Induction Cell and Pulser Needs for IBX

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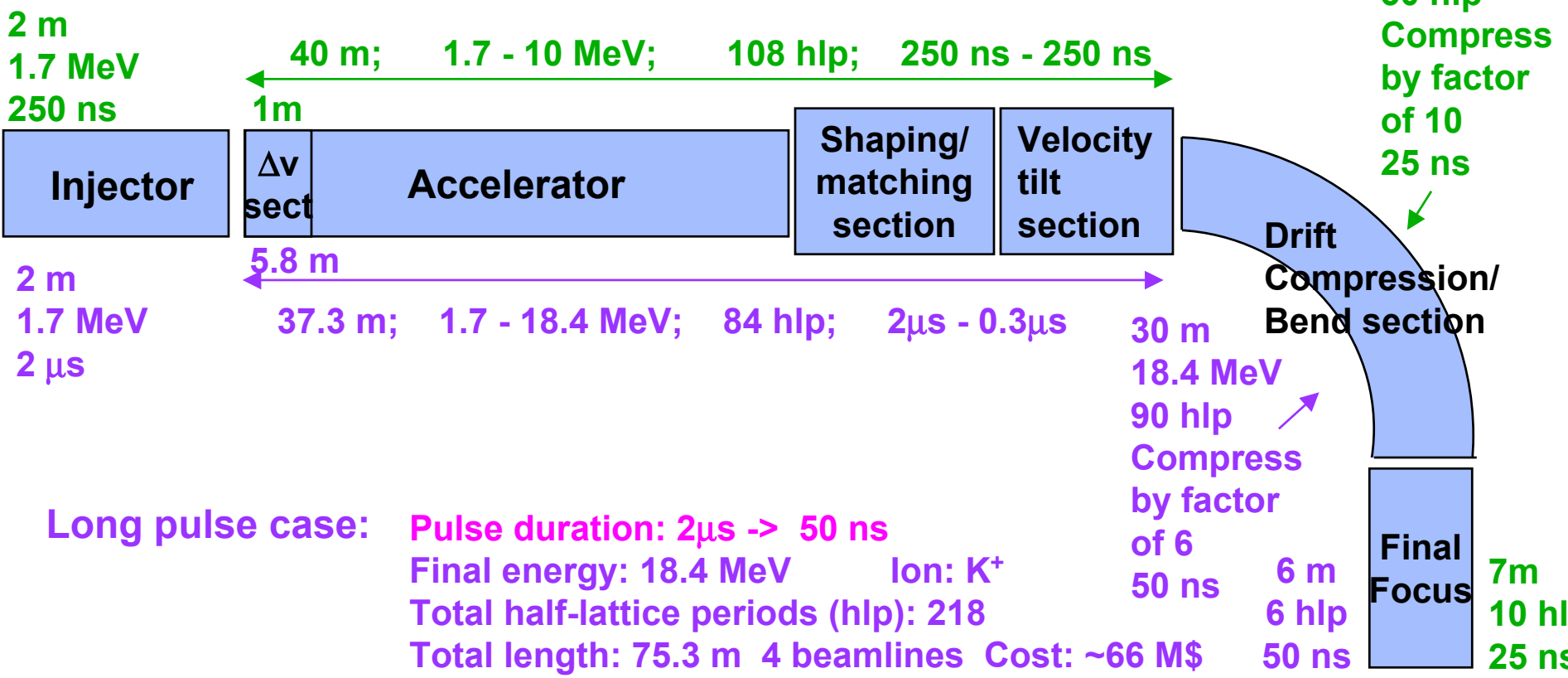
Outline

- IBX requirements
- Main acceleration waveforms
- Ear waveforms
- Tilt waveforms
- Development needed for IBX
- Present status of technology for IRE and driver
- Conclusion

IBX Workshop Considered Two Cases For IBX

Short pulse case:

