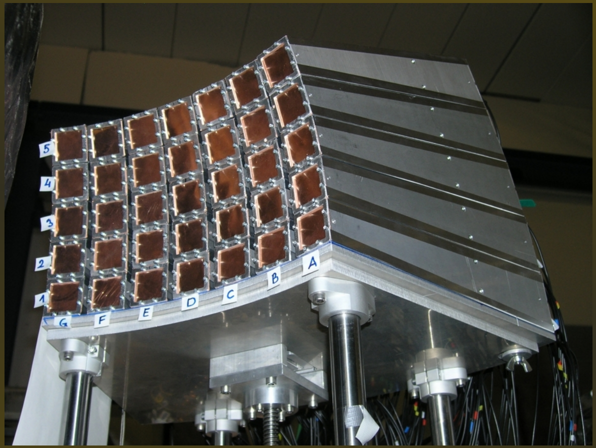
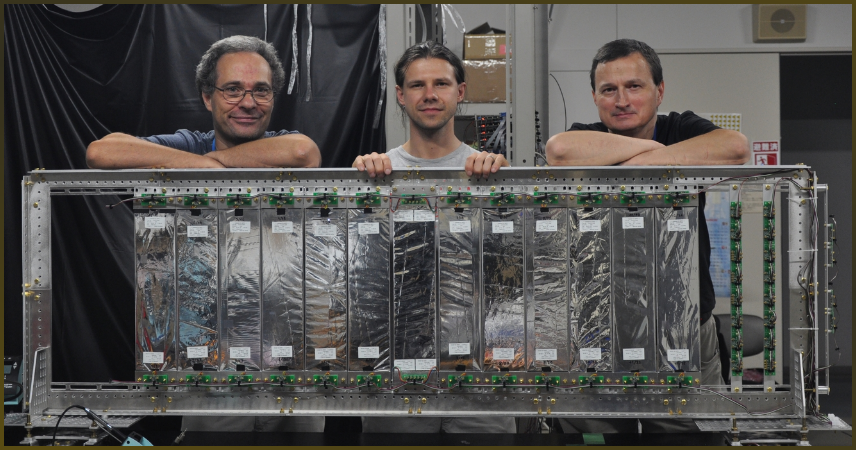
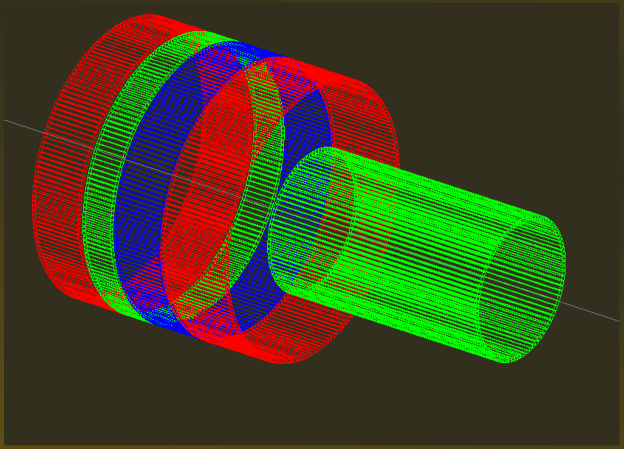
KRATTA



KATANA



KRAB



NUSYM17, GANIL
Caen, 4-7.09.2017

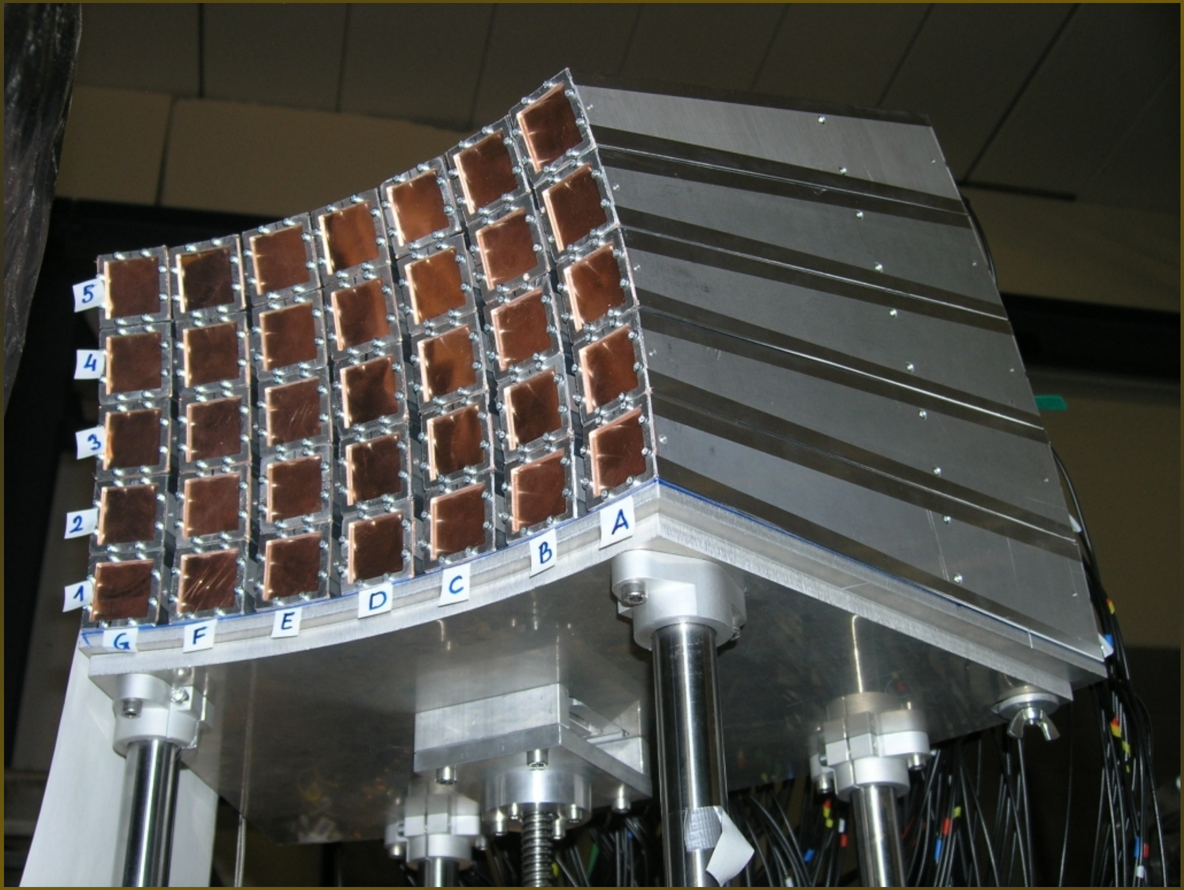
Work supported by Polish Ministry of Science and Higher Education, grant No. DPN/N108/GSI/2009 and by Polish National Science Center, contract Nos. UMO-2013/10/M/ST2/00624, UMO-2013/09/B/ST2/04064

Jerzy Łukasik
IFJ PAN Kraków, Poland

Outline

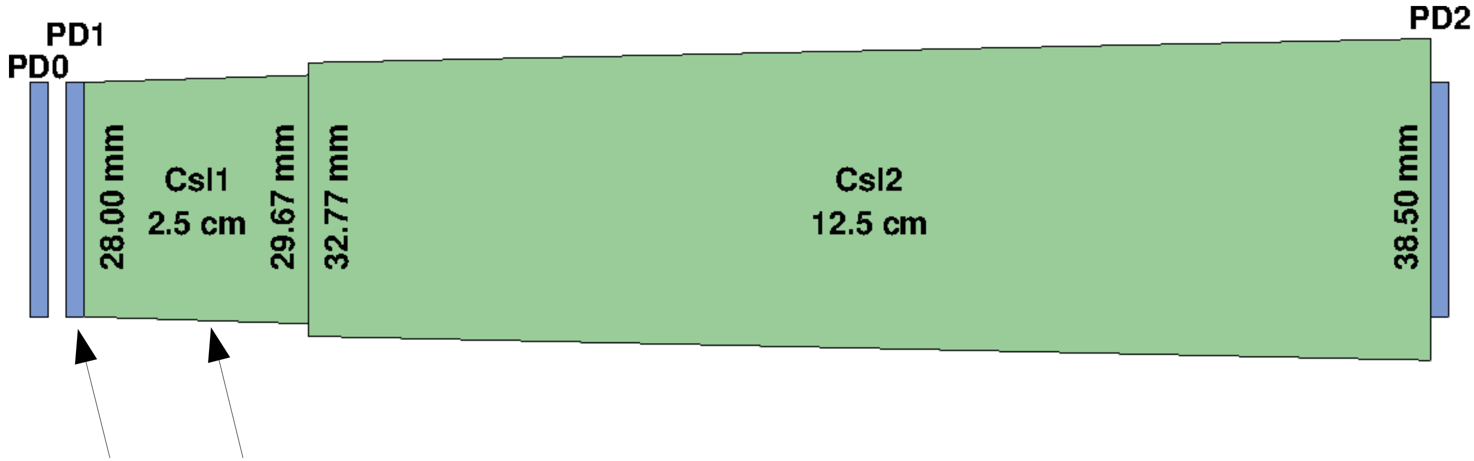
- Main characteristics and properties
- Performance
- Some results
- Possible improvements

KRATTA



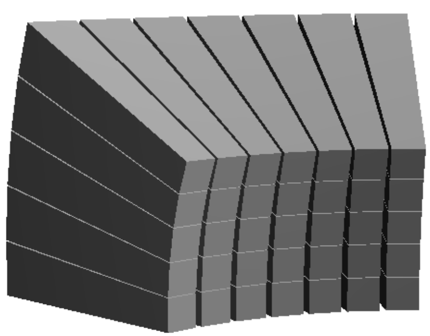
KRAków Triple Telescope Array

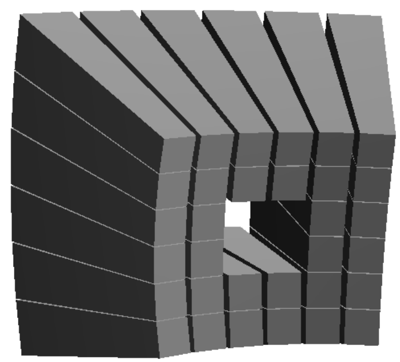
Active elements

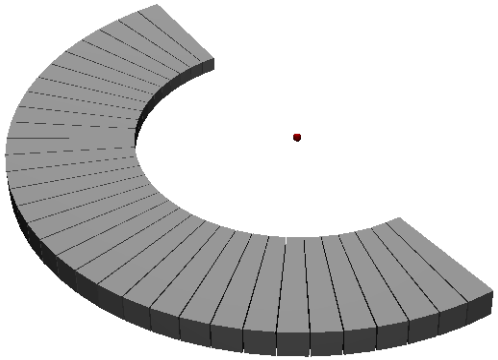


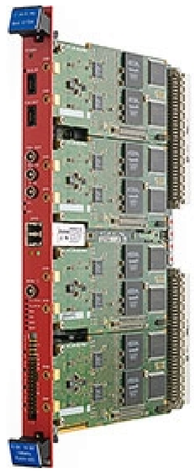
PD1 + CsI1 = SCT (Single Chip Telescope) [G. Pasquali et al. NIMA 301(91)101]

