EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
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CERN - PS DIVISION

PS/ BD/ Note 99-16 (Tech.)

BEAM MEASUREMENT SYSTEMS FOR THE ANTIPROTON DECELERATOR

Edited by V. Chohan

Abstract

A Special Technical Meeting was held on 1-Dec-99 to present the different beam measurement and diagnostics systems that have been developed and used for the commissioning of the Antiproton Decelerator (AD). Particular emphasis was placed on the requirements for the AD, proposed and implemented solution as well as the limits encountered to date. The meeting was intended to expose the particular problem areas and the related future work. The time allocations for some of the items in the Agenda of the Meeting partly reflected these concerns. This document is a collection of all the work presented at this meeting.

Geneva, Switzerland
10 December 1999

Agenda of the special Technical Meeting held on 1, Dec. 1999

Beam Measurement Systems for the Antiproton Decelerator

Wednesday, 1 Dec 1999 at 0900 hrs. : PS Auditorium

After a general introduction, various systems specialists from the BD group will elucidate on the development of their particular measurement systems used in commissioning the AD to date. Particular emphasis will be placed on the requirements for the AD, proposed and implemented solution and the problems as well as the limits encountered to date. The meeting is intended for the members of the BD group and other interested persons.

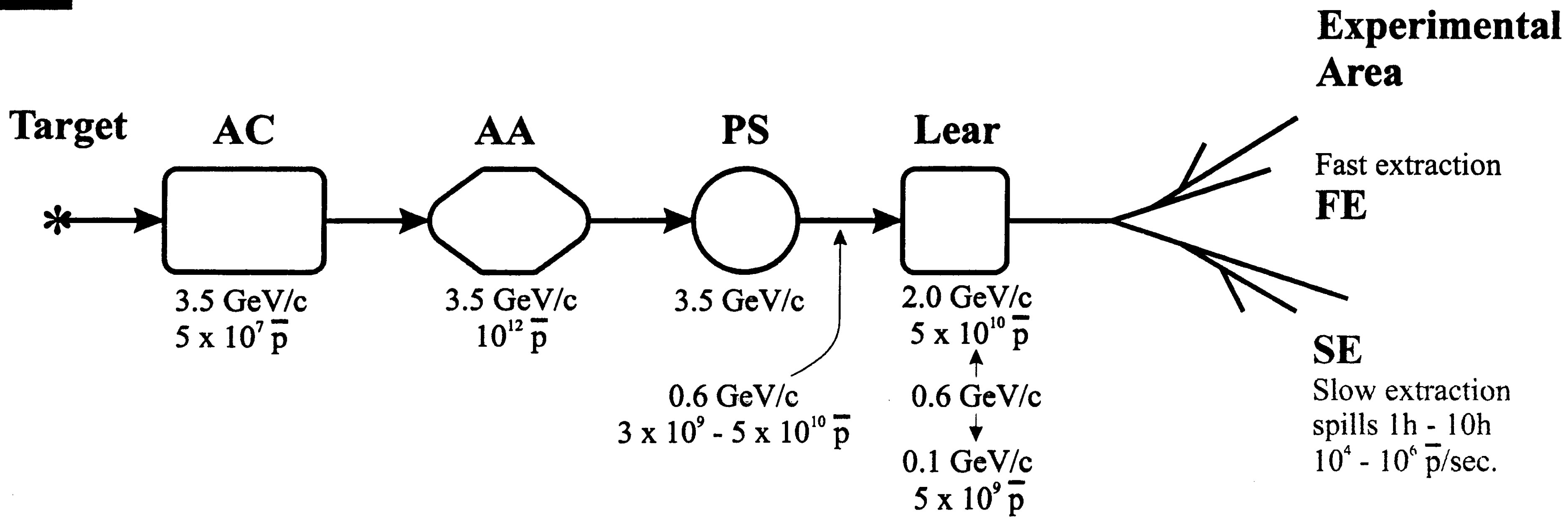
- General: A Brief Introduction to the Antiproton Decelerator : Beam Measurement Systems as planned in 1996-97 : Fast Beam Current Transformers & Scintillator Screens :	V.Chohan	7'
- DC Beam Current Measurements :	P Odier	5'
- The AD Closed Orbit System:	L.Soby	15'
- Digitzers & Injection Coherent Oscillations:	M.Ludwig	5'
- Transverse Scrapers & use for measurements	V.Chohan	5'
- New Schottky PickUp (H,V,L)	O. Marqversen	20'
- DRX/DSP based System for Schottky Signal Analyses:	ME Angoletta	15'
- Diagnostics using the modified old Schottky PickUp(42MHz) as well as the New Longitudinal Schottky PickUp	G.Tranquille	15'
- BIPM & Wire Chambers in the beam lines	G.Molinari	7'
- DRFQ Diagnostics	V.Prieto	5'

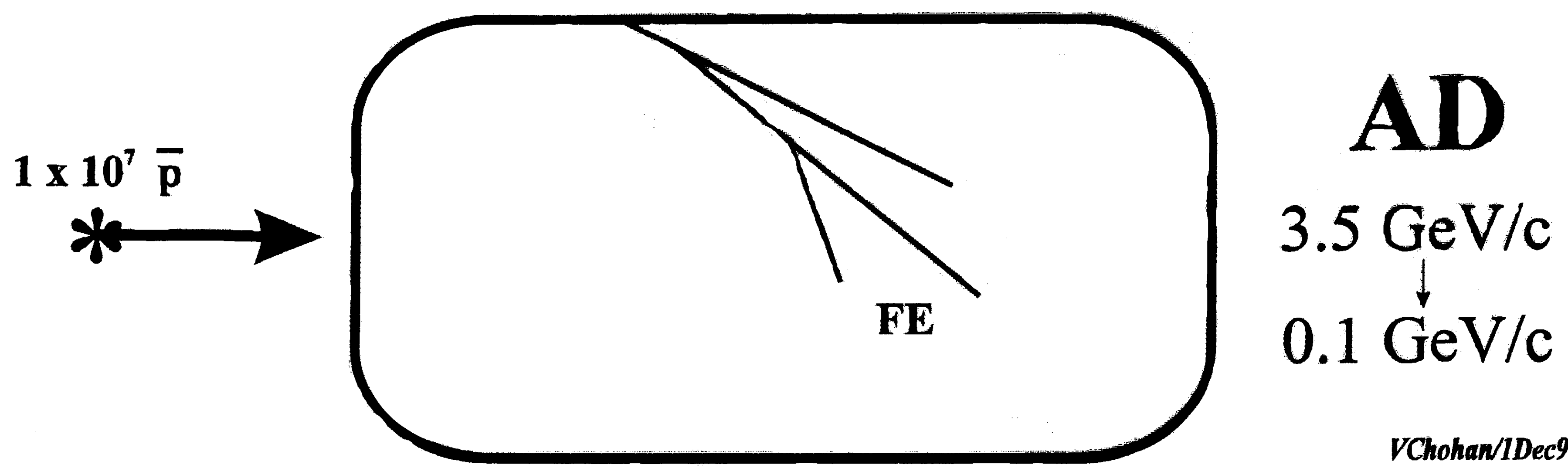
The Antiproton Decelerator :

A Brief Introduction

V. Chohan

Simplified Antiproton Facility





VChohan/1Dec99

A

In General:

- AD will provide at 100 MeV/c (5 MeV kinetic energy) bursts of $10^7\ \bar{p}$/minute, 200 to 500ns long

- In 1999 :
  AD Commissioning

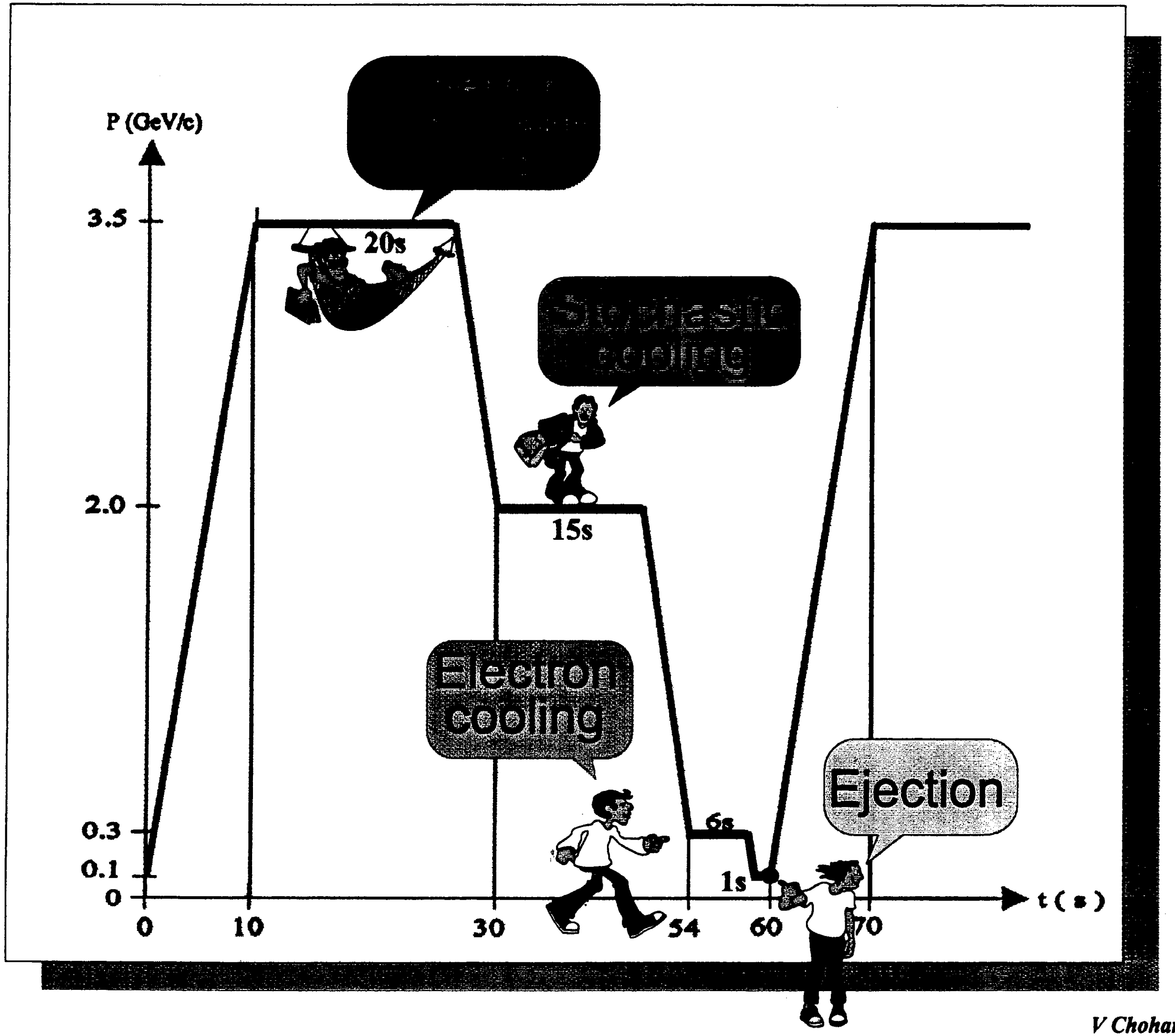
- from ~ May 2000 to 2005 (?) :
  Antiproton Physics

Further machine information from: CERN/PS 96-43(AR [Design Study] Including details of Beam Instrumentatio Systems foreseen

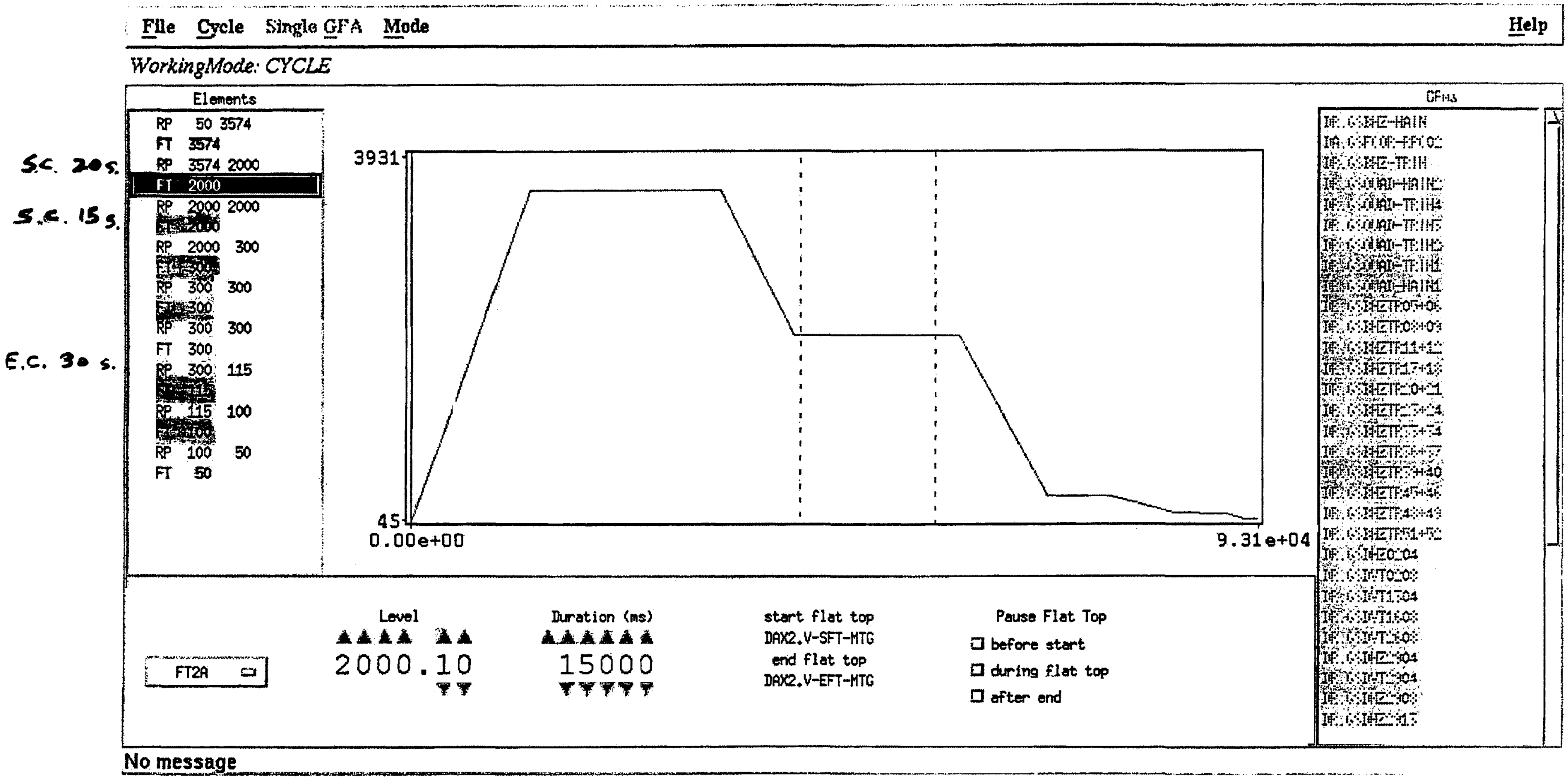
V.Chohan/1Dec99

Basic AD Deceleration Cycle

(Schematic form as planned in the Design Report)



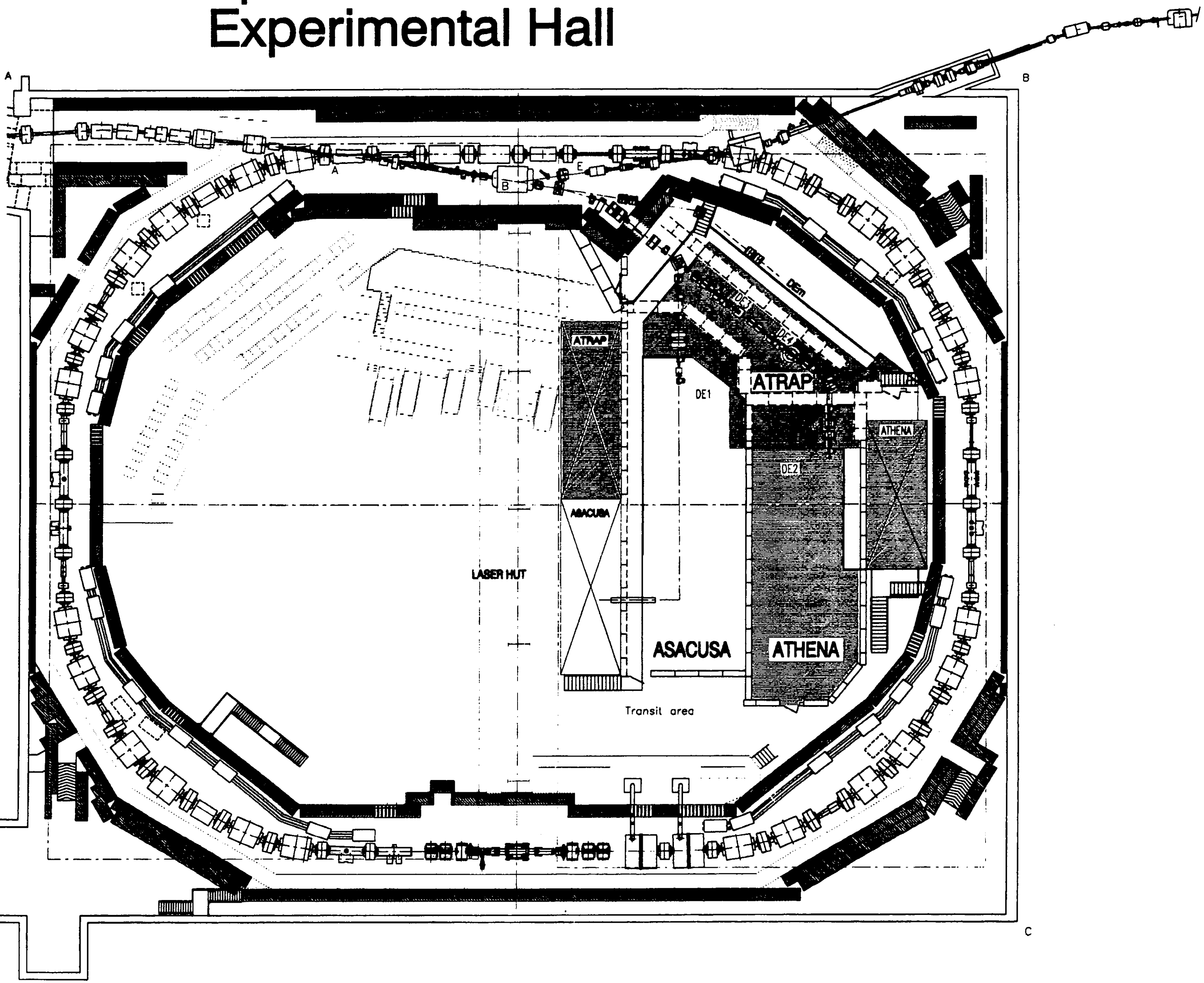
In reality: TYPICAL AD CYCLE WITH MULTIPLE PLATEAUX (FT's)



Cycle length ~ Variable > 100 sec ($\bar{p}$ operation)
So, have to wait multiples of supercycles (14.4 sec, 19.2 sec)
to make certain measurements.

Chohan/1/12/99

Antiproton Decelerator Experimental Hall



PS/PO 1541

AD Beam Measurement Systems as planned in 1996-1997

V. Chohan

AD Devices- what was foreseen in 1997(see date below) for installation/modifications

- **Fast Transformers**
  - TRAs 9012,9053,6006,5302
  - suppress 8006 (close enough to 8084) unless strong objections
  - TRA7044 + 2 (3) more to be equipped with new electronics (Rubbia T7 style) to m'sure low intensities (experimental attempt)
  - OB Names List needs correction/update
  - PS Standard EM "TRAFO" with MPV908
- **DC Transformer**
  - Timing Details & Specs review : PS 2.4 sec vs. AD 60 sec
  - M'ment every 20 msec good enough? Need precise time points in cycle ? Etc
  - PS Standard "TRAFO" with ICV196 or similar
- **Orbit Pickups**
  - Under Design; Network Analyser HPIB control etc

AD Devices- what was foreseen in 1997(see date below) for installation/modifications

- **MTV Screens**
  - re-Check OB names & numbers & location
  - Standard PS installation & EM "MTV"
  - hopefully no problems on ACR & MCR visualisation
- **Scrapers**
  - SHV1305 : 4 blades ;
  - standard new-type PS installation with EM "STEP"
- **Fast Digitizers for Inj. Coh. Osc.**
  - Provide same functionality as in AAC with CAMAC modules driven thro' VME and EM access "DGTZ"

AD :

- Fast Beam Current Transformers

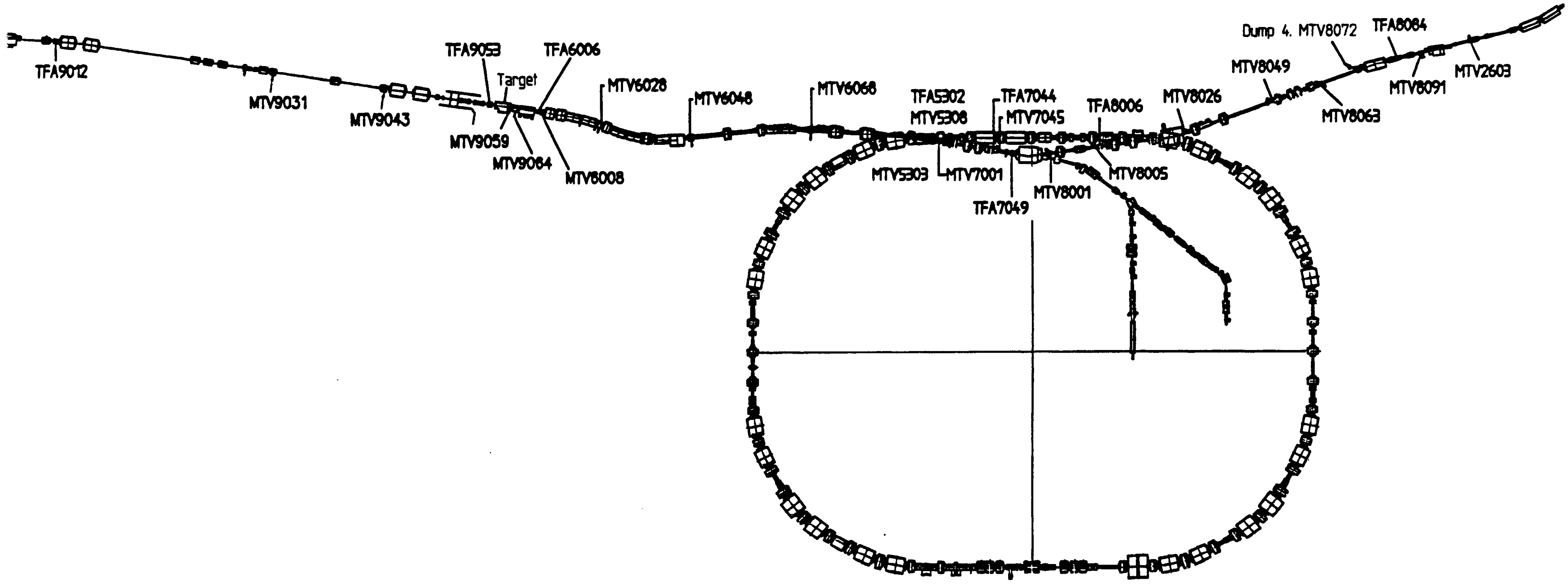
- Scintillator Screens for beam observation

V. Chohan

Layout in AD of MTV Stations & Fast Beam Current Transformers

The MTV were integrated into the new VME based controls like in other PS Accelerators; however, a special local(ACR) usage application had to be developed.
The fast BCT's needed new interfacing for integration into the new VME based systems using standardized Integrators and ADC's

- ***Total : 18 Scintillator Screens - MTV Stations***
  : 8 Fast Beam Current Transformers



1 Dec 1999

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AD MTV Stations

- *Total :18 Scintillator Screens - MTV Stations*
  - **2 in Ring : MTV5303 {stopper }, MTV5308 { AC Inj }**
  - **6 in Loop Line(8000): MTVs 8091, 8063, 8049, 8026, 8005, 8001**
  - **2 in DE Line(7000) : MTVs 7001, 7045**
  - **4 After Target (6000): MTVs 6008, 6028, 6048, 6068**
  - **3 Before Target(9000): MTVs 9031 9043, 9059**
  - **1 Target Screen: MTV9064 (no in/out)**

AD Fast Beam Current Transformers

- *Total : 8 Fast BCTs*
  - **1 in Loop Line(8000) Before D4 for protons via loop: TFA8084**
  - **1 in Loop Line(8000) After D4 for Protons via loop: TFA8006**
  - **2 in DE Line(7000)**
    - **for protons : TFA7044 and**
    - **for pbars Ejected :TFA7049 (not yet available)**
  - **1 Just Before AD pbar Injection: TFA5302** (sees pions rather than antiprotons)
  - **1 After Target line(6000): TFA6006 (for reverse proton Inj)**
  - **2 in Before Target line(9000) for Proton Prod. Beam: TFAs 9012 , 9053**

DC Beam Current Measurements

P. Odier

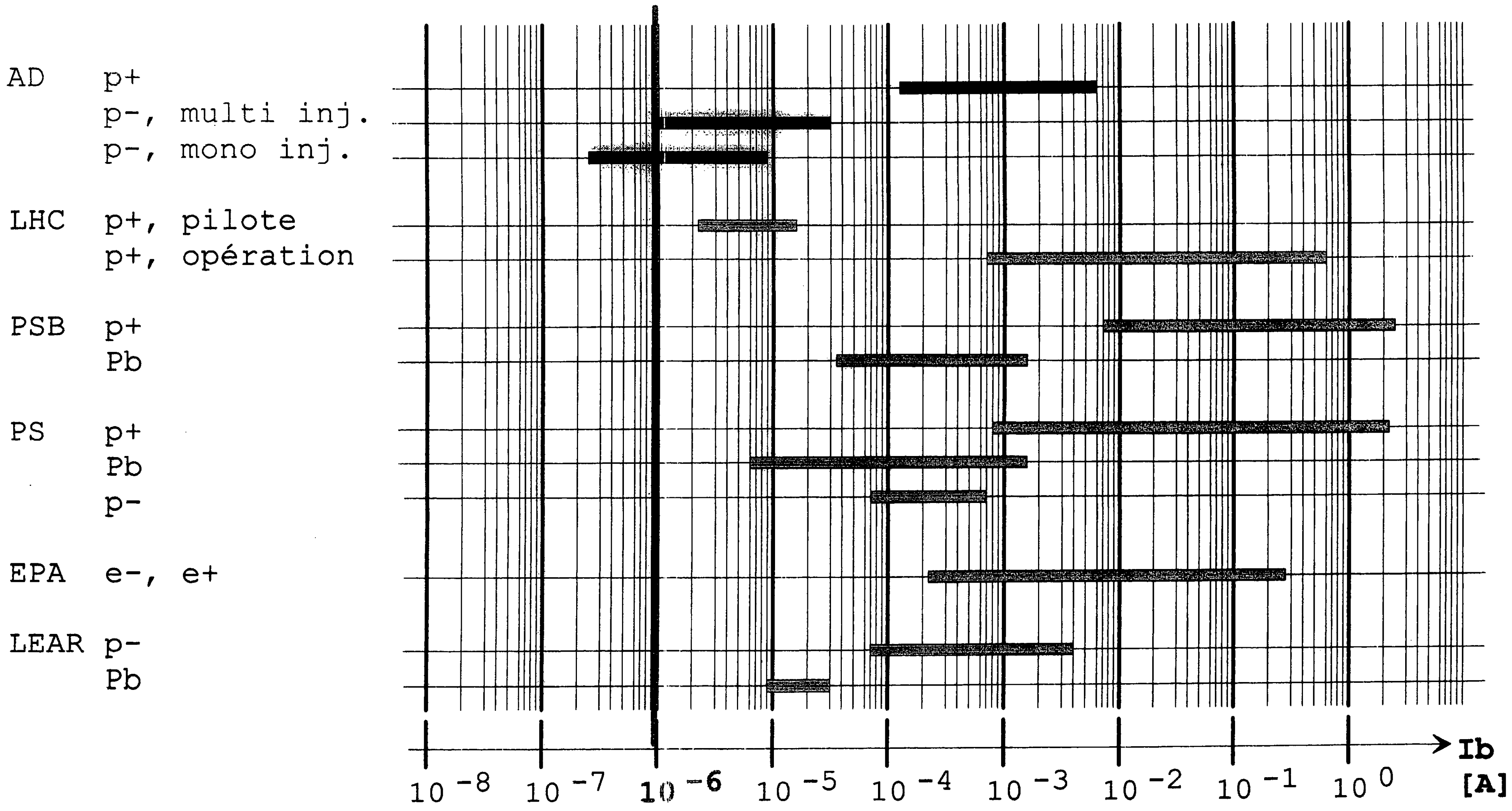
La mesure du courant dc circulant dans AD

