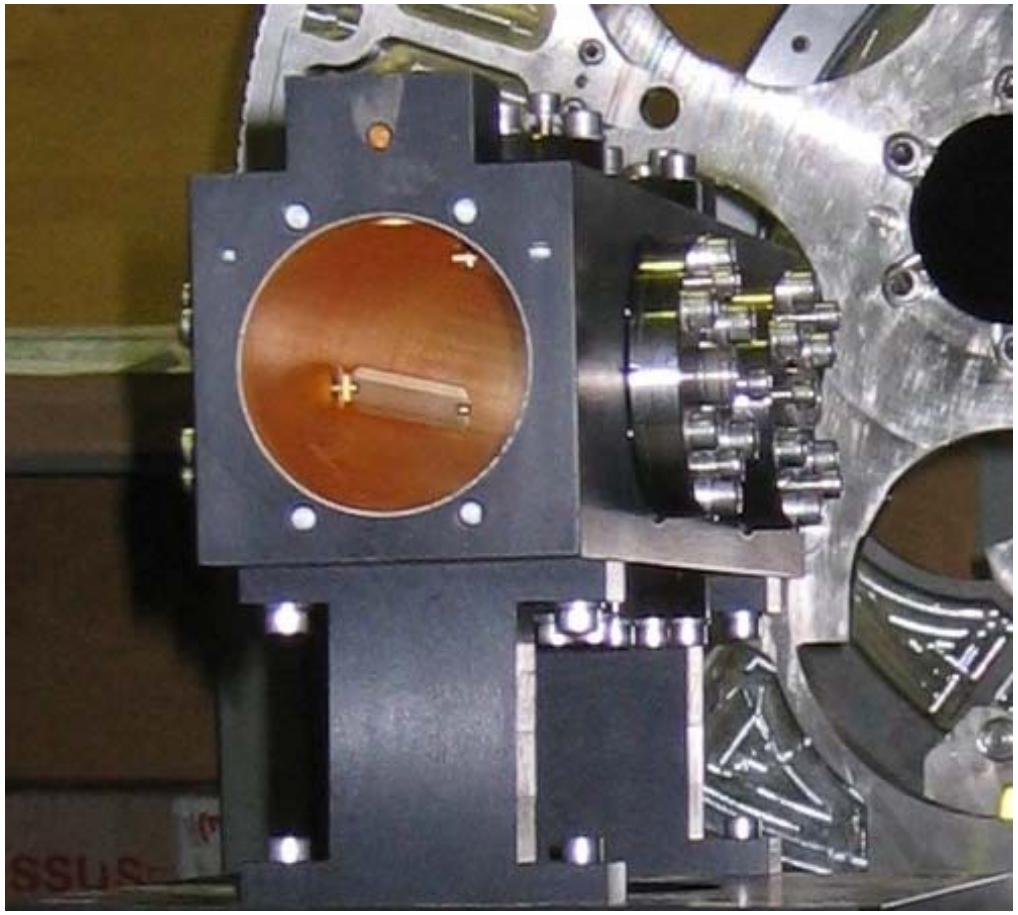
Intensity Range:
1×10^{12} to 3.5×10^{13}





The CNGS Target Beam Position Monitor

Construction of the CNGS Target Station Monitor (BPKG)



Coupler Body
- *Aluminium alloy*
- *lowers remnant radiation*

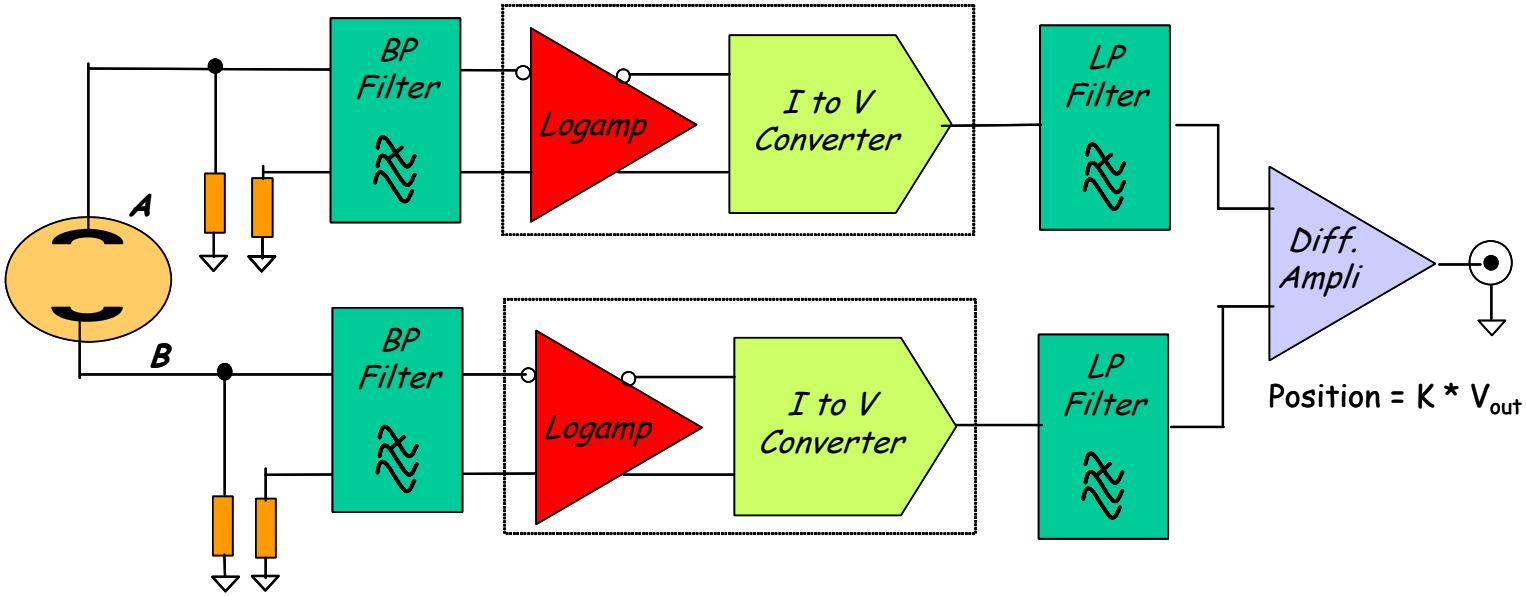
Outer Surface Treatment
- *penetrating oxide layer*
- *withstands radiation effects*
- *gives thermal stability*

