

# **Search for Excess Heat and Tritium in Nickel Alloys Exposed to Pulsed H/D Plasmas**

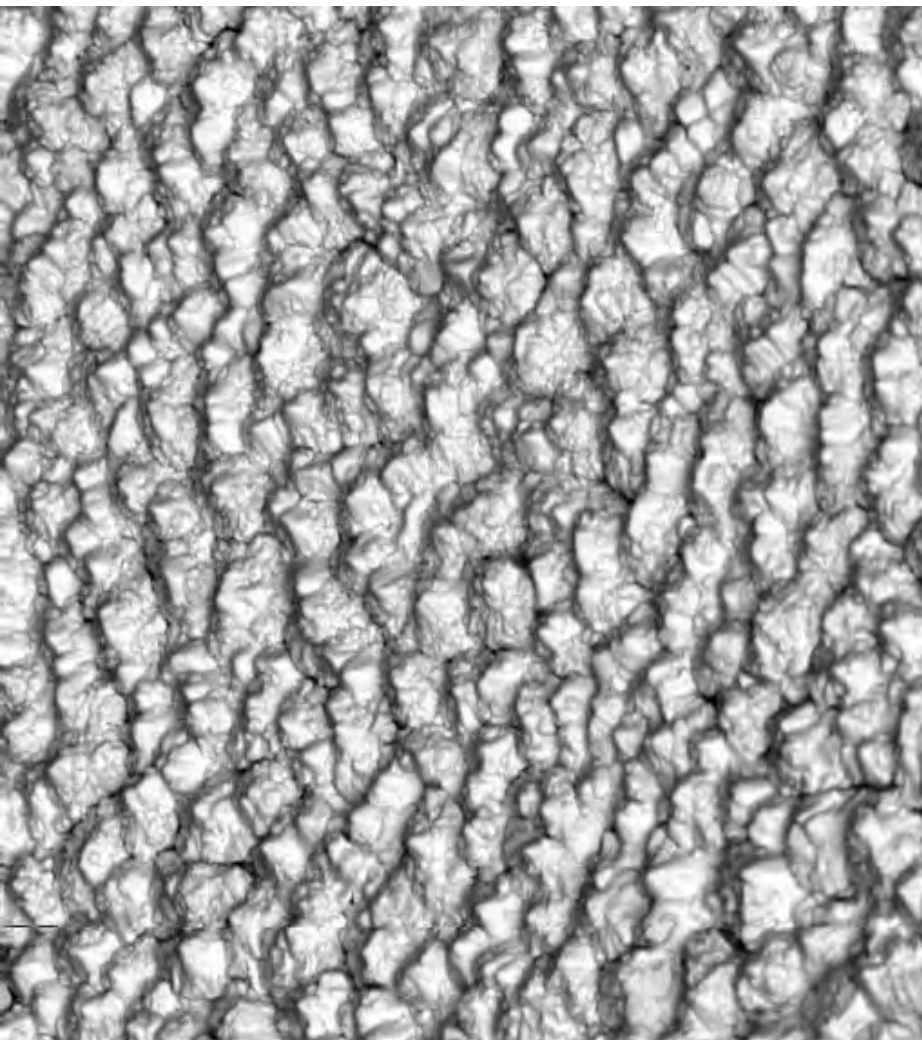
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July 1-3, William and Mary Univ., Virginia

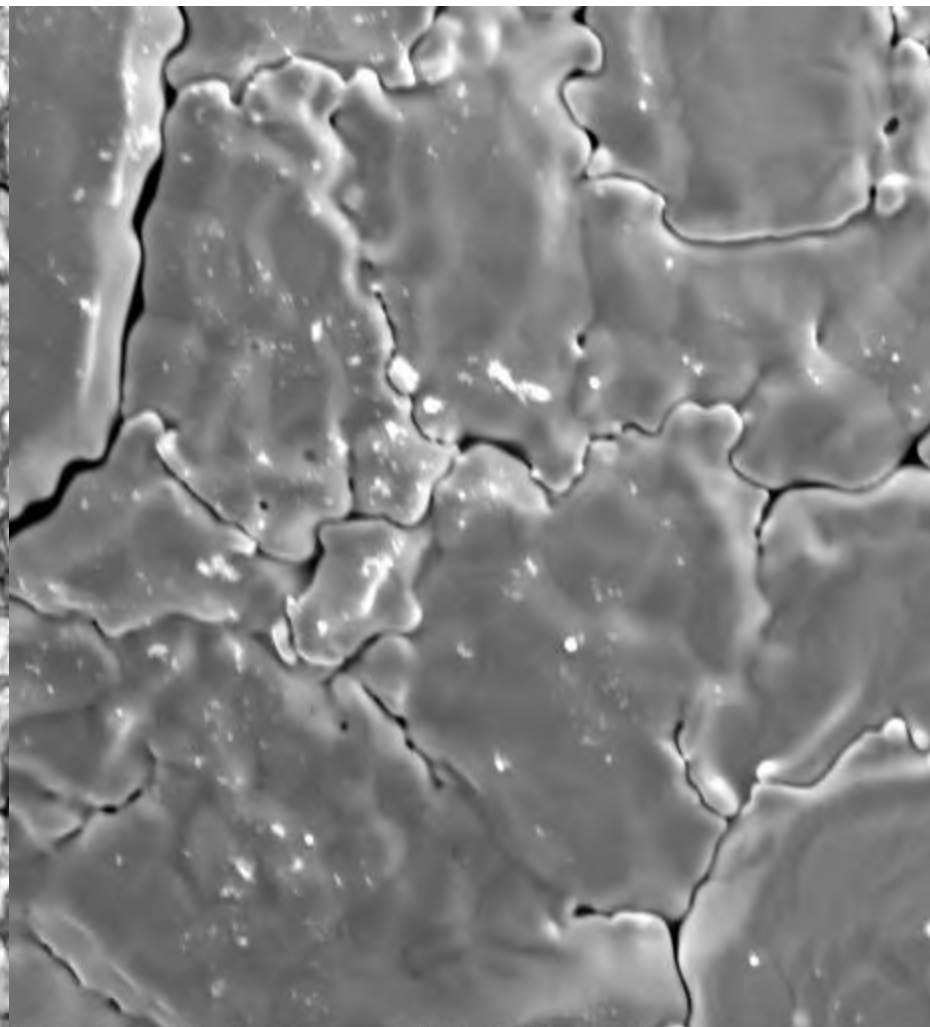
# Samples of Interest:



