Luminosity

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Question: How do we normalize our data?

Answer: Compare with a known physics process.

- QCD
  - Record minimum bias triggers and compare to $\sigma_{p\bar{p}}$.
- Electroweak
  - Count reconstructed W's & Z's and compare with theory.
- Cross-checks
  - Event counts versus scalers;
  - Detector effects proportional to $\mathcal{L}$ such as calorimeter HV current draw, multiplicities, etc;
  - Beam parameters.

Outline

- Machine Luminosity
- Luminosity Monitor
- Measuring Luminosity
- Luminosity Constant
- Exposure and You
- Normalization
- Data Acquisition
- Validation
- Run 2 so far
- Accessing Luminosity Offline

Machine Luminosity

The instantaneous luminosity is given by:

$$\mathcal{L} = \frac{\mathrm{fBN_pN_{\bar{p}}}}{2\pi(\sigma_{\mathrm{p}}^2 + \sigma_{\bar{\mathrm{p}}}^2)}\mathrm{F}(\sigma_{\mathrm{l}}/\beta^{\star}),$$

where

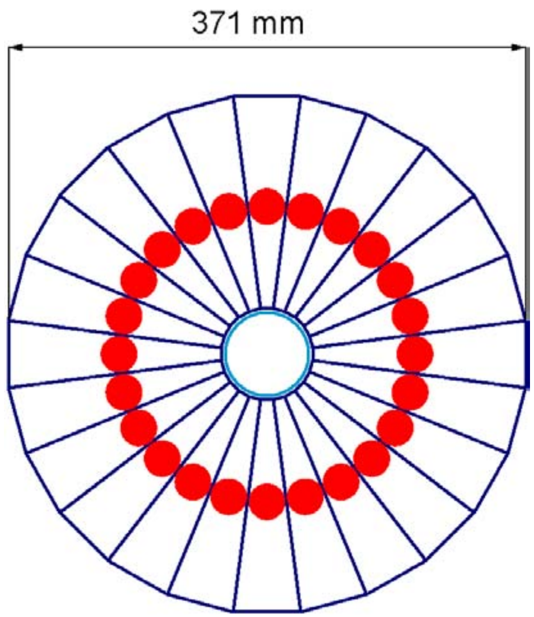
- f=47.713 KHz,
- B is the number of bunches in each beam,
- $\mathrm{N_p}$ ($\mathrm{N_{\bar{p}}}$) is the number of protons (anti-protons) in each bunch,
- σ_{p} ($\sigma_{\bar{\mathrm{p}}}$) is the RMS transverse size of the proton (anti-proton) beam at the interaction point,
- F is a form factor that depends on the ratio of the bunch length, σ_{l}, to the beta function at the interaction point, $\beta^{\star}$.

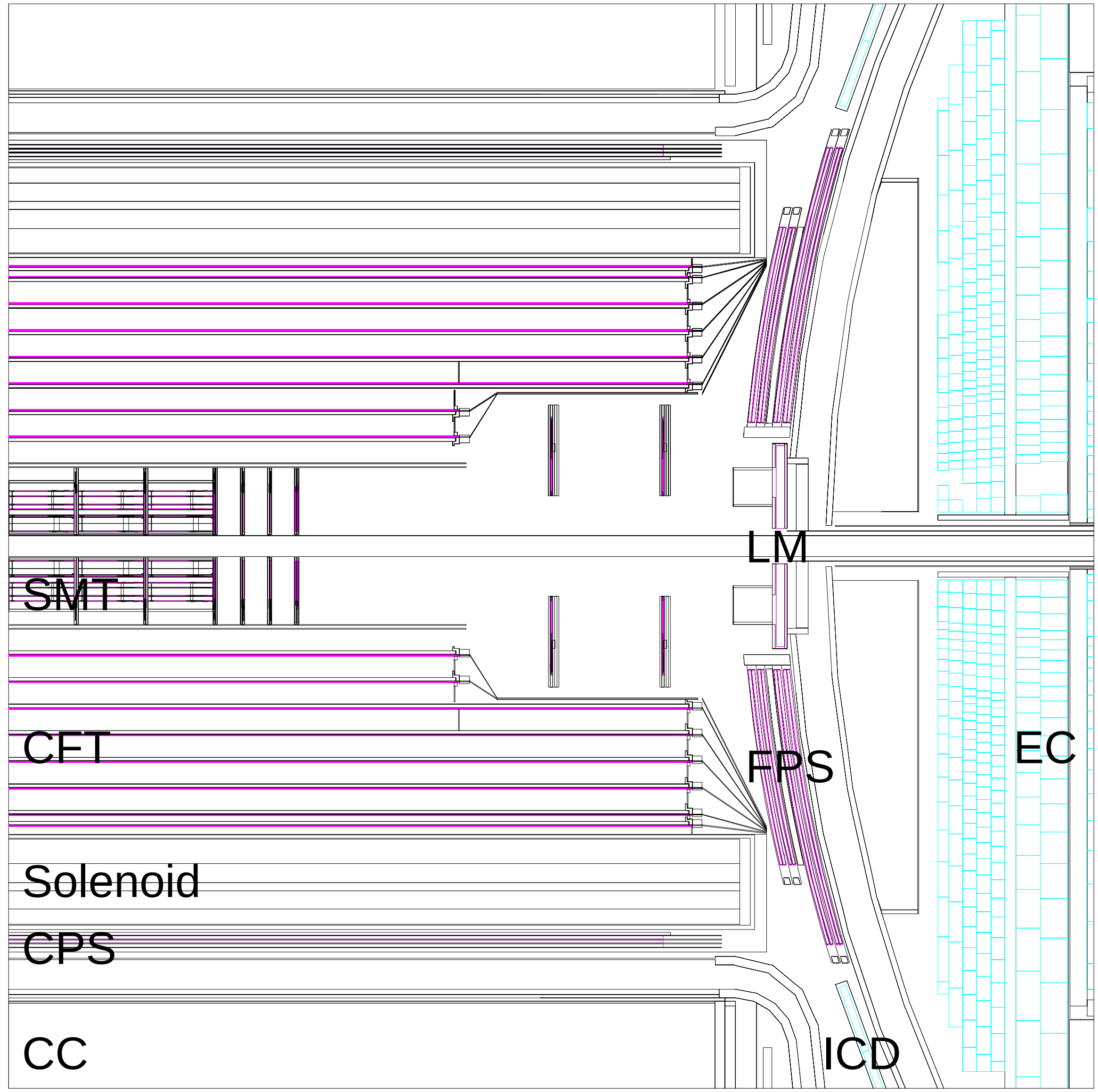
$\mathcal{L}$ is expressed in units of $\mathrm{cm^{-2}s^{-1}}$. Extracting $\mathcal{L}$ from this expression requires detailed knowledge of beam characteristics not available to DØ.

DØ measures the luminosity by counting coincidences in the Luminosity Monitor.

