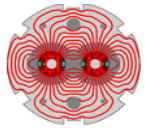
Ions for LHC: Sources, Linac3



A Glimpse on the LHC injector chain

- Nominal lead beam in LHC

ECR Source, Linac3 issues

- Intensity in allowed emittance

Lighter Ions

- Estimated yields from source, Linac, stripper
- Possible improvements

Low Energy Ion Ring (LEIR) or Laser Ion Source (LIS)?

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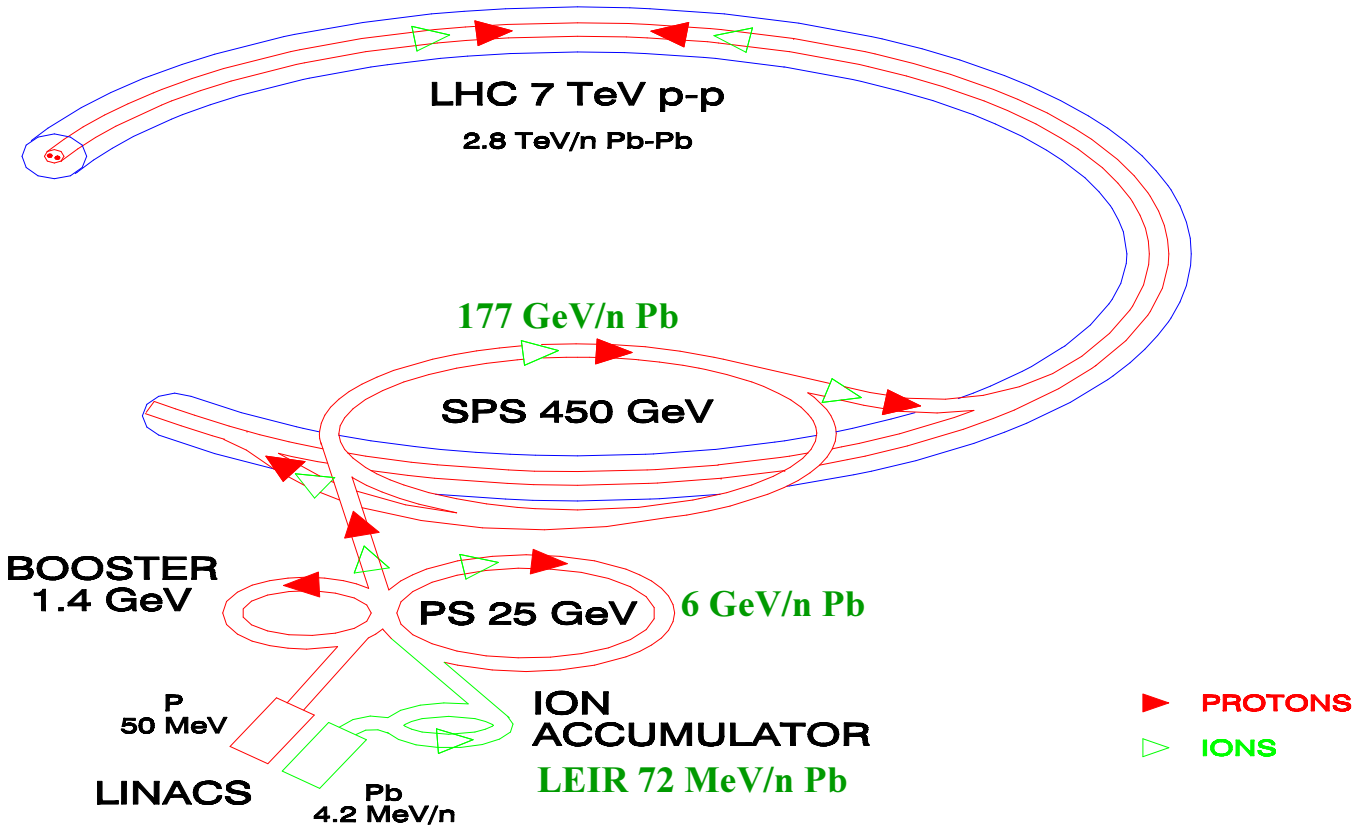
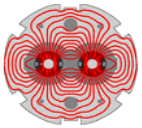
Daniel Brandt, Michel Chanel, Carlo Wyss for welcome suggestions

