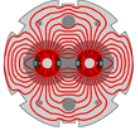

Operational Results from the LHC Luminosity Monitors

PAC'11 (March 30th, 2011)

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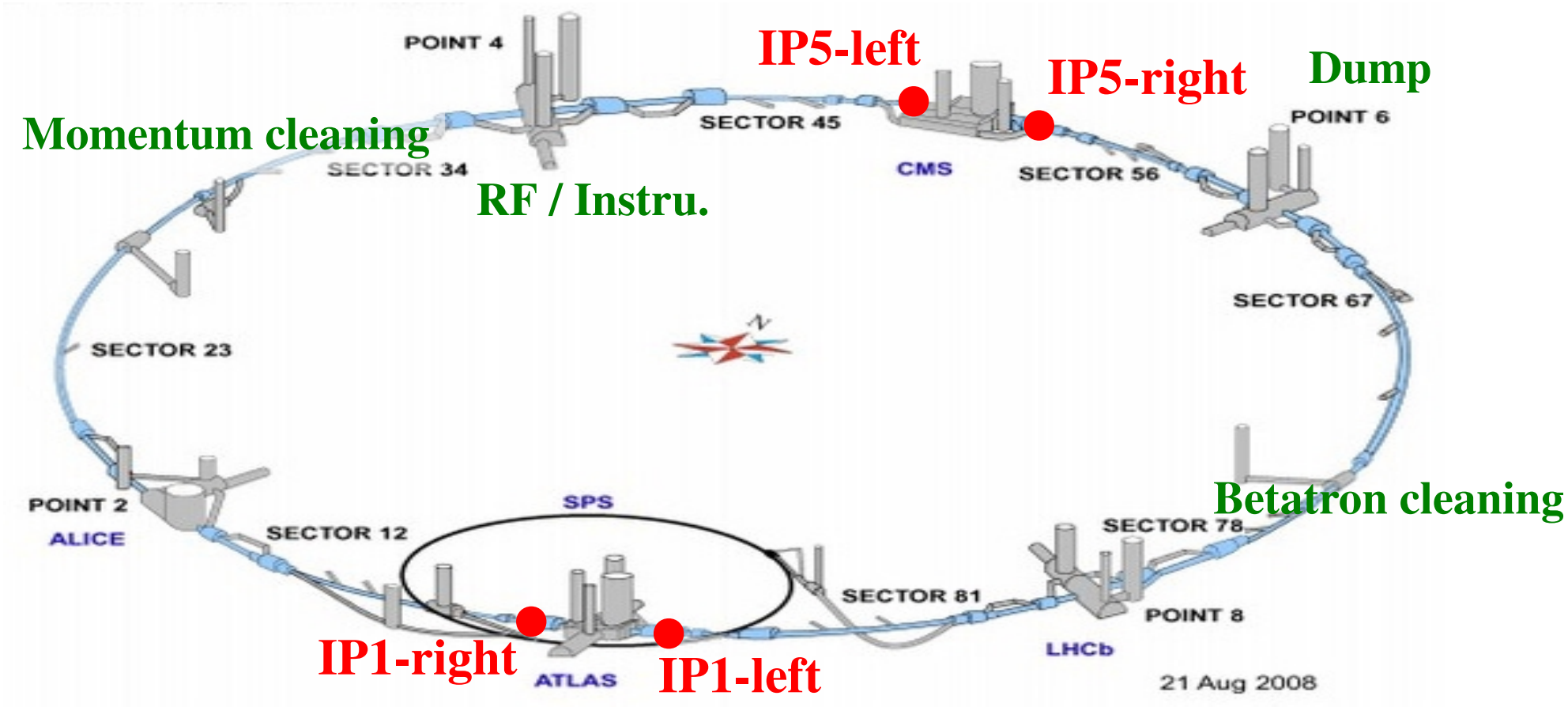
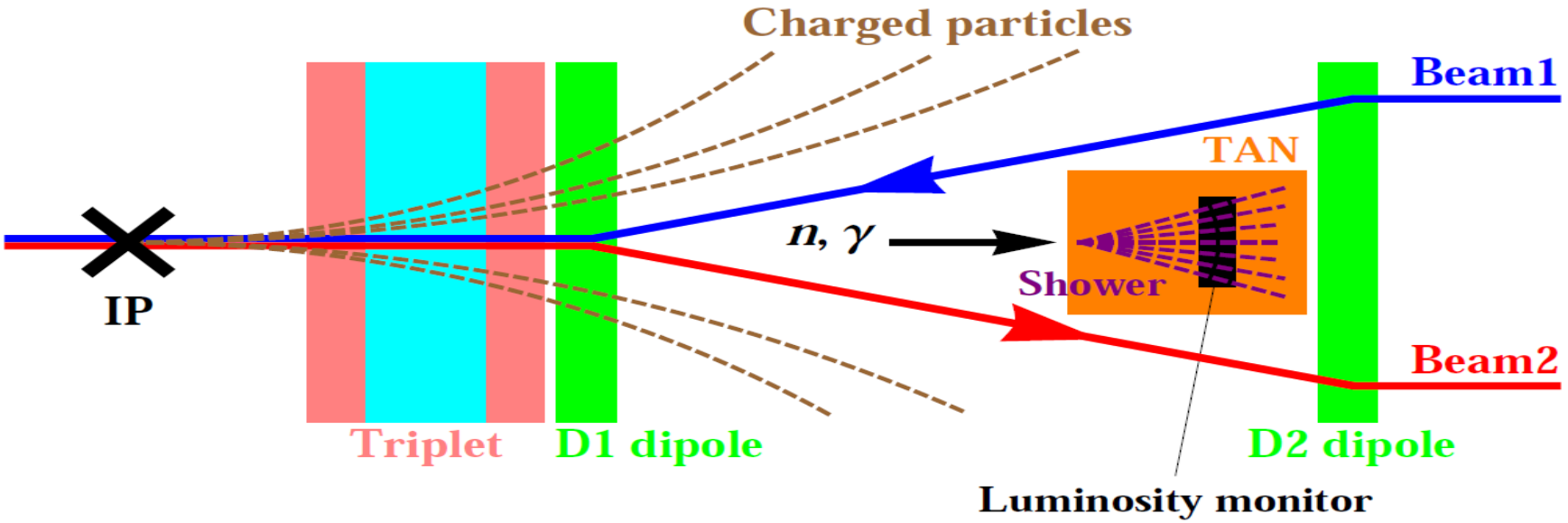
Special thanks to S. M. White

LHC

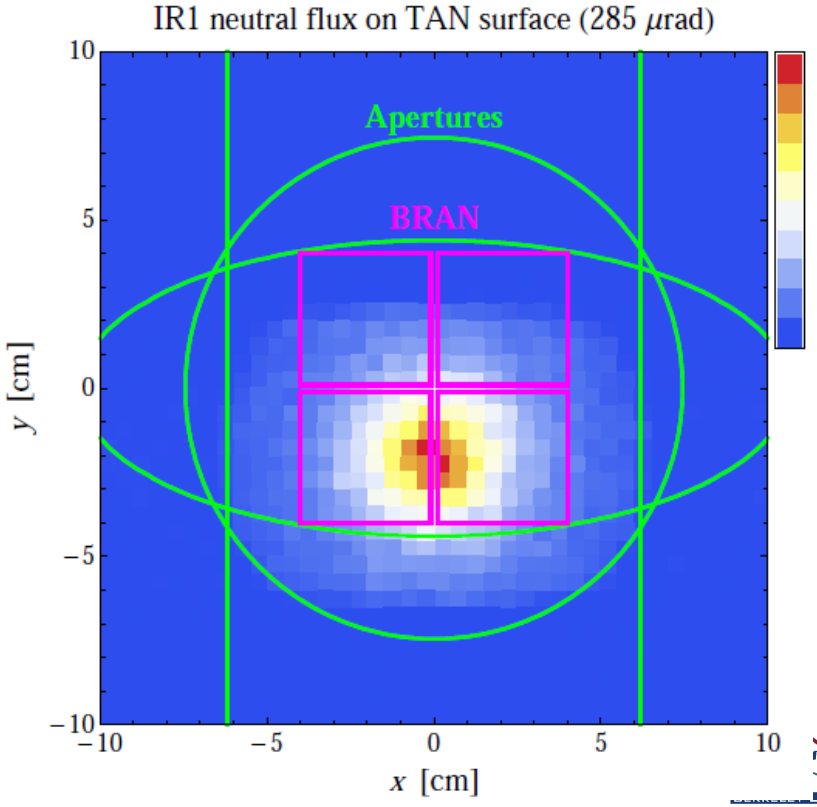


- Important to monitor and optimize luminosity, particularly at IP1 and IP5.
- Online monitoring tools (independent of the experiments) is useful.
→ Gas ionization chambers inside neutral absorbers on both sides IP1 and IP5.