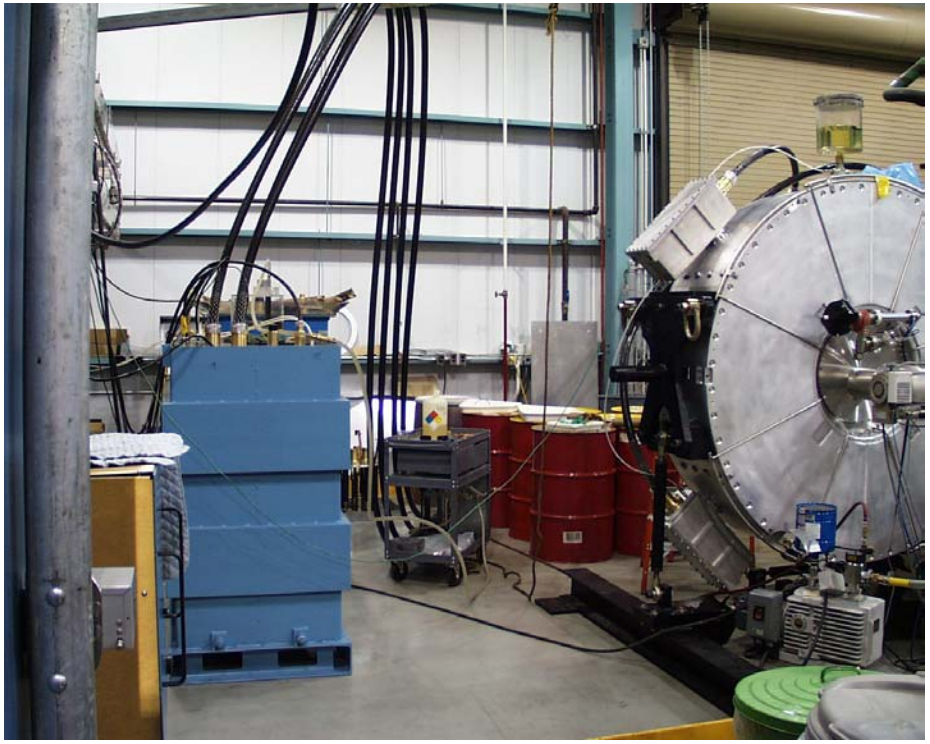
Pulse duration: 250 ns -> 25 ns
Final energy: 10 MeV Ion: K^+
Total half-lattice periods (hlp): 148
Total length: 64 m 1 beamline Cost: ~38 M$



Long pulse case:

Pulse duration: 2μs -> 50 ns
Final energy: 18.4 MeV Ion: K^+
Total half-lattice periods (hlp): 218
Total length: 75.3 m 4 beamlines Cost: ~66 M$

