Kicker Work Summer 2018

Chris Stoughton
For the Kicker Team

Kicking is how we
Get our muons in orbit
To precess in peace

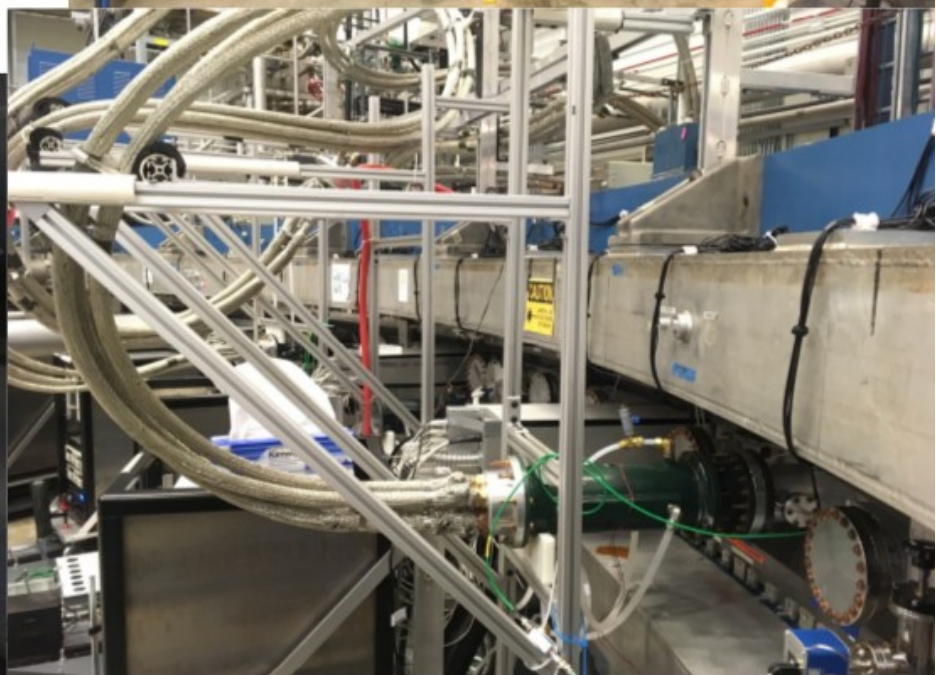
June 13 8:20 AM

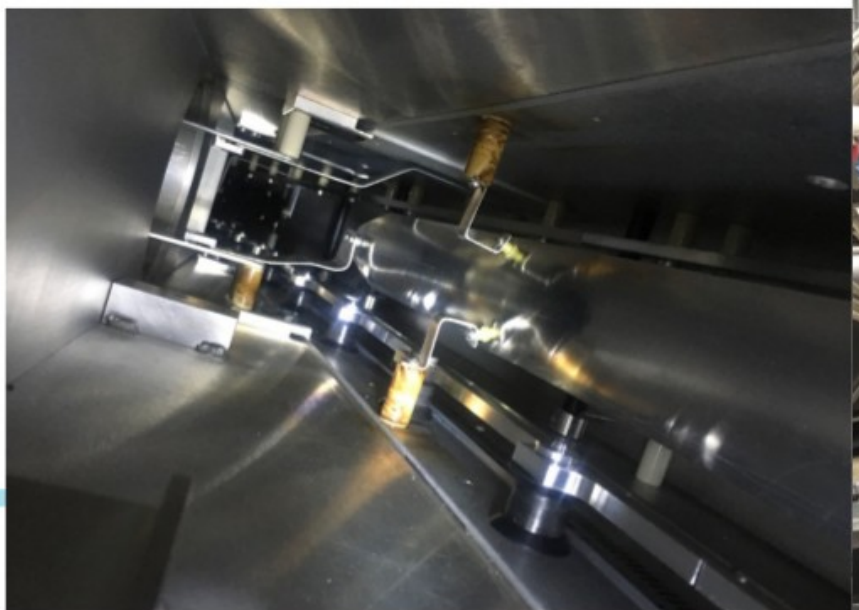
The Kicker Team

- Adam Schreckenberger (100%)
- Milorad Popovic (50%)
- Chris Stoughton (50%)
- Robyn Madrak (25%)
- Chris Polly (20%)
- Lee Roberts (15%)
- Antoine Chapelain (10%)
- “a new post-doc” (? %)
- Regis undergrad Intern for FPGA integration (3 weeks?)
- Howard Pfeffer (20%)
- Chris Jensen (20%)

How a kick is made?