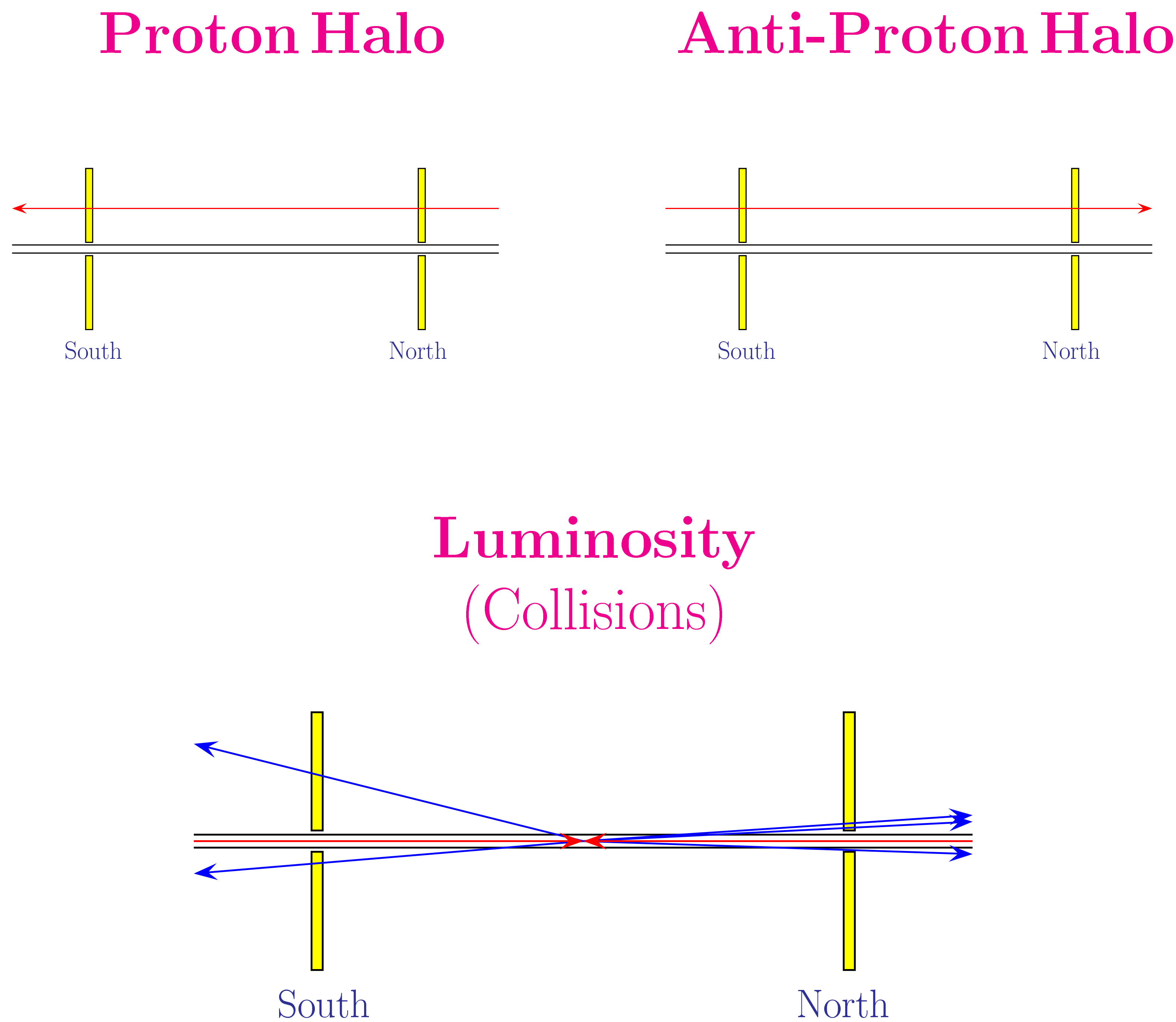
Luminosity Monitor

- Plastic scintillators with photomultipliers.
- 24 wedges mounted on each calorimeter end-cap at $z \approx \pm 140$cm.





- Coverage is $2.7 < |\eta| < 4.4$.
- Located in ≈ 1 Tesla magnetic field.
- Time-of-flight resolution ≈ 200 ps.


Proton Halo
South
North
Anti-Proton Halo
South
North
Luminosity
(Collisions)
South
North

Counting Zeros

The average number of interactions per beam crossing, μ, is proportional to the luminosity and follows a Poisson distribution. The probability of n interactions in a given crossing is

$$\mathrm{P(n)} = \frac{\mu^{\mathrm{n}}}{\mathrm{n}!}\, \mathrm{e}^{-\mu}.$$

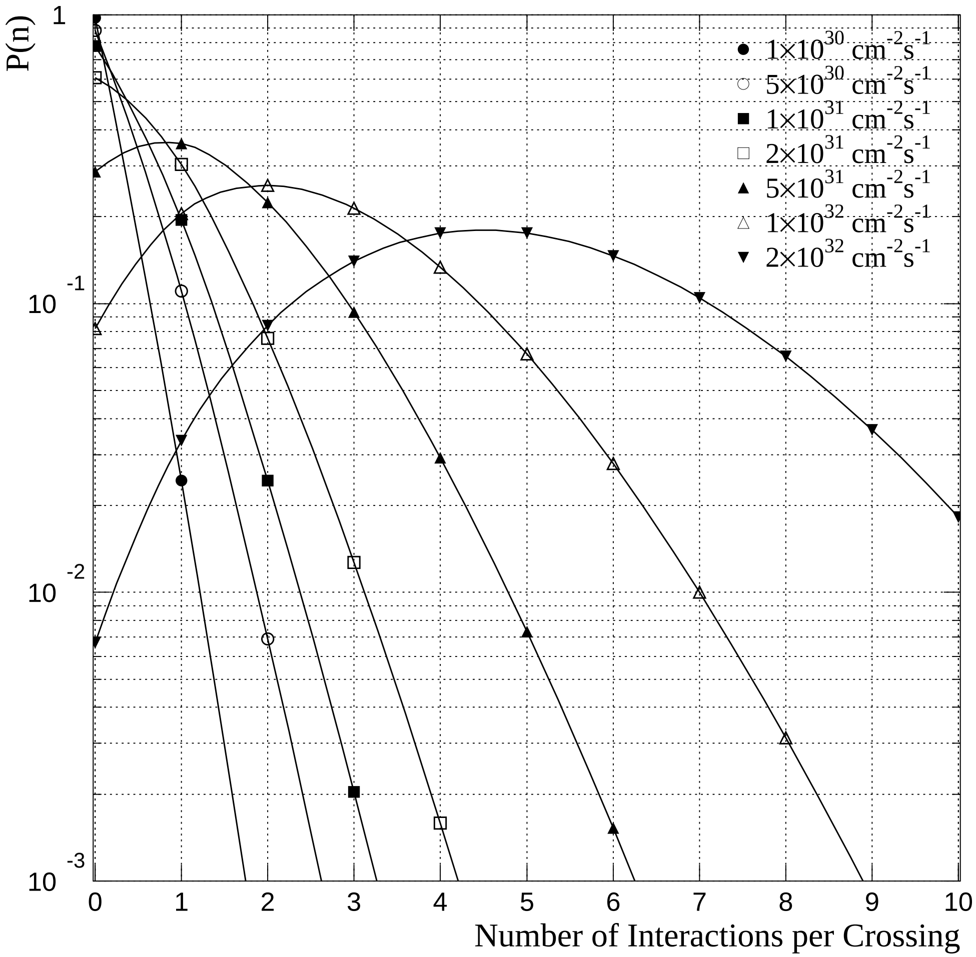
The probability of at least one interaction (detector signal) is

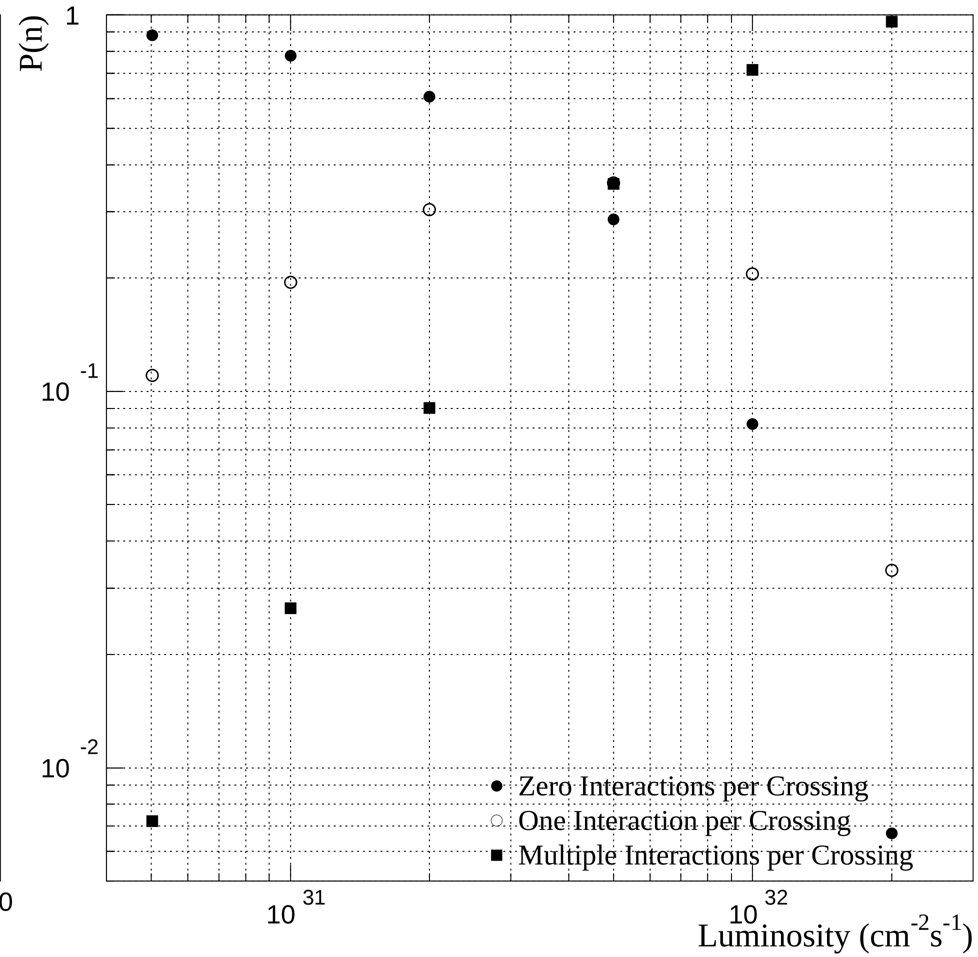
$$\mathrm{P(n > 0)} = 1 - \mathrm{e}^{-\mu}.$$

Since $\mu = \mathcal{L}\sigma_{\mathrm{eff}}/\text{crossing rate}$,

$$\mathcal{L} = -\frac{\text{crossing rate}}{\sigma_{\mathrm{eff}}}\, \ln\big(1 - \mathrm{P(n > 0)}\big)$$

Interactions





Delivered Luminosity

Luminosity is calculated for every tick using the per bunch scalers:

$$\mathcal{L} = \frac{\text{crossing rate}/159}{\sigma_{\text{eff}}} \sum_{\text{i}=1,159} \ln\left(1 - \frac{\Delta \text{LM}_{\text{i}}}{\Delta \text{ticks}/159}\right)$$

- $\Delta \text{LM}_\text{i}$ is the count of North $\wedge$ South for tick i
- crossing rate $=$ RF Frequency$/7 = 7.5863$ MHz
- $\sigma_{\text{eff}} = 43$ mb