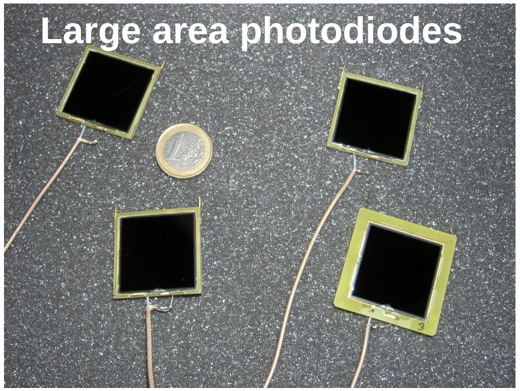
J. Łukasik et al., NIMA 709 (2013) 120

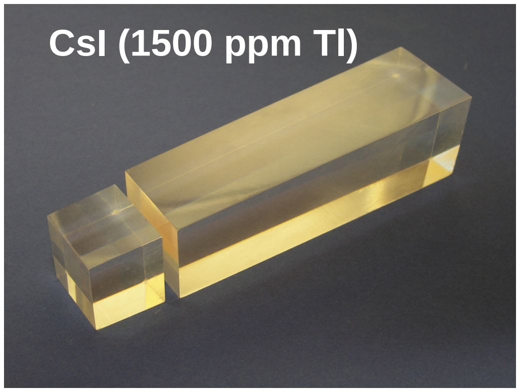


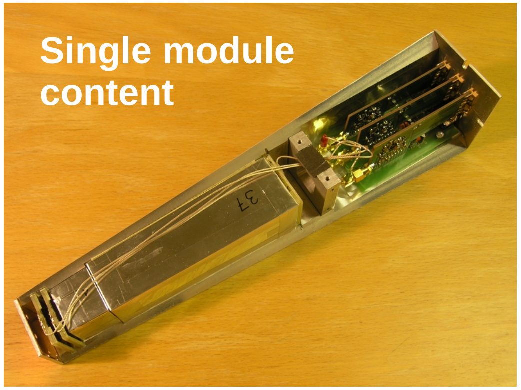




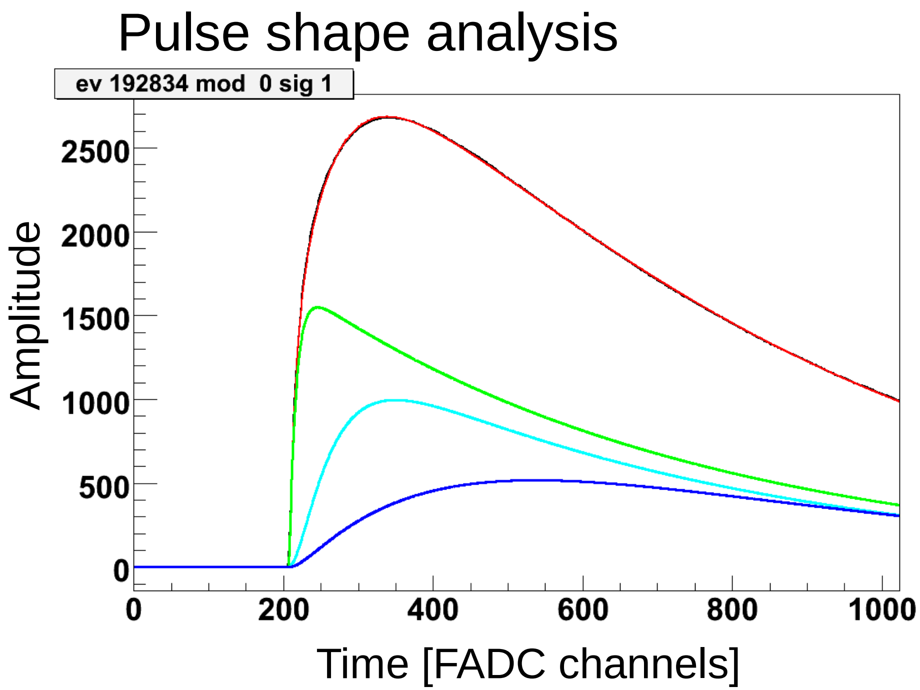


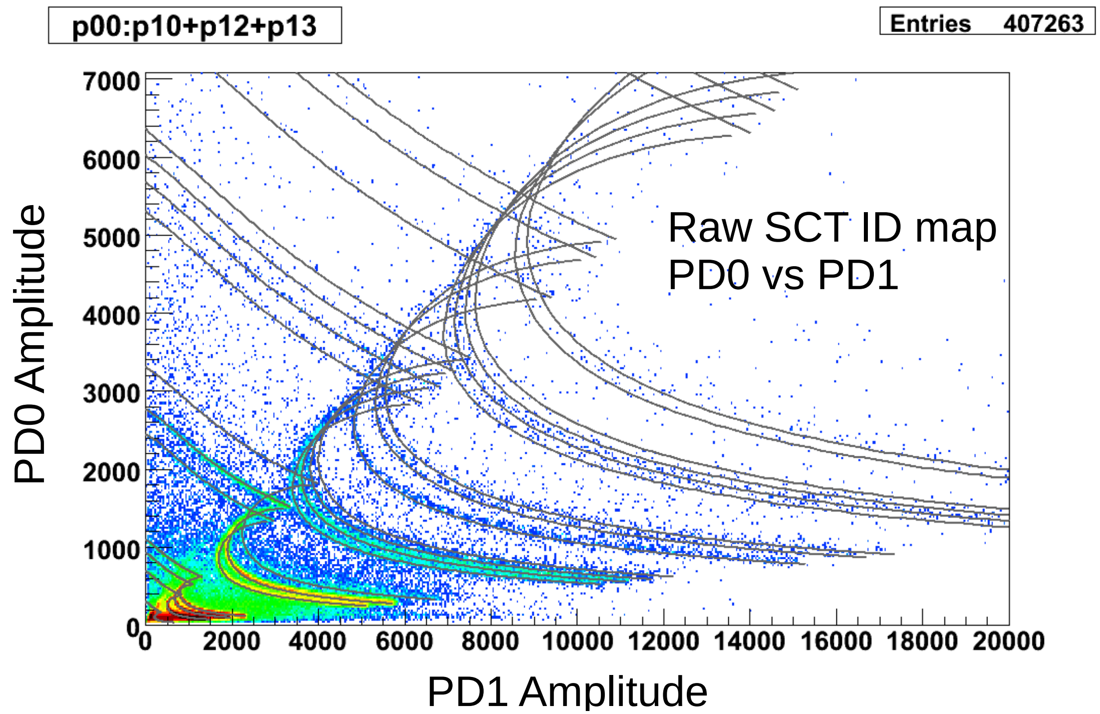


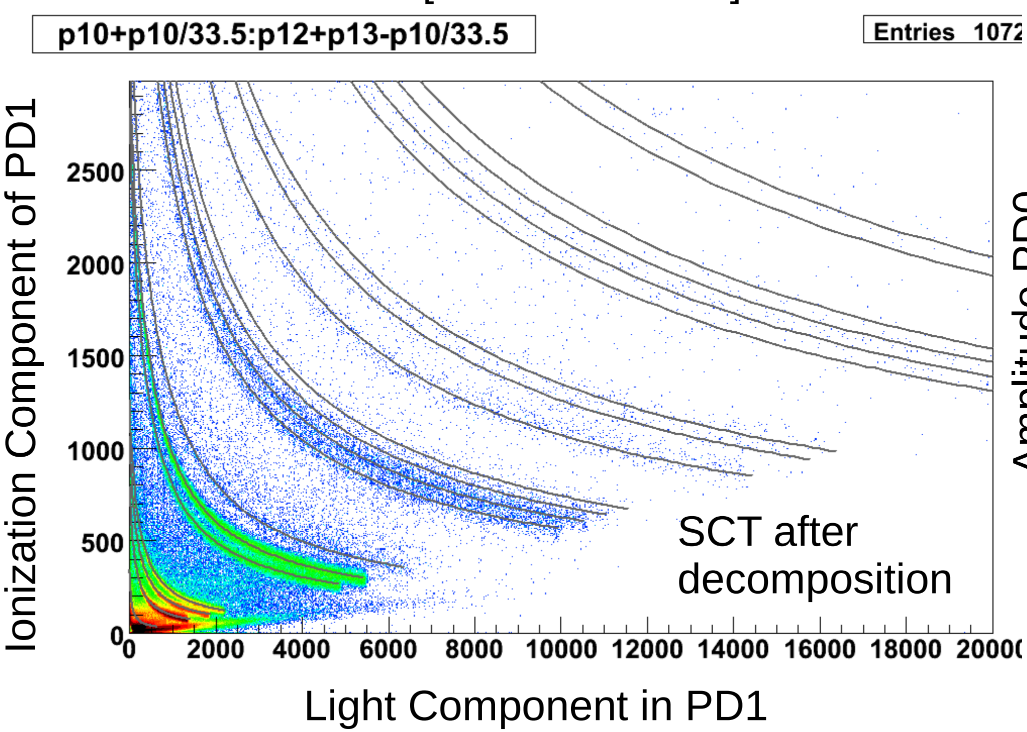


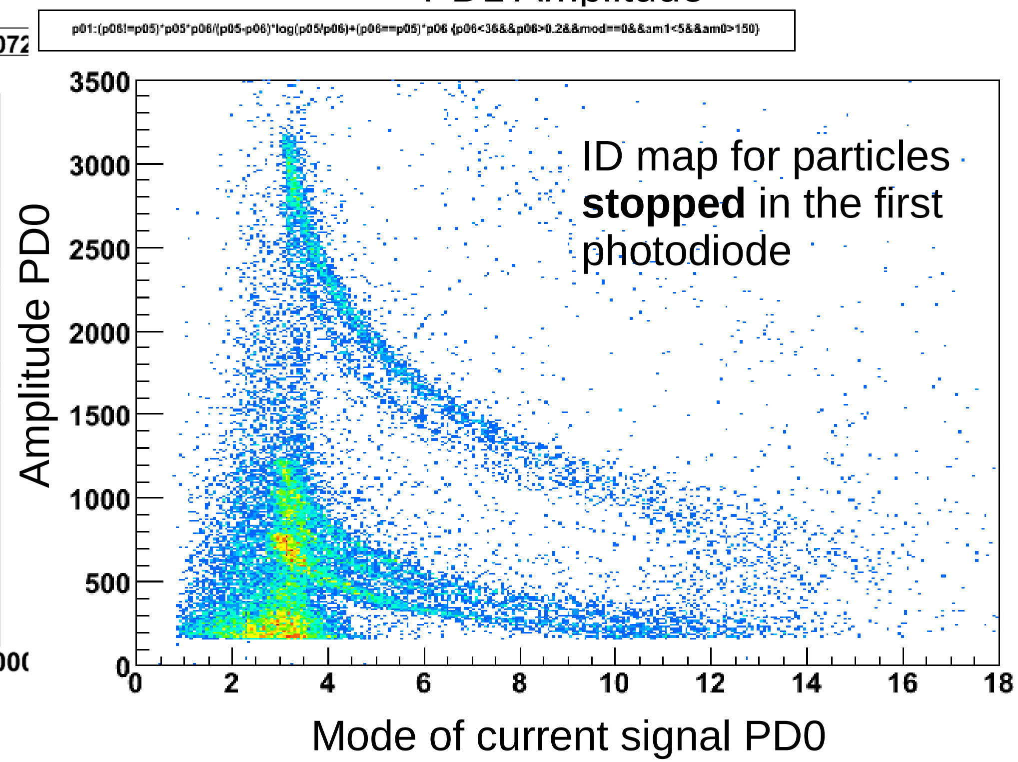


Performance

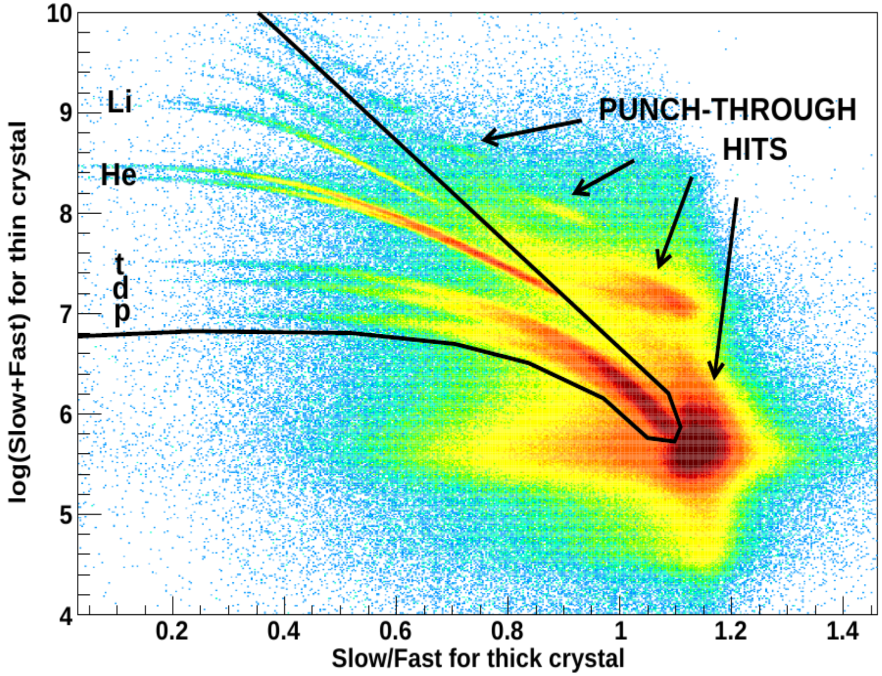


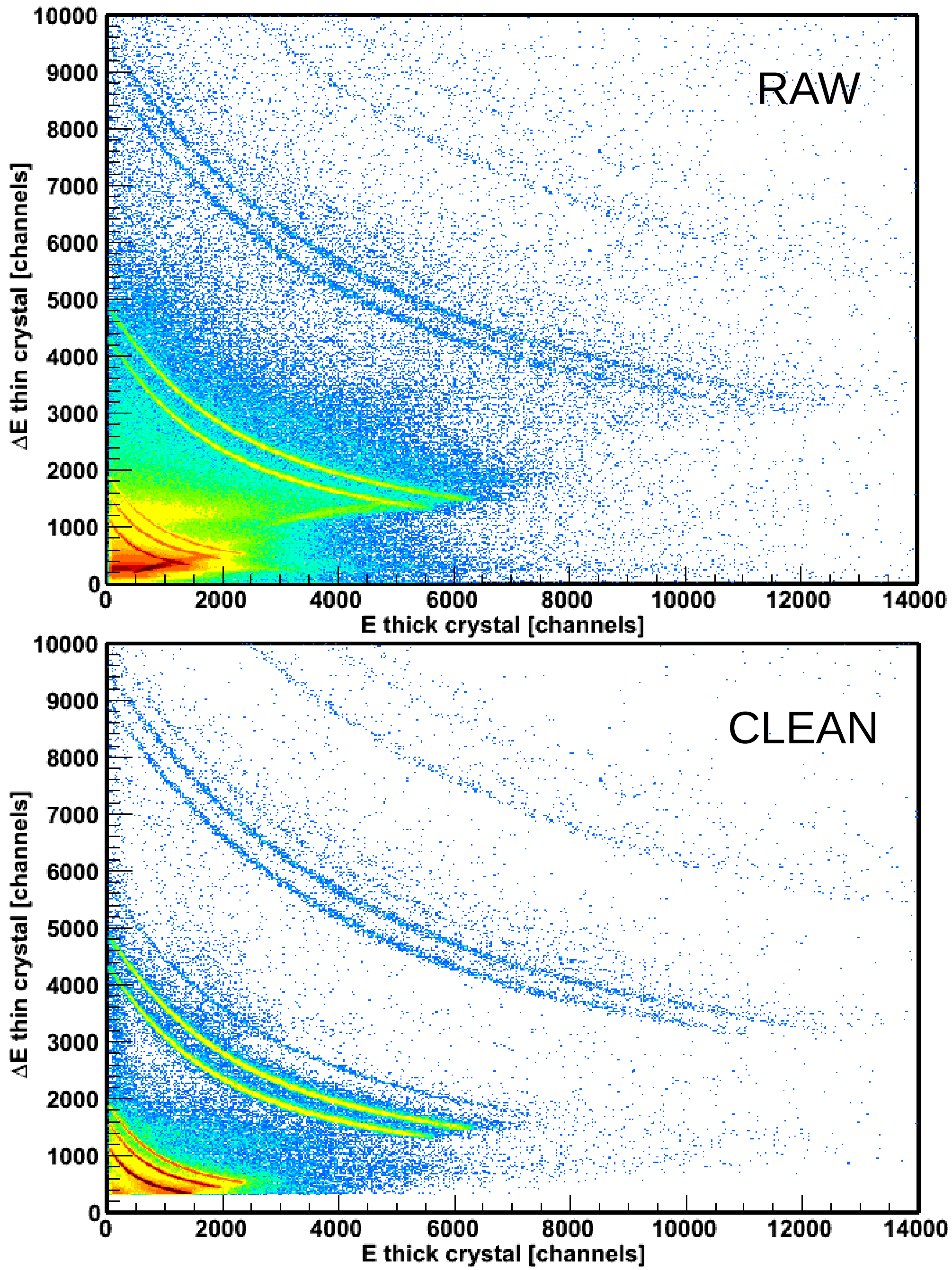






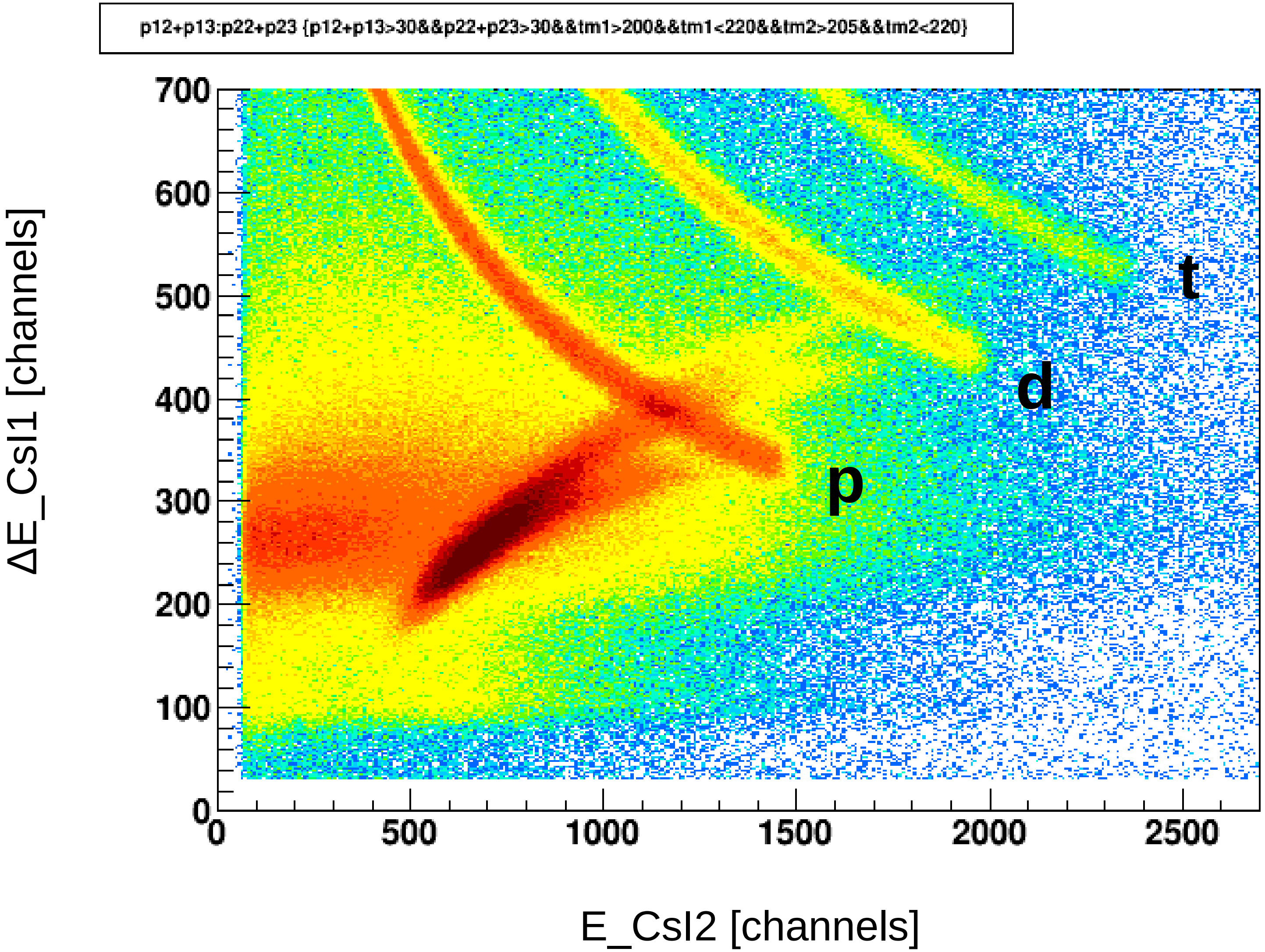
Background reduction in long CsI(Tl) crystals



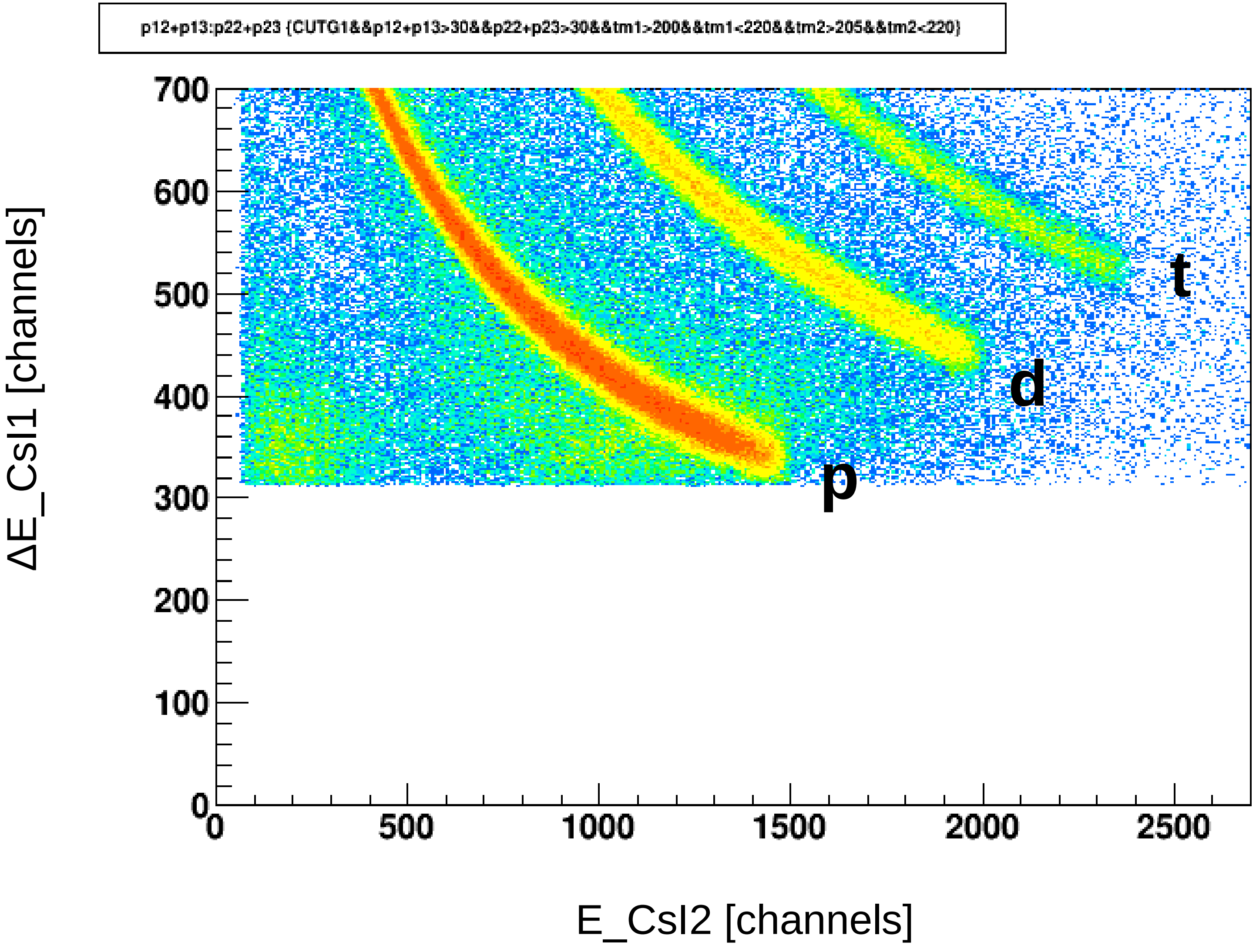


J. Łukasik et al., EPJ Web of Conf. 88, 01017 (2015)

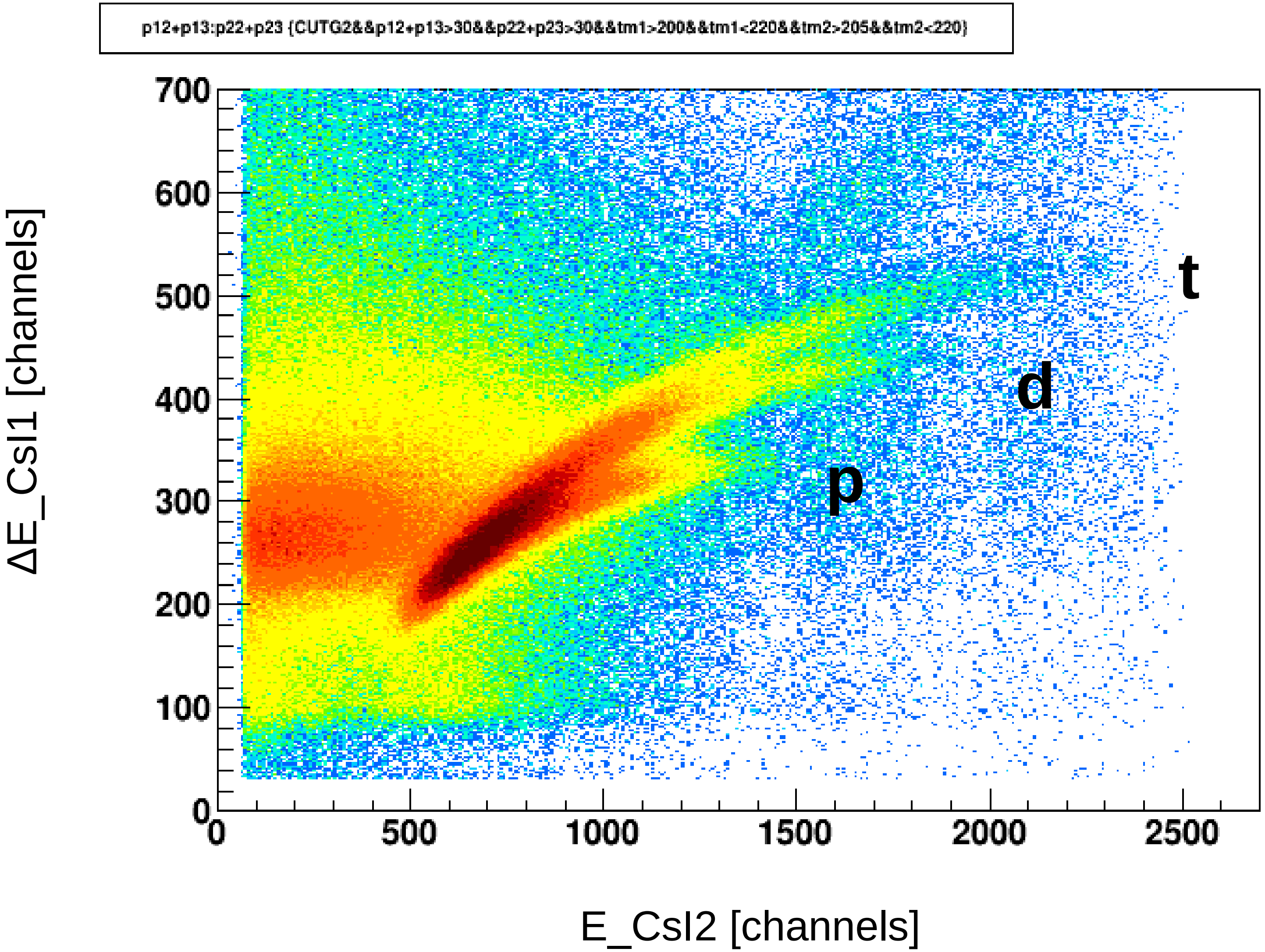
p, d, t


p12+p13:p22+p23 {p12+p13>30&&p22+p23>30&&tm1>200&&tm1<220&&tm2>205&&tm2<220}
ΔE_CsI1 [channels]
E_CsI2 [channels]
p
d
t
0
100
200
300
400
500
600
700
500
1000
1500
2000
2500

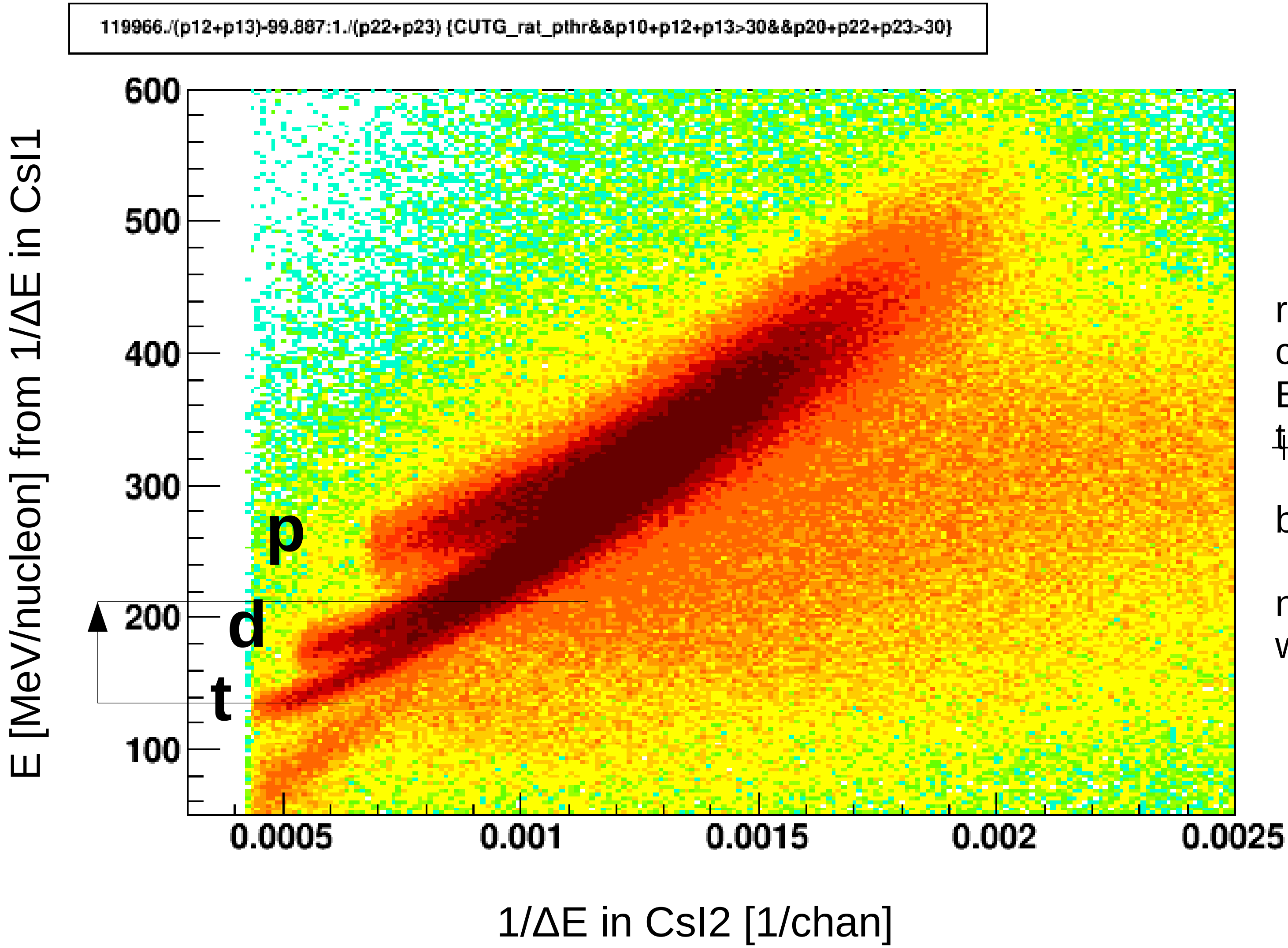
p, d, t, stopped in CsI2



p, d, t punching through CsI2



Analyze p, d, t, punch-through segments increase energy range



rough energy/nucleon calibration from "1/ΔE" -> E/A ~ $Z^2/\Delta E$ for punching through Z=1

