# EXPERIMENTAL AREA MAGNETS
# PS EAST HALL + SPS NORTH AREA

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## I PS EAST HALL MAGNETS

1. Overall magnet status
   - Interventions
   - Installed magnets & spares
   - Details MNP23 ➔ ANNEX 1
2. Status of ‘weak’ magnets
3. Proposal for an improved East Hall layout

   Missing documentation ➔ ANNEX 2

II SPS NORTH EXP. AREA MAGNETS

1. Overall magnet status
   - Interventions
   - Installed magnets & spares
2. Status of 'weak' magnets

III INSUFFICIENT STAFF

IV CONCLUSIONS

Acknowledgement: D. Bodart + P. Ziegler have contributed effectively to compile information on the East Hall magnets.

# East hall layout

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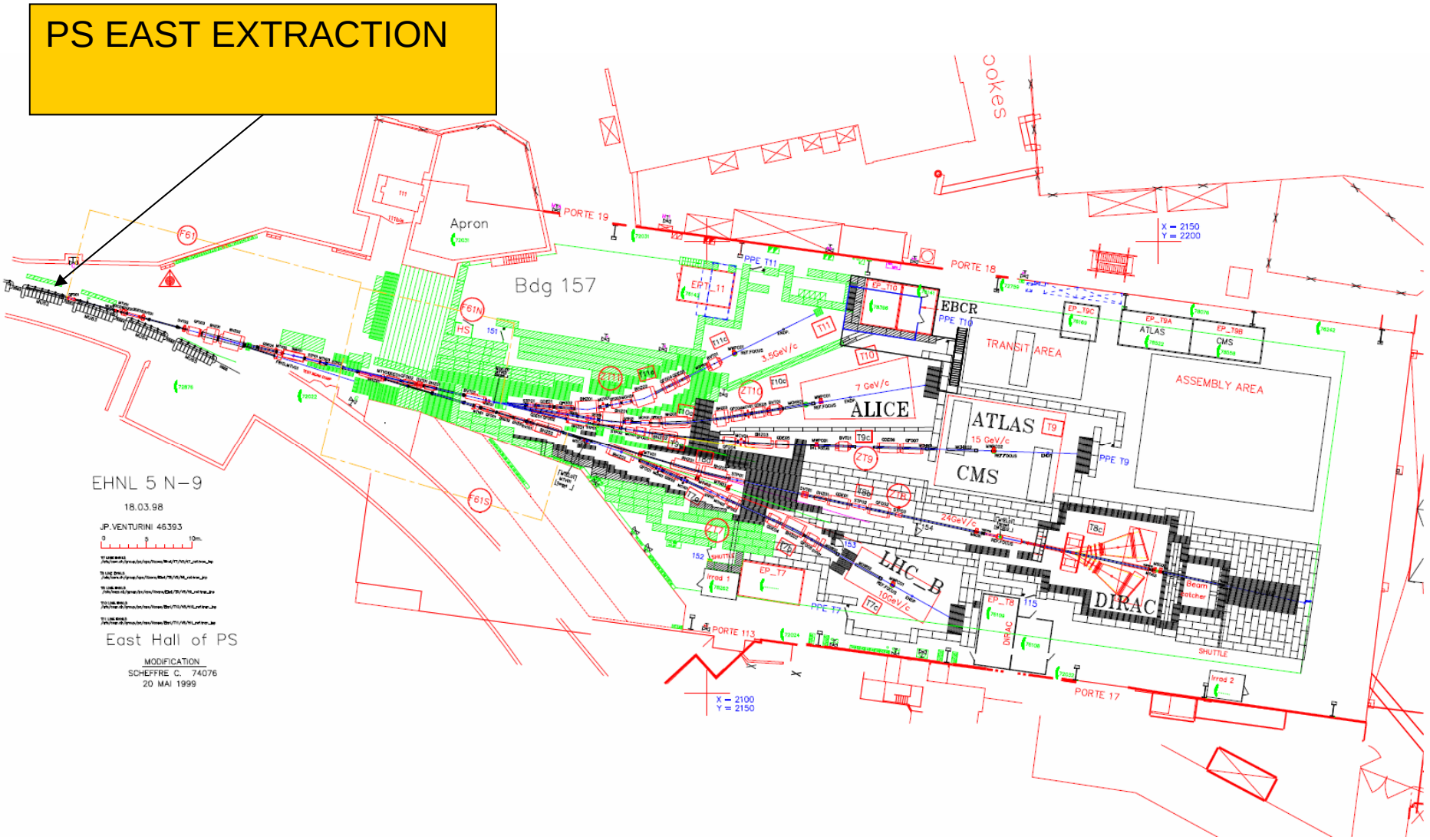
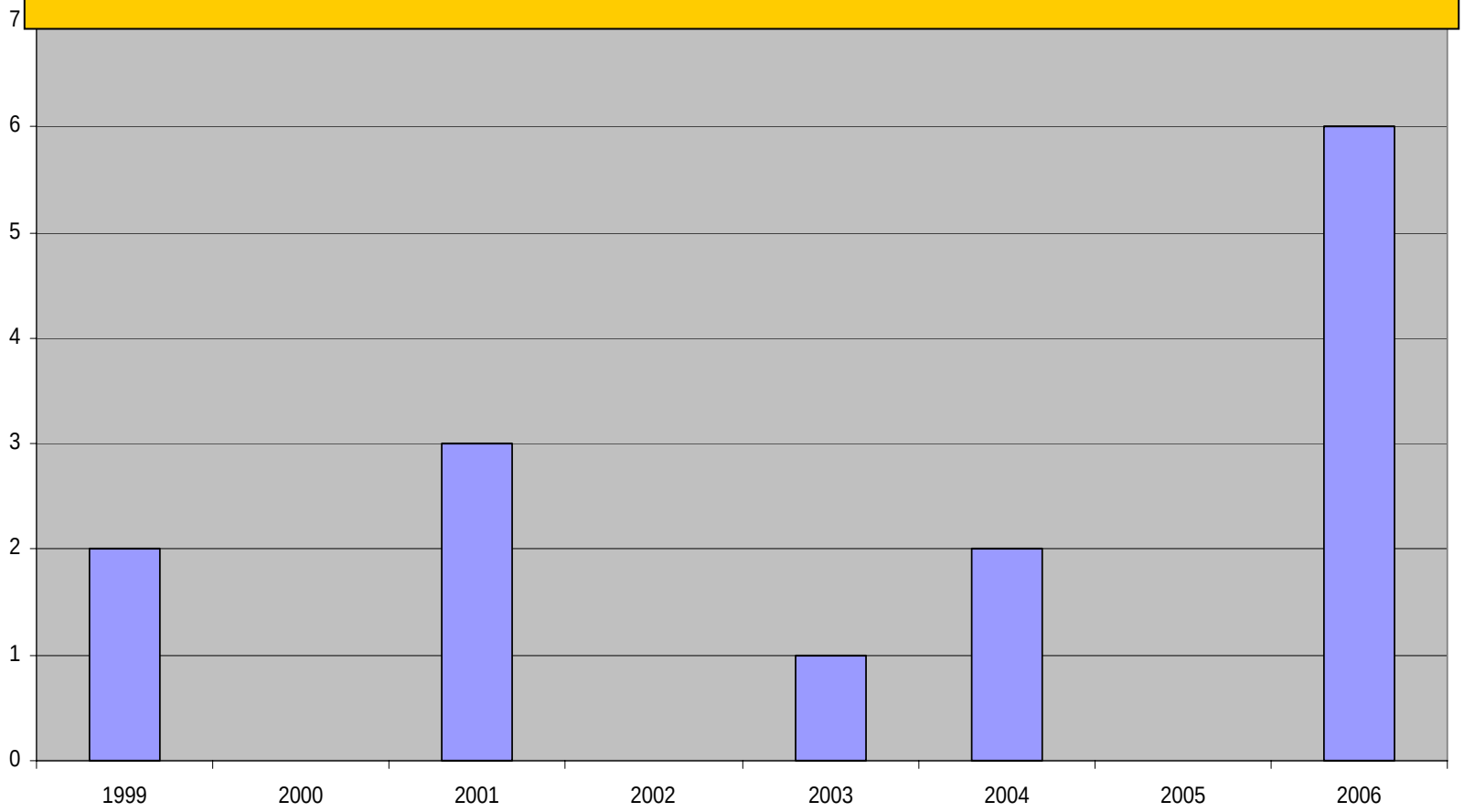


**2003-4: 3x F61S.BHZ01.MNP23-OSWALD**

**2006: 2x F61S.BHZ01.MNP23-SEF, T7.QFO01.Q606, T11.QDE01.Q604, F61.QFO01.Q74, F61.QDE02.Q12**



# East hall F61 line 2nd part
# Access impossible during PS operation

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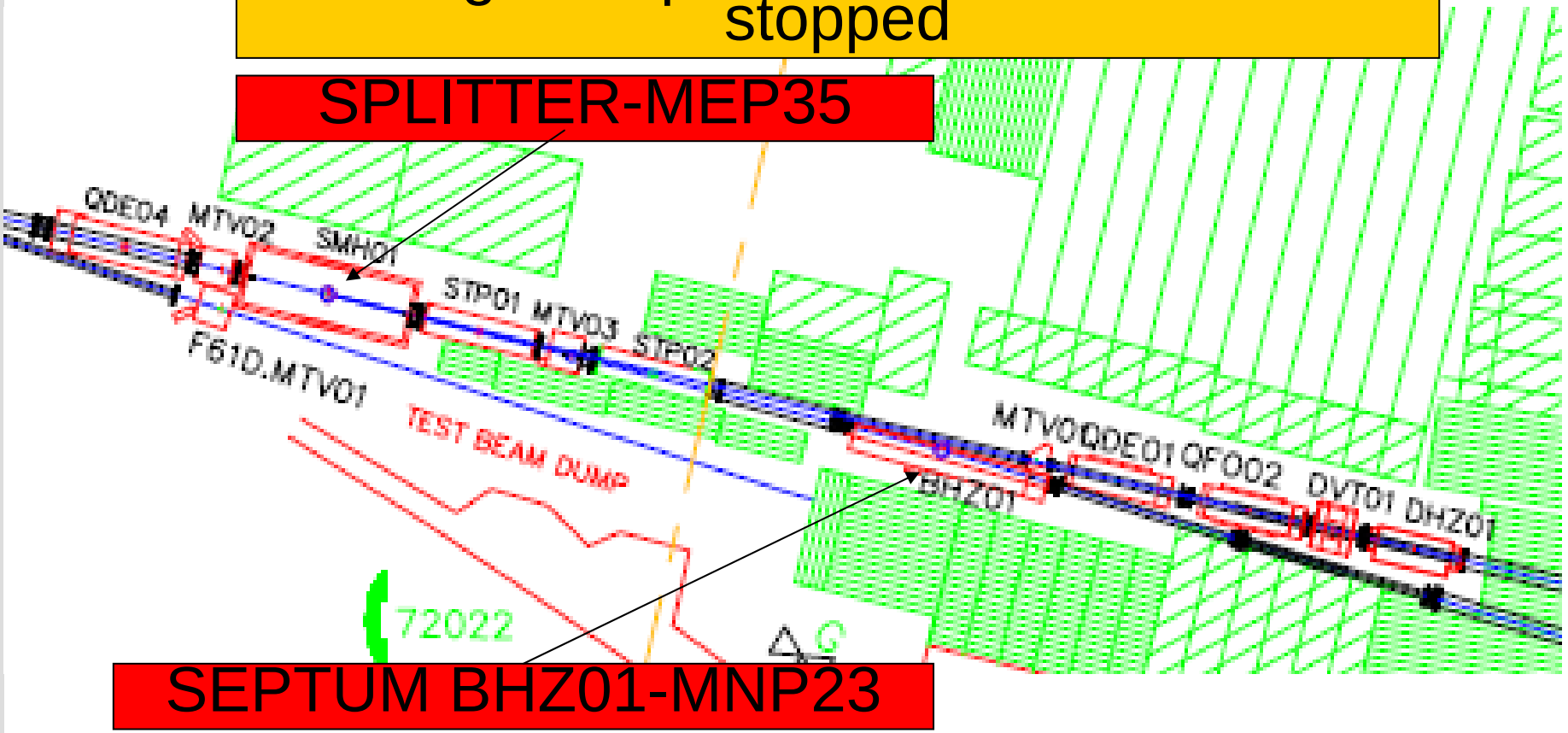
Access via PS Main Ring ➔ for any magnet replacement PS must be stopped



# F61S.BHZ01.MNP23-SEF under test

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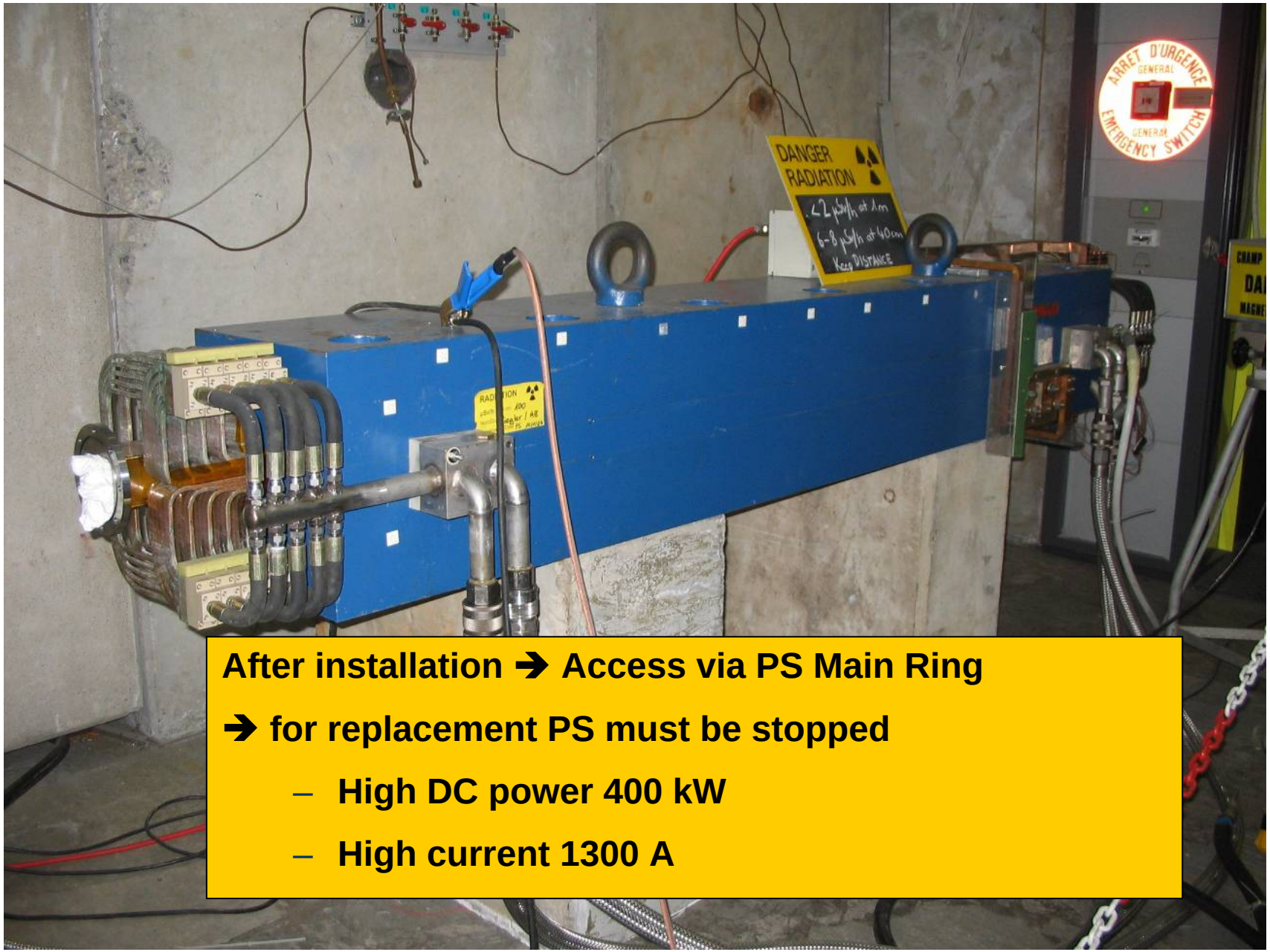
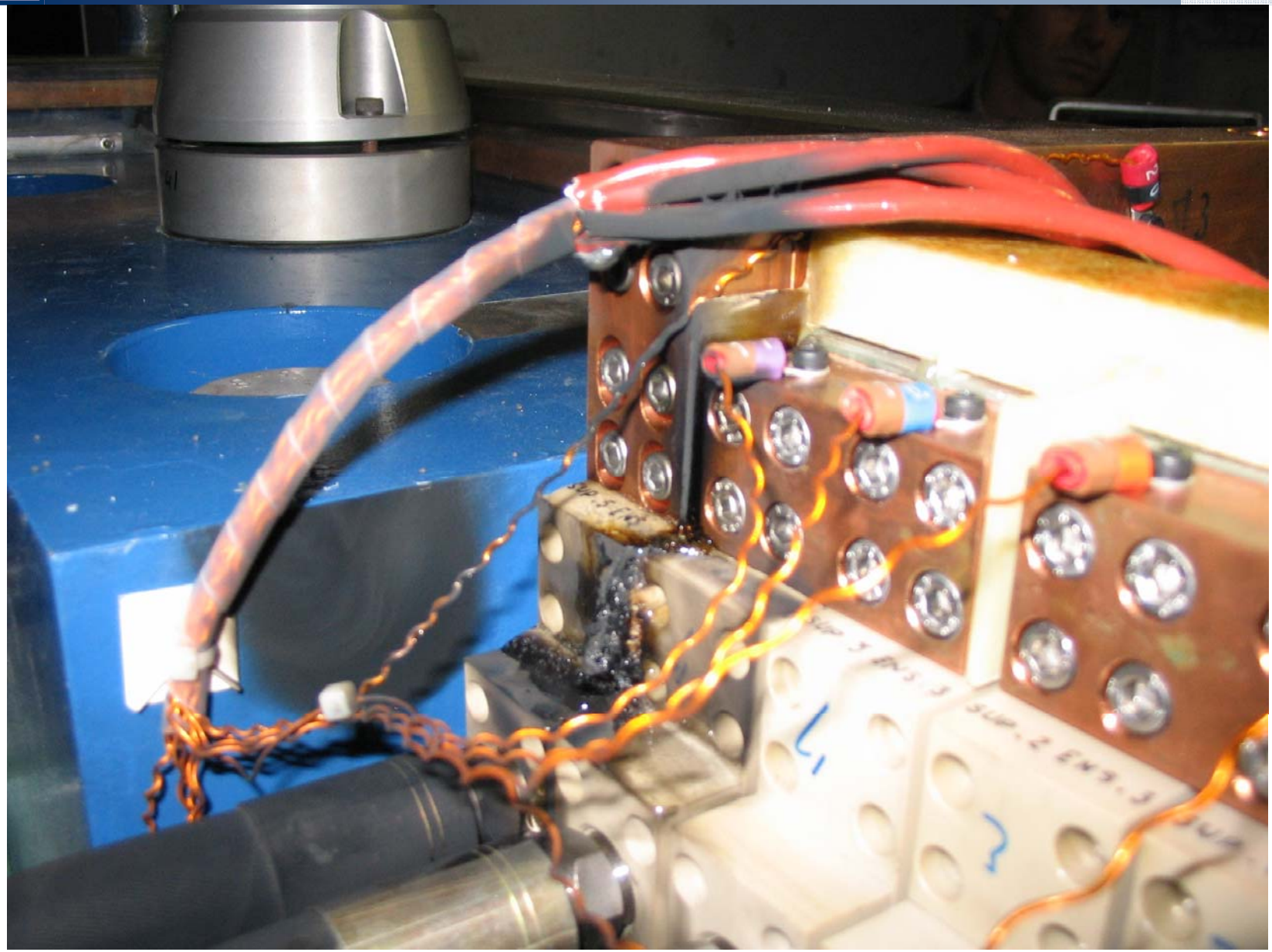



