Silicon Track Trigger

Lars Sonnenschein

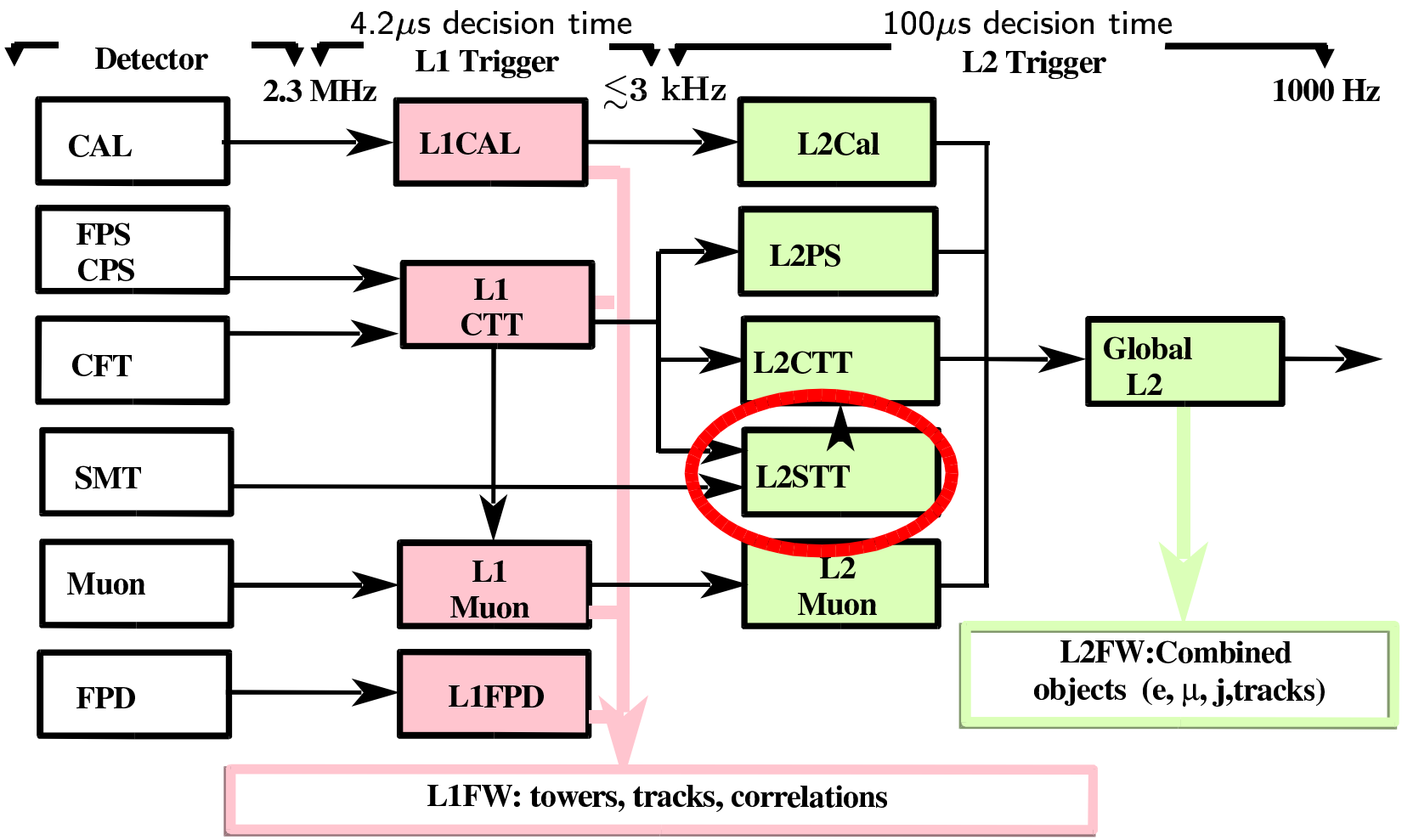
Boston University

- Introduction
- Design
- Status

• Introduction

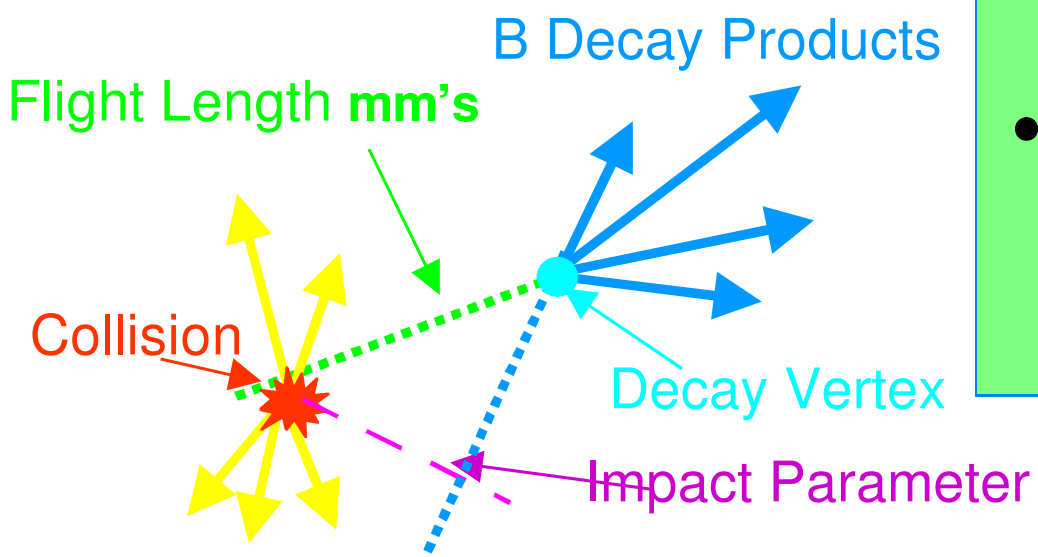
- **Boston University**
  - U. Heintz, M. Narain, E. Popkov (PD), L. Sonnenschein (PD), J. Wittlin (PD), K. Black (GS), S. Fatakia (GS), A. Zabi (GS), A. Das (GS), W. Earle (Eng), E. Hazen (Eng), S. Wu (Eng)
- **Columbia University**
  - H. Evans, G. Steinbrück (PD), J. Steele (PD), T. Bose (GS), A. Qi (Eng), Tom Fitzpatrick (FNAL Eng)
- **Florida State University**
  - H. Wahl, H. Prosper, S. Linn, T. Adams, N. Buchanan (PD), B. Lee (PD), S. Tendindo Repond (PD), S. Sengupta (GS), J. Lazoflores (GS), D. Kau (GS)
- **SUNY Stony Brook**
  - J. Hobbs, W. Taylor (PD), H. Dong (GS), C. Pancake (Eng), B. Smart (Eng), J. Wu (Eng)

DØ Trigger system



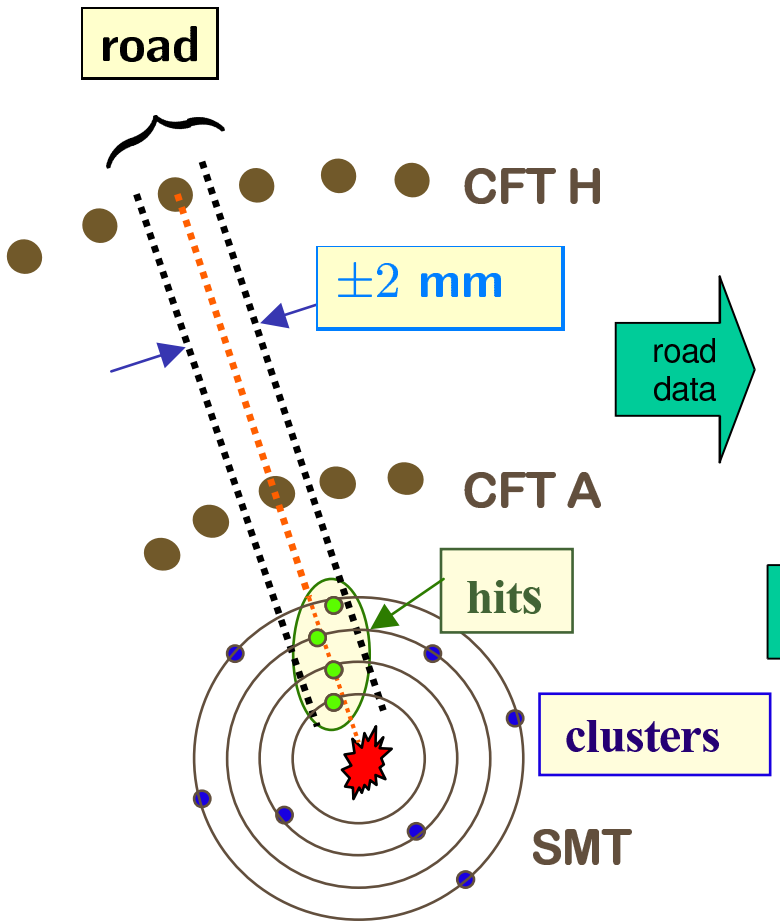
The idea

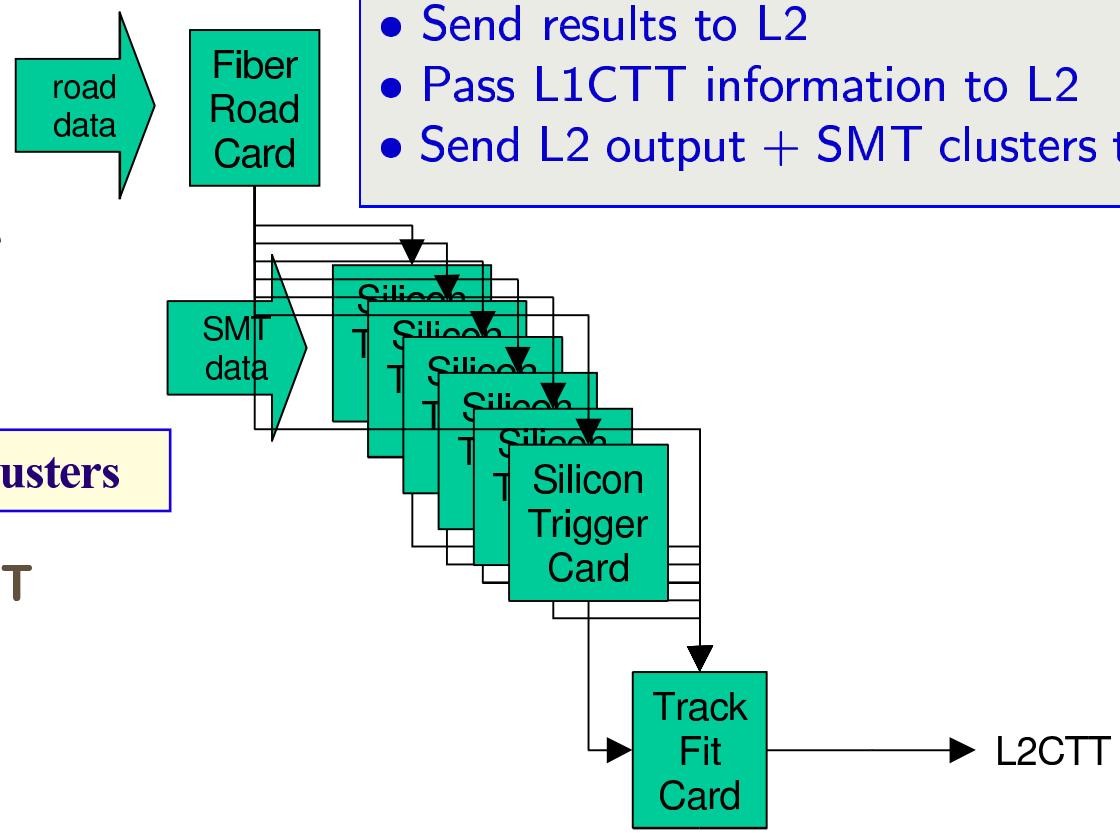
Need to make
very fast decisions!