- a *charging power supply* charges up
- *capacitor bank* to low voltage (700 V) that is discharged
- through a *transformer* into
- a *Blumlein*, which is a HV capacitor (55 kV), that is discharged through
- four *50 Ohms resistors*, which convert high voltage into high current into
- in-vacuum *plates*, where the current generates magnetic field that rotates momentum vector of muons





Terminology

- Power Supply, charging signal
- Capacitor Bank, transfer charge signal
- Transformer, secondary V monitor
- Thyratron, discharge signal
- Blumlein, castor oil
- Cables, 4-connector flanges
- Bazooka, fluorinert, resistors
- Vacuum Feed Through, bdot coil
- Leads to plates
- Plates

Work Breakdown Structure

1. Reliability

2. Performance

3. Test Stand

1.1 Vacuum Feed Throughs

1.1	**Vacuum Feed Thrus**
1.1.1	design vacuum feed through
1.1.2	**fabricate**
1.1.2.1	make parts vacuum feed through
1.1.2.2	assemble vacuum feed through
1.1.3	test vacuum through
1.1.4	install vacuum feed through

Design started by Erik V to address
- issues with vacuum seal inside insulator
- Assembly procedure
- Reliability

M&S Cost: $30k

1.2 Connectorize Cables

1.2	**Connectorize Cables**
1.2.1	**4-cable flanges**
1.2.1.1	design 4-cable flange
1.2.1.2	fabricate 4-cable flange
1.2.1.3	purchase large coax connectors
1.2.1.4	assemble 4-cable flanges
1.2.1.5	prepare cables

Mayling is ready to draft the solution

- HV coaxial cables fail
- The existing cables are glued in place
- Reduce down time to replace
- Cable already purchased

M&S Cost: $40k

1.3 In vacuum insulators

1.3	In vacuum insulators
1.3.1	fabricate in vacuum insulators
1.3.2	install in vacuum insulators

These support the plates
- Original design uses ceramic cylinders
- Replacement is “curvy” macor
- Design done; some replacements delivered

M&S Cost: none additional. This is covered under existing commitment to Cornell

1.4 Bazooka Upgrade

1.4	**Bazooka Upgrade**
1.4.1	**Bazooka Resistors**
1.4.1.1	specify bazooka resistors
1.4.1.2	purchase bazooka resistors
1.4.1.3	design bazooka housing
1.4.1.4	specify bazooka current transformer
1.4.1.5	purchase bazooka current transformer
1.4.1.6	fabricate bazooka housing
1.4.1.7	install bazooka
1.4.1.8	monitor bazooka current transformer
1.4.2	**Monitor Fluorinert Flow**
1.4.2.1	Install Fluorinert Flow Switch
1.4.2.2	Monitor Fluorinert Flow Switch

Resistors carbonize
- Original design uses “fragile” resistors
- AD uses more robust resistors
- Chance to lower inductance
- Install a reliable current monitor

M&S Cost: $40k

1.5 Blumlein Maintenance

1.5	**Blumleins Maintenance**
1.5.1	Disassemble and Clean
1.5.2	Test two new thyratrons
1.5.3	**Fabricate large and small Blumleininsulato**
1.5.3.1	Specify blumlein insulator rings
1.5.3.2	fabricate blimlein insulator rings
1.5.4	Blumlein Controller Heater Cable Fix
1.5.5	**Transformer Upgrade**
1.5.5.1	Inspect Transformer
1.5.5.2	specify voltage transformer
1.5.5.3	purchase voltage transformer
1.5.5.4	install voltage transformer
1.5.6	**Thyratron Heater Cables**
1.5.6.1	Specify thyratron heater cables
1.5.6.2	Install thyratron heater cables