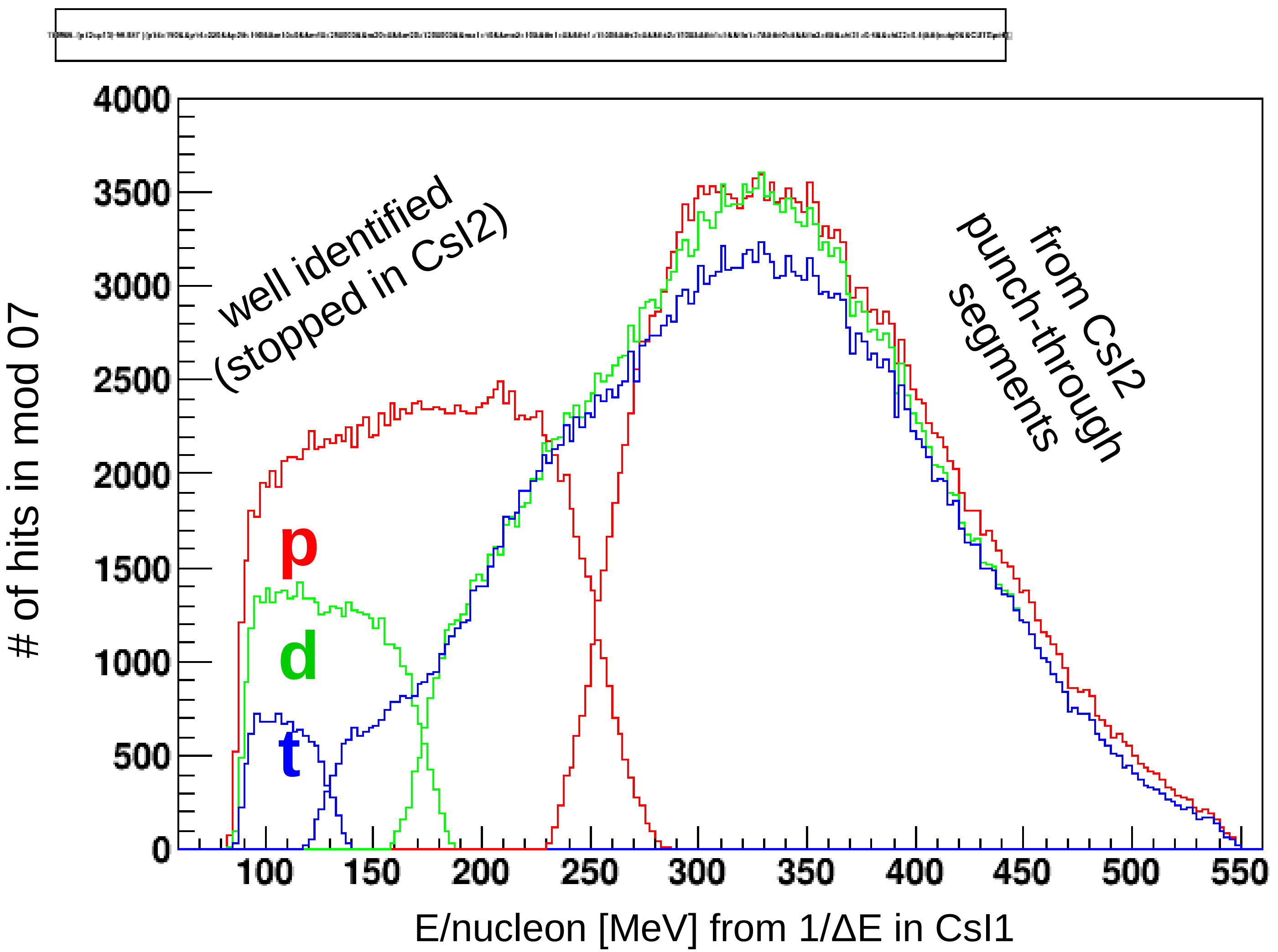
but

no mass resolution and weak energy resolution

using punch through segments would allow to increase the upper energy threshold for t from ~130 AMeV to ~200 AMeV.

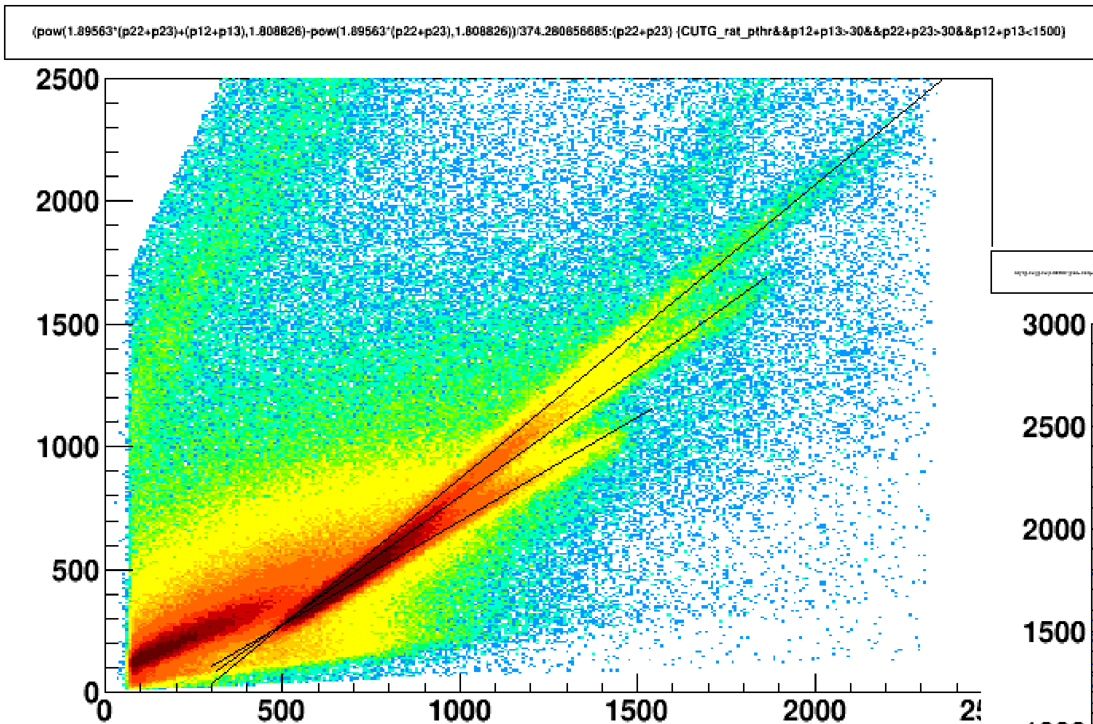
KRATTA

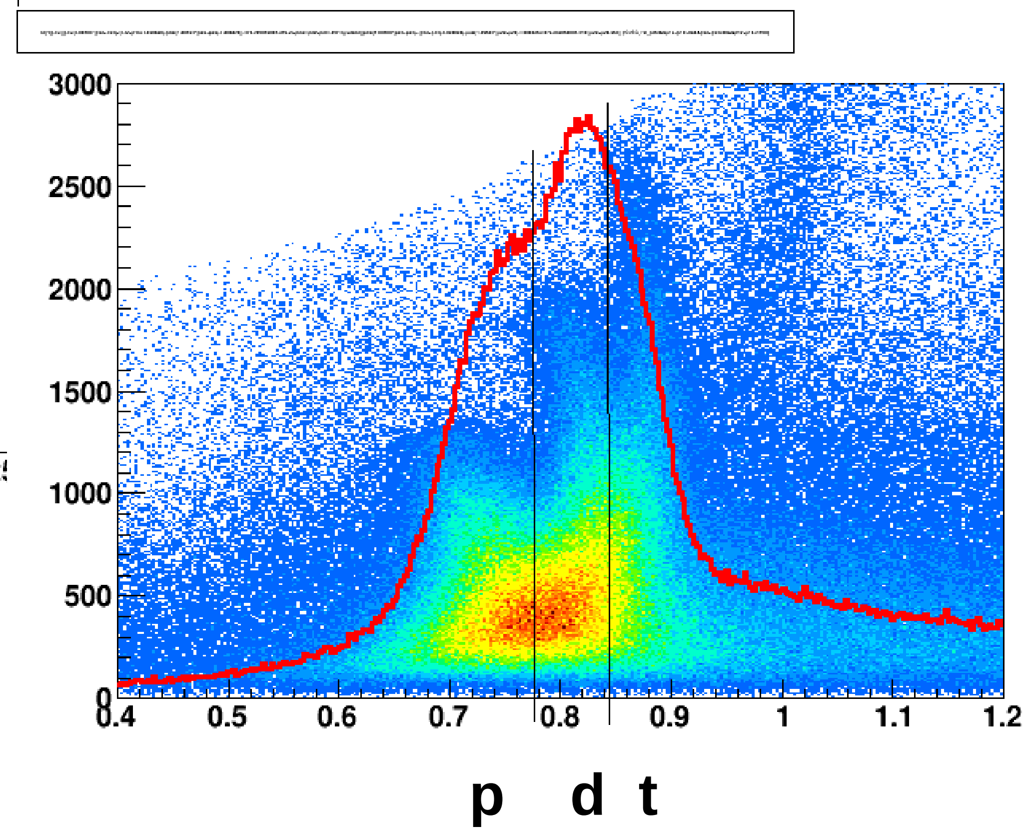
Energy/nucleon spectra for p, d, t



... a work in progress ...

After some “stretching, rotating, projecting...” (a'la Tassan-Got, using Range-Energy tables etc) a work in progress...

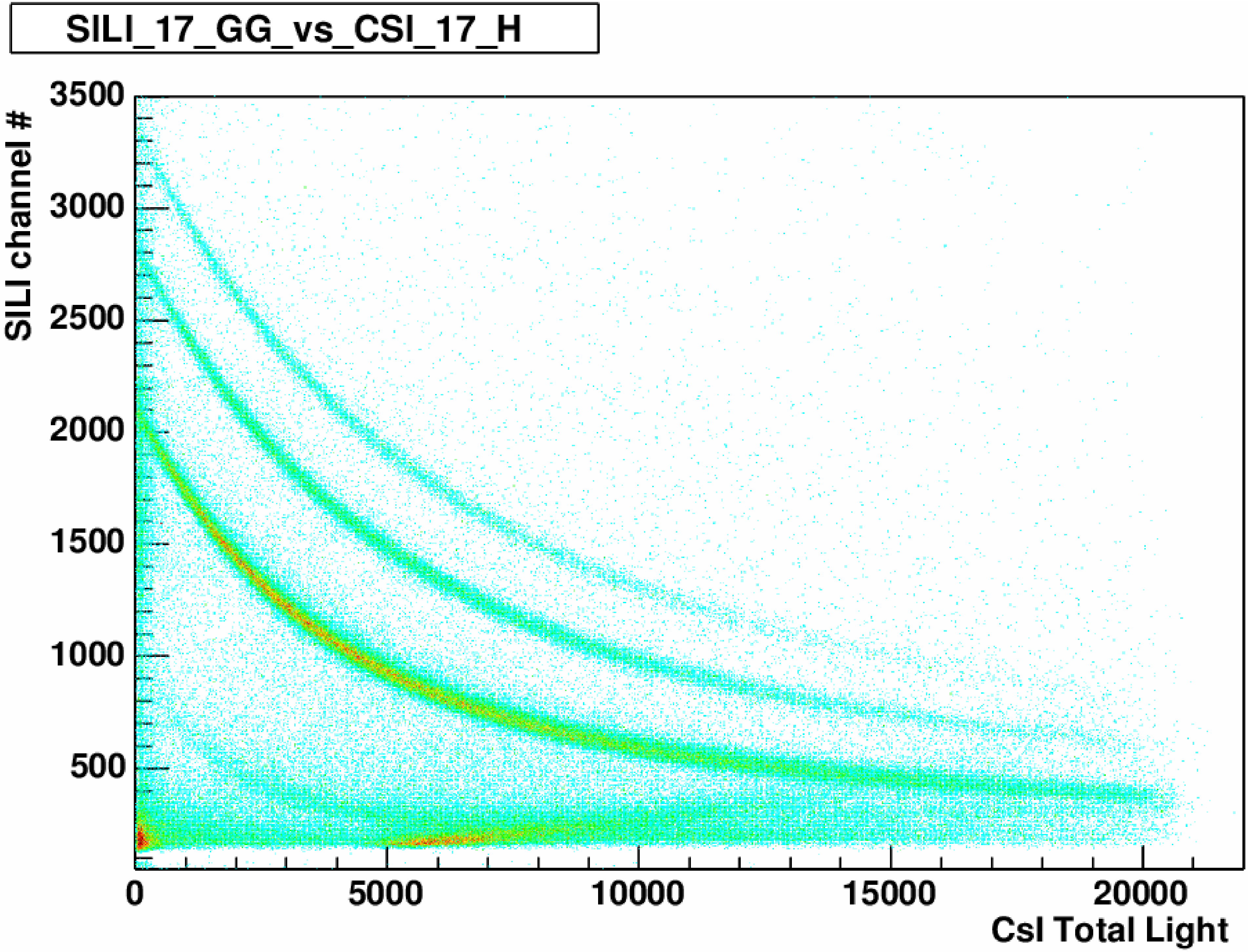




... it is not excluded that it might be possible to obtain a very, very rough identification and energy calibration for p, d, t punching through CsI2

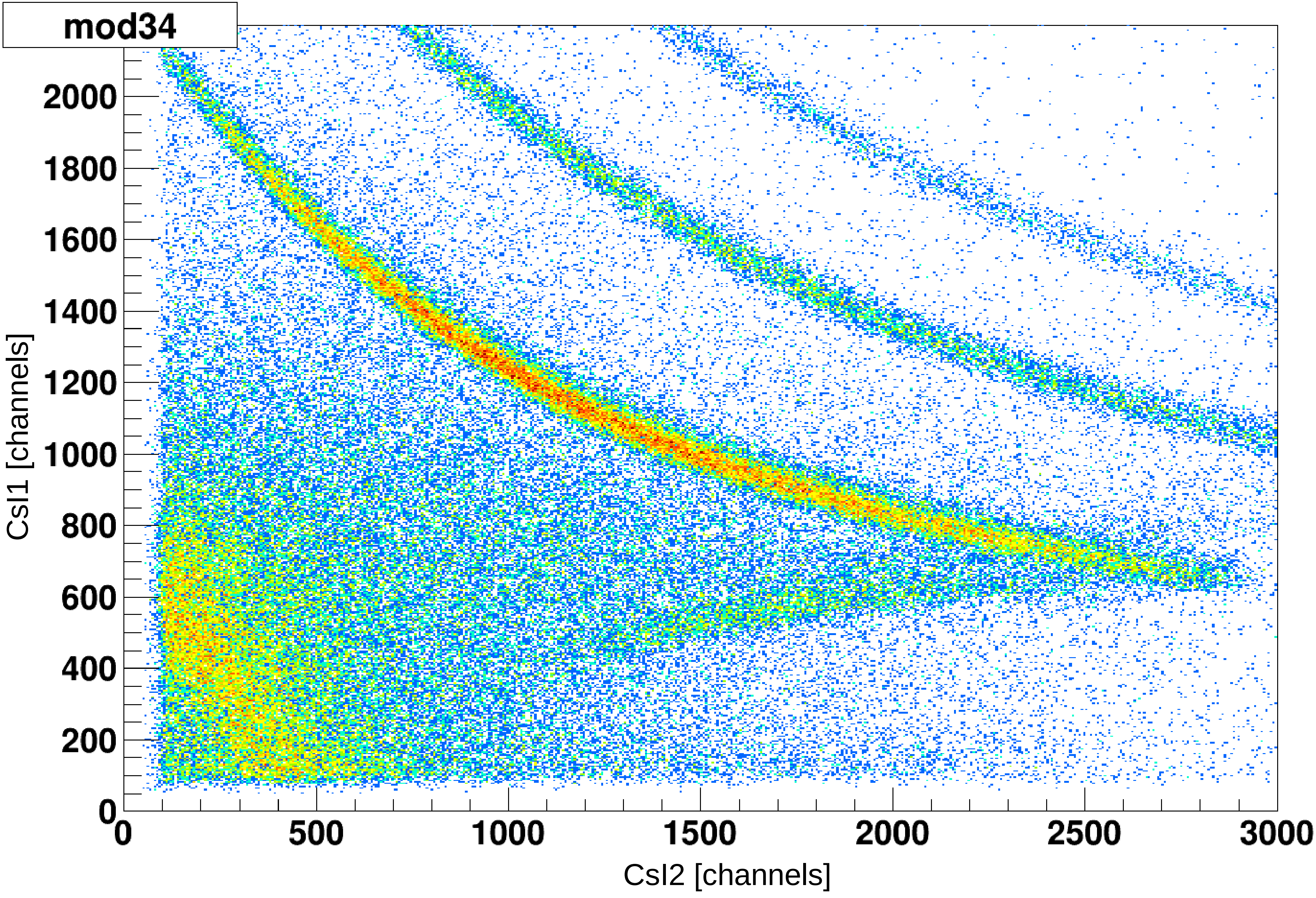
and where are the pions?

INDRA@GSI (Feb/Mar 99) C+Au @ 1 AGeV, 166°, 13.2 msr

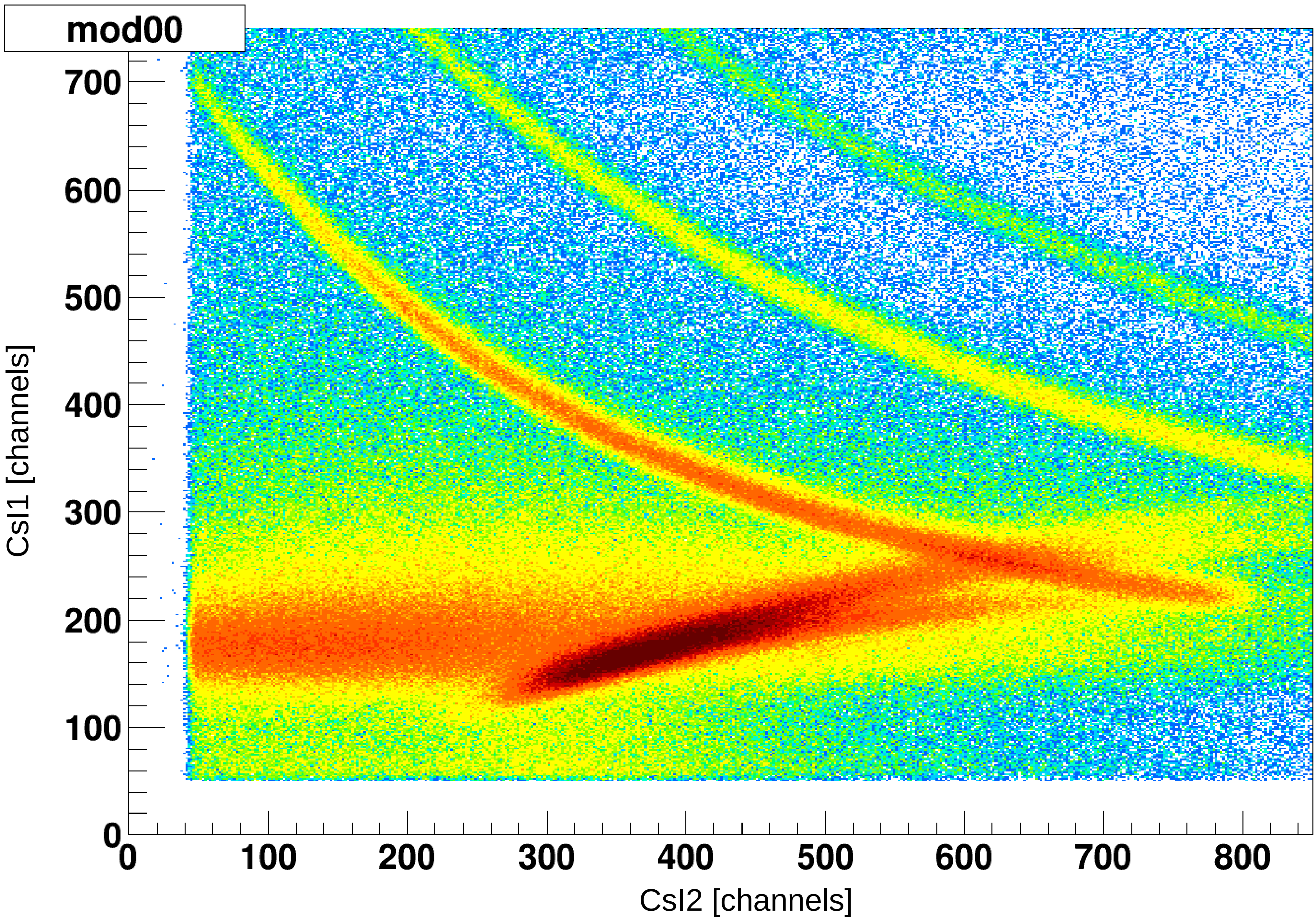


see K. Turzo et al.,Eur. Phys. J. A 21, 293 (2004)