Effective Cross Section

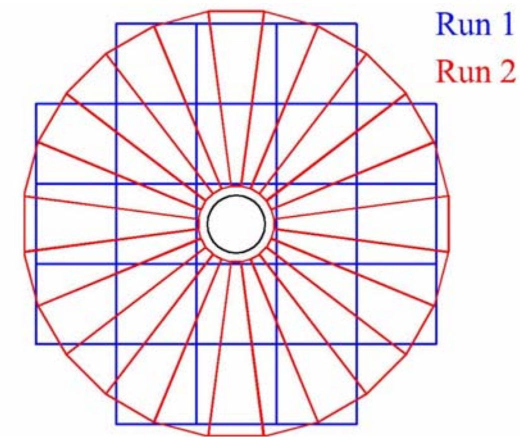
Three factors go into σ_{eff}, the effective cross section seen by the luminosity monitor:

- Cross sections for hard core, single diffractive, and double diffractive processes;
- Acceptance for each process;
- Detection efficiency of luminosity monitor counters.

$$\sigma_{\mathrm{eff}} = \epsilon_{\mathrm{LM}}(\mathrm{A}_{\mathrm{HC}}\,\sigma_{\mathrm{HC}} + \mathrm{A}_{\mathrm{SD}}\,\sigma_{\mathrm{SD}} + \mathrm{A}_{\mathrm{DD}}\,\sigma_{\mathrm{DD}})$$

Luminosity Constant

- We are currently using the same $\sigma_{\rm eff}$ as was used for Run 1B, assuming differences are small and generally cancel.
- No change in the cross sections since Run 1B (we're negotiating with CDF on the new world average)
- Slight increase in Run 2 LM acceptance not yet included (small effect — acceptance was 97.1±2.0% for dominant hard core process)



- Expect similar LM efficiency
  - Currently using Run I electronics setup
  - Running with small inefficiency to avoid saturating the electronics
  - Run 1 efficiency was 90.7 ± 1.7% (also to avoid saturation)
- Run 2A measurement is expected to be consistent with Run 1 to with 5–10%.

Effective Cross Section

$$\sigma_{\rm eff} = \epsilon_{\rm LM}(A_{\rm HC}\,\sigma_{\rm HC} + A_{\rm SD}\,\sigma_{\rm SD} + A_{\rm DD}\,\sigma_{\rm DD})$$

Factor	σ (mb)	Acceptance
Hard Core	46.69 ± 1.63	0.97 ± 0.02
Single Diffractive	9.57 ± 0.43	0.15 ± 0.05
Double Diffractive	1.29 ± 0.20	0.72 ± 0.03

$$\epsilon_{\rm LM} = 0.907 \pm 0.02$$

$$\sigma_{\rm eff} = 43.26 \pm 2.07$$

Total Cross Section

$$\sigma_{\rm tot} = \frac{4(\rm hc)^2}{\pi} \frac{\rm B}{1+\rho^2} \frac{\rm N_{el}}{\rm N_{el}+N_{in}}$$

- $\rm N_{el}$ is the rate of elastic events;
- $\rm N_{in}$ is the rate of inelastic events;
- $\rm B = \frac{1}{N_{el}} \frac{dN_{el}}{dt}\Big|_{t\to 0}$;
- ρ is the ratio of the real to the imaginary part of the forward elastic scattering amplitude.

- There were three measurements of $\sigma_{\rm tot}$ at $\sqrt{\rm s} = 1.8$ TeV:
  - CDF $\sigma_{\rm tot}(1+\rho^2) = 81.83 \pm 2.29$ mb
  - E710 $\sigma_{\rm tot}(1+\rho^2) = 74.2 \pm 2.8$ mb
  - E811 $\sigma_{\rm tot}(1+\rho^2) = 72.66 \pm 2.22$ mb

- CDF and E710/E811 disagree by several sigma. In Run 1, DØ used 76.6 ± 2.9 mb while CDF used their own result.

World Average

- DØ and CDF have been working on a new world average $\sigma_{p\bar{p}}$ for Run 2. We decided to concentrate on the inelastic cross section, σ_{in}, since neither luminosity detector is sensitive to elastic events.
- E811 was a follow-up to E710 using the same techniques, but with an upgraded detector and higher statistics. We decided to drop the E710 measurements from the σ_{in} world average.
- We will use PDG scaling to scale the uncertainties.
- σ_{in} at $\sqrt{s} = 1.8$ TeV:
  - CDF $\sigma_{in}(1+\rho^2) = 61.7 \pm 1.4$ mb
  - E811 $\sigma_{in}(1+\rho^2) = 56.5 \pm 1.2$ mb

    (DØ used 58.8 ± 1.6 mb in Run 1.)
- PDG average:

$$\sigma_{in}(1+\rho^2) = 58.7 \pm 2.3\,\text{mb}$$

Ratio Method

E811 didn't measure B, but instead used the average of CDF & E710 (essentially the CDF value). The two measurements are therefore correlated. One way to decorrelate these measurements is to consider the relative rates of $\mathrm{N_{el}}$ and $\mathrm{N_{in}}$.

$$\sigma_{\mathrm{in}} = \frac{4(\mathrm{hc})^2}{\pi} \frac{\mathrm{B}}{1+\rho^2} \frac{\mathrm{N_{el}N_{in}}}{(\mathrm{N_{el}}+\mathrm{N_{in}})^2}$$

Defining $\mathrm{R} = \mathrm{N_{in}}/\mathrm{N_{el}}$ for simplicity,

$$\sigma_{\mathrm{in}} = \frac{4(\mathrm{hc})^2}{\pi} \frac{\mathrm{B}}{1+\rho^2} \frac{\mathrm{R}}{(1+\mathrm{R})^2}$$

Problem with this method is that R and B are correlated through the elastic measurements. We (CDF & DØ) are still working on this problem. Hopefully, we'll have more concrete results by the collaboration meeting.

Other World Averages

- The world average value for ρ is

$$\rho = 0.135 \pm 0.044.$$

  (DØ assumed 0.145 in Run 1.)

- The single diffractive cross section is the average of E710 (9.4 ± 1.4 mb) and CDF (9.46 ± 0.44 mb) scaled to the new σ_{in}.

$$\sigma_{\text{sd}} = 9.4 \pm 0.4\,\text{mb}.$$

  (DØ used 9.57 ± 0.43 mb in Run 1.)

- There is a recent double diffractive measurement from CDF. That is the only measurement at $\sqrt{s} = 1.8$ TeV, but it required significant Monte Carlo (MBR) to correct for acceptance. This measurement has large uncertainties.

$$\sigma_{\text{dd}} = 6.3 \pm 1.7\,\text{mb}$$

  (DØ assumed 1.29 ± 0.20 mb in Run 1.)

Exposure Groups

- Exposure groups were implemented to allow detailed and accurate monitoring of the luminosity of each L1 trigger.
- An Exposure Group is a set of L1 triggers that have common dead-time and read-out.

- The various sources of trigger disable signals correlated to the beam structure (i.e., things that control the integral luminosity seen by the trigger) are collected together in the Exposure Group.
- Each Exposure Group has 159 scalers (one for each tick).
- There are 8 sets of Exposure Group scalers implemented in the hardware.

- There is one scaler per Level 1 trigger to keep track of beam decorrelated contributions (e.g. L3 disable).

Exposure Groups in More Detail

- Each Exposure Group specifies a set of:
  - And/Or terms (correlated with beam structure/exposure)
  - Level 1 triggers
  - Geographic Sections (crates)
- Every Level 1 trigger must belong to an Exposure Group.
- The And/Or terms relevant for an Exposure Group apply to each of its L1 triggers. L1 triggers may have additional And/Or requirements.
- While Geographic Sectors and And/Or terms can overlap between Exposure Groups, L1 triggers can not.
- Every run requiring the TFW must contain at least one Exposure Group (both PDAQ & SDAQ).
- If any L1 trigger belonging to an Exposure Group fires and an L2 Accept is issued, then that Exposure Group's Geographic Sections will be read out.

Some reasons we have more than one Exposure Group defined

- More than one run at a time.
  There is no difference to the underlying framework between a physics run and one exercising a test stand.
- More than one set of correlated requirements at a time:
  - Single Interaction vs. Multiple Interaction triggers
  - Specific tick selection (e.g. first bunch of a super-bunch, cosmic gap)
  - Requirements on interaction Z position (vertex cuts)
  - Veto on the Luminosity Monitor signals
- Different sets of Geographic Sectors to be read out:
  - "In-turn" calibration (e.g. CFT, FPD)
  - Different detector configurations for some triggers

Exposed Luminosity

Luminosity is calculated for each tick using the Exposure Group scalers.

$$\mathcal{L}_{\mathrm{EG}} = \sum_{\mathrm{i=1,159}} \frac{\Delta\text{exposure scaler}_{\,\mathrm{i}}}{\Delta\text{ticks}/159} \mathcal{L}_{\mathrm{i}}$$

We cannot store information about correlations between Exposure Groups, so every Exposure Group must be treated independently.

This is one reason why we do not report luminosity per run.

Triggered Luminosity

The luminosity per Level 1 trigger is

$$\mathcal{L}_{\mathrm{L1\,bit}} = \frac{\Delta\mathrm{decorrelated\ scaler}}{\Delta\mathrm{ticks}}\,\mathcal{L}_{\mathrm{EG}}.$$

You cannot inclusively utilize L1 triggers belonging to different Exposure Groups in your normalized analyses.

