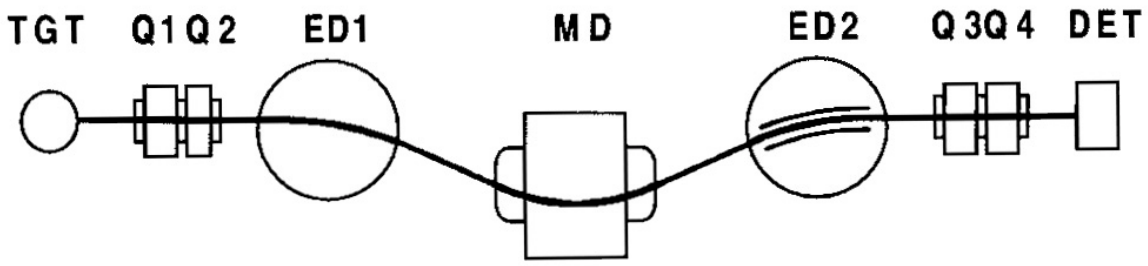
Design Study for a Recoil Separator for Superheavy Element Chemistry*

CHEMSEP Workshop, Darmstadt, Germany March 21, 2002

- Properties of energy-dispersionless recoil mass spectrometers
- Application to superheavy element research
- Preliminary transmission results
- Conclusions

* Supported by the U.S. Dept. of Energy

Fragment Mass Analyzer (FMA)



- **Solid Angle Acceptance** **5 msr**
- **Energy Acceptance** **± 20%**
- **M/q Acceptance** **± 4%**
- **M/q Dispersion** **0 → 20 mm/%**
- **Rotation Angular Range** **-5° → +45°**
- **Length** **8.2 m**

Operating Principle of the FMA

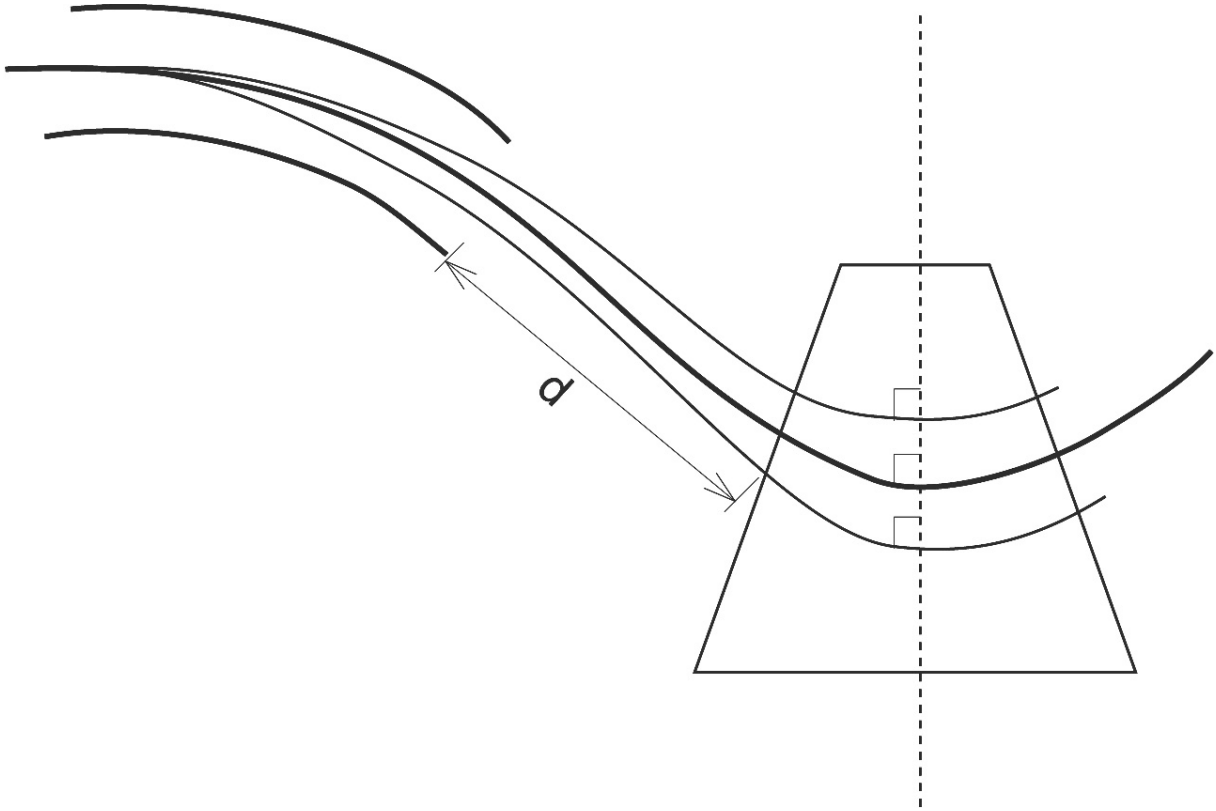
x = deviation from the central trajectory in the transverse (dispersion) direction.

