
Progress report on Aging Study for SiD Hcal and Muon System RPCs

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Outlines of the report

- Review of the main motivation of project 6.19.
- Where we are standing after 7 months of working?
 - ♣ Set up a cosmic ray trigger array;
 - ♣ Finished second round of aging test, confirmed the aging phenomena in the first round test, on which we proposed this R&D project;
 - ♣ Purchased a Nikon microscope;
 - ♣ Microscope study of the aged RPC inner surface and Bakelite samples exposed to HF vapor;
- Plan for next 5 months and additional two years of the R&D.
 - ♣ Develop new variant Bakelite to improve the resistance to HF vapor.



Review: original motivation of project 6.19

- Addresses aging issues in RPCs built from the new type of Bakelite developed by the BESIII Muon group of IHEP (Beijing) and Gaonengke, Inc. (Beijing) for use in the BES III and Daya Bay Muon Systems;
- RPCs using this material have achieved acceptable dark noise rates without Linseed oil coating, but aging effects have not been thoroughly studied - there is no published report available on this topic;
- A preliminary study of Daya Bay Muon System RPCs has indicated a significant aging effect that must be understood and mitigated prior to use of this technology for SiD;
- In the longer-term, a collaboration with IHEP and XianHu, Inc. will lead to develop new variants of Bakelite that are more resistant to aging.



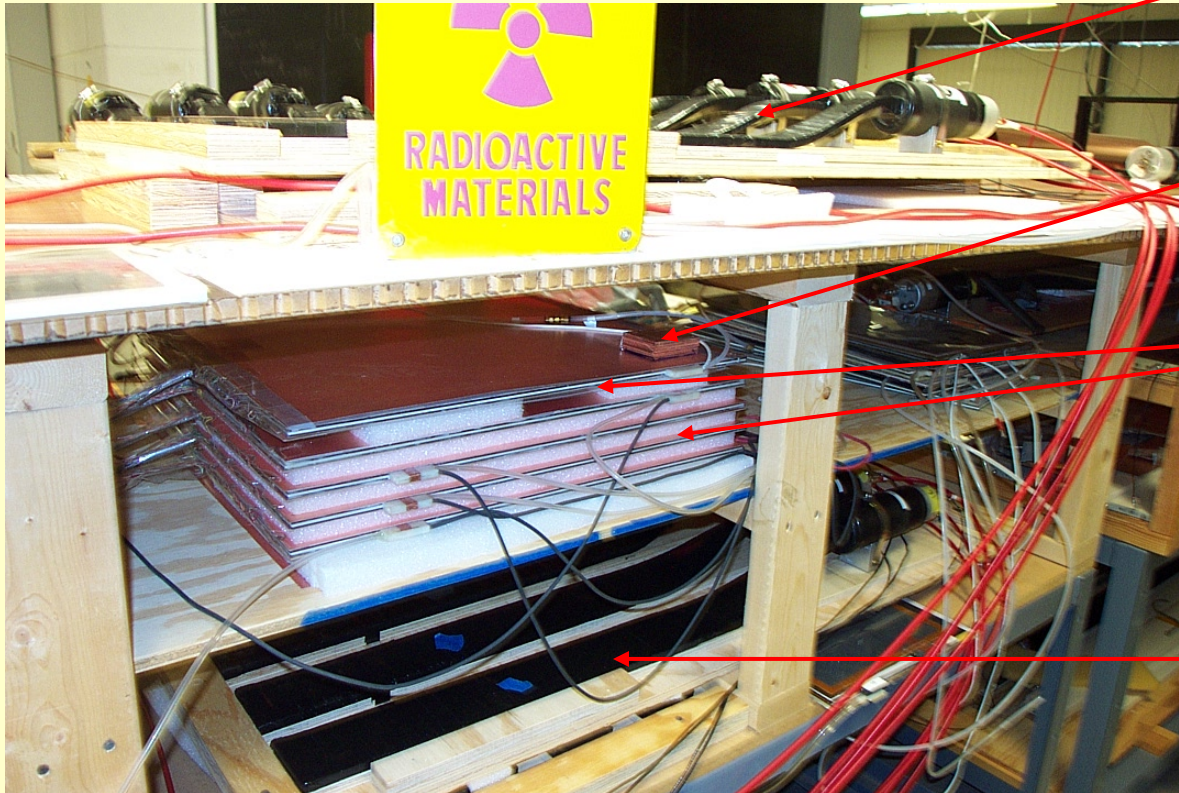
Where we are standing after 7 months of working?

- Set up a 16 strip scintillation counter trigger array for cosmic ray test;
- Assembled 5 BESIII-type aging test RPCs;
- Finished second round aging test for these chambers;
- Purchased a Nikon microscope to study surface morphology before and after the aging;
- Verified the aging test results from the first round of aging test — w/o oil coating BESIII-type RPC is vulnerable to HF attack;
- Developing new variant Bakelite electrode based on our aging test results;
- Starting third round of aging test with new RPCs that are made out of new variant Bakelite electrode.



What we have done: Test set-up

Second round aging test



Upper trigger array (x and y, 4 for each).

