(g-2) FAST KICKER STATUS REPORT

Cornell kicker team

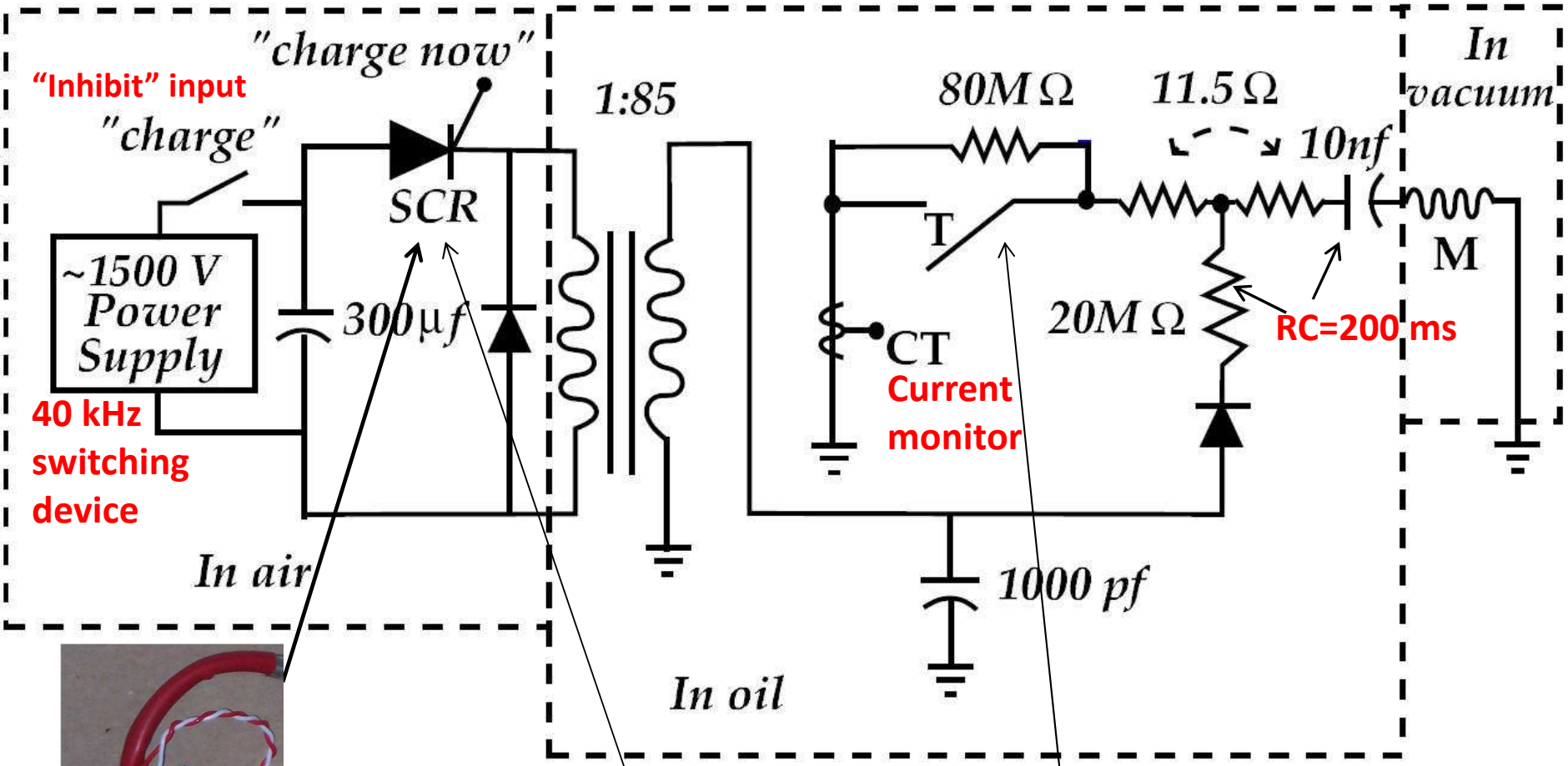
(G-2) COLLABORATION MEETING

By phone

July 12, 2012

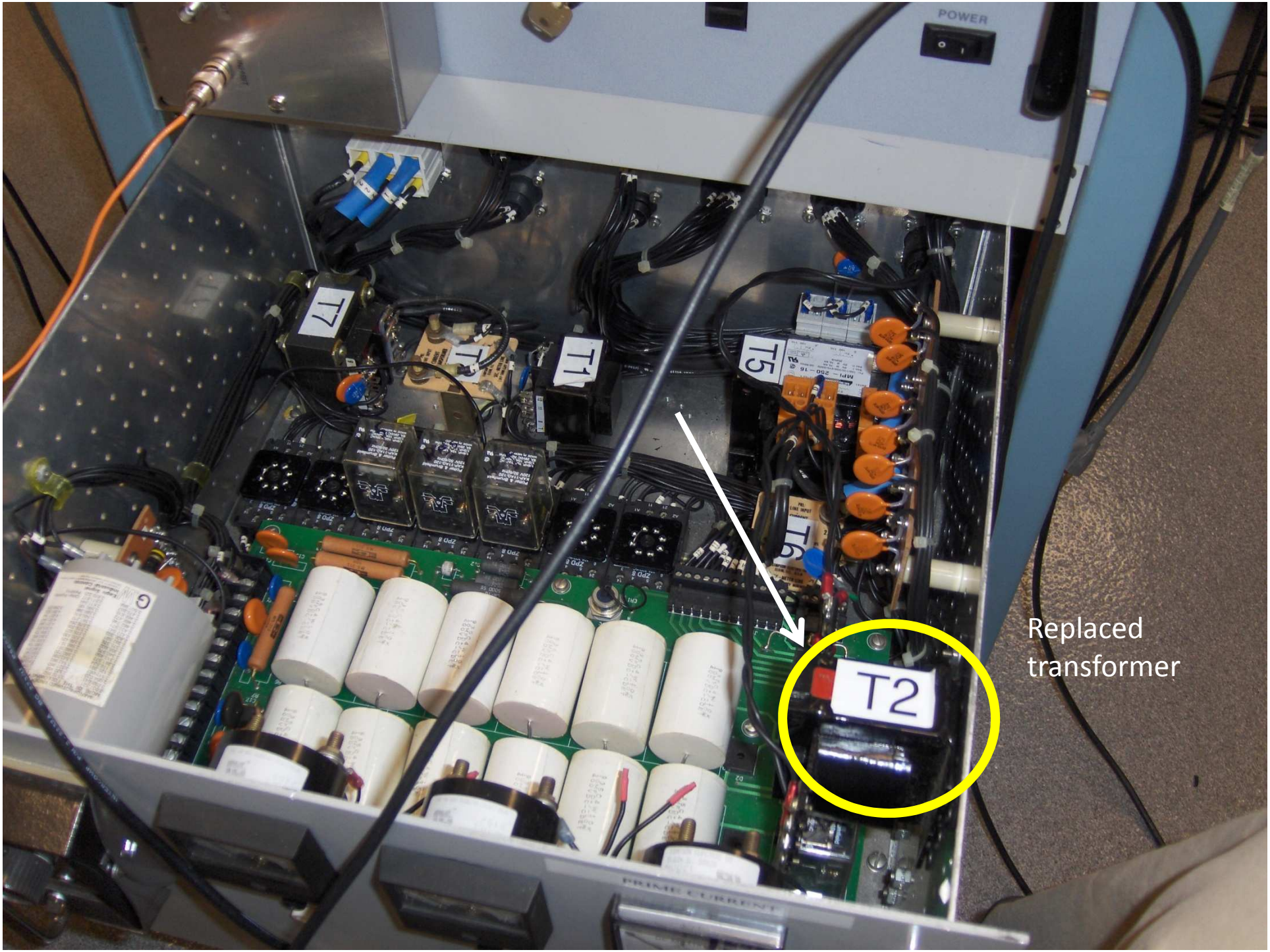
ELECTRIC SCHEME OF HV PULSER USED IN E821

