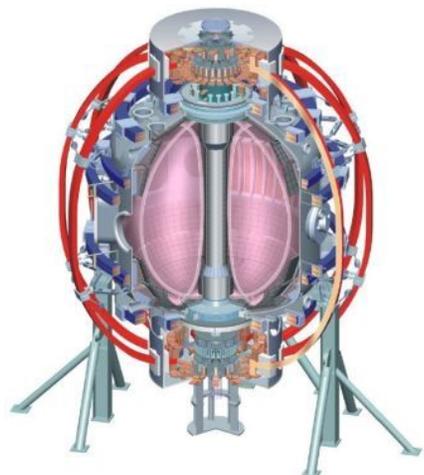


# Potential Upgrades to the NBI System for NSTX-Upgrade

## SPG, TS

- Beam dumps
- Power supplies
- Injection Angle

*Columbia U*  
*CompX*  
*General Atomics*  
*FIU*  
*INL*  
*Johns Hopkins U*  
*LANL*  
*LLNL*  
*Lodestar*  
*MIT*  
*Nova Photonics*  
*New York U*  
*ORNL*  
*PPPL*  
*Princeton U*  
*Purdue U*  
*SNL*  
*Think Tank, Inc.*  
*UC Davis*  
*UC Irvine*  
*UCLA*  
*UCSD*  
*U Colorado*  
*U Illinois*  
*U Maryland*  
*U Rochester*  
*U Washington*  
*U Wisconsin*



*Culham Sci Ctr*  
*U St. Andrews*  
*York U*  
*Chubu U*  
*Fukui U*  
*Hiroshima U*  
*Hyogo U*  
*Kyoto U*  
*Kyushu U*  
*Kyushu Tokai U*  
*NIFS*  
*Niigata U*  
*U Tokyo*  
*JAEA*  
*Hebrew U*  
*Ioffe Inst*  
*RRC Kurchatov Inst*  
*TRINITI*  
*NFRI*  
*KAIST*  
*POSTECH*  
*ASIPP*  
*ENEA, Frascati*  
*CEA, Cadarache*  
*IPP, Jülich*  
*IPP, Garching*  
*ASCR, Czech Rep*

# Ion Dumps Limit Pulse Length for a Given Voltage

## Example Performance Impact

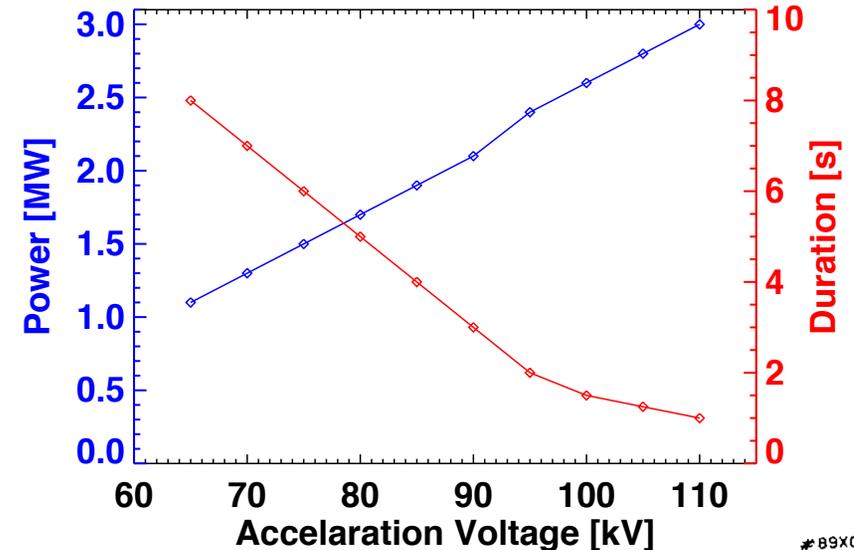
100% non-inductive scenario at  $B_T=1$  T, 6 sources,  $H_{98y,2}=1$

V [kV]	$I_p$ [MA]	$W_{tot}$ [kJ]	Duration [s]
80	800	425	5
100	1050	650	1.5

Also:

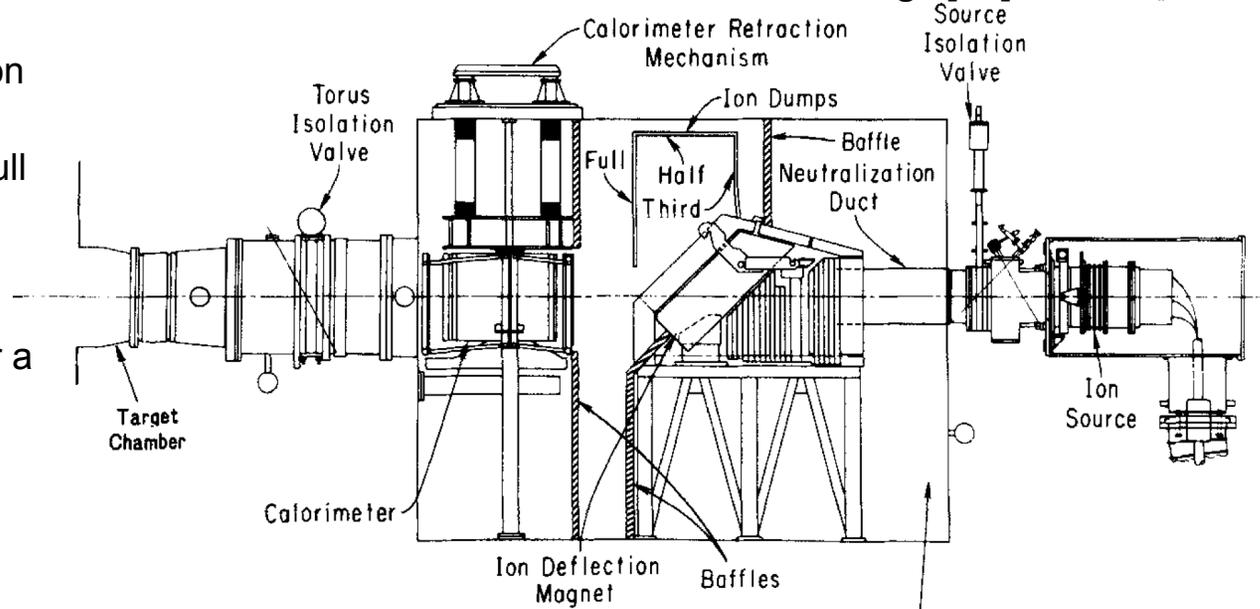
Beam diagnostics will have significant issues at 80 kV due to small beam penetration.

Will be an issue even if the higher power is not desired.



#89X0193

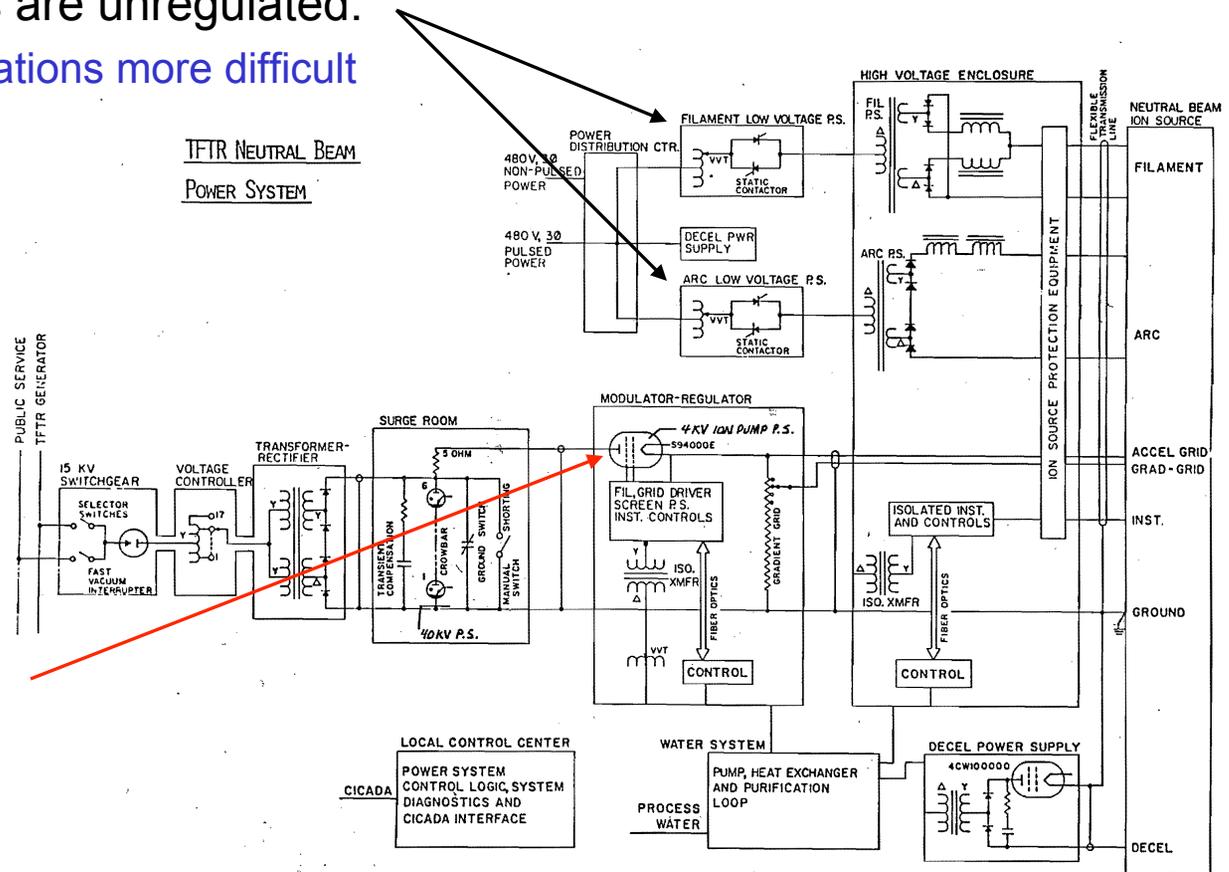
- Pulse duration limit is due to low-cycle fatigue & surface cracking on the primary energy ion dump.
- Done on an “every 2.5 minutes, full pulse duration, 10 hour day, 3 months a year” basis.
  - May be very conservative
- TFTR ran 95 kV for 4 seconds for a few shots, with no observed damage.
- Can maybe extend limits after engineering revisits assumptions, but if not...



