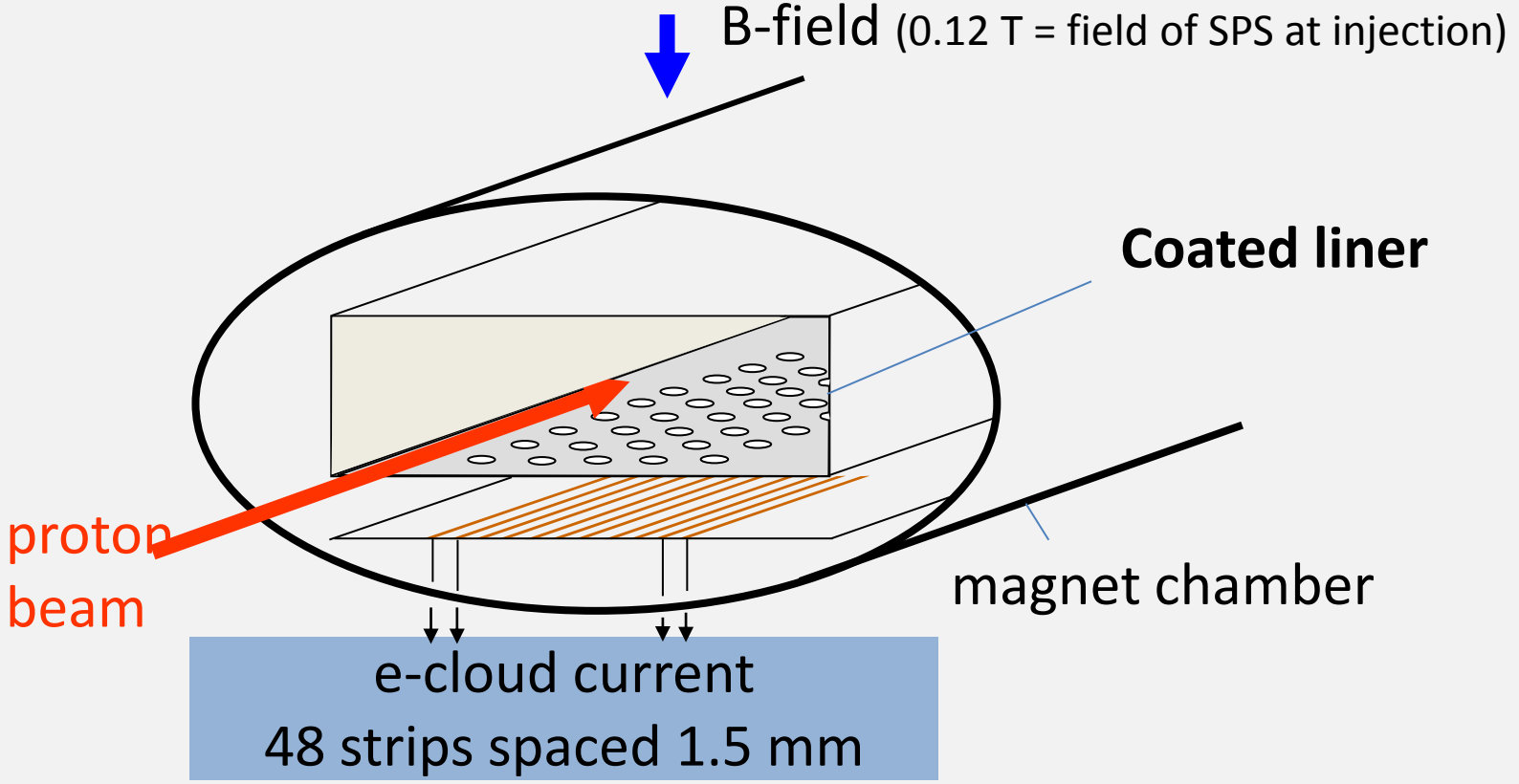
SPS measurements and mitigation techniques

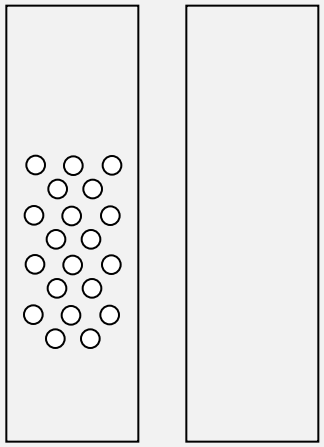
M.Taborelli and C.Yin-Vallgren

CERN-GS electron cloud workshop, 7-8/3/2011, CERN

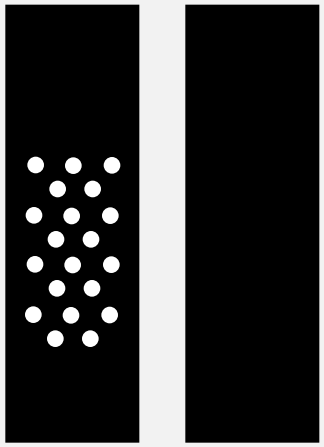
Measurements of currents in electron cloud monitors



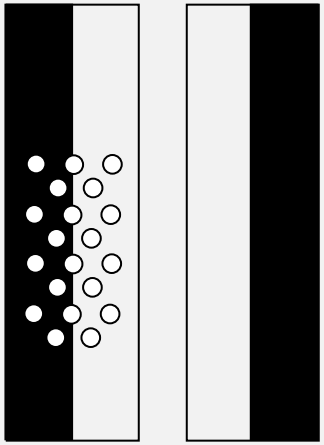
Materials and coatings tested in ECM :