Recorded Luminosity

Luminosity is always calculated per L1 trigger. The luminosity of a L3 trigger requires adjusting for prescales at L2 and L3 and correcting for losses downstream of L2.

The zero_bias and min_bias triggers are not rejected by the trigger. We can use these triggers to account for DAQ losses.

$$\mathcal{L}_{\rm recorded}(\rm n) = \frac{\#\text{zero\_bias}_{\rm recorded} + \#\text{min\_bias}_{\rm recorded}}{\#\text{zero\_bias}_{\rm L1} + \#\text{min\_bias}_{\rm L1}} \, \mathcal{L}_{\rm L1}(\rm n).$$

This correction methodology requires that the zero_bias and min_bias triggers are handled exactly the same way as the other triggers — differences bias the recorded luminosity.

Losses not accounted for by this method must be included in the trigger efficiency.

Luminosity Data Acquisition

The luminosity data acquisition system records information necessary for measuring and monitoring luminosity at DØ. It reads and stores the detector and trigger scalers, information about Level 3, and event catalogs from Datalogger. The $\mathcal{L}$DAQ also serves as the gateway between Beams Division and DØ. The $\mathcal{L}$DAQ has been running since July 2000.

v0 July 2000 through February 2001 (80 nb^{-1} recorded)
v1 March 2001 through October 2001 (11.5 pb^{-1} recorded)
v2 Current

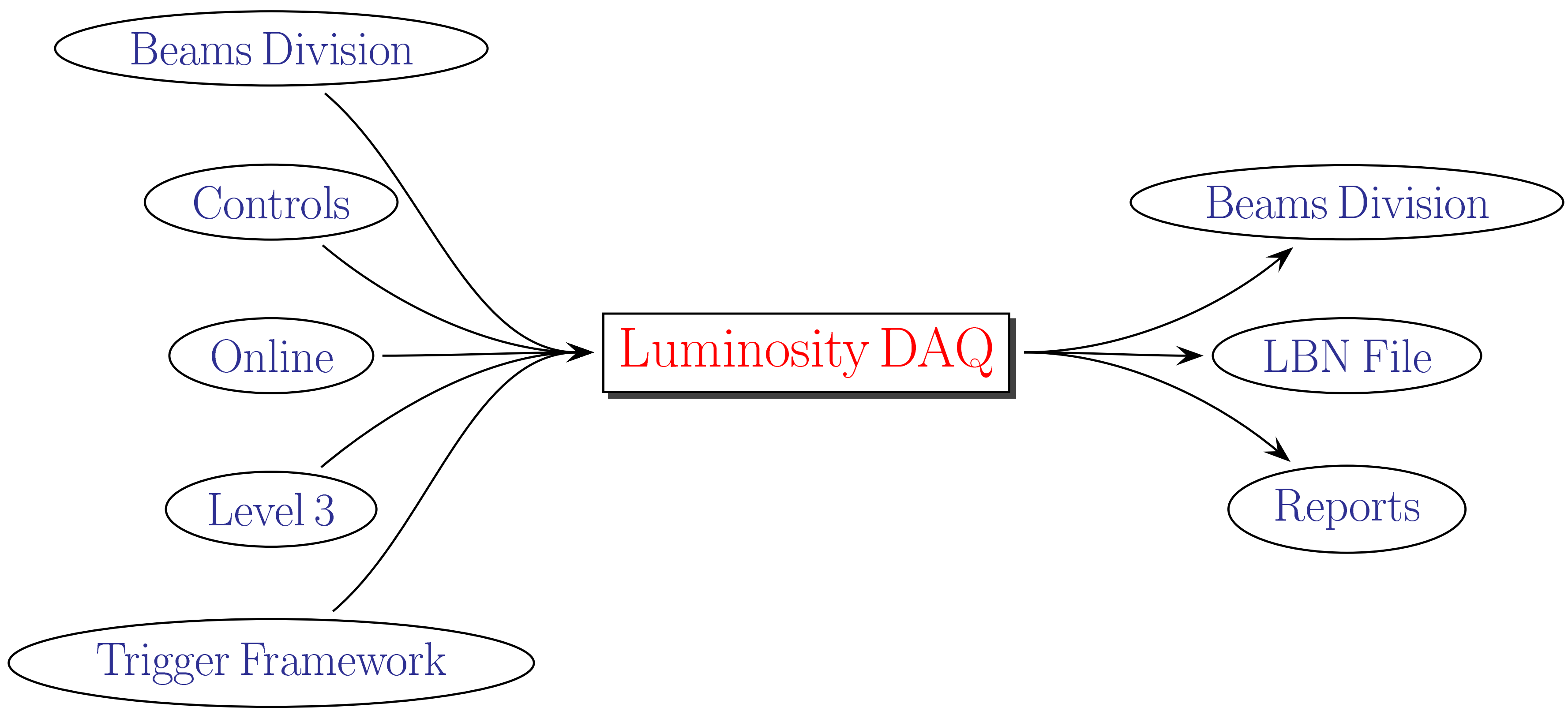
Luminosity Block

The Luminosity Block is the period of time over which all luminosity related quantities are measured. It is nominally 1 minute long.

The Luminosity Block Number (LBN) is the unique index for the luminosity blocks. It is a 32-bit number and increases through Run 2. The first official LBN was on April 20, 2001; there are about 1 million LBN per year.

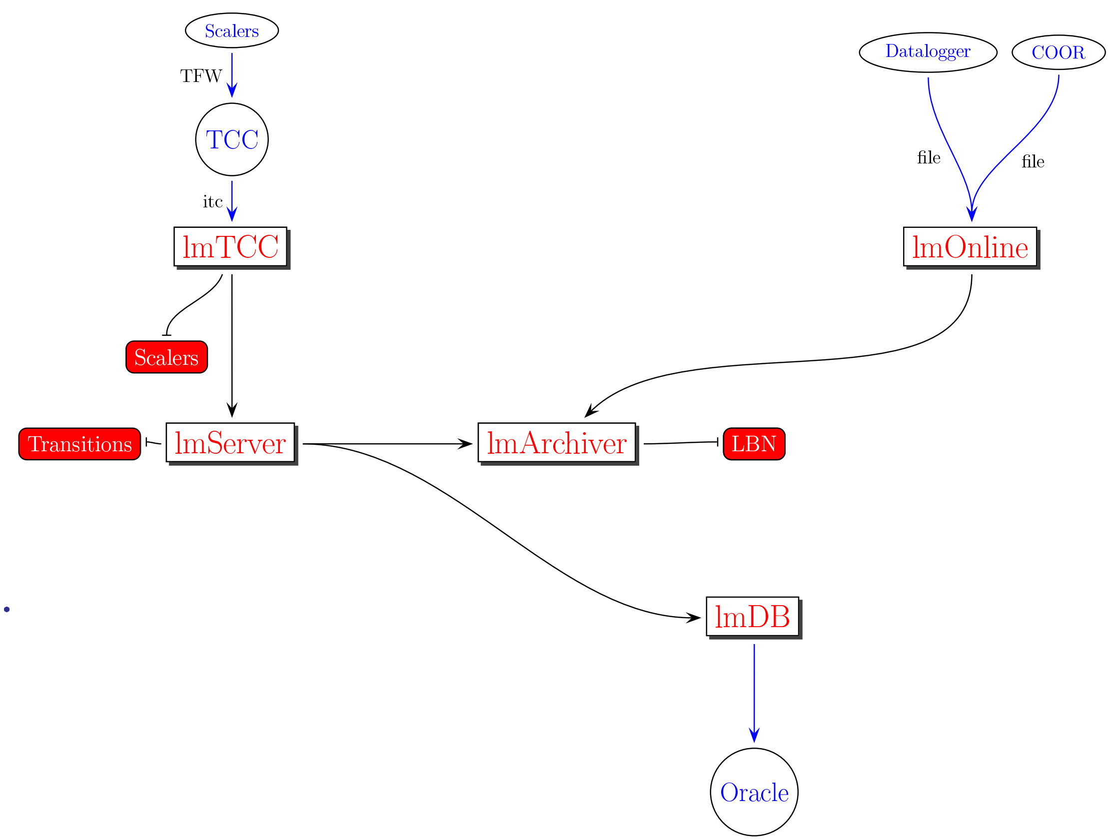
- The LBN is incremented upon store transitions (begin/end), run transitions (begin/end/pause/resume), inits (SCL, TFW), by request (COOR, Luminosity DAQ), and, otherwise, by 60-second timer.
- The LBN is stored in the event record in the TFW chunk.
- The LBN, event number, and run number uniquely identify an event.