**After installation ➔ Access via PS Main Ring**

**➔ for replacement PS must be stopped**

- **High DC power 400 kW**
- **High current 1300 A**

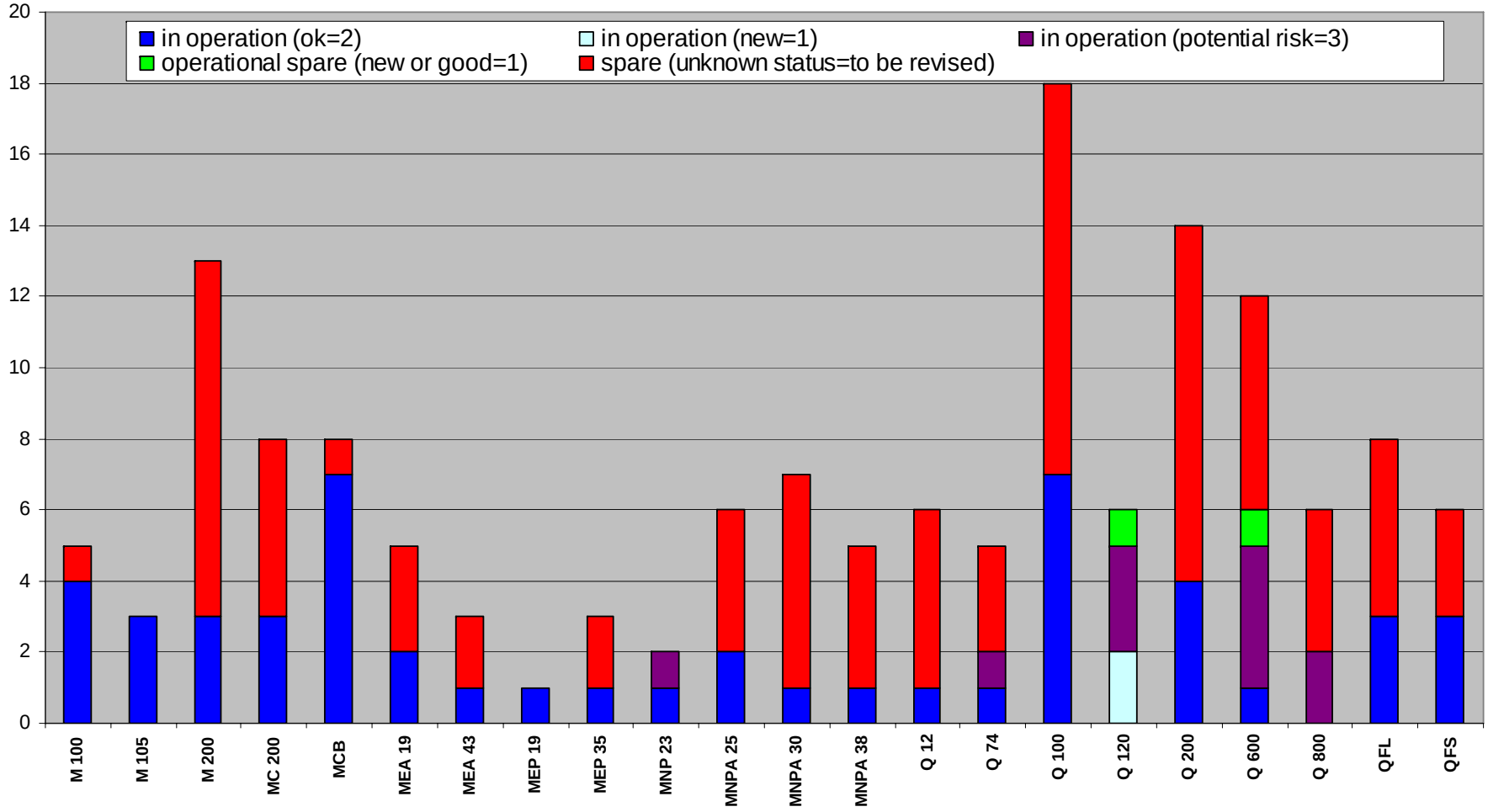
# F61S. BHZ01.MNP23 10-2006 breakdown 3rd coil SEF



# East Hall Magnets: in operation & spares as per January 2007







# I.2 Status 'weak' magnets

**'weak' magnet definition**:

➔high risk for operation:

- failure is likely to happen in the coming years
- mainly because of the bad state of the coil insulation due to severe radiation damage

➔low or zero operational spare number

➔long down-time when replaced during operation:

- long cooling-down due to high induced radiation level or
- requires the opening + closing of the top shielding = 2 weeks or PS stop.

**high impact for whole East Hall:**

Operates in primary lines: F61, F61S, F61N

# ‘weak’ magnets

**High priority**

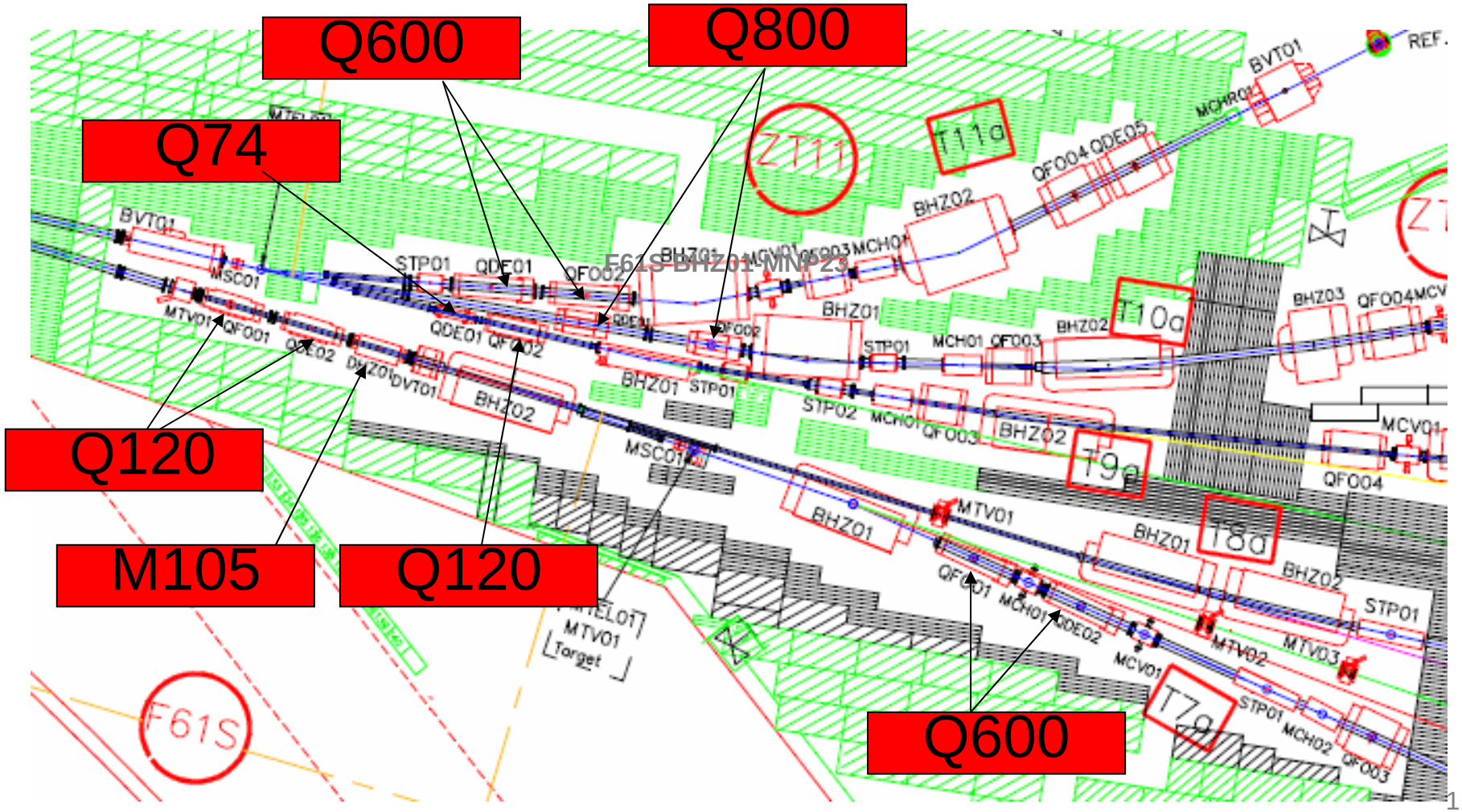
- for revision and/or
- new fabrication shall be given for:

**‘weak’ magnets of**

- high impact for the
- operation of the whole East Hall.

# East hall primary zone: Access possible during PS operation

Extremely densely packed + covered with concrete shielding roof ➔ for any magnet replacement an opening + closing takes 2 weeks + cool-down + magnet exchange period



# ‘weak’ magnet F61S. BHZ01.MNP23





**As MNP23 problems have been presented in several ATC sessions in 2006 I skip it here + leave it for questions.**

➔ **For full story ➔ see Annex 1.**

➔ February 2007: install C-shaped MCB magnet to replace MNP23 for 2007 operation.

# ‘weak’ magnets Q74

# ‘weak’ magnets Q74

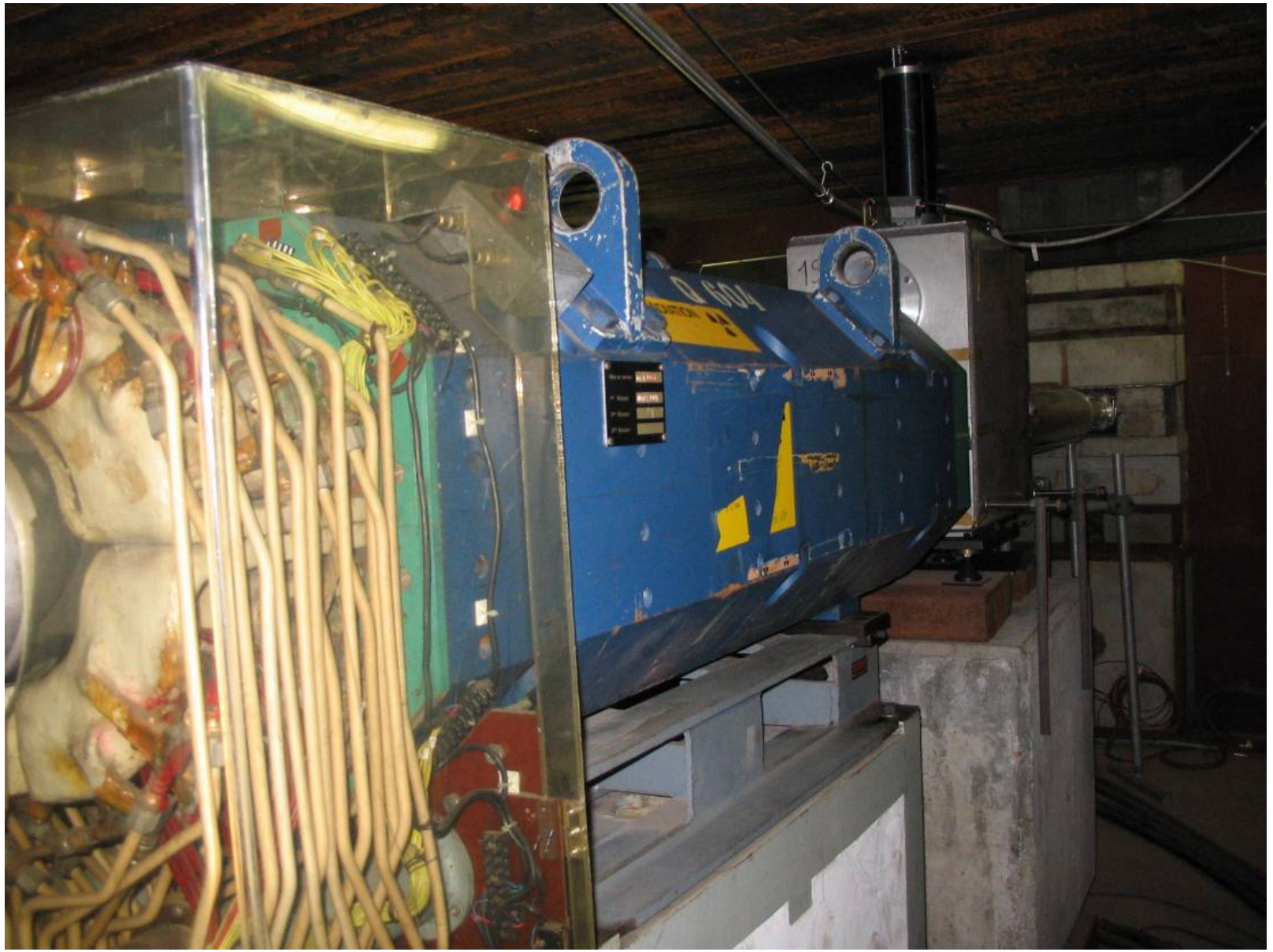




| | NEW | OK | RISKY | SUM |
|---|---|---|---|---|
| OPERATING | 0 | 1 | 1 | 2 |
| | NEW | OK | UNKNOWN | SUM |
| SPARES | 0 | 1 | 0 | 1 |

| | |
|---|---|
| Importance issues | Risky magnet is in T9 line at QDE01.Q74.02 for AMS/T2K-KEK. |
| 2007 | Replace risky magnet in 2007 if feasible.<br>If high priority ➔ ask budget for 1 new magnet. |
| 2008 | If budget + additional staff obtained, 1 new magnet could be fabricated. |
| 2009 | 1 spare available |

