KLOE-2 Status

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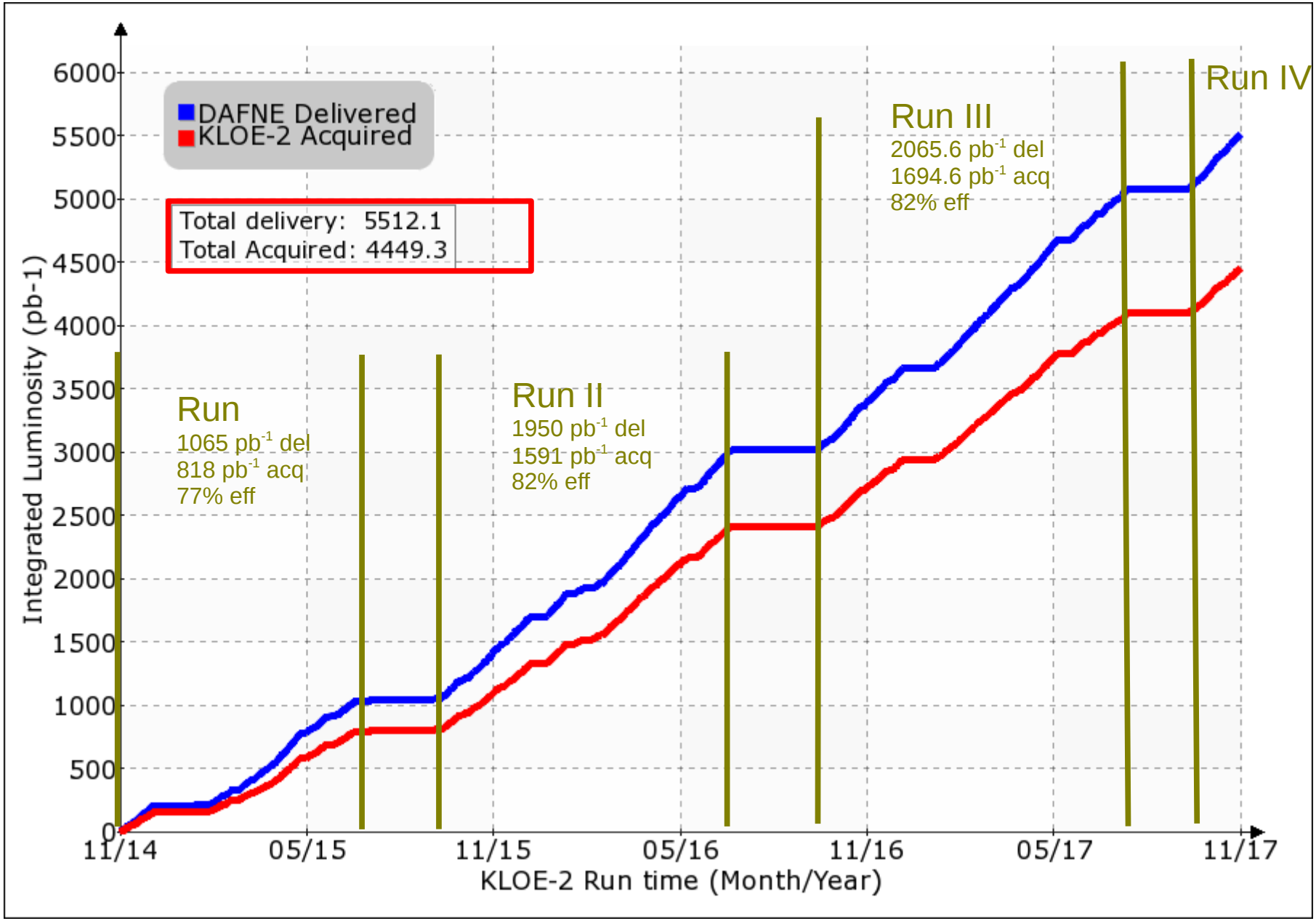
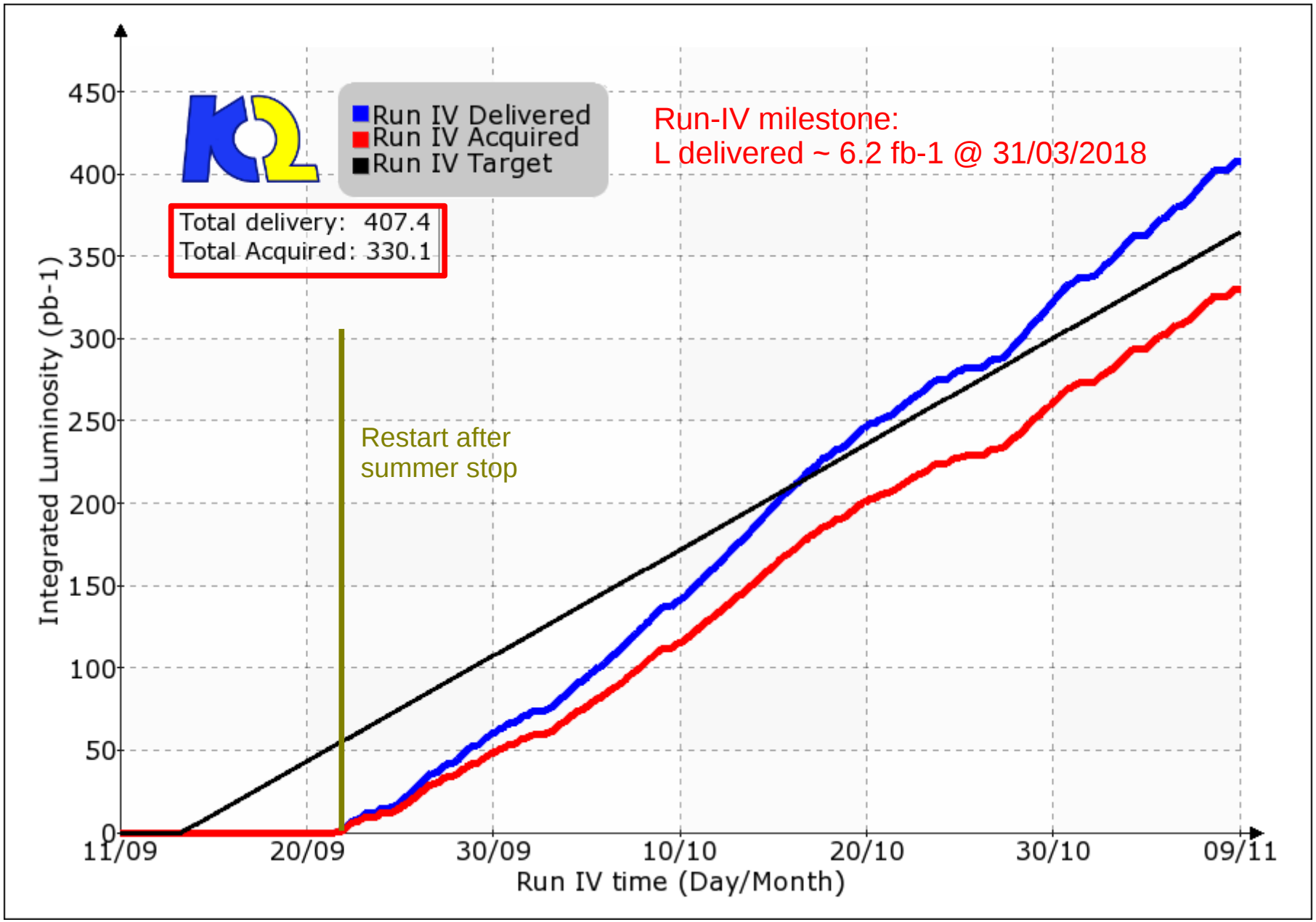
On behalf of the KLOE-2 collaboration