- b quarks are key in many areas:
  - B physics
  - top quark physics ($t \to Wb$)
  - Higgs Physics ($ZH \to \nu\bar{\nu}b\bar{b}$)
- B hadrons have finite lifetime
  - travel mm's before decay
  - $\Rightarrow$ displaced tracks
- Trigger on displaced tracks
  - using SMT precision
  - IP resolution 55 μm @ high $p_\perp$
    (Including 35 μm from beamspot)

• Design



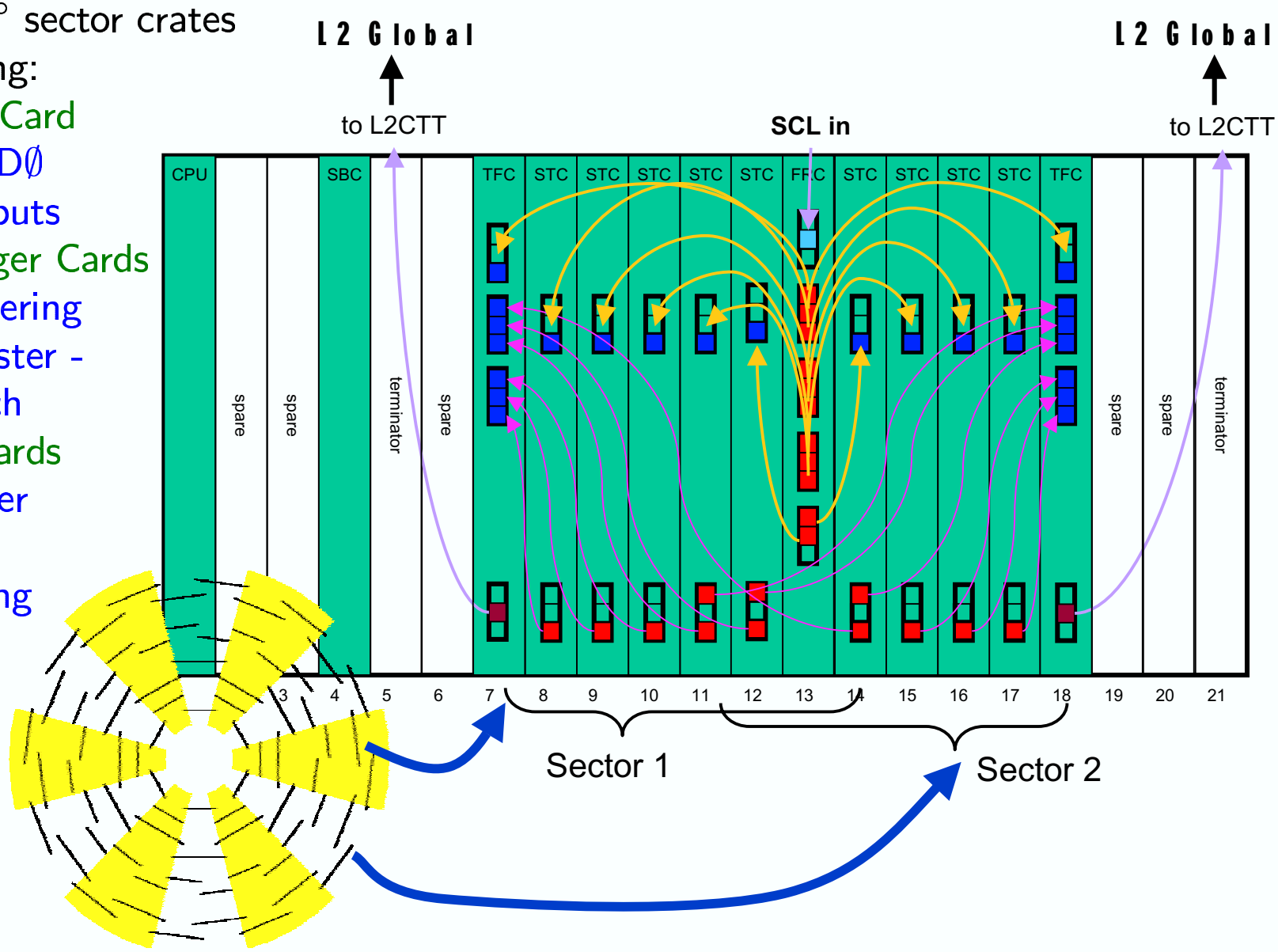


- L1CTT ⇒ tracks in CFT
  - Define road in SMT
- Select axial SMT hits in roads
- Fit trajectory to L1CTT+SMT hits
  - Measure $p_\perp$, IP and azimuth ϕ
- Send results to L2
- Pass L1CTT information to L2
- Send L2 output + SMT clusters to L3

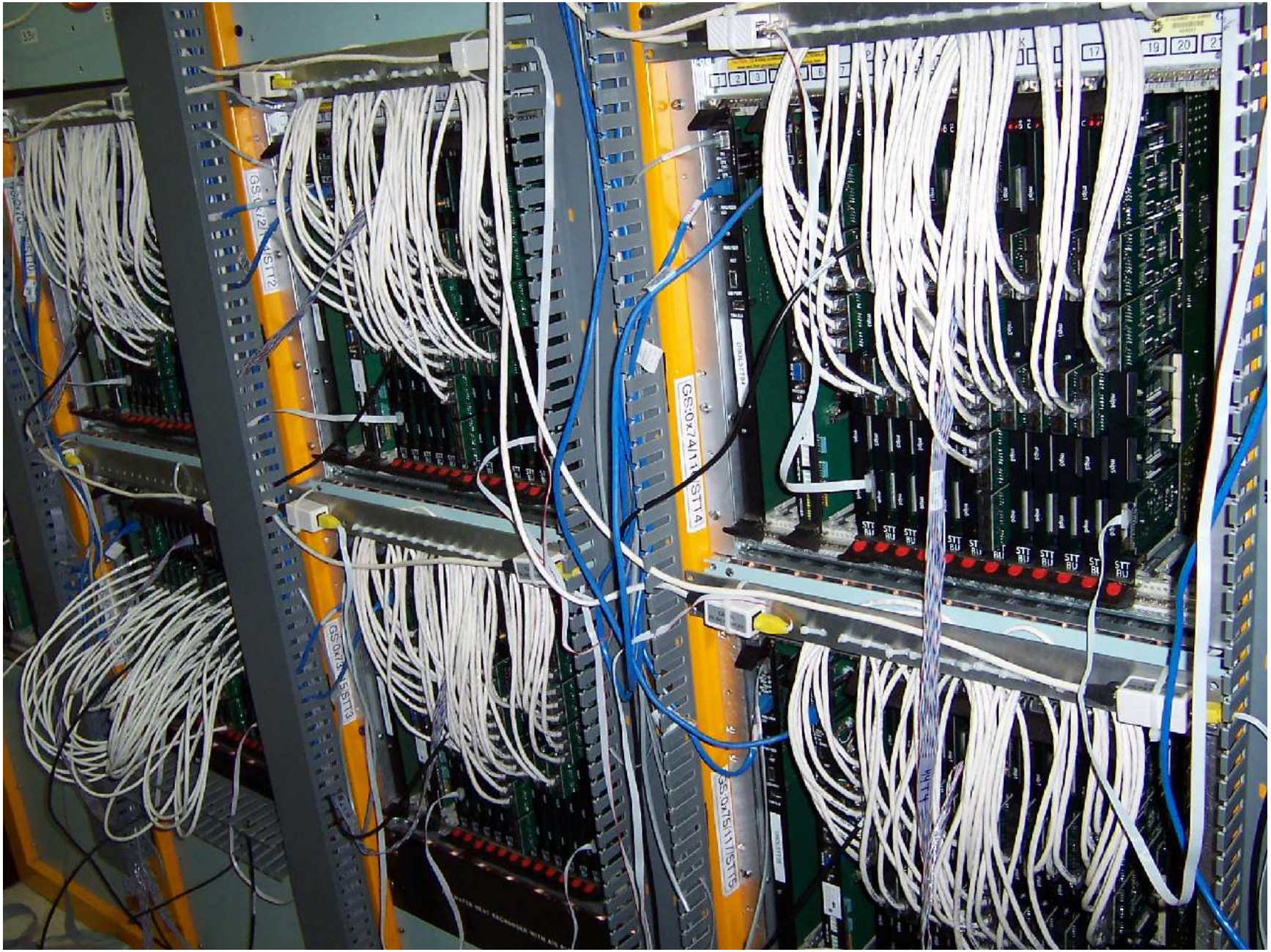
STT Crate Layout

6 identical 60° sector crates each containing:

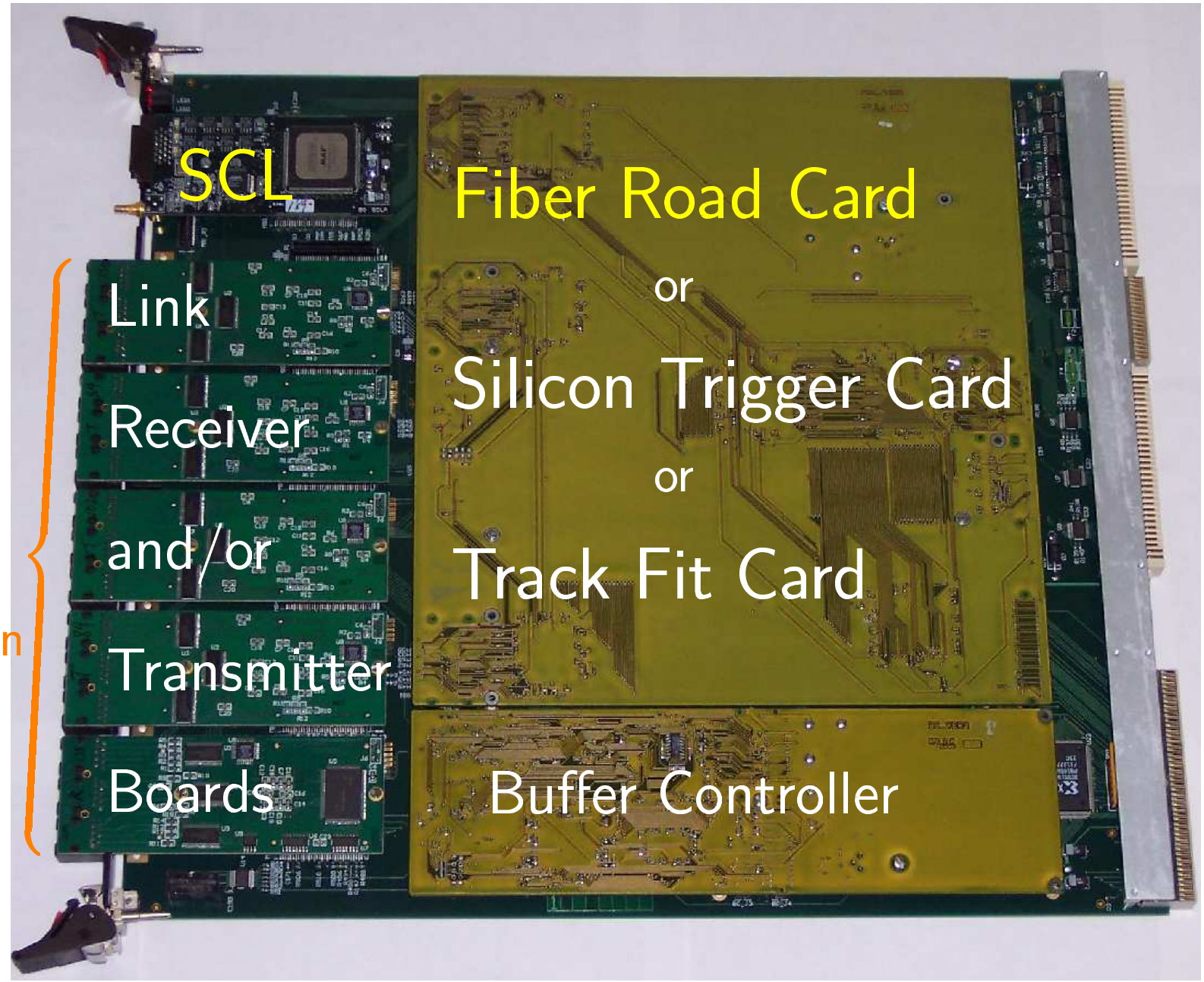
- 1 Fiber Road Card
  - sync with DØ
  - L1CTT inputs
- 9 Silicon Trigger Cards
  - SMT clustering
  - Coarse cluster - road match
- 2 Track Fit Cards
  - Final cluster selection
  - Track fitting