# ‘weak’ magnets Q600



# ‘weak’ magnets Q 600

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| | NEW | OK | RISKY | SUM |
|---|---|---|---|---|
| **OPERATING** | **0** | **1** | **4** | **5** |
| | **NEW** | **OK** | **UNKNOWN** | **SUM** |
| **SPARES** | **0** | **3** | **2** | **5** |
| **Importance issues** | T7.QFO01.Q606+QDE02.Q607 for OPERA.<br>T7 Beam energy reduced: 10 ➔ 9 GeV<br>T11.QDE01.Q604 + QFO02.Q602 for CLOUD | | | |
| **2007** | 2 risky magnets will be replaced; 1 OK-spare kept.<br>The 2 spare units (unknown) must be revised in order to obtain 2 operational spares.<br>If successful, replace 3rd + 4th risky magnet in 2008.<br>If unsuccessful + priority ➔ budget for 1-2 new magnets. | | | |
| **2008** | If budget + additional staff obtained, 1-2 new magnets could be fabricated. | | | |
| **2009** | risky magnet could be replaced + 1 spare left | | | |

# ‘weak’ magnets Q800

# ‘weak’ magnets Q 800

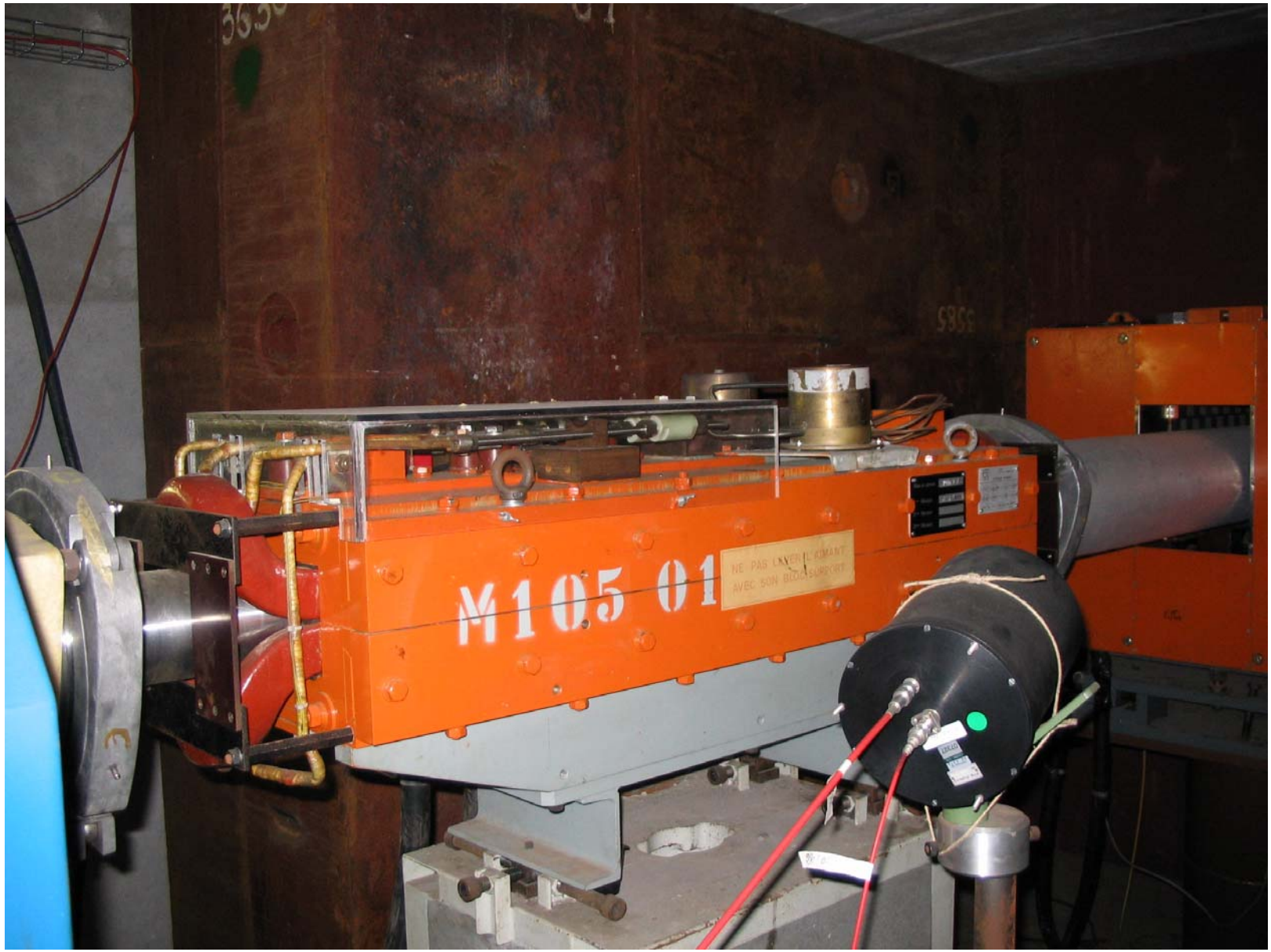




| | NEW | OK | RISKY | SUM |
|---|---|---|---|---|
| **OPERATING** | **0** | **0** | **2** | **2** |
| | **NEW** | **OK** | **UNKNOWN** | **SUM** |
| **SPARES** | **0** | **0** | **1** | **1** |
| **Importance issues** | 2 operating magnets are overheating.<br>T10 beam energy reduced: 7 ➔ 6 GeV ALICE<br>T10.QDE01.Q804 + QFO02.Q803<br>Already 3 broken non-repairable units. | | | |
| **2007** | 1 (highly radio-active) spare must be revised in order to obtain 1 operational spare.<br>If successful, keep it as spare.<br>If unsuccessful + high priority ➔ ask budget for 3 new magnets. | | | |
| **2008** | If budget + additional staff obtained, 3 new magnets could be fabricated. | | | |
| **2009** | risky magnets could be replaced + 1 spare | | | |

# ‘weak’ magnets M 105





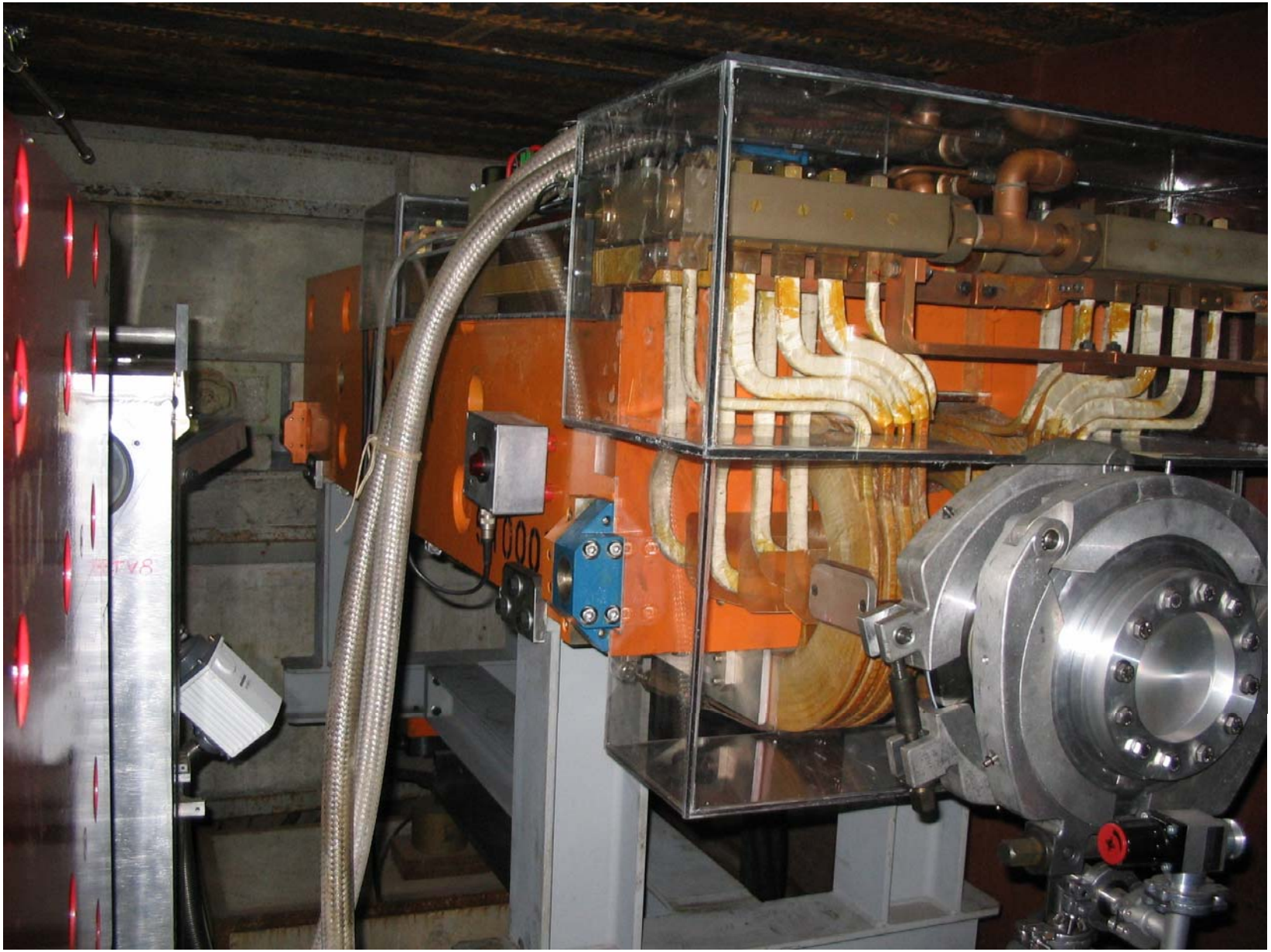
# ‘weak’ magnets M105





| | NEW | OK | RISKY | SUM |
|---|---|---|---|---|
| **OPERATING** | **0** | **3** | **0** | **3** |
| | **NEW** | **OK** | **UNKNOWN** | **SUM** |
| **SPARES** | **0** | **0** | **0** | **0** |
| **Importance issues** | No spare for primary lines<br>F61N.DHZ01.M105.02+F61S.DHZ01.M105.03<br>T8.DHZ01.M105.01 | | | |
| **2007** | No spare unit ➔ Define priority ➔ If high, ask budget for 1 new magnet. | | | |
| **2008-9** | If budget + additional staff obtained, 1 new magnet could be fabricated. | | | |
| **2010** | spare status ok | | | |

# ‘weak’ magnets MEP19



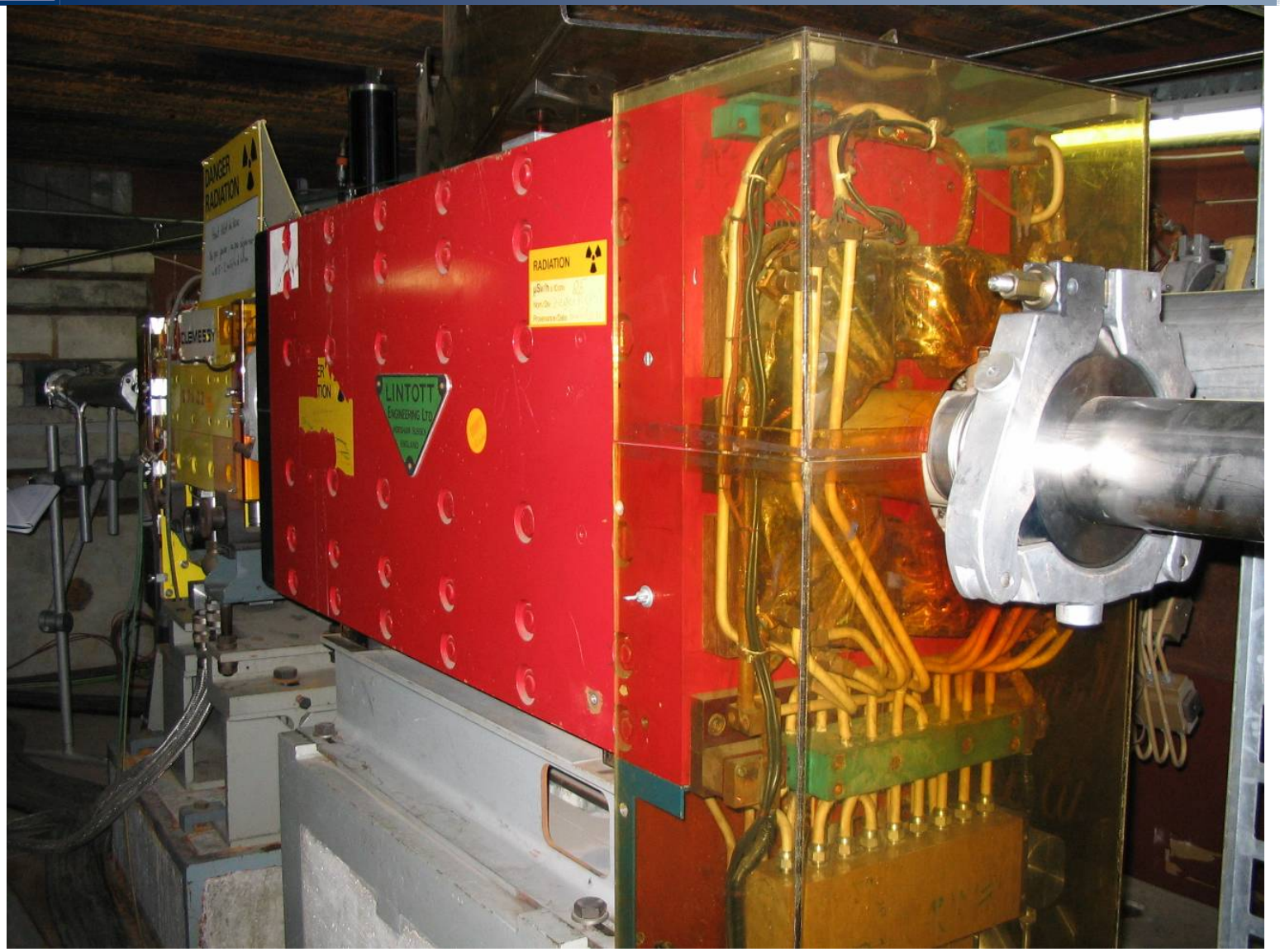
# ‘weak’ magnets MEP19





| | NEW | OK | RISKY | SUM |
|---|---|---|---|---|
| **OPERATING** | **0** | **0** | **1** | **1** |
| | **NEW** | **OK** | **UNKNOWN** | **SUM** |
| **SPARES** | **0** | **0** | **0** | **0** |
| **Importance issues** | No spare<br>F61N.BVT01.MEP19 with high induced radiation level. | | | |
| **2007** | No spare unit ➔ Define priority ➔ If high, ask budget for 1 new magnet. | | | |
| **2008** | If budget + additional staff obtained, 2 new magnets could be fabricated. | | | |
| **2009** | spare status ok | | | |

