Simulation of BFPP measurements at RHIC

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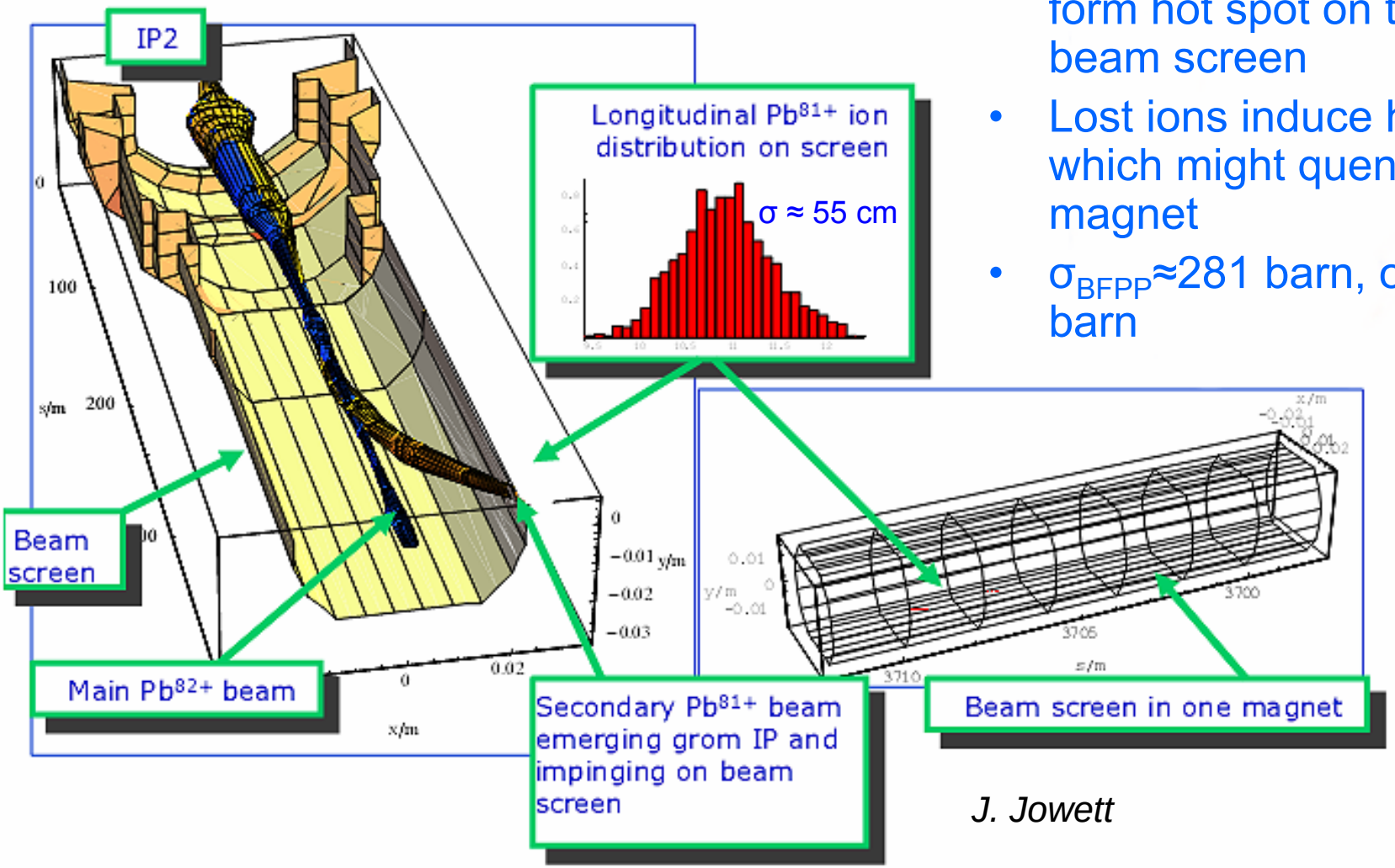
Motivation

- BFPP might limit luminosity for Pb^{82+} in the LHC
- Accurate and reliable simulations as well as a good understanding of the underlying physics are necessary in order to predict the behavior in the LHC
- Experiment at RHIC gives an excellent opportunity to benchmark the tools and models used for the LHC
- First experiment ever on a high energy collider that measures BFPP
- RHIC experiment could confirm predicted cross section for the BFPP process