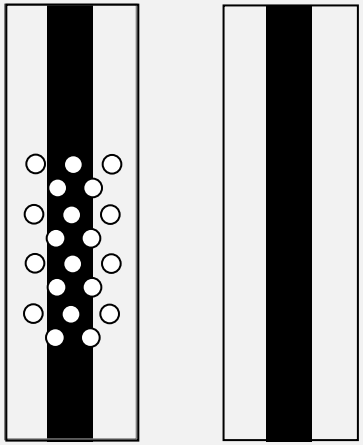
StSt



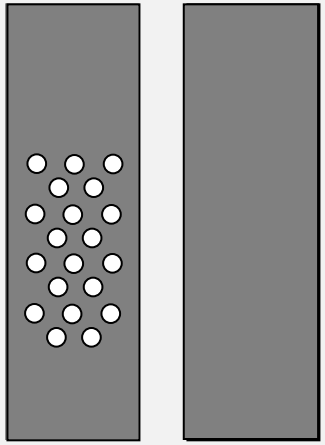
a-C



a-C half coated

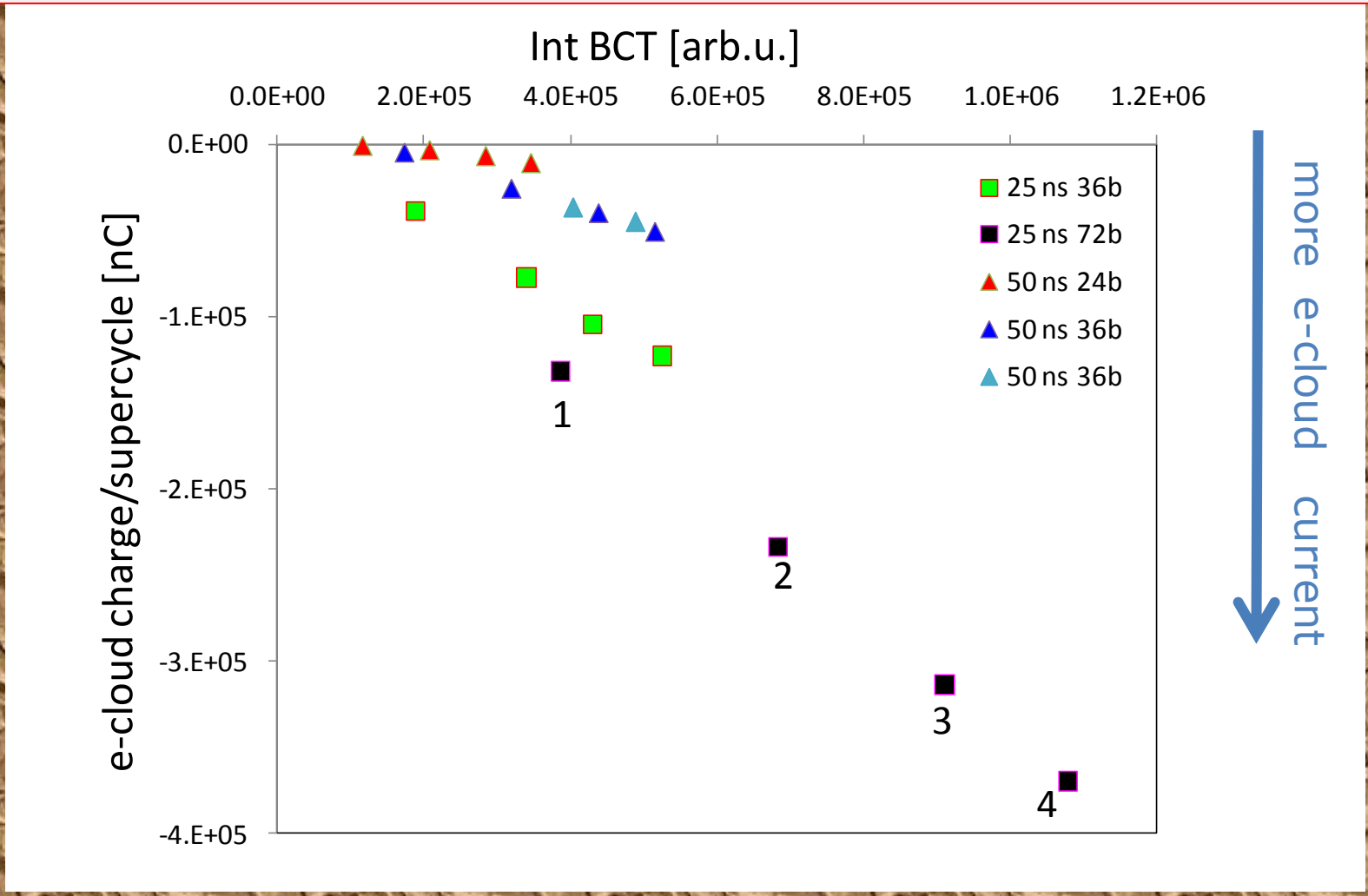


a-C stripe
40 mm wide



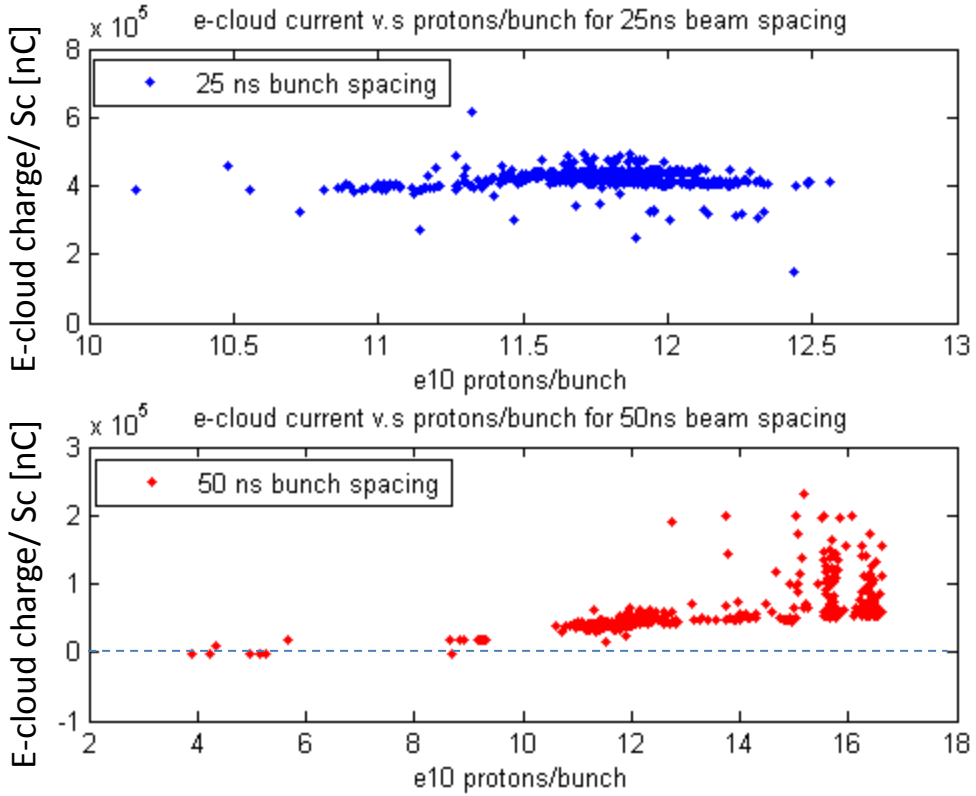
DLC
KEK (from S.Kato)

E-cloud as a function of number of batches, bunches, spacing (StSt, not conditioned)



Larger bunch spacing → lower e-cloud current
Less bunches/batch → lower e-cloud current
Linear increase for 25 ns as a function of batch number

StSt as a function of protons per bunch

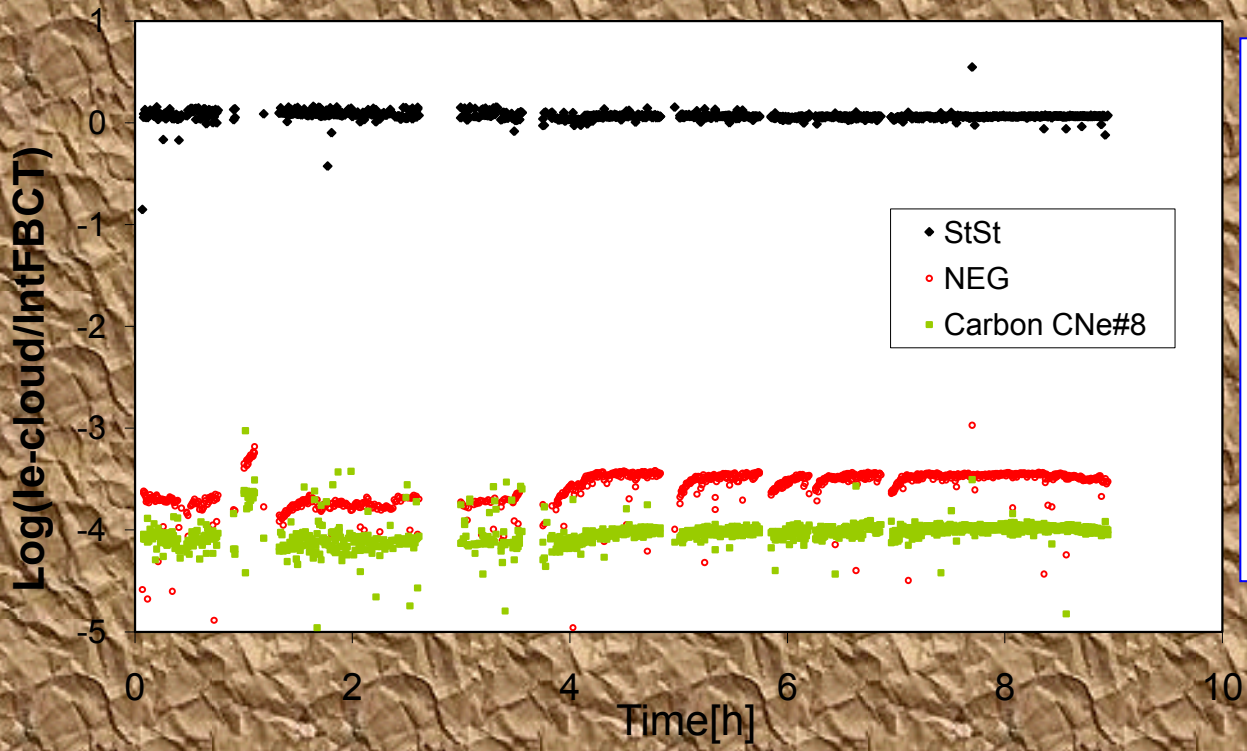


4x72 with 25 ns bunch spacing:
The investigated range is very narrow, difficult to see a dependence

4x36 with 50 ns bunch spacing:
e-cloud signal increases with increasing of beam intensity (large scattering)

a-C coatings in e-cloud monitors

Beam: 2-3 batches, 72 proton bunches, 25 ns spacing, 450 GeV/c



StSt for 2h air exp. δmax=2.25

TiZrV-NEG fully activated, δmax=1.1

CNe for 2h air exp.δmax=0.95

The a-C coating decrease e-cloud current by **10^4** times with respect to StSt

a-C does not need bake or activation; all a-C inserted (6) showed similar performance

Current map of various liners

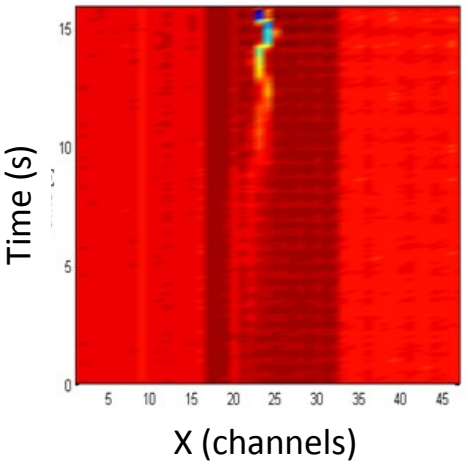
The pattern of current is similar for all excepted for the half coated (only one stripe) and a-C (faint stripe in the center)

e-cloud current:

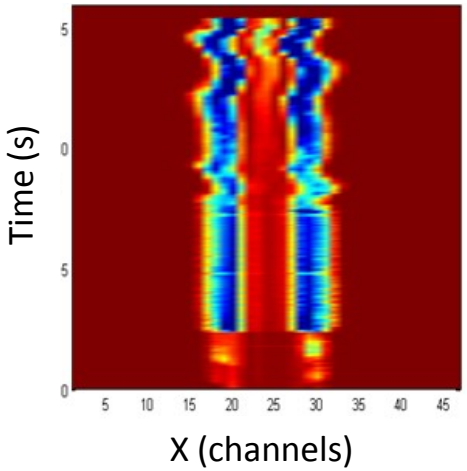
I (a-C) *10000 = I (DLC) *2.5 = I(half)*1.9 = I(StSt)

A coated stripe of 40 mm width in the center is suppressing almost entirely the e-cloud

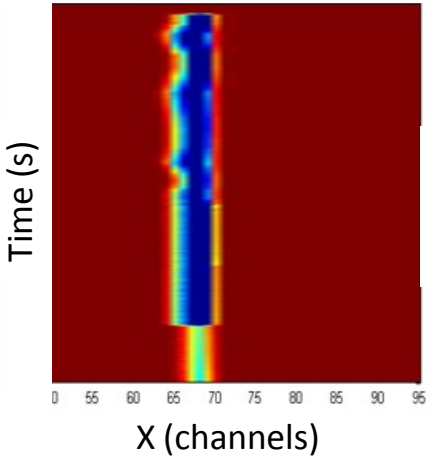
a-C (CNe13)