Inner Surface Treatment
- *30μm gold layer*
- *withstands radiation effects*
- *maintains good conductivity*

Feedtroughs
- *Ceramic dielectric (vac seal)*
- *simple 50Ω construction*

The CNGS BPM Electronics

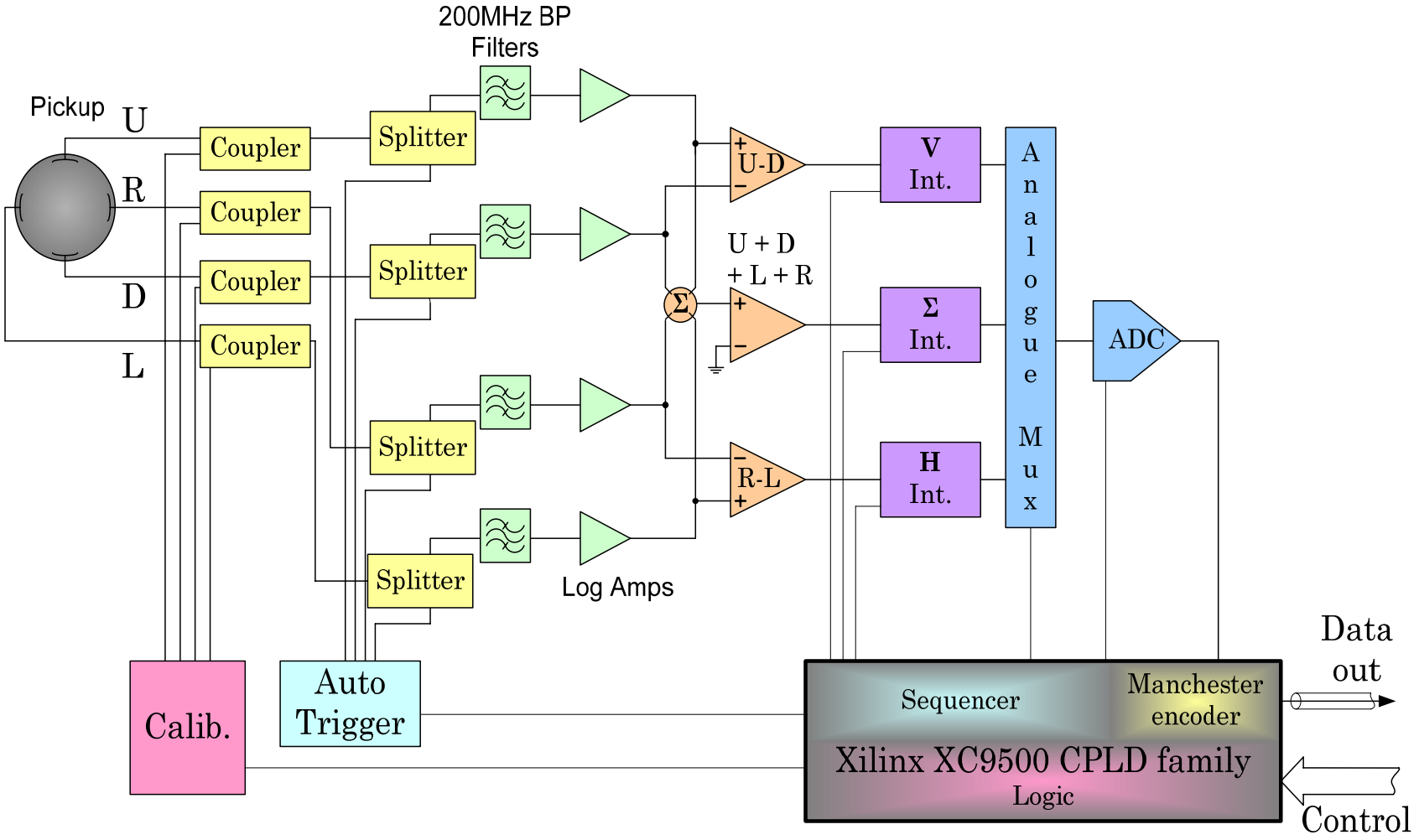
CNGS Beam Position Measurement Acquisition System



