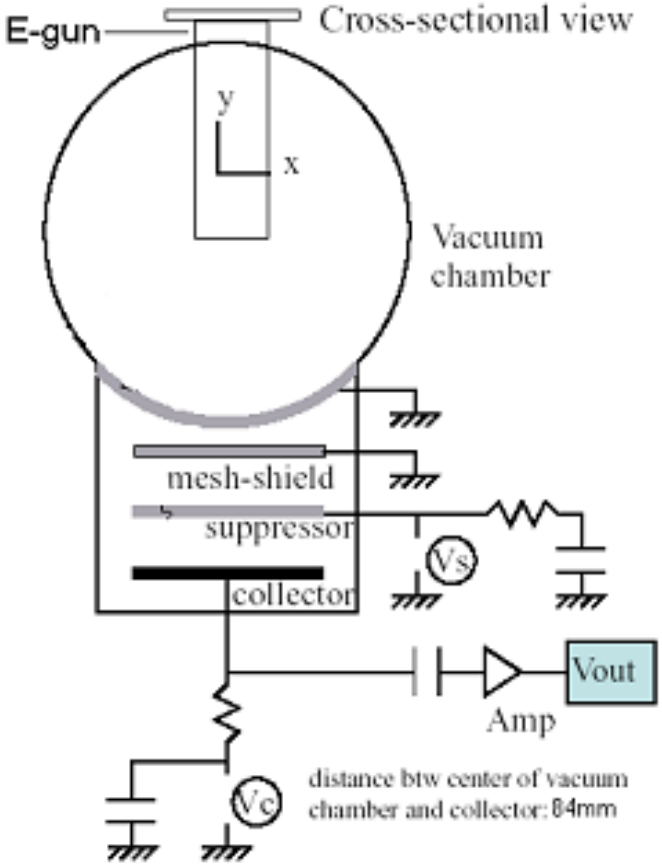
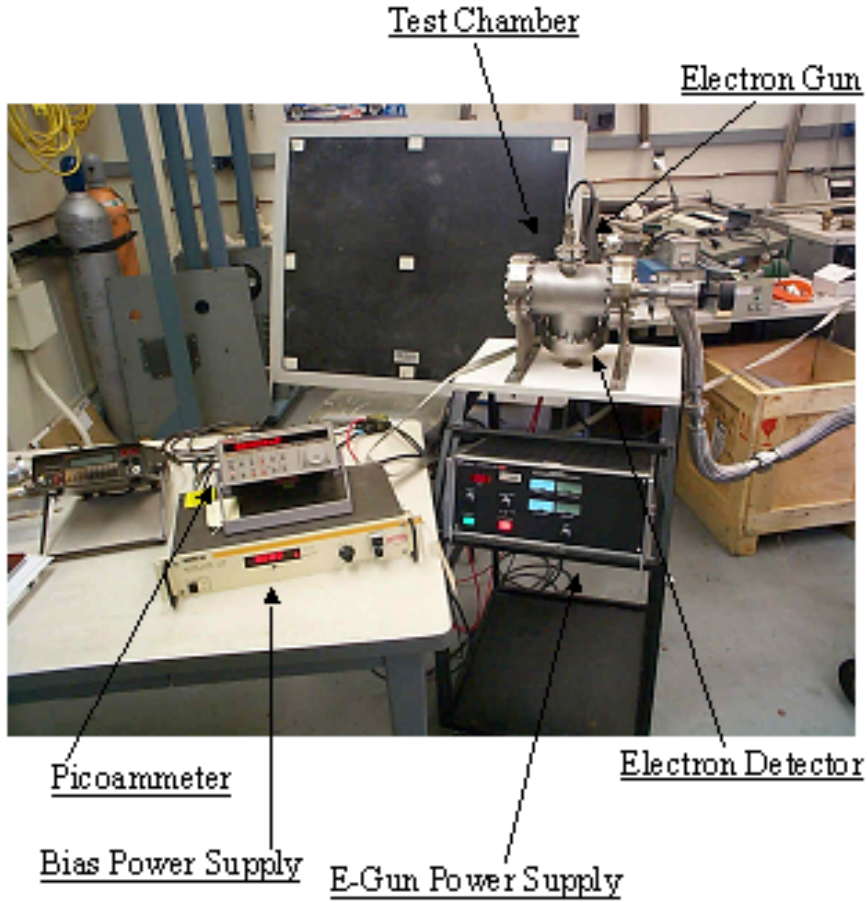
RHIC electron cloud and vacuum pressure rise characteristics

Study Motivation

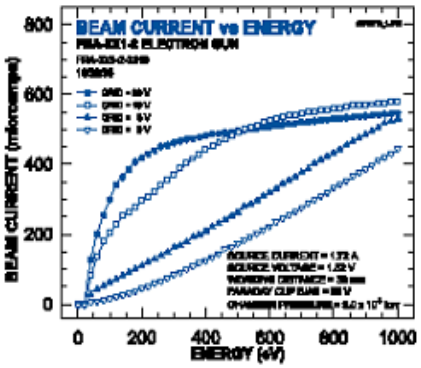
- a) By changing electron detector second grid retarding voltage, scanning the energy spectra, to get the energy distribution of secondary electrons.
- b) Gas composition and its evolution along the pressure rise. Electron stimulated desorption due to multipacting, measured by means of a residual gas analyzer(RGA). We should see the gas composition varying is related to multipacting as a function of time.





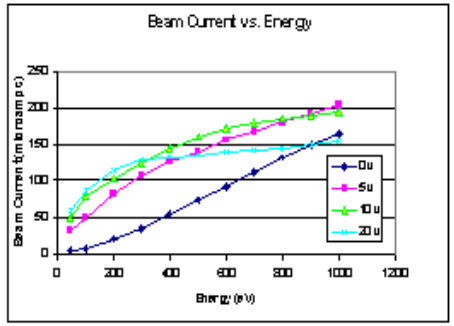
Electron Detector Test Bench

Typical Performance(Manual)

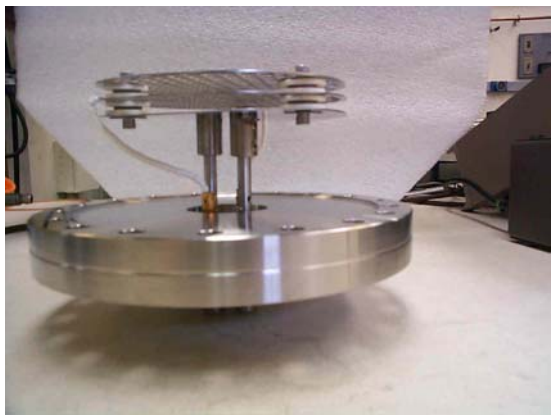


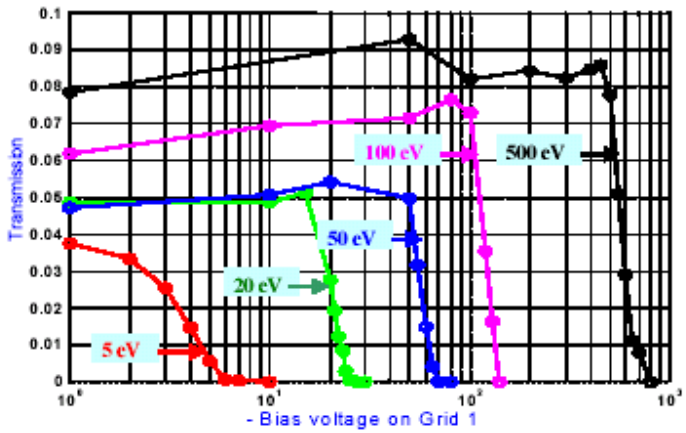
Source Current = 1.72 A; Source Voltage = 1.52 V
Working Distance = 30 mm
Chamber Pressure = 3.0 x10(-6) Torr

Bench Test Results(Measured)

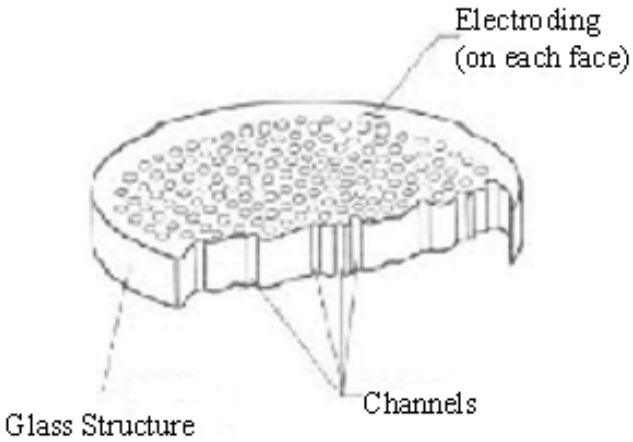


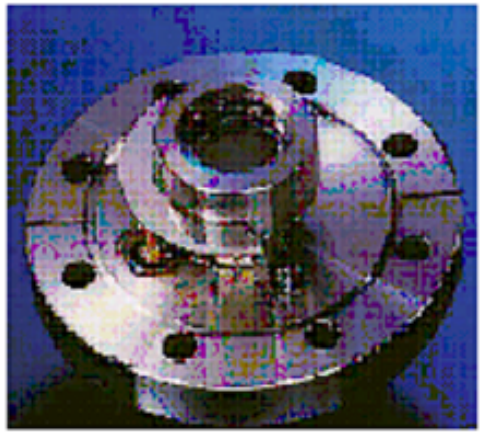
Source Current = 1.65 A; Source Voltage = 1.40 V
Working Distance = 84 mm
Chamber Pressure = 1.3 x10(-7) Torr

