Production and identification of RIB at relativistic energies

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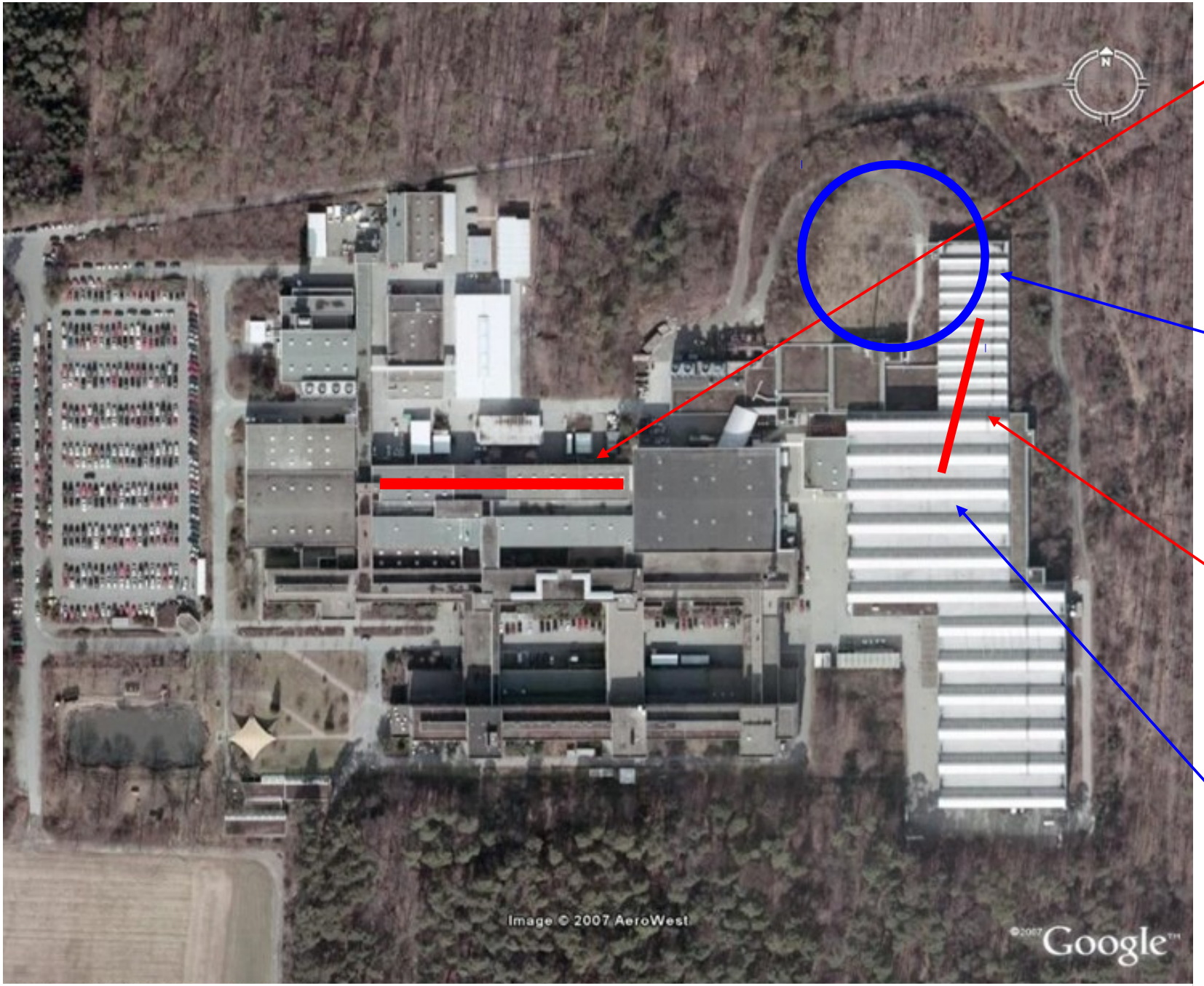
EGAN school