# ‘weak’ magnets Q120



# ‘weak’ magnets Q120

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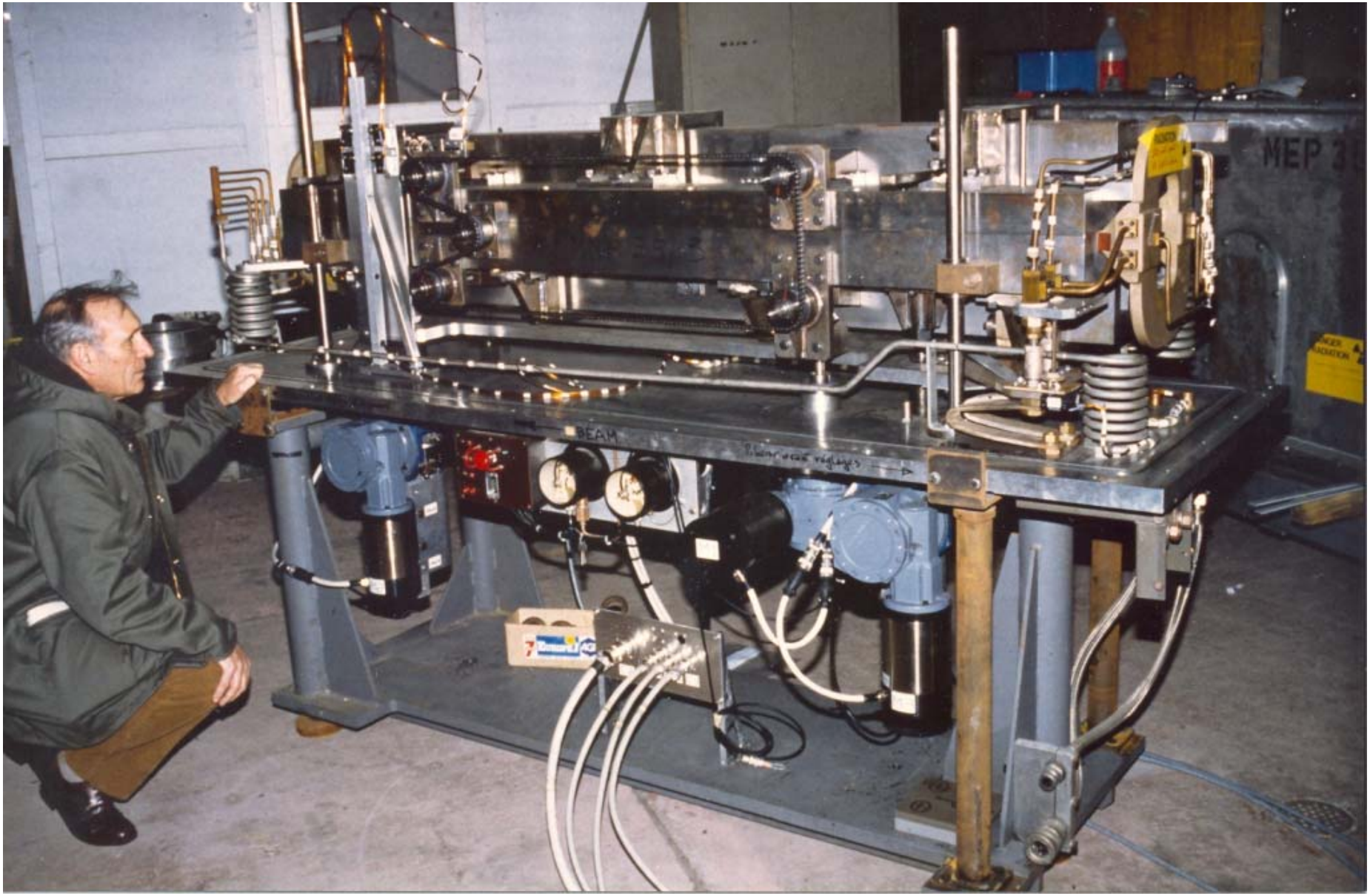
| | NEW | OK | RISKY | SUM |
|---|---|---|---|---|
| OPERATING | 2 | 0 | 3 | 5 |
| | NEW | OK | UNKNOWN | SUM |
| SPARES | 1 | 0 | 0 | 1 |
| Importance issues | F61S.QFO01.Q120.04+QDE02.Q120.06<br>T9.QFO02.Q120.02 AMS/T2K-KEK | | | |
| 2007 | Consolidation budget obtained.<br>M. Karppinen AT-MEL-MI will launch + follow-up the fabrication.<br>3 Magnets will be fabricated. | | | |
| 2008 | 3 risky magnets could be replaced, leaving 1 new spare. | | | |

# ‘weak’ magnets MEP 35



# ‘weak’ magnets MEP 35

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| | NEW | OK | RISKY | SUM |
|---|---|---|---|---|
| OPERATING | 0 | 1 | 0 | 1 |
| | NEW | OK | UNKNOWN | SUM |
| SPARES | 0 | 0 | 2 | 0 |
| 2007 | Splitter Magnet in primary line F61.SMH01producing the beam intensity sharing between North and South branch.<br>Magnet fully enclosed in vacuum container + motorized yoke.<br>Maintenance of motorization shall be done by AB as AT-MEL-MI has no staff in this professional category.<br>1 spare unit shall be revised; if unsuccessful + high priority ➔ ask budget for 1 magnet. | | | |
| 2008-2009 | If budget + additional staff obtained, 1 new magnet could be fabricated. | | | |
| 2010 | spare status ok | | | |

# ‘weak’ magnets MNPA 38

# ‘weak’ magnets MNPA 38





| | NEW | OK | RISKY | SUM |
|---|---|---|---|---|
| OPERATING | 0 | 1 | 0 | 1 |
| | NEW | OK | UNKNOWN | SUM |
| SPARES | 0 | 0 | (5) | (5) |
| 2007 | T7.DVT01.MNPA 38.02<br>No spare unit, but could be replaced by MNPA 30 (5 spares of unknown state).<br>➔ Do revision of MNPA 30 to get 1 spare magnet. | | | |

# 1.3 Proposal for an improved East Hall layout



- Magnets installed 63
- Risky Magnets (now: 11) at start-up of 2007: 8
- Magnet types 22
- Installed per type 2.9

Maintenance of such a high number of different types is:

- expensive and
- with increasing number of breakdowns
- cannot be managed with available staff.

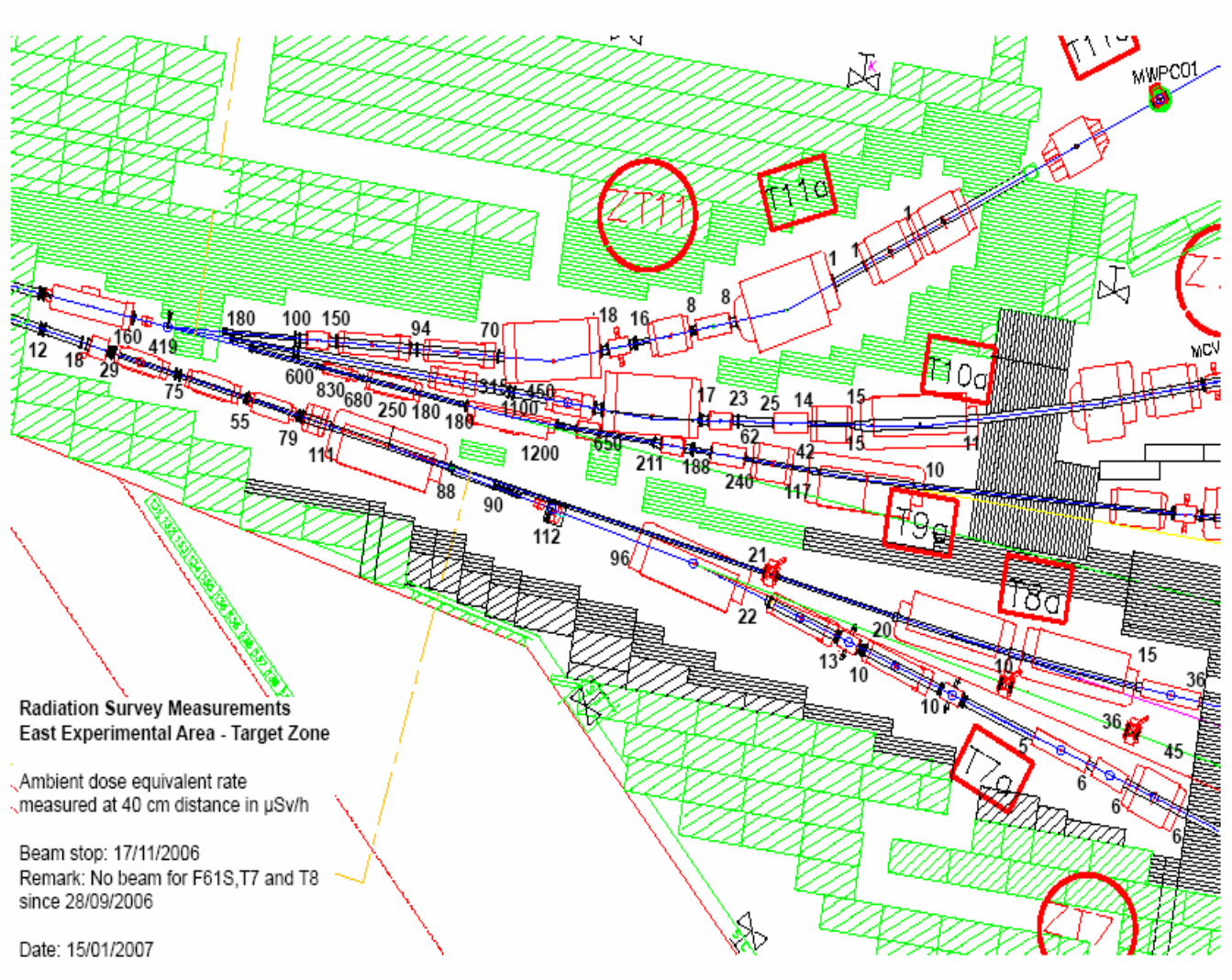
# Proposal for an improved East Hall layout

Insufficient space required the design of too delicate magnets like the MNP23 & Q120.

Many of the installed magnets are

- have radiation-damaged coil insulation
- unreliable for operation
- expensive in production
- result in too high radiation doses to people
- and too high costs for :
  - Interventions
  - Maintenance
  - replacements

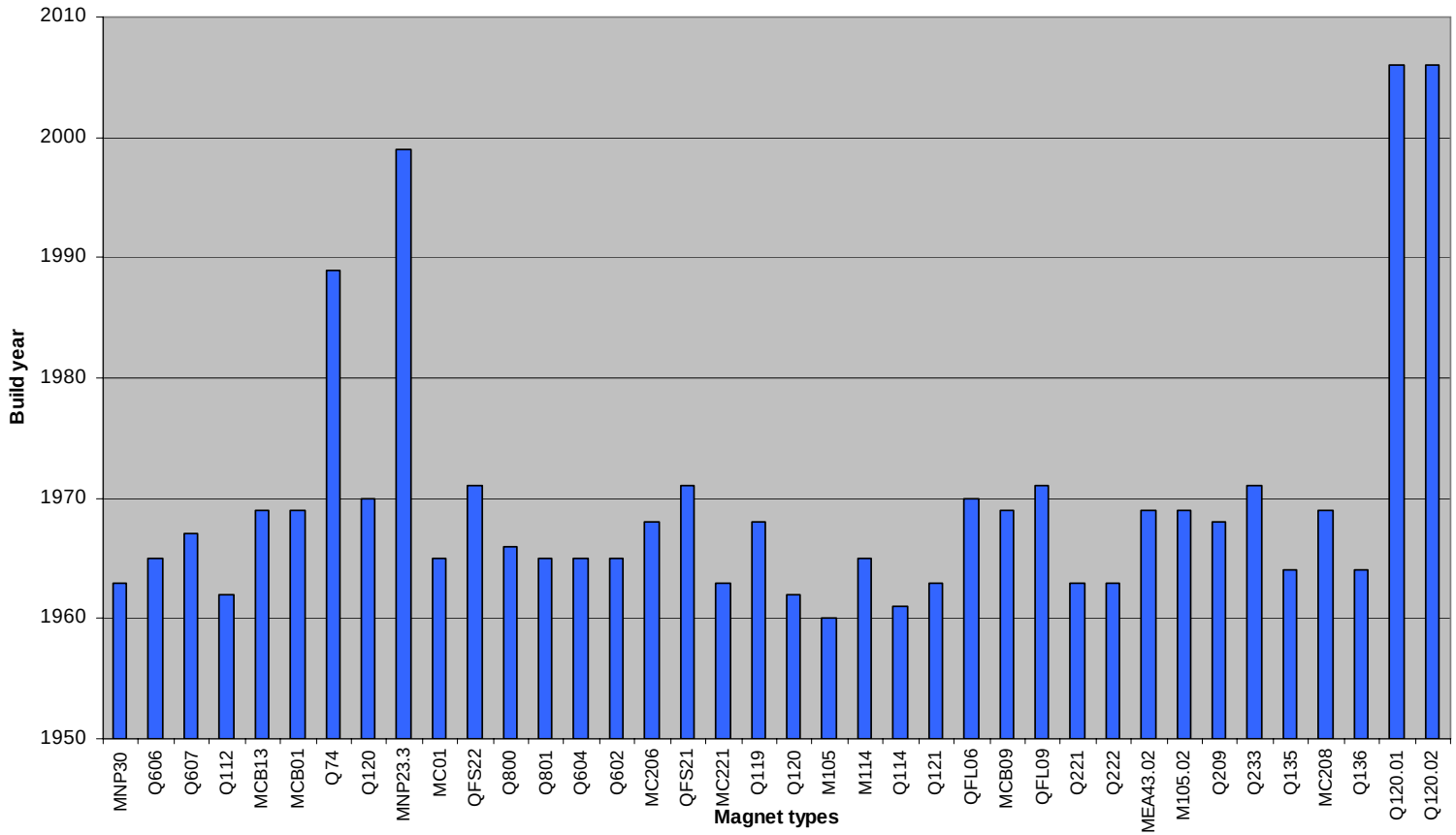
# Radiation survey 15/01/2007



# East Hall magnets: start of service







# Proposal for an improved East Hall layout





The East Hall magnets after about 40 years of service have mostly arrived the end of their lifetime.

East Hall magnets: 8% of NEA but same FTE ➔ 12 times more expensive !

Therefore, it seems the right moment to think about a redesign of the East Hall with fewer magnet types and more space + less lines.

Keeping in mind the savings in

- Manpower
- Radiation budget

combined with less down-time for physics

this could even be the more economic solution.

