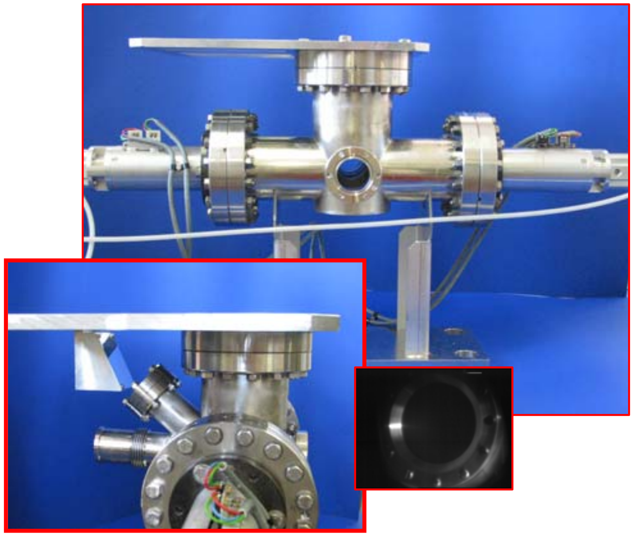
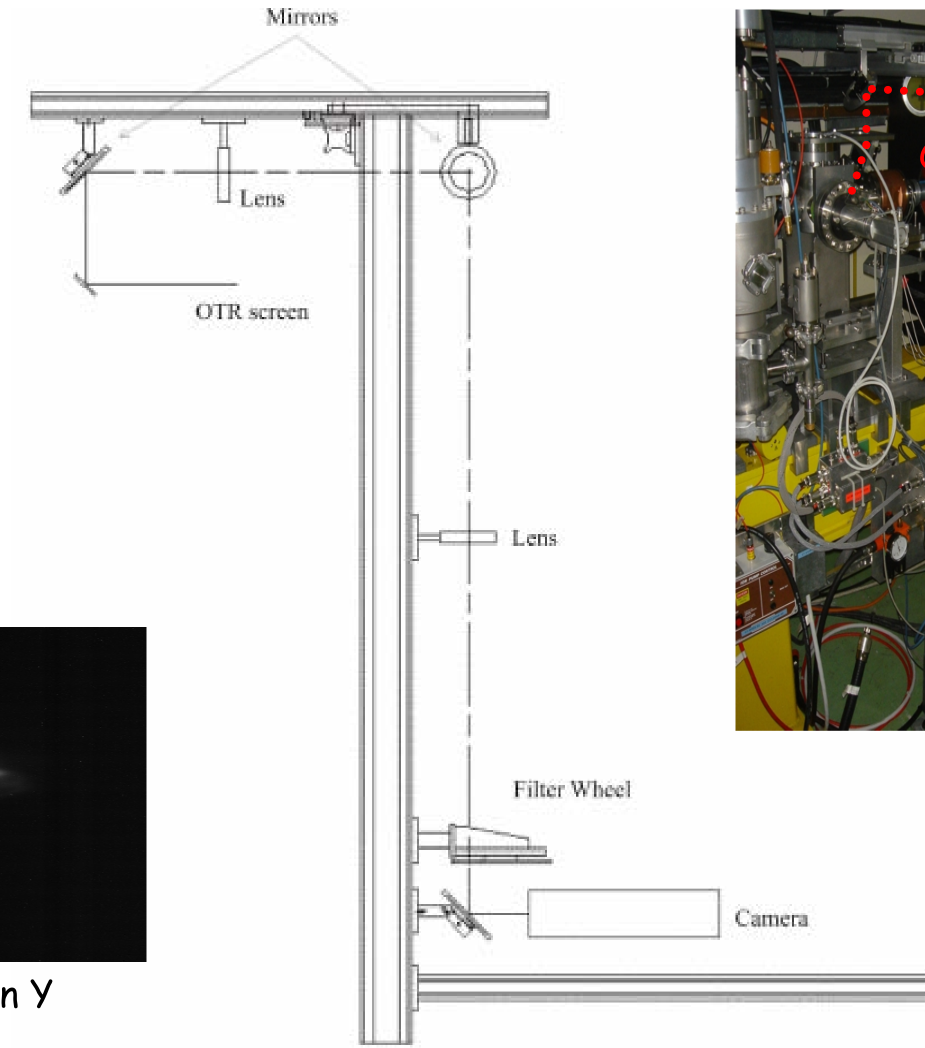
Beam Instrumentation

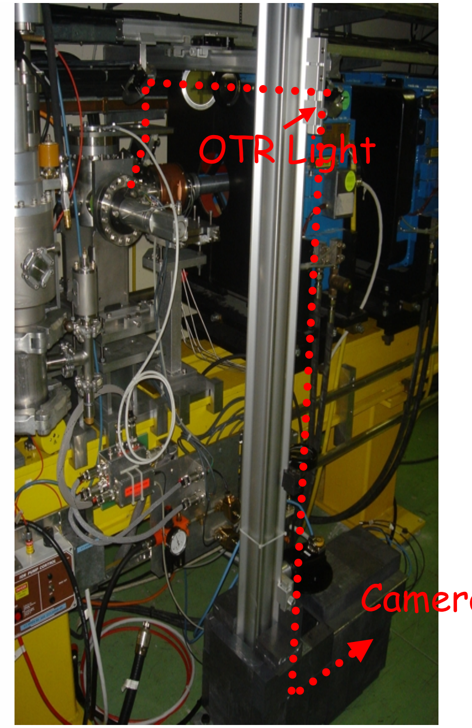
- Performances of Emittance Measurements
- Profile measurements in Spectrometer Line
- Time resolved energy measurements
- Delay loop Monitors
- Beam Halo Monitoring

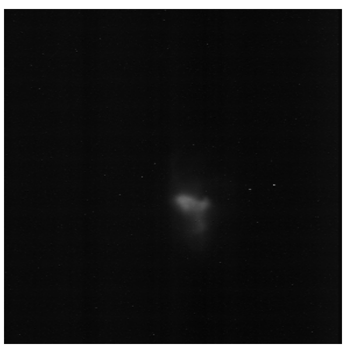
For the CERN and INFN Beam diagnostic group

Emittance Measurements









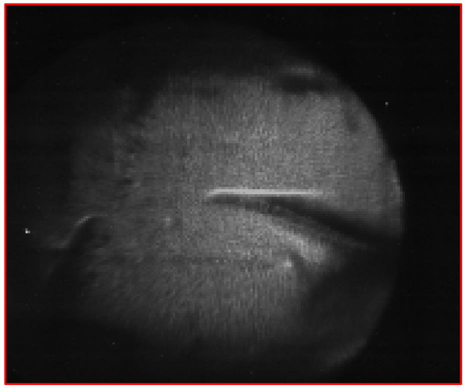
Scan in X

Scan in Y

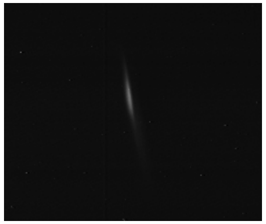
Improving the surface quality of the screens

High reflectivity screens for low charge beam

- Thin Al foil is fragile

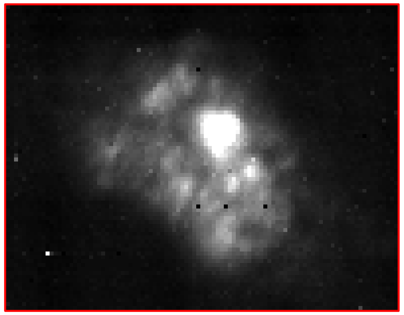


- Using 200μm Si wafer with a very good surface quality
- Adding an Aluminum coating to provide an excellent reflectivity coefficient (90%)



Thermal resistant material for high charge beam

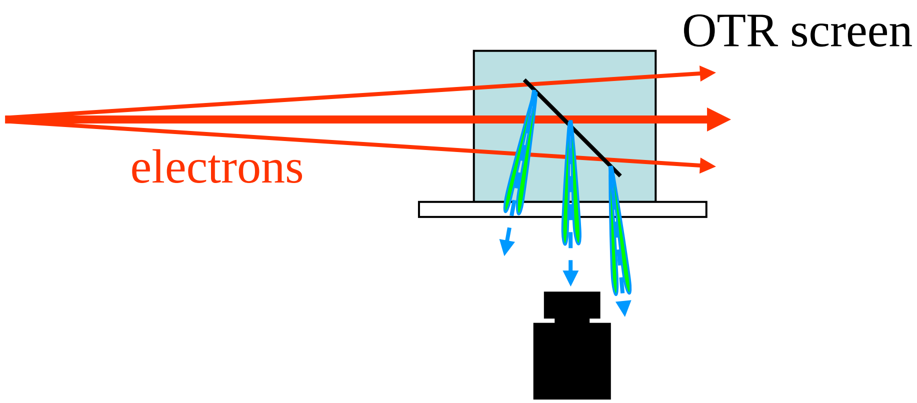
- Non homogeneous surface of C



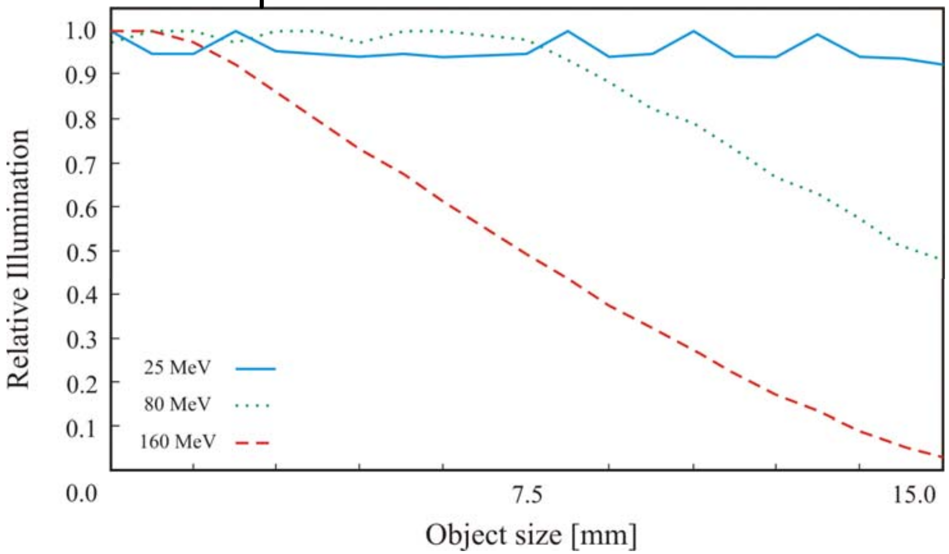
- 200μm thick Polished CVD SiC

30% Reflectivity coefficient

- The Light intensity changes as a function of the beam position. Maximum in the center of the screen, it the light then decreases rapidly for an off centered beam position
- This is due to the acceptance of the optical system, the small angular aperture (~1/γ) of the OTR light and the size of the screen
- Effect stronger considering any beam angle



