Key figures for AFTER

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Physics at A Fixed Target ExpeRiment (AFTER) using the LHC beams

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AFTER @ LHC

thanks to F. Fleuret (LLR), S.J. Brodsky (SLAC), C. Hadjidakis (IPNO), M. Anselmino (Torino), R. Arnaldi (Torino), V. Chambert (IPNO), J.P. Didelez (IPNO), B. Genolini (IPNO), E.G. Ferreiro (USC), C. Lorcé (IPNO),A. Rakotozafindrabe (CEA), P. Rosier (IPNO), I. Schienbein (LPSC), E. Scomparin (Torino), and U.I. Uggerhøj (Aarhus)

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- Good thing: small forward detector $\equiv$ large acceptance
- Bad thing: high multiplicity $\Rightarrow$ absorber $\Rightarrow$ physics limitation

Backward physics ?

- $\sqrt{s}$ is large, let's adopt a different strategy and look at larger angles
  · particles with sufficient p_T to be detected
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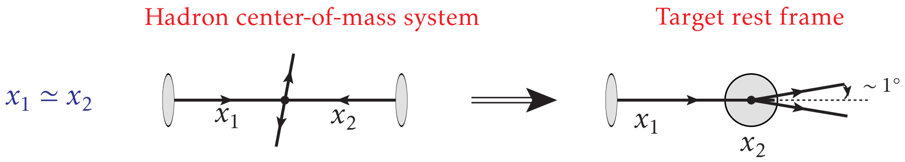

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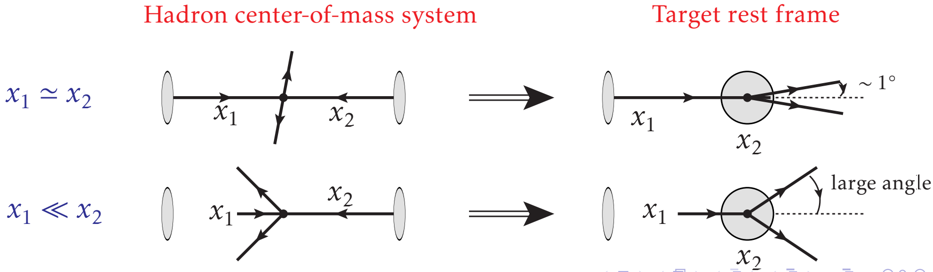

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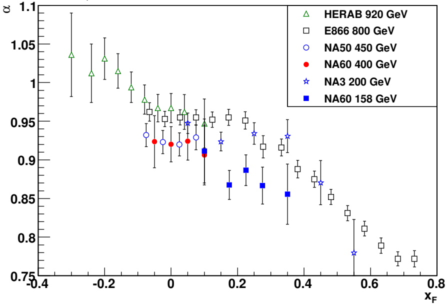
J/ψ suppression in pA collisions



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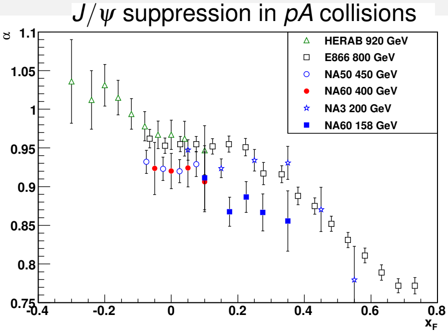

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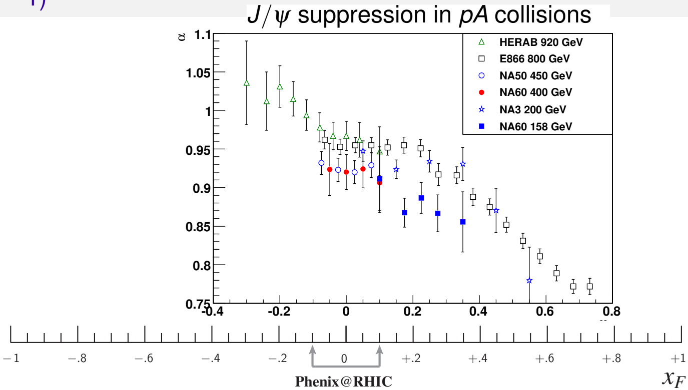

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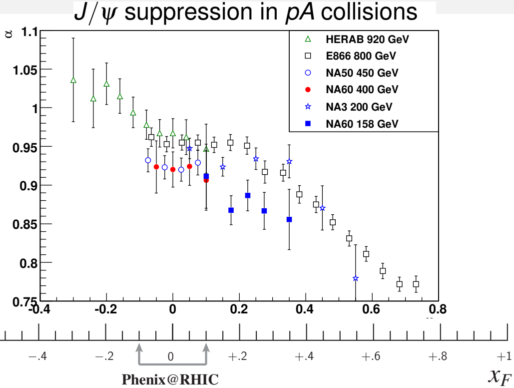

