Luminosity Monitors for the LHC Status Update and Integration Plans

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Outline

- Status
- Ongoing R&D activities
- Organization and Planning
- System integration
- Conclusions

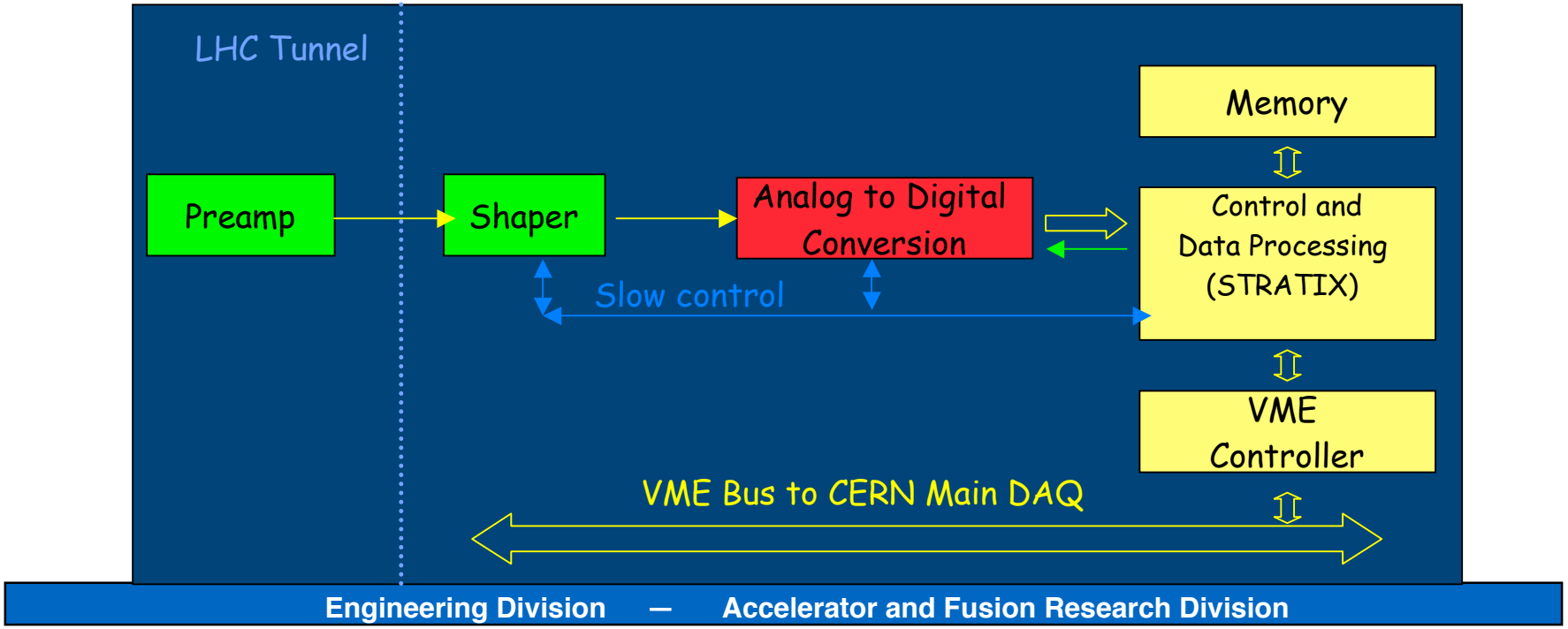
Status

- Luminosity instrumentation funded by the US DoE through the LARP program
  - Have entered the final design stage
    - FDR in April 2006
- Activity originally proposed in ~1997
- We will instrument IP1 and IP5
  - Atlas and CMS
- Other groups plan to instrument TANs
- We are here to coordinate with other interested parties
  - Have a mock-up of the BRAN (LM) to test in the TAN

BRAN Detector

Signal Processing

- Very low noise pre-amp in the tunnel (by the INFN-PV group)
- Shaper section completes the analog signal processing
- ADCs integrated in a VME64 mezzanine card
  - Interface defined by CERN BDI group
- Plan to build the same system for Atlas ZDC