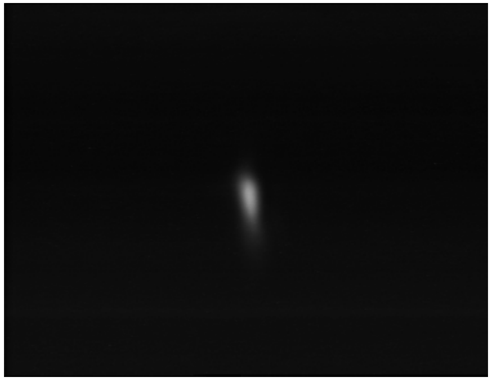
Optical simulation with ZEMAX

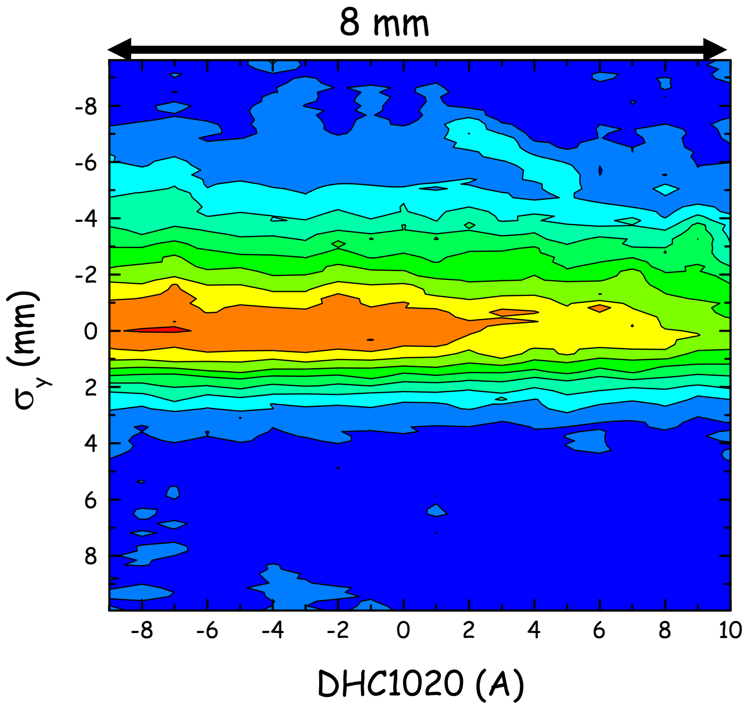


OTR light intensity vs position

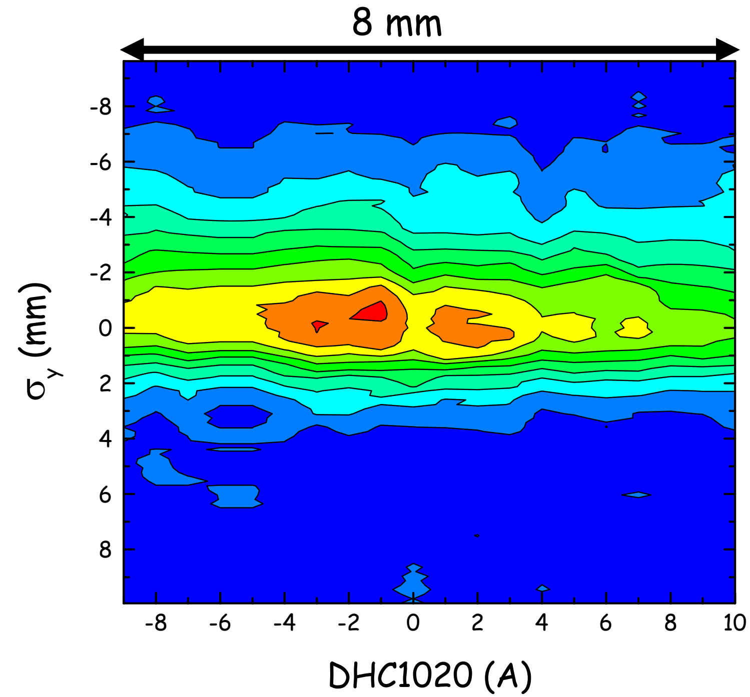
@CL.MTV1030 - 93.5MeV

Carbon screen



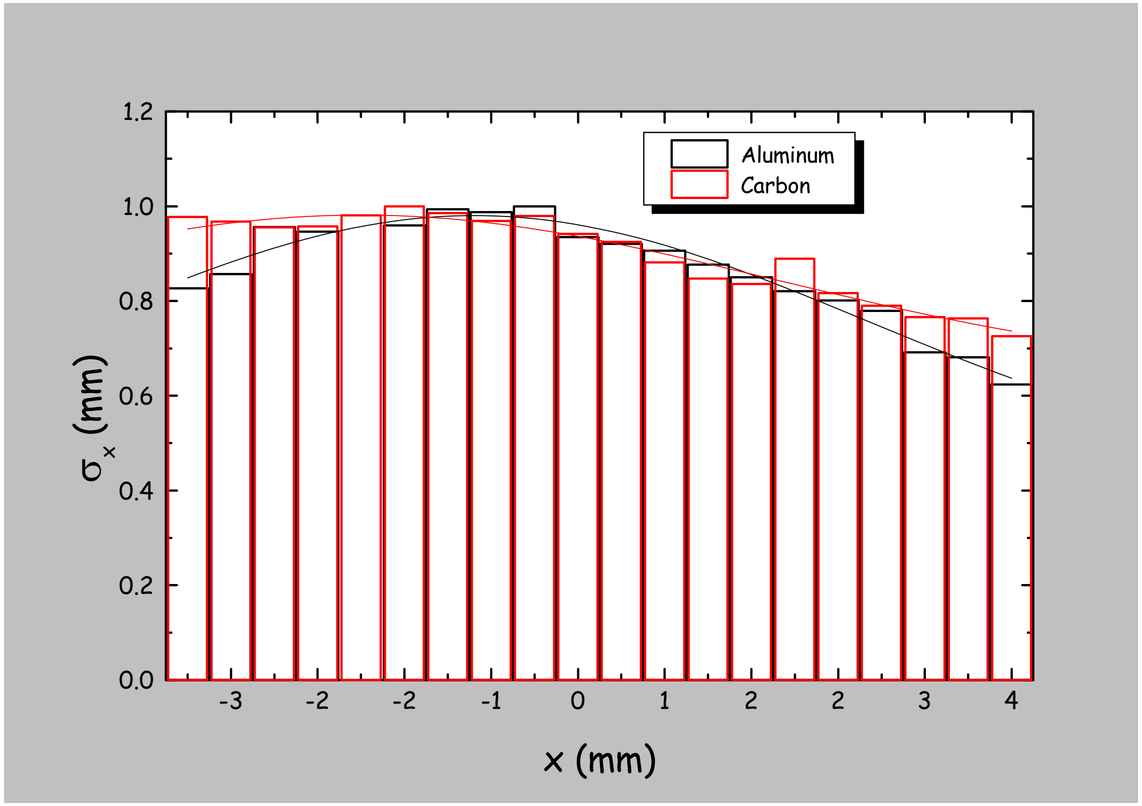


Aluminum screen



OTR light intensity vs position

@CL.MTV1030 – 93.5MeV



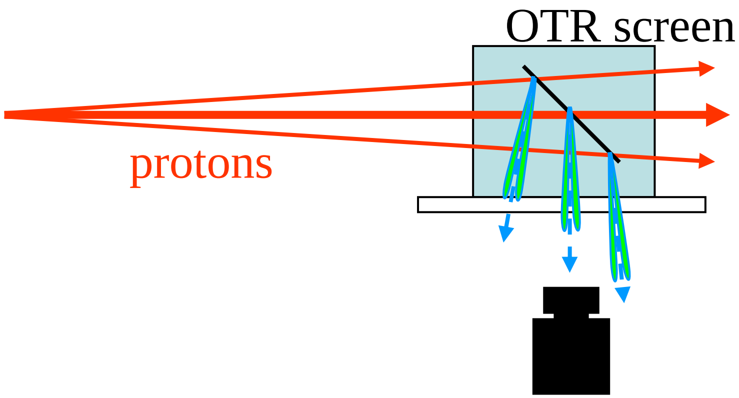
σ_{Al} = 7.7mm
ΔI_{Al} = 37% over 8mm

σ_C = 8.6mm
ΔI_C = 28% over 8mm

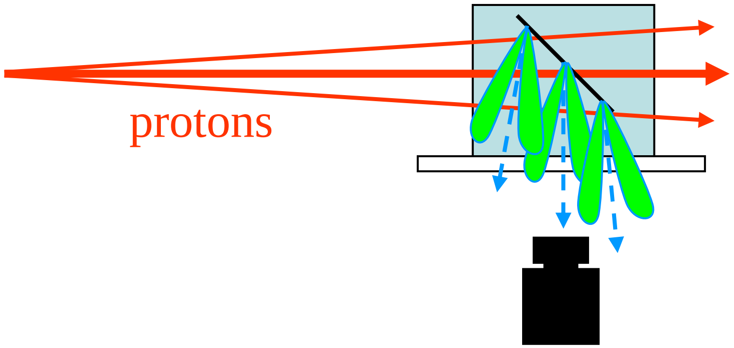
- Effect negligible for small beam size
- Smaller for diffusive screen surface (like carbon)

