SCINTILLATING SCREENS USE AT CERN

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OUTLINE

- More than 50 years experience with scintillating screens
- Screens as beam observation systems
- Issues using screens as measurement devices
- New challenges for screens
- Screens in the LHC era

AND THERE WAS THE SCREEN

- Use of fluorescent screens to detect "particles" dates back to the time of Rutherford, Röntgen and the like (late 1800)

- Until late 1960's screens were mainly based on Zinc-Sulphide depositions fixed on metallic substrates by a binder

- Zinc-Sulphide has a large conversion efficiency, but suffers from radiation damage and the outgassing is not compatible with most accelerators vacuum

DOPED ALUMINA

- In 1969 R.W. Alison et Al. at Berkeley lab developed the first chrome-activated aluminium oxide scintillators

- Material produced by anodising aluminium with an electrolyte containing chromium

- For several years CERN used these home made screens, until demand exceeded the supply capacity at LBNL

CHROMOX

- In 1974 demand for scintillating screens at CERN was high and this triggered a search for industrial procurement

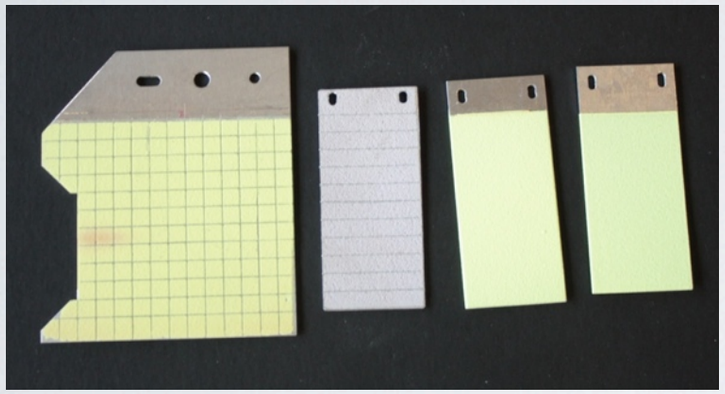
- Found very soon that commercial chromium doped alumina plates, used for their thermal properties in industry, made for rather good scintillators ("AF-225 Rouge" from Desmarquest & C.)

- Alumina was also mechanical and thermally sturdy and showed no sign of radiation damage, even under heavy irradiation

CHROMOX STUDIES

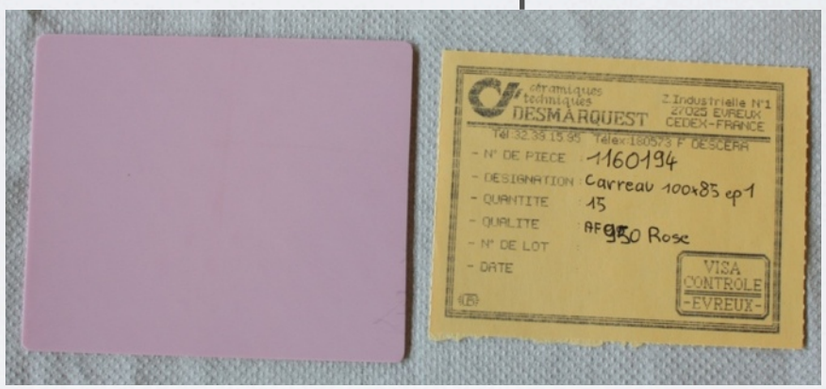
- Soon it was found that CERN had been lucky with this material as doped aluminas from other sources did not behave the same
- Thermal effects on the emission efficiency were also observed
- Little R&D with Andermann & Ryder Ltd. lead to a even better scintillator known then as “Chromox CERN type 6”