# II SPS North Exp. Area Magnets NEA





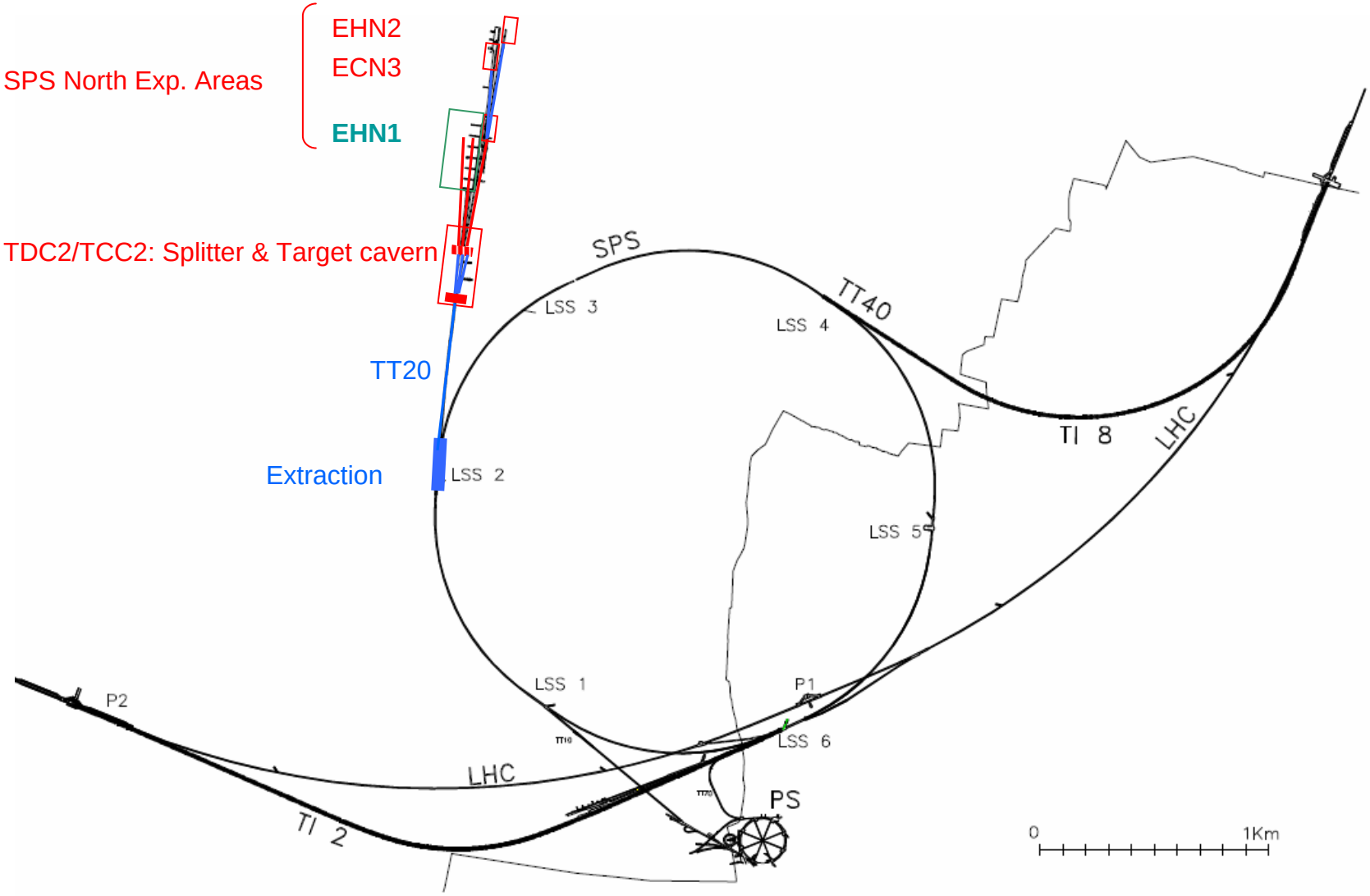
SPS North Exp. Areas

EHN2
ECN3
**EHN1**

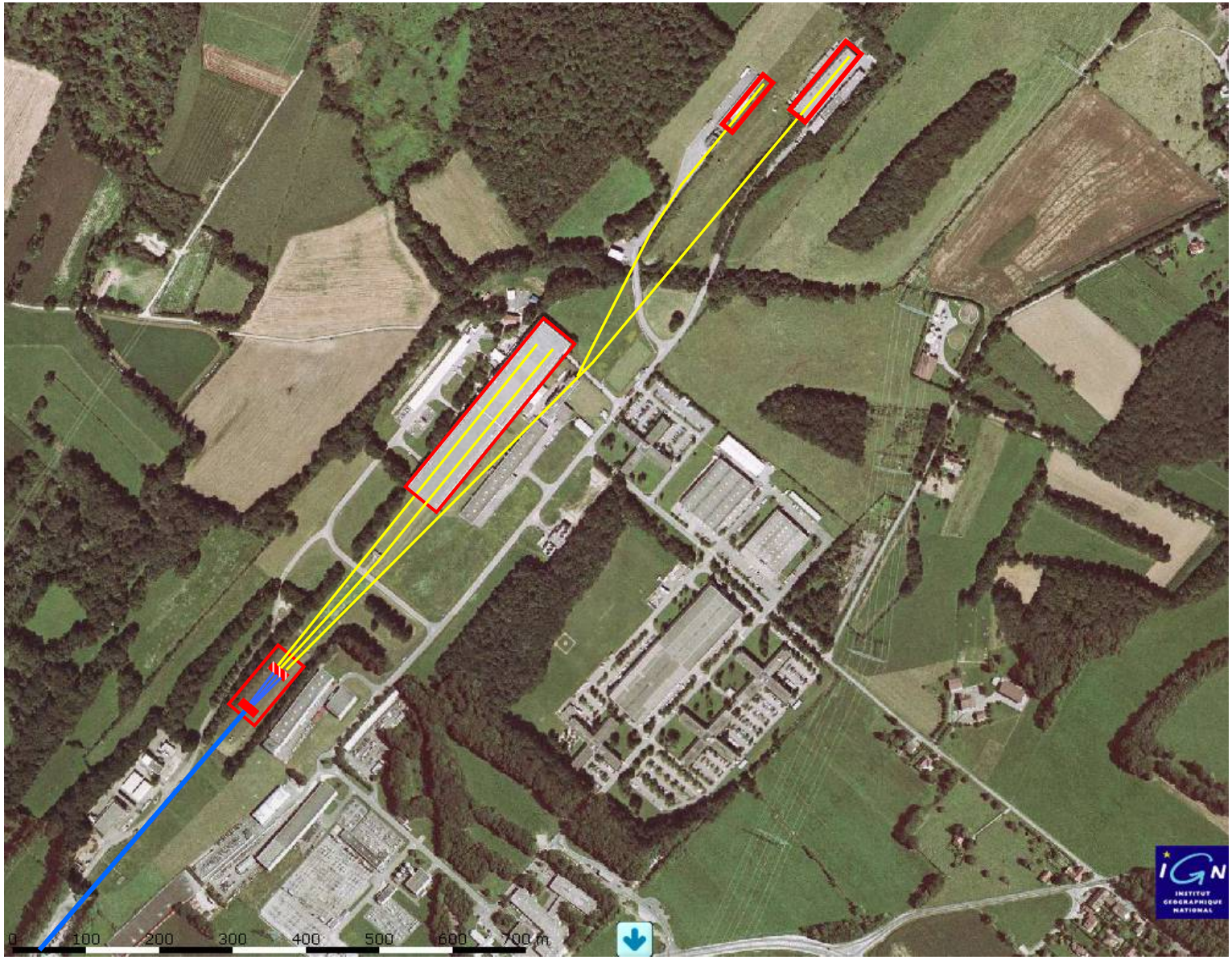
TDC2/TCC2: Splitter & Target cavern

TT20

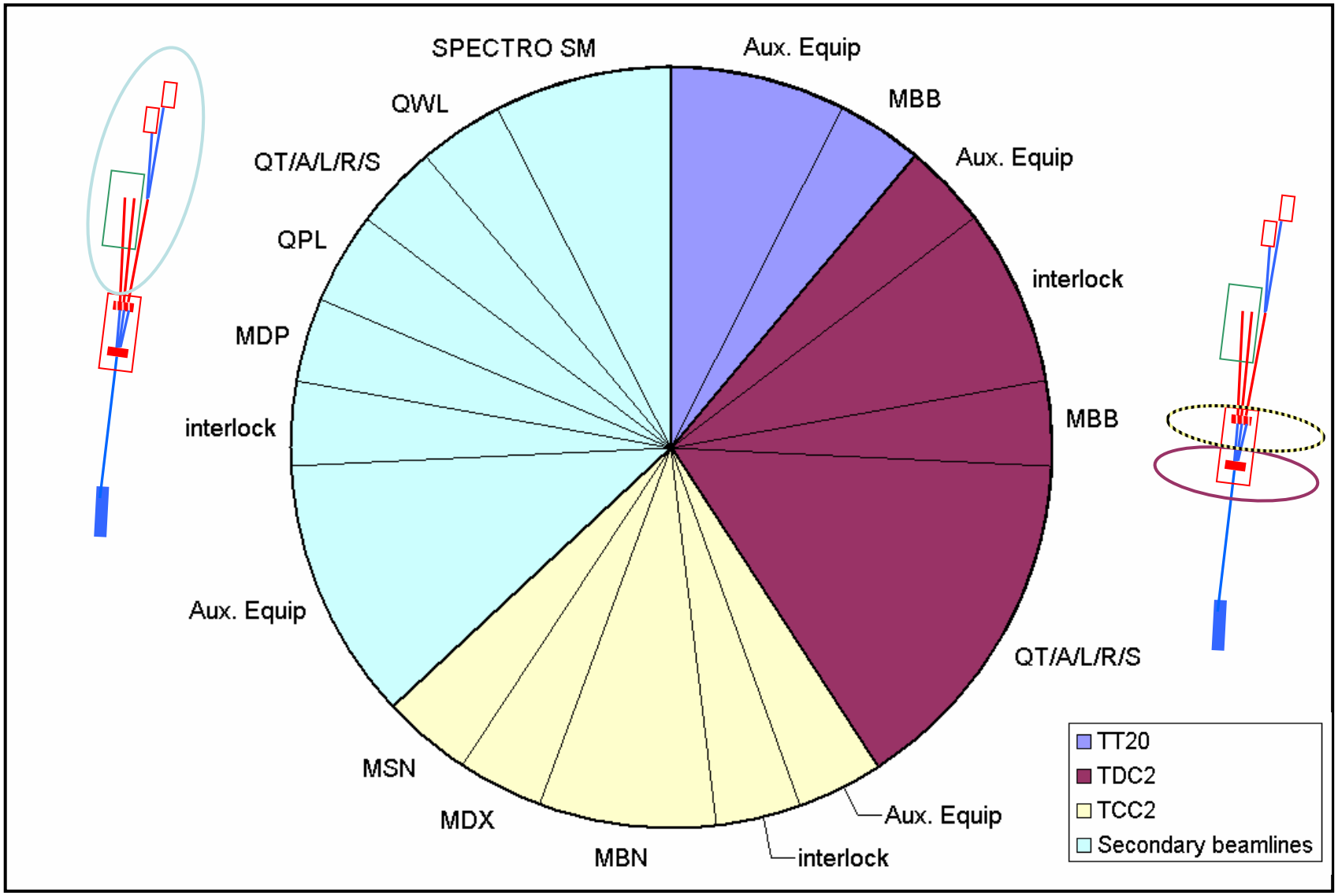
Extraction



# North Experimental Area

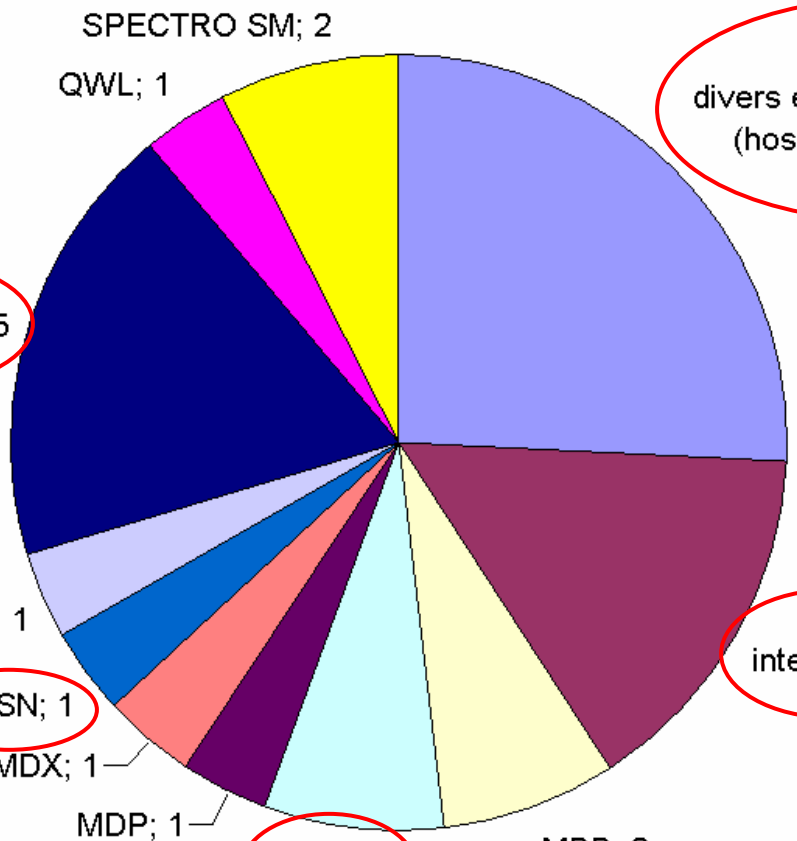


# II.1 Interventions per type & per area



# Identification of failures






Mainly caused by weak coil manifold. Consolidation program ongoing

Failure rate can only be reduced with more maintenance & preventive exchange of parts

! No spare parts.
! Very Radioactive

Radiation damages on water manifolds. Requires a Consolidation program

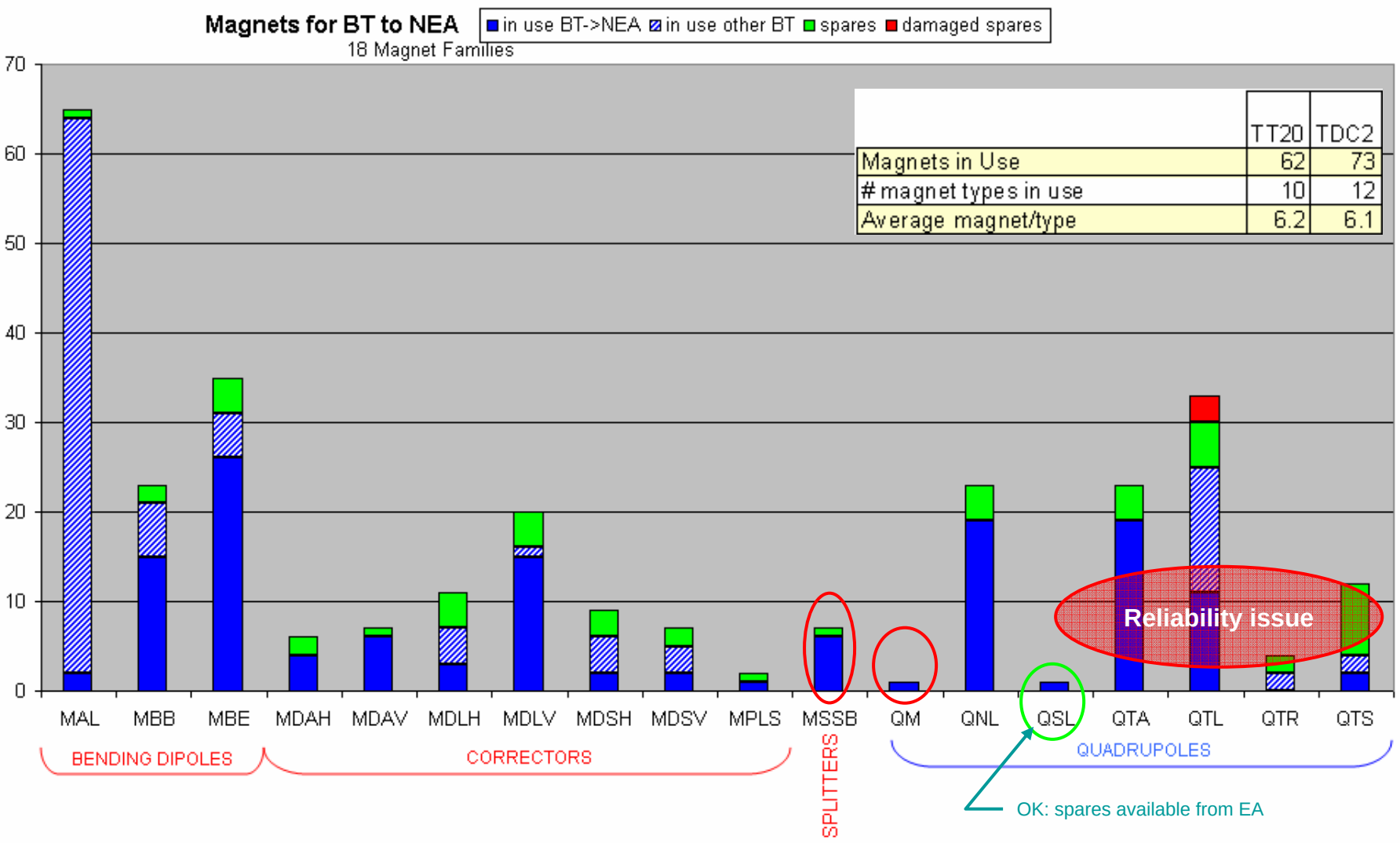
Obsolete system. Failure rate can only be reduced by an important consolidation program

Mainly corrosion problems on the vacuum chamber.

# Magnet Status for the primary Beam Transfer







# Magnet status for the NEA & secondary Beams

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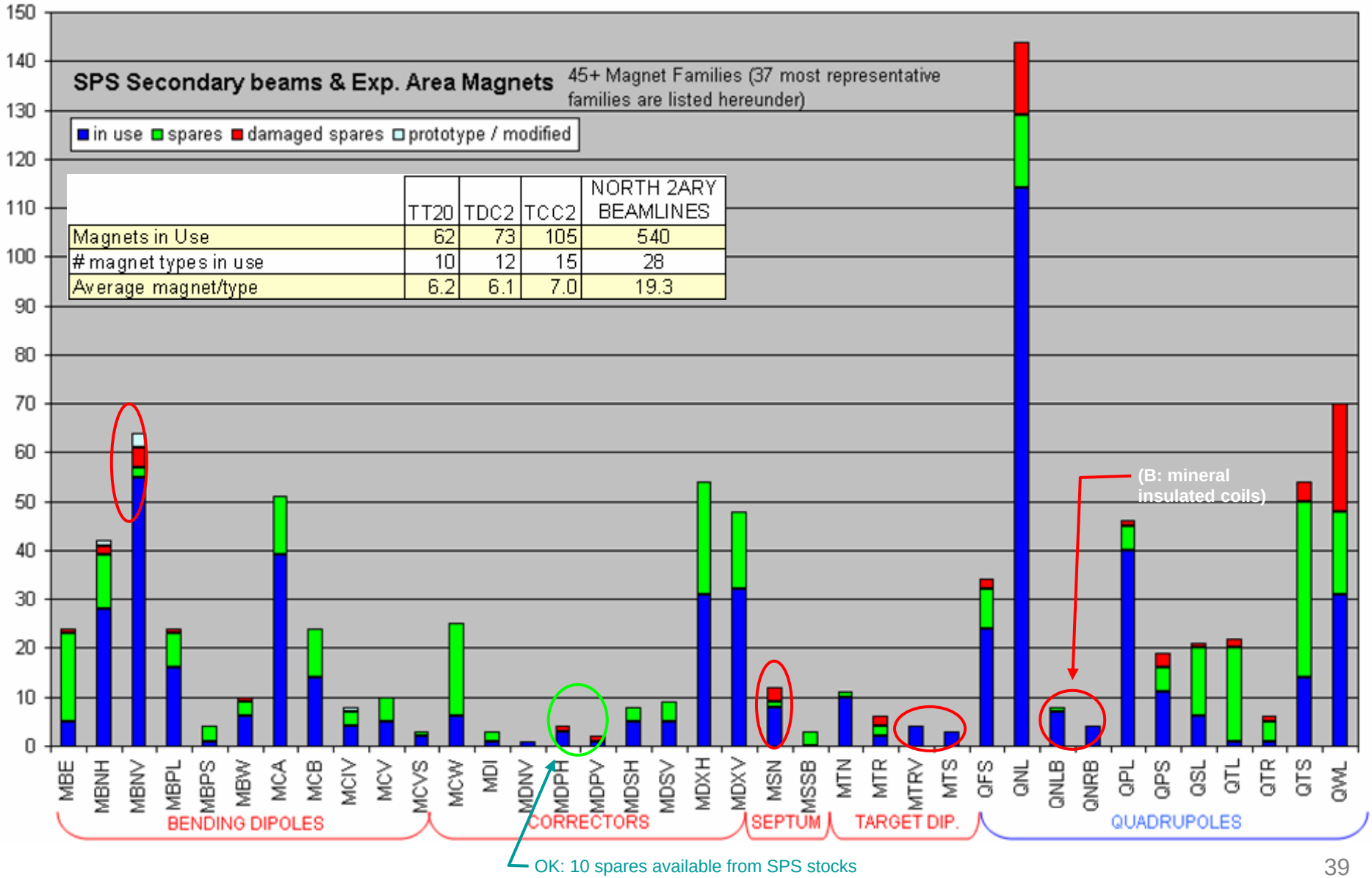


