Beam profile measurements

- Screens and MTV systems
- Time resolved measurements in the spectrometer lines
- Status and plans for the Uppsala RF pick-up
- Synchrotron Light Monitors in the INFN chicane

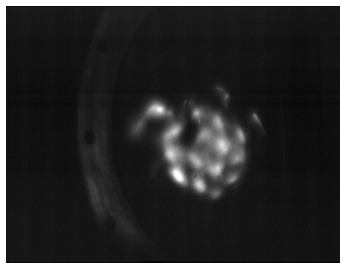
CERN, INFN, Uppsala University

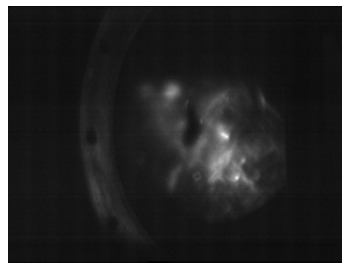
Screens and Optical Systems

Beam profile measurement after the gun

- 5μm thick P47 Phosphor ($Y_2SiO_5:Ce$) deposition on a 10μm thick aluminum foil

  - With 1μm grain size
  - Spectral response : [370, 480nm], Max at 450nm
  - Decay time : 100ns (90-10%) , 2.9μs (10-1%)

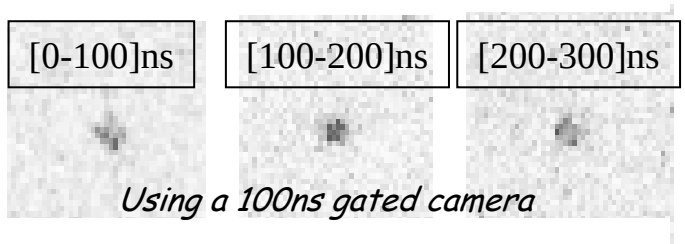




  - Good for dark current monitoring (only)
  - Screen already damaged, to be replaced..

- 5μm thick Thin carbon foil (OTR)

  - Spectral response : visible region [400-600nm]
  - Temporal response : few fs
  - few photons (10^4 less than the scintillating screen)



Using a 100ns gated camera

  - To be used with an gated and intensified camera
  - Installation during this shutdown to be used during the sub harmonic buncher commissionning

Screens and Optical Systems

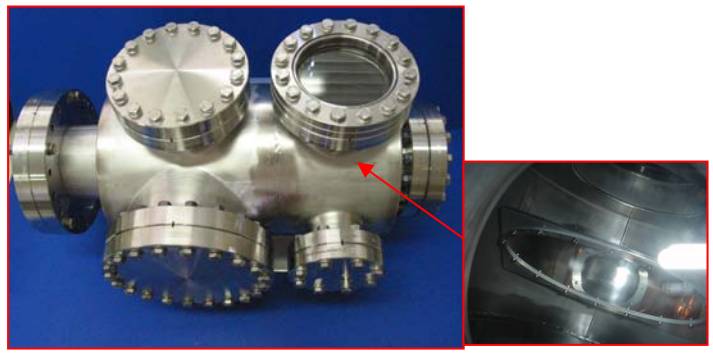
In the Linac (Quad scan) for emittance measurements

- Backward OTR screens :
  - Two screens mounted on pneumatic arms
  - Screens tilted to 22.5° (observation at 45 °)
  - 10μm thick Aluminum foil (~90% reflectivity)
  - 100μm thick Carbon foil (~26% reflectivity)
  - Active Size : Ø3cm

Scan in X

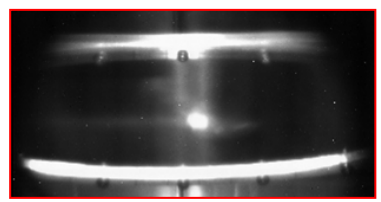
Scan in Y

In the spectrometer line for Energy and Energy dispersion measurements



- Backward OTR screen :
  - Fixed screen tilted at 45° (observation at 90 °)
  - 10μm thick Aluminum foil (~90% reflectivity)
  - Active Size : 10cmx4cm