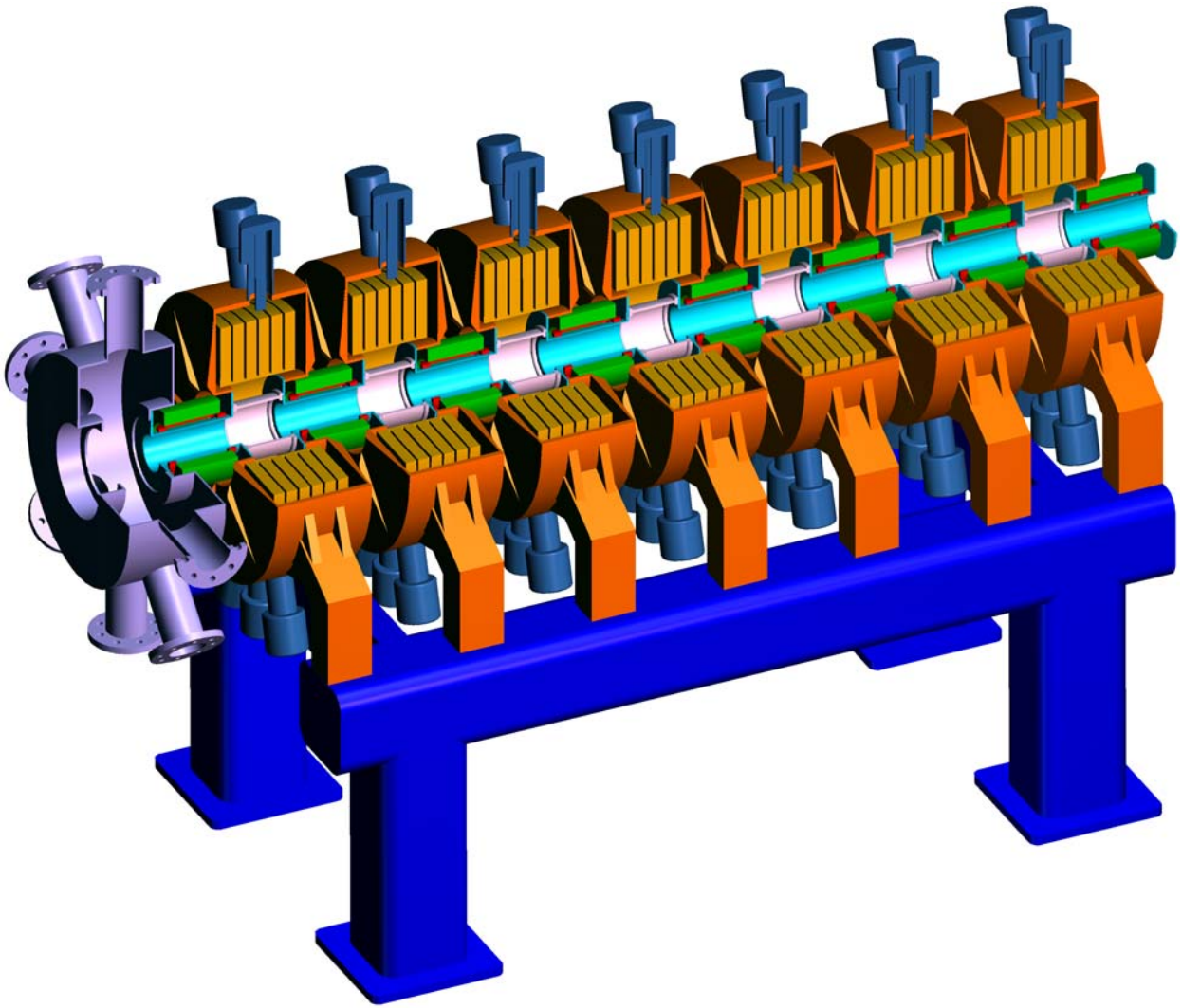
Long and Short Pulse Induction Cells



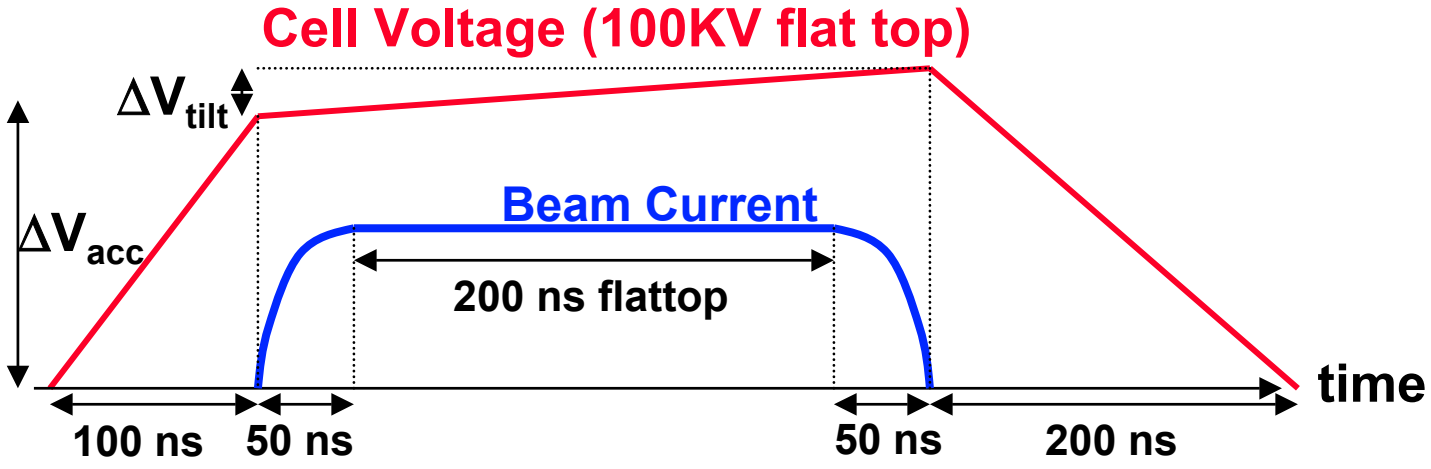
DARHT-II (200KV, 3us FWHM)