HIC for FAIR
Helmholtz International Center

December 4, 2012

GSI
TECHNISCHE UNIVERSITÄT DARMSTADT

Production of radiative beams



UNILAC
E < 11.5 MeV/u

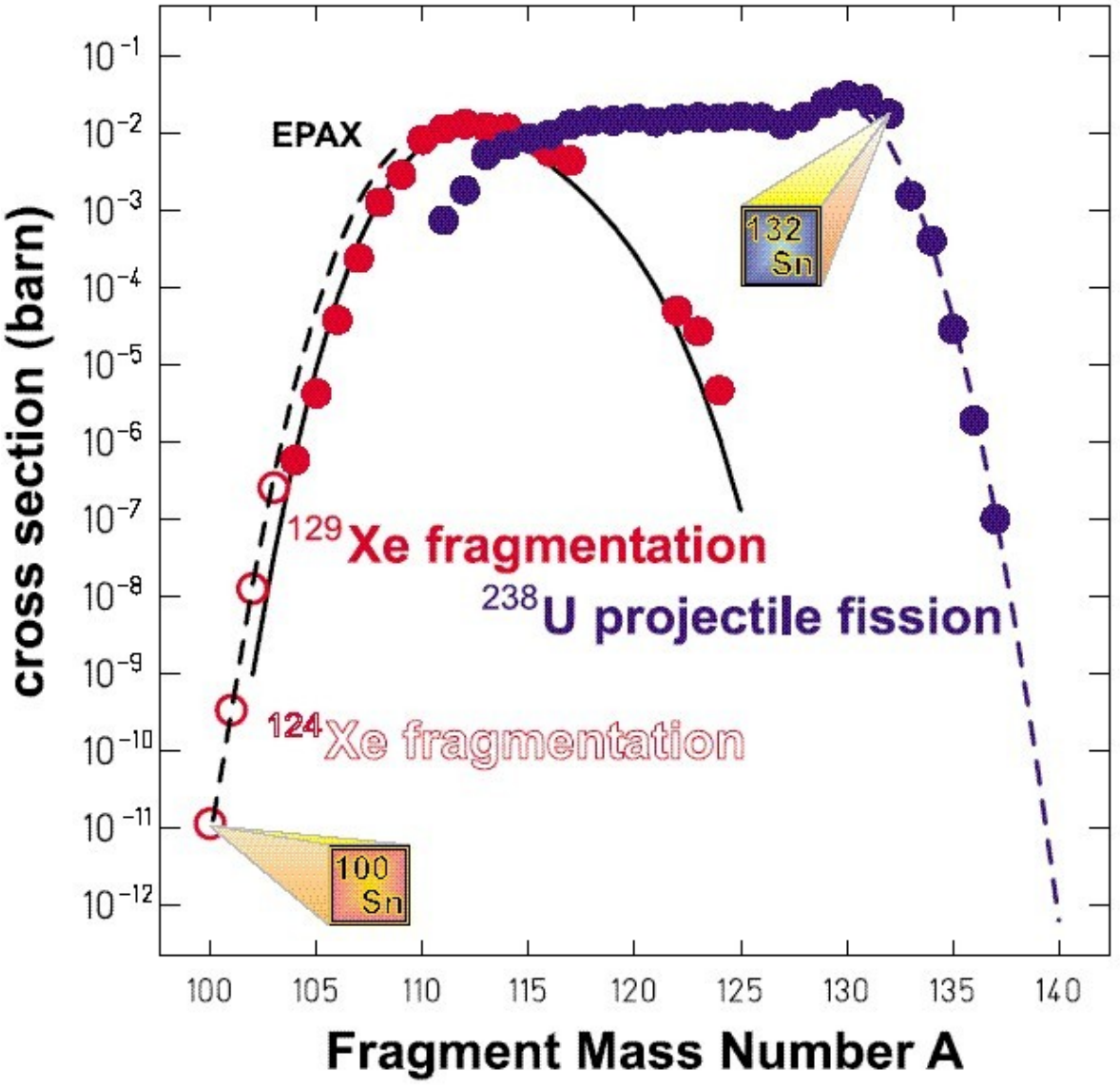
SIS 18
^{238}U 1 GeV/u
>10^8 pps

FRagment Separator

PreSPEC

AGATA
ADVANCED GAMMA TRACKING ARRAY

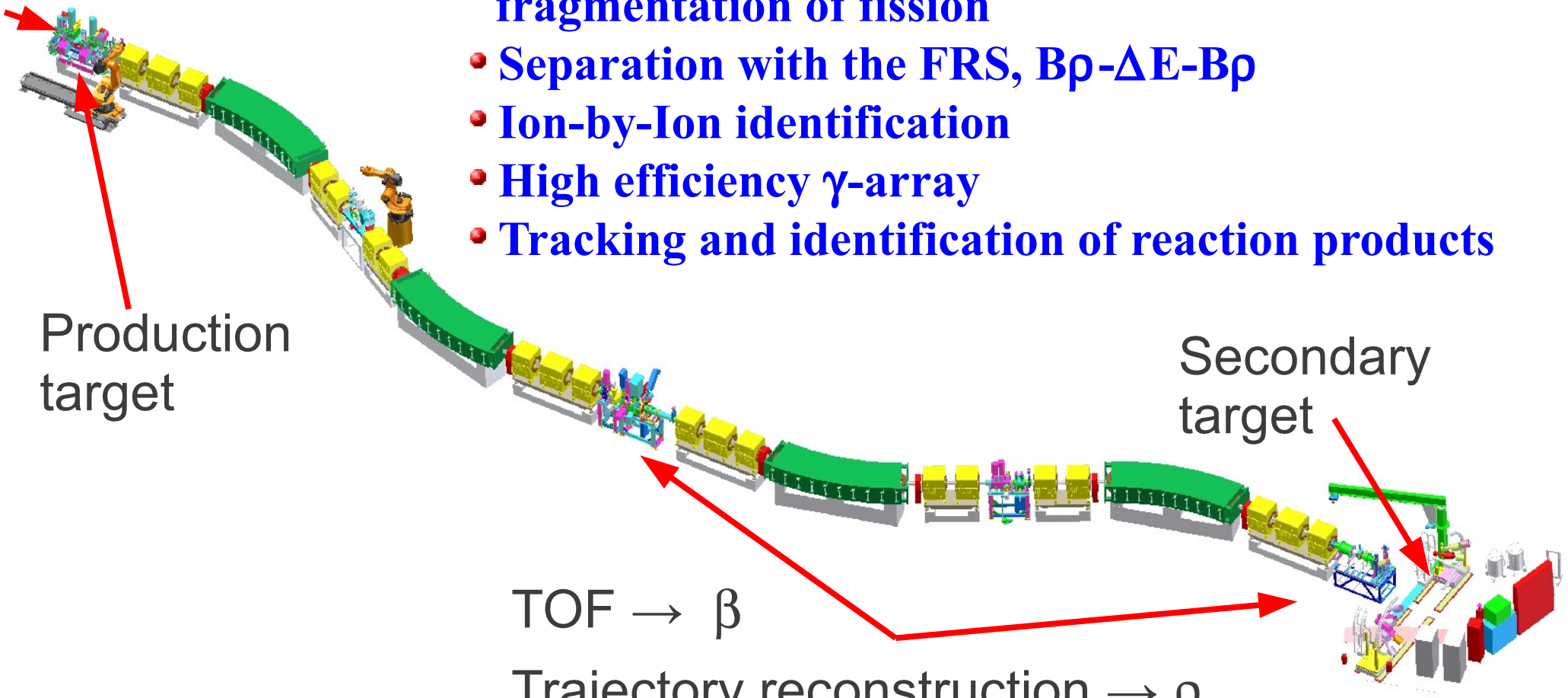
Production of RIB, fragmentation vs. fission.



γ-spectroscopy at GSI

TOF through FRS ~ 300ns

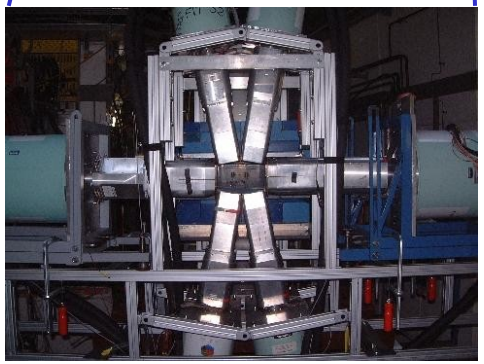
- **Intense stable beams delivered from UNILAC-SIS**
- **Production of radioactive beams through fragmentation of fission**
- **Separation with the FRS, Bρ-ΔE-Bρ**
- **Ion-by-Ion identification**
- **High efficiency γ-array**
- **Tracking and identification of reaction products**



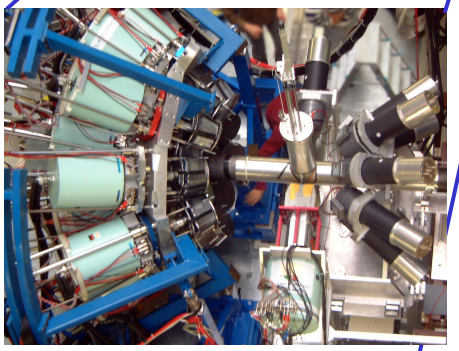
History

1998 2000 2002 2004 2006 2008

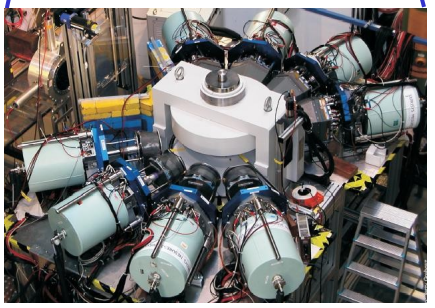
VEGA
Isomer campaign



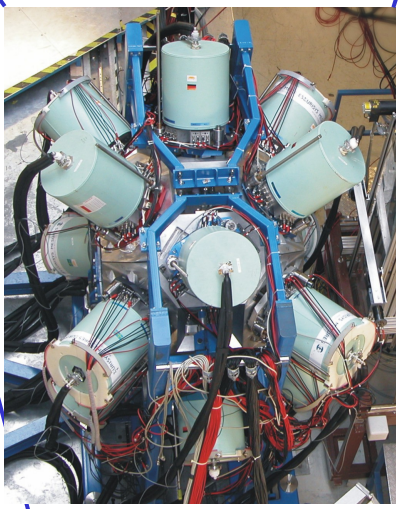
RISING
Fast campaign



g-RISING

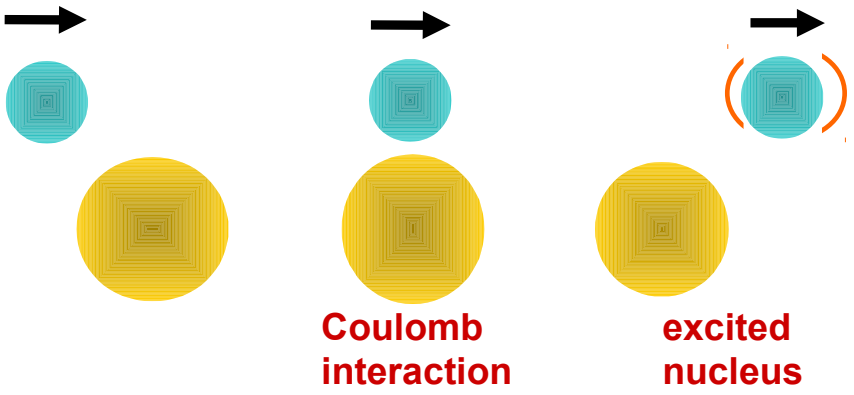


RISING
Stopped campaign

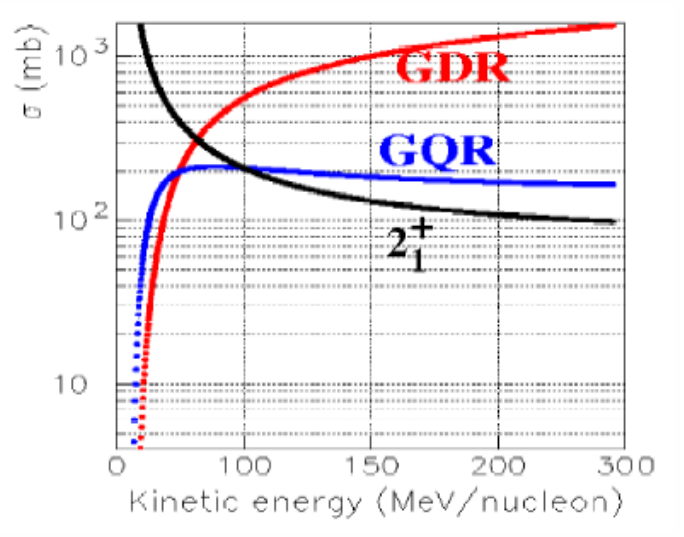


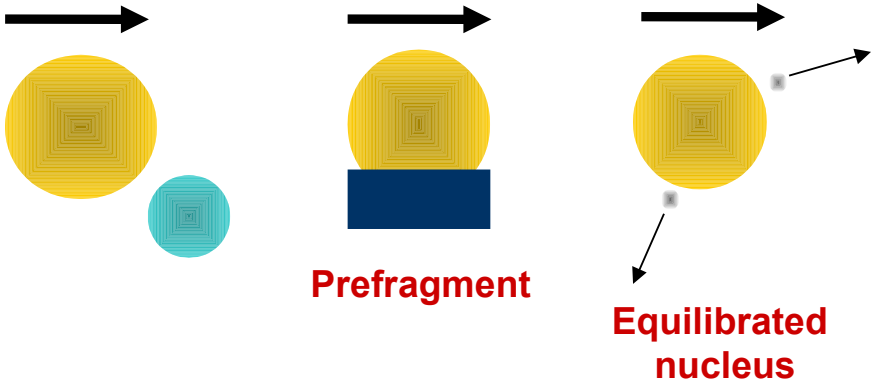
RISING

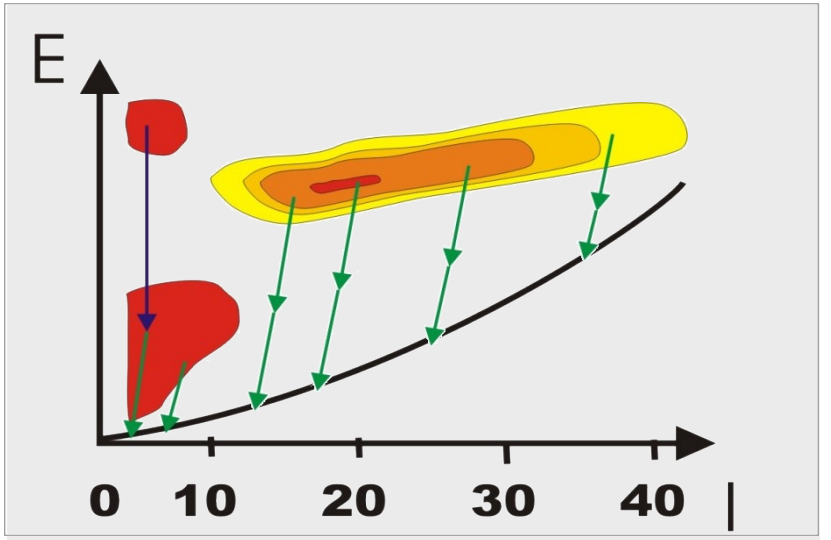
γ-spectroscopy at relativistic energies



^{112}Sn →Au







GSI projectile FRagment Separator (FRS)