LUMI Front-End Amplifiers: Cold Termination – Pavia Amplifier

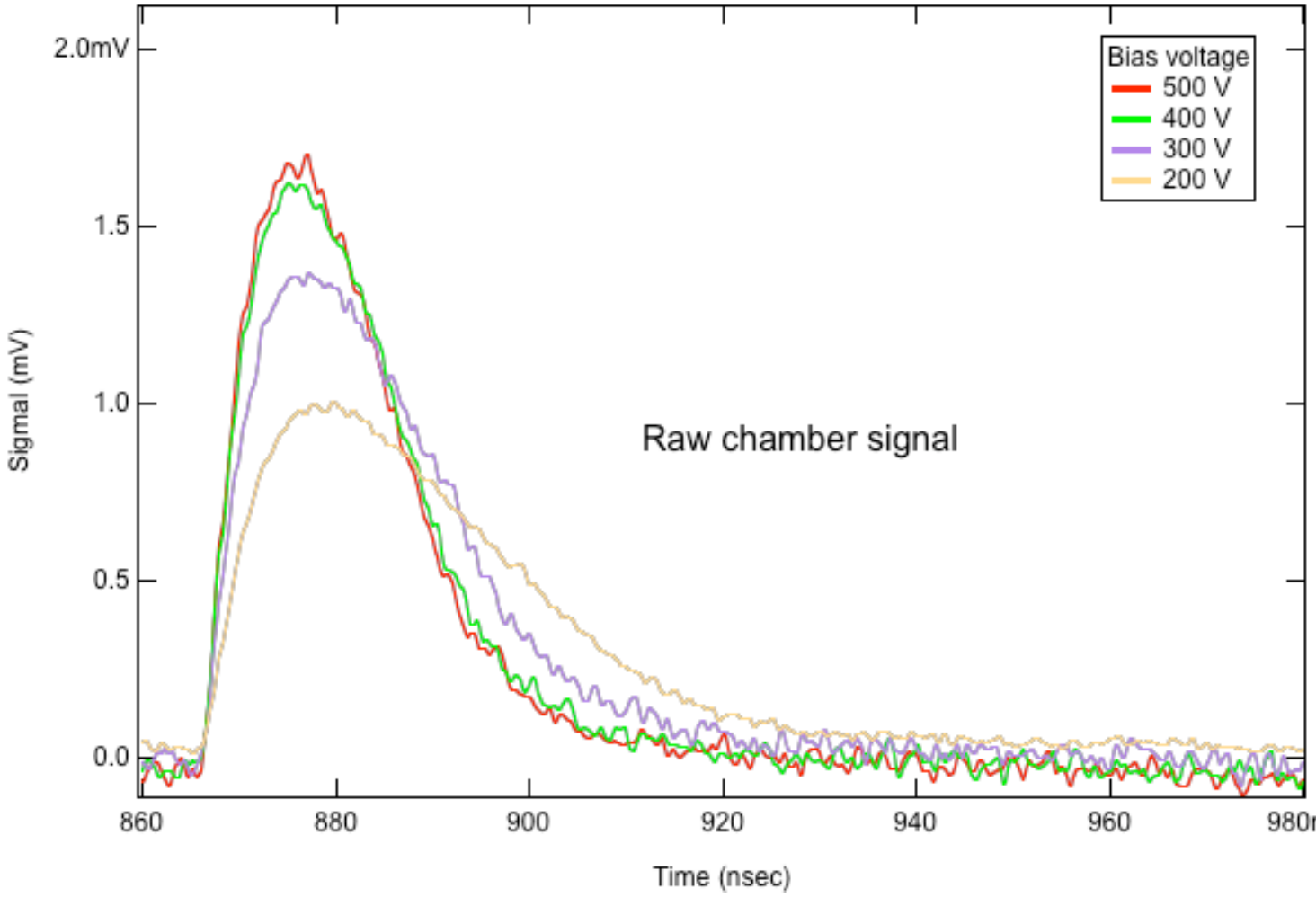
- Original Design developed by P.F. Manfredi, L. Ratti and G.Traversi of the University of Pavia using a cold termination technique:

- *E. Gatti, P.F. Manfredi, IEEE Trans. Nucl. Sci, vol. NS 25, 1978, pages 66-74*