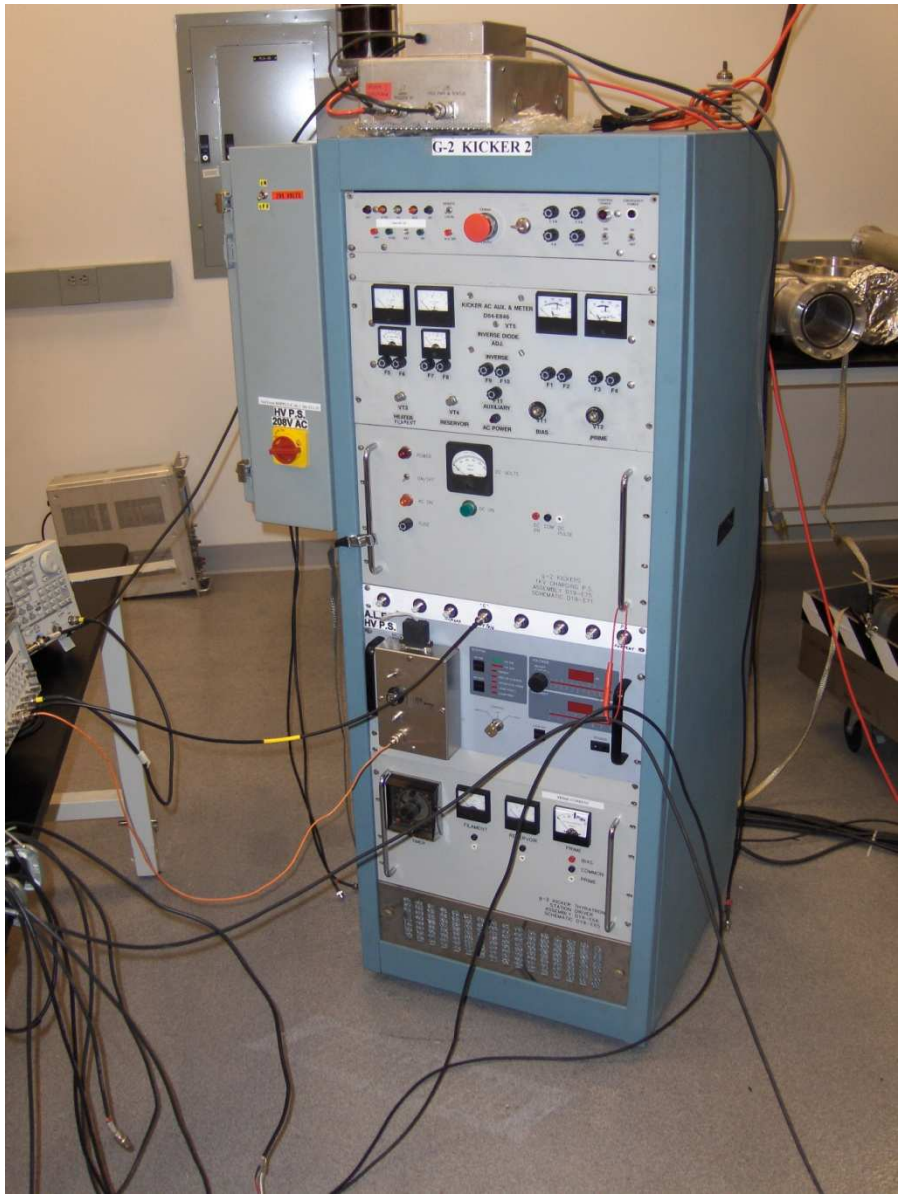
RLC discharge scheme



SCR — Silicon Controlled Rectifier -Thyristor

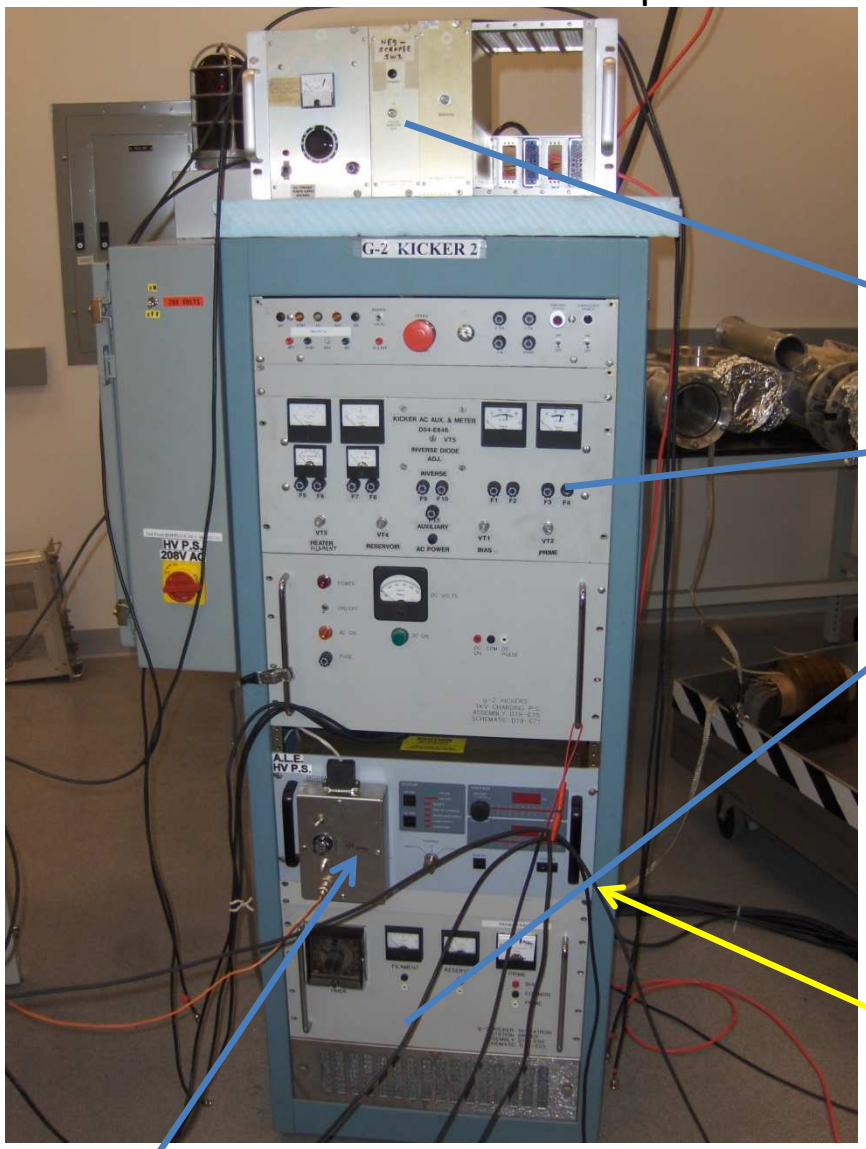
The time between "charge now" and the thyratron triggering was ~2 ms


POWER
T7
T1
T5
T6
T2
Replaced
transformer



Fully operational now

We recommend to purchase the thyratron feeding unit for the future



NORTH STAR
HIGH VOLTAGE

North Star High Voltage
12604 N New Reflection Dr
Marana, AZ, 85658
520 260 8687
206 219 4205 FAX
sales@highvoltageprobes.com
www.highvoltageprobes.com

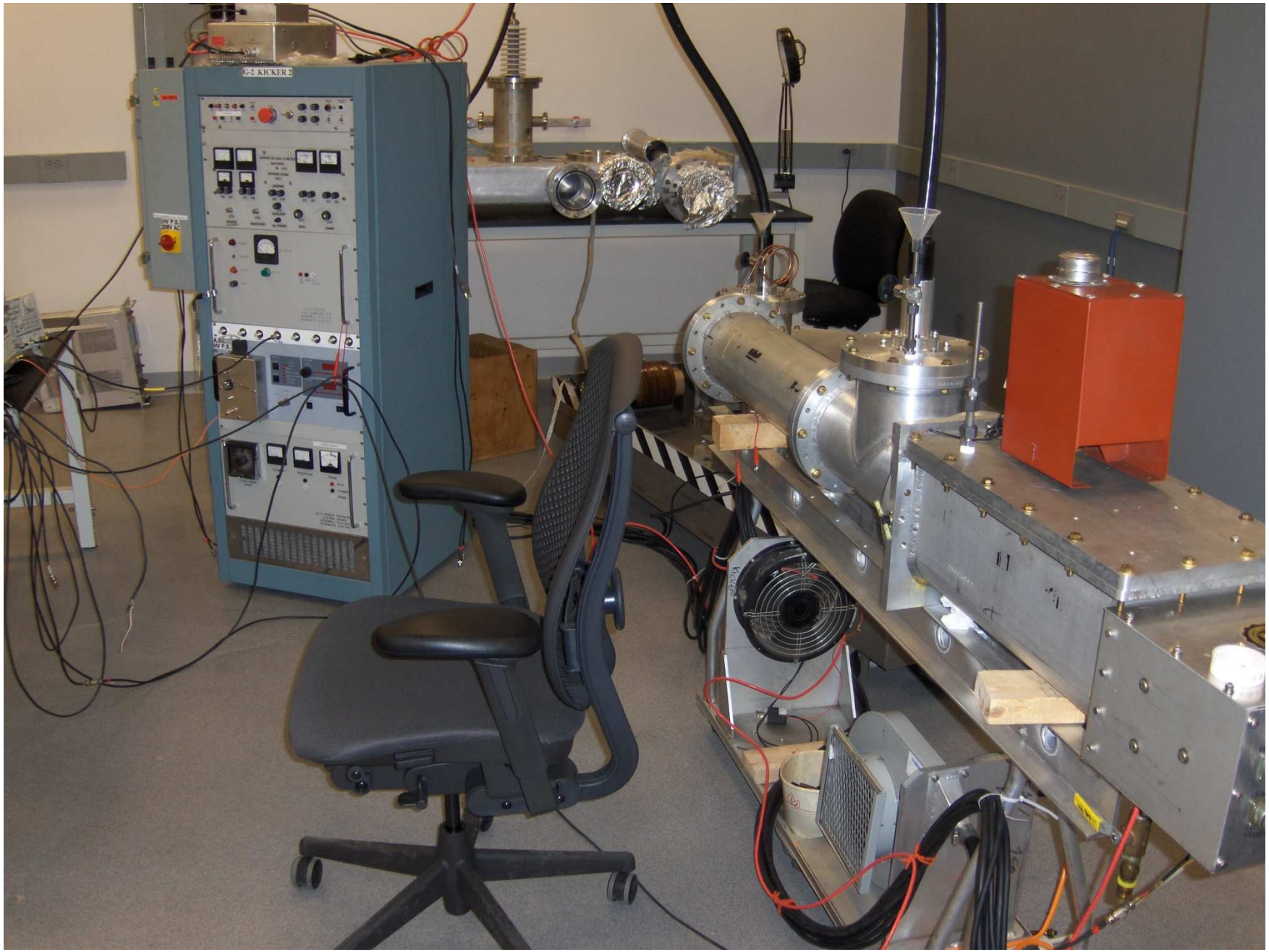
Thyratron Chassis with Driver, Heater and Reservoir Power

This block **replaces** the thyratron triggering pulser, the PS for the heater, reservoir, prime, bias.

The cost is $5500/one
$15000/set of three

For the reference: the cost of this HV PS is 12.5k$

New HV regulation block


G-2 KICKER

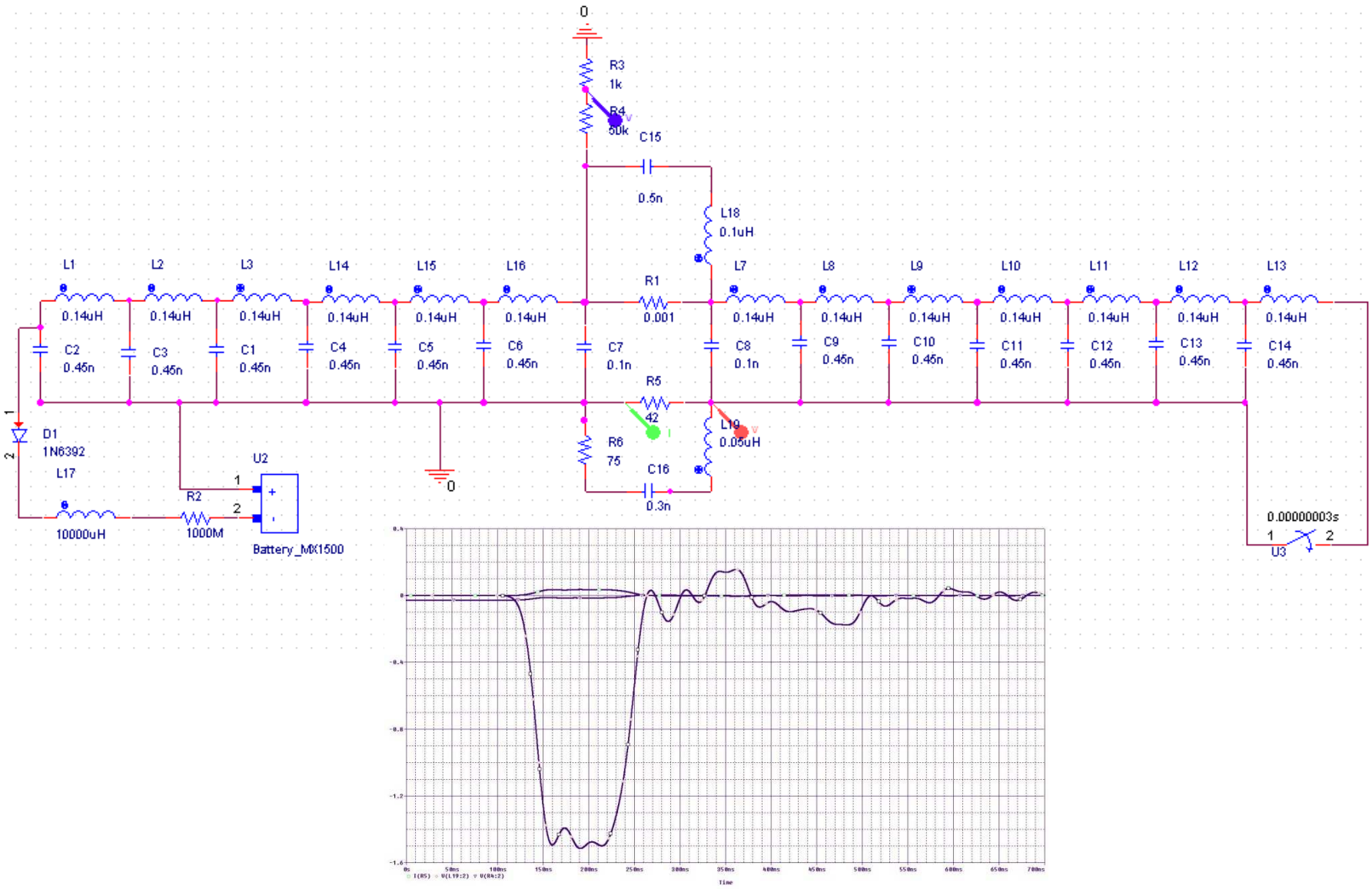
System operates currently at ~35kV, 1.5 uH dummy load

