Experiments with liquid jets

C.Johnson

CERN

History

CERN Mercury Jet Target - version 1985

Muon Collider Collaboration

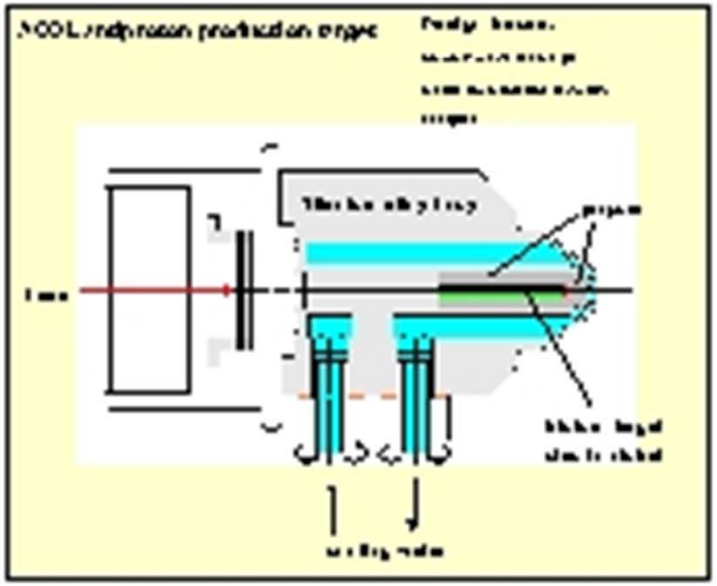
Targetry Workshops 1997-99

CERN Mercury Jet target - version 1999

Experiments with liquid jets

History:

1984 CERN High power targetry for pbar production - solid target ⇒



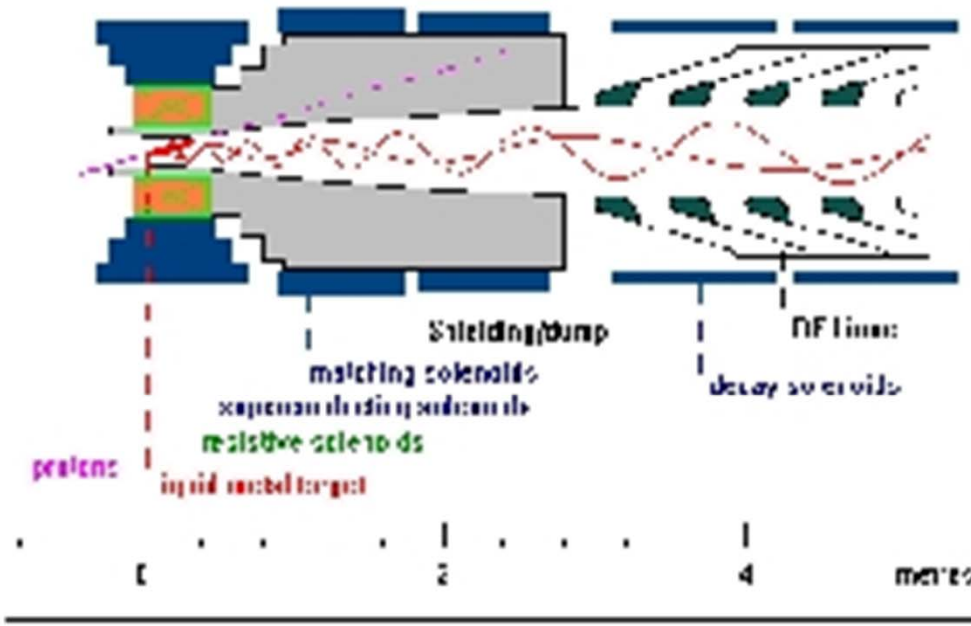
Then in 1985 studied series of pulsed-current targets to improve pbar yield by factor 2-3

A. Poncet proposed self-switching target in form of Hg jet and constructed prototype ⇒

High-speed photograph of mercury jet-target

Experiments with liquid jets

Muon Collider Collaboration default solution for target is liquid-metal jet ⇒



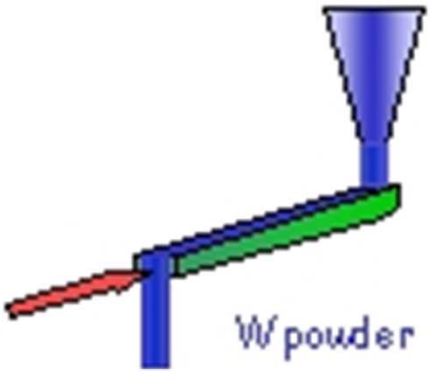
Other options studied:

Tungsten powder target

Band saw target

Liquid slurry jet

Problem with W slurry⇒

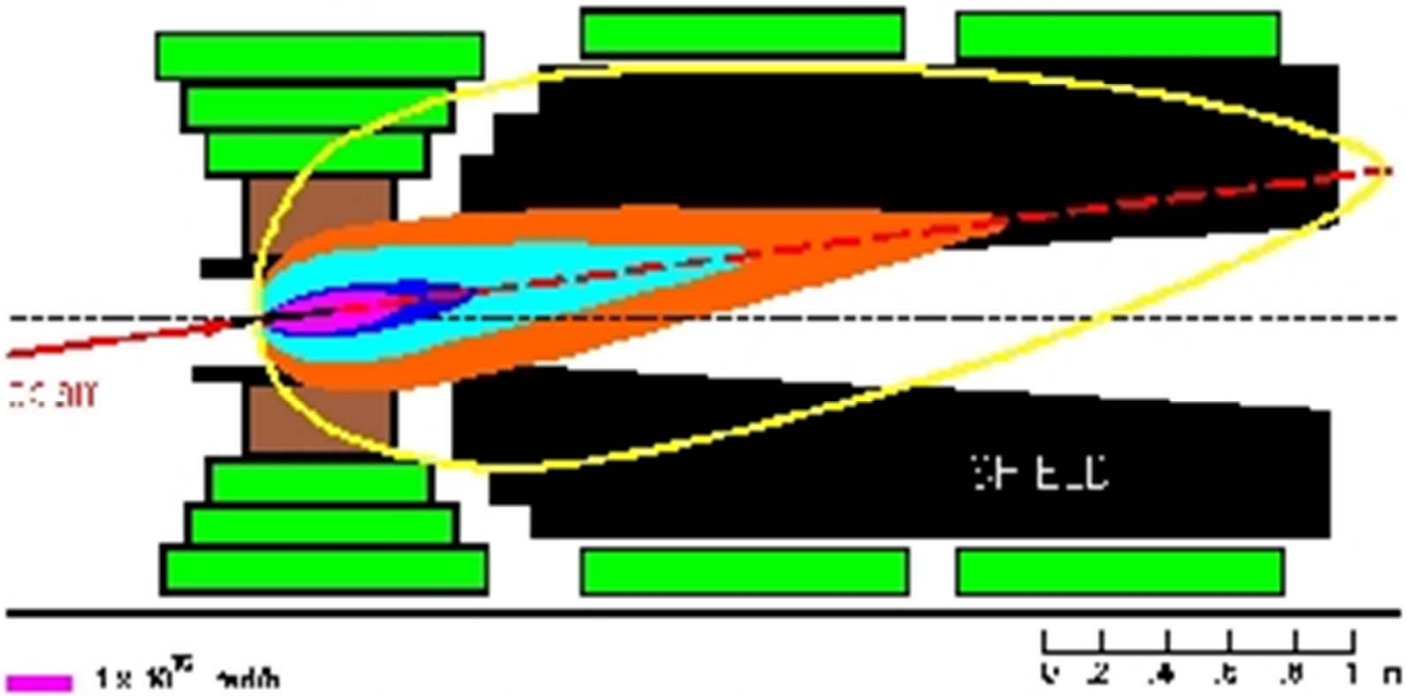


V - Fast99

Experiments with liquid jets

Proton flux: $3\ 10^{15}$ protons $cm^{-2}\ s^{-1}$	Si	old units
After 1 month of use the specific activity of a heavy metal fixed target (3 λ) would be:	= $-3\ 10^{12}$ Bq g^{-1}	
And the total activity:	= $-5\ 10^{15}$ Bq	$1.3\ 10^{5}$ Ci
For a liquid target the specific activity would be greatly diluted - useful if manual intervention considered.		
The dose rate at 1 m from the fixed target (1 day decay time)	= -100 Sv h	10^{4} rem h^{-1}
If the target is water cooled then the from a typical closed-circuit heat exchanger the equilibrium dose rate at 1 m would be	N.B. 10 X for the Beam Dump = -1 to 3 Sv h^{-1}	100 to 300 rem h^{-1}
The total activity of volatile spallation products (e.g. xenon, iodine) would be:	= -10^{12} Bq	270 Ci
These would have to be captured in the target enclosure air/vacuum system		

Experiments with liquid jets



Isodose contours show radiation dose in rad/h for
1.5×10^{16} protons/s on target (from A.H. Sullivan)
based on measurements in AA and ACOL target areas

Pion production target and capture solenoids

Experiments with liquid jets

The extremely high induced activity levels may well provide the overriding reason for the use of a mercury jet target.