40 MHz Demonstration

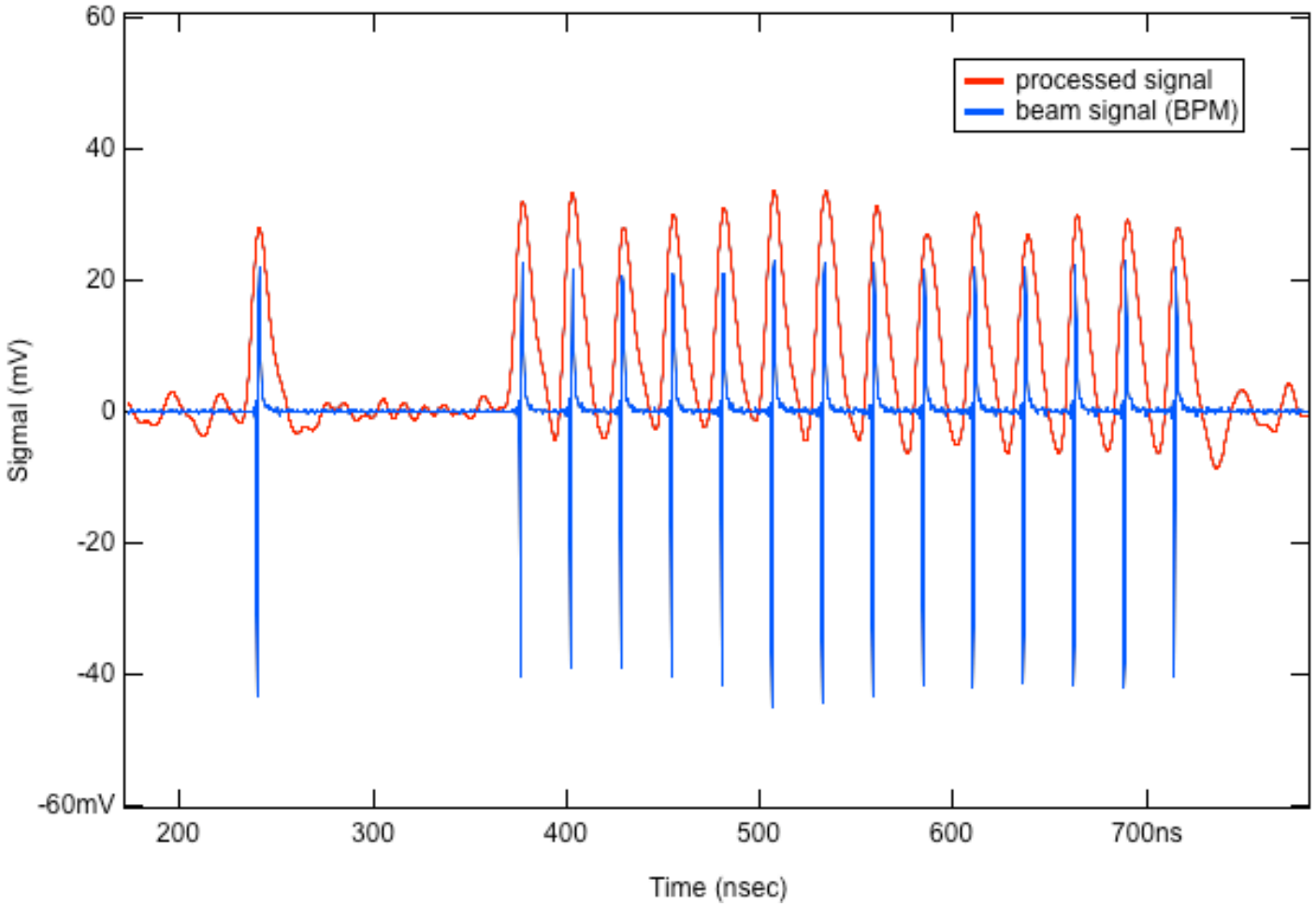
- Tested the lumi detector at one of the hard x-ray beamlines at the ALS
  - X-ray to ion pair production very hard to calculate
  - White light configuration ~70-80 keV X-rays
- Chamber modification needed
- Tested proof of principle in August
- Complete set of data taken in September
- Required dedicated machine time to fill the ring with a 40 MHz bunch pattern
  - Pattern used allowed for a gap to measure single bunch response
  - Also tested without gap to see 'continuous' beam

Raw Chamber Signal



20 ns/div

After Pre-amp and Shaper



Current R&D Issue - Radiation hardness

- Planning a meaningful test of the materials is really hard: in most cases, test conditions are drastically different from LHC conditions
  - Shower vs. neutrons
  - Dose rate very different
- Parallel paths to minimize risk
  - Careful research of materials properties
  - Beam test - if possible
- The most attractive setting is the CERN PS Booster
  - With 10^13 pps we estimate ~ 25:1 gain
    - 1 month in PSB ~2 years at LHC high luminosity
  - Will be discussing this possibility next week
  - Other sites are also being considered

Plans for a test in RHIC

- Installed in IR 10
  - Former experiment, now empty
- Goals
  - Become familiar with operation in a hadron collider environment
  - Benchmark device against the proven RHIC ZDC luminosity monitors
  - Investigate some sources of background
  - Develop signal processing implementation
  - Integrate electronics in accelerator environment
- RHIC run 6 will have p-p and Au-Au
  - Run planned for starting this week to ~Jun. 2006
- Multiple reasons to prefer Au-Au collisions
  - More neutron yield
  - Better neutron energy
  - Dedicated collisions have less effect on lifetime than in p-p mode
    - Beam-beam stronger in p-p

Installation Planning

- Gas Installation and Distribution
  - Done by CERN
    - With the help of Christof Schaffer and David McFarlane
- Electronics in IP1 and IP5
  - Racks reservation:
    - 24 Us in USA 15 (L+R) and USC55 (L+R)
  - Cables - at each location:
    - 1 NG28, 14x2x1mm^2, shielded twisted pair for power and control
    - 2 CNH50 coax cable for high voltage
    - 16 CK50 low loss coax cable for signal

