H.B. Dreis
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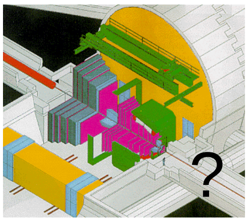
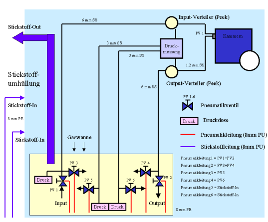
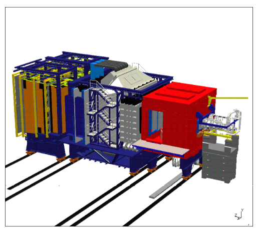
and HERA-B Collaboration)

Gas Support Systems
for
Hadronic High-Rate Detectors



The Example of the Inner Tracker of HERA-B





Introduction

Future: dramatic changes in radiation environment of HEP experiments and in detector technology

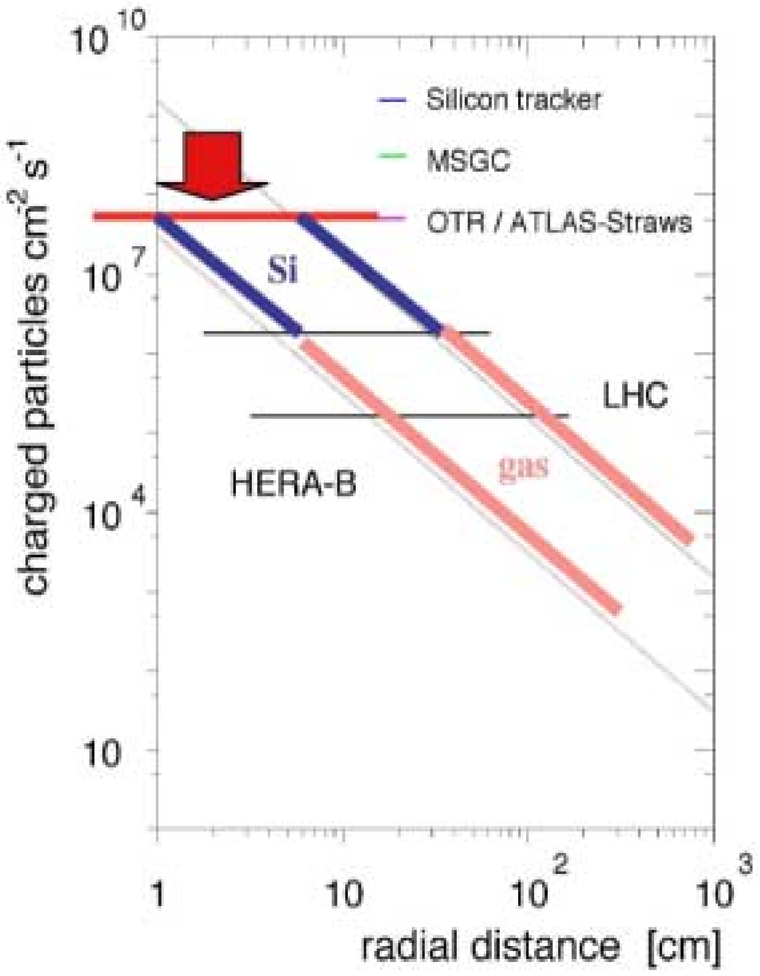
Ageing since ages known and investigated is going to get a new quality.

HERA-B is the first of a number of experiments going to accumulate radiation doses in the order of magnitude of 1 Mrad per year.

HERA-B uses tracking detectors of carbon honeycomb (OTR), carbon straws (high Pt) and MSGC technology (ITR)

Also gas support systems as being an equivalent part of the detectors inner surface must adopt new requirements

