

Results of first TASCA commissioning

experiments

1. Study of ion-optical parameters
of High Transmission and Small Image modes

2. Comparison experimental data with Monte-Carlo
simulations

Experiment 1 (27 April 2006):

^{30}Si (5.45 MeV / u) + ^{181}Ta (400 μg / cm^2) \rightarrow $^{205-206}\text{Fr}$

Experiment 2 (16 - 17 May 2006):

^{54}Cr (4.18 MeV / u) + $^{\text{nat}}\text{Gd}$ (500 μg / cm^2) \rightarrow $^{208-211}\text{Ra}$

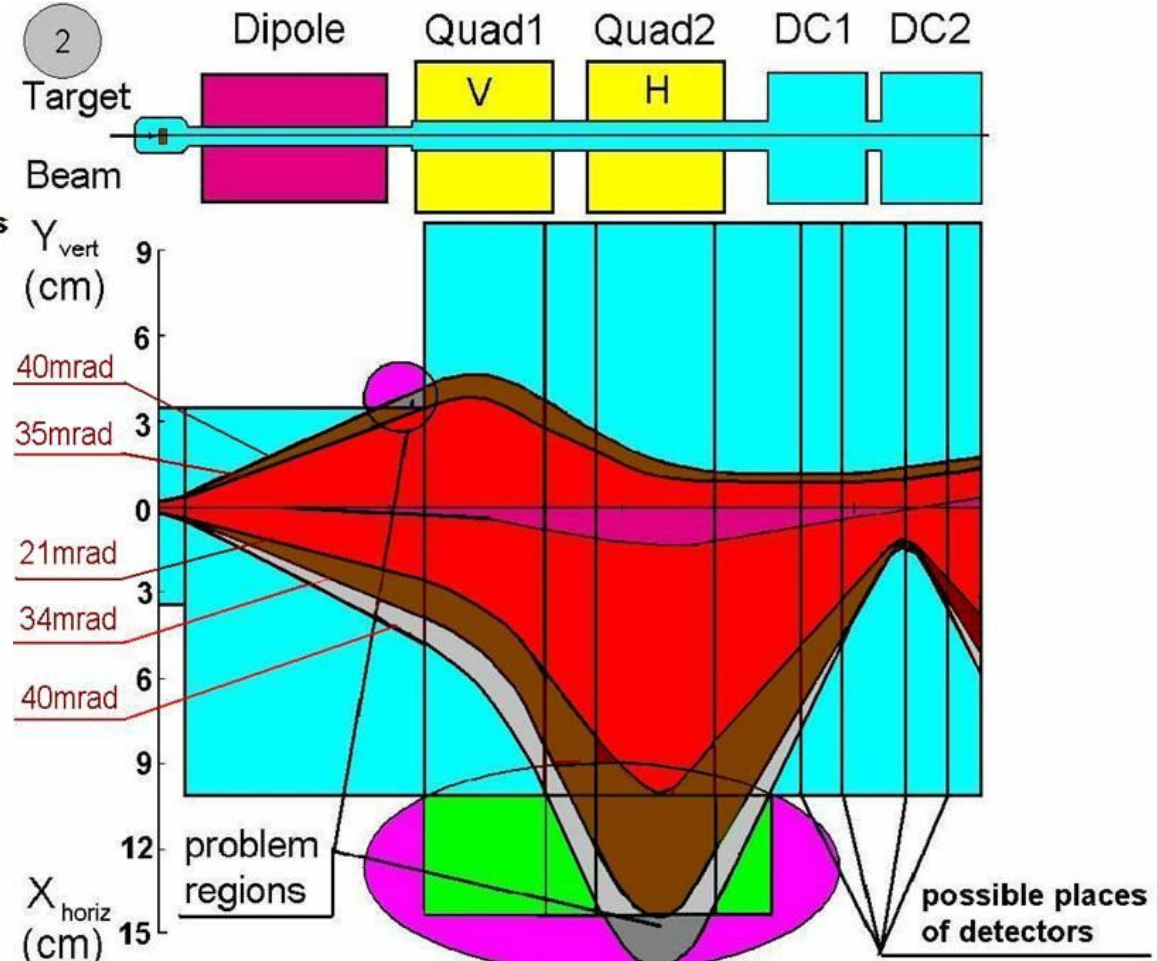
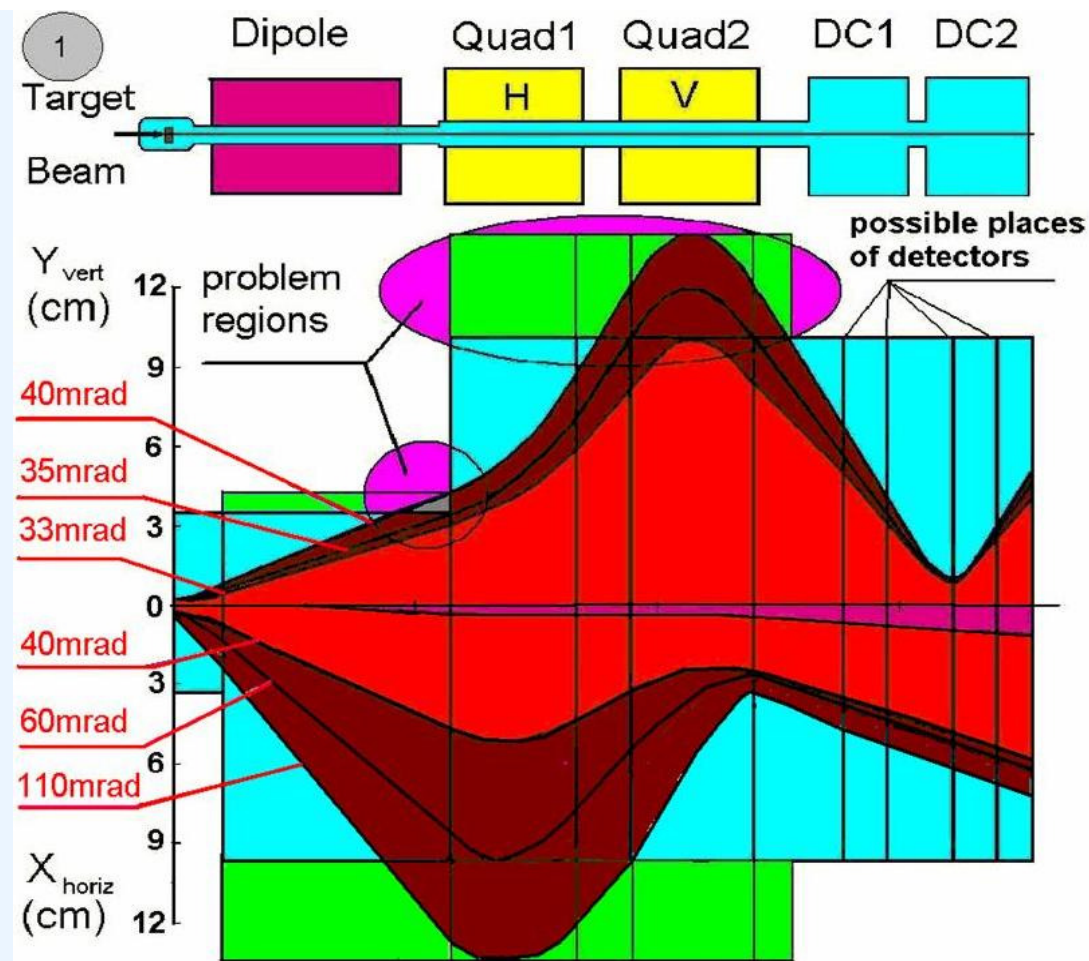
TRANSPORT ion - optical calculations