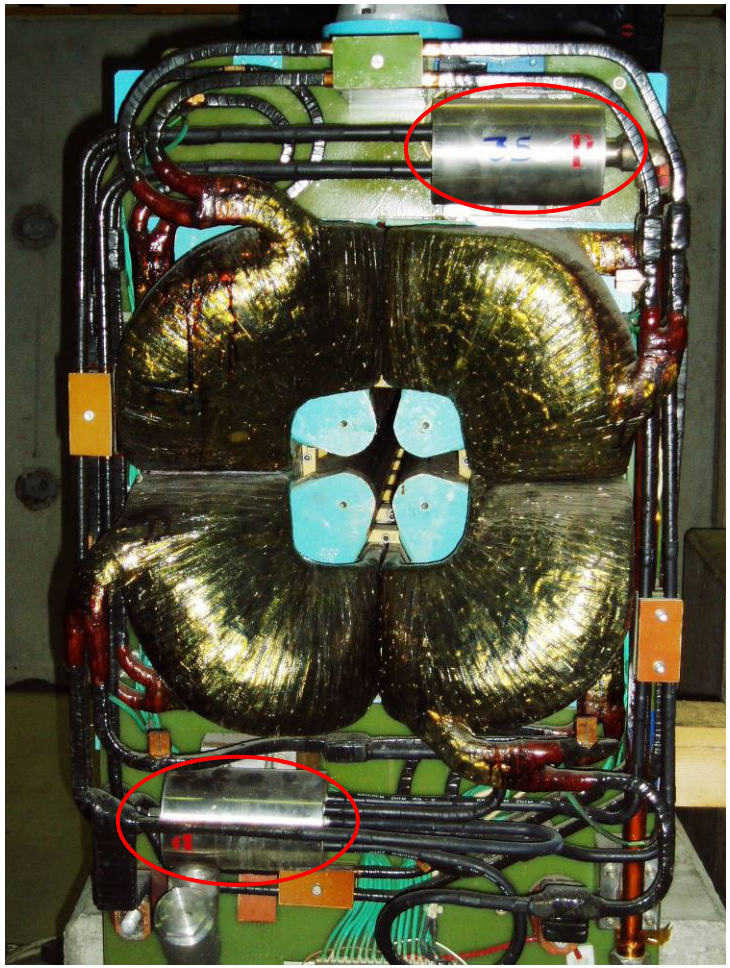
# II.2 Status 'weak' magnets + Potential Risks

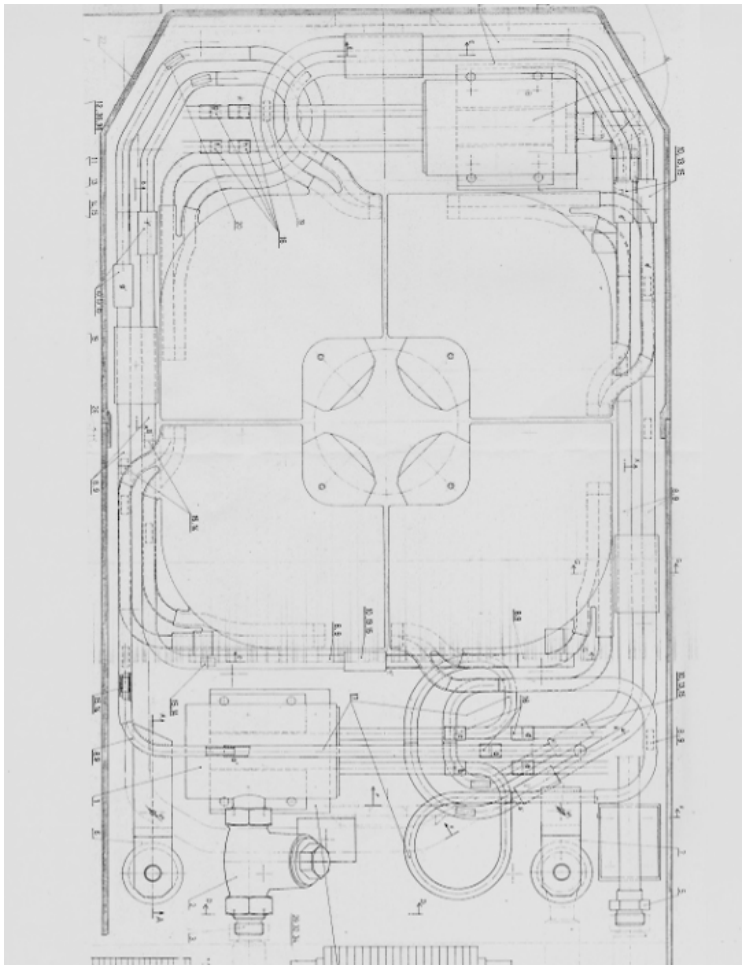




| | Magnet Type | Risk | Rating Risk*Impact | Proposed action |
|---|---|---|---|---|
| TT20 / TDC2 | QTA/L (48 magnets in use in TT20/TDC2/NEA) | Failure of the Coil Water manifold | High (~20 risky magnets ) (several repairs every year) | 2007: supply of new manifolds for repairs. Next Shutdown: Replacement of weak parts on 20 magnets |
| | MSSB (6 magnets in use) | Failure of vacuum tank or magnet coil due to corrosion | Medium to high (unpredictable) *Risk of breakdown in series* | 2008: Conversion of 1 (or 2) West Area splitter(s) into NEA splitter |
| TCC2 | MBN (83 magnets in use in TCC2/NEA) | Vacuum Leak due to corrosion in radioactive areas (*PVC covers*) | High | *PVC covers replaced on magnet in radioactive environment last years.* Vacuum related problem. But it uses spare magnets. |
| | MSN (8 in use in TCC2) | Failure of the Coil Water manifold | Medium (probable within 5y) | 2007: supply of new manifolds for repairs. 2008-2010: refurbishment of the 3 damaged MSN |
| | MTR/MTS/QLNRB/ QNLB | Lifetime elapsed. Probably coil failure | Low to medium (unpredictable) | 1 spare MTS coil available. Consolidation proposal not yet assessed. |

# QTA/QTL weak point: water distributors





# Weak Magnets: QTA/L/R/S





| | Situation | RISKY | SUM |
|---|---|---|---|
| **OPERATING** | **EA standard: QTA:0 / QTL: 1 / QTR: 0 / QTS: 14**<br>**BT standard:**<br>**in TT20/TDC2 :QTA:19 / QTL: 11 / QTR: 0 / QTS: 2**<br>**in other BT lines: QTA:0 / QTL: 14 / QTR: 2 / QTS: 2**<br>**TOTAL: 65** | **> 20 magnets** | **65 magnets in operation.**<br>**30% of them risky** |
| **SPARES** | **EA standard: QTA:0 / QTL: 19 / QTR: 4 / QTS: 36**<br>**BT standard: QTA:4 / QTL: 5 / QTR: 2 / QTS: 8** | **Not assessed** | **78 magnets spare !**<br>**Mostly QTS** |

| | |
|---|---|
| **Importance issues** | **Main BT quadrupoles for primary beamline TT20/TDC2. Mainly QTA magnets in TDC2, few spare QTA** |
| **since 2006** | **Assembly Tool + workshop + spare coils to reconstruct QTA/QTL/QTR/QWL** |
| **2007** | **Small consolidation budget available. Manufacture of new parts for 25 magnets (targeting repairs of QTA and QTL in TDC2 – 24 magnets)** |
| **2008** | **Replacement of weak parts in situ (TDC2).** |

# TDC2 – Splitter MSSB Overview

# MSSB Splitters: Version 1 WEA - Version 2 NEA

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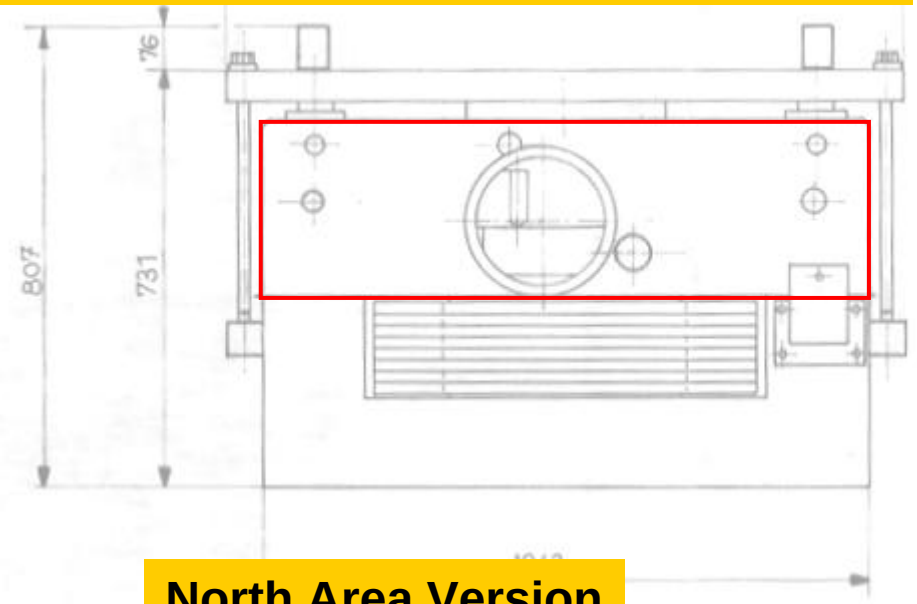
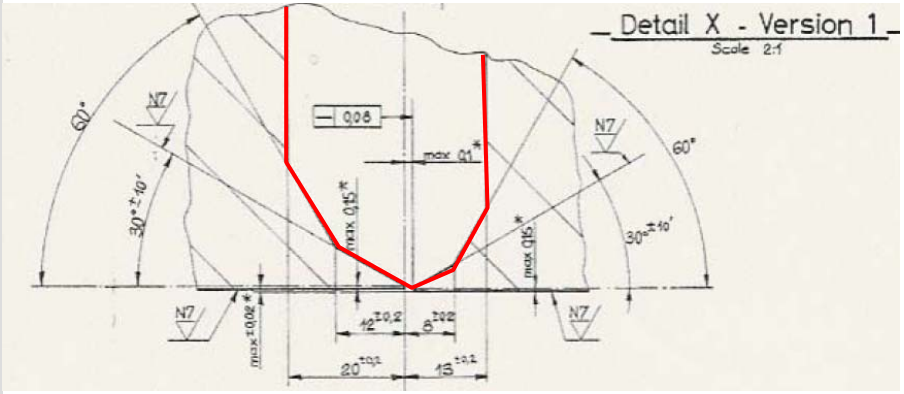
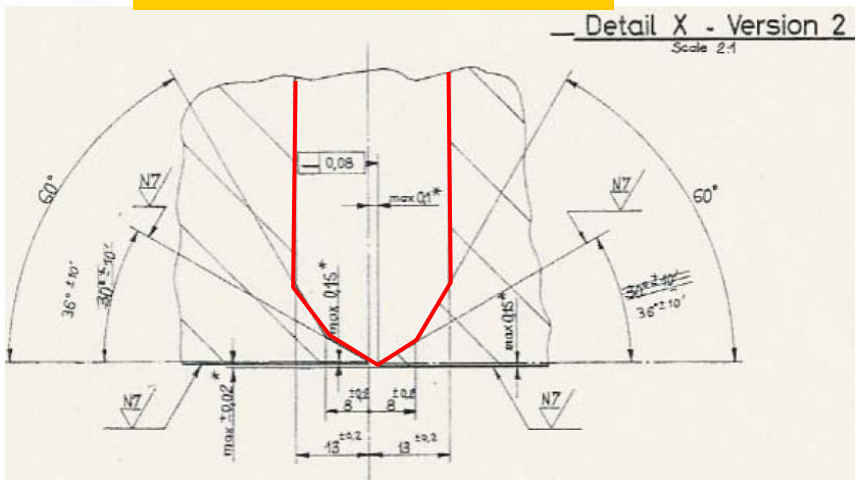
**Replacement of 1 complete upper yoke+vacuum tank: ~115kCHF**

- **MSSB Splitter Magnet Situation**
  - **1 spare magnet for North Area**
  - **Corrosion problem on all 6 North Area MSSB magnets**
- **Risk of several failures in a row**
- **Availability of 3 West Area MSSB magnets (different septum profile)**
  - **Conversion WEA MSSB into NEA MSSB seems possible**

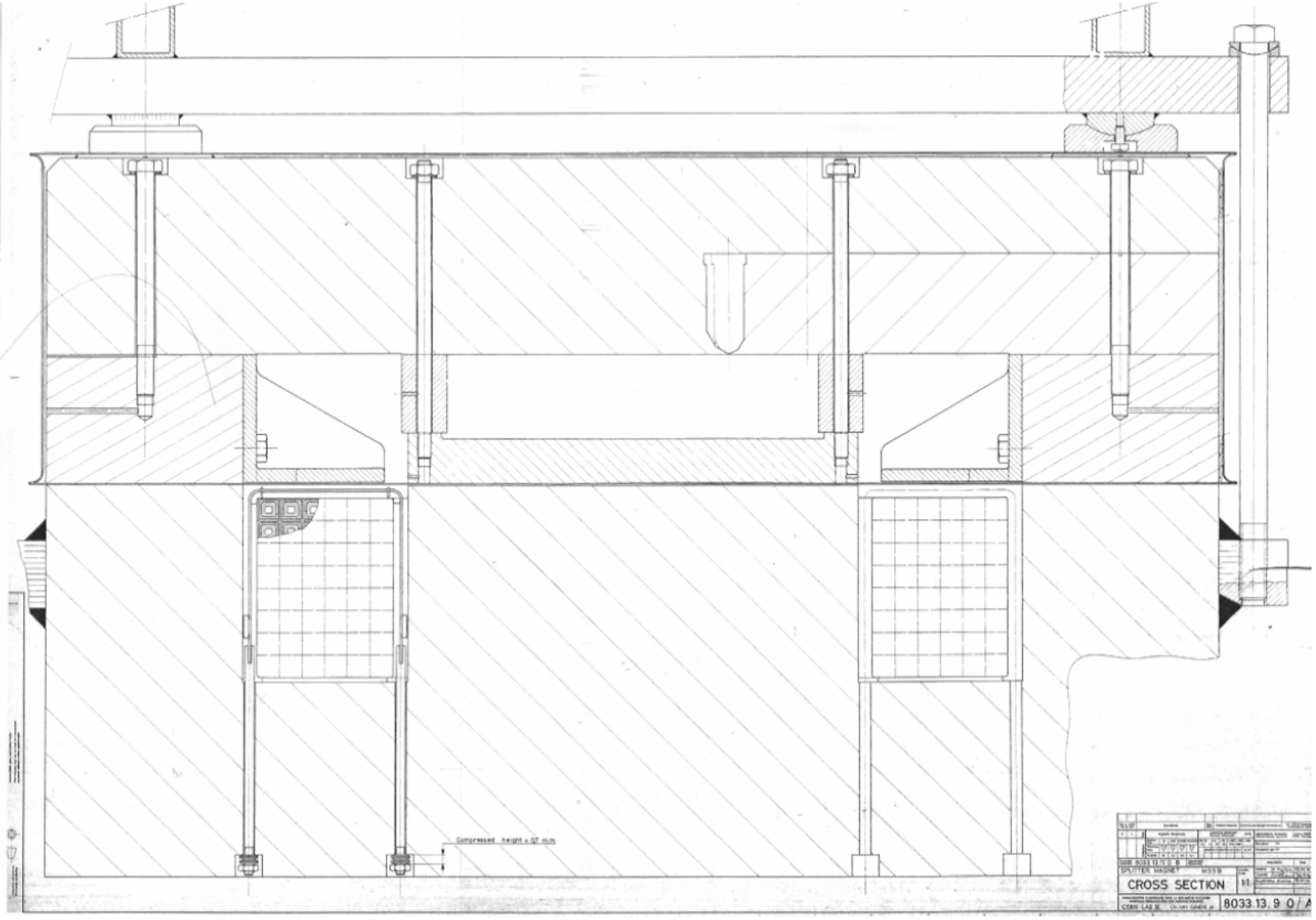



**North Area Version**



# MSSB Splitter magnet: Cross Section



# Weak Magnets: splitters MSSB





| | Situation | RISKY | SUM |
|---|---|---|---|
| **OPERATING** | **NEA standard: MSSB Type 2: 6 magnets in use in TDC2**<br>**WEA standard: MSSB Type 1: 0 in use** | **All MSSBs in TDC2** | **6** |
| **SPARES** | **NEA standard: MSSB Type 2: 1 spare new magnet**<br>**WEA standard: MSSB Type 1: 4 spares (recuperated magnets)** | **None** | **5 spares**<br>**(4 not compatible with NEA)** |
| **Importance issues** | **2 triplets of MSSB used to split the primary beam toward T2/T4/T6 targets** | | |
| **2007** | **No consolidation budget available. Study feasibility to convert WEA MSSB into NEA MSSB (NEW UPPER YOKE + VACUUM TANK REQUIRED)** | | |
| **2008-09** | **If consolidation money available, conversion of 1 to 2 WEA to NEA MSSB** | | |