All 6 sector crates installed



STT mother- and daughterboards



Serial board links for inter-communication

Silicon Trigger Card (STC) Design

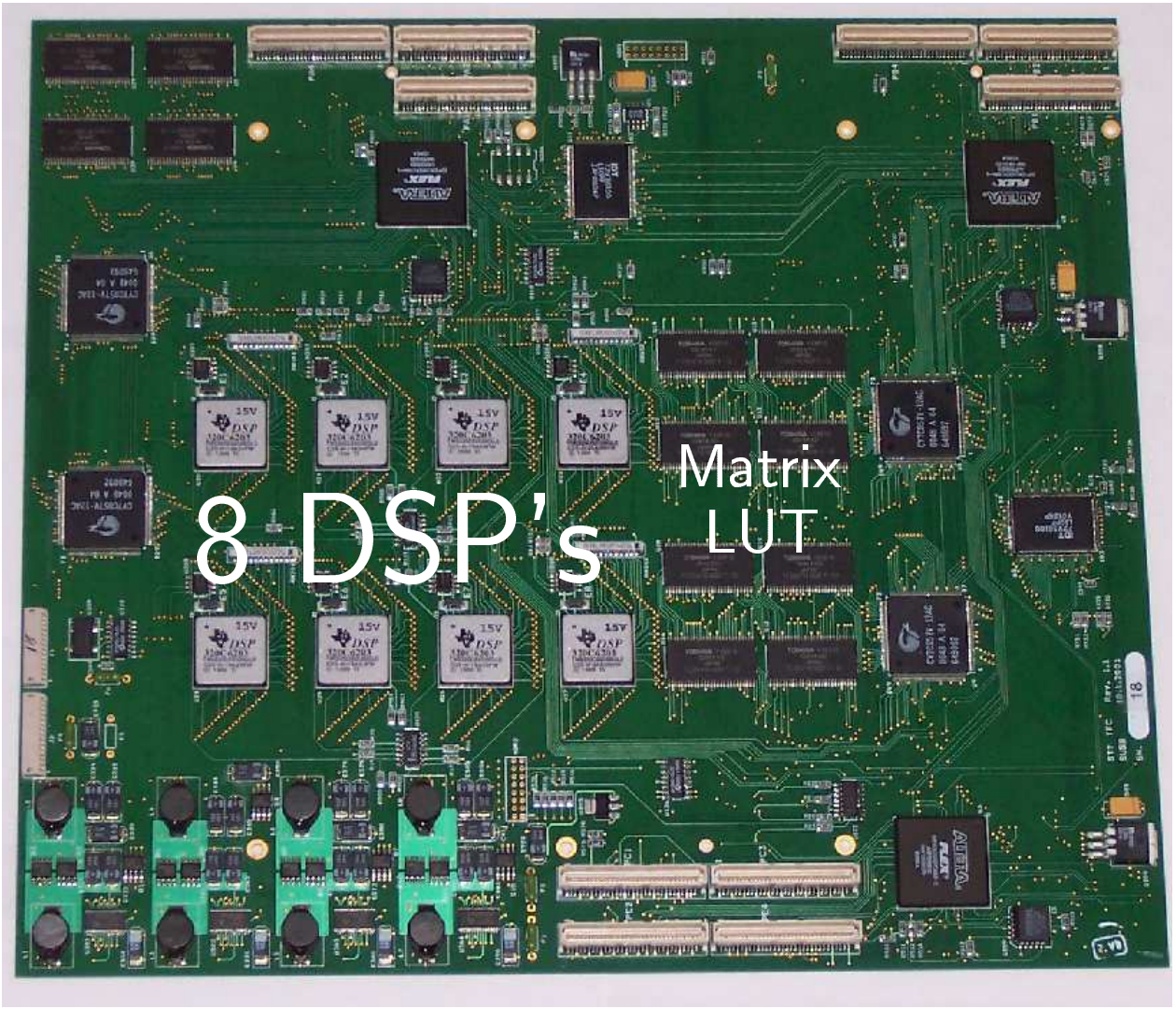
Performs silicon clustering and cluster-road matching

Clusters adjacent SMT hits (axial and stereo)

Axial clusters are matched to ± 2 mm-wide roads around each fiber track via precomputed LUT

Masks bad strips and applies pedestal/gain corrections (via LUT)

Track Fit Card (TFC) Design



Performs final SMT cluster filtering and track fitting

Receives 2 CFT hits and axial SMT clusters in CFT road

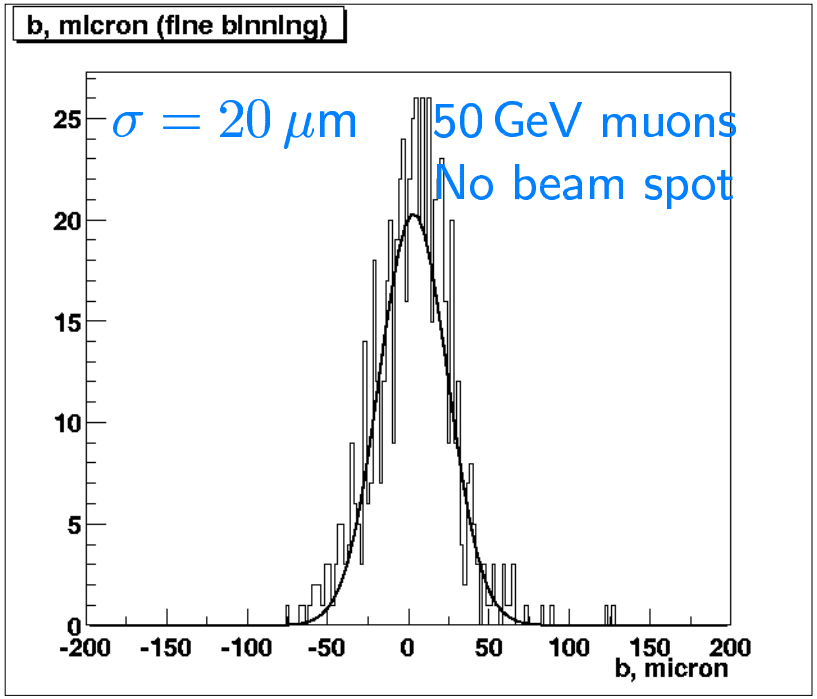
Selects clusters closest to road center and performs linearized track fit using precomputed matrix elements stored in on-board LUT

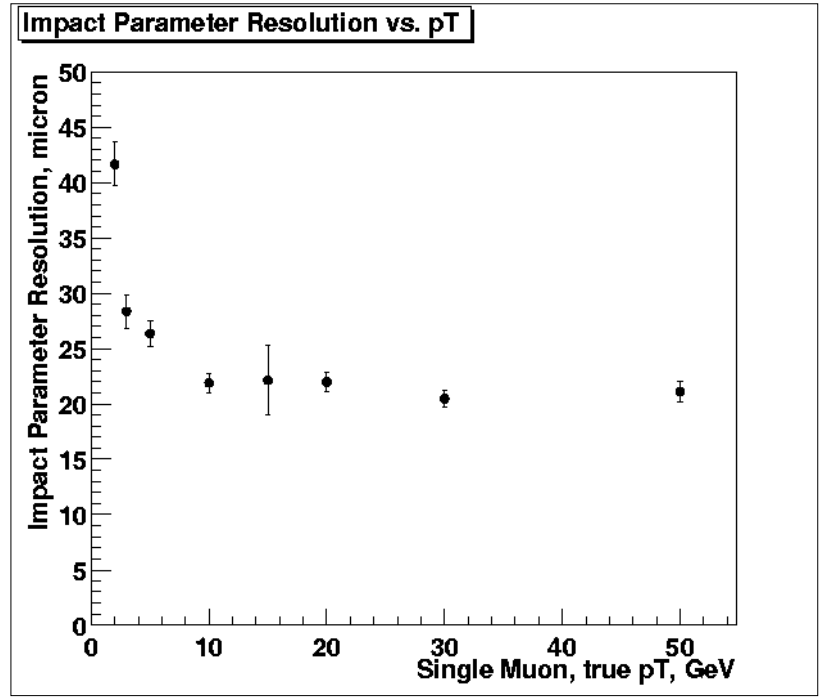
$$\phi(r) = \frac{b}{r} + \kappa r + \phi_0$$

Requires only 3 out of 4 silicon layers

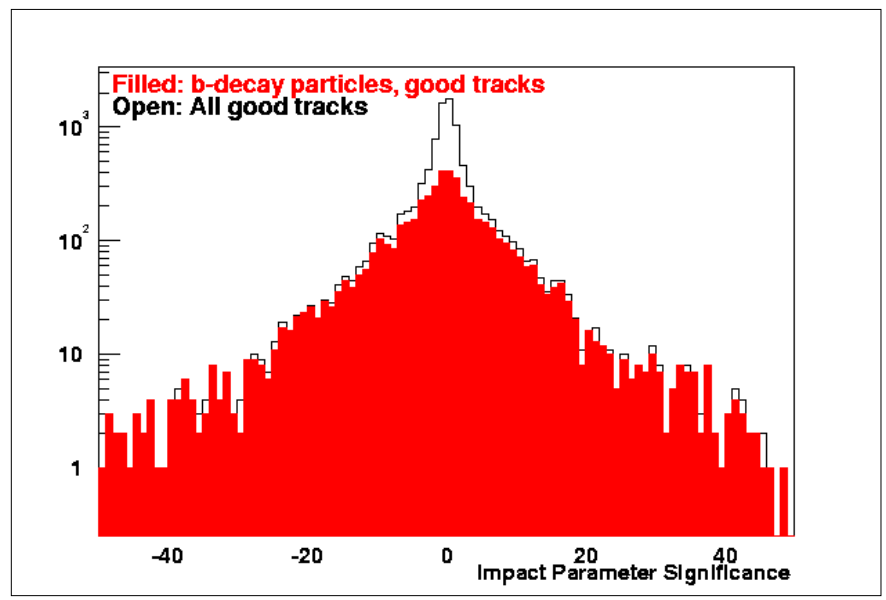
Output to L2CTT via Hotlink Transmitter cards

