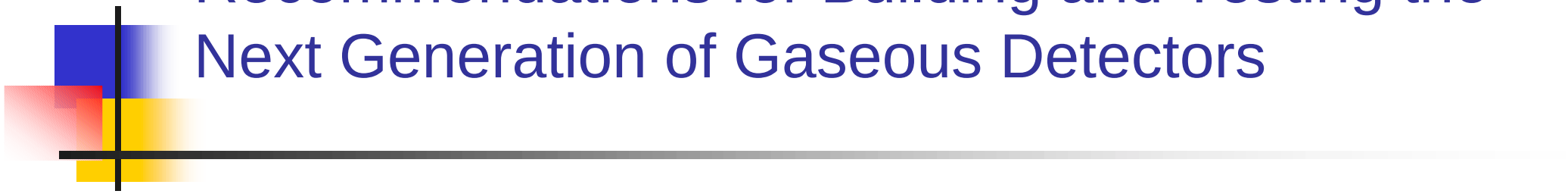


Recommendations for Building and Testing the Next Generation of Gaseous Detectors

Bernhard Schmidt
DESY - Hamburg

After 1986 ….

- New class of gaseous detectors for high radiation level environment (LHC, HERA-B , ++)
  - Radiation levels not even thought of in’86

    from mC/cm → manyC/cm

Two different classes of detectors

'standard radiation level'
(LEP, HERA-ep,BaBar..)

- Basic rules for construction, testing and operation are known
- Established
- Demonstrated to work and survive

'high radiation level'
(LHC, HERA-B, ++…)

- Enormous R & D done
- Many *NoNoNo* are known
- Some basic rules found
- Real world and final proof still to come !

Recommendations for standard detectors

- Construction
  - Profit from >40 years of experience
    - **Avoid the well known ‘never do’**
      (silicon oil, certain glues, PVC tubing, wooden insulators..)
    - **‘Moderate care’ in building them**
      (somehow clean environment, cleaning procedures, good old materials..
    - **Huge variety of gases**
      (hydrocarbons, freons, alcohols, methylal, ammonia, magic mixtures..)
    - Operation : avoid excessive radiation levels !
      (switched to ‘safe’ under conditions FAR from LHC normal operation)

….. standard detectors

If it fails : you have done something wrong !

Finally : if you observe ‘aging’
(if it gets sick)

Apply additives !
(H_2O, alcohol..
some..)

..additives

That's what we need !

The real challenge : LHC type detectors

Recommendations more complicated, proof still to come !

- Materials (see talk by Mar Capeans)
  - The list of ‘never use’ is much longer now
  - Use the NASA book + RD28 experience as a guideline to start with
  - This is your basis ! You have to do TESTS to match you specific requirements
  - Outgasing is serious. Normal and *radiation induced* outgasing !
    (disintegration, chemical reactions..)

gases

- Almost all is excluded now !
- Left with:
  - Noble gases, CO_2 , CF_4
  - Plus ‘traces’ of water…

Dangerous companion
offers a lot, but hard to control,
agressiveness,…
Can he be trusted ??

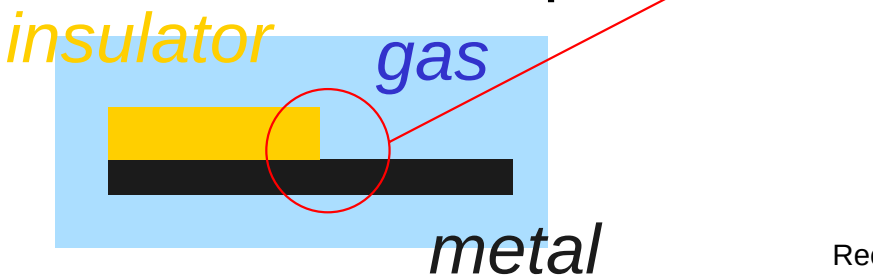
The good old
medicines won’t work !
(alcohol, water,
methylal..)