Luminosity Data Acquisition



$\mathcal{L}$DAQ **Luminosity Data Taking**

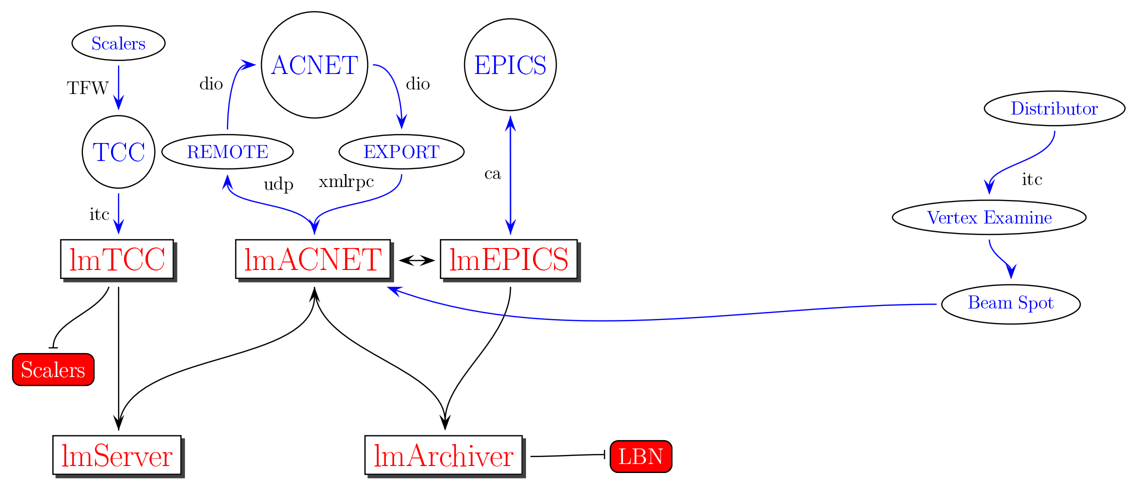
- Acquire scaler data via TCC, calculate the luminosity, and store it to disk.
- Read Datalogger and COOR files and store normalization information to disk.
- lmTCC stores scalers locally in case there are $\mathcal{L}$DAQ problems.
- Single point of failure is the connection between TCC & lmTCC (scalers).



- All data is recoverable as long as the connection to the TCC is live.
- This is the minimum information necessary to normalize the data.

$\mathcal{L}$DAQ **Accelerator Gateway**

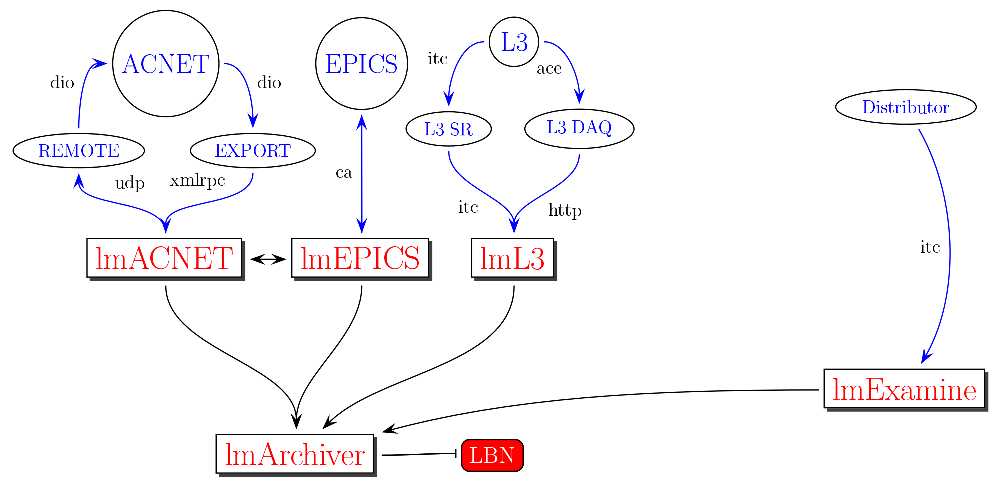
- Main interface between Beams Division controls system (ACNET) and DØ controls system (EPICS).
- Gateway used for Luminosity, Radiation Monitoring, FPD, Magnets, Beam Spot Monitoring, etc.
- Uses XML-RPC format to receive data from ACNET (EXPORT), but still uses binary UDP format to send data (REMOTE).



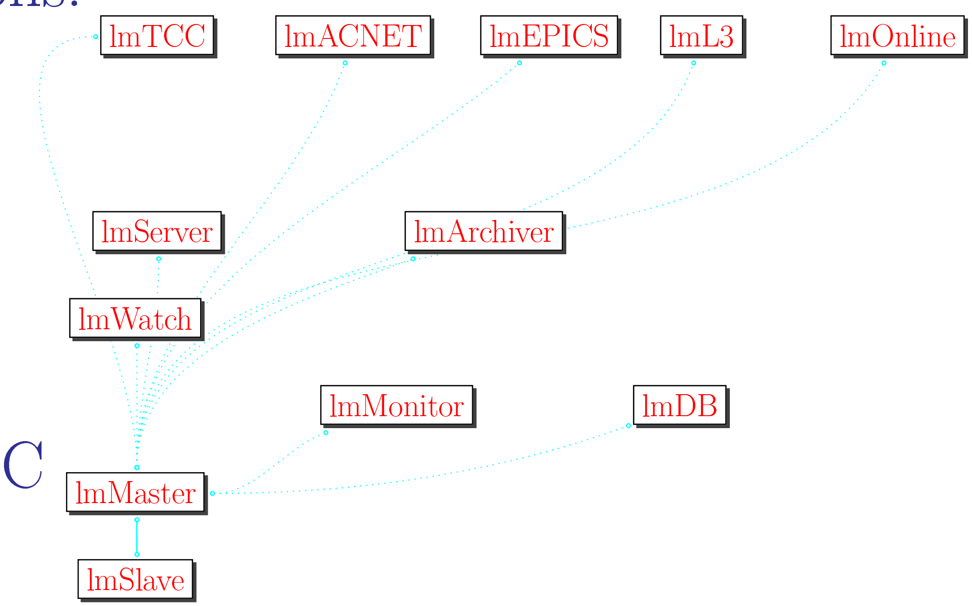
- Transfers information between lmACNET applications and lmEPICS.
- The gateway has two dedicated di-NIC computers – one NIC in BD subnet, one NIC in Online subnet (no routing).

$\mathcal{L}$DAQ **Luminosity Monitoring**

- Monitors normalization quality using information from ACNET, EPICS, and L3. This will eventually include a dedicated Examine.
- Data include:
  - HV & magnet settings;
  - Per-bunch intensities and coalescence;
  - CDF measurements;
  - Lost events (missing crates) by trigger;
  - ScriptRunner I/O by trigger (L3 accepts).



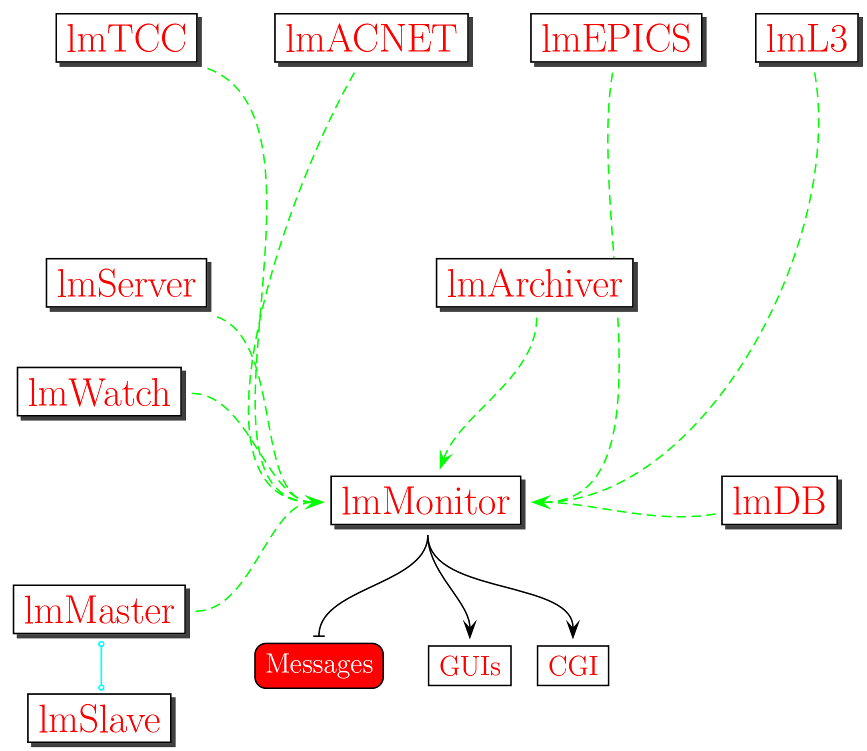
$\mathcal{L}$DAQ **Command & Control**



- Routes commands between applications.
- Keeps track of all applications.
- Extensive heartbeat system.
- Supported by numerous cron jobs (application downtime $\approx$ 1 minute).
- lmSlave runs on a different computer than lmMaster and maintains the C&C network if lmMaster exits. Monitors lmMaster for performance and sanity.
- lmWatch runs on every computer used for the $\mathcal{L}$DAQ. Can execute arbitrary shell commands; monitors system resources.