STT performance MC studies





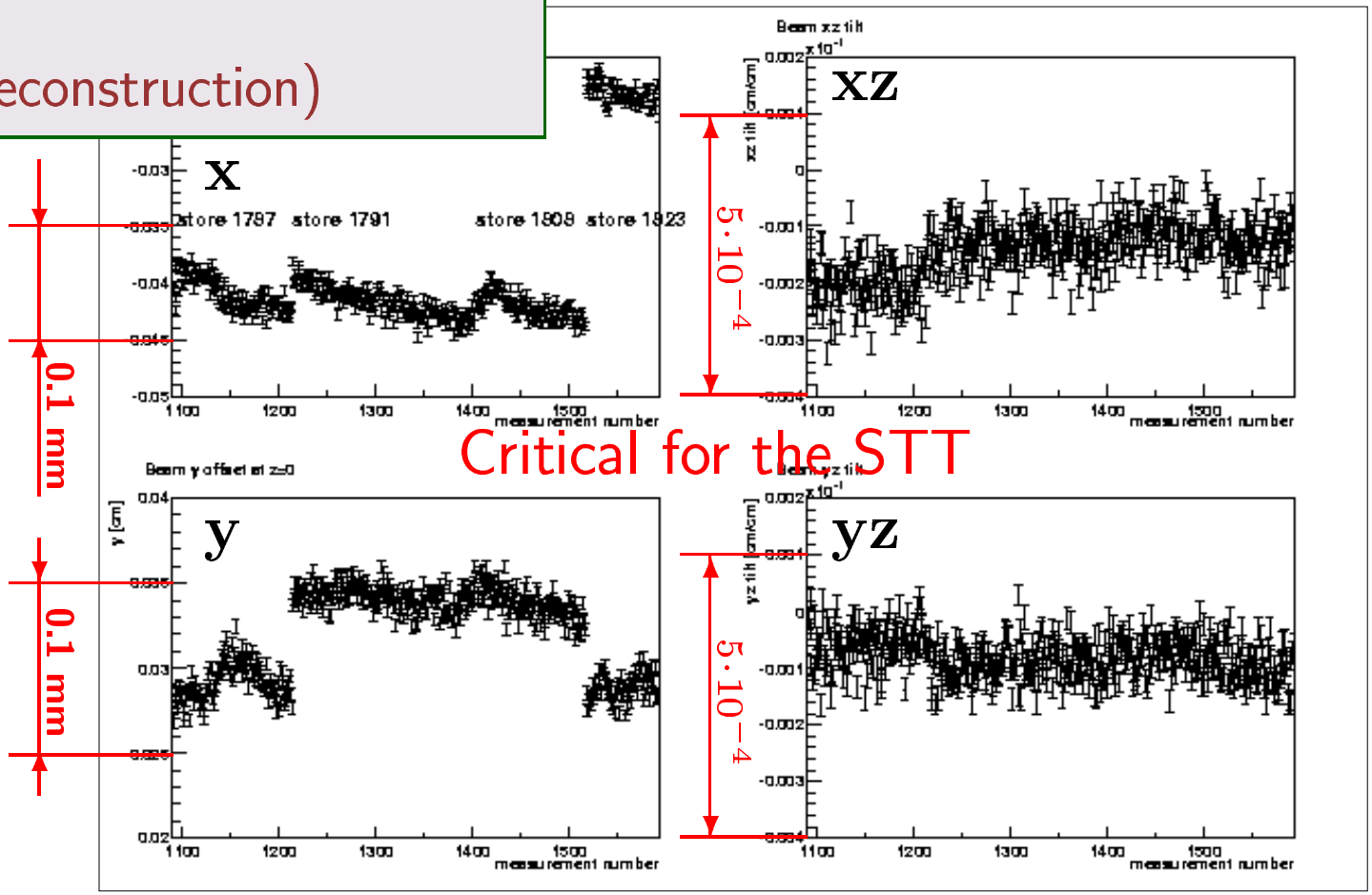
- Plots from **STT trigger simulator**
- Can use exact DSP fitting code
- Has been instrumental in developing the fitting algorithm
- Produces test vectors for all cards



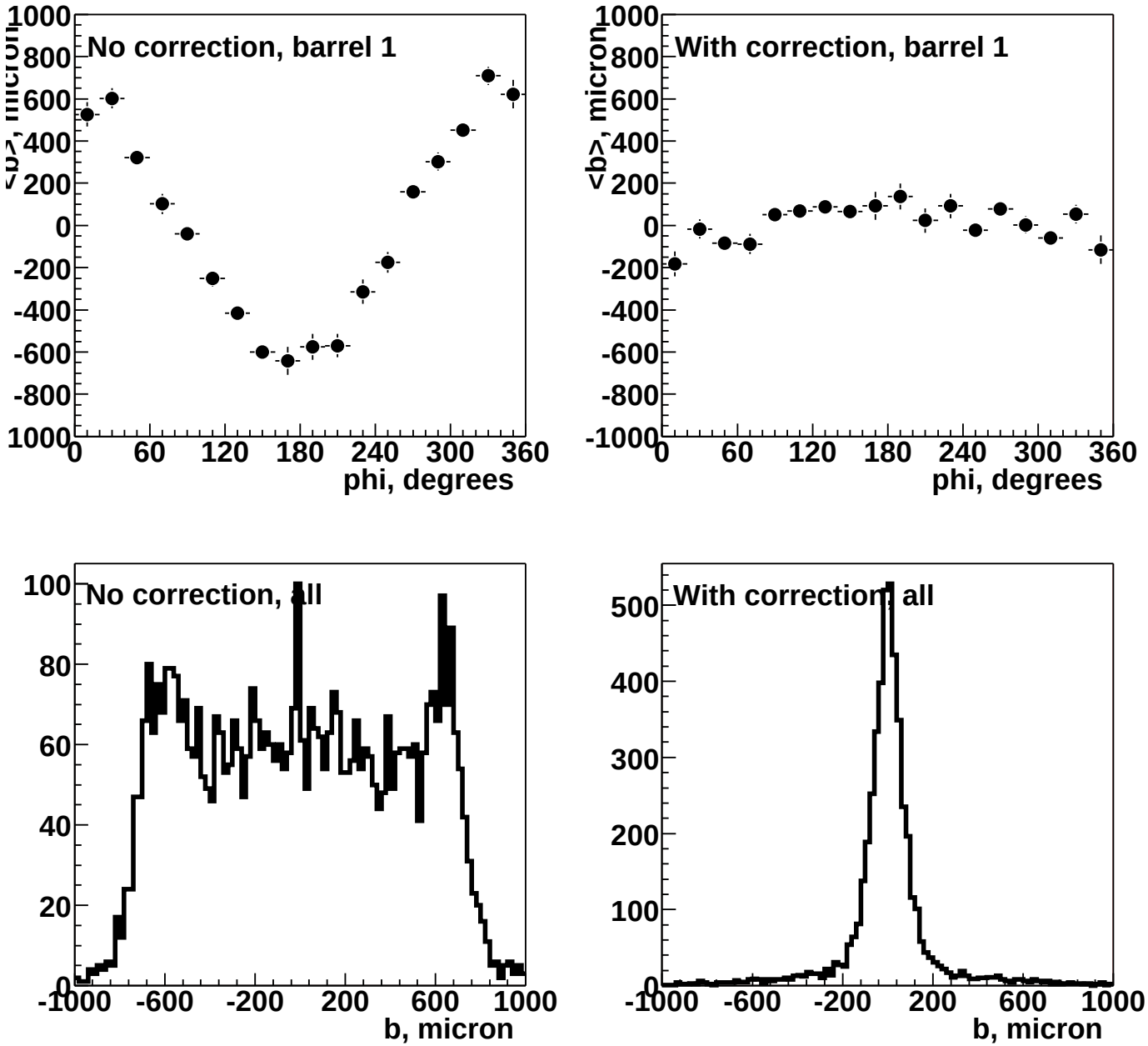
Beamspot Monitoring

- Beamspot determined by vertex examine
- Written to coor name value server
- At beginning of run:
  coor tells comics to download values to
  - STT
  - L3 farms (for reconstruction)

Allowable beamspot variation for the STT:
- position < 1 mm
- tilt $< 5 \cdot 10^{-4}$



Beamspot Correction: Data through trigsim



• Status

- STT crates have been in global run
  - since autumn last year
- All six sector crates are implemented
- Routinely running
- Taking shifts to ensure integration with DØ
- Have taken about 10^8 events
  in 30 stores (about 180 runs)
- Downtime (last couple of weeks):
  about 1 %, tendency decreasing

STT Monitoring GUI

File View

FRC | LRB | TFC | CPU | STC0 | STC1 | STC2 | STC3 | STC4 | STC5 | STC6 | STC7 | STC8

Crate 70 STC 0 Status Information

Device	Run Ctl	Misc Ctl	L3 wd cnt	Run Ctl	Misc Ctl
STT STC 700	0x41f0ff01	0x03000011	48	GOOD	GOOD

Crate 70 STC 0 Number of strips by chip

Device	chip0	chip1	chip2	chip3	chip4	chip5	chip6	chip7	chip8
STC_700 chan 0	21819	32200	21409	21779	33780	40952	41151	51415	30443
STC_700 chan 1	20227	17160	20874	25773	19687	35813	18700	24182	45852
STC_700 chan 2	29044	28253	21344	17523	20714	13532	21551	32567	19493
STC_700 chan 3	32434	39702	27434	32008	39235	21971	24237	27420	22989
STC_700 chan 4	28825	29657	28741	35960	34068	33046	0	0	0
STC_700 chan 5	32922	37900	38617	36846	34500	34920	0	0	0
STC_700 chan 6	17237	22000	24633	12501	16040	12620	0	0	0
STC_700 chan 7	18973	37107	25810	35758	15092	13922	0	0	0