$DQ_h Q_v$ ← configurations → $DQ_v Q_h$

INPUT PARAMETERS:

Beam size: \varnothing 5 mm

Dispersion: $D_p = \pm 5\%$



MONTE - CARLO

simulations

DQ_hQ_v

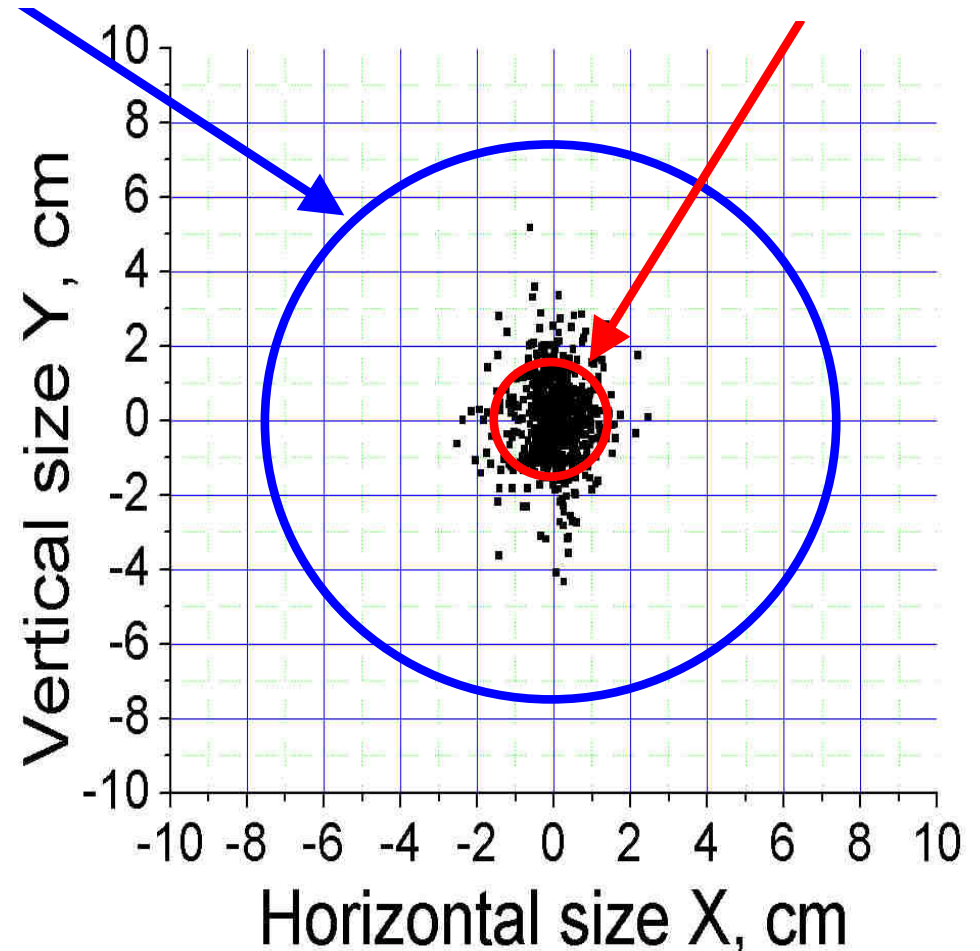
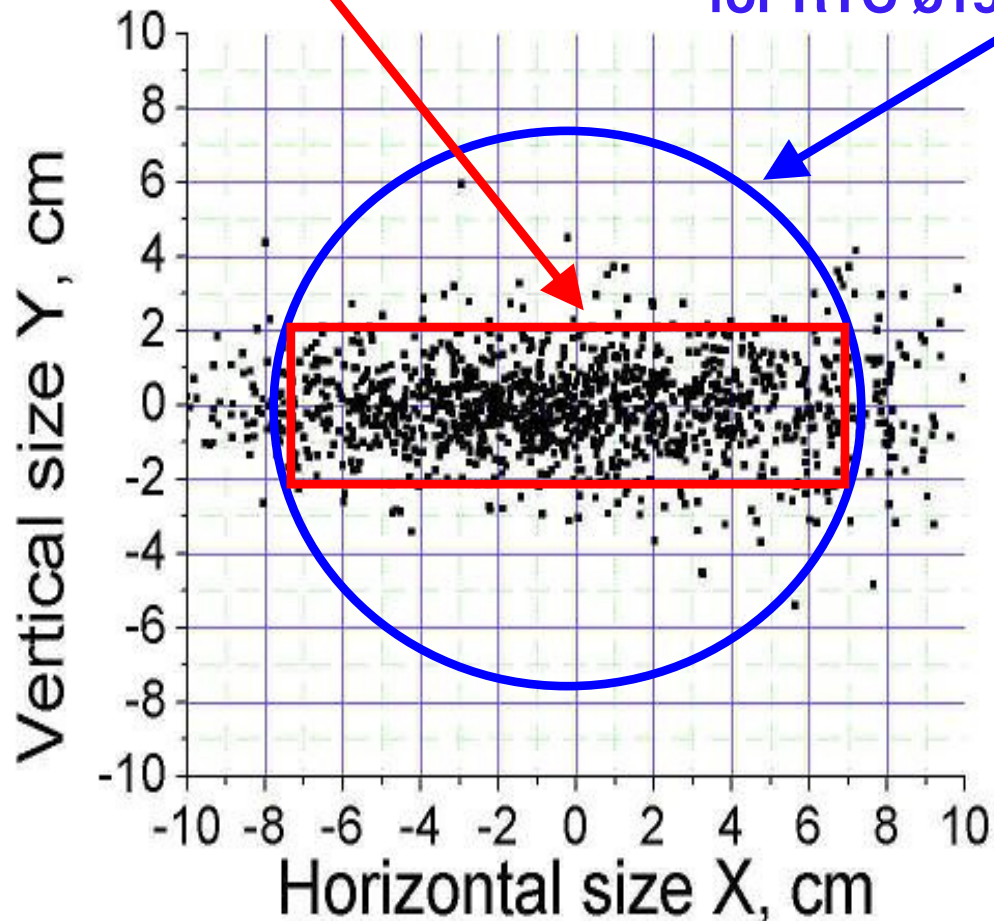


DQ_vQ_h

Large Recoil Transfer Chamber, RTC window size: $14 * 4 = 56 \text{ cm}^2$

Detector chamber exit flange for RTC $\varnothing 15 \text{ cm}$

Small Recoil Transfer Chamber, RTC window size $\varnothing 3 \text{ cm} \Rightarrow 7 \text{ cm}^2$



Results of calculations and simulations:

DQ_hQ_v



DQ_vQ_h

TRANS-
PORT:

MONTE-
CARLO:

Angular
Acceptances:

TRANS-
PORT:

MONTE-
CARLO:

± 110 mrad ≈ 80 mrad ←
± 40 mrad ≈ 46 mrad ←

Horizontal
Vertical

→ ≈ 34 mrad ≈ 34 mrad
→ ≈ 40 mrad ≈ 42 mrad

≈ 14 msr ≈ 12 msr ←

Solid angle

→ ≈ 4.3 msr ≈ 4.5 msr

≈ 65 % ≈ 59 % ←

Transmission

→ ≈ 40 % ≈ 35 %

≈ 14 cm ≈ 16 cm ←

Horiz. image size

→ ≈ 3 cm ≈ 4 cm

≈ 2.5 cm ≈ 3 cm ←

Vert. image size

→ ≈ 3 cm ≈ 4 cm

≈ 35 cm² ≈ 48 cm² ←

Image area

→ ≈ 7 cm² ≈ 12 cm²

Results from *test experiments* (distribution in the FPD)

DQ_hQ_v

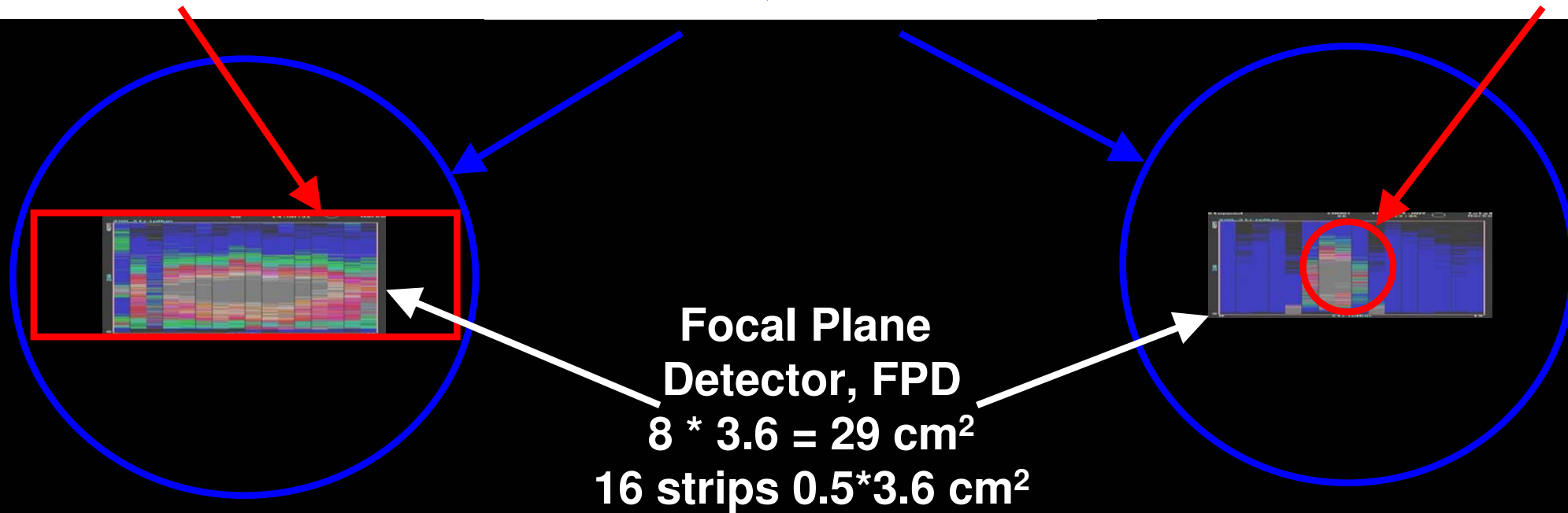
DQ_vQ_h



Large Recoil Transfer Chamber, RTC window size: $14 * 4 = 56 \text{ cm}^2$

Detector chamber exit flange for RTC $\varnothing 15 \text{ cm}$

Small Recoil Transfer Chamber, RTC window size $\varnothing 3 \text{ cm} \Rightarrow 7 \text{ cm}^2$

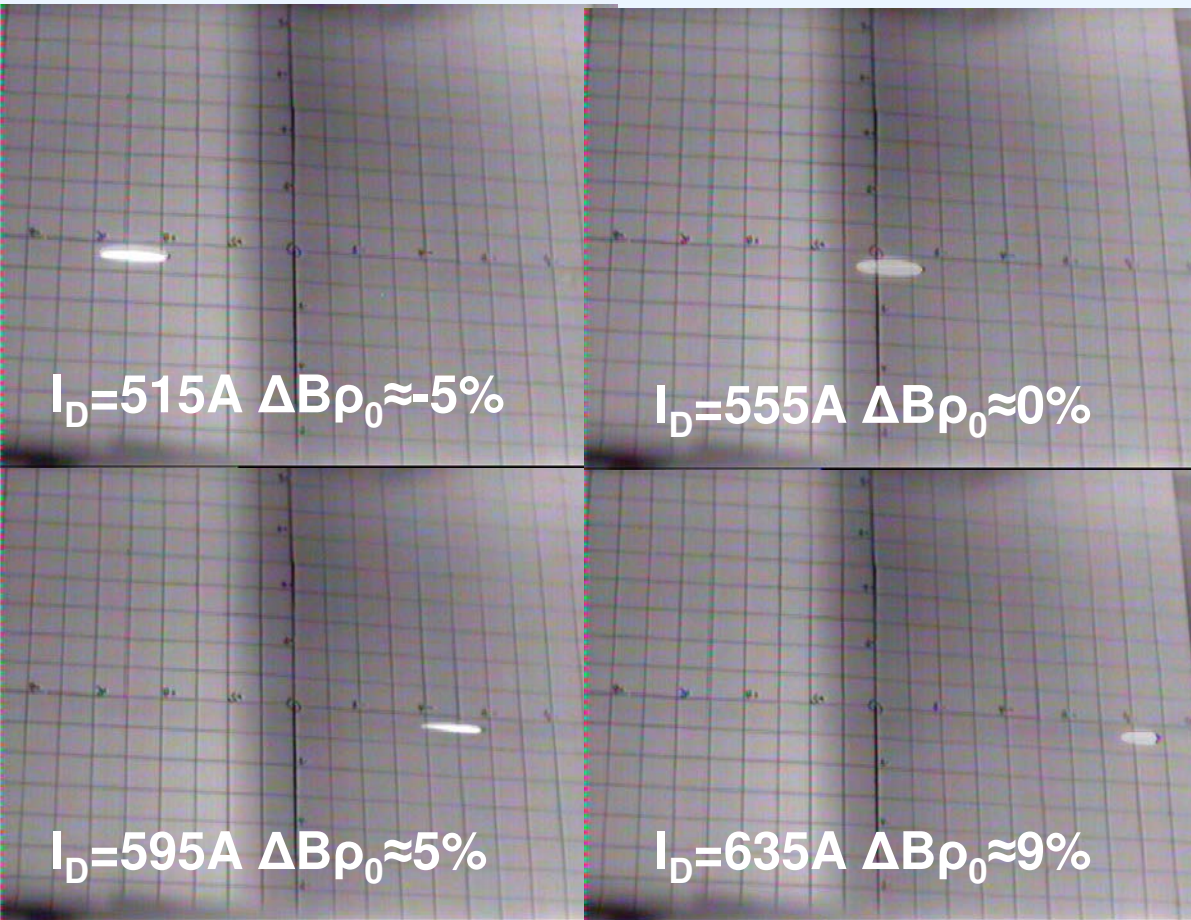


Parameters of the first test in Vacuum mode
 ^{30}Si beam through TASCA

Parameter	Test with beam
Particle	^{30}Si
Energy	7.7 MeV/u
Total kinetic energy (TKE)	230.8 MeV
Charge state from accelerator	6 +
Magnetic Rigidity	2 Tm
Size in the target position	∅ 6 mm
Maximum possible angular spread	< 3 mrad
Beam current	~ 16 nA _{part}

Beam image on Luminescent screen (FPD position)

Large Transmission mode - DQ_HQ_V



Charge state +6
($B\rho_0 = 2.0 \text{ Tm}$).

