EXPERIMENTAL AREA MAGNETS
PS EAST HALL + SPS NORTH AREA

W. Kalbreier, D. Smekens, T. Zickler AT-MEL-MI

I PS EAST HALL MAGNETS

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

II SPS NORTH EXP. AREA MAGNETS

1. Overall magnet status
   - Layout SPS NEA
   - Breakdowns
   - 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 MAGNETS: BREAKDOWNS DURING OPERATION

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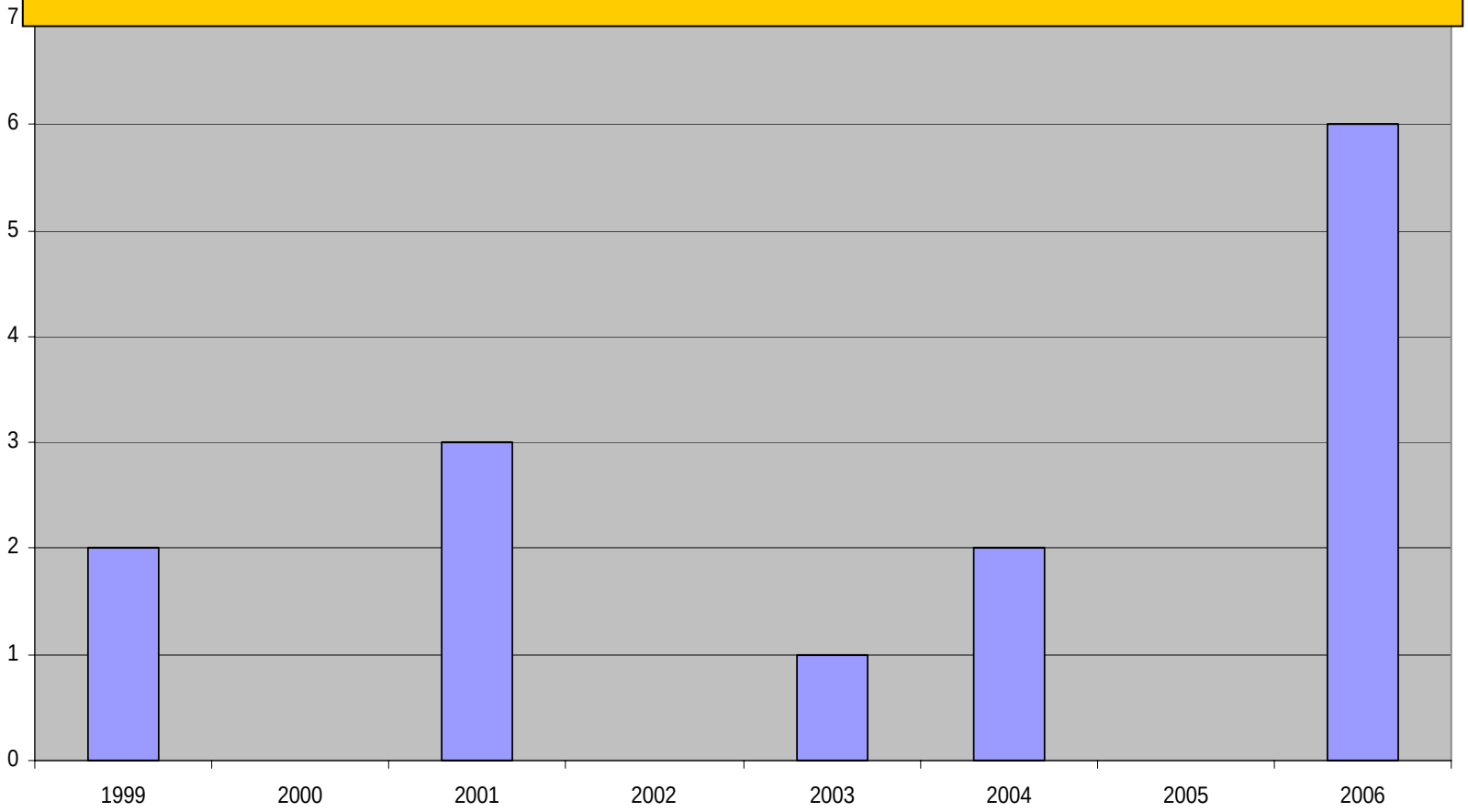
2003-4: 3x F61S.BHZ01.MNP23-OSWALD

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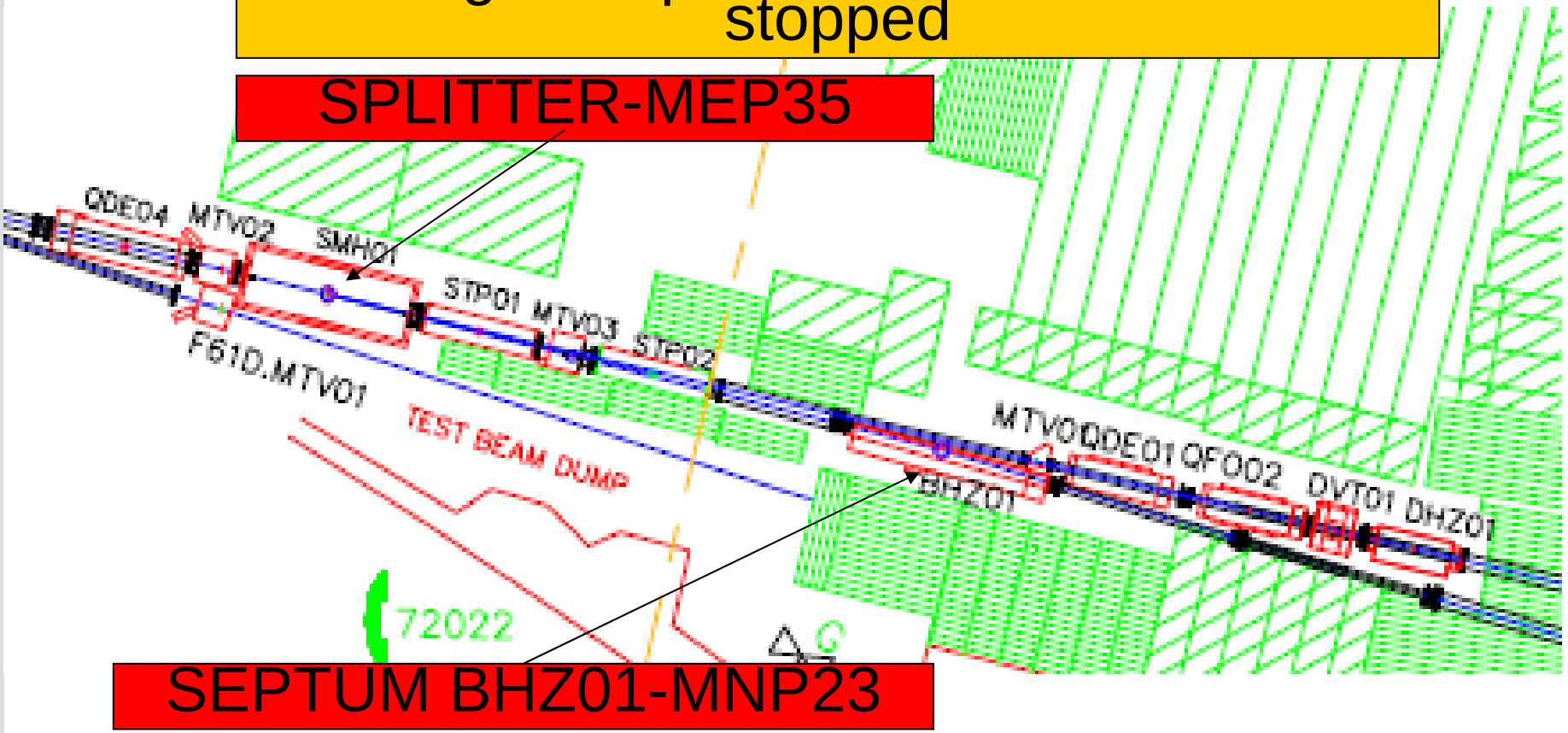
Access via PS Main Ring ➔ for any magnet replacement PS must be stopped

SPLITTER-MEP35



SEPTUM BHZ01-MNP23

F61S.BHZ01.MNP23-SEF under test

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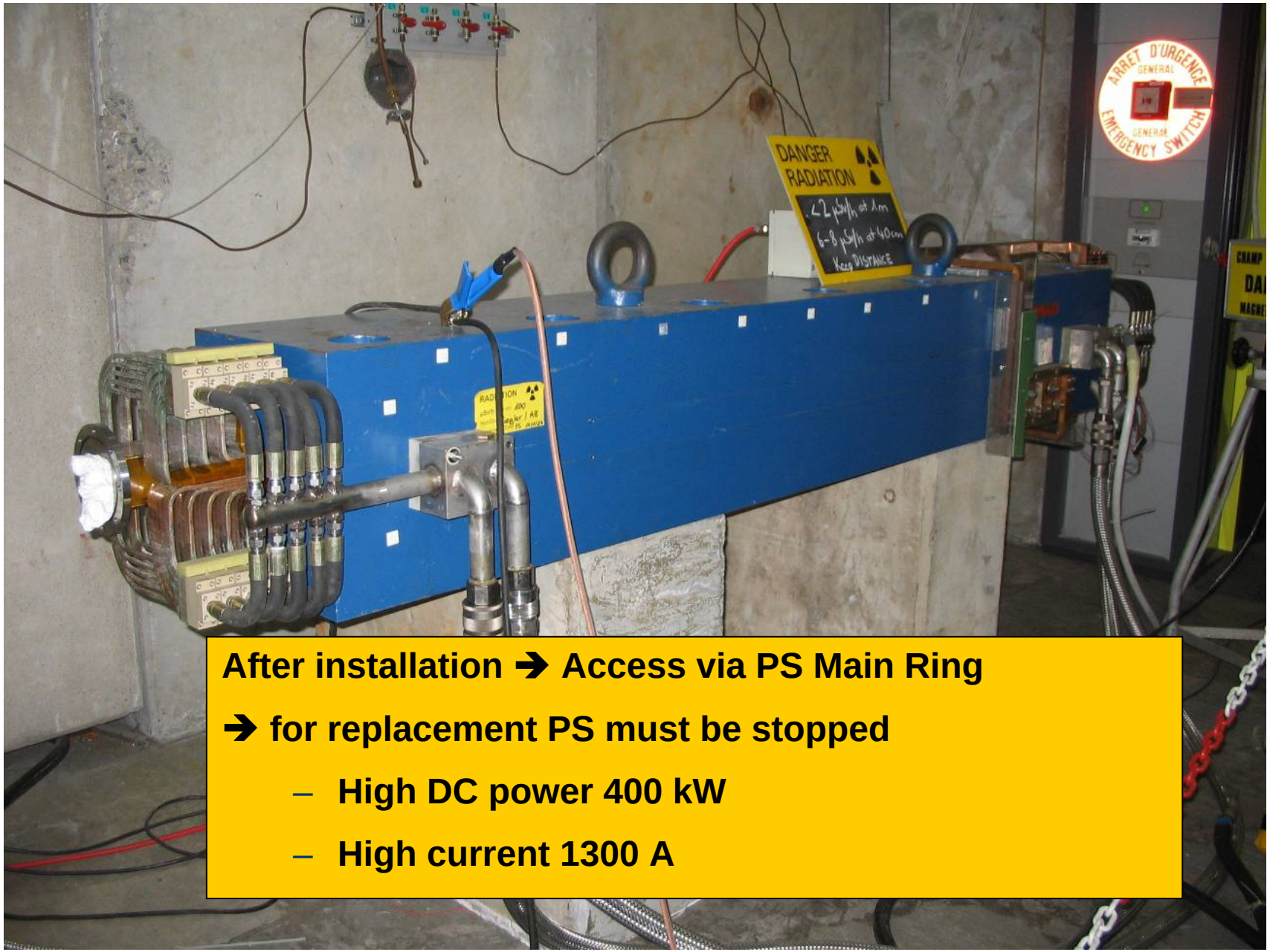
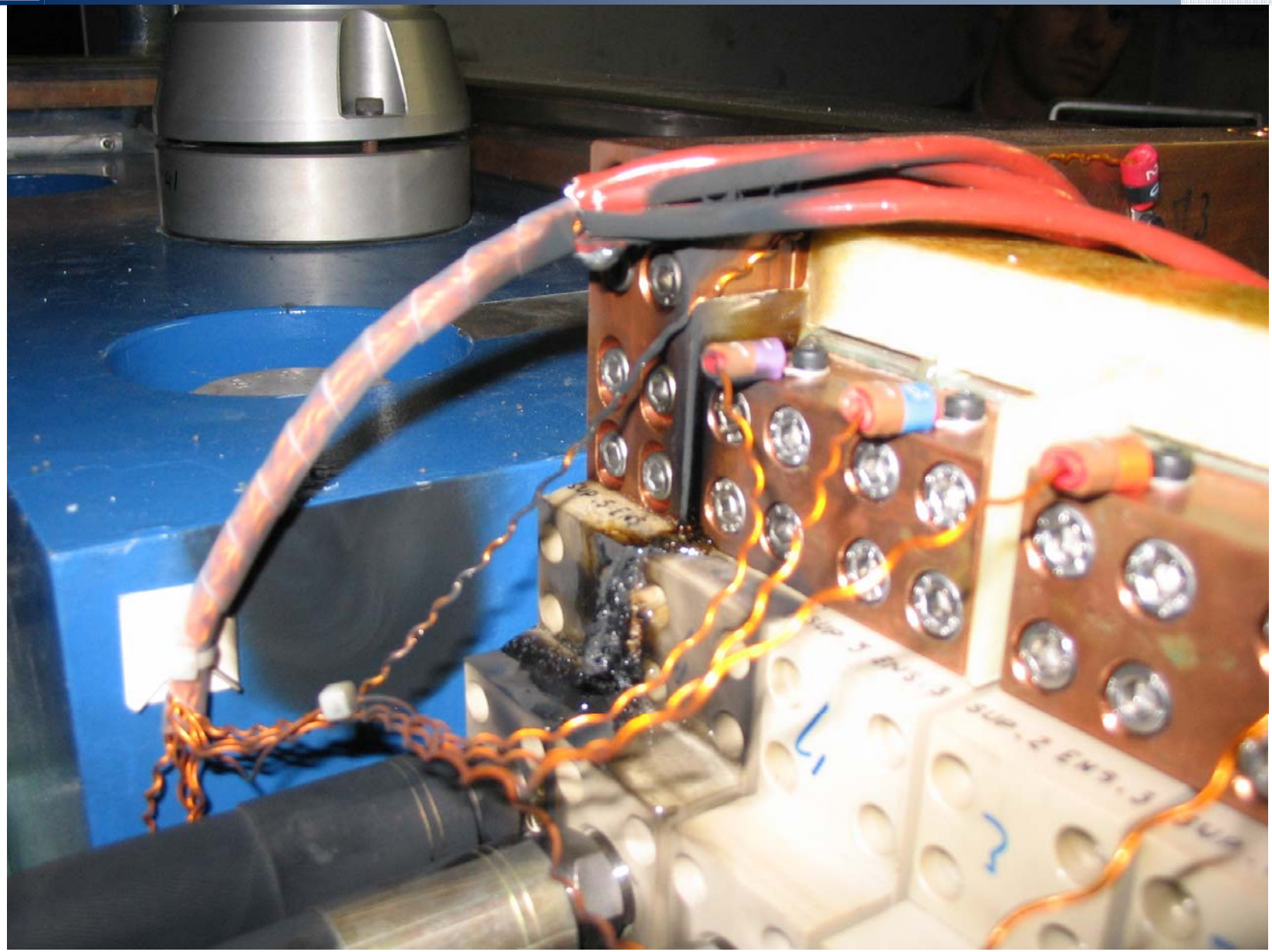