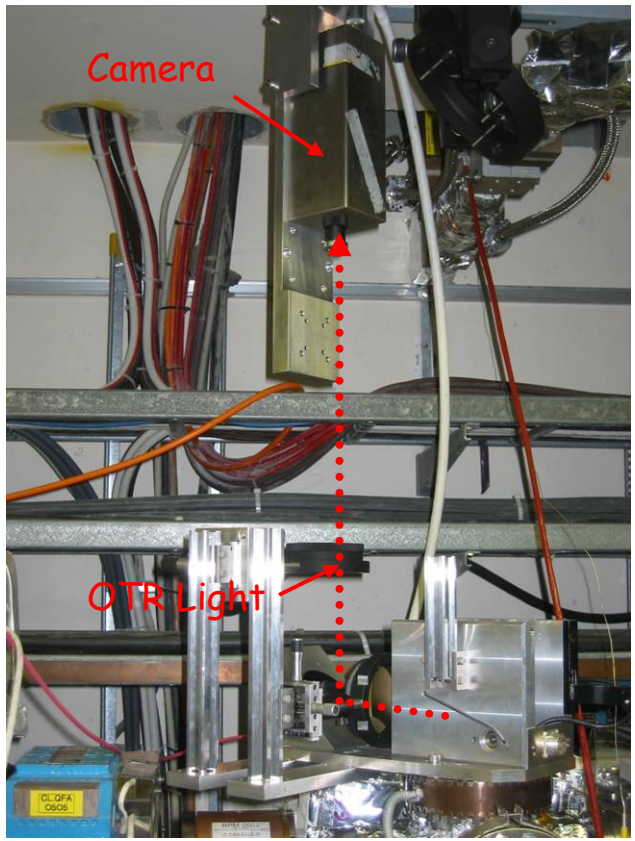
Light off



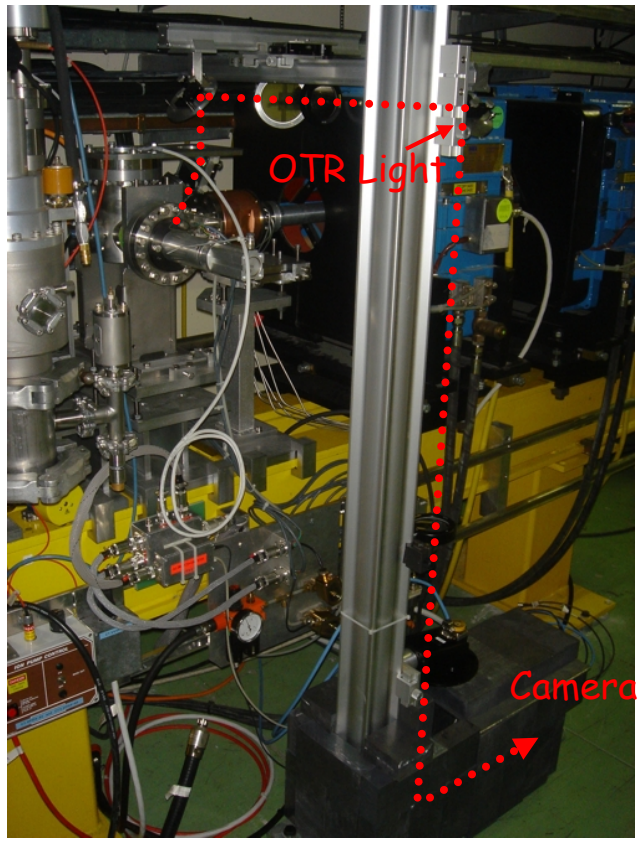
Light on

Screens and Optical Systems

2003



2004

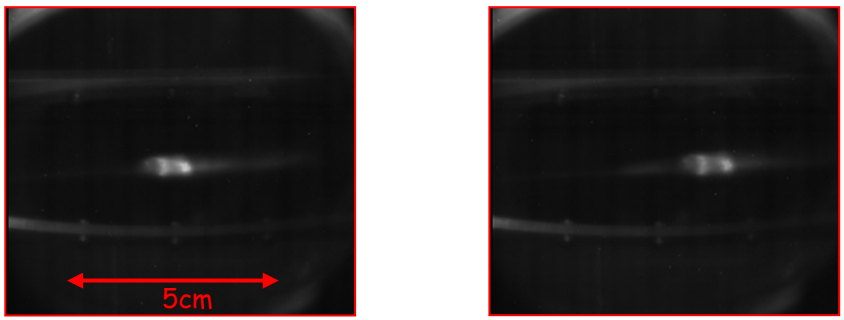


Optics of 'all' systems was modified in order to replace the radiation hard cameras by CCD cameras to improve the sensitivity of the measurement

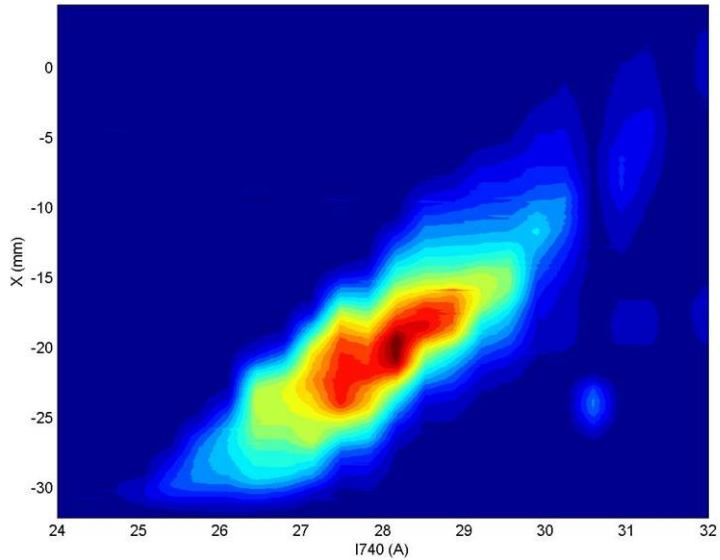
Screens and Optical Systems

Problem linked to the optical acceptance

- Displacing the beam position using the spectrometer dipole magnet
- For each values of the dipole current (A), measuring the horizontal profiles