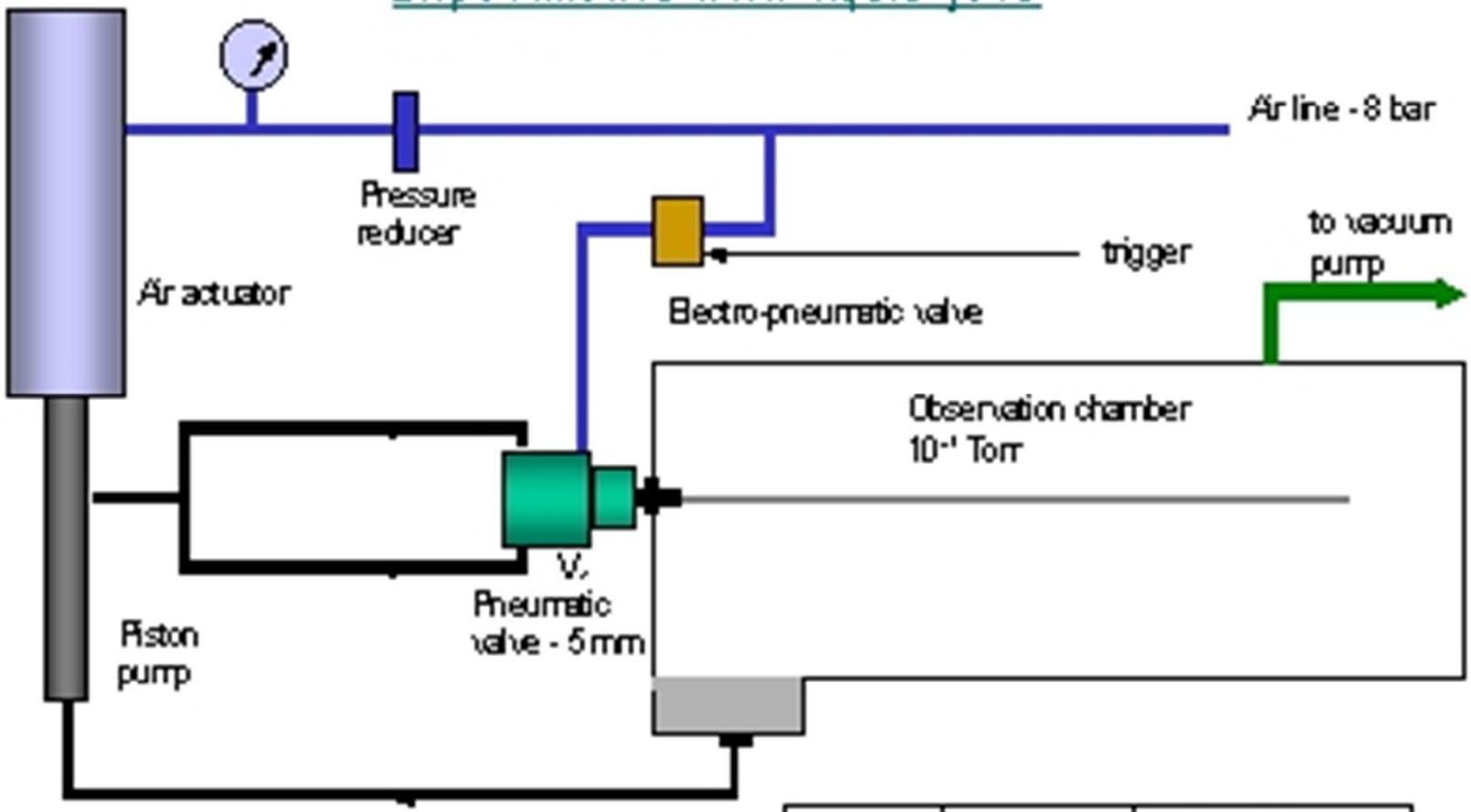
The specific activity is greatly reduced compared to a fixed target (the 'band-saw' target is somewhere between the two).

In addition, as proposed by Helge Ravn, the mercury would be distilled to remove most non-volatile spallation products. Volatile products would also be removed from the target area into filters or tanks.

Remember that the tungsten shield around the target must absorb 10 times the beam power in the target itself. A beam dump incorporated into this shield would resemble a spallation or transmutation source target - i.e. another liquid metal system (possibly Hg).