TOF through FRS ~ 300ns
L~70m

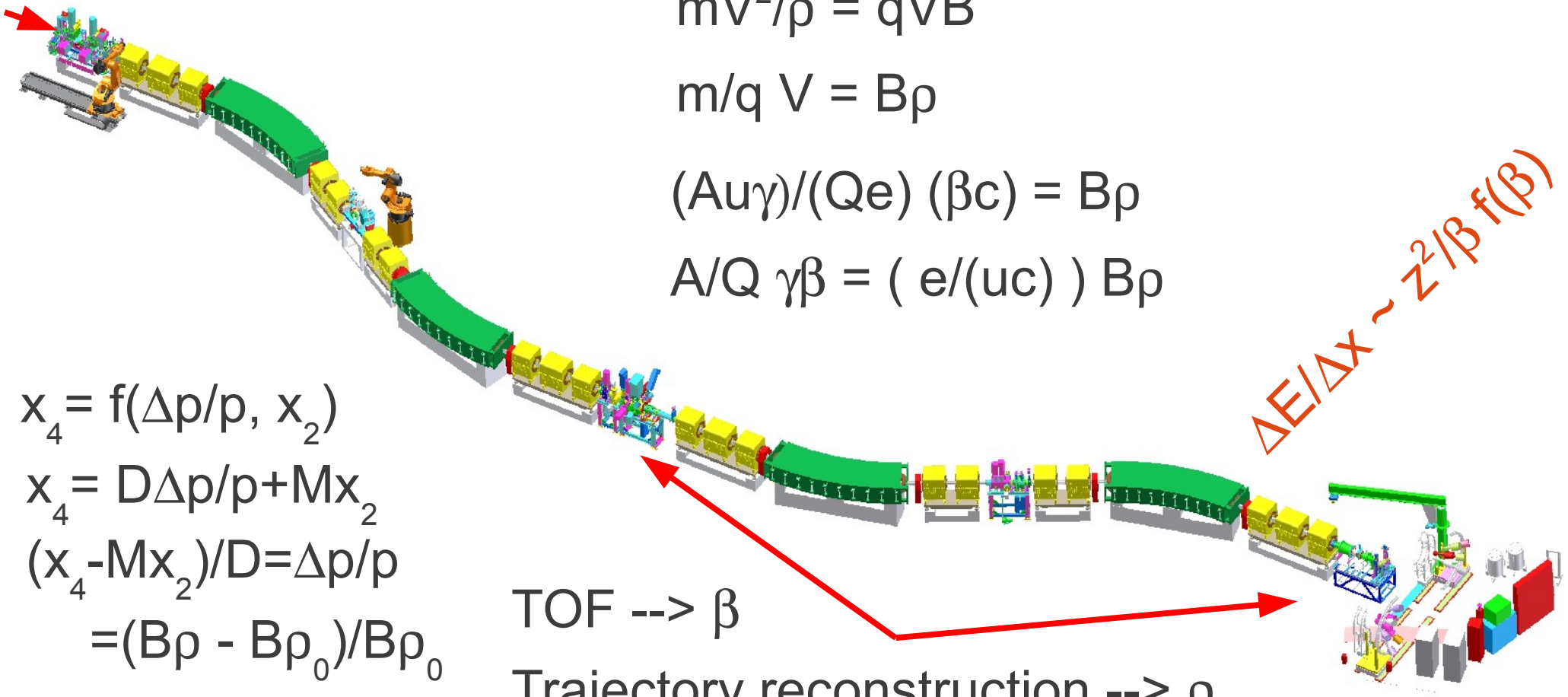
RIB @ 0.6-0.7 GeV/u

$mV^2/\rho = qVB$

$m/q\ V = B\rho$

$(Au\gamma)/(Qe)\ (\beta c) = B\rho$

$A/Q\ \gamma\beta = (\ e/(uc)\ )\ B\rho$



$\Delta E/\Delta x \sim z^2/\beta\ f(\beta)$

$x_4 = f(\Delta p/p, x_2)$

$x_4 = D\Delta p/p + Mx_2$

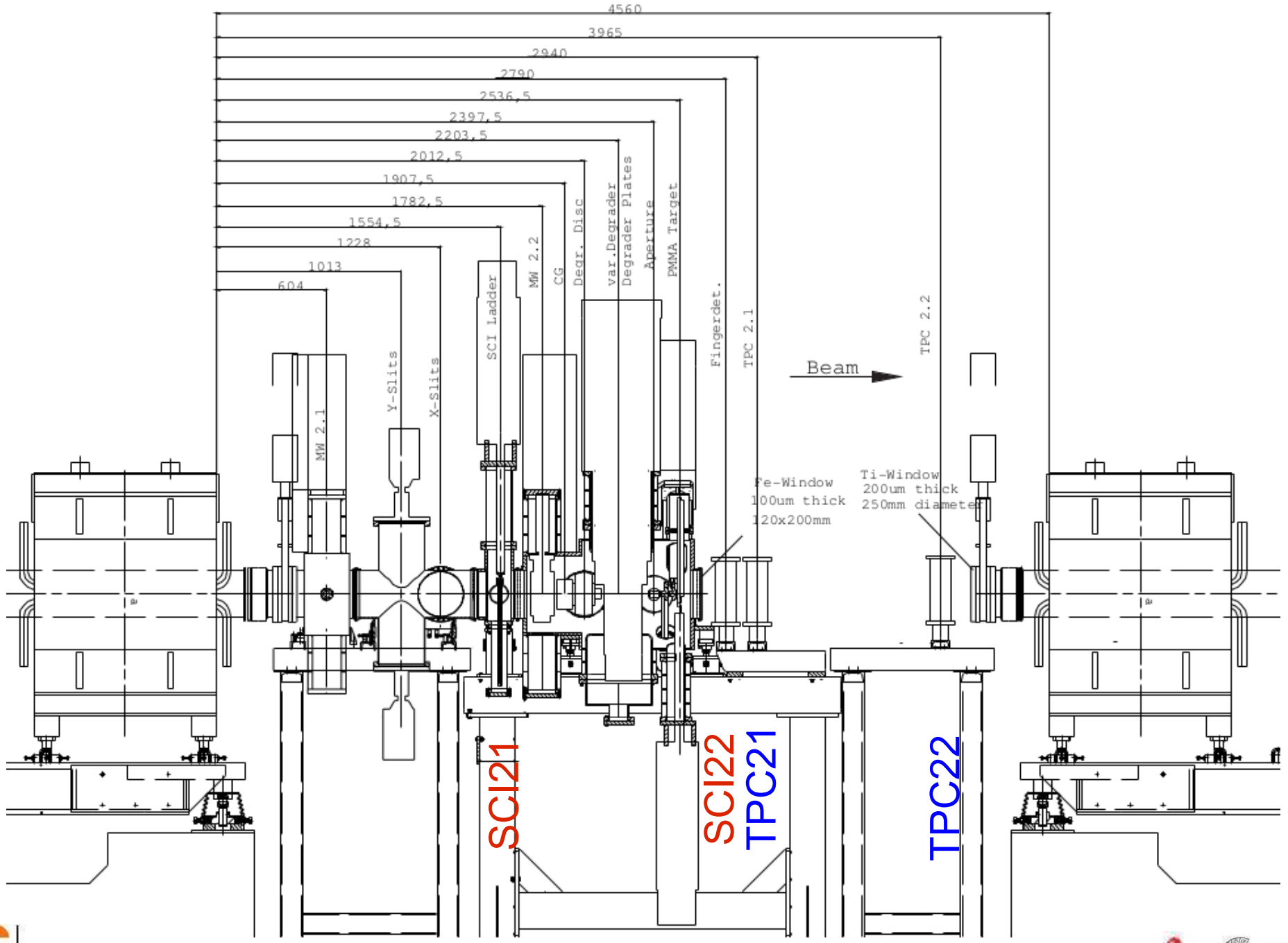
$(x_4 - Mx_2)/D = \Delta p/p$

$= (B\rho - B\rho_0)/B\rho_0$

TOF --> β

Trajectory reconstruction --> ρ

S2-detectors



560 MeV/u

250 MeV/u

