

Acceleration of Pb Ions in the CERN SPS

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August 1988

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U.S. Department of Energy

USDOE Office of Science (SC)

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AD/RHIC-RD-11

Acceleration of Pb Ions in the CERN SPS

Dr. Krsto Prelec
BNL

ACCELERATION OF Pb IONS AT CERN

FIRST PROPOSAL: R. STOCK, R. BOCK, SEPT. 1986

PRESENT SCHEDULE: SUBMIT PROPOSAL LATE 1988

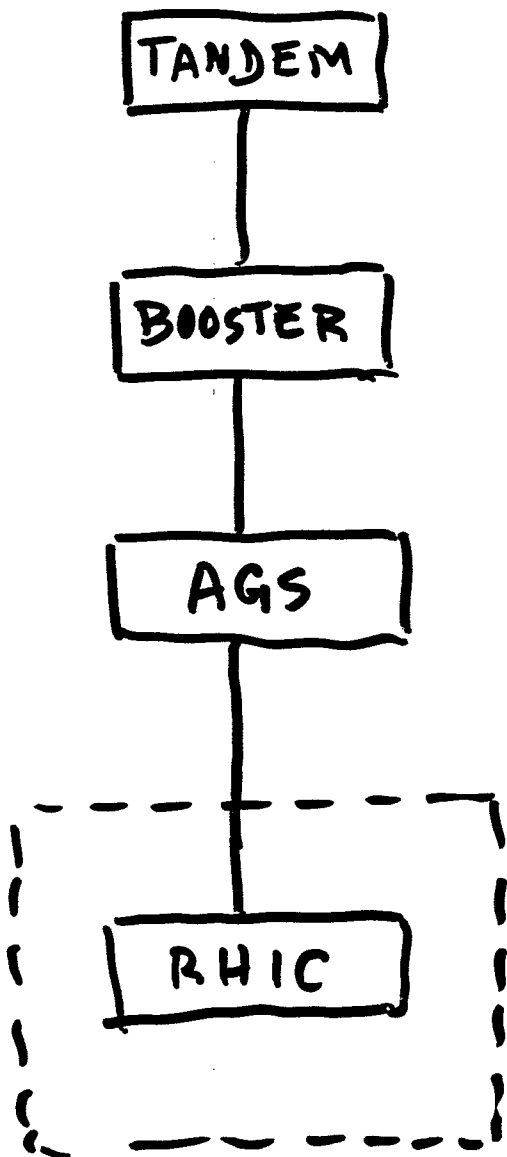
DECISION: MID 1989

PROJECT LEADER	H. HASEROTH	10/88
SECRETARY (SCIENTIFIC)	U. TALLGREN	
SOURCE	C. HILL, R. GELLER	
RFQ, LINAC	9/88 M. WEISS, D. WARNER, et al.	
VACUUM	M. BROUET, A. PONCET	
RF	G. NASSIBIAN, C. ZETTLER	
BOOSTER SPECS	K. SCHINDL et al.	
CONTROLS, INSTRUMENTATION	P. TÊTU, U. RAICH	
PS PROBLEMS	R. CAPPI	
COORDINATION, GEN. PROBLEMS	H. HASEROTH	
	T. A. SHERWOOD	