54th LNF Scientific Committee Meeting
Frascati, 13 November 2017

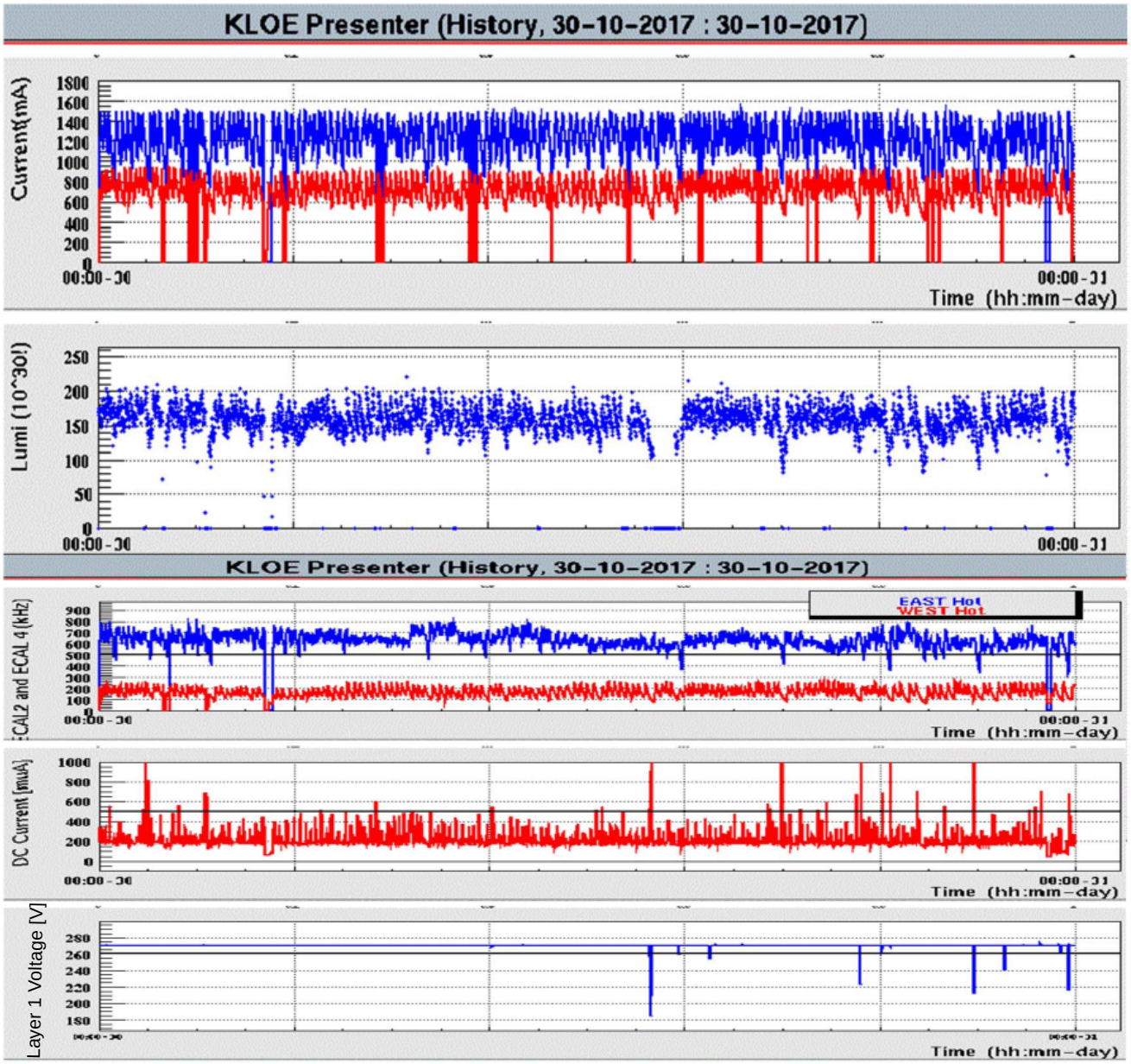
Data taking Summary



Data taking Run-IV



Daily Activities



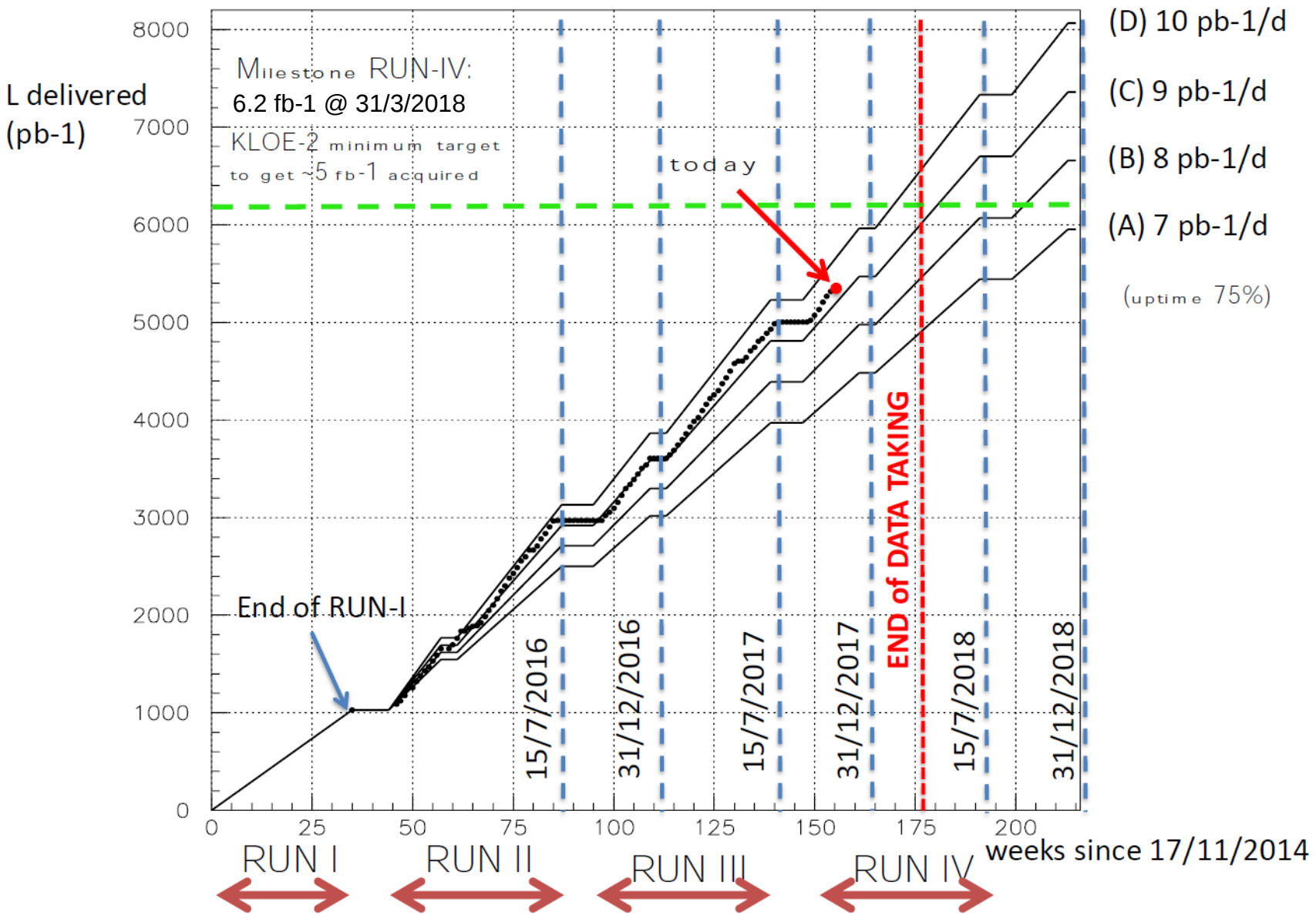
L delivered: ~13.52 pb-1
L acquired: ~10.75 pb-1

Hot End-caps counters
electrons now over 500 kHz
positrons < 300 kHz

DC averaged integrated current
Mostly < 400 μA

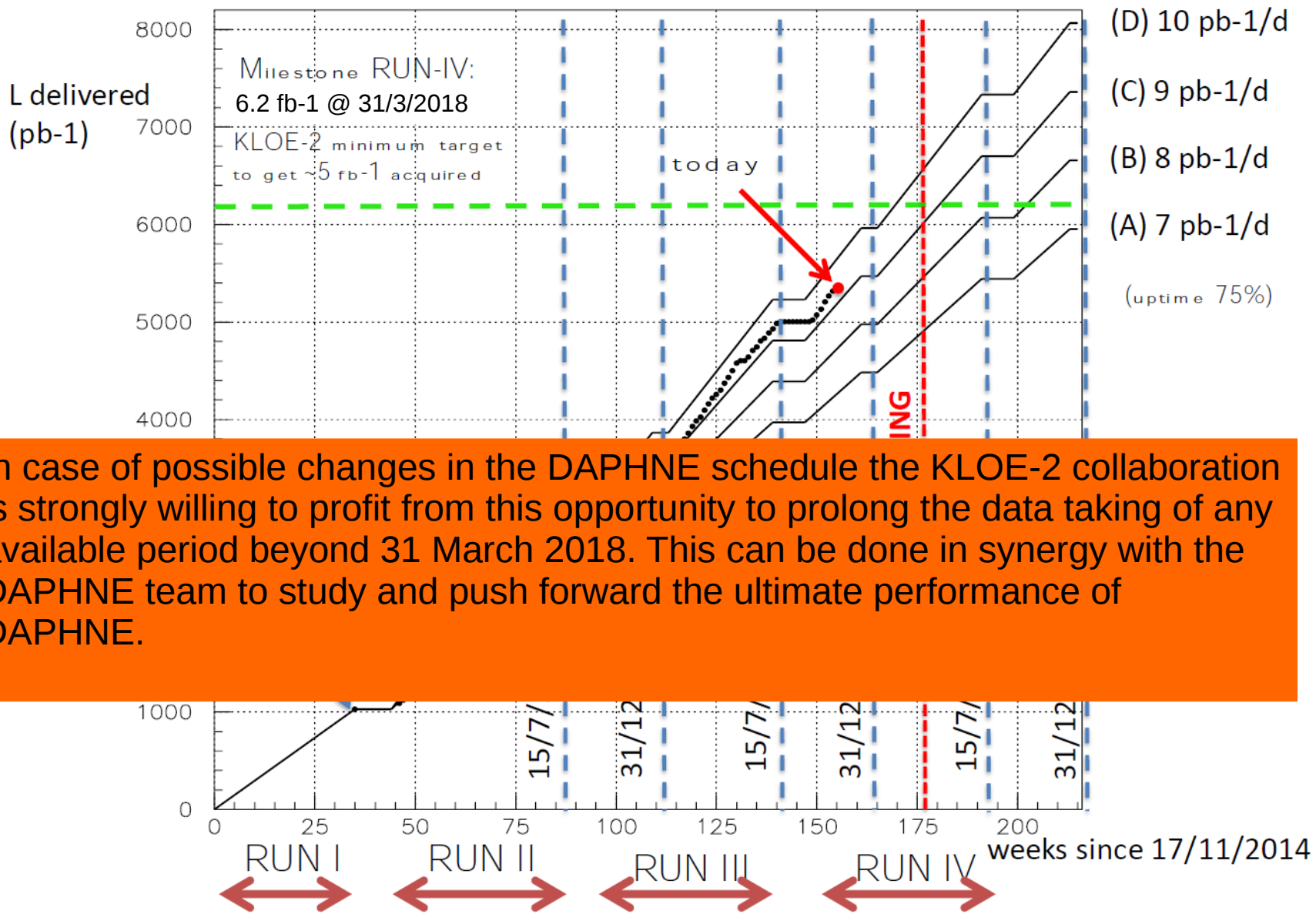
IT layer 1 voltage

Data taking plan



RUN-III milestone L > 2 fb-1 accomplished: L delivered 5 fb-1
in line with the minimum requirement of 6.2 fb-1 => L acquired ~5 fb-1 for end March 2018

