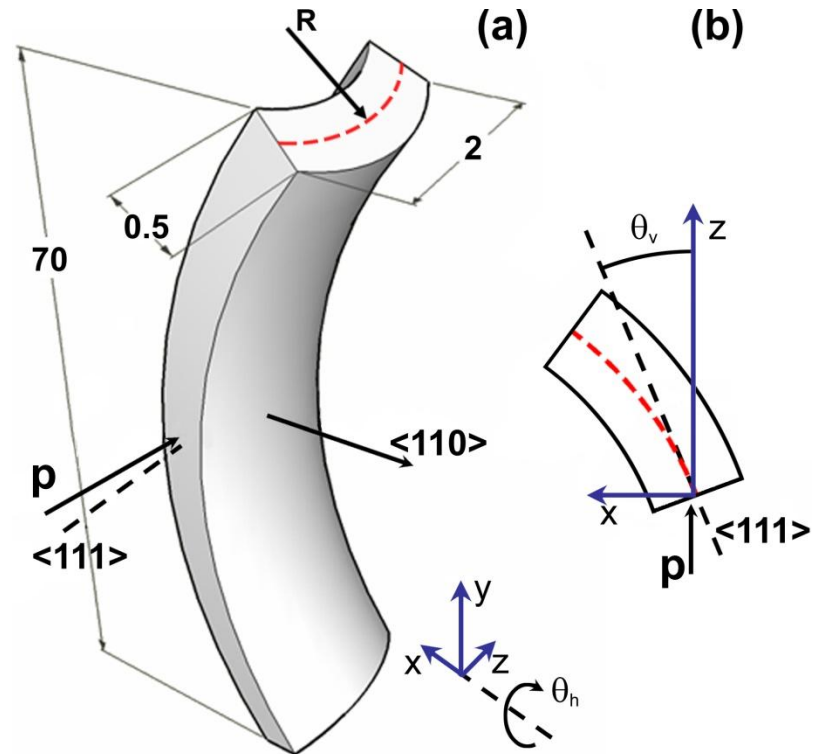
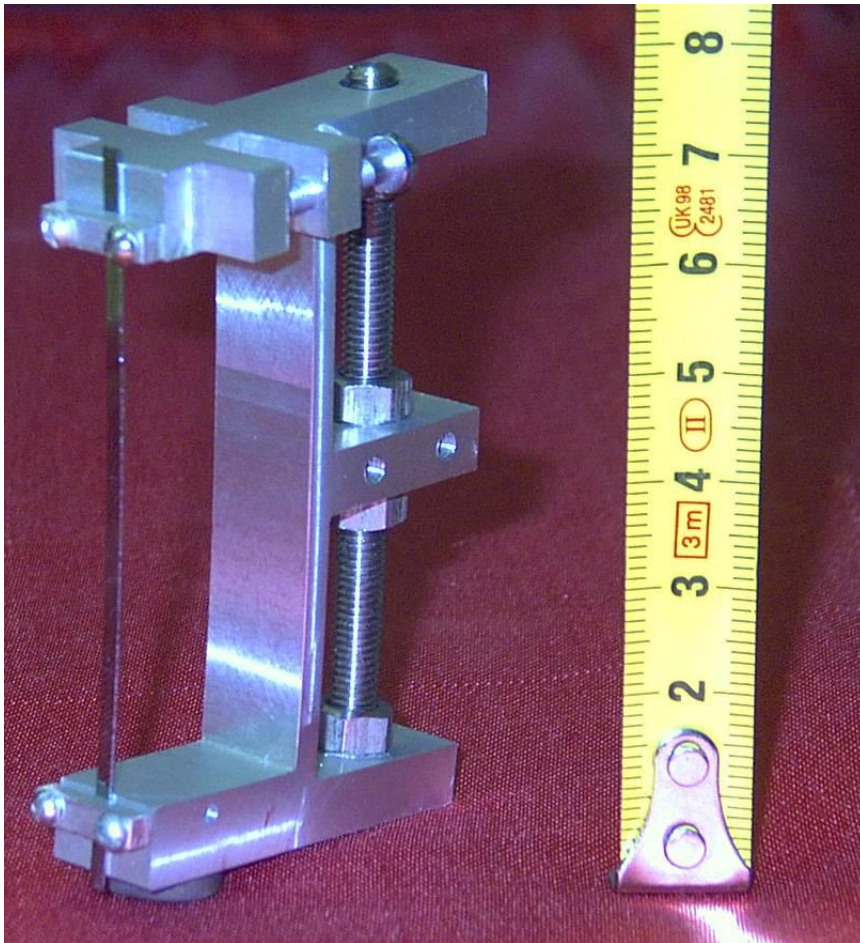