HV Breakdown while charging
Readout of transformers does not make sense
Heater cables not rated for the power

M&S Cost: $10k

1.6 FPGA spark detector

1.6	FPGA spark detector
1.6.1	Change Firmware to veto charging signal
1.6.2	Spark Detector GUI integration
1.6.3	Integrate FPGA veto with charge signal

After a “big” spark, more sparking is likely
Similar to quench protection
We have a s/w work around
It is not reliable
The FPGA works; needs integration

M&S Cost: $0k

1.7 System Integration

1.7	**System Integration**
1.7.1	Raise alarms to shifters consistently
1.7.2	Interlock on oil,fluorinert sensors
1.7.3	**Digitize all charging and discharging signals**
1.7.3.1	specify charging and discharging signals
1.7.3.2	implement charging and discharging signal readout
1.7.3.3	DQM for charging and discharging signals

We are running by the seat of our pants
Many diagnostics would help data quality
Risk reduction

M&S Cost: $2k

1.8 Electronics Racks

1.8	▼ Electronics Racks
1.8.1	Repackage with fire protection
1.8.2	Fourth rack for power, monitoring, and LOTO circuit breakers

The racks as delivered were problematic
Some quick fixes applied
Difficult to maintain
LOTO simplified
Enhance fire detection

M&S Cost: $30k

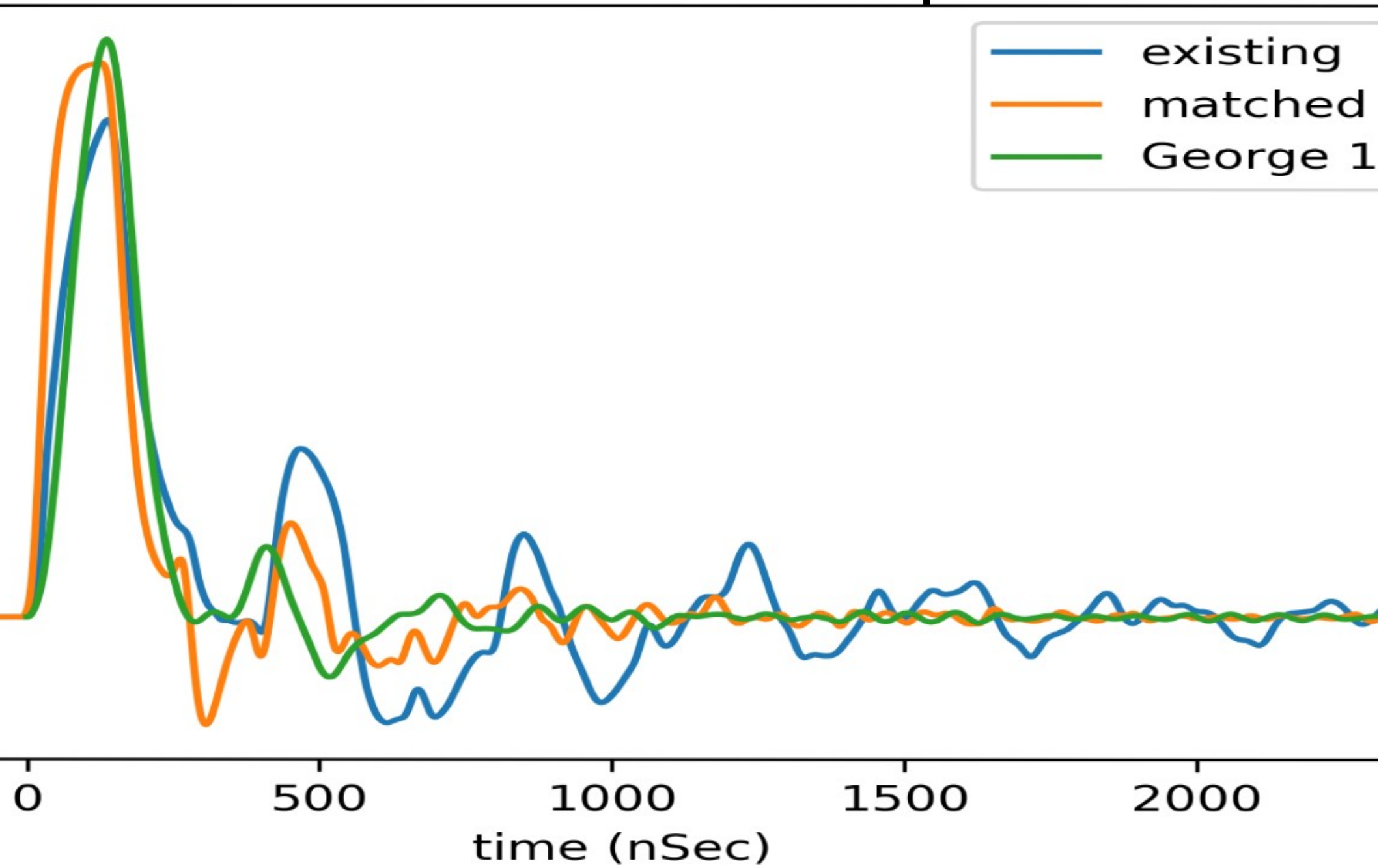
1.9 Charging Trigger Logic