KRATTA@GSI (May 11) Au+Au @ 0.4 AGeV, 66°, 4 msr

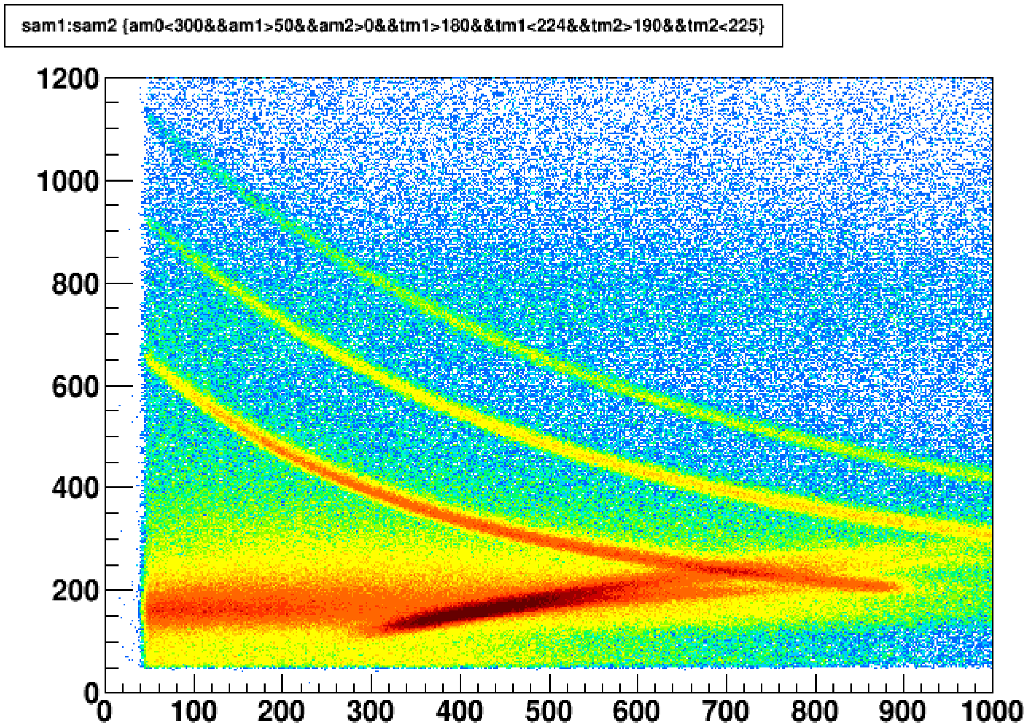


KRATTA@GSI (May 11) Au+Au @ 0.4 AGeV, 26°, 4 msr



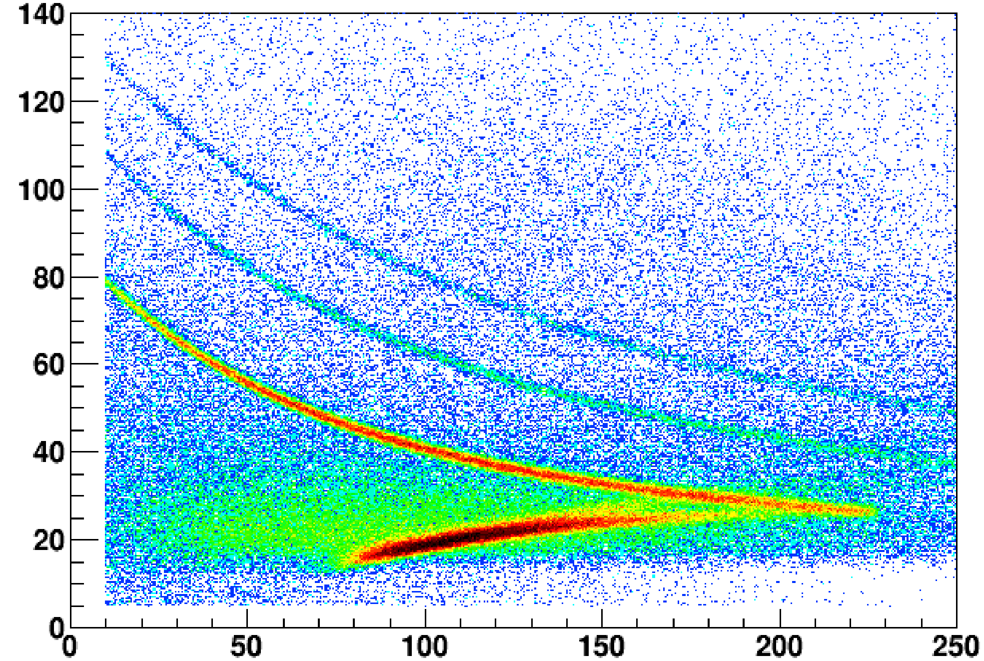
Au+Au @ 400 AMeV

KRATTA



DE-E [channels]

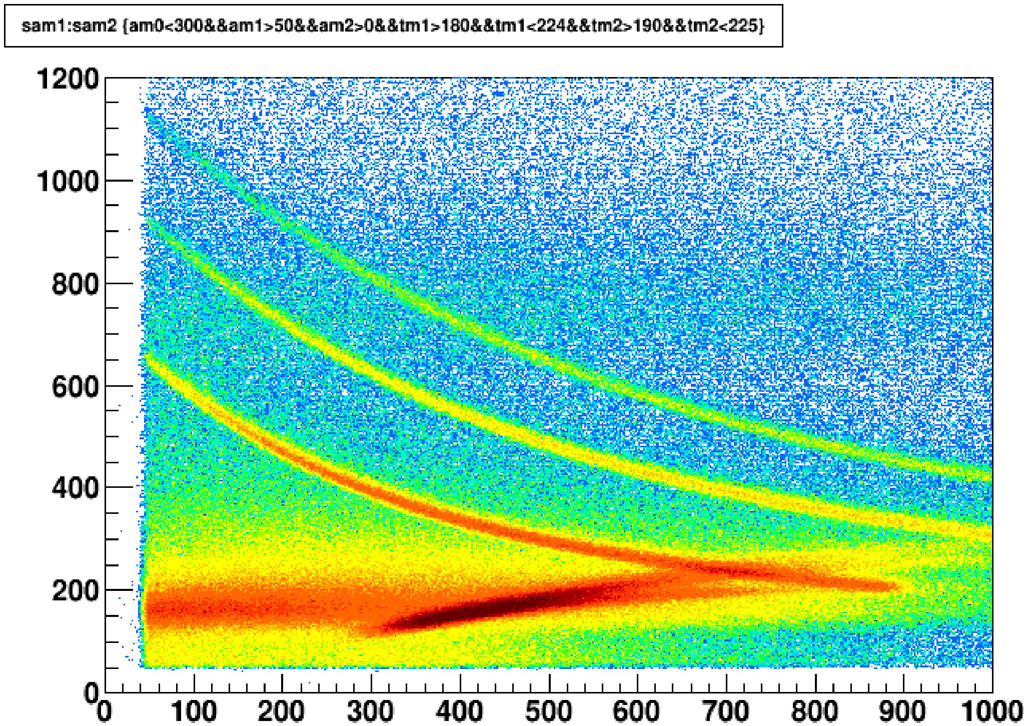
UrQMD + Clustering + GEANT4



DE-E [MeV]

Au+Au @ 400 AMeV

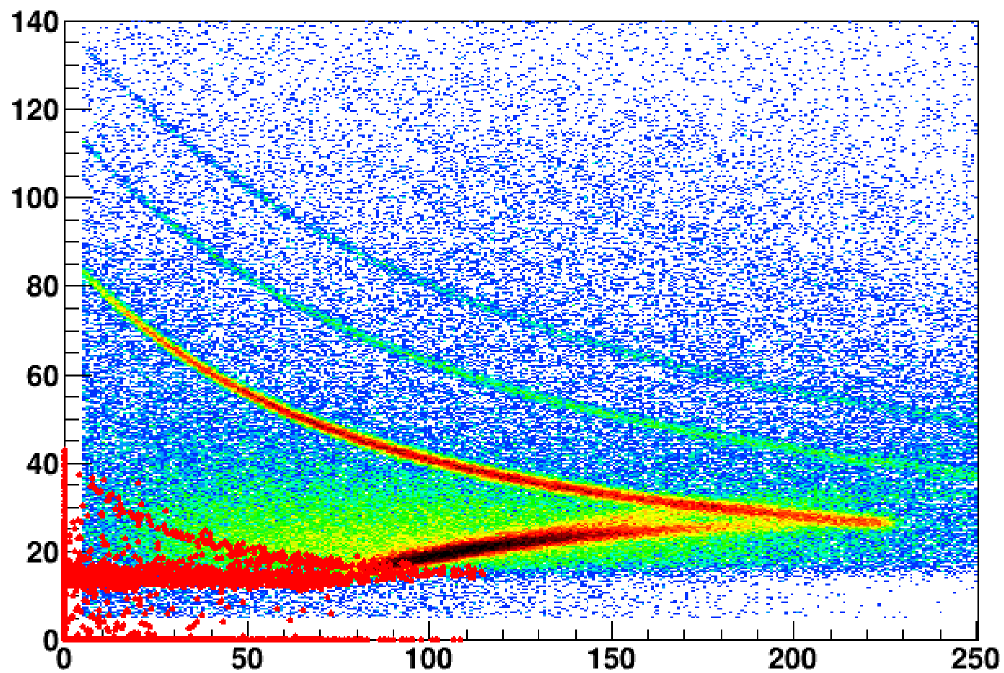
KRATTA



DE-E [channels]

UrQMD + Clustering + GEANT4

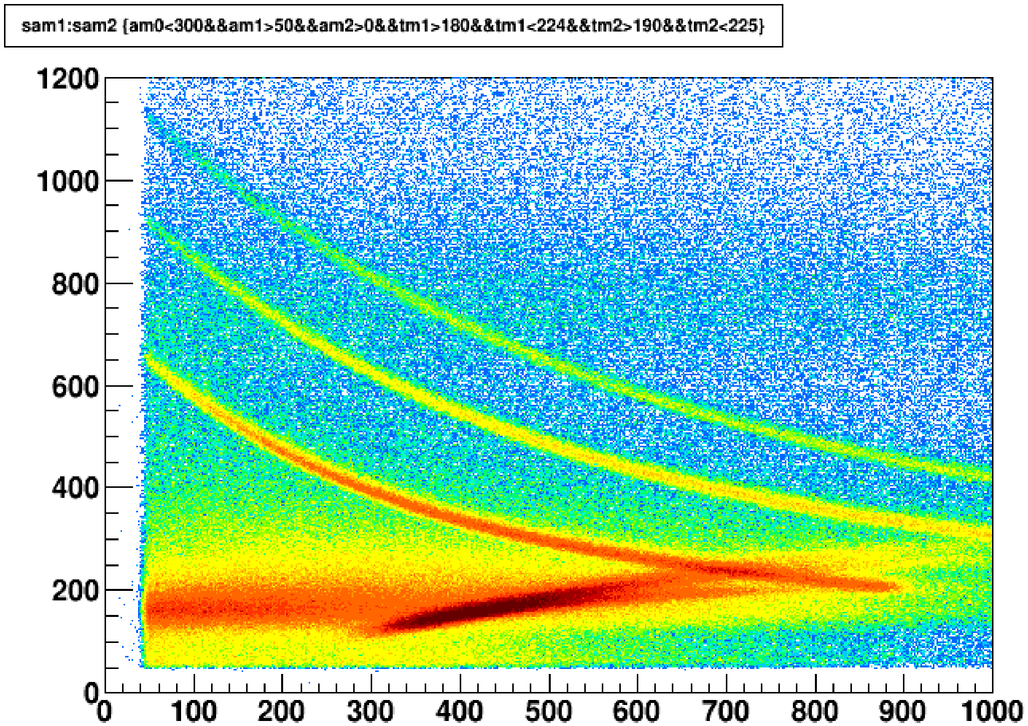
$\pi+$



DE-E [MeV]

Au+Au @ 400 AMeV

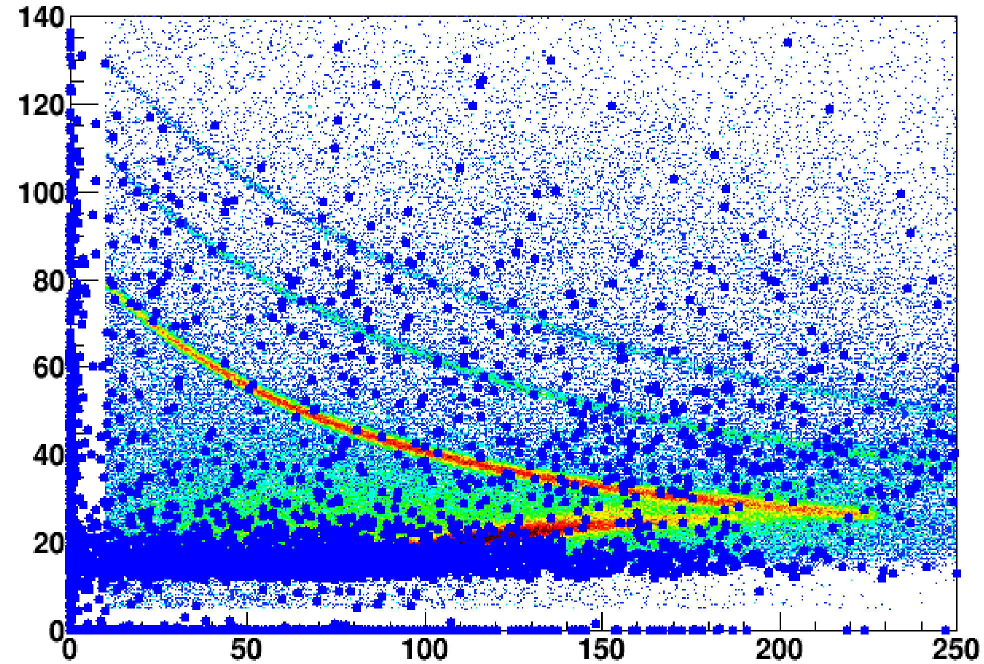
KRATTA



DE-E [channels]

UrQMD + Clustering + GEANT4

π^-

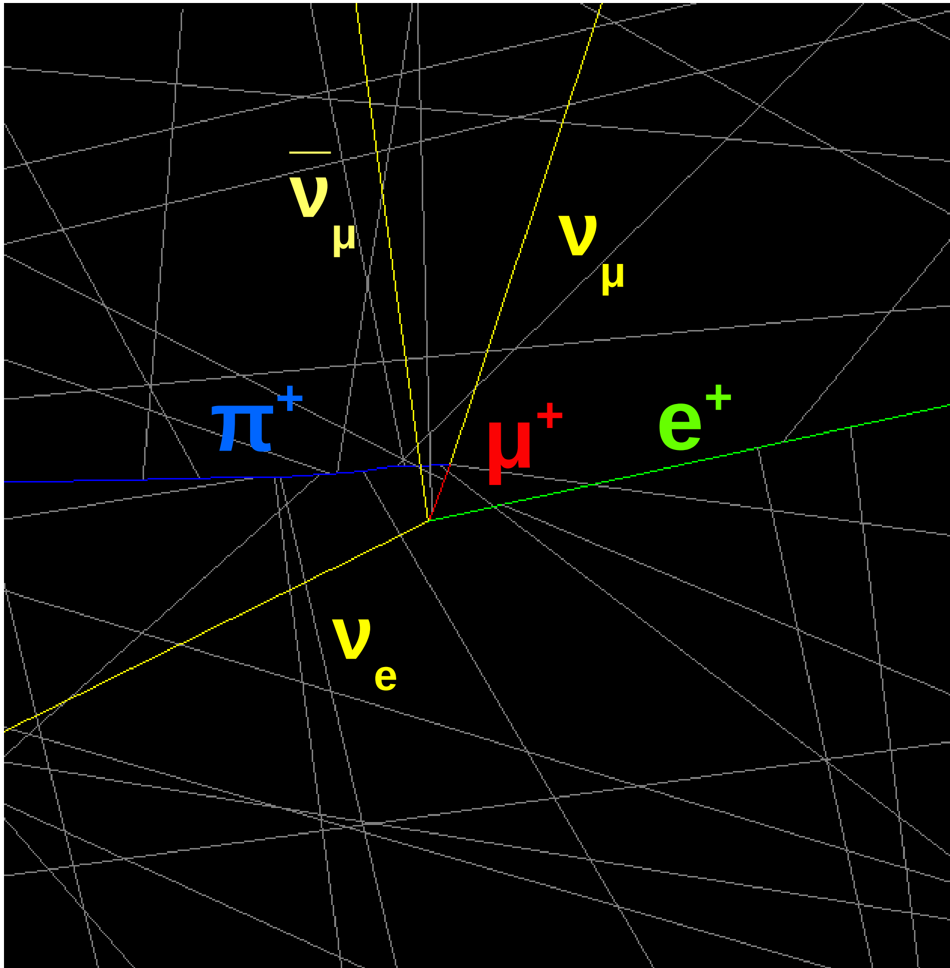


DE-E [MeV]

π^+ decay

$\pi^+ \rightarrow \mu^+ + \nu_\mu$ $\tau_\pi \approx 26$ ns, $E_\mu = 4.12$ MeV, $R_\mu^{plastic} \approx 1.2$ mm

$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$ $\tau_\mu \approx 2.2$ μs



π^- capture/disintegration

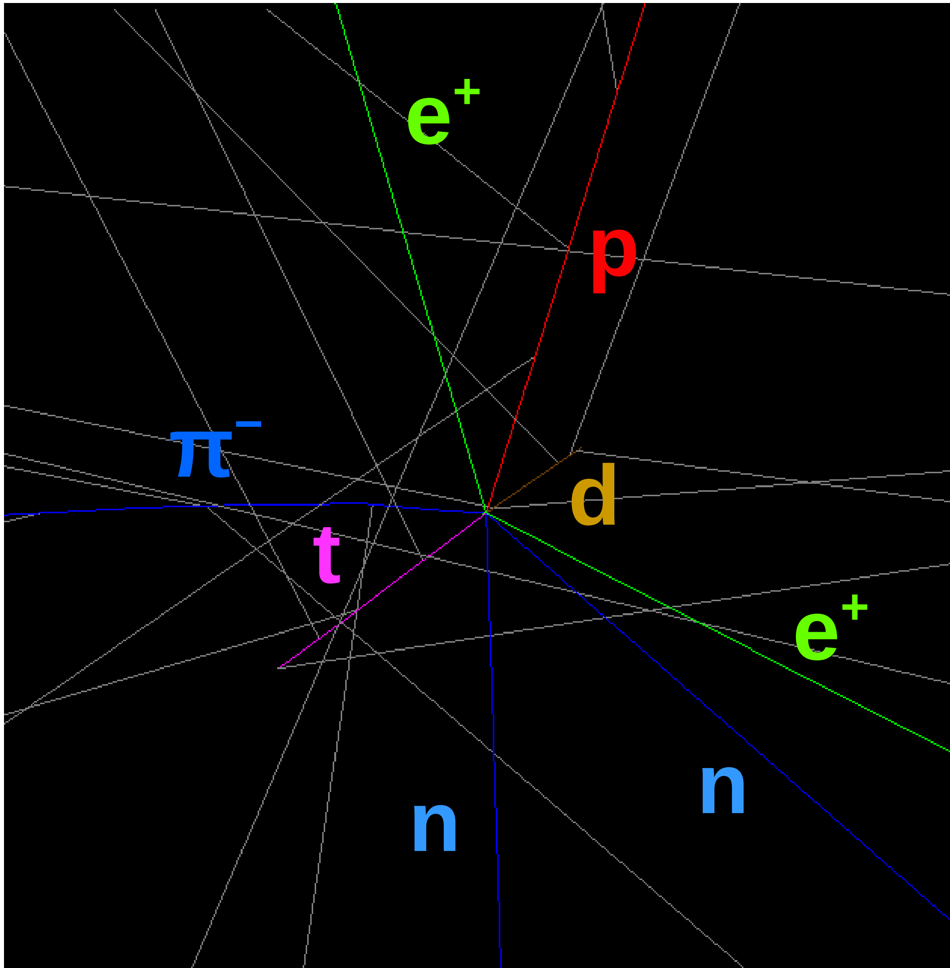
$\pi^- + A \rightarrow A' + n, p, d, t, \alpha, \ldots$ "star events"

$\pi^- + p \rightarrow n + \pi^0 \rightarrow 2\gamma + n$ pionic atom $\tau < 1$ ps