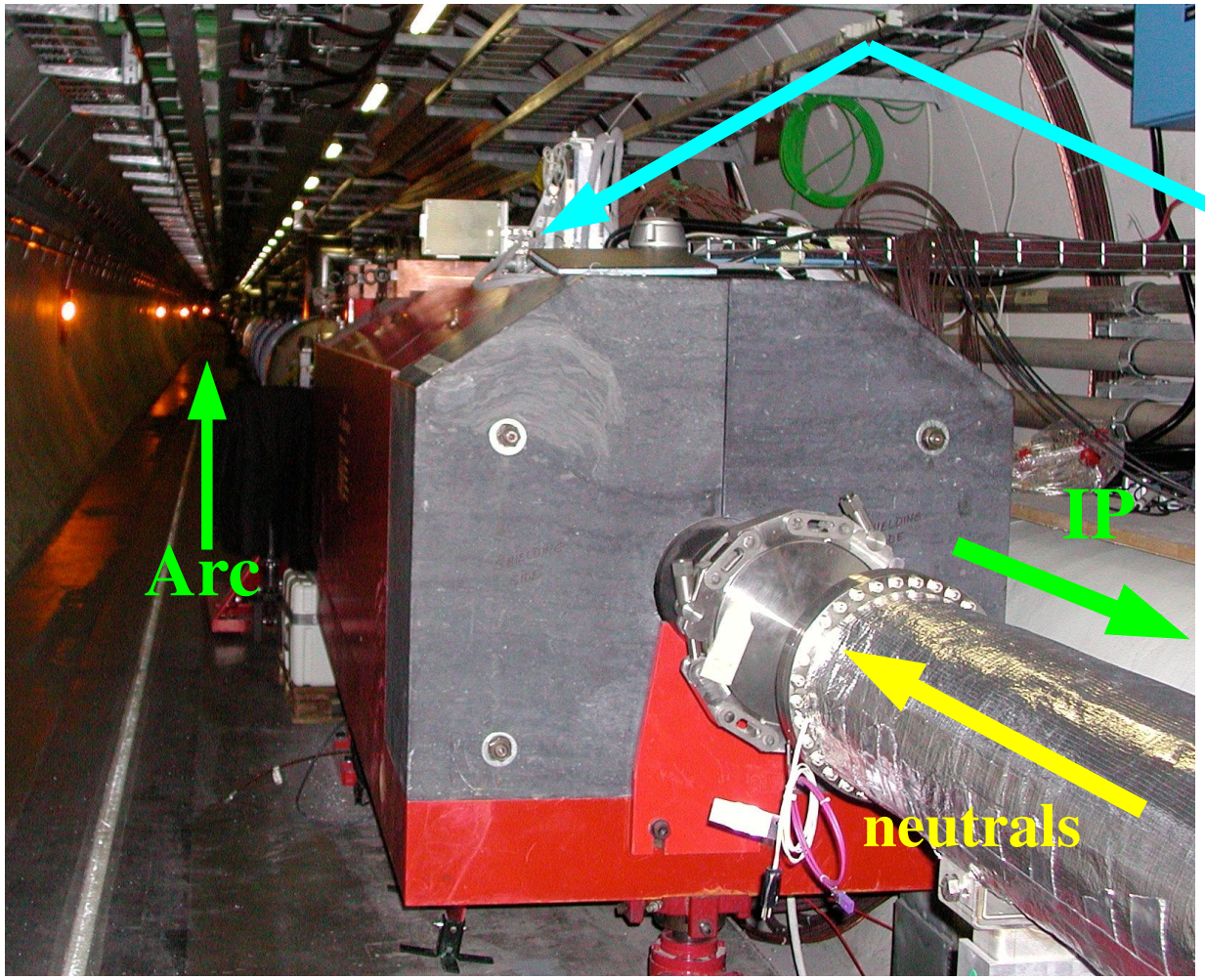
BRAN luminosity monitor concept

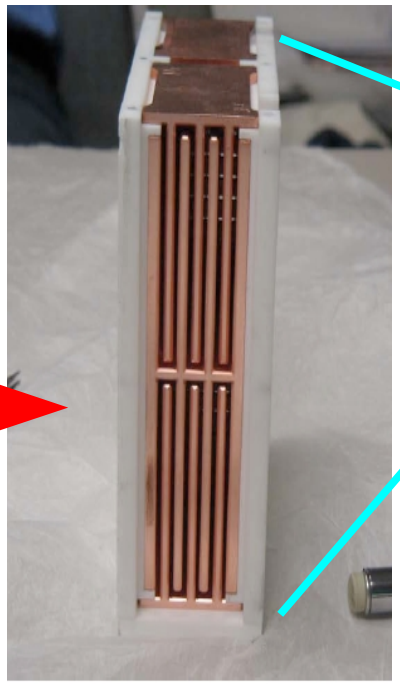


BRAN (Beam RAte Neutrals):
- Argon gas (+6% N_2) ionization chamber.
- Measures **bunch-by-bunch** (40 MHz)
  · average flux (***pulse height mode***, high lumi).
  · rate (***counting mode***, low and medium lumi)
- Withstands the **extreme radiation** (~1 GGy/y)
- Quadrant structure
  → sensitive to the **crossing angle**.
- Precision goal: **1%** relative measurements



