# Deuterons beam parameters measurements of the Nuclotron using SSNTD

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# Participants:

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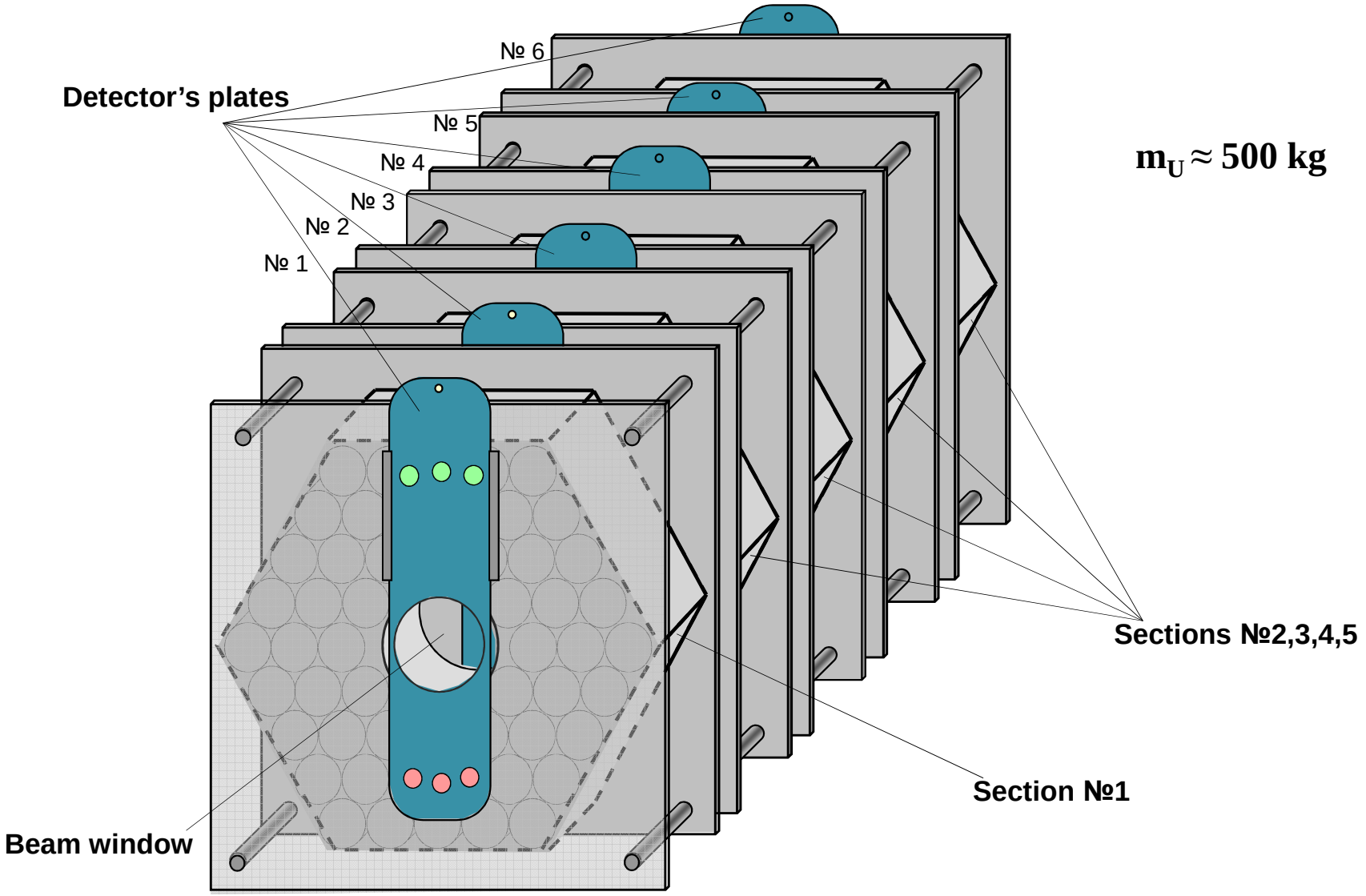
3. Joint Institute for Nuclear Research, Dubna, Russian Federation
4. CPTP “Atomenergomash”, Moscow, Russian Federation

