Reaction Rates for Explosive Nuclear Synthesis

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X-Ray Bursts – short intro

- Most frequent thermonuclear explosions in the universe
- Over 90 Galactic X-ray bursting sources detected to date
- Provide a unique window into the physics of neutron stars
- With the recent advances in observational astrophysics there is a large amount of data
- Problem:
  - Need a reliable nuclear physics database to interpret it
  - In particular, need good understanding of the rp-process

X-Ray Bursts – short intro

- The critical nuclear data in the rp-process:
  - nuclear masses
  - β-decay rates
  - nuclear reaction rates
- Most nuclei in rp-process are unstable
- Indirect methods have been used
- Large uncertainties
- Radioactive beams needed

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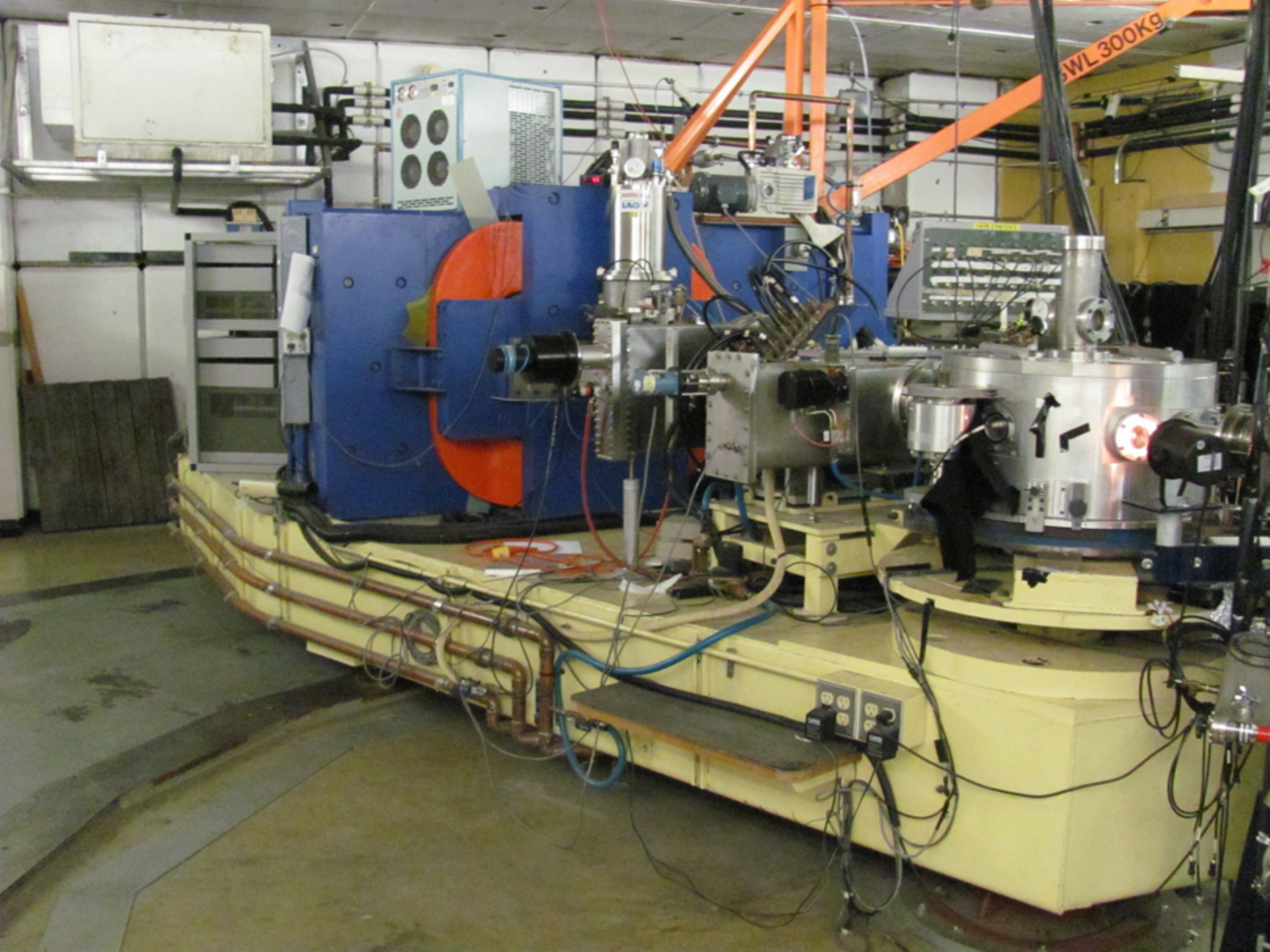
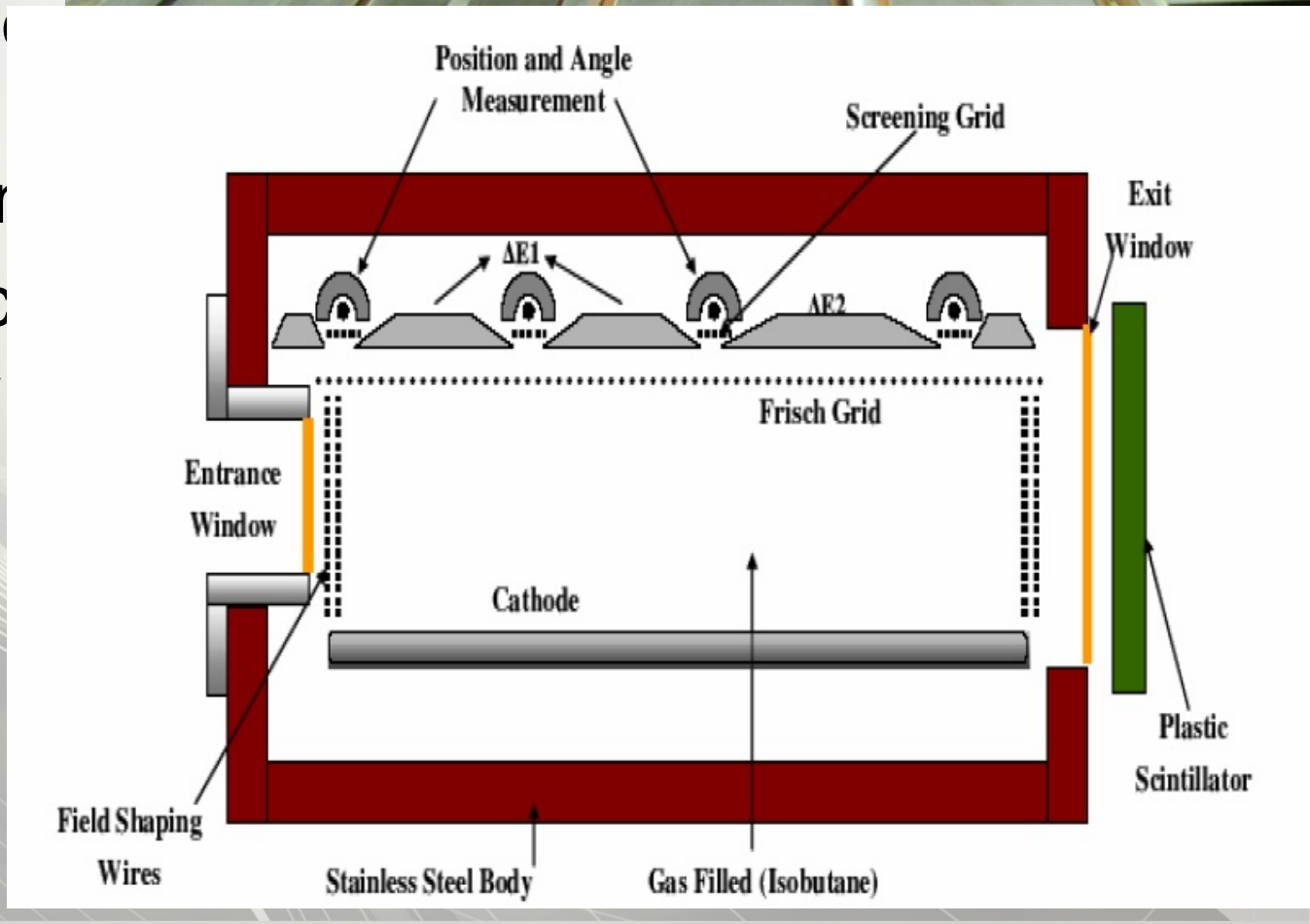
T-REX

