The 13th ICFA Beam Dynamics Mini-Workshop
Beam Induced Pressure Rise in Rings

RHIC electron cloud and vacuum pressure rise characteristics

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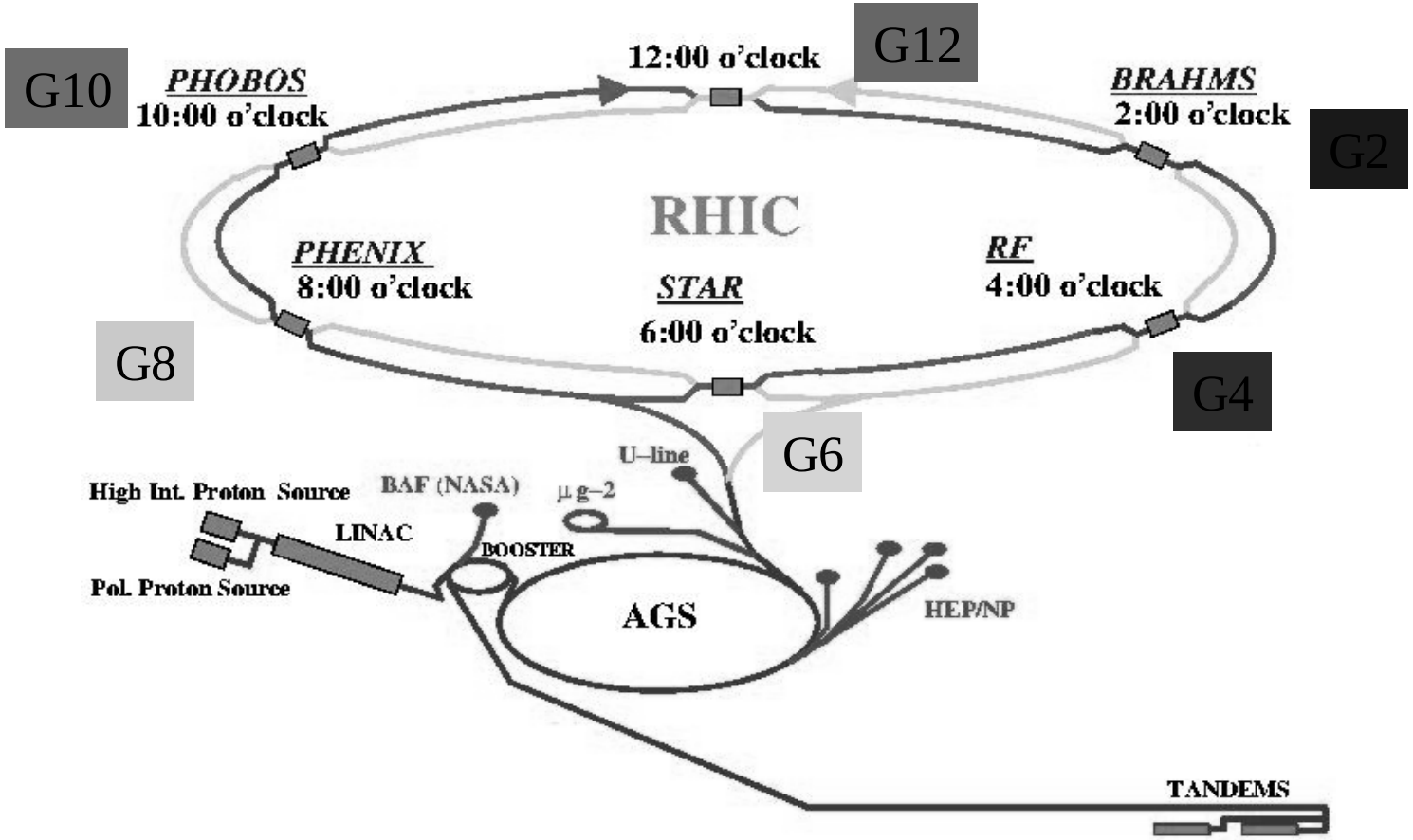
Outline

Part I: Residual gas composition during RHIC pressure rise

Part II: Solenoid field effect on RHIC e-cloud

Accelerator Complex

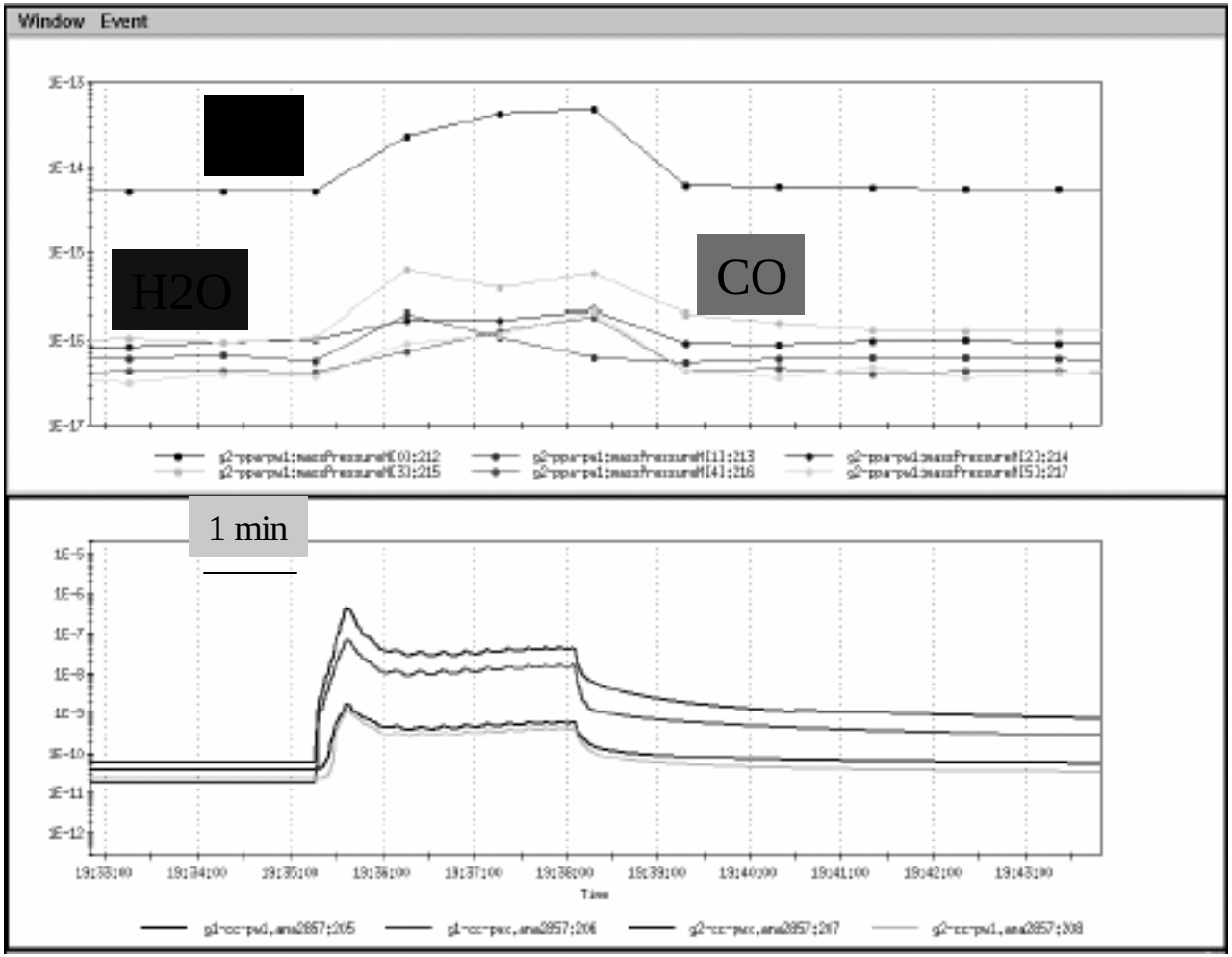


Two type of pressure rises observed at RHIC 2003 run

***the beam transition pressure rise for ions**

***the electron cloud induced pressure rise at the injection**

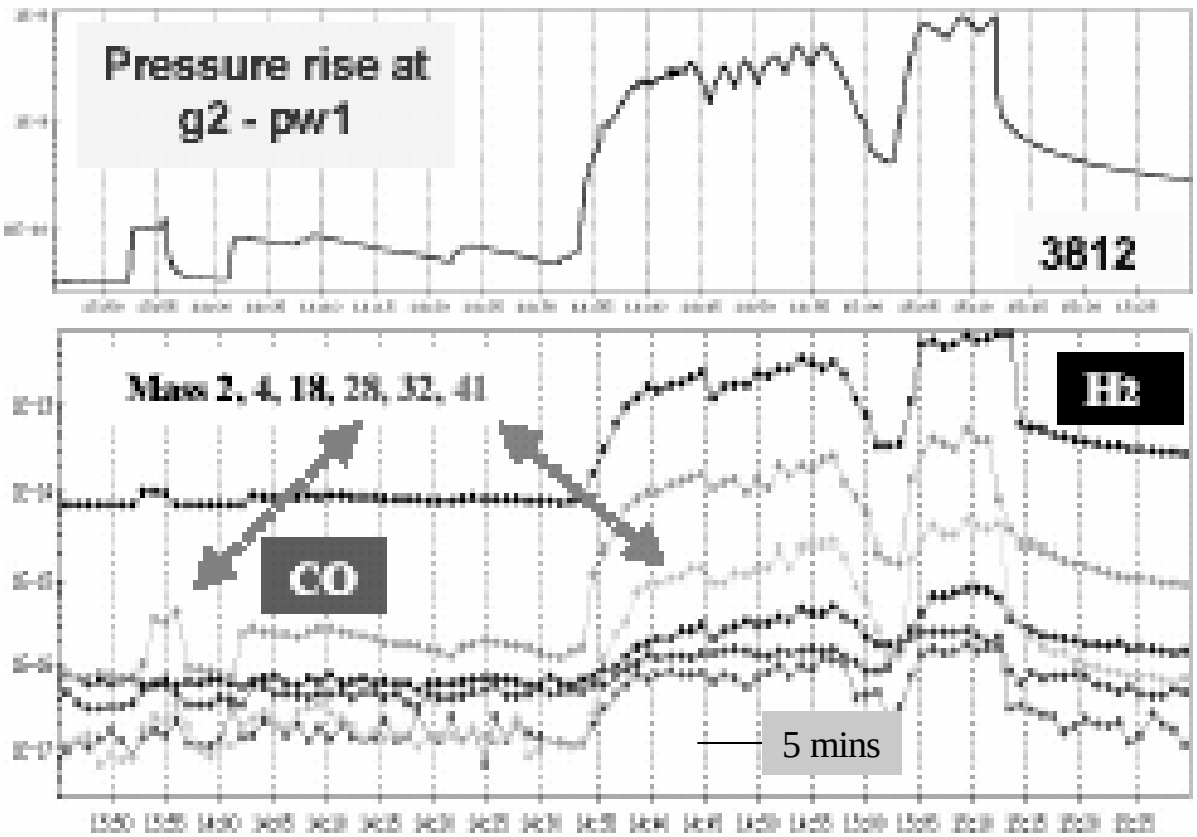
The residual gas composition during multipacting and its evolution along the pressure rise is very helpful toward our understanding in this critical issue



Gas Composition and its Evolution along the Pressure Rise(G2)-Beam Transition Pressure Rise