SEM MAG: 1.14 kx  
HV: 20.0 kV  
DET: BSE Detector  
DATE: 09/01/04



50 µm



MAG: 1.48 kx  
HV: 20.0 kV  
DET: SE Detector  
DATE: 06/29/12  
Device: TS5130SB



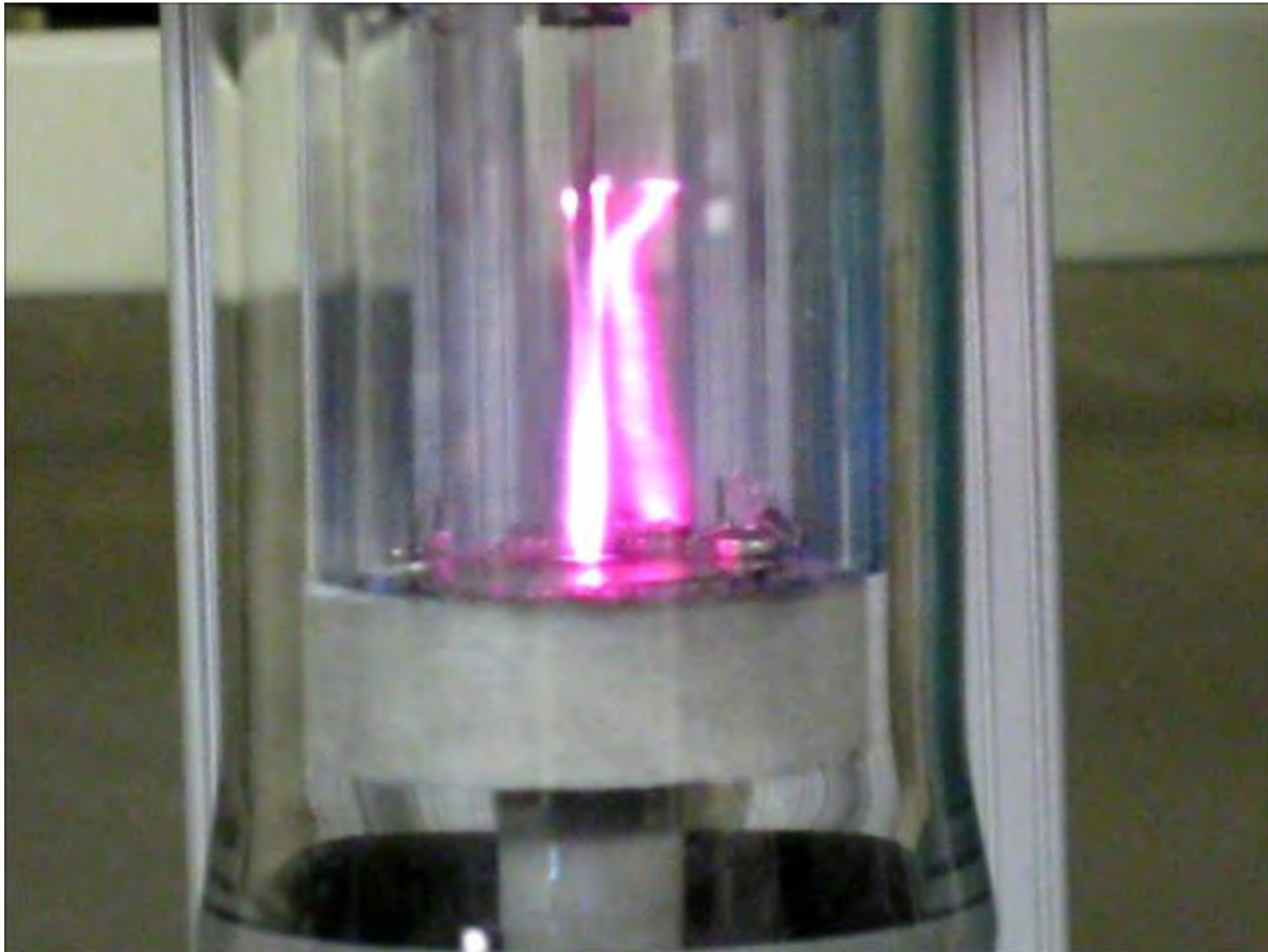
20 µm

Vega ©Tescan  
Digital Microscopy Imaging

Modes of operation: Arcing



Modes of operation: ion channel and attachment



# Various Metal "Shielding" Factors (Raiola et al 2006)

## Metals with Highest Uo

<b>Pd</b>	<b>800ev</b>
<b>Sb</b>	<b>720ev</b>
<b>Pt</b>	<b>670ev</b>
<b>Co</b>	<b>640ev</b>
<b>Tl</b>	<b>550ev</b>
<b>Ni</b>	<b>380ev</b>
<b>Rh</b>	<b>230ev</b>