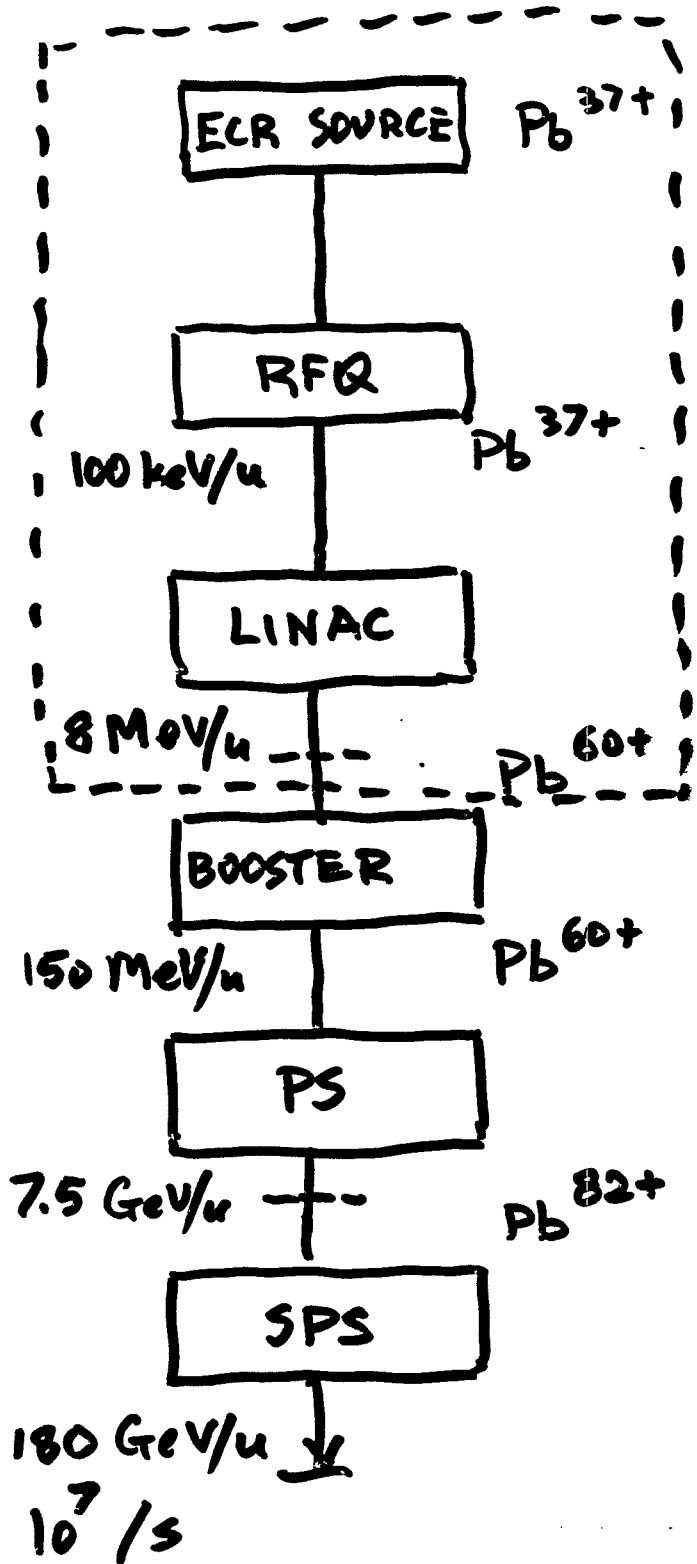
ABOUT 25-30 PEOPLE, SEVERAL OUTSIDE
CONSULTANTS

SO FAR 7 MEETINGS AND 1 WORKSHOP

BNL



CERN , FIRST PROPOSAL (1986)



ION SOURCE

REQUIRED

HIGH CHARGE STATE
SUFFICIENT INTENSITY
RELIABLE OPERATION
AVAILABLE WITHIN 3 YEARS
FROM OUTSIDE

GENERAL PROPERTIES OF HEAVY ION SOURCES

	SOURCE TYPE	CHARGE STATES	CURRENT	
	"HIGH CURRENT"	LOW	1-100 mA	1 YEAR
	PIG	MEDIUM	0.1 - 5 mA	1 YEAR
*	ECR	HIGH	0.01 - 0.5 mA	3 YEARS
	EBIS	VERY HIGH	0.1 - 1 μ A (for 1 Hz)	> 3 YEARS

SELECTED ION SOURCE : ECR

ASSUMED PARAMETERS :

1986 30 GHz, Pb^{37+}

1987 30 GHz, Pb^{35+} , 30-40 μA
(GELLER, private comm.)

1988 20 GHz, 6 kW, ~~30~~

Pb^{30+} , 30 μA
(GELLER, WORKSHOP 1988)

FINAL DESIGN PARAMETERS
(MAY 1988)

Pb^{25+} , 30 μA

ECR ION SOURCES

(GELLER, 1988 CERN WORKSHOP)

EXISTING

10 GHz
0.5 kW

O^{6+} , 100 μA

15 GHz
2 kW

S^{12+} , 30 μA
 Ar^{13+} ,

EXTRAPOLATION

20 GHz
6 kW

Pb^{30+} , 30 μA

REQUIRED: 3 YEARS, 2 M \$

30 GHz
3 kW

Pb^{30+} , 30 μA

(UNCERTAIN EXTRAPOLATION)

$30 \mu A \rightarrow 1 pA \rightarrow 6 \times 10^{12} s^{-1}$ of Pb^{30+}

INJECTION INTERVAL

400 μs

INJECTED # OF PARTICLES

2.4×10^9

REPORT ON DUBNA HEAVY ION SOURCES
(SHERWOOD, JUNE 1988)

LASER SOURCE

CO₂ LASER

Li³⁺, 2×10^{11} part. from Linac
15 μ s

C⁶⁺, 10^{12} from source
 2×10^{10} from Linac
3 μ s

Mg¹²⁺, 10^9 from Linac, after stripping.

