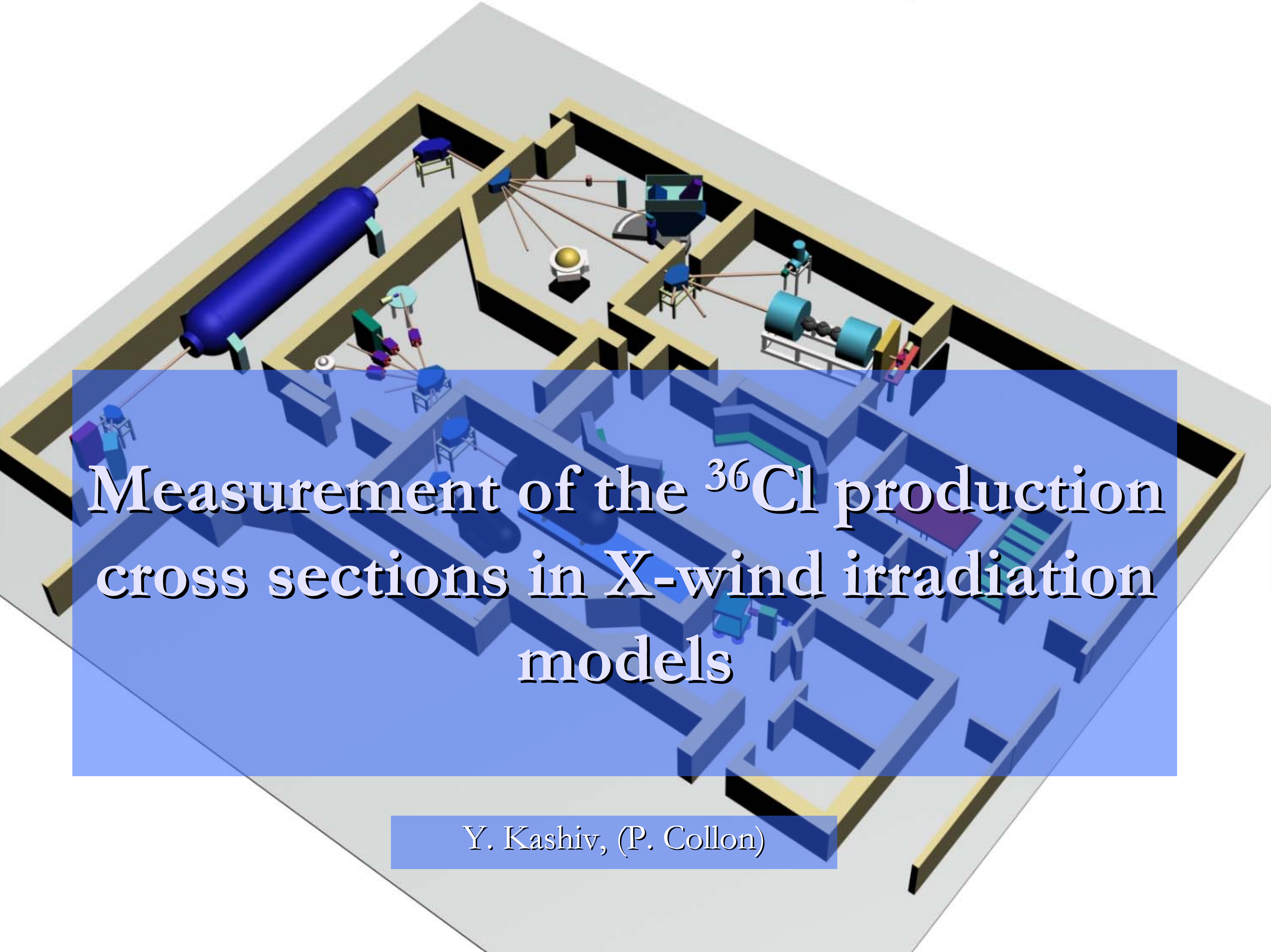


Measurement of the ^{36}Cl production cross sections in X-wind irradiation models

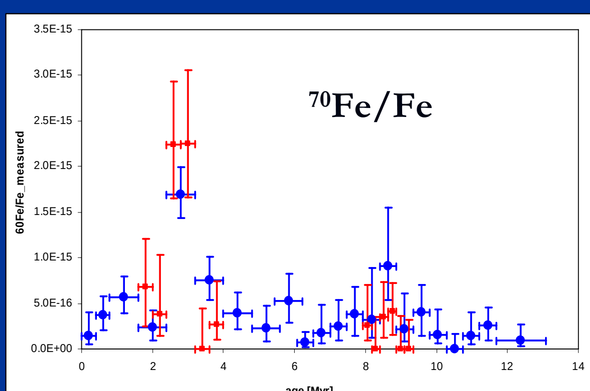
Y. Kashiv, (P. Collon)

Short-lived radionuclides in meteorites

An important result concerning the formation of the solar system is the discovery of several short-lived nuclides (with half-lives varying from ~10^5 to ~10^8 years) in meteorites (^{10}Be, ^{26}Al, ^{36}Cl, ^{41}Ca, ^{60}Fe, ^{53}Mn.....)