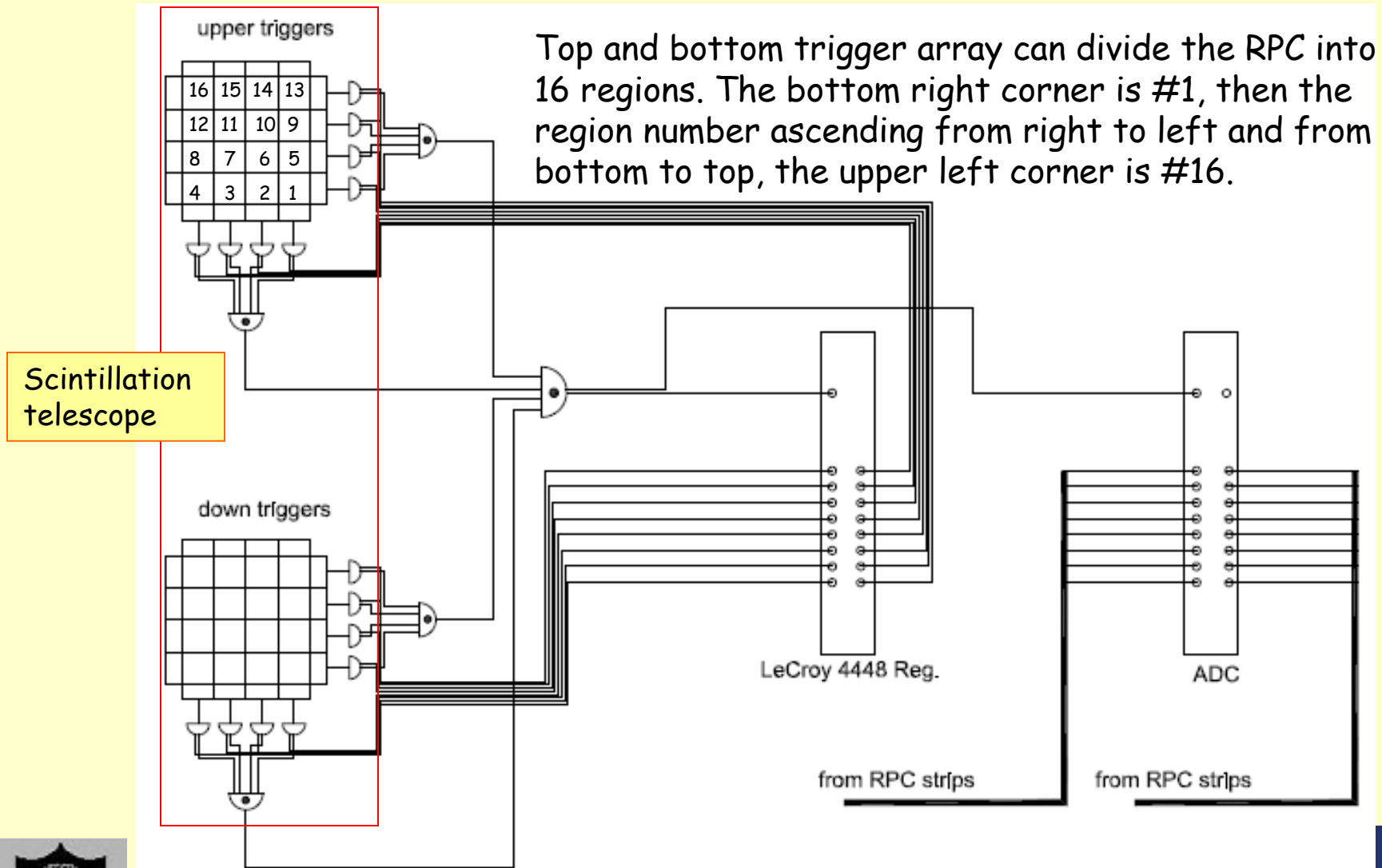
Copper plates, Co-60 source sits on.

Aging test RPCs.

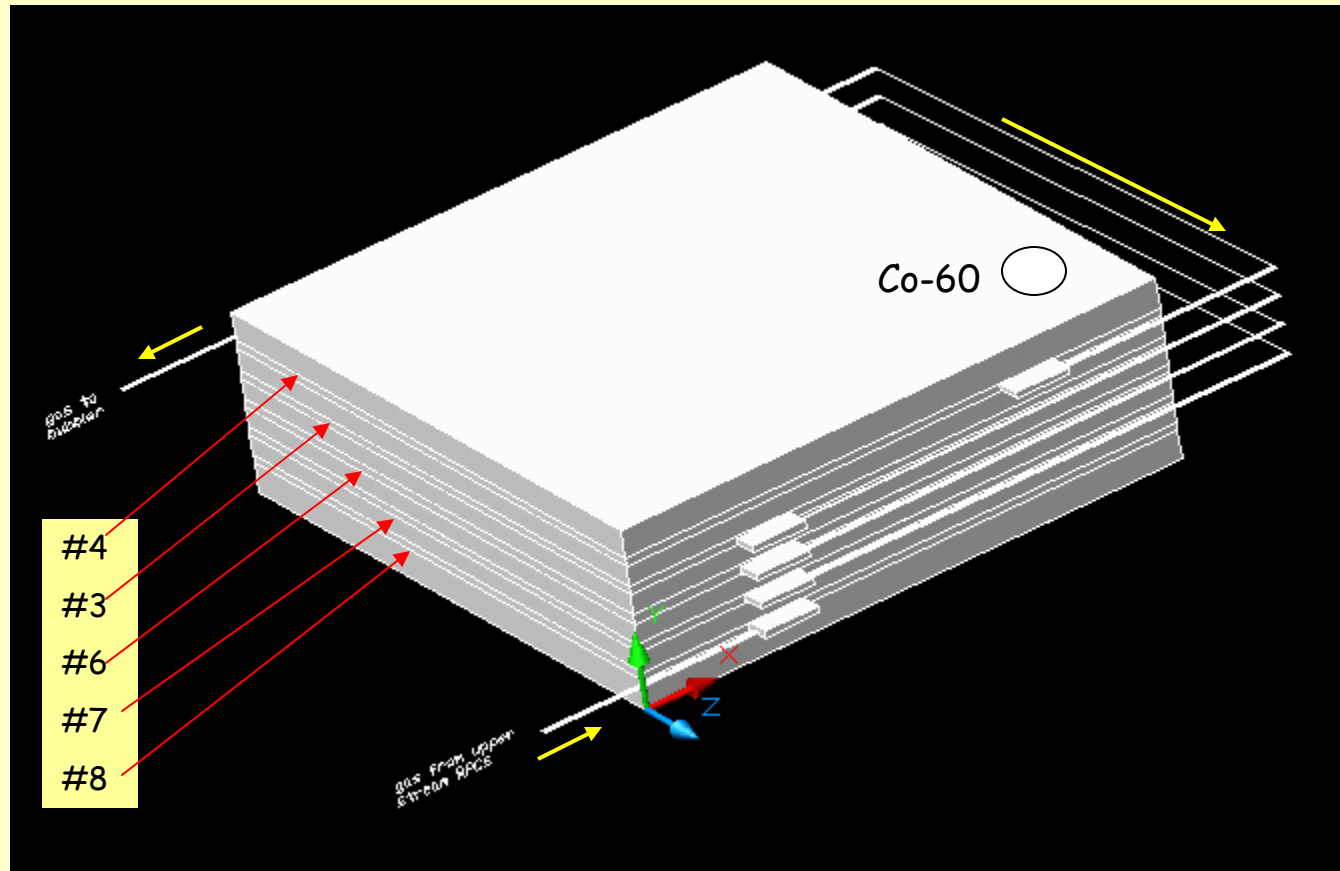
Bottom trigger array (x and y, 4 for each).