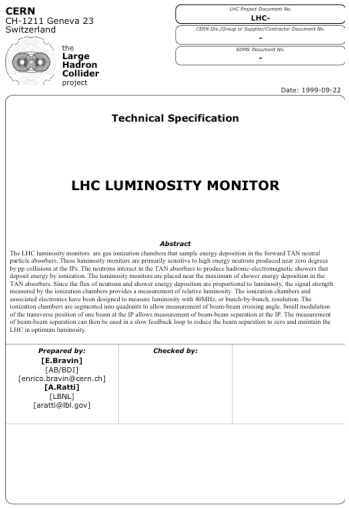
Scope and Responsibilities

- LBNL will deliver for BRAN
  - 4 chambers with electronics for IP1 and 5
  - Gas control system
  - DAQ with programming
  - Installation support
  - Hardware commissioning

- CERN will provide
  - Local installation
  - Gas supply and distribution
  - HV and DC power supplies
  - Control system integration
  - VME64 infrastructure and DABIV boards

Integration planning at CERN

- Complete system description
  - Technical, installation, safety, electronics, responsibilities, deliverables…
- Met with all relevant parties at CERN
- EDMS process underway



CERN
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the Large Hadron Collider project

LHC Project Document No.
LHC-
CERN Div./Group or Supplier/Contractor Document No.
-
EDMS Document No.
-

Date: 1999-09-22

Technical Specification

LHC LUMINOSITY MONITOR

Abstract

The LHC luminosity monitors are gas ionization chambers that sample energy deposition in the forward TAN neutral particle absorbers. These luminosity monitors are primarily sensitive to high energy neutrons produced near zero degrees by pp-collisions at the IPs. The neutrons interact in the TAN absorbers to produce hadronic-electromagnetic showers that deposit energy by ionization. The luminosity monitors are placed near the maximum of shower energy deposition in the TAN absorbers. Since the flux of neutrons and shower energy deposition are proportional to luminosity, the signal strength measured by the ionization chambers provides a measurement of relative luminosity. The ionization chambers and associated electronics have been designed to measure luminosity with 40MHz, or bunch-by-bunch, resolution. The ionization chambers are segmented into quadrants to allow measurement of beam-beam crossing angle. Small modulation of the transverse position of one beam at the IP allows measurement of beam-beam separation at the IP. The measurement of beam-beam separation can then be used in a slow feedback loop to reduce the beam separation to zero and maintain the LHC in optimum luminosity.

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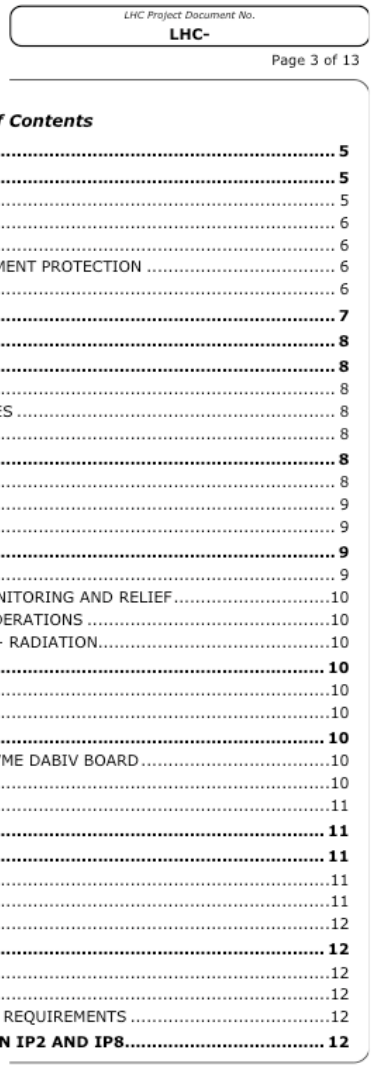

LHC Project Document No.
LHC-

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Lumi - Current Plans for FY06

- Build one complete unit. This includes:
  - Final design review (by April 06)
  - a chamber, mating TAN bar, gas handling system, tunnel electronics package (pre-amps)
  - Complete DAQ chain w. shapers, mezzanine boards and acquisition firmware integrated in CERN VME system
  - no luminosity specific firmware/software
- Complete documentation of chamber production and electronic processing system
- Test existing prototype in RHIC
- Rad hard study and tests (if possible)

All beamline devices will be delivered to CERN in time for LHC tunnel installation before the beam runs