There are 2 generally accepted possible models for the production of short-lived radionuclides at the formation of Calcium-Aluminium-rich inclusions (CAIs).

They either originated from the ejecta of a nearby supernova



K. Knie et al., Phys. Rev. Lett. 93(2004)171103

They originated in the in-situ irradiation of nebular dust by energetic particles (mostly, p, α, ^{3}He: X-wind irradiation model

Provides a model for the formation of both CAIs and Chondrules in primitive solar nebula

The X-wind model

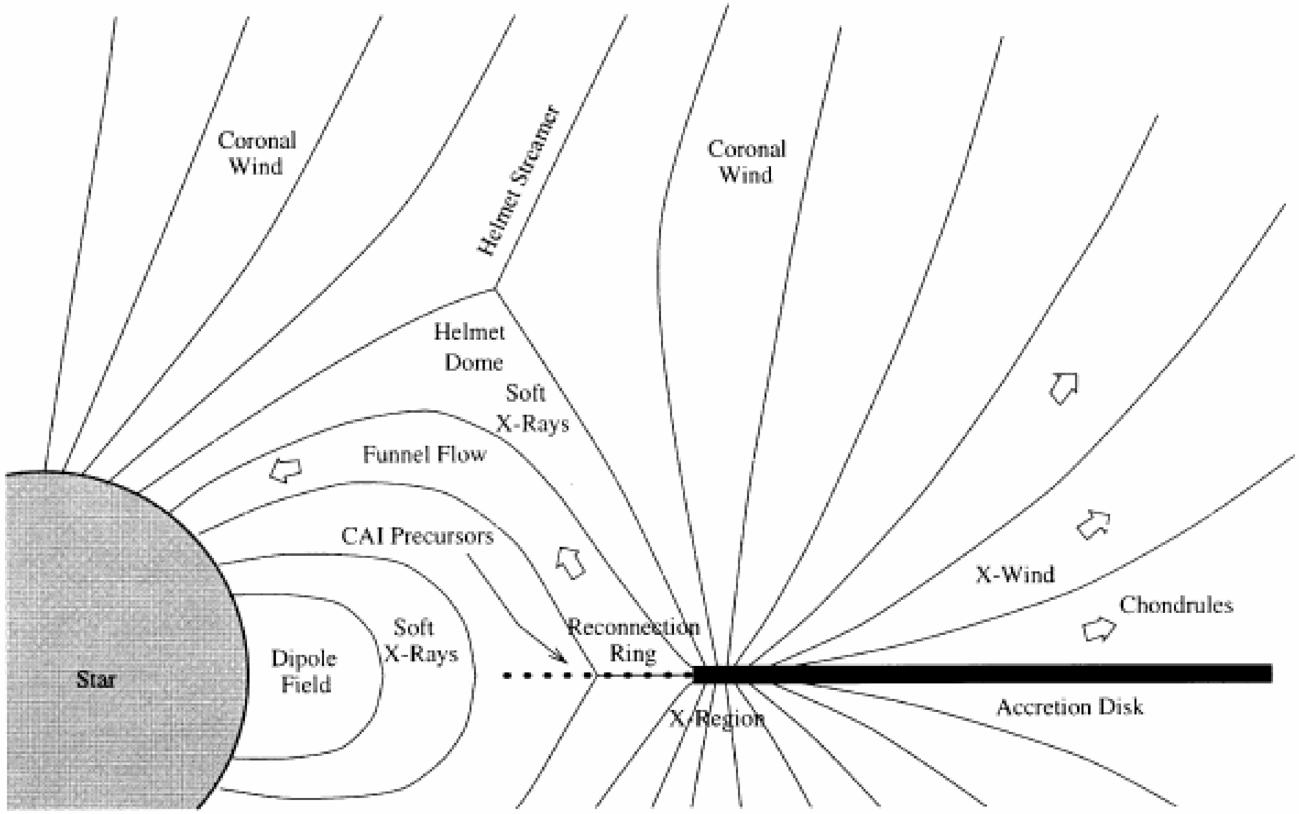
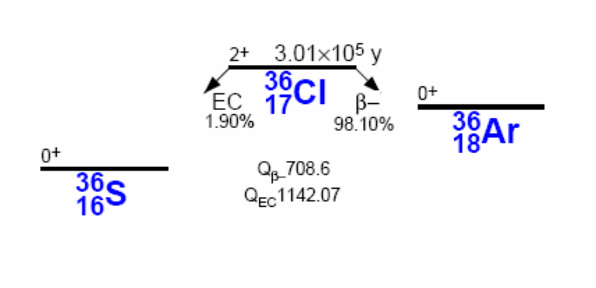


FIG. 1.—Schematic drawing of the X-wind model for the formation of CAIs and chondrules. On either side of a dead zone (the middle third of the magnetic flux trapped by the X-region) the field lines bend sufficiently inward or outward to force electrically conducting gas in the X-region to be funneled toward the star or to be expelled in an X-wind. The case shown assumes that an outflow of hot plasma in a coronal wind from the star and disk has helped magnetocentrifugal effects to open the field lines in the dead zone, but the dead zone field lines could also be closed, as are those below the helmet dome, without much affecting the discussion of our model. (After Shu et al. 1997).