1.9	▼ Charging Trigger Logic
1.9.1	Generate Triggers in computer room
1.9.2	Run charging trigger cables
1.9.3	Integrate and test charging trigger logic

Current implementation is noisy
– perhaps leading to blown fuses??
Control is awkward
Needs integration with spark detector

M&S Cost: $3k

Kicker Pulse Shapes



2.1 Increase Capacity of Charging Circuit

2.1	Increase Capacity of Charging Circuit
2.1.1	purchase HV supplies
2.1.2	integrate with charging signals

Existing system under rated
AD identified new supplies to purchase
Control signals similar to existing
Will be installed in “new” electronics racks
Upgrade resistors/diodes in cap banks.

M&S Cost: $2k additional
($33k already spent)

2.2 Reduce Inductance of Leads

2.2	Reduce Inductance of leads from feed through to plates
2.2.1	Prototype leads to plates
2.2.2	Fabricate leads to plates
2.2.3	Install leads to plates

Existing system has large loop
These are flat Al plates bent to shape
Insulate with Teflon/Kapton

M&S Cost: $10k

2.3 Lengthen Kicker Plates

2.3	Lengthen Kicker Plates
2.3.1	Design Kicker Plate Extension
2.3.2	Fabricate Kicker Plate Extension
2.3.3	Install Kicker Plate Extension

Kick = B ● L
Increasing L helps a lot!
The added inductance is not that bad.

(Note: more simulations needed to quantify)