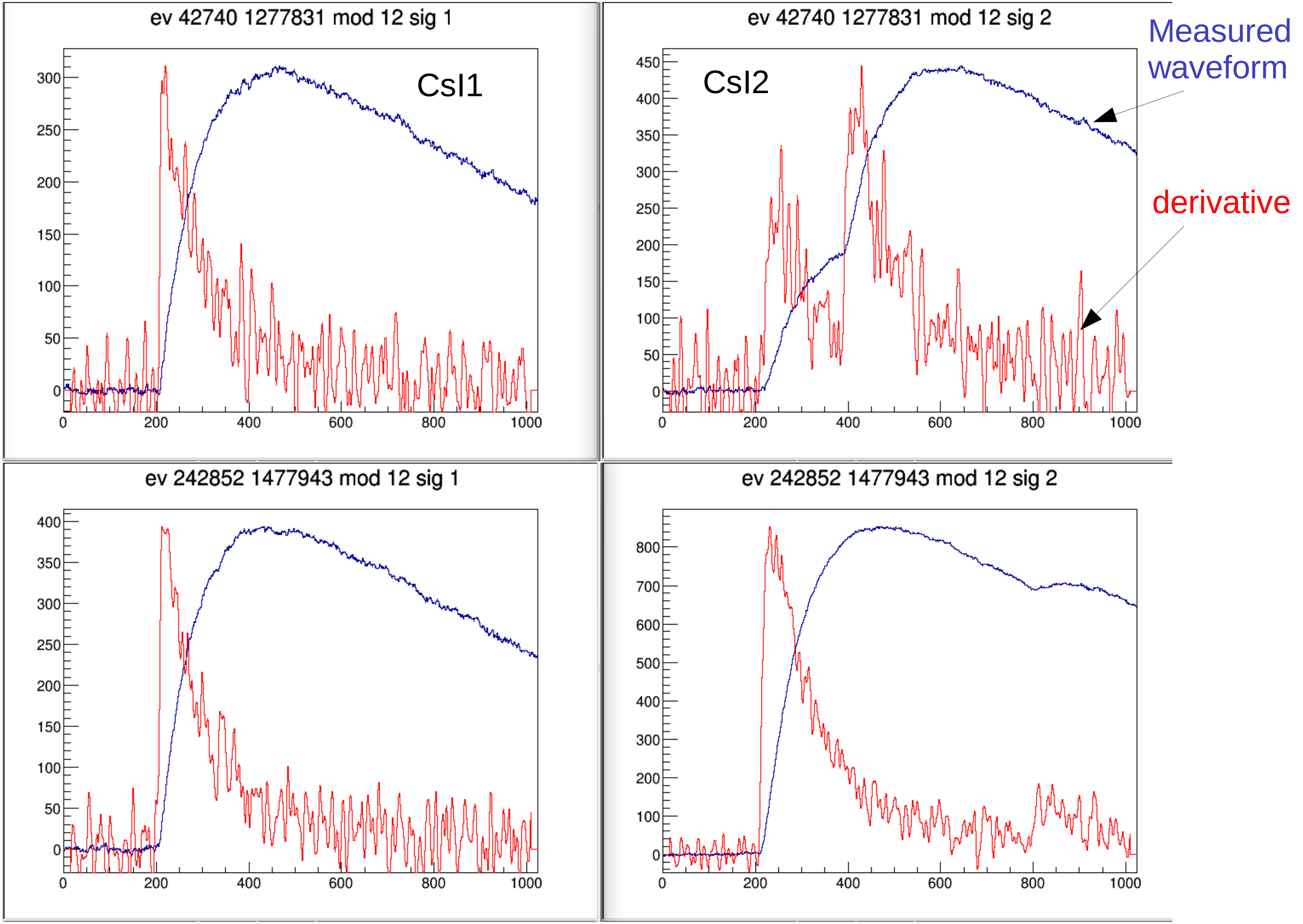
$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$ $\tau_\pi \approx 26$ ns, $E_\mu = 4.12$ MeV, $R_\mu^{plastic} \approx 1.2$ mm

$\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$ $\tau_\mu \approx 2.2$ μs

$\mu^- + p \rightarrow n + \nu_\mu$ muonic atom



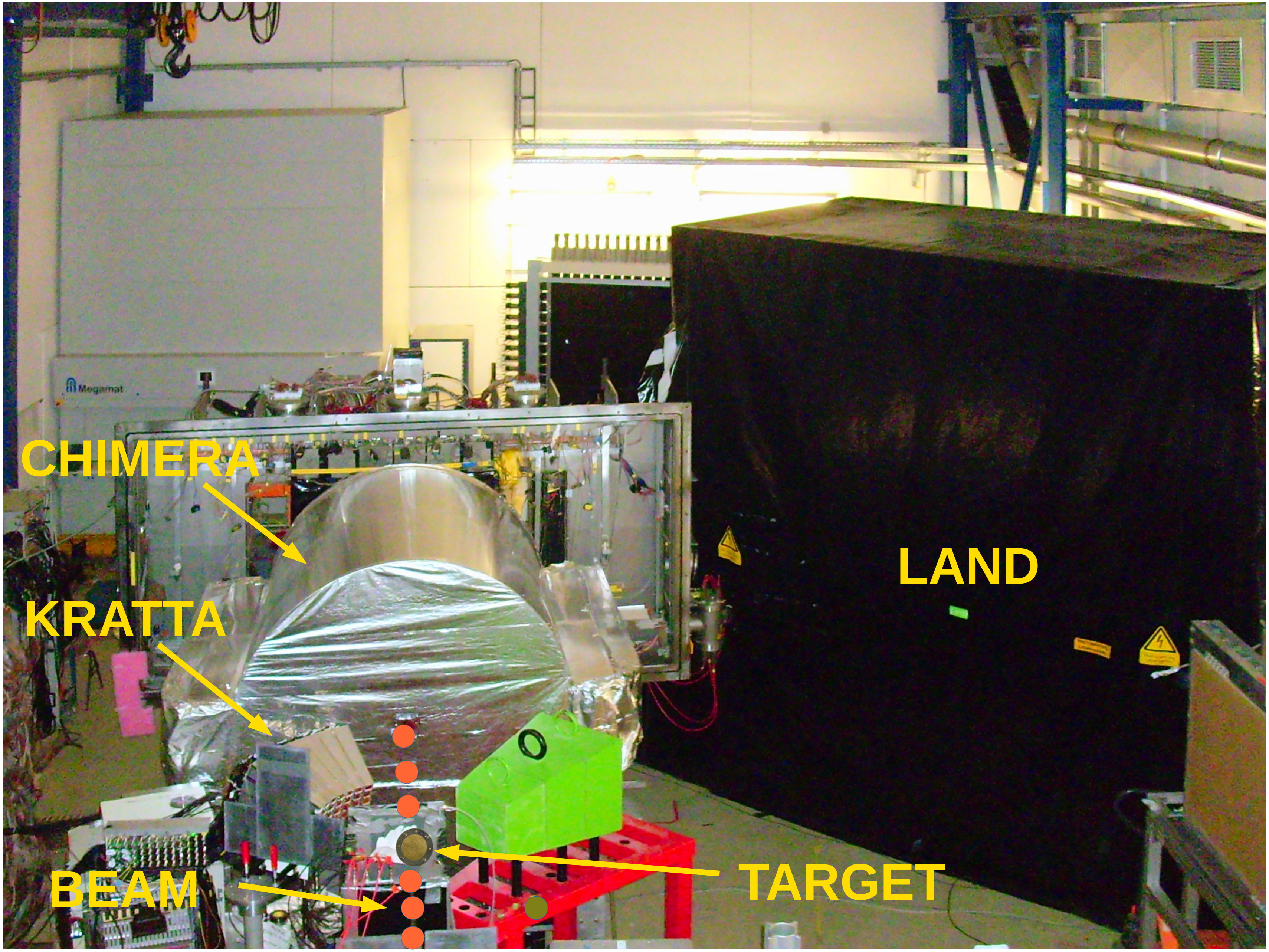
some candidates for π+ in KRATTA



Time [10 ns/bin]

KRATTA @ GSI (Au+Au at 400 AMeV, 2011)

ASY-EOS Experimental Setup



P. Russotto et al., PRC, 94 (2016) 034608

J. Łukasik et al., NIMA 709 (2013) 120

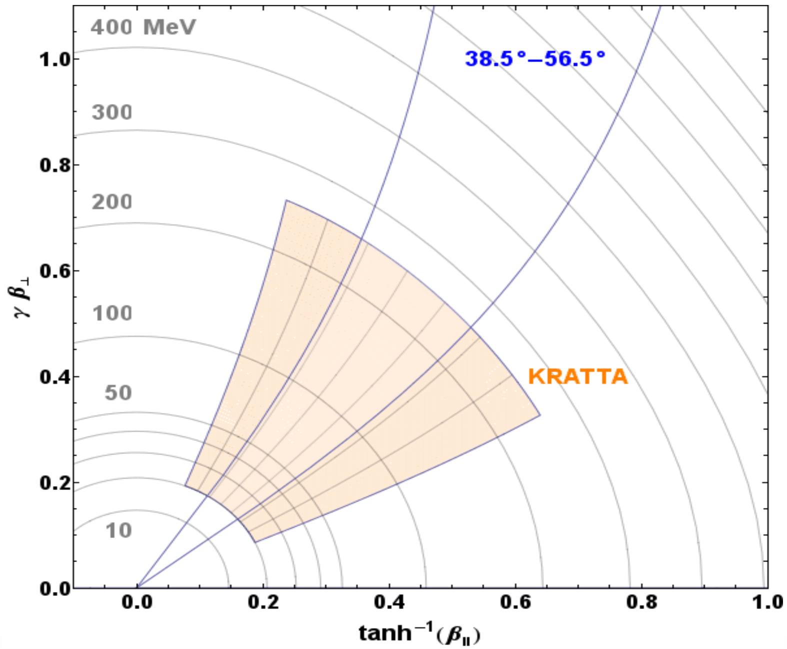
Flows of light charged particles in Au (400 MeV/u) + Au reactions: KRATTA vs FOPI results

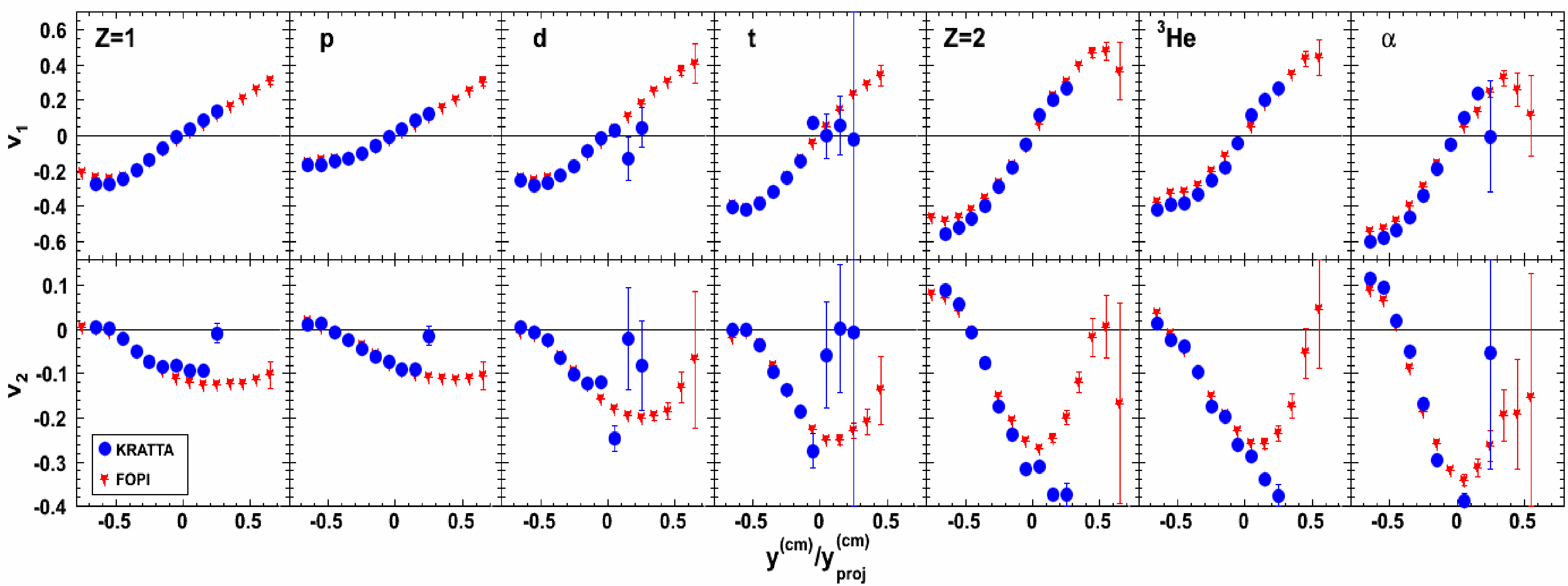
Fourier decomposition of the azimuthal distributions with respect to the reaction plane (ϕ_R) :

$$\frac{dN}{d(\phi-\phi_R)} = \frac{N_0}{2\pi}\left(1 + 2\sum_{n\geq 1} v_n \cos n(\phi-\phi_R)\right)$$

$v_1 \equiv \langle\cos(\phi-\phi_R)\rangle$ directed flow

$v_2 \equiv \langle\cos 2(\phi-\phi_R)\rangle$ elliptic flow





S. Kupny, PHD thesis, Jagiellonian University, Kraków (2016)

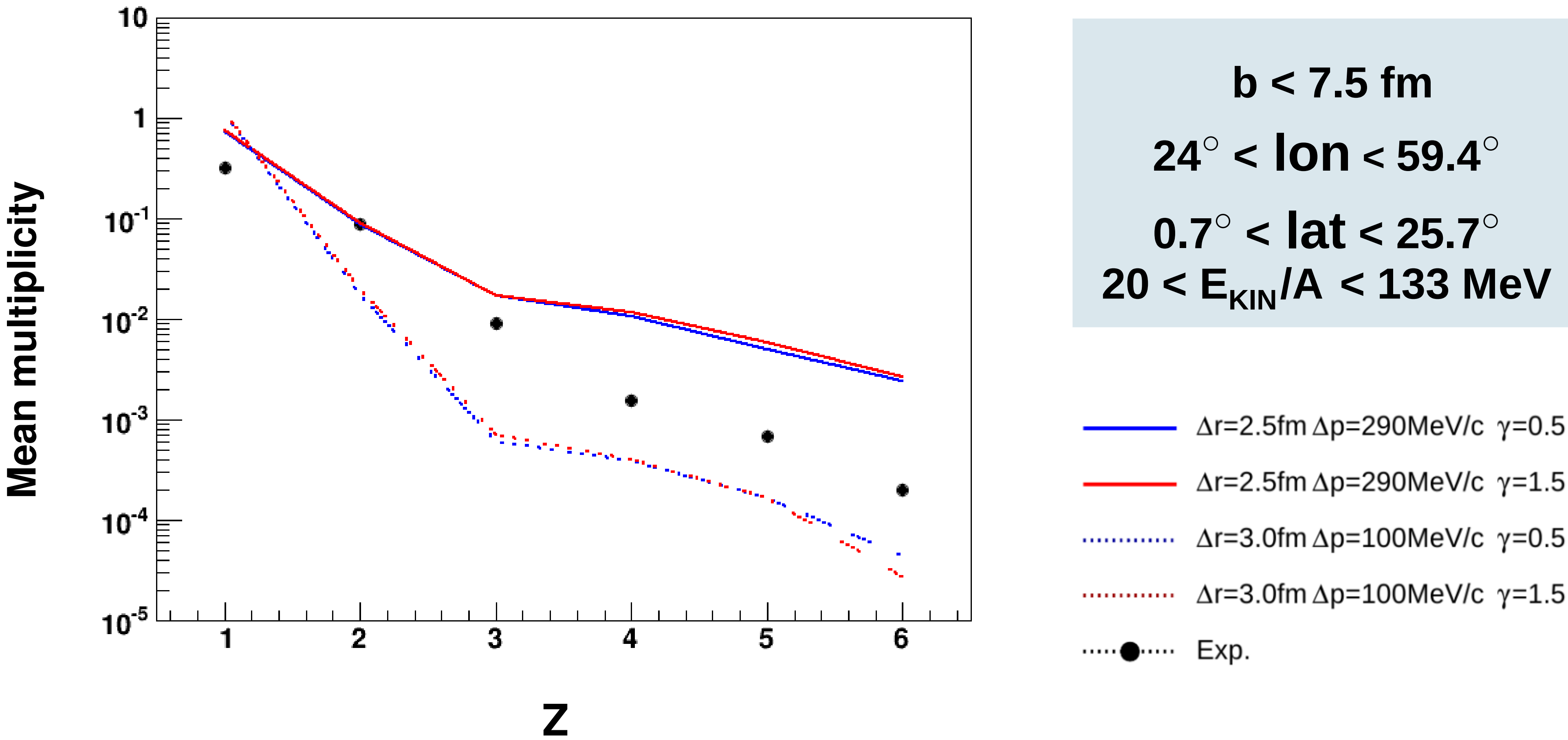
Charge distribution Au (400 MeV/u) + Au

KRATTA data ⟷ UrQMD predictions

● KRATTA data

ASY - SOFT (blue)

ASY - STIFF (red)



b < 7.5 fm

24° < lon < 59.4°

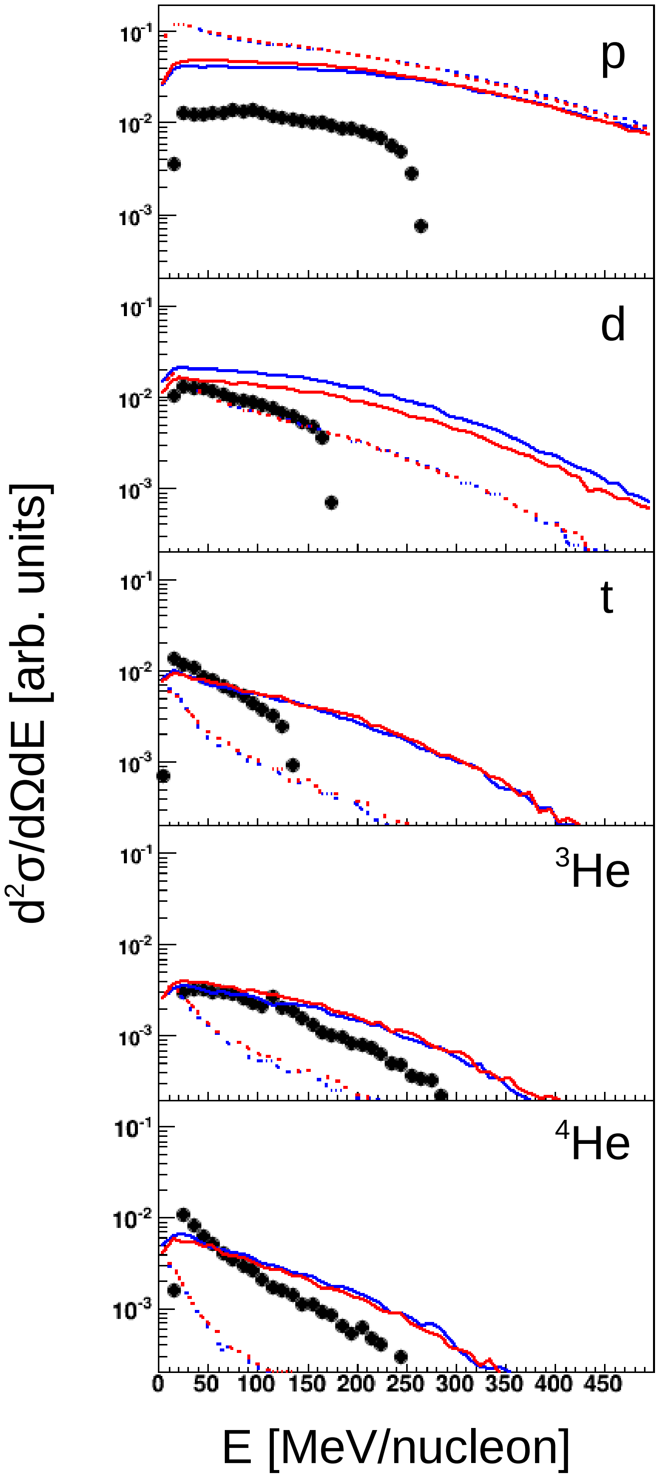
0.7° < lat < 25.7°

20 < E_{KIN}/A < 133 MeV

S. Kupny, PHD thesis, Jagiellonian University, Kraków (2016)

Energy/nucleon

Au(400 MeV/u) + Au



Δr=2.5fm Δp=290MeV/c γ=0.5

Δr=2.5fm Δp=290MeV/c γ=1.5

Δr=3.0fm Δp=100MeV/c γ=0.5

Δr=3.0fm Δp=100MeV/c γ=1.5

Exp.