On single-turn slow extraction
from individual bunches
using Bent Crystal and pulsed
dipole corrector

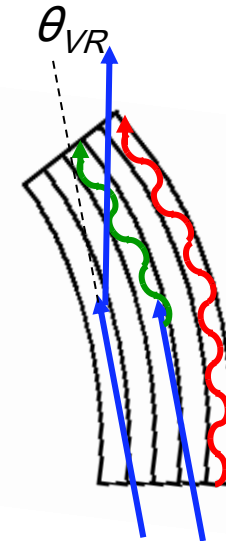
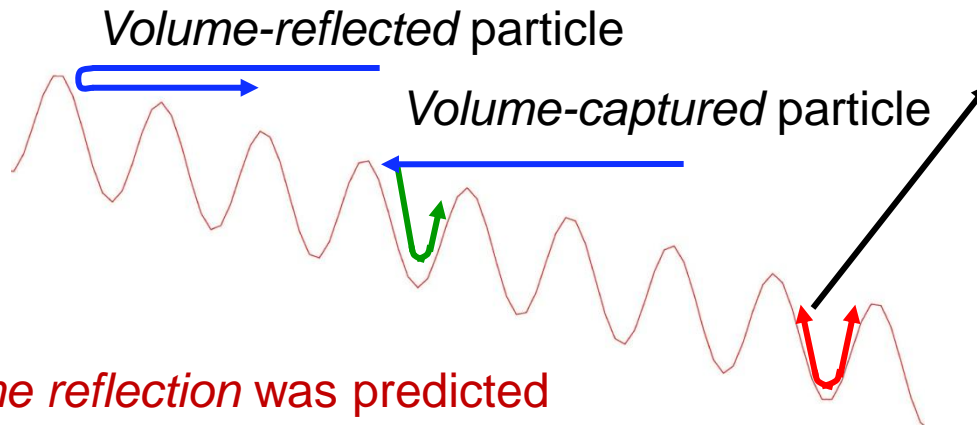
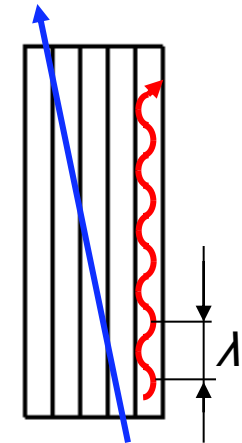
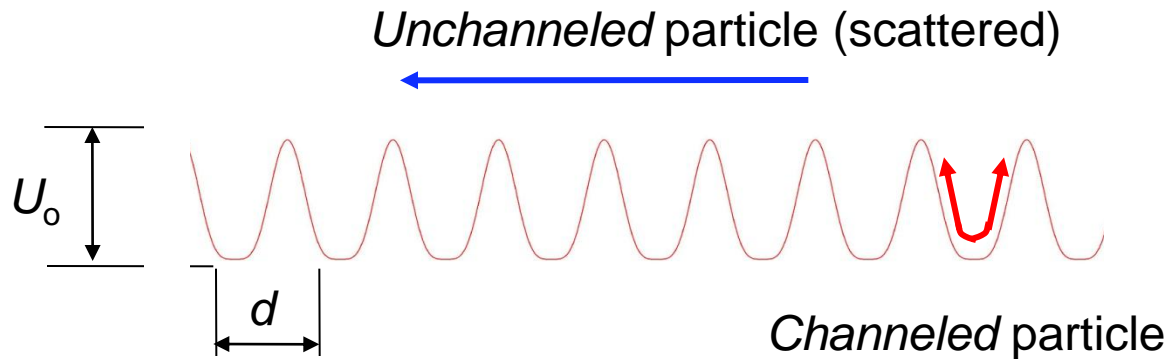
V.Shiltsev 9/29/2011

What is *bent crystal*?