A CRATER FORMS AFTER ≈ 1000 PULSES

EBIS SOURCES

- OPERATING SOURCE 10^{11} CHARGES / PULSE
(FOR Pb³⁰⁺, $\approx 10^9$ PART. / PULSE)
- SOURCE FOR ATOMIC PHYSICS FULLY STRIPPED Xe
(LOW INTENSITY)
- TEST BENCH SOURCE, HOPE: FULLY STRIPPED U

RFQ AND NEW LINAC

LOW ENERGY END: Pb^{30+} INJECTED FROM THE ECR SOURCE

FINAL: Pb^{25+}
TRANSFER: 0.25 MeV/u

HIGH ENERGY END: Pb^{30+} BEAM STRIPPED AND INJECTED INTO PSB

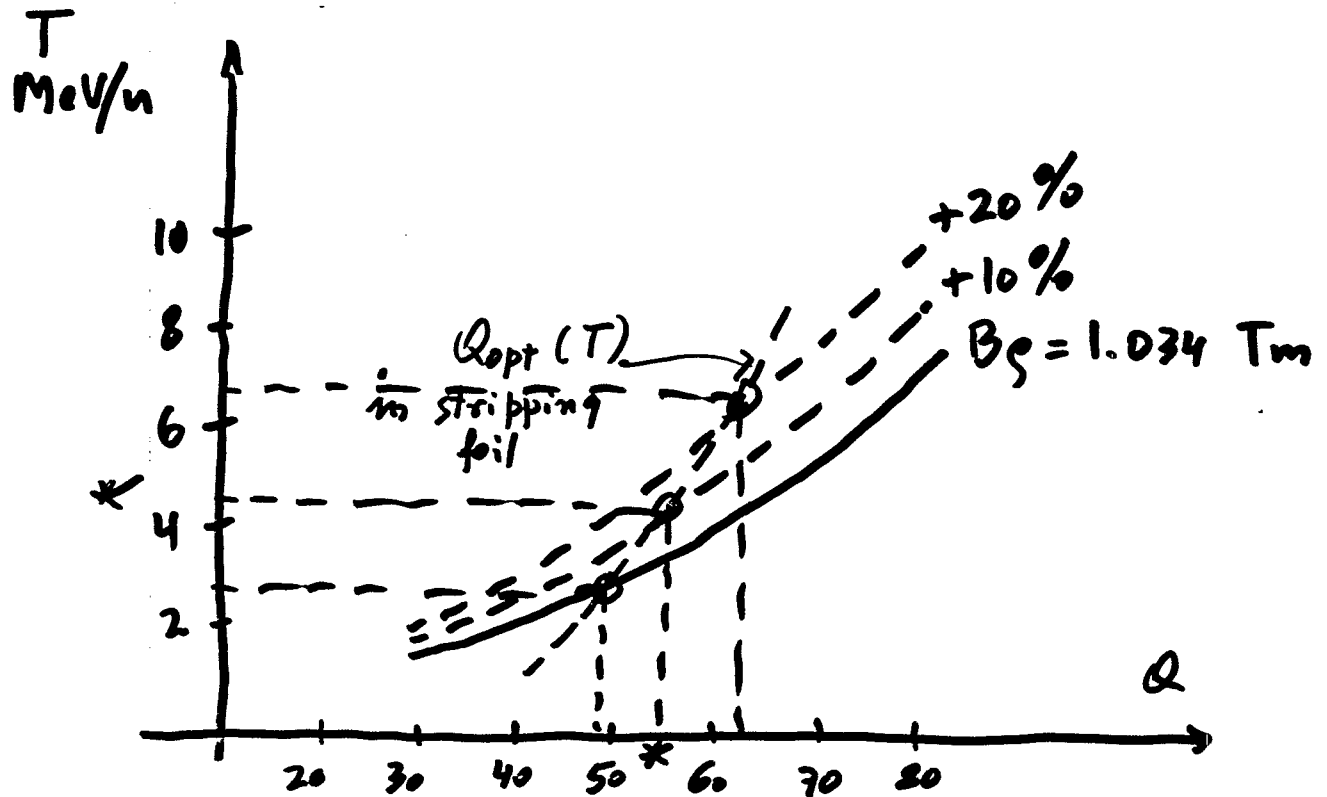
TWO REQUIREMENTS TO BE SATISFIED SIMULTANEOUSLY

- OUTPUT ENERGY (FROM LINAC) AND CHARGE STATE AFTER STRIPPING SHOULD MATCH THE EXISTING TRANSFER LINE RIGIDITY WITHIN 10%
- OUTPUT ENERGY SHOULD BE MATCHED TO THE OPTIMUM CHARGE STATE IN FOIL STRIPPER

LENGTH!