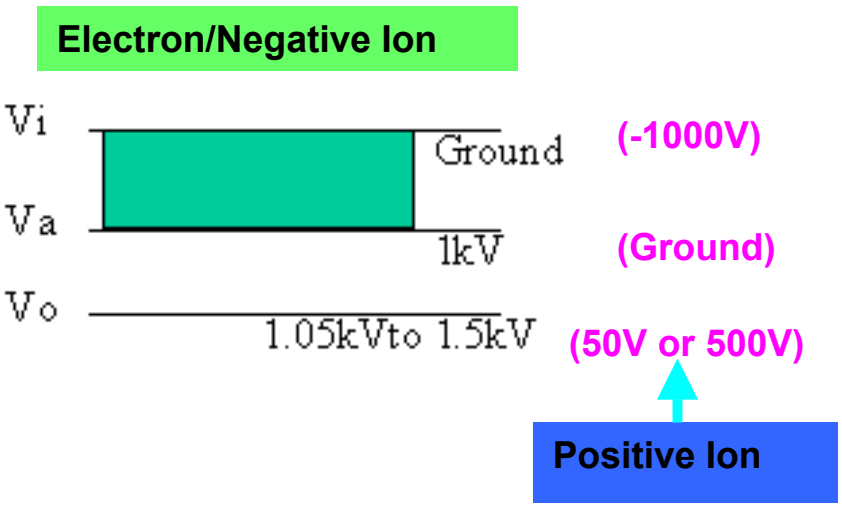




Electron Detector Test Results

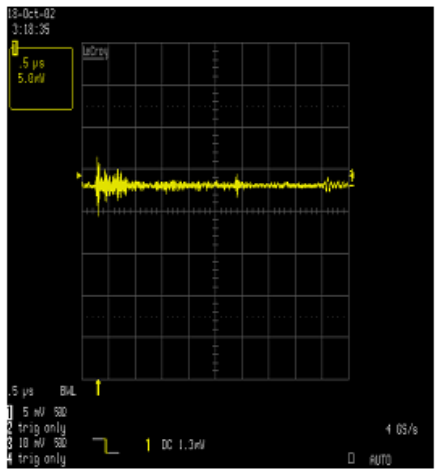




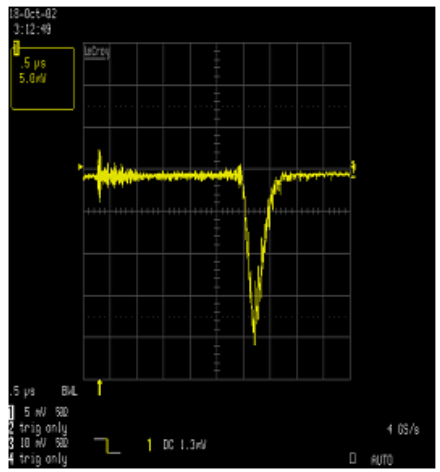


MCP Output Signal

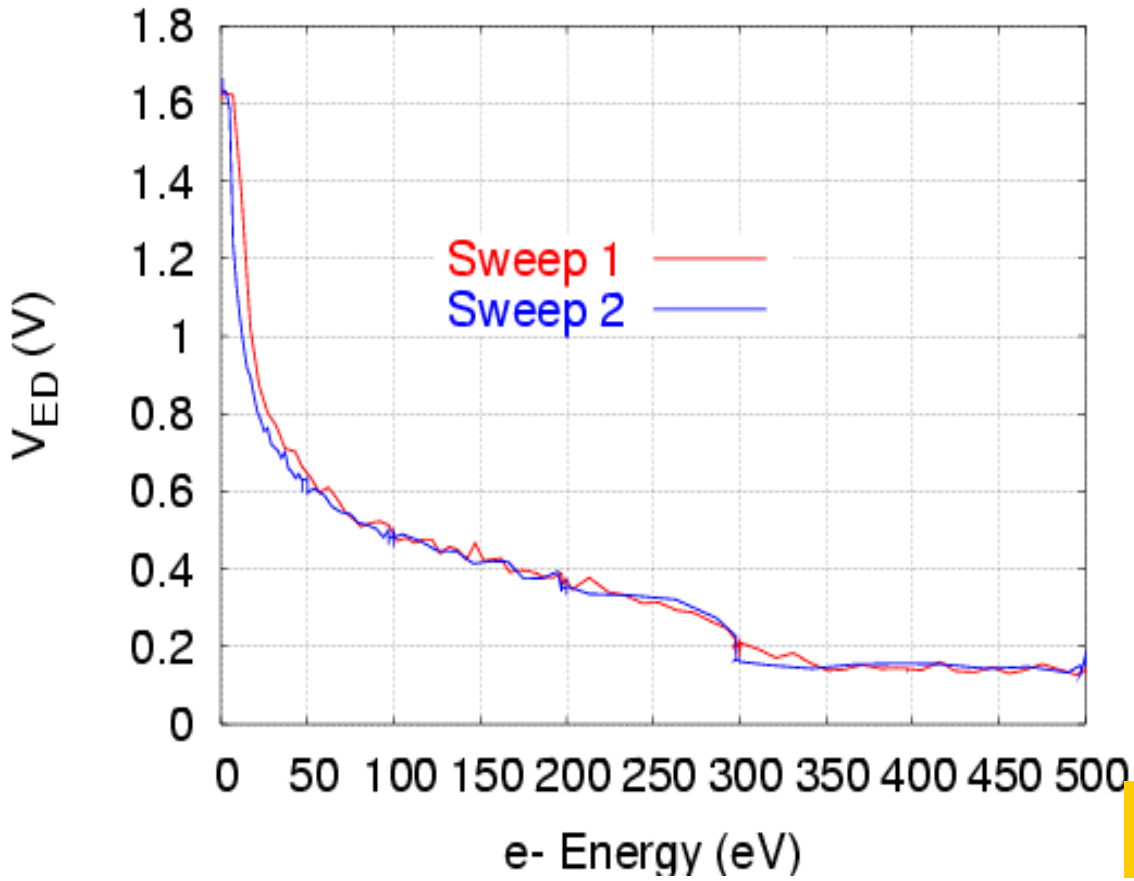
Va=0V; Vo=0V



Va=0.9kV; Vo=1.0kV



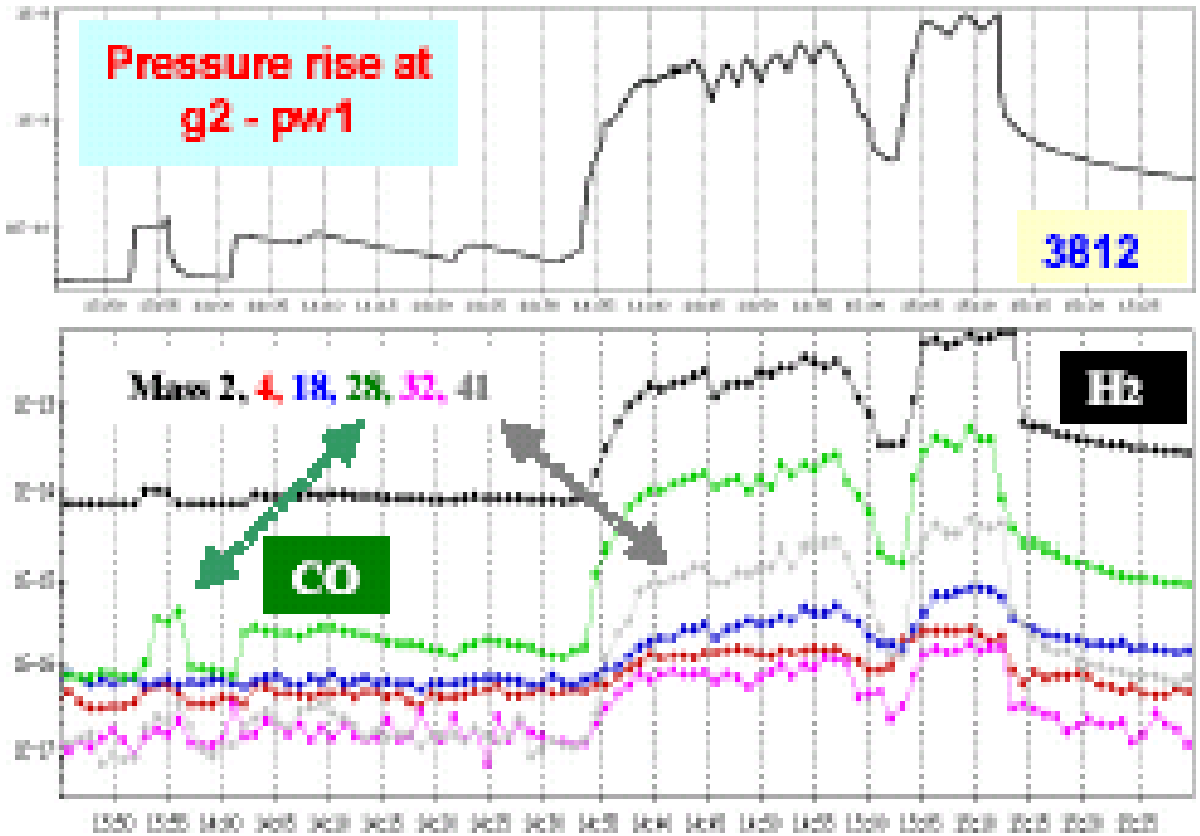