Preparations to fill with oil, although the tubes for BL are around…

Outer tubes for the Blumlein, each tube is ~ 1.5 m long (the pulse will be ~ 50 ns)

Detailed view to the flange

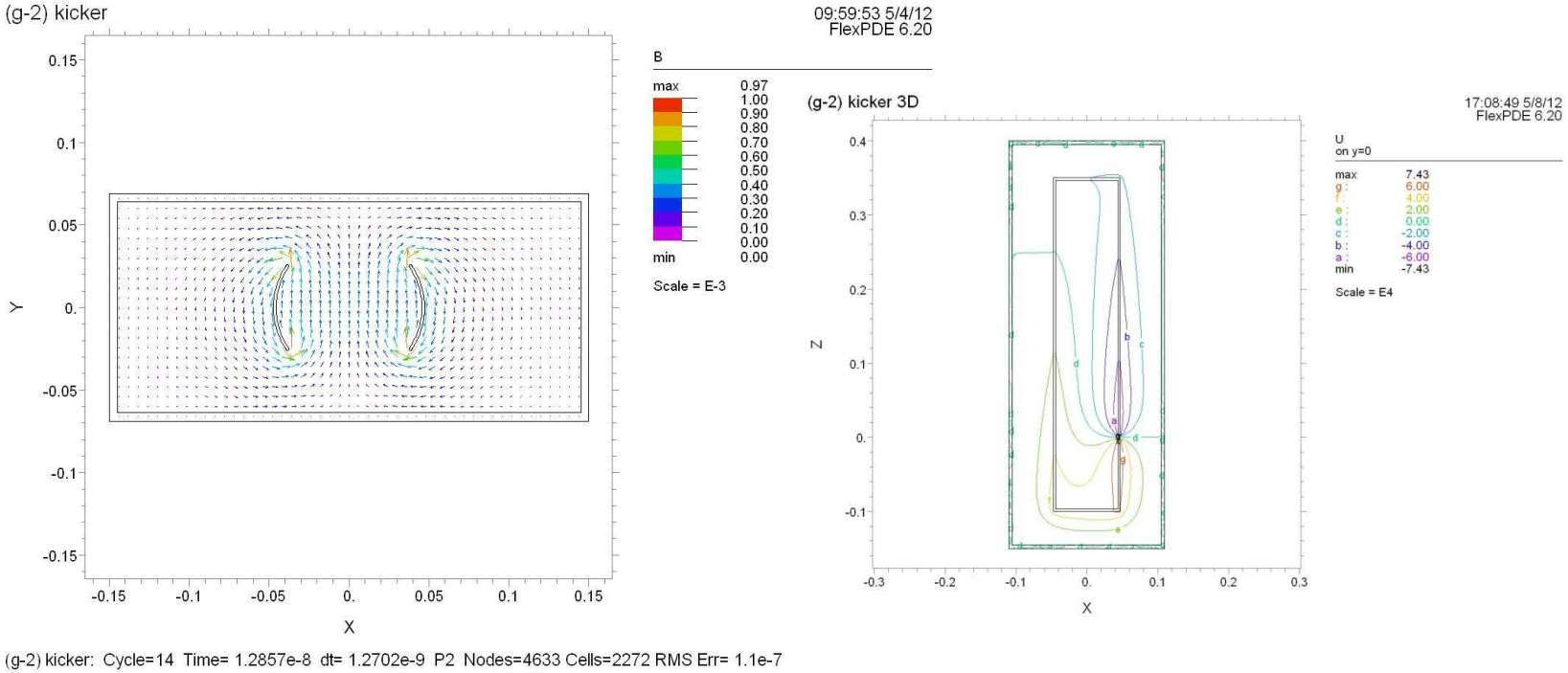
Modeling with PSPICE is in progress…



Next step will be modeling with Microwave studio, FlexPDE and HFSS

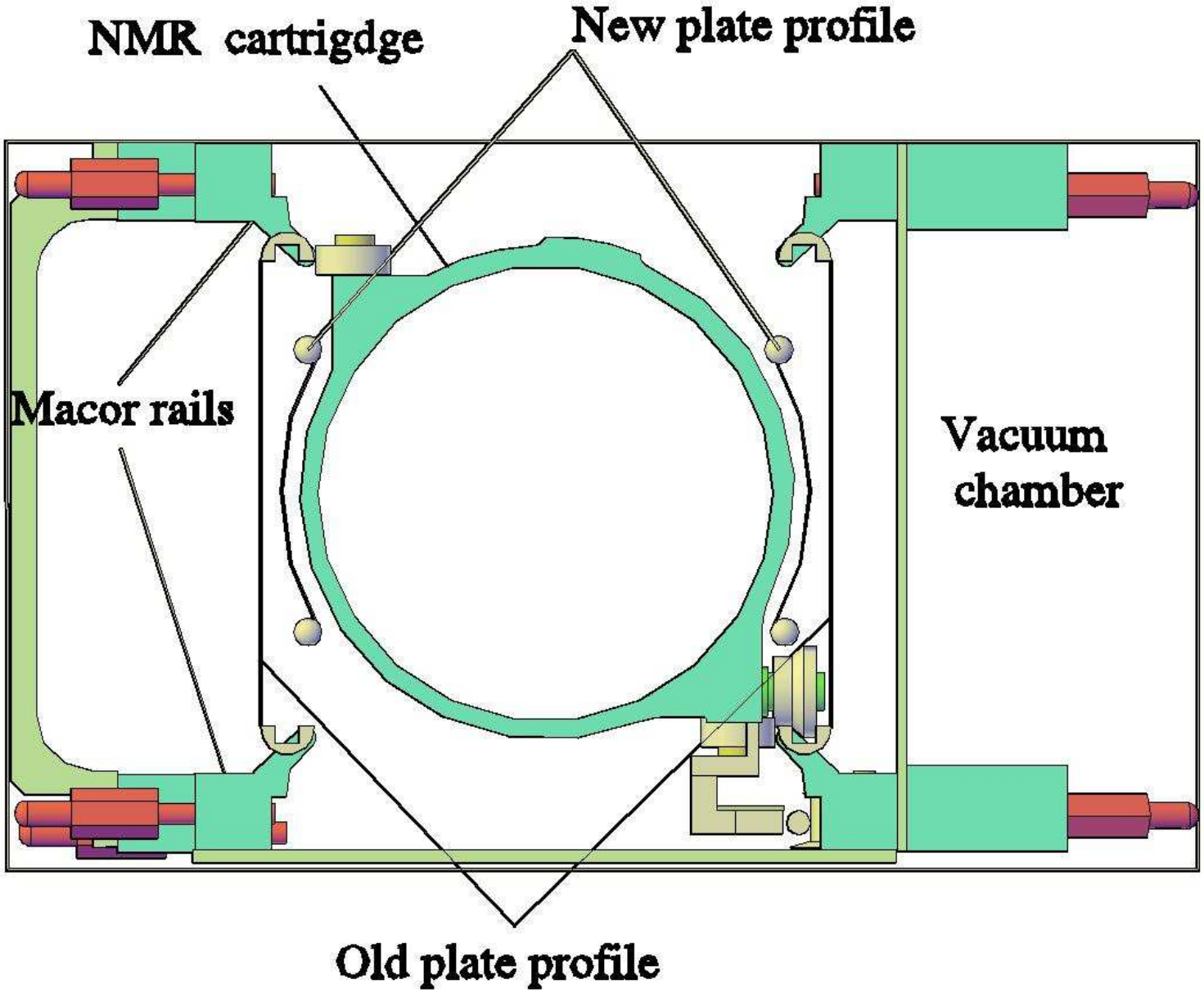
3D field calculation is in progress with FlexPDE

Plans to do this with HFSS and CTS studio (License granted)



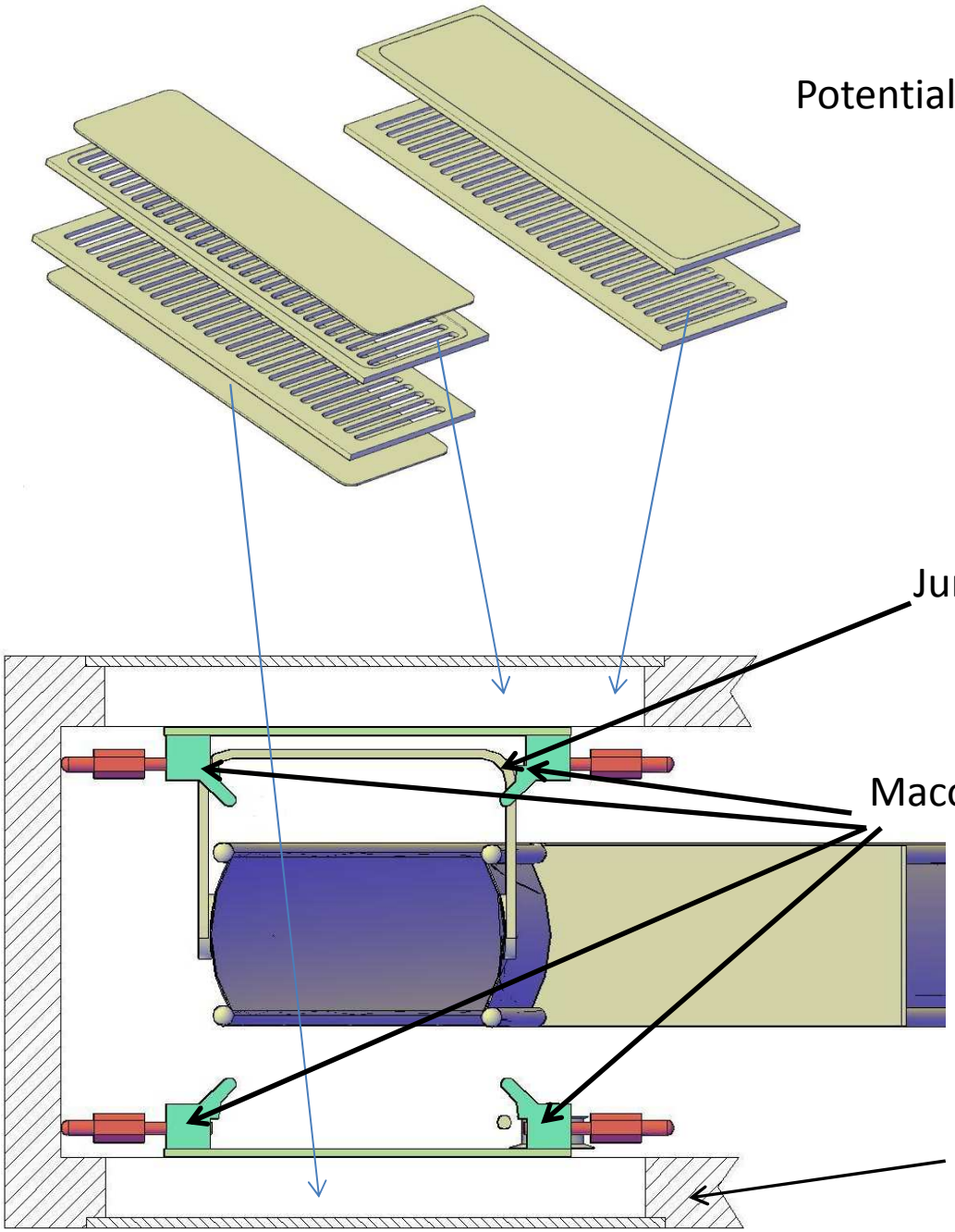
Field distribution in a transverse plane