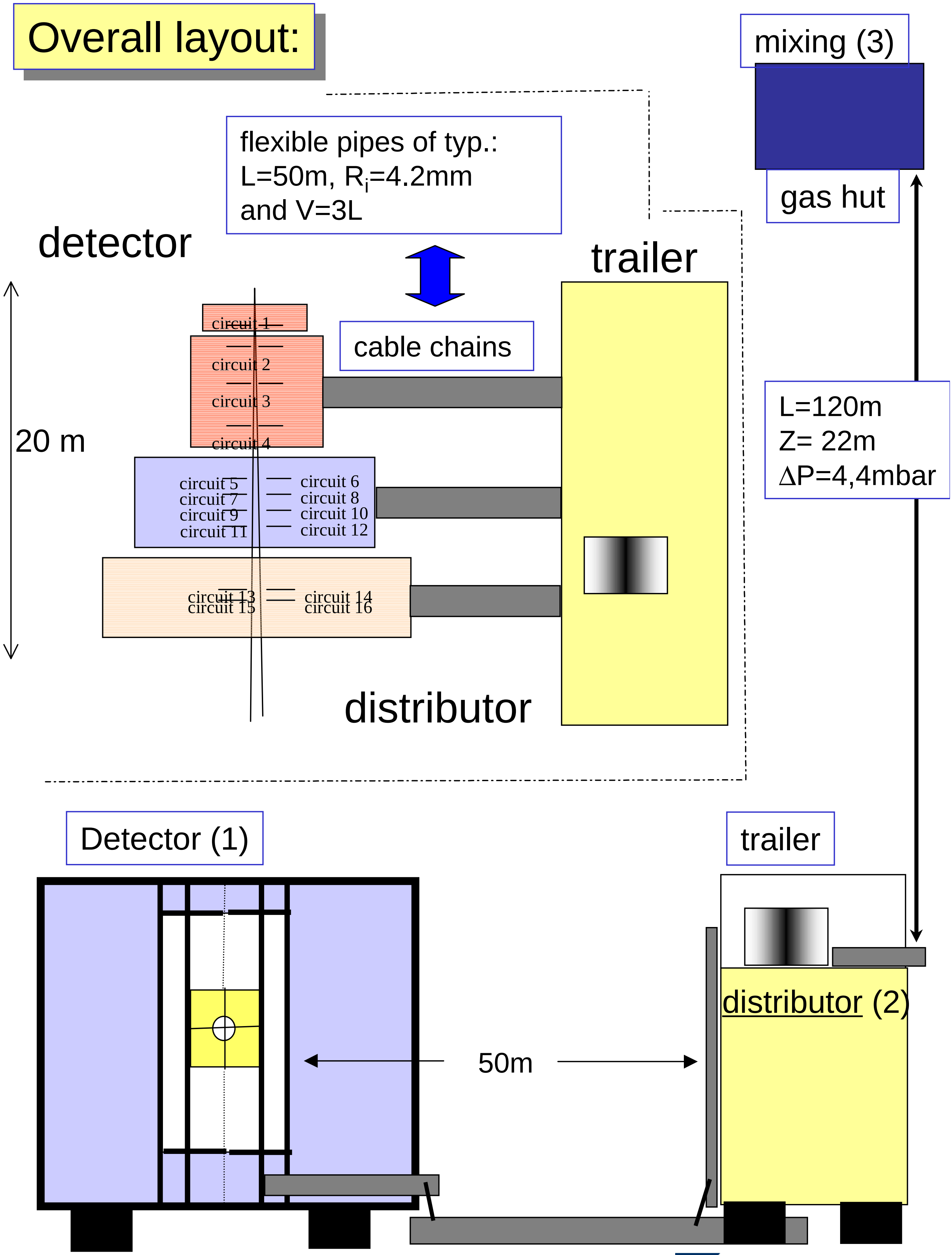
Radiation Conditions



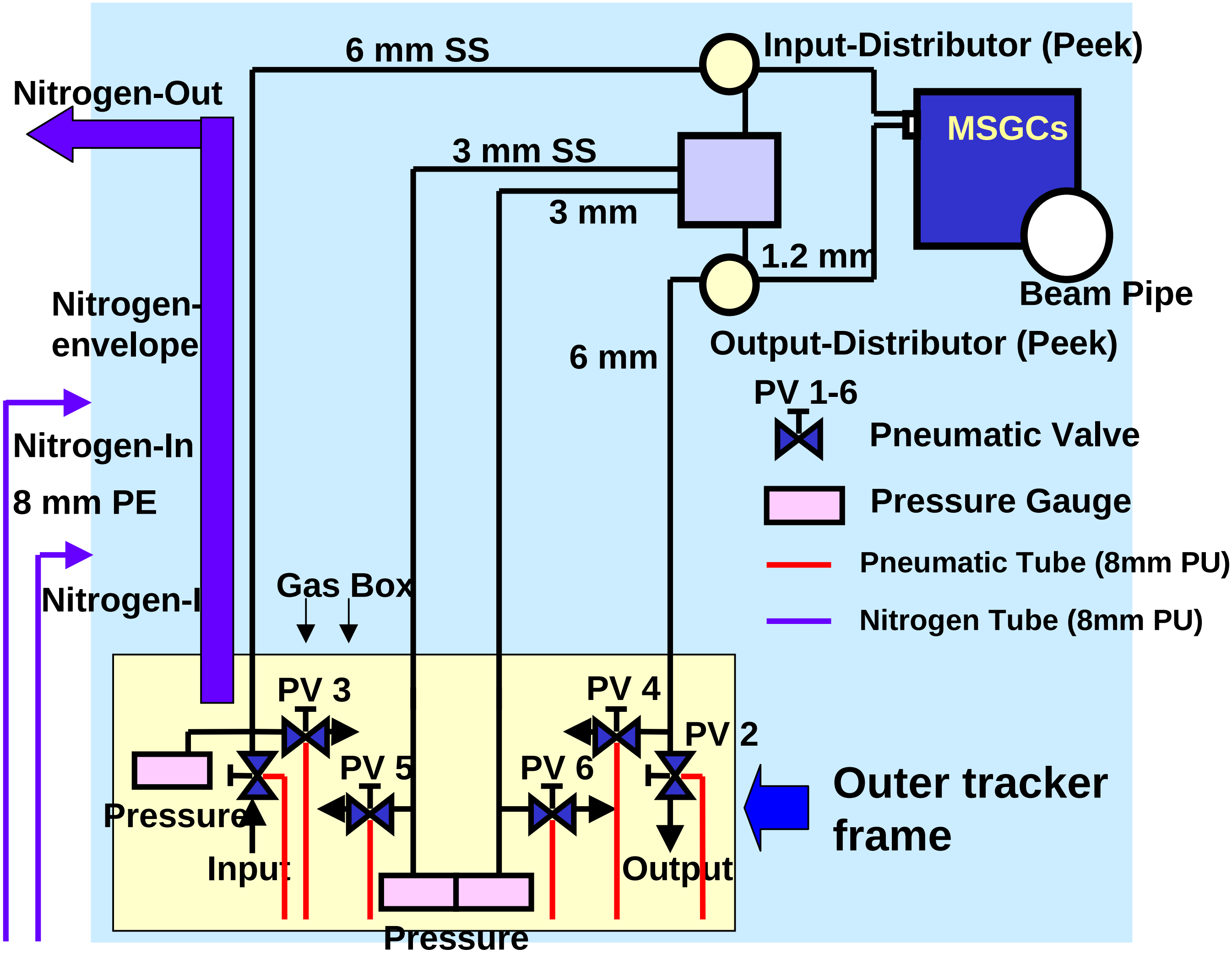
Rate per cm and s on Wire or Strip (max.):

HERA (bunch crossings 10^7/s)		
HERA-B	ITR	~ O(10^4) /cm s
	OTR	~ O(10^4) /cm s
H1	Jet Chamber	~ O(10^1) /cm s
LHC (bunch crossings 4x10^7/s)		
Atlas	TRT	~ O(10^4) /cm s
LEP (bunch crossings 4x10^4/s)		
Opal	Jet Chamber	~ O(10^{-1}) /cm s

Overall layout:

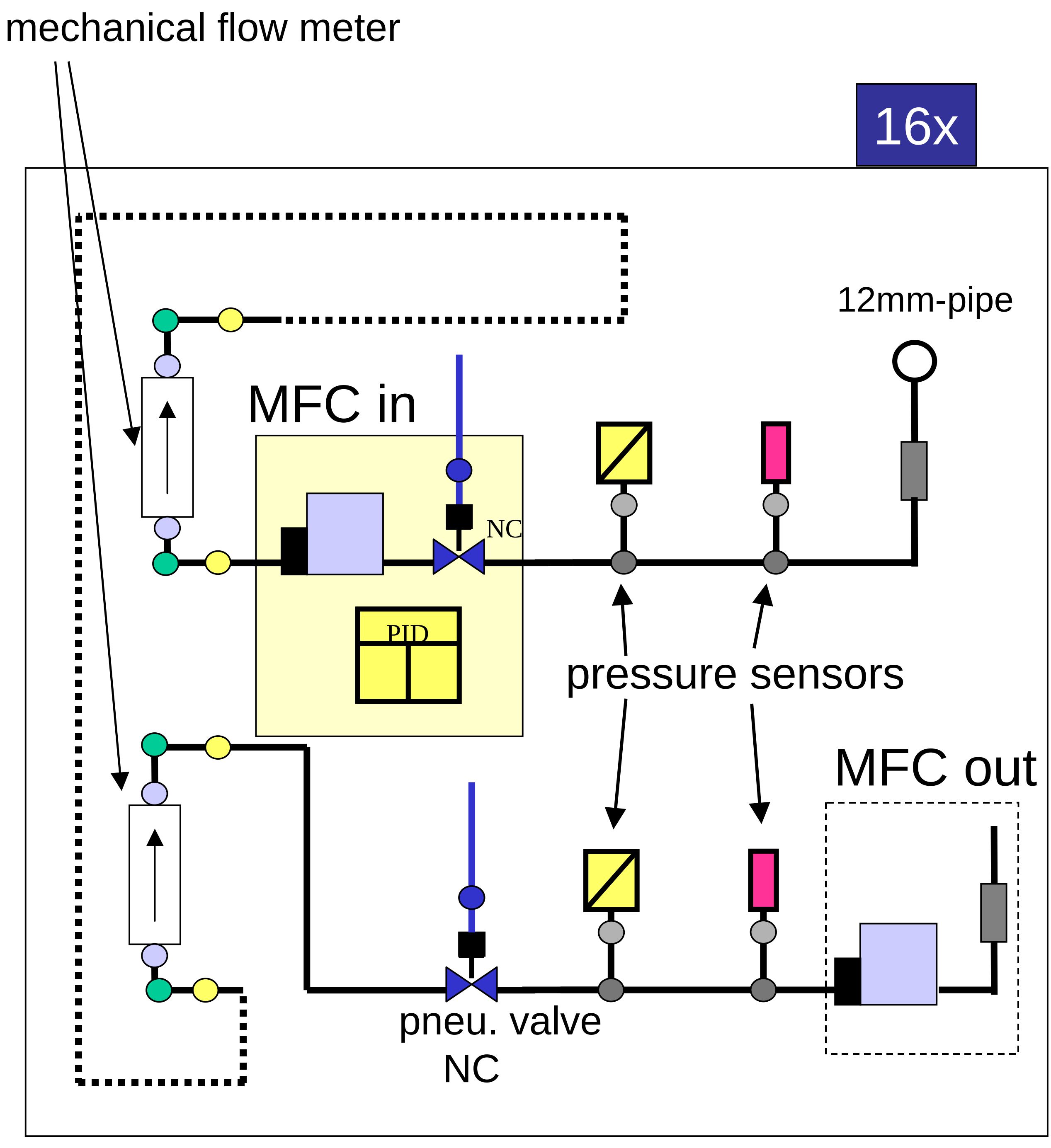


distribution at the detector



Main features:

- 2 Peek volumes for pressure measurement
- 2 independent pressure measurements
- emergency valves at input and output



MFC = Mass Flow Controller

Basic Question:

How clean must a gas system be in high rate environment ?

Answer:

At least, we don’t know !

Most of what we know is of qualitative nature !

We can measure the surviving of a detector after a lifetime like dose using some material !

For most materials we do not know any vapour concentrations !

We do not know how to project accelerated radiation onto real radiation of detectors !

What can we measure ?

Measure Limits and Concentrations !

Typical measure limit of GC/MS : 1 ppm
Typical measure limit of GC/ECD : 1 ppb

1 ppm = 1 : 10^6
1 ppb = 1 : 10^9

Not "out gassing" is no precise measure !

=> measure limit between 10^{13}/l and to 10^{16}/l particles of one impurity compound

- **Difference between measurable or not can be small**
- **Invisible Impurities of 10^{13}/l to 10^{16}/l possible**
- **Fundamental problem of trace measurement:**
- **Relation: ageing and specific impurity in the gas ?**
- **Results always qualitative !**
- **Projection and Quantification**
- **context dependencies**
- **Ageing prevention is prophylaxis**
- **Use the sum of all know problems as input.**

Parameters of ITR Gas System

Volumes

V_{MSGC} ~ 300, 330 and 340 cm^3 resp.

$V_{gas} = V_{MSGC} + V_{pipes}$ = 58l + 117l = 175l

Flows

normal flow 10cm^3/min. => 1 Vol./30min.

Max. flow 50cm^3/min. => 1 Vol./5min.

Pressures

$P_{measure}$ = +100µbar above ATM.

$\Delta P_{measure}$ = +/- 10µbar

Drift

Electrical drift max. observed 100µbar

Electrical drift typ. < 50µbar/3month

Limits

P_{max_soft} = + 200µbar (130µbar)

P_{min_soft} = - 100µbar (70µbar)

P_{max_hard} = + 600µbar (400µbar)

P_{min_hard} = - 500µbar (-300µbar)

P_{damage} = ~ + 3000µbar

= ~ - 2500µbar

$P_{measure}$ typ. 1,5 * P_{MSGC} (cal. reserve of 30%)

Surfaces in the ITR and Gas System

GEM-MSGC:

Substrate:	14.0 m^2
Copper:	29.0 m^2
Kapton:	1.6 m^2
G10:	1.1 m^2
Stycast:	0.1 m^2
H72:	0.1 m^2
Eccobond:	0.04 m^2
All:	**45 m^2**

Pipes:

Stainless Steel TCC Quality:	17.6 m^2
Ring Corrugated Pipes:	64.0 m^2
All:	**80 m^2**

Result: Surface of pipes twice of detector

Plastic bulk:

O-rings:	70 cm^3 of bulk Kalrez
	85 cm^2 surface
Valve Seats:	8 cm^3 of bulk Kel-F
Peak:	1.2 l of bulk Peak
	0.6 m^2 Peak surface

Frequently used gas system materials

Metal
brass (pressure reducer, fittings)
copper (pipes)
stainless steel (pipes, fittings)
hasteloy (steel for membranes)

catalytic processes, out gassing ?