OTR light intensity vs position

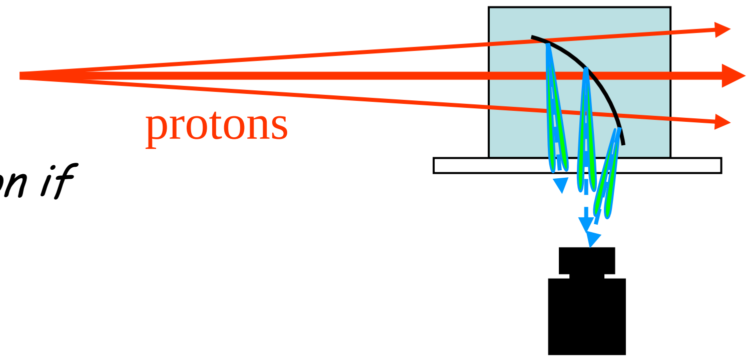
- Normal screen



- *Diffusive screen*
  - *better homogeneity*
  - *Less photons*



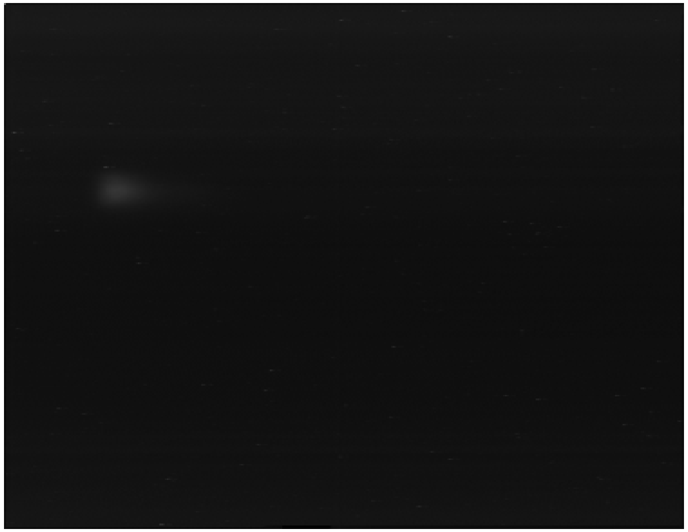
- *Parabolic screen*
  - *Very good homogeneity*
  - *No intensity diminution*
  - *Very small image distortion if using large parabola (~1m)*

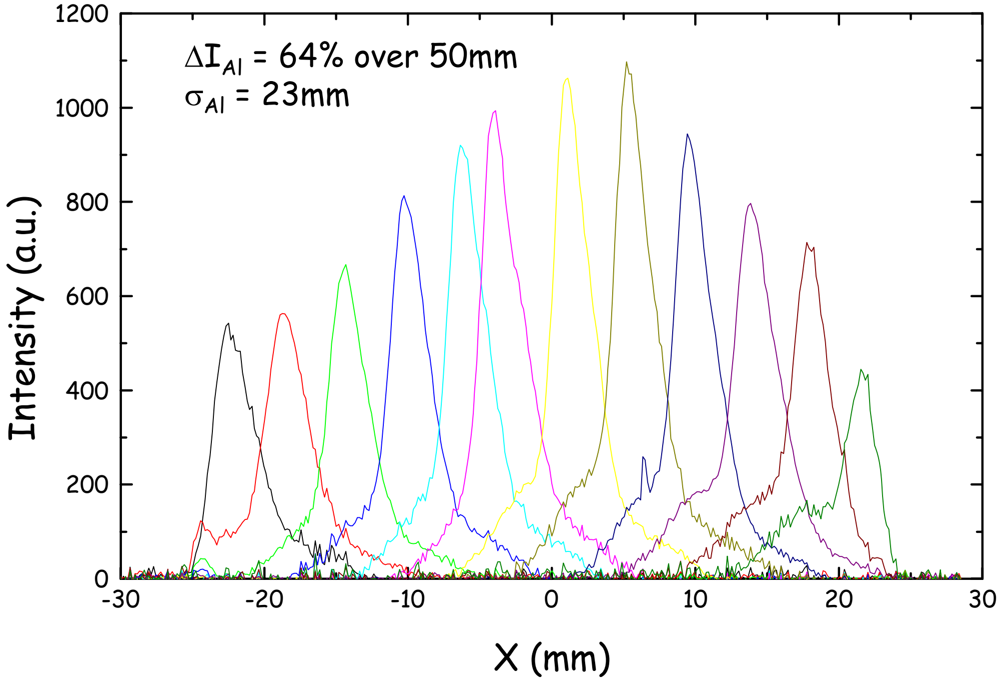


Beam size is bigger in the dispersive region

@CTS.MTV0455 – delay loop beam – 1A

Using diffusive Aluminum foil

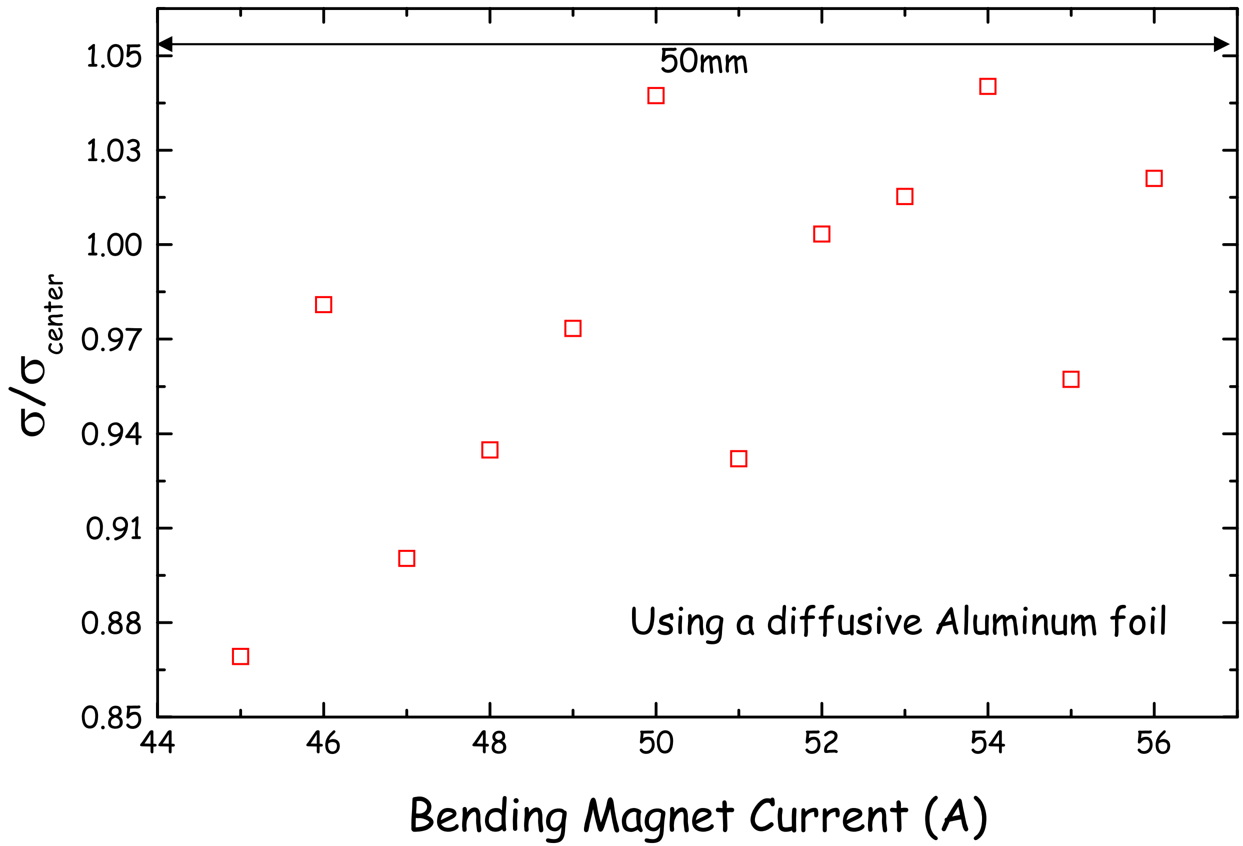




Deformation of the beam profile

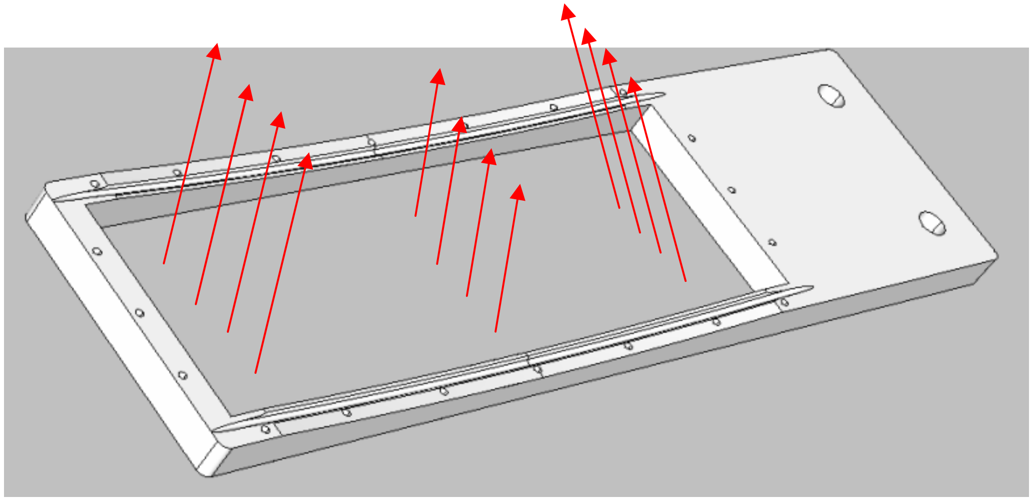
Beam size is bigger in the dispersive region