## Metals showing little or no Effect

### Transition Metals

Ti	<30
Sc	<30
Hf	<30
Zr	<40

### Lanthanides

Nd	<30
Sm	<30
Ce	<30

### Rare Earths

Dy	<30
Tb	<30
Gd	<30



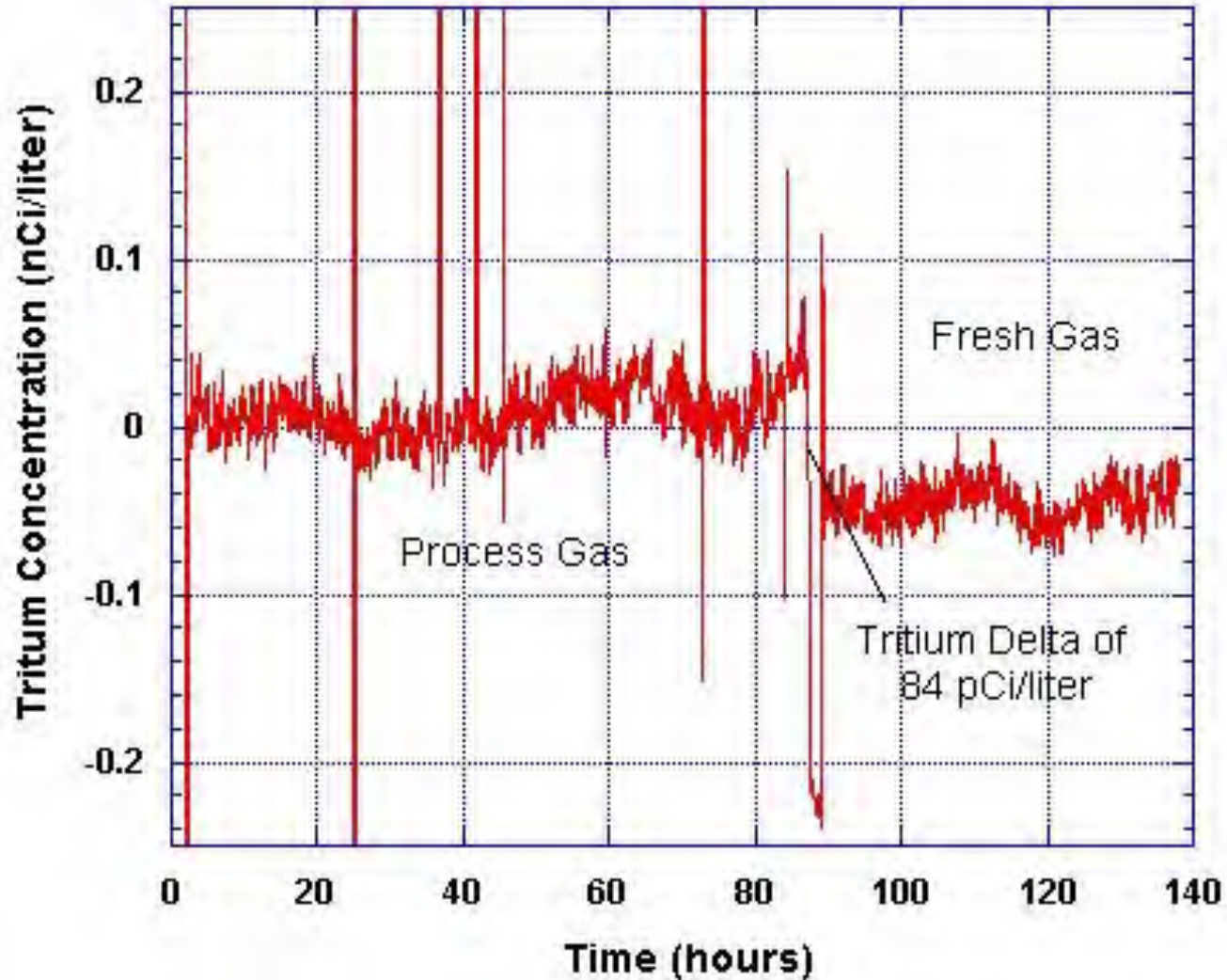
Lanthanide Series	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.96
Actinide Series	80 Th 232.0391	81 Pa 231.0359	82 U 238.029	83 Np 237.0482	84 Pu (244)	85 Am (243)	86 Cm (247)	87 Bk (247)	88 Cf (251)	89 Es (254)	90 Fm (257)	91 Md (258)	92 No (259)	93 Lr (260)

