A Quest for Measuring Ion Bunch Longitudinal Profiles with One Picosecond Accuracy in the SNS Linac.

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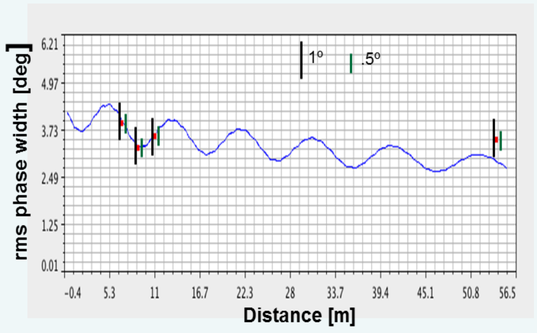
NEUTRON SCIENCES

Longitudinal profiles use : determination of longitudinal Twiss parameters and beam matching



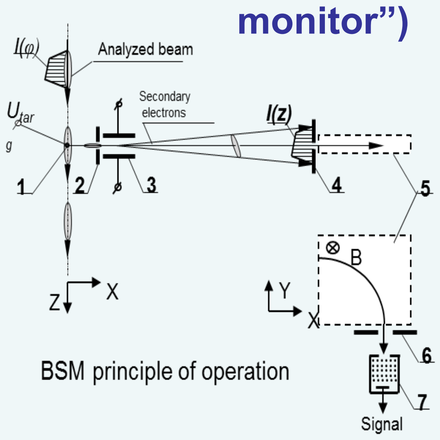
Measured longitudinal bunch size vs. model

Typical bunch RMS size : ~ 10 ps ,

[3° @805MHz or 1.5mm]

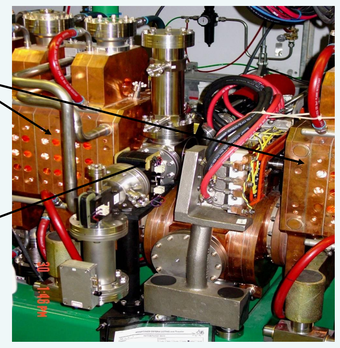
Desirable accuracy : ~ 10% or 1 ps

Beam Shape Monitor (aka "Feschenko monitor")



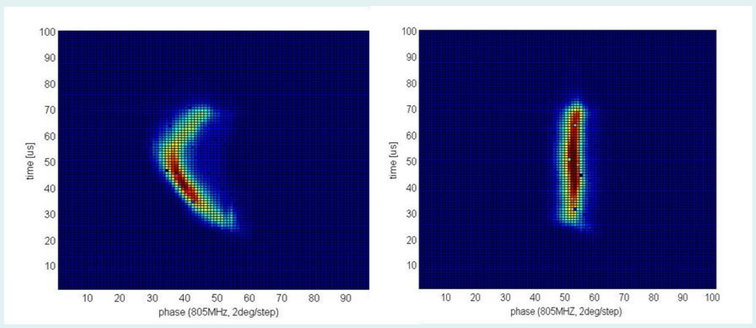
BSM principle of operation

CCL segments



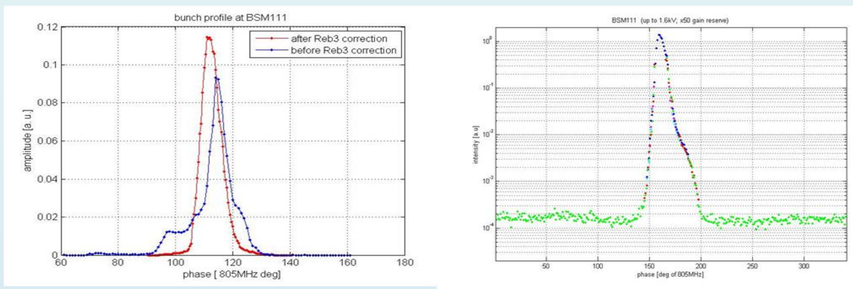
Examples of BSM measurements

Time-resolved longitudinal profile measurements along the beam pulse



Longitudinal profile averaged over whole beam pulse

Large dynamic range



Factors determining resolution and accuracy

1. **Secondary emission temporal response**
   - **Expect to be less than 1ps, no reliable experimental data**
2. **Space charge effect in the beam pipe**
   - **Can be a major factor, subject of current study**
3. **Resolution of the deflector/analyzer**
   - **Main focus of our improvement program**

