Main Injector Note: XXX
October 11, 2002.
Version 1.0

Transverse Beam Profile with Scraper Scans

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Abstract

In this report, we measure the transverse beam profile with Scrapper Scans for cooled antiprotons.

Transverse Beam Profile from Scraper Scans

During scraper scans, we normally obtain the position of the scraper and the remaining beam current at each step of the scraper. To obtain transverse beam profile, the following steps must be done along with knowing the center of the beam reasonably well. First transform to the phase space variable from the position coordinate:

$$u = \frac{x}{\beta^{1/2}}$$

Obtain the density function g(u):

$$g(u) = \frac{1}{2\pi u}[\frac{dI(u)}{du}]$$

The distribution N(x) can be cast as:

$$N(x) = 2\int_{|x\beta^{-1/2}|}^{\infty} du \frac{ug(u)}{\sqrt{\beta u^2 - x^2}}$$

$$N(x) = \frac{1}{\pi}\int_{|x\beta^{-1/2}|}^{\infty} du[\frac{dI(u)}{du}]\frac{1}{\sqrt{\beta u^2 - x^2}}$$

The 95% emittance can be computed using:

$$\epsilon_{95\%} = \pi u_{95\%}^2$$

$$0.95 I_0 = 2\pi \int_0^{u_{95\%}} du g(u)$$

We could also compute normalized emittance:

$$\epsilon_{95\%N} = \frac{6\pi\beta\gamma\sigma^2}{\beta_{lat}}$$

where σ is beam profile width.

Applications

- Calibration of Emittance Monitors
- Beam time evolution studies
- RR Acceptance
- Beam shapes and associated beam dynamics

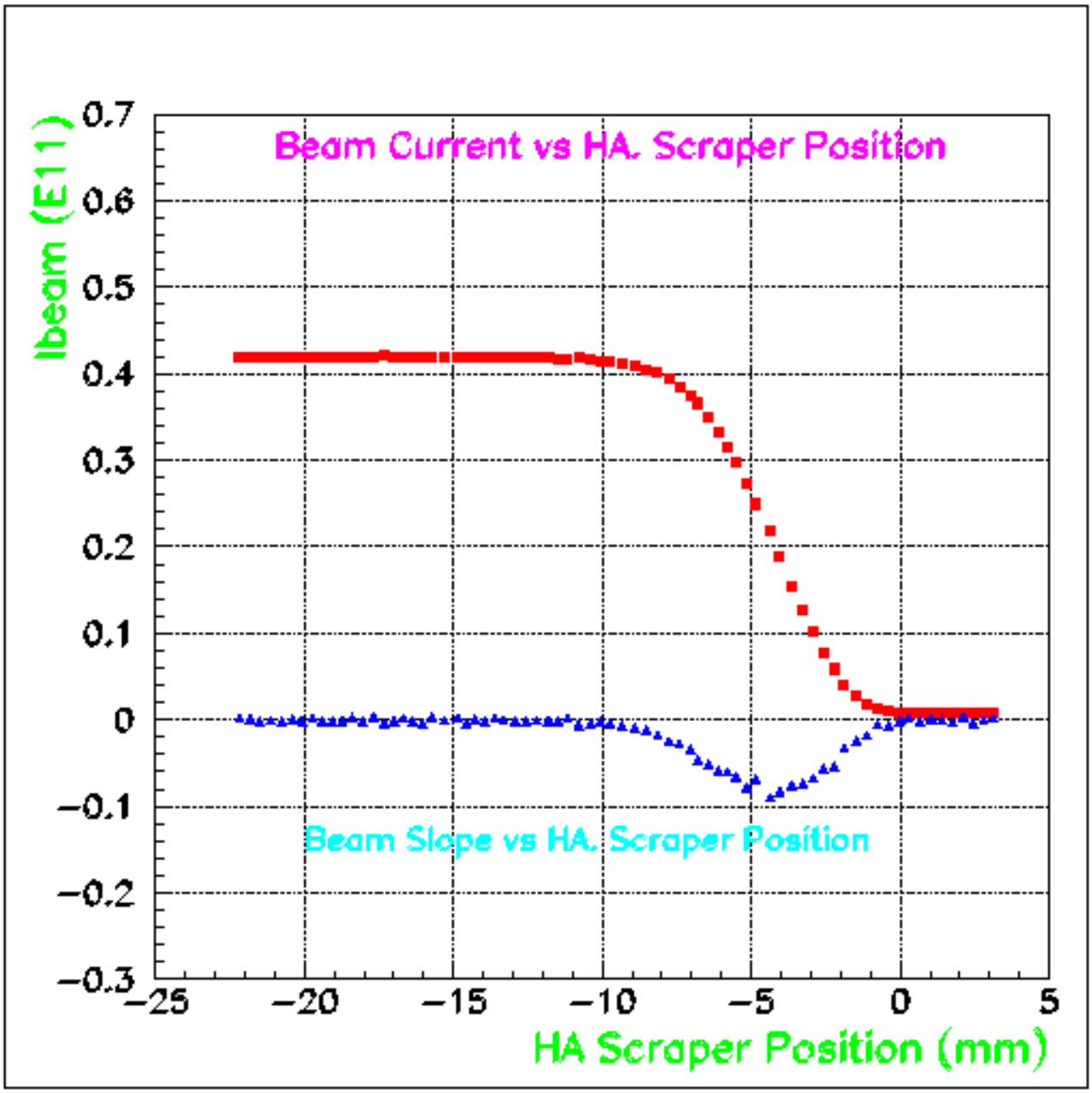

Figure 1: Cooled Antiprotons scraped horizontally using AILSE JAW - No MI ramping