Potential distribution.
Longitudinal cut, top view


NMR cartrigdge
New plate profile
Macor rails
Vacuum chamber
Old plate profile

Potential for another 20% increase of kick

This technology fights against the eddy currents as well !



CONCLUSIONS

At Cornell site right now:

E-821 scheme restored works currently at 35; ready to be filled by oil

Numerical modeling of the time dependent fields in progress;

Arranging fast field measurements system-plans;

Detailed 3D drawings of the Blumline pulser under development.

We recommend to purchase a power supply/triggering unit for future applications ($5500 per just single unit; $15000 for three of them).

Spare slides

The current on the kicker plates represented in [1] in the form of

$$I(t) = I_0 e^{-\frac{\gamma}{2}t} Sin(2\pi f_d t + \varphi_d), \qquad (1)$$

where $f_d = \frac{1}{2\pi}\left(\frac{1}{LC}\right)^{1/2}\left\{1 - \frac{R^2 C}{4L}\right\}^{1/2} = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$

$\gamma = \frac{R}{L}$, $\quad I_0 = \frac{V_0}{2\pi f_d L}$.

The shape of current could be obtained also by solving the differential equation associated with the scheme from Fig.1 as the following

$$\ddot{I}(t) + \frac{1}{LC} I(t) + \frac{R}{L}\dot{I}(t) = 0 \qquad (2)$$

which reflects the Kirchhoff law for the LCR circuit applied to the voltages.

Appropriate initial conditions set are $I(0)=0$, $\dot{I}(0)= \dot{I}_0$

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[1] The New (g-2) Experiment: A proposal to Measure the Muon Anomalous Magnetic Moment to ±0.14 ppm Precision, Submitted to DOE Office of High Energy Physics, April 5, 2010, New (g-2) Collaboration.

E.Efstihadis, *et.al.*,"A Fast Non-Ferric Kicker for the Muon (g-2) experiment", NIM, Elsevier Sci., 15 July, 2002.

The shape of current from (1) and (2) can be obtained from Mathematica©

```
V0 = 50000.
L = 1.6 10^-6
Cp = 10^-8
R = 11.5
γ = R / L
I0 = V0 / 2 / π / fd / L
fd = 1. / 2. / π * (1 / (L Cp))^1/2 * (1. - R^2 Cp / (4 L))^1/2
sol = NDSolve[{y''[t] + 1. / L / Cp * y[t] + R / L * y'[t] == 0., y'[0] == 3. 10^10, y[0] == 0.}, y, {t, 0., 1 10^-6}]
Plot[Evaluate[y[t] /. sol], {t, 0., 1 10^-6}, Frame → True, PlotRange → All, GridLines → Automatic]
Plot[Evaluate[I0 * e^(-γ/2.*t) * Sin[2 π fd t], {t, 0, 1 10^-6}], Frame → True, PlotRange → All, GridLines → Automatic]
Plot[Evaluate[y'[t] * L /. sol], {t, 0., 1 10^-6}, Frame → True, PlotRange → All, GridLines → Automatic]
ParametricPlot[Evaluate[{y[t] * R, L * y'[t]} /. sol], {t, 0., 1 10^-6}, Frame → True, PlotRange → All,
 GridLines → Automatic]
```

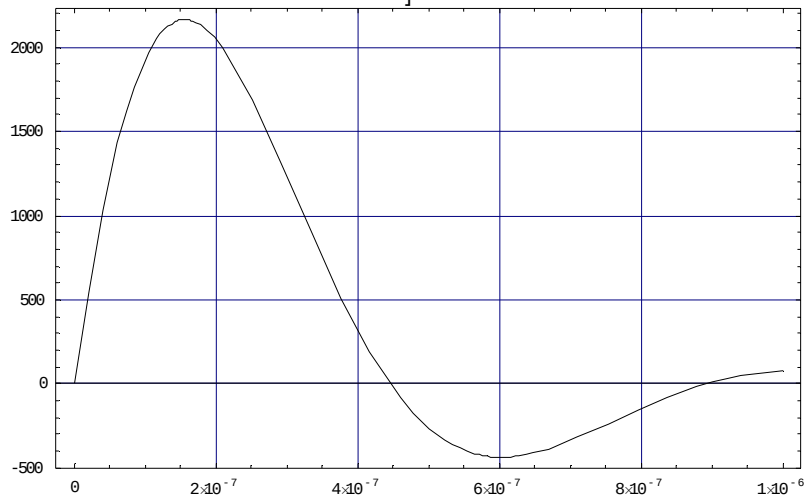


Figure 2. The pulse shape obtained from (2).

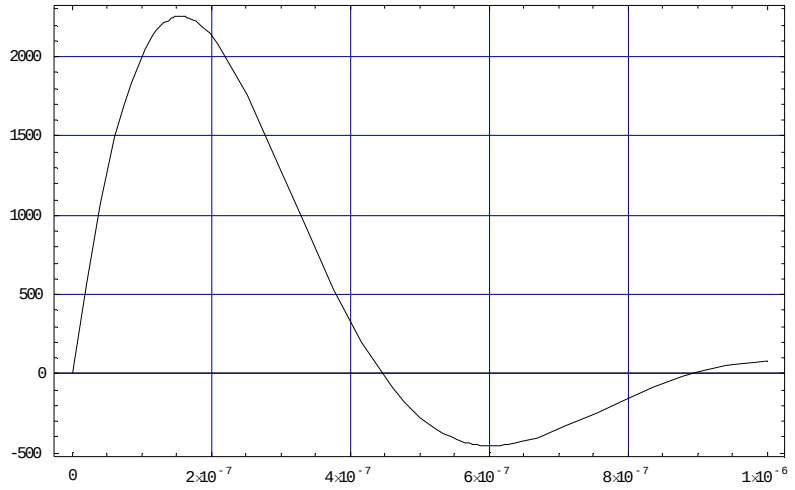
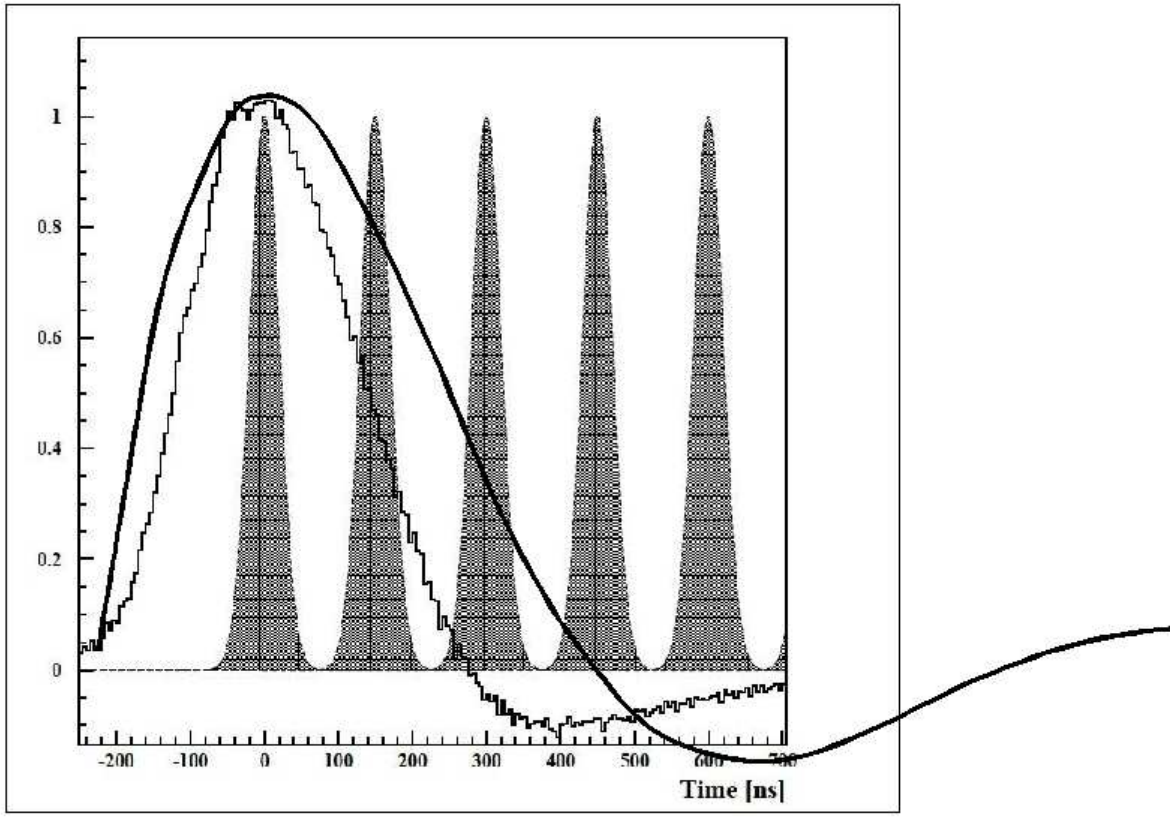


Figure 3. The pulse shape obtained from (1).

One can see that the pulses obtained by two different ways (from equation (1) and from equation (2)) are identical.