limiting factor #3: deflector/analyzer optics

- **Reduce analyzing slit size**
- **Optimize deflecting RF voltage**
- **Improve electron optics tuning**

$$x = a_{\max} \cdot \sin\varphi$$

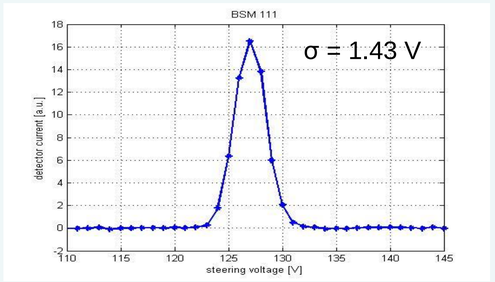
$$\frac{dx}{d\varphi} = a_{\max} \cdot \cos\varphi$$

$$\delta\varphi = \left.\frac{d\varphi}{dx}\right|_{x=0} \cdot \delta x = \frac{\delta x}{a_{\max}} \approx \frac{\sqrt{d^2+\sigma_x^{\,2}}}{a_{\max}} = \frac{\sqrt{d^2+\sigma_x^{\,2}}}{g \cdot V_{RF}}$$

beamlet size

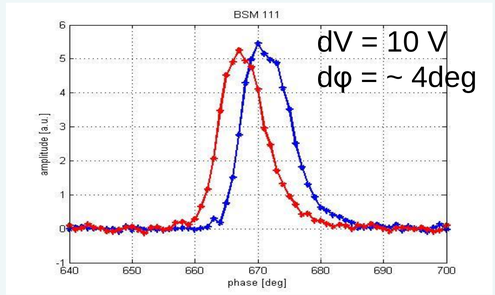
slit width

deflecting voltage



Measuring the beamlet size:

- deflecting RF is OFF
- Scan the beamlet across the slit with DC voltage



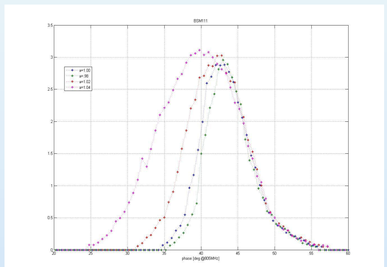
Measuring the deflector strength $\frac{d\varphi}{dV_{RF}}$

- deflecting RF is ON
- Scan the bunch profile -> Change the DC corrector voltage by dV -> Scan the bunch profile

	BSM107	BSM109	BSM111
σ_V [V]	2.28 old slit, ~1mm	1.94 old slit, ~1mm	1.43 new slit,~0.3mm
dφ/dV [º/V]	0.36	0.47	0.38
δ_φ [º]	0.83	0.85	0.54

- Can expect σ_V of ~ 1.5V, dφ/dV of ~ .4 º/V
- δ_φ [º] of ~ .6º should be achievable

limiting factor #1: secondary emission temporal response

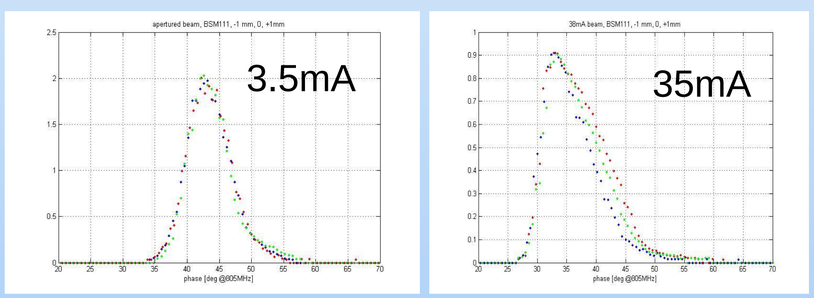


Demonstrating shortest possible beam with "zero" current

σ_φ = [5.8° 4.1° 3.3° 2.9°]

~ .4º resolution is achievable

limiting factor #2: space charge



The effect is measurable

Study and mitigation strategy development is ongoing