## Recent tritium results: pCi/hr

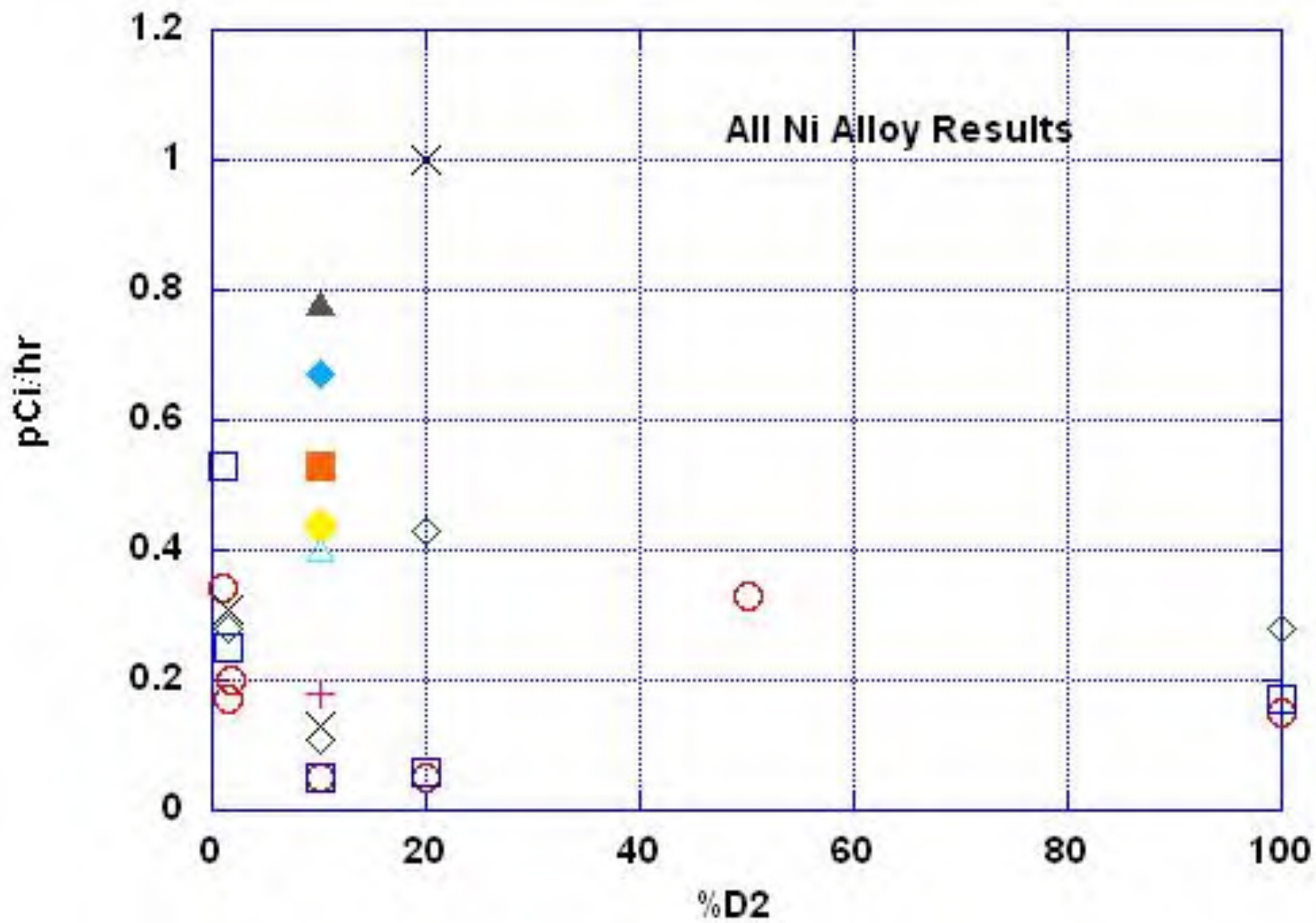
Ni	Ni alloy	Fe-Ni	Fe	Ag	Pt	Pd/alloys
0.53	1.0	0.0	0.0	0.1	0.30	0.33
0.28	0.78				0.08	0.21
0.24	0.67				0.21	
	0.59				0.12	
	0.53				0.10	
	0.44					
	0.43					
	0.40					
	0.34					
	0.31					
	0.28					
	0.28					
	0.26					
	0.20					
	0.18					