Pictures taken on the CLS.MTV0750



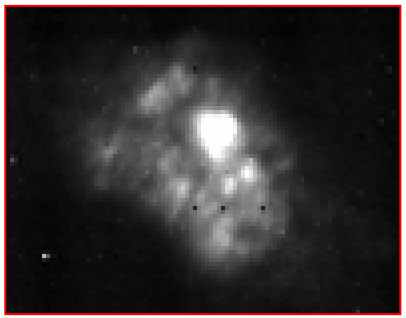
- The optical acceptance decreases rapidly as the beam position changes
- The optical acceptance is constant (80%) over a distance smaller than 1cm (~ as the beam size)

- This effect was observed on all the MTV's (linac and spectrometer line) and is due to the small angular aperture (~1/γ) of the OTR light
- Need to modify the optical lines in consequence but there will be a compromise between the optical acceptance, the light intensity and aberrations

Screens and Optical Systems

Problem linked to the screen itself

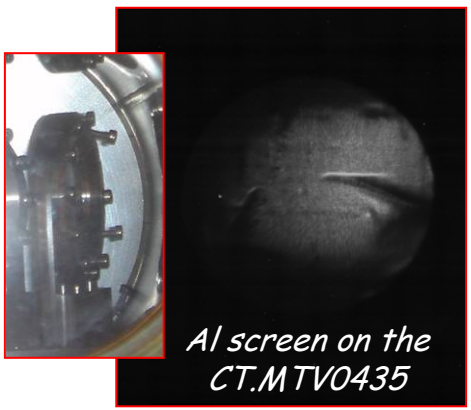
→ The non perfect homogeneity of the C screen affects the local reflectivity of the screen



Pictures taken on the CT.MTV0435

- Problem to measure accurately beam profiles and halo distribution

→ Support in order to stretch the foil



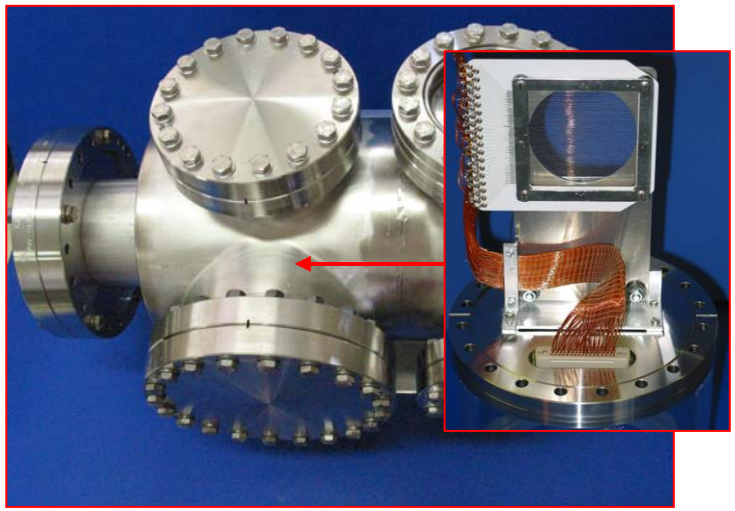
Al screen on the CT.MTV0435

- The stretching of the foil can be degraded by the bake out procedure of the vacuum tank : *Observed on a spectrometer line 7*
- Human Mistake … ?

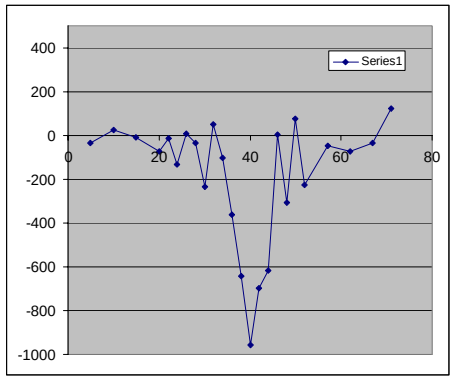
⇒ Replacing the screens by 300μm Si wafer, Al coated SI wafer for higher reflectivity, and probably polished C or SIC for high charge beam

Time Resolved Measurements in the Spectrometer lines

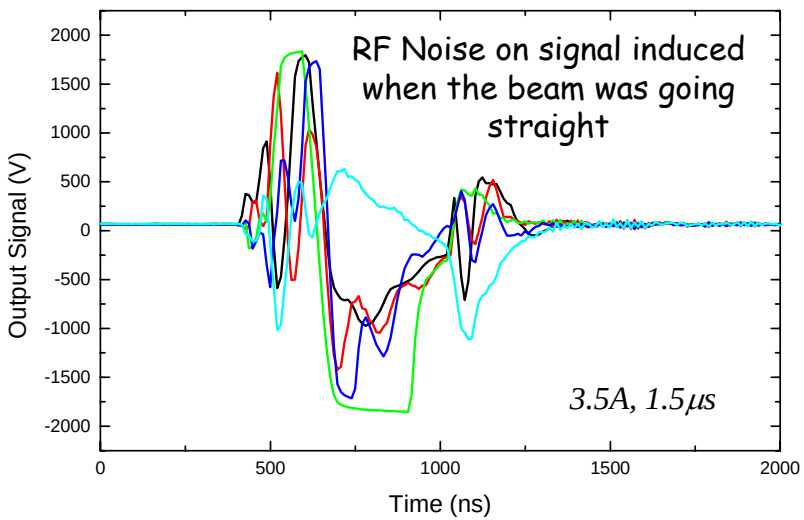
In 2003 Time resolved measurements were done using SEMGrids (two were installed)