@CTS.MTV0455 - delay loop beam - 1A



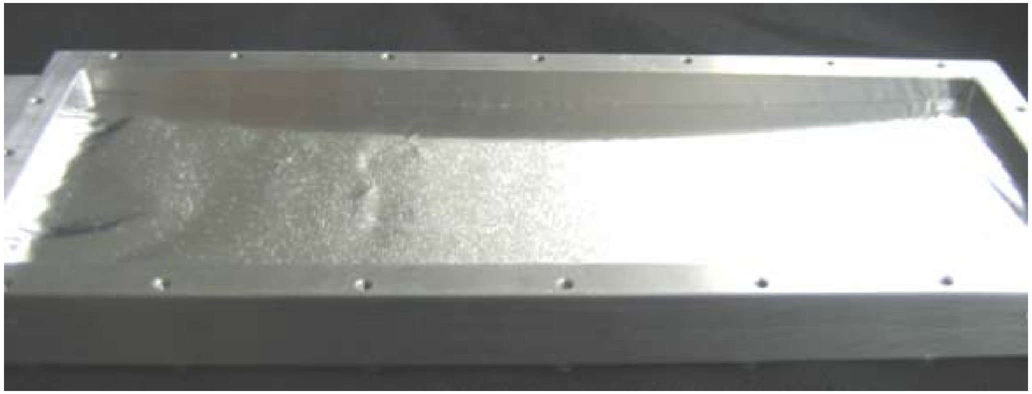
Error < 15%

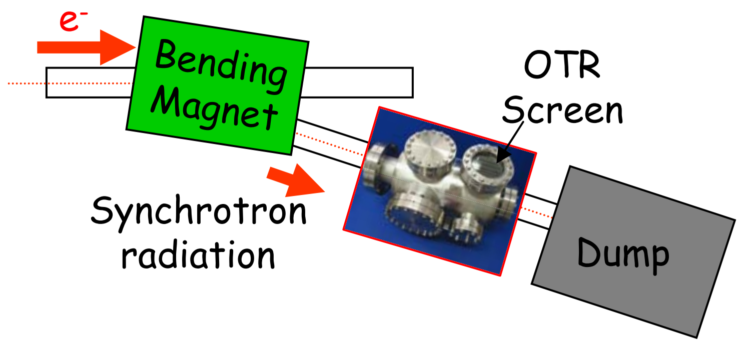
Parabolic Support

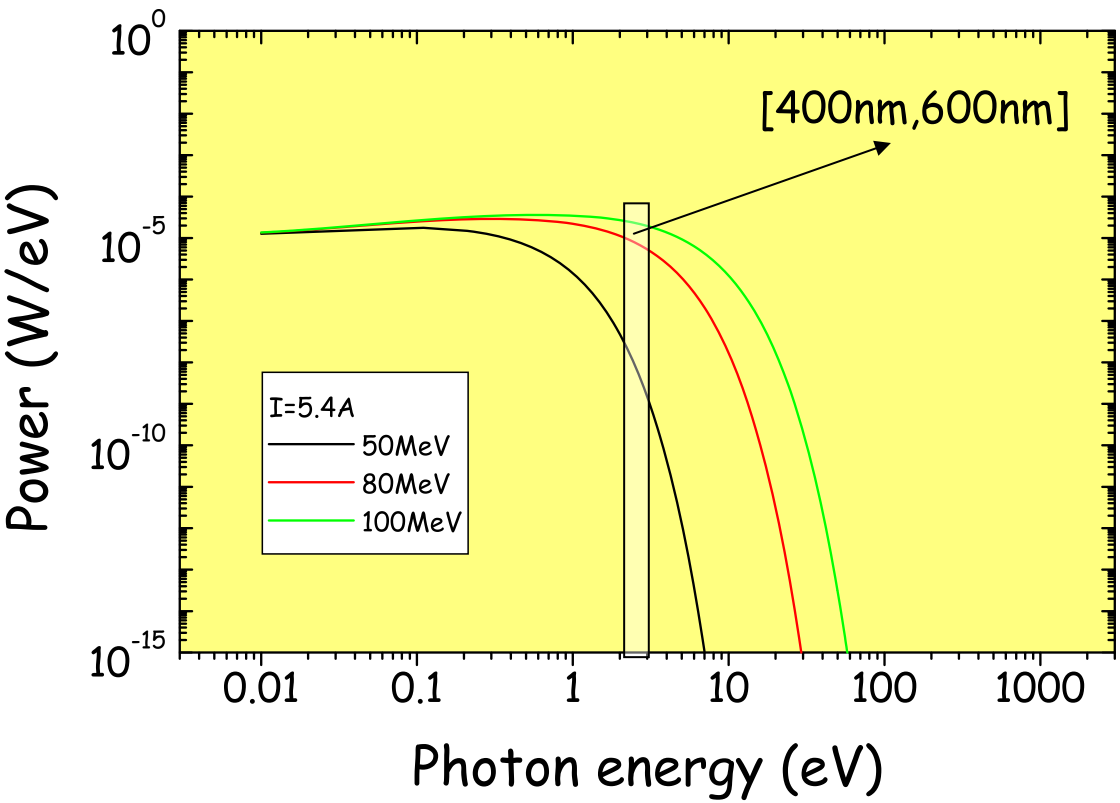


$$z = \frac{1}{4 \cdot f} \cdot x^2$$

- Mechanic under development
- Ready for 2006



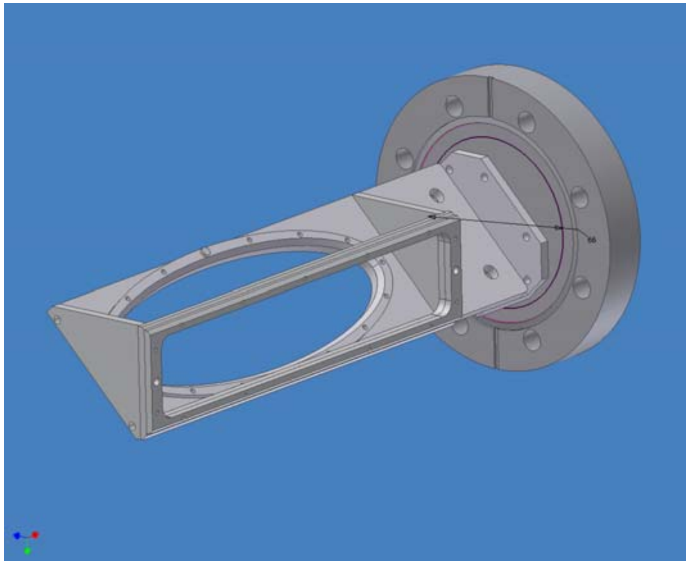


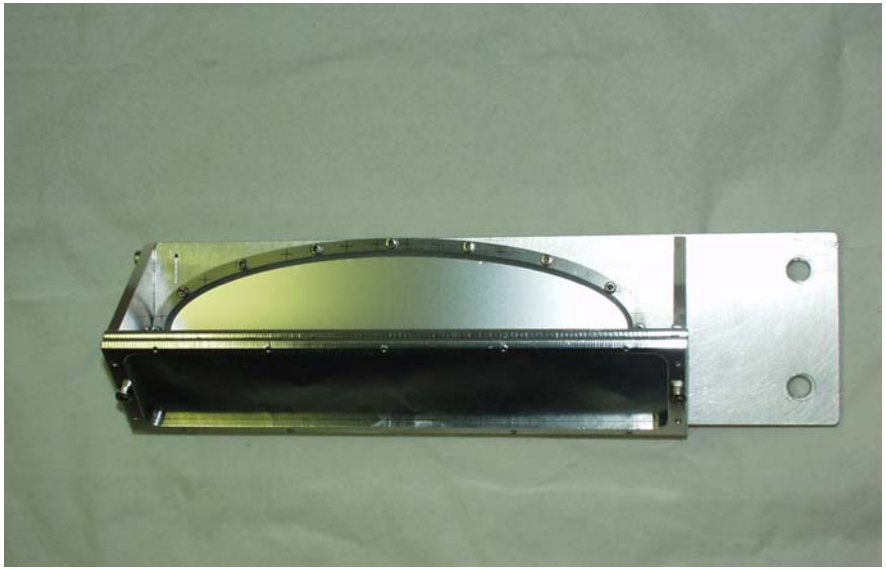


- At 50 MeV:
  $1.5\ 10^{-9}$(SR) $7.7\ 10^{-3}$ (OTR)
- At 80MeV :
  $5\ 10^{-4}$(SR) $8.6\ 10^{-3}$ (OTR)
- At 100MeV :
  $4\ 10^{-3}$(SR) $9\ 10^{-3}$ (OTR)

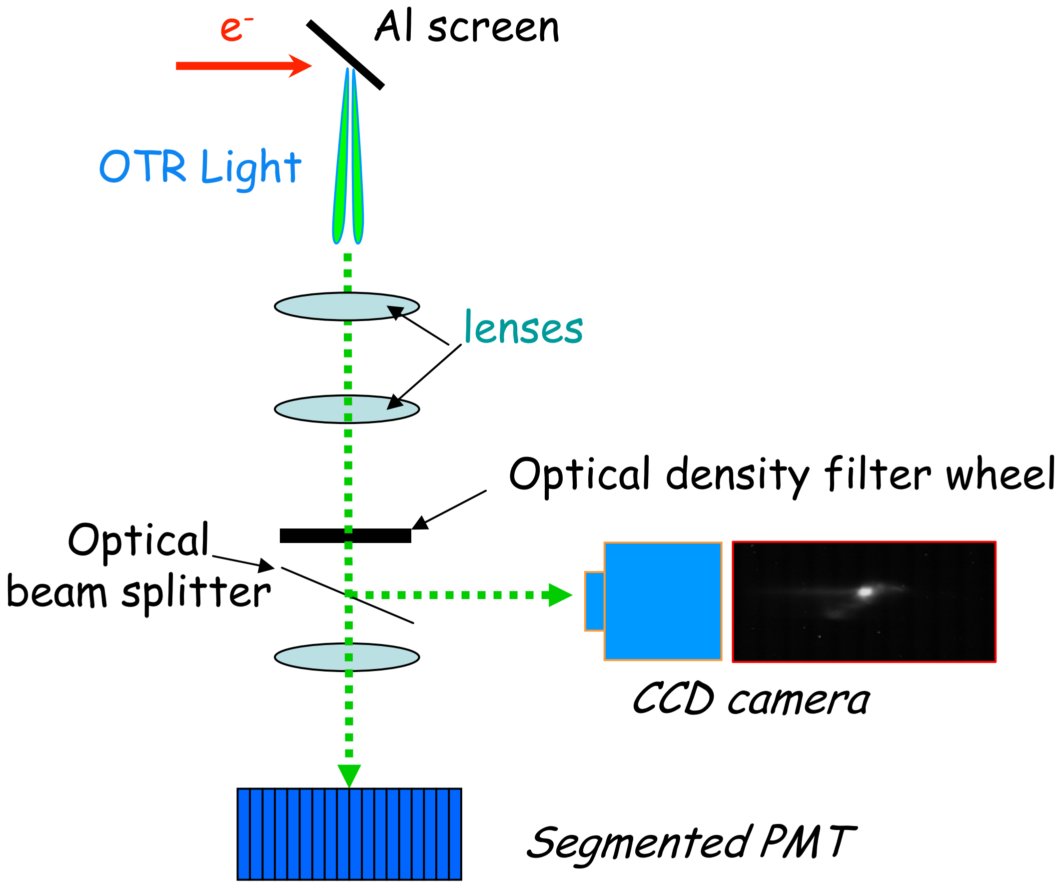
Synchrotron radiation in the spectrometer line