# Tritium Femtotech Data

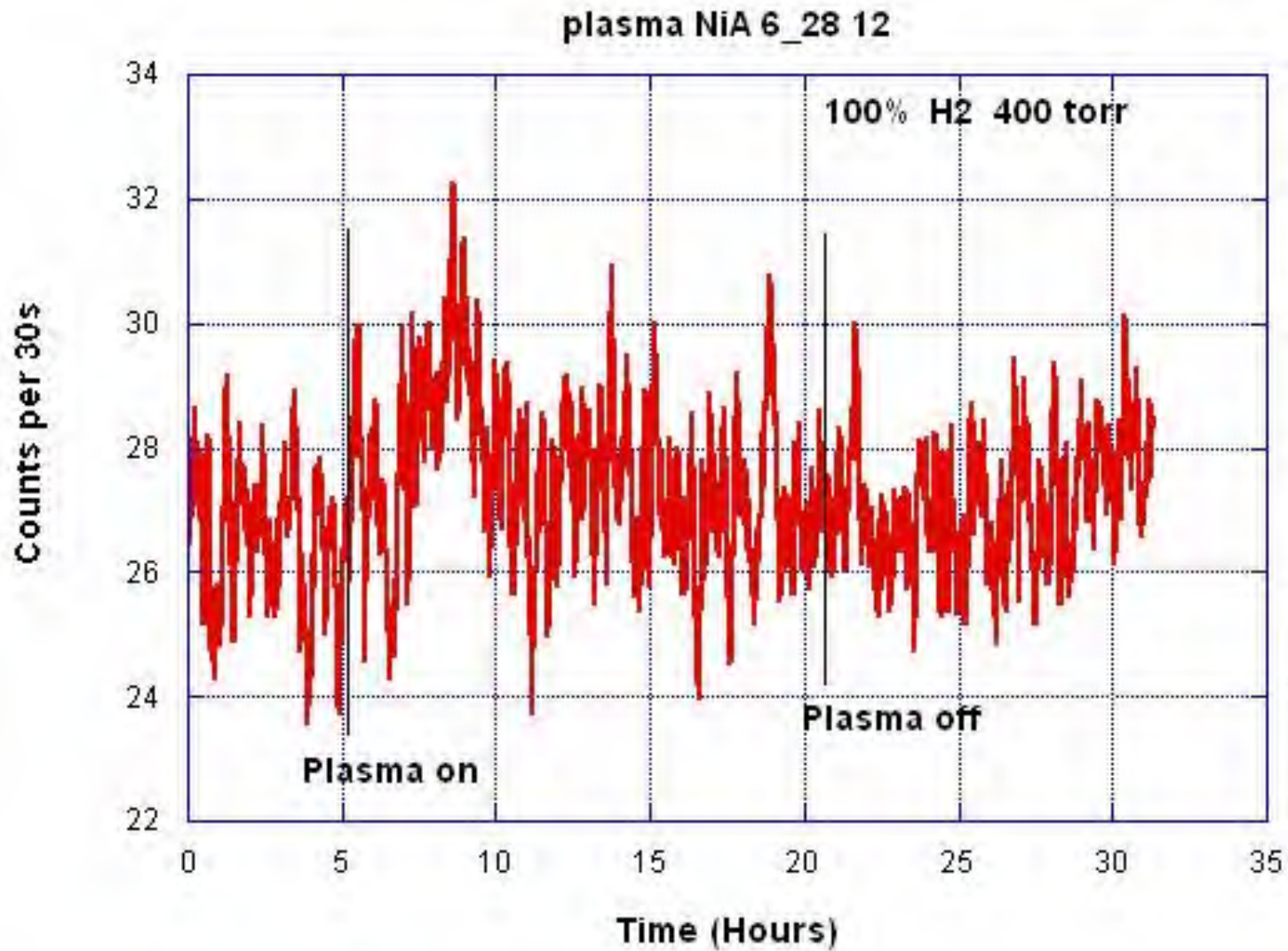


# Ni Alloy Tritium Output as a Function of %D2



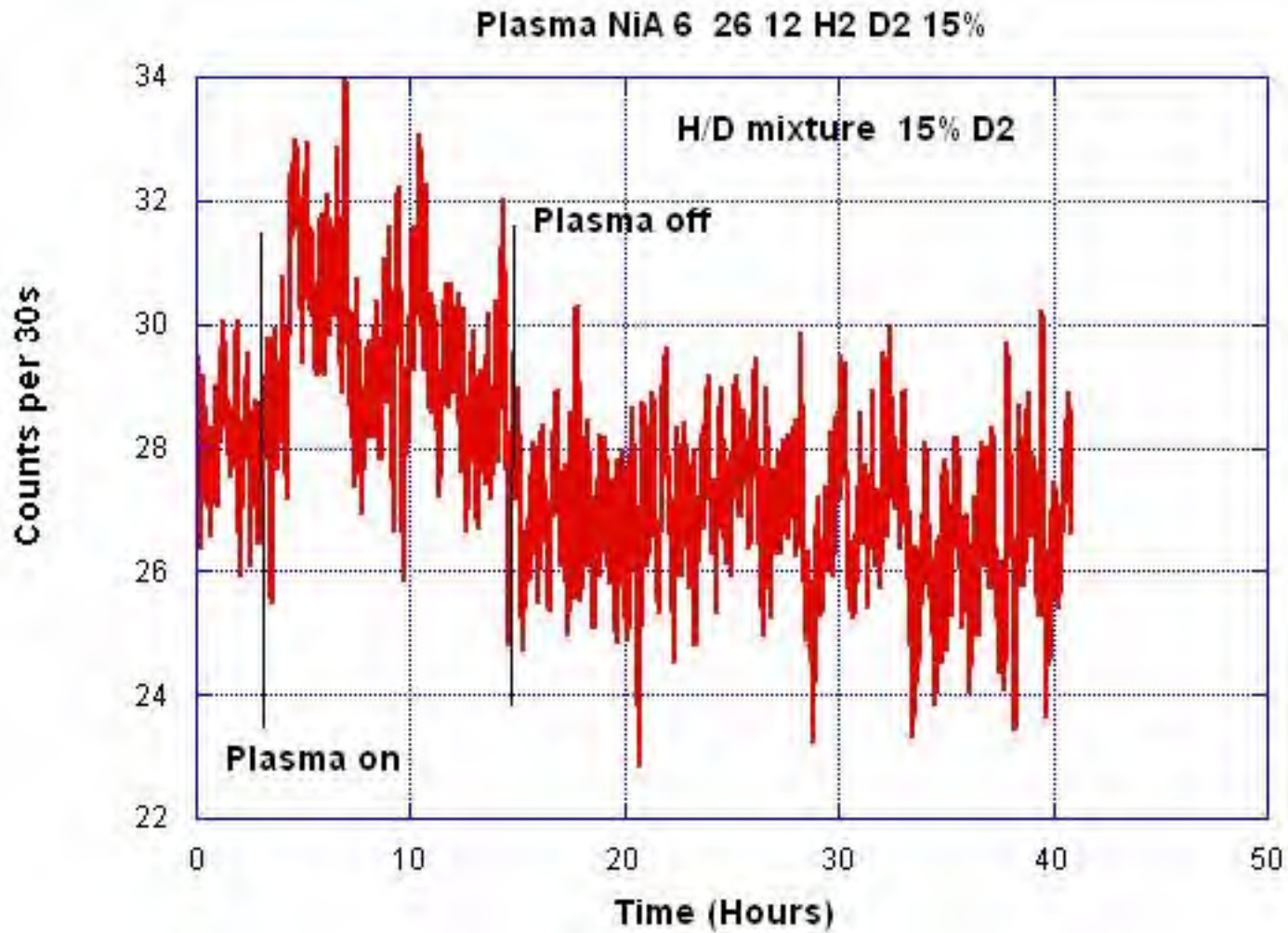