For these reasons we decided to re-construct the Hg jet target.
(gallium/tin and gallium/indium room-temperature liquid metals have been studied. They both have undesirable wetting properties (at least for lab tests) and the former produces an oxide scum)

Experiments with liquid jets

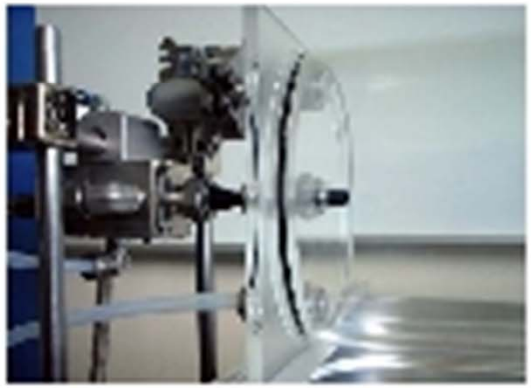


	Single shot	Continuous pulsed jet 15 Hz
V_1	triggered	open

Model liquid-metal jet target

CERN 1999

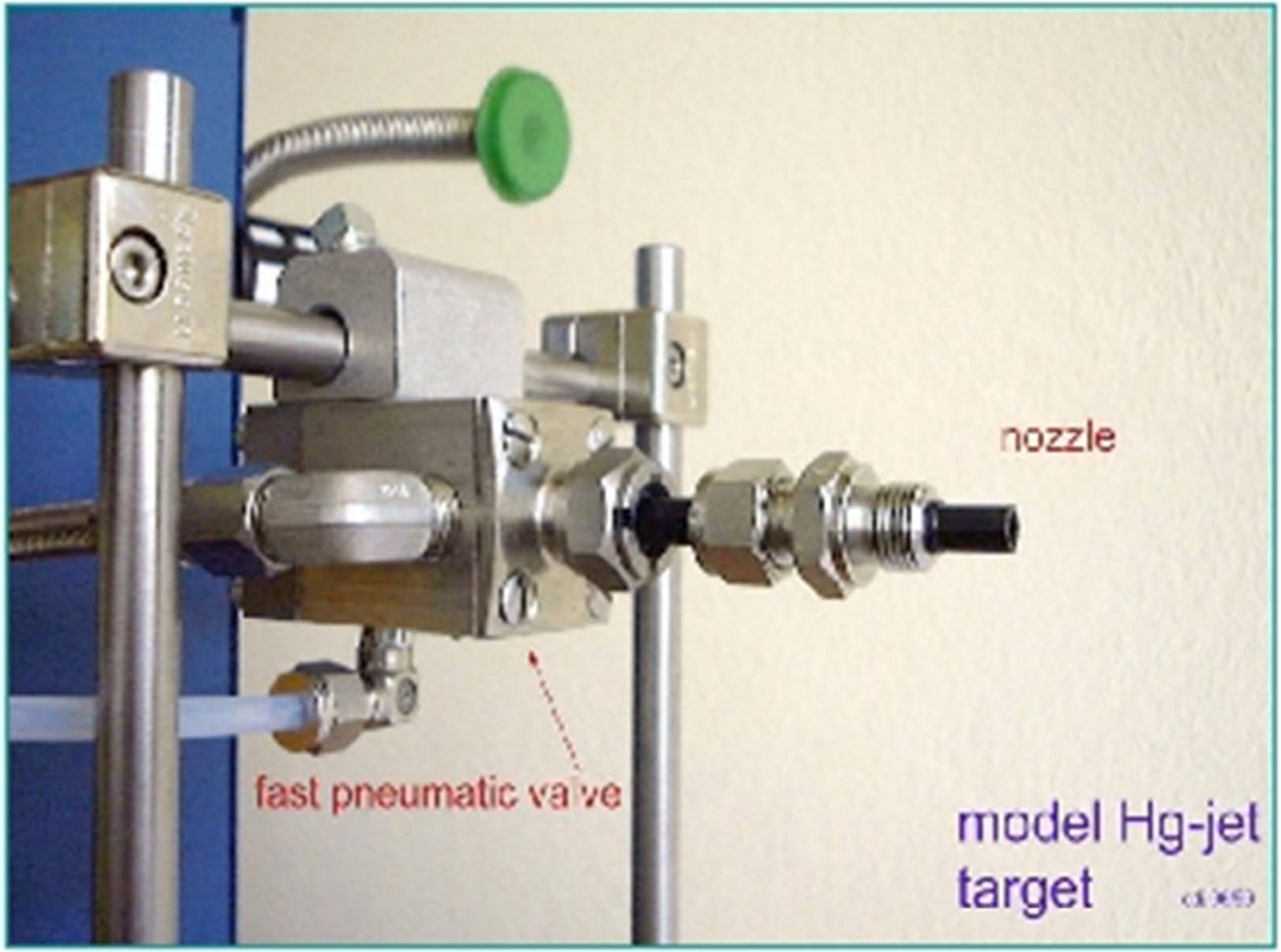
Experiments with liquid jets



Model jet target ... ...

V-Fast99

Experiments with liquid jets



Experiments with liquid jets

New jet target delivers 30 ml of liquid per shot at pressure from 0 to 100 bar

Single-shot or up to 15 Hz repetition rate

Tested with water.

Awaiting minor modification before filling with mercury.

Then study hydrodynamics as function of:

pressure

time

nozzle size and length

Later - magnetohydrodynamics in 20 T solenoid field and

Shock effects in beam