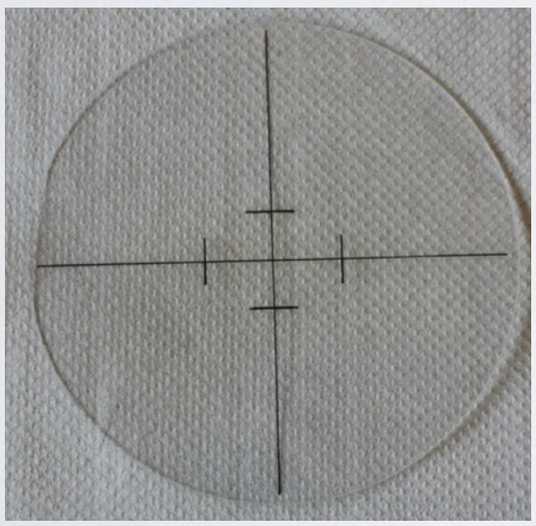
SCREENS PALETTE



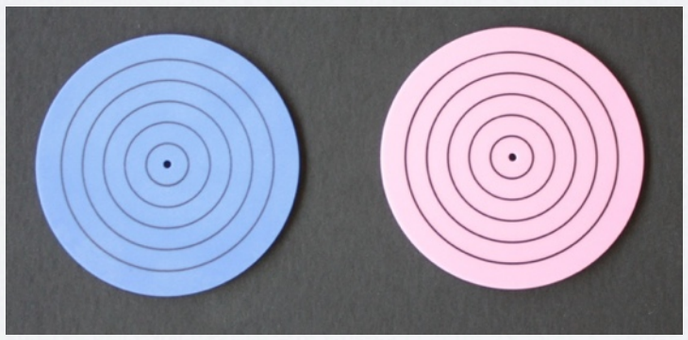
ZnS

Test samples





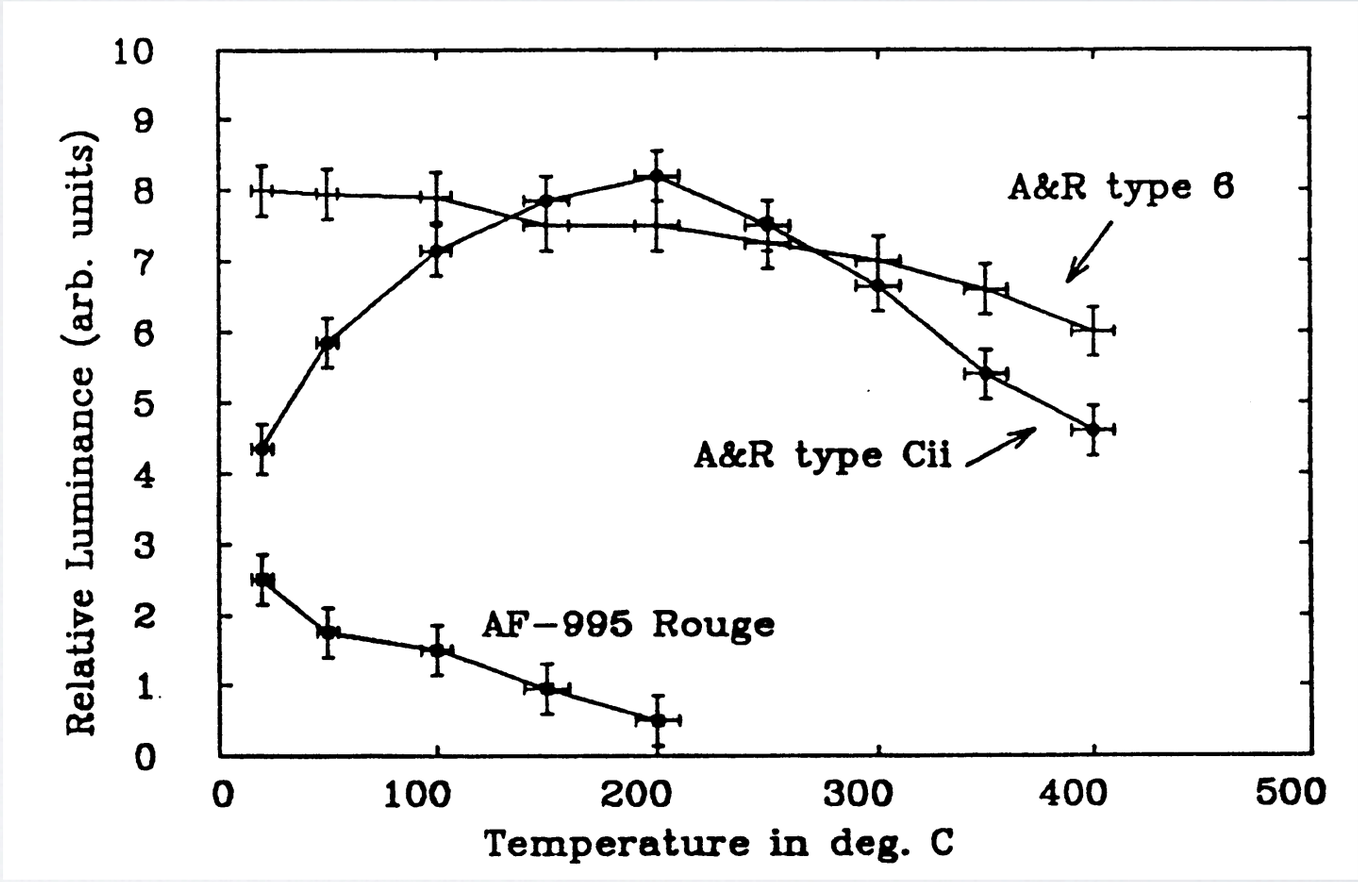
Li glass (Ce)