CONSEQUENCE: FIRST PROPOSAL FOR INJECTION OF Pb^{60+} AT 8 MeV/u INTO PSB HAD TO BE CHANGED BECAUSE IT WOULD REQUIRE 40% HIGHER RIGIDITY

RFR AND LINAC CONSIDERATION



DESIRED: • AS HIGH A CHARGE STATE AS POSSIBLE TO INCREASE SPS INJECTION ENERGY AND REDUCE # OF HARMONIC JUMPS

SELECTED: • LINAC OUTPUT ENERGY 4.2 MeV/u
INJECTION LINE RIGIDITY 1.034 + 11%
CHARGE STATE 53+
(WHY NOT 54+?)

TO BE DECIDED: RFR DESIGN (NOT A PROBLEM)
TYPE OF LINAC

TRANSMISSION IN THE PSB

PRESENT VACUUM

3×10^{-8} torr

IMPROVED VACUUM

10^{-9} torr
(400-700 kSF_r)

MANY STUDIES ON TRANSMISSION LOSSES DUE TO
CAPTURE / LOSS OF ELECTRONS

FRANZKE (GSI)

BARON (GANIL)

GOULD (LBL)

MOST RECENT RESULTS FOR Pb^{30+} (TRANSMISSION)

	GSI		LBL	
	SLOW	FAST	SLOW	FAST
10^{-9} torr	77%	83%	68%	76%

SELECTED : CAPTURE WITH $h = 17$
DEBUNCH, REBUNCH $h = 10$

INJECTION
EJECTION

4.2 MeV/u
96 MeV/u

TRANSMISSION IN THE PS

INJECTION ENERGY DETERMINED BY THE
TRANSFER LINE RIGIDITY

$$T = 96 \text{ MeV/m}$$

CAPTURE

$$h = 20$$

(TWO BOOSTER BUNCHES
PER PS BUCKET)

Pb⁵³⁺

PRESENT
VACUUM

$$\underline{5.3 \times 10^{-9} \text{ torr}}$$

	GSI		LBL	
	SLOW	FAST	SLOW	FAST
PS		67 %		67 %
PSB + PS	52 %	56 %	46 %	51 %

IMPROVED
VACUUM

$$\underline{8 \times 10^{-10} \text{ torr}}$$

	GSI		LBL	
	SLOW	FAST	SLOW	FAST
PS		94 %		94 %
PSB + PS	72 %	78 %	64 %	71 %

ACCELERATION IN SPS

INJECTION ENERGY LIMITED BY $(B\rho)_{\min}$ IN SPS

AND BY $(B\rho)_{\max}$ IN PS FOR 1.2 s CYCLE.

ALSO, γ_{tr} SHOULD BE AVOIDED ($\gamma_{tr} = 6.1$)

TENTATIVE PARAMETERS:

INJECTION ENERGY 4.16 GeV/u

ONE HARMONIC JUMP

FREQUENCY SWING 0.5%

ESTIMATED SPS INTENSITY

SOURCE OUTPUT

30 μ A OF Pb²⁵⁺

OF IONS LEAVING THE SOURCE, PER SPS PULSE

$$N = \frac{4 \times 30 \times 10^{-6} \times 400 \times 10^{-6}}{1.6 \times 10^{-19} \times 25} = \underline{1.2 \times 10^{10} \text{ Pb ions}}$$

4 PS PULSES PER SPS PULSE

TRANSMISSION LOSSES

RFQ	0.9
LINAC	0.9
I. STRIPPING	0.16
PSB	0.35
PS	0.7
SPS	0.4
	<u>1.27%</u>

SPS INTENSITY : 1.5×10^8 / pulse

USER REQUEST : 5×10^7 / pulse

cf.

OXYGEN	1.6×10^9	PEAK ,	1.2×10^8	AVERAGE
SULPHUR	5.6×10^7	PEAK,	10^7	AVERAGE