Carbon foil as a synchrotron light shielding

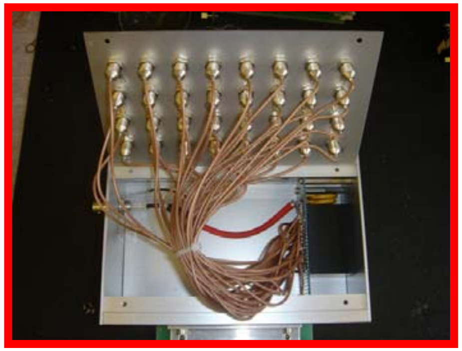




Already implemented in the last two spectrometer lines in the CT line

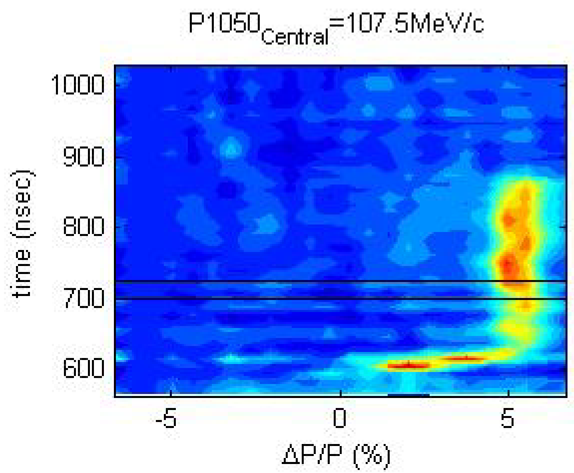


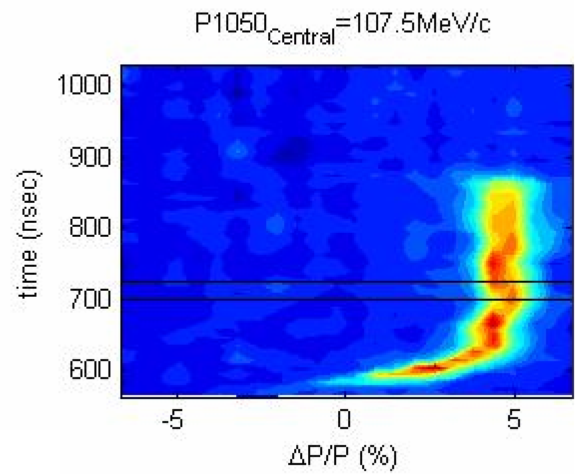
- *Optical line magnification: 0.36*
- *Resolution of the PMT segments is 2.8mm*
- *Fast Amplifier sit in the klystron gallery close to the ADC*

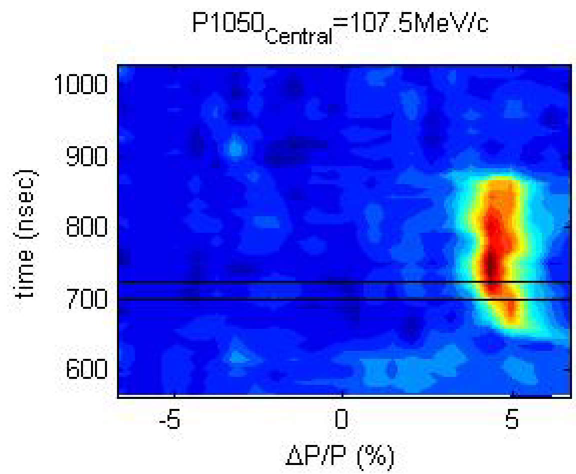


@CLS.SegPMT1050 – PETS Beam 3.5 A

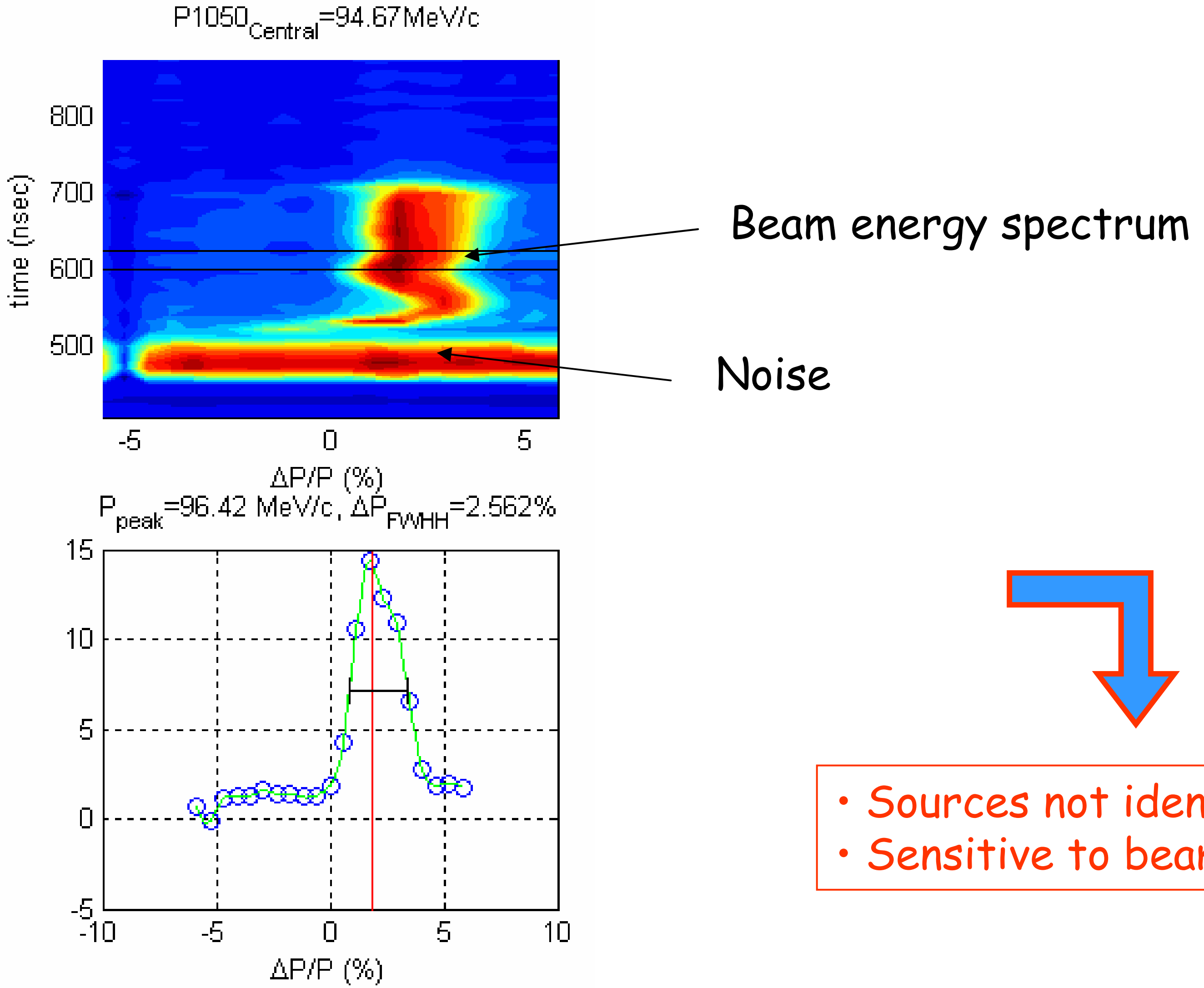
Displacing klystron 5&6 for transient compensation







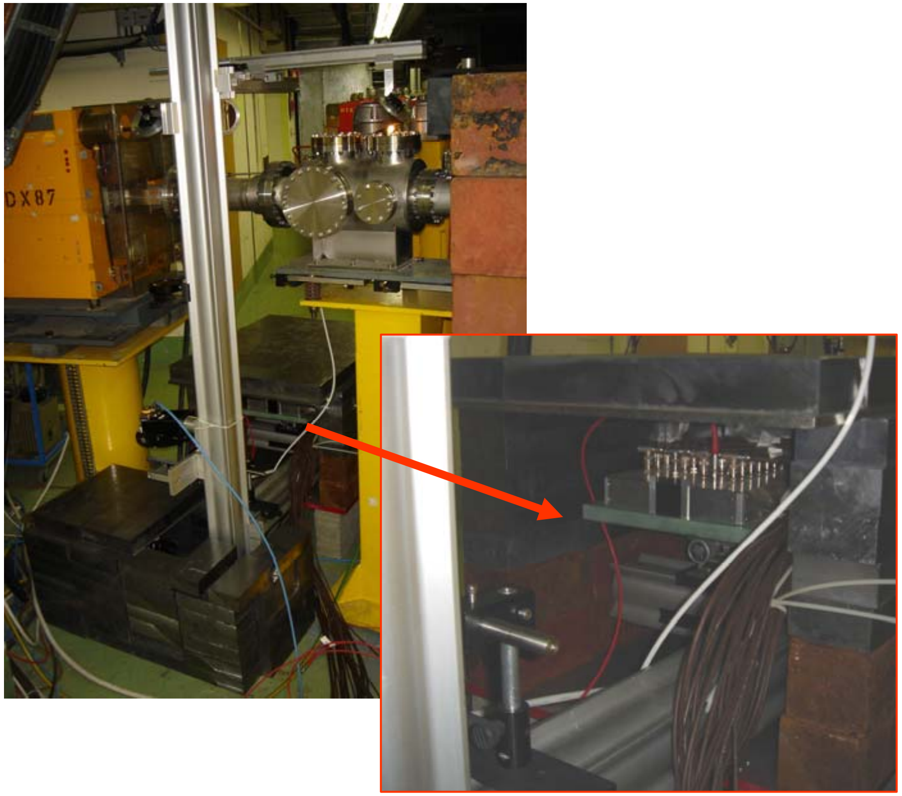
@CLS.SegPMT1050 – PETS Beam 5 A



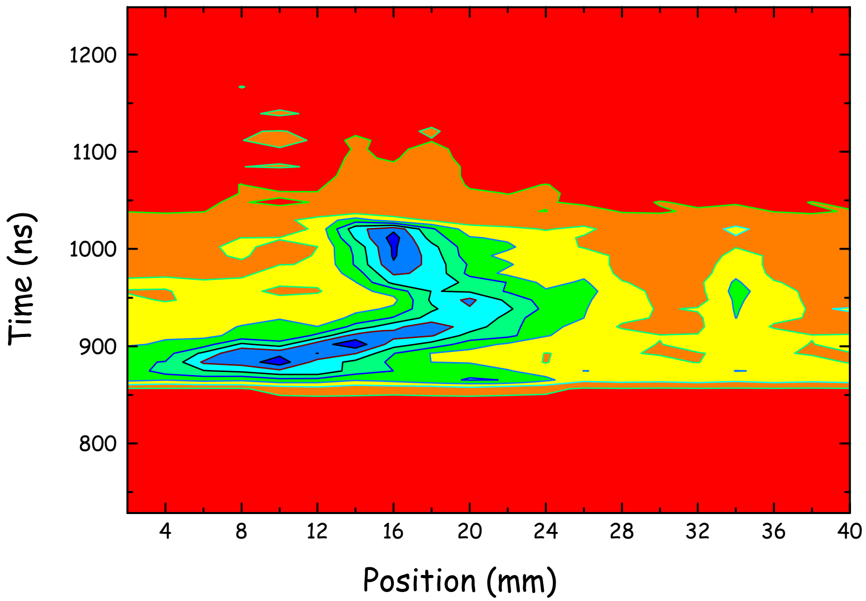
- Sources not identified clearly
- Sensitive to beam losses conditions