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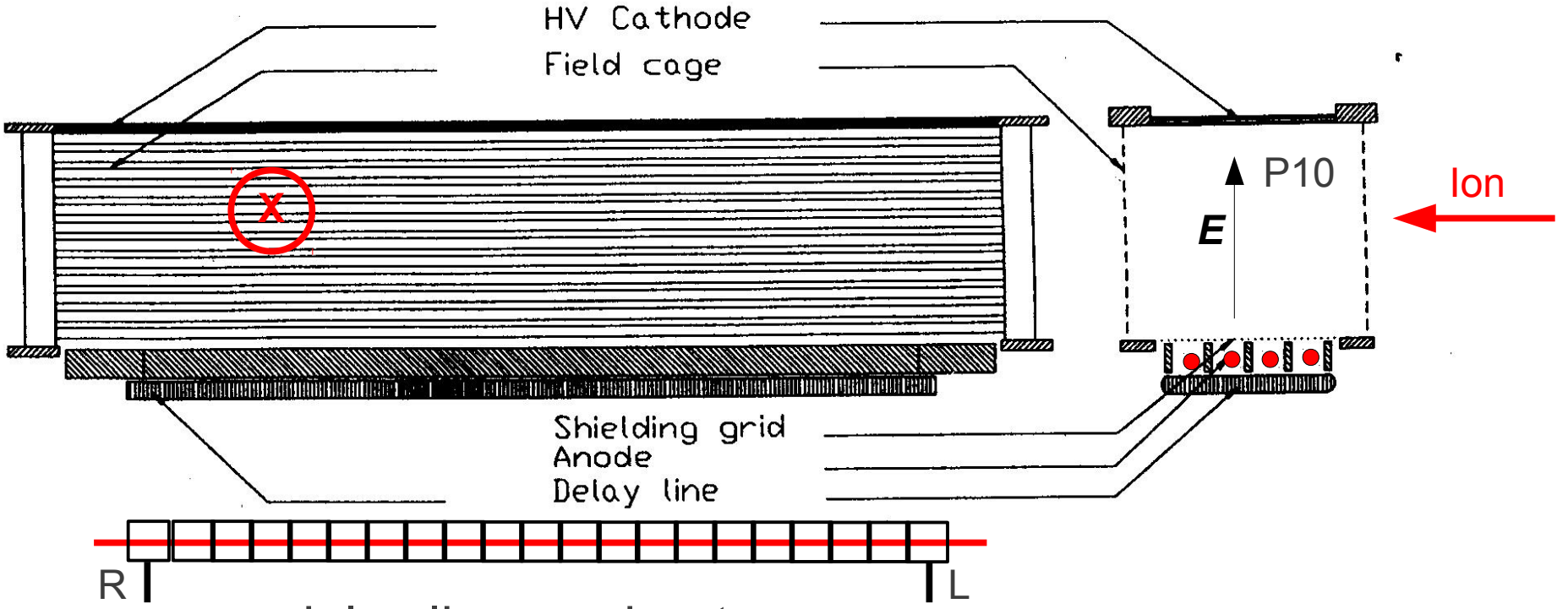
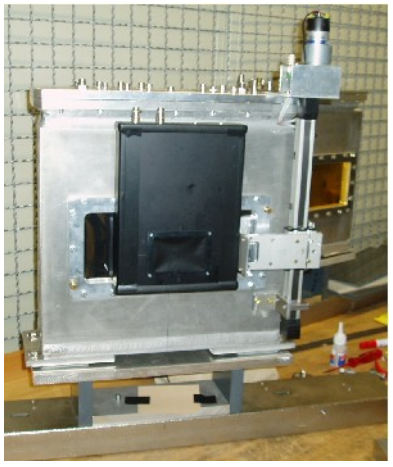
Time Projection Chambers(TPC)





delay line read-out
2 x-position measurements
4 y-position measurements

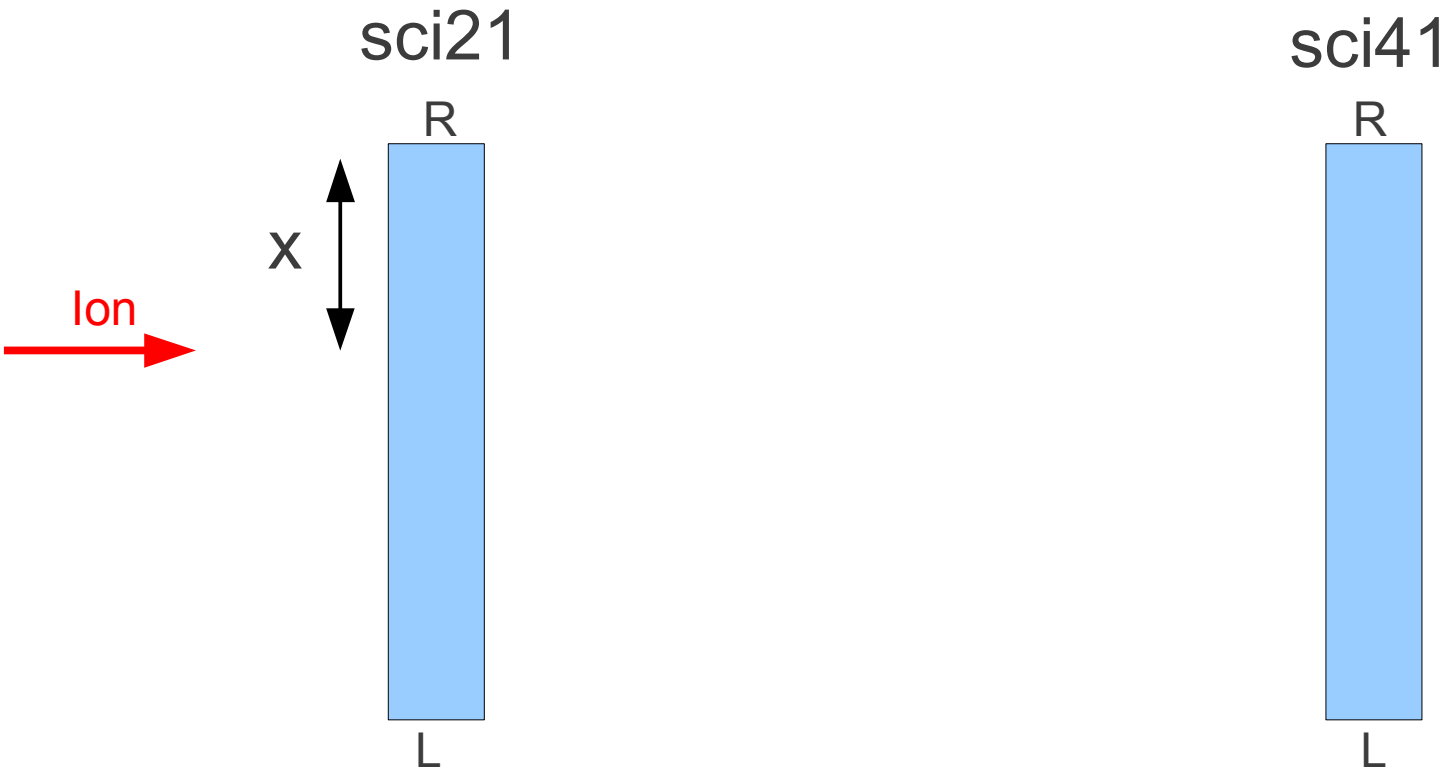
Check sum:

$T_L = t_Y + t_L$; $T_R = t_Y + t_R$;

$T_L + T_R - 2t_Y = \text{const}$

http://www-wnt.gsi.de/frs/index.asp

Scintillators



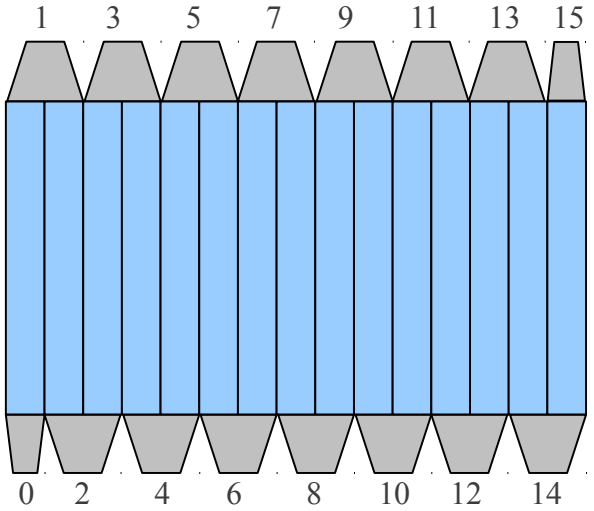
$$\Delta T = x/v_0 - (L-x)/v_0 = 2x/v_0$$