Cost estimates of the LIS route by **Stephan Maury**

The LHC Injector Chain



Lead Ions in LHC and Injectors - Nominal



LHC Pb Luminosity = 1 10^{27} cm^{-2} s^{-1}

	LINAC3	LEIR	PS	SPS	LHC
Energy [GeV/n]	**0.0042**	**0.072**	**6**	**177**	**2760**
Pb charge state	**54+**	**54+**	**54+**	**82+**	**82+**
bunch spacing [ns]			**95, 5**	**100**	**100**
ions/LHC bunch	**6 10^8 (20 μA)**	**2.25 10^8**	**1.2 10^8**	**9 10^7**	**7 10^7**
ε* (= (βγ)*σ^2/β)	**0.3**	**0.7**	**1**	**1.2**	**1.5** (1)
# bunches		**2**	**4 pairs**	**~52**	**592/ring (2)**
pulses to fill downstream machine	**5** (up to 5 Hz)	**1**	**~13**	**12**	***9' filling per ring***

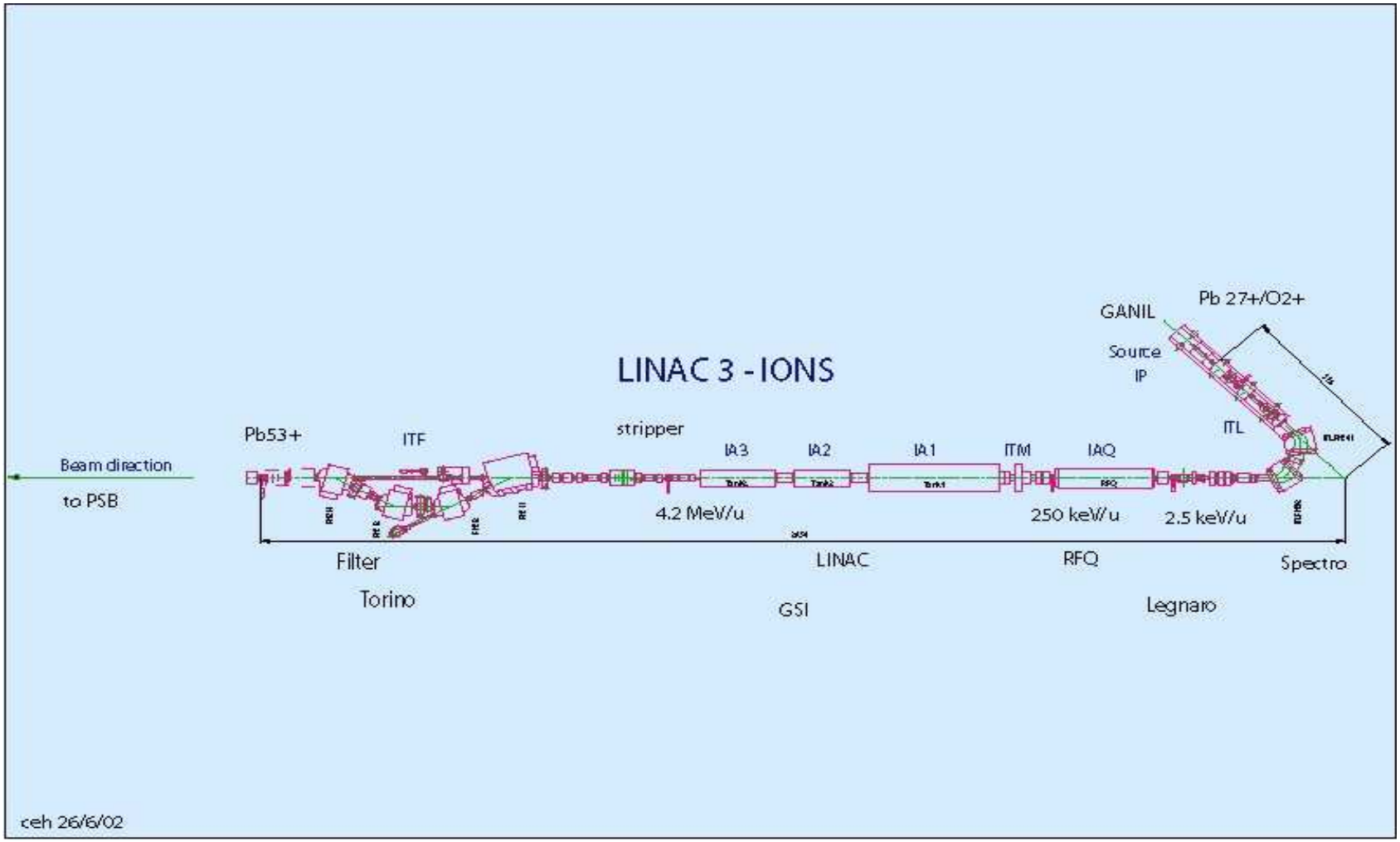
stripper

stripper

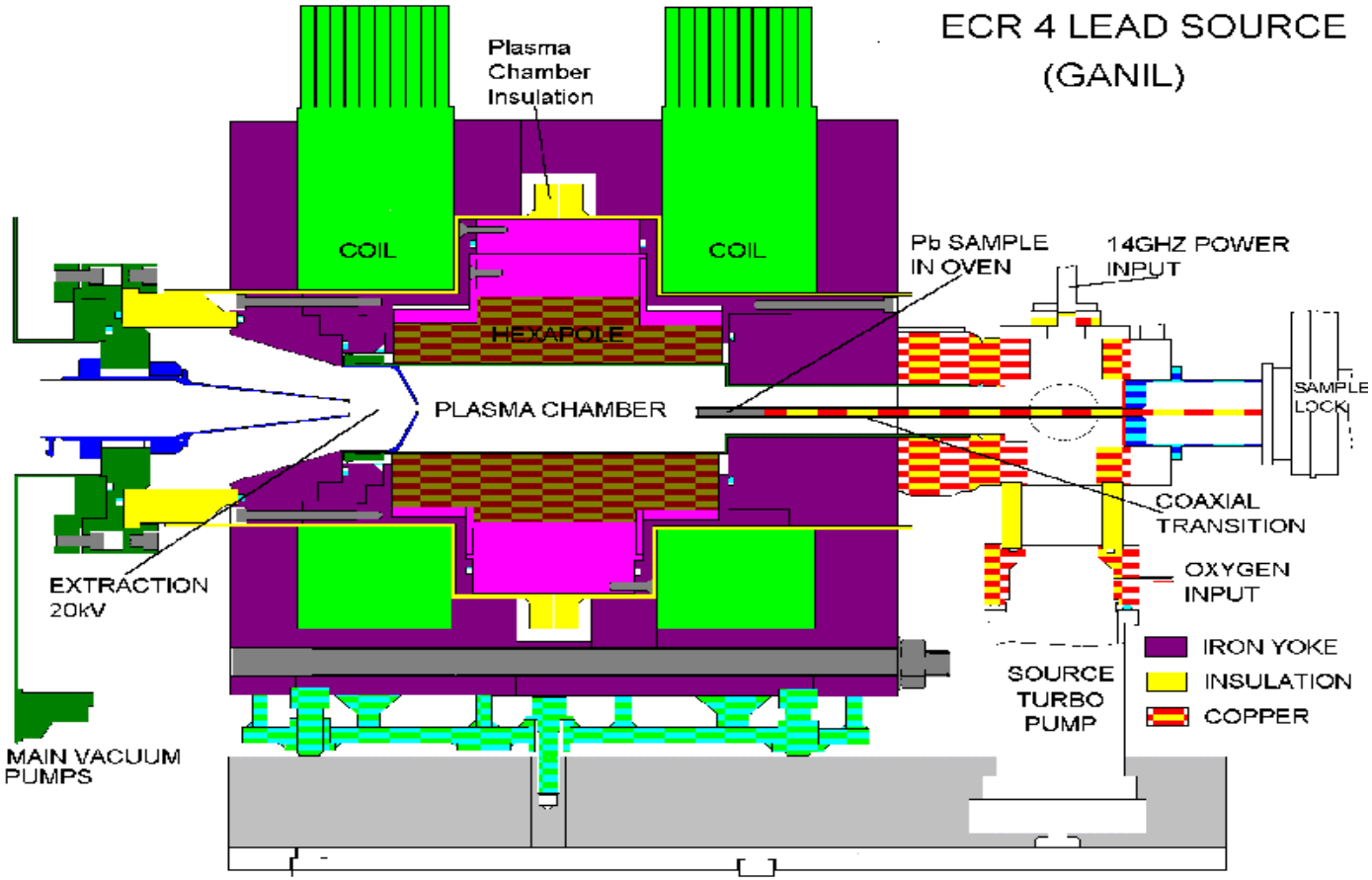
(1) Same physical emittance as protons, with the same tight emittance budget