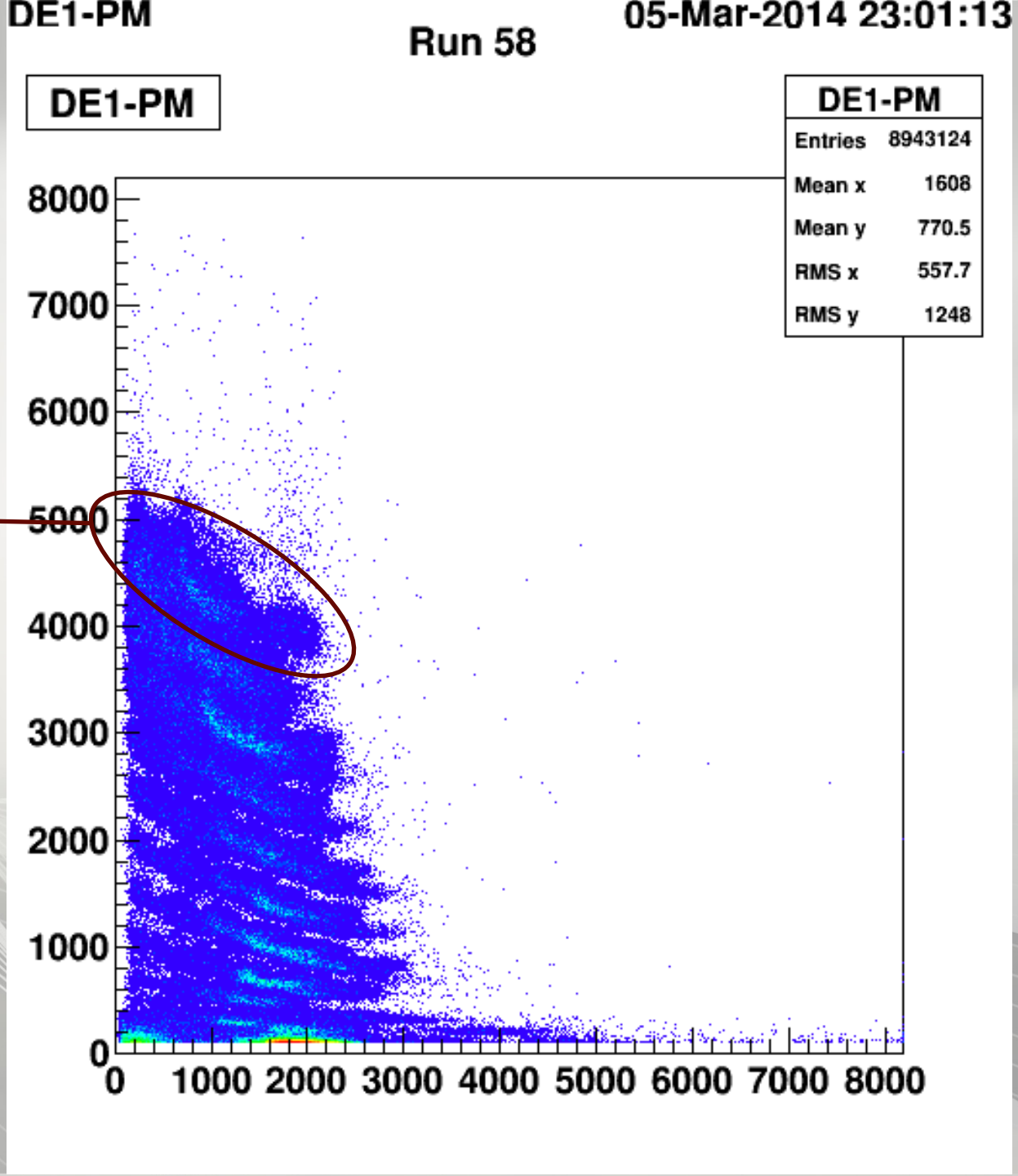
[TAMU Reaccelerated Exotics]


WL 300Kg

MDM-Oxford detector

- Oxford dete
  - Gridded i
    chamber
    proportion
  - Plastic sc
    PMTs for

