

First experiences operating and using ILDG 2.0

Gunnar Bali & Giovanni Pederiva

Ed Bennett, David A. Clarke, Issaku Kanamori, Giannis Koutsou, Hideo Matsufuru, Hiroshi Ohno, Dirk Pleiter, Antonio Rago, Hubert Simma

*On behalf of the Working Groups and Board of the
International Lattice Data Grid*



27/07/2026, College Park, MA, USA
43rd International Symposium on Lattice Field Theory

ILDG 2.0 and its Operation

What is the ILDG?

International Lattice Data Grid

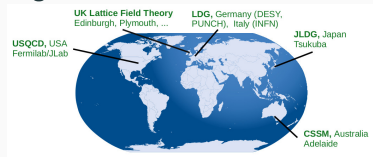
<https://ildg.net>

- Established in 2002, to allow sharing of lattice QCD gauge configurations
- Federation of autonomous Regional Grids, forming a single **Virtual Organization (VO)**
- Composed of **ILDG board**, **Metadata (MDWG)** and **Middleware (MWWG)** working groups
- ILDG defines **specifications** for metadata schema, file format, API

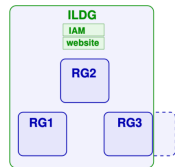
Standardization enables:

- sharing ensembles within collaborations
- sharing across collaborations
- reproducibility of results

Regional Grids

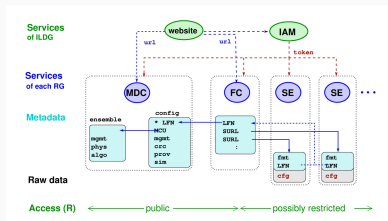


- Provide catalogue services and storage elements
- Can apply specific policies and technologies



Highlights of ILDG 2.0

- Revised Metadata schemata, fully FAIR-compliant and addressing all known user requests
- New central user registration (IAM/eduGAIN)
- Complete transition from certificates to tokens
- New catalogue implementation, easy to deploy
- Reactivation of regional grids
- Hands-on 2025 for data providers enabled new uploads



MDC: Metadata catalogue, FC: File catalogue, SE: Storage element

We are now **fully operational** and accept new ensembles from data providers!

- ☐ Acceptable Use Policy
- ☐ VO Policy

Many new features were part of the ILDG 2.0 revamp:

- The new metadata schema QCDml 2.0 was designed to incorporate requests from 9 collaborations/initiatives (CLS, ETMC, FASTSUM, HotQCD, JLQCD, OpenLAT, PACS, QCDSF, TELOS)
 - reduced data format, packing of multiple configurations into one file
 - license statement and funding information
 - **required acknowledgment/citation**
 - new actions, e.g. QCD+QED
 - new gauge groups beyond SU(3)
 - open boundary conditions
- Support of embargo periods
 - was requested for collaboration-internal sharing of data
- File transfer service (FTS) with token-based authentication

Current Status of ILDG 2.0

- ILDG 2.0 is fully operational since 2025
- 3 Regional Grids are active (JLDG, LDG, UKLFT)
- 14 collaborations showed interest in making their ensembles available (≈ 900 ensembles, ≈ 9 PB of data)
- Work is underway on improving the user tools and facilitating the upload of new ensembles
- Latest minor update: QCDmlEnsemble2.0.1.xsd (April 2026)
 - Added anisotropic improved gauge action upon request from the FASTSUM collaboration
- Discussion on data publishing/DOI in progress

ILDG Uploads Over the Past Year

	Ensembles	Configurations	Data Volume (TB)
JLQCD	1	100	0.12
HotQCD	8	60000	55
ETMC	1	??	??
CLS	48	39000	205
OpenLAT	1	??	??

HotQCD are using the new packaging format with ~ 100 configs per binary file.

How to Download an Ensemble from ILDG

How to Download an Ensemble

Step 1: Search for an ensemble in the ILDG catalogue, using e.g. [simple listings](#), [FacetNavi](#) or [the web-gui](#). Obtain its Markov Chain URI (MCU), i.e. its unique identifier

The screenshot shows the ILDG Metadata Catalog Web Interface. At the top, there's a navigation bar with "Ensemble" and "Gauge Fields" tabs. Below the navigation bar, a yellow warning box states: "The web interface is still under development and not fully stable." The main content area is titled "Ensemble Collection" and contains a table with the following data:

Catalog	URI	Collaboration	Project	Creation Date
LDG	mc://ldg/etmc/tmqcd_nf2/1N200-000	CLS	NF-2+1	2025-05-07T18:03:50Z
LDG	mc://ldg/etmc/tmqcd_nf2/1N200-001	CLS	NF-2+1	2025-05-07T18:03:50Z
LDG	mc://ldg/etmc/tmqcd_nf2/1N200-002	CLS	NF-2+1	2025-05-07T18:03:50Z
LDG	mc://ldg/etmc/tmqcd_nf2/1N200-003	CLS	NF-2+1	2025-05-07T18:03:50Z
LDG	mc://ldg/etmc/tmqcd_nf2/1N200-004	CLS	NF-2+1	2025-05-07T18:03:50Z
LDG	mc://ldg/etmc/tmqcd_nf2/1N200-005	CLS	NF-2+1	2025-05-07T18:03:50Z

Below the table, there's a "Search Filters" section with a "Markov Chain URI" input field and a "Management" dropdown menu. The "Management" dropdown is currently set to "All rights reserved".

The screenshot shows the ILDG Metadata Catalog Web Interface. At the top, there's a navigation bar with "Ensemble" and "Gauge Fields" tabs. Below the navigation bar, a yellow warning box states: "The web interface is still under development and not fully stable." The main content area is titled "Details of Ensemble mc://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003". The details are organized into several sections:

- Catalog:** LDG
- markovChainURI:** mc://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003
- Management:**
 - Collaboration: etmc
 - Project name: tmqcd_nf2
 - Archive History: action = add; participant = 0000-0003-1412-7502; date = 2008-06-23T12:20:24+00:00;
- License:**
 - License conditions: All rights reserved
- Physics:**
 - Size: $x = 20; y = 20; z = 20; t = 40;$
 - Glaze [M]: treelevel Symmetrized improved action (glossary: <http://www.lqd.org/ldg/action/Glossaries/treelevelSymmetrizedGlazeAction.pdf>)
 - Seta [M]: SU(3) gauge group, fundamental representation, BC: x:periodic; y:periodic; z:periodic; t:periodic; beta=4.05; nonlocalisation=wg; surf_is_ane; ds=1.69666667; c1=0.0833333333; c2=0.0; c3=0.0
 - Quark [M]: Wilson twisted mass action (glossary: <http://www.lqd.org/ldg/action/Glossaries/wilsonTwistedQuarkAction.pdf>)
 - nr2Laplace normalization, default (fundamental) representation, BC: x:periodic; y:periodic; z:periodic; t:periodic; numberOfflavors=2; kappa=0.15701; mu=0.003;

How to Download an Ensemble

Step 1b: Use MCU to query the catalogue for the list of configurations and their Logical File Names (LFNs)

List of Configurations (399)

[lfns://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0000](#)

[lfns://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0010](#)

[lfns://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0020](#)

[lfns://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0030](#)

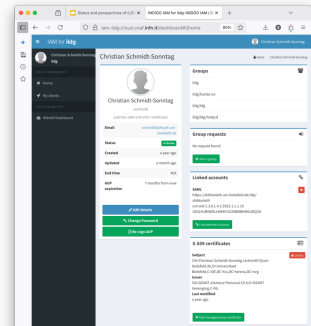
[lfns://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0040](#)

[lfns://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0050](#)

```
[koutsou1@]wlogin24 try-client]$ perl try-mdc -lc mc://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L2
[us_show] 'HASH'
#check = 'OK'
#Code = '200 OK'
#Op = 'GET'
#URL = 'https://ldfix-vml0.zeuthen.desy.de/ldg/etmc/config/query?mcu=mc://ldg/etmc
15701_mu0.0030limit=5000'
result → H[4]:
  limit = 5000
  offset = 0
  result → A[399]:
    lfn://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0000
    lfn://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0010
    lfn://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.0020
    ...
    lfn://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.3960
    lfn://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.3970
    lfn://ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.3980
  total = 399
  status = 'MDC_SUCCESS'
# DONE: 1 sec
```

How to Download an Ensemble

Step 2: Request membership of ILDG VO IAM and wait for approval



- At present $\exists \approx 110$ members.
- Registration of users may fail due to an eduGAIN non-compliant configuration of a new institution's identity provider.
- Due to eduGAIN integration, unrelated to ILDG or INDIGO IAM (Identity and Access Management).
- Detailed instructions are [here](#).