(2) 891 bunch places per ring

The CERN Ion Linac 3



Electron Cyclotron Resonance (ECR) Source

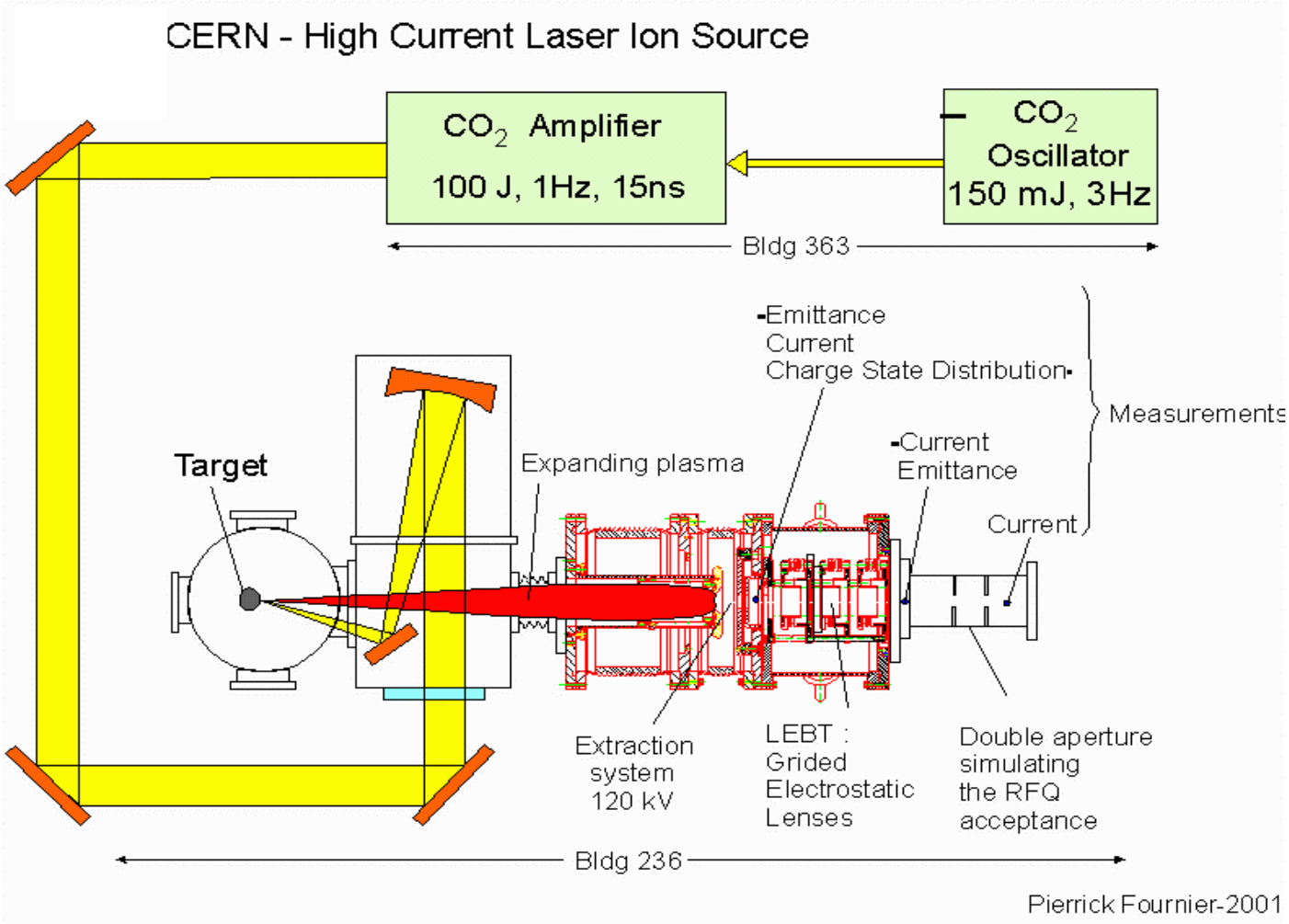


ECR Source and Linac3: Speculations on Lighter Ions

	$_{208}$Pb(82)	$_{115}$In(49)	$_{84}$Kr(36)	$_{40}$Ar(18)	$_{16}$O(8)	$_{4}$He(2)
charge state ion source	**27+**	**21+**	**11+**	**8+**	**2+**	**1+**
current source (μA_e) estim.	**100**	100	150	200	**300**	500
stripped to (after Linac)	**53 (54)+**	**37+**	**29+**	**16+**	**8+**	**1+**
current (μA_e), 14 GHz source	**20**	**25**	30	75	170	**160**
18 GHz source *4.2 MeV/u*	*41-44*	*44-49*		*132*		
28 GHz source(1) *4.2 MeV/u*	*100-108*	*108-120*		*320*		
#ions injected LEIR per Linac pulse ECR 14 GHz), 50 "effective" turns	**$4\ 10^8$**	$6.5\ 10^8$	$9\ 10^8$	$4.3\ 10^9$	$1.8\ 10^{10}$	$1.4\ 10^{11}$
#ions from LEIR per LHC bunch (with 5 Linac3 pulses)	**$3\ 10^8$**	$5\ 10^8$	$6.8\ 10^8$	$3.2\ 10^9$	$1.4\ 10^{10}$	$1\ 10^{11}$
η LHC collision/LEIR ejection	0.3	0.4	0.5	0.5	0.6	0.6
Source vs other limitations						
# ions/bunch, 2.8 TeV/u, source	**$9\ 10^7$**	**$2.6\ 10^8$**	**$3.4\ 10^8$**	**$1.6\ 10^9$**	**$8.1\ 10^9$**	**$6.3\ 10^{10}$**
# ions/bunch, 2.8 TeV/u, other limits	**$7\ 10^7$**	**$2.2\ 10^8$**	**$3.3\ 10^8$**	**$5.5\ 10^8$**	**$1\ 10^9$**	**$5.2\ 10^9$**
	marginal	**marginal**	**marginal**	(1)	(1)	(1)

(1) fewer Linac pulses required

Laser Ion Source (LIS) – an Alternative?

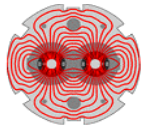


LIS Power Laser and Source

The Russian 100 J, 1 Hz CO_2 Laser Amplifier in building 363 (“Farady Cage”), being commissioned

The prototype Laser Ion Source in building 236 on a HV platform (~100 kV) to decrease space charge

Could we go the LIS Route? It's still R&D!