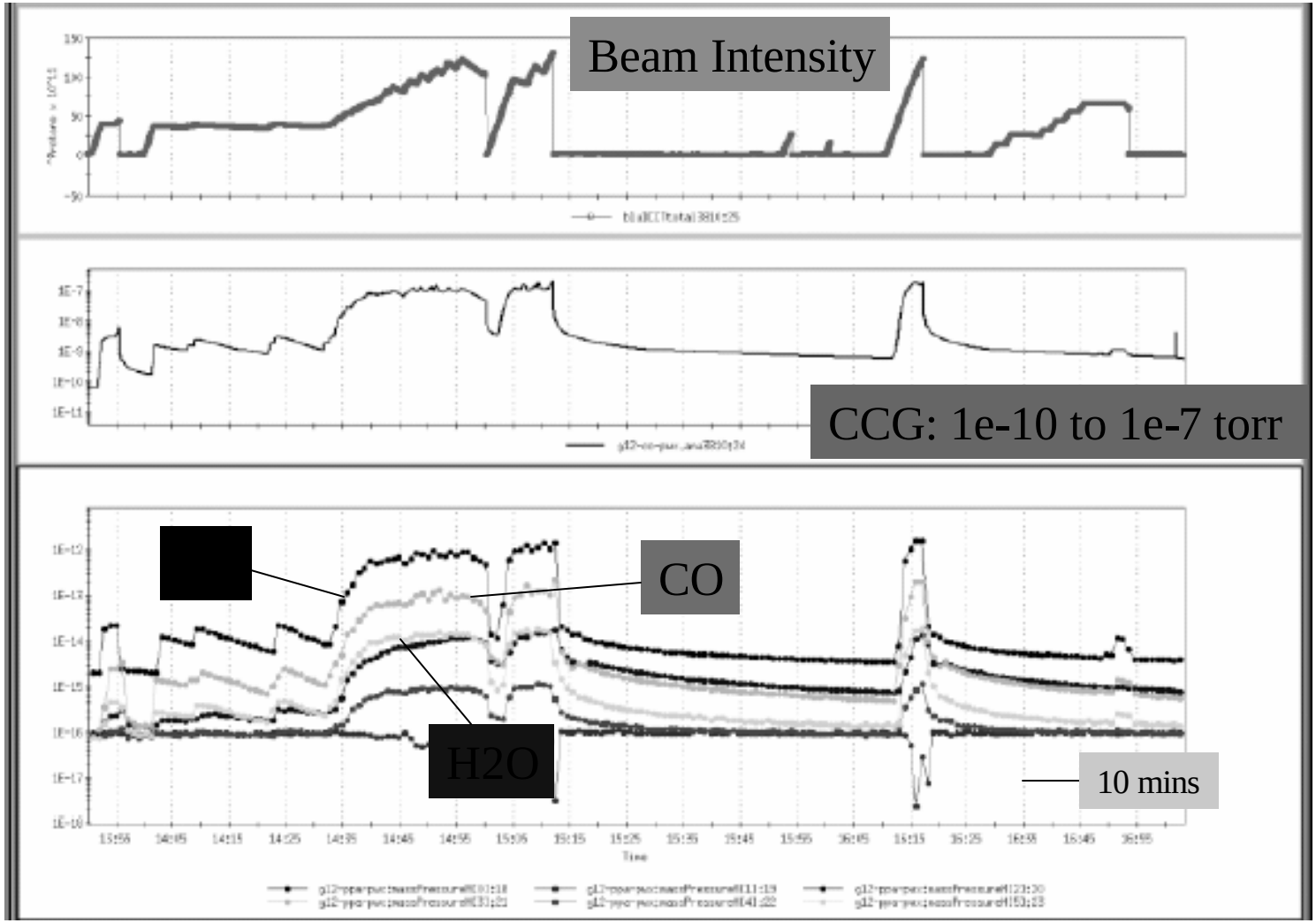
More Concern about Gas Composition and its Evolution along the Electron Cloud induced pressure rise at the injection

We will focus on that!

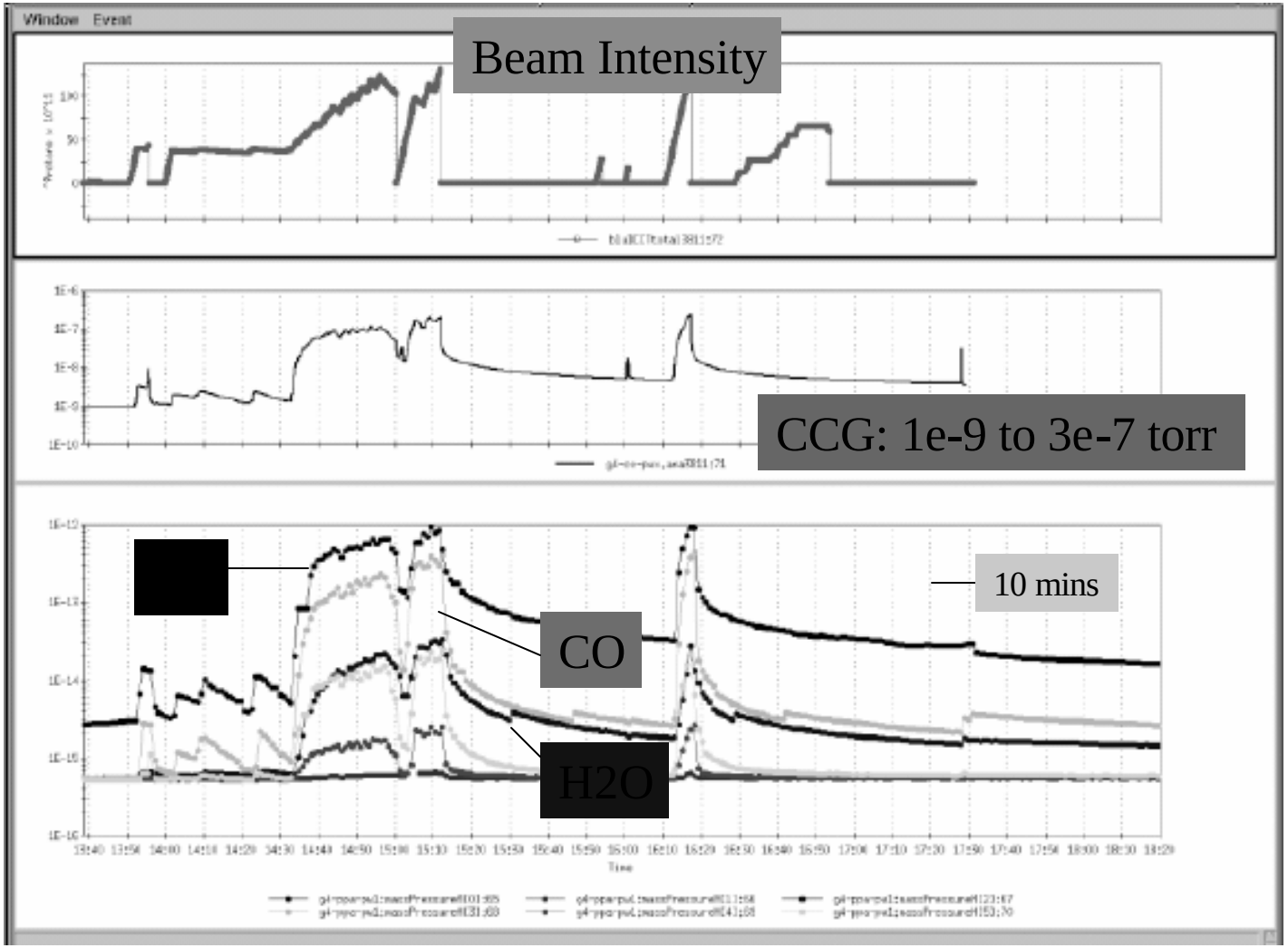


S.Y.Zhang

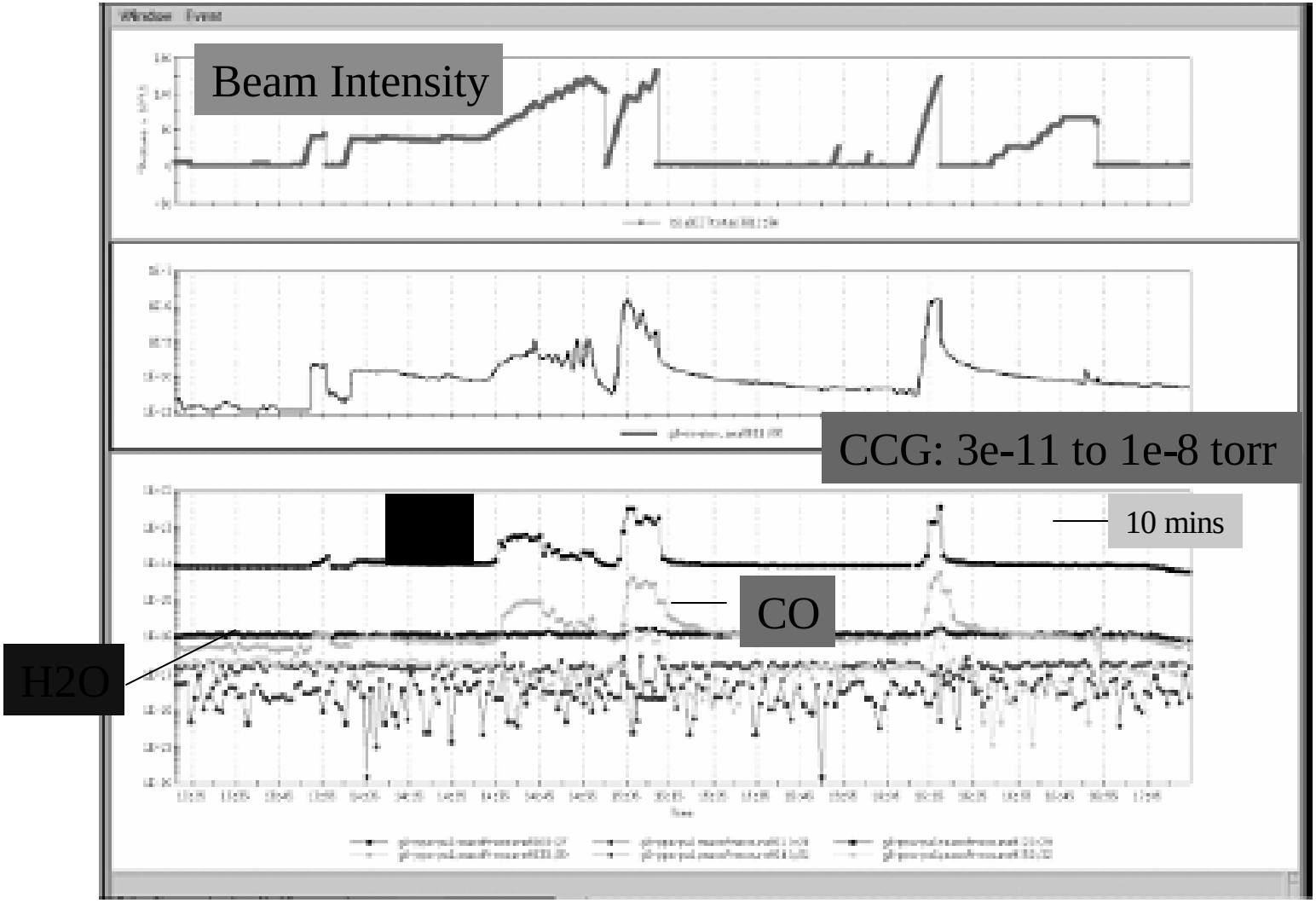
Gas Composition and its Evolution along the Pressure Rise(G2)



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)