# Pancake data

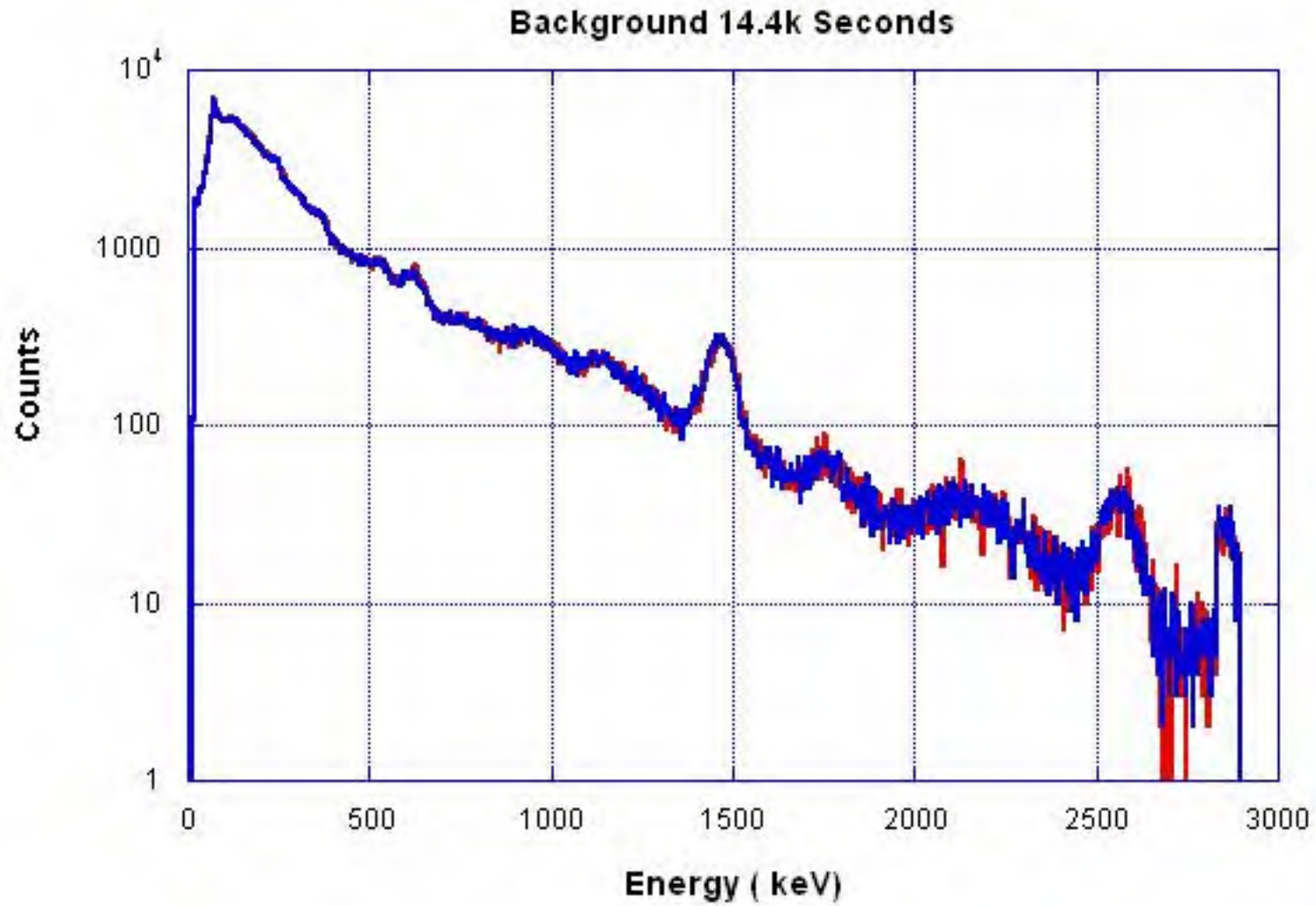


H2 or D2 only 7.5W 8.5 cm away

# Pancake Detector beta/gamma



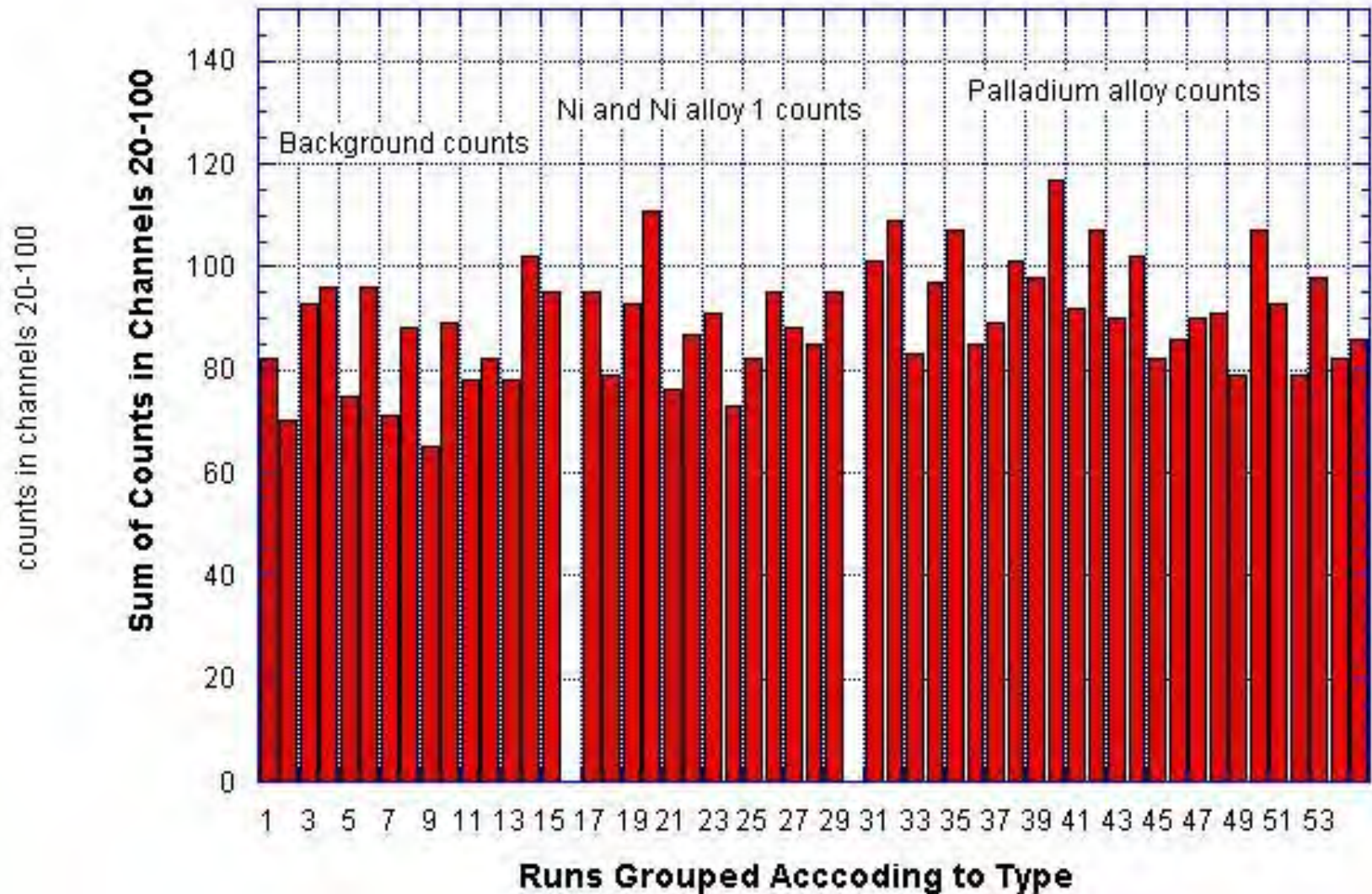