After installation ➔ Access via PS Main Ring

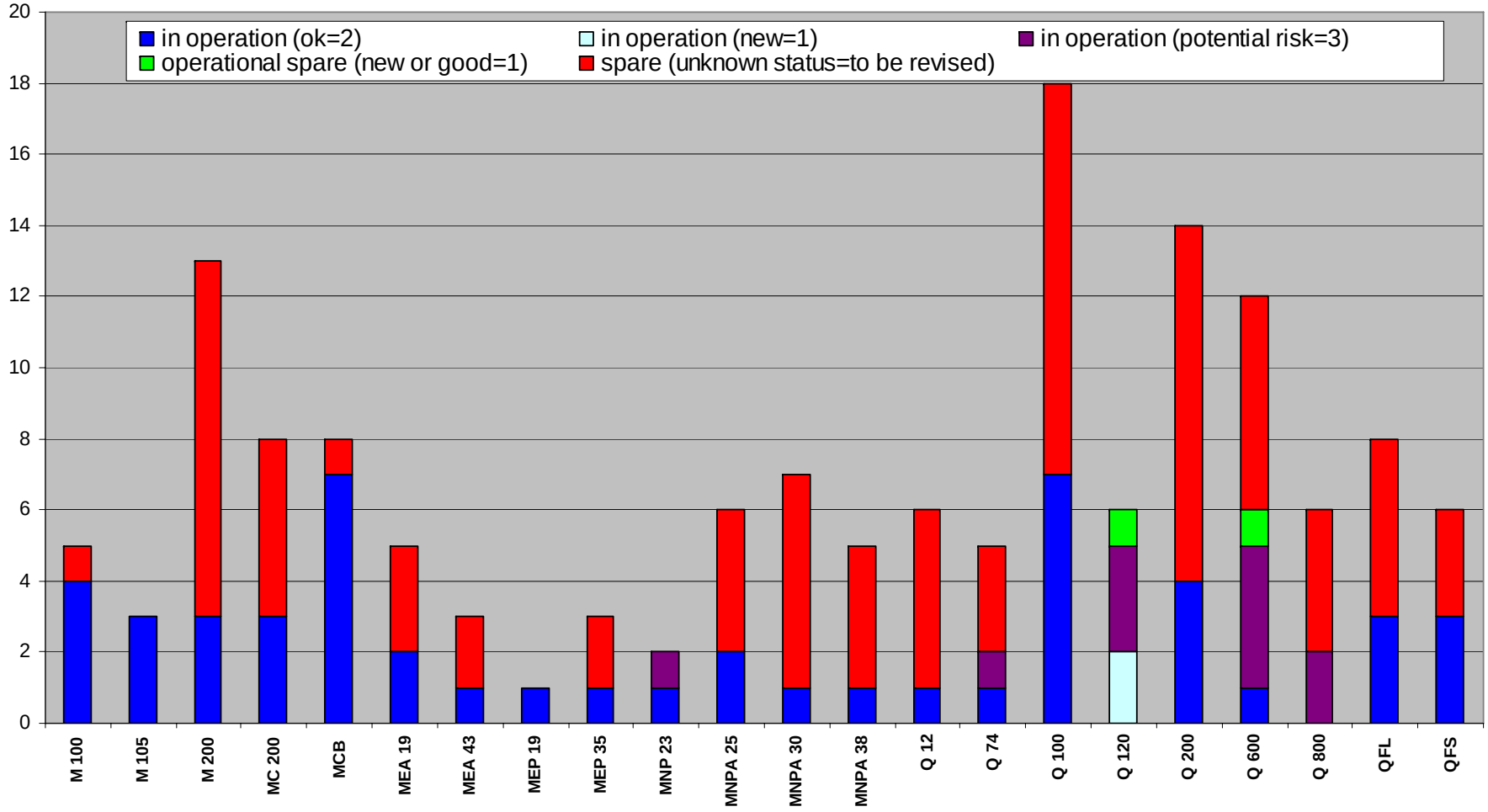
➔ for replacement PS must be stopped

- **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



‘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

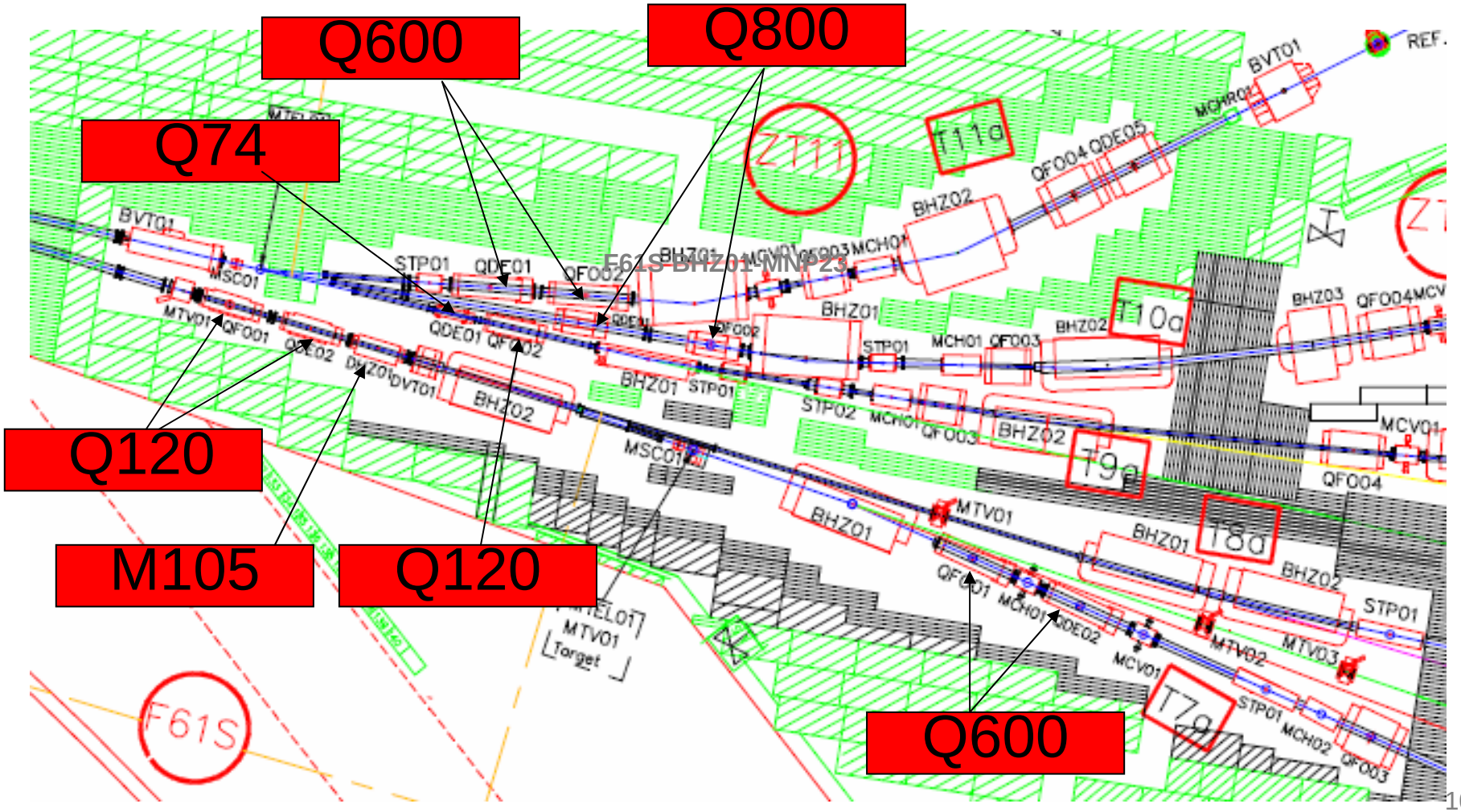
- for revision and/or
- new fabrication shall be given for:

‘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.

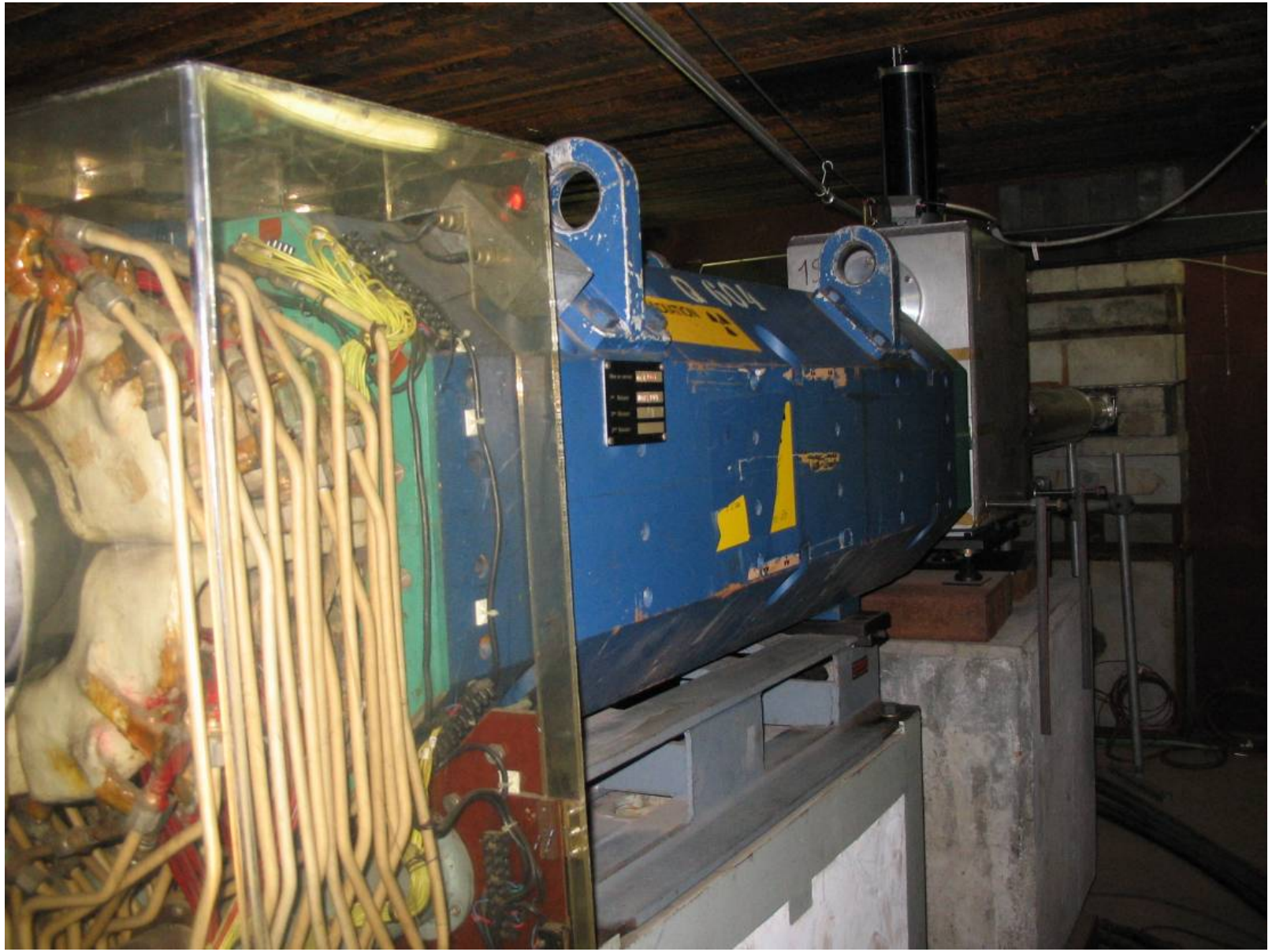
‘weak’ magnets Q74

‘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. 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. T7 Beam energy reduced: 10 ➔ 9 GeV T11.QDE01.Q604 + QFO02.Q602 for CLOUD			
2007	3 risky magnets will be replaced. The 2 spare units (unknown) must be revised in order to obtain 2 operational spares. If successful, replace 4th risky magnet in 2008. 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

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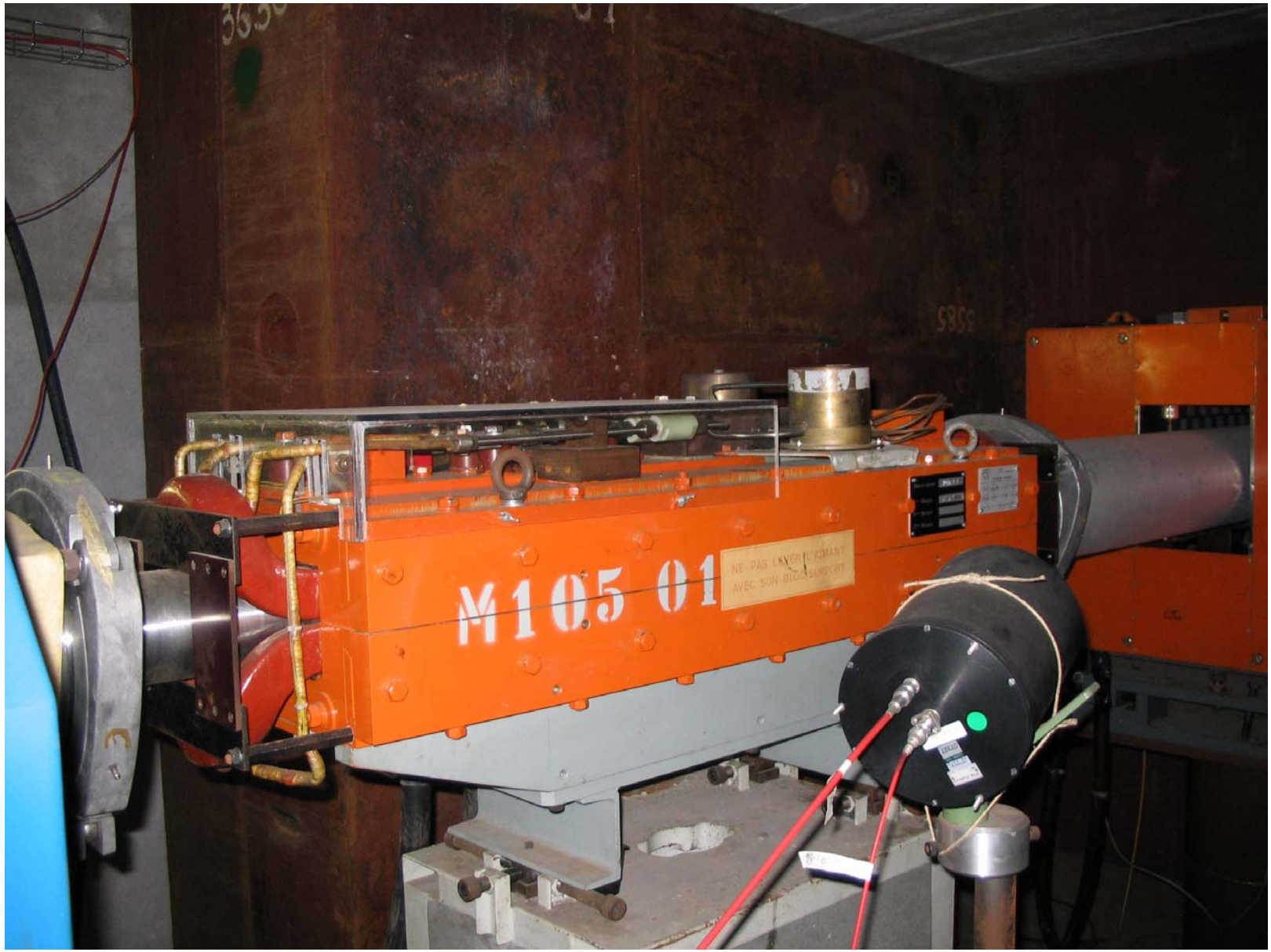
	NEW	OK	RISKY	SUM
OPERATING	**0**	**0**	**2**	**2**
	NEW	**OK**	**UNKNOWN**	**SUM**
SPARES	**0**	**0**	**1**	**1**
Importance issues	2 operating magnets are overheating. T10 beam energy reduced: 7 ➔ 6 GeV ALICE T10.QDE01.Q804 + QFO02.Q803 Already 3 broken non-repairable units.			
2007	1 (highly radio-active) spare must be revised in order to obtain 1 operational spare. If successful, keep it as spare. 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

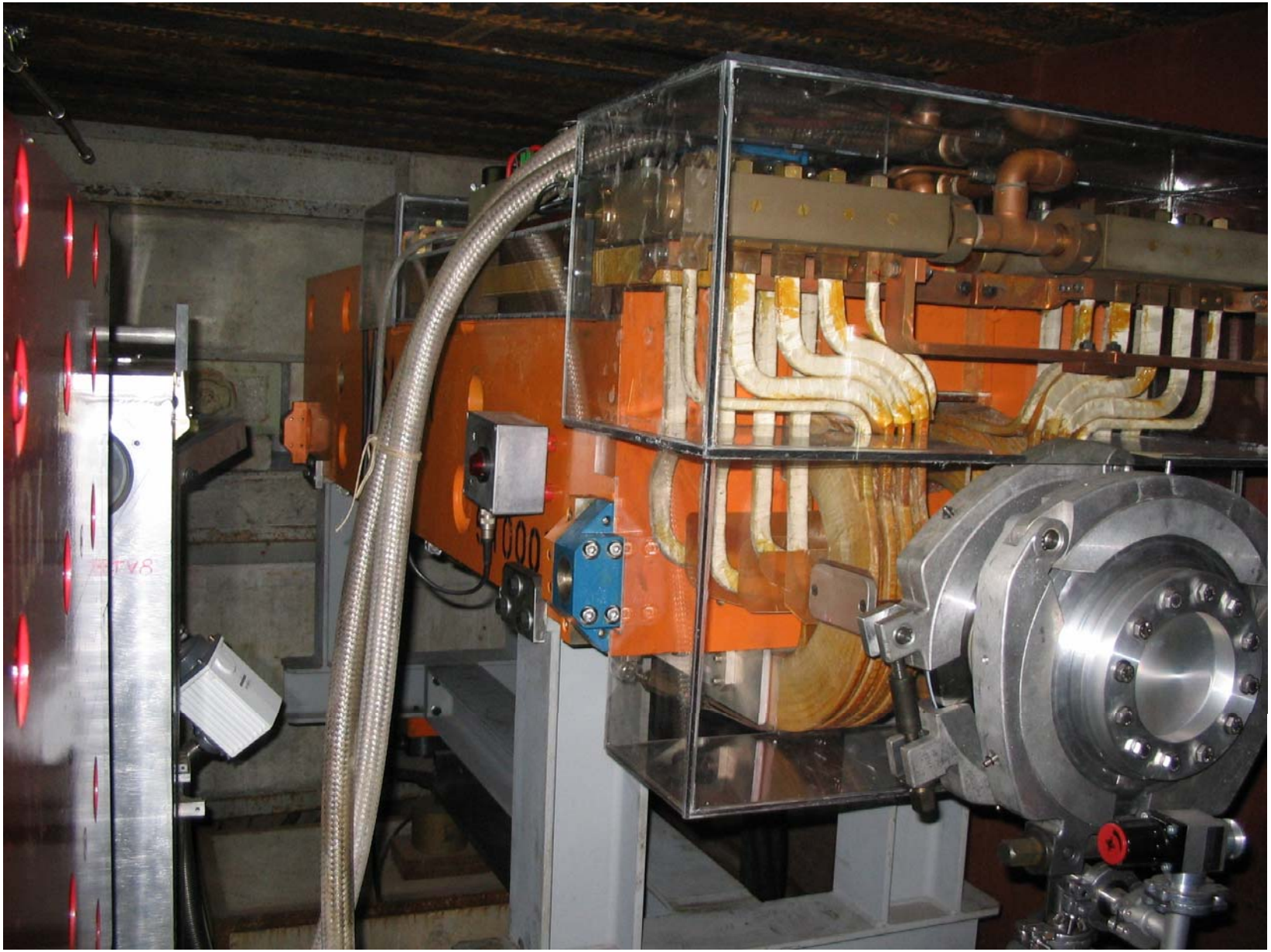


‘weak’ magnets M105

Accelerator Technology Department

	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 F61N.DHZ01.M105.02+F61S.DHZ01.M105.03 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