# MBN Weak points: Corrosion of vacuum chamber





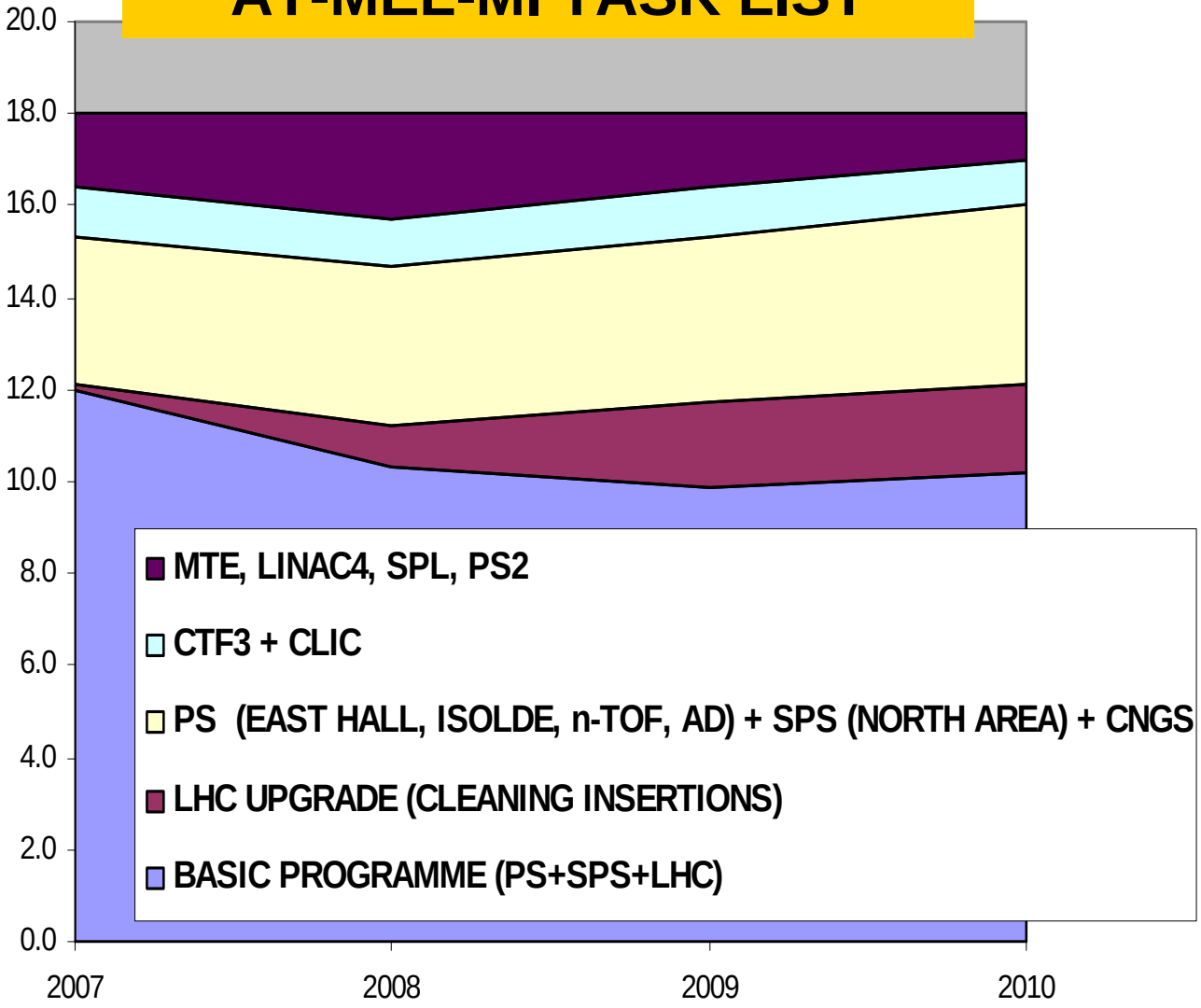
- Vacuum leaks. Due to corrosion of the stainless steel in contact with the PVC material used for the covers (made in the 70's).
- Not repairable in situ. Leaky Magnets have to be replaced

# III Insufficient staff





## AT-MEL-MI TASK LIST

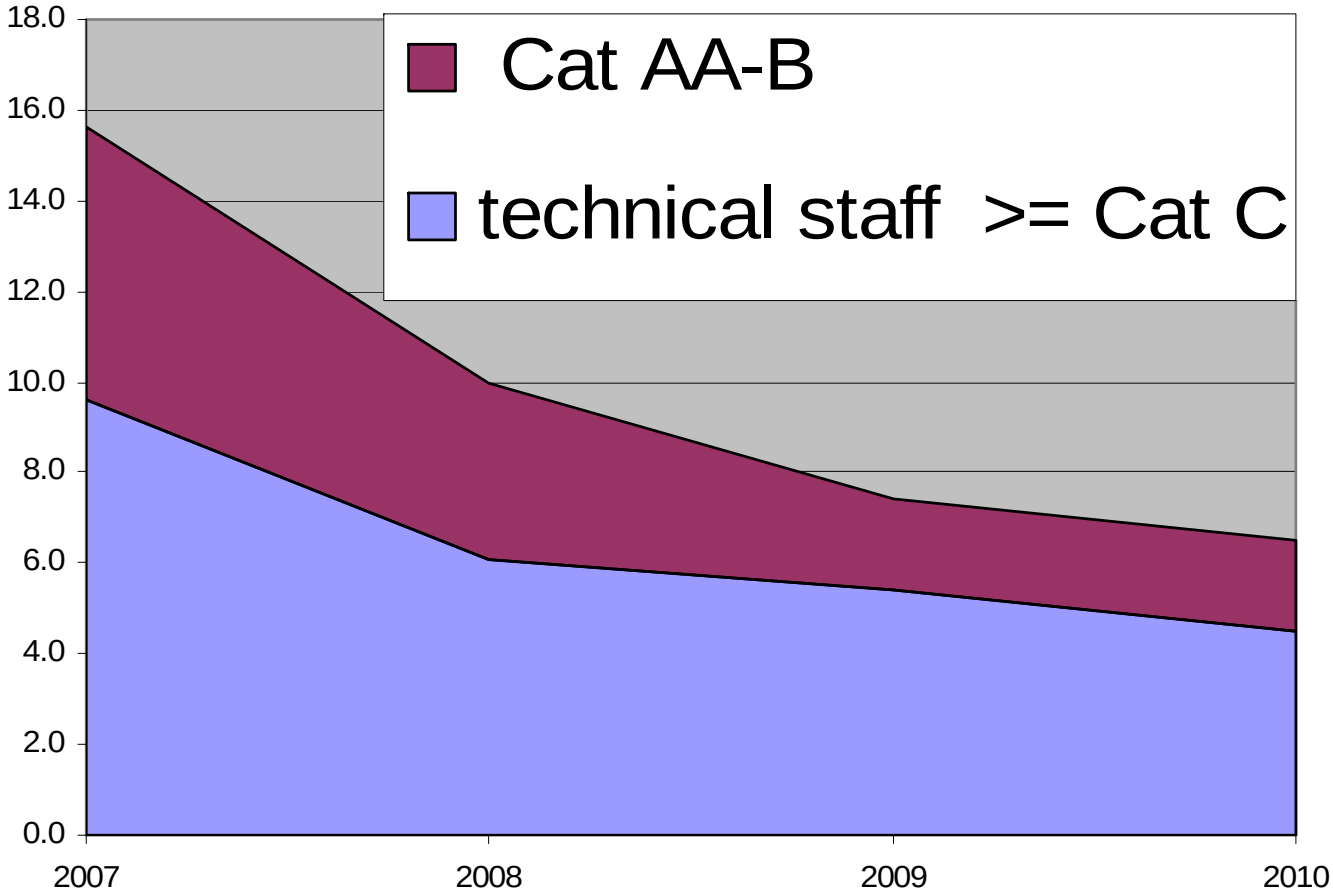


# STAFF PROBLEM





## AT-MEL-MI STAFF EVOLUTION



# CONCLUSIONS 1 East hall magnets





Severe reliability problems due to

- About 40 years old magnets
- Coils heavily radiation damaged
- Yokes often with high induced radio-activity ➔high irradiation of staff at maintenance + repair
- Low or zero operational spares for several types
- Too many (22) types for 63 magnets
- Some of too delicate design + expensive in production

# CONCLUSIONS 2 East hall magnets

The East Hall magnets have mostly arrived at the end of their lifetime.

Therefore, it seems the right moment for a

- redesign of the East Hall with
- fewer magnet types and more space.

Otherwise a considerable effort in P+M must be invested to:

- Replace risky magnets
- Improve the current spare situation

# CONCLUSIONS 3 NEA magnets

Status is less critical than for the PS East Hall.

Magnets are about 30 years old.

Primary lines: 240 magnets, magnets/type 6-7

Secondary lines: 540 magnets, magnets/type 19

➔ TDC2/TCC2 concentrate most of the problems.

➔ Expected improvements by 2008:

- QTA/QTL water manifold problem solved in TT20/TDC2
- 2 to 3 Spare MSSB magnets available in case of breakdowns

➔ by 2010 : Additional spare MSN magnets

# CONCLUSIONS 4 NEA magnets

Remaining Issues:

- No spares for 1 QM + 3 MTS + 4 MTRV + 4QNRB
- Only 1 MSN spare unit
- Few MBNV spare units
- Obsolete Magnet Interlock System

# CONCLUSIONS 5 AT-MEL-MI STAFF PROBLEM





The staff is declining dramatically due to:

- Ending LD contracts end 2007 to mid 2008.
- Already 4 staff Cat 2xC, D, E have left to AB.
- Retiring staff
- Replacements inside MEL done 9-2006.

➔ Huge loss in expertise + effectiveness

Already for the basic programme we do just have

- sufficient staff for 2007,
- But NOT for the following years.

# CONCLUSIONS 6 AT-MEL-MI STAFF PROBLEM



We need already in the current of 2007 strong influx of experienced staff (cat C + D) to be trained in magnet manufacture, testing and maintenance.

Without this input of experienced staff :

➔ We cannot fullfill for >2007 our tasks for the basic programme : PS+ SPS + LHC (nc magnets)

➔ Consequently beyond the basic programme we have to decline all tasks for:

- PS + SPS Experimental Areas + CNGS
- CTF3 + CLIC
- PS-MTE + LINAC4 + SPL + PS2

# ANNEX 1 F61S BHZ01-MNP23

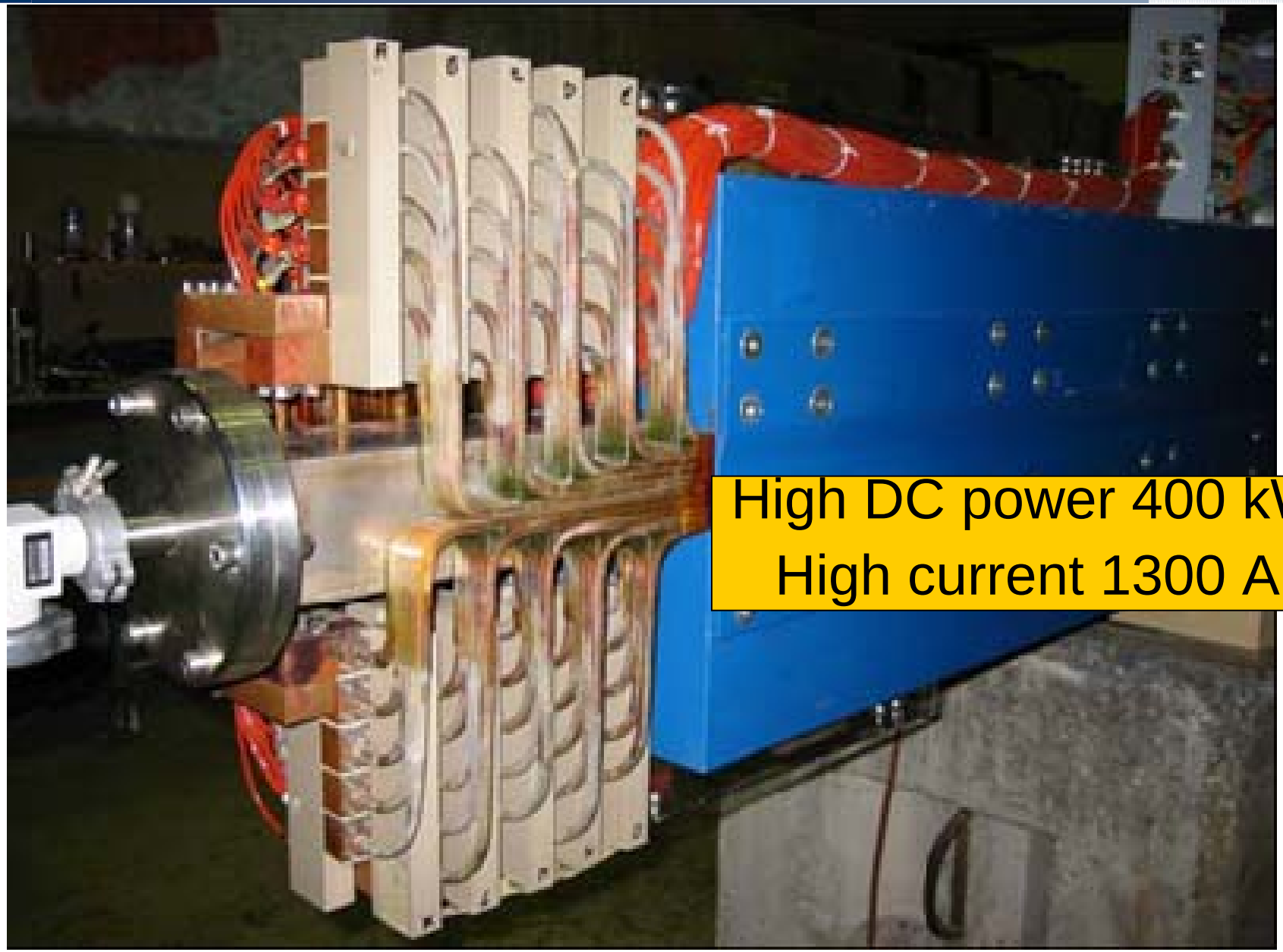




- 1st generation (3 different designs) showed coil insulation + water cooling + short circuit leading to completely burnt coil insulations) problems starting already in the 1990s.