TRANSPORT
calculated
beam size:
 $16*2 \text{ mm}^2$

$^{30}\text{Si} (+6)$ beam ($B\rho_0 = 2.0 \text{ Tm}$)

$E = 230.8 \text{ MeV}$ **Vacuum mode**

Results:

Dispersion:

calculated $\approx 0.9 \text{ cm}/\%$
measured $\approx 1 \text{ cm}/\%$

Momentum acceptance: $\pm 9 \%$

Initial beam parameters:

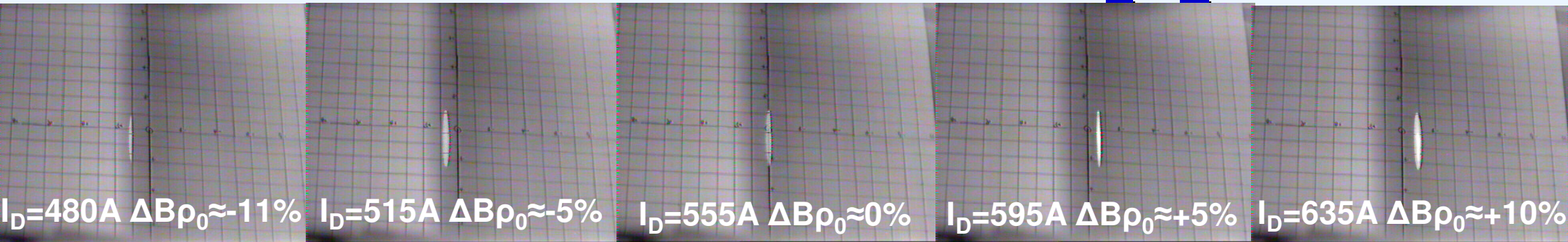
$\varnothing 6 \text{ mm}$
 $X' \& Y' < 3 \text{ mrad}$

Separator magnification (1st order TRANSPORT calculations):

Horizontal – 2.6
Vertical – 0.34

Beam image on Luminescent screen (FPD position)

Small Image mode - $DQ_V Q_H$



Charge state +6
($B\rho_0 = 2.0 \text{ Tm}$).

TRANSPORT
calculated
beam size:
 $1.7 \times 21 \text{ mm}^2$

Initial beam
parameters:

$\varnothing 6 \text{ mm}$
 $X' < 3 \text{ mrad}$
 $Y' < 3 \text{ mrad}$

Separator magnification
(1st order TRANSPORT
calculations):

Horizontal – 0.28
Vertical – 3.5

Results:

Dispersion:

calculated $\approx 0.1 \text{ cm}/\%$
measured $\approx 0.1 \text{ cm}/\%$

Momentum acceptance: $\pm 10 \%$

$^{30}\text{Si} (+6)$ beam ($B\rho_0 = 2.0 \text{ Tm}$)

$E = 230.8 \text{ MeV}$ *Vacuum mode*

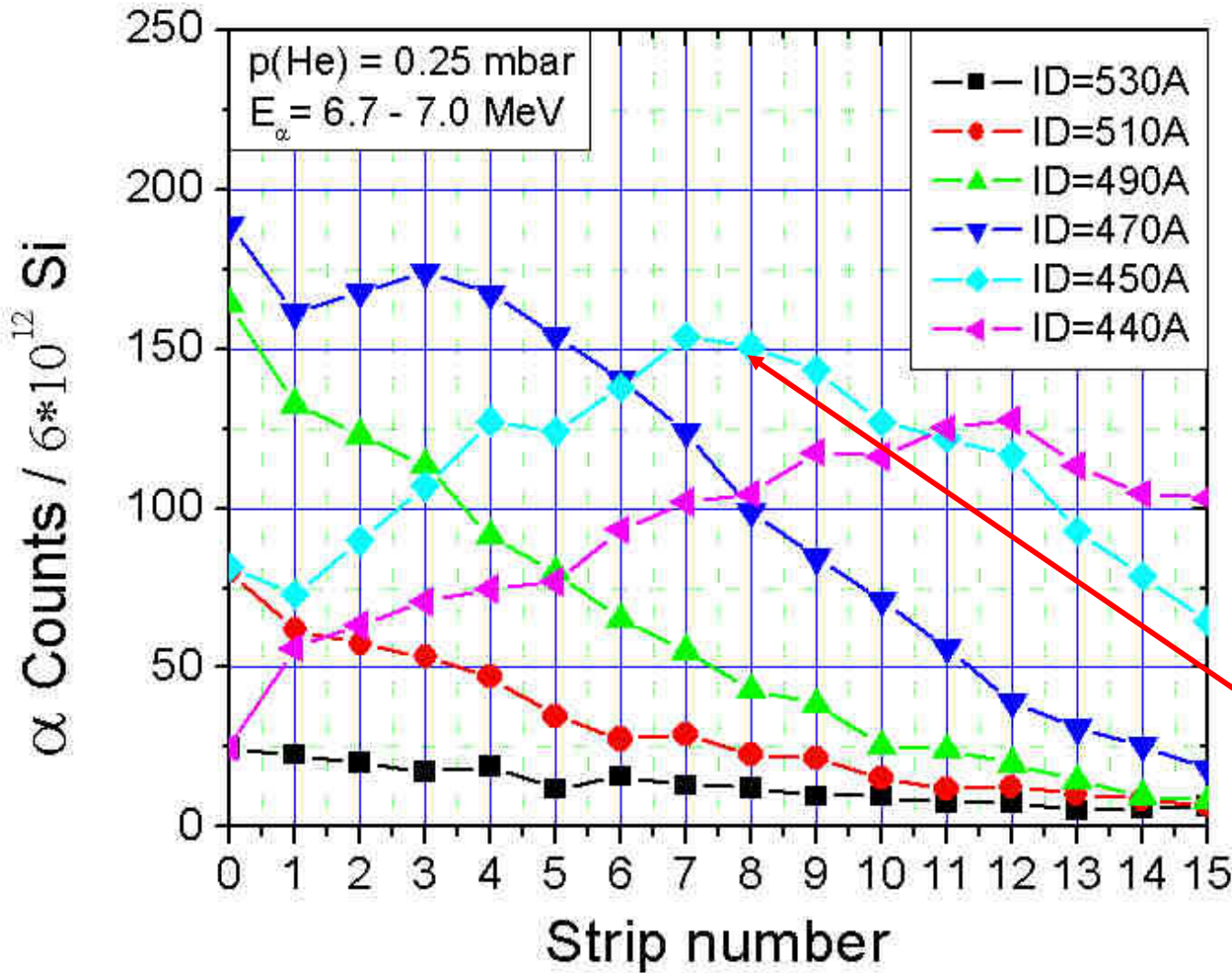
Test in *gas - filled mode with reaction products:*