Crate 70 STC 0

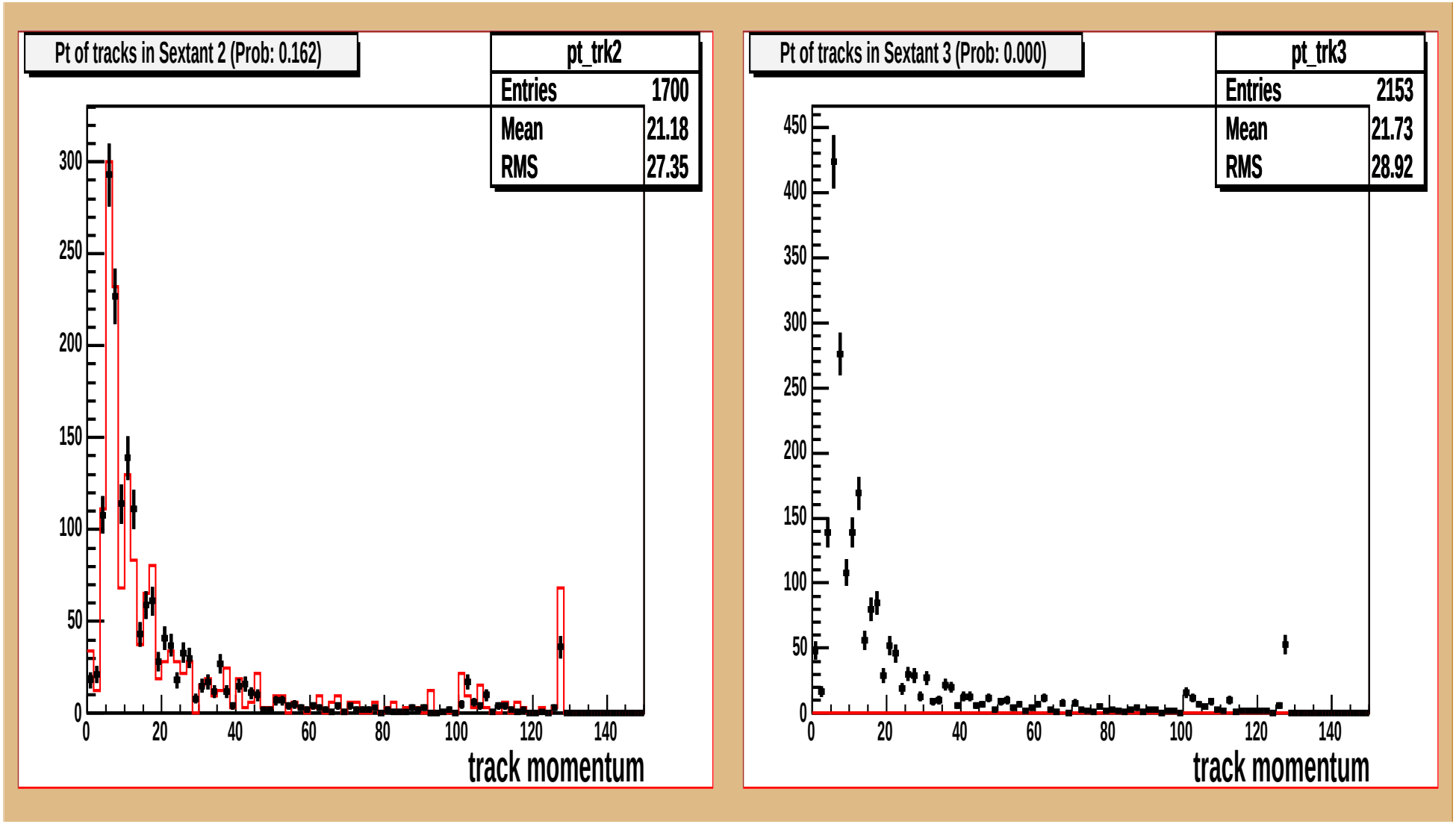
Device	VtmErr	ID Err	0 Byte Ms	Undef	Stereo	Axia	90 deg
STC_700 chan 0	0	0	0	0	4748	4027	0
STC_700 chan 1	0	0	0	0	5745	4403	0
STC_700 chan 2	0	0	0	0	5204	3480	0
STC_700 chan 3	0	0	0	0	5247	4919	0
STC_700 chan 4	0	0	0	0	0	9548	9028
STC_700 chan 5	0	0	0	0	0	10156	9652
STC_700 chan 6	0	0	0	0	0	2774	2653
STC_700 chan 7	0	0	0	0	0	5734	7298

Status: Pend_io failed for STT_STC_700 chan 6 - User specified timeout on IO operation expired