Time Resolved Measurements in the Spectrometer lines

@CTS.SegPMT 0455 – Delay loop operation



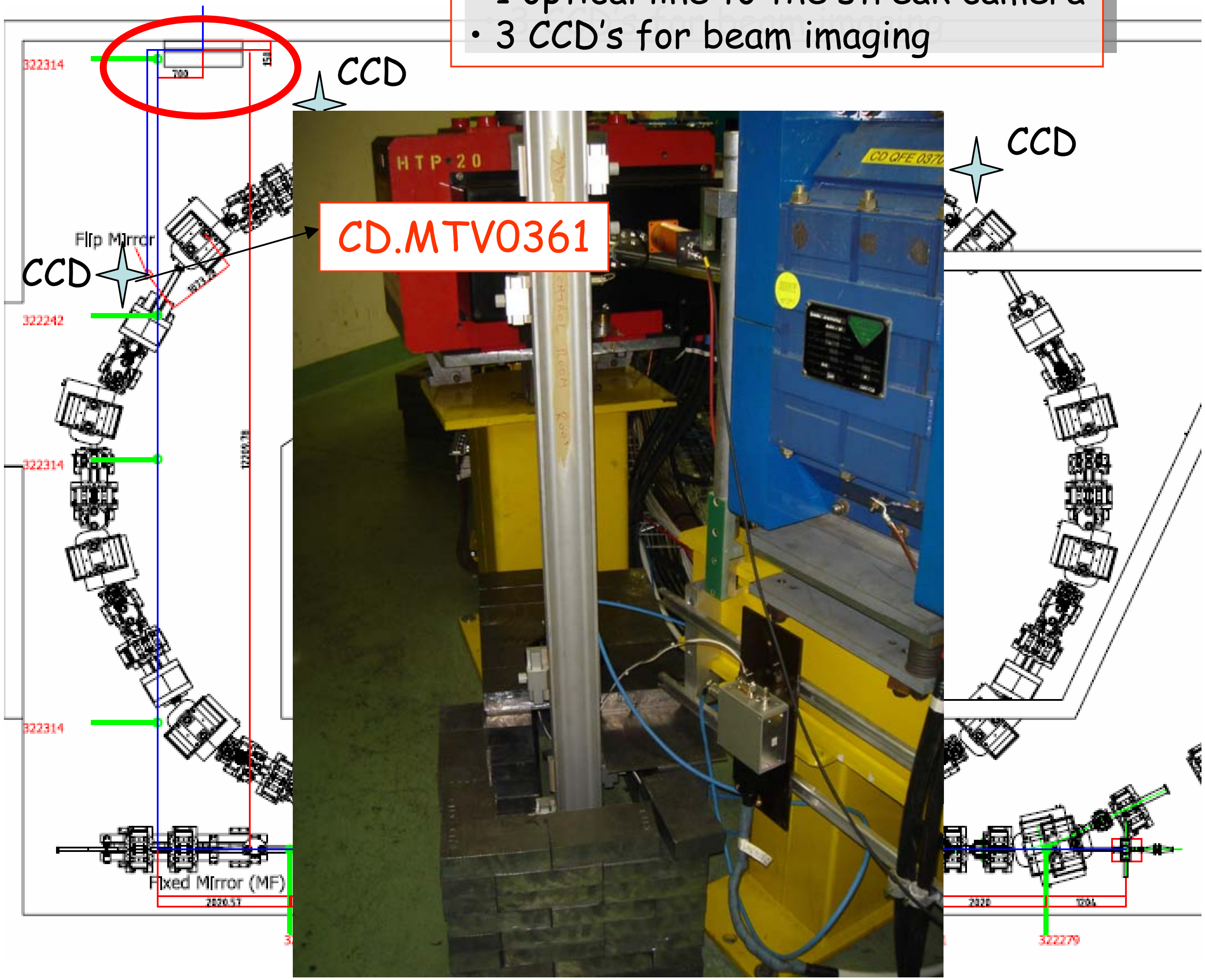
Segmented PMT with an embedded amplifier



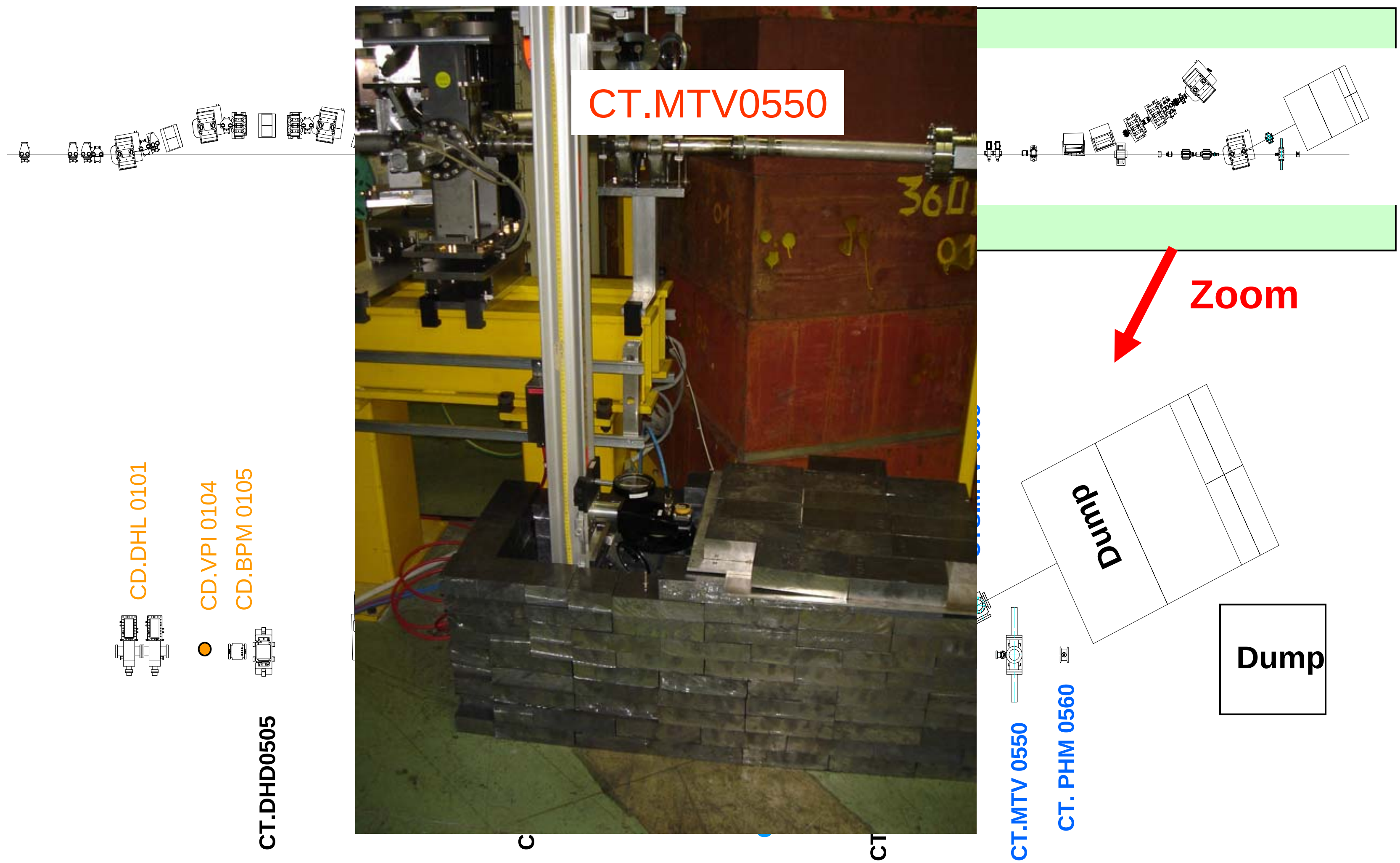
- No real difference observed so far with the system in Girder 10
- More compact and less radioactive waste to have the amplifier in the Klystron gallery