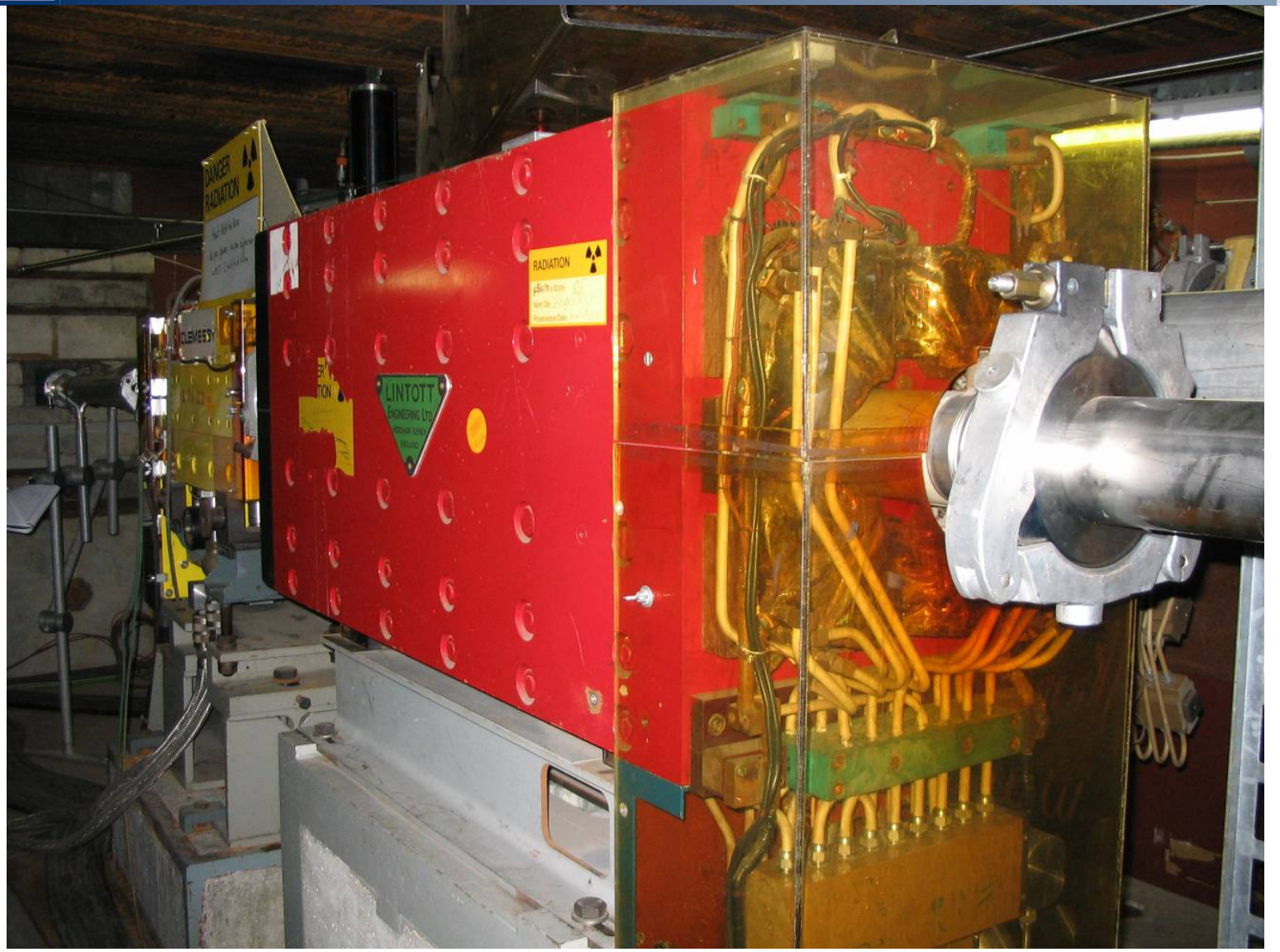


‘weak’ magnets MEP19

Accelerator Technology Department

	NEW	OK	RISKY	SUM
OPERATING	**0**	**0**	**1**	**1**
	NEW	**OK**	**UNKNOWN**	**SUM**
SPARES	**0**	**0**	**0**	**0**
Importance issues	No spare 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, 1 new magnet could be fabricated.			
2009	spare status ok			

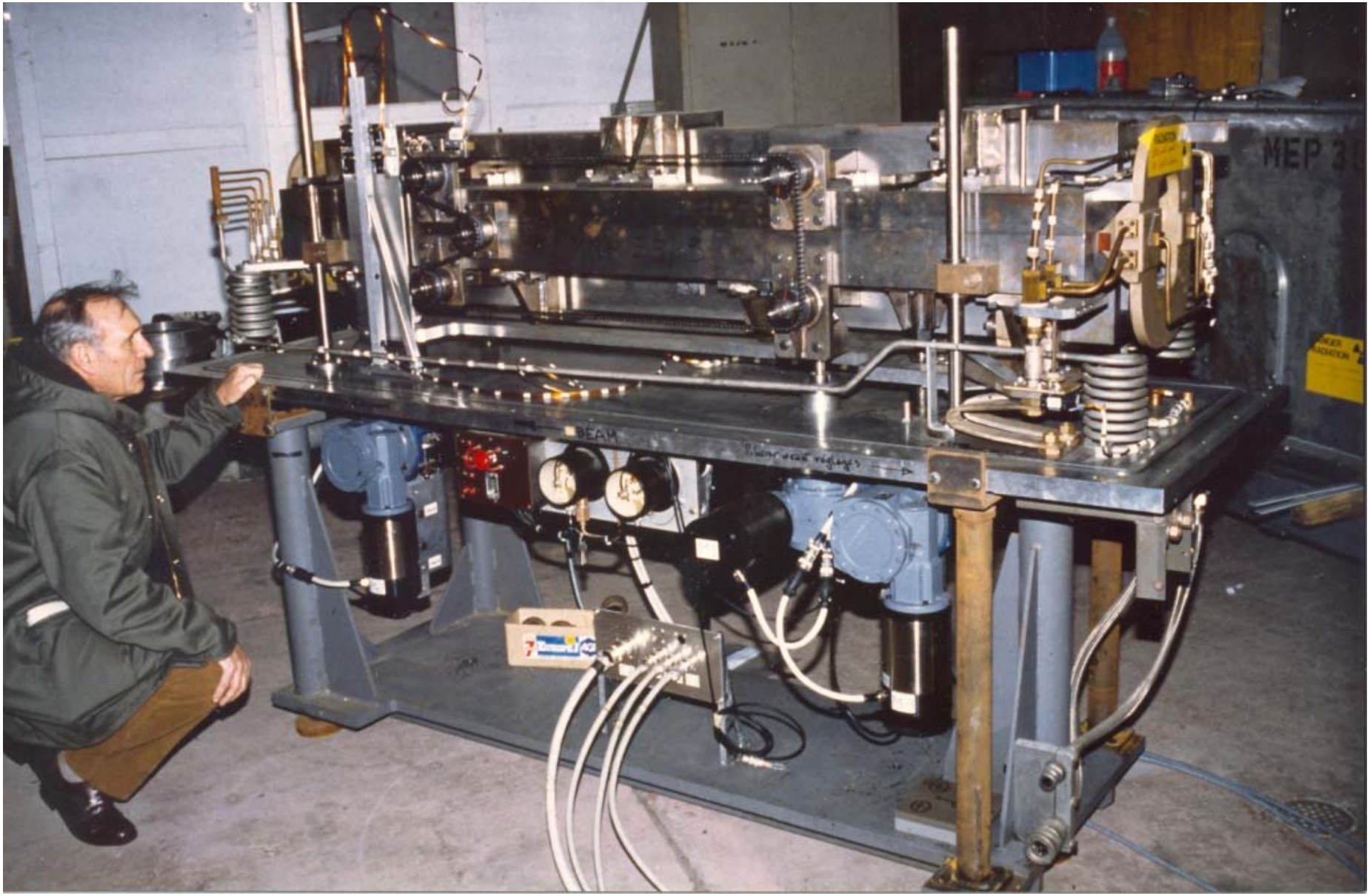
‘weak’ magnets Q120



‘weak’ magnets Q120

	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 T9.QFO02.Q120.02 AMS/T2K-KEK			
2007	Consolidation budget obtained. M. Karppinen AT-MEL-MI will launch + follow-up the fabrication. 3 Magnets will be fabricated.			
2008	3 risky magnets could be replaced, leaving 1 new spare.			

‘weak’ magnets MEP 35



	NEW	OK	RISKY	SUM
OPERATING	0	0	1	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. Magnet fully enclosed in vacuum container + motorized yoke. Maintenance of motorization shall be done by AB as AT-MEL-MI has no staff in this professional category. 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			

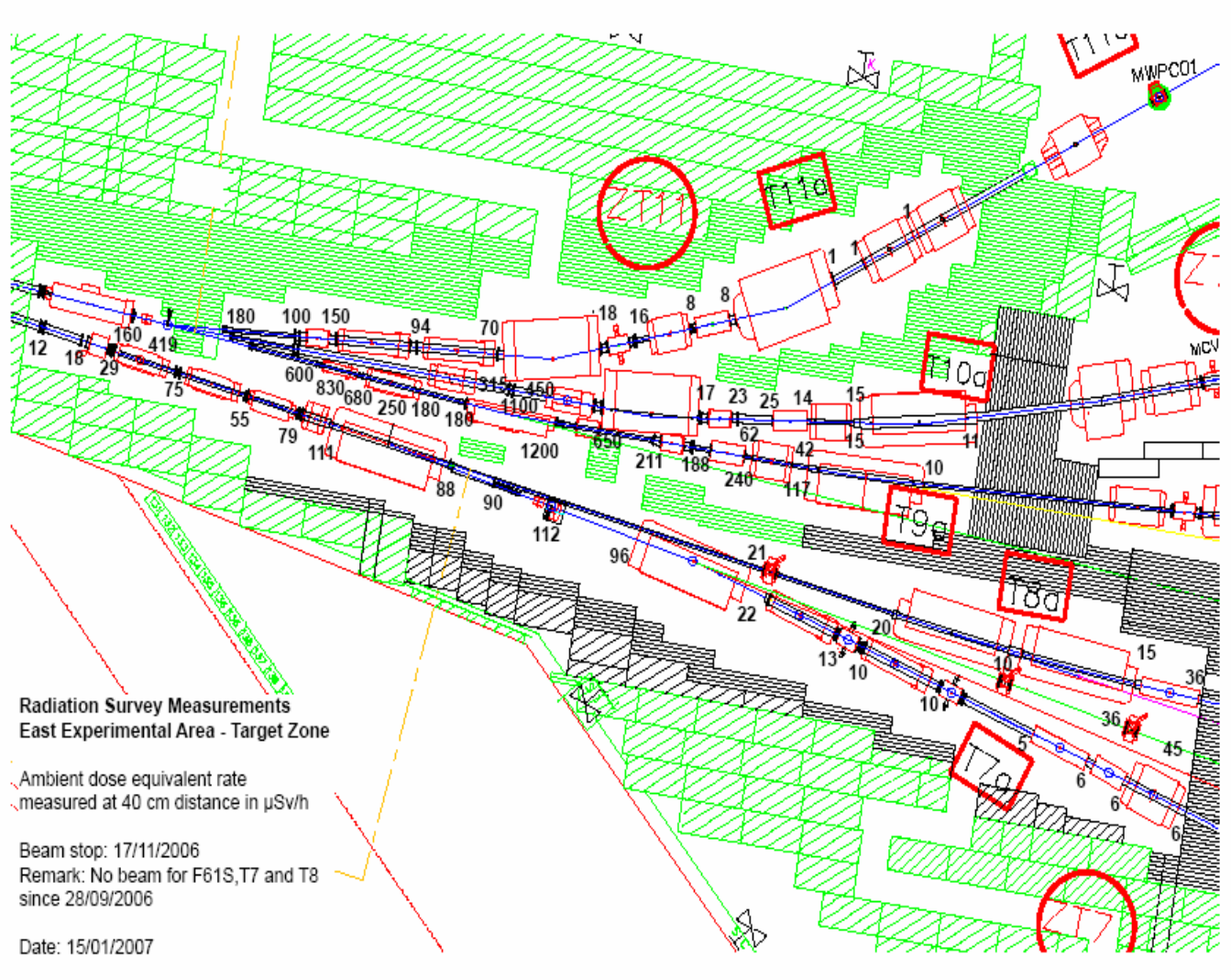
Proposal for an improved East Hall layout

- 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.

Radiation survey 15/01/2007



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

Keeping in mind the savings in

- Manpower
- Radiation budget

combined with less down-time for physics

this could even be the more economic solution.