$$\Delta T(SCI21L\text{-}SCI41L)+\Delta T(SCI21R\text{-}SCI41R)$$

$$= x/v_0 + TOF(S2\text{-}S4)+ \ldots + (L-x)/v_0 + TOF(S2\text{-}S4) \ldots$$

$$\sim TOF(S2\text{-}S4)$$

Finger detector

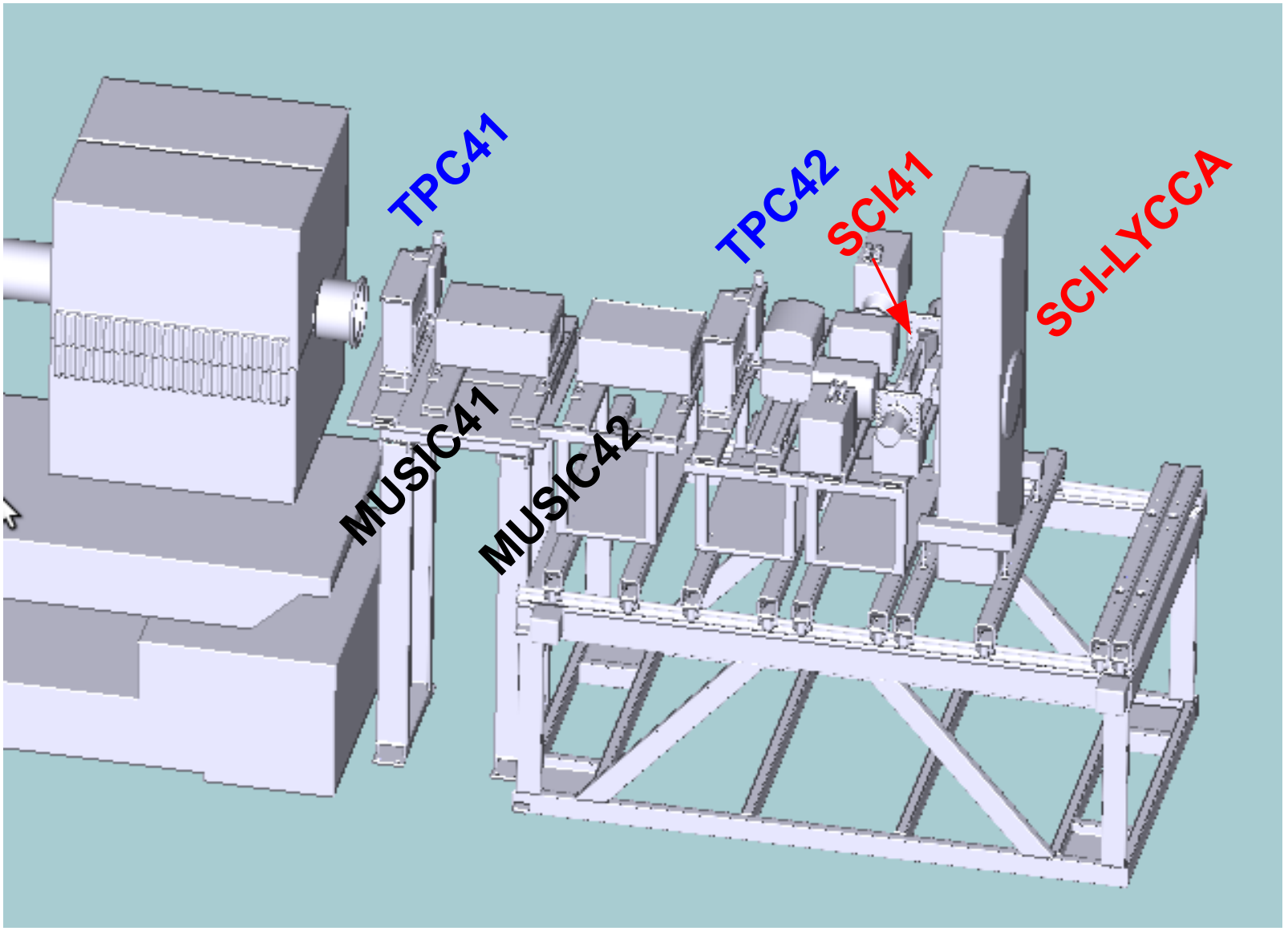


- Time aliment
- Amplitude cut using QDC data
- Selecting the “proper hit”

from the multi-hit TDC data

ΔX=13 mm

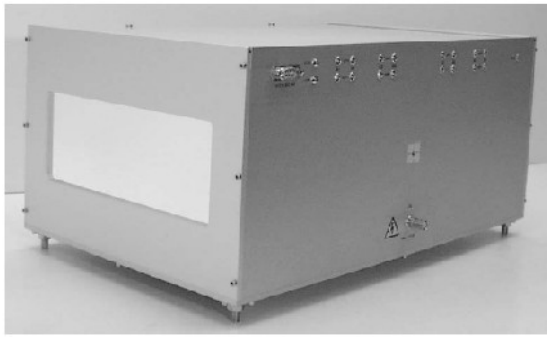
S4-detectors



250 MeV/u

170MeV/u

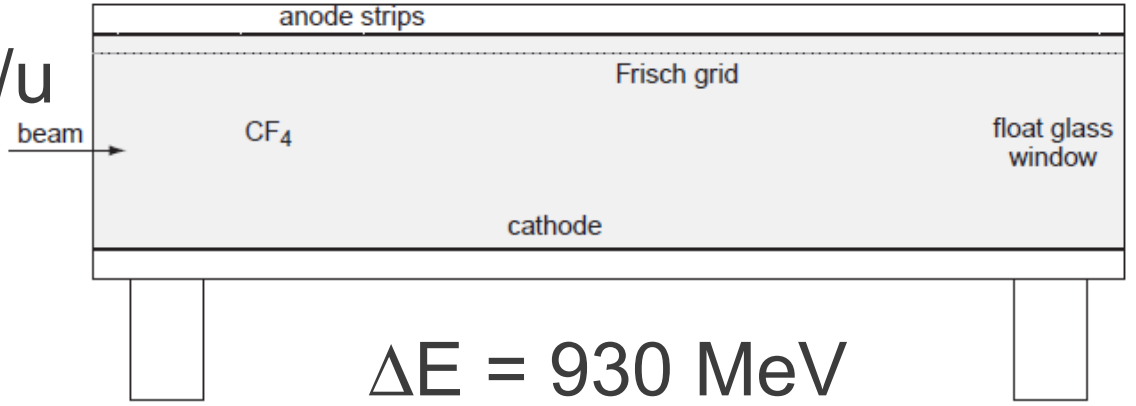
MUSIC



$\Delta E/\Delta x \sim z^2/\beta\, f(\beta)$

measure ΔE 8 times

E= 396 MeV/u
β= 0.71



E= 382 MeV/u
β= 0.705

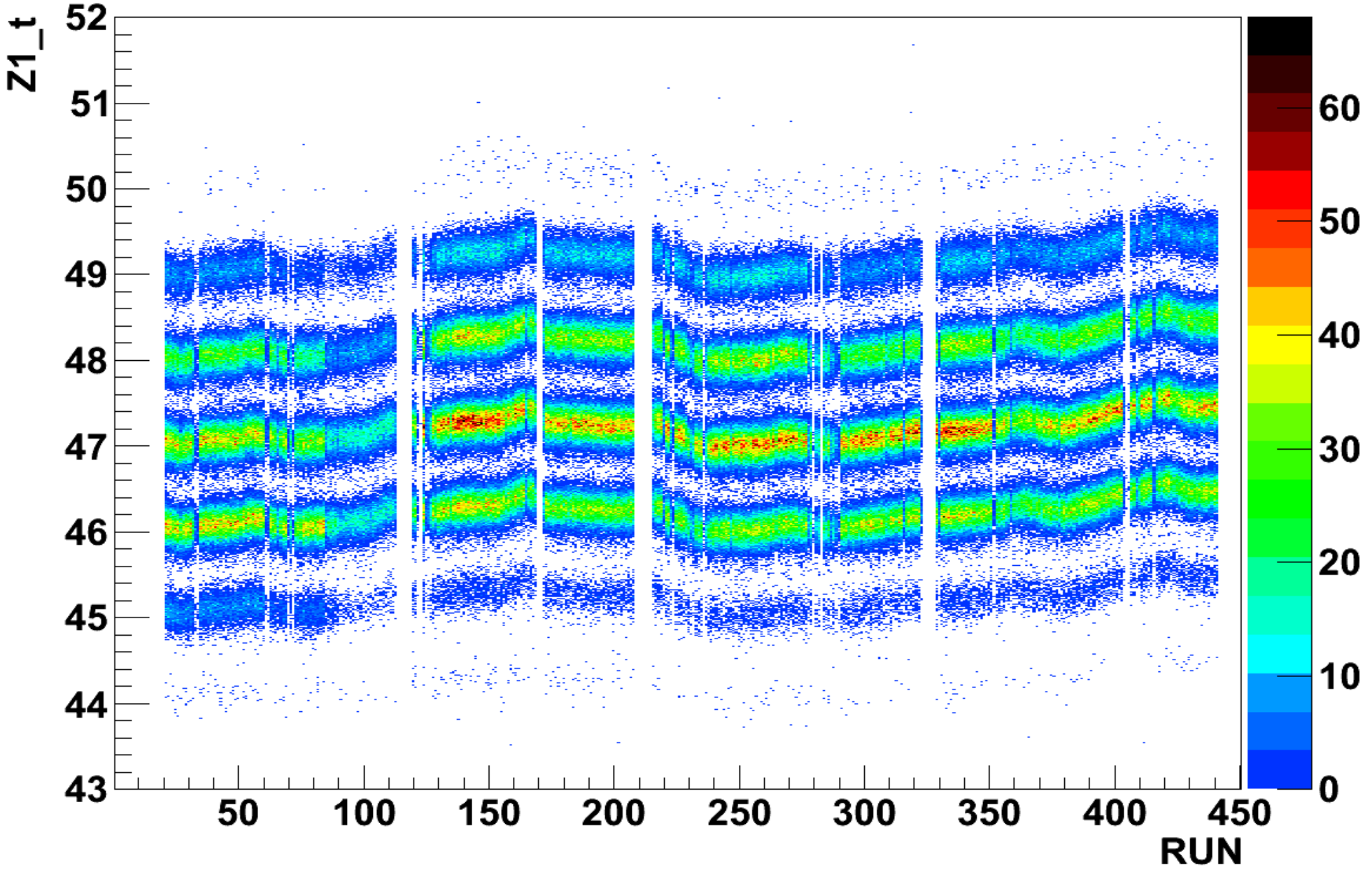
ΔE = 930 MeV

= 115.3 + 115.4 + 115.6 + 115.8 +
115.9 + 116.1 + 116.2 + 116.4 MeV

$\Delta E_{i+1} = p\, \Delta E_i$ $\qquad$ $\delta E=(\Pi \Delta E_i)^{1/8} \sim z^2$