Bound Free Pair Production (BFPP) for nominal luminosity in the LHC

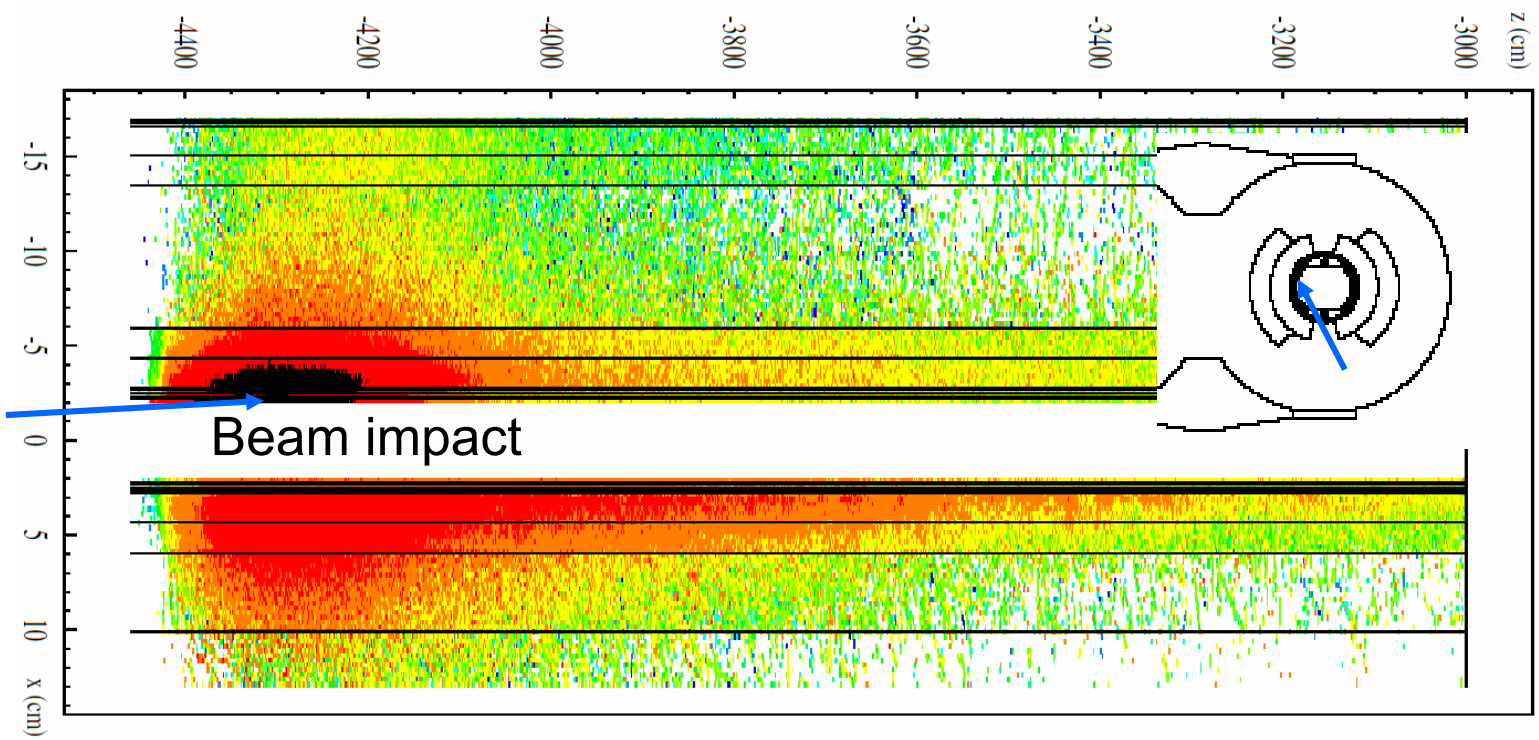
$$^{208}Pb^{82+} + {}^{208}Pb^{82+} \xrightarrow{\gamma} {}^{208}Pb^{82+} + {}^{208}Pb^{81+} + e^{+}$$

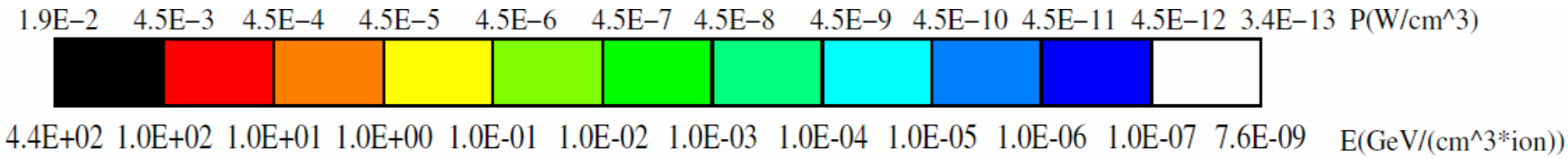
- Pb^{81+} ions lost in the dispersion suppressor form hot spot on the beam screen
- Lost ions induce heating which might quench a magnet
- $\sigma_{BFPP} \approx 281$ barn, $\sigma_H \approx 8$ barn



