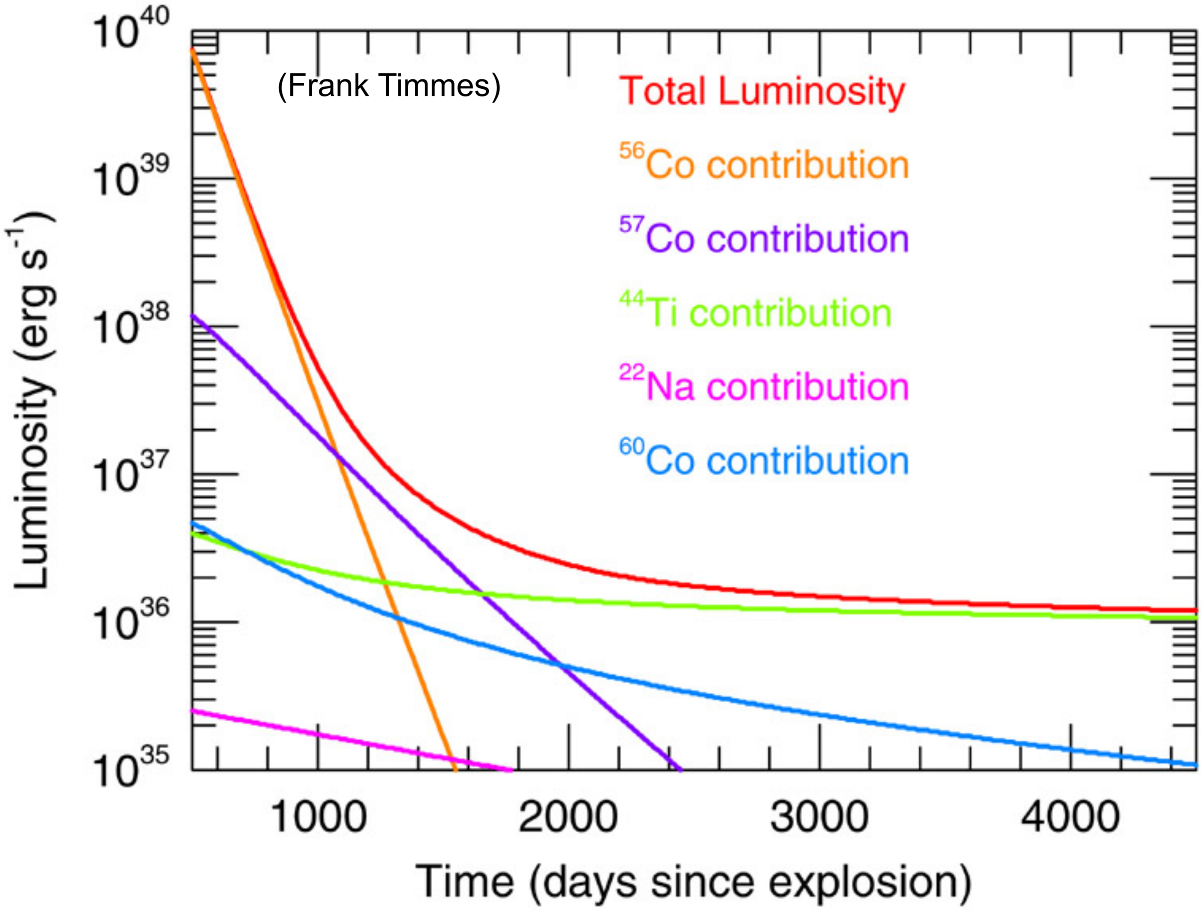
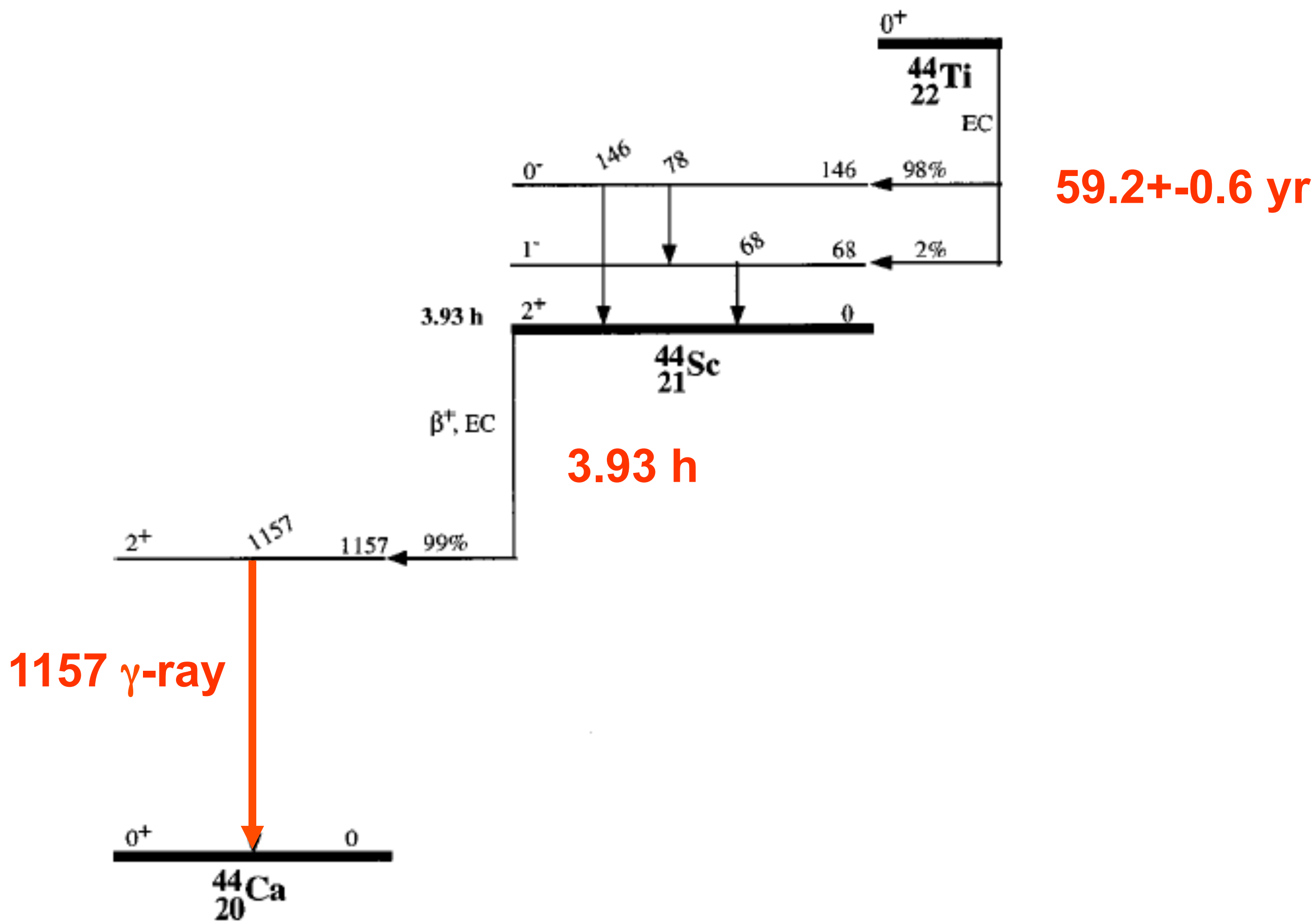
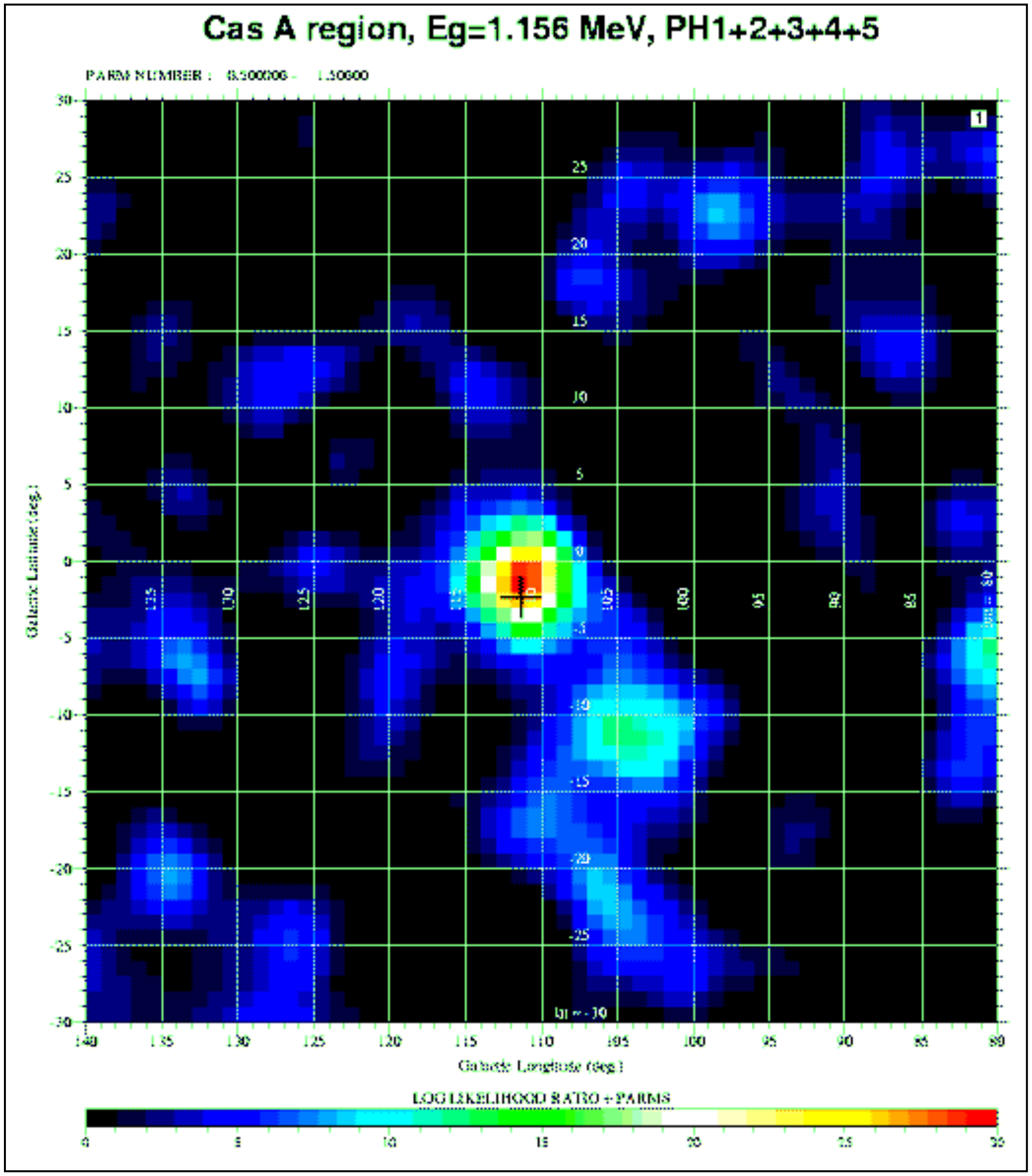
There is another effect that extends SN light curves: Radioactive decay !