ETA-II cell modification
for RTA (100KV, 250ns FWHM)

IBX Accelerator Section (Short Pulse)



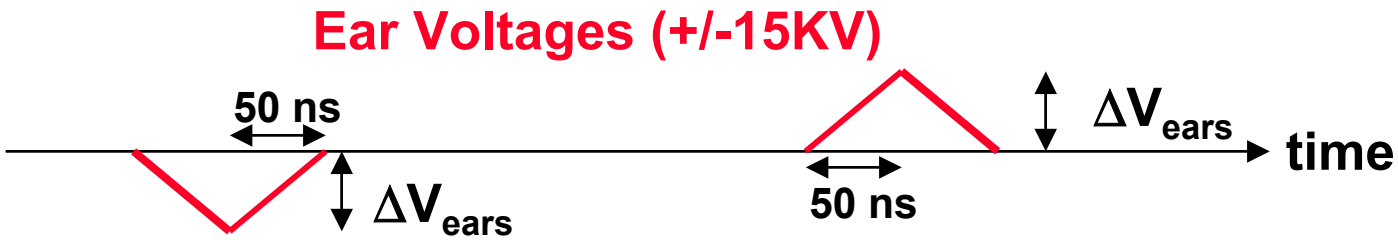
Main Acceleration Waveforms



These requirements can be met with a lumped element PFN or Marx charged water PFL (both using spark gaps).

PFN's are easier to tune, but PFL's can drive more cells in parallel at a given risetime.

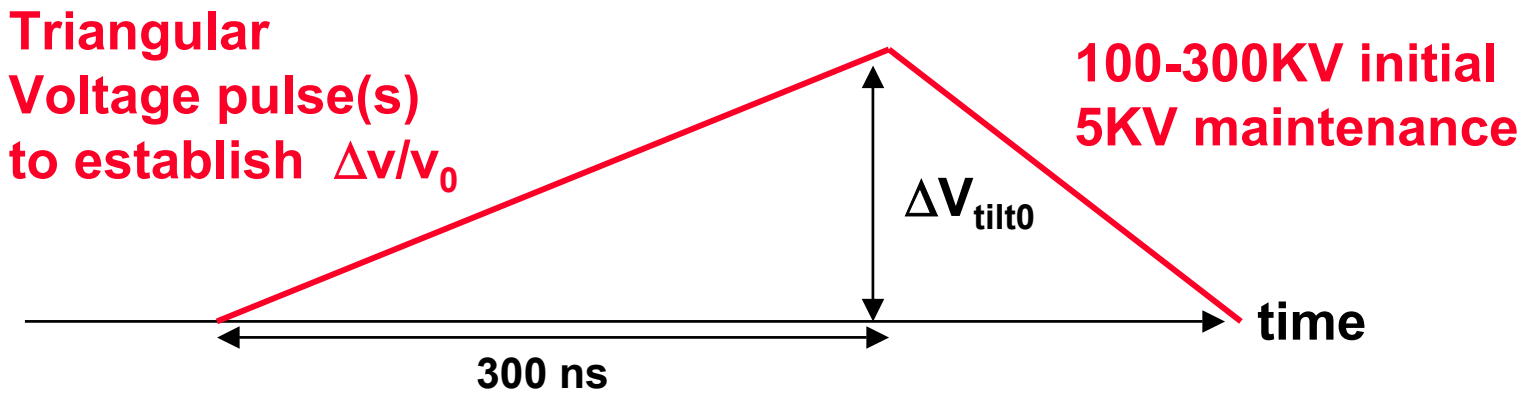
Ear Waveforms



These requirements can be met with the solid state modulator being developed under a phase II SBIR for HCX by First Point Scientific. The design is similar to a GSI buncher modulator which was operated at lower peak power.

The modulator will take a signal from an arbitrary waveform generator, so the actual waveform will be flexible within voltage and slew rate limitations.