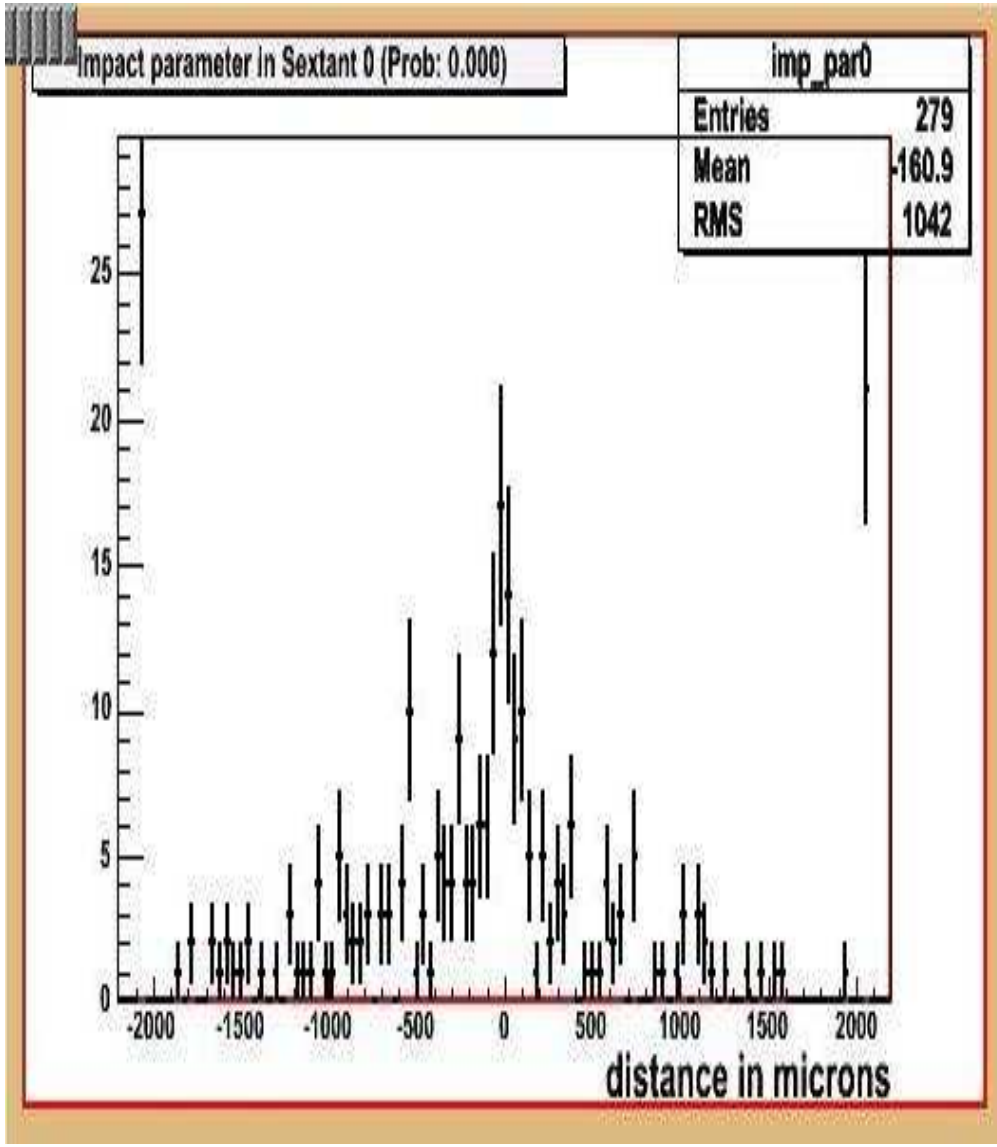
Reconnect

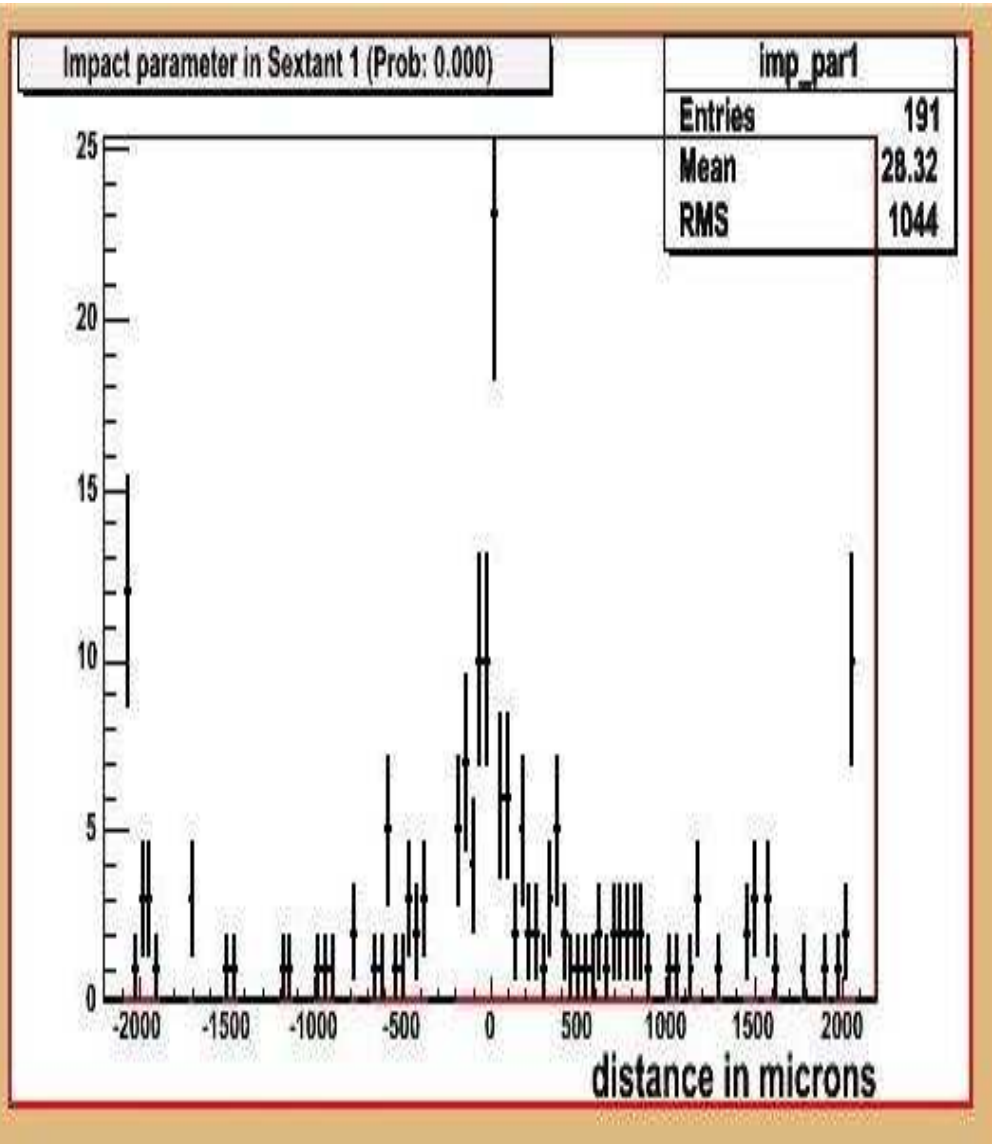
Sat Feb 27 20:40:47 2004

STT Examine: Track transverse momentum

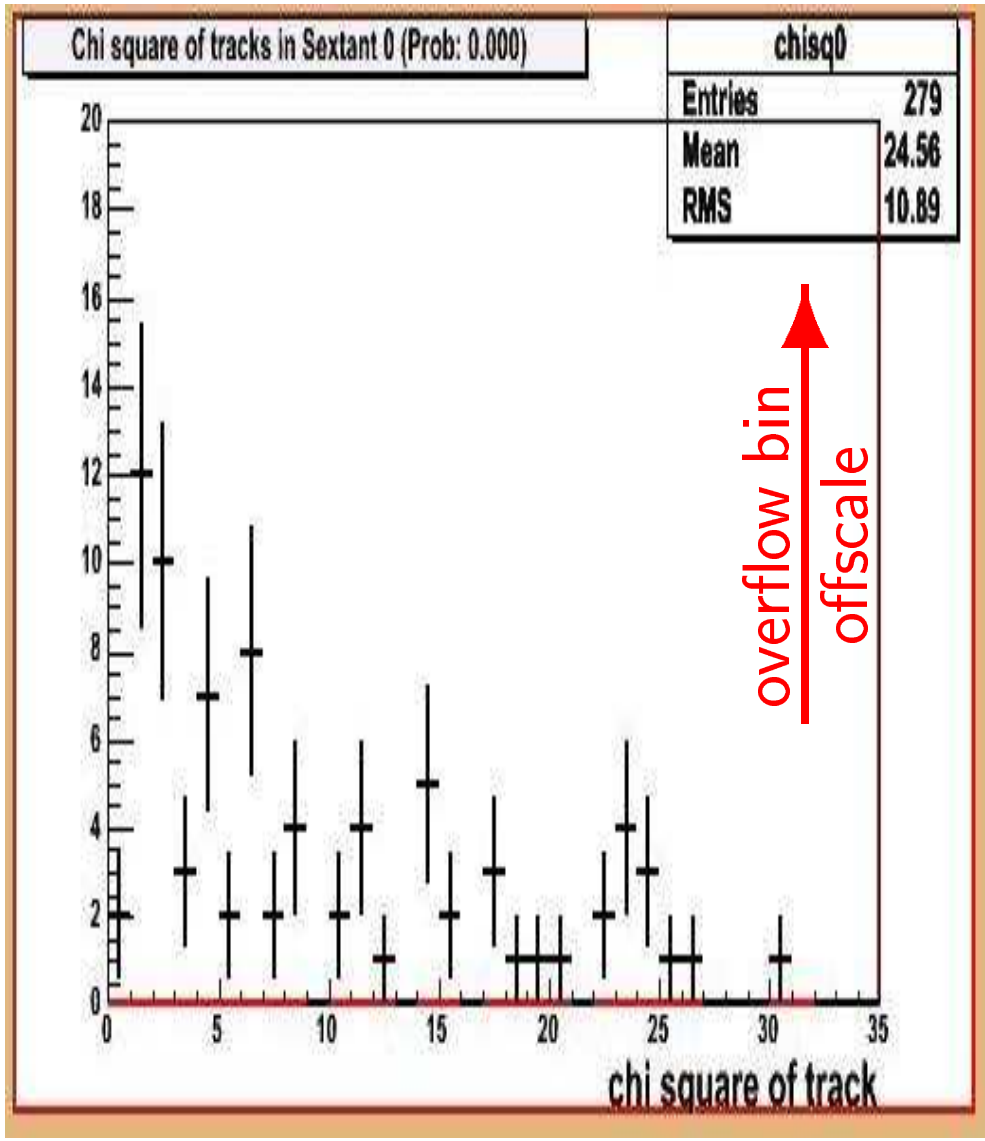


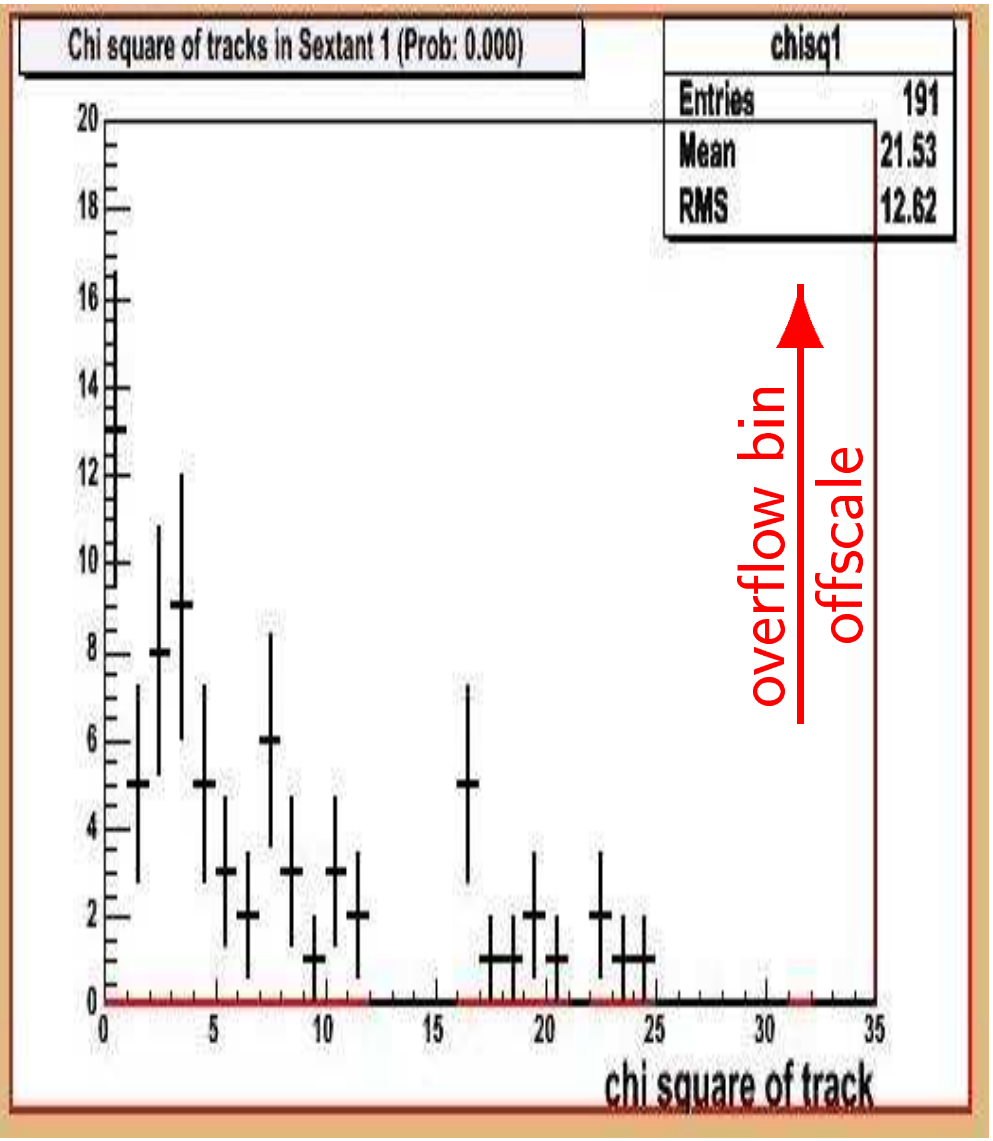
STT Examine: Impact Parameter