Screens for targets

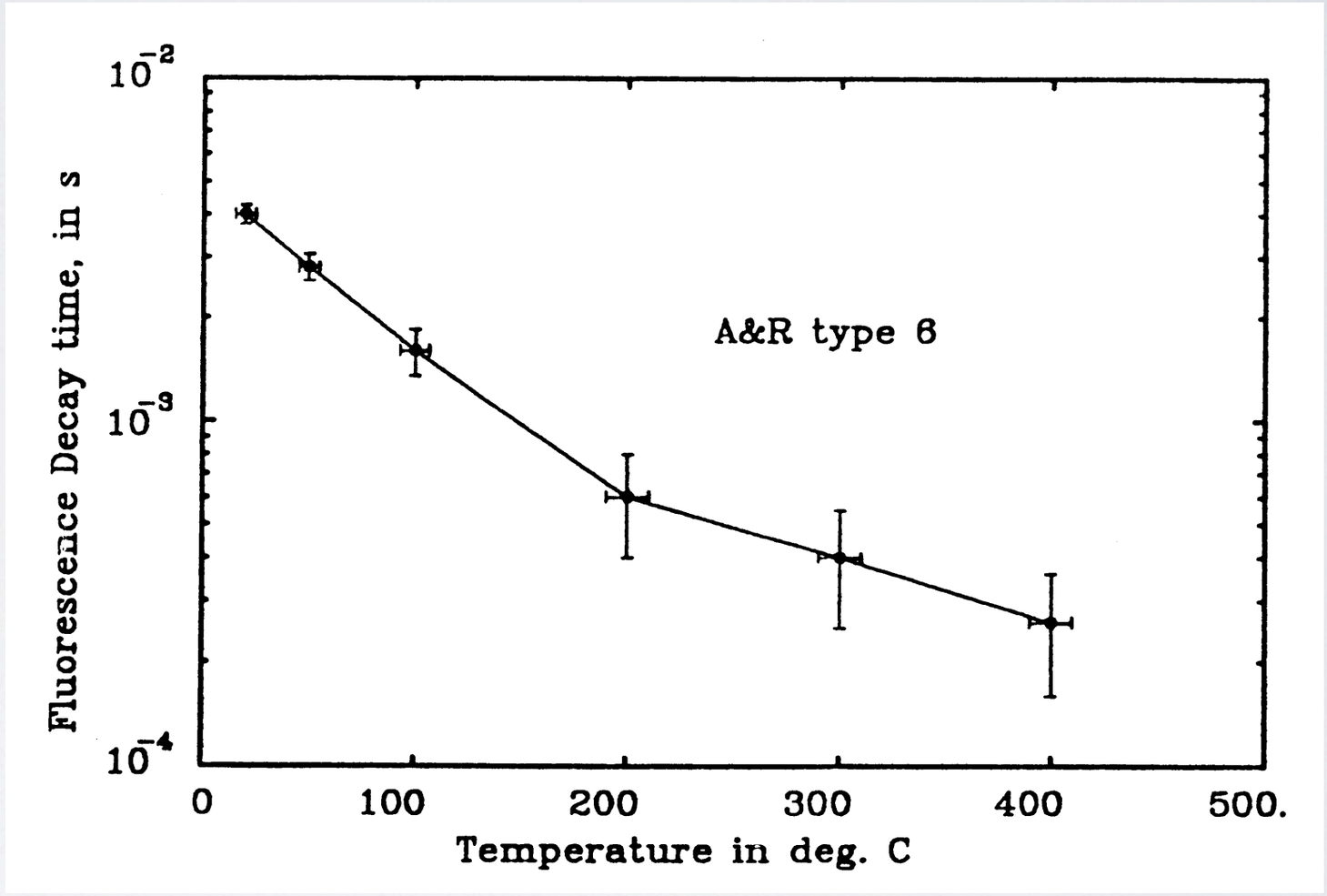
THERMAL QUENCHING

- Visible emission suppressed increasing the temperature
- Different sample behave differently
- Mainly caused by impurities and defects in the crystals



DECAY TIME VS. TEMPERATURE

- The decay time is also affected by the temperature



R&D RESULTS

- The results of the R&D with A&R consists in samples of many different colours: red, green, purple...

- Due to the thermal properties the red coloured "Type 6" was adopted as "the chromox" at CERN

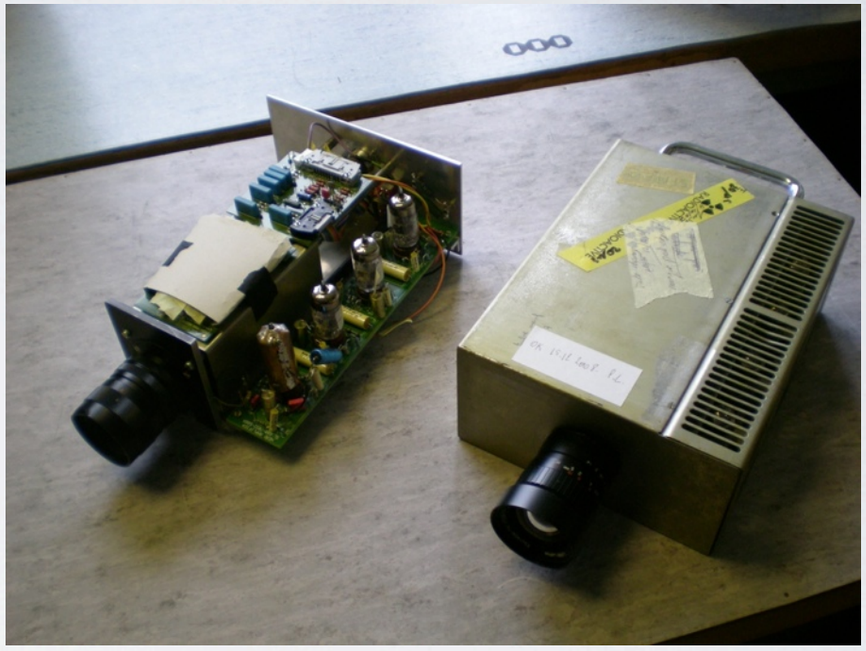
- This material is still available as Morgan technical ceramics MAC-A994R

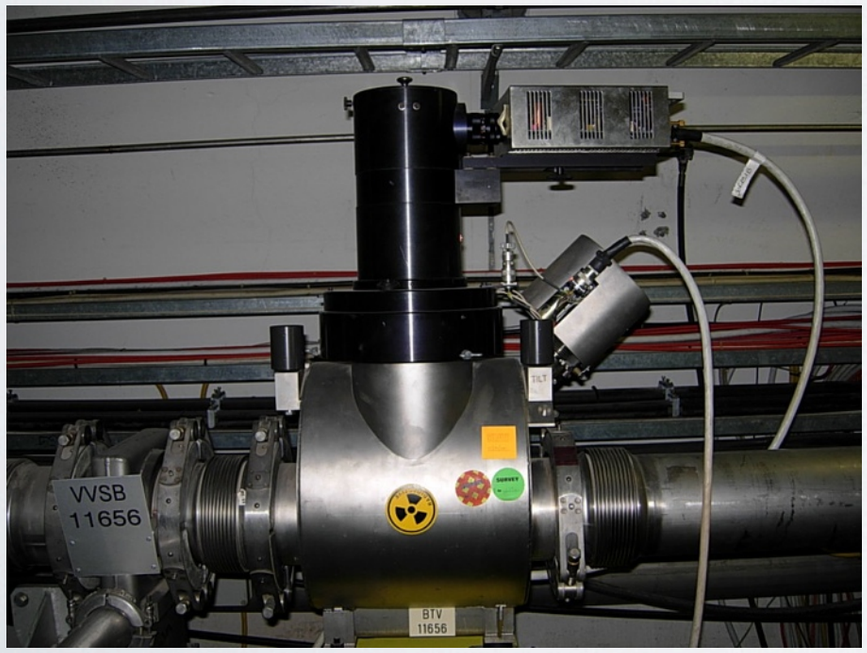
- It consists of 99.4% Al_2O_3 + 0.5 Cr_2O_3, 10-15µm grains