MCP Test Results



Noise level

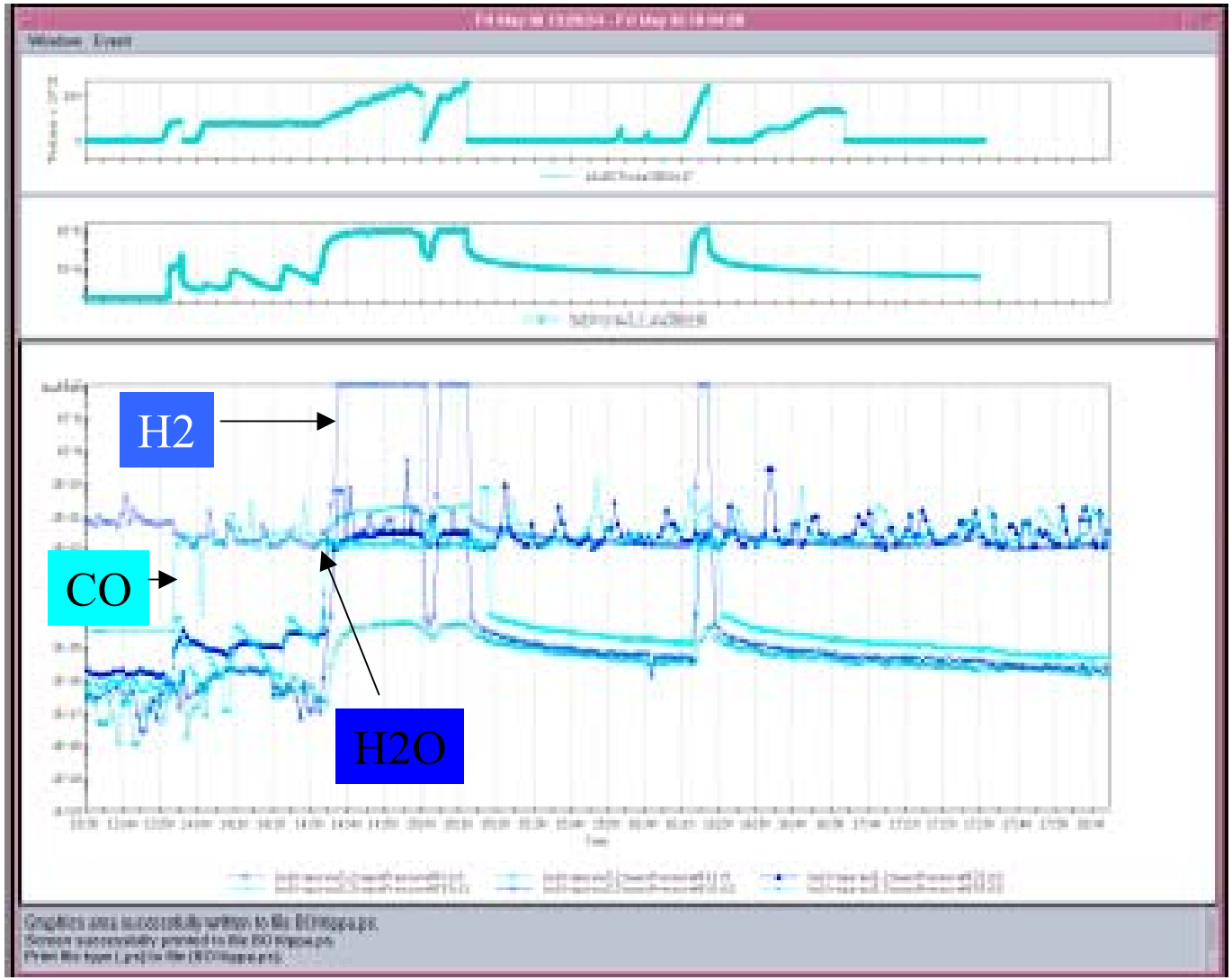
Ubaldo

Electron Energy Spectrum

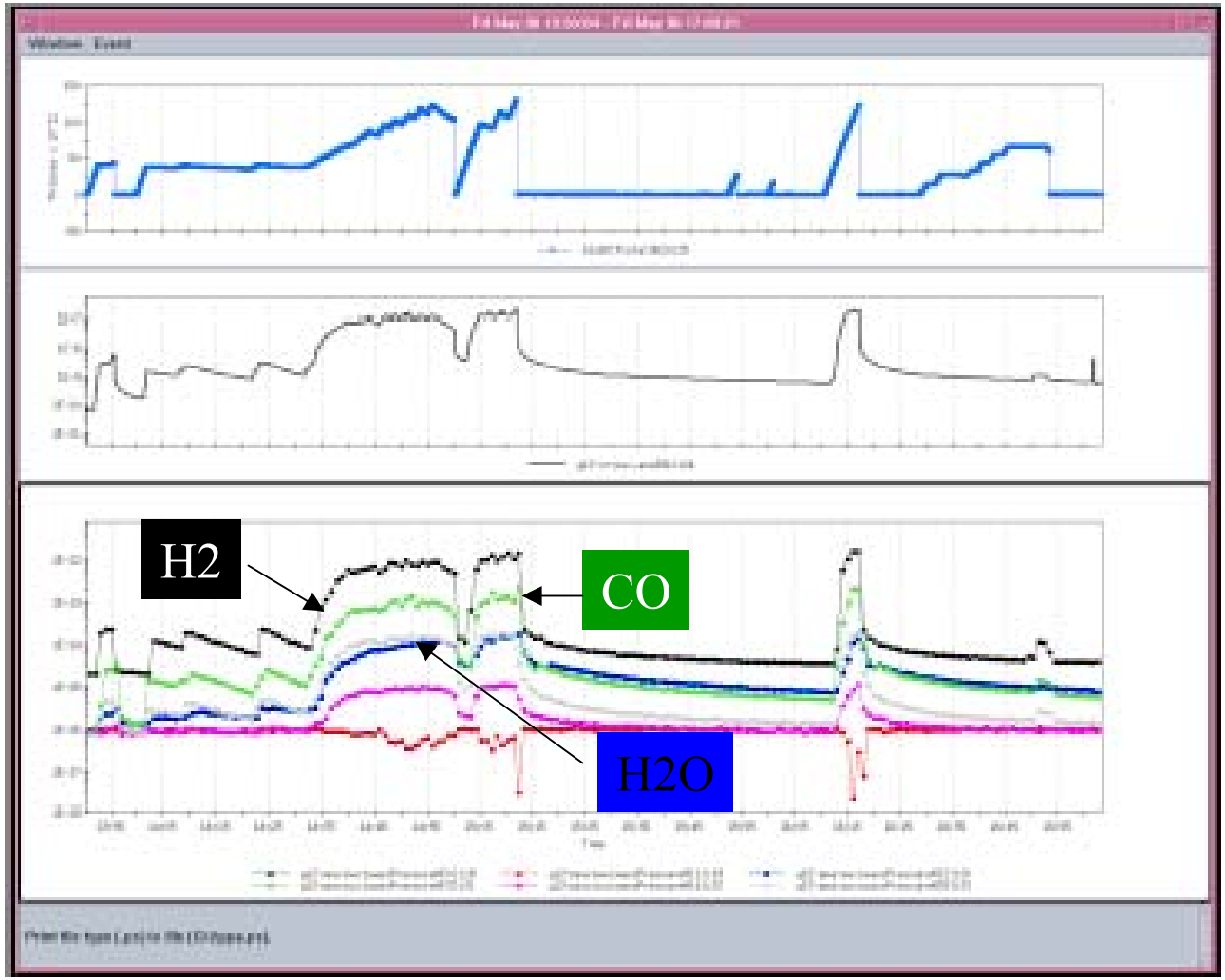


S.Y.Zhang

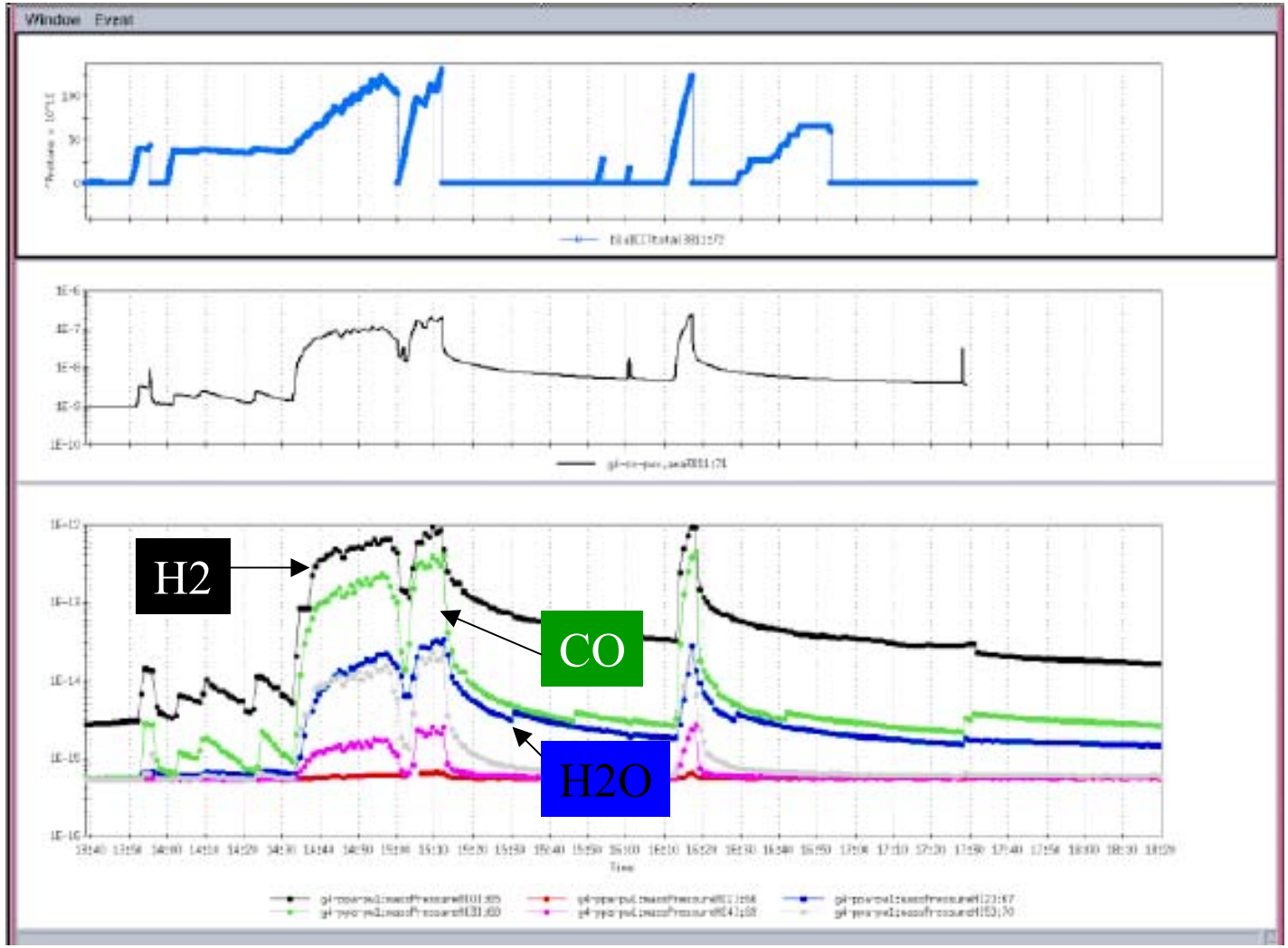
Gas Composition and its Evolution along the Pressure Rise