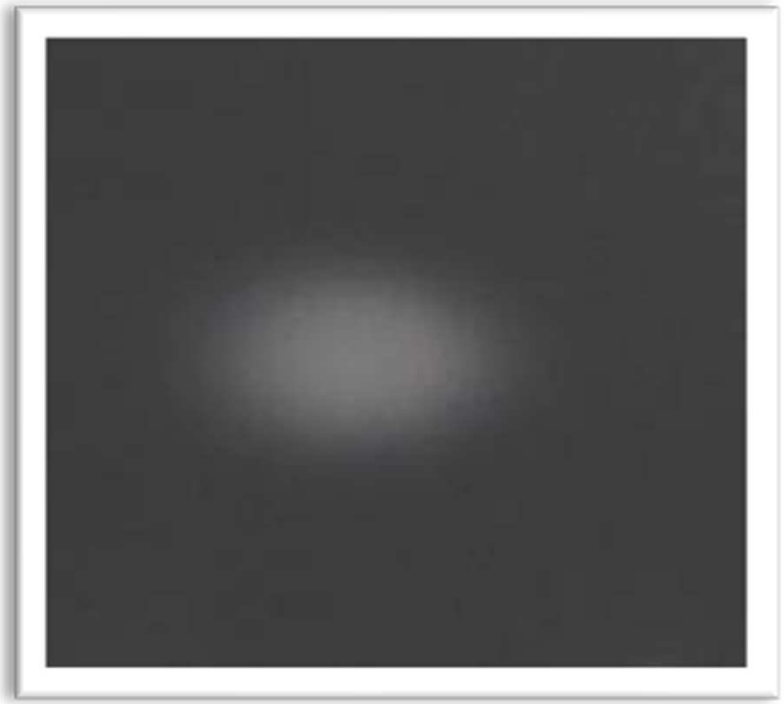
# Experiments objectives

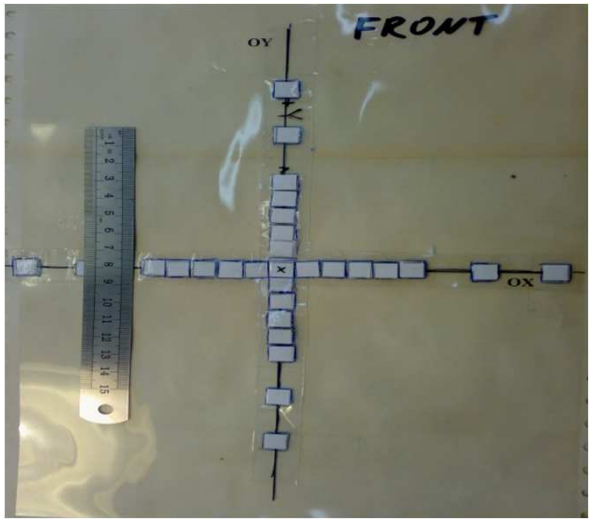
- Check the setup alignment along the beam axis.
- Precise determination of the beam position on the target.
- Beam parameters determination: beam size (FWHD), beam shape.
- Deuteron beam flux measurement.

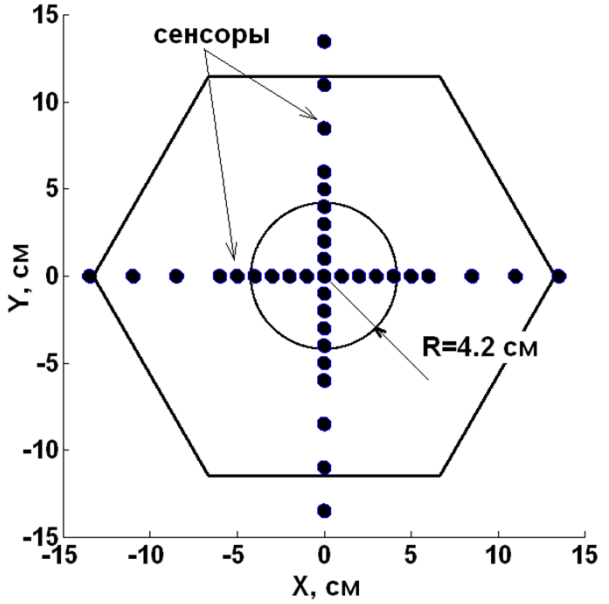
# Experimental assembly “QUINTA”