SPS towards North Exp. Area

SPS North Exp. Areas

EHN2

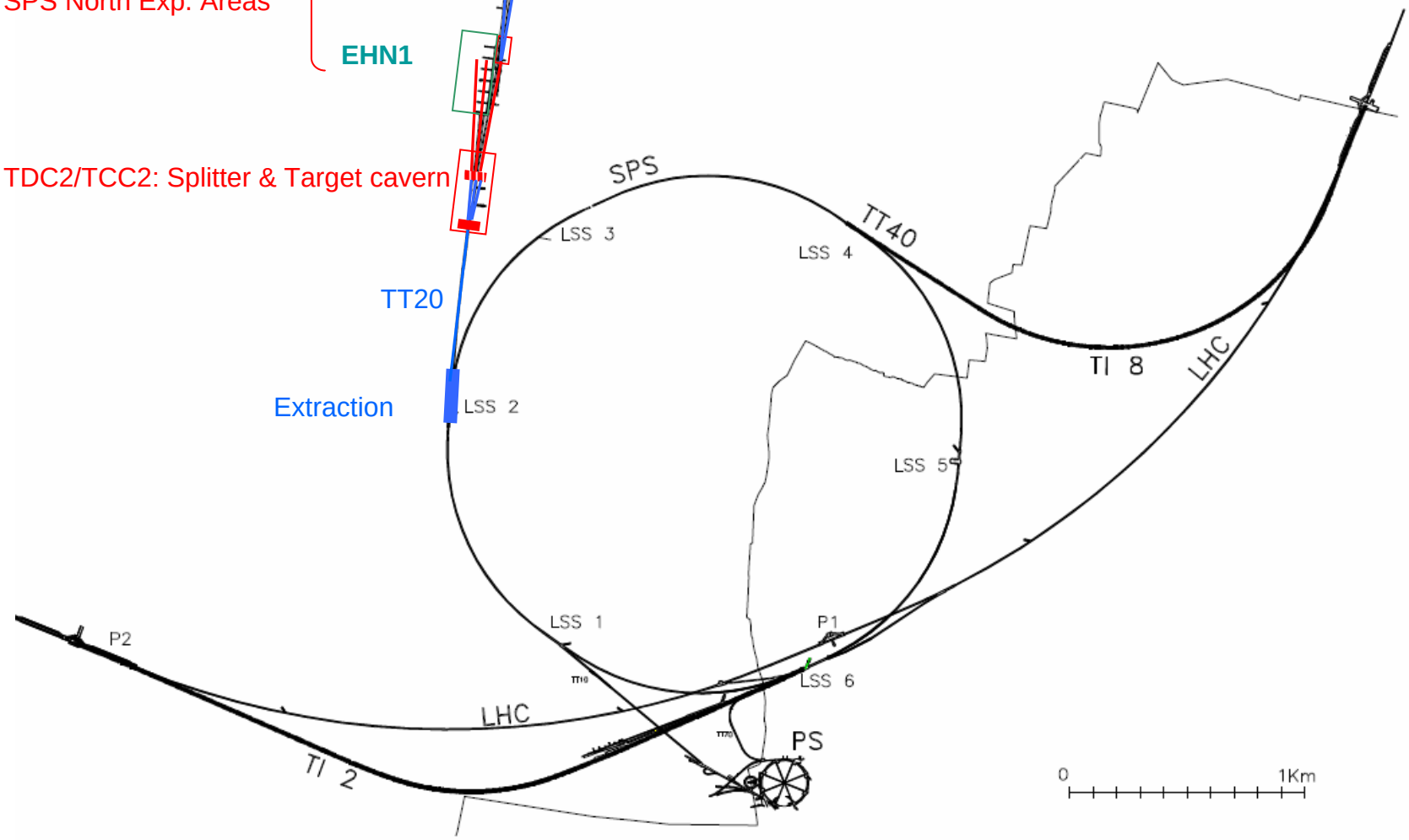
ECN3

EHN1

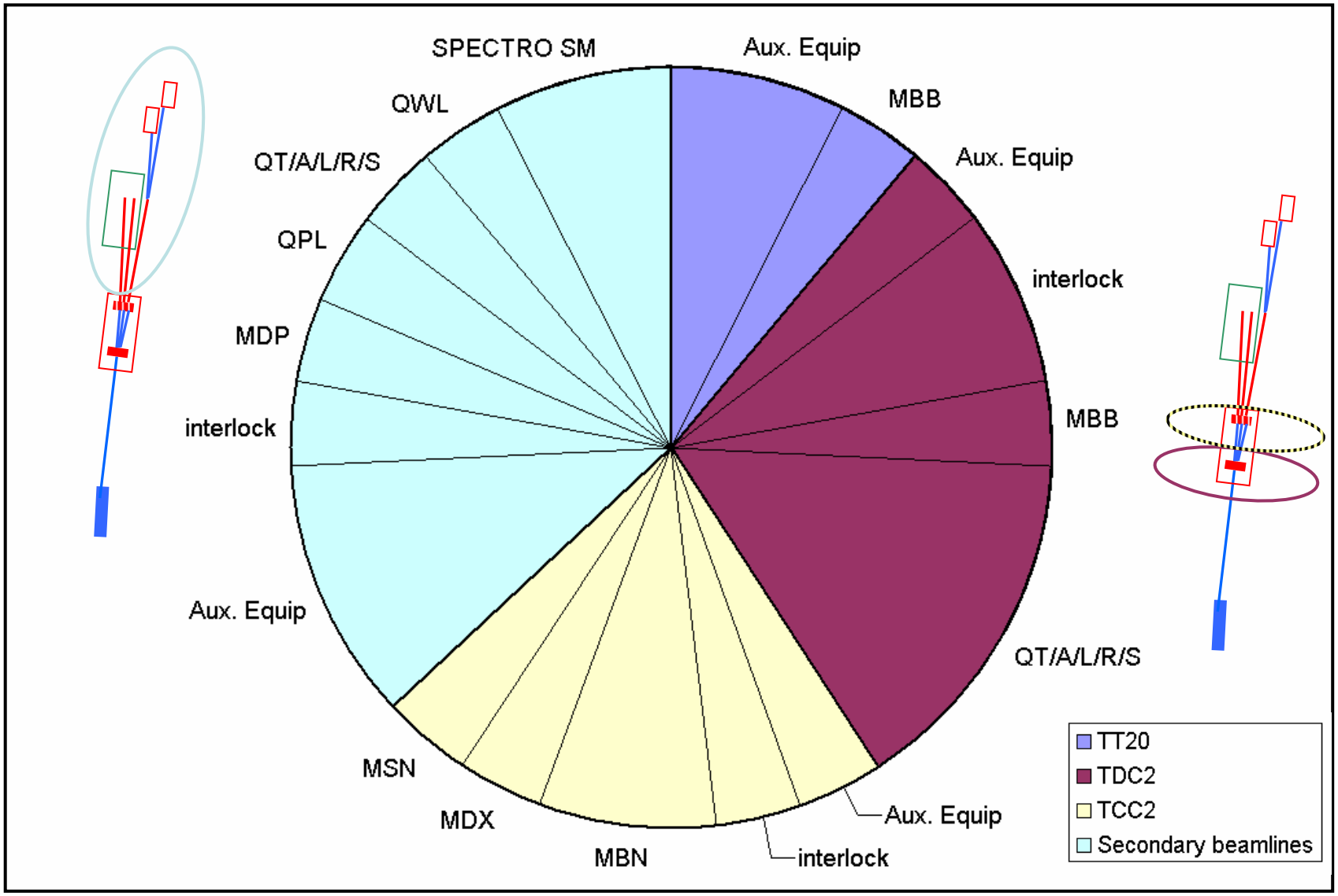
TDC2/TCC2: Splitter & Target cavern

TT20

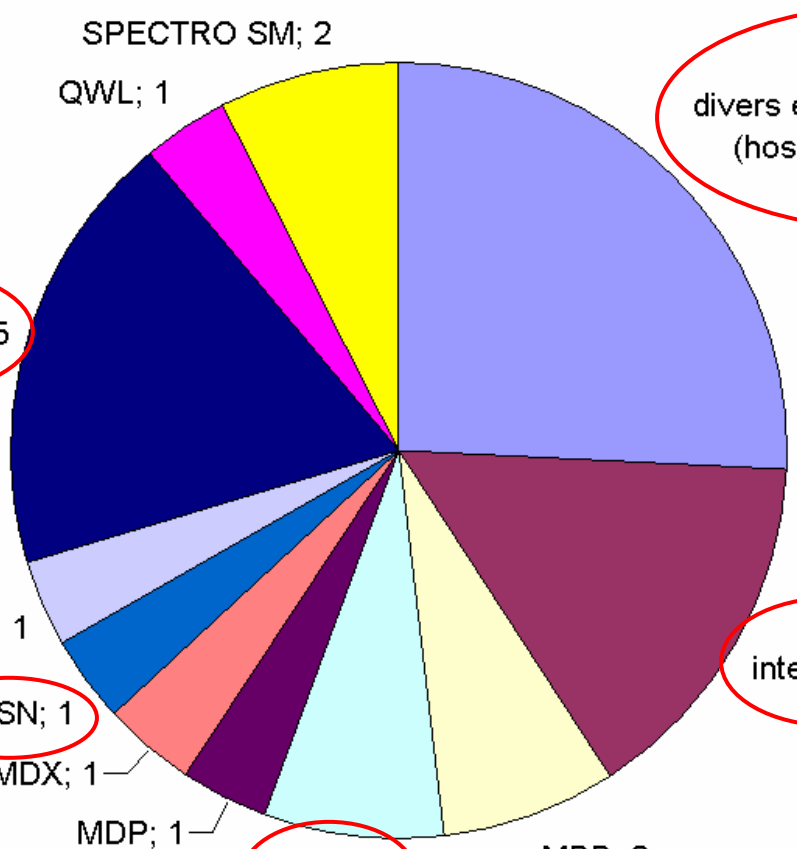
Extraction



Breakdowns per type & per area



Identity of failures



Mainly caused by weak coil manifold. Consolidation program ongoing

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

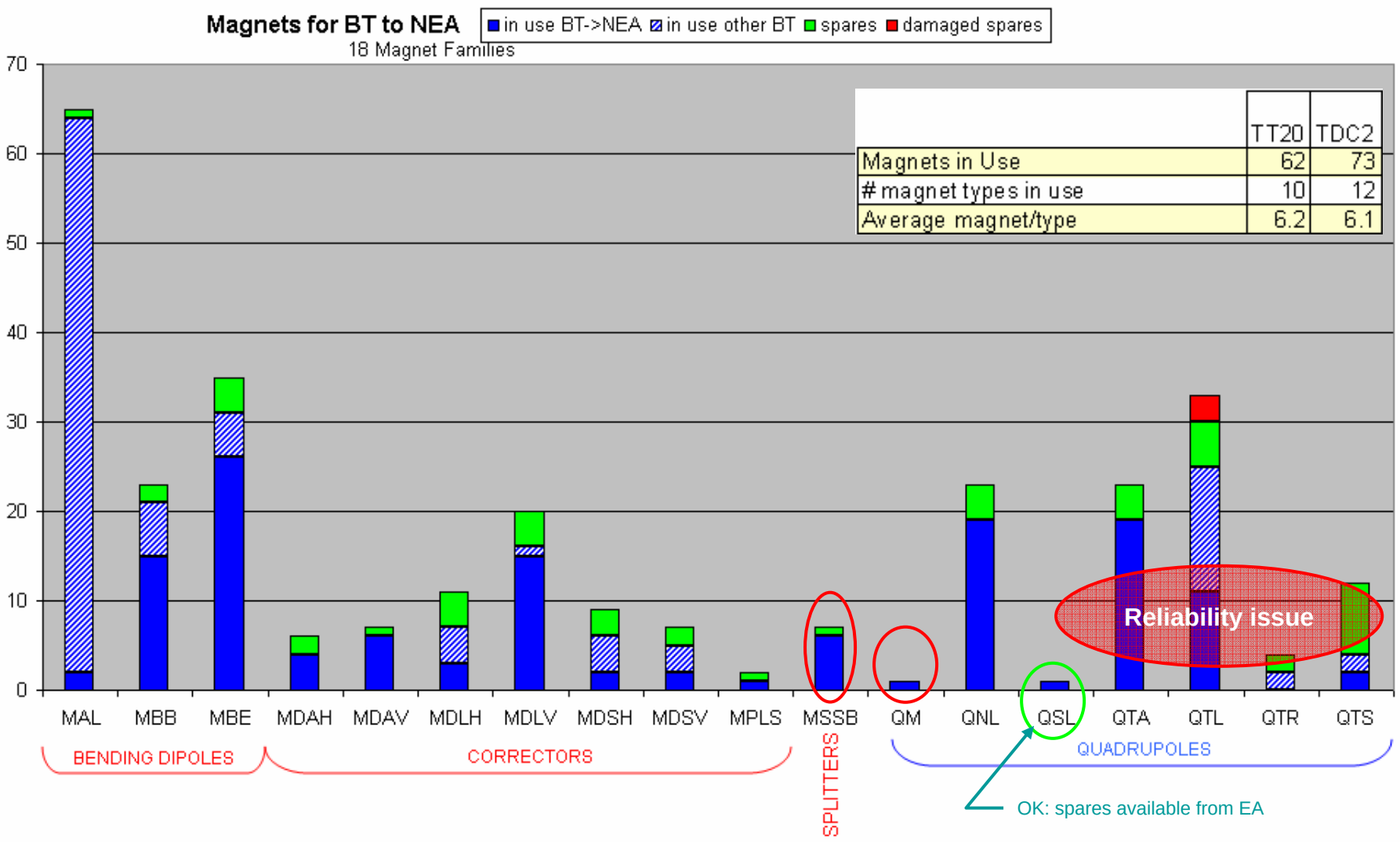
! No spare parts.
! Very Radioactive

Radiation damages on water manifolds. Requires a Consolidation program

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

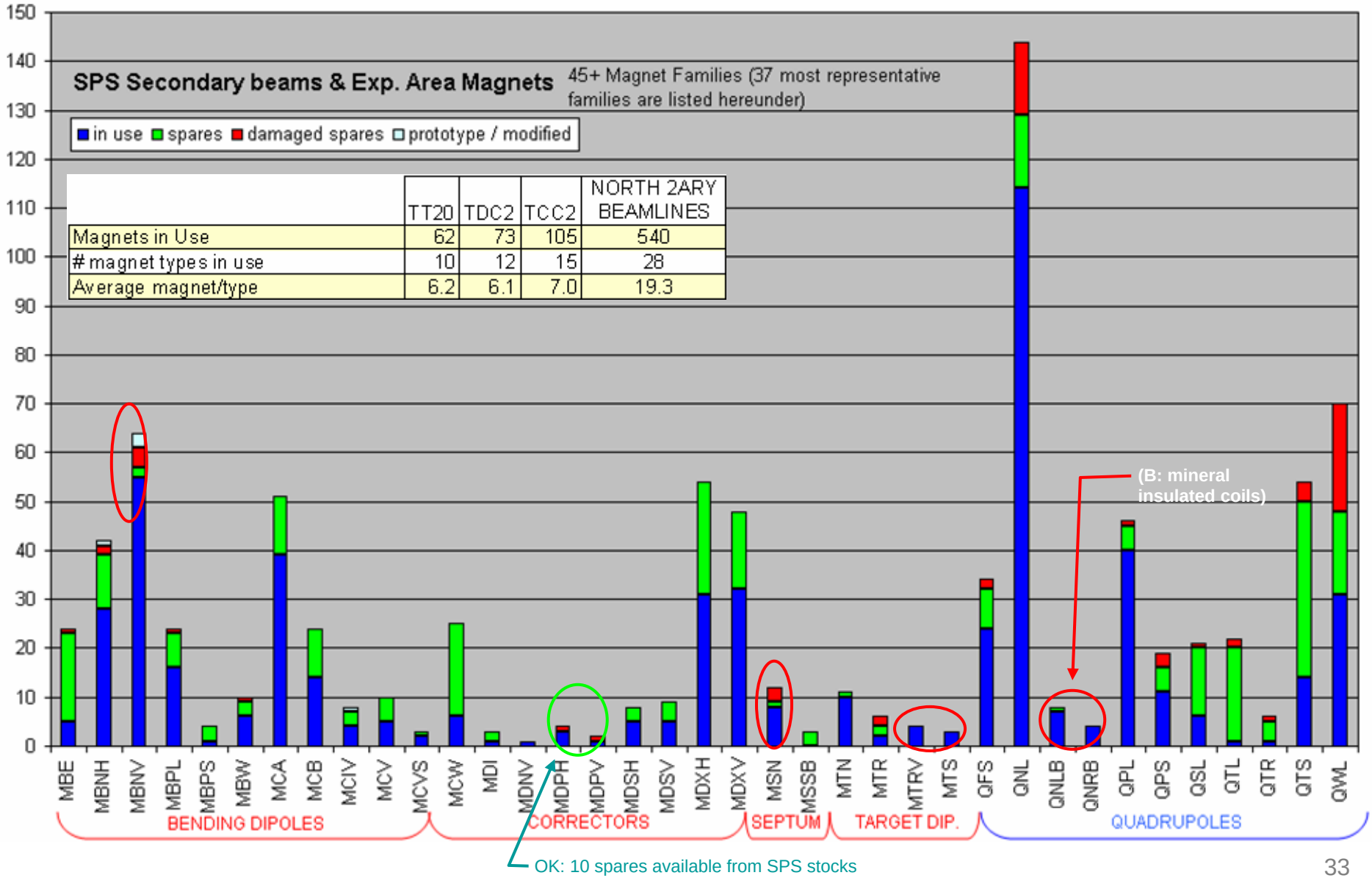
Mainly corrosion problems on the vacuum chamber.

Magnet Status for the primary Beam Transfer



Magnet status for the NEA & secondary Beams

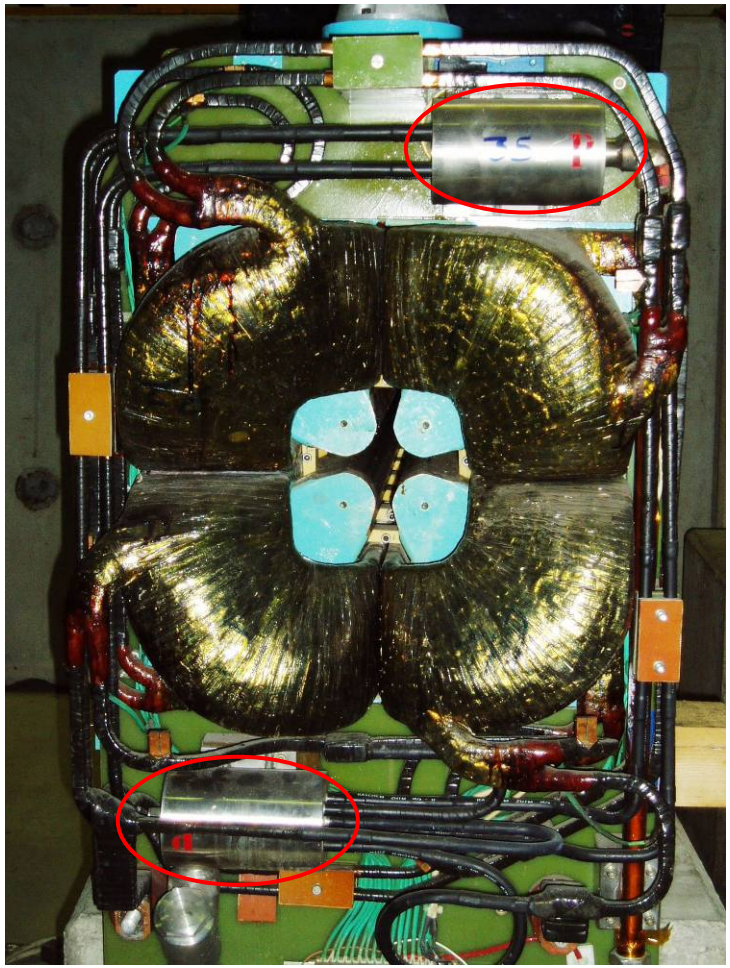
Accelerator Technology Department

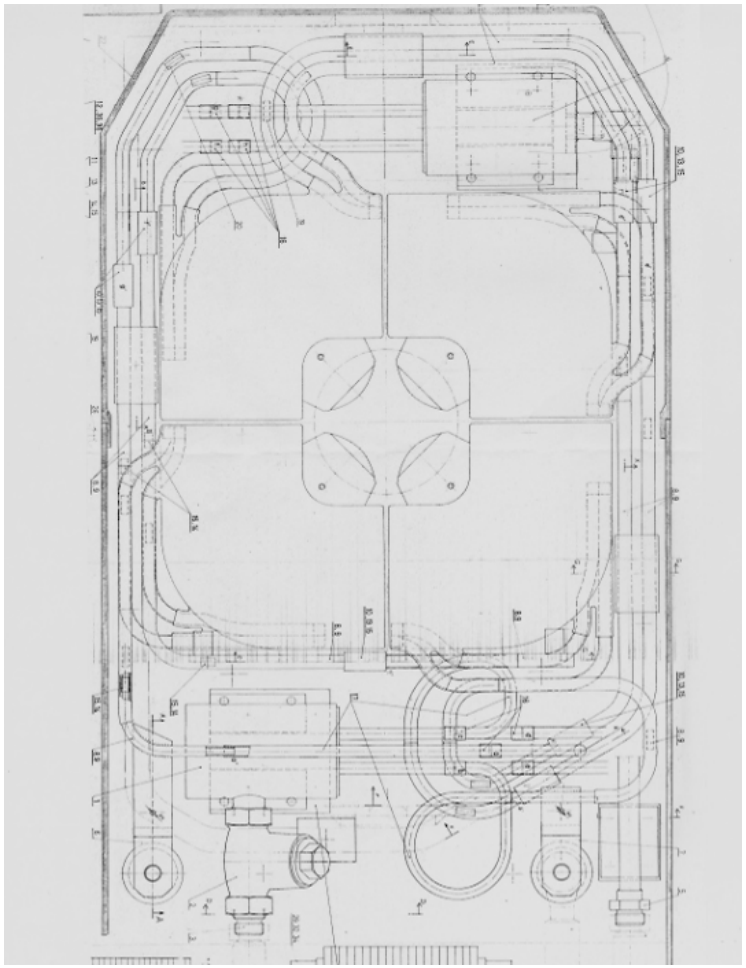


Potential Risks identified ('weak' magnets)