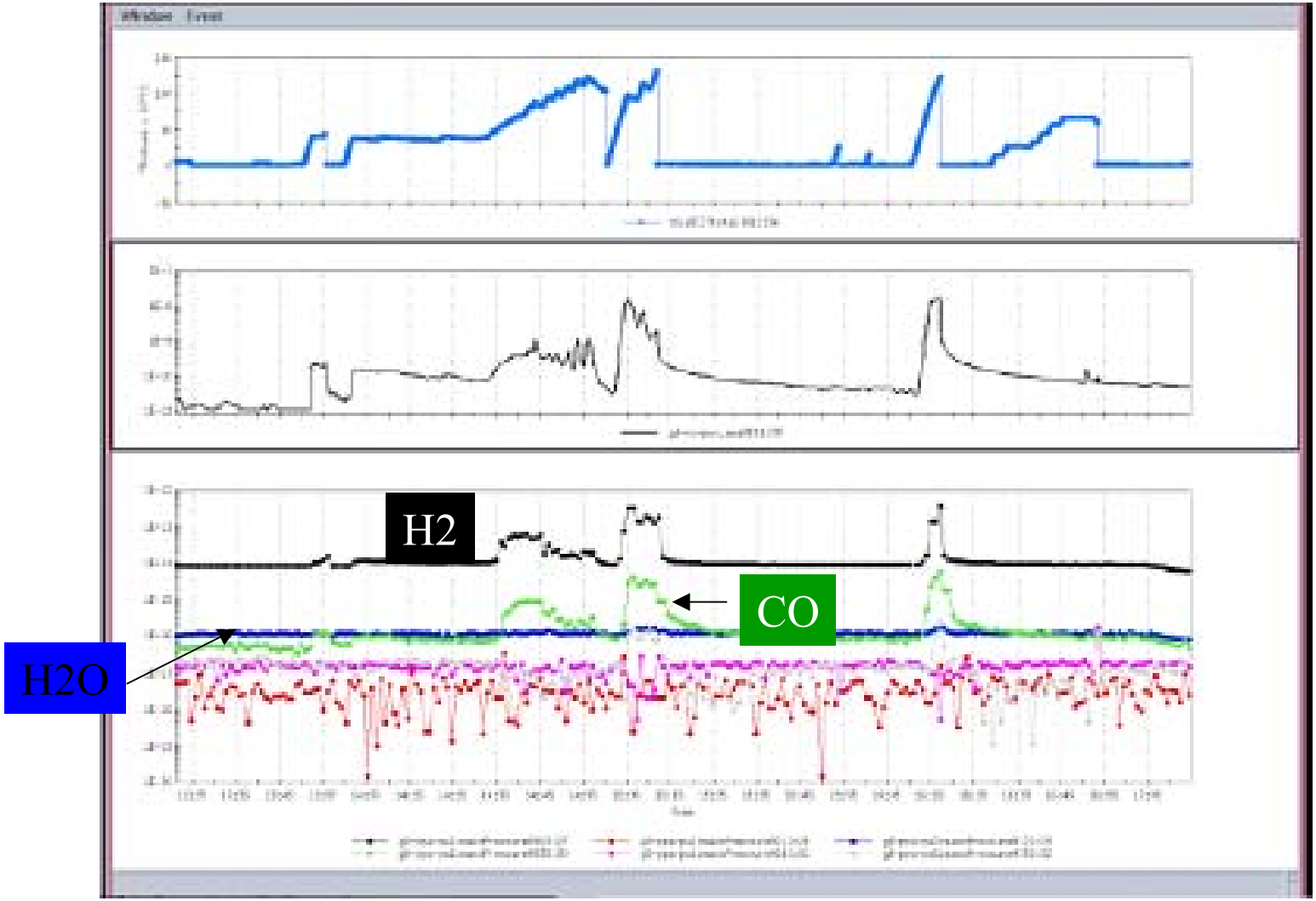
Gas Composition and its Evolution along the Pressure Rise(BO10)



Gas Composition and its Evolution along the Pressure Rise(G12)



Gas Composition and its Evolution along the Pressure Rise(G4)



Gas Composition and its Evolution along the Pressure Rise(G8)

Residual Gas Spectrum, during multipacting (CERN)

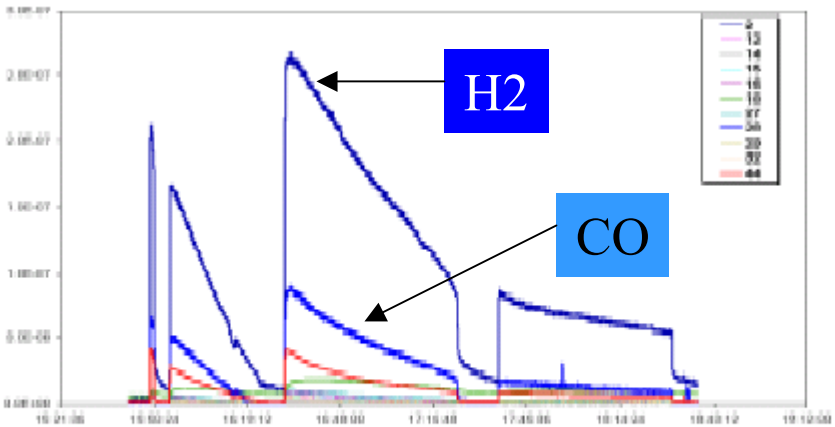


Figure 5-5: *Residual gas spectrum, during multipacting. Current $I^{+}_{G_i}$, measured on the RGA gauge collector (see appendix E).*

Different scale respect to the above figure, where peak 2(H2) and 28 have been omitted, to show the behaviour of the peak 18(H2O)

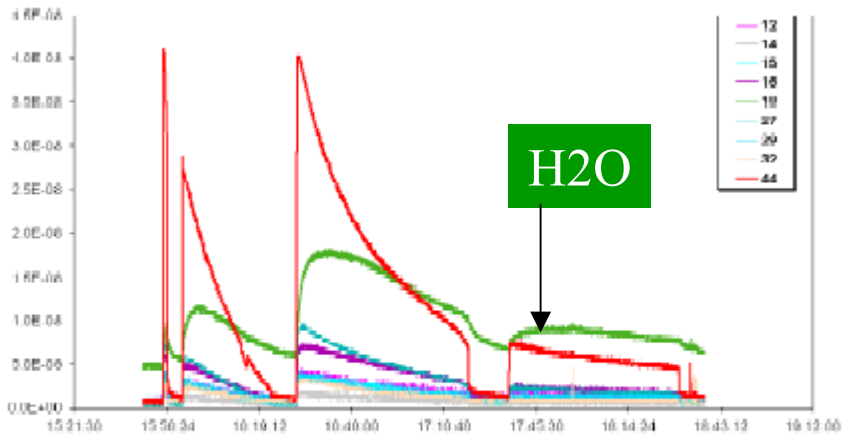


Figure 5-6: *Residual gas spectrum, during multipacting. Different scale respect to the preceding figure, where peaks 2 (H_2) and 28 have been omitted, to show the behaviour of the peak 18 (H_2O).*

Extensive studies at CERN have shown that *water vapour* plays an important role in the contribution of the SEY. It is possible that the presence of water molecules increases the sticking probability for other gases.