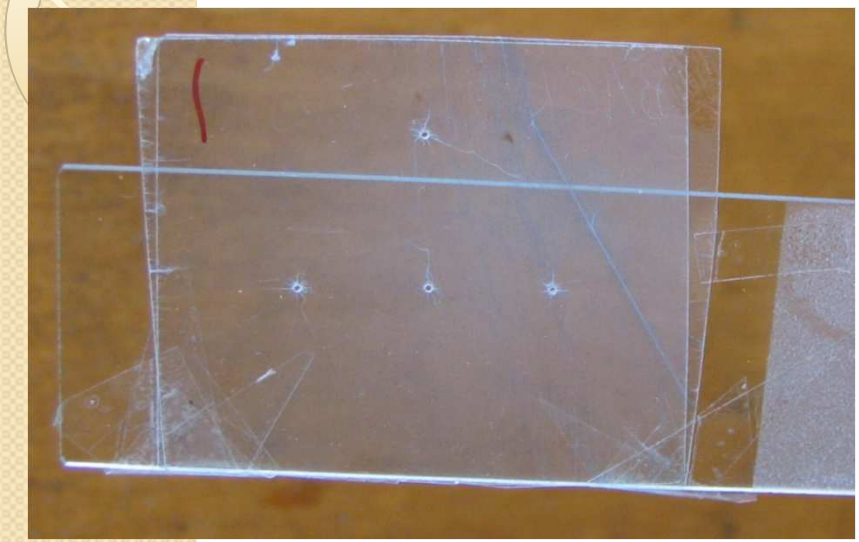
# Scheme of sensor’s disposition

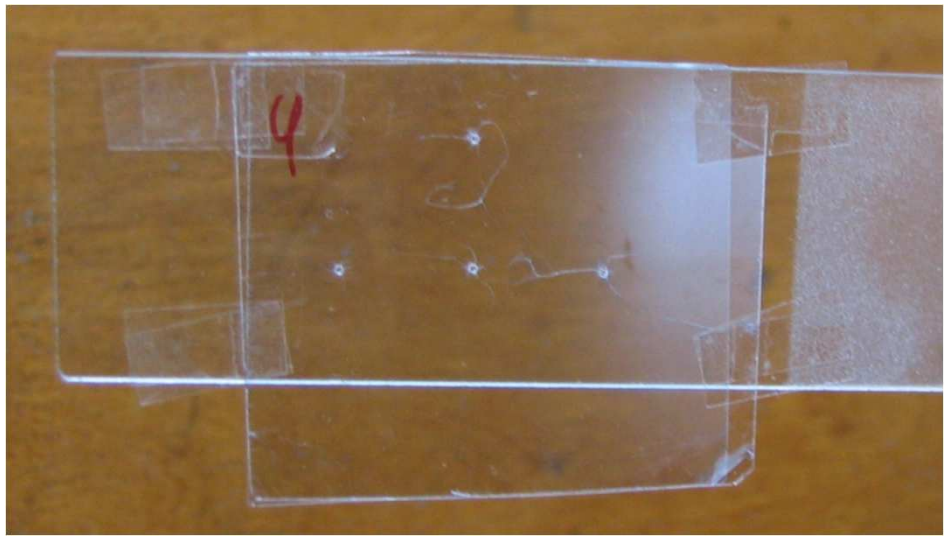


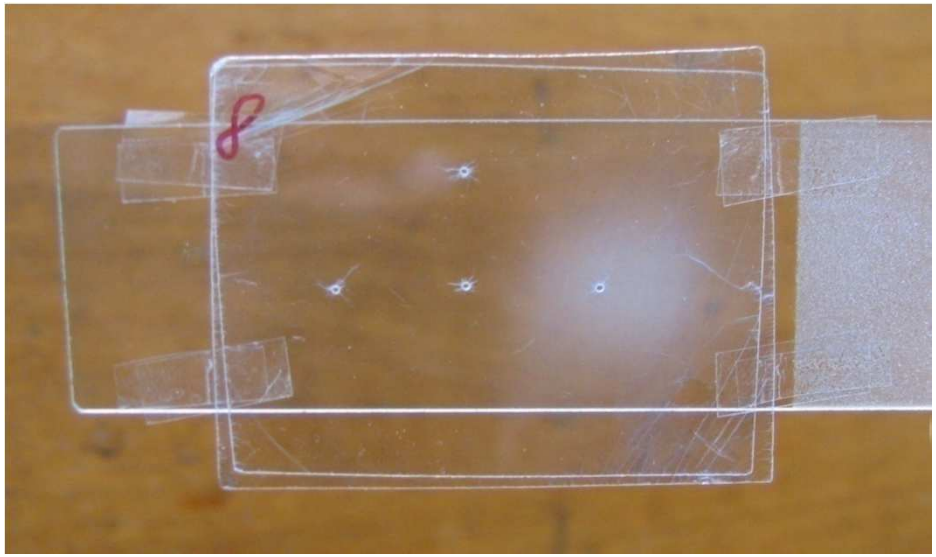


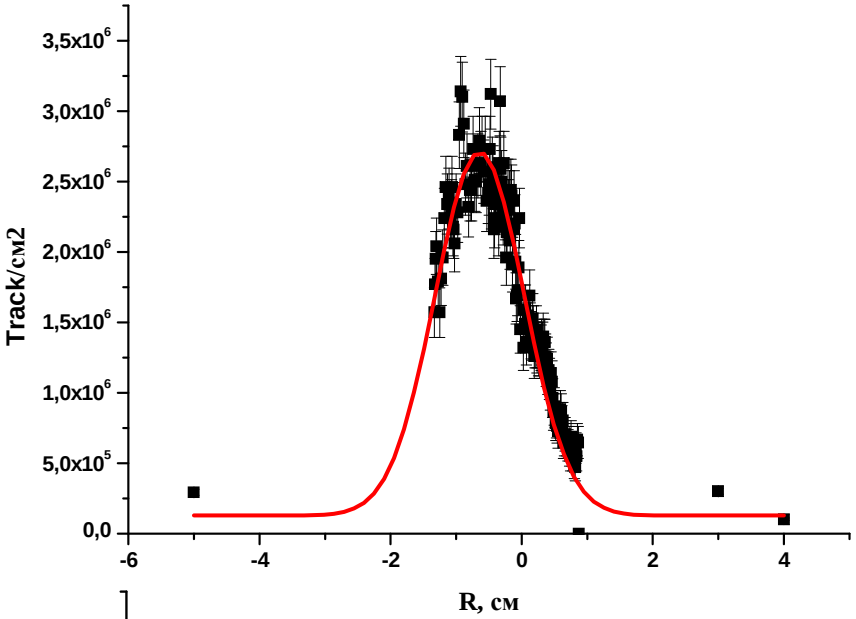
# Track detectors after etching. March 2012.