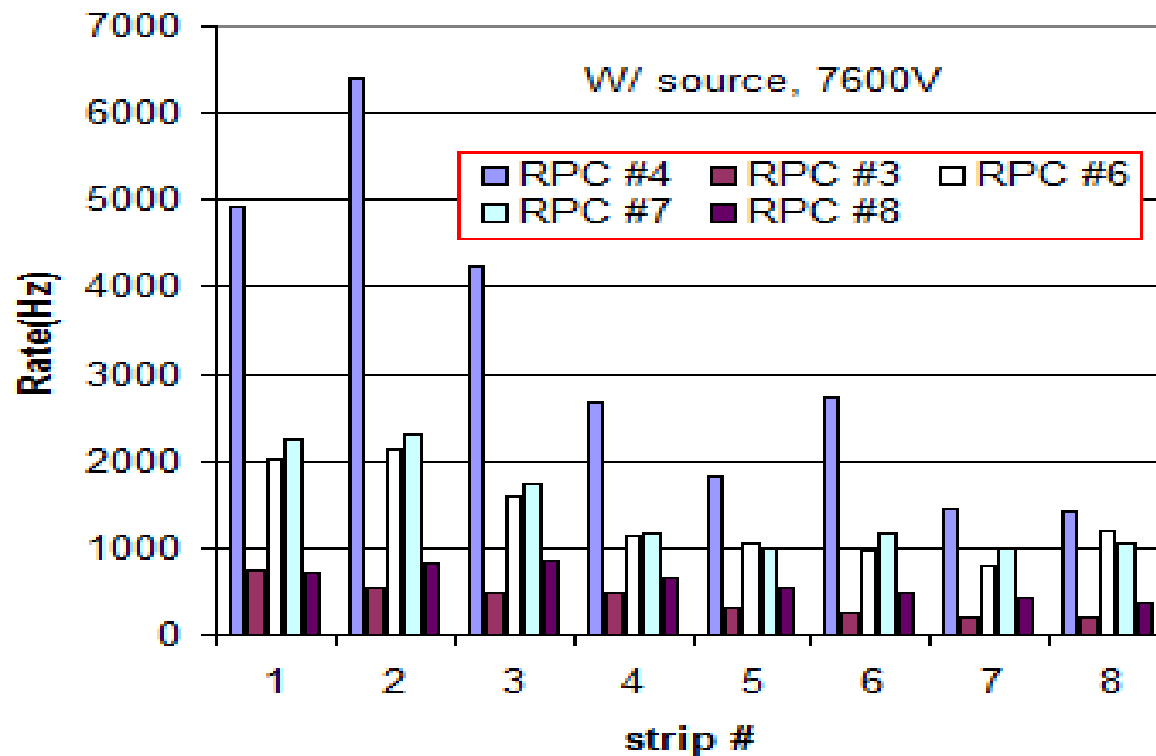
Test set-up: Scintillation telescope & trig logic



Test set-up: five RPC chamber stack



Second round of aging test: Single's rate

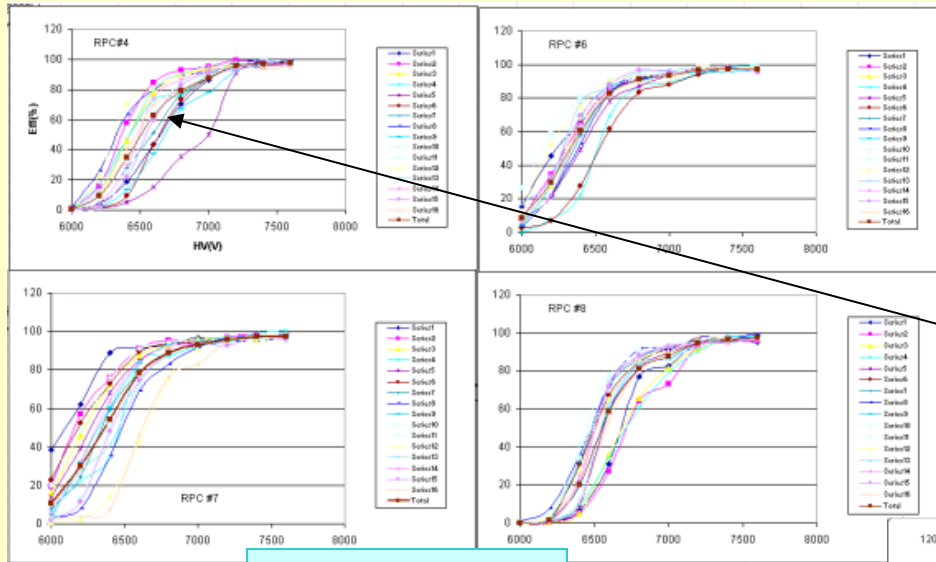


Singles' rates w/ source are quite different for RPCs. RPC #4 is the noisiest, ~6kHz for strip #2. RPC #8 is the quietest, ~0.8kHz for strip #2.