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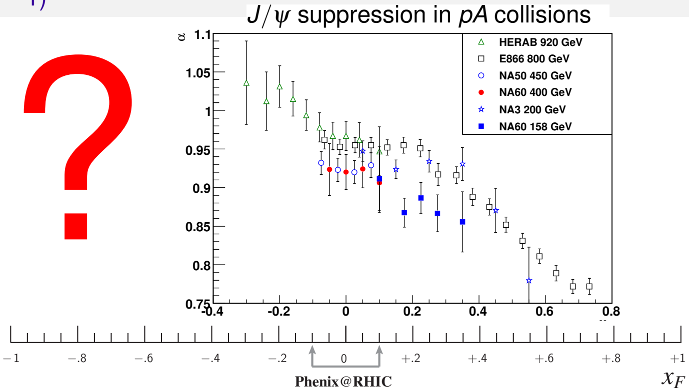

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- If we measure $\Upsilon(b\bar{b})$ at $y_{\rm cms} \simeq -2.5 \Rightarrow x_F \simeq \frac{2m_\Upsilon}{\sqrt{s}} \sinh(y_{\rm cms}) \simeq -1$

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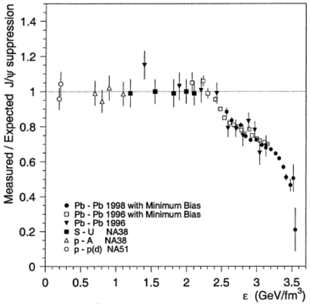

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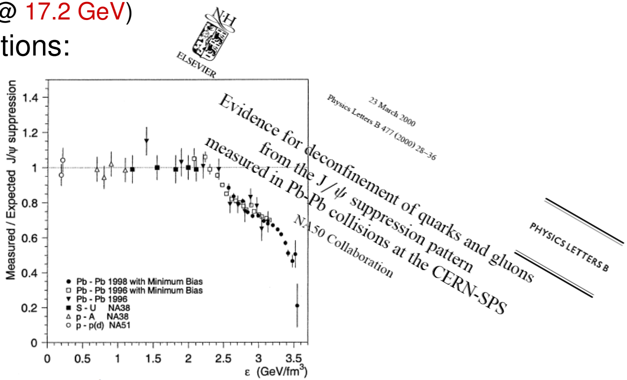

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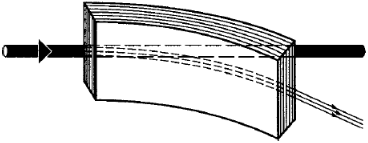

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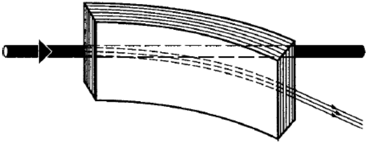

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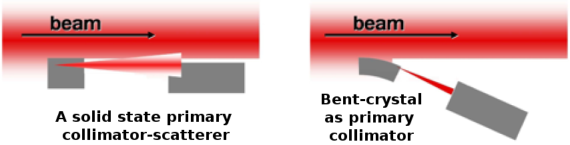

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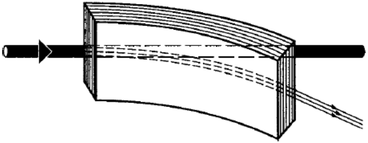

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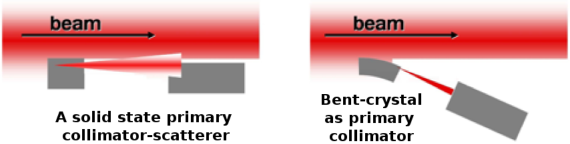

★ Tests will be performed on the LHC beam:
LUA9 proposal approved by the LHCC

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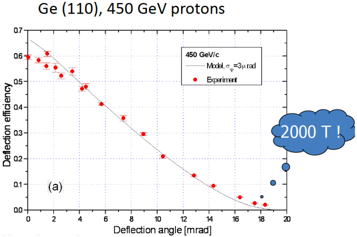

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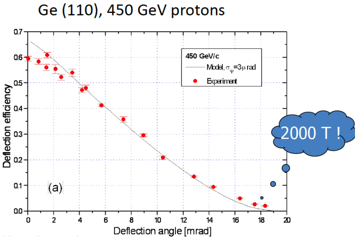

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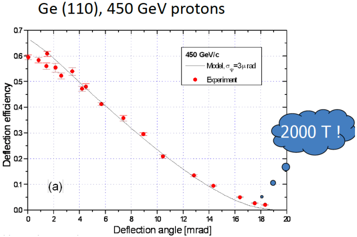

