Ions at the Future Hadron Collider

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This is a report on:

- how we have started to organize work within the heavy ion communitytowards the FHC project

- first physics considerations/ directions to explore

1st preparatory meeting on 16/17 Dec 2013 @ CERN
organized by A. Dainese, S. Masciocchi, UAW
https://indico.cern.ch/conferenceTimeTable.py?confId=288576#20131216

Topics discussed:

-First look at FHC operations with heavy ions
(M. Schaumann, J. Jowett)

-Physics:
- Hard and elmag. probes in A+A
(N. Armesto, C. Salgado)
- Soft probes in A+A
(T. Pierog, A. Andronic)
- Small-x physics/ saturation in p+A
(M. v. Leeuwen, UAW)
- Others: ultraperipheral collisions, cosmic rays
(D. D'Enterria)

-Organization of work

Heavy Ion Operations at a VHE-LHC

- see slides of M. Schaumann

  https://indico.cern.ch/getFile.py/access?contribId=0&resId=1&materialId=slides&confId=288576

- Basic considerations for physics studies

$$\sqrt{s_{NN}} = \sqrt{\frac{Z_1 Z_2}{A_1 A_2}}\sqrt{s_{pp}} \quad \Rightarrow \quad \sqrt{s_{PbPb}} = 39\ TeV, \quad \sqrt{s_{pPb}} = 63\ TeV \quad \text{for} \quad \sqrt{s_{pp}} = 100\ TeV$$

First estimates:

https://indico.cern.ch/getFile.py/access?contribId=0&resId=1&materialId=slides&confId=288576

TABLE 1. Peak luminosity and Integrated luminosity per month of running.

	LHC Run 2 [1]	LHC after LS2 [1]	FHC [2]
Pb–Pb peak $\mathcal{L}$ ($\mathrm{cm^{-2}s^{-1}}$)	10^{27}	5×10^{27}	13×10^{27}
Pb–Pb L_{int} / month ($\mathrm{nb^{-1}}$)	0.8	1	5
p–Pb peak $\mathcal{L}$ ($\mathrm{cm^{-2}s^{-1}}$)	10^{29}	t.b.d.	3.5×10^{30}
p–Pb L_{int} ($\mathrm{nb^{-1}}$)	80	t.b.d.	1000

Heavy Ion Operations – further comments/questions

- M Schaumann emphasized that machine parameters used currently are from a first personal look
  - values not yet approved by, study not yet fully coordinated within by BE department

  How to improve this situation?

- Will CDR planning of FHC and injectors aim at being compatible with a possible operation in A+A and p+A mode?

  How/ on what level can one ensure that it is?

Soft physics in A+A

Basic motivation:

Increasing cms energy => denser initial system => longer lifetime
=> bigger spatial extension => stronger collective phenomena

-To frame discussion of physics opportunities, start with simple estimates of Pb-Pb collision properties

-Physics that comes into experimental reach: thermal charm, high-multiplicity events (in small systems, for EbyE analysis), ….

TABLE 2. Pb–Pb collisions at 2.76, 5.5 (extr) and 39 (extr) TeV.

