UT-BATTELLE

MERIT Hg System Final Design Review

Hg Target System Controls

V.B. Graves

P.T. Spampinato

T.A. Gabriel

MERIT Collaboration Meeting

MIT Plasma Science & Fusion Center

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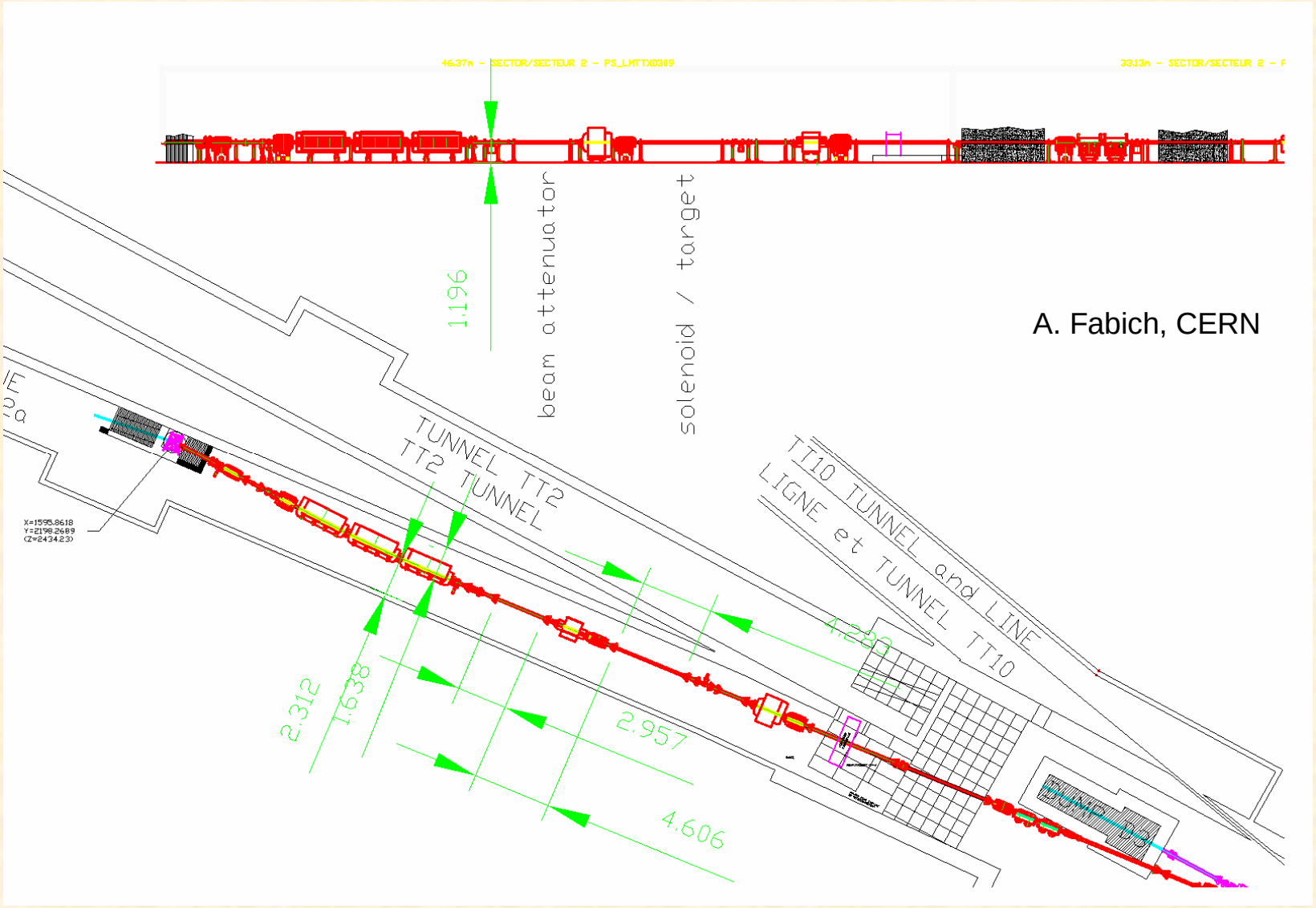
OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

