Status and Plans
for the Analogue and Digital electronics

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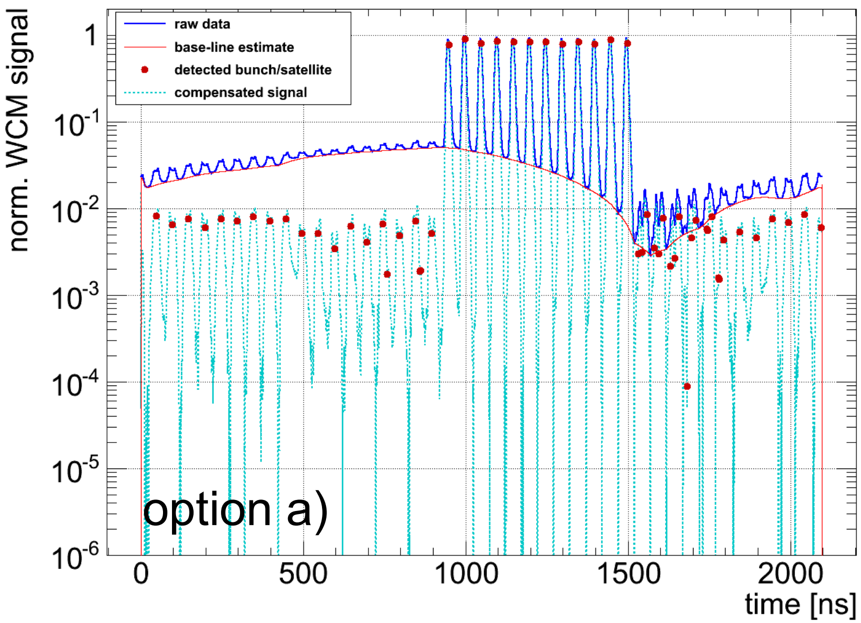
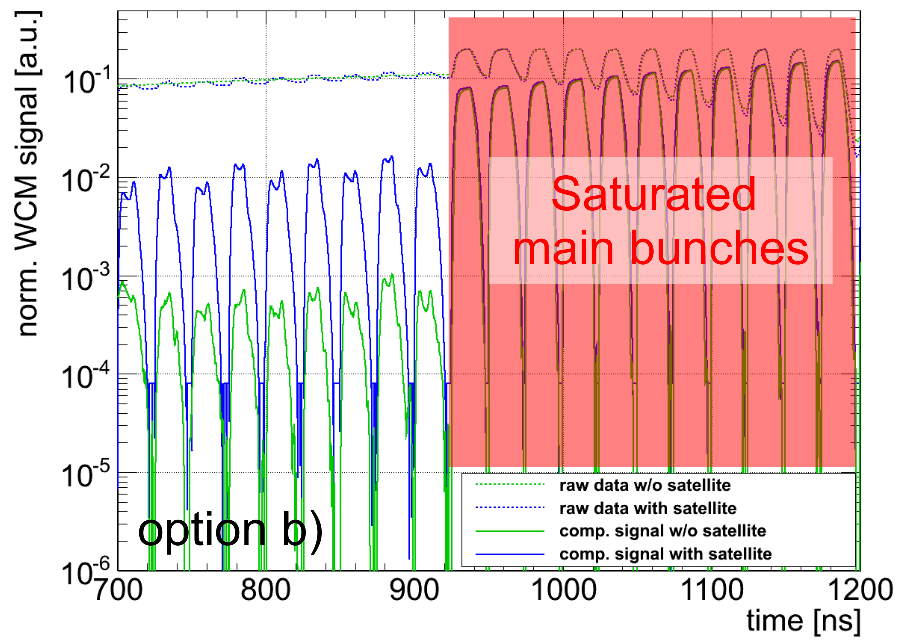
PS Ghost and Satellite Detection
Executive Summary

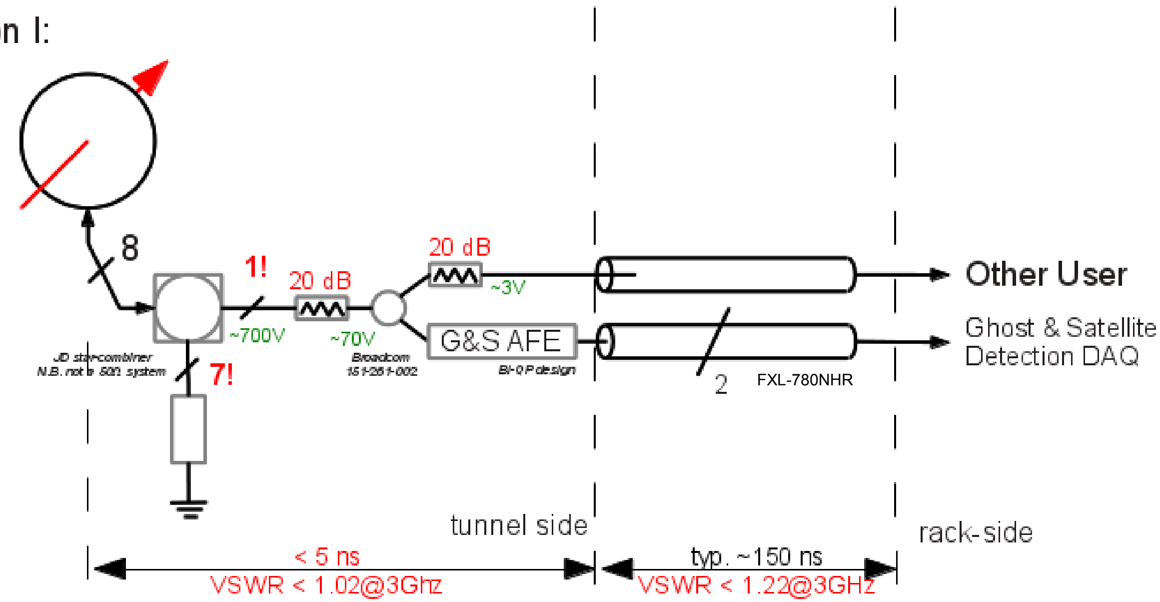
- Nom. empty LHC RF buckets may be filled with minute amounts of particles → aka. 'Satellites' and 'Ghosts' up to 10^{-6} smaller than nominal bunches
- Proof-of-Concept test confirmed that the existing system...
  - can achieve 10^{-5} resolutions @3 GHz over a few turns or single-shot via:
    a) turn-by-turn averaging over a couple of hundred turns
    b) splitting signal and saturating its copy to specifically detect satellites
  - Requires beam-based baseline compensation and reflection control « 1%
- Original publication:
  - BI Seminar 2012-06-15 – slides & BIW'12 Publication: CERN-ATS-2012-249