Shu et al. ApJ 548:1029-1050, 2001

Short lived ^{36}Cl in CAI-rich inclusions from the Ningqiang Carbonaceous chrondrite

^{36}Cl: $t_{1/2} = 0.3$Myr   decays to ^{36}S



Excesses of sulfur-36 in sodalite, a chlorine-rich mineral, in a calcium- and aluminum-rich inclusion from the Ningqiang carbonaceous chondrite linearly correlate with chorine/sulfur ratios, providing direct evidence for the presence of short-lived ^{36}Cl in the early solar system.

Lin et al Proc. Natl. Acad. Sci. 102, (2005)1306

Lin et al. 2006

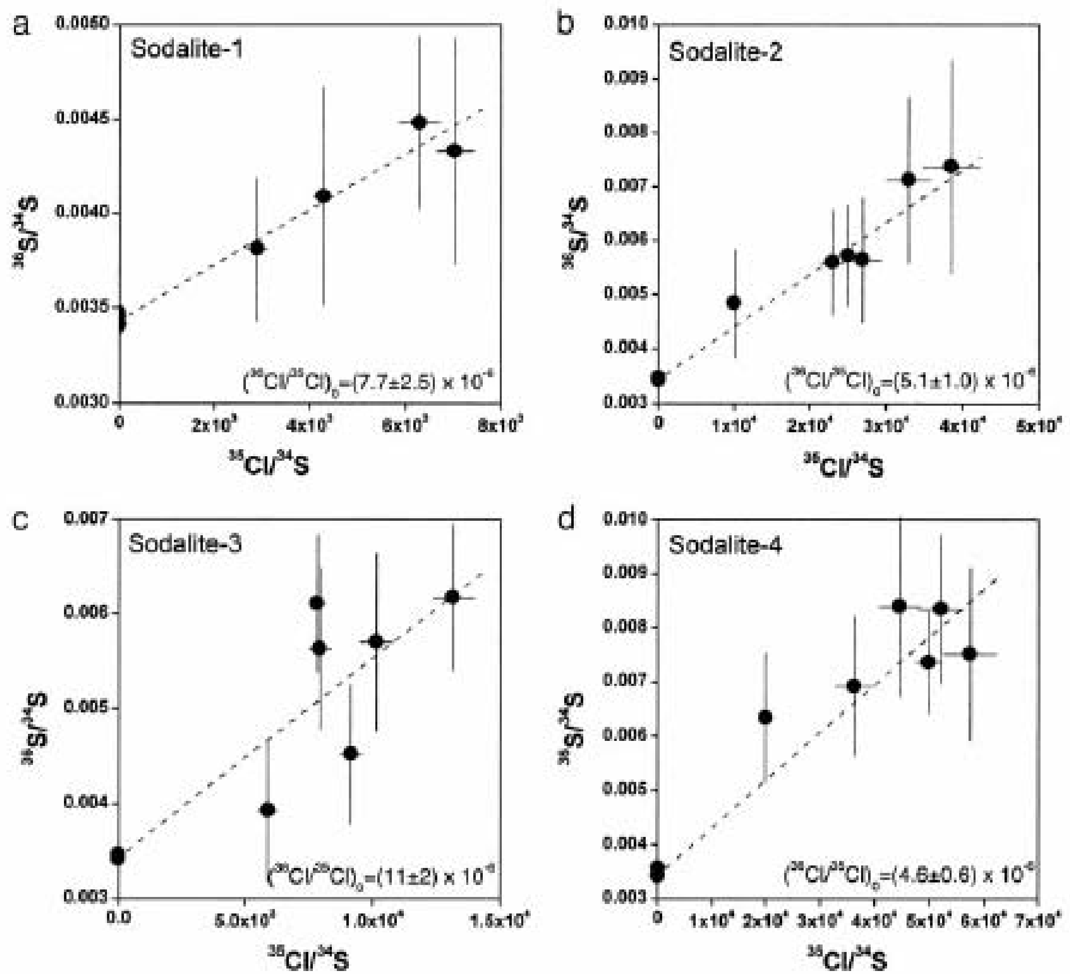


Fig. 2. Sulfur isotopic compositions of four sodalite-rich assemblages of the CAI (NQJ1-1#1) from the Ningqiang meteorite. All four analyses show clear excess of ^{36}S that linearly correlates with the Cl/S ratio, indicating *in situ* decay of ^{36}Cl in the assemblages. Error bars are 2σ. The inferred $(^{36}Cl/^{35}Cl)_0$ ratios of the assemblages at the time of alteration are determined from the slopes of the best-fit correlation lines and are calibrated in proportion to the decay of ^{36}Cl to ^{36}S.