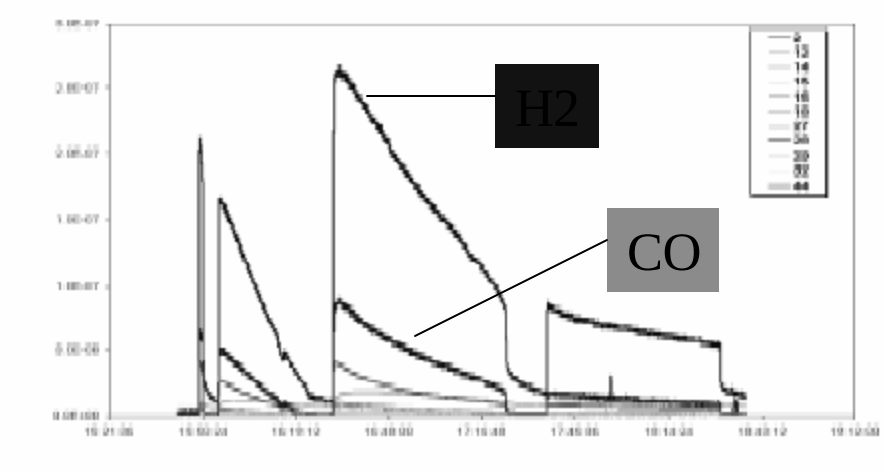


Figure 5-5: *Residual gas spectrum, during multipacting. Current $I^{+}_{G_i}$, measured on the RGA gauge collector (see appendix E).*

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)

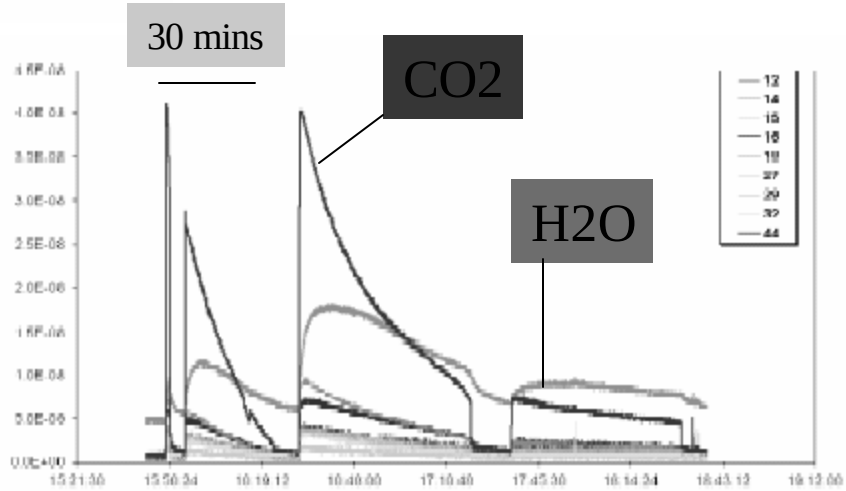


Figure 5-6: *Residual gas spectrum, during multipacting. Different scale respect to the preceding figure, where peaks 2 (H_2) and 28 have been omitted, to show the behaviour of the peak 18 (H_2O).*

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.

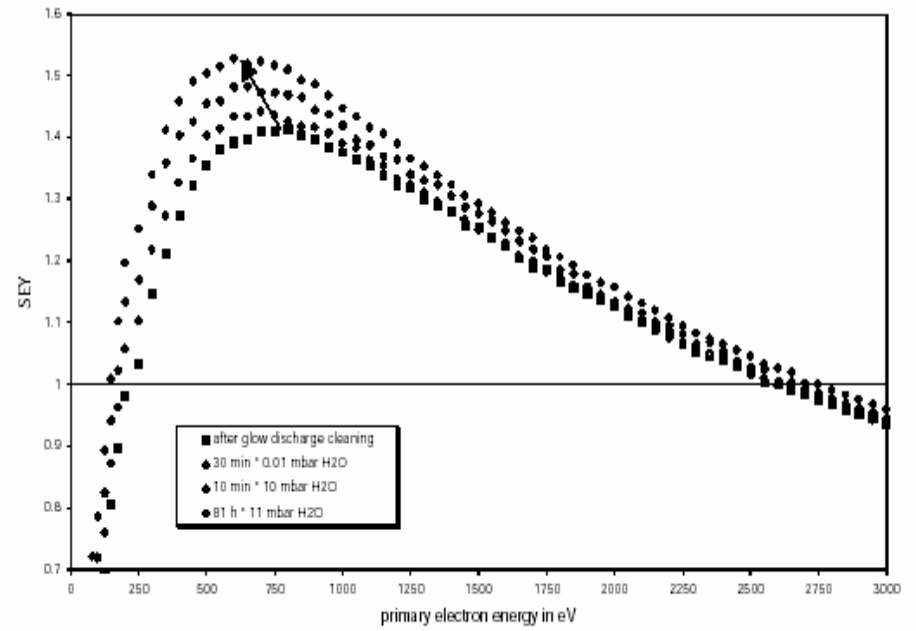
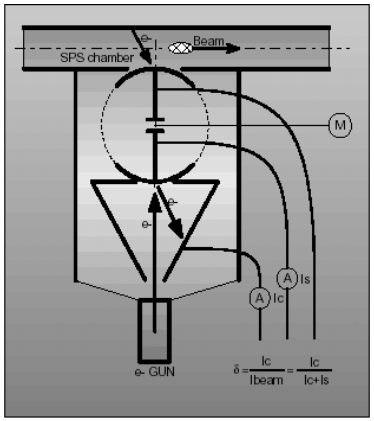
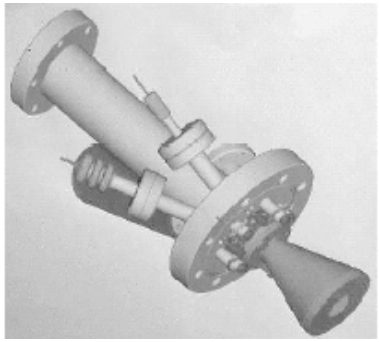


Figure 18; Total SEY δ after different doses of H_2O as a function of the primary electron energy. The SEY increases with the exposed dose of H_2O.





N.Hilleret

In-Situ SEY Measurement

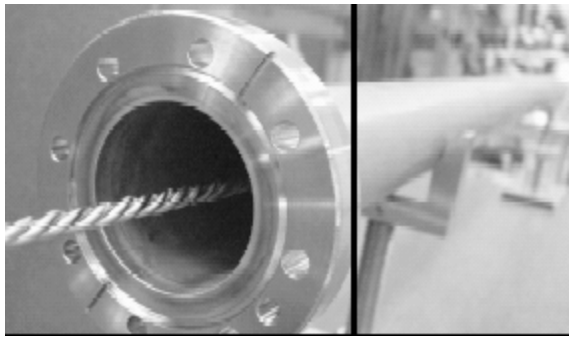
(CERN)

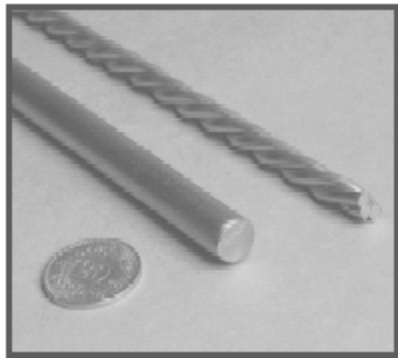
RHIC Installed 11 x 5.2m x 12cmF TiZrV coated pipes this summer

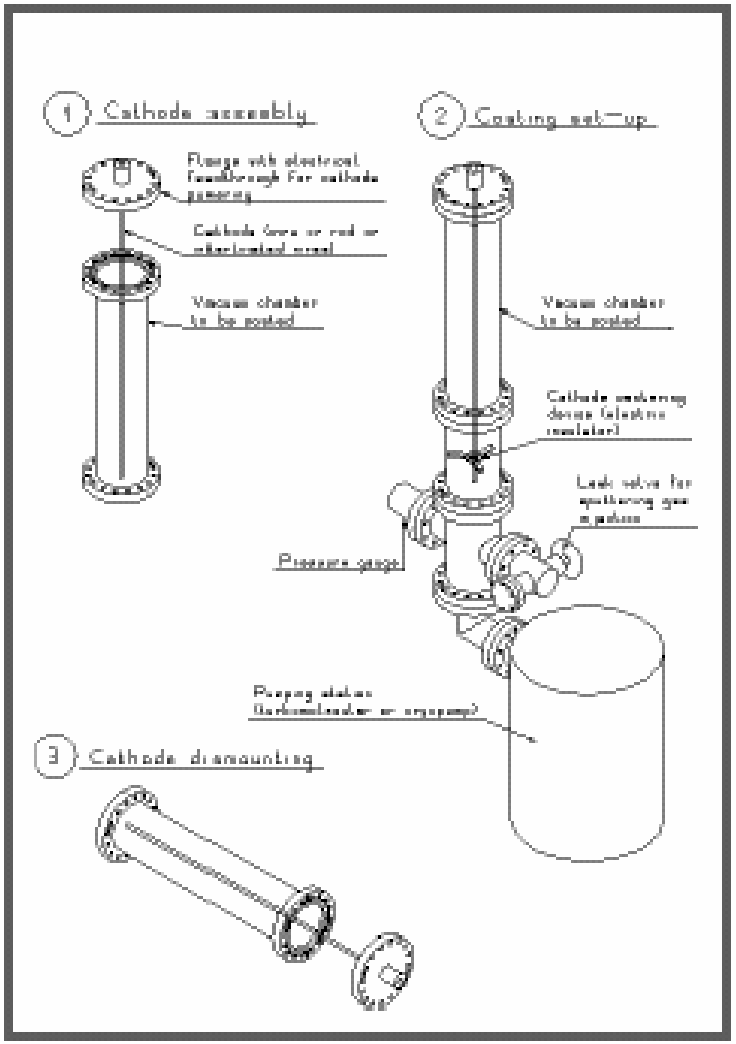
coated by SAES Getters with license from CERN