# NaI Detector Data





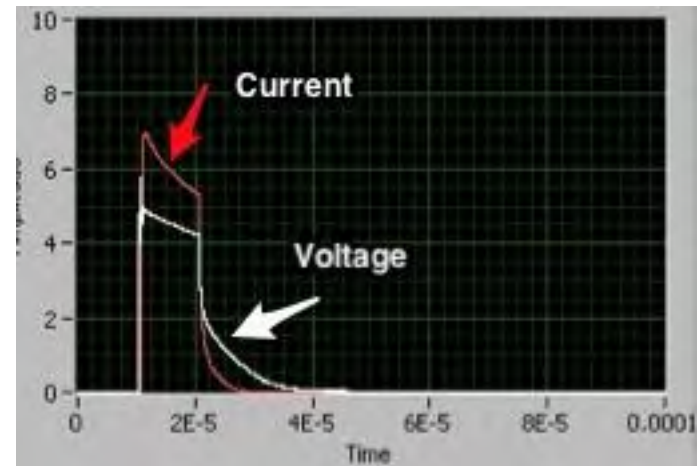
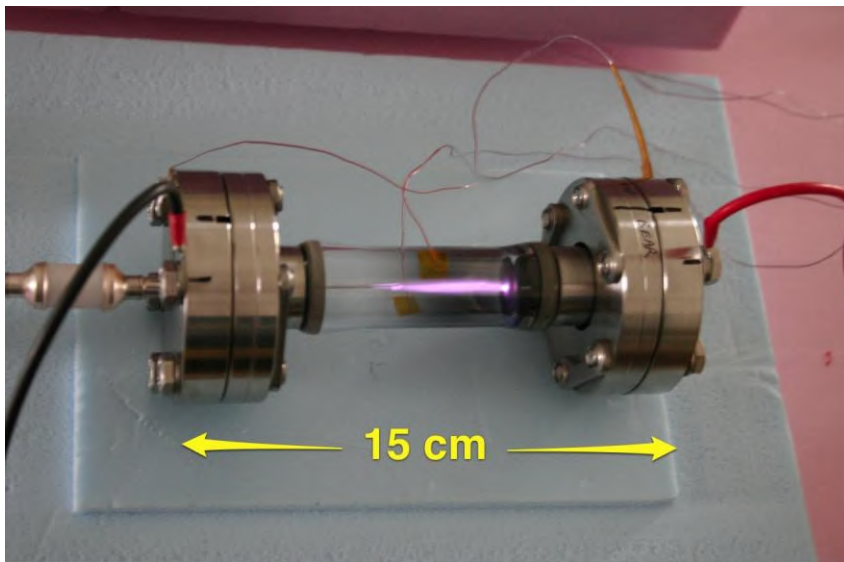
counts in channels 20-100