Crystal bending is accomplished through *anticlastic* deformation

Five Processes in Crystals



Volume reflection was predicted by Taratin and Vorobiov in 1987

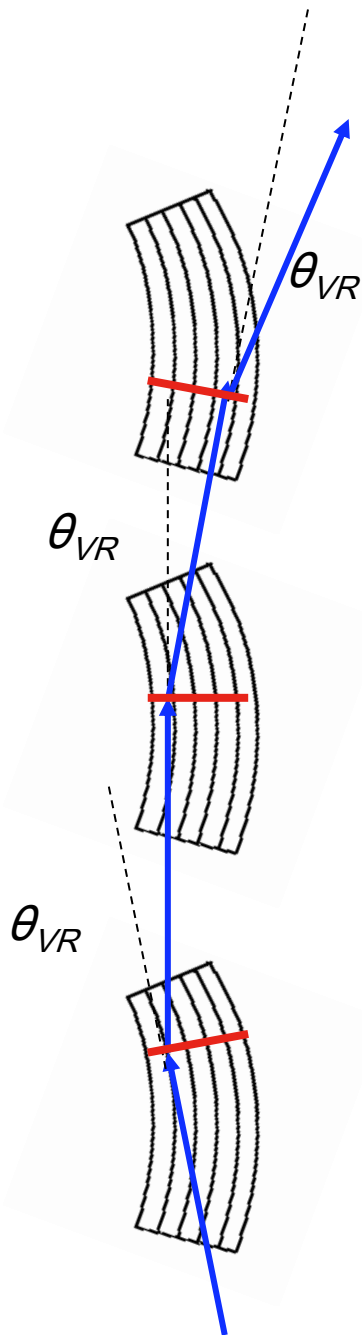
Channeled particle de-channeled

Single or multiple Volume Reflection regime

One crystal $\theta_{VR} = 90 \mu\text{rad}$ for 8 GeV proton

$\theta_{bend} = 200 \mu\text{rad}$

8 crystals $\theta_{VR} = 90 \times 8 = 720 \mu\text{rad}$



8 Crystal "Strips" (IHEP, Protvino)

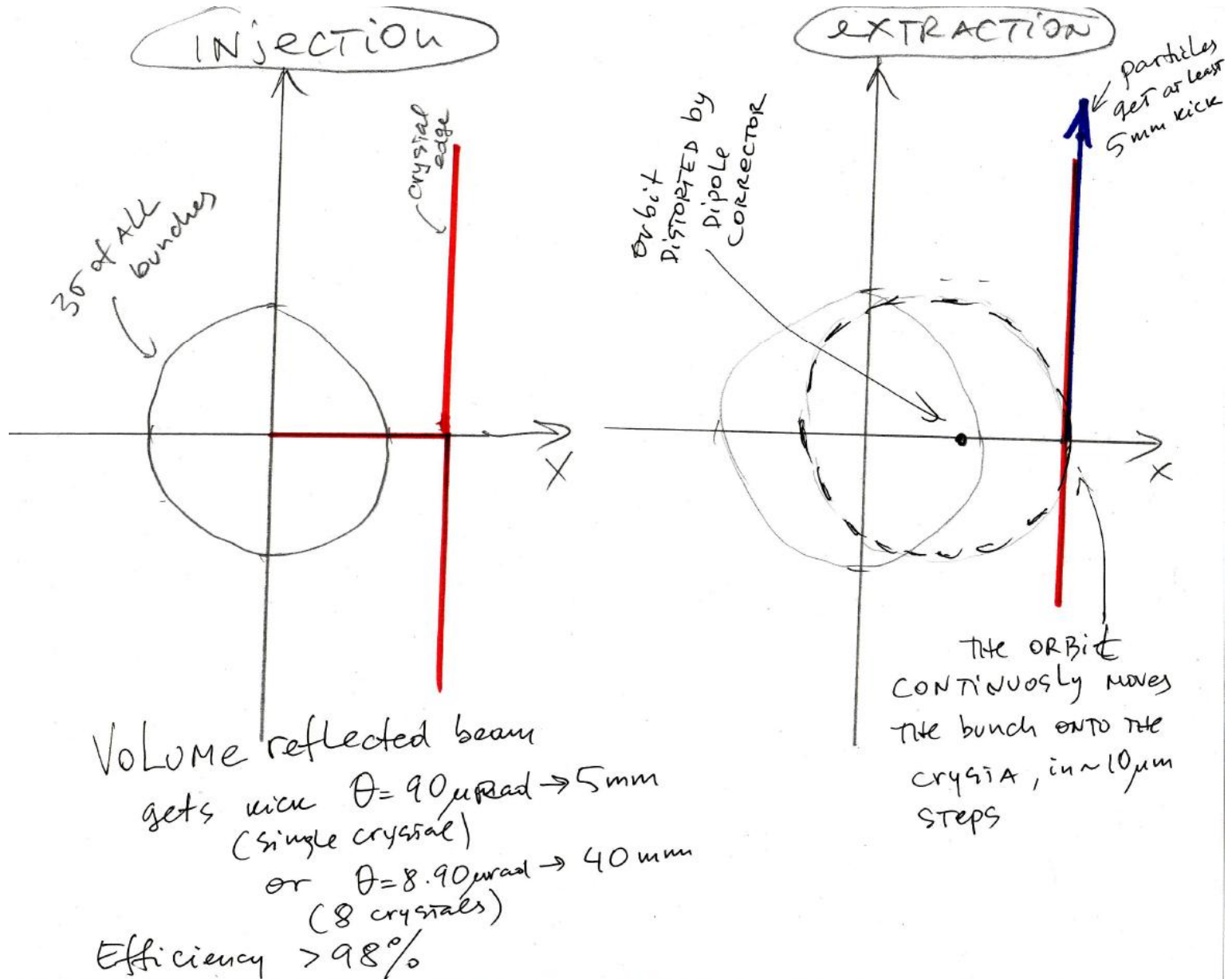
Notes:

1. The concept of bent crystals has been studied in great depth during the Tevatron T980 experiments
2. Technology is proven, two goniometers available from Tevatron, various types tested
3. Enormous radiation hardness of Si crystals, better than SS
4. Efficiency for collimation demonstrated in the Tevatron and SPS, see T980 papers in :
 1. N.Mokhov, et al, PAC'2009
 2. V.Shiltsev et al, IPAC'2010
 3. V.Zvoda et al , PAC'2011

What's needed for the scheme of slow extraction with use of the bent crystals: (8 GeV proton beam example)

1. Crystals (some 5 mm long) and mechanical system for their alignment (goniometer - ~1 m long each)
2. Pulsed dipole corrector , to act on only 10 bunches at once (200 ns flat top, 4 m long each, with two some 1.5-2 kV pulsers) (maybe the second one to form a slow bump)
3. Septum – might or might NOT be required

How such extraction works



Discussion:

1. the scheme does not require sextupoles or other nonlinear elements – it's a single turn extraction
2. Seemingly needs much less aperture
3. In volume reflection regime, single crystal provides some 90 urad kick (5 mm) – septum might still be required
4. Multi-strip crystal can kick by 8x that =40 mm – **no septum** needed whatsoever
5. Efficiency of VR extraction is (est 98%), remaining 2% will be scattered, some of that will be recaptured by the crystal on the next turns
6. Requires pulsed dipole corrector that provides slowly varying orbit correction but only for the bunch or bunches of interest

Discussion:

- There ways to control the VR deflection angle – by bending radius for 1 strip or by selecting number of strips (16 max?)
- Angular acceptance of the VR regime is enormous – some 100-200 urad, so no tight alignment is needed
- Tevatron experience shows that the crystals are very rad hard – are they hard to the level of 10kWs of 8 GeV protons being reflected by them?
- Beam Dynamics simulations should show whether there are any issues with the scheme (theoretically, I can see none so far).