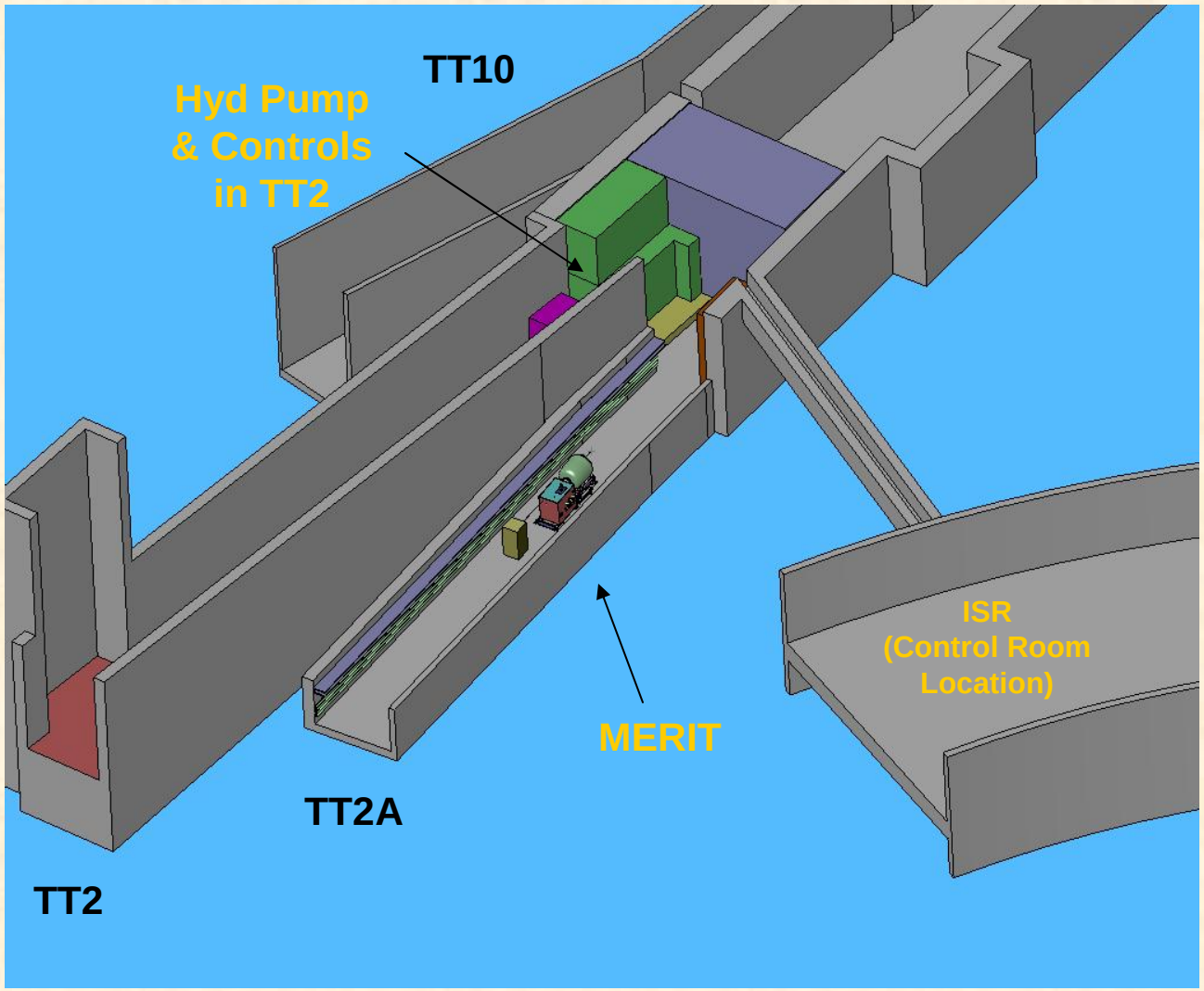
Outline

- **Operating environment**
- **Requirements / constraints**
- **Power requirements**
- **Instrumentation**
- **Control system scheme**
- **Issues**

CERN Tunnel Plan View



MERIT Layout



TT2A Photos

Photos from A. Fabich, CERN

Control System Requirements & Constraints

- **No existing power available in tunnel**
- **Control system mounted on hydraulic pump reservoir**
- **Operator controls 60m away**
- **Will require some level of communication with other control systems (solenoid, beam, diagnostics) and/or a supervisory control system**