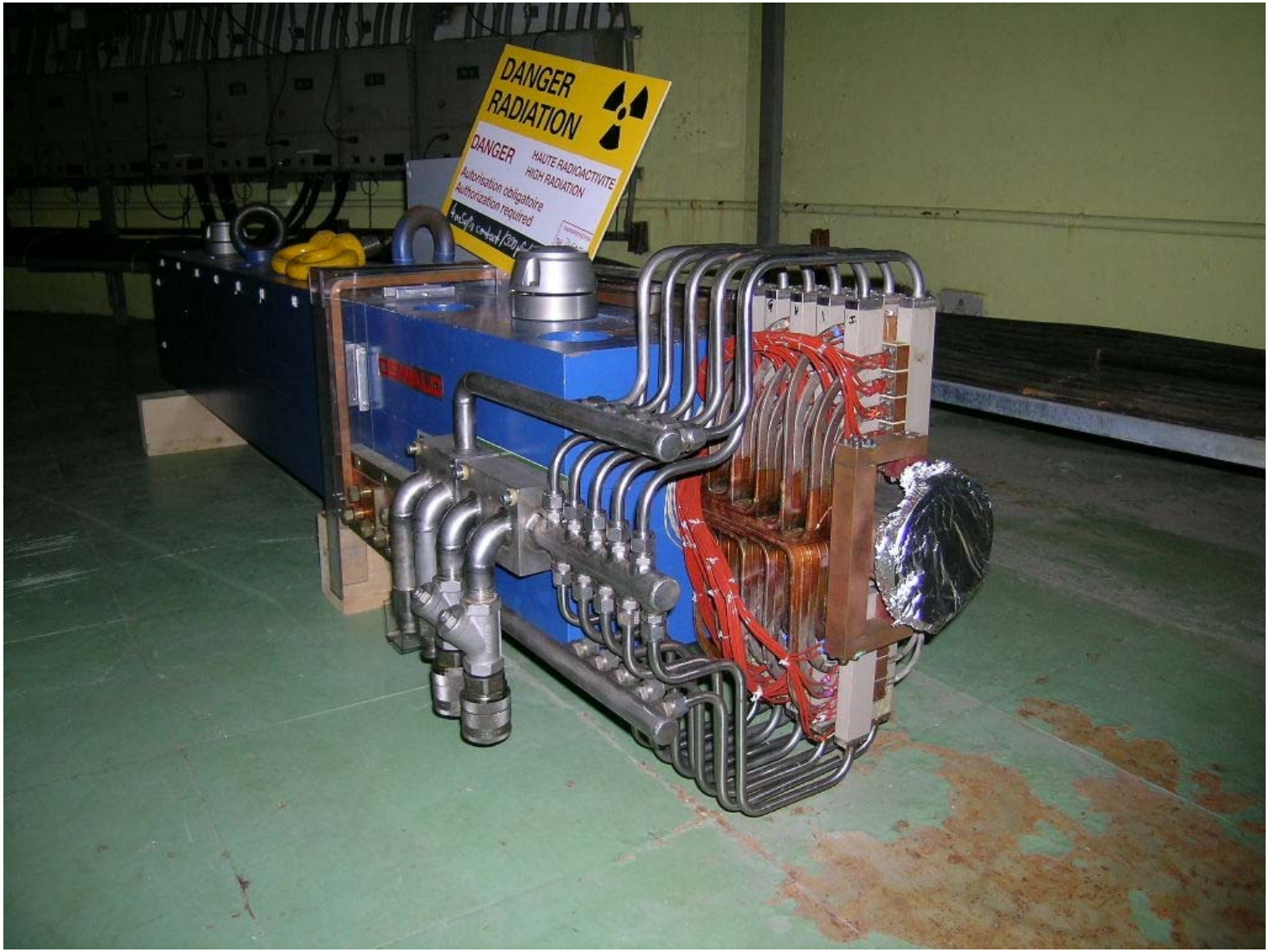
Status in 2001. → No more spares from 1st generation + F61S-BHZ01 needed to be replaced.

- → 3 new magnets were built in 2001 at OSWALD/DE by T. Zickler (2nd generation).
- → Damaged unit in F61S was replaced the 1st unit of the new septum in March 2002 & operated until November 2003 (→ water leak + cooling channels blocked due to corrosion).


High DC power 400 kW
High current 1300 A

# ANNEX 1 F61S.BHZ01.MNP23-OSWALD





# ANNEX 1 F61S.BHZ01.MNP23





- ➔ July 2004: high leakage current + cooling channels blocked by a deposit stemming from corrosion. ➔ required the replacement of the 2nd unit operating since March 2004.
- ➔ November 2004: same problems with the 3rd unit operating since September 2004.

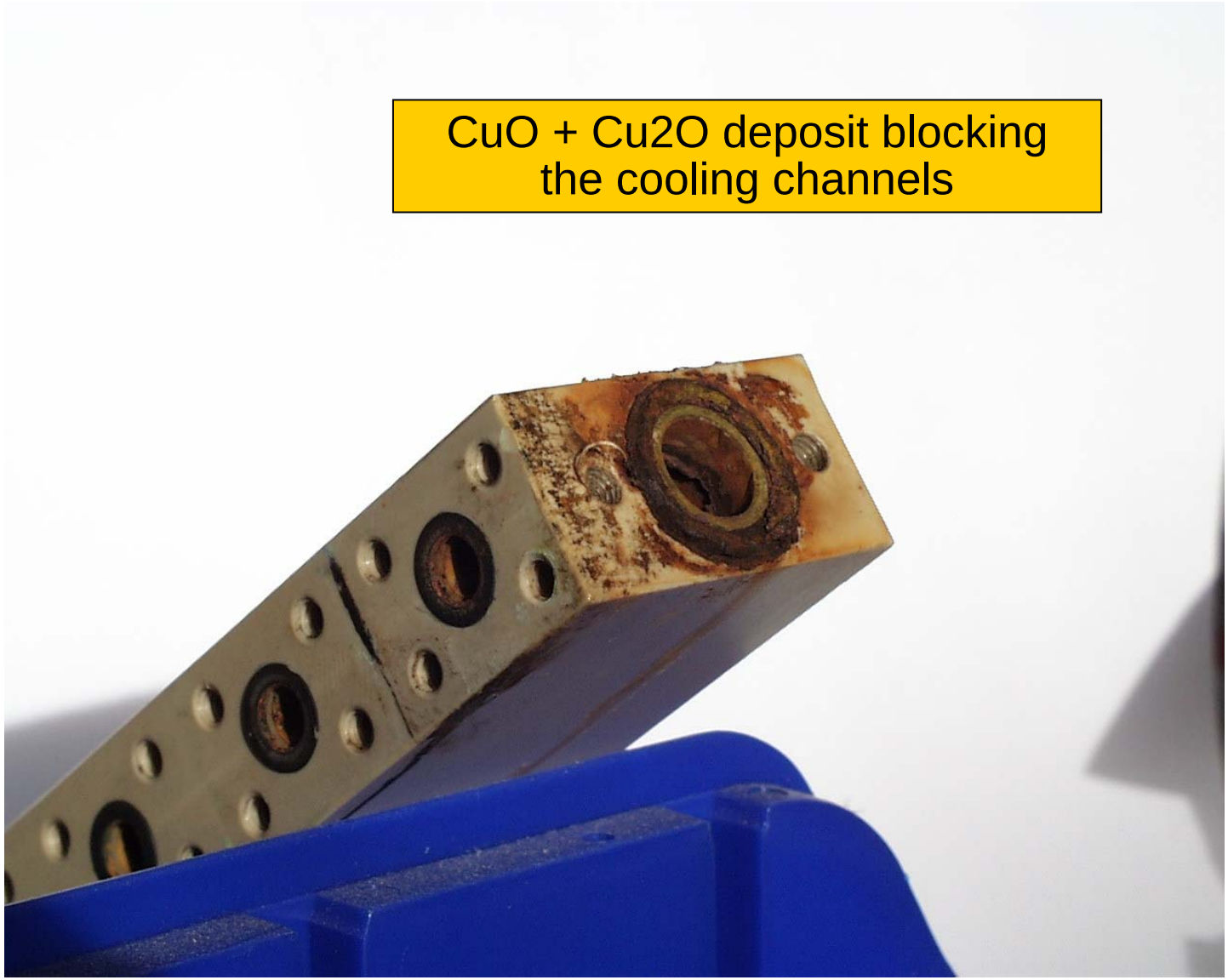
- An analysis by V. da Silva AT/MEL/MI in 2005 showed that corrosion problems were due to insufficient quality of the demineralized water:
  - too high conductivity (up to 15 microS/cm, nominal 0.5 microS/cm),
  - resin cartridges not regularly exchanged and problems of monitoring the conductivity.
  - As a consequence of the low water quality the inner walls of the cooling channel were corroded resulting in a deposit of CuO + $Cu_2O$ blocking the water circulation of the coils .
- In close collaboration with TS/CV we purchased + installed new devices to monitor the water quality online (operational since 3-2006).

# ANNEX 1 CORROSION AT F61S.BHZ01.MNP23-OSWALD





CuO + Cu2O deposit blocking the cooling channels



# ANNEX 1 CORROSION AT F61S.BHZ01.MNP23-OSWALD

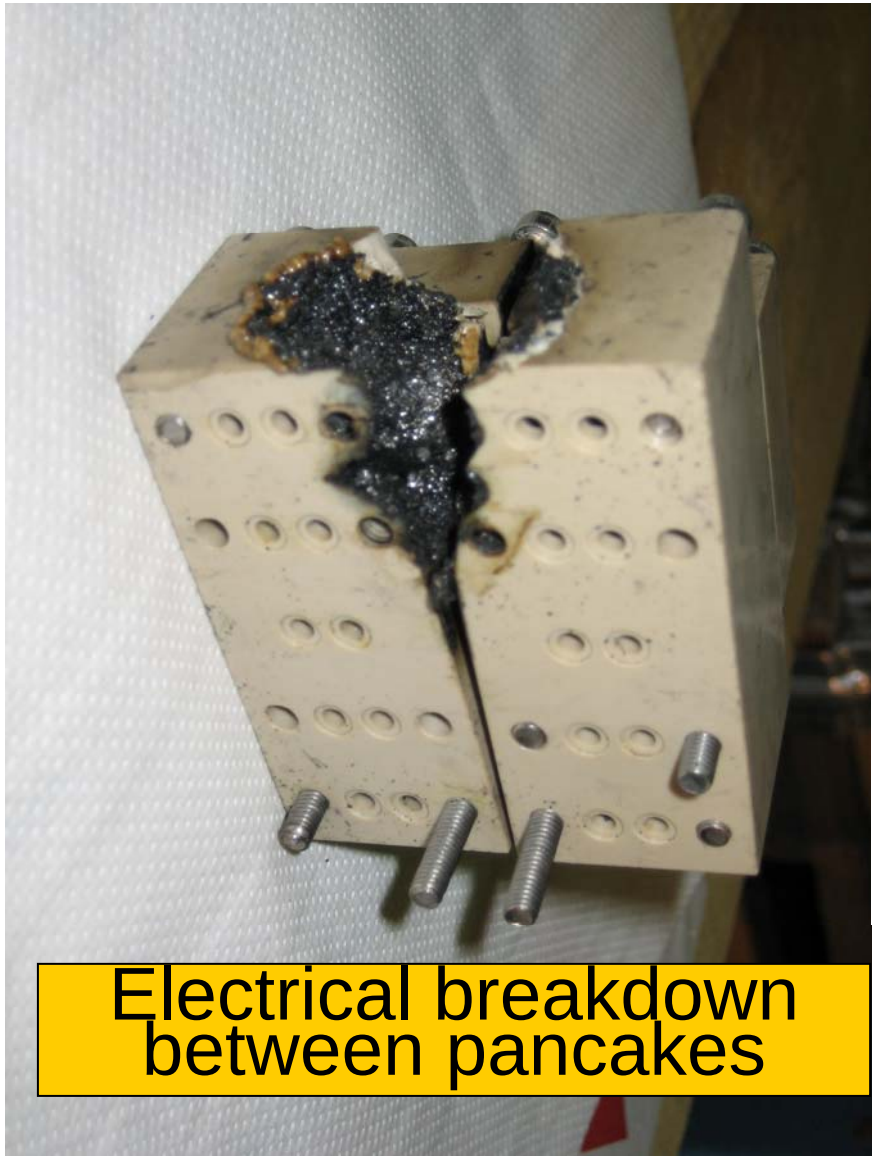


CuO + Cu2O deposit blocking the cooling channels

- 2005: Fabrication of 5 new coil sets (3rd generation) to be mounted in the existing yokes at SEF/FR. The coils had improved cooling features (cooling per half-turn instead per full-turn) in order to reduce the very high water speed and the maximum coil temperature.
- March 2006: Installation of MNP23 with 1st new coil set from SEF.
- April 2006: a short circuit required the replace-ment of the MNP23 just before beam operation.
- July 2006: an electrical breakdown in the 2nd coil set required the replacement of the magnet.
- October 2006: an electrical breakdown in the 3rd coil set ended its operation after 4 weeks only.

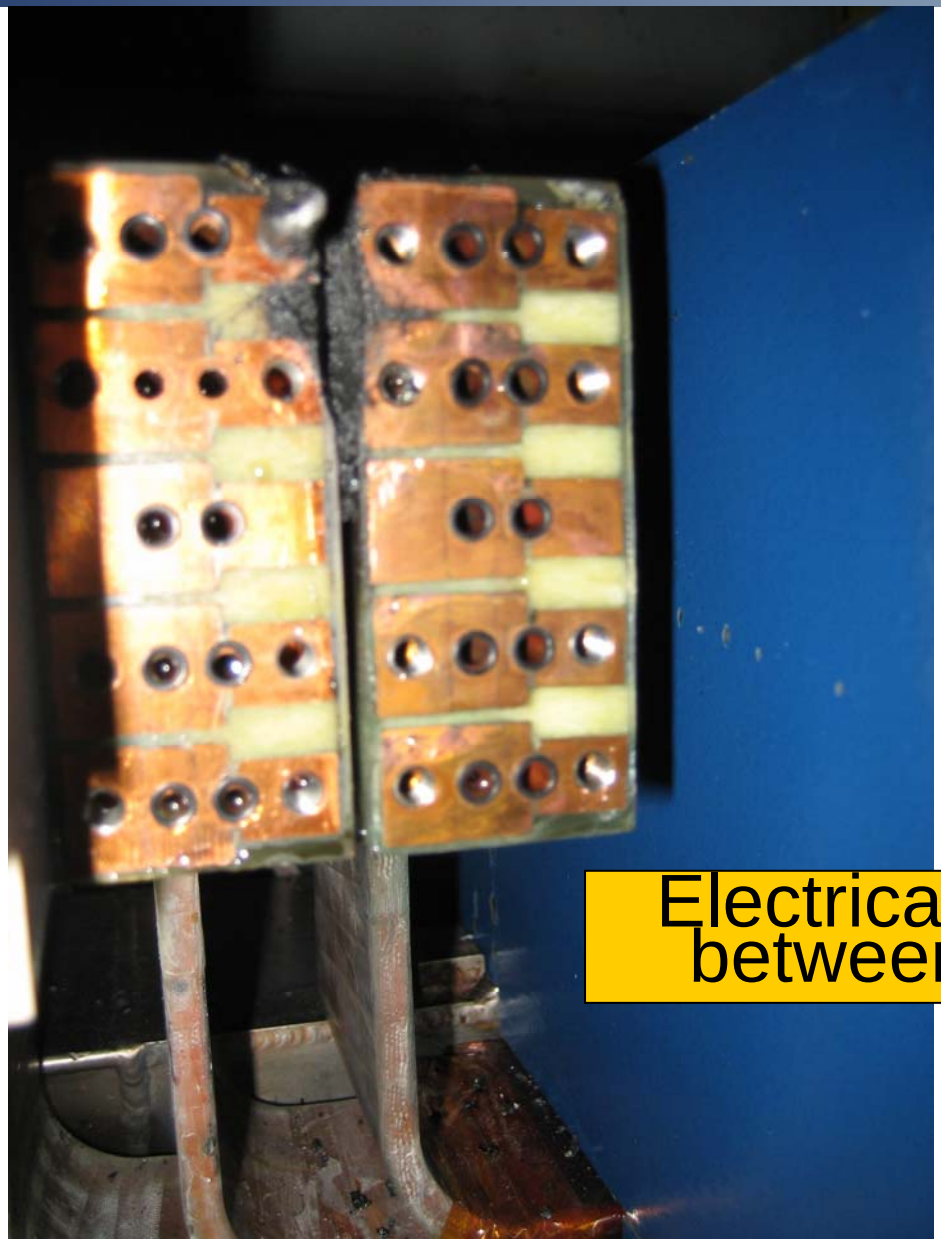
# ANNEX 1 F61S.BHZ01.MNP23 SEF





# ANNEX 1 F61S.BHZ01.MNP23 SEF





Electrical breakdown between pancakes

# ANNEX 1 F61S.BHZ01.MNP23 SEF

- As the origin of the breakdown was fully unclear, it had been decided to use the 4th coil set in order to launch a study including simulations and measurements under true operating conditions (except beam).
- A study started in November 2006 by M. Zerlauth AB-CO & J. Kozak AT-MTM, D.Bodart AT-MEL & A.Beuret AB-PO using the 4th coil set. .
- The preliminary results after about 4 weeks were as follows:
  - no convincing fault explanation yet
  - the max over-voltage spikes from the power converter are only about 50% above the nominal max of 400 V.
  - several kV are required for causing the severe damage observed!

# ANNEX1 F61S. BHZ01.MNP23



- Mid-February 2007: The study will continue when cooling water is again available until the origin is found.
- Results will be used for an improved fabrication of the 5th new coil set followed by long-term testing before an eventual re-installation in 2008.
- February 2007: install C-shaped MCB magnet to replace MNP23 for 2007 operation.

# ANNEX 2 EAST HALL MAGNET RESPONSIBILITY

| | Magnet ownership | Magnet maintenance | Co-ordination Magnet installation, book-keeping, alignment, vacuum |
|---|---|---|---|
| 1996-2004 | PS → AB-ATB | SL-MS → AT-MEL | PS → AB-ATB |
| 11-2004 | AT-MEL | AT-MEL | AB-ATB |

see Memo dated 18 August 2004 about the responsibility for normal-conducting magnets (ref. OUT-2004-058-annex Rev.1).

- Up to now AT-MEL (with exception of a magnet listing + X-section layout) has not received the required documentation needed for a proper maintenance or rebuilding of the magnets.
- This 'electronic' documentation for each type shall consist of:
  - Scanned specifications
  - Drawings in CDD

  This task is really urgent + shall be done by AB-ATB, as they have the documents + were the owners. AT-MEL has no manpower for this.

  Per type it will take at least 1 week.

  So for 22 types it is 6 months work of a good Cat 3 person.