$= (x|x)x_o + (x|\theta)\theta_o + (x|\delta_E)\delta_E + (x|\delta_M)\delta_M$

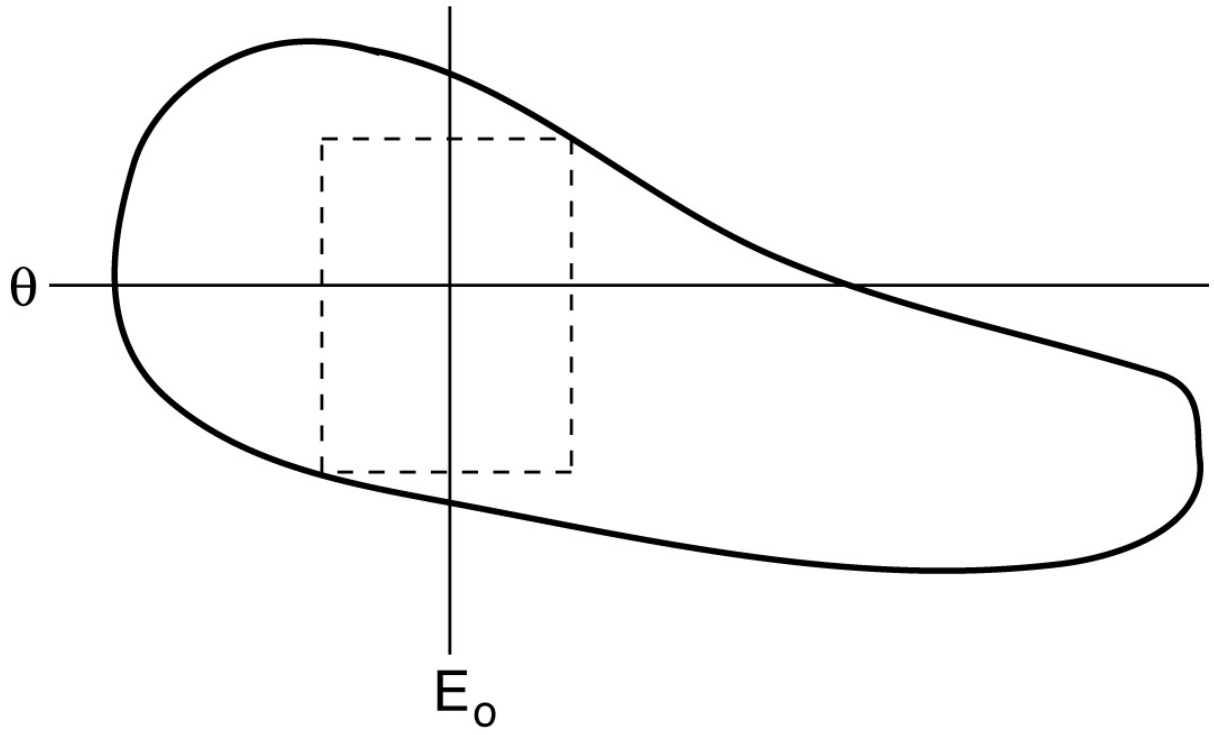
where $\delta_E = \Delta E/E_o$ and $\delta_M = \Delta M/M_o$