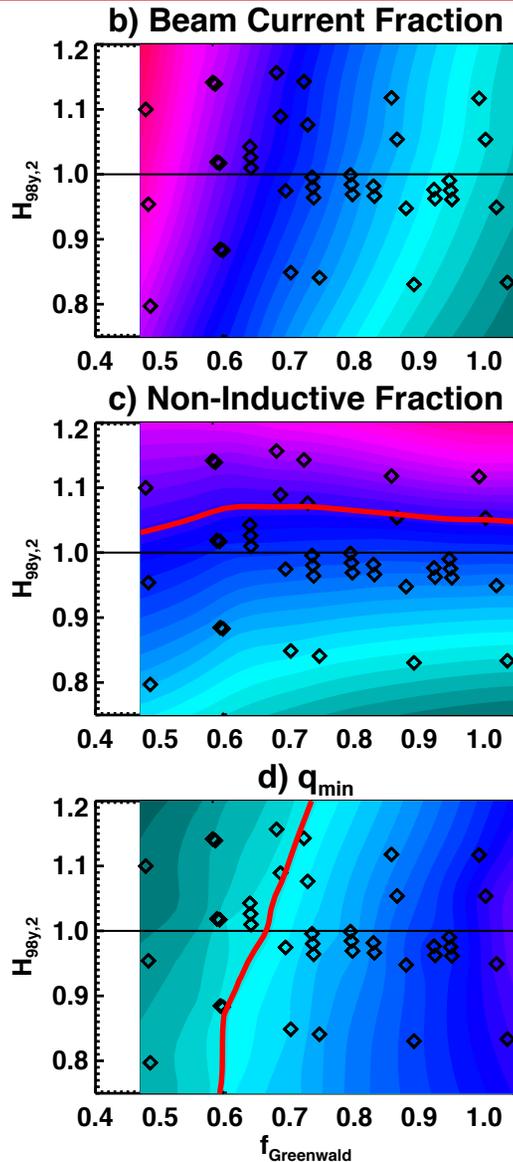


# Power Supply Side Considerations

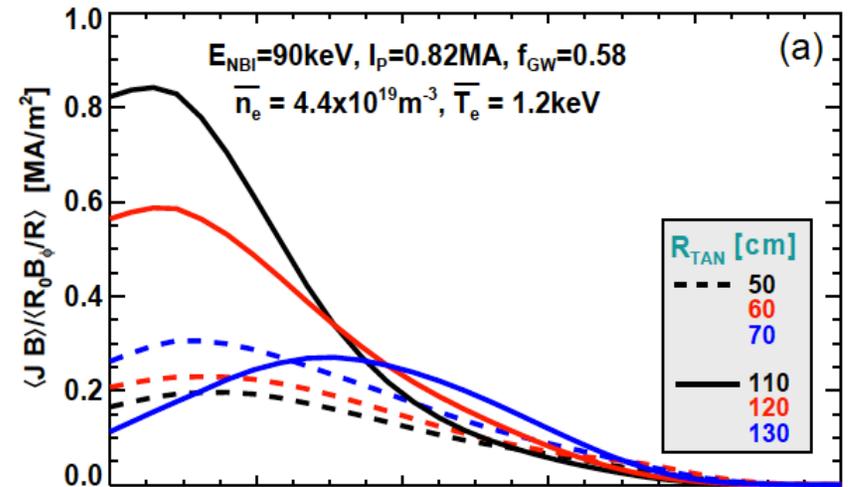
- Much of the NSTX-Upgrade physics program assumes that beams can be arbitrarily modulated.
  - Concerns about the grid power handling were somewhat alleviated by successful 15 ms on/off modulation in 2011
- Arc and filament supplies are unregulated.
  - Can make beam modulations more difficult
- Could upgrade them to IGBT supplies.
  - Propose to see how things work, then consider upgrades here as necessary.
- Limited supply of high-voltage modulator tubes.
  - Increased pulse length at high power will tax the tubes more heavily.



# Elevated $q_{\min}$ Operating Space Might Be Extended By Tilting 2<sup>nd</sup> Beamline



*1 T, 1 MA, 6 source,  
90 kV scenarios*



- Sources 2B & 2C ( $R_{\text{tan}}=110$  &  $120$ ) tend to have strong central current drive.
  - Outer gaps of 15 or more cm help alleviate the problem for the 2C source.
- Results in  $q_{\min}$  being driven under 1.0 for many lower-density scenarios.
  - 2C source at  $R_{\text{tan}}=110$  cm may not be that useful for long-pulse.
- Tilting the beamline would move this peak off-axis, potentially widening stable the operating space.
  - Need to do TRANSP simulations as part of the 5-year plan lead-in.