construction

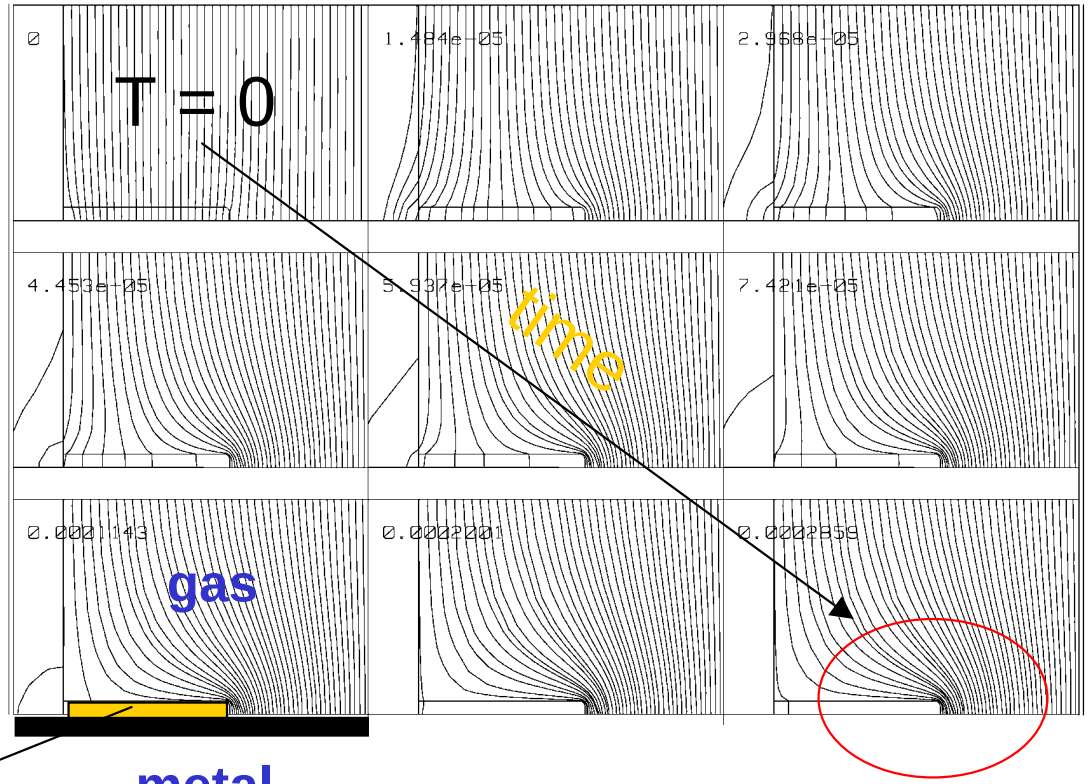
- Start with non-suspicious material (metall,ceramics, glass..) and add plastic with greatest care
- Think about the electric field distribution very carefully

  (gas gain, cathode fields, discharges, ion transport, polar molecules..

  - It might look different under irradiation !
  - N.B.: the counting gas under irradiation is a MUCH better conductor than your insulators
  - Avoid ‘triple junctions’ in high fields, they are prone to develop problems !



A triple junction under irradiation



Creating virtual tips

More on construction

- Think about the gas distribution very carefully (main gas, avalanche products, radicals..)
  - In all but straw chambers, the internal gas distribution is *complex* !
    - forced flow + diffusion + convection

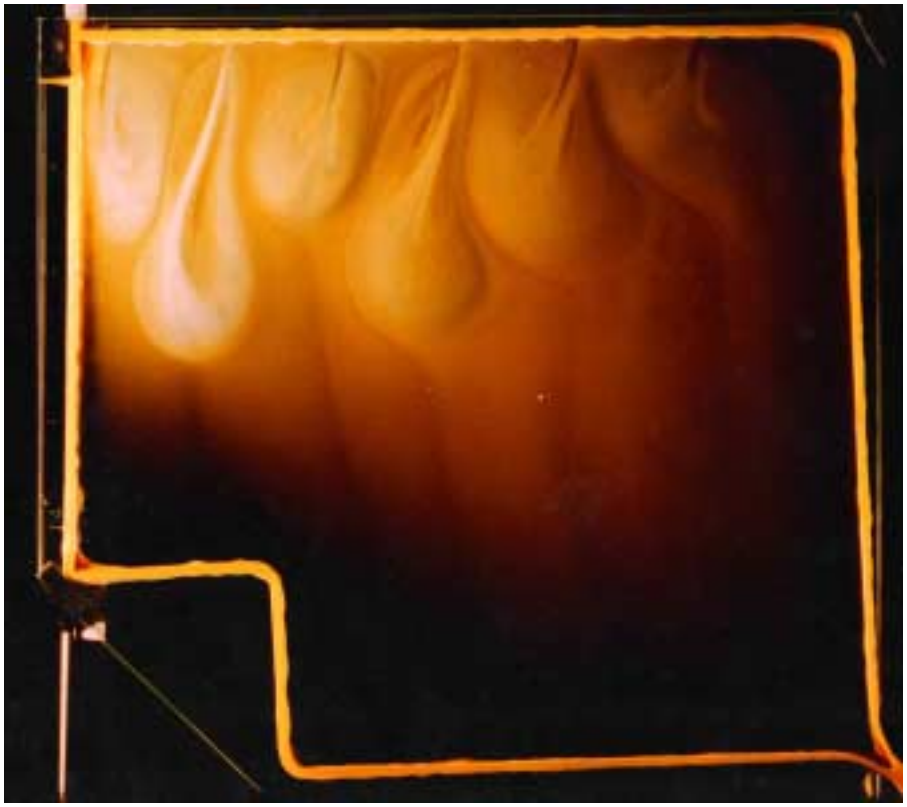
Might be completely different in your prototypes and test chambers !