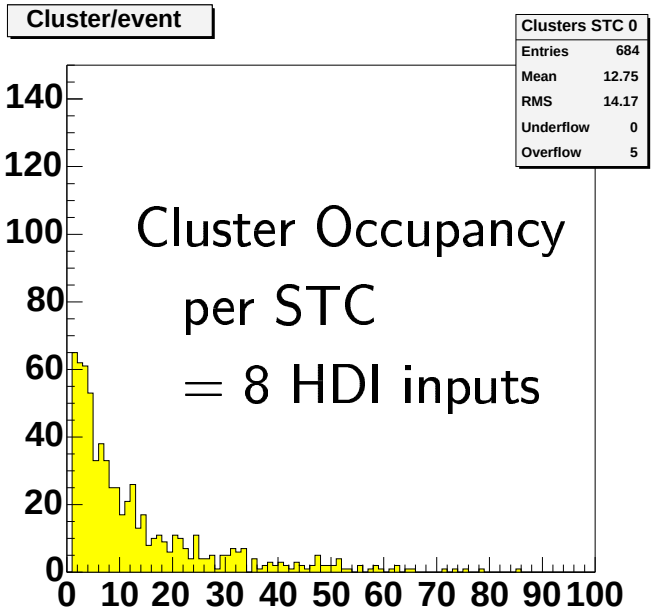


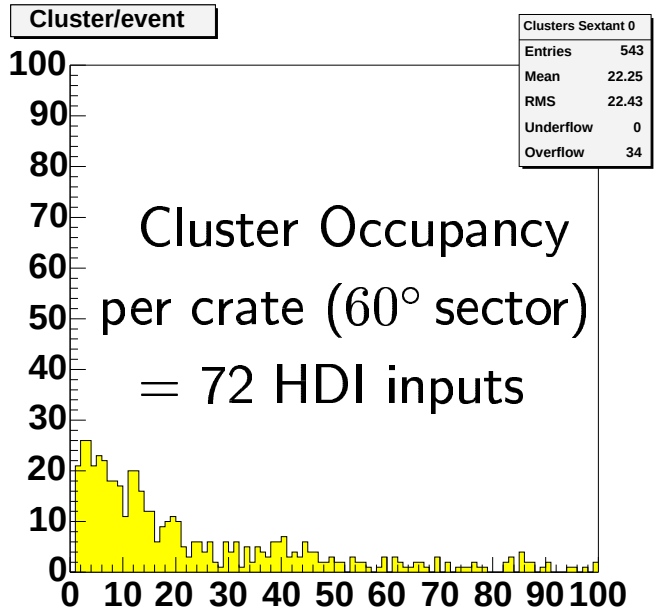
STT Examine: Track fit χ^2 distribution

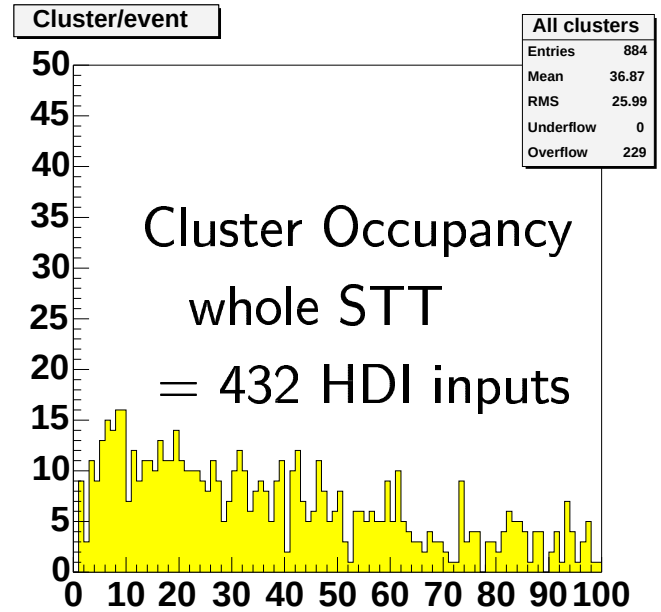


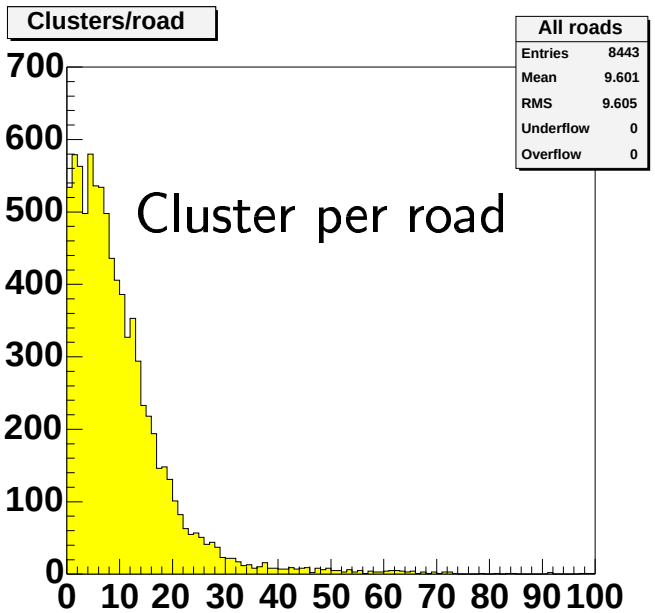


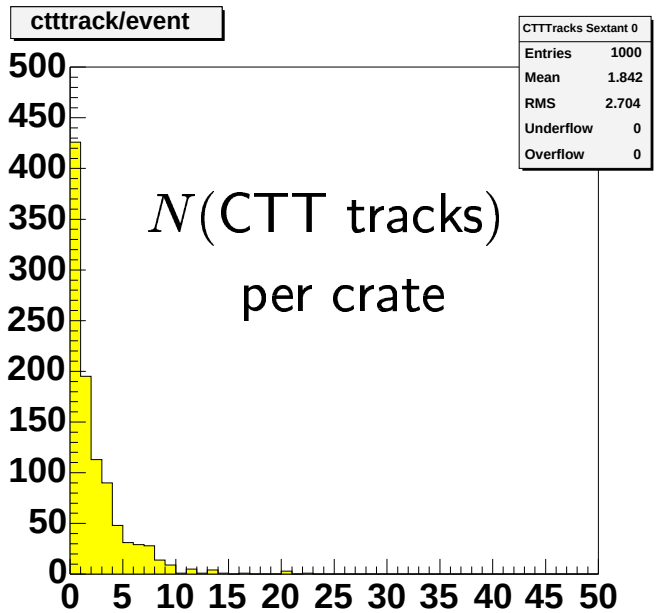
Data (taken 22nd February 2004)