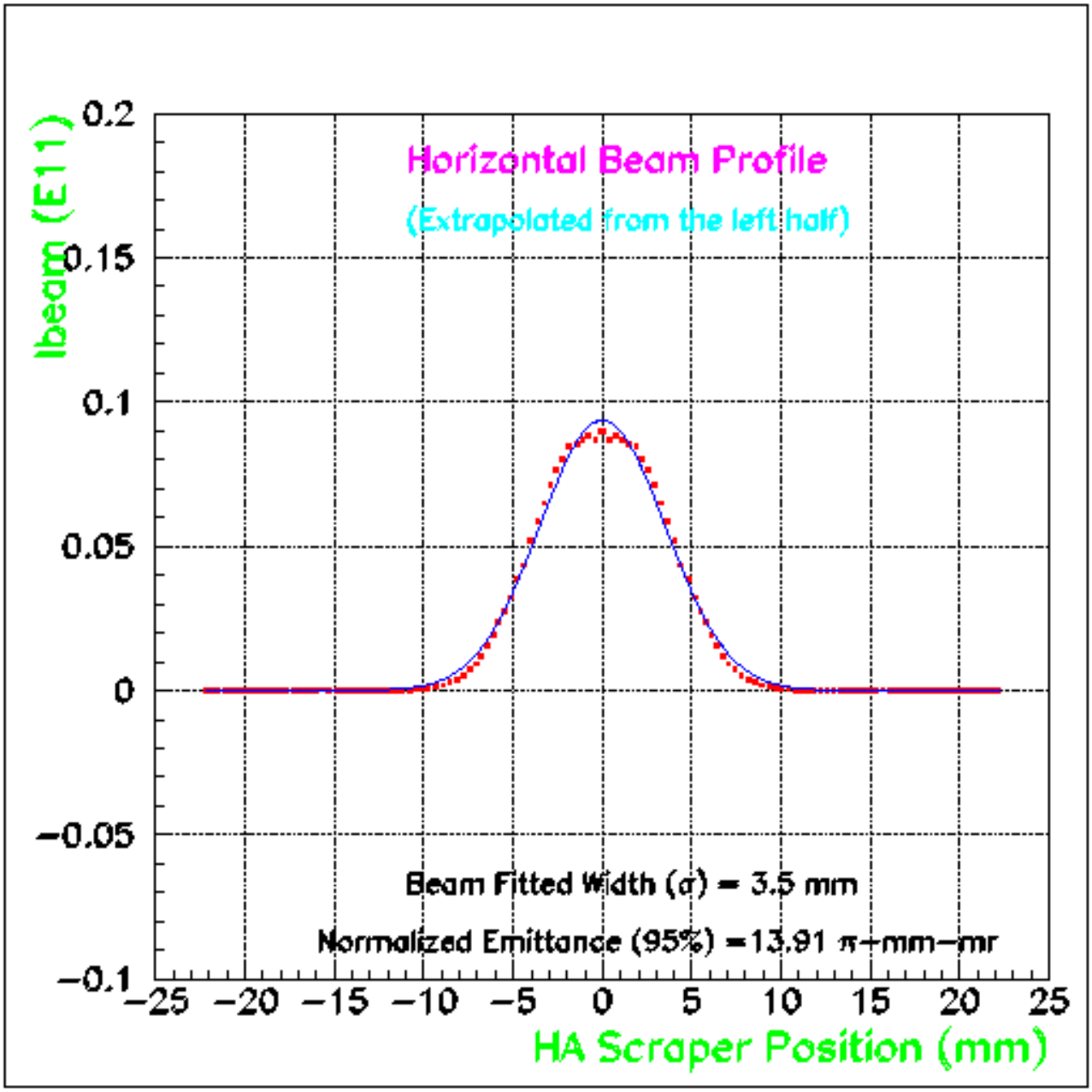

Figure 2: Cooled Antiprotons scraped horizontally using AILSE JAW with no MI ramping - Gaussian Fit