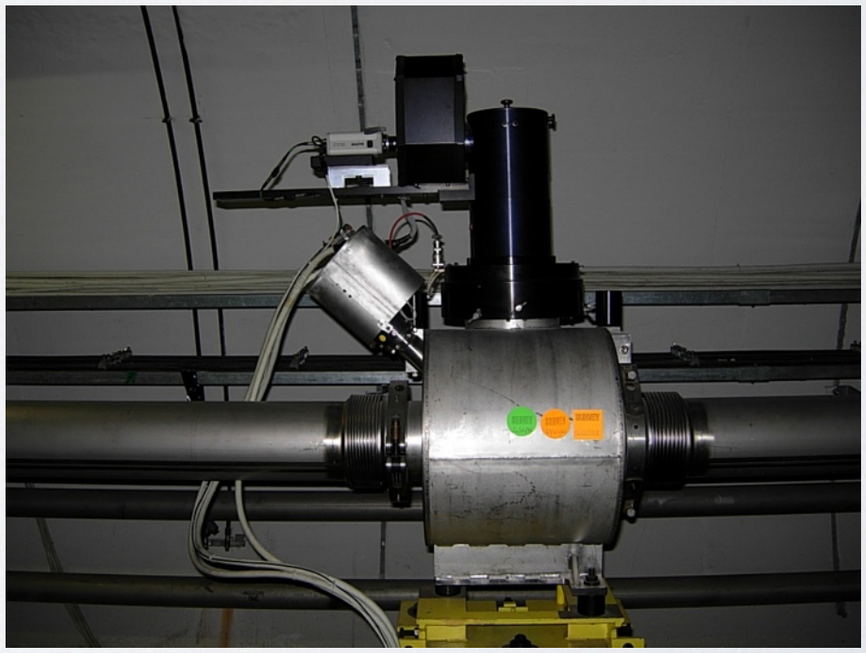
BEAM OBSERVATION

- In many locations the radiation level is too high for sensitive cameras, only tube devices based on VIDICON can be used
- Tube cameras have poor linearities and were rarely used for beam measurement
- With the advent of CCD cameras and frame grabbers screens were also used for measurements
- OTR is however the preferred radiator where possible

CAMERAS







THE MARKS

- Crosses and grids on the screen were used in order to help adjusting the beam just by looking at the TV screen

- For digitised images the marks in the beam area are a source of error in the computation

- Unfortunately all old installations have marks and one would have to replace the screens in order to improve the situation

EFFECT OF MARKS

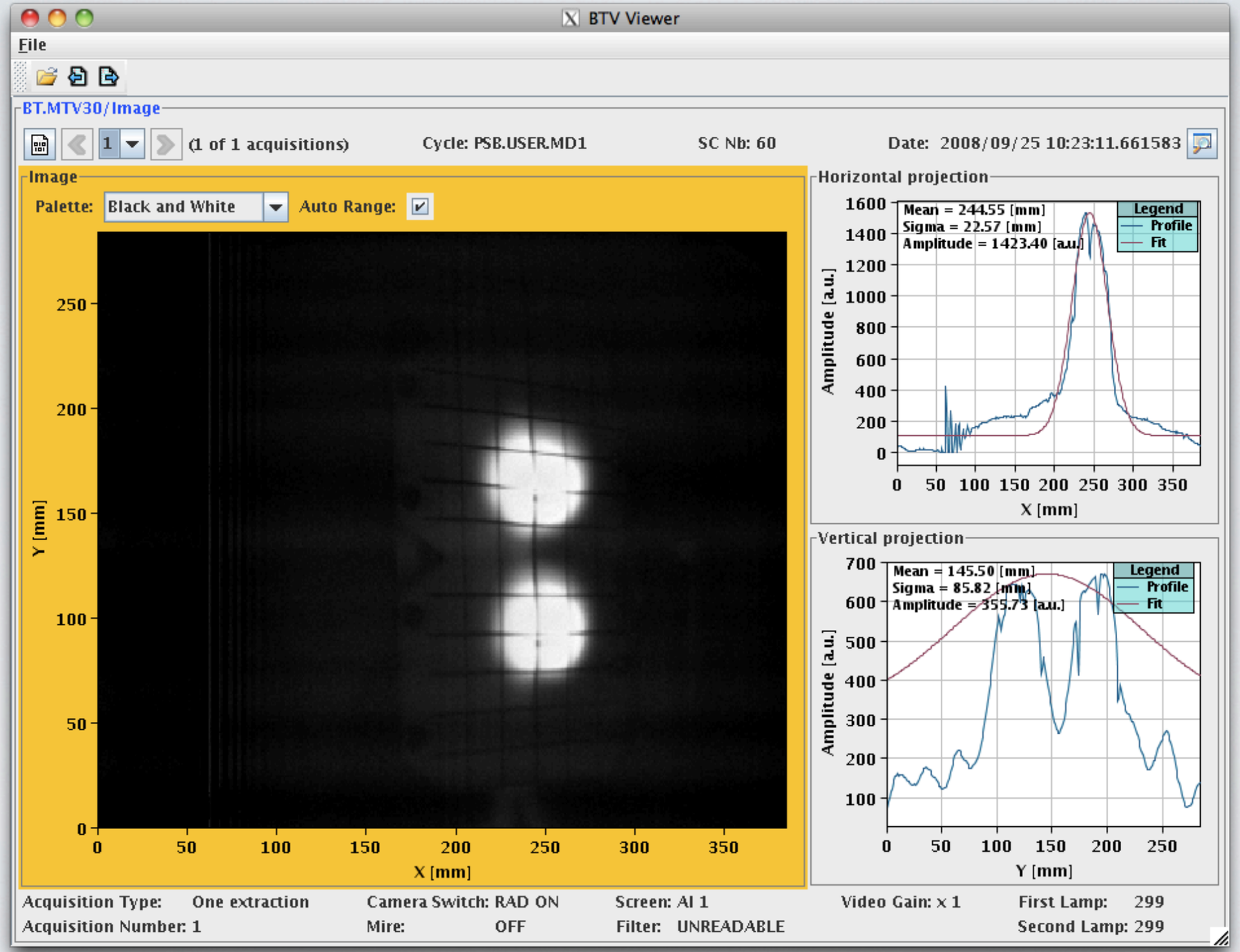
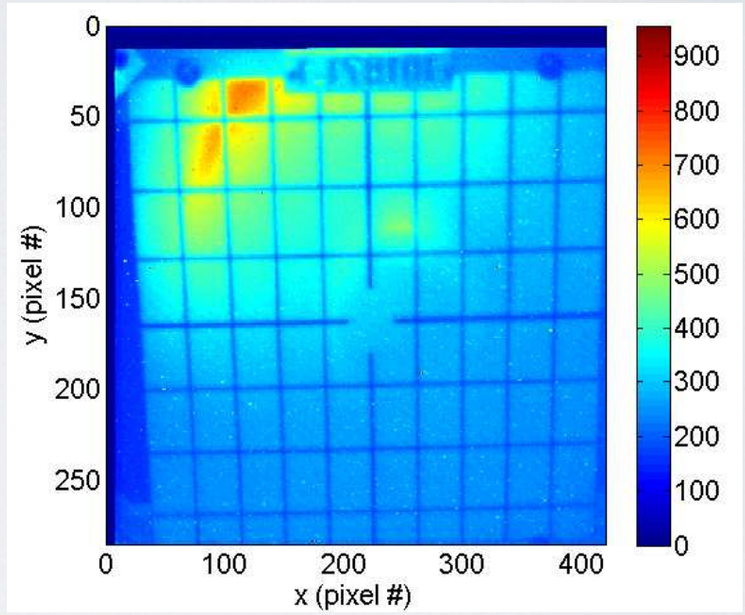
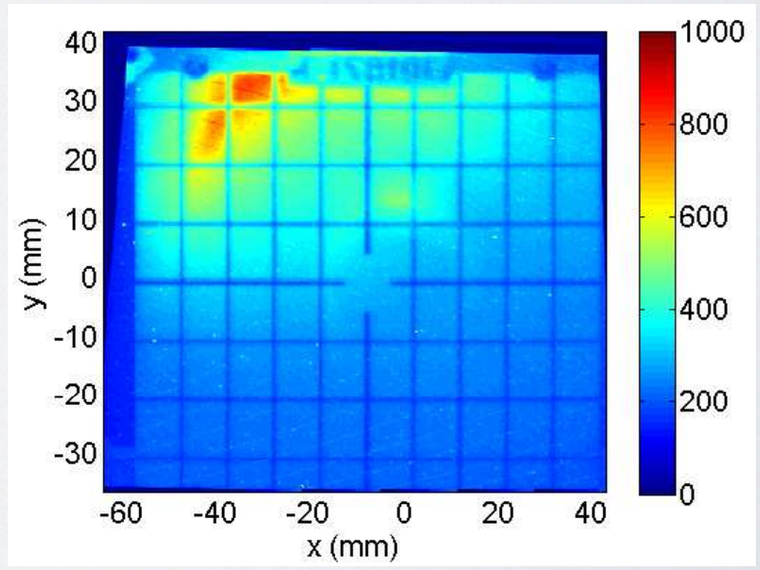