Data taking plan



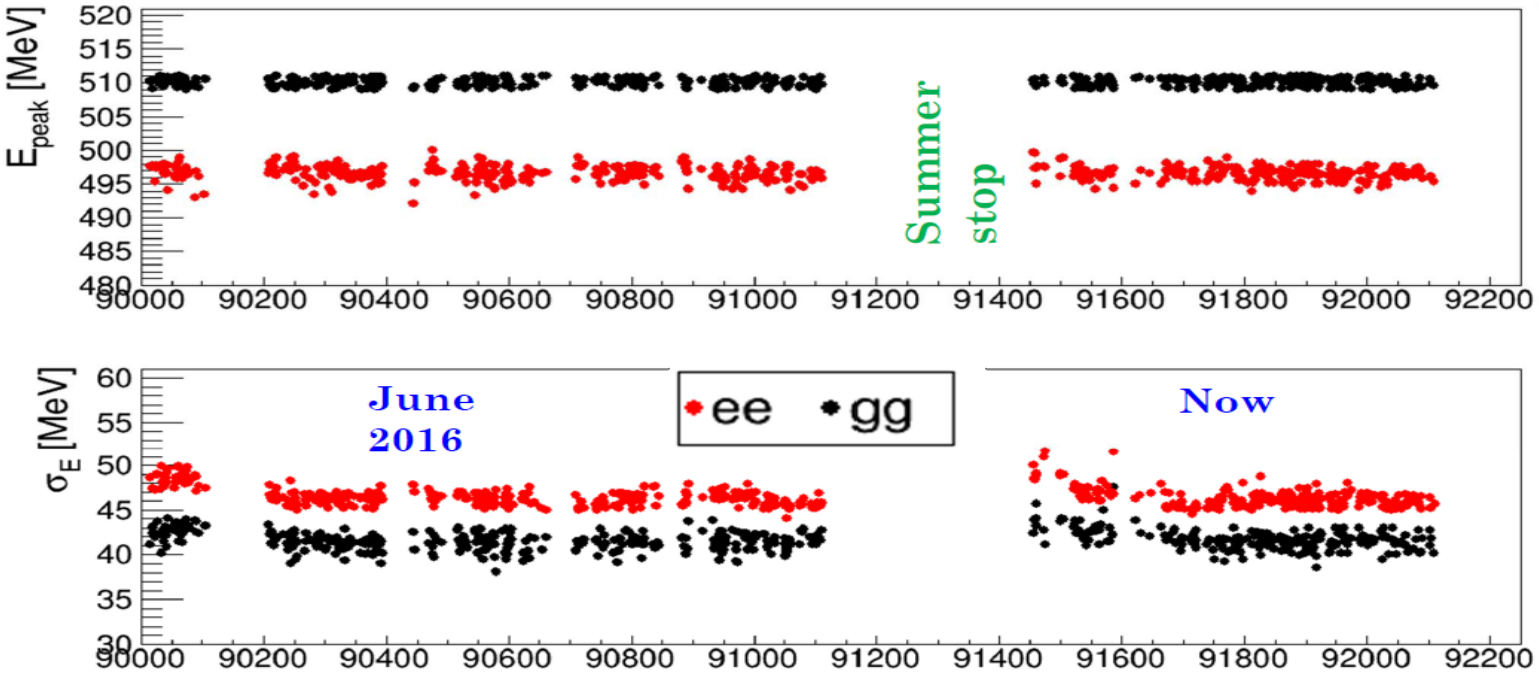
In case of possible changes in the DAPHNE schedule the KLOE-2 collaboration is strongly willing to profit from this opportunity to prolong the data taking of any available period beyond 31 March 2018. This can be done in synergy with the DAPHNE team to study and push forward the ultimate performance of DAPHNE.

RUN-III milestone L > 2 fb-1 accomplished: L delivered 5 fb-1
in line with the minimum requirement of 6.2 fb-1 => L acquired ~5 fb-1 for end March 2018

Detector status

EMC calibration

- Calibration procedure improved → all runs from Run I to III successfully re-calibrated
- Calibration stable over time



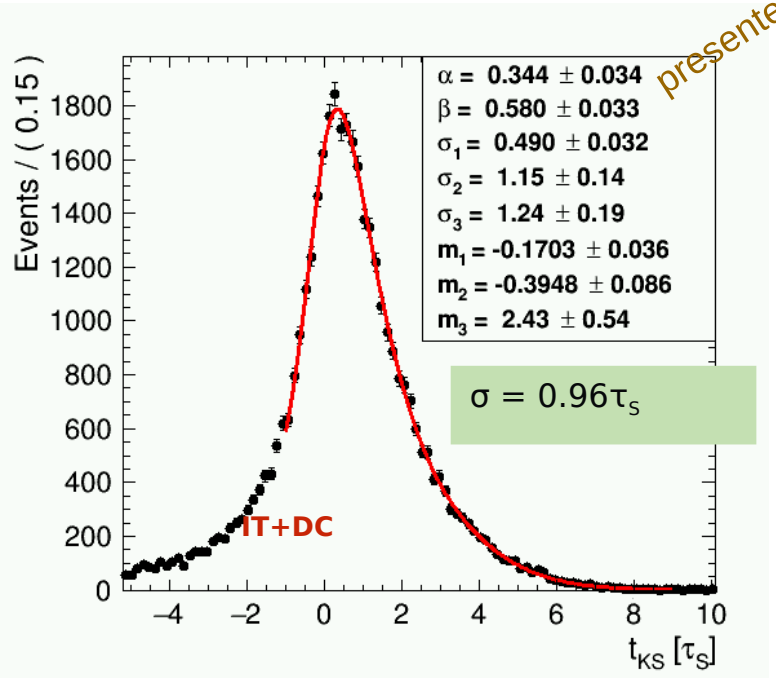
DC calibration

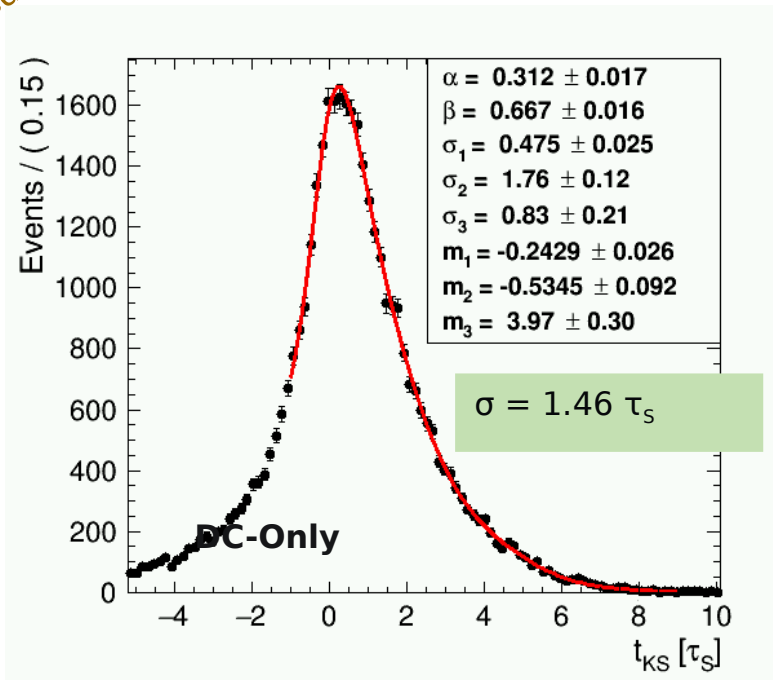
- Online calibration following up the data-taking

Analysis with Inner Tracker: K_S lifetime

- Vertex reconstruction improvement with KS→π+π- and $\phi \rightarrow \pi^+\pi^-\pi^0$ presented at the last Scientific Committee
- KS lifetime with KLOE-2 data wit IT+DC integrated reconstruction
  - K_S proper time distribution is τ_S units
  - Resolution from 1.5 τ_S to 1 τ_S using IT 1st Alignment & Calibration parameters
  - Expected improvement with refined Alig & Calib and optimized reconstruction

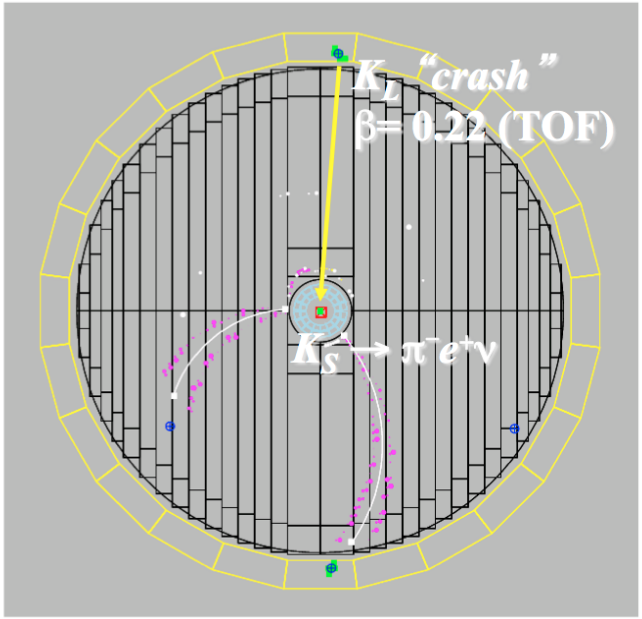
presented @ EPS-HEP 2017





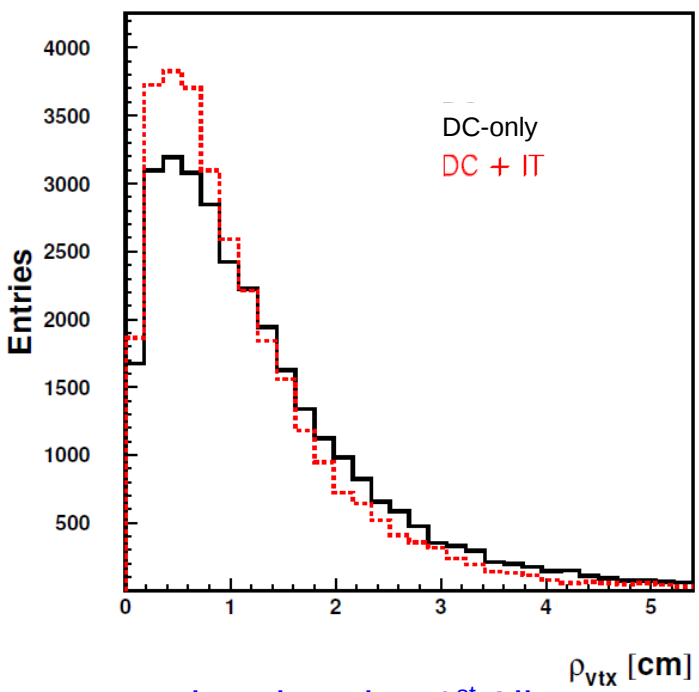
Analysis with Inner Tracker: K_S semileptonic