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

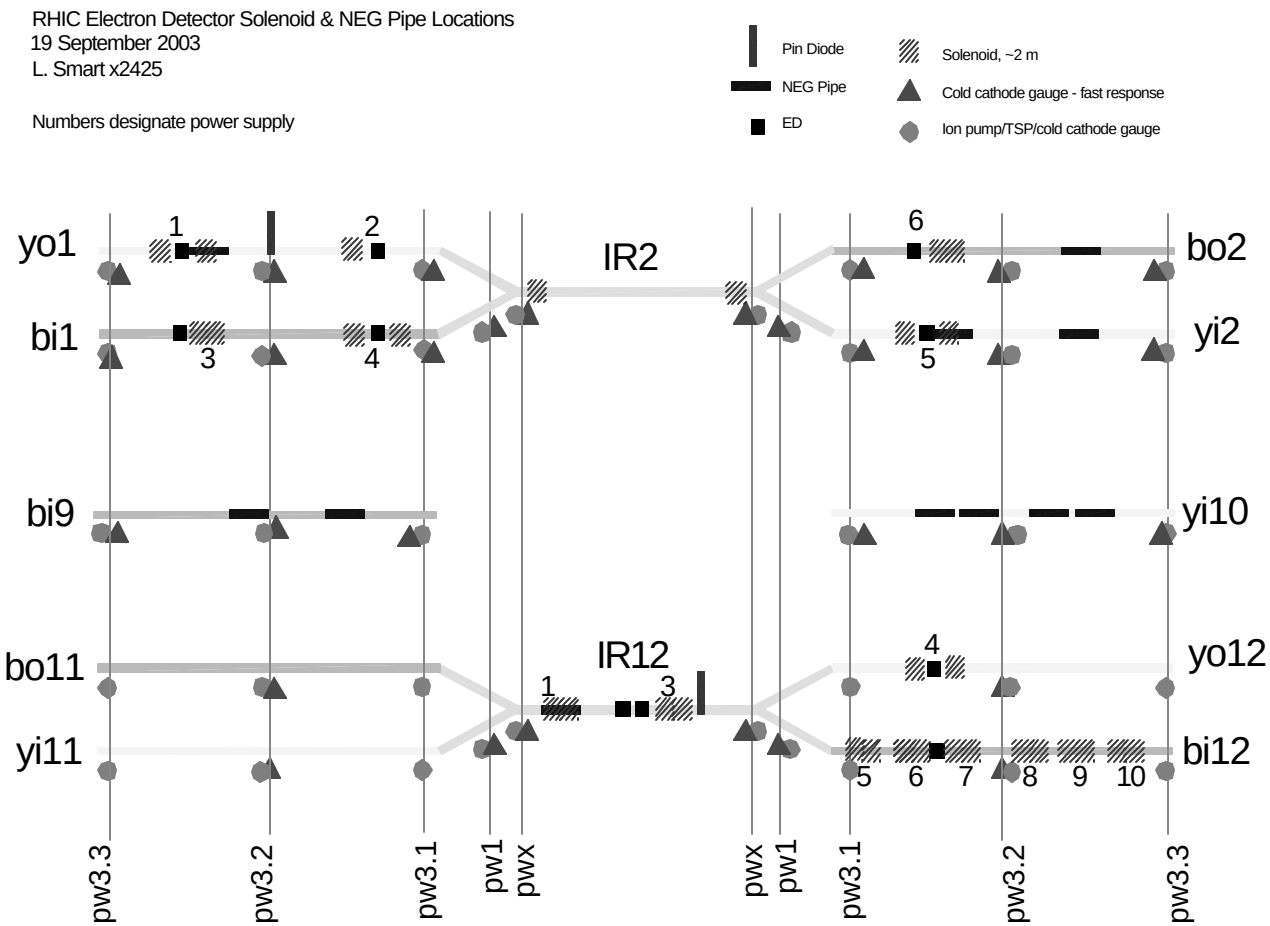
yo1, bo2, yi2(2), bi9(2), yi10(4), ip12



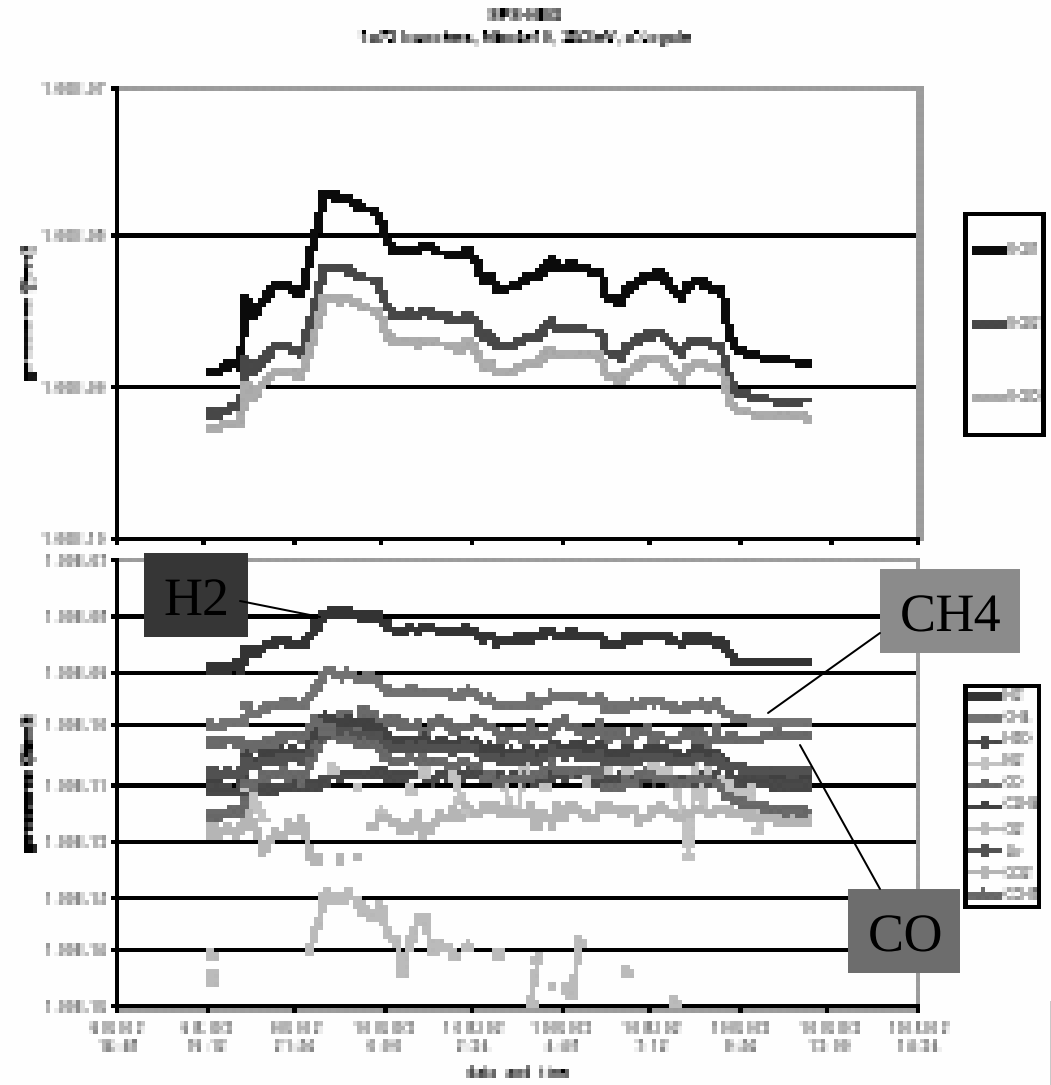




TiZrV NEG coating pipes

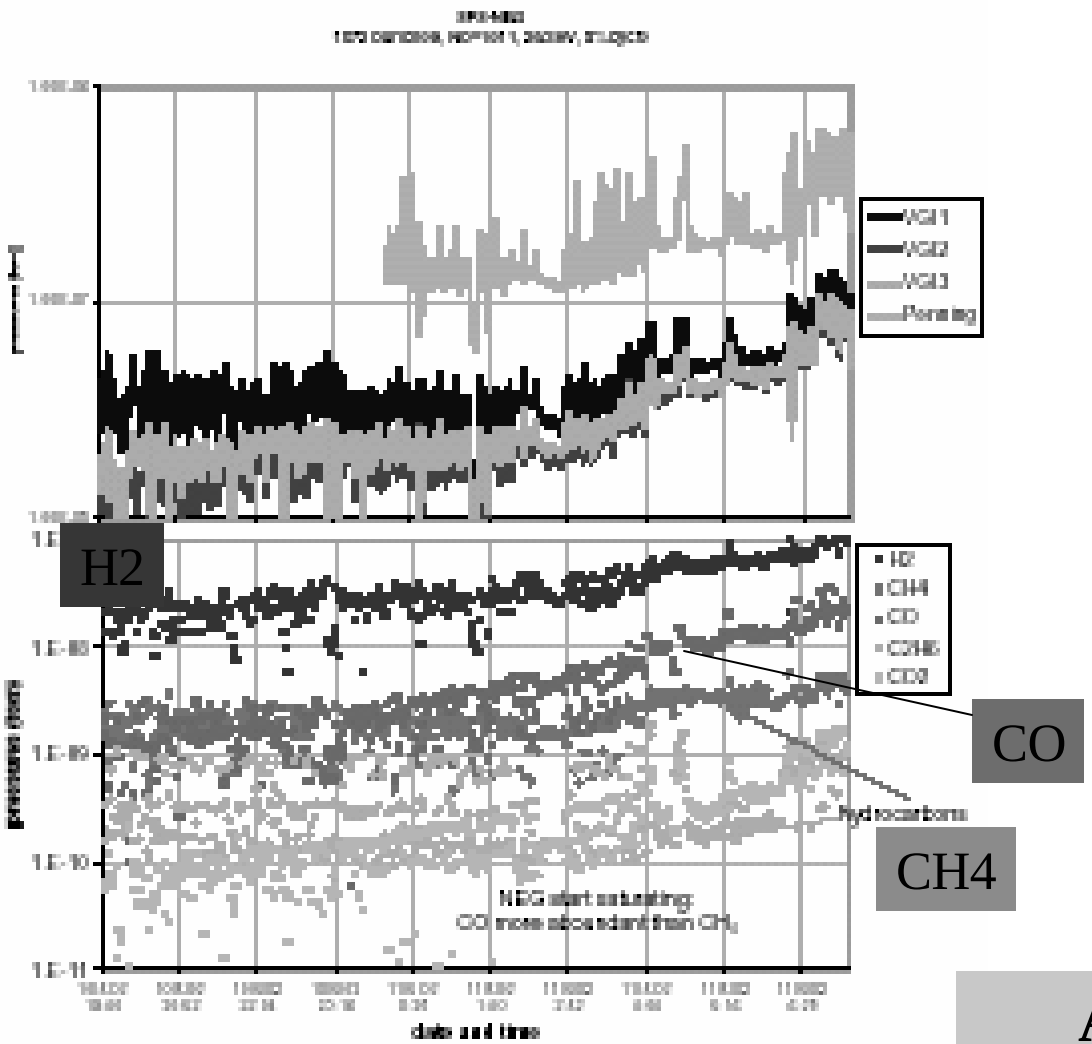


New Components for 2004 Run