J. Jowett

Energy deposition in the median plane

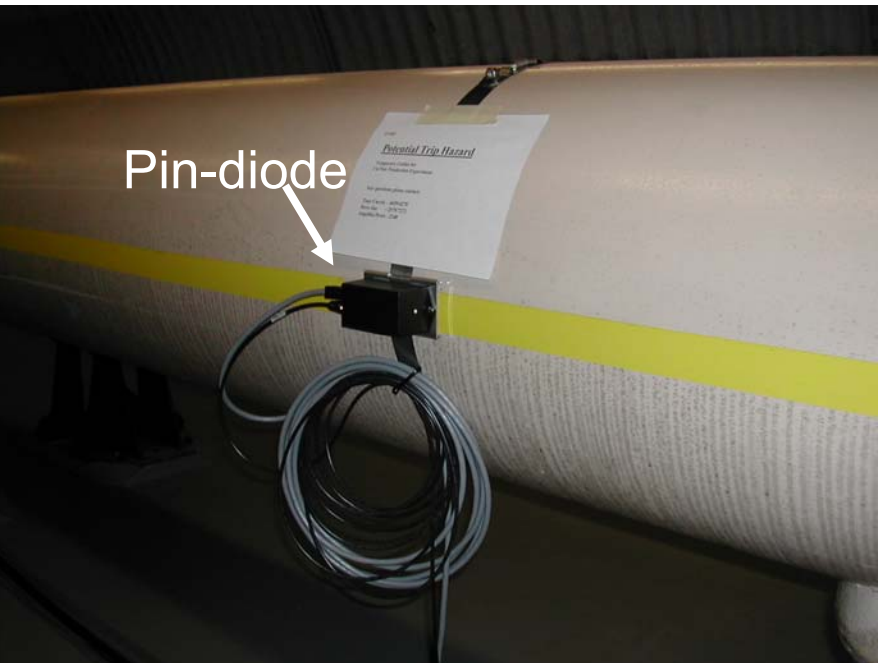




Preliminary result for the LHC: Magnet is not likely to quench although the quench limit is not well known

BFPP experiment at RHIC

- Cu^{29+} collisions at 100 A GeV
- BFPP proceess: $Cu^{29+} + Cu^{29+} \rightarrow Cu^{29+} + Cu^{28+} + e^{+}$
- Possibility to observe BFPP due to larger momentum deviation than for Au-Au run. Lower cross section than for Pb-Pb means no danger for quench
- PIN diode detectors located outside the cryostat around the expected impact point
- Secondary shower particles measured

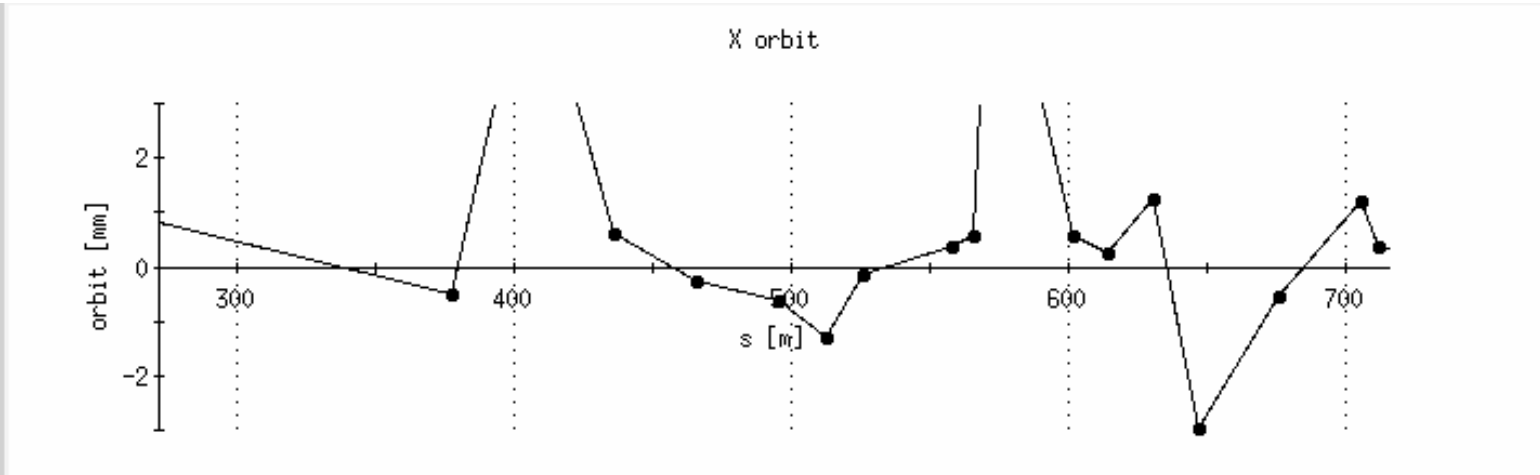


Simulation setup

- MadTomma tracking shows impact point and angle
- FLUKA simulation of the shower gives secondary particles emerging outside the cryostat => expected detector signals