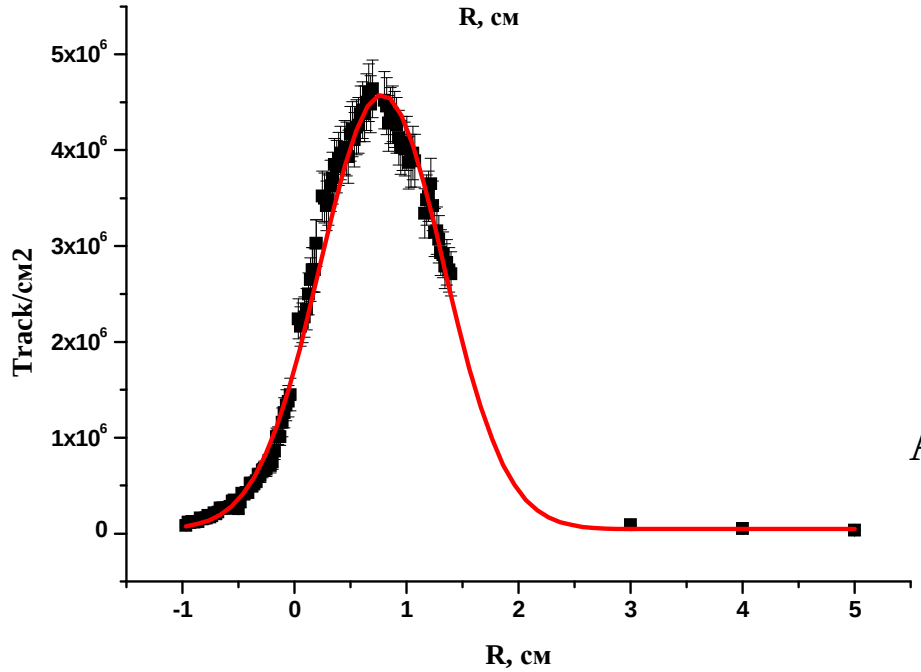



# Track density, track/cm$^2$




Beam shape

Axis X




Axis Y

# Deuterons beam parameters. December 2011.

| Deuteron's energy, GeV | Beam centre coordinates, [cm] | | FWHM of distributions, [cm] | |
|---|---|---|---|---|
| | Xc | Yc | $FWHM_X$ | $FWHM_Y$ |
| 1 | 1.3±0.2 | 0.2±0.1 | 2.6±0.3 | 3.5±0.3 |
| 4 | 1.4±0.0 | 0.2±0.0 | 1.5±0.0 | 1.4±0.0 |
| 8 | -0.5±0.0 | 0.0±0.0 | 0.6±0.1 | 1.2±0.1 |

# Deuterons beam parameters. March 2012.

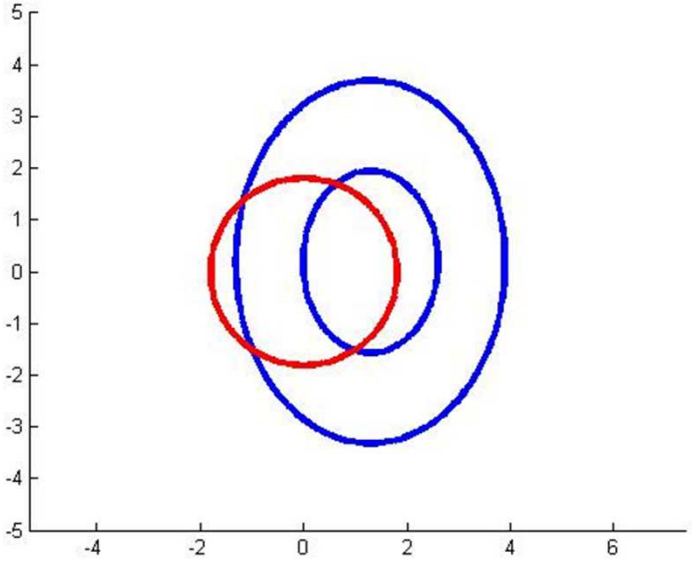
| Deuteron's energy, GeV | Beam centre coordinates, [cm] | | FWHM of distributions, [cm] | |
|---|---|---|---|---|
| | Xc | Yc | $FWHM_X$ | $FWHM_Y$ |
| 1 | 0.6±0.0 | 0.9±0.0 | 2.9±0.1 | 3.2±0.1 |
| 4 | 2.0±0.0 | 0.8±0.0 | 1.1±0.1 | 1.2±0.1 |
| 8 | 1.2±0.0 | 0.1±0.0 | 0.9±0.1 | 1.2±0.0 |

# Beam position on target. E= 1 GeV

December 2011

$I_{tot}=1.47\cdot 10^{13}$

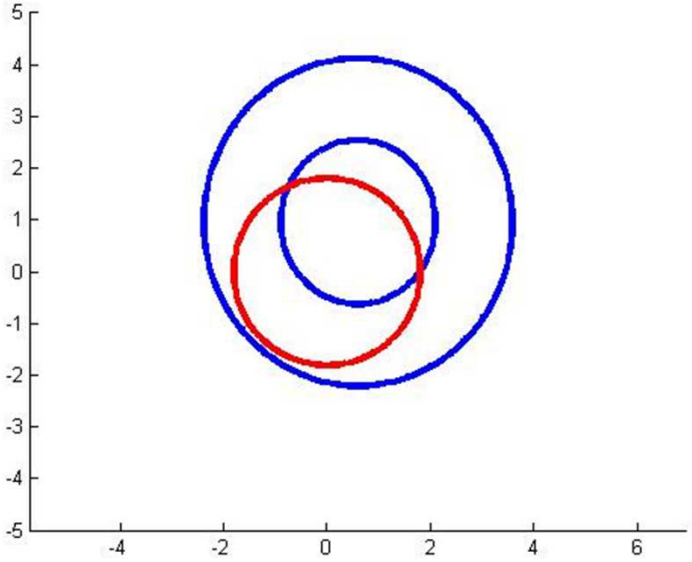
(Xc,Yc)=(1.3,0.2)




March 2012

$I_{tot}=1.9\cdot 10^{13}$

(Xc,Yc)=(0.6,0.9)