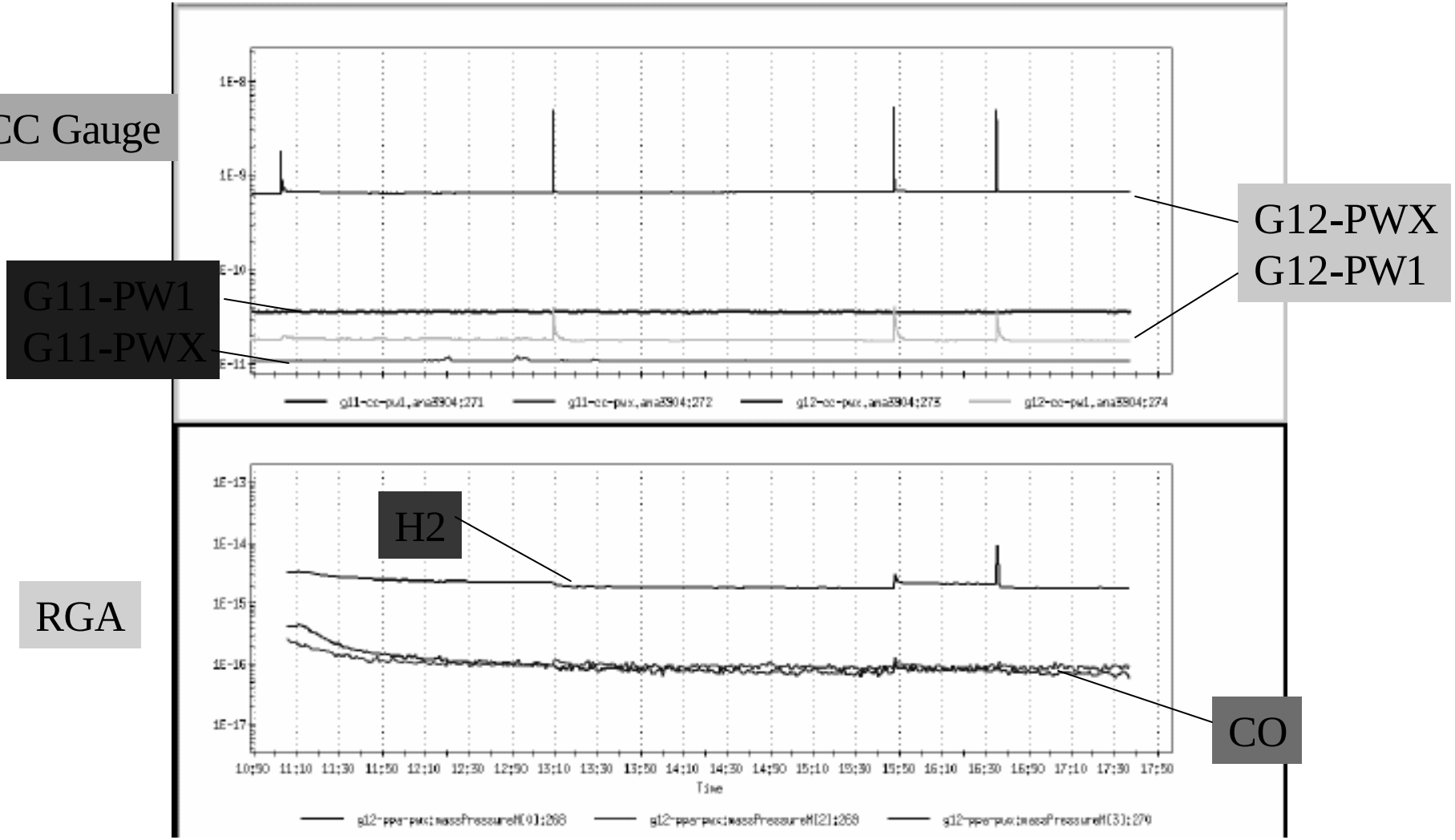
A. Rossi

NEG still pumping

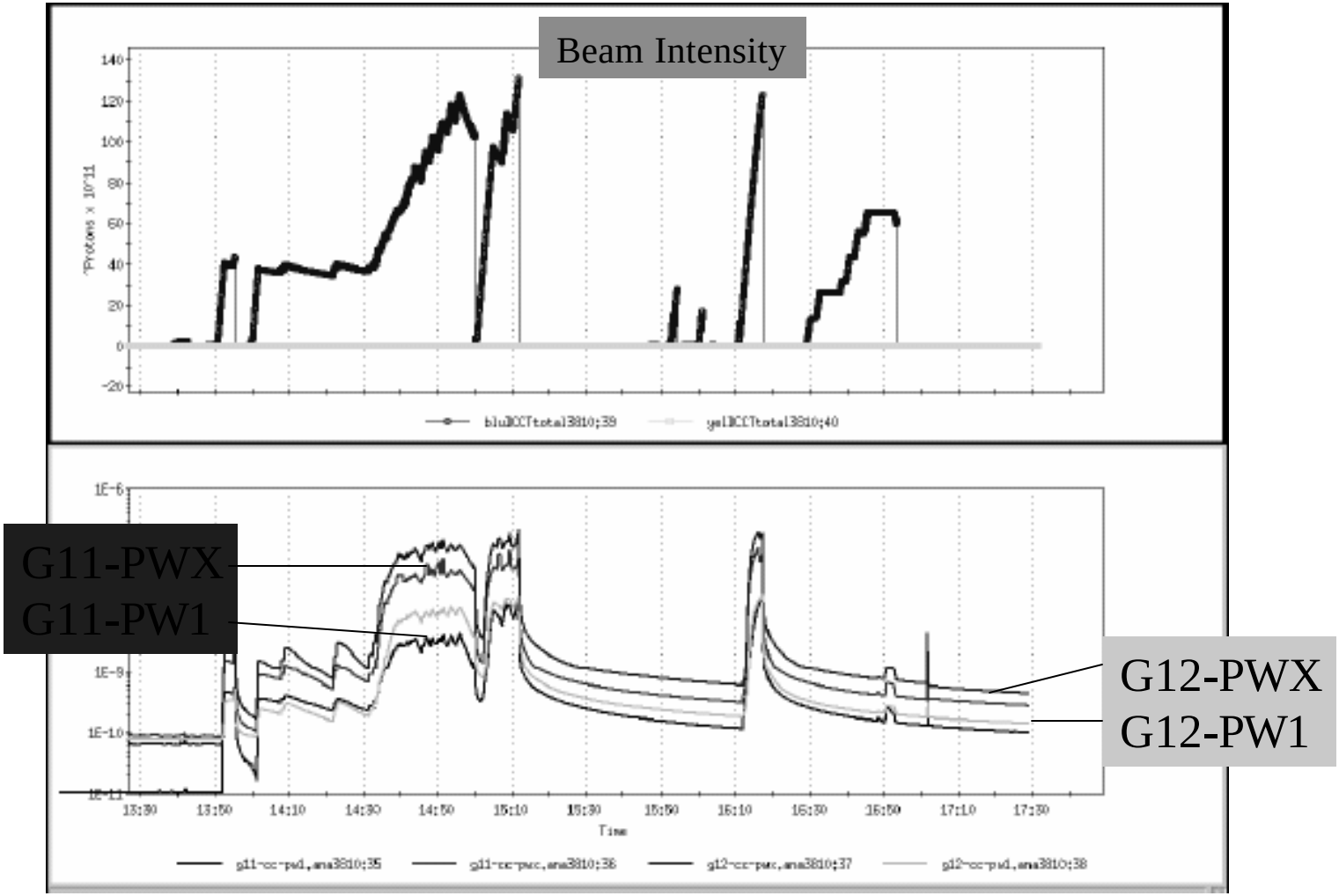


A. Rossi

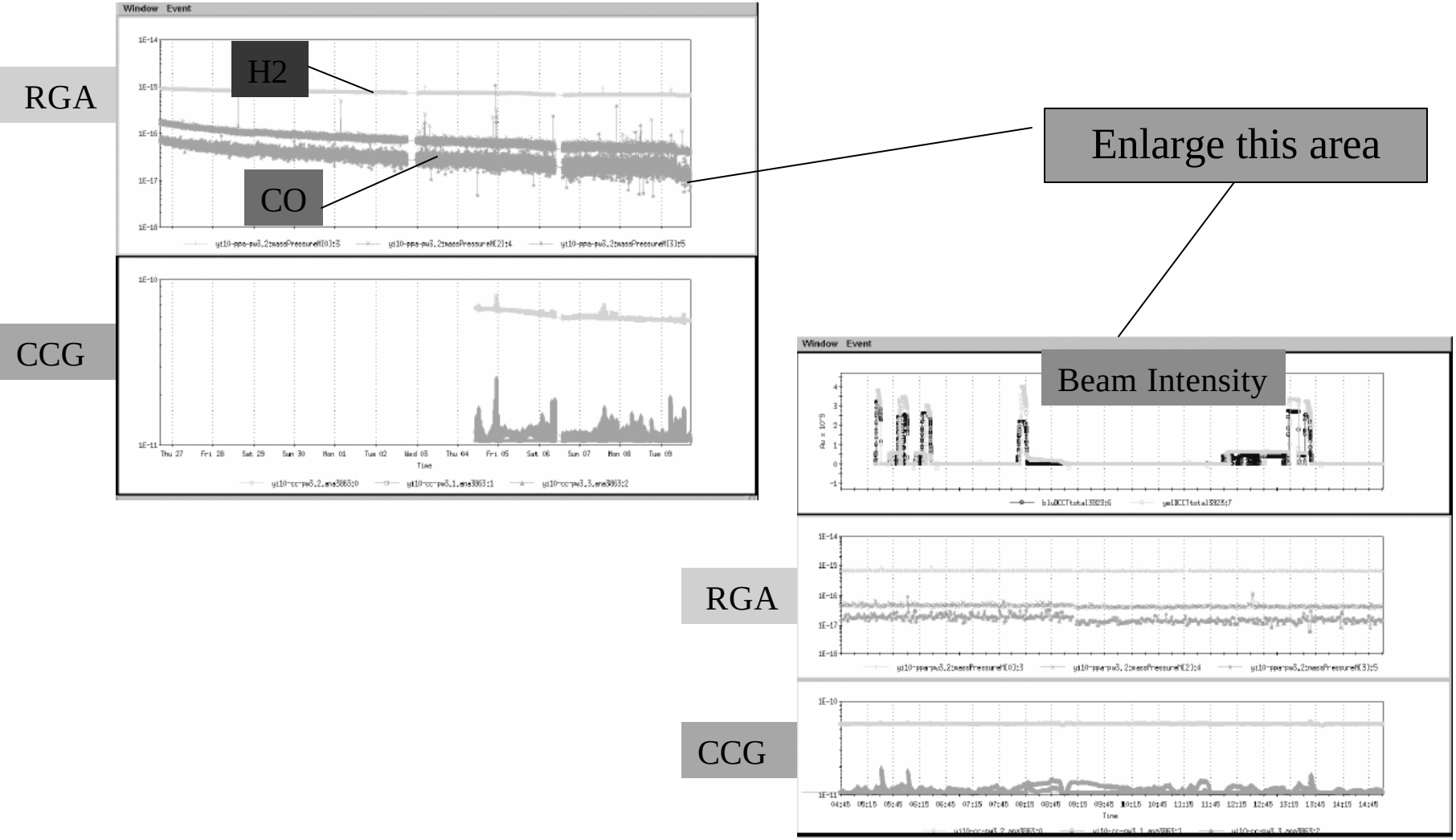
Evidence of NEG saturation



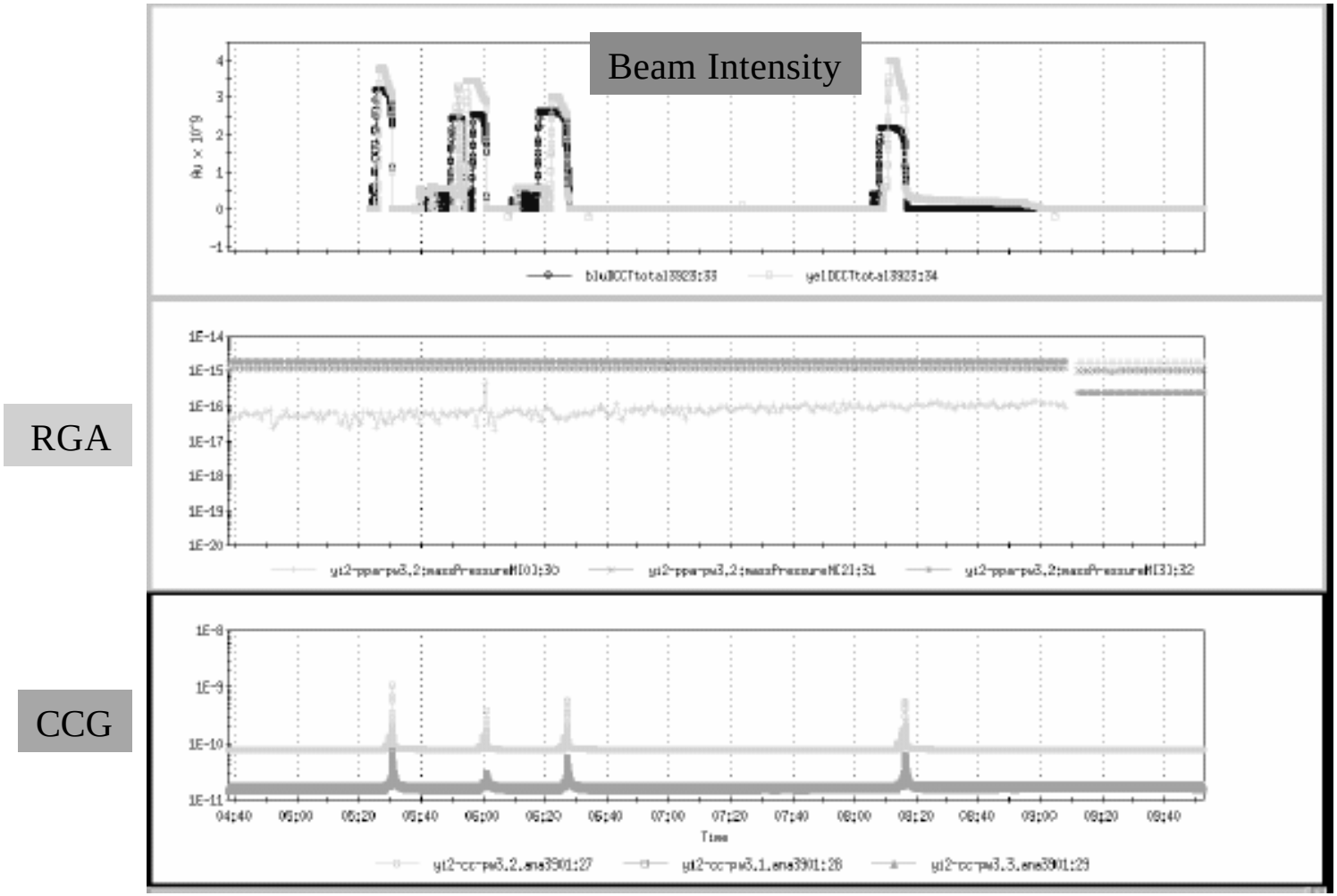
Run 2004: one NEG pipe at G11