IMAGE DEFORMATIONS

- Usually screens are tilted at 45° or similar
- This introduces the "trapeze" aberration
- Need to calculate and apply a correction algorithm

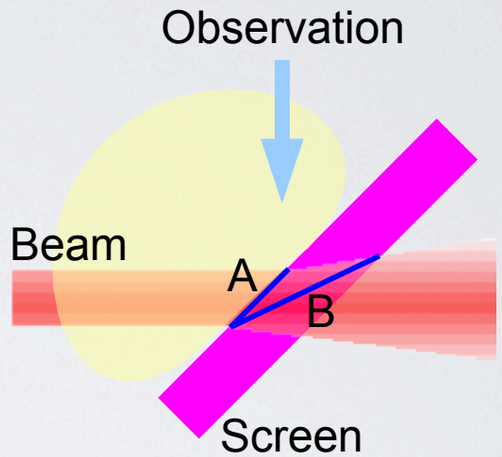




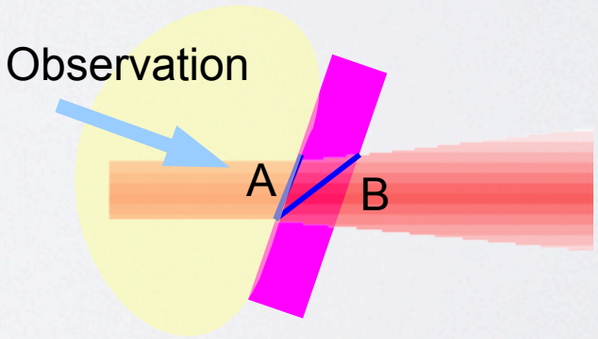
SCREEN THICKNESS

- The thickness of the screen can increase the measure size if installed at an angle