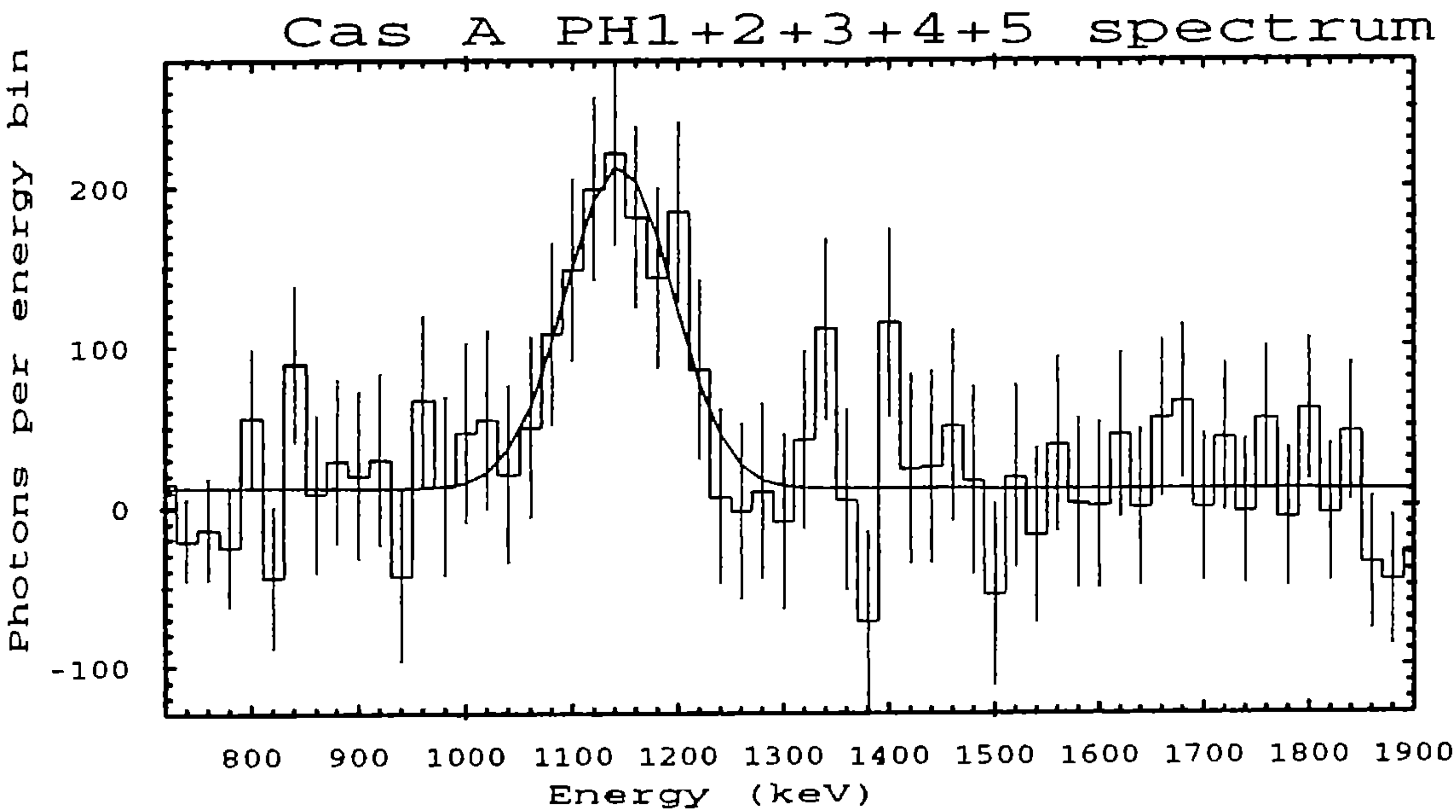
→ Radioactive isotopes are produced during the explosion
→ there is explosive nucleosynthesis !