Parameter	
Beam particle	^{30}Si
Energy	5.45 MeV/u
Total kinetic energy (TKE)	163.4 MeV
Charge state from accelerator	6 +
Magnetic rigidity	1.7 Tm
Size in the target position	∅ 6 mm
Maximum possible angular spread	< 3 mrad
Beam current	~ 16 nA _{part}
Thickness of the Carbon vacuum window foil	52 µg/cm ²
Target material (self-supported)	^{181}Ta (metallic)
Thickness	400 µg/cm ²

Dipole magnet current optimization

DQ_hQ_v



**α - counts
concentrated
in 12 strips**

**Horizontal image
size:
6 cm**

**Best case
 $I_{DM} = 450 \text{ A}$**

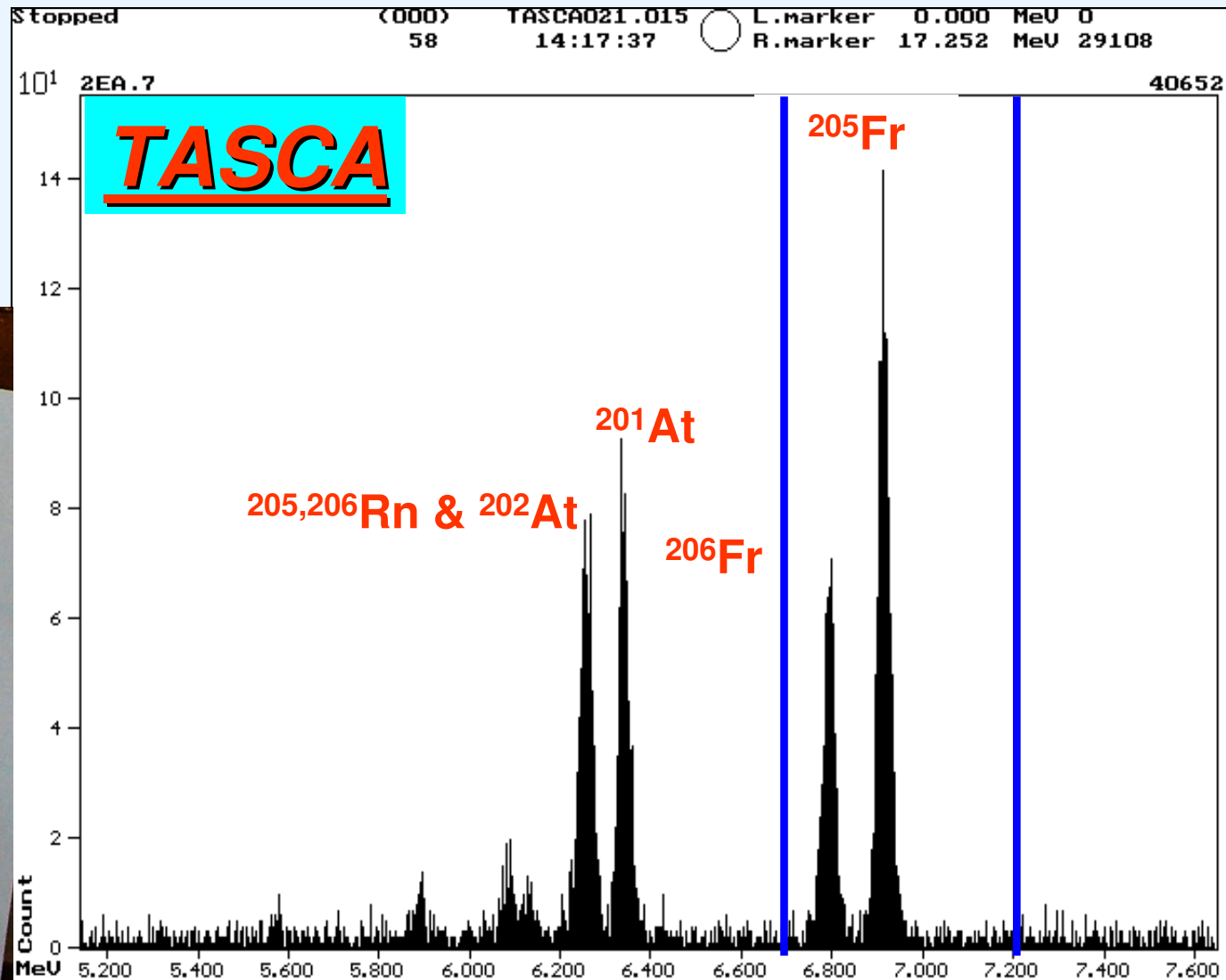
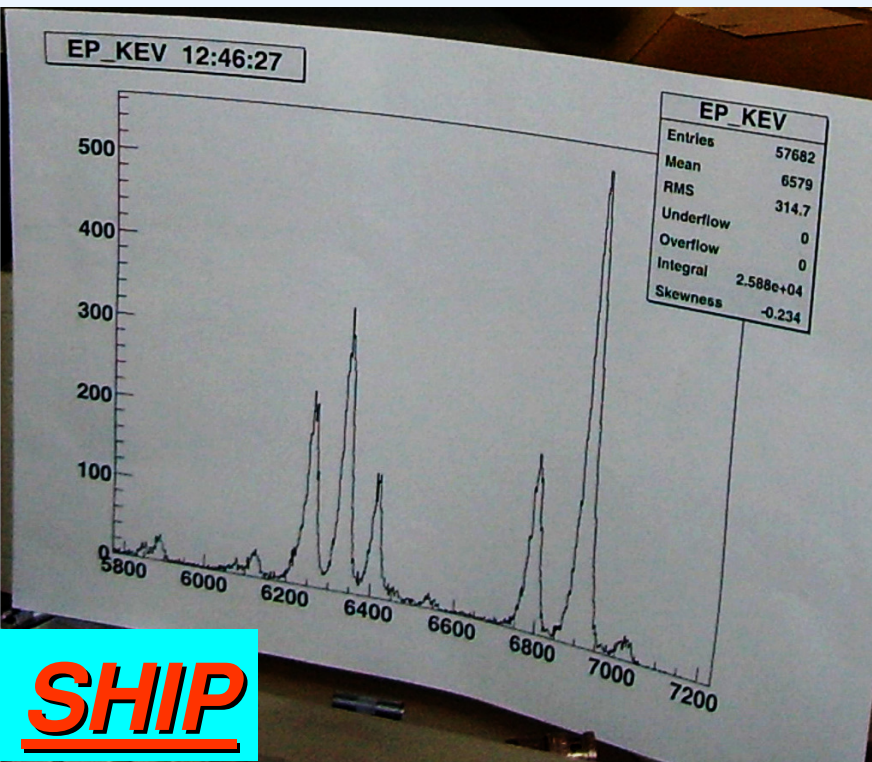
α - spectrum in the FPD:



Energy spectra limits
6.6 - 7.2 MeV

$I = 16 \text{ nA}_{\text{part}}$

$T = 600 \text{ s}$



Parameters of the second test Beam & Target

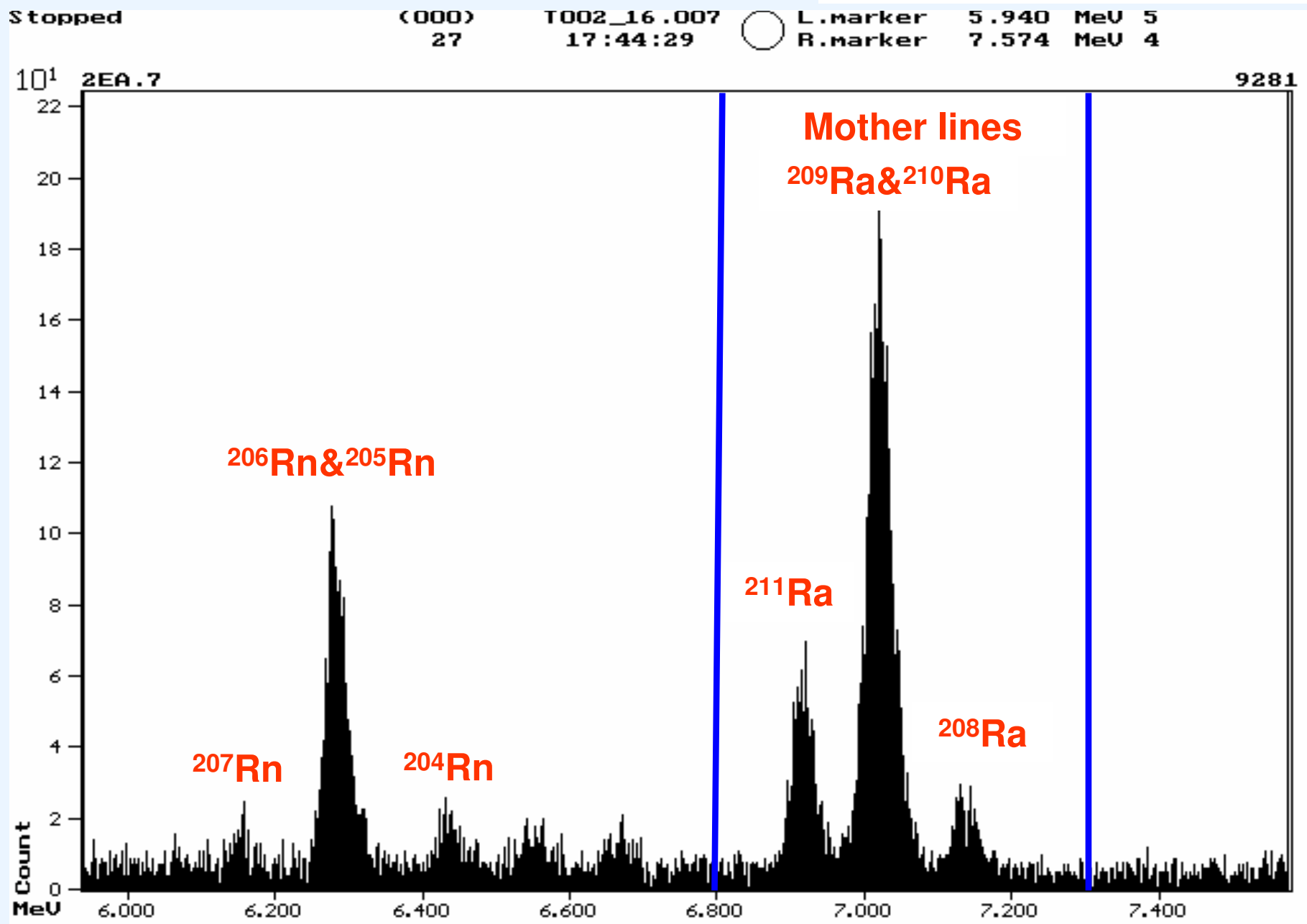
Parameters of the beam

<u>Beam</u> particle	<u>^{54}Cr</u>
Energy / TKE : - initial beam - at the centre of the target	5.08 MeV/u / 274 MeV 4.25 MeV/u / 229 MeV
Charge state from accelerator	7 +
Magnetic rigidity in vacuum	2.5 Tm
Size in the target position	∅ 6 mm
Maximum possible angular spread	< 3 mrad

Parameters of the target

<u>Target</u> material	<u>natGd_2O_3</u>
Thickness	500 $\mu\text{g} / \text{cm}^2$ (Gd)
Atomic number of most enriched isotopes	155, 156, 157, 158, 160

α - spectrum in the FPD: $^{54}\text{Cr} + \text{nat Gd} \rightarrow ^{208-211}\text{Ra}$