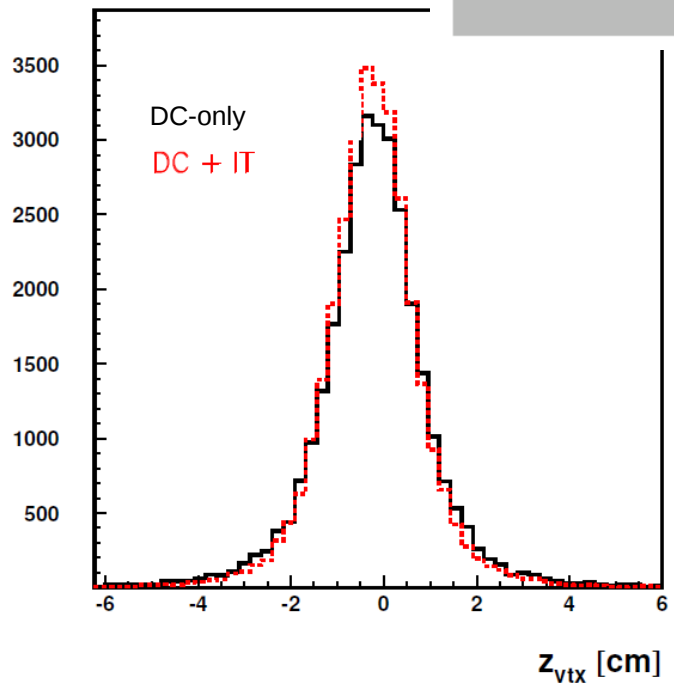
$K_S \rightarrow \pi e \nu$ analysis



Analysis of $K_S K_L \rightarrow K_L$(crash) $\pi e \nu$ starting with KLOE-2 data

Vertex distributions with and without integrated tracking



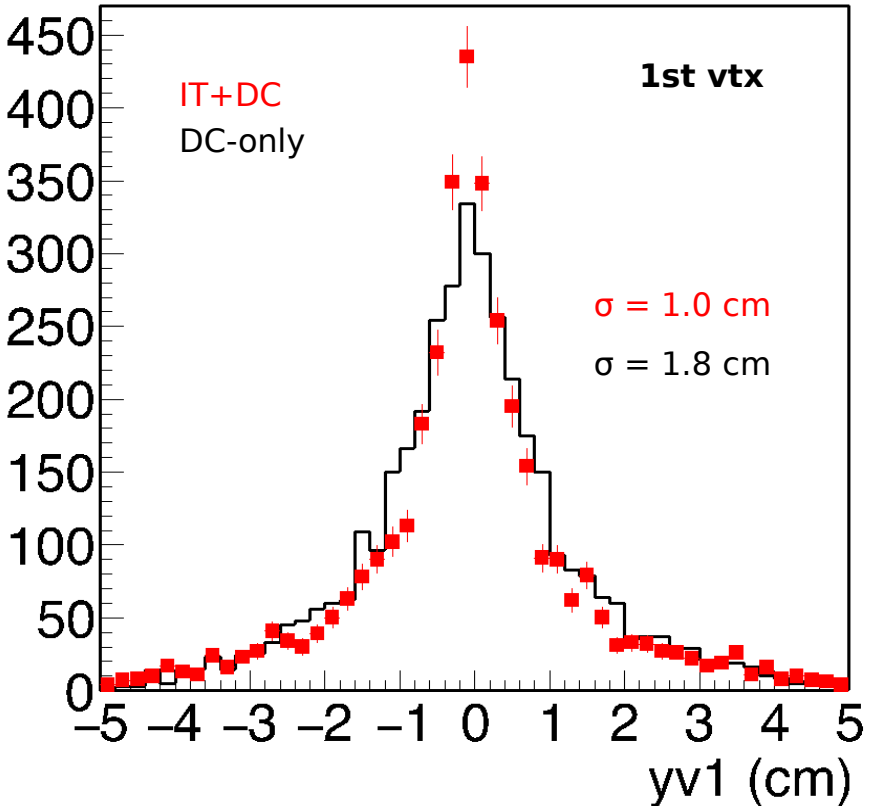


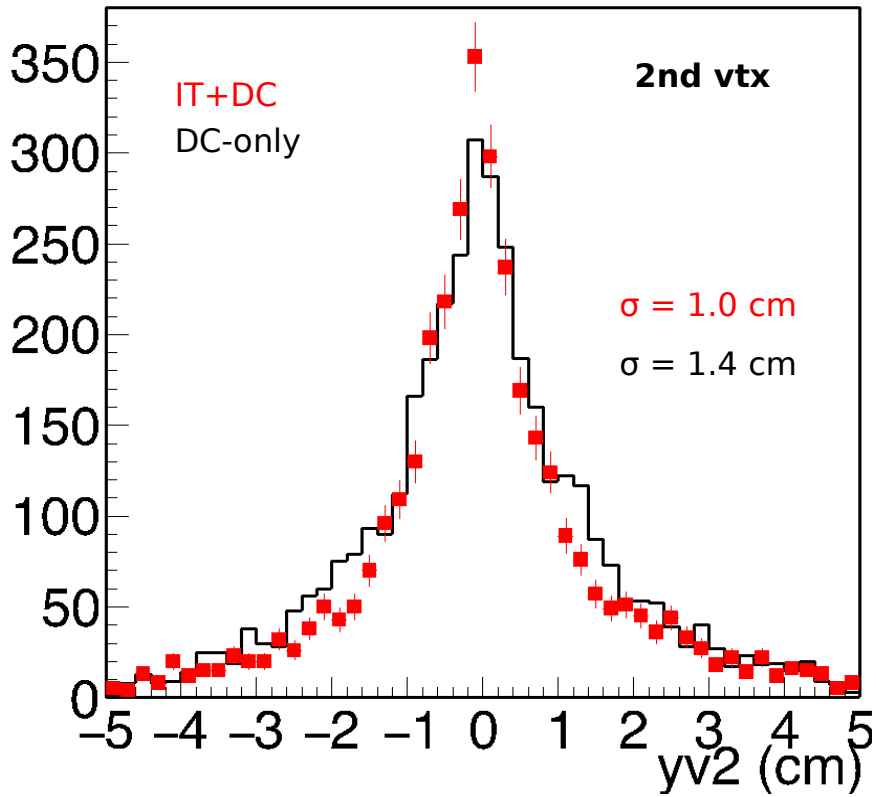
Improvements already using 1st Alignment & Calibration

Analysis with Inner Tracker: $K_S K_L \rightarrow$ 4 tracks

Improving vertex reconstruction towards $K_S K_L \rightarrow 4\pi$ processes

- 4 tracks from IP with p_T > 10 MeV, 2 vertices close to IP
- R_{vtx} < 5 cm && $|z_{vtx}|$ < 5 cm
- YV contributors: vertex resolution ⊕ K_S lifetime and K_L lifetime in acceptance
- Good improvement. Both vertices exhibit same resolution with IT+DC





KLOE-2 Analysis: $K_S \to 3\pi^0$

Data sample used of 420 pb^{-1}

Pre-selection:

KL-crash: E>150 MeV, $0.2 < \beta < 0.225$

prompt photons: $E_{cl} > 20$ MeV; $|\cos\theta_{cl}| \le 0.915$

and $|\Delta T_{cl}| \le \mathrm{Min}(3.0 \cdot \sigma_T(E_{cl}), 2\ \mathrm{ns})$

presented @ EPS-HEP 2017

$$F_{k\gamma} = \frac{N_{k\gamma}}{\sum_{k=1}^{10} N_{k\gamma}}$$

Ks->3pi0:

check of the old analysis chain on a subsample of 300 pb^{-1} (last sci.com.)

Taking into account the used statistics this translates to a very preliminary upper limit of $O(10^{-7})$

Normalization sample: $K_S \to 2\pi^0$

KLOE results:

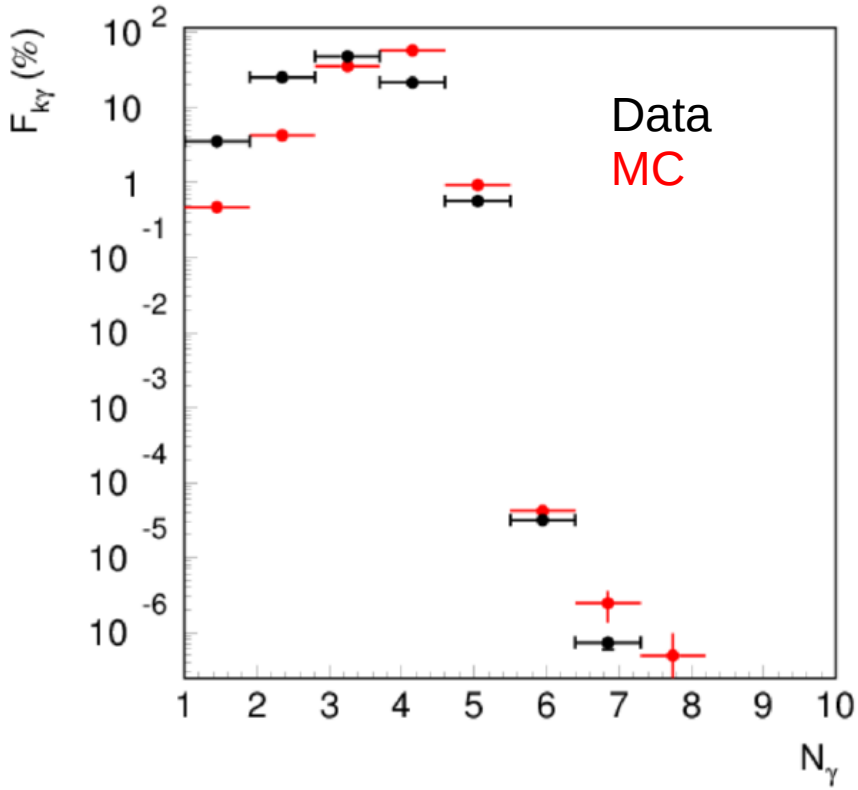
$BR(K_S \to 3\pi^0) < 1.2 \times 10^{-7}$ with 450 pb^{-1} [PLB 619 (2005) 61]