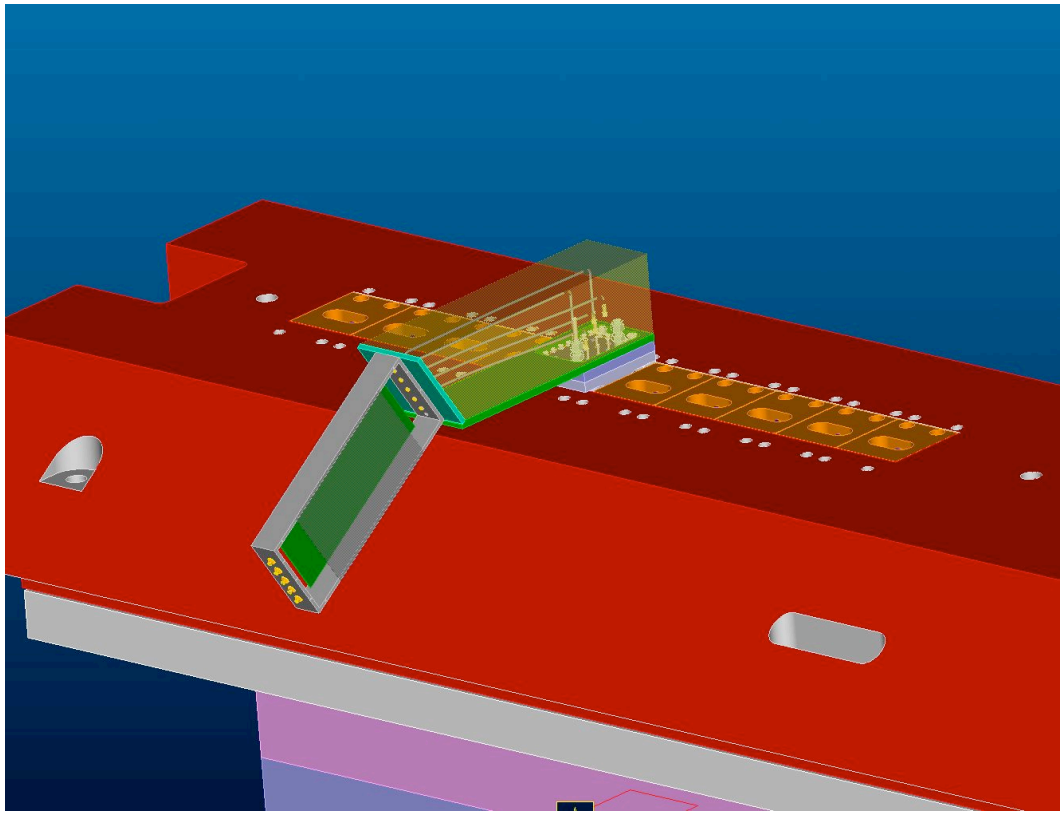
System Integration Approach

- Space we claim:
  - All vertical space above the device
  - Some longitudinal space next to our device
    - Front end electronics and cabling conduit
  - Space at the end of TAN for front end pre-amps
    - Current plan is to place electronics on the side of the TAN

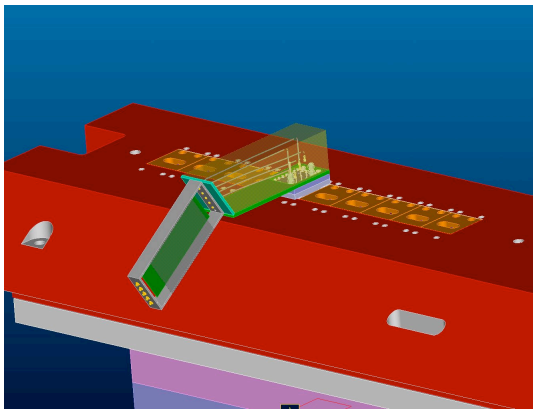
- Need ~ 1-2 interaction lengths of material before LUMI
  - Important to keep the working conditions similar if surroundings change
  - IE if a detector is removed, replace it with an equivalent material and size