Lin et al Proc. Natl. Acad. Sci. 102, (2005)1306

Production of ^{36}Cl

Adopted nuclear cross section from Hauser-Feshbach codes

In a first step we will study the ^{36}S(p, n)^{36}Cl and ^{33}S(α, p) ^{36}Cl reaction at energies < 10MeV/A and down

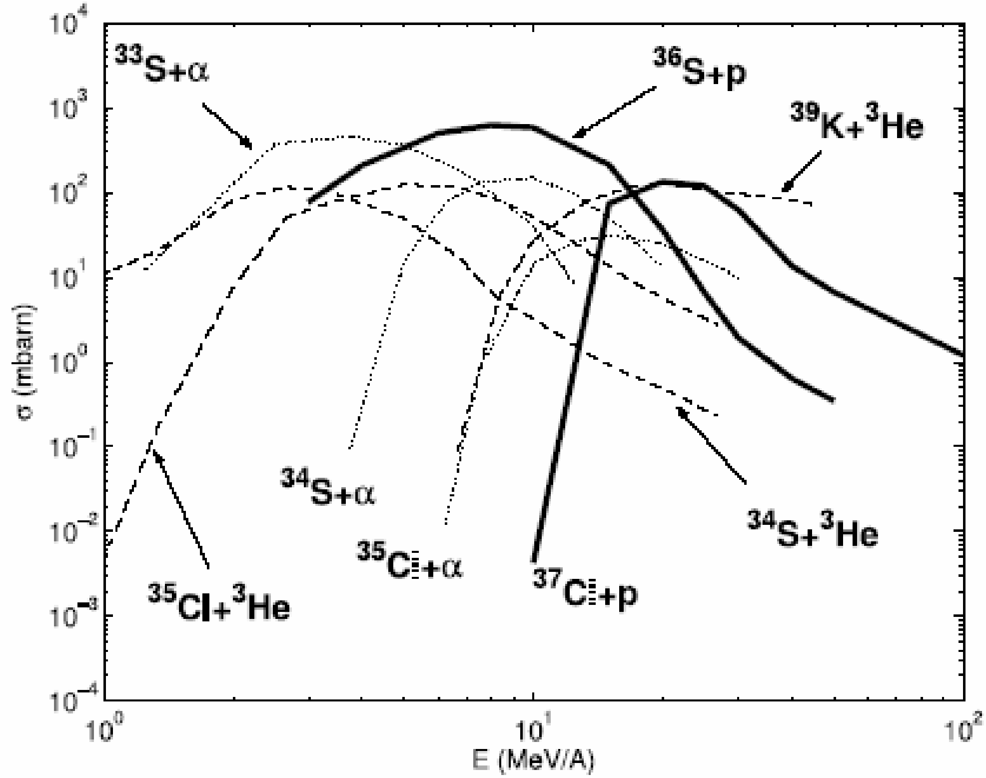
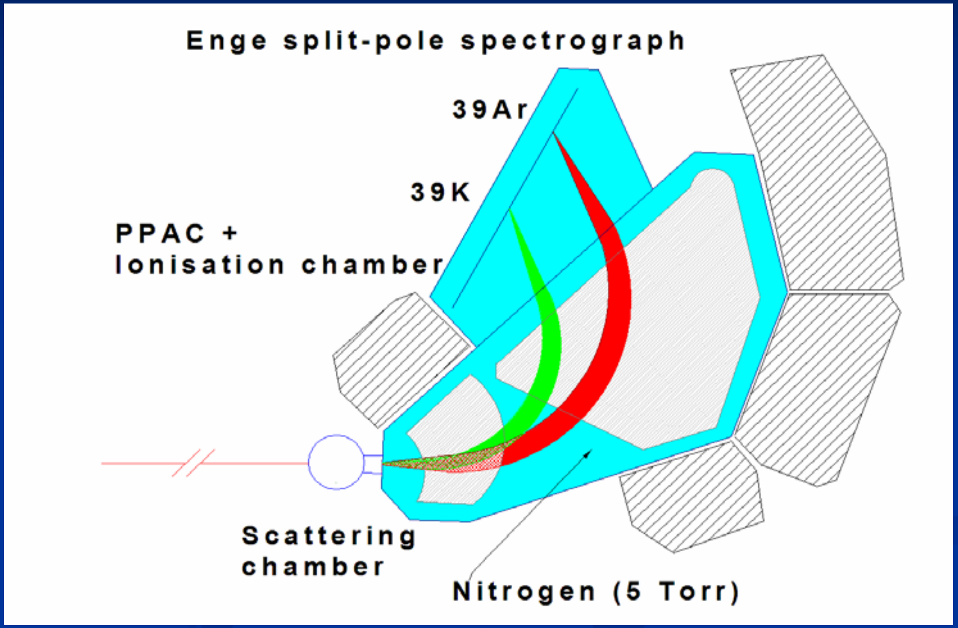


FIG. 2.—Adopted nuclear cross sections for the proton- (*thick line*), α- (*dotted line*), and ^{3}He-induced (*dashed line*) reactions for the production of ^{36}Cl. The cross sections are based on numerical simulations using fragmentation and Hauser-Feshbach codes. In the absence of experimental data points, the input parameters have been chosen so that the calculations reproduce data obtained for lower and higher masses (e.g., Al, Ca, Fe) for which some data exist.