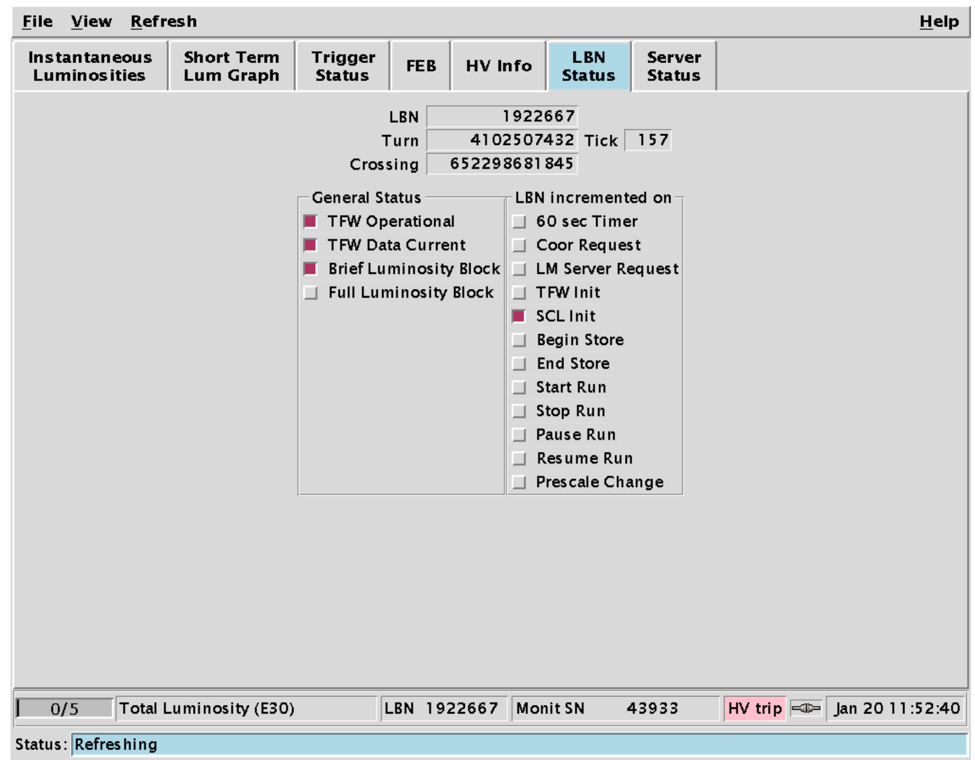
$\mathcal{L}$DAQ **Monitoring System**

$\mathcal{L}$DAQ has an internal monitoring system. lmMonitor receives data and status messages from every $\mathcal{L}$DAQ application. Data are collated and passed to various client processes.



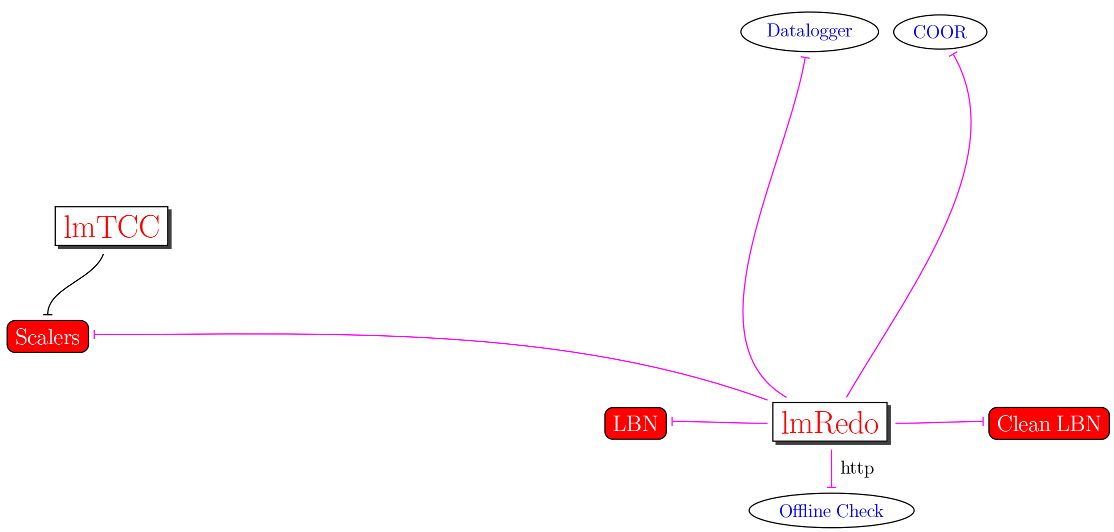
$\mathcal{L}$DAQ Monitoring GUIs

- Several variants of the GUI run in the Control Room.
  - lmExpert for Luminosity experts
  - lmCaptain for Shift Captains
  - lmShifter for DAQ shifters
  - lmTrigger for Global Monitor shifters
  - lmFPD for FPD shifters
- Uses the standard D0Gui package.



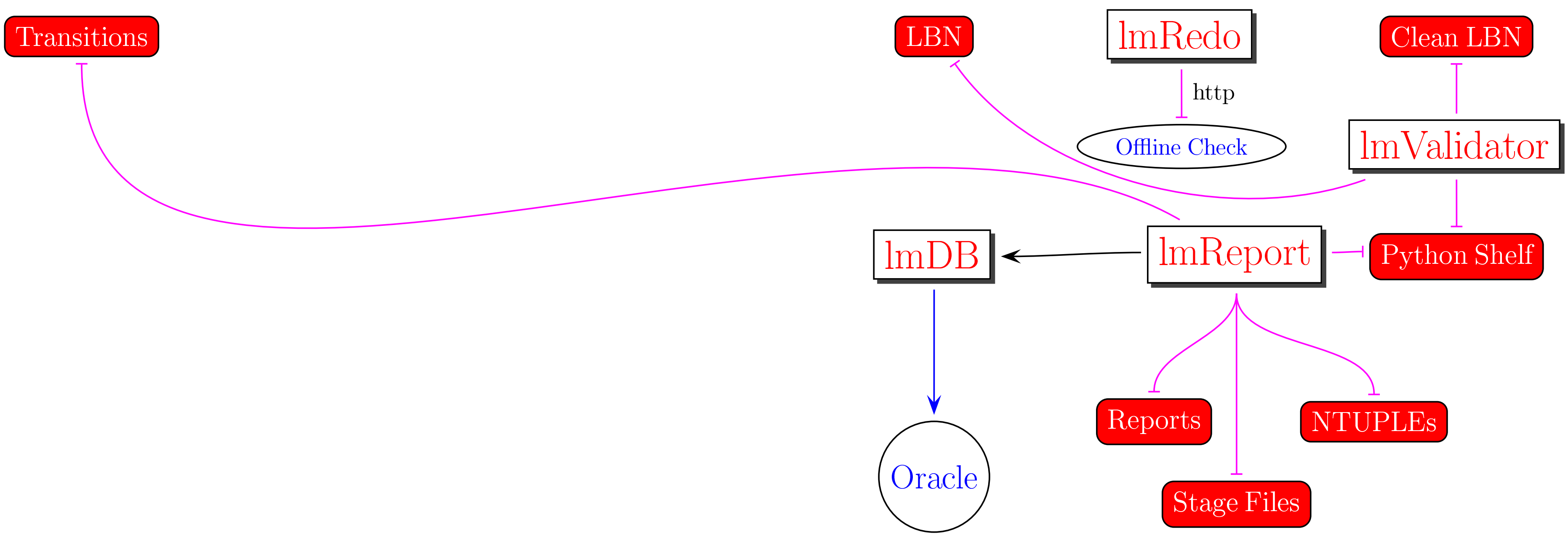
$\mathcal{L}$DAQ **Recovery**

There is a full recovery system (lmRedo) that can recreate LBN files from source information (lmTCC, Datalogger, COOR). It is also used to repair scaler information. In addition, lmRedo acquires data collected by the offline luminosity checks (run on every farm-produced root-tuple or thumbnail).



$\mathcal{L}$DAQ **Validation & Reporting**

Luminosity scalers are validated daily, weekly, monthly, and whenever necessary. Validated data are stored in a python database. These shelves are processed by lmReport to create the operations reports and normalization files.



Validation

Luminosity inputs are periodically validated:

- Scalers
  - $\mathcal{L}$DAQ LBN files
  - lmTCC scaler files (TCC dumps)
- COOR
  - brun & erun files
  - Runs database
- Datalogger
  - event catalogs
  - run summaries
  - lost event catalogs
  - SAM

Bad scalers are fixed where possible.

Is this a good luminosity block?

- Is the scaler file available? Is the data OK?
- Was the Luminosity Monitor High Voltage on and at the proper value?
- Was the TFW operational? Are the scalers self-consistent?
- Was this a good DAQ or Trigger "run"
  (e.g., bad hardware, stuck bits, multibuffering errors)?
- Are we in a store?
- Was there any delivered luminosity?
- Were any events lost between ScriptRunner and Datalogger?

Is this run normalizable?

- Was the run recorded?
- Did it use an official trigger list?
- Was the trigger configuration type physics or global?
- Was there at least one exposure group with a valid zero_bias and min_bias trigger defined?
- Did COOR and L3 agree on the run number?

Is this a normalizable trigger?

- Did the trigger belong to a normalizable exposure group?
- Was the trigger exposed? Did the exposure make sense?
- Does the $\mathcal{L}$DAQ know the trigger name?
  Did it contain NOLUM?
- Was the prescale valid? Did it have a L3 prescale?
- Do COOR and TCC agree on the prescale and exposure group?
- Do TCC and L3 agree about the trigger bits?
- Do COOR and L3 agree on the trigger name and bit assignment?
- Does the trigger satisfy unitarity?