44Ti


0+
44
22 Ti
EC
0-
146
78
146
98%
59.2+-0.6 yr
1-
68
68
2%
3.93 h
2+
0
44
21 Sc
β+, EC
3.93 h
2+
1157
1157
99%
1157 γ-ray
0+
0
44
20 Ca



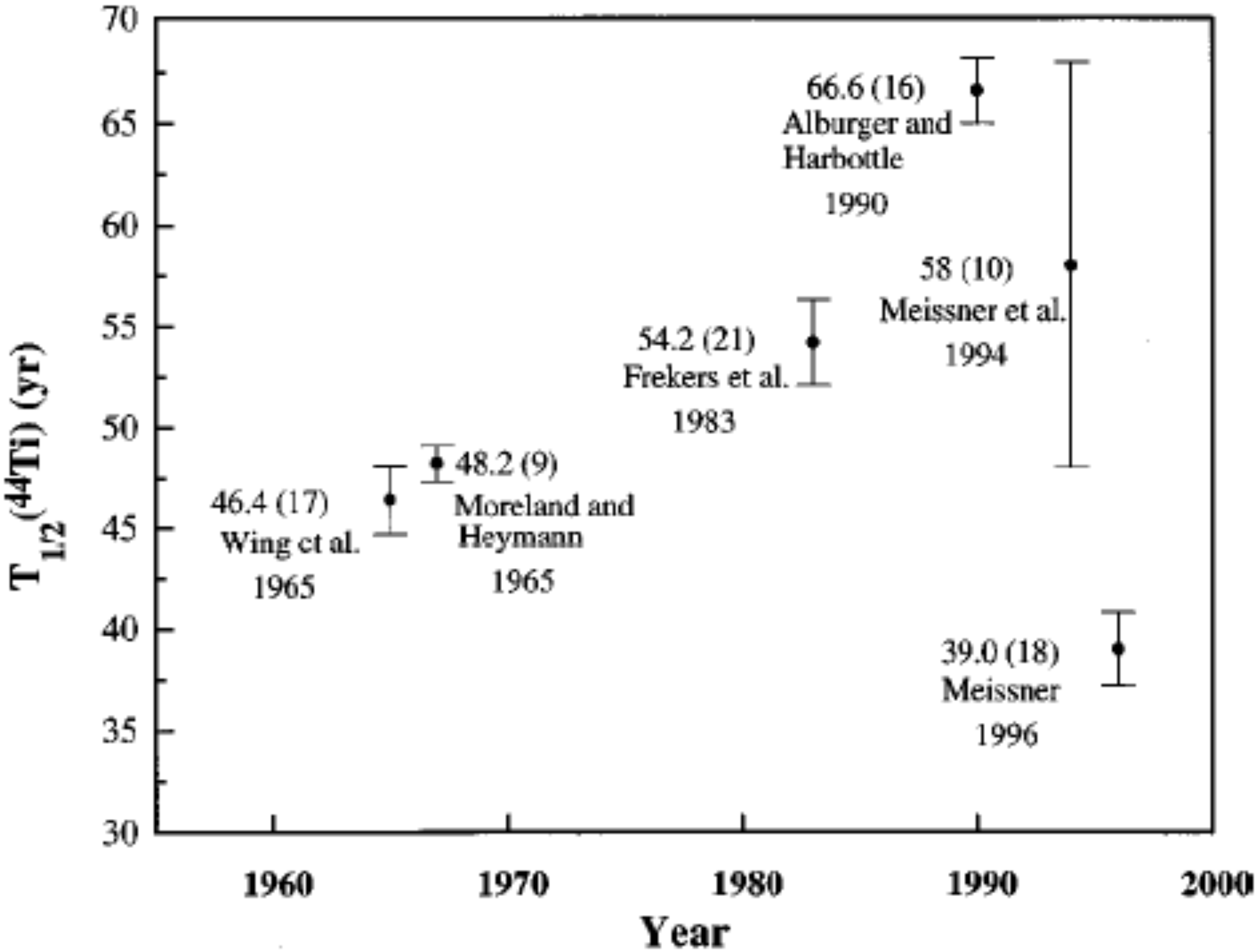
Distance 10,000 ly



Iyudin et al. 1997

Measure the half-life of ^{44}Ti

It's not so easy: Status as of 1997:



Method 1:

Prepare sample of 44Ti and measure activity as a function of time

number of sample nuclei N:

$$N(t) = N_0 e^{-\lambda t}$$

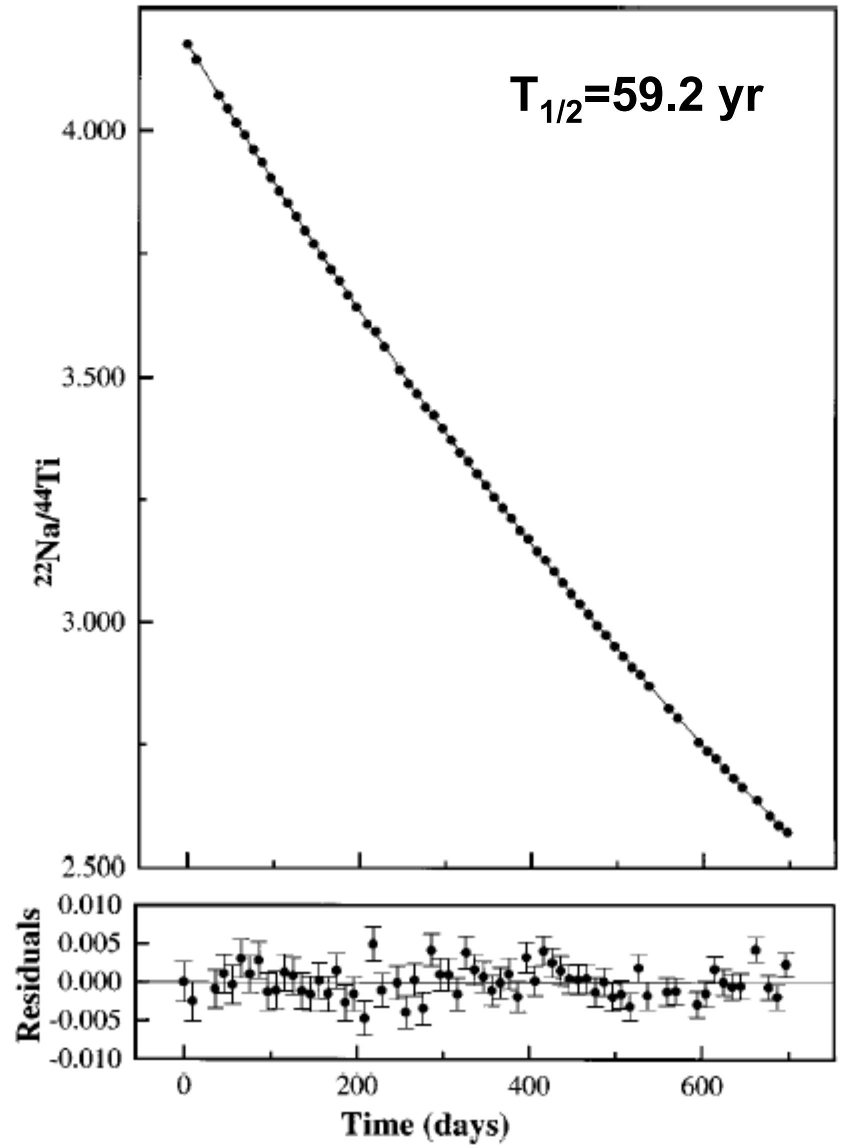
activity = decays per second:

$$A(t) = \lambda N(t) = \lambda N_0 e^{-\lambda t}$$

Measure A with γ-ray detector as a function of time A(t) to determine λ

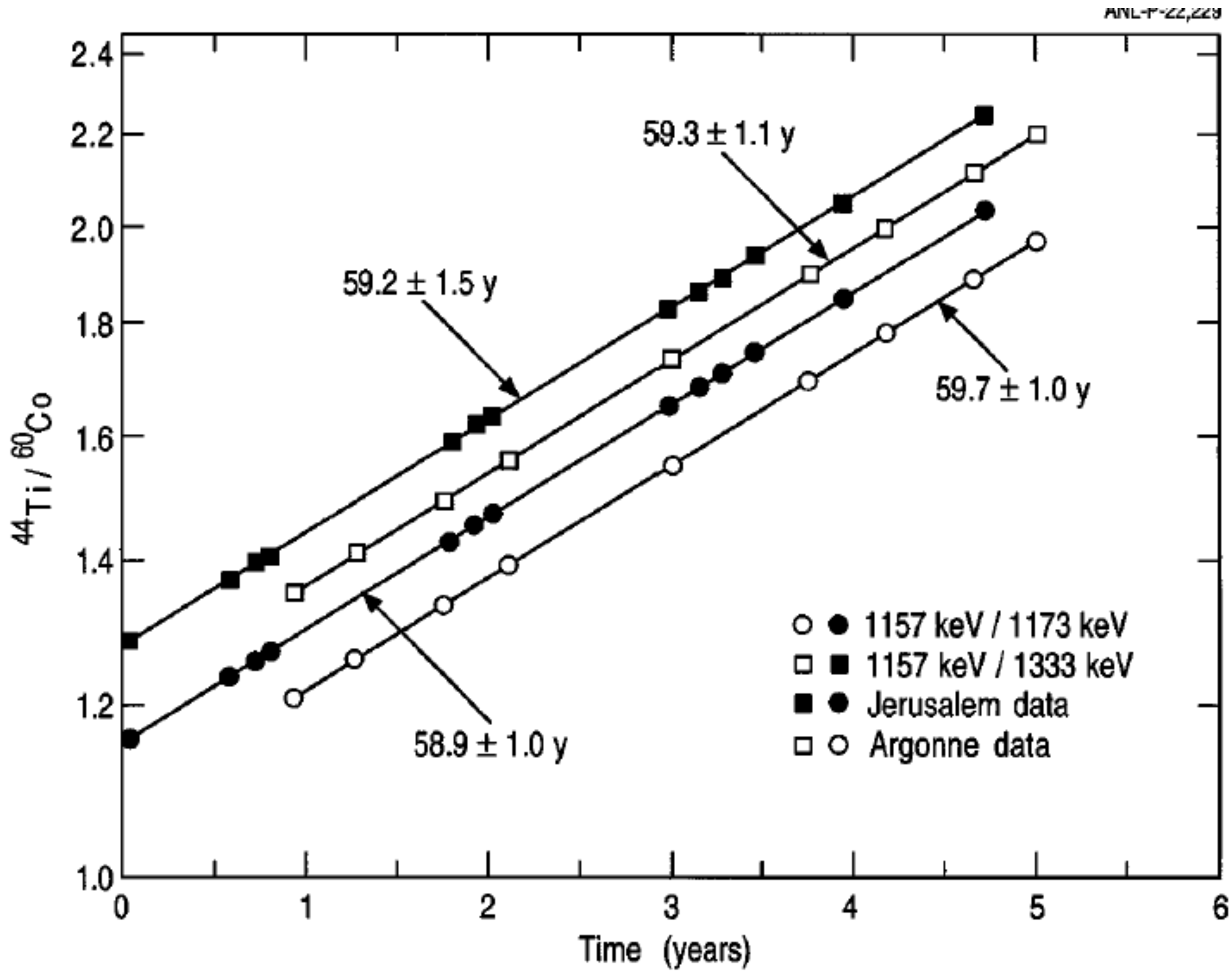
$$\lambda = \frac{\ln 2}{T_{1/2}}$$

Berkeley:



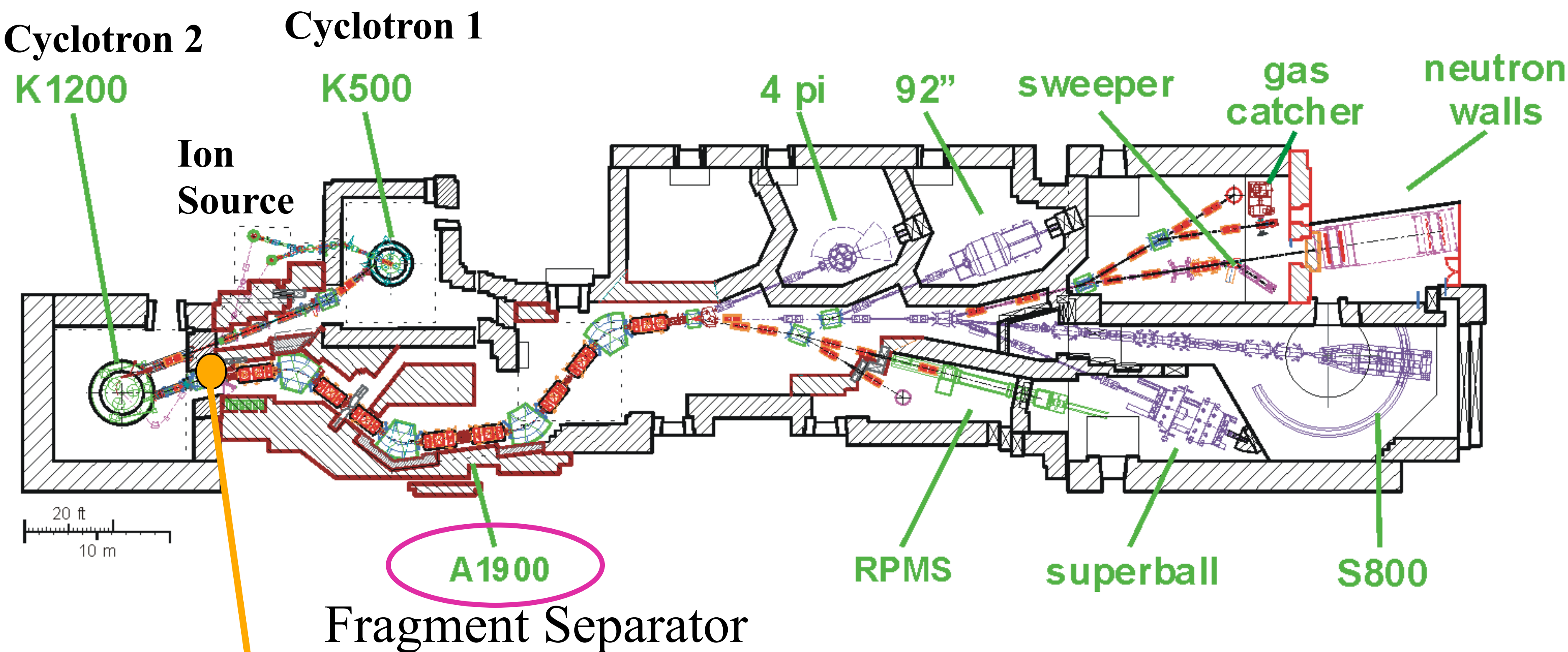
Norman et al. PRC57 (1998) 2010

ANL:

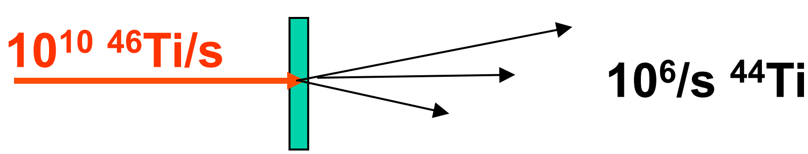


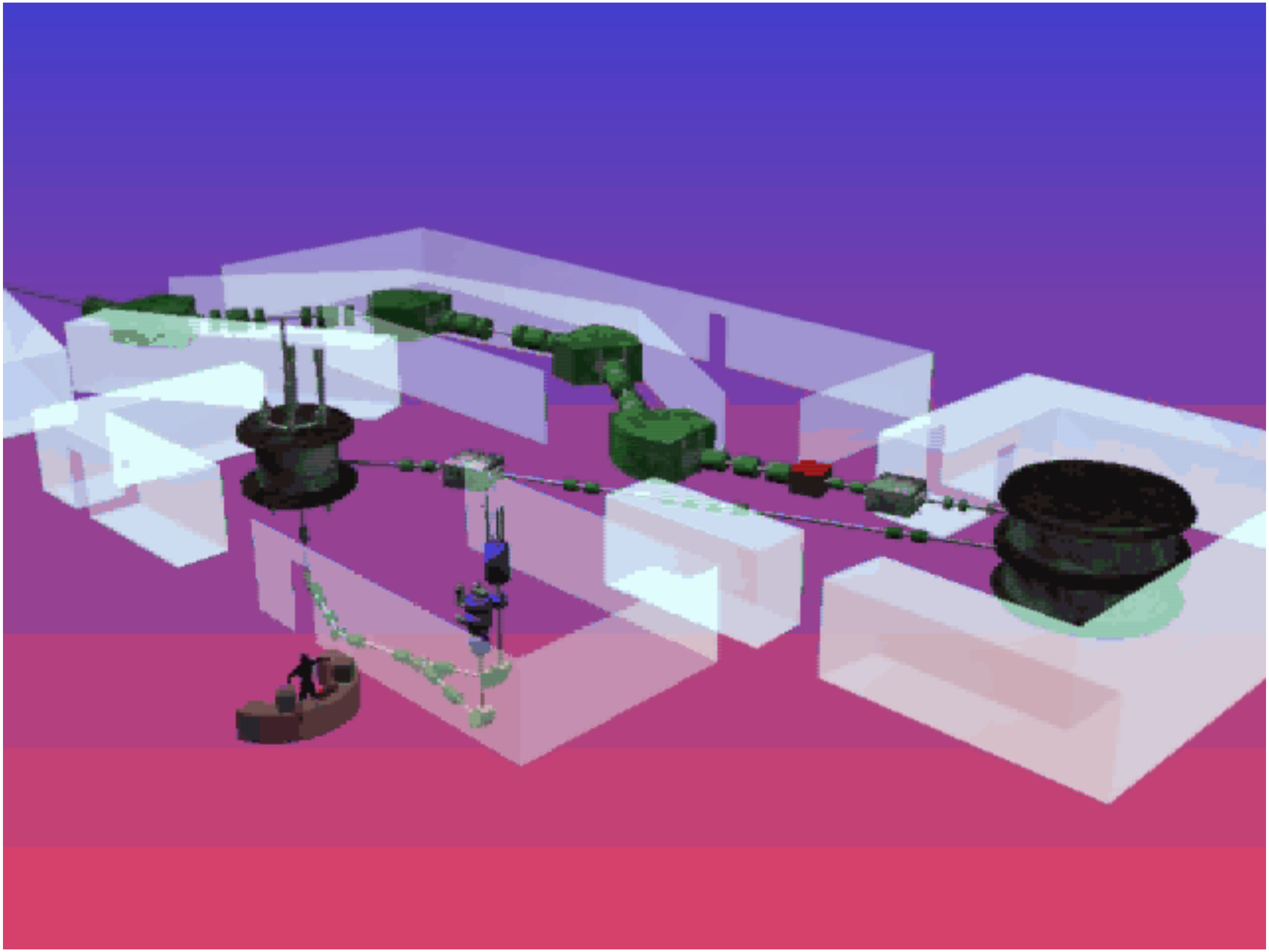
Ahmad et al. PRL 80 (1998) 2550

National Superconducting Cyclotron Facility at Michigan State University



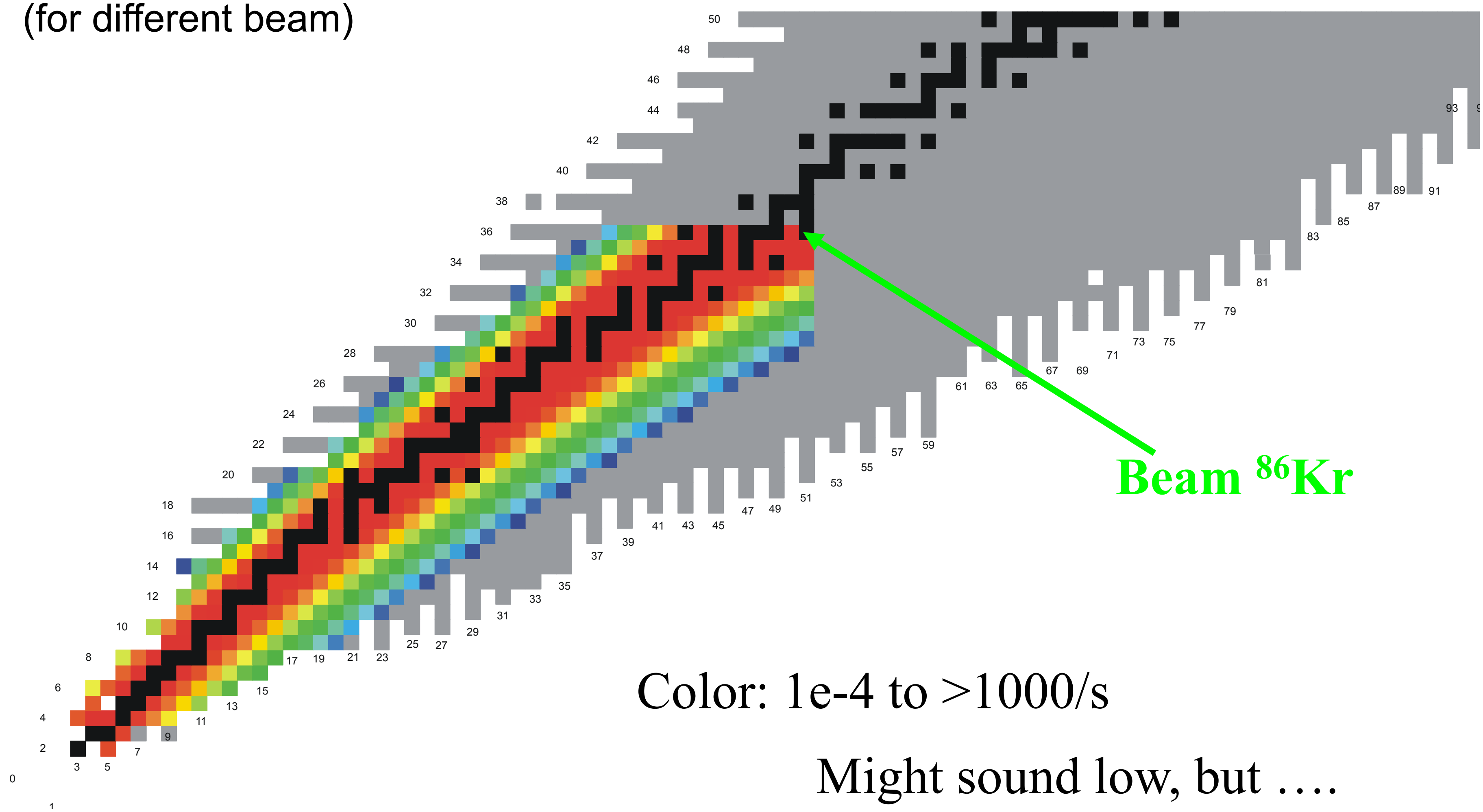
Make ^{44}Ti by fragmentation of ^{46}Ti beam





Fast beam feature 1: production of broad range of beams

Example: Fragmentation Technique
(for different beam)