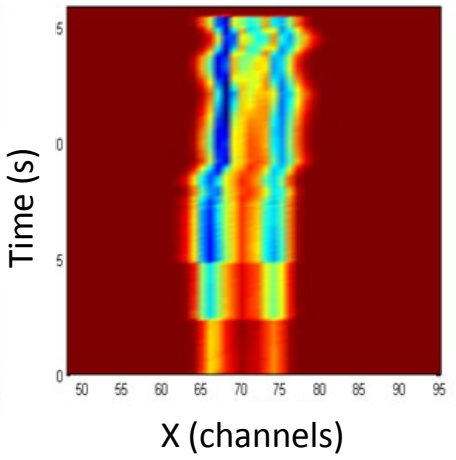
DLC



CNe70 half coated



StSt



SEY= 0.9-1.0

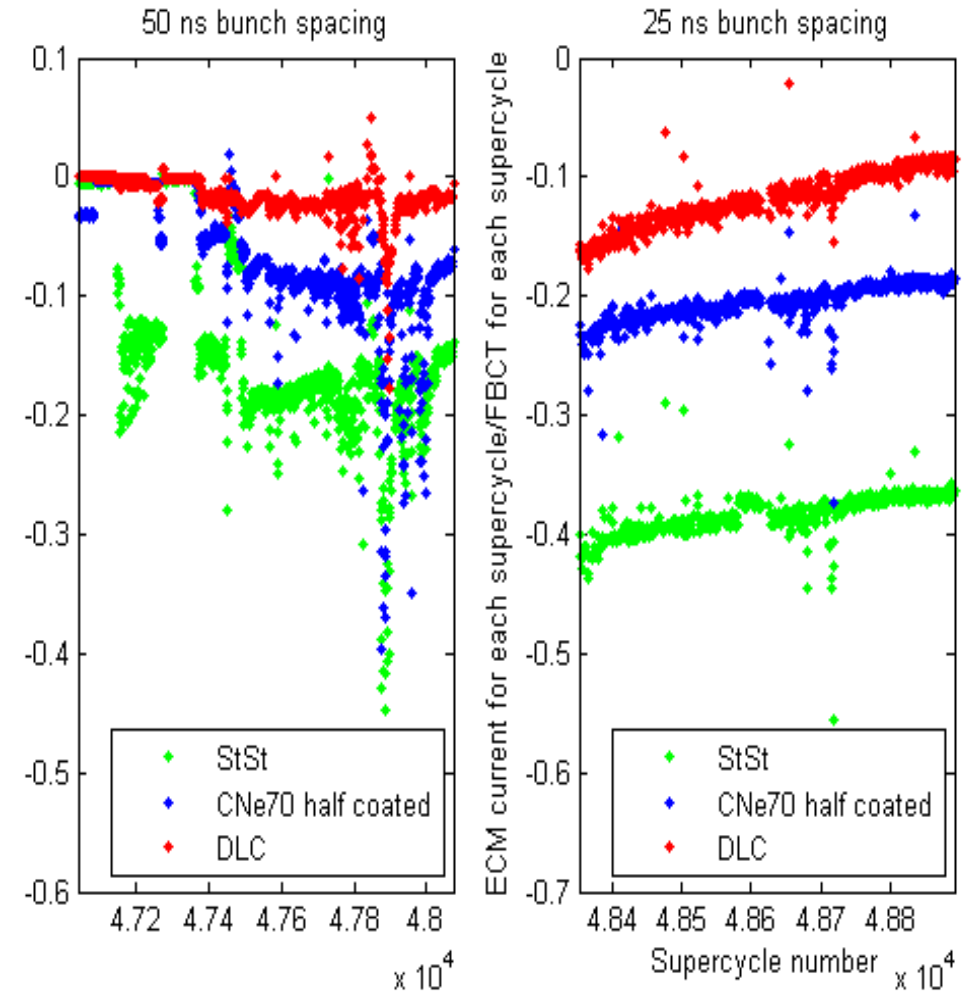
SEY= 1.8

Emax=180+/-25 eV

SEY= 2.2-2.5

Emax=280+/-25 eV

I (DLC)*2.5 = I(half)*1.9 = I(StSt)

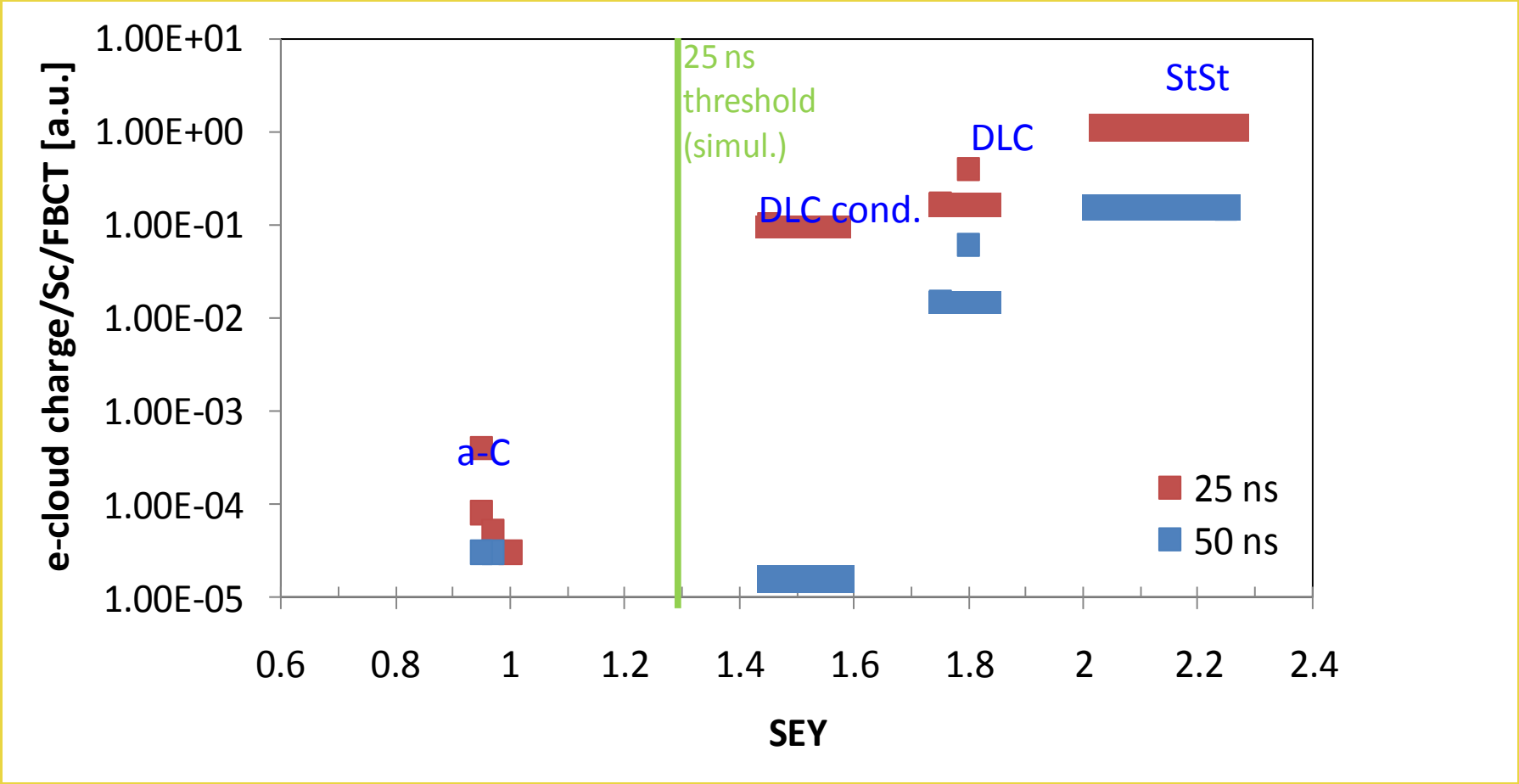


DLC conditions very fast.
Factor of 2 in current gained in one night scrubbing with 25 ns 4x72 LHC nominal beam.