- *Each signal is compressed by a logarithmic amplifier, filtered and applied to a differential amplifier.*
- *The position response is: Pos ≡ [log(A/B)] = [log(A)-log(B)] ≡ (V_{out}) where V_{out} is the voltage difference between the log-amp outputs*

The CNGS BPM Electronics

CNGS Beam Position Measurement Front-end



The CNGS BPM Electronics

CNGS Beam Position Measurement Acquisition System

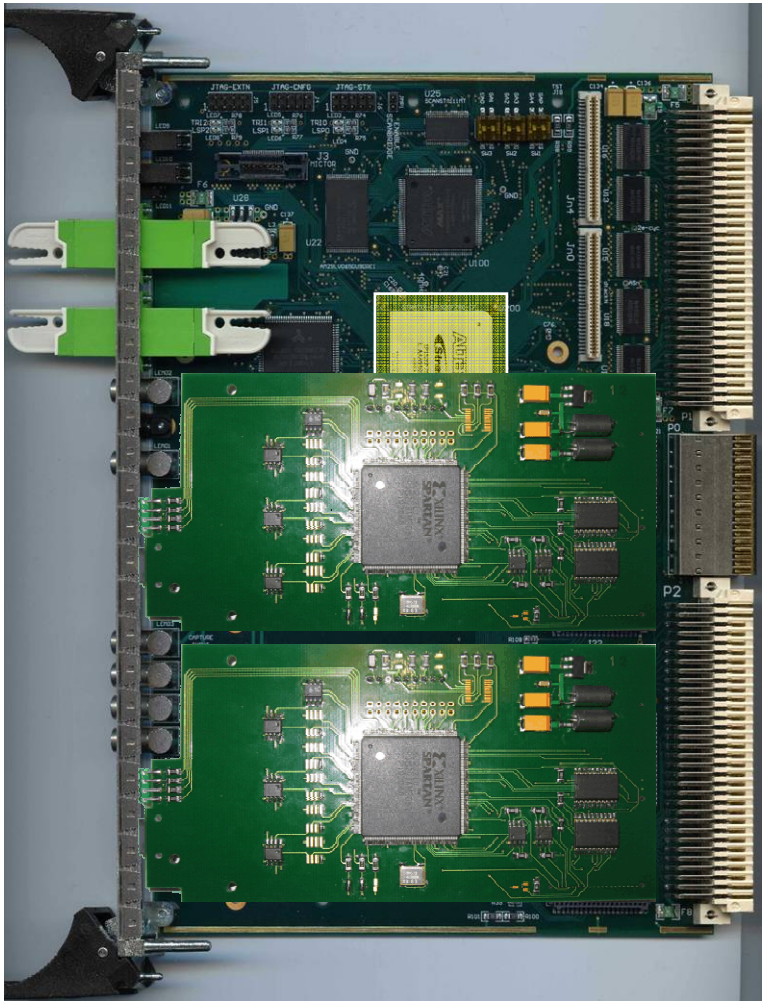
Based on LHC BPM system:

⇒ *VME64x Digital Acquisition Board*
- *DAB64x (TRIUMF, Canada)*

⇒ *Altera Stratix (EP1S20) FPGA*
- *use same code as for LHC BPMs*

⇒ *Mezzanine Card*
- *receives info from 6 front-ends*
- *performs manchester decoding*
- *Xilinx FPGA treats data to give correct input for DAB64x*

⇒ *Final configuration*
- *2 DAB64x with 2 mezzanines*
- *processing data from 23 CNGS PUs*



The CNGS BPM Electronics

CNGS Beam Position Measurement Acquisition System

Why this choice of front-end?