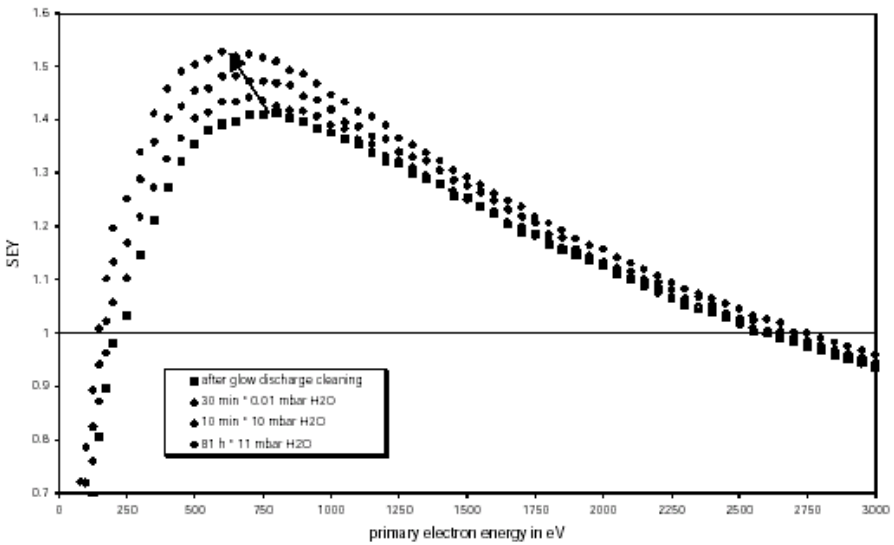
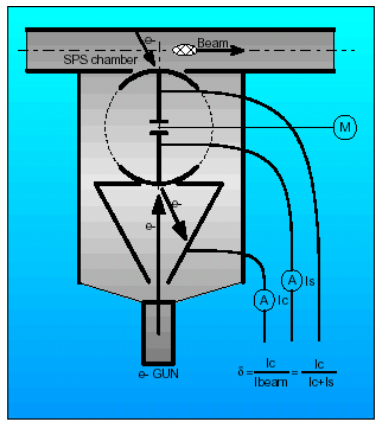
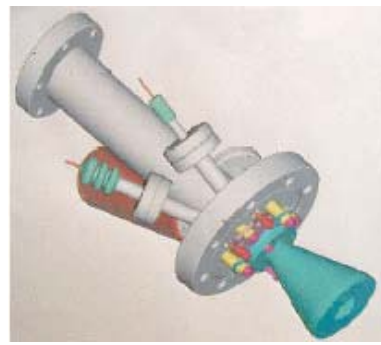


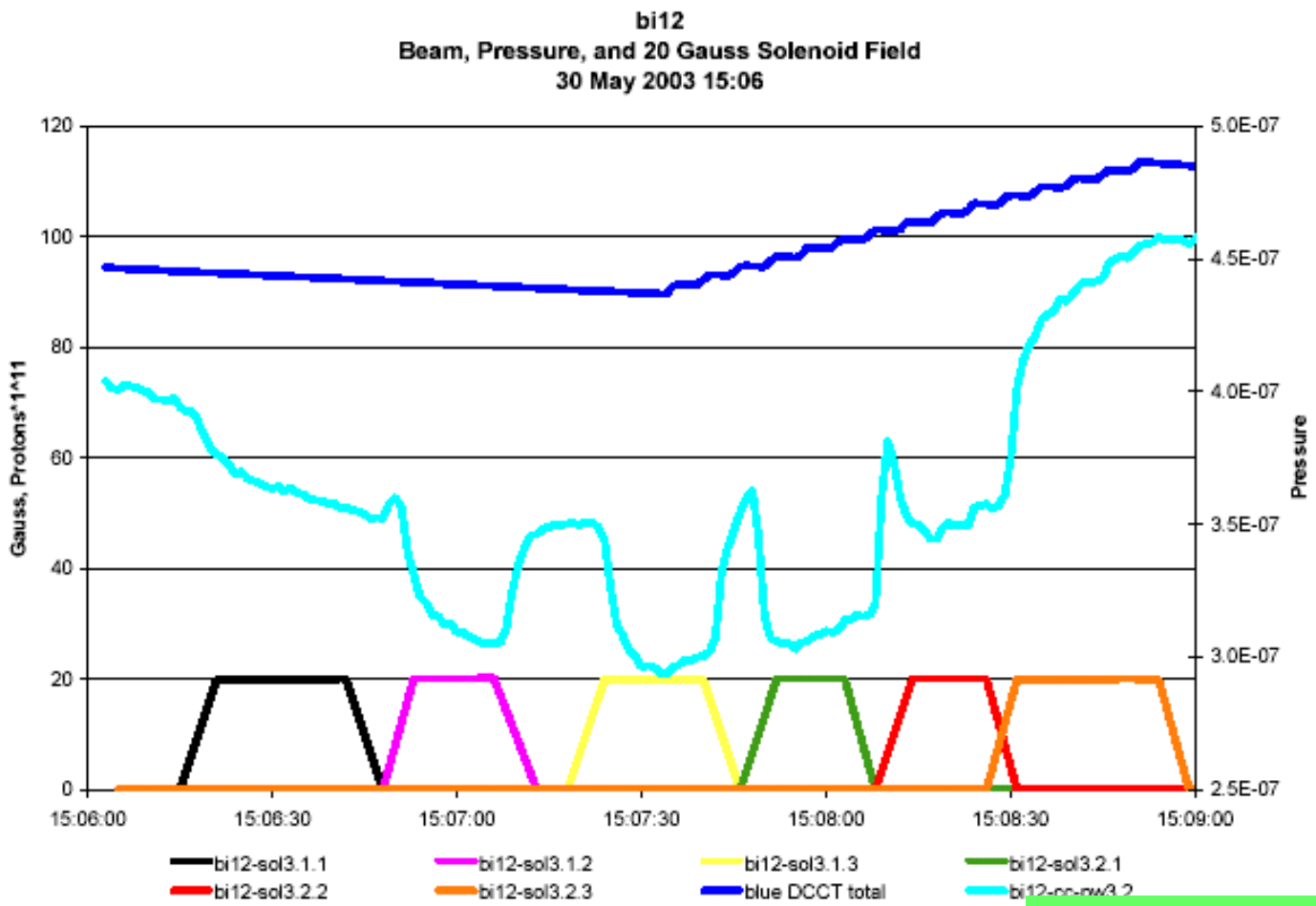
Figure 18; Total SEY δ after different doses of H_2O as a function of the primary electron energy. The SEY increases with the exposed dose of H_2O.





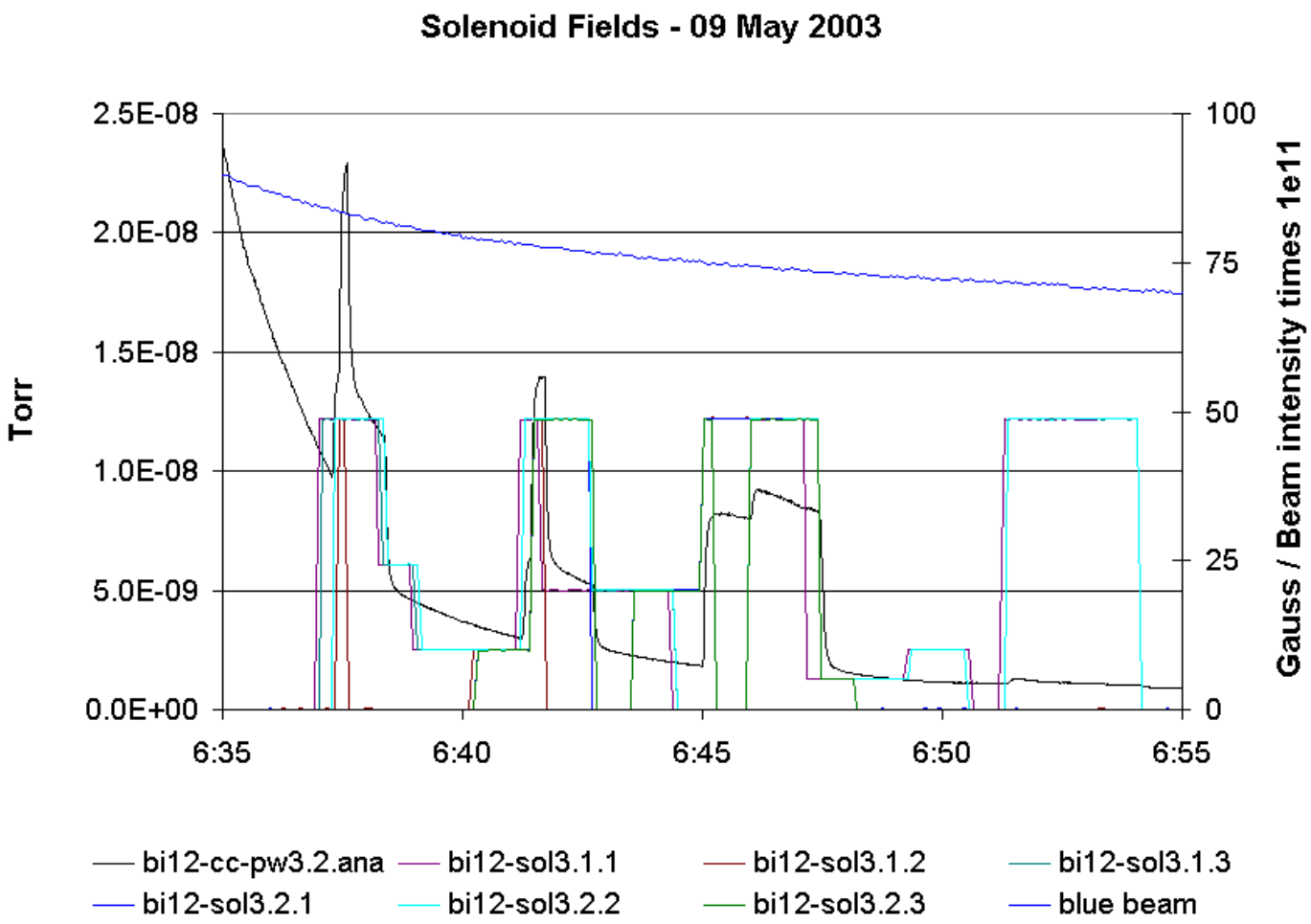
In-Situ SEY Measurement

(CERN)