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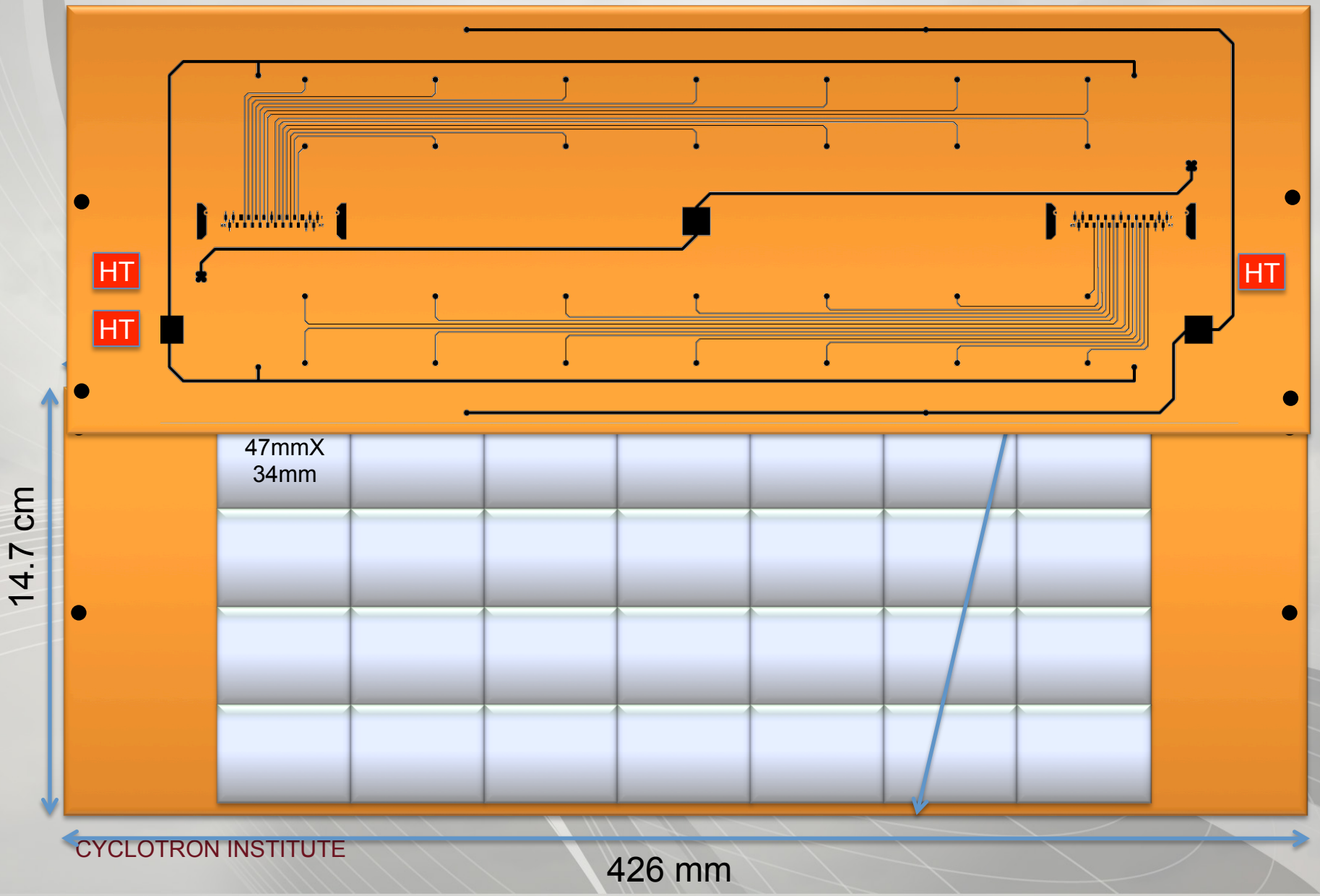
RMS y 1248
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1000 2000 3000 4000 5000 6000 7000 8000

Mg isotopes

Micromegas

Micro Mesh Gaseous Structure, Y. Giomataris, Ph. Rebourgeard, J-P Robert and G. Charpak, NIM A376, 1996, p29 (CEA-biospace patent)

New anode with Micromegas pads



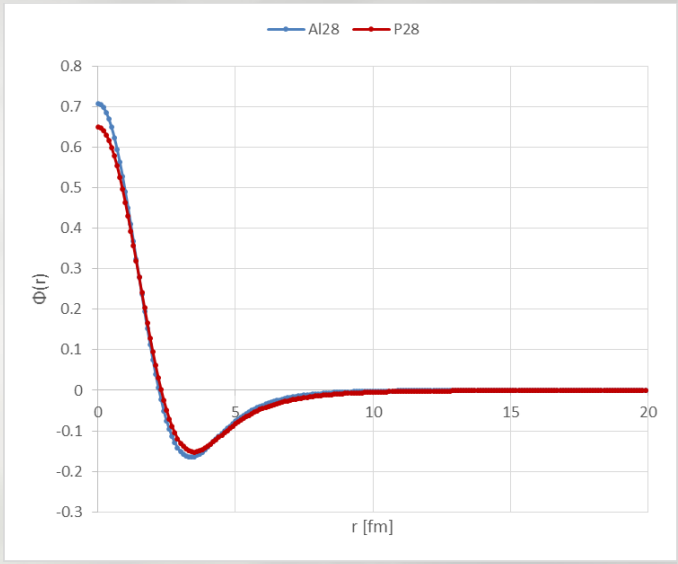
X-Ray bursts – $^{27}Si(p,\gamma)^{28}P$

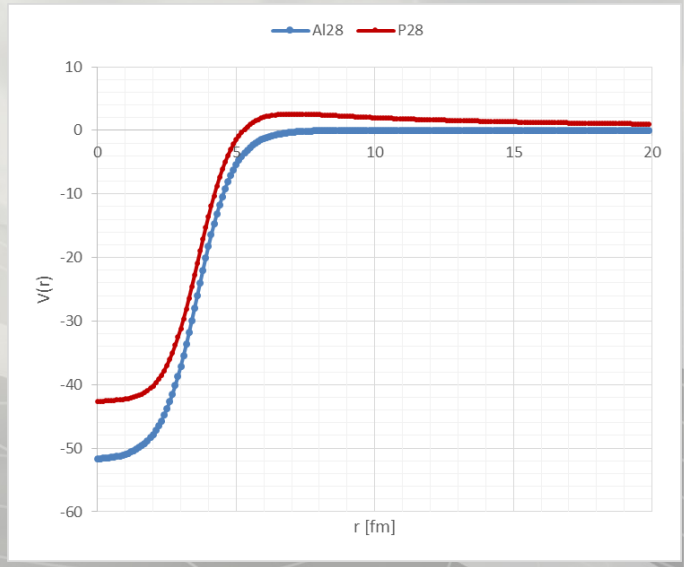
- $^{27}Si(p,g)$ – bottleneck
  - $T_{1/2}$=4.15 s ; **no experimental data**

- Use indirect method, theoretical estimations until radioactive beam available:
  - ^{28}P energy levels
  - Reaction Q-value
  - Spectroscopic data from mirror nucleus ^{28}Al