$BR(K_S \to 3\pi^0) < 2.6 \times 10^{-8}$ with 1.7 fb^{-1} [PLB 723 (2013) 54]

MC simulation:

$K_S \to 3\pi^0$ signal

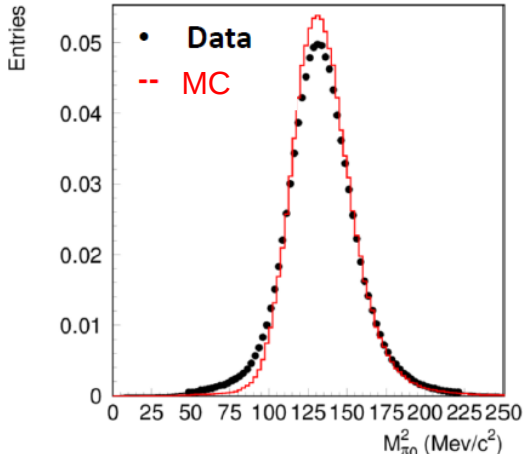
Background and control sample: All_phys production 260 pb^{-1}

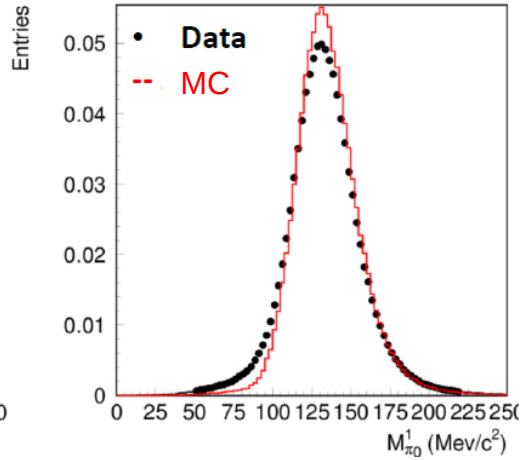


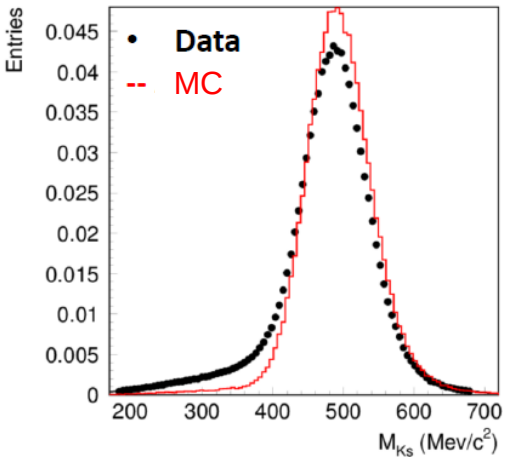
KLOE-2 DATA Analysis: $K_S \rightarrow 3\pi^0$

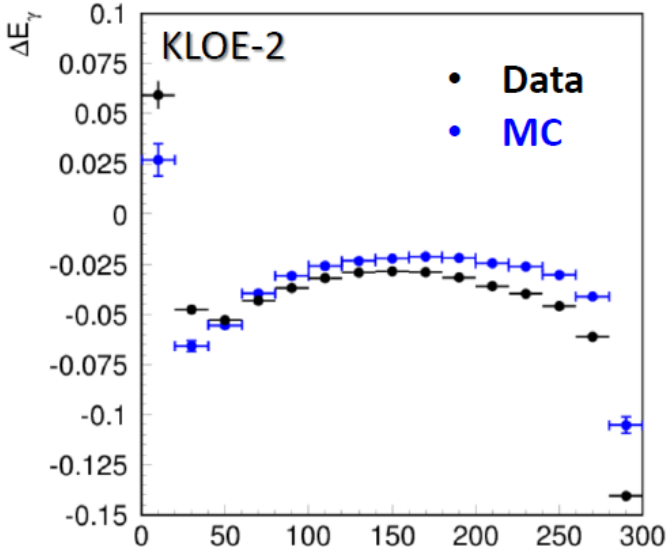
MC studies and normalization sample: $K_S \rightarrow 2\pi^0$

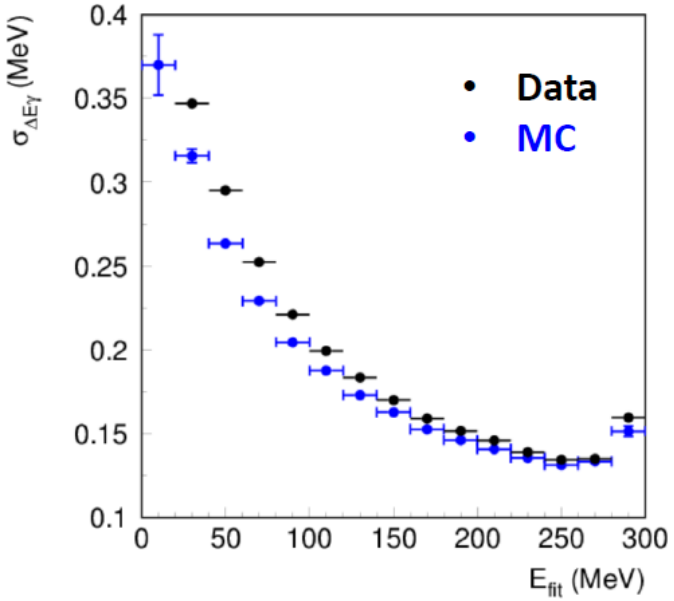
First comparison MC/data
MC validation energy scale









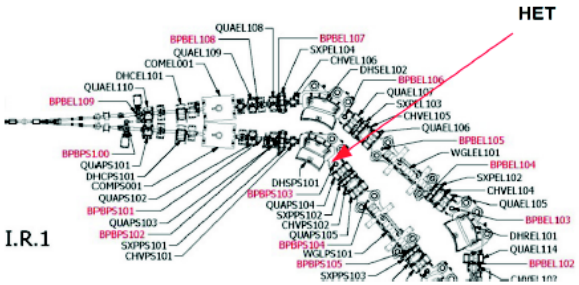


New energy scale corrections

$$\Delta E_\gamma = \langle (E_{cl} - E^{fit}{}_{cl}) / E^{fit}{}_{cl} \rangle$$

HET Analysis: $\gamma\gamma \rightarrow \pi^0$ (I)

BDSIM trajectories IP to HET simulation



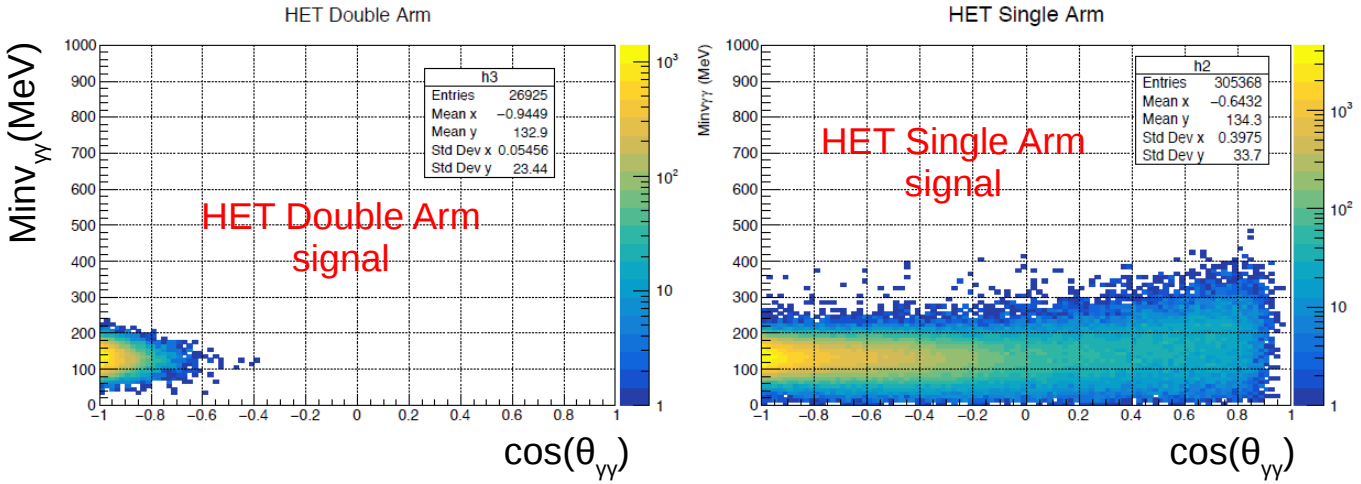
- Analyses of Double-arm and Single-arm HET tagged events show at the present stage no evidence of π^0 production
- Detailed beam transport studies: BDSIM simulation of the particle trajectory from IP to HET
- Background characterization to reduce background and training multivariate analysis

- **BDSIM** is a GEANT4 toolkit used to simulate the particle trajectories from the IP to the HET in the DAPHNE magnetic fields
- All magnets are simulated : Electron and Positron Rings are not exactly the same
- HET vertical dimension is the critical point for the tagger acceptance
- We have compared **all** the **simulated orbits** with the Beam-Position-Monitors placed in DAPHNE and slightly modified the magnetic setup in order to fit at best such positions