BRAN luminosity monitor





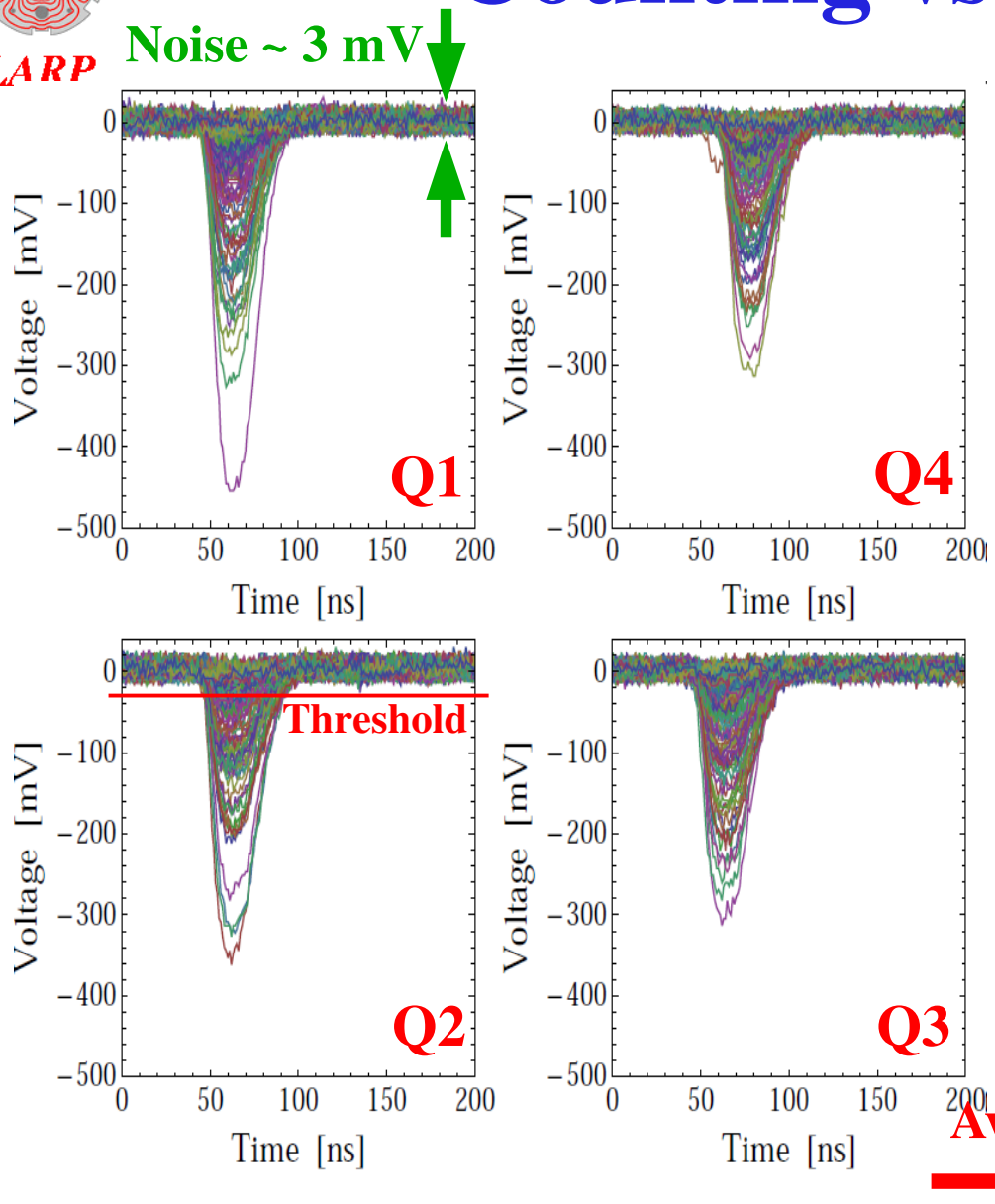
neutrals

LHC and BRAN parameters

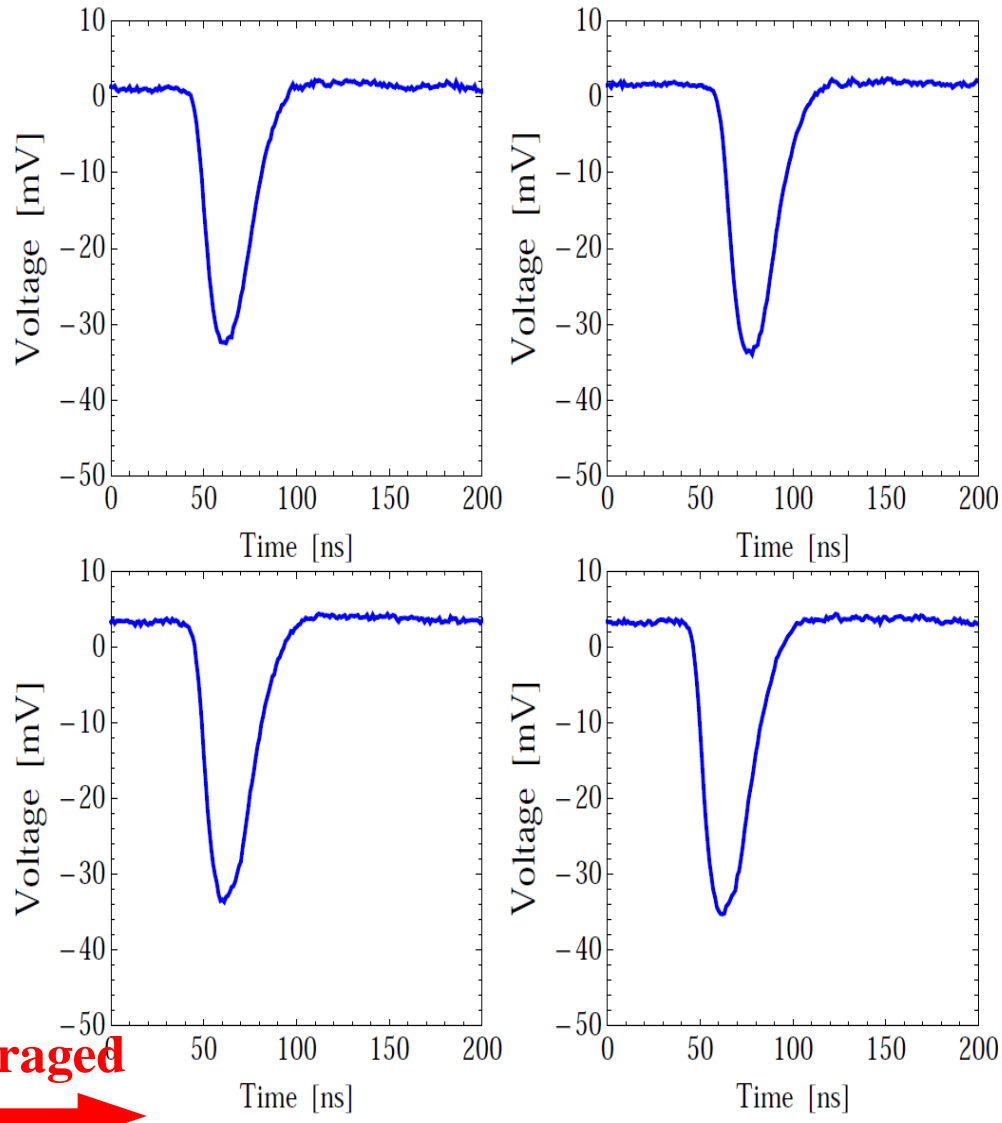
	2010	2011	nominal
Beam energy [TeV]	3.5	3.5	7
Luminosity [$cm^{-2}s^{-1}$]	2E32	2E33	1E34
Bunches/beam	368	1404	2808
Bunch intensity	1E11	1.2E11	1.15E11
Emittance [μm]	2.5	2.5	3.75
Beta* [m]	3.5	1.5	0.55
multiplicity	< 4	~10	~20
BRAN acceptance [%]	5	5	20

Quadrant area [mm^2]	1600
Plate gap [mm]	1
Number of gaps	6
Gas type	Ar (94%) + N2 (6%)
Gas pressure [atm]	6
Bias voltage [kV]	1.2
E/p [V/mm-atm]	200
e^- drift speed [mm/ns]	0.045
RMS noise [mV]	~3