Unitarity Violation

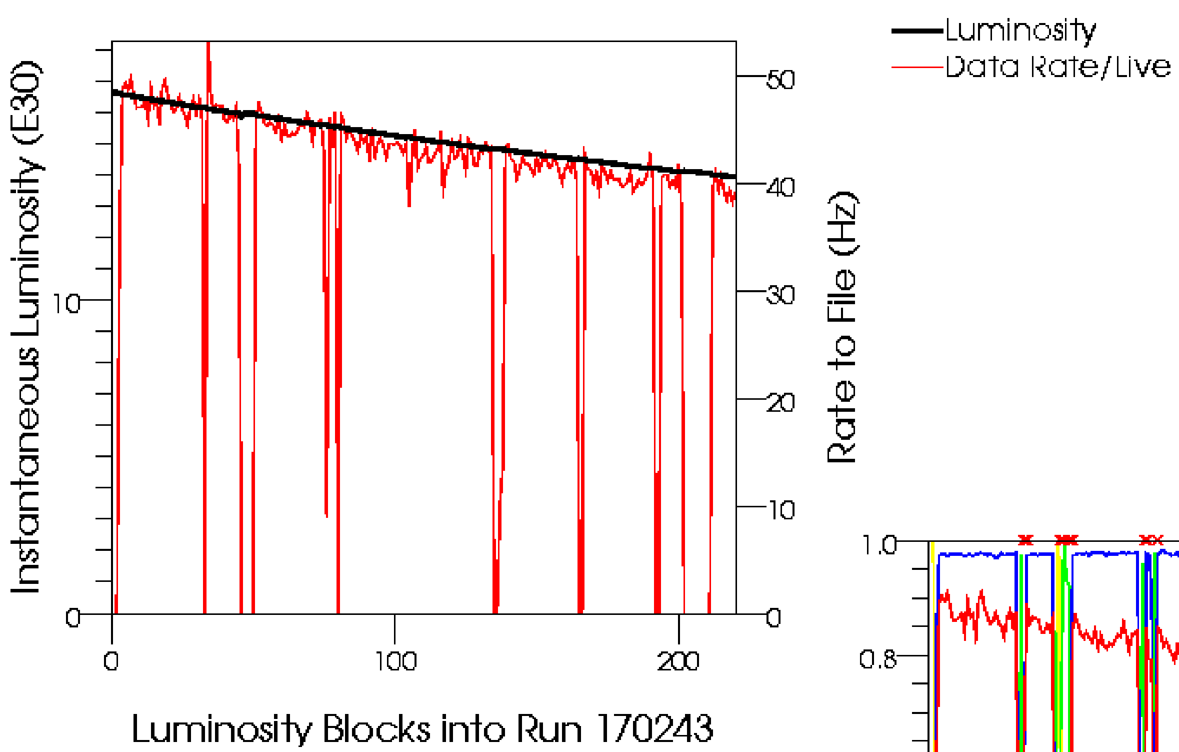
- more accepts at L3 than L1
- more accepts at L2 than L1
  (jitter of ± 16 due to multibuffering)
- number of accepts at L1 and L2 differ for min_bias and zero_bias triggers
  (jitter of ± 16 due to multibuffering)
- rejection at L2 prior to start of L2 triggering (LBN$<$ 1158684)
- more events recorded from L3 than accepted by L1, L2, or L3 or recorded from L2
- more events recorded from L2 than accepted by L1, L2, or recorded from L1
- more events recorded from L1 than accepted by L1

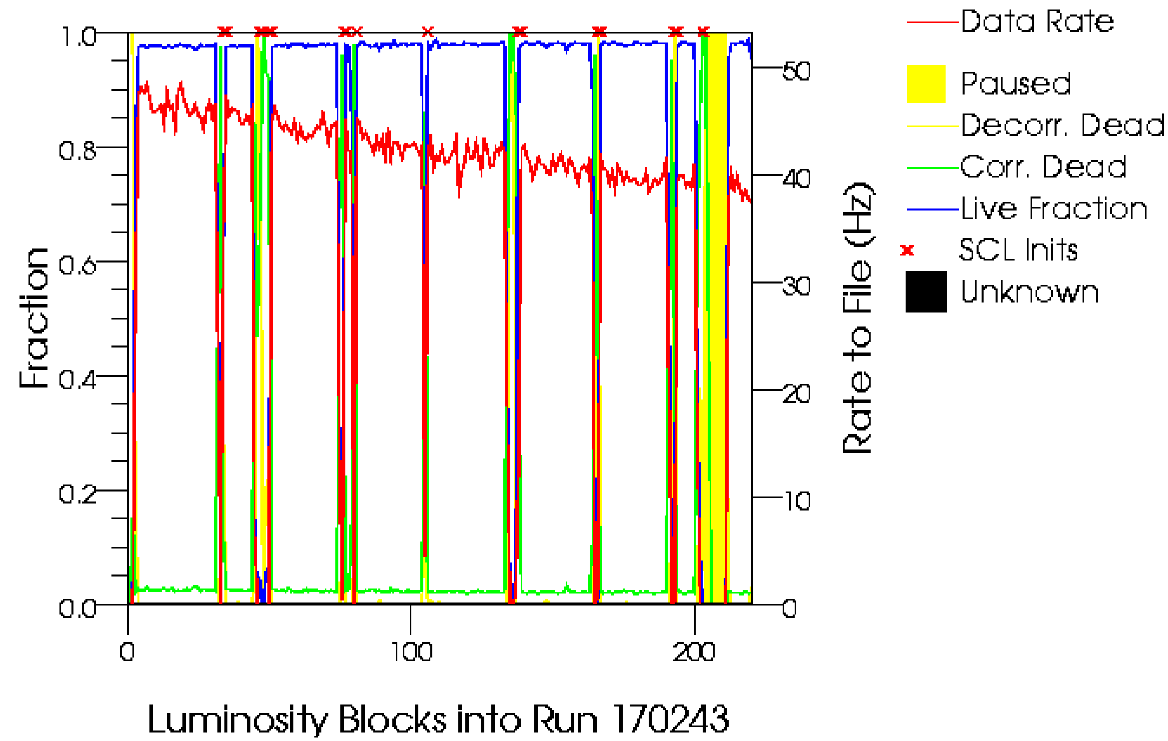
Streaming Checks

- Do COOR and Datalogger agree on the defined streams?
- Did the events end up in allowed streams?
- Were any streams/files missing?

Operations Reports

http://www-d0online.fnal.gov/www/groups/lum/reports





Reconstructed Luminosity

Every file created by the production farms is checked by the Luminosity group. The reconstructed luminosity is valid (equal to the recorded luminosity) for a given software version if

- The file information in SAM was self-consistent;
- The number of reconstructed triggers agrees with the number of recorded triggers for each trigger in the file in the block;
- All streams are reconstructed and available.