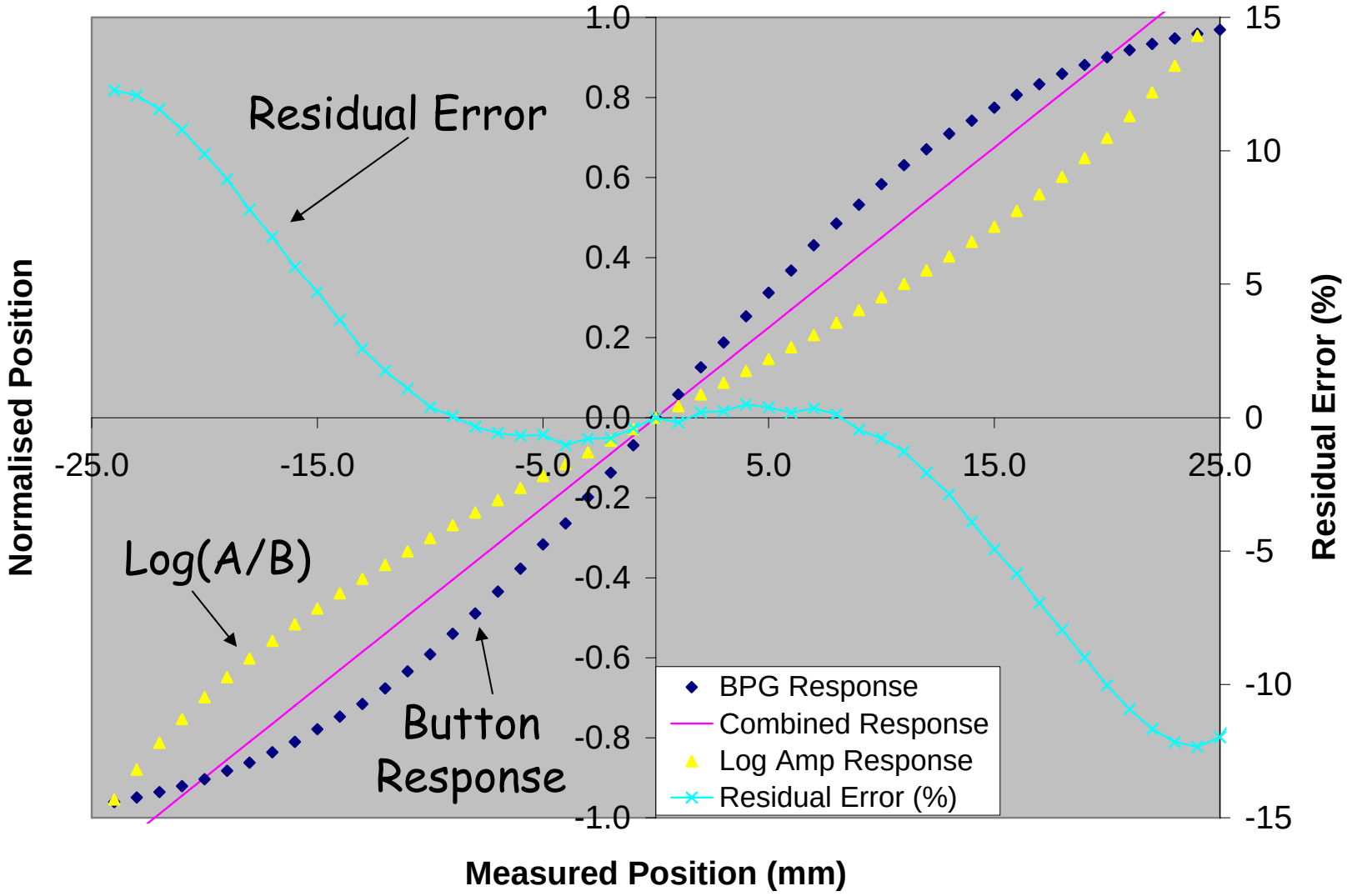
⇒ *low cost – as it requires only 1 coax cable per pick-up.*
⇒ *large dynamic range without requiring gain switching.*
⇒ *simple engineering*
⇒ *auto-triggered - no requirement for external timing in the tunnel*

Why this choice of digital acquisition?

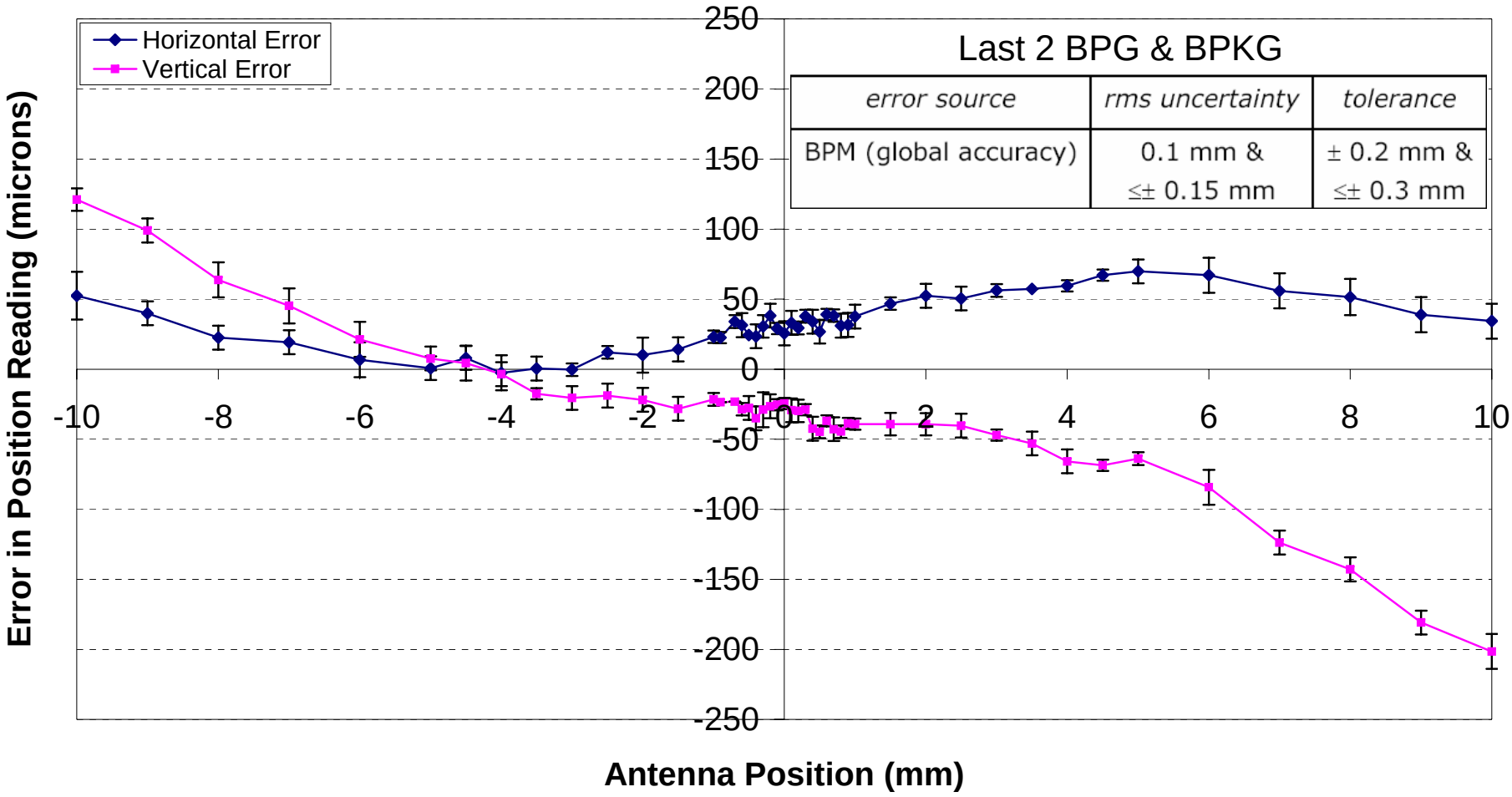
⇒ *uses standard LHC BPM digital acquisition card*
- *software architecture already in place*
- *guarantees hardware & software support*