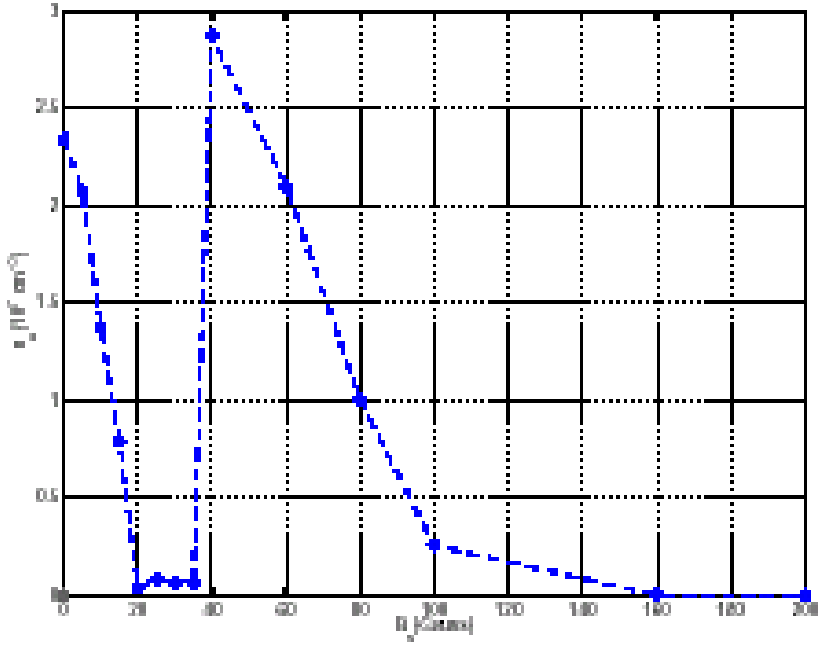
L.Smart

Solenoid Field Effect(1)-May 30



Solenoid Field Effect(2)-May 09

SLAC-PUB-9813



Cyclotron Resonance Condition

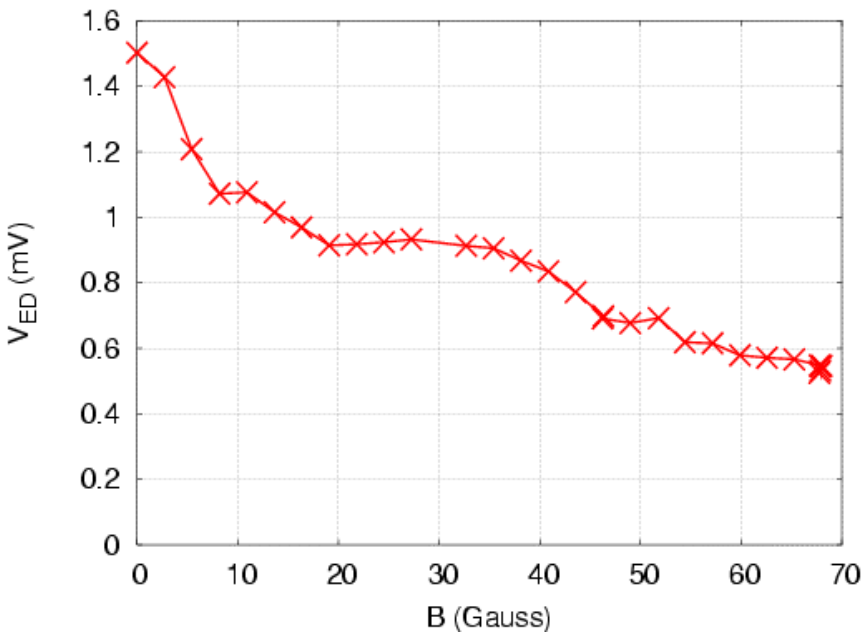
$$B_x^c = \frac{\pi m c^2}{e S_b}.$$

Cyclotron Resonance?

Cyclotron frequency does not match bunch spacing

-further study needed

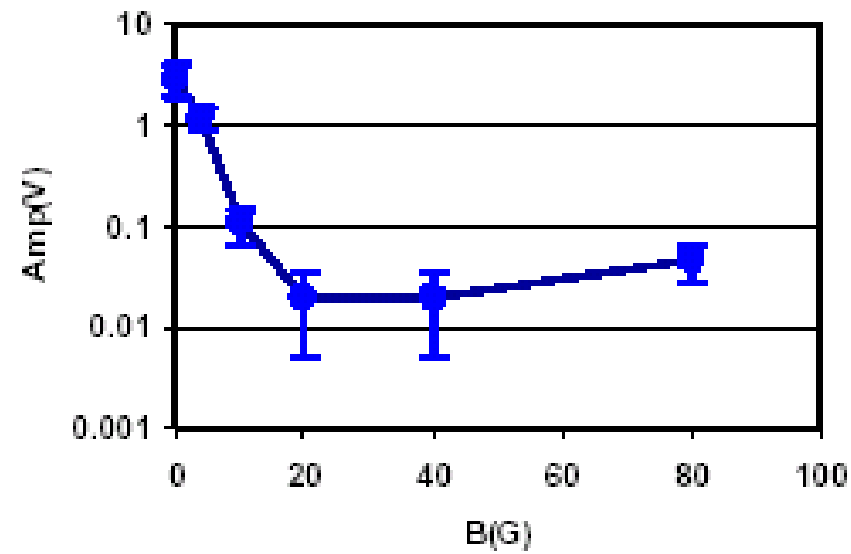
B - Sweep during fill #3812.
($N=1.5 \cdot 10^{10}$ *p-pb*).



Even at the maximum value of B, V_{ED} is only reduced by a factor of ~3 (not enough to fully suppress the cloud).

~in RHIC we have ~7% solenoids covering, Maybe more solenoid needed in the future.

PSR Test Result

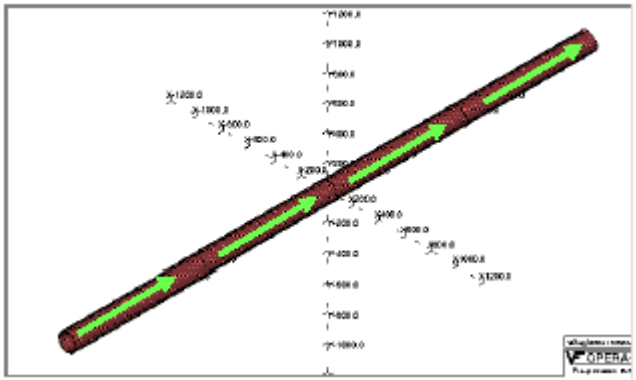


EC was reduced by a factor ~50 by ~20G solenoid field.

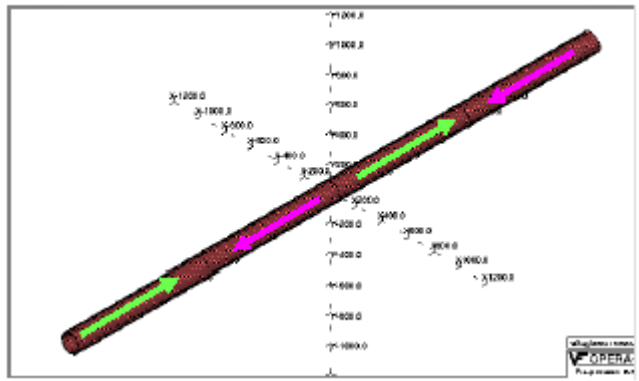
However, there was no measurable effect on the instability threshold when weak solenoids covering ~10% of the ring circumference were excited.

Solenoid Field Effect(3)

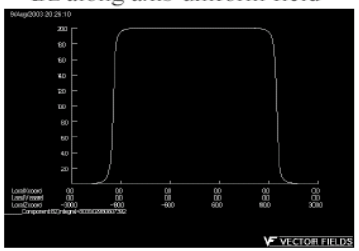
Uniform Solenoid

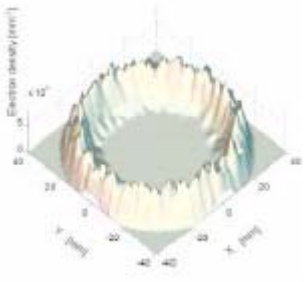


Non-uniform Solenoid

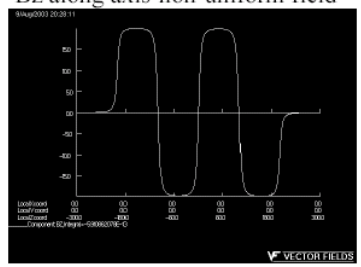


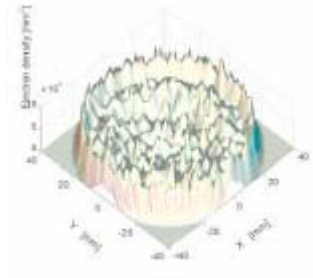
Bz along axis-uniform field





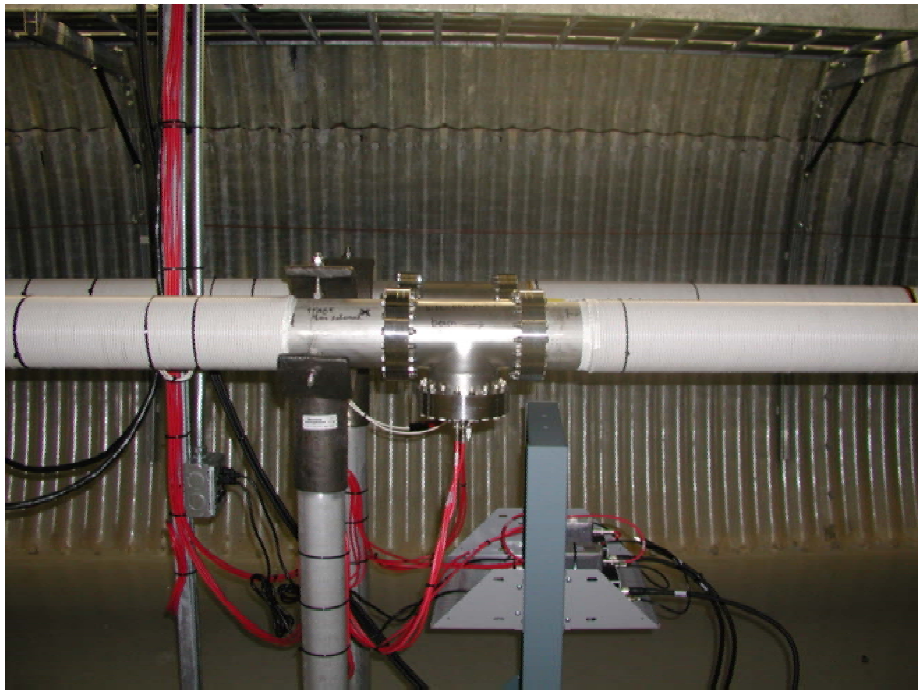
Bz along axis-non-uniform field





From the simulation, we can see no electron in the center of the beam pipe if we use equal polarity solenoid field