- Screen thickness should be less than beam size



A is what we would like to obser
B is what we really obtain



CHROMOX LIMITS

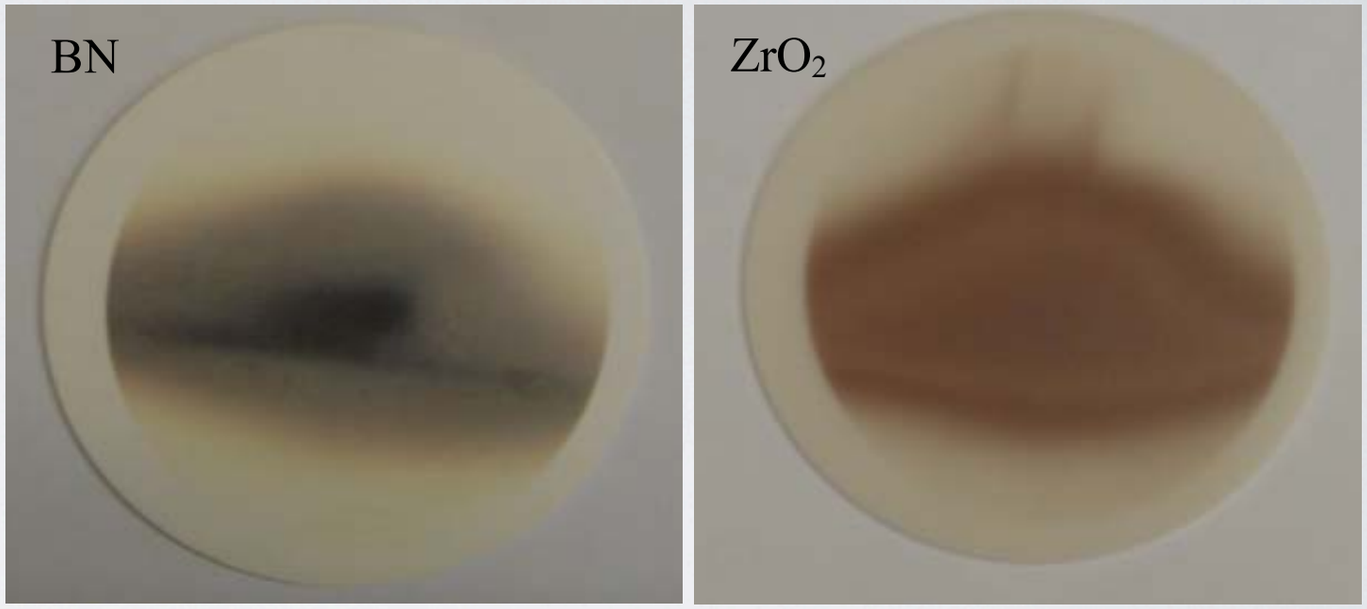
- In 1997 testing the feasibility of using the old LEAR ring for storing and cooling heavy ions for LHC it was noticed that the light produced by the existing chromox screens was fading with time

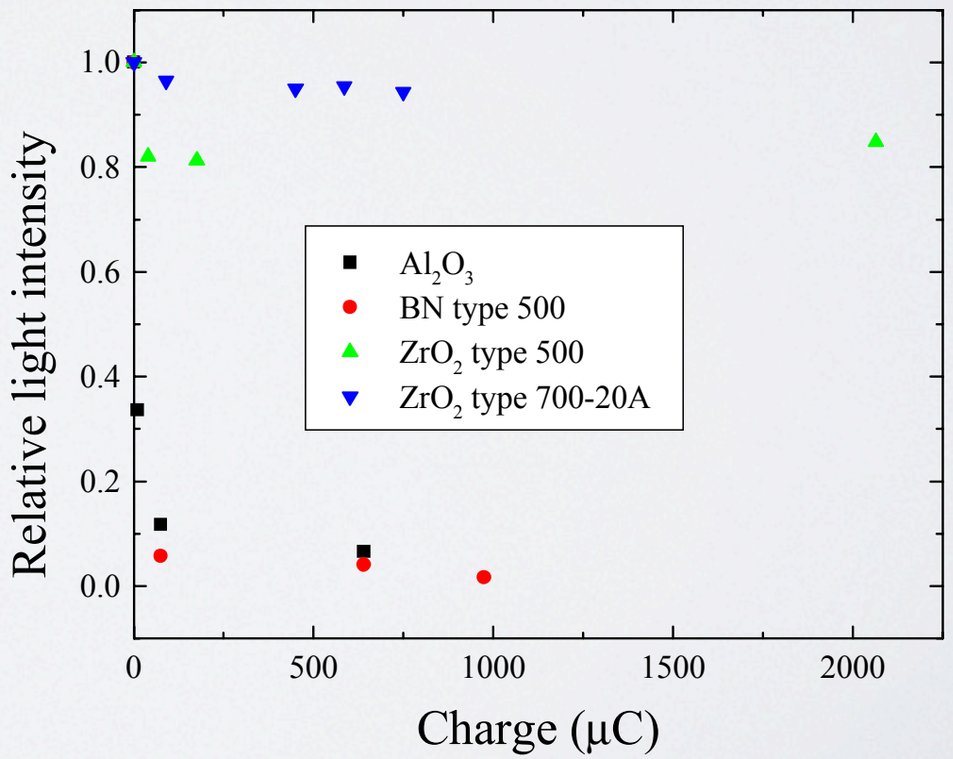
- This triggered the search for more resistant materials

- Unfortunately the finding was not properly documented and chromox was not tested again for this application