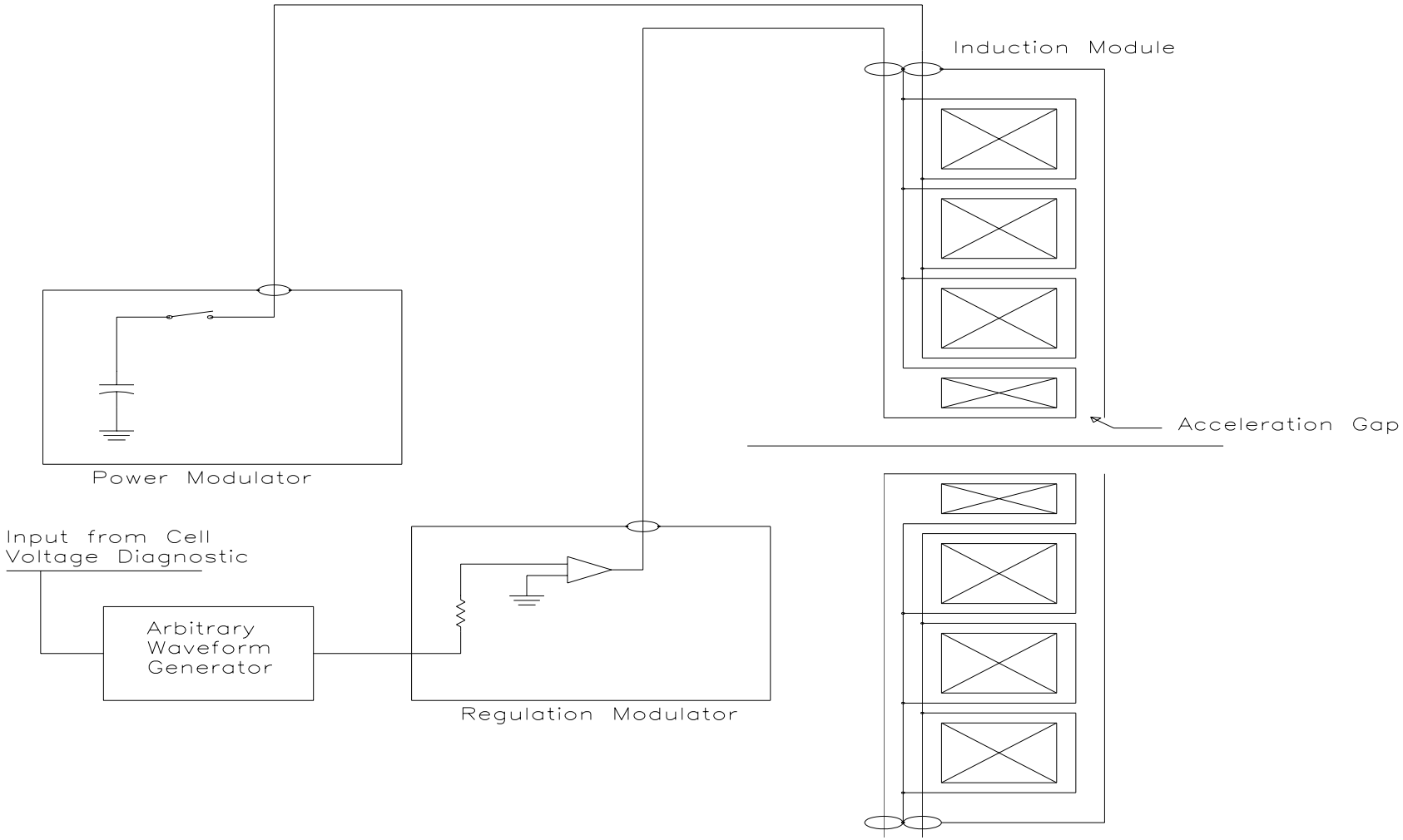
Tilt Waveforms



The initial voltage tilt will be a multiple of 100KV and will require a lumped element circuit and spark gaps.

To maintain this tilt, less than 5KV at each gap will be required. These requirements can be met with the solid state modulator being developed under a phase II SBIR for HCX by First Point Scientific. The modulator will take a signal from an arbitrary waveform generator, so the actual waveform with be flexible within voltage and slew rate limitations.

Induction Module With Multiple Modulators



Development Needed for IBX

No development work beyond the testing and downselection from conventional hardware options (insulators, core material, etc.).

The SBIR phase II hardware will be installed and tested on HCX in FY03. This will confirm the solid state variable waveform pulser performance and provide realistic cost estimates.

Prototype cells and pulsers must be built and tested for early IBX milestones.