Delay loop installation

- 1 optical line to the streak camera
- 3 CCD's for beam imaging

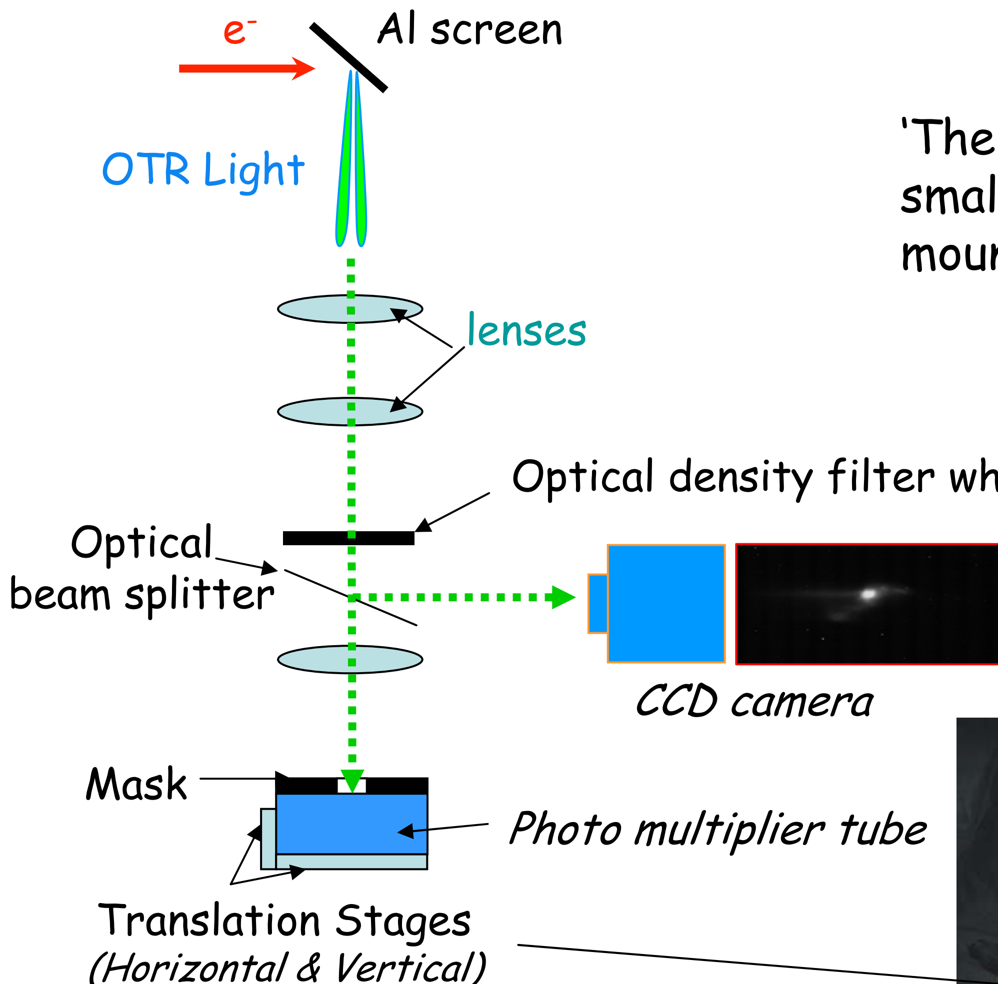


MTV's in the CT line



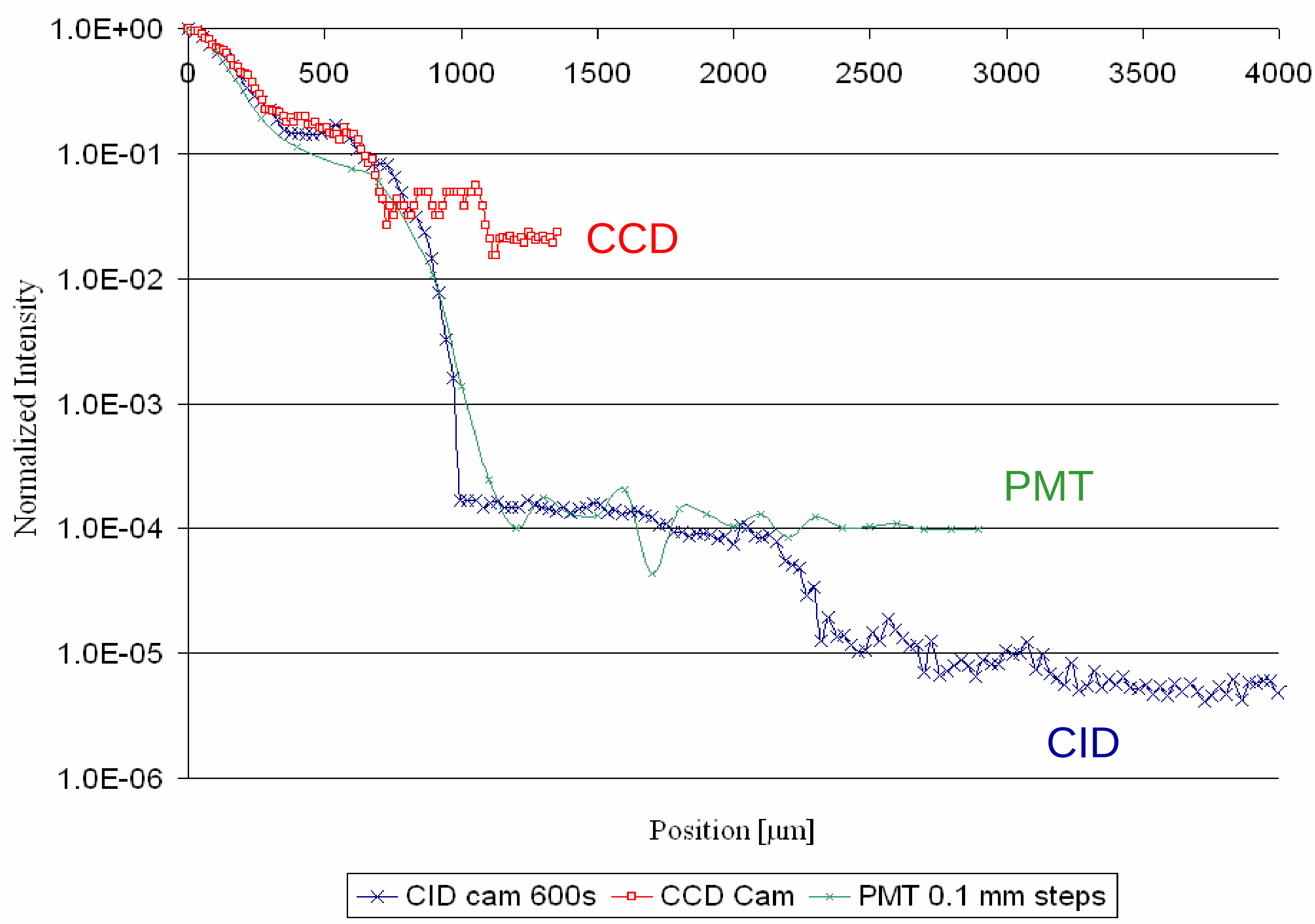
High dynamic range & time resolved emittance measurements

'The image plane is scanned by a small PMT with a small diaphragm mounted on two translation stages'



High dynamic range & time resolved emittance measurements

Measuring a laser beam profile in our lab

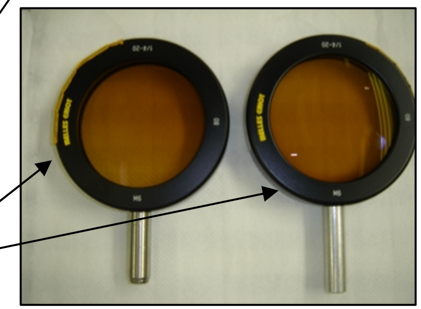


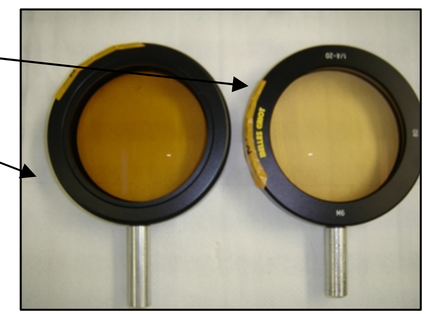
Radiation damage

• After the first run 2005 (3weeks), All CCD's have now at least 10% of dead pixels, two CCD's were replaced (>50% dead pixels)

• Lenses are getting dark

	Relative light output (%)	Relative losses (%)
no lens	1	--
new lens	0.939759036	1
CLS.MTV0440 lens 1 : 2 years	0.674698795	0.717948718
CLS.MTV0440 filed lens : 2 years	0.578313253	0.615384615
CL.MTV1030 lens 1 : 3 weeks	0.807228916	0.858974359
CL.MTV1030 field lens : 3 weeks	0.638554217	0.679487179



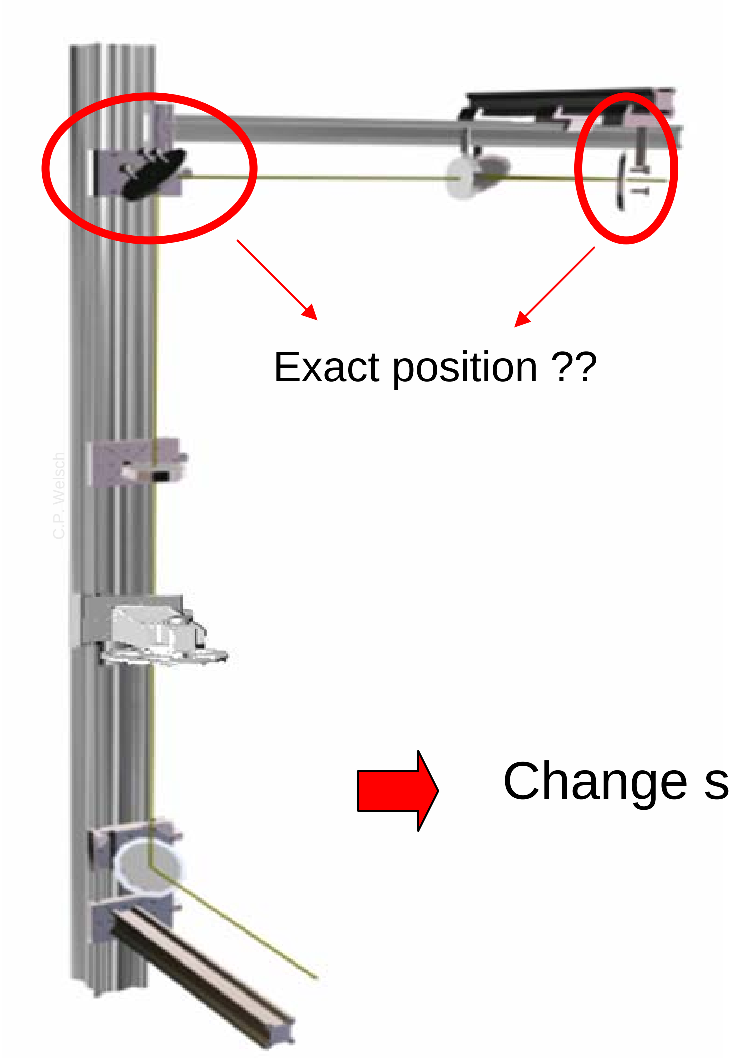


• for MTV0440 the light intensity reduction loss is 55.8% (two years of operation at 1-5Hz)

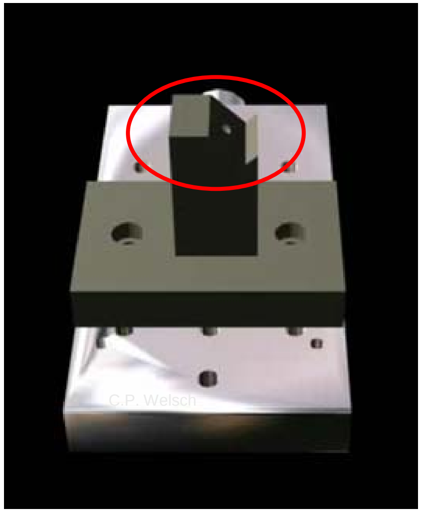
• for MTV1030 the light intensity reduction loss is 41.6% (3 weeks of operation at 33HZ)