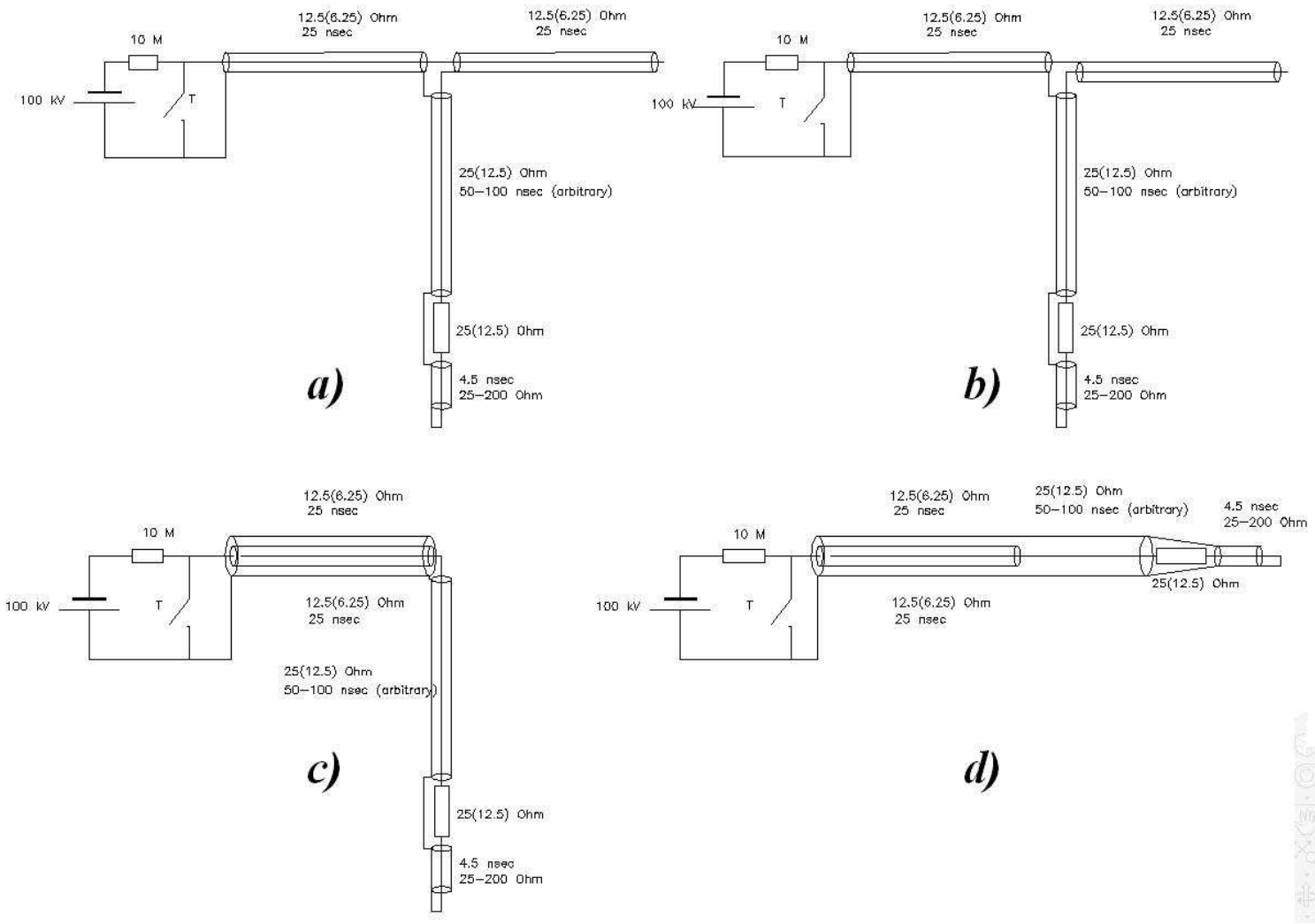
Meanwhile the current shape from previous figures, if embedded in Fig. 51 from [1] (and all other publications), become as the following



The Fig.51 from [1] with superimposed pulse shape obtained from Mathematica©.

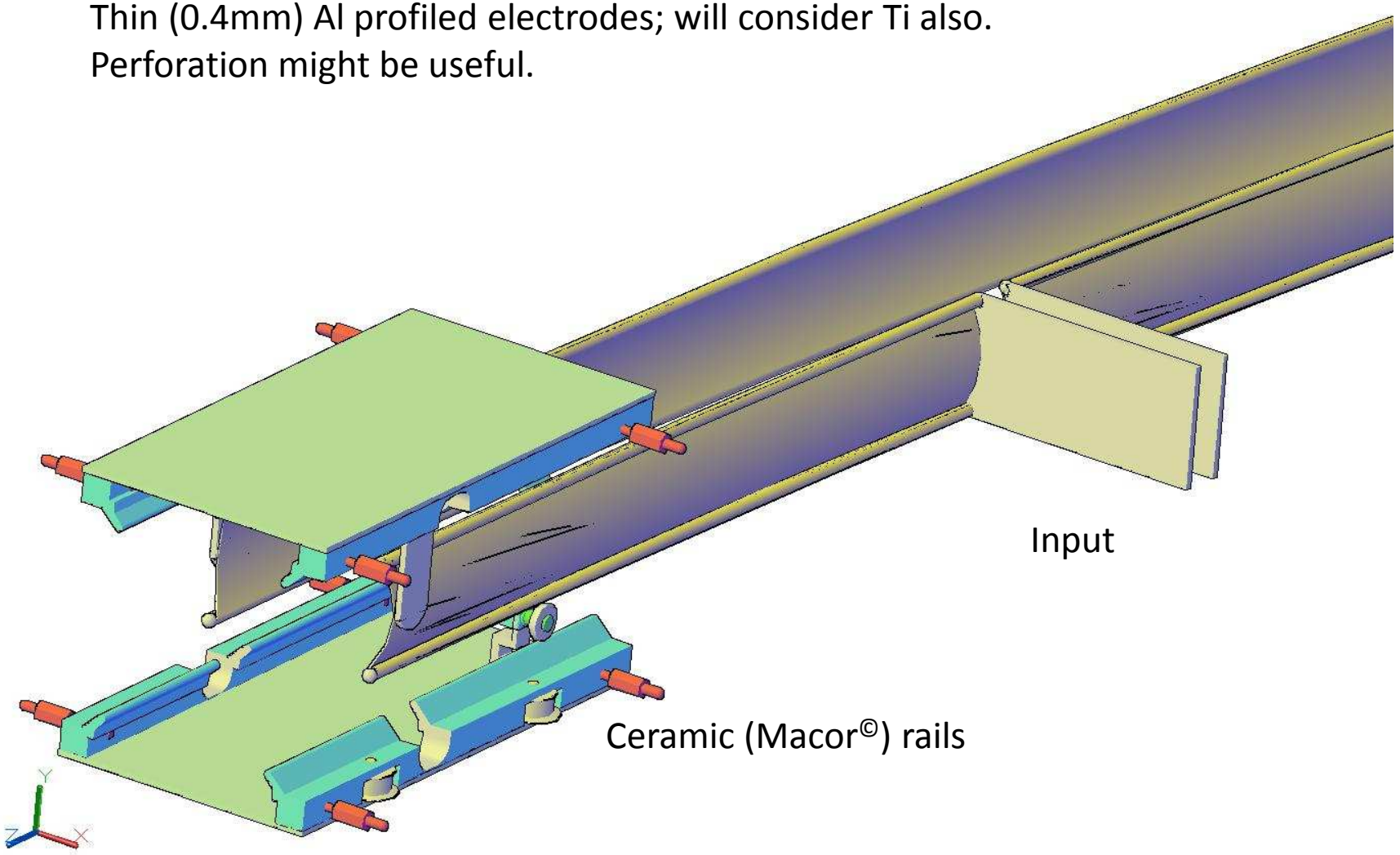
The source of this discrepancy is under investigation.

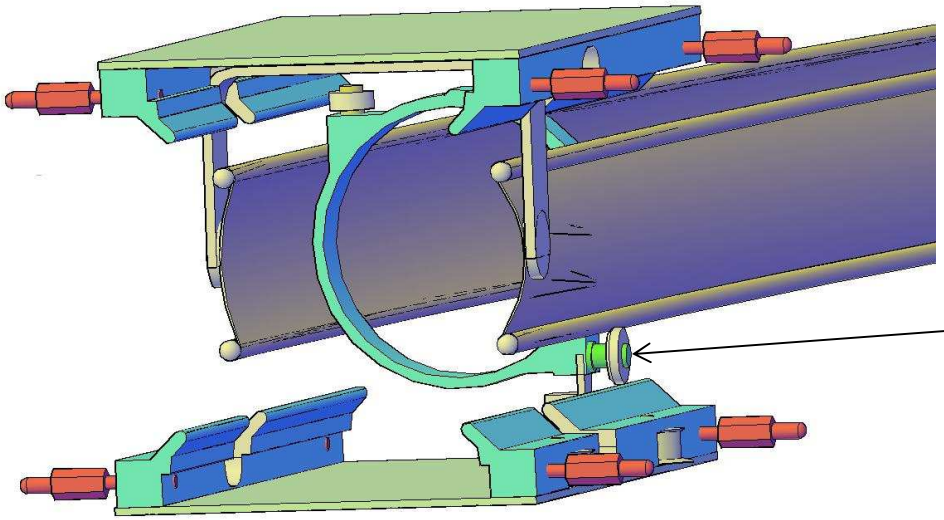
For modeling with PSPICE (Cadence)



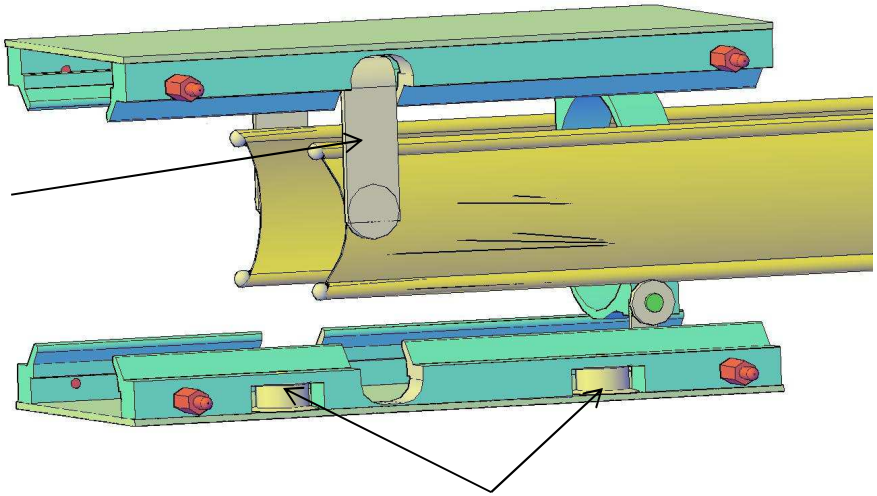
a) Original Blumlein scheme;
b) In a second coaxial the conductors are switched, so the potential of inner left coaxial is the same as the potential of outer right coaxial;
c) Right coaxial inserted into the left one. For this purposes its radiuses increased accordingly.
d) Final scheme.

Thin (0.4mm) Al profiled electrodes; will consider Ti also.
Perforation might be useful.