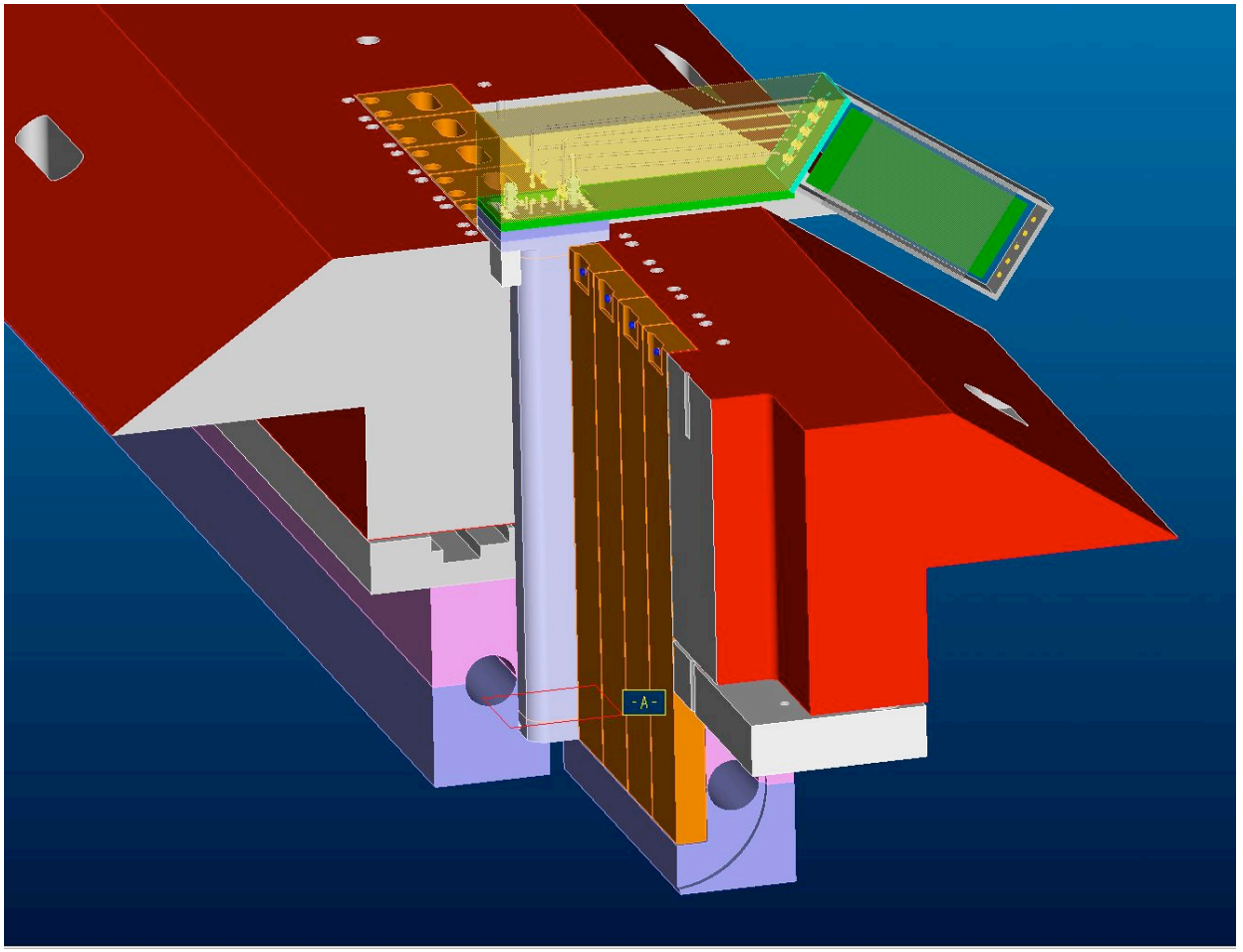
Proposed Installation

- Finalizing the installation plan
- Optimal for electronics performance
- Checking radiation dose levels