⇒ *minimal development for CNGS team*
- *develop a single (relatively simple) mezzanine board to convert CNGS signal to compatible format*

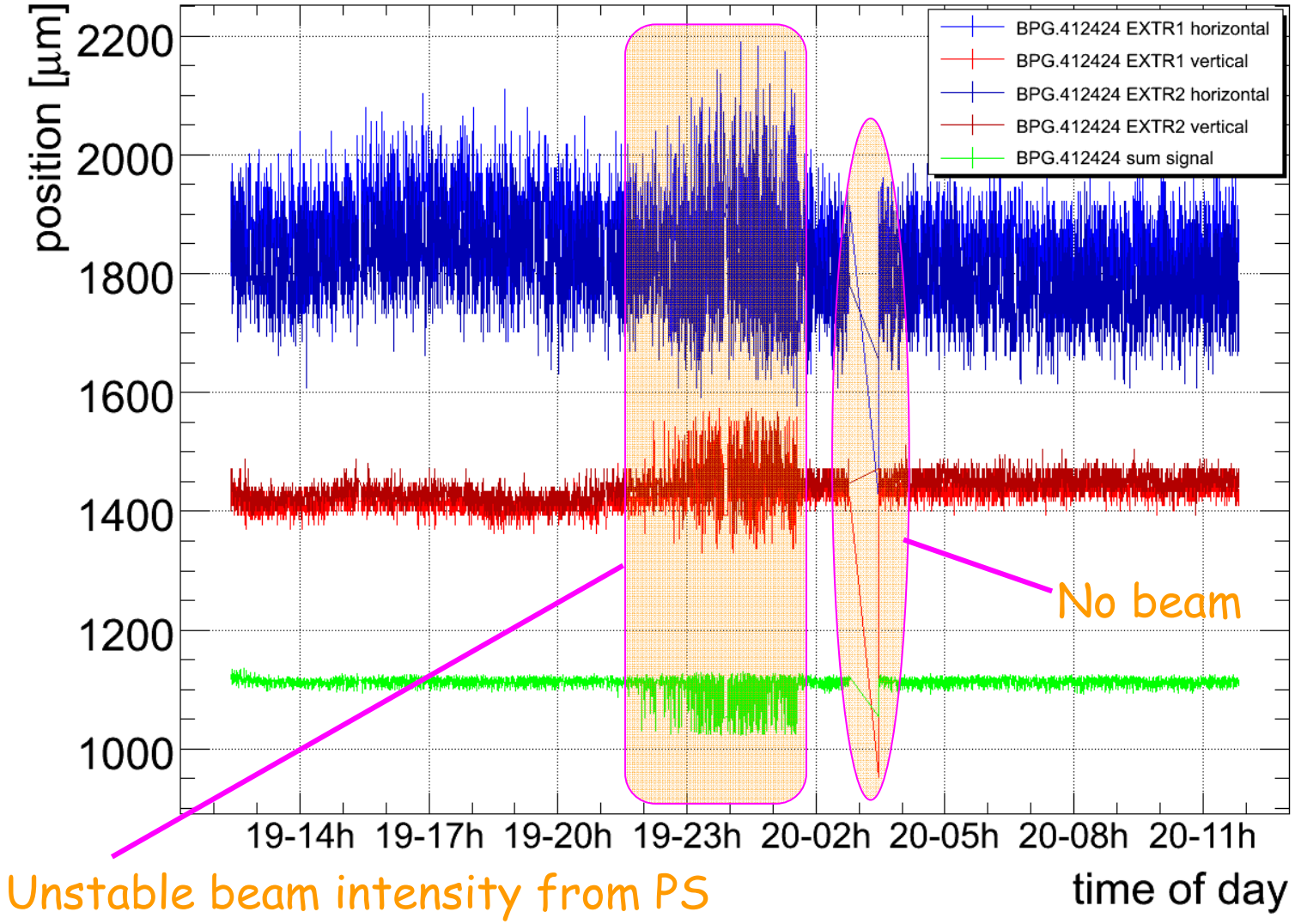
Combining a Button Pick-up with a Log Amp Acquisition System