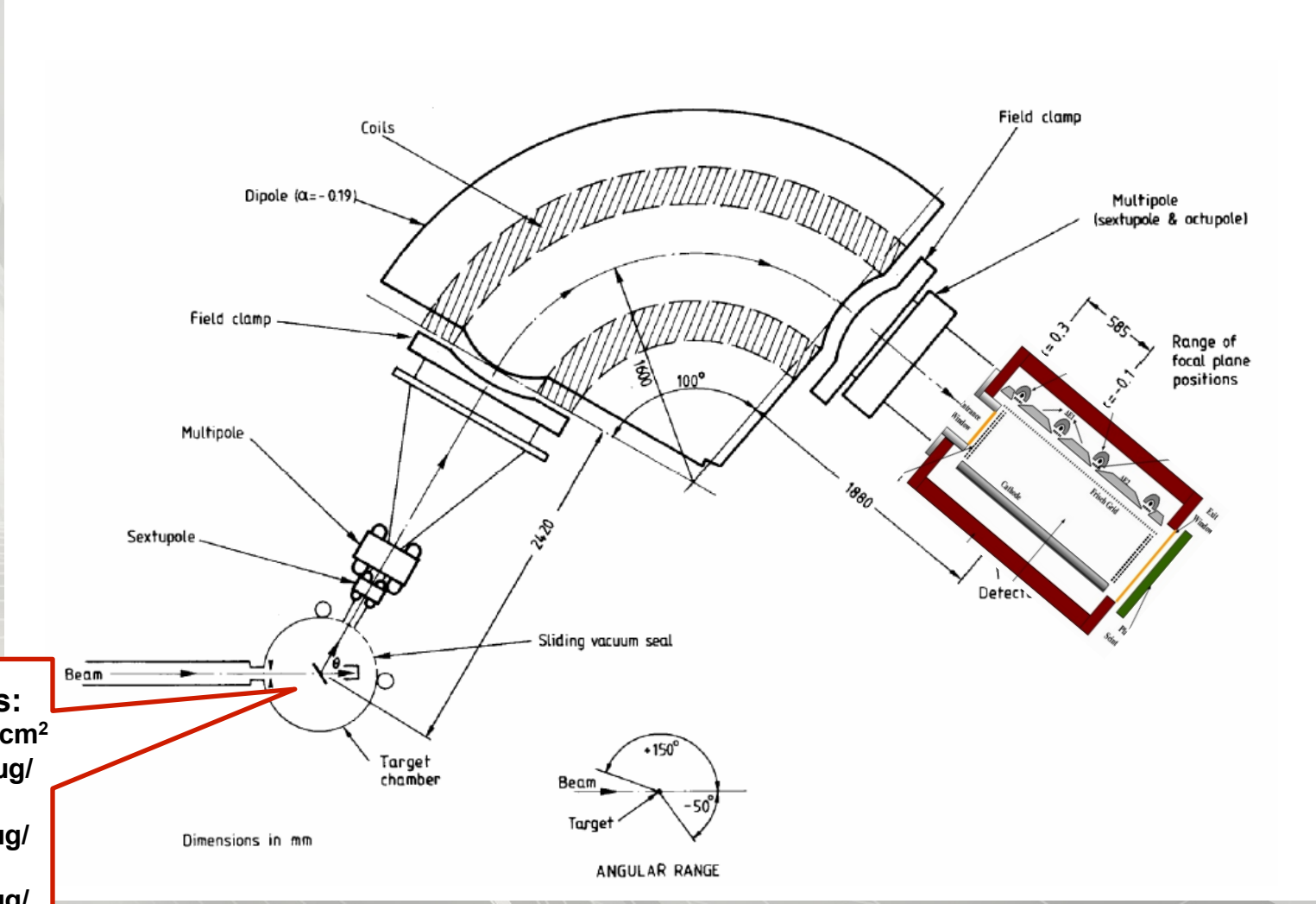
Mirror system $^{27}Al(n, \gamma)^{28}Al$

- Study of $^{27}Al+n \rightarrow {}^{28}Al$ with MDM spectrometer
  - Beam of ^{13}C @ 12 MeV/n on ^{27}Al target
  - Get angular distribution from elastic scattering $^{27}Al(^{13}C,^{13}C)^{27}Al$
  - Fit distribution to obtain Optical Potential Model parameters
  - Use OMP parameters to predict angular distribution for transfer reaction $^{27}Al(^{13}C,^{12}C)^{28}Al$
  - Compare with experimental data to extract ANC





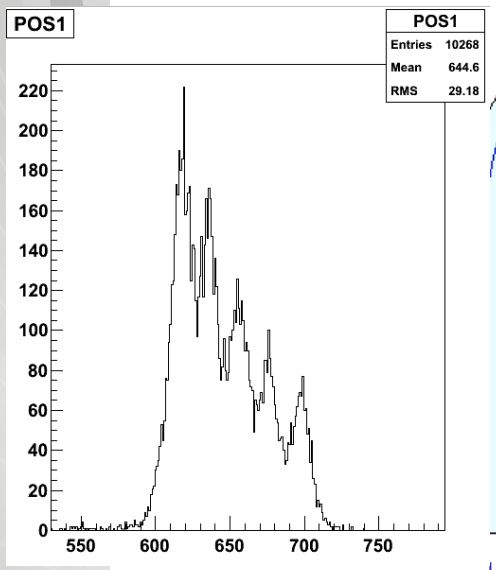
TAMU Multipole-Dipole-Multipole (MDM)

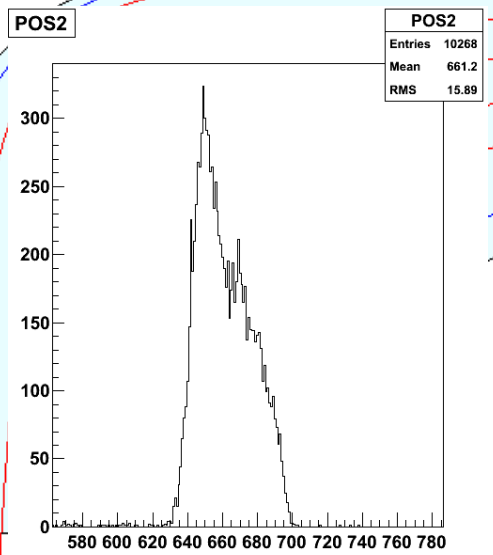


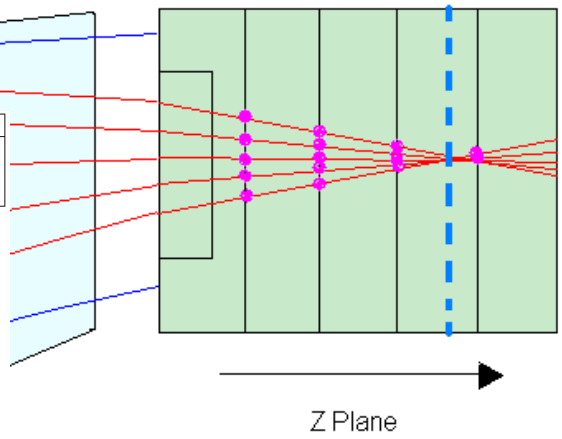
4 targets:
- Au 200 μg/cm^2
- ^{27}Al 105 μg/cm^2
- ^{27}Al 324 μg/cm^2
- ^{27}Al 800 μg/cm^2

