MEASUREMENT OF ION BEAM LOSSES DUE TO BOUND-FREE PAIR PRODUCTION IN RHIC

J. M. Jowett, R. Bruce, S. Gilardoni,
CERN, Geneva, Switzerland
A. Drees, W. Fischer, S. Tepikian,
BNL, Upton, NY, USA
S. R. Klein, *LBNL, Berkeley, CA, USA*

Abstract: When the LHC operates as a Pb^{82+} ion collider, losses of Pb^{81+} ions, created through Bound-free Pair Production at the collision point, and localized in cold magnets, are expected to be a major luminosity limit. With Au^{79+} ions at RHIC, this effect is not a limitation because the Au^{78+} production rate is low, and the Au^{78+} beam produced is inside the momentum aperture. When RHIC collided Cu^{29+} ions, secondary beam production rates were lower still but the Cu^{28+} ions produced were predicted to be lost at a well-defined location, creating the opportunity for the first direct observation of BFPP effects in an ion collider. We report on measurements of localized beam losses due to BFPP with copper beams in RHIC and comparisons to predictions from tracking and Monte Carlo simulation.

Conclusions:

- Clear measurements of Bound Free Pair Production (BFPP) process at RHIC.
- Optical tracking and Monte Carlo simulations of the shower agree with measurements within the error bars
- Error bar source identified as misalignments of magnets and beam pipe and initial orbit errors at the IP.

	σ_{BFPP} / barn	$L/10^{27}$ $cm^{-2}s^{-1}$	BFPP rate /kHz	δ / %
LHC Pb-Pb 2750 A GeV	281	1	280	1.2
RHIC Au-Au 100 A GeV	114	1.5	170	1.3
RHIC Cu-Cu 100 A GeV	0.15	24	3.6	3.5
RHIC Cu-Cu 31 A GeV	0.08	1	0.08	3.5

BFPP cross sections, peak luminosity, rates

Simulation

BFPP process at the IP creates wrongly charged beam outside machine acceptance. These ions are lost downstream in the ring on a localized spot.

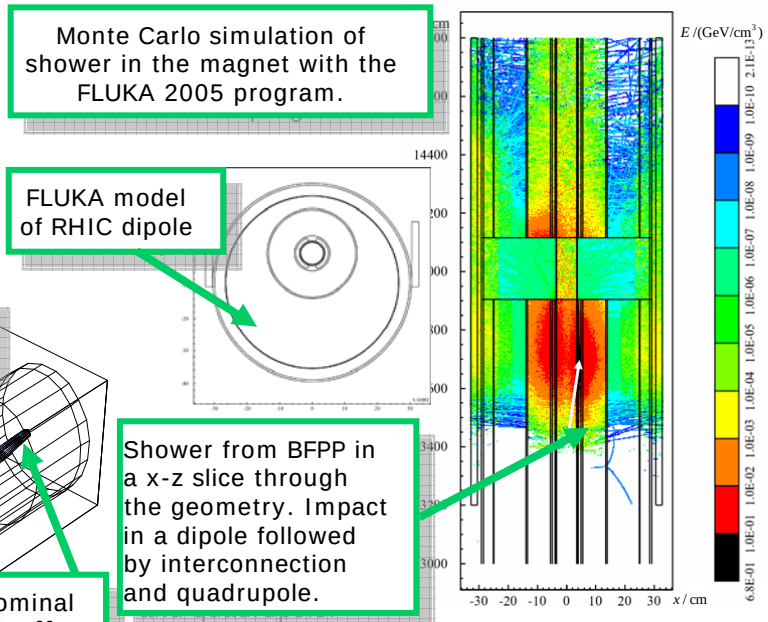
BFPP expected to be a major factor for luminosity decay in the LHC but not at RHIC

BFPP may cause magnet quenches in the LHC through localized beam pipe heating

Opportunity to study at RHIC with Cu ions

$$^{64}Cu^{29+} + {}^{64}Cu^{29+} \xrightarrow{\gamma} {}^{64}Cu^{29+} + {}^{64}Cu^{28+} + e^{+}$$