From Gounelle et al., Astro. Phys. J. (2006)

ND AMS system



$$< B\rho > \propto mv / \overline{q} \propto m / f(z)$$

$$\overline{q} = f(z) \bullet v$$

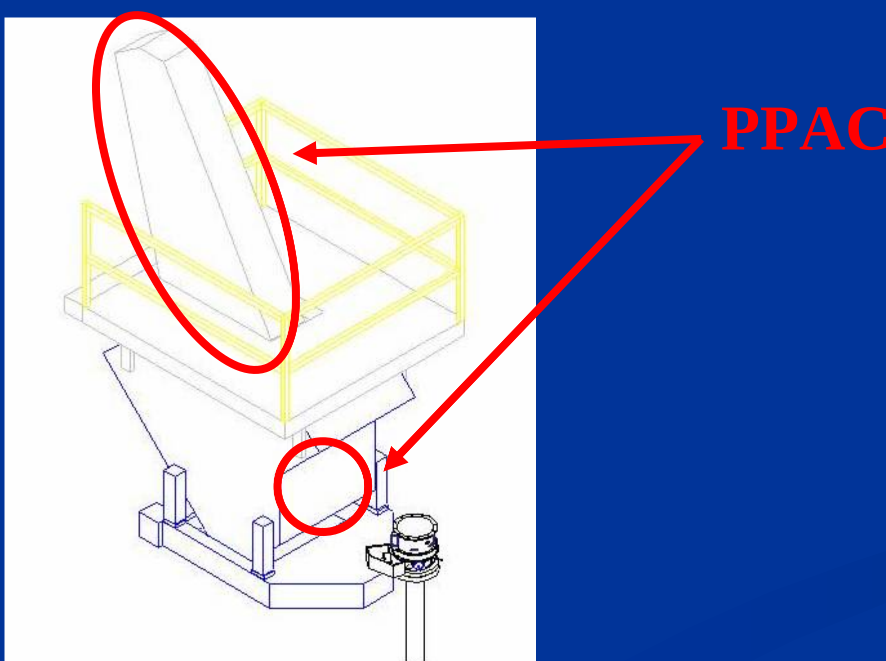
Detection System

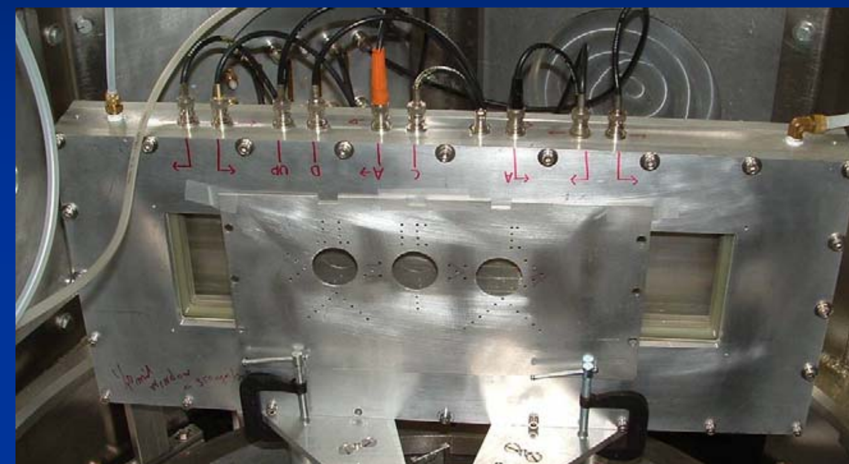
PPAC and Ionisation Chamber (IC) for position and energy determination