Comparison with Run 2003: no NEG pipe at G11



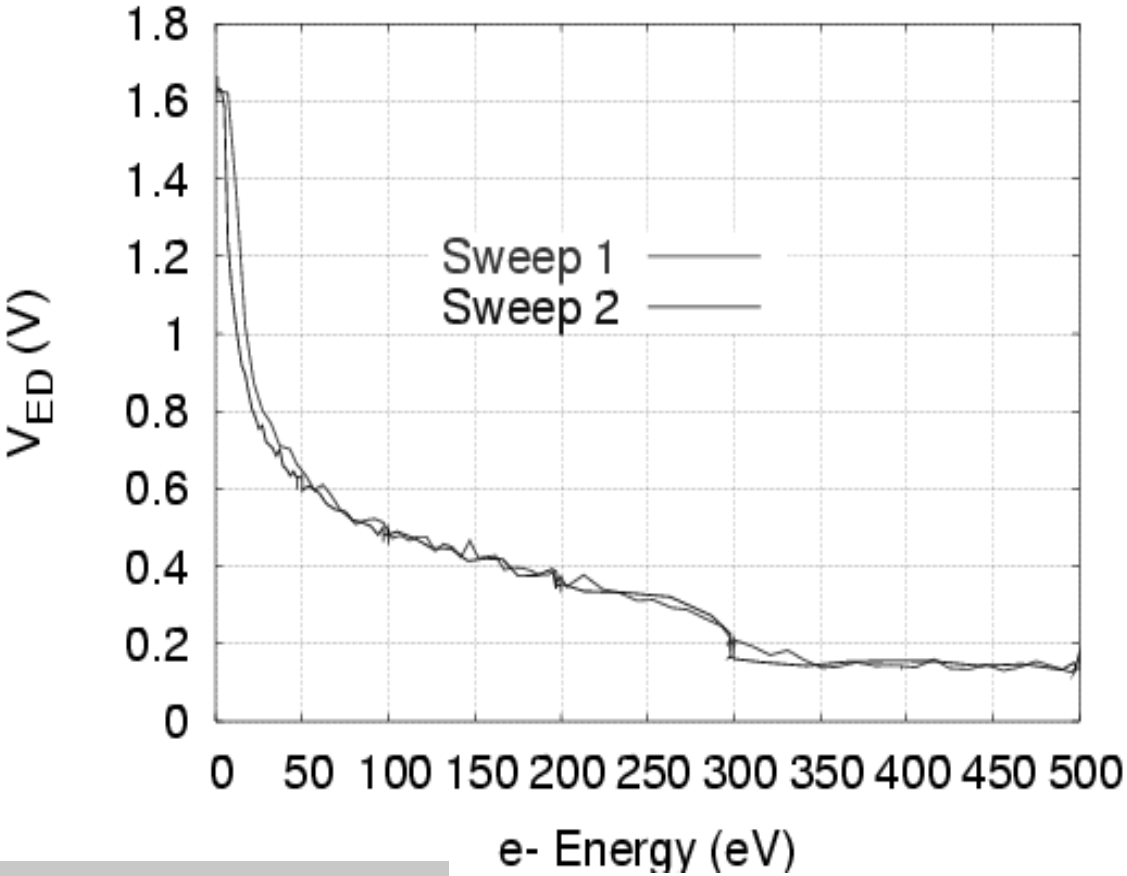
Run 2004: four NEG pipes at YI10



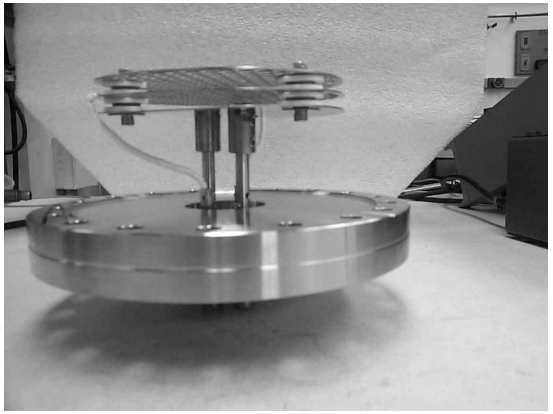
Run 2004: two NEG pipes at YI2

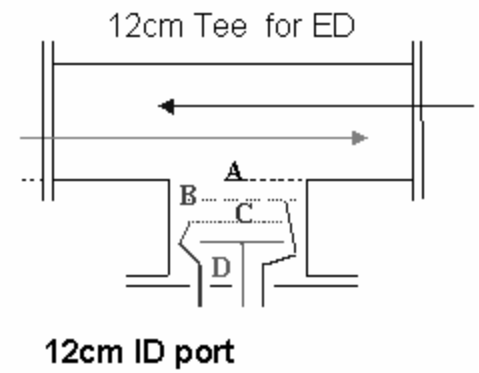
Part I: Residual gas composition during RHIC pressure rise