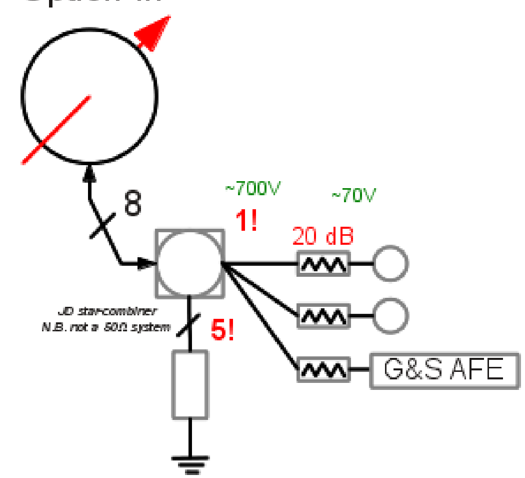


Proposed PS WCM Analog-Front-End (AFE) Layout V1

Option I:

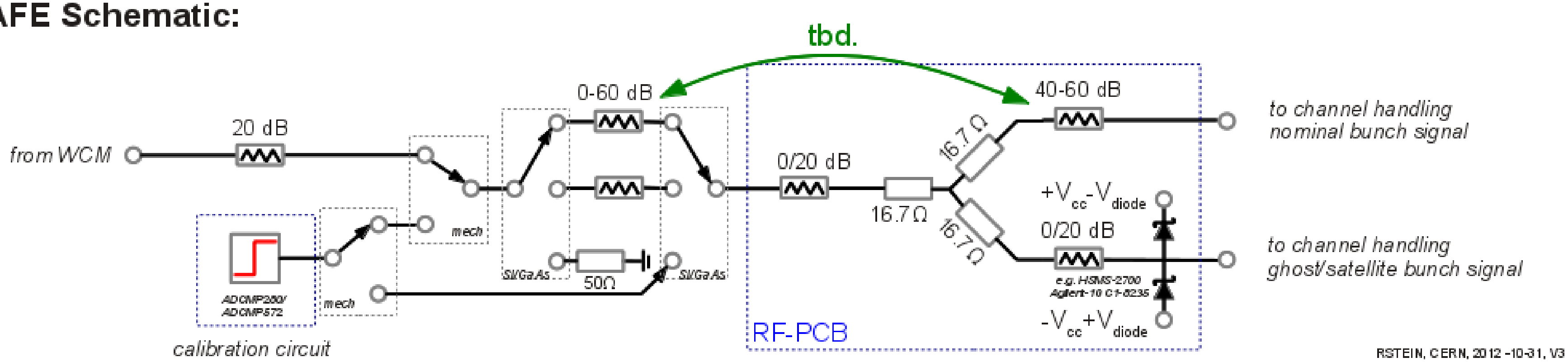


Option II:



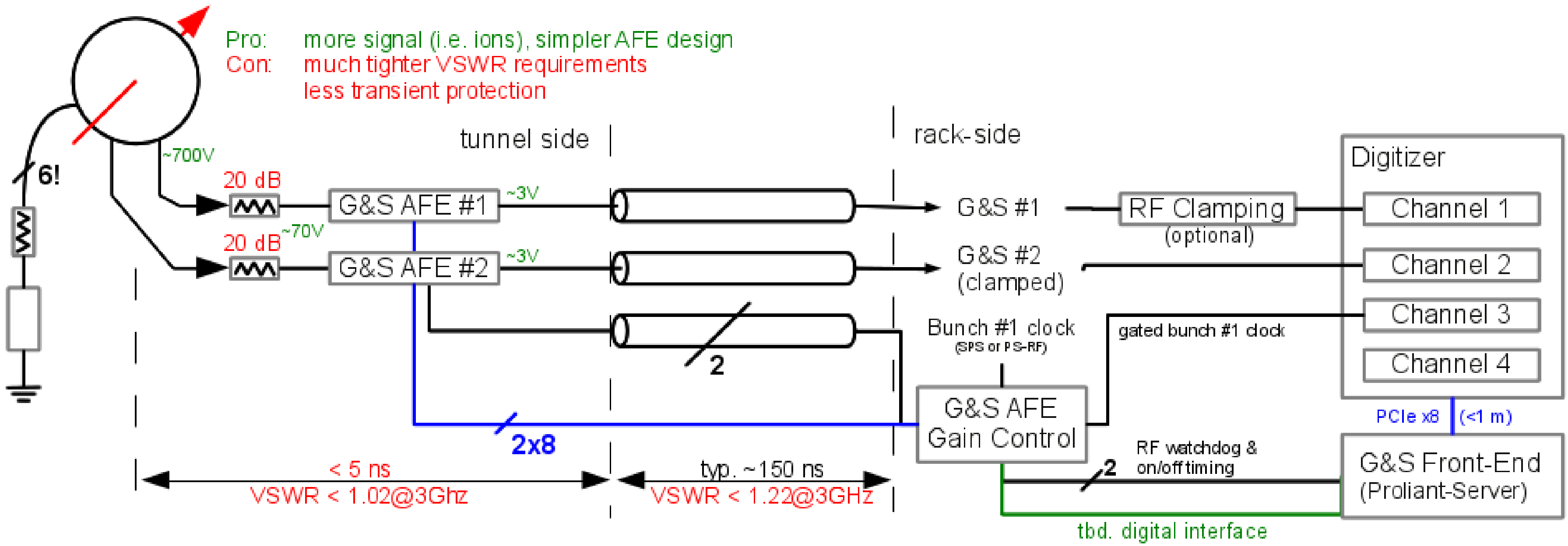
Pro: more signal (i.e. ions)
Con: much tighter VSWR requirements
less transient protection