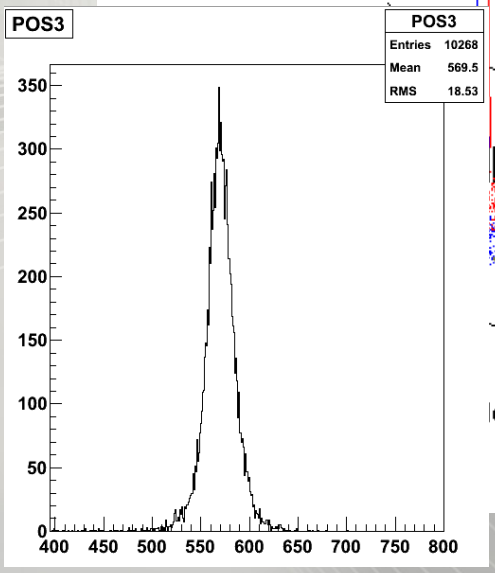
Detector

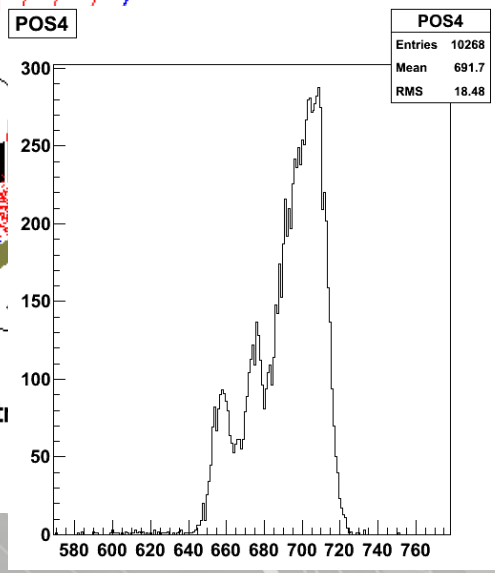
Dipole Magnet Separates
Beam by Magnetic Rigidity (p/q)