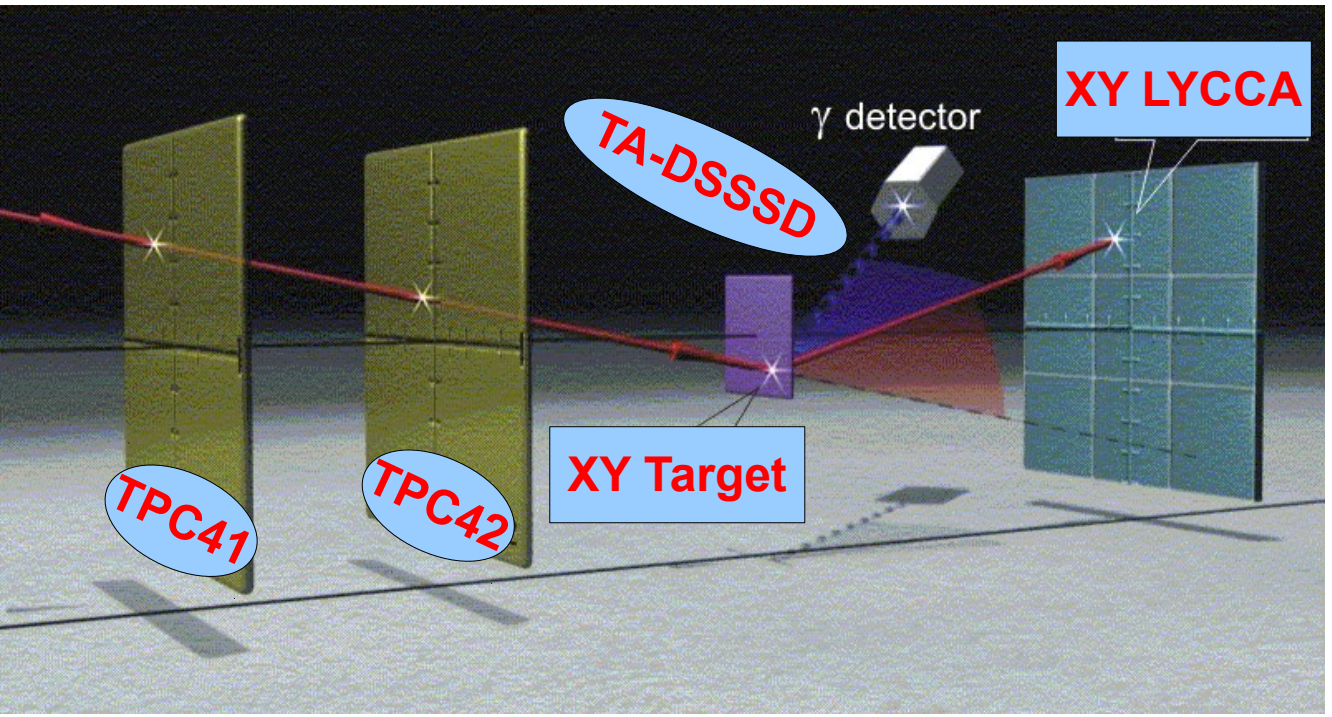
$z = z_0(\delta E/\delta E_0(a_0+a_1\beta+a_2\beta^2))^{1/2}$

Z-drift



Pressure correction: P ~ ΔE/Δx

Scattering experiment at 150 MeV/u



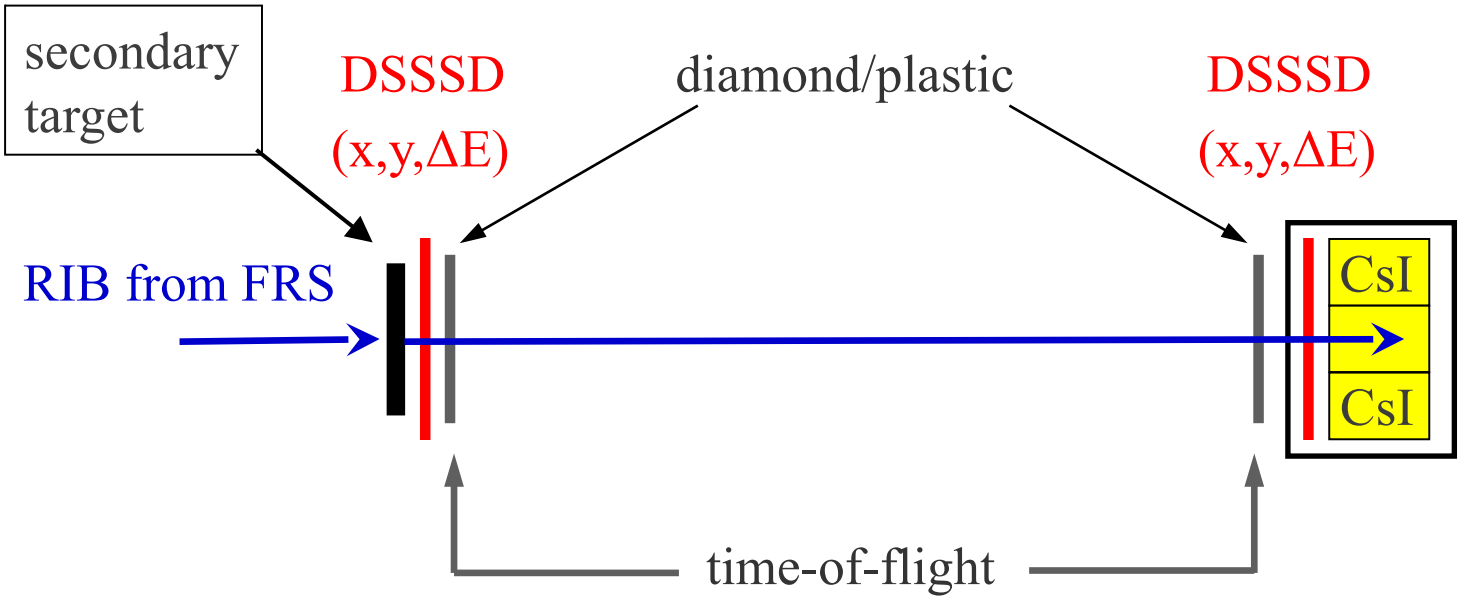
Secondary fragmentation:

$\Delta E\text{-}E \rightarrow Z$

$TOF_{LYCCA} \rightarrow Mass$

Coulomb excitation:

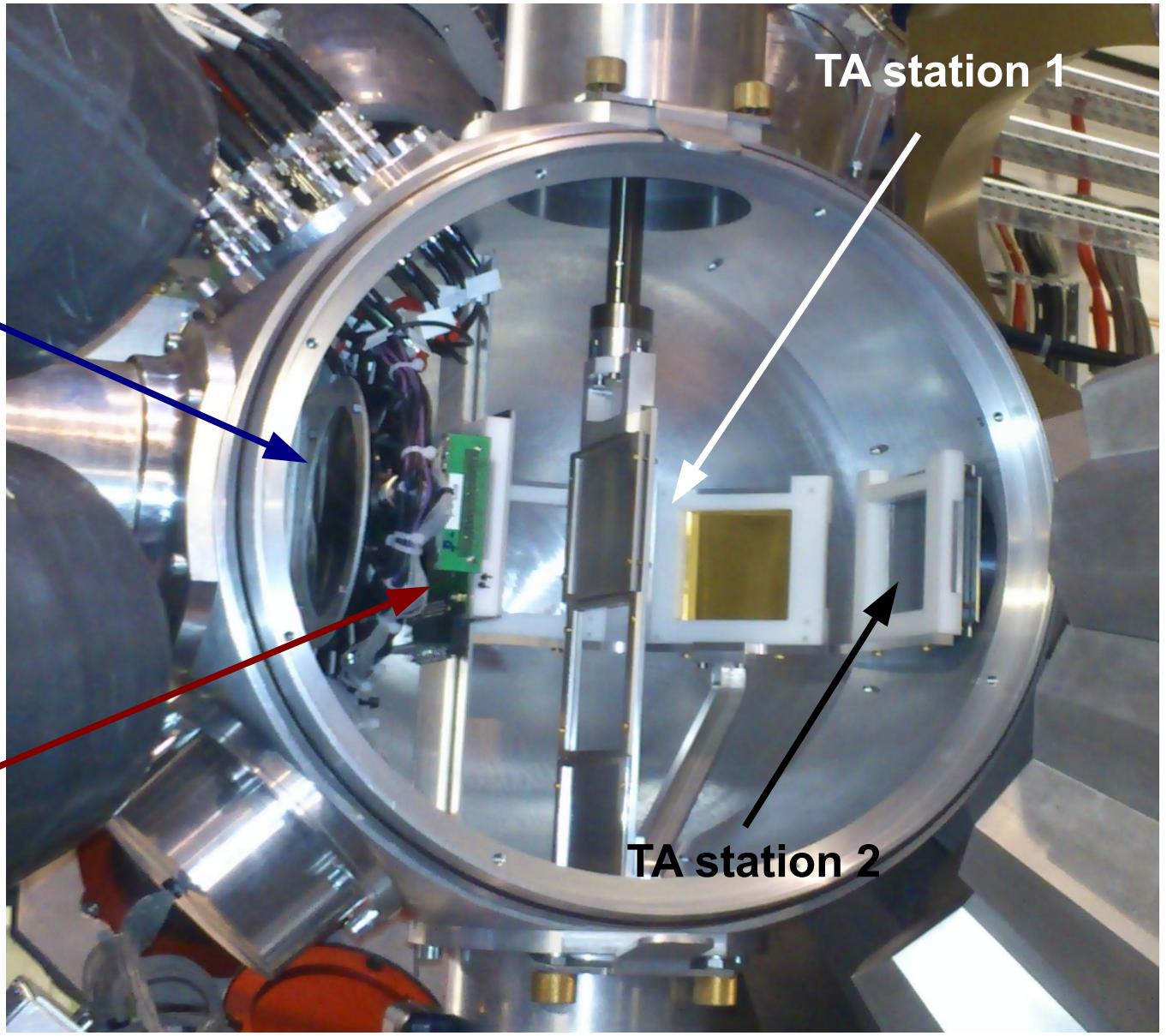
$\vartheta_1^{lab} < \vartheta_{grazing}$