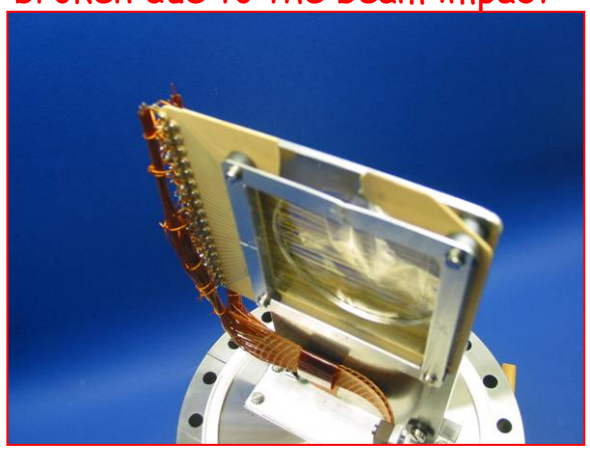
SEMgrid profiles
~ 1 A – 320 ns – 25.5 MeV



- Problems to measure profiles for higher beam charge

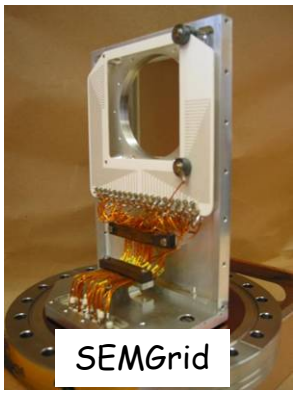


- One SEMGrid was damaged: Its ceramic support was broken due to the beam impact

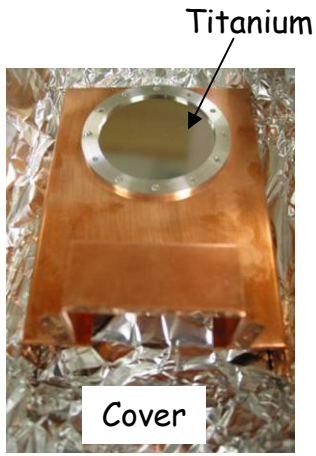


Time Resolved Measurements in the Spectrometer lines

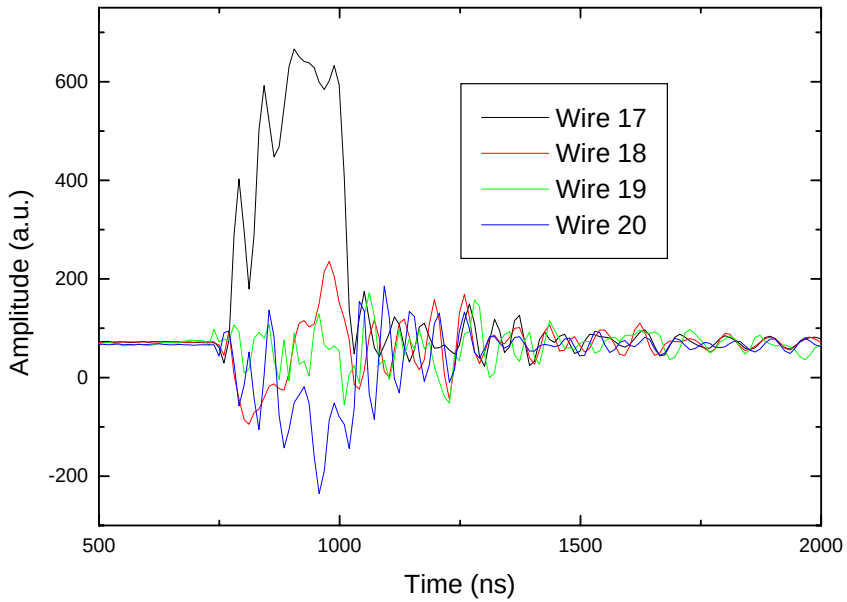
Performance of the new SEMGrid



New support to avoid mechanical stress induced by the beam



New shielding to minimize the RF noise

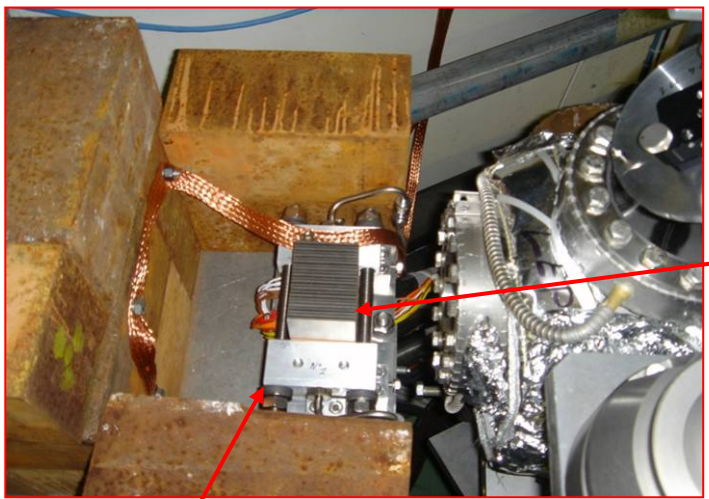


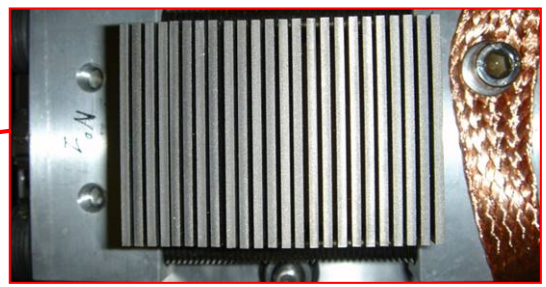
- The beam induced RF noise seems to be smaller than before and the time signal looks acceptable