MINTS

http://www-d0.fnal.gov/phys_id/luminosity/data_access/processing_status

Summaries by trigger type

Trigger	Number of runs	First run	Date	Last run	Date	RAW data events	DST events	thumbnails or ROOT tuples	Last update
global_CMT_10.0	21	170247	09-JAN-03	170374	12-JAN-03	4713303	0	0	20-JAN-03
global_CMT_9.5	94	169524	19-DEC-02	170246	09-JAN-03	30435319	28761775	26877686	20-JAN-03
global_CMT_9.3	161	168028	13-NOV-02	169523	19-DEC-02	43102931	42433283	41211078	23-DEC-02
global_CMT_9.2	81	167019	30-OCT-02	168033	14-NOV-02	17030440	16781001	16798916	25-NOV-02
global_CMT_8.4	154	165635	04-OCT-02	167015	30-OCT-02	33125644	27370799	26593601	25-NOV-02
global_CMT_8.30	66	164380	19-SEP-02	165601	04-OCT-02	9828423	7291973	7287594	14-OCT-02
global_CMT_8.20	159	162458	22-AUG-02	164321	19-SEP-02	28920697	10790477	10780538	14-OCT-02
global_CMT_8.10	91	161101	02-AUG-02	162351	22-AUG-02	12440997	5116423	4683430	14-OCT-02
global_CMT_8.00	51	160582	26-JUL-02	161620	09-AUG-02	4716356	1596608	1586365	14-OCT-02
global_CalMuon_noL2MU_7.4	139	158535	30-JUN-02	160554	26-JUL-02	20468424	9453545	6669210	14-OCT-02
global_CalMuon_7.4	4	158465	29-JUN-02	158532	30-JUN-02	47171	17143	0	14-JUL-02
global_CalMuon_7.4	4	158465	29-JUN-02	158532	30-JUN-02	47171	17143	0	14-JUL-02
global_CalMuon_7.3	39	155465	30-MAY-02	158069	26-JUN-02	2164822	1286601	581550	14-JUL-02
global_CalMuon_7.2	57	154566	17-MAY-02	155605	01-JUN-02	4805742	4114810	4116481	14-JUL-02
global_CalMuon_7.1	1	154494	17-MAY-02	154494	17-MAY-02	166205	148509	148509	14-JUL-02
global_CalMuon_7.0	10	153792	09-MAY-02	153889	10-MAY-02	794319	785123	785123	14-JUL-02
global_CalMuon_5.1	59	153170	02-MAY-02	154492	17-MAY-02	8296224	8029867	7544547	14-JUL-02
global_CalMuon_5.0	214	149269	22-MAR-02	153340	04-MAY-02	17055751	16329462	15971621	14-JUL-02
global_CalMuon_4.2	120	147717	28-FEB-02	149275	22-MAR-02	8883102	8585888	8406000	14-JUL-02
global_CalMuon_4.1	44	146437	14-FEB-02	147722	28-FEB-02	2780340	2723439	2688154	14-JUL-02
global_CalMuon_4.0	52	145626	07-FEB-02	146582	18-FEB-02	8341676	8255266	8210745	14-JUL-02
global_CalMuon_3.4	4	143816	19-JAN-02	143876	20-JAN-02	80390	80390	80390	17-MAY-02
global_CalMuon_3.3	129	143729	17-JAN-02	145599	07-FEB-02	5130382	5023855	5022050	14-JUL-02
global_CalMuon_3.2	3	143722	17-JAN-02	143725	17-JAN-02	97005	97005	97005	17-MAY-02
global_CalMuon_3.1	115	142198	23-DEC-01	143482	14-JAN-02	3765628	3755115	3755115	17-MAY-02
global_CalMuon_3.0	36	141737	18-DEC-01	142145	22-DEC-01	443761	441728	441728	17-MAY-02
global_CalMuon_2.1	42	140695	09-DEC-01	141724	18-DEC-01	840467	840465	840465	17-MAY-02
global_CalMuon_2.0	101	139626	28-NOV-01	140686	09-DEC-01	1378325	1372741	1370580	17-MAY-02
global_CalMuon_1.5	26	132830	04-OCT-01	133020	06-OCT-01	686250	504656	499858	17-MAY-02
global_CalMuon_1.4	69	132320	27-SEP-01	132650	02-OCT-01	806493	622157	582001	17-MAY-02
global_CalMuon_1.3	46	131788	20-SEP-01	132170	26-SEP-01	1482242	1431442	1404509	17-MAY-02
global_CalMuon_1.2	36	131371	17-SEP-01	131781	20-SEP-01	456124	386785	379937	17-MAY-02
global_CalMuon_1.1	45	131101	14-SEP-01	131365	17-SEP-01	1057289	888066	866855	17-MAY-02
global_CalMuon_1.0	35	130448	06-SEP-01	131093	14-SEP-01	871949	688807	670504	17-MAY-02
cosmics	238	129285	26-AUG-01	160181	20-JUL-02	3813807	74438	74438	14-OCT-02
minimum_bias	17	139615	28-NOV-01	168727	02-DEC-02	737327	520427	520427	14-DEC-02
zero_bias	1702	129290	26-AUG-01	170699	19-JAN-03	8906281	260838	258570	20-JAN-03
others	357	129194	25-AUG-01	170323	10-JAN-03	11267001	6348699	5797559	20-JAN-03

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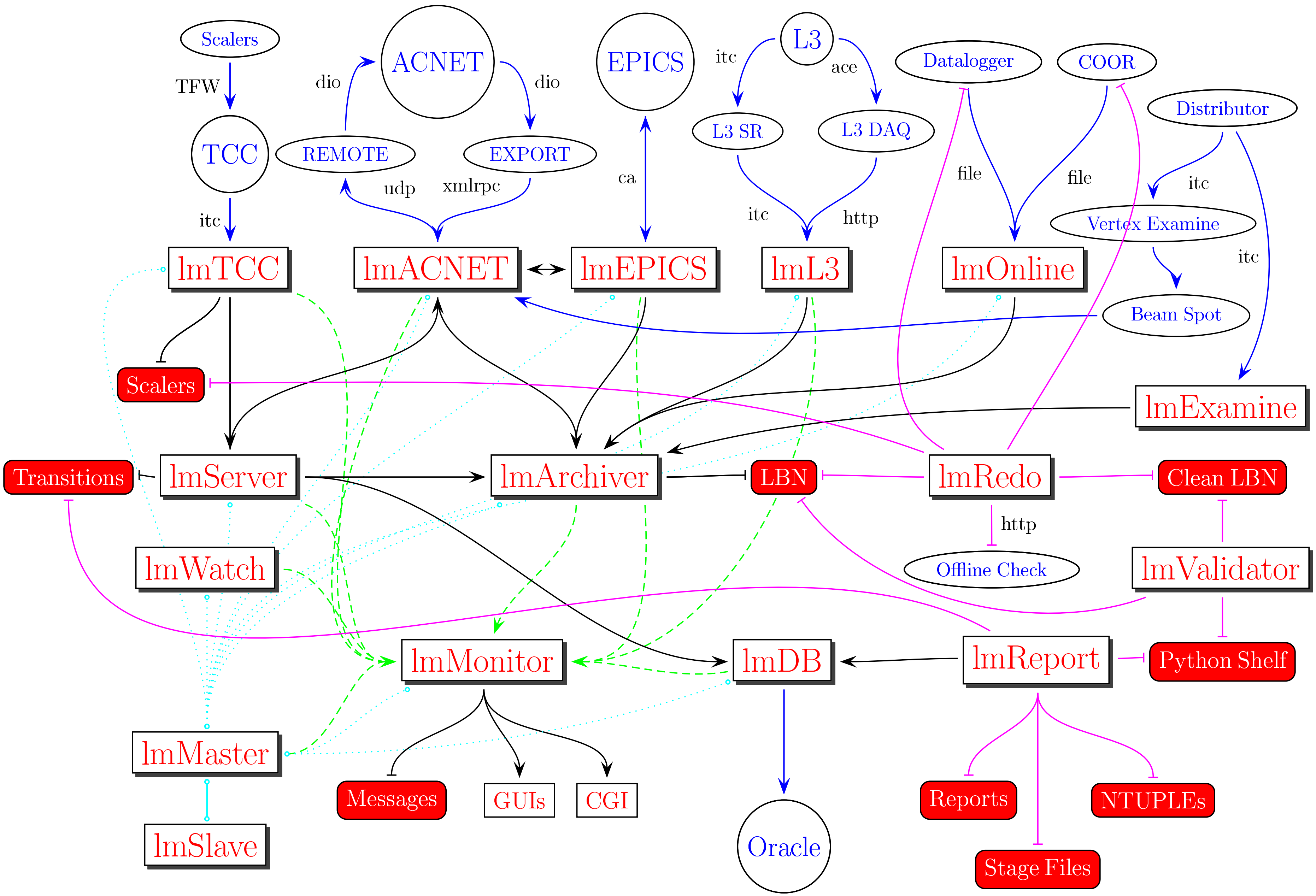
Luminosity Data Acquisition



Acquired Luminosity

Year	Month	Store Time (hours)	Luminosity (pb^{-1}) Delivered	Recorded	Processed	Events (millions)
2000	October		0.04			
	November		0.04			
2001	April					
	June	208.5	0.05			
	July	125.6	0.76			
	August	356.1	4.35	0.08	0.08	1.7
	September	375.6	4.77	0.50	0.50	5.8
	October	61.8	1.15	0.06	0.06	0.9
	November	16.8	0.17	0.00	0.00	0.1
	December	336.4	4.30	0.23	0.23	3.9
2002	January	307.1	3.56	0.16	0.16	3.8
	February	267.5	5.47	1.68	1.65	13.4
	March	332.1	6.59	2.44	2.25	11.8
	April	249.2	7.71	3.05	2.45	12.1
	May	295.4	10.48	3.07	2.58	10.4
	June	89.6	1.32	0.52	0.37	3.0
	July	282.8	9.21	5.40	2.26	21.6
	August	316.4	11.09	6.35	2.87	22.5
	September	367.1	16.49	9.24	7.27	29.4
	October	378.3	21.65	13.92	13.87	34.2
	November	354.0	20.60	15.44	15.36	35.1
	December	370.4	22.65	17.08	16.74	37.2
2003	January	147.8	8.88	6.57	6.18	19.2

Moriond 2003 Sample

Year	Month	In Store (hours)	Luminosity (pb^{-1})				Events (millions)
			Delivered	Recorded	Processed	p13.04/5/6	
2002	June	89.6	1.32	0.52	0.37		3.0
2002	July	282.8	9.21	5.40	2.26		21.6
2002	August	316.4	11.09	6.35	2.87	1.30	22.5
2002	September	367.1	16.49	9.24	7.27	7.09	29.4
2002	October	378.3	21.65	13.92	13.87	13.36	34.2
2002	November	354.0	20.60	15.44	15.36	15.05	35.1
2002	December	370.4	22.65	17.51	17.08	17.08	37.2
2003	January	147.8	8.88	6.57	6.18	6.18	19.2
Moriond		2306.4	111.89	74.95	65.26	60.06	202.2

Accessing Luminosity Offline

- A tool exists to access the luminosity from the offline analysis code. This package is called lm_access and is available in CVS.
- lm_access provides the integrated luminosity per trigger per LBN.
- We also provide instantaneous luminosities, etc, but there are currently no access methods implemented.
- Luminosity can only be retrieved for good LBNs. You MUST exclude data from bad LBNs in your normalized analyses!
- Each LBN resides in a file on d0mino & clued0. Do not make your own copies of these files! They are subject to change without notice.
- Included in this package are tools for handling some offline bookkeeping tasks.
- More information on this tool may be found on the Luminosity ID web pages.