temperature profile !

… gas distribution

- Study by ‘classical methods’

Transparent prototype +
some good cigars
(not recommended)



- Recommended :
  get professional help !
  (invest money and time)

Building the detector

- Work under clean and controlled conditions
  - ‘dust particles’ are not the *only* thing to consider
  - Do not introduce bad components by improper handling (unfiltered air, greasy fingers, polluted tools…)

    (see talks by Mar Capeans and Cristobal Padilla)
  - Document what you have done ! Rigorously !
  - Keep samples of all materials (actual ones, not just ‘the same’..)

…building..

- *Verify* that rules are not violated !
- Be aware of ‘slip in’ changes

Example: glueing techniques

stick to the proven procedure of
mixing, curing, outgasing, application….
a detail might have FATAL consequences !

Same story : soldering techniques

solder tin is NOT a unique product

… a little example ..

- The in-famous ‘capacitor problem’ of the HERA-B Outer Tracker :

2 out of 18 capacitors per HV distribution board were glued with a different technique (without notice)

‘Break down time’
< 50 years

times 16 000 ⇒ fatal !

Quality control

- Check and validate intermediate steps, not only the final product

- In regular intervals: take ‘samples’ and test them rigorously (modular production)

to be clear : this is NOT the final quality test which every item has to pass ! The samples should NOT be used for the final detector but tested to the limits.

more on production

- Do not mix ‘identical’ material from different suppliers. It is difficult enough to keep one under control !
- Avoid ‘ad hoc’ changes !
  - If problems occur : verify your remedies !

    (you might introduce new hidden problems)
  - This will take time : include it the schedule !

… finally : time and money

- Do not produce in a rush !

  (ever seen this happening ???)

- A big and complex system which has to last for a long time needs CARE and can not be build in a crash effort !
- Do not save money on the wrong place !
  It will pay off !

Tools, man power, testing equipment, prototypes…

preparatory work

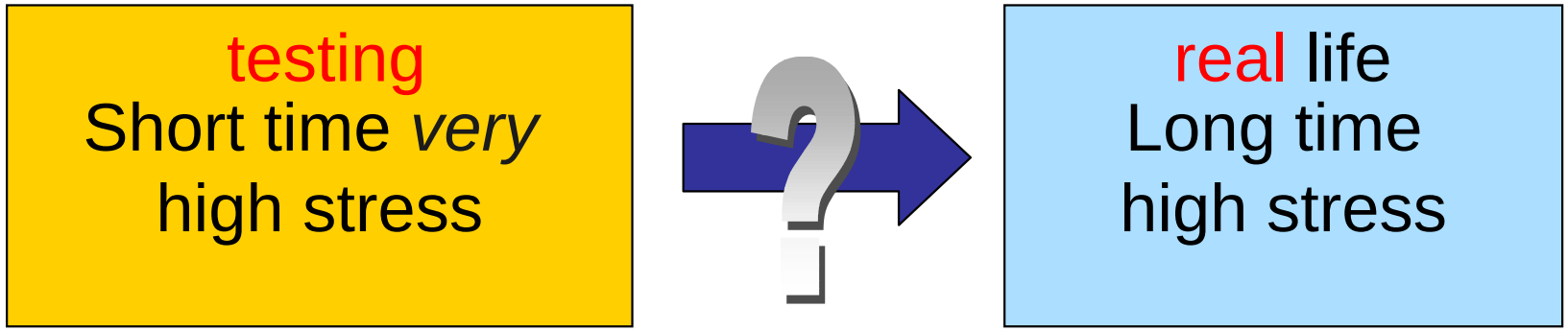
“Test, test, test, test ……”

Cristobal Padilla
Aging workshop at DESY Hamburg
October 2001

Recommendations for doing ageing tests

- The fundamental problem:
  you can not do a 'real time test' !