- The SEM signal is supposed to be negative with our electronic but from one wire to the next everything can happen..
- No profile was measured and SEMGrid's in the CTF3 will be presumably abandoned

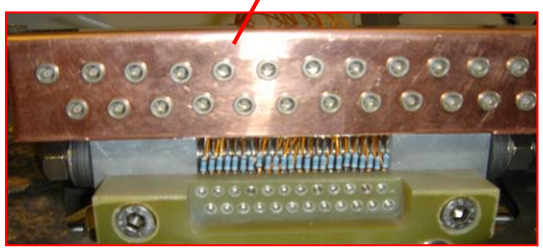
Time Resolved Measurements in the Spectrometer lines

• Just before the end of the run 2003, a test was done using a segmented dump which was developed for CTF2 to measure the time evolution of a 1nC electron beam

• <u>Two Segmented Dumps were built in 2004:</u>







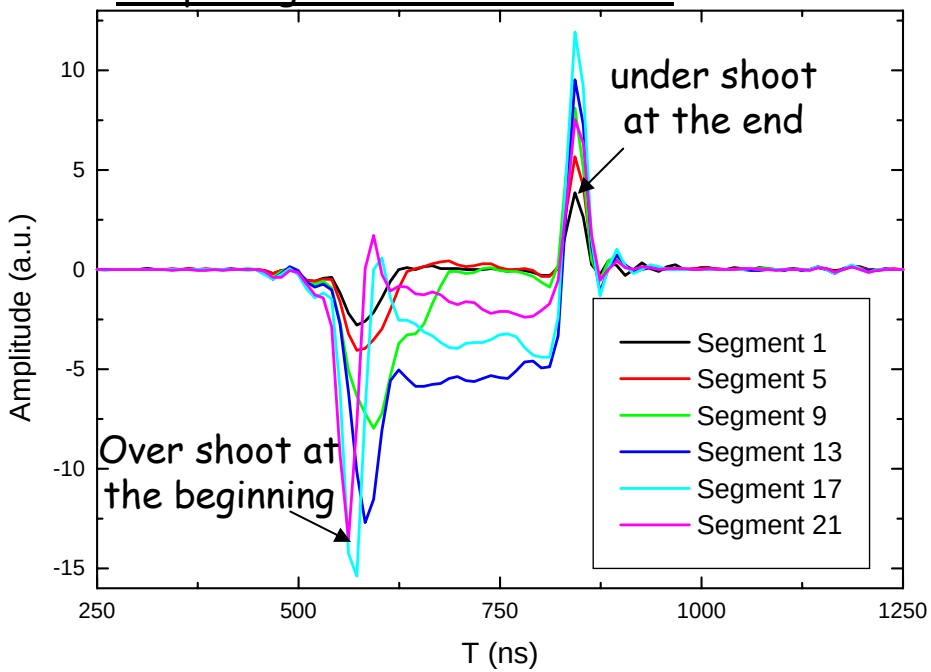
• 24 Tungsten plates (2mm thick) spaced by ~ 1mm
• Water cooled
• Connected to 1Ω in serie and 50 Ω to the ground

Installed in spectrometer lines on girders 4 and 7

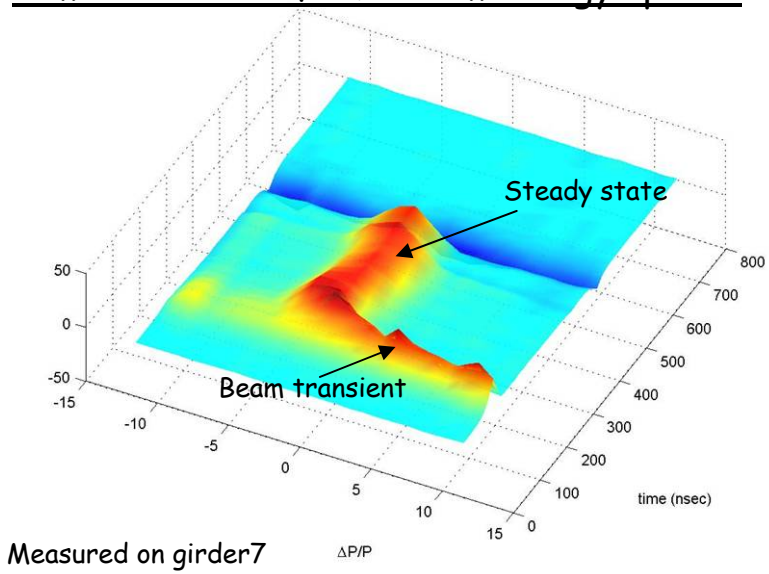
Time Resolved Measurements in the Spectrometer lines