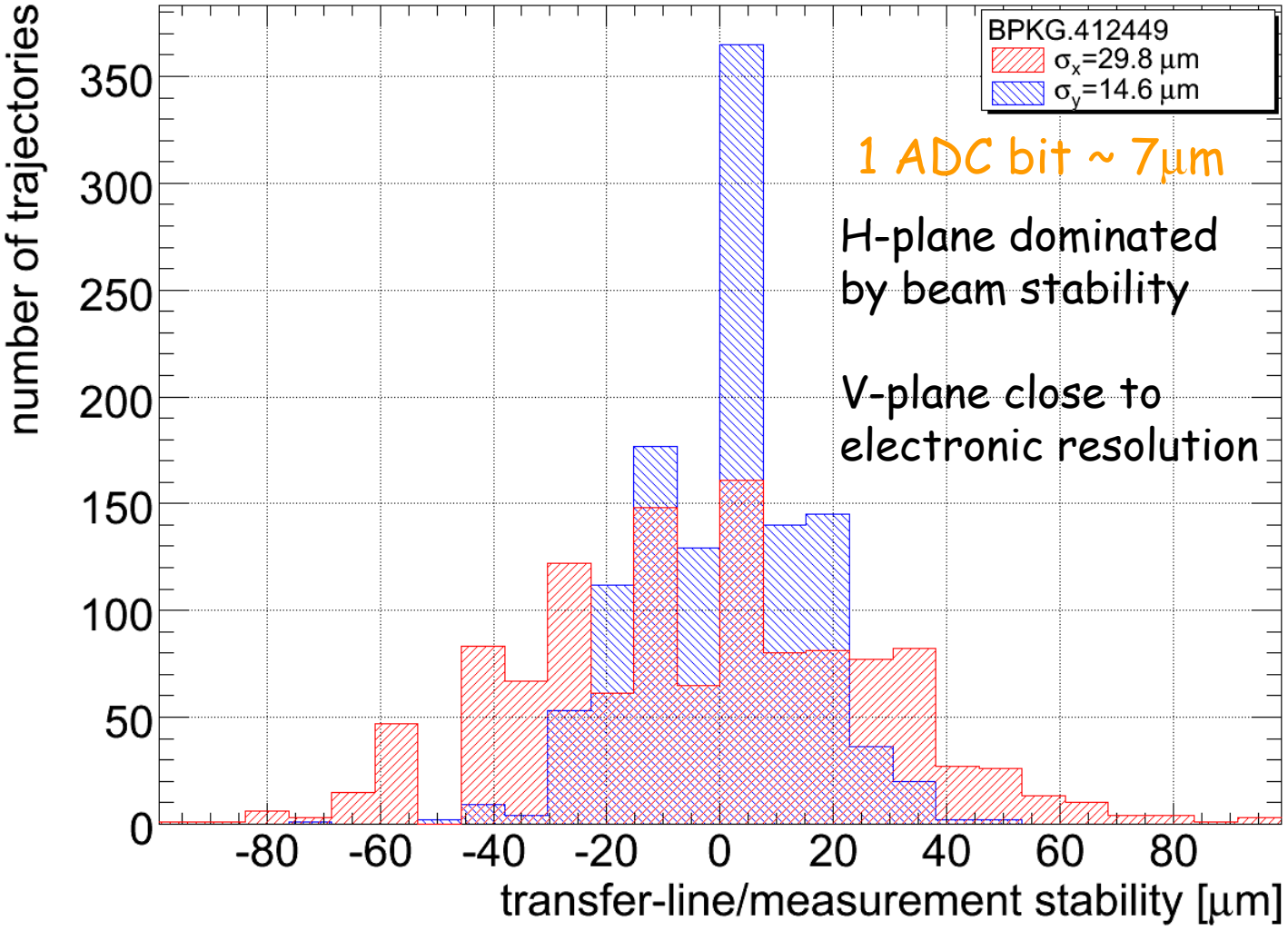
Laboratory Results of the CNGS BPM System