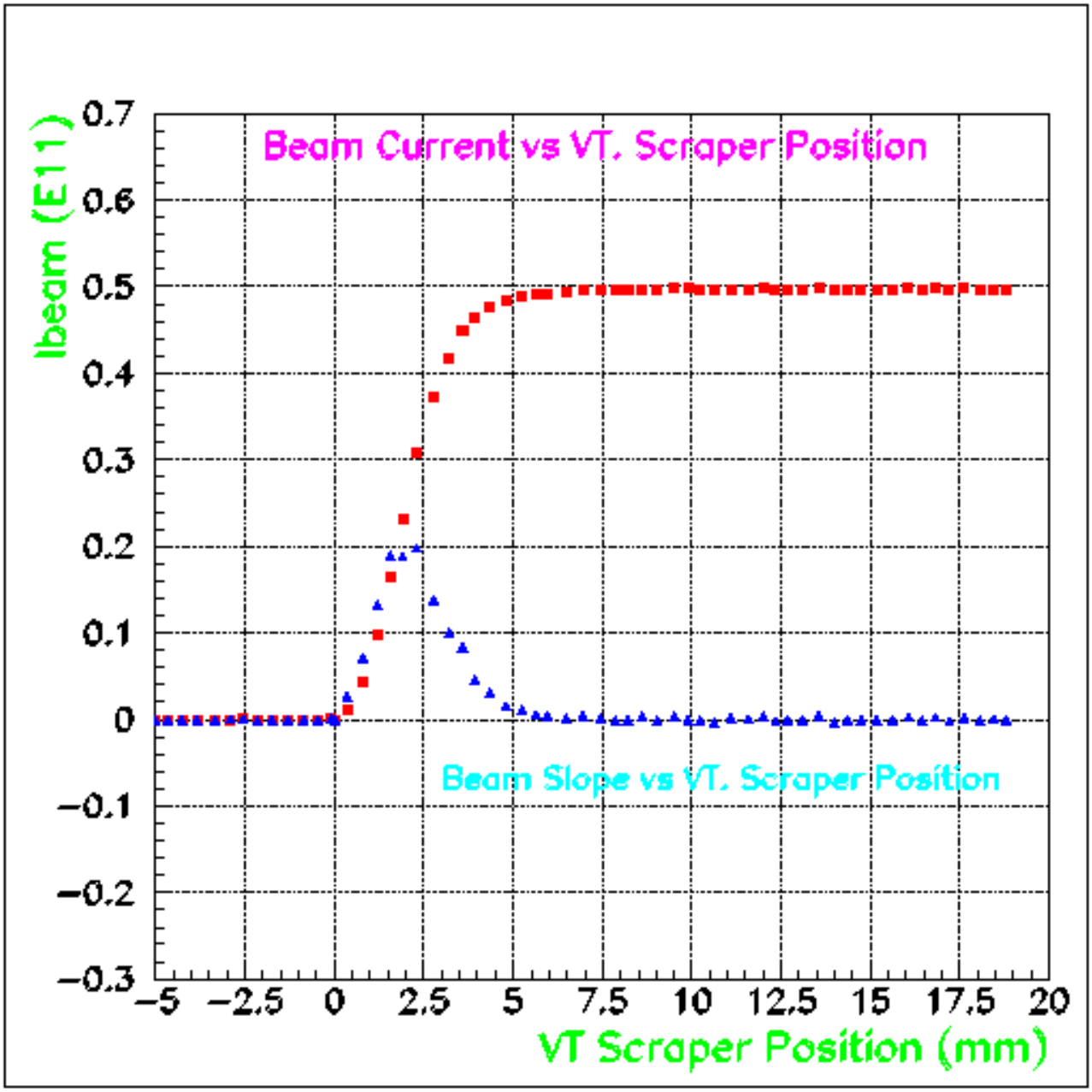

Figure 3: Cooled Antiprotons scraped vertically using TOP JAW with no MI ramping

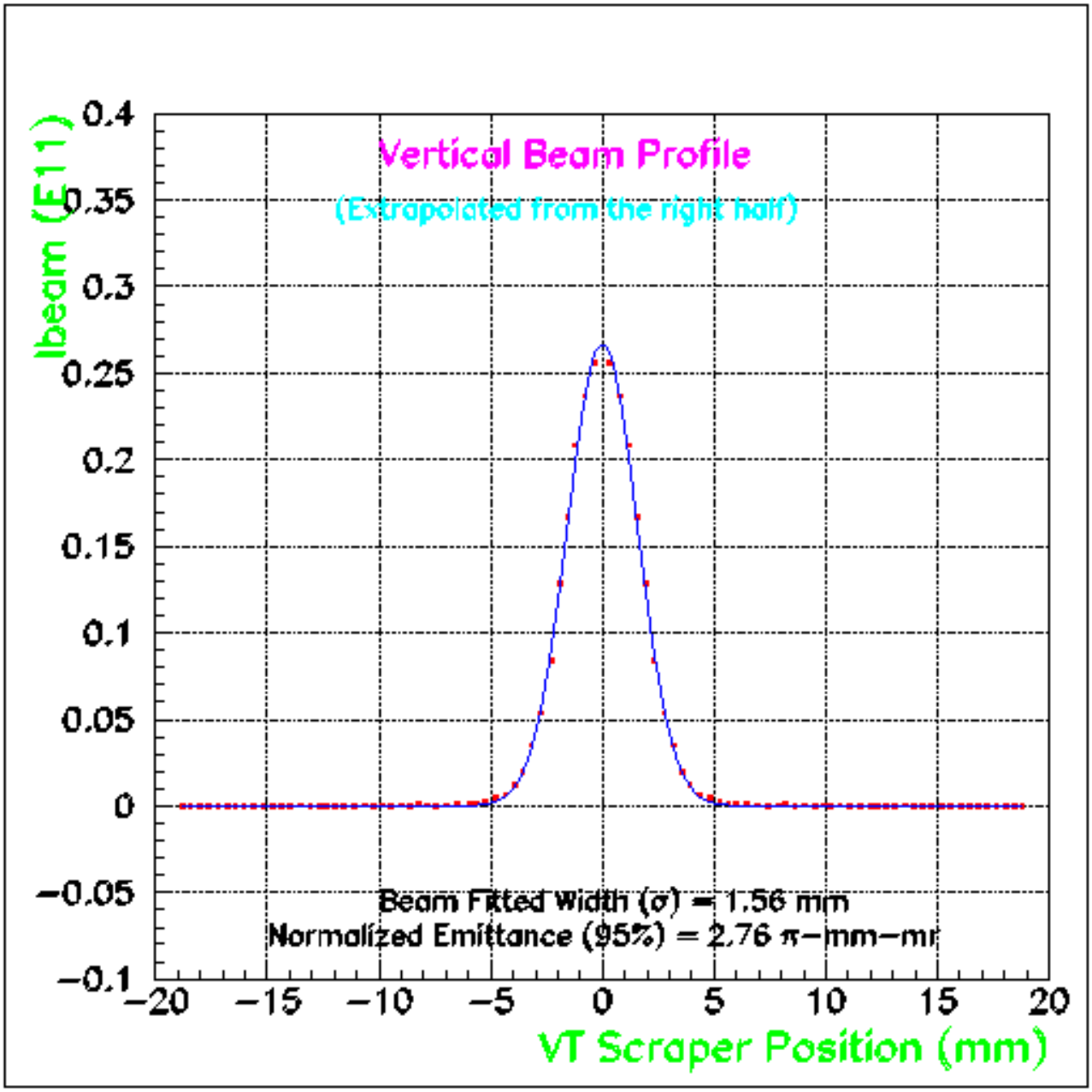

Figure 4: Cooled Antiprotons scraped vertically using TOP JAW during no MI ramp - Gaussian Fit