G&S AFE Schematic:

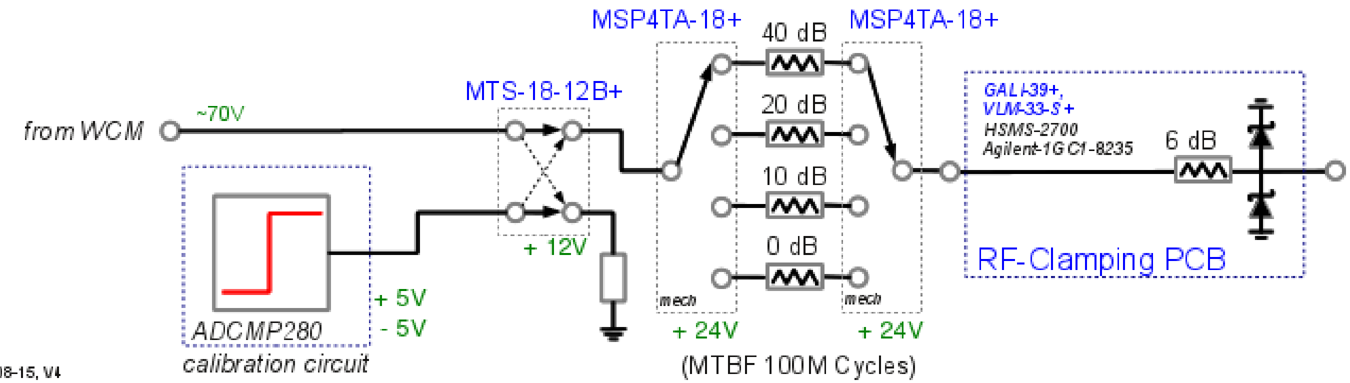


- To be discussed – do we add a second WCM installation to
  a) avoid splitting signal between G&S and other clients?
  b) Divide-and-conquer: nominal (V_{pp}>700V) and pilot/ion beams (V_{pp}>~ 1V)

Proposed PS WCM Analog-Front-End (AFE) Layout V4



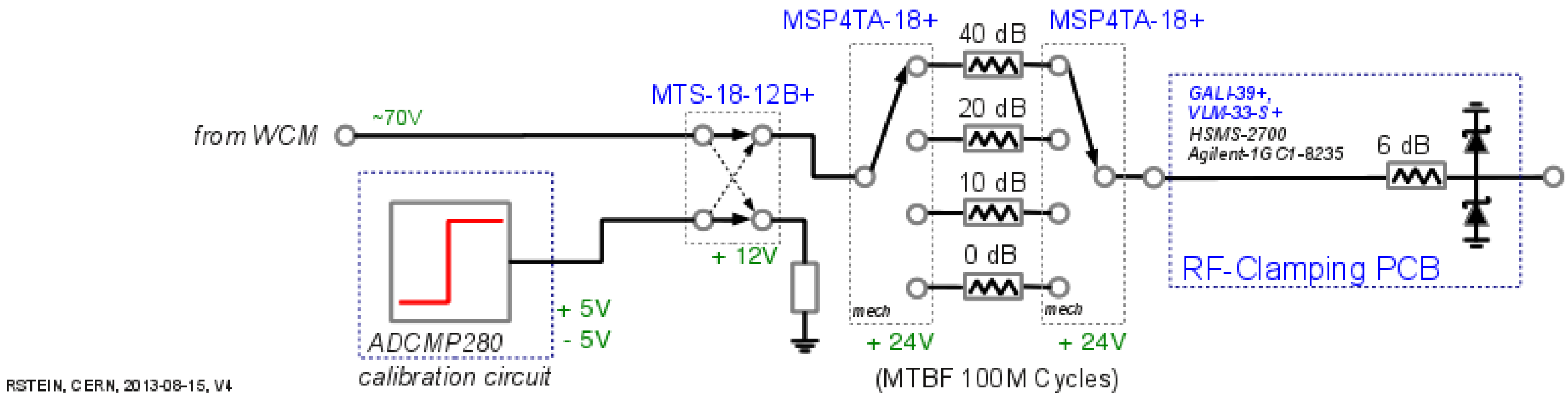
G&S AFE Schematic:



RSTEIN, CERN, 2013-08-15, V4

PS WCM Installation Discussion, Ralph.Steinhagen@CERN.ch, 2013-09-15

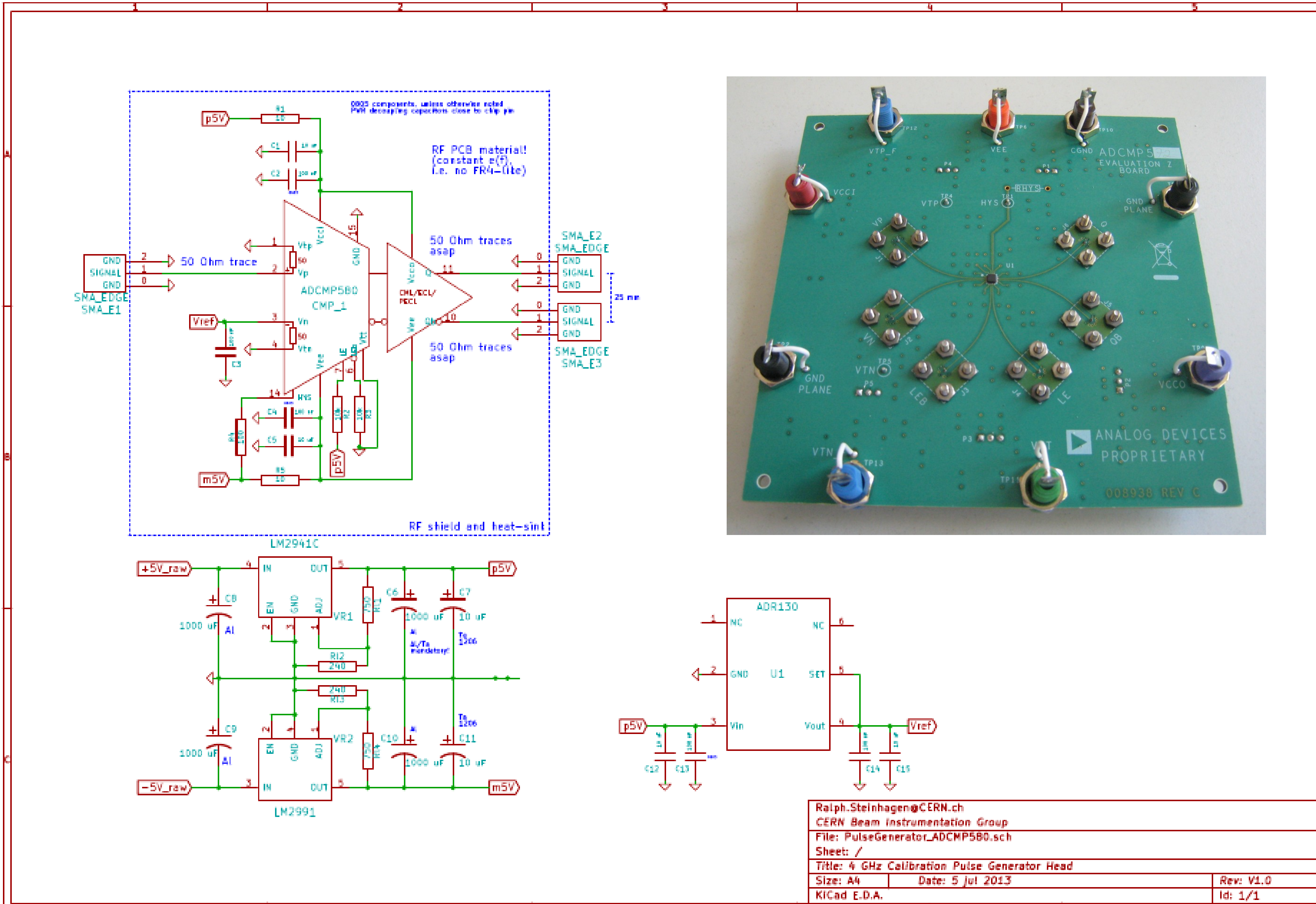
Proposed PS WCM Analog-Front-End (AFE) Layout I/III



- Gain stage – *adjusts RF levels between 'long & low intensity' vs. 'short & high intensity' bunches*
  - Evaluated relay vs. SI/GaAs-switch options → RF relay preferable
    - better linearity & power handling, notably: no 'R_s-vs-T dependence'
  - RF switches with MTBF 100M cycles/10yr (<400(+200) $/pc.)
  - Replace ~3-4 years (e.g. during annual shutdown) based on:
    - actual/counted switch state changes (→ SW functionality)
    - response to calibration test signal (→ SW/DB functionality)
  - Need couple of supply, drive voltages (±5V, +12 V,relays 1x12V,4x24V = 8 Voltages)
  - Main item missing: mechanical integration

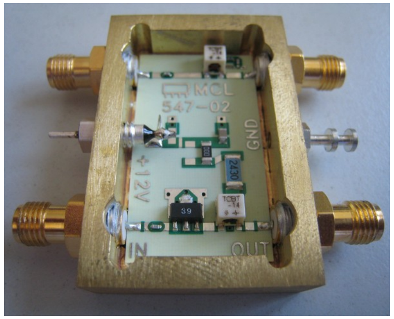
- Calibration Test-Signal Generator – OK
  - Based upon: ADCMP580, nom. 35 ps rise/fall time ↔ ~10 GHz bandwidth)
  - Need (simple) series PCB design, packaging and production for integration that can be deployed in accelerator tunnel (~30-50? units, also needed for HT, LHC-WCM)

Proposed PS WCM Analog-Front-End (AFE) Layout II/III
ADCMP580-based Wide-Band Calibration Circuitry



Proposed PS WCM Analog-Front-End (AFE) Layout III/III
RF Clamping Circuit – Nominal