LEIR SCREENS

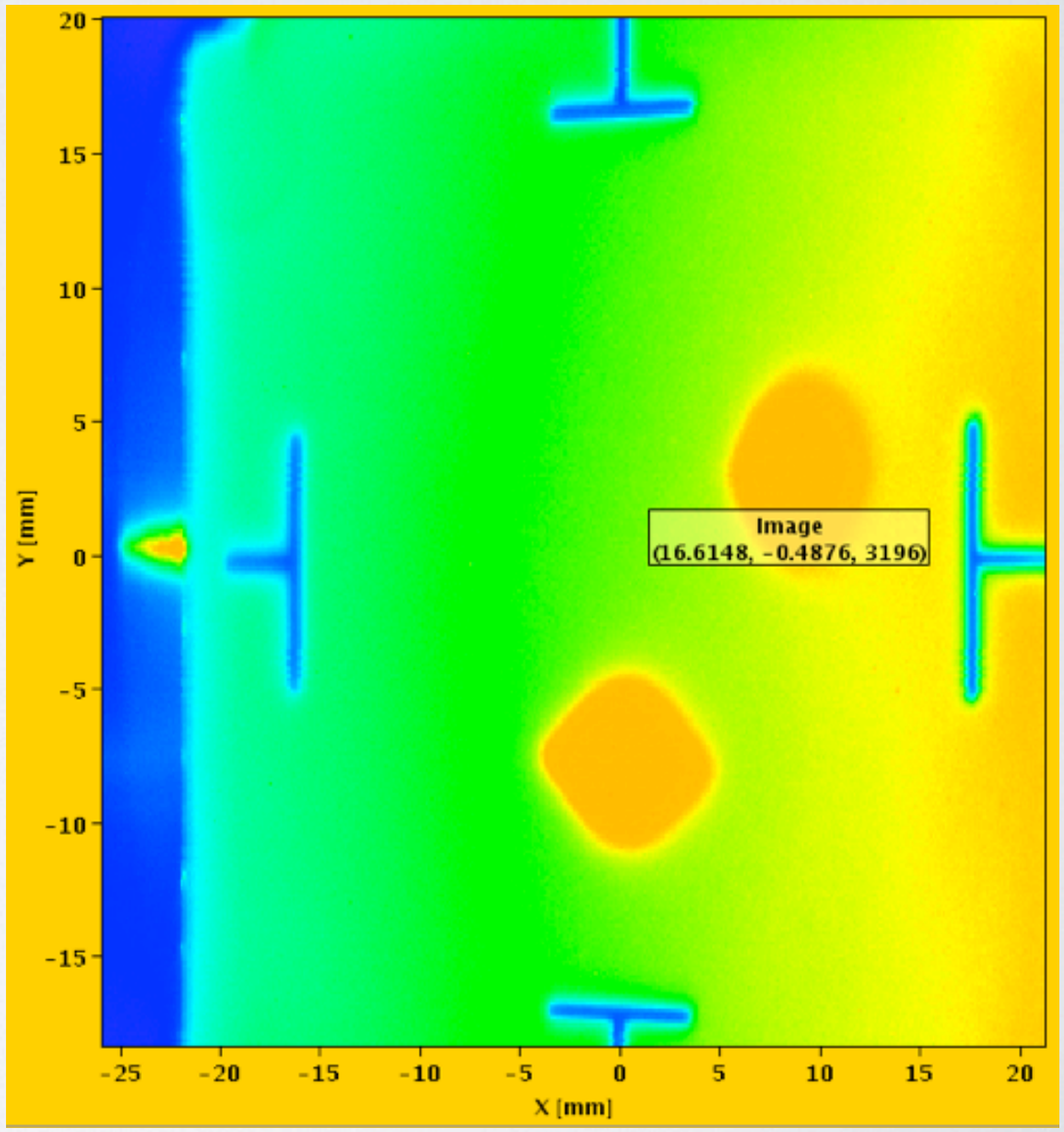
- Al_2O_3, ZrO_2 and BN have been tested
- Loose efficiency with irradiation (Pb^{54+} 4.2 MeV/u)
- Change in colour observed
- Annealing works on alumina and ZrO_2