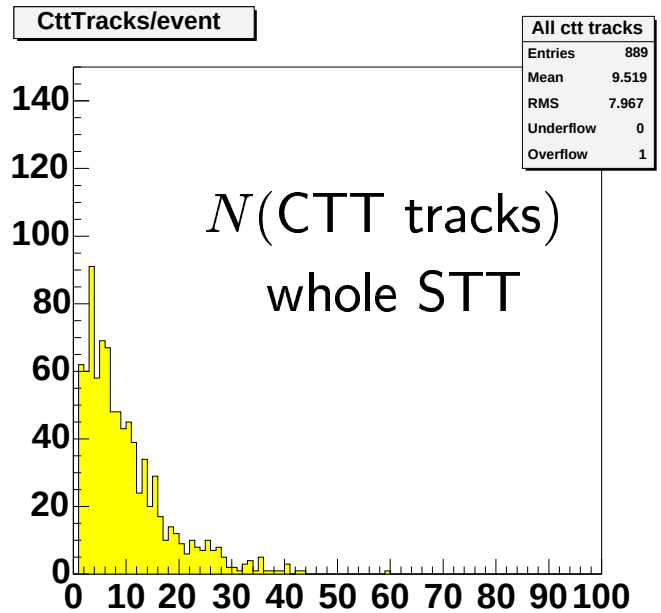






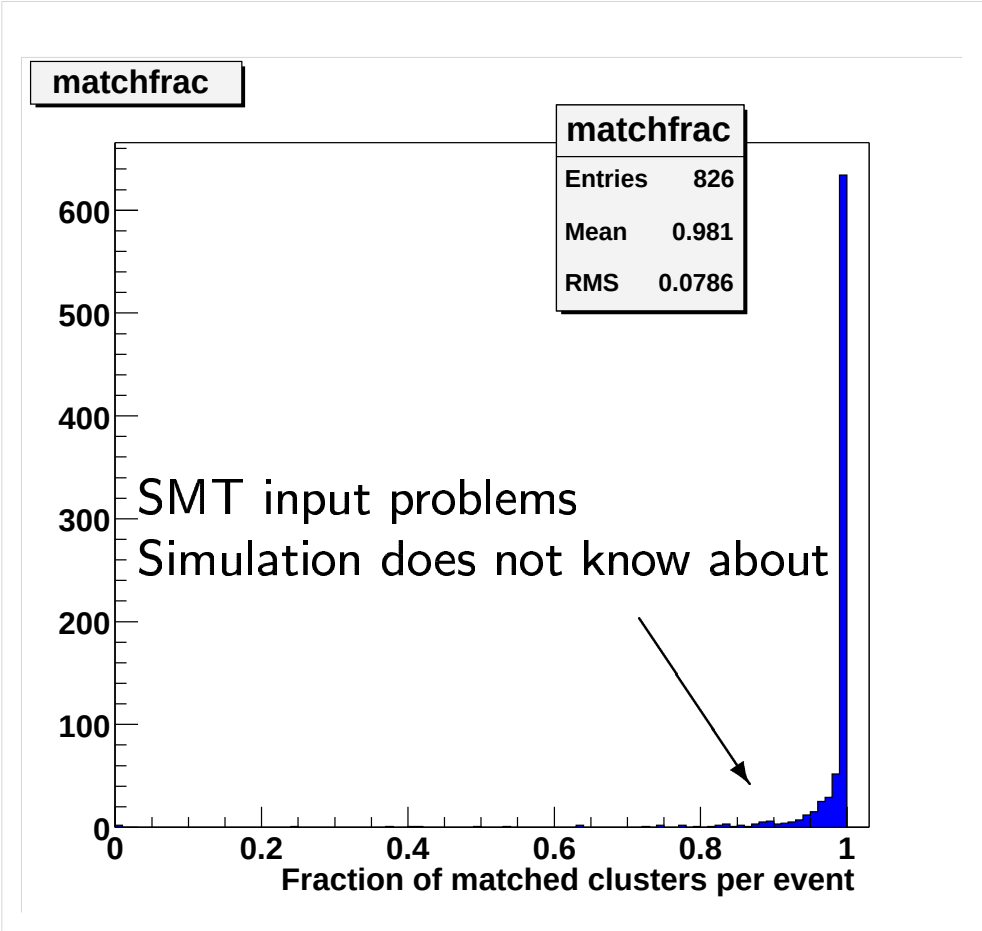




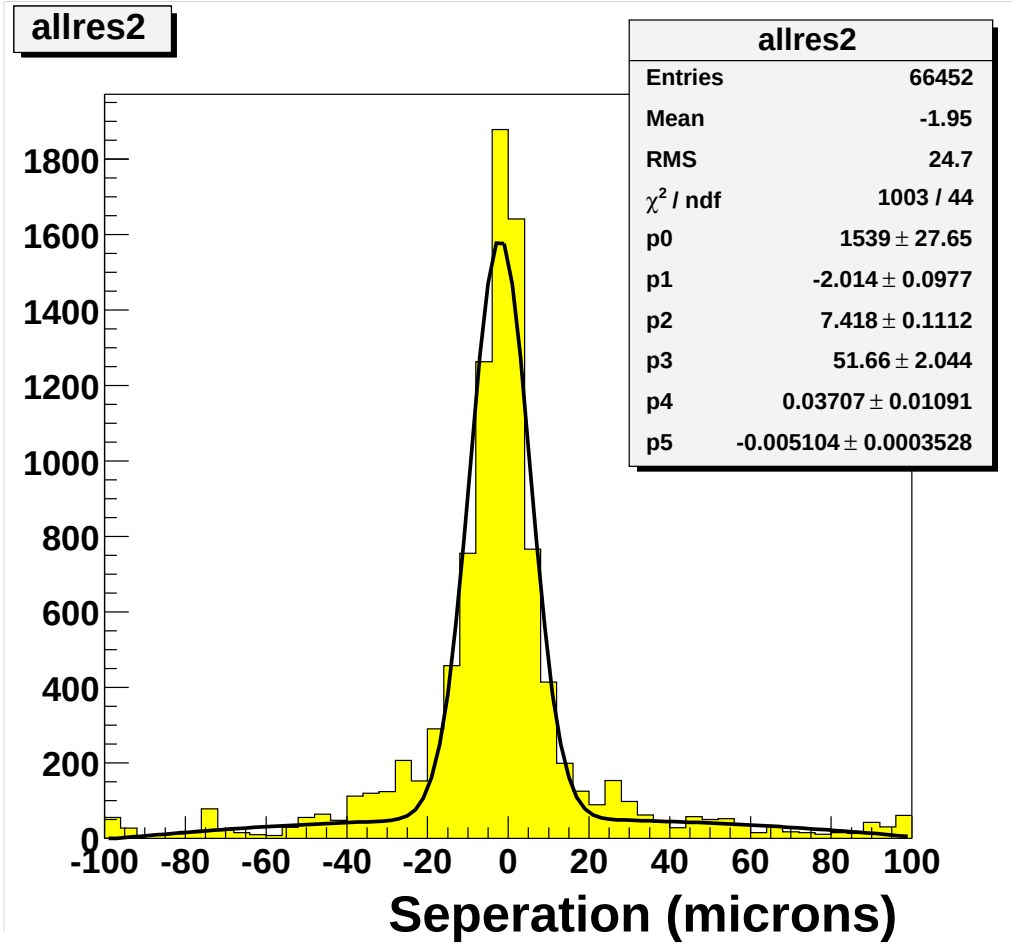


Data verification: Reconstructed cluster

STT Data: hardware vs. simulation

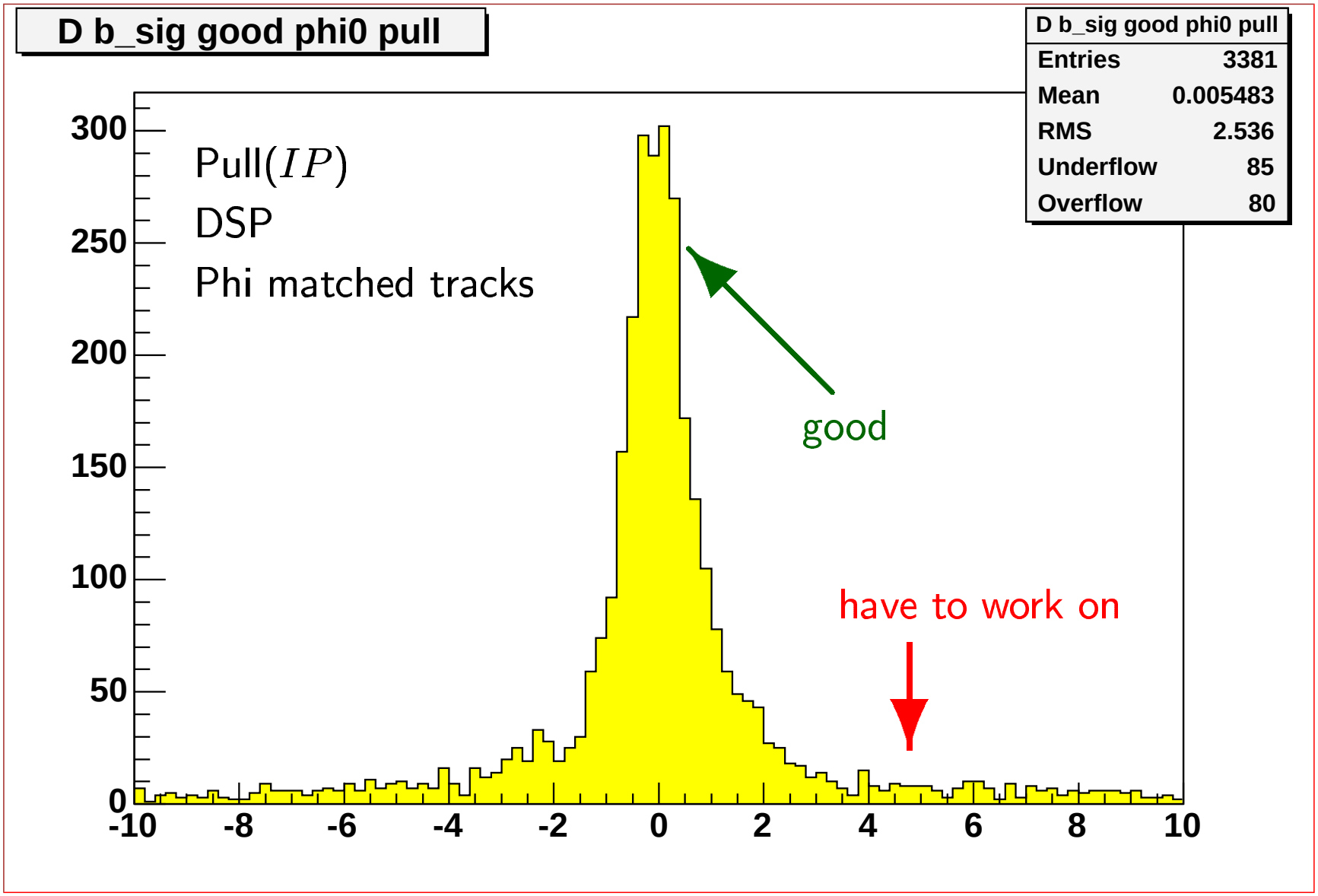


STT simulation vs. dØreco

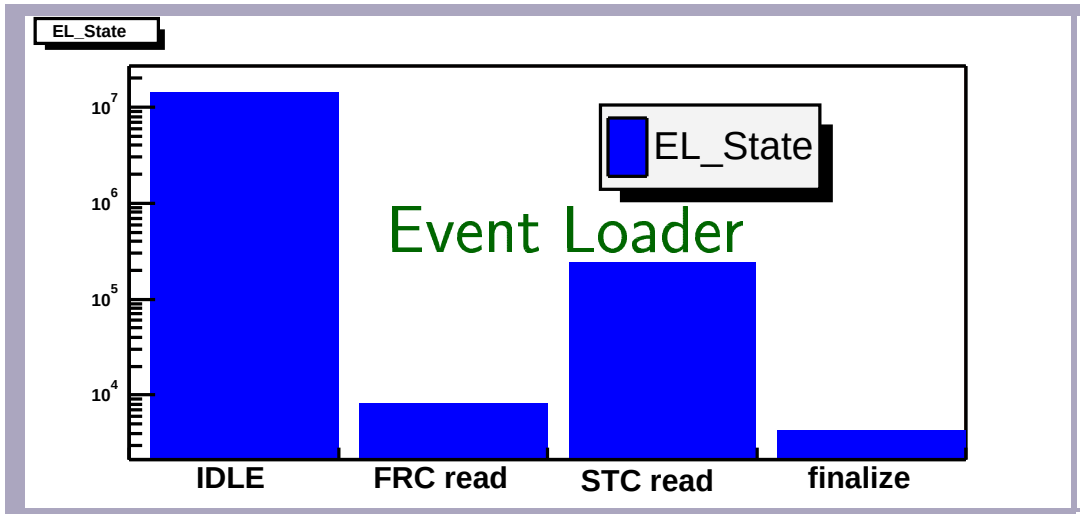


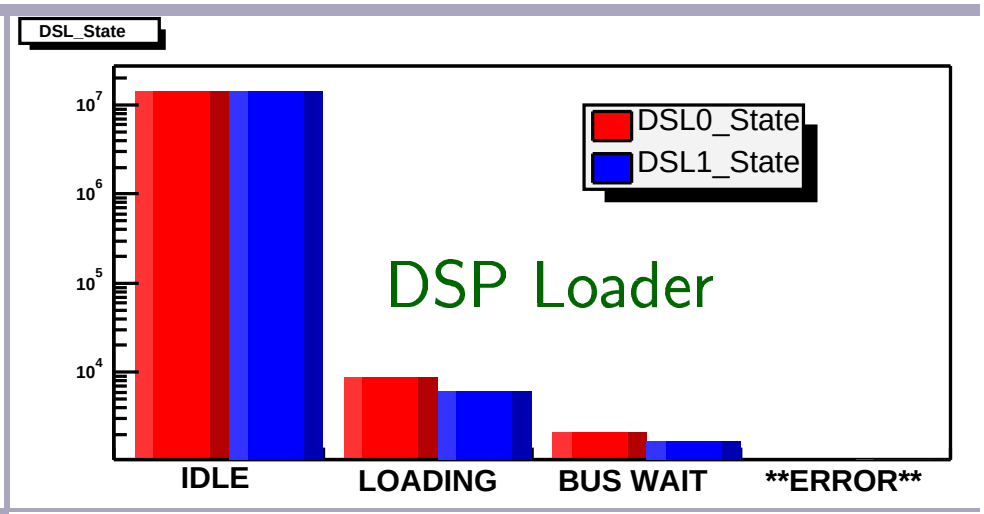
$\Rightarrow$ Find real hits!

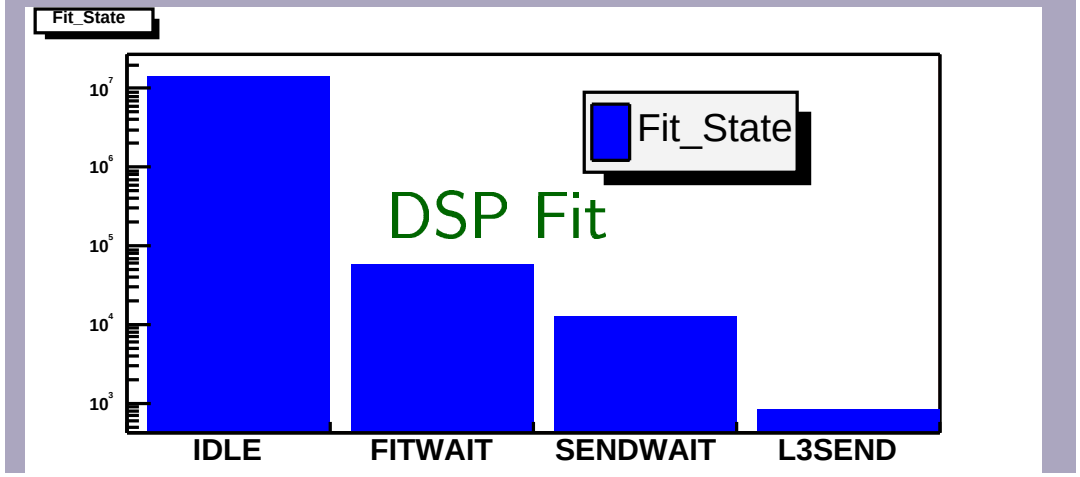
Data verification: L1CTT data through `trigsim` vs. d∅reco



TFC Monitoring histograms

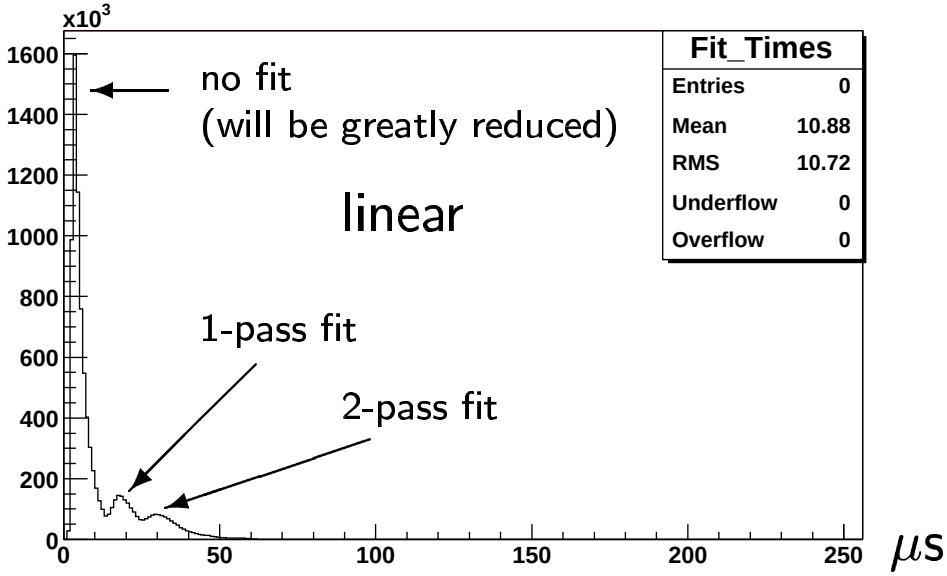




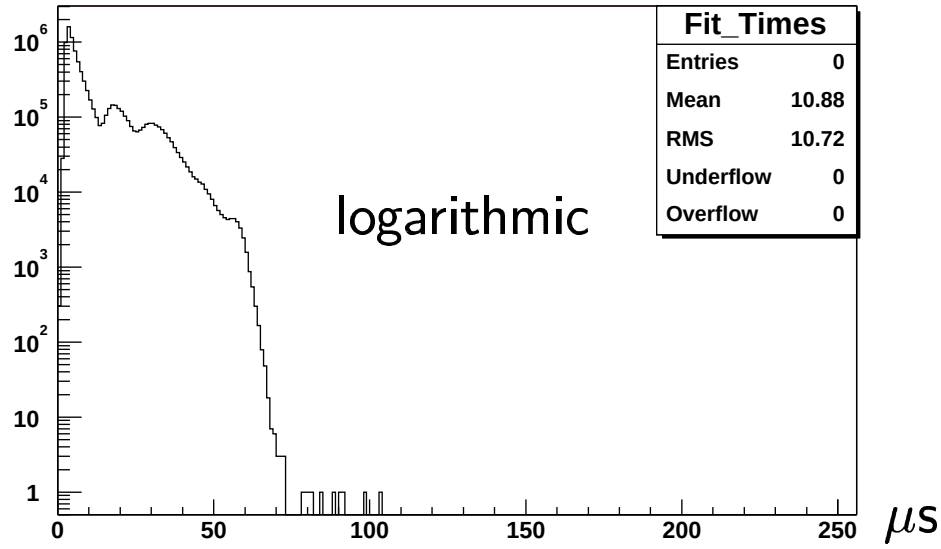


Firmware is IDLE most of the time (@20E30)

Fitting time consumption during global physics run (@20E30)



Mean time consumption has to be less than 50 μs



STT well within the required performance

CTT Input to STT: test vector vs. hardware

- **Previously verified internal data transfer quality**

- **Decoding the data words (comparing CTT data to trigsim)**
  - **CTT trigger sector is "always" right (TS CFT)**
  - **CTT H doublet, TSIM = DATA + 1 (10σ in STT fitting)**
  - **CTT track curvature is always inverted • FIXED, 2/26!**

- **Clearly,we're working on tracking these down**
  - CTT group helping

When will STT be usable?

- Current limitations:
  Inputs significantly different from what is expected
  $\Rightarrow$ Can't verify performance

- Hardware is in place and working
  - Remaining firmware issues expected to be settled end of March
  - Running smoothly in global run
    compared to six weeks ago

- Started data verification

- Plan to put test triggers including σ_{IP} in V13
  - Expect to be used in the V14 trigger list