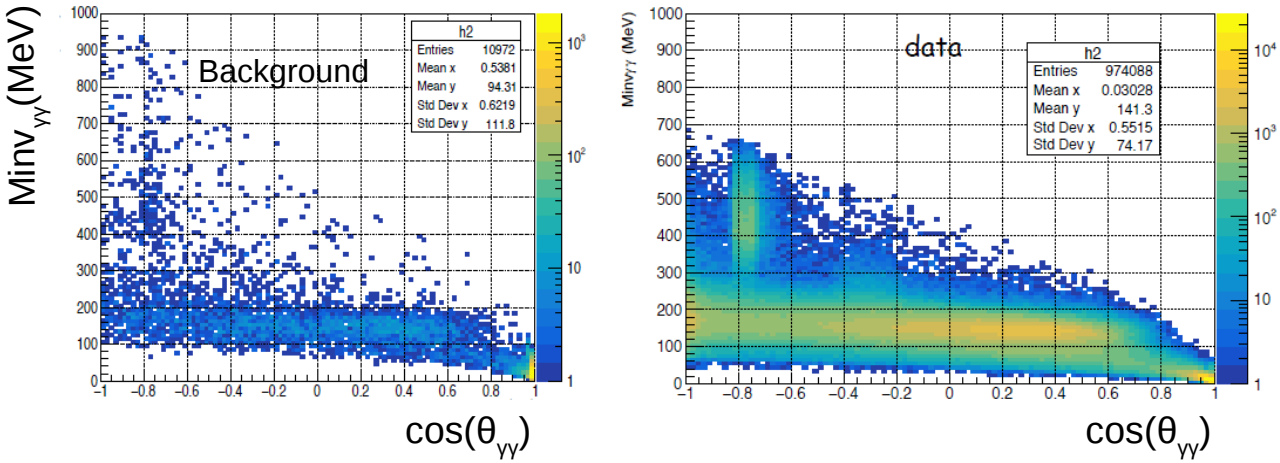
HET Analysis: $\gamma\gamma \rightarrow \pi^0$ (II)

Background characterization: sources

M_{inv} vs Cosθ from Ekhara + bdsim(BigMatrix) + Kloe resolution and trigger efficiency



- Investigating the origin of the background and simulated the distribution starting from real distributions recorded by the experiment
- Distribution of γγ-pairs reconstructed far from the trigger (not-triggering pairs)
- Then trigger conditions are applied to such pairs to select those in the background sample

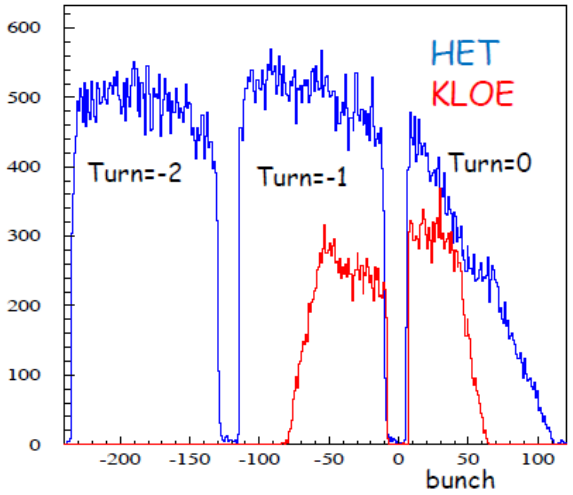


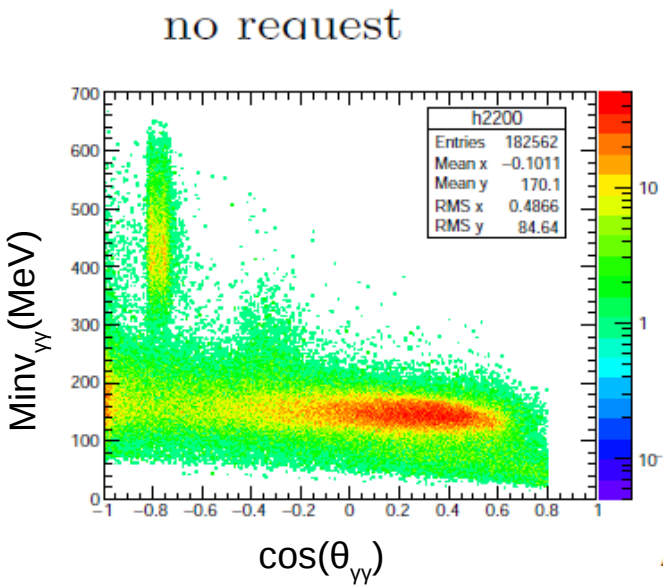
The background sample used after applying the triggerr conditions (dominated by Touschek events) is able to cover the entire kinematic range found for the background at low invariant masses

HET Analysis: $\gamma\gamma \rightarrow \pi^0$ (III)

Background characterization: cuts and HET-KLOE DAQ window comparison

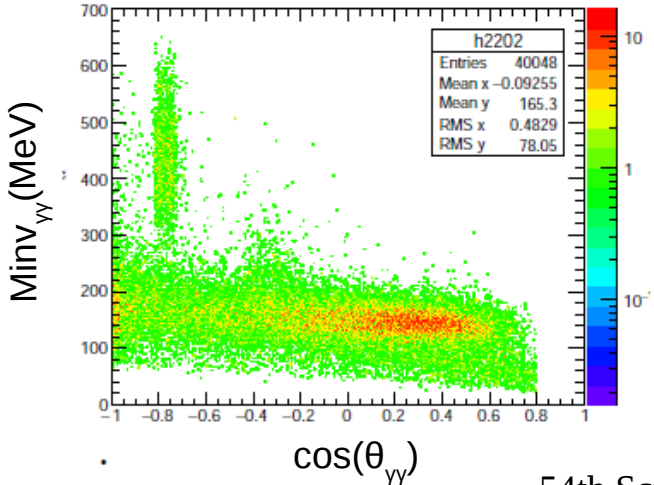
- KLOE open DAQ window for almost a DAPHNE turn for each trigger
- HET DAQ stores data for almost 3 DAPHNE turn for each trigger
- There is an overlap (W_{OK}) window where we can find tagged $\gamma\gamma$ events
- There is a region (W_{NO}) where there are no tagged events (out of coincidence window)



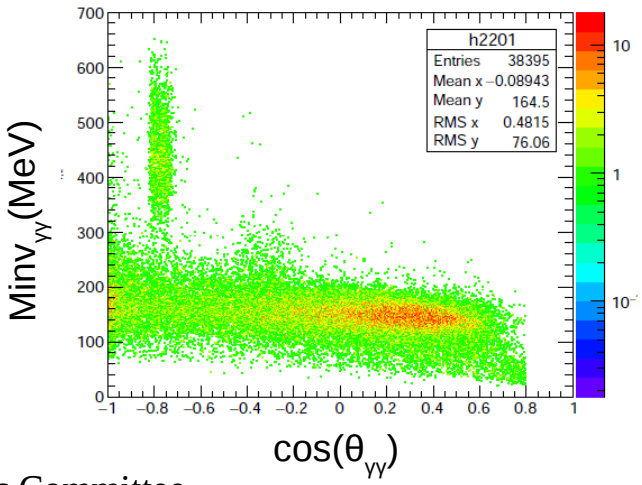


- The Background evaluation is done run by run by using an “untagged" data sample (Single Arm electrons or positrons) which are out of the coincidence window (W_{NO}) with KLOE DAQ (events matching the bunch but not the right turn)

Turn out (W_{NO})



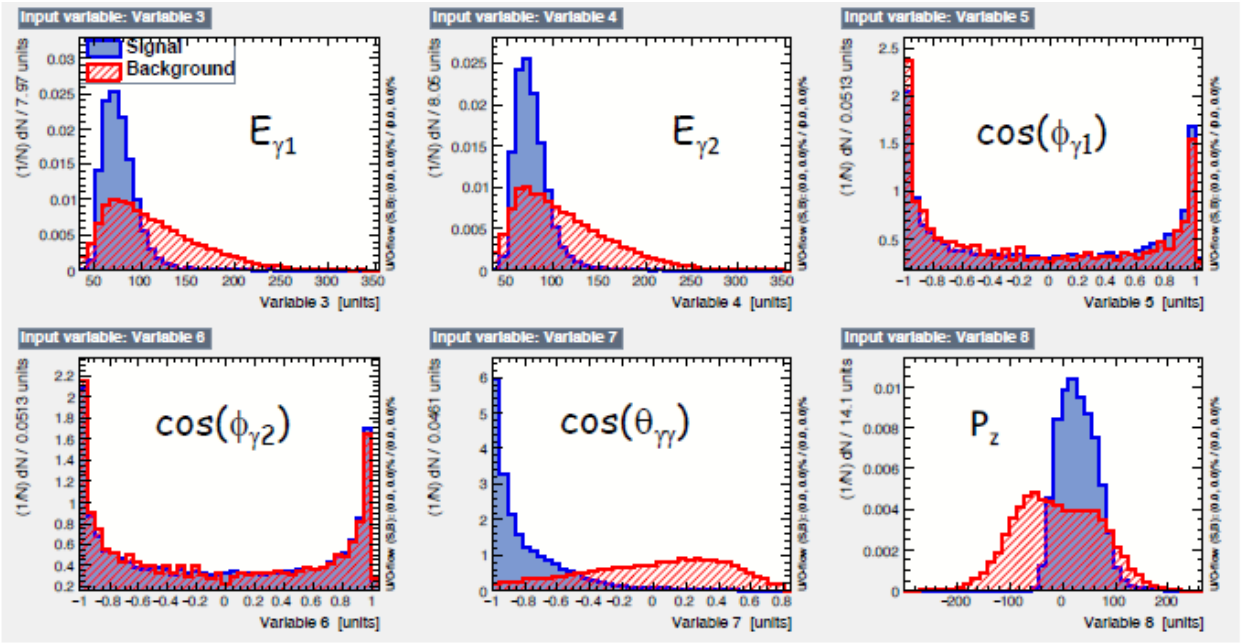
Turn in (W_{OK})



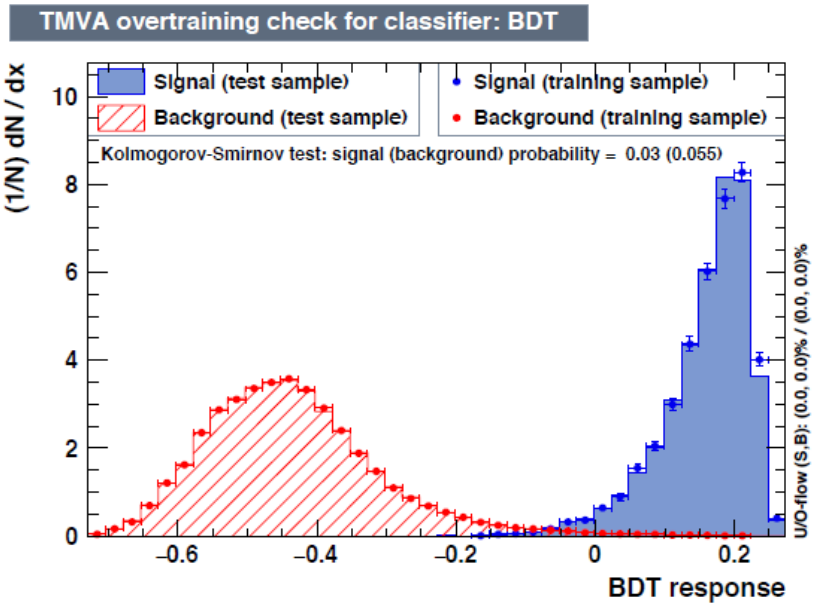
HET analysis: MVA strategy

- root Multi Variate Analysis : TMVA which can be used stand-alone or root-environment
- Signal sample, data from simulation : Ekhara + bdsim(BigMatrix) + Kloe resolution and trigger efficiency
- ”background” data coming from the time Window W_{NO}
- Both : single and double arm events