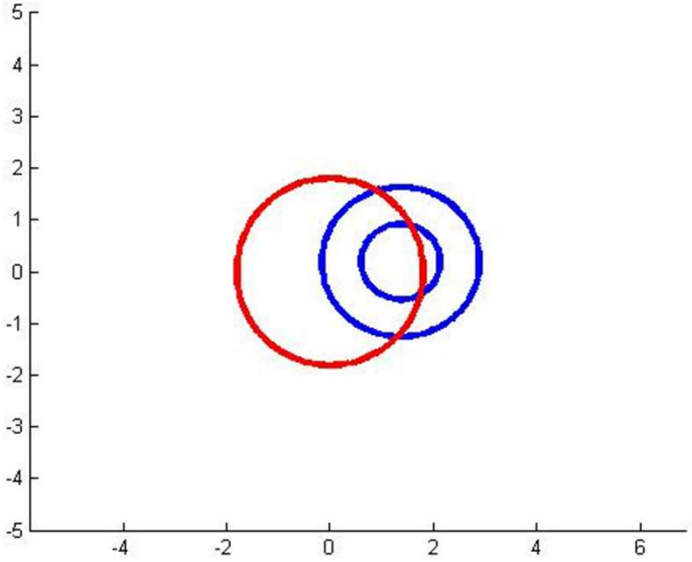


# Beam position on target. E= 4 GeV

December 2011

$I_{tot}=1.96\cdot 10^{13}$

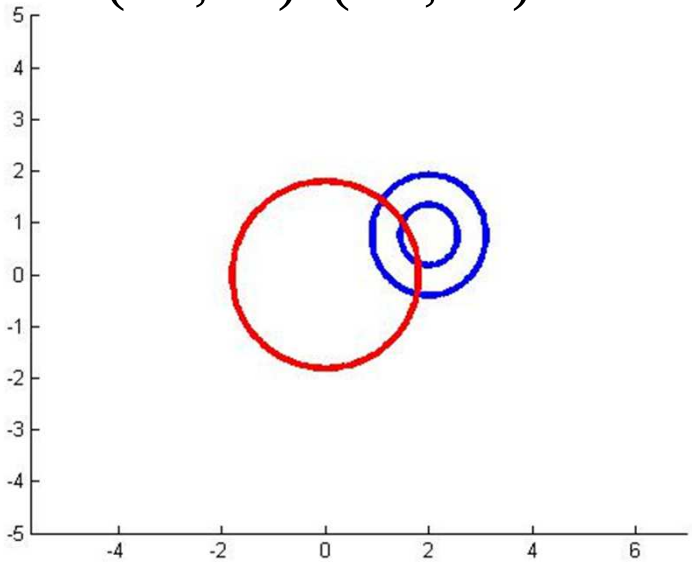
(Xc,Yc)=(1.4,0.1)




March 2012

$I_{tot}=2.7\cdot 10^{13}$

(Xc,Yc)=(2.0,0.8)

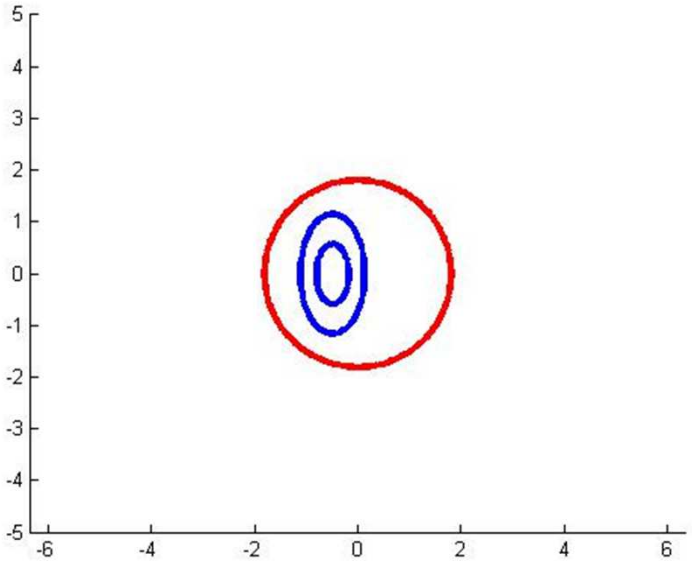


# Beam position on target. E= 8 GeV

December 2011

$I_{tot}=6.3\cdot 10^{10}$

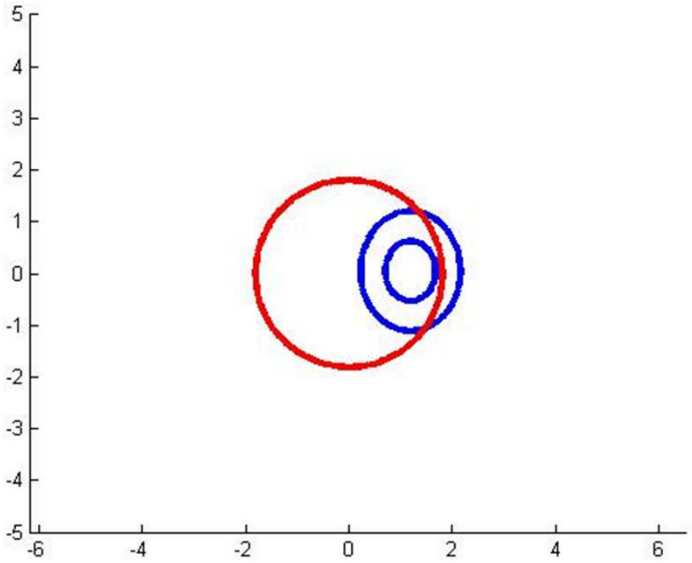
(Xc,Yc)=(-0.5,0.0)




March 2012

$I_{tot}=3.7\cdot 10^{12}$

(Xc,Yc)=(1.2,0.1)



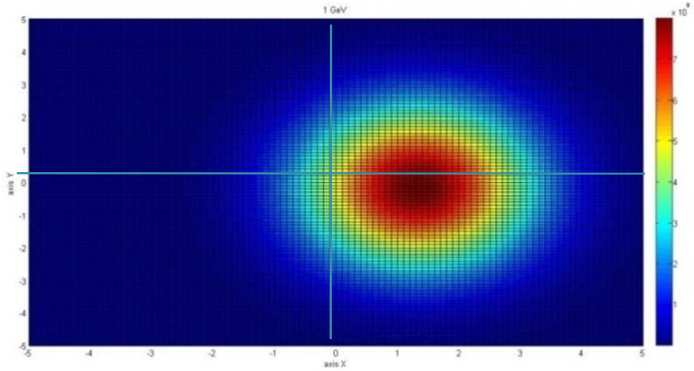
# Track density distribution approximated by Gaussian function (2D- and 3D-projection). E= 1 GeV