### alpha count summary 1\_1\_10 to 5\_1\_10



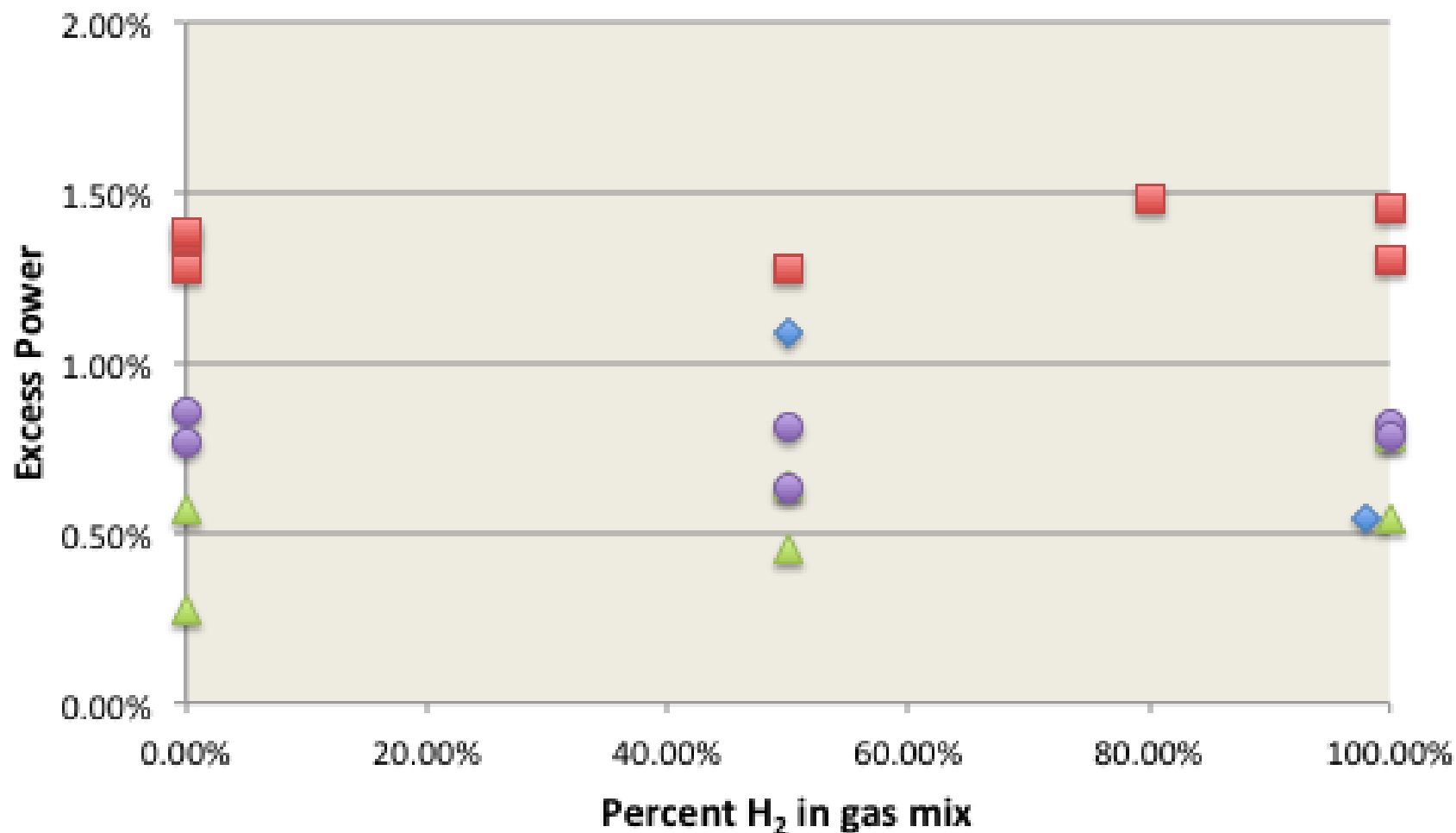
# Plasma characteristics

- 150-250 torr
- 900-1300 volts, 5-10 amps
- 5-20  $\mu$ s pulse @ 50-100 Hz
- Constant power operation
- Sample V & I @ 14-bit, 100 M-sample/sec





## Excess Power with various cathodes



◆ Zr Cathode #5

■ Ni alloy Cathode #6

▲ Pd Cathode #7

● Ni Cathode #8

## Is there Helium?

Table 2. Gas analysis of initial gas and post-process gas  
Finnigan 270 can easily separate He peaks from D<sub>2</sub>

Gas	<sup>4</sup> He	<sup>3</sup> He	
D <sub>2</sub> from bottle	90+-30 ppb	< 1ppb	Gettered
Plasma run H/D 24/75	400 ppb	<200 ppb	Non gettered

## Conclusions

Ni Alloy is reproducible, (this is a big deal!)

Tritium can be several sigma over background

Effect can be obtained in 1-2 days

Excess heat is small but not inconsistent with Helium data

If X-ray effect can be increased then might serve as a “CB” demo

Parameter space, effects of pressure, electrical driving conditions, temperature, etc. have only been partially explored.

Other issues