Part II: Solenoid field effect on RHIC e-cloud



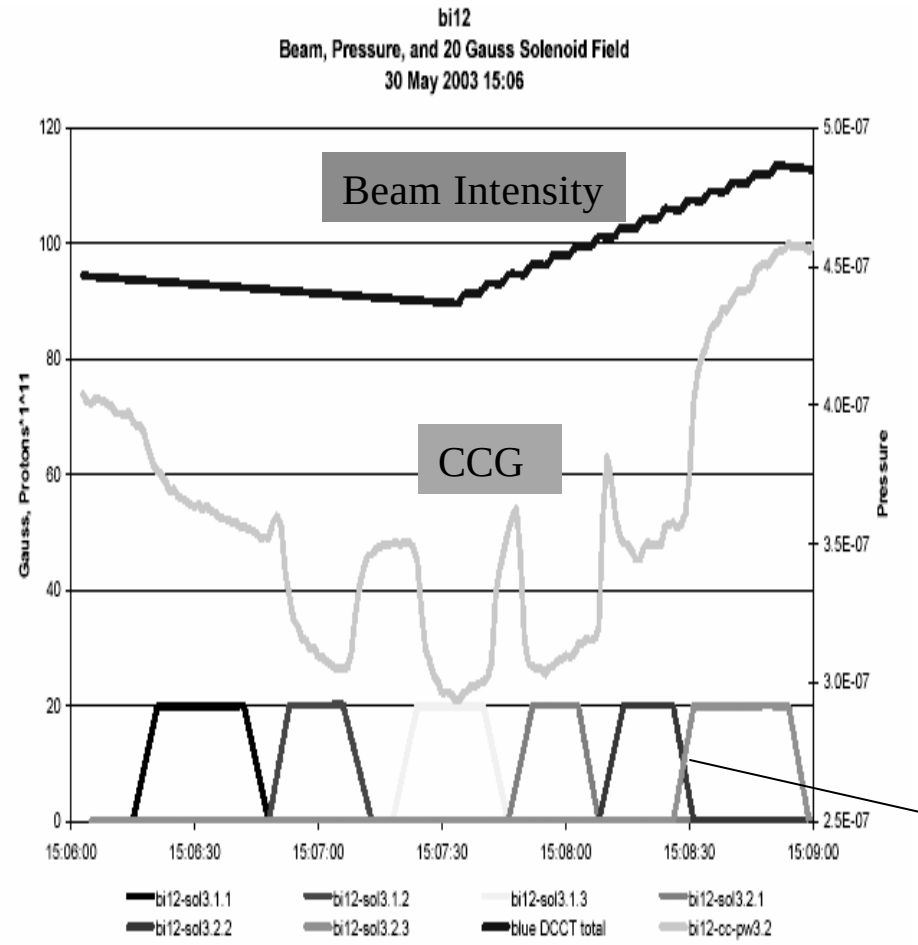
Noise level

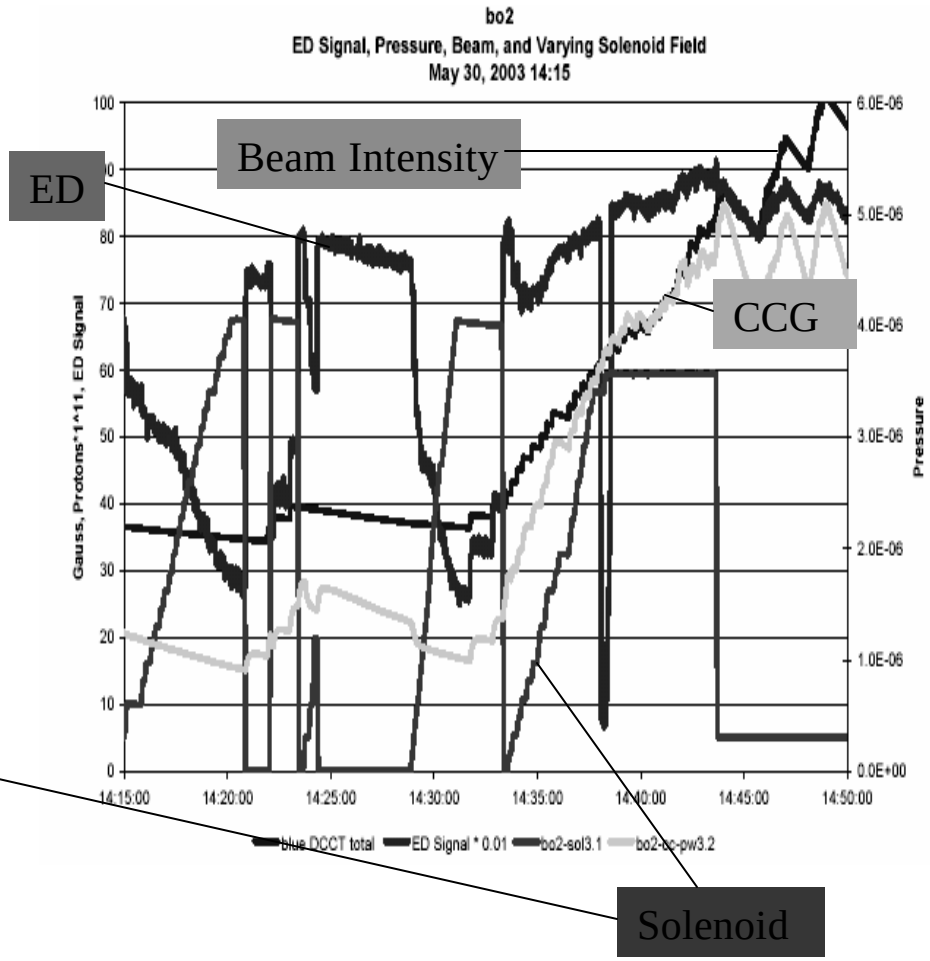




Ubaldo

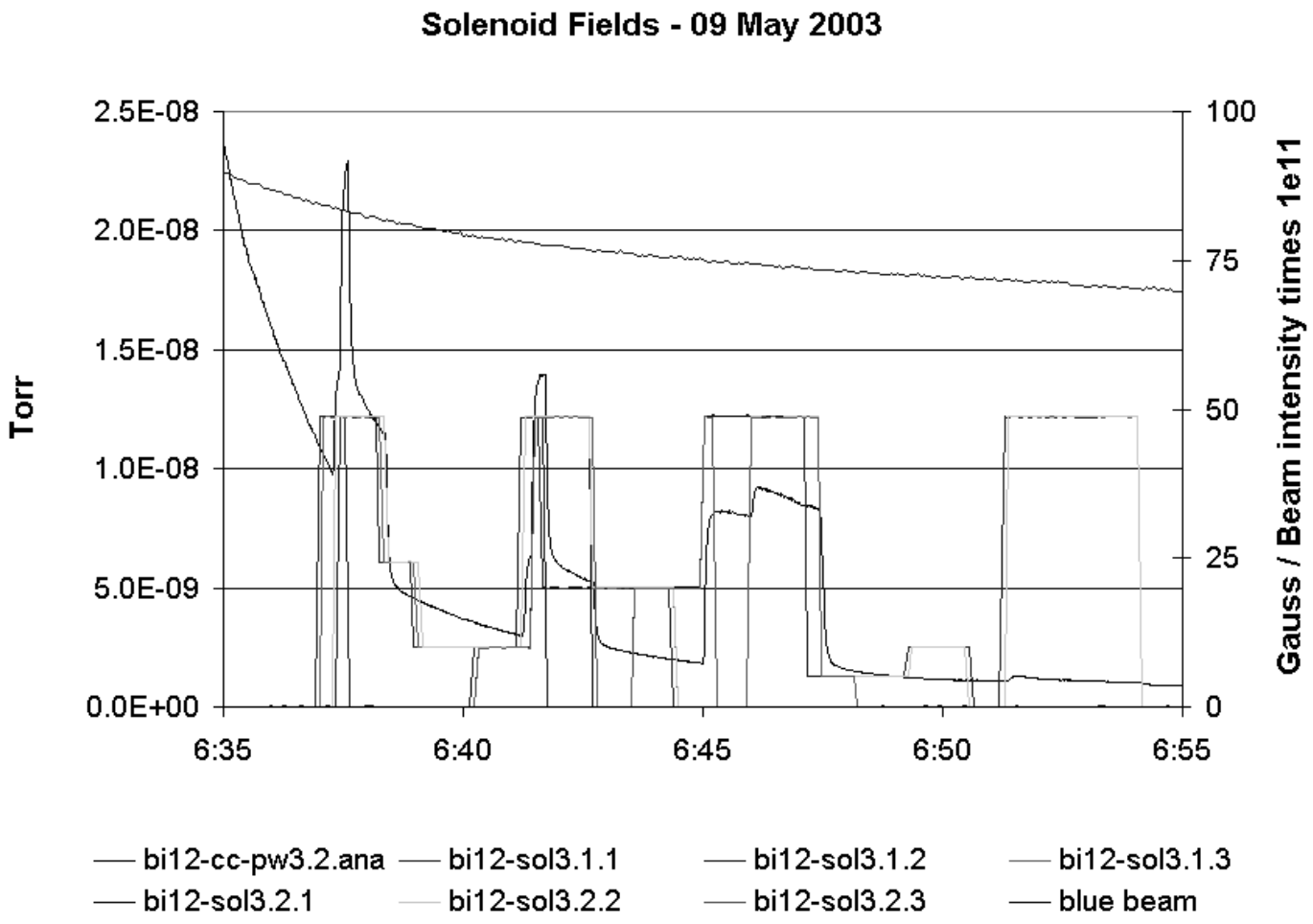
Electron Energy Spectrum



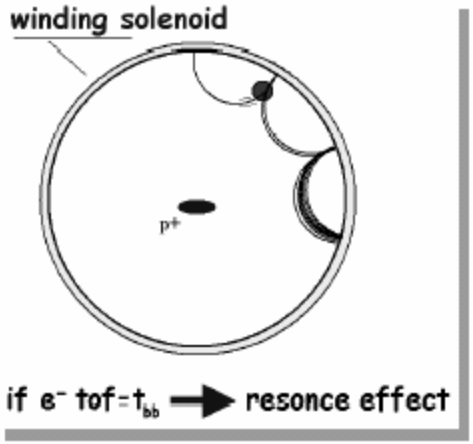


L.Smart

Solenoid Field Effect(1)-May 30



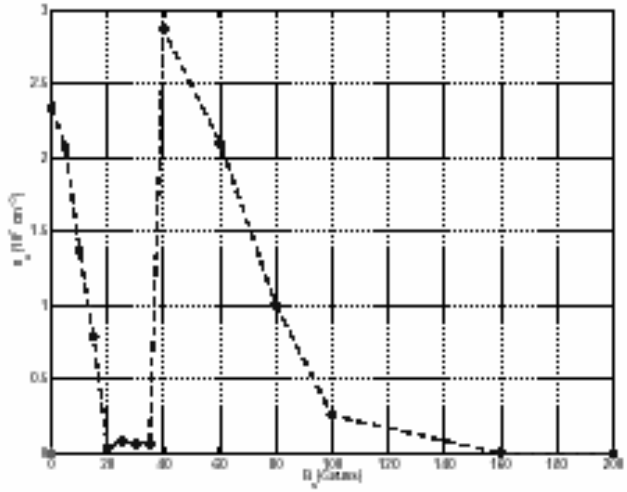
Solenoid Field Effect(2)-May 09



Resonance multipacting in solenoid field when the electron time of flight is equal to the bunch spacing

M.Pivi

SLAC-PUB-9813



Cyclotron Resonance Condition

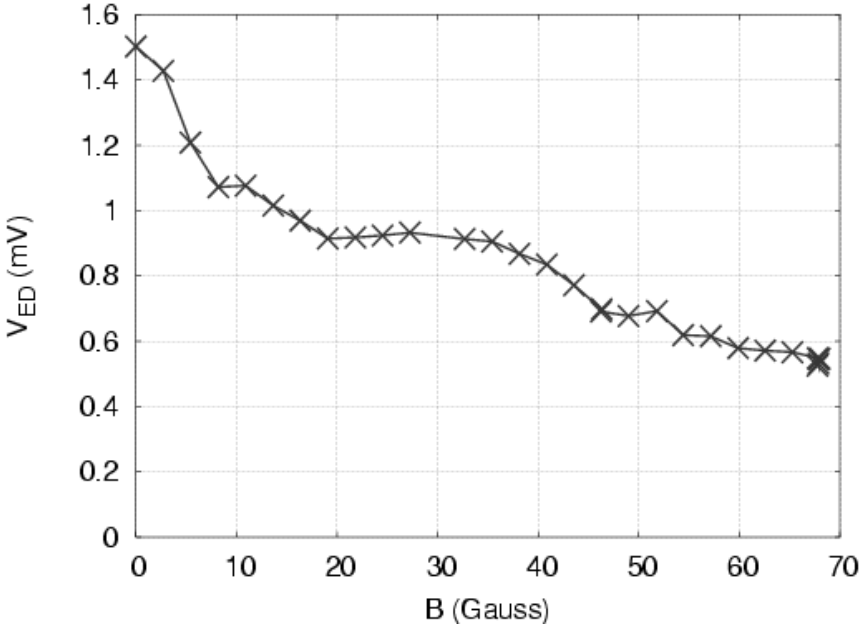
$$B_z^c = \frac{\pi m c^2}{e S_b}.$$

Cyclotron Resonance at RHIC?

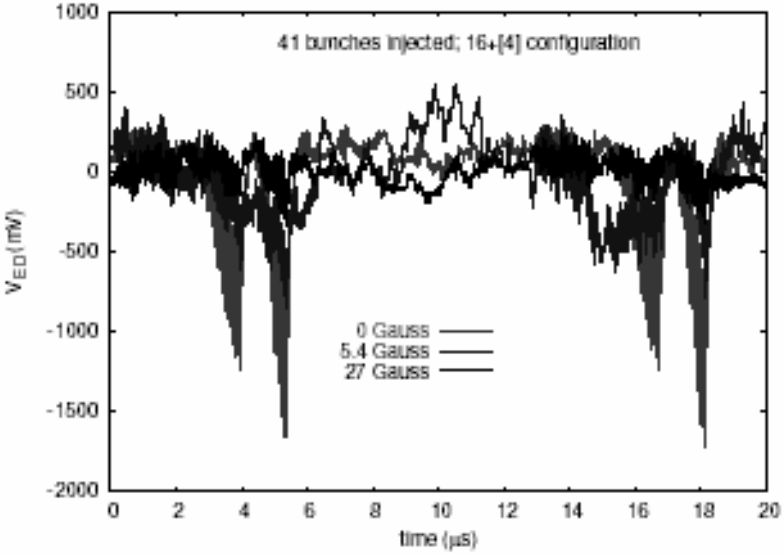
Cyclotron frequency does not match bunch spacing

-further study needed

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



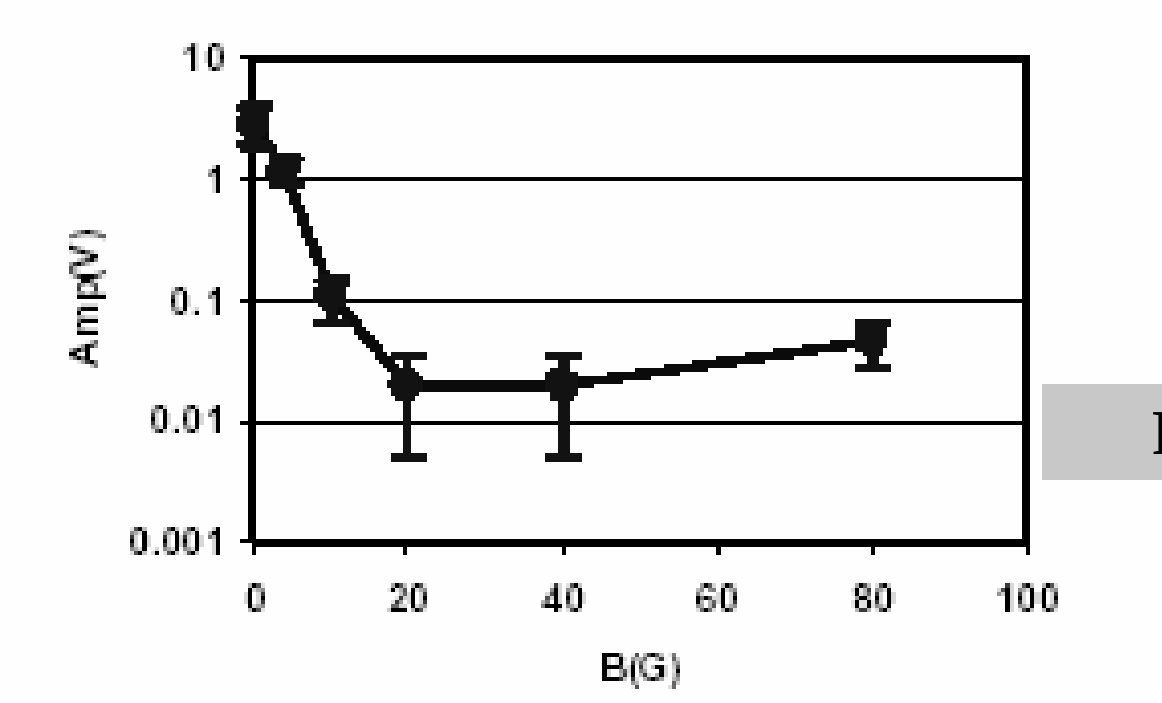
B can help to fully suppress the e-cloud during fill #3530.
(*N=1.1 •10^{10} p-pb*).



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.