Present Status of Technology for HIF

	IBX (long)	IBX (short)	IRE	Driver	Information
Insulators	$0.01/V Mycalex	$0.01/V	$0.01/V	$0.01/V	not high enough gradient
Energy Storage	$2/J DARHT	$20-30/J RTA	$3-10/J	$1-5/J	architecture dependent
Switches	$\$10^{-5}$/W spark gaps	$\$10^{-5}$/W	$\$10^{-5}$/W	$\$3\times10^{-6}$/W	spark gaps not acceptable for IRE or driver
Magnetic Cores	$16/Kg 2605SC as cast	$16/Kg	$5-10/Kg	$5/Kg	2605SC as cast will not be the only material used

NRE costs not included

These numbers are accurate for bulk energy only, not special waveforms and regulation

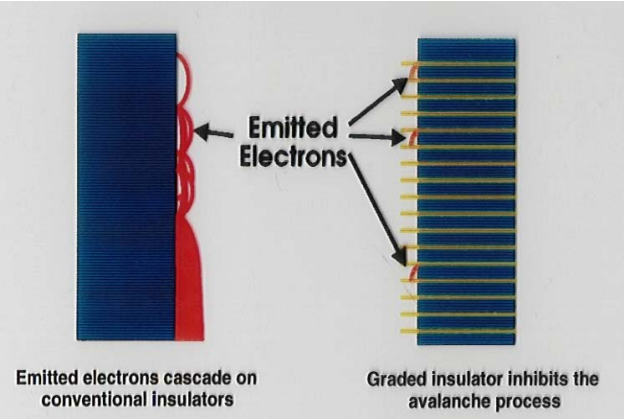
Cost of Variable Waveform Pulser

Because the solid state switches are limited in peak power, the cores they must drive need to be low loss to limit the required drive current. Hitachi Finemet is very low loss, but it costs about twice as much as 2605SC in large quantities.

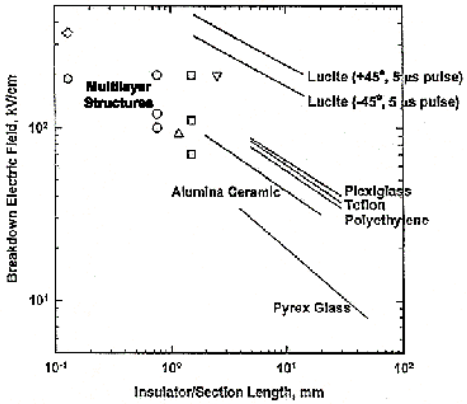
The two cores for the maintenance tilt and ear waveforms at each gap are estimated to be less than $150 each for the previously stated voltages per gap.

The pulser costs will be better known after the SBIR hardware is complete, but it is likely that we will use these pulsers on a limited number of gaps, based on cost. For example, the tilt waveforms which are <5KV per gap could be combined to 15KV at every third or fourth gap.

LLNL and Honeywell Insulator Development

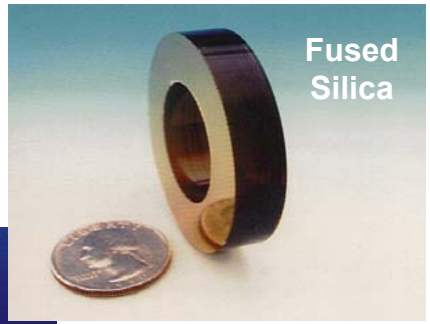


Closely spaced conductors are believed to inhibit the breakdown process



The effect scales inversely with spacing of the conductive planes

The ability to manufacture these structures is being perfected



Insulator Test Cell

Beam Dump

The technology has been demonstrated with beam on ETA-II (175 kV/cm in a high radiation field with no breakdowns)

Conclusion

IBX induction cells and pulsers can be based on conventional technology and therefore be low risk and low cost, but there should also be variable waveform pulsers based on solid state switches to provide ear, tilt, and correction waveforms. These pulsers will provide the regulation needed as well as some degree of flexibility in the acceleration schedule. The variable waveform pulsers need to be integrated into the design and cost estimates.

Though based on conventional technology, IBX prototype induction cells and pulsers will be required.

There should be continued development of ferromagnetic materials, insulators, and solid state pulsers, because IBX technology will not have the required performance or cost for an IRE or driver.