M&S Cost: $10k

2.3 Test Stand

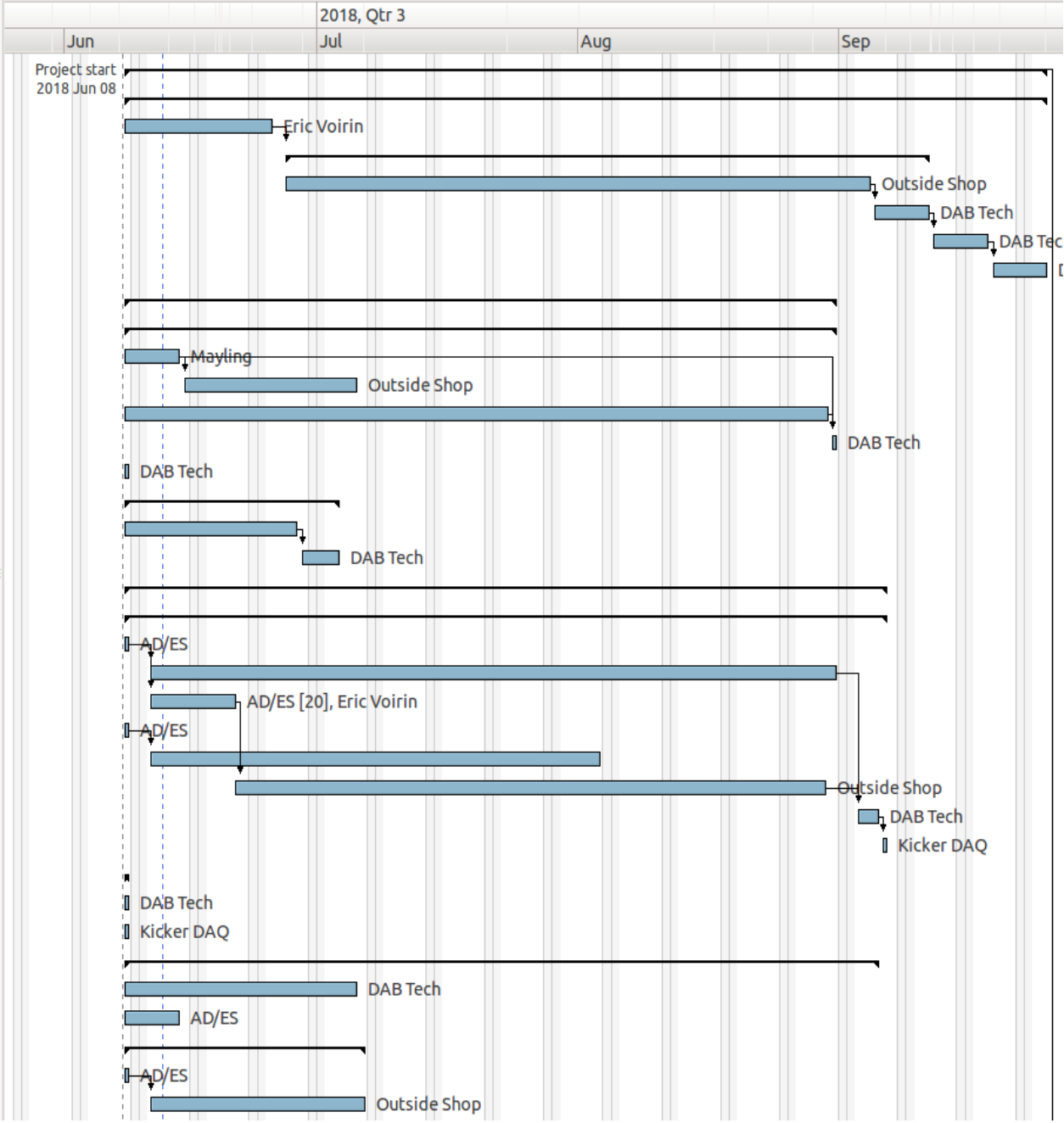
3	▼ Test Stand
3.1	▸ Capacitive Matching
3.2	▸ isolation/grounding