Hard Plastics (i.e. for seats in valves, frames)
Teflon [PTFE] (everywhere, ball valves)
Peek (Polyetheretherketone) good for crafting, no glas
G10 [FR4, AT8000] (glass loaded epoxy) extreme strong
Nylon
Kel-F [PCTFE] valve seats
Kynar [PVDF] (Polyvinylidene fluorides)
Ultem (peek like) can be injection molded
Vespel (special polyamide) analytical chemistry

out gassing ?

Elastomeres (gaskets and O-rings)
Viton [FKM]
Buna-N [NBR]
Chemraz [FFKM]
Kalrez® 4079 [FFKM] Copolymer of tetrafluoroethylene+perfluorovinyl ether
Parofluor [FFKM]
Aegis [FFKM]
Silicone [MQ, PMQ, VMQ, PVMQ]
Teflon [PTFE]
EPDM Copolymer of ethylene and propylene, or terpolymer with butadiene
Teflon Encapsulated
Neoprene
Fluorsilicone
Polyurethane

out gassing ?

Glues
Araldite Types
Locktide Types

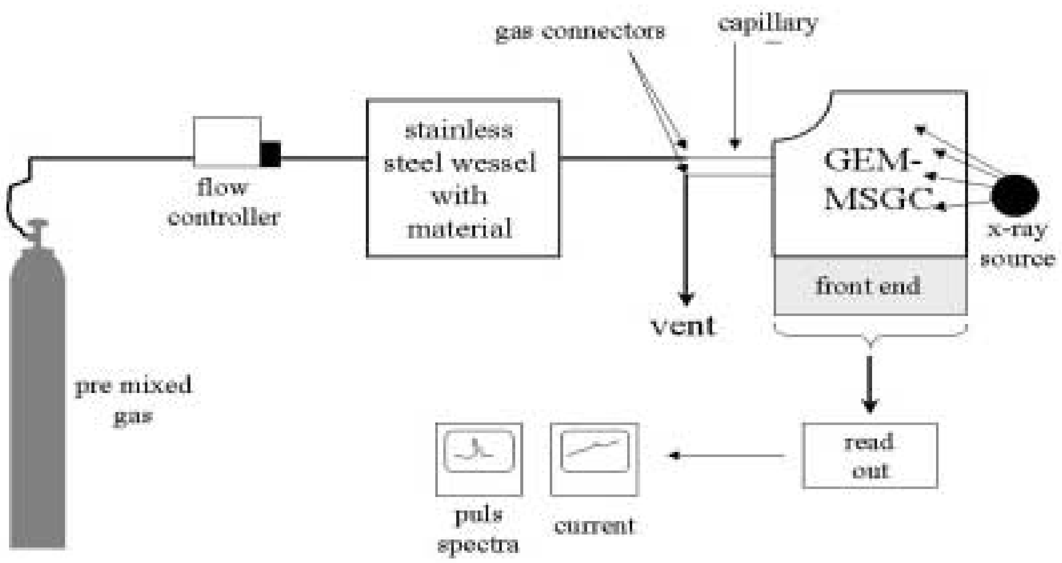
out gassing ?

Silicon grease (vacuum fat)

Selection of Materials

- CERN – test beam
- GC/MS Gas Analysis System (M. Capeans, F. Sauli)
- Heidelberg x-ray system
- other HEP labs
- Literature (i.e. ageing papers, Textbooks, NASA documents)
- <u>the fact that one cannot test all</u>
- <u>price</u>

Radiation Test after Selection



get winner material !

High rate x-ray tests

- pulse height and shape measurement
- optical inspections
- integrated rate up to 5 years of HERA-B
- acceleration up to 40 x HERA-B max.

ITR gas system “winner“ materials

Metal
brass (pressure reducer, fittings)
copper (pipes)
stainless steel (pipes, fittings) electro polishing -> acerbity depth of 0,4µm
hasteloy (steel for membranes)