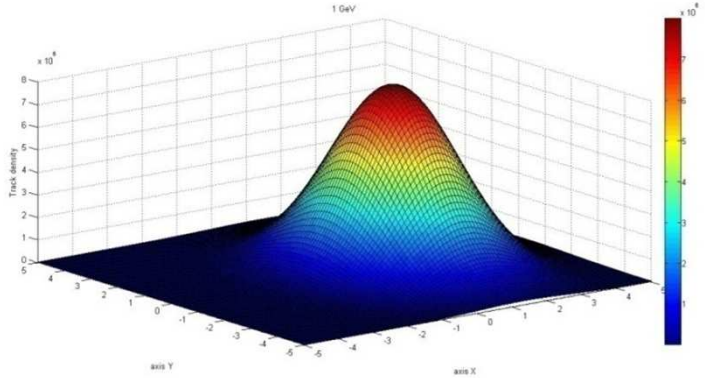
December 2011

$I_{tot}=1.47\cdot 10^{13}$

(Xc,Yc)=(1.3,0.2)

(FWHMx,FWHMy)=(2.6,3.5)



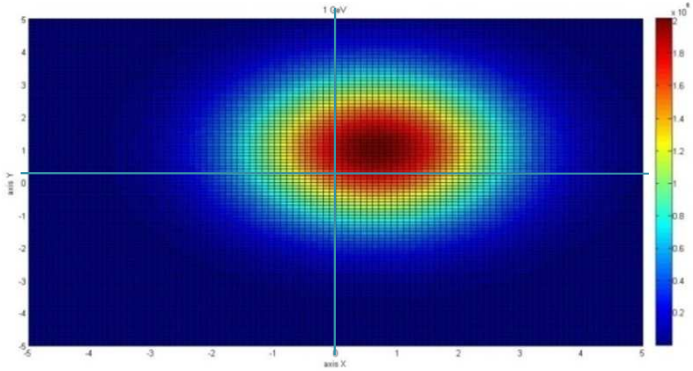



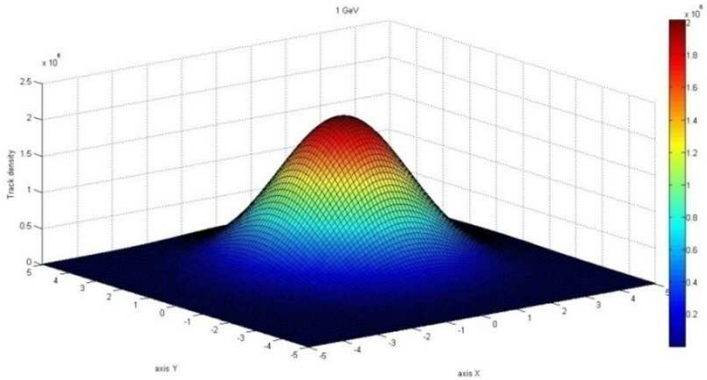

March 2012

$I_{tot}=1.9\cdot 10^{13}$

(Xc,Yc)=(0.6,0.9)

(FWHMx,FWHMy)=(2.9,3.2)



# Track density distribution approximated by Gaussian function (2D and 3D-projection). E= 4 GeV

December 2011

$I_{tot}=1.96\cdot 10^{13}$

(Xc,Yc)=(1.4,0.1)

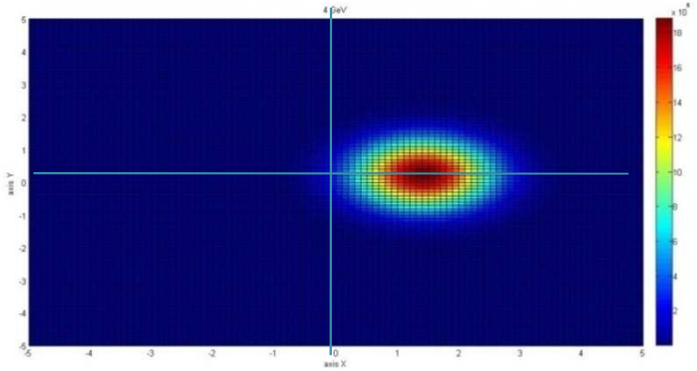
(FWHMx,FWHMy)=(1.5,1.4)

