Beam tracking with LYCCA, Si performance

Lund

York

Cologne

Calorimeter

LYCCA: Detection principle

ToF-ΔE-E telescope for PreSpec @ FRS / HiSpec @ NUSTAR/FAIR

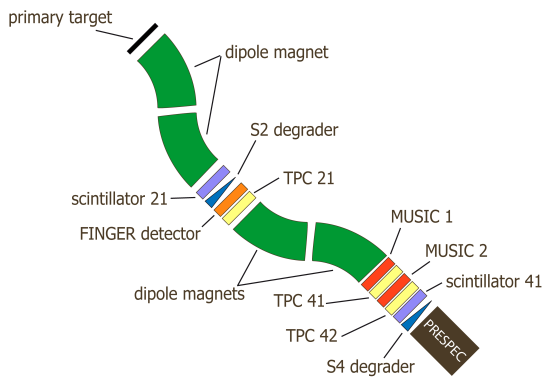
Main objective: event-by-event identification:

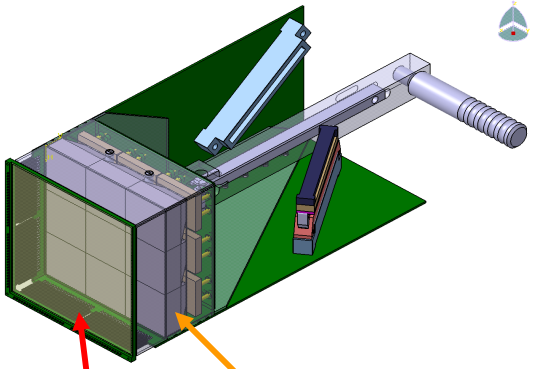
- **position** → **tracking**
- **ΔE & TKE** → **charge Z**
- **ToF & TKE** → **mass A**

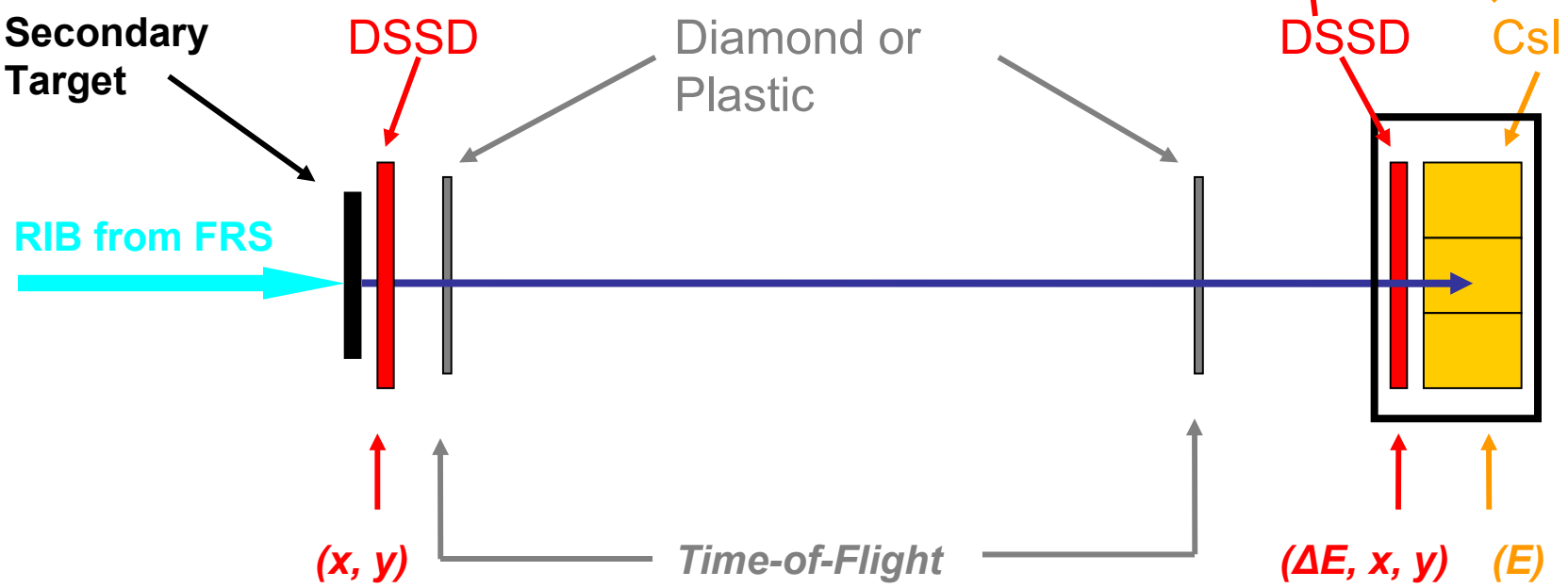
of fragmentation products after secondary target for particle energies 80-200 MeV/u

On October 14th 2008 the LYCCA TDR was approved by the FAIR scientific council based on the recommendation of the Head of Research of the FAIR Joint Core Team. It thus marks the **first** experiment related TDR of NuSTAR having received green light for construction.