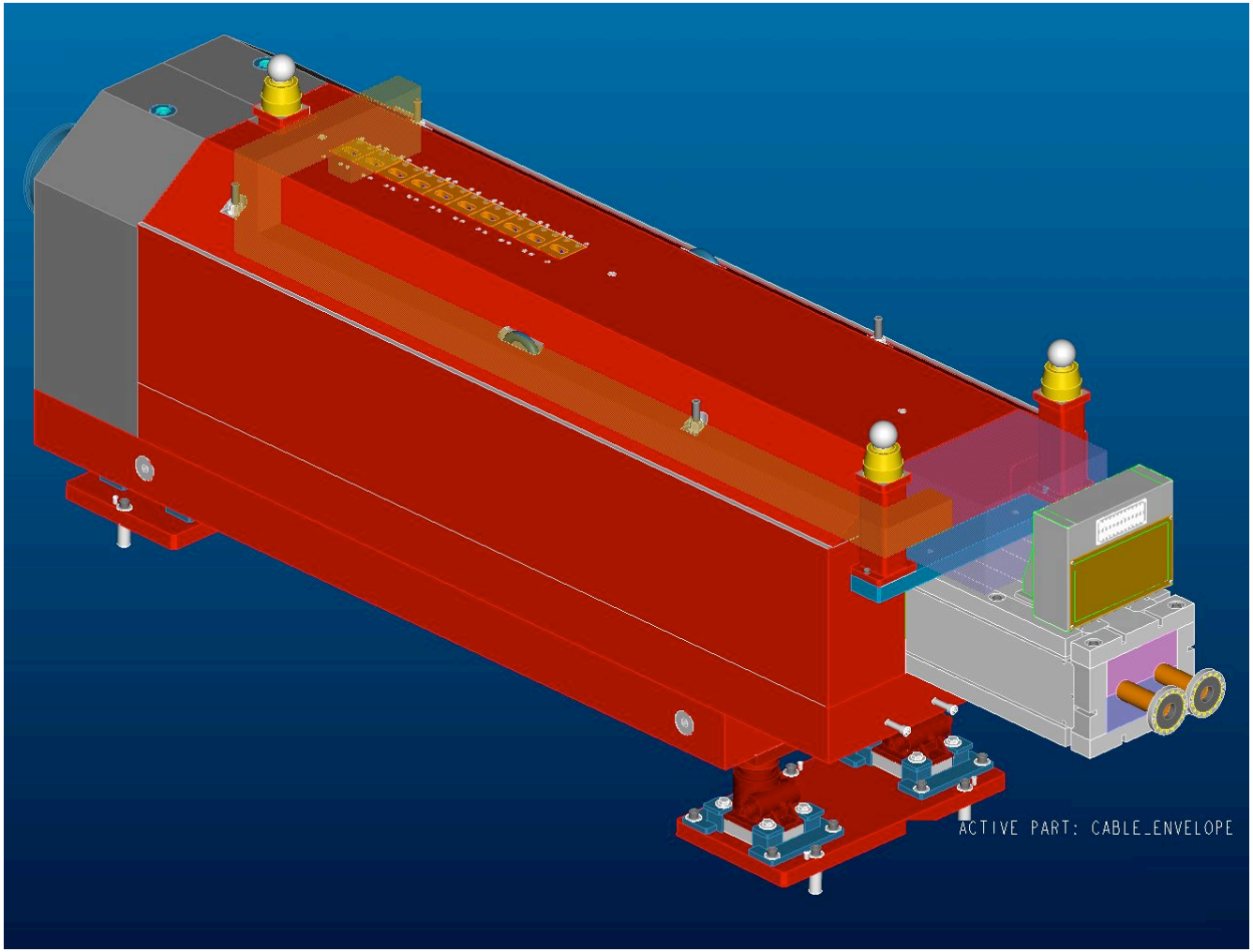


Proposed Installation (cont.)