- Nouveautés depuis AC et actions entreprises
- Ordre de grandeur des courants en jeu
- Schéma bloc du transformateur dc
- Description sommaire du système d'acquisition
- Aperçu des résultats obtenus
- Performances actuelles et améliorations envisagées

Nouveautés depuis AC et actions entreprises

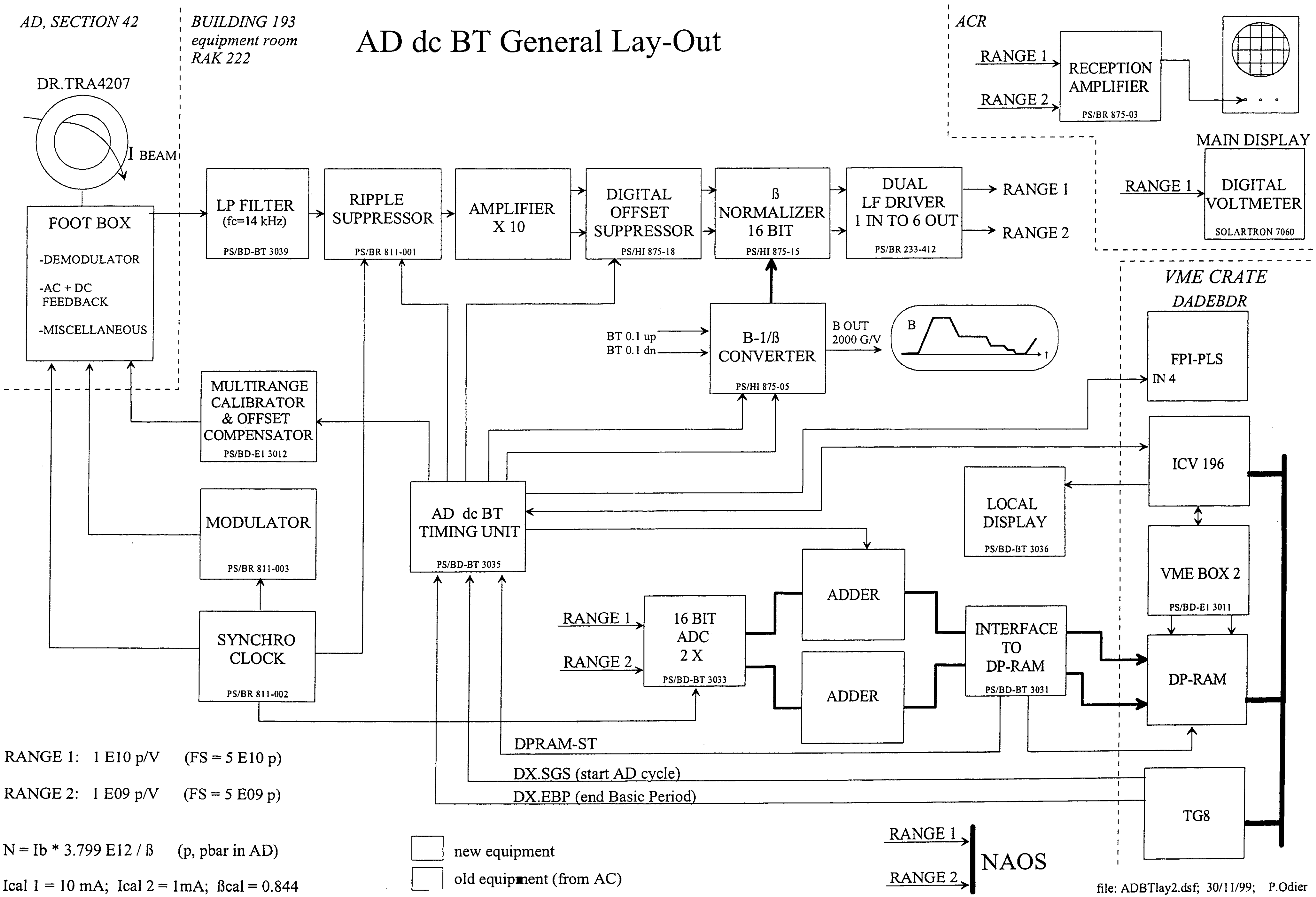
décélération du faisceau 1 > ß > 0.1	normalisation en ß • basée sur B
très faible courant de faisceau • nombre de pbar petit • ß petit	deuxième gamme de mesure
nouveau système de contrôle • "standard" PS, réseau • VME	nouveau programme d'acquisition • tâche temps réel spécifique • *equipment module* standard

Ordre de grandeur des intensités moyennes des faisceaux circulant dans les accélérateurs au CERN



file:log2.dsf 25/11/99 P.Odier

AD dc BT General Lay-Out



RANGE 1: 1 E10 p/V (FS = 5 E10 p)

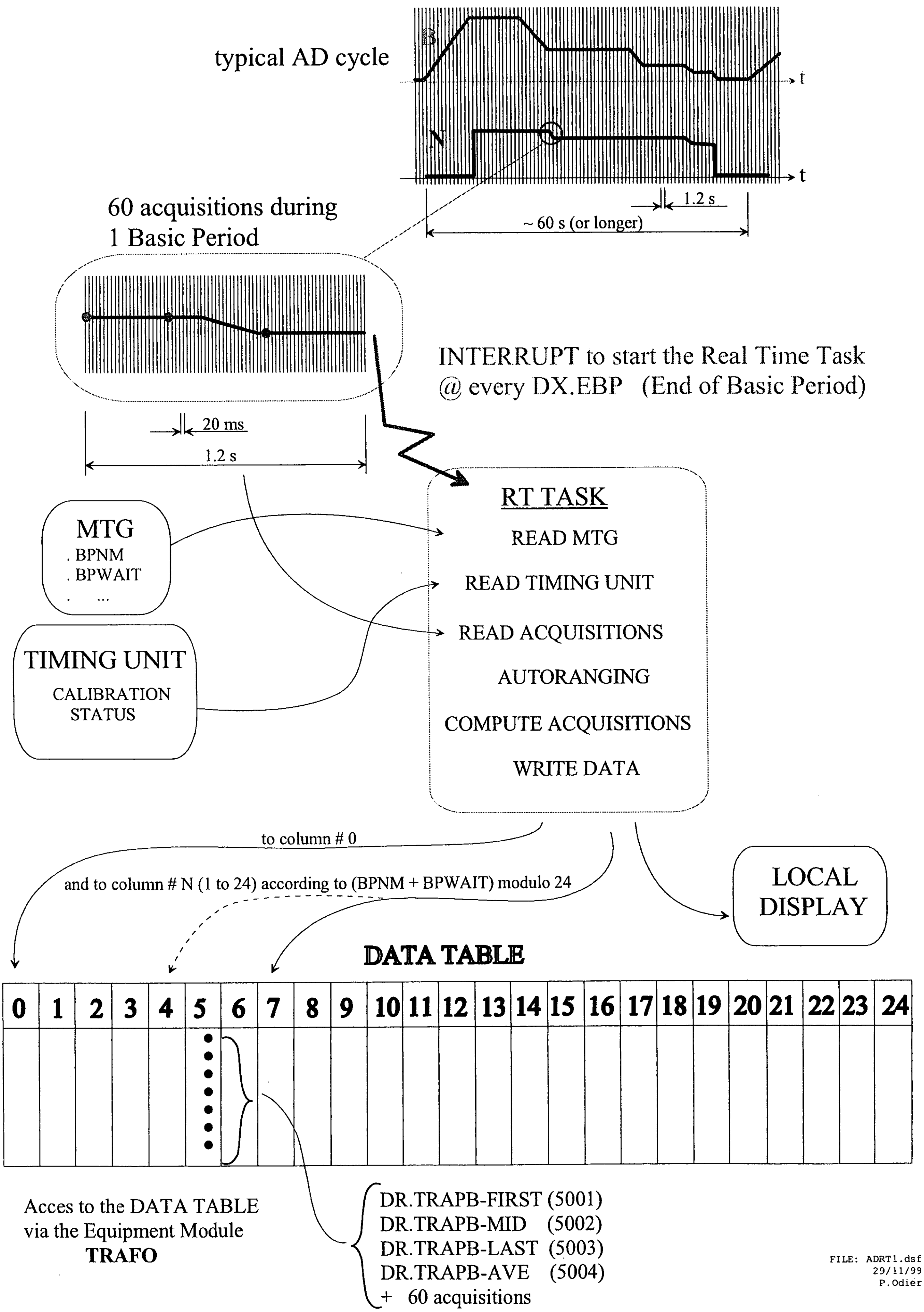
RANGE 2: 1 E09 p/V (FS = 5 E09 p)

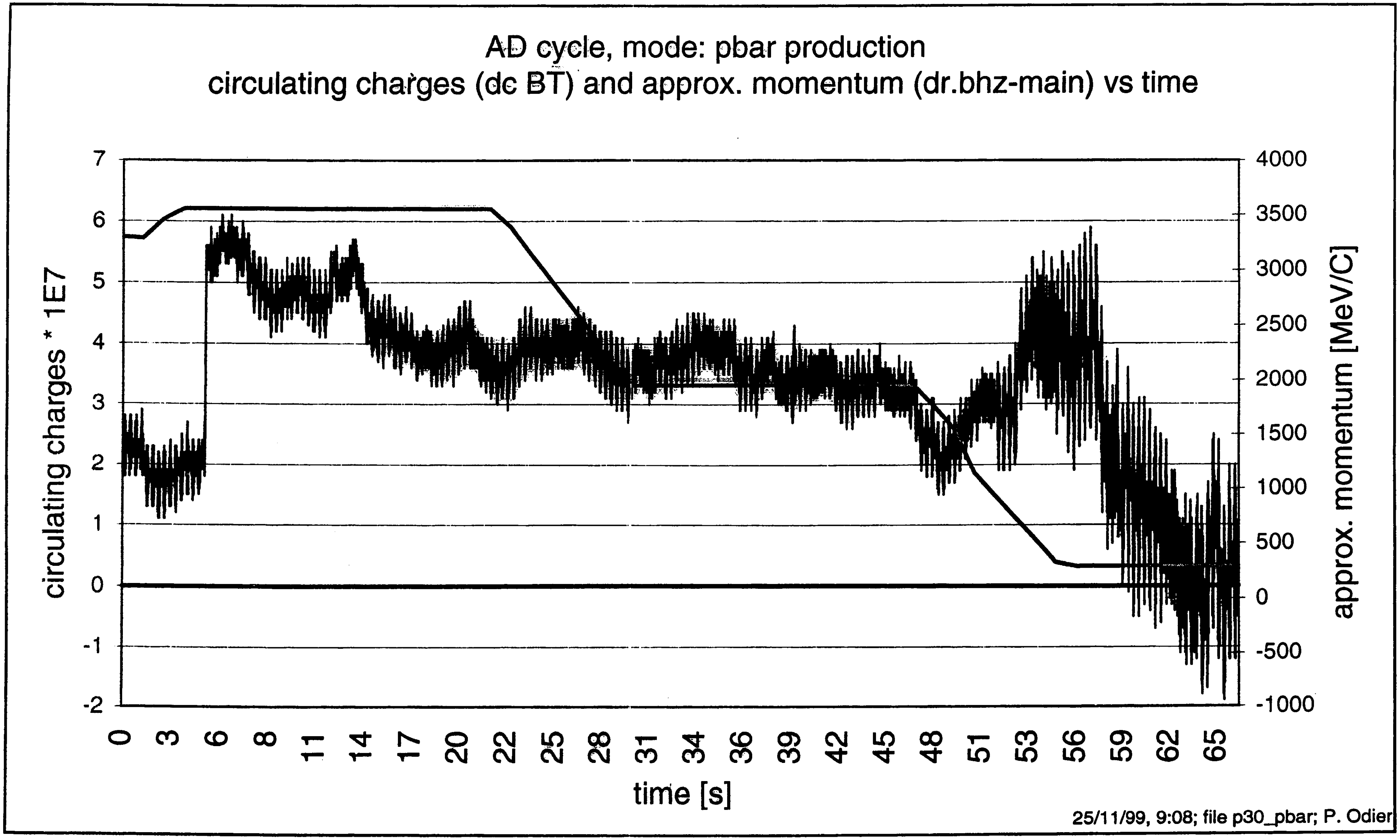
N = Ib * 3.799 E12 / ß (p, pbar in AD)

Ical 1 = 10 mA; Ical 2 = 1mA; ßcal = 0.844

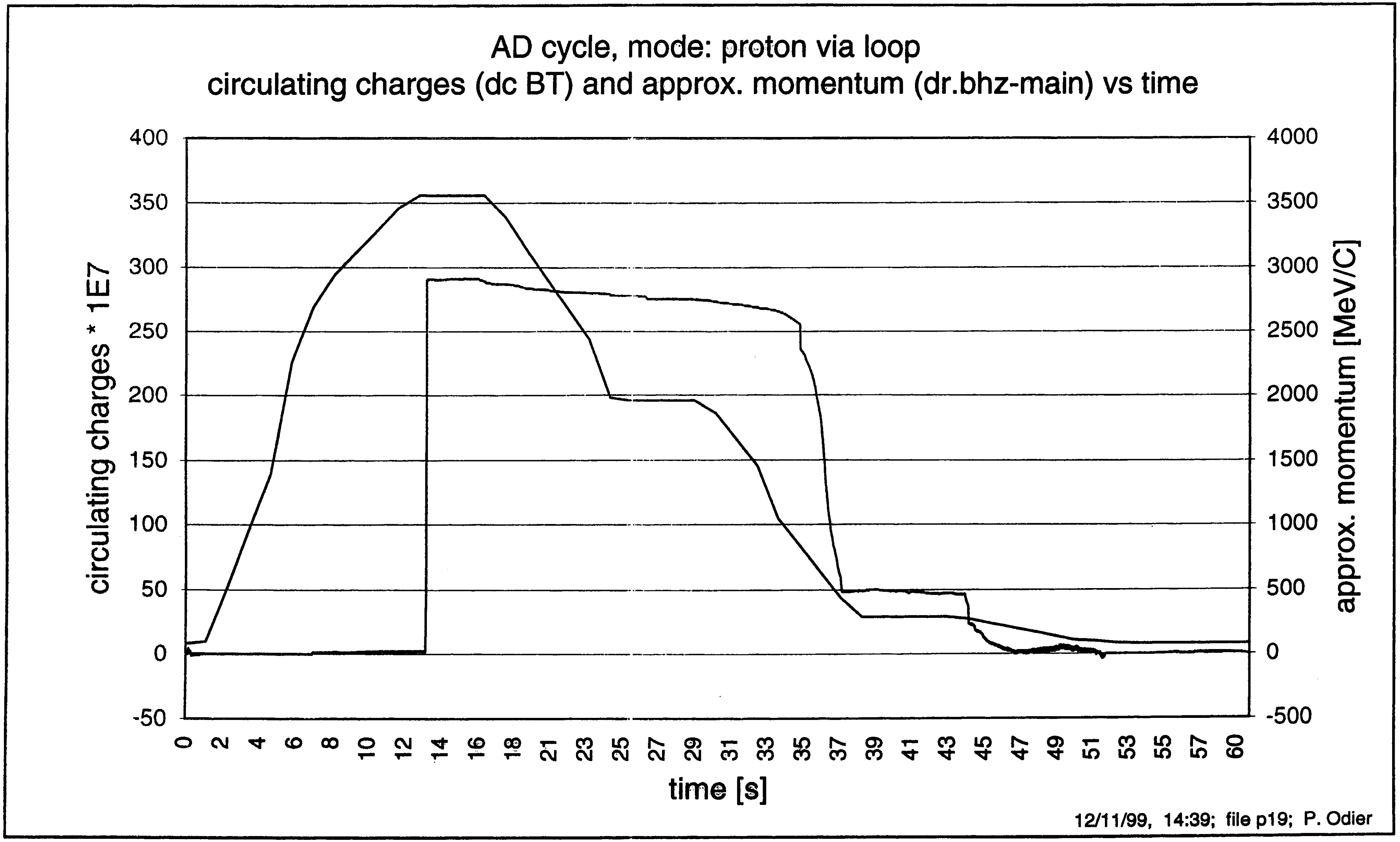
file: ADBTlay2.dsf; 30/11/99; P.Odier

AD dc BEAM TRANSFORMER ACQUISITION





AD cycle, mode: pbar production
circulating charges (dc BT) and approx. momentum (dr.bhz-main) vs time
circulating charges * 1E7
approx. momentum [MeV/C]
time [s]
7
6
5
4
3
2
1
0
-1
-2
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
0 3 6 8 11 14 17 20 22 25 28 31 34 36 39 42 45 48 51 53 56 59 62 65
25/11/99, 9:08; file p30_pbar; P. Odier


AD cycle, mode: proton via loop
circulating charges (dc BT) and approx. momentum (dr.bhz-main) vs time
circulating charges * 1E7
400
350
300
250
200
150
100
50
0
-50
approx. momentum [MeV/C]
4000
3500
3000
2500
2000
1500
1000
500
0
-500
0 2 4 6 8 10 12 14 16 18 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 60
time [s]
12/11/99, 14:39; file p19; P. Odier

Performances actuelles

Limitées par le bruit basse fréquence crête-crête observé à 3.5 GeV/V:

2 à 3 10^7 charges (10 fois plus à 100 MeV/C !)

correspond à un courant rms de: 1 à 1.5 µA

Améliorations envisagées

1. modification du matériel hérité de AC (*FOOT BOX, MODULATOR*, ...)
   - réduction espérée du bruit basse fréquence: facteur 2

2. mode multi-injection
   - nombre de charges augmenté d'un facteur 3 (1 E8 charges)

1+2. > rapport signal/bruit: 10 à 3.5 GeV/C (1 à 100 MeV/C)

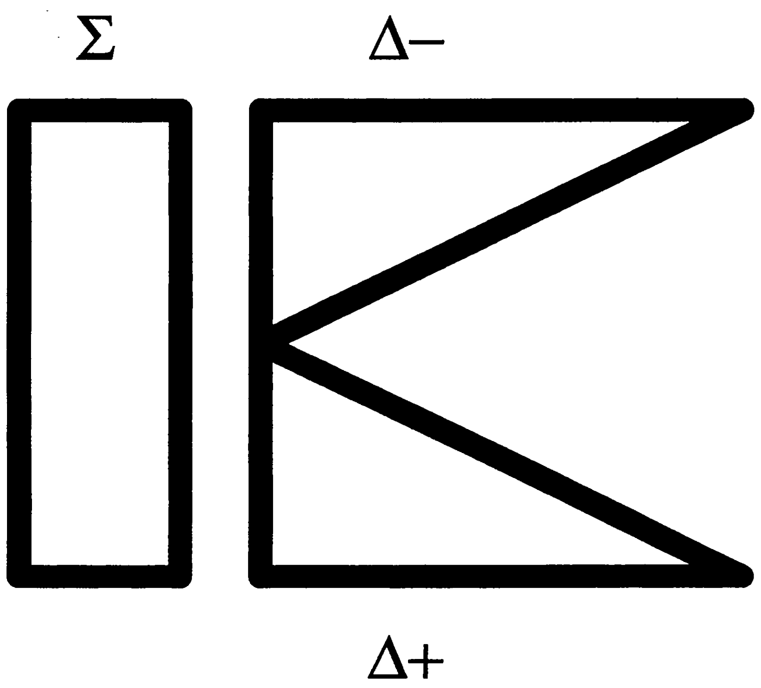
Closed Orbit Measurement System

L. SØBY

AD Closed Orbit measurement system.

- Beam parameters and objectives.
- PUs and signals.
- Low noise amplifier.
- The analog signal chain.
- The network analyzer.
- Derivation of position.
- Performance.
- Future improvements.

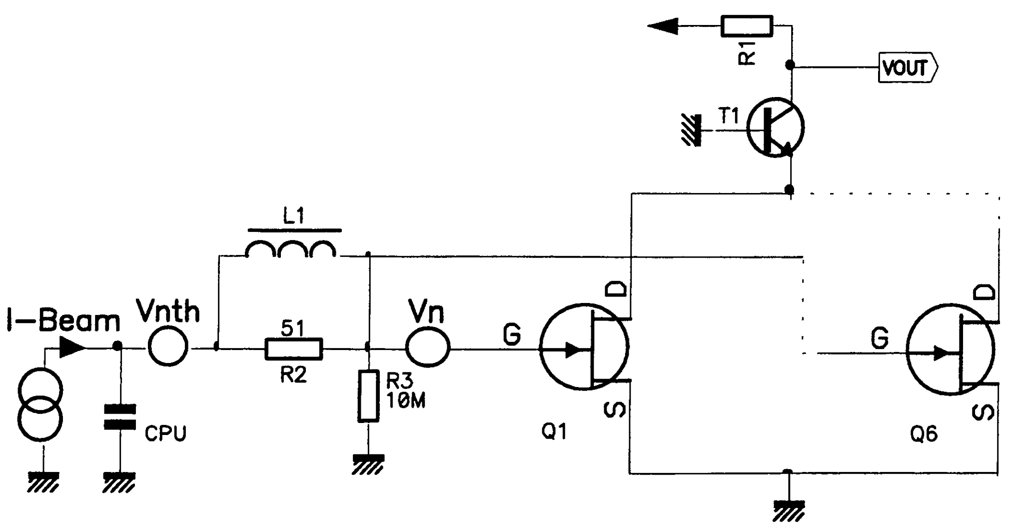
PUs and signals

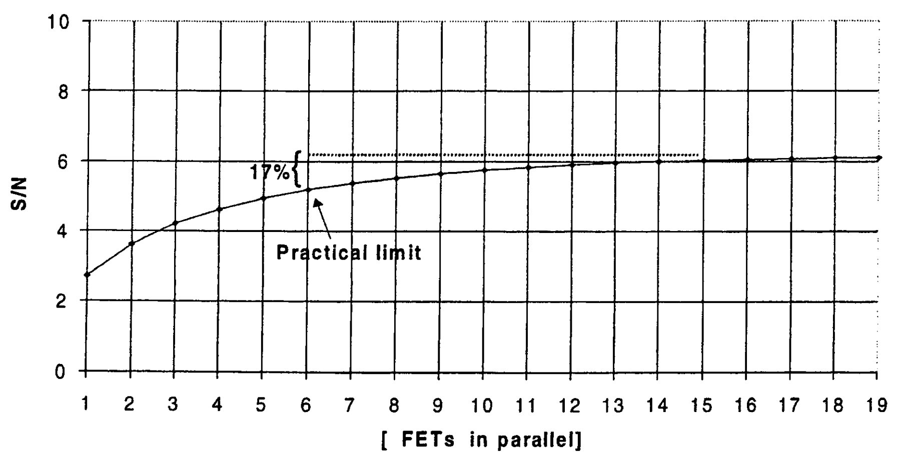


- **Σ and Δ- Electrodes:**
  - $V_{Min.} = 4\mu V$
  - $V_{Max.} = 80mV$
- **Δ - Signal:**
  - Min. : 100nV / mm
  - Max. : 2mV / mm
- **Δ / Σ:**

  Gives the intensity independent beam position.