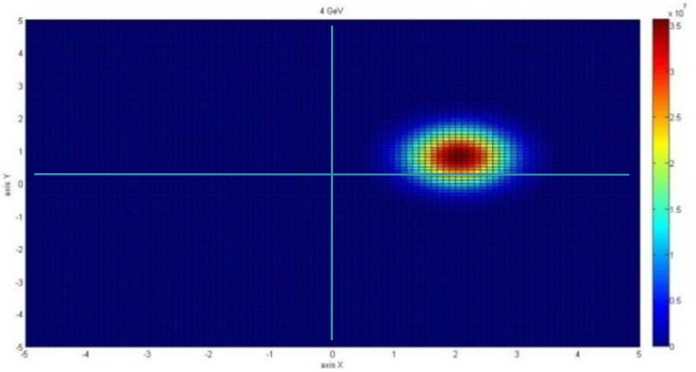
March 2012

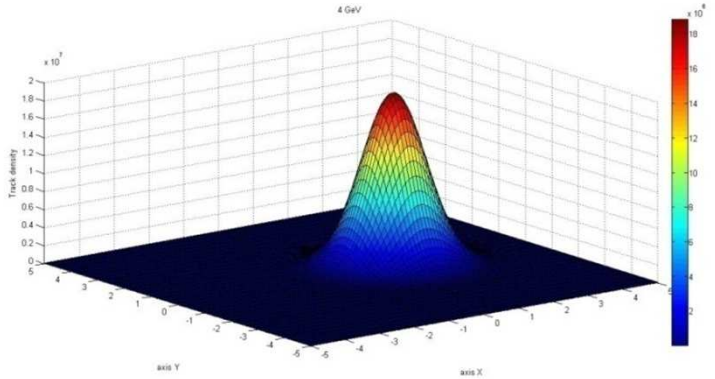
$I_{tot}=2.7\cdot 10^{13}$

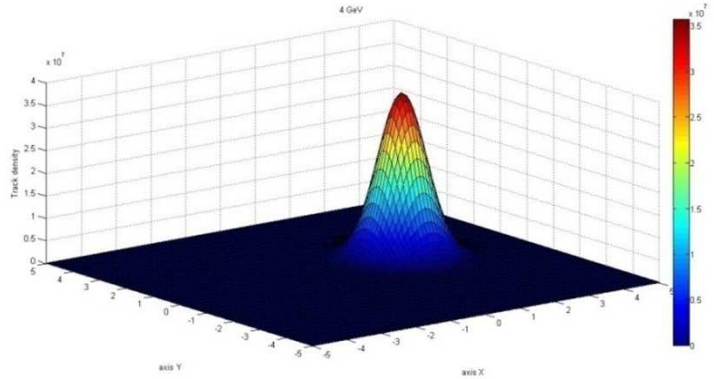
(Xc,Yc)=(2.0,0.8)

(FWHMx,FWHMy)=(1.1,1.2)









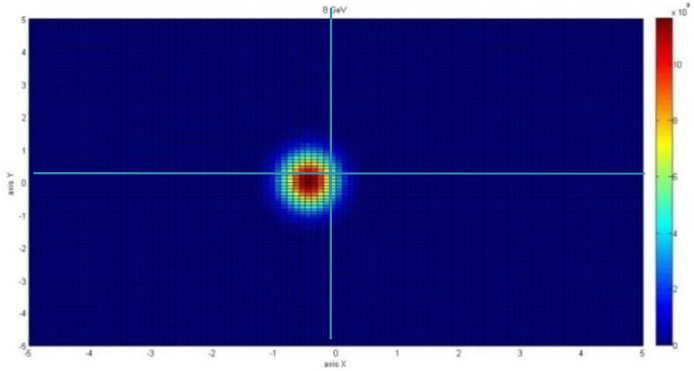
# Track density distribution approximated by Gaussian function (2D- and 3D-projection). E= 8 GeV

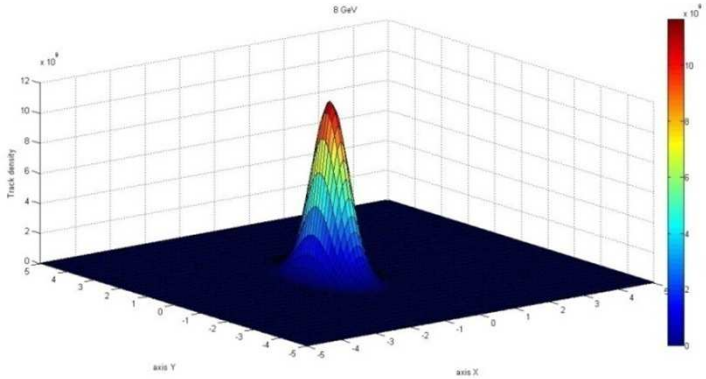
December 2011

$I_{tot}=6.3\cdot 10^{10}$

(Xc,Yc)=(-0.5,0.0)

(FWHMx,FWHMy)=(0.6,1.2)



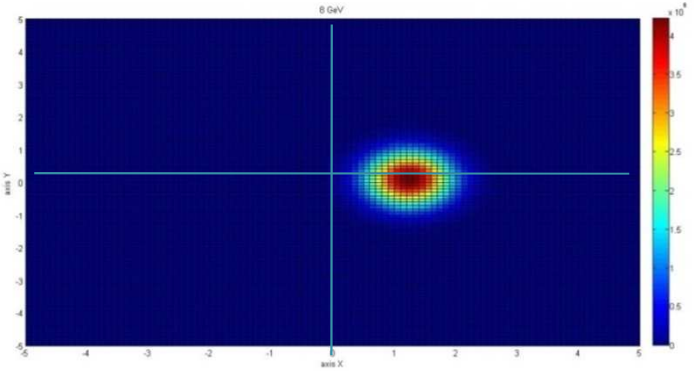


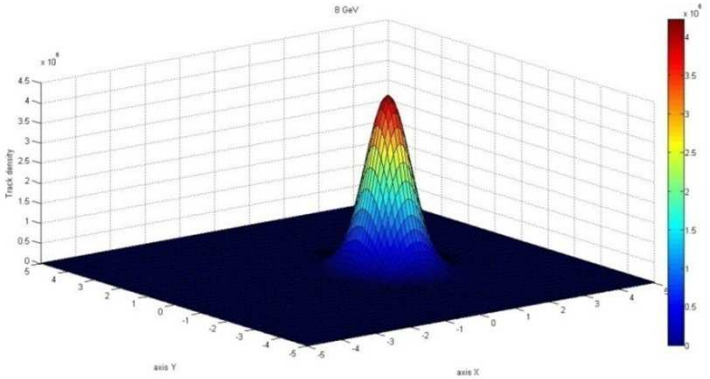
March 2012

$I_{tot}=3.7\cdot 10^{12}$

(Xc,Yc)=(1.2,0.1)