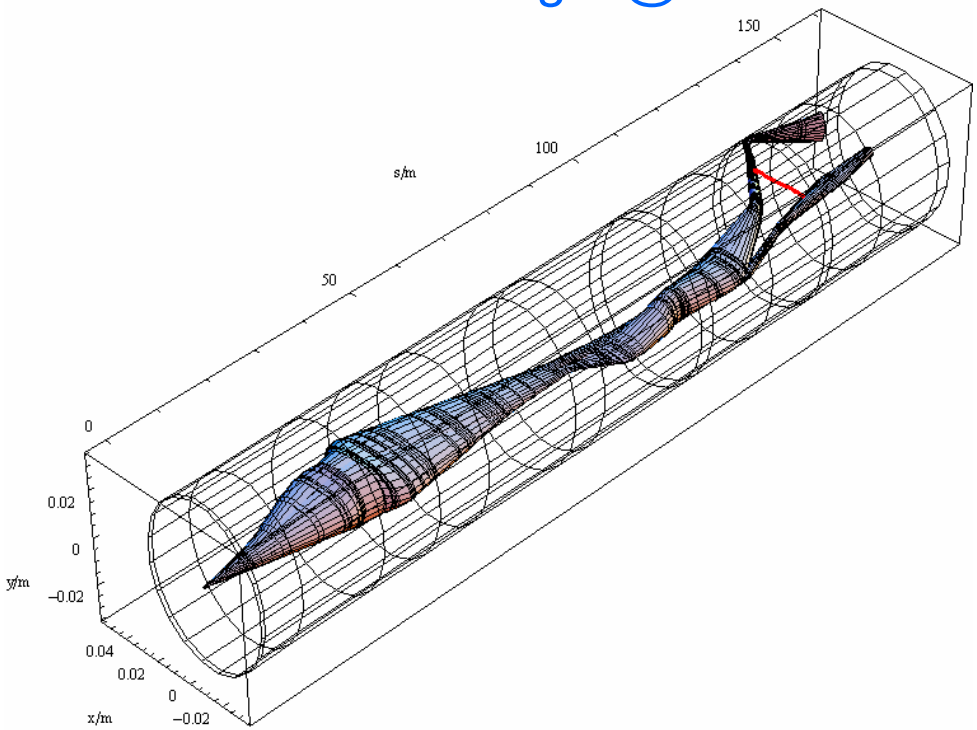
Uncertainties in tracking:

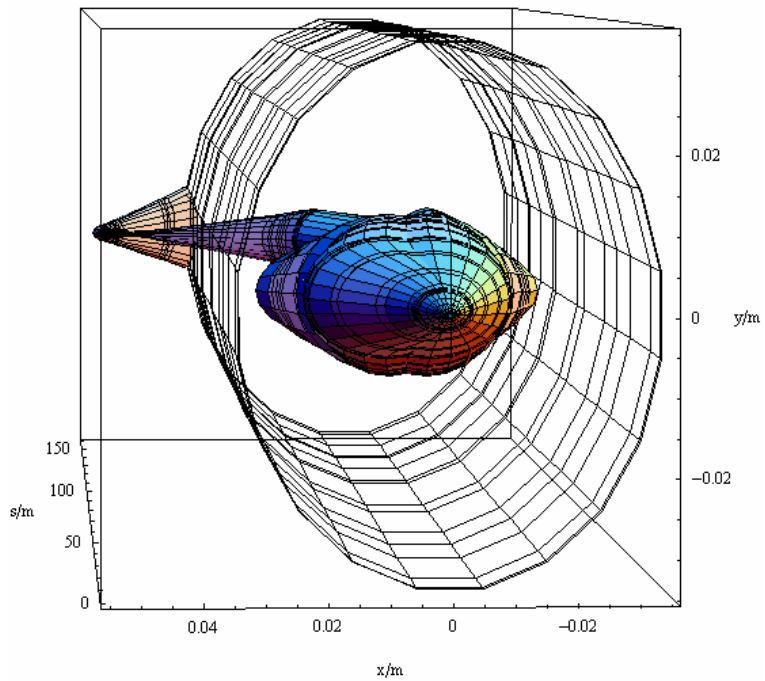
- Optics errors, Orbit deviations shown by BPMs (hard to find fit to measured orbit). 1mm offset @ impact likely
- Horizontal beam pipe misalignment:a few 0.1 mm offset likely, 1mm offset possible



MadTomma Tracking in RHIC lattice

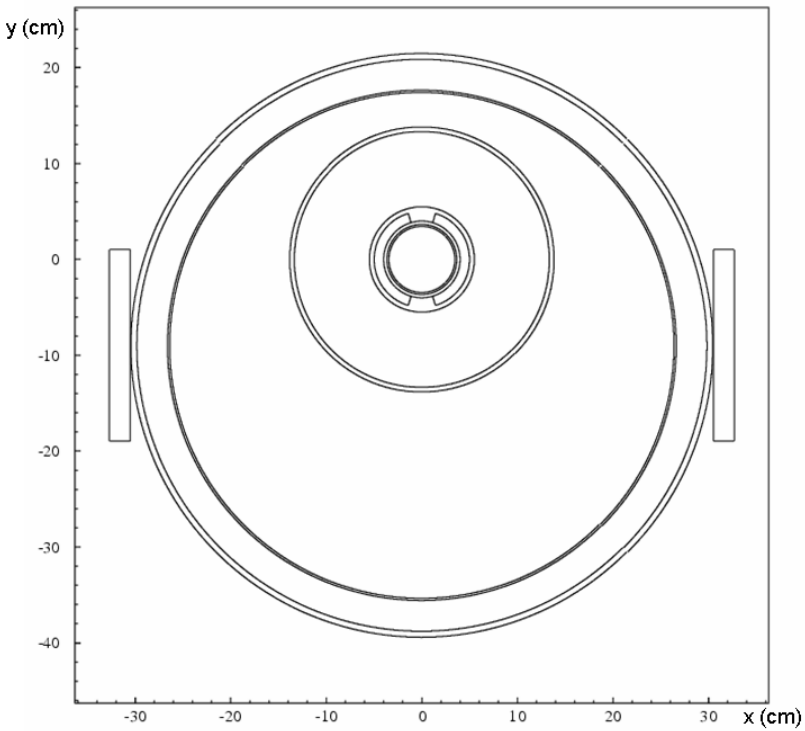
- With orbit correctors the expected impact point of the BFPP beam is 136.4 m, without 135.5 m. Magnet errors unknown.
- A 1mm orbit or pipe displacement @ impact moves the impact point another 35 cm away from the IP.
- A 1mm orbit displacement @ IP moves the impact point ±1 m.
- A 0.1 mrad angle @ IP moves impact 20 cm towards IP