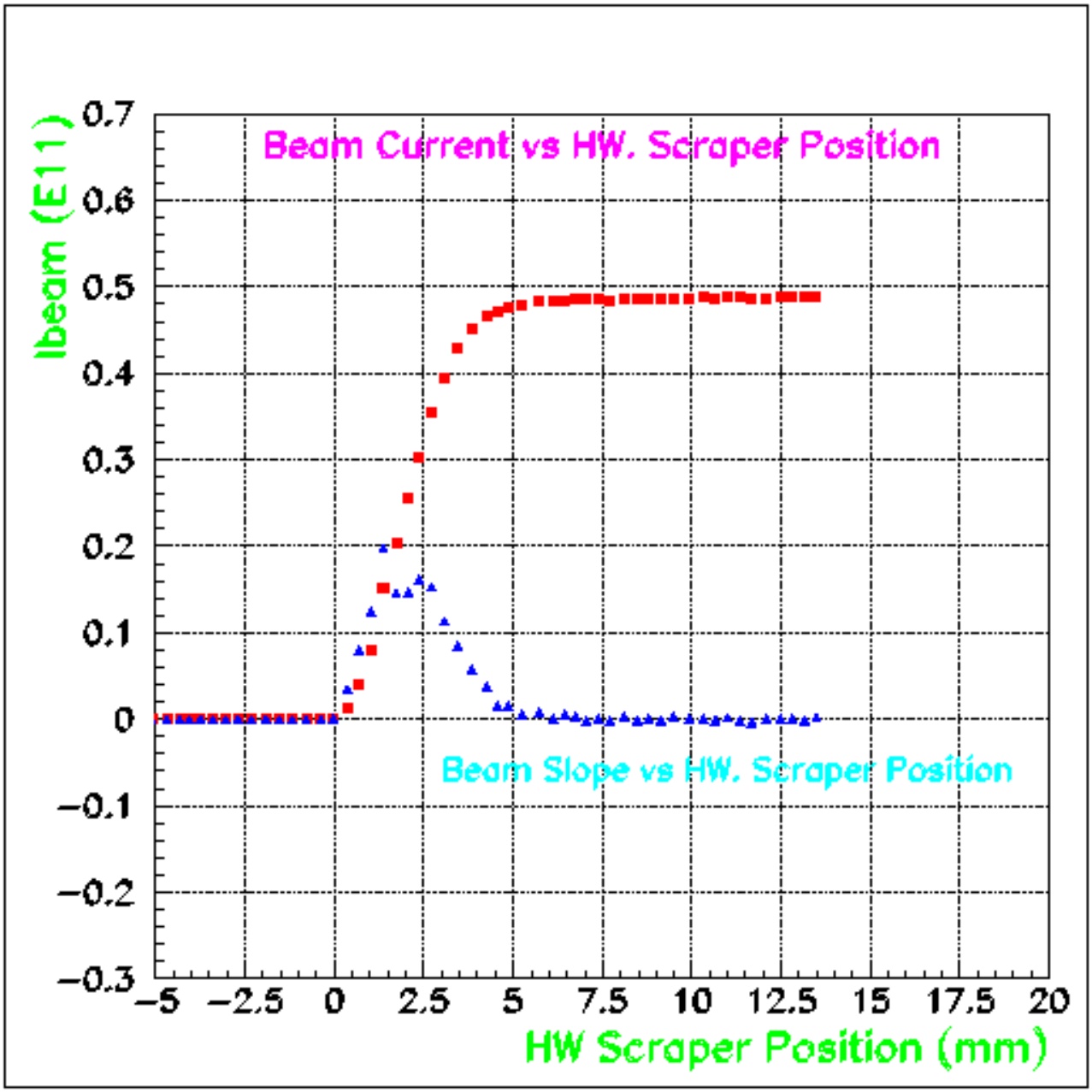

Figure 5: Cooled Antiprotons scraped horizontally using WALL JAW - no MI ramping