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

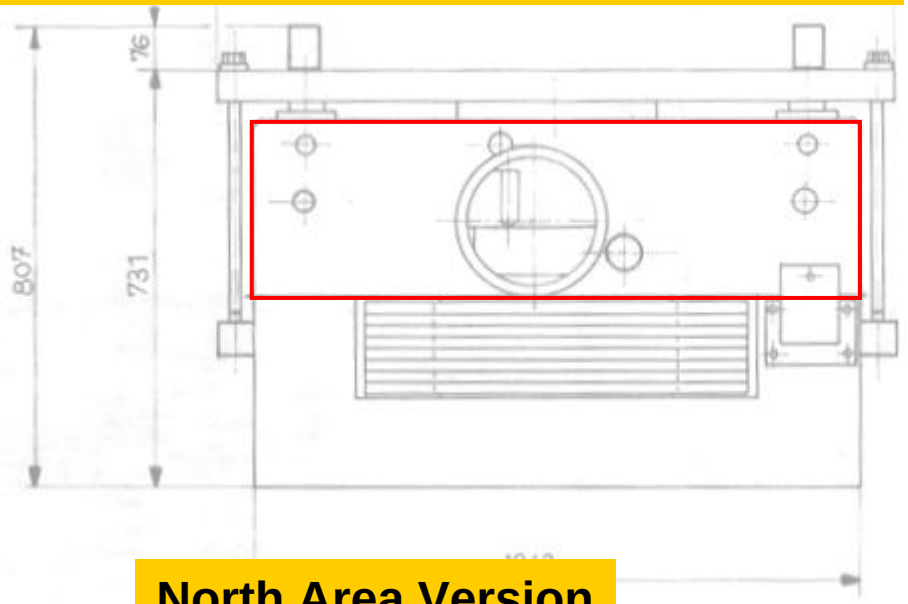
Importance issues	Main BT quadrupoles for primary beamline TT20/TDC2. Mainly QTA magnets in TDC2, few spare QTA
since 2006	Assembly Tool + workshop + spare coils to reconstruct QTA/QTL/QTR/QWL
2007	Small consolidation budget available. Manufacture of new parts for 25 magnets (targeting repairs of QTA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

TDC2 – Splitter MSSB Overview

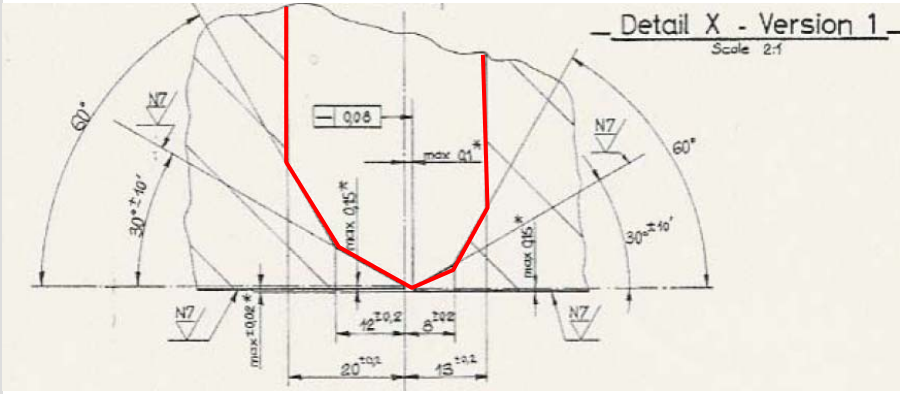
MSSB Splitters: Version 1 WEA Version 2 NEA

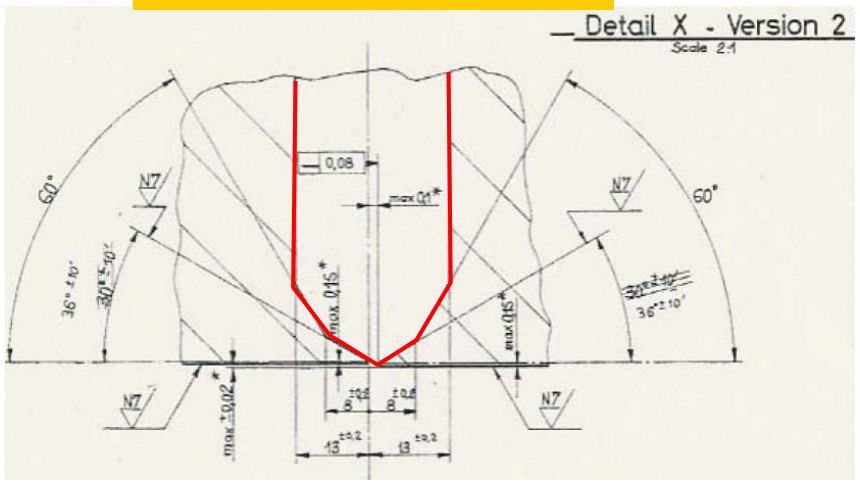
- **MSSB Splitter Magnet Situation**
  - **1 spare magnet for North Area**
  - **Corrosion problem on all 6 North Area MSSB magnets**
- **Risk of several failures in a row**
- **Availability of 3 West Area MSSB magnets (different septum profile)**
  - **Conversion WEA MSSB into NEA MSSB seems possible**

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

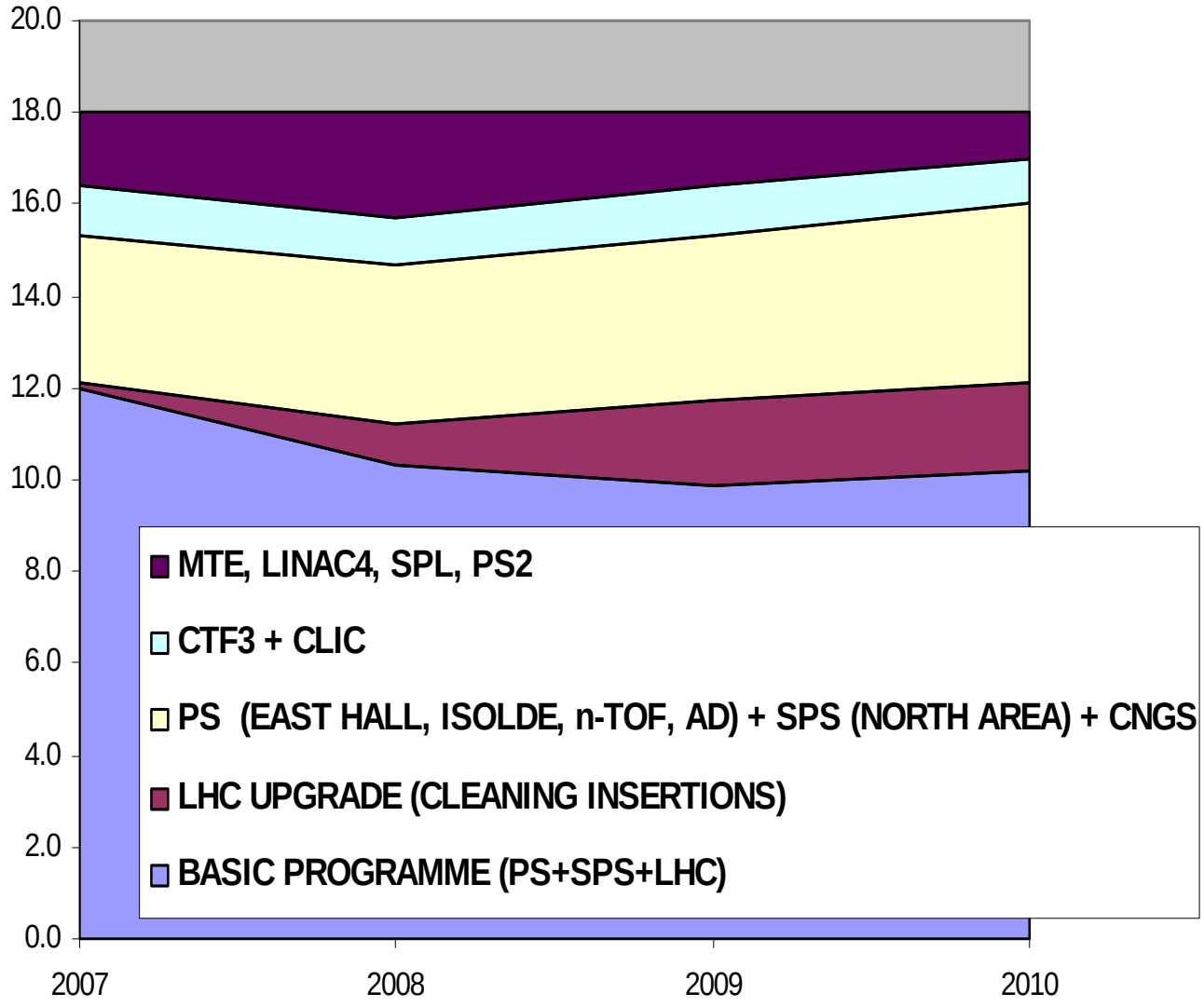


North Area Version



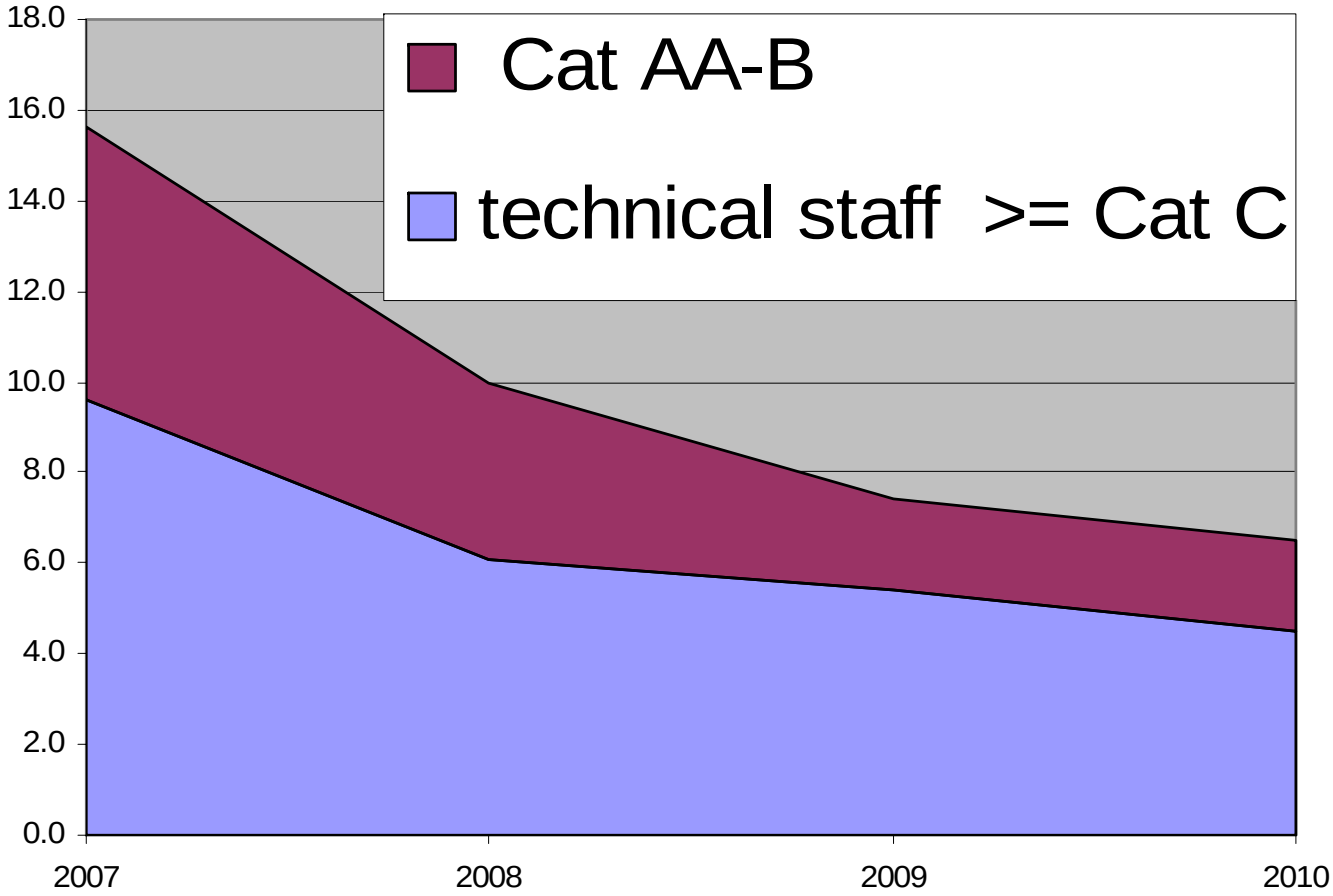


AT-MEL-MI TASK LIST



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

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

➔ Start of Annex 1 below.

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).