A lab where we can prototype

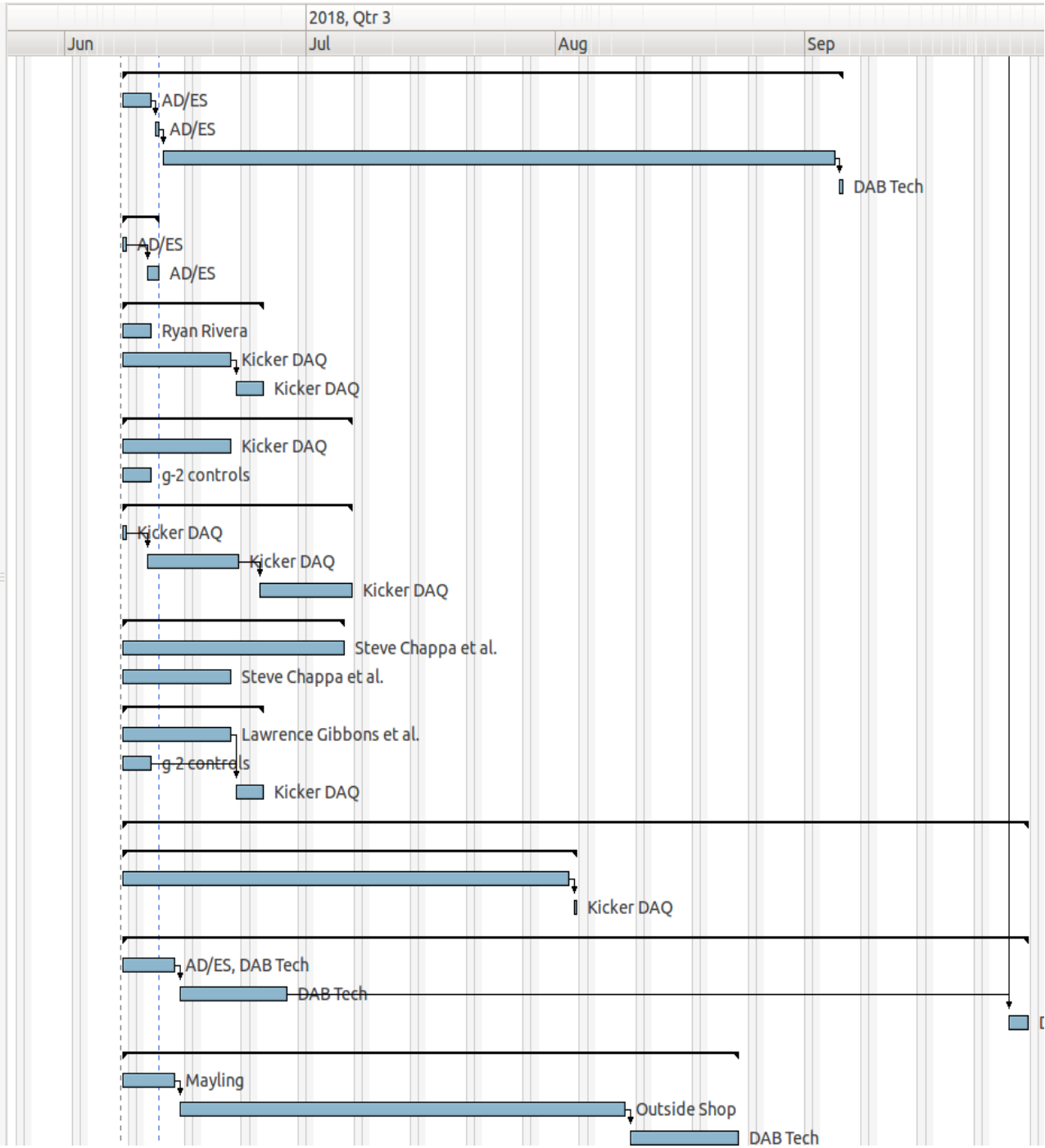
The correct solution:
– Add capacitors bridging the plates
– Terminate with 12.5 ohms at end
– prototype to confirm SPICE model
– capacitors in vacuum; non-magnetic