Step 2b: Install the ILDG client tools from:

<https://gitlab.desy.de/ildg/hands-on/try-client.git>

How to Download an Ensemble

Step 3 (optional): Use LFN to query the catalogue for the list of replicas and their Storage URLs (SURLs) (This does not strictly require VO membership.)

```
demo@zan526:~/try-client$ perl try-fc -ll lfn://ldg/cls/nf21/H200r000/H200r000n12
lfn                               | surl                               | created                               |
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
lfn://ldg/cls/nf21/H200r000/H200r000n12 | https://dcache-desy-webdav.desy.de:2800/pnfs/desy.de/ldg/ldg/cls/nf21/H200r000/H200r000n12.ln | 2025-07-03T00:05:15.370775Z |
Total = 1 (llnlt = 100)
# DONE: 0 sec
```

If multiple replicas of the same file are present, we can select the storage element from which to get our file.

How to Download an Ensemble

Step 4: Get a token from the ILDG IAM service. We need authentication to download files (e.g. embargo times for non-collab members).

```
demo@zam526:~/try-client$ perl try-token -c
[token] Using public client d945d43c-adf6-40c3-bfa0-c4c90b5e435b (access_token)

Please open the following URL in the browser and approve issuing of the token:
https://iam-ildg.cloud.cnaf.infn.it/device?user_code=7DZWEPS8

[token] ... authorization pending since 5 secs
```

How to Download an Ensemble

Step 5: Use LFN (or SURL, see step 3) to download the configuration.

```
demo@zan526:~/try-client$ perl try-se -get lfn://ldg/etmc/tmqcd_nf2/tlSym_b4.05_
L20T40_k0.15701_mu0.003/conf.3980
... downloading https://dcache.fz-juelich.de:2880/pnfs/fz-juelich.de/data/ildg/l
dg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.3980 to conf.3980
OK (200 OK) 18 sec get from https://dcache.fz-juelich.de:2880/pnfs/fz-juelich.de
/data/ildg/ldg/etmc/tmqcd_nf2/tlSym_b4.05_L20T40_k0.15701_mu0.003/conf.3980
-rw-rw-r-- 1 demo demo 184321760 Jul 24 14:56 conf.3980
```

Caveat:

When the storage element is a tape archive, the files first need to be staged to disk. This can take a long time. It is recommended to cache all the required configurations first, before proceeding to the download.

User Experiences (Example: CLS)

- Information (except funding) was already automatically collected during ensemble generation and scripts existed to display this on an internal webpage.
- Corresponding scripts for conversion into the necessary QCDml (QCD markup language) metadata and for file conversion had to be developed.
- The standard (mostly automatized) workflow is
 1. Get configs from (tape-)archive
 2. Convert, pack and upload configs
 3. File catalogue (FC) registration
 4. Extract and pack metadata into the config and ensemble XMLs, adding funding info and publications
 5. Upload the XMLs
- Throughput:
 1. / 2. 10 TB/day (however, delays due to busy tape robot and manual recovery from mirror if tape broken)
 3. 1000 configs/second
 4. / 5. 1000 configs/min (after manually adding the missing info)

Please Contact Us!

Should any problems arise, please contact the email below:

[ildg-contact\(at\)desy.de](mailto:ildg-contact(at)desy.de)

We are happy to help you!

Acknowledgements

Development, setup and operation of ILDG 2.0

Basavaraja Bheemalingappa Sagar, Ed Bennett, Daniel Knüttel, Craig McNeile, Hiroshi Ohno, GP, Hubert Simma, Osamu Tatebe, INDIGO-IAM team at INFN-CNAF, IT teams at DESY, Jülich, U. Tsukuba

ILDG working groups

Giuseppe Andronico, Basavaraja Bheemalingappa Sagar, Carleton DeTar, Georg von Hippel, Olaf Kaczmarek, Giannis Koutsou, Hideo Matsufuru, Yoshifumi Nakamura, Hiroshi Ohno, GP, Dirk Pleiter, Antonio Rago, Hubert Simma, James N. Simone, Carsten Urbach, Tomoteru Yoshie

ILDG board

Yasumichi Aoki, Ed Bennett, Francesco Di Renzo, Robert Edwards, Frithjof Karsch, Yoshinobu Kuramashi, Derek Leinweber, Hideo Matsufuru, Craig McNeile, Hubert Simma, James Simone, Finn Stokes

LDG: Lattice4PUNCH

GB, Olaf Kaczmarek, Frithjof Karsch, Daniel Knüttel, Stefan Krieg, GP, Christian Schmidt-Sonntag, Carsten Urbach, Tilo Wettig

GB and GP acknowledge funding by the Deutsche Forschungsgemeinschaft (DFG) under project number 460248186 (PUNCH4NFDI).