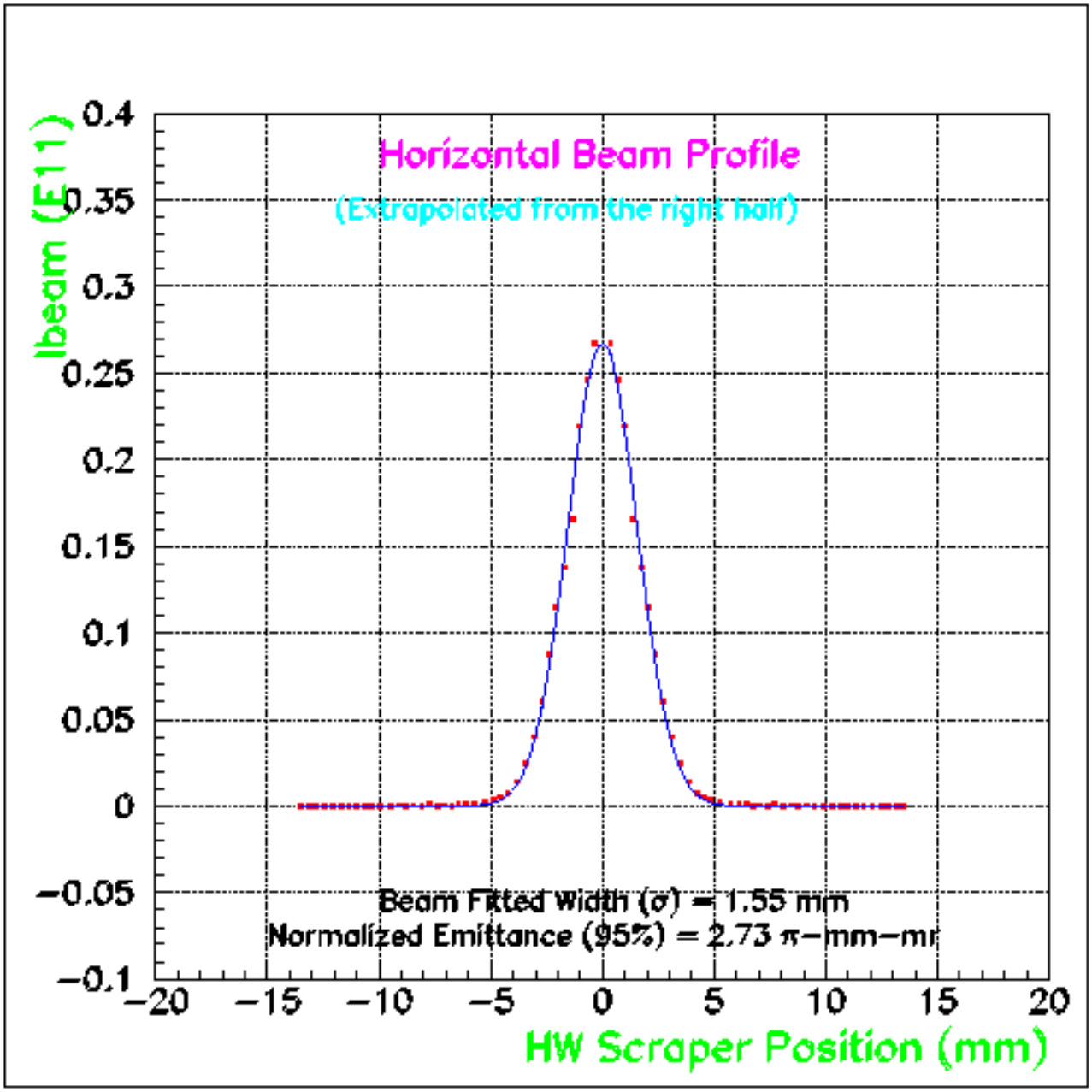

Figure 6: Cooled Antiprotons scraped horizontally using WALL JAW during no MI ramping - Gaussian Fit