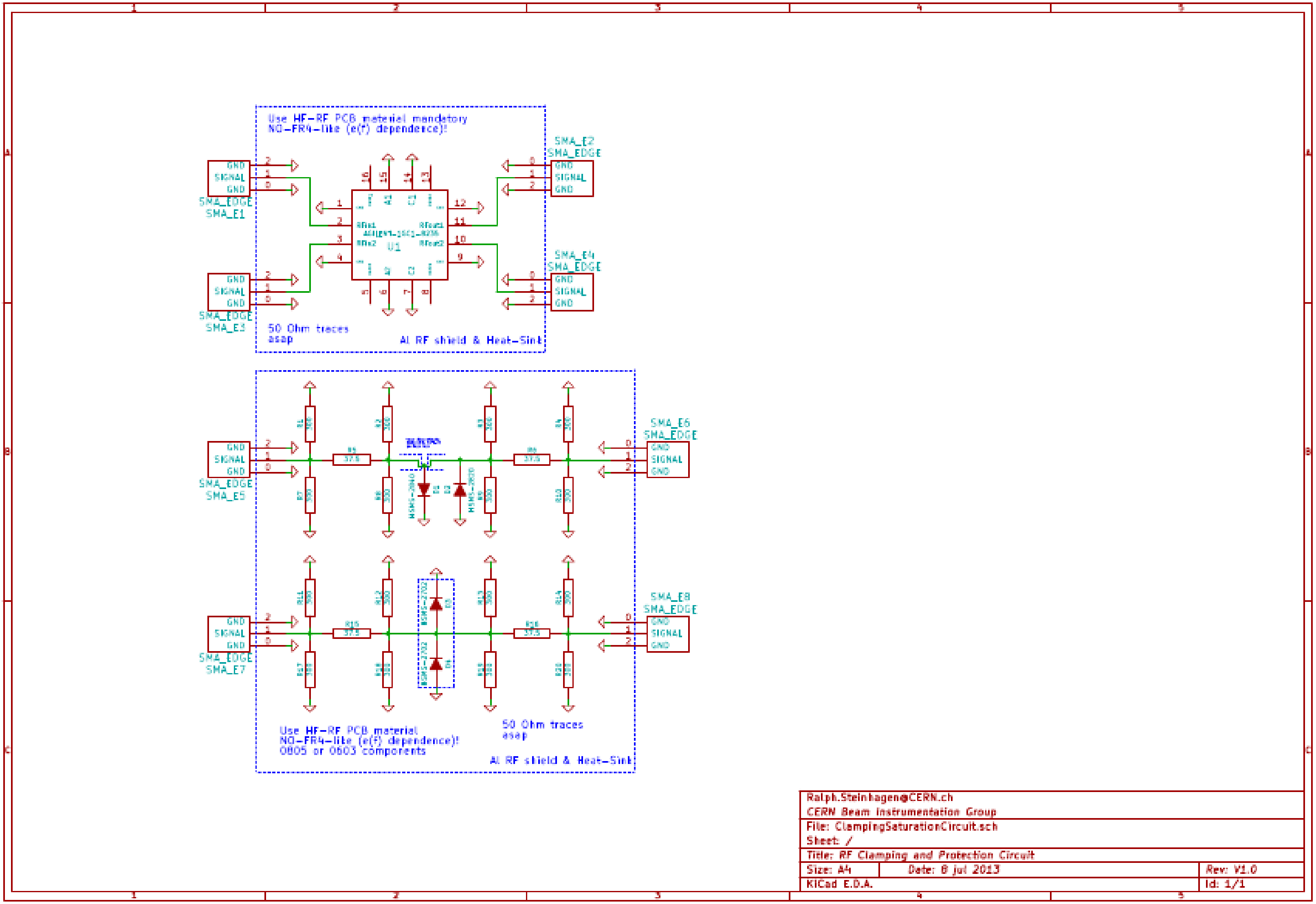
1. *GALI-39+ – clamps @-10 dBm – best performing option (~1.2$)*
   - *Low-noise, wide-band amplifier (2.4 dB N.F., DC-7 GHz)*
   - *fastest recovery time, also used in MIM-RF AFE*
   - *option to measure also very low-intensity ion beams*
   - *req. RF-PCB design, or use of prototype PCB (not ideal)*
   - *no data on radiation hardness*



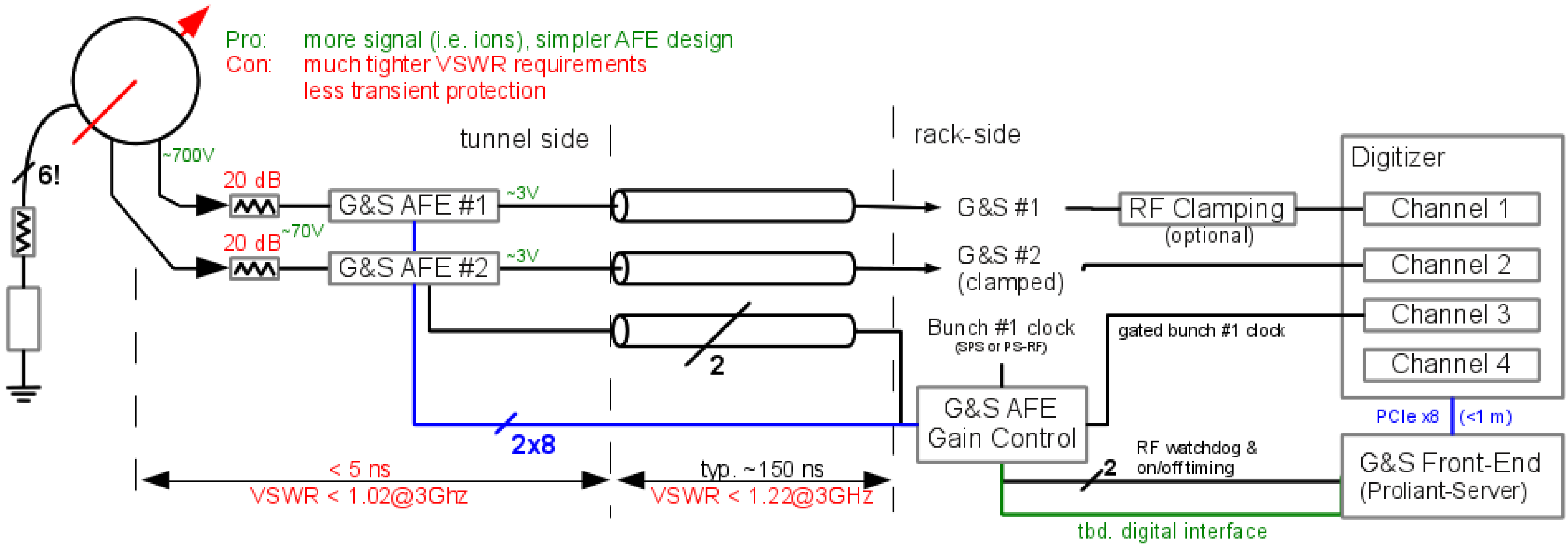
2. *HSMS-2840/20 or Agilent-1GC1-8235 circuit – clamps @10-18 dBm*
   - *Lowest noise, wide-band passive clamp (DC-4/20 GHz)*
   - *Simple PIN/Schottky contacts → expected to be radiation tolerant/hard*
   - *Used to passively protect oscilloscope's AFE-input*
   - *requires RF-PCB design*