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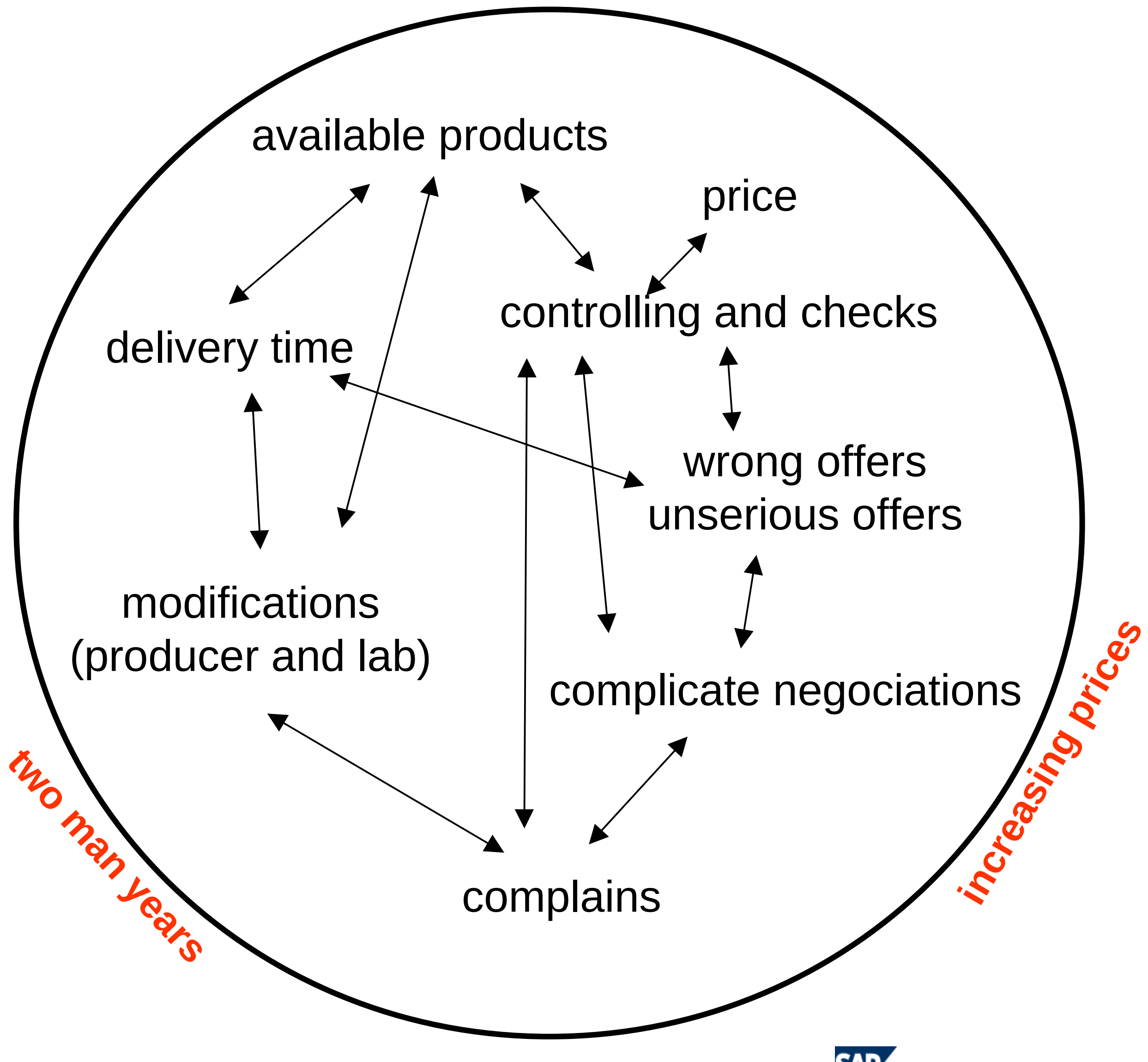
Glues
Araldite Types
Locktide Types
Stycast, Eccobond, H72

Silicon grease (vacuum fat)

Consequences of the material exclusion

All parts must be made of winner material
or
must contain only winner material
and
as much steel as possible
as less plastics as possible

big impact on...



Special Problems: Ring Corrugated Tubes 1

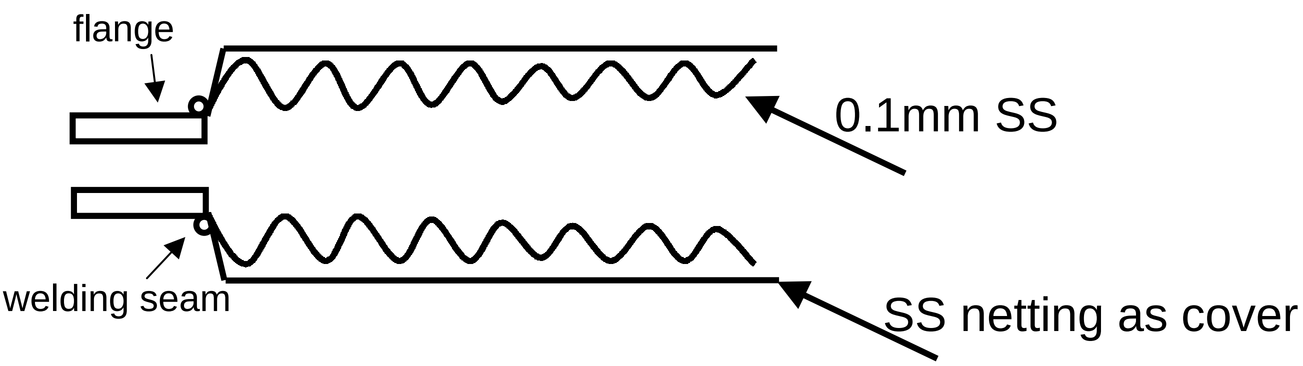
Ring Corrugated Tube ? → flexible stainless steel pipes

Flexible Pipes ?