Solenoid Field Effect(3)

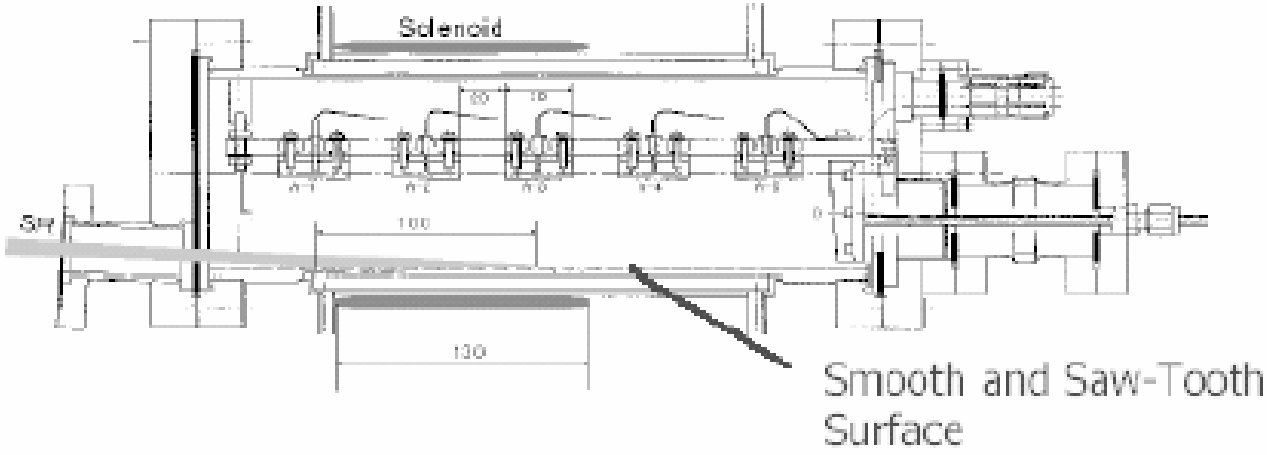
PSR:



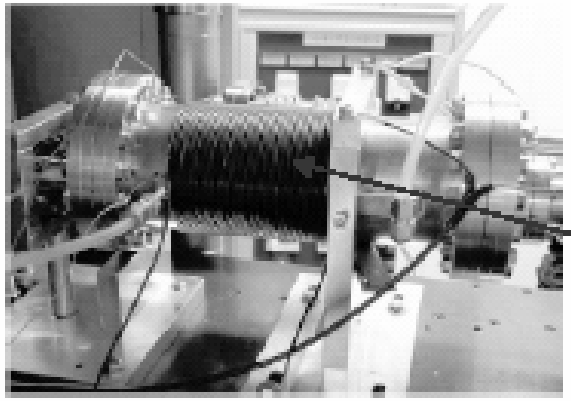
R.Macek

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.

KEK PF:



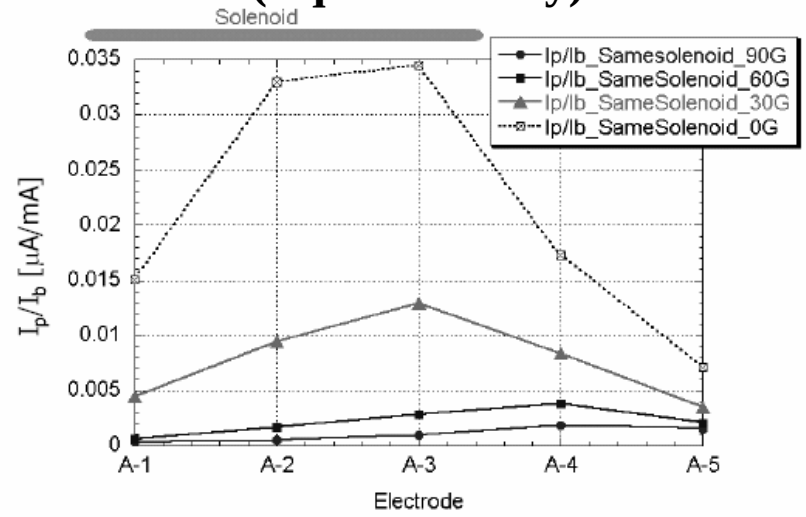
The total solenoid length was about 130mm. Atypical axial magnetic field just near the surface is about 20G at the solenoid current of 5A.



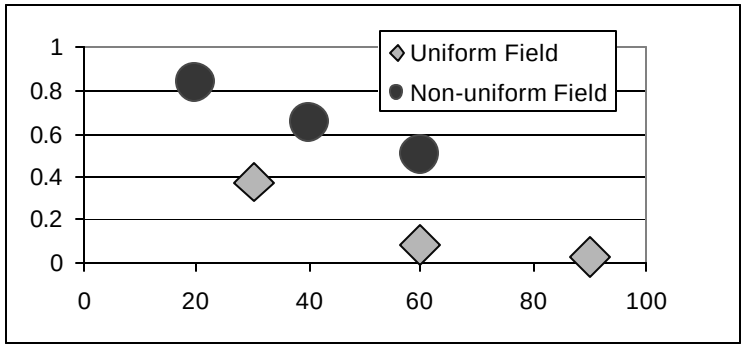
Solenoid around the test chamber

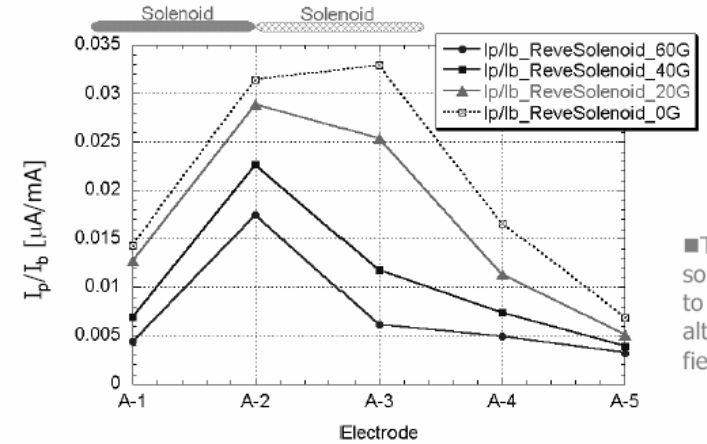
Y. Suetsugu

Uniform Solenoid Field (Equal Polarity)



	Peak I_p/I_b (A-1 – A-3)	Ratio to No Solenoid
No Solenoid	0.0345	1
Uniform 30G	0.0129	0.373(1/4)
Uniform 60G	0.00284	0.0823(1/12)
Uniform 90G	0.000992	0.0288(1/35)
Non Uniform 20G	0.0289	0.838
Non Uniform 40G	0.0226	0.655
Non Uniform 60G	0.0175	0.507(1/2)



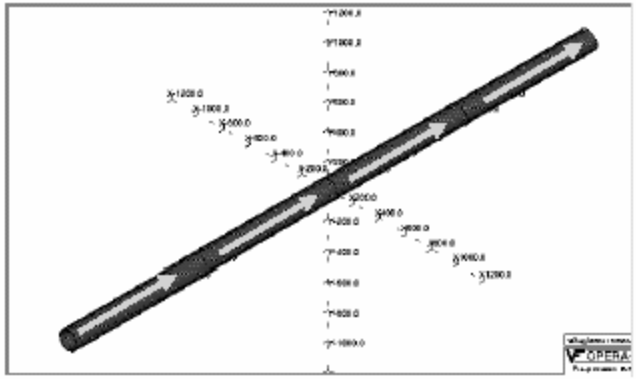


■The previous solenoid was divided to a half and the alternative solenoid field was generated.

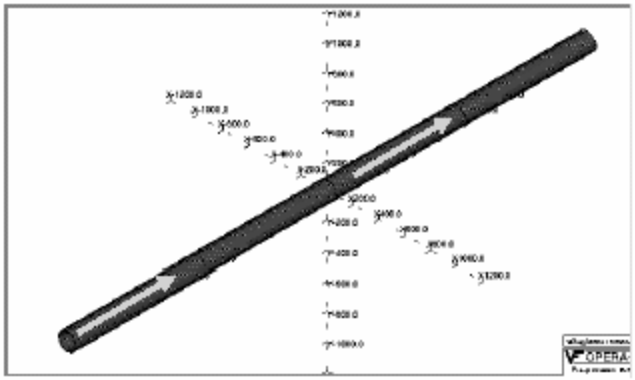
Y. Suetsugu

Non-uniform Solenoid Field (Opposite Polarity)

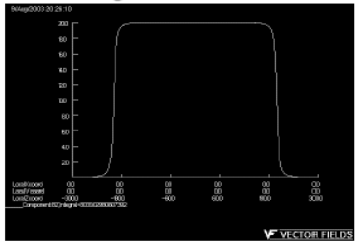
Uniform Solenoid

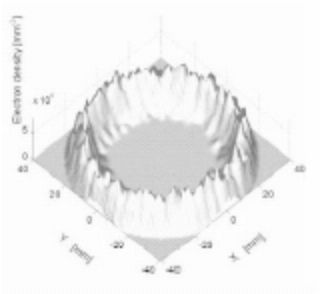


Non-uniform Solenoid

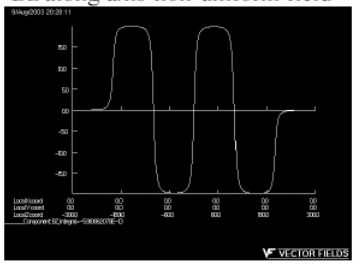


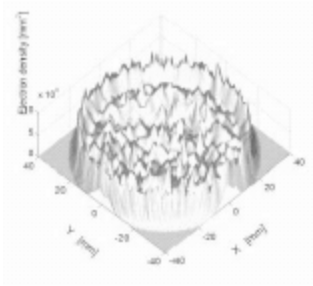
Bz along axis-uniform field





Bz along axis-non-uniform field

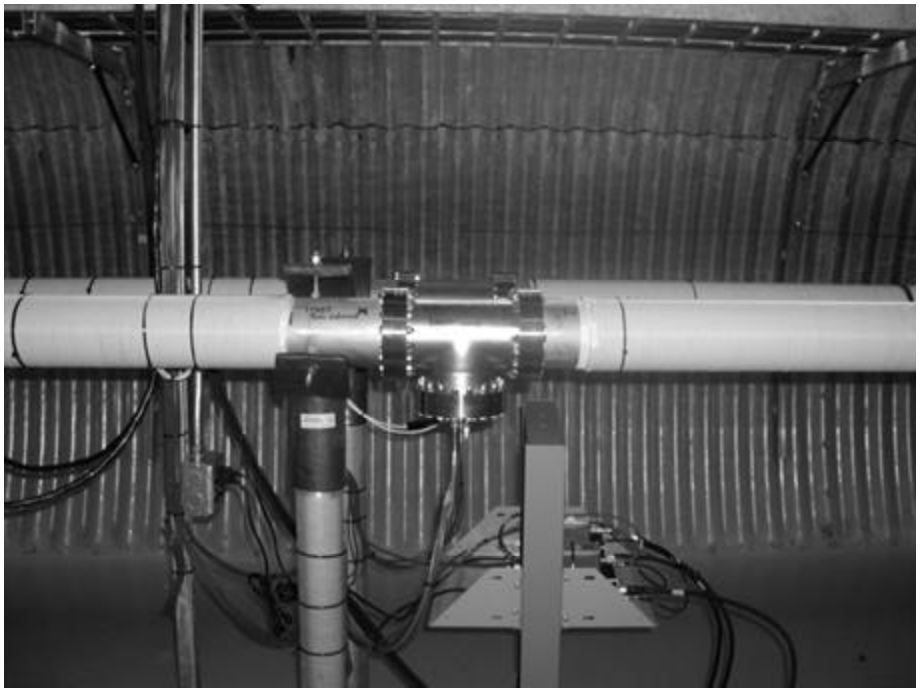




From the simulation, we can see no electron in the center of the beam pipe if we use equal polarity solenoid field

Run 2004, RHIC solenoid in equal polarity

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

- 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($\delta_{max} \sim 1.1$) and also after saturation ($\delta_{max} < 1.2 \sim 1.3$)
- More solenoid(~30%), more NEG pipes(~300m), *in-situ* SEY measurement

Conclusions and Future Works