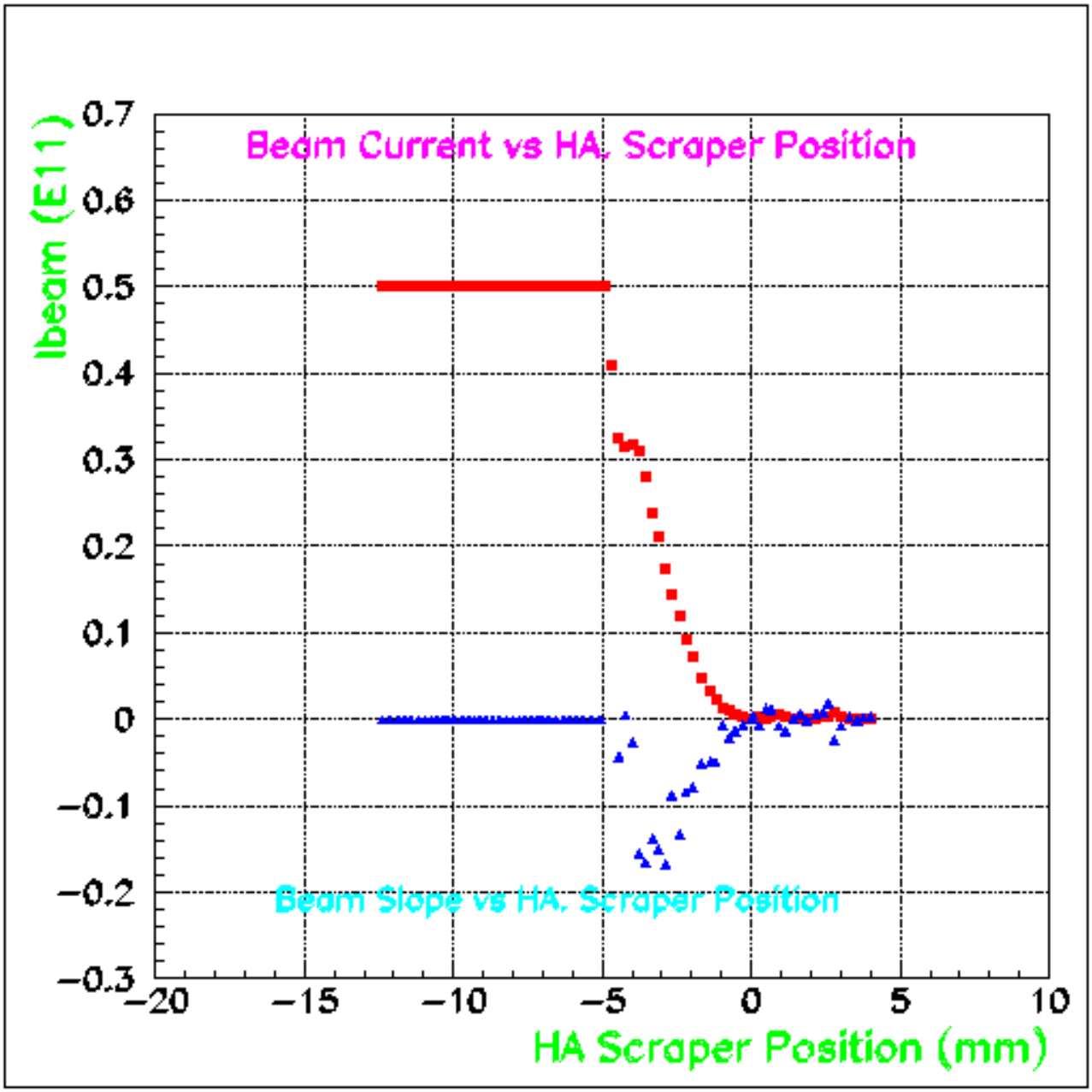

Figure 7: Proton beam scraped horizontally using WALL JAW while MI is ramping

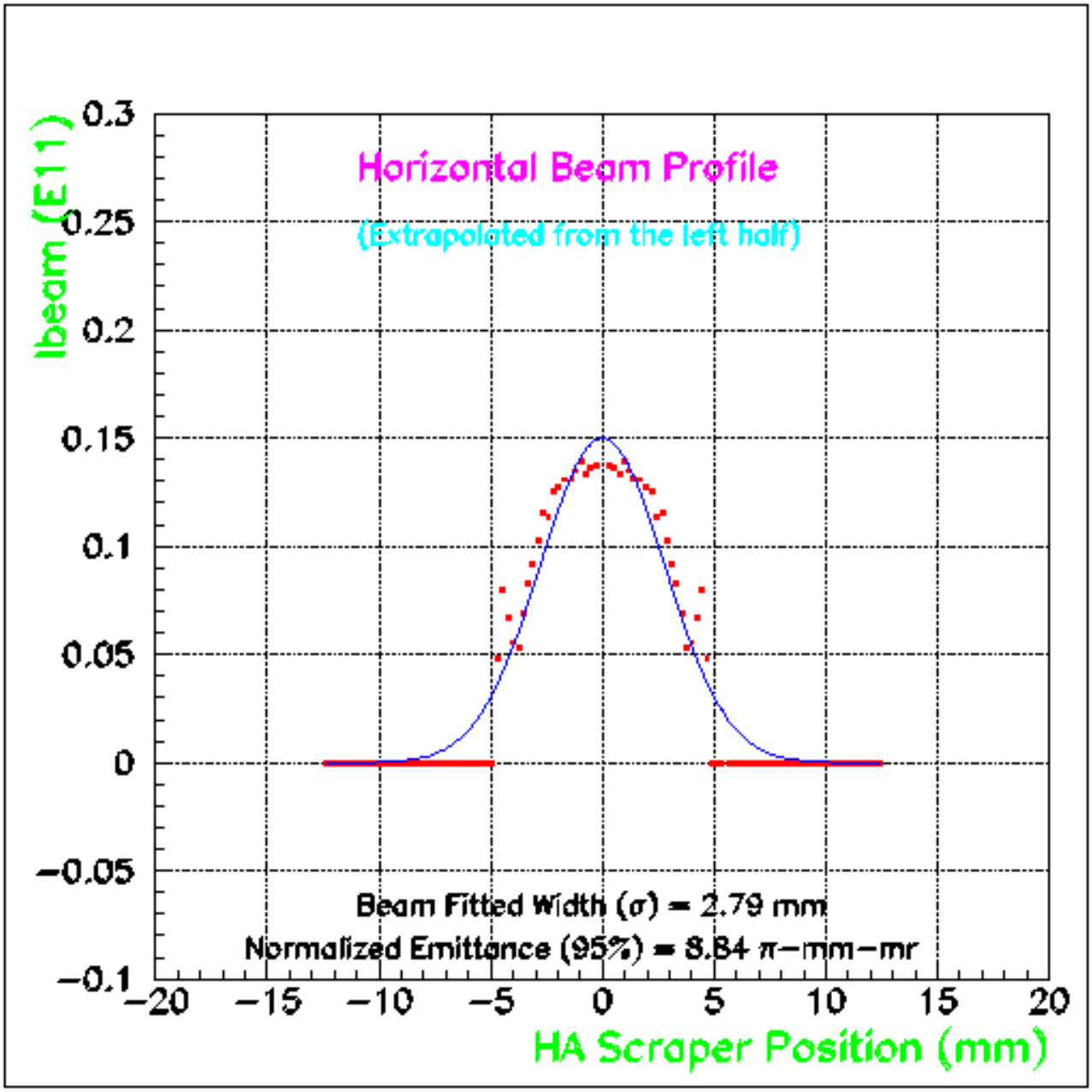

Figure 8: Proton beam scraped