Estimated dose in the range 10^{-3}Clb/mm^2

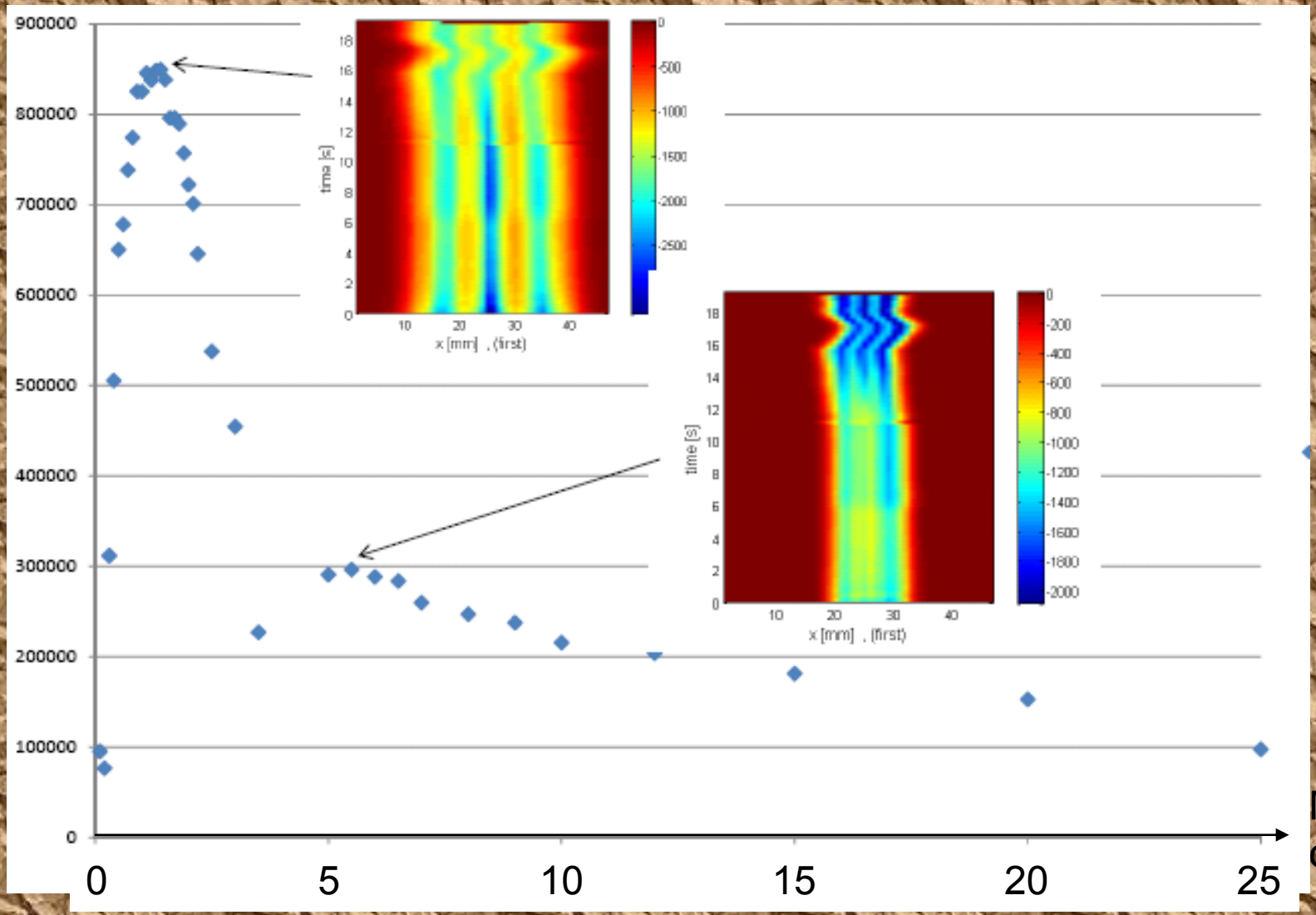
E-cloud current as a function of SEY

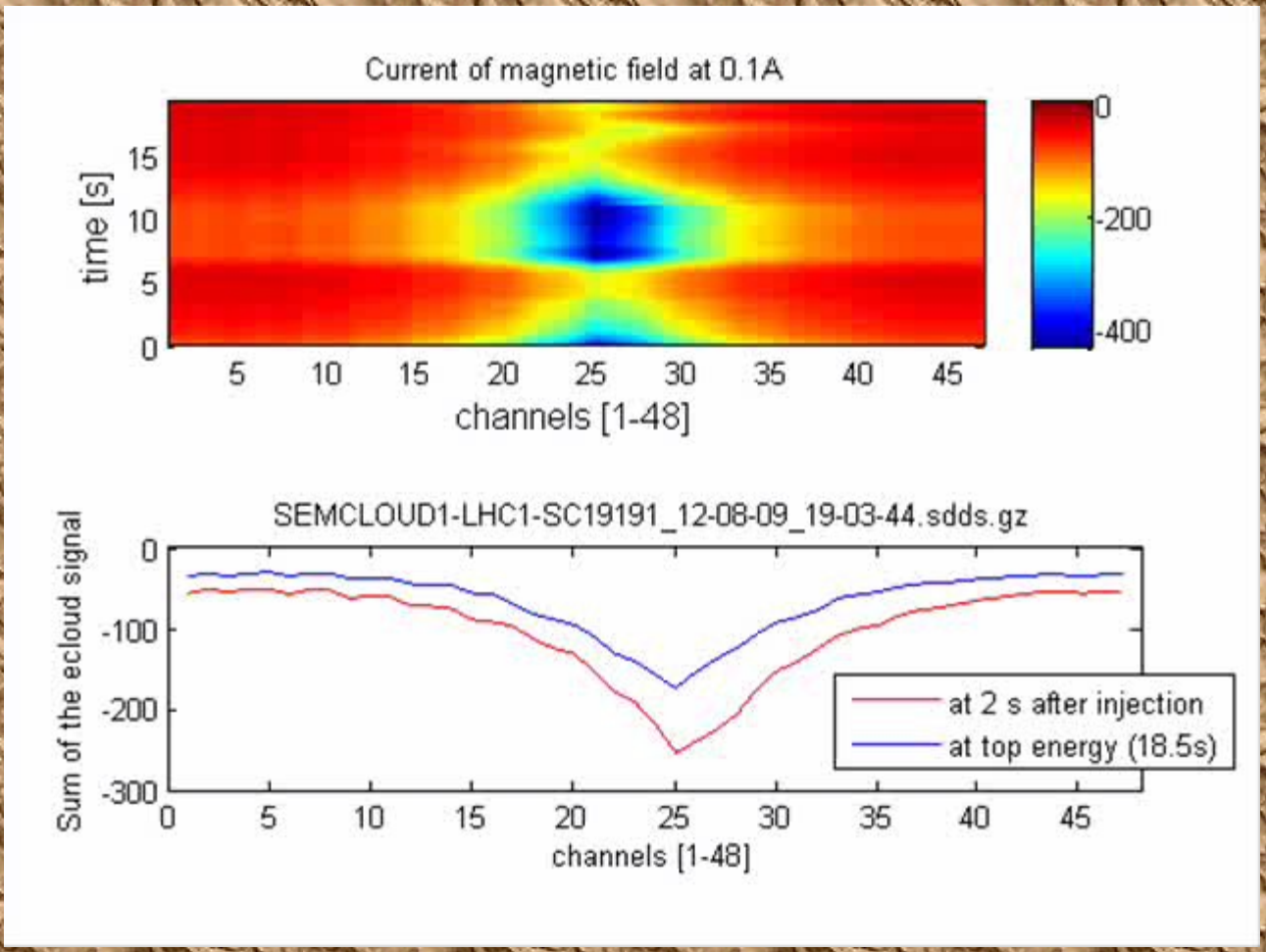
The SEY values were measured after extraction and cutting of the liners



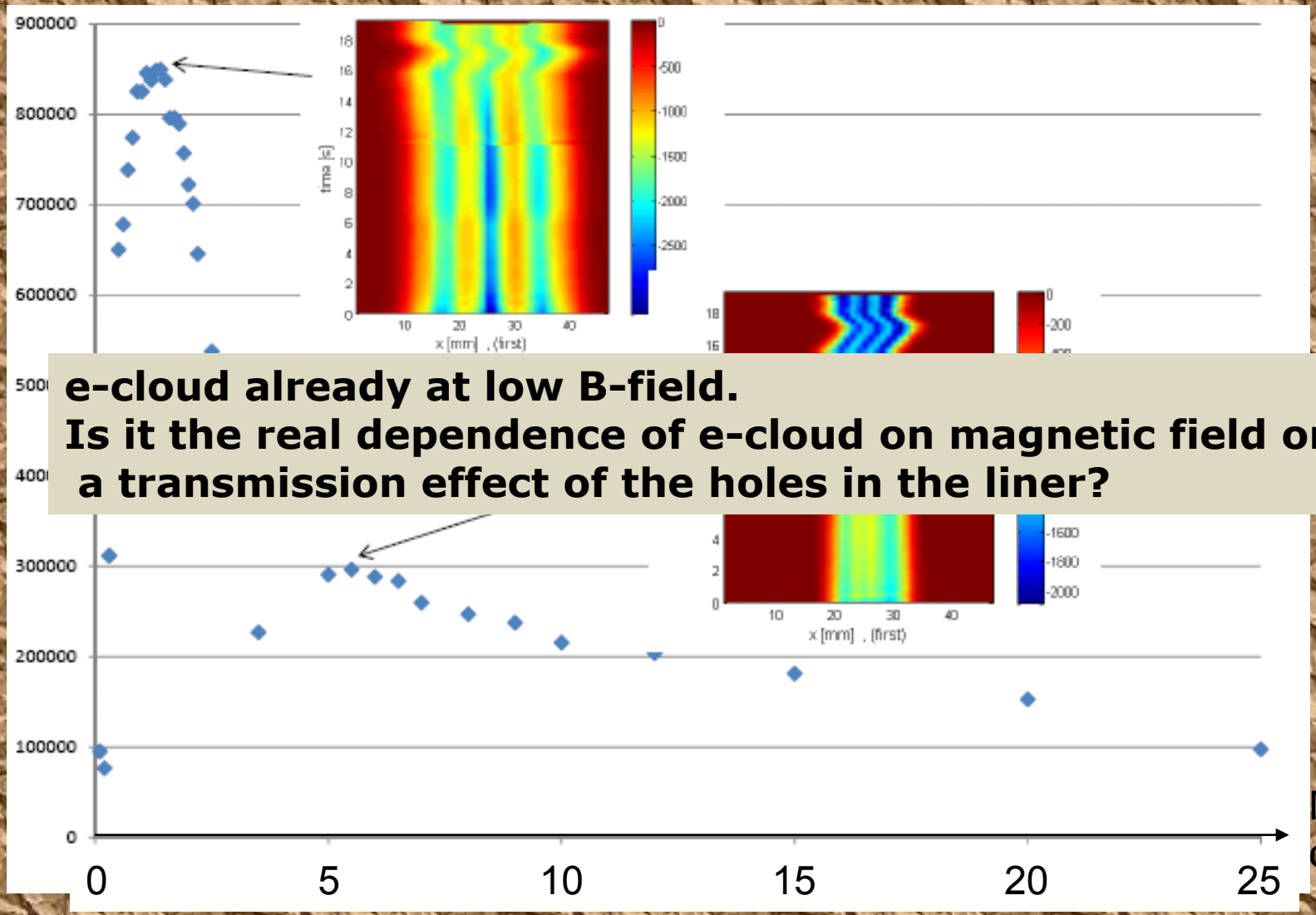
The threshold SEY for 50 ns is higher.
We can condition StSt in SPS down to 1.5 (mobile sample)

ECM signal as a function of applied magnetic field (StSt)




Current of magnetic field at 0.1A
time [s]
channels [1-48]
SEMCLOUD1-LHC1-SC19191_12-08-09_19-03-44.sdds.gz
Sum of the ecloud signal
channels [1-48]
at 2 s after injection
at top energy (18.5s)

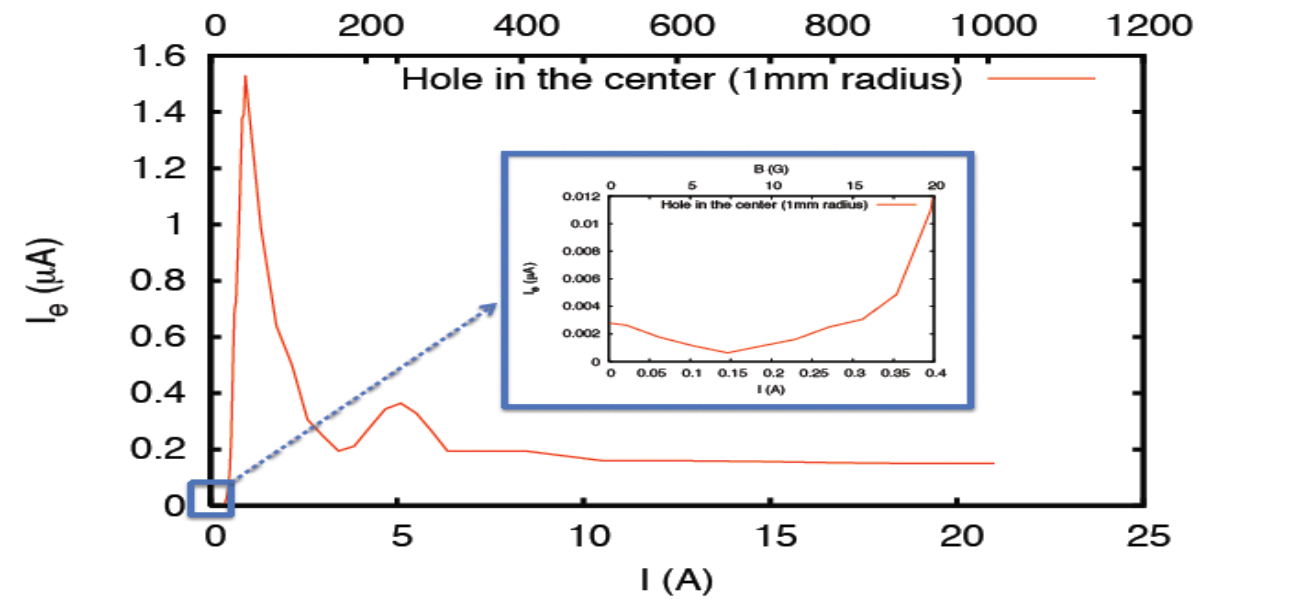
ECM signal as a function of applied magnetic field (StSt)