Performance of the new Segmented Dumps

Output signals on 50MHZ ADC's

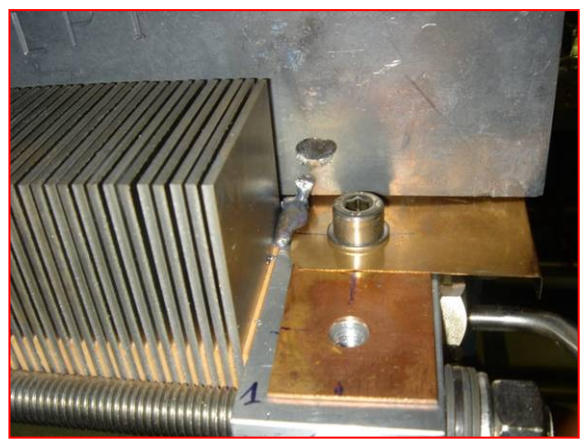


Time evolution of the beam energy spread



Measured on girder7

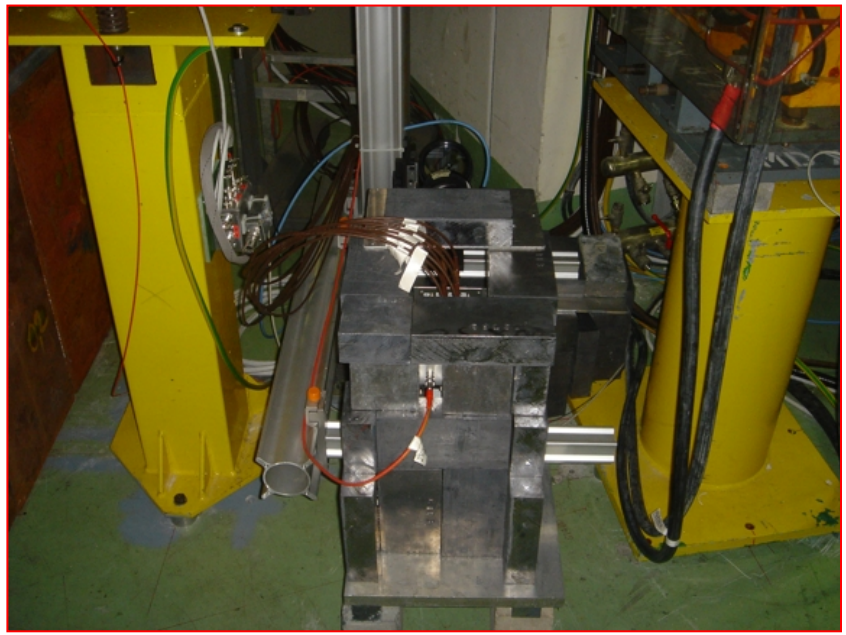
- Bandwidth limited (parasitic noise)
- Destructive method (long term reliability)

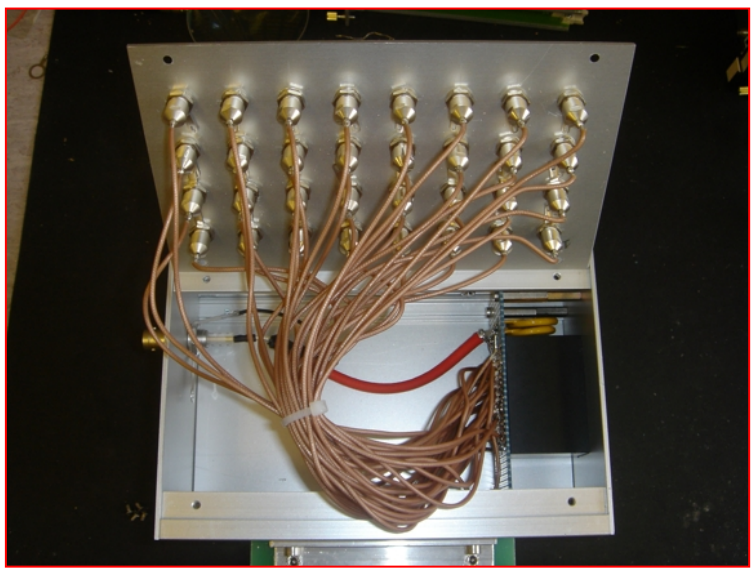


Time Resolved Measurements in the Spectrometer lines

A Segmented Photomultiplier installed on the optical of the spectrometer line in the CT line

- Using a 32 channels Segmented photomultiplier from Hamamatsu Corp.
- Observing the OTR light produced by the Al screen
- Installed a beam splitter installed on the optical line to the CCD camera