Operating Scenario

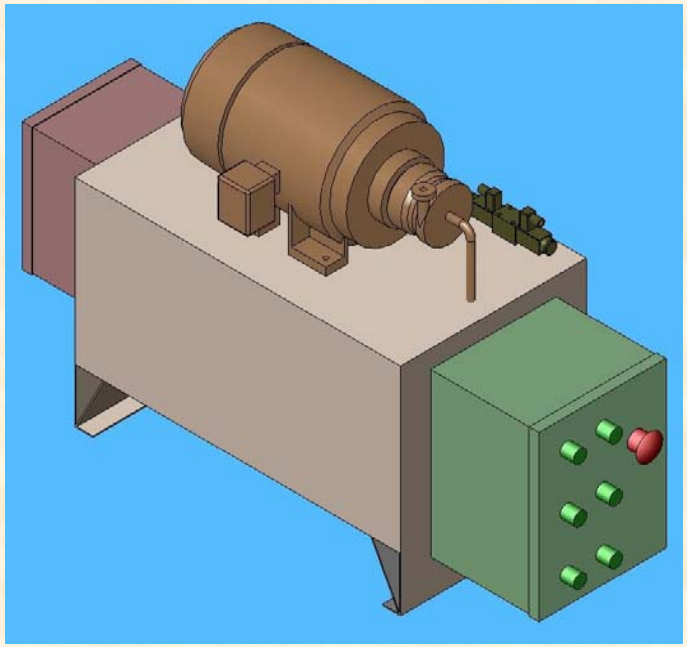
Time (sec.)	Solenoid **		Target Pump System	Proton Beam	Optical Diagnostic
	Cryogenics	Power Supply			
minus 30	Magnet full of LN_2 @ 80ºK	Standby	Fill Hg supply line	Call for beam	Off
minus 10	Purge LN_2 with gaseous He	Standby	Standby	Wait for beam	Standby
0 to 9.5	Magnet full of He gas	Start ramp to full current	Ramp Hg to full flow	Wait for beam	Standby
8 to 9.0	Magnet full of He gas	Ramping to full current	Steady state Hg jet	Wait for beam	Turn on laser lighting
9.5 to 10.5	Magnet full of He gas	At full current	Steady state Hg jet	24 GeV, 1 MW	Operate high speed camera
10.5 to 11.0	Magnet full of He gas	Begin de-energizing	Shut down syringe pump	Standby	Turn off laser light and camera
11.0 to 15.0	Magnet full of He gas	De-energize to zero	Standby	Standby	Off
15.0 to 1800.0*	Fill magnet with LN_2 @ 80ºK	Cool down to ~80°K	Refill syringe cylinder	Standby	Off

* Assumes a 30-minute dwell period.

** Solenoid power supply is in “Standby” for zero-field operation.

Power Requirements

- **Hydraulic pump – 380/460VAC, 50-60Hz, 60A**
- **Proportional control valve – 24VDC**
- **Heater foil – 120VAC**
- **Hg vapor monitor – 120VAC**
- **Instruments – 24VDC**



Minimum Signal Requirements

- **Trigger (time till pulse)**
- **Ready signal from Hg system**
- **Enable signal from supervisory control system**
  - **Also used as abort signal**

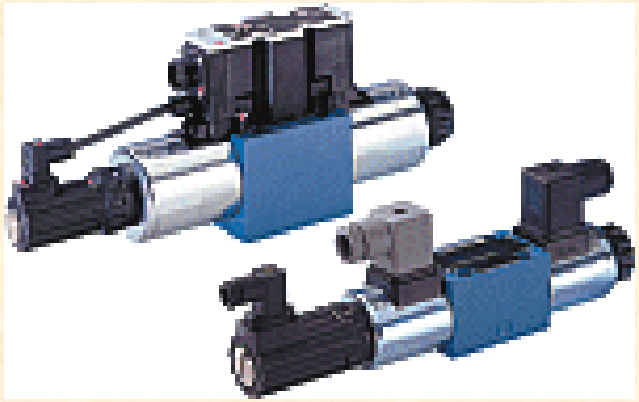
Instrumentation & Sensors

Controlled Components			
Hydraulic pump	Proportional control valve*	Heater foil	
Analog Sensor Inputs			
Hg discharge pressure	Hg level	Hg sump thermocouple	Secondary containment thermocouple
Cylinder 1 position*	Cylinder 2 position	Hg vapor 1	Hg vapor 2
Hydraulic fluid high pressure	Hydraulic fluid low pressure	Beam window 1 pressure*	Beam window 2 pressure*
Digital Sensor Inputs			
Hydraulic filter dirty switch	Hydraulic low level switch	Conductivity probe	