Aging dose per day is different among these RPCs, their ratio is (#8): (#6, #7): (#4) ~ 1: 2.5: 7.5.



Second round test: Efficiency degrading with aging

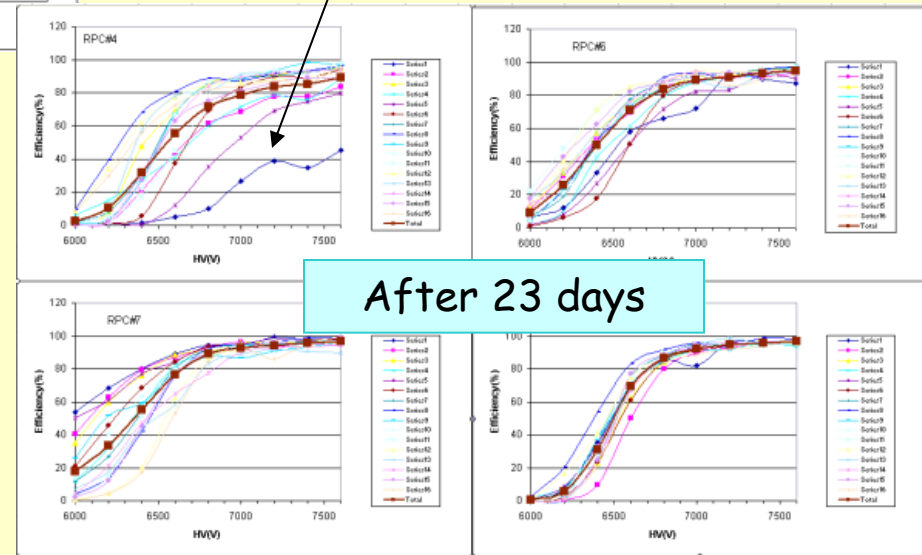


Initial

Followed this test a new Linseed oil coated RPC joins the aging test, the test results show this RPC performs much better than w/o oil coating. See next slides.

Aging dose: Because RPC#4 is very noisy, 1 month ~ 120 months of normal cosmic ray background operation.

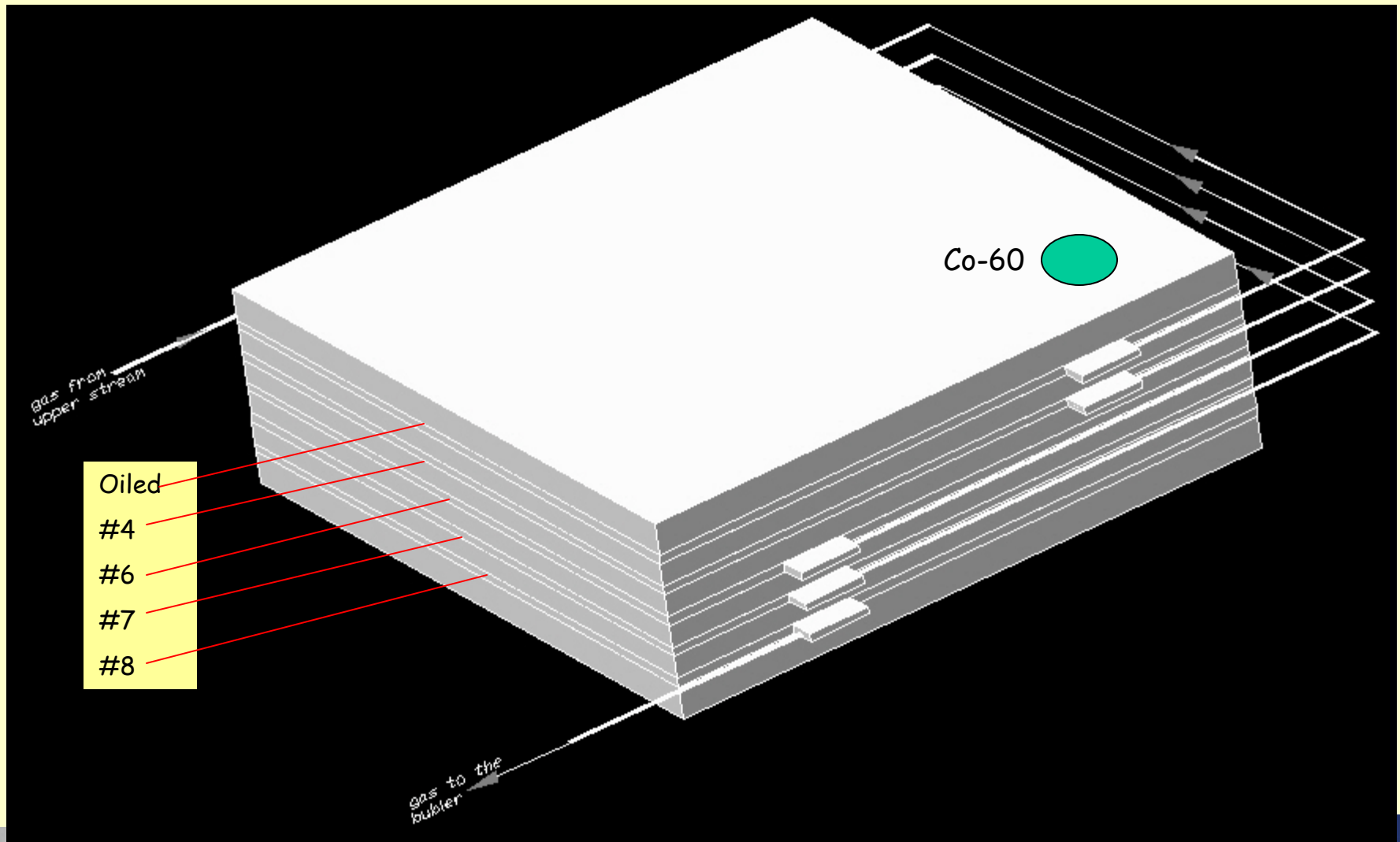
Serious aging (equivalent to 7.6 years of cosmic ray run) !!