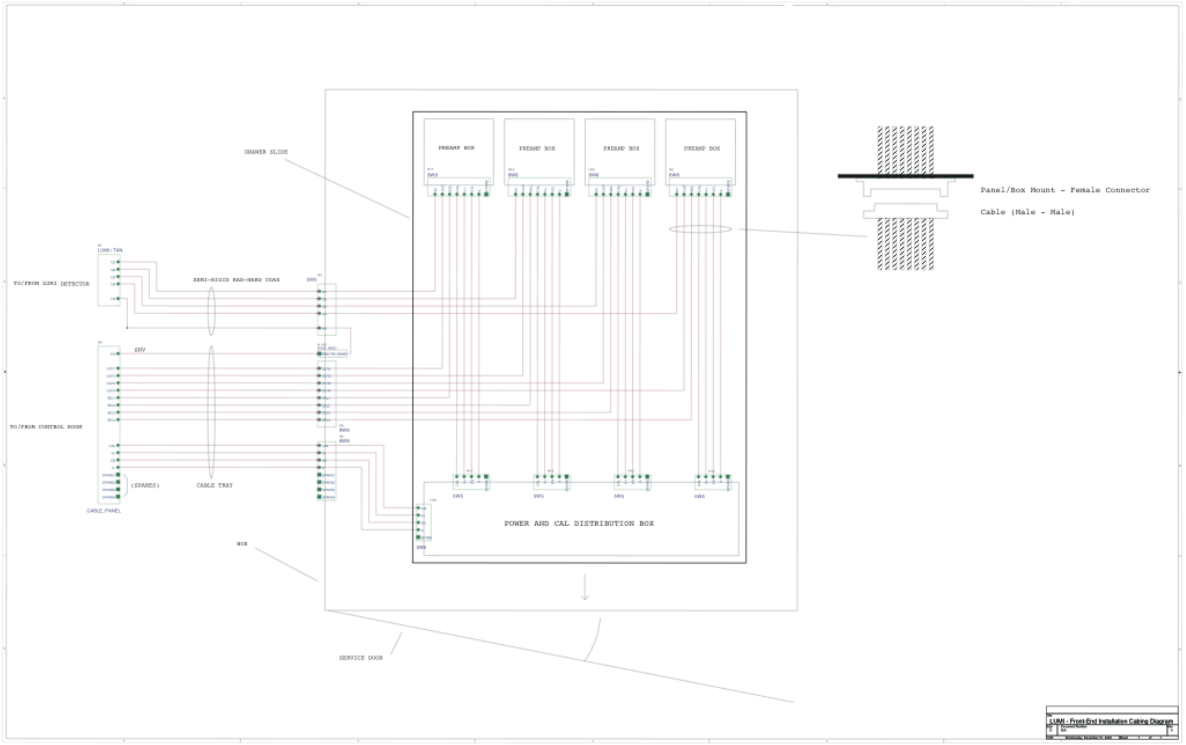




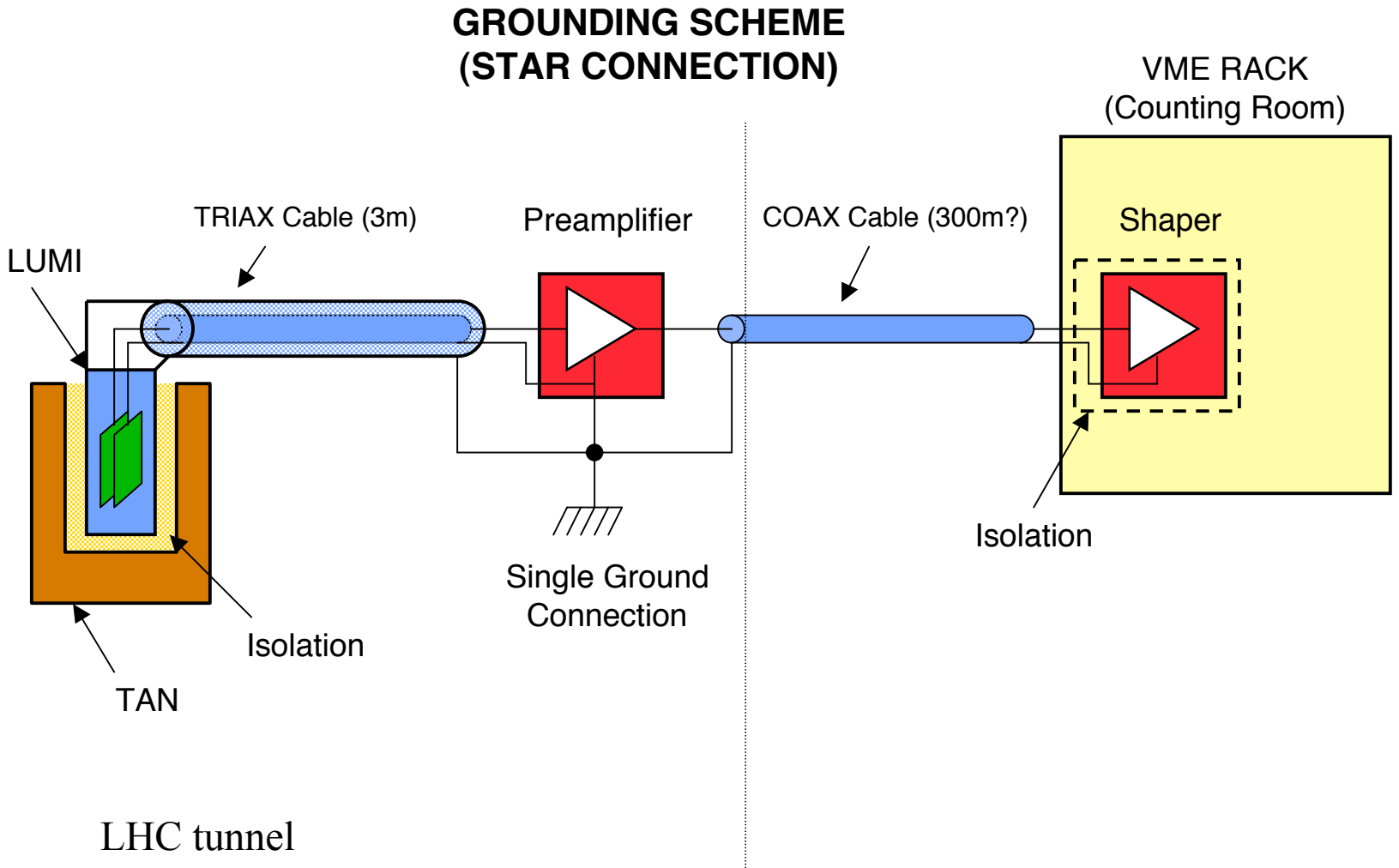
Alternate Installation



Cabling Diagram



System Grounding



Conclusions

- BRAN is on track to be completed on time for first LHC beam collisions
  - Collaboration between LARP and CERN
- Important R&D is being done in parallel with the final design
  - RHIC test will expedite LHC operation with beams
  - Rad hard test will help final choice of critical components
- TAN areas are likely to be very crowded
  - We want to plan ahead and ensure compatibility
  - We look forward to the test of the mockups
- We have integrated our schedule with that of the LHC