b < 7.5 fm

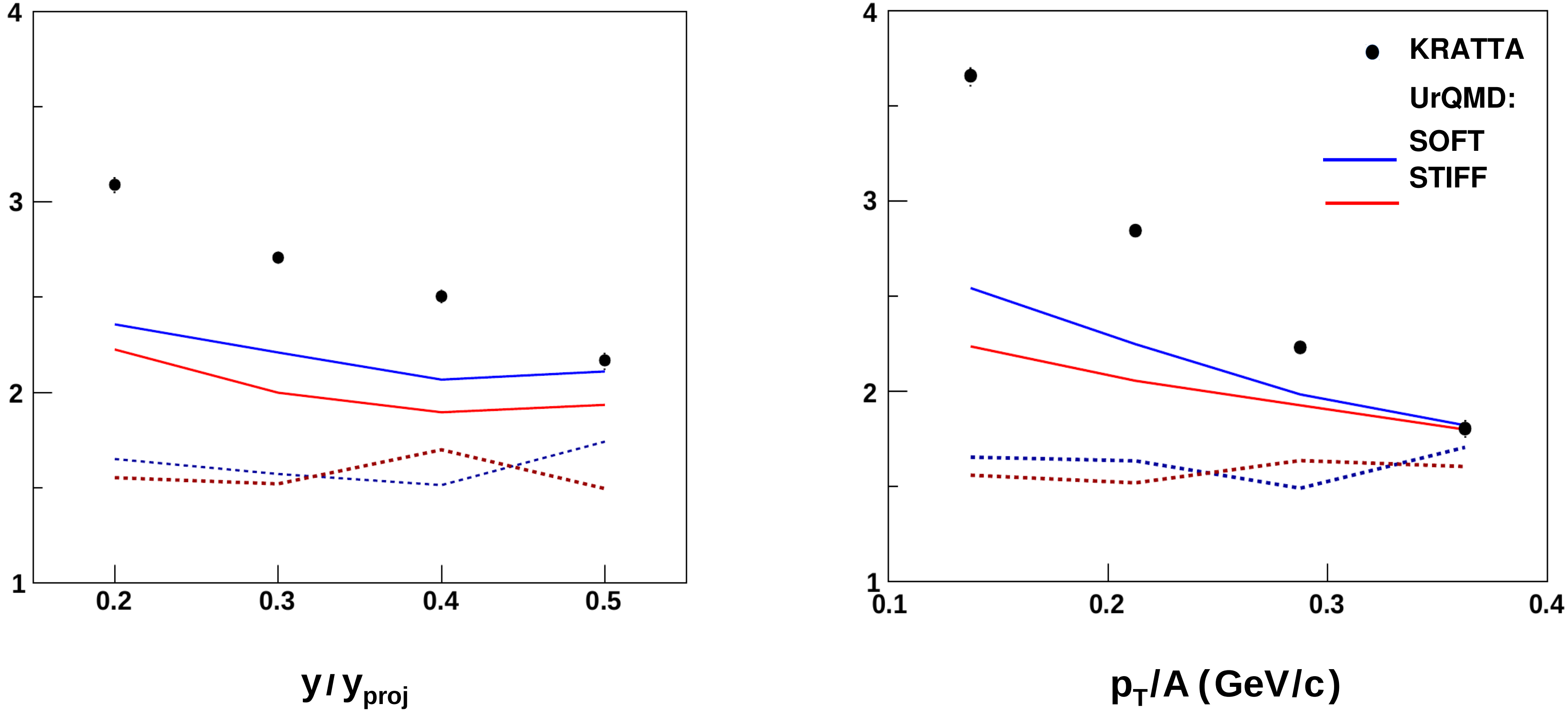
24° < lon < 59.4°

0.7° < lat < 25.7°

S. Kupny, PHD thesis, Jagiellonian University, Kraków (2016)

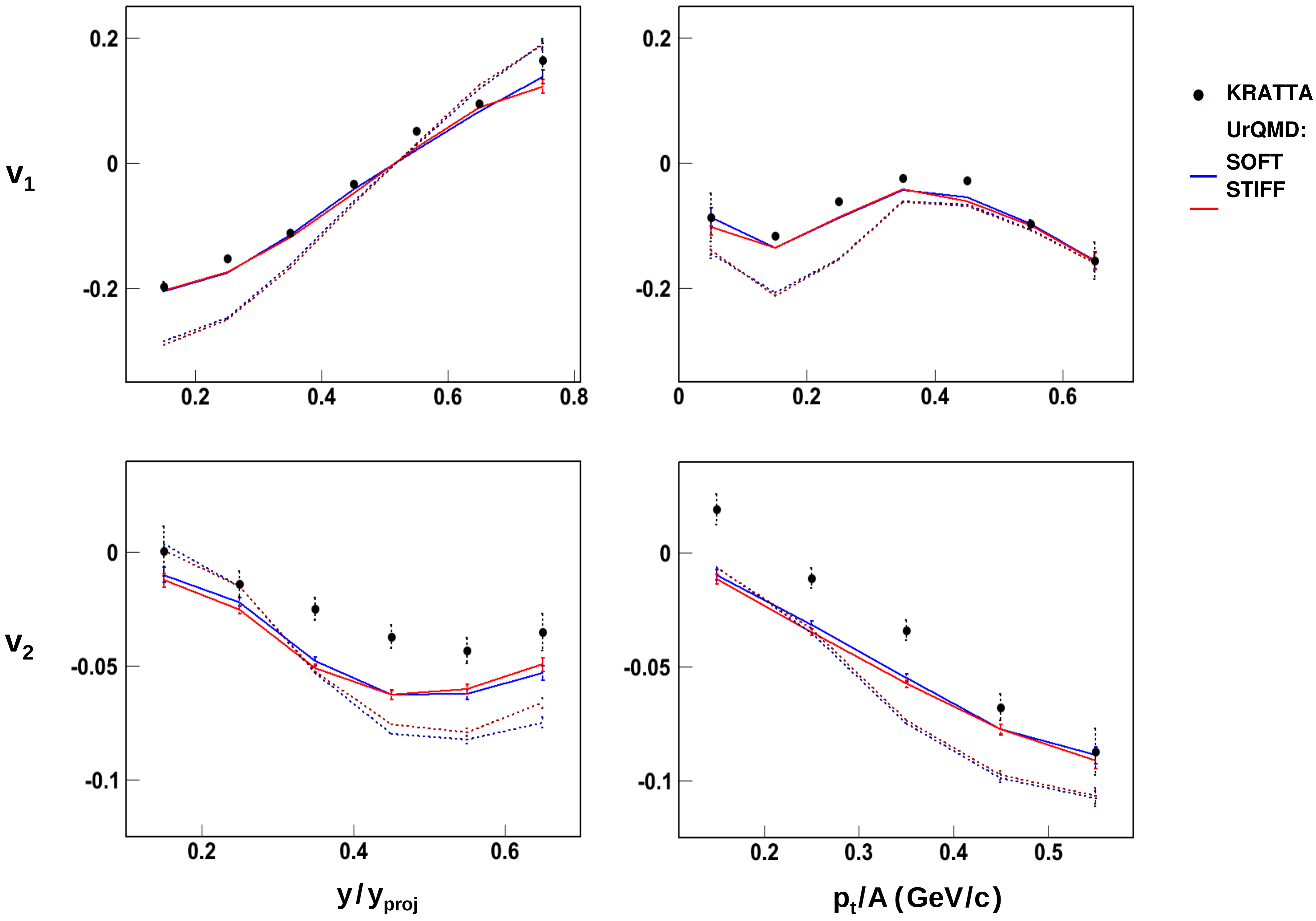
$t/^3He$ isotope ratios (20 < E_{kin}/A < 133 MeV)

Au (400 MeV/u) + Au
5.5 < b < 7.5 fm
24° < Θ_{LAB} < 62°
20 < E_{KIN}/A < 133 MeV



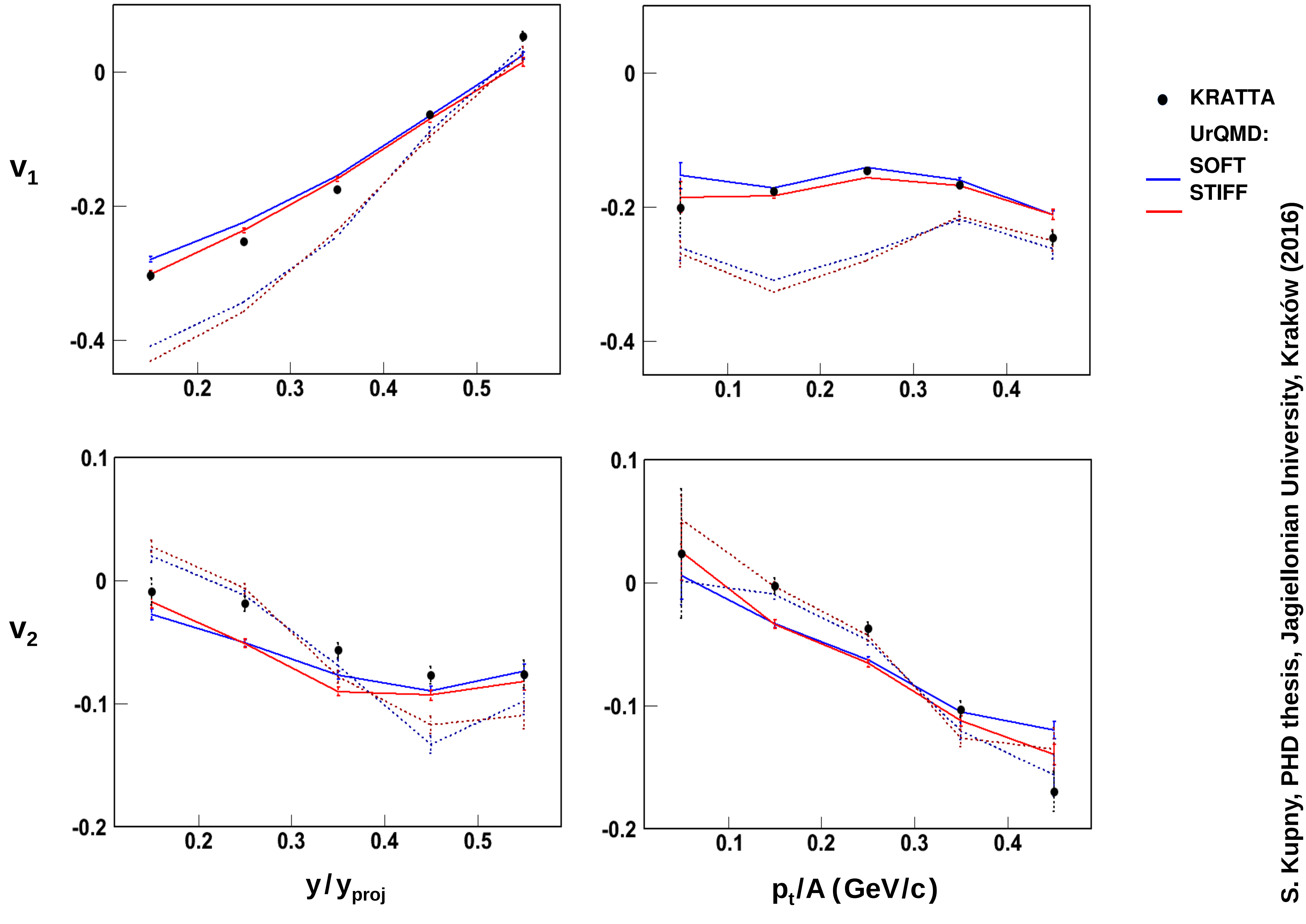
S. Kupny, PHD thesis, Jagiellonian University, Kraków (2016)

Proton flow (20 < E_{kin} < 250 MeV)

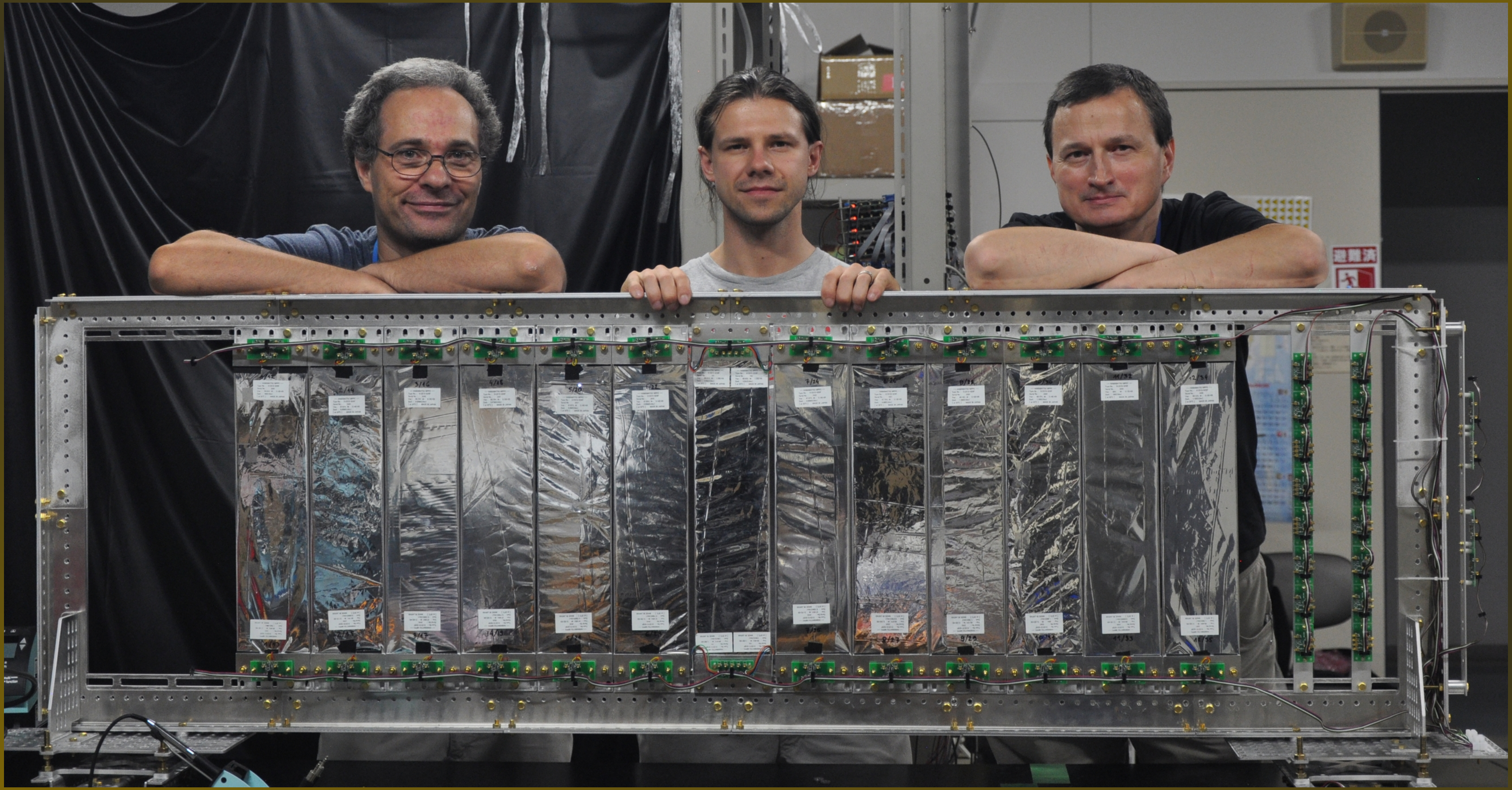


S. Kupny, PHD thesis, Jagiellonian University, Kraków (2016)

Deuteron flow (20 < E_{kin}/A < 160 MeV)



KATANA



Kraków Array for Triggering with Amplitude discrimiNAtion

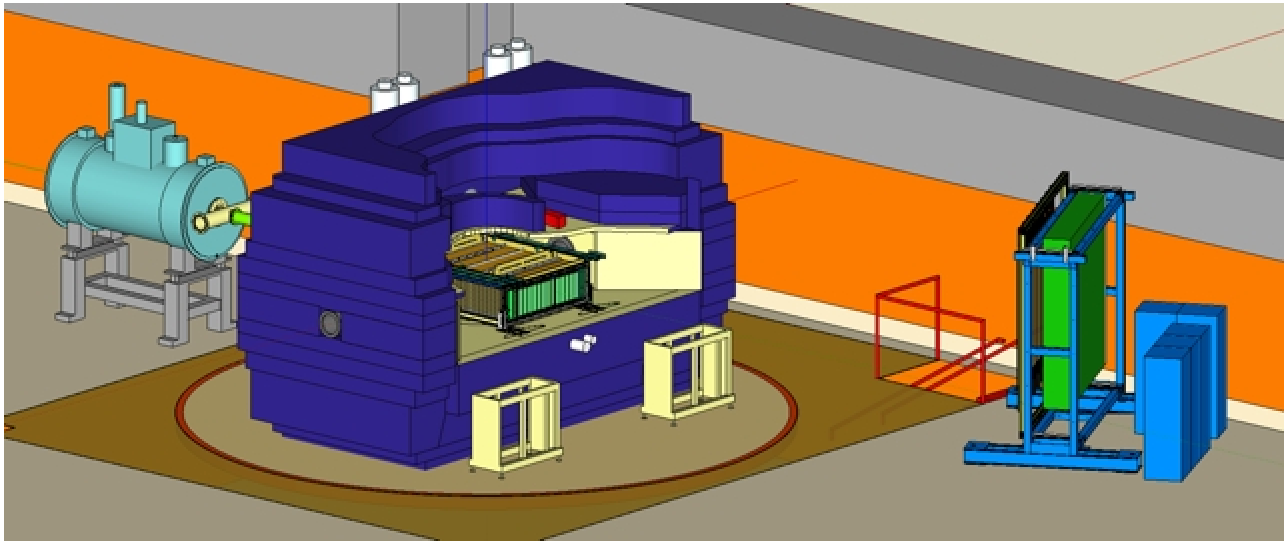
KATANA main requirements
(more than just a trigger...)

- High trigger efficiency for central and semi-central collisions → GEANT4 + UrQMD simulations to test various options and setups
- Fast VETO signal for fragments with Z>20 to close the Gating Grid → Fast plastics (BC404)
Fast preamps
Trigger Box with FPGA logic
- Insensitivity to magnetic field → MPPCs (HAMAMATSU)
- Possibly low position dependence of the signal amplitudes → Wave Length Shifters (BCF-92) for VETO paddles
- Stability and beam time respect → Remote control of discriminator thresholds, bias voltages and temperatures
- Provide data, handle Active Collimator signals → Include trigger detector in DAQ

SPiRIT @ RIKEN (2016)

Determination of the density and momentum dependence of the EOS at supra-saturation densities

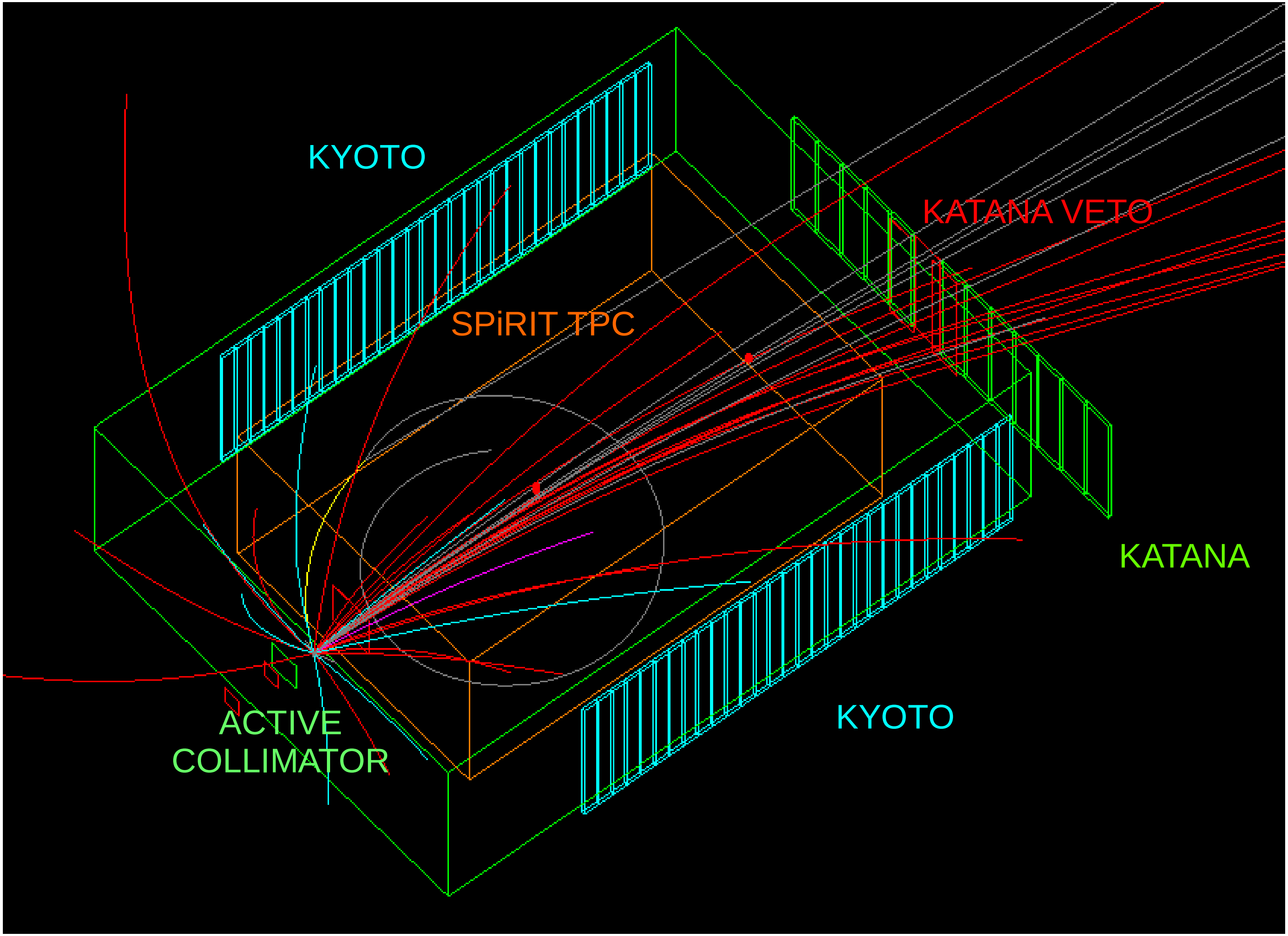
Stable and radioactive systems at 300 AMeV
$^{132}Sn+^{124}Sn$; $^{124}Sn+^{112}Sn$
$^{108}Sn+^{112}Sn$; $^{112}Sn+^{124}Sn$



Observables:
ratios: π^-/π^+, n/p, t/^{3}He,
flow: n, p, t, ^{3}He

Main detectors:
SPiRIT TPC inside SAMURAI
KYOTO + KATANA
NeuLAND

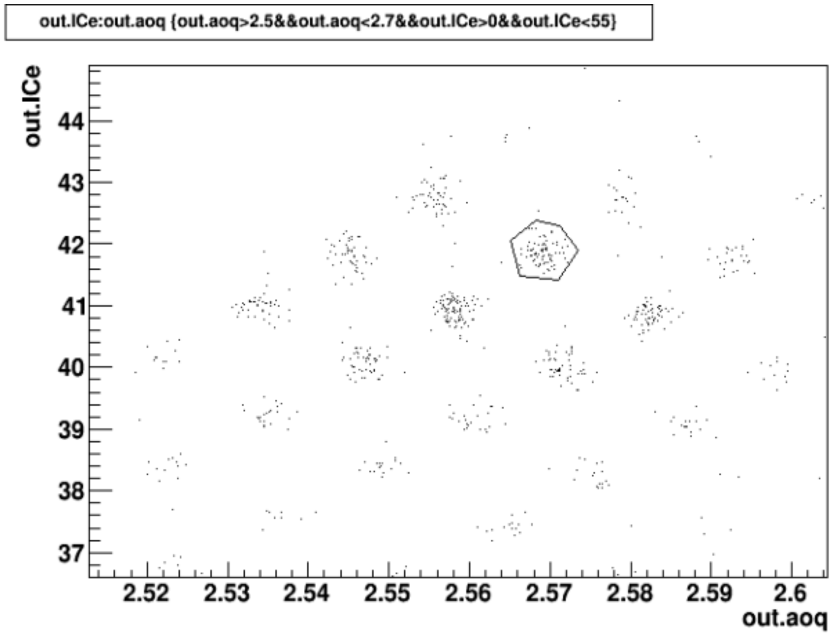
SPiRIT @ RIKEN (2016)