After 23 days

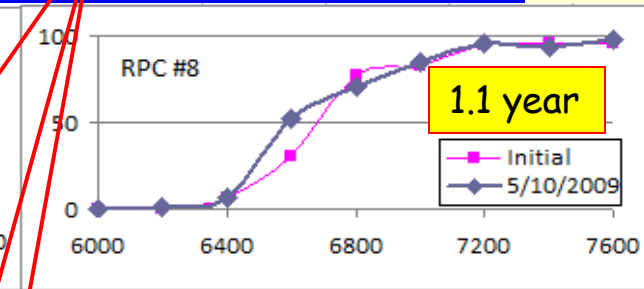
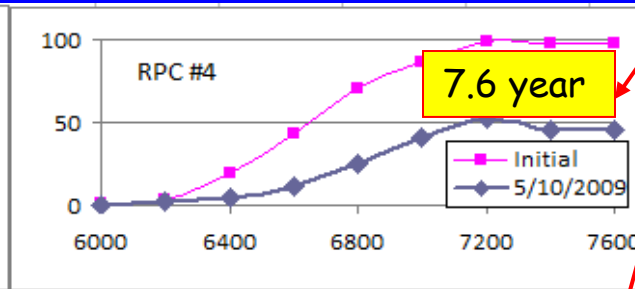
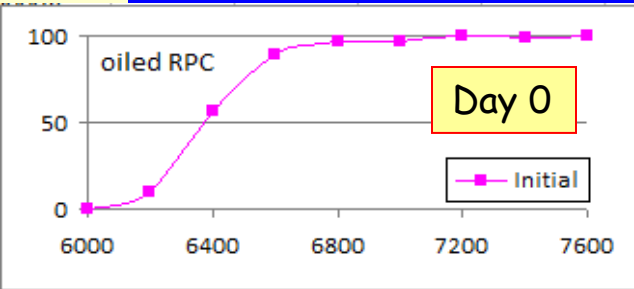


Oiled RPC joins the test

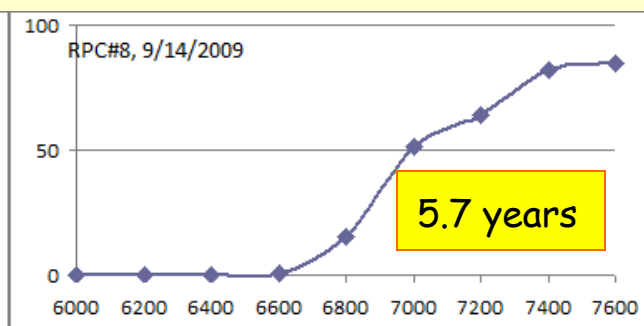
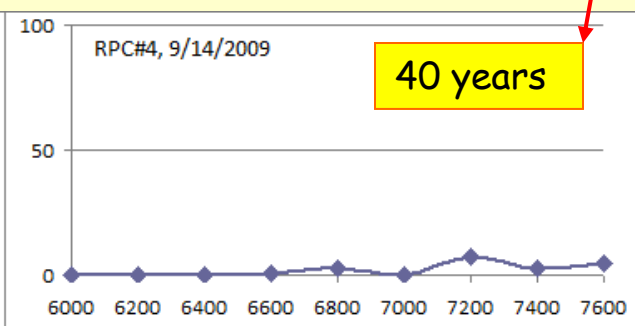
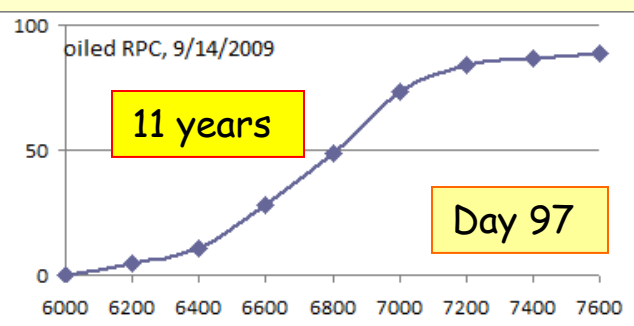
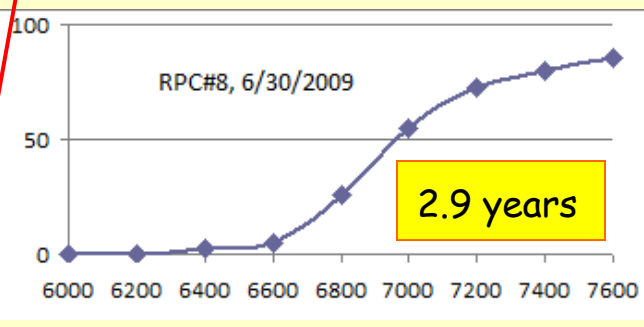
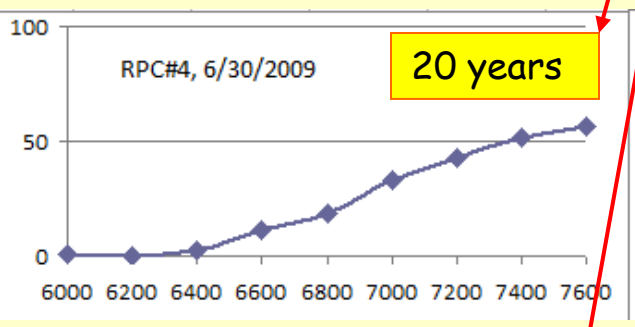
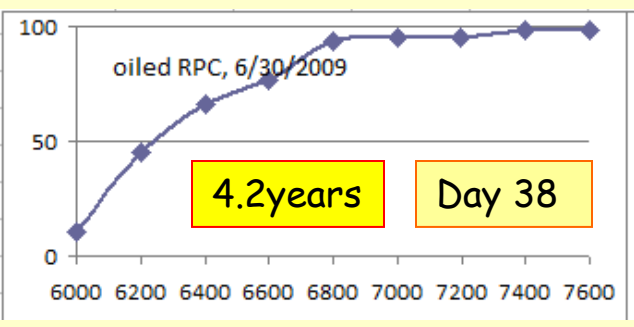


Evolution of aging test RPC's efficiency

Equivalent cosmic ray run years.