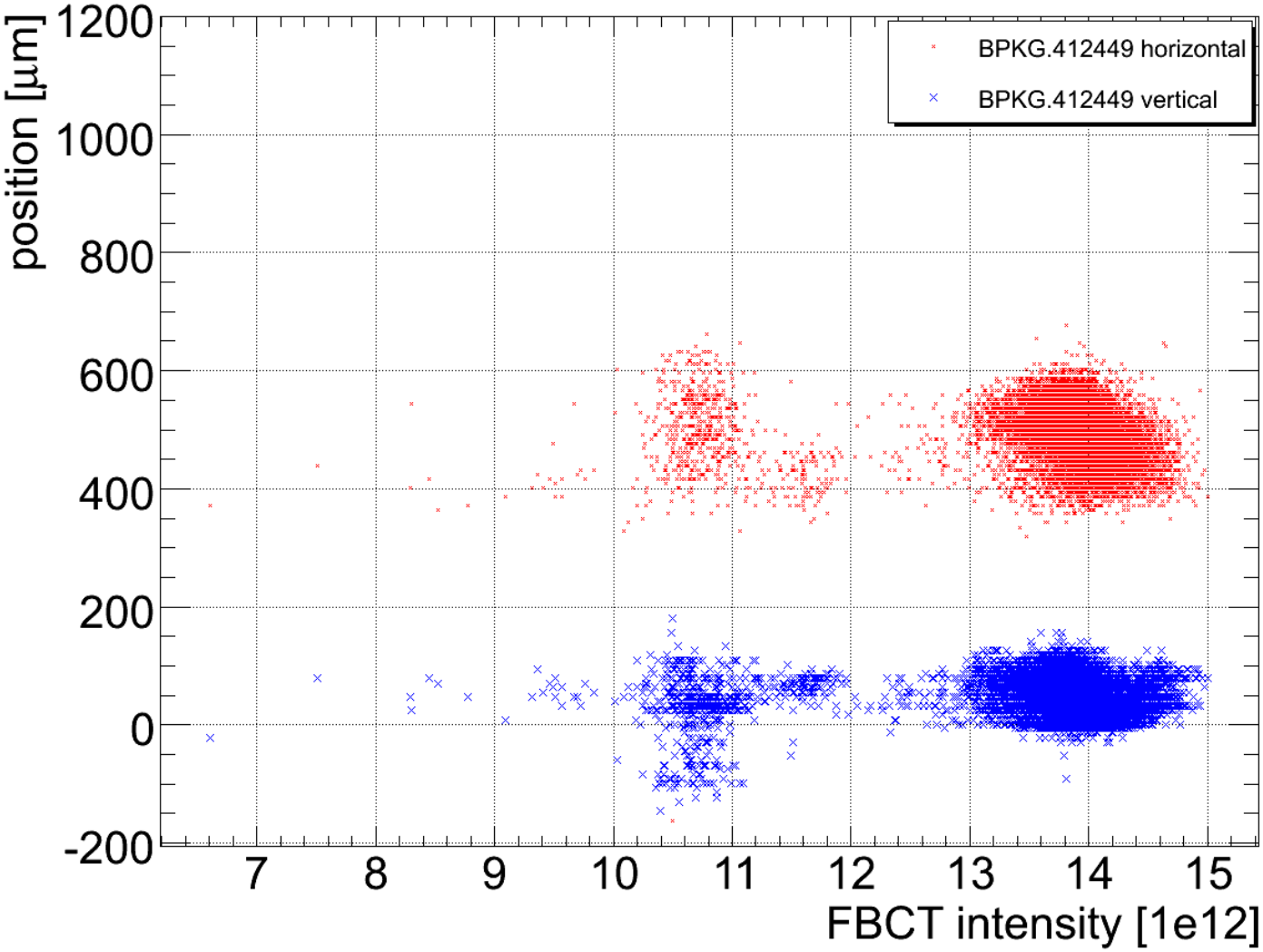
Performance with Beam - One Day CNGS Beam Stability



Performance with Beam – Stability of CNGS Target BPM Reading



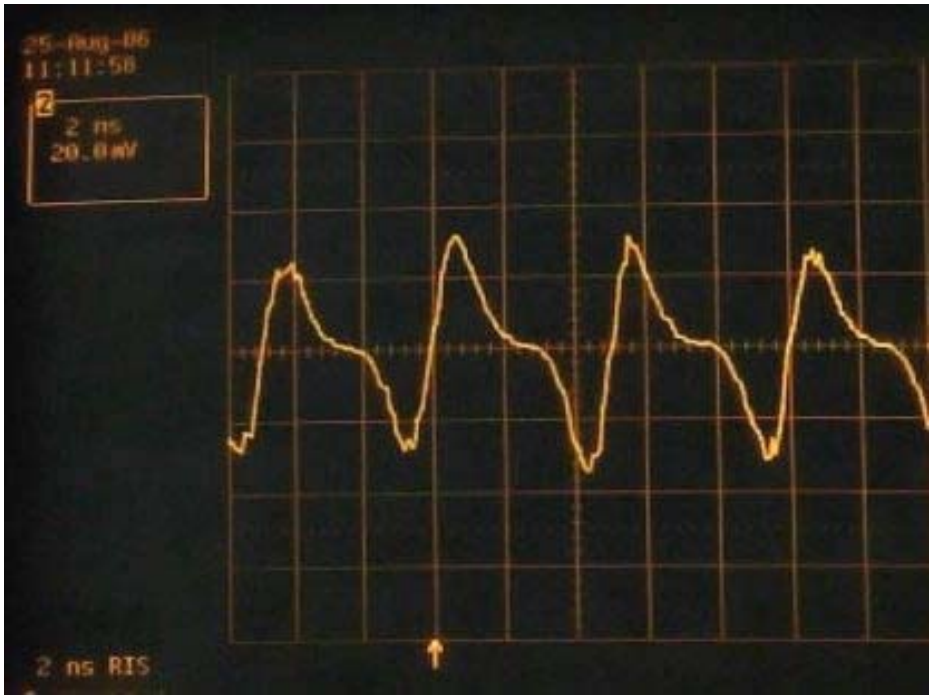
Performance with Beam – Target Position Reading with Intensity