Counting vs. pulse height

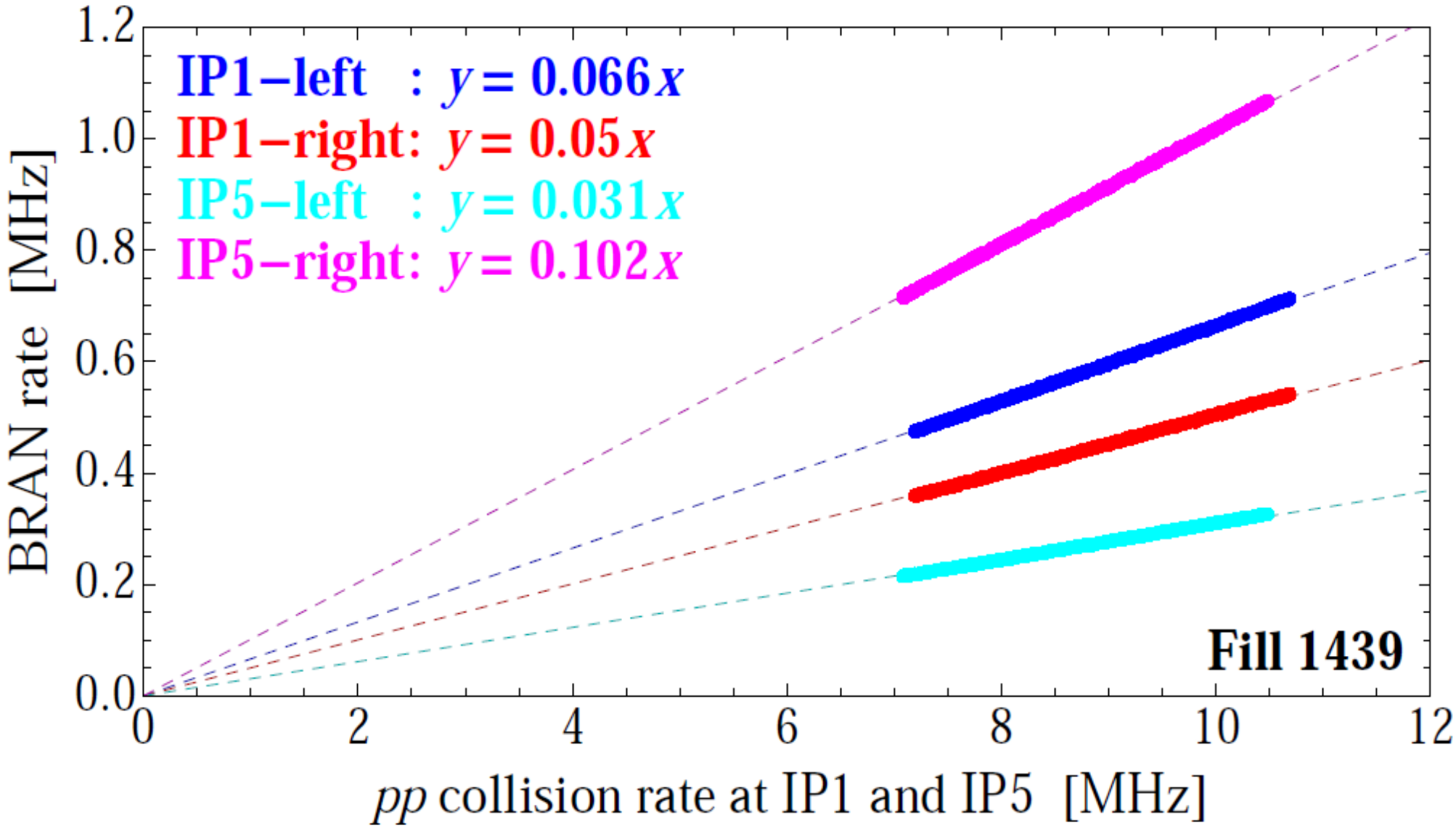


Averaged



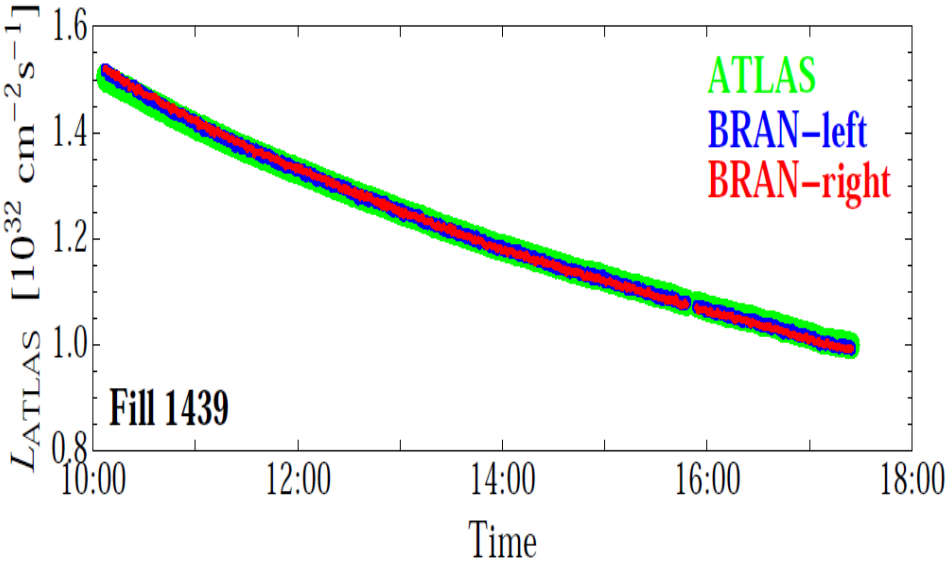
pp collisions per bunch crossing:
- ~20 for the nominal LHC → must use the pulse height
- ~3 in 2010 → counting mode still effective