Color: 1e-4 to >1000/s

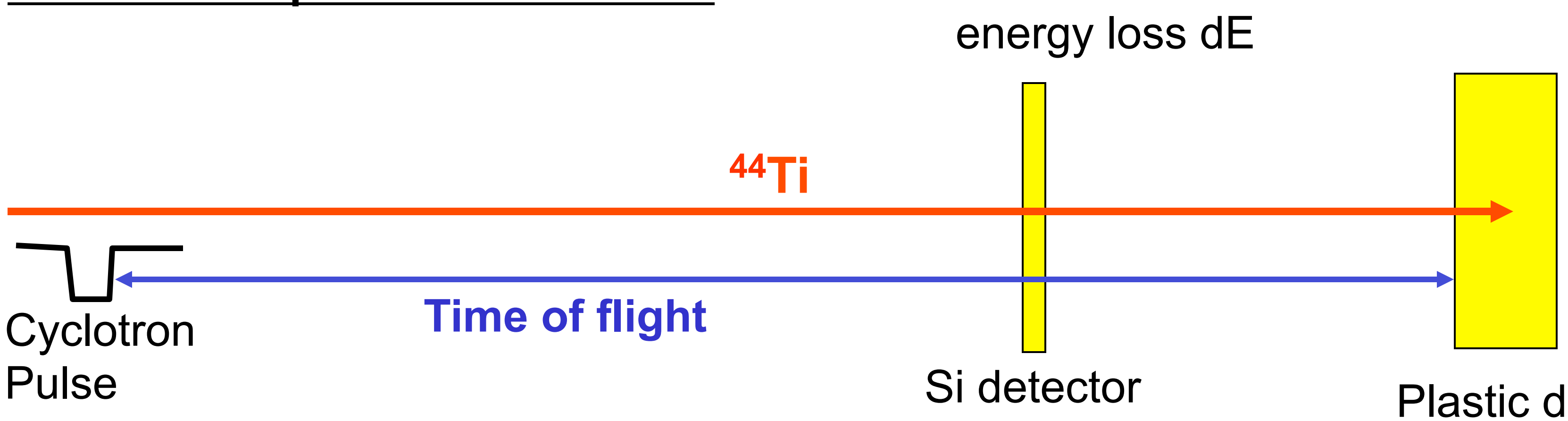
Might sound low, but ….

Method 2:

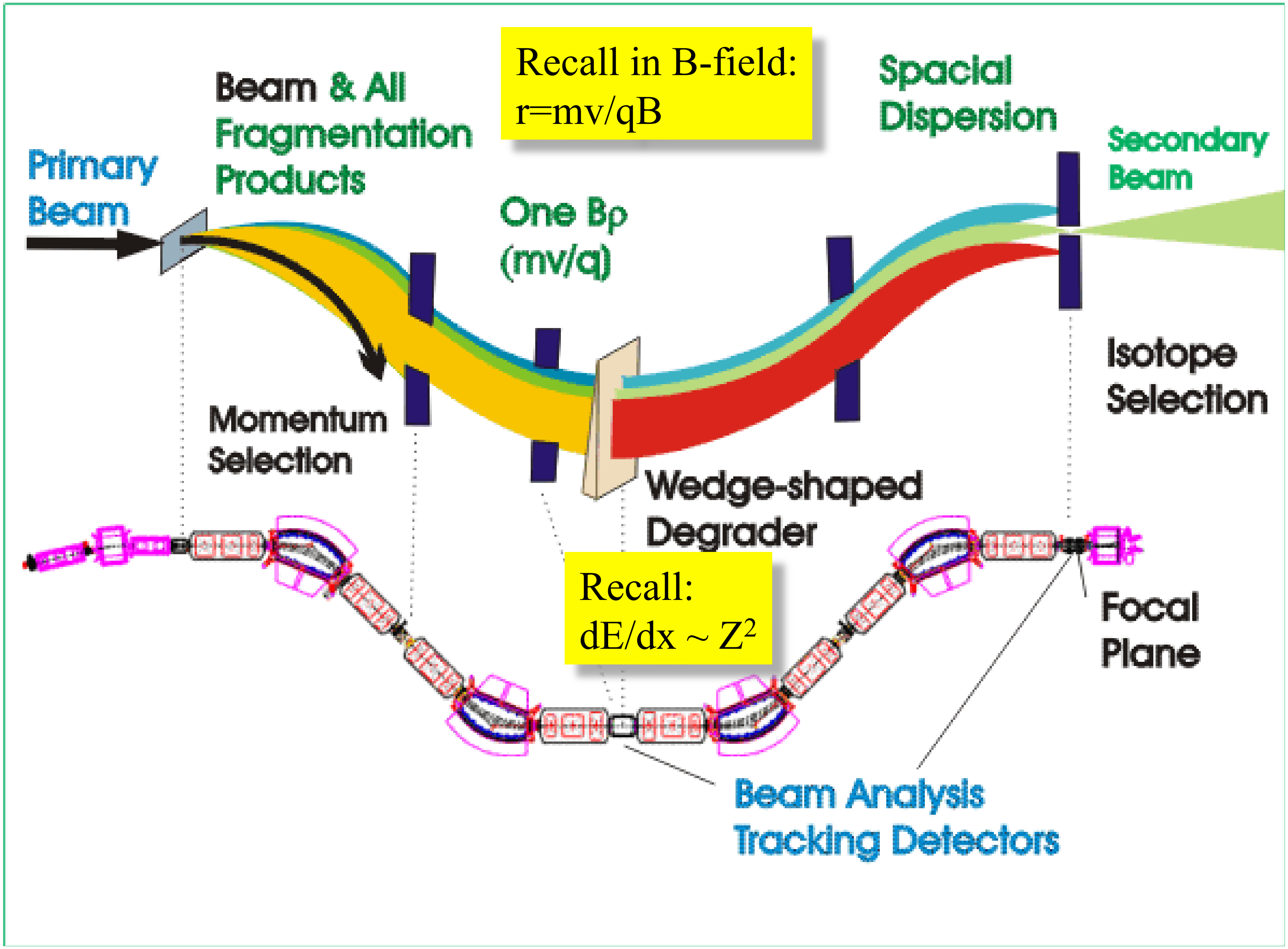
Measure A AND N_0 at a one time $$A(t) = \lambda N(t) = \lambda N_0 e^{-\lambda t}$$

Standard Setup:

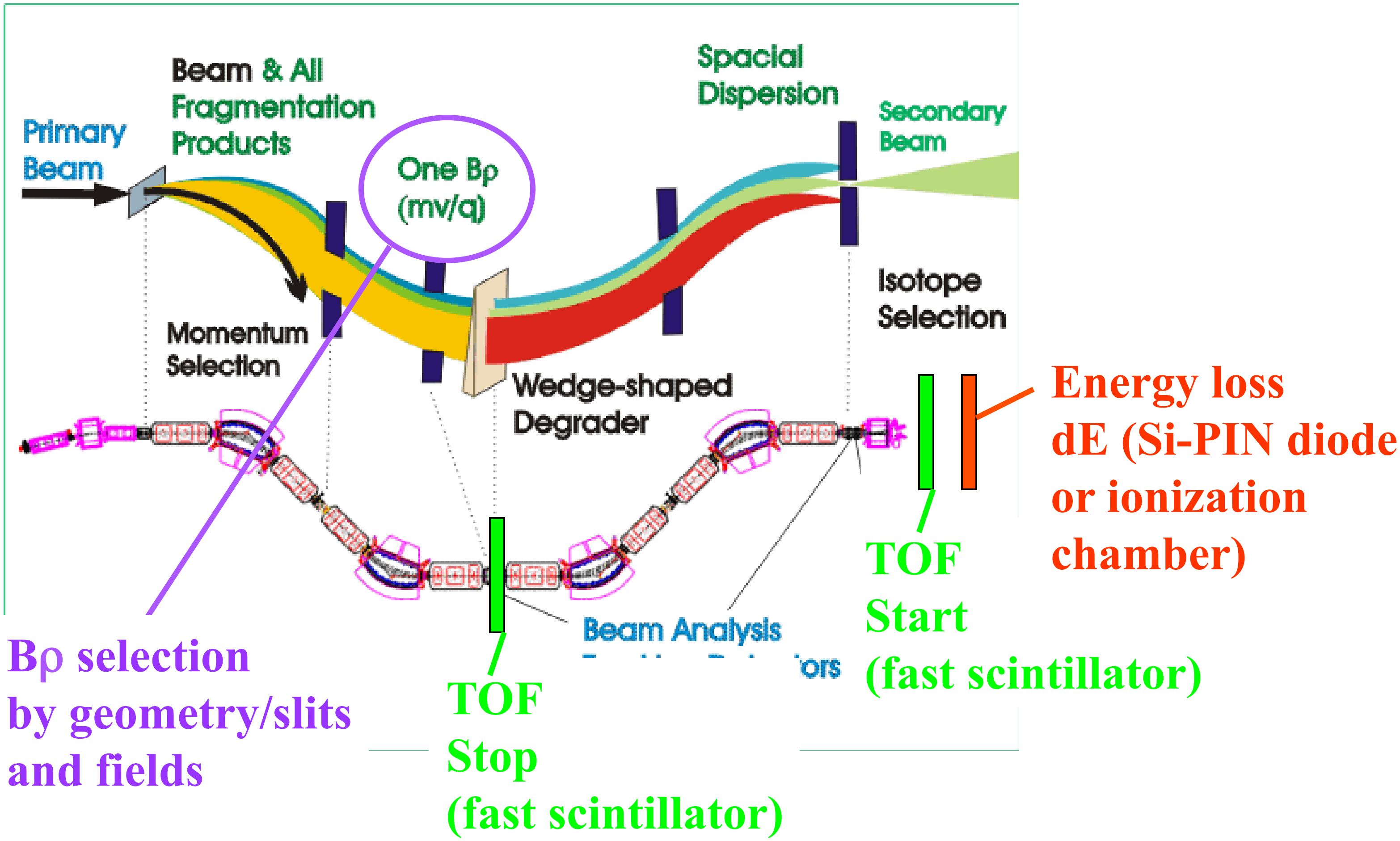
Use this setup from time to time:



Fast beam feature 2: high selectivity – step1: Separator



Fast beam feature 2: high selectivity – step2: Particle ID



<u>measure m/q:</u>

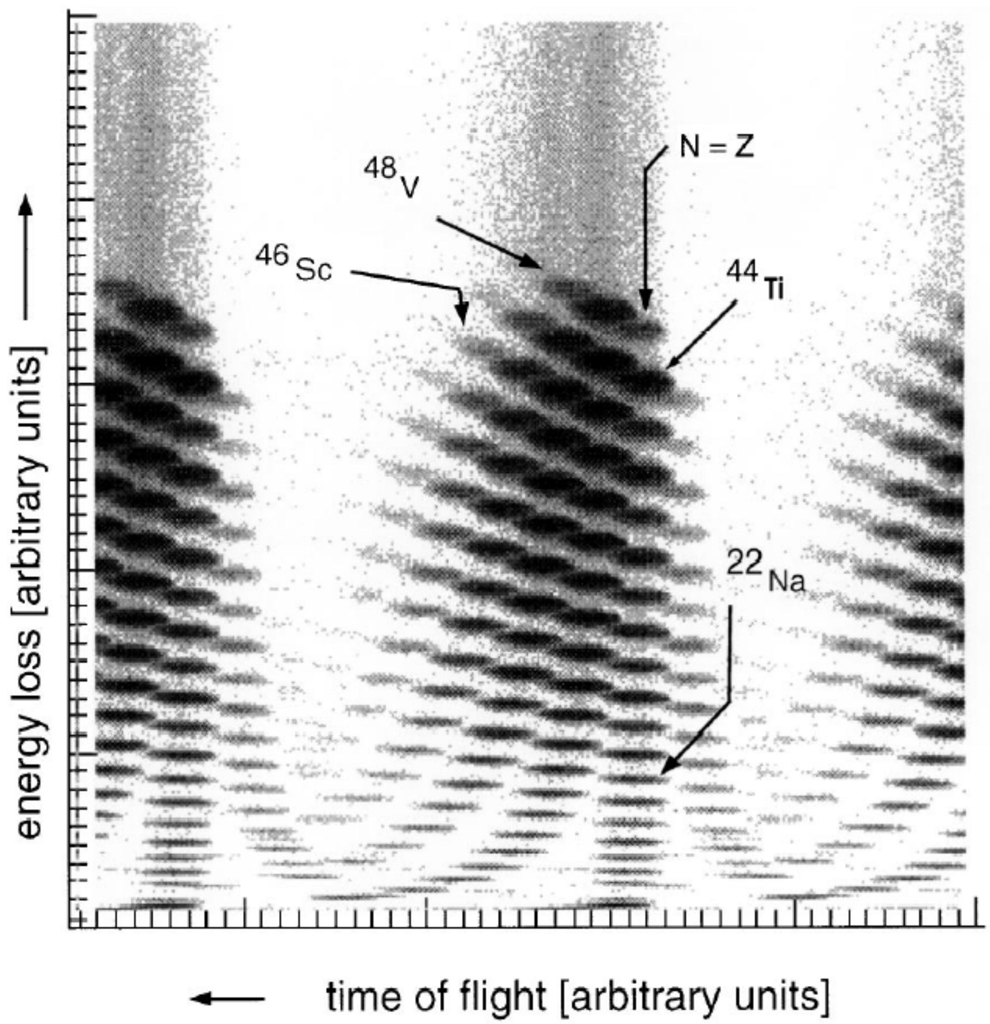
$B\rho = mv/q$ (relativistic $B\rho=\gamma mv/q$!)

$m/q = B\rho/v$

└ $v=d/TOF$

<u>Measure Z:</u>

$dE \sim Z^2$



→ determine number of implanted ^{44}Ti

→ 60.3 +- 1.3 years Goerres et al. Phys. Rev. Lett. 80 (1998) 2554