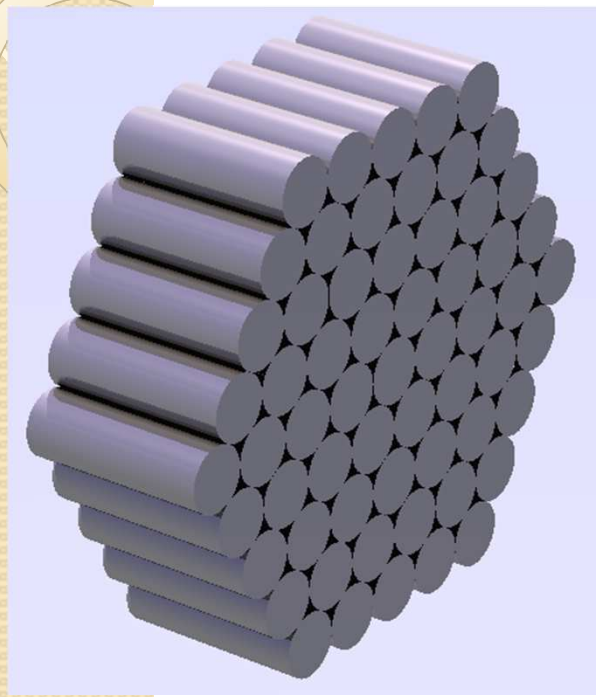
(FWHMx,FWHMy)=(0.9,1.2)



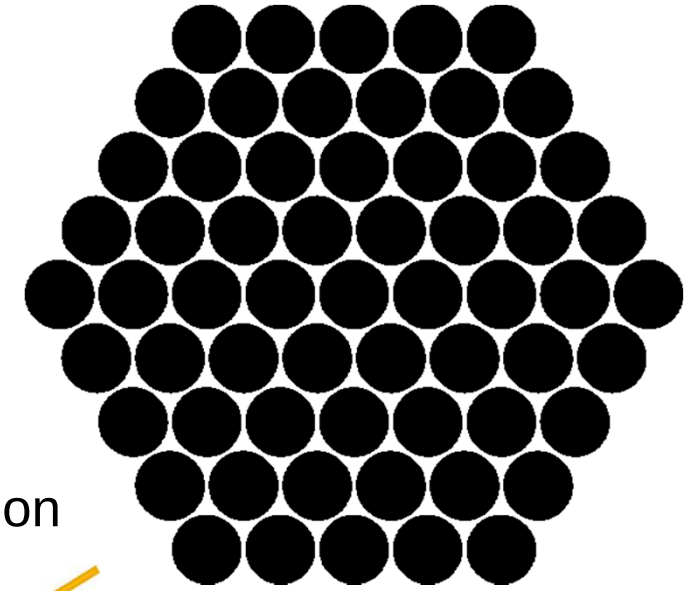


# Primary deuterons striking into the fissionable material

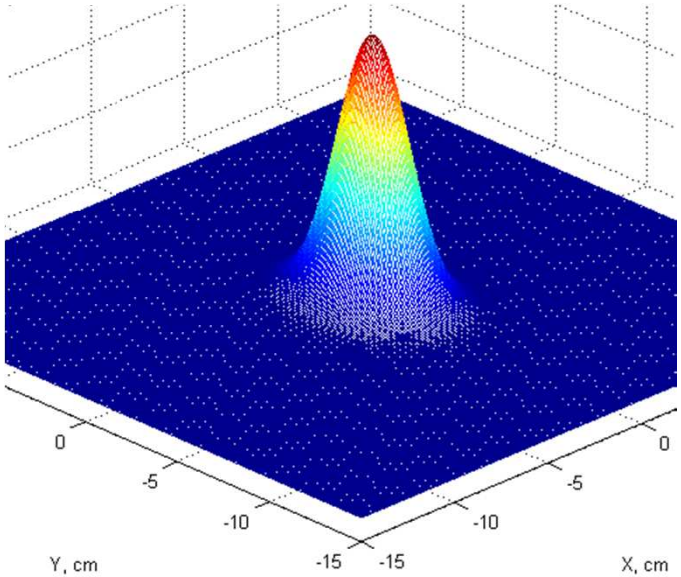
Uranium rods



Fissionable material (natural uranium) in th transverse plane XY



Beam 2D distribution




Integration of the Beam distribution by the area of fissionable materials gives the number of deuterons striking into the target

# Primary deuterons striking into the fissionable material

| Run in December 2011 | | Run in March 2012 | |
|---|---|---|---|
| D energy, GeV | Beam part striking the target, % | D energy, GeV | Beam part striking the target, % |
| 1,0 | 81,1 | 1,0 | 81,5 |
| 4,0 | 79,7 | 4,0 | 65,1 |
| 8,0 | 99,3 | 8,0 | 84,8 |

**The calculations were done only for the top plane of the 2 section.**
**The total effect can be calculated using Monte-Carlo method.**
**THE DATA SHOWS THE PROBLEM**
**OF CORRECT COMPARISION DIFFERENT SETS OF EXPERIMENTS !!!**

# Conclusions:

- The technique for precise determination of the beam position on the target was developed. Resolution of the method is 1 mm.
- Beam position on the target was determined for the experiments of the years 2011-2012, where Quinta setup has been irradiated by deuteron beams with the energies of 1, 4 and 8 GeV.
- Beam parameters (beam shape and beam size) were determined for the mentioned experiments. It is shown that the increase of beam energy leads to smaller beam size.
- It is shown that more precise primary alignment of the target along the beam axis is needed. Or, if it is not possible, the central part of the setup (uranium rods, d=3,6 cm) should be replaced by a lead target with bigger diameter, in order to avoid beam losses in the gaps between the rods.

***Thank you for your attention!***