Input variables



Output example of training sample with S/B = 1

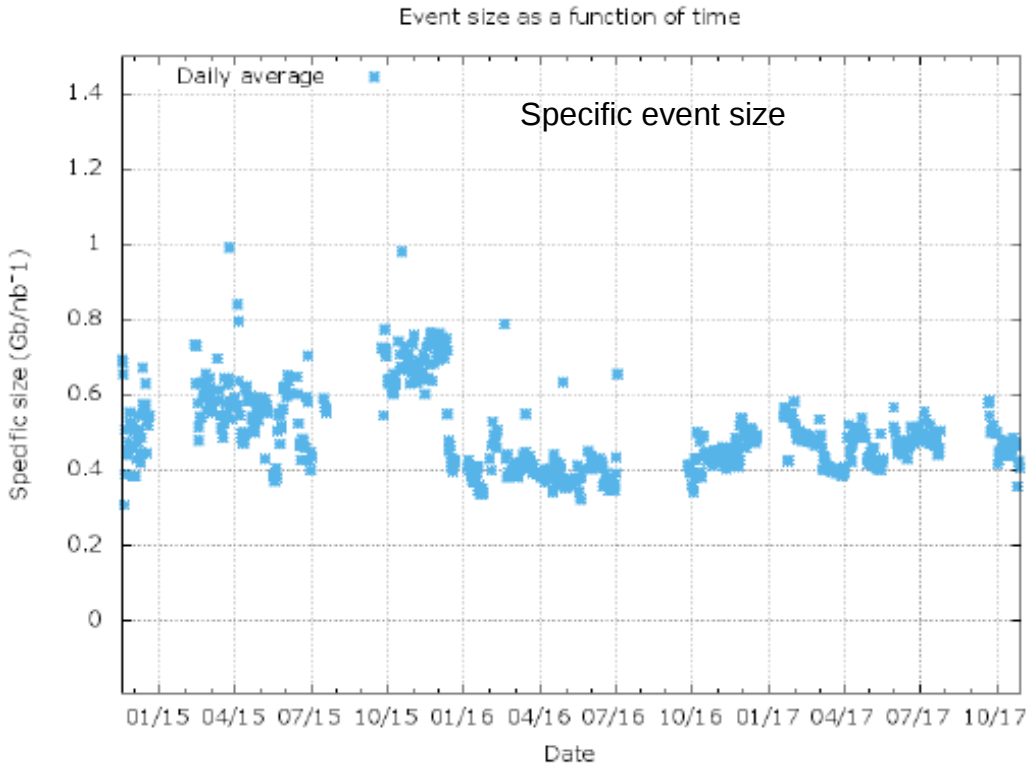


Data volume and Reconstruction

Data volume

Run-III consistent with expected 0.5 PB/fb-1

	Run-I	Run-II	Run-III	Run-IV
L [fb-1]	0.80	1.62	1.63	0.344
RAW [TB]	457	867	946	170
REC [pb-1]	30	586	285	1



Reconstruction

- New version 3.0 of the DC-IT integrated tracking and vertex successfully tested and inserted in reconstruction → already used in the results presented in this talk
- Implemented a new stream for events collected by the Single Photon Trigger → SPHOT: Selection module + new stream / output
- Test of new selection module for yy-physics
- Reconstruction rate ~10 pb-1/day OK to follow data taking → additional Power8 machine arriving at the end of the year
- Validation of all changes done with runs already reconstructed with previous versions
  - Reconstructed ~22% of the total luminosity
- Optimization studies and profiling of the code ongoing:
  - Tirocinio LNF-KLOE ICT student of VIA University College in Denmark on reconstruction performance optimization (5 months starting from August '17)

List of Analysis/Publications

BR and Transition Form Factor of $\varphi \to \pi^0 e^+ e^-$	PLB 757 (2016) 362
Dalitz plot analysis of $\eta \to \pi^+ \pi^- \pi^0$	JHEP 1605 (2016) 019
Hadron Vacuum Polarization in $e^+e^- \to \mu^+\mu^-\gamma$	PLB 767 (2017) 485
U boson search in $e^+e^- \to U\gamma$, $U \to \pi^+\pi^-$	PLB 757 (2016) 356
Semileptonic charge asymmetry of $K_S \to \pi e \nu$ CP/CPT	**Paper in preparation**
T/CPT test with $\varphi \to K_S K_L \to 3\pi^0\, \pi l \nu$, $\pi\pi\, \pi l \nu$	Δt distributions preliminary @ EPS-HEP 2017
BR of $K_S \to \pi^+\pi^-\pi^0$	PhD thesis preliminary
U boson search: combined limit from $\mu\mu\gamma/\pi\pi\gamma$	Preliminary @ EPS-HEP 2017
a_m and pion FF: combined result	**Submitted to JHEP**
BR of $\eta \to \pi^0\gamma\gamma$: χ_{pT} Golden mode	in progress
B boson search in $\varphi \to \eta\, \pi^0\gamma$	in progress
Improved UL of BR $K_S \to 3\pi^0$: CP/CPT (new K2 data)	Preliminary @ EPS-HEP 2017
$\gamma\gamma$ physics for π^0 search (KLOE-2 Data)	In progress
$K_S \to \pi^+ \pi^-$ and $K_L \to \pi^+ \pi^-$ (KLOE-2 Data)	Benchmark analysis
$\varphi \to \eta\, \gamma$ with $\eta \to 3\pi^0$, $\eta \to \gamma\gamma$ (KLOE-2 Data)	Benchmark analysis

Combined result of $\sigma(e^+e^- \to \pi^+\pi\gamma(\gamma))$ and $a_\mu^{\pi+\pi-}$

https://arxiv.org/abs/1711.03085

- New result with improved uncertainty
- Combined result of previous KLOE measurements fully taking into account correlation of statistical and systematical uncertainties

Combination of KLOE $\sigma\left(e^+e^- \to \pi^+\pi^-\gamma(\gamma)\right)$ ISR measurements and $a_\mu^{\pi^+\pi^-}$ between $0.1 \leq s \leq 0.95$ GeV^2

The KLOE-2 Collaboration

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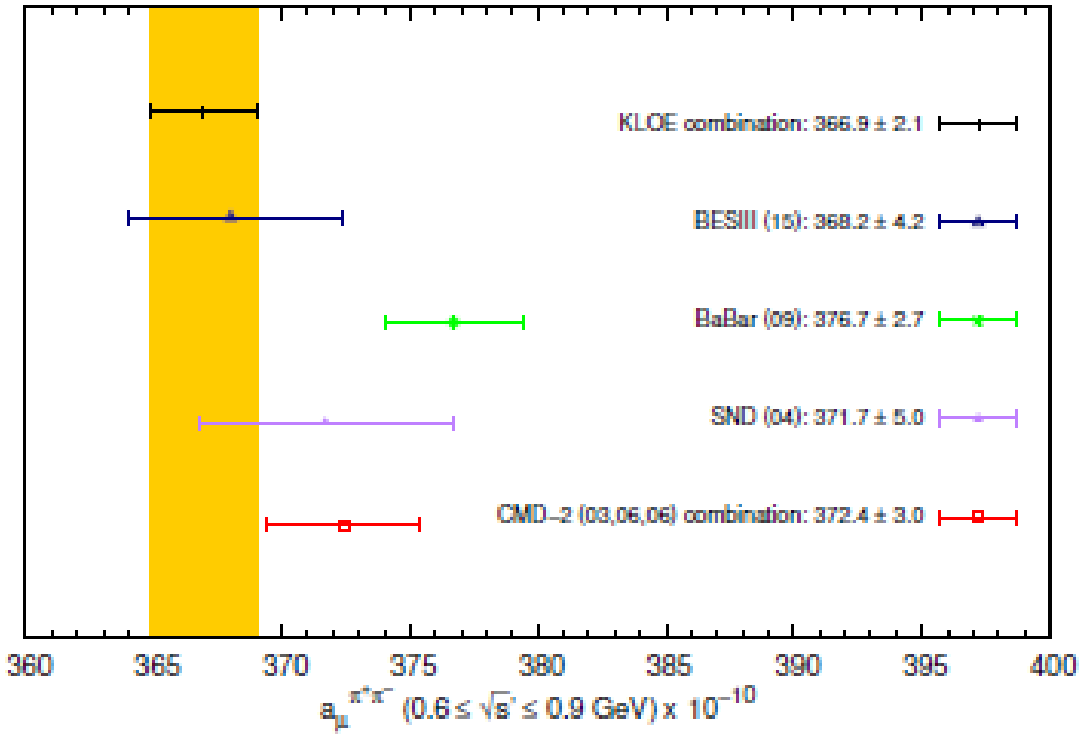