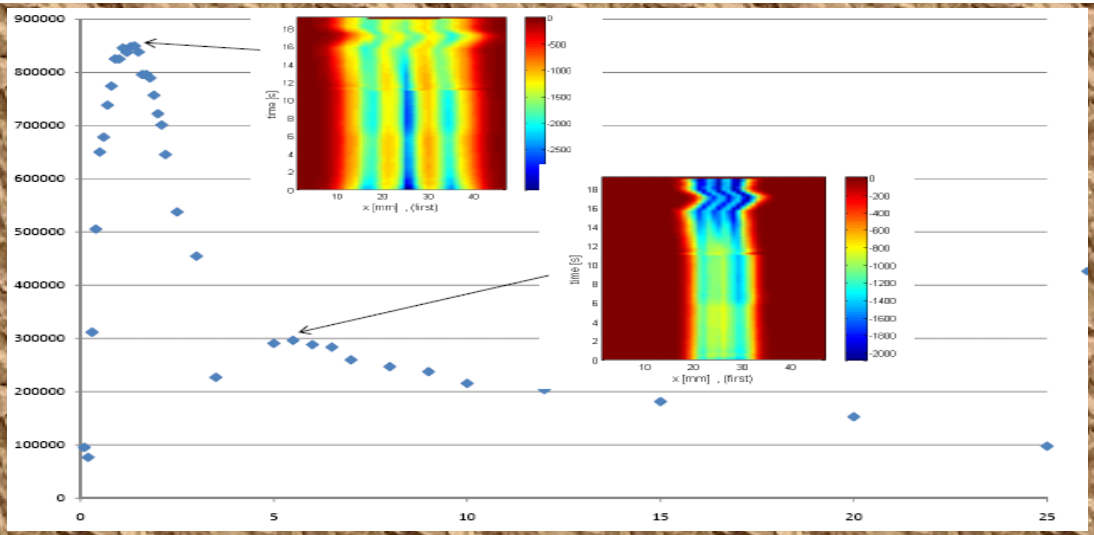
e-cloud already at low B-field.
Is it the real dependence of e-cloud on magnetic field or a transmission effect of the holes in the liner?

0 0.2 0.4 0.6 0.8 1 1.2 Magnetic field [kGauss]

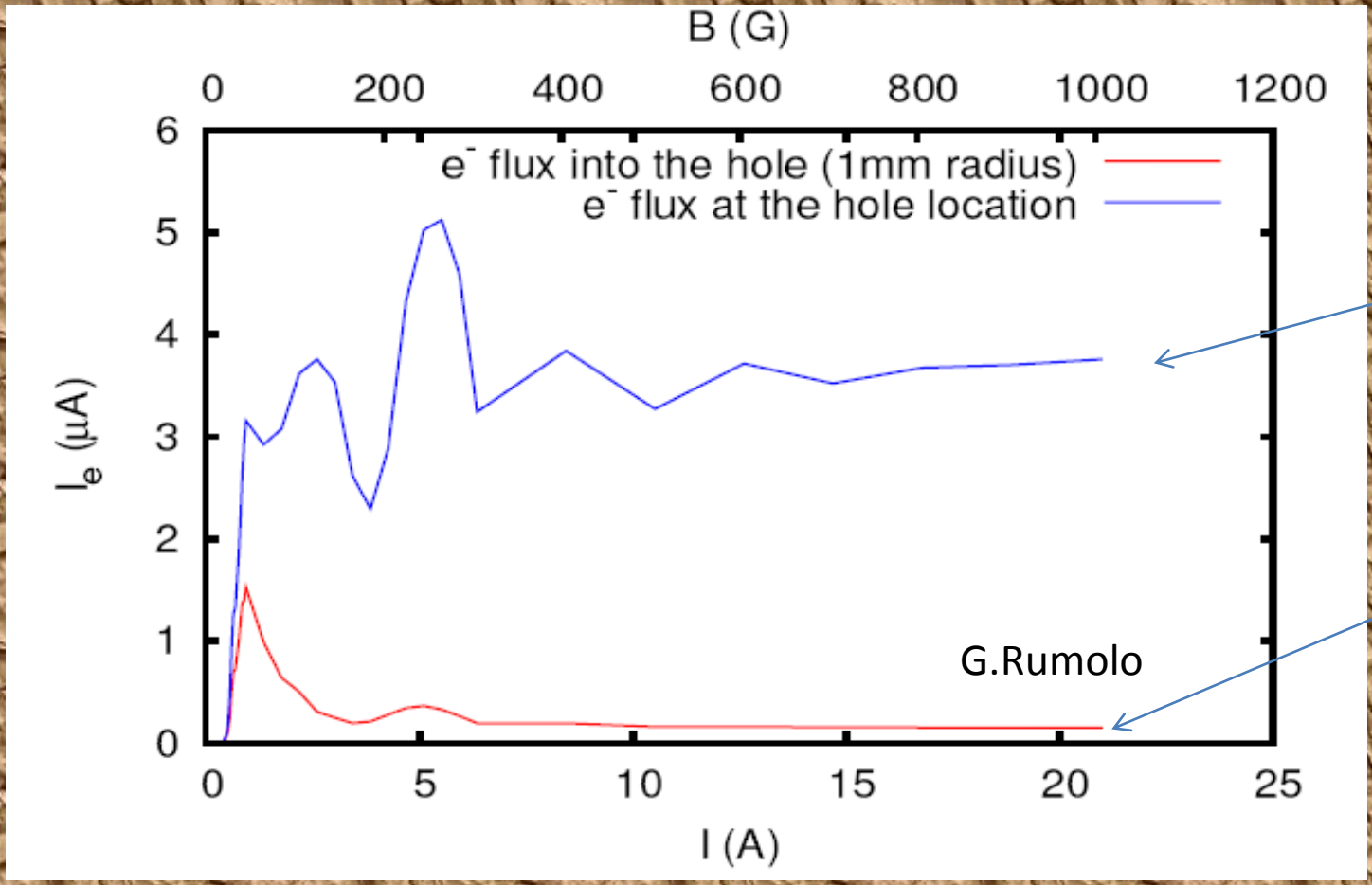
Comparison with simulation (by G.Rumolo):



Current through a central hole of 1 mm



Comparison of e-cloud measured in the hole and e-cloud without hole



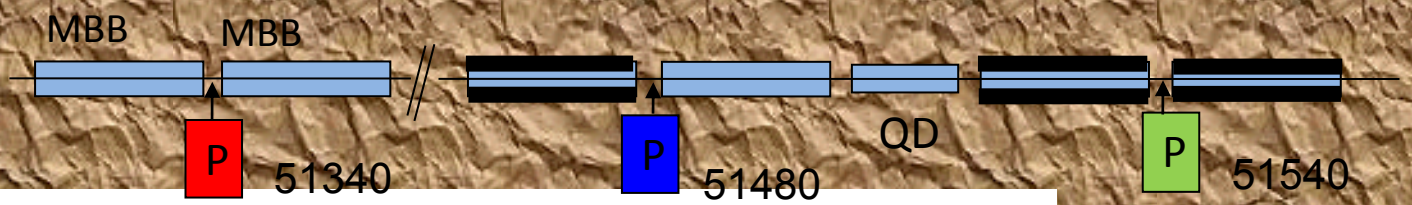
Effective e-cloud without effect of hole transmission