LYCCA: Detection principle

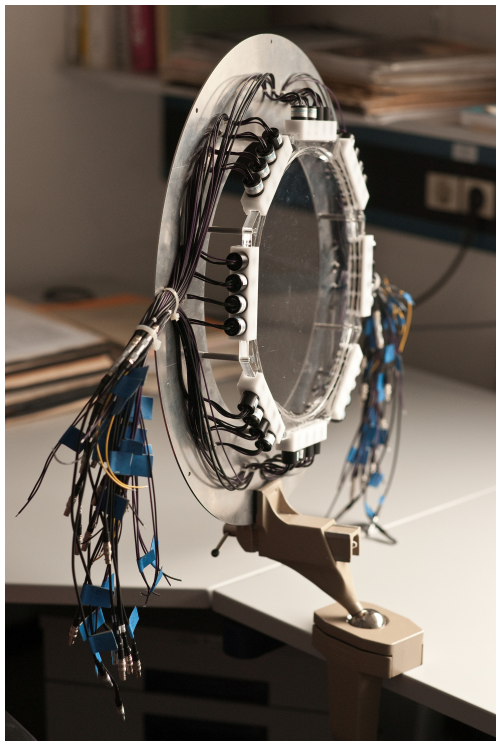




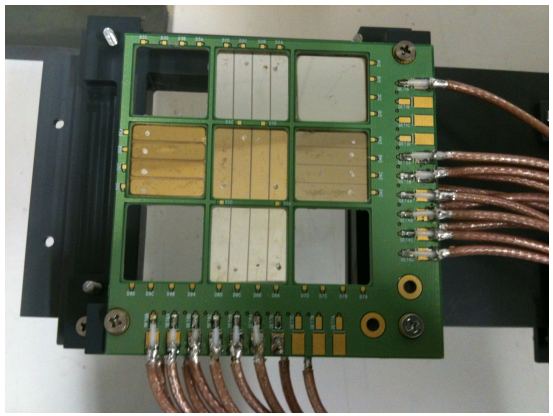


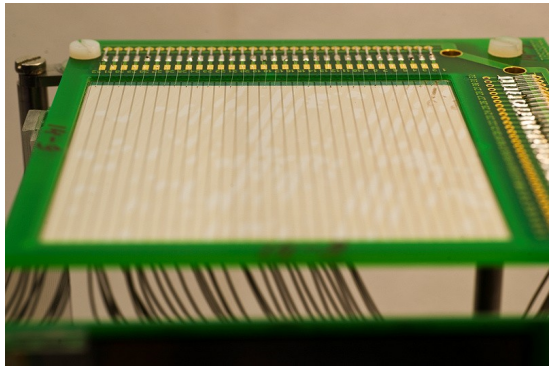
LYCCA: Detectors

ToF detectors:
2 plastic Scintillators

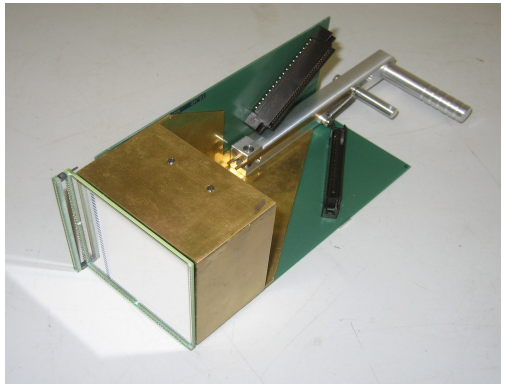


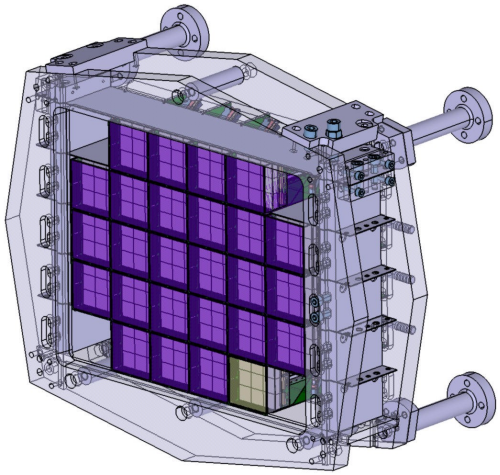
Target Station:
- DSSSD
- Diamond



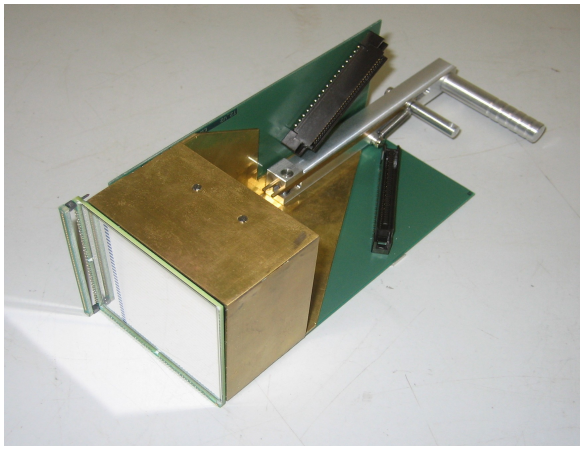


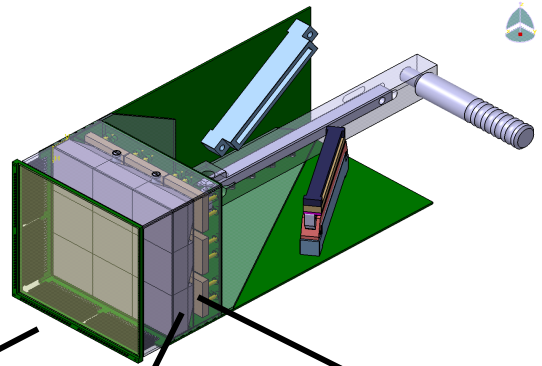
ΔE-E telescope:
DSSSD + 9 CsI





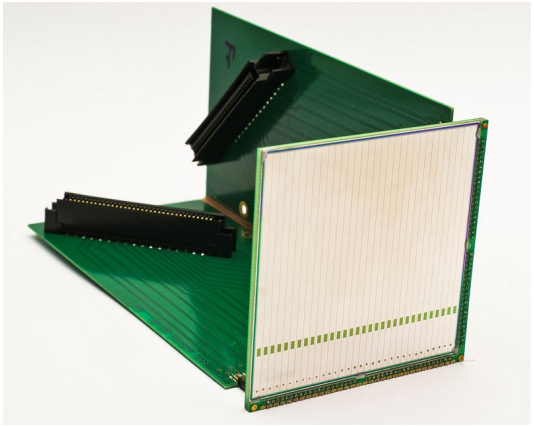
LYCCA: ΔE-E Telescope



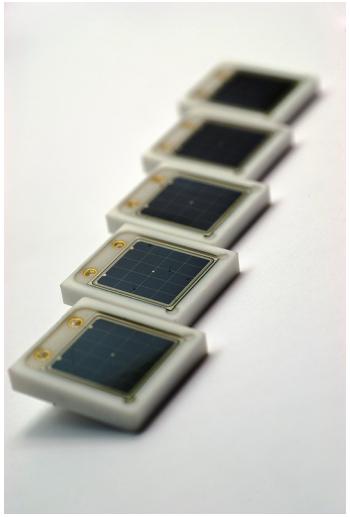


PD

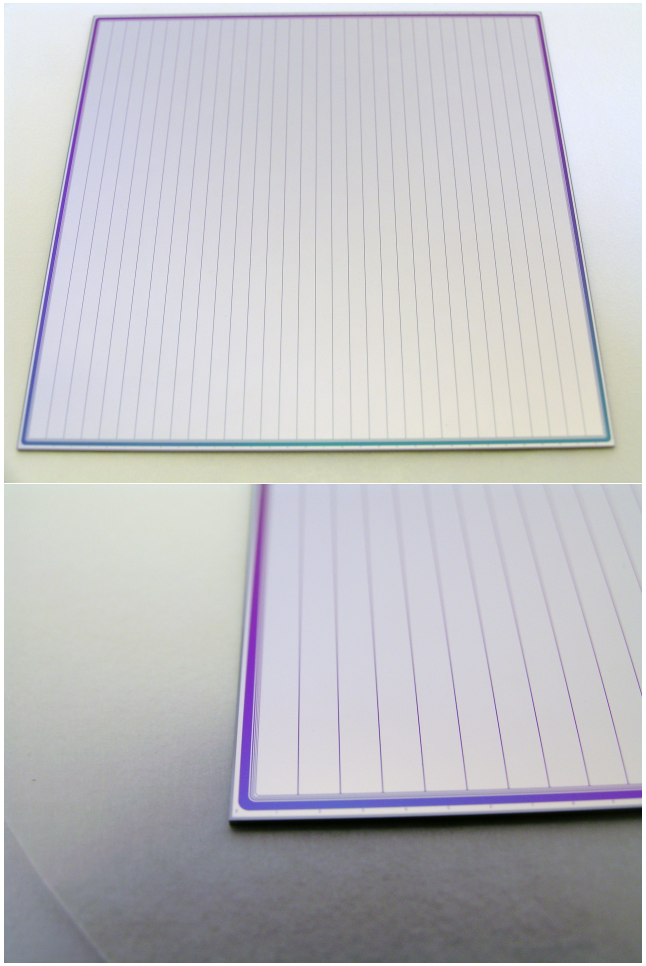
DSSSD



CsI



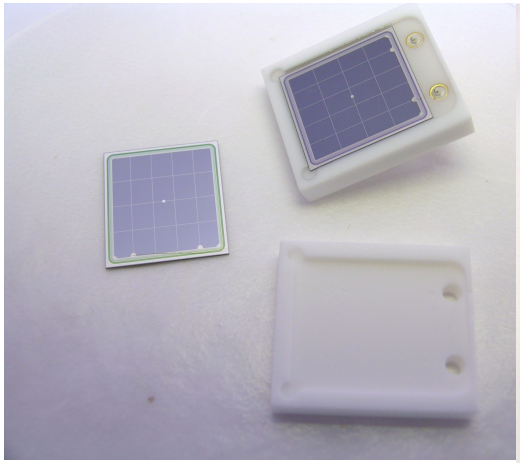
Silicon Detectors (LYCCA)

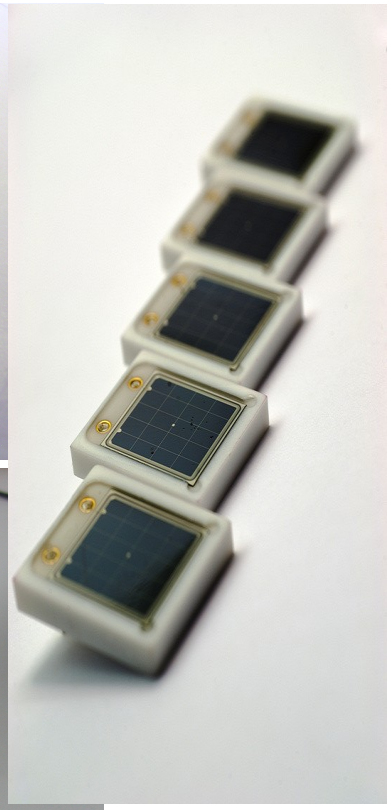


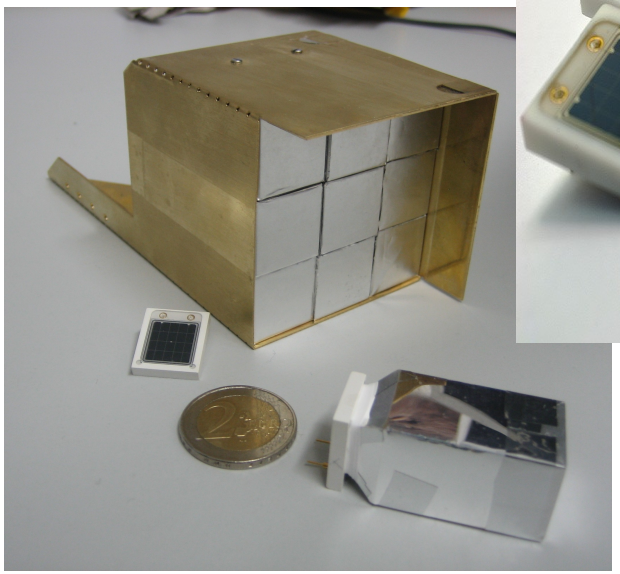
LYCCA 300 µm DSSSD

- Produced at RADCON Ltd., Zelenograd, Russia
- 1.4 – 1.6 k€/DSSSD
- Bonded to custom made frames at Lund
- 32 x 32 strips
- Nominal resistivity: 4.3 – **10** kΩ cm
- Wafer: N <100>
- Technology: Ion implanted, tot. Deplited, Multi-guard
- Dead layers: junction/ohmic – 0.5 ÷1.0/1.85 µm
- Active area size: 58.5 mm x 58.5 mm
- Chip size: 58.0 x 58.0 mm
- Inter strip distance: 75 µm
- Capacity: 33.12 pF/strip +
- Full depletion: ~ 50V
- Leakage current: 5-10 nA/strip
- Energy resolution: alpha 5.485 MeV, 25 keV/strip

Photodiodes: CsI(Tl) readout



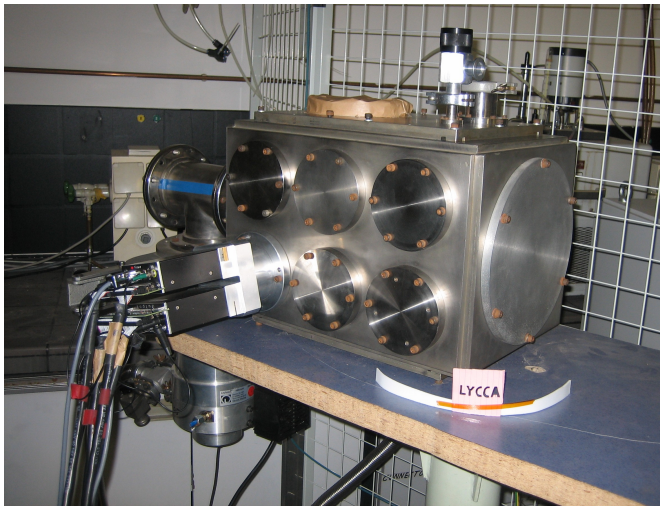




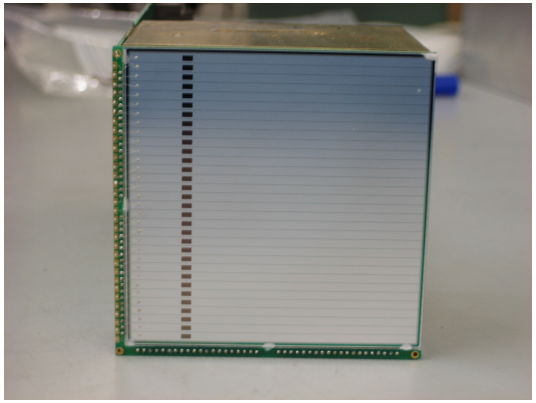
LYCCA Photodides

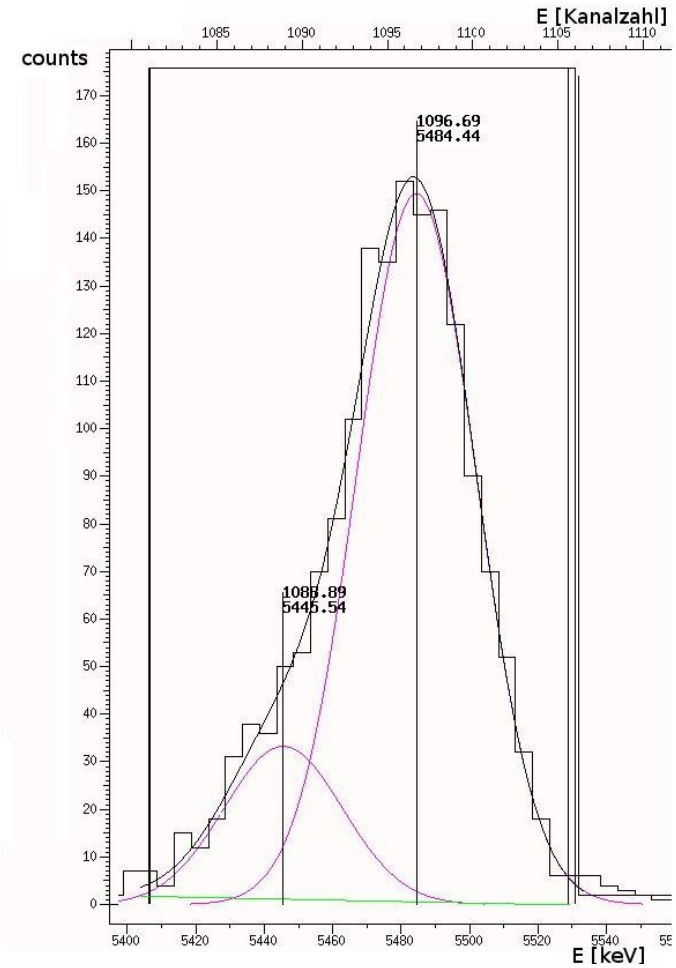
- Produced at RADCON Ltd., Zelenograd, Russia
- Doubleside thermobonding, Au wires
- Precision Ceramics Ltd.: frames
- PD mounting in Lund
- CsI(Tl)/PD assembling and testing in Lund
- Nominal resistivity: 6 – **7.5** kΩ cm
- Wafer: N <100>
- Technology: Ion implanted, tot. Deplited, Multi-guard
- Dead layers: junction/ohmic – 0.06/0.6 μm
- Spectral response range 320-1060 nm
- Peak sensitivity: 920 nm
- Quantum efficiency (for 560 nm) ~82-86%
- Active area size: 10.6 mm x 11.6 mm
- Chip size: 12.4 x 13.4 mm
- Full depletion: ~ 50V
- Leakage current: 1-2 nA
- Capacitance (full deplition): 38-40 pF

Acceptance tests: DSSSD



Test chamber





FWHM: 41 keV @ 5484 keV
~ 0,75 % (^{241}Am)

Electronics

32ch - CSP

Charge Sensitive Preamplifier **Series CSP_07**

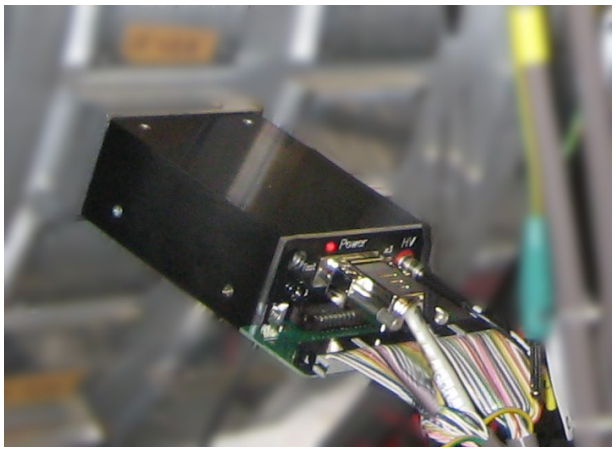
Specification

Dynamic Range: 5 GeV equivalent Si detectors CSP_07(5GeV)
200 MeV equivalent Si detectors CSP_07(200MeV)

Number of Channels: 32

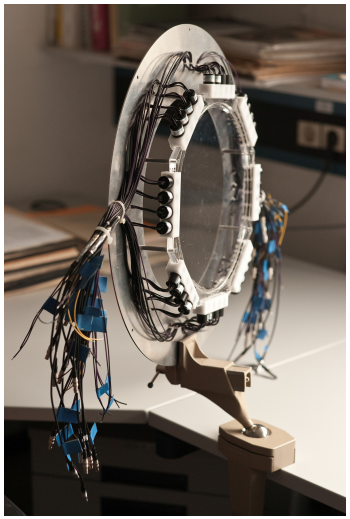
Noise: ~ 3.5 keV (Si) + 0.05 keV / pF (detector capacity)

Sensitivity: ~ 50 mV (+/- 20%) / 200 MeV differential, terminated * (5 GeV vers.)
~ 50 mV (+/- 20%) / 5 MeV differential, terminated * (200 MeV vers.)
~ Range switch: x1, x3 *(optionally x1; x4 or x5 ..)

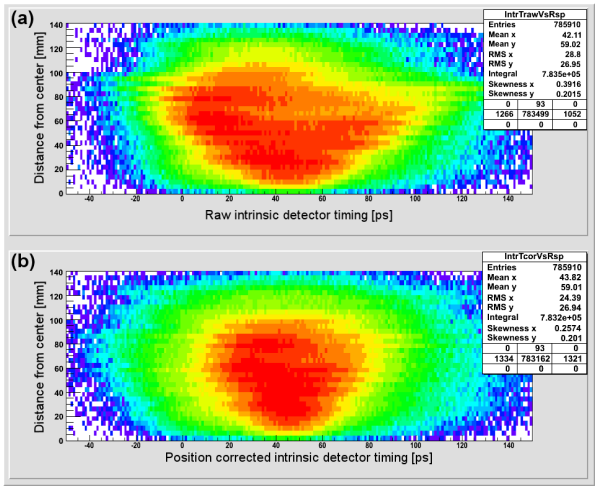


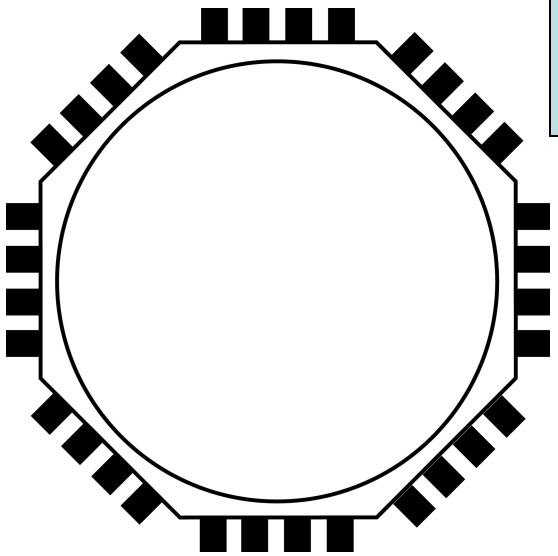
- AIDA FEE readout card for LYCCA DSSSD readout *(I. Lazarus)*
- FEBEX Sampling ADC *(N.Kutz)*

LYCCA: fast timing (plastic)



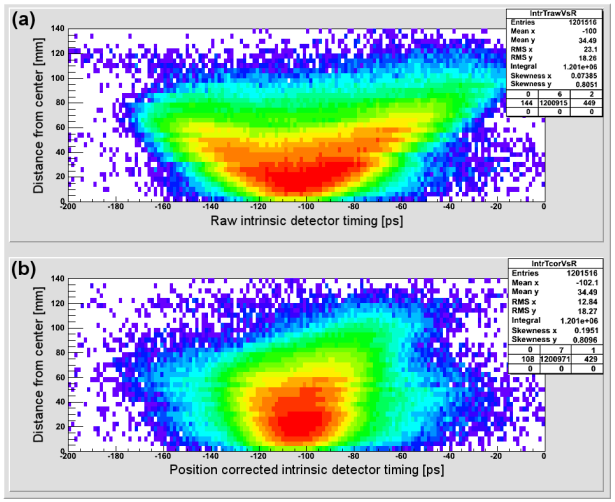
Ni-beam results:
σ=14.4 ps (without pos. cor.)
σ=12.2 ps (with pos. cor.)
Intrinsic resolution across whole area



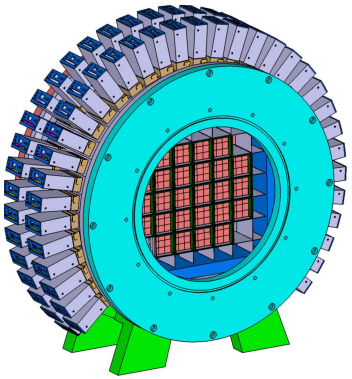


- 32 fast PMTs (R7400U)
- Fast plastic scintillator (BC-420)

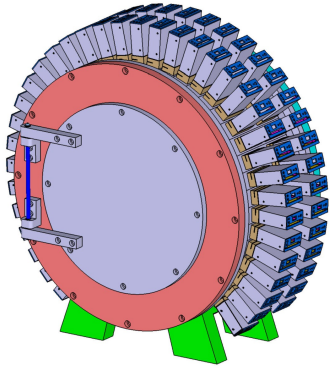
Xe-beam results:
σ=11.6 ps (without pos. cor.)
σ=6.4 ps (with pos. cor.)
Intrinsic resolution across whole area



LYCCA-0 mechanics



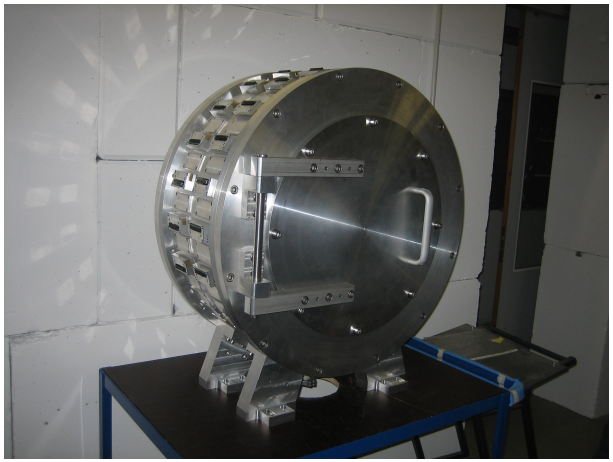
(front)



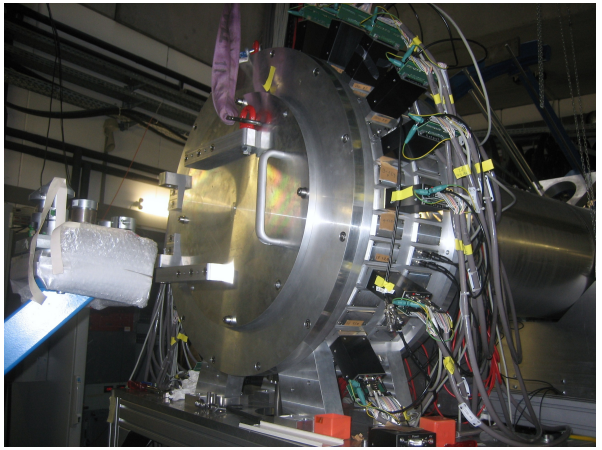
(back)

LYCCA chamber:

- up to 72 KEL-Feethroughs
- 32 SHV+Lemo-FT



(Chamber @ X7)



(Chamber @ S4)

LYCCA commissioning and experiments

Mar 2010 | Sept./Oct 2010 | Oct.10-May 11 | 2012/13

Test @ S272
I.Tanihata et al.

LYCCA-0 Comissioning @ FRS

- ^{64}Ni / ^{63}Co (17.-24.09)
- ^{86}Kr (13.-17.10)

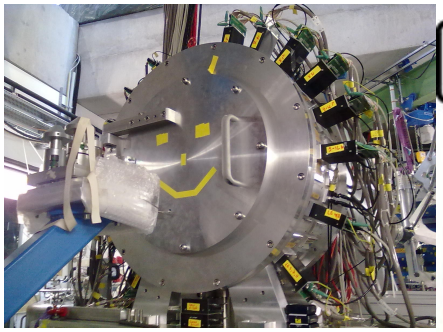
PreSpec I @ FRS

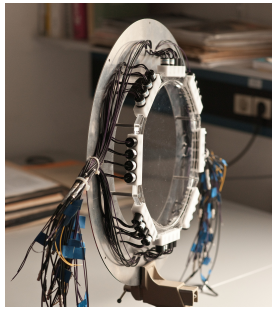
Experiments:

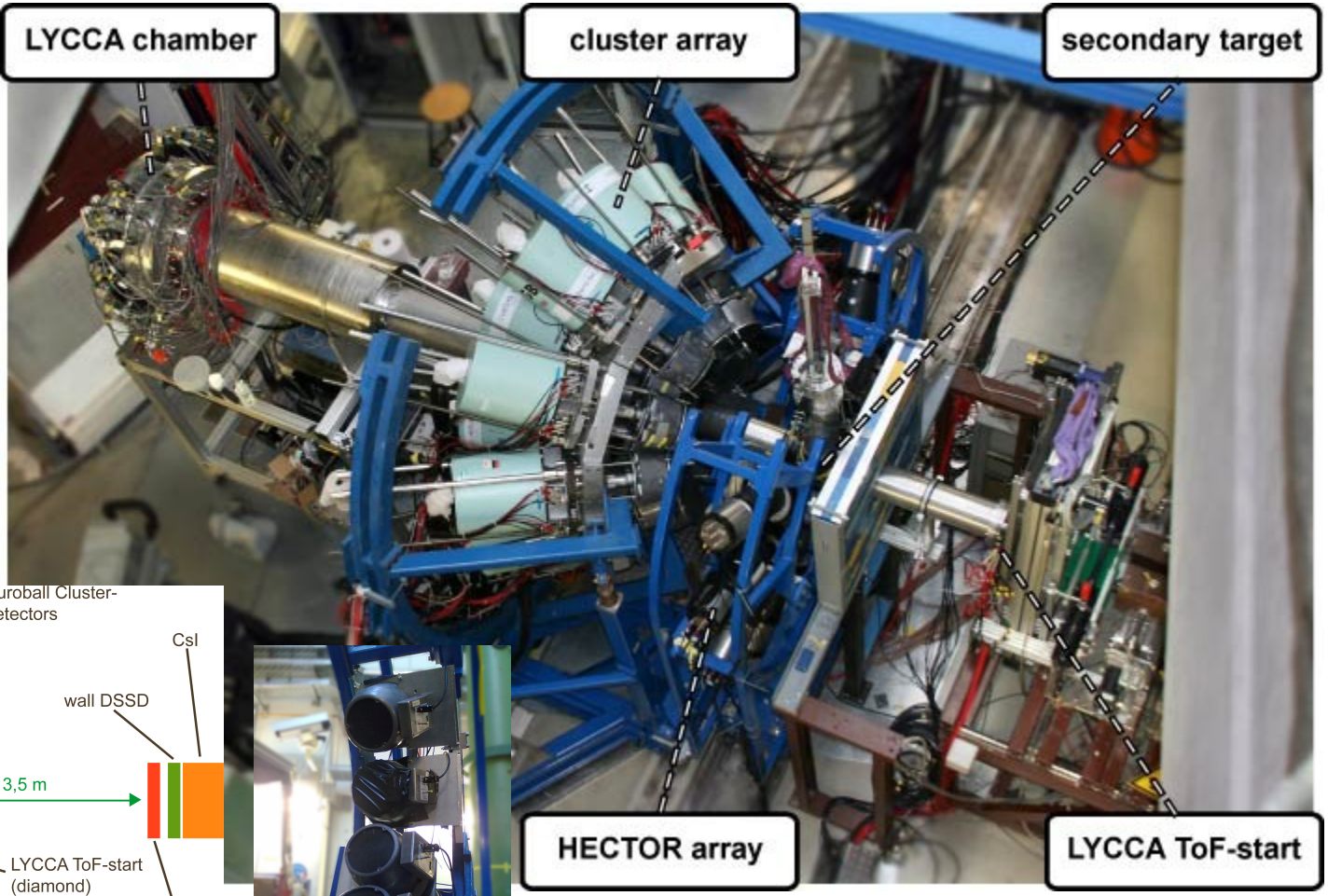
- **^{88}Kr (10/2010) S369**
  Jolie et al.
- **^{104}Sn (11/2010) S392**
  Cederkall, Gorska et al.
- **^{36}Ar (05/2011) S377**
  Reiter et al.

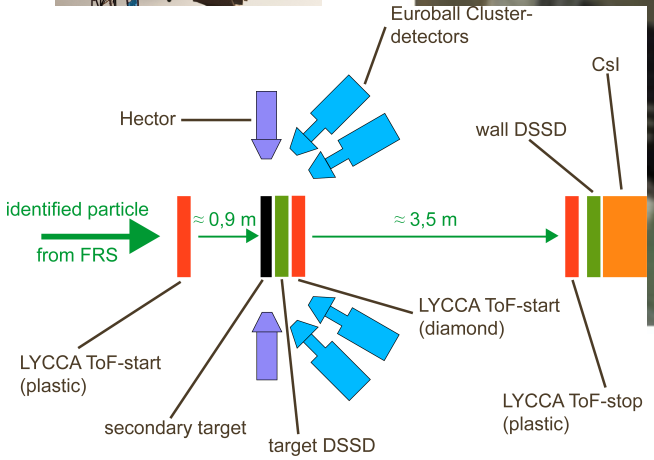
AGATA @ FRS

LYCCA first experiments



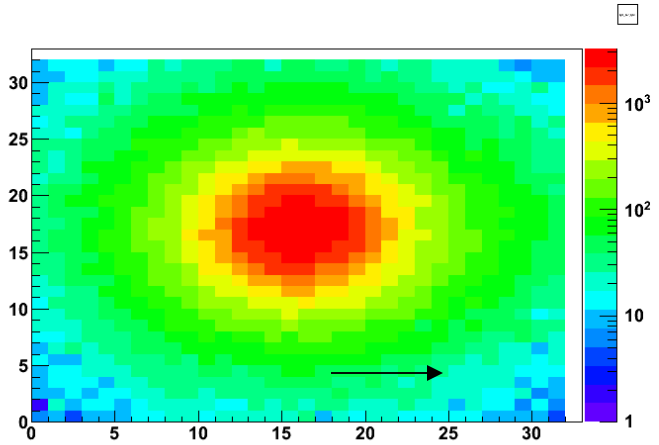




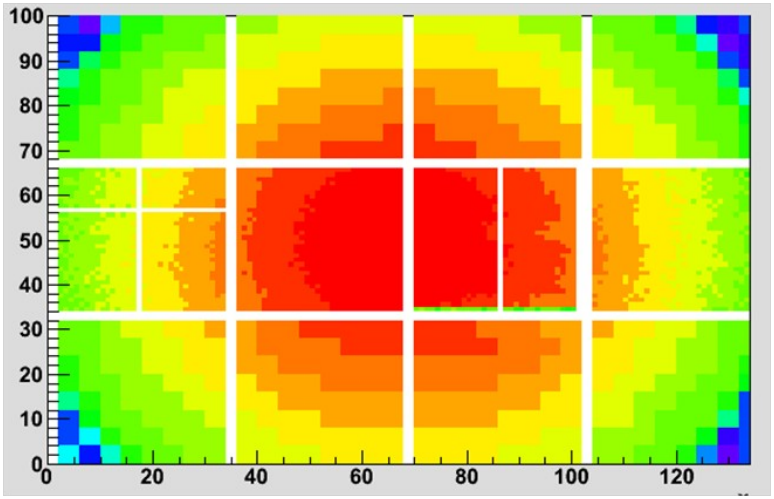


LYCCA Hitpattern

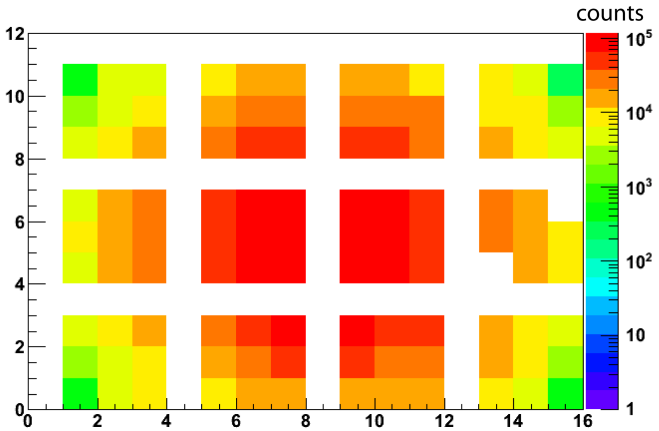
Target DSSSD



LYCCA Si Wall

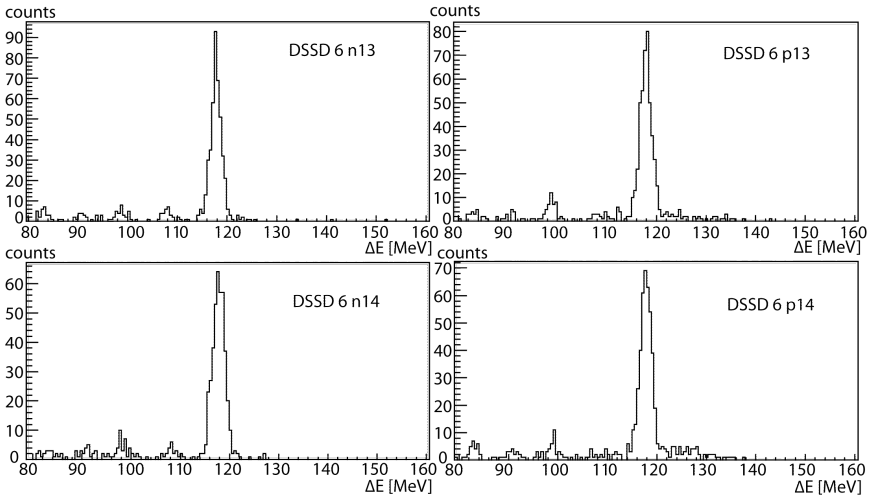


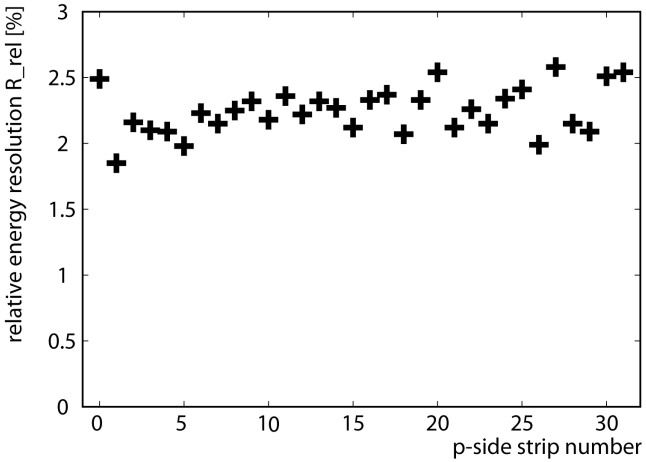
LYCCA CsI Wall

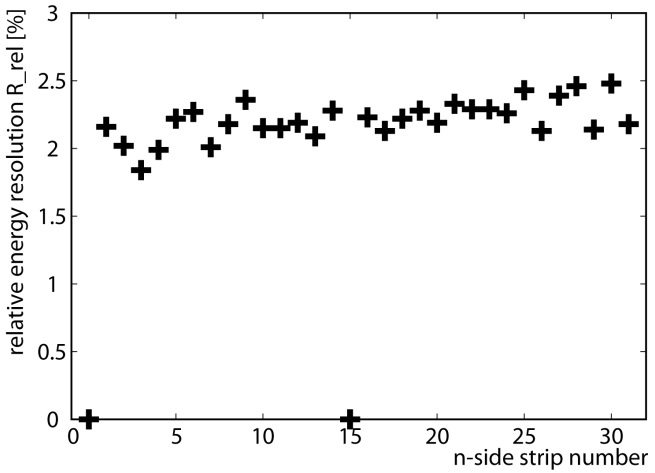


LYCCA: DSSSD energy resolution

- In-beam: ^{36}Ar, primary beam, FRS ID
- energy loss 117,8 MeV
- $\langle R_{Si_p} \rangle = 2.25 \pm 0.18\%$
- $\langle R_{Si_n} \rangle = 2.10 \pm 0.21\%$
- beam energy spread -> cut on $\Delta\beta_{LYCCA}$

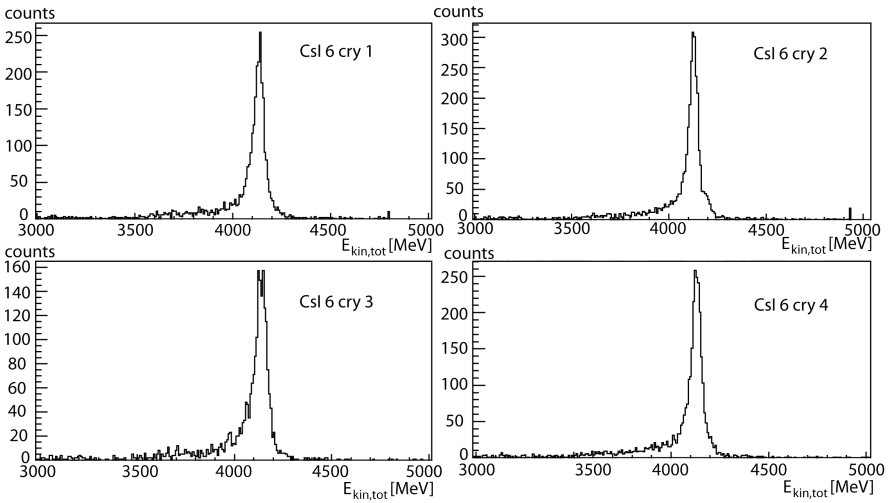


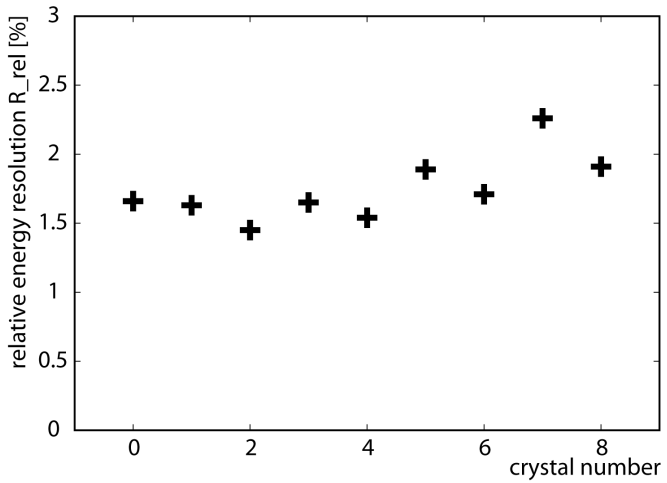




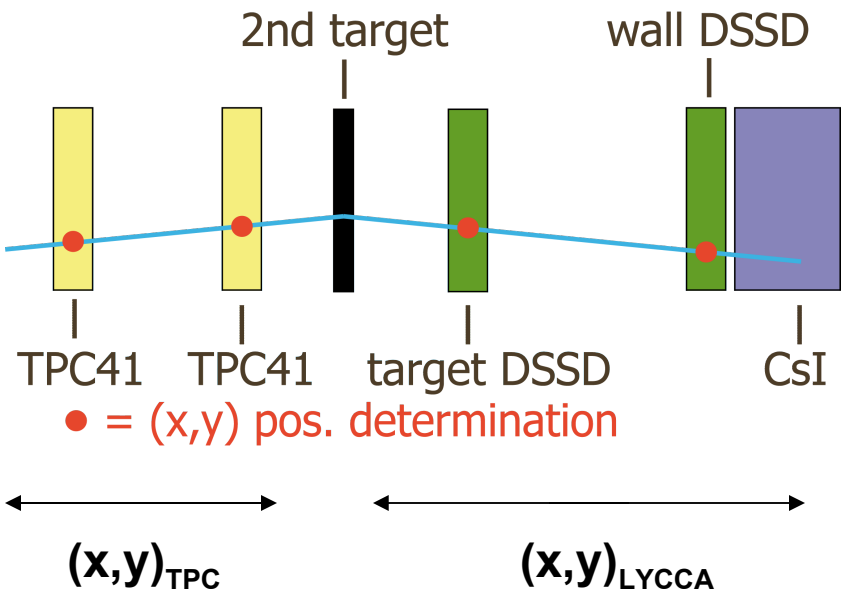
LYCCA: CsI/PD energy resolution

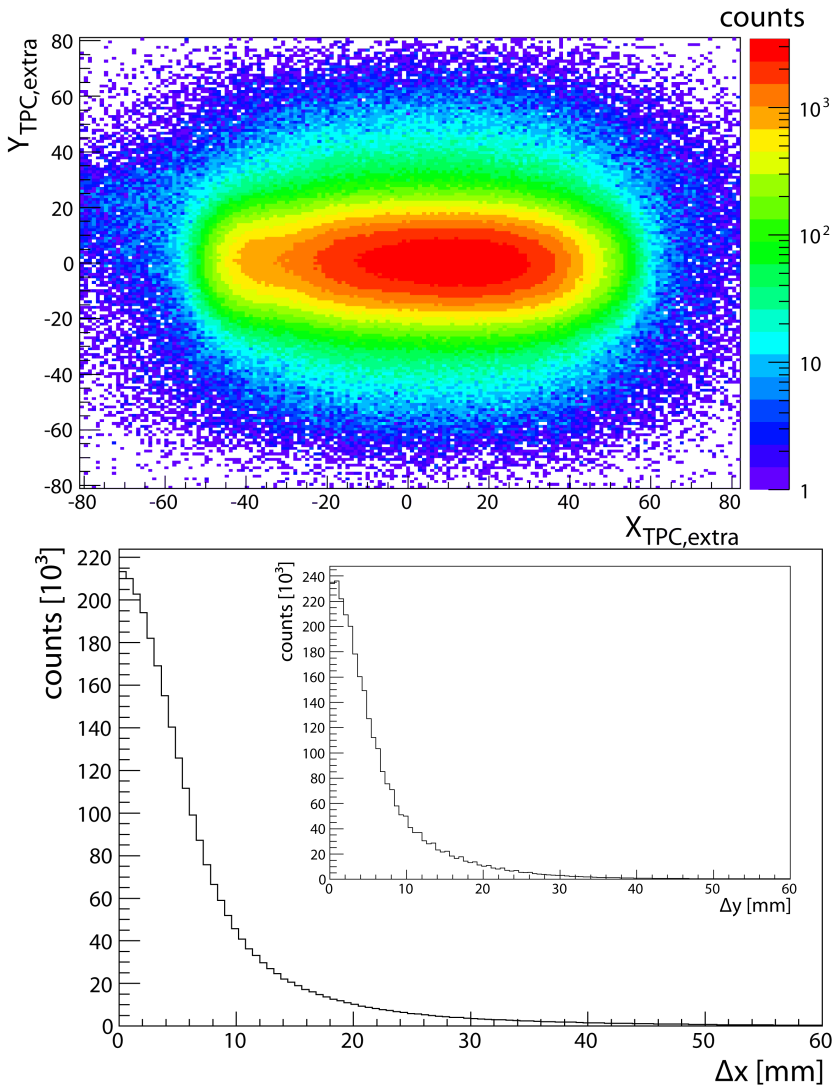
- In-beam: ^{36}Ar, primary beam, FRS ID
- energy deposition 4.151 GeV
- $<R_{CsI}>=1.84\pm0.37\%$
- beam energy spread -> cut on $\Delta\beta_{LYCCA}$





LYCCA: Tracking accuracy

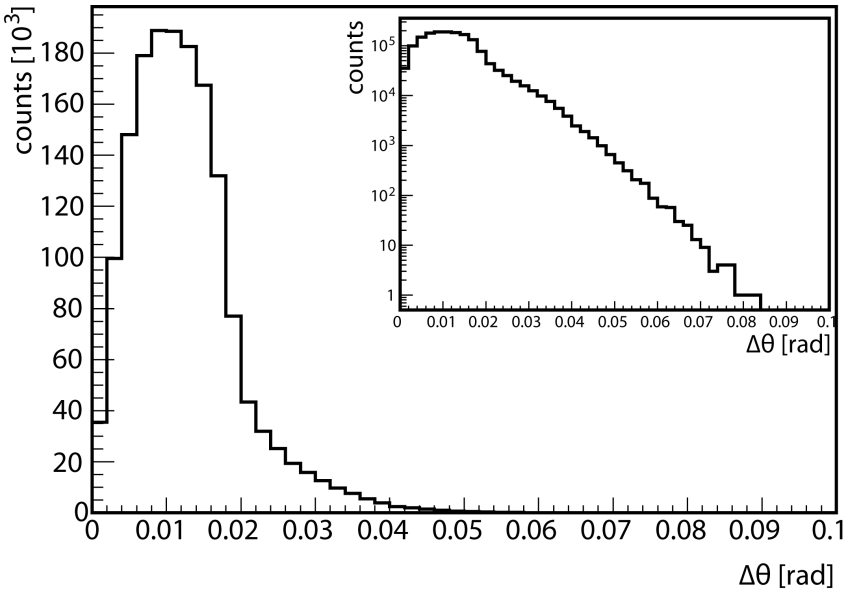




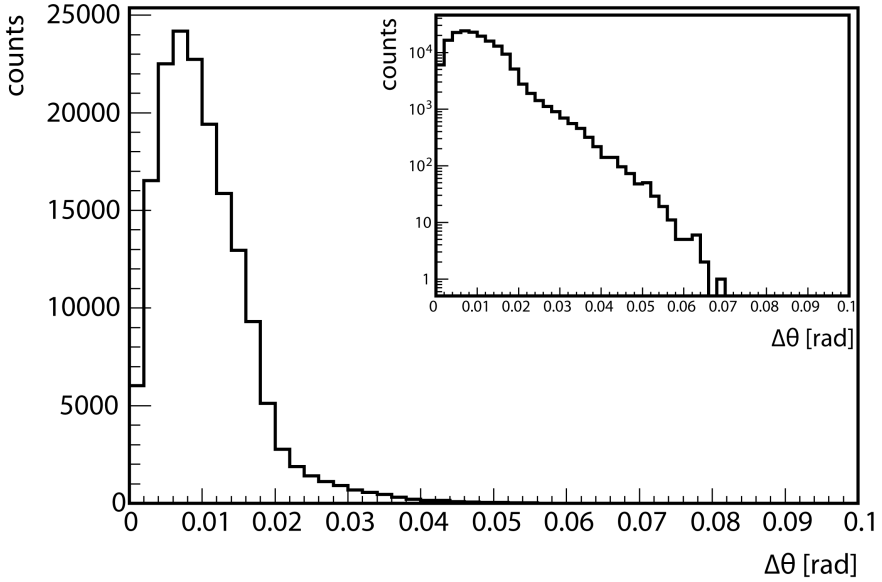
Tracking for in-beam γ-spectroscopy experiments:

- Scattering angle (corr. for ToF, reaction channel)
- Doppler correction (pos. sensitive Ge + particle tracking)

Tracking: angular change ^{84}Kr



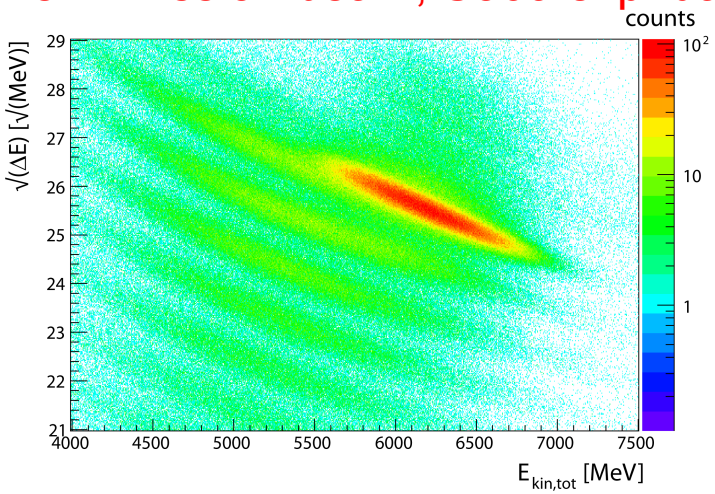
Particle - γ corr. trigger



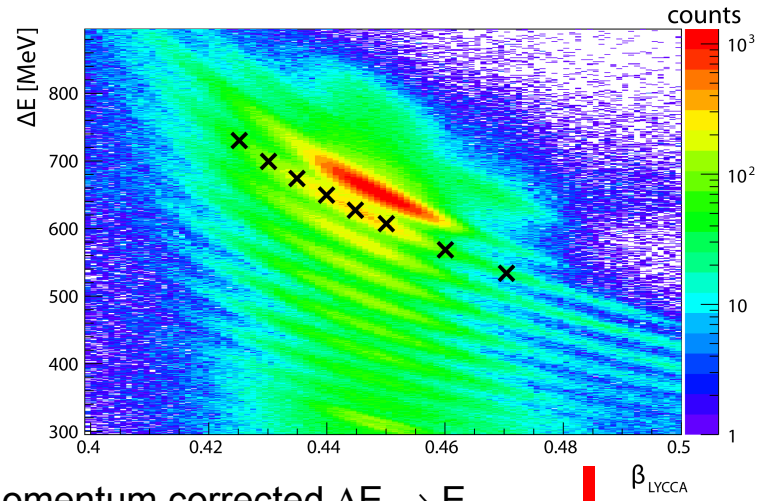
Particle trigger

LYCCA: Z Identification

84Kr fission beam, S369 exp. data

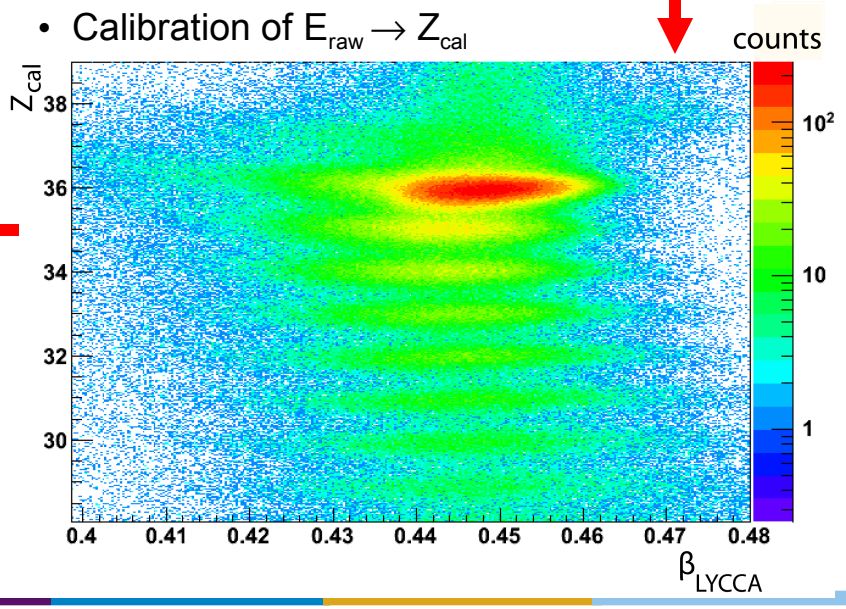


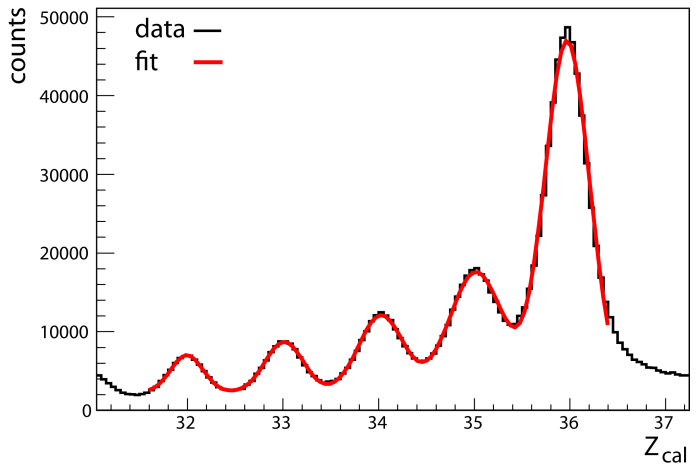
• ΔE vs $\Delta\beta_{LYCCA}$



• momentum corrected ΔE → E_{raw}

• Calibration of $E_{raw} \rightarrow Z_{cal}$

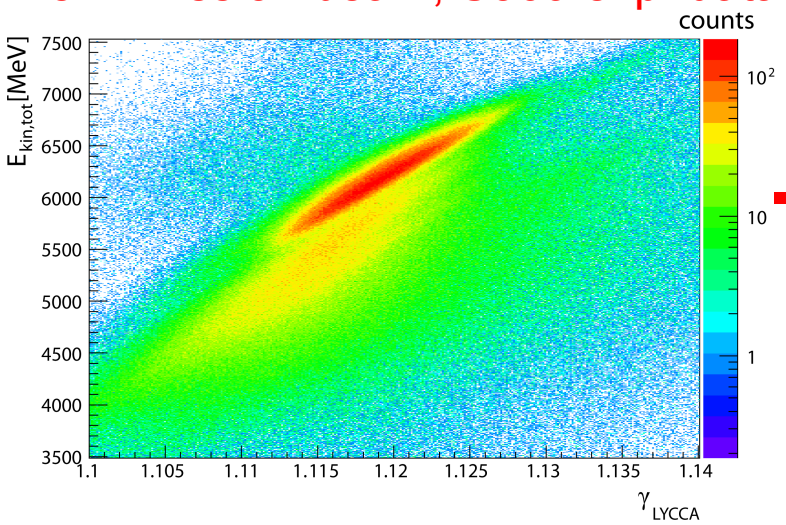




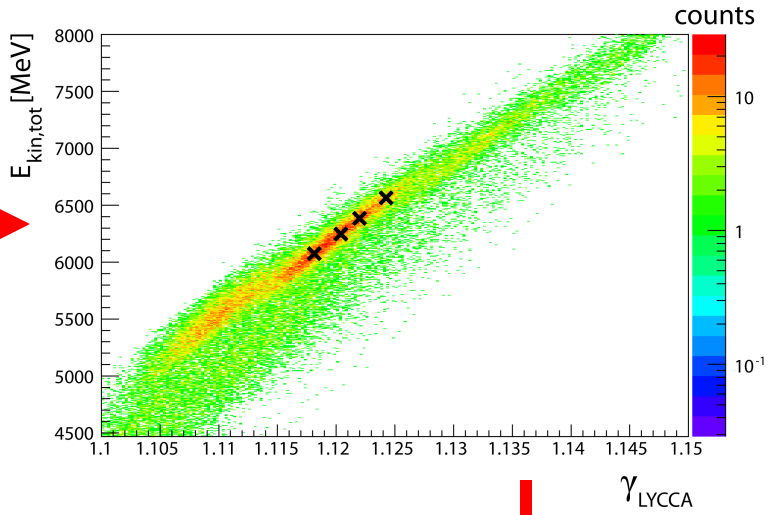
$\Delta Z = 0.55 \pm 0.07$ for $33 \leq Z \leq 36$

LYCCA: A Identification

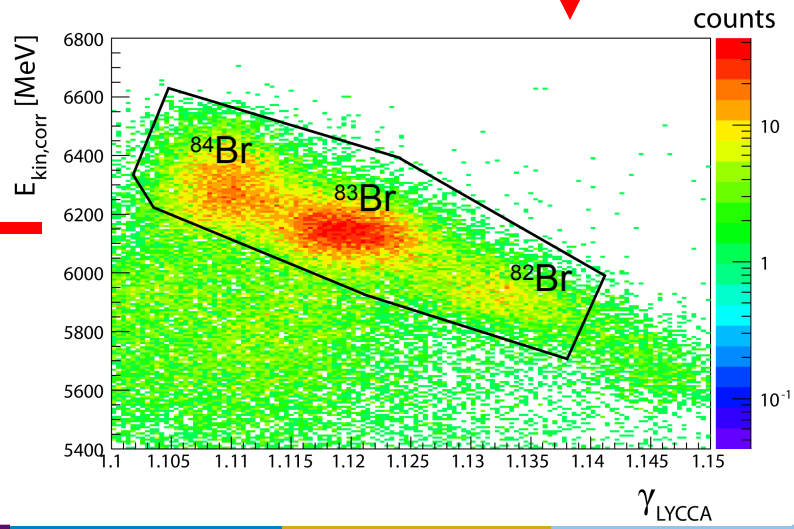
84Kr fission beam, S369 exp. data



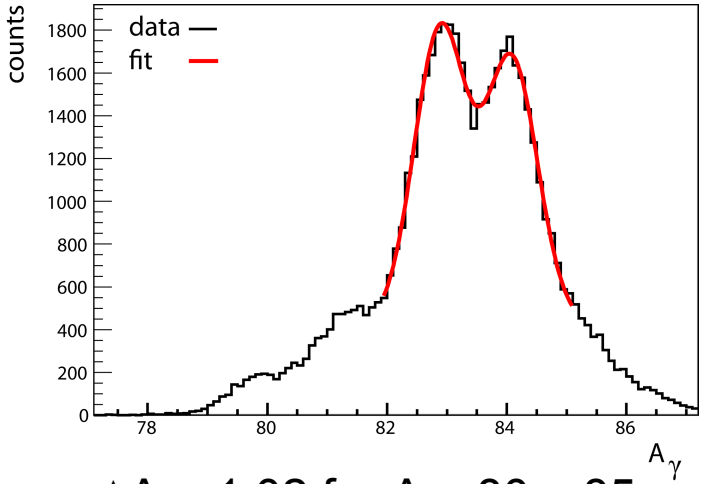
FRS gate: Z=35



Ekin,tot moment corr



Mass calibr.



$\Delta A = 1.02$ for $A \sim 80 \div 85$

Summary

LYCCA:

- LYCCA calorimeter array was successfully put into operation @FRS-S4 focal plane
- In beam commissioning
- First three PRESPEC experimens used LYCCA for particle ID after secondary TA
- LYCCA meets its specs, integrated into PRESPEC setup
- LYCCA capabilities of tracking, Z and A ID after secondary TA
- TA DSSSD tracking is cross-checked against TPCs
- Doppler correction
- LYCCA will be essential part of the upcoming AGATA @GSI experiments
- 30 modules production for FAIR