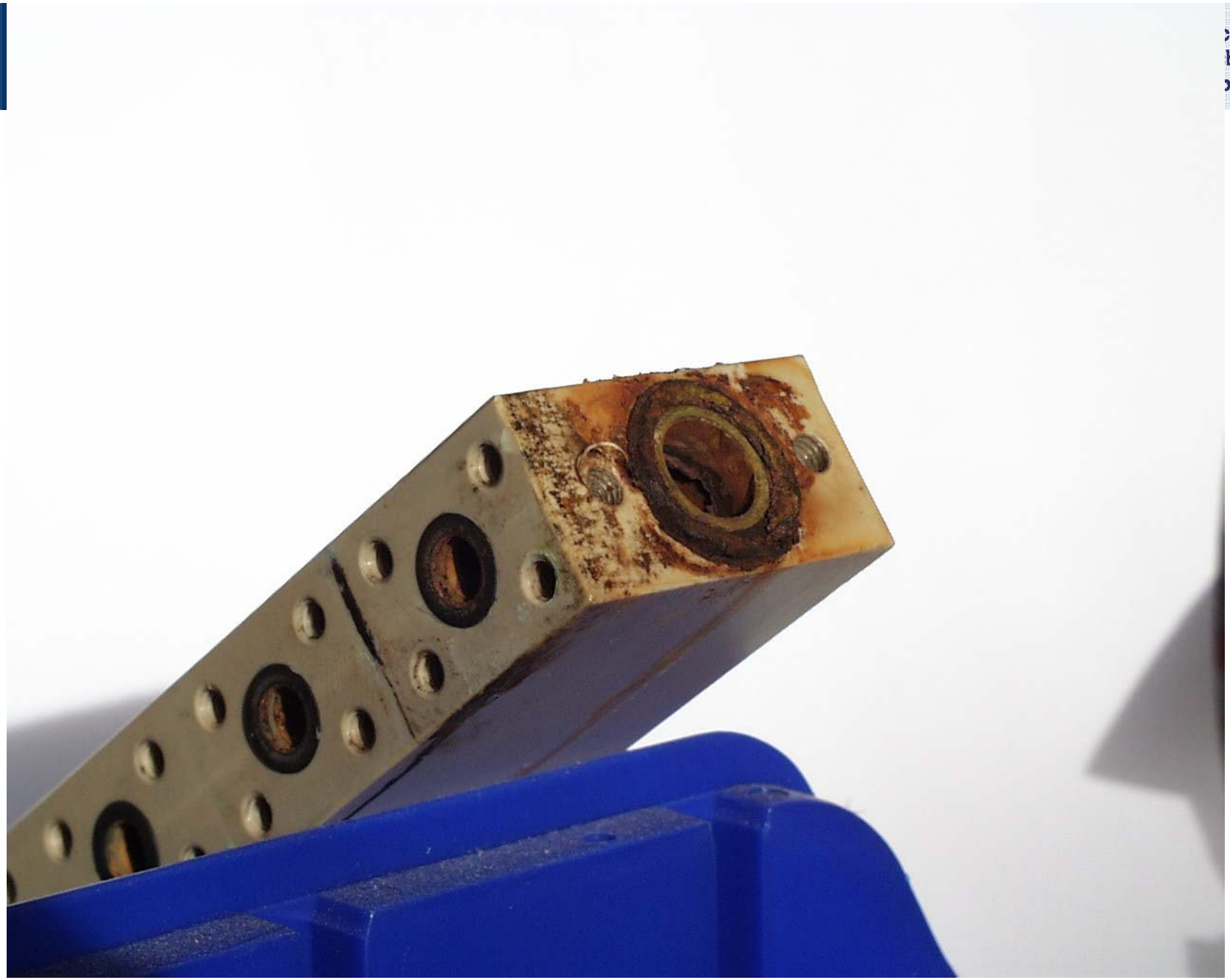
ANNEX 1 F61S.BHZ01.MNP23

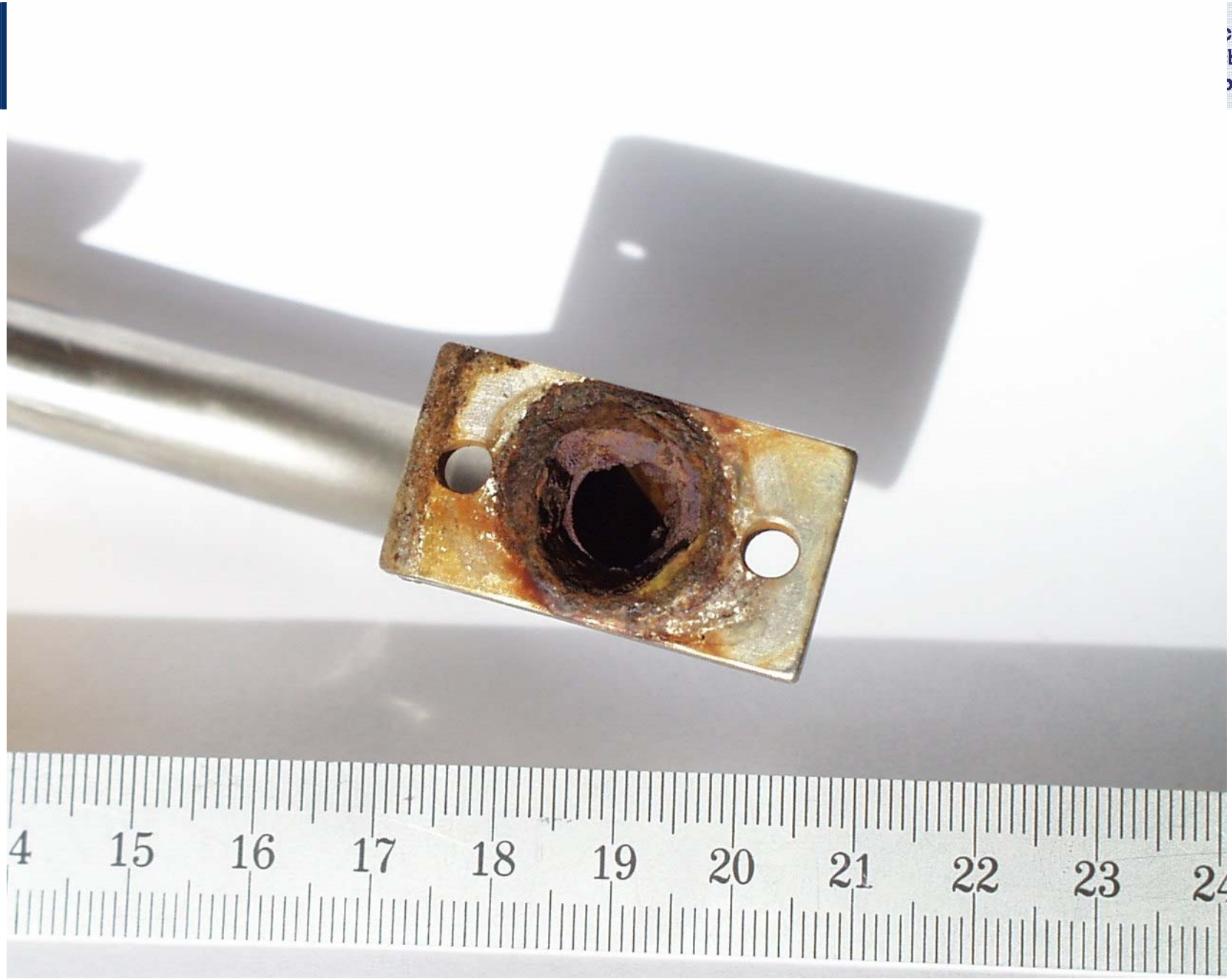
- July 2004: high leakage current + cooling channels blocked by a deposit stemming from corrosion. → required the replacement of the 2nd unit operating since March 2004.
- November 2004: same problems with the 3rd unit operating since September 2004.

ANNEX 1 F61S BHZ01-MNP23

ANNEX 1 F61S.BHZ01.MNP23

- 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).

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ANNEX 1 F61S.BHZ01.MNP23

- 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.

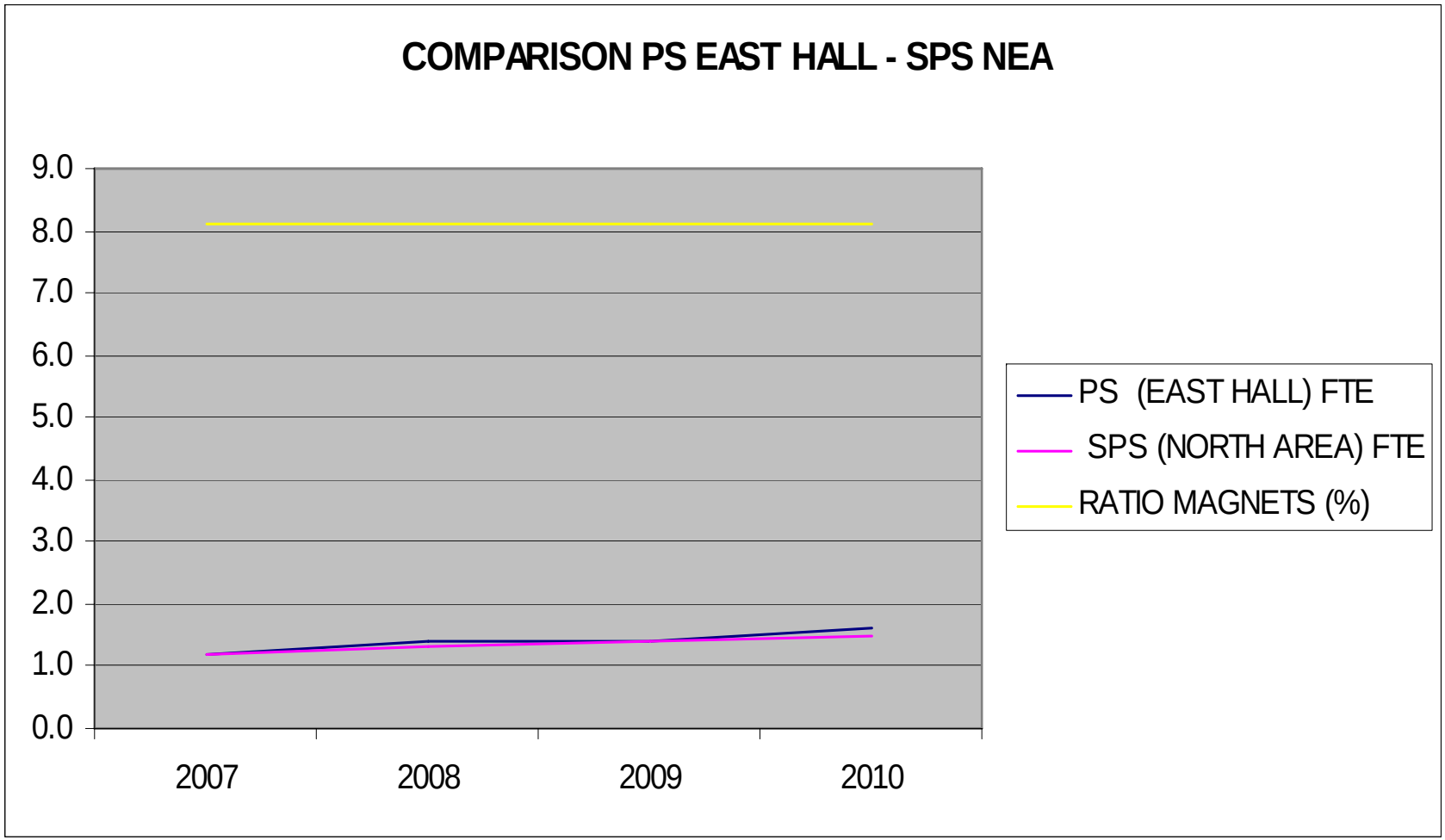
- As the origin of the breakdown was fully unclear, it had been decided to use the 4th coil set in order to launch a study including simulations and measurements under true operating conditions (except beam).
- A study started in November 2006 by M. Zerlauth AB-CO & J. Kozak AT-MTM, D.Bodart AT-MEL & 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.

➔ SPARE SLIDES BELOW

PS VERSUS SPS EA MAGNETS



Quest for an improved East Hall layout

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

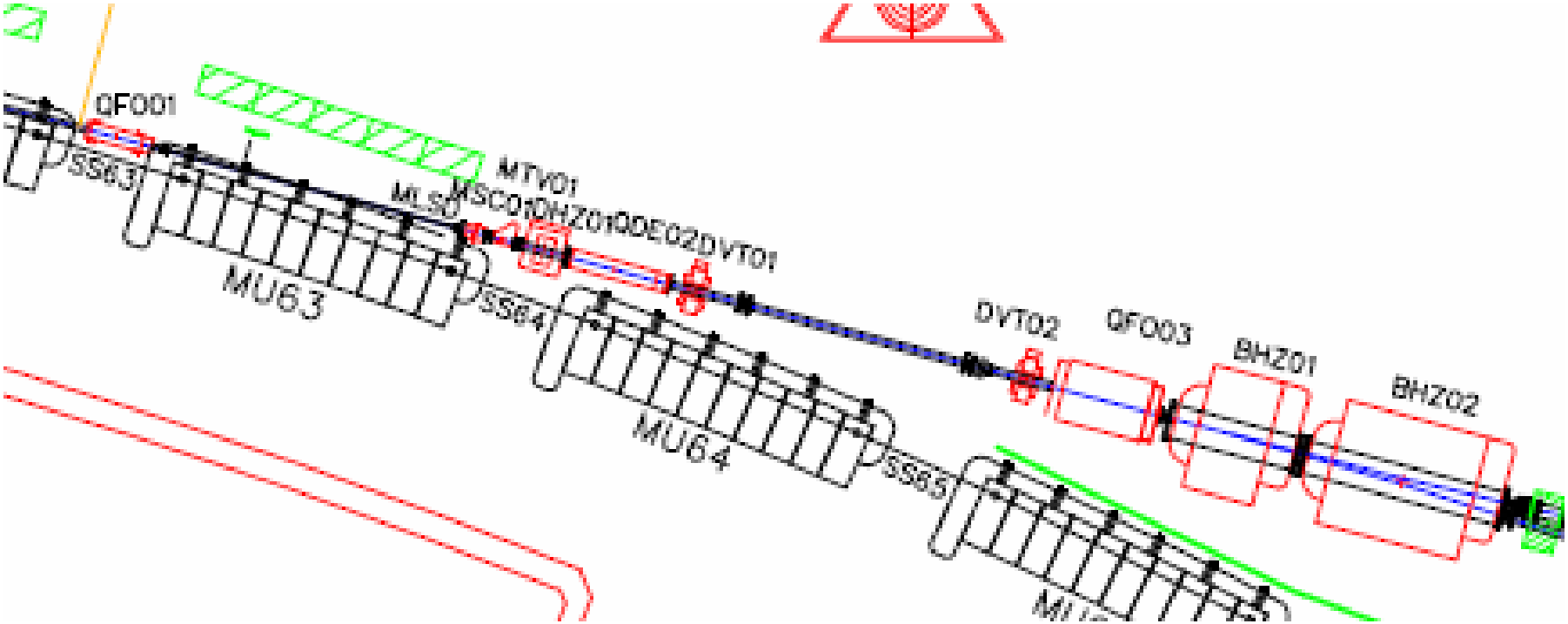
Many of the installed magnets are

- About 40 years old + 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

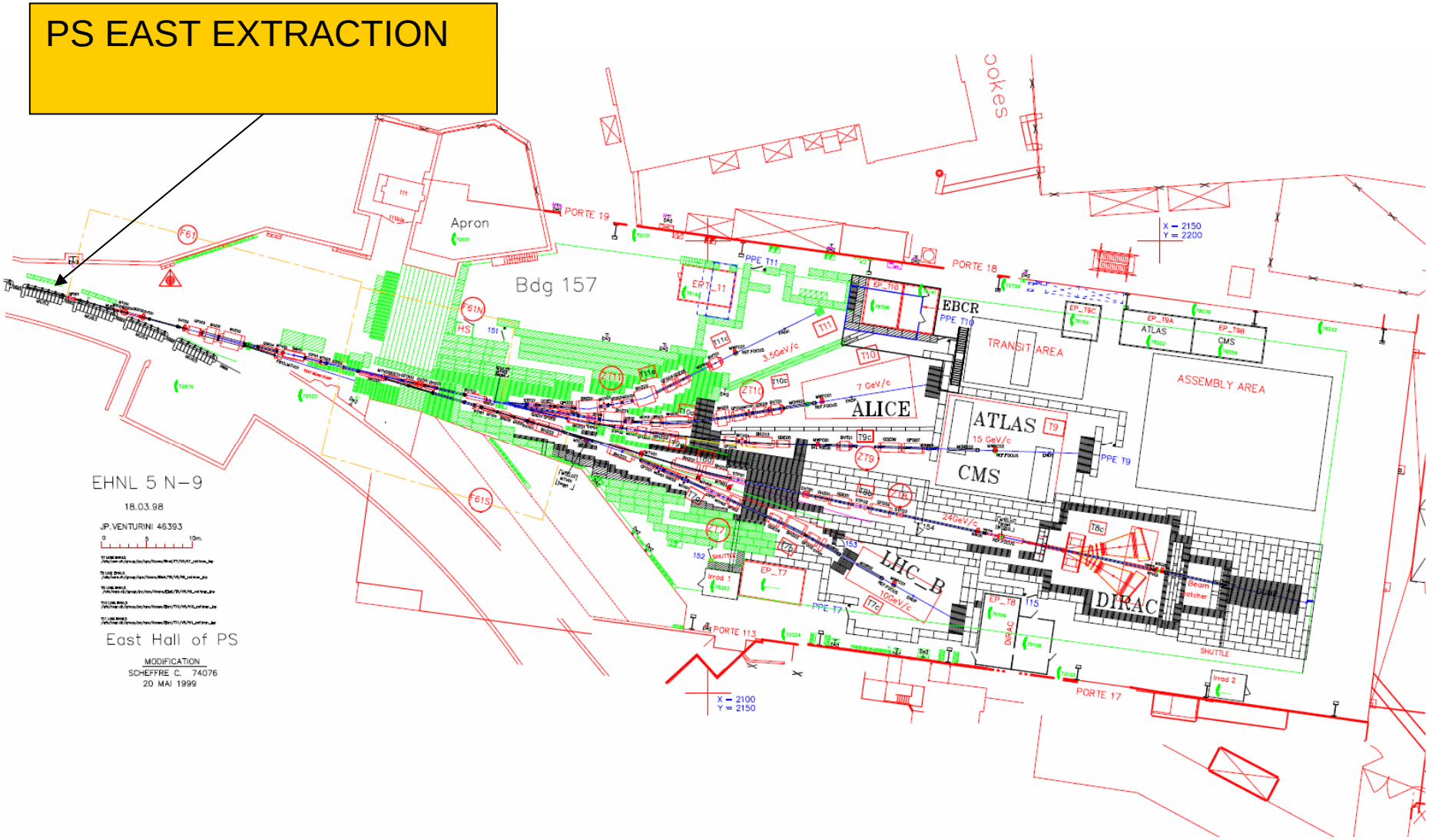
East hall F61 line 1st part
Access impossible during PS operation