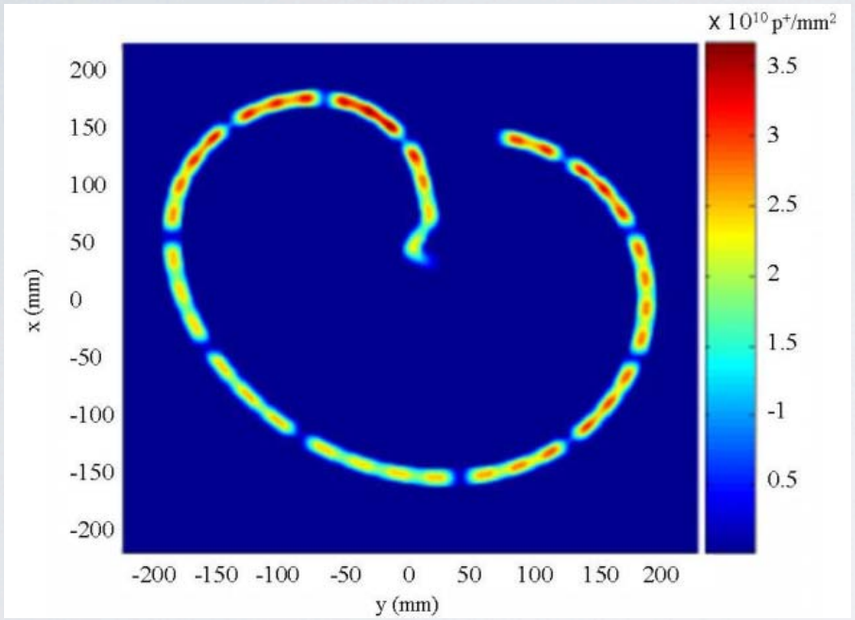


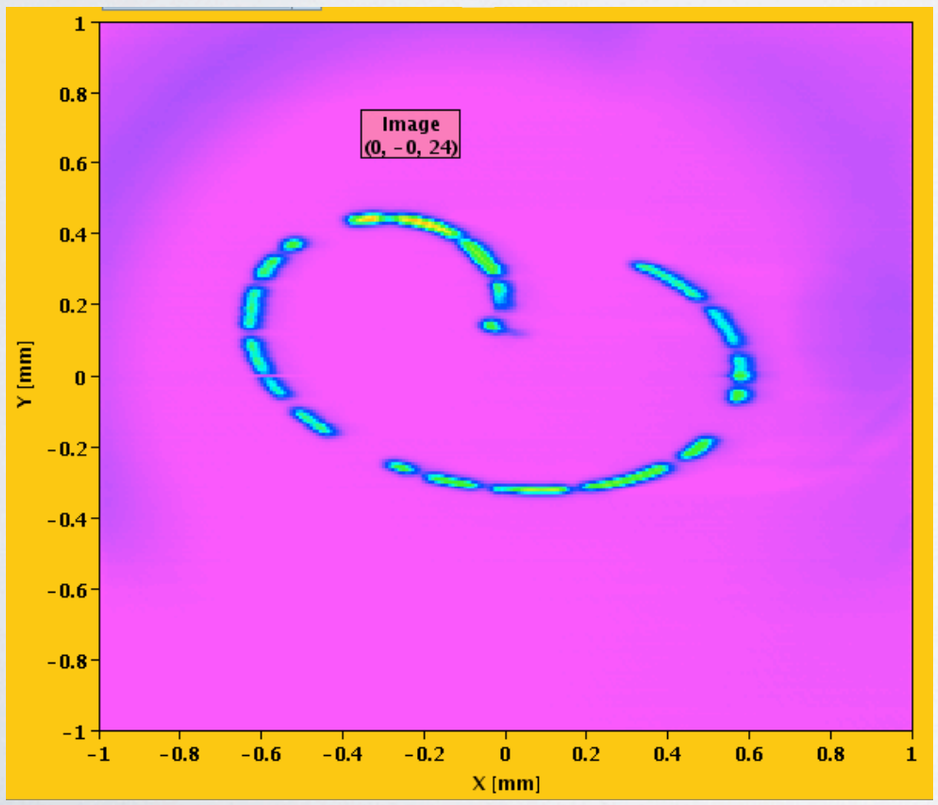
SCREENS IN LHC

- 19 stations in the ring
- 18 stations in the transfer lines
- Chromox + OTR Ti foil everywhere (but BTVDD)
- CCD or CIDTEC cameras



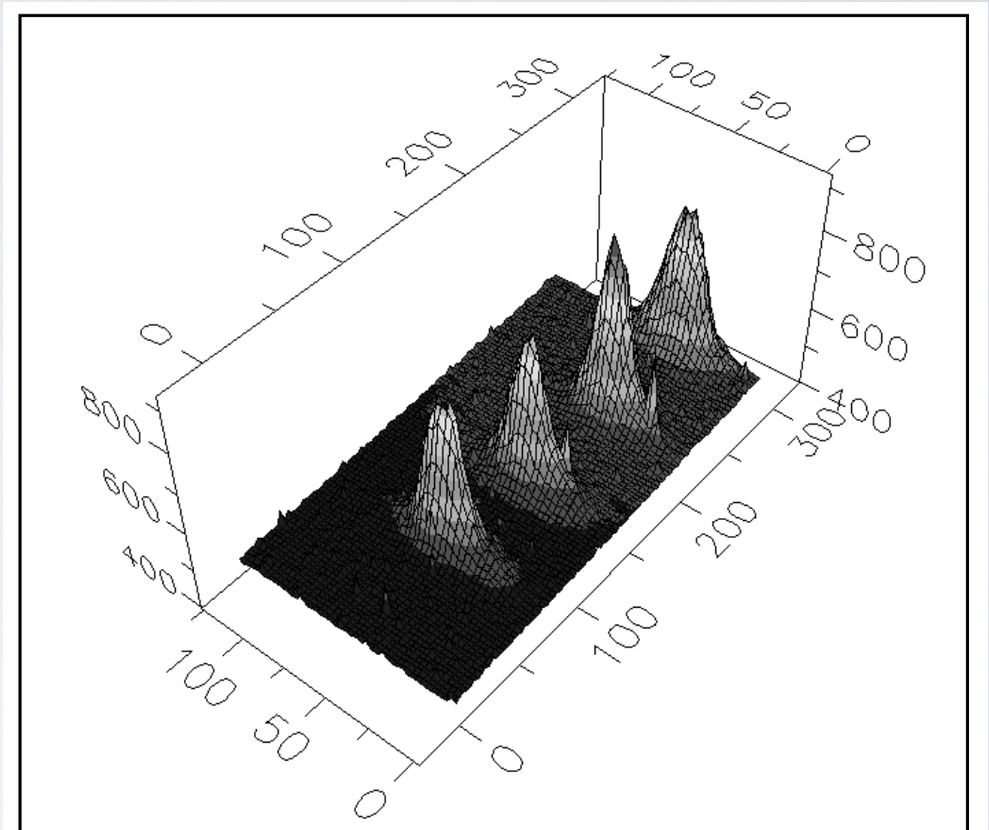
LHC DUMP SCREENS

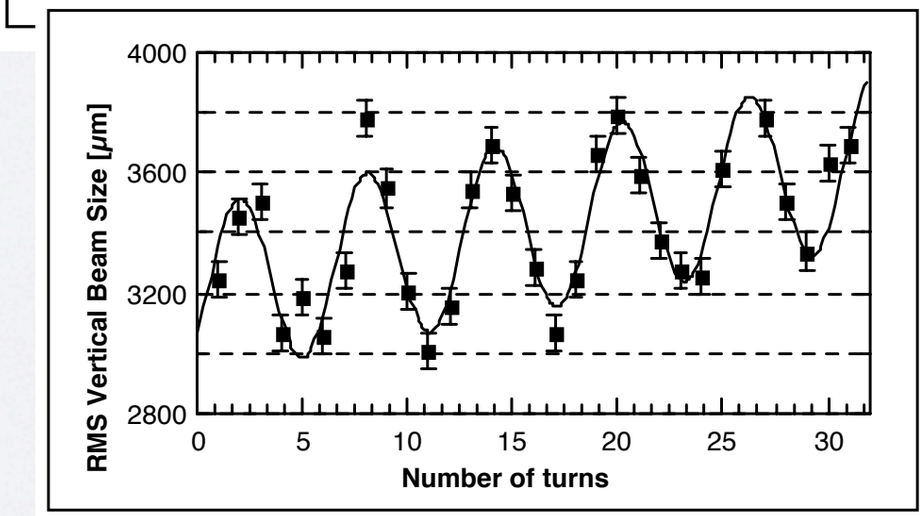




MULTI PASS SCREENS

- Thin OTR foils can be used in multi-pass mode
- This technique has been used both in the SPS and in the LHC for optics and mismatch measurement





SUMMARY

- Chromox still used everywhere at CERN
- We tend to use OTR for precise measurement
- Little research / tests done recently on scintillators
- Still looking for a stable solution for LEIR
- The reference marks are more than a detail
- Main open problem is however the camera