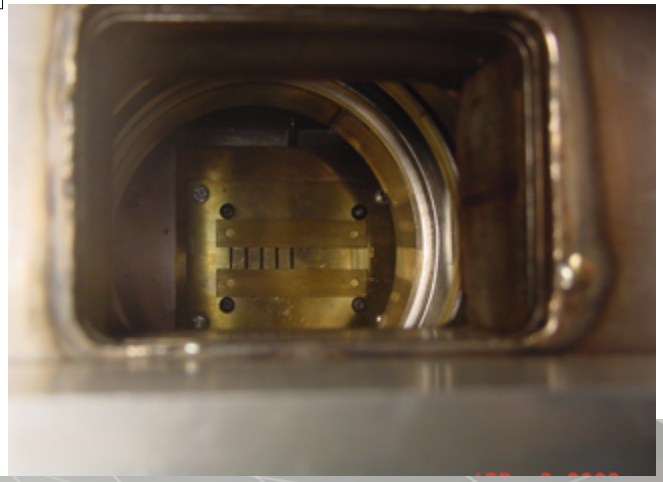




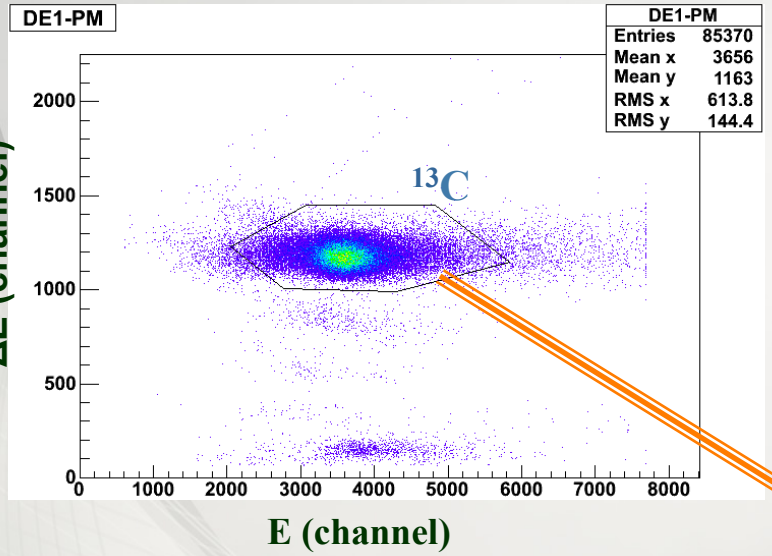


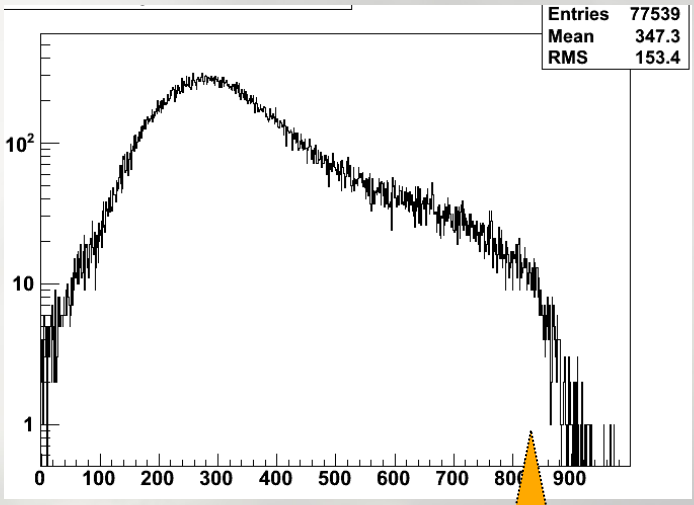


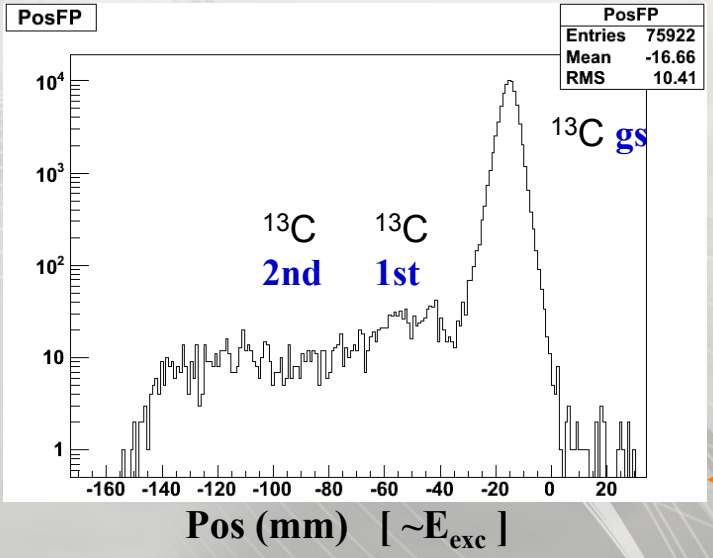


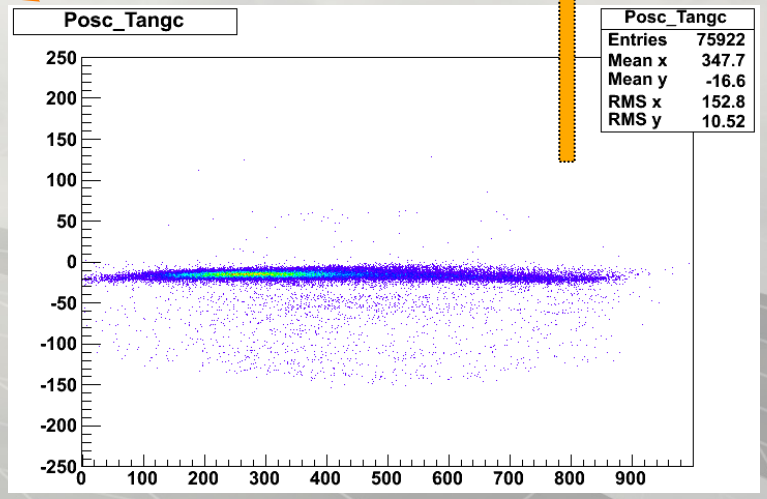


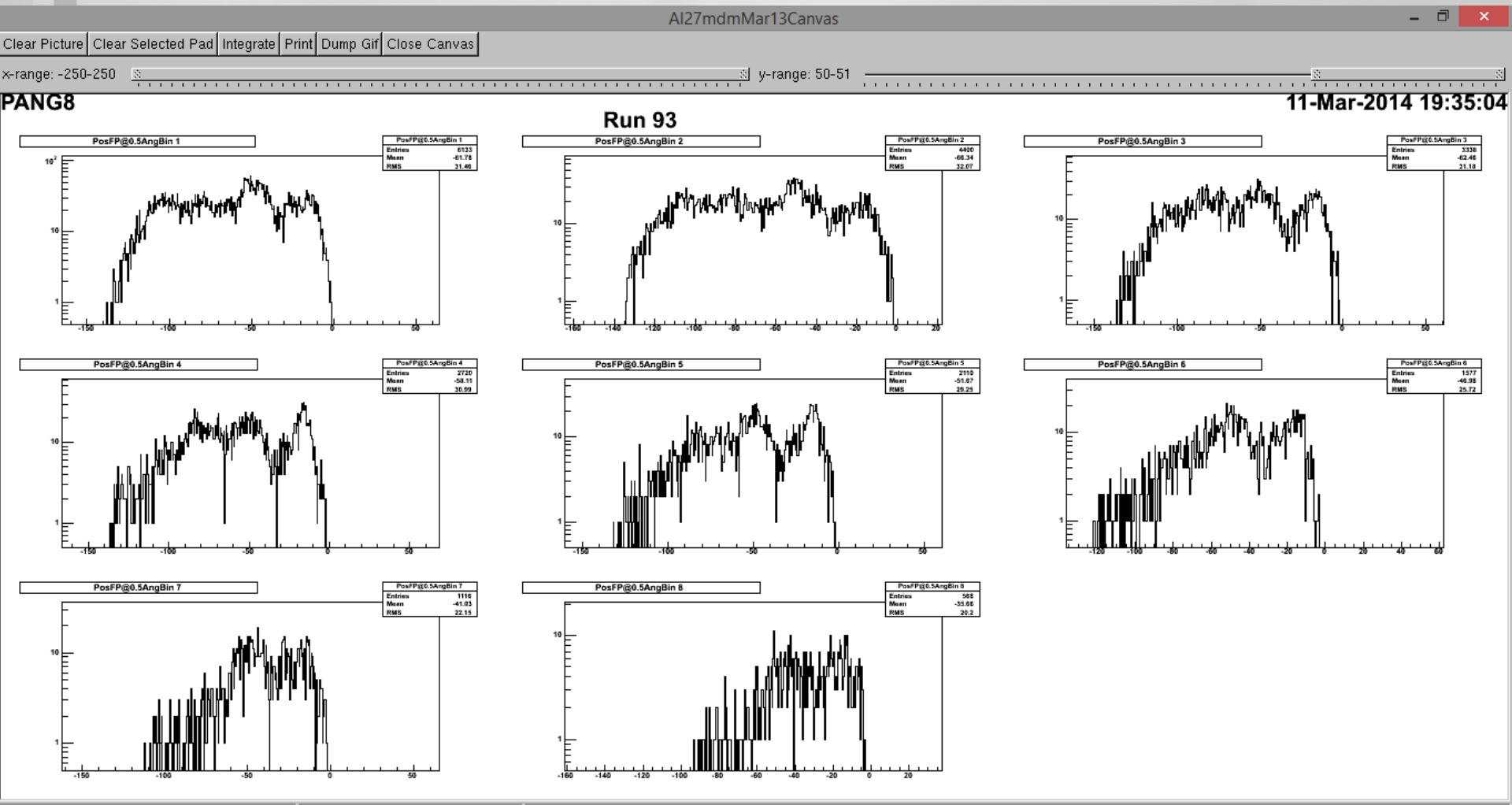
$^{27}Al(^{13}C,^{13}C)^{27}Al$







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Clear Selected Pad
Integrate
Print
Dump Gif
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y-range: 50-51