Accelerator Technology Department

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



East hall layout



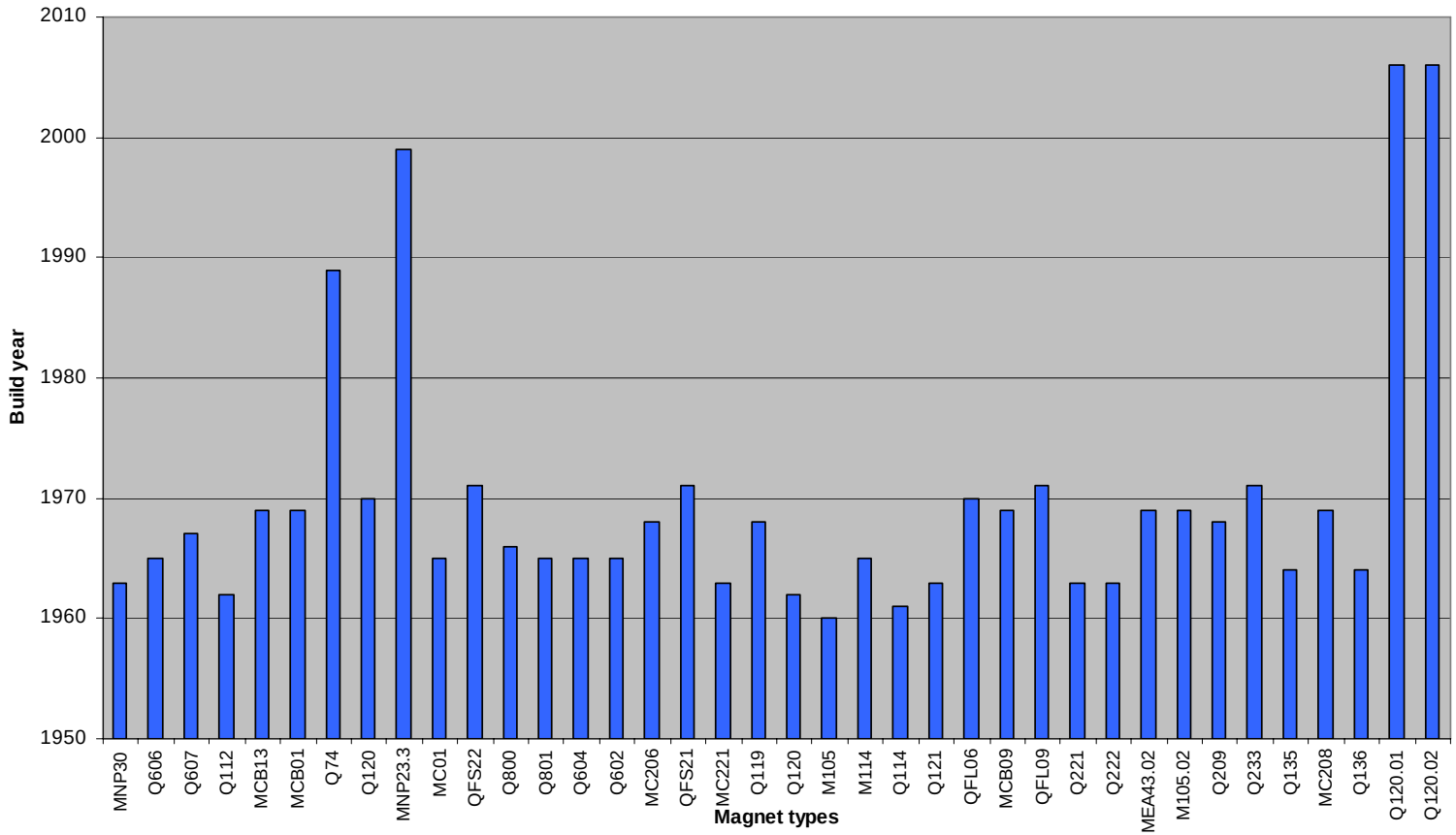
ANNEX2 ‘weak’ magnets MNPA 38

ANNEX 2 'weak' magnets MNPA 38

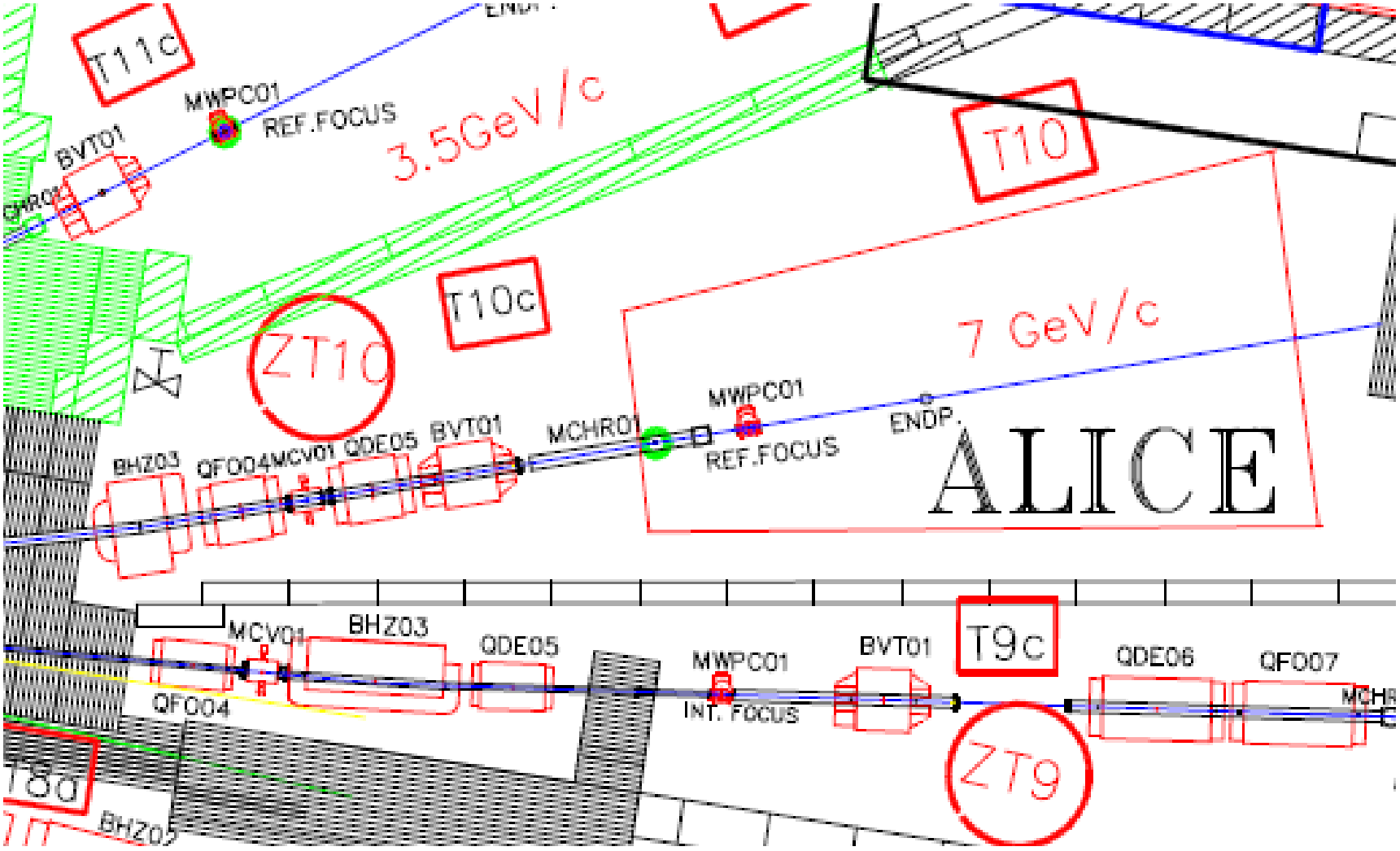
Accelerator Technology Department

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

East Hall magnets: start of service

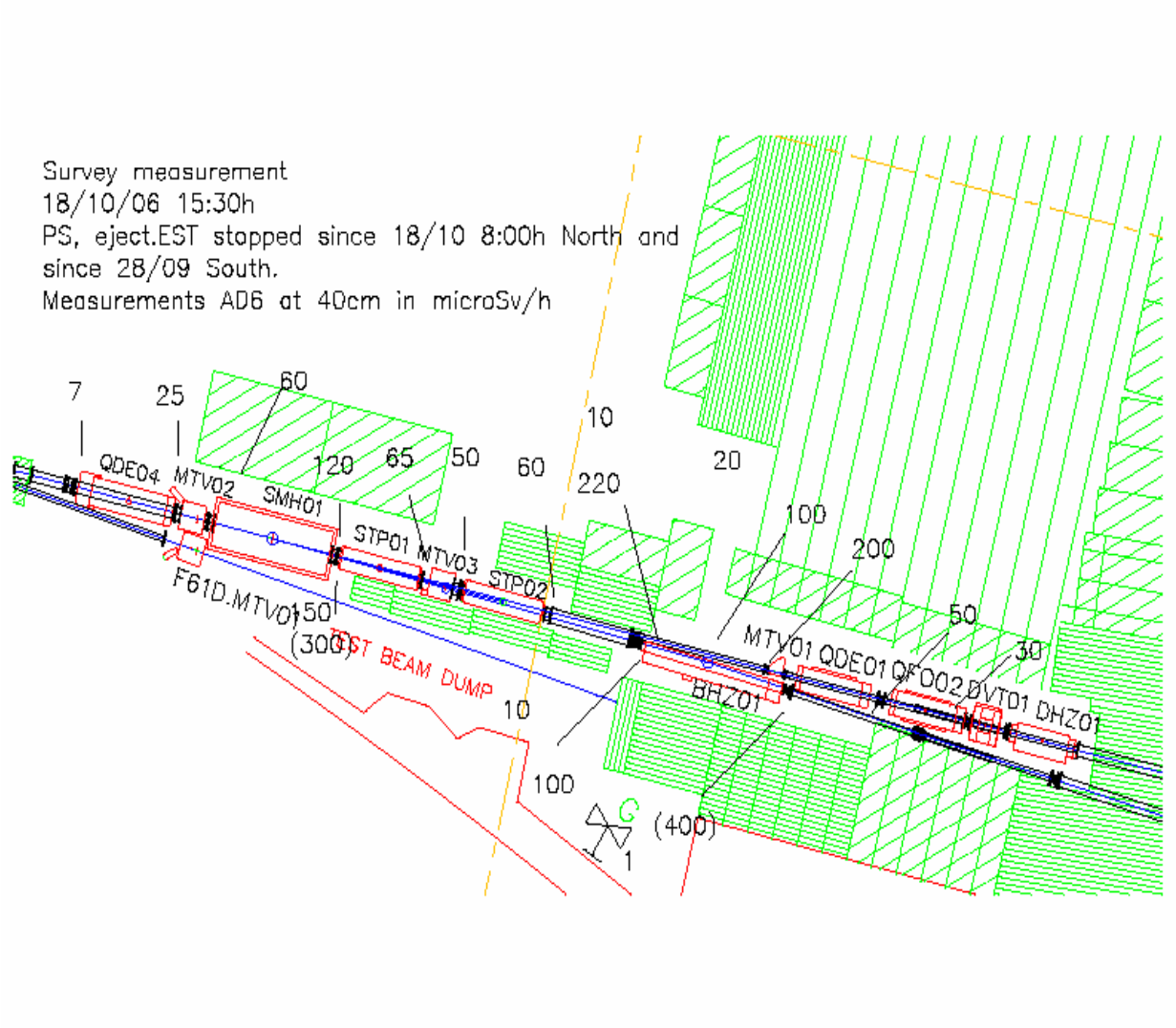


East hall T9 T10 T11 secondary zones

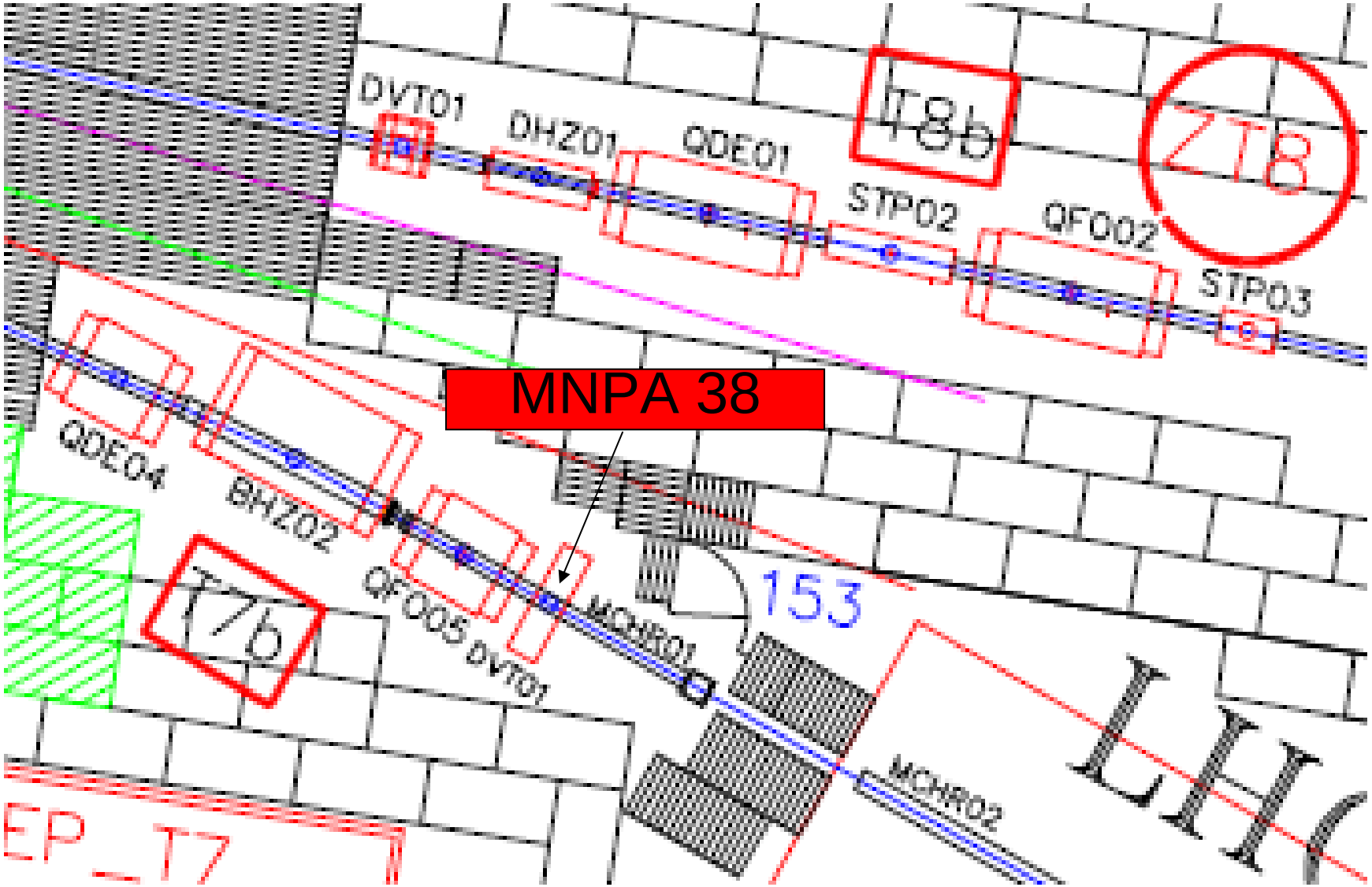


East hall T7 T8 secondary zone: access via experiment

Radiation survey 18/10/2006



East hall T7 T8 secondary zone: access via experiment

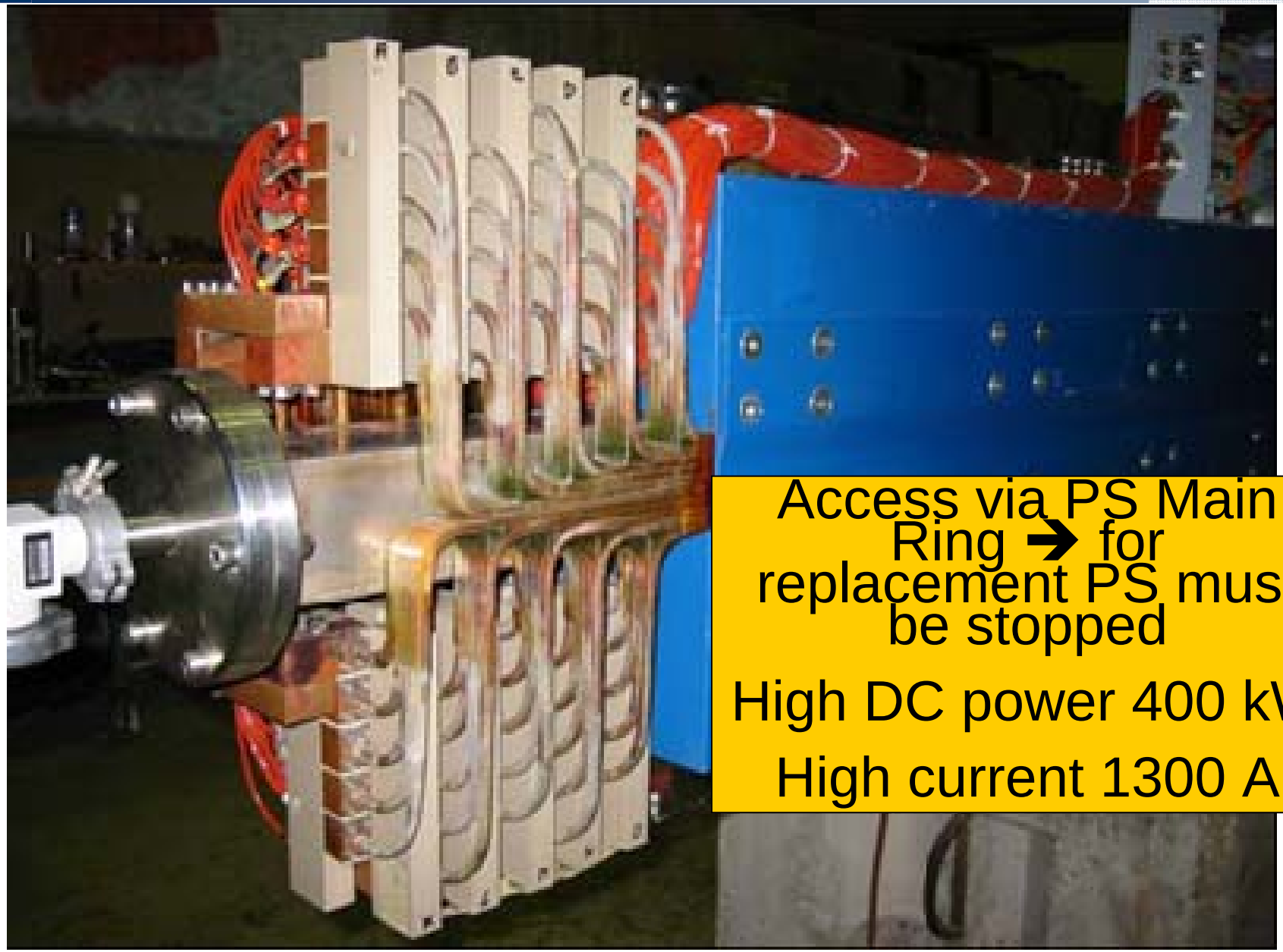


Proposal for an improved East Hall layout

➔ Beam line layout for F61 + F61S+N + line T10:

- Insufficient space for interventions
- In high dose level zones insufficient transversal space
  - ➔ one can only move along the lines and
  - ➔ thus it takes too long to escape rapidly from the radiation field.