Mechanical support and Optical alignement

Improve the mechanical support for a better alignment, avoiding tilt angle

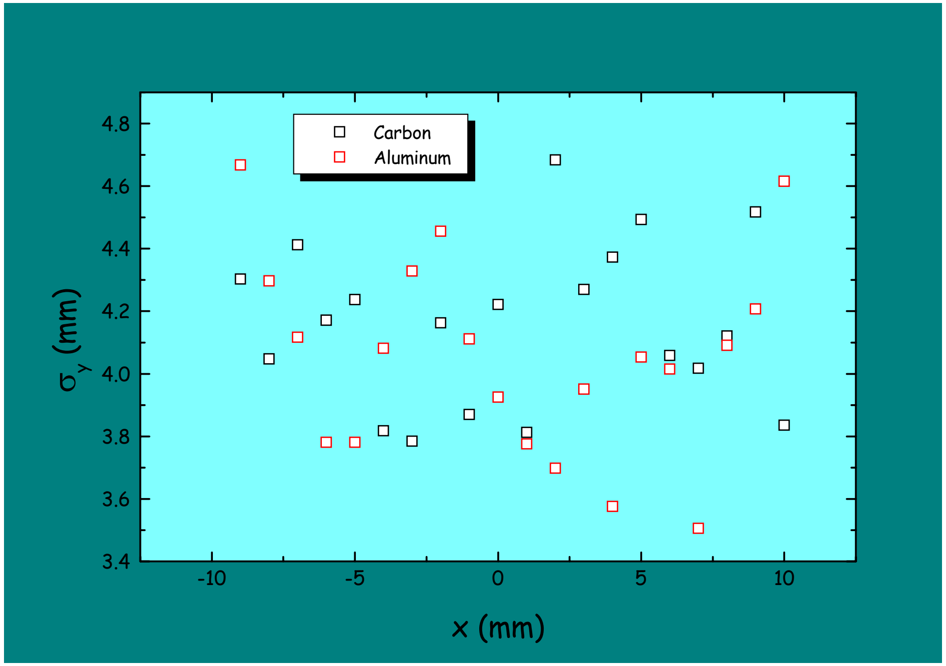


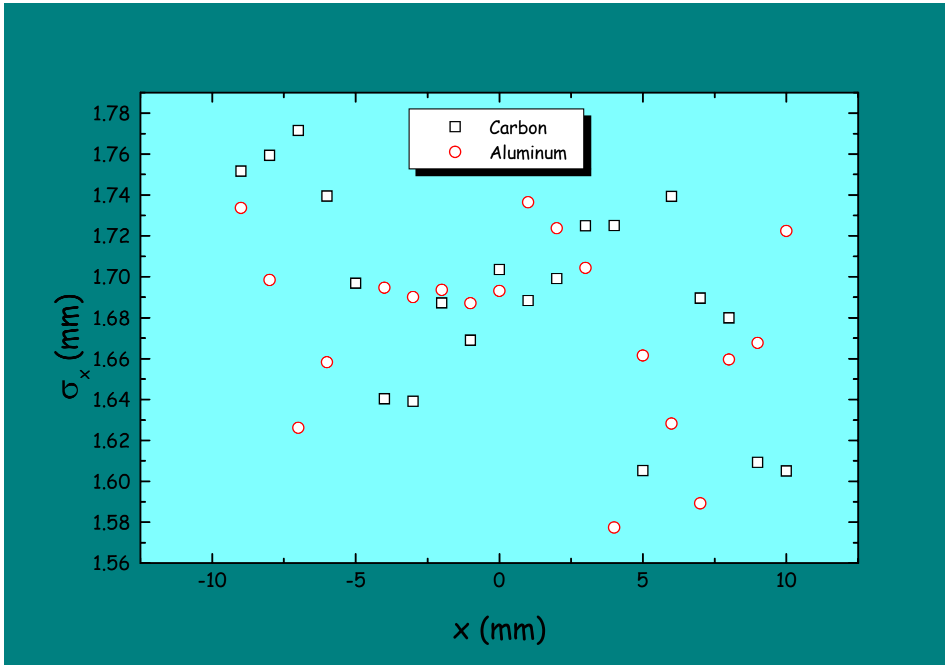
Change support !



OTR light intensity vs position

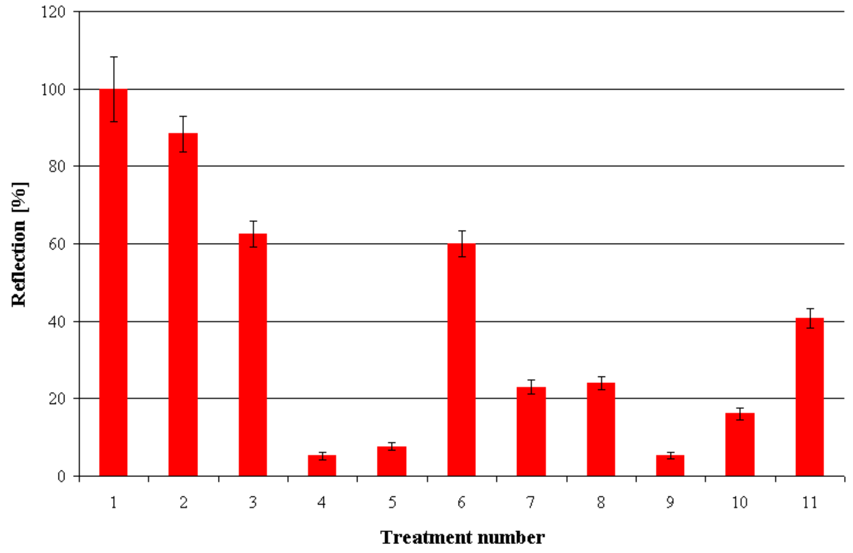
@CL.MTV1030 - 93.5MeV

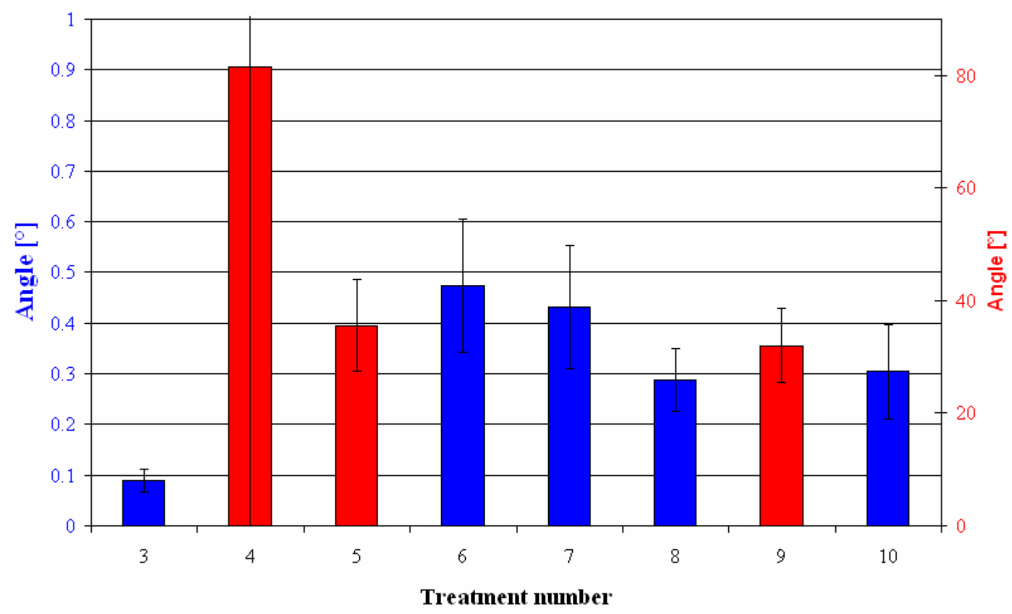




Diffusive surface : Surface treatments

Number	Description of surface treatment
1	Direct illumination of photomultiplier tube
2	Mylar foil + Aluminum
3	Reference plate, mechanically polished
4	Silver-plated
5	Sand blasting
6	Degreasing
7	Degreasing + HNO_3 + HF
8	Degreasing + HNO_3 + HF + NaOH
9	Glass bead blasting
10	oxidation
11	unpolished


120
100
80
60
40
20
0
Reflection [%]
1
2
3
4
5
6
7
8
9
10
11
Treatment number


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Angle [°]
80
60
40
20
0
Angle [°]
3
4
5
6
7
8
9
10
Treatment number

CTF3 beam & diagnostic requirements

MTV's	Beam energy (MeV)	Beam charge (nC)	Beam size (mm)	Screen Size (mm)	Spatial resolution (mm/pixel)	Light intensity (photons)**
CL.MTV0165	0.140	10-7500+	>1	> Ø 50	0.2	$3\ 10^4$ – $2.4\ 10^7$
CLS.MTV0440	20	7.5-5600*	>1	100x50	0.25	$1.5\ 10^8$ – $1.1\ 10^{11}$
CL.MTV0500	20	-	>0.8	> Ø 30	0.1	-
CL.MTV1030	70	-	>0.4	> Ø 30	0.1	$2.6\ 10^8$ – $2\ 10^{11}$
CLS.MTV1050	70	-	>1	100x50	0.25	-
CL.MTV0435	150	-	>0.15	> Ø 30	0.1	$3.2\ 10^8$ – $2.4\ 10^{11}$
CLS.MTV0455	150	-	>1	100x50	0.25	

+ assuming commissioning conditions @100mA,100ns and nominal conditions @3.5A,1.56μs

* assuming 25% beam loss in the 3GHz bunching mechanism

** number of OTR photons emitted in the spectral band [400,600]nm

Camera	Minimum light intensity (photons) ++	Price (CHF)
Proxitronic	$>10^4$	20kCHF
CCD	$>10^7$	1kCHF
CID (0.5Mrad)	$> 10^8$	6kCHF
Vidicon	$>10^9$	10kCHF

57dB range

++ assuming a profile with 8 pixels per sigma

Cost of a system

Data Aquisition	
VME CRATE, fully equipped	2,500
Interface card for video signal, control & acquisition	*2,000*
CCD camera incl. connection	1,000
Cables (filter wheel, camera and motor)	2,000
Support	
Various manufacturing pieces for workshop	600
Optical rails	1,550
Optics	
Different small supports for lenses, filters, etc.	80
Lens holders	250
Lenses	2,000
Translation stages, columns	760
Adjustable Mirror (3d)	2,600
Control for adjustable mirror	2,200
Mirrors	500
Mounts	800
Optical filter wheel & filters	1,750
Screen / Support	
Support and fixing	150
OTR screen	560
Motorized arm, control	*CERN*
Flip mirror	*CERN*
Vacuum Chamber	
Design Work	*CERN*
Components	*CERN*
View ports, flanges, etc.	3,000
Construction	10,000
Shielding	1,000
Total:	35,300