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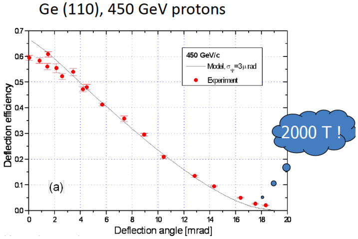

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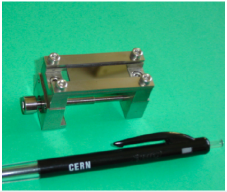
- Simple and robust way to extract the most energetic beam ever:



Beam extraction

- **Beam extraction @ LHC**

… there are extremely promising possibilities to extract 7 TeV protons from the circulating beam by means of a bent crystal.

… The idea is to put a bent, single crystal of either Si or Ge (W would perform slightly better but needs substantial improvements in crystal quality) at a distance of $\simeq 7\sigma$ to the beam where it can intercept and deflect part of the beam halo by an angle similar to the one the foreseen dump kicking system will apply to the circulating beam.

… ions with the same momentum per charge as protons are deflected in a crystal with similar efficiencies

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Strong crystalline fields – a possibility for extraction from the LHC

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If the crystal is positioned at the kicking section, the whole dump system can be used for slow extraction of parts of the beam halo, the particles that are anyway lost subsequently at collimators.

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Target	ρ (g.cm^{-3})	A	$\mathcal{L}$ (μb^{-1}.s^{-1})	$\int\mathcal{L}$ (pb^{-1}.yr^{-1})
Sol. H_2	0.09	1	**26**	**260**
Liq. H_2	0.07	1	**20**	**200**
Liq. D_2	0.16	2	**24**	**240**
Be	1.85	9	**62**	**620**
Cu	8.96	64	**42**	**420**
W	19.1	185	**31**	**310**
Pb	11.35	207	**16**	**160**

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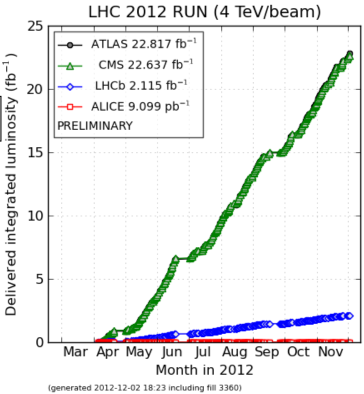

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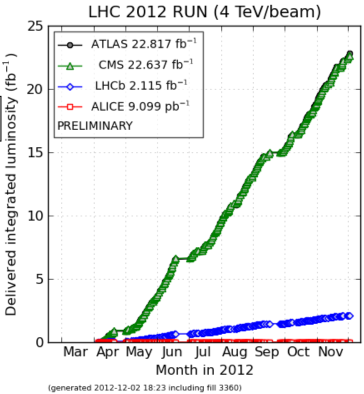

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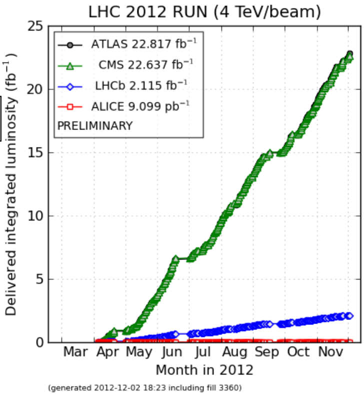


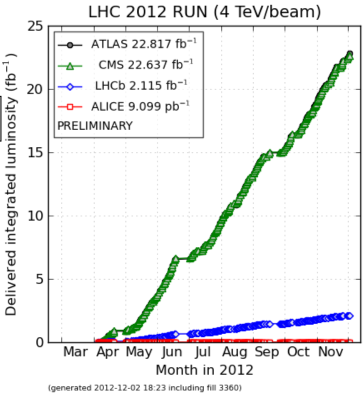
Luminosities

- 1 meter-long liquid H_2 & D_2 targets can be used (see NA51, ...)
- This gives: $\mathscr{L}_{H_2/D_2} \simeq 20\ \text{fb}^{-1} y^{-1}$
- Recycling the LHC beam loss, one gets

a luminosity comparable to the LHC itself !