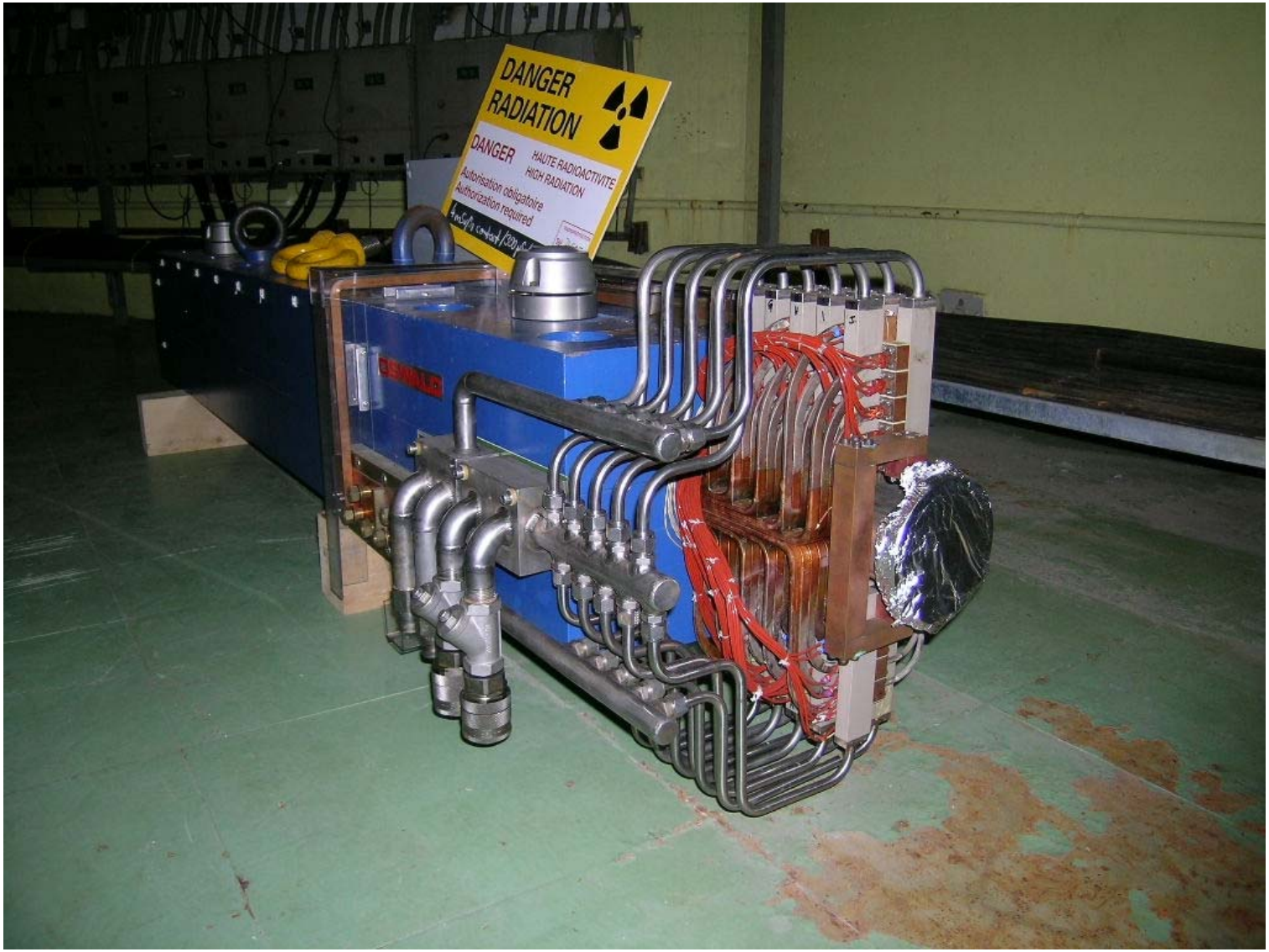
‘weak’ magnet F61S.BHZ01.MNP23-OSWALD



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

High DC power 400 kW

High current 1300 A


DANGER
RADIATION
DANGER
HAUTE RADIOACTIVITE
HIGH RADIATION
Autorisation obligatoire
Authorization required

ANNEX 3

➔ BELOW

ANNEX 3 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

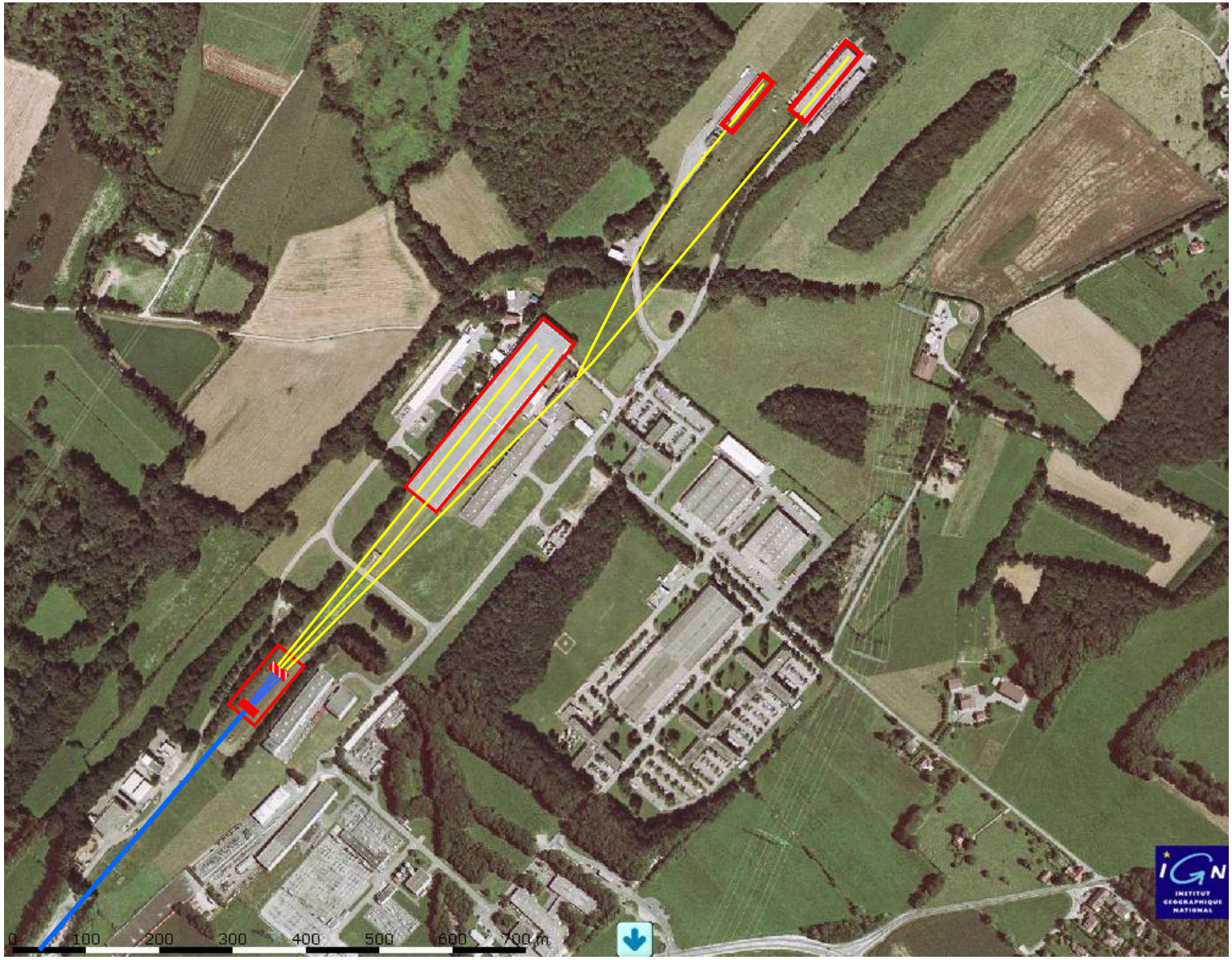
  This task is really urgent + shall be done by AB-ATB, as they have the documents + were the owners. AT-MEL has no manpower for this.

  Per type it will take at least 1 week.

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

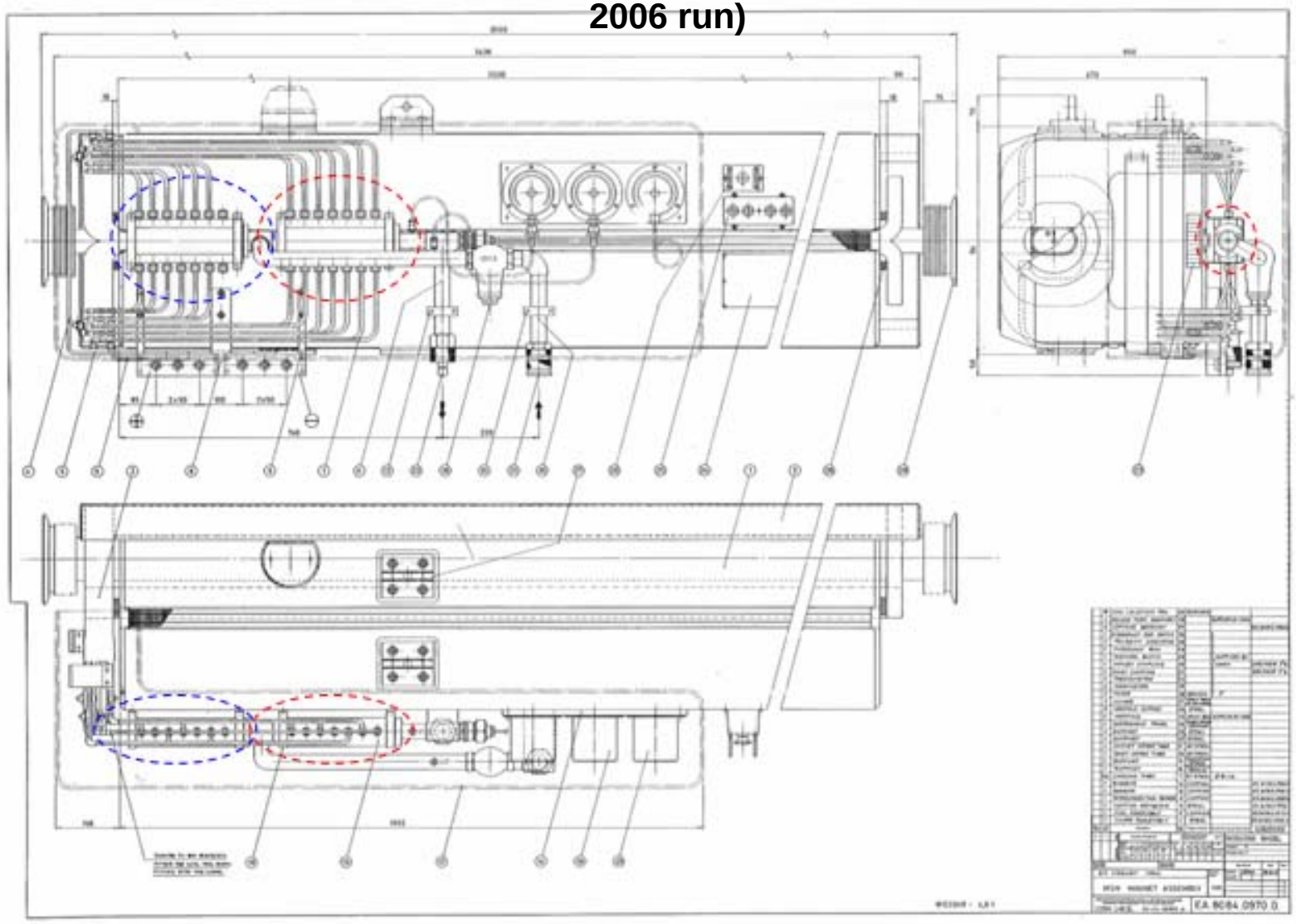
➔ SPARE SLIDES BELOW

North Experimental Area NEA



MSN Weak points: Manifolds & Coils

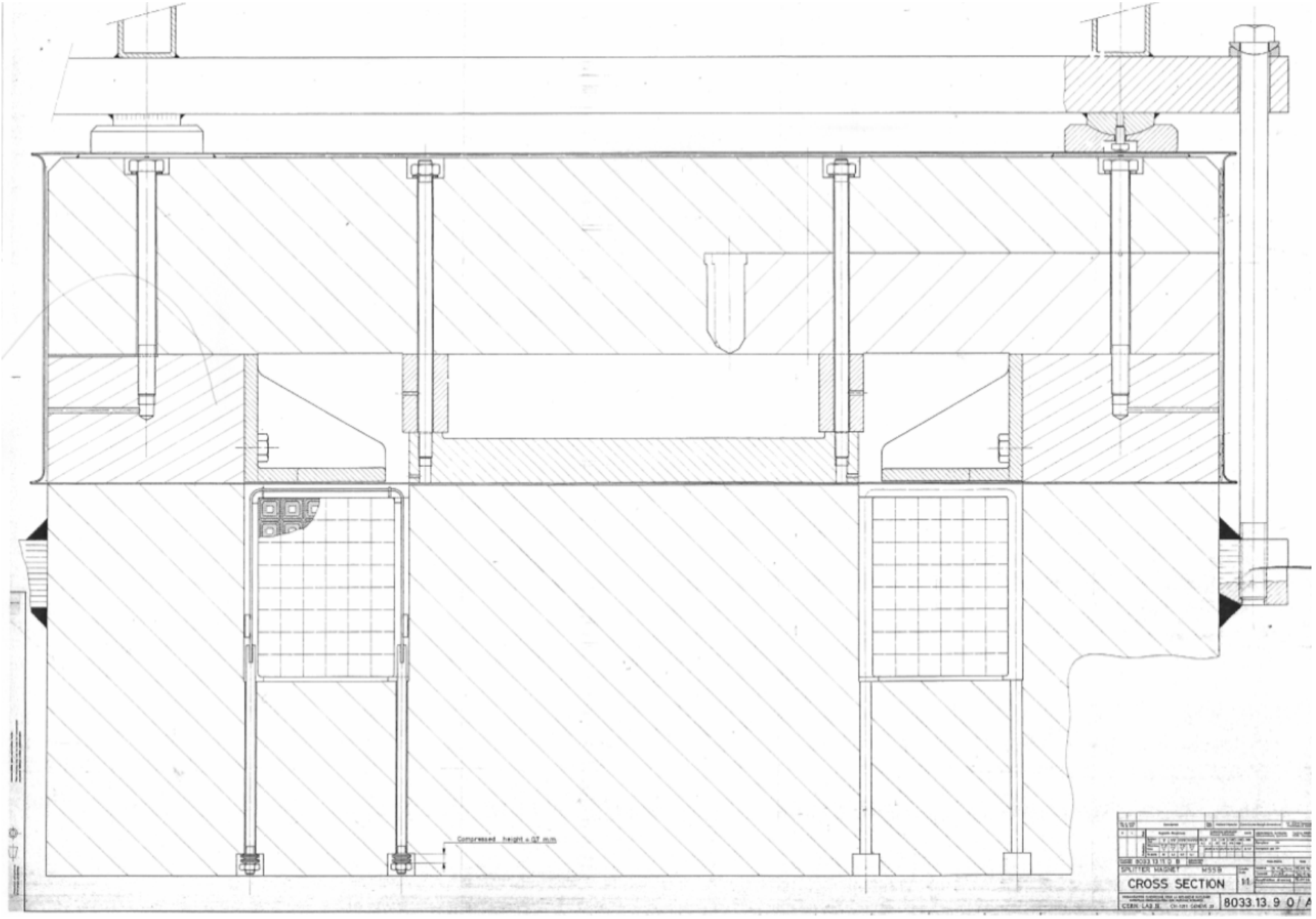
➔ **2 recent breakdowns on MSN manifolds (1 during 2005 shutdown, 1 during 2006 run)**



Weak Magnets: splitters MSSB

	Situation	RISKY	SUM
OPERATING	**NEA standard: MSSB Type 2: 6 magnets in use in TDC2** **WEA standard: MSSB Type 1: 0 in use**	**All MSSBs in TDC2**	**6**
SPARES	**NEA standard: MSSB Type 2: 1 spare new magnet** **WEA standard: MSSB Type 1: 4 spares (recuperated magnets)**	**None**	**5 spares** **(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**		

MSSB Splitter magnet: Cross Section



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

Conclusions: NEA

- 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: NEA

➔Remaining Issues:

- No spares for 1 QM + 3 MTS + 4 MTRV + 4QNRB (all these magnets are installed in hot places of TDC2/TCC2)
- Only one MSN spare unit (MSNs are installed in hot places of TDC2/TCC2)
- Few MBNV spare units
- Obsolete Magnet Interlock System