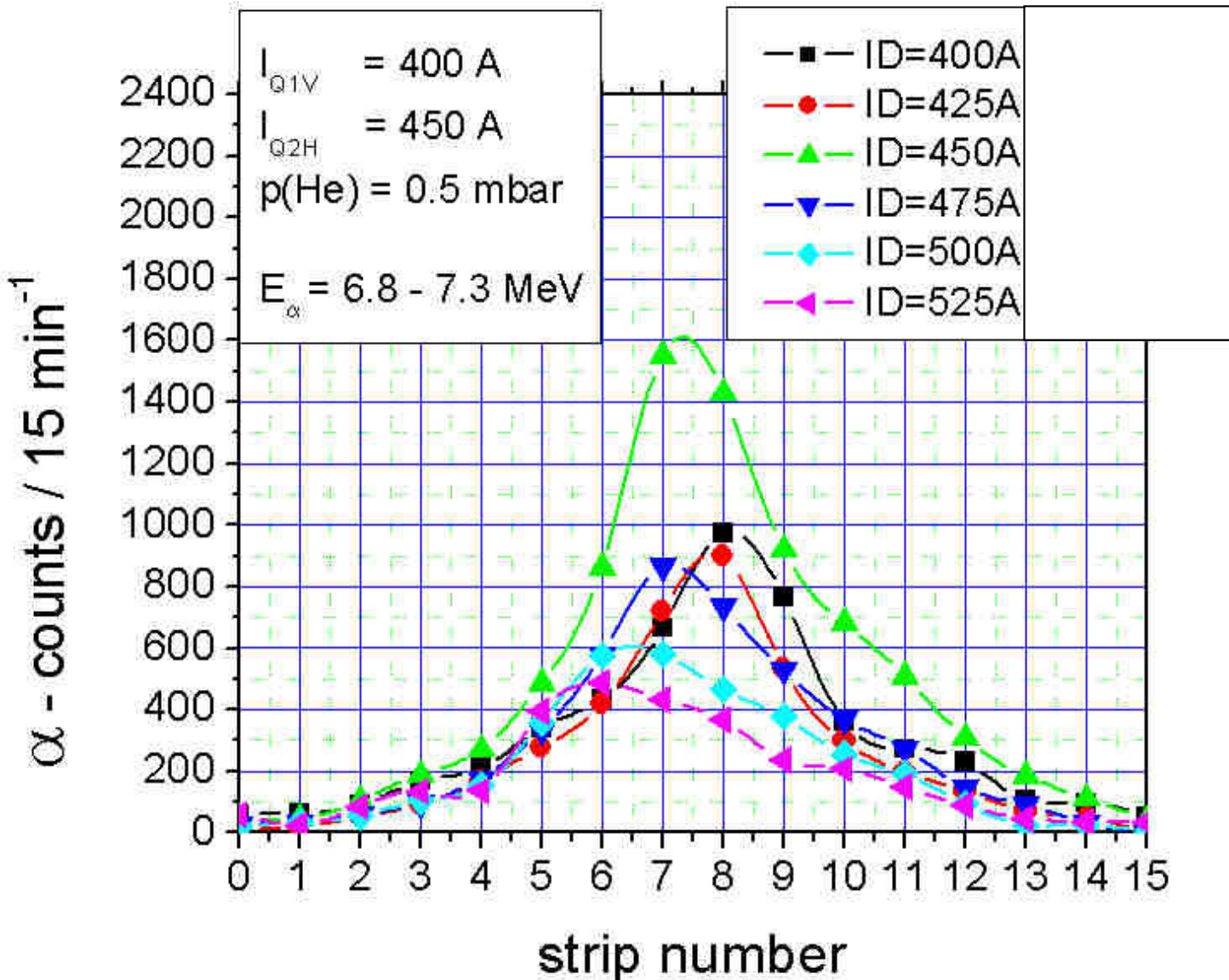
$I = 30 \text{ nA}_{\text{part}}$

$T = 900 \text{ s}$

Energy spectra limits
6.8 - 7.3 MeV

Dipole magnet current optimization

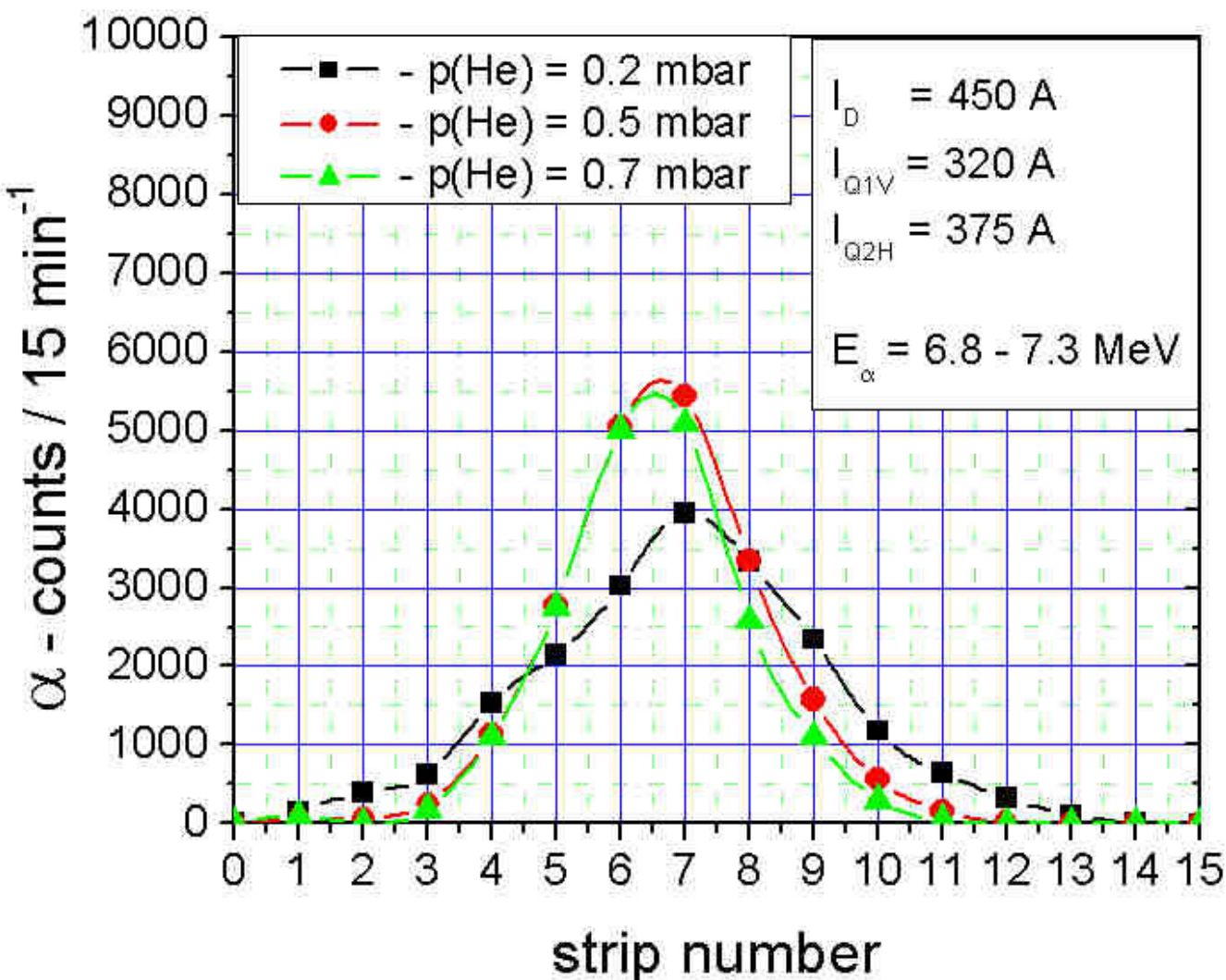
$^{54}\text{Cr} + \text{nat Gd} \rightarrow ^{208-211}\text{Ra}$