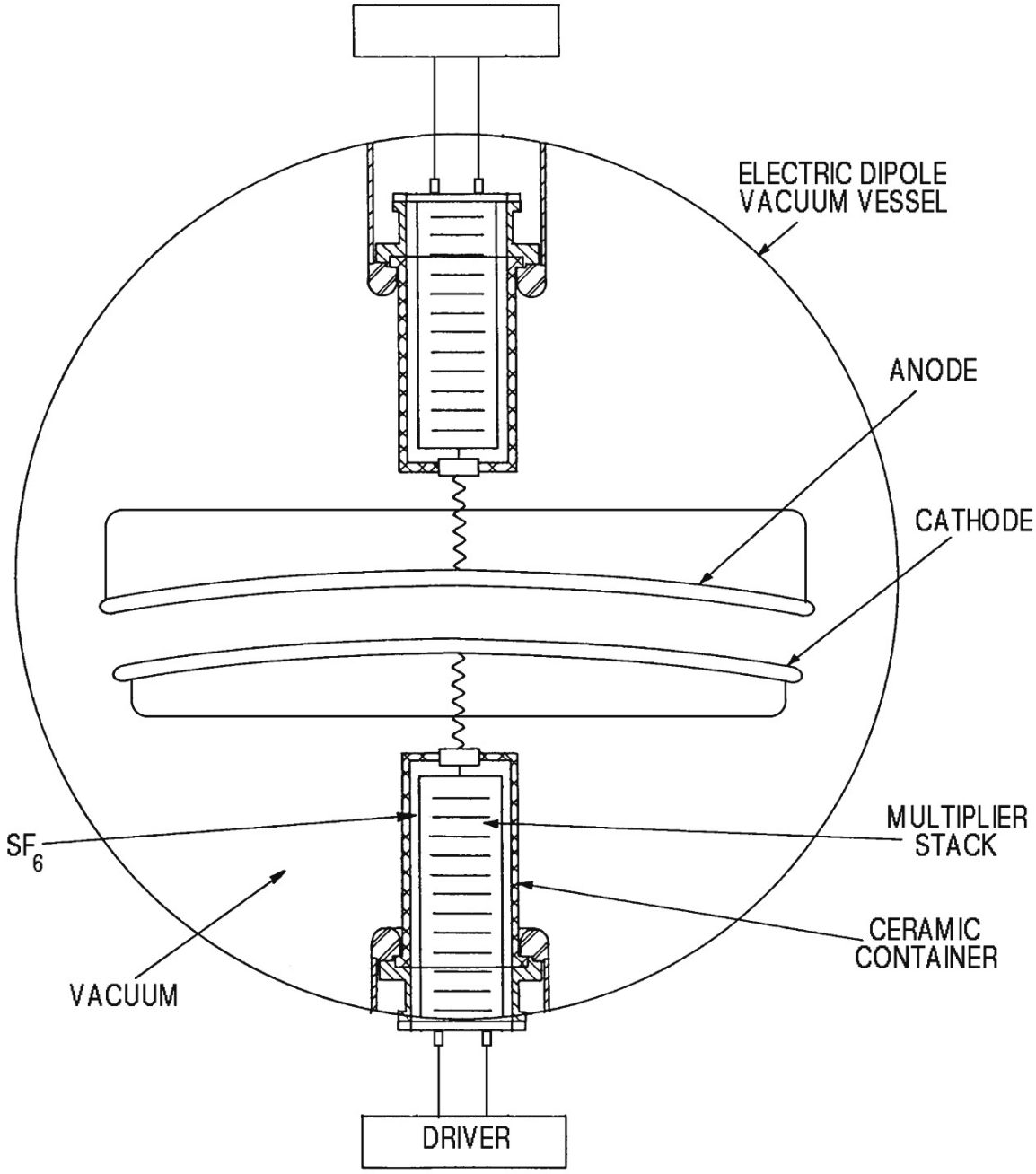
- We want a focus in x, so $(x|\theta)$ must = 0
- We want mass dispersion, so $(x|\delta_M) \neq 0$
- $(x|x)$ is the image magnification (usually 1 – 2)

So we MUST have $(x|\delta_E) = 0$ (energy dispersion cancellation). In the FMA it is achieved by the distance between electric and magnetic dipoles.