3. *VLM-33-S+ – clamps @18 dBm (~47 $)*
   - *off-the-shelf limiter,* passive, quick plug-in-replacement
   - limited bandwidth (3 GHz), ~10 ns recovery time
   - no data on radiation hardness

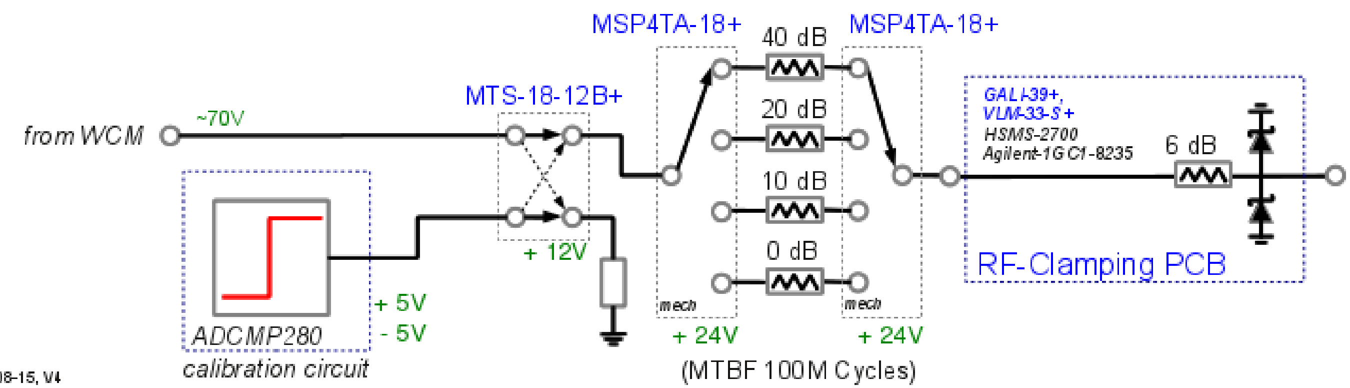
Proposed PS WCM Analog-Front-End (AFE) Layout III/III
RF Clamping Circuit – Alternative in case of Radiation Issues



Proposed PS WCM Analog-Front-End (AFE) Layout V4



G&S AFE Schematic:



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Gain Control Unit – Functional Description

A) Relay control – 10 relay states
   - 4 gain stages for full-range/saturated signal (24V, 0.5A)
     - relays have to be put into safe-state for non-LHC type beams
   - transfer switch state (12V, 0.5A), calibration unit on/off (±5V, 0.4A)

B) Gating of 'RF bunch#1 trigger' (logic 'and') – TTL input from CTR(I)
   - needed for ms-level synchronisation withing given PS user
   - H. Damerau, two options: either PS or SPS RF master clock
   - Piggy-back/relay RF trigger to generate calibration pulse for ADCMP580

C) RF-Watchdog to put relays into safe-state in case, i.e. via
   - slow (100-200 Hz) FESA-based toggling of HW output (TTL logic)
   - Periodic SW command (i.e. via UDP), if absent → open transfer switch

- … mostly TTL logic and providing a reliable interface to the G&S FESA server
  - to be defined/decided: TTL level interfaces only, MCU, or other card?