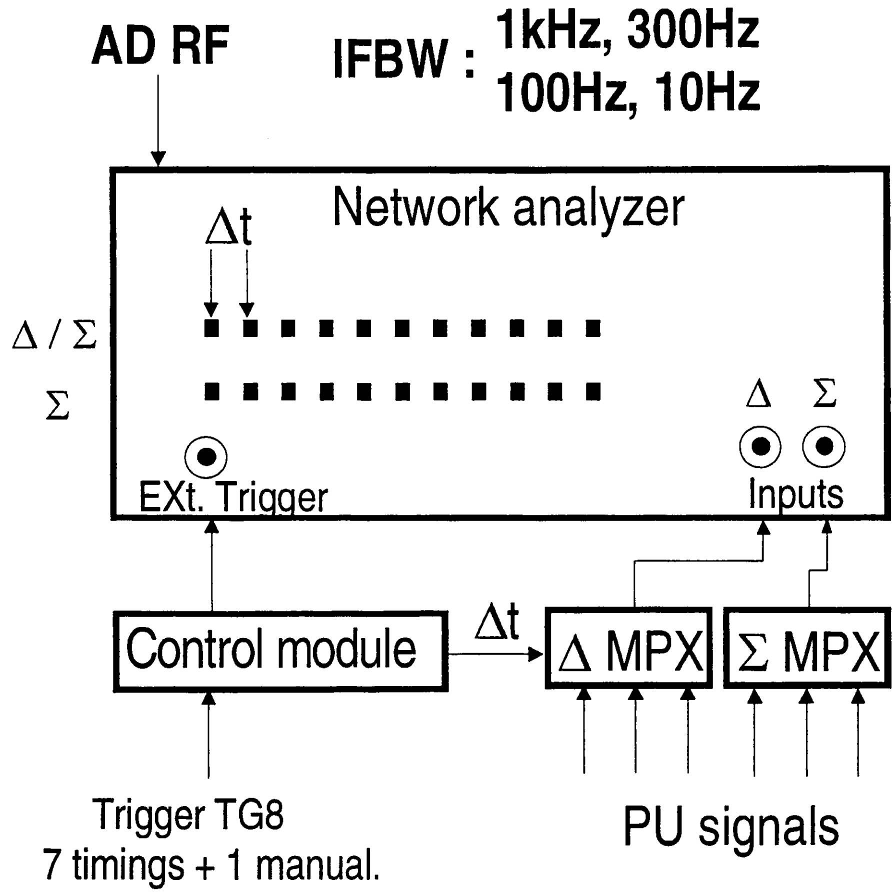
Low noise head Amplifier





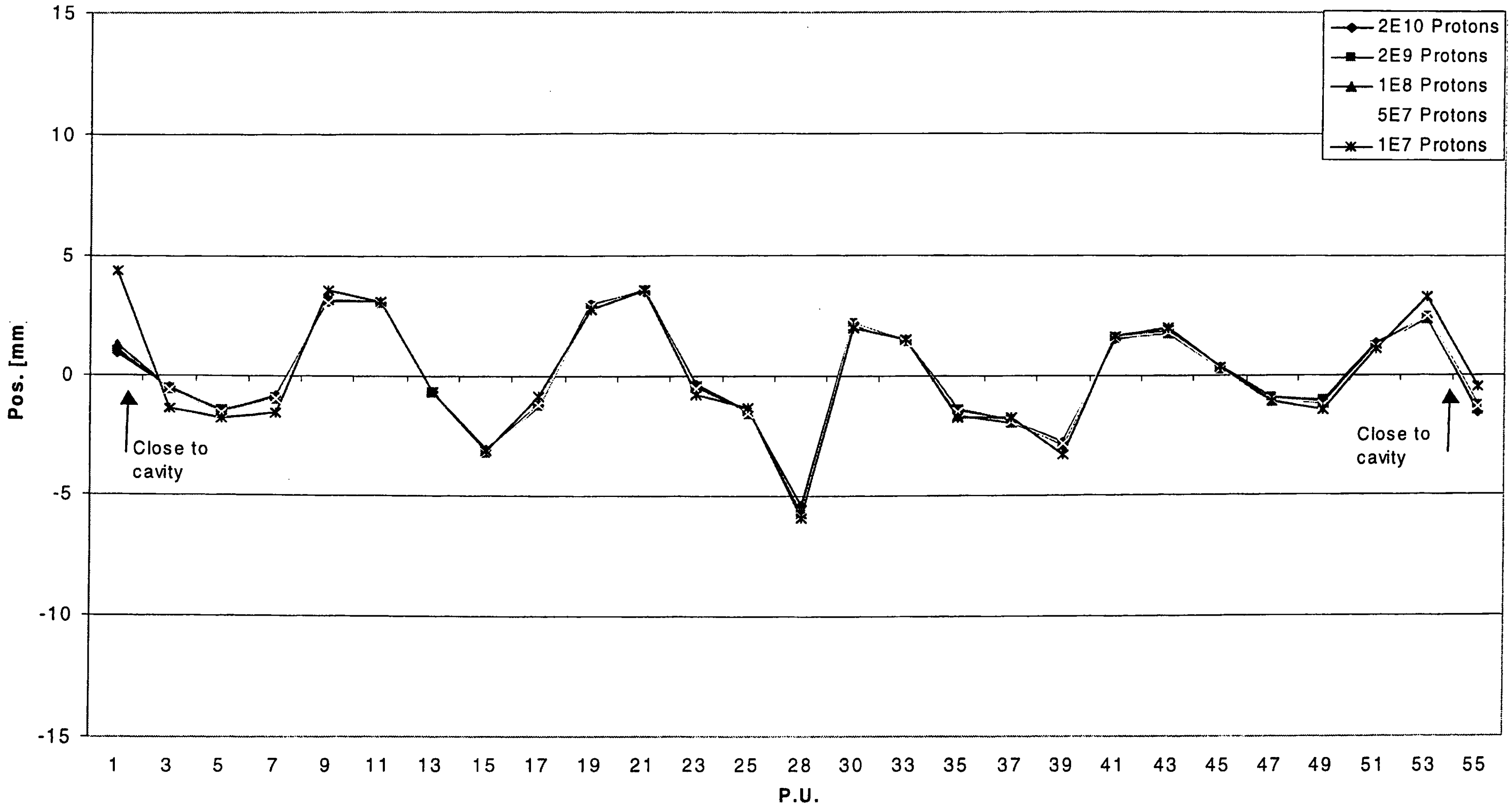
- The input voltage noise goes down with the sqrt. of paralleled FETs.
- The current noise increases linearly.
- The input capacitance increases linearly.
- An optimum S/N can be found, but the practical limit is lower.
- The input line is properly terminated if the input capacitance is high.

The network analyzer



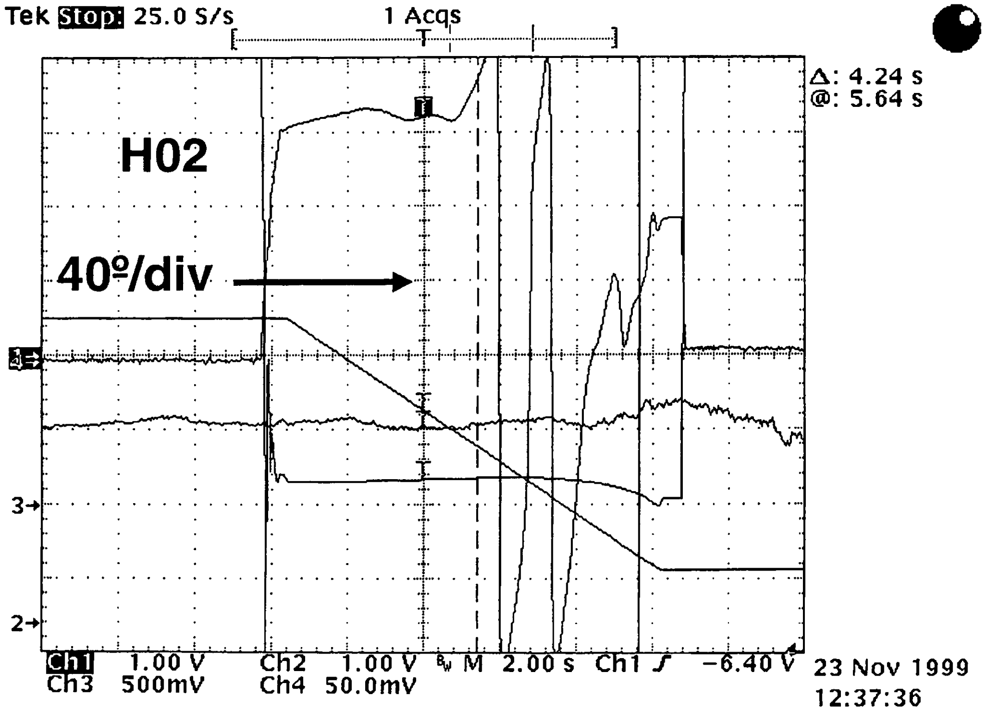
- Used as a tracking filter, locked onto the RF of the AD.
- It is used in a CW-time mode, where the sweep time (Δt) is determined by the NB. Of points (101) and the IFBW.
- The Control module increments the MPX channels at exactly the same rate (Δt) as the network analyzer.
- A sync signal of known amplitude is used to verify the synchronization of the control module and the network analyzer.

Performance



AD Closed Orbit measurement system.

Performance



- Very bad PU close to the cavity.
- The big phase excursion indicates an induced RF noise much bigger than the beam signal.

Digitizers and Coherent Oscillations

M. Ludwig

Digitizers and Coherent Oscillations

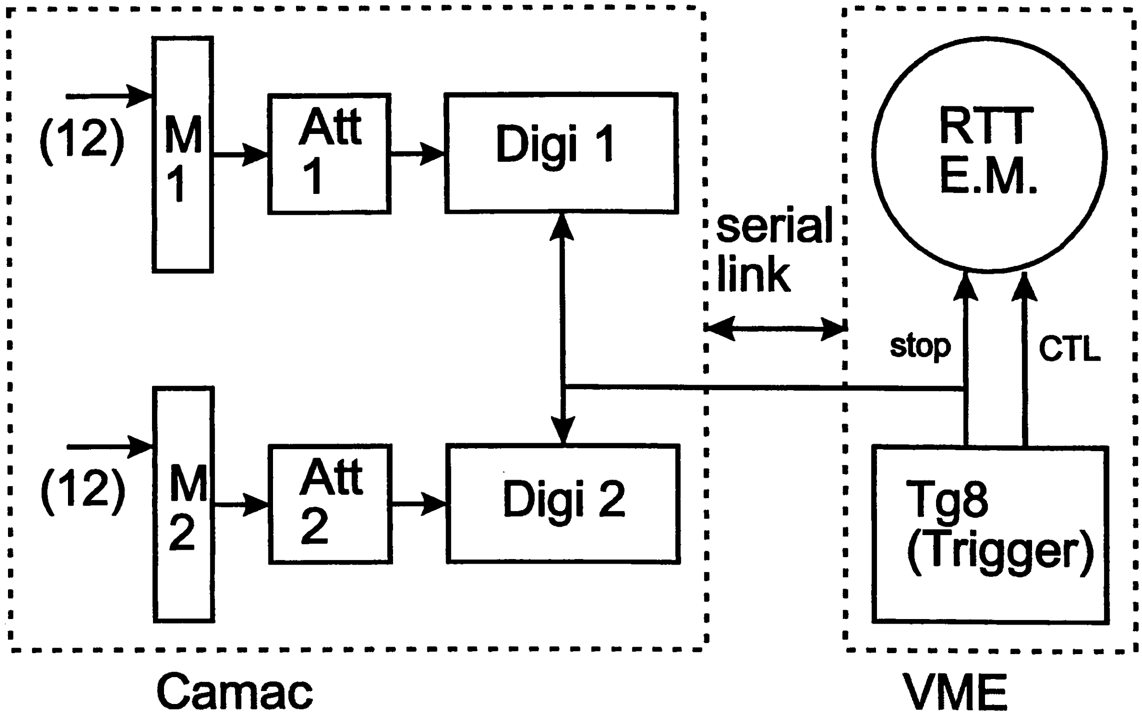
What was intended

- Measure transversal beam positions at a ΔPU over many turns for the AD
- Calculate and correct transversal coherent oscillations from the data
- Use existing CAMAC transient recorders and associated modules
- Fully integrate into Control System
- Simple to use and flexible

… "a 100MHz two channel storage oscilloscope with enhanced trigger functions controlled by VME and an Equipment Module"

What was done (1)

- System layout (no new hardware):



- write a new Equipment Module (E.M.)
- program a VME to control the CAMAC hardware via serial link and interface with the E.M.
- install an instance for the AD

What was done (2)

- New Application Program
  - Septum and Kicker correction for H
  - DVT7013 and BTI8002 correction for V
  - Discrete Fourier transform on the data for $q*f_{rev}$ to gain sine and cosine parts

- Perform correction (i.e. horizontal):

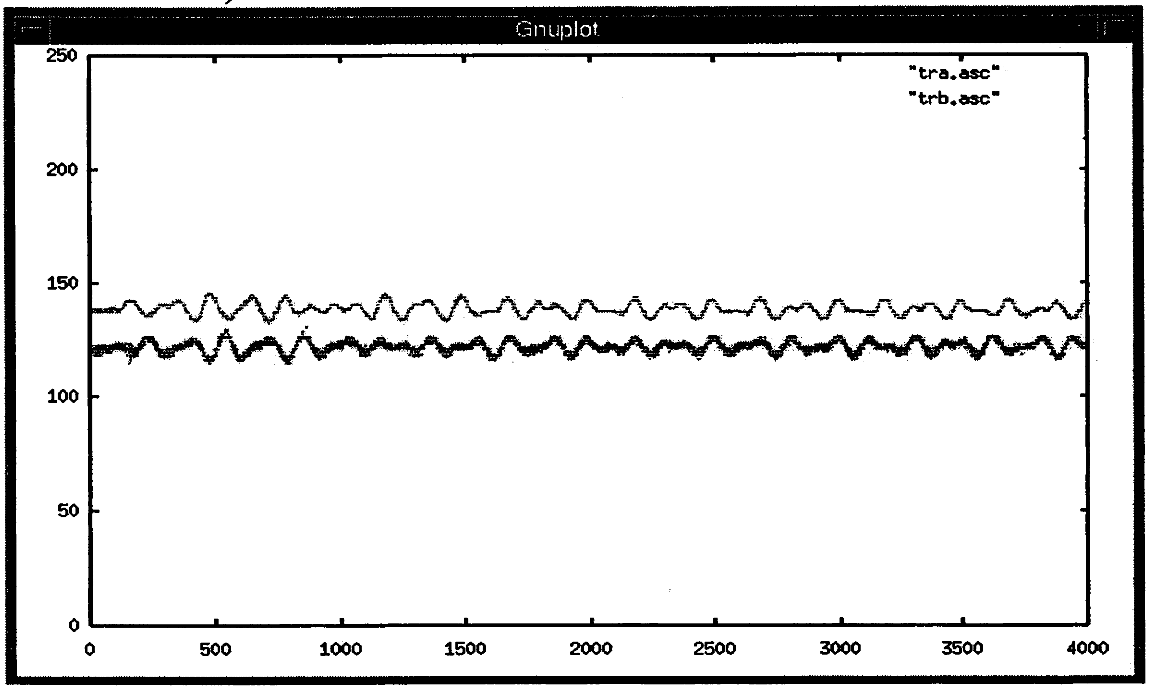
$$\begin{Bmatrix} \text{septum} \\ \text{kicker} \end{Bmatrix} = \begin{Bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{Bmatrix} \begin{Bmatrix} \sin(DFT_H) \\ \cos(DFT_H) \end{Bmatrix}$$

correction = correction matrix x coh. Oscillations

- measure correction matrix by varying the correctors

Results

- Horizontal and Vertical signal on ΔPU after 1MHz low-pass filter, protons via loop, 40,000 ns (approx 50 turns)



- AD-logbook 12 November 23h10:

"New H correction matrix entered ... we could decelerate down to 130 MeV/c after the first iteration..."

Outlook

- Graphical application interface for AD coherent oscillations needed with more functions. To be specified and written (volunteer welcome !)
- Use digitizer to measure pions after injection for AD ?
- Use for other fast measurements AD ?
- Install for other accelerators ?

Contributions from:

Vinod Chohan	PS/BD
Barbara Holzer	PS/OP
Masashi Shirakata	PS/OP (1998)
Flemming Pedersen	PS/RF

Technical Information Sheet:
PS/BD Note 98-13 (Info), CERN

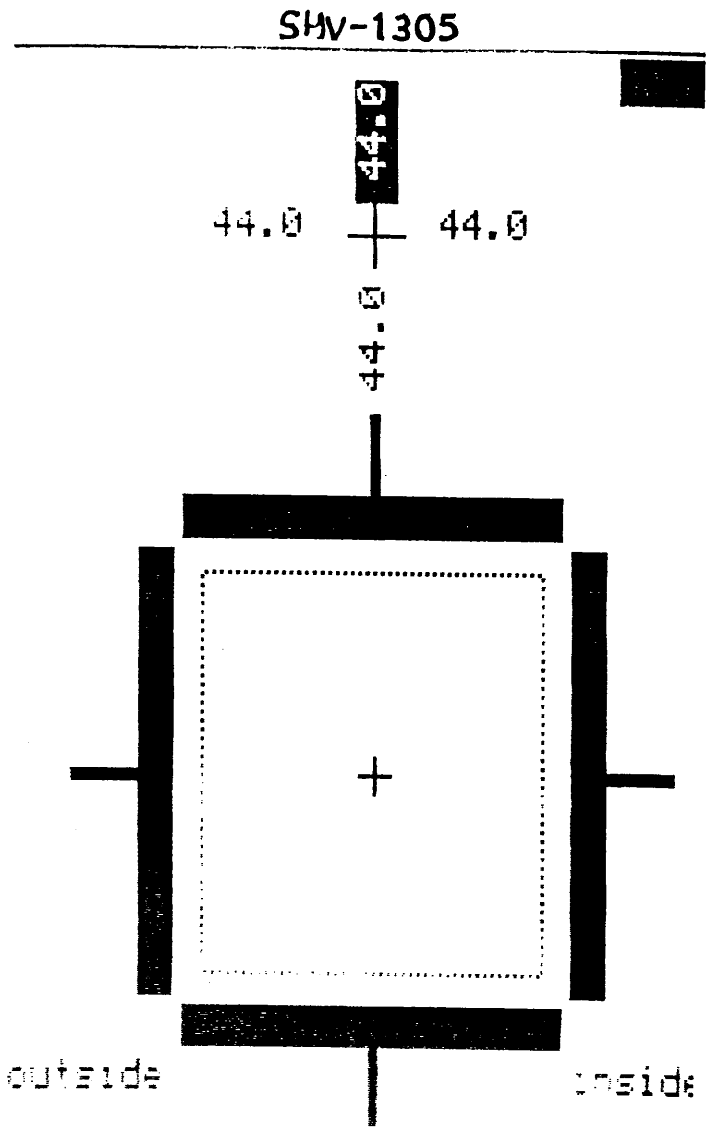
Transverse Scrapers
And Use for Measurements

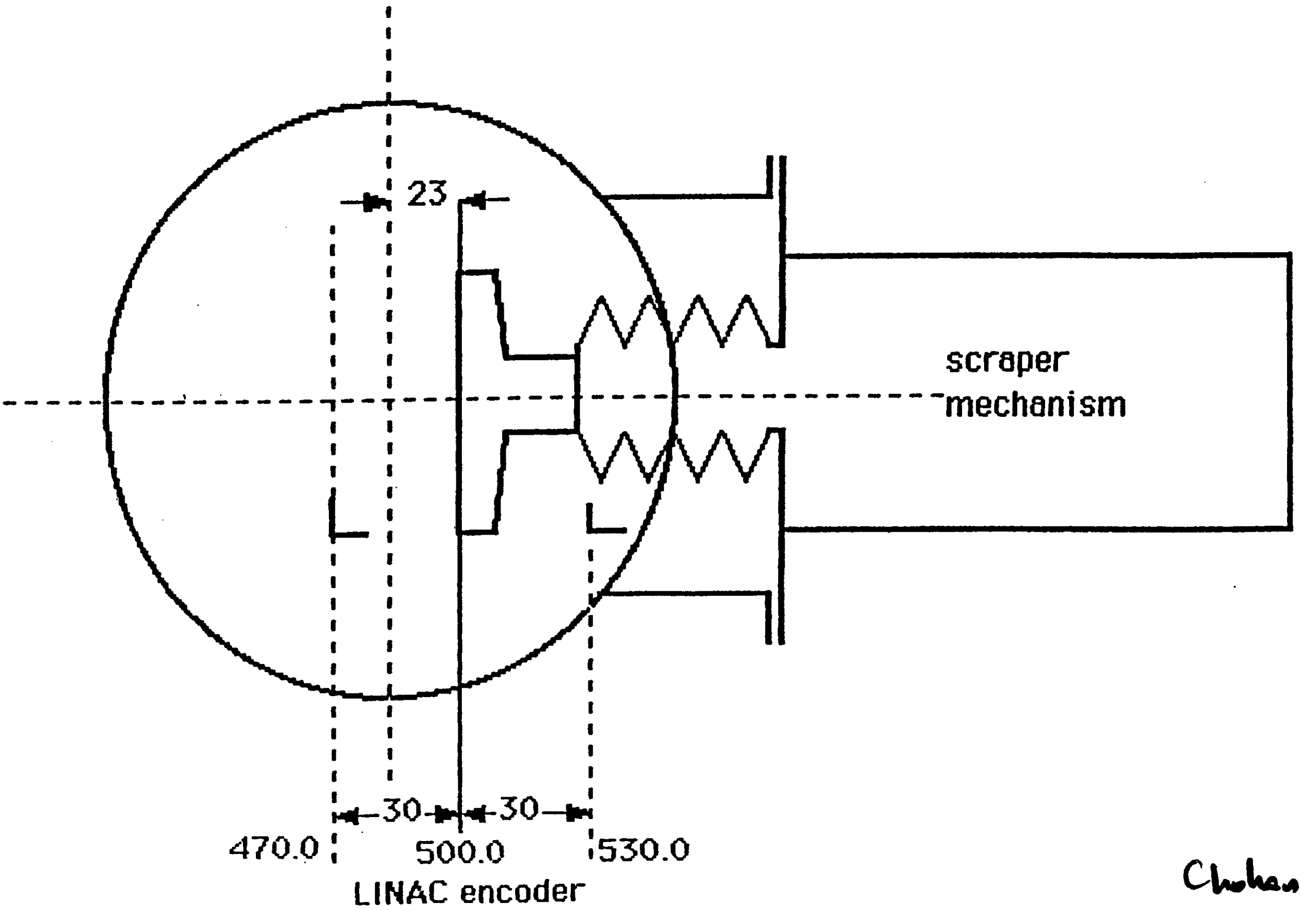
V. Chohan

AD Scrapers and Use

- ***SHV1305 is a 4 blade System : 2 Horiz & 2 Vert. placed in a zero-dispersion region***
- **System is useful at different machine energies for:**
  - Beam Emittance (size) measurements of proton beams of sufficient intensity by going through the beam with a blade and measuring the remaining beam current, using the DC beam Current transformer. *Thus obtain a beam profile by correlating the scraper position versus beam current.*
  - Beam Emittance (size) measurements of weak antiproton beams or even low intensity proton beams by going through the beam with a blade and using counts from a scintillator counter downstream to get the beam profile, i.e., *count rate versus scraper position*
  - The above can be refined to do 'before' & 'after' cooling with antiprotons
  - Machine Acceptance Measurements (in each plane) with protons after blowing up the beam with transverse excitation to fill the full aperture and using the same method as mentioned above for protons
  - Literally using the Scrapers to 'scrape' or collimate so as to limit the beam Size or Intensity
- **Other 'exotic' use in discovering "hollow", "two-centred" or " mis-steered" beams or even discovering that the pickup-kicker movement system for stochastic cooling has been left in the 'in" position**

SCRAPERS SCHEMATICS





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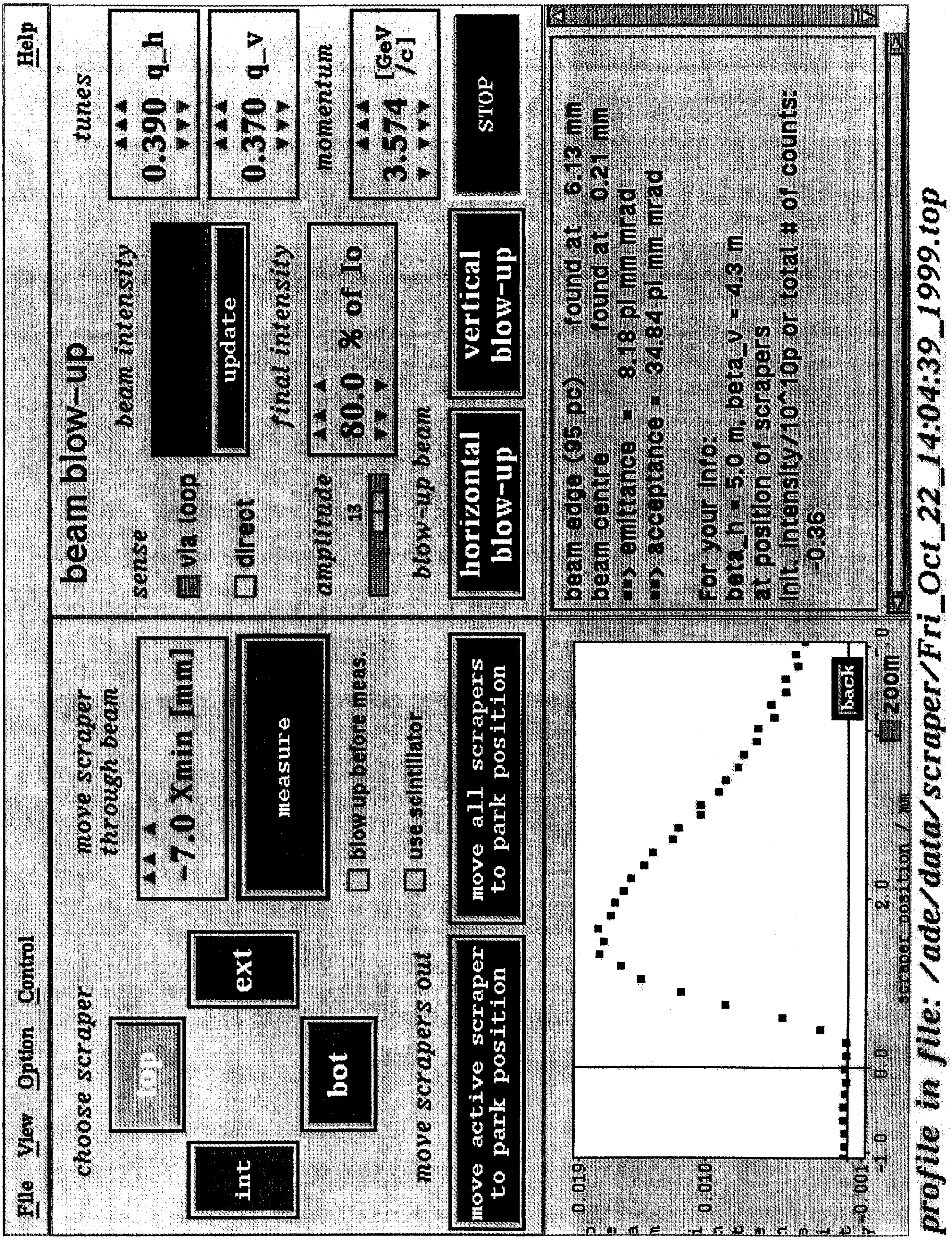
AD Scrapers and Use

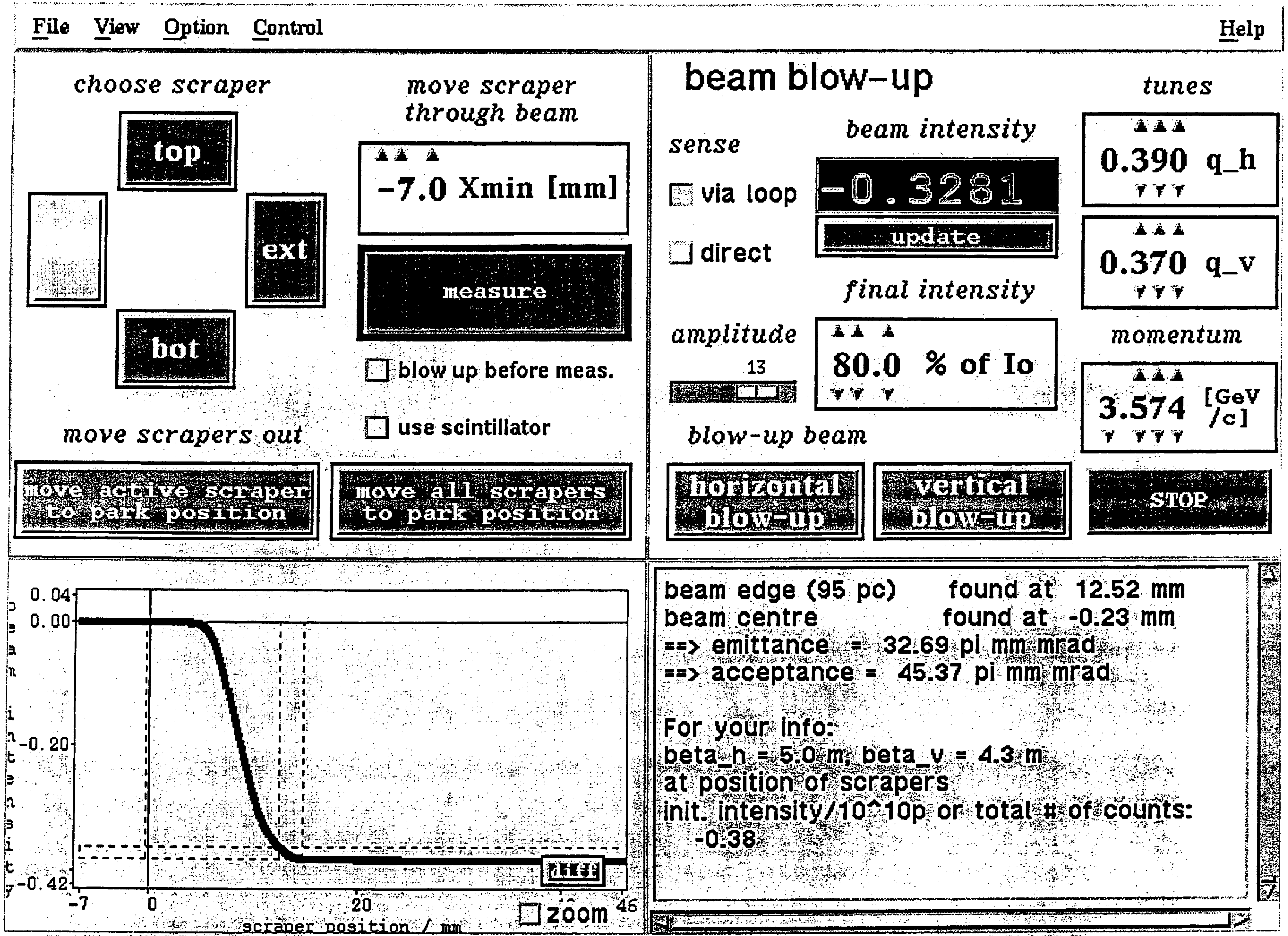
- ***Particular Problems in AD for use of the Scrapers:***
  - In the AA and AC, the measurements of Acceptance or beam Emittance with proton beams were possible without time tagging the measurements. This was because all the systems used one and the same front-end Computer and the measurement program ran in the same computer; now in AD, the different VME crates are independent processors themselves and the measurement program runs in a workstation. Hence one needs a global tagging mechanism to know precisely say, the value of the DC beam current at a given instant when the scraper blade was at a certain position. Therefore, the scraper system required an extra facility to provide this time tagging feature. Similarly, the Scintillator Counting mechanism too needed a time tagging feature. The Counter and the Scraper movement both must be synchronised to the same 'start' trigger.
  - AD has beam lifetime problems at low energy so , the measurement acquisitions are collected (in different VME crates) by sweeping a scraper through the beam in one go to get the profile - rather than with small steps at a time as in AA or AC

Example of what Workstation Program looks like



Notice all options in usage like Blowup beam, use DC-BCT or Scintillator Counts etc.

V. Chohan / 1 Dec 99



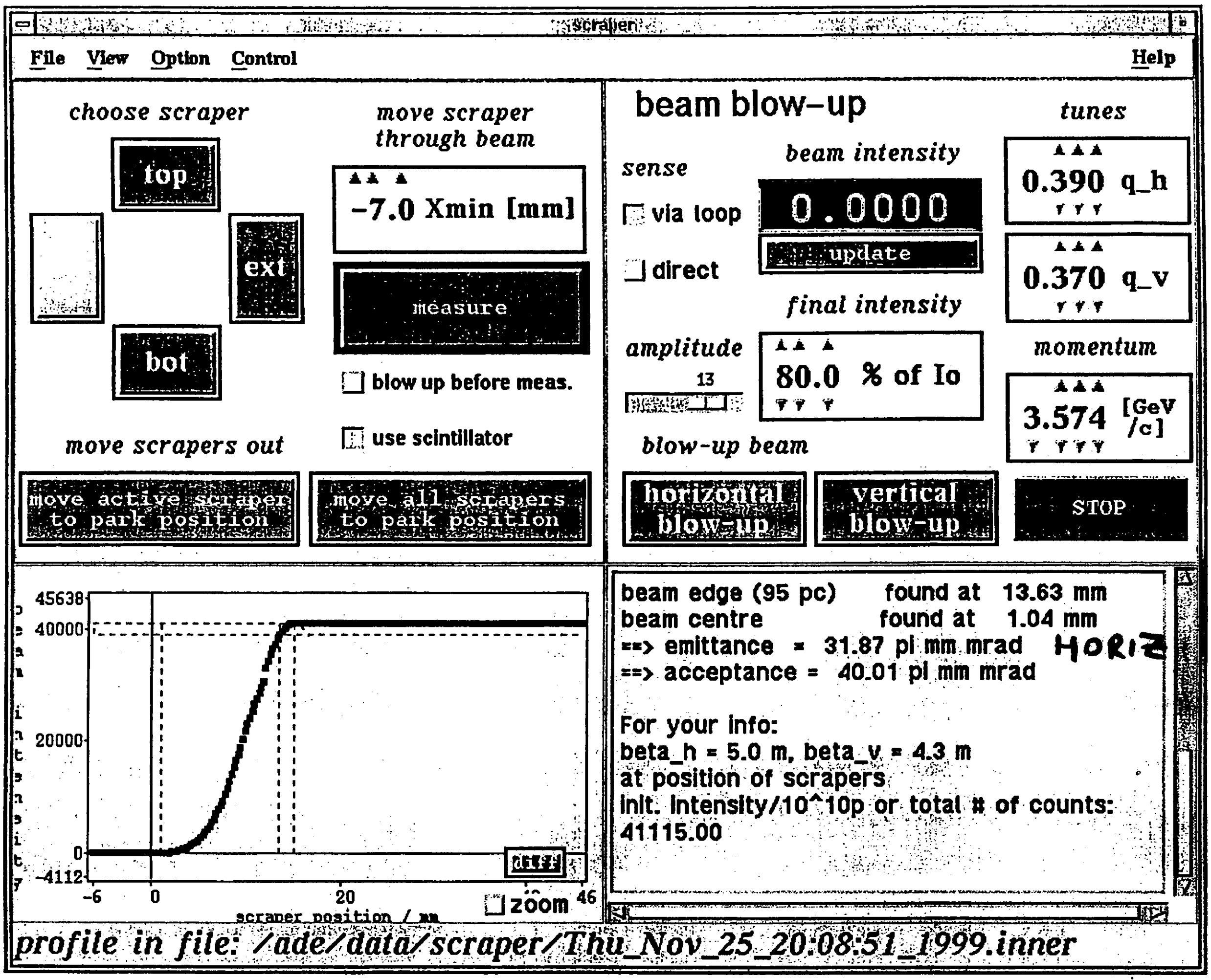
profile in file: /ade/data/scraper/Wed_Oct_20_22:50:01_1999.inner

<using DC BCT vs. Scraper position : protons via loop>

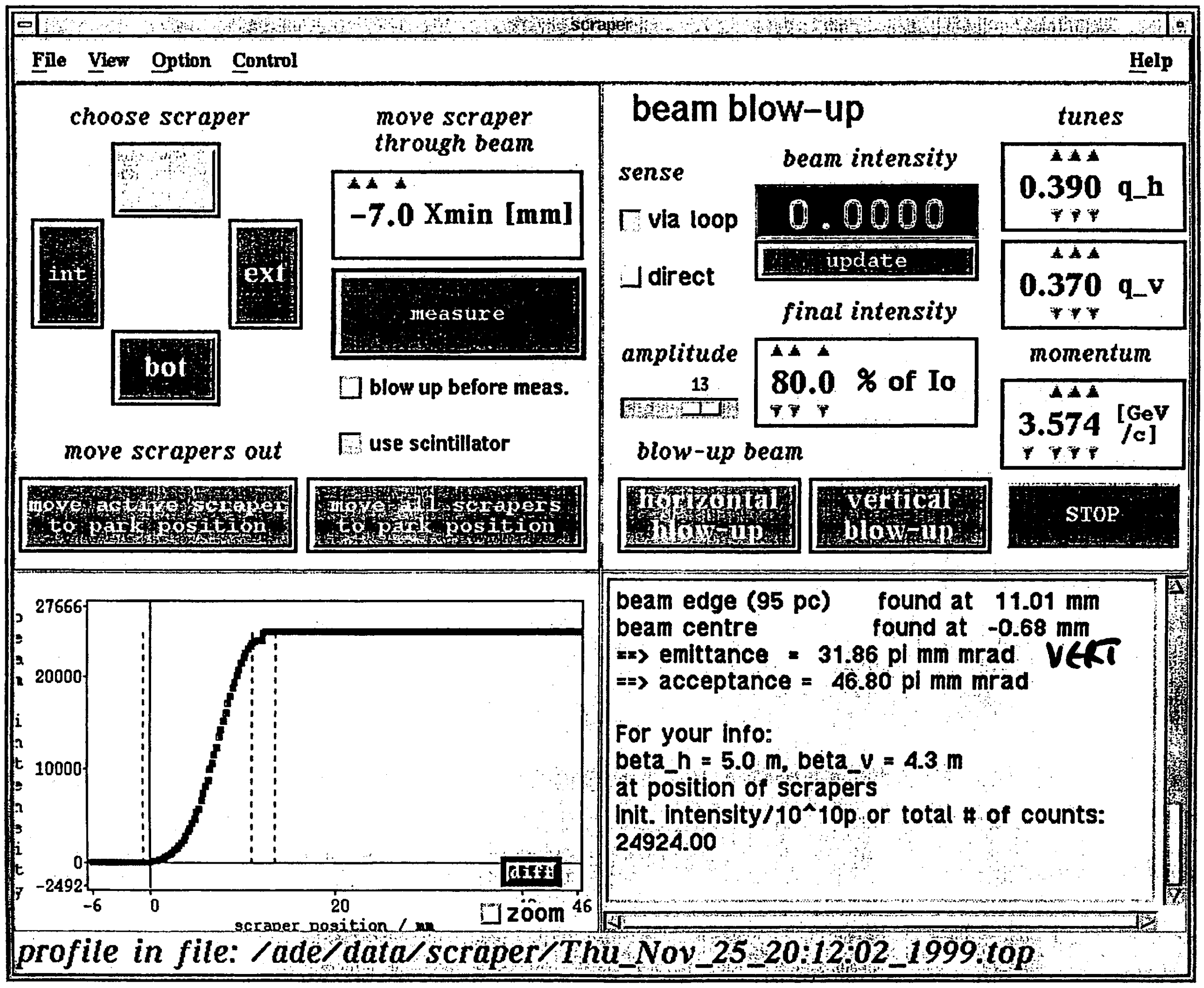
Chohan 1/12/99

AD LOG BOOK 25 Nov 99 pbars

Emittances at 102.4 MeV/c

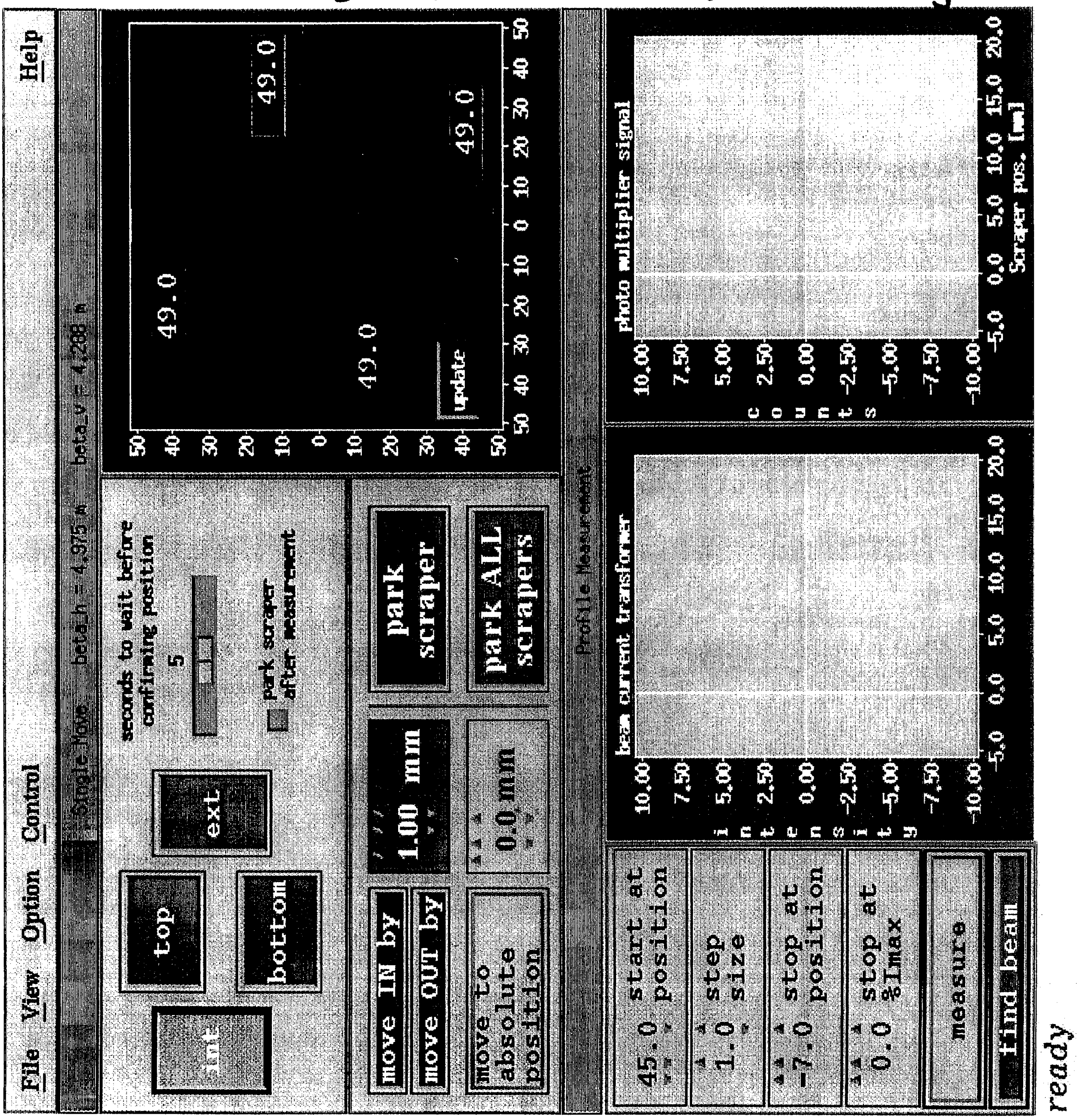


<Using Scintillator Counts vs. Scraper position>



Chohan/1/12/99

Example of the "generic" Scraper program
(meaning blade movement step-by-step)
& keeping the position – useful for "collimating"



V. Chohan
1 Dec 99

AD Scrapers and Use

- The Scraper System Applications were developed by T.Spickermann as an AD Associate, working in BD Group - Systems Integration section
- The Scraper System using Stepping Motors is provided by G.Martini with standard VME, MIL1553 controls.
- The Scintillators- photomultipliers hardware is under the responsibility of L.Soby. A new VME Counter has replaced the old CAMAC module.
- The Beam Blow-up system uses transverse excitation hardware and a controllable Signal Generator provided by L.Soby; standard I/O and GPIB interface hardware/software have been used.
- U. Raich provided the very crucial real-time tasks and equipment Modules for Scraper position time tagging as well as Scintillator counts time tagging.
- **References:**
  - The Scraper Companion for the AD Operator, PS/BD/Note 99-13 (Tech)
  - Application Software for the AD Scrapers, PS/BD/Note 99-14 (Tech)

New Transverse Schottky Pickup

O. Marqversen

Schottky PU and head amp.

- **Transverse AND** Longitutinal **!?**

Longitudinal:

Used to measure intensity direct and using schottky.

The hardware:

- **It's two "normal" fast beam current transformer made resonate:**
  Two to cover the needed frequency band.
- **The transversal and longitudinal uses the same amplifier principle. (Transversal though differential)**

Noise:

- **1pA/Hz^1/2 in the most sensitive range**

Status:

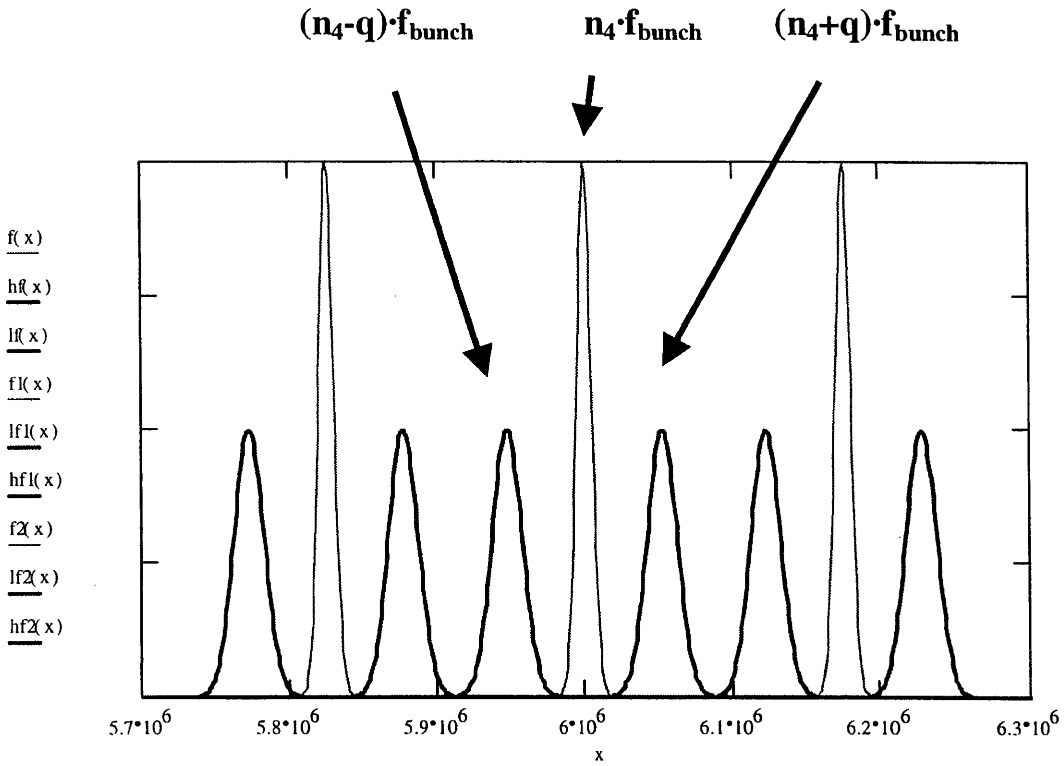
- **The high frequency transformer works !**
- **The low frequency transformer is installed, but no amplifier ready.**

It is Flemming Pedersen's and Alan Findley's system. ....

Transversal Schotthy in AD

- **We want to measure q value via Schottky or BTF**

(Plus what come more with schottky dq, ξ, ε..)



• The schottky signals

Power in a side band:

$$\mathrm{Irms} = \sqrt{\frac{\mathrm{emittance}/6}{\mathrm{Acceptance}}} \cdot \sqrt{\frac{\mathrm{N}}{2}} \cdot e \cdot f \cdot \sin\left(\frac{l_{PU} \cdot \omega}{\beta \cdot c}\right)$$

No chromaticity

- **Beam modulation**
- **DC current**
- **PU sensiticity**

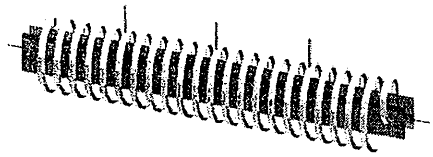
Bandwidth of a side band:

$$\frac{\Delta f}{f} = \left(\frac{1}{\gamma^2} - \frac{1}{\gamma_{tr}^2}\right) \cdot \frac{\Delta P}{P}$$

i.e. The Bandwidth of a schottky sideband is propottional to observation frequency !!

We can see is : $$\frac{\mathrm{I_{rms}}}{\sqrt{\Delta f}} = \frac{pA}{\sqrt{Hz}}$$

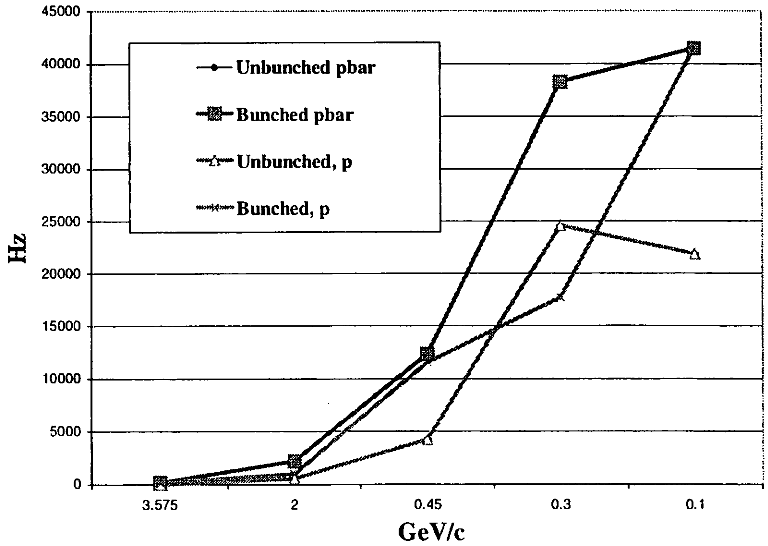
Schottky PU and head amp.



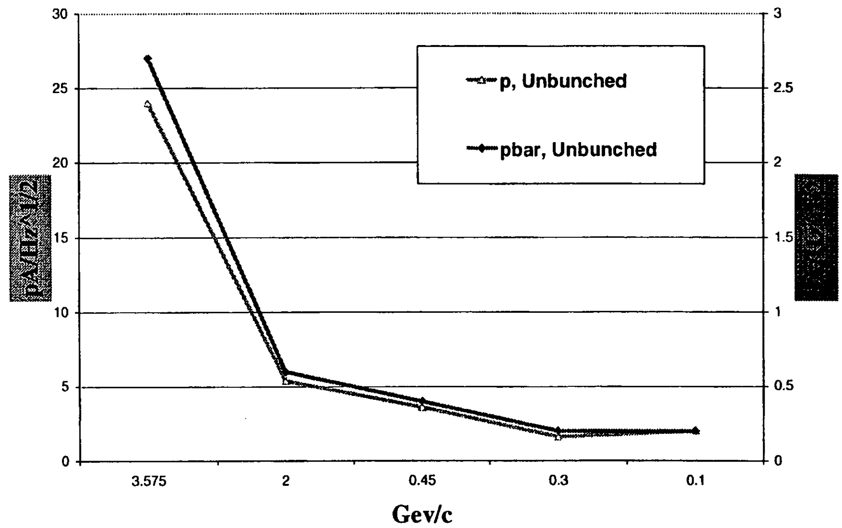
- **Some numbers @ 6MHz**

5·10^7 pbars, 4·10^9 protons

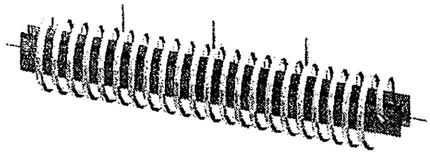
delta f



Irms / delta f

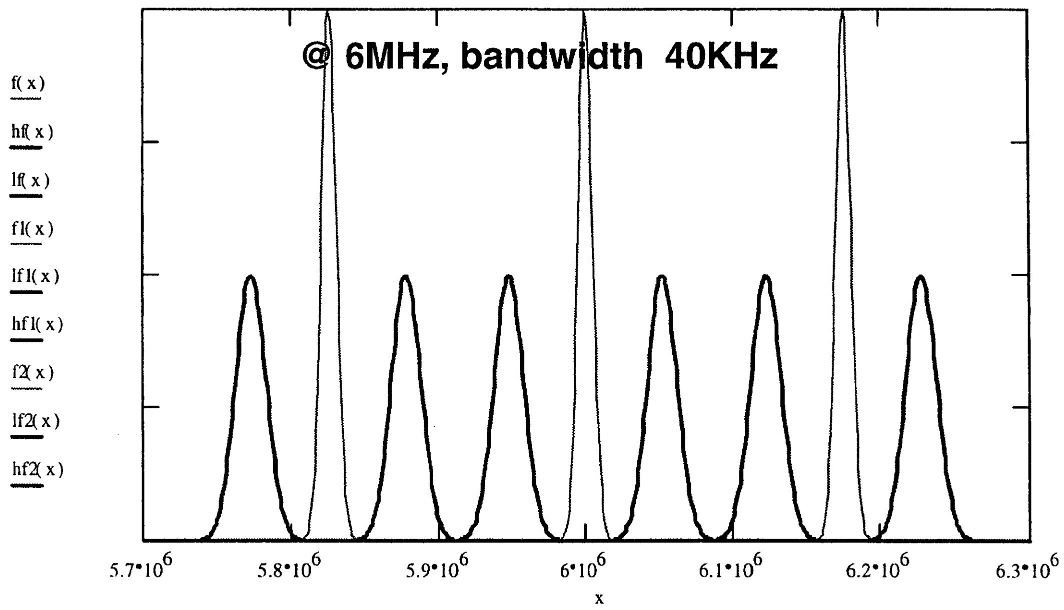


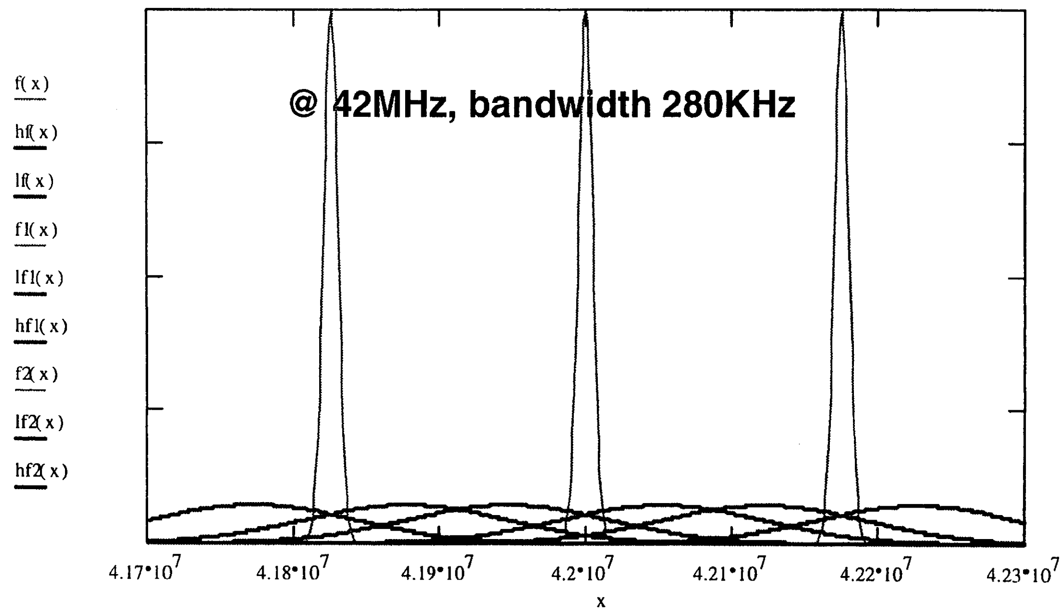
Based on estimated dP/P and emittance. Chromaticity is taken to be 0. Calculations are made for a electrostatic PU length 1m @ 6MHz.

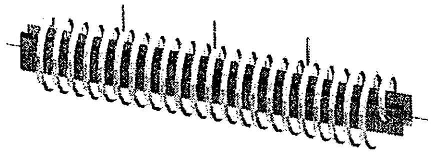


- **A new PU is needed.**

At 100MeV/c the bunch repetition frequency is 175KHz







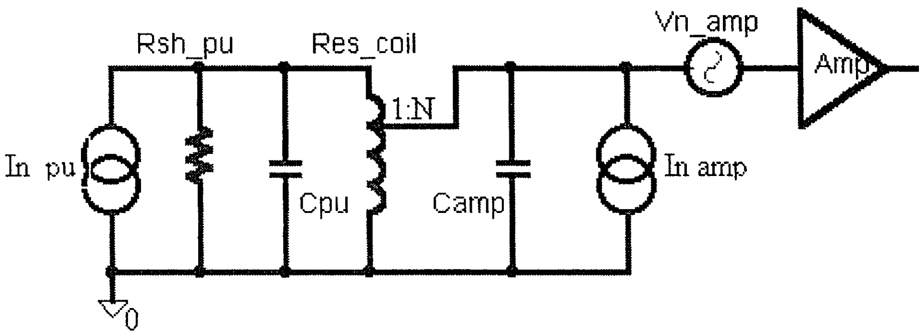
- **Signal to noise ratio**

  S/N = 0dB is OK, worse needs averaging => slow measurements

- **Noise**

  - The Gool is to make the PU noise as low as possible, and than make the amplifier noise lower.

  - The noise equivalent diagram:



- **The resonant PU's Noise**

  $I_{n\ pu}$ is the Johnson noise from $R_{sh\ pu}$ i.e. given by the Q (factor of merrit) of the resonant coil.

  Q is 900, L is 5.6µHy => Rsh = 190KΩ => ~0.3pA/Hz^1/2

  With the coil in the vaccum chamber serie resistance in the feedthroughs and cables becomes les important.

  The resistance at 6MHz of the feedthroughs in the PU is ≈0.2Ω (measured value)
  The resistance at 6MHz of 1m RG58 coax is ≈0.2Ω

- **The Head Amp.**

- Discrete FET's are used, since they have a lower I_n then bipolaer.
- JFET's has the lowest corner frequency for the 1/f noise.
(No integrated solution that match the noise spec.)

The noise from the amplifier:

$$V_{n\ amp} = \sqrt{\frac{8 \cdot k \cdot T}{3 \cdot gm}} \quad [V/\sqrt{Hz}]$$

- The voltage noise is inversly proportional to the transconductance (A/V i.e. how many amps in the channal per voltage on the gate) of a FET. This means that we can lower the V_n by parallelling FET's.

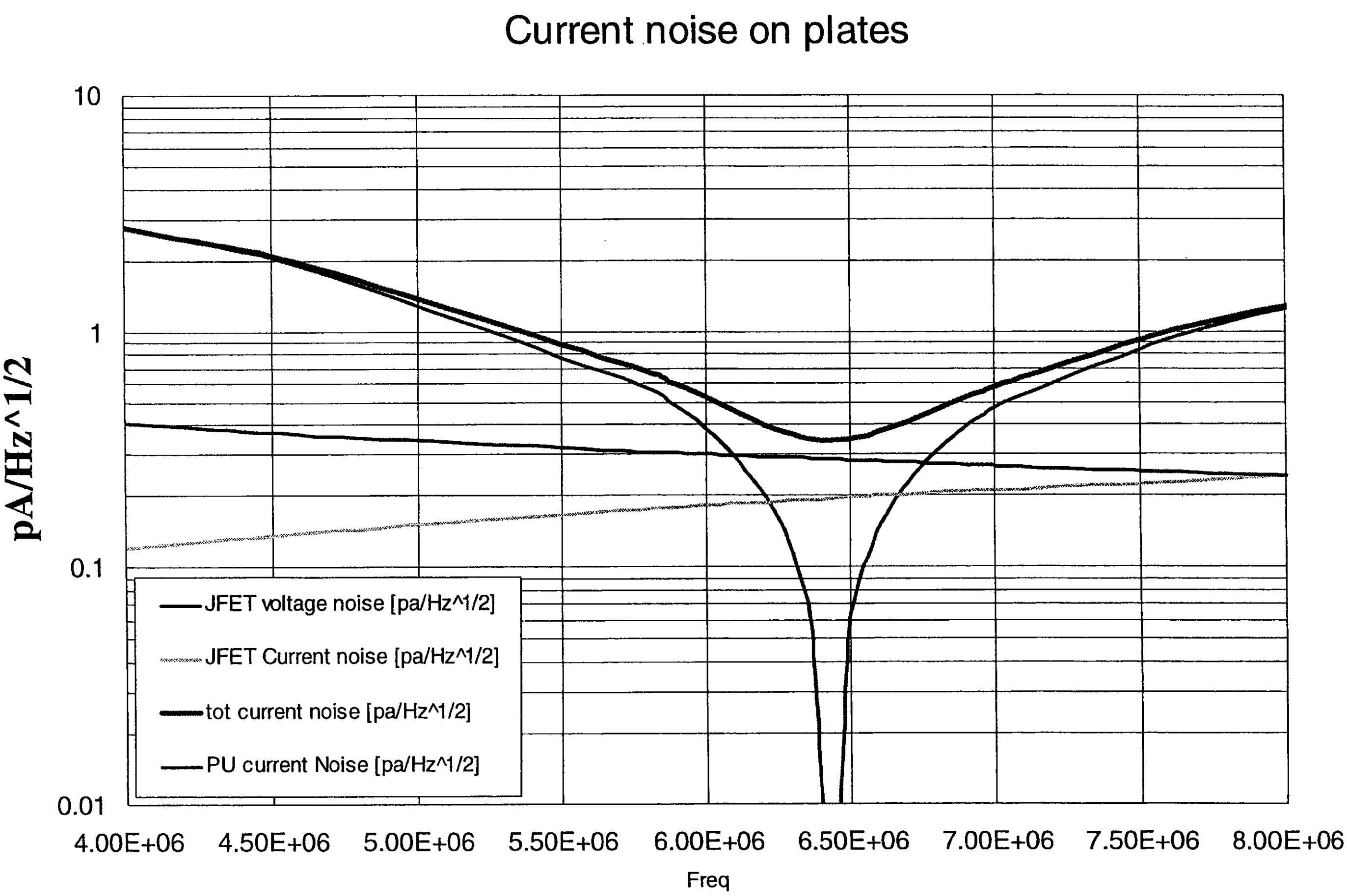
$$I_{n\ amp} = \omega \cdot C_c \cdot V_n \quad [A/\sqrt{Hz}]$$

C_C is ~2/3 of the total gate to channel capacity, C_{gs}.

When paralling FET's we will get more current noise.

- **Noise puzzle**

  - Now we can play with the number of FET's and the transformation to get a frequency band where the PU noise is dominante.



• Noise data

Calculated noise 0.4pA/Hz^1/2

Measured value 0.9pA/Hz^1/2

- **The difference comes from the real world, not being perfect:**
- **Serie resistance in feedthrougs and cables makes the outside capatance have a lower Q.**
- **PCB tg(δ).**
- **.....**

How low are these numbers

A 12cm wire on the PCB needed to get to all the FET's, makes approx. 10pF

$$C_{IN\ PCB} = \frac{A \cdot \varepsilon}{d} = \frac{0.001 \cdot 0.12 \cdot 4.7 \cdot \varepsilon_0}{0.5 \cdot 10^{-3}} \approx 10\text{pF}$$

FR4 pcb, tg (δ) = 0.025 [@1MHz], Rsh @ 6MHz :

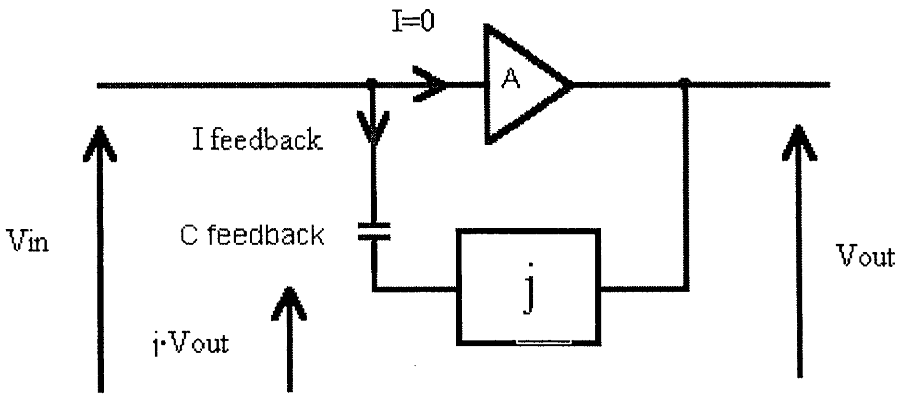
$$R_{sh} = \frac{X_C(6MHz)}{0.025} \approx 106\text{K}$$

$$I_n = \sqrt{\frac{4 \cdot k \cdot T}{R_{sh}}} \approx 0.4 \quad \text{pA}/\sqrt{\text{Hz}}$$

Transformed to the plates it gives 0.2pA/Hz^1/2

• Making the PU broad banded by feedback

The High Q of the PU needed to reduse the noise, makes it very narrow banded.



$$\text{I feedback} = \frac{\text{Vin} - j\cdot\text{Vout}}{\frac{1}{j\omega c}}$$

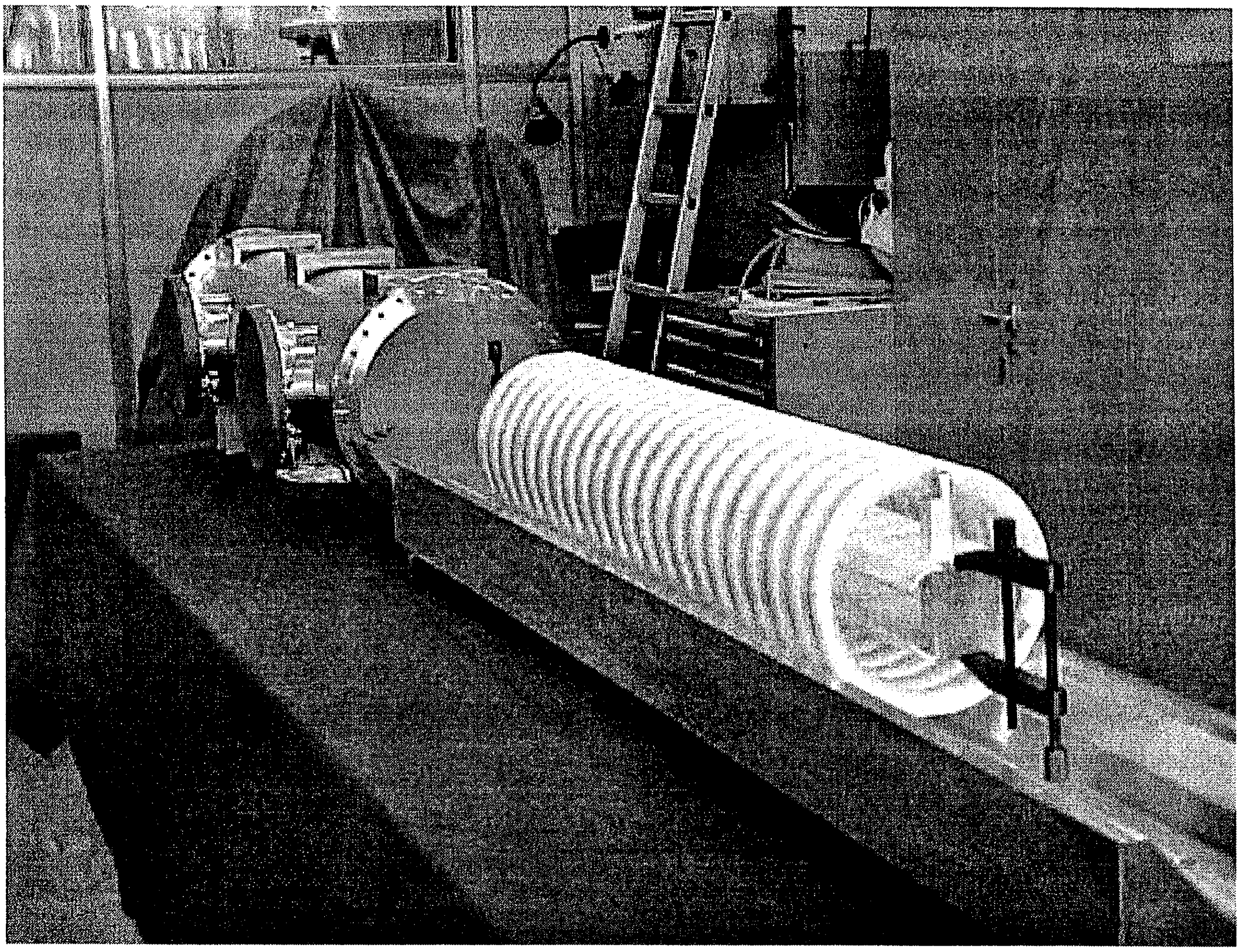
$$Zin = \frac{Vin}{Ifeedback} = \frac{1}{A\omega c + j\omega c}$$

Eg. A=75, $\omega = 2\cdot\pi\cdot 6*10^6$, c=1pF

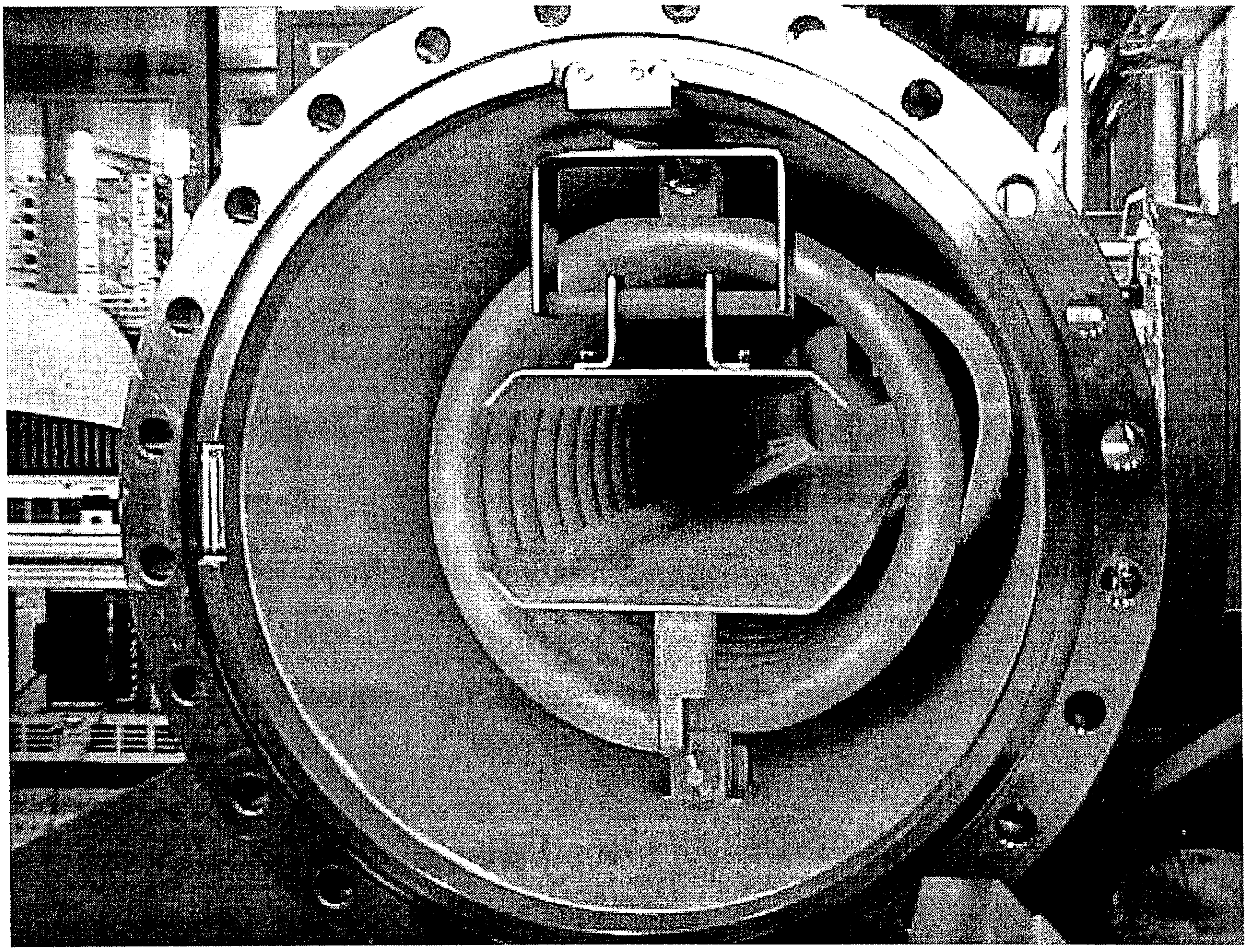
Zin = 354 $\angle 0.8^{\circ}$ i.e. real.

In this way Zin is a function of frequency, this is delt with by making the j (90°) in a lowpass filter so "j" becomes inverse proportional to frequency.

- **The PU**



- **The PU**



- **Extra resonances.**

With the coil in the vaccum chamber we "win" some extra resonanses.

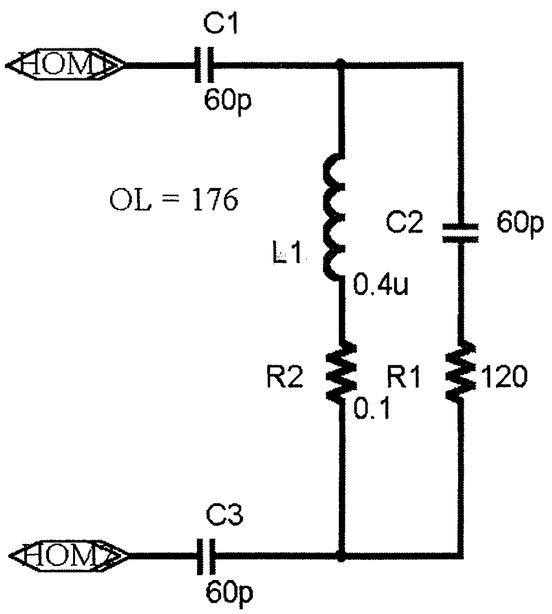
Common mode resonances

- A midtpoint on the coil makes it possible to kill commen mode resonances without touching the difference mode resonance.

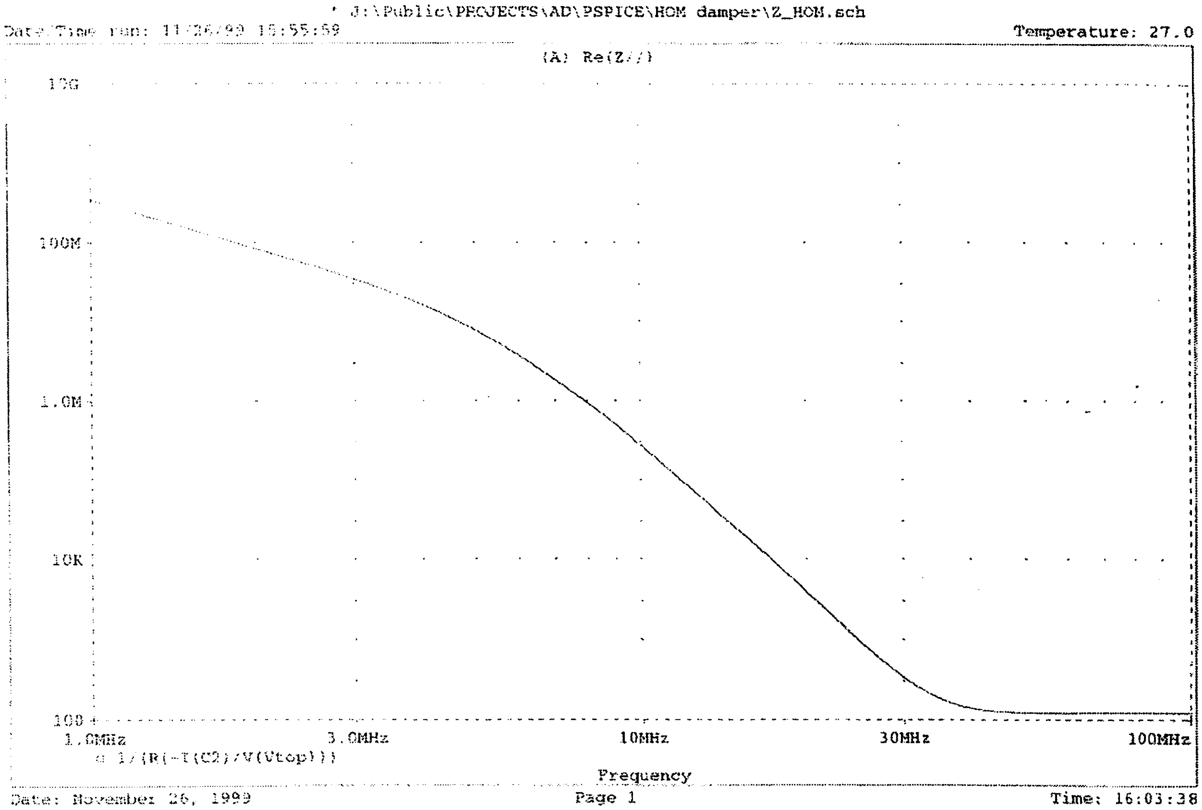
Difference mode resonances

- The feedback on the amplifier damping the resonances only work up to a limited frequency.

HOM damper:



Re (Z//) plot :



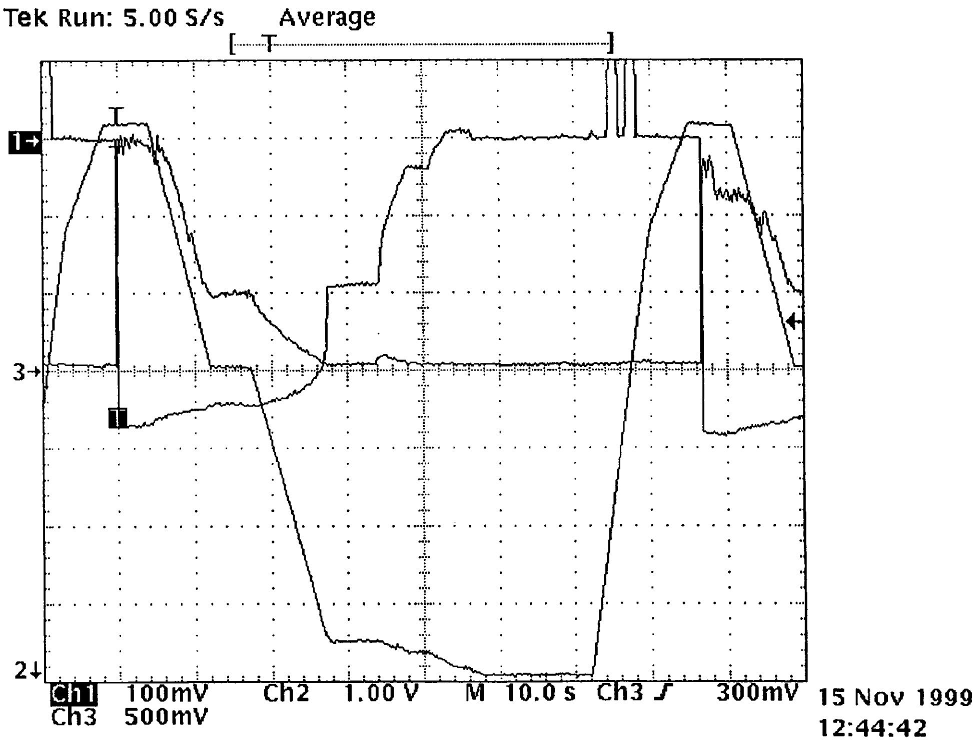
* J:\Public\PROJECTS\AD\PSPICE\HOM damper\Z_HOM.sch
Date/Time run: 11/26/99 15:55:59
Temperature: 27.0
(A) Re(Z//)
10G
100M
1.0M
10K
100
1.0MHz
3.0MHz
10MHz
30MHz
100MHz
1/(R(-I(C2)/V(Vtop)))
Frequency
Date: November 26, 1999
Page 1
Time: 16:03:38

• PU Problem

The beamposition/common mode signal in the PU is not suppressed as expected.

How does it look:

3.5·10^{9} protons:



Ch1: DC-transformer 1V = 10^{10} charges.
Ch2: Peak detected (output from Schottky head amp -6dB).
Ch3: The B field in the AD 2KGauss/V.

Same measurment with 4·10^{7} pbars gives a max of 5mV$_{p}$ during deaccelerations.

Schottky PU and head amp.

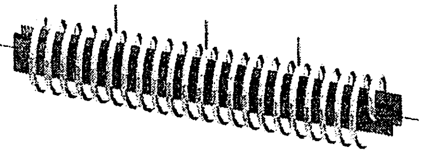
What does this mean:

Saturation "kills" the signals.

- The Head amp has ~160dBc/Hz^1/2.
  (a netwotk analyzer has ~110dBc/^1/2 a spectrum analyzator has ~140dBc/Hz^1/2)

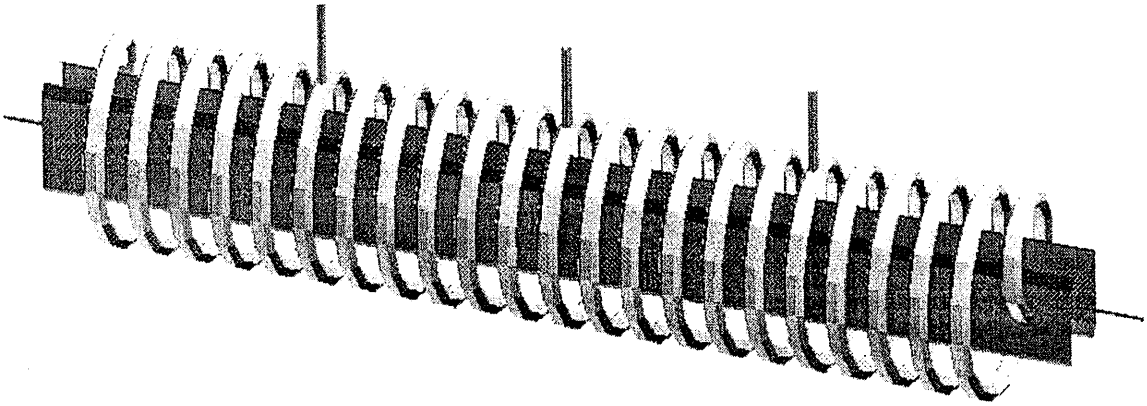
- The ADC is a 12 bit (72dB dynamic range). But via downmixing of only a part of the available frequency spectrum, plus FFT (averaging) It scould give 135dBc/Hz^1/2, *to be confirmed !!.*

- We can only measure proton beam debunched.
- If ADC is as good as the theory, pbar's will be OK, *to be confirmed !!*



- *Why do it occure:*

1. **Magnetic coupling:**



$$\oint E \bullet dl = -\frac{d}{dt}\int B \bullet dS \ , \qquad B(r) = \frac{Ipeak \cdot \mu_0}{2 \cdot \pi \cdot r}$$

For $5 \cdot 10^9$ protons at 3.5 GeV/c we get E_{diff} ~11mVp.

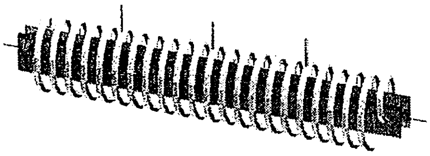
This effect will go down with with decreasing energy, as Ipeak.

2. **Transit time:**

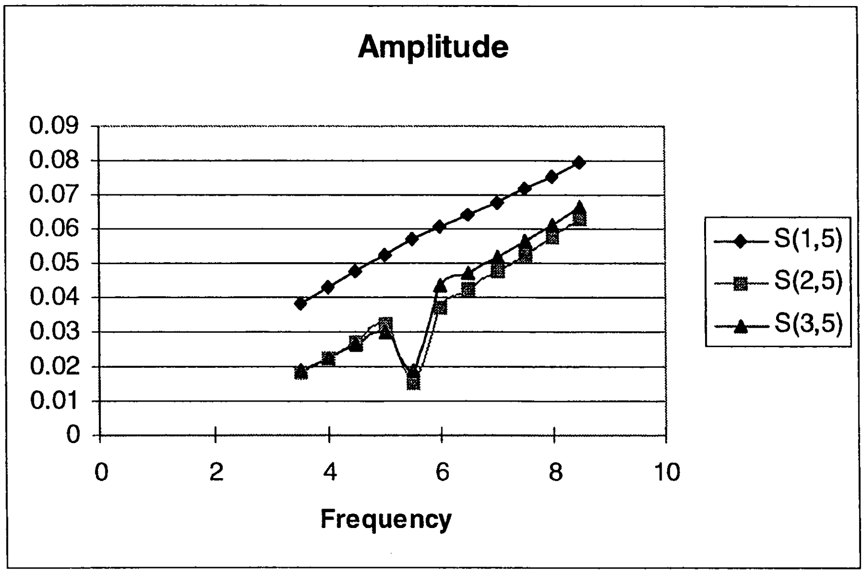
The coil is connected in oppersite ends of the PU plates.

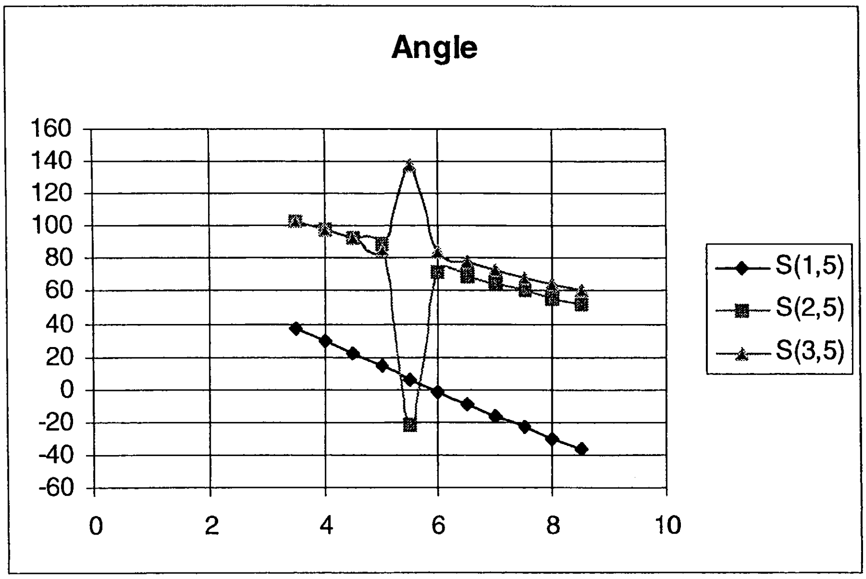
Not just a simple delay problem. Coupling all the way throug the PU (speed: in plates ~c / beam βc)

No analytic solution, but simulations and measurments agrees



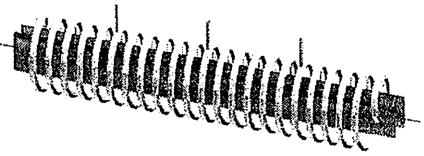
- **The PU in "Maxwell"**





@ ~5.5MHz we have the resonance : Don't belive this point.

Schottky PU and head amp.



- **Status**

  - 6MHz system, with no schottky sideband overlap (q~0.3).

  - Noise in PU and head amp 6dB more than the theoretical value i.e. 0.9pA/Hz^1/2.

    This is not low enough to measure purely with schottky, BFT needed !

  - Dynamic range out of amp of 160dBc/Hz^1/2.

  - No freq tuning needed.

  - Some injected noise, that comes in via the Ionpump on the vertical PU.

  - Commonmode (beamposition) signal problem with protons (for pbar's to be confirmed !?!).

    Can't see anything at 3.5GeV with $3{\cdot}10^9$ bunched protons, unbunched OK.
    Problems for the ADC for bunched protons

- **Whats next**

  - **We have to wait to see if the real dynamic range of the ADC's are as good as the theoretical value.**

  - **If not we can gain 30-40dB of commonmode suppression by making the PU outputs symmetrical and taking the coil out (35dB measured in the lab).**
    We need the closed orbit to be centered in the PU's.

  - **External coil:**

    - **Ferrite coil => small size, "low" cost, "high" noise (estimated + 10dB)**

      OR

    - **Air coil big size, higher cost, unchanged noise (depending on the quality of the feedthroughs) .**
      The Air coil in a big box under the PU : lower the Cap of the PU + possible higher Q of the Coil due to higher L if longer distance to shielding.

DSP-based System for Schottky Signal Analysis

M.E. Angoletta

What was intended

To develop a fast spectrum analyser based on 3 PU signals

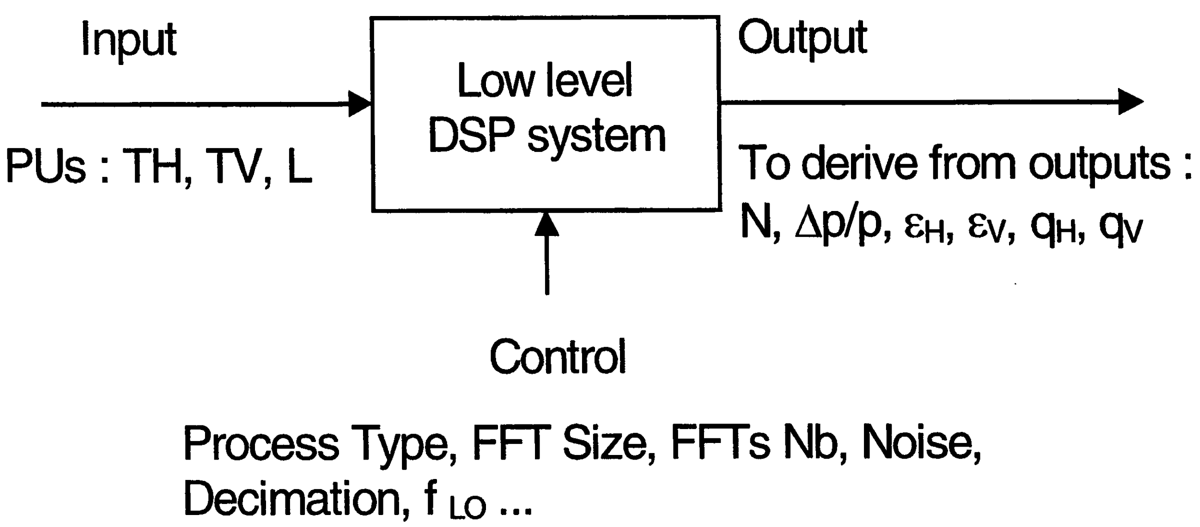


Fig. 1: Schematics of the DSP-based Schottky system.

System specifications

- Settings for each measurement decided on-line depending on (mainly)
  - f_{REV} ⬅ ***main control param.***
  - beam state (bunched / unbunched).

- Processing:
  - At least 6 different data processing channels (4 Transv., 2 Long.)
  - "Fast" meas.: every 20 ms (bunched beam).
  - "Slow" meas.: beam parameters ***AND*** FFT-averaged spectrum as output.

System current status

- Low level hardware tested and installed.

- Software:
  - Low level system completed.
  - RTT under development.
  - EM installed.

- Input from Long. PU used only, since Transv. PU too noisy.

- Inputs from other systems: some still missing, others only recently provided.

Hardware: Pentek 6510 DRX

- On board floating point DSP (TMS320C40).
- 4 inputs (A..D).
- 8 on-line, indip. tunable "channels".
- Data exchange with high level s/w in global memory (128 K x 32 bit).

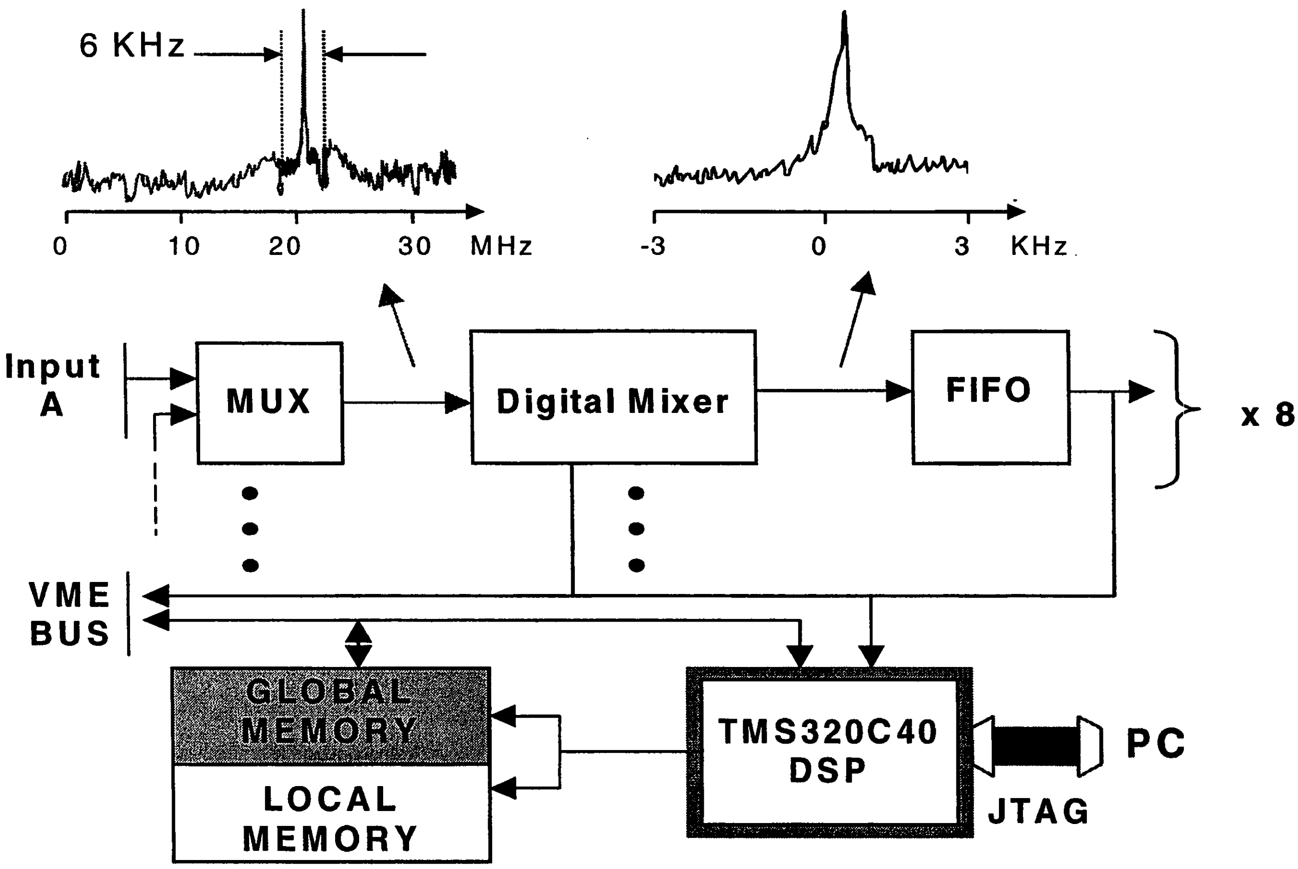
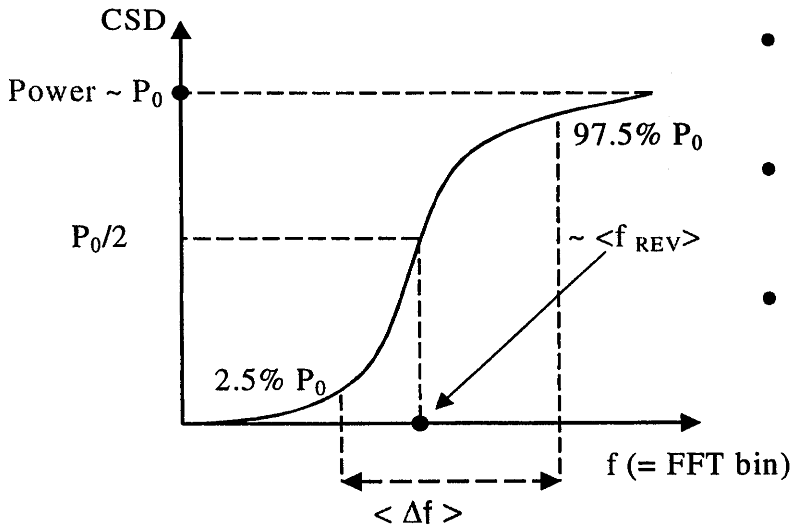


Fig. 2: Schematics of Pentek 6510 DRX board.

Longitudinal processing

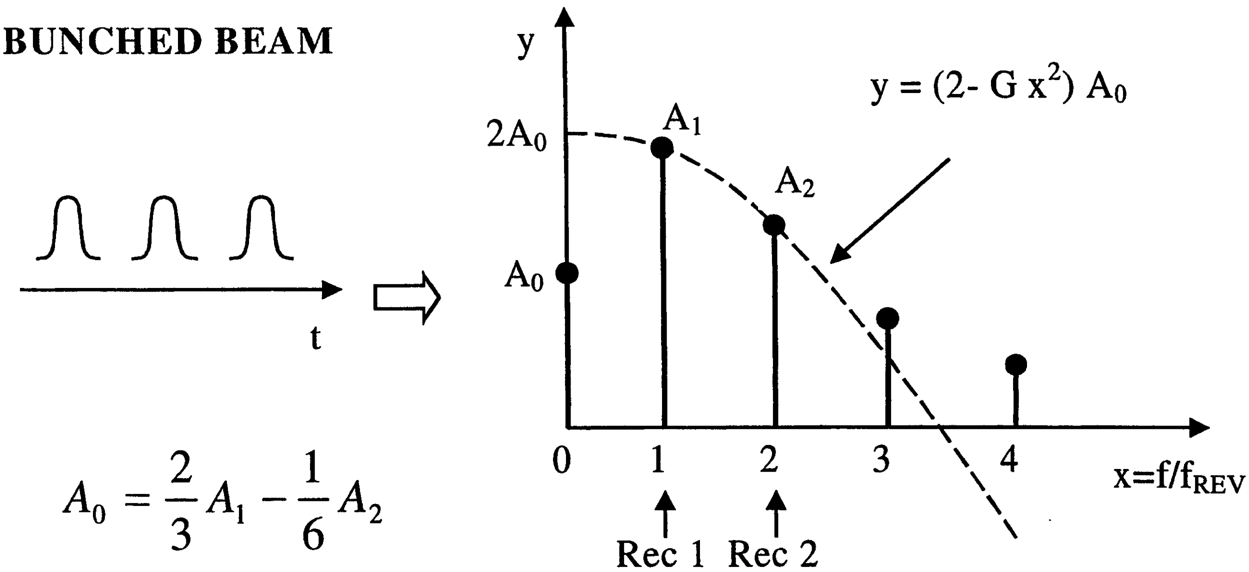
UNBUNCHED BEAM



- A 512-points complex FFT calculated in 4 ms
- High f_{REV} ➡ processing limited by DAQ
- Low f_{REV} ➡ processing limited by proc. time.

Fig. 3: Parameters extraction for unbunched-beam case

BUNCHED BEAM



$$A_0 = \frac{2}{3}A_1 - \frac{1}{6}A_2$$

Fig. 4: Parameters extraction for bunched-beam case

Some results -1

Machine conditions:

- Unbunched beam
- Antiprotons, 2 GeV/c flat-top

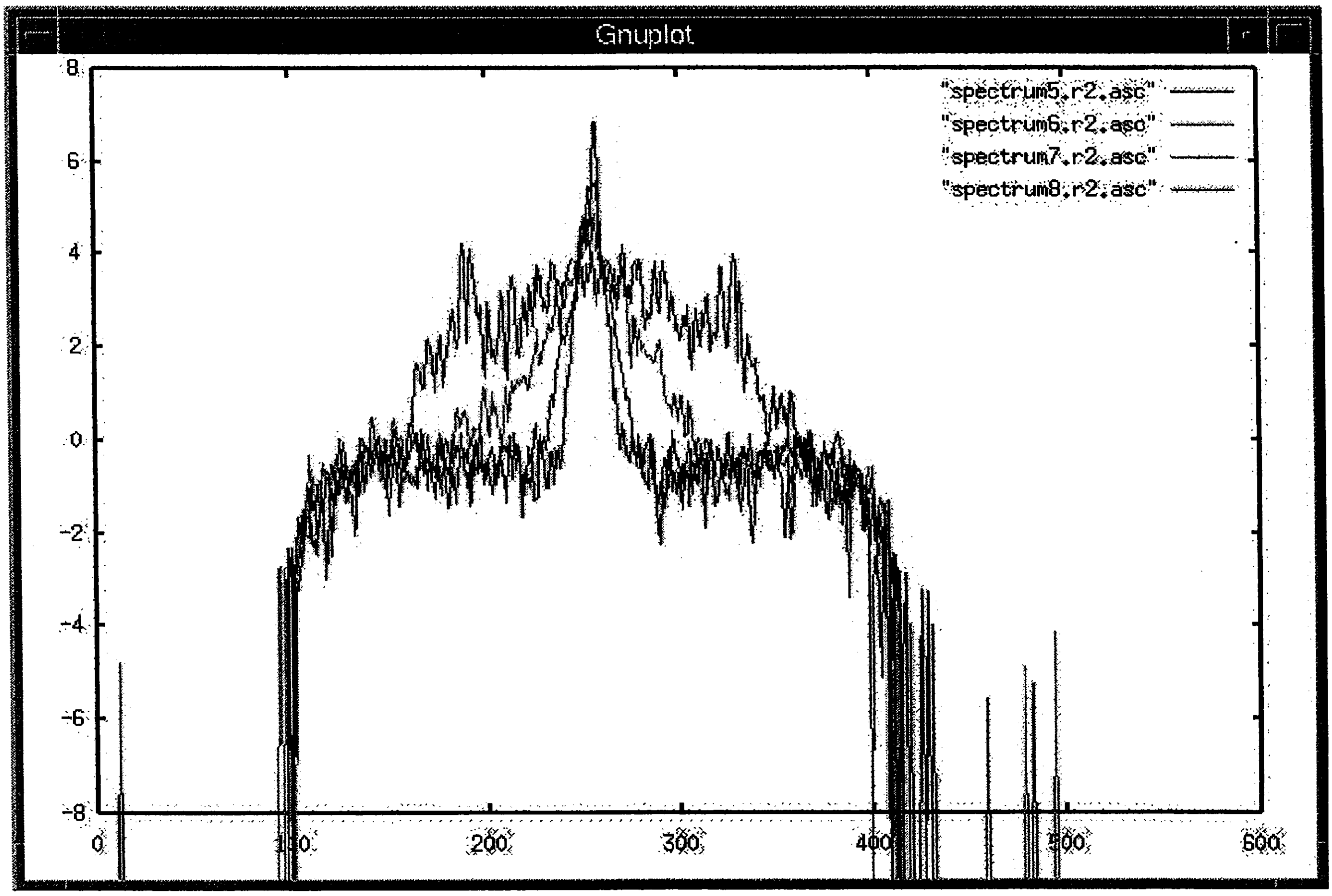


Fig. 5: Effect of stochastic cooling on the antiproton beam. The data are consecutive averages of 10 FFTs (512 points). Each average is taken every 700 ms.

Some results - 2

Machine conditions: same as for 1.

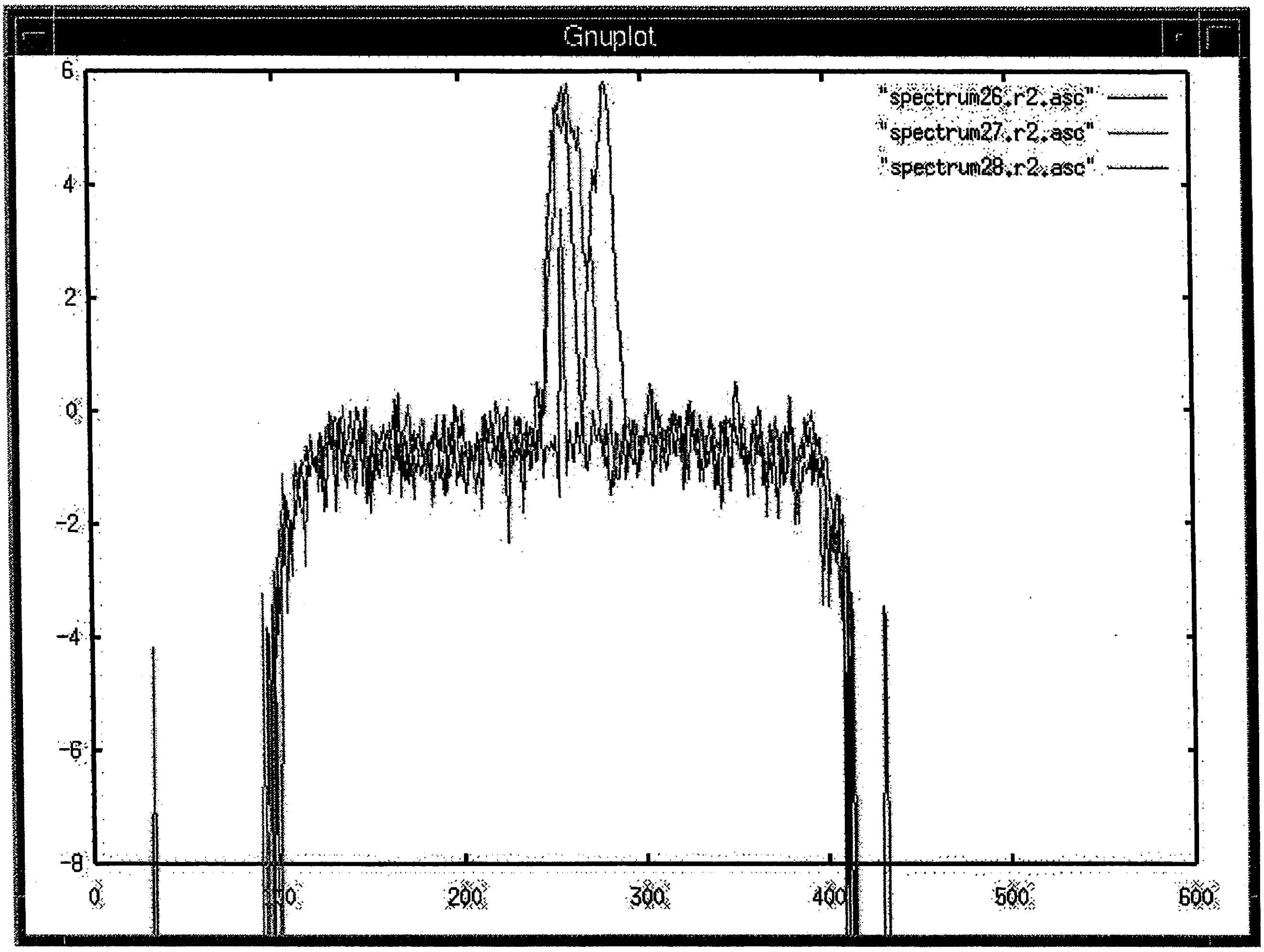


Fig. 6: Shift at the end of flat-top 2 due to a magnetic field shift. The data are consecutive averages of 10 FFTs (512 points). Each average is taken every 700 ms.

Some results - 3

Machine conditions:

- Bunched beam
- Protons, calibrated against BT

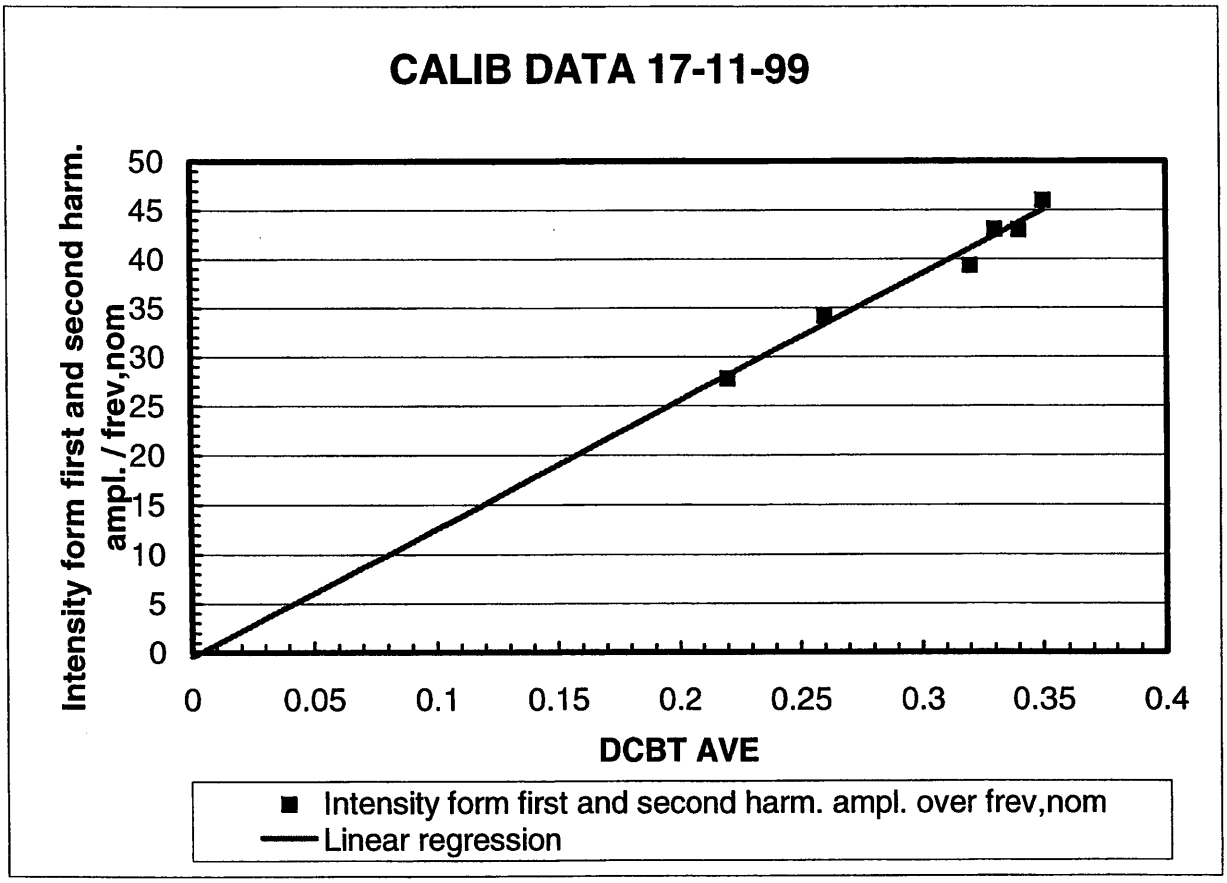


Fig. 7: Plot of Intensity (from first and second harm. amplitude) over f_{REV} vs. DC BT Average.

Problems and future outlook

- *Data exchange* : DRX⟺ RTT comm. thru' shared memory ***can*** affect DRX data acquisition (not always). ➡ need to implement a driver.

- *Data processing* : Transverse pickups S/N unfavourable ➡ tune measurements require another method (BTF).

Current and future: Complete high level software development, so low level system can be used to full capabilities

Schottky Diagnostics using Old (H, V, L) and New (L) Schottky Pickups

G. Tranquille

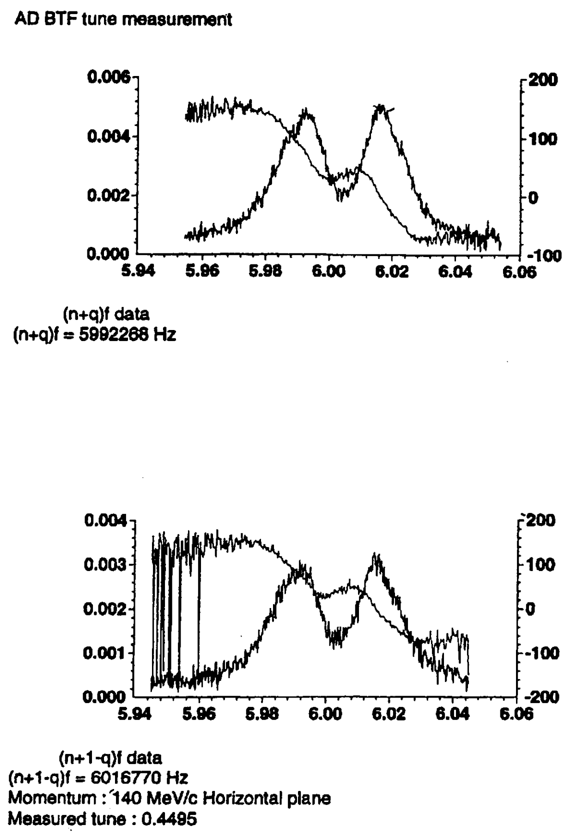
AD Schottky Diagnostics

- Hardware :
  - 'Old' AC Schottky pick-ups, strip line, resonant at 42 MHz (Fritz)
  - Low frequency high gain pick-ups (Ole, Alan, Flemming)
  - Signals connected to spectrum analysers, FFT analyser, or DAQ cards. Analysis on PC.
- Measurements
  - Q on flat-top (spectrum, BTF)
  - Q on ramp
  - Beam intensity
  - Momentum spread
  - Cooling performance

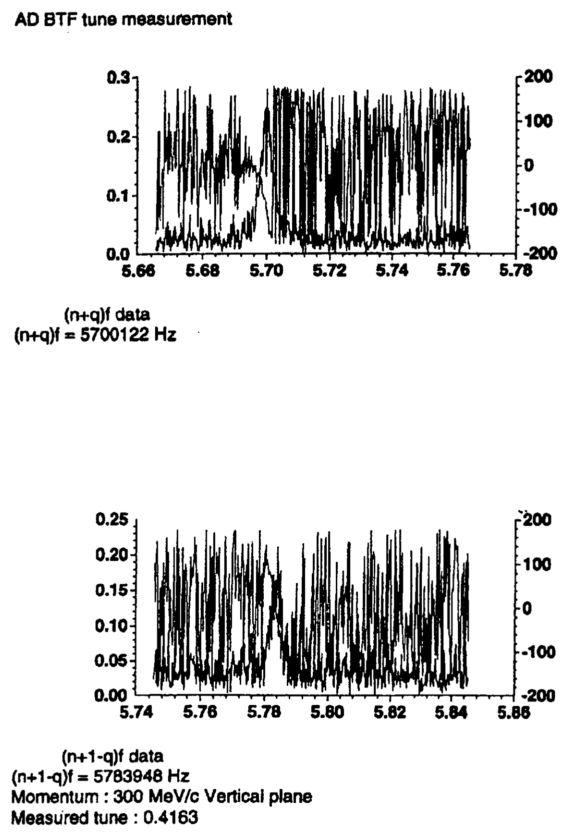
What was done

- Tune measurements on FTs
  - with higher intensities, no problem with spectrum analyser
  - BTF only way to measure with low intensity beams
- Beam intensity using longitudinal signal
  - calibration of both pick-ups done at 3.5 GeV/c with protons
  - used to estimate number of pbars at 300 MeV/c

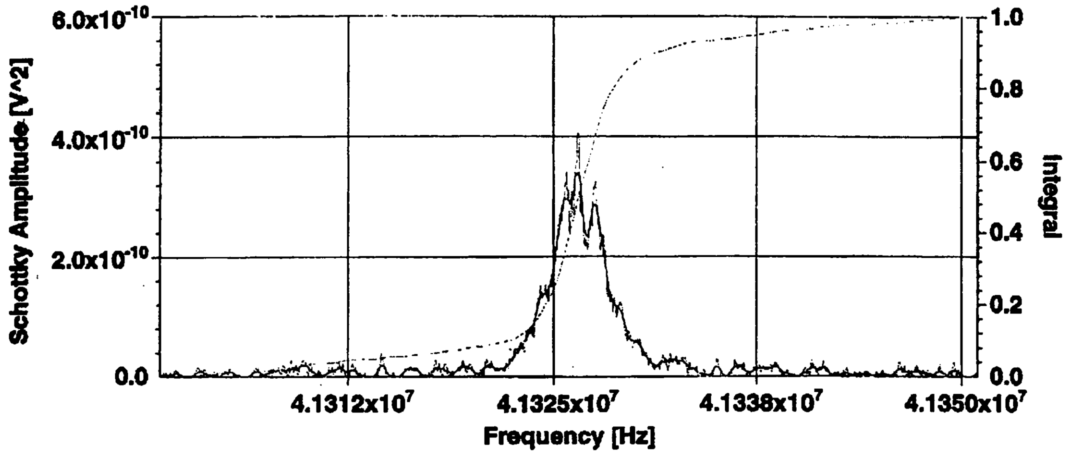
Examples



Horizontal tune measurement at 140 MeV/c. N>1x10^8 protons

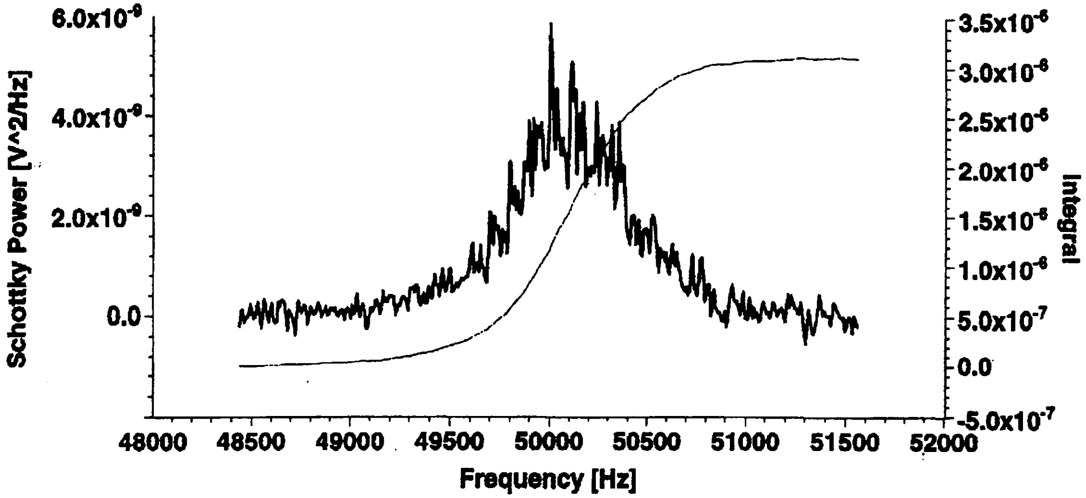


Vertical tune measurement at 300 MeV/c. N=1x10^7 pbars



Longitudinal
Schottky scan
42 MHz PU
+ spectrum analyser

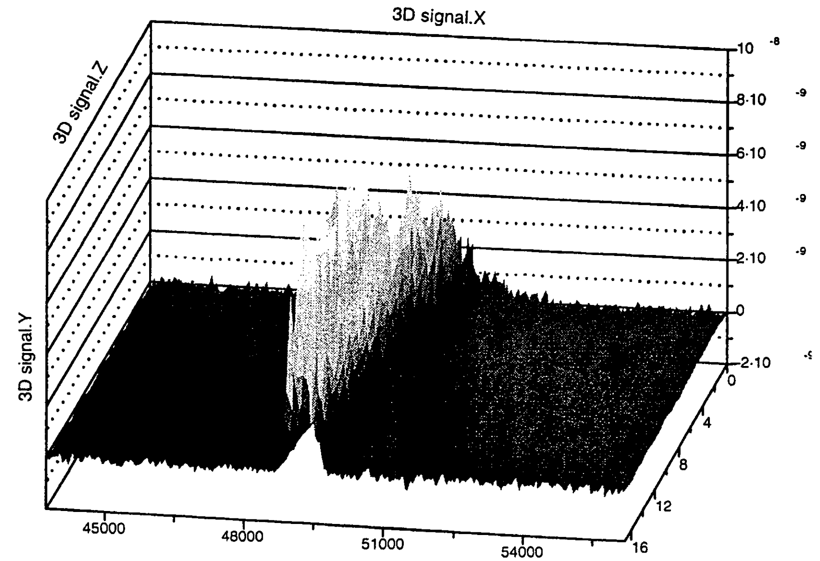
3.5 GeV/c
N=2x10^{7} pbars

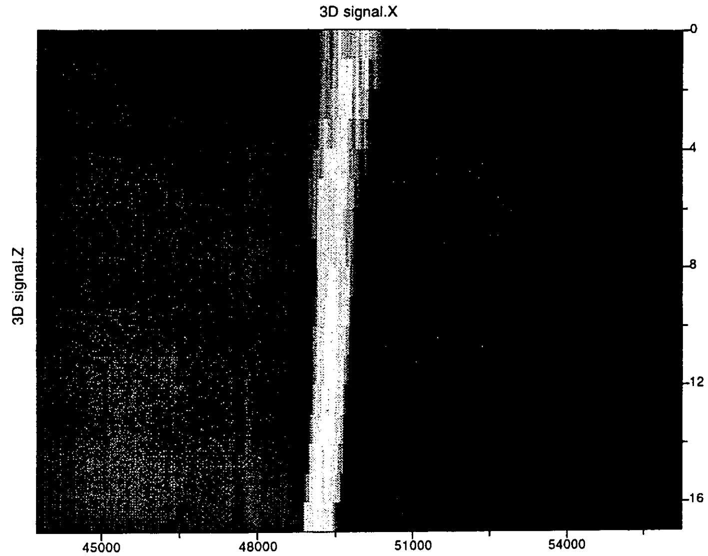


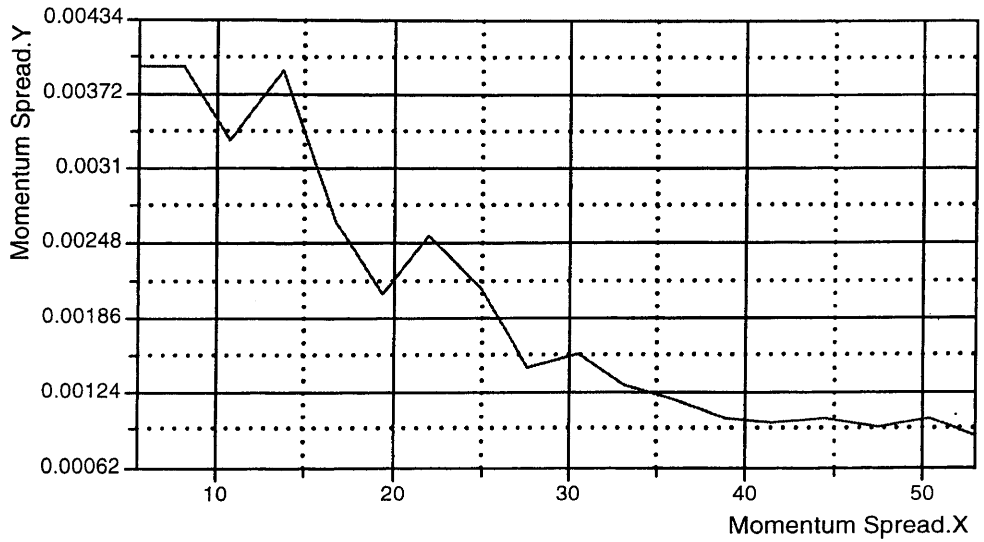
Longitudinal
Schottky scan
low frequency PU
+ FFT analyser

300 MeV/c
N=1x10^{7} pbars
gain = 30 dB

Momentum Cooling at 300 MeV/c







Electron cooling of $1x10^7$ pbars at 300 MeV/c

Problems & future outlook

- NO MAJOR PROBLEMS (except a little doubt on the intensity measurements and low momenta).
- The measurement systems have given good results and are very flexible and quick to develop.
- With DSP based system the present system should become obsolete, but…..?
- 42 MHz system very useful and should be consolidated.
- With a little development tune measurement on ramp could be done using the 42 MHz pick-ups. However the kick method (coherent oscillations) seems to be easier to implement but needs the installation of a fast kicker. This has been tested at injection and works very well.

Diagnostics & Instrumentation for Decelarating RFQ in the Beam Line DE1

V. Prieto

Extraction Rapide

- 10^7 pbars
- Durée: ≈ 500 ns
- 100 MeV/c $\xrightarrow{\text{RFQ}}$ 50KeV

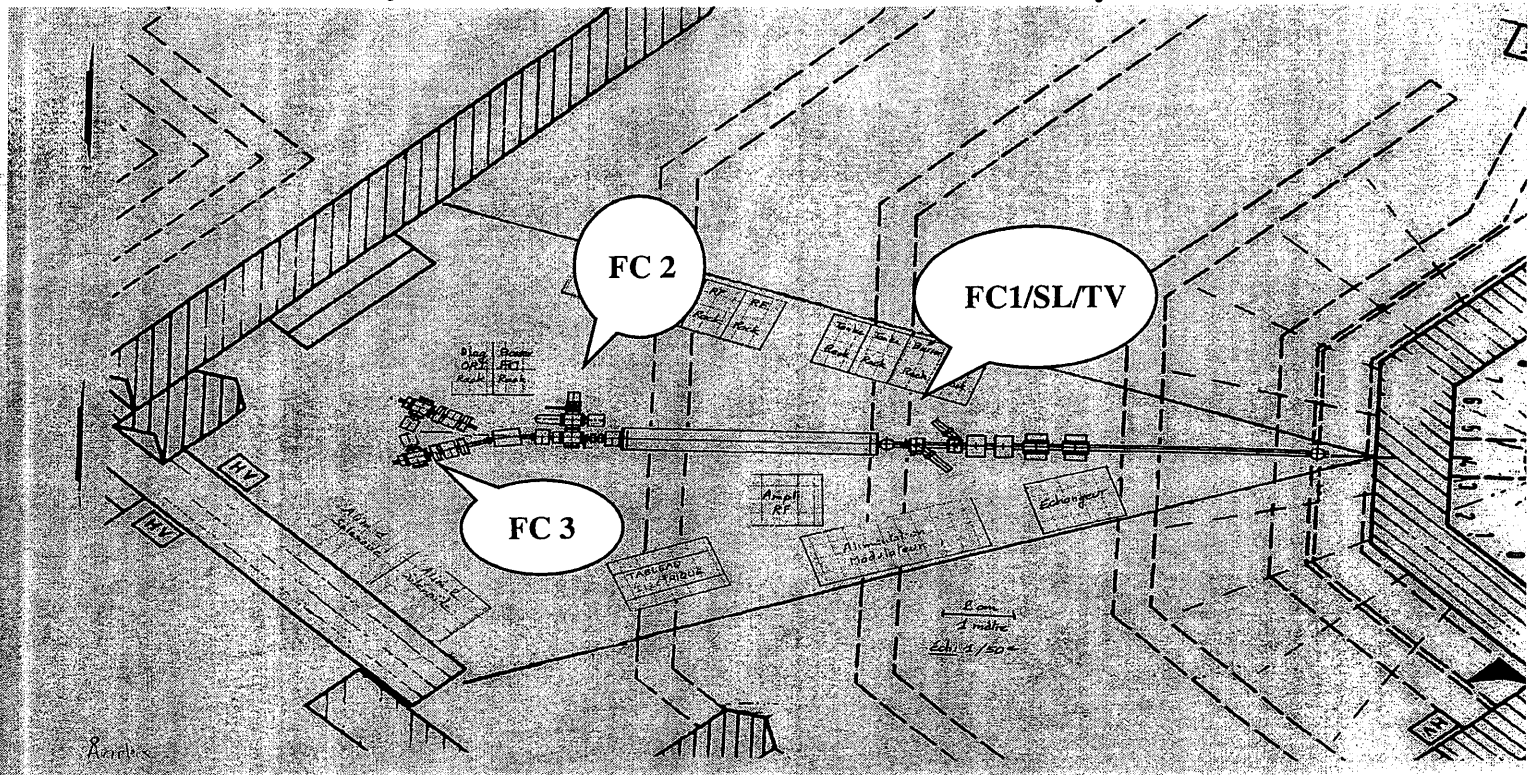
Détecteurs

- Ecran TV Plein/Troué (Profil) (G. Martini)
- Coupe de Faraday (Intensité p) (Priet./Molin.)
- Strip Line (Profil) (R. Maccaferri)

Détecteurs avec système IN/OUT
Ils vont être opérés en mode Local (Baraque ASACUSA/AD)

Tests RFQ Åarhus (Mars'0

- **Protons, 100MeV/c, ≈ 1μA sur ∀μs**

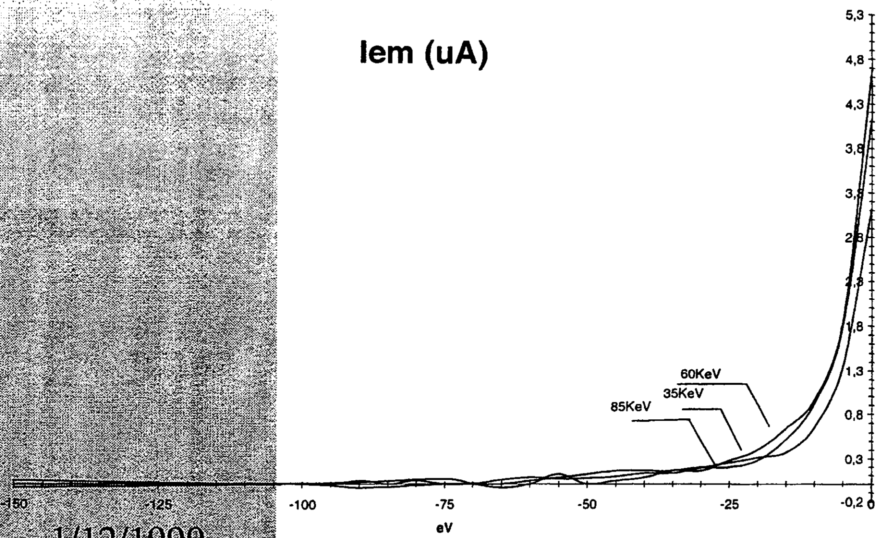


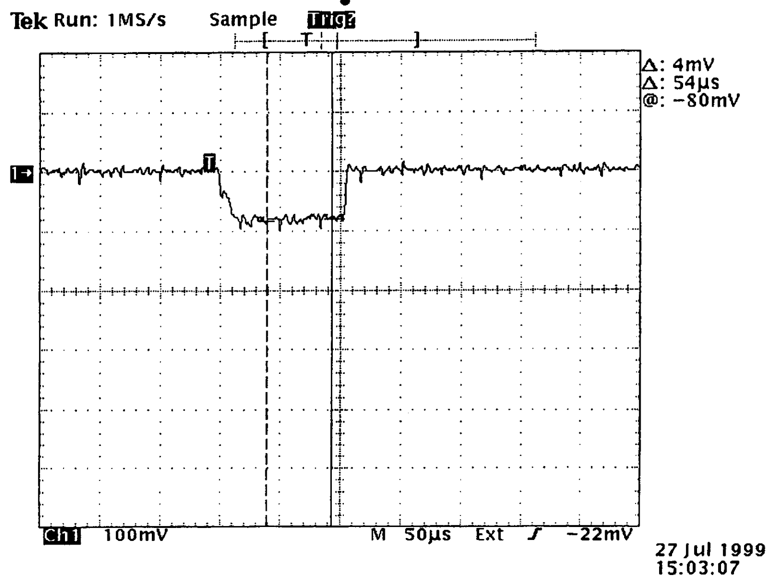
Mesures AD (Sept. 2000)

- Mesures profils avec écrans pleins et creux.
- Faraday Cup: Problèmes d'annihilation.
  - Scintillateur + Photomultiplicateur
- Strip Line: Mesures de profil.

Résultats Préliminaires (1)

- Coupe de Faraday:Duoplasmatron (p)
  - Bonne réponse dans les μA
  - Eléctronique: integrateur/amplificateur



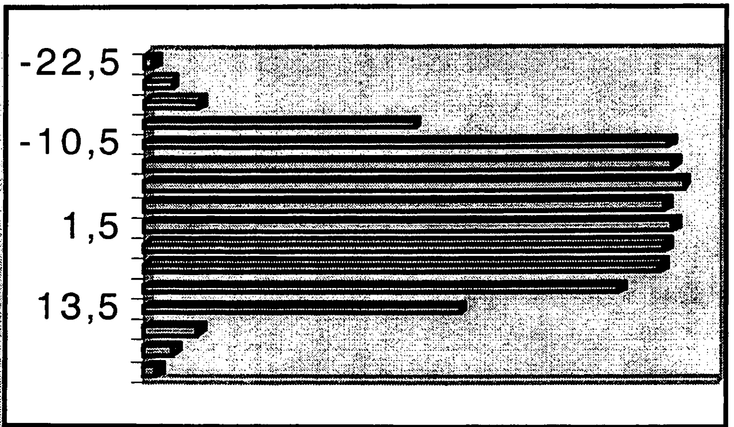


1/12/1999

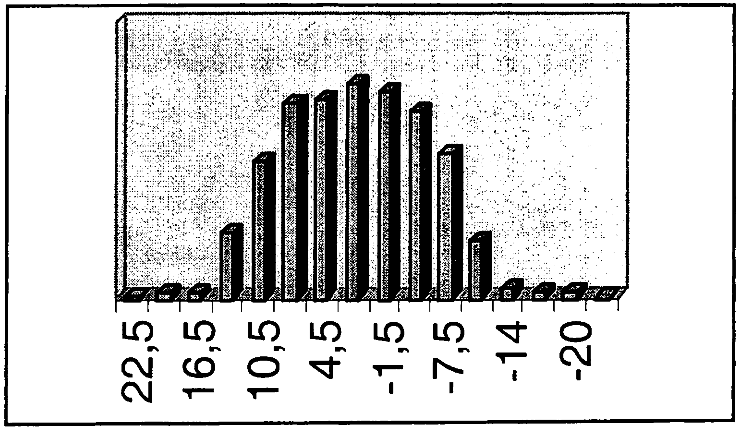
Résultats préliminaires (2)

- Strip line

	Horizontal	Vertical	
mean	1,391968	0,043597	mm
sigma	6,812752	8,489446	mm
sum	154121	128266	counts



Vertical



Horizontal

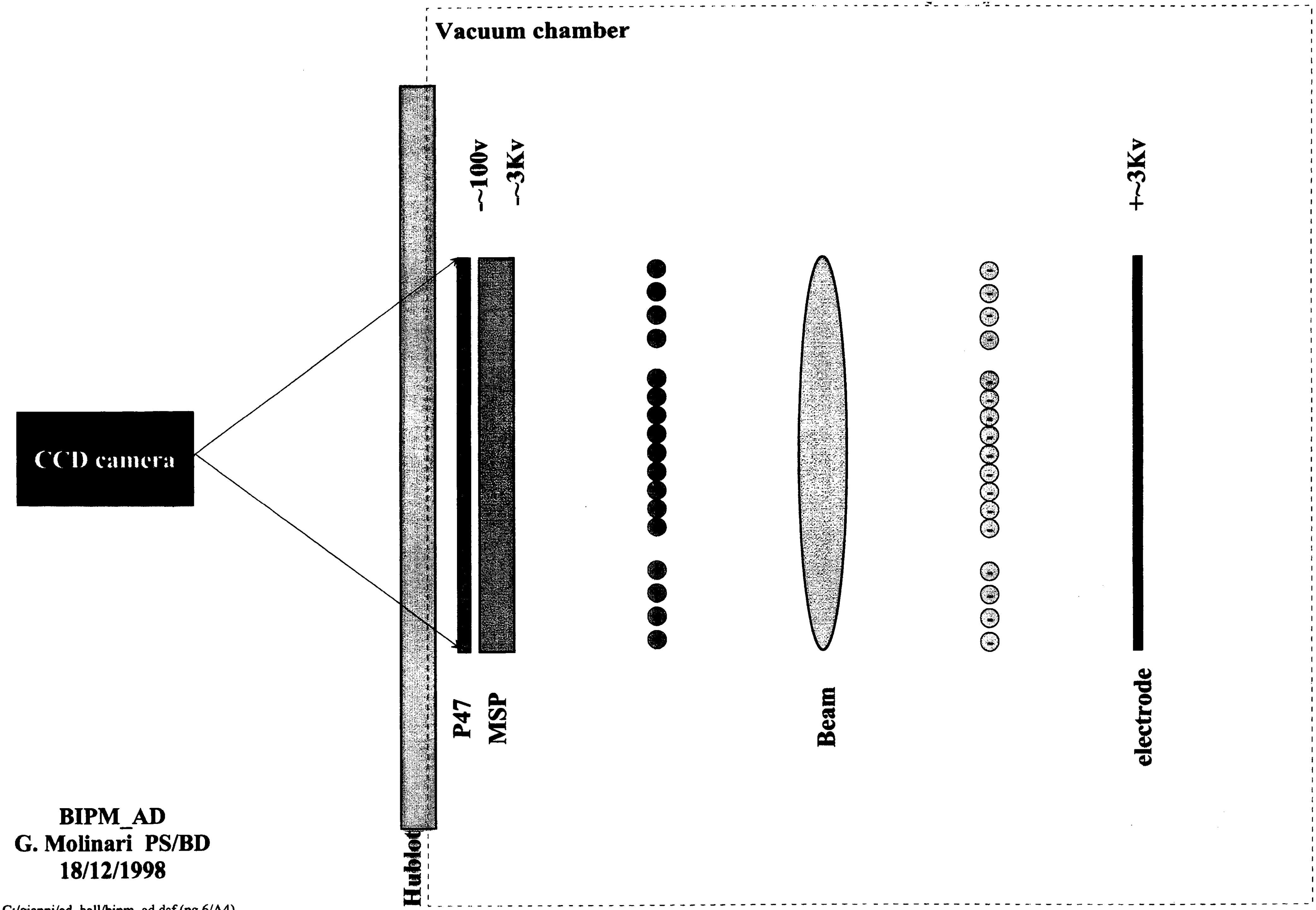
→ Intensité: $\approx 10^7$ (protons (SPS))

Résultats Préliminaires (3)

- Micro Channel Plate + Phosphore
  - On espére la tester à 50KeV avec la source Duoplasmatron.

Beam Ionisation Profile Monitor

G. Molinari



BIPM_AD
G. Molinari PS/BD
18/12/1998

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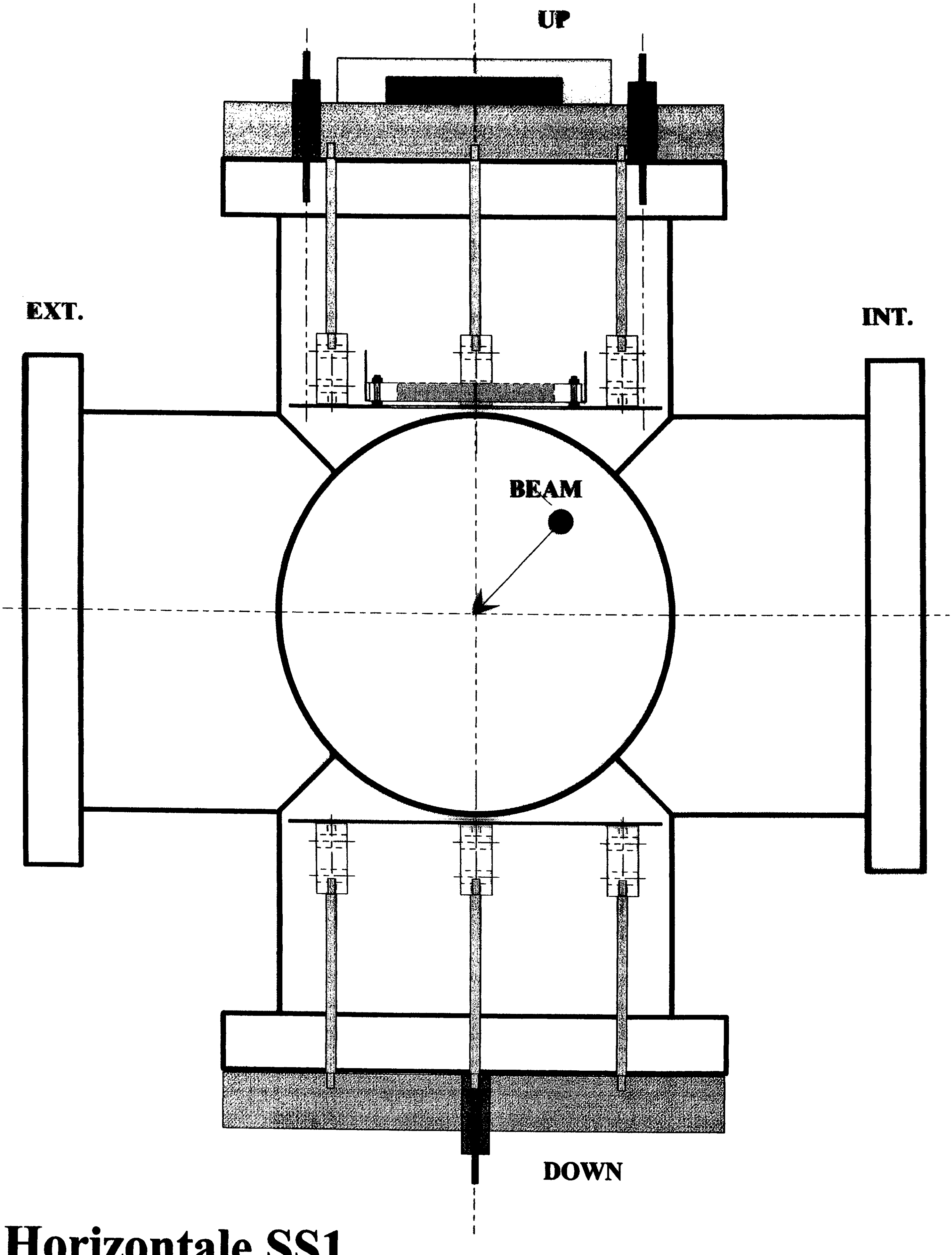


Horizontale SS1

MSP C070DTP47
N.0101846

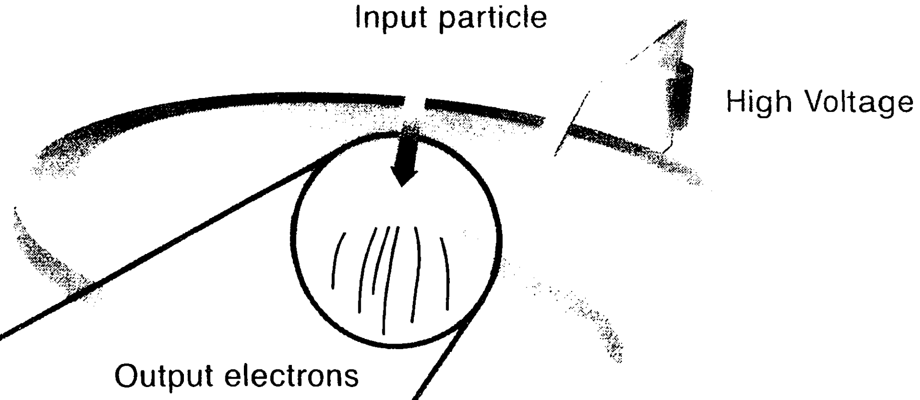
Tank BIPM
(ensemble)
G.Molinari PS/BD
03/03/1999
C:/gianni/ad_hall/bipm_ad.dsf (pg.18/A4)

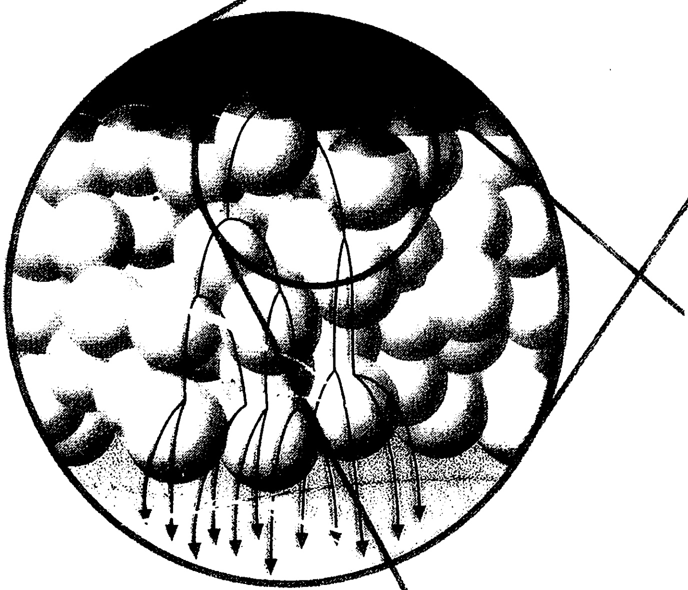
MicroSphere Plate

El-Mul

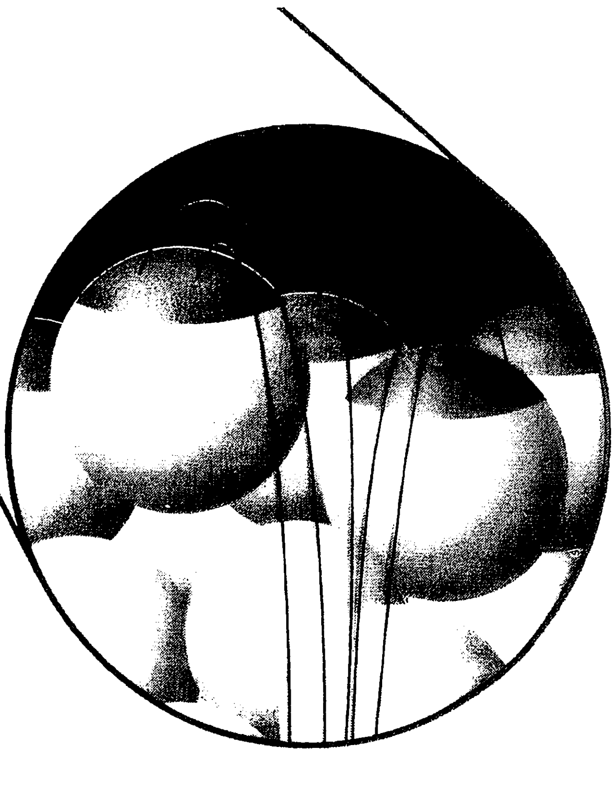
El-Mul Technologies Ltd.
Soreq, P.O.Box 571, Yavne 81104, Israel.
Tel: 972-8-9422677, Fax: 972-8-9422676,
e-mail: 100274.16@compuserve.com
WWW: http://el-mul.co.il

A MicroSphere Plate (MSP) is a compact electron multiplier. It consists of 50 μm glass beads sintered to form a thin porous plate.





Input particles hitting the MSP produce secondary electrons. These electrons are accelerated by the electric field through the porous plate and collide with the beads' walls. In each collision more secondary electrons are generated. Finally, a large number of electrons emerge from the output side of the MSP.

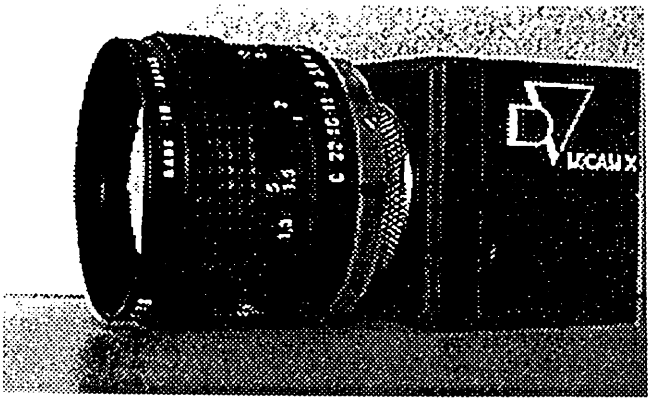


Secondary electrons generated at the front surface are directed by the electric field into the MSP. Due to this 'funneling effect', nearly the entire MSP front surface is active.

DIGITAL VISION TECHNOLOGIES

N°T0300C

MICAM X



PRESENTATION GENERALE

L)améras **MICAM X**, extrêmement compactes, ont été conçues pour de nombreuses applications industrielles spécifiques
Haute résolution,haute sensibilité, temps d'intégration pilotable et boîtier de petite taille font de la **MICAM X**, la caméra idéale pour les applications de robotique, contrôles industriels, guidage , nécessitant une caméra miniature performante et robuste.
La gamme **MICAM X** comprend les modèles **XR** et **OEM**.
Ces deux caméras ont en commun l'ensemble électronique et le boitier mécanique. Elles se différencient par leur interface connectique.
La **MICAM XR** est un produit standard. Ses fonctions "figées", directement utilisables donnent lieu à une mise en oeuvre simple et rapide.
La **MICAM X OEM** est un produit "ouvert".Les signaux disponibles sur le connecteur de la face arrière permettent un contrôle précis de chaque fonction. La caméra autorise une grande souplesse d' utilisation et des possibilités d'adaptation à la spécificité de toute application.

SPECIFICATIONS

	CCIR	EIA
Capteur	SONY ICX 027	SONY ICX 026
Pixels	500 (H) x 582 (V)	500 (H) x 494 (V)
taille cellule	12.7 (H) x 8.3 (V) microns	12.7 (H) x 9.8 (V) microns
zone sensible	6.46 (H) x 4.83 (V) mm	6.45 (H) x 4.84 (V) mm
Balayage	625 lignes, 2:1 entrelaçé	525 lignes, 2:1 entrelaçé
Horloge pixel	9.458 MHz	9.545 MHz
Freq .Horiz	15.625 KHz	15.734 KHz
Freq .Vert	50.0 Hz	60.0 Hz
Résolution TV	> 400 lignes	> 400 lignes
Caractéristiques électroniques		
S/N ratio	48 dB (CAG OFF)	
Sensibilité	0.3 lux (F / 1.2)	
CAG	ON (16 dB standard, 32 dB max)	
Sortie video	1.0 V CàC video composite , 75 Ohms	
Alimentation		
Tension	de 8 à 13 VDC	
Consommation	maxi 160 mA	
Contraintes d'environnement		
Temp Fonctionnement	-10°C à + 55 °C	
Temp Stockage	-30°C à +80°C	

C.A.G ET GAIN FIXE

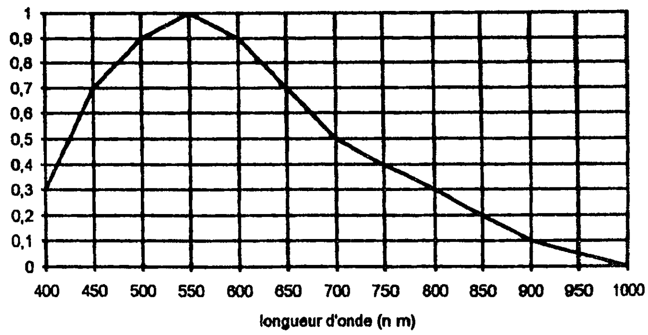
Le commutateur C.A.G se trouve sur la face arrière de la caméra)
- **CAG OFF** : Pas de correction automatique de gain.Position gain fixe.
Le niveau de signal dépend du réglage du gain de l'ampli vidéo donné par le réglage du potentiomètre de "GAIN" .Le potentiomètre se trouve sur la face arrière de la caméra.
- **CAG ON** : Correction automatique de gain active.
Le C.A.G maintient le niveau du signal vidéo à une valeur moyenne constante pour différents éclairements de la scène.

OBTURATEUR ELECTRONIQUE

Le temps d'intégration de l'obturateur électronique de la caméra **MICAM X** peut varier du 1/ 50 ème au 10 000 ème de seconde.
La roue codeuse (shutter) située sur la face arrière permet aisément de faire varier le temps d'intégration.

Position	Temps d'intégration
0	1/50(CCIR)- 1/60 (EIA)
1	1/100(CCIR)-1/120 (EIA)
2	1/250
3	1/500
4	1/1000
5	1/2000
6	1/4000
7	1/10000 (100 microsecondes)

REPONSE SPECTRALE

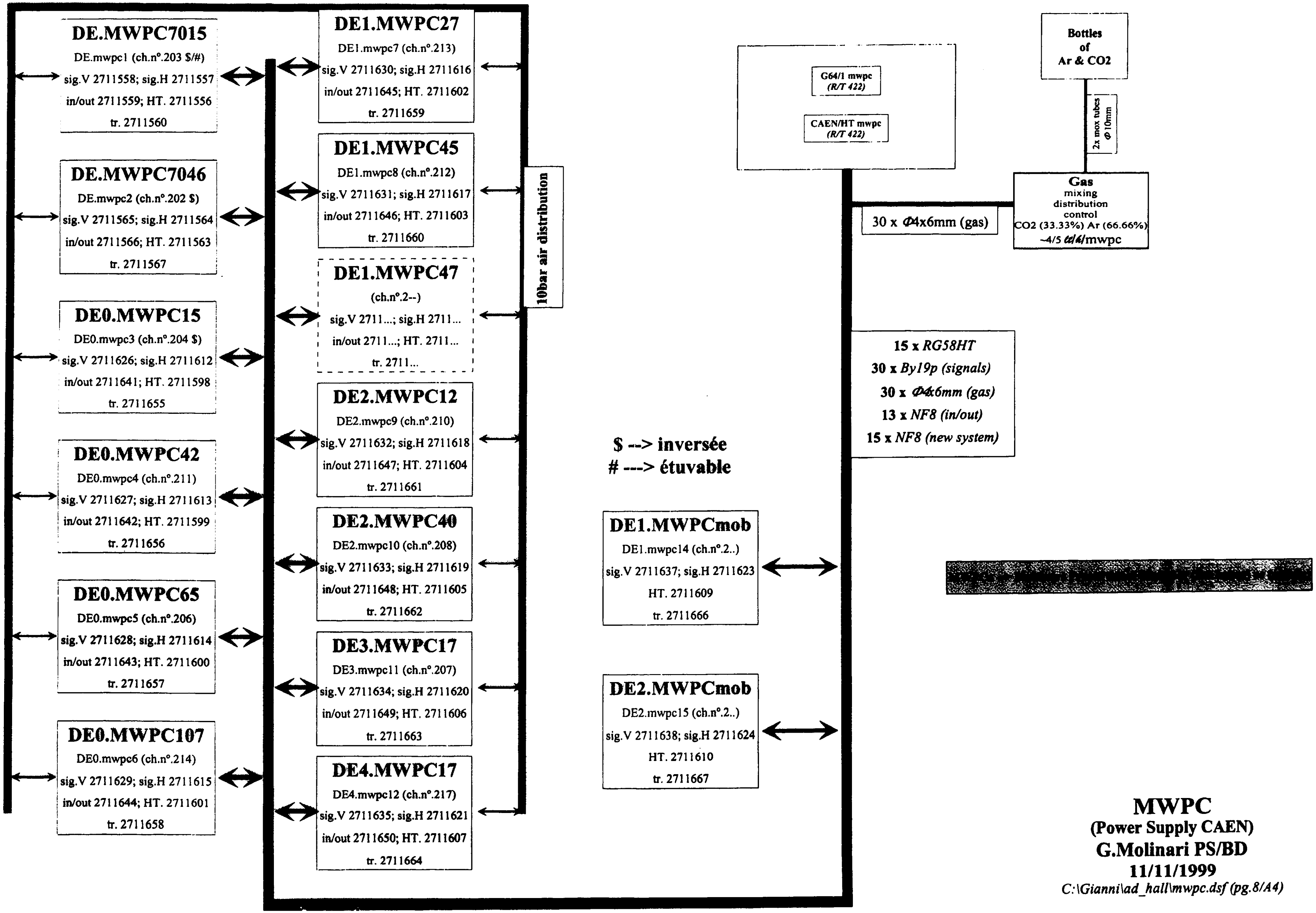


MONTURE OPTIQUE C OU CS

Tous les modéles de la gamme **MICAM X** sont prévus pour fonctionner avec les deux standards d'objectifs C et CS.
Pour l'utilisateur, les deux normes se distinguent par le tirage optique.
le tirage optique est la distance qui sépare "l'objectif" du capteur de la matrice CCD Cette distance est de 12 millimètres pour la norme CS et de 17,25 millimètres pour la norme C
Une bague de 5,25 millimètres d'épaisseur vissée. ou non-vissée sur la face avant de la caméra permet de s'adapter aux deux normes.
La bague de conversion CS/C est livrée avec votre caméra

MWPC in Beam Lines for Physics

G. Molinari



MWPC
(Power Supply CAEN)
G.Molinari PS/BD
11/11/1999
C:\Gianni\ad_hall\mwpc.dsf (pg.8/A4)

The voltage applied between the cathodes and the wires can be adjusted in order to tune the MWPC sensitivity to the intensity and energy of the beam to observe, and must not exceed 3.5 kV. Each plane is composed of 100 wires which are combined such as to form 16 groups connected to a 16-channel integrator module. According to the position of the MWPC on the ejected beam and the resolution needed, the central wires are connected to the integrator channels in groups of 1, 2, 4, or 6, while the remaining lateral wires are grouped together on channels 1 and 16. The total interacting mass represents the equivalent of 340 μm of aluminium, including the vacuum windows. To avoid a beam degradation, the MWPC has to be retractable when not in use. Thus the MWPC is fitted in a moving assembly, named pendulum, inside a vacuum box (Fig. 3). The MWPC movement can be controlled either from a local switch panel, or from the main control system.

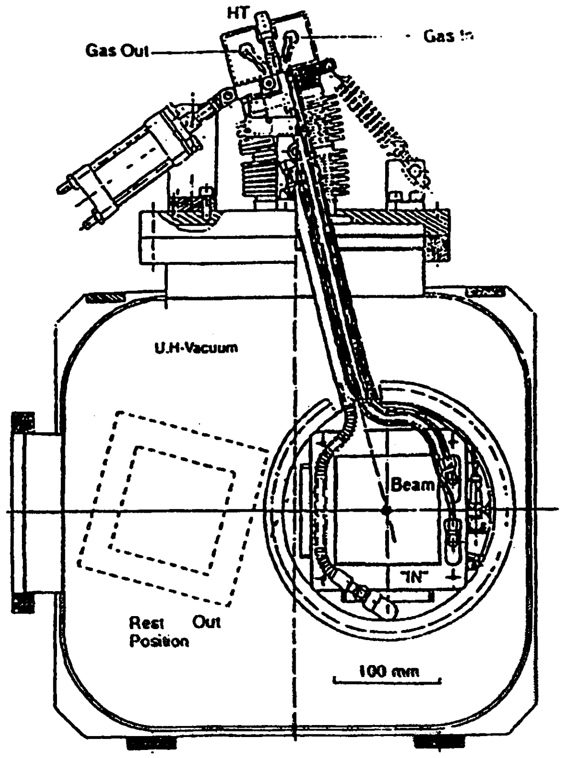
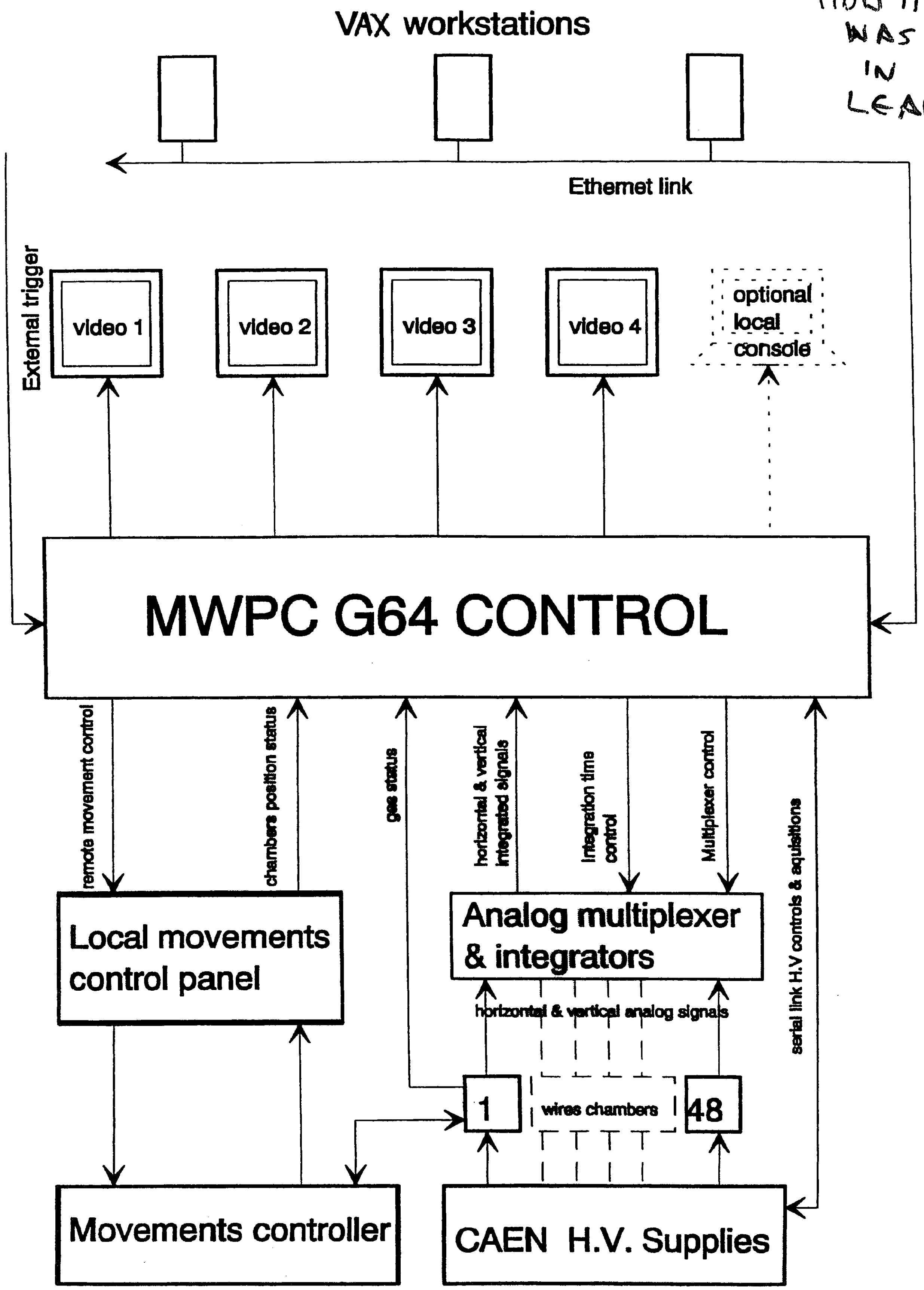


Fig. 3 - MWPC mechanical assembly (pendulum)

The gases (CO_2 and Ar) for the chambers, are supplied through a distribution rack, where the gases are mixed. Each MWPC gas supply is equipped with a flow-meter to adjust the flow between 1 to 2 l/h and a bubbler to control the circuit pressure. The gas status "OK" or "BAD" is generated by a reed-relay on the flow-meter.

4. MWPC CONTROL

The local control panel is the master, and has a Local/Remote switch. When a beam profile is needed, the chamber is moved into the beam by the corresponding switch on the panel or from the workstation. Then the status "IN" is given by a micro-switch on the pendulum mechanism. Integration starts automatically if the selected mode is continuous, or with an external trigger if the mode is one-shot. When the required integration time (typically 1 sec for continuous mode) is finished, the integrator voltage is acquired for each wire with a fast ADC (analogue-to-digital converter) and stored in the memory. Finally, the integrators are discharged and a new cycle can start. A software algorithm treats the stored data and shows the beam profile as a video histogram. Optionally the profile can also be shown as a shaded spot which reconstructs the beam cross section. (Fig. 4).



HOW IT WAS IN LEAR

APPENDIX 3 – *General system layout*