Aging dose: oiled RPC, 1 month ~ 40 months of normal cosmic ray operation (rate at 2kHz/m²).

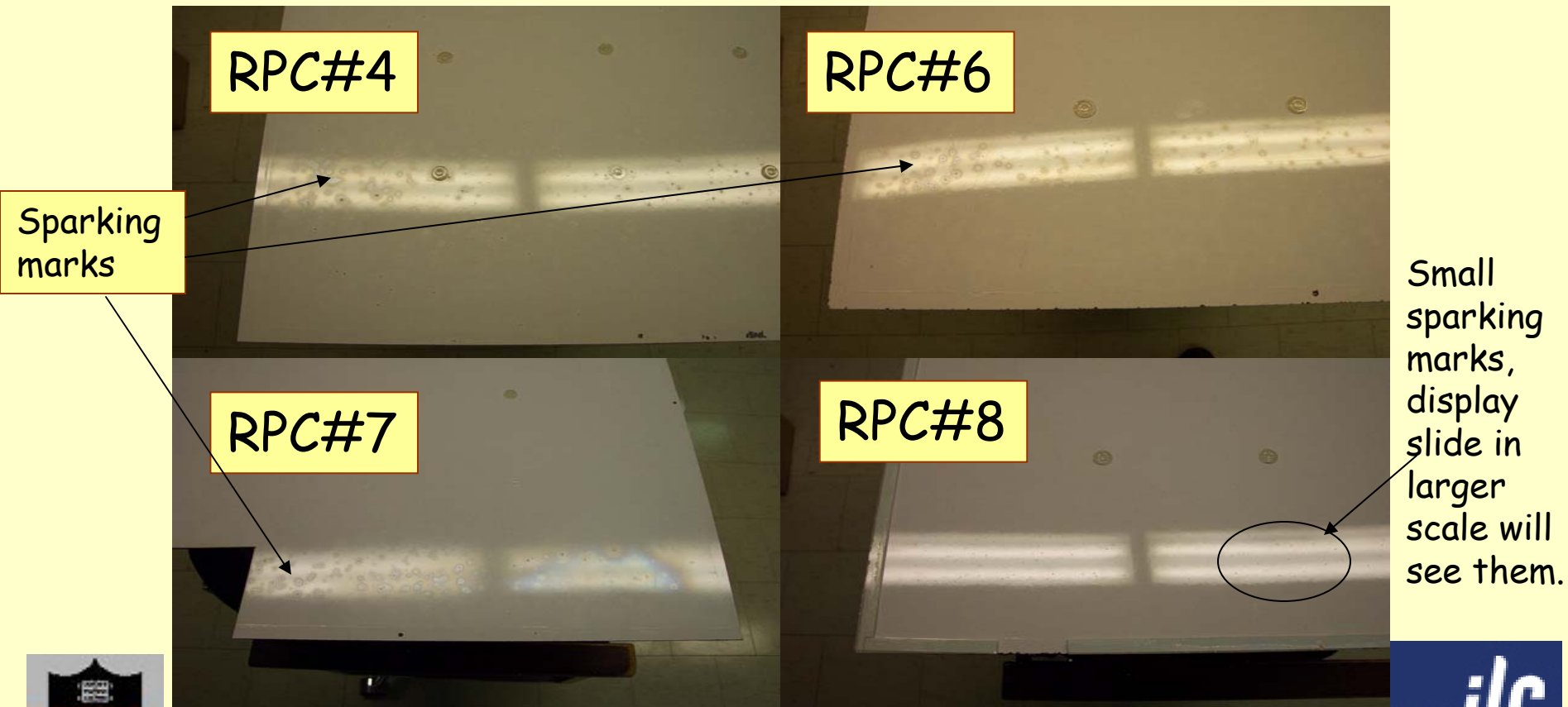


Linseed oil coated RPC has better aging performance.