With Pb^{25+} from LIS, one could use the PS Booster instead of LEIR if:

- Current **> 5mA** during ~ 5μs
- Norm. transverse rms emittance ε^*_{rms} **< 0.15 μm**
- Source stable, reliable, small jitter….

Needs other major investments

- Make an operational laser (spare parts…) + installation in Linac 3;
- A new RFQ;
- Upgrading of PSB injection and vacuum systems;
- (list not exhaustive) summing up to 10…14 MCHF

☺ A few millions cheaper than LEIR

☺ Much less exploitation cost compared to LEIR

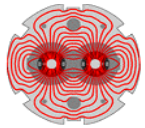
☹ Laser will (hopefully) work this summer, but then R&D starts!

☹ We cannot afford to go the LEIR **and** LIS routes in parallel

☹ Even if conclusive results by end 2002, **Pb to LHC not before 2009**

☹ Lighter ions: speculations, needs more R&D (e.g. for gaseous elements)

Conclusions on Sources and Linac 3



ECR Sources:

- The **present 14 GHz source** could **(just) do the job** for Pb, In, Kr, and easily do it for Ar, O, He. Due to uncertainty of extrapolation, an upgrading to
- **18 GHz** (+ proportional field increase) is envisaged: potential increase of ~1.5
- Collaboration with outside labs to achieve **28 GHz (a factor > 4 in intensity?)**
- Even a factor 10 increase would not be sufficient for the PS Booster route

Laser Ion Source:

- Still a prototype in the R&D phase
- implementation of an operational source and other hardware **would cost at least 10 MCHF**, but would **save resources for exploitation of LEIR**
- Lighter ions? Much more R&D needed (which also costs scarce resources)
- **Pb ions not ready for LHC before 2009**

Conclusion: If we want to have Pb ions ready for LHC in 2008 with a reasonable confidence level, decide NOW for LEIR + (upgraded) ECR source