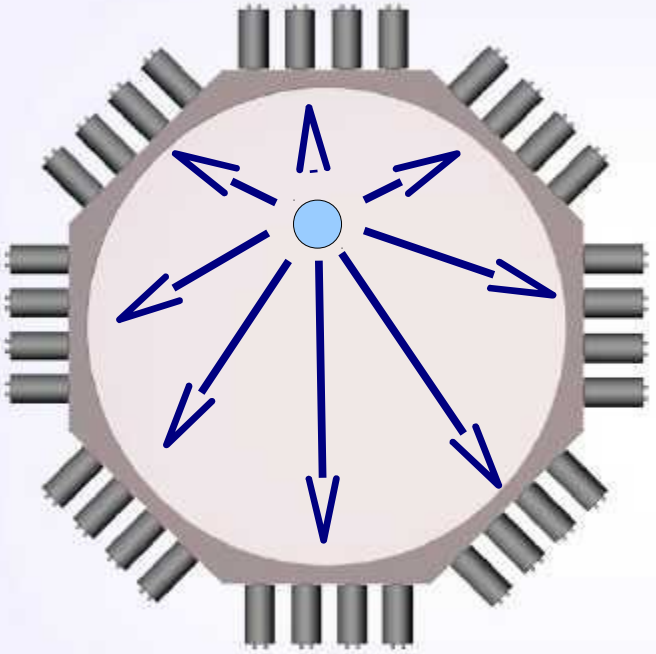
Scattering chamber

TA-TOF-START
0.5 mm BC 420
12 PMT

TA-XY
DSSSD
58 x 58 mm²
32 x 32 strips



Fast timing



More PMTs ->

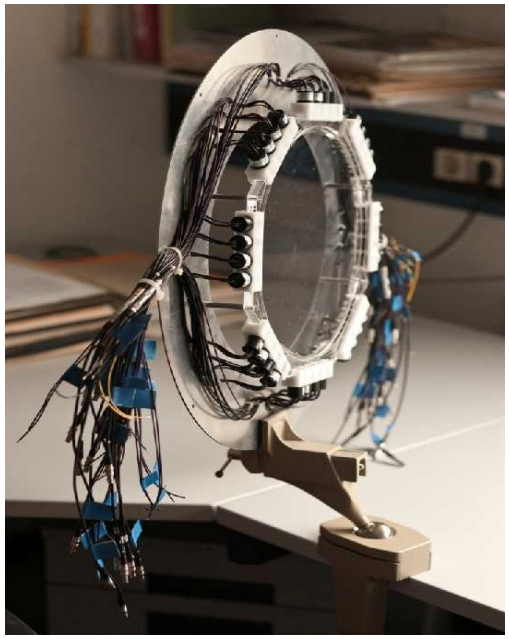
Better time resolution

TOF start and stop

32 PMTs on BC-420
CFDs+TDC

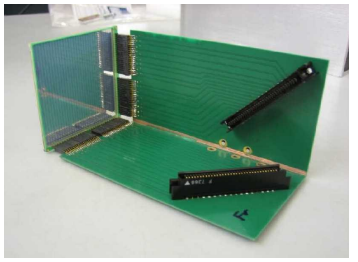
Needs:
Very good position info (tracking) for correction

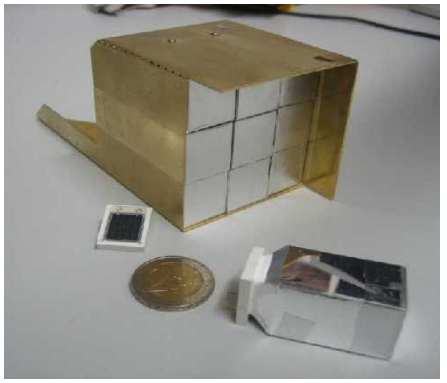
Lund York Cologne CAlorimeter

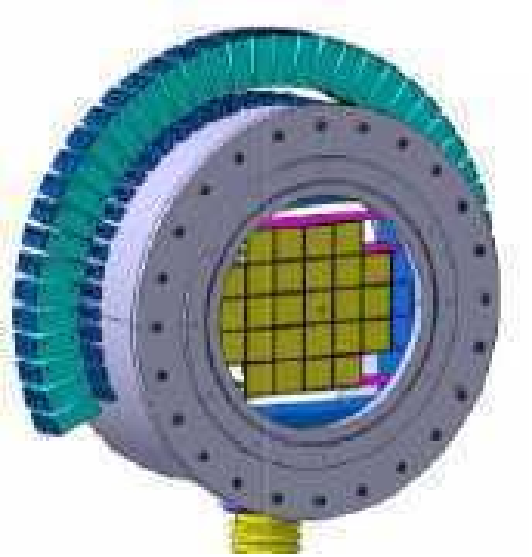


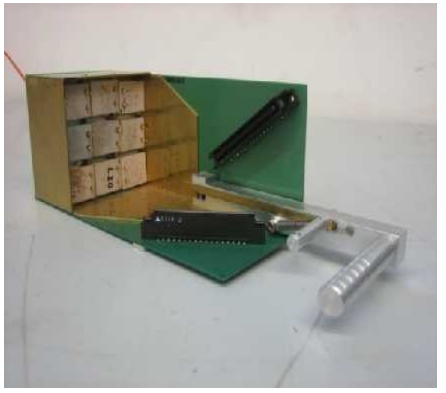
2 mm BC 420 32 PMT

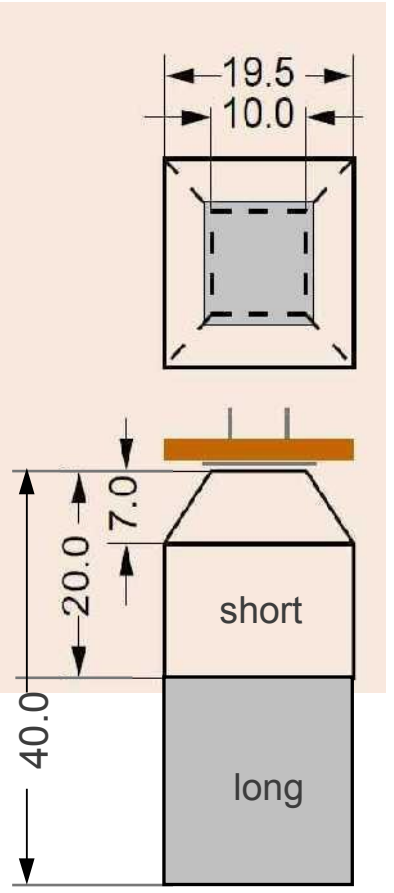
- 32 x 32 strips
- Active area 58 x 58 mm²
- Interstrip distance : 75 µm
- thickness: 300 µm