Solenoid Field Effect(4)



1002B ED Sol PS

PS	ED SOL Name	seg a	pol	seg b	pol	seg c	pol	seg d	pol	seg e	pol	Tot Len
1	yo1-sol3.1	0.5	B	1	A	1	B	1	A	0.5	B	3.5
2	yo1-sol3.2	1	A	1	B	1	A	1	B			4
3	bi1-sol3.1	1		1		1		1				4
4	bi1-sol3.2	1		1		1		1				4
5	yi2-sol3.1	1	A	1	B	1	A	1	B			4
6	bo2-sol3.1	0.5	B	0.5	A	1	B	1	A	1	B	3
*	g1-solx	1		1		0.3						2.3
*	g2-solx	1		1		0.3						2.3

1012A ED Sol PS

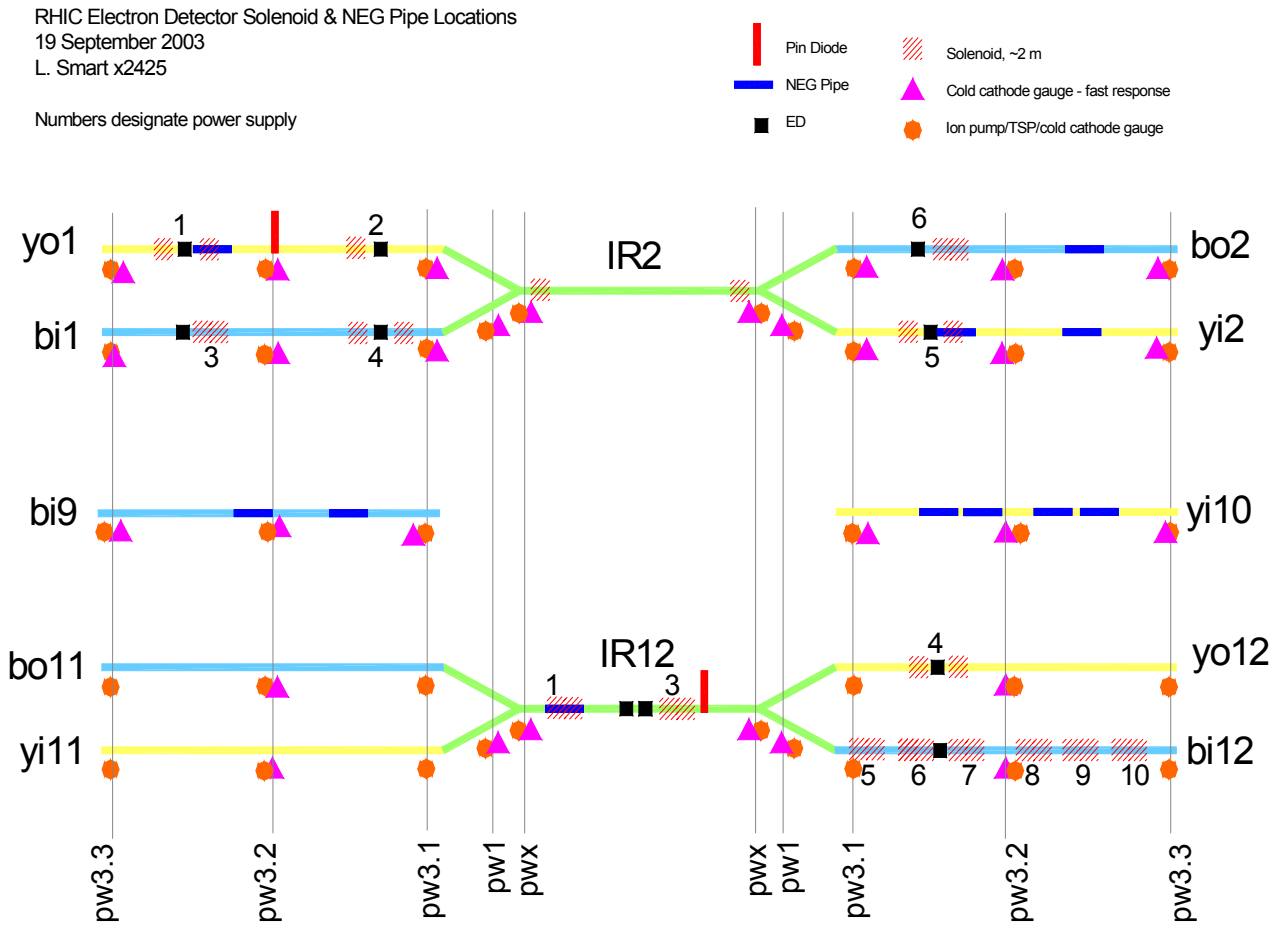
PS	ED SOL Name	seg a	pol	seg b	pol	seg c	pol	seg d	pol	seg e	pol	Tot Len
1	g11-solx.2	1	B	1	A	1	B	1	A			4
2	g11-solx.1	1	B	1	A	1	B					3
3	g12-solx	0.8	A	1	B	1	A	0.7	B			3.5
4	yo12-sol3.1	1	B	1	A	1	B	1	A			4
5	bi12-sol3.1.1	1	A	1	B	1	A	1	B			4
6	bi12-sol3.1.2	1	A	1	B	1	A	1	B			4
7	bi12-sol3.1.3	1	A	1	B	1	A	1	B			4
8	bi12-sol3.2.1	1	A	1	B	1	A	1	B			4
9	bi12-sol3.2.2	1	A	1	B	1	A	1	B			4
10	bi12-sol3.2.3	1	A	1	B	1	A	0.8	B			3.8

All lengths are in meters.
Solenoid segments are arranged clockwise - segment B is to the right of segment A.
* No PS assigned to these solenoids

Polarity conventions - not set in stone
Yellow or Blue beam pipes:
A polarity:positive current generates a magnetic field in the direction of the beam
B polarity: positive current generates field against the direction of the beam.

For "Green" common beam tubes:
A polarity:positive current generates a magnetic field in the direction of the BLUE beam
B polarity: positive current generates field against the direction of the BLUE beam.