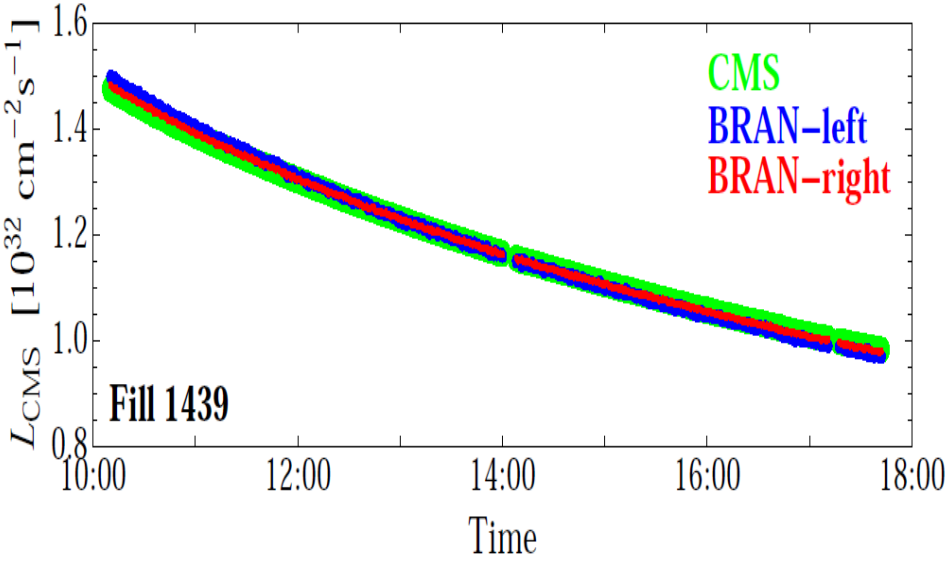
Collision rate vs. BRAN rate

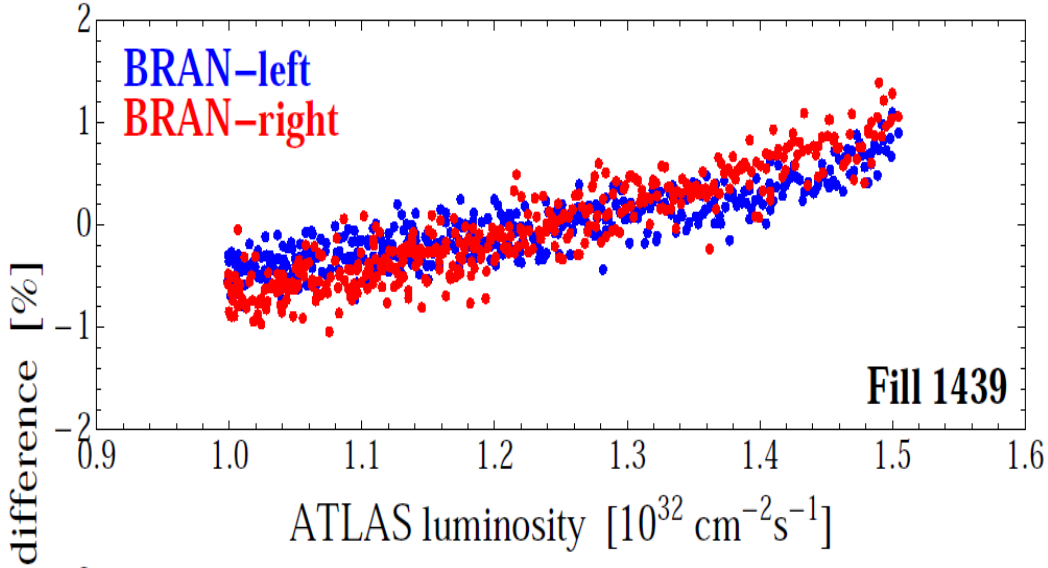


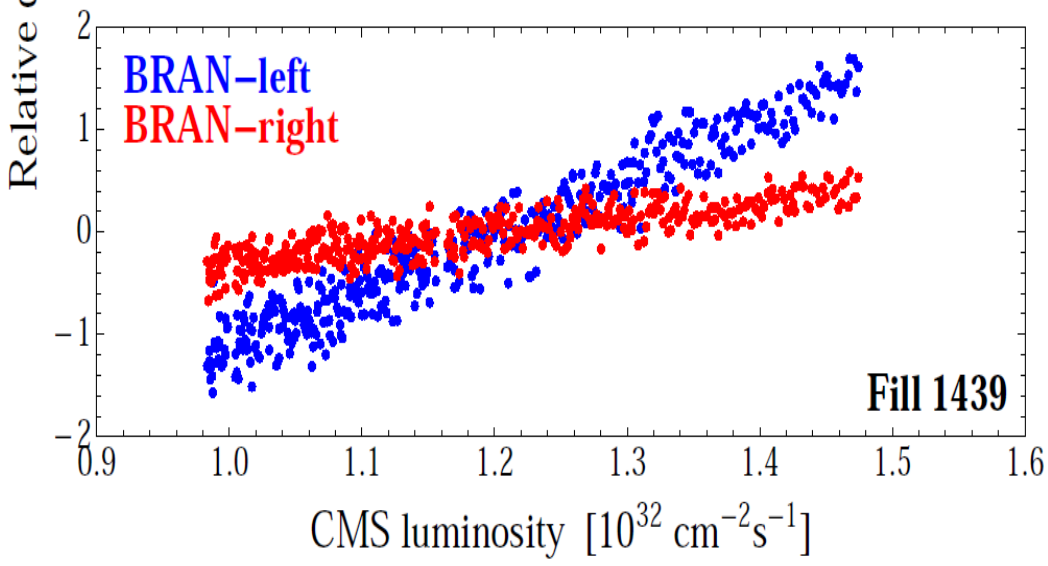
- Data is for 295 bunch collisions and $L \sim 10^{32}$ cm^{-2}s^{-1}.
- A recent simulation predict 5% acceptance.