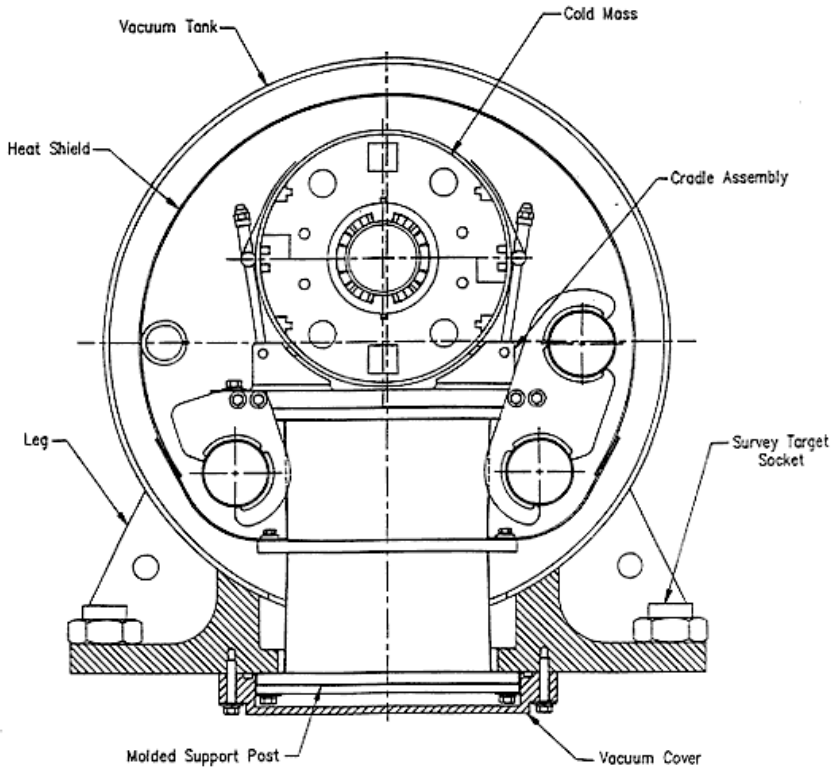




Shower simulations

- RHIC dipole implemented in FLUKA
- Shower simulated with initial conditions from the tracking
- Energy deposition in continuous silicon blocks outside the cryostat scored