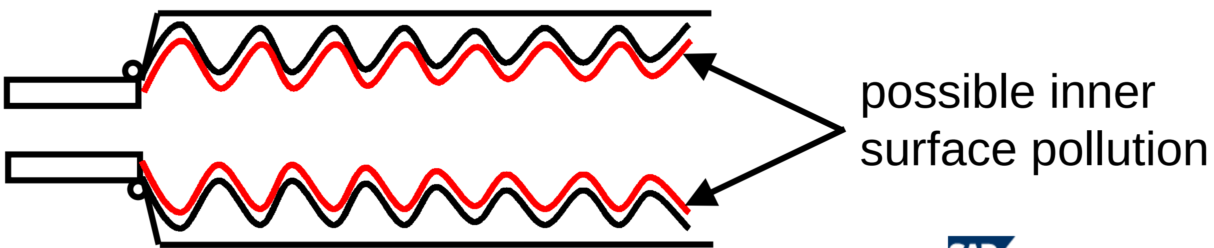
necessity ? → yes (movable detector parts)
number ? → ~ O (150) at HERA-B
→ 32 for ITR
lenght ? → ~ 7,5 km
→ 1.6 km for ITR

If flexible Pipes, **why** Ring Corrugated Tubes ?

flexible and acceptable robust
radiation hard
inert
no diffusion
not out gassing **if** clean inside
→ no plastics (!) BUT (!)



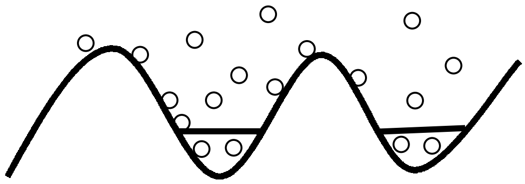
big inner surface, perfect capacitor for liquids



Special Problems: Ring Corrugated Tubes 2

Ring Corrugated Tube ? → Production

Production process requires lubricant !



lubricant remains inside

Question:
what kind of lubricant and how to remove?

Cleaning requires a solvent for the lubricant

Danger: traces of lubricant and its solvent may remain in the tubes. Both could be detector killers!

Consequences:
MEA3/HERA-B production and cleaning procedure.
- find a working solution
- find a company to do it
- find a payable solution
- match the time scedule

Result:
- soap like lubricant (water is solvent)
- leak test with N_2 under water (equ. 10^{-4} mbar l/s Helium)
- circuit washed with hot water (60°C)
- drying at 100°C
- flushing with N_2 (5.0) until H_20 dew point under -10° C
- Flushing with as much clean Argon or N2 as possible after delivery

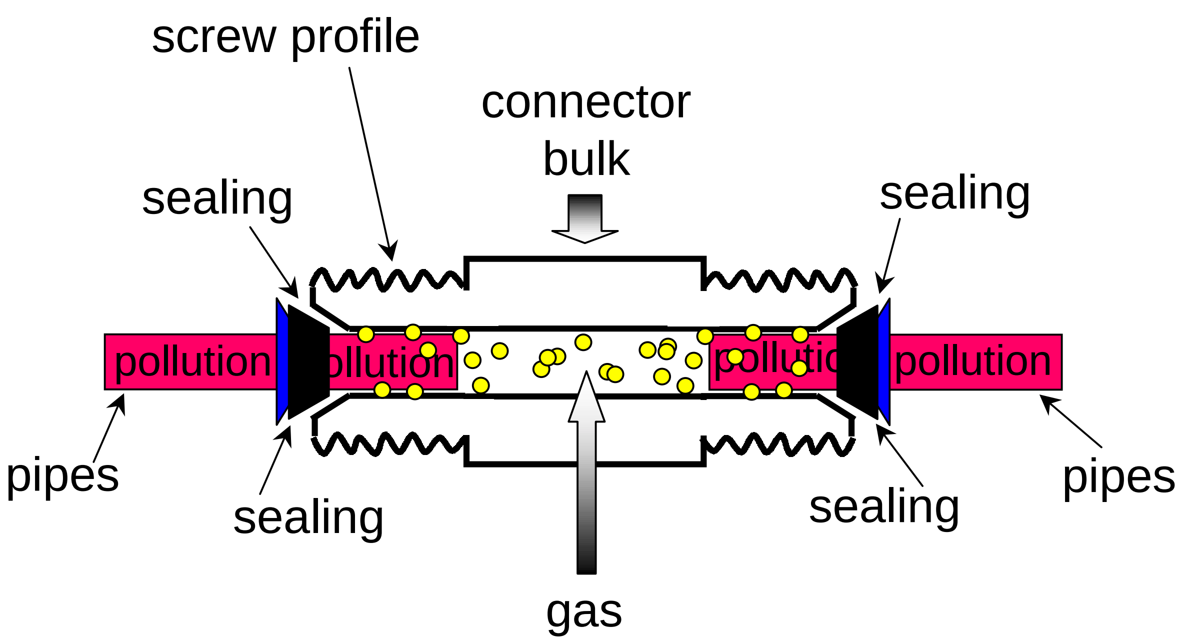
Special Problems: The Outside of Gas Pipes