Luminosity by BRANs and Experiments



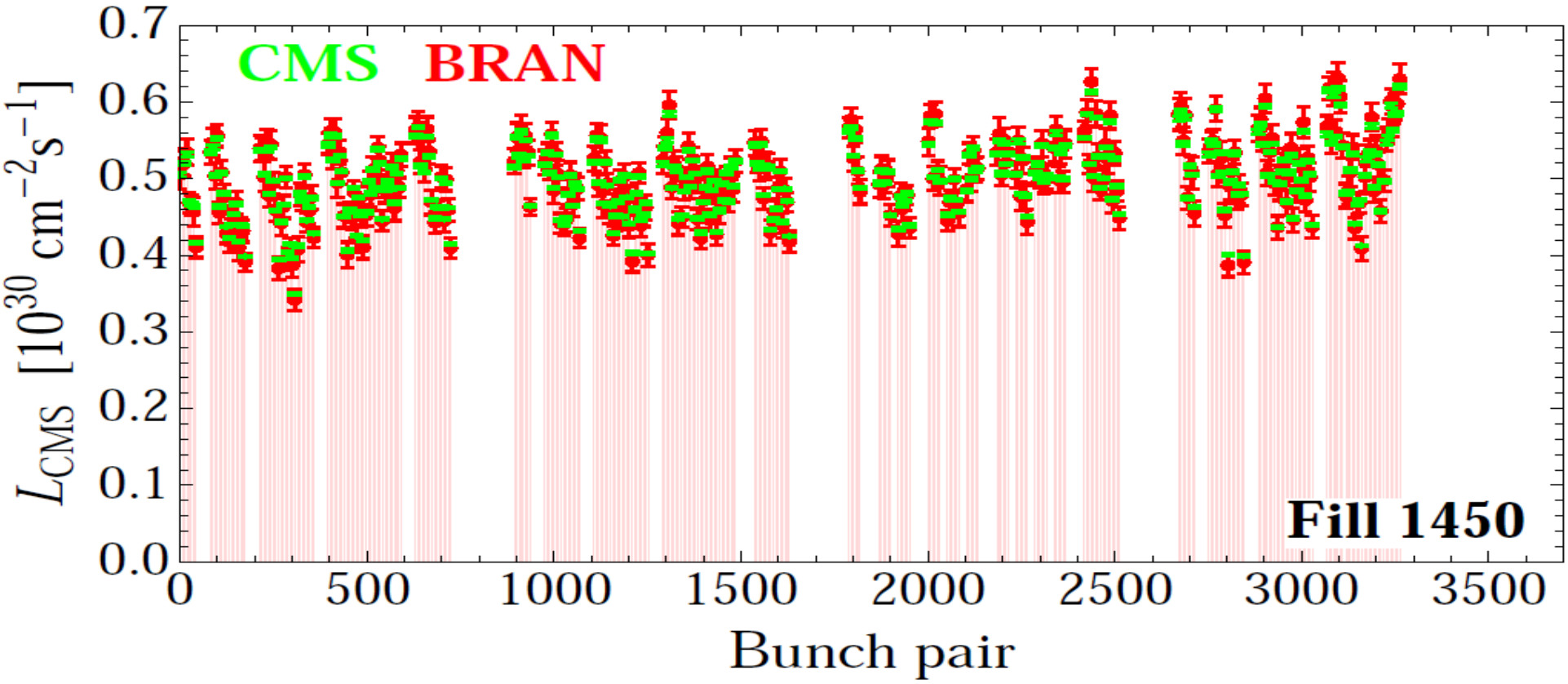


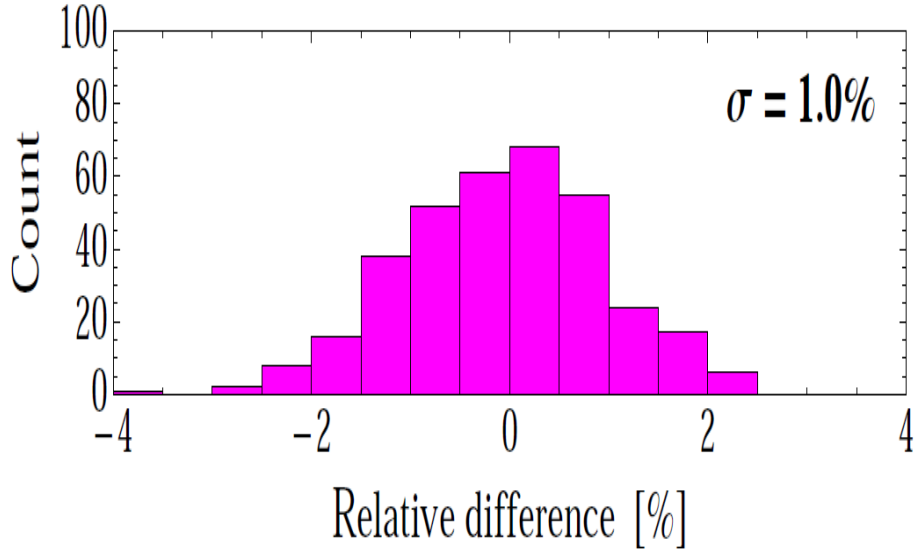




Systematic difference is about ±1%

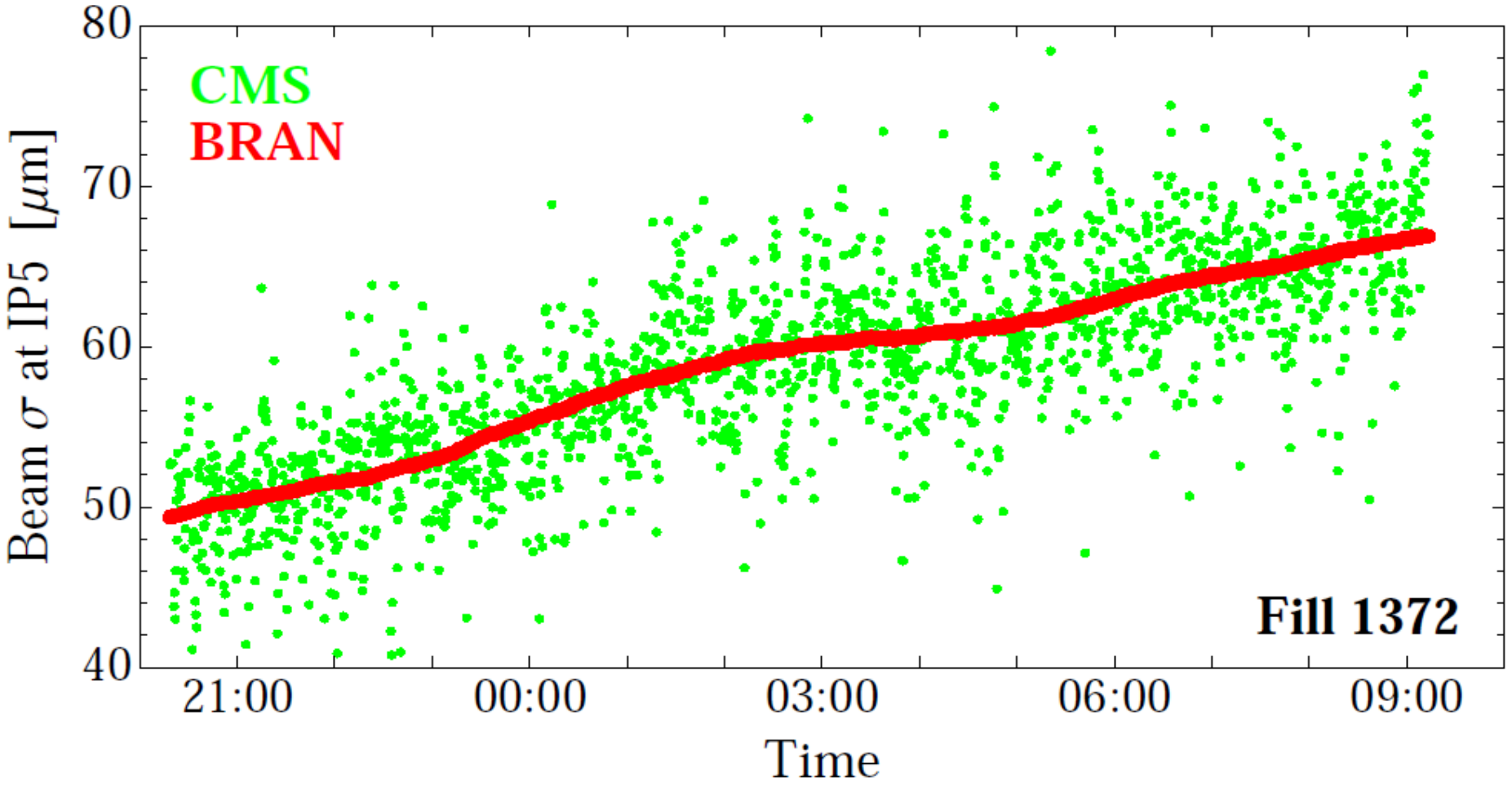
Bunch-by-bunch luminosity





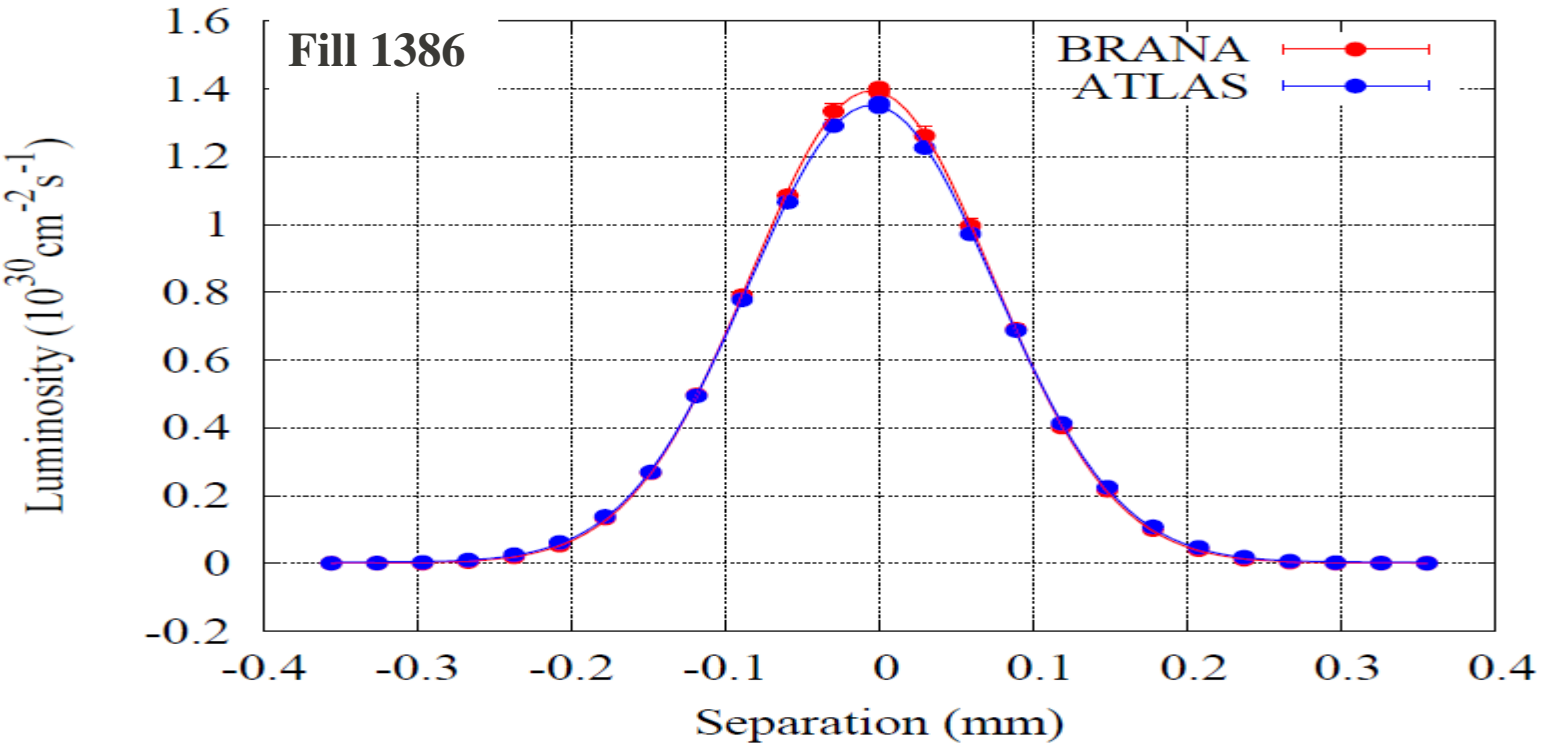
- Discrepancy is ~1% for bunch-by-bunch measurements as well.
- The discrepancy seems systematic rather than statistical.

Evolution of the beam size at IP5



- The interaction area (converted to the beam size) from the luminosity of the BRAN and the luminous region measurement of CMS.
- Bunch-by-bunch measurement is available to study e-could, beam-beam, and etc.
- The measurement from the luminosity has less fluctuation...
- ... but can only measure the average over the planes/beams...