Solenoid at RHIC tunnel & Solenoid PS



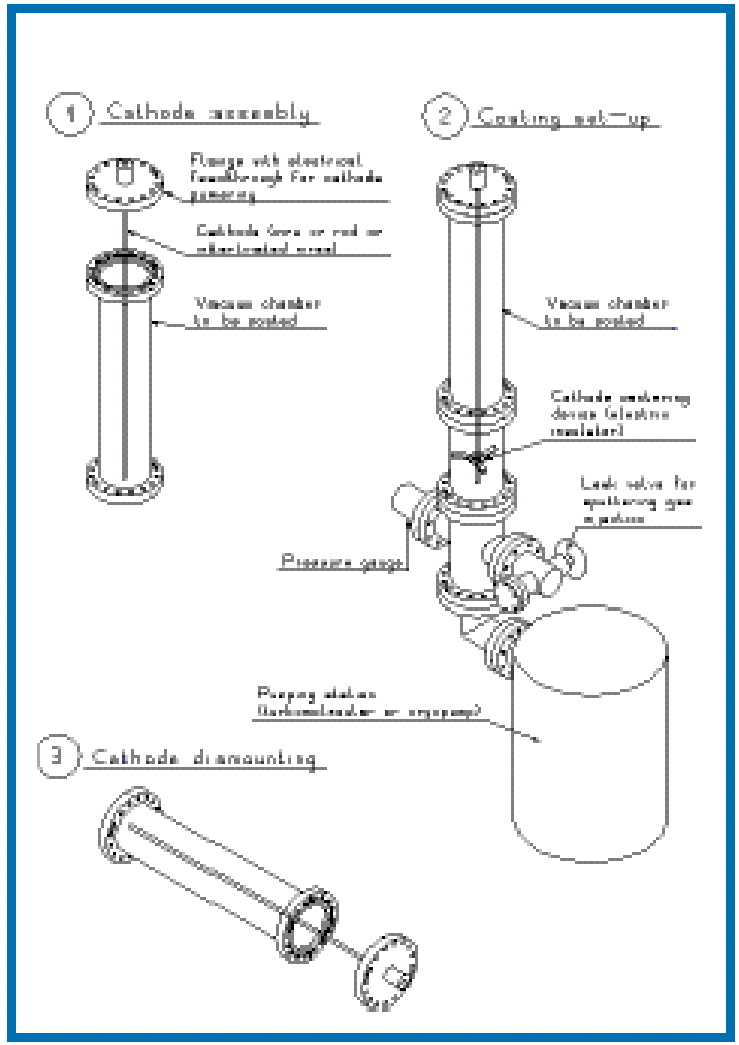
New Components for 2004 Run

RHIC will Install 11 x 5.2m x 12cmΦ TiZrV coated pipes this summer

coated by SAES Getters with license from CERN

at Q3-Q4 with high P during d-Au runs

yo1, bo2, yi2(2), bi9(2), yi10(4), ip12

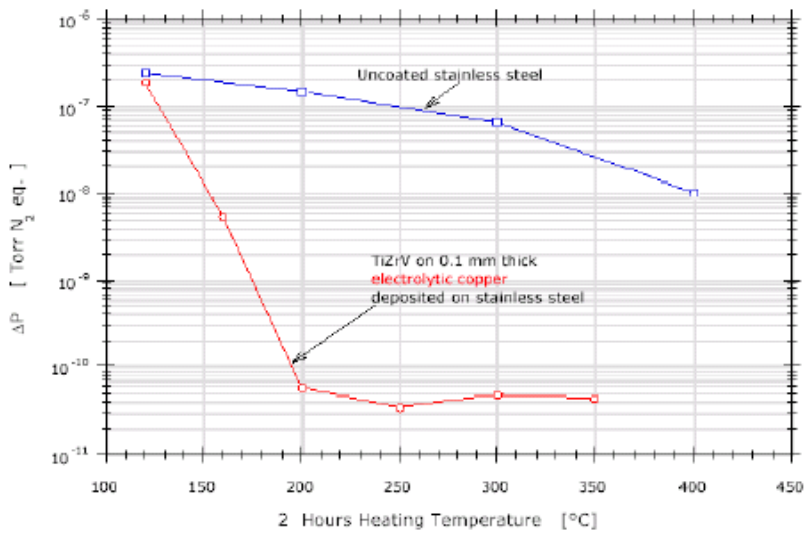


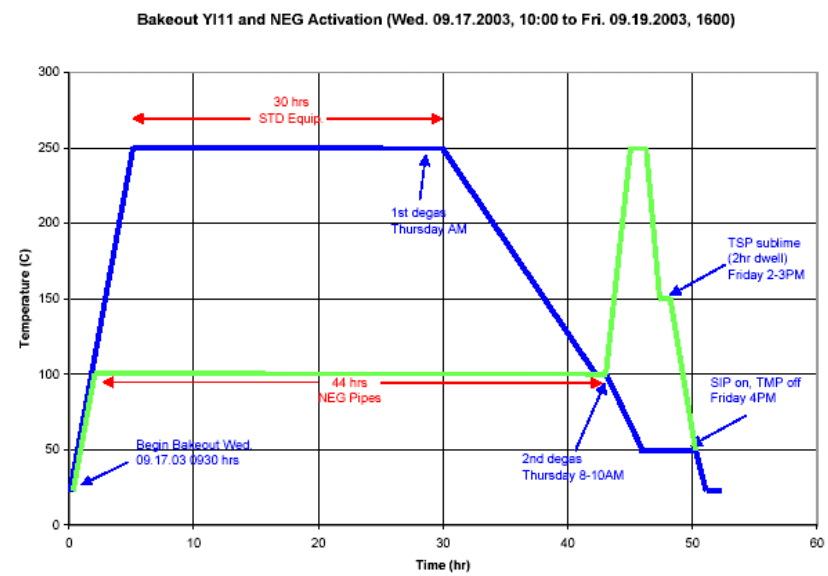
TiZrV NEG coating pipes

- TiZrV NEG(Non Evaporable Getter) coating

- against ion induced pressure instability(low mass pump)
- to limit electron cloud build up(low SEY) once activated at 200~250°C(δ_{max} ~ 1.1) and also after saturation (δ_{max} <1.2~1.3 after exposition to water vapour)
- to reduce the background pressure(electron induced desorption main gas source)

TiZrV NEG coating advantages





TiZrV NEG coating activation process

- Electron desorption yields

Intrinsic desorption yields

For St Steel heated at 300°C x 2 h:

H_2 ~ 1×10^{-2} molecules/electron

CH_4 ~ 1.5×10^{-3} molecules/electron

CO ~ 8×10^{-3} molecules/electron

For a fully activated TiZrV coating:

H_2 ~ 2×10^{-4} molecules/electron

CH_4 ~ 5×10^{-6} molecules/electron

CO ~ 1×10^{-4} molecules/electron

For St Steel heated at 400°C x 2 h:

H_2 ~ 3×10^{-3} molecules/electron

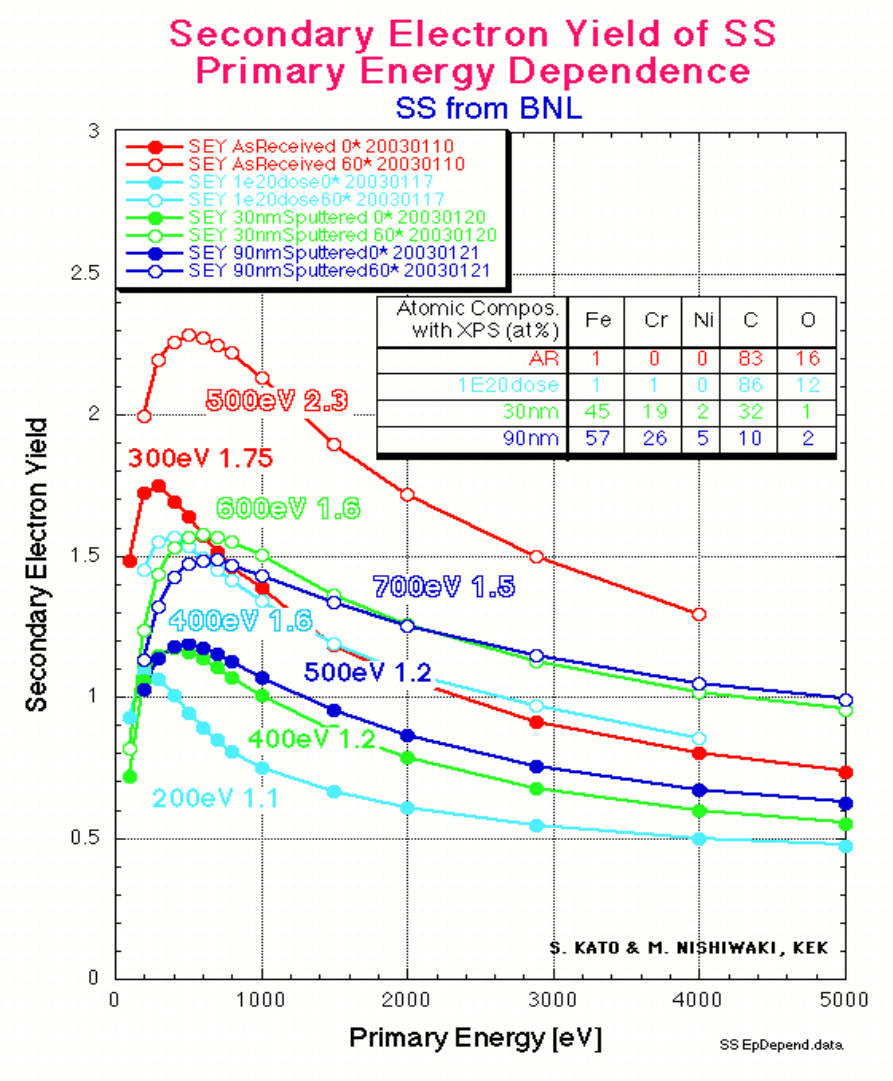
CH_4 ~ 5×10^{-4} molecules/electron

CO ~ 1×10^{-3} molecules/electron

- Ion desorption yields

will be reported later … ***Tandem Test***

TiZrV NEG coating Electron desorption &Ion desorption



Atomic Compos. with XPS (at%)	Fe	Cr	Ni	C	O
AR	1	0	0	83	16
1E20dose	1	1	0	86	12
30nm	45	19	2	32	1
90nm	57	26	5	10	2

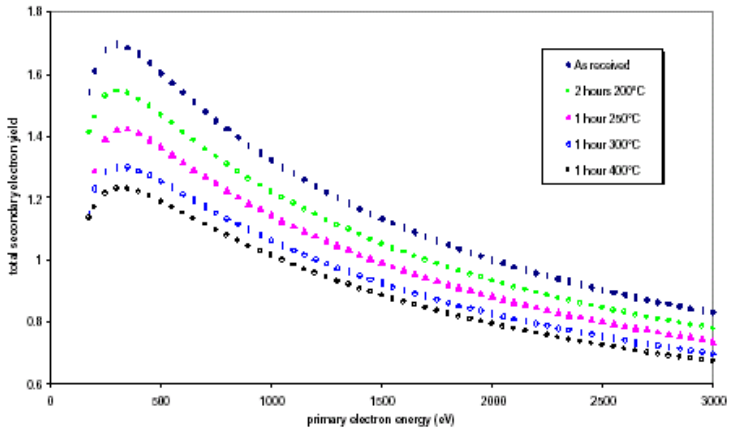


Figure 2, SEY of NEG TiZrV on Cu as a function of the primary electron energy, after 2 hours 200°C, 1 hour 250°C, 300°C and 400°C in-situ activation following 9 previous activation / venting cycles (each cycle consisted of a 24 hour activation at 250°C and subsequent 30 minutes air exposure at room temperature)

SEY Measurements of SS&NEG

Kapton Wire Solenoid

- 8 AWG wire, 234 turns per meter
- ~2.9 Gauss/Amp (17.25 A = 50 Gauss)
- Wrapped in 1-m segments, unless constrained by pipe supports, etc
- To be installed in IR12, bi12, yo12, IR2, yo2, bi2

- New Amplifier for ED
- Two more RGA at YI2 and YI10
- One more MCP at BI1
- ……

More …

- Evidence that solenoid will help to reduce the electron cloud build up
- Residual gas spectrum show electron stimulated desorption due to multipacting

- Improve electron detector design
- Verify experimentally the effectiveness TiZrV NEG coating to reduce the electron cloud build up after activated at 250°C(δ_{max} ~ 1.1) and also after saturation (δ_{max} <1.2~1.3)
- More solenoid(~30%), more NEG pipes(~300m), *in-situ* SEY measurement

Conclusions and Future Works