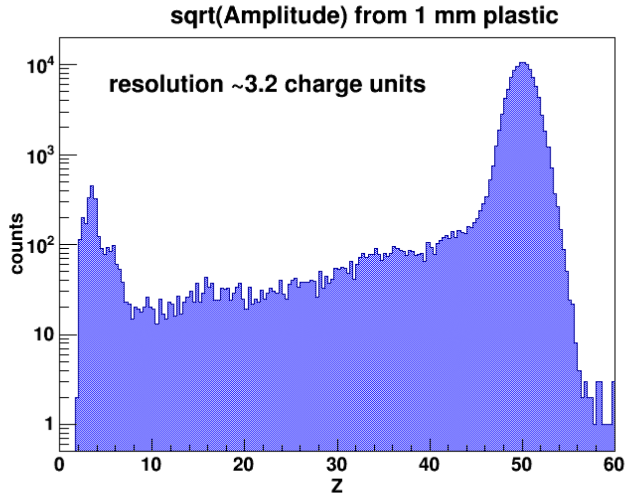


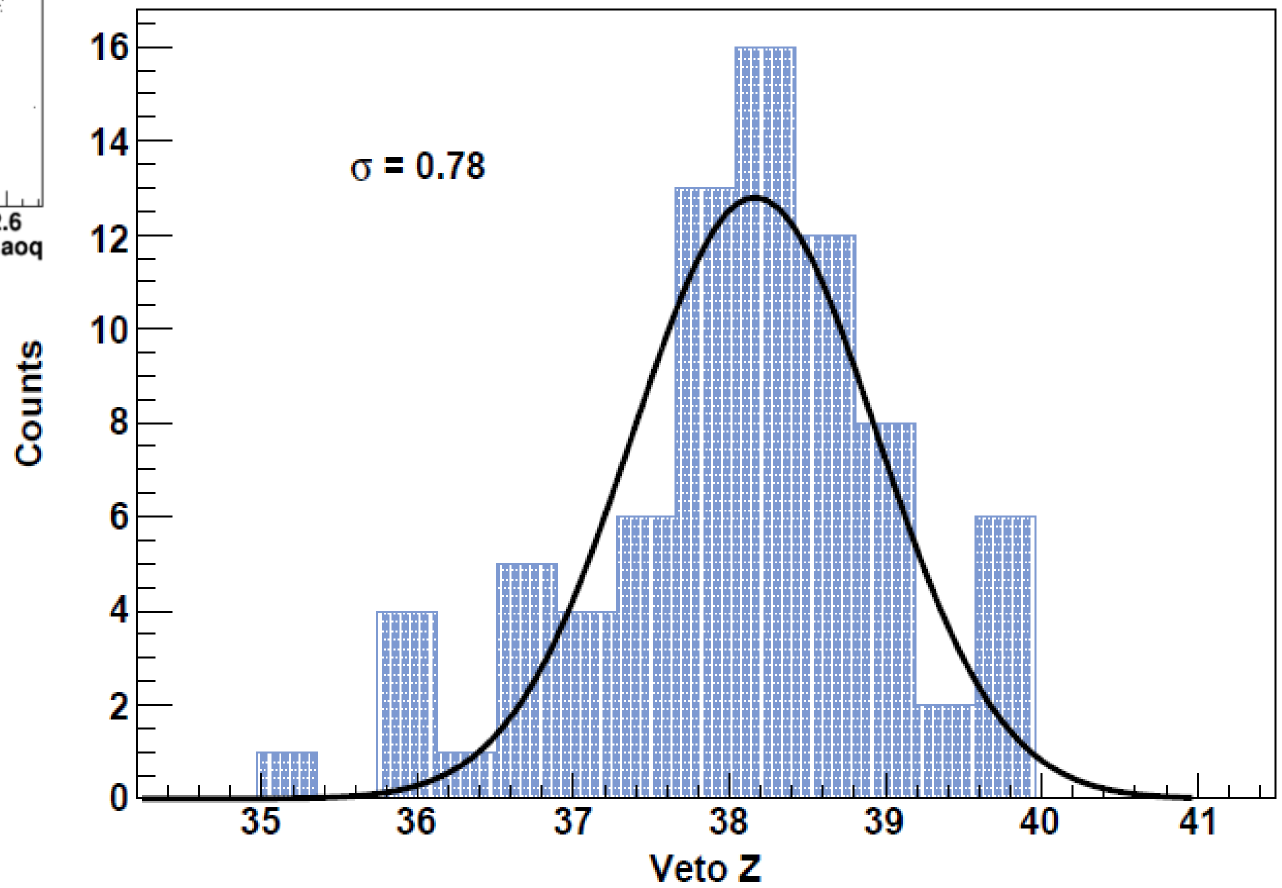
UrQMD+GEANT4 simulation

Charge resolution

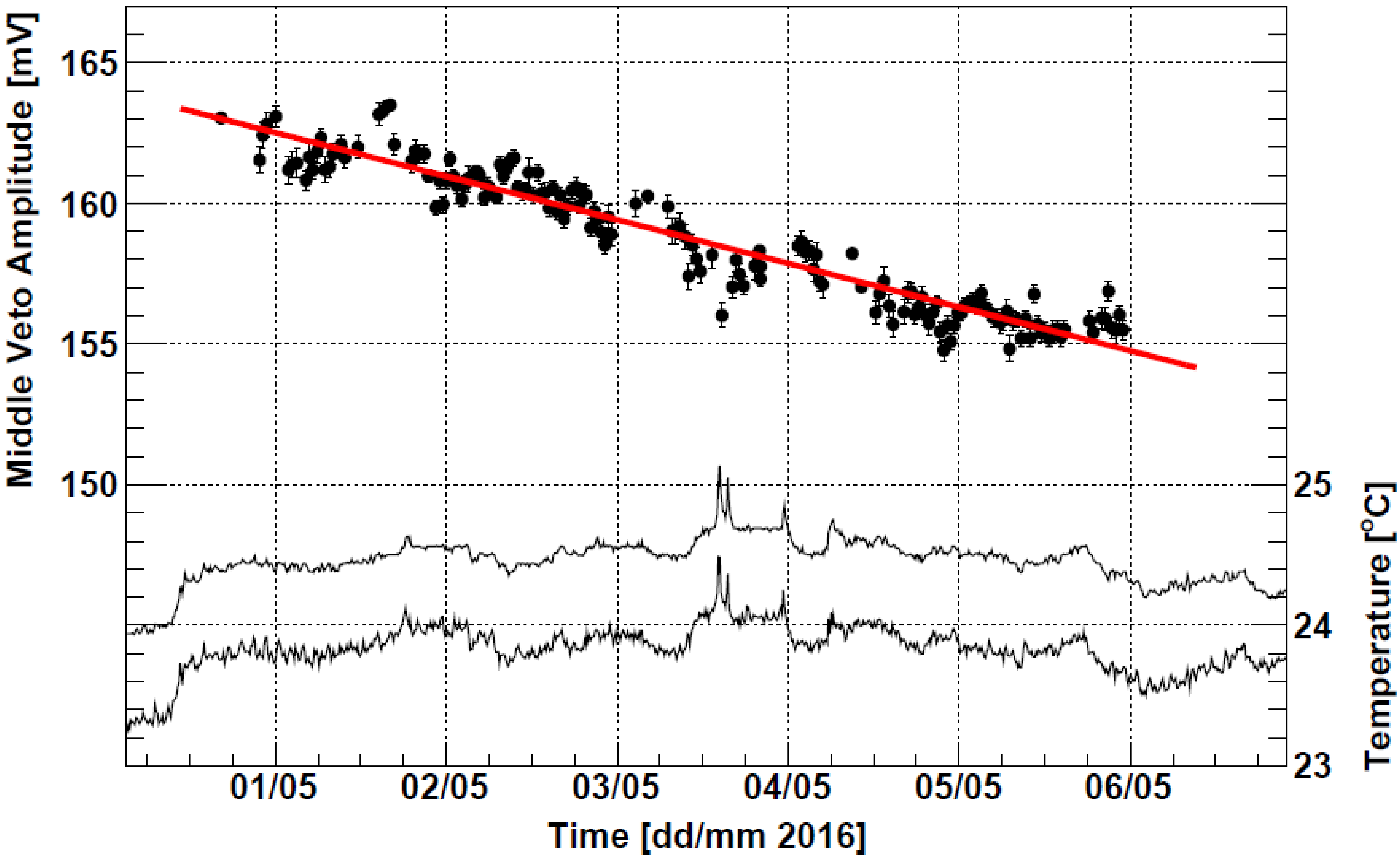
Taking a single Z “blob” from the upstream chamber and projecting it on KATANA Z calibration we get charge resolution of ~1.8 Z FWHM which is still worse than at HIMAC (~1.3 Z FWHM at Z=54, digital sum) but much better than from the cocktail beam peak (~3.2 Z for run 2350)