horizontally using WALL JAW during MI ramp - Gaussian Fit

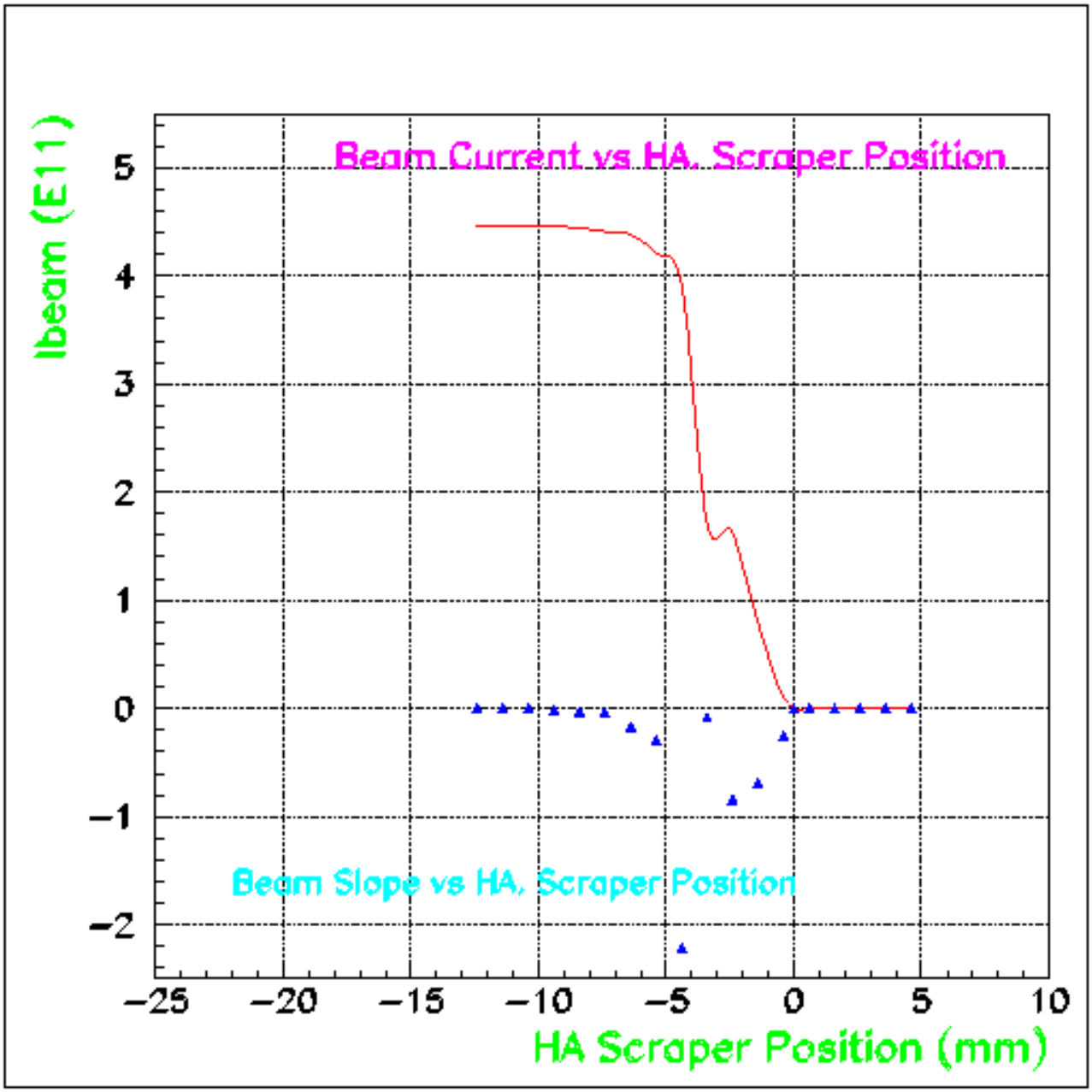

Figure 9: 4.5E11 Antiproton beam scraped horizontally using WALL JAW while MI is ramping