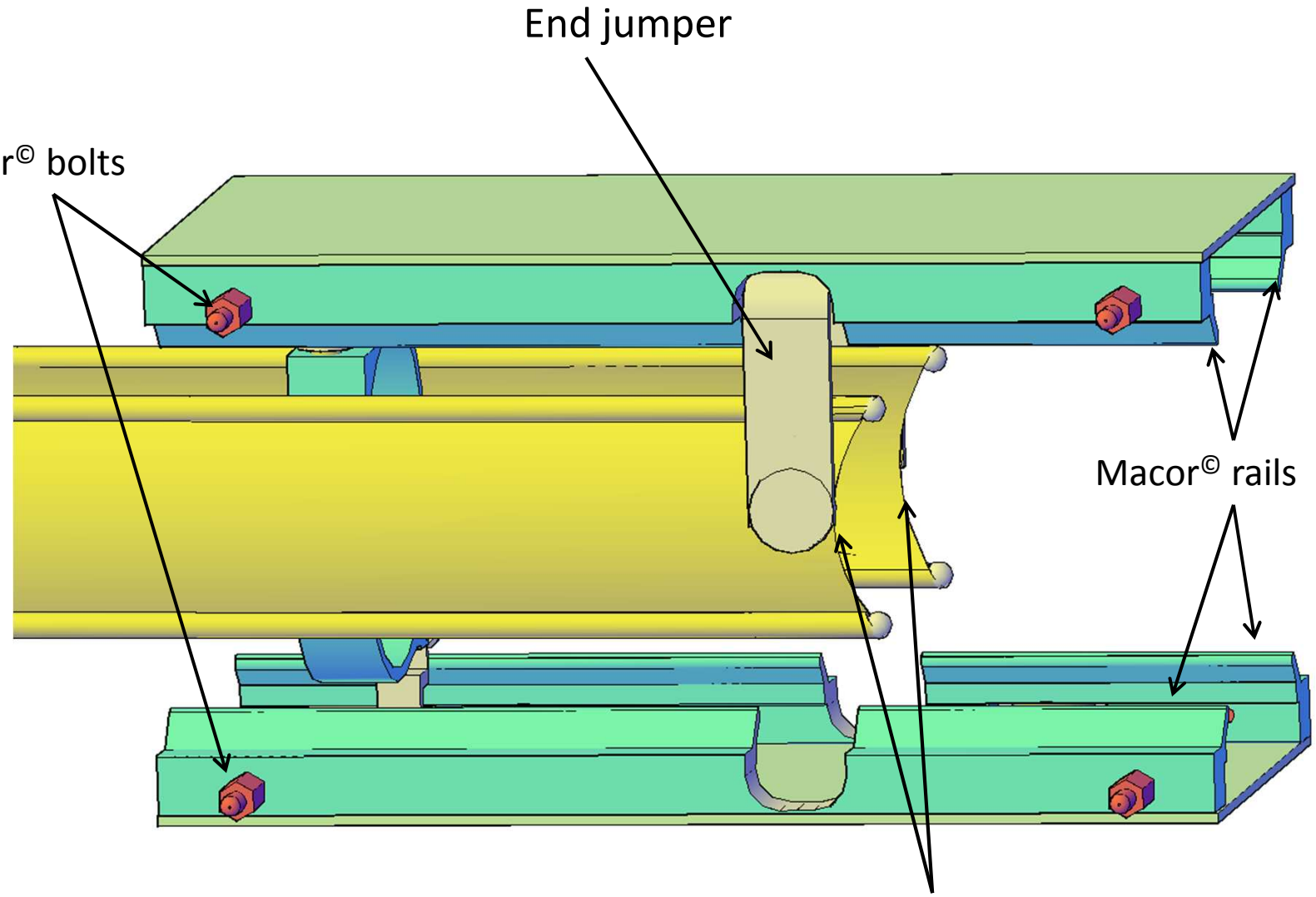


The NMR cartridge profile



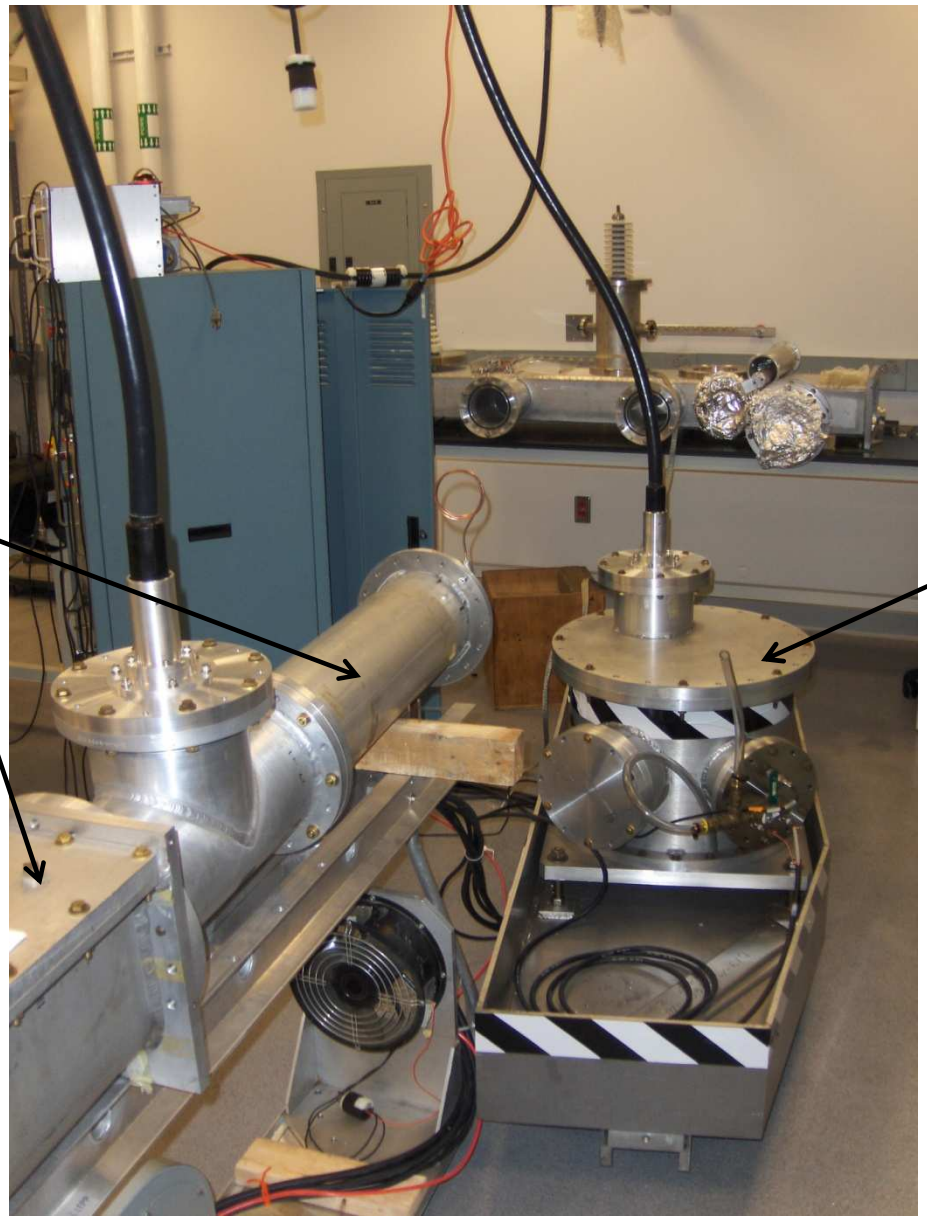
End jumper

NMR cable duct wheels

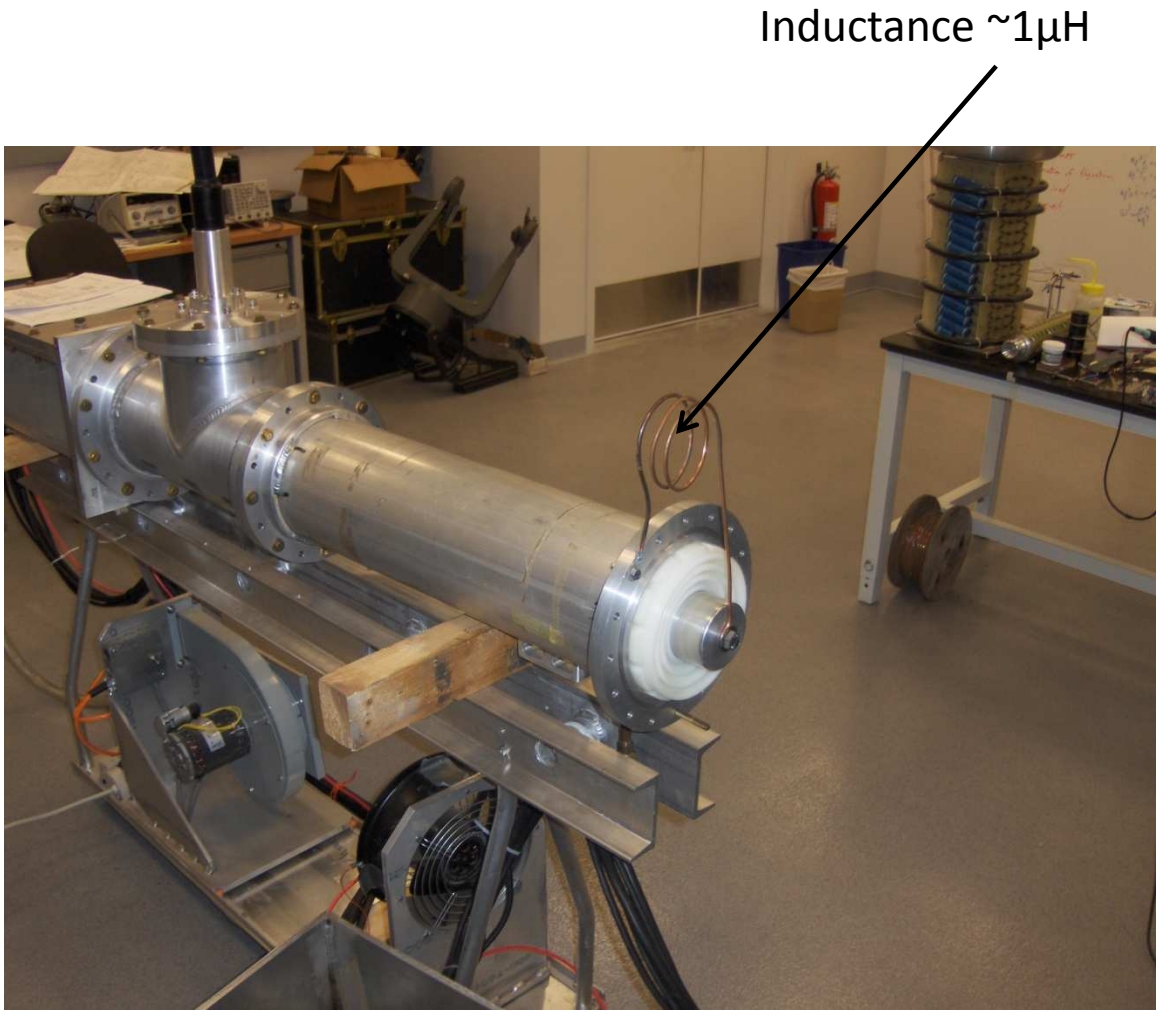


Electrodes at the end will have the chamfer (similar to the magnetic pole chamfer) for better 3D field distribution. (The same could be recommended for the electrostatic Quadrupole)