Additional Slides

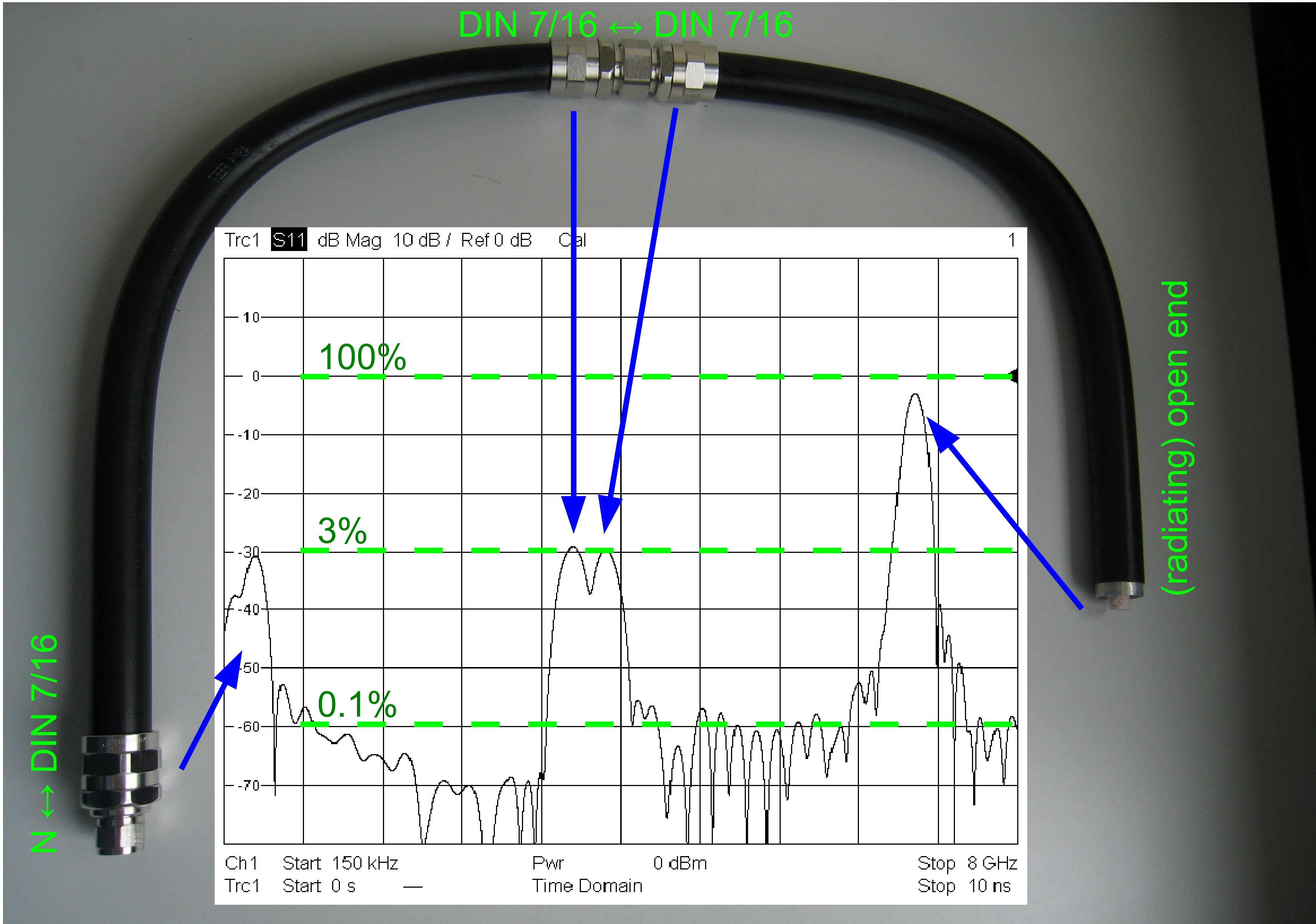
For Discussion

- Ghost-and-satellite detection on the sub-percent level requires installation systematics (notably reflections and bandwidth) to be controlled better than a percent → need to agree on a VSWR<1.02@3GHz or dedicated pick-up.

- Analogue front-end
  - Switches for gain stage established some confirmation tests pending
  - Need to start to develop series PCB production for calibration unit
  - Some details to be worked out w.r.t. saturation module and SW interfaces
  - Of note:
    - High-power levels → recommend protection of DAQ inputs
    - Low signal levels → recommend 2nd WCM dedicated to ions/pilots

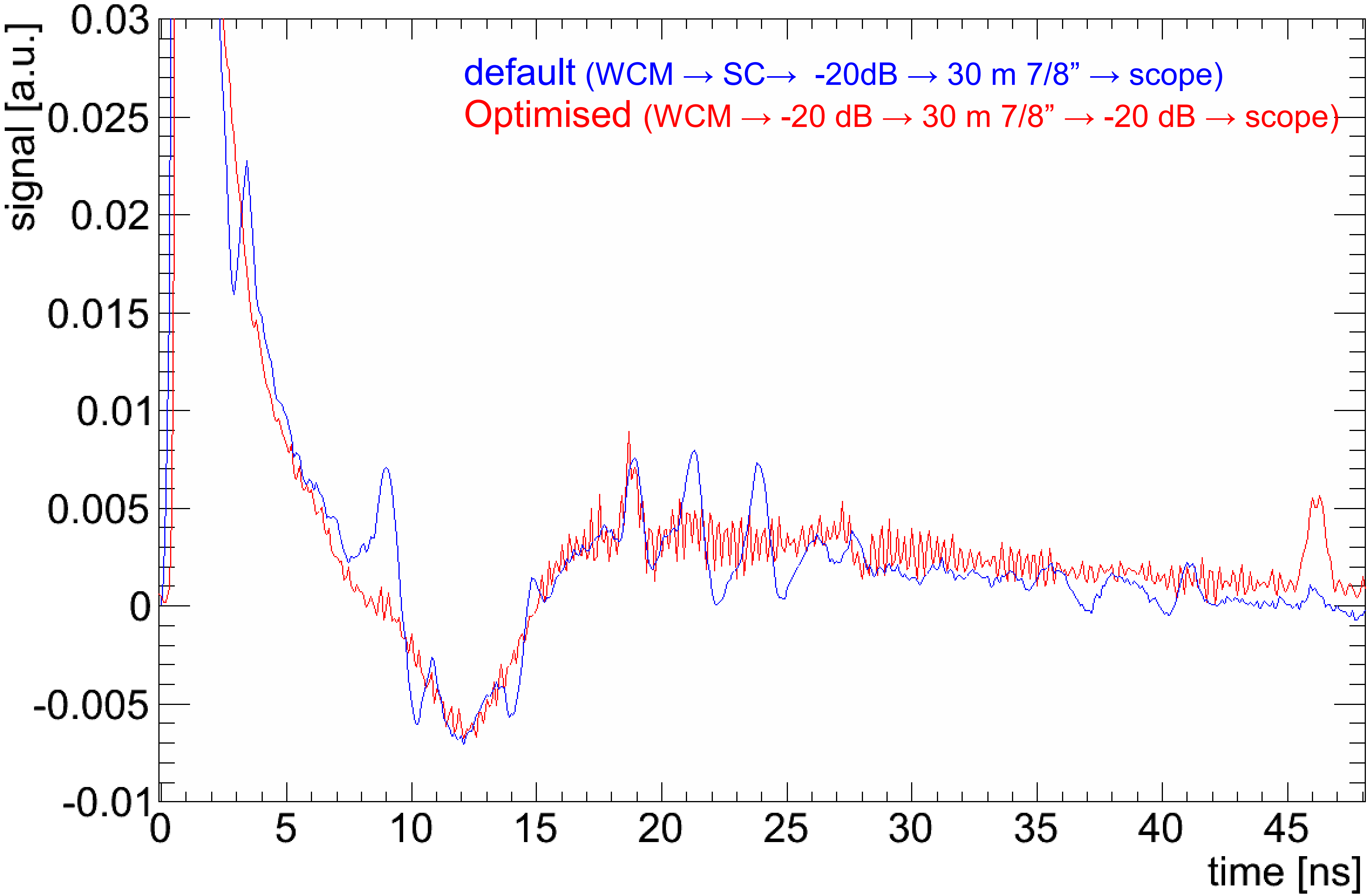
- Digital Acquisition System: need nominally 2+1 channel
  - 2 analogue channels + 1 trigger to recover revolution period
  - Keep the same system for PS and LHC?
  - minimal CO support (probably only server HW, OS + timing card setup)