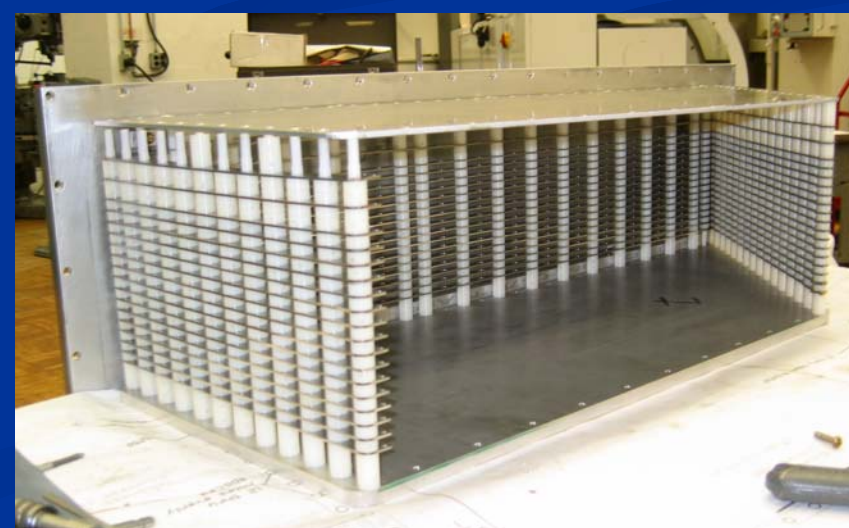
Both containing Isobutane gas

Thin Mylar windows, low energy loss

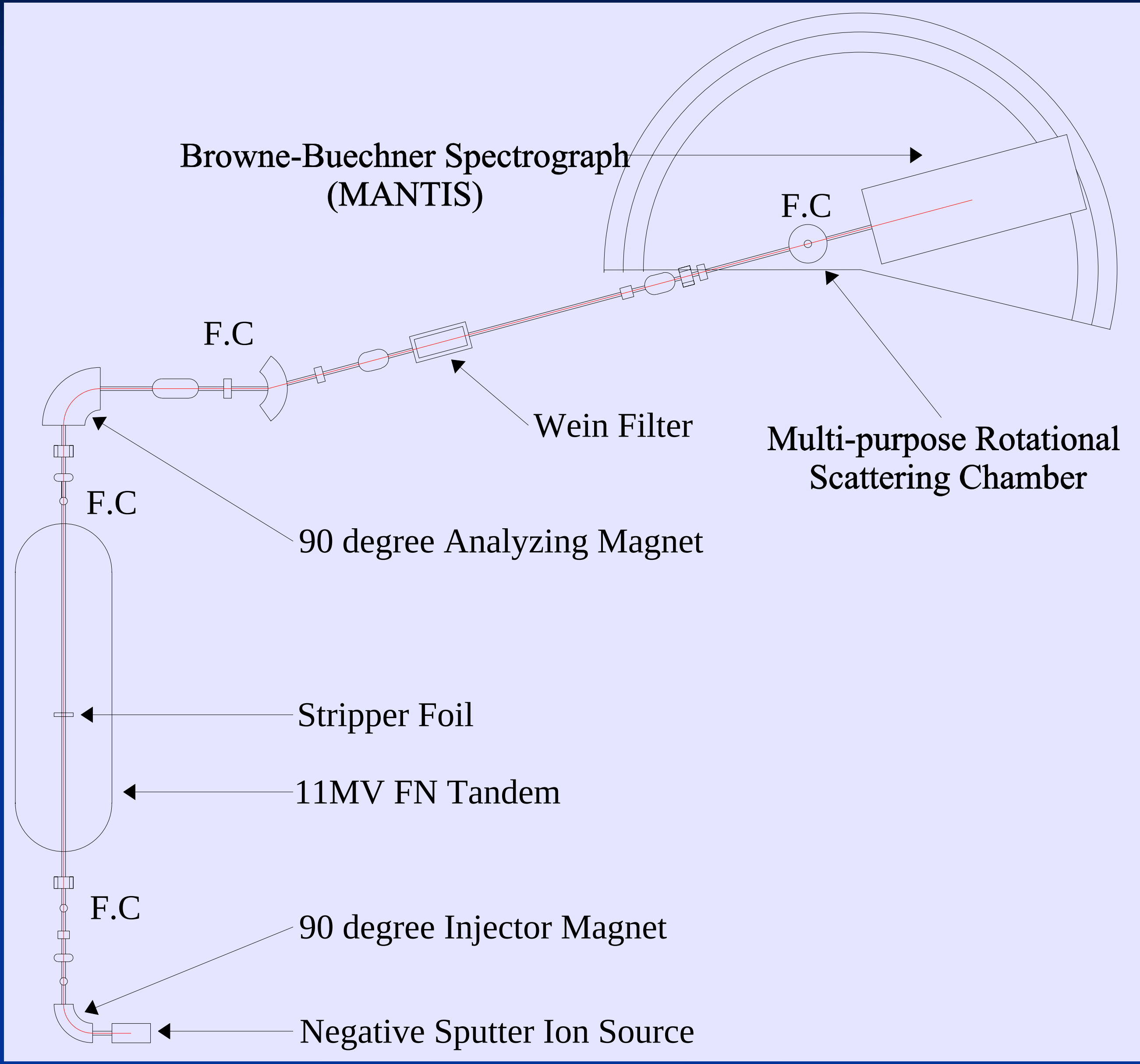
TOF can aid in particle identification



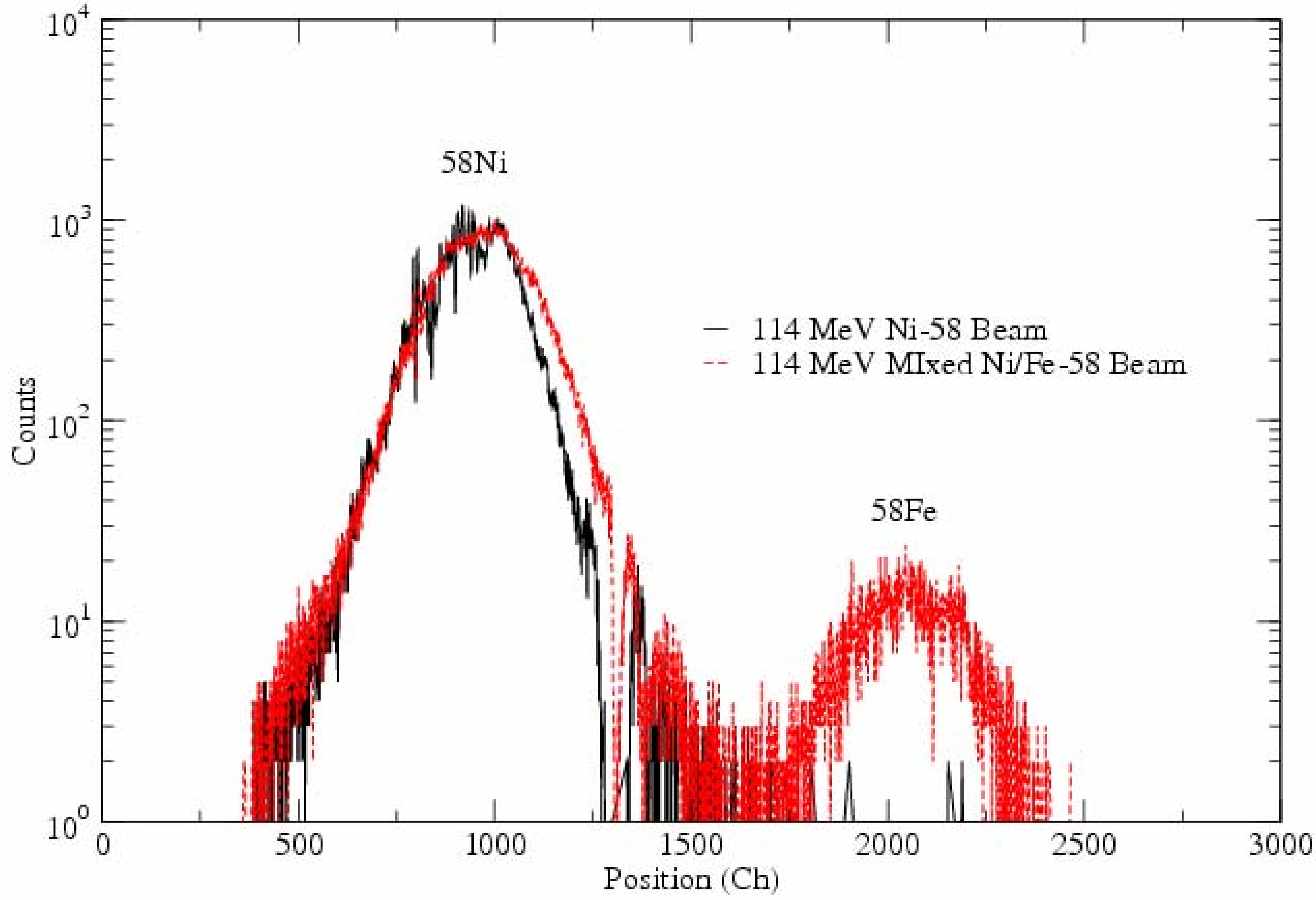




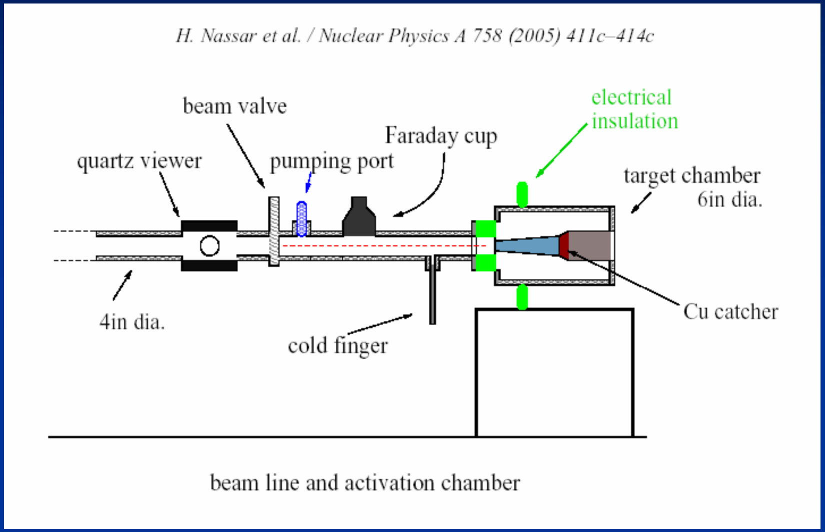
Experimental layout



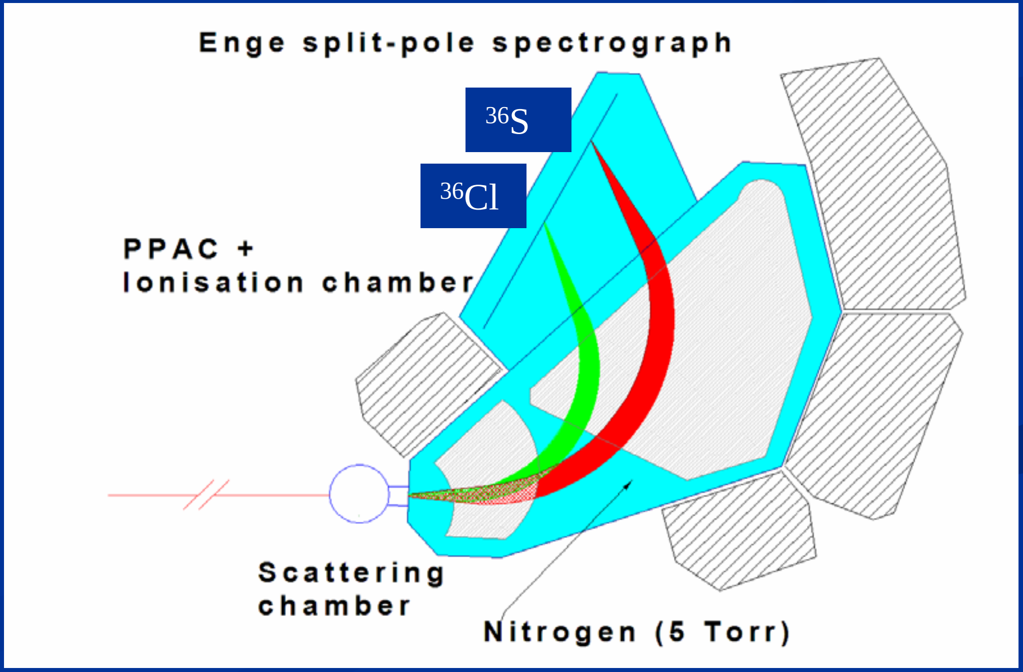
First AMS Measurements



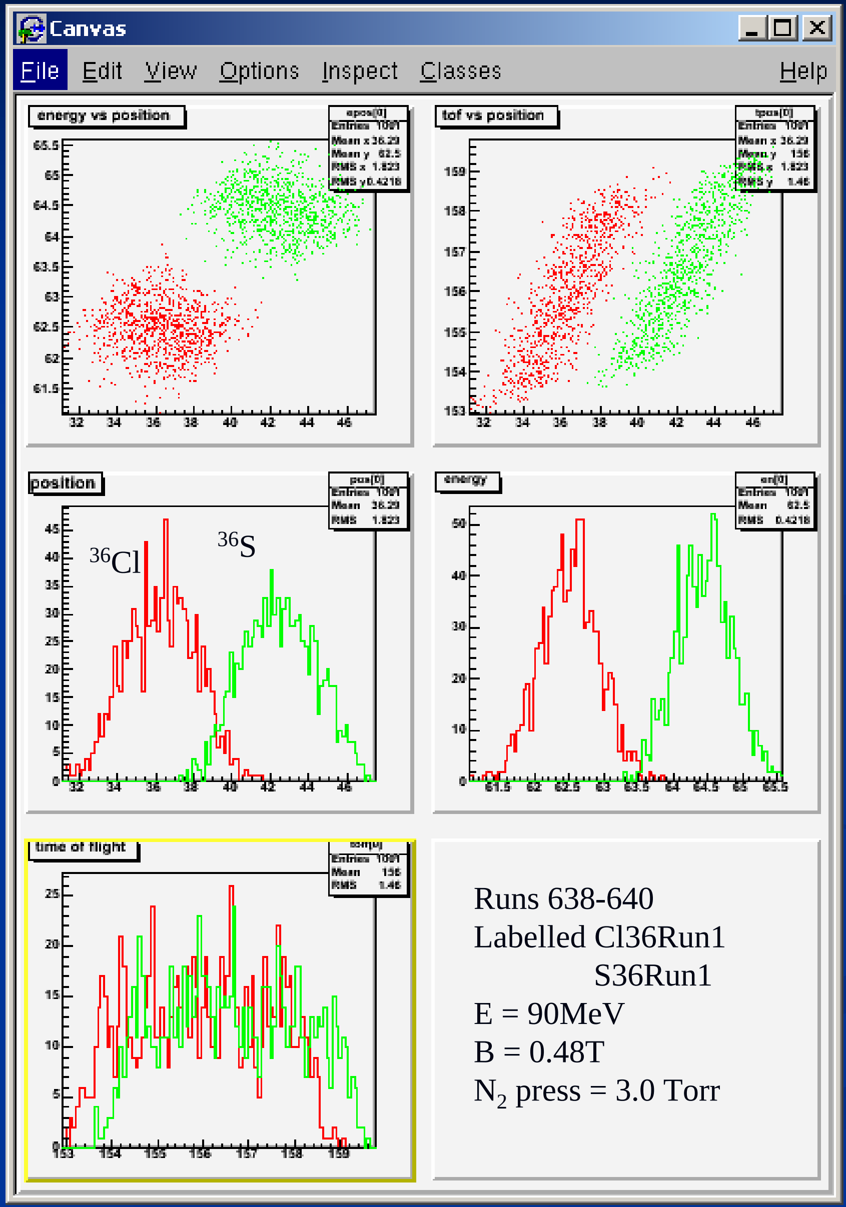
Implantation and AMS measurement



Chemical extraction of the Chlorine from the catcher



Raytrace predictions (GFmode)



Search for ^{93}Zr in carbonaceous chondrites

^{93}Zr: $t_{1/2}$=1.53 Myr

Like ^{60}Fe, ^{93}Zr is produced by neutron capture and has approximately the same half-life however unlike ^{60}Fe it is mainly an s-process isotope. We are developing in collaboration with the research group of Michael Paul from the Hebrew University in Jerusalem an AMS detection method at ND that would enable us to measure ^{93}Zr in sediment samples. This program is driven by a number of reasons :

(a) It is the most promising isotope a priory, after ^{53}Mn and ^{60}Fe to be detected in sediments,

(b) It is expected t be produced by the same processes and in the same locations in massive stars as ^{60}Fe,

(c) There are a number of sediment samples available.

(d) This will privide an opportunity to measure 92Zr(n, g)93Zr using activation followed by AMS