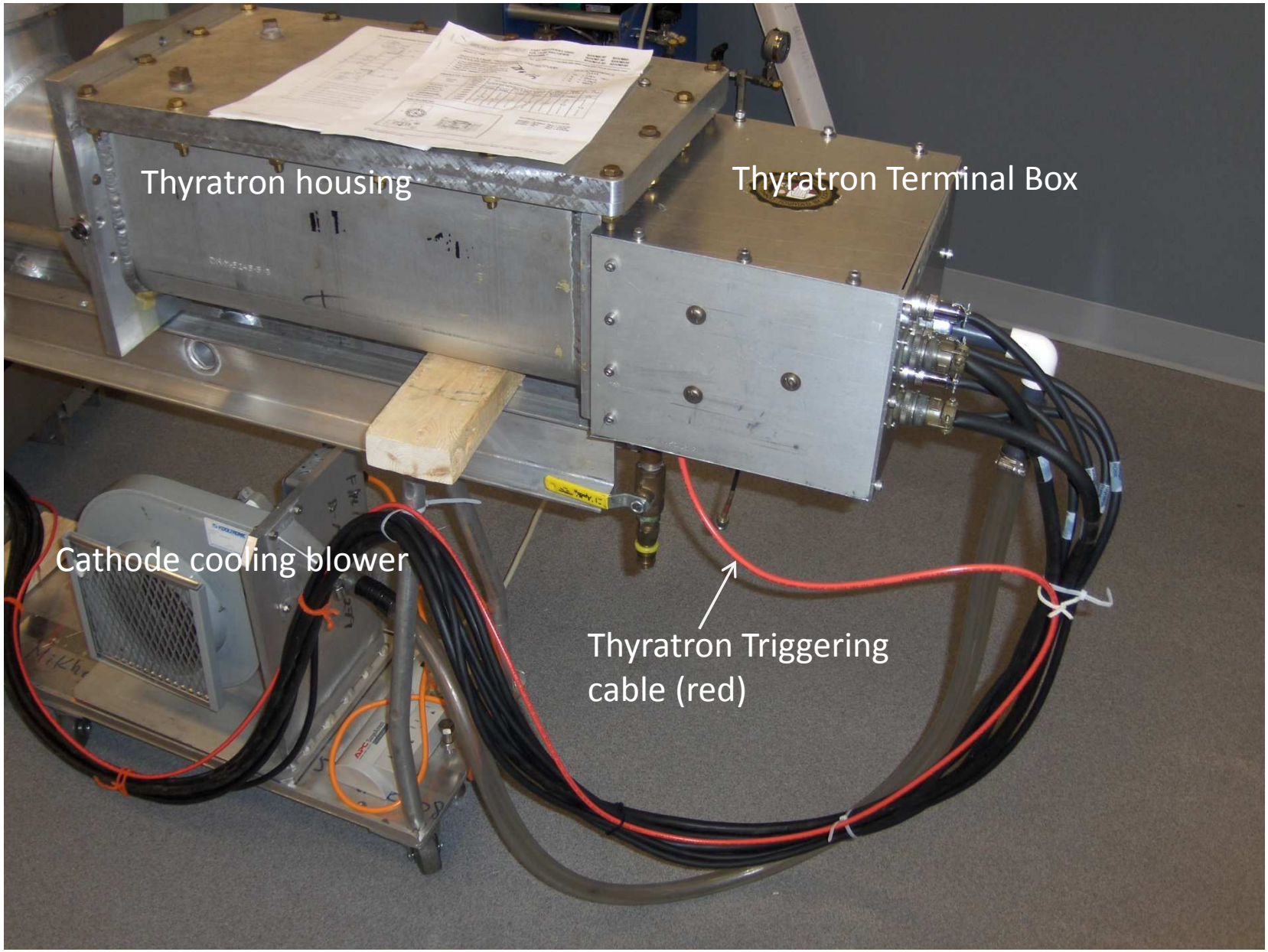
Thyratron/capacitor

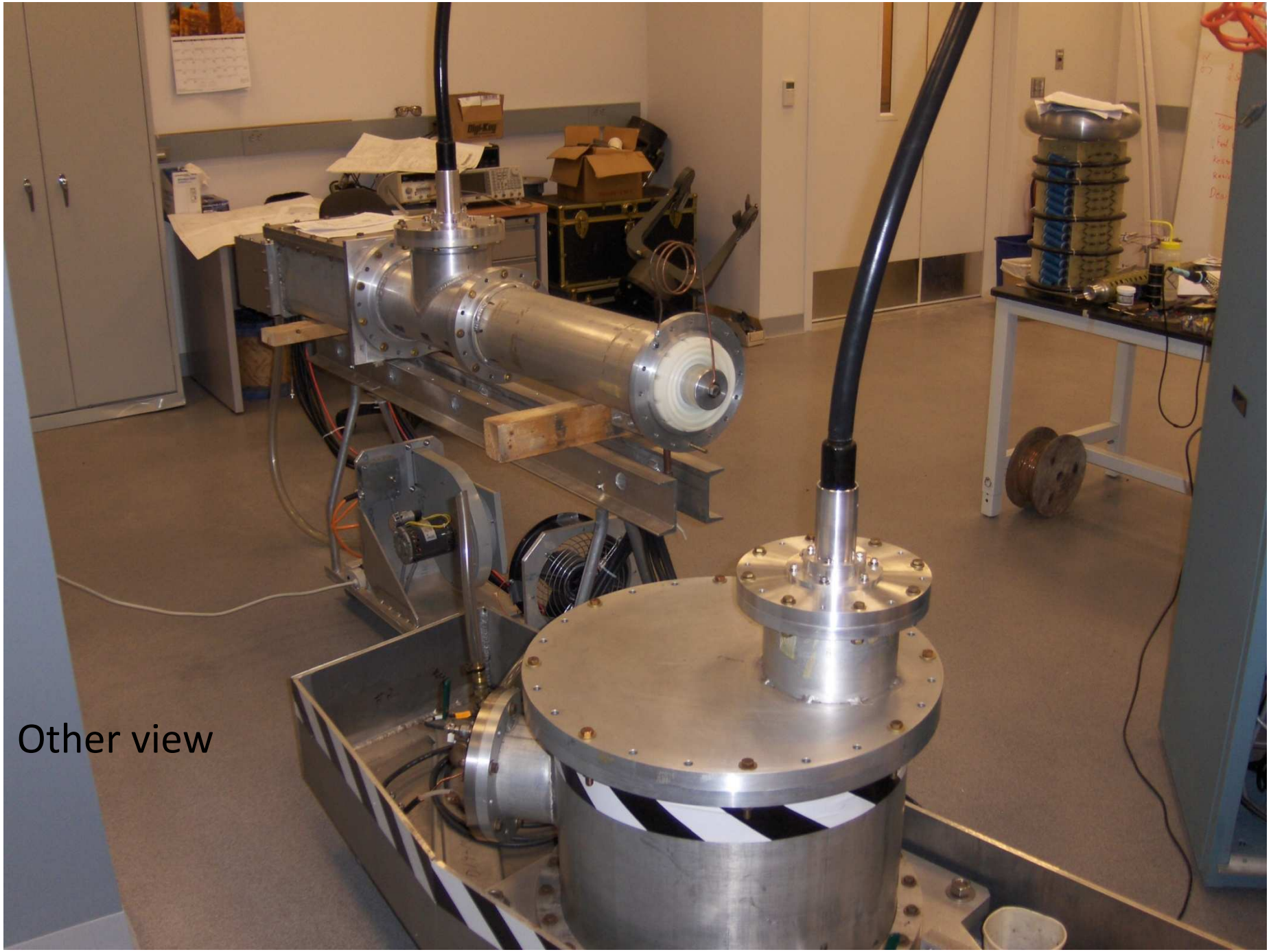


HV transformer tank

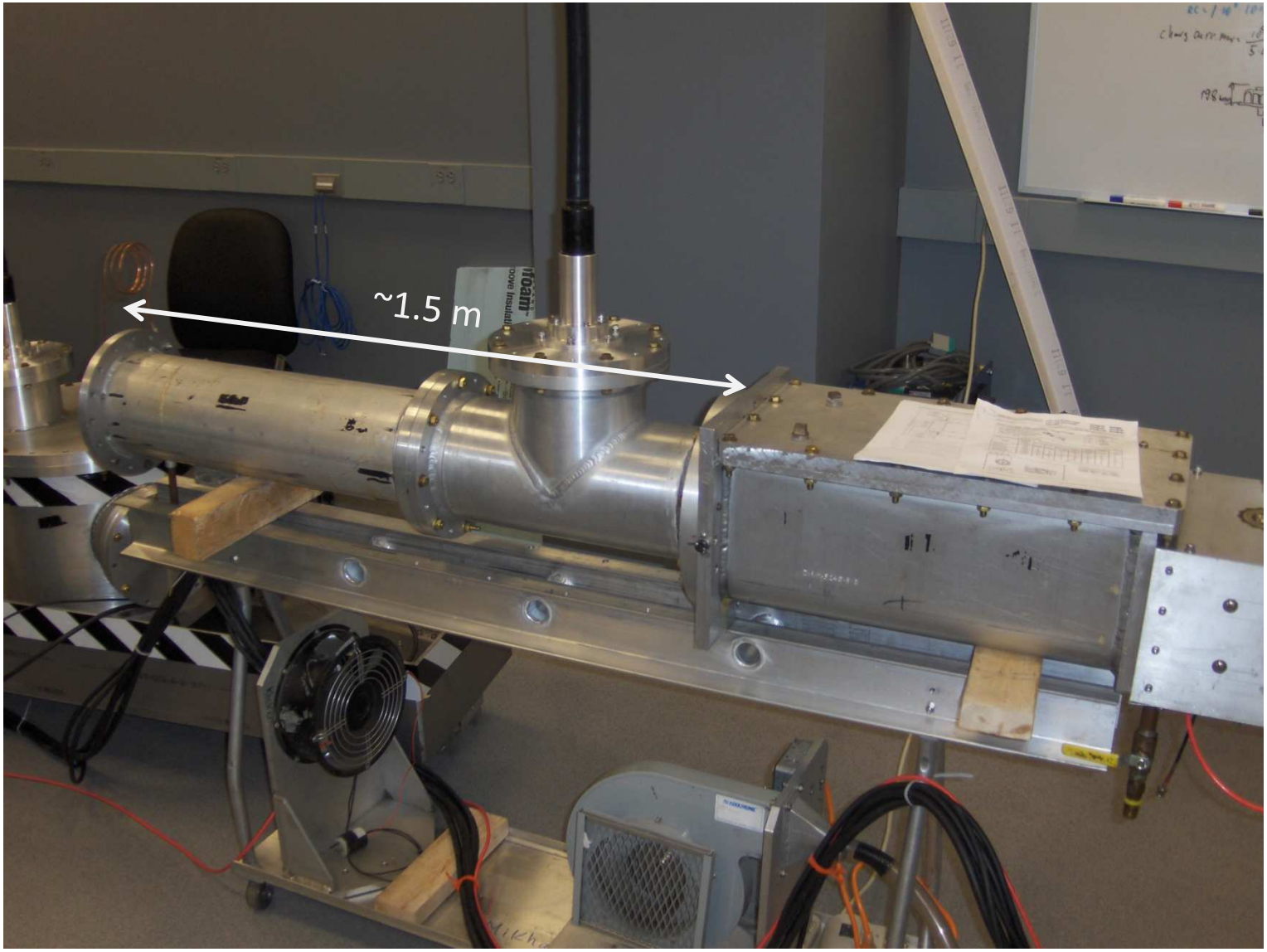


Without oil this device can operate at ~ 30KV


Thyratron housing
Thyratron Terminal Box
Cathode cooling blower
Thyratron Triggering cable (red)