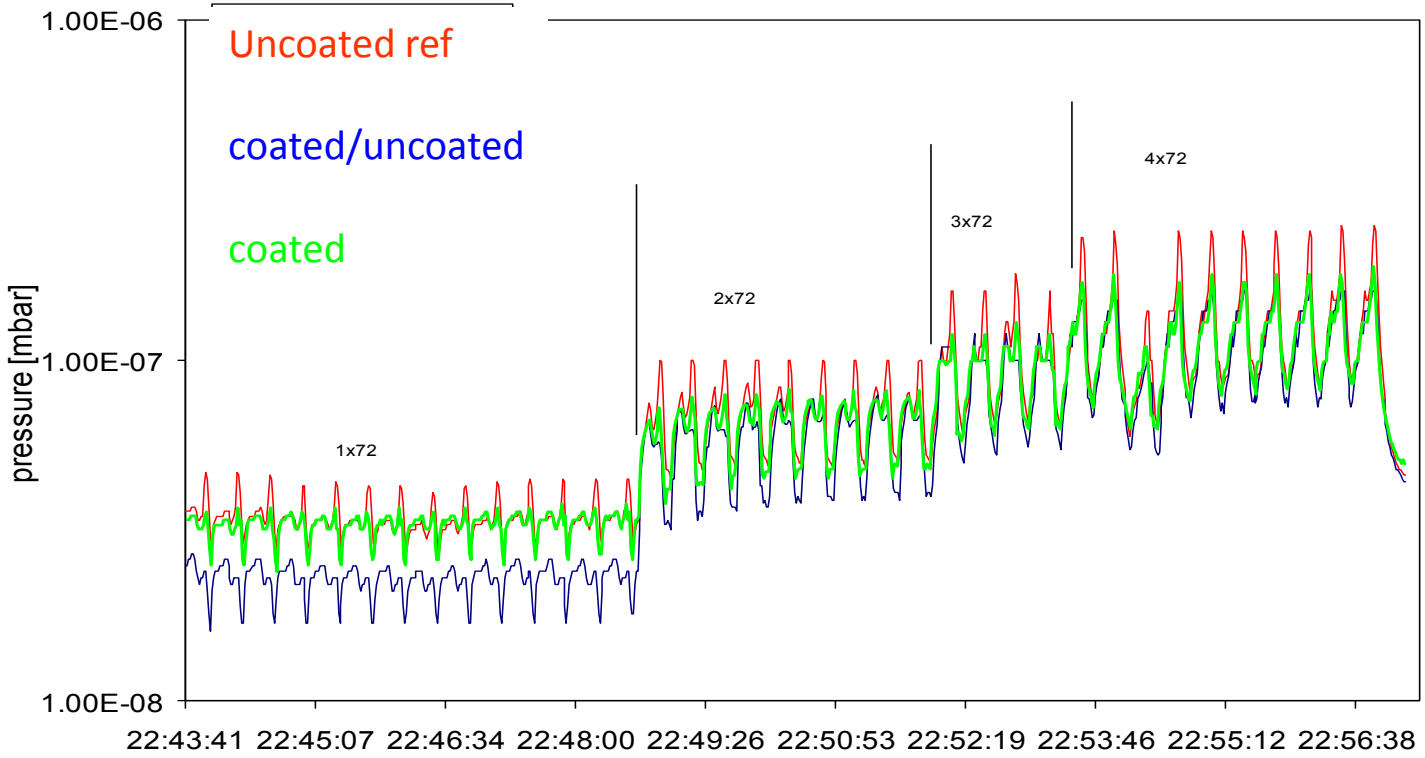
Effect of hole transmission

Indeed the e-cloud is intense already at low B fields

Results on coating of main dipoles of SPS:

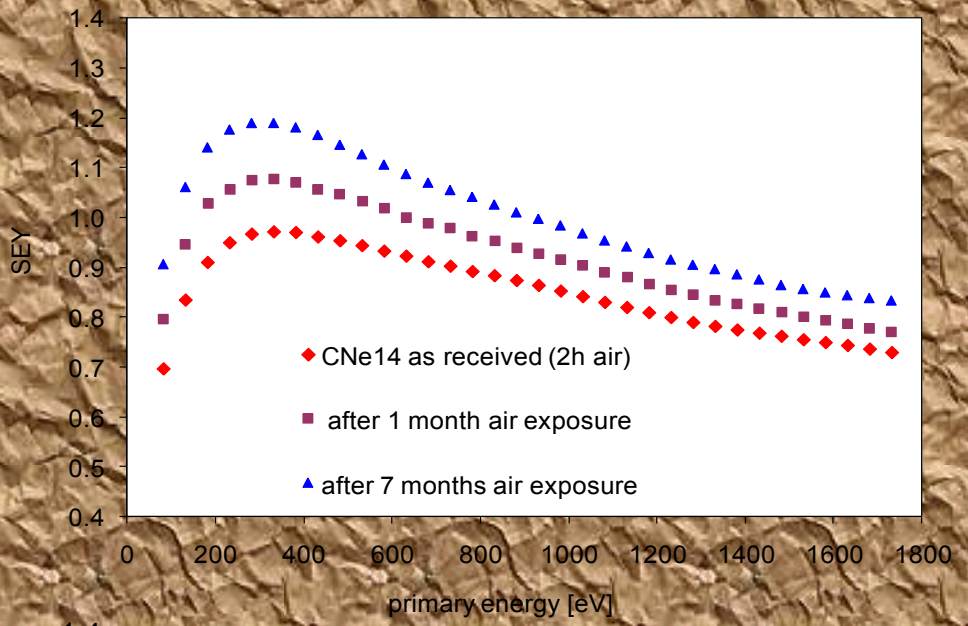
-No direct diagnostics (current measurement) installed in the dipoles excepted RF transmission (F.Caspers, S.Federmann)
-Only pressure readings, showing no clear improvement: is the pressure rise really generated only by the e-cloud?



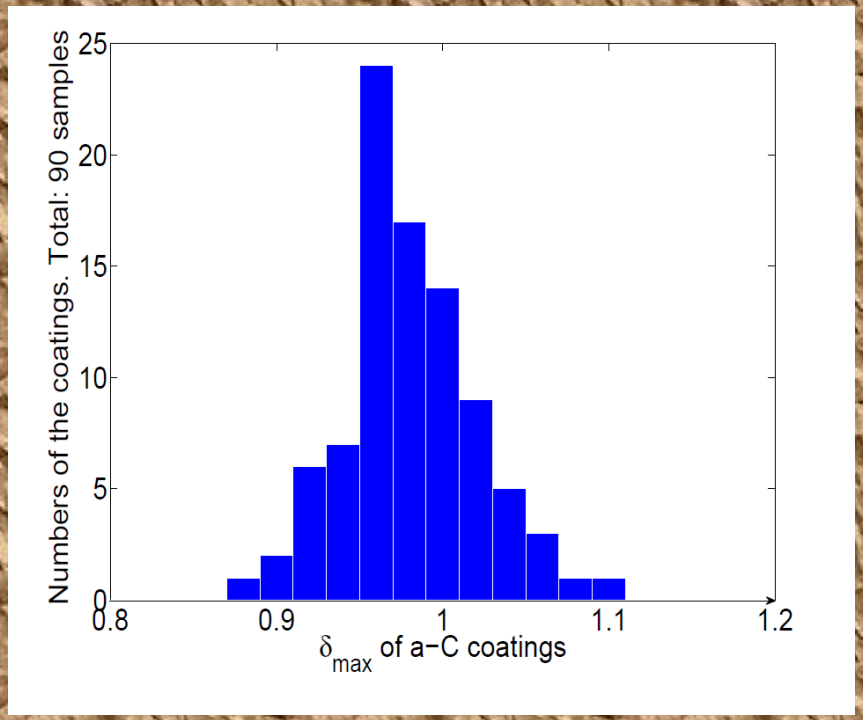


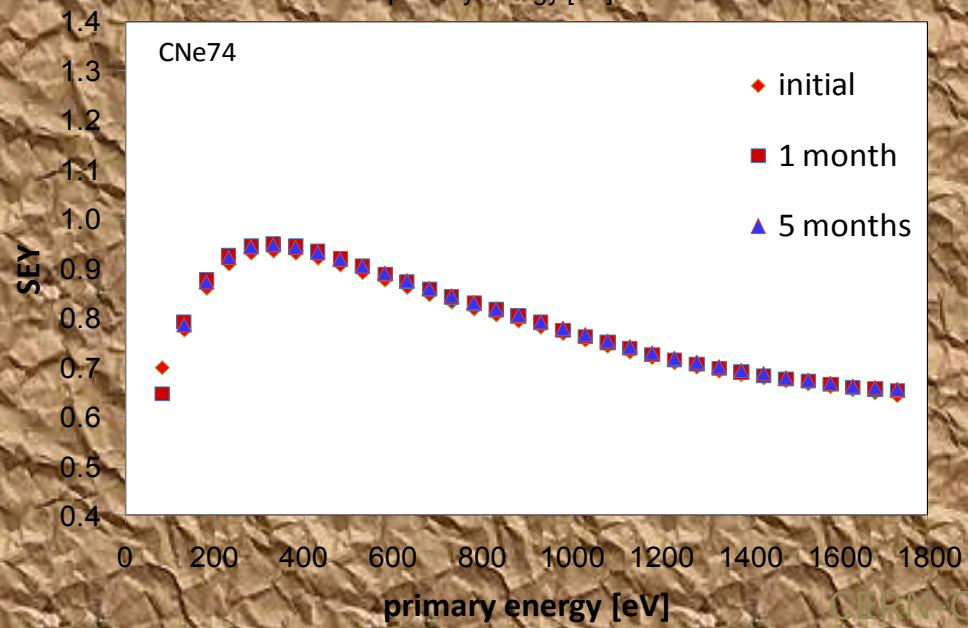
NB: No clear behaviour, since in other cases the pressure rise is higher for the coated

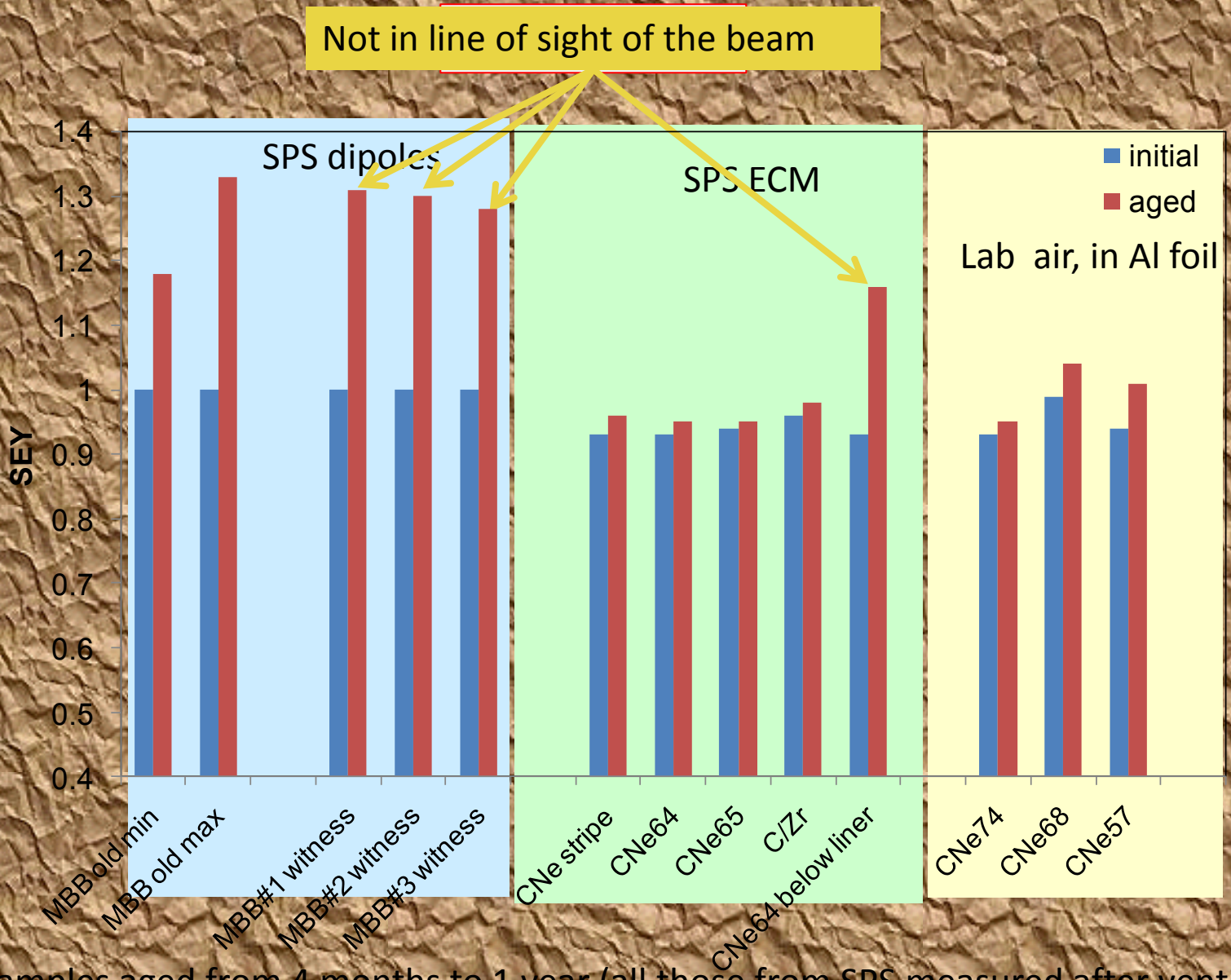
SEY of produced a-C coatings:



Coatings with maximum SEY close to 1 can be produced with good reliability







All samples aged from 4 months to 1 year (all those from SPS measured after venting and days/weeks of air exposure

In air aging is due to adsorption of either water or hydrocarbons, or both

Conclusions:

-ECM show more e-cloud at shorter bunch spacing

-The B-field effect on the ECM signal is well reproduced by the simulations; strong e-cloud already at low (50G) magnetic field

-In ECM the carbon coating strongly reduces e-cloud

-Aging of the carbon coatings in the ECM is very limited, but is larger in other samples stored in the machine vacuum

-A central stripe of 40 mm coating is almost sufficient to suppress e-cloud

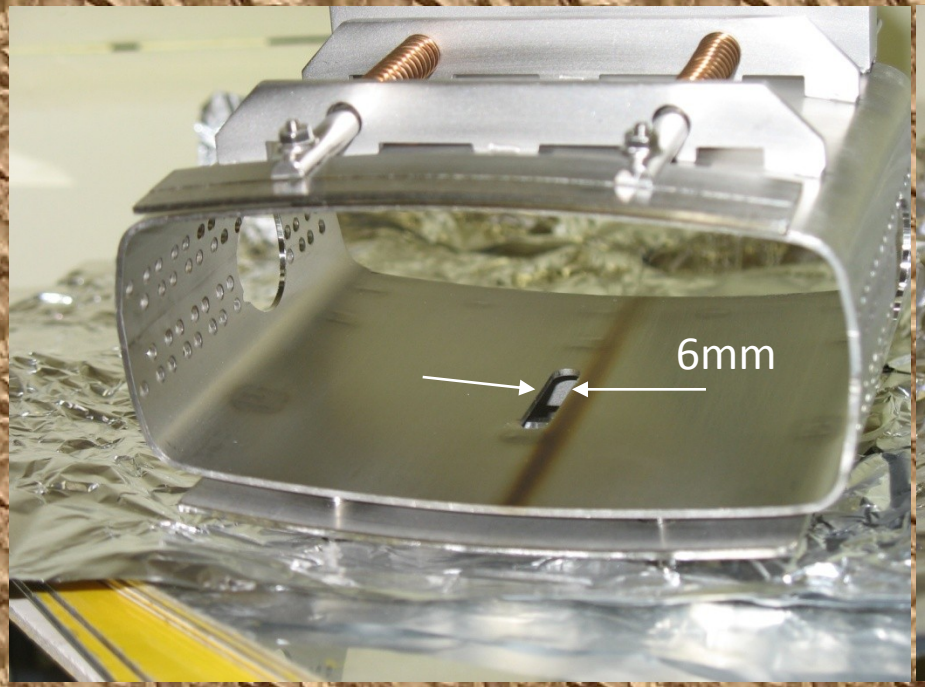
-Pressure rise with the carbon coatings in the dipoles is similar to stainless steel case: not understood

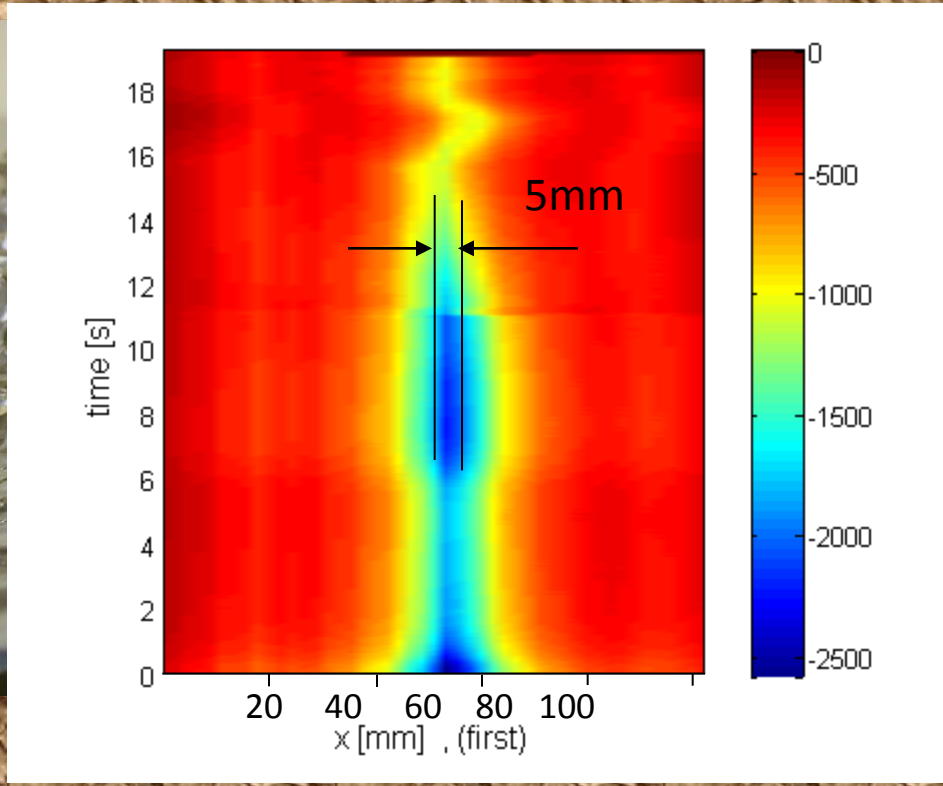
Thanks to:

SPSU working group (E.Shaposhnikova (chair), G.Arduini,J.Bauche, F.Caspers, K.Cornelis, S.Federmann, E.Metral, G.Rumolo, B.Salvant, F.Zimmermann, E.Mahner, B.Henrist, S.Calatroni, P.Chiggiato, M.Taborelli, C.Yin-Vallgren)
H. Neupert

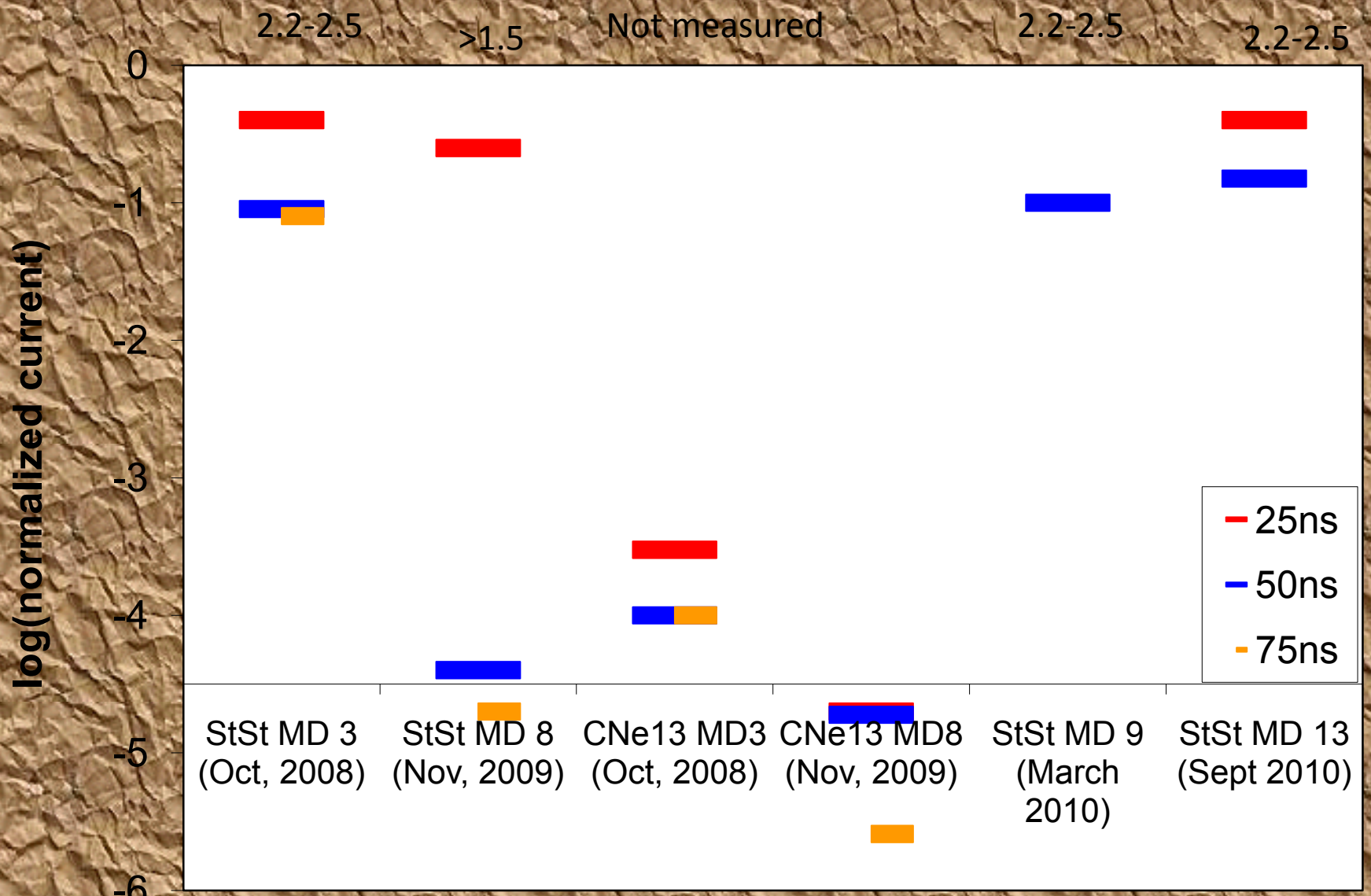
S. Kato, KEK

RF shield with antenna holes 24mm, extracted from SPS on 6/10/2009 from 51540 (between coated magnets)