*** Critical for system operation or safety**

Proportional Directional Control Valve

- **Bosch Rexroth 4WREE**
  - **Operating pressure: up to 3000psi (210 bar)**
  - **Nominal flow: 8.45gpm (32 l/min)**
  - **Sensitivity: <= 0.05% (equates to 0.003 m/sec nozzle velocity)**
  - **Supply voltage: +24VDC**
  - **Command signal: ±10VDC**



Original Position Sensor

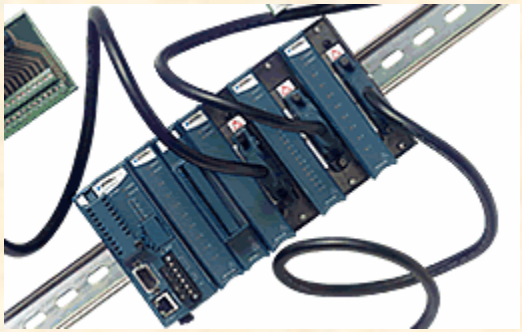
- **Temposonics G-series linear position sensor**
  - **Measured variable: displacement**
  - **Measuring range: 2-100in**
  - **Repeatability: 0.001% full stroke**
  - **Output: voltage or current**
  - **Update time: <1ms**
  - **Supply voltage: +24VDC**
- **Installed in hydraulic cylinder**
- **Problems: on-board electronics, operates using magnetic field**

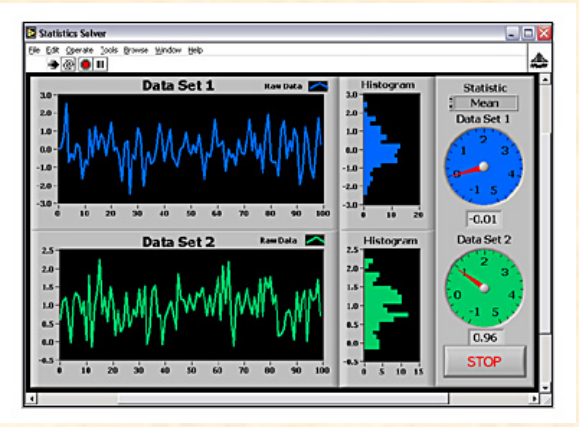
Current Position Sensor

- **Celesco CLWG linear potentiometer**
  - **Redundant sensor on cylinder #2**
  - **Aluminum body**
  - **Voltage divider output**
    - **Variable resistor, no on-board electronics**
    - **Repeatability < 0.01mm**
    - **Linearity 0.05%FS for 450mm range (0.225mm)**
- **Position sensor critical to system control**
  - **Piston start/stop locations**
  - **Piston position/velocity ⇨ Hg flow rate ⇨ Jet velocity**
  - **Electrical noise may be problem**

LabView-Based Control System

- **Remote control over long distance limited choices**
  - **Analog I/O modules need to be close to equipment and power supplies**
- **LabView controller on laptop computer was chosen**
  - **National Instruments recommends CompactPCI I/O modules**
  - **Communicates to laptop via EtherNet cable**
  - **Allows custom operator interface, data logging if required during development**
  - **Should allow straightforward integration with other control systems**
- **Control system development to begin late October**





Procurement

- **National Instruments hardware & software procured by Princeton**
  - **LabView software already procured**
- **Laptop computer provided by BNL**
- **Most instruments specified in Hg delivery system procurement package**

Conclusions

- **Control system scheme chosen**
- **System development to begin November 2005**
  - **Ready when syringe delivered**
- **Most instruments provided with Hg delivery system**
- **Integration with supervisory control system TBD**