Learn in short time about the long time behavior



how to extrapolate ?

Aging tests

Aging phenomena

(polymerisation, etching, corrosion, deposits, rupture, swelling….)

depend on many highly correlated microscopic parameters

(electron density, ion density, radicals, photons, electric field….

What you can steer : macroscopic parameters

(gas flow, radiation density, radiation type, potentials, *main* gas components..)

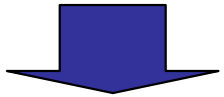
…. ageing

- NO test will reproduce exactly the microscopic parameters of the system under real operation !

MICRO *Model assumptions* MACRO

The simplest model :

- gas avalanches are independent
- the ‘damage rate’ is proportional to the local current



‘single variable scaling’ : *accumulated charge*

… assumptions..

This model is not proven for high intensity applications !

Many hints that it is not adequate !

- Evidence for non-linear dependence on *local* radiation load
- Evidence for dependence on *size* of irradiated area (aging as non-local phenomenon)
- IF *long lived species* are involved (evidence !) which are produced in the avalanche

automatically violated
(non- local *and* intensity dependent)

How to scale ?

Creating dangerous species dominates

→ ‘downstream enhanced

Burning away dangerous species dor

→ ‘upstream enhanc

Reality is complex mixture pf many processes

- depends on integral radiation load
- non linear with local intensity

Explicitly depends on gas exchange rate !
Recommendation :
scale your flow with ‘irradiated volume !’

Recommendations how to plan aging tests

- Choose parameters carefully
- Vary all parameters systematically to explore the parameter space

  are your assumptions about dependences valid ?
- Reproduce your results !

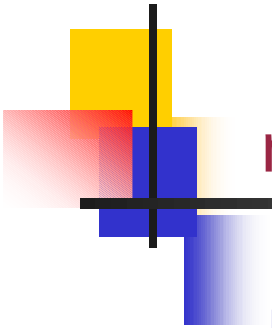
  If you can't reproduce, you can't extrapolate !

Parameters to vary

- Radiation intensity, local
- Radiation intensity, integral
- Radiation type (photons, hadrons…)
- Gas exchange
- Gas composition
  - (explore ‘small components’ like H_2O, O_2 ..)

Some ‘micro management’

- Make sure you have a strategy what you want to learn
- Do it in a systematic way, never change two parameters at once
- Document and record all accessible parameters
  - Minimally :
    - Gas
      - INCLUDING water content, oxygen, flow, temperature, pressure…
    - Radiation level as function of time and space
    - All currents, all voltages
    - Who has done what and when
- Check the status by measuring the pulse height distribution as function of position, inside and outside irradiated area (currents are integral quantities and might hide important facts)



more micro management

- IF you observed unexpected things :
  do not stop at ‘might be due to….’ level
- Verify and cross check !
- Do not continue until you have clarified the point !
- Be aware of hidden parameters !

My credo on extrapolations ..

- Do not extrapolate ANY parameter by more than one order of magnitude !

You MIGHT recover from a missing factor 3
you WONT from a factor 100…..

After you found and established a stable working point :

- Build a ‘full size prototype’

  (the smallest full size independent element of your detector..)

- Expose it to the real radiation profile (not a small spot) of realistic radiation type
  - If this is not possible :
    - Go for it !
      - Go as close as possible and confirm the extrapolations

More on prototypes

- Test the prototypes extensively
  - If possible : exceed the envisaged final stress !
- $$$$ should not be a main issue in planning tests !
  - Testing HAS to be substantial fraction of the total cost of the system.
    Saving money is hazardous !

Some final remarks

- Building gaseous detectors is a complex art !
- It needs a lot of *communication*, common efforts and sharing of know how of all people in the business

Thanks to all of you for contributing to this workshop and for coming to DESY

More thanks

Thanks to the organizers for the

- ✓ Enormous
- ✓ Professional
- ✓ Responsible
- ✓ Encouraging

Work !

Do not forget

Aging is unavoidable……

Make your detectors survive !