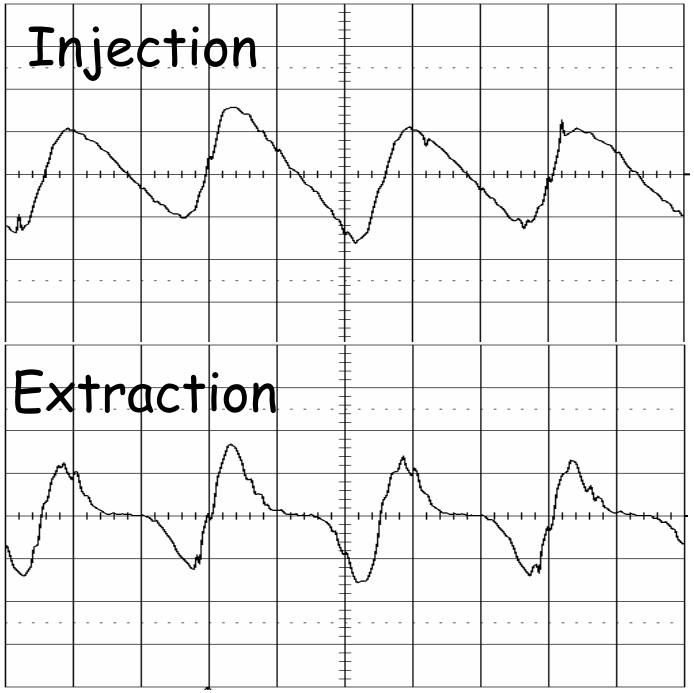


Problems Encountered During BPM Commissioning

Auto-trigger Circuit:

- No triggers at all for low intensity & haphazard triggering for high intensity
  - ⇒ Same circuit used for years in PS to SPS transfer line
- Circuit tested with circulating beam in SPS
  - ⇒ Trigger found sensitive to bunch length & batch structure





Problems Encountered During BPM Commissioning

Auto-trigger Circuit (cont):

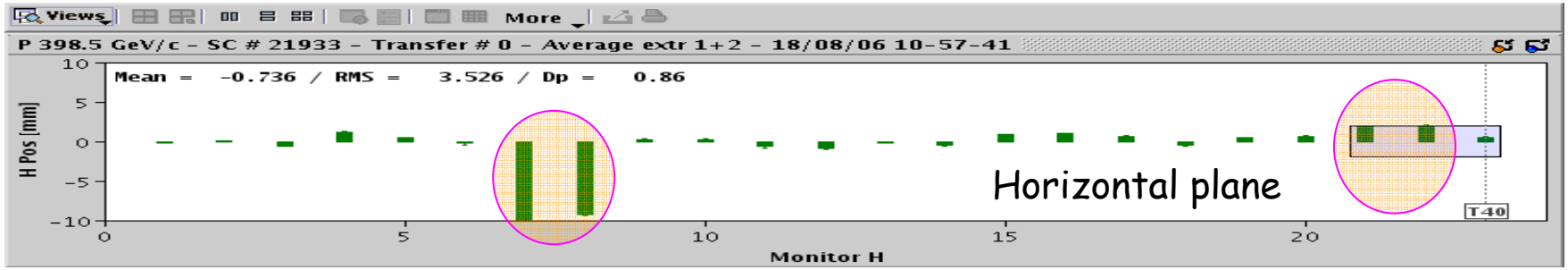
- Diagnosis
  - ⇒ Short bunch lengths produced switching times which were too fast for the auto-trigger circuit to deal with.
- Solution
  - ⇒ At first possible access, all front-end cards were removed
  - ⇒ All were modified with a quick-fix & re-installed within 1 day
- Performance after quick-fix
  - ⇒ Correct functioning for high intensity, still a few circuits which did not trigger all the time with very low intensity
- Longer Term Solution
  - ⇒ Re-design of auto-trigger circuit based on this experience with beam!

Problems Encountered During BPM Commissioning

Other Problems:

- Large offsets in 2 monitors after 1 week of running
  - ⇒ Suspected short circuits in recuperated LEP buttons.
  - ⇒ Will attempt to "burn away" shorts using HV discharge.

- Last two line monitors seen to give spurious readings on first shots when beam turned back on after being off a few cycles
  - ⇒ Currently no explanation for this based on BPM system.
    - ⇒ Same front-end crate as 3 other monitors which work OK
  - ⇒ Requires more study with correlation between BPM & BTV to determine if it's beam or monitor related



Commissioning of the CNGS BPM System

Summary of NBI2005 – Open Issues

- Linearity of BPM system
  - ⇒ Similar front-end gives good results in PS to SPS line
  - ⇒ Test bench available once electronics ready
- Performance of target pick-up in air
  - ⇒ Will only be possible to evaluate with beam!

Summary of NBI2006

- Linearity of BPM system
  - ⇒ Accuracy seen to be better than 250μm over ±10mm range
  - ⇒ Resolution at the 20μm level for nominal beam
- Performance of target pick-up in air
  - ⇒ Performs with the same characteristics as the line BPMs
- Problems encountered during commissioning
  - ⇒ A few teething problems that will be solved for future runs