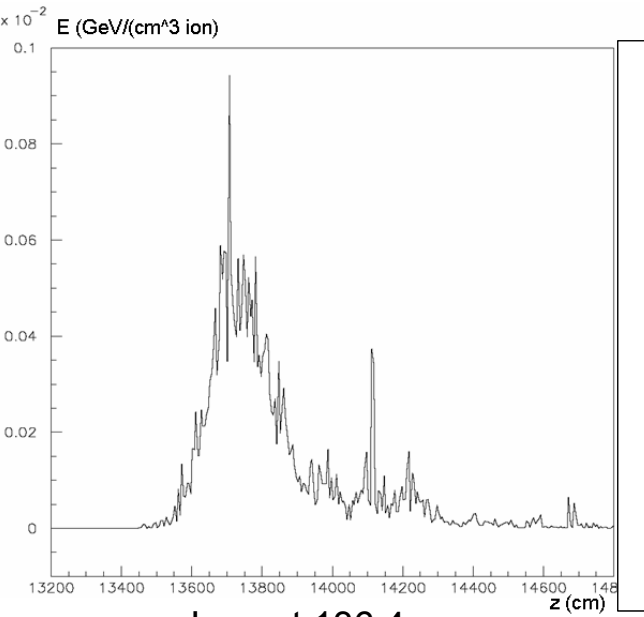




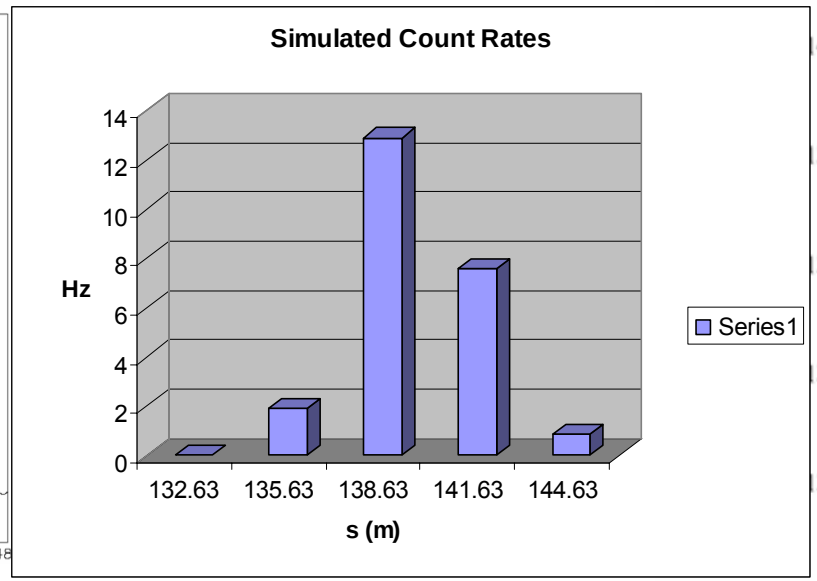
RHIC CRYOSTAT WITH MOLDED PLASTIC SUPPORT POST

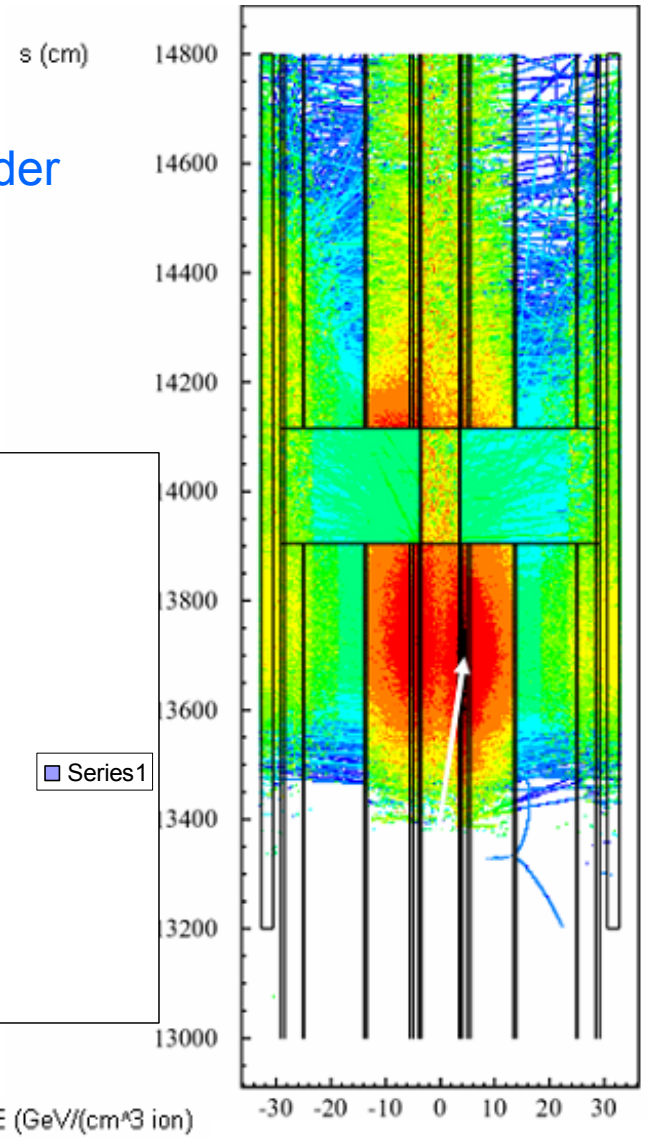
Simulation results

- Maximum energy deposition outside the cryostat expected at s=136.4 m, expected count rates order of 10 Hz
- Error bars: Displacing the impact point changes the shower behavior