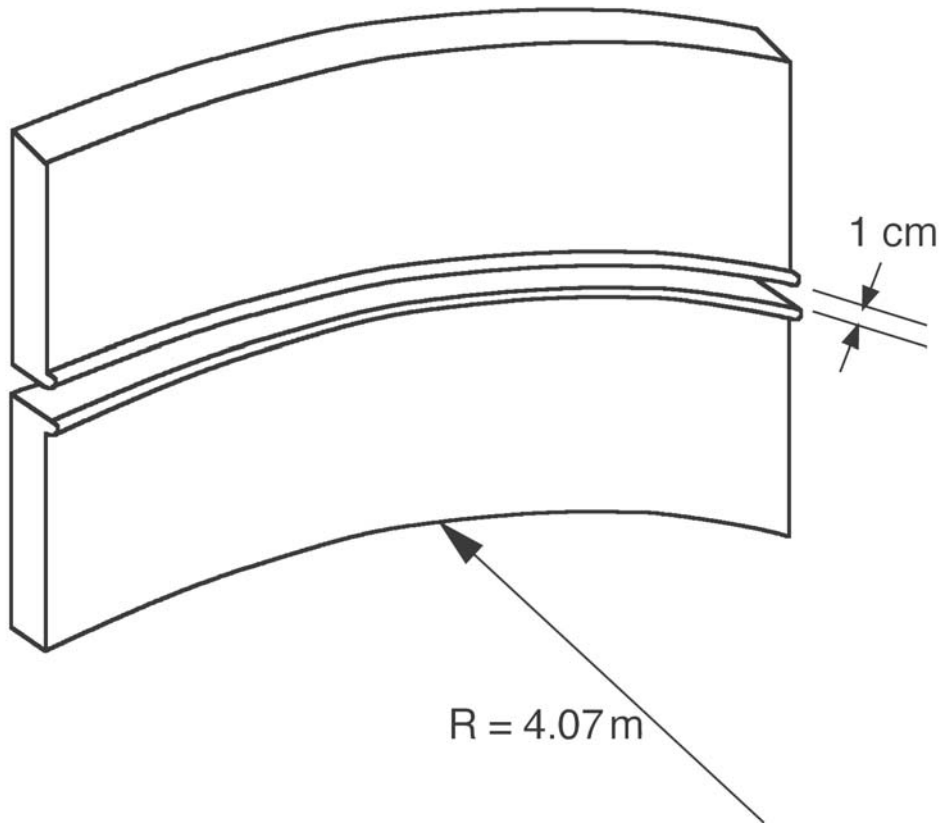

d

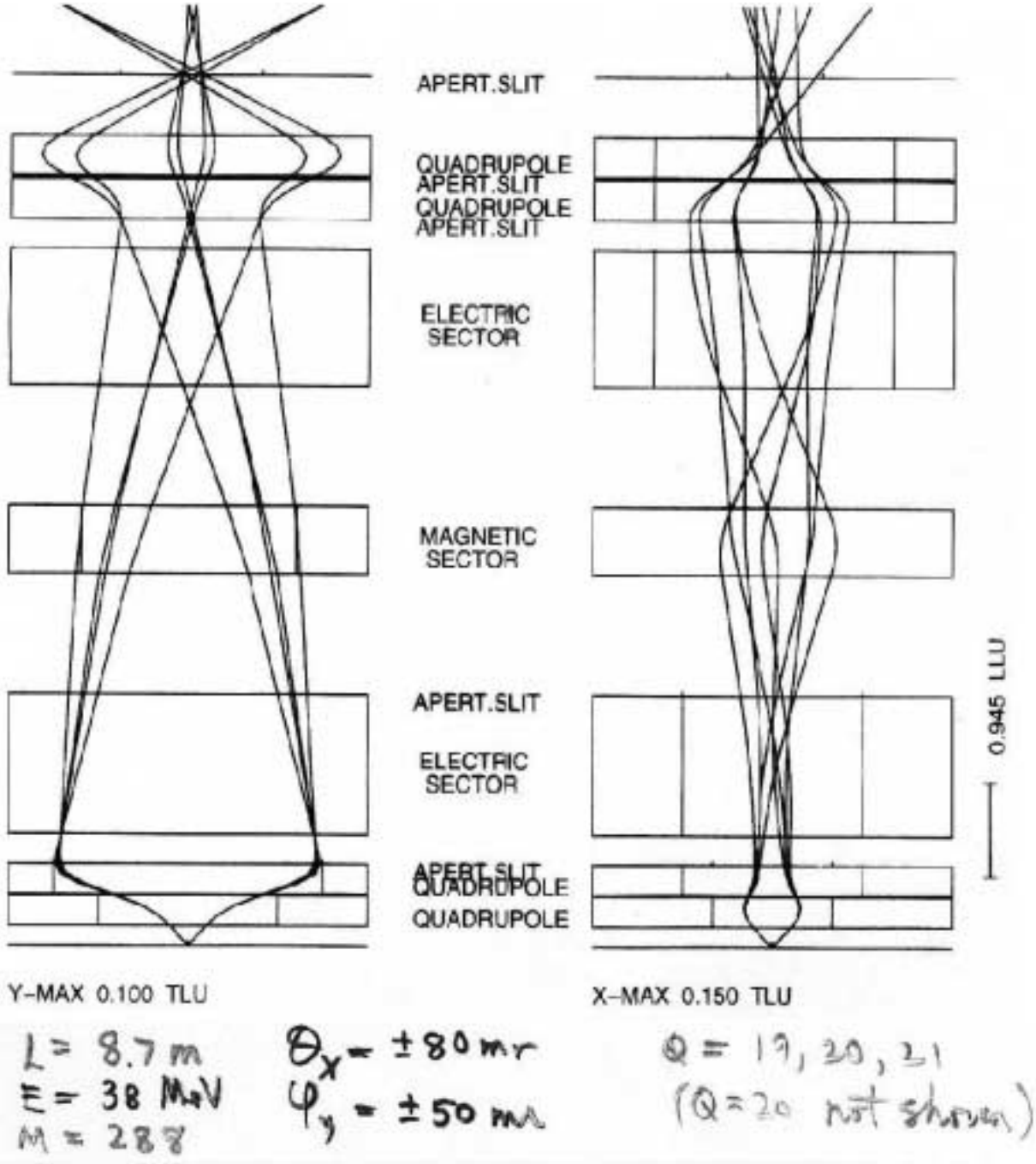
Phase Space Acceptance




ELECTRIC DIPOLE
VACUUM VESSEL
ANODE
CATHODE
MULTIPLIER
STACK
SF_6
CERAMIC
CONTAINER
VACUUM
DRIVER

SPLIT ANODE FOR EDI OF THE FMA




APERT.SLIT
QUADRUPOLE
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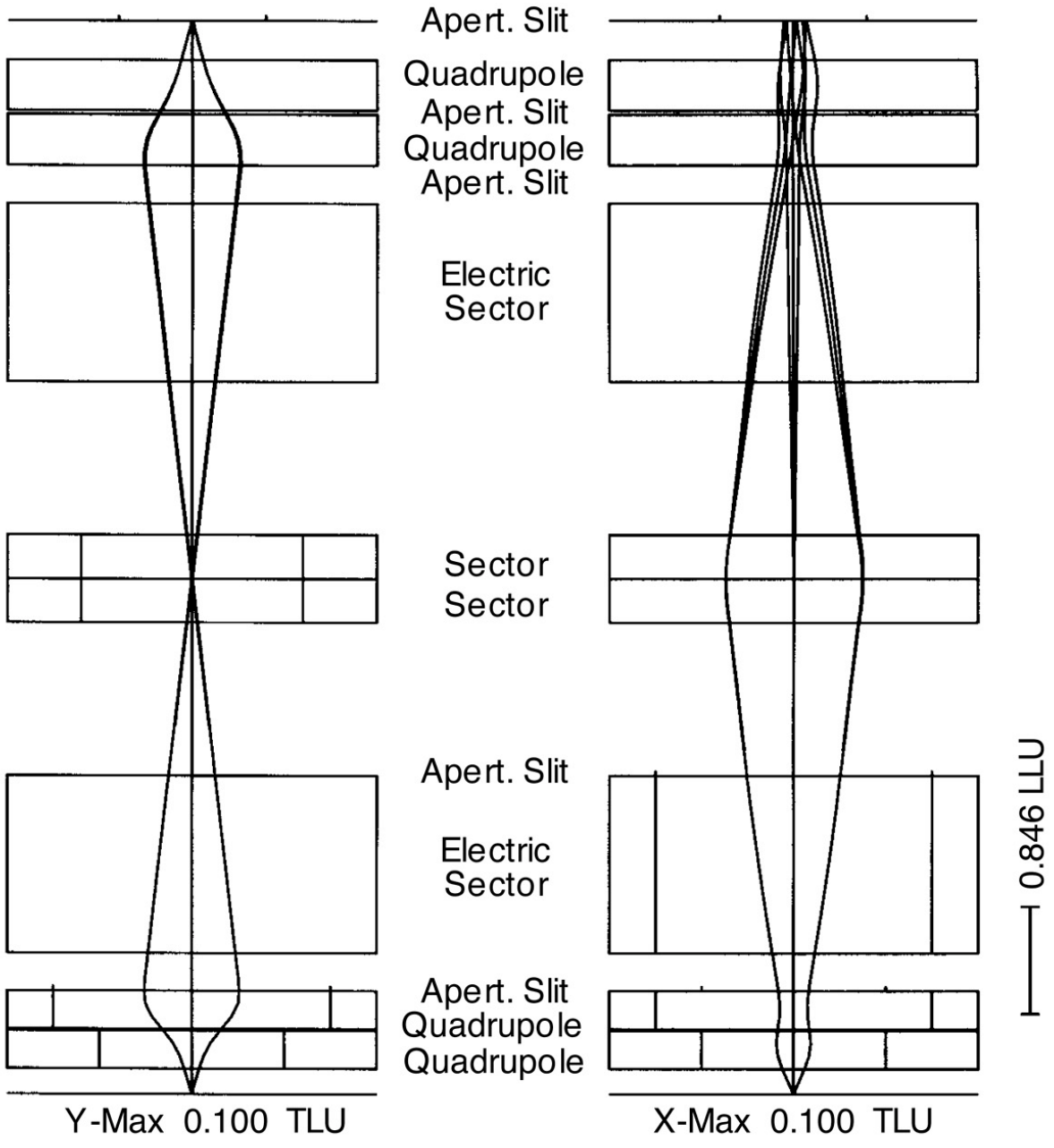
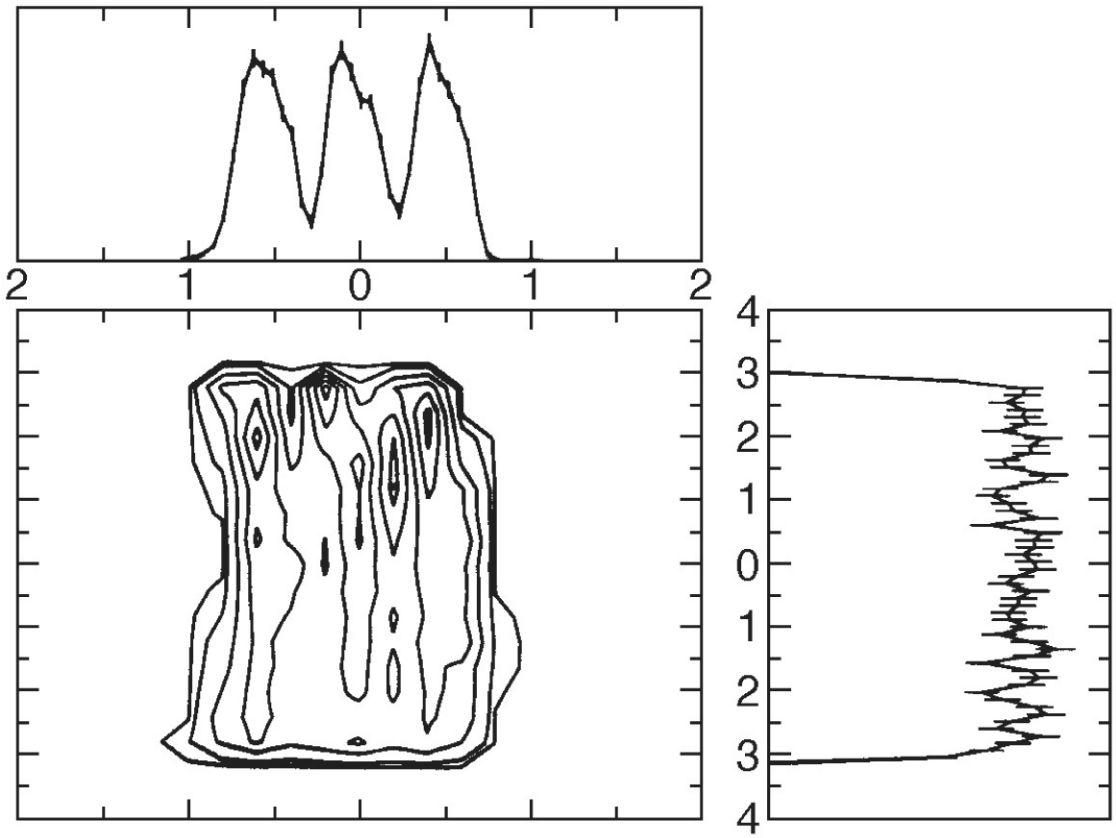