Reflections: RF Connector and Cable Geometry
Real-Life Example



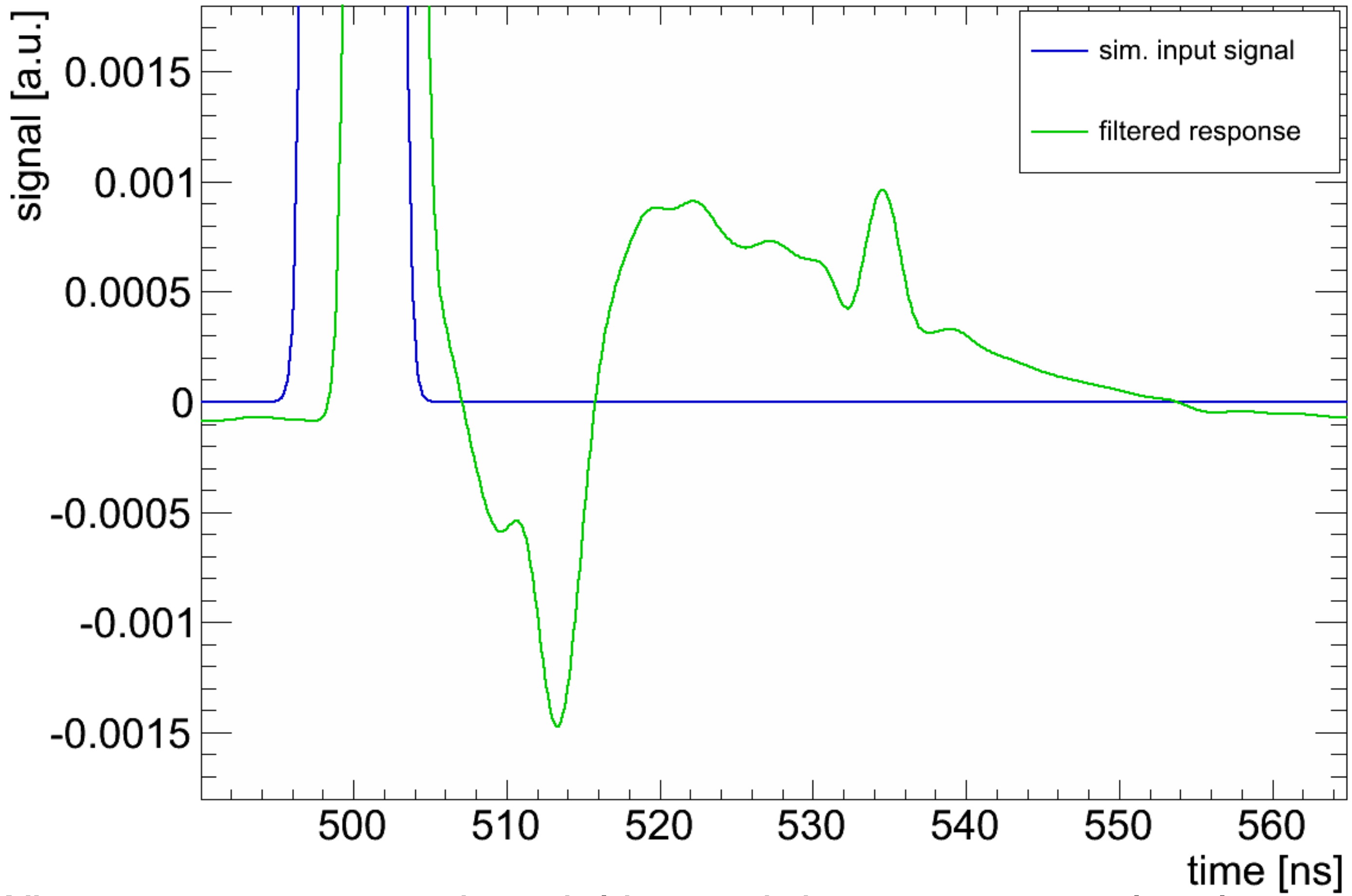
For comparison: LHC WCM Installation I/II

- Comparison of standard vs. optimised installation:



For comparison: LHC WCM Installation II/II

- LHC APWL lab-based measurements (T. Bohl, 2006)



- APWL measurements and model is good down to percent-level
  → to be refined for higher accuracy during LS-1 (also of RF interest: T. Bohl)
- Need similar measurements for PS WCM for targeted sub-% G&S resolution