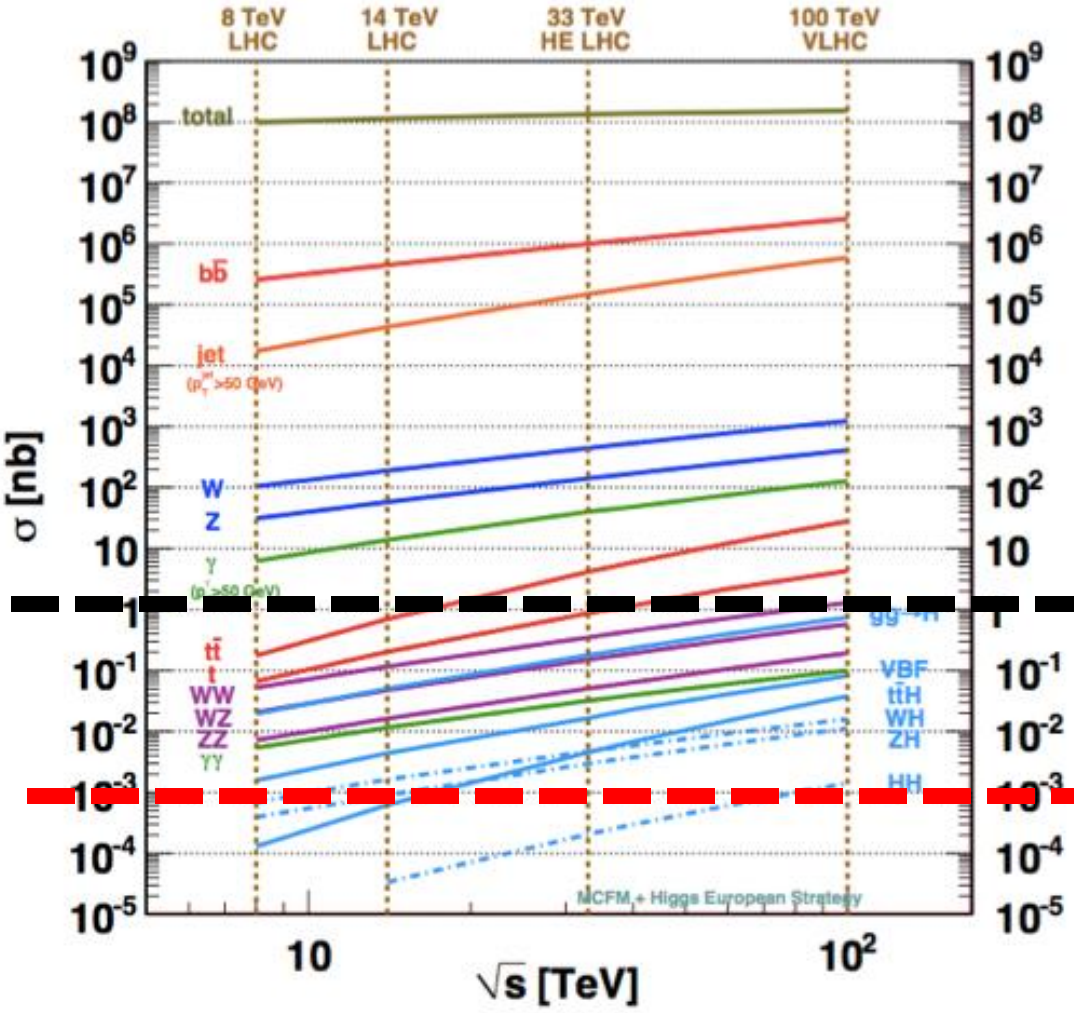
Quantity	Pb–Pb 2.76 TeV	Pb–Pb 5.5 TeV	Pb–Pb 39 TeV
$\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ at $\eta = 0$	1600	2000	3600
Total N_{ch}	17000	23000	50000
$\mathrm{d}E_{\mathrm{T}}/\mathrm{d}\eta$ at $\eta = 0$	2 TeV	2.6 TeV	5.8 TeV
BE homogeneity volume	5000 fm^3	6200 fm^3	11000 fm^3
BE decoupling time	10 fm/c	11 fm/c	13 fm/c
T at $\tau = 1$ fm/c	280 MeV	300 MeV	365 MeV
ϵ at $\tau = 1$ fm/c	12 $\mathrm{GeV}/\mathrm{fm}^3$	16 $\mathrm{GeV}/\mathrm{fm}^3$	35 $\mathrm{GeV}/\mathrm{fm}^3$
x_2 at $y = 0$ vs. Q^2	$Q\,(\mathrm{GeV})\ 4 \times 10^{-4}$	$Q\,(\mathrm{GeV})\ 2 \times 10^{-4}$	$Q\,(\mathrm{GeV})\ 3 \times 10^{-5}$
x_2 at $y = 4$ vs. Q^2	$Q\,(\mathrm{GeV})\ 8 \times 10^{-6}$	$Q\,(\mathrm{GeV})\ 4 \times 10^{-6}$	$Q\,(\mathrm{GeV})\ 6 \times 10^{-7}$
x_2 at $y = 6$ vs. Q^2	$Q\,(\mathrm{GeV})\ 1 \times 10^{-6}$	$Q\,(\mathrm{GeV})\ 5 \times 10^{-7}$	$Q\,(\mathrm{GeV})\ 8 \times 10^{-8}$

Hard Probes in A+A

Basic questions:

What can we learn beyond LHC(5.5 TeV) by embedding rare hard probes in A+A (and p+A)?

