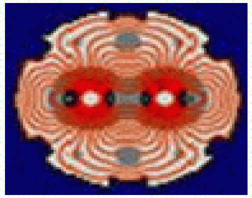
Report from Chamonix XIII

LHC Project Workshop
CHAMONIX XIII
19-23 January 2004

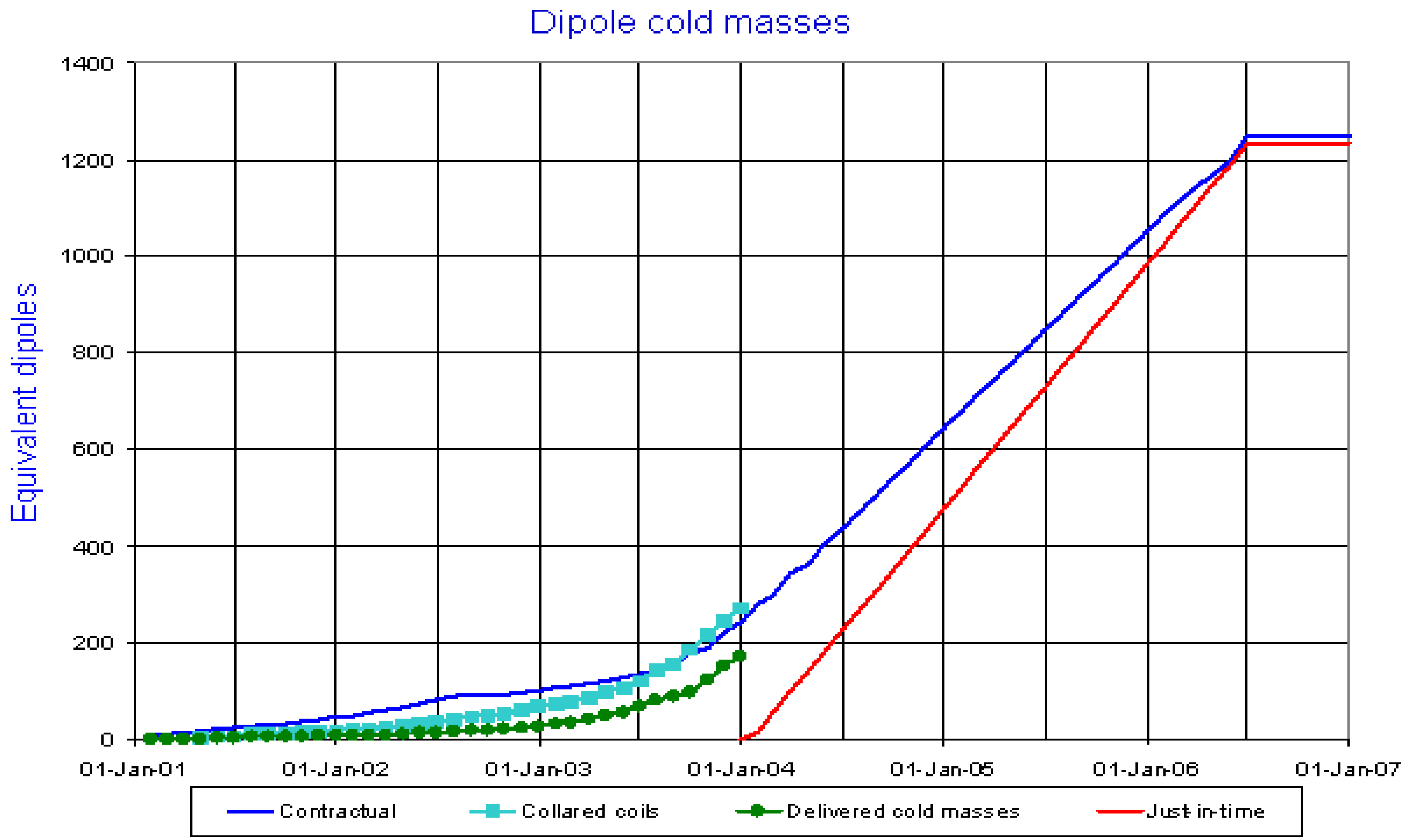


The workshop focused on the performance and operation of the LHC as well as the construction, installation and commissioning of the project :

Day	Morning Session	Afternoon Session
Monday 19 January	Outstanding Issues in the Injector Complex	LHC Beam Milestones 2003-2007
Tuesday 20 january	Beam Cleaning and Collimation	Magnets (i) Hardware, (ii) Performance (part I)
Wednesday 21 January	Magnets (i) Hardware, (ii) Performance (part II)	Installation, Commissioning, Cold Checkout
Thursday 22 January	Running-in the LHC (part I)	Running-in the LHC (part II)
Friday 23 January	LHC Operation from the CCC	Discussions and Decisions

LHC Progress Dashboard

Accelerator Technology Department



Updated 31 Dec 2003 Data provided by P. Lienard AT-MAS

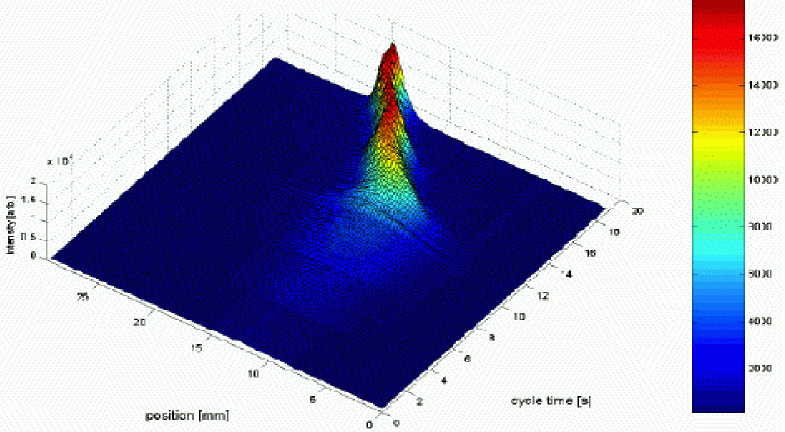
“LHC Beams in the SPS”

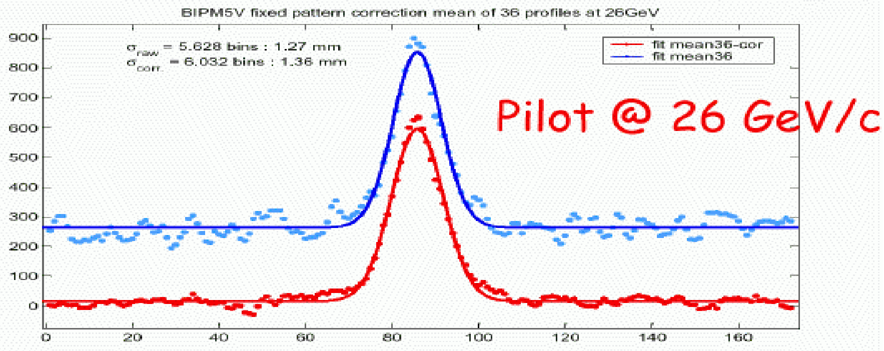
G. Arduini

New Ionization Profile Monitor - 2003

- During SD and summer 2003 important modifications of the HV part to fight against electron cloud (NEG coating of the electrodes) and beam induced EMI
- No more sparking or background problems
- First qualitative (quantitative being verified) V-beam profile evolution through the ramp.
- First V-profiles with Pilot bunch
- Preparing the New IPM - H

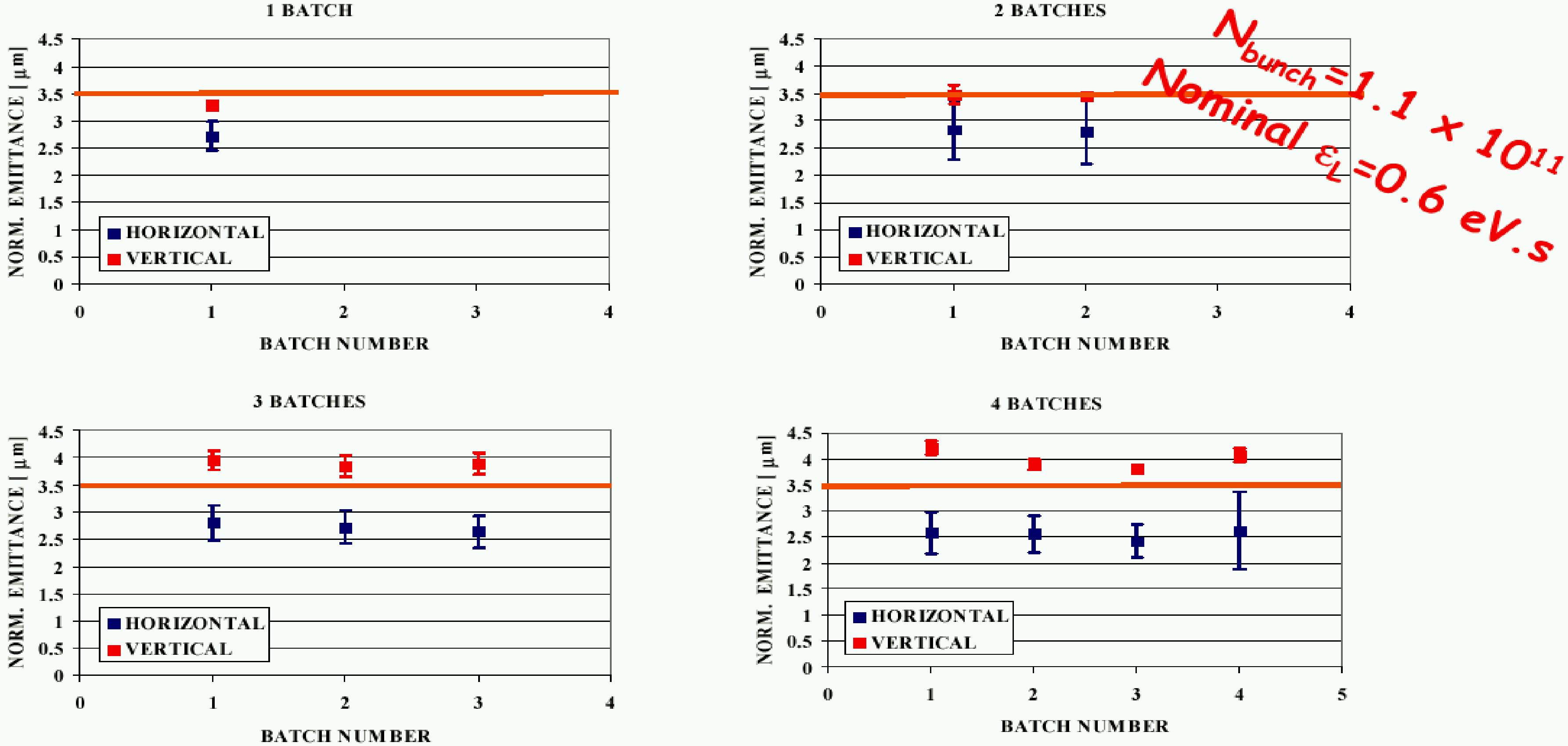
Nominal LHC beam





25 ns beam

Close to the goal



75 ns beam

Electron cloud

- Threshold vs. spacing (1 batch – 26 GeV)

Spacing [ns]	Threshold N_{bunch} $[10^{11}]$	#bunches/ batch
25	0.3	72
50	0.6	36
75	1.2	24

- Increase of the threshold intensity by a factor 4 (1 batch)
- Appearance of the electron cloud signal with more batches already at injection and then during the ramp

BROOKHAVEN NATIONAL LABORATORY

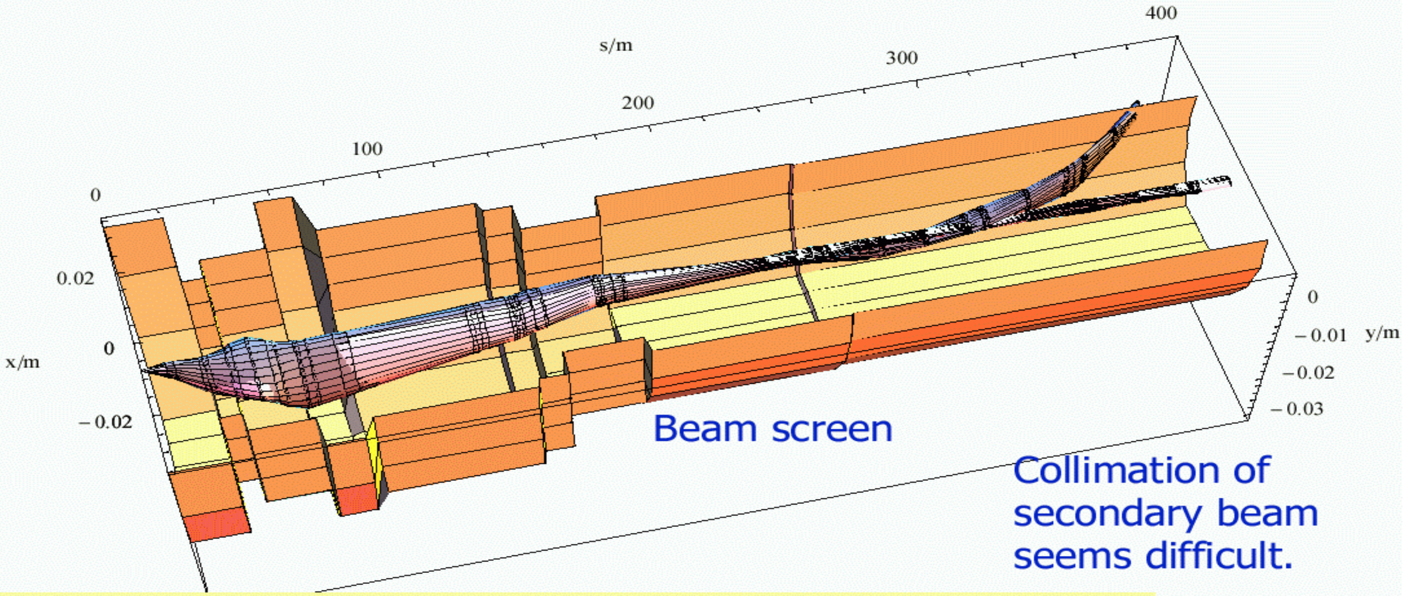
“Ions in the LHC”

J. Jowett

Electron capture by pair production (ECPP)	$^{208}Pb^{82+} + ^{208}Pb^{82+} \xrightarrow{\gamma} ^{208}Pb^{82+} + ^{208}Pb^{81+} + e^{+}$ Electron can be captured to a number of bound states, not only 1s.	Secondary beam out of IP, effectively off-momentum" $\delta_p = \frac{1}{Z-1} = 0.012 \quad \text{for Pb}$

Main and ECPP secondary beams

5σ beam envelopes, emerging to right of IP2



Collimation of secondary beam seems difficult.

Uncorrected strong chromatic effects of low-b insertion
⇒ cannot use linear beam sizes for Pb^{71+} beam

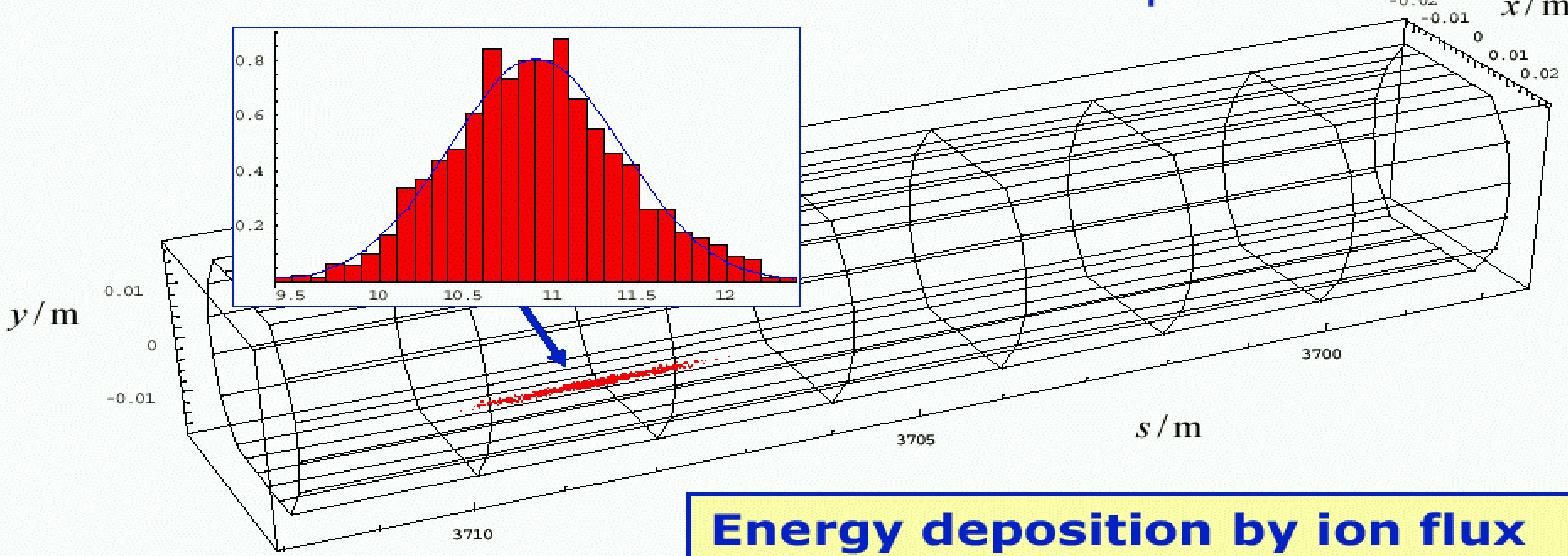
Secondary beam spot

Quench limit (conservative) is 8×10^4 Pb/m/s

Dilution over $l_d \approx 1$ m,

In quadrature with shower length 1 m $\approx$ 1.4 m

Beam screen in a dispersion suppressor dipole

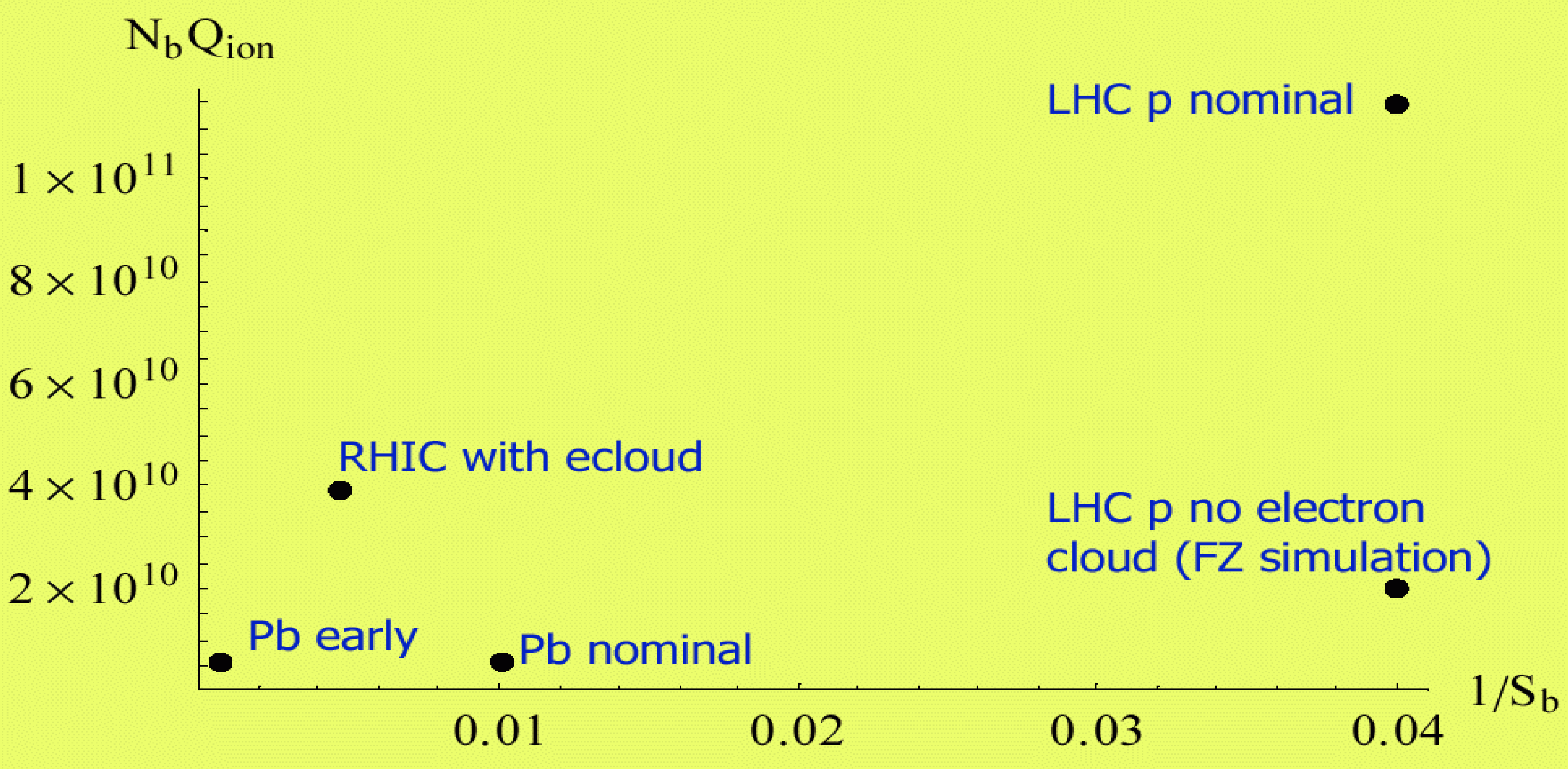


Energy deposition by ion flux from ECPP exceeds *nominal* quench limit of superconducting magnets by factor 2 at nominal luminosity.
DIRECT LIMIT ON LUMINOSITY.

Plan to improve heat deposition estimate with FLUKA calculations.

Electron Cloud effect with ions ?

- Key parameters are charge/bunch and bunch spacing
  - We do not expect electron cloud effects with Pb ions.



Luminosity and beam lifetime

- *Initial* beam (intensity) lifetime due to beam-beam interactions (non-exponential decay)

$$\tau_{NL} = \frac{k_b N_b}{n_{\exp} L \sigma_{\text{tot}}} = \frac{22.4 \text{ hour}}{n_{\exp}} \quad \text{for nominal } L = 10^{27} \text{ cm}^{-2}\text{s}^{-1} \text{with Pb - Pb}$$

  - where n_{exp} is the number of experiments illuminated
- But luminosity may be limited by experiment or quench limit

$$L = \frac{k_b N_b{}^2 f_0}{4\pi\sigma^{*2}} = \frac{k_b N_b{}^2 f_0}{4\pi\beta^* \varepsilon_n}\gamma$$

$$\Rightarrow \text{ can have same luminosity by varying } \beta^* \propto N_b{}^2$$

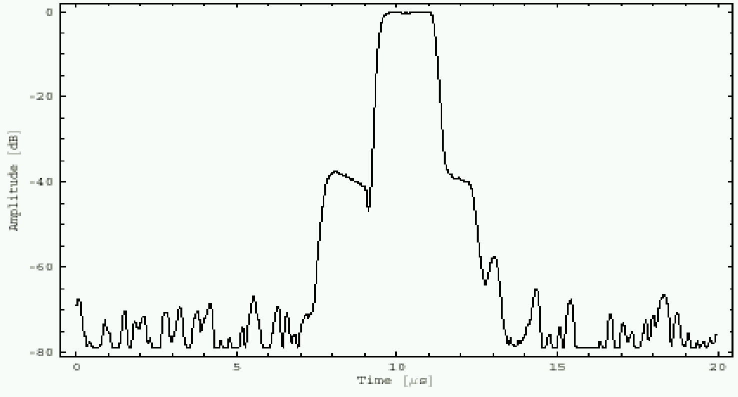
β*-tuning during collision to maximise integrated luminosity – especially if N_b can be increased.

“Impedance Effects in the SPS”

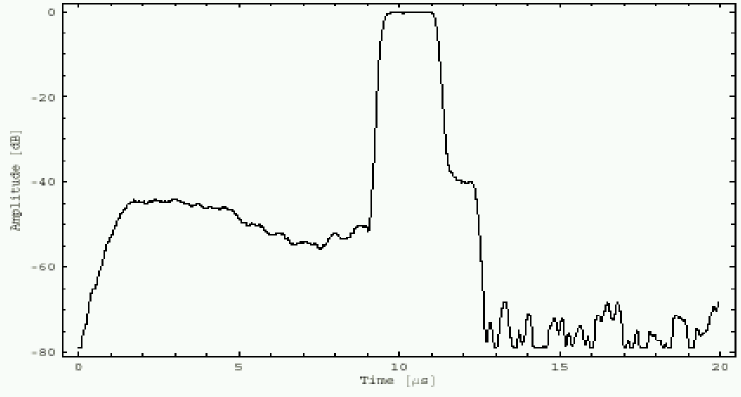
E. Shapashnikova

200 MHz beam component on the flat bottom

after injection



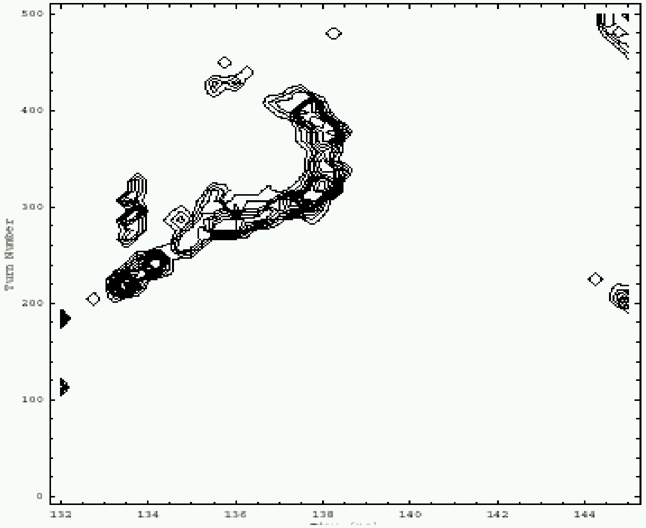
3 s later



→ Asymmetric character of losses in energy (negative energy deviation)

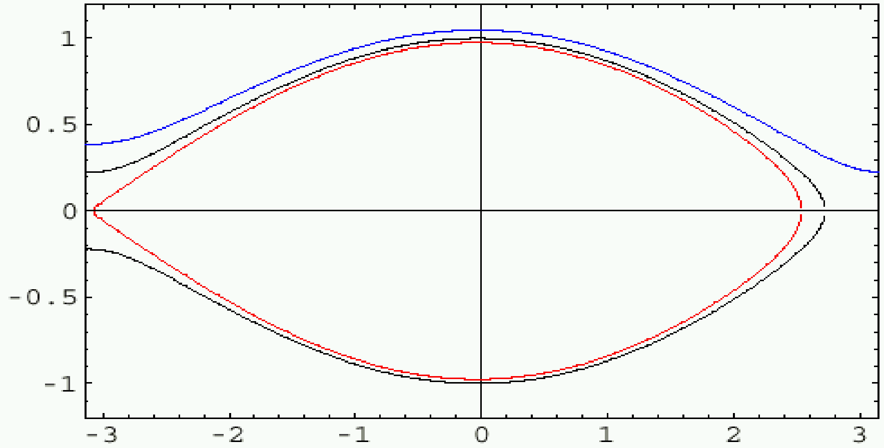
- Asymmetry could be reduced by small changes in B-field at injection (±2 Gauss) and f_{rf} (50 Hz) → more capture losses
- No significant difference was measured between the first turn trajectory and a closed orbit established after capture (*G. Arduini, J. Wenninger*)
- Asymmetric losses were also observed after sharp reduction of voltage on the flat bottom

Density plot



t (ns)

Motion in phase space ($\phi_s = 1.8$ deg)



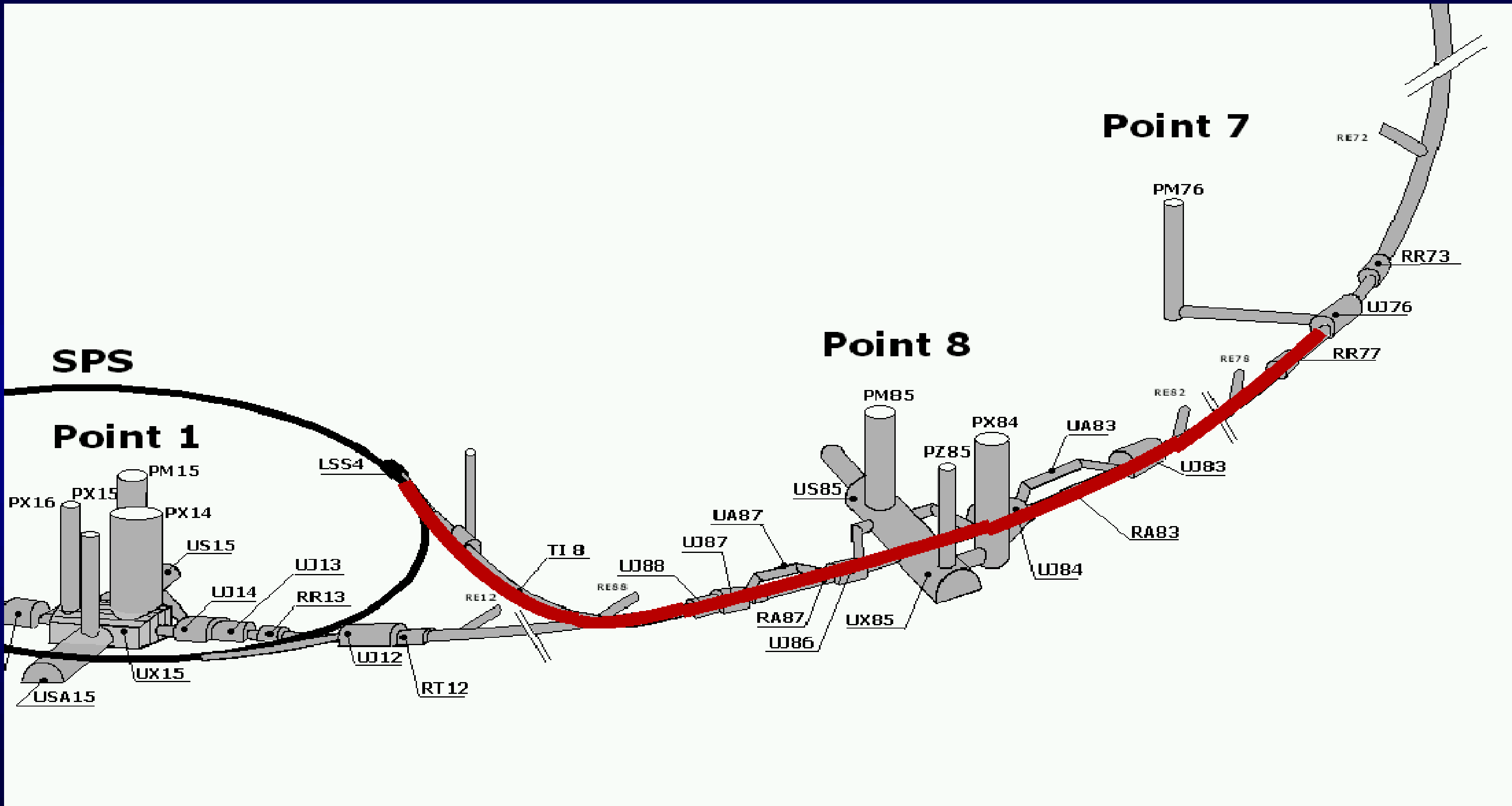
ϕ (rad)

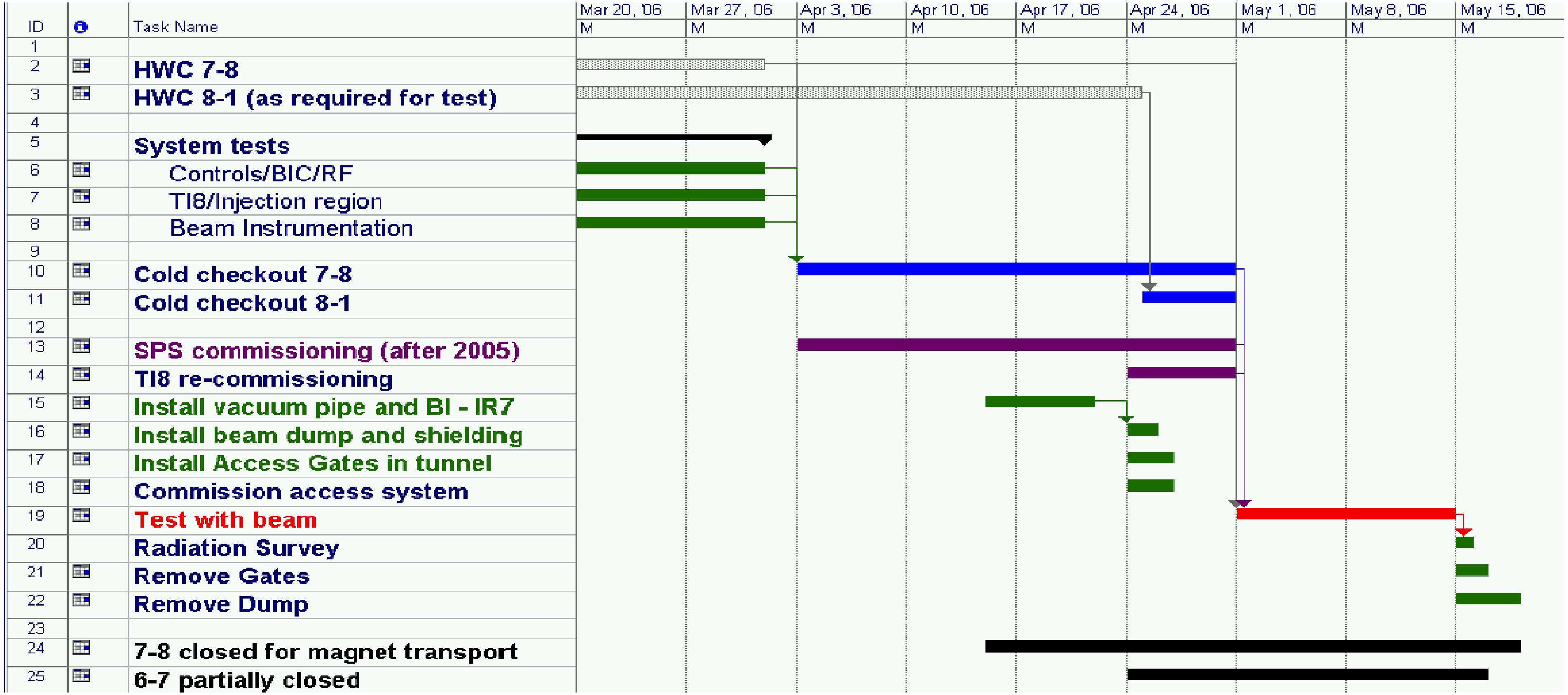
- Asymmetric losses are due to particle energy loss $U \to$ accelerating bucket with synchronous phase $\phi_s \simeq U/(eV)$ on the flat bottom.
- The azimuthal size of the gap between buckets $\delta\phi \simeq 2\sqrt{\pi \sin \phi_s}$.
- For 0.5 ns gap one needs $\phi_s = 1.8$ deg at 200 MHz and $U/(eV) \sim 0.03 \to$ $U = 60$ keV for $V = 2$ MV.

“LHC Injection Test 2006”

M. Lamont

LHC sector test 2006




ID
Task Name
Mar 20, '06
Mar 27, '06
Apr 3, '06
Apr 10, '06
Apr 17, '06
Apr 24, '06
May 1, '06
May 8, '06
May 15, '06
M
1
2 HWC 7-8
3 HWC 8-1 (as required for test)
4
5 System tests
6 Controls/BIC/RF
7 TI8/Injection region
8 Beam Instrumentation
9
10 Cold checkout 7-8
11 Cold checkout 8-1
12
13 SPS commissioning (after 2005)
14 TI8 re-commissioning
15 Install vacuum pipe and BI - IR7
16 Install beam dump and shielding
17 Install Access Gates in tunnel
18 Commission access system
19 Test with beam
20 Radiation Survey
21 Remove Gates
22 Remove Dump
23
24 7-8 closed for magnet transport
25 6-7 partially closed

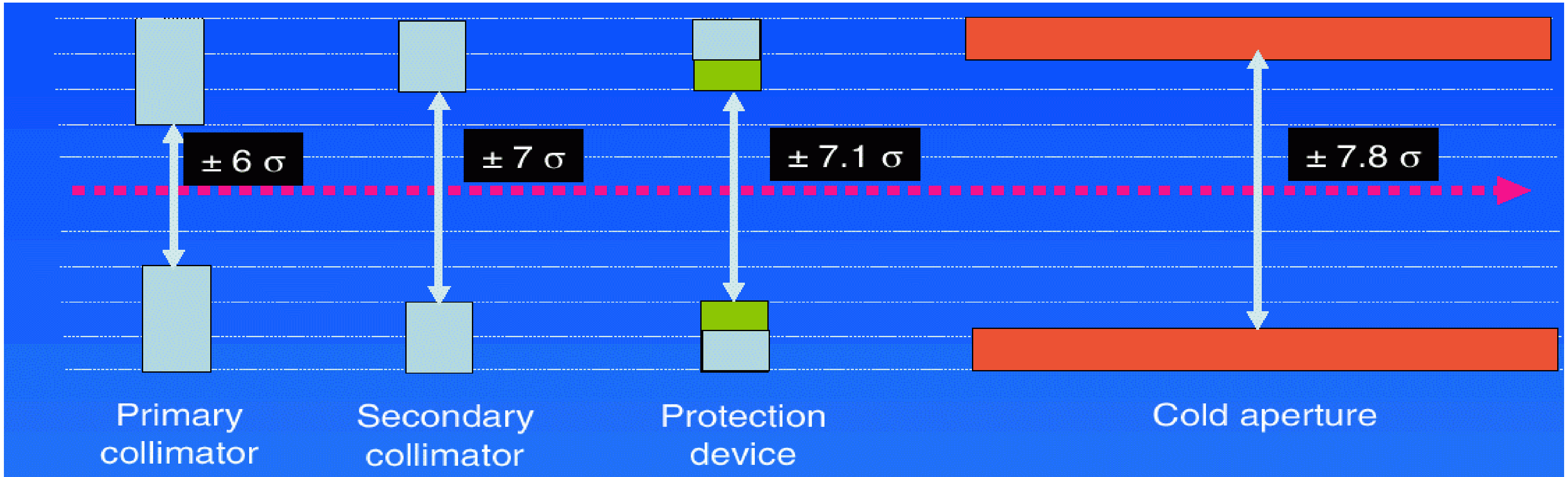
“Status of the Collimation Project”

R. Assmann

Introduction: Movable aperture restrictions

Number of movable elements: 112-155

Acronym	Movable	Material	Length [m]	Number	Locations	Purpose
Scrapers						
TCSP	yes	tbd	tbd	6-8	IR3, IR7	Beam scraping
Collimators						
TCP	yes	C/C-C	0.2	8-9	IR3, IR7	Primary collimators
TCSG	yes	C/C-C	1.0	30-44	IR3, IR7	Secondary graphite collimators
TCSM	yes	tbd	1.0	30-44	IR3, IR7	Hybrid metallic secondary collimators
TCT	yes	Cu	1.0	12-16	IR1, IR2, IR5, IR8	Tertiary collimators
TCDI	yes	C	3.0	10-18	Transfer lines TI2, TI8	Injection collimation
Diluters						
TCLI	yes	tbd	tbd	4	IR2, IR8	Injection protection
TCDQ	yes	sandwich	9.5	2	IR6	Protection against irregular dump
TCDS	no	sandwich	5	2	IR6	Dump septum protection
Absorbers						
TDI	yes	Sandwich	4.0	2	IR2, IR8	Injection protection
TCDD	no	Cu	1.0	2	IR2, IR8	Injection shielding upstream D1
TCLP	yes	Cu	1.0	8	IR1, IR5	Secondaries from IP
TAS	no	Cu	1.8	4	IR1, IR5	Secondaries from IP
Dumps						
TDE	no	Sandwich	7.7	2	UD62, UD68	Dump for ejected beam



- Closely coupled system.
- **Protection devices act as secondary collimators.**
- Consequences to be studied in detail (hardware tolerances, activation, quench limitations, operational difficulties, …).
- **Coherent strategy for all collimators** is crucial ➔ CWG mandate extended to settings of all movable elements after Chamonix 2002.

Life in the real world: TEVATRON example

Analysis of Tevatron 16 House Quench on December 5, 2003

D. Still, Fermi National Accelerator Laboratory*, Batavia, IL, 60510 USA

INTRODUCTION

On December 5, 2003 at 10:35:41 the Tevatron

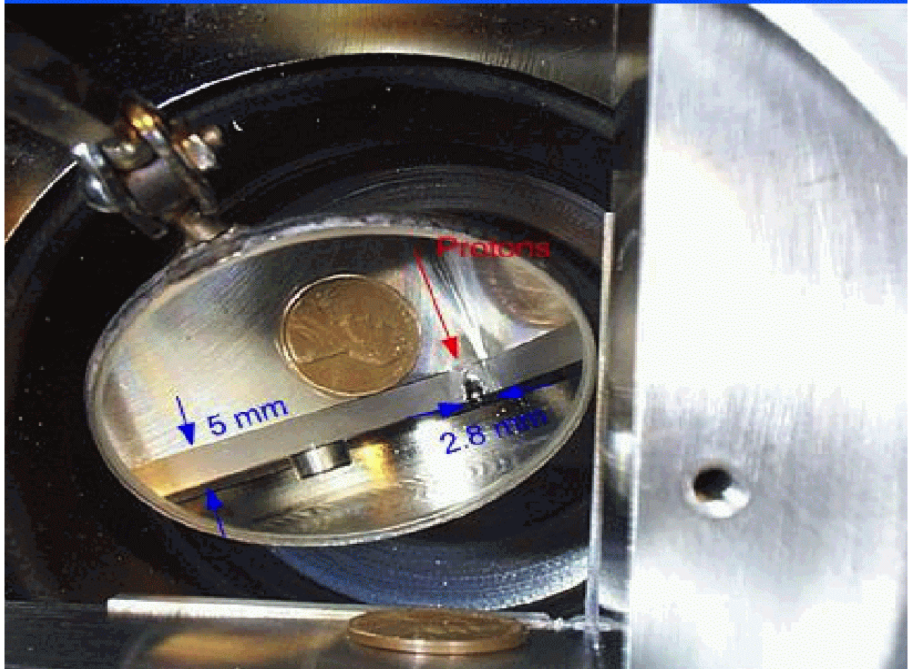
the file to be manually sent again in an attempt to move it.

3) Sending the retract file a second time caused the

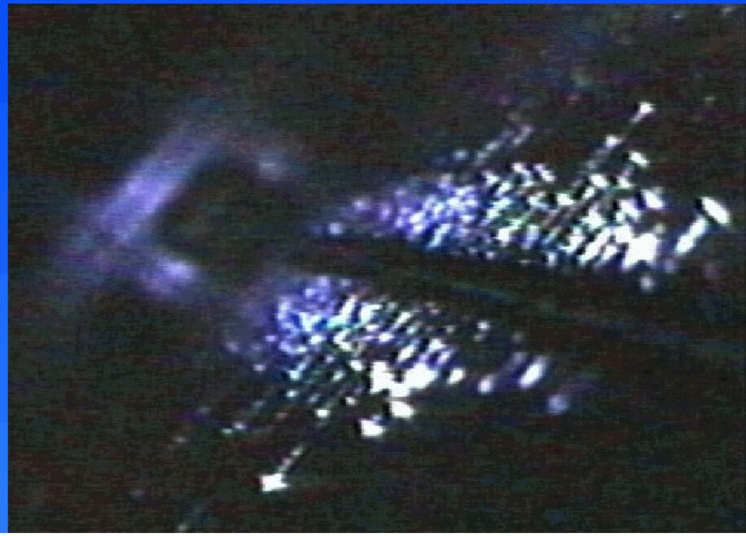
Stored energy: 350 times less than nominal LHC

- ➔ **Roman pot** re-inserts itself while set to move out.
- ➔ Scraped halo leads to **quench of 16 magnets**
- ➔ 3 mm **orbit** change
- ➔ drill **hole** through primary collimator
- ➔ **hit and damage** secondary collimator
- ➔ beam abort from quenches (BLM's by-passed to allow ramping)

Primary tungsten collimator

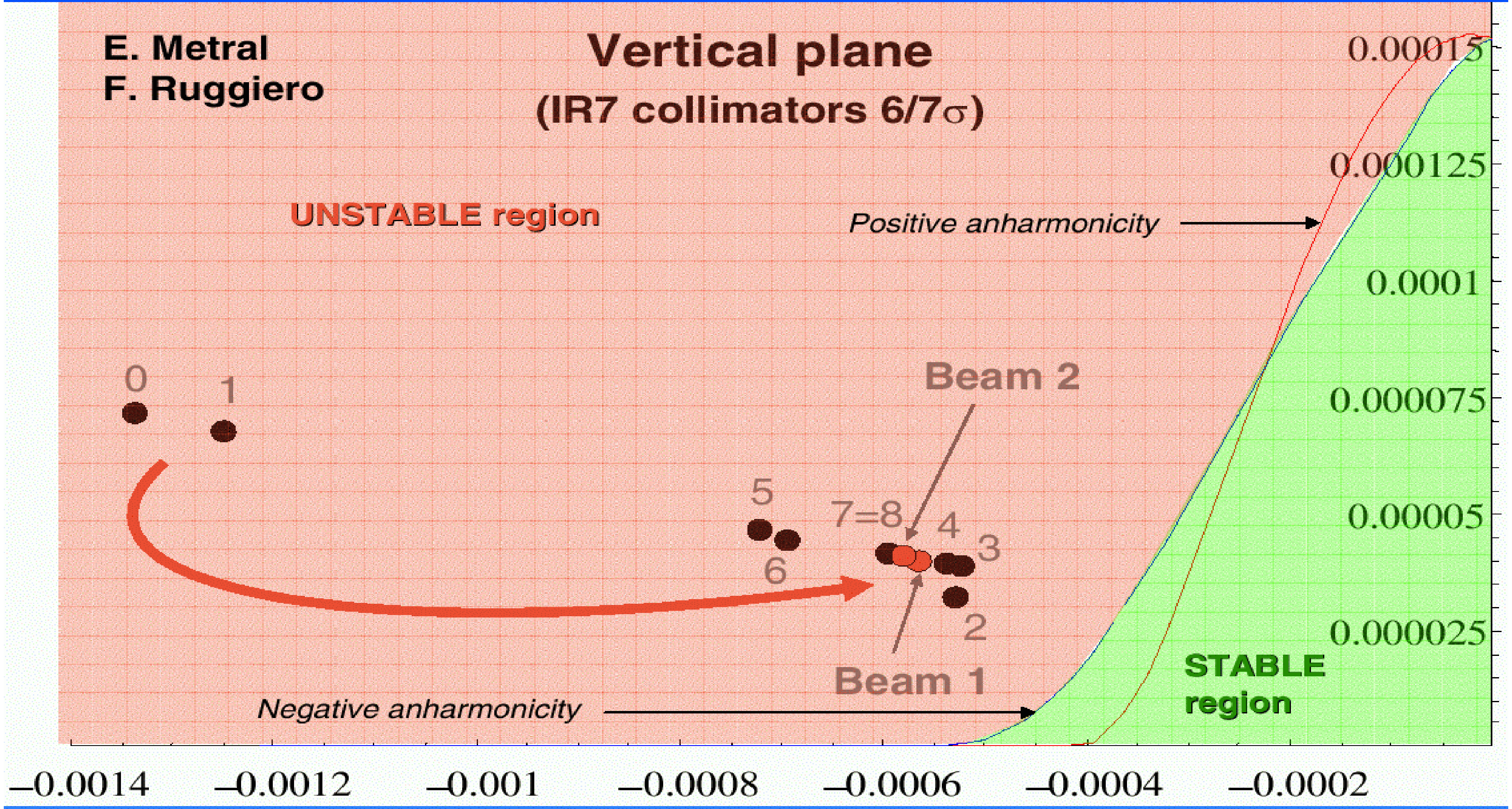


Secondary tungsten collimator



Helium leak in spool piece

Impedance: Stable and unstable regions



Impedance limit ➔ Reduce beam current until we are in stable regime (performance limit)

Physics and Tuning Studies

We will have robust collimators in 2007! What to do with it?

Understand:

- its **properties** from realistic models (simplified models used for design)
- **beam dynamics of the beam halo**
- influence of **imperfections** and **performance limits**
- the relevant beam **observables** (BLM's) to be included in simulation
- ways of **beam-based tuning** and optimization

HERA: "black magic". Full scale simulations in SIXTRACK:

- Additional help in ABP available (fellow, PhD student)
- Additional CPU power will be requested

Goals:

- **Set-up of 1 LHC collimator in the SPS.**
- **Procedures for the LHC.**
- **Maximum knowledge base before facing LHC problems.**

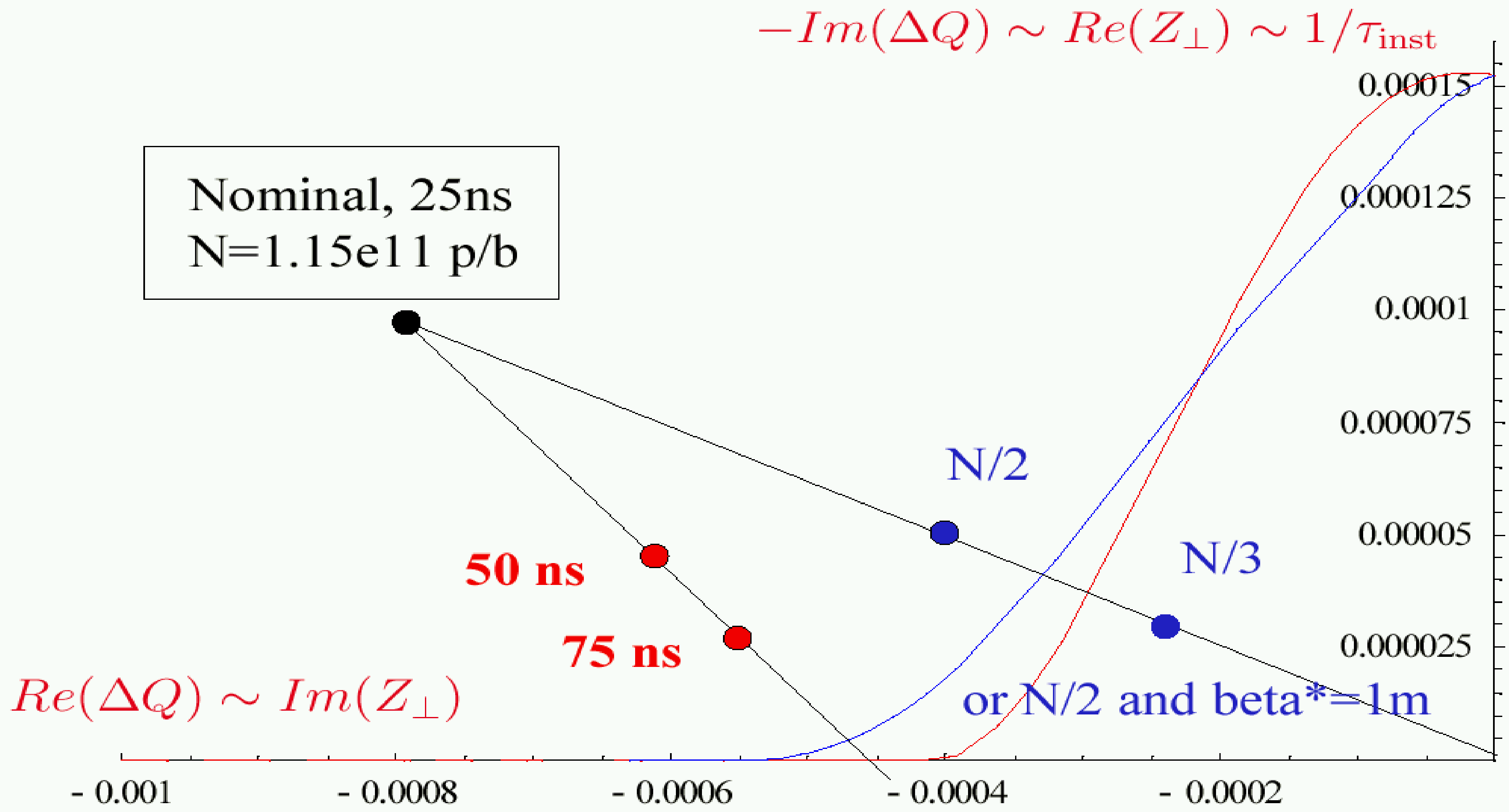
Conclusions

- **Collimation project is under control** thanks to the help and work of all involved.
- **Decisive beam tests** in 2004 will test the quality of our work.
- Significant work is ahead in 2004 → No time for long breaks…
- **Some delays** visible but can be caught up.
- **Experienced resources** available to advance fast
- **Serious problem** for motorization, local control, reliability → Action needed…
- We have confidence that we will make it work...

“Operational Constraints ... due to the Collimation System”

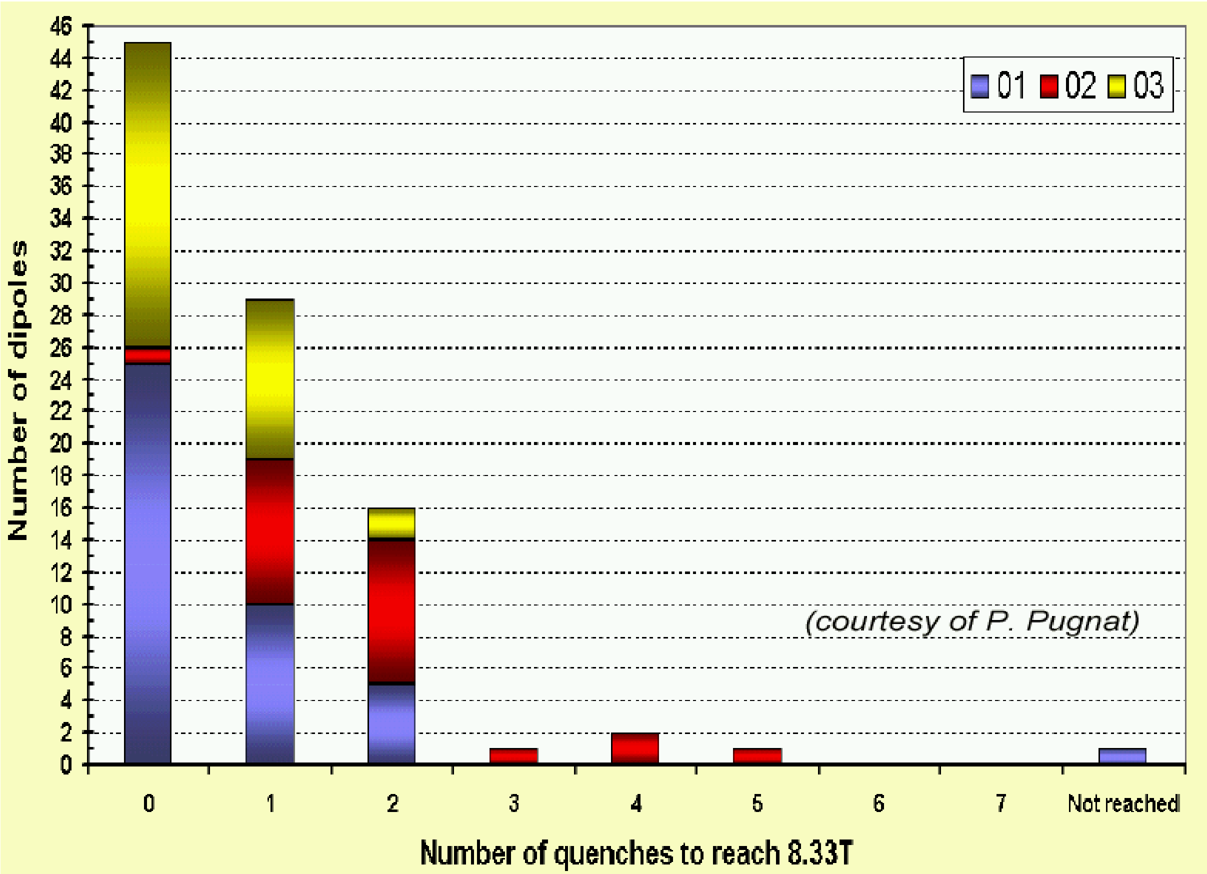
B. Jeanneret

7 TeV, vary beam parameters



“Dipole Cold Mass Assembly”

M. Modena



- *All (practically) c.m. reach 8.33 Tesla with less than 6 quenches.*
- *47% of c.m. reach 8.33 T with no quenches.*
- *Today one Cold Mass Assembler is producing less performing c.m. compare with the other two. Several hypothesis are under investigation, and corrective actions are under study and test*

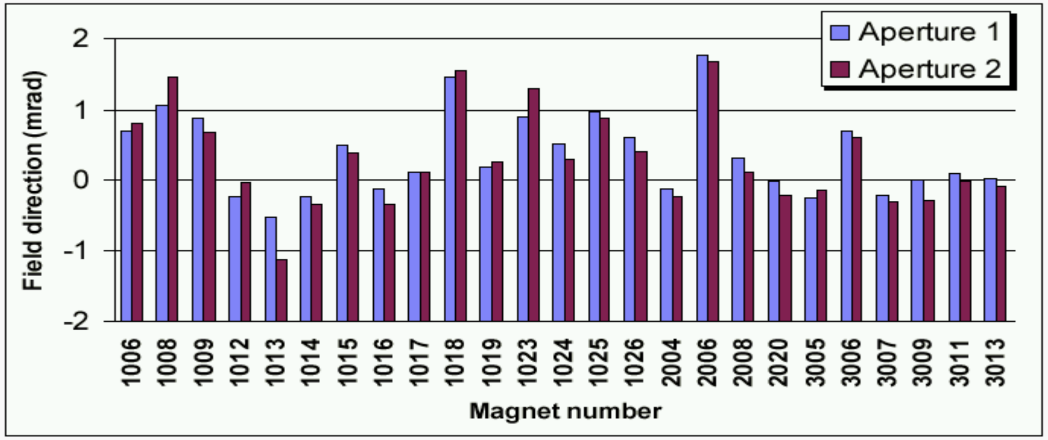
(see forward)

•*Measurements performed at CERN put in evidence magnets with large angle deviation (> ±1mrad).*

•*We have start to analyze and investigate the following possible causes:*

a. *Tilt of mid plane due to difference in coils size.*
b. *Horizontal mismatch between collars' cavities.*
c. *Tilt of coil cavity due to tilted collars' "noses".*
d. *Distortion during cold mass assembly.*

•*For the moment all these possible causes were excluded by the investigation.*



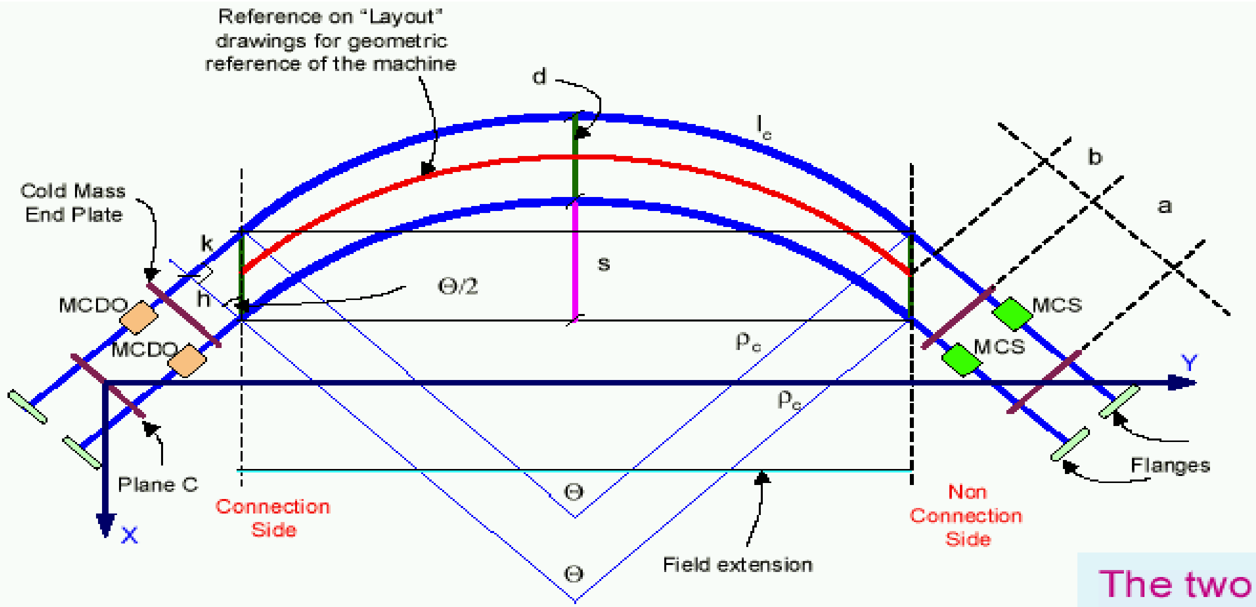
•*Other actions to investigate the problem are under study.*

(ref. to talk of E.Wildner)

The End

“Dipole Geometry”

E. Wildner



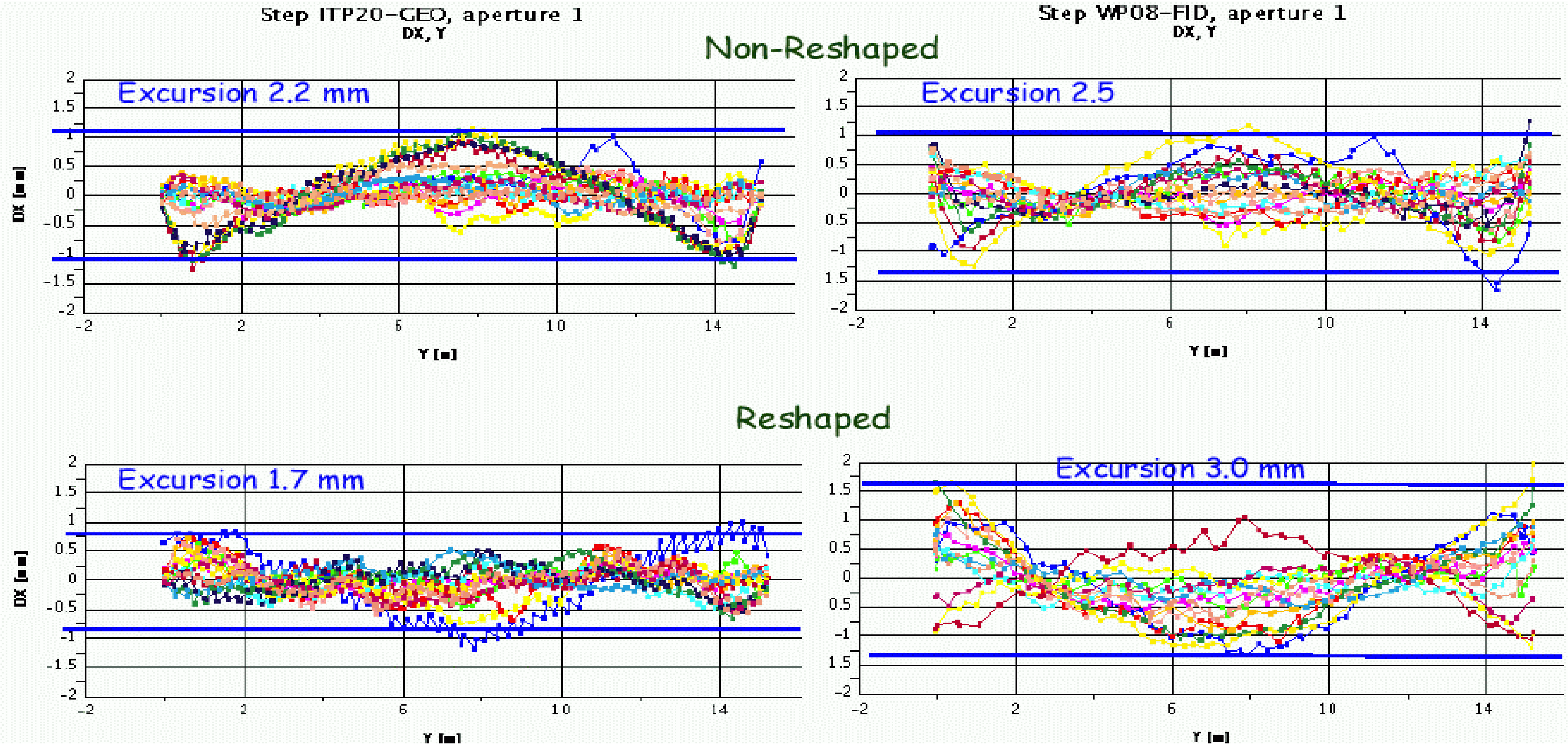
x/y represent the plane of the accelerator

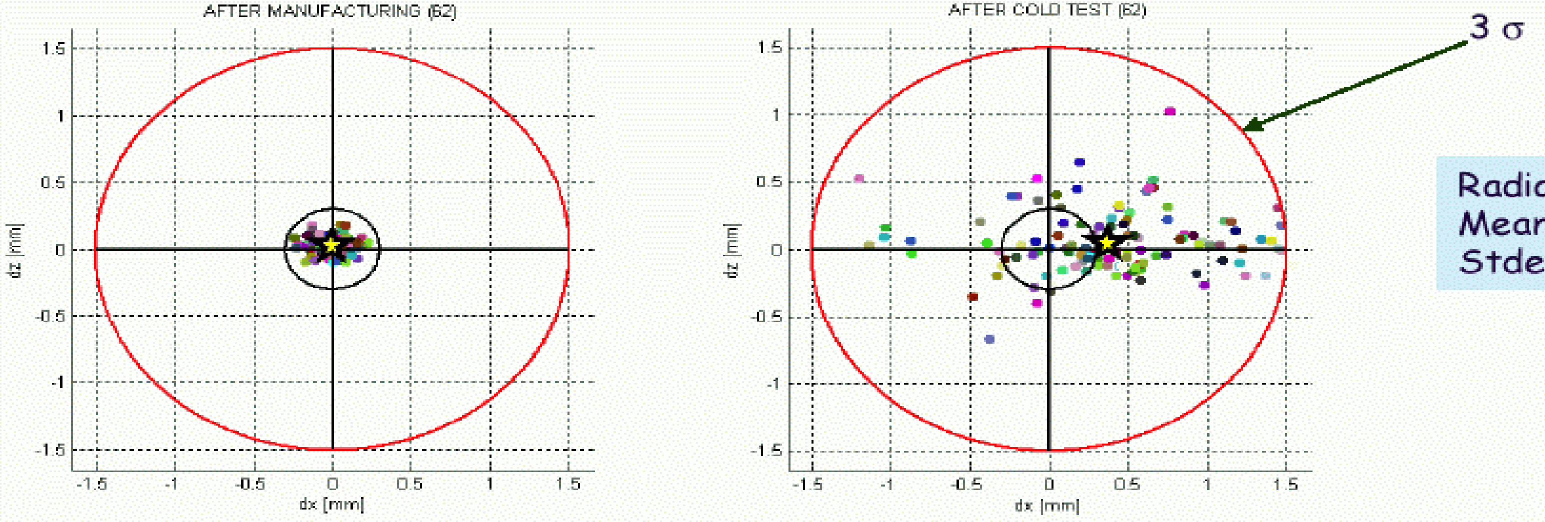
Limitations are imposed on

The body (curved, magnetic part): feed down effects
The body and the extremities: aperture
The extremities: interconnectivity
The extremities: spool piece feed down

The two theoretical beam trajectories are fitted to the 3D measurements and this is defined as the geometrical mean plane of the cold mass

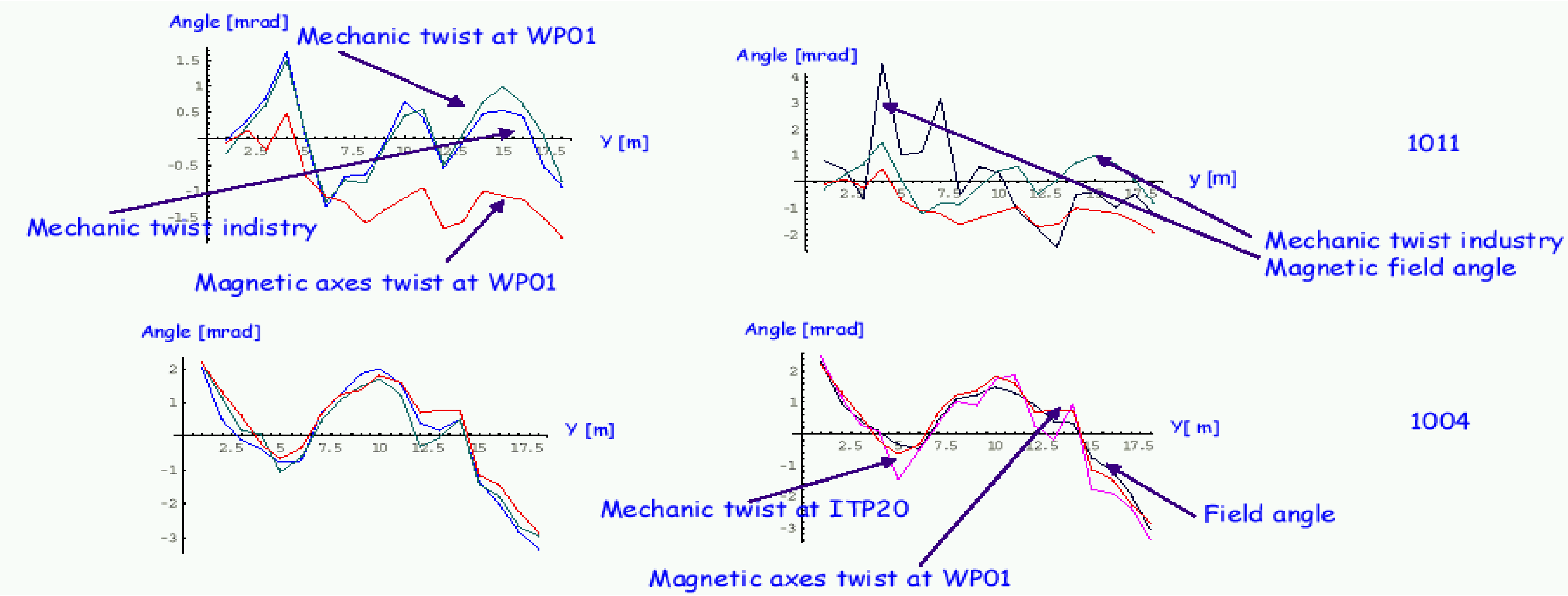
The representations of the measurements show the difference between the measurements and the best fitted theoretical shape


Step ITP20-GEO, aperture 1
DX, Y
Step WP08-FID, aperture 1
DX, Y
Non-Reshaped
Excursion 2.2 mm
Excursion 2.5
Reshaped
Excursion 1.7 mm
Excursion 3.0 mm
DX [mm]
Y [m]



	Number of dipoles	Av. [mm]	St.Dev. [mm]
	Horizontal directions		
After Manufacturing	***62 (43,19)***	***-0.01 (-0.01, 0.00)***	***0.09 (0.10, 0.06)***
After Cold Test	***62 (43,19)***	***+0.37 (0.37, 0.35)***	***0.56 (0.51, 0.67)***
	Vertical directions		
After Manufacturing	***62 (43,19)***	***+0.02 (0.02, 0.03)***	***0.06 (0.06, 0.05)***
After Cold Test	***62 (43,19)***	***+0.04 (0.04, 0.05)***	***0.23 (0.25, 0.18)***

All (non reshaped,reshaped)

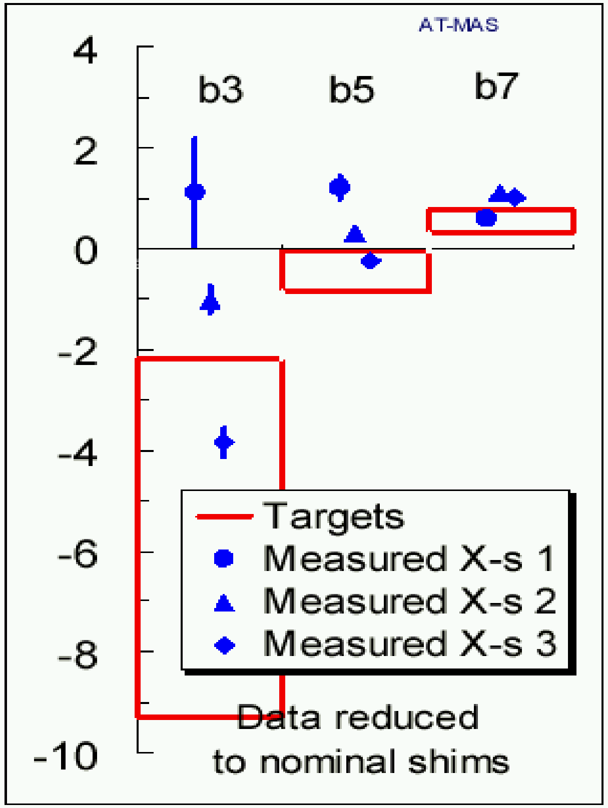

Angle [mrad]
Mechanic twist at WP01
Y [m]
Mechanic twist indistry
Magnetic axes twist at WP01
Angle [mrad]
y [m]
1011
Mechanic twist industry
Magnetic field angle
Angle [mrad]
Y [m]
Angle [mrad]
Y[m]
1004
Mechanic twist at ITP20
Field angle
Magnetic axes twist at WP01

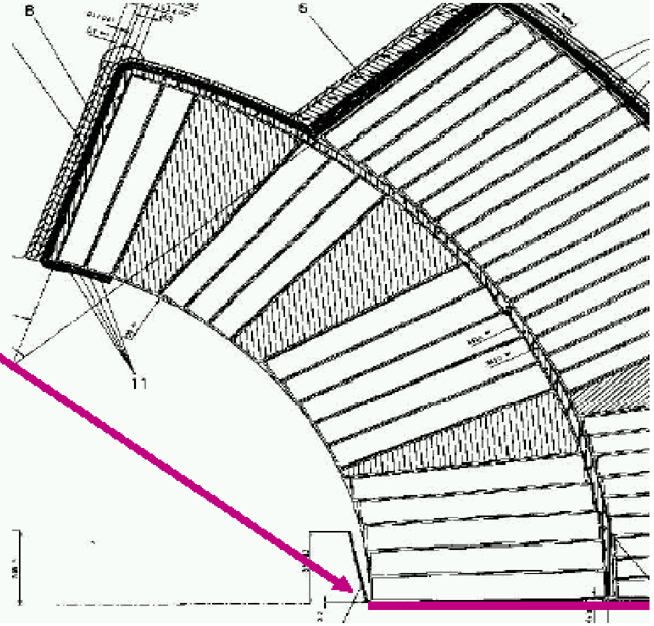
“Field Quality ...”

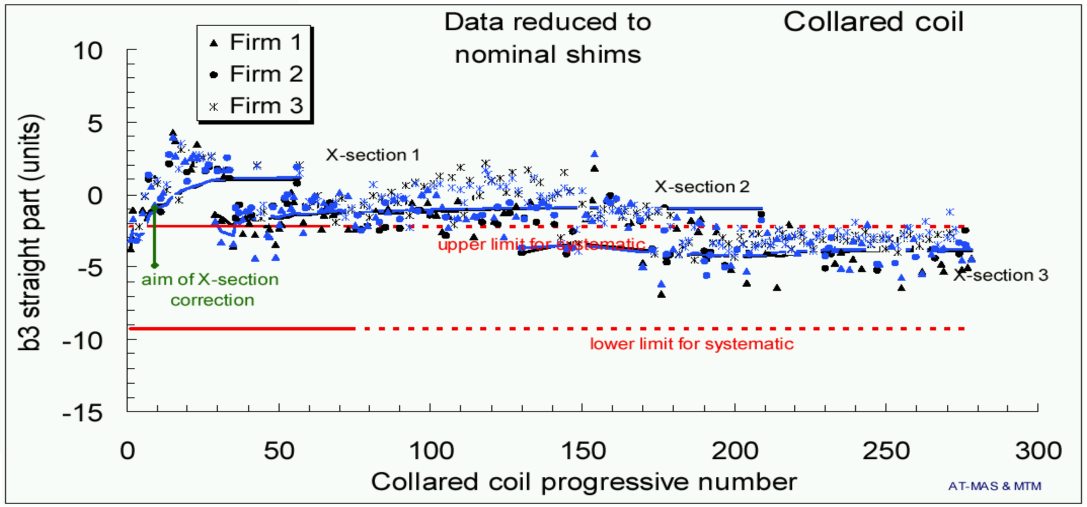
E. Todesco

Fine tuning of odd multipoles

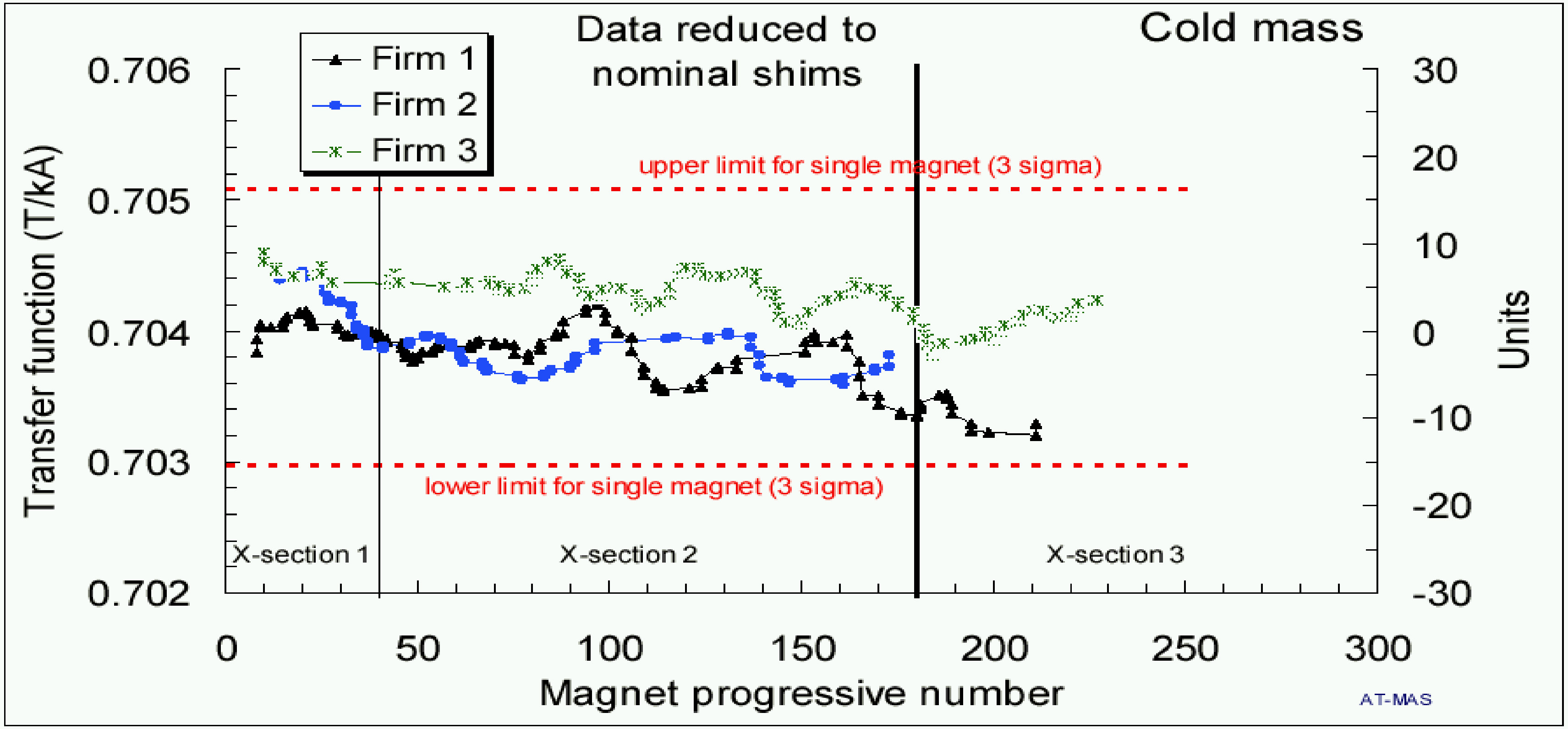
- With cross section 2, still out for b3 b5 b7 (too high in all cases)
- Ideal for increasing midplane insulation !







- Cold mass data confirm the observed patters, but
  - Firm3 curve is shifted down of around 5 units, I.e. the effect of yoke on main field is lower in Firm3 (confirmed at 1.9 K)



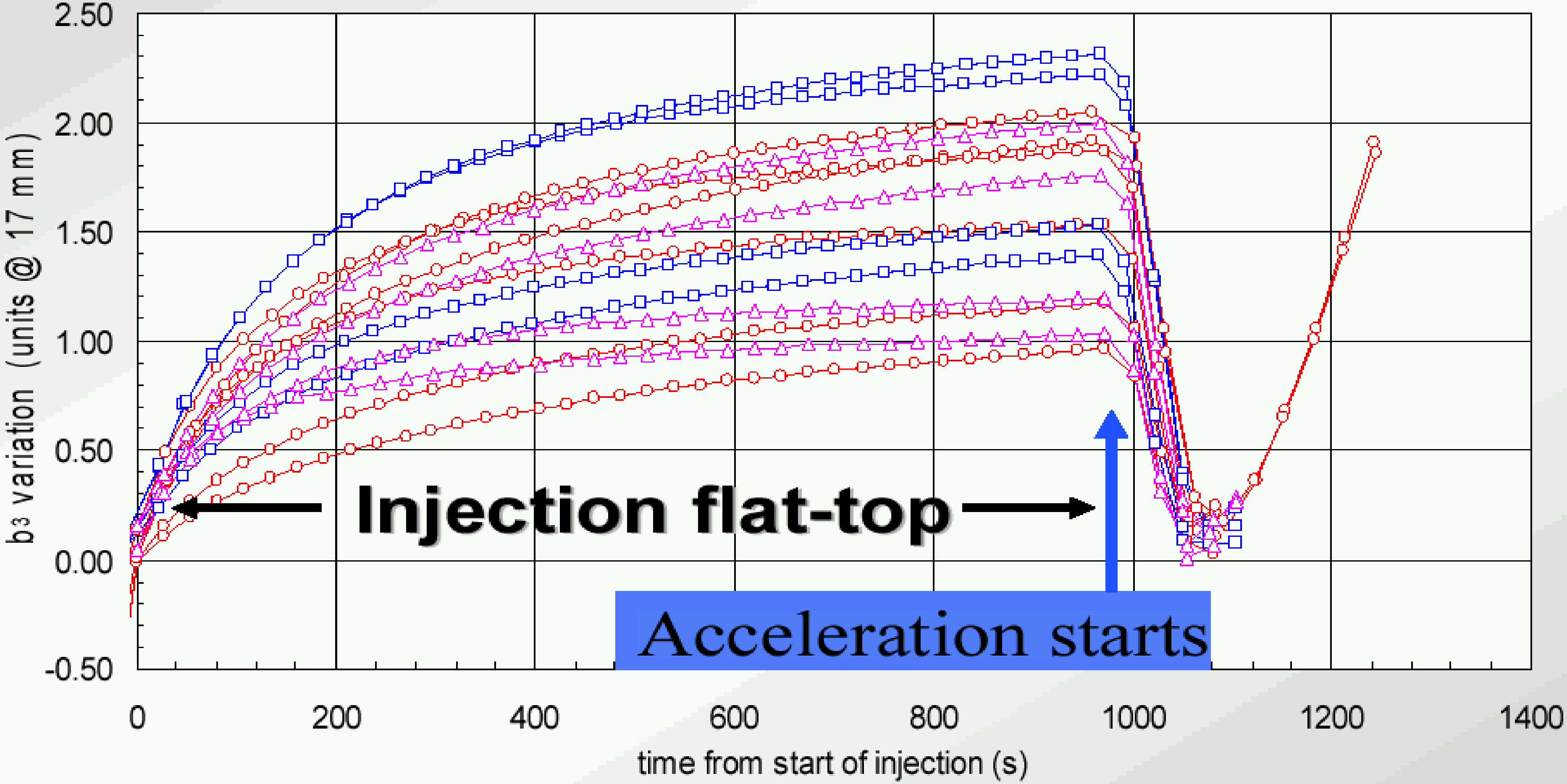
“Tests & Measurements of the Mags ..”

L. Walckiers

Decay and Snap-back

Tuning sextupole to control chromaticity

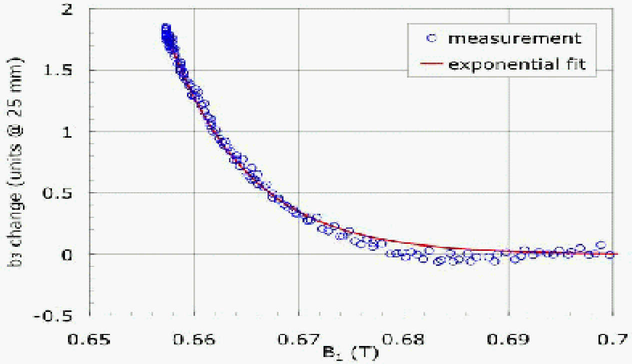
$\Delta\, b_3 = 0.02$ unit creates $\Delta\, Q' = 1$ unit



Snap-Back Model

Courtesy : L. Bottura

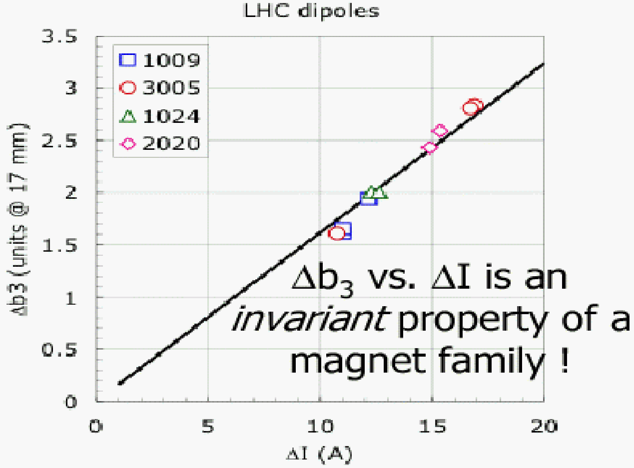
$$b_3^{snap-back}(t) = \Delta b_3 e^{-\frac{I(t)-I_{injection}}{\Delta I}}$$

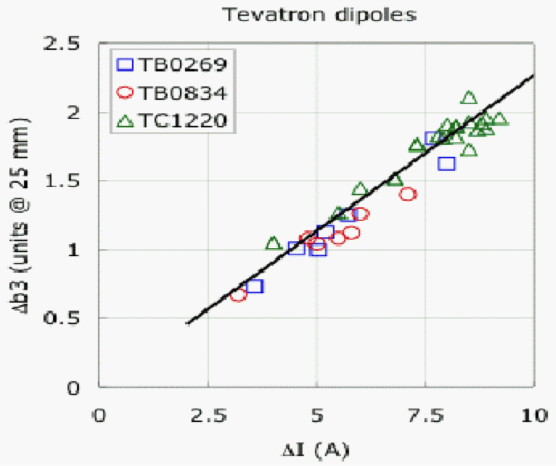


The physics of injection decay and SB is now better understood

beam-based compensation could be possible without pushing instrumentation techniques to extreme performance

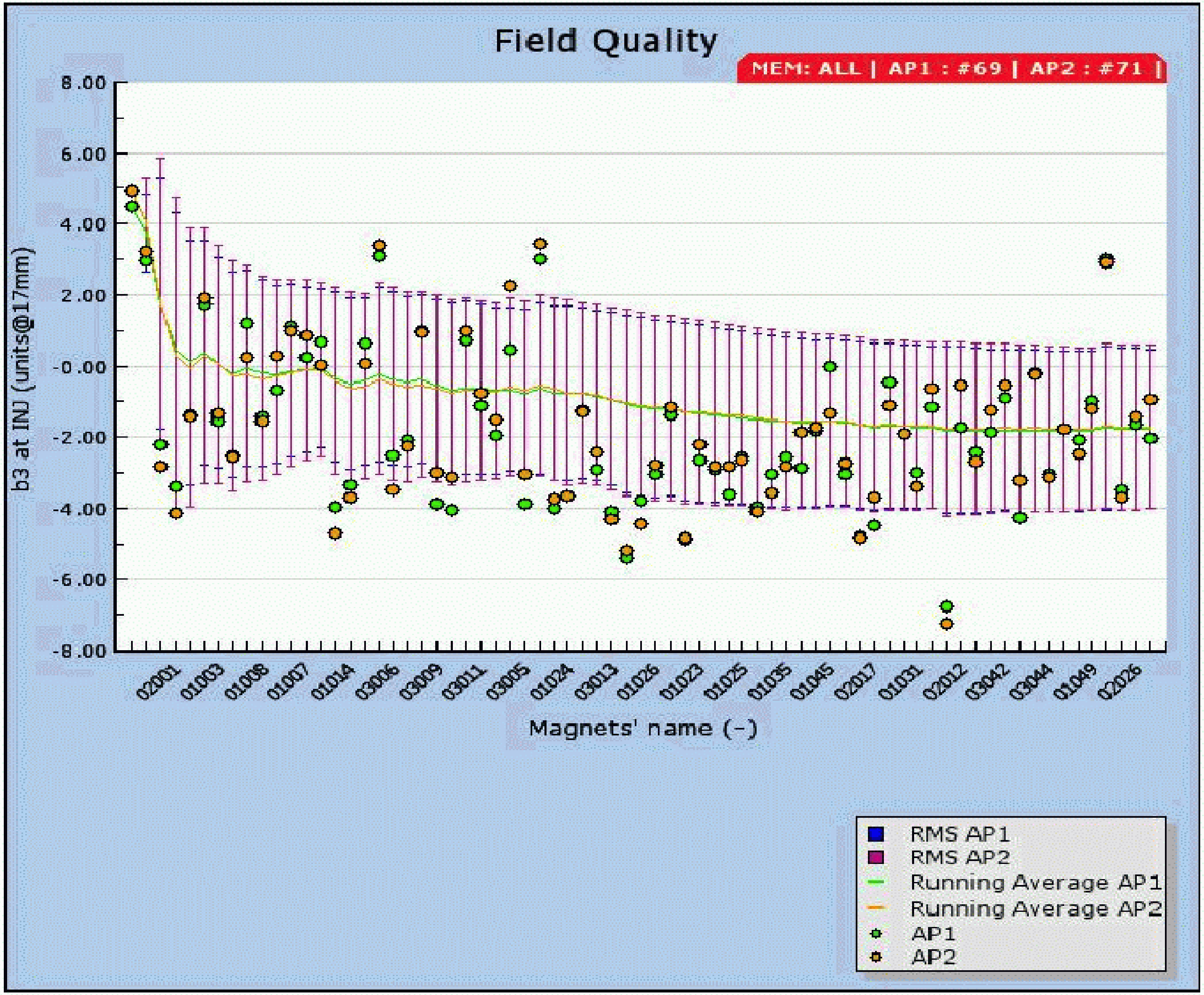
two MD experiments are proposed at Tevatron and RHIC to verify the concept (POP)





“Classification of Main Dipoles & Installation Strategy”

S. Fartouhk



b3 at injection measured on 70 magnets

To analyze the impact of the random b3 on the DA at injection, the following 7 cases have been studied:

- ✓ **Case I:** Blind installation. No random b3 → *academic.*
- ✓ **Case II:** Blind installation. Random b3 of 1.4 units (Gaussian distribution cut to 3σ , i.e. without long tails) → *closest to reality but still optimistic.*
- ✓ **Case III:** Blind installation. Random b3 of 2.4 units
  → *a bit pessimistic since the production tends to stabilize.*
- ✓ **Case IV:** Random b3 of 2.4 units but with "tic-tac pairing'', i.e. arrangement in **pair** of consecutive magnets with $| b3^{(2i-1)} + b3^{(2i)} - 2\langle b3\rangle_{sector} | < 0.1$ units , i=1 …616.
  → *very constraining.*
- ✓ **Case V:** Random b3 of 2.4 units but with "flip-flop pairing'', i.e. arrangement in **pair** of consecutive magnets with $b3^{(2i-1)} > \langle b3\rangle_{sector}$, $b3^{(2i)} < \langle b3\rangle_{sector}$, , i=1 …616.
  → *soft tic-tac scheme, much more realistic.*
- ✓ **Case VI:** Random b3 of 2.4 units but with "up and down arrangement'', i.e **chain** of 154 dipoles in each arc with $b3^{(i-1)} > \langle b3\rangle_{sector}$, $b3^{(i)} < \langle b3\rangle_{sector}$, $b3^{(i+1)} > \langle b3\rangle_{sector}$, ….
  → *unrealistic for the LHC* because assuming a perfect correlation between b3 and magnet type (type A and B).
- ✓ **Case VII:** Random b3 of 2.4 units but with "π-pairing'', i.e. magnets of similar b3 (that is above or below the b3 average) arranged in **pair** spaced by π: $b3^{(i)} \sim b3^{(i+12)}$ (excluding the DS's).
  → *does not go in the direction of minimizing the holes during the installation process.*

Conclusions and outstanding issues

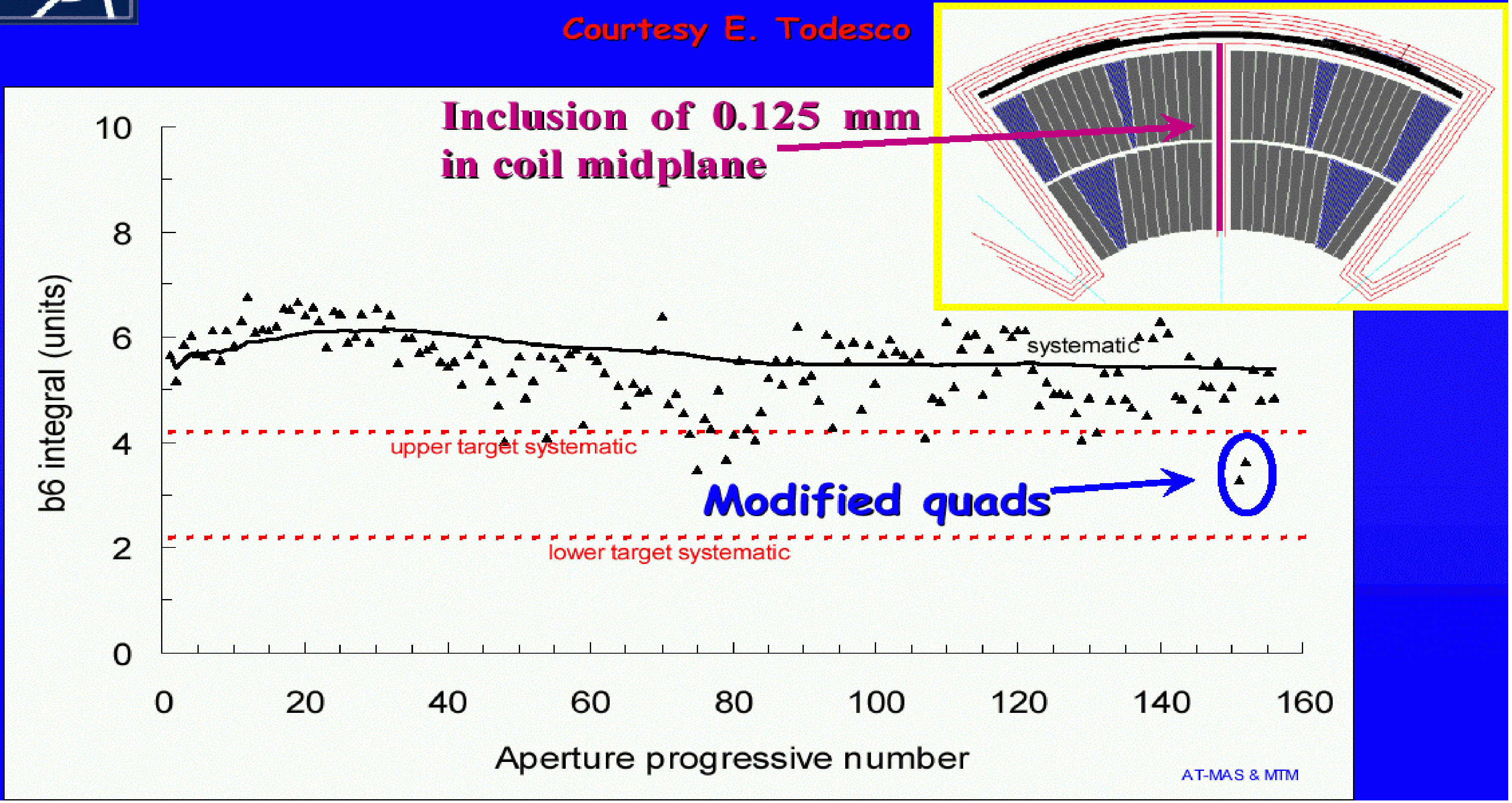
- ✓ In view of the present state of production, the proposed algorithm **should anticipate all possibilities**, **without significant interferences with the installation process**.
- ✓ **Solid indicators** are **mandatory** to judge **individually** each dipole**,** i.e. for the **geometry**, the **FD** (e.g. via SSW warm measurement) and **TF at nominal**, and **b3 at 450 GeV.**
- ✓ In a **reduced cold measurement program,** the uncertainty on the **warm-cold offset on b1 and b3** is more or less acceptable to **classify** and/or **flag** the non-cold measured magnets

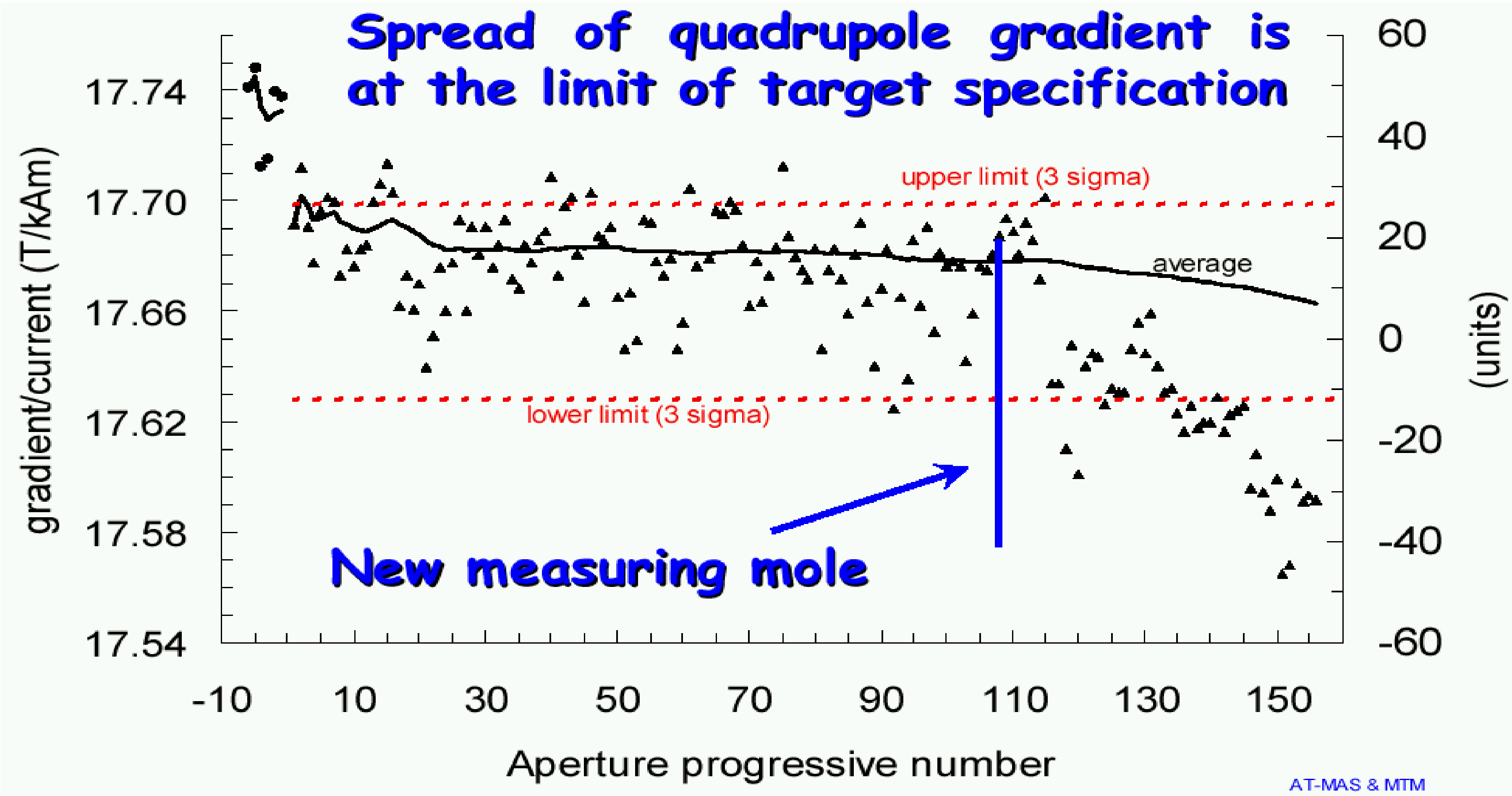
“Field Quality Issues for ... Quads & Separation Dipoles”

M. Giovannozzi

Corrective actions for MQs

Courtesy E. Todesco





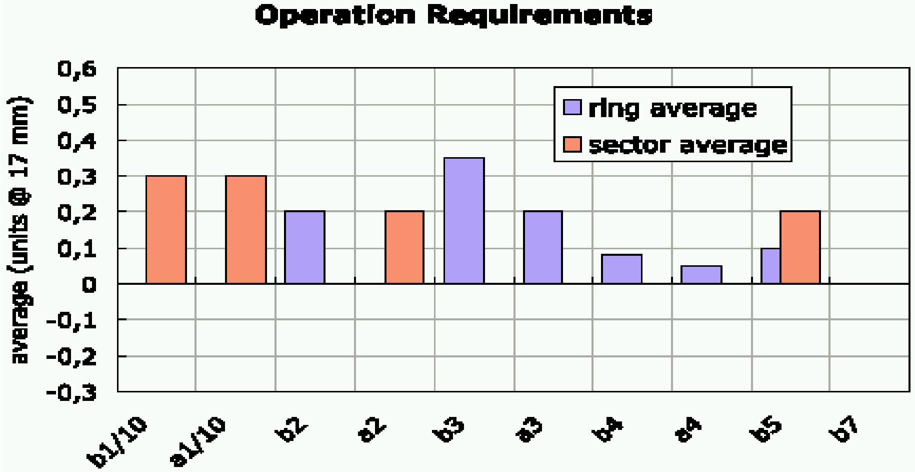
Spread of quadrupole gradient is at the limit of target specification
upper limit (3 sigma)
average
lower limit (3 sigma)
New measuring mole
17.74
17.70
17.66
17.62
17.58
17.54
gradient/current (T/kAm)
60
40
20
0
-20
-40
-60
(units)
-10
10
30
50
70
90
110
130
150
Aperture progressive number
AT-MAS & MTM

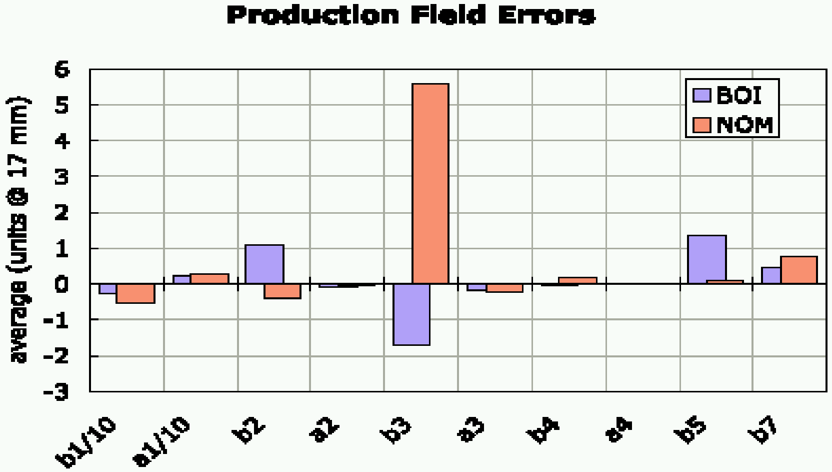
“Reference Magnets”

L. Deniau

Motivations

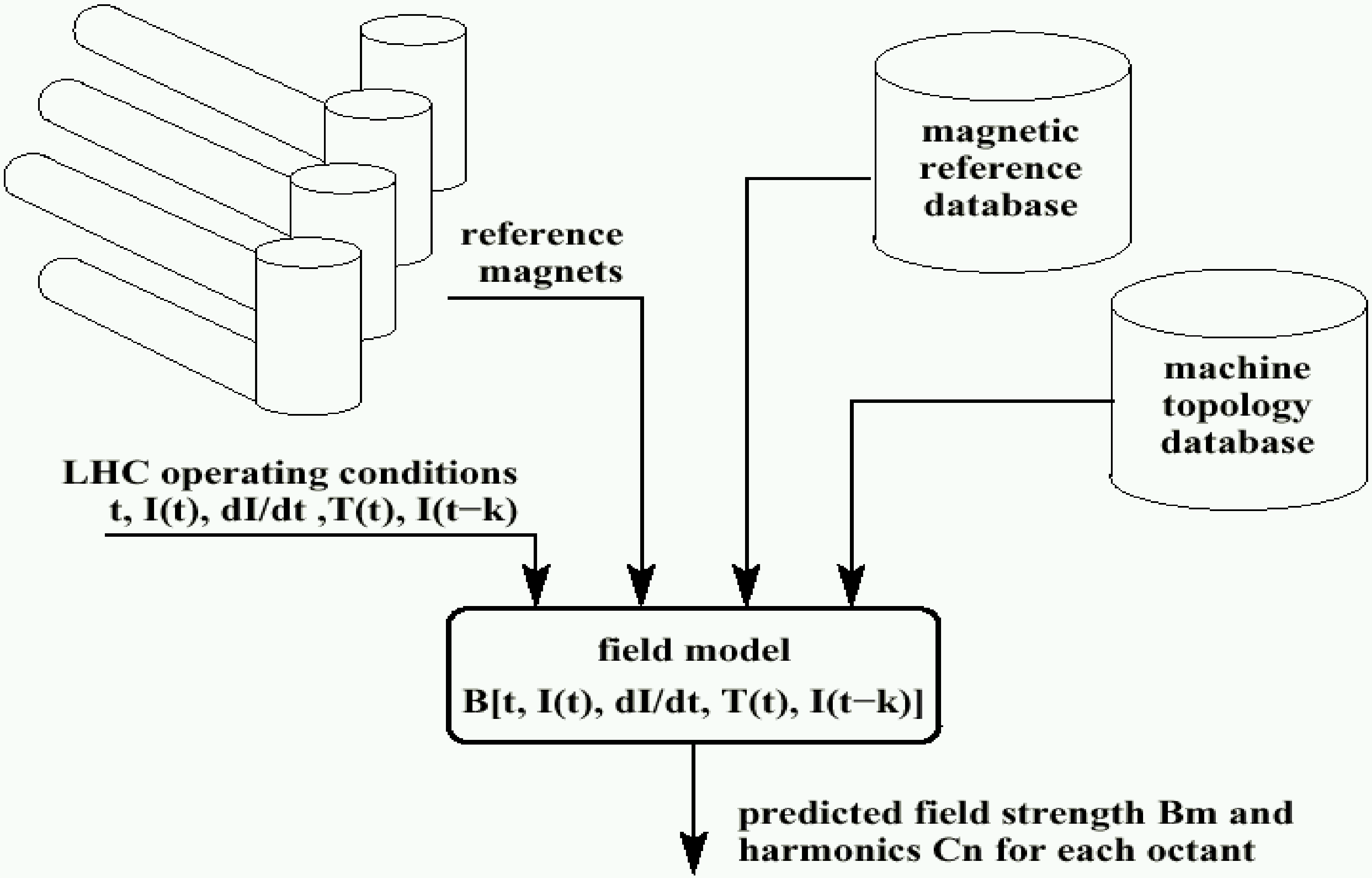
- The field quality control of the main optics elements (dipoles, quadrupoles) relies on the effectiveness of the correction scheme.
- The effectiveness of the correction scheme depends itself on the the accuracy of the knowledge of the field errors.
- Random errors are at least one order of magnitude smaller.





Courtesy to L. Bottura

RMS Components



“What LHC Ops will look like”

R. Bailey

Resulting proposal for year 1 (Chamonix 03)

Start high energy operation at 6.5TeV or even 6TeV
Move to 7TeV whenever machine stability permits it (1 step)

Phase 1 : Establish colliding beam operation with 43 on 43

- Machine de-bugging without / with crossing angle
- Parasitic physics, limited by event pileup, low luminosities

Phase 2 : Establish multi-bunch operation with 75ns spacing and relaxed machine parameters

- Luminosity tuning, limited by event pileup, may reach 5 10^{32} $cm^{-2}s^{-1}$
- Establish routine operation in this mode
- Move to nominal squeeze and crossing angle (lower emittance ?)

Phase 3 : Move to 25ns operation for standard physics running

- Production physics running, limited by electron cloud and beam dump
- Luminosity should be > 10^{33} cm^{-2} s^{-1} , pileup OK with 4 10^{10} / bunch
- Scrubbing run needed to go higher (1 week studies in any case)

Other things for year 1

Single beam runs

- Will do this before we try colliding beam runs
- Will do it for beam 1 and beam 2
- Experiments are interested in these runs
- LHCb only interested in clockwise beam (beam 1)

TOTEM running

- 156 on 156
  - requires 4 equally spaced bunches from injectors; not yet done
- Total Cross Section and Elastic scattering
  1. Single beam runs
  2. Several 1 day runs with $\beta^* = 1500$m
  3. Several 1 day runs with $\beta^* = 18$m
- Diffraction and minimum bias
  1. Runs with CMS with $\beta^* = 1500$m
  2. Runs with CMS with $\beta^* = 0.55$m

> Both TOTEM and ION runs will take time to set up

Ion running

- Start with early ion scheme — 62 bunches @ 1350ns spacing
- If we can do it in SPS — 592 bunches @ 100ns spacing

Strategy for following years (25ns protons)

Year 2

- Scrubbing run (3 weeks)
- 25ns operation
- Limited to 5 10^{10} / bunch by beam dump
- Could go to higher bunch currents with 75ns if experiments require

Peak 2 10^{33} cm^{-2} s^{-1}
η = 0.24
~ 40 pb^{-1} / day

Year 3

- Install beam dilution kickers
- Install additional collimators (phase II)
- Scrubbing run (3 weeks)
- Start pushing the intensity
- Aim for nominal (= ultimate in the booster !!)

Year 4

- Scrubbing run (2 weeks)
- Production running at 10^{34} $cm^{-2}s^{-1}$
- Retire

Peak 10^{34} cm^{-2} s^{-1}
η = 0.24
~ 200 pb^{-1} / day

“Operating the LHC Initially at a Lower Energy”

R. Schmidt

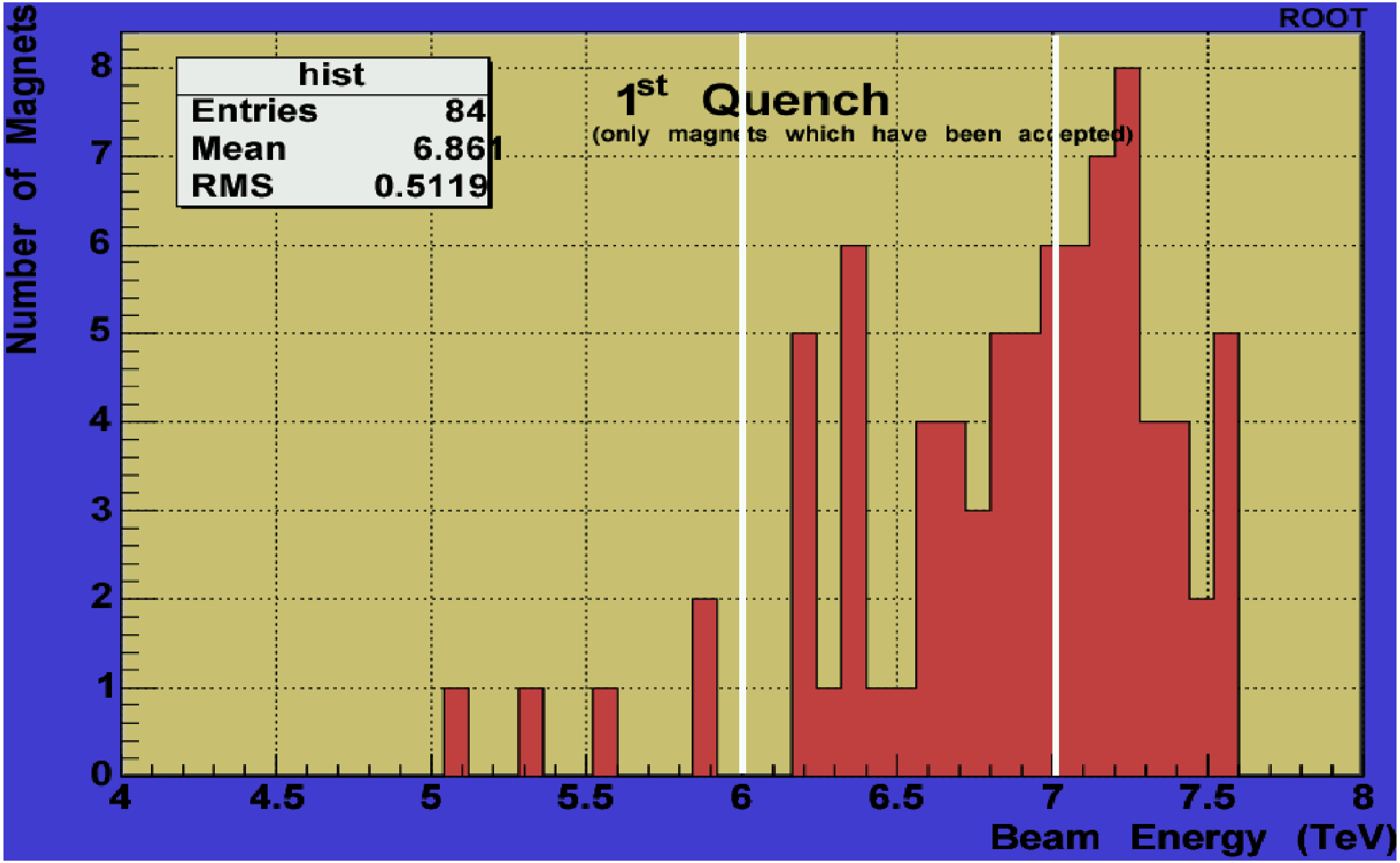
- For a light Higgs (120 GeV), the relative potential R is decreased by 10% for 6 TeV compared to 7 TeV assuming the same luminosity (from particle physics, A.Verdier 2003)
  - R[7 TeV] = 1, R[6 TeV] = 0.9
- Discovery potential and luminosity:

$$HDP = R[E] \cdot \sqrt{\int L(t) \cdot dt}$$

- The LHC is a challenging complex accelerator – both from the hardware point of view and from operation
- Initially, the **efficiency of the operation** will to a large extent determine the integrated luminosity

Quenches induced by beam losses will inevitably occur

- at 7 TeV, a fast loss of a tiny fraction of the nominal beam (10^{-7}) would induce a quench in a superconducting magnet
- at 450 GeV, a fast loss of some 10^{-4} of the nominal injected beam would quench a magnet


ROOT
hist
Entries 84
Mean 6.861
RMS 0.5119
1st Quench
(only magnets which have been accepted)
Number of Magnets
0
1
2
3
4
5
6
7
8
4
4.5
5
5.5
6
6.5
7
7.5
8
Beam Energy (TeV)

“Beam-based & Reference Magnet Measurements...”

M. Lamont

- **Powering history dependent persistent currents at t_0**
- **Decay of these powering history dependent persistent currents**
- **Start of ramp at indeterminate time t_{inj} after t_0**
- **Snapback**

b1,a1	**Orbits, tunes (via chromaticity)**
a2,b2	**Tune & coupling**
a3, b3	**Chromaticity, differential tunes& coupling**
a,b,4,5	**Differential chromaticities, dynamic aperture**

Tight Tolerances

and the configuration and dynamic behaviour of the correction elements with which we hope to deal with these effects…

Reference magnets

- Rotating coils. 1Hz - Main field, Harmonics (& transfer functions)
- Fast measurements from Hall plates give b3 and b5 at around 10 Hz with less precision than the rotating coils. Should be capable of +/- 0.1 units of b3 after calibration.
- NMR probe giving b1 at some what less than 1 Hz. Capable of 10^{-5} accuracy after calibration.

Reproducibility

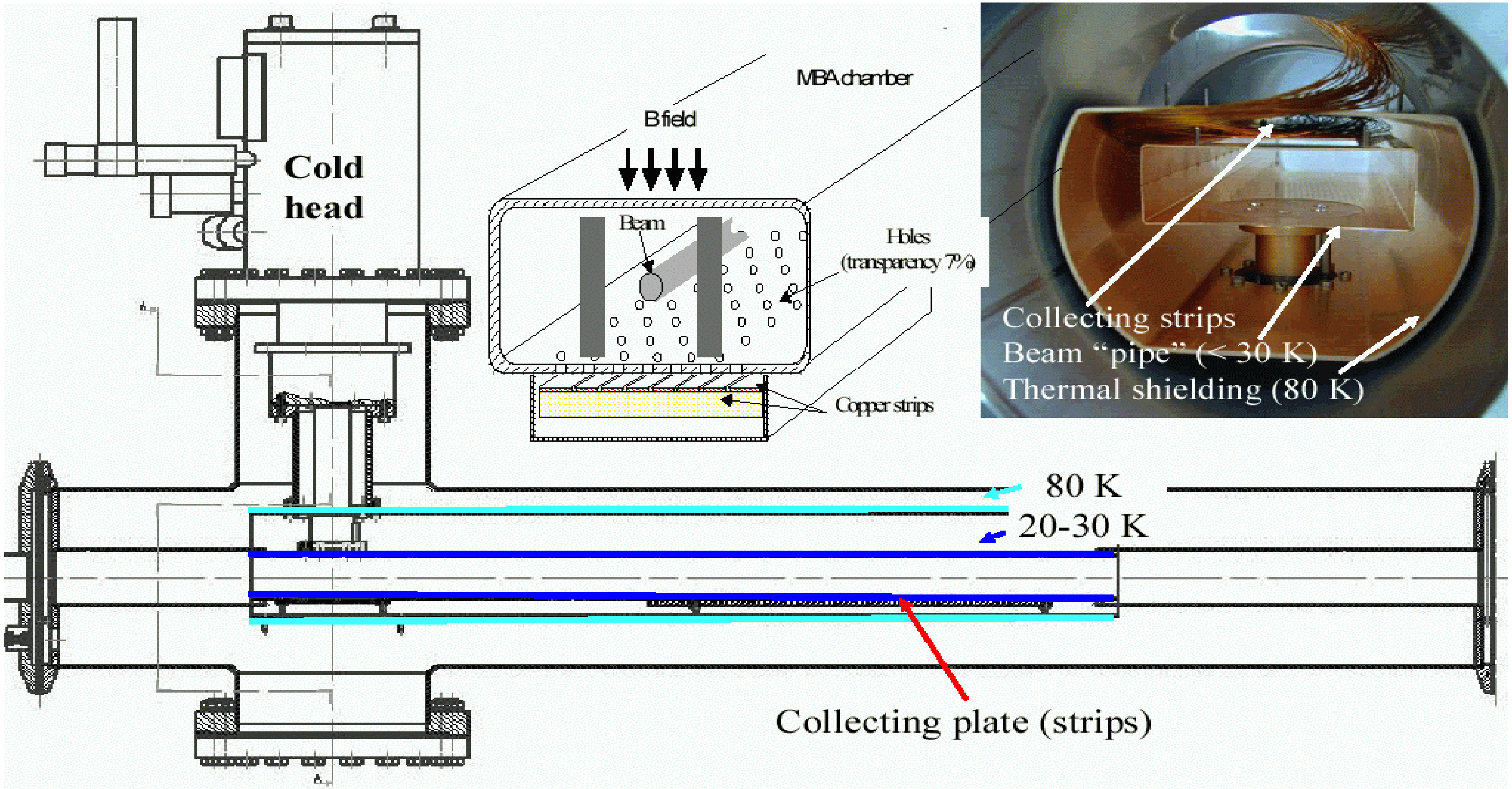
- Well defined machine cycle with re-cycle in case of problems
- Experience. We will be able to feed forward any trims into machine settings for use in the future.
- If we have sufficient reproducibility - replay settings and thus run without RMS if necessary.

Conclusions

- **Strategy:**
  - **Reproducibility**
    - well defined operational cycle
    - full recycle in case of problems
  - **Magnetic measurements coupled with models of multipole behaviour which take into account powering history – predictions of $b_n(t)$ during decay and snapback.**
  - **On-line reference magnet measurements & feed-forward**
  - **Beam based measurements & feed forward**
  - **Beam based feedback**
  - **Run-to-run feed-forward of experience**
- **RMS predictions essential.**
- **Feed forward from reference magnets not needed for sector test & first commissioning. Needed when we start pushing.**

“Latest News on Electron Cloud & Vacuum Effects”

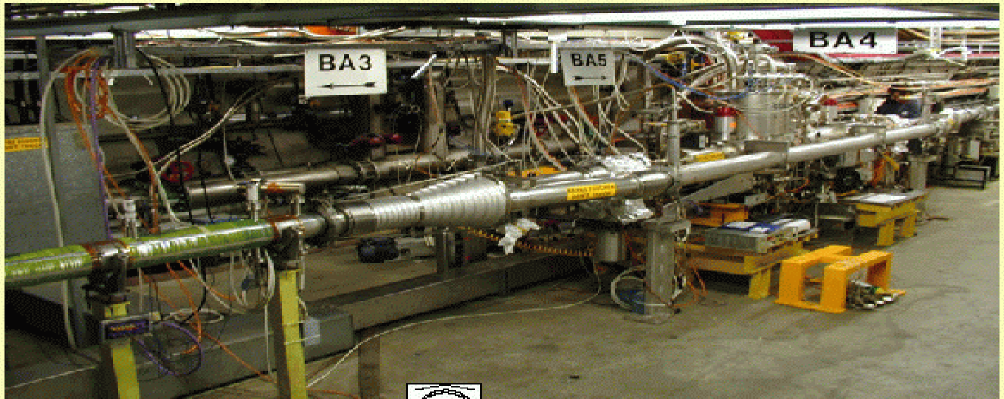
M. Jimenez



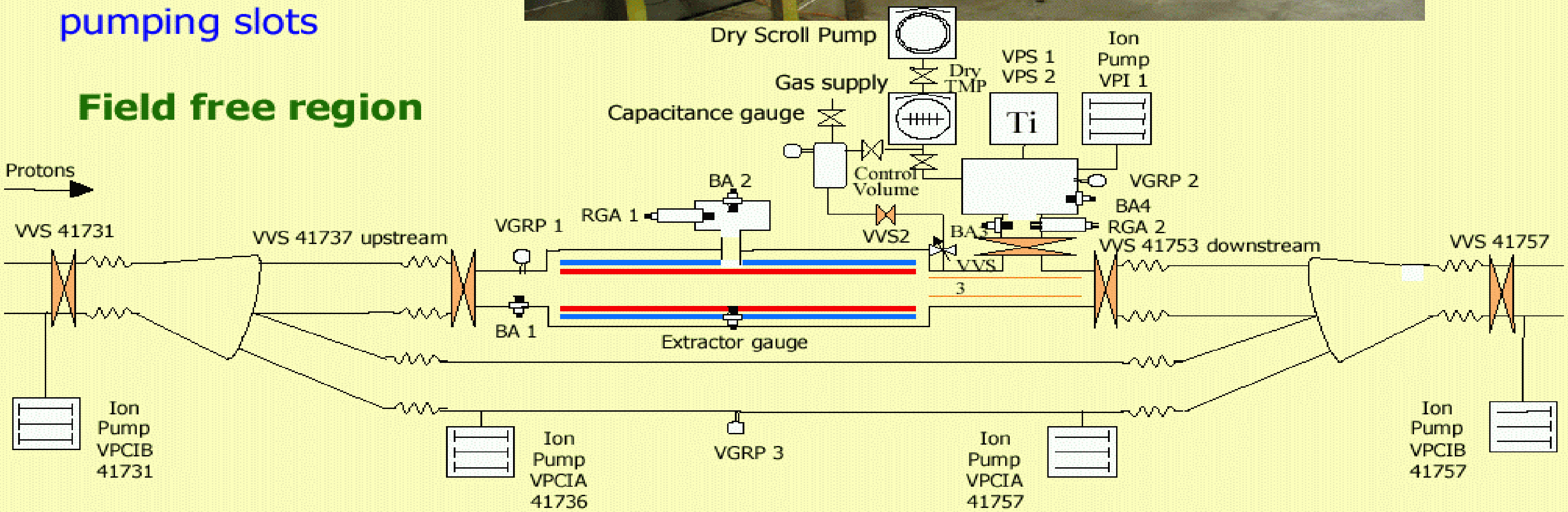
Cold head
MBA chamber
B field
Beam
Holes (transparency 7%)
Copper strips
Collecting strips
Beam "pipe" (< 30 K)
Thermal shielding (80 K)
80 K
20-30 K
Collecting plate (strips)

...COLDEX (principle)...

Cold bore at 3K
Cold copper beam screen:
- length: 2.2 m, ID=67 mm,
- temperature controlled between 5 and 150K,
- 1% BS area with shielded pumping slots

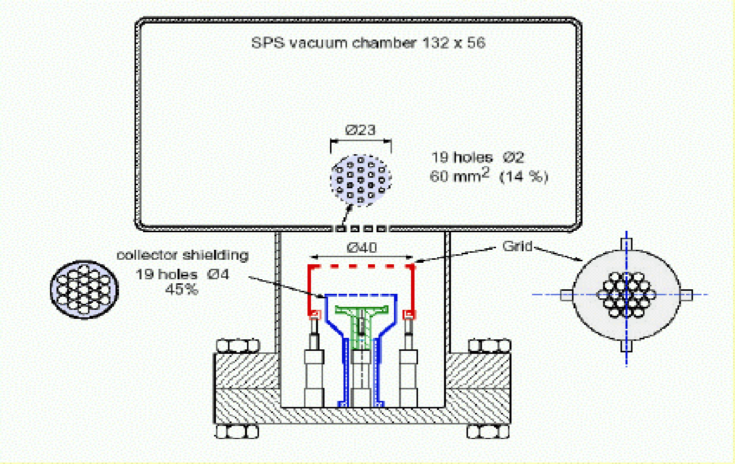


Field free region

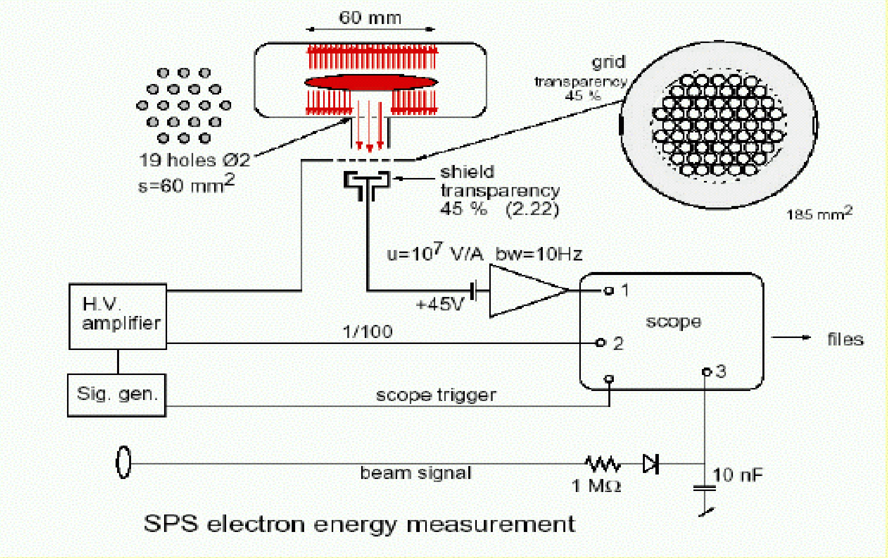


Retarding Field detector

Field free region

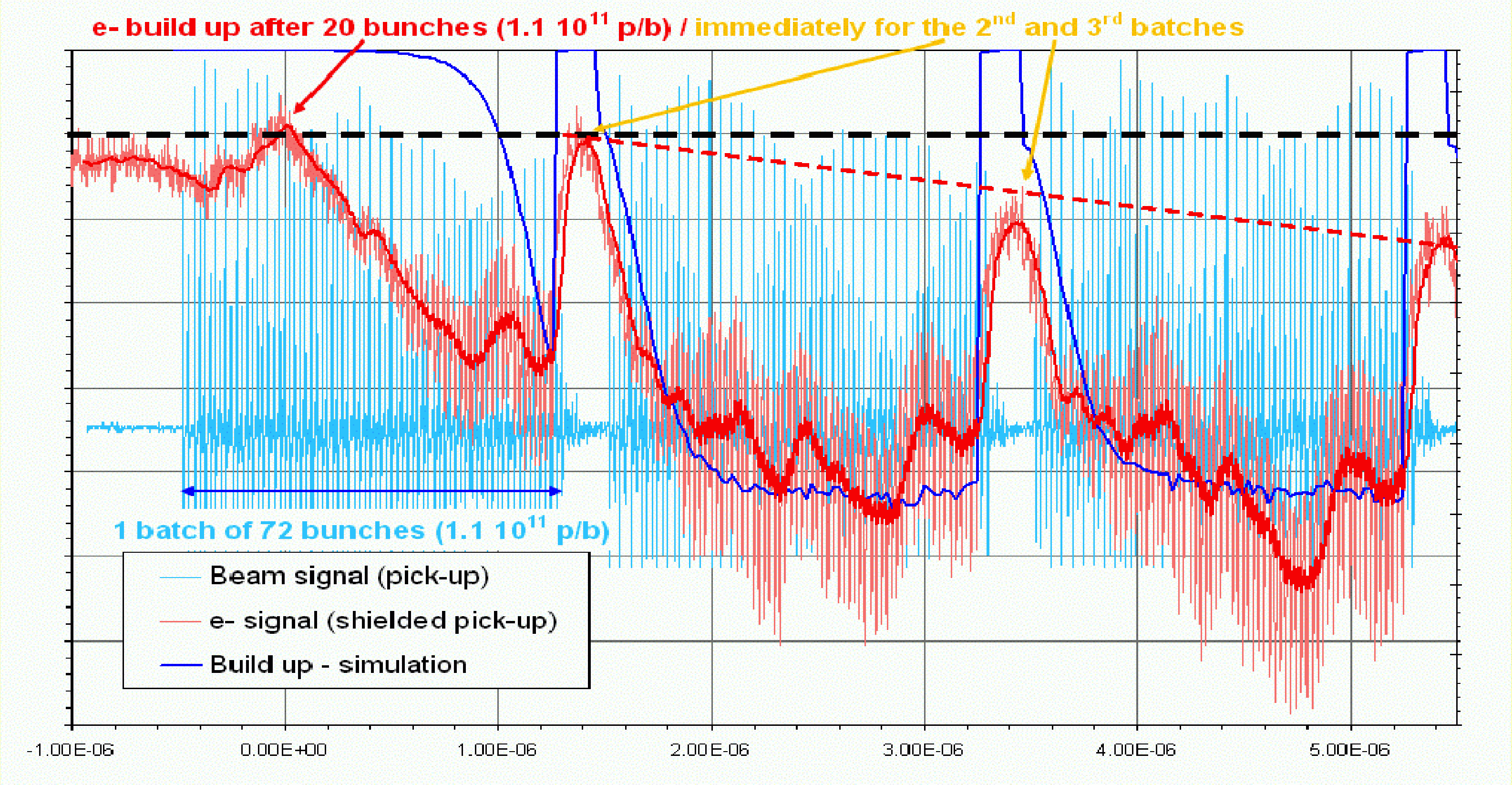


Layout



The voltage on the grid is swept from 0 to 1 kV while the beam is present. The energy spectrum of the electrons can be deduced from the derivative of the collected current versus time.

Electron cloud build up @ 25 ns



- *Dependence on filling pattern (above threshold)*
  - Linear dependence of the collected electron current and heat load with bunch intensity and with number of batches (filling factor)
  - > 550 ns spacing required between batches to decouple the effect of two successive batches on the build up

Scrubbing & Conditioning in COLDEX

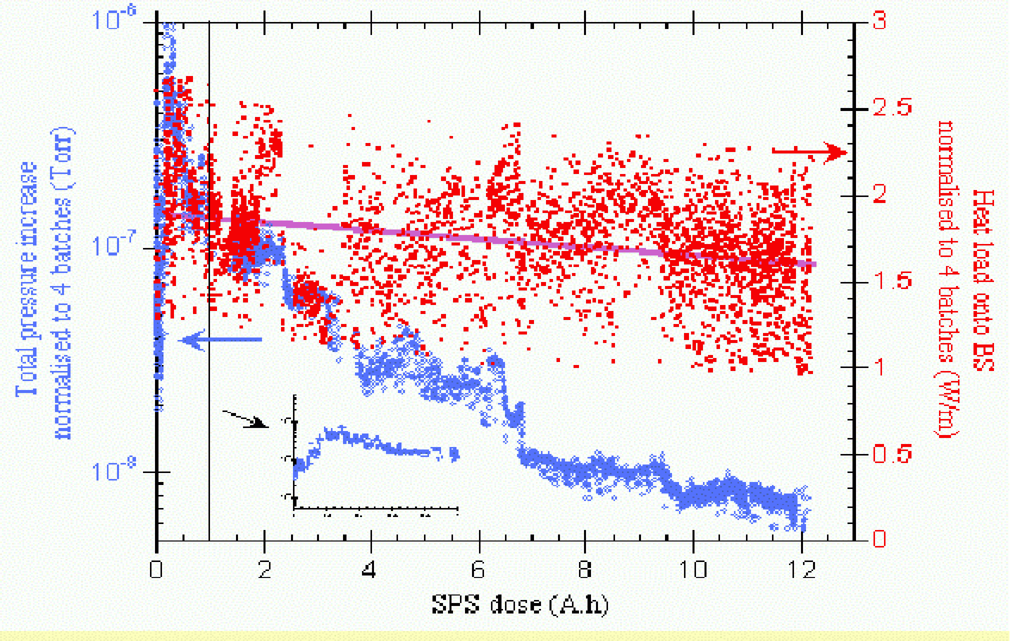
Accelerator
Technology
Department

Experimental difficulties:
Large fluctuations of beam intensity, scatter too large for reliable conclusions

Significant vacuum cleaning is observed:
ΔP drops from 5 10^{-7} to 7 10^{-9} Torr

Slow beam conditioning is observed:
~15 % reduction after 12 Ah
Heat load to beam screen: ~1.5 W/m, proportional to number of batches.
A few monolayers of H_2, CO and CO_2 do not significantly change the deposited heat load

Beam data is normalised to 4 batches of ~1.1 10^{11} p/bunch

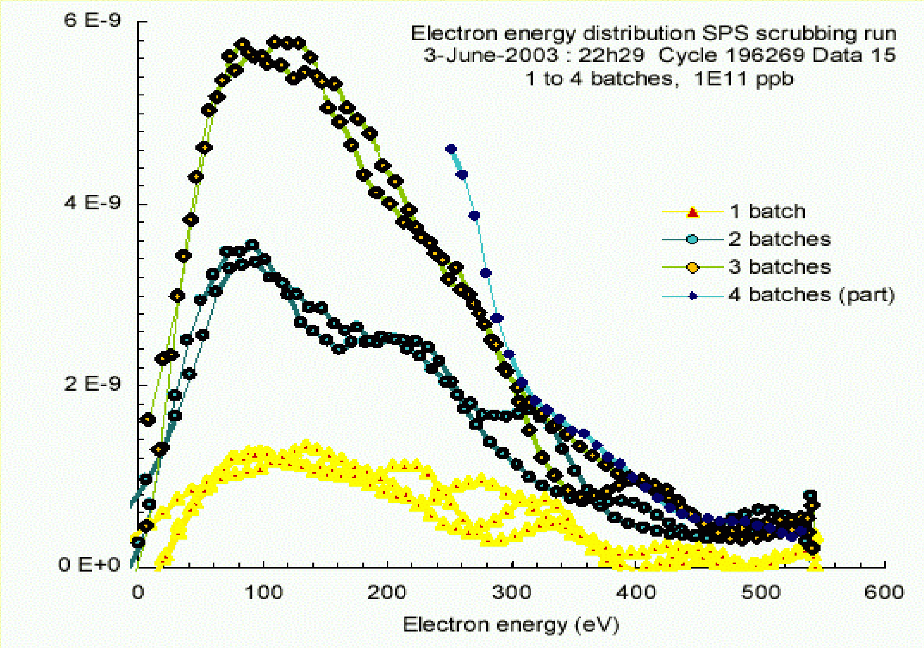


•**But**
Current on pumping slot shield decreases:
$I_{final}/I_{initial} \sim 0.7$

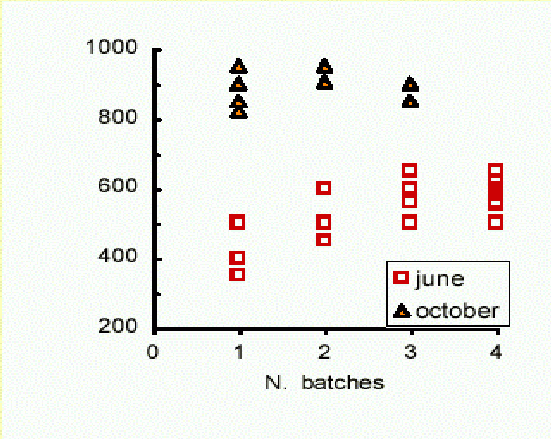
A shift in the energy spectrum of the electrons towards higher energies during the scrubbing run could explain why the heat load does not decrease proportionally to the electron current.

Accelerator Technology Department

Measurements of Electron Energies with the Retarding Field Detector



The increase in current between batch 1 and 2 shows proportionality, the lower value of batch 1 reflects the threshold or "build up" mechanism.

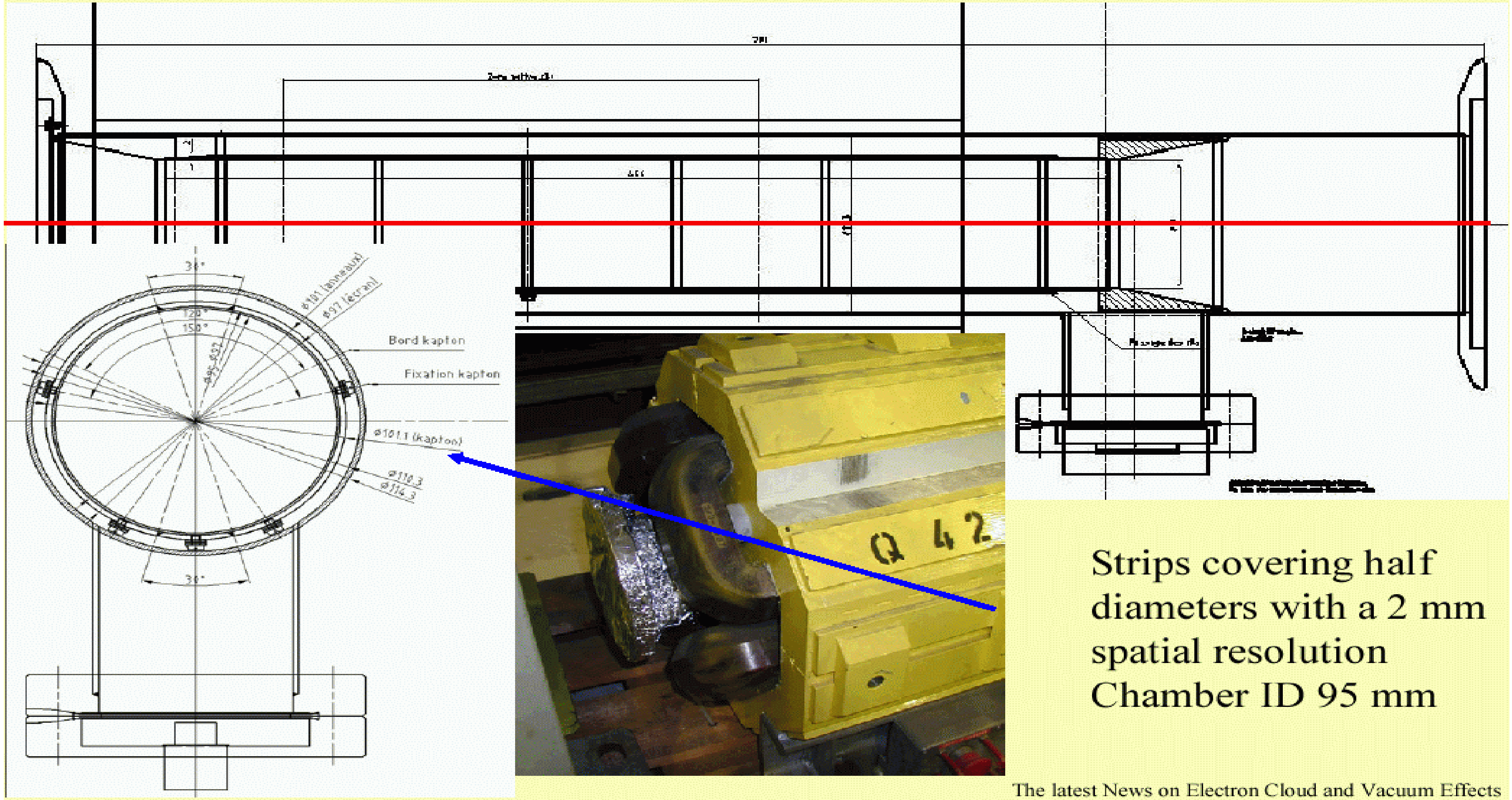


Electrons with energies as high as 900 eV could clearly be observed at RT, which account for a shift of the average energy of the electron spectrum towards higher values.

Accelerator
Technology
Department

News concerning the detectors
Quadrupole Strip Detector

CERN



Strips covering half diameters with a 2 mm spatial resolution
Chamber ID 95 mm

The latest News on Electron Cloud and Vacuum Effects

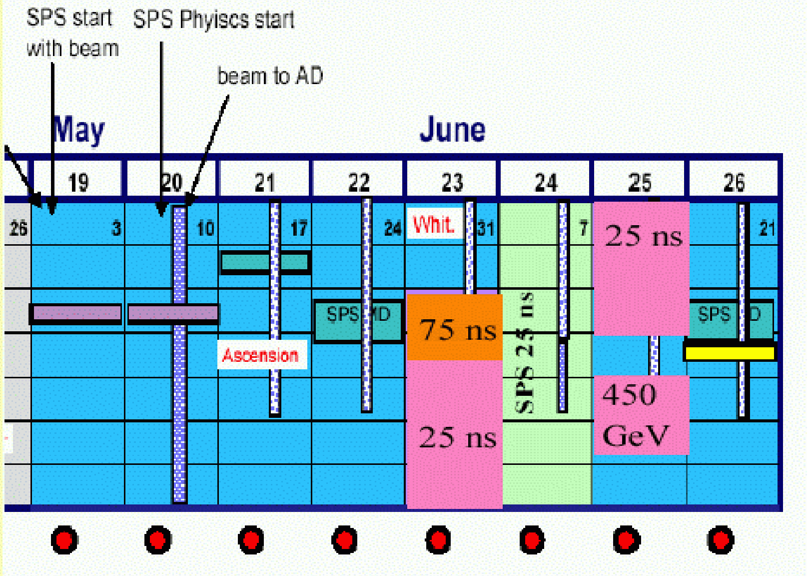
BROOKHAVEN NATIONAL LABORATORY

Proposed Schedule for SPS in 2004

Accelerator Technology Department

- Start with a 75 ns period
  - verify results obtained in 2003, while minimising conditioning
- Run for 3-4 days at 25 ns, with 2 batches so as to avoid problems with injection kickers
  - Measure heat loads
  - Measure electron currents
  - Measure energy distribution
  - Measure e- cloud positions
- *SPS with 25 ns LHC beam (low intensity)*
  - Evaluate results from first run
  - Correct experimental setup if required
- Run for 3 days at 2 to 4 batches
- Ramp to 450 GeV (2 days)
  - Measure dependence upon bunch length

Draft SPS schedule 2004



Beam conditions must be as stable as possible as they play a paramount role in the evaluation of the results. We must be free to choose beam conditions (e.g. intensity)

“Making the Collimation System *Collimate*”

J. Wenninger

World of extreme conditions

Collimation (in)efficiency :

- Collimation in-effiency < 10^{-4}
- Local in-effiency < $2\ 10^{-5}$ / m

> 2 orders of magnitude better than existing machines …

OP must achieve Loss Free Steering on > 4000 *local in-effiency meters* :
3000 BLMs, 1200 dipoles, insertions quads…

Jaw tolerances :

- position < $\sigma/2 - \sigma/3$
- angle < 25-50 μrad

This will be a complex, lengthy and **iterative** tuning job.

- The complexity of the system is also worrying for operation :

Number collimators / beam

	Betatron	Momentum
Primary collimators	4	1
Secondary collimators	16	6

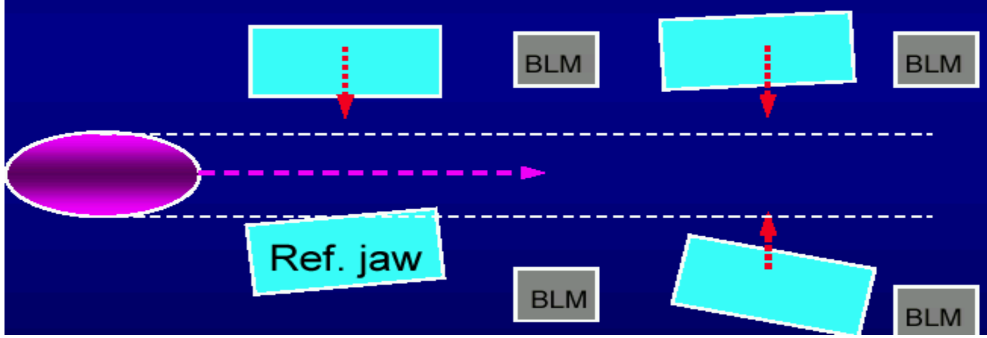
→ > 100 jaws to adjust !

\+ tertiary collimators, injection protection devices, TCDQs…

At LEP 4 polarization knobs were just manageable … in 24 hours !

Align jaw by jaw (like B. Jeanneret @ Sp$\bar{p}$S, LEP & elsewhere) :

a) Select a reference jaw → primary aperture n1 (with some error).
b) Move in opposite jaw until it becomes the primary aperture.
c) Repeat for all jaws…



- ✓ Collimator center wrt beam.
- ✓ Cross-calibration of the collimator openings → optics.
- ✓ Position secondary by scaling the opening n2/n1.
- ✓ Minimum 'external' information.

Official injection scenarios specify filling times of ≈ 15 minutes.

This leaves at best a couple of minutes for collimation @ injection :

- Coll. protect cold aperture → no freedom for big changes.
- The machine must be sufficiently reproducibility to maintain FIXED settings.
  → acceptable ε range, β-beat must be reproducible.
- Orbit feedback must maintain a constant reference orbit !
  Orbit corrections / changes affecting the cleaning section require a re-adjustment of the jaws that are affected.

→ we have similar time constraints at top energy, for the squeeze…