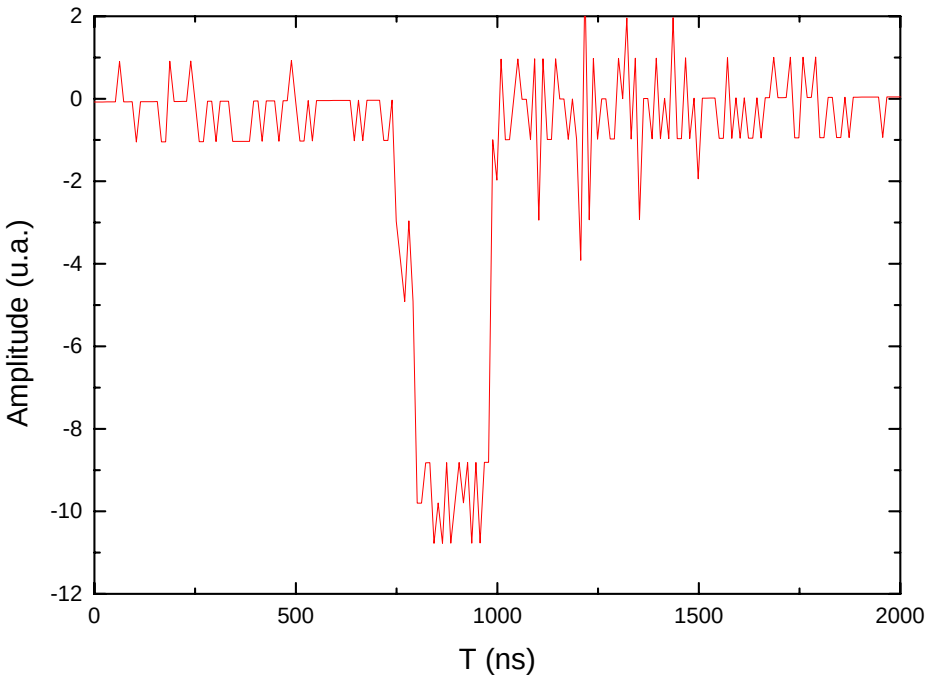
General characteristic

- *Optical line magnification: 0.36*
- *PMT assembly:*
  - *Size of a segment : 0.8mm*
  - *Distance between segments : 1mm*
- *Total distance covered by the PMT is 89.6mm*
- *Resolution is 2.8mm*

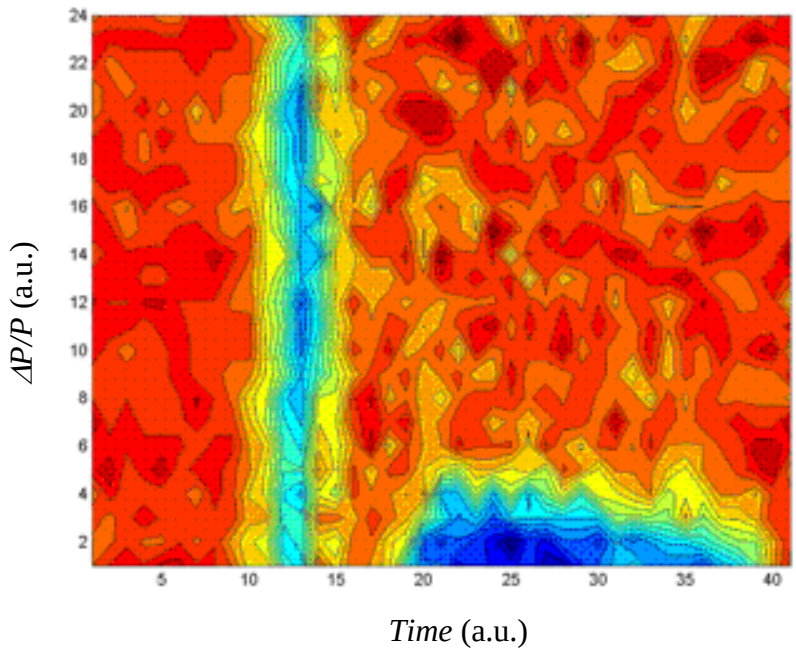
Time Resolved Measurements in the Spectrometer lines

Performances of the Segmented Photomultiplier

Time response of one PMT channel

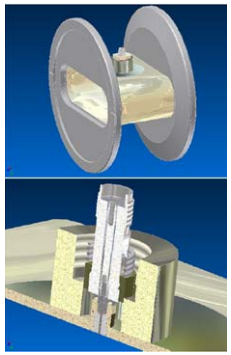


Temporal Profile as a function of the beam position

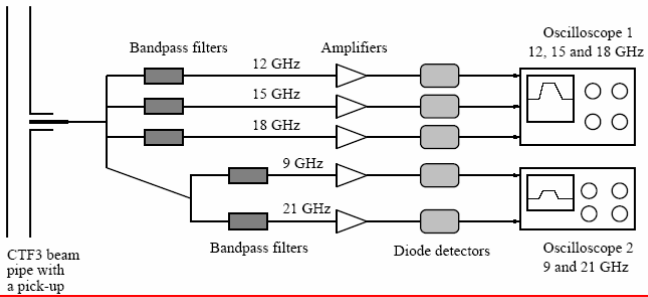


- Good time resolution (ns)
- Need to be amplified to get a better S/N ratio
- Problem linked to the screen quality and the optical line acceptance