J.M. Campbell et al. , arXiv:1310.5189

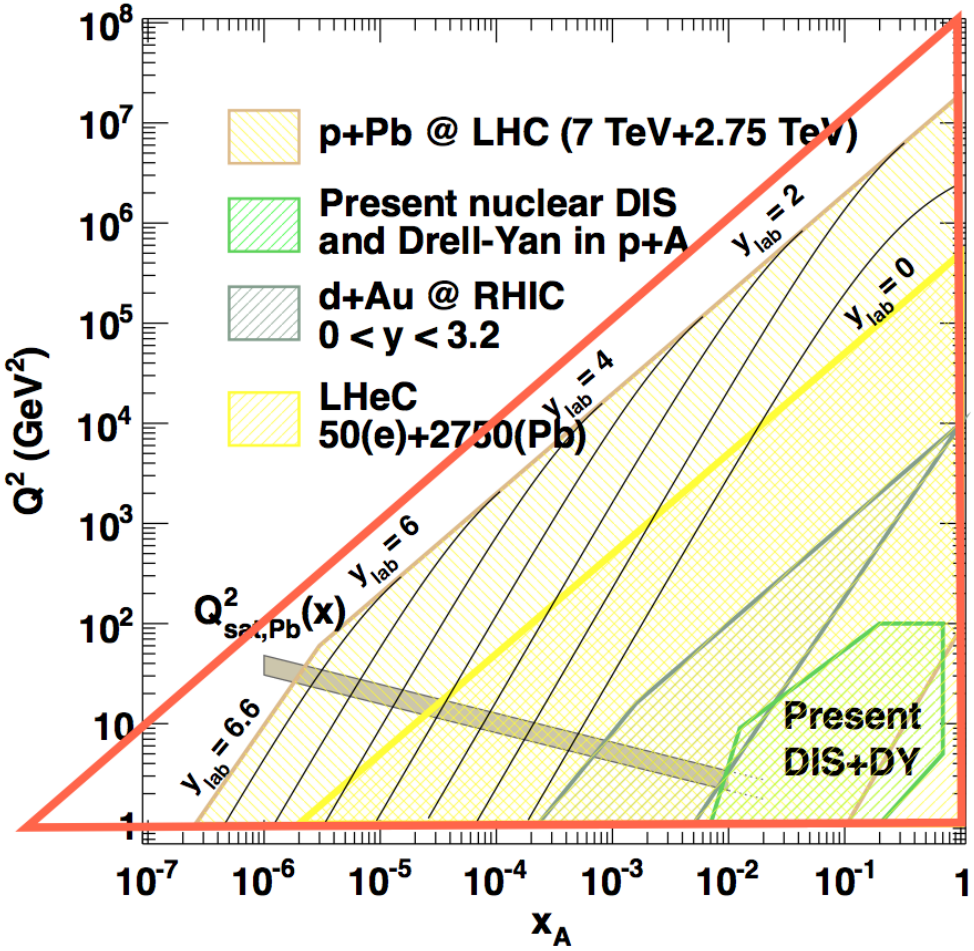


~ 5 events/month in Pb+Pb @ FHC

~ 1 event/month In p+Pb @ FHC

Small-x / saturation physics

- Access regime of non-linear small-x evolution, Q_{sat} is very large
  (A-dependence enhances non-linearities)
- Constrain npdfs, (test their process independence)
  (this is crucial input for phenomenology of A+A)



Assuming 50+20 FHC

$$x_{\mathrm{FCC}} \sim x_{\mathrm{LHC}}\, e^{-2}$$

Organization

- Clearly, work is ahead of us.

- We specified groups looking at different physics topics
  - soft physics (current contact Urs Wiedemann)
  - hard probes (contact A. Dainese, C. Roland, C. Salgado)
  - small-x (contact N. Armesto, M.v. Leeuwen)
  - UPC/others (contact D. d'Enterria)

- Next Meeting on 29 January at CERN

- Next aim: Input into Geneva kick-off meeting:
  - one talk on machine
    (in session on hadron collider design?)
  - one talk on physics considerations
    (in session on hadron physics?)