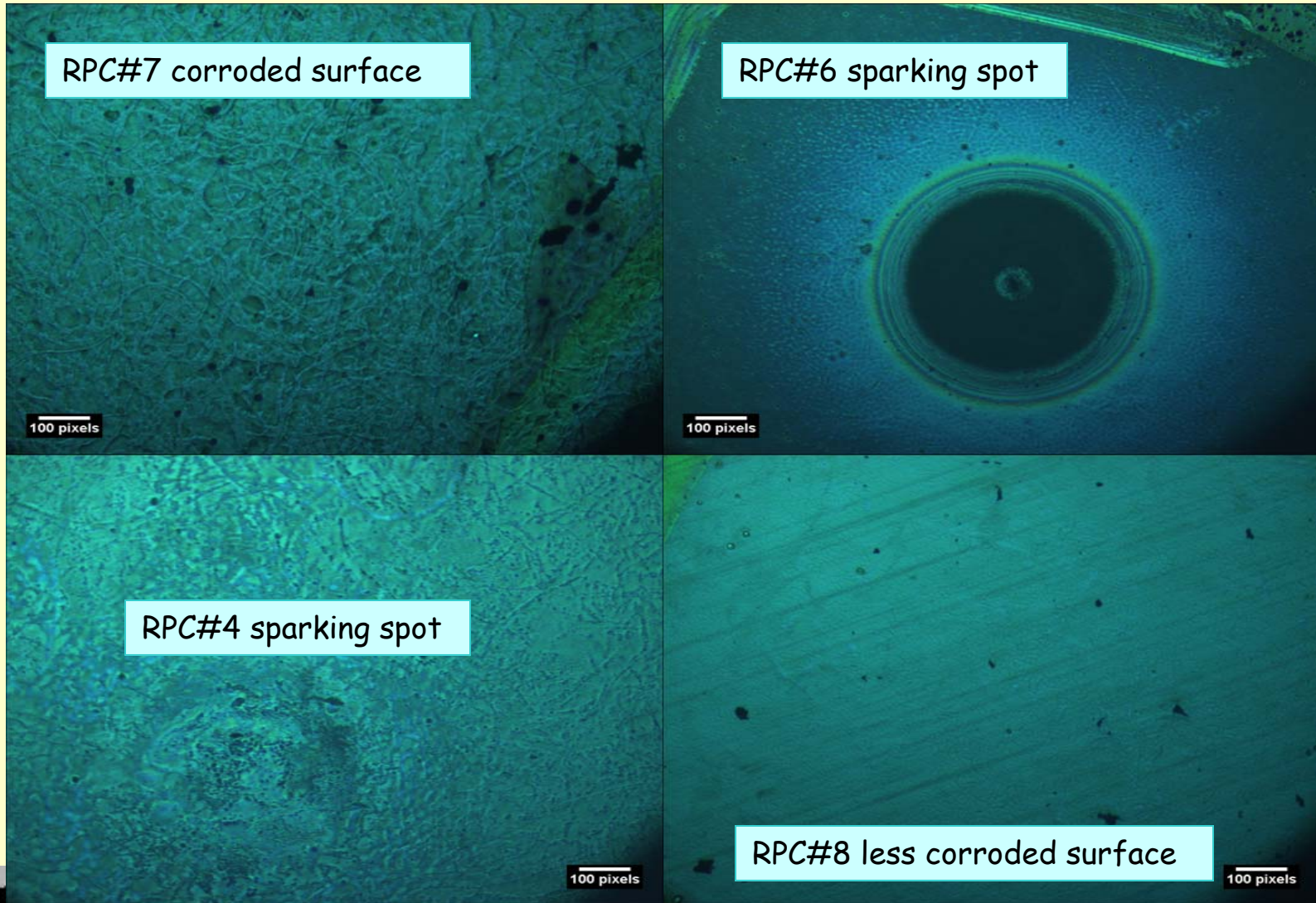


Aged RPC inner surface

Opened the aged RPCs we can see very dense sparking marks populated all over the inner surface. RPC#8 has much smaller size sparking marks. The microscope images of the inner surface are shown in the following slides.



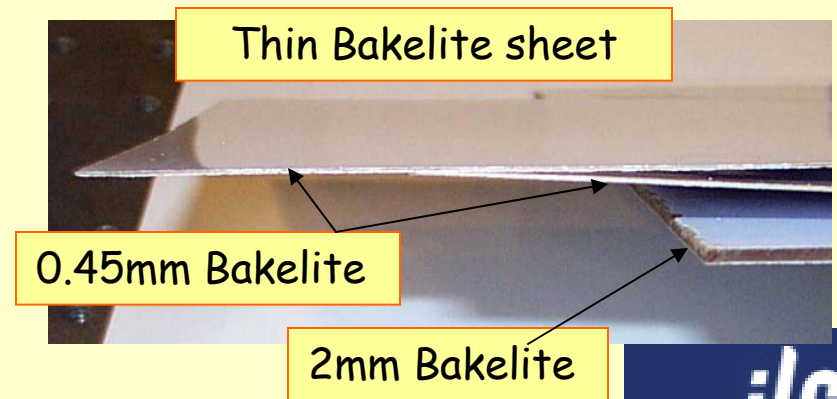
Microscope study: aged RPC inner surface



Develop variant Bakelite

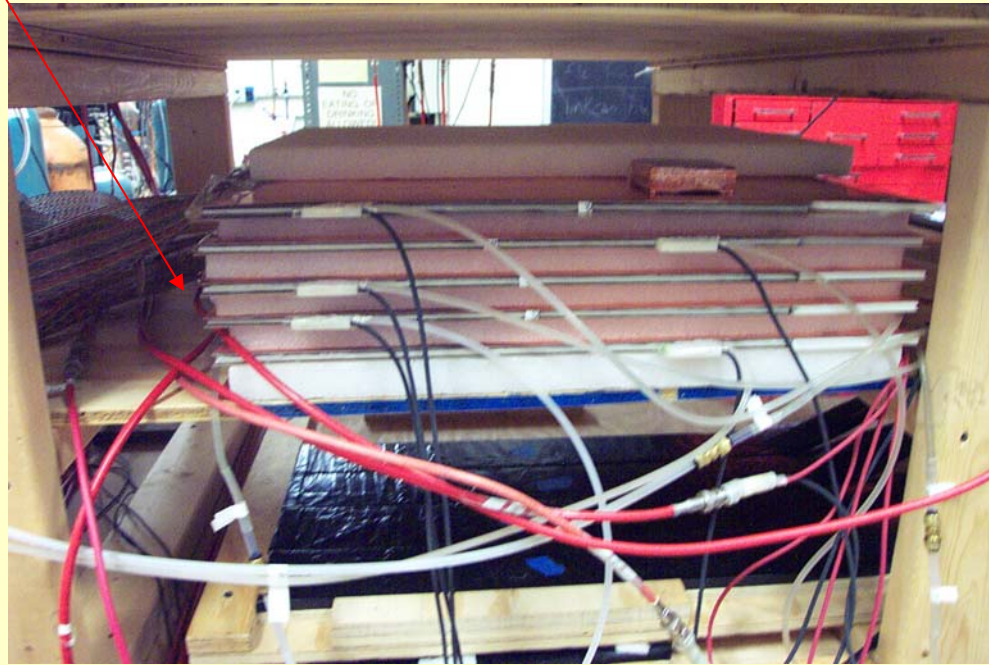
We now know the oil coating can protect the Bakelite surface from HF attack. Based on this observation XianHu, Inc. is developing new techniques to integrate this coating into the Bakelite production procedure. We have obtained some small sample pieces. The surface smoothness is not as good as ordinary Bakelite, it certainly needs further improvement. Five RPC prototypes with the new Bakelite are undergoing the aging test. We are also developing mirror quality surface Bakelite sheet. Such Bakelite is presently available on market, but expensive. The goal of this R&D is lower the cost, make it affordable.