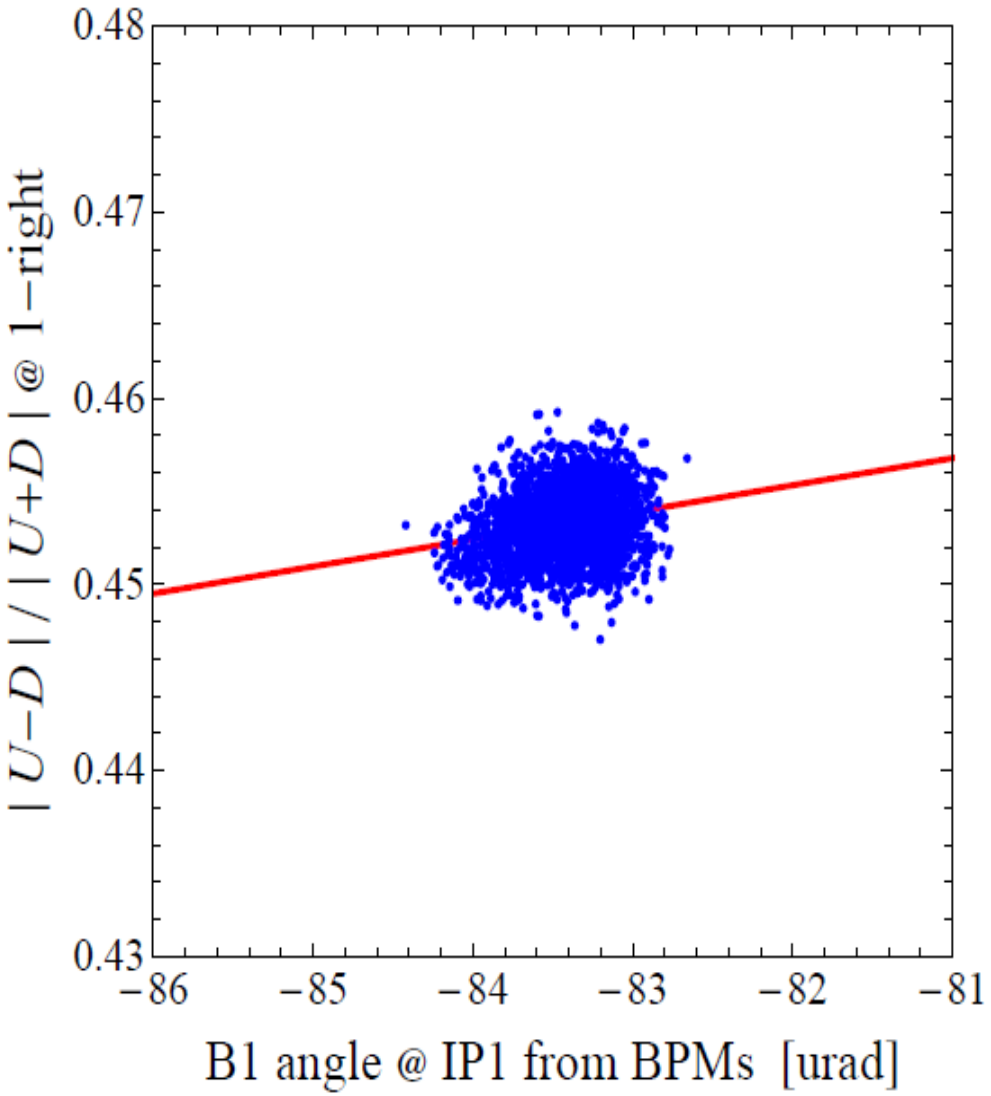
Luminosity optimization and profile measurement based on luminosity

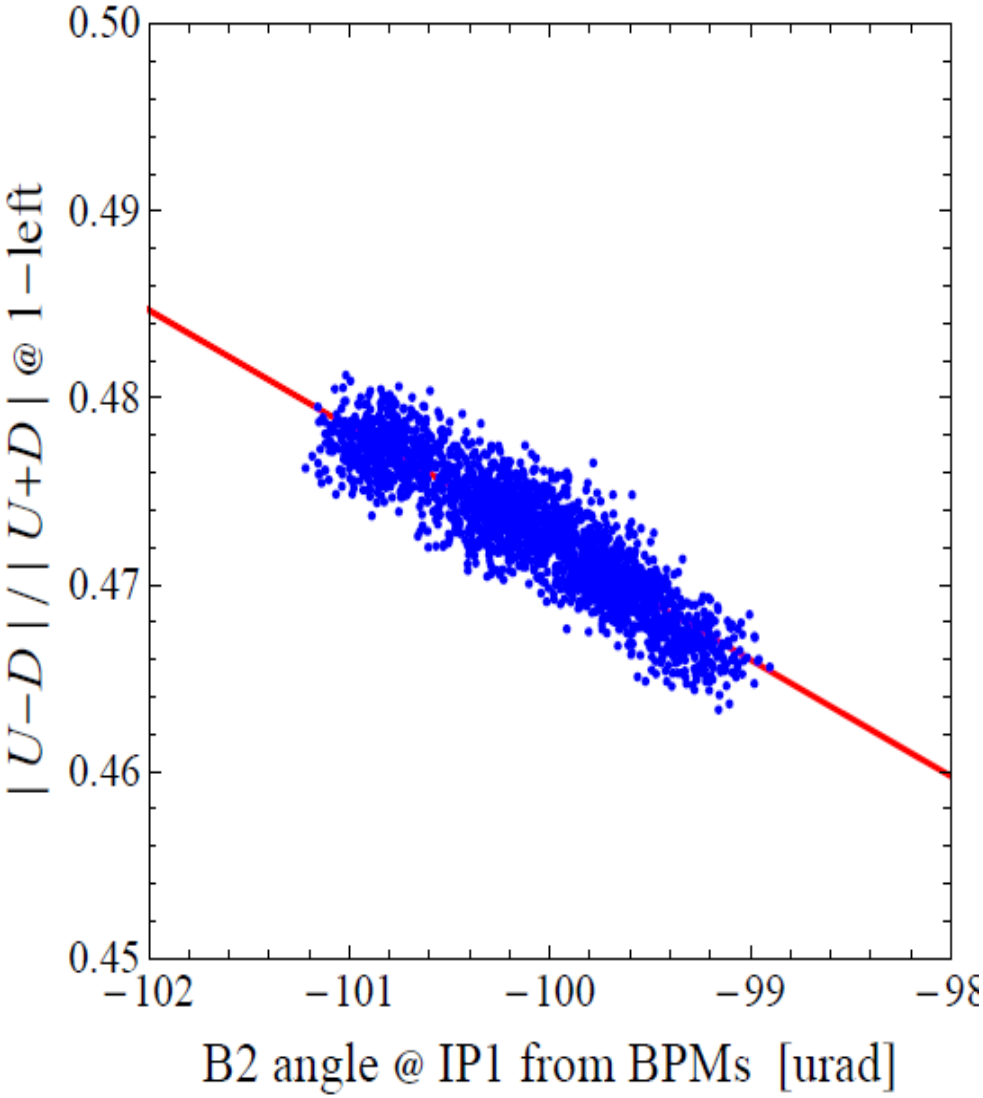


Courtesy of S. White

	σ_{effx} (mm)	σ_{effy} (mm)	Mean x (mm)	Mean y (mm)
BRAN IP1 (1)	0.0591+/-0.002	0.0624+/-0.0034	0.007+/-0.0001	0.002+/-0.0001
BRAN IP1 (2)	0.0585+/-0.034	0.0618+/-0.0034	0.006+/-0.0001	4e-5+/-0.0001
ATLAS (1)	0.0589+/-0.0004	0.0622+/-0.001	0.007+/-0.0001	0.002+/-0.0001
ATLAS (2)	0.0590+/-0.0005	0.0623+/-0.0009	0.006+/-0.0001	4e-5+/-0.0001
BRAN IP5 (1)	0.0548+/-0.0018	0.0596+/-0.0022	-0.01+/-0.0001	0.003+/-0.0001
BRAN IP5 (2)	0.0556+/-0.0018	0.0598+/-0.0022	-0.01+/-0.0001	0.002+/-0.0001
CMS (1)	0.0553+/-0.0006	0.0596+/-0.0005	-0.01+/-0.0001	0.003+/-0.0001
CMS (2)	0.0554+/-0.0005	0.0602+/-0.0004	-0.01+/-0.0001	0.002+/-0.0001