K_S -> πeν charge asymmetry

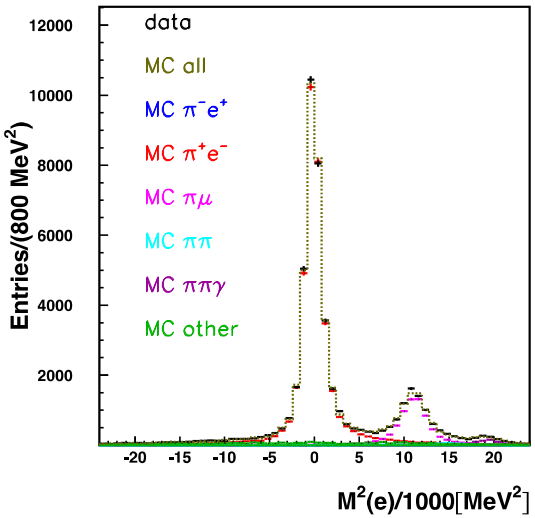
$A_{S,L} \neq 0$ => CP violation

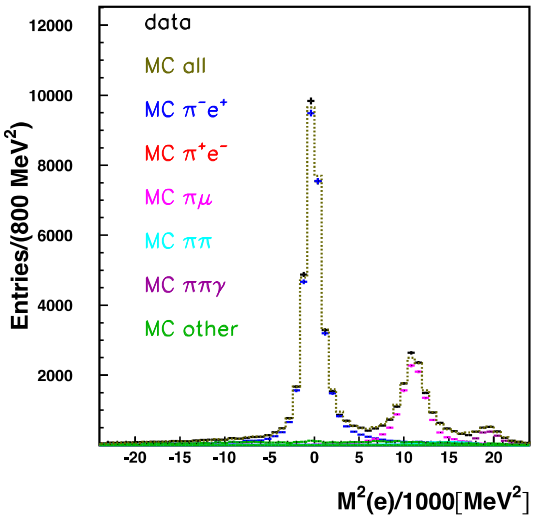
$A_S \neq A_L$ => CPT violation

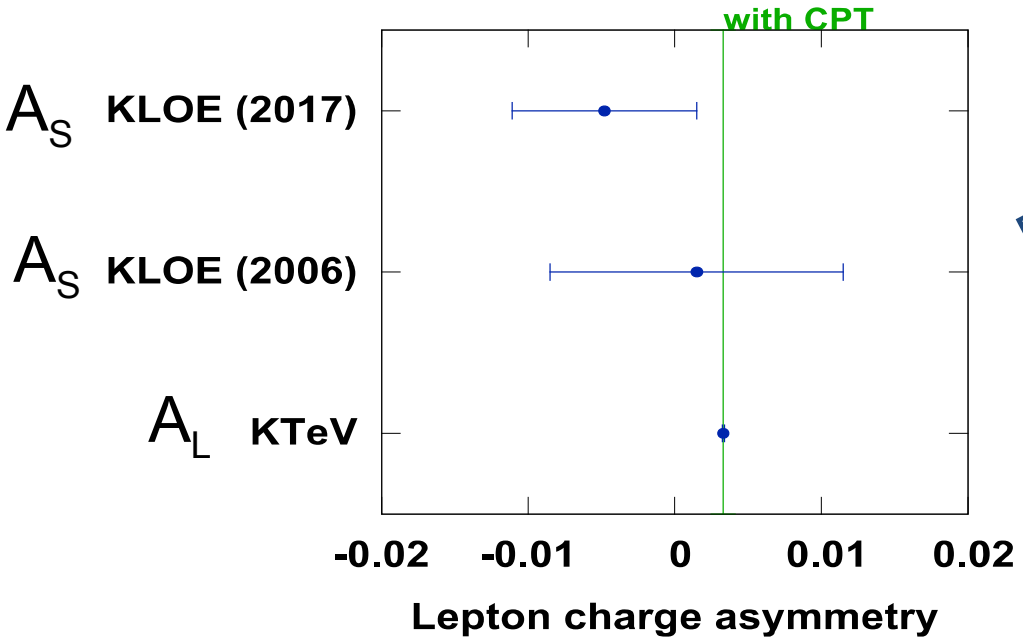
One of the cleanest and most precise test of CPT symmetry

- Fit of $M^2(e)$ distribution
- Control sample: K_L-> πeν close to IP tagged by K_S->$\pi^0\pi^0$
- track to EMC cluster and TOF efficiency correction from data c.s.

Final result and paper in preparation







FINAL RESULT

KLOE (2017)

$$A_S = (-4.8 \pm 5.7 \pm 2.6) \times 10^{-3}$$

with KLOE-2 data: $\delta A_S(\text{stat}) \rightarrow \sim 3\times10^{-3}$

Conclusions

- L delivered up to now 407 nb-1, acquired L~330 nb-1
  Restart only one month ago

- RUN-III milestone L > 2 fb-1 accomplished
- L acquired ~5 fb-1 for end March 2018

- In case of possible changes in the DAPHNE schedule the KLOE-2 collaboration is strongly willing to profit from this opportunity to prolong the data taking of any available period beyond 31 March 2018. This can be done in synergy with the DAPHNE team to study and push forward the ultimate performance of DAPHNE.

- KLOE-2 Data Analysis:
  - Preliminary results from IT+DC integrated tracking and vertexing algorithm for the K_S lifetime and $K_S \rightarrow \pi e \nu$ analysis. Good improvement also shown with 4-tack final state
  - Analysis to improve the limit on BR of KS->3p0 : MC validation and increasing data statistics towards analysis optimization
  - Analyses of Double-arm and Single-arm HET tagged events show at the present stage no evidence of π^0 production. Detailed beam transport studies performed. Characterization of the background and Multivariate Analysis in progress.

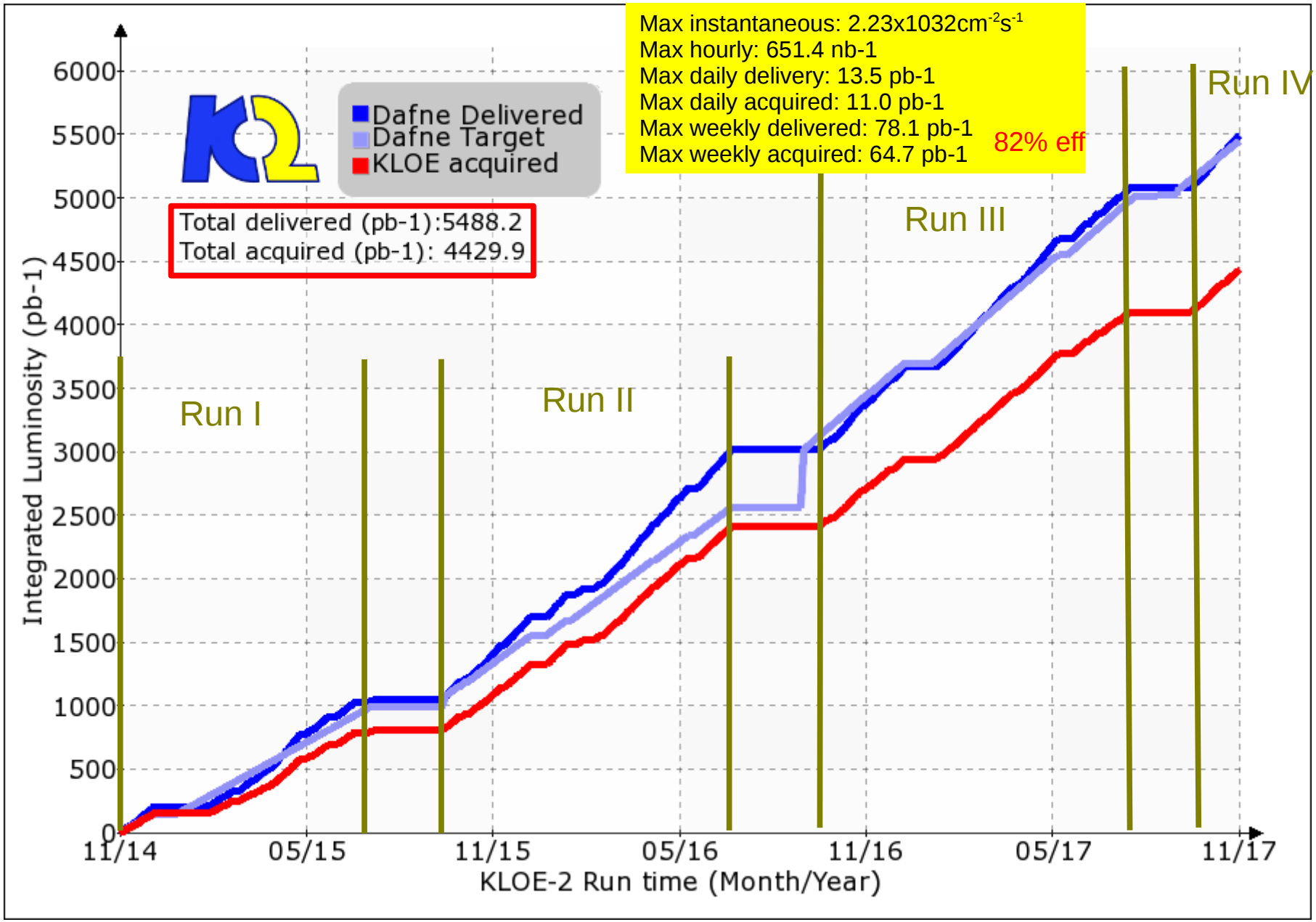
- Data quality is continuously monitored with several benchmark analysis.

- Data reconstruction with integrated IT+DC tracking and including Single Photon Trigger selection ongoing using the new data handling (GPFS+Disk Array) architecture scheme.

- Two new publications soon: Combined results of $a_\mu^{\pi^+\pi^-}$ and charge asymmetry of $KS \rightarrow \pi e \nu$ CP/CPT test

Backup slides

Data taking


Max instantaneous: 2.23x1032cm-2s-1
Max hourly: 651.4 nb-1
Max daily delivery: 13.5 pb-1
Max daily acquired: 11.0 pb-1
Max weekly delivered: 78.1 pb-1
Max weekly acquired: 64.7 pb-1
82% eff
Dafne Delivered
Dafne Target
KLOE acquired
Total delivered (pb-1):5488.2
Total acquired (pb-1): 4429.9
Run I
Run II
Run III
Run IV
Integrated Luminosity (pb-1)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
11/14
05/15
11/15
05/16
11/16
05/17
11/17
KLOE-2 Run time (Month/Year)

Start Analysis with IT: $K_S K_L \rightarrow$ 4 tracks

- 4 tracks from IP with $p_T > 10$ MeV, 2 vertices close to IP
- $R_{vtx} < 5$ cm && $|z_{vyx}| < 5$ cm
- YV contributors: vertex resolution ⊕ K_S lifetime
- Improvements observed