Other view

For the Blumlein generator prototyping this 1.5 m-long section will be extended by 4 meters

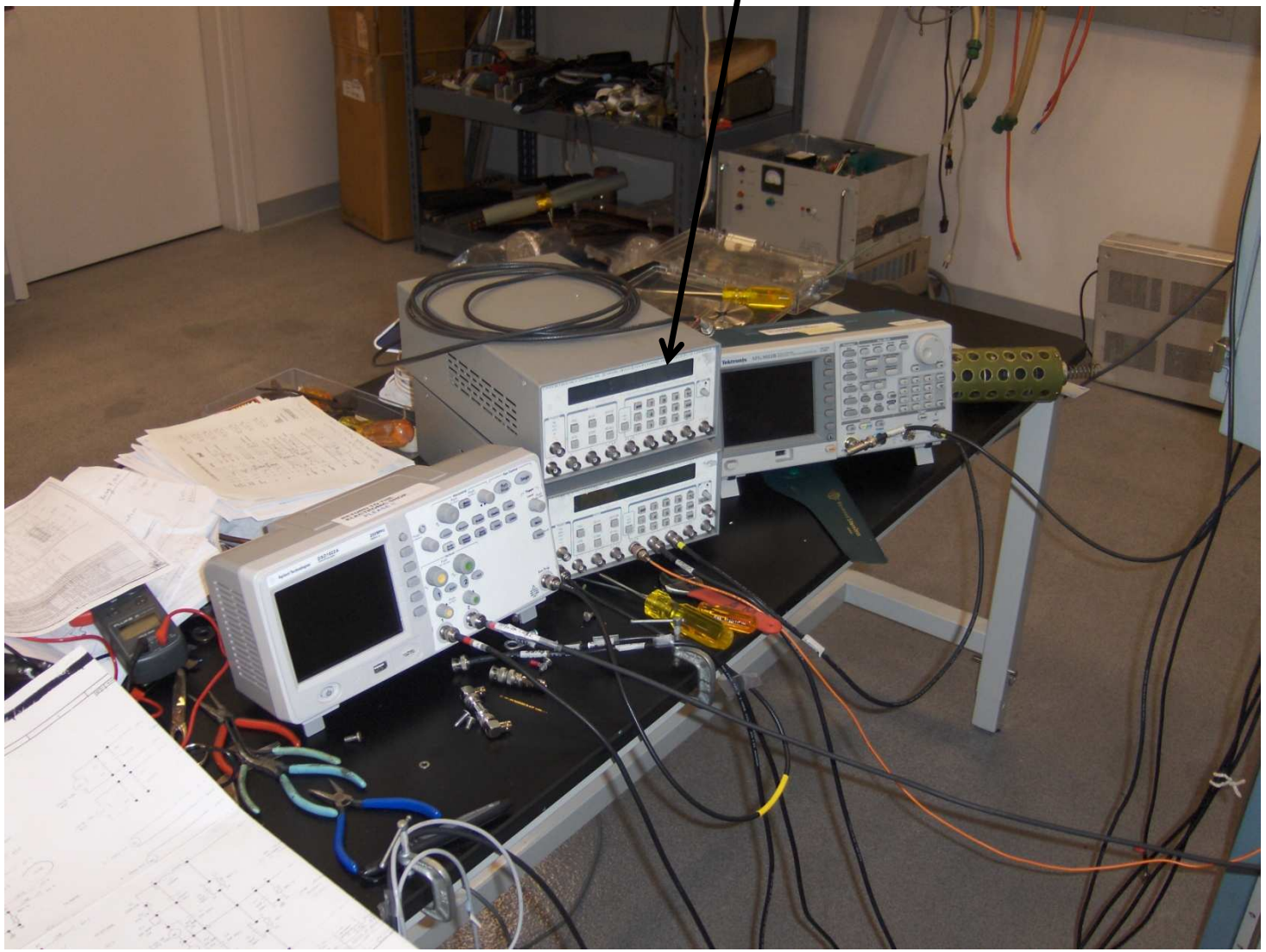


This will allow having 50ns flat top pulse
Fits in the room

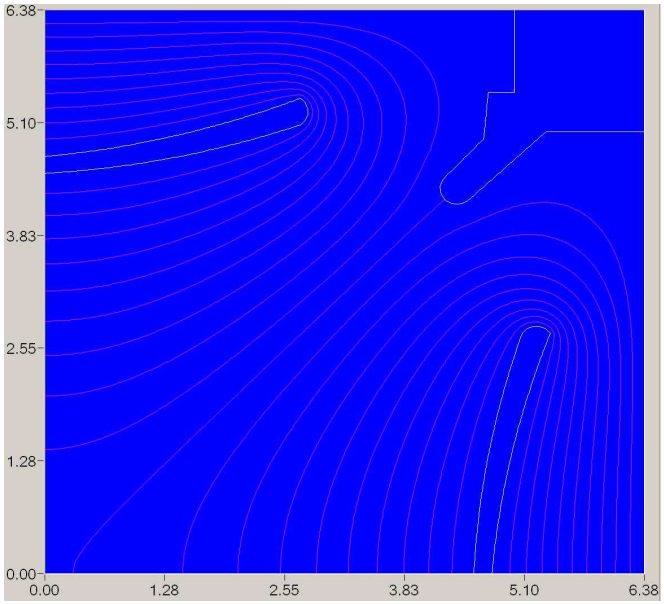
Three sections of the Blumlein generator in a machine shop.

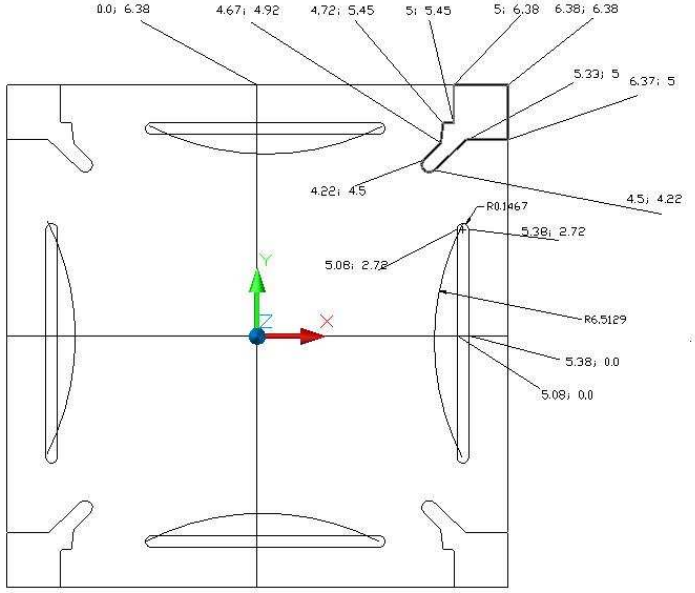
Few triaxial Blumlein generators at RHIC inflector

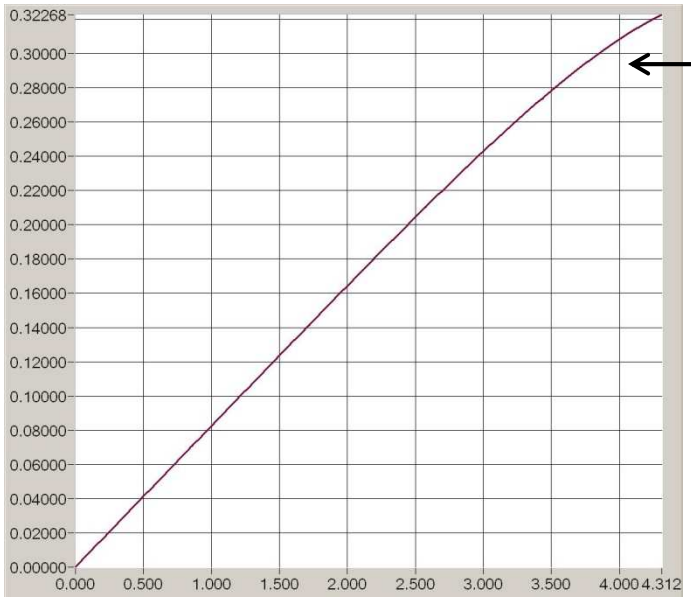
4-channel timing unit



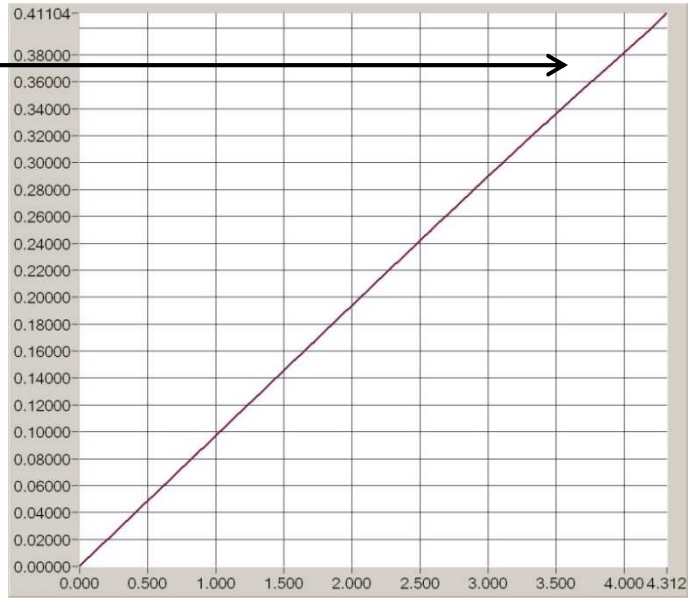
Even slightly bent **Quadrupole** electrodes deliver much better field quality.







Flat electrodes (E-821)



Slightly bend electrodes