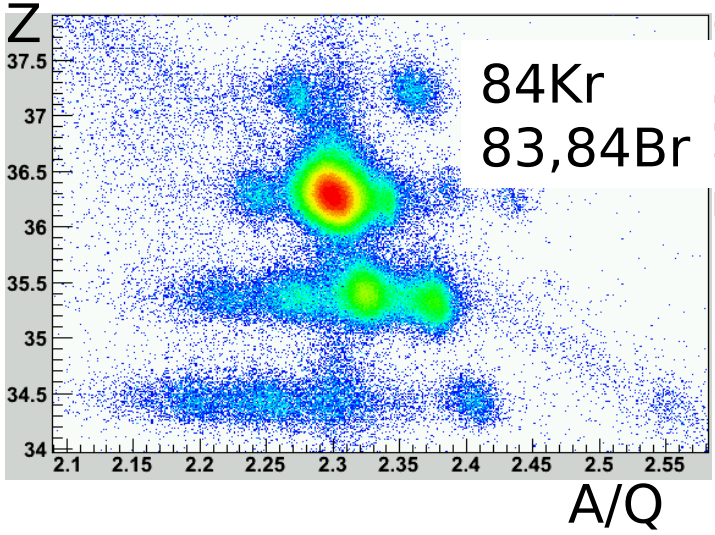




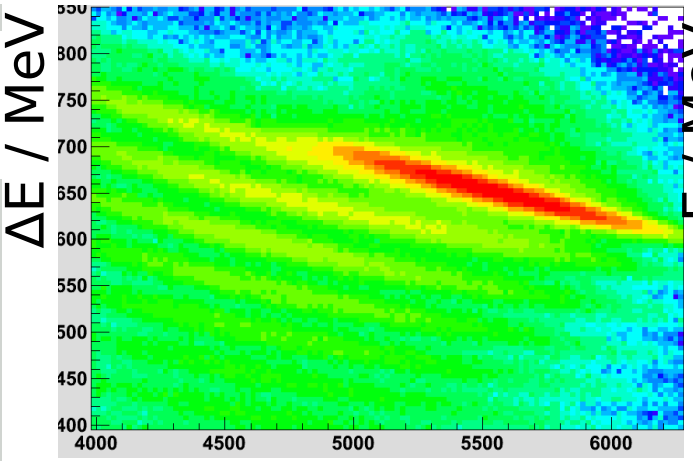


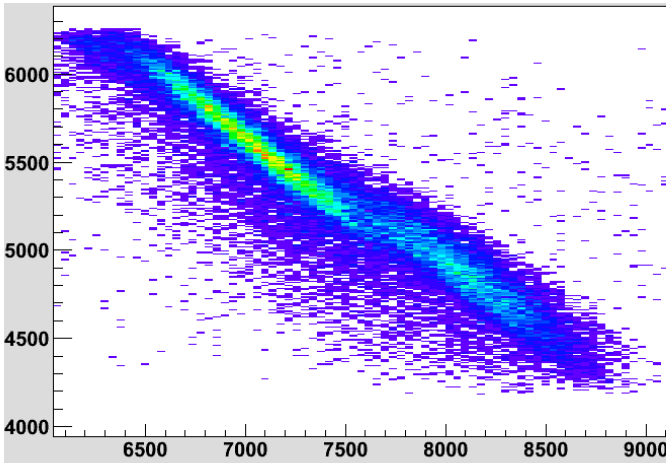
LYCCA identification for mass A≈80

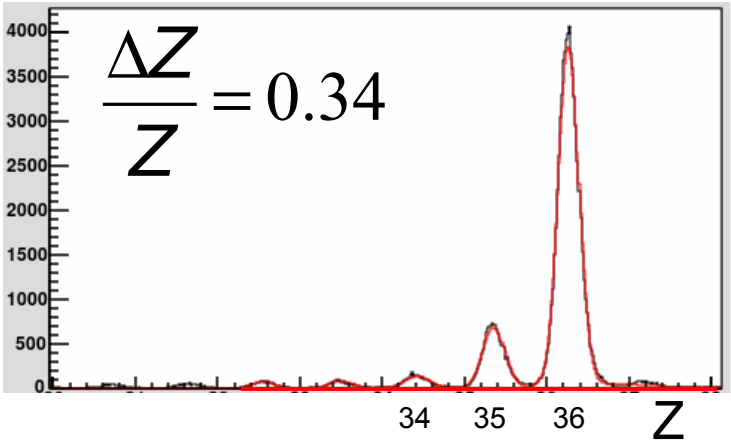
FRS identification

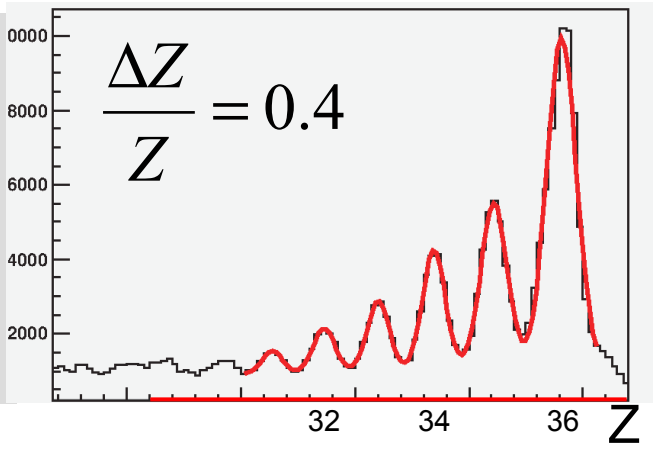


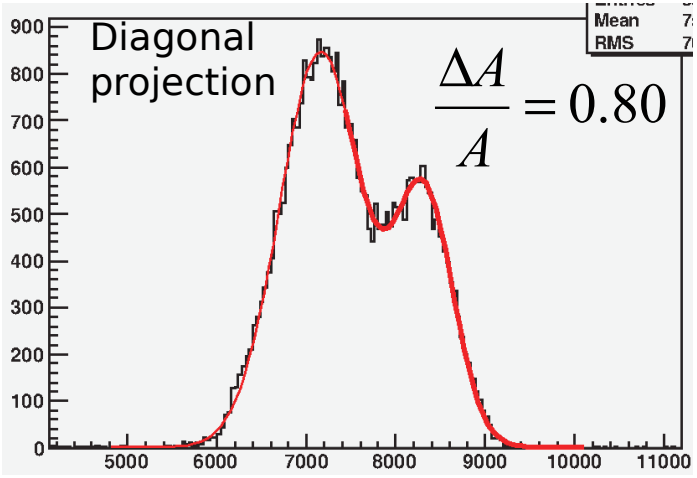
LYCCA identification











- Z separation similar for LYCCA and FRS detectors
- Mass separation achieved with LYCCA for A≈80-100 (depending on target & degrader thickness etc.)
- LYCCA identification efficiency currently 50-60%

Doppler correction

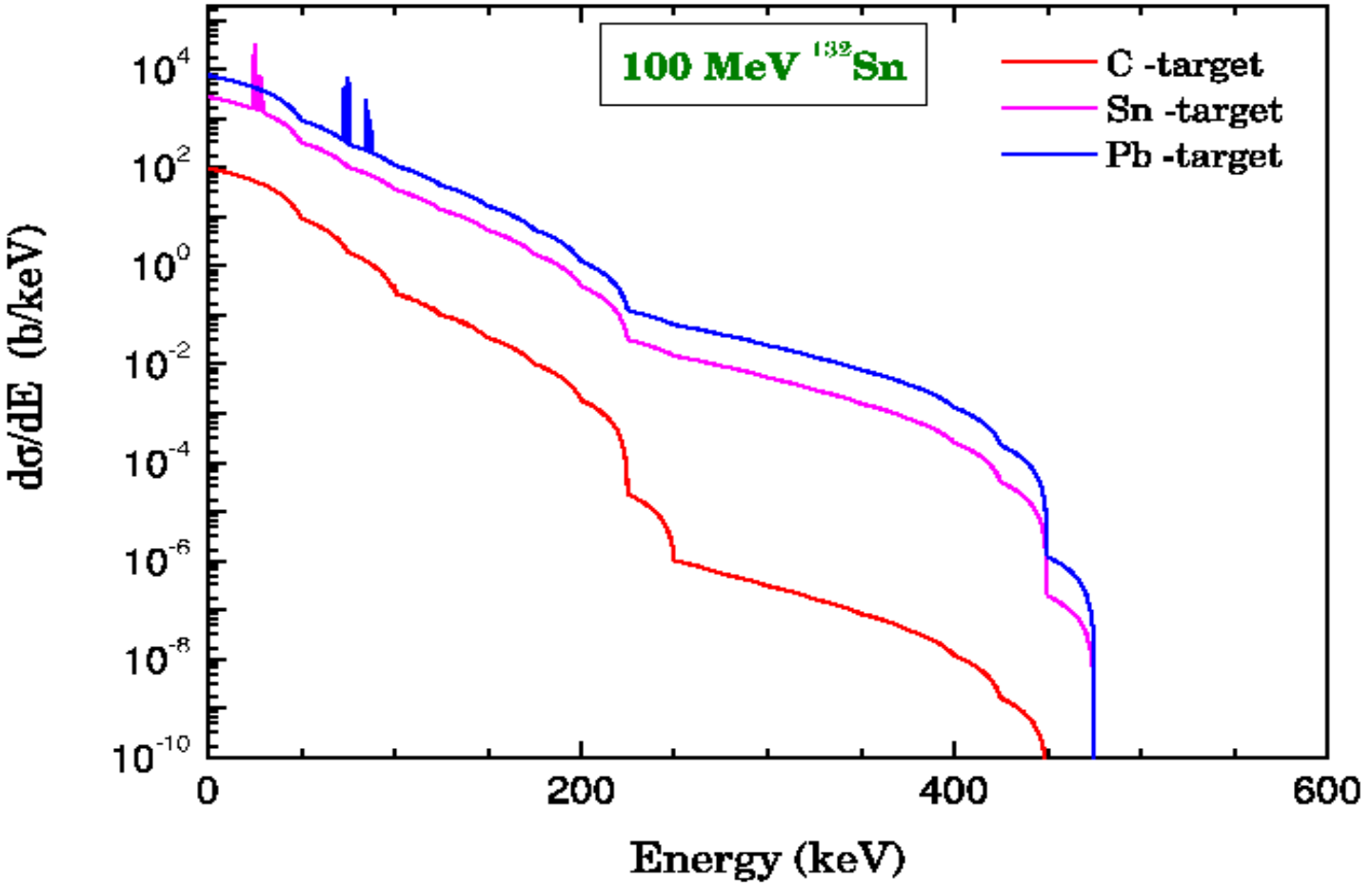
$$E_\gamma^{cm} = \gamma E_\gamma^{lb}(1-\beta \cos \theta^{lb})$$

XY-Target, XY-LYCCA DSSSD Wall, E_γ^{lb}(X,Y,Z)-AGATA → θ^{lb}

LYCCA TOF → β

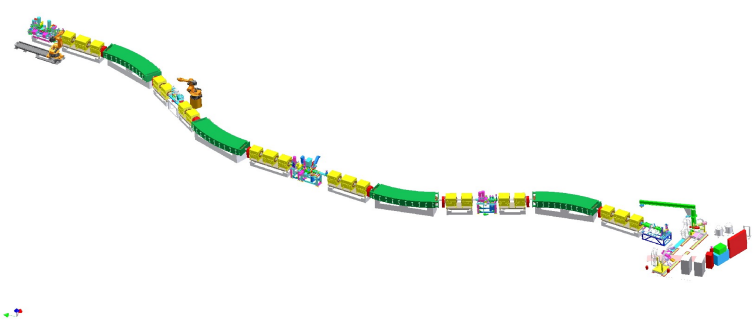
First order: $\beta_{FRS} = \beta + \text{const}$

Atomic background



Suppression with gate on ($T_{particle}$ – T_{γ})

PreSPEC-AGATA fast beam setup



Operation rates of tracking detectors

Detector	Max. Rate [pps]
X,Y: Multi-wire chambers	$<10^4$
X,Y: Current grids	$>10^8$
X,Y: TPC	$<10^6$
dE: MUSIC detectors	$<2\times10^5$
TOF: Scintillators	$<10^6$
Finger Scintillator	a few 10^6
DSSSD	a few 10^4