Another by-product from this R&D is thin Bakelite sheet. We have produced 0.33mm thick Bakelite sheet, which has good potential application for making double gap RPC and mRPC.



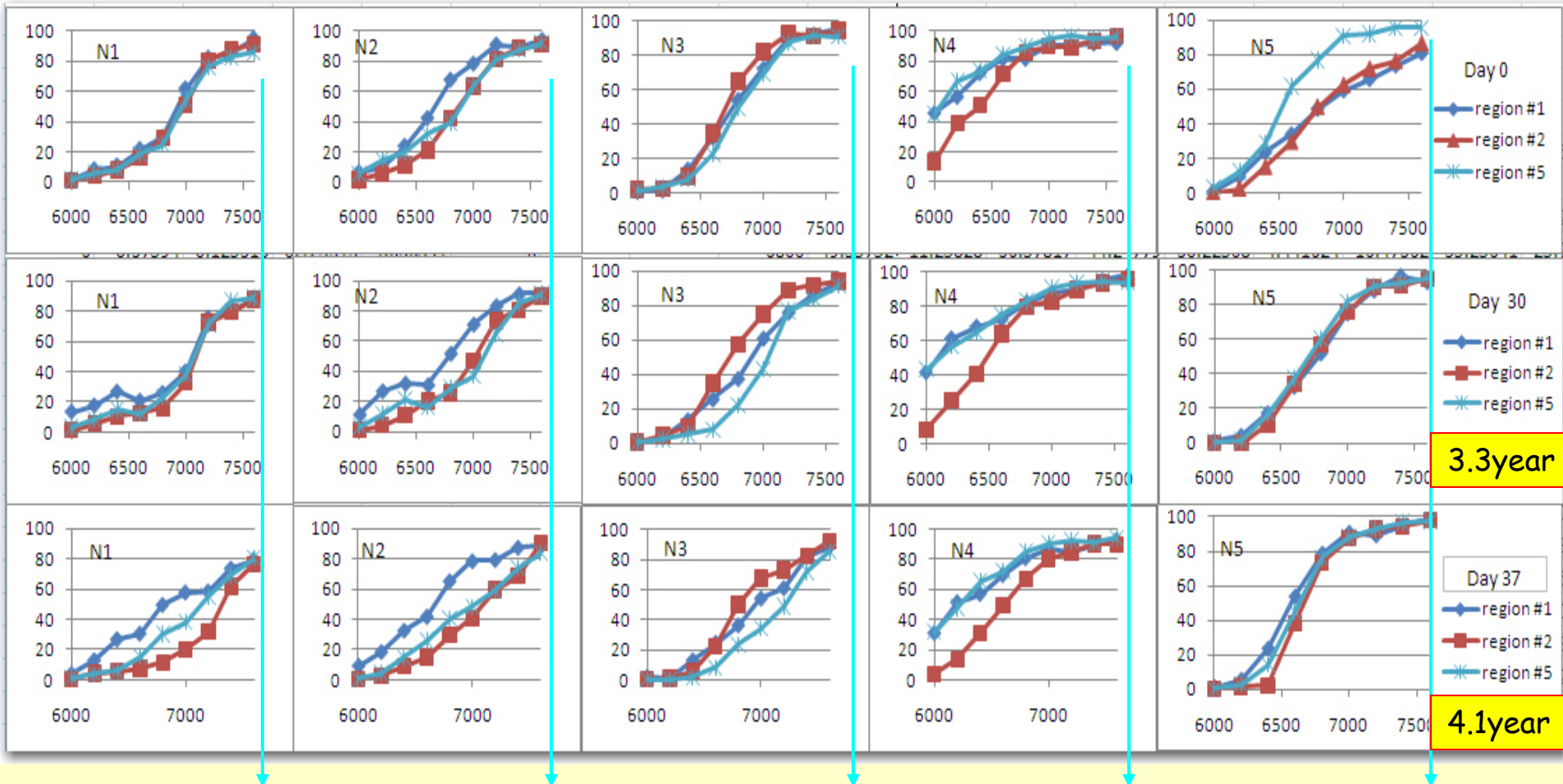
3-d round of aging test

5 new generation RPCs that are made out of oil embedded Bakelite have been assembled, their initial performance has been checked. The new Bakelite used different resin, which mixes Linseed oil into normal resin. Preliminary test shows its resistance to HF is somewhat better than original BESIII Bakelite. Aging test on these RPCs will tell us if this technique works.



Preliminary test results for new generation RPC

Pick up 3 regions: #1, #2 and #5, they are under the source or neighbors. Plot 0, 30-th and 37-th day efficiency curves.



Efficiency getting worse with time

Efficiency not change much

Efficiency getting better with time

Summary of 3-d round test

Third round of aging test results are mixed, some RPCs aging performance is similar to original version of the BESIII RPC, but one RPC looks much better (N5). The reason is unknown yet. Mixing Linseed oil into the resin seems to have some influence on the aging performance.

We have found that the surface smoothness produced by this new technique is not satisfactory, this is the reason why they are noisier than Linseed oil coated RPC initially. The surface protection mechanism has not been established yet through this round of test, some are better, but some have no change.

We are developing mirror quality surface Bakelite sheet. If we can combine this with oil embedded technique together we can expect the new RPC will have better aging performance.