α - counts
concentrated
in 4 - 6 strips

Horizontal
image size:
2 - 3 cm

Pressure modification in **TASCA**



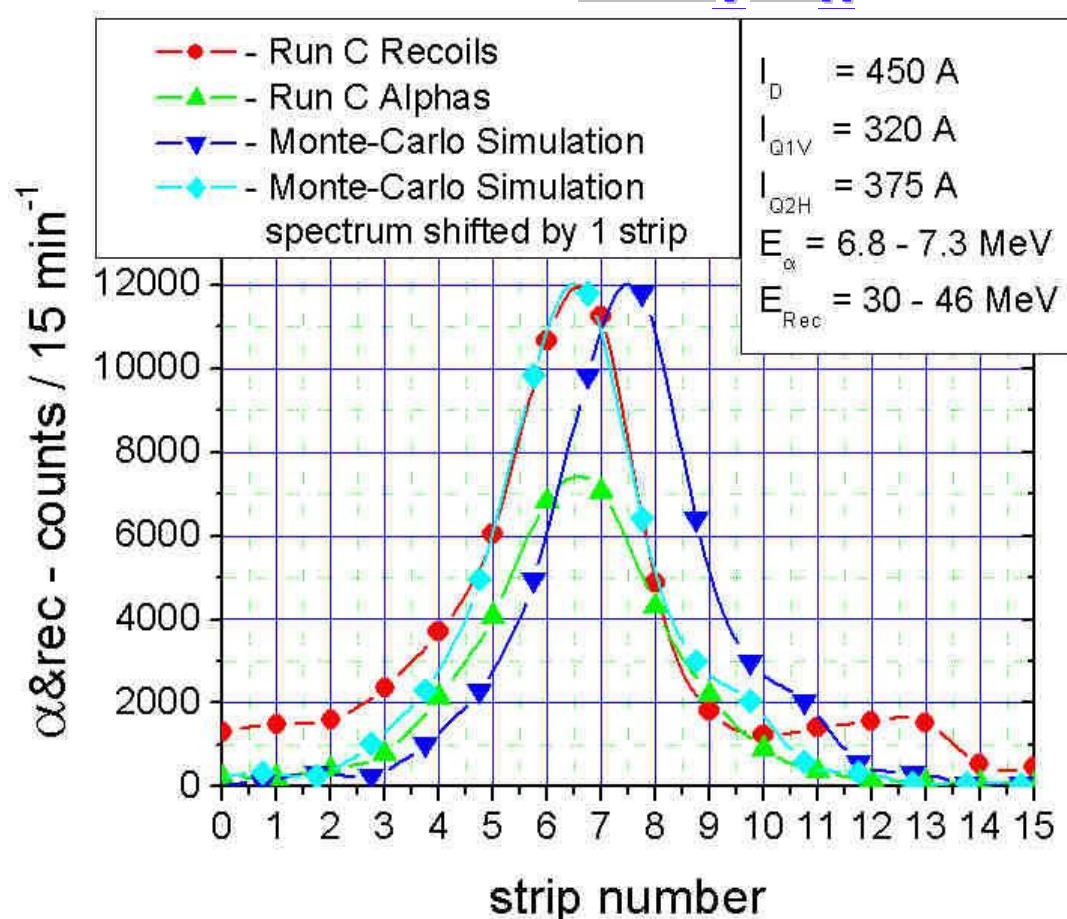
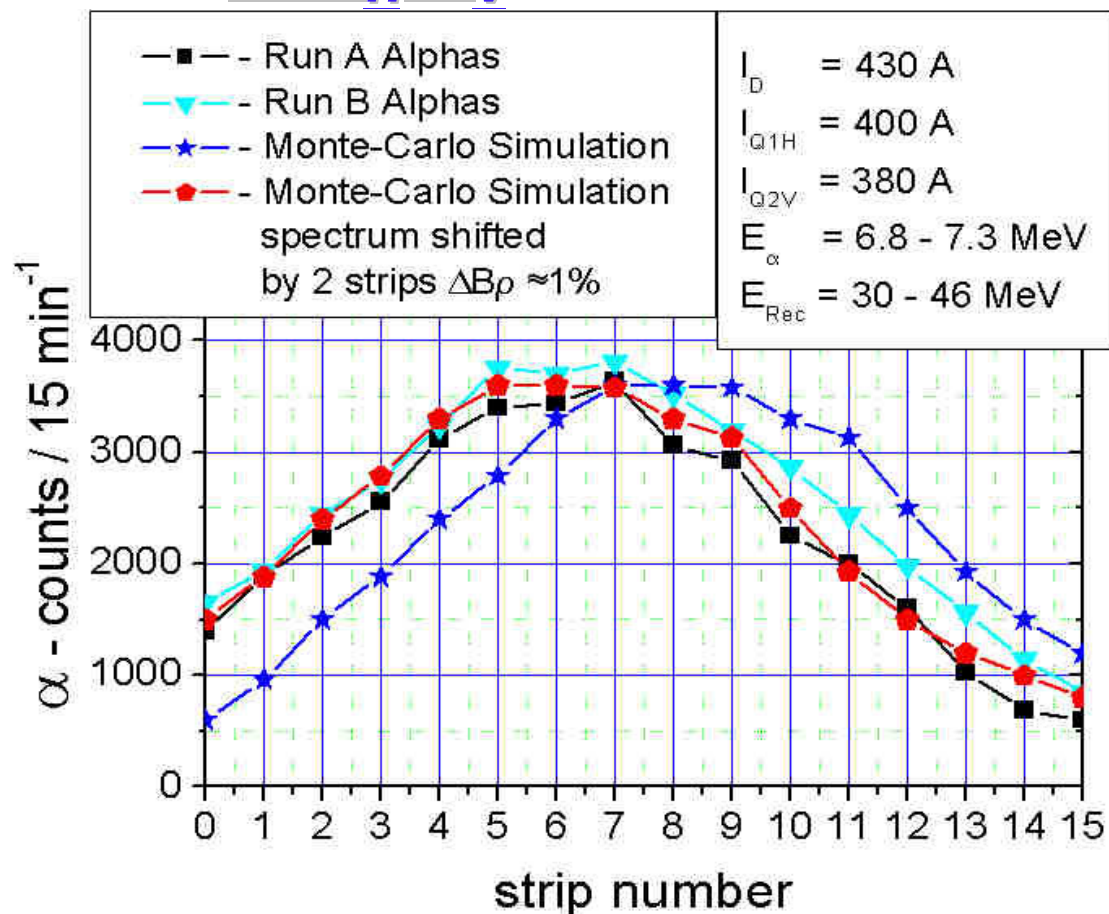
Best cases:
P(He) =
0.5 & 0.7 mbar.

Results from test experiments compared with MONTE-CARLO simulations

DQ_hQ_v

$^{54}\text{Cr} + \text{natGd} \rightarrow ^{208-211}\text{Ra}$

DQ_vQ_h



CONCLUSIONS:

DQQ – configuration is the optimized **TASCA** configuration:

→ *most efficient and most versatile*

High Transmission ($DQ_h Q_v$) and Small Image ($DQ_v Q_h$) mode:

→ *successfully tested*

Distribution of experimentally observed products in the **Focal Plane Detector** compared with ion-optical calculations and **Monte - Carlo** simulations:

→ *very good agreement*

High Transmission mode for "slow" SHE chemistry:

→ $14 \times 4 \text{ cm}^2$ RTC window will have *very high transmission*

Small Image mode for "fast" SHE chemistry:

→ $\varnothing 3 \text{ cm}$ RTC window will have *high transmission*

Next TASCA commissioning experiments using intense ^{40}Ar beams

Reactions (November 2006):

1. $^{40}\text{Ar} + ^{238}\text{U} \rightarrow$ - background and target test using FPD
2. $^{40}\text{Ar} + ^{208}\text{Pb} \rightarrow ^{248}\text{Fm}^* \rightarrow ^{245}\text{Fm} + 3n$
- high rigidity ($B\rho \approx 2.06 \text{ T}\cdot\text{m}$) test using FPD + RTC
3. $^{40}\text{Ar} + ^{144}\text{Sm} \rightarrow ^{184}\text{Hg}^* \rightarrow ^{180}\text{Hg} + 4n$ - FPD + RTC test
4. $^{40}\text{Ar} + ^{154}\text{Sm} \rightarrow ^{194}\text{Hg}^* \rightarrow ^{190}\text{Hg} + 4n$ - RTC test
5. $^{40}\text{Ar} + ^{160}\text{Gd} \rightarrow ^{200}\text{Pb}^* \rightarrow ^{196}\text{Pb} + 4n$ - RTC test

Next TASCA experiments with ^{40}Ar beam

Simulated parameters of reactions:

Targ.	Thick. $\mu\text{g}/\text{cm}^2$	Com. Nuc.	Exit ch.	Prod. Isot.	Calc. Bp/Tm	Simulated Transm. %		Detector	
						H	S	FPD	RTC
^{208}Pb	420	$^{248}\text{Fm}^*$	3n	^{245}Fm	2.06	48	29	H/S	H/S
^{144}Sm	470	$^{184}\text{Hg}^*$	4n	^{180}Hg	1.57	59	37	S	S
^{154}Sm	470	$^{194}\text{Hg}^*$	4n	^{190}Hg	1.66	50	31		(H/S)
^{160}Gd	470	$^{196}\text{Pb}^*$	4n	^{190}Hg	1.65	55	35		H

In the table denotes: **H** - High Transmission and **S** - Small Image mode

Cave X8: Beam Line + TASCA (DQQ)

**UNILAC
Beam**

Target

**Dipole Magnet,
30°**

Quadrupoles

Q₁

Q₂

**Focal Plane
Detector –
FPD**

1m