QUADRUPOLE
APERT.SLIT
ELECTRIC SECTOR
MAGNETIC SECTOR
APERT.SLIT
ELECTRIC SECTOR
APERT.SLIT
QUADRUPOLE
QUADRUPOLE
0.945 LLU
Y-MAX 0.100 TLU
X-MAX 0.150 TLU
L = 8.7 m
E = 38 MeV
M = 288
$\theta_x = \pm 80$ mr
$\varphi_y = \pm 50$ mr
Q = 19, 20, 21
(Q = 20 not shown)



$\theta_x = \pm 30mr$ 3 Masses 287, 288, 289

$\phi_y = \pm 40mr$



Superheavy Target @ 0.20, 3/02 Mass Disp.
Z = 0.846E+01

Preliminary Transmission Calculations

- Used the $^{244}Pu(^{48}Ca,4n)^{288}114$ reaction at 236 MeV (central recoil energy 38 MeV).
- Used rectangular angle, energy, and charge state distributions.
- Angles: ±105 mr (±6° vertical and horizontal).
- Energy: ±5%.
- Charge states: ±15% (Q = 17 – 23 inclusive).
- Transmission = 30%.

Conclusions

- **We report on a preliminary design for a recoil separator to be used for superheavy element chemistry. It has a high acceptance and an image size of 1 x 4 cm^2.**
- **It can also be operated with mass dispersion, allowing a measurement of M/Q.**
- **Target- and beam-like transfer products will be outside the transmission range because the first element is an electric dipole.**
- **Cost: in the neighborhood of €3M.**