- PHENIX lumi in their decadal plan
  · Run14pp 12 pb^{-1} @ $\sqrt{s_{NN}} = 200$ GeV
  · Run14dAu 0.15 pb^{-1} @ $\sqrt{s_{NN}} = 200$ GeV
- AFTER vs PHENIX@RHIC:
  3 orders of magnitude larger
- Lumi for Pb runs in the backup slides

(roughly 10 times that planned for the LHC)



Luminosities

- Instantaneous Luminosity:
  $\mathscr{L} = \Phi_{beam} \times N_{target} = N_{beam} \times (\rho \times \ell \times \mathscr{N}_A)/A$
  $\Phi_{beam} = 2 \times 10^5$ Pb s^{-1}, $\ell = 1$ cm (target thickness)
- Integrated luminosity $\int dt \mathscr{L} = \mathscr{L} \times 10^6$ s for Pb
- Expected luminosities with 2×10^5Pb s^{-1} extracted (1cm-long target)

Target	ρ (g.cm^{-3})	A	$\mathcal{L}$ (mb^{-1}.s^{-1})=$\int\mathcal{L}$ (nb^{-1}.yr^{-1})
Sol. H_2	0.09	1	**11**
Liq. H_2	0.07	1	**8**
Liq. D_2	0.16	2	**10**
Be	1.85	9	**25**
Cu	8.96	64	**17**
W	19.1	185	**13**
Pb	11.35	207	**7**

- Planned lumi for PHENIX Run15AuAu 2.8 nb^{-1} (0.13 nb^{-1} at 62 GeV)
- Nominal LHC lumi for PbPb 0.5 nb^{-1}

A few figures on the (extracted) proton beam

- Beam loss: $10^9\ p^+ s^{-1}$
- Extracted intensity: $5 \times 10^8\ p^+ s^{-1}$ (1/2 the beam loss) **E. Uggerhøj, U.I Uggerhøj, NIM B 234 (2005) 31**

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  - the crystal sees 2808×11000 s^{-1} $\simeq 3.10^7$ bunches s^{-1}
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These protons are lost anyway !

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- similar figures for the Pb-beam extraction

AFTER, among other things, a quarkonium observatory in *pp*

- Interpolating the world data set:

Target	$\int \mathcal{L}$ ($fb^{-1}.yr^{-1}$)	$N(J/\Psi)\ yr^{-1}$ = $A\mathcal{L}\mathcal{B}\sigma_\Psi$	$N(\Upsilon)\ yr^{-1}$ = $A\mathcal{L}\mathcal{B}\sigma_\Upsilon$
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LHC pp 14 Tev (low pT)	0.05 (ALICE) 2 LHCb	$3.6\ 10^7$ $1.4\ 10^9$	$1.8\ 10^5$ $7.2\ 10^6$
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- Probe of the (very) large *x* in the target

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Target	A	$\int\mathcal{L}$ (fb^{-1}.yr^{-1})	N(J/Ψ) yr^{-1} = $A\mathcal{L}\mathcal{B}\sigma_{\Psi}$	N(Υ) yr^{-1} = $A\mathcal{L}\mathcal{B}\sigma_{\Upsilon}$
1cm Be	9	0.62	$1.1\ 10^8$	$2.2\ 10^5$
1cm Cu	64	0.42	$5.3\ 10^8$	$1.1\ 10^6$
1cm W	185	0.31	$1.1\ 10^9$	$2.3\ 10^6$
1cm Pb	207	0.16	$6.7\ 10^8$	$1.3\ 10^6$
LHC pPb 8.8 TeV	207	10^{-4}	$1.0\ 10^7$	$7.5\ 10^4$
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  - not to mention ratio with **open charm, Drell-Yan,** etc ...

AFTER: also an heavy-flavour observatory in *PbA*

- Luminosities and yields with the extracted 2.76 TeV Pb beam ($\sqrt{s_{NN}} = 72$ GeV)

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The same picture also holds for open heavy flavour

LHB

Our idea is not completely new

Nuclear Instruments and Methods in Physics Research A 333 (1993) 125–135
North-Holland

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH
Section A

LHB, a fixed target experiment at LHC to measure CP violation in B mesons

Flavio Costantini

University of Pisa and INFN, Italy

A fixed target experiment at LHC to measure CP violation in B mesons is presented. A description of the proposed apparatus is given together with its sensitivity on the CP violation asymmetry measurement for the two benchmark decay channels $B^0 \to J/\psi + K_s^0$, $B^0 \to \pi^+\pi^-$. The possibility of obtaining an extracted LHC beam hinges on channeling in a bent silicon crystal. Recent results on beam extraction efficiencies measured at CERN SPS based on this technique are presented.

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This paper presents a fixed target experiment to measure CP violation in the B system based on the possibility of extracting the 8 TeV LHC proton beam using a bent silicon crystal [4]. A 10% extraction efficiency of the LHC beam halo will give an extracted beam intensity of about 10^8 protons/s allowing the production of as many as 10^{10} $B\overline{B}$ pairs per year, i.e. about two orders of magnitude more than what could be produced by an e^+e^- asymmetric B factory with 10^{34} $cm^{-2}s^{-1}$ luminosity [5].

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