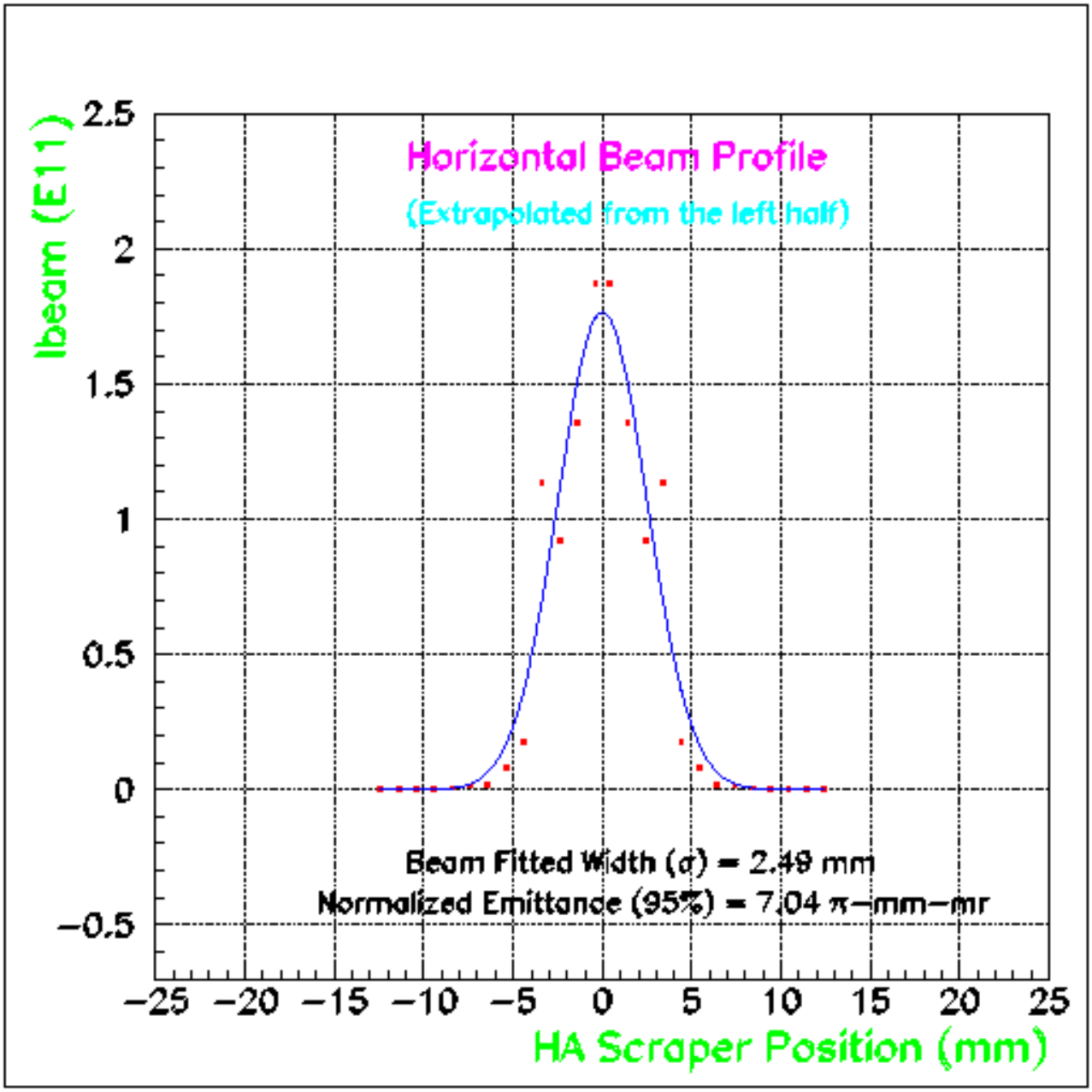

Figure 10: 4.5E11 Antiproton beam scraped horizontally using WALL JAW during MI ramp - Gaussian Fit

Summary and Outlook

We have used the RR Scrapers to determine the transverse beam profile of cooled antiprotons while MI not ramping and protons when MI is ramping. The results look very encouraging. The RR Scrapers will be useful for many studies:

- Beam profiles are needed for understanding the time evolution of the beam in RR. We can extract vacuum information directly from beam profiles.
- Calibration of emittance measuring devices such as Schotkky Detectors, IPM etc.. This gives another handle to calibrate them.
- RR Acceptance measurements

Looking ahead:

- We need to do recalibration of our emittance monitors
- As a next step, we will study the proton beam profiles when injected and especially long after the beam has filled the aperture (during quiet time).
- It will be useful to setup utility so that everytime we scrape the beam, we can get the beam profile displayed online!