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Run 93
11-Mar-2014 19:35:04
PosFP@0.5AngBin 1
PosFP@0.5AngBin 2
PosFP@0.5AngBin 3
PosFP@0.5AngBin 4
PosFP@0.5AngBin 5
PosFP@0.5AngBin 6
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pict
892 607
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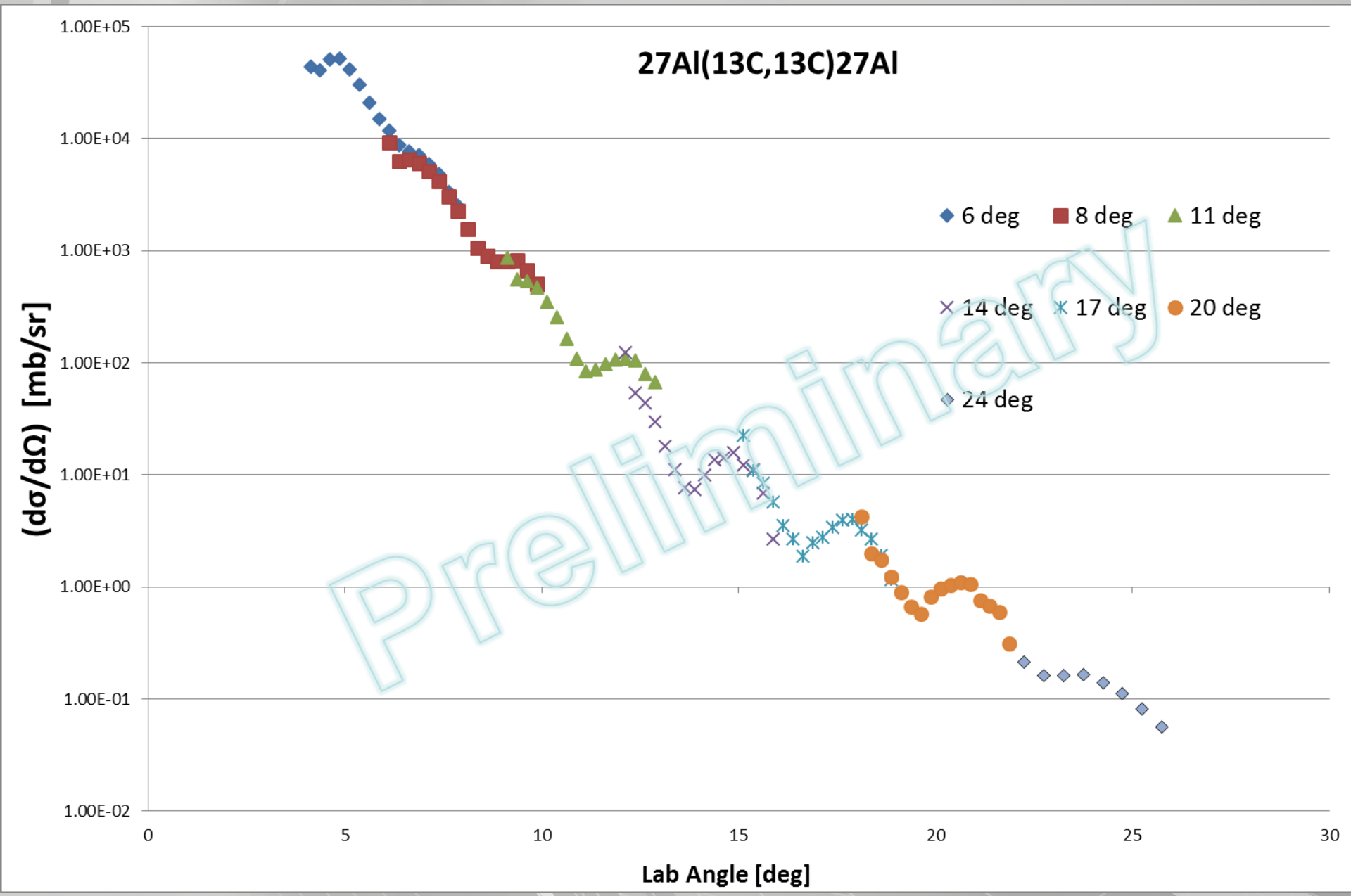
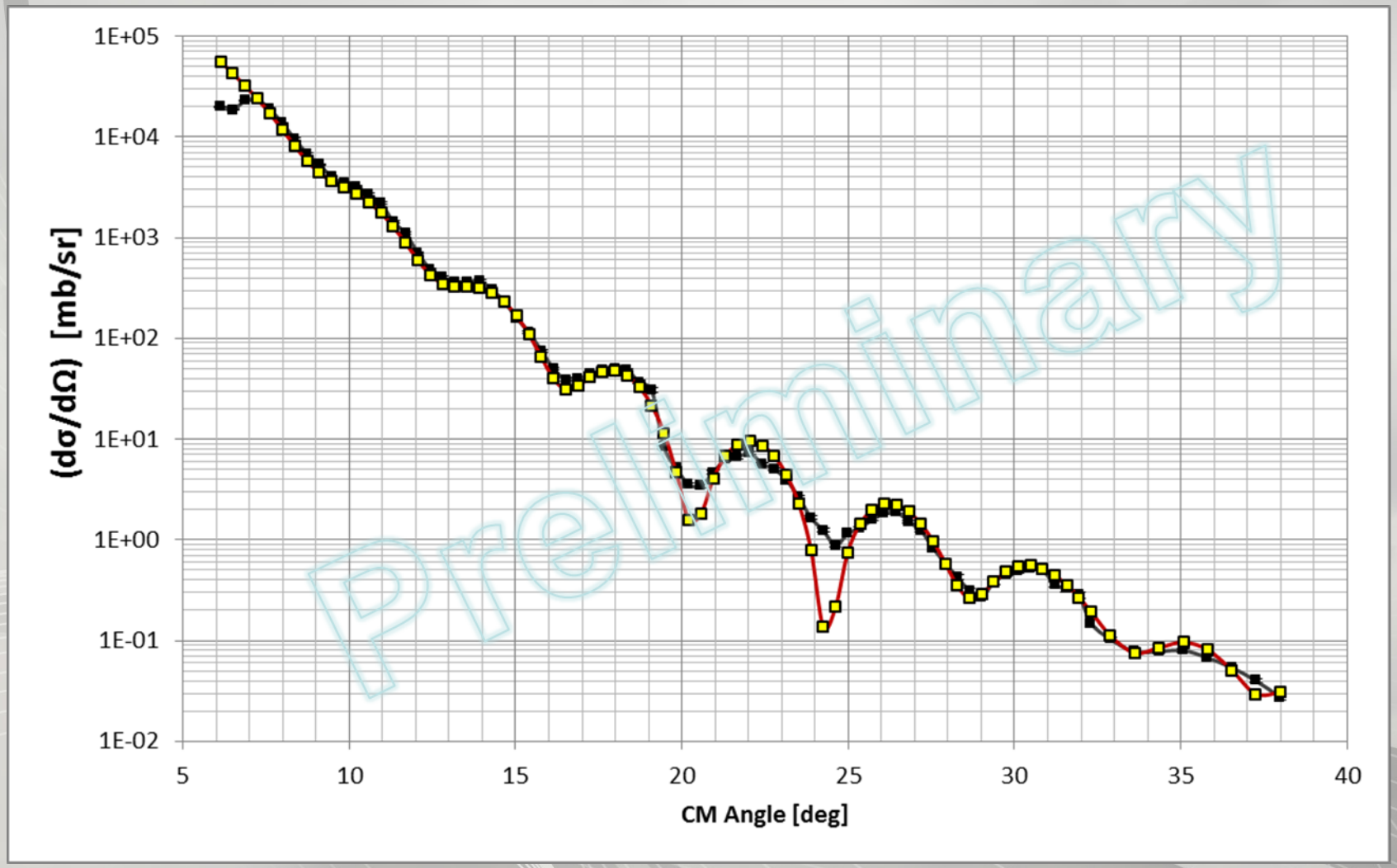
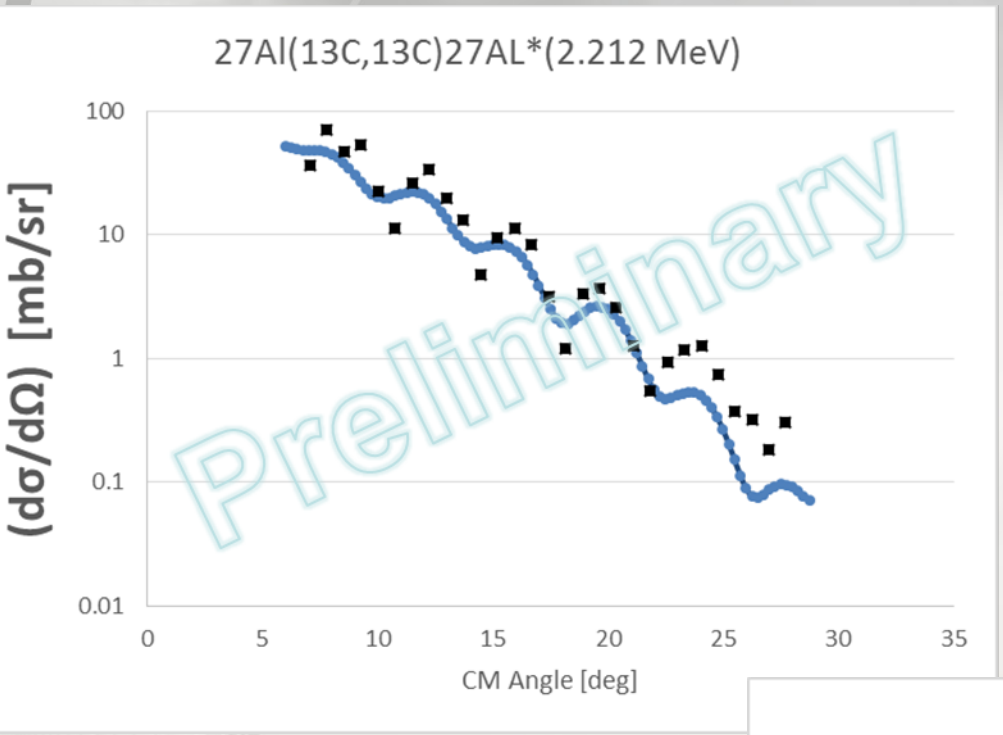