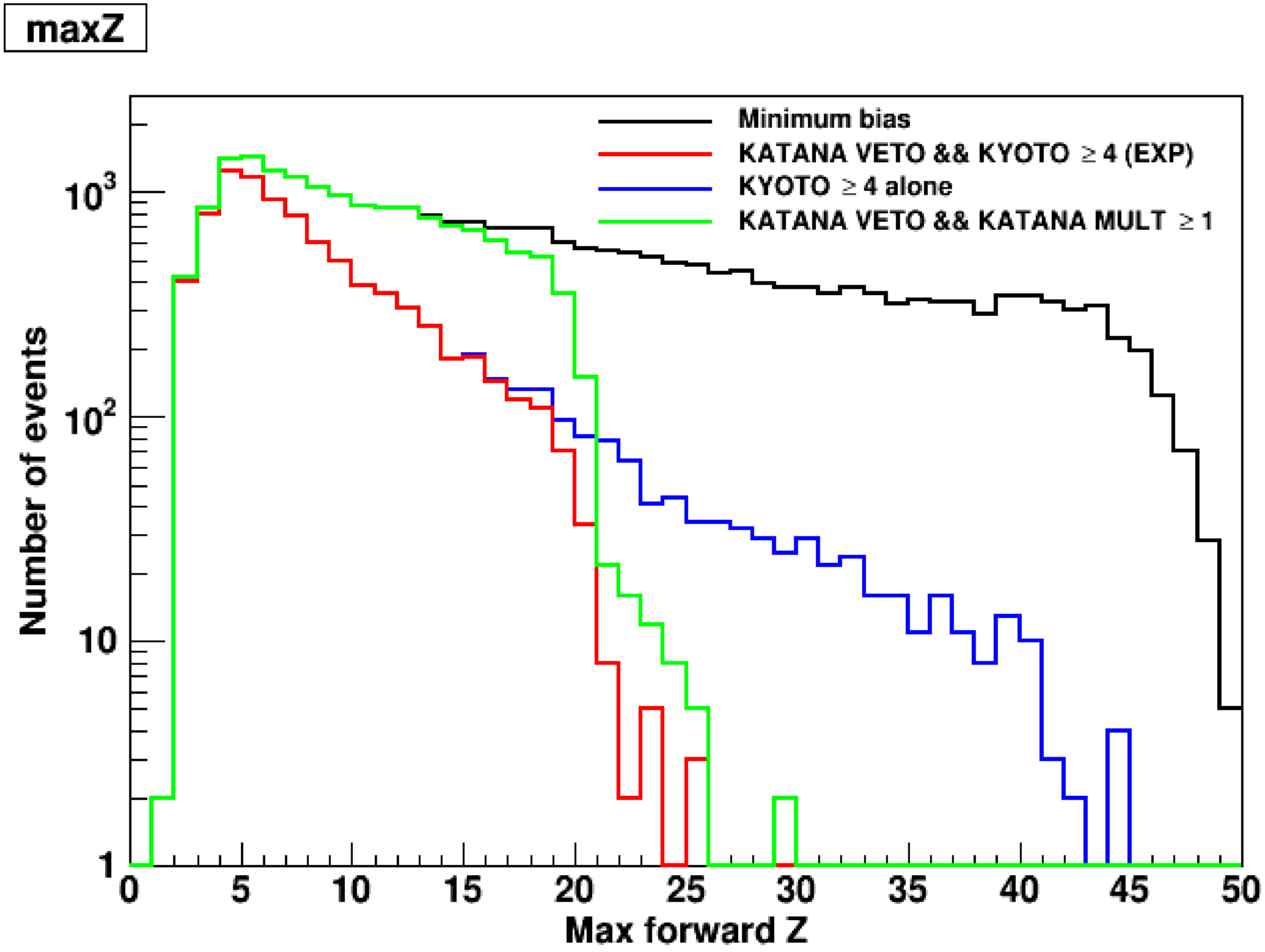


Amplitude drop: ~1% / day



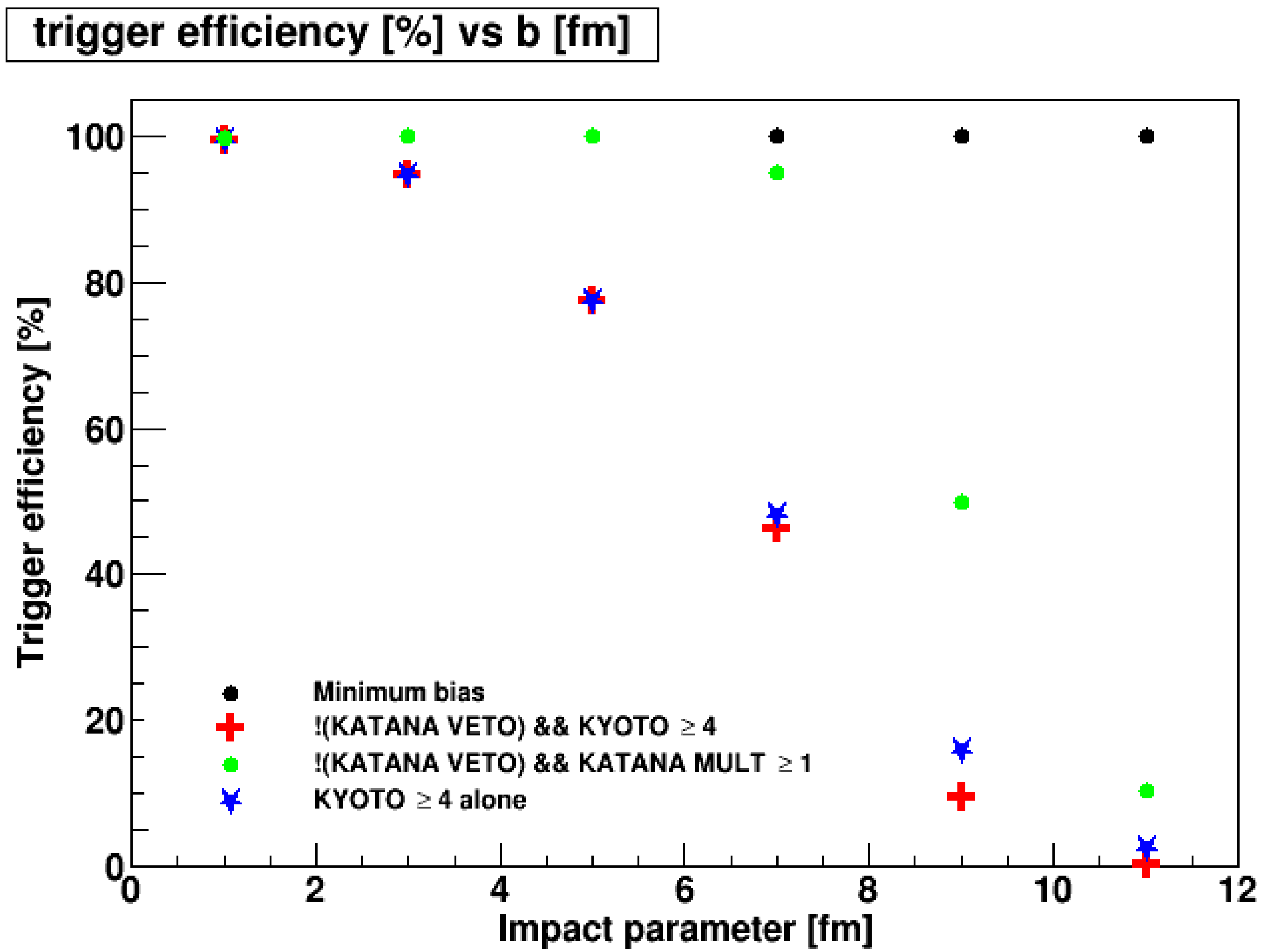
P. Lasko et al. NIM A 856 (2017) 92

Veto efficiency for heavy charges



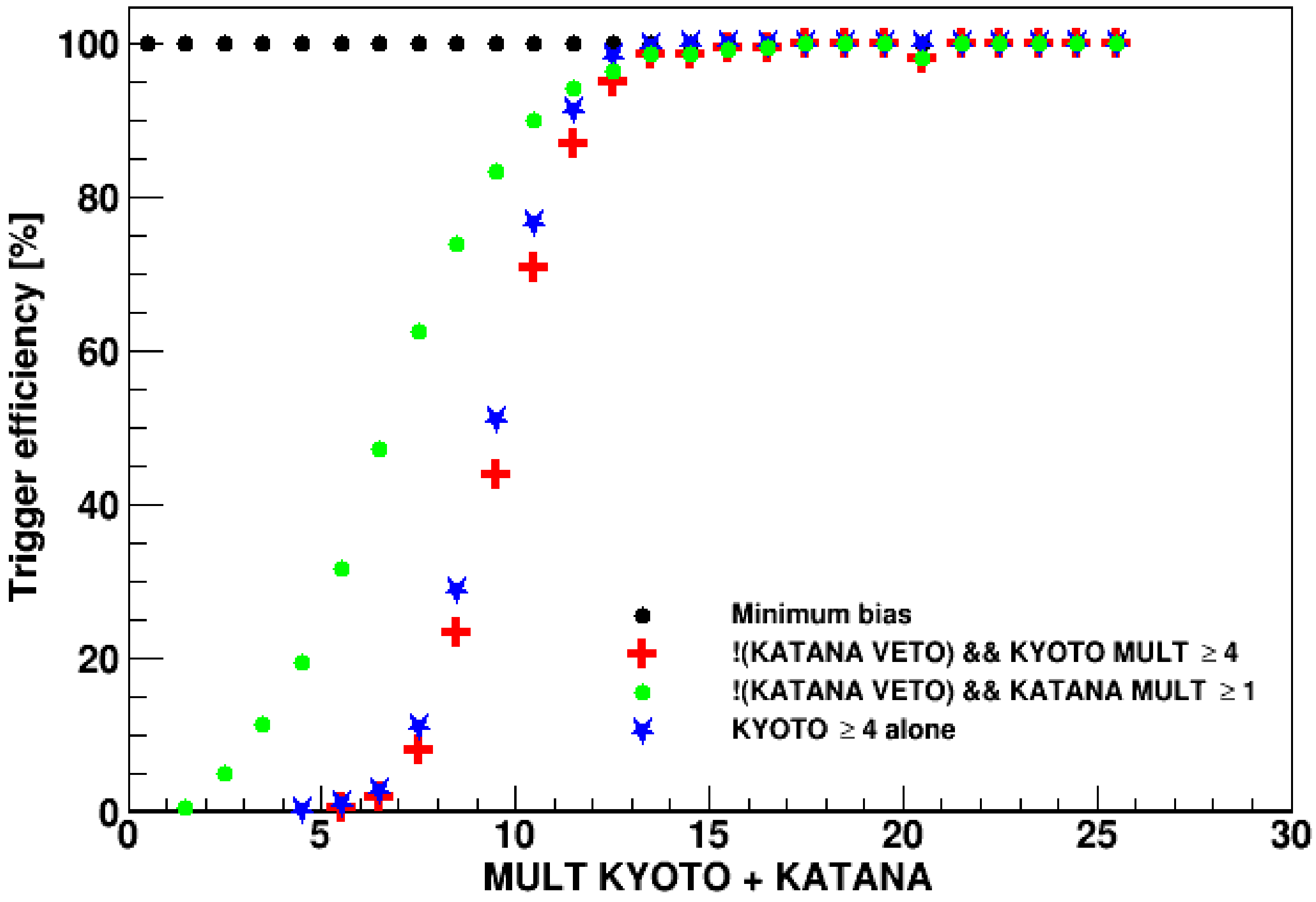
UrQMD+GEANT4 simulation

Trigger efficiency vs b



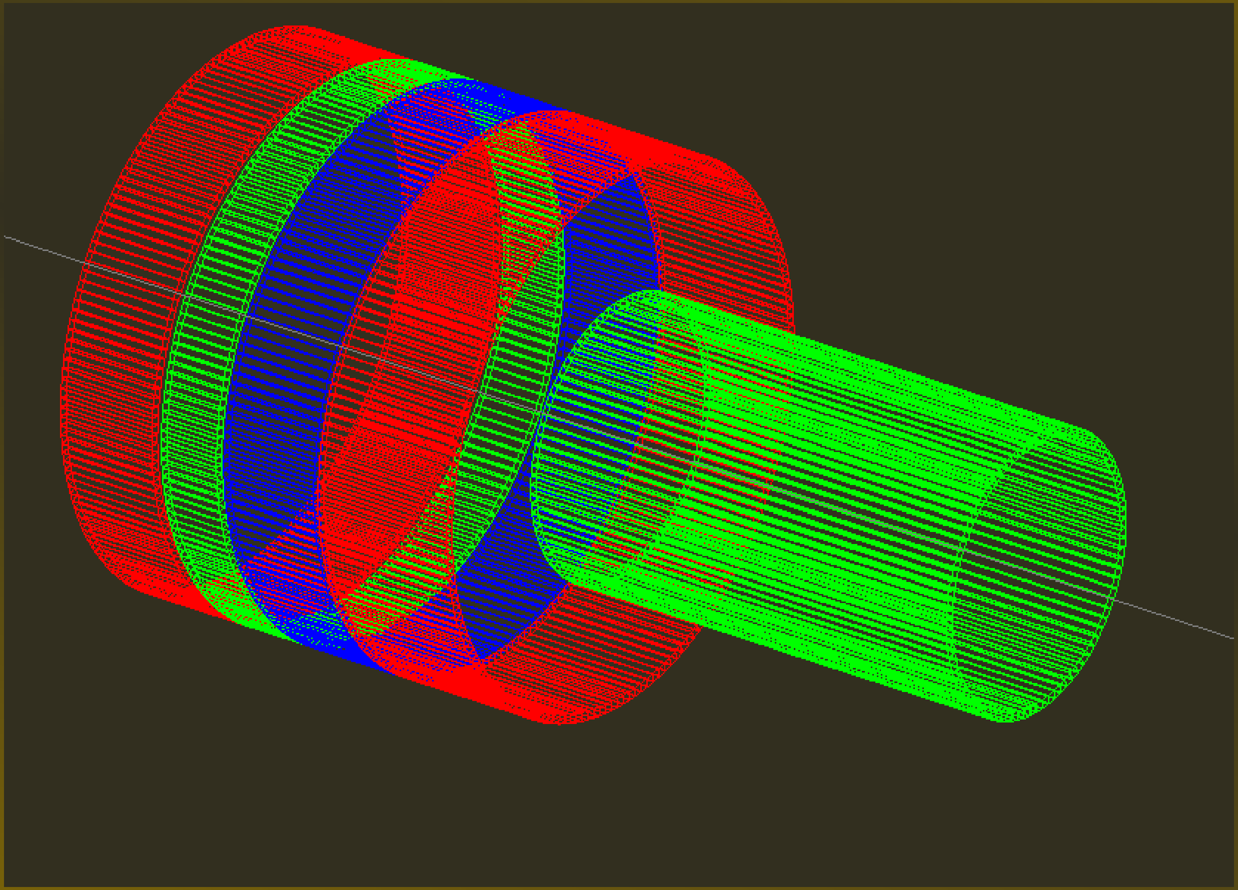
UrQMD+GEANT4 simulation

Trigger efficiency vs MULT



UrQMD+GEANT4 simulation

KRAB



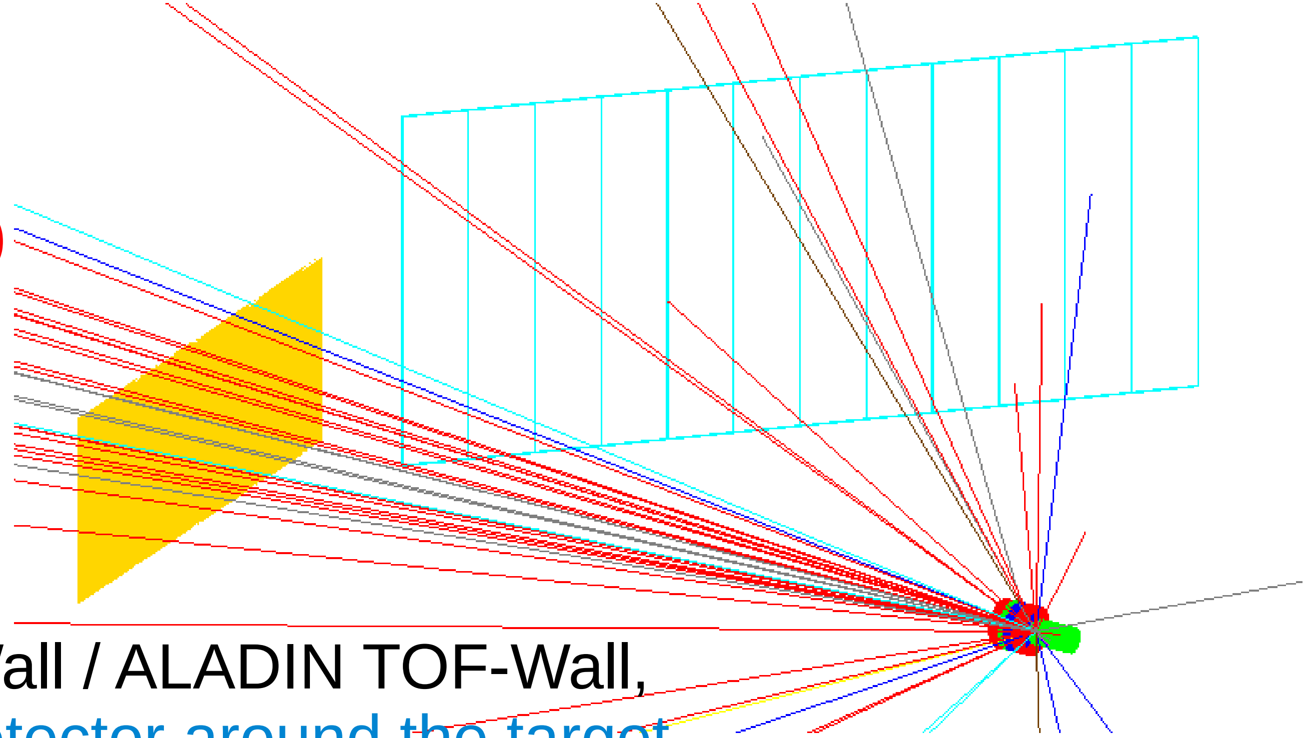
KRAków Barrel

ASY-EOS II @ FAIR (2019?)

Determination of the density dependence of the EOS at supra-saturation densities

Symmetric and asymmetric systems
^{108}Sn, ^{132}Sn, ^{197}Au @ 0.4, 1, 1.2 AGeV

Observables:
ratios: n/p, t/^{3}He, π^{-}/π^{+}(?)
flow: n, p, t, ^{3}He



Main detectors:
NeuLAND, FOPI PlasticWall / ALADIN TOF-Wall,
Trigger/Reaction Plane detector around the target

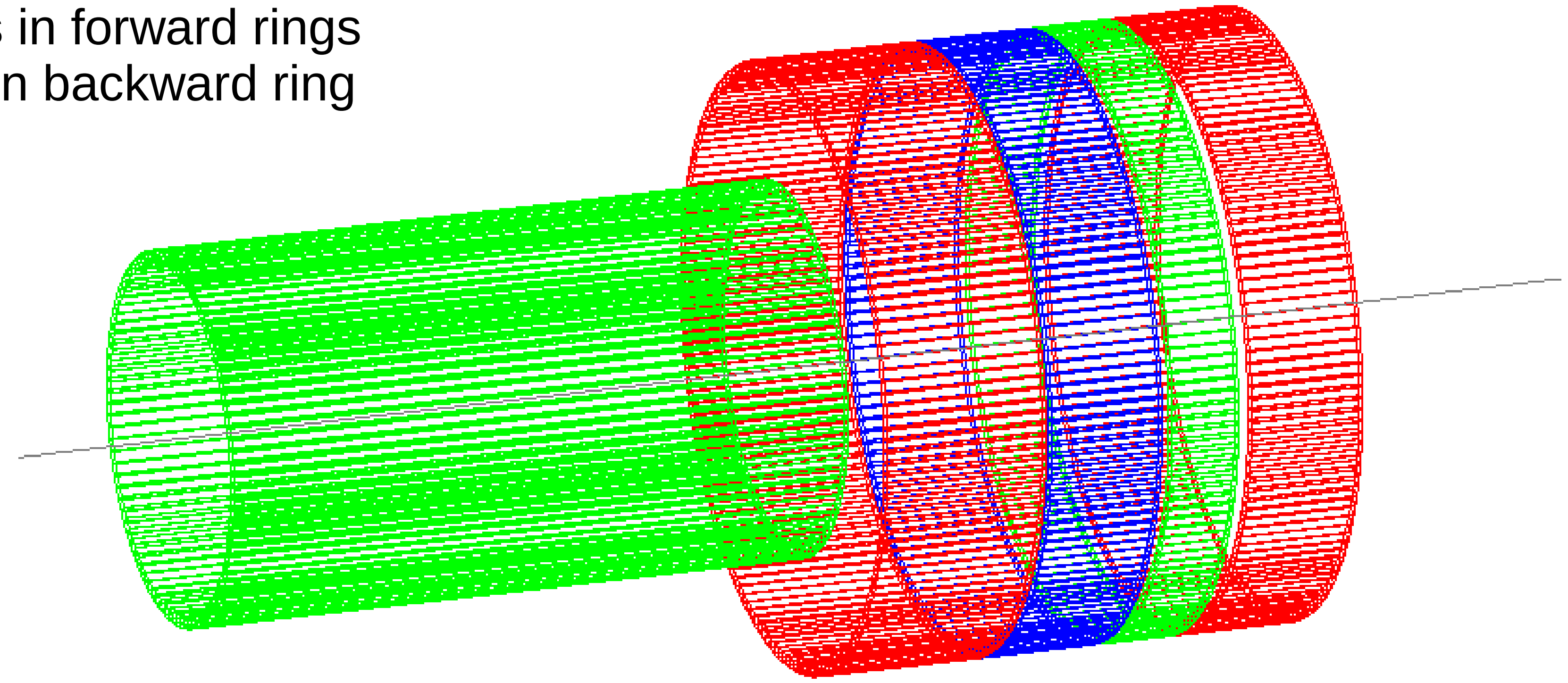
Trigger/Reaction Plane detector around the target

requirements:

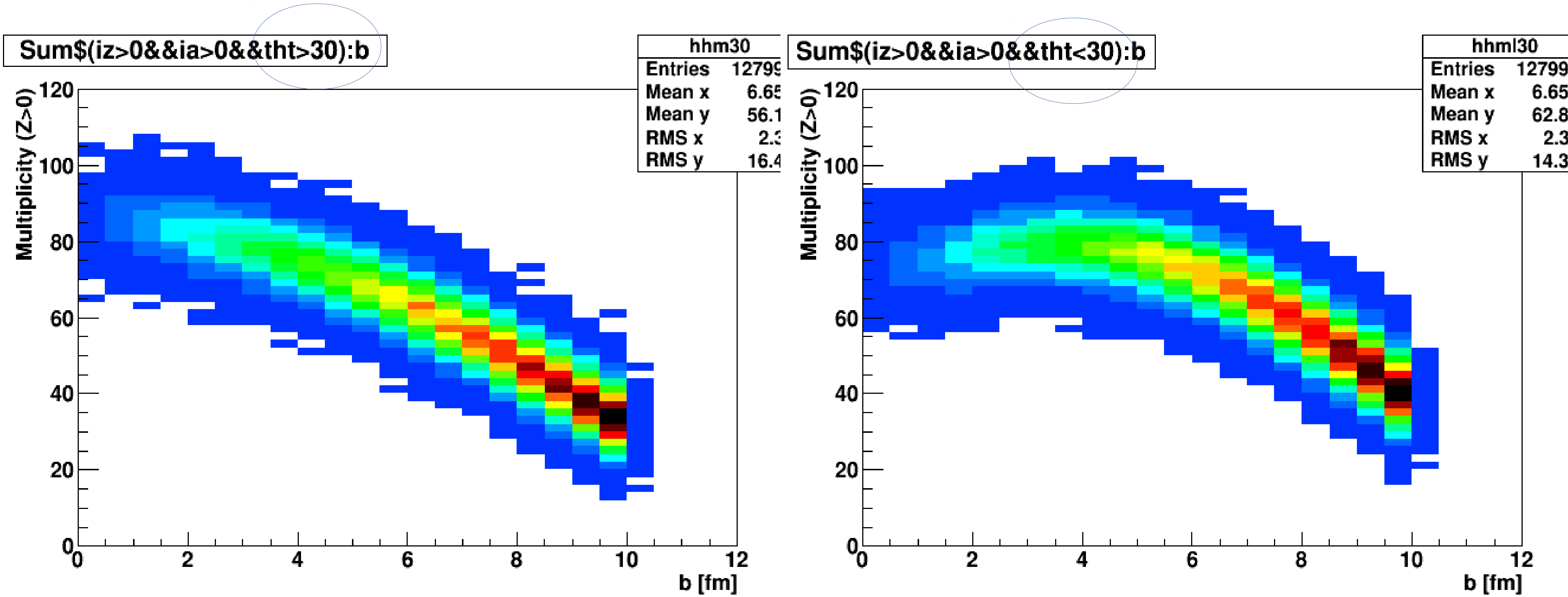
- should cover angles > 30^{o},
- high segmentation in azimuthal angle,
- high geometrical efficiency,
- low multihit probability,
- fast timing

Trigger/Reaction Plane detector around the target:

- 5 rings of 4x4 mm^2 fast scintillating fibers (e.g. BCF-20) read out by SiPMs
- covers angles from 30^o to 165^o,
- segmentation assures more or less uniform count rates for Au+Au at 1 AGeV,
- geometrical efficiency ~95%
- ~10% of charged particles involved in multihits,
- ~5% multihit probability
- sufficiently large for radioactive beams
- sufficiently small and lightweight not to disturb neutrons
- min radius - 6 cm,
- max radius - 12 cm
- length 43 cm
- 180 segments in forward rings
- 90 segments in backward ring
- 810 channels

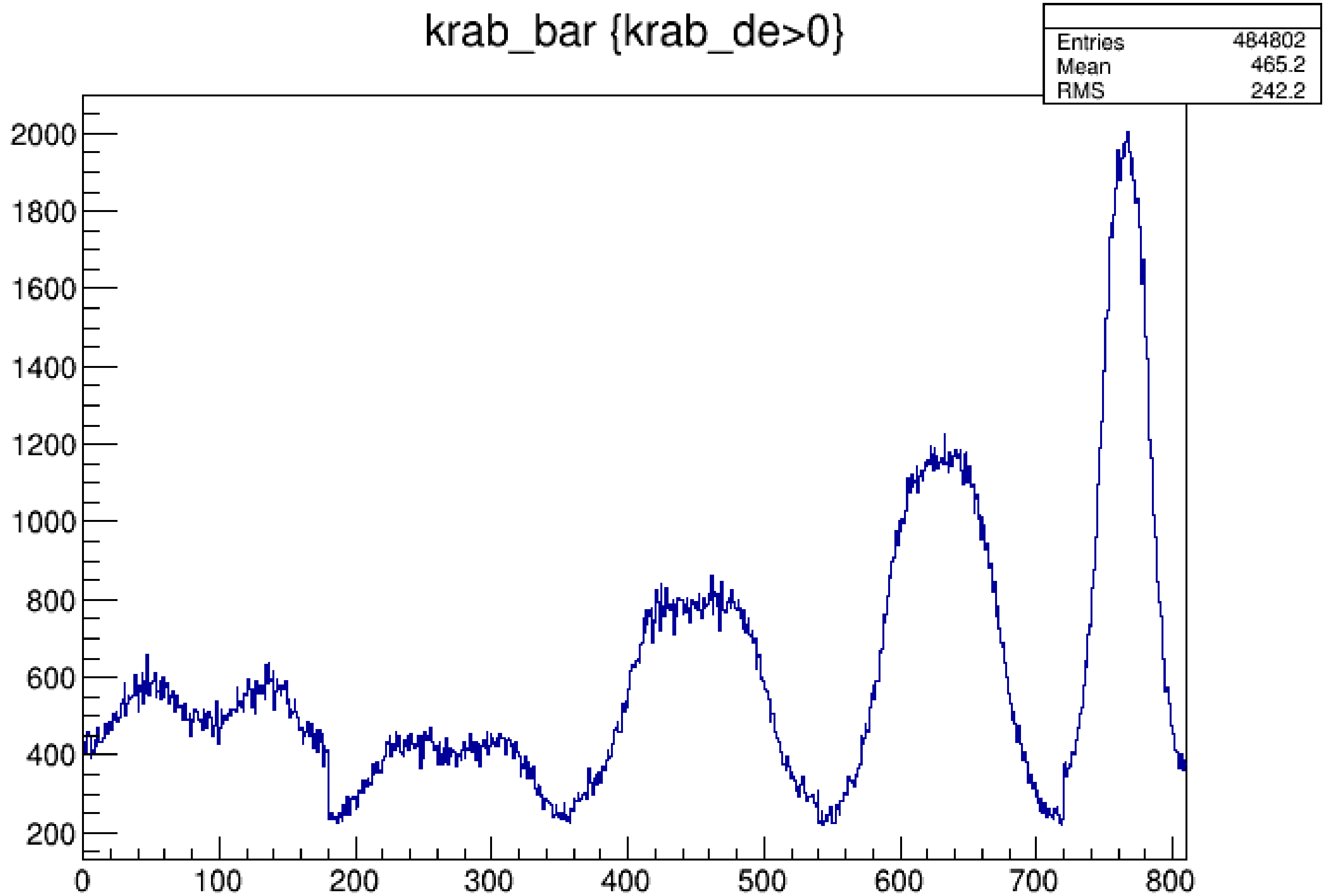


UrQMD + clustering: Au+Au 1000 AMeV, 0-10 fm, 200 fm/c

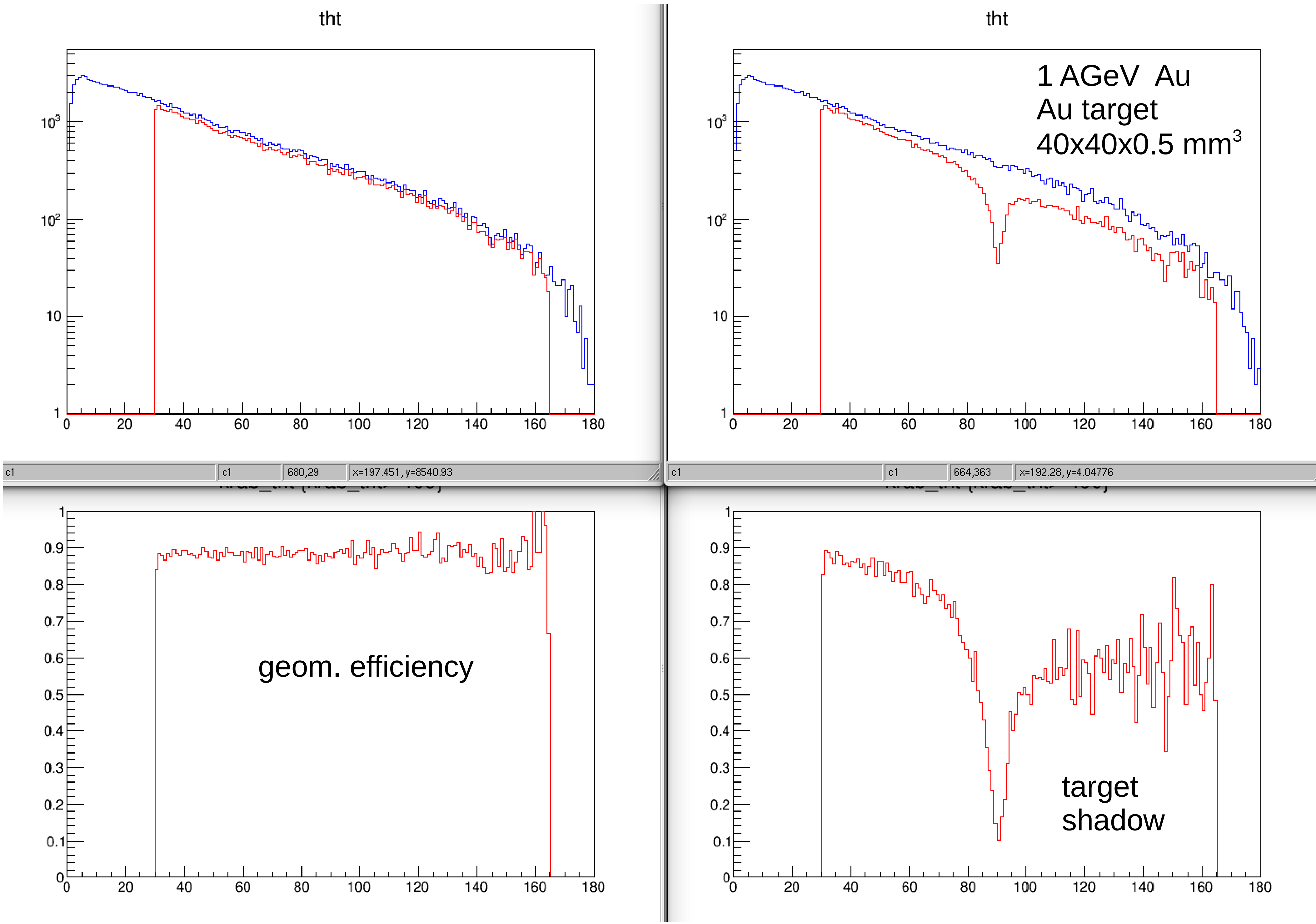


better correlation

hits/segment



SciFi segment number


tht
tht
1 AGeV Au
Au target
40x40x0.5 mm3
c1
c1
680,29
x=197.451, y=8540.93
c1
c1
664,363
x=192.28, y=4.04776
geom. efficiency
target
shadow

Summary and Conclusions

KRATTA
- good detector performance
- flow parameters consistent with FOPI data
- UrQMD (+ clustering) fails in reproducing isotope ratios
- realistic description of cluster formation needed
- advantages of pulse shape analysis
- attempt to obtain approximate isotopic identification in punch through regions
- attempt to identify pions (at least π+)

KATANA
- charge resolution of the VETO paddle: > 1.8 charge units FWHM
- amplitude drop of the central VETO: about 1% per day of the beam time
- trigger efficiency ~100% for MULT KYOTO+KATANA>14

KRAB
- design of the multiplicity trigger/reaction plane detector for the ASY-EOS II