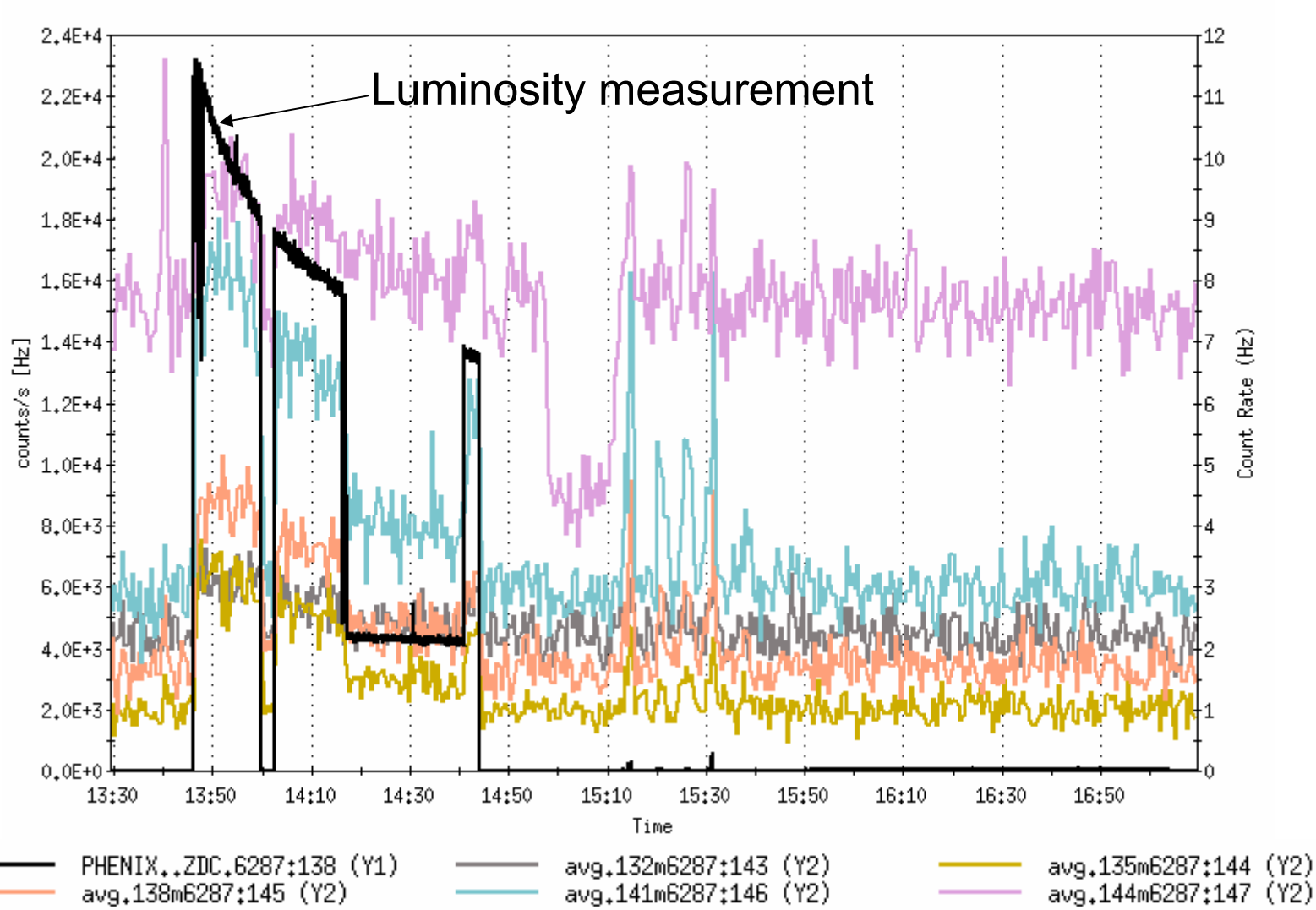


Impact 136.4 m





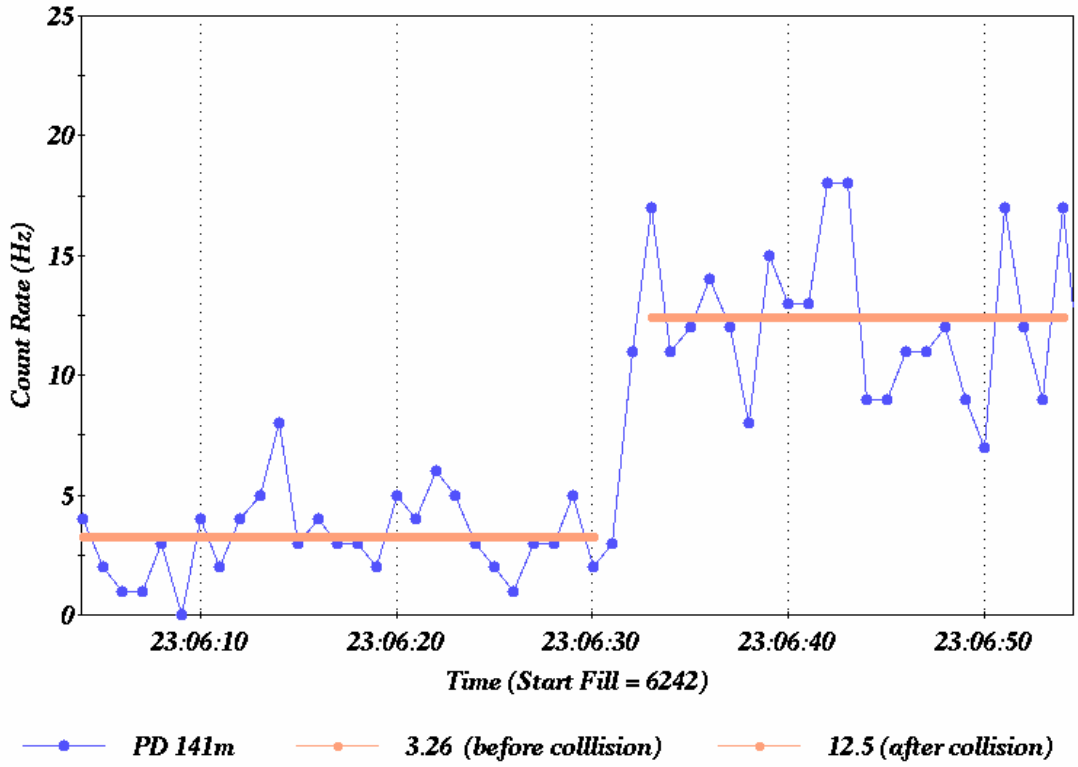
Experimental results

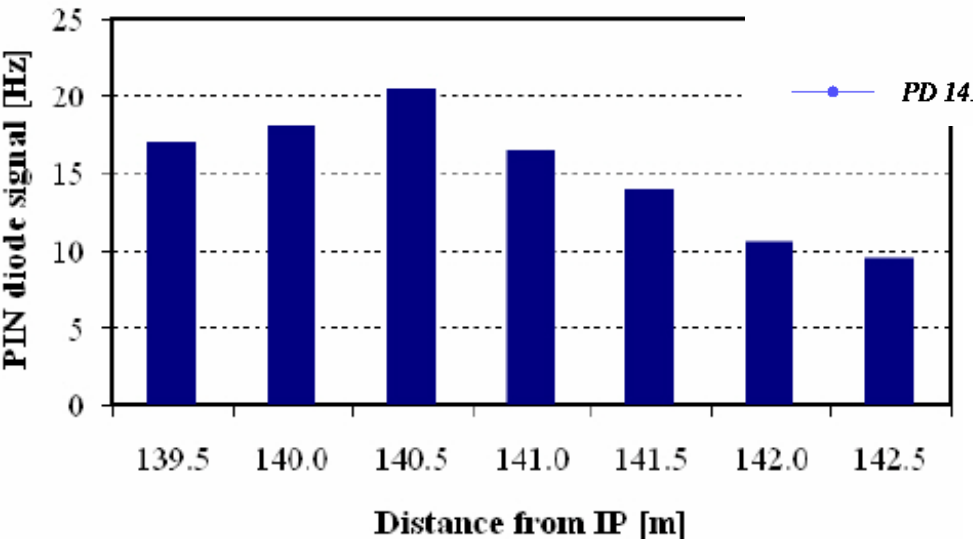


Clear correlation between luminosity and PIN diode count rates!

Results (cont.)

- In second stage PIN diodes moved closer around the observed impact point
- Longitudinal profile determined

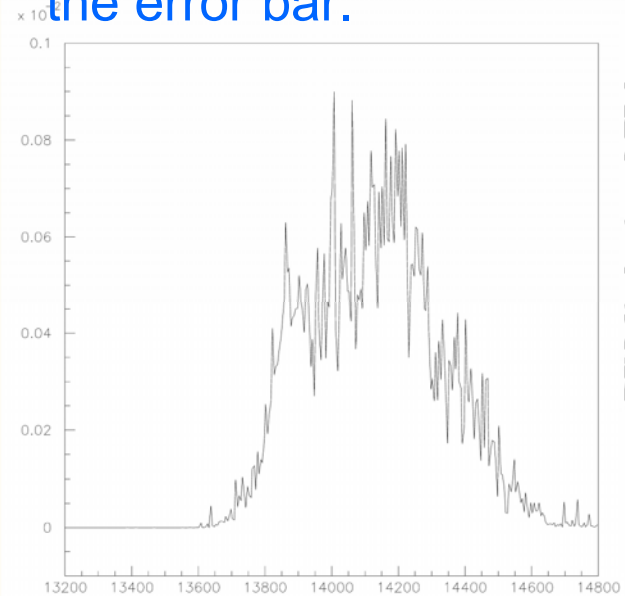


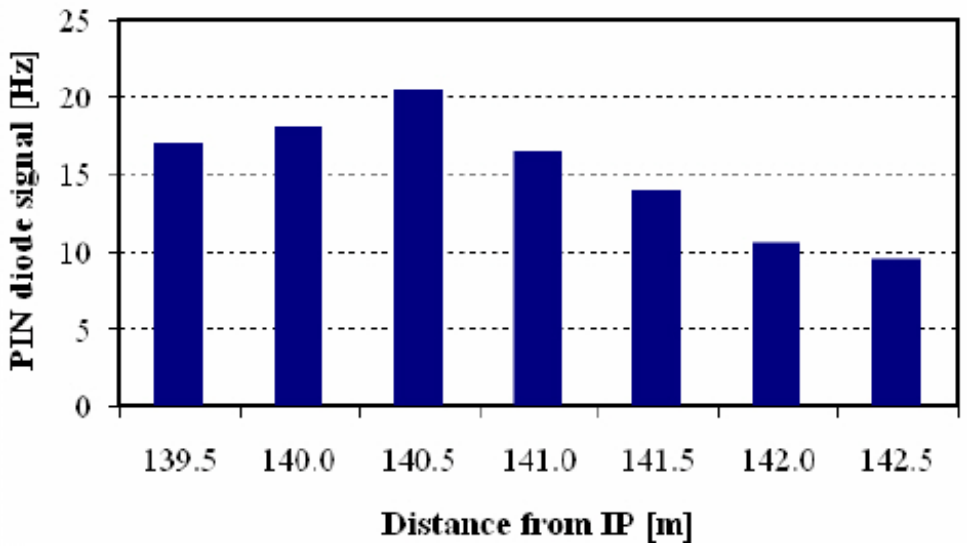


Maximum observed at s=140.5 m, which does not agree exactly with simulation, count rates ~0-20 Hz

Comparison between simulation and data

- Without taking the unknown magnet errors into account, all the other error sources mentioned add up to a total error bar of 2.35 m on the impact point.
- Very good agreement on the order of magnitude of the count rates.
- Displacing the impact point to 138 m reproduces fairly the shape of the measured energy deposition => The primary tracking predicts the impact point 1.6 m closer to the IP, which is within the error bar.





Conclusions

- There is a clear correlation between luminosity and measured signal in the PIN diode: First measurement ever of BFPP on a high energy collider
- The simulation reproduces well the measured data. The predicted impact point is 1.6 m off, which is within the error bar.
- We can trust the corresponding simulations for the LHC if we do the same error analysis
- Cross section seems to be on the right order of magnitude

Thanks to RHIC collaborators:
Angelika Drees
Wolfram Fischer