Why does the outside of the tubes play a role?

-ions of organic type of colors

and

pipes are connected with O(1000) screwable connectors



Cleaning inside and outside with
aceton and ethanol necessary

Special Problems: Mounting in practice

Mounting must be done under clean conditions!
(not even clean room like but clean)

Practical in the lab !

Difficult (!) at the experiment → on the fly mounting

Experience shows clearly that this problem is rather underestimated (esp. by co-workers and management)

Typical Problems:
Dust is all around but contains often oil in experimental areas

Parts (esp. seal rings) fall frequently to the ground and are picked up by hand → dust and oil + fat from fingers

Parts are open stored in experimental areas for weeks
→ oil with dust can settle

Parts are frequently stored in not clean boxes
(paper or dirty plastics)

Requirement of clean infrastructure, storage systems and - most important - discipline of the working personal.

Tracking of contaminated parts and routinely cleaning in ultrasonic bathes and back storage necessary.

Special Problems: Pumps

Pumps for **open** and **closed** circuits

Open circuits: danger of back diffusion

Closed circuits: direct contamination and accumulation

Pumps are especially problematic because of high temperatures
➔ increased out gassing

Constrains:
architecture of circuits, pressures, volume per hour (a.m.)

Excluded for high rates:
• Oil vacuum pumps
• Rubber membrane pumps
but
• most pumps contain parts from
➔ teflon, rubber seals, rotation seals

• possible solution for low pressure systems (p_{back} ~ 1 bar abs.):
➔ dry rotary vane pumps

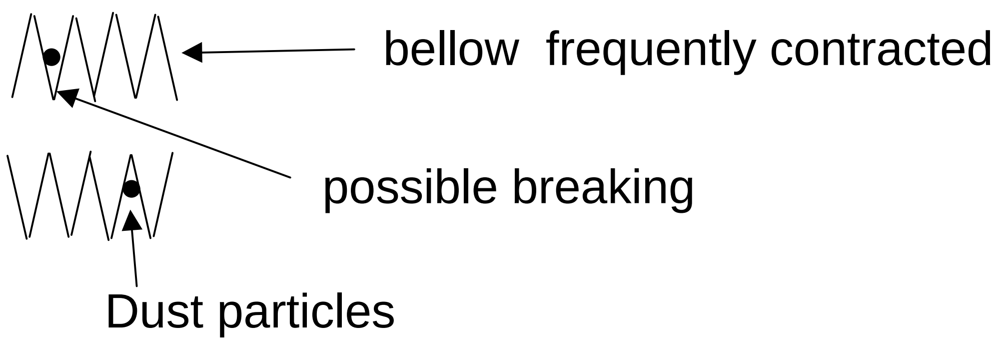
• possible solution for higher pressure (p_{back} < 3 bar)
➔ bellow pumps

Special Problems: Pumps

For all solutions:
Individual modifications in collaboration with producer are typical
→ i.e. replacement of teflon rotation seals by graphit
→ i.e. replacement of teflon coatings by metals
Disadvantage: reduced lifetimes possible
more regular checks neccessary

Experience of HERA-B with OTR bellow pumps:

bellow often damaged possibly due to dirty environm.



Possible : contamination with oxygen
Worst case: contamination with oil (i.e. oil in air of pump house)
(has not happened so far)

summary

- **new conditions**: reduced spectrum of potential materials
  ➔ selection conducted by global knowledge
- **context problem**
  ➔ remaining materials must be tested with final gas composition and detector prototype
- **matching of materials and available parts difficult**
  ➔ modifications
  ➔ time consuming
  ➔ price increases
- **clean conditions while installation have sharpened**
  ➔ increase of organisation and logistic load
  ➔ manpower intensive
  ➔ knowledge transportation (also outside) to co workers
- **pollution quantification mostly impossible**
  ➔ prophylaxis is the strategy **(**one must act always as careful as possible)
- **status HERA-B:** so far no aging
  ➔ hope to stay there
- **much more knowledge available as on slides here**
  ➔ people should use it (knowledge transfer)