M&S Cost: $50k

WBS	Name	Work
1	**Reliability**	**549d**
1.1	**Vacuum Feed Thrus**	**77d**
1.1.1	design vacuum feed through	12d
1.1.2	**fabricate**	**55d**
1.1.2.1	make parts vacuum feed through	50d
1.1.2.2	assemble vacuum feed through	5d
1.1.3	test vacuum through	5d
1.1.4	install vacuum feed through	5d
1.2	**Connectorize Cables**	**82d**
1.2.1	**4-cable flanges**	**82d**
1.2.1.1	design 4-cable flange	5d
1.2.1.2	fabricate 4-cable flange	15d
1.2.1.3	purchase large coax connectors	60d
1.2.1.4	assemble 4-cable flanges	1d
1.2.1.5	prepare cables	1d
1.3	**In vacuum insulators**	**18d**
1.3.1	fabricate in vacuum insulators	15d
1.3.2	install in vacuum insulators	3d
1.4	**Bazooka Upgrade**	**168d**
1.4.1	**Bazooka Resistors**	**166d**
1.4.1.1	specify bazooka resistors	1d
1.4.1.2	purchase bazooka resistors	60d
1.4.1.3	design bazooka housing	10d
1.4.1.4	specify bazooka current transformer	1d
1.4.1.5	purchase bazooka current transformer	40d
1.4.1.6	fabricate bazooka housing	50d
1.4.1.7	install bazooka	3d
1.4.1.8	monitor bazooka current transformer	1d
1.4.2	**Monitor Fluorinert Flow**	**2d**
1.4.2.1	Install Fluorinert Flow Switch	1d
1.4.2.2	Monitor Fluorinert Flow Switch	1d
1.5	**Blumleins Maintenance**	**113d**
1.5.1	Disassemble and Clean	20d
1.5.2	Test two new thyratrons	5d
1.5.3	**Fabricate large and small Blumleininsulator rings**	**21d**
1.5.3.1	Specify blumlein insulator rings	1d
1.5.3.2	fabricate blimlein insulator rings	20d



WBS	Name	Work
1.5.4	**Transformer Upgrade**	**64d**
1.5.4.1	Inspect Transformer	2d
1.5.4.2	specify voltage transformer	1d
1.5.4.3	purchase voltage transformer	60d
1.5.4.4	install voltage transformer	1d
1.5.5	**Thyratron Heater Cables**	**3d**
1.5.5.1	Specify thyratron heater cables	1d
1.5.5.2	Install thyratron heater cables	2d
1.6	**FPGA spark detector**	**14d**
1.6.1	Change Firmware to veto charging signal	2d
1.6.2	Spark Detector GUI integration	10d
1.6.3	Integrate FPGA veto with charge signal	2d
1.7	**System Integration**	**33d**
1.7.1	Raise alarms to shifters consistently	10d
1.7.2	Interlock on oil,fluorinert sensors	2d
1.7.3	**Digitize all charging and discharging signals**	**21d**
1.7.3.1	specify charging and discharging signals	1d
1.7.3.2	implement charging and discharging signal readout	10d
1.7.3.3	DQM for charging and discharging signals	10d
1.8	**Electronics Racks**	**30d**
1.8.1	Repackage with fire protection	20d
1.8.2	Fourth rack for power, monitoring, and LOTO circuit breakers	10d
1.9	**Charging Trigger Logic**	**14d**
1.9.1	Generate Triggers in computer room	10d
1.9.2	Run charging trigger cables	2d
1.9.3	Integrate and test charging trigger logic	2d
2	**Performance**	**119d**
2.1	**Increase Capacity of Charging Circuit**	**41d**
2.1.1	purchase HV supplies	40d
2.1.2	integrate with charging signals	1d
2.2	**Reduce Inductance of leads from feed through to plates**	**23d**
2.2.1	Prototype leads to plates	10d
2.2.2	Fabricate leads to plates	10d
2.2.3	Install leads to plates	3d
2.3	**Lengthen Kicker Plates**	**55d**
2.3.1	Design Kicker Plate Extension	5d
2.3.2	Fabricate Kicker Plate Extension	40d
2.3.3	Install Kicker Plate Extension	10d



Kicker Resource Roll Up

Labor (FTE Days)

Engineering:

- Eric Voirin 38
- Steve Chappa 32
- Ryan Rivera 2
- Jensen/Pfeffer 42

g-2 Technical help:

- DAB Tech 132
- g-2 controls 4

g-2 scientists

- Kicker DAQ 36
- Lawrence Gibbons 10

M&S:

- FY18 $187k
- FY19 $50k