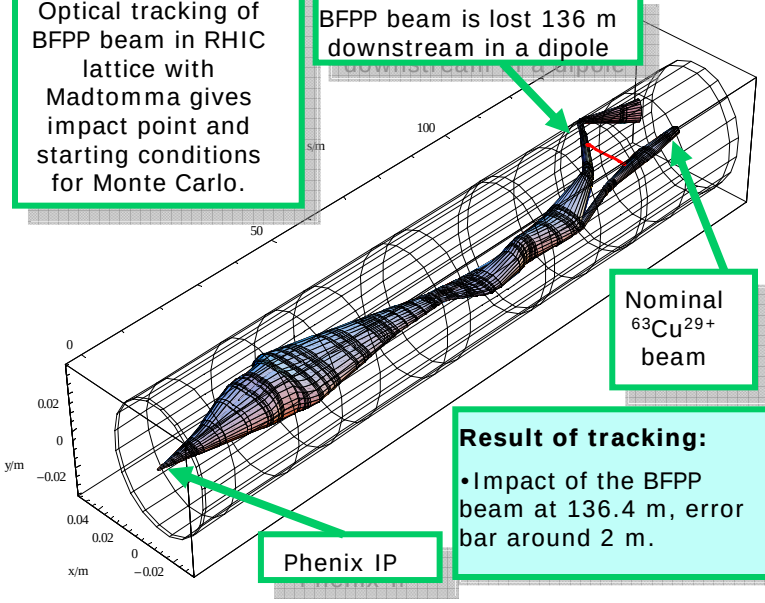
Monte Carlo simulation of shower in the magnet with the FLUKA 2005 program.



FLUKA model of RHIC dipole

Optical tracking of BFPP beam in RHIC lattice with Madtomma gives impact point and starting conditions for Monte Carlo.

BFPP beam is lost 136 m downstream in a dipole



Nominal $^{63}Cu^{29+}$ beam

Phenix IP

Shower from BFPP in a x-z slice through the geometry. Impact in a dipole followed by interconnection and quadrupole.

Result of tracking:

- Impact of the BFPP beam at 136.4 m, error bar around 2 m.

Result of shower simulation:

- Shower maximum outside cryostat around 1 m downstream of impact when the whole shower is inside the magnet, longer if the impact is close to the end of the first magnet.
- Expected PIN diode signals on the order of 10 Hz

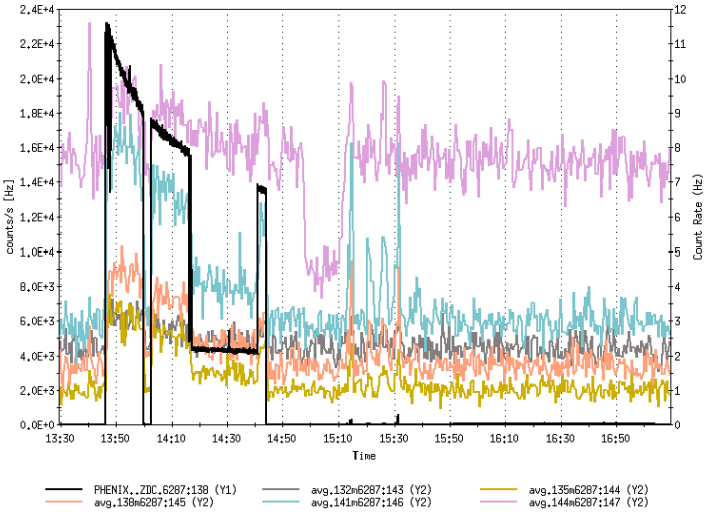
You can download a preprint of the paper or this poster at
http://cern.ch/jowett/epac2006/

Measurements

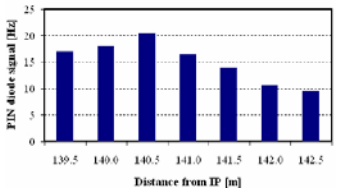
Measurement of BFPP process performed during 100 A GeV operation with Cu^{29+} at RHIC.

PIN diodes mounted outside the magnet cryostat around the expected loss location to count shower particles in wide configuration (3 m apart) and close configuration (1 m apart – not shown here).

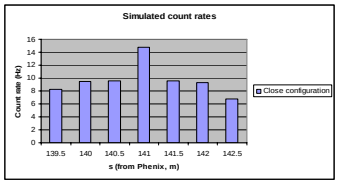
PIN diodes mounted on the RHIC cryostat



- Signal from PIN diodes (coloured curves) recorded when luminosity (ZDC, black) is varied
- Clear correlation between PD signal and luminosity evidence of BFPP process (also van der Meer scans).
- Maximum measured at 140.5 m, which is further downstream than expected from simulations but within error margin
- Very good agreement between data and PIN diode simulations for the order of magnitude of the count rates



Measured signals



Simulated signals