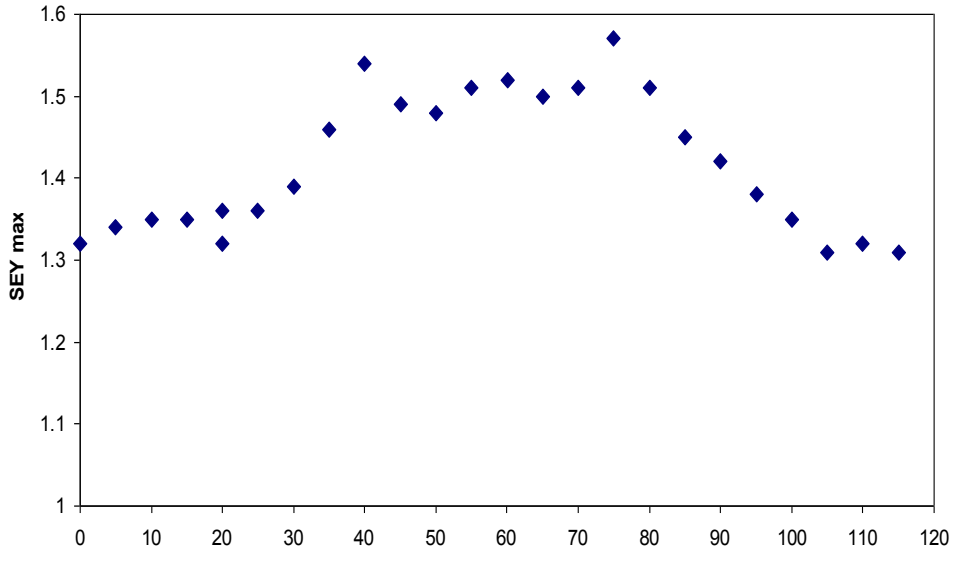


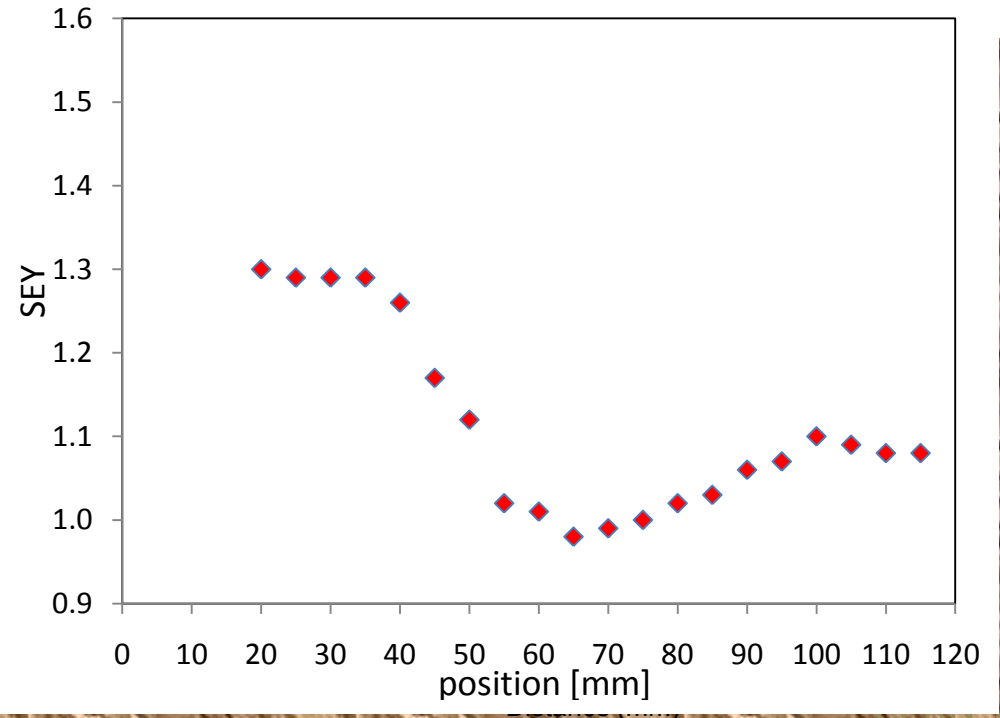
Shields were inserted in SPS in March 2009, after drilling the holes and chemical cleaning
The width is 5 mm, comparable with the most intense region of e-cloud measured for low field (0.4A ~20Gauss nominal) in the monitors



DLC 1.8 inserted, 1.6 conditioned: I=-0.17E4 (25 ns and
Stripe SEY on SPSU 25/2/10

SEY along the mobile sample





CNe14 (produced 08/05/08, in air 4 months up to 24/09/08, inserted SPS 4 months, extracted 26/01/09)

➔Aging up to 1.55 at the center is related to e-cloud irradiation

➔Aging from 1.1 (initial value) to 1.3 on the edge is related possibly to the residual gas only. As for samples stored in the MBB pumping port and below liners

CNe57 (produced 15/3, inserted same w11, in SPS 4months, extracted w29)

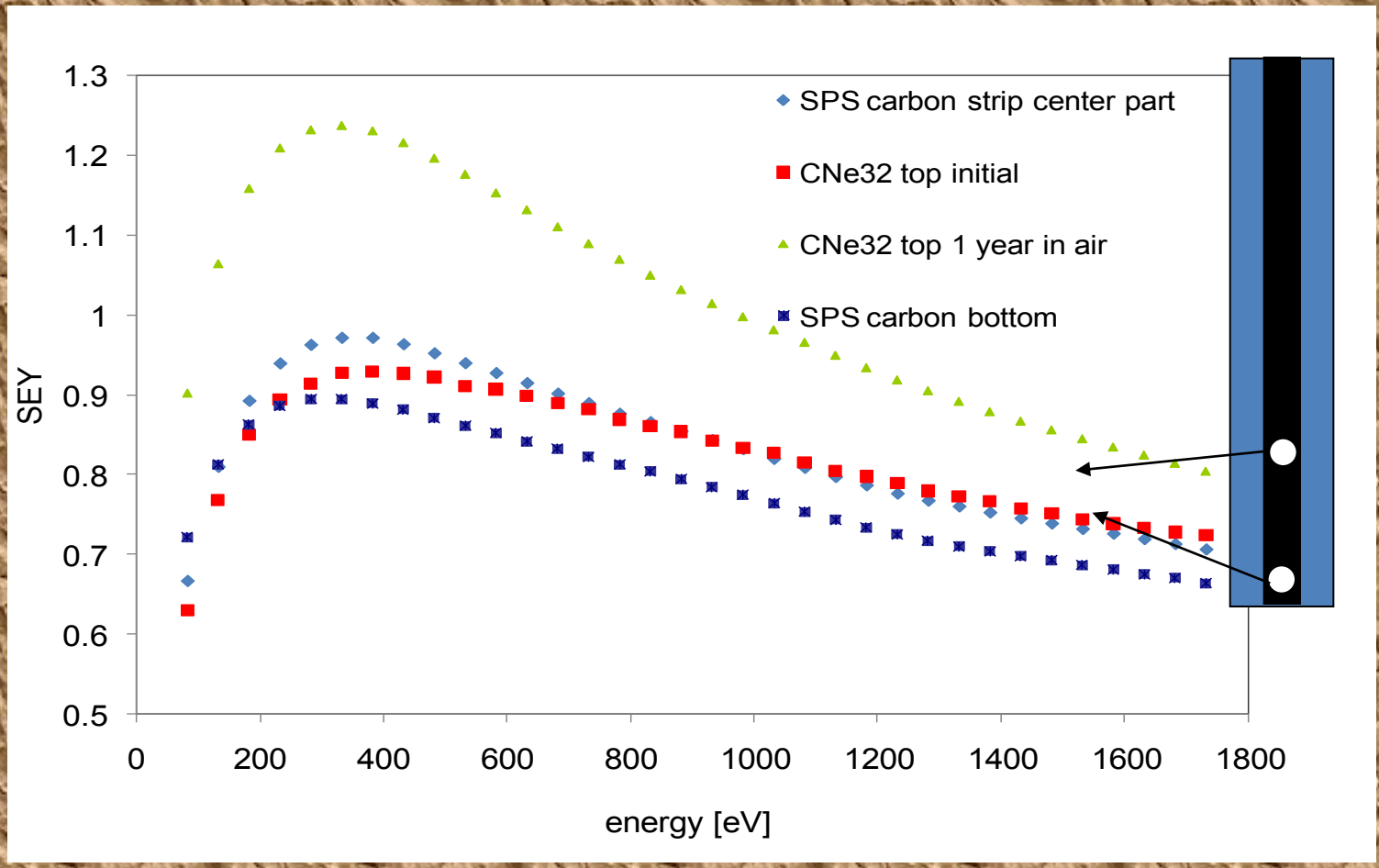
➔Minor aging in the center (0.92 to 1.0)

➔Aging from 0.92 (initial value) to 1.3, as all samples stored in the SPS vacuum

➔ Central region (irradiated?) does not age fast if it is initially clean, but non-irradiated (?) regions age: keep it 1 month in unbaked UHV in the transfer system and re-measure

SEY of a sample cut from liner

History: the liner was 1 year in SPS + 1 month in air



Both spots on the pieces cut out of the liner strip have still low SEY