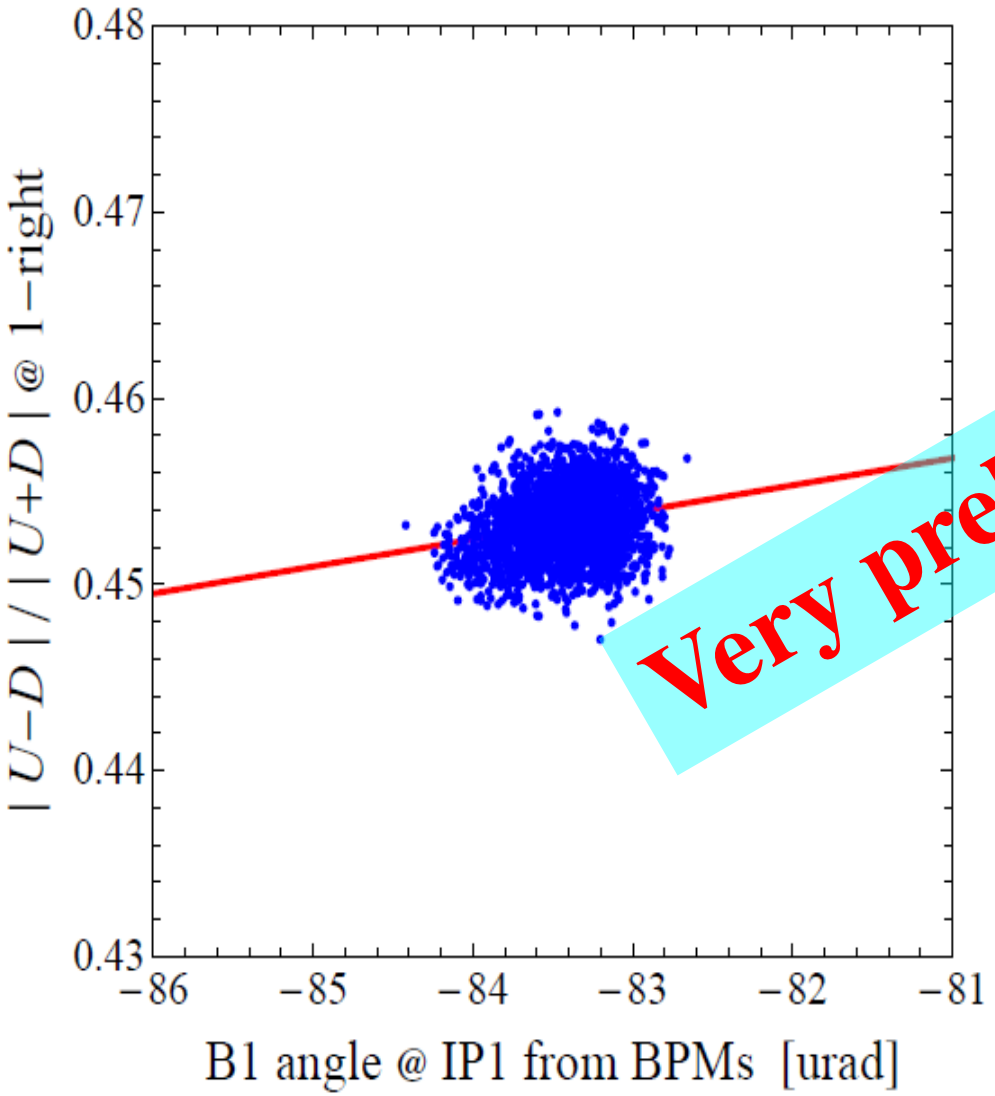
Crossing angle measurement

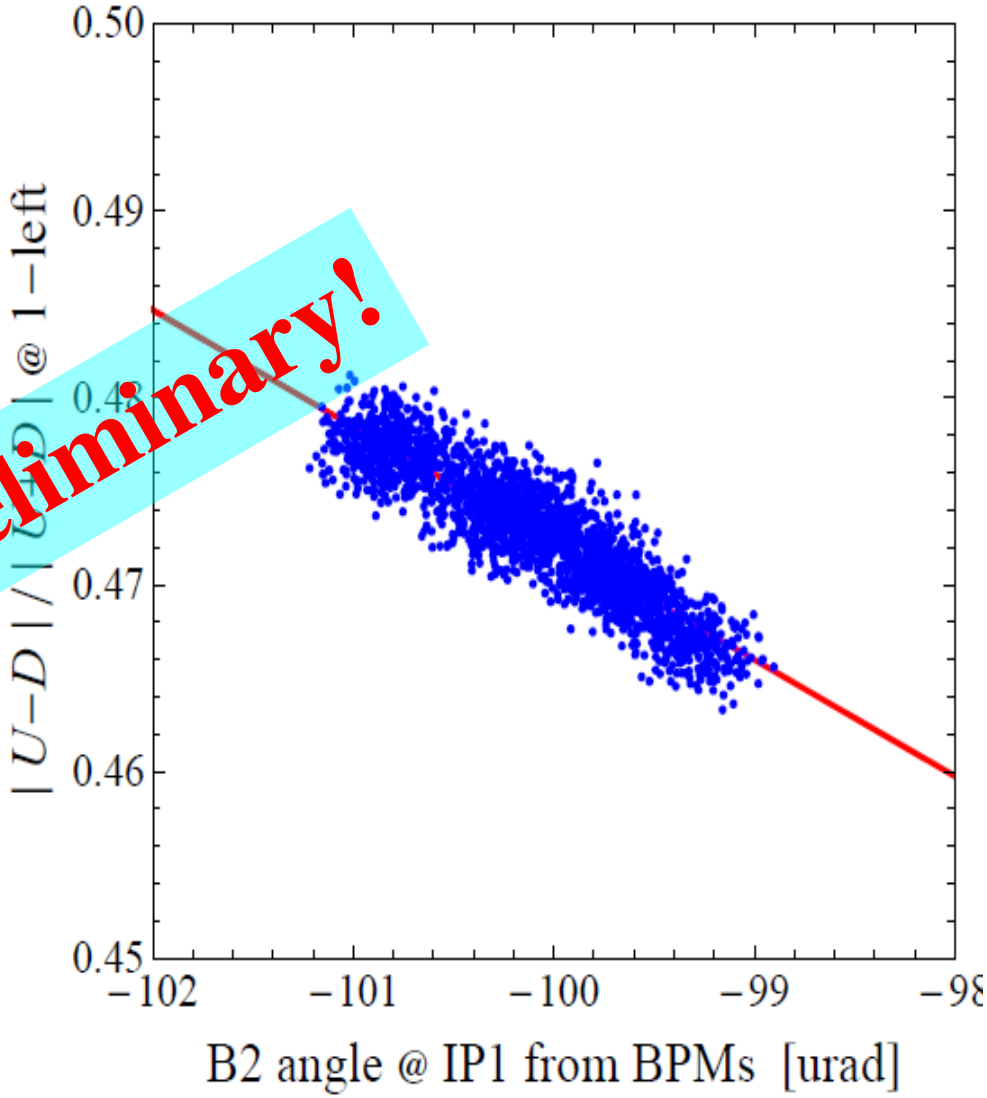




- The detector seems sensitive to the crossing angle but the asymmetry is ~50% off from the simulation.
- The measurement is sensitive to the calibration and threshold (for counting).

Crossing angle measurement





Very preliminary!

- The detector seems sensitive to the crossing angle but the asymmetry is ~50% off from the simulation.
- The measurement is sensitive to the calibration and threshold (for counting).

Conclusions

- BRAN luminosity monitors are Argon gas (+6% N_2) ionization chambers which measure showers inside the neutral particle absorbers produced by the high energy neutral particles.
- BRANs have been used to monitor and optimize the luminosity at IP1 and IP5 since the 2009 run.
- It was demonstrated that, in the machine condition of 2010, BRANs on the counting mode could provide both total and bunch-by-bunch relative luminosity measurements with a precision of ~1%
- BRANs can measure the interaction area and is sensitive to the crossing angle, as well.
- Future plans:
  - The multiplicity of *pp* collisions approaches 10 in 2011, the BRANs will be operated in the average pulse height mode.
  - Deconvolution algorithm required for 25 and 50 ns bunch spacing.
  - Development of a fix-display ongoing.