27Al(13C,13C)27Al
(dσ/dΩ) [mb/sr]
1.00E+05
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
1.00E-01
1.00E-02
0
5
10
15
20
25
30
Lab Angle [deg]
6 deg
8 deg
11 deg
14 deg
17 deg
20 deg
24 deg
Preliminary

$^{27}Al(^{13}C,^{13}C)^{27}Al$



V=71.231 W=14.195 r_V=1.046 r_W=1.213 a_V=0.537 a_W=0.938 Rc=1.764 $\chi 2$=10.17


27Al(13C,13C)27AL*(2.212 MeV)
(dσ/dΩ) [mb/sr]
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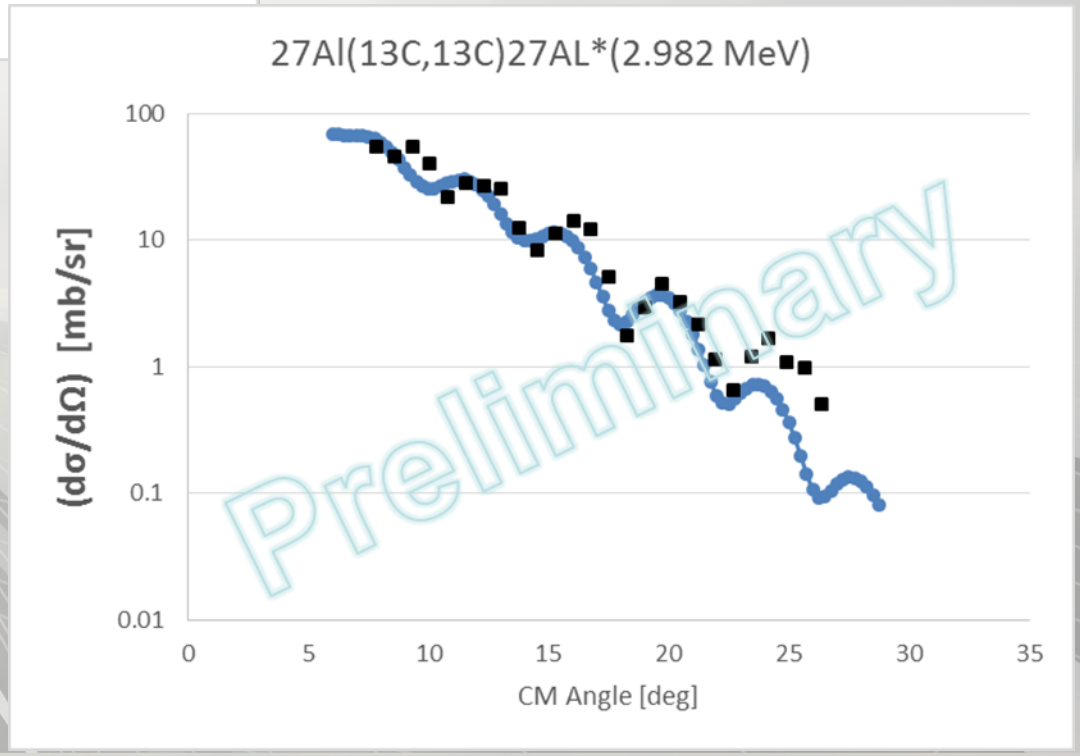
10
1
0.1
0.01
0
5
10
15
20
25
30
35
CM Angle [deg]
Preliminary


27Al(13C,13C)27AL*(2.982 MeV)
(dσ/dΩ) [mb/sr]
100
10
1
0.1
0.01
0
5
10
15
20
25
30
35
CM Angle [deg]
Preliminary

Future plan

- Take data for $^{27}Al(^{13}C,^{12}C)^{28}Al$ – May 2014
- Test Oxford upgrades – June 2014
- If successful, measure ^{13}C (^{27}Al, ^{28}Al) ^{12}C
- ^{27}Si beam – Fall 2014 (hopefully?)

Thank you for your attention!