Status and Plans for the Uppsala monitor



Bunch phase monitor



'To measure phase error in the RF bunch combination on CTF3'
(already used on the EPA ring in 2002 during the preliminary phase)

Installation in 2003-2004 on the CTF3 linac to test it on higher beam charge and to study its sensitivity to bunch length and beam current

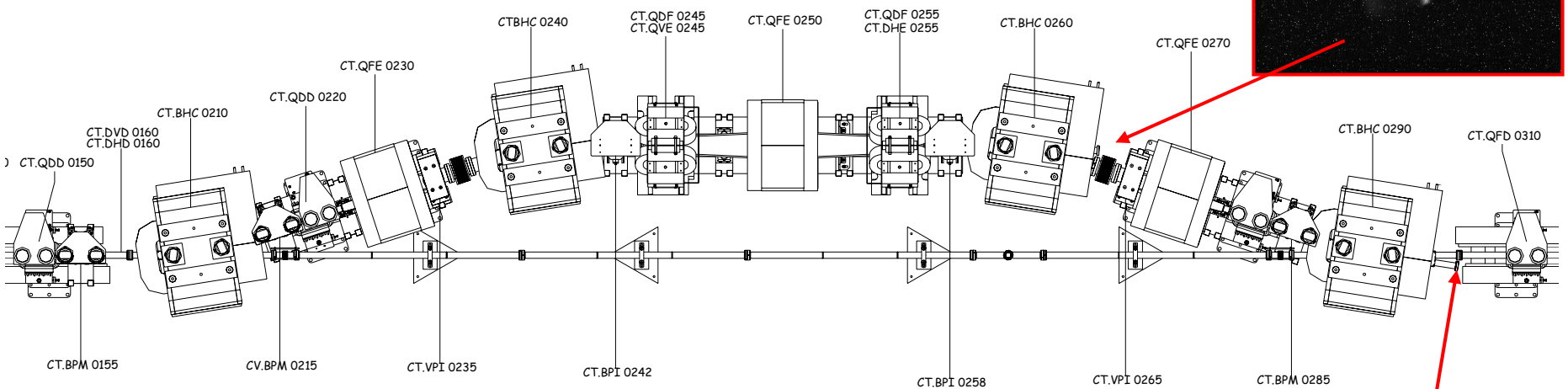
- Modified electronic : Measurement of 5 beam harmonics (6, 9, 12, 15 and 18 GHz)
- The frequency dependance of the Pick-Up transfer impedance is similar to the MAFIA predictions, but the observed signals are much higher than expected ….
- Clear signs of parasitic coupling to the RF waveguide mode
- The analysis of its bunch length dependance is not finished yet…

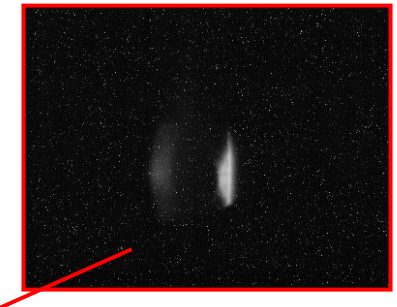
Plans for 2005

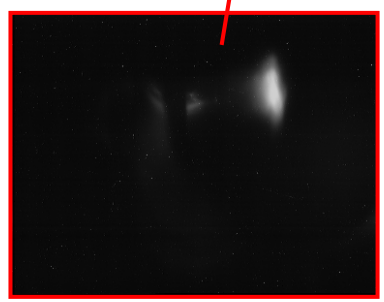
- For the 1.5 GHz beam bunching : New electronics at 10.5, 12.0, 13.5 and 15.0 GHz where the sensitivity is highest
- During the first run 2005, the Pick-Up can still be used in the linac to test the new electronic
- When the delay loop is operational eventually:
  - Installation foressen at the end of the linac, downstream of the delay loop to measure the bunch frequency multiplication by a factor two (disappearance of 10.5 and 13.5 GHz, twice more signal for 12 and 15 GHz).
  - Use the wiggler in order to modify the phase between two consecutive bunches, and check the sensitivity to bunch phase differences.
- In the EUROTeV framework, study of a confocal resonator pick-up, not sensitive to the waveguide modes (simulations and test-bench tests, aim for an installation in CTF3 in early 2007).

INFN Chicane and RF deflector

- Two Synchrotron light monitors installed in the INFN chicane







- First observation
- Exhaustive study of the diagnostic performances must still be done

- RF Deflector measurement very promising and mainly limited by the quality of the screen

Conclusion and perspectives

New devices or modifications in the linac

- Optical lines must be modified to increase the optical acceptance
- Screens itself will also be modified (new material) to minimize the non homogeneity.

- Time resolved measurement:
  - Stop the SEMGrid developments
  - Use Segmented Dumps and/or Segmented photomultiplier (to be developed)
  - Use gated cameras (2 cameras were bought this year)

- Bunch phase measurement downstream of the delay loop using the Uppsala Pick-Up

- Development in collaboration with Northwestern University (Anne Dabrowski) of an RF pickup for non-destructive monitoring of the bunch length (sub ps measurement).

Delay loop Instrumentation

- BPM's

